


CMS Program Part II: Muon Chambers and Muon-Related Analyses

Jim Pivarski

Texas A&M University

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Organization of this talk

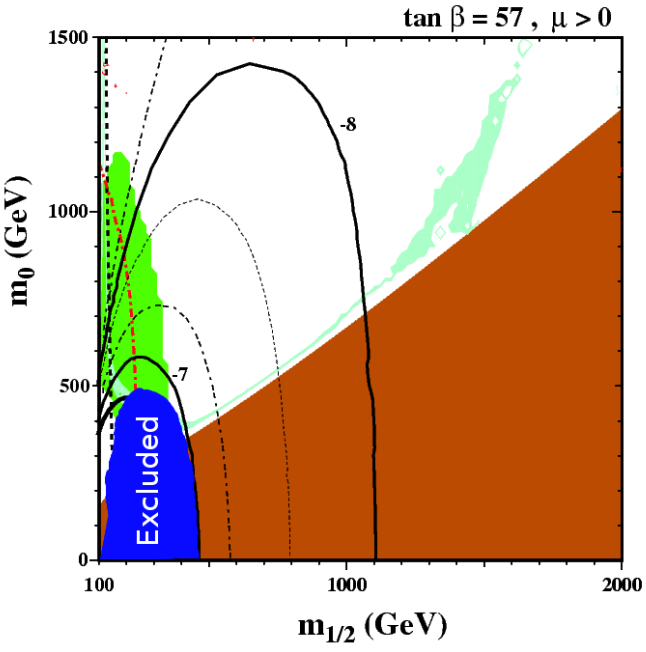
- Muon Experience from CDF
- CMS EMU Projects: Low Voltage and Alignment
- $Z' \rightarrow \mu\mu$ Search
- Aligning Muon Chambers with Tracks (software)
- Hardware EMU Alignment
- Super-LHC Upgrade

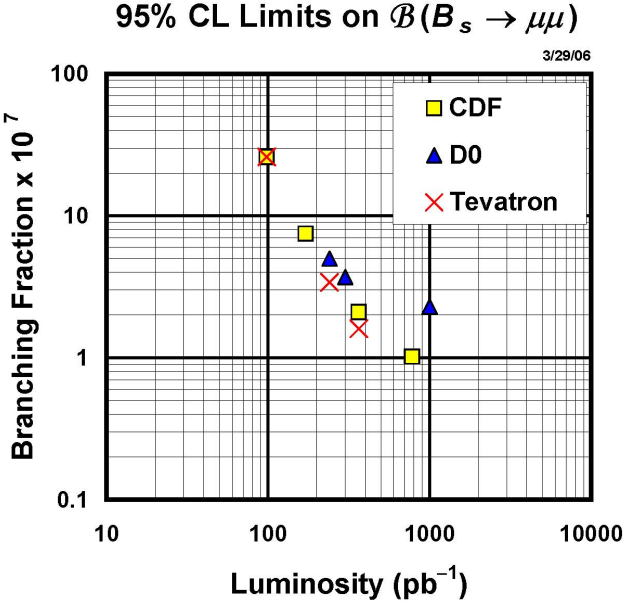
A&M's muon experience at CDF

- Muon Reconstruction (Kamon, Krutelyov)
  - SimpleExtrapolator matches central tracker tracks to muon stubs
  - Fast and accurate
  - Now part of standard CDF muon reconstruction
- Low p_T di-muon trigger (Kamon, Krutelyov)
  - Used to search for $B_s \to \mu\mu$

SUSY constraint through $B_s \to \mu\mu$

- Co-proposed by Kamon, previously overlooked test of SUSY
- One of the strongest CDF constraints on high tan β SUSY
- World's best upper limit $\mathcal{B} < 1.0 \times 10^{-7}$ at 95% C.L. (780 pb^{-1})
- First SUSY paper from CDF Run II
- We are using a neural net and extending to 1 fb^{-1} (Weinberger, Kamon)
- Interested in continuing at CMS





A&M's involvement in CMS EMU

- Good fit to our interests and experience
- EMU members since June 2006
- Took charge of critical areas:
  - Low voltage power supply
  - Chamber alignment

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- Good fit to our interests and experience
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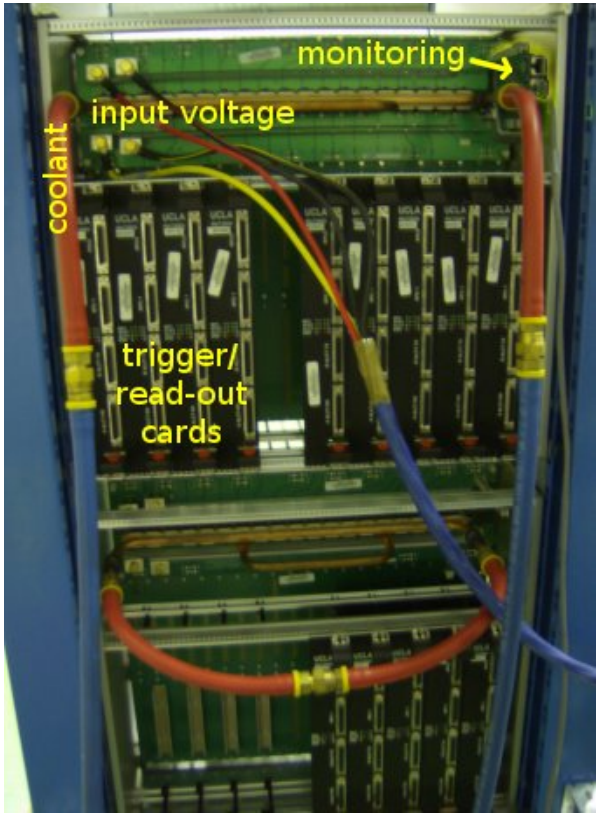
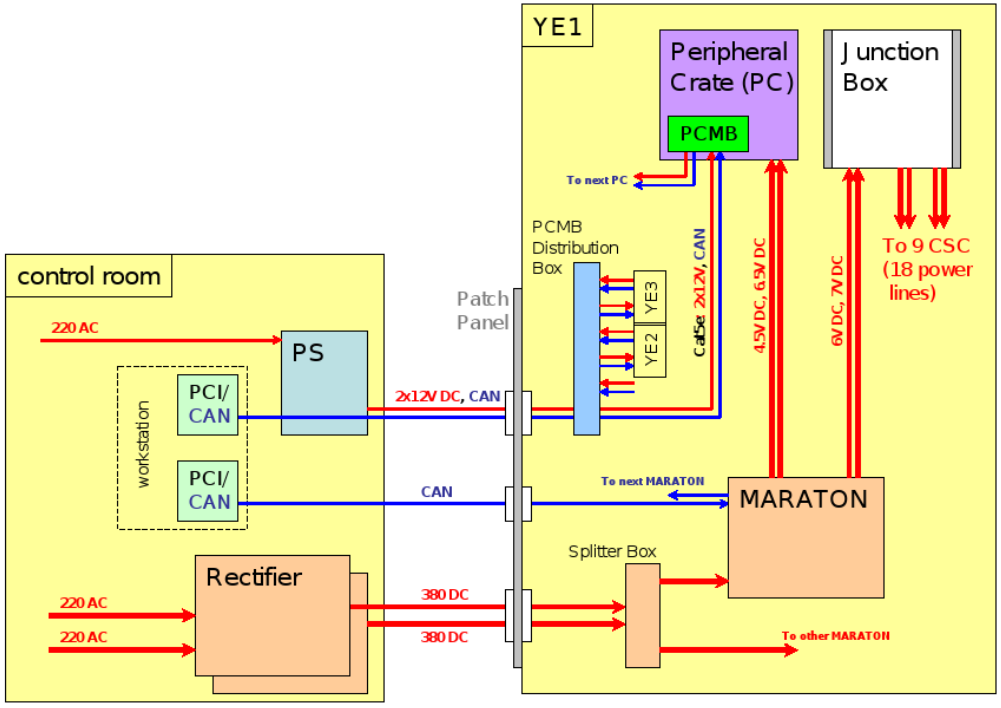
  - Chamber alignment
- Hired Alexander Golyash July 2006
  - lead engineer on construction and commissioning of low voltage
  - will provide long-term support
- Hired Jim Pivarski (me) September 2006
  - wrote muon alignment software
  - developing an alignment strategy
  - will study $Z' \to \mu\mu$

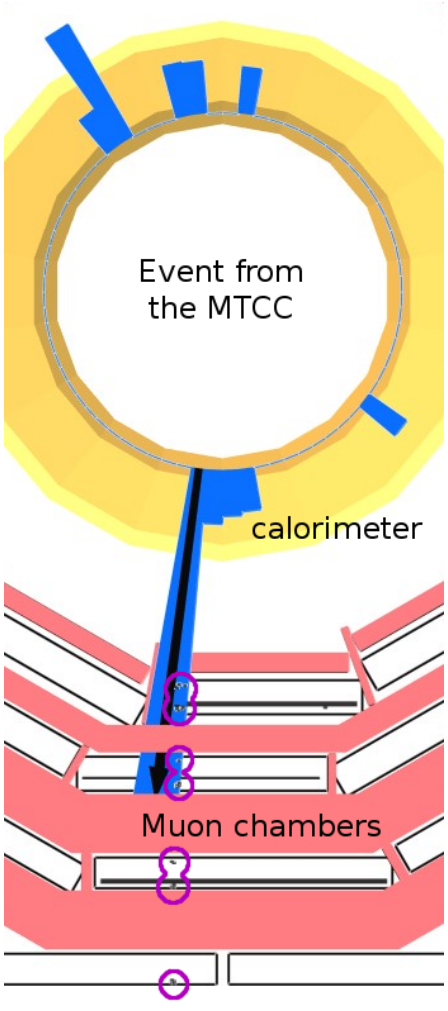
Low voltage power supply

- Powers trigger/read-out crates and on-board electronics
- Even though it's a part of a subsystem, it's an involved project

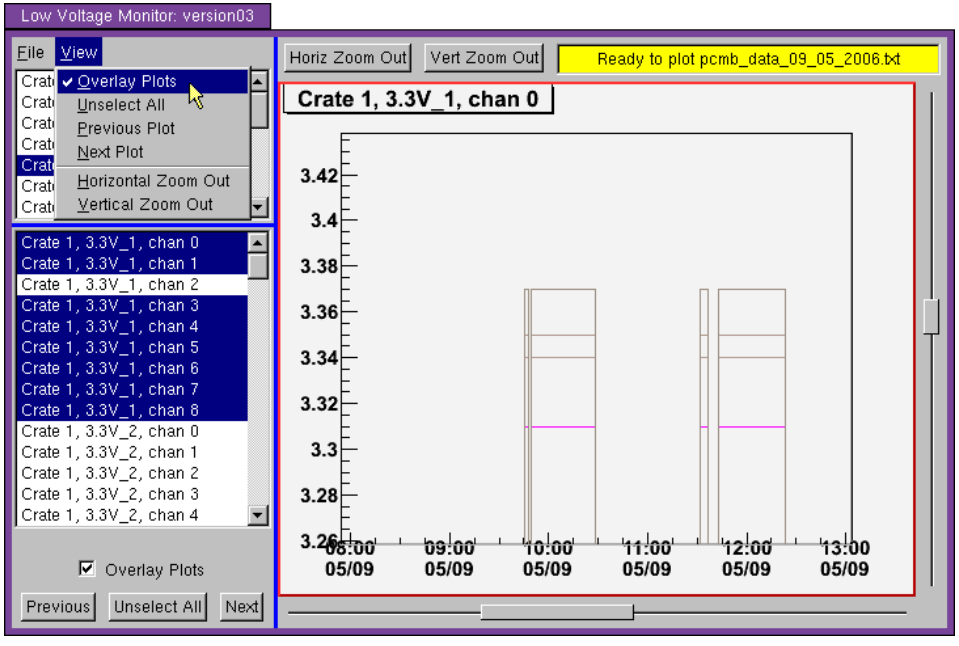




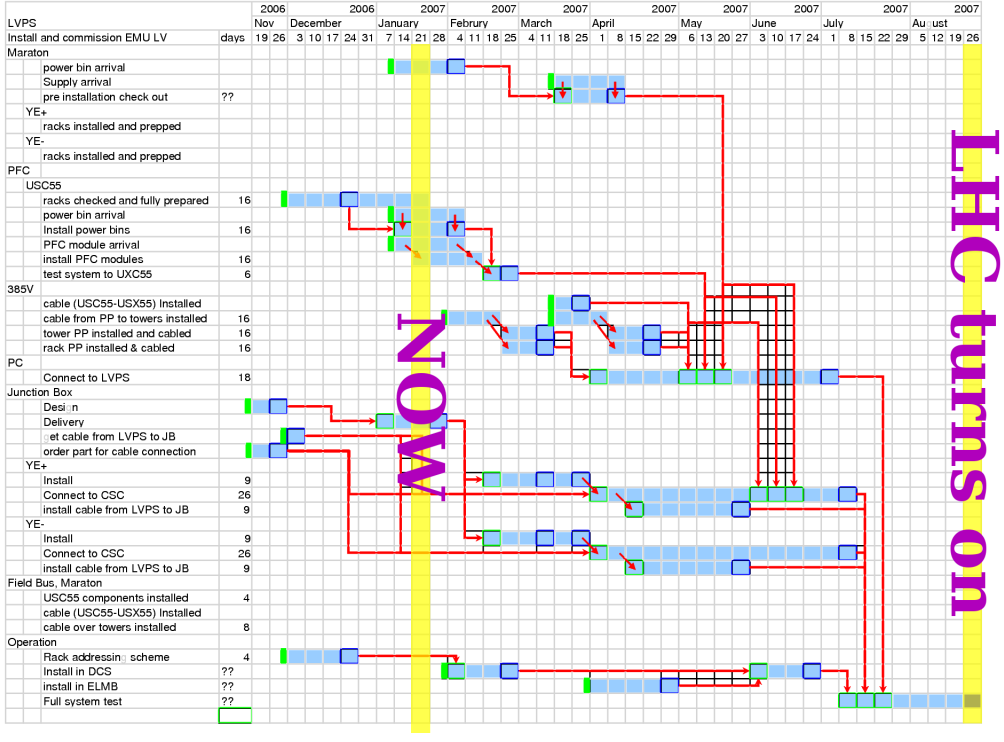
Monitoring low voltage



- Recorded voltages and currents from MTCC (summer 2006 slice test)
- Needed a way to organize large logfiles
- We developed an expert tool for diagnostics



There's still a lot of work to be done



- Ordered components, shipping schedule is tight
- Need to coordinate with other projects for electricity, lifts, and space underground

Physics interest: $Z' \to \mu\mu$

Many theories predict a heavy neutral boson, generically called Z'

- Unification gauge groups
- Excitation of Z^0 or graviton in extra dimensions
- $\tilde{\nu}$ in R-parity violating SUSY

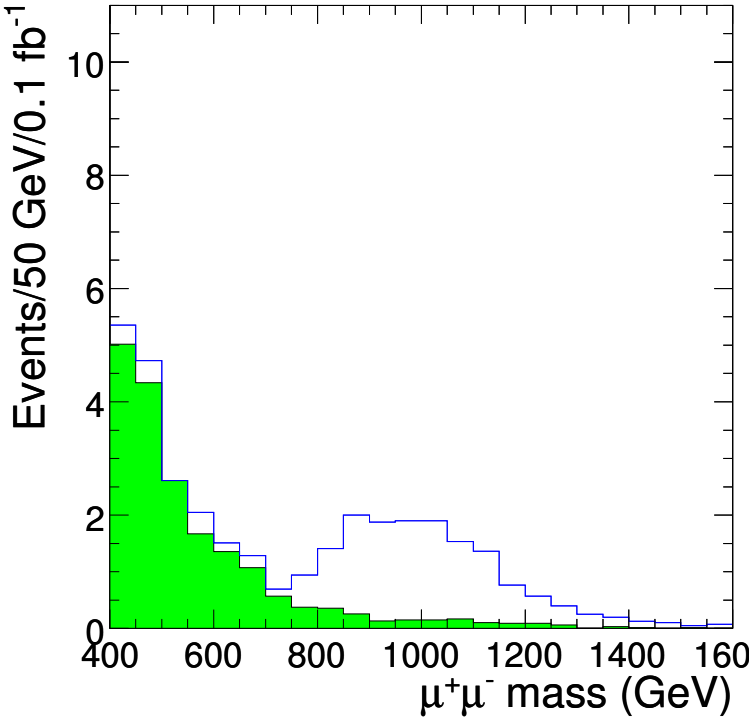
Experimentally striking feature:

a peak in $\mu\mu$, e^+e^-, and di-jet mass spectra

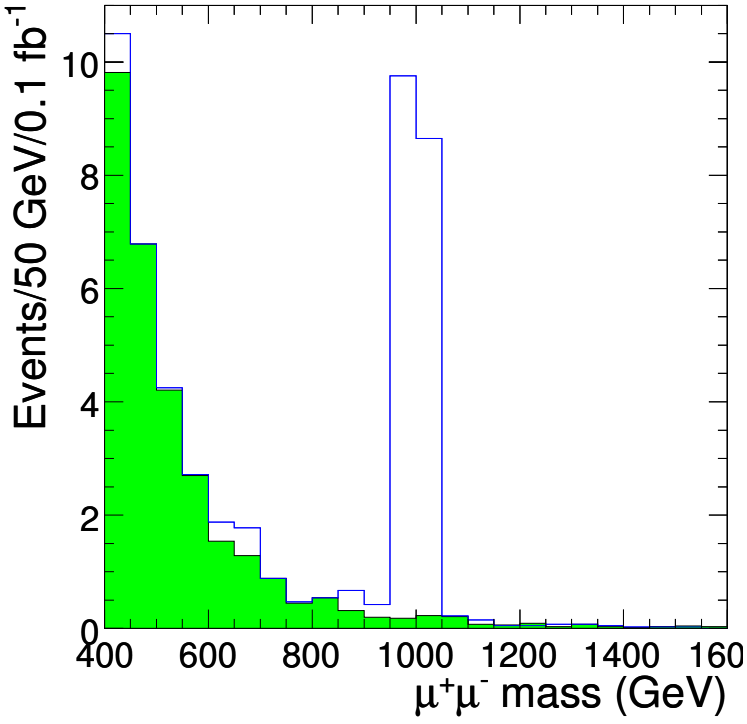
(A concrete way to search for New Phyics model-independently!)

Early CMS result!

$Z' \to \mu\mu$ signal is diluted by misalignment

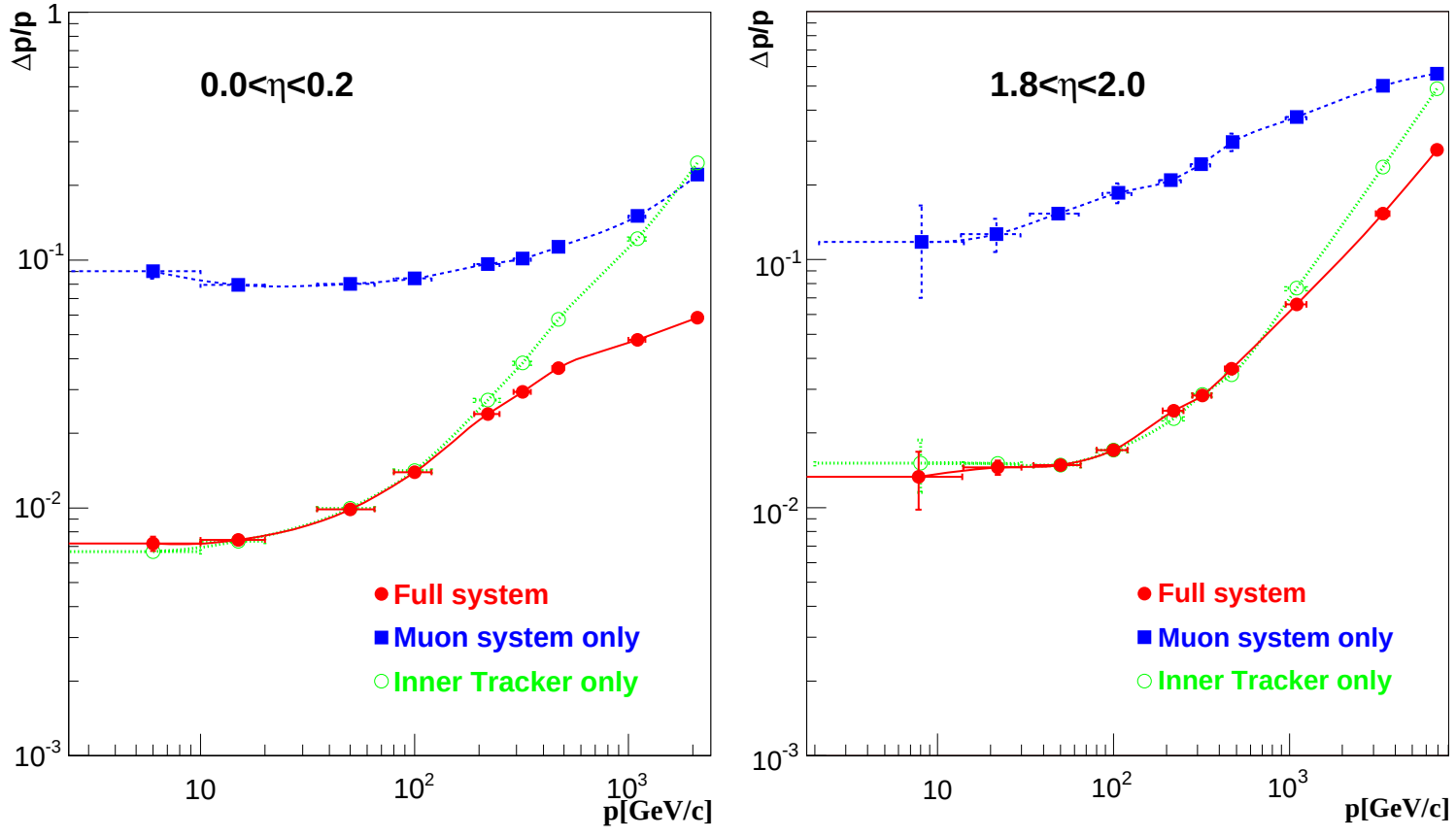


"First data" misalignment



Ideal alignment

Muon chambers are important for resolution at high p_T



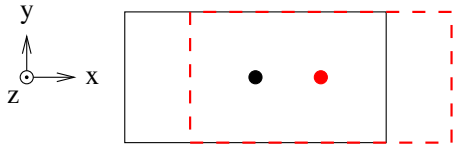
- Very straight tracks, long lever arm helps!

Muon chamber alignment with tracks

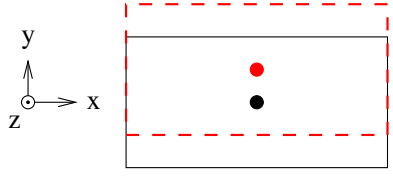
- Provides the final alignment that will be used for $Z' \to \mu\mu$
- A&M's expertise:
  - CDF muon reconstruction
  - Pivarski was CLEO's alignment expert (2000–2004)

Muon chamber alignment with tracks

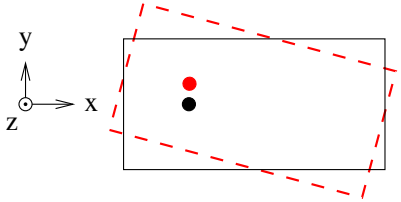
- Provides the final alignment that will be used for $Z' \to \mu\mu$
- A&M's expertise:
  - CDF muon reconstruction
  - Pivarski was CLEO's alignment expert (2000–2004)
- Simple, transparent approach: iteratively move chambers to minimize residuals



x: offset in r_x



y: offset in r_y

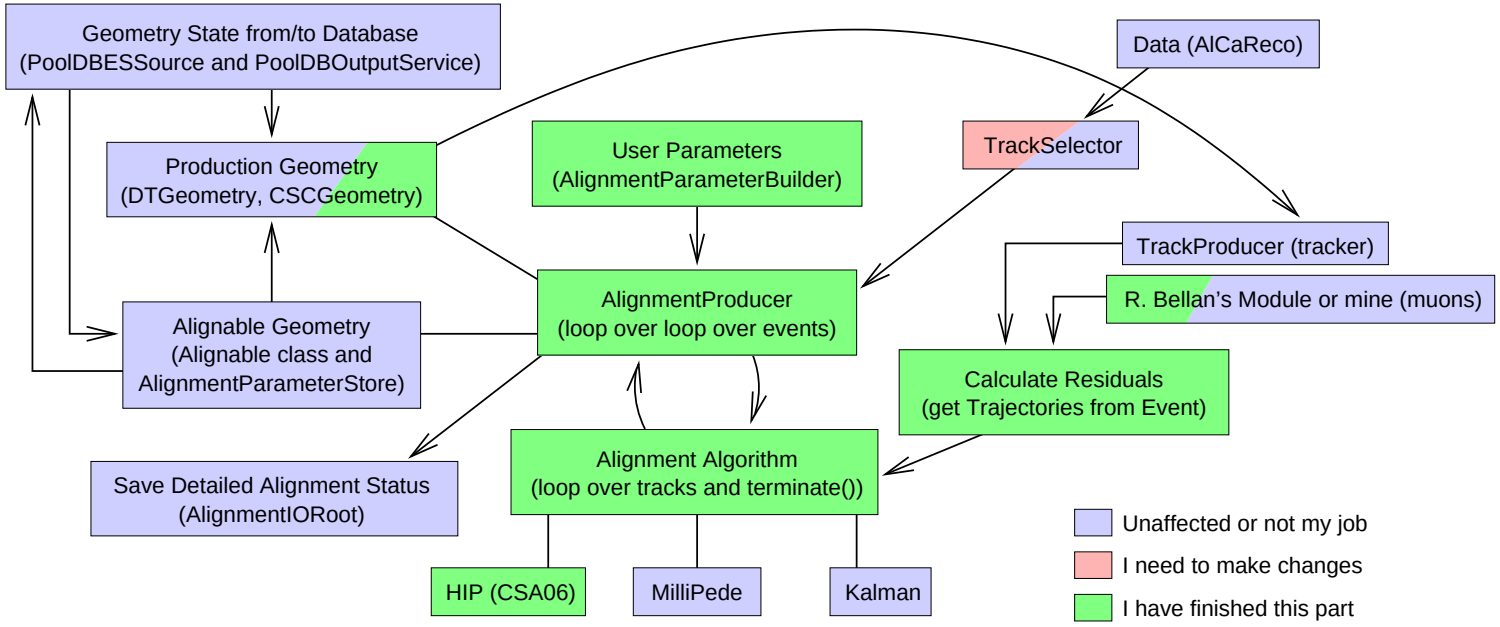


ϕ_z: r_x linear in y and r_y linear in x

- Began CMS muon alignment in October 2006
- Combined barrel + endcap alignment

Software development is nearly done

Integrated our muon alignment code into CommonAlignment

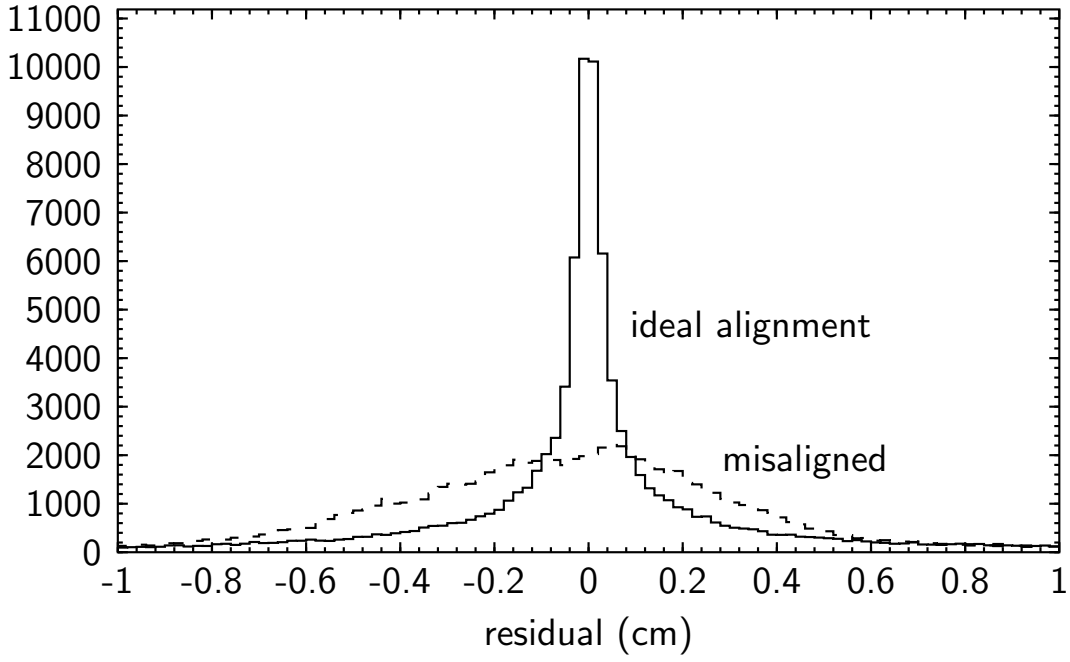


- Unifies tracker alignment and muon chamber alignment
- Easy to apply global-fit algorithms to muon chambers (MillePede and Kalman-based, in development)

Beginning study of alignment procedure

Potential sources

- $Z \rightarrow \mu\mu$
- $W \rightarrow \mu\nu$
- $b \rightarrow \mu X$
- beam halo, cosmics

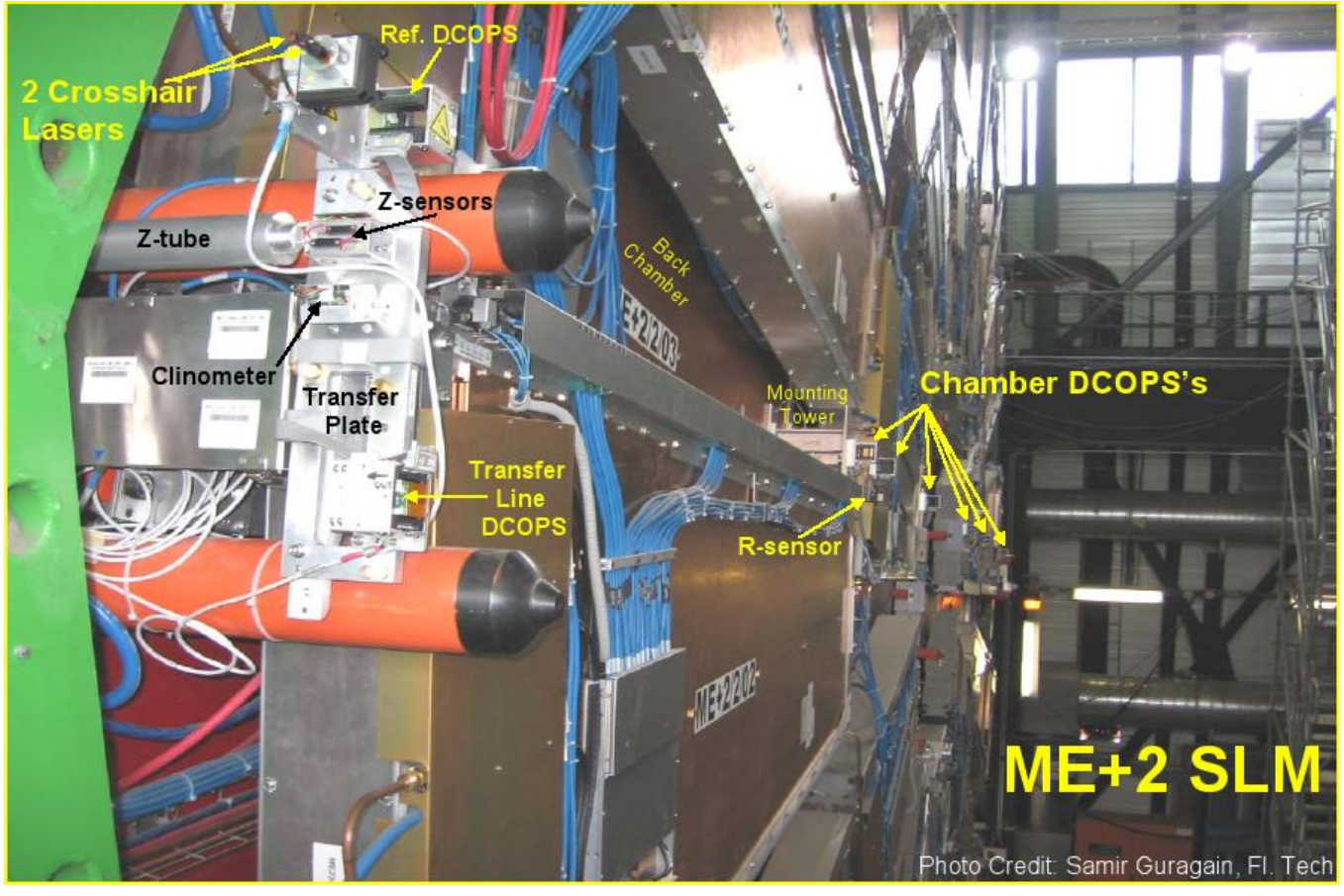


At high luminosity ($10^{33}/\text{cm}^2/\text{s}$, scheduled for 2008), $Z \rightarrow \mu\mu$ and $W \rightarrow \mu\nu$ will be sufficient:

17 hours for 200-300 μm in barrel (410,000 muons),
10 hours for 100-150 μm in endcap (220,000 muons)

Hardware EMU alignment system

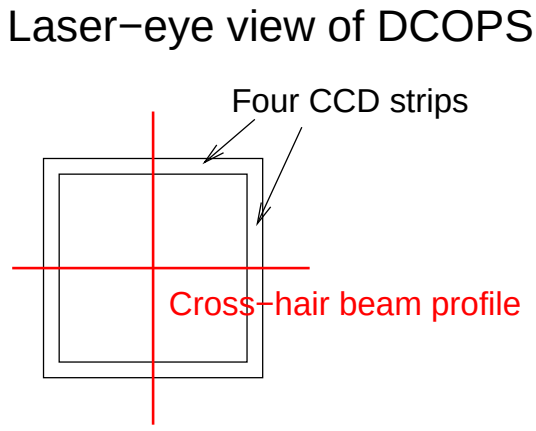
Active collaboration with Wisconsin, FIT, FermiLab



Contribution to laser alignment

DCOPS sensor boxes measure position along laser line spanning EMU disk

Existing algorithm computes mean of laser light peak



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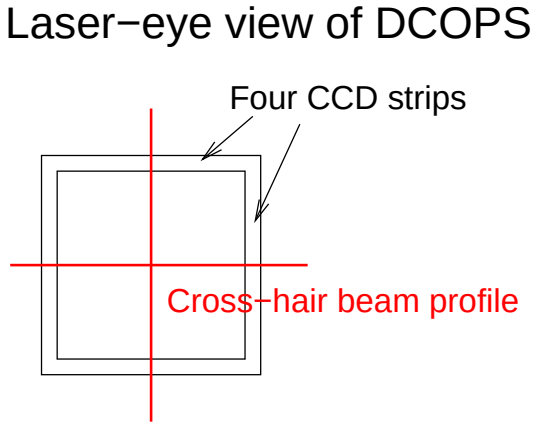

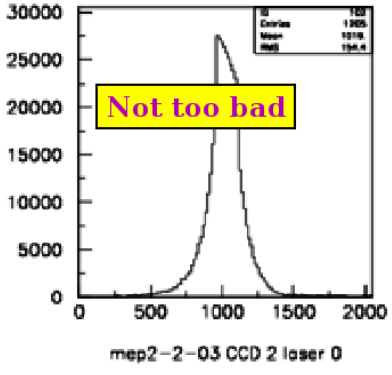

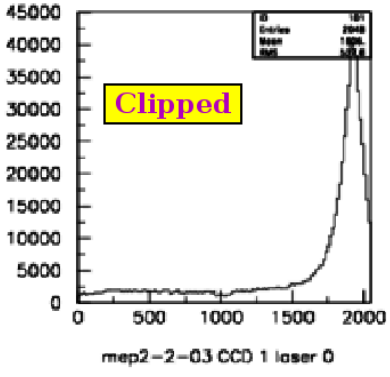

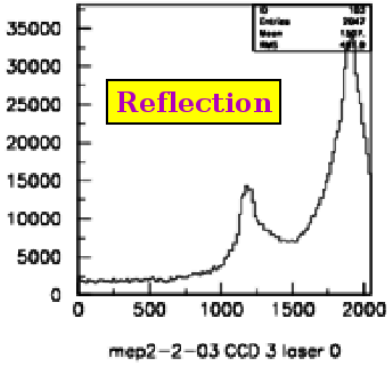

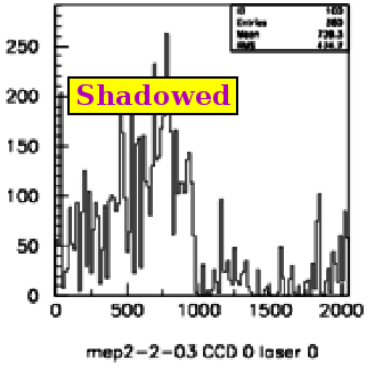

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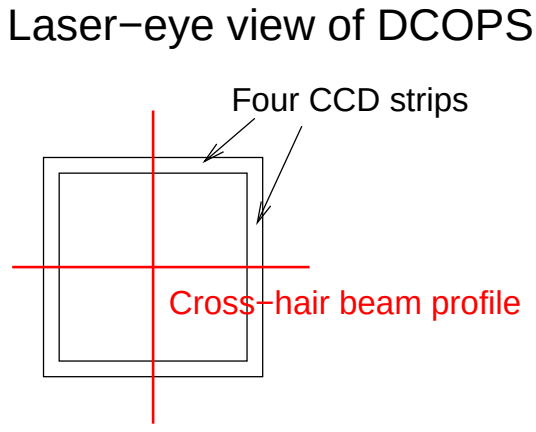
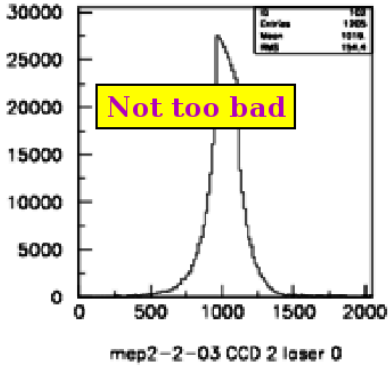
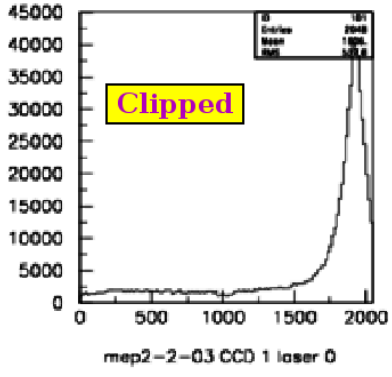
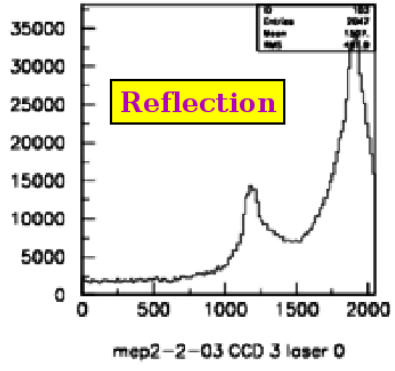
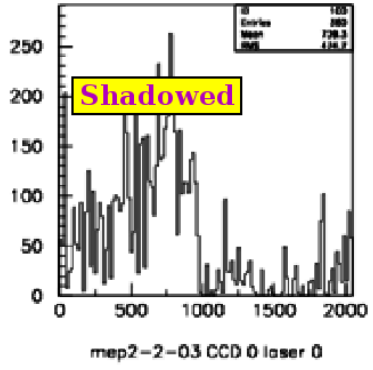










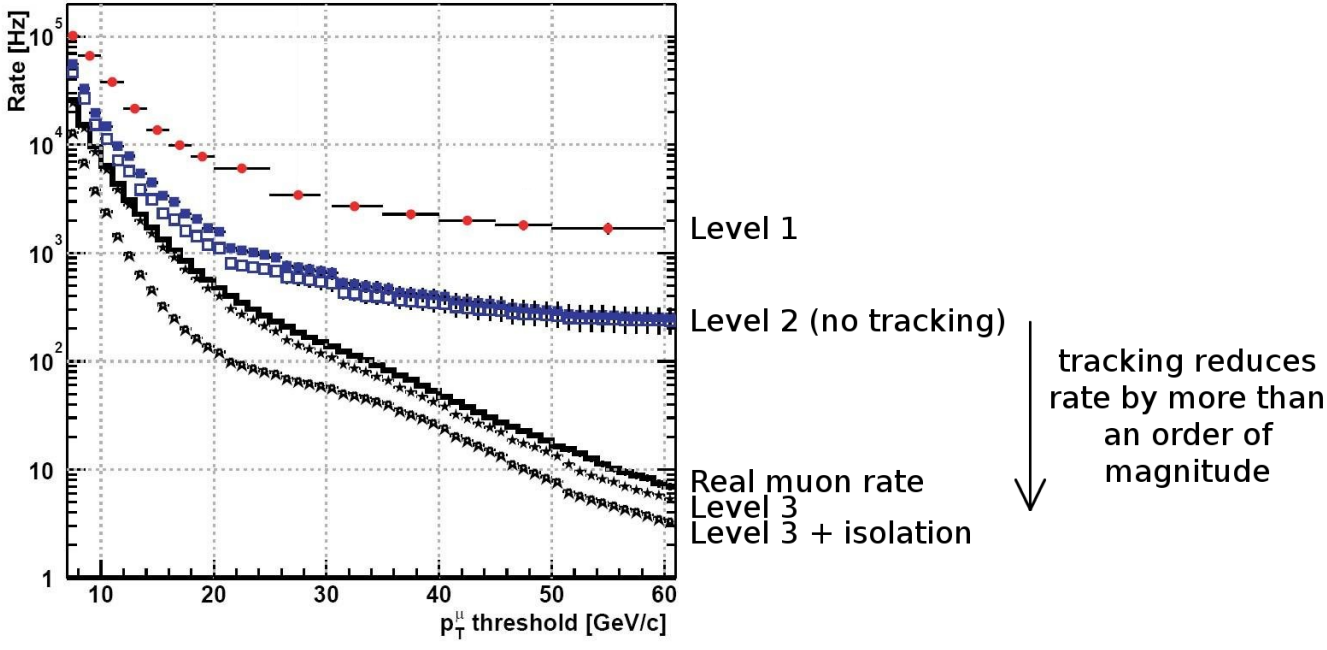
- Dmitry Yakorev (A&M grad student) developing algorithms
- Golyash (our engineer) is reprogramming firmware

Super-CMS EMU upgrade

- c. 2015, LHC upgrade to $10^{35}/\text{cm}^2/\text{s}$: a trigger challenge!

Super-CMS EMU upgrade

- c. 2015, LHC upgrade to $10^{35}/\text{cm}^2/\text{s}$: a trigger challenge!
- Current CMS trigger does not include tracking in Level 1



- Plan to work on design of the upgraded trigger system for Super-CMS (Yakorev, Kamon, Safonov)
- Both EMU and global trigger

Recap of A&M muon projects

CDF

- Muon reconstruction (Krutelyov, Kamon)
- Low-p_T di-muon trigger (Krutelyov, Kamon)
- $B_s \to \mu\mu$ analysis (Weinberger, Kamon)

CMS

- EMU low voltage and monitoring (Golyash, Pivarski, Safonov)
- $Z' \to \mu\mu$ analysis (Pivarski, Safonov, Kamon)
- Track-based alignment (Pivarski, Safonov, Kamon)
- Hardware alignment (Golyash, Yakorev, Pivarski, Safonov, Kamon)

Super-CMS

- EMU upgrades (Yakorev, Kamon, Safonov)