CMS Muon System

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DOE Review

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Wisconsin EMU Personnel

- **Dick Loveless -- Distinguished Scientist**
  - EMU Technical Coordinator (former L2 for Construction & Common Projects)
  - EMU L2 Deputy Manager, US-CMS Election Committee – Co-chair
  - Editor – CMS Muon Upgrade Proposal (soon Muon Upgrade Manager?)
- **Armando Lanaro -- Associate Scientist**
  - EMU Field Technical Coordinator – responsibility for all CSC operations
  - EMU DPG Deputy Coordinator – responsibility for physics data quality
  - EMU Safety Officer
  - Proposed ME4/2 Upgrade Factory Manager
- **Duncan Carlsmith – Associate Professor**
  - Leader of the endcap alignment task force
- **Jim Bellinger -- Associate Scientist**
  - EMU Alignment Readout & Analysis, moving to EMU simulation
- **Lindsey Gray -- Graduate Student**
  - EMU CEO (CSC Expert Operator) – serve weekly shifts operating EMU
  - Data Validation

Endcap Muon System

- 473 Cathode Strip chambers
  - Typical sizes -- 1.5m x 1.8 m, 3.3m x 1.3 m
  - Typical weights – 200 kg to 400 kg
- Large number of electronics boards
  - CFEB (strips) – 2268 boards
  - AFEB (wires) -- 11448 boards
  - Trigger mother board -- 473 boards
  - Data mother board -- 473 boards
  - Many others – low voltage, high voltage, monitoring etc.
  - Most boards have FPGAs (need programming via firmware)
    - Flexibility – make changes without access
    - New maintenance problem (downloading firmware)

CSC Maintenance

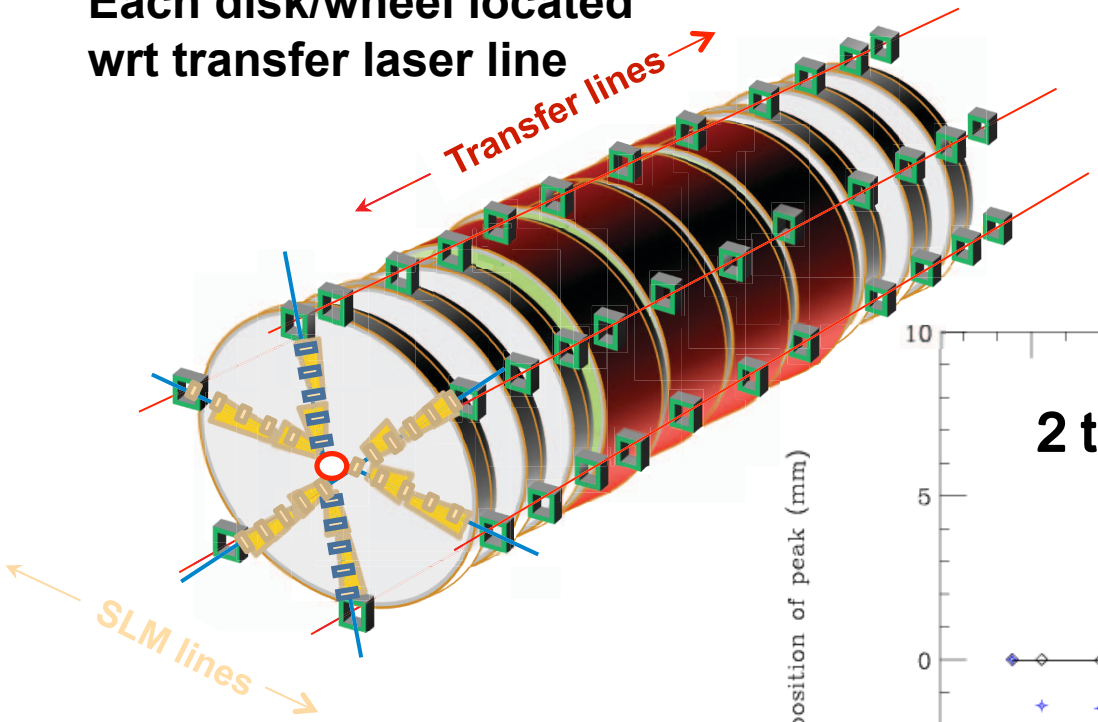
- **Mechanics & infrastructure**
  - **Wisconsin installed the mechanics of CSC system and is responsible their operations**
    - Maintenance on such an extensive system difficult
  - **Armando is Field Technical Coordinator – crucial position**
    - Responsible for all parts of CSC system
    - Armando keeps the system operating
  - **PSL engineers available for consulting and design**
- **Example – cooling leak**
  - **In Oct '09 a small bushing cracked and caused a leak**
  - **CMS contains over 400 such bushings**
  - **CMS decided to do an emergency opening during Xmas '09**
  - **Dick , Armando, and Dan led a team of 6 Polish techs to replace all 400 bushings in a two-week period**

DPG (Detector Performance Group)

- **A. Lanaro is Deputy DPG Co-ordinator**
  - **Supervise maintenance/implementation of software tools**
    - Offline monitoring of CSC system performance
    - Online monitoring of data quality
      - L. Gray is working on CSC data validation
    - Upgrades of reconstruction software
  - **Provide constant feedback to CSC Operations Group**
    - Update lists of faulty chambers, channels, boards, etc.
    - Organization of weekly joint DPG-Operations meetings
  - **Improve coordination with other muon groups (DT, RPC)**
    - Organize and chair joint meetings to resolve overall problems
  - **Provide feedback to Physics Objects Group (POG) and Physics Analysis Groups (PAG)**
    - Info on general muon reconstruction, identification, efficiency

Endcap alignment

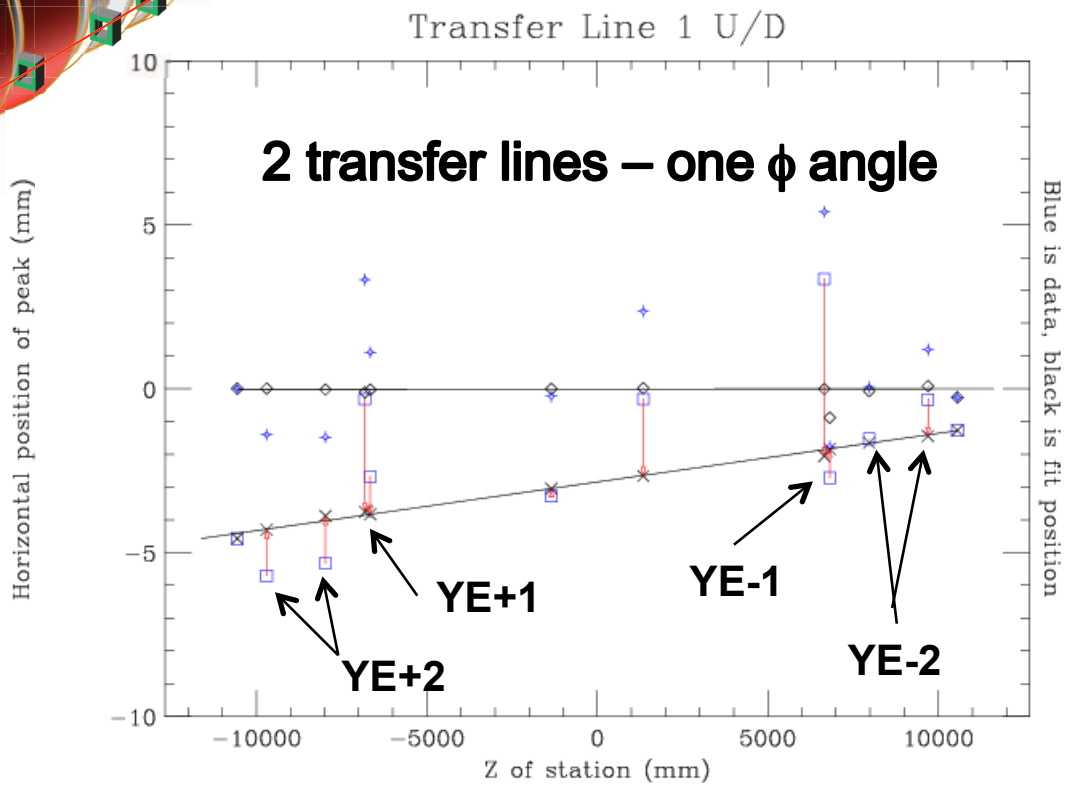
Each disk/wheel located wrt transfer laser line



12 transfer laser lines -- 6 from one end, 6 from other

Residual fit ~ 90 μ

Jim Bellinger responsible for almost all the endcap alignment analysis



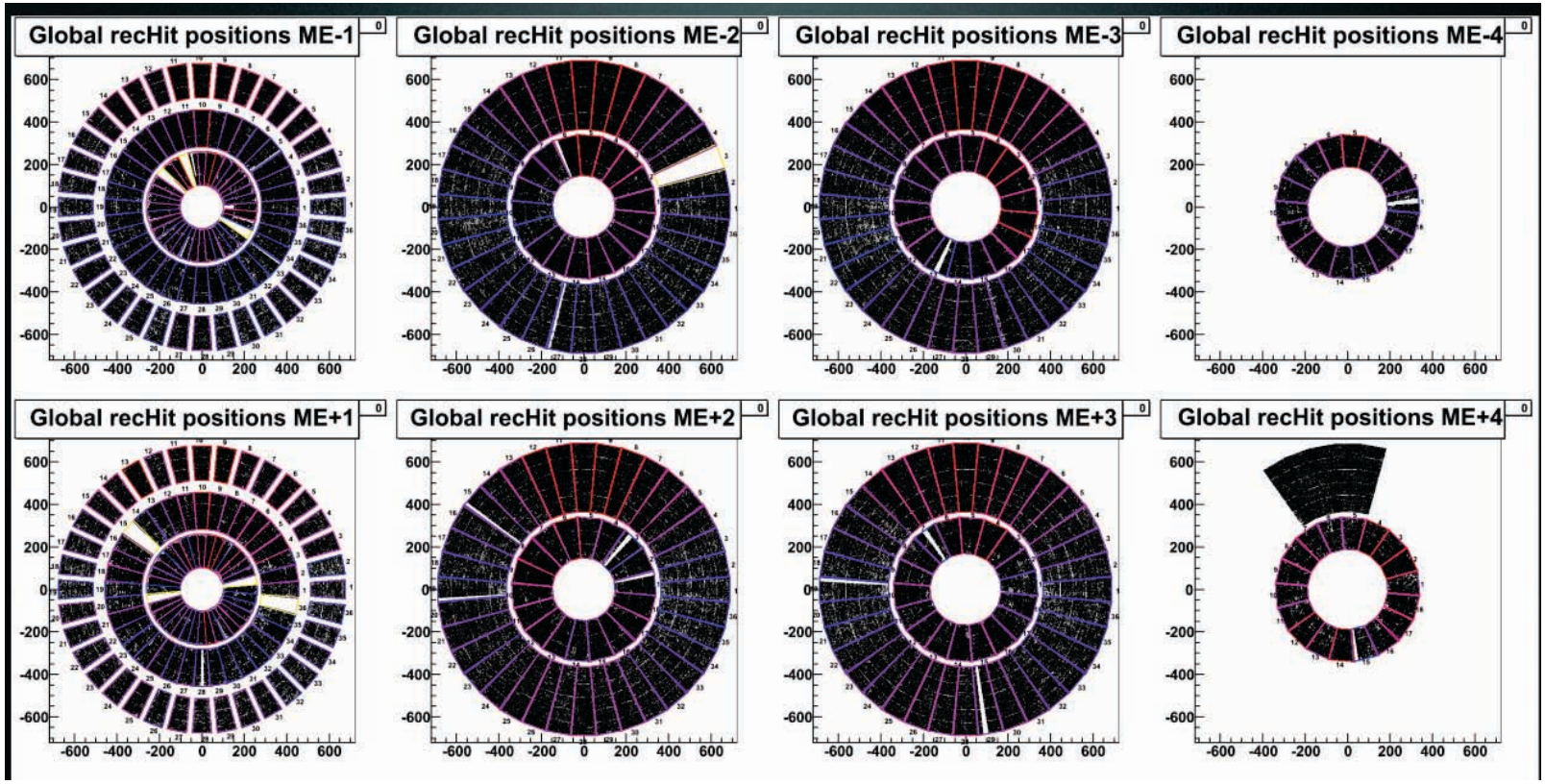
EMU Simulation

- **Jim Bellinger**
  - **Finish major alignment analysis by end of 2010**
  - **Move to Simulation Task Leader (CDF experience)**
    - Represent EMU at bi-weekly CMS Simulation meetings
    - Improve matrix fitting
    - Tune strip-charge distributions to match data
      - **Basically model the gas gain effects in the CSC chambers**
    - Introduce field-on geometry to simulation models
      - **Disks bend ~15 mm when B field in on**

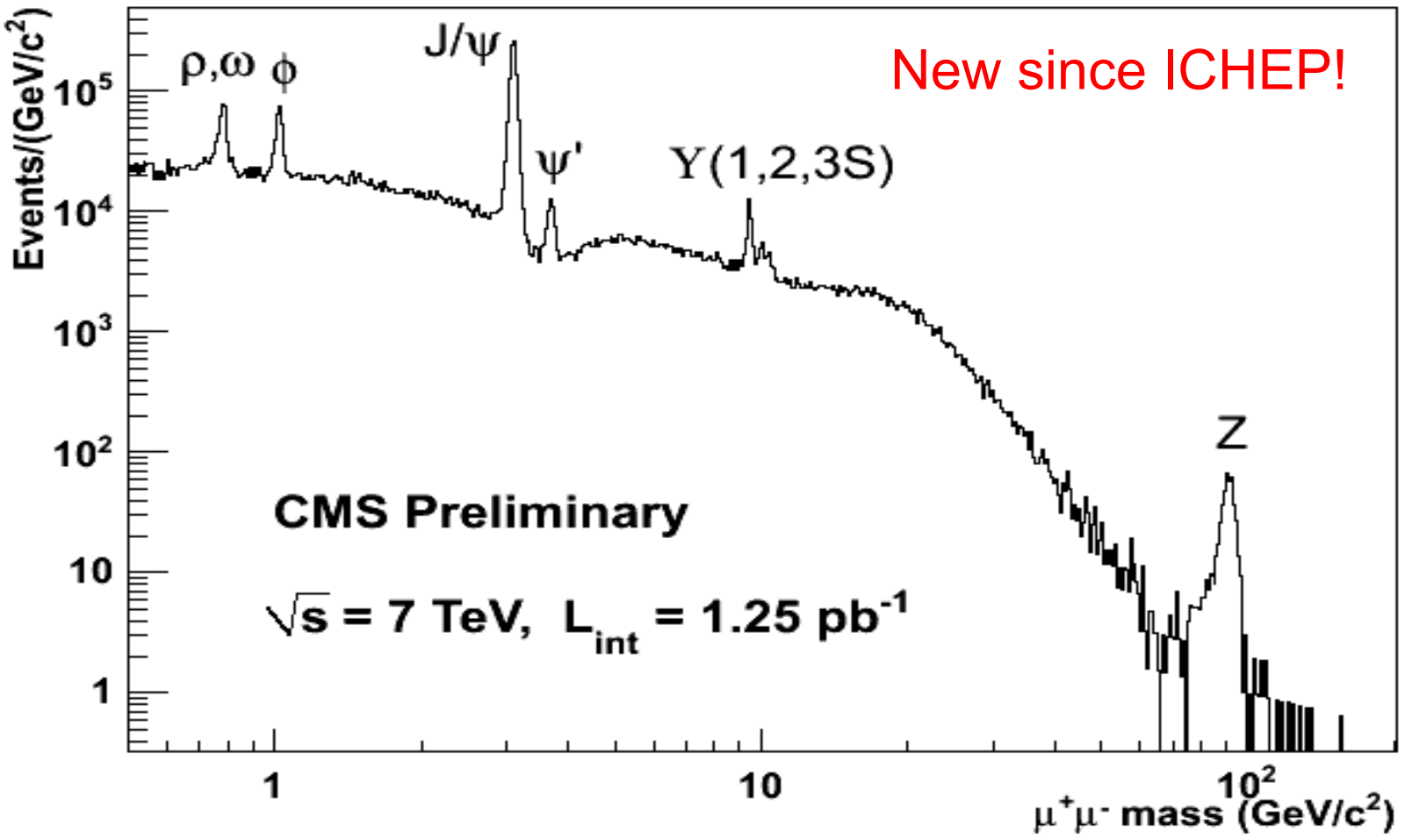
CSC Performance

Cosmic Run
24 August 2010

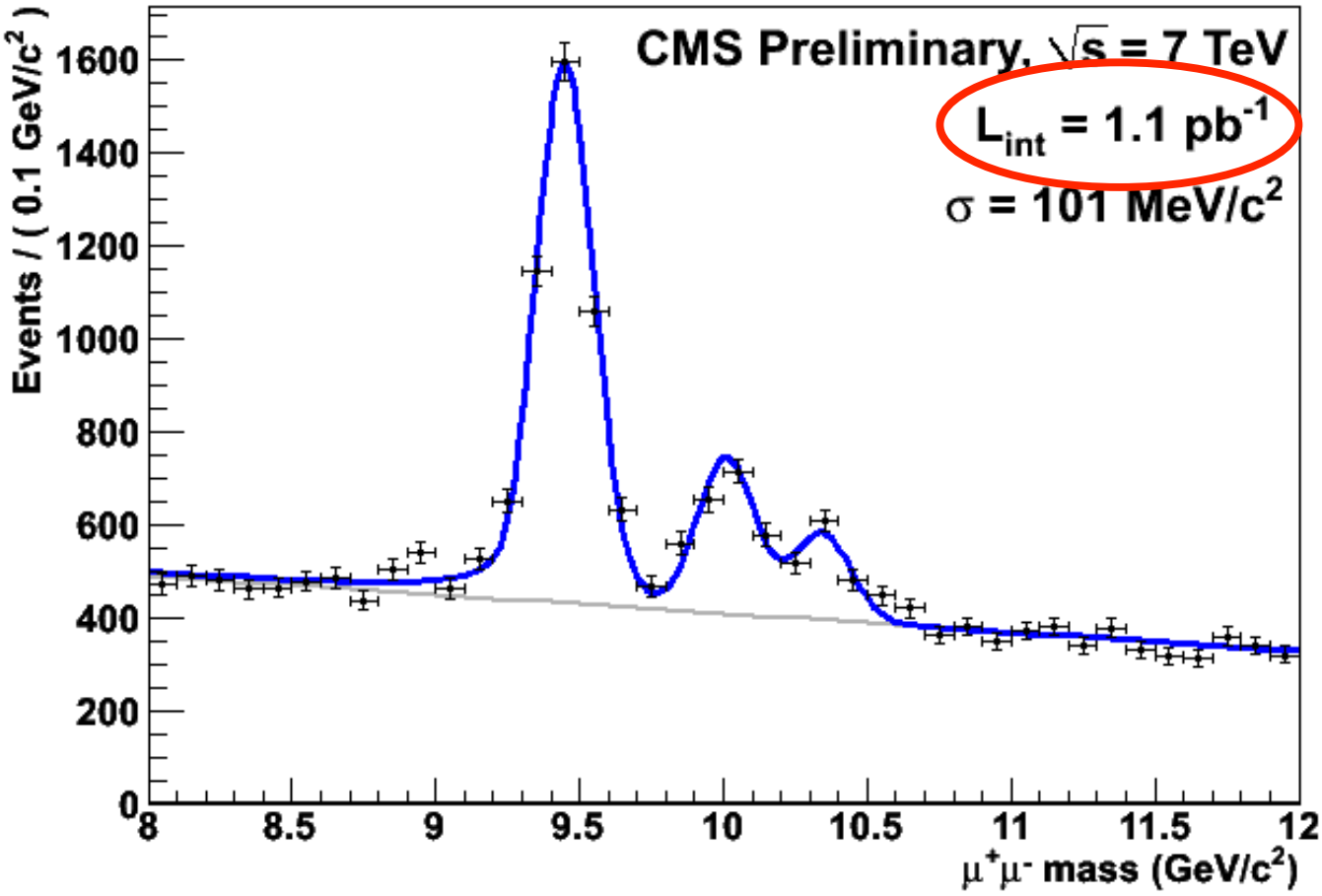
- Each muon shows as a one dot in each disk
- Gaps show dead chambers or boards
- More than 98% of chambers are working
- More than 99% of channels are working



$\mu^+\mu^-$ Spectrum



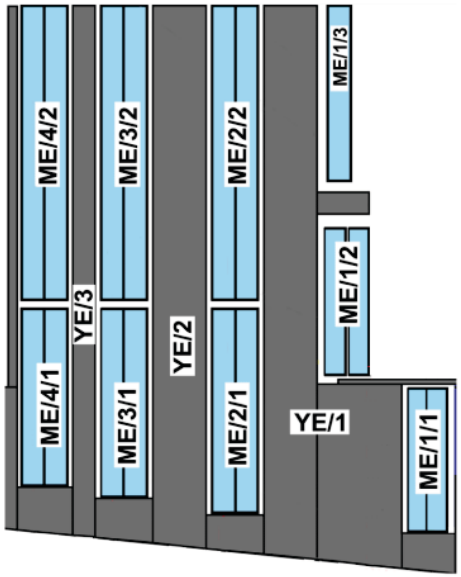
Upsilon Production



Addition of ME4/2 chambers

Requirements for Forward Muon System

- Sufficient redundancy to reduce background
  - Bremsstrahlung, neutrons, halo muons, etc.
  - Chamber efficiencies (gaps, dead electronics, etc.)
- Good enough resolution to match Tracker tracks
  - Multiplicity increasing faster than expected
  - Need 4 stations of chambers as luminosity increases



ME4 chambers were descoped at the beginning of the construction project

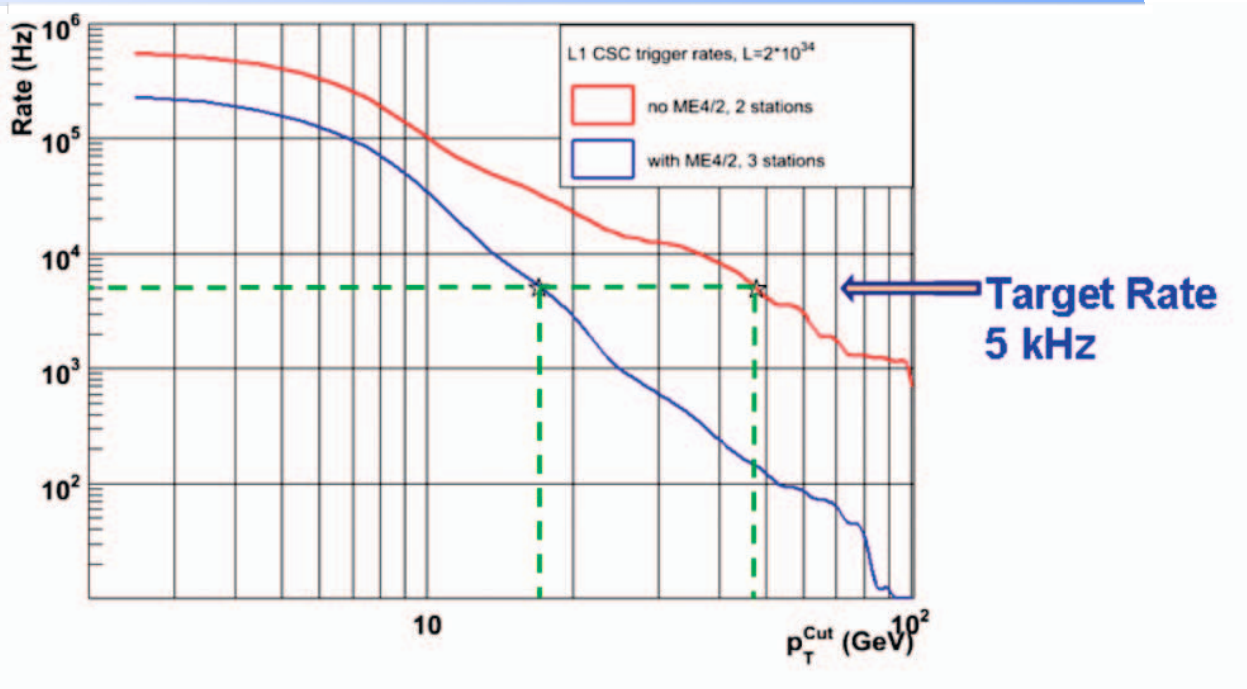
ME4/1 chambers recovered using contingency

ME4/2 chambers not yet funded

Trigger simulation

At L = 2 x 10^{34}

Triggering becomes very difficult without the ME4/2 station, and the threshold for 5 kHz rate becomes 48 Gev, instead of 20 Gev



By adding the ME4/2 station we can reduce the trigger threshold to less than 20 GeV even for events with a missing station

CMS Endcap Plans I

- **Geometry**
  - **ME4/2 chamber mount close to the iron disk YE3**
    - Must be installed first
  - **RE4 (RPC) chambers mount above the CSC chambers**
  - **YE4 shielding wall built on the outside**
    - Protect muon system from collimator spray
- **Schedule**
  - **CMS plans to rebuild the 4th station in 2012 shutdown**
  - **2016 shutdown for replacing pixel, HCAL SPIMs**
    - No access planned for muon systems
  - **ME4/2 station is not funded, will not be ready for 2012**

CMS Endcap Plans II

- **CMS has offered help for ME4/2**
  - **Building 904 factory**
    - 1000 m^2 space for chamber assembly
      - **Open area, clean, has services (gas,power, air, etc.)**
    - Occupancy in early 2011
    - Shipping tooling from Fermilab this Fall
    - Armando Lanaro will be factory manager
  - **1 MCHF funding to get production started**
    - Almost sufficient funding for 30 chambers M&S
      - **With spares, prototypes enough for 1 endcap**
    - Difficult to use with US vendors (EU bidding reqs)

Plans for ME4/2 station

- Added 5 spare ME 4/2 chambers to YE+3
- Parts for 3 prototypes will be assembled in 2011 in the B904 factory
- Will try to complete this endcap during 2012 shutdown
- Get remaining ME4/2 station ready for 2016

Beam Pipe Shielding

- **CMS has asked us to design beam pipe shielding that will permit CMS maintenance after beam pipe (and EE) activation**
  - Safety requirement from CERN/French Nuclear Agency
  - Wisconsin had a leading role in designing/building beam supports
  - CMS providing funding
- **Dick and Dan Wenman are leading the design effort**
- **Looking at mechanical shielding for the next few years**
- **Substantial radiation shielding for high luminosity**
  - Large weight of lead shielding (Pb 2 to 4 cm thick)
  - Needs to be easy to install with small exposure to personnel
  - Install around beam pipe in various opening scenarios
- **Schedule**
  - Review design during Autumn 2010, then begin production
  - Trials during 2012 shutdown

Summary

- **EMU Status**
  - CSC chambers operating very well
  - Delivering good triggers and reconstructed muons
  - Wisconsin team is an important ingredient
- **Goals**
  - Provide maintenance, keep EMU operating well
  - Complete ME4/2 station as soon as possible
  - Complete design and production of beam pipe shielding