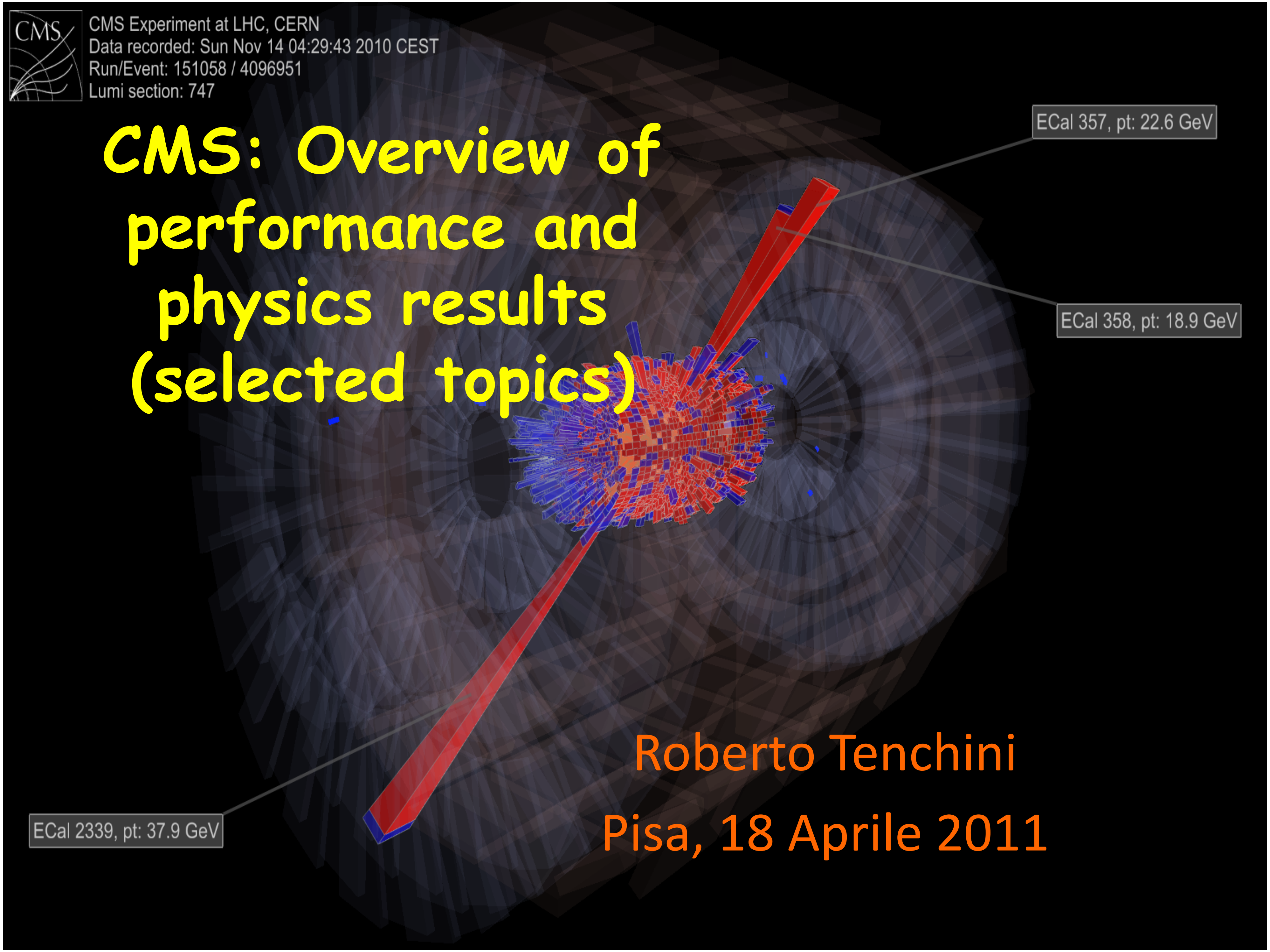
CMS: Overview of performance and physics results (selected topics)

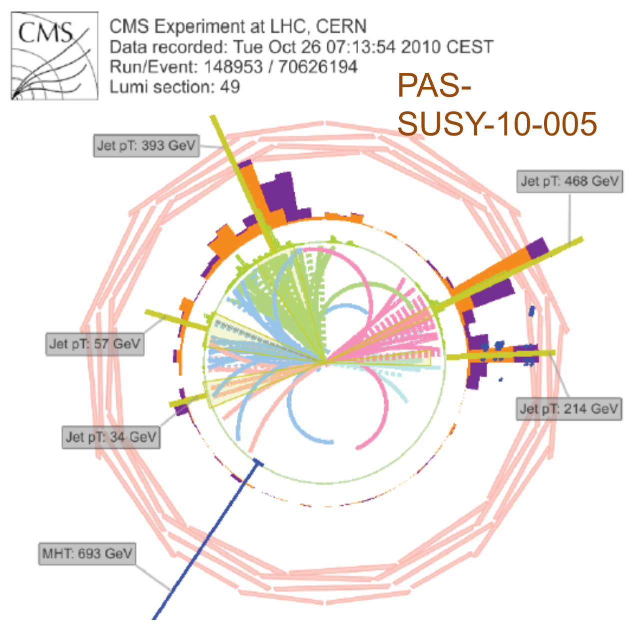


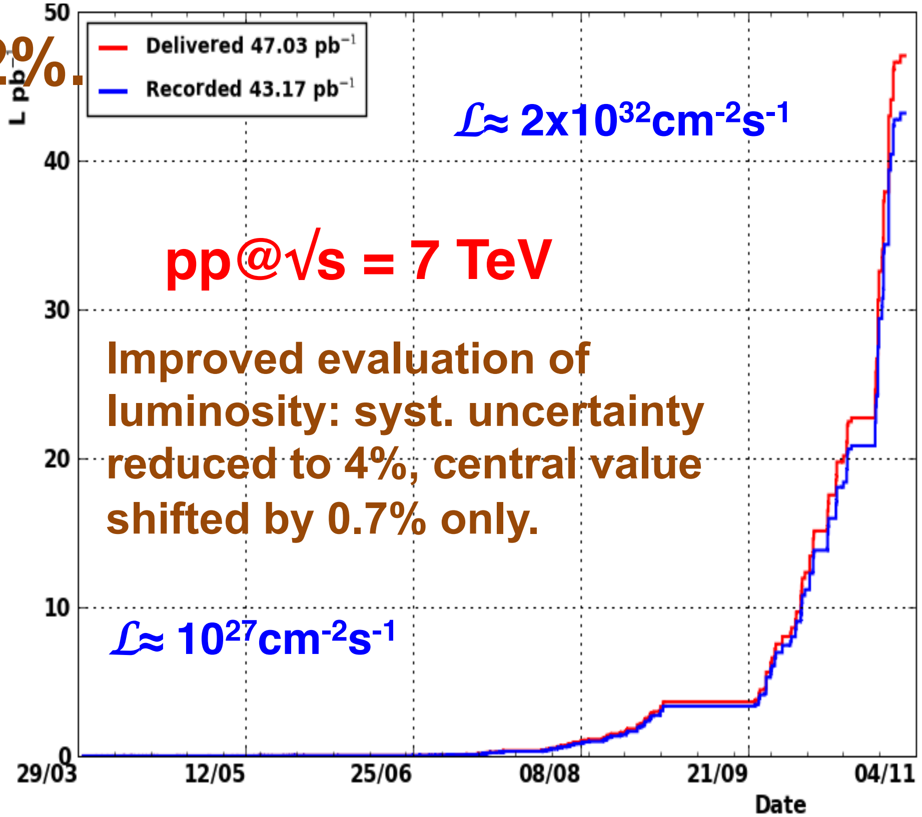
Roberto Tenchini

Pisa, 18 Aprile 2011

LHC and CMS Performance

2010 pp: ~**47pb^{-1}** delivered by LHC and **~43pb^{-1}** collected by CMS.
Overall data taking efficiency **~92%.**

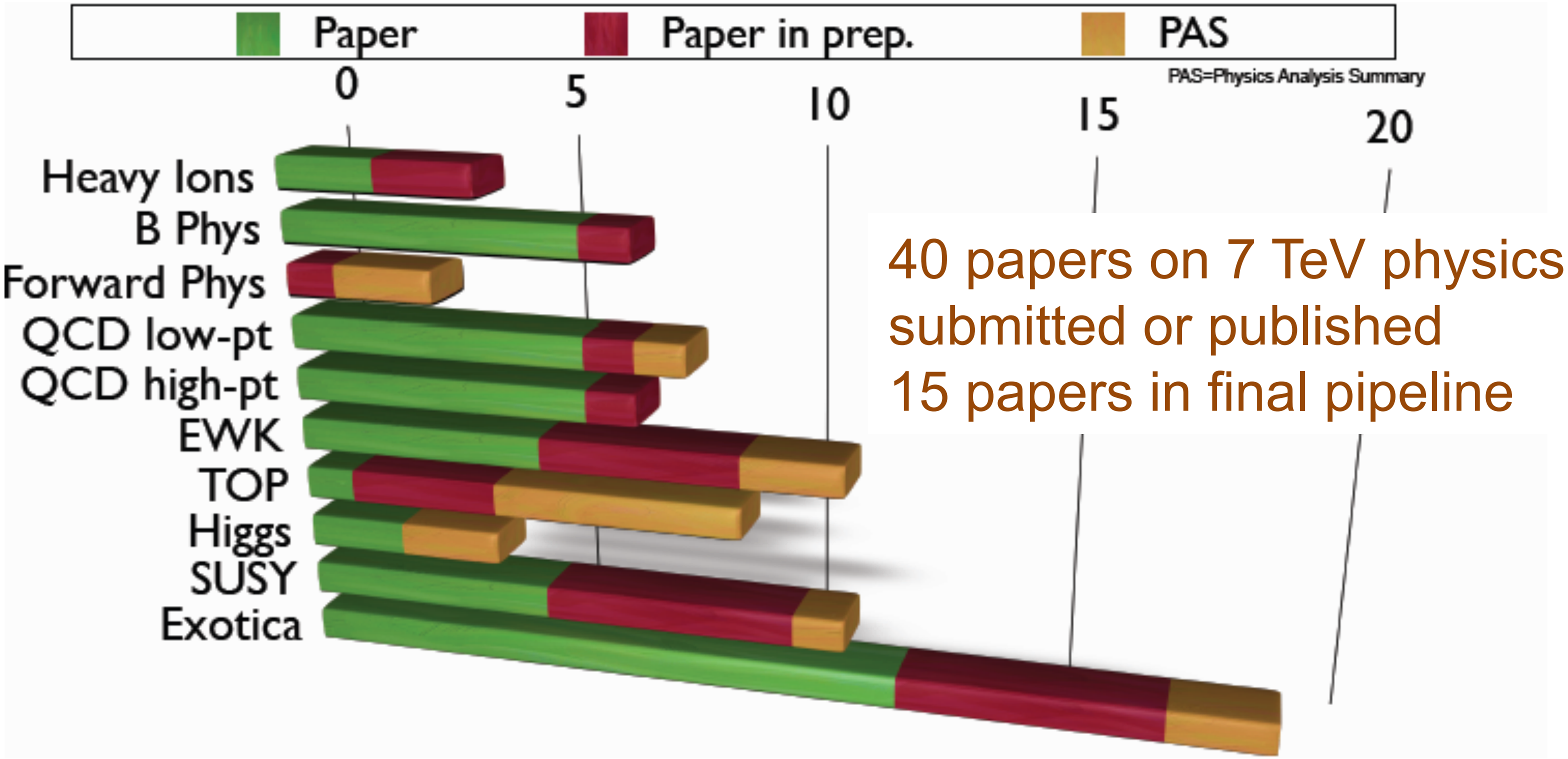




Average fraction of operational channels per CMS sub-system **>99%.**
Quality of the data for physics (any analysis) **~85%** of recorded data.

Many Physics Results

With 2010 data, more than 80 physics analyses.



40 papers on 7 TeV physics submitted or published
15 papers in final pipeline

For complete information see

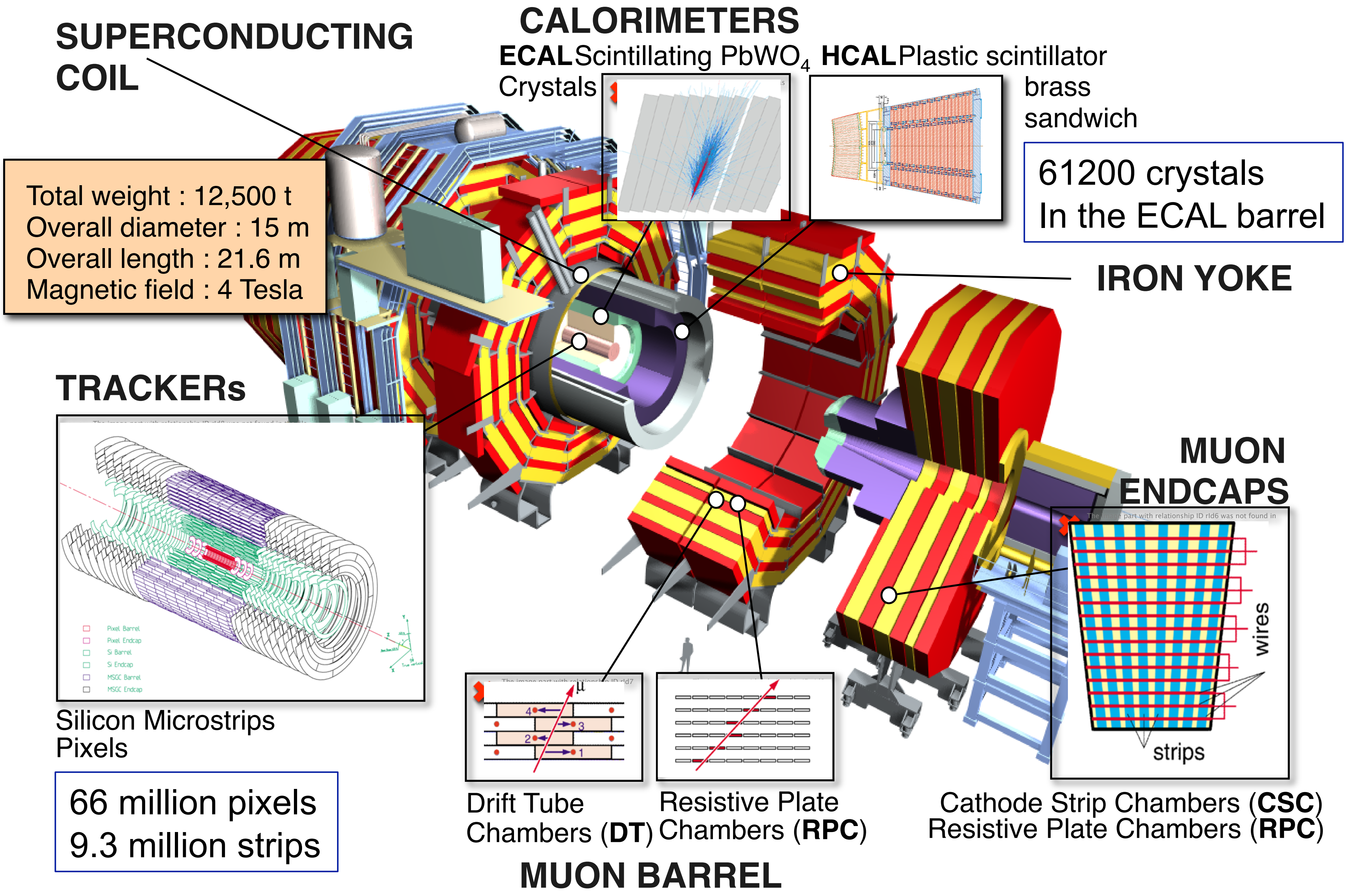
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults

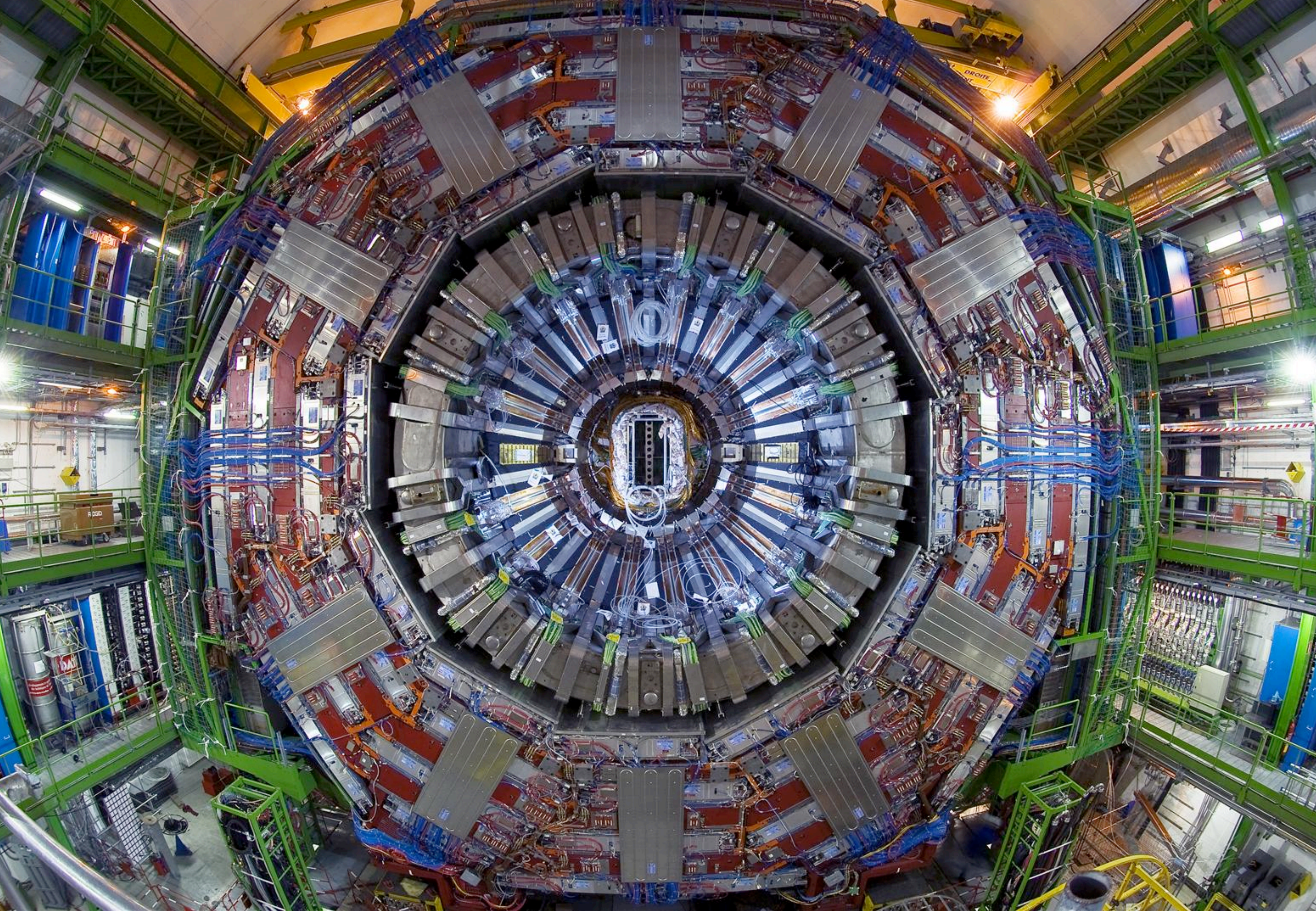
http://cdsweb.cern.ch/collection/CMS Papers

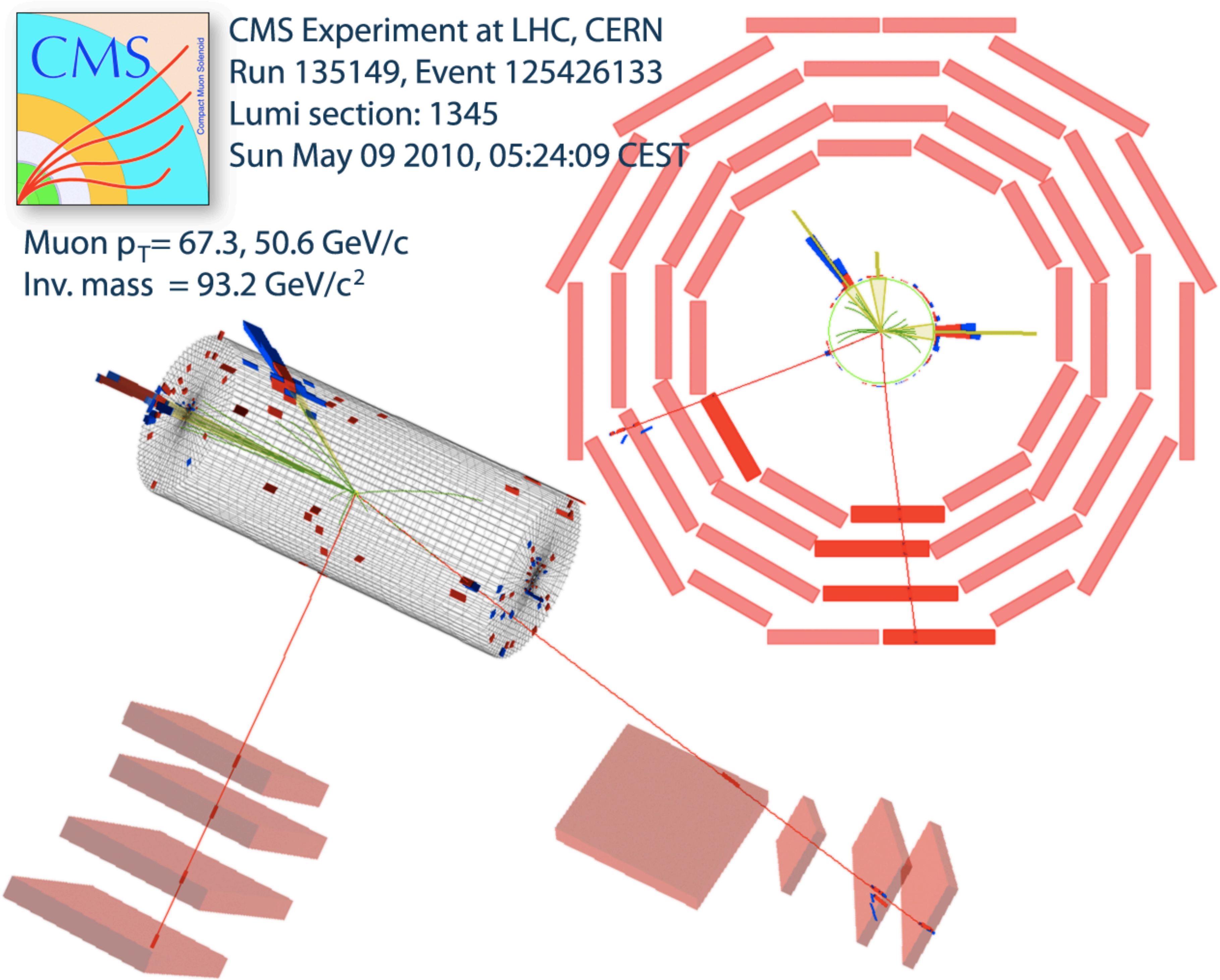
CMS Talks at this Workshop

- **Jet and Multijet Results (Konstantinos Kousouris)**
- **Jet reconstruction and measurements of jet performance (Hartmut Stadie)**
- **Vector Boson productions and Higgs searches (Jonatan Piedra Gomez)**
- **W/Z+jets (Massimo Nespolo)**
- **Top quark and ttbar mass measurements (Roberto Chierici)**
- **New Physics Searches with jets (Daniel Duggan)**
- **Supersymmetry Searches in multijet events (Raffaele Tito D’Agnolo)**

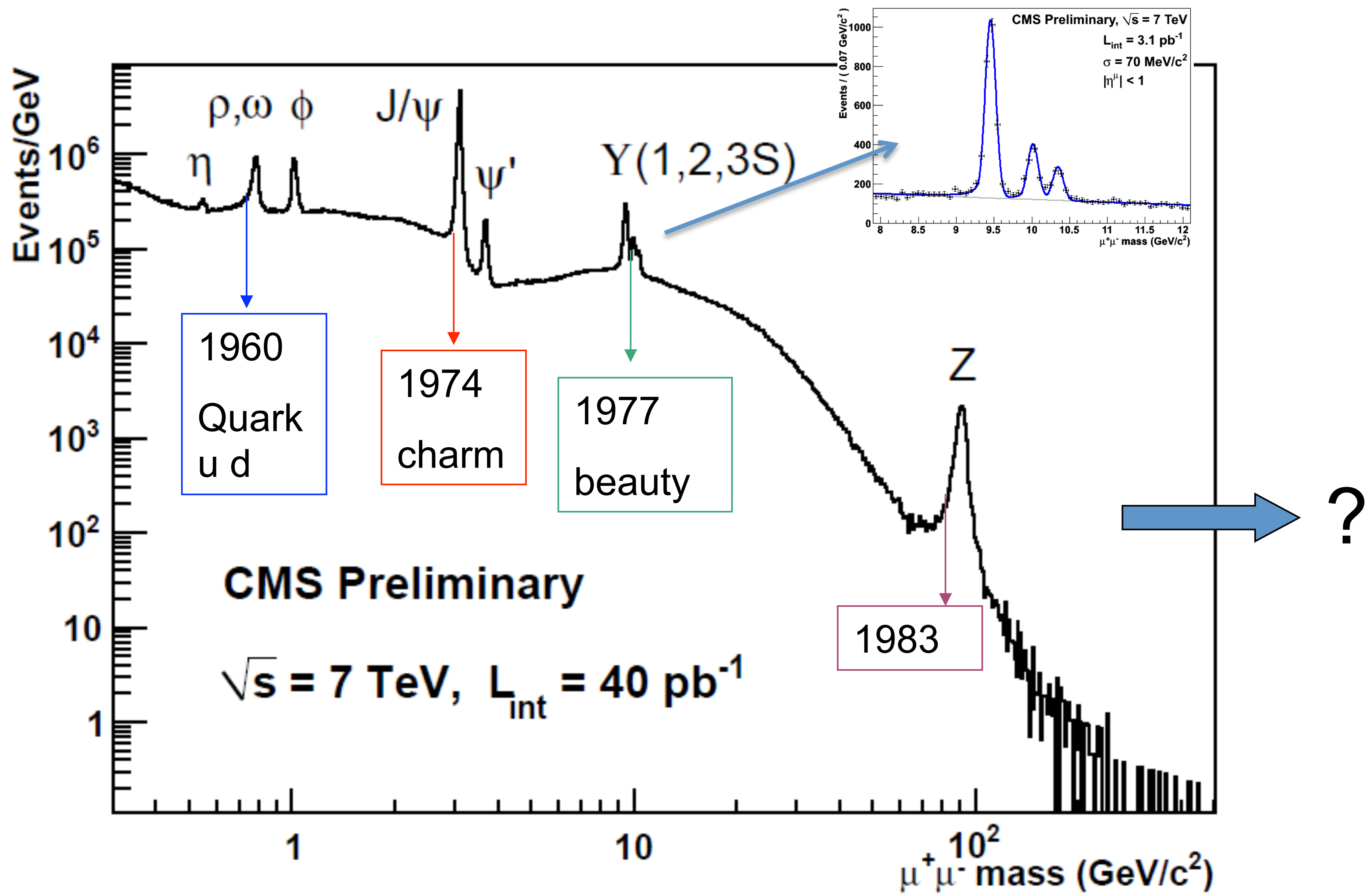
The Compact Muon Solenoid (CMS)





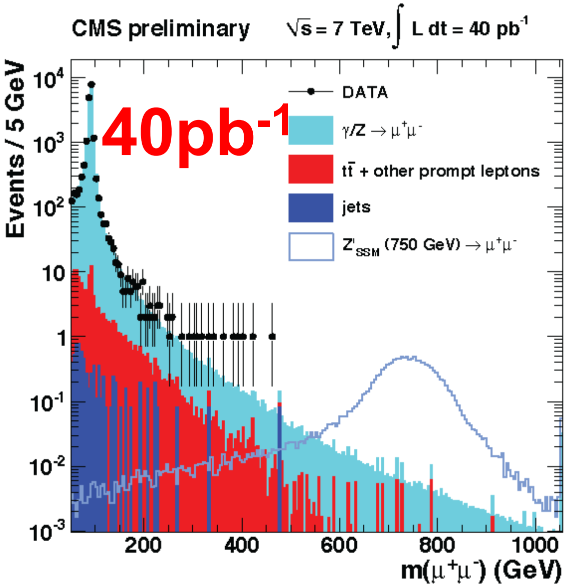

CMS
Compact Muon Solenoid
CMS Experiment at LHC, CERN
Run 135149, Event 125426133
Lumi section: 1345
Sun May 09 2010, 05:24:09 CEST
Muon p_T= 67.3, 50.6 GeV/c
Inv. mass = 93.2 GeV/c^2

Rediscovered the Standard Model in 2010: example μ+μ- inv mass spectrum

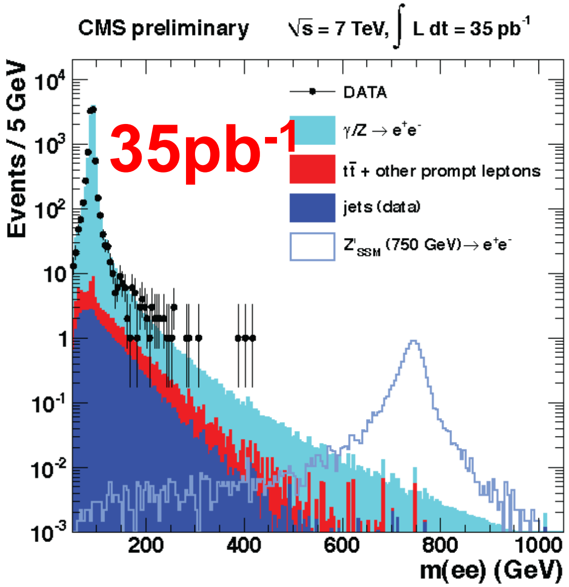


Search for Z' in dileptons

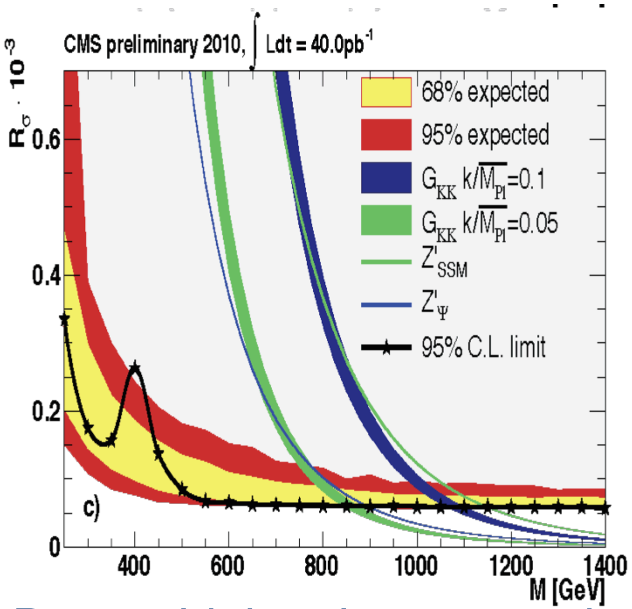
Z'→$\mu^+\mu^-$



Z'→e^+e^-



arXiv:1103.0981



The spectra are consistent with known SM processes. By combining the $\mu^+\mu^-$ and e^+e^- channels, the following 95% C.L. lower limits on the mass of a Z′ resonance are obtained: **1140 GeV** for the Sequential Standard Model Z'_{SSM}, and **887 GeV** for Super-String inspired models, Z'_{ψ}. RS Kaluza-Klein Gravitons are excluded below **855-1079 GeV** at 95% C.L. for values of couplings parameters (k/M_{Pl}) 0.05-0.1.

Most stringent limits to date.

Prospects for 2011-12: explore deeply the multi TeV region.

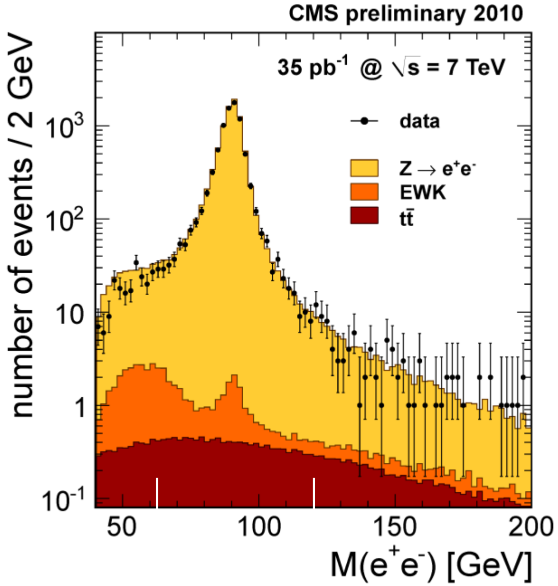
With 2.9/pb JHEP01(2011) 080, Latest result with 35/pb PAS-EWK-10-005

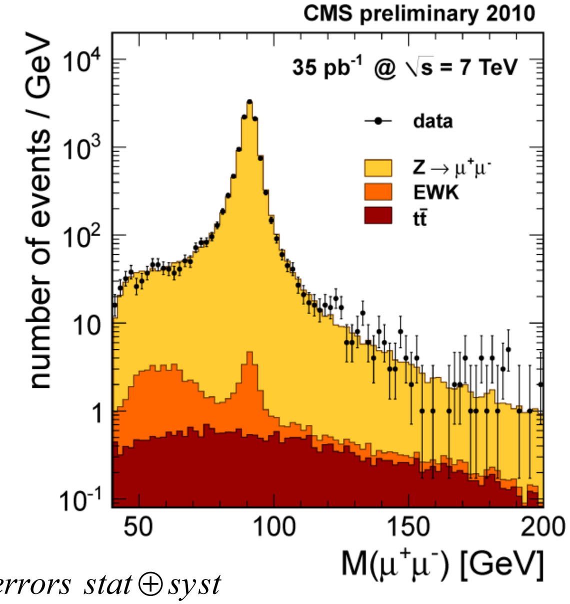
Rediscovering the Standard Model

Z events are important tool: control lepton efficiency, scale, resolution and E_T^{miss} (hadronic recoil)

Data driven methods used in analyses

Z

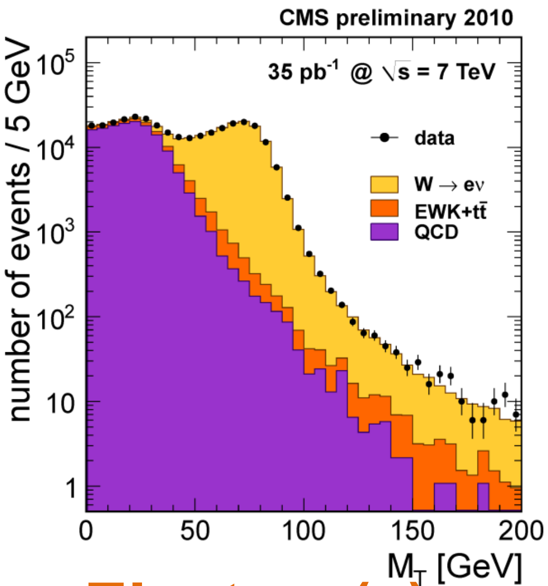


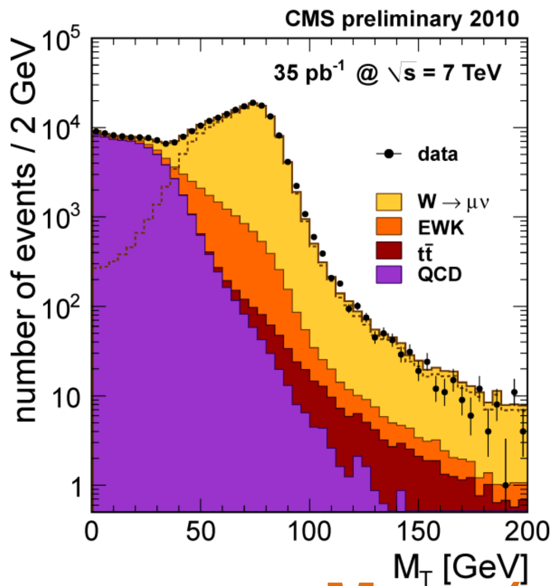


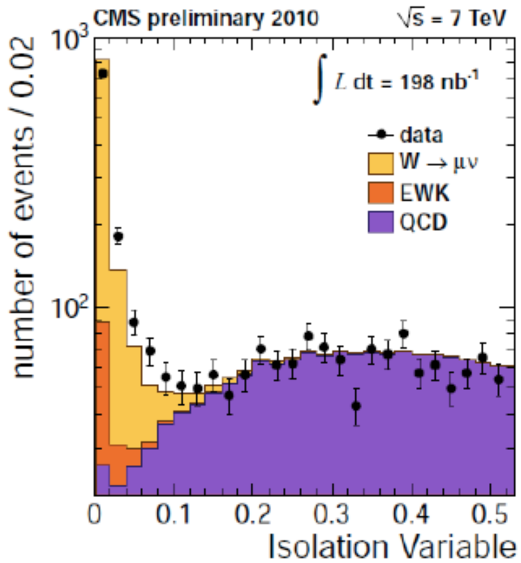
errors stat⊕syst

W Boson

Boson



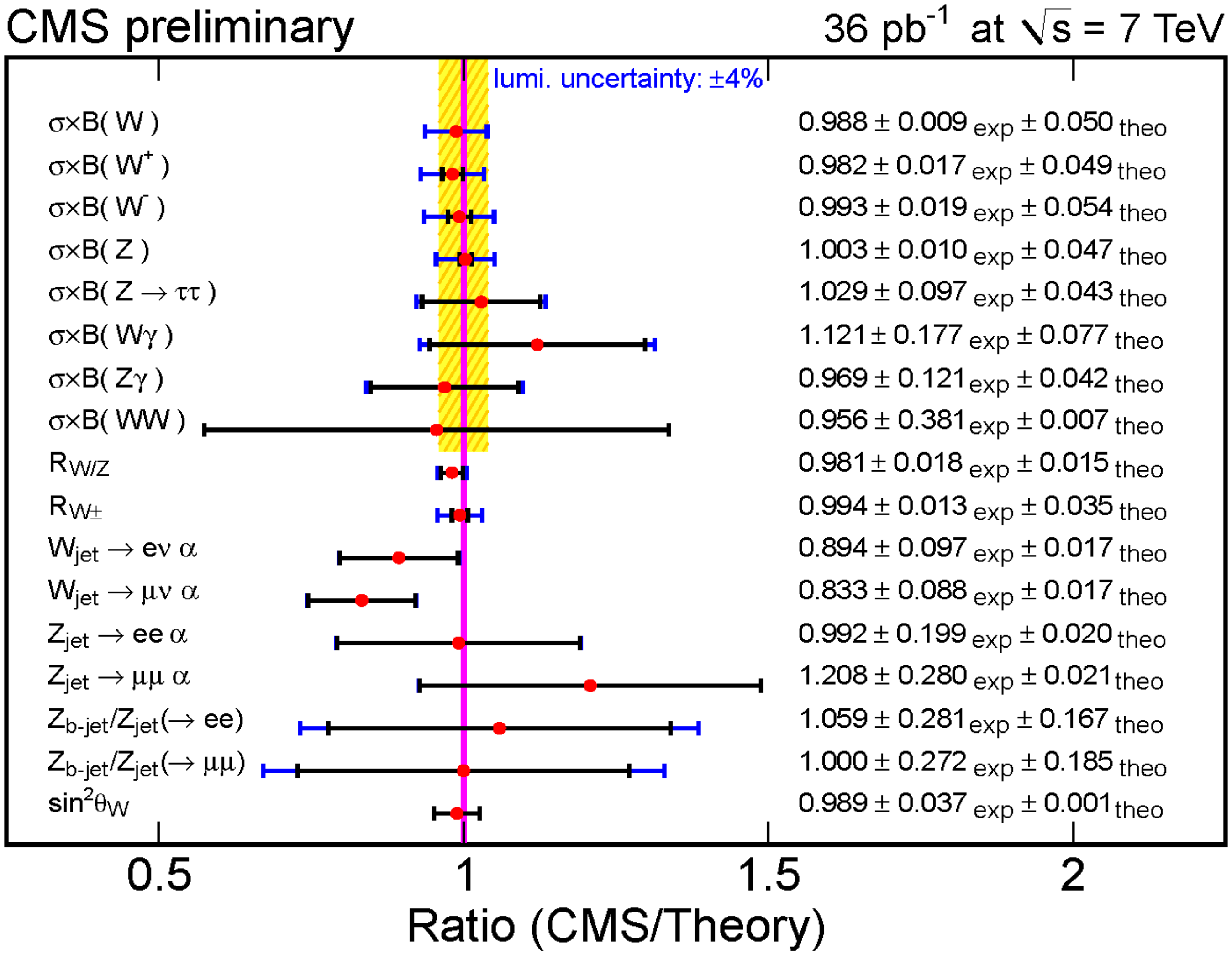




Electron(s)

Muon(s)

Summary of W, Z Measurements



Standard Model at 7 TeV

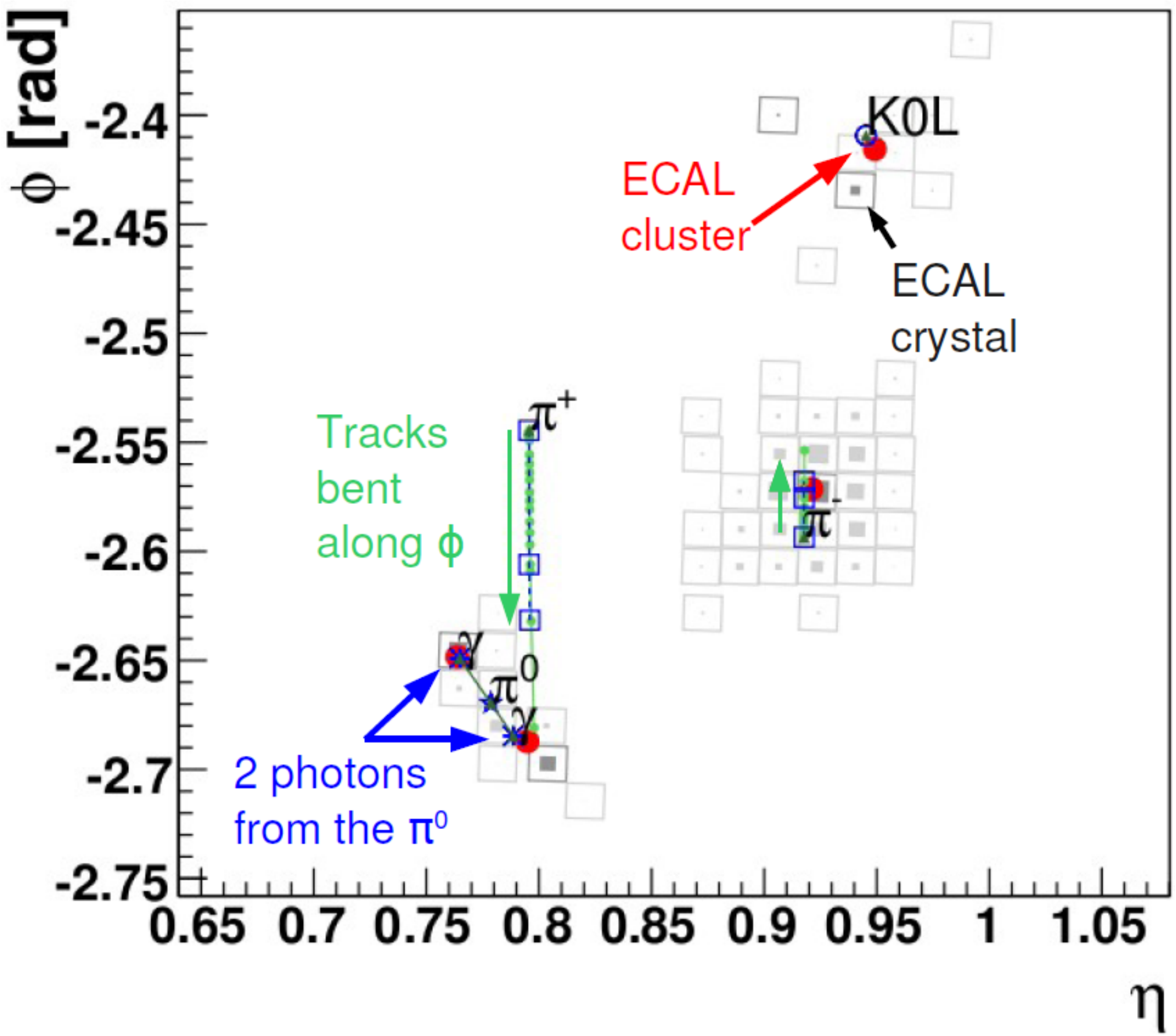
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEWK

What about jets ?

- Jet are objects typically made by
  - 65% charged tracks
  - 25% photons
  - 10% neutral hadrons.
- The high granularity of CMS, and the excellent resolution for measuring momenta of charged tracks and energy of photons is exploited.
- In most CMS published measurement jets are clustered starting from particles (charged hadrons, photons, neutral hadrons, electrons, muons) with the anti-kt algorithm (*) with cone size R=0.5

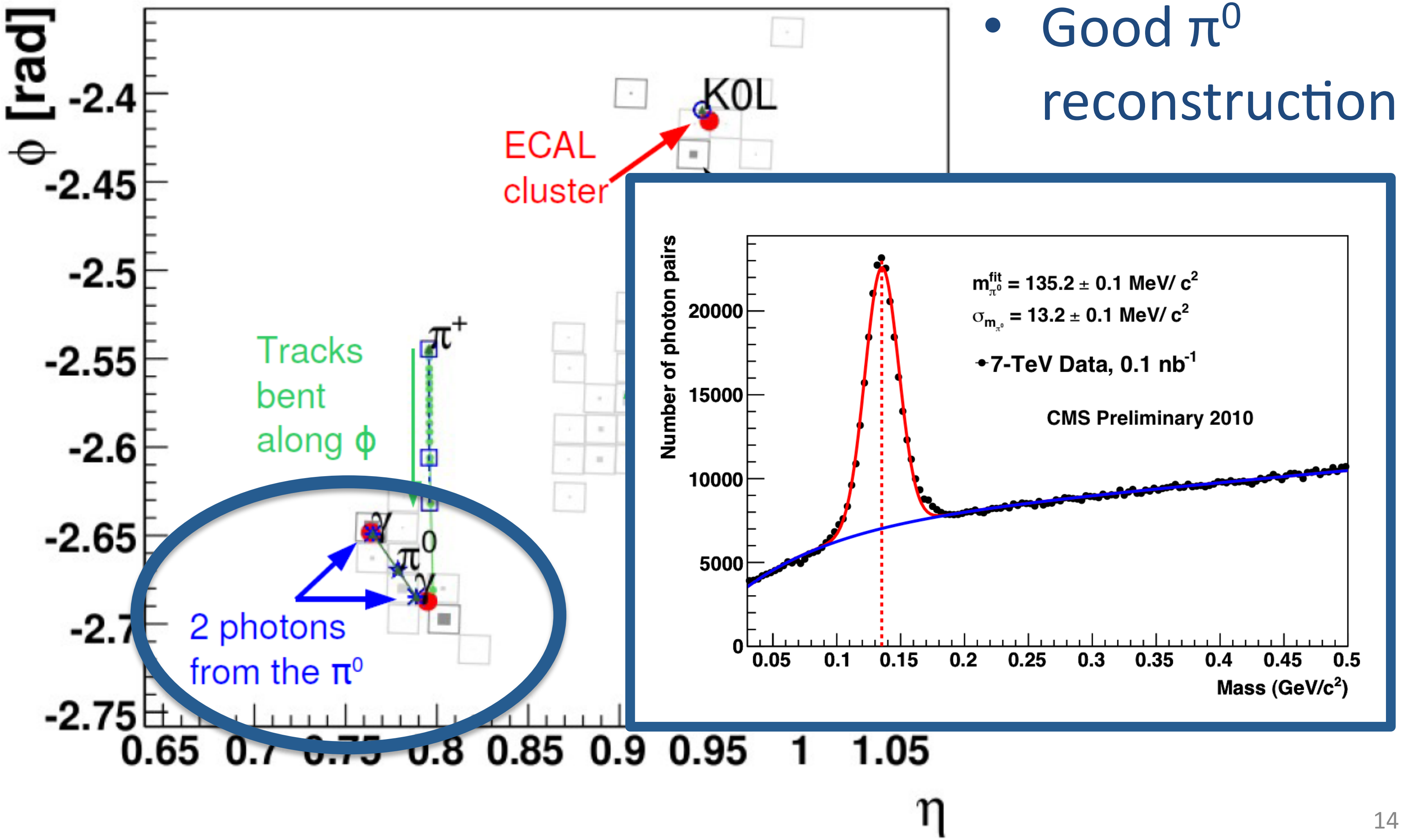
(*) M. Cacciari, G. P. Salam, and G. Soyez, “The anti-k(t) jet clustering algorithm”, JHEP **04** (2008) 063.

Neutral/charged separation: ECAL granularity



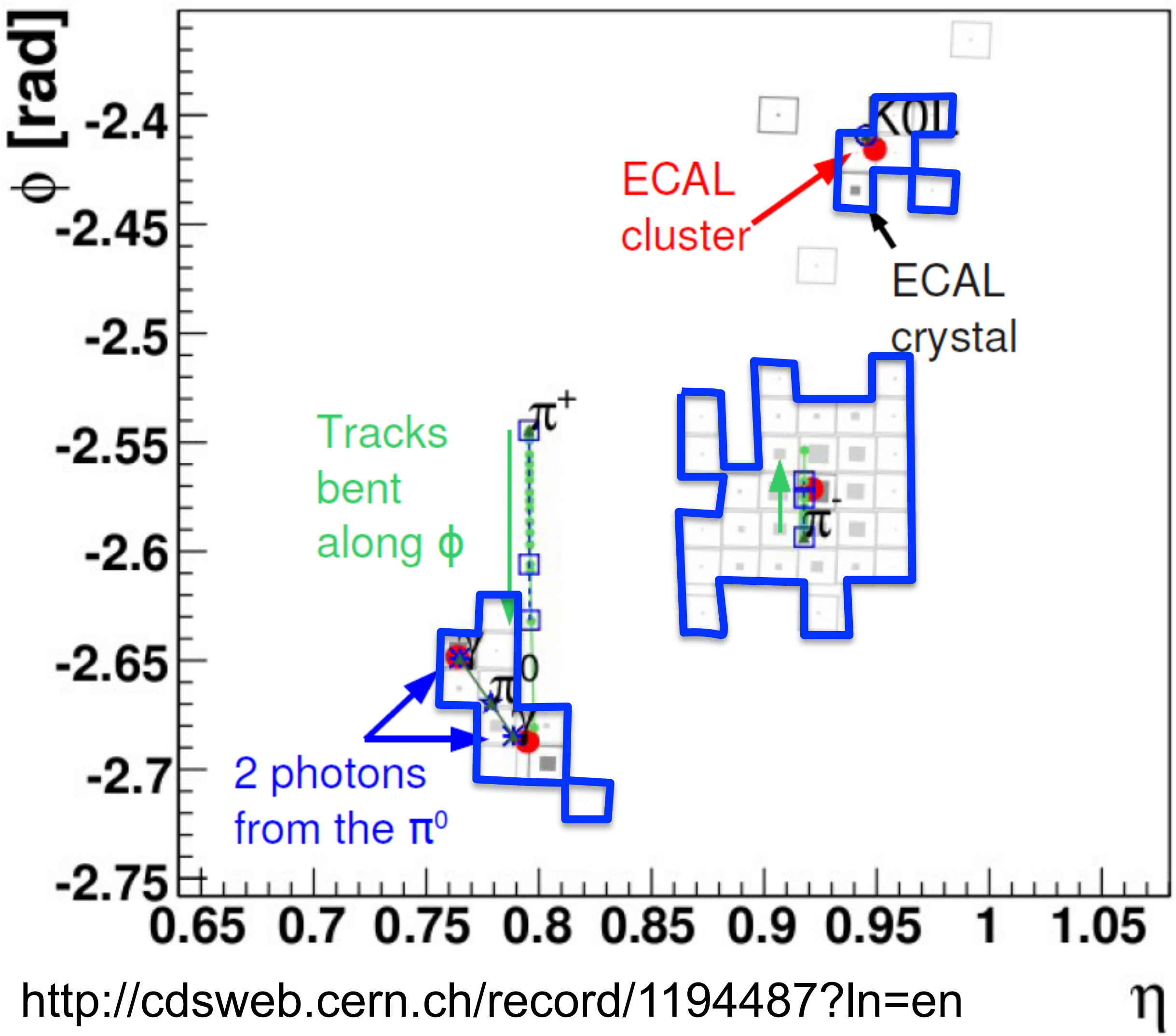
- A typical jet
  - pT = 50 GeV/c
- ECAL Cell size:
  - 0.017x0.017

PF Clustering, ECAL



- Good π^0 reconstruction

Linking – ECAL view



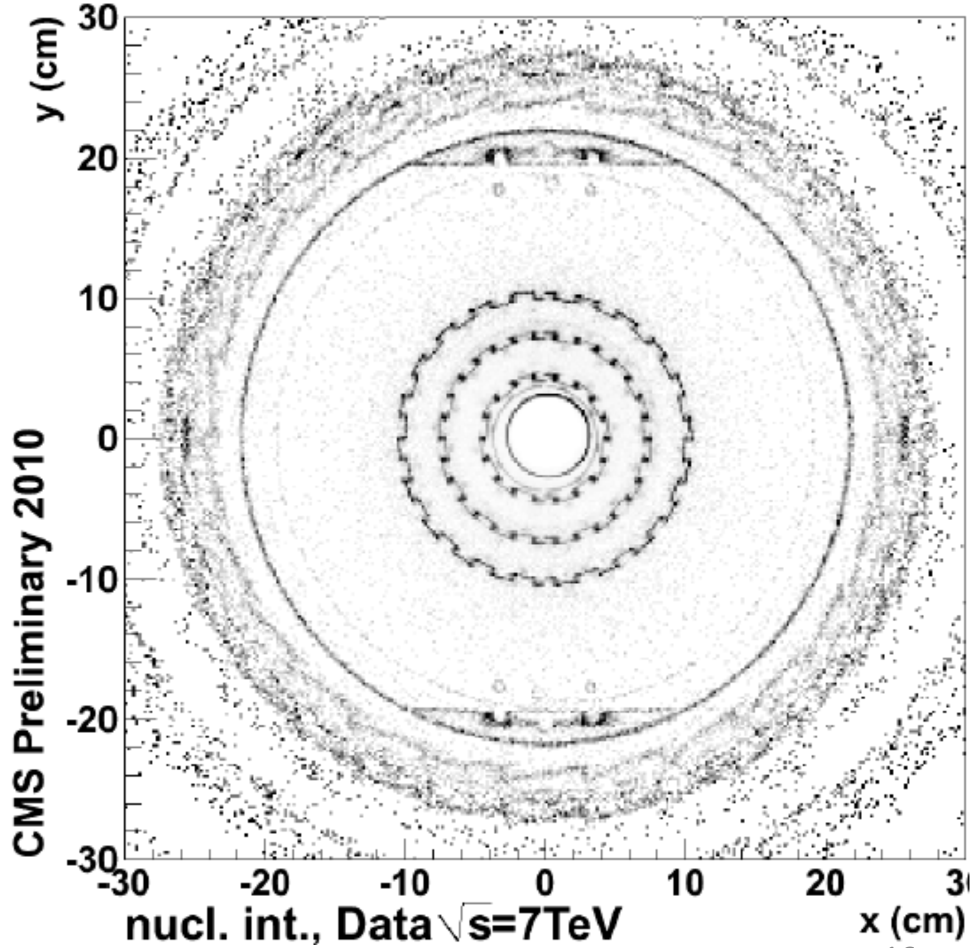
http://cdsweb.cern.ch/record/1194487?ln=en

- Track impact within cluster boundaries
  → track & cluster linked
- Perform clustering in iterative way in ECAL, HCAL, preshower

Tracking and Double counting

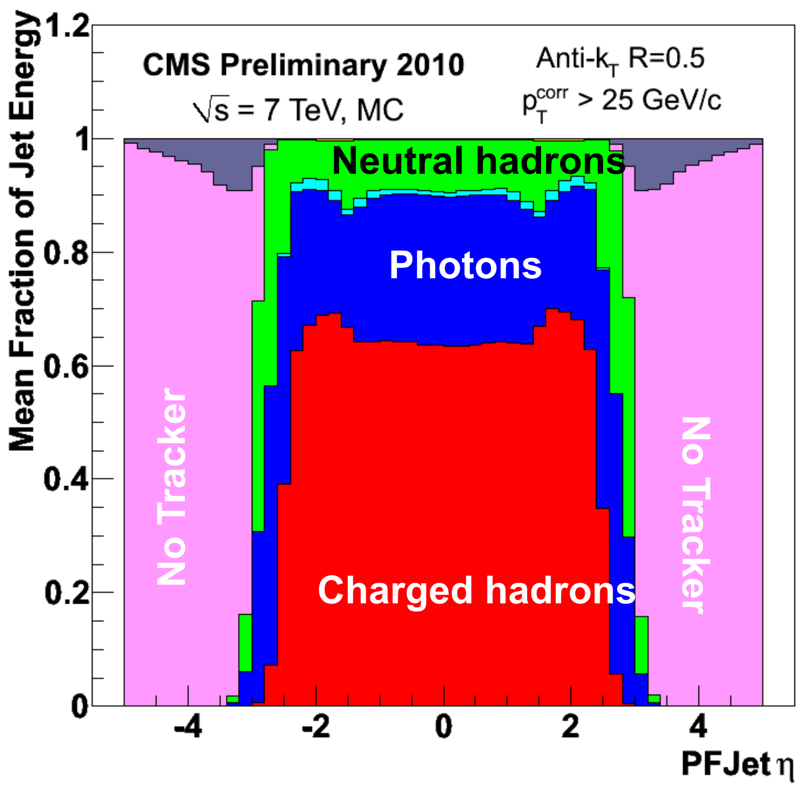
- Secondary tracks used in Particle Flow:
  - Charged hadrons from nuclear interactions
    - No double-counting of the primary track momentum
  - Conversion electrons
    - Converted brems from electrons (cf electron slide later)

Nuclear interaction vertices

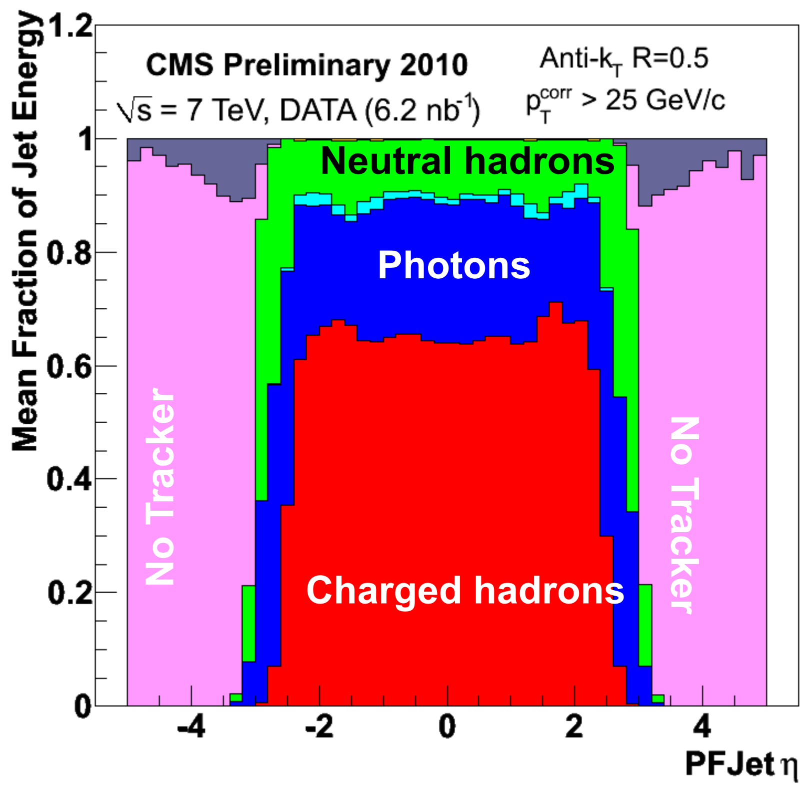


Jet Composition

Simulation

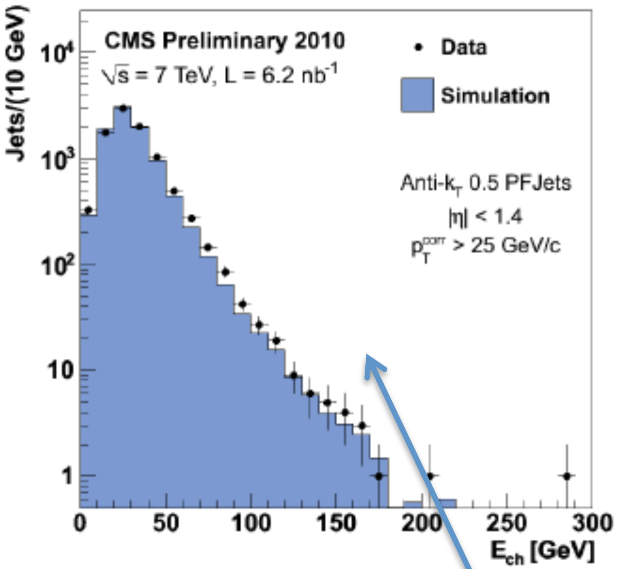


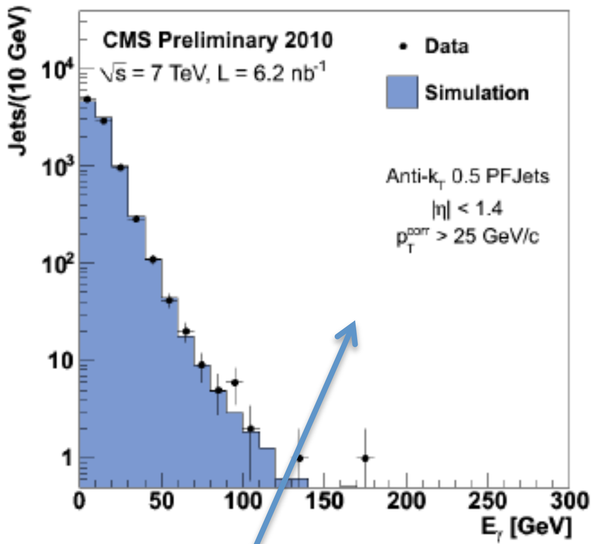
Data

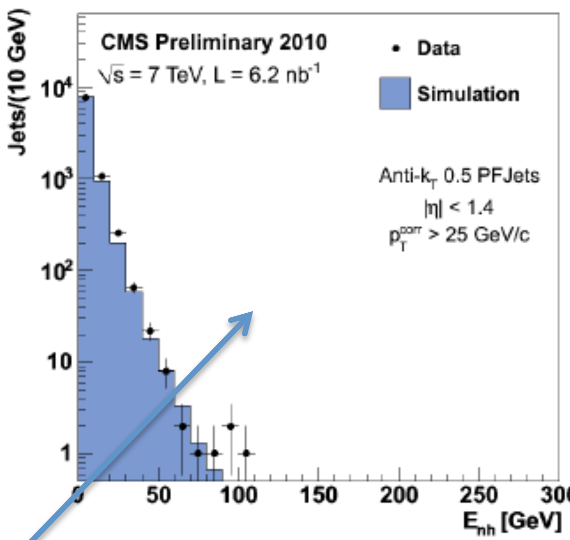


http://cdsweb.cern.ch/record/1279341?ln=en

Particle Flow: basic performance

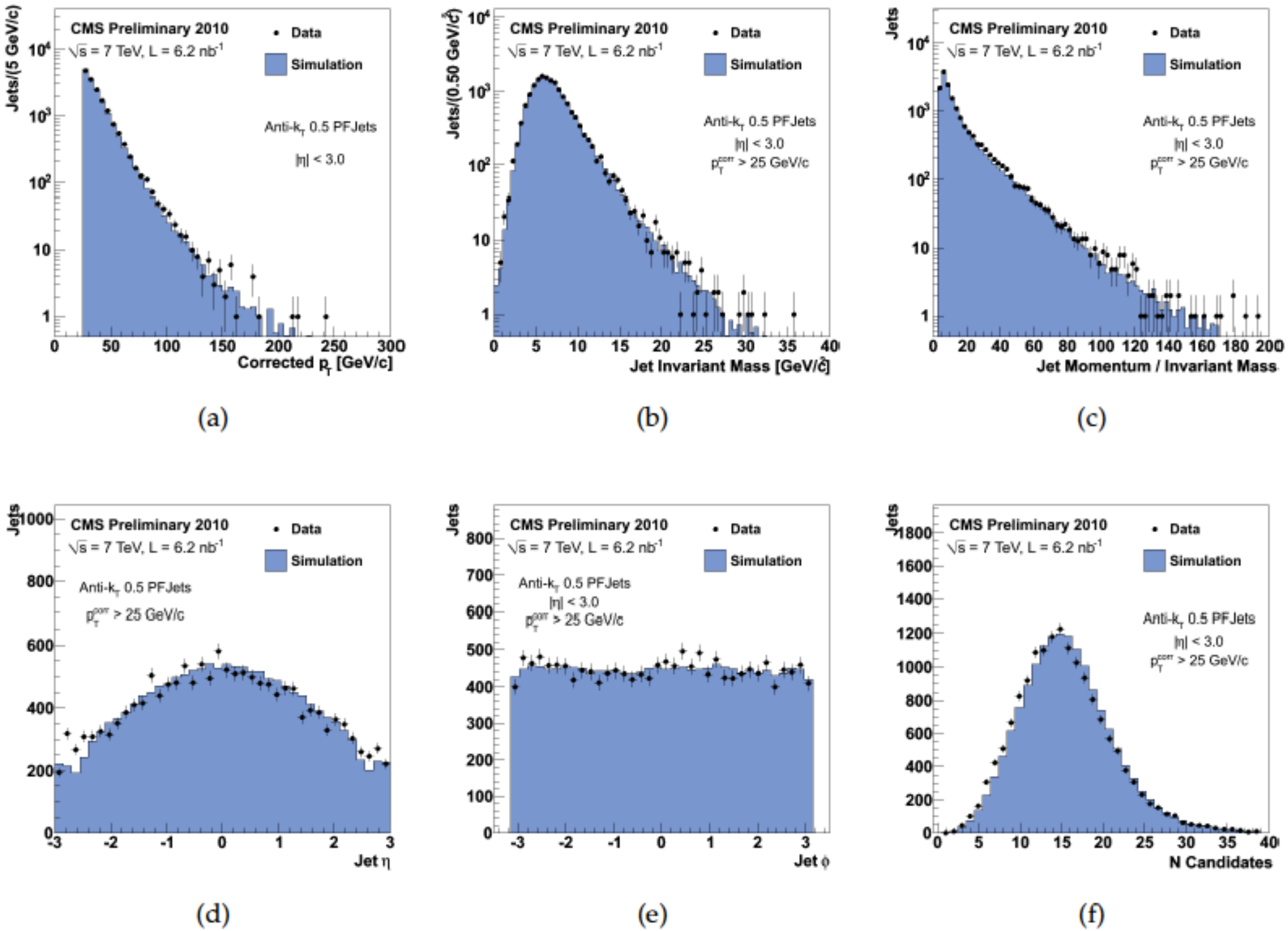




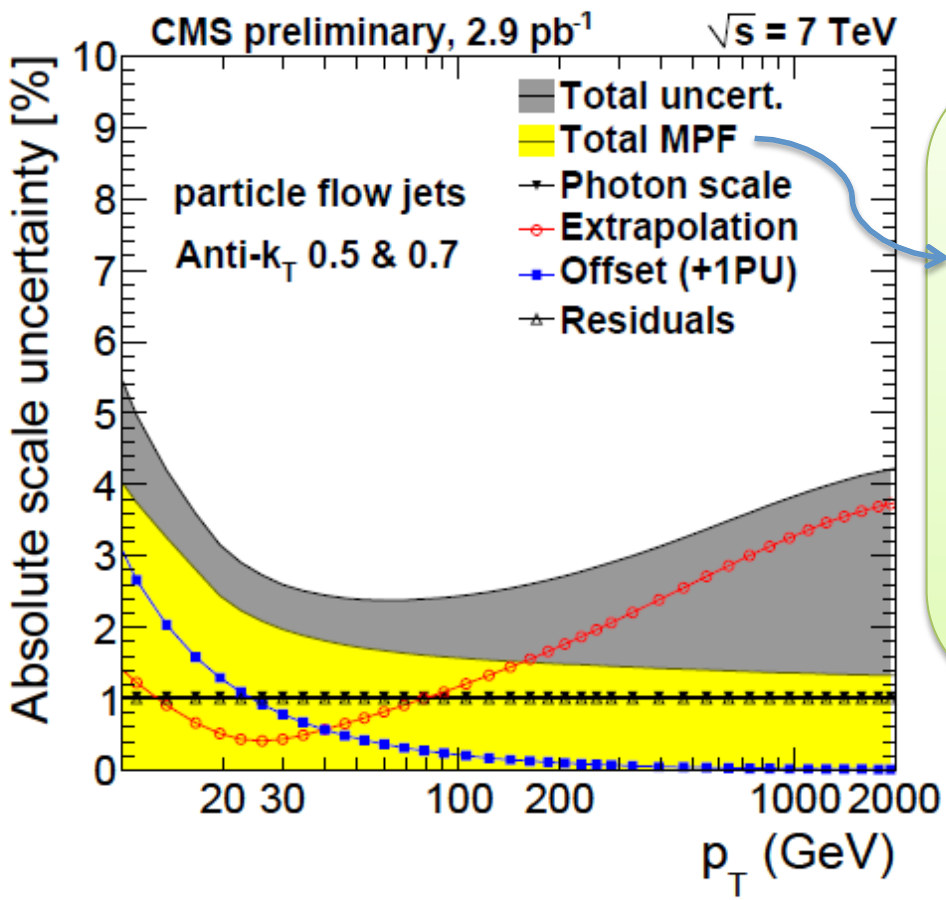


65% charged tracks
25% photons
10% neutral hadrons.

Particle Flow: basic performance



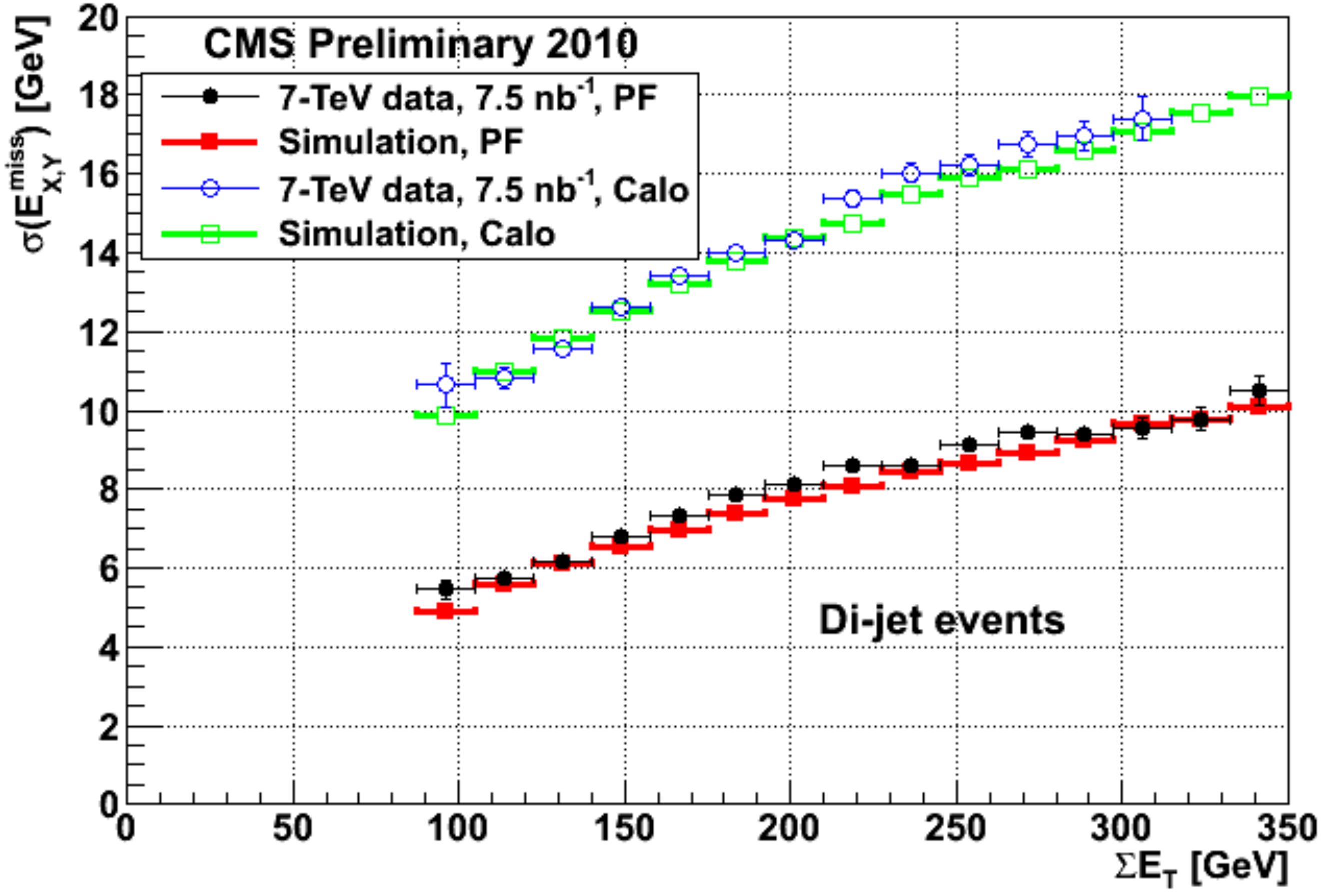
Jet Energy Scale Uncertainty



- γ+jet events
- Total MPF Includes:
  - Flavour uncertainty
  - Parton correction
  - Proton fragments
  - …

http://cdsweb.cern.ch/record/1308178?ln=en

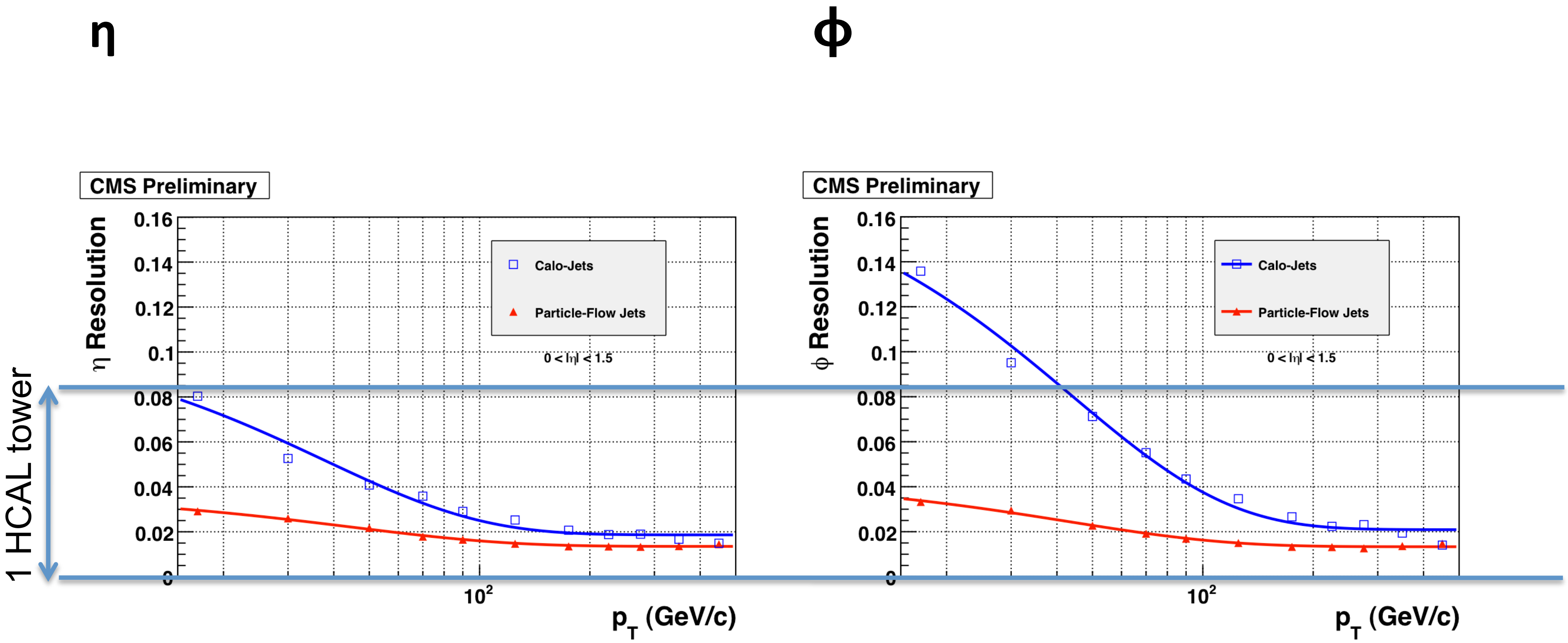
MET Energy resolution (di-jets, data)



$$\frac{55\%}{\sqrt{\Sigma E_T}}$$

http://cdsweb.cern.ch/record/1279341?ln=en

Jet η and ϕ Resolution



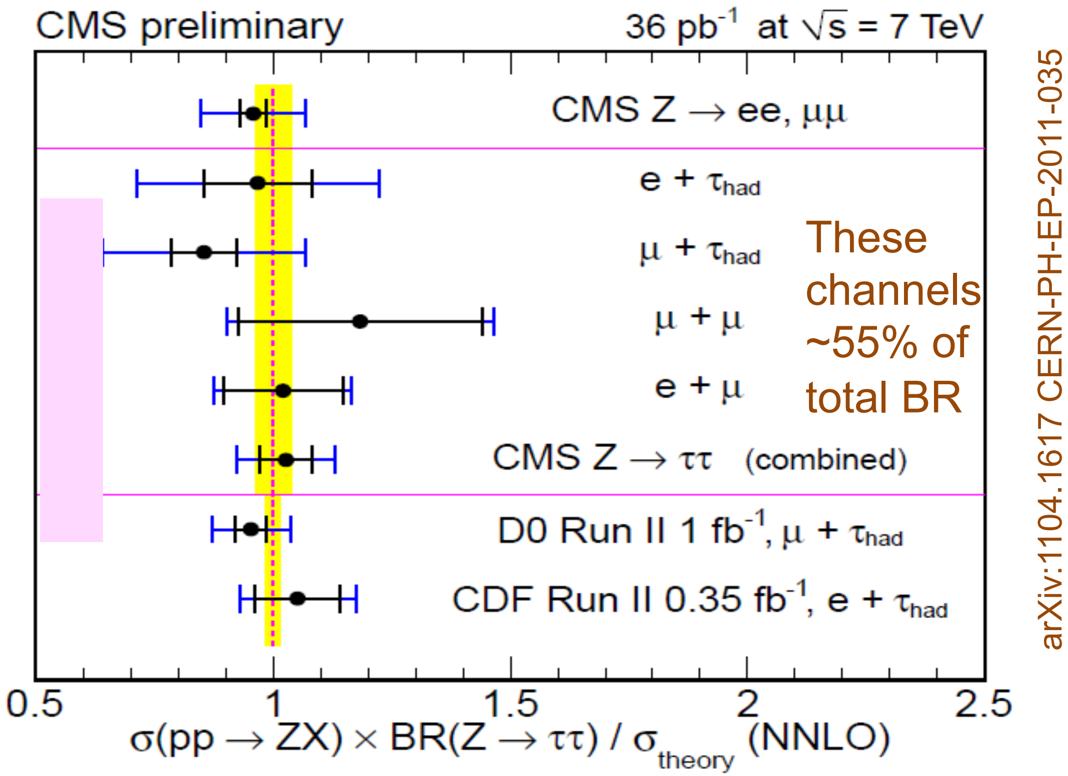
http://cdsweb.cern.ch/record/1194487?ln=en

A FEW MORE PHYSICS RESULTS …
… NOT COVERED IN OTHER TALKS

arXiv:1104.1617

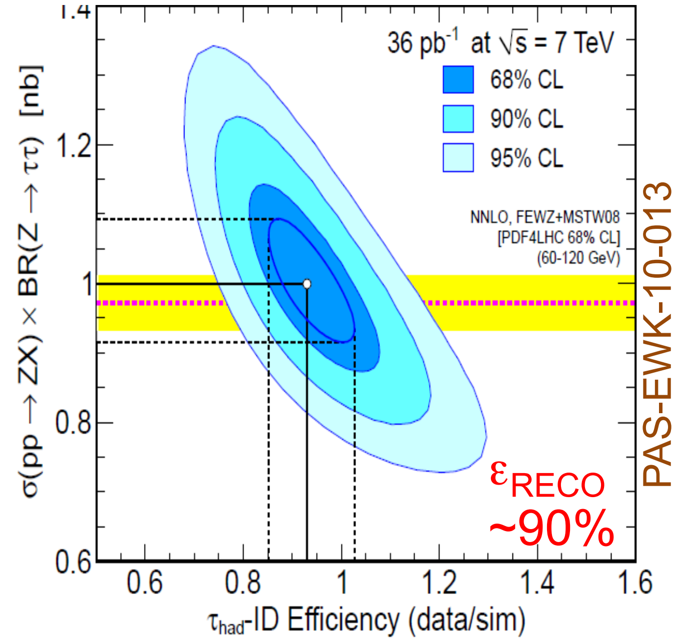
Tau Performance

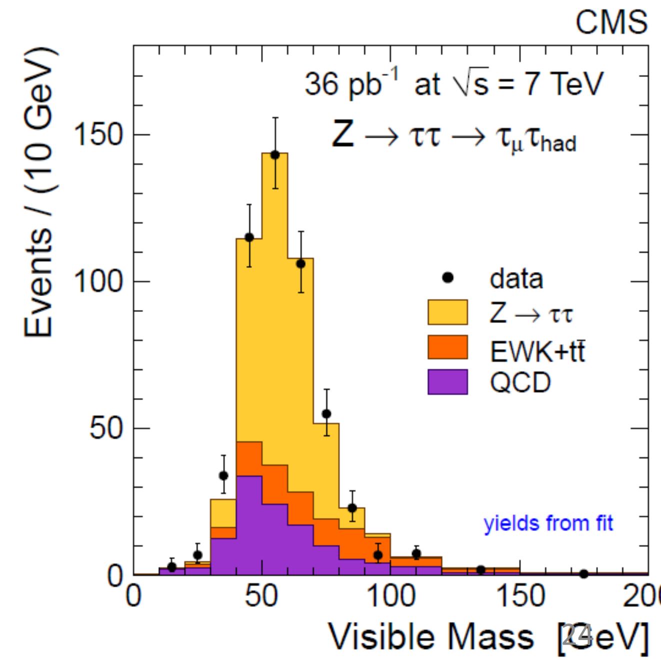
- Reconstruction of individual decay modes of tau leptons based on particle flow
- Inclusive measurement of $Z \rightarrow \tau\tau$.



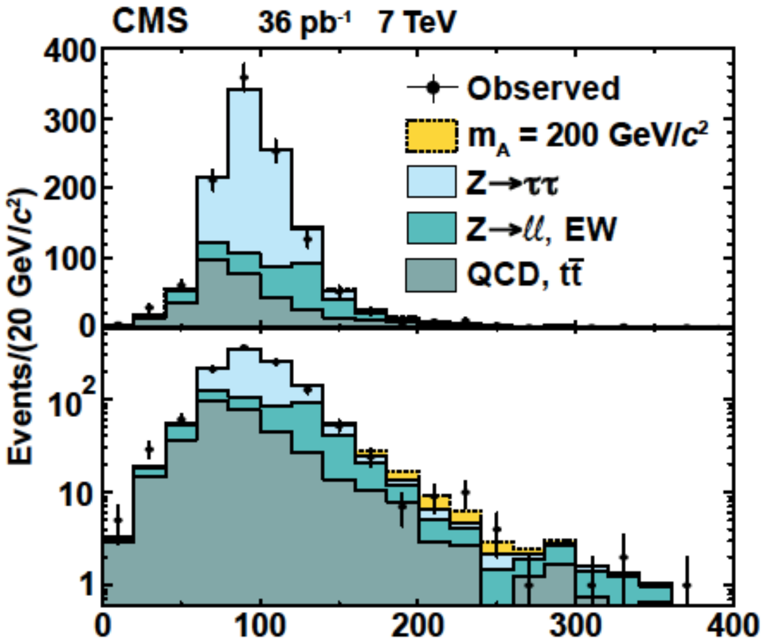
- Established tau as an important tool for many analyses, in particular Higgs

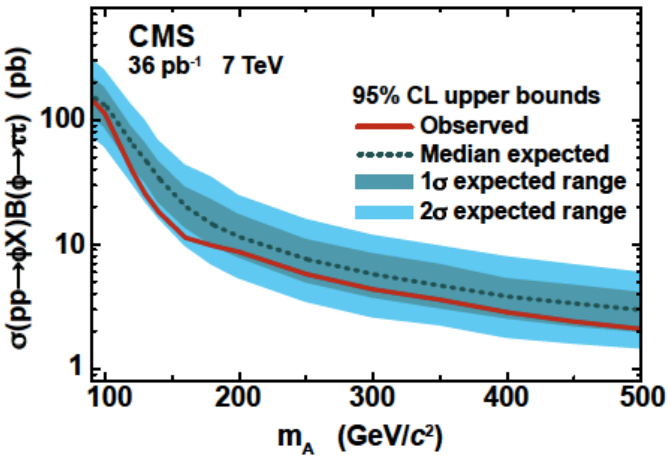
Combined results in the σ×B versus τ-ID-efficiency plane



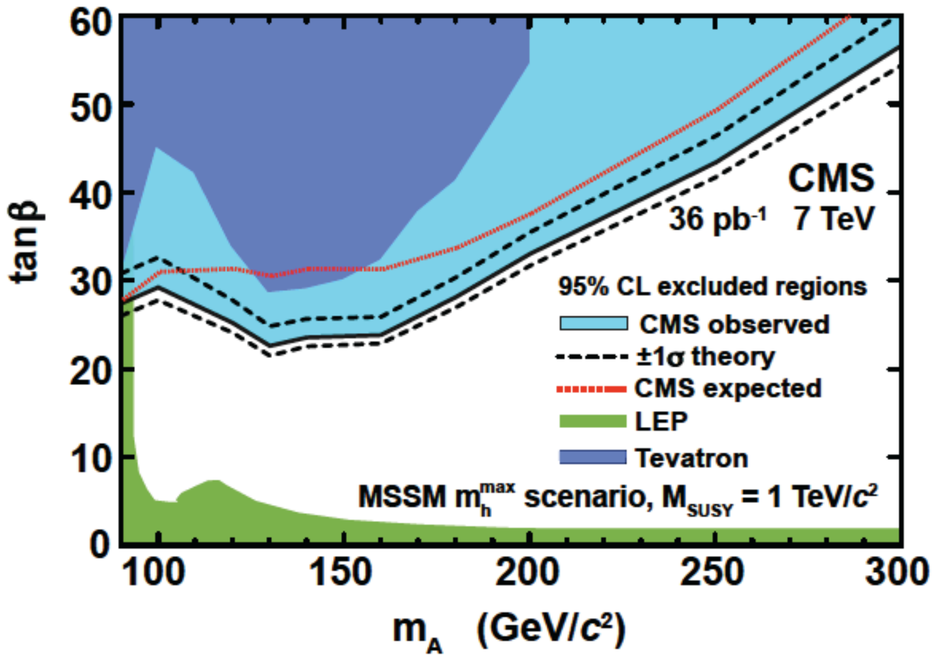


MSSM Higgs -> ττ



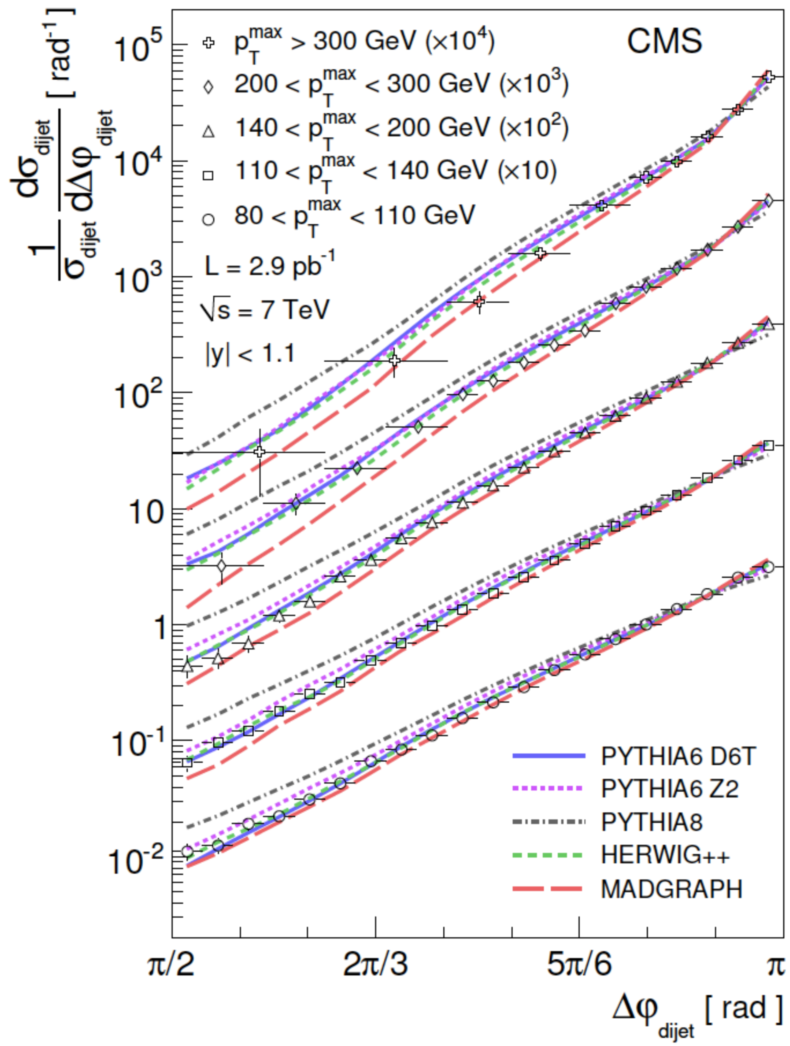


arXiv:1104.1619



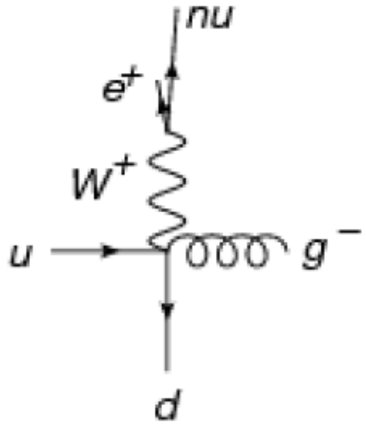
Dijet azimuthal decorrelations

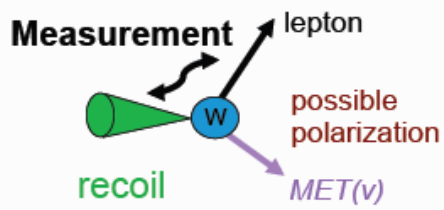
- dijet azimuthal distributions are sensitive to initial-state gluon radiation
- At Born level, dijets are produced with equal pT and back-to-back in the azimuthal angle (Δϕdijet = ϕjet1 − ϕjet2 = π)
- Soft-gluon emission decorrelates the two leading jets and causes small deviations from π.



Measurement of the W polarization

- At LHC most W+1 jet events are from the process qg→Wq
- The V-A structure of weak currents induces a left-handed polarization
- Build a polarization analizer

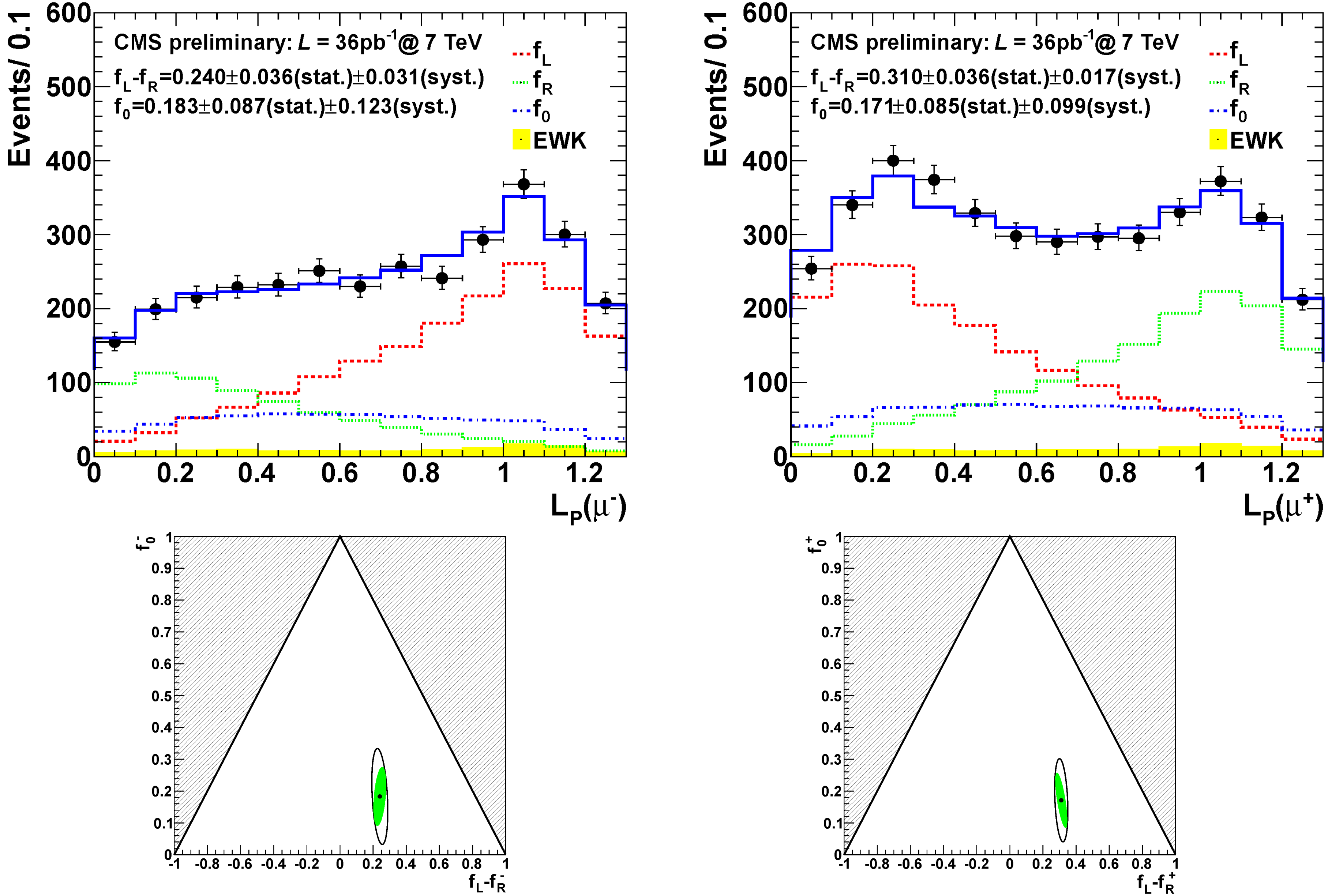




$$\mathrm{LP} = \frac{\vec{p}_T(\ell) \cdot \vec{p}_T(W)}{|\vec{p}_T(W)|^2}$$

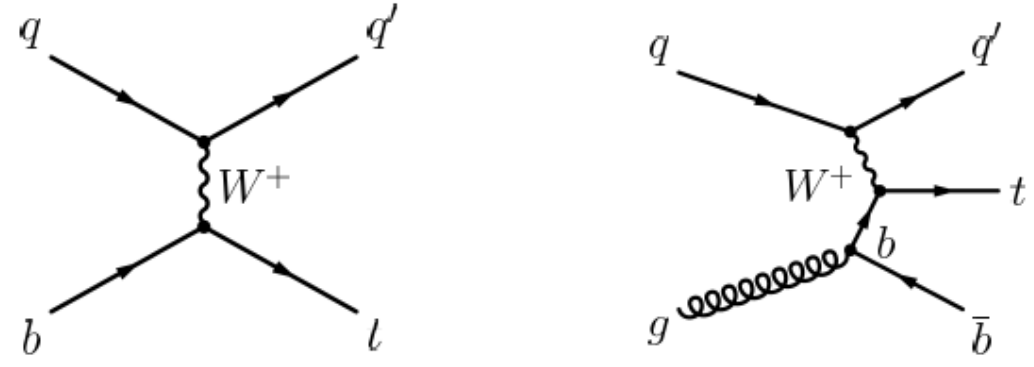
$$p_T(W) > 50\,\mathrm{GeV}$$

Measurement of the W polarization



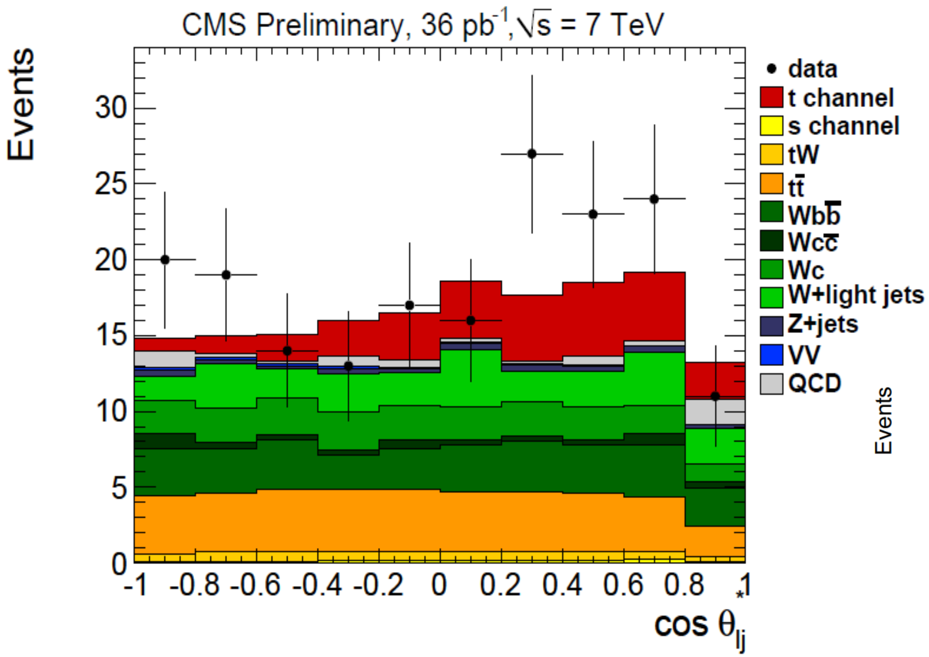
Measurement of single top cross sec

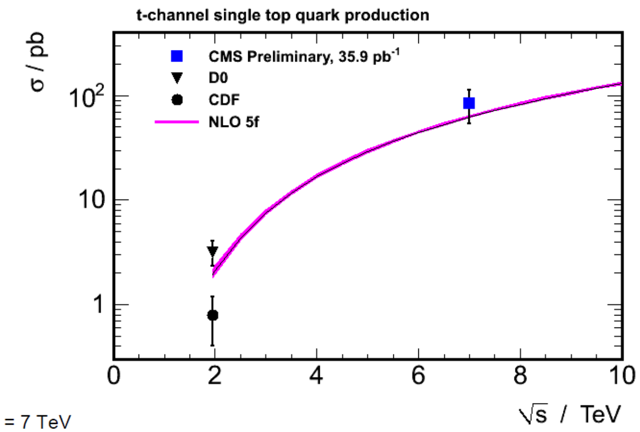
- Single top production at LHC is relatively large (64 pb at 7 TeV for the t-channel)
- Electroweak production: signatures due to the V-A structure of the current

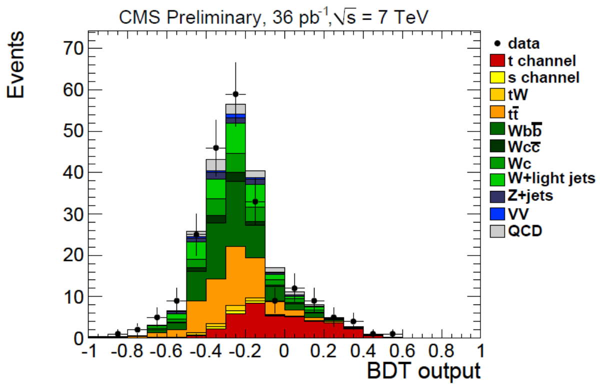


Measurement of single top cross sec

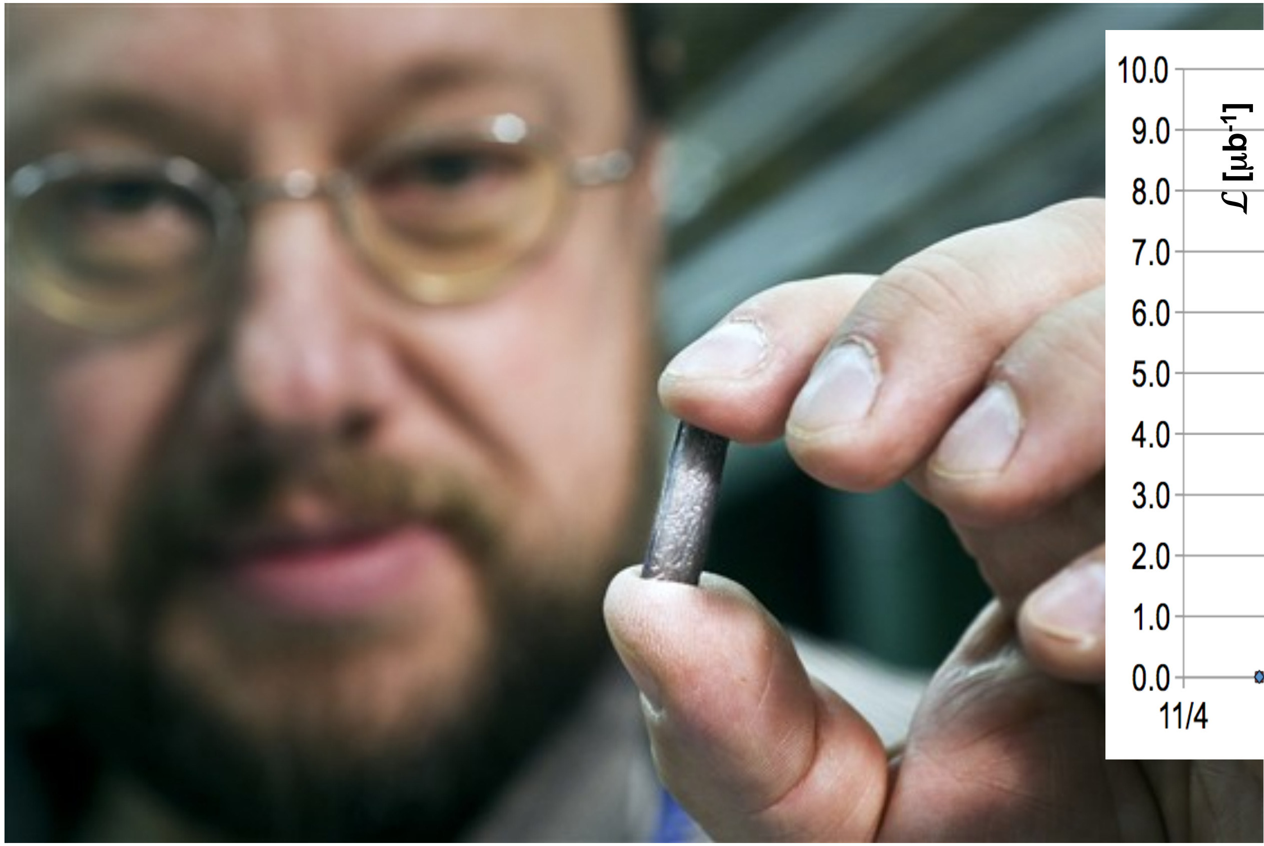
- Select a isolated muon (electron) pT > 20 (30) GeV, one b-tagged jet, one non-btagged jet
- Exploit polarization of top quark taking angle between untagged jet and lepton in top rest frame



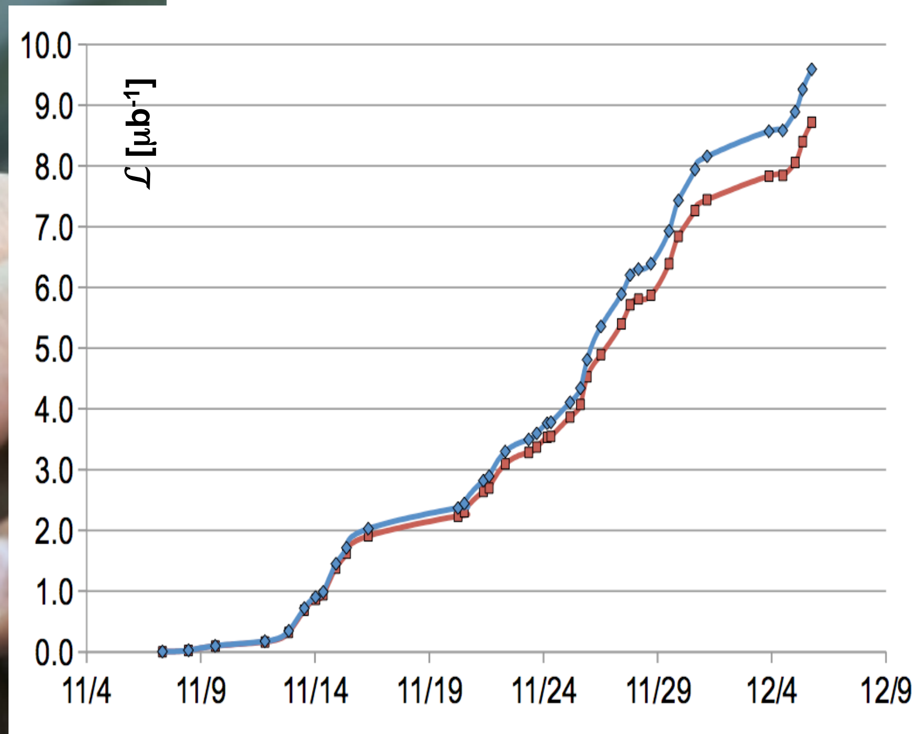




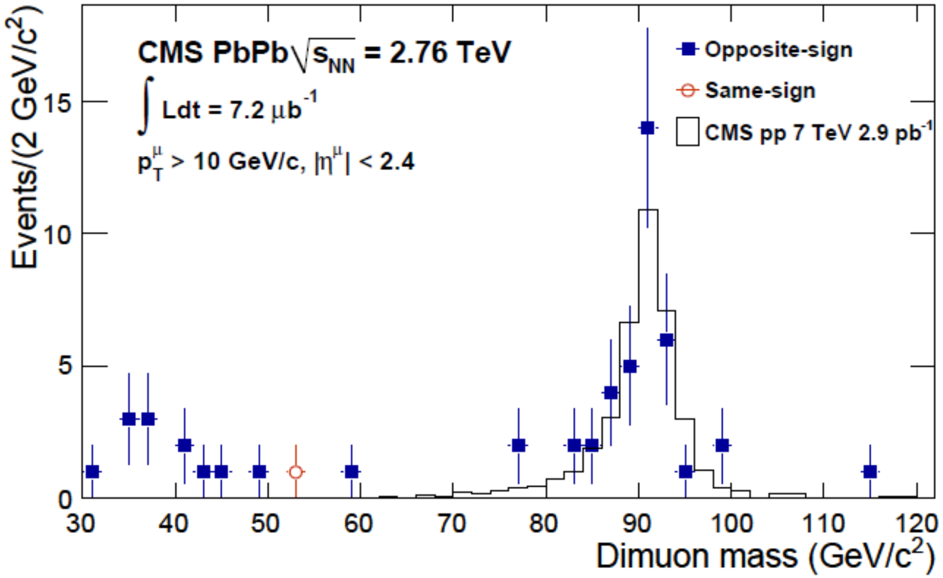
Lead-Lead collisions

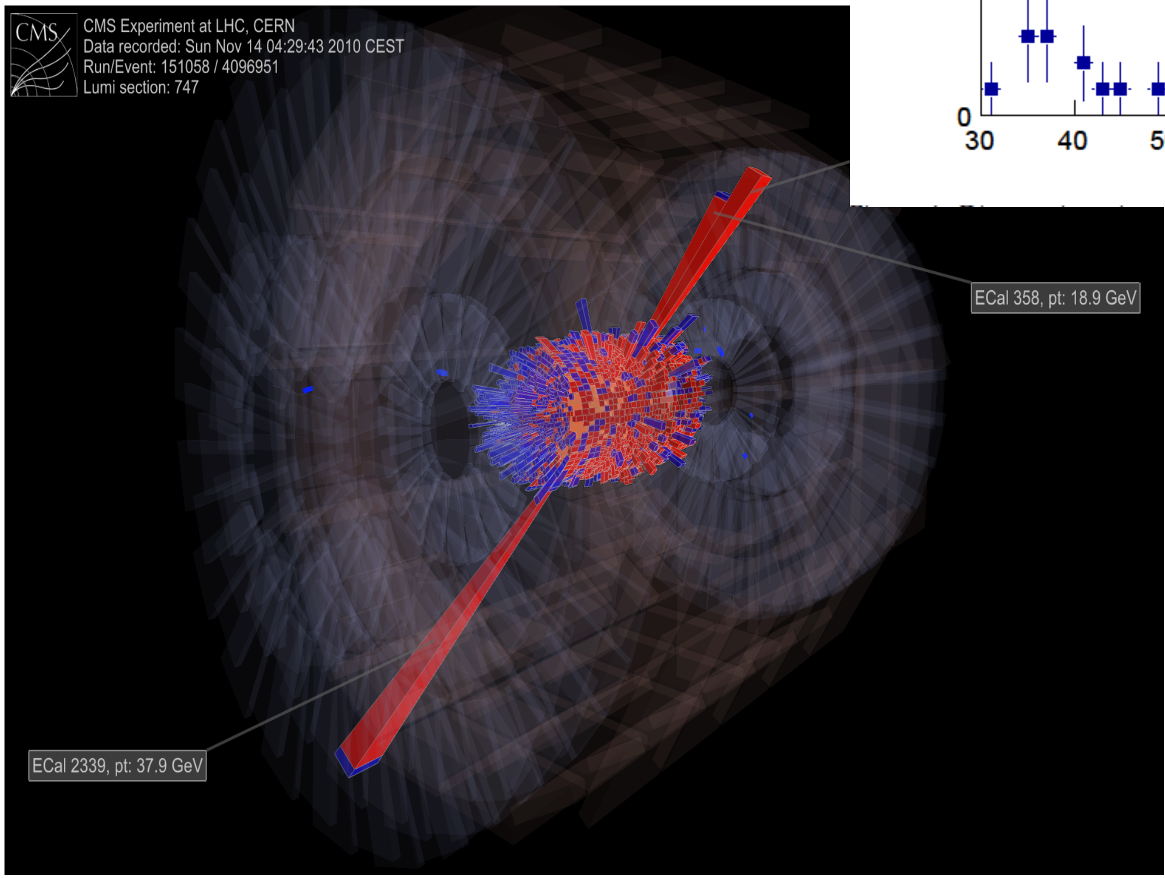


Pb-Pb@$\sqrt{s_{NN}}$=2.76TeV



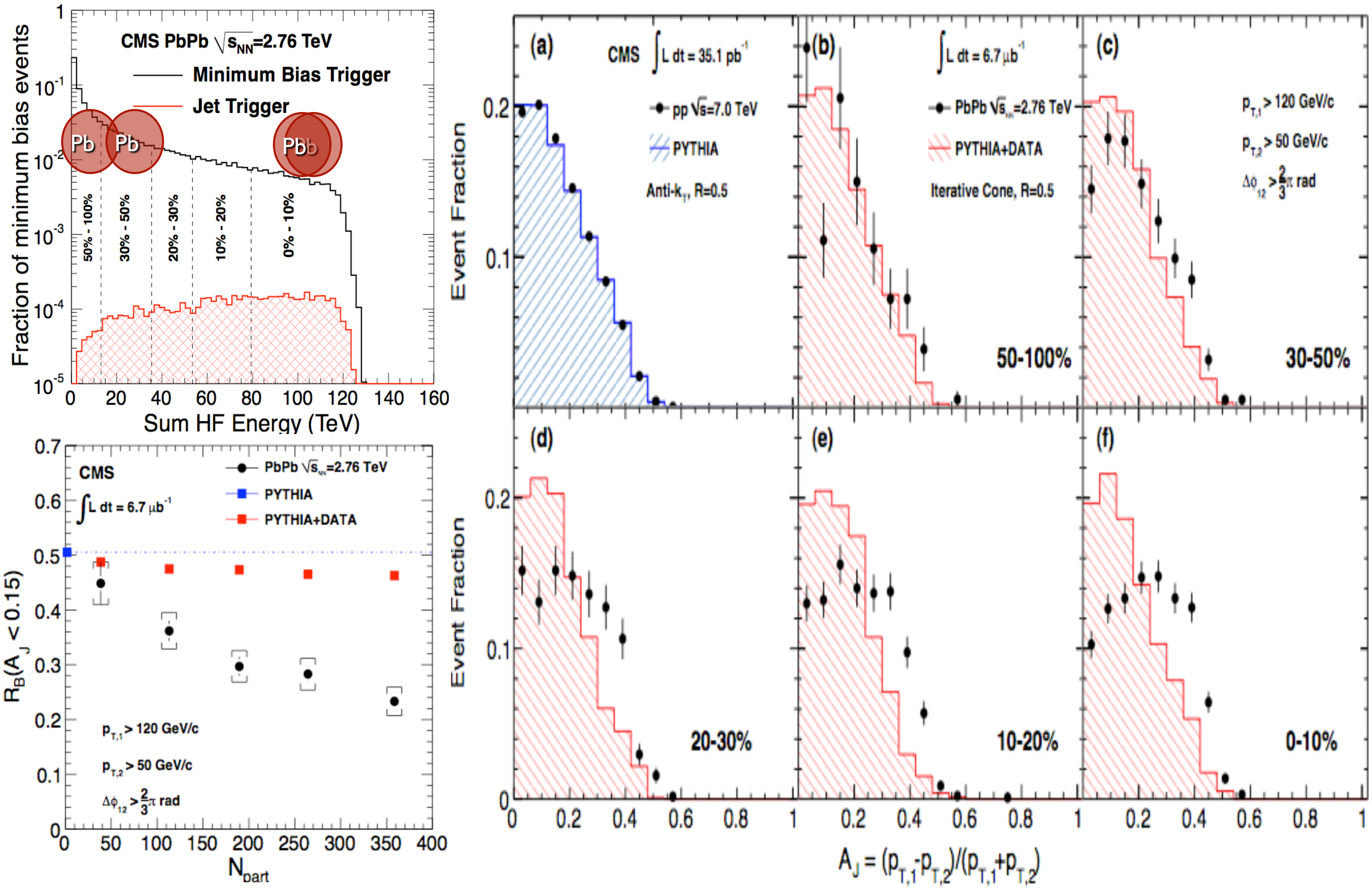
Observation of Z in Heavy Ion collisions



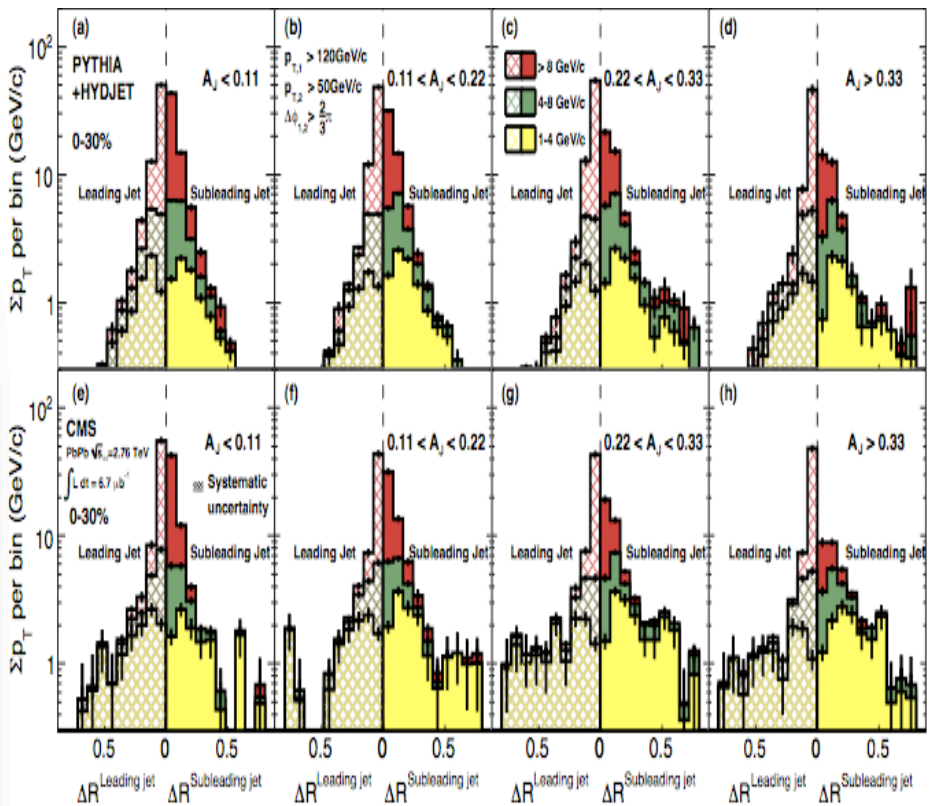


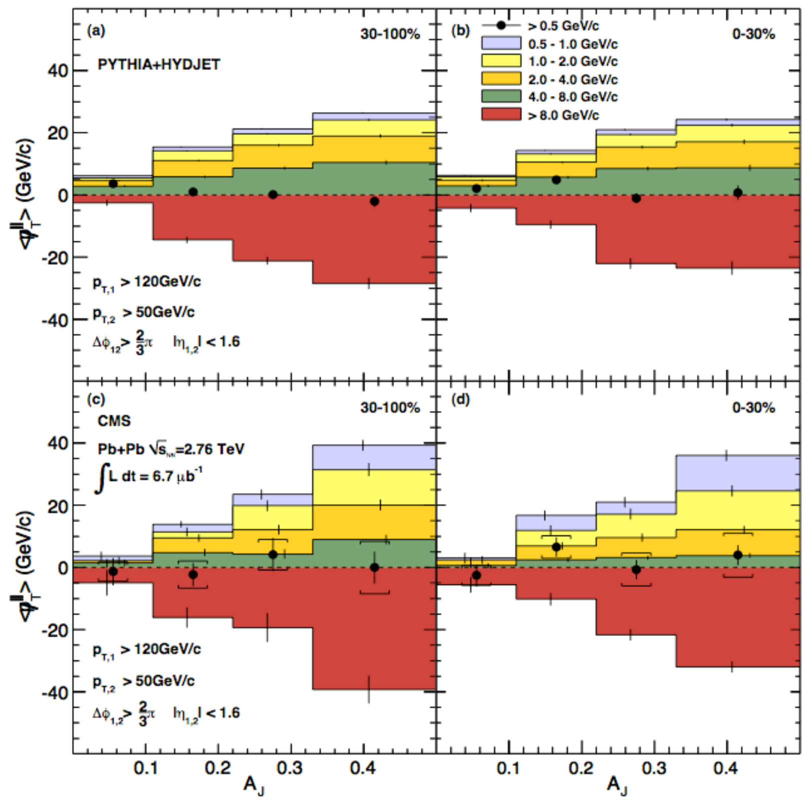
Important because non affected by the medium in quark gluon plasma

direct observation of Jet-quenching



First detailed understanding of jet quenching





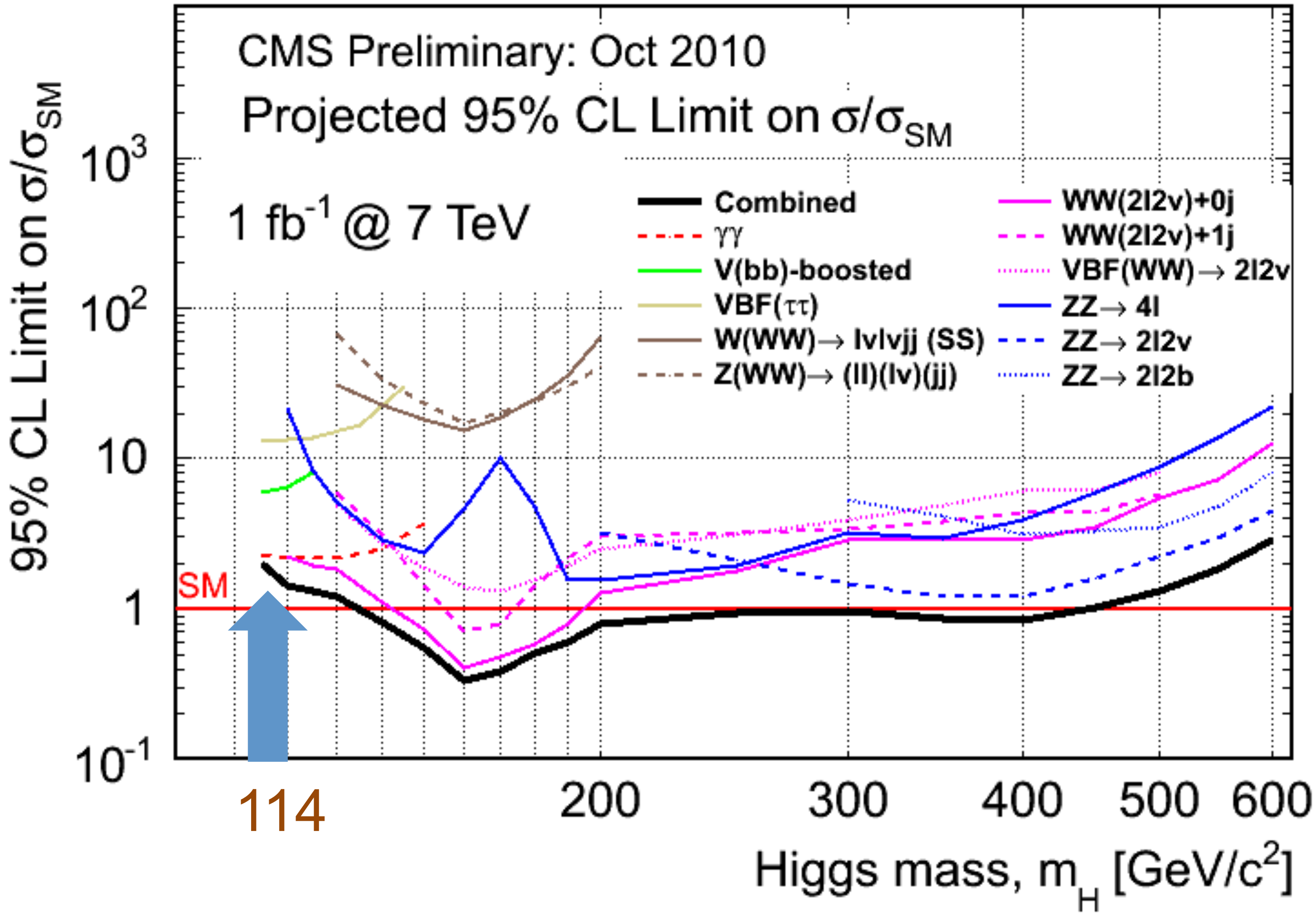
The phenomenon of jet quenching in Heavy-Ion collisions is now described in detail and fully understood.

The di-jet momentum balance is fully recovered if we consider the low p_T tracks distributed over a wider angular range wrt the jet axis.

arXiv:1102.1957 ; CERN-PH-EP-2011-001.

Projected Exclusions with 1fb^{-1}@7 TeV

LEP M_H>114 GeV Tevatron 158 < M_H<173 GeV

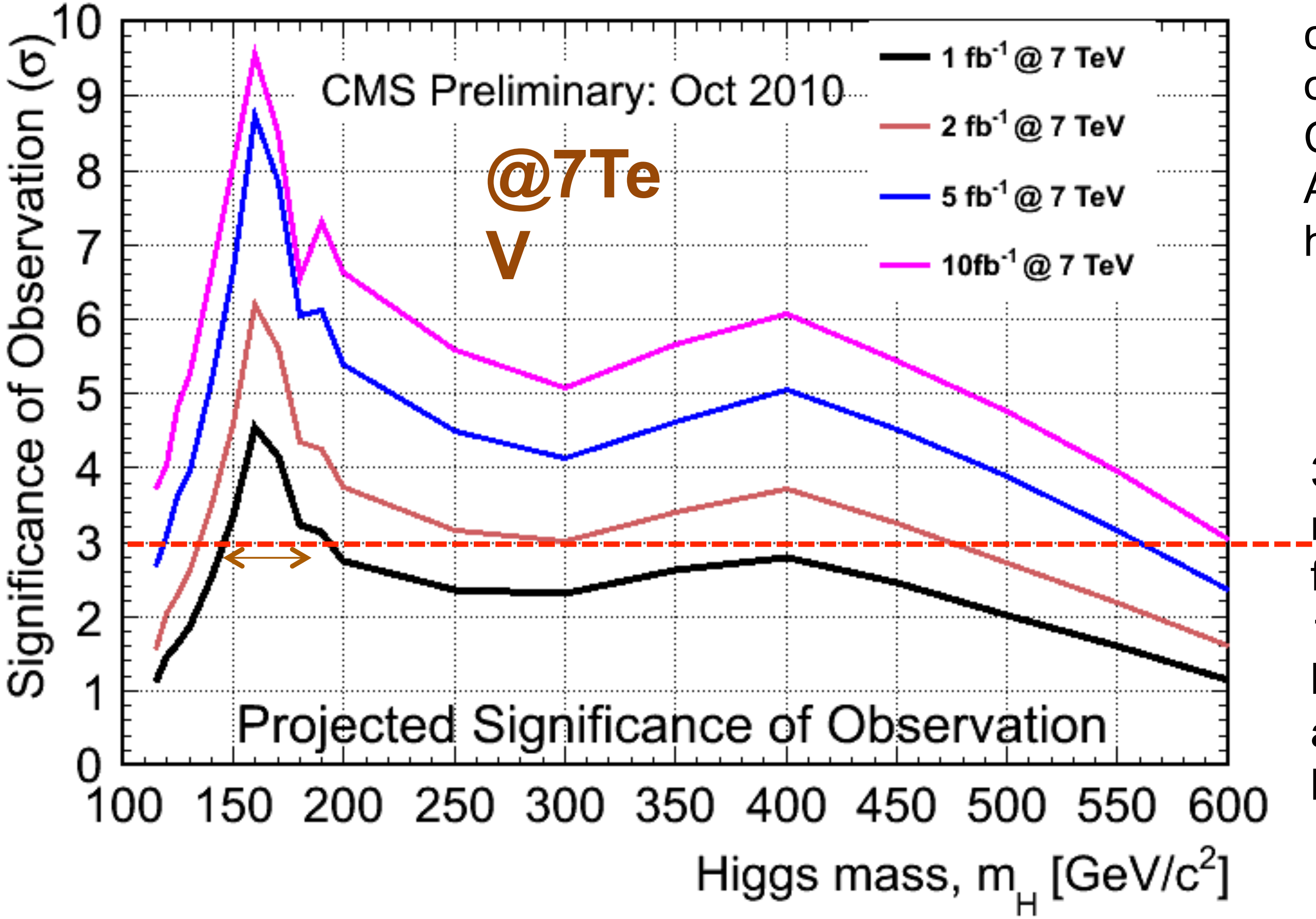


Combination of many channels would just allow to exclude a wide mass range 130<M_H<450GeV

Below 130GeV extremely challenging. Needs H→γγ

Projected Observation Significance

LEP M_H>114 GeV Tevatron 158 < M_H<173 GeV



Observation very challenging for one experiment. Combination effort ATLAS + CMS has started

3σ can be reached with 2/fb for 150<M_H<470GeV but partially already excluded by Tevatron

Summary

- With the 2010 data taking CMS has performed a comprehensive set of Standard Model measurements at 7 TeV for W, Z, top and QCD. First precision measurements.
- Many searches for new physics are performed. Unfortunately nothing found yet. New limits have been set, in many areas, exceeding the current best limit.
- Prospects for Higgs and other searches in 2011-12 appear to be very promising.
- Challenge for 2011 – 2012 is pileup and maintain the trigger band.

Awaiting eagerly more data in 2011

Stay tuned