CMS Overview

Robert Schöfbeck (HEPHY Vienna)
on behalf of the
CMS collaboration

ICNFP 2014 Greece

CMS Collaboration

2680 physicists (891 students)
859 engineers, 281 technicians
182 institutes, 42 countries

CMS: the detector

Total weight
14000 t
Diameter 15 m
Length 28.7 m

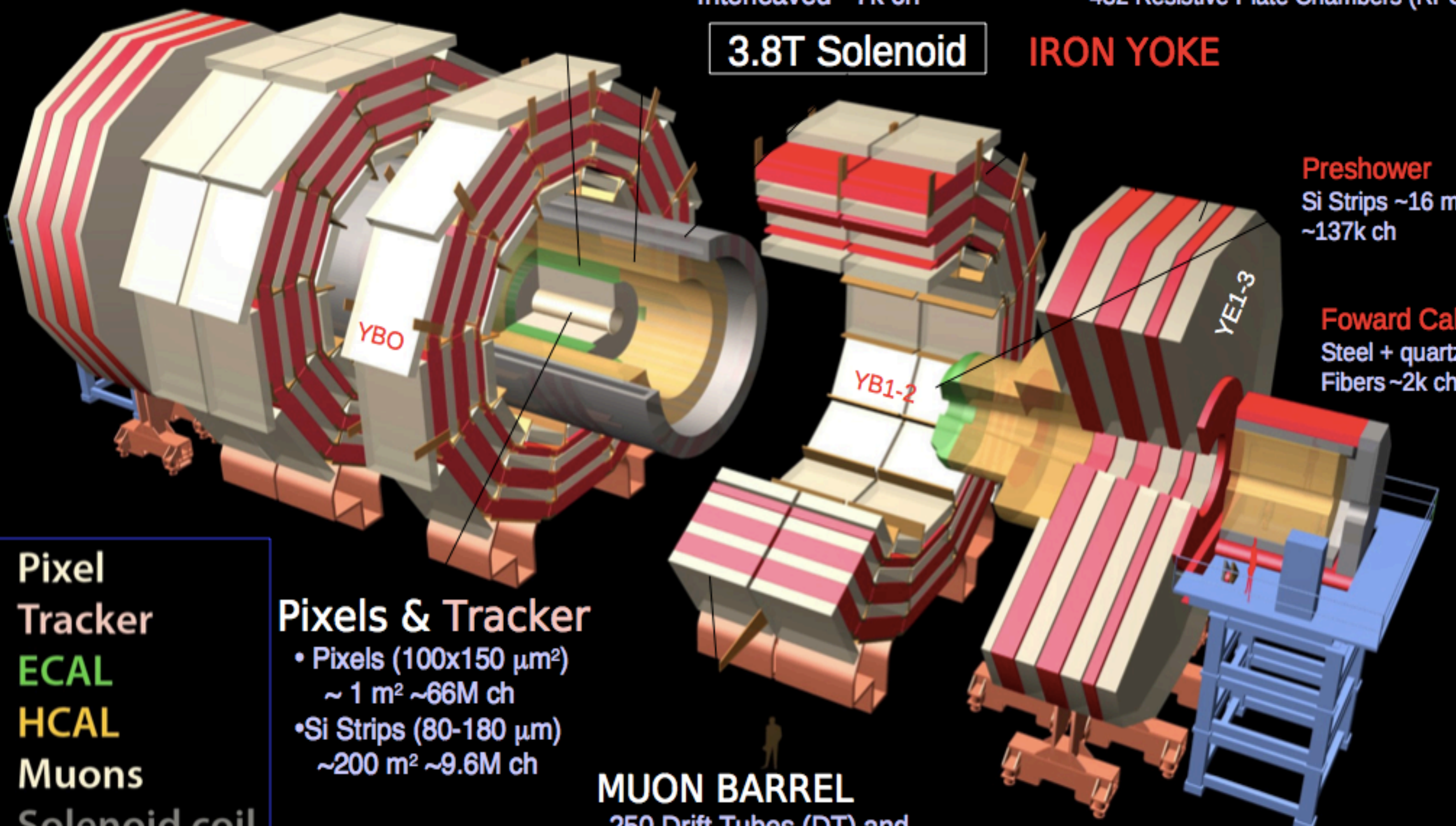
ECAL 76k scintillating $PbWO_4$ crystals

HCAL Scintillator/brass Interleaved ~7k ch

MUON ENDCAPS
473 Cathode Strip Chambers (CSC)
432 Resistive Plate Chambers (RPC

3.8T Solenoid

IRON YOKE



Preshower
Si Strips ~16 m
~137k ch

Foward Cal
Steel + quartz
Fibers ~2k ch

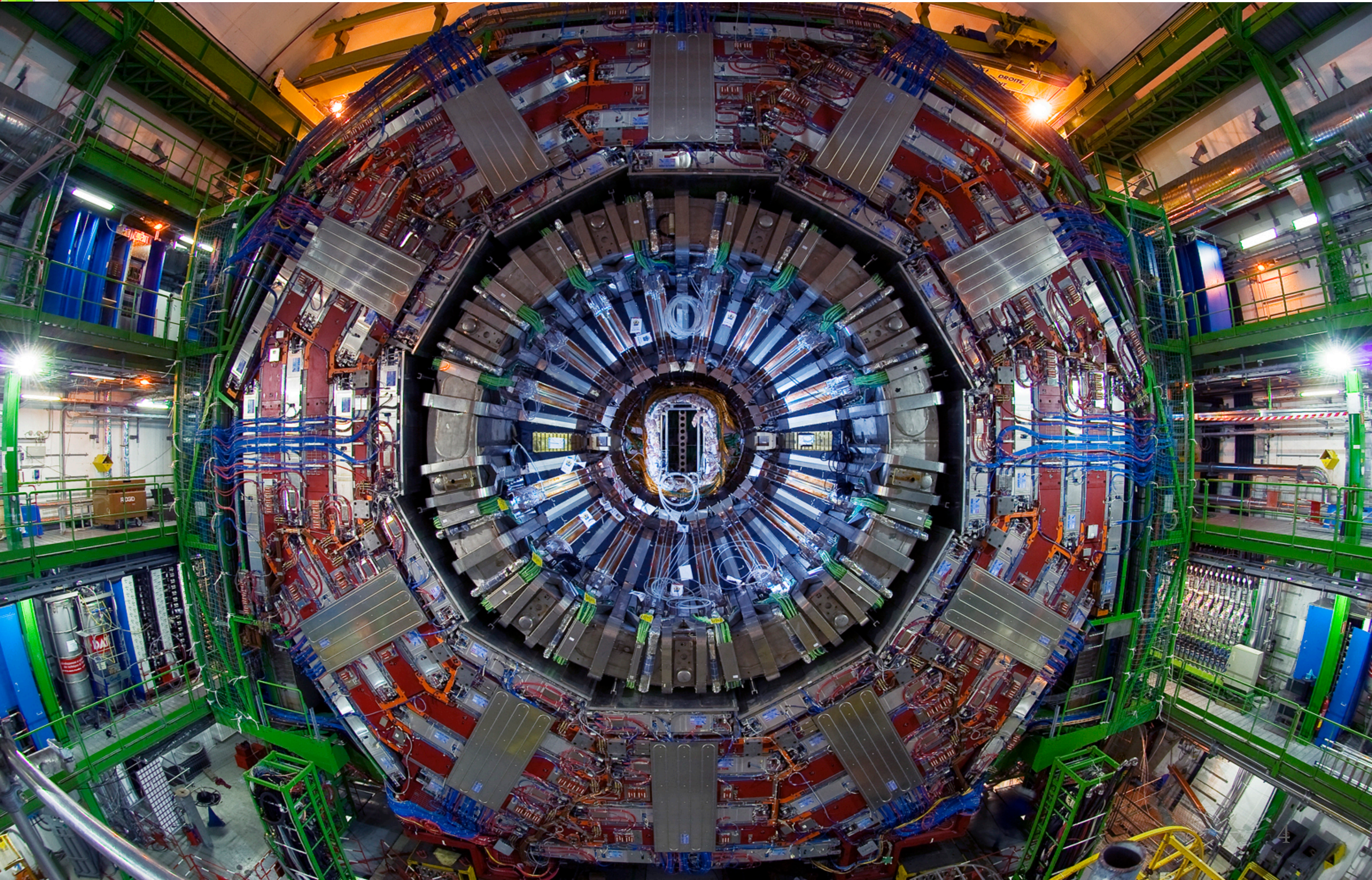
Pixel
Tracker
ECAL
HCAL
Muons
Solenoid coil

Pixels & Tracker

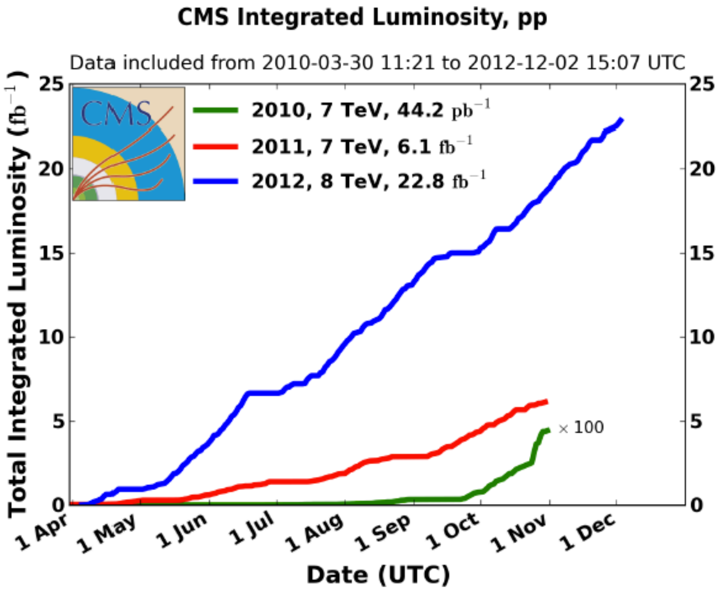
- Pixels (100x150 μm^2) ~ 1 m^2 ~66M ch
- Si Strips (80-180 μm) ~200 m^2 ~9.6M ch

MUON BARREL
250 Drift Tubes (DT) and
480 Resistive Plate Chambers (RPC)

CMS in reality



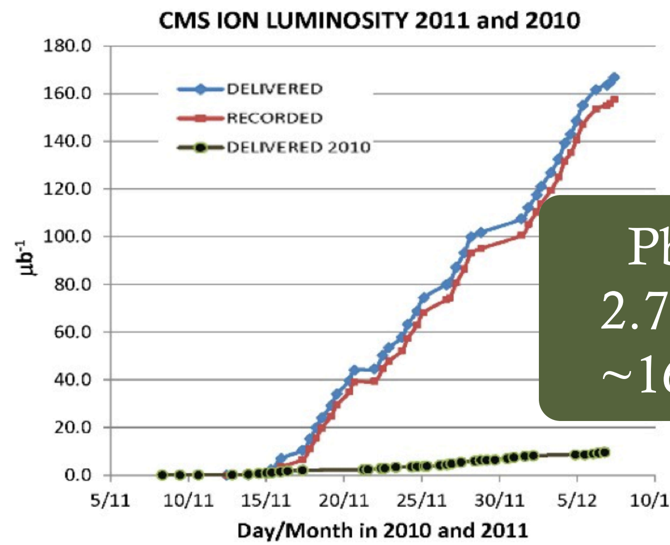
2010-12 LHC operation



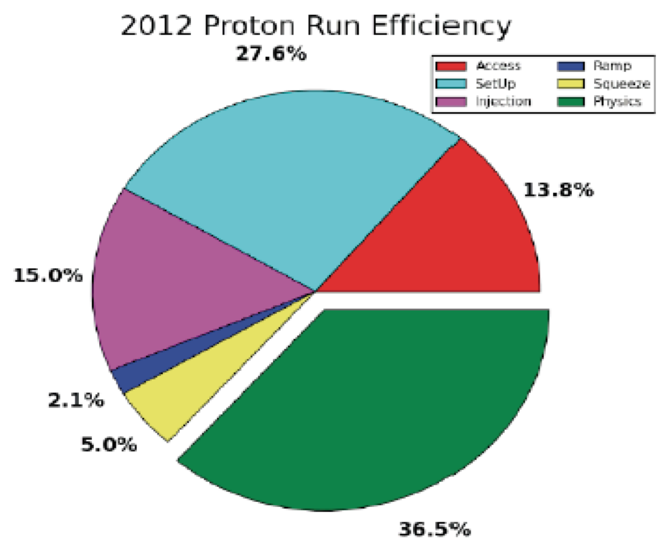
~5 fb^{-1}
7 TeV

~ 20 fb^{-1}
8 TeV

p-Pb 5TeV
~34 nb^{-1}



Pb-Pb,
2.76 TeV
~160µb^{-1}

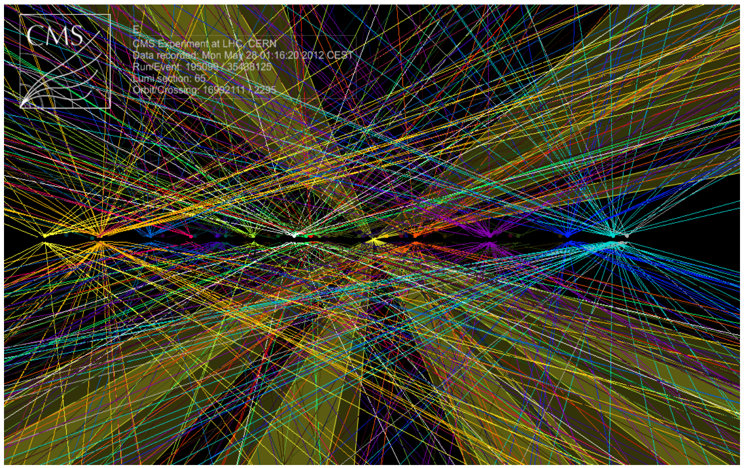


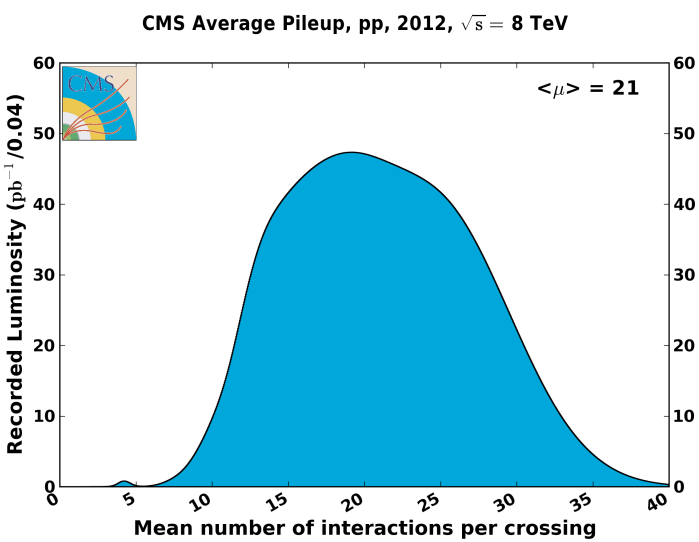
fraction of LHC operations used for physics

2010	16.5%
2011	23.7%
2012	36.5%

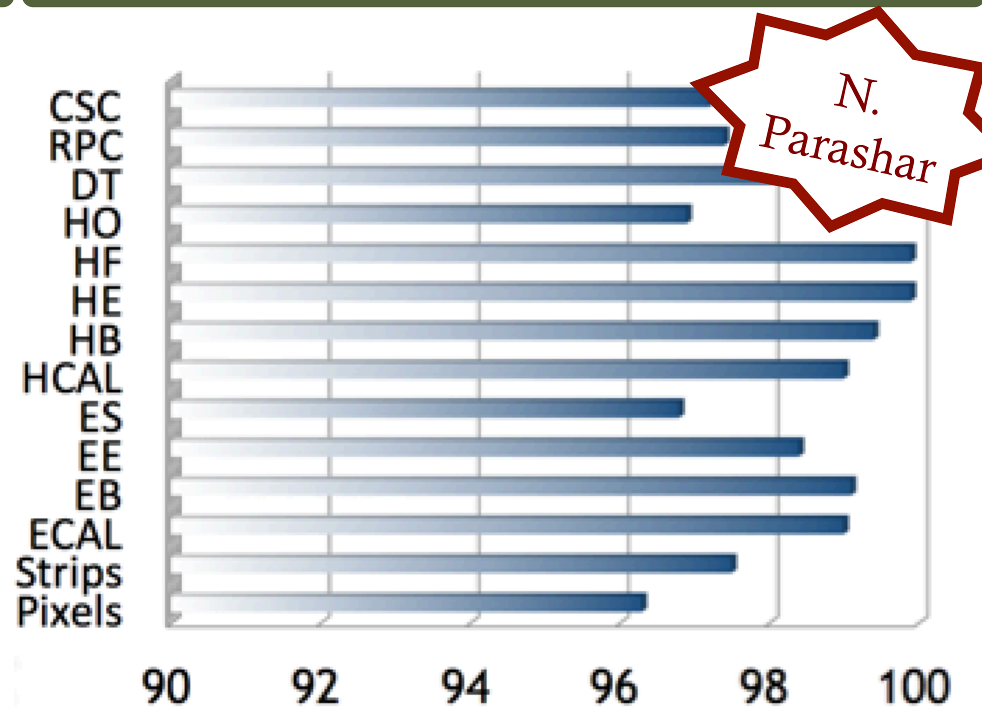
CMS operation

avg. of ~ 20 collisions per BX



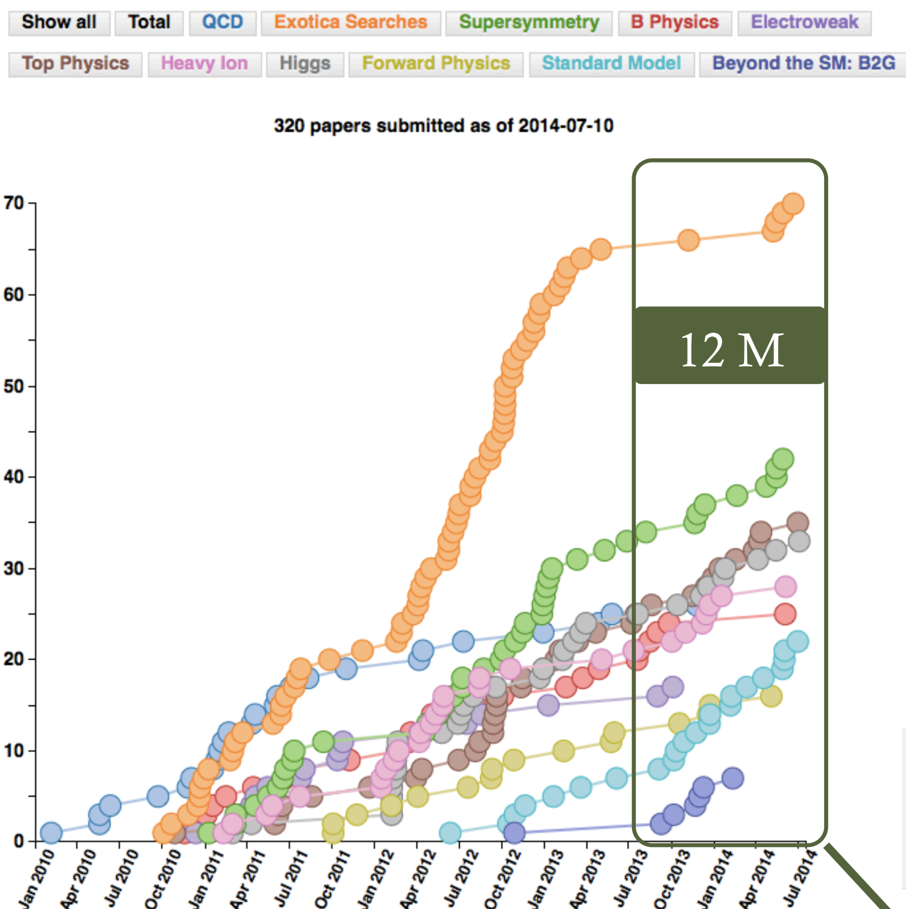


operational efficiency (Dec. 2012)



Excellent overall detector performance after 3 years: ≥96% of channels functional for each subdetector

publication statistics



start of data taking spring 2010

CMS publications
323 submitted/published

1 paper / 4.4 days

Number of internal collaboration meetings:

CMS meetings	62,488 events
ATLAS Meetings	123,198 events

last years science output: Let me discuss these papers *one by one*!

other CMS talks

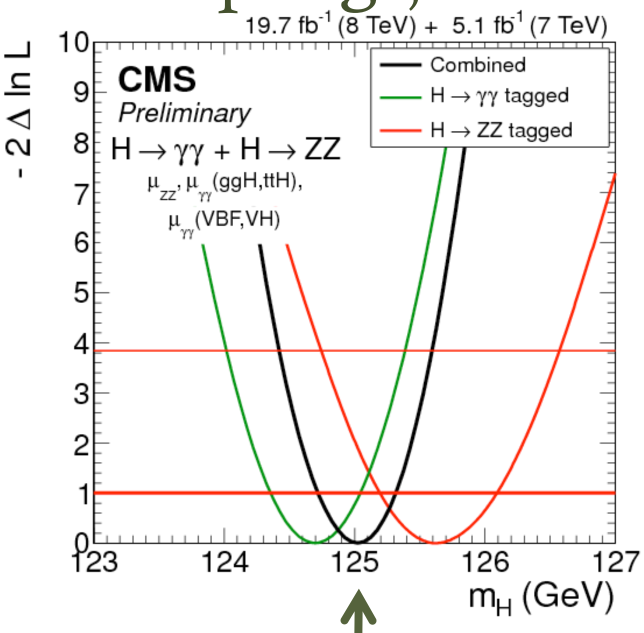
A. Mohammadi	Thu.	Higgs @ CMS
G. Bruno	Thu.	HI Physics (all CERN achievements)
K. Theofilatos	Fri.	Search for an ‘edge’ (SUSY)
M. Takahashi	Fri.	Single and di-boson production
A. Savin	Fri.	Higgs and SM measurements at HL-LHC
V. Gori	Sat.	Higgs in bosonic channels
R. Mankel	Sat.	Search for Higgs in BSM
A. Hinzemann	Sat.	Exotica
A. Garcia-Bellido	Sat.	SUSY
R. Venditti	Sat.	Identification of hadronic tau decays
N. Parashar	Tue.	CMS Detector Performance
G. D’Imperio	Wed.	Jet and vector-bosons, α_S and PDFs
C. Beluffi	Wed.	Higgs in fermionic channels
S. Tosi	Wed.	Top Physics
K. Hoepfner	Wed.	Upgrades and future plans
C. Wulz	Wed.	B-Physics and Quarkonia

disclaimer: Will present a biased overview of the (to me) most interesting results
find all results under: http://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults

Higgs

A. Mohammadi,
A. Savin, V. Gori,
R. Mankel,
C.Beluffi

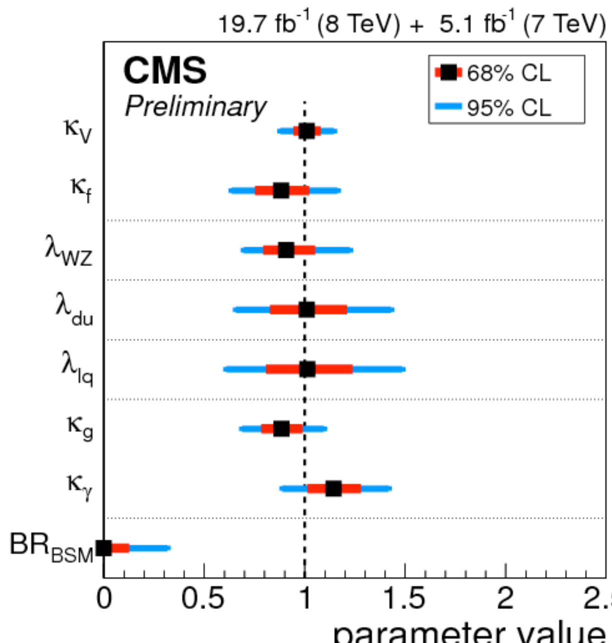
- two years anniversary of the Higgsdependence day on July 4th, 2012!
- shift in scope from discovery mode to (precision) measurements: mass, BR/couplings, x-sec.

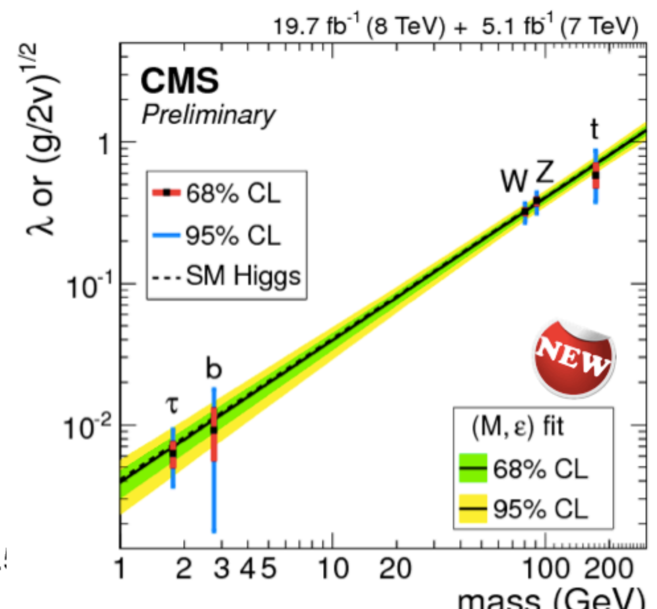


$125.03\ ^{+0.26}_{-0.27}\ \text{(stat.)}\ ^{+0.13}_{-0.15}\ \text{(syst.) GeV}$

CMS PAS-HIG-14-009

coupling modifier fit

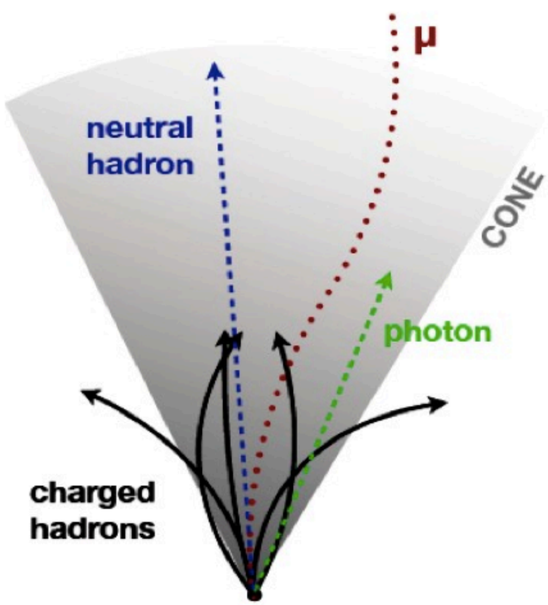


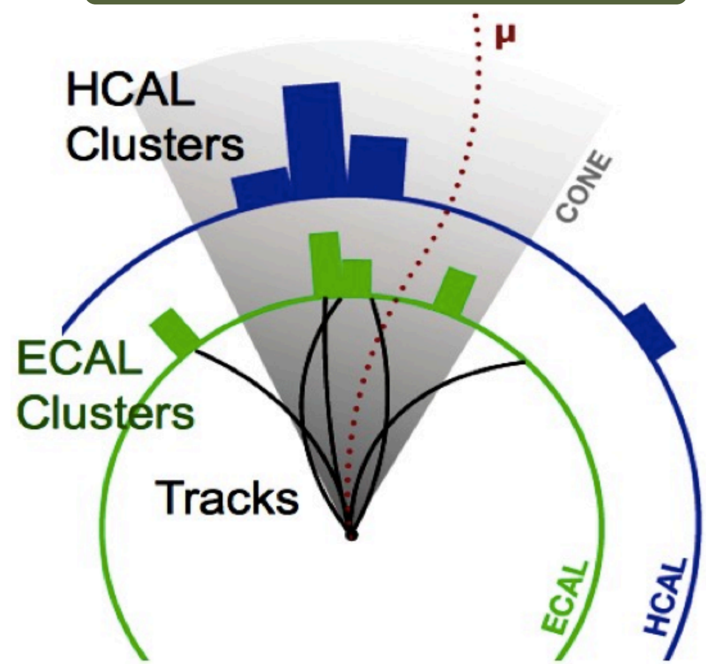


PF reconstruction

R. Venditti

particles	Reconstruction





D. d'Enterria @ LISHEP13

Particle-Flow algo links tracks to calorimetry clusters and identifies e, μ , γ , charged & neutral hadrons

Those become *inputs* to jets, b-jets, taus, E_t^{miss} and isolation quantities.

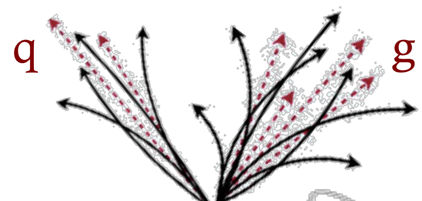
PF is a workhorse!

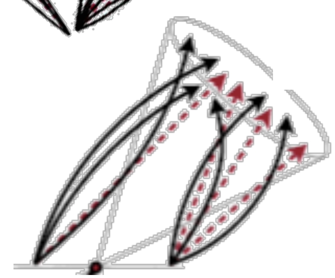
CMS PAS PFT-009-01

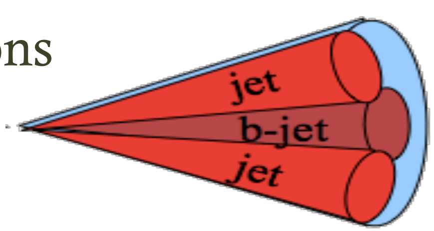
jet performance

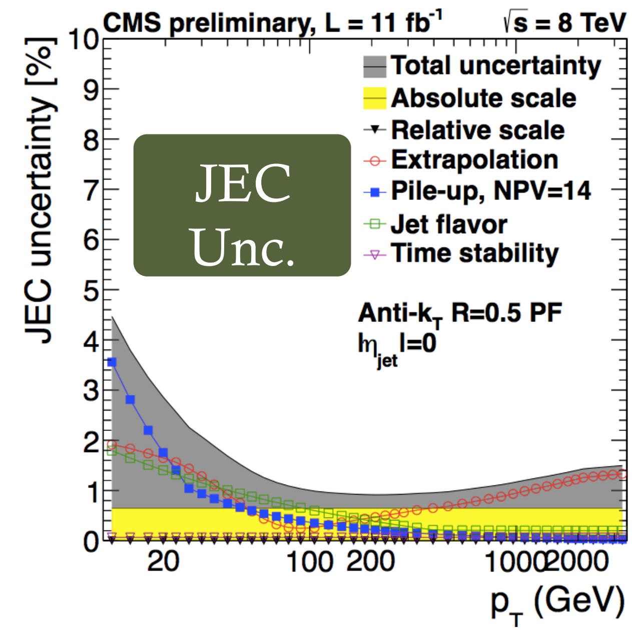
JME-13-002, JME-13-005
JME-13-006, JME-13-007

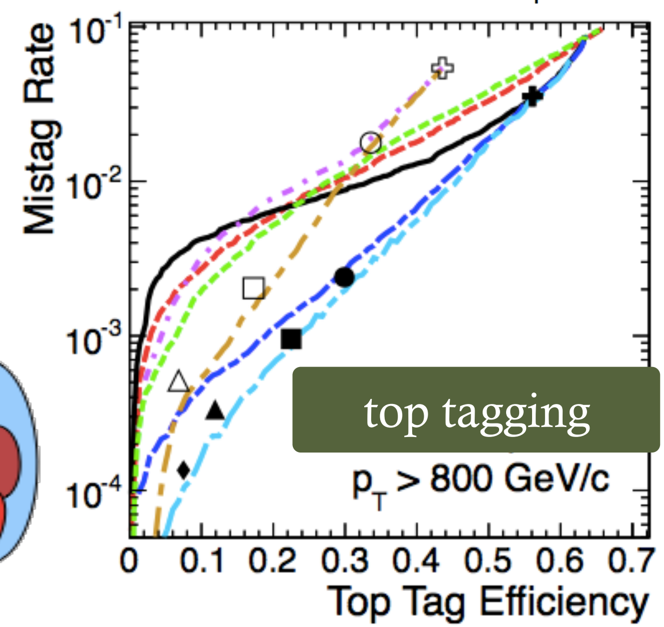
- jets are clusters of reconstructed PF particles
- energy scale uncertainty at ~ 1-2%, resolution generally below 10%
- for 13 TeV: developed multi-variate techniques to
  - discriminate quarks and gluons
  - identify jets that do *not* originate from the primary collision vertex
  - identify boosted W bosons or boosted top quarks using sub-jet techniques







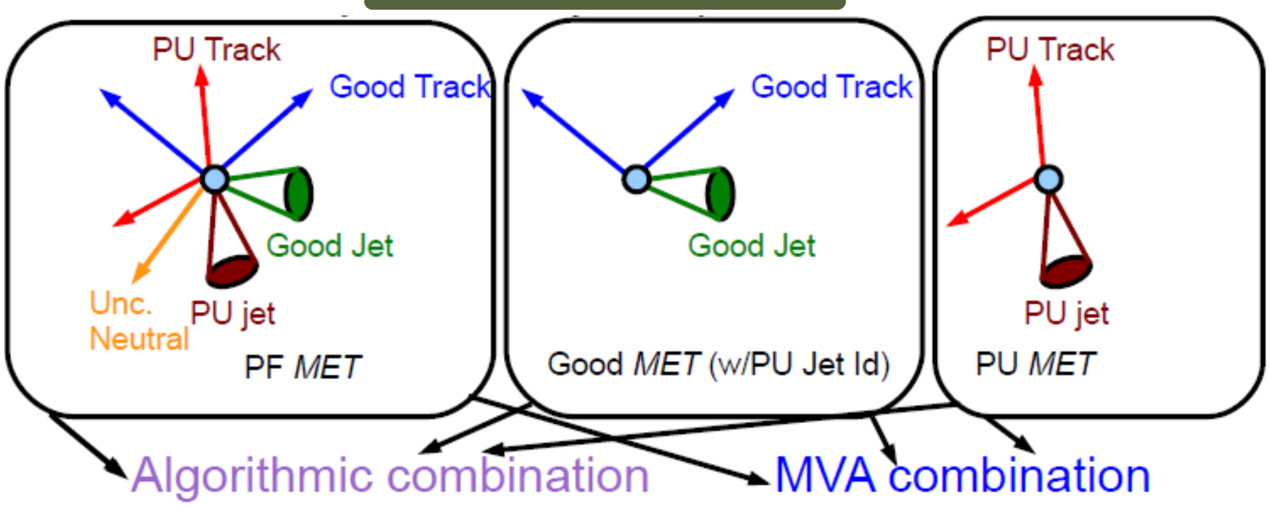




E_T^{miss} performance

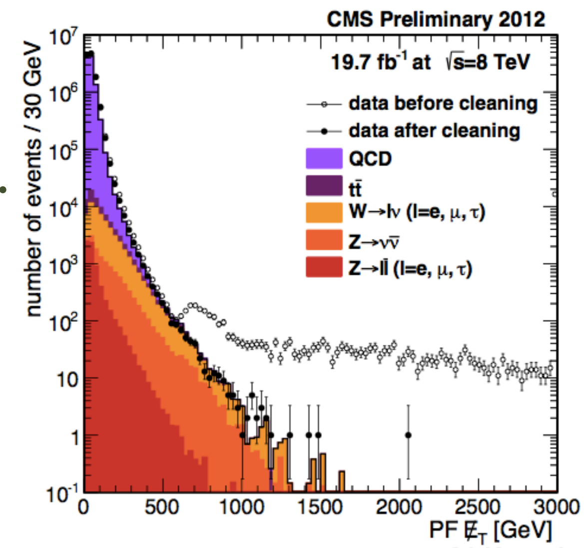
- very good control of E_T^{miss} observables
- 13 TeV run: expect on avg. ~50 events per bx. dedicated MVA tools to mitigate 'PU' effects.

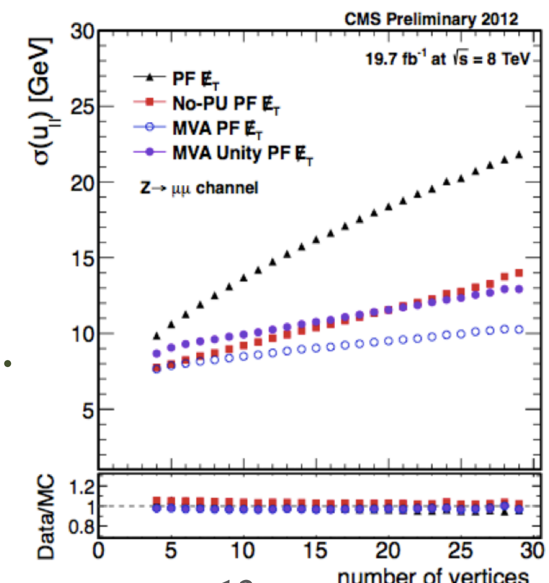
CMS PAS-JME-13-003



σ_{PU}= ~3.5, 2.0, and 1.5 GeV per nvtx in quad.

- important if we have significant amount of data at 50ns at the beginning of Run-II



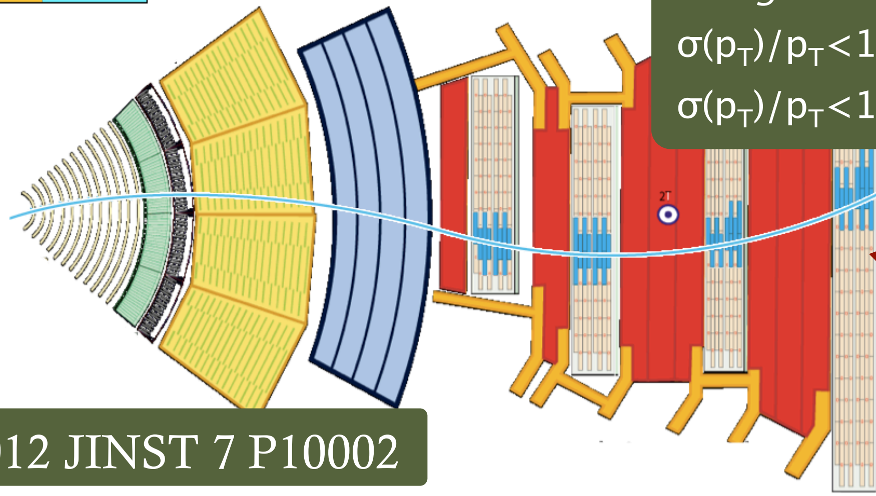


muons/electrons

Design:

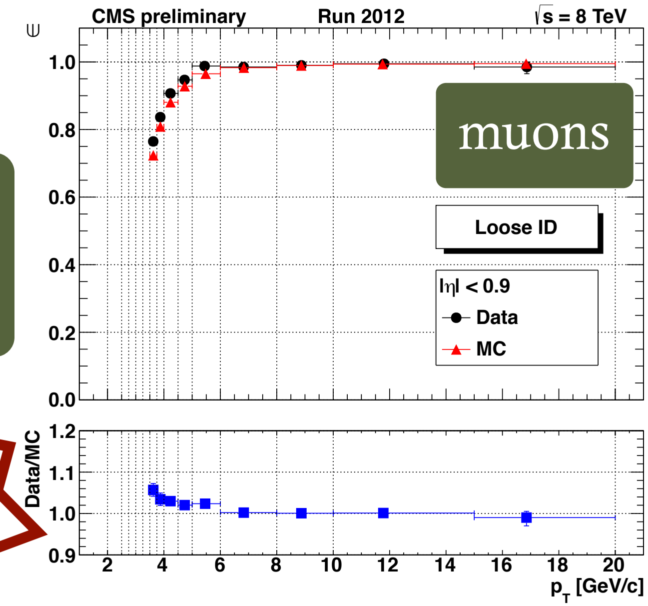
$\sigma(p_T)/p_T < 1\%$ for 100 GeV

$\sigma(p_T)/p_T < 10\%$ for 1 TeV



N. Parashar

2012 JINST 7 P10002

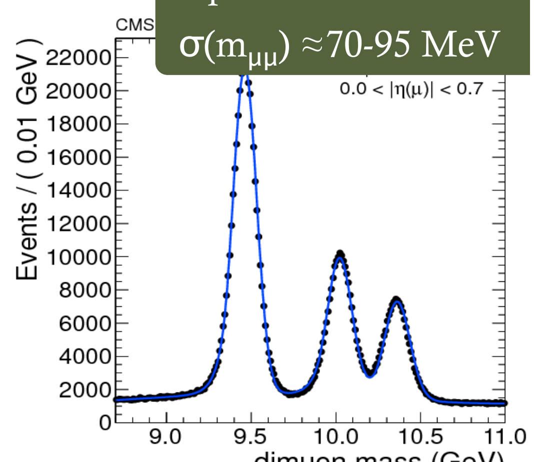


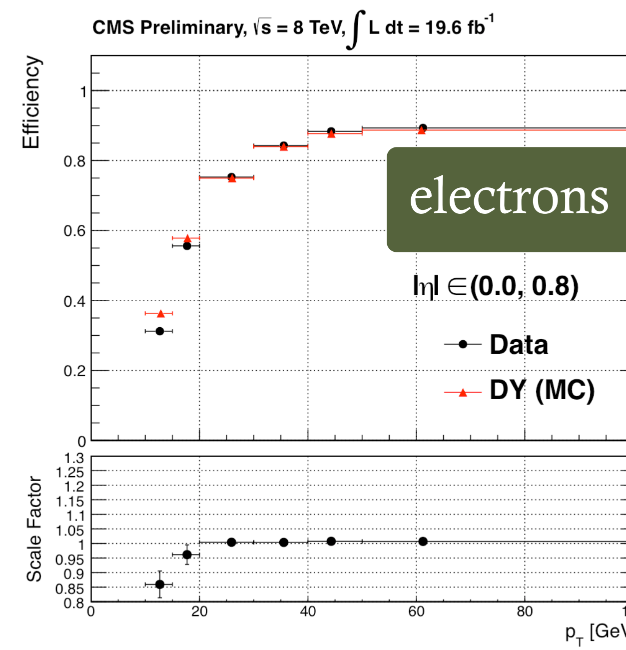
muons

- ✧ 3 years of data-taking: Understand muons down to 3 GeV, $\sigma(p_{T\mu})$~1-4%, ~7% @ 350 < p_T < 2 TeV
- ✧ excellent e ID p_T>10 $\sigma(p_{Te})$~2-4%
- ✧ exceeding spec, reproduced in Sim. at % level.

Upsilon:

$\sigma(m_{\mu\mu}) \approx$70-95 MeV





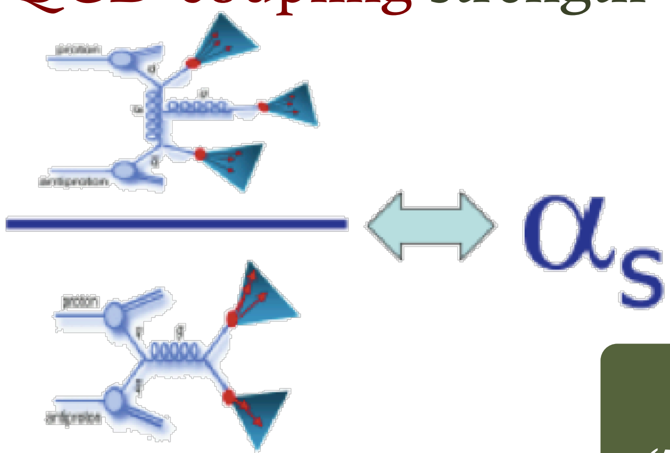
electrons

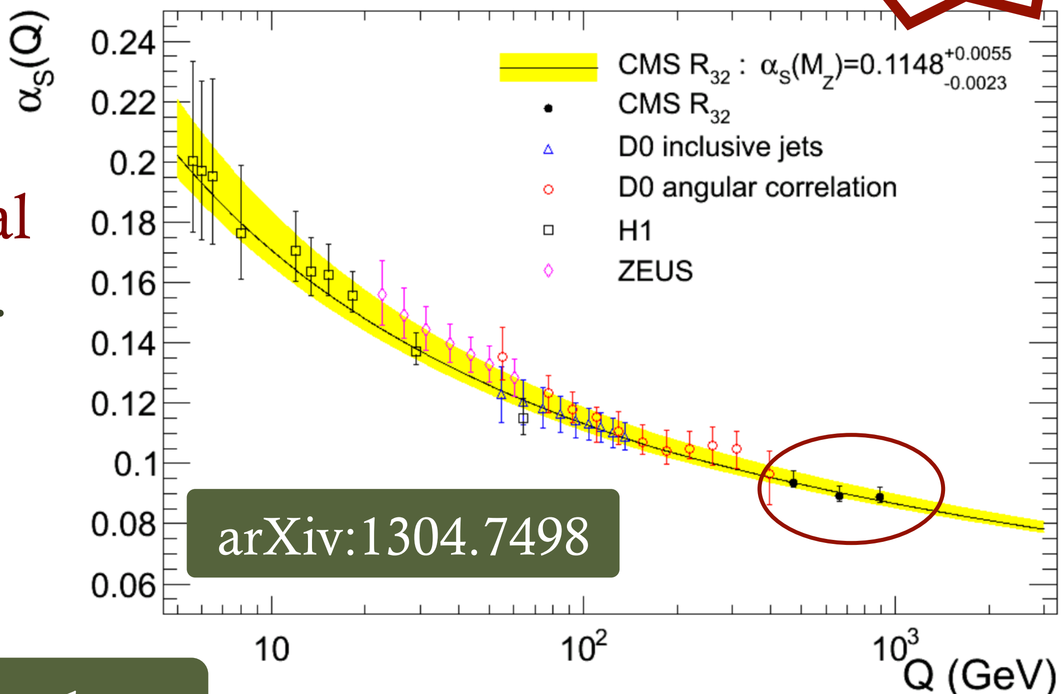
recent results:
Standard model

3/2-jet cross section ratio

G. D'Imperio

✧ The ratio of the diff. x-sec in 3- and 2-jet events is sensitive to the fundamental QCD coupling strength α_S.





result:
(7TeV 5fb^{-1})

$$\alpha_S(M_Z) = 0.1148 \pm 0.0014\,(\text{exp.}) \pm 0.0018\,(\text{PDF}) \pm 0.0050\,(\text{theory}).$$

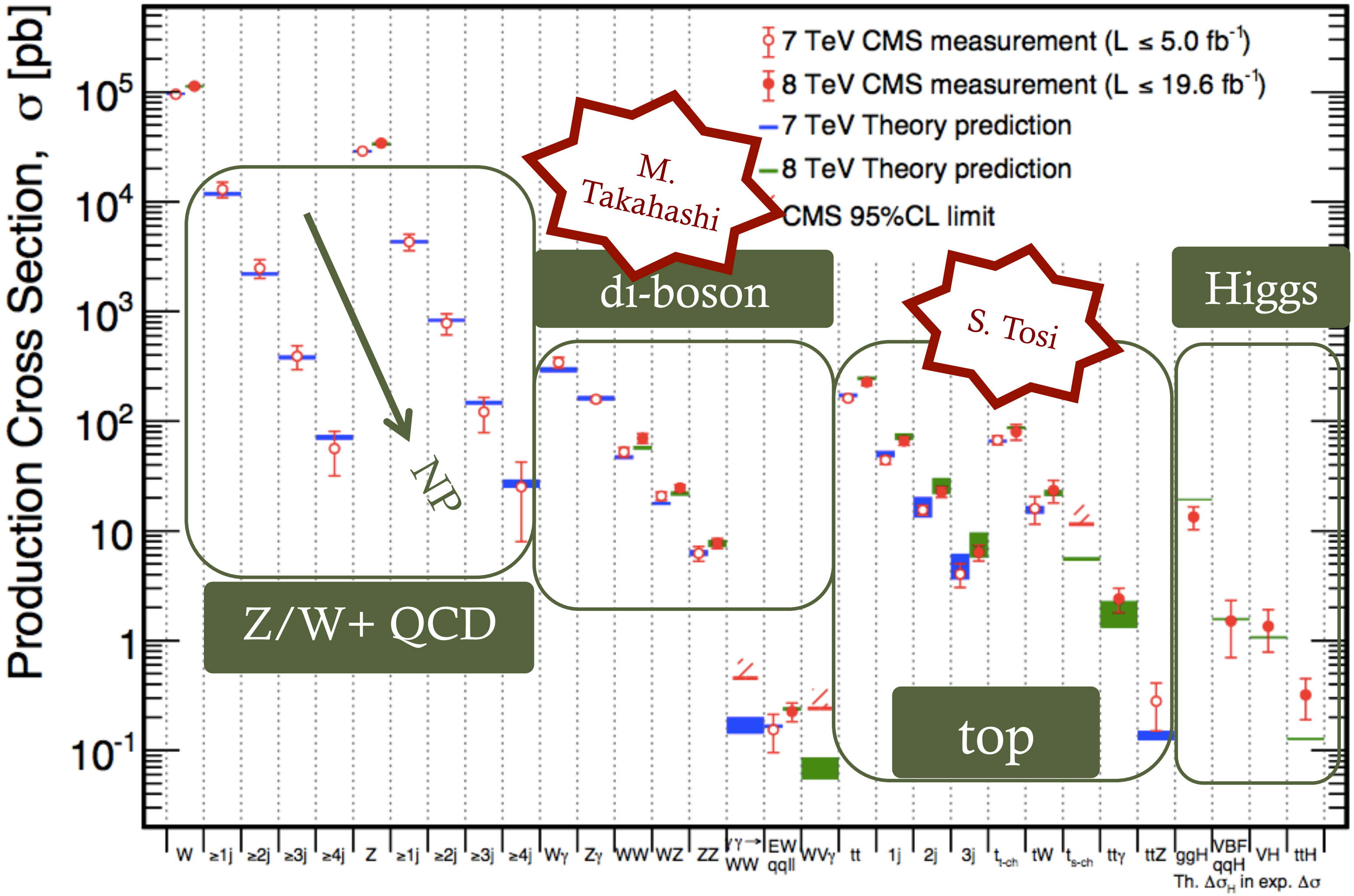
$$R_{32} = \frac{d\sigma_{3+}/dp_T}{d\sigma_{2+}/dp_T} \propto \alpha_s(Q)$$

$$Q = \langle p_{T1,2} \rangle = \frac{p_{T1} + p_{T2}}{2}$$

world average: $\alpha_s(M_Z^2) = 0.1184 \pm 0.0007$

electro-weak physics

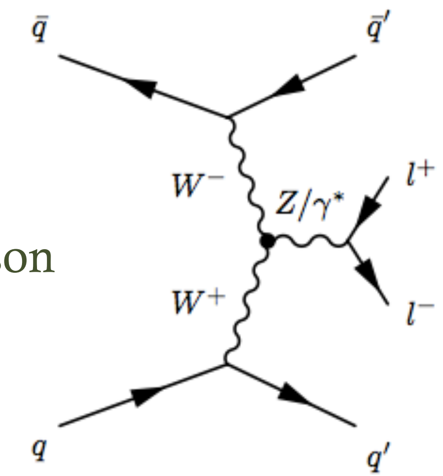
- ✧ SM gauge group + EWSB → production channels involving EWK and strong interactions → test ground for SM @ LHC



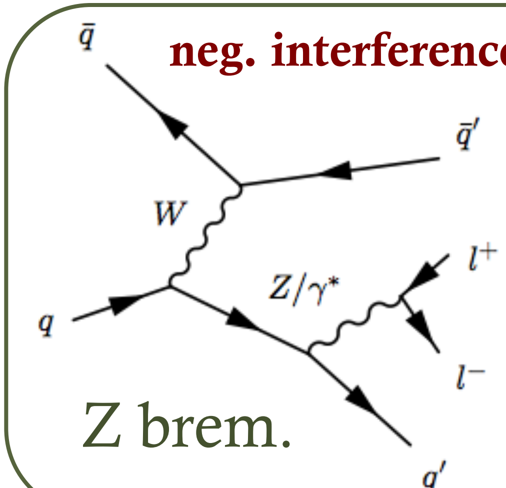
Z bosons produced by fusion of W bosons

CMS PAS FSQ-12-035

'VBF'
vector-boson
fusion

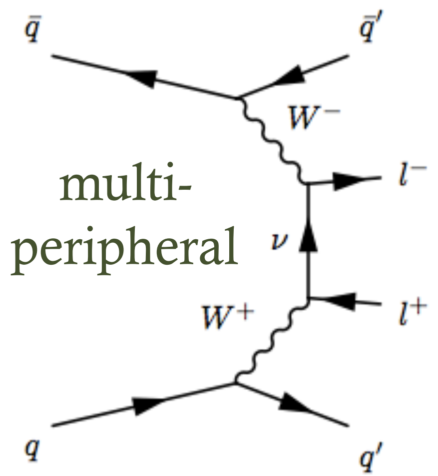


neg. interference



Z brem.

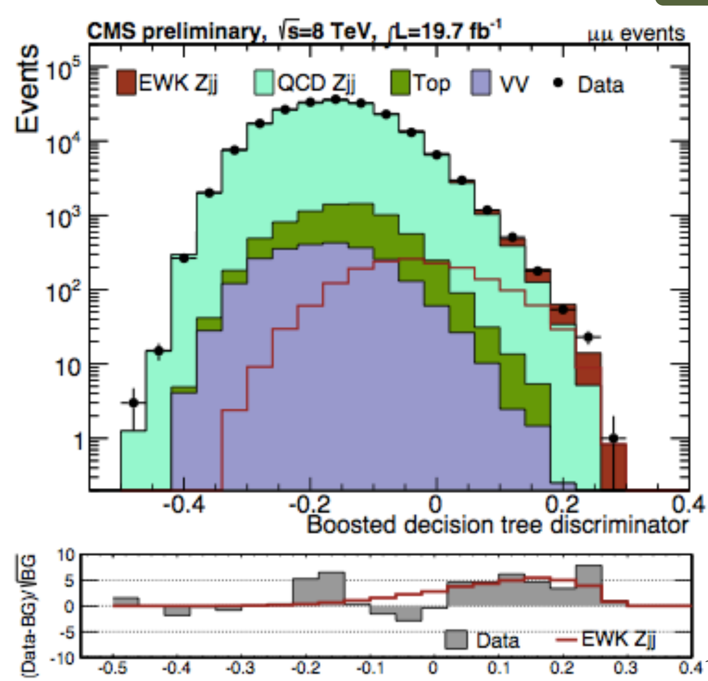
multi-
peripheral



- ✧ subject to large neg. interference
- ✧ require two jets with large rapidity gap
- ✧ MVA and cut-based analysis

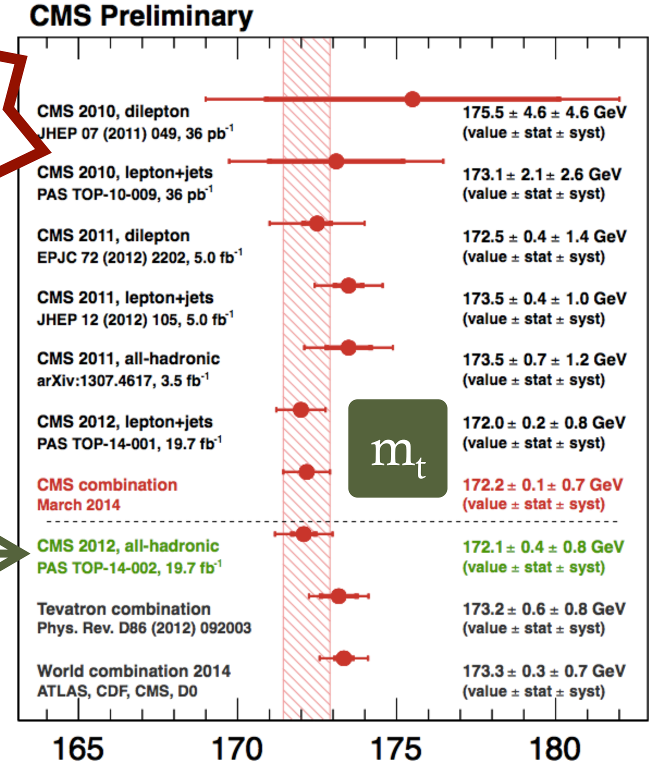
σ (EWK lljj) = 226 ± 26_{stat} ± 35_{sys} fb
σ (SM,NLO) = 239 fb

- ✧ 5.0 σ significance (expected: 5.9 σ)



top quark

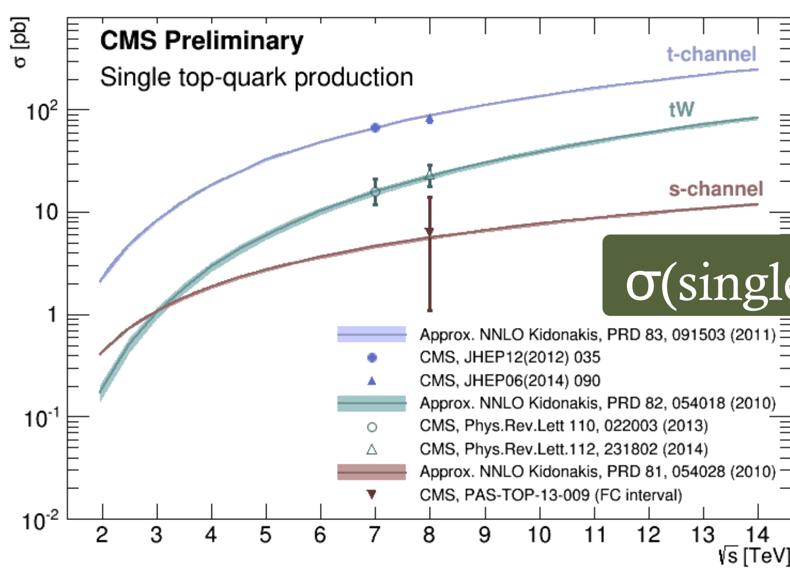
S.Tosi

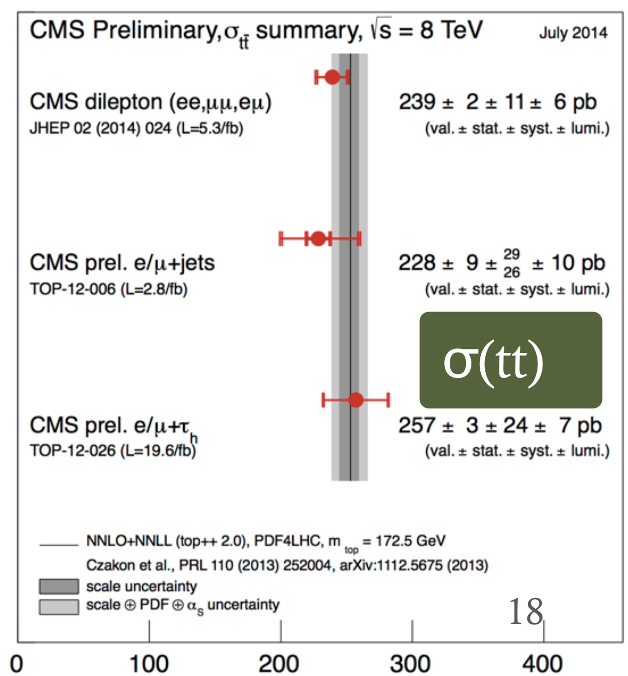


- CMS has measured m_t with unprecedented precision.

CMS PAS TOP-14-002 *hadronic* (new)
m_t = 172.08±0.36(stat.+JSF)±0.83(syst.) GeV

- sys.: non-p. QCD , c.-reconnection, UE tune
- Measurements of σ(tt) and σ(single-t)





top physics

arxiv:1406:7830

S.Tosi

- ✧ tt+W x-sec. meas. with same-sign di-leptons

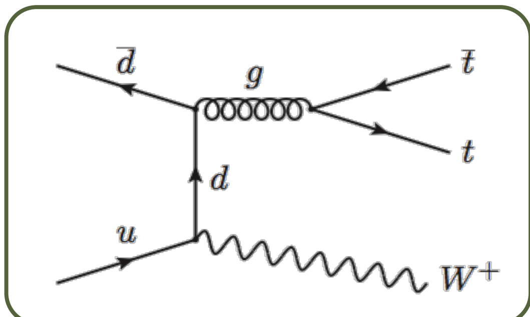
$\sigma(ttW) = 170\ {+90 -80}\ (\text{stat.}) \pm 70\ (\text{sys.})\ \text{fb}$

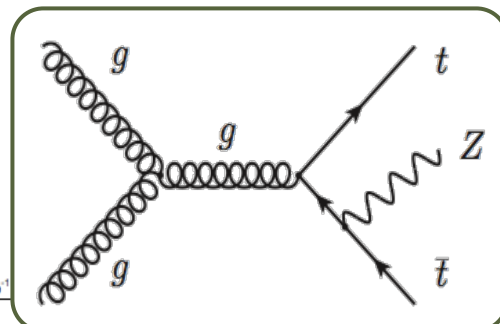
- ✧ tt+Z x-sec. meas. with 3 and 4 leptons

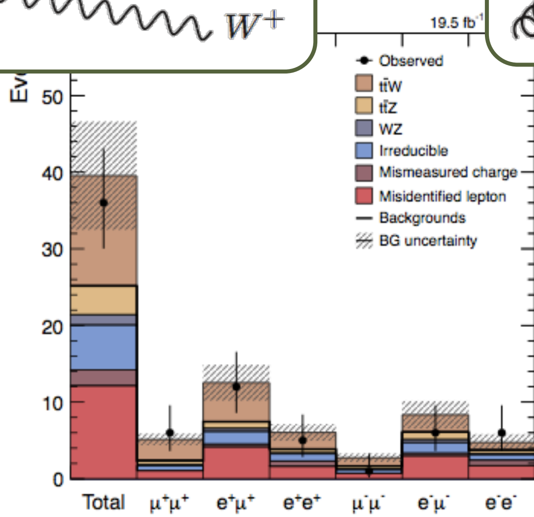
$\sigma(ttZ) = 200\ {+80 -70}\ (\text{stat.}) \pm 40\ (\text{sys.})\ \text{fb}$

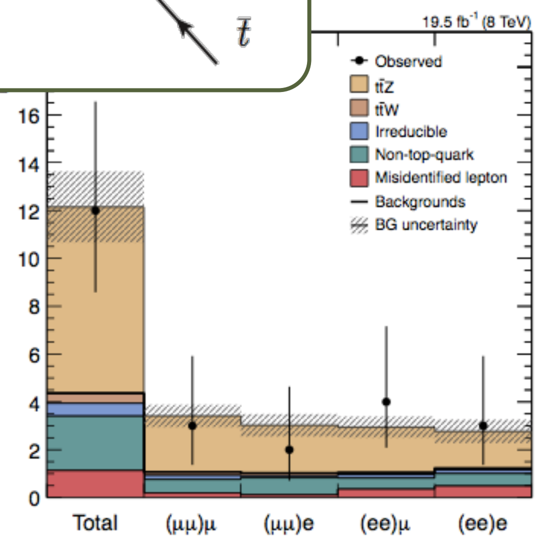
- ✧ ttW~1.6σ, ttZ~3.2σ
- ✧ combination (~3.7σ)

$$\sigma_{t\bar{t}V} = 380^{+100}_{-90}\,(\text{stat})\,^{+80}_{-70}\,(\text{syst})\ \text{fb}$$





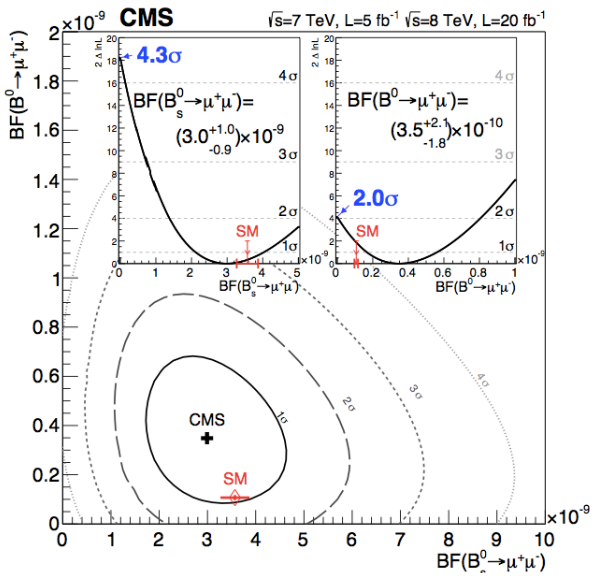


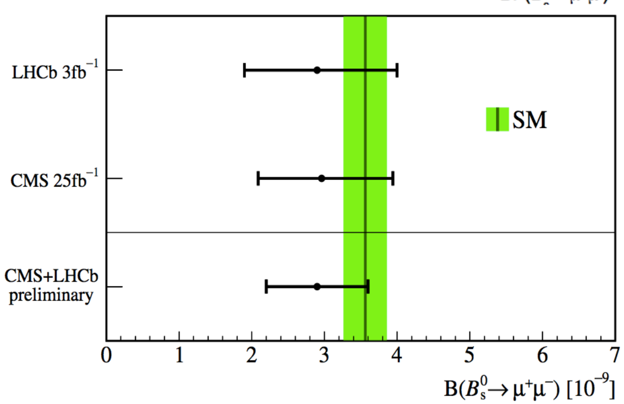


B physics

C. Wulz

- $B^0_{(s)} \to \mu^+\mu^-$ $BR_{SM} = (3.57\pm0.3)*10^{-9}$ loop induced, helicity suppressed decay
- very sensitive to flavour physics BSM



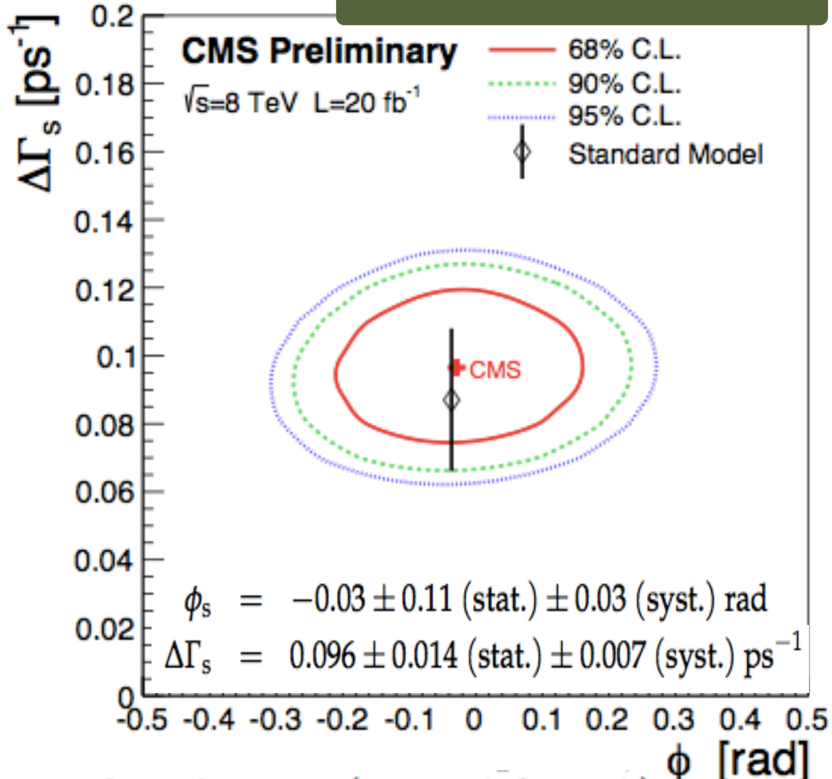


arxiv:1307:5025

CMS PAS-BPH-13-007

- measurement of CP weak phase Φ_s and decay width difference $\Delta\Gamma_s$ in $B_s \to J/\psi(\mu\mu)\Phi(KK)$

CMS PAS-BPH-13-012



$$\phi_s = -0.03 \pm 0.11\,(\text{stat.}) \pm 0.03\,(\text{syst.})\text{ rad}$$

$$\Delta\Gamma_s = 0.096 \pm 0.014\,(\text{stat.}) \pm 0.007\,(\text{syst.})\text{ ps}^{-1}$$

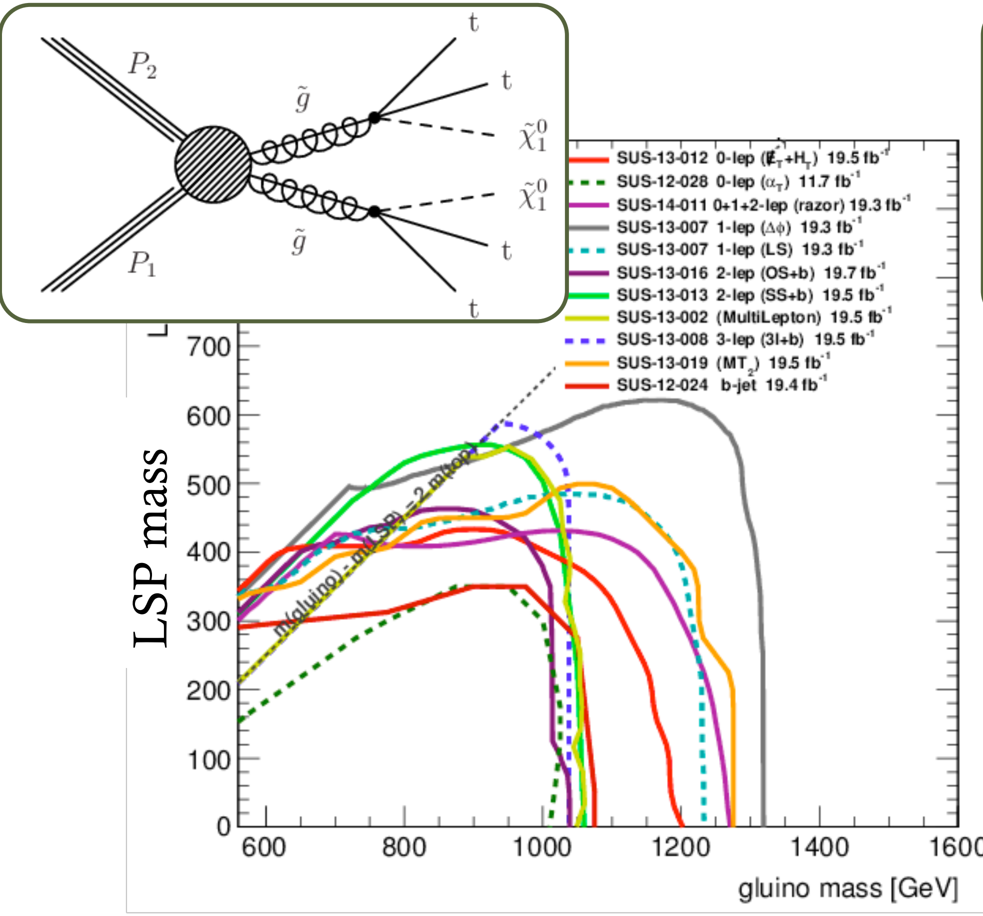
$$\phi_s \simeq -2\beta_s, \quad \beta_s = \arg(-V_{ts}V^*_{tb}/V_{cs}V^*_{cb})$$

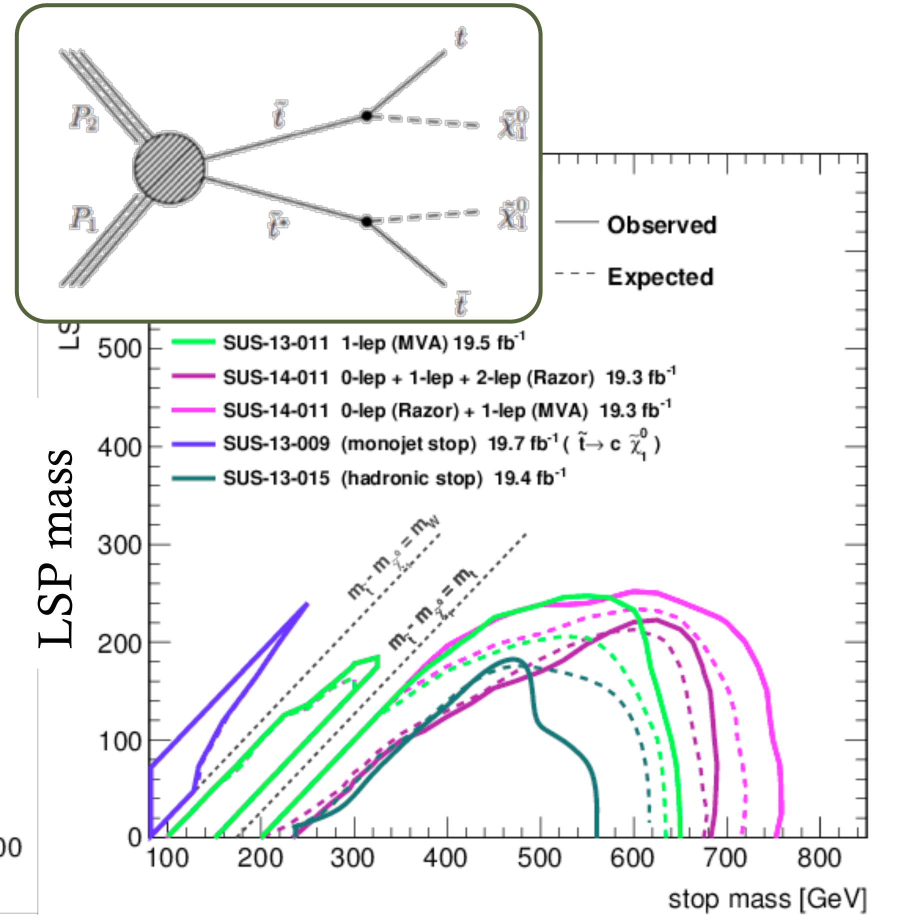
SM: $2\beta_s = 0.0363^{+0.0016}_{-0.0015}$

recent results: beyond the SM

BSM: SUSY overview

K.Theofilatos
A.Garcia-Bellido



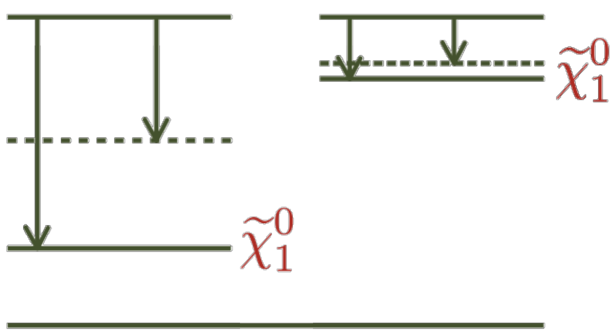


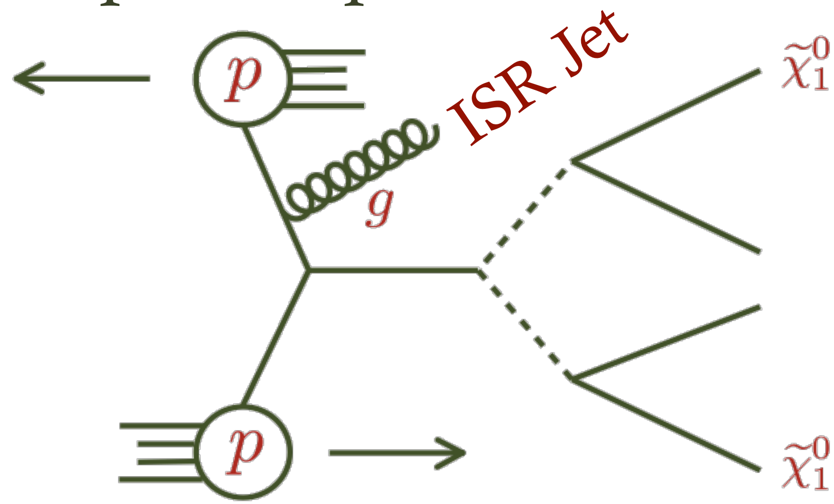
- limits on strong production of 3rd generation SUSY in (or close to) the TeV range
- recent focus on compressed spectra

jets + E_T^{miss} = SUSY

K.Theofilatos
A.Garcia-Bellido

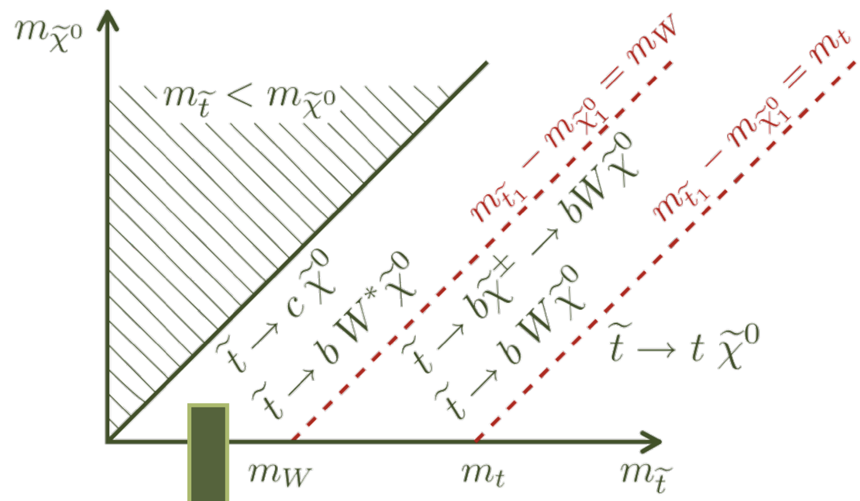
- ✧ special regions in phase space require careful analysis

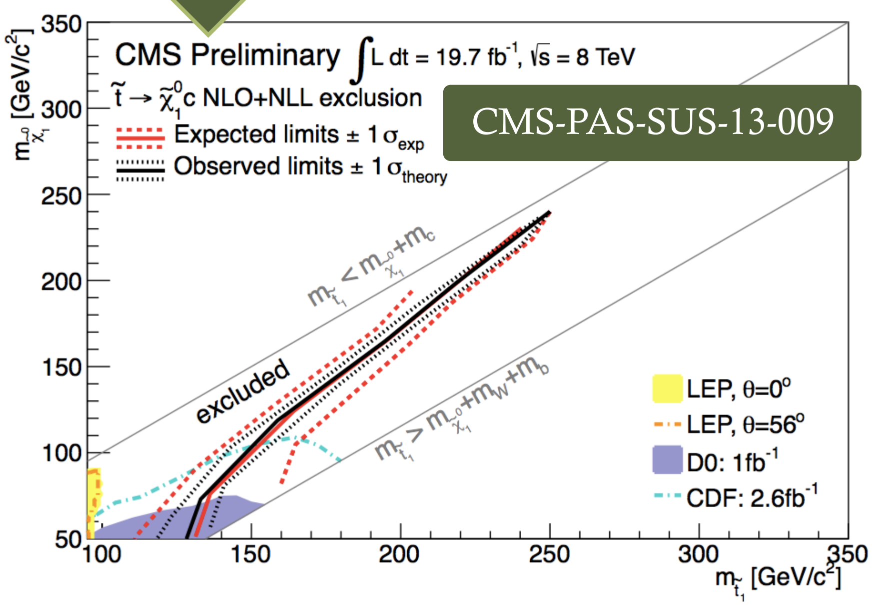


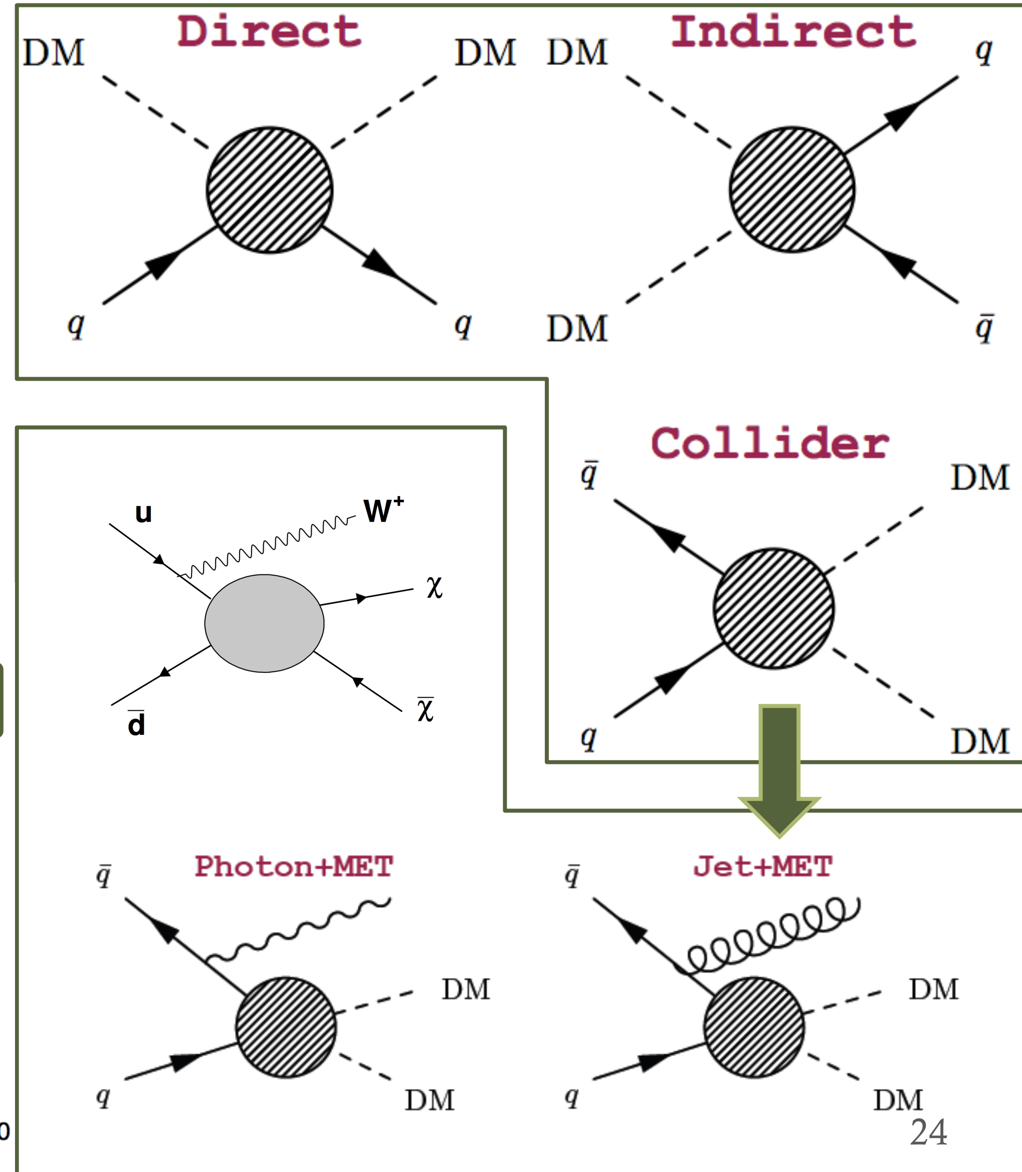


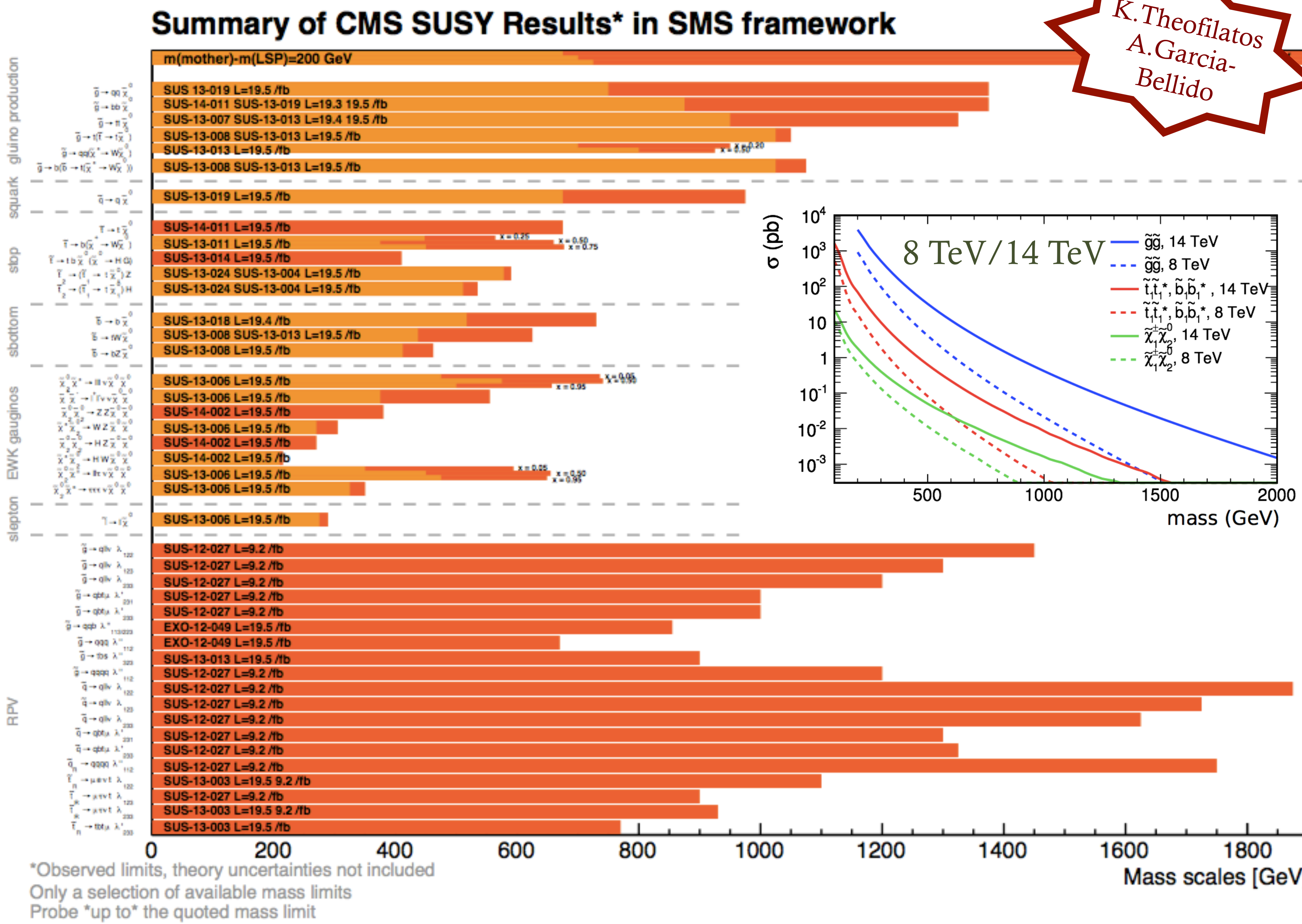
- ✧ compressed spectra reduce visible energy → loss of acceptance
- ✧ requires dedicated low-threshold triggers and dedicated object reconstruction
- ✧ high p_T initial-state-radiation (ISR) parton forms a jet, boosts heavy system → increase of acceptance

SUSY = 1 jet + E_T^{miss}









K.Theofilatos
A.Garcia-Bellido

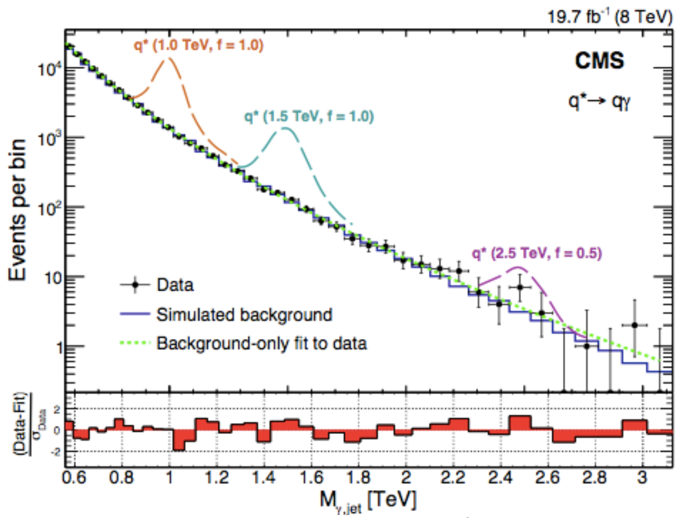
more exotic searches

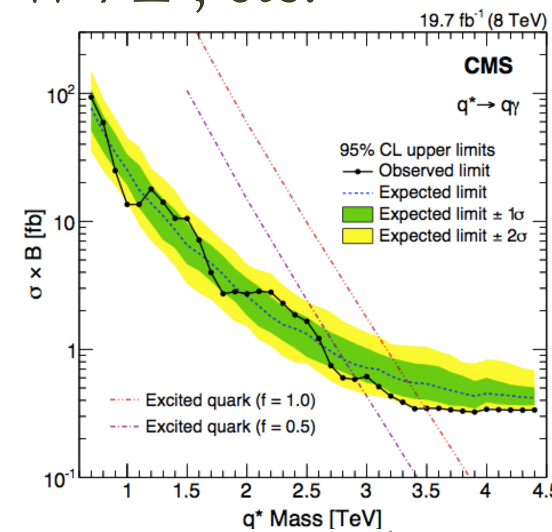
A. Hinzemann

- ✧ rich program covering each corner (we could think of): excitations of SM particles, resonances, leptoquarks, W'/Z', etc.

arxiv:1406:5171

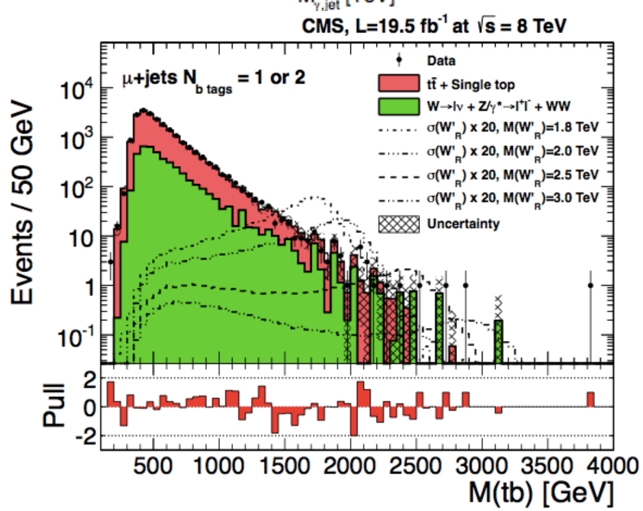
excited quarks decaying via high p_T photon (γ+jet channel)

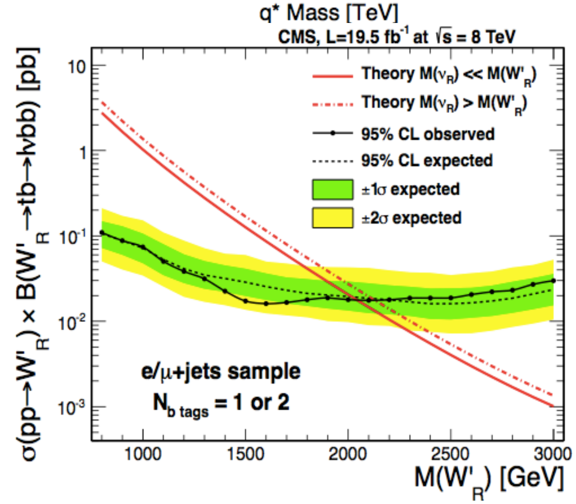




arxiv:1406:5171

W' →tb resonance search in the 1l-channel





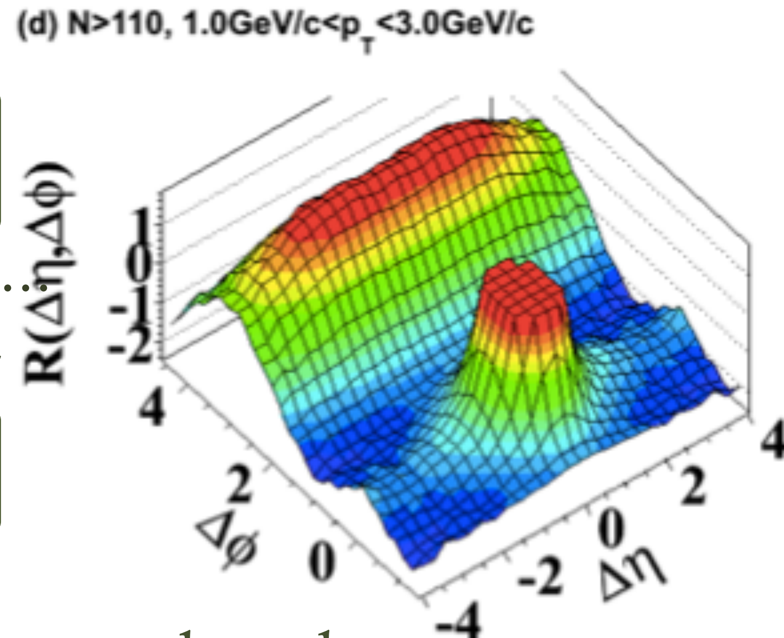
heavy ion physics

heavy ion physics

G. Bruno

HIN-14-002/006
HIN-14-008/012/013

- collective phenomena in PbPb, pPb collisions (elliptic and triangular flow), ridge in pp in 2010



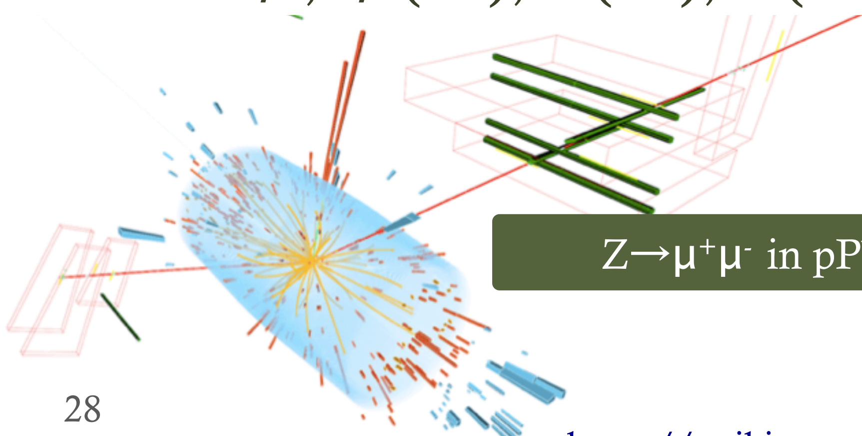
HIN-12-003
HIN-14-010

- energy loss in the medium: jets, b-jets, Jet fragmentation & shape,…

- melting of Quarkonia (suppression of higher mass states)

HIN-13-003
HIN-12-007

  - J/ψ, $\psi(2S)$, Υ(1S), Υ(2S), Υ(3S)



$Z \rightarrow \mu^+\mu^-$ in pPb

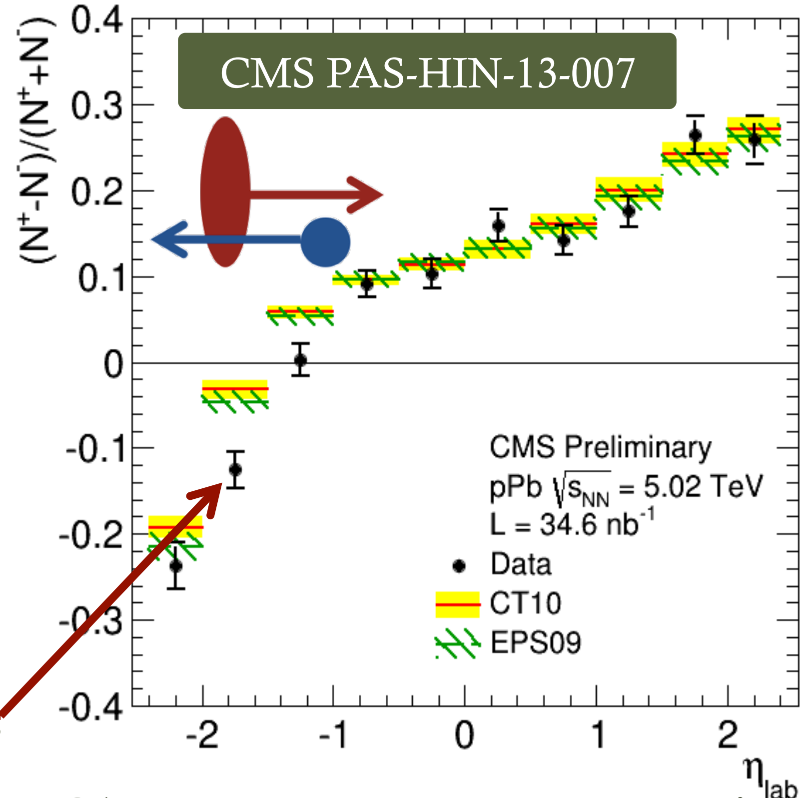
- electroweak probes
  Z/W bosons provide sensitivity to nuclear PDF
- new results from pPb run bridging pp and PbPb

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

HI Physics: pPb run

- pPb LHC run ($35 nb^{-1}$) in Jan.'13
- asymmetric system; study of EWK probes (Z/W) providing sensitivity to the nuclear PDF
- Z bosons: fwd./bkwd. ratio of diff. x-sec using 2183 candidates.

CMS PAS-HIN-13-007

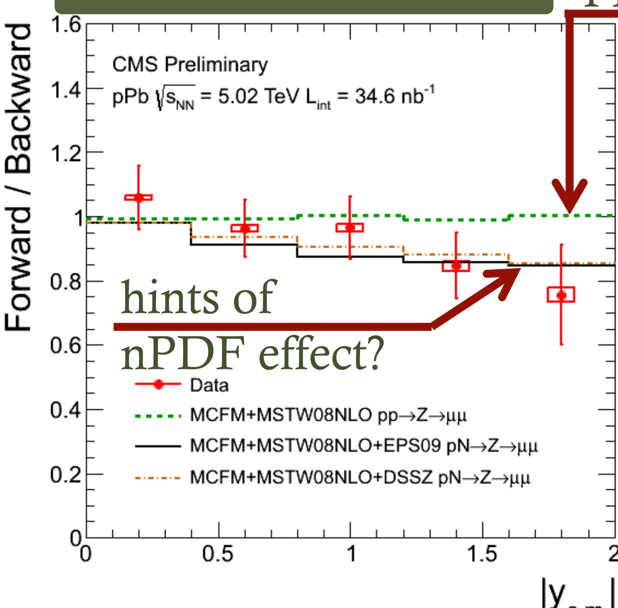


CMS PAS-HIN-14-003

pp prediction

Different scaling of u/d in nPDF?

hints of nPDF effect?

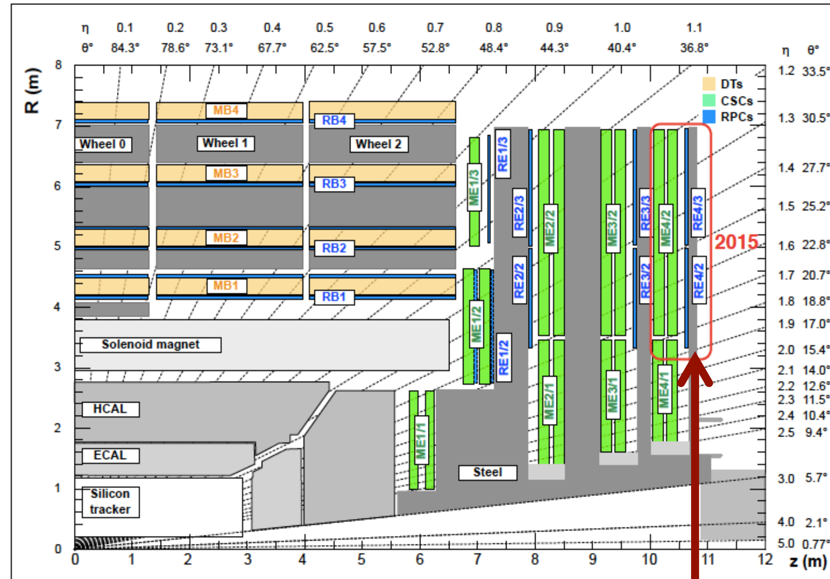


- W bosons: Charge asymmetry vs. η_l in ~37k events with a $W \rightarrow l\nu$ decay
- isospin universality assumed in nPDF fits
- different nuclear modification of u/d?

CMS upgrade

CMS LS1 activities

- ✧ Silicon tracker sealed and cooled. operation at -15°C to -20°C
- ✧ channel count 96% → 99.2%
- ✧ forward Calorimetry upgrade: multi-anode PMTs with thin windows (reject noise), new backend electronics



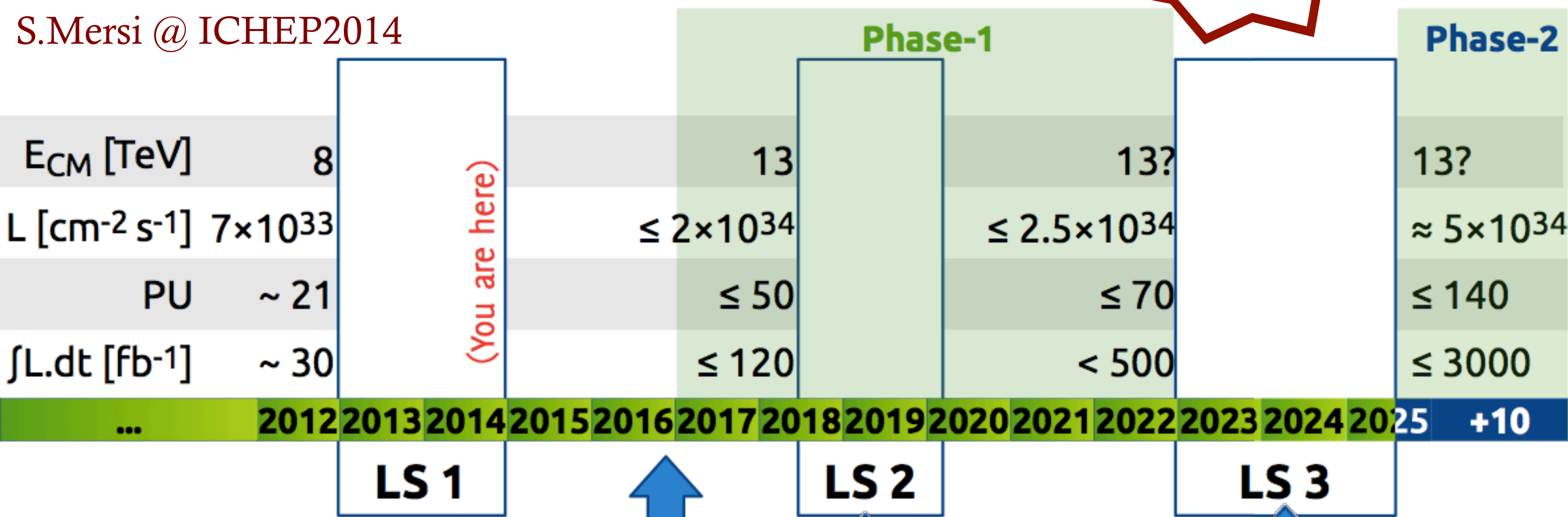
- ✧ new Muon station installed improvements in efficiency and trigger rate
- ✧ trigger system (L1): major upgrade, implemented in stages during Run II: better lepton isolation and PU subtraction algorithms

LHC operation schedule

K. Hoepfner

HL-LHC

S.Mersi @ ICHEP2014



new Pixel detector: 4 layers, 3 disks
boost in performance,
avg. track-eff + 10%, b-tag eff +10%

HCal Upgrade
(PD, Electronics)
New L1 Trigger

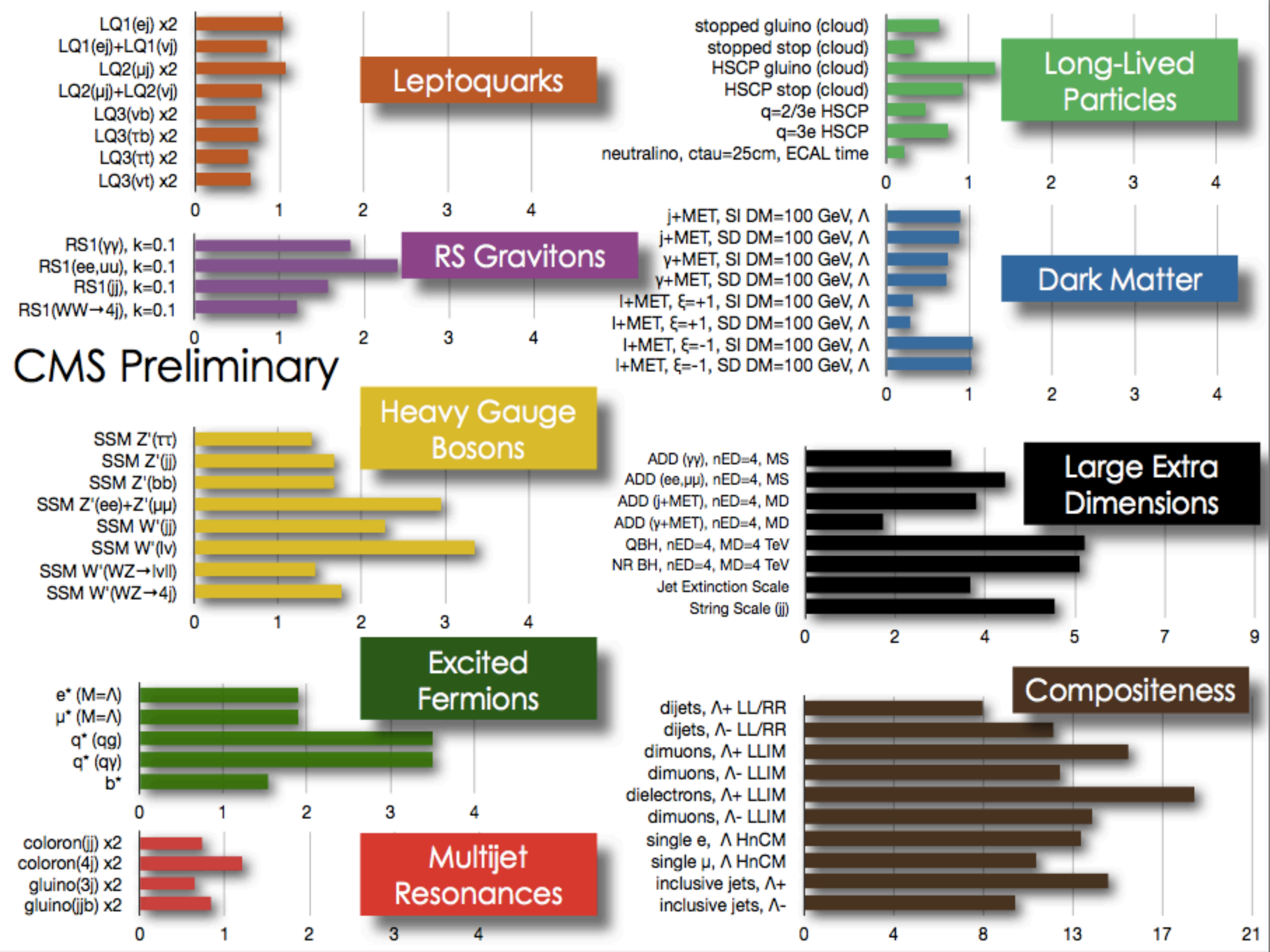
major redesign.
Replace endcaps,
new tracker up to
$|\eta| < 4$, new L1
Trigger

summary

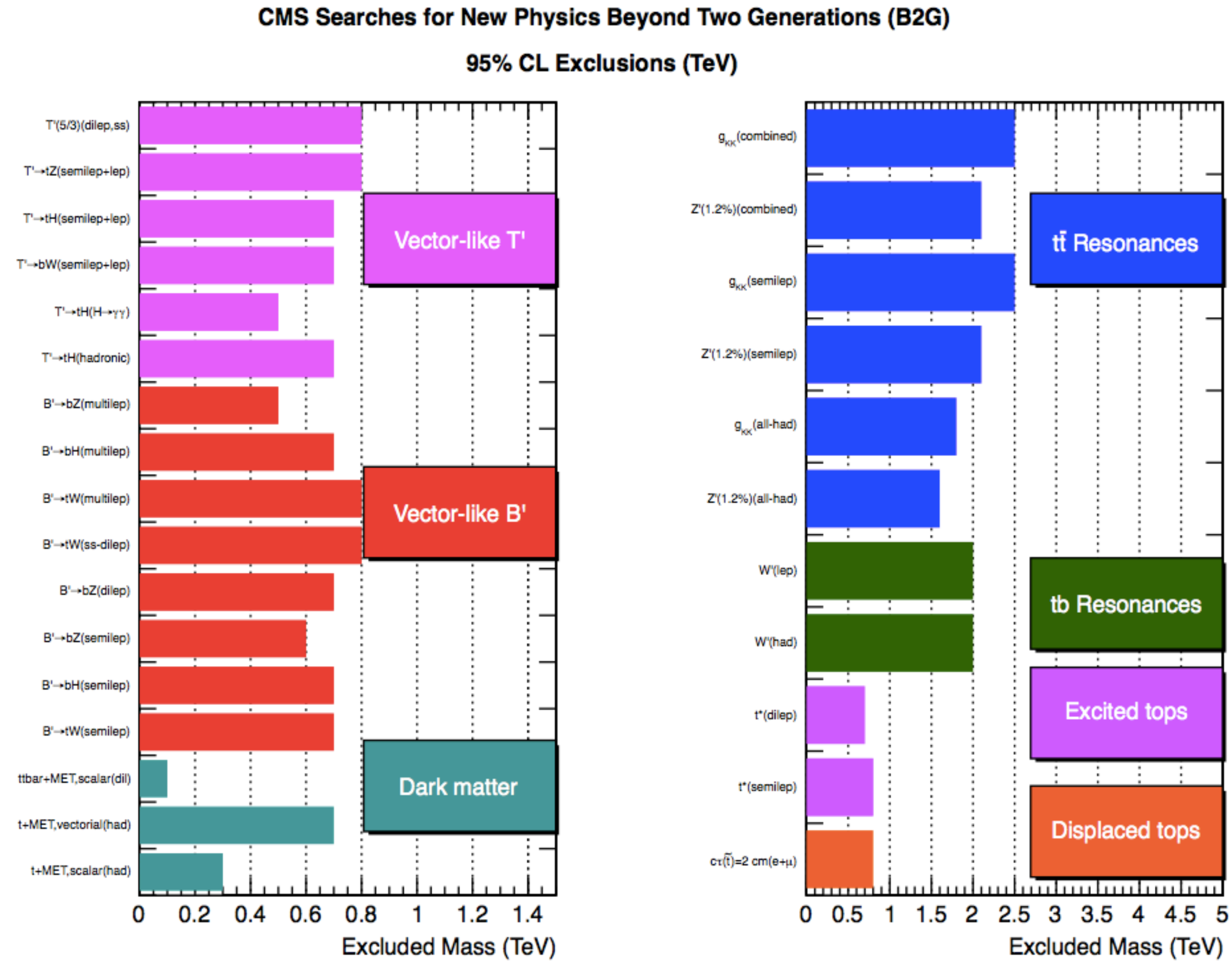
- CMS has successfully completed the 7 and 8 TeV pp runs and the HI runs
- physics output still accumulating,
  many more results in the pipeline
- we are on track for the 13 TeV run starting 2015
- what are the frontiers?
  - close the case of low energy (natural) supersymmetry
  - precision measurements in Higgs/top/EWK sectors
  - keep looking in all corners of phase space
- please enjoy many more details in the other CMS talks

BACKUP

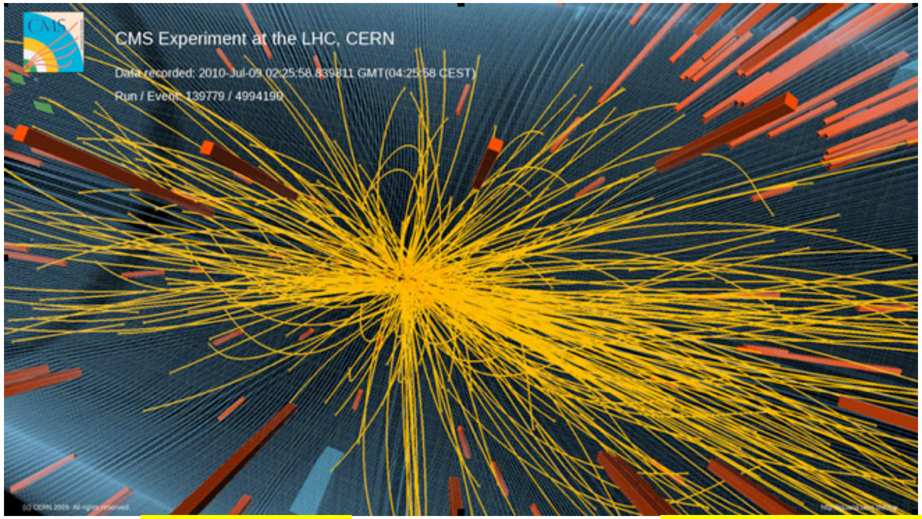

LHCb
ATLAS
CERN Meyrin
PS 628 m
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km



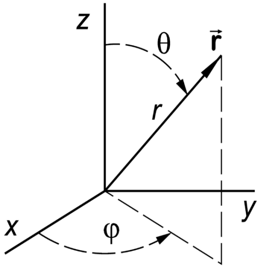
CMS Preliminary
Leptoquarks
LQ1(ej) x2
LQ1(ej)+LQ1(νj)
LQ2(μj) x2
LQ2(μj)+LQ2(νj)
LQ3(νb) x2
LQ3(τb) x2
LQ3(τt) x2
LQ3(νt) x2
RS Gravitons
RS1(γγ), k=0.1
RS1(ee,μμ), k=0.1
RS1(jj), k=0.1
RS1(WW→4j), k=0.1
Heavy Gauge Bosons
SSM Z'(ττ)
SSM Z'(jj)
SSM Z'(bb)
SSM Z'(ee)+Z'(μμ)
SSM W'(jj)
SSM W'(lν)
SSM W'(WZ→lνll)
SSM W'(WZ→4j)
Excited Fermions
e* (M=Λ)
μ* (M=Λ)
q* (qg)
q* (qγ)
b*
Multijet Resonances
coloron(jj) x2
coloron(4j) x2
gluino(3j) x2
gluino(jjb) x2
Long-Lived Particles
stopped gluino (cloud)
stopped stop (cloud)
HSCP gluino (cloud)
HSCP stop (cloud)
q=2/3e HSCP
q=3e HSCP
neutralino, ctau=25cm, ECAL time
Dark Matter
j+MET, SI DM=100 GeV, Λ
j+MET, SD DM=100 GeV, Λ
γ+MET, SI DM=100 GeV, Λ
γ+MET, SD DM=100 GeV, Λ
l+MET, ξ=+1, SI DM=100 GeV, Λ
l+MET, ξ=+1, SD DM=100 GeV, Λ
l+MET, ξ=-1, SI DM=100 GeV, Λ
l+MET, ξ=-1, SD DM=100 GeV, Λ
Large Extra Dimensions
ADD (γγ), nED=4, MS
ADD (ee,μμ), nED=4, MS
ADD (j+MET), nED=4, MD
ADD (γ+MET), nED=4, MD
QBH, nED=4, MD=4 TeV
NR BH, nED=4, MD=4 TeV
Jet Extinction Scale
String Scale (jj)
Compositeness
dijets, Λ+ LL/RR
dijets, Λ- LL/RR
dimuons, Λ+ LLIM
dimuons, Λ- LLIM
dielectrons, Λ+ LLIM
dimuons, Λ- LLIM
single e, Λ HnCM
single μ, Λ HnCM
inclusive jets, Λ+
inclusive jets, Λ-
0 1 2 3 4
0 2 4 5 7 9
0 4 8 13 17 21


CMS Searches for New Physics Beyond Two Generations (B2G)
95% CL Exclusions (TeV)
T'(5/3)(dilep,ss)
T'→tZ(semilep+lep)
T'→tH(semilep+lep)
T'→bW(semilep+lep)
T'→tH(H→γγ)
T'→tH(hadronic)
B'→bZ(multilep)
B'→bH(multilep)
B'→tW(multilep)
B'→tW(ss-dilep)
B'→bZ(dilep)
B'→bZ(semilep)
B'→bH(semilep)
B'→tW(semilep)
ttbar+MET,scalar(dil)
t+MET,vectorial(had)
t+MET,scalar(had)
Vector-like T'
Vector-like B'
Dark matter
0 0.2 0.4 0.6 0.8 1 1.2 1.4
Excluded Mass (TeV)
g_KK(combined)
Z'(1.2%)(combined)
g_KK(semilep)
Z'(1.2%)(semilep)
g_KK(all-had)
Z'(1.2%)(all-had)
W'(lep)
W'(had)
t*(dilep)
t*(semilep)
cτ(t̃)=2 cm(e+μ)
tt̄ Resonances
tb Resonances
Excited tops
Displaced tops
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Excluded Mass (TeV)

Correlations Between Produced Particles



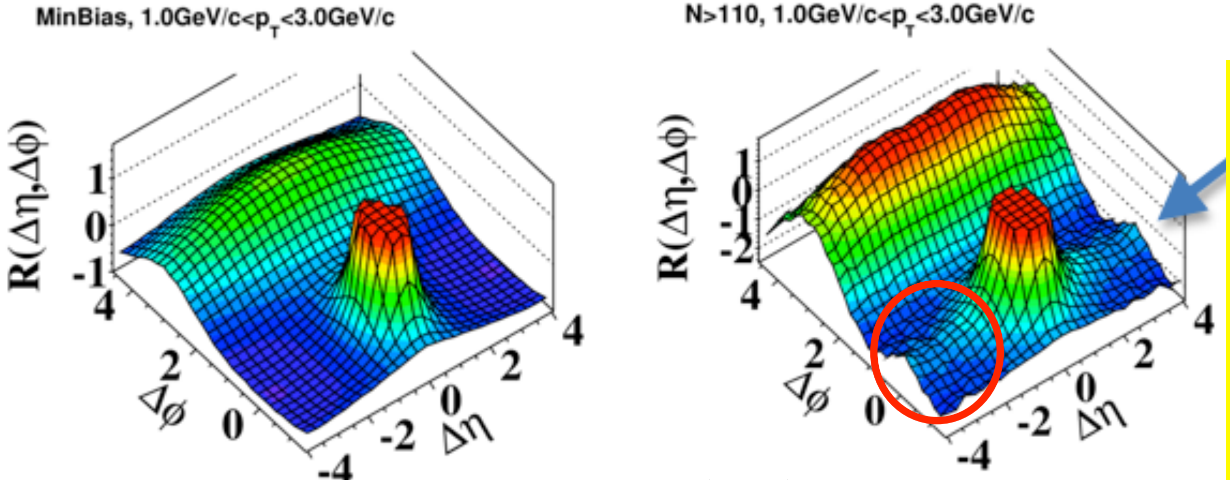
- Select high multiplicity events
- Study the correlation between two charged particles in the angles φ (transverse): Δφ and θ (longitudinal): Δθ



η= -ln tanθ/2

All events

High multiplicity events



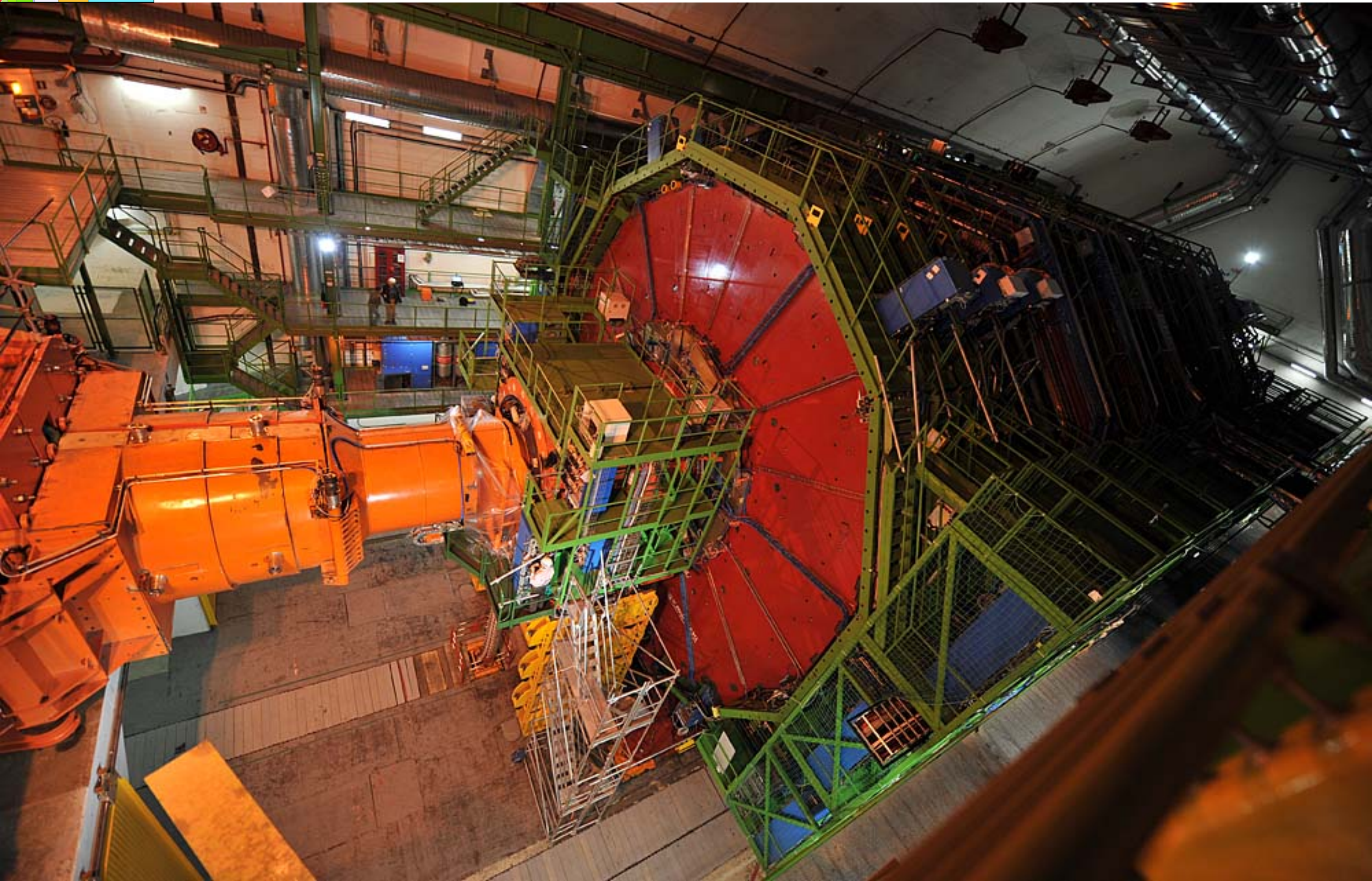
JHEP 1009 (2010) 091

A new phenomenon in the 'stronge force'?
- Multiple interactions?
- C-glass condensates?
- Hydrodynamic models?

…

Understanding the "Ridge" in pp collisions in MC? Need for new measurements?

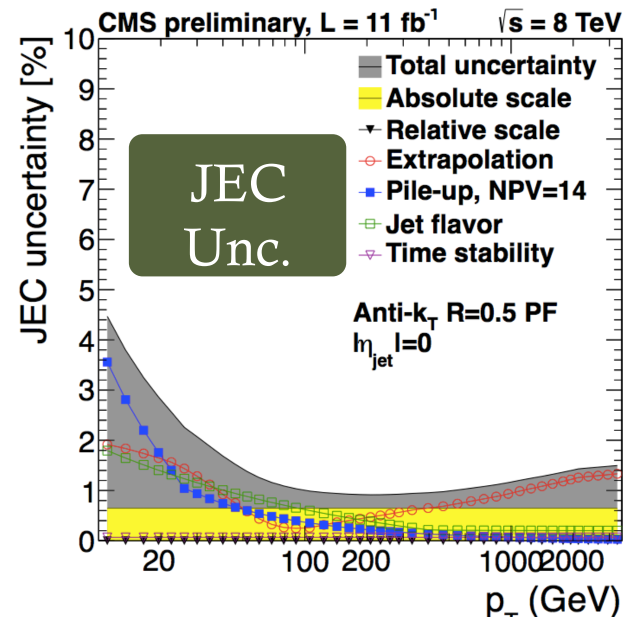
CMS in reality

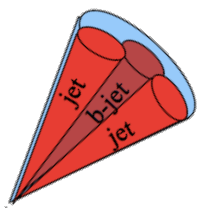


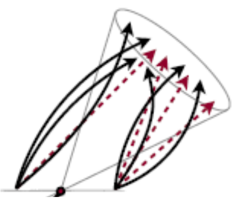
jet performance

JME-13-002, JME-13-005
JME-13-006, JME-13-007

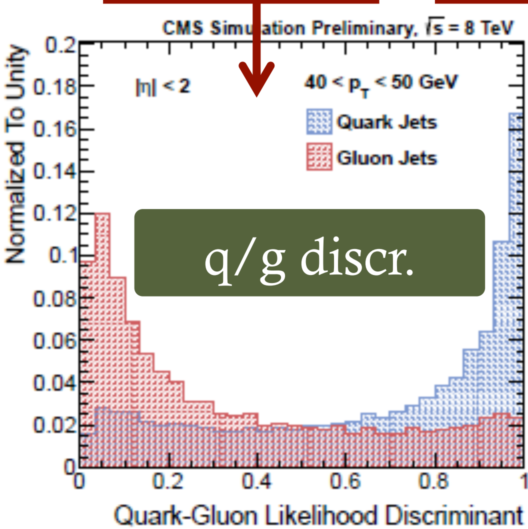
- jets are clusters of reconstructed PF particles (AK5)
- JES uncertainty at ~ 1-2%, JER generally below 10%

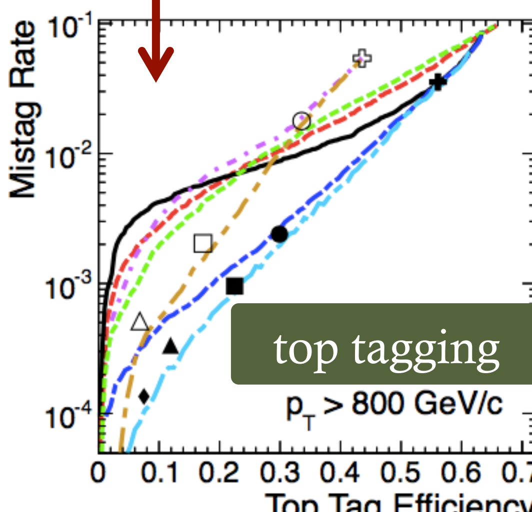


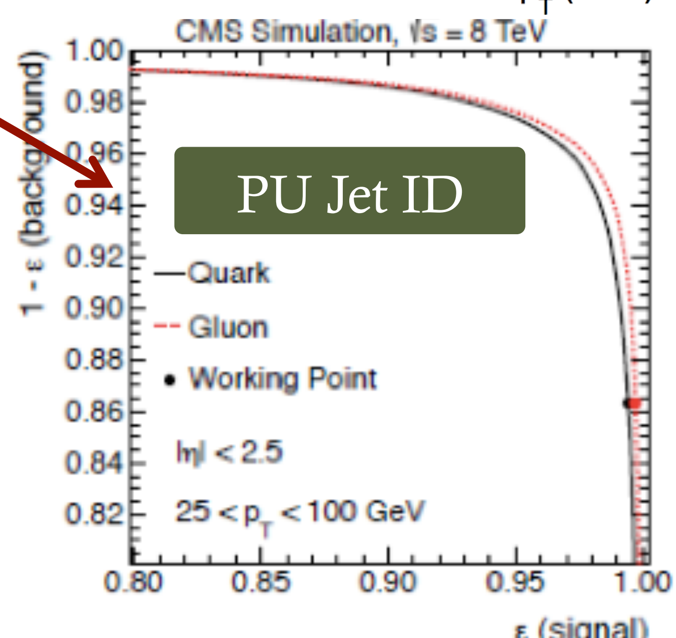




q/g Disc., W/top tag, PU jet ID



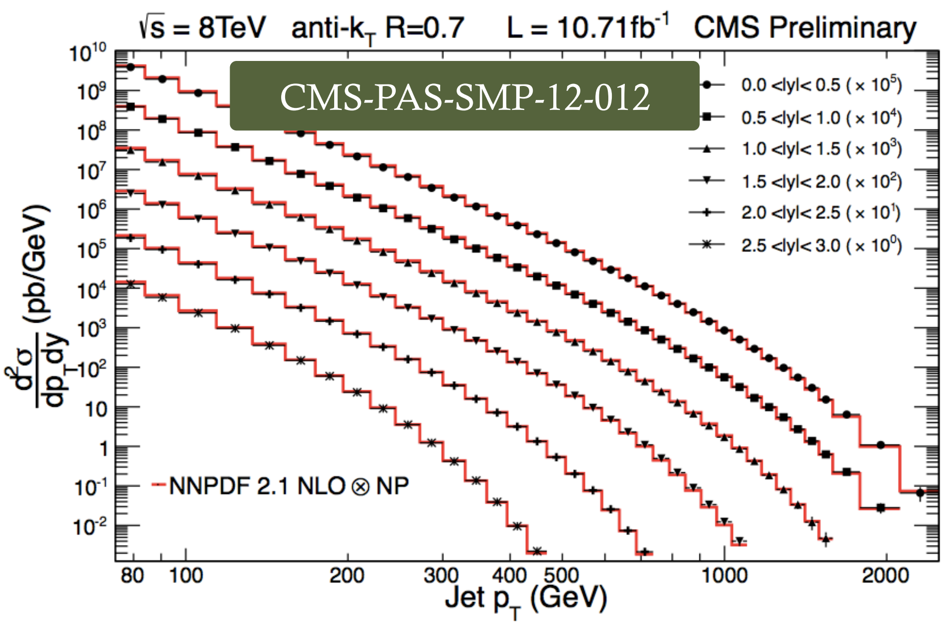


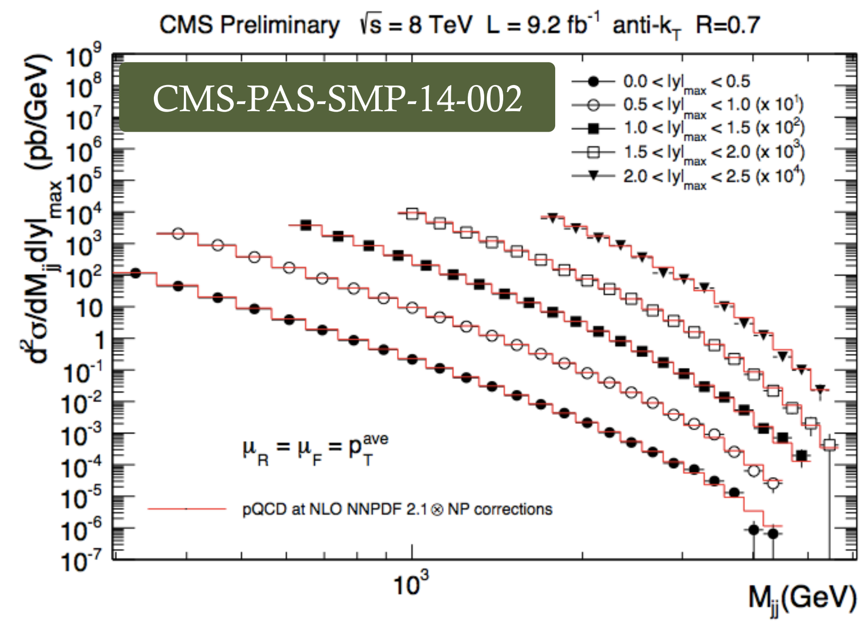


physics: jets

G. D'Imperio

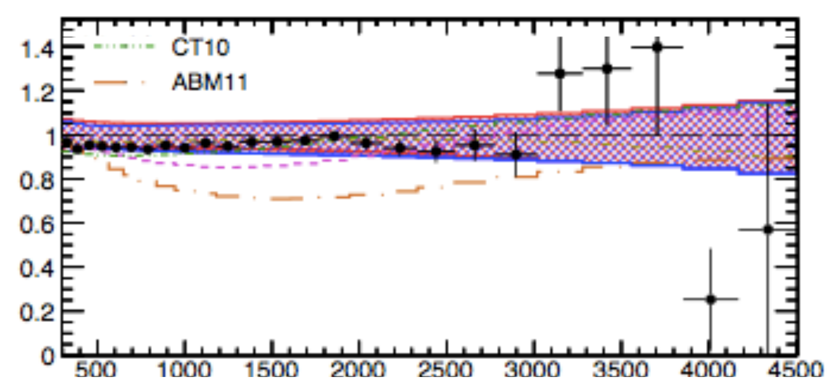
✧ measurement of differential inclusive and dijet jet x-sec





✧ excellent agreement with pred. from perturbative NLO QCD

✧ provide constraints for PDF fits

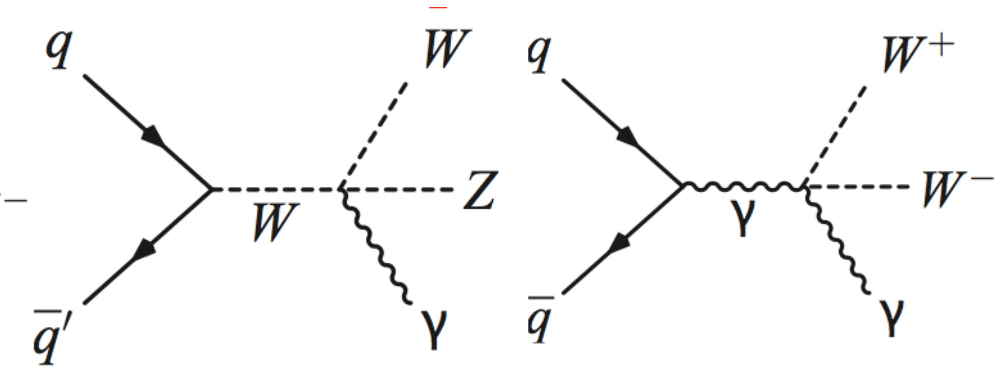


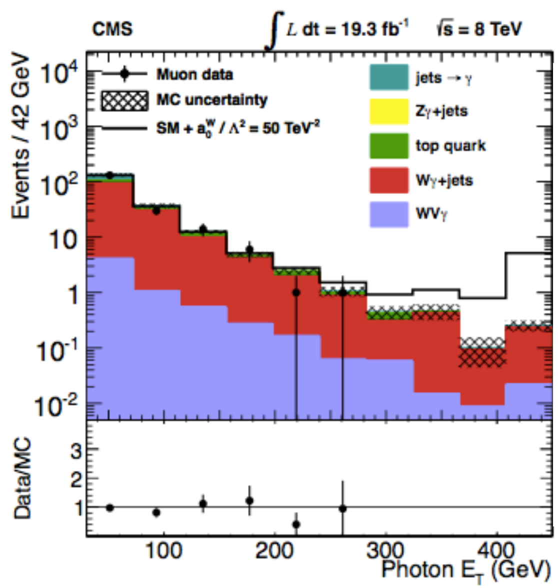
WV γ and limits on aQGC

- search for WV γ prod. in W(lυ)W/Z(jj) γ with l=e,μ
- σ(m_{jj}) is around Δ $m_{Z,W}$, can't differentiate
- set limit on WV γ

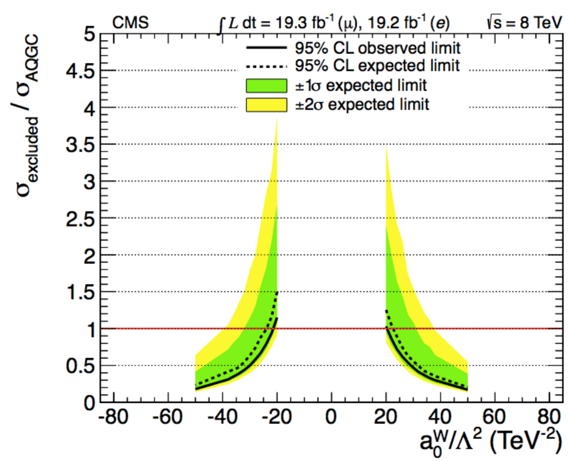
σ (excl 95%) = 311 fb ≈ 3 σ_{SM}

- SM predicts WWWW, WWZZ, WWZ γ and WW γ γ providing a crucial test ground for EWK SB.
- deviations parametrized by dim. 6 and 8 operators





$p_T(\gamma)$ sensitive to aQGC!



arxiv:1404.4619

top physics

S.Tosi

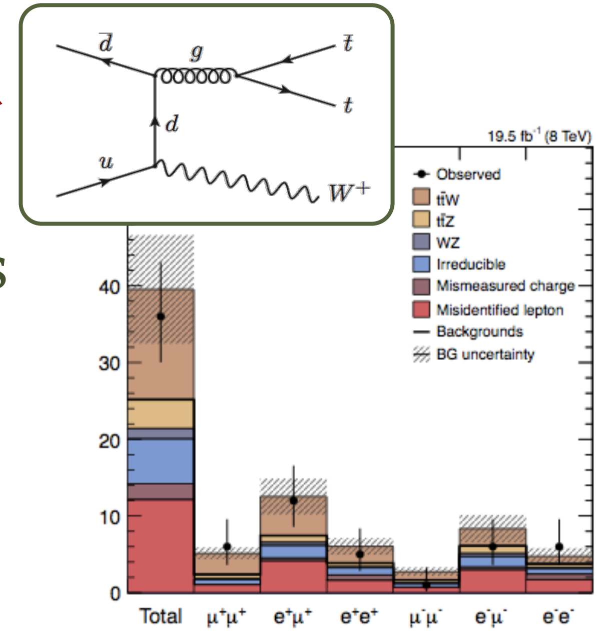
arxiv:1406:7830

- ✧ tt+W x-sec. meas. with same-sign di-leptons

σ(ttW) = 170 +90-80 (stat.) ± 70 (sys.) fb

- ✧ tt+Z x-sec. meas. with 3 and 4 leptons

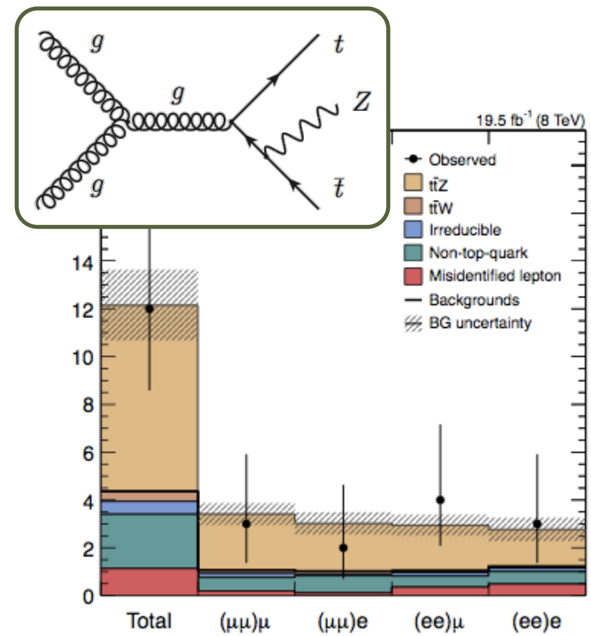
σ(ttZ) = 200 +80-70 (stat.) ± 40 (sys.) fb



arxiv:1404:2292

- ✧ extract B(t→ Wb)/B(t→Wq) from b-tag multiplicity fit in di-leptonic ttbar.
- ✧ lower limit on $|V_{tb}|>0.975$
- ✧ using t-channel x-sec, turn into an indirect measurement of the top total decay width

Γ=1.36 ± 0.02 (stat.) +0.14-0.12 (sys.)

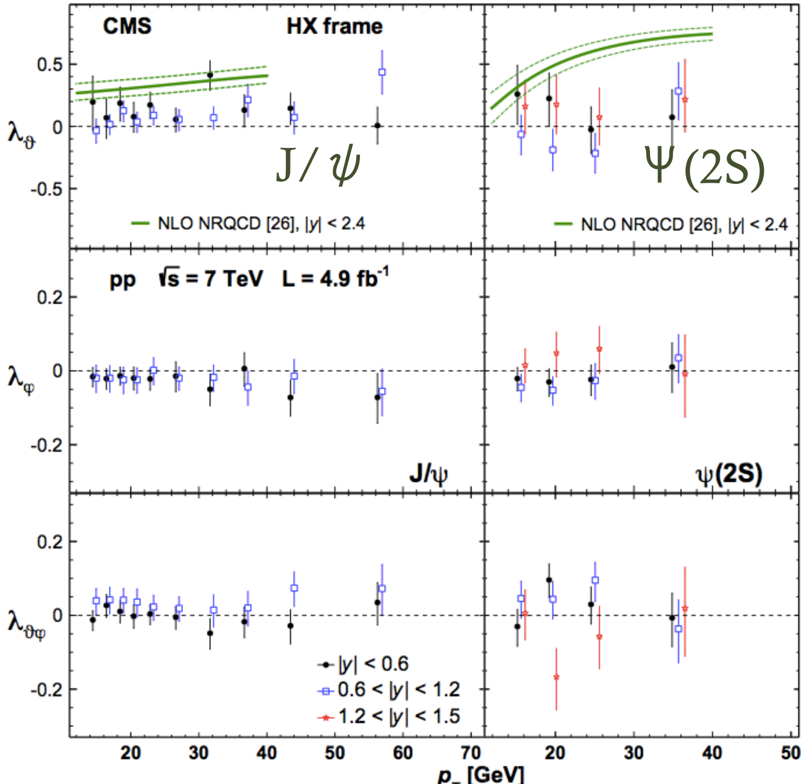


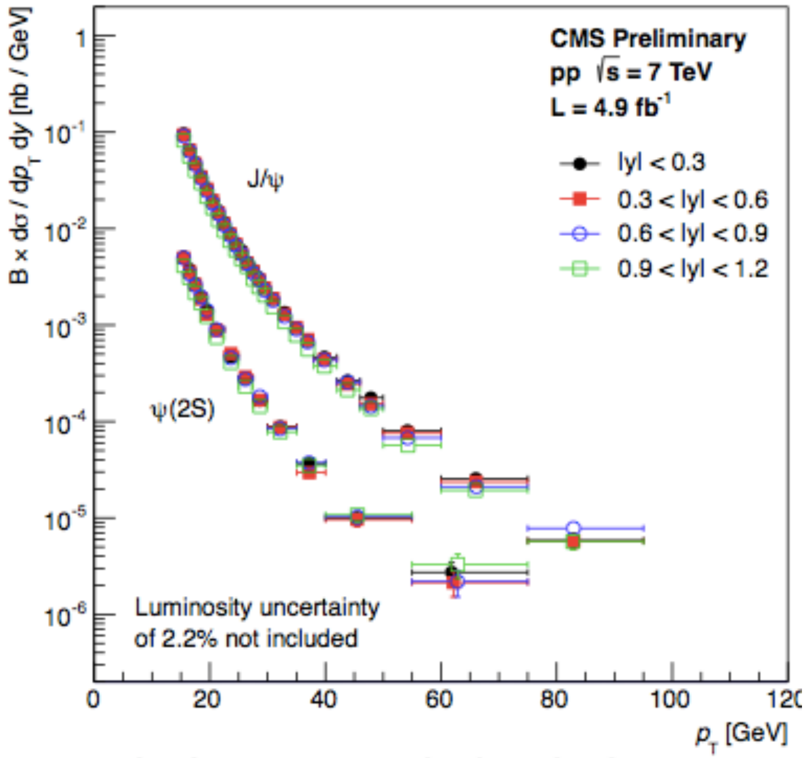
Quarkonia

C. Wulz

CMS PAS-BPH-14-001

- ✧ new 7 TeV measurement of J/ψ and Ψ(2S) diff. production x-sec:
- ✧ Quarkonia polarization puzzle:





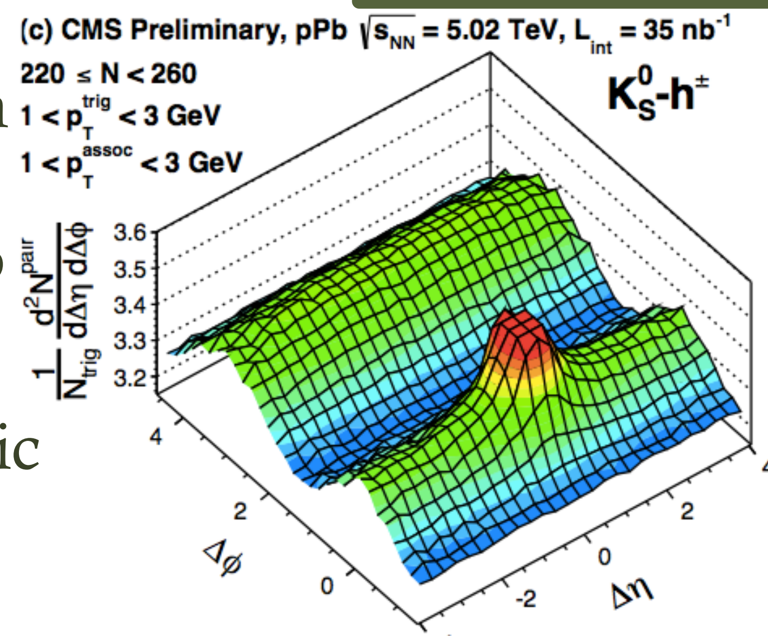
- ✧ NRQCD prediction for quarkonia polarization does not reproduce measurement

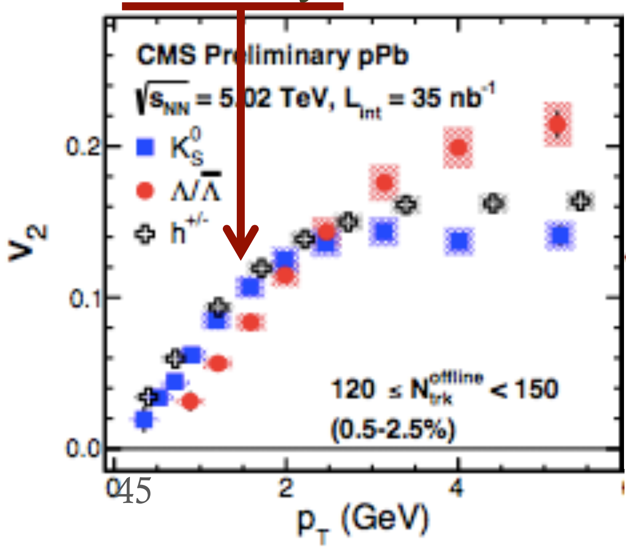
arxiv:1307:6070

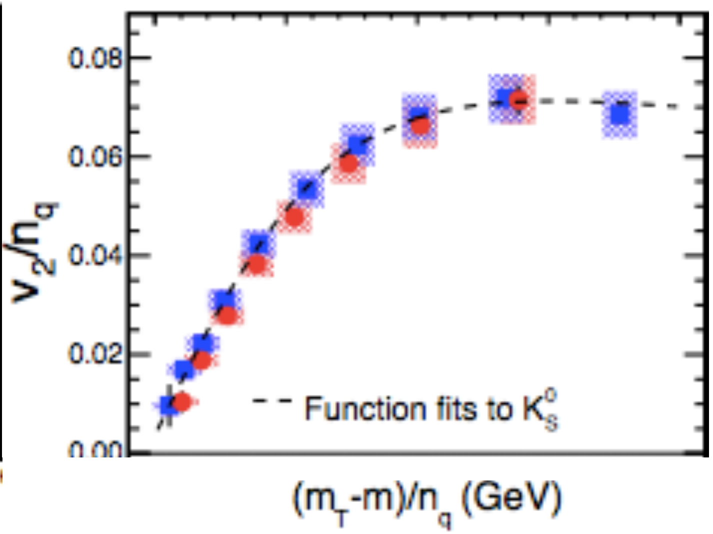
pPb: collective phenomena

CMS PAS-HIN-14-002

- ✧ long-range 2-particle correlations probe collective flow phenomena in a ‘strongly interacting, expanding medium’ Here: K_{0S}, $\Lambda/\bar{\Lambda}$ +h in pPb
- ✧ 1D $\Delta\Phi$ correlation for $|\Delta\eta|>2$
- ✧ elliptic and triangular flow harmonic $v_{2,3}$: low p_T mass ordering expected from hyd. models



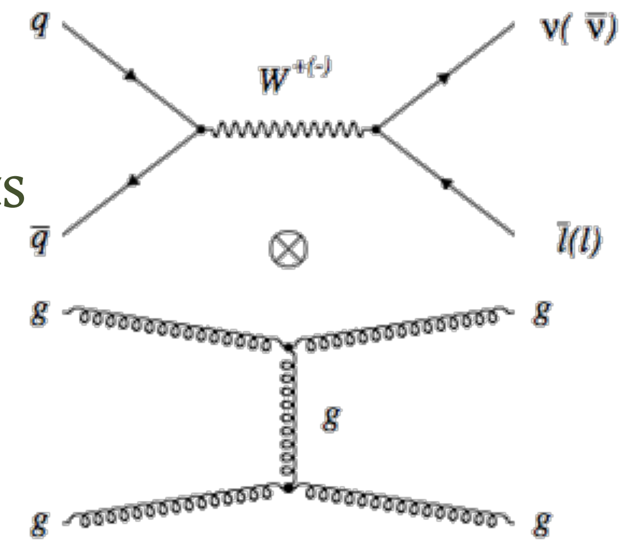




- ✧ v_2/n_q shapes as fkt. of $E_{kin,T}/n_q$ within 10%
- ✧ collective flow in constituent quarks?

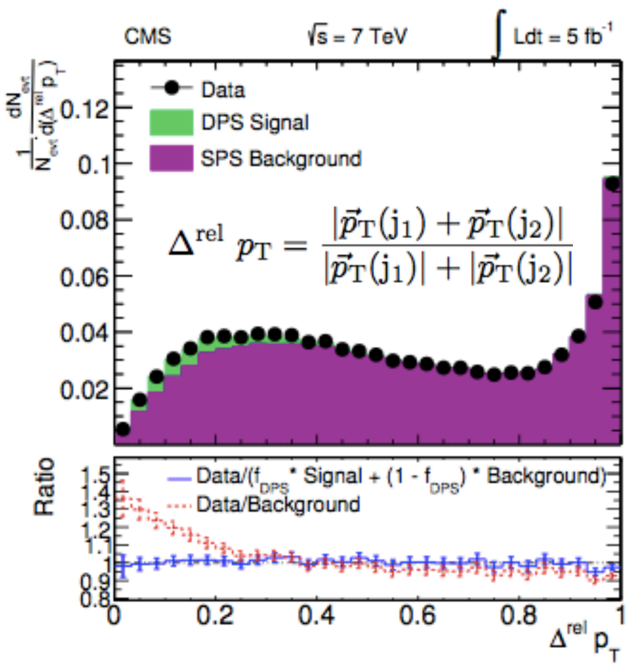
low-x physics: DPS

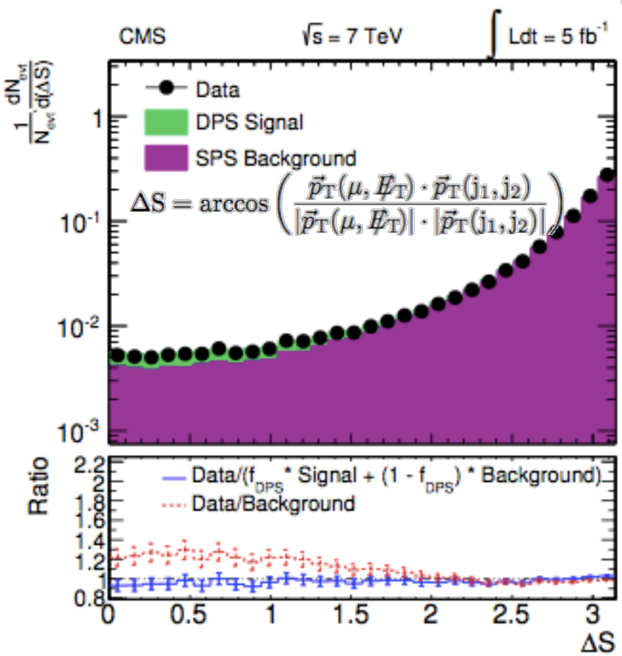
JHEP 03 (2014) 032

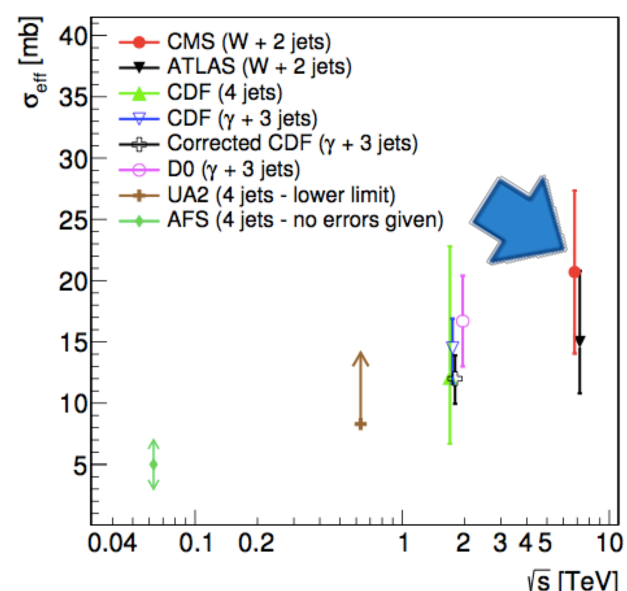


- ✧ double parton scattering in W+2 jet events
- ✧ probe x~10^{-3}, $5fb^{-1}$ at 7TeV

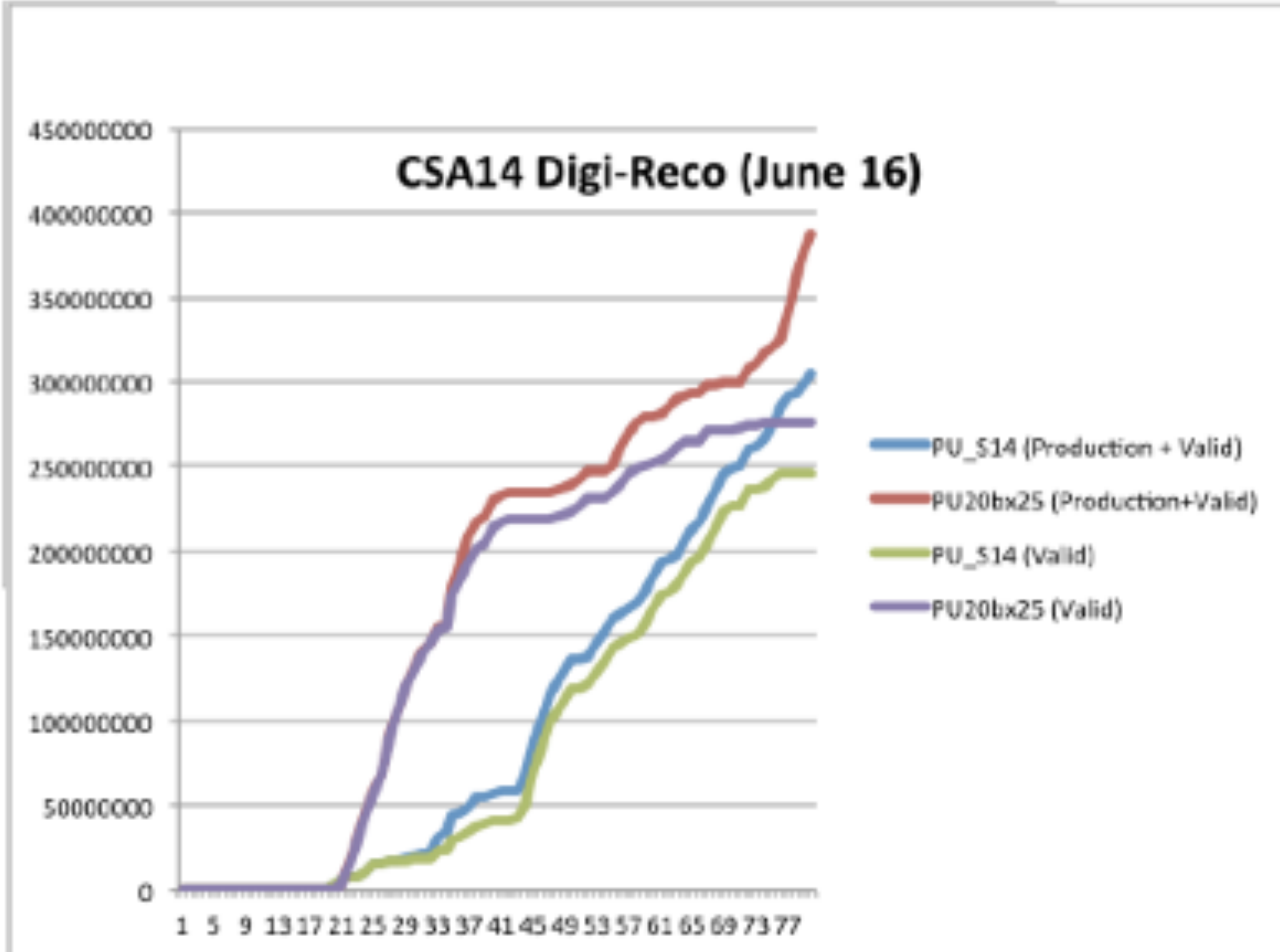
$$f_{\rm DPS} = 0.055 \pm 0.002\,(\text{stat.}) \pm 0.014\,(\text{syst.})$$

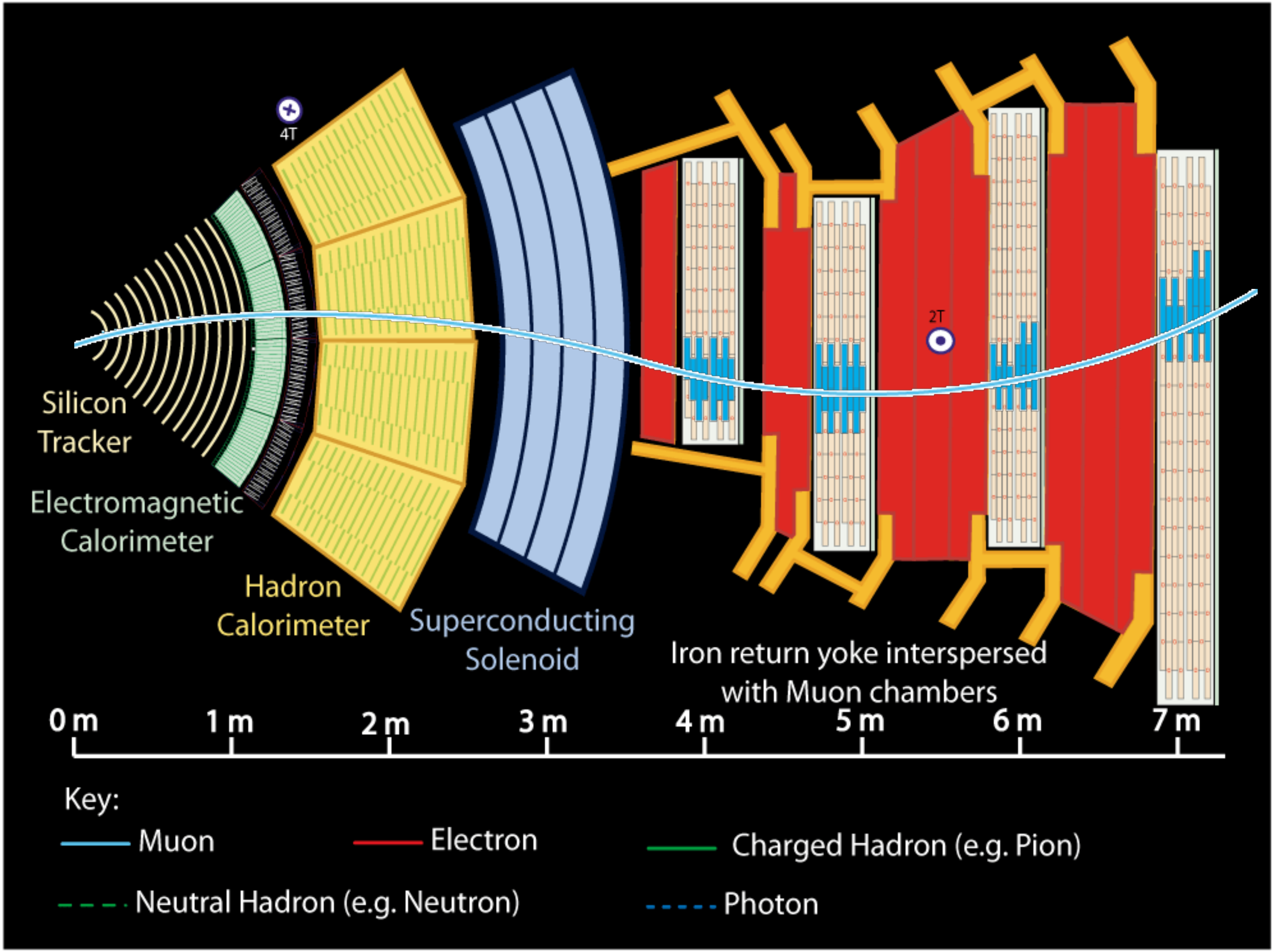


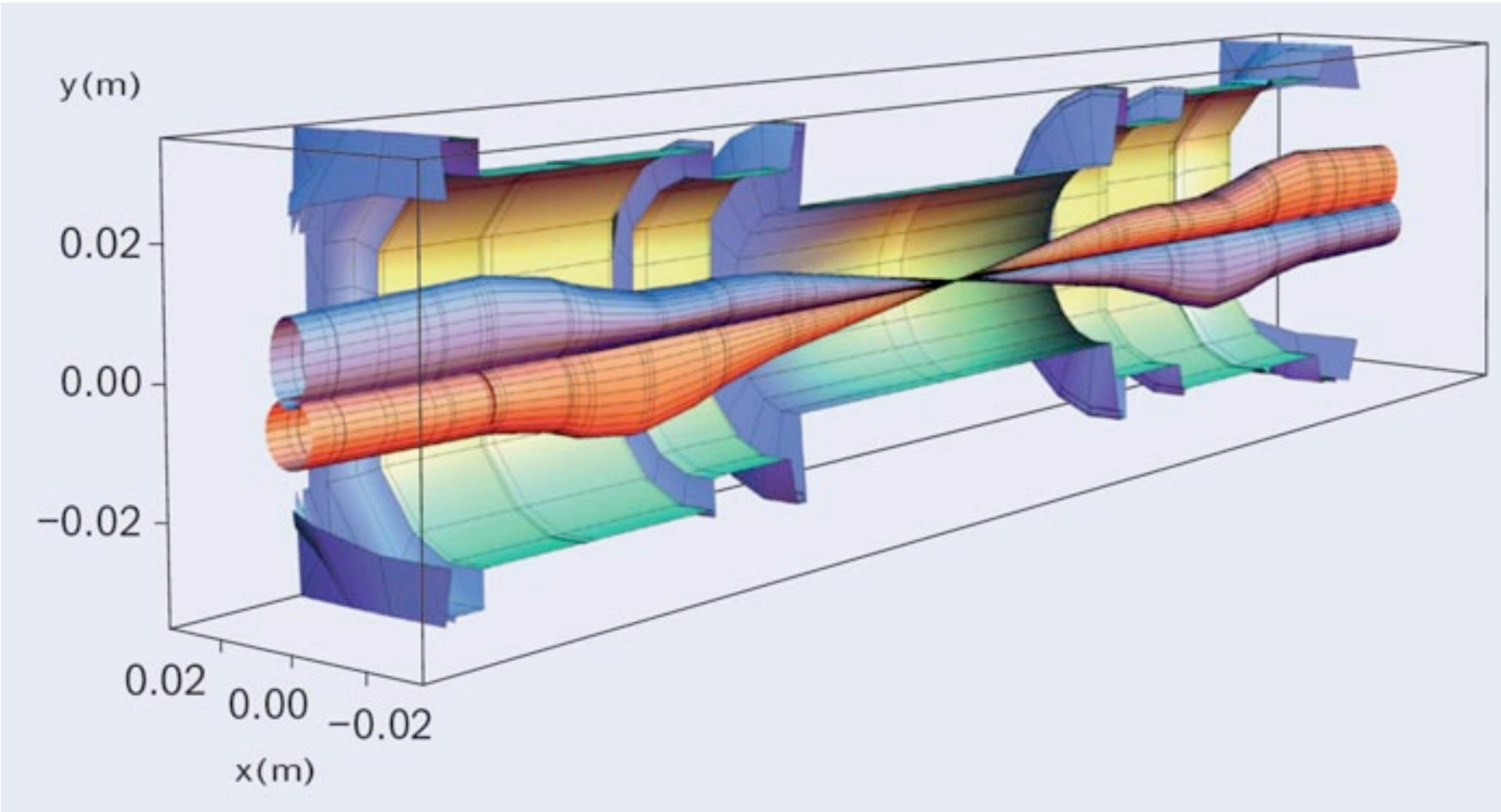




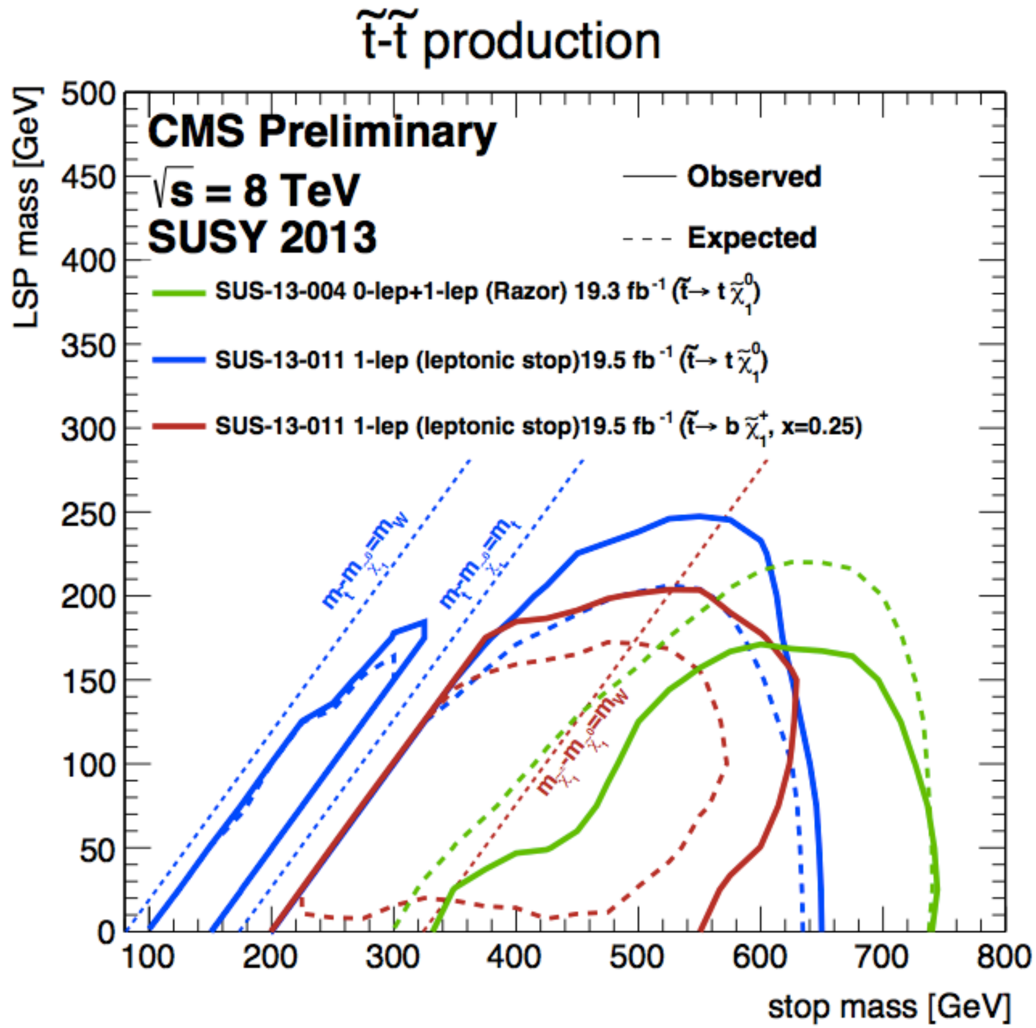
MC generation




4T
2T
Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
Iron return yoke interspersed with Muon chambers
0 m
1 m
2 m
3 m
4 m
5 m
6 m
7 m
Key:
Muon
Electron
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon


y(m)
0.02
0.00
−0.02
0.02
0.00
−0.02
x(m)

summary on light top squark



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: Moriond 2014

ATLAS Preliminary

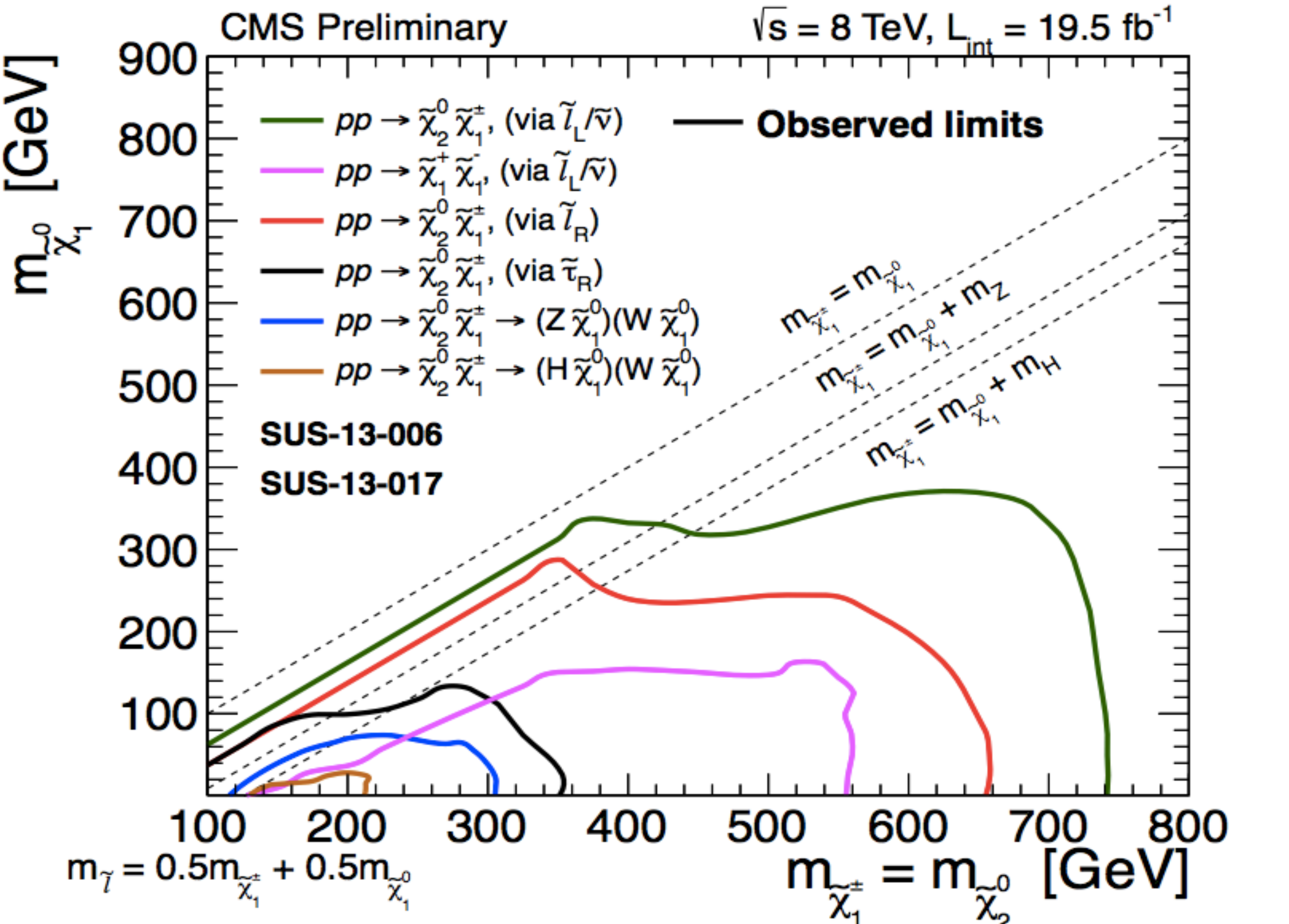
$\int \mathcal{L}\, dt = (4.6 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7, 8$ TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$		Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}, \tilde{q}\rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow qq\tilde{\chi}_1^{\pm}\rightarrow qqW^{\pm}\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^{\pm})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g}\rightarrow qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\tau}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta$ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$	1.28 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2014-001
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H})$>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3^{rd} gen. $\tilde{g}$ med.	$\tilde{g}\rightarrow b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\rightarrow b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
3^{rd} gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$	100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\rightarrow t\tilde{\chi}_1^{\pm}$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$	275-430 GeV	$m(\tilde{\chi}_1^{\pm})$=2 $m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\rightarrow b\tilde{\chi}_1^{\pm}$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\rightarrow Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-210 GeV	$m(\tilde{\chi}_1^0)$ =$m(\tilde{t}_1)$-$m(W)$-50 GeV, $m(\tilde{t}_1)$<<$m(\tilde{\chi}_1^{\pm})$	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	$\tilde{t}_1$	215-530 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1403.4853
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\rightarrow b\tilde{\chi}_1^{\pm}$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\rightarrow c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\rightarrow\tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$	290-600 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\rightarrow\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$	90-325 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\rightarrow\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}$	140-465 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\rightarrow\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$	180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$	700 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	1402.7029
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$	420 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e, μ	2 b	Yes	20.3	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$	285 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$	270 GeV	$m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^{\pm})$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\rightarrow\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\rightarrow qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\rightarrow\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\rightarrow e + \mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\rightarrow\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\rightarrow e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$	760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0, \tilde{\chi}_1^0\rightarrow\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$	350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\rightarrow qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\rightarrow\tilde{t}_1 t, \tilde{t}_1\rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon$\rightarrow q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\rightarrow t\bar{t}$	2 e, μ (SS)	2 b	Yes	14.3	sgluon	350-800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

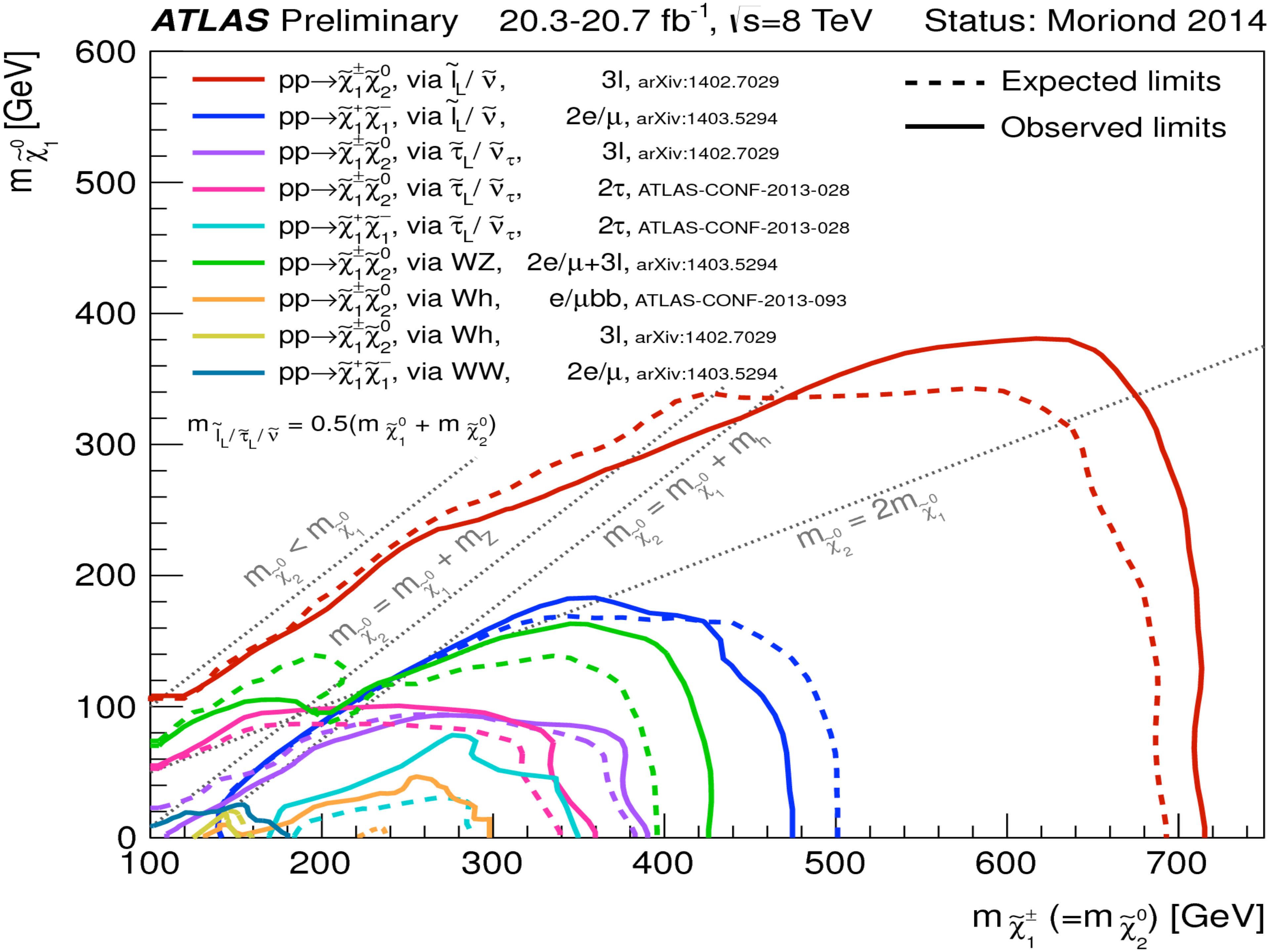
Mass scale [TeV]: 10^{-1}, 1

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

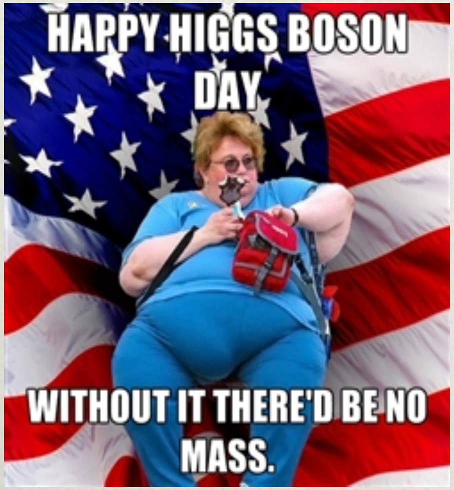
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.



CMS Preliminary
$\sqrt{s}$ = 8 TeV, L_{int} = 19.5 fb^{-1}
$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm$, (via $\tilde{l}_L/\tilde{\nu}$)
$pp \rightarrow \tilde{\chi}_1^+ \tilde{\chi}_1^-$, (via $\tilde{l}_L/\tilde{\nu}$)
$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm$, (via $\tilde{l}_R$)
$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm$, (via $\tilde{\tau}_R$)
$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm \rightarrow (Z \tilde{\chi}_1^0)(W \tilde{\chi}_1^0)$
$pp \rightarrow \tilde{\chi}_2^0 \tilde{\chi}_1^\pm \rightarrow (H \tilde{\chi}_1^0)(W \tilde{\chi}_1^0)$
Observed limits
SUS-13-006
SUS-13-017
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0} + m_Z$
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_1^0} + m_H$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$ [GeV]
$m_{\tilde{l}} = 0.5 m_{\tilde{\chi}_1^\pm} + 0.5 m_{\tilde{\chi}_1^0}$



ATLAS Preliminary 20.3-20.7 fb^{-1}, $\sqrt{s}$=8 TeV Status: Moriond 2014
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via $\tilde{l}_L/\tilde{\nu}$, 3l, arXiv:1402.7029
$pp\rightarrow\tilde{\chi}_1^{+}\tilde{\chi}_1^-$, via $\tilde{l}_L/\tilde{\nu}$, 2e/μ, arXiv:1403.5294
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via $\tilde{\tau}_L/\tilde{\nu}_\tau$, 3l, arXiv:1402.7029
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via $\tilde{\tau}_L/\tilde{\nu}_\tau$, 2τ, ATLAS-CONF-2013-028
$pp\rightarrow\tilde{\chi}_1^{+}\tilde{\chi}_1^-$, via $\tilde{\tau}_L/\tilde{\nu}_\tau$, 2τ, ATLAS-CONF-2013-028
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via WZ, 2e/μ+3l, arXiv:1403.5294
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via Wh, e/μbb, ATLAS-CONF-2013-093
$pp\rightarrow\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, via Wh, 3l, arXiv:1402.7029
$pp\rightarrow\tilde{\chi}_1^{+}\tilde{\chi}_1^-$, via WW, 2e/μ, arXiv:1403.5294
Expected limits
Observed limits
$m_{\tilde{l}_L/\tilde{\tau}_L/\tilde{\nu}} = 0.5(m_{\tilde{\chi}_1^0} + m_{\tilde{\chi}_2^0})$
$m_{\tilde{\chi}_2^0} < m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_2^0} = m_{\tilde{\chi}_1^0} + m_Z$
$m_{\tilde{\chi}_2^0} = m_{\tilde{\chi}_1^0} + m_h$
$m_{\tilde{\chi}_2^0} = 2m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{\chi}_1^\pm}$ ($=m_{\tilde{\chi}_2^0}$) [GeV]
0
100
200
300
400
500
600
700

4. Juli 2012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Die Presse

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KUNSTLIEBE

Kulturpolitik. Die Österreicher gehen wenig ins Museum. Ein Experte gibt Tipps, wie man die Liebe neu wecken kann. SEITE 23

Physik. Am Kernforschungszentrum CERN in Genf hat man das lange gesuchte Teilchen gefunden, das allen anderen erst Masse verleiht, das Higgs-Boson. Ganz sicher ist man sich allerdings noch nicht.

Happy Higgs Day

Neues Elementarteilchen

Entdeckt? Nein, nur beobachtet!

„Es geht darum, die Welt zu verstehen“

Porträt des Tages. Wie der Brite Peter Higgs vom Außenseiter zur Galionsfigur wurde.