The Run II DØ Muon Detector System and Muon Identification at the Fermilab Tevatron

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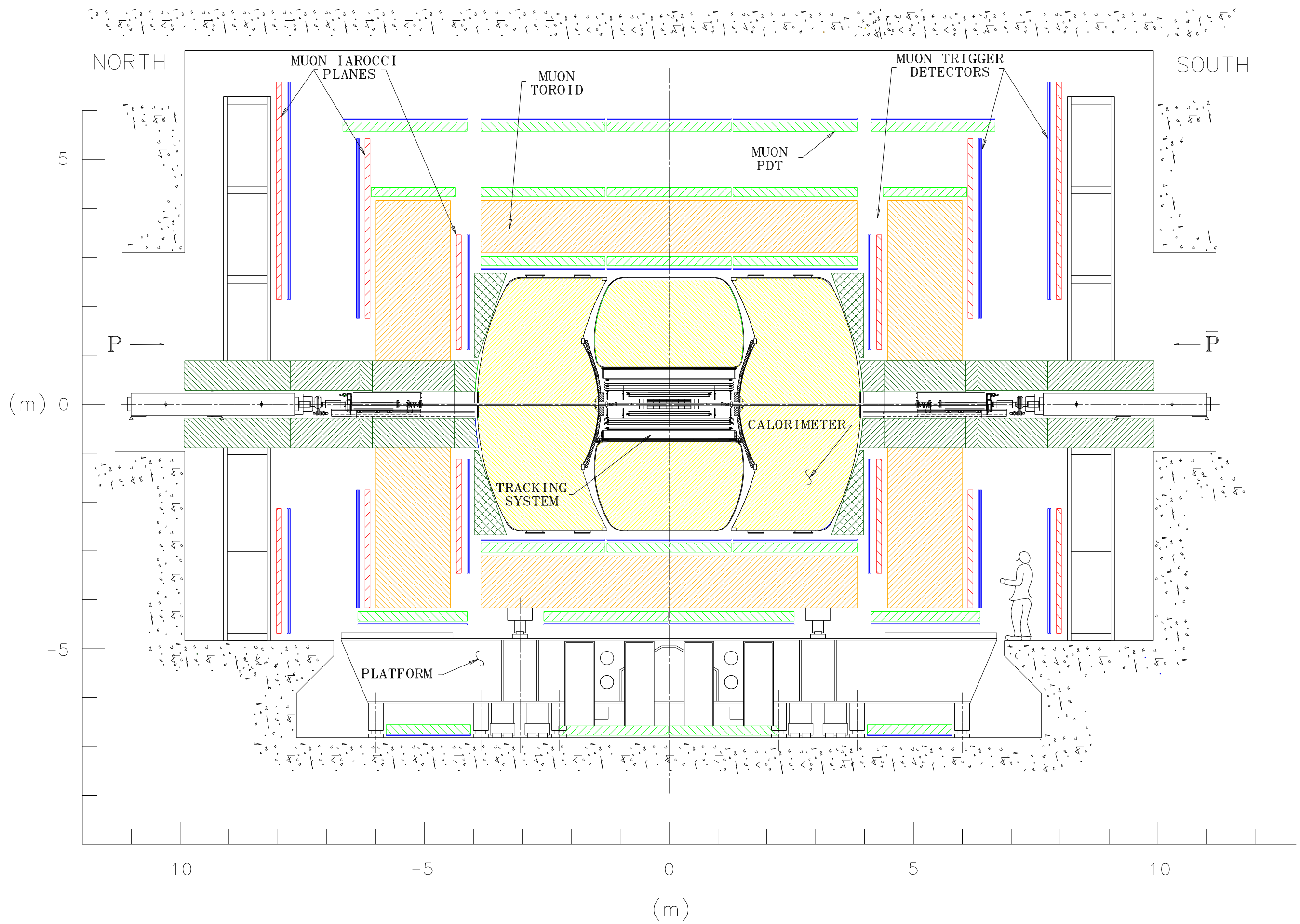
Overview

1. Front End Muon Detector Systems
    - Geometrical layout,
    - Muon detectors used at DØ.
2. Muon Trigger and Readout
    - Front End Electronics,
    - Readout System,
    - Three Levels of Trigger.
3. Offline Muon Identification
    - Muon Reconstruction,
    - Muon Object Quality Criteria.
4. Physics Signals

DØ Muon Detectors



Muon Detectors (Continued)

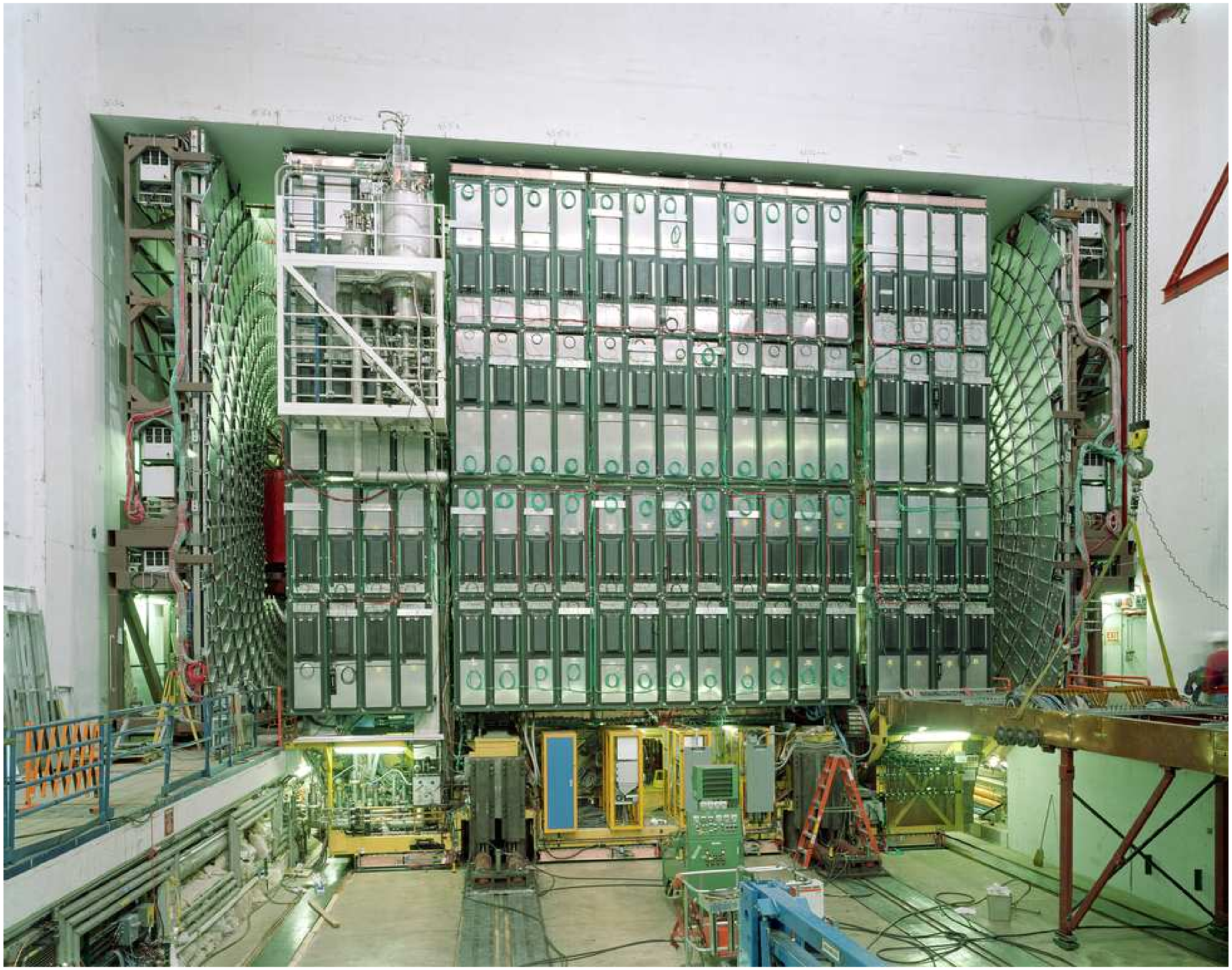
Central Tracking Chambers: Proportional Drift Tubes (PDT's) — 6624 $10.1\,\mathrm{cm} \times 5.5\,\mathrm{cm}$ drift cells in 94 three- and four-deck chambers

Central Scintillation Counters: 360 "cosmic cap" counters outside the toroid ($\Delta\phi = 22.5°$) and 630 "$A-\phi$" counters inside ($\Delta\phi = 4.5°$); $\Delta\eta = 0.1$

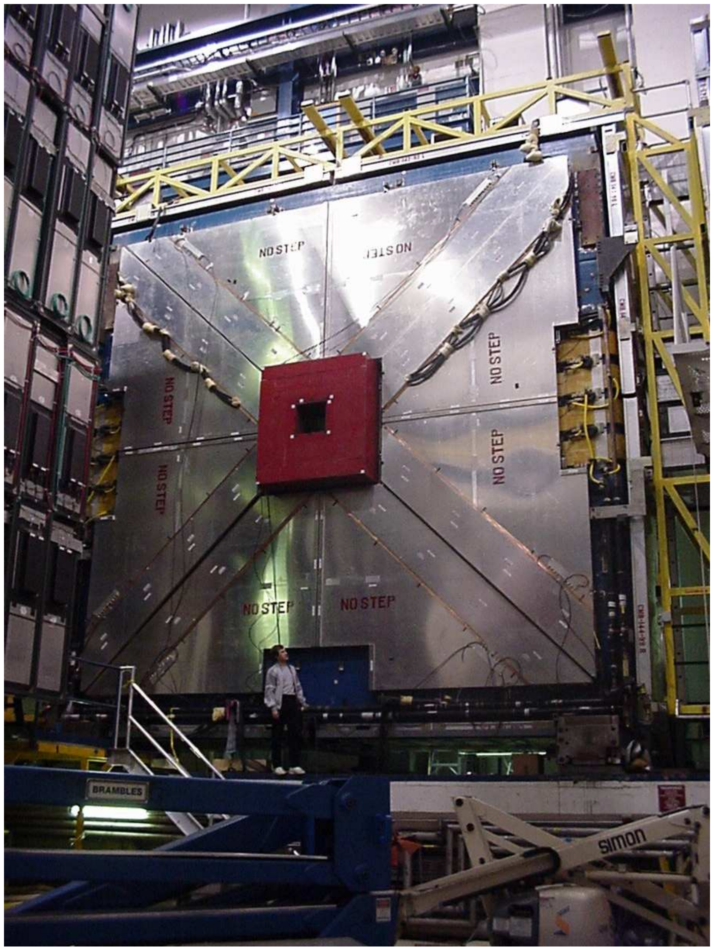
Forward Tracking Chambers: Mini Drift Tubes (MDT's) — 6080 eight-cell tubes in 8 octants per layer on the north and south side, cell cross section $9.4\,\mathrm{mm} \times 9.4\,\mathrm{mm}$

Forward Scintillation Counters: 4214 pixel counters on the north and south side of the detector, $\Delta\phi = 4.5°$ matches the Fiber Tracker trigger sector size, $\Delta\eta = 0.12$ except the last three rows where $\Delta\eta = 0.07$

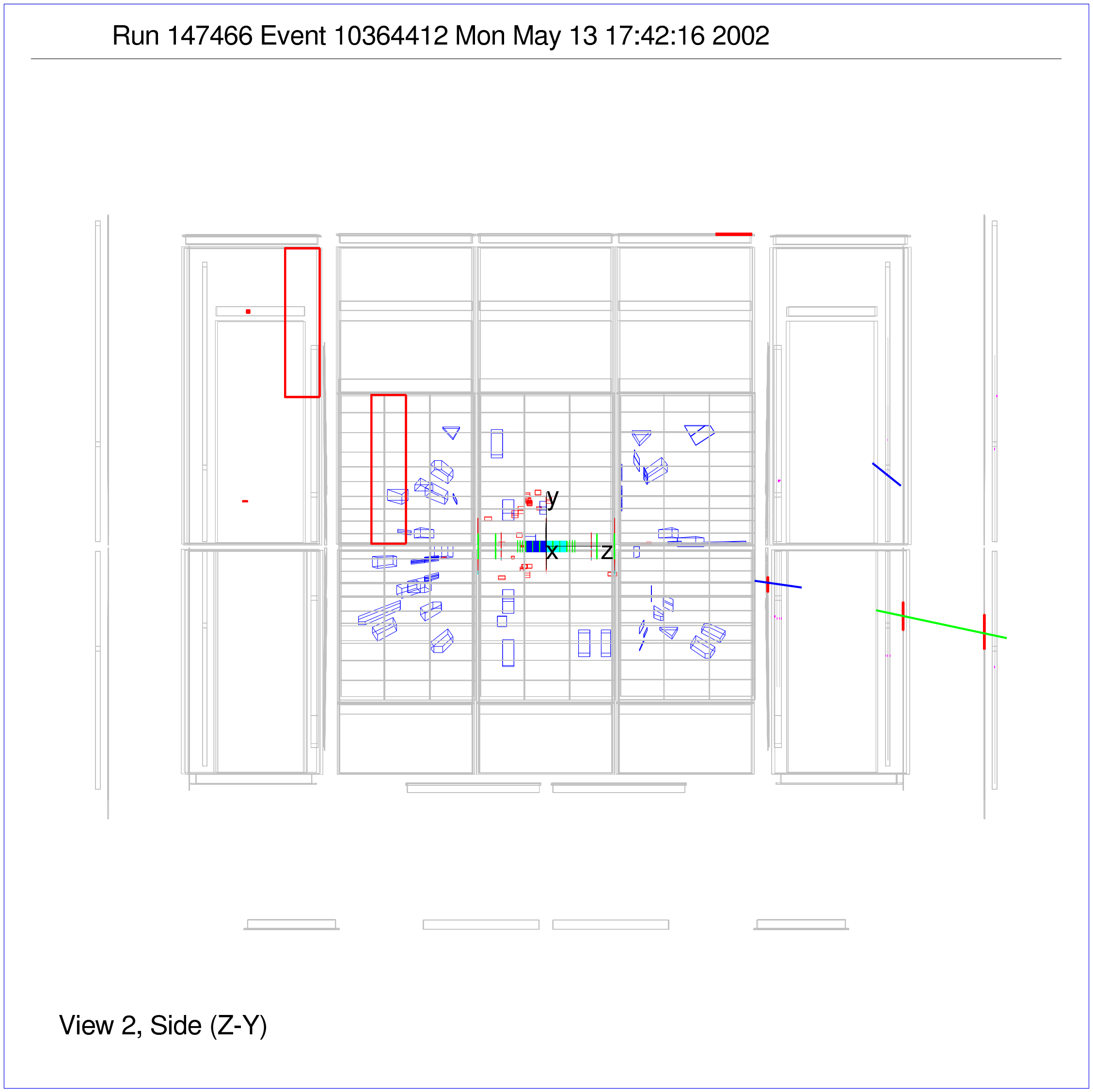
DØ Muon Detectors (Continued)



DØ Muon Detectors (Continued)



A Muon Event



Run 147466 Event 10364412 Mon May 13 17:42:16 2002
y
x
z
View 2, Side (Z-Y)

Front End Muon Electronics

PDT:

Custom designed DSP Front End and Control boards.

MDT:

Amplifier Discriminator Boards and VME crates with the Readout Controller and Digitizer cards.

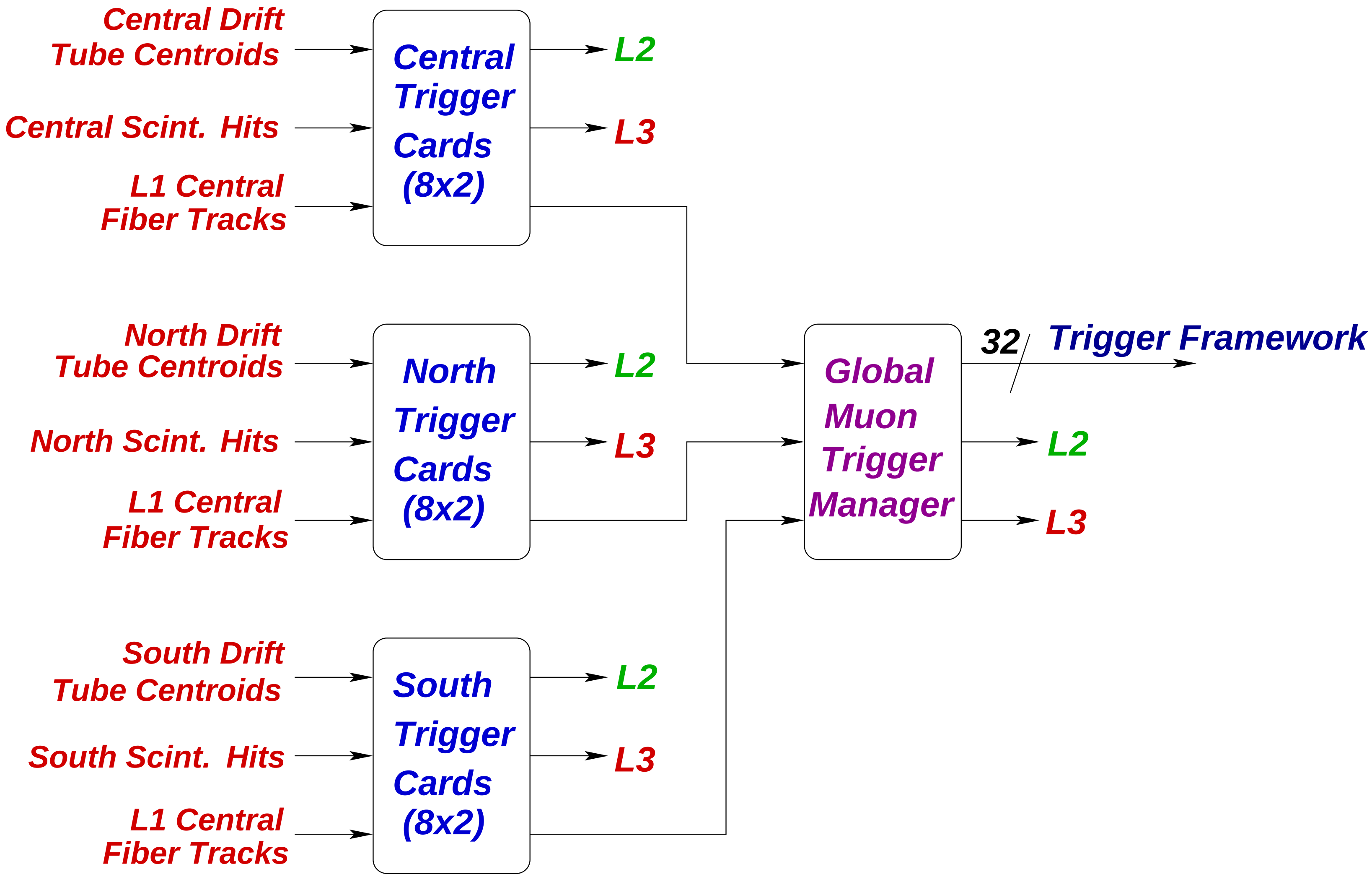
Scintillator:

VME crates with Readout Controller and Front End cards.

All muon Front Ends implement a uniform buffered readout scheme:

- Front End data pipeline,
- L1 FIFO,
- L2 FIFO.

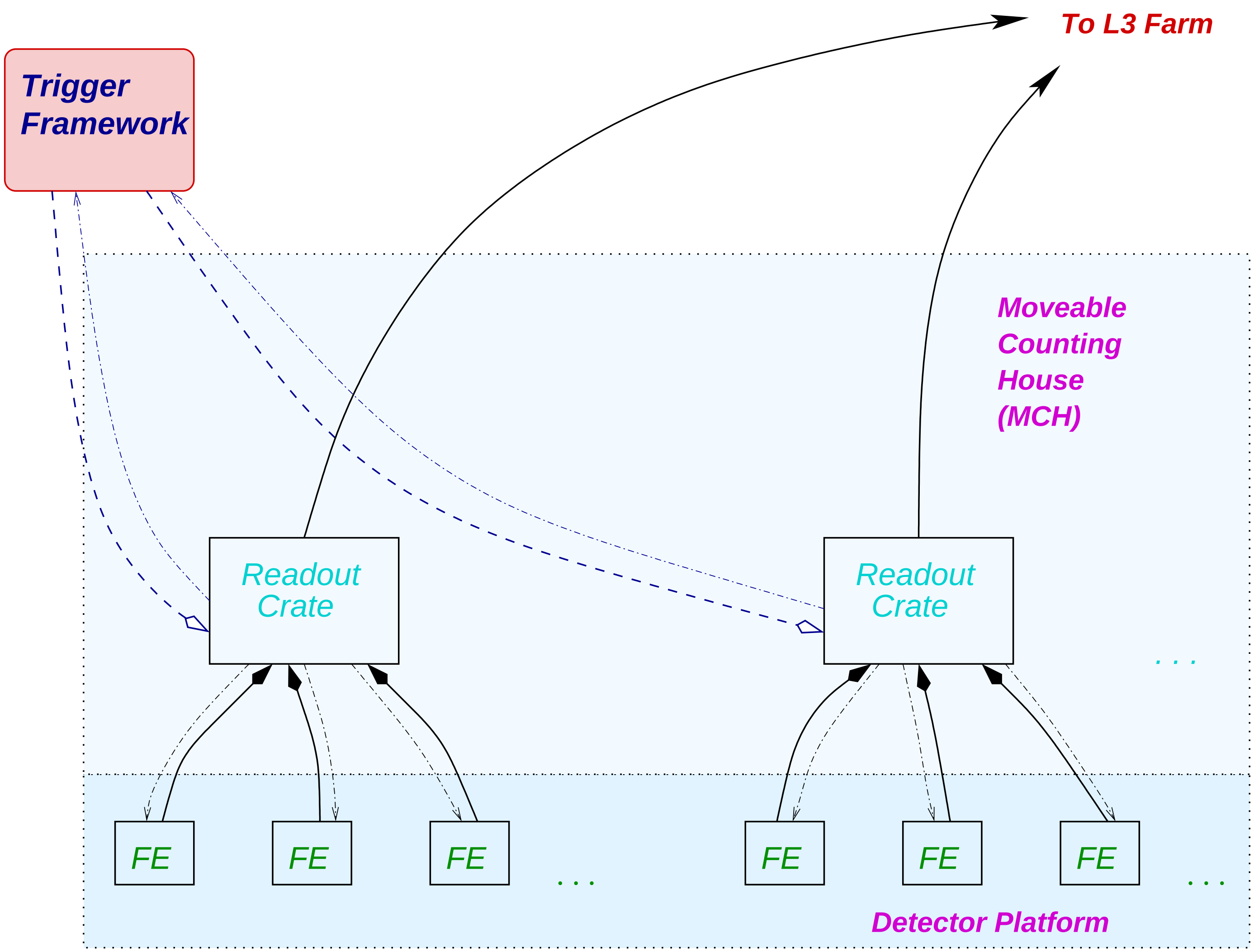
Level 1 Muon Trigger



Level 2 Muon Trigger

1. Track Segment Finding (DSP Boards):
   - Inputs from the front end and L1 muon systems are used to build track segments ("stubs") inside and outside the toroid.
2. Track Assembly (ALPHA Preprocessors):
   - All reported stubs are compared to search for matches,
   - Matches (or single stubs) are assembled into L2 muon candidates,
   - Track parameters are reported to Level 2 Global and Level 3.
3. Level 2 Global Trigger Decisions:
   - Muon candidates related to other L2 objects,
   - Trigger decisions reported.

Muon Readout System



Level 3 Muon Filter

Unpacking

- Raw wire hit data from the muon readout crates unpacked and converted to space points.

Local Tracking

- Hit space points are used to reconstruct track segments in a single module,
- Segments are linked inside and outside the toroid to make a full track.

Under Development:

- Central track matching,
- Calorimeter confirmation and isolation,
- Narrowing the time window using the scintillator hit information.

Offline Muon Reconstruction

1. Reconstruction in the Muon System

   Hit Reconstruction

   Performed separately for PDT's, MDT's and scintillation counters,

   Track Segment Reconstruction

   Hits are combined in segments in central and forward region and filtered,

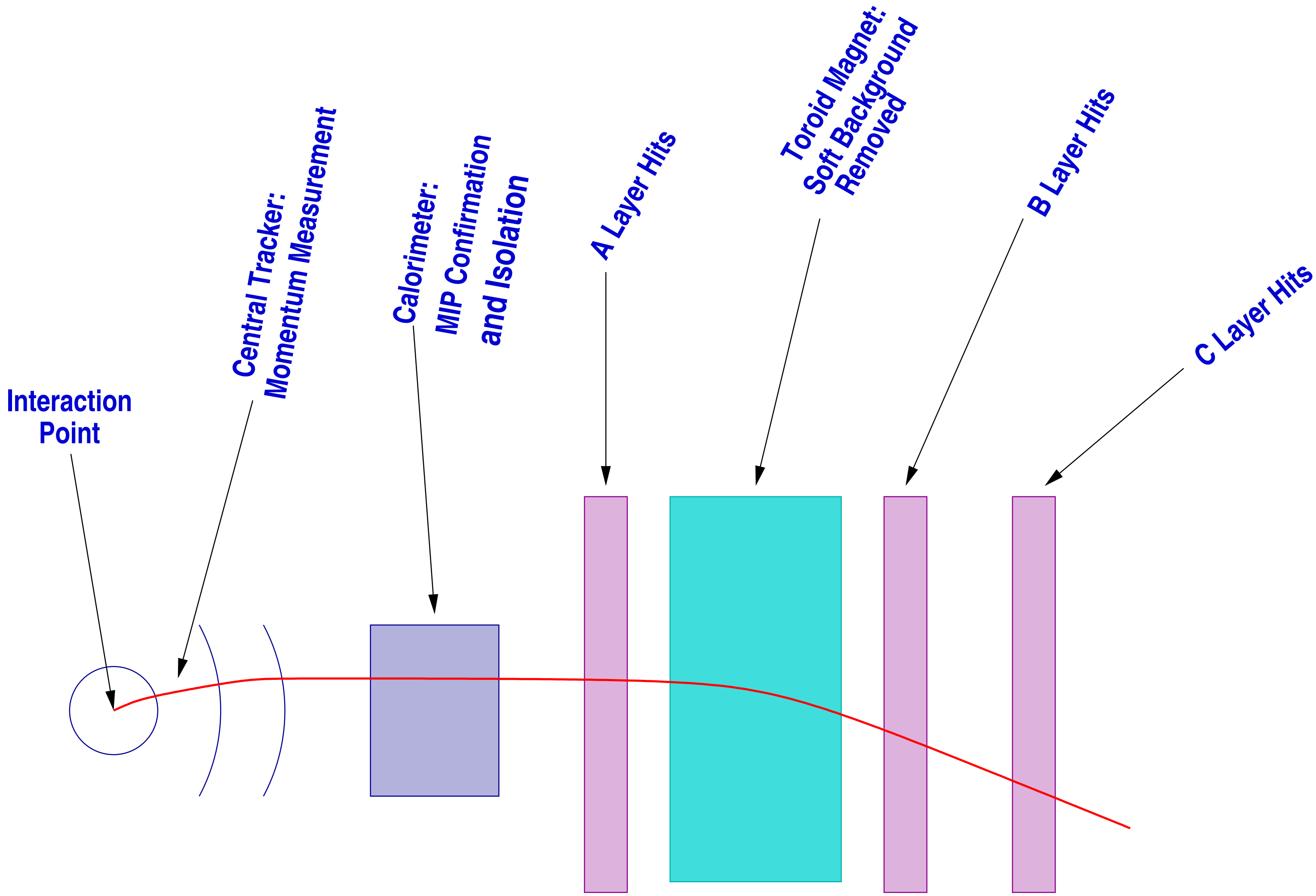
   Track Finding and Fitting

   Track segments found inside and outside the toroid are combined into tracks in the muon system alone.

2. Global Fit

   - Central Track Matching,
   - Muon Tracking in the Calorimeter.

Offline Muon Reconstruction (Continued)



Muon Object Quality Criteria

"Tight" Muon:

- At least two wire hits and a matching scintillator hit inside the toroid,
- At least three wire hits and at least one matching scintillator hit outside the toroid,
- Muon track fit successfull ($\chi^2 > 0$).

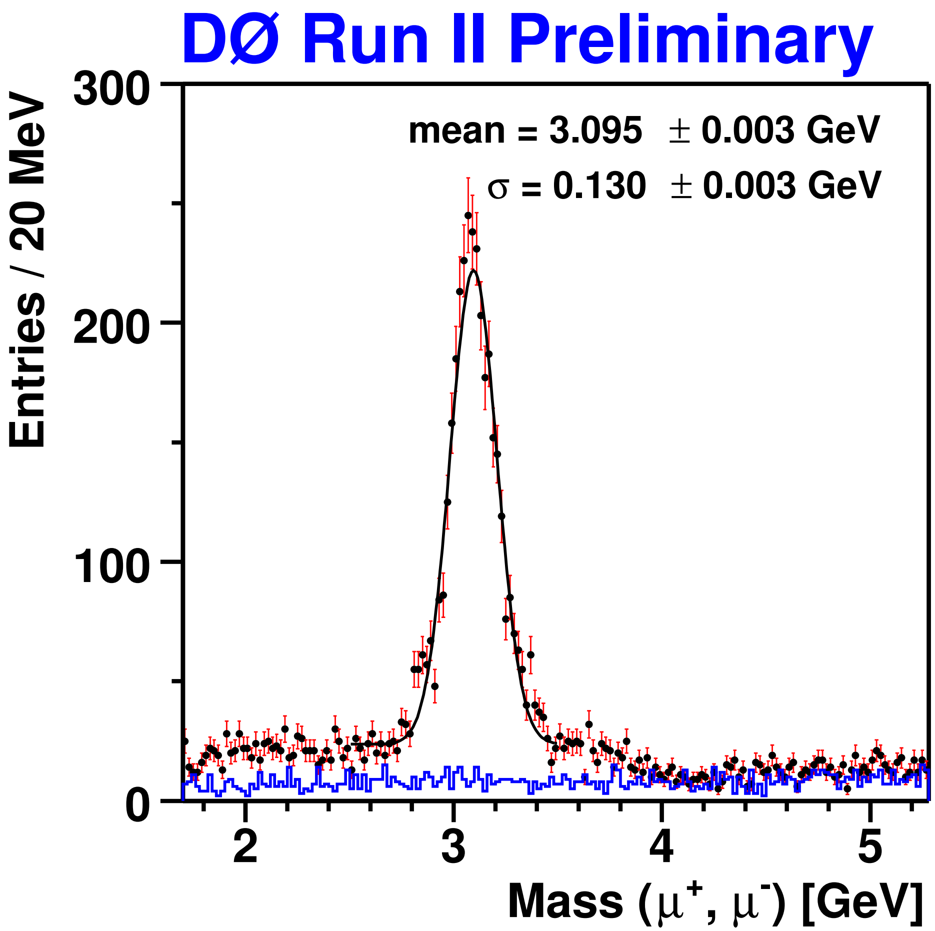
"Medium" Muon:

- At least two wire hits and a matching scintillator hit inside the toroid,
- At least two wire hits outside the toroid,
- At least one matching scintillator hit outside the toroid.

"Loose" Muon:

A "medium" muon with one of the criteria failed.

Physics Signals in the Muon System: J/ψ

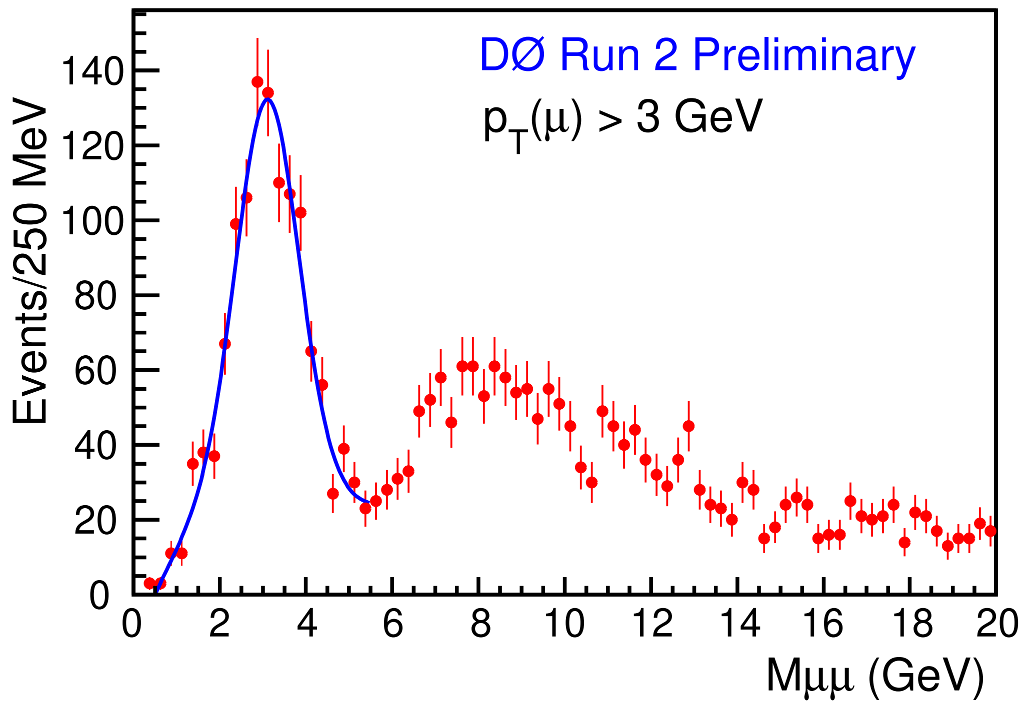


- Central and forward muons combined,
- $p_{\mathrm{T}}^{\mu} > 2\,\mathrm{GeV}/c$.

Red — opposite sign muons,

Blue — like sign muons.

Physics Signals in the Muon System: J/ψ (continued)



- Central and forward muons combined,
- p_T measured in the muon system only,
- $p_T^\mu > 2\,\mathrm{GeV}/c$.

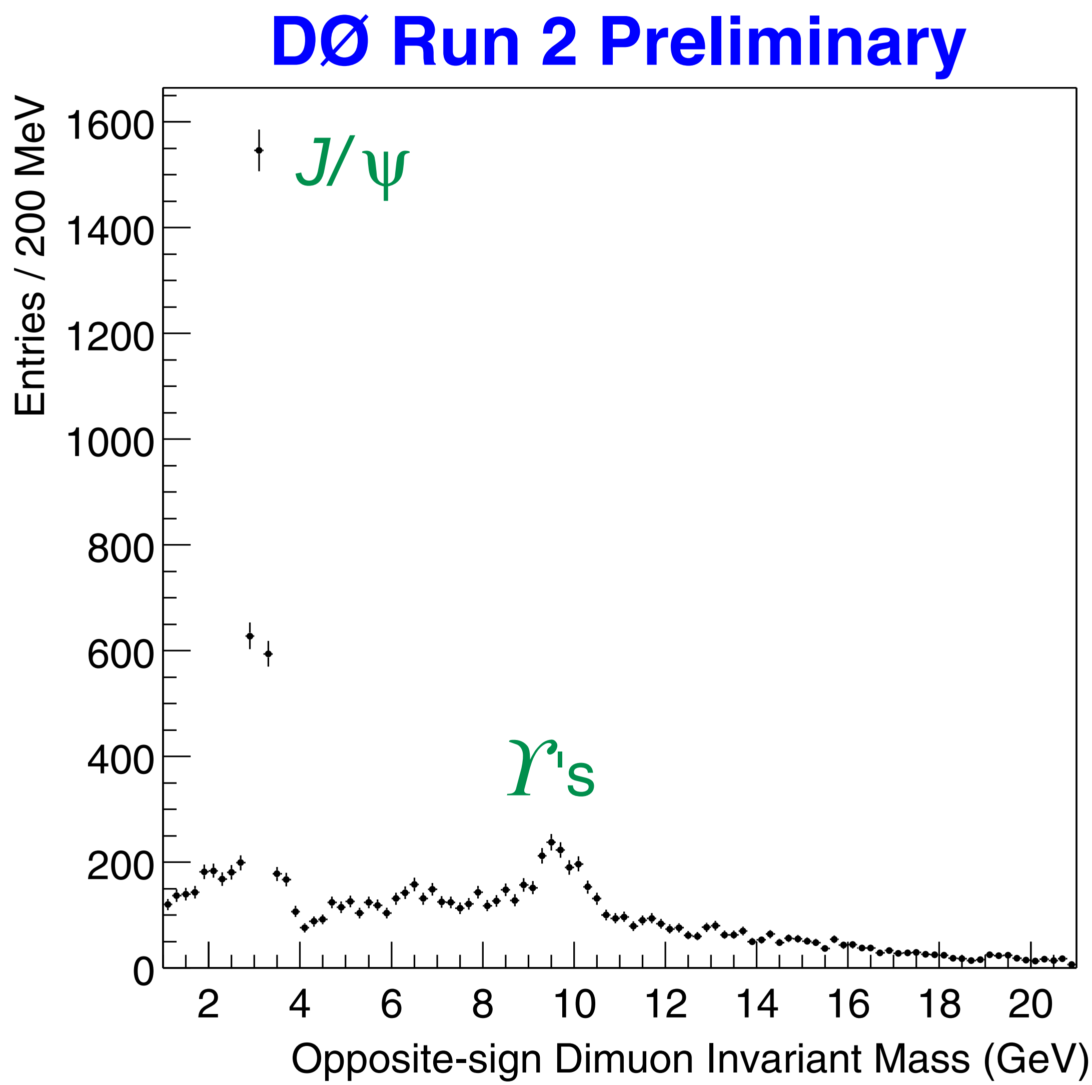
Fit result:

$N_{J/\psi} = 865$ ($\pm 10\%$ uncertainty in the background level),

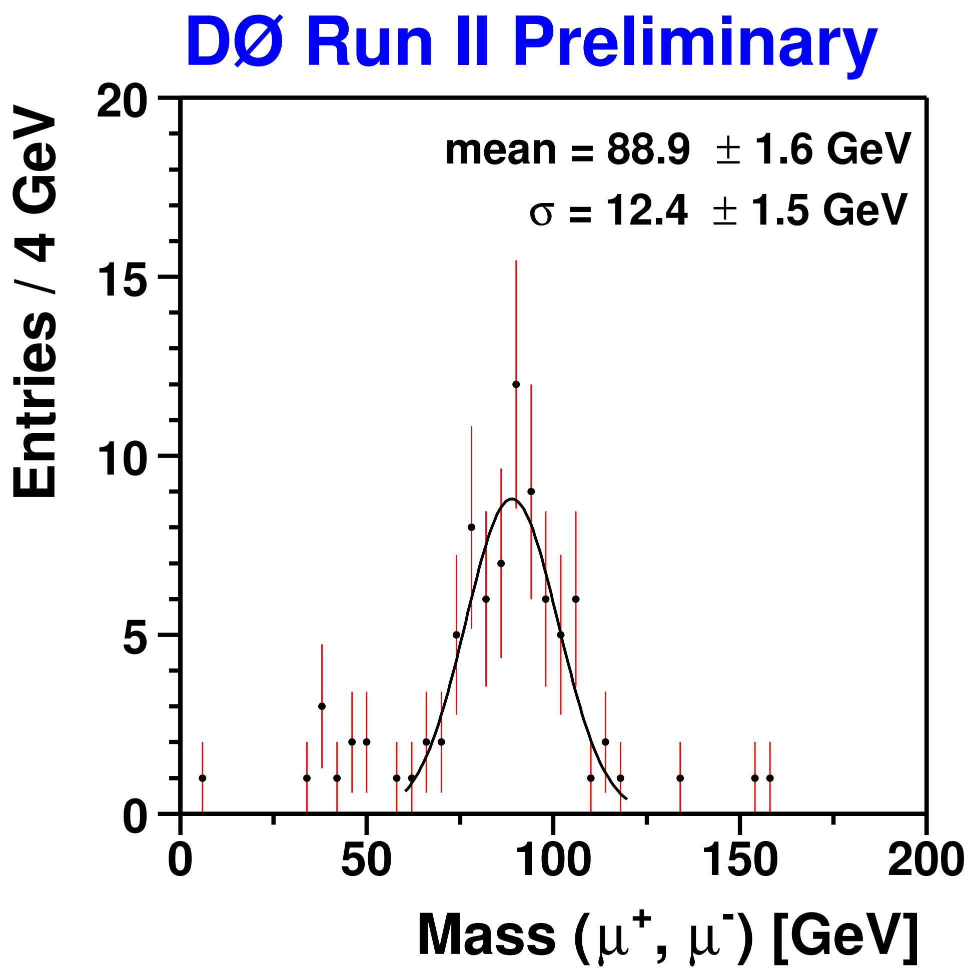
$M = 3.08 \pm 0.04\,\mathrm{GeV}$,

$\sigma = 0.78 \pm 0.08\,\mathrm{GeV}$.

Physics Signals in the Muon System: Υ



Physics Signals in the Muon System: $Z \rightarrow \mu^+\mu^-$



Selection:

- Isolation from jet $\Delta R > 0.5$,
- Central track match,
- Central track $p_{\mathrm{T}} > 15\,\mathrm{GeV}/c$.

Conclusion

- DØ muon detector system is complete and running stably. Over 99% of channels operational. All three levels of muon trigger are in use.
- Have preliminary understanding of efficiencies and resolution. Work underway to improve alignment and algorithm efficiencies.
- We see physics signals in the muon data!