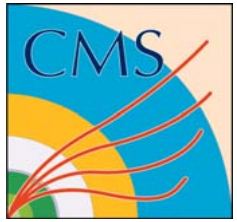

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Towards to the First Measurement of the Drell-Yan Dimuon Differential Cross Section with the CMS detector

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for the Compact Muon Solenoid Collaboration

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Outline

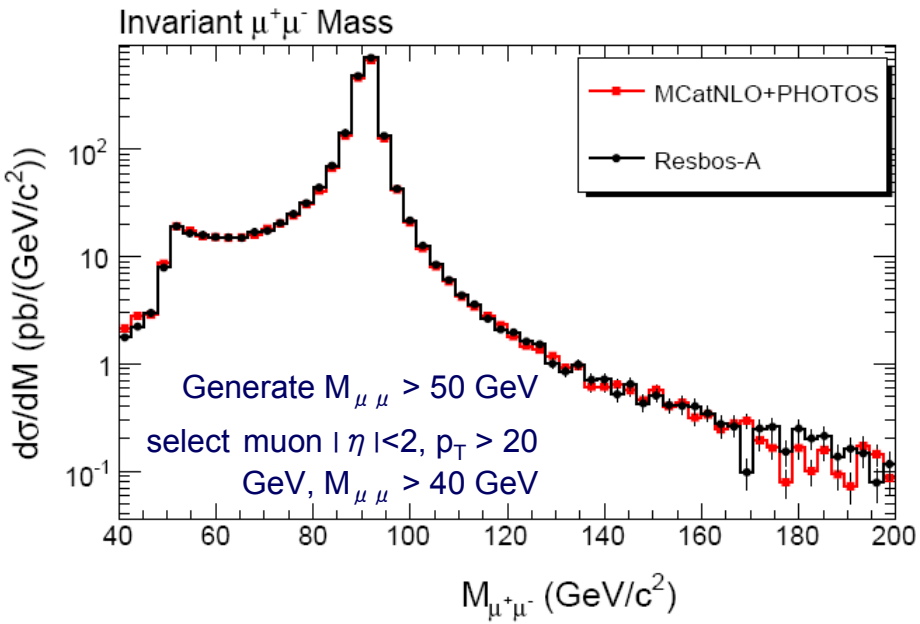
- Drell-Yan dimuon production
- The CMS detector at the LHC
- Cross section measurement
- Event selection and acceptance
- Efficiency measurements
- Preparation for the first collisions
- Summary

Drell-Yan Dimuon Production

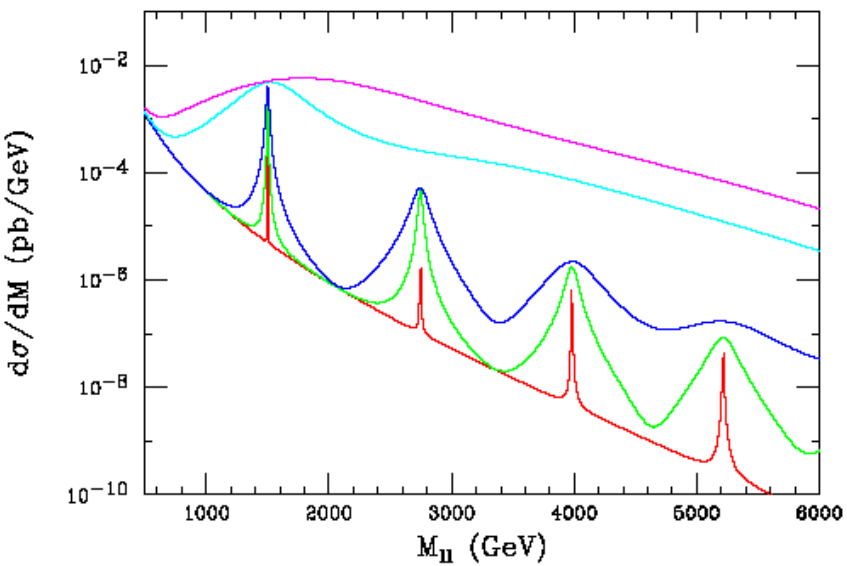
- Drell-Yan process
  - The lepton pair production mechanism via quark-antiquark annihilation by the exchange of a virtual photon or Z-boson.
  - Provides information about parton density function (PDF) used for other measurements.
  - Clean signature and low experimental backgrounds.
  - Prerequisite for new physics search with same signature.
  - New physics could appear as a modification of the DY dimuon mass spectrum or narrow resonances (Z' or Similar)

Theoretical Cross Section

- Cross section of Z
  - Comparison of $\mu^+\mu^-$ invariant mass distributions for the process Z/γ-> $\mu^+\mu^-$(n γ) in MC@NLO with PHOTOS (red) and Resbos-A (black).

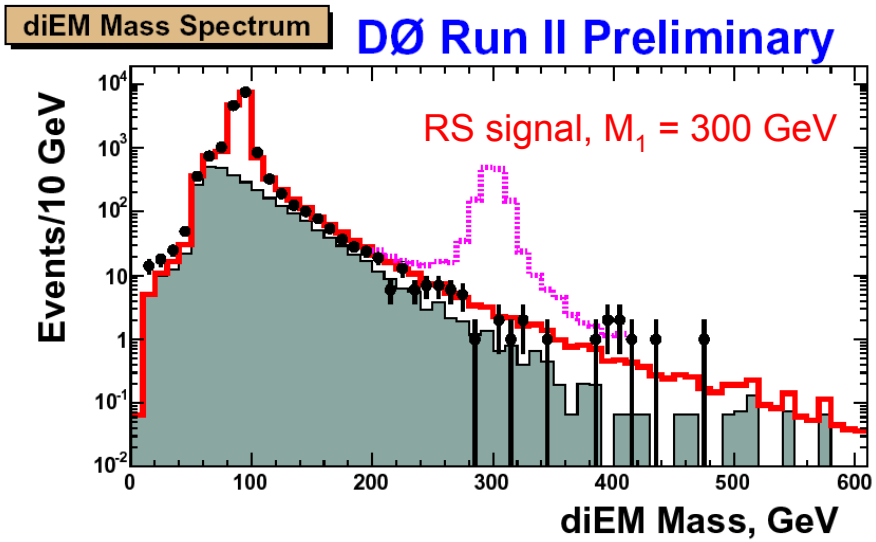


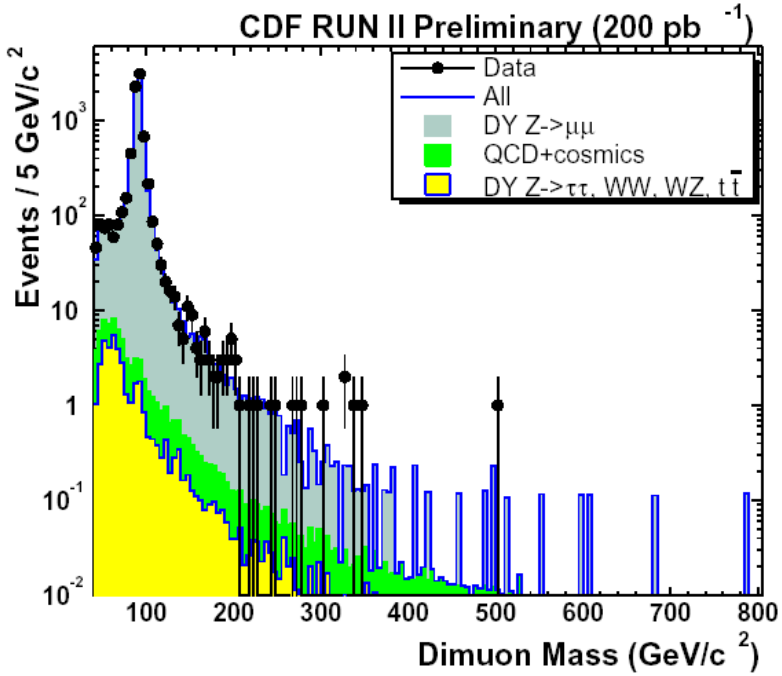
- Possible new physics
  - Invariant mass distribution for Drell-Yan process with modification from RS1 model, with different parameters
    - from top to bottom, the curves are for coupling values c = 1, 0.5, 0.1, 0.05, 0.01



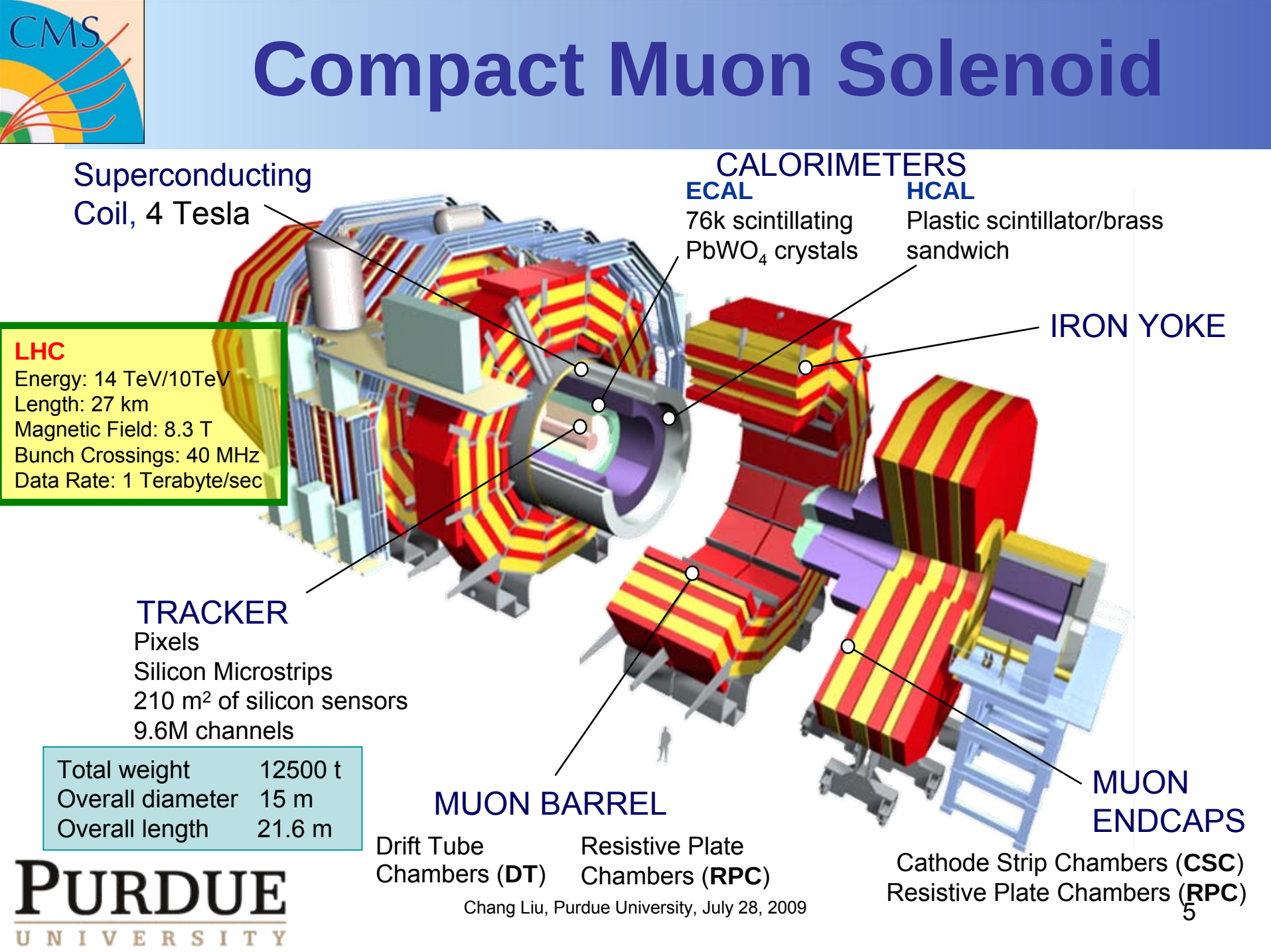
Previous Results

- Experiments at the Tevatron have measured the Drell-Yan cross section
- Good agreement with Standard Model prediction
- Excluded Z' up to ~900 GeV combining data from μ μ and ee channels





Compact Muon Solenoid



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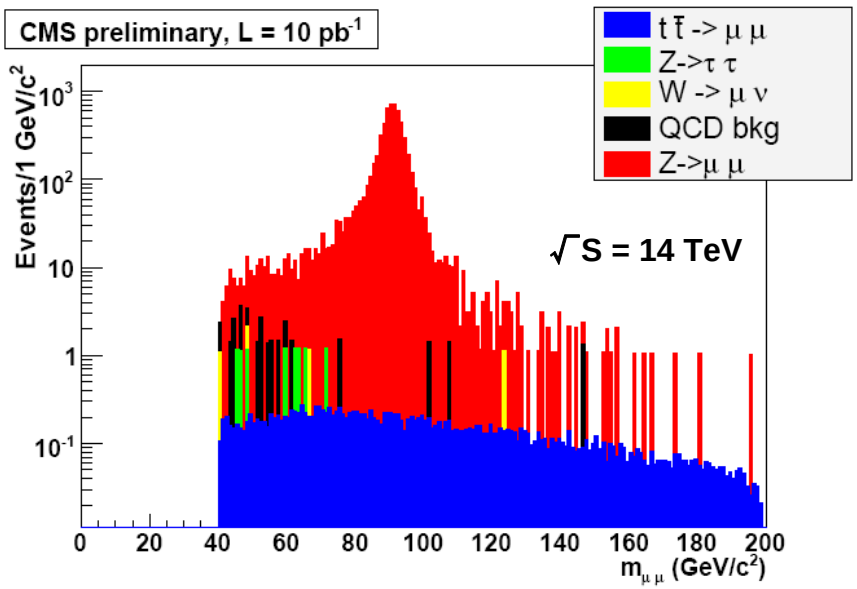
Cross Section Measurement

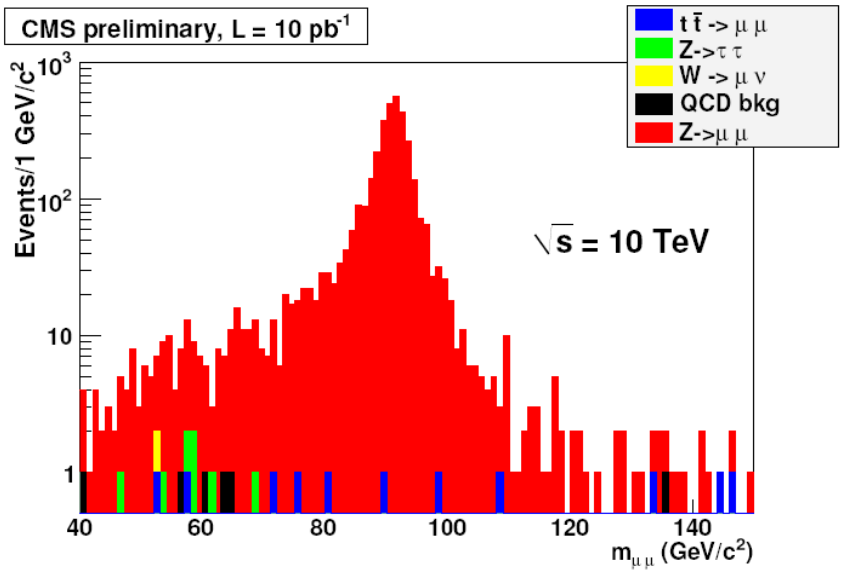
$$\sigma = \frac{N_{sign}^{sel} - N_{backgr}}{A \times \varepsilon \times \int Ldt}$$

- Selection cuts are relative simple
  - 2 opposite-sign isolated energetic muons
- The challenge is the control of systematics (especially at start-up)
  - Acceptance: detector description, MC, PDF, theory,…
  - Efficiency (trigger, reconstruction, isolation)
    - All components need to be measured from data
  - Backgrounds are relatively low
  - Luminosity

Z Boson Selection

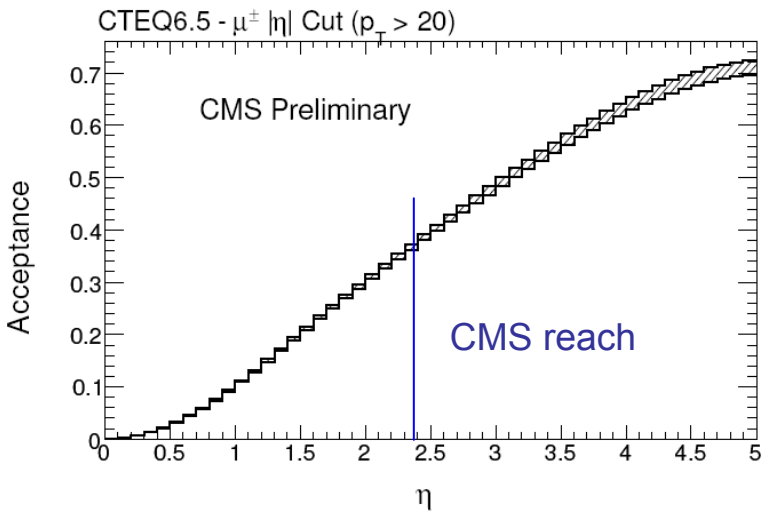
- Drell-Yan and background processes as a function of the reconstructed invariant mass for dimuon events after Z-> $\mu^+\mu^-$ selection cuts
- Trigger
  - Relaxed single-muon trigger (L3 muon p_T > 16 GeV) OR isolated single-muon trigger (L3 muon p_T > 11 GeV & isolated) OR dimuon trigger (both L3 muons p_T > 3 GeV)
- Selection
  - Two isolated muons with tracks reconstructed from hits in both the tracker system and the muon chambers.
  - Transverse momentum of muon in a pair: p_T > 20 GeV.
  - Isolation criteria: Σp_T (in a cone of $\Delta R = 0.3$) < 3 GeV.
  - Invariant mass of the $\mu^+\mu^-$ pair must be greater than 40 GeV.

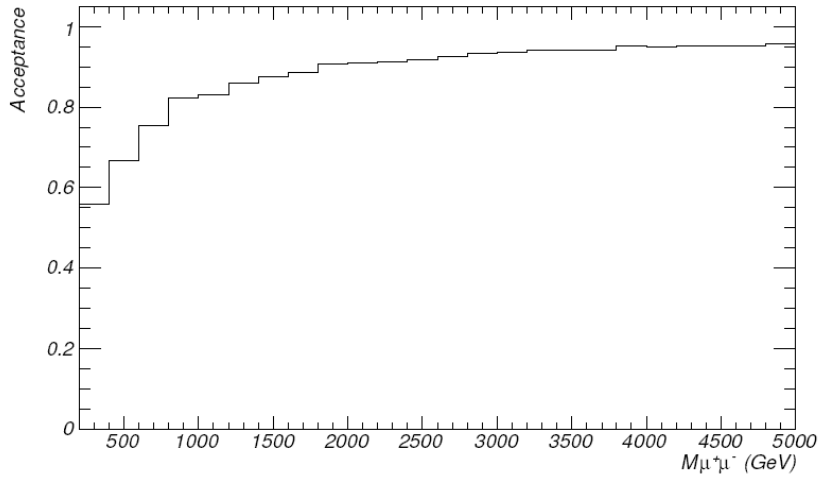




Geometrical Acceptance

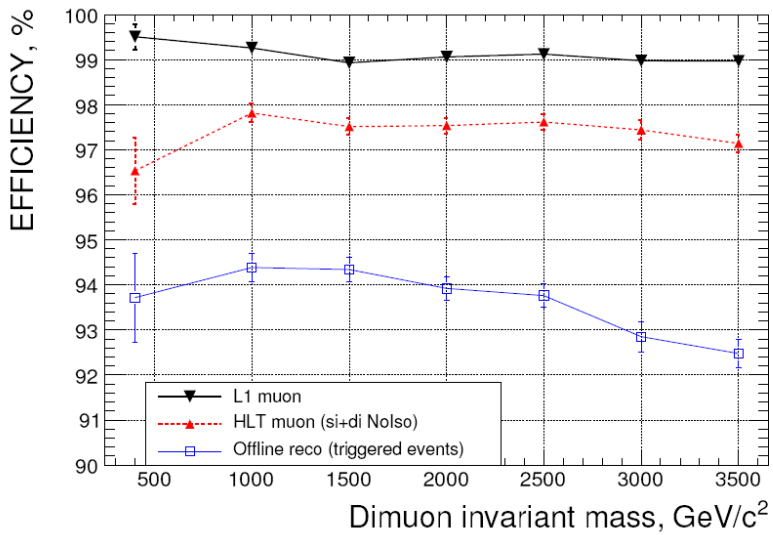
- Z/γ -> $\mu^+ \mu^-$ acceptance and uncertainty band due to PDF variations for different values of the muon |η| cut.
- Defined as the fraction of events with both μ^+ and μ^- within the geometrical acceptance of the muon system (|η| < 2.4).



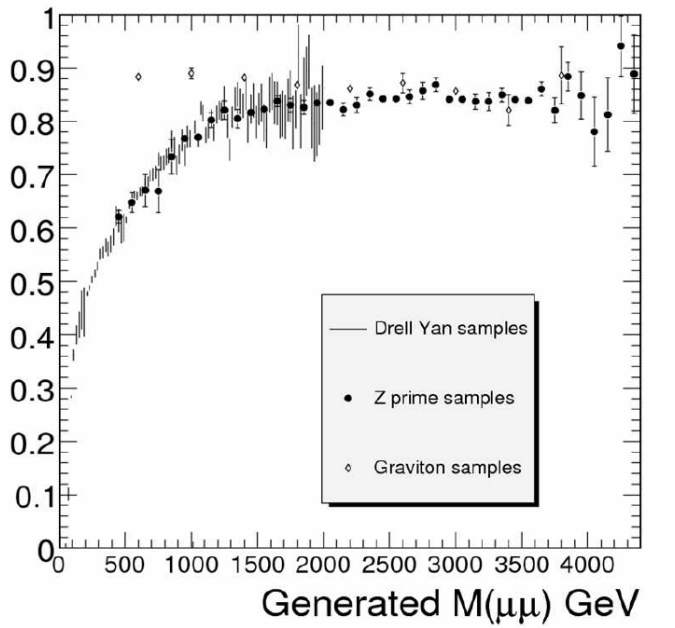


High-mass Dimuon Selection Criteria and Efficiencies

- Events must pass logical OR of single-muon and dimuon non-isolated triggers.
- Events must contain at least one pair of oppositely-charged muons reconstructed offline.
- Transverse momentum of muon in a pair: p_T > 20 GeV.
- Isolation requires both muon Σp_T (in a cone of $\Delta R = 0.3$) < 10 GeV.



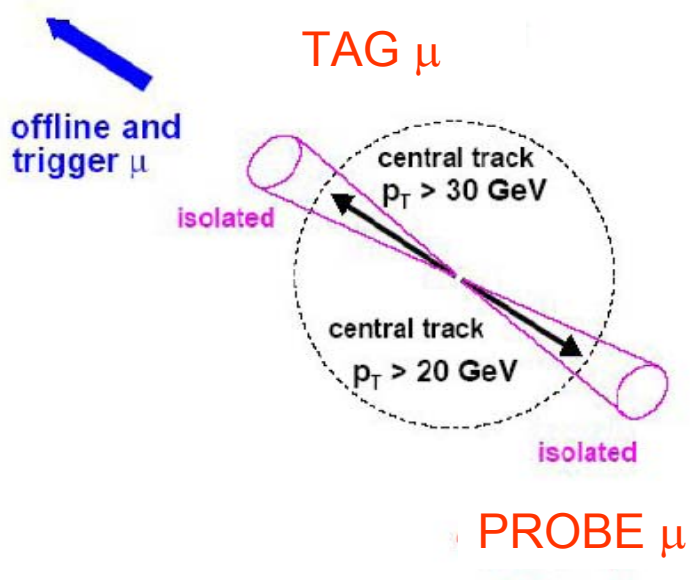
Trigger and reco efficiencies



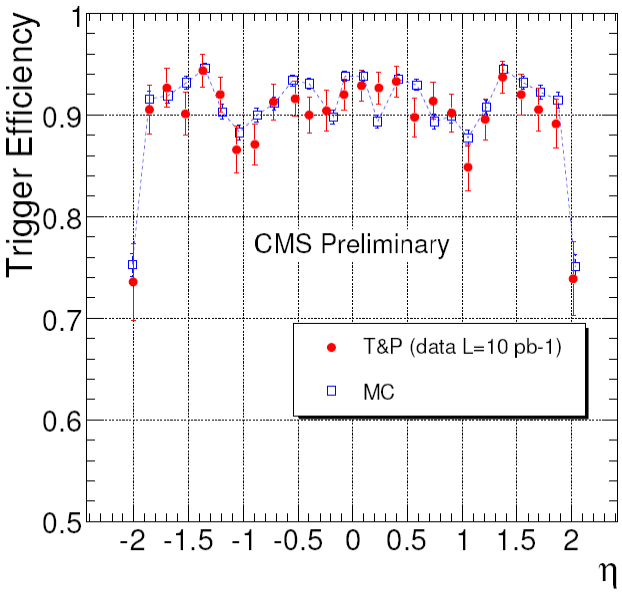
Overall eff. (including acceptance)

Efficiency Measurements

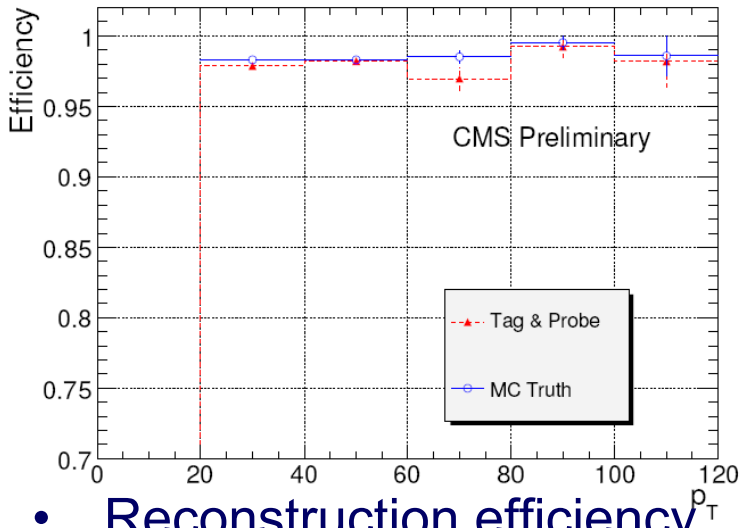
- Z/γ -> $\mu^+ \mu^-$ events are selected by
  - applying tight cuts (larger p_T, isolation, ..) on one of the muons, as the "tag"
  - Efficiency is measured with the other muon, as "probe"



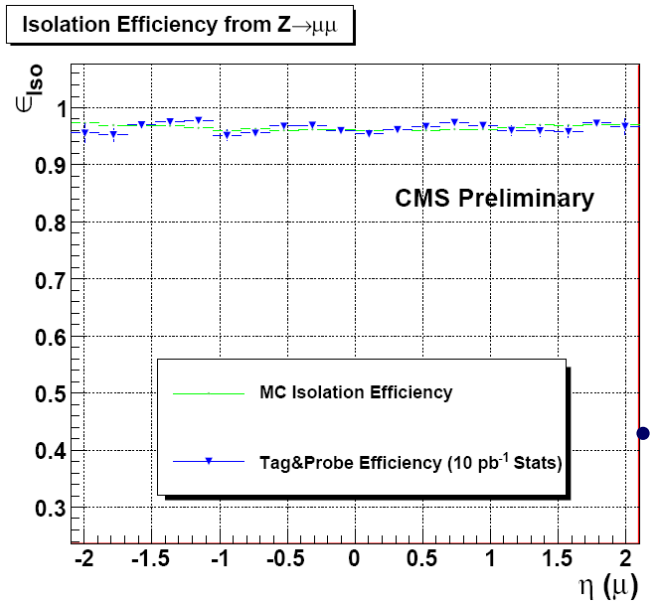
Efficiencies



- Trigger efficiency



- Reconstruction efficiency



- Isolation efficiency

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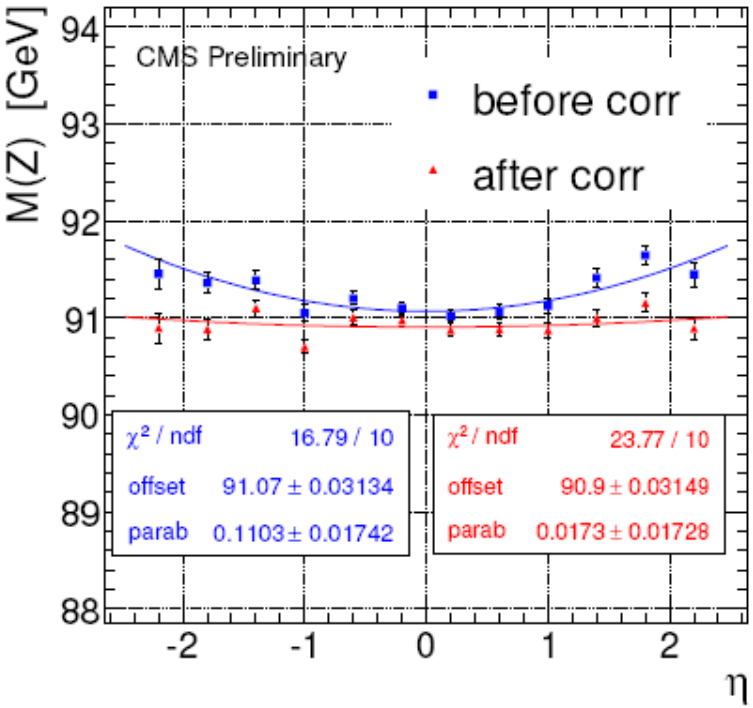
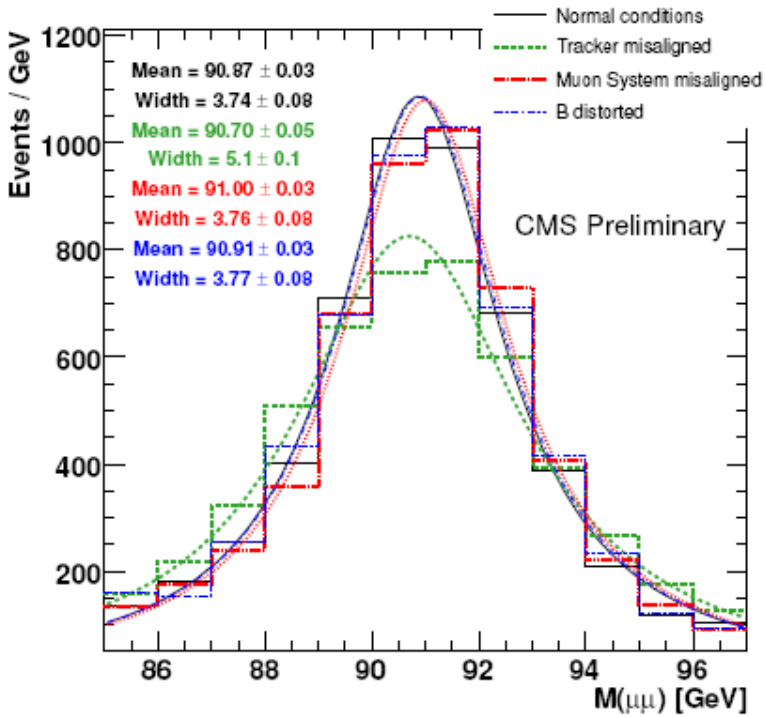
Momentum Calibration

- Likelihood technique
  - Extract muon corrections as a function as kinematics to force the Z peak in the right position





From Z Resonance to Drell-Yan Spectrum

- The large cross section at the Z peak can be used as a normalization for the theory predictions and a starting point for measurements at higher and lower masses
- A "ratio" method can be used to reduce the systematic uncertainties
  - Cancel out luminosity and PDF uncertainties
- Only the shape of relative quantities depending on mass remains
  - K-factor
  - Electroweak radiative corrections

Conclusions

- Cross section measurements for Drell-Yan dimuon production in senario of 10 TeV and 14 TeV were presented
- The measurement is important for physics commissioning and is a prerequisite for all searches for new physics with dimuon signature
- Data-driven methods were developed to measure efficiencies
- Final cross section measurement of Z should have systematics < 5 % (+ luminosity)
- Precise measurement of Z cross section helps cross section measurement of the spectrum and searches for new physics in high mass region

- Expecting the first real data from collisions!