Tau 2010

$Z \rightarrow \tau\tau$ studies with CMS at $\sqrt{s}$= 7 TeV
First Results

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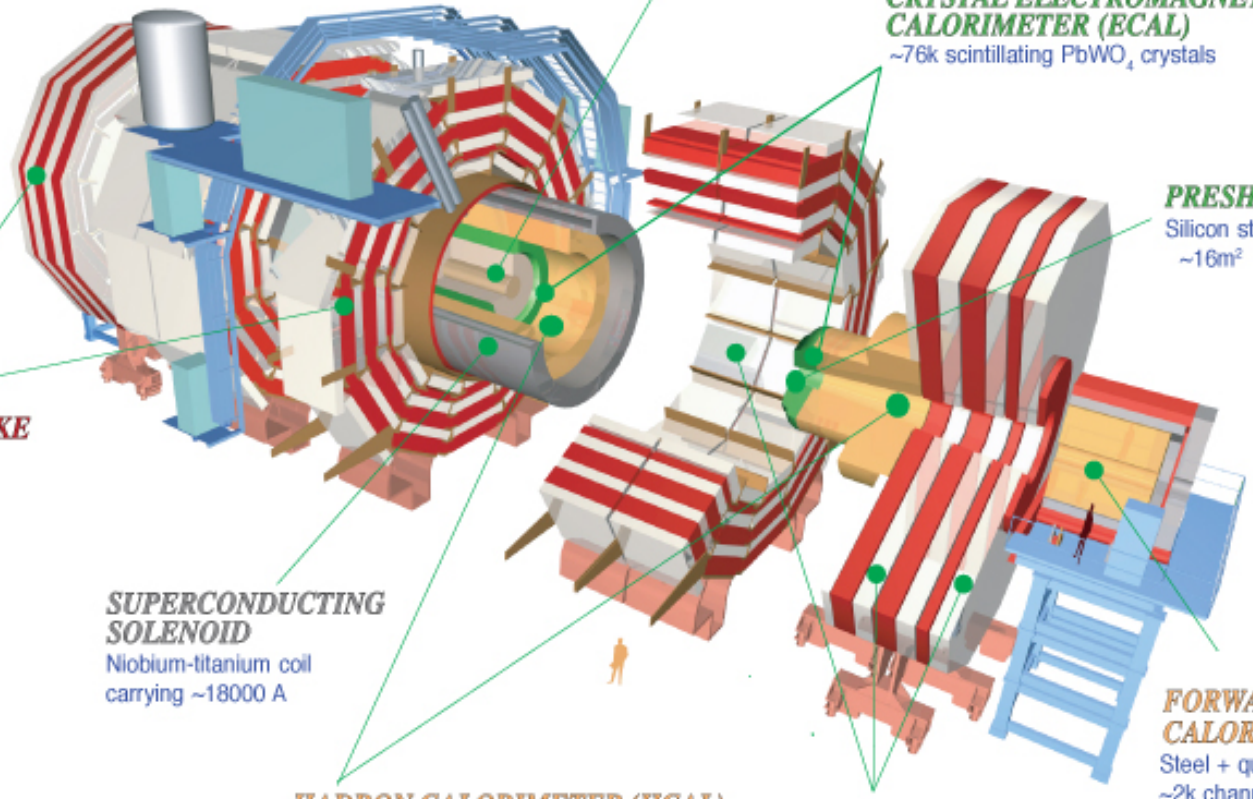
On behalf of the CMS collaboration

Why Z → tau tau?

- Measurement of Z cross section in the tau channel and ratios to the muon and electron channels is a test of the SM in the new LHC energies
- Z → tau tau provides a source of real hadronic taus for
  - Study of the Tau Identification Algorithms
  - Measurement of the hadronic tau trigger efficiency with real taus
- Z → tau tau is a candle signal for new physics searches
  - SM, MSSM H → tau tau has similar topology
  - The analysis selection and data driven methods can be exercised and optimized in Z

The CMS Detector



Pixels
Tracker
ECAL
HCAL
Solenoid
Steel Yoke
Muons

SILICON TRACKER
Pixels (100 x 150 μm²)
~1m² ~66M channels
Microstrips (80-180μm)
~200m² ~9.6M channels

CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
~76k scintillating $PbWO_4$ crystals

PRESHOWER
Silicon strips
~16m² ~137k channels

STEEL RETURN YOKE
~13000 tonnes

SUPERCONDUCTING SOLENOID
Niobium-titanium coil
carrying ~18000 A

FORWARD CALORIMETER
Steel + quartz fibres
~2k channels

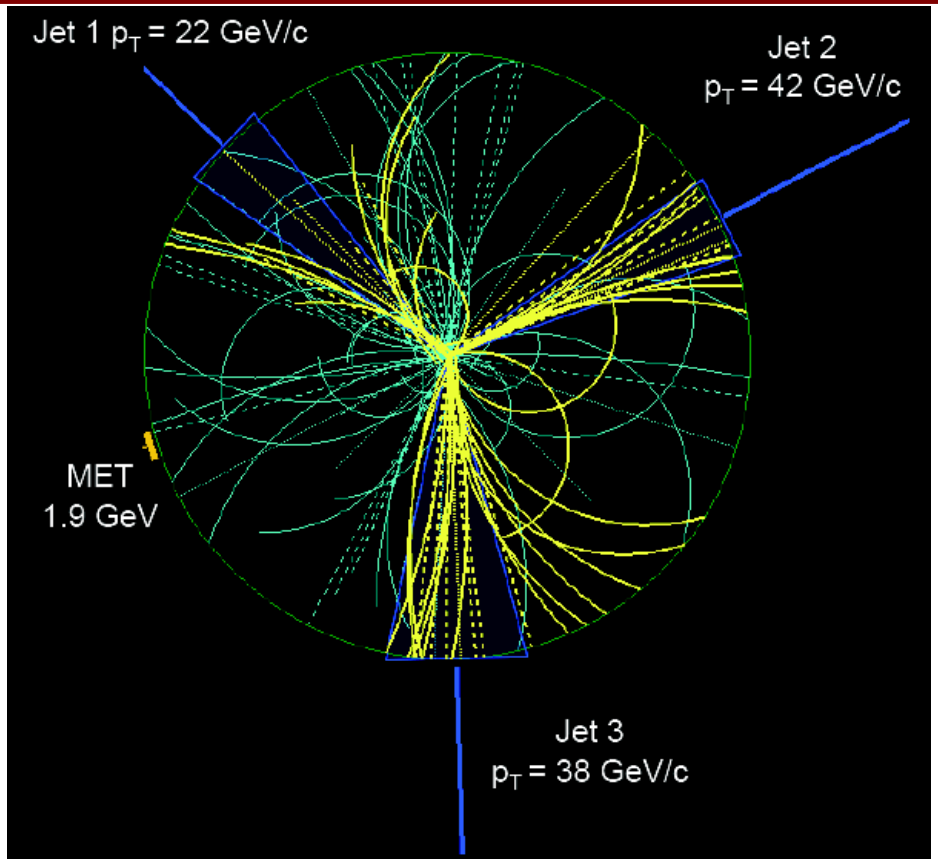
HADRON CALORIMETER (HCAL)
Brass + plastic scintillator
~7k channels

MUON CHAMBERS
Barrel: 250 Drift Tube & 480 Resistive Plate Chambers
Endcaps: 468 Cathode Strip & 432 Resistive Plate Chambers

Total weight	**: 14000 tonnes**
Overall diameter	**: 15.0 m**
Overall length	**: 28.7 m**
Magnetic field	**: 3.8 T**

Particle Flow Reconstruction

- Particle Flow(PF) combines information from all sub-detectors to provide a unique event description
  - Particles!
- PF reconstructs charged hadrons, neutral hadrons, photons, electrons and muons
- In this analysis Particle Flow objects are used for Tau ID, muon isolation and Missing E_T reconstruction

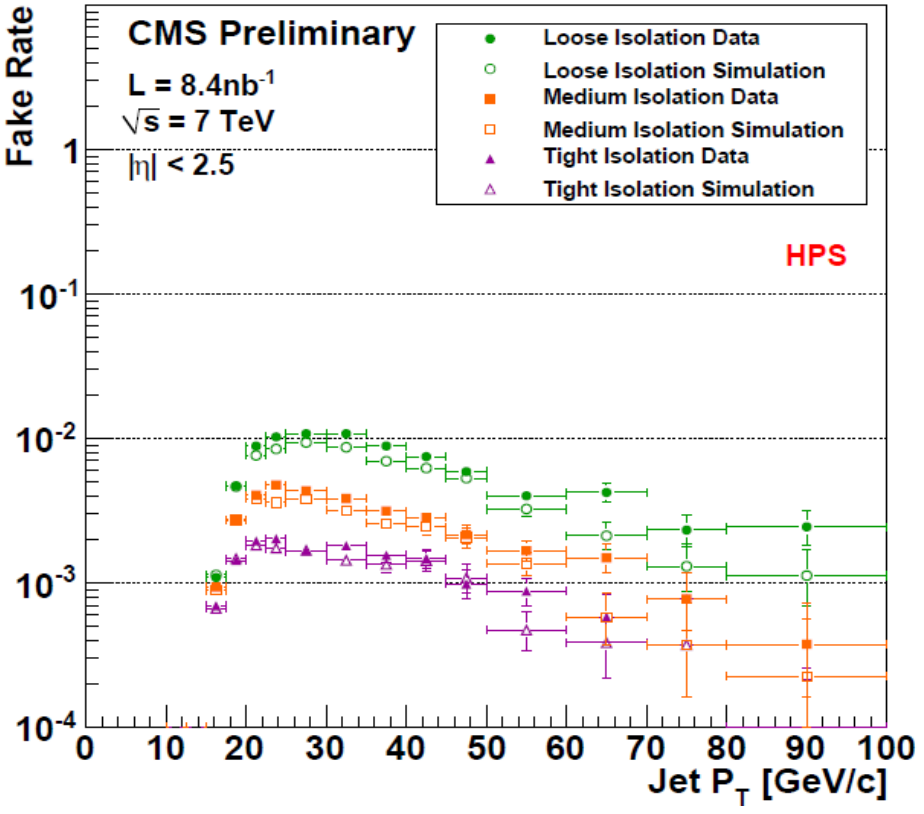


- Particle Flow event display for event recorded at $\sqrt{s}$=2.4 TeV

Tau Identification

- Tau ID in CMS is well advanced
  - See E.Friis talk
- For this study the Hadron Plus Strips (HPS) algorithm is used
  - Merges photons into strips to account for conversions
  - Reconstructs tau decays
    - One Prong
    - One Prong+strip
    - Three prongs
  - Applies isolation

HPS Fake rate measured in data



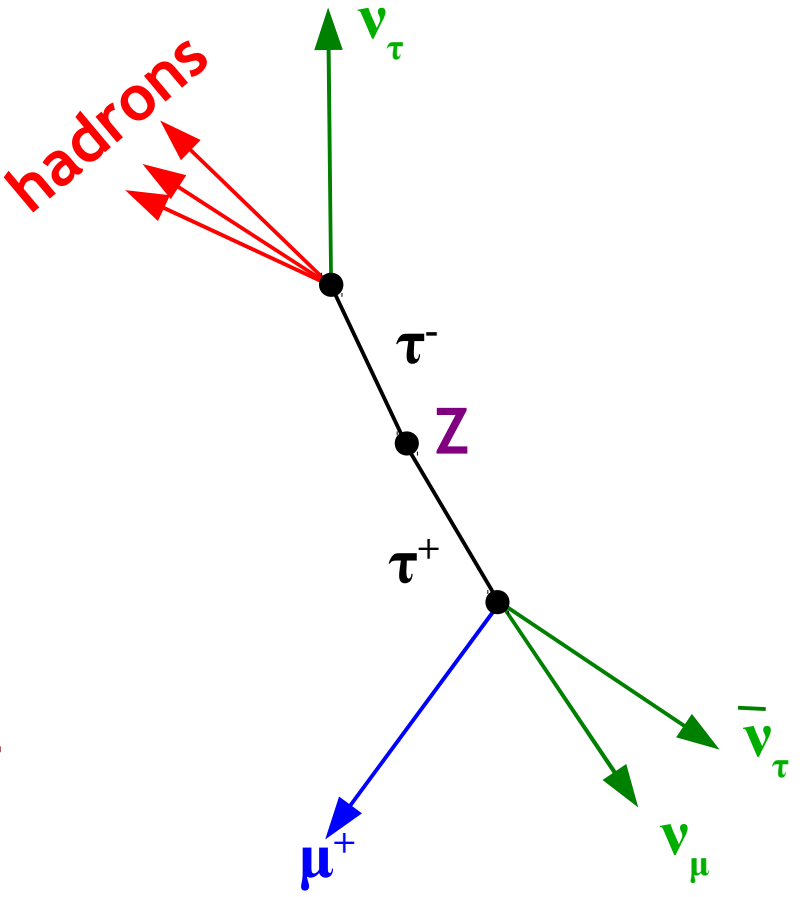
- For this study, HPS loose isolation is used
  - No charged hadrons w P_T>1 GeV/c and no photons w E_T>1.5 GeV in a cone of $\Delta R = 0.5$

Data and Simulation samples

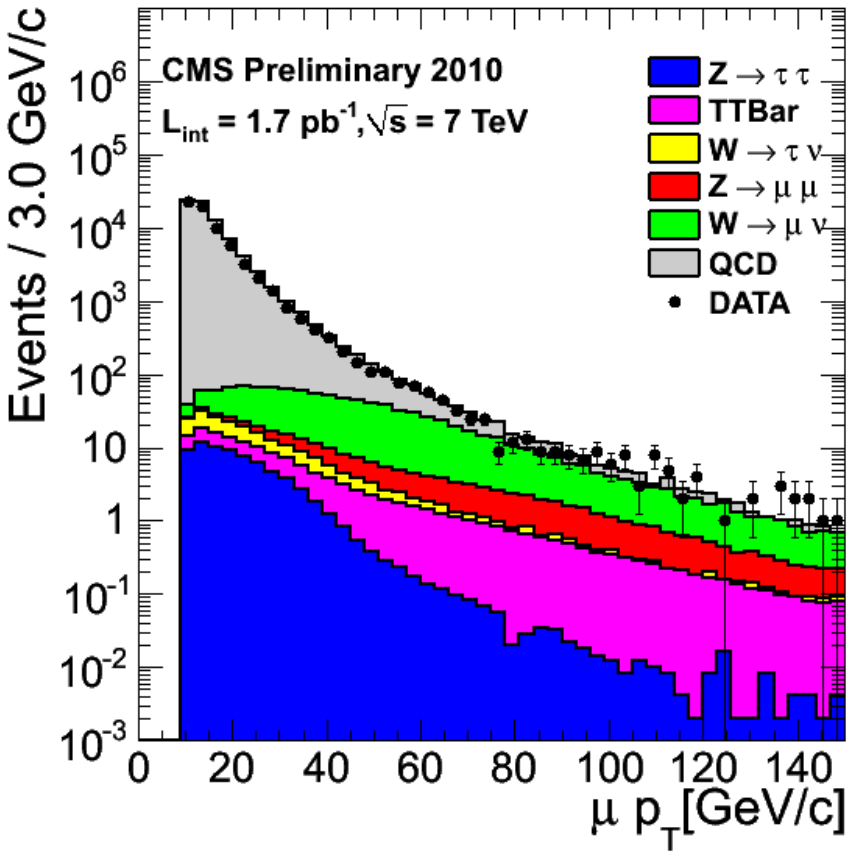
- Data collected up to the end of August
- $\int Ldt = 1.7\ pb^{-1}$ analyzed
- Data quality ensured both through data certification and validation of the reconstructed objects
- Official CMS MC produced samples were used
  - EWK Processes generated with NLO MC (POWHEG)
  - QCD simulated with LO MC(PYTHIA)
  - TAUOLA was used for all tau related samples

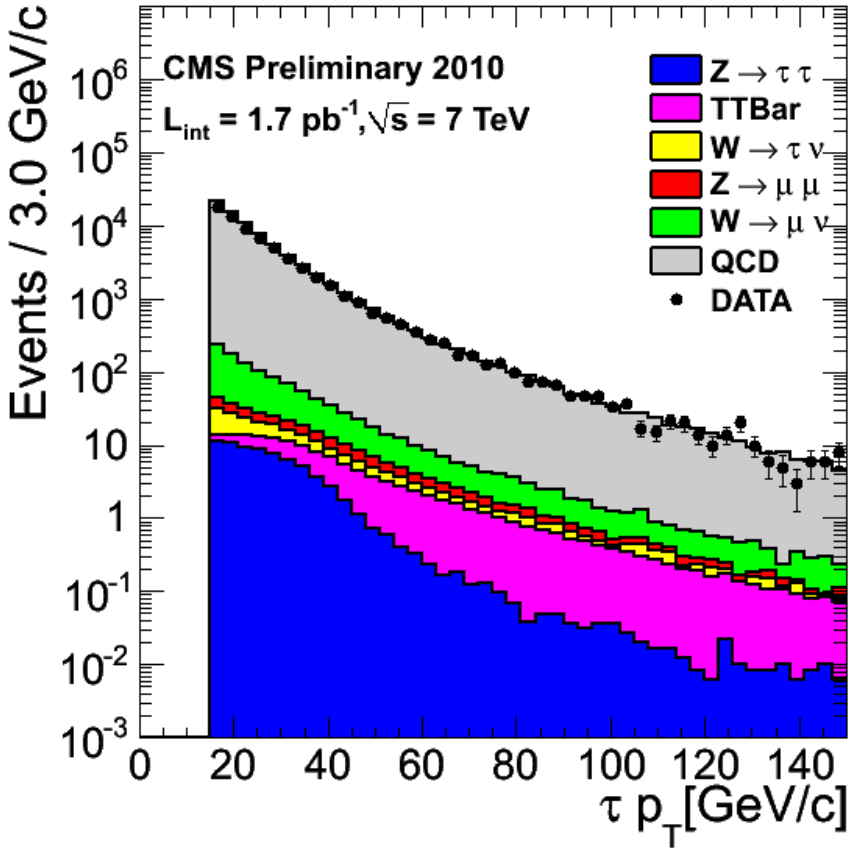
Event pre-selection

- Muon + hadronic Tau decay was studied
  - One tau decays to a muon
  - One tau decays to hadrons
- Preselection
  - Muon trigger with P_T>9 GeV/c
  - Offline Muon P_T> 10 GeV, $|\eta|$<2.1
  - Tau P_T> 15 GeV/c, $|\eta|$<2.4



Muon and Tau transverse momentum distributions

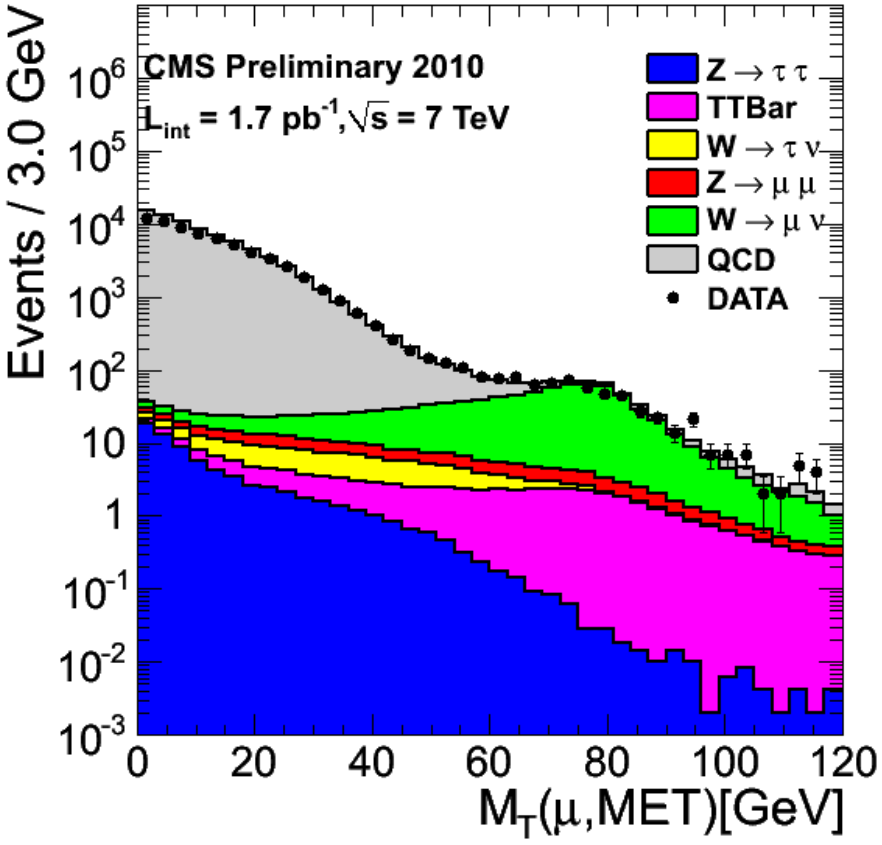




- Control plots dominated by QCD (no isolation applied)
- Good agreement with MC

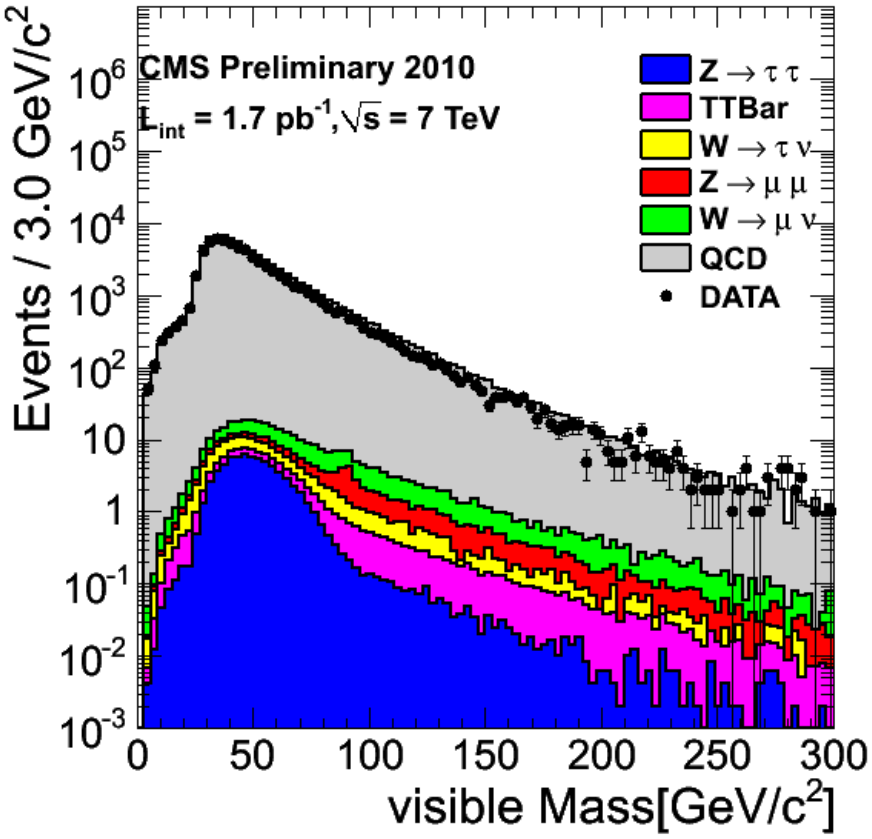
Rejecting W+Jets : $M_T(\mu, MET)$

- W+Jets second dominant background
  - After QCD
- The transverse mass of the muon and missing ET can be used to reject W → μν
  - Z → ττ expected to peak at low values
- Good agreement with MC
  - Also for EWK contributions



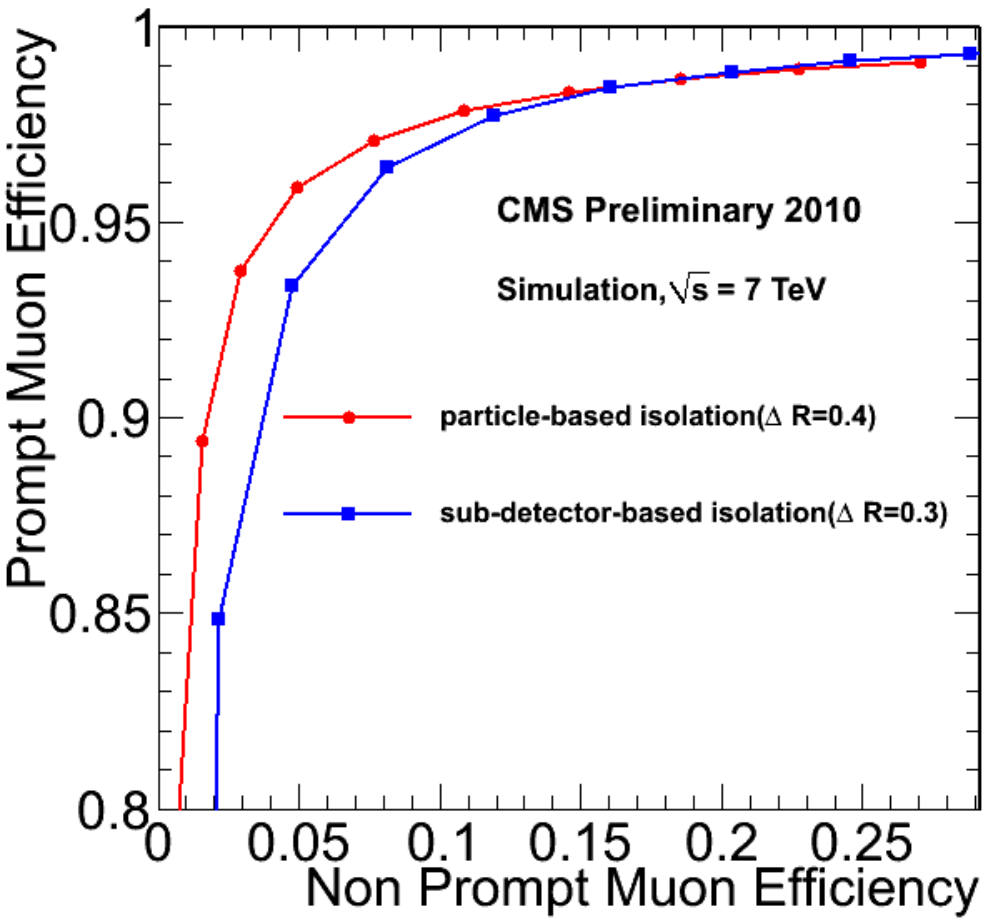
Visible mass (μ,τ)

- No isolation applied
- Broad Z → tau tau peak due to the neutrinos in final state
- QCD distribution peaks under signal
  - Turn on due to the PT thresholds and falling spectrum
- S/B ~ 1/1000

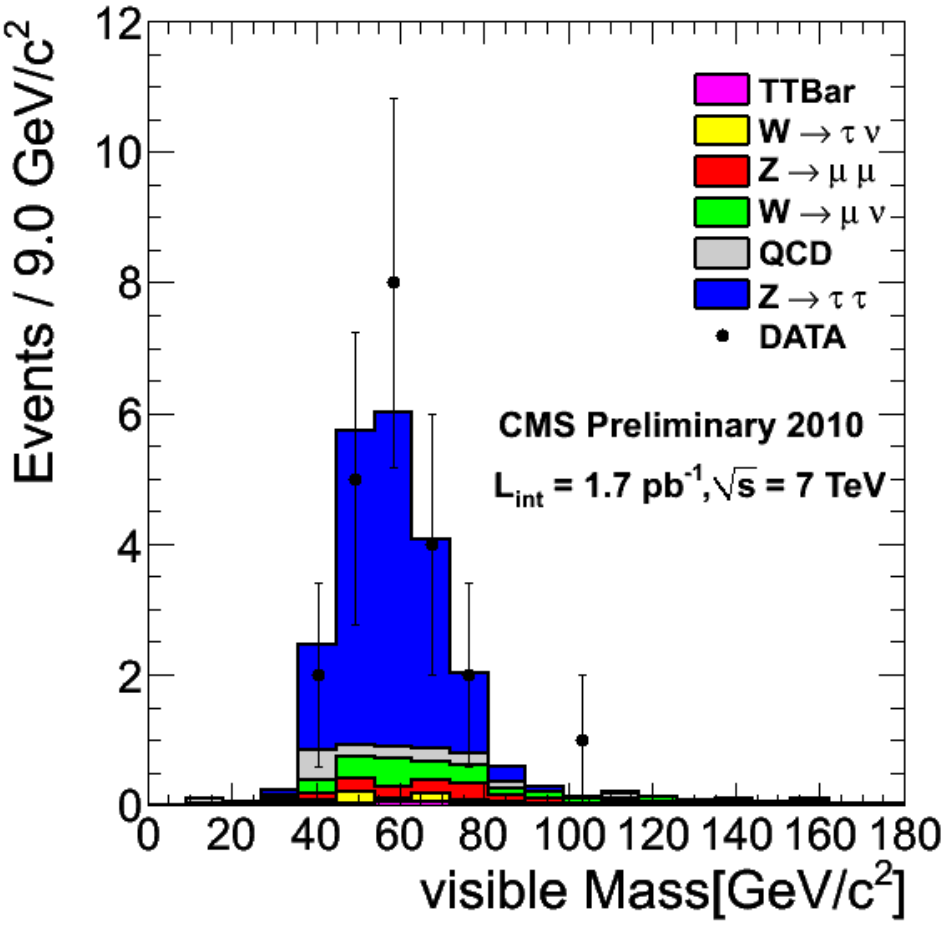


Muon Isolation

- For muons, particle based isolation is used
  - Expected to improve results since PF avoids double counting of particle energies in different detectors
- All PF particle transverse momenta are added in a cone of 0.4
- Relative isolation is used
- Σ PF P_T /μ P_T <0.1



Visible mass after all selections



Clean Z → ττ signal observed

Final selection applied

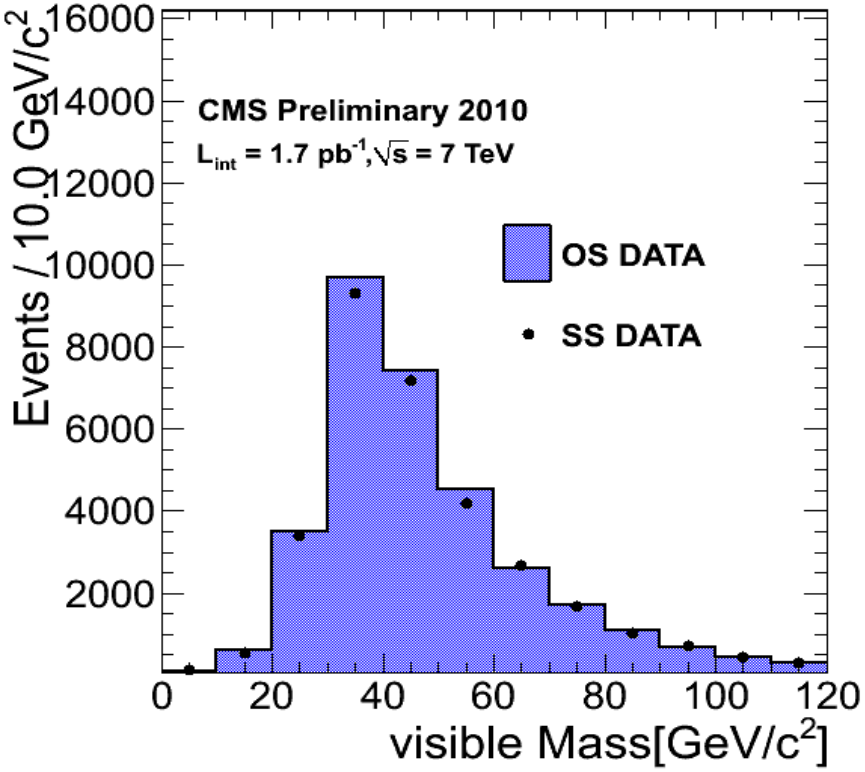
- Muon P_T>15 GeV/c
- Tau P_T > 20 GeV/c
- Loose HPS Tau Isolation
- Muon relative PF combined Isolation
- MT(μ,MET)<40 GeV/c²

22 events expected (signal + background)

- 22 events observed
- Expected purity ~75%

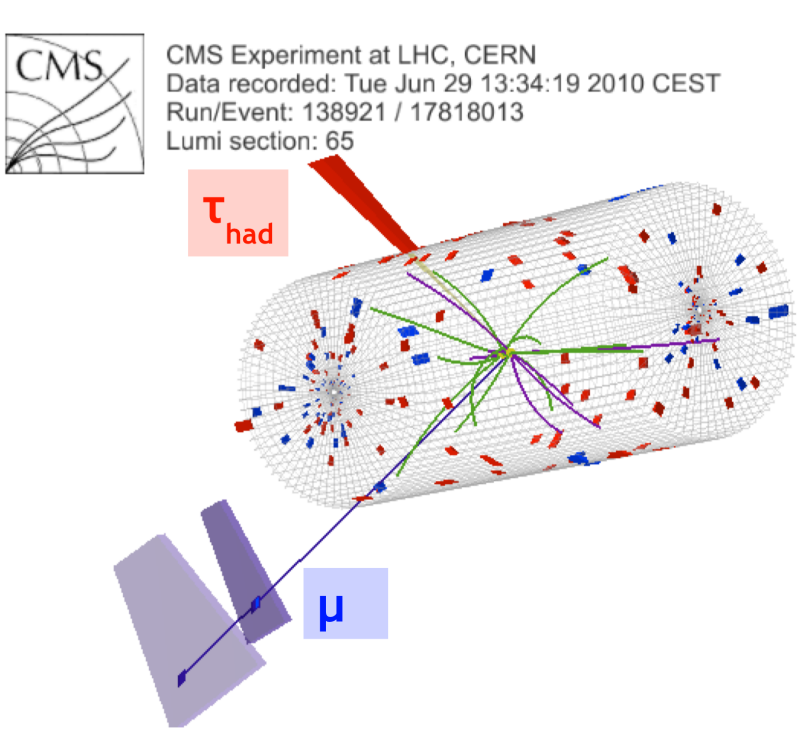
QCD background estimation from data

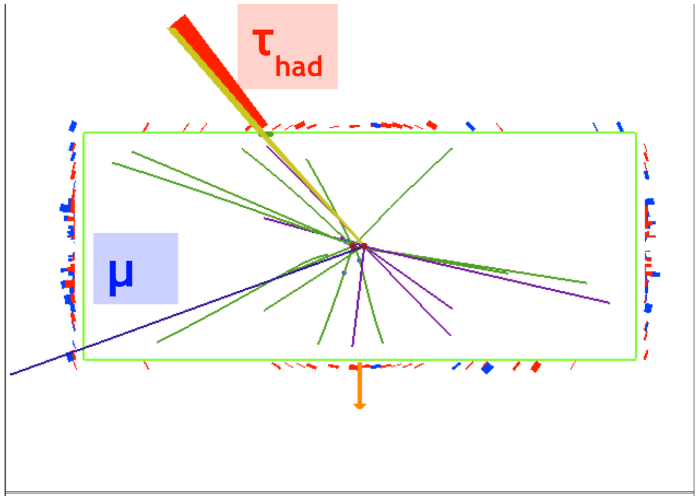
- Data driven background estimation is an important aspect of di - tau analysis
- QCD background can be estimated by SS data.
  - After subtracting EWK contributions
- A first test is performed in a QCD dominated sample
  - No isolation applied
- OS/SS shapes in agreement
- Slightly more OS data

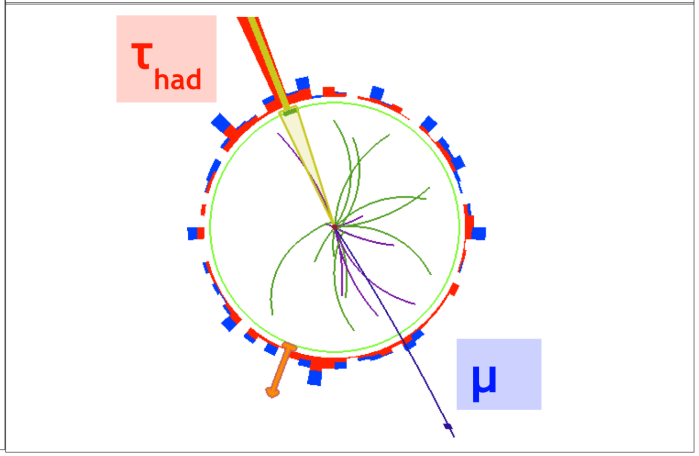


- OS/SS(DATA) = 1.03 ± 0.01 (stat)
- OS/SS(MC) = 1.036 ± 0.002

$Z \rightarrow \tau\tau$ candidate (one prong + π^0)





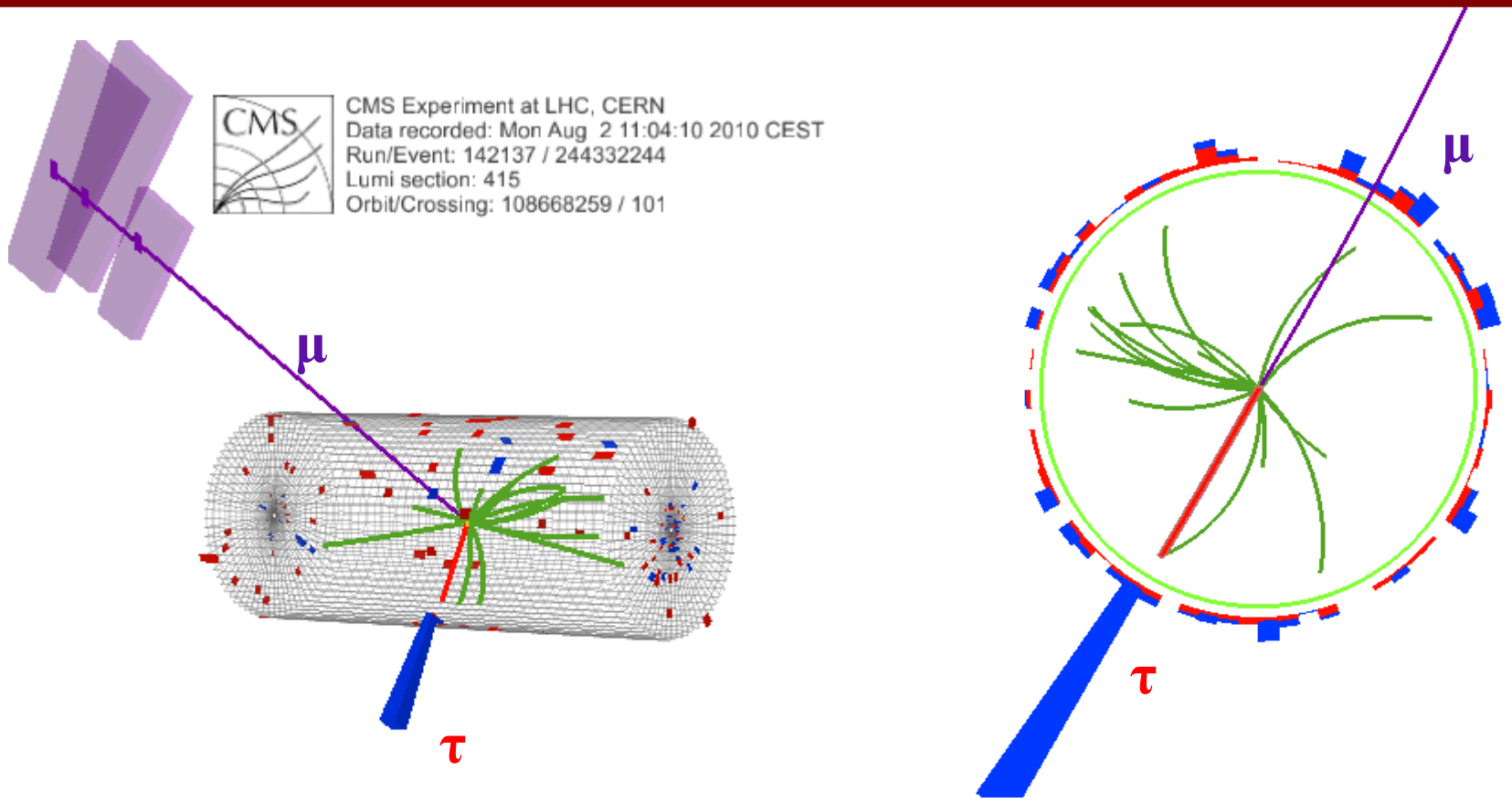


μ p_T = 22.8 GeV/c

T_{had} E_T = 32.9 GeV

Vis. Mass = 60.8 GeV/c^2
M_T(μ,MET) = 10.1 GeV

Z → ττ candidate (one prong)



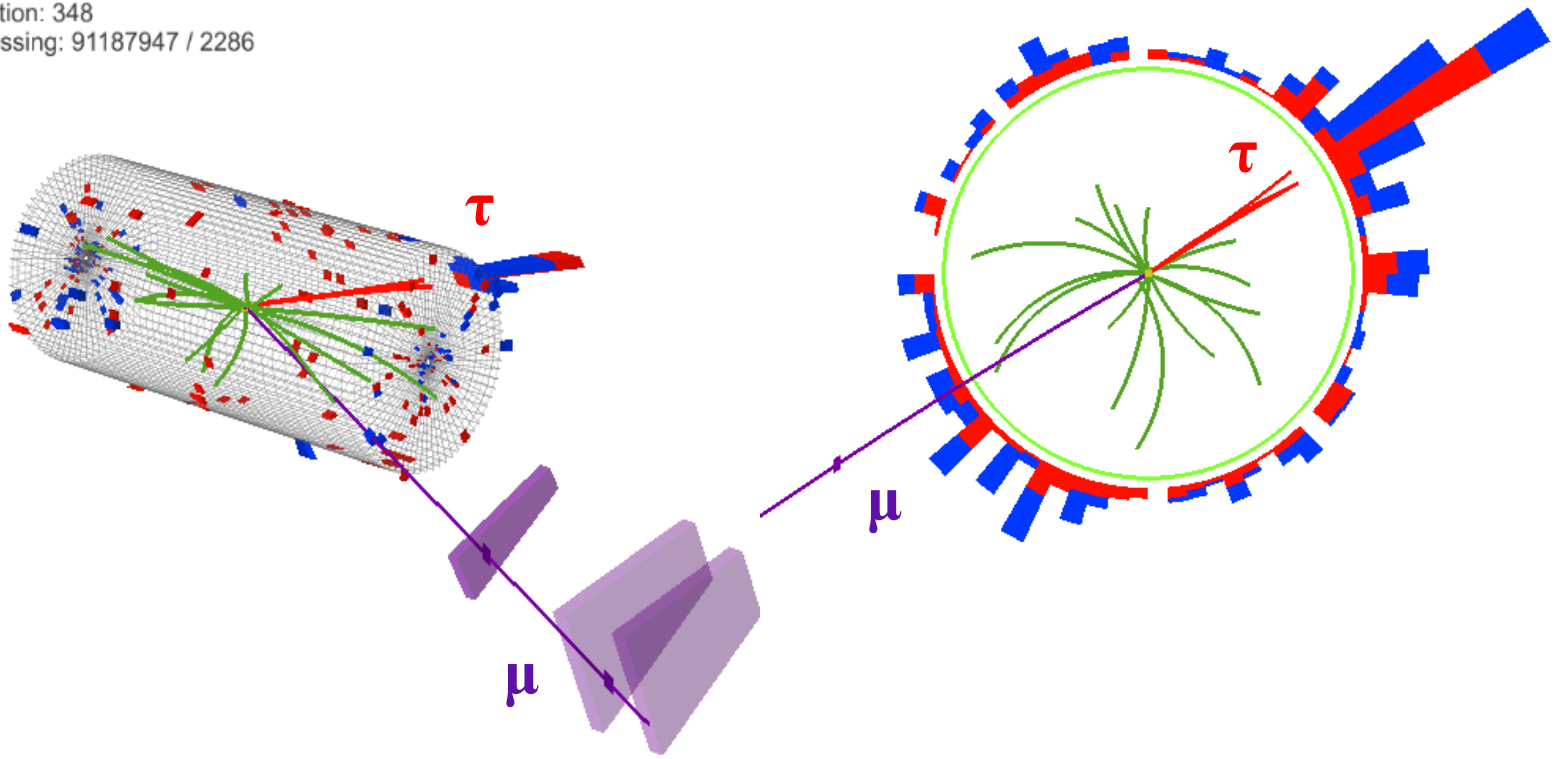
μ Pt = 23.1 GeV/c
η = -1.31

τ Pt = 36.8 GeV/c
η = 0.03

Vis. Mass= 73 GeV/c^2
M_T(μ,MET) =3.3 GeV

Z → tau tau candidate (three prongs)

CMS Experiment at LHC, CERN
Data recorded: Sun Aug 15 03:57:48 2010 CEST
Run/Event: 142971 / 323188785
Lumi section: 348
Orbit/Crossing: 91187947 / 2286



μ Pt = 32.4 GeV/c
η = 1.7

τ Pt = 37.4 GeV/c
η = 1.5
Mass = 1.2GeV/c^2

Vis. Mass= 70 GeV/c^2
M_T(μ,MET) =4.1 GeV

Conclusions

- First convincing Z → tau tau signal has been observed in CMS with 1.7 pb^{-1} of data in the muon + τ_{had} channel
  - Proof of the excellent performance of CMS detector, reconstruction and tau identification
- Physics with tau leptons has just started
  - Measurements of Z → ττ and W → τ ν are ongoing
  - First searches of the MSSM charged and neutral Higgs bosons are on the way
- Stay tuned...