

# LHCP 2013 - First Large Hadron Collider Physics Conference

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## Book of Abstracts



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## Coffee

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## Contribution 1

2

## Contribution 2

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## Searching for supersymmetry in $Z'$ decays

**Author:** Gennaro Corcella<sup>None</sup>

**Corresponding Author:** gennaro.corcella@lnf.infn.it

I will discuss  $Z'$  production at the LHC in the Sequential Standard Model and in GUT-inspired  $U(1)'$  models. In particular, I will account for possible  $Z'$  decays in supersymmetric particle pairs, such as sleptons, charginos and neutralinos in the MSSM. The number of supersymmetric events in  $Z'$  decays at the LHC is estimated and the impact of the inclusion of supersymmetric decays on the current  $Z'$  mass exclusion limit is debated.

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## Higher moments of net kaon multiplicity distributions at RHIC energies for the search of QCD Critical Point

**Author:** amal (For the STAR COLLABORATION) sarkar<sup>1</sup>

<sup>1</sup> *Indian Institute of Technology Bombay*

**Corresponding Author:** amal@rcf.rhic.bnl.gov

The Relativistic Heavy-Ion Collider (RHIC), at BNL, has started its beam energy scan(BES) program by colliding heavy-ions extending the reach in baryonic chemical potential upto 400 MeV. One of the main goals of this beam energy scan program is to locate the critical point which is postulated to lie at the end of the phase transition boundary between partonic and hadronic matter. Finite temperature lattice QCD calculations at baryon chemical potential  $\mu_B = 0$  suggest a crossover above a critical temperature  $T_c \sim 170 - 190$  MeV from a system with hadronic degrees of freedom to a system where the relevant degrees of freedom are quarks and gluons. Several QCD based calculations find

the quark-hadron phase transition to be first order at large  $\mu_B$ . The point in the QCD phase plane ( $T$  vs  $\mu_B$ ) where the first order phase transition ends is the QCD critical point (CP). In a static, infinite medium, the correlation length ( $\xi$ ) diverges at the CP.  $\xi$  is related to various moments of the distributions of conserved quantities such as net baryons, net charge, and net strangeness [1]. Typically variances ( $\sigma^2 = \langle \Delta N \rangle^2$ ;  $\Delta N = N - M$ ; where  $M$  is the mean) of these distributions are related to  $\xi$  as  $\sigma^2 \propto \xi^2$  [2]. Finite size and time effects in heavy-ion collisions put constraints on the values of  $\xi$ . A theoretical calculation suggests  $\xi \approx 2 - 3$  fm for heavy-ion collisions [2, 3]. It was recently shown that higher moments of distributions of conserved quantities, measuring deviations from a Gaussian, have a sensitivity to CP fluctuations that is better than that of  $\sigma^2$ , due to a stronger dependence on  $\xi$  [2, 3, 4]. The numerators in skewness ( $S = \langle \Delta N \rangle^3 / \sigma^3$ ) go as  $\xi^{4.5}$  and kurtosis ( $k = [\langle \Delta N \rangle^4 / \sigma^4] - 3$ ) go as  $\xi^7$  [5]. Presence of a Critical Point might result in divergences of the correlation lengths.

Here we report the measurements of the various moments (standard deviation ( $\sigma$ ), skewness ( $S$ ) and kurtosis ( $k$ )) and their products ( $k\sigma^2$ ,  $S\sigma$ ) of the net kaon multiplicity measured by the STAR detector at mid-rapidity for Au+Au collisions at  $\sqrt{s_{NN}} = 7.7$  to 200 GeV center of mass energies. The energy and centrality dependence of higher moments of net-kaons and their products (such as  $S\sigma$  and  $k\sigma^2$ ) will be presented in all BES energies. Theoretical calculations, containing the non-CP physics from the HIJING, AMPT, UrQMD models will be compared to the data.

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## The Higgs: supersymmetric partner of the neutrino

**Author:** Francesco Riva<sup>1</sup>

<sup>1</sup> EPFL

Recent LHC searches have provided strong evidence for the Higgs, a boson whose gauge quantum numbers coincide with those of a SM fermion, the neutrino. This raises the question of whether Higgs and neutrino may be related by supersymmetry. I will show explicitly the implications of models where the Higgs is the sneutrino: from a theoretical point of view an R-symmetry, acting as lepton number is necessary; on the experimental side, squarks exhibit novel decays into quarks and leptons, allowing to differentiate these scenarios from the ordinary MSSM.

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## Parton Distributions in the Higgs Boson Era

**Author:** Juan Rojo Chacon<sup>1</sup>

<sup>1</sup> CERN

**Corresponding Author:** juan.rojo@cern.ch

With the recent discovery of the Higgs boson at the LHC, particle physics has entered a new era, where it is of utmost importance to

provide accurate theoretical predictions for all relevant high energy processes for signal, background and New Physics production. Crucial ingredients of these predictions are the Parton Distribution Functions, which encode the non-perturbative dynamics determining how the proton's energy is split among its constituents, quarks and gluons. To bypass the drawbacks of traditional analyses, a novel approach to PDF determination has recently been proposed, based on artificial neural networks, machine learning techniques and genetic algorithms.

In this talk we motivate their relevance of PDFs for LHC phenomenology and describe the latest developments of PDFs with LHC data.

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## Inclusive Deep Inelastic Scattering at High $Q^2$ with Longitudinally Polarised Lepton Beams at HERA

**Author:** . H1 Collaboration<sup>1</sup>

<sup>1</sup> DESY

**Corresponding Authors:** daum@mail.desy.de, e.rizvi@qmul.ac.uk

Inclusive  $e$ -pmp single and double differential cross sections for neutral and charged current deep inelastic scattering processes are measured with the H1 detector at HERA. The data were taken at a centre-of-mass energy of  $\sqrt{s} = 319\text{GeV}$  with a total integrated luminosity of  $333.7\text{ pb}^{-1}$  shared between two lepton beam charges and two longitudinal lepton polarisation modes. The differential cross sections are measured in the range of negative four-momentum transfer squared,  $Q^2$ , between 60 and  $50\,000\text{GeV}^2$ , and Bjorken  $x$  between 0.0008 and 0.65. The measurements are combined with earlier published unpolarised H1 data to improve statistical precision and used to determine the structure function  $xF_3^{\gamma Z}$ . A measurement of the neutral current parity violating structure function  $F_2^{\gamma Z}$  is presented for the first time. The polarisation dependence of the charged current total cross section is also measured. The new measurements are well described by a next-to-leading order QCD fit based on all published H1 inclusive cross section data which are used to extract the parton distribution functions of the proton.

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## Combination and QCD Analysis of Charm Production Cross Section Measurements in Deep-Inelastic ep Scattering at HERA

**Author:** . H1 and ZEUS Collaborations<sup>1</sup>

<sup>1</sup> DESY

**Corresponding Author:** daum@mail.desy.de

Measurements of open charm production cross sections in deep-inelastic ep scattering at HERA from the H1 and ZEUS Collaborations are combined. Reduced cross sections  $\sigma_{\text{red}}^{\bar{c}}$  for charm production are obtained in the kinematic range of photon virtuality  $2.5 < Q^2 < 2000\text{ GeV}^2$  and Bjorken scaling variable  $0.00003 < x < 0.05$ . The combination method accounts for the correlations of the systematic uncertainties among the different data sets. The combined charm data together with the combined inclusive deep-inelastic scattering cross sections from HERA are used as input for a detailed NLO QCD analysis to study the influence of different heavy flavour schemes on the parton distribution functions. The optimal values of the charm mass as a parameter in these different schemes are obtained. The implications on the NLO predictions for  $W^{\text{pm}}$  and Z production cross sections at the LHC are investigated. Using the fixed flavour number scheme, the running mass of the charm quark is determined.

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## Higgs boson production in the SM and MSSM to NNLO

**Author:** Matthias Steinhauser<sup>1</sup>

<sup>1</sup> *KIT*

**Corresponding Author:** matthias.steinhauser@kit.edu

In this talk higher order corrections to Higgs boson production cross section both in the Standard Model and its minimal extension (MSSM) are discussed. As special focus is put on the recent next-to-next-to-leading order (NNLO) corrections within the MSSM and on the first step towards third-order corrections within the Standard Model.

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## Parton Shower Unitarity and NLO Matching

**Author:** Leif Lönnblad<sup>1</sup>

<sup>1</sup> *Lund University (SE)*

**Corresponding Author:** leif.lonnblad@thep.lu.se

During the last years, much effort has gone into increasing the precision of event generators by carefully matching or merging parton shower programs with exact fixed-order matrix elements. The merging of tree-level matrix elements has now become the standard for multi-jet events, but these leading order procedures lack in precision, and also suffer from a dependence on an unphysical merging scale. For many processes the matching of Next-to-Leading Order (NLO) matrix elements with parton showers has become state-of-the-art, but the standard programs can typically only handle the lowest possible jet-multiplicities.

In this talk I will present a new algorithm where multi-jet NLO matrix elements are correctly merged with parton showers. The new algorithm is based on an improvement of the so-called CKKW-L scheme for tree-level merging where the combination of different multiplicities is treated in a unitary way. The algorithm has been implemented in the Pythia8 event generator and will in principle be able to handle any process where multi-jet partonic states can be produced to NLO precision, however, in this talk I will only present results for W+jets and Higgs+jets observables.

**Opening plenary / 33**

## Welcome

**Corresponding Author:** cavalli@ifae.es

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## Opening vision talk

Corresponding Author: sergio.bertolucci@cern.ch

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## Contribution 1

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## Contribution 2

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## Opening vision talk

Corresponding Author: sergio.bertolucci@cern.ch

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## Opening vision talk

Corresponding Author: sergio.bertolucci@cern.ch

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## Opening vision talk

Author: Sergio Bertolucci<sup>1</sup>

<sup>1</sup> CERN

Corresponding Author: sergio.bertolucci@cern.ch

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## Opening vision talk

**Opening plenary / 42**

## **Opening vision talk**

**Corresponding Author:** sergio.bertolucci@cern.ch

**Opening plenary / 43**

## **LHC machine: status and plans**

**Corresponding Author:** mirko.pojer@cern.ch

**Plenary / 44**

## **ATLAS SM Higgs results**

**Corresponding Author:** andrew.mehta@cern.ch

**Plenary / 45**

## **CMS SM Higgs results**

**Corresponding Author:** pablo.garcia@cern.ch

**Plenary / 46**

## **Tevatron Higgs results**

**Corresponding Author:** tuchming@cea.fr

**Plenary / 47**

## **SM Higgs theory and SM Higgs production**

**Corresponding Author:** harlander@physik.uni-wuppertal.de

**Plenary / 48**

## **BSM Higgs results from ATLAS and CMS**

**Corresponding Author:** martin.flechl@cern.ch

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## **SM/BSM Higgs theory**

Corresponding Author: antonio.pich@uv.es

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## **Time reserved for potential breaking news (TBC)**

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## **Heavy Ions theory overview**

Corresponding Author: urs.wiedemann@cern.ch

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## **Jets and bosons in Heavy Ion collisions**

Corresponding Author: begona.delacruz@ciemat.es

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## **Heavy flavour and quarkonia in Heavy Ions**

Corresponding Author: andrea.rossi@cern.ch

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## **Soft particle production, flow and correlations in Heavy Ions**

Corresponding Author: michele.floris@cern.ch

Plenary / 55

## **HF theory (CKM matrix, decays)**

Corresponding Author: jure.zupan@cern.ch

Plenary / 56

## **CP violation and mixing**

Corresponding Author: anton.poluektov@cern.ch

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## **Rare decays**

Corresponding Author: che@physik.uzh.ch

Plenary / 58

## **Charm physics**

Corresponding Author: jeroen.van.tilburg@cern.ch

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## **Theory: Highlights from pQCD and tools**

Corresponding Author: cacciari@lpthe.jussieu.fr

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## **Jet Physics at the LHC and the Tevatron**

Corresponding Author: jay.dittmann@cern.ch

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## **Weak Boson + jet production at LHC and Tevatron**

Corresponding Author: lucia.di.ciaccio@cern.ch

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## **Heavy flavour and quarkonium production at the LHC**

Corresponding Author: hermine.woehri@cern.ch



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## **ALFA/Totem and elastic/diffractive physics**

Corresponding Author: risto.orava@cern.ch

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## **Soft QCD**

Corresponding Author: rene.bellwied@cern.ch

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## **Hadron spectroscopy and exotic states**

Corresponding Author: antonio.augusto.alves.junior@cern.ch

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## **First results from pPb collisions at the LHC**

Corresponding Author: cloizides@lbl.gov

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## **Non-SUSY BSM Theory**

Corresponding Author: andreas.weiler@cern.ch

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## **Searches for resonances at LHC and Tevatron**

Corresponding Author: vacavant@in2p3.fr

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## **Searches for non-resonant new phenomena**

Corresponding Author: tulika.bose@cern.ch

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## **Searches for squarks and gluinos in events with missing transverse momentum**

Corresponding Author: [alessandro.gaz@cern.ch](mailto:alessandro.gaz@cern.ch)

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## **SUSY theory overview**

Corresponding Author: [mreece@physics.harvard.edu](mailto:mreece@physics.harvard.edu)

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## **Searches for 3rd generation SUSY and heavy top or bottom partners at LHC and Tevatron**

Corresponding Author: [p.fabrizio.salvatore@gmail.com](mailto:p.fabrizio.salvatore@gmail.com)

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## **Searches with multilepton final states**

Corresponding Author: [celso.martinez.rivero@cern.ch](mailto:celso.martinez.rivero@cern.ch)

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## **Searches with long-lived or unusual signatures at LHC and Tevatron**

Corresponding Author: [sigve.haug@lhep.unibe.ch](mailto:sigve.haug@lhep.unibe.ch)

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## **W/Z precision physics**

Corresponding Author: [isabel.josa@ciemat.es](mailto:isabel.josa@ciemat.es)

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## **W mass measurement**

**Corresponding Author:** ashutosh.kotwal@cern.ch

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## **Diboson production at LHC and Tevatron**

**Corresponding Author:** cpw1@hep.phy.cam.ac.uk

Plenary / 78

## **EW theory and global fit**

**Corresponding Author:** luca.silvestrini@roma1.infn.it

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## **Top production including Afb**

**Corresponding Author:** schwanen@fnal.gov

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## **Top mass and properties at LHC and Tevatron**

**Corresponding Author:** maria.jose.costa@cern.ch

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## **Boosted tops and $t\bar{t}$ resonances**

**Corresponding Author:** justin.pilot@cern.ch

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## **Top theory**

**Corresponding Author:** fabio.maltoni@cern.ch

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## **CMS upgrades and performance**

Corresponding Author: [austin.ball@cern.ch](mailto:austin.ball@cern.ch)

Plenary / 84

## **ATLAS upgrades and performance**

Corresponding Author: [heinz.pernegger@cern.ch](mailto:heinz.pernegger@cern.ch)

Plenary / 85

## **ALICE upgrades and performance**

Corresponding Author: [thomas.peitzmann@cern.ch](mailto:thomas.peitzmann@cern.ch)

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## **LHCb upgrades and performance**

Corresponding Author: [richard.jacobsson@cern.ch](mailto:richard.jacobsson@cern.ch)

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## **Neutrino physics**

Corresponding Author: [pilar@ific.uv.es](mailto:pilar@ific.uv.es)

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## **Closing experimental summary**

Corresponding Author: [tatsuya.nakada@cern.ch](mailto:tatsuya.nakada@cern.ch)

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## **Closing theory summary**

Corresponding Author: [joseph.david.lykken@cern.ch](mailto:joseph.david.lykken@cern.ch)

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## Combining searches of $Z'$ and $W'$ bosons

**Author:** Manuel Manuel Perez-Victoria<sup>1</sup>

**Co-authors:** Javier M. Lizana<sup>1</sup>; Jorge de Blas<sup>2</sup>

<sup>1</sup> *University of Granada*

<sup>2</sup> *Notre Dame University*

**Corresponding Author:** mpv@ugr.es

Gauge invariance imposes model-independent correlations in the couplings and masses of heavy neutral and charged vector bosons. We show how to take advantage of these correlations in combined analyses of dilepton and lepton-plus-missing-energy signals at the LHC.

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## Distinguishing LNV scalars at the LHC

**Author:** Francisco del Aguila<sup>1</sup>

**Co-author:** Mikael Rodriguez Chala<sup>2</sup>

<sup>1</sup> *University of Granada (ES)*

<sup>2</sup> *LIP Laboratorio de Instrumentacao e Fisica Experimental de Particu*

**Corresponding Author:** faguila@ugr.es

Lepton number violating scalars decaying into lepton pairs, as those mediating the see-saw of type II, always include doubly -charged components. If these are observed at LHC, their quantum numbers can be determined accounting for their leptonic decays in pair and single production.

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## Top-quark mass measurements using jet rates at LHC

**Authors:** Adrian Irlles Quiles<sup>1</sup>; Juan Fuster Verdu<sup>1</sup>; Marcel Vos<sup>1</sup>; Patricia Fernandez Martinez<sup>1</sup>; Peter Uwer<sup>2</sup>; S. Moch<sup>3</sup>; Simone Alioli<sup>4</sup>

<sup>1</sup> *Universidad de Valencia (ES)*

<sup>2</sup> *Humboldt-Universität zu Berlin*

<sup>3</sup> *UHH*

<sup>4</sup> *LBNL & UC Berkeley*

**Corresponding Author:** adrian.irlles@desy.de

This work presents a new method to measure the top-quark mass in hadronic collisions. The method uses the sensitivity of the  $t\bar{t}+1\text{Jet}$  production on the top-quark mass. In detail we study the  $R$  distribution defined as the  $t\bar{t}+1\text{Jet}$  normalized differential cross section in the invariant mass of the total system and calculated at NLO accuracy. We prove that the  $R$  distribution

has a high sensitivity to the top-quark mass. Furthermore we also investigate and quantify the impact of the dominant theoretical and experimental uncertainties. The results obtained show, that the method will be competitive in precision with established approaches and allows a complementary measurement of the top-quark mass at hadron colliders. We emphasize that in the proposed method the mass parameter is uniquely defined through one-loop renormalization.

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## The 4D Composite Higgs model and the 125 GeV Higgs like signal at the LHC

**Author:** Daniele Barducci<sup>1</sup>

**Co-authors:** Alexander Belyaev<sup>2</sup>; Giovanni Marco Pruna; Matthew Brown<sup>3</sup>; Stefania De Curtis<sup>4</sup>; Stefano Moretti<sup>2</sup>

<sup>1</sup> *University of Southampton / NExT Institute*

<sup>2</sup> *STFC - Science & Technology Facilities Council (GB)*

<sup>3</sup> *University of Southampton*

<sup>4</sup> *Universita e INFN (IT)*

**Corresponding Author:** db3e11@soton.ac.uk

General Composite Higgs models provide an elegant solution to the hierarchy problem present in the Standard Model (SM) and give an alternative pattern leading to the mechanism of electroweak symmetry breaking (EWSB).

We present a recently proposed realistic realization of this general idea analyzing in detail the Higgs production and decay modes. Comparing them with the latest Large Hadron Collider (LHC) data we show that the 4D Composite Higgs Model (4DCHM) could provide a better explanation than the SM to the LHC results pointing to the discovery of a Higgs like particle at 125 GeV.

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## Enhanced $B_d \rightarrow \mu^+\mu^-$ Decay: What if?

**Author:** George W.S. Hou<sup>1</sup>

<sup>1</sup> *National Taiwan University*

The very rare  $B_d \rightarrow \mu^+\mu^-$  decay may be the last chance for New Physics in flavor sector at the LHC, before the 13 TeV run in late 2014. Partially motivated by the known tension in  $\sin 2\beta/\phi_1$ , enhancement beyond  $(3-4) \times 10^{-10}$  would likely imply the effect of a fourth generation of quarks. If observed at this level, the 126 GeV boson may not be the actual Higgs boson, while the  $b \rightarrow d$  quadrangle (modulo  $mt'$ ) would jump out. The 2011-2012 data is likely not sensitive to values below  $3 \times 10^{-10}$ , and the mode should continue to be pursued with the 13 TeV run.

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## Searches for Higgs and Higgs-like particles at LHCb

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

The LHCb detector is a forward single arm spectrometer designed primarily for the study of CP-violation and other rare phenomena in the decays of beauty and charm particles. LHCb is very powerful in probing New Physics by performing indirect searches. Nevertheless, a program of direct searches for Higgs and Higgs-like particles also exists. Here we present some recent results and perspectives.

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## LHCb results from the pA run

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

With a unique forward acceptance, and excellent vertexing and particle identification capability, LHCb is well-placed to make important contributions to heavy ion physics through measurements performed using data taken during pA and Ap collisions. The first studies of these data will be presented. These include measurements of particle multiplicity and studies of strange and charmed particle and onia production.

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## Studies of soft QCD at LHCb

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

Due to its unique pseudorapidity coverage and the possibility of extending measurements to low transverse momenta, LHCb provides important input to the understanding of particle production in a kinematical range where QCD models have large uncertainties. Measurements of charged, strange and charmed particle production and energy flow are performed in the approximate pseudorapidity range  $2 < \eta < 5$ , which corresponds to the acceptance of the LHCb spectrometer. The results are compared to predictions given by several Monte Carlo event generators.

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## Electroweak boson production at LHCb

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

We report measurements of electroweak boson production in the forward region, using data collected at the LHCb experiment with a centre of mass energy of  $\sqrt{s}=7$  TeV with an integrated luminosity of up to  $1.0 \text{ fb}^{-1}$ . W and Z bosons are reconstructed in leptonic decay channels, and their cross-sections determined using data-driven techniques. All results are compared to NNLO predictions.

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## Quarkonia and quarkonia-like spectroscopy at LHCb

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

The latest years have seen a resurrection of interest in searches for exotic states motivated by tantalising observations by Belle and CDF. Using the data collected at pp collisions at 7 and 8 TeV by the LHCb experiment we present studies of the X(3872) properties as well as preliminary studies and prospects for studies of putative states such as the Z(4430)+

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## Charm mixing and CP violation

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

LHCb has collected the world's largest sample of charmed hadrons. This sample is used to search for direct and indirect CP violation in charm, and to measure D0 mixing parameters. Preliminary measurements from several decay modes are presented, with complementary time-dependent and time-integrated analyses.

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## Rare decays at LHCb

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

Rare decays of beauty and charm hadrons and lepton flavour/number violating decays of tau leptons test the flavour structure of the underlying theory at the level of quantum corrections. They provide information on the couplings and masses of heavy virtual particles appearing as intermediate states. A review of recent results obtained by LHCb on these topics will be presented.



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## Measurement of $\gamma$ from $B \rightarrow DK$ decays

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

The angle  $\gamma$  of the CKM unitarity triangle remains the least precisely measured parameter of the CKM mixing matrix. The precision measurement of this parameter is one of the main goals of the LHCb experiment. We present a wide range of measurements of CP violation and partial rates in  $B \rightarrow DK$  decays, as well as the latest LHCb measurement of  $\gamma$  combining all the individual inputs.

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## Studies of charmless B decays

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

Decays of B hadrons without charmed particles in the final state offer rich opportunities to test the Standard Model. For example, CP violation in charmless charged two-body and three-body B decays provides ways to measure the CKM angle  $\gamma$  and to search for New Physics. The angular distributions of decays to vector-vector final states provide additional interesting observables. We present the latest results on hadronic charmless B decays from LHCb.

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## CP violation in the B system

**Author:** Marta Calvi<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

**Corresponding Author:** marta.calvi@mib.infn.it

The study of CP violation in  $B_s$  oscillations is one of the key goals of the LHCb experiment. Effects are predicted to be very small in the Standard Model but can be significantly enhanced in many models of new physics. We present the world's best measurement of the CP-violating phase  $\phi_1$  using  $B_0 \rightarrow J/\psi \pi^0$  and  $B_0 \rightarrow J/\psi \pi^+ \pi^-$  decays, and of the time integrated asymmetry in semileptonic  $B_s$  decays. Measurements of, and prospects for, comparable measurements in the  $B_d$  sector are also discussed.

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## Direct photon results from CDF

**Author:** Tingjun Yang<sup>1</sup>

<sup>1</sup> FNAL**Corresponding Author:** tjyang@fnal.gov

Prompt photon production is a field of very high interest in hadron colliders. It provides probes to search for new phenomena and to test QCD predictions. I will present two direct photon results using the full CDF Run II data set: diphoton cross section measurements and photon + heavy flavor cross section measurements. Both measurements are compared with a wide variety of theoretical predictions, including both fixed-order calculations and parton-shower generators. A good understanding of the QCD diphoton cross sections is critical for the precision measurement of Higgs boson in the diphoton channel. The photon+heavy flavor results provide valuable information to the modeling of heavy-flavor parton density and the gluon splitting rates to heavy flavors.

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## Recent photon physics results from the ALICE experiment at LHC

**Author:** Nicolas Arbor<sup>1</sup><sup>1</sup> Centre National de la Recherche Scientifique (FR)**Corresponding Author:** nicolas.arbor@cern.ch

Depending on their energy and their production mechanism, photons probe different properties of strongly interacting matter produced in heavy ions collisions. Neutral meson spectra, reconstructed via their two-photon decays, are considered to be sensitive to the medium transport. In addition to that, direct photons can be used to perform a tomography of the initial states of the collision. At high  $p_T$  direct photons can provide invaluable information on the medium interaction with quarks through gamma-hadron (jet) correlations. At low  $p_T$  direct photons can give important information on the medium conditions, such as its temperature and anisotropic flow.

The ALICE experiment at the LHC reconstructs photons by using the two electromagnetic calorimeters (photon spectrometer, sampling calorimeter) and central tracking systems for photon converted  $e^+e^-$  pairs in the material of the inner ALICE detectors. Transverse momentum spectra of  $\pi^0$  and direct photons at mid-rapidity in pp and Pb-Pb collisions have been measured at LHC energies by the ALICE detector. Parton fragmentation has been estimated from gamma-hadron correlations in pp collisions to be used as a baseline for further Pb-Pb analysis.

We present an overview of the analysis of all the above mentioned photon measurements. Neutral pion spectra measured in pp collisions at 0.9, 2.76 and 7 TeV allow better tuning for pQCD calculations. In Pb-Pb collisions the direct photon spectrum underpredicts the data below 4 GeV/c where it is expected to have a contribution from thermal radiations. The nuclear modification factor  $R_{AA}$  of the  $\pi^0$  production at different collision centralities shows a clear pattern of strong suppression in a hot QCD medium with respect to pp collisions. Finally, parton fragmentation following hard collisions are investigated by correlating high momentum direct photons and charged hadrons with the goal of revealing new insights into medium effects in the QGP.

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## Open heavy-flavour measurements in heavy-ion collisions with ALICE at the LHC

**Author:** Chiara Bianchin<sup>1</sup><sup>1</sup> University of Utrecht (NL)

**Corresponding Author:** chiara.bianchin@cern.ch

The ALICE experiment studies the properties of the strongly-interacting matter created in high energy heavy-ion collisions. This state of deconfined matter, called Quark-Gluon Plasma (QGP), is predicted by Quantum Chromodynamics (QCD).

Heavy quarks are a powerful probe to investigate such a state of matter, since they are predominantly produced in hard scattering processes during the early stage of the collision and they pass through all the deconfined phase.

A mass and colour charge hierarchy is expected to be observed in the in-medium parton energy loss being smaller for heavy quarks than for light quarks and gluons. The energy loss and the transport coefficient (dynamical properties) of the QGP can be quantified via the nuclear modification factor RAA, which is the ratio of the yield measured in Pb-Pb to that observed in pp scaled with the number of binary nucleon-nucleon collisions

In semi-central collisions, the spatial azimuthal anisotropy of the interaction region is transferred to a momentum anisotropy of the final state particles through the interactions among the medium constituents. The anisotropy is described by the second coefficient of the Fourier expansion, known as  $v_2$  or elliptic flow. The elliptic flow of heavy-flavour particles provides insight into the degree of thermalization of the medium at low pT and into the path length dependence of heavy quark in-medium energy loss at high pT.

The ALICE experiment studies open heavy flavours via their hadronic and semi-electronic decays at mid-rapidity and the semi-muonic decay channel at forward rapidity. In this talk recent results on open heavy-flavour nuclear modification factor and azimuthal anisotropy measurements will be presented.

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## Top and Bottom Partners in Composite Higgs Models at the LHC

**Author:** Mikael Rodríguez Chala<sup>1</sup>

**Co-authors:** Adrián Carmona<sup>2</sup>; Jose Santiago<sup>3</sup>

<sup>1</sup> *Universidad de Granada*

<sup>2</sup> *Institute for Theoretical Physics (Zurich)*

<sup>3</sup> *Granada University*

**Corresponding Author:** miki@ugr.es

Top and Bottom partners, predicted by Composite Higgs Models, can be singly produced through the decay of new octet resonances (heavy gluons), which are naturally present in these models whenever partial compositeness is considered. We study in detail this new production mechanism in the  $Ht\bar{t}$ ,  $Zb\bar{b}$  and  $Hb\bar{b}$  channels at the LHC in a wide region of the parameter space. The sizably cross sections and very distinctive kinematics allow us to nicely disentangle the signal over the Standard Model background. We thus almost close the theoretical strategy for the study of the composite nature of the top and bottom quarks in this scenario. We also point out that this new mechanism can lead to some of the cleanest LHC signals of new scalar particles present in non minimal models.

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## Higgs production in gluon fusion beyond NNLO

**Author:** Marco Bonvini<sup>1</sup>

**Co-authors:** Giovanni Ridolfi <sup>2</sup>; Richard Ball ; Simone Marzani <sup>3</sup>; Stefano Forte <sup>4</sup>

<sup>1</sup> *Deutsches Elektronen-Synchrotron (DE)*

<sup>2</sup> *INFN, Genova*

<sup>3</sup> *IPPP / Durham University*

<sup>4</sup> *Università degli Studi e INFN Milano (IT)*

**Corresponding Author:** marco.bonvini@cern.ch

The large contributions of known NLO and NNLO QCD corrections to the Higgs cross section call for a reliable prediction of higher order QCD corrections.

In this talk, an approximate expression for the Higgs production inclusive cross section in gluon fusion at NNNLO in QCD with finite top mass is presented.

We argue that an accurate approximation can be constructed combining (and improving) the large- and small- $z$  behaviours of the partonic cross section, which are both known to all orders from soft-gluon (Sudakov) and high-energy (BFKL) resummations, respectively.

We support our argument by comparing our approximation against the known NLO and NNLO results, finding an excellent agreement.

For a 125 GeV Higgs production at LHC at 8 TeV, we find an increase of the order of 15% with respect to the NNLO inclusive cross section, hinting that higher order QCD corrections are possibly underestimated by presently available results from soft-gluon resummation. We also find a significant reduction of the scale uncertainty.

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## HERAFitter - an open source QCD fit framework

**Authors:** Hayk Pirumov<sup>1</sup>; Ringaile Placakyte<sup>2</sup>; Voica Ana Maria Radescu<sup>3</sup>

<sup>1</sup> *PI Heidelberg*

<sup>2</sup> *Hamburg University*

<sup>3</sup> *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** voica.ana.maria.radescu@cern.ch

The proton parton distribution functions (PDFs) are essential for precision physics at the LHC and other hadron colliders. Their current level of accuracy dominates the theory uncertainties in Higgs production and it affects substantially theory predictions for Beyond Standard Model high mass production.

The determination of the PDFs is a complex endeavor involving several physics process.

The main process is the lepton proton deep-inelastic scattering (DIS), with data collected by the HERA ep collider covering a large kinematic phase space needed to extract PDFs.

Further processes (fixed target DIS, ppbar collisions etc.) provide additional constraining powers for flavour separation. In particular, the precise measurements obtained or to come from LHC will continue to improve the knowledge of the PDF.

HERAFitter project is an open source QCD fit framework ready to extract PDFs and assess the impact of new data which we would like to present

here. The framework includes modules allowing for a various theoretical and methodological options, capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. This framework is already used in many analyses at the LHC.

A new release is available publicly with added features for different parametrisation methods, alternative options to assess the impact of new data based on bayesian reweighting technique, different representation of the chisquare, as well as the option to accomodate for asymmetric systematic uncertainties.

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## Results on strange hadron and resonance production in Pb–Pb collisions at the LHC with ALICE

**Author:** Maria Nicassio<sup>1</sup>

<sup>1</sup> *GSI - Helmholtzzentrum für Schwerionenforschung GmbH (DE)*

**Corresponding Author:** maria.nicassio@cern.ch

Strange hadrons and resonances are among the most sensitive probes to investigate the characteristics of the system formed in heavy-ion collisions.

The ALICE Collaboration has measured strange hadrons and meson resonances decaying into (final) charged particles. Results on the production of  $\phi$  and  $K^{*0}$  resonances,  $K_S^0$ ,  $\Lambda$ ,  $\Xi^-$  and  $\Omega^-$  and their anti-particles at mid-rapidity in  $\sqrt{s_{NN}} = 2.76$  TeV Pb–Pb collisions will be shown and compared with those at lower energy and in proton–proton interactions. Our current understanding will be discussed focussing on particle ratios, thermal model fits to particle yields, strangeness enhancement and baryon anomaly.

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## The ATLAS trigger evolution and performance during Run 1

**Author:** Elisabetta Pianori<sup>1</sup>

<sup>1</sup> *University of Warwick (UK)*

During the data-taking period from 2009 until 2012, the ATLAS trigger has been used very successfully to collect proton-proton data at LHC center-of-mass energies between 900 GeV and 8 TeV. The three-level trigger system reduces the event rate from the design bunch-crossing rate of 40 MHz to an average recording rate of about 300 Hz. Using custom electronics with input from the calorimeter and muon detectors, the first level rejects most background collisions in less than 2.5 $\mu$ s. Two subsequent levels of software-based triggers achieve further rejection. The trigger system is designed to select events by identifying muons, electrons, photons, taus, jets, and B-hadron candidates, as well as using global event signatures, such as missing transverse energy.

We give an overview of the strategy and performance of the different trigger selections based mainly on the experience during the 2011 and 2012 LHC proton-proton runs, when the trigger menu had to be adapted quickly in response to the continuous increase of luminosity and pileup. Examples of trigger efficiencies and resolution with respect to offline-reconstructed signals are presented. These results illustrate that we have achieved a very good level of understanding of both the detector and

trigger performance and successfully selected streamed data samples suitable for analysis. Furthermore, we describe how the trigger selections and overall trigger menu have evolved and have been further optimized (by, e.g., adding topological triggers, using forward jets for Vector Boson Fusion signal topologies, using isolation or using multi-variate techniques) to cope with the increase of center-of-mass energy and pileup conditions during Run 1.

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## The Design and Performance of the ATLAS jet trigger

**Author:** Francesco Rubbo<sup>1</sup>

<sup>1</sup> *Universitat Autònoma de Barcelona (ES)*

The ATLAS jet trigger, in combination with other triggers, provides an important ingredient to studies of Standard Model physics and searches for new physics at the LHC. The ATLAS jet trigger system has undergone substantial modifications over the past few years of LHC operations, as experience developed with triggering in a high luminosity and high event pileup environment. In particular, the region-of-interest (ROI) based strategy has been replaced by a full scan of the calorimeter data at the third trigger level, and by a full scan of the level-1 trigger input at level-2 for some specific trigger chains. Hadronic calibration and cleaning techniques are applied in order to provide improved performance and increased stability in high luminosity data taking conditions. In this presentation we describe the structure and performance of the jet trigger in recent data taking conditions.

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## The ATLAS Muon Trigger Performance in pp collisions at $\sqrt{s} = 8\text{TeV}$

**Author:** Joel Alexander Klinger<sup>1</sup>

<sup>1</sup> *University of Manchester (GB)*

Events with muons in the final state are an important signature for many physics topics at the Large Hadron Collider (LHC), for instance searches for muonic Higgs boson decays or new phenomena, or measurements of the standard model (SM) processes like top-quark, W-boson, and Z-boson production. The use of efficient trigger muon selections during data taking and a good understanding of their performance is crucial for these physics studies. At the LHC high rejection power against the large SM backgrounds, while simultaneously maintaining high efficiency for rare signal events, is required at the online trigger stage. The ATLAS experiment employs a multi-level trigger architecture that selects the events in three sequential steps of increasing complexity and accuracy to cope with this challenging task. This presentation reports about efficiency, resolution, and general performance of the ATLAS muon trigger for proton-proton collision data at  $\sqrt{s}=8\text{TeV}$  collected in year 2012.

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## Searching for intrinsic charm inside the proton at the LHC

**Author:** Mikhail Demichev<sup>1</sup>

**Co-authors:** Gennady Lykasov<sup>2</sup>; Mark Stockton<sup>3</sup>; Tzvetalina Stavreva<sup>4</sup>

<sup>1</sup> *Joint Institute for Nuclear Research, Duna, Russia*

<sup>2</sup> *Joint Institute for Nuclear Research, Dubna, Russia*

<sup>3</sup> *McGill University (CA)*

<sup>4</sup> *LPSC*

**Corresponding Author:** gennady.lykasov@cern.ch

Searching for the intrinsic heavy quark component in the proton suggested in [1] was proposed recently in the forward charmed meson production in pp collisions at the LHC [2]. We extend this study to the inclusive LHC pp-production of c(b)-jets accompanied by photons. It is stimulated by the DØ and CDF results for the production of prompt photons and c(b)-jets in p<sup>-</sup>p collisions at the TEVATRON, where an indication of the possible contribution of the intrinsic charm in the proton was observed [3, 4, 5, 6]. In particular, a possibility to study the intrinsic charm and bottom contributions to processes like pp !

+ c(b) + X is discussed. Some

promising theoretical expectations for these processes are given, which could be searched for and verified at the LHC in pp-collisions at ps = 7–14 TeV. We show that the ratio of pT spectra of prompt photons produced in the hard process pp ! +c(jet)+X at ps =8 TeV with and without the intrinsic charm contribution can be about 250%-400% at high transverse momenta pT >200 GeV/c of the photon.

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## Higgs properties in a stealth doublet model

**Author:** Glenn Wouda<sup>1</sup>

**Co-authors:** Johan Rathsman<sup>1</sup>; Rikard Enberg<sup>1</sup>

<sup>1</sup> *Uppsala University*

**Corresponding Author:** glenn.wouda@fysast.uu.se

I present a model with two scalar doublets and a softly broken Z<sub>2</sub> symmetry, where only one of the doublets gets a vacuum expectation value and couples to fermions at tree-level. The softly broken Z<sub>2</sub> symmetry leads to interesting phenomenology such as mixing between the two doublets and a charged scalar which can be light and dominantly decays in W gamma. The model can also naturally reproduce the enhanced gamma gamma signal of the newly observed particle at the LHC with mass 125 GeV.

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## Viability of strongly-coupled scenarios with a light Higgs-like boson

**Author:** Ignasi Rosell<sup>1</sup>

<sup>1</sup> *Universidad CEU Cardenal Herrera & IFIC, Valencia*

**Corresponding Author:** rosell@uch.ceu.es

We present a one-loop calculation of the oblique S and T parameters within strongly-coupled models of electroweak symmetry breaking with a light Higgs-like boson. We use a general effective Lagrangian, implementing the chiral symmetry breaking  $SU(2)_L \otimes SU(2)_R \rightarrow SU(2)_L + R$  with Goldstones, gauge bosons, the Higgs-like scalar and one multiplet of vector and axial-vector massive resonance states. The estimation is based on the short-distance constraints and a dispersive approach. The experimentally allowed range forces the vector and axial-vector states to be heavy, with masses above the TeV scale, and suggests that the Higgs-like scalar should have a WW coupling close to the Standard Model one.

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## Gauge Invariance at work in Four Dimensional Regularization (FDR): the Higgs decay into two photons.

**Author:** Roberto Pittau<sup>1</sup>

**Co-author:** Alice Maria Donati<sup>2</sup>

<sup>1</sup> *Universidad de Granada (ES)*

<sup>2</sup> *Universidad de Granada*

**Corresponding Author:** adonati@ugr.es

We present the first complete calculation performed within the Four Dimensional Regularization scheme (FDR), namely the loop-induced on-shell amplitude for the Higgs boson decay into two photons in an arbitrary gauge. FDR is a new technique -free of infinities- for addressing multi-loop calculus, which automatically preserves gauge invariance, allowing for a 4-dimensional computation at the same time. We obtained the same result as that assessed in dimensional regularization, thereby explicitly verifying, in a realistic case, that FDR respects gauge invariance.

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## Light-flavour hadron production in pp and PbPb collisions in the ALICE experiment at the LHC

**Author:** Francesco Barile<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

**Corresponding Author:** francesco.barile@cern.ch

Nuclear matter under extreme conditions can be investigated in ultra-relativistic heavy-ion collisions. The measurement of transverse momentum ( $p_T$ ) distributions and yields of identified particles is a fundamental step in understanding collective and thermal properties of the matter produced in such collisions. At intermediate transverse momentum, it allows for testing the “recombination models” where hadrons could be formed by the coalescence of quarks from a deconfined quark-gluon plasma (QGP). At higher transverse momenta, particle spectra allow one to investigate the mechanism of parton energy loss in the hot and dense medium created in the heavy ion collisions. The measurement of spectra in pp not only provides the baseline for the heavy-ion data but also allows for the tuning and optimization of QCD-inspired models.

The latest ALICE results on identified and inclusive light-flavour charged particles in pp collisions at  $\sqrt{s} = 0.9, 2.76$  and 7 TeV and Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV will be reviewed.  $p_T$  spectra, yields and ratios in pp as a function of the collision energy will be shown and compared to previous experiments and Monte Carlo predictions. Recent Pb-Pb results in different centrality intervals will be presented and compared to  $\sqrt{s_{NN}} = 200$  GeV Au-Au collisions at RHIC. Comparison with predictions from thermal and hydrodynamic models will be also discussed.



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## Production of hadrons in proton-nucleus collisions: from RHIC to LHC

**Author:** Michal Krelina<sup>1</sup>

**Co-author:** Jan Nemchik<sup>1</sup>

<sup>1</sup> *Czech Technical University (CZ)*

**Corresponding Author:** michal.krelina@cern.ch

We study nuclear effects in production of large- $p_{\{T\}}$  hadrons on nuclear targets at different energies corresponding to RHIC and LHC experiments.

For calculations we employ the QCD improved parton model including the intrinsic parton transverse momenta and nuclear broadening. This model is firstly tested reproducing well the data on  $p_{\{T\}}$  spectra of hadrons produced in proton-proton and proton-nucleus collisions at different energies.

Besides nuclear modification of parton distribution functions we observe that the complementary effect of initial state interaction causes rather strong nuclear suppression at large  $p_{\{T\}}$  and forward rapidities violating so the QCD factorization.

Numerical results for nucleus-to-nucleon ratios are compared with available data from experiments at RHIC and LHC.

We perform also predictions for nuclear effects in production of high- $p_{\{T\}}$  hadrons at forward rapidities which are expected to be measured in the future at LHC.

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## Heavy-flavour measurements in proton-proton collisions with ALICE at the LHC

**Author:** Markus Fasel<sup>1</sup>

<sup>1</sup> *Ruprecht-Karls-Universitaet Heidelberg (DE)*

**Corresponding Author:** markus.fasel@cern.ch

Heavy-flavour production in proton-proton collisions serves as a precise test for perturbative QCD. Furthermore it provides the reference for the corresponding studies in heavy-ion collisions. The measurements are performed by ALICE in hadronic channels as well as in the semi-electronic decay channels at midrapidity, profiting from the excellent particle identification capabilities and the good impact parameter resolution, and in the semi-muonic channels at forward rapidity. In particular, electrons from beauty hadron decays can be measured at low- $p_T$  by selecting electrons with a large distance to the primary vertex or by using electron-hadron correlations. Furthermore ALICE provides the unique opportunity to study the D meson yields as function of the multiplicity. We present heavy-flavour measurements in the various channels in pp collisions at  $\sqrt{s} = 7$  TeV and  $\sqrt{s} = 2.76$  TeV, and discuss the results by comparing them to perturbative QCD calculations.

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## Inclusive searches for squarks and gluinos with the ATLAS detector

**Author:** pamela ATLAS Collaboration<sup>1</sup>

<sup>1</sup> *Ferrari*

**Corresponding Author:** pamela.ferrari@cern.ch

Despite the absence of experimental evidence, weak scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS results on inclusive searches for supersymmetric squarks and gluinos in events containing jets, missing transverse momentum with and without light leptons, taus or photons.

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## **Searches for gluino-mediated production of third generation squarks with the ATLAS detector**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Real and virtual production of third generation squarks via decay of a gluino can be significant if the mass of the gluino does not exceed the TeV scale. The talk presents recent ATLAS results from searches for gluino mediated stop and sbottom pair production.

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## **Searches for direct pair production of third generation squarks with the ATLAS detector**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. Top or bottom squarks with masses less than a few hundred GeV can also give rise to direct pair production rates at the LHC that can be observed in the data sample recorded by the ATLAS detector. The talk presents recent ATLAS results from searches for direct stop and sbottom pair production.

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## **Searches for electroweak production of supersymmetric neutralinos, charginos and sleptons with the ATLAS detector**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Many supersymmetry models feature neutralinos, charginos and also sleptons with masses less than a few hundred GeV. These can give rise to direct pair production rates at the LHC that can be observed in the data sample recorded by the ATLAS detector. The talk presents results from searches for neutralinos, charginos and slepton pair production in final states with leptons.

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## Searches for supersymmetry in resonance production, R-parity violating signatures and events with long-lived particles with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

An extended QCD sector beyond the minimal supersymmetric standard model or the admission of R-parity violation introduces new signatures to the search for supersymmetry at the LHC. Strongly interacting resonances may decay to jets, sleptons may decay via lepton-flavour violating processes and lightest supersymmetric particles may decay into many leptons with or without missing transverse momentum. Several supersymmetric models also predict massive long-lived supersymmetric particles. Such particles may be detected through abnormal specific energy loss, appearing or disappearing tracks, displaced vertices, long time-of-flight or late calorimetric energy deposits. The talk presents recent results from searches supersymmetry in resonance production, R-parity violating signatures and events with long-lived particles with the ATLAS detector.

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## Single top quark production cross section at LHC in ATLAS

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

Measurements of the single top quark production cross sections in proton-proton collisions with the ATLAS detector at the Large Hadron Collider are presented.

Measurements of single top-quark production in the  $t$  and  $Wt$ -channels are presented and determination of the CKM matrix element  $|V_{tb}|$  is discussed. We also discuss the separate measurement of the top and antitop quark and the ratio. These measurements are sensitive to the parton distribution function in the proton.

In addition, the  $s$ -channel production is explored and limits on exotic production in single top quark processes are discussed. This also includes the search for flavor changing neutral currents and the search for additional  $W'$  bosons in the  $s$ -channel.

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## Top quark pair production cross section at LHC in ATLAS

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

Measurements of the top quark production cross sections in proton-proton collisions with the ATLAS detector at the Large Hadron Collider are presented. The measurement require no, one or two electrons or muons in the final state (single lepton, dilepton, hadronic channel).

In addition, the decay modes with tau leptons are tested (channels with tau leptons). The main focus are measurements of differential spectra of  $t\bar{t}$  final states, in particular, measurements that are able to constrain the modelling of additional parton radiation like the jet multiplicity distribution.

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## **Intrinsic top quark properties top mass, charge and polarisation at LHC in ATLAS**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

Properties of the top quark are measured with the ATLAS detector using LHC proton-proton collisions data. Measurements of the top-quark mass, charge and polarisation, as well as of the polarization of W bosons in top quark decays to probe the  $Wt\bar{b}$ -vertex are presented.

In addition, measurements of the spin correlation between top and antitop quarks as well as of the top-quark charge asymmetry, which constitute important tests of QCD and are sensitive to new physics, are discussed. The search for flavour changing neutral current processes in top quark decays is reviewed.

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## **Top quark pair properties spin correlations, charge asymmetry and complex final states at LHC in ATLAS**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

In proton-proton collisions at the LHC, pairs of top and antitop quarks are expected to be mostly produced through gluon fusion, in contrast to production at the Tevatron, where quark annihilation dominates. Making use of the large number of top quark pairs, we present measurements of the spin correlation between top and antitop quarks as well as of the top-quark charge asymmetry which constitute important tests of QCD and are sensitive to new physics. We also discuss top production in association of photons and Z bosons.

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## **Search for heavy resonances with the ATLAS detector**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

Resonances decaying into a pair of particles are an obvious place to look for phenomena beyond the Standard Model.

This talk summarizes recent results on searches for resonances in pairs of jets, lepton pairs, leptons and missing transverse energy and pairs of photons or W/Z bosons. Various models are considered such the  $Z'$  and  $W'$ , the Randall-Sundrum gravitons as well as the ADD large extra dimension scenario, excited quarks, quantum black holes, technicolor and contact interactions. Results from  $\sqrt{s} = 8$  TeV are presented.

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## Searches for long-lived particles and lepton-jets with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

Several extensions of the Standard Model predict the existence of massive long-lived particles, some of these postulate the existence of a hidden sector of particles. We report on searches for weakly-interacting long-lived particles decaying to collimated lepton-jets far away from the interaction point, and for production of multicharged particles. The talk presents the final results of analyses using data recorded in 2011 at  $\sqrt{s}=7$  TeV centre-of-mass energy by the ATLAS experiment at the LHC.

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## Searches for monojets and monophotons with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

The compactification of the extra spatial dimensions in the Arkani-Hamed, Dimopoulos, and Dvali model results in a Kaluza-Klein tower of massive graviton modes. These graviton modes are produced in association with a jet or a photon and do not interact with the detectors, resulting in a monojet or a monophoton signature. This channel is also sensitive to a large class of SUSY models. The talk presents results from searches for new physics in final states containing a single jet or a single photon and missing transverse energy studied by the ATLAS experiment at the LHC.

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## Searches for fourth generation vector-like quarks and $t\bar{t}$ resonances with the ATLAS detector (joint with the TOP group)

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Various extensions of the Standard Model predict the existence of new types of quarks. We report on several search channels such as vector-like quarks decaying to a Higgs boson and a top quark or to a W boson and a b quark. The talk presents results from searches for new resonances decaying to a top-antitop pair, including the use of boosted top quark reconstruction techniques. These searches use data recorded in either 2011 or 2012 at  $\sqrt{s}=7$  TeV or 8 TeV, respectively, by the ATLAS experiment at the LHC.

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## The ATLAS Tile Calorimeter Calibration and Performance at the LHC

**Author:** Christopher John Meyer<sup>1</sup>

<sup>1</sup> *University of Chicago (US)*

The Tile Calorimeter (TileCal) is the central section of the ATLAS hadronic calorimeter at the Large Hadron Collider. Scintillation light produced in the tiles is transmitted by wavelength shifting fibers to photomultiplier tubes (PMTs). The resulting electronic signals from approximately 10000 PMTs are measured and digitized before being transferred to off-detector data-acquisition systems. It is a key detector for the measurement of hadrons, jets, tau leptons and missing transverse energy. Because of its very good signal to noise ratio it is also useful for the identification and reconstruction of muons.

The calorimeter response is monitored to better than 1% using radioactive source, laser, and charge injection systems. This multi-faceted calibration system allows to monitor and equalize the calorimeter response at each stage of the signal production, from scintillation light to digitization. The performance of the calorimeter has also been established through test beam measurements, cosmic ray muons and the large sample of pp collisions.

Results on the calorimeter performance are presented, including the absolute energy scale, time resolution, and associated stabilities.

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## Upgrading the ATLAS Tile Calorimeter electronics

**Author:** Fernando Carrio Argos<sup>1</sup>

<sup>1</sup> *Universidad de Valencia (ES)*

The Tile Calorimeter (TileCal) is the hadronic calorimeter covering the most central region of the ATLAS experiment at LHC. The TileCal readout consists of about 10000 channels. Its main upgrade will occur for the High Luminosity LHC phase (phase 2) where the luminosity will have increased 5-fold compared to the design luminosity ( $1034 \text{ cm}^{-2}\text{s}^{-1}$ ) but with maintained energy (i.e. 7+7 TeV). An additional luminosity increase by a factor of 2 can be achieved by luminosity leveling. This upgrade will probably happen around 2022.

The upgrade aims at replacing the majority of the on- and off- detector electronics so that all calorimeter signals are directly digitized and sent to the off-detector electronics in the counting room. To achieve the required reliability, redundancy has been introduced at different levels. An ambitious upgrade development program is pursued studying different electronics options. Three different options are presently being investigated for the front-end electronic upgrade. Which one to use will be decided after extensive test beam studies. High speed optical links are used to read out all digitized data to the counting room. Here two different options are considered with 5 or 10 Gbps transmission rates. For the off-detector electronics a new back-end architecture is being developed, including the initial trigger processing and pipeline memories.

A demonstrator prototype read-out for a slice of the calorimeter with most of the new electronics, but still compatible with the present system, is planned to be inserted in ATLAS already in mid 2014 (at the end of the phase 0 upgrade).

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## Searches for the Higgs decaying to b-quarks by the ATLAS experiment

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** [pamela.ferrari@cern.ch](mailto:pamela.ferrari@cern.ch)

Recent results from the ATLAS experiment of searches for the Higgs boson decaying to pairs of b-quarks using data delivered by the LHC at 7 and 8 TeV are presented. The results include two Higgs production modes: associated production with either a W or Z vector boson and associated production with a pair of top quarks.

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## Measurements of Properties of the Higgs boson in di-boson channels

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** [pamela.ferrari@cern.ch](mailto:pamela.ferrari@cern.ch)

Measurements of the mass, couplings and spin/CP properties of the recently discovered Higgs boson in the di-boson ( $H \rightarrow \gamma\gamma$ ,  $H \rightarrow ZZ \rightarrow 4l$ ,  $H \rightarrow WW \rightarrow l\nu l\nu$ ) final states are presented.

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## Combined Measurements of the couplings of the Higgs boson

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Combined measurements of the couplings of the newly discovered Higgs boson are presented.

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## **Beyond-the-Standard Model Higgs Physics using the ATLAS Experiment**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

The discovery of a Higgs boson with a mass of about 125 GeV has prompted the question of whether or not this particle is part of a much larger and more complex Higgs sector than that envisioned in the Standard Model. In this talk, we outline the current results from the ATLAS Experiment regarding Beyond-the-Standard Model (BSM) Higgs hypothesis tests. Searches for additional Higgs bosons are presented and interpreted in well-motivated BSM Higgs frameworks, such as two-Higgs-doublet Models and the Minimal Supersymmetric Standard Model.

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## **Search for the Higgs boson in Rare and Invisible Decay Modes with the ATLAS Detector**

**Author:** Joseph David Price<sup>1</sup>

<sup>1</sup> *University of Liverpool (GB)*

Searches for rare decay modes (e.g.  $Z\gamma$  or  $\mu\mu$ ) of the recently discovered Higgs boson with a mass of approximately 125 GeV are presented. The results of searches for invisible decays of the Higgs boson are also discussed.

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## **New Physics searches in heavy flavors.**

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Precision determinations of the flavor sector allow the search for indirect new physics signatures. At the forefront of these studies are the determinations of interference of new physics with known  $D_f=1$  and  $D_f=2$  processes.

The ATLAS collaboration explores this area with competitive results measuring the CP violating phase  $\phi_s$  from  $B_s \rightarrow J/\psi$  decays and investigating rare B decays with dileptons in the final state.

The latest ATLAS results relevant for new physics searches in the heavy flavor sector will be discussed.



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## Heavy Flavors production and spectroscopy in ATLAS

**Authors:** Constantinos Melachrinos<sup>1</sup>; Stefanos Leontsinis<sup>2</sup>

<sup>1</sup> *University of Chicago (US)*

<sup>2</sup> *National Technical Univ. of Athens (GR)*

ATLAS has a wide programme of study of production cross section and of properties of particles with beauty, as well as charmonium and of bottomonium states.

Recent results on the production the  $Y(nS)$ ,  $n=1-3$  and of charged B mesons are discussed. In both cases, the differential

production cross section is measured over a range of transverse momentum up to about 100 GeV, much wider than in previous measurements.

The production of Y is compared to prediction based on color singlet and evaporation models.

The production of  $B^{+/-}$  production cross section is compared to POWHEG+PYTHIA, MC@NLO+HERWIG and FONLL showing different levels of agreement over the range of transverse momenta accessed by the experiment.

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## Recent QCD results from ATLAS

**Author:** Christopher John Meyer<sup>1</sup>

<sup>1</sup> *University of Chicago (US)*

The ATLAS collaboration has performed studies of a wide range of QCD phenomena.

Recent soft-QCD measurements include studies of underlying event, hadronic event shapes, double parton scattering, diffraction and forward energy flow.

The internal structure of jets produced in proton-proton collisions at 7 TeV centre-of-mass energy provides a direct test of QCD calculations of gluon and quark radiation, and have sensitivity to hadronisation and the underlying event. Measurement of jet shapes for jets initiated by heavy quarks compared to light quarks were also performed.

An overview of these results is given.

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## Jet and photon measurements from ATLAS

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** [pamela.ferrari@cern.ch](mailto:pamela.ferrari@cern.ch)

Differential measurements of inclusive and dijet production provide stringent tests of higher order QCD predictions and provide input for determination of parton density functions.

Inclusive jet multiplicity ratios are sensitive to the strong coupling constant  $\alpha_S$  and have reduced sensitivity to the uncertainties due to parton distribution functions.

Measurements of the inclusive prompt isolated photon and diphoton cross sections provide a direct probe of short-distance physics, complementary to that from measurements of jets or vector-bosons,

and are sensitive to the gluon density of the proton.  
The results are compared to next-to-leading-order or higher-order QCD calculations.

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## Measurements of vector bosons plus jets production with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

The production of jets in association with a W or Z boson in proton-proton collisions at 7 TeV study multi-leg QCD diagrams. The cross sections, differential in several kinematics variables, have been measured up to high jet multiplicities and compared to new higher-order QCD calculations.

Measurements of vectors bosons in association with heavy flavor, such as W+c and W+b production, have unique sensitivity to the heavy quark density of the proton. Differential cross sections are presented and compared to QCD predictions at NLO.

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## Measurements of inclusive W and Z production in ATLAS

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

The production of the W and Z bosons is the standard candle process at the LHC. The differential Z/gamma\* and the charge dependent W+ and W- cross sections are provided in bins of boson rapidity and lepton pseudorapidity.

A measurement of angular correlations in Drell-Yan lepton pairs for neutral current process via the *phobservable is also presented. This variable probes the same physics as the Z/gamma boson* transverse momentum (pT) with a better experimental resolution, especially for low transverse momenta.

Neutral current Drell Yan off-Z resonance peak cross section is sensitive to the proton parton distribution functions, in particular to u-bar quark density. An overview of these results is given.

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## Measurement of diboson production with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> NIKHEF (NL)

**Corresponding Author:** pamela.ferrari@cern.ch

ATLAS measurements of diboson production processes involving combinations of W, Z and isolated photons are summarized. Measurements using data at 7 TeV as well as new results using data at 8 TeV are presented. The measurements are performed using leptonic decay modes, including the invisible decay  $Z \rightarrow \nu\nu$ , as well as semileptonic channels. Differential and total visible cross sections are presented and are used to place constraints on anomalous triple-gauge boson couplings. An overview of these results is given.

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## Studying the p+Pb ridges using two-particle correlations and cumulants with the ATLAS detector

**Author:** Pamela Ferrari<sup>1</sup>

<sup>1</sup> *NIKHEF (NL)*

**Corresponding Author:** pamela.ferrari@cern.ch

Two particle correlation measurements in p+Pb collisions at the LHC have shown a feature or features commonly referred to as the “ridge” in high-multiplicity events. The ridge describes a long-range correlation in relative pseudorapidity originally observed at small azimuthal angle separations. More recent measurements have shown a similar feature for pairs of particles with azimuthal angle difference near  $\pi$ . Theoretical calculations assuming saturation at low  $x$  can reproduce the measured correlations, but similarities between the transverse momentum dependence of the two-particle correlations in p+Pb and Pb+Pb collisions have also led to speculation that the ridges might arise from collective dynamics similar to that observed in Pb+Pb collisions. Results will be presented for ATLAS measurements of two-particle correlations and multi-particle cumulants in p+Pb collisions using data from the 2012 p+Pb run. The implications of these measurements for the interpretation of the ridge phenomenon will be discussed.

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## ATLAS measurements of Drell-Yan lepton-pair production as probes of the Standard Model

**Author:** Manuella Vinciter<sup>1</sup>

<sup>1</sup> *Carleton University (CA)*

Precision measurements of Drell-Yan lepton-pair production in pp collisions with the ATLAS detector at the LHC will be presented. Measurements of production cross sections and associated angular correlations can provide unique insight into perturbative QCD in the absence of colour flow between initial and final states, the V-A nature of the interactions, as well as enhance the knowledge of parton distribution functions in the proton. Drell-Yan production is also an important source of background for other Standard-Model processes such as Higgs boson production as well as for new phenomena, particularly at high dilepton invariant mass, and so must be evaluated precisely at the LHC.

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## Dynamics of isolated-photon and jet production in pp collisions at 7 TeV with the ATLAS detector

**Author:** Josu Cantero Garcia<sup>1</sup>

<sup>1</sup> *Universidad Autonoma de Madrid (ES)*

The dynamics of isolated-photon plus jet production in pp collisions at a centre-of-mass energy of 7 TeV has been studied with the ATLAS detector at the LHC. Measurements of isolated-photon plus jet differential cross sections are presented as functions of photon transverse energy, jet transverse momentum and jet rapidity. In addition, the differential cross sections as functions of the difference in azimuthal angle between the photon and the jet, the photon-jet invariant mass and the scattering angle in the photon-jet centre-of-mass frame have been measured. Next-to-leading-order QCD calculations are compared to the measurements and provide a good description of the data, except in the case of the azimuthal angle.

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## Measurement of double parton scattering in W + 2 jets production at $\sqrt{s} = 7$ TeV with the ATLAS detector

**Author:** Miroslav Myska<sup>None</sup>

The presence of double parton scattering in proton-proton collisions at  $\sqrt{s} = 7$  TeV was measured by the ATLAS detector at the LHC. The analysed dataset was recorded in 2010 and corresponds to an integrated luminosity of 36 pb<sup>-1</sup>. The process under study is the production of a W boson, decaying into an electron or muon, in association with two jets. The fraction of double parton scattering events is found to be  $0.08 \pm 0.01$  (stat.)  $\pm 0.02$  (syst.). This corresponds to a measurement of the effective area parameter for hard double-parton interactions of  $15 \pm 3$  (stat.)  $\pm 5$  -3 mb.

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## Tuning of PYTHIA6 to Minimum Bias and Underlying Event data

**Author:** Nameeqa Firdous<sup>1</sup>

**Co-author:** Gerald RUDOLPH<sup>1</sup>

<sup>1</sup> *University of Innsbruck*

**Corresponding Author:** nameeqa@yahoo.com

In this work, new tunings of the PYTHIA6 Monte Carlo event generator using Minimum Bias(MB) and Underlying Event (UE) data published by the ATLAS Collaboration are presented. Altogether six parameters are varied: four parameters of the Multiple Parton Interaction model and two Lambda\_QCD parameters. The fragmentation parameters are taken from tunes to ALEPH e+e-Z peak data. It is shown that reasonably good descriptions of both MB and UE data distributions at two proton-proton collision energies, 0.9 TeV and 7TeV, are obtained provided that charge particles with  $p_t > 500$  MeV are used. In addition it is found that equally good fits are obtained for all three types of parton density functions (PDF's) of the proton: leading order(LO), next-to-leading order (NLO) and modified LO.

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## Measurement of the $WW$ Production Cross Section in Proton-Proton Collisions with the ATLAS Detector

Author: Jiri Hejbal<sup>1</sup>

<sup>1</sup> Acad. of Sciences of the Czech Rep. (CZ)

A measurement of the  $W+W^-$  production cross section in proton-proton collisions is presented. The  $W+W^-$  leptonic decay channels are analysed using data collected by the ATLAS detector at the CERN Large Hadron Collider.

The results are first obtained in kinematic regions defined by the decay kinematics and then extrapolated to the full phase space. Comparisons to NLO QCD predictions are presented. A detailed understanding of this process is also important in searches for new phenomena to which  $W+W^-$  production is a background.

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## Search for squarks and gluinos using final states with jets and missing transverse momentum with the ATLAS detector in 20 fb<sup>-1</sup> of $\sqrt{s}=8$ TeV pp collisions

Author: Geert Jan Besjes<sup>1</sup>

<sup>1</sup> Radboud University Nijmegen (NL)

A search for squarks and gluinos in final states containing jets, missing transverse momentum and no high-pt electrons or muons is presented. The data were recorded in 2012 by the ATLAS experiment in  $\sqrt{s}=8$  TeV proton-proton collisions at the Large Hadron Collider, with a total integrated luminosity of 20 fb<sup>-1</sup>.

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## Search for supersymmetry in final states with jets, missing transverse momentum and isolated leptons with the ATLAS detector in 5 fb<sup>-1</sup> of $\sqrt{s}=8$ TeV pp collisions

Author: Yuichi Sasaki<sup>1</sup>

<sup>1</sup> University of Tokyo (JP)

This poster presents a new inclusive search for supersymmetry (SUSY) by the ATLAS experiment at the LHC in proton-proton collisions at a center-of-mass energy  $\sqrt{s} = 8$  TeV in final states with jets, missing transverse momentum and one isolated electron or muon. The search is based on data from the early 2012 data-taking period, corresponding to an integrated luminosity of 5.8 fb<sup>-1</sup>. A dedicated signal region is introduced to be sensitive to decay cascades of SUSY particles.

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## Search for direct top squark pair production in final states with one isolated lepton, jets, and missing transverse momentum in $\sqrt{s} = 8$ TeV pp collisions using 21 fb<sup>-1</sup> of ATLAS data

**Author:** Kilian Rosbach<sup>1</sup>

<sup>1</sup> *Universite de Geneve (CH)*

The poster presents latest results of the search for top squark pair production in final states with one isolated lepton, jets, and missing transverse momentum in  $\sqrt{s}=8$  TeV pp collisions using  $L=21$  fb<sup>-1</sup> of ATLAS data. Two top squark decay scenarios are considered: (a) to a top quark and a long-lived undetected neutral particle (LSP), (b) to a bottom quark and a chargino, where the chargino decays via an on- or off-shell W boson to the LSP. The analysis also employs a new dedicated shape-fit method to target the challenging parameter region where  $m(\text{stop})$  is close to the kinematic boundary  $m(\text{top}) + m(\text{LSP})$ .

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## **Search for supersymmetry in events with three leptons and missing transverse momentum in 20.7 fb<sup>-1</sup> pp collisions at $\sqrt{s}=8$ TeV with the ATLAS detector**

**Author:** Basil Schneider<sup>1</sup>

<sup>1</sup> *Universitaet Bern (CH)*

This poster presents results of a search for supersymmetry in events with three leptons and missing transverse momentum. The analysis uses a sample corresponding to 21 fb<sup>-1</sup> of proton-proton collision data delivered by the LHC at  $\sqrt{s} = 8$  TeV and recorded by the ATLAS detector. Results are interpreted in phenomenological minimal supersymmetric and simplified models.

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## **Investigation of phenomenological models combinations implemented in PYTHIA6 :Tuning results**

**Author:** Nameeqa Firdous<sup>1</sup>

**Co-author:** Gerald Rudolph<sup>1</sup>

<sup>1</sup> *University of Innsbruck*

**Corresponding Author:** nameeqa@yahoo.com

We investigate different phenomenological models implemented in PYTHIA6 using data from ATLAS experiment to find best fit. These models include Multiple Parton Interactions model, different scenarios of Matter Overlap and Color Reconnection models as well as Lambda\_QCD selection in  $\alpha_s$ . We used three different parton density functions (PDFs) to study their effects on the selected models.

We show that each combination of models describes data differently, though overall results do not vary greatly except for selection of fixed Lambda value chosen according to the selected PDF. We have found that it is not possible to describe data well with fixed Lambda value approach. All selected model combinations with varying lambda value approach, when appropriately tuned, can describe data reasonably well almost independent of PDFs used.

This study provides better understandings of different model combinations and helps to select better model combinations for tuning purposes.

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## Search for Single Top Quark Production via Flavour Changing Neutral Currents in ATLAS data

**Author:** Conrad Friedrich<sup>1</sup>

<sup>1</sup> *Deutsches Elektronen-Synchrotron (DE)*

In the Standard Model (SM) transitions between top quarks and other quark flavours mediated by neutral gauge bosons, so-called Flavour Changing Neutral Currents (FCNC), are forbidden at tree level and highly suppressed at higher orders due to the Glashow-Iliopoulos-Maiani (GIM) mechanism. However, there exist several new physics models, which significantly enhance rates of FCNC processes compared to the Standard Model predictions. Therefore any observation of such processes would be a strong indicator for new physics. Data collected with the ATLAS detector are used and searched for FCNC events in which a light quark (u or c) interacts with a gluon to produce a single top quark, either with or without the associated production of another light quark or gluon. Candidate events of top quarks decaying leptonically are selected and classified into signal and background like events using a neural network.

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## Measurement of top quark polarisation with the ATLAS experiment

**Author:** Sara Borroni<sup>1</sup>

<sup>1</sup> *Deutsches Elektronen-Synchrotron (DE)*

While in the Standard Model top quarks are predicted to be produced unpolarized at the LHC, several models beyond the SM predict a nonzero polarization. In particular, some of the models predicting a larger forward-backward  $t\bar{t}$  asymmetry than predicted in the SM, as measured at the Tevatron, predict a positive top quark polarization. Using 4.7 fb<sup>-1</sup> of data collected by the ATLAS experiment at a centre of mass energy of 7 TeV, a measurement of the top quark polarization is presented. The full  $t\bar{t}$  system is reconstructed from final states with at least one charged lepton, and a template fit to the distribution of the angle between the charged lepton and the top quark is performed to measure the top quark polarisation.

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## Evidence for the associated production of a W boson and a top quark in ATLAS

**Author:** Jan Andre Stillings<sup>1</sup>

<sup>1</sup> *Universitaet Bonn (DE)*

In proton-proton collisions at the LHC, top quarks can be produced in pairs via the strong interaction and individually via the weak interaction. The weak interaction production can be subdivided into three channels: the t-channel,

the s-channel and the associated production of a W boson and a top quark. The total production cross section of these three channels is about one third of the total top quark production cross section. The t-channel has the dominant cross section and has been measured both at the Tevatron and the LHC. However, the  $Wt$  associated production has not yet been observed. Different final states can be used to isolate the associated  $Wt$  production from background processes, depending on the decay modes of the two W bosons. The channel with two leptons in the final state has already been used to present evidence for  $Wt$  associated production at  $\sqrt{s} = 7$  TeV. The measurement uses a boosted decision tree to separate signal from background. The latest results from the ATLAS experiment for the  $Wt$  production process will be presented.

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## Conceptual design and performance simulations of super-compact electromagnetic calorimeter

**Author:** Libor Skoda<sup>1</sup>

<sup>1</sup> *FNSPE CTU in Prague*

**Corresponding Author:** libor.skoda@cern.ch

Measurements of particle production at forward rapidities in high energy p-p, p-A and A-A collisions provide access to physics processes at very low Bjorken  $x$ . These measurements will allow to study the gluon saturation scale and improve our knowledge of parton distribution in nuclei. Specific requirements must be fulfilled for a calorimeter to successfully operate in high-multiplicity forward region within often stringent space limits. Here we present a study of a conceptual design of super-compact electromagnetic calorimeter being developed at Czech Technical University in Prague. The design of the sampling calorimeter is based on a sandwich structure of thin tungsten and scintillator layers oriented in parallel to the beam. It is aimed for the detector to allow measuring of high energy photons ( $1 < E < 1000$  GeV) in forward rapidities ( $2.5 < \eta < 4$ ). The used optical readout of individual scintillator pads guarantees the required high radiation hardness of the detector. We present simulation of the expected performance of the optical pad readout together with overall detector performance.

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## Searches for decays of the Higgs boson to $\mu+\mu^-$ pair with the ATLAS detector

**Author:** Christian Jorg Rudolph<sup>1</sup>

<sup>1</sup> *Technische Universitaet Dresden (DE)*

The Higgs-like boson discovered by the ATLAS and CMS collaborations is a candidate for the last unobserved particle predicted by the Standard Model (SM). The next experimental step is the measurement of its properties, most notably its couplings to fermions. This contribution will present a search for the SM Higgs boson via decays to dimuon pairs using 20.7 fb<sup>-1</sup> of 8 TeV collision data recorded by the ATLAS detector in 2012. The SM prediction of the branching ratio for this decay is small, making this a challenging measurement. The results of the search in this channel are presented and compared with the SM predictions for Higgs boson decays to dimuon pairs.



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## Search for a Higgs boson produced in association with a top pair using the ATLAS detector

**Author:** Javier Montejo Berlingen<sup>1</sup>

<sup>1</sup> *IFAE - Barcelona (ES)*

Since the discovery of a Higgs-like boson by the ATLAS and CMS experiments at the LHC, the emphasis has shifted towards measurements of its properties in order to determine whether the new particle is the Standard Model (SM) Higgs boson, or something else. Of particular importance is top-Higgs Yukawa coupling which, due to the large top quark mass, is close to unity, making the top quark the most strongly-coupled SM particle to the electroweak symmetry breaking sector and responsible for the instability of the Higgs boson mass against radiative corrections and motivates physics beyond the SM. The top-Higgs Yukawa coupling can be measured by identifying events with a Higgs boson is produced in association with a  $t\bar{t}$  pair ( $t\bar{t}H$ ). This poster presents the latest results on the search for  $t\bar{t}H$  production by the ATLAS experiment using the  $H \rightarrow b\bar{b}$  decay mode, which has a large branching ratio and allows the kinematic reconstruction of the Higgs boson. This results in spectacular final state signatures involving one or two isolated leptons (electron or muon), high transverse missing energy, and at least four  $b$ -tagged jets. However, this measurement is very challenging due to the large physics background from  $t\bar{t} + \text{jets}$ , affected by large systematic uncertainties, and large combinatorial backgrounds.

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## Search for the Higgs boson produced in association with a vector boson and decaying to a pair of $b$ -quarks

**Author:** Kevin Michael Mercurio<sup>1</sup>

<sup>1</sup> *Harvard University (US)*

With the observation of a new particle of mass 125 GeV decaying to a pair of photons,  $W$  bosons or  $Z$  bosons, the current critical question in the field of particle physics is whether this particle is the Standard Model Higgs boson or something else. Observing the decay of the new particle to fermions and in particular  $b$ -quarks is vital to answer these questions. We present the latest results from the ATLAS experiment in the search for a Higgs boson produced in association with a vector boson and decaying to pairs of  $b$ -quarks using the 2011 and 2012 datasets.

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## Search for $t\bar{t}$ resonances in ATLAS

**Author:** Benjamin Dechenaux<sup>1</sup>

<sup>1</sup> *Centre National de la Recherche Scientifique (FR)*

The search for  $t\bar{t}$  resonances that could be produced at the CERN Large Hadron Collider allow the investigation of a wide range of physics beyond the Standard Model. In such a scheme, the top quark is often produced with a transverse momentum that is large as compared to its mass. The decay of such highly boosted top leads to a topology that differs in several respects from that encountered

when the top quarks are produced approximately at rest. In particular, for high mass  $t\bar{t}$  with a lepton + jets final state, the distance between the three jets originating from the hadronic top decay ( $t \rightarrow Wb \rightarrow q\bar{q}b$ ) becomes small, leading to an important jet merging.

We present the analysis applied to the 2012 proton-proton collisions at 8 TeV in the center of mass recorded by the ATLAS experiment, aiming to search for  $t\bar{t}$  resonance where the complete 3-body decay of the hadronic top is reconstructed as a single fat jet and identified by investigating its substructure.

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## Search for pair-produced Vector-Like Quarks with the ATLAS detector

**Author:** Antonella Succurro<sup>1</sup>

<sup>1</sup> *Universitat Autònoma de Barcelona (ES)*

The high energy frontier opened by the LHC is allowing us to explore physics scenarios where new physics might lay. The need to go beyond the Standard Model (SM) comes from various unanswered questions, like where does the matter-antimatter asymmetry comes from? What is the nature of Dark Matter? How can the hierarchy problem be solved?

The recent discovery of an Higgs-like boson tends to disfavour the existence of a heavy 4th generation of quarks which would change the Higgs SM cross section and branching ratio in a way it is not experimentally observed. At the same time, vector-like quarks become a more compelling possibility due to their important role stabilizing the Higgs boson mass against radiative corrections. The purpose of this poster is to review the latest results in the searches for pair production of vector-like quarks at the ATLAS experiment.

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## Search for new phenomena in monojet events with the ATLAS detector

**Author:** Valerio Rossetti<sup>1</sup>

<sup>1</sup> *Universitat Autònoma de Barcelona (ES)*

We present results by the ATLAS experiment on a search for new phenomena in pp collision events with one high momentum jet and large missing transverse energy. The data are compared to the SM predictions, dominated by the irreducible background from W/Z+jets production with neutrinos and mis-identified electrons and muons in the final state. The results are interpreted in the context of different Beyond the Standard Model scenarios: ADD models with Large Extra Dimensions, generic dark matter WIMP production, and Gauge Mediated SUSY Breaking with production of light gravitinos.

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## Search for high-mass dilepton resonances in 20/fb of pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS experiment

**Author:** James Christopher Coggeshall<sup>1</sup>

<sup>1</sup> *Univ. Illinois at Urbana-Champaign (US)*

The ATLAS detector is used to search for heavy neutral gauge bosons ( $Z'$ ) decaying to an electron-positron pair or a muon-antimuon pair. Results are presented based on the analysis of pp collisions at a center-of-mass energy of 8 TeV corresponding to an integrated luminosity of approximately 20 fb<sup>-1</sup>. A  $Z'$  with Standard Model Z couplings to fermions is excluded at 95% C.L. for masses below 2.79 TeV in the electron channel, 2.48 TeV in the muon channel, and 2.86 TeV in the two channels combined. Limits on other model interpretations are also presented, including a Grand Unification model based on the E<sub>6</sub> gauge group, a Randall-Sundrum graviton and a technicolor model with a composite Higgs boson.

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## Search for resonant $WZ \rightarrow 3\ell \nu$ production in $\sqrt{s} = 8$ TeV pp collisions with 13 fb<sup>-1</sup> at ATLAS

**Author:** Merlin Davies<sup>1</sup>

<sup>1</sup> *Universite de Montreal (CA)*

Although recent LHC results are compatible with an electroweak symmetry breaking through the Standard Model Higgs mechanism, the inherent implausible fine-tuning it requires suggests new phenomena must exist at or beyond energies of O(1) TeV. In this perspective, diboson resonances would be key signatures in understanding the structures beyond the Standard Model. With 13 fb<sup>-1</sup> of ATLAS recorded data using 8 TeV pp collisions at the LHC, a search for fully leptonic WZ resonances are presented. Two important benchmark models were used to interpret the results: Extended Gauge and Low Scale Technicolor models. No localized deviation from expectation was observed in the reconstructed WZ invariant mass system, hence upper limits on the production cross section times branching ratio were computed.

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## Multi-charged particle search at ATLAS

**Author:** Simone Zimmermann<sup>1</sup>

<sup>1</sup> *Universitaet Bonn (DE)*

A search for long-lived, multi-charged particles has been performed using the ATLAS detector. We have examined data taken during the 2011 LHC running, corresponding to an integrated luminosity of 4.4 fb<sup>-1</sup>. A search was made for charged particle tracks exhibiting anomalously high ionization consistent with stable massive particles with charges from  $|q|=2e$  to  $|q|=6e$ . For this search new variables of specific energy loss per path length ( $dE/dx$ ) have been developed and used in the candidate selection. No excess is observed with respect to the prediction of Standard Model processes. The 95% C.L. cross-section limits are also interpreted as exclusion limits for a simplified Drell-Yan production model.

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## Measurement of D0-D0bar Mixing at CDF

**Author:** Jonathan Lewis<sup>1</sup>

<sup>1</sup> *Fermilab*

The full CDF Run II data set, corresponding to an integrated luminosity of 9.3/fb of p-pbar collisions at 1.96 TeV, is used to measure the time-dependent ratio of decay rate for  $D^0 \rightarrow K^+ \pi^-$  to that for  $D^0 \rightarrow K^- \pi^+$ . The ratio is used to determine the mixing parameters  $R_D$ ,  $x'^2$ , and  $y'$  and the significance of excluding the no-mixing hypothesis  $x'^2 = y' = 0$ .

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## Vector Boson Productions of SUSY Sleptons, Chargino and Neutralinos

**Author:** Bhaskar Dutta<sup>1</sup>

<sup>1</sup> *Texas A&M University*

**Corresponding Author:** dutta@physics.tamu.edu

Vector Boson Fusion (VBF) processes allow us to study the non-colored sectors of supersymmetric extensions of the Standard Model at a hadron collider. I will present a feasibility study for searching for the chargino/neutralino system and sleptons in the  $R$ -parity conserving Minimal Supersymmetric Standard Model. The high

$ET$  forward jets in opposite hemispheres are utilized to trigger VBF events which reduce the Standard Model backgrounds. I will develop cuts to extract signals from various production processes, e.g., lightest neutralino pair (for wino, bino and Higgsino types), chargino pair, smuon and stau pairs. Since most of these particles appear in the dark matter content calculation, we will be able to understand the dark matter connection of the SUSY models. I will also discuss the possibilities of identifying different dark matter scenarios at 8 TeV and 14 TeV LHC.

This talk is based on arXiv:1210.0964 (to appear in Phys. Rev. D) and two more upcoming publications.

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## Measurement of the top quark production cross section and the differential distributions of top quarks with the D0 detector

**Author:** regina demina<sup>1</sup>

<sup>1</sup> *university of rochester*

We present the most recent measurement of the top quark pair cross section with the D0 detector at the Tevatron proton-antiproton collider in lepton plus jet and dilepton channels and the measurements of differential distributions of top quarks in the lepton plus jet channel using full D0 Run-II data. The measured spectra, binned in several observables, are compared to those obtained from Monte Carlo

simulation and perturbative QCD at approximate NNLO. We also present a search for the s-channel electroweak production of top quarks.

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## Multi-jet cross section ratios and a determination of the strong coupling constant in ppbar collisions at $\sqrt{s}=1.96\text{TeV}$

**Author:** Lee Sawyer<sup>1</sup>

<sup>1</sup> *Louisiana Tech University (US)*

We present measurements of three different multi-jet cross section ratios. These include the very first measurements of the new quantities  $R_{\Delta\phi}$  and  $R_{\Delta R}$ , and a measurement of  $R_{3/2}$ . The variable  $R_{\Delta\phi}$  measures the average number of neighboring jets for jets from an inclusive jet sample. The variable  $R_{\Delta R}$  measures the fraction of the inclusive dijet events in which the azimuthal separation of the two jets with the highest transverse momenta is less than a specified value of the parameter  $\Delta\phi_{\text{max}}$ . The quantity  $R_{3/2}$  is the ratio of the inclusive 3-jet and 2-jet cross sections. All three measurements

use an event sample corresponding to an integrated luminosity of  $0.7\text{fb}^{-1}$  collected with the D0 detector at the Fermilab Tevatron Collider. The results are compared to predictions of perturbative QCD calculations at next-to-leading order

in the strong coupling with corrections for non-perturbative effects. In most kinematic regions, the theory predictions describe the data well. The  $R_{\Delta R}$  data are used to determine the strong coupling constant over a large range of momentum transfers from 50–400 GeV, testing the predictions of the renormalization group equation for its running in a new range of momentum transfers.

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## Measurement of the photon + b/c-jet and diphoton production differential cross section in ppbar collisions at $\sqrt{s}=1.96\text{TeV}$

**Author:** Lee Sawyer<sup>1</sup>

<sup>1</sup> *Louisiana Tech University (US)*

We present measurements of the differential cross section  $d\sigma/dp_T^\gamma$  for the inclusive production of a photon in association with a b/c-quark jet. The results are based on data corresponding to an integrated luminosity of  $8.7\text{fb}^{-1}$ , recorded with the D0 detector at the Fermilab Tevatron ppbar collider at  $\sqrt{s}=1.96\text{TeV}$ . The measured cross sections are compared with next-to-leading order perturbative QCD calculations using different sets of parton distribution functions as well as to predictions based on the kT-factorization QCD approach, and those from the Sherpa and Pythia Monte Carlo event generators. We also present measurements of the direct photon pair production cross sections using  $8.5\text{fb}^{-1}$  of data collected with the D0 detector. The results are shown as differential distributions with respect to the photon pair mass, pair transverse momentum, azimuthal angle, and polar scattering angle in the Collins-Soper frame. Measurements are performed for the photon transverse momenta  $p_T > 17$  and  $18\text{GeV}$  with rapidities  $|y| < 0.9$ . The results are compared with the predictions from (N)NLO QCD and Monte Carlo event generators.

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## Combined search for the SM Higgs Boson at D0

**Authors:** Bob Hirosky<sup>1</sup>; Rick Van Kooten<sup>2</sup>

<sup>1</sup> *University of Virginia (US)*

<sup>2</sup> *Indiana University (US)*

**Corresponding Author:** bob.hirosky@cern.ch

We present the combination of searches for the Standard Model Higgs boson at a center-of-mass energy of  $\sqrt{s}=1.96$  TeV, using the full Run 2 dataset collected with the D0 detector at the Fermilab Tevatron collider. The major contributing processes include associated production ( $WH \rightarrow \nu b b$ ,  $ZH \rightarrow \nu b b$ ,  $ZH \rightarrow l l b b$ , and  $WH \rightarrow W W()$ ) and gluon fusion ( $gg \rightarrow H \rightarrow W W()$ ). The significant improvements across the full mass range resulting from the larger data sets, improved analyses and inclusion of additional channels are discussed. The combination of all channels results in significantly improved sensitivity across the 90-200 GeV mass range.

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## Spin/parity of a Higgs-like particle of mass 125 GeV and non-standard-model enhanced final states

**Authors:** Bob Hirosky<sup>1</sup>; Rick Van Kooten<sup>2</sup>

<sup>1</sup> University of Virginia (US)

<sup>2</sup> Indiana University (US)

**Corresponding Author:** bob.hirosky@cern.ch

We present tests of different spin and parity hypotheses for a particle H of mass 125 GeV produced in association with a vector boson and decaying into a pair of b-quarks. We use the combined analysis of the  $WH \rightarrow \nu b b$ ,  $ZH \rightarrow \nu b b$ , and  $ZH \rightarrow l l b b$  channels using the full Run 2 dataset collected at a center-of-mass energy of  $\sqrt{s}=1.96$  TeV with the D0 detector at the Fermilab Tevatron collider. We also present a search for neutral supersymmetric Higgs bosons in the  $b h \rightarrow b b b$  and  $b b h \rightarrow b b b b$  final states. Resulting experimental limits and techniques used to enhance signal sensitivity and to model dominant backgrounds will be discussed.

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## Measurements of charge asymmetries from W boson decay in electron and muon channels and measurement of $Z/\gamma^* \phi^*$ distribution at D0

**Authors:** Bob Hirosky<sup>1</sup>; Rick Van Kooten<sup>2</sup>

<sup>1</sup> University of Virginia (US)

<sup>2</sup> Indiana University (US)

**Corresponding Author:** bob.hirosky@cern.ch

We present the measurements of charge asymmetries from W boson decay in both electron and muon channels and also the  $Z/\gamma^* \phi^*$  distribution with RunII data from  $7.3 \text{ fb}^{-1}$  to  $9.7 \text{ fb}^{-1}$  collected by the D0 detector at the Fermilab Tevatron Collider. In the electron charge asymmetry measurement, we present the lepton asymmetry as a function of the electron transverse momentum and pseudorapidity in the interval  $(-3.2, 3.2)$ ; we also present results from W charge asymmetry, as a function of W boson rapidity. The asymmetries are compared with expectations from next-to-leading order calculations in perturbative quantum chromodynamics. In the muon charge asymmetry measurements, we present the lepton asymmetry for five kinematic ( $p_T^\mu$ , MET) bins. These charge asymmetry measurements will allow more accurate determinations of the proton parton distribution functions. We also present a measurement of the distribution of  $Z/\gamma^*$  variable  $\phi^*$ , which probes the same physical effects as the  $Z/\gamma^*$  boson transverse momentum, but is less susceptible to the effects of experimental resolution and efficiency. The  $\phi^*$  measurement includes results from the low invariant

mass region (30-60 GeV),  $Z$  peak mass region (70, 110 GeV), and high mass region ( $> 160$  GeV), and is compared with higher order predictions.

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## CP Violation studies at DØ

**Authors:** Bob Hirosky<sup>1</sup>; Rick Van Kooten<sup>2</sup>

<sup>1</sup> *University of Virginia (US)*

<sup>2</sup> *Indiana University (US)*

**Corresponding Author:** bob.hirosky@cern.ch

We present results of the measurements of CP-violating parameters for a variety of b hadron species using the full Run 2 data set collected by the DØ detector. These include a new analysis testing for direct CP violation in B<sup>+</sup> decays, specific semileptonic charge asymmetries of B<sub>s</sub> and B<sub>0</sub> decays testing for CP violation in mixing, and a new update of the DØ dimuon charge asymmetry as a combination of CP violation in mixing in the B<sub>s</sub> and B<sub>0</sub> system.

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## On equivalence of gluon-loop exchange in the inelastic processes in perturbative QCD to pion exchange in $\phi^3$ theory

**Authors:** Andrii Tykhonov<sup>1</sup>; D. Ptashynskyy<sup>2</sup>; Grygorii Sokhrannyi<sup>2</sup>; Igor Sharf<sup>2</sup>; Kirill Merkotan<sup>2</sup>; Maksym Deliyergiyev<sup>3</sup>; Natalia Podolyan<sup>2</sup>; Oleksiy Potiyenko<sup>2</sup>; Vitaliy Rusov<sup>2</sup>; Y. Volkotrub<sup>2</sup>

<sup>1</sup> *Institute Jozef Stefan, Ljubljana, Slovenia*

<sup>2</sup> *Odessa National Polytechnic University, Odessa, Ukraine*

<sup>3</sup> *Jozef Stefan Institute, Ljubljana, Slovenia*

**Corresponding Author:** andrii.tykhonov@cern.ch

We consider the hadron-hadron inelastic scattering in the framework of QCD perturbation theory. It is shown that in QCD due to conservation of colour it is prohibitive to consider tree-level diagrams of inelastic scattering and one has to consider the diagrams with loops. We examine the simplest type of such diagrams, where the diagram can be split into blocks, so that the integration over four-momenta of virtual particles in each block is done independently of the other blocks. It is shown that for these diagrams the squared modulus of scattering amplitude has a point of maximum, similar to that of [Sharf et. al. arXiv:1110.4945], if one takes into account the relations between the arguments of scattering amplitude, imposed by the energy-momentum conservation law. This enables to apply the Laplace's method for the calculation of inelastic-scattering cross sections. It is shown that the diagrams of gluon-loop exchange in QCD are equivalent to the diagrams of pion exchange in  $\phi^3$  theory, whereby the new mechanism of cross-section growth, discovered in  $\phi^3$  theory [Sharf et. al. arXiv:1110.4945], also takes place in perturbative QCD. This may explain the origin of experimentally-observed growth of inelastic-scattering cross section as a function of energy of colliding hadrons [ALICE collaboration, arXiv:1109.4510]. The discovered mechanism can't emerge in any Regge-based model due to the premises on the particle kinematics, made in these models.

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## Longitudinal WW scattering in light of the 'Higgs' discovery

**Author:** Domenec Espriu<sup>1</sup>

**Co-author:** Brian Yencho

<sup>1</sup> *University of Barcelona (ES)*

WW scattering is dominated at high energies by their longitudinal components, which are the most sensitive to the nature of the electroweak symmetry breaking. Prior to the discovery at the LHC of a Higgs-like particle, unitarization tools were extensively used to show that, in the absence of a light Higgs boson, new resonances resulting from the would-be strongly-interacting electroweak sector would appear, and furthermore these techniques would approximately predict their masses, widths, and signal strengths. With the discovery of a Higgs-like particle now firmly established, we re-investigate these techniques assuming this particle couples as in the SM, but stilln being open to the possibility of an extended symmetry breaking sector. While the SM itself is free from problems with perturbative unitarity in the electroweak sector, “anomalous” self-couplings of the vector bosons – low-energy remnants of such higher-energy symmetry breaking sectors – are easily shown to re-introduce them. We demonstrate how new resonances should still appear in the scattering of EW vector bosons after imposing constraints from unitarity, and we discuss their ability to be probed with current and future LHC data.

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## Tevatron combined top quark mass

**Authors:** David Toback<sup>1</sup>; Homer Wolfe<sup>2</sup>; Jonathan Wilson<sup>3</sup>

<sup>1</sup> *Texas A & M University (US)*

<sup>2</sup> *Ohio State University (US)*

<sup>3</sup> *University of Michigan*

**Corresponding Author:** jsw@fnal.gov

We summarize the top-quark mass measurements from the CDF and D0 experiments at Fermilab. We combine published Run I (1992–1996) measurements with the most precise published and preliminary Run II (2001–2012) measurements using a data set corresponding to up to 8.7/fb of ppbar collisions. Taking uncertainty correlations into account, and adding in quadrature the statistical and systematic uncertainties, the resulting preliminary Tevatron average mass of the top quark is  $m_t = 173.20 \pm 0.87 \text{ GeV}/c^2$ .

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## Leptonic asymmetry in $t\bar{t}$ production at CDF

**Authors:** David Toback<sup>1</sup>; Homer Wolfe<sup>2</sup>; Jonathan Wilson<sup>3</sup>

<sup>1</sup> *Texas A & M University (US)*

<sup>2</sup> *Ohio State University (US)*

<sup>3</sup> *University of Michigan*

**Corresponding Author:** jsw@fnal.gov

We measure the asymmetry of the lepton in semileptonic  $t\bar{t}$  decays in the full Run II sample of 9.4/fb. We develop a new technique to correct for the incomplete lepton acceptance and derive a parton-level asymmetry. The result of  $A_{fb}(\text{lep}) = 0.094^{+0.032}_{-0.029}$  is approximately  $2\sigma$  above the current Standard Model NLO prediction of  $A_{fb}(\text{lep}) = 0.036$ .



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## Search for rare Z decays into Two Reconstructed Photons at CDF

**Authors:** David Toback<sup>1</sup>; Homer Wolfe<sup>2</sup>; Jonathan Wilson<sup>3</sup>

<sup>1</sup> *Texas A & M University (US)*

<sup>2</sup> *Ohio State University (US)*

<sup>3</sup> *University of Michigan*

**Corresponding Author:** jsw@fnal.gov

We report the most sensitive search to date for forbidden and exotic decays of the Z boson to a pair of photons, a pair of neutral mesons, or a neutral meson and a photon. The search is using the full CDF dataset corresponding to 10.0/fb of integrated luminosity. The two decay products are reconstructed in the electromagnetic calorimeter, spanning a rapidity range of  $|\eta| < 1.1$ , and their momenta are used to reconstruct the invariant mass of the pair that is used to identify Z bosons. Bayesian 95% C.L. limits on the signal branching ratio are derived by fitting the signal and background expectations to the data in the Z-mass window of [80,102] GeV/c<sup>2</sup>, using a binned likelihood based on the mass distribution. The observed branching ratio limits presented here are  $1.66 \times 10^{-5}$  for  $Z \rightarrow \gamma\gamma$ ,  $2.28 \times 10^{-5}$  for  $Z \rightarrow \pi^0\gamma$ , and  $1.73 \times 10^{-5}$  for  $Z \rightarrow \pi^0\pi^0$ . The  $Z \rightarrow \gamma\gamma$  and  $Z \rightarrow \pi^0\gamma$  limits are more sensitive by factors of 3.1 and 2.3, respectively, than the most stringent Particle Data Group limits reported by experiments at the LEP collider. The  $Z \rightarrow \pi^0\pi^0$  branching ratio limit is the first limit reported in this decay mode.

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## Search for a Two-Higgs-Boson Doublet Using a Simplified Model at CDF

**Authors:** David Toback<sup>1</sup>; Homer Wolfe<sup>2</sup>; Jonathan Wilson<sup>3</sup>

<sup>1</sup> *Texas A & M University (US)*

<sup>2</sup> *Ohio State University (US)*

<sup>3</sup> *University of Michigan*

**Corresponding Author:** jsw@fnal.gov

We present a search for new particles in an extension to the standard model that includes a heavy Higgs boson ( $H_0$ ), a lighter charged Higgs boson ( $H_{\pm}$ ), and an even lighter Higgs boson  $h_0$ , with decays leading to a W-boson pair and a bottom-antibottom quark pair in the final state. We use events with exactly one lepton, missing transverse momentum, and at least four jets in data corresponding to an integrated luminosity of 8.7/fb collected by the CDF II detector in proton-antiproton collisions at  $\sqrt{s}=1.96$  TeV. We find the data to be consistent with standard model predictions and report the results in terms of a simplified Higgs-cascade-decay model, setting 95% confidence level upper limits on the product cross section and branching fraction from 1.3 pb to 15 fb as a function of  $H_0$  and  $H_{\pm}$  masses for  $m(h_0)=126$  GeV/c<sup>2</sup>.

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## Photoproduction of J/Psi in UPC of PbPb and pPb at the LHC with the ALICE detector

**Author:** Guillermo Contreras<sup>1</sup>

<sup>1</sup> *CVUT Prague*

Ultra-relativistic heavy ions generate strong electromagnetic fields which offer the possibility to study, at the LHC, gamma-nucleus processes in PbPb collisions and gamma-proton processes in pPb collisions. These events are called ultra-peripheral collisions (UPC). The photoproduction of J/Psi vector mesons in PbPb (pPb) UPC is sensitive to the gluon distribution of the interacting nuclei (proton).

Here we report on the ALICE measurement of the cross section for J/Psi coherent photoproduction measured in PbPb UPC at  $\sqrt{s_{NN}} = 2.76$  TeV for the rapidity ranges  $-3.6 < y < -2.6$  and  $|y| < 0.9$ , where the J/Psi has been identified through its leptonic decays. Furthermore, we present first results on the photoproduction of J/Psi in pPb UPC at  $\sqrt{s_{NN}} = 5.02$  TeV

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## Quarkonia measurement in hadronic collisions with ALICE at the LHC

**Author:** Loic MANCEAU<sup>1</sup>

<sup>1</sup> *INFN sezione di Torino*

**Corresponding Author:** [lmanceau@to.infn.it](mailto:lmanceau@to.infn.it)

ALICE is the LHC experiment dedicated to the study of the Quark-Gluon Plasma (QGP). Among the prominent probes of the QGP, quarkonia are abundantly produced at the LHC energies. The design of the ALICE detector was optimised to allow quarkonia detection down to zero transverse momentum. This is performed in the forward muon spectrometer ( $2.5 \leq \eta \leq 4$ ) and in the central barrel ( $|\eta| < 0.9$ ) via the dimuon and dielectron decay channels, respectively.

The measurement of quarkonia in AA collisions is expected to provide essential information about the temperature of the QGP. In pp collisions, high precision data provides the essential baseline for the measurements in AA collisions and serves as crucial test for several competing models of quarkonium hadroproduction.

The emphasis will be put on the recent results on quarkonia production in Pb-Pb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV and selected results from pp collisions will be discussed.

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## Search for SM Higgs decaying to bb in associated production with Z boson decaying in the invisible channel

**Author:** Silvio Donato<sup>1</sup>

<sup>1</sup> *Sezione di Pisa (IT)*

**Corresponding Author:** [silvio.donato@cern.ch](mailto:silvio.donato@cern.ch)

A search for the standard model Higgs boson decaying into two b-jets using associated production of the Higgs with Z boson decaying into invisible channel is presented. The CMS data sample of 4.7 fb<sup>-1</sup> of pp collisions at the energy of 7 TeV and 19.5 fb<sup>-1</sup> at the energy of 8 TeV have been analyzed. The techniques used in order to discriminate signal from background are explained.

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## The ZZ/WZ signal in ZH/WH ( $ll, \nu\nu$ )/ $l\nu b\bar{b}$ search at CMS experiment.

**Author:** Caterina Vernieri<sup>1</sup>

<sup>1</sup> *Sezione di Pisa (IT)*

**Corresponding Author:** caterina.vernieri@cern.ch

The WZ/ZZ (VZ) associated production channel with Z decaying to bottom quarks, is one of the less reducible background for the standard model Higgs boson search in the same event topology (VH). The study of the VZ signal proposed here should be accounted as a validation of the analysis strategy developed for the VH search in the boosted regime. It is also the first attempt to measure the VZ cross section in the  $Z \rightarrow b\bar{b}$  final state at CMS, which represents an important background for the analogue Higgs search.

The 8 TeV data sample comprising 19.5 fb<sup>-1</sup> from the 2012 running period has been analyzed in the  $Z(\mu\mu, ee, \nu\nu)Z$  and  $W(e\nu, \mu\nu)Z$  channels.

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## Searches for the Higgs-like boson decaying into bottom quarks in the WH channel

**Author:** Christian Boser<sup>1</sup>

<sup>1</sup> *KIT - Karlsruhe Institute of Technology (DE)*

**Corresponding Author:** christian.boser@cern.ch

The most important discovery of the LHC so far was the discovery of the Higgs-like boson at 125 GeV in 2012. We present the most recent results of the search for the Higgs-like boson decaying into bottom quarks, when produced in association with a W boson. Only events where the leptonically decaying W boson and the Higgs boson possess large transverse momenta are selected. The full proton-proton collision data recorded by the CMS detector in 2011 and 2012 at 7 and 8 TeV respectively, corresponding to an integrated luminosity of 25/fb is used for the search.

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## Search for a Higgs-like boson decaying into bottom quarks in the ZH channel

**Author:** Philipp David Eller<sup>1</sup>

<sup>1</sup> *Eidgenoessische Tech. Hochschule Zuerich (CH)*

**Corresponding Author:** philipp.eller@cern.ch

After the discovery of a Higgs-like Boson with a mass close to 125 GeV at the LHC in summer 2012, we are showing the update on the analysis of the VH channel. In this channel the Higgs-like Boson is produced in association with a vector boson and decaying into b-quarks. We present the updated results on the full 2011 and 2012 7+8 TeV dataset.

This poster will focus on one of the tree modes that are combined in this analysis, where the associated vector boson is a Z boson, that is decaying leptonically into two electrons or muons, respectively.

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## Diffraction studies with ALICE

**Author:** Karel Safarik<sup>1</sup>

<sup>1</sup> *CERN*

The measurement by the ALICE Collaboration of Single and Double Diffraction cross-sections in pp collisions, at  $\sqrt{s} = 0.9, 2.76$  and 7 TeV will be presented. The relevance of diffraction to the understanding of inelastic pp interactions will be discussed and the measurement of the inelastic pp cross-section will be presented. A brief status of ALICE studies of centrally produced systems, selected with a two-pseudorapidity gap topology, will also be given, together with ALICE plans for diffraction studies in p-Pb collisions and in the future LHC pp run at  $\sqrt{s} \geq 13$  TeV.

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## Identified Hadron Production in pp collisions at LHC

**Author:** Eulogio Serradilla Rodriguez<sup>1</sup>

<sup>1</sup> *Universidad Nacional Autonoma (MX)*

**Corresponding Author:** eulogio.serradilla@cern.ch

The unique particle identification capabilities of ALICE at LHC allow systematic studies of the production of identified particles in pp collisions. In this talk we will present measurements of several light flavour particles, including resonances and multi-strange particles. Results will be discussed and systematically compared with data from Monte Carlo models, such as recent Pythia tunes. A particular focus will be made on light nuclei and antinuclei production, studied in the framework of coalescence models and compared to HBT correlation results.

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## Multi Higgs and Vector boson production beyond the Standard Model

**Authors:** Alexander Belyaev<sup>1</sup>; Rogerio Rosenfeld<sup>2</sup>

**Co-authors:** Alexandra Oliveira<sup>2</sup>; Marc Thomas<sup>1</sup>

<sup>1</sup> *University of Southampton*

<sup>2</sup> *IFT-UNESP*

If the electroweak symmetry breaking is originated from a strongly coupled sector, as for instance in composite Higgs models, the Higgs boson couplings can deviate from their Standard Model values. In such cases, at sufficiently high energies there could occur an onset of multiple Higgs boson and longitudinally polarised electroweak gauge boson ( $V_L$ ) production. We study the sensitivity to anomalous Higgs couplings in inelastic processes with 3 and 4 particles (either Higgs bosons or  $V_L$ 's) in the final state. We show that, due to the more severe cancellations in the corresponding amplitudes as compared to the usual 2 to 2 processes, large enhancements with respect to the Standard Model can arise even for small modifications of the Higgs couplings. In particular, we find that triple Higgs production provides the best multiparticle channel to look for these deviations. We briefly explore the consequences of multiparticle production at the LHC.

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## The LHC Tier1 at PIC: experience from first LHC run

**Authors:** Alexey Sedov<sup>1</sup>; Andreu Pacheco Pages<sup>2</sup>; Antonio Maria Perez Calero Yzquierdo<sup>3</sup>; Arnau Brià<sup>4</sup>; Bruno Rodríguez<sup>4</sup>; Carles Acosta<sup>4</sup>; Elena Planas<sup>4</sup>; Elisa Lanciotti<sup>5</sup>; Esther Acción<sup>4</sup>; Fernando López<sup>4</sup>; Francisco Martínez<sup>4</sup>; Gerard Bernabeu<sup>6</sup>; Gonzalo Merino Arevalo<sup>3</sup>; Jordi Casals<sup>4</sup>; Jose Flix Molina<sup>3</sup>; Manuel Delfino Reznicek<sup>6</sup>; Marc Caubet Serrabou<sup>6</sup>; Mari Carmen Porto<sup>4</sup>; Ricard Cruz<sup>4</sup>; Vanessa Acin<sup>4</sup>; Victor Mendez Muñoz<sup>7</sup>; Xavier Espinal Curull<sup>5</sup>

<sup>1</sup> *Universitat Autònoma de Barcelona*

<sup>2</sup> *Institut de Física d'Altes Energies - Barcelona (ES)*

<sup>3</sup> *Centro de Investigaciones Energ. Medioambientales y Tecn. - (ES)*

<sup>4</sup> *PIC*

<sup>5</sup> *CERN*

<sup>6</sup> *Universitat Autònoma de Barcelona (ES)*

<sup>7</sup> *Port d'Informació Científica (PIC), Universitat Autònoma de Barcelona, ES-08193 Bellaterra (Barcelona) Spain*

**Corresponding Authors:** pacheco@ifae.es, jose.flix.molina@cern.ch

The Large Hadron Collider (LHC), in the European Laboratory for Particle Physics (CERN, Switzerland), is the largest scientific instrument ever built. It started operating in November 2009 and it has generated a few hundreds of Petabytes of raw, simulated and processed data, from all of its detectors, since the stop of the successful first run in February 2013. Managing this amount of data and enabling its analysis by thousands of physicists around the world is, and has been, a technological challenge. This is addressed by the largest scientific distributed computing infrastructure in the world: the Worldwide LHC Computing Grid (WLCG), adding up the computing resources of more than 170 centers in 34 countries. In the WLCG, the computing centers are functionally classified in Tiers. Tier0 is at CERN, where the raw data is stored and promptly reconstructed. A copy of these data are distributed via a dedicated high-speed network to eleven Tier1 centers, which provide permanent storage and perform data-intensive analysis and re-processing. Finally, Tier2 centers concentrate on simulation and end-user analysis. Spain contributes to the WLCG with one Tier1 centre: Port d'Informació Científica (PIC), located in the campus of the Universitat Autònoma de Barcelona, near the city of Barcelona. PIC provides Tier1 services to three of the LHC experiments: ATLAS, CMS and LHCb, and acts as a reference Tier1 for the Tier2 centers in Spain and Portugal. This contribution summarizes the operational experience of the PIC Tier1 from first LHC run. During the Long Shutdown (LS1) of the accelerator, the LHC experiments are entering into a review phase of their computing models and operations. The current ongoing activities prior to the restart of the LHC program in 2015 are as well reviewed.

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## Effective Higgs Lagrangian

**Author:** Margherita Ghezzi<sup>1</sup>

<sup>1</sup> *Roma 1, La Sapienza*

The discovery of a Higgs-like boson, together with no hint of the existence of any additional new particle, makes us face with the problem of finding strategies to study the properties of the electroweak symmetry breaking sector. In this talk, the effective Lagrangian that describes a light Higgs-like boson will be reviewed, focusing on the reasonable case in which the Higgs-like particle is a CP-even scalar of an SU(2)<sub>L</sub> doublet. In this framework, the dimension-6 operators which encode the leading New Physics effects will be presented, highlighting in particular the strategy to determine whether the dynamics responsible for the electroweak symmetry breaking is weakly or strongly interacting.

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## The initial state in heavy ion collisions

**Author:** Javier Lopez Albacete<sup>1</sup>

<sup>1</sup> *Granada*

I shall present a brief review of recent theoretical developments and related phenomenological approaches for understanding the initial state of heavy ion collisions, with emphasis on the Color Glass Condensate effective theory formalism and the phenomenon of gluon saturation. I shall also discuss how the data on p+Pb collisions at the LHC can be used to constrain the quantitative characterisation of the initial state of HIC

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## Multi-particle production in the CGC framework

**Author:** Cyrille Marquet<sup>1</sup>

<sup>1</sup> *Ecole Polytechnique*

Within the Color Glass Condensate (CGC) framework, I will discuss particle production in the collision of a dilute projectile with a dense hadronic target. For years CGC studies focused on the dipole scattering amplitude, and its evolution towards high energies or small  $x$ . One has now reached an accuracy sufficient to quantitatively describe single inclusive particle production in p+A type collisions, at least in the forward rapidity region, sensitive to the smallest values of  $x$ . Recently the focus has turned to the quadrupole amplitude, necessary to compute the two-particle inclusive case. Actually in the large- $N_c$  limit, only dipoles and quadrupoles contribute, and I will show that this is the case irrespectively of the numbers of particles measured in the final state.

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## Colour Decompositions and Multi-Jet QCD

**Author:** Tom Melia<sup>1</sup>

<sup>1</sup> *CERN*

I will talk about the role that colour decompositions play in the calculations of multi-jet QCD processes at the LHC. In particular I will discuss the use of the  $1/N_c$  expansion and the treatment of amplitudes involving multiple quark-antiquark pairs.

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## Squark flavour violation and naturalness at the LHC

**Author:** Monika Blanke<sup>None</sup>

While the presence of top partners below the TeV scale is predicted by naturalness, the search at ATLAS and CMS for these states has so far been unsuccessful. Focussing on supersymmetry, we show that a large mixing between the right-handed charm and top squarks (i) is consistent with low-energy flavour constraints;

- (ii) reduces significantly the experimental bound on the stop mass;
- (iii) has a mild, but beneficial, effect on fine-tuning;
- (iv) leads to interesting flavour violating signatures at the LHC not presently investigated by experiments.

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## On lepton flavor universality in B decays

**Author:** Jernej Kamenik<sup>1</sup>

<sup>1</sup> *Jozef Stefan Institute*

Present measurements of  $b \rightarrow c \tau \nu$  and  $b \rightarrow u \tau \nu$  transitions differ from the standard model predictions of lepton flavor universality by almost  $4\sigma$ . We examine new physics interpretations of this anomaly. An effective field theory analysis shows that minimal flavor violating models are not preferred as an explanation, but are also not yet excluded. Allowing for general flavor violation, right-right vector and right-left scalar quark currents are identified as viable candidates. We discuss explicit examples of two Higgs doublet models, leptiquarks as well as quark and lepton compositeness. Finally, implications for LHC searches and future measurements at the (super)B- factories are presented.

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## NNLO top quark pair production

**Author:** Paul Fiedler<sup>1</sup>

<sup>1</sup> *Aachen*

I give an overview on the current theoretical status of the top quark pair production total cross section focusing on the recently derived NNLO result for the gluon fusion channel, which completes the fixed order NNLO calculations. Using our result to provide the NNLO+NNLL prediction for the total cross section, I discuss its phenomenological impact and compare it with the most precise LHC and Tevatron data. In particular I explain the influence of the available NNLO PDF sets on the theoretical prediction as well as how top quark pair production can be used to constrain the gluon PDF at large  $x$ , which can lead to improved predictions for Beyond the Standard Model processes at the LHC.

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## Top AFB and BSM: moving forward or backward?

**Author:** Cedric Delaunay<sup>None</sup>

We will discuss LHC implications of TeV scale new physics responsible for the large top forward-backward asymmetry observed at the Tevatron. We will first present generic predictions based on an effective field theory description of the top dynamics. We will then consider more specific expectations in the framework of composite Higgs models.

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## A Higgs-like dilaton

**Author:** Javi Serra Mari<sup>1</sup>

<sup>1</sup> *Cornell University*

We reexamine the possibility that the 125 GeV Higgs-like resonance recently discovered at the LHC actually corresponds to a dilaton: the Goldstone-boson of spontaneous breaking of scale invariance at TeV energies. We further review the expected phenomenological deviations from the SM-Higgs and compare with other Goldstone-Higgs scenarios.

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## SUSY after LHC8

**Author:** enrico bertuzzo<sup>1</sup>

<sup>1</sup> *CEA Saclay*

After a brief summary of the 8 TeV LHC results for direct searches of SUSY particles, I will analyse their implications in the context of various supersymmetric scenarios, including both minimal and non minimal models.

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## EW processes at LHC

**Author:** Luca Barze<sup>1</sup>

<sup>1</sup> *CERN*

The LHC is expected to improve the measurements of the fundamental parameters of the Standard Model, allowing to probe the electroweak symmetry breaking mechanism. Among other things, it will measure the W boson mass with an uncertainty of about 10 MeV and it will test the non-abelian nature of the electroweak force measuring the gauge boson self-couplings in the high energy limit. The seminar will illustrate the state-of-the-art of Monte Carlo event generators related to single and double vector boson production, in view of the latest experimental data.

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## Electroweak constraints on new physics

**Author:** Jorge de Blas Mateo<sup>1</sup>

<sup>1</sup> *University of Notre Dame*

We briefly review the global Standard Model fit to electroweak precision data. After that we analyze the electroweak constraints on new interactions, following a model-independent approach based on a general dimension-six effective Lagrangian. Finally, we also discuss the limits on several common new physics additions.



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## The Quark Gluon Plasma as a Jet Resolver

**Author:** Jorge Casalderrey Solana<sup>1</sup>

<sup>1</sup> *University of Barcelona (ES)*

When high energy jets propagate through a hadronic medium, several of their partonic fragments interact simultaneously with the system. The ability of the medium to tell apart different fragments depends on a medium resolution scale, which is a property of the system. In this talk I discuss how this scale emerges from the breaking of color coherence among the different jet fragments induced by the medium and how this picture can be used to understand the medium modification of jet observables.

241

## The top quark meets its heavy partners

**Author:** Juan Antonio Aguilar-Saavedra<sup>1</sup>

<sup>1</sup> *University of Granada*

Current limits on the mixing of the top quark with heavy partners are presented, drawing their implications for top anomalous couplings and for single production of top partners at LHC.

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## MEPS@NLO predictions for H-> WW\* backgrounds in exclusive jet bins using Sherpa and OpenLoops

**Author:** Stefano Augusto Pozzorini<sup>1</sup>

<sup>1</sup> *Universitaet Zuerich (CH)*

OpenLoops is a fast and flexible generator of one-loop scattering amplitudes, which allows to compute NLO corrections to many-particle processes within the Standard Model. Using OpenLoops in combination with Sherpa permits to prepare NLO simulations in a fully automated way. Matching and merging at NLO with the novel MEPS@NLO technique are also fully supported. As a first non-trivial application of Sherpa+OpenLoops, MEPS@NLO predictions for the irreducible background to H->WW\* in the 0- and 1-jet bins will be presented.

246

## Measurements of properties of the Higgs-like Particle at 125 GeV by the CMS collaboration

**Author:** Andrea Davide Benaglia<sup>1</sup>

<sup>1</sup> *Universita & INFN, Milano-Bicocca (IT)*

CMS results are presented on the measurement of properties of the Higgs-like particle discovered last summer with a mass in the range of 125-126 GeV, based on the full statistics of about 25 fb<sup>-1</sup>, collected in 2011 and 2012 at 7 and 8 TeV respectively. A discussion will be given on the mass measurement, couplings and the spin-parity properties of this new particle. The most recent results will be presented.

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## Study of Higgs Production in Bosonic Decay Channels at CMS

**Author:** Pasquale Musella<sup>1</sup>

<sup>1</sup> *CERN*

Results are presented on the study and search for Higgs-like particles decaying into a ZZ, WW and 2 photon final states, based on the full statistics of about 25 fb<sup>-1</sup>, collected in 2011 and 2012 at 7 and 8 TeV respectively with the CMS experiment. Different production channels namely inclusive, VBF and associated production are studied for the 2-photon final state. The following ZZ decay channels are studied: 4 charged leptons, 2l 2nu, 2l 2tau and 2l 2q. Special attention will be to the low mass region where evidence for a new particle was reported earlier in 2012. The WW channel includes the study of full leptonic and semi-leptonic final states. The most recent results will be presented.

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## Study of Higgs Production in Fermionic Decay Channels at CMS

**Author:** Niklas Mohr<sup>1</sup>

<sup>1</sup> *ETH Zurich (CH)*

Results are presented on the study of the Higgs-like particle at 125 GeV decaying into final states consisting of either two taus, or a b anti-b quark pair, based on the full statistics of about 25 fb<sup>-1</sup>, collected in 2011 and 2012 at 7 and 8 TeV respectively with the CMS experiment. Leptonic and hadronic decay channels for the tau lepton are included in the search. Different production channels namely inclusive, VBF and associated production have been studied. The b bbar decay channel is studied in associated production with W/Z and top quarks. SM and MSSM interpretations of the data will be given for both decay channels. The most recent results will be presented.

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## Searches for Exotic Higgs decays in CMS

**Author:** Federica Primavera<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

Results are presented from CMS on searches for Higgs-like particles in models beyond the Standard Model and searches for rare or exotic decays of the 125 GeV particle. Light Higgses as predicted in the NMSSM models are searched for. Decays of the 125 GeV Higgs-like particle into muons are explored. The most recent results will be presented.

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## Vector boson + jets measurements at CMS

**Author:** Marco Musich<sup>1</sup>

<sup>1</sup> *INFN Torino (IT)*

The associated production of jets and vector bosons allows for stringent tests of perturbative QCD calculations and is sensitive to the possible presence of new physics beyond the Standard Model. Measurements of jet production rates in association with W, Z or photons, in proton-proton collisions at 7 TeV center-of-mass energy is presented, using data collected with the CMS detector. Measurements include inclusive jet multiplicity, differential jet cross sections, as well as associated charm- and bottom-quark jet production.

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## Top Quark Pair Cross Section Measurements

**Author:** Martin Goerner<sup>1</sup>

<sup>1</sup> *Hamburg University (DE)*

Measurements of inclusive and differential top quark pair production cross section at 8 TeV are presented, performed using CMS data collected in 2012. The total cross section is measured in the lepton+jets and dilepton channels, including the tau-dilepton mode. Differential cross sections are measured as a function of various kinematic observables, including the transverse momentum and rapidity of the (anti)top quark as well as the top-antitop system, as well as multiplicity and transverse momenta of jets produced in addition to the top pair. The results are combined and confronted with precise theory calculations. The data allow for tests and determinations of MC-parameters, such as those related to the scales for renormalization and factorization and for the matching between the matrix-element and parton-shower level. Differential cross sections are also provided for observables corresponding to top quark final states at particle level ("pseudo-top").

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## Top quark mass measurements with CMS

**Author:** Hamed Bakhshiansohi<sup>1</sup>

<sup>1</sup> *School of Particles and Accelerator Inst. for Res. in Fundam. S*

Measurements of the top quark mass are presented, obtained from CMS data collected in 2011 and 2012 at a centre-of-mass energy of 7 TeV and 8 TeV. The mass of the top quark is measured using several methods. The results of the various channels are combined and compared to the world average. The dependence of the top-quark mass measurement on event kinematics is studied. The top mass and also alphas are extracted from the top pair cross section measured at CMS, including a determination of  $m_{\text{top}}$  in the  $\overline{\text{MS}}$  scheme.

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## Measurements of the top-quark properties at CMS

**Author:** Abideh Jafari<sup>1</sup>

<sup>1</sup> *School of Particles and Accelerator Inst. for Res. in Fundam. S*

Measurements of several top-quark properties are presented, obtained from the CMS data collected in 2011 and 2012 at centre-of-mass energies of 7 and 8 TeV. The results include measurements of the top pair charge asymmetry, the W helicity in top decays, the top quark charge, and of the  $t\bar{t}$  spin correlation and the search for anomalous couplings. The fraction of top quarks decaying into a W-boson and a b-quark relative to all top quark decays,  $R = \text{BR}(t \rightarrow Wb) / \text{Sum}(\text{BR}(t \rightarrow Wq))$ , is determined. Furthermore, the cross sections of  $t\bar{t}$  events produced in association with a photon or a W or a Z boson are measured.

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## Single top quark production with CMS

**Author:** Davide Piccolo<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

Measurements of single top quark production are presented, performed using CMS data collected in 2012 at centre-of-mass energies of 8 TeV. The cross sections for the electroweak production of single top quarks in the t-channel and in association with W-bosons is measured and the results are used to place constraints on the CKM matrix element  $V_{tb}$ . Measurements of top quark properties in single top quark production are also presented. The results include the W-helicity in top quark decay and the search for anomalous couplings.

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## W and Z boson production at CMS

**Author:** Francesco Romeo<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

We present selected measurements done with W and Z bosons performed with the CMS detector, based on samples of events collected during 2011 and 2012 physics runs. Measurements include W and Z inclusive cross sections, the lepton charge asymmetry in W events, and differential cross sections of Z and Drell-Yan production.

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## Production of multiple electroweak bosons at CMS

**Author:** Lara Lloret Iglesias<sup>1</sup>

<sup>1</sup> *Universidad de Oviedo (ES)*

We present studies of diboson production in pp collisions at 7 TeV and 8 TeV center-of-mass energy based on data recorded by the CMS detector at the LHC in 2011 and 2012. These include precise measurements of W and Z production in association with a photon, as well as WW, WZ, and ZZ production at the LHC. The results are interpreted in terms of constraints on anomalous triple gauge couplings.

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## Search for Heavy Resonances in Leptonic Final States

**Author:** John Stupak<sup>1</sup>

<sup>1</sup> *Purdue University Calumet (US)*

We present searches for heavy resonances, such as the  $Z'$ ,  $W'$ , or leptoquarks, in final states with leptons.

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## Searches for New Physics in Multijet Final States

**Author:** Carl Vuosalo<sup>1</sup>

<sup>1</sup> *Ohio State University (US)*

A variety of new physics models predict heavy resonances that decay to multiple hadronic jets. These models include axigluons, colorons, diquarks, excited quarks, Randall-Sundrum gravitons, string resonances, and  $Z'$  models, among others. Using the data collected in 2012 at a center-of-mass energy of 8 TeV, the CMS collaboration has searched for such resonances that decay to two or more hadronic jets, and the results of these searches will be presented. No evidence of new physics has been observed, and these results set new limits on the parameters of these models.

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## Searches for Extra Dimensions and Dark Matter

**Author:** Steven Worm<sup>1</sup>

<sup>1</sup> *CERN*

We present searches for extra dimensions in a variety of final states. Direct and virtual graviton production are considered, as well as black hole production. Interpretations of the monojet and monophoton signatures in terms of dark matter searches are presented.

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## Searches for Long-Lived Particles

**Author:** Livia Soffi<sup>1</sup>

<sup>1</sup> *Universita e INFN, Roma I (IT)*

We present searches for long-lived particles at CMS. These include long-lived gluinos, fractionally and multiply charged particles, and displaced particles that decay into leptons, photons, or jets.

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## Search for New Physics in Top-like Final States

**Author:** Yeng-Ming Tzeng<sup>1</sup>

<sup>1</sup> *National Taiwan University (TW)*

We present searches for massive top and bottom quark partners at CMS using data collected at  $\sqrt{s}=7$  and 8 TeV. Such partners can be seen in 4th generation models, or can be found in models predicting vector-like quarks to solve the Hierarchy problem and stabilize the Higgs mass. Other searches focus on excited states of composite heavy objects that decay to top quarks and jets. The searches span a range of final states, from multi-leptonic to entirely hadronic, and limits are set on mass and production cross sections as a function of branching ratios.

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## Search for stop pair production at the LHC using the CMS detector

**Author:** Verena Ingrid Martinez Outschoorn<sup>1</sup>

<sup>1</sup> *Fermi National Accelerator Lab. (US)*

In this talk, the latest results from CMS on stop pair production are reviewed. We present searches performed for different stop decay modes using up to 20/fb of data from the 8 TeV LHC run of 2012.

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## Search for Supersymmetry in the four W and multiple b-quark final state

**Author:** Didar Dobur<sup>1</sup>

<sup>1</sup> *University of Florida (US)*

In this talk, the latest results from CMS on searches for new physics in final states with four W bosons and multiple b-quarks are presented using up to 20/fb of data from the 8TeV LHC run of 2012. This final state is of special importance in the context of the search for third generation squarks in gluino or sbottom cascade decays. The four W final state is reconstructed in a variety of final states ranging from zero to four leptons, and including up to eight or more jets and MET.

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## Search for RP violating Supersymmetry

**Author:** Fedor Ratnikov<sup>1</sup>

<sup>1</sup> *KIT - Karlsruhe Institute of Technology (DE)*

In this talk, the latest results from CMS on RP violating Supersymmetry are reviewed. We present results using up to 20/fb of data from the 8 TeV LHC run of 2012. Interpretations of the experimental results in terms of production of squarks, gluinos, charginos, neutralinos, and sleptons within RP violating susy models are presented.

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## **SUSY searches for EWK production of Gauginos and Sleptons at the LHC**

**Author:** Marc Dunser<sup>1</sup>

<sup>1</sup> *Eidgenoessische Tech. Hochschule Zuerich (CH)*

In this talk, the latest results from CMS on searches for EWK production of Gauginos and Sleptons, in a variety of complementary final state signatures and methods, will be presented using up to 20/fb of data from the 8 TeV LHC run of 2012.

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## **Search for Supersymmetry in Gauge Mediated Supersymmetry breaking scenarios**

**Author:** Tae Jeong Kim<sup>1</sup>

<sup>1</sup> *Korea University (KR)*

In this talk, the latest results from CMS on searches for Supersymmetry with GMSB in final states with photons and leptons are presented using data from the 7 and 8 TeV LHC run. The experimental results are interpreted in terms of weak as well as strong production of SUSY particles, followed by cascade decays to a Gravitino as lightest supersymmetric particle.

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## **Exclusive and diffractive physics with CMS**

**Author:** Sandro Fonseca De Souza<sup>1</sup>

<sup>1</sup> *Universidade do Estado do Rio de Janeiro (BR)*

In this talk, recent CMS physics analysis on the measurement of central exclusive production as well as soft and hard diffractive processes are discussed. Measurement of the exclusive two-photon production of WW pairs in pp collisions at 7 TeV, based on samples of events collected during 2011 physics runs, is presented. In particular, these measurements should provide unique sensitivity to anomalous quartic couplings of the gauge bosons. Exploratory studies showed potential for extending the experimental reach by several orders of magnitude with respect to the best limits so far obtained at LEP. A search for central exclusive gamma pair production and observation of central exclusive electron pair production in pp collisions at 7 TeV is also presented. An upper limit on the diphoton production cross section is set at 95% confidence level, and a comparison between the measurement and the QED prediction is discussed for dielectron production.

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## Quarkonium production and polarization

**Author:** Carlos Lourenco<sup>1</sup>

<sup>1</sup> *CERN*

Studies of the production of heavy quarkonium states are very important to improve our understanding of QCD and hadron formation, given that the heavy quark masses allow the application of theoretical tools less sensitive to nonperturbative effects.  $J/\psi$  and Upsilon cross sections can be reproduced by nonrelativistic QCD calculations, dominated by “color octet” production, but the corresponding predictions of strong transverse polarizations are in strong disagreement with the negligible polarizations measured at the Tevatron for the  $J/\psi$ . However, this comparison is affected by the feed-down decays from  $\chi_c$  mesons, of unknown influence on the measurements. Given their heavier masses, measurements of the Upsilon production cross sections and polarizations are a more decisive test of NRQCD, especially at the high transverse momentum ranges reachable at the LHC.

This talk presents recent CMS measurements of the differential cross sections and polarizations of the Upsilon(1S), Upsilon(2S) and Upsilon(3S) mesons produced in proton-proton collisions at  $\sqrt{s} = 7$  TeV, using the dimuon data sample collected in 2011, corresponding to an integrated luminosity of  $4.9 \text{ fb}^{-1}$ . This is the most comprehensive measurement of Upsilon properties made at hadron colliders so far.

All the three frame-dependent polarization parameters ( $\lambda_\theta$ ,  $\lambda_\phi$  and  $\lambda_{\theta\phi}$ ), plus the frame-invariant parameter  $\tilde{\lambda}$ , are measured in three different polarization frames, in five transverse momentum bins and two rapidity ranges, significantly extending the  $p_T$  and rapidity ranges probed by previous experiments. The observations are in disagreement with the available theoretical expectations.

Preliminary results on  $J/\psi$  and  $\psi(2S)$  polarizations will also be shown.

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## Heavy Ions

**Author:** Thiago Tomei Fernandez<sup>1</sup>

<sup>1</sup> *UNESP - Universidade Estadual Paulista (BR)*

The capabilities of the CMS experiment allow to investigate various hard probes, as well as bulk particle production and collective phenomena, using the calorimetry, muon and tracking systems covering a large range in pseudorapidity. In this talk selected results of the CMS experiment from pp and PbPb collisions at  $\sqrt{s_{NN}} = 2.76$  TeV will be discussed. First results from the recent pPb Run at  $\sqrt{s_{NN}} = 5.02$  TeV will also be presented.

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## Search for new physics using events with two same-sign isolated leptons in the final state

**Authors:** Marc Dunser<sup>1</sup>; Santiago Folgueras<sup>2</sup>

<sup>1</sup> *Eidgenoessische Tech. Hochschule Zuerich (CH)*



<sup>2</sup> *Universidad de Oviedo (ES)*

Although same sign dileptons final states are very rare in the SM context, they appear naturally in many different new physics scenarios such as SUSY where two same-sign dileptons can be produced in the decay chain of supersymmetric particles.

Different scenarios can be presented: Same-sign dileptons accompanied by b-quarks can arise from SUSY processes where 3rd generation quark superpartners are lighter than other squarks, resulting in an abundance of top and bottom quarks produced in the cascade decays. In general, same-sign dileptons can be particularly sensitive to SUSY models with compressed spectra where the mass of the LSP is very close to the mass of the produced supersymmetric particle, either if it is produced via strong production (squarks or gluinos) when it is accompanied with high hadronic activity or if it is produced via EW production (charginos or neutralinos) when almost no hadronic activity is present. In all cases the SUSY decay chain ends with the LSP, that escapes undetected and therefore contribute strongly to the MET of the event.

We therefore search for SUSY using same sign dilepton events with/without hadronic activity and large missing ET, using the full 2012 integrated luminosity and we interpret our results in the context of various SUSY models.

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## Probing the Higgs coupling to top quark in events with associated Higgs production with top-anti top pair and Higgs decay in two photons

**Author:** Francesco Micheli<sup>1</sup>

<sup>1</sup> *Universita e INFN, Roma I (IT)*

We present here the results of the first search for the associated production of the Higgs boson with a  $t\bar{t}$  pair, using the events where the Higgs boson decays to two photons in CMS. In order to maximize acceptance and sensitivity to such a small signal, we devise two different sets of event selection criteria, optimized for semileptonic and all-hadronic  $t\bar{t}$  decays.

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## Standard Higgs boson search in the $H \rightarrow WW \rightarrow 2l2\nu$ decay channel with the CMS detector.

**Authors:** Hugues Louis Brun<sup>1</sup>; Lara Lloret Iglesias<sup>1</sup>

<sup>1</sup> *Universidad de Oviedo (ES)*

The search of the standard model Higgs boson in the  $H \rightarrow WW \rightarrow 2l2\nu$  channel with the CMS detector is described. This analysis is performed in categories, depending of the number of jets and the leptons flavour, in order to enhance the Higgs signal respect to the expected irreducible backgrounds. The largest backgrounds are estimated with data-driven methods. In some categories a fit with a 2D template, using kinematics variables, is performed to improve the sensitivity and to be sensitive to the Higgs boson spin and parity. The result with the 5.1 fb<sup>-1</sup> of data recorded in 2011 with 7 TeV in the center of mass and with 19.5 fb<sup>-1</sup> recorded at 8 TeV in 2012 is presented.

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## Phenomenological MSSM interpretation of the CMS 2011 5/fb results

**Authors:** Denis Rathjens<sup>1</sup>; Lukas Vanelderen<sup>1</sup>

<sup>1</sup> *Hamburg University (DE)*

We interpret within the phenomenological MSSM (pMSSM) results obtained by CMS using a pp data set collected in 2011 at 7-TeV, corresponding to an integrated luminosity of 5/fb. The pMSSM is a 19-parameter realization of the MSSM defined at the SUSY scale, that captures most of the features of the general R-parity conserving weak-scale MSSM. A global Bayesian analysis is performed that yields posterior probability densities of model parameters, masses and observables. We provide conclusions that are more generic, and therefore more robust, than those derived in more constrained setups, including simplified models and models that impose particular SUSY breaking schemes, such as the CMSSM. Our results also comprise implications for the MSSM Higgs sector, as well as for dark matter searches. Furthermore, we discuss which scenarios currently escape detection despite a high production cross section. Our study thus gives a coherent global picture of how the current CMS searches constrain supersymmetry in general.

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## Search for heavy lepton partners of neutrinos in pp collisions at 7 TeV in the context of the type III seesaw mechanism

**Author:** Sara Vanini<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

A search is presented in proton-proton collisions at 7 TeV for fermionic triplet states expected in type III seesaw models. The search is performed using final states with three isolated charged leptons and an imbalance in transverse momentum. The data, collected with the CMS detector at the LHC, correspond to an integrated luminosity of 4.9 /fb. No excess of events is observed above the background predicted by the standard model, and the results are interpreted in terms of limits on production cross sections and masses of the heavy partners of the neutrino in type III seesaw models. Depending on the considered scenarios, lower limits are obtained on the mass of the heavy partner of the neutrino that range from 180 to 210 GeV.

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## Rare B decays with the CMS detector.

**Author:** Sara Vanini<sup>1</sup>

**Co-author:** Jacopo Pazzini<sup>1</sup>

<sup>1</sup> *Universita e INFN (IT)*

The study of rare processes allows the indirect search of new physics through the comparison with the standard model (SM) expectations. Flavor-changing neutral current decays of b hadrons are forbidden at tree level in the SM, resulting in small SM rates. These processes are therefore good candidates for the search of new physics, such as minimal supersymmetric extension of the standard model or extended Higgs sectors. The results of the search for rare B decays by the CMS detector at LHC will be reported.

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## Search for an excited quark decaying to a top quark plus gluon.

**Author:** Ta-Wei Wang<sup>1</sup>

<sup>1</sup> *National Taiwan University (TW)*

We perform a search for a pair-produced-excited top quark,  $t$ , that decays exclusively to a top quark and a gluon using data collected by the CMS detector from  $pp$  collisions at  $\sqrt{s} = 8$  TeV. The search is performed using events consistent with the semi-leptonic decay of the  $t\bar{t}$  system, that is events having a single isolated muon or electron, missing energy, and at least six well-reconstructed jets, one of which must be identified as originating from the fragmentation of a  $b$  quark. The data analyzed corresponds to an integrated luminosity of  $19.6 \text{ fb}^{-1}$  in both muon and electron channel. No significant excess over expectations is observed and we set a lower limit is on a  $t$ -quark mass at 95% confidence level.

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## Jet Energy Calibration in the CMS experiment

**Authors:** Denis Rathjens<sup>1</sup>; Lukas Vanelderen<sup>1</sup>

<sup>1</sup> *Hamburg University (DE)*

Jet reconstruction and calibration in the CMS experiment are complicated by the nonlinear response of the calorimeters and the high pileup conditions. These difficulties are mitigated at CMS by utilizing the particle flow approach. The measurements of the jet energy calibration in CMS are summarized and presented. They are performed with data samples collected in proton-proton collisions at a centre-of-mass energy of 8 TeV corresponding to an integrated luminosity of 12.1/fb. The final jet energy calibration is derived with dijet,  $\gamma$ +jet and Z+jet events. Here, we focus on the estimation of the inter- $\eta$ -calibration using dijet events and discuss the uncertainties on the jet energy corrections.

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## Search for a Standard Model Higgs Boson in the $H \rightarrow ZZ \rightarrow 4l$ Channel at CMS

**Author:** Donald Austin Belknap<sup>1</sup>

<sup>1</sup> *University of Wisconsin (US)*

The most recent CMS results are presented for a search for a Standard Model Higgs boson in the  $ZZ$  decay channel where the  $Z$  bosons decay into two charged leptons. The full dataset of LHC  $pp$  collisions at 7 and 8 TeV recorded by CMS is utilized.

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## Light stau search through squark/gluino cascade decays at CMS

**Author:** Andres Guillermo Delannoy Sotomayor<sup>1</sup>

<sup>1</sup> *Vanderbilt University (US)*

A search for physics beyond the standard model is performed with one or more hadronically decaying  $\tau$ -leptons, highly energetic jets, and large momentum imbalance in the final state. The data sample corresponds to an integrated luminosity of  $5.0 \text{ fb}^{-1}$  of pp collisions at  $\sqrt{s} = 7 \text{ TeV}$  collected with the CMS detector at the LHC.

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## **MET performance at 8 TeV in CMS**

**Authors:** Jonatan Piedra Gomez<sup>1</sup>; Lara Lloret Iglesias<sup>2</sup>

<sup>1</sup> *Universidad de Cantabria (ES)*

<sup>2</sup> *Universidad de Oviedo (ES)*

We present the performance of missing transverse momentum (MET) reconstruction in CMS, using 8 TeV pp collision data corresponding to an integrated luminosity up to  $12.2 \pm 0.5 \text{ fb}^{-1}$ . Events with anomalous MET are studied, and the performance of algorithms used to identify those events is presented. The scale and resolution for MET, including the effects of multiple pp interactions in the same and neighboring bunch crossings (pileup interactions), are measured using events with an identified Z boson or isolated photon. Advanced MET reconstruction algorithms are also developed specifically to mitigate the effects of large numbers of pileup interactions on MET resolution. Using these advanced algorithms we show that the dependence of the MET resolution on pileup interactions is reduced significantly.

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## **Measurements of Properties of the Higgs boson in di-boson channels with the ATLAS detector**

**Corresponding Author:** [lashkar.kashif@cern.ch](mailto:lashkar.kashif@cern.ch)

**Parallel: Higgs 1 / 291**

## **Study of Higgs Production in Bosonic Decay Channels at CMS**

**Corresponding Author:** [pasquale.musella@cern.ch](mailto:pasquale.musella@cern.ch)

**Parallel: Higgs 1 / 292**

## **Effective Higgs Lagrangian**

**Corresponding Author:** [margherita.ghezzi@roma1.infn.it](mailto:margherita.ghezzi@roma1.infn.it)

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## **Searches for Higgs and Higgs-like particles at LHCb**

Corresponding Author: victor.coco@cern.ch

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## **Multi Higgs and Vector boson production beyond the Standard Model**

Corresponding Author: rogerio.rosenfeld@cern.ch

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## **Searches for the Higgs boson decaying into fermion pairs with the ATLAS detector**

Corresponding Author: david.jamin@cern.ch

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## **Study of Higgs Production in Fermionic Decay Channels at CMS**

Corresponding Author: niklas.mohr@cern.ch

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## **Higgs production in gluon fusion beyond NNLO**

Corresponding Author: marco.bonvini@cern.ch

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## **Combined search for the SM Higgs Boson at D0**

Corresponding Author: emilien.chapon@cea.fr

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## **Higgs boson production in the SM and MSSM to NNLO**

**Corresponding Author:** matthias.steinhauser@uka.de

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**Corresponding Author:** andrea.benaglia@cern.ch

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**Corresponding Author:** gabriel.facini@cern.ch

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**Corresponding Author:** tuchming@cea.fr

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**Corresponding Author:** adonati@ugr.es

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**Corresponding Author:** matthew.beckingham@cern.ch

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**Corresponding Author:** federica.primavera@cern.ch

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**Corresponding Author:** domenec.espriu@cern.ch

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**Corresponding Author:** lara.lloret.iglesias@cern.ch

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**Corresponding Author:** suen.hou@cern.ch

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**Corresponding Author:** chiara.bianchin@cern.ch

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**Corresponding Author:** lmanceau@to.infn.it

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Corresponding Author: [cyrille.marquet@cern.ch](mailto:cyrille.marquet@cern.ch)

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Corresponding Author: [gabriel.stoicea@cern.ch](mailto:gabriel.stoicea@cern.ch)

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Corresponding Author: [burkhard.schmidt@cern.ch](mailto:burkhard.schmidt@cern.ch)

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Corresponding Author: [maria.nicassio@cern.ch](mailto:maria.nicassio@cern.ch)

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Corresponding Author: [jesus.guillermo.contreras.nuno@cern.ch](mailto:jesus.guillermo.contreras.nuno@cern.ch)

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**Corresponding Author:** amal@rcf.rhic.bnl.gov

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**Corresponding Author:** jorge.casalderrey@cern.ch

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**Corresponding Author:** thiago.tomei@cern.ch

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**Corresponding Author:** nicolas.arbor@cern.ch

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**Corresponding Author:** francesco.barile@cern.ch

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**Corresponding Author:** leif.lonnblad@thep.lu.se

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**Corresponding Author:** lea.michaela.caminada@cern.ch

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**Corresponding Author:** marco.musich@cern.ch

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**Corresponding Author:** pozzorin@physik.uzh.ch

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**Corresponding Author:** tjyang@fnal.gov

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**Corresponding Author:** lee.sawyer@cern.ch

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**Corresponding Author:** joao.gentil.saraiva@cern.ch

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**Corresponding Author:** sandro.fonseca@cern.ch

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Corresponding Author: alex.grecu@cern.ch

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Corresponding Author: barbara.guerzoni@bo.infn.it

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Corresponding Author: juan.rojo@cern.ch

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Corresponding Author: e.rizvi@qmul.ac.uk

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Corresponding Author: kenan.mujkic@desy.de

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Corresponding Author: t.melia1@physics.ox.ac.uk

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**Corresponding Author:** jernej.kamenik@ijs.si

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**Corresponding Author:** maximilian.schlupp@cern.ch

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**Corresponding Author:** cibran.santamarina.rios@cern.ch

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**Corresponding Author:** stefanos.leontsinis@cern.ch

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**Corresponding Author:** monica.pepe.altarelli@cern.ch

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**Corresponding Author:** markus.fasel@cern.ch

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Corresponding Author: [george.wei-shu.hou@cern.ch](mailto:george.wei-shu.hou@cern.ch)

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Corresponding Author: [harry.victor.cliff@cern.ch](mailto:harry.victor.cliff@cern.ch)

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Corresponding Author: [monika.blanke@cern.ch](mailto:monika.blanke@cern.ch)

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Corresponding Author: [roel.aaij@cern.ch](mailto:roel.aaij@cern.ch)

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Corresponding Author: [sir.integra@gmail.com](mailto:sir.integra@gmail.com)

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Corresponding Author: [iftah@tx.technion.ac.il](mailto:iftah@tx.technion.ac.il)

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Corresponding Author: [rick.van.kooten@cern.ch](mailto:rick.van.kooten@cern.ch)

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Corresponding Author: paul.fiedler@kunstkosmos.de

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Corresponding Author: martin.goerner@cern.ch

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Corresponding Author: kevin.finelli@cern.ch

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Corresponding Author: r.demina@cern.ch

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Corresponding Author: adrian.irles@desy.de

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Corresponding Author: pavol.bartos@cern.ch

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**Corresponding Author:** hamed.bakhshian@cern.ch

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**Corresponding Author:** fabrice.balli@cern.ch

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**Corresponding Author:** jan.andre.stillings@cern.ch

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**Corresponding Author:** davide.piccolo@cern.ch

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**Corresponding Author:** cedric.delaunay@cern.ch

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**Corresponding Author:** stefano.camarda@cern.ch

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**Corresponding Author:** juan.antonio.aguilar.saavedra@cern.ch

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Corresponding Author: francesco.rubbo@cern.ch

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Corresponding Author: abideh.jafari@cern.ch

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Corresponding Author: carl.vuosalo@cern.ch

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Corresponding Author: faguila@ugr.es

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Corresponding Author: steven.worm@cern.ch

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Corresponding Author: jalal.abdallah@cern.ch

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Corresponding Author: livia.soffi@cern.ch

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Corresponding Author: daniela.salvatore@cern.ch

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Corresponding Author: mikael.rodriquez.chala@cern.ch

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Corresponding Author: snezana.nektarijevic@cern.ch

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Corresponding Author: yeng-ming.tzeng@cern.ch

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**Corresponding Author:** mpv@ugr.es

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**Corresponding Author:** lulu.liu@cern.ch

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**Corresponding Author:** john.stupak@cern.ch

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**Corresponding Author:** enrico.bertuzzo@sns.it

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**Corresponding Author:** alex.kastanas@cern.ch

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**Corresponding Author:** verena.martinez@cern.ch

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**Corresponding Author:** mirjam.fehling@physik.uni-freiburg.de

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Corresponding Author: didar.dobur@cern.ch

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Corresponding Author: claudia.giuliani@cern.ch

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Corresponding Author: francesco.riva@cern.ch

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Corresponding Author: dutta@physics.tamu.edu

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Corresponding Author: marc.dunser@cern.ch

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Corresponding Author: mrelich6@gmail.com

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**Corresponding Author:** gennaro.corcella@cern.ch

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**Corresponding Author:** fedor.ratnikov@gmail.com

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**Corresponding Author:** andres.florez@cern.ch

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**Corresponding Author:** tae.jeong.kim@cern.ch

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**Corresponding Author:** luca.barze@cern.ch

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**Corresponding Author:** jack.robert.goddard@cern.ch

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**Corresponding Author:** francesco.romeo@cern.ch

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**Corresponding Author:** [ronan.wallace@cern.ch](mailto:ronan.wallace@cern.ch)

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**Corresponding Author:** [jdeblasm@nd.edu](mailto:jdeblasm@nd.edu)

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**Corresponding Author:** [hengne.li@cern.ch](mailto:hengne.li@cern.ch)

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**Corresponding Author:** [carlos.lourenco@cern.ch](mailto:carlos.lourenco@cern.ch)

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**Corresponding Author:** [rosell@uch.ceu.es](mailto:rosell@uch.ceu.es)

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## **Introduction**

**Corresponding Author:** [mmp@ifae.es](mailto:mmp@ifae.es)

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## Measurement of D<sup>0</sup>-D<sup>0</sup>bar Mixing at CDF

**Corresponding Author:** paolo.maestro@cern.ch

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## Possible effect of mixed phase and deconfinement upon spin correlations in the Lambda-antiLambda pairs generated in relativistic Heavy-Ion collisions

**Author:** Valery Lyuboshitz<sup>1</sup>

**Co-author:** Vladimir Lyuboshitz<sup>2</sup>

<sup>1</sup> *Joint Institute for Nuclear Research (Dubna)*

<sup>2</sup> *Joint Institute for Nuclear Research (Dubna)*

Spin correlations for the  $\Lambda$   $\Lambda$  and  $\Lambda$   $\bar{\Lambda}$  pairs, generated in relativistic heavy ion collisions, and related angular correlations at the joint registration of hadronic decays of two hyperons, in which space parity is not conserved, are analyzed. The correlation tensor components can be derived from the double angular distribution of products of two decays by the method of “moments”. The properties of the “trace” of the correlation tensor ( a sum of three diagonal components ), determining the relative fractions of the triplet states and singlet state of respective pairs, are discussed. Spin correlations for two identical particles (  $\Lambda$   $\Lambda$  ) and two non-identical particles (  $\Lambda$   $\bar{\Lambda}$  ) are considered from the viewpoint of the conventional model of one-particle sources. In the framework of this model, correlations vanish at sufficiently large relative momenta. However, under these conditions, in the case of two non-identical particles (  $\Lambda$  - anti-  $\Lambda$  ) a noticeable role is played by two-particle annihilation ( two-quark, two-gluon ) sources, which lead to the difference of the correlation tensor from zero. In particular, such a situation may arise when the system passes through the “mixed phase”.

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## On the coherent inelastic binary and multiparticle processes in the ultrarelativistic hadron – nucleus, photon – nucleus and nucleus – nucleus collisions

**Author:** Valery Lyuboshitz<sup>1</sup>

**Co-author:** Vladimir Lyuboshitz<sup>2</sup>

<sup>1</sup> *Joint Institute for Nuclear Research (Dubna)*

<sup>2</sup> *Joint Institute for Nuclear Research (Dubna)*

The coherent inelastic processes of the type  $a \rightarrow b$ , which may take place in the interaction of hadrons and  $\gamma$  quanta with nuclei at very high energies (the nucleus remains the same), are theoretically investigated. For taking into account the influence of the nucleus matter, the optical model, based on the concept of refraction index, is used. Analytical formulas for the effective cross section  $\sigma_{\text{coh}}(a \rightarrow b)$  are obtained, taking into account that at ultrarelativistic energies the main contribution into  $\sigma_{\text{coh}}(a \rightarrow b)$  is provided by very small transferred momenta in the vicinity of the minimum longitudinal momentum transferred to the nucleus. It is shown that the cross section  $\sigma_{\text{coh}}(a \rightarrow b)$  may be expressed through the "forward" amplitudes of inelastic scattering  $f_{\{a + N \rightarrow b + N\}}(0)$  and elastic scattering  $f_{\{a + N \rightarrow a + N\}}(0)$ ,  $f_{\{b + N \rightarrow b + N\}}(0)$  on a separate nucleon, and it depends on the ratios  $L_a / R$  and  $L_b / R$ , where  $L_a$ ,  $L_b$  are the respective mean free paths in the nucleus matter for the particles  $a$  and  $b$ , and  $R$  is the nuclear radius. The above formalism may be generalized also for the case of coherent inelastic multiparticle processes on a nucleus of the type  $a \rightarrow \{b_1, b_2, b_3 \dots b_i\}$  and for the case of coherent processes at collisions of two ultrarelativistic nuclei.