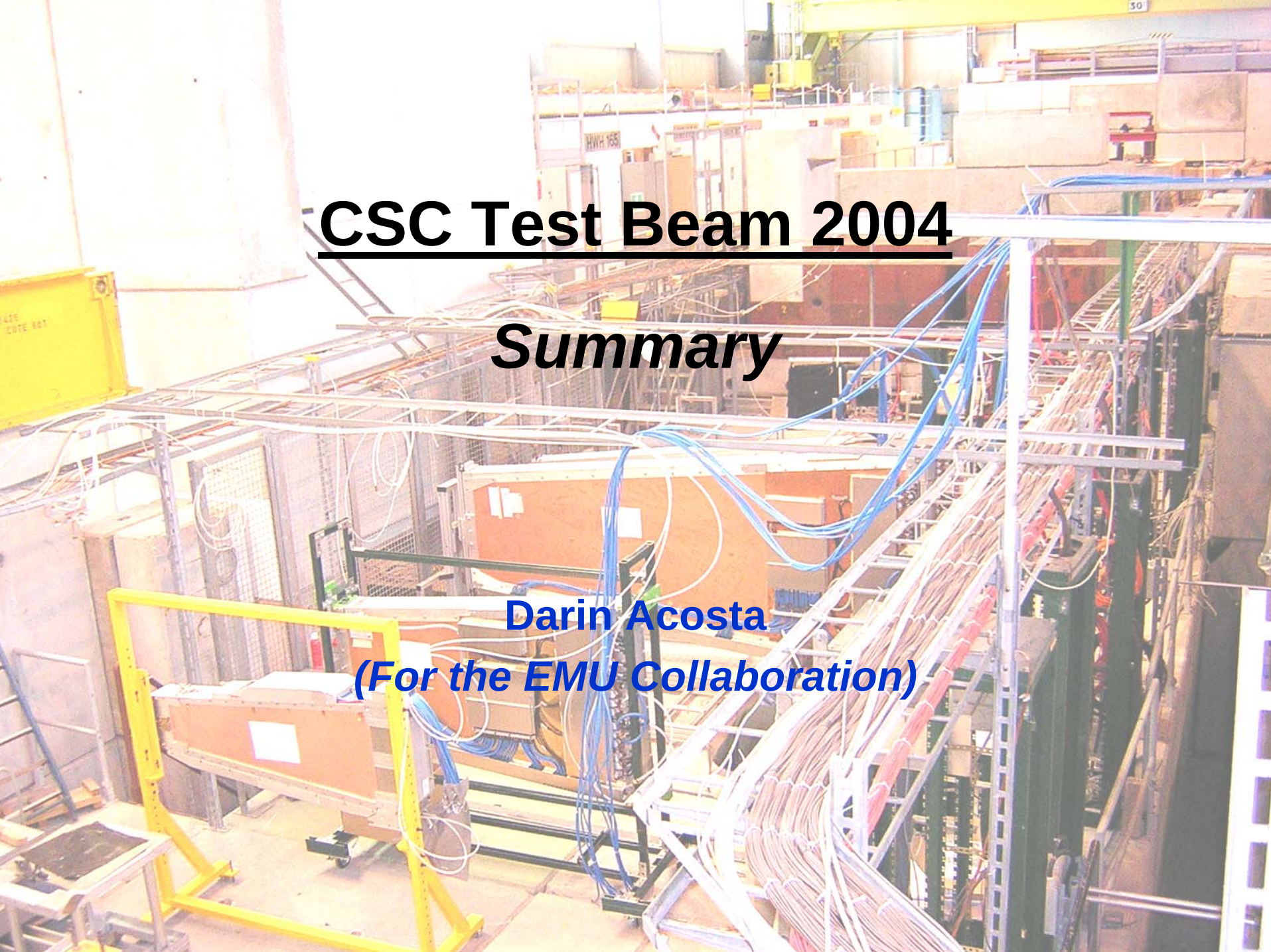


CSC Test Beam 2004

Summary

Darin Acosta

(For the EMU Collaboration)

Previous Tests

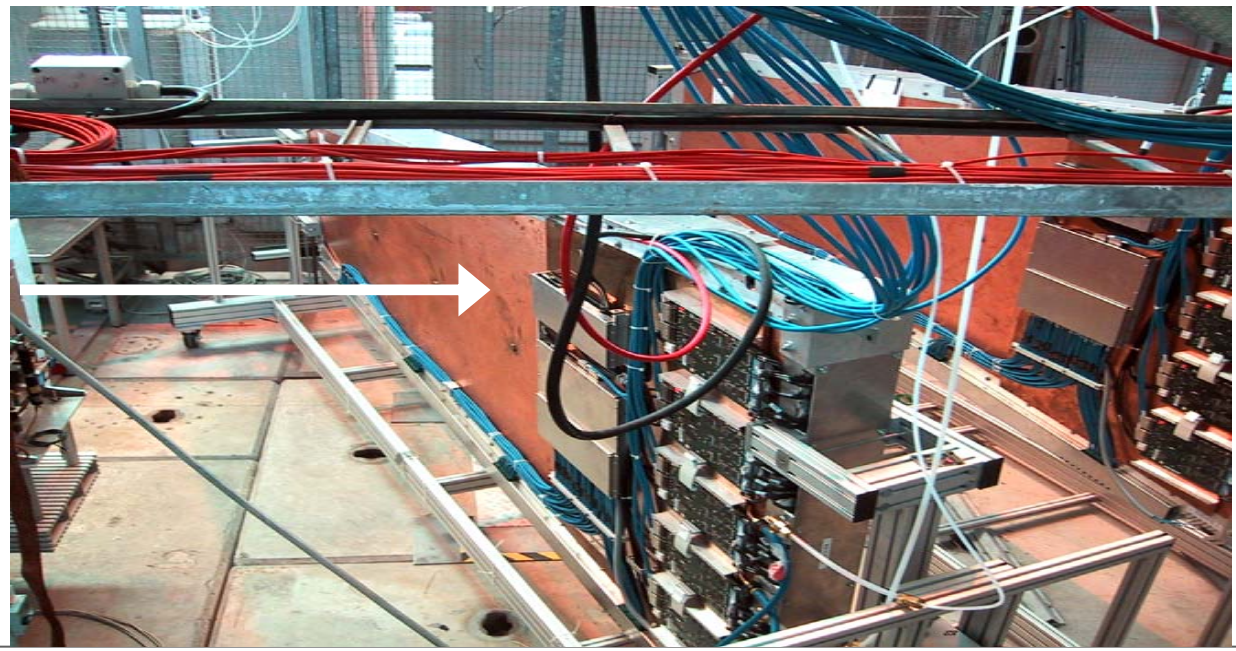
The EMU group tested CSC pre-production chambers at CERN in 1997 and 1998, along with early electronic prototypes

R&D on CSC performance was performed in beam tests even earlier

More recently, the EMU group had two test beams in 2003, with the goal of validating peripheral crate electronics and testing trigger path with LHC-like beam for first time

Two chambers tested:

μ/π



Goals for 2004

- **We know that the CSC chambers work, along with the front-end electronics and peripheral electronics**

- **What we want to do is stress-test the system with more chambers, the latest pre-production prototypes, and a new radiation tolerant clock distribution system**
  - **Trigger, DAQ, software**

- **More importantly, we are testing/developing integration and synchronization procedures, which will help us with the commissioning CMS**

2004 Beam Test Goals

(As set out in April)

- **Base goal:**
  - **Set up pre-production system of USCMS EMU electronics and repeat prior tests using LHC-like 25 ns structured beam**
    - **Test new radiation tolerant clock and control timing module (CCB 2004), which is required before production**
- **Additional goals:**
  - **Test CSC trigger primitive logic with RPC and CSC Anode transition card (so-called "RAT" transition card on TMB2004)**
  - **Use fully functional XDAQ-based run control and event builder**
  - **Use fully functional Level-1 Track-**
  - **~~Use new DDU+DCC (so-called Fro~~**
  - **~~Use new peripheral crate VME controller developed by OSU~~**
  - **Add in ME1/1 (Dubna groups)**
  - **Add an ME1/2 chamber (IHEP group)**
  - **Construct and mount an endcap RPC on ME1/2 (CERN, Korea, China)**
  - **Connect and test RPC trigger Link board to RAT (Warsaw)**
  - **Add a small block of iron absorber between to validate OSCAR/ORCA simulation**

This marks a first "slice test" in the CMS Muon community

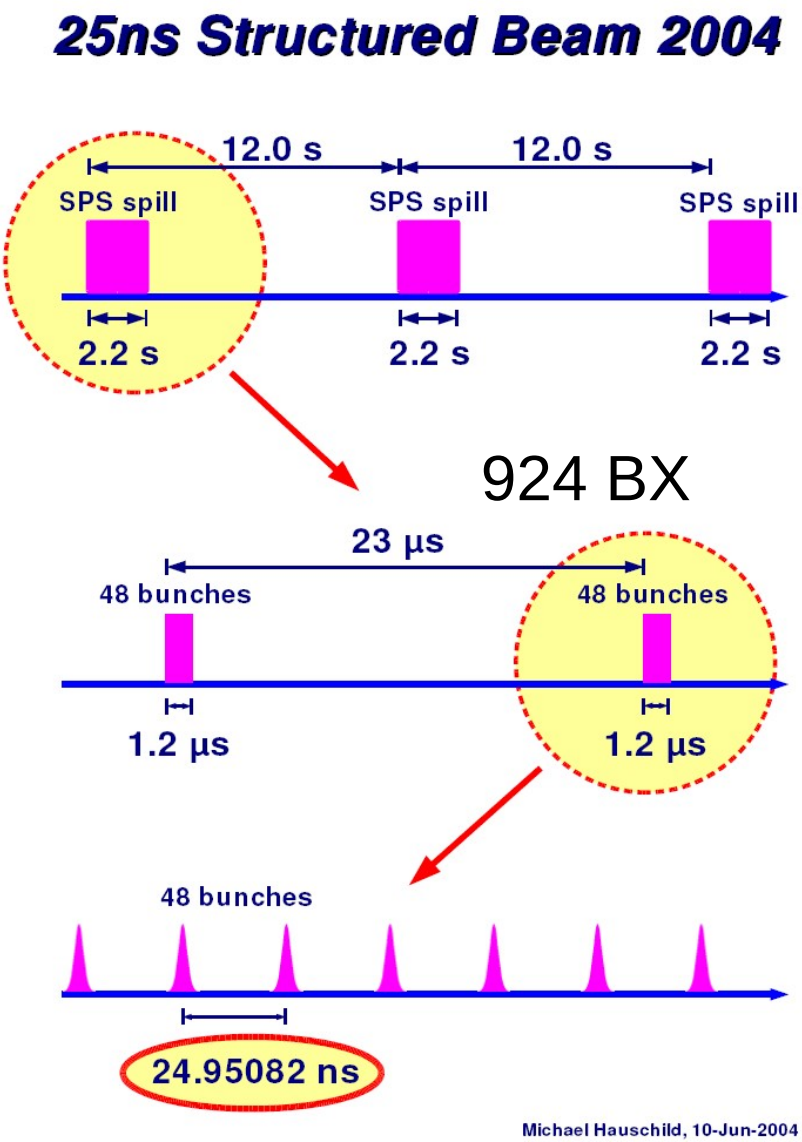
Even more goals added once started

- Test slow control (DCS) prototype
- Test data quality monitoring (DQM) prototype
- Unify Track-Finder and Peripheral Crate run control
- Add automated calls to database to log run configuration
- Test multiple peripheral crates
  - Toward a Slice Test of the CMS Endcap Muon system, where one peripheral crate corresponds to one disk
- Test multiple Sector Processors to one Muon Sorter
  - A 1/6 trigger "data challenge" of Track-Finder crate
  - Tests SP↔MS communication with real tracks
- Test new trigger primitive logic for anodes (ALCT) with ghost-busting improvements
- Spatial and HV scan of the Dubna ME1/1 chamber
- *Offline simulation of testbeam setup*
- *Injection of raw data into ORCA*

CSC Cosmic Ray Test Facility

- **Much of the DAQ and trigger development can be tested (and has been tested) at a cosmic ray test stand devoted to such purposes in Florida**
  - **But the cosmic rate is low (Hz), and asynchronous of course**
  - **Only have CSC chambers**

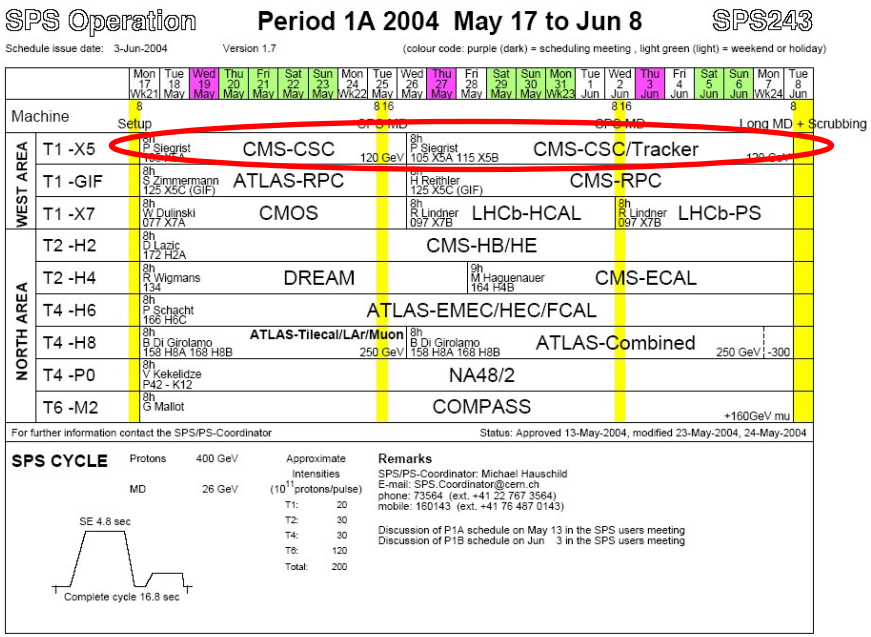
25 ns Structured Beam



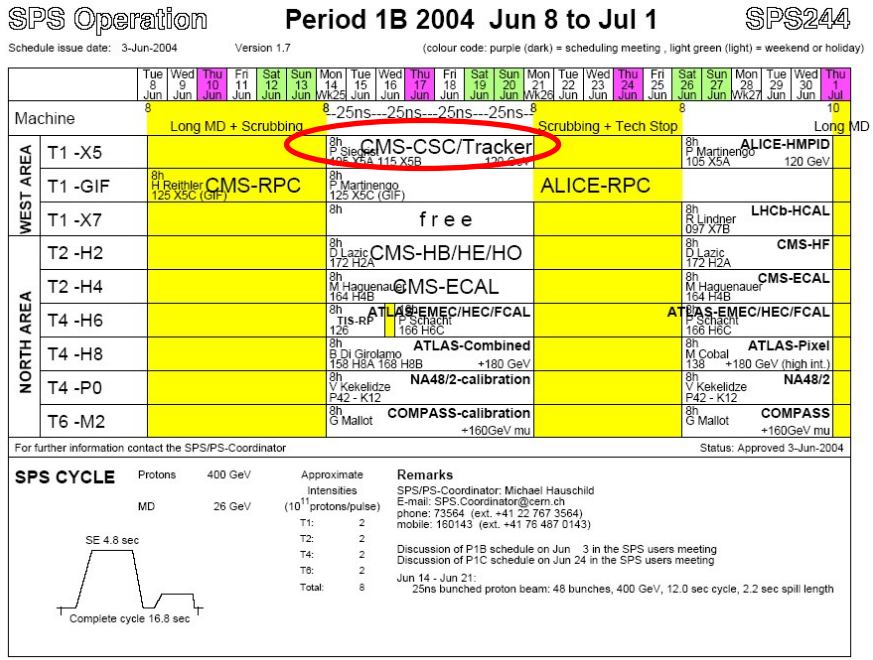
- **LHC-like bunch structure during synchronous running**
- **Trigger rates at X5A during spill**
  - **Muons: 3–10 kHz**
  - **Pions: >100 kHz**
- **CSC readout system is designed for a L1A*LCT rate at LHC design luminosity of order 5 kHz**

May/June Running Periods

3 weeks asynchronous beam

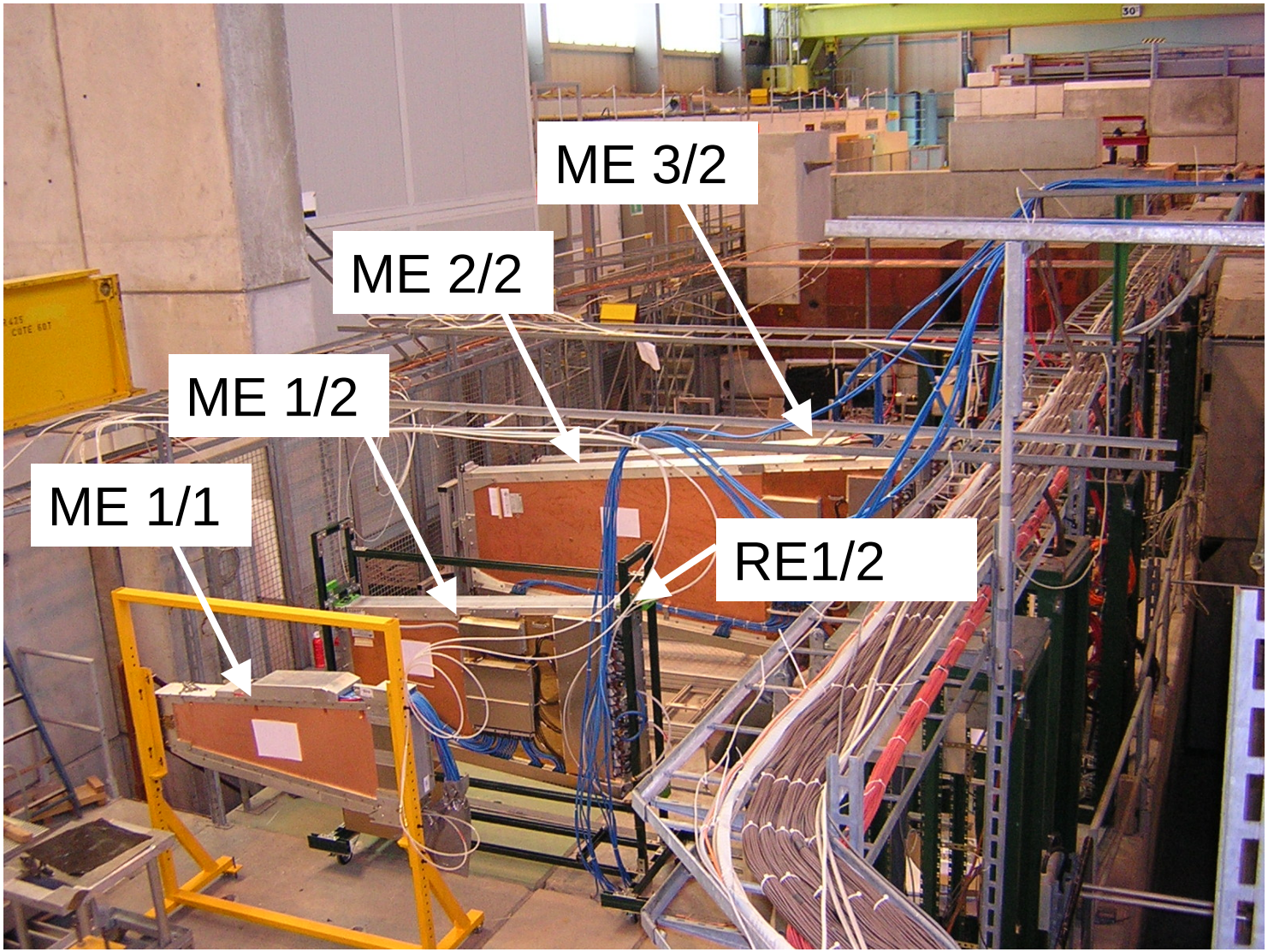


1 week asynchronous beam

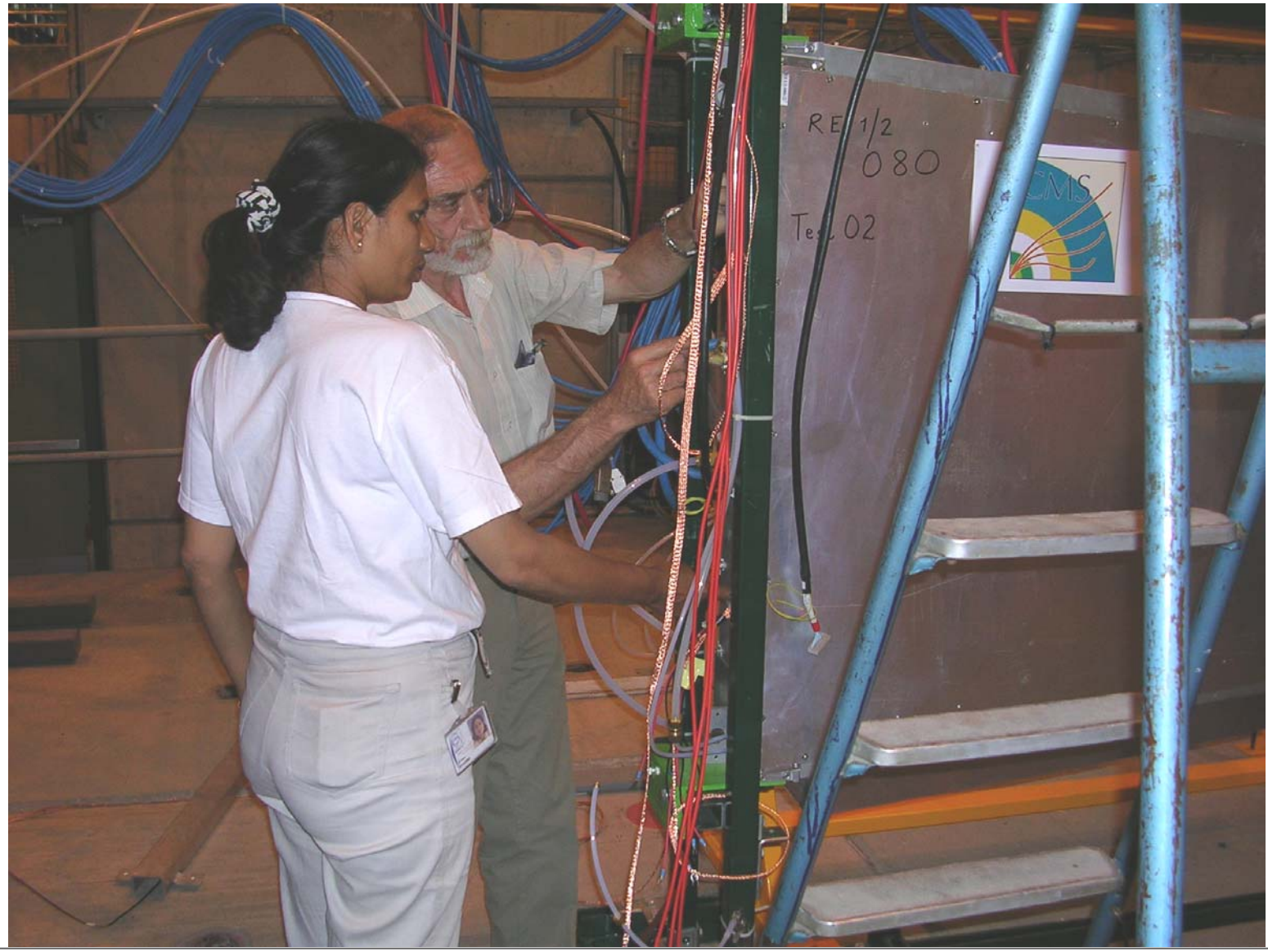


Location of tests: x5a in CERN “West Area”

2004 CSC Beam Test (Muon Slice Test)

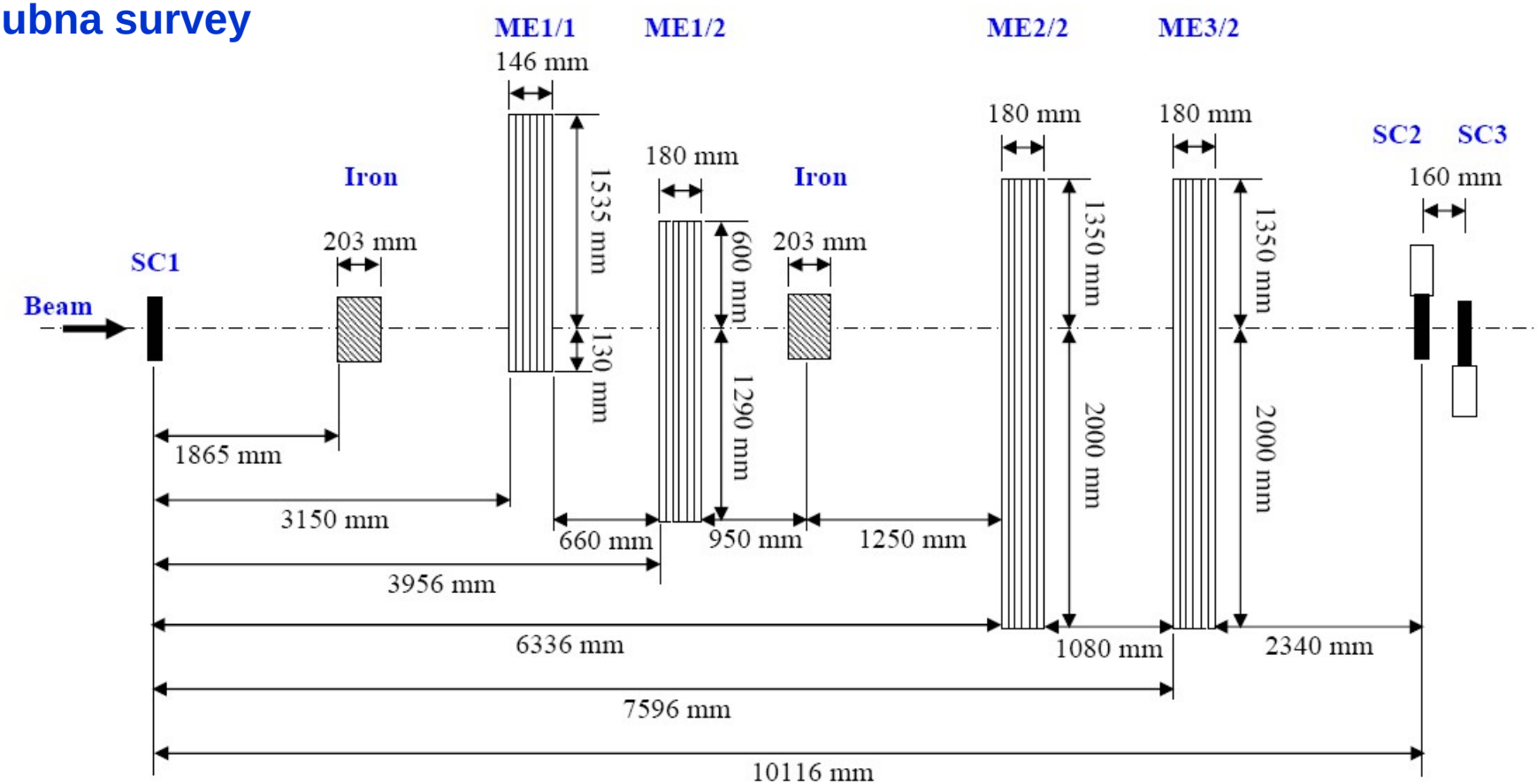


RE1/2 Installation (Endcap RPC)



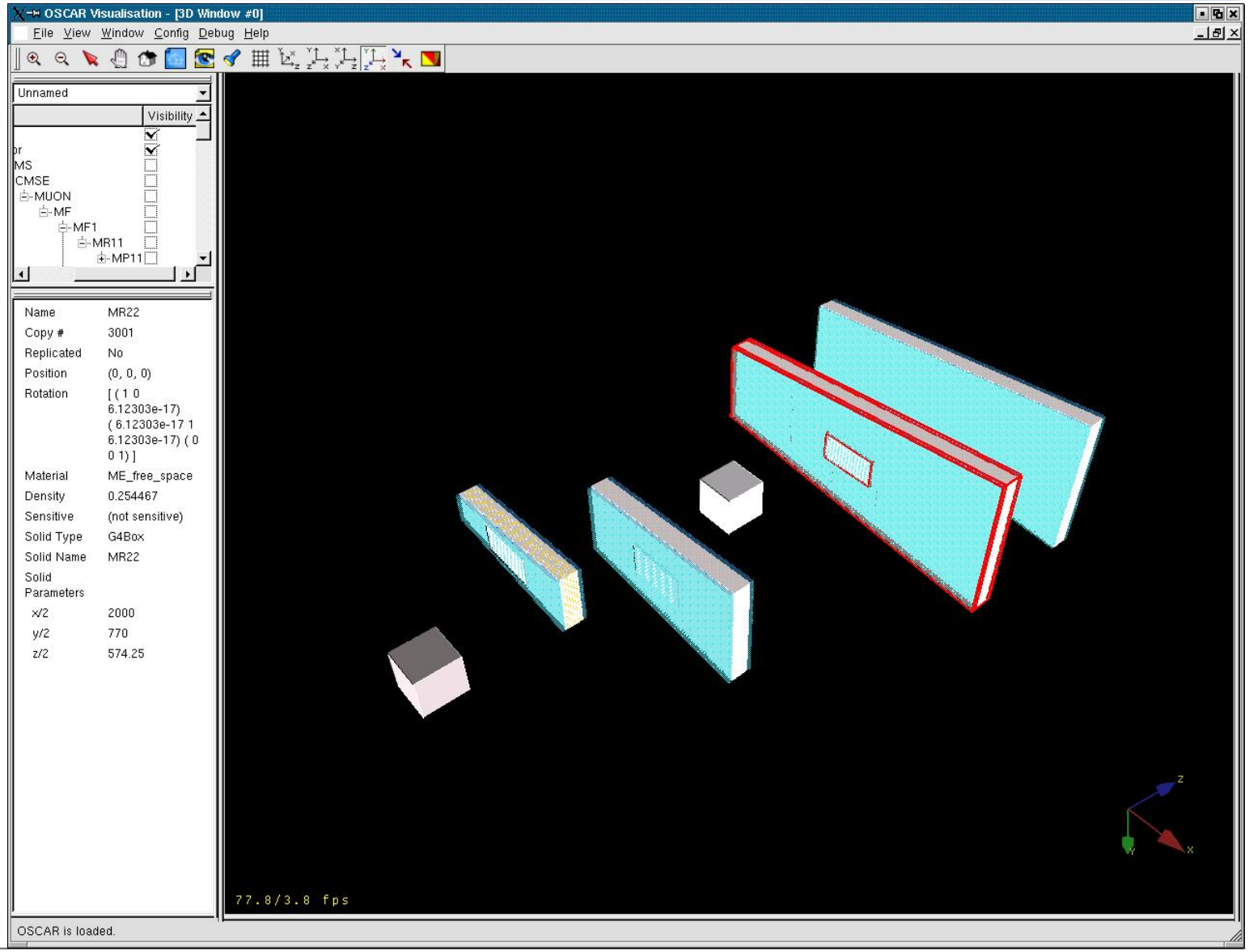
Initial Geometry

Dubna survey

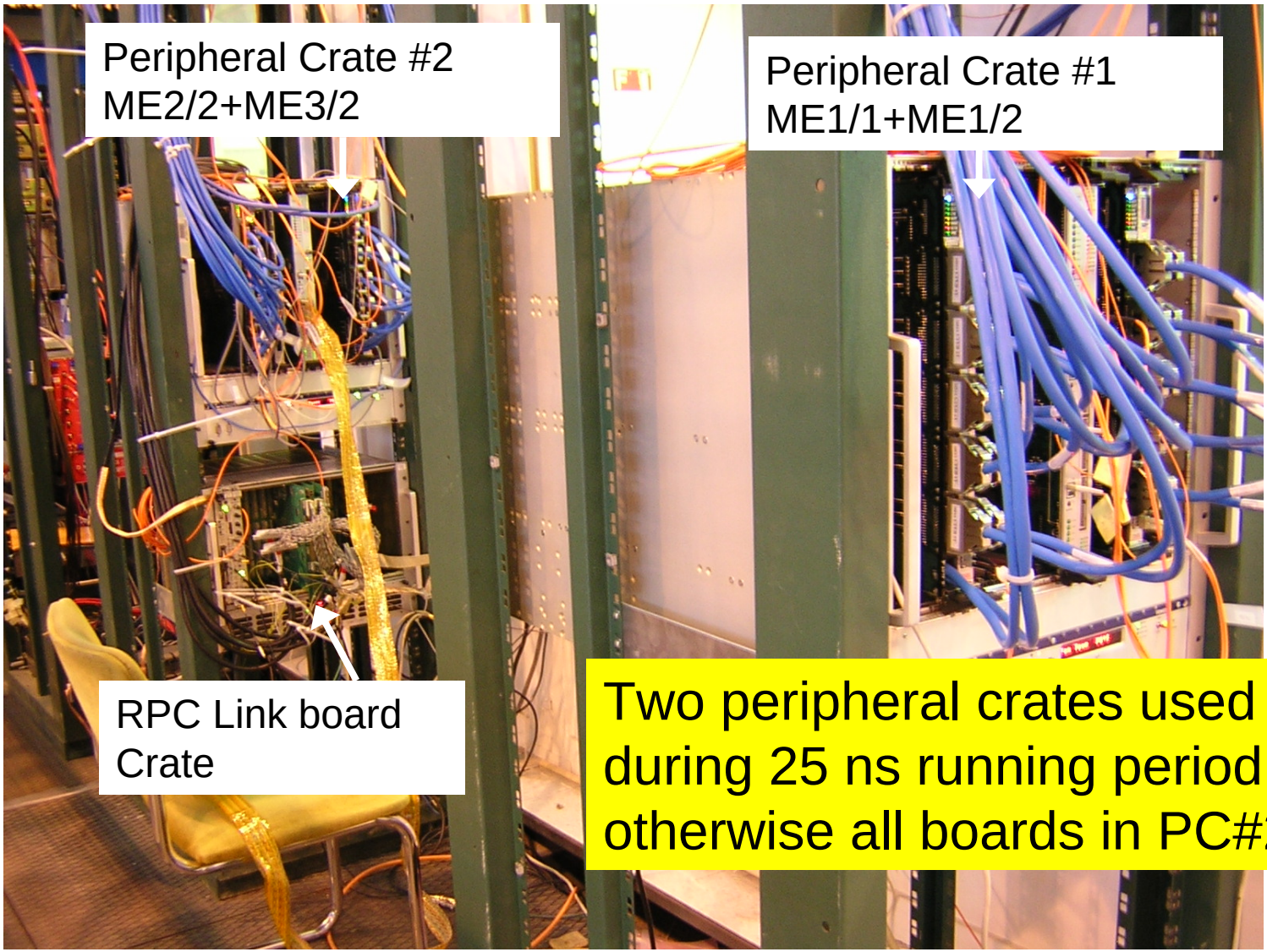


XML Geometry Description

XML version created by Michael Case



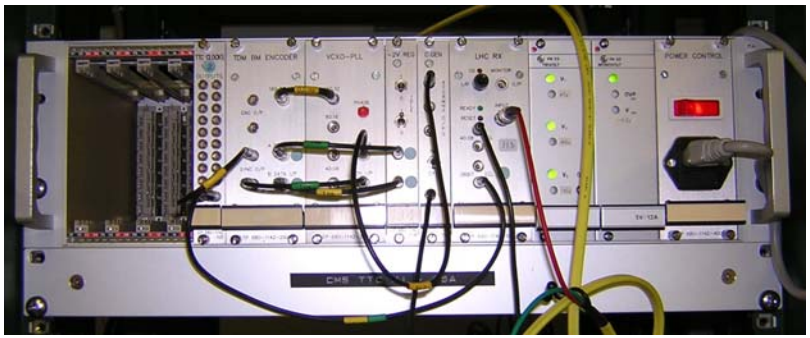
Peripheral Electronics



Two peripheral crates used only during 25 ns running period, otherwise all boards in PC#2

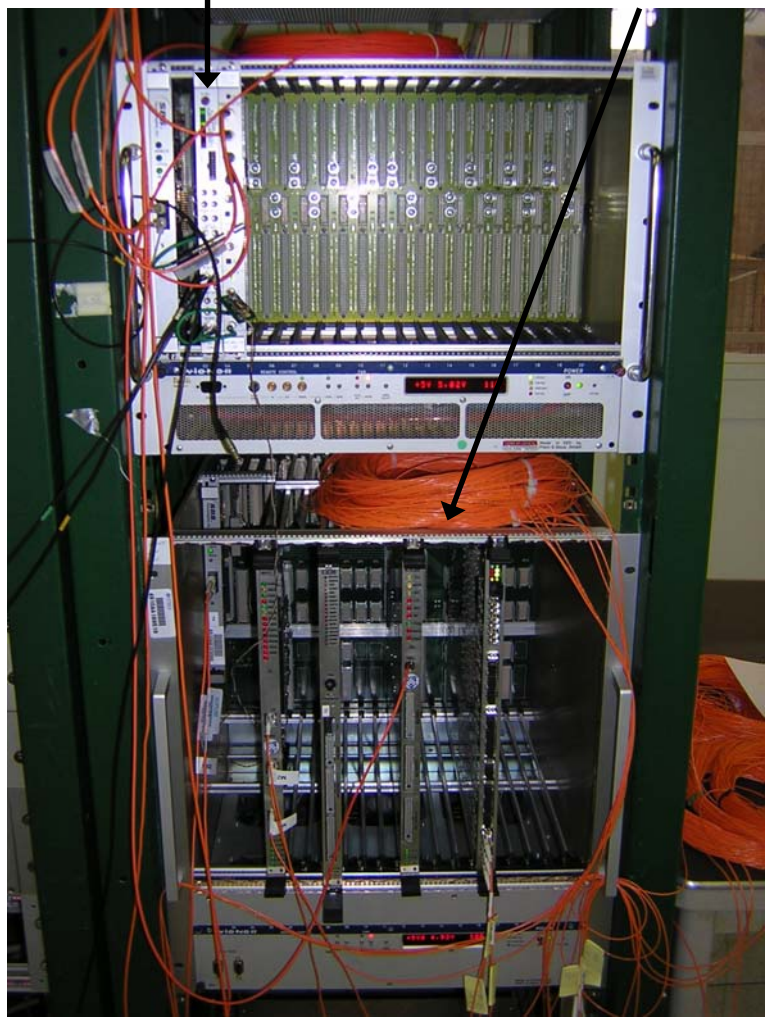
Track-Finder, TTC & Trigger Electronics

TTCmi crate
(machine interface for clock & orbit)



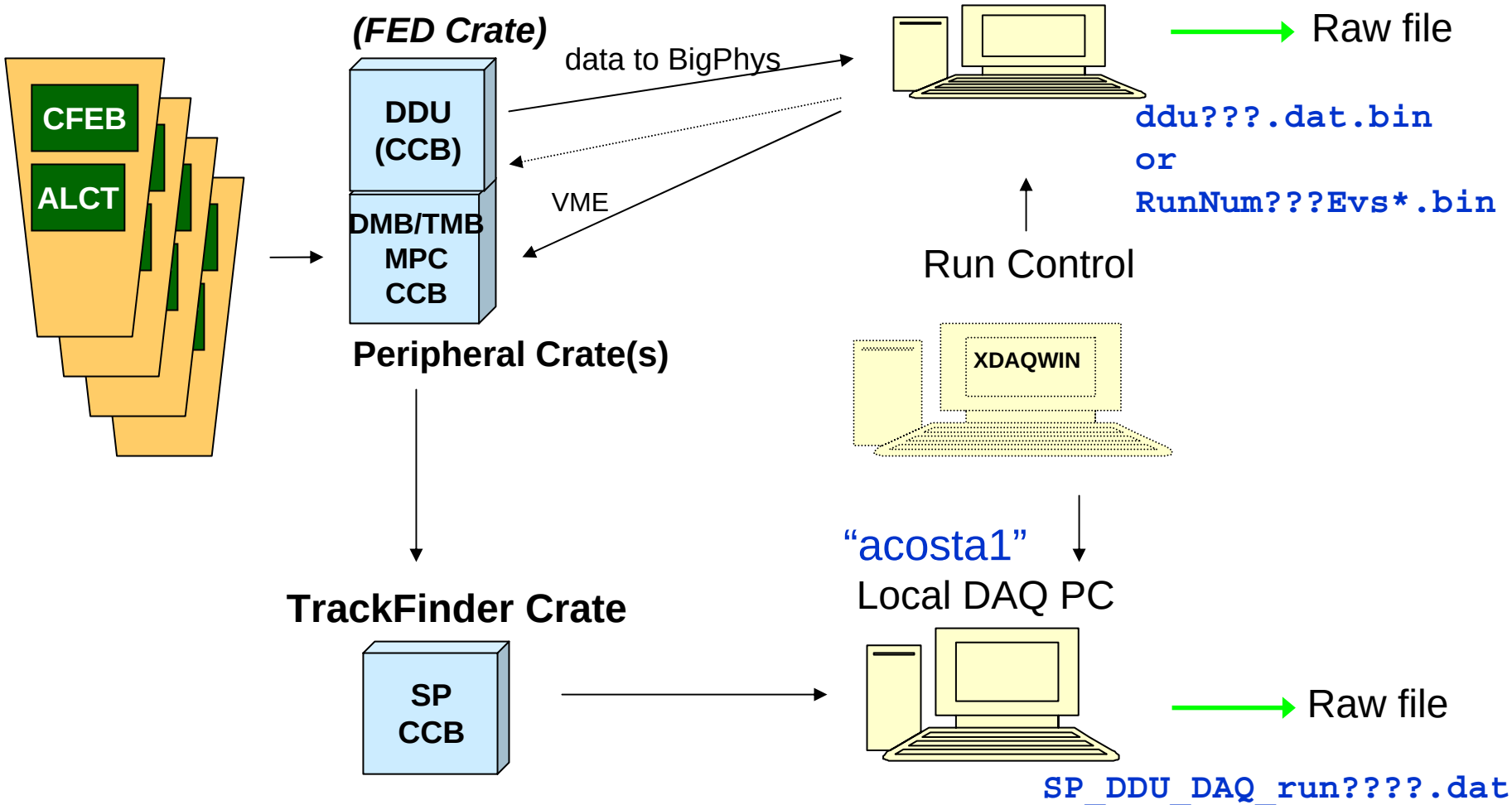
TTCvi crate

Level-1
Track-Finder crate

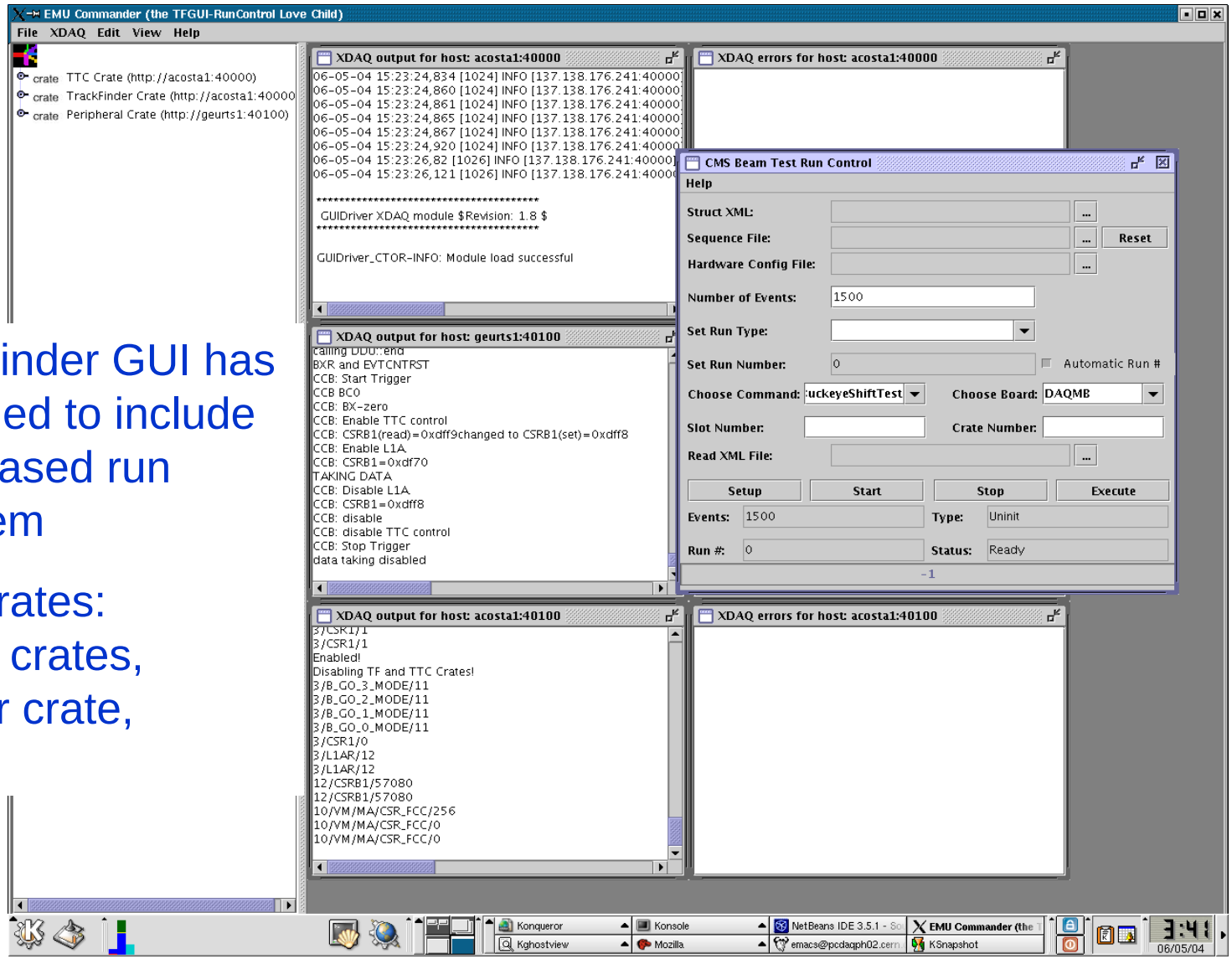


Test Beam 2004 DAQ Configuration

Configuration commands distributed via XDAQ.
Event-building tested



The Integrated EMU GUI



The Track-Finder GUI has been extended to include the XDAQ-based run control system

Controls 4 crates:
2 Peripheral crates,
Track-Finder crate,
TTC crate

EmuDAQ TB2004 Data

- **130GB of data collected in various DAQ modes**
  - **raw reader from bigphysarea device**
    - **debugging purposes**
  - **EmuFED-based standalone reader**
    - **debugging purposes**
  - **EventBuilder based EVB output**
    - **official output**
  - **Standalone Track-Finder output**

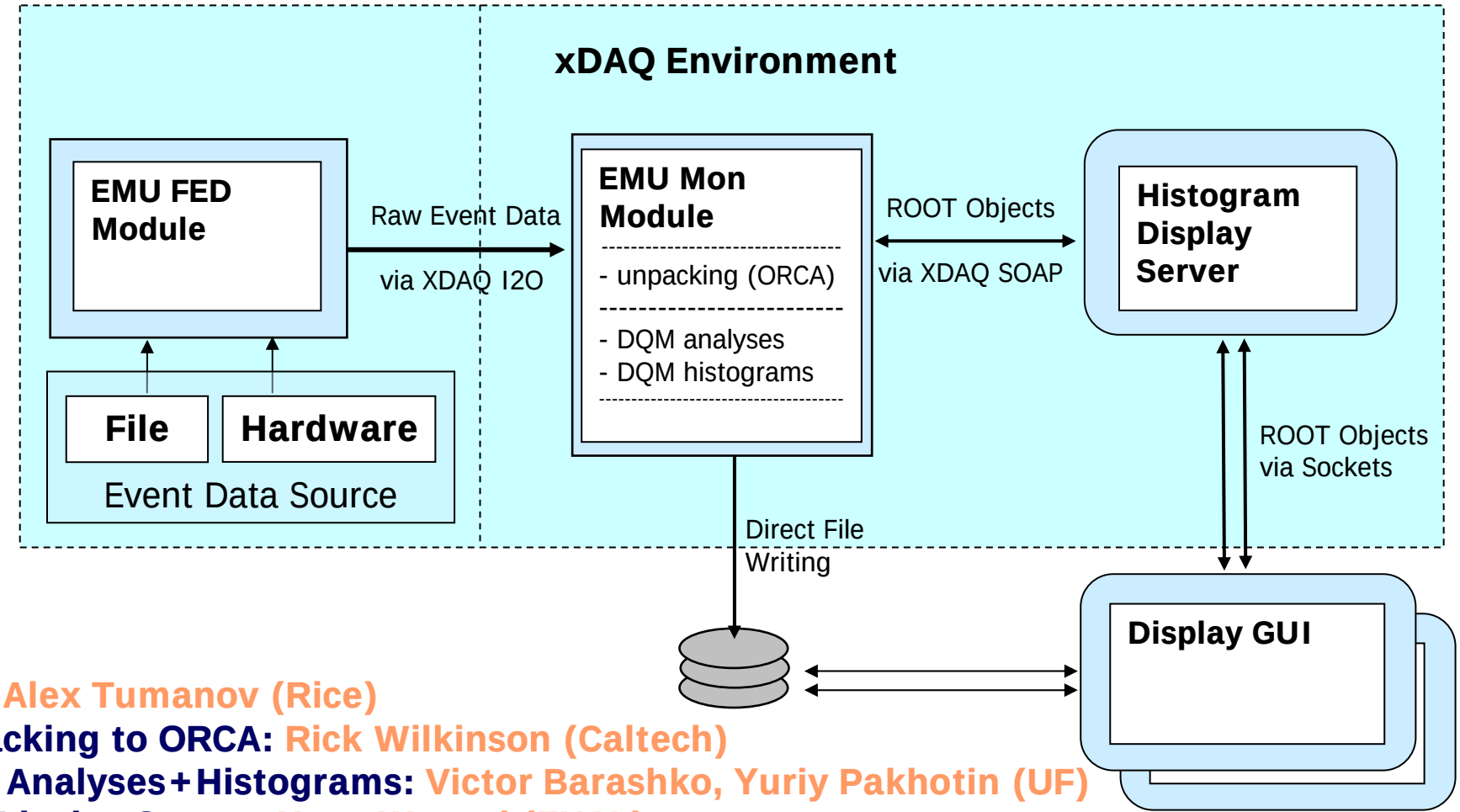
- **data sample sizes:**
  - **ddudumper (raw reader):**
    - **64GB**
  - **hardwareDumper:**
    - **57.4GB**
  - **EVBOutput:**
    - **11GB**
  - **SPFed data:**
    - **0.5GB**

Trigger data volume is much smaller than CSC data (as expected)

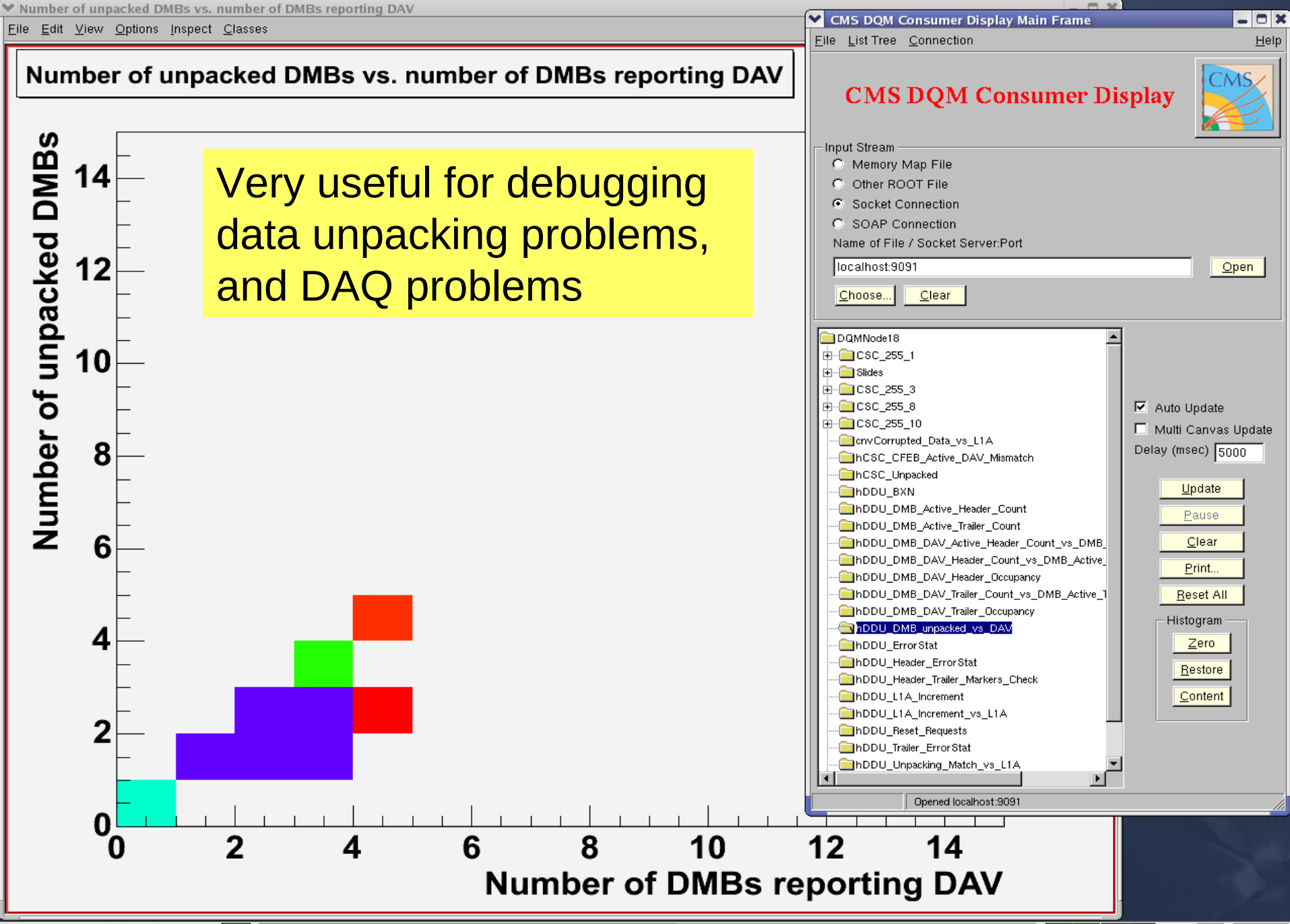
Accomplishments

- Using new Peripheral Crate (XDAQ) software to control 4 chambers and multiple crates
- Single column of event builder tested
- Monitoring prototype working offline
- DCS prototype working
- CCB2004 with radiation-tolerant discrete logic capable of driving all electronics
  - Drives gigabit optical links on trigger path, for example
- Level-1 Track-Finder is successfully finding tracks and self-triggering the experiment
  - Became default mode of triggering for the last week
- RPC signals seen in coincidence with the CSC trigger

TB2004 DQM Architecture

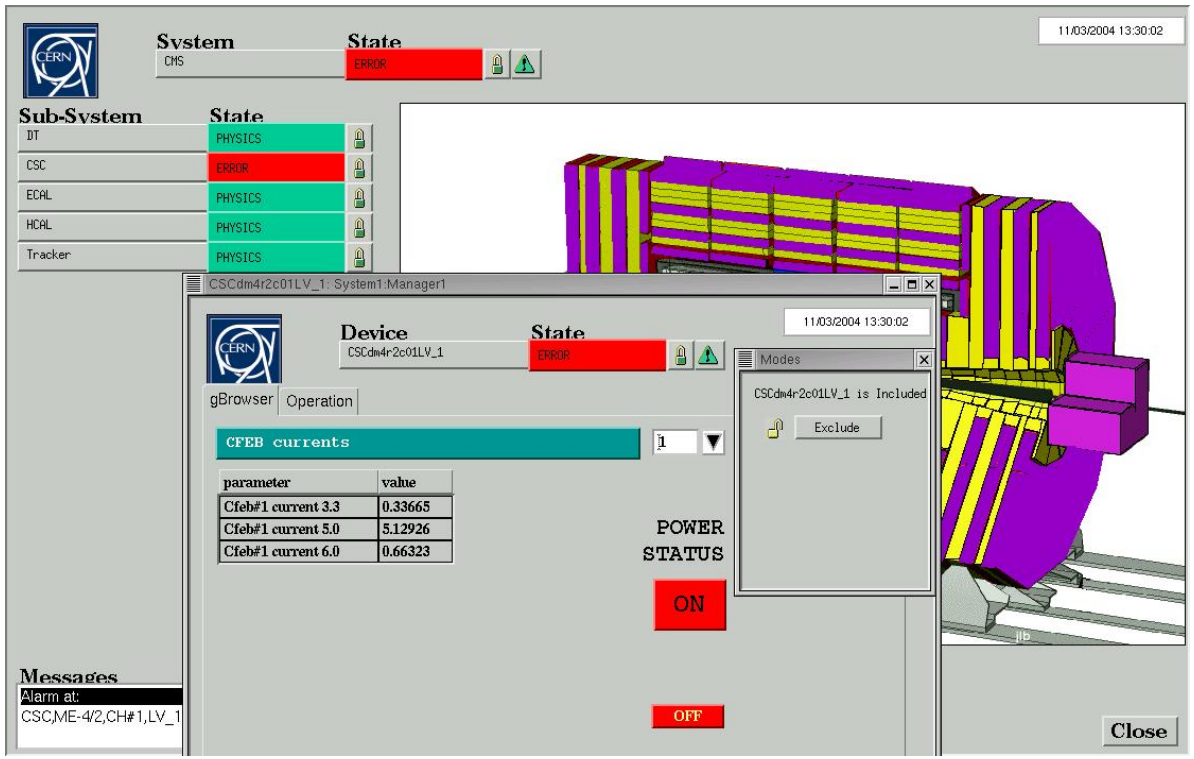


- **FED:** Alex Tumanov (Rice)
- **Unpacking to ORCA:** Rick Wilkinson (Caltech)
- **DQM Analyses+Histograms:** Victor Barashko, Yuriy Pakhotin (UF)
- **CDF Display Server:** Hans Wenzel (FNAL)
- **Display Server adaptation for xDAQ:** Victor Barashko (UF)
- **CDF Display GUI:** Kaori Maeshima (FNAL)
- **Integration:** Victor Barashko (UF)


Number of unpacked DMBs vs. number of DMBs reporting DAV
File Edit View Options Inspect Classes
Number of unpacked DMBs vs. number of DMBs reporting DAV
Number of unpacked DMBs
Number of DMBs reporting DAV
0
2
4
6
8
10
12
14
Very useful for debugging data unpacking problems, and DAQ problems
CMS DQM Consumer Display Main Frame
File List Tree Connection Help
CMS DQM Consumer Display
Input Stream
Memory Map File
Other ROOT File
Socket Connection
SOAP Connection
Name of File / Socket Server:Port
localhost:9091
Open
Choose...
Clear
DQMNode18
CSC_255_1
Slides
CSC_255_3
CSC_255_8
CSC_255_10
cnvCorrupted_Data_vs_L1A
hCSC_CFEB_Active_DAV_Mismatch
hCSC_Unpacked
hDDU_BXN
hDDU_DMB_Active_Header_Count
hDDU_DMB_Active_Trailer_Count
hDDU_DMB_DAV_Active_Header_Count_vs_DMB_
hDDU_DMB_DAV_Header_Count_vs_DMB_Active_
hDDU_DMB_DAV_Header_Occupancy
hDDU_DMB_DAV_Trailer_Count_vs_DMB_Active_T
hDDU_DMB_DAV_Trailer_Occupancy
hDDU_DMB_unpacked_vs_DAV
hDDU_ErrorStat
hDDU_Header_ErrorStat
hDDU_Header_Trailer_Markers_Check
hDDU_L1A_Increment
hDDU_L1A_Increment_vs_L1A
hDDU_Reset_Requests
hDDU_Trailer_ErrorStat
hDDU_Unpacking_Match_vs_L1A
Auto Update
Multi Canvas Update
Delay (msec) 5000
Update
Pause
Clear
Print...
Reset All
Histogram
Zero
Restore
Content
Opened localhost:9091
dqm@pcmstbhv01:~ - Shell
Number of unpacked DMBs v
CMS DQM Consumer Displ
CPU
Mem
12:35

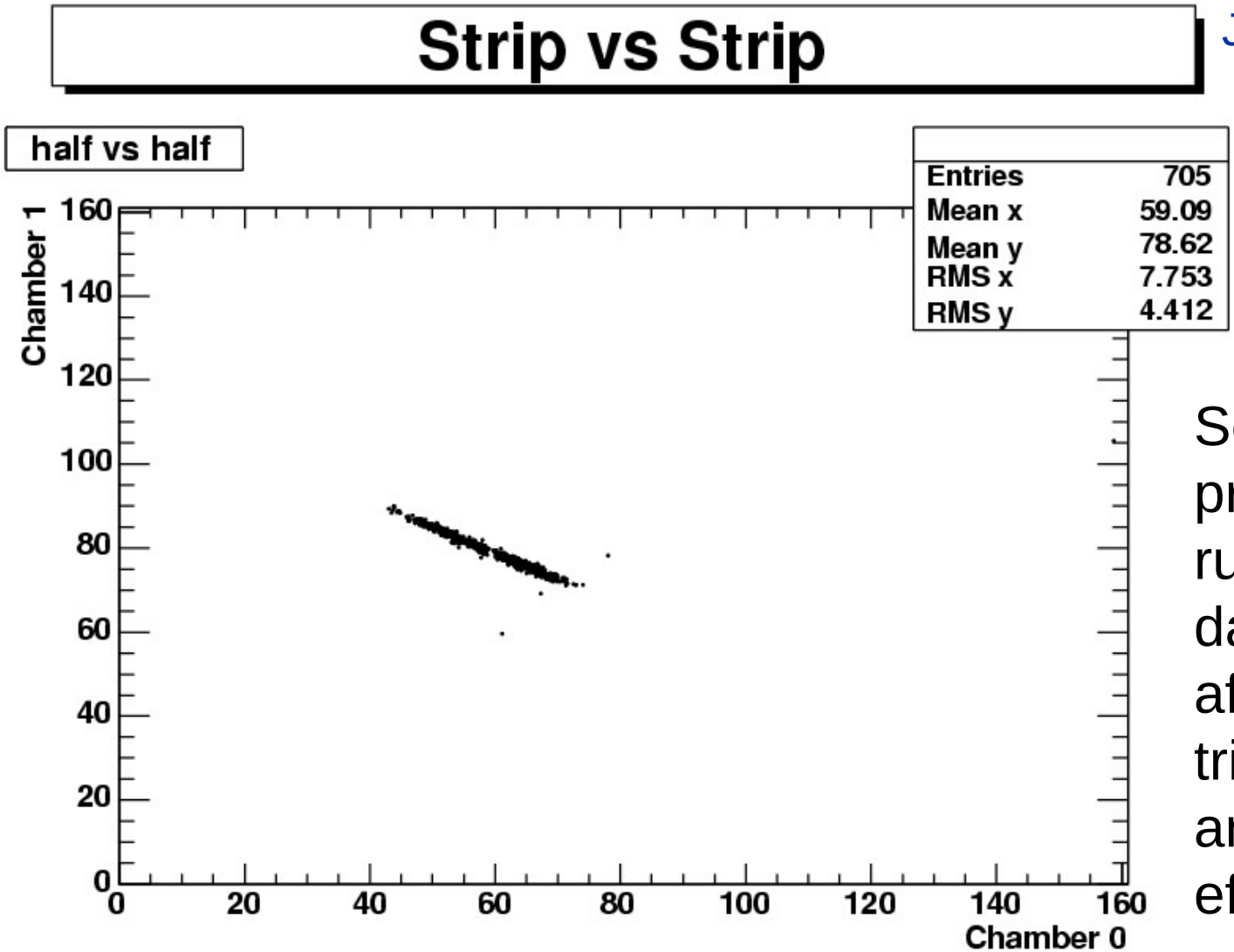
DCS

- Valeri Sytnik has working DCS prototype using PVSS II for EMU peripheral crate electronics
- Upgraded to handle TMB2004 and CCB2004 at beam test, and demonstrated to work
- Will need to resolve issues with sharing access to peripheral crate



Data analyses: Trigger Primitives

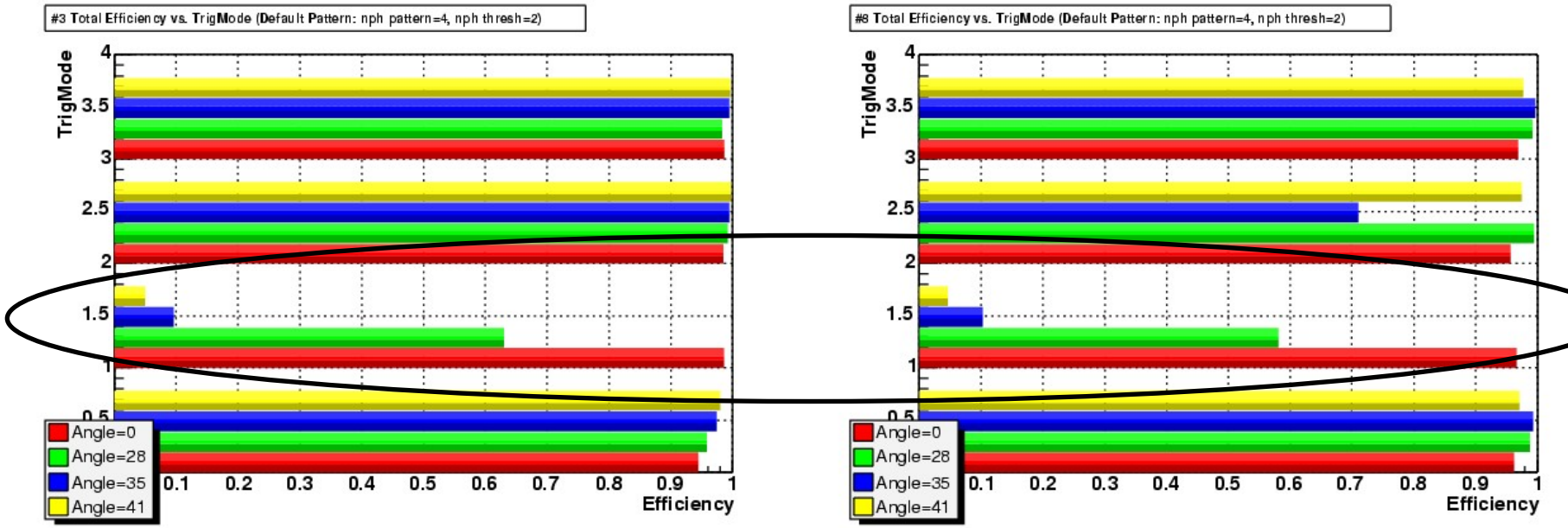
J.Mumford (UCLA)



Several offline programs were run to validate data immediately after run taken for trigger efficiency and any strange effects

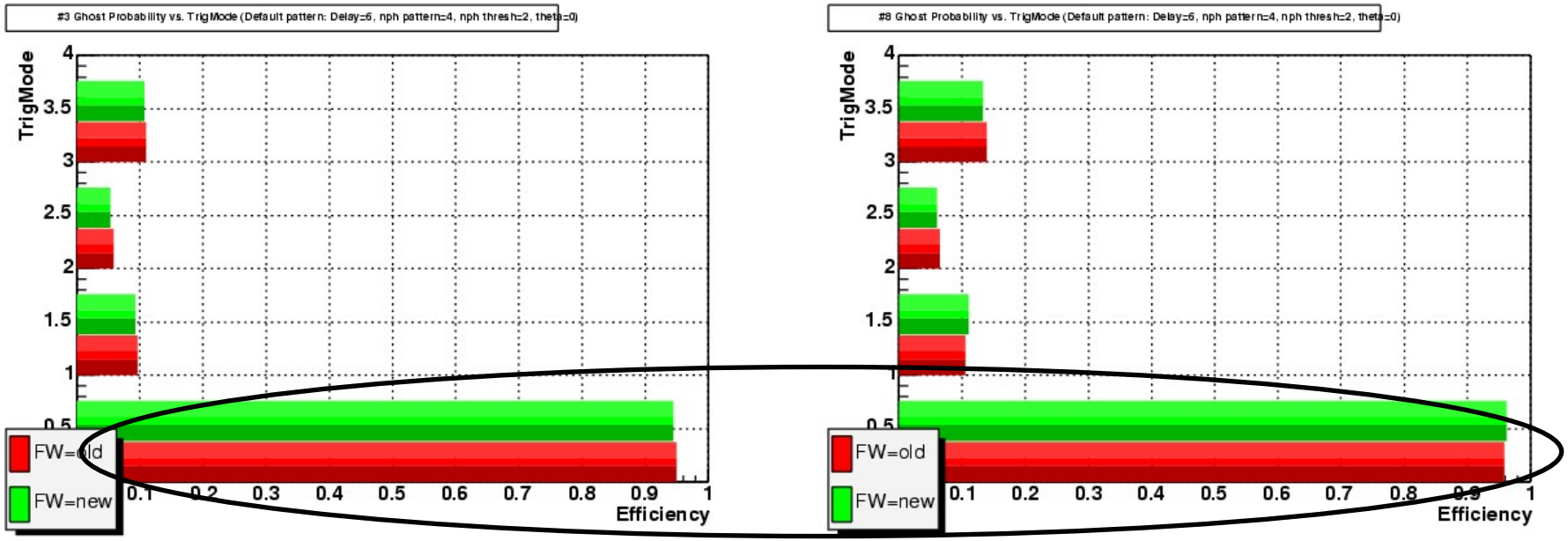
Anode Trigger Primitive Study (ALCT)

Offline analyses continuing as well…



- **Accelerator muon pattern efficiency (straight tracks in wires) decreases with angle as you would expect**

ALCT Ghost Rate



- **Ghost rate very high if accelerator patterns and collision patterns both enabled without ghost cancellation mode (would flood trigger links)**

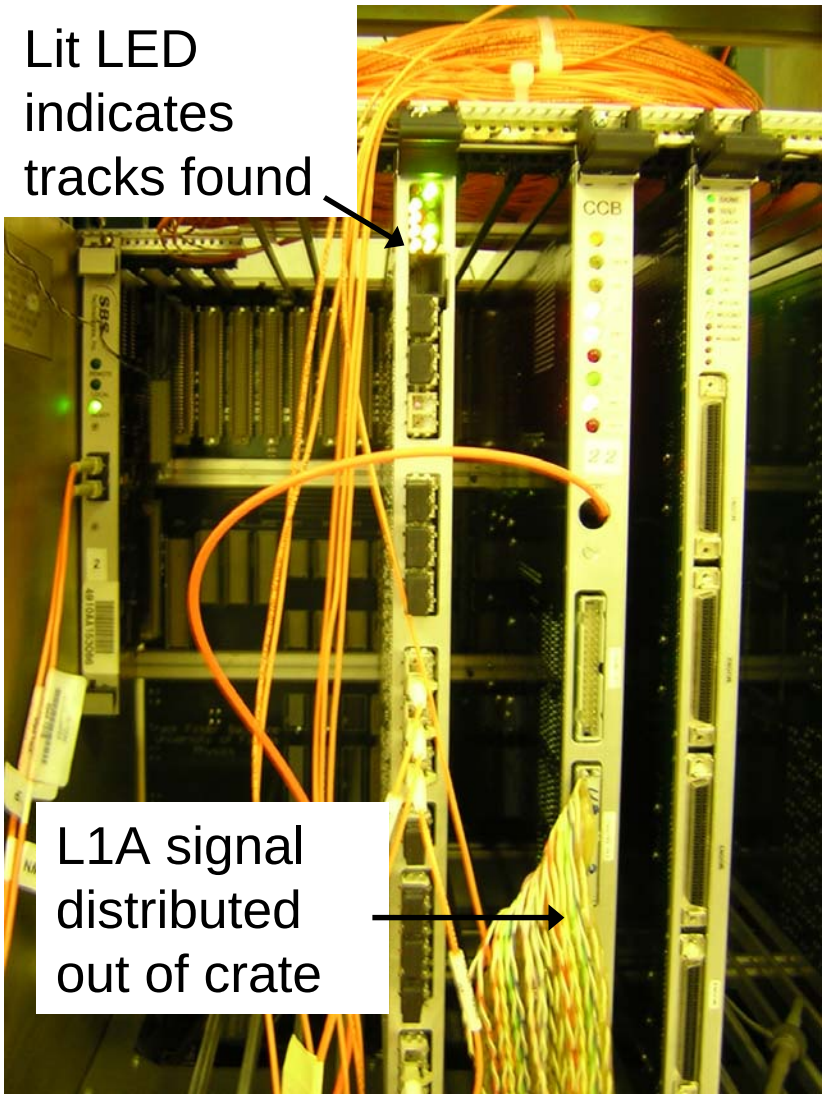
ALCT Pattern Studies

- **Several other ALCT parameters were varied and will be studied by summer student**
- **For example, ALCT Patterns:**
  - **Default** **"Miss4"** **"Andrey" Pat A and Pat B**

```
  | |          . | |                  | | .     . | .
  | |          . |                    | .       | |
  |            |                      |         |
 | |          | |                    | |       . |
| | |        | | .                  . | .     . | |
| | |        | | .                  | | .     . | |
```

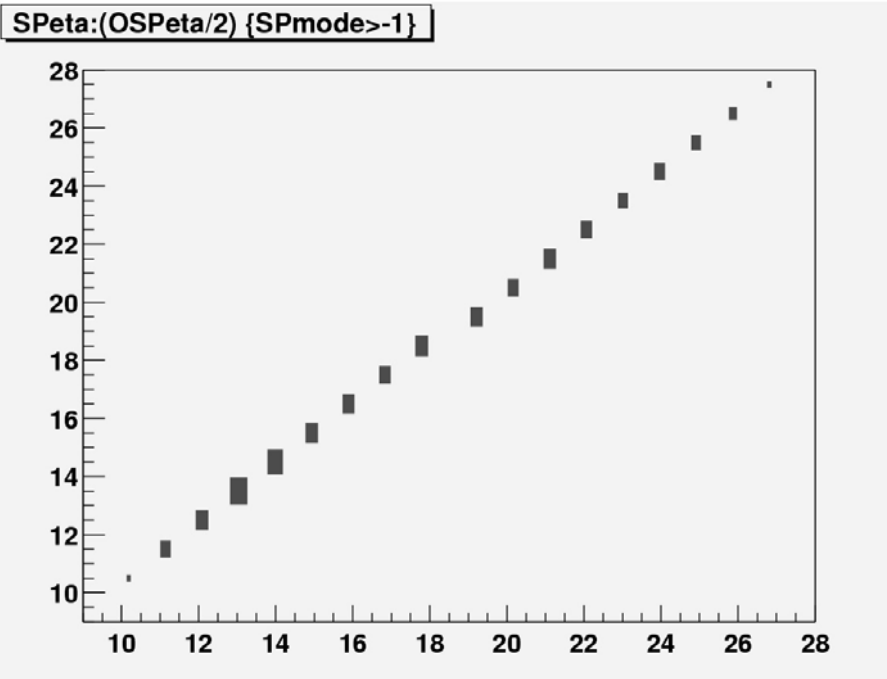
- **Goal is to achieve high efficiency, low ghost rate, and good discrimination between collision and accelerator patterns**
- **Hardware results should be validated against ORCA**

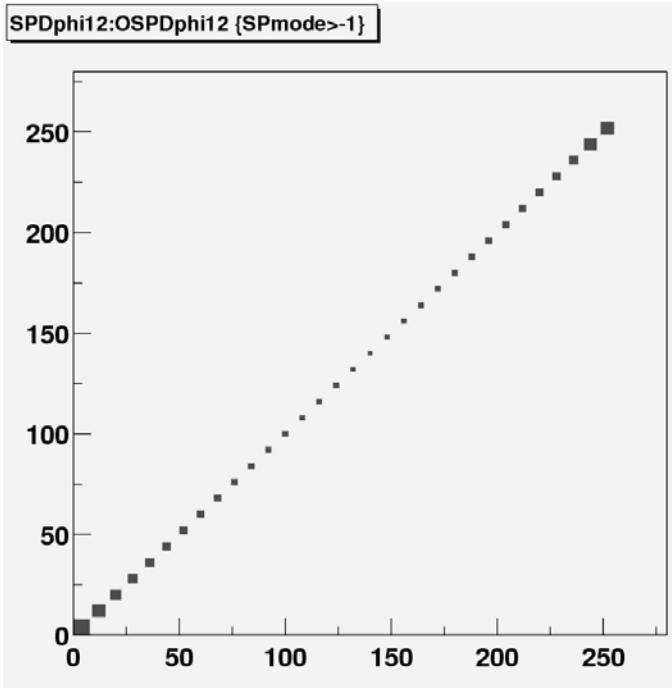
Track-Finder Tests



- **First time we tested with full Track-Finding logic to identify tracks in data**
- **Full DAQ logging of inputs and outputs for offline comparisons**
  - **Can compare with data sent by Peripheral Crates as well as internal TF logic**
- **L1A generation a major synchronization accomplishment for trigger**
  - **Data must be aligned spatially and temporally**
  - **Very useful for slice tests**

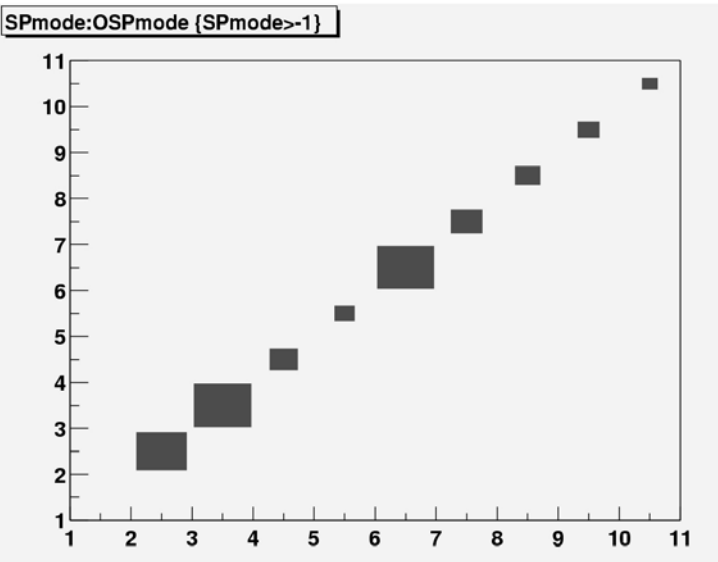
TF: ORCA vs. Hardware Check





Run 366, Scurlock

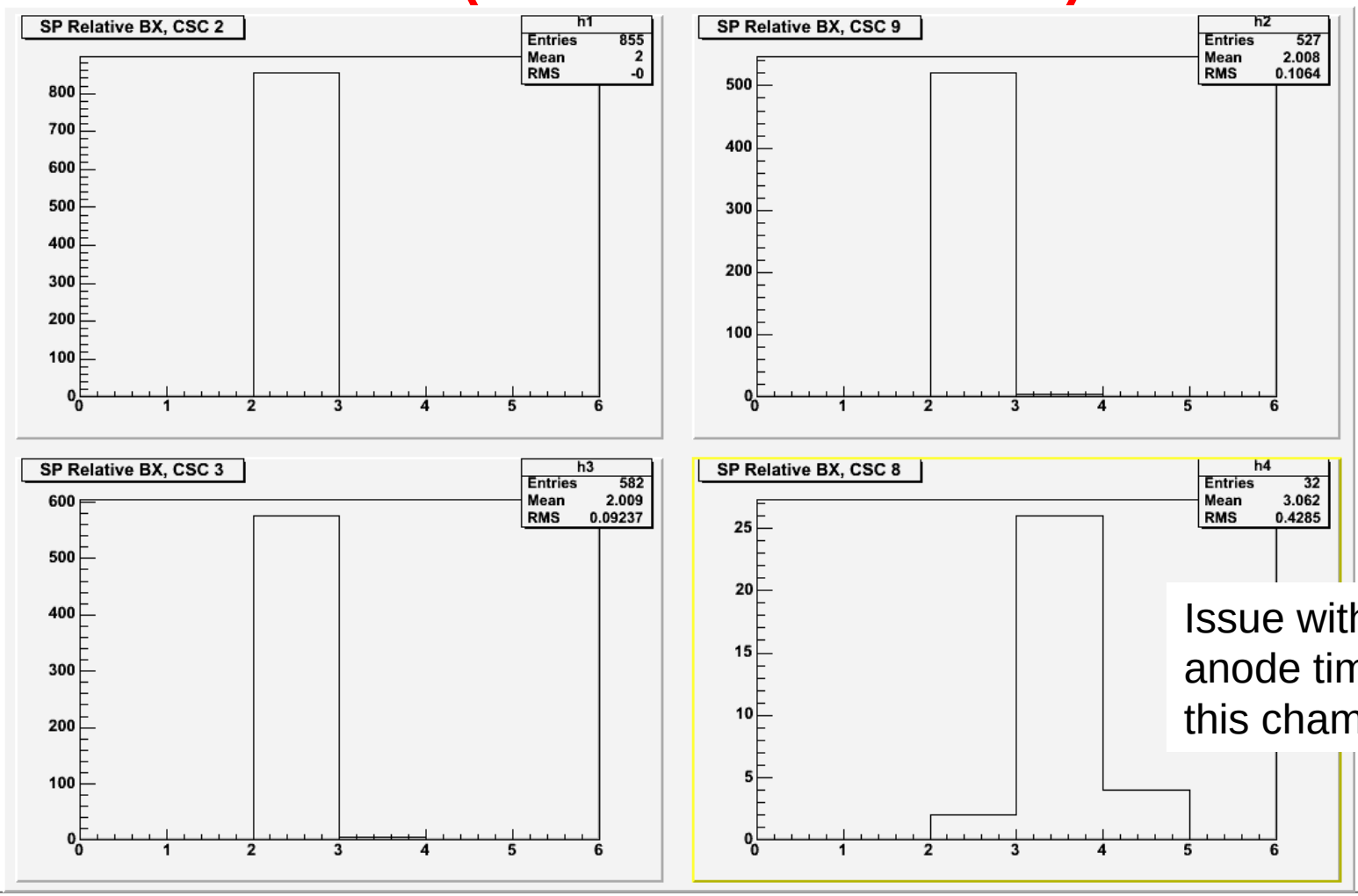
64K events



- **Correlation of track η, $\Delta\phi$ between 2 stations, and track type agrees perfectly between hardware and ORCA simulation**
  - **n.b. Some aspects of the standalone ORCA trigger package still must be incorporated into CERN repository**

Time Alignment of CSC data in Track-Finder

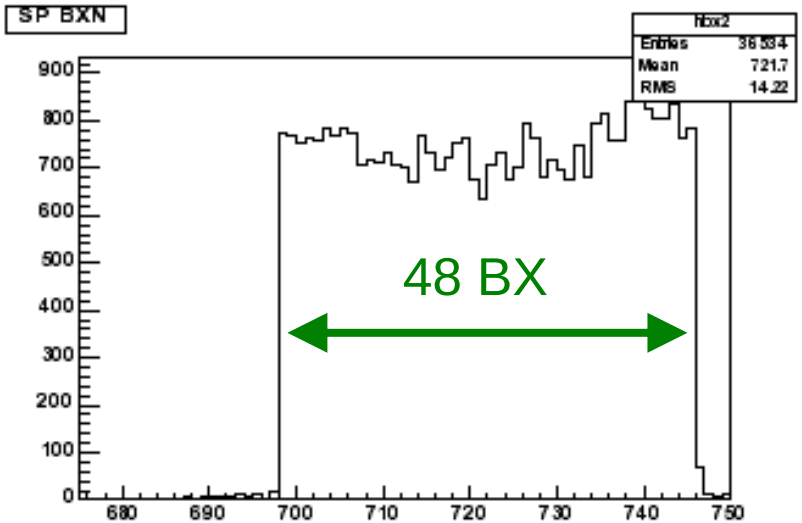
- **Able to get all trigger data from multiple chambers and crates on same BX (at least for some runs):**

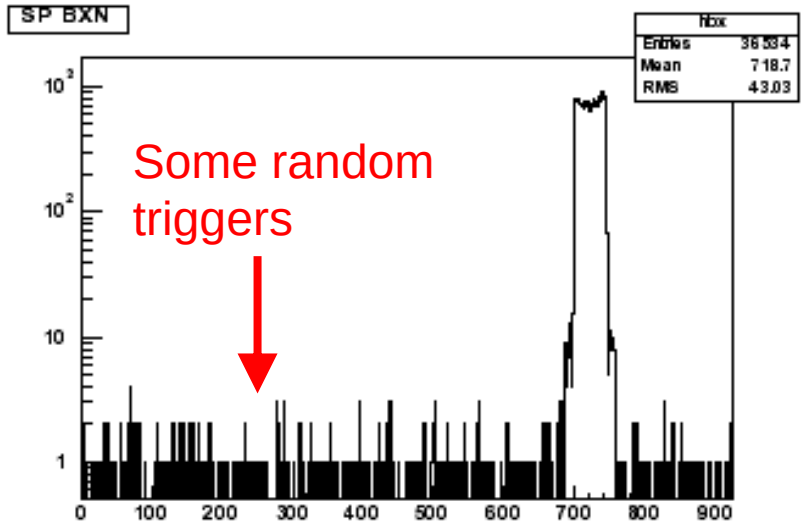


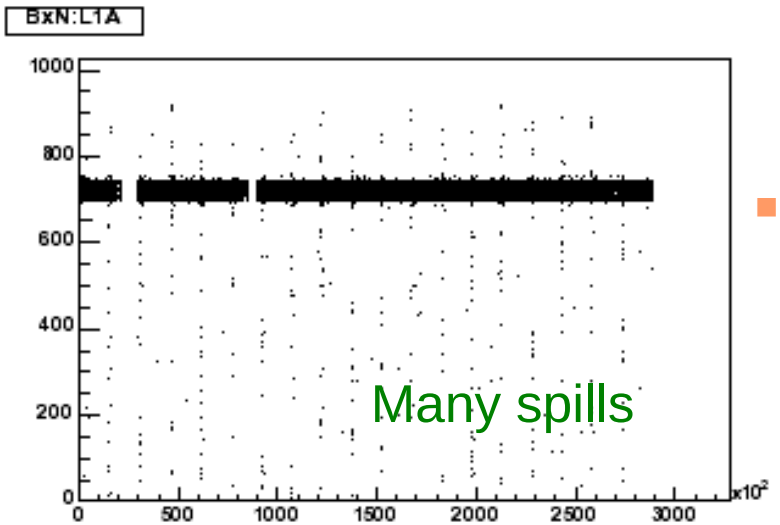
Issue with anode timing for this chamber

Run 293

Sector Processor BX Distribution



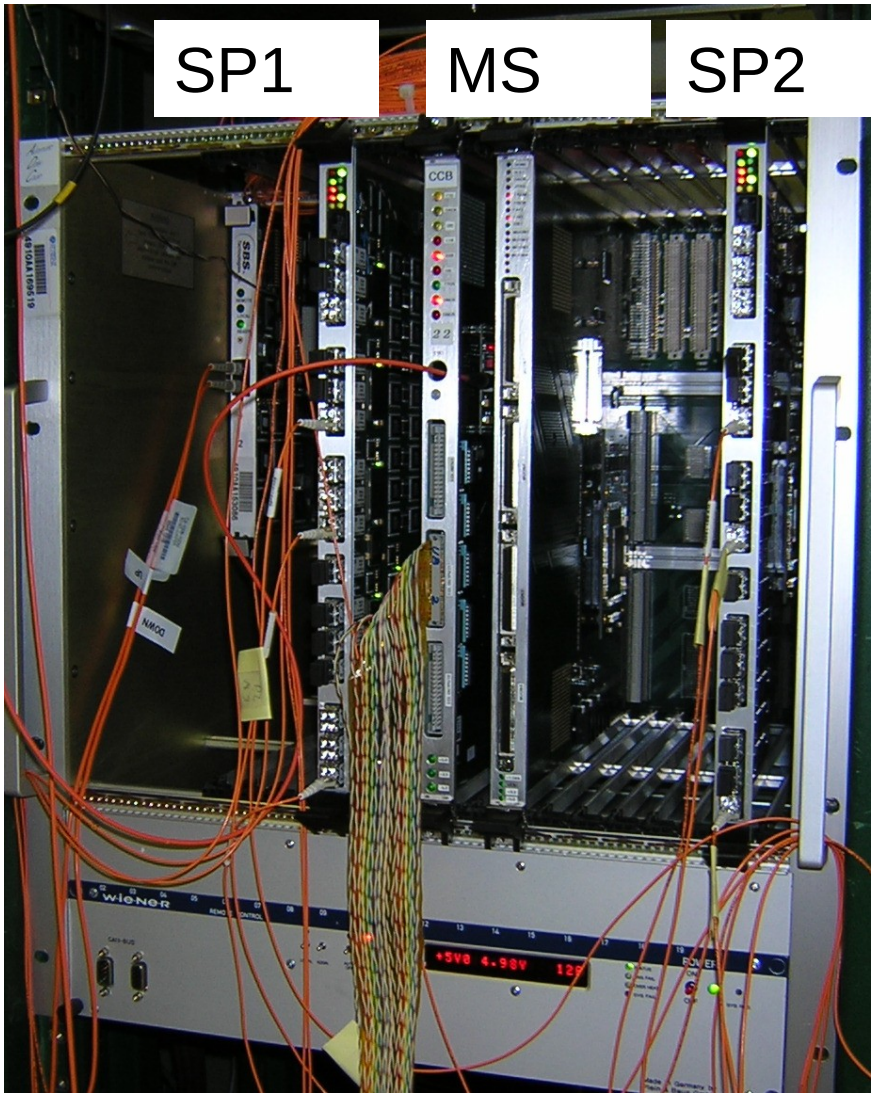




- **BX counter resets every time BC0 arrives**

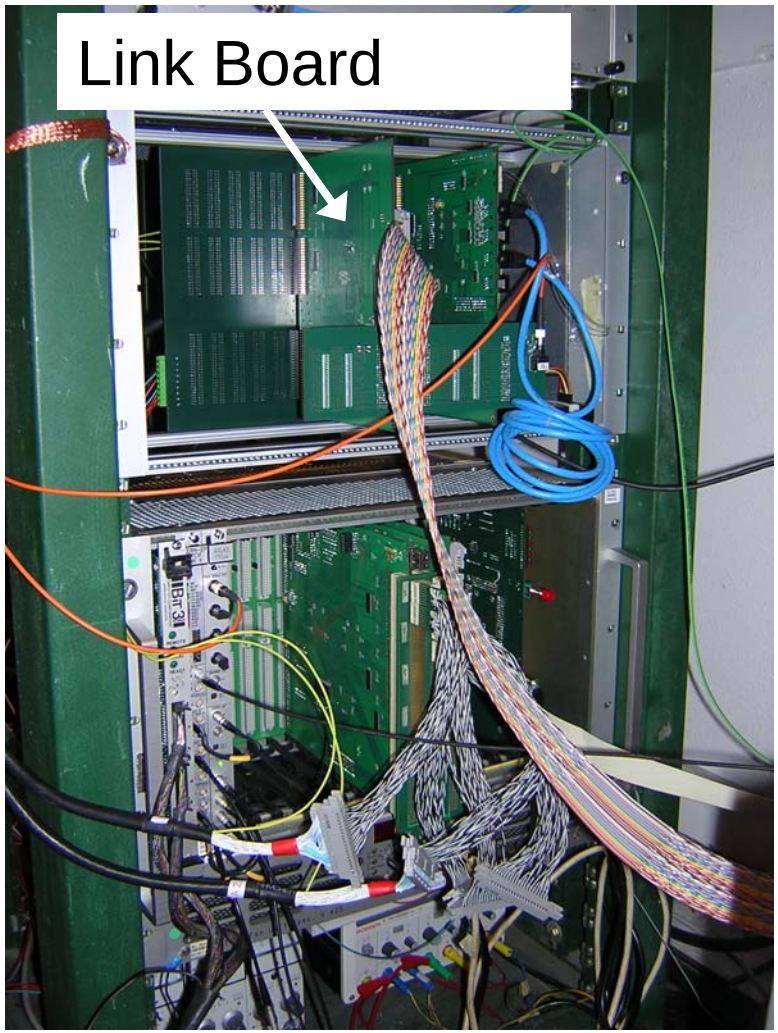
Run 380, muons

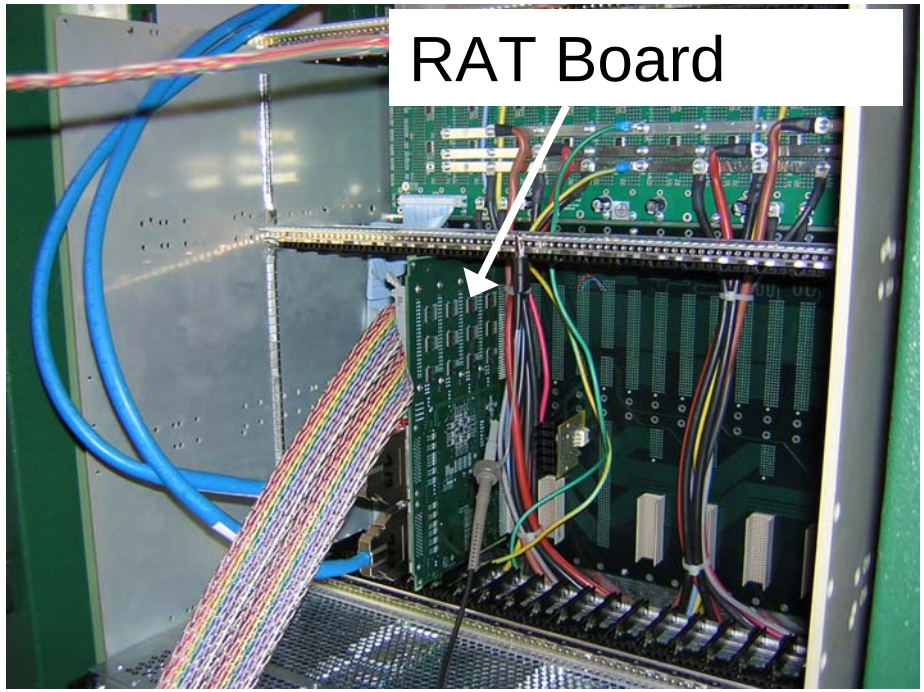
Track-Finder Crate Tests Cont'd



- **First test of multiple peripheral crates to TF crate**
  - **Synchronization test**
- **Various clocking solutions tried to test robustness of optical links**
  - **MPC used QPLL 80 MHz clock on backplane for 25 ns runs?**
- **First test of multiple Sector Processors to one Muon Sorter**
  - **Detailed offline checks of exchanged data should follow to validate boards**

RPC ↔ CSC Interface Test





Preliminary RPC/CSC Results

- **RPC chamber operating efficiently at 9.1 kV**
  - **Both single gap and double gap modes tested**
- **RPC signals seen in coincidence with Track-Finder trigger by Link Board monitoring package**
- **Correlated RPC data seen in CSC trigger motherboard (local trigger primitive logic for cathodes)**
- **Detailed quantitative checks must still be done**
- **Problem: the RPC and Anode Transition card (RAT) seems to be significantly reducing ALCT efficiency**

Continuation of Integration Tests

- Plans are underway to move our Muon "slice test" to the H2 beam line to integrate with HCAL in September
  - Will be crowded: DT also will there, as maybe Tracker
- This extends the integration to another CMS subsystem
- Main objective would be to synchronize the two systems with respect to each other, possibly triggering from CSC's
- Possible to merge to some degree the run control and DAQ software, since based on a common framework
  - Degree to which this is done depends on remaining amount of time

Offline: Data Unpacking

A.Tumanov, R.Wilkinson

- **Two CSC packages exist:**
- **DataFormat**
  - Standalone package that reads raw CSC data
  - Has been used extensively for over a year, including 2003 CSC TB
  - Still widely used in analyses (e.g. trigger studies)
- **METBRawFormat**
  - It is integrated with official CERN ORCA, at least for earlier ORCA versions (but private CVS version kept as well)
  - Constraint: ORCA/Muon cannot depend on ORCA/Trigger
    - Need to think where to put trigger primitive data classes
  - Needs updating to the latest ORCA FED redesign by G.Bruno
    - Max Chertok (UC Davis) volunteers to work on this
- **Problems:**
  - Both packages frequently crash on recent data, and must be made more robust
    - Due to data corruption, subtleties in CSC data format

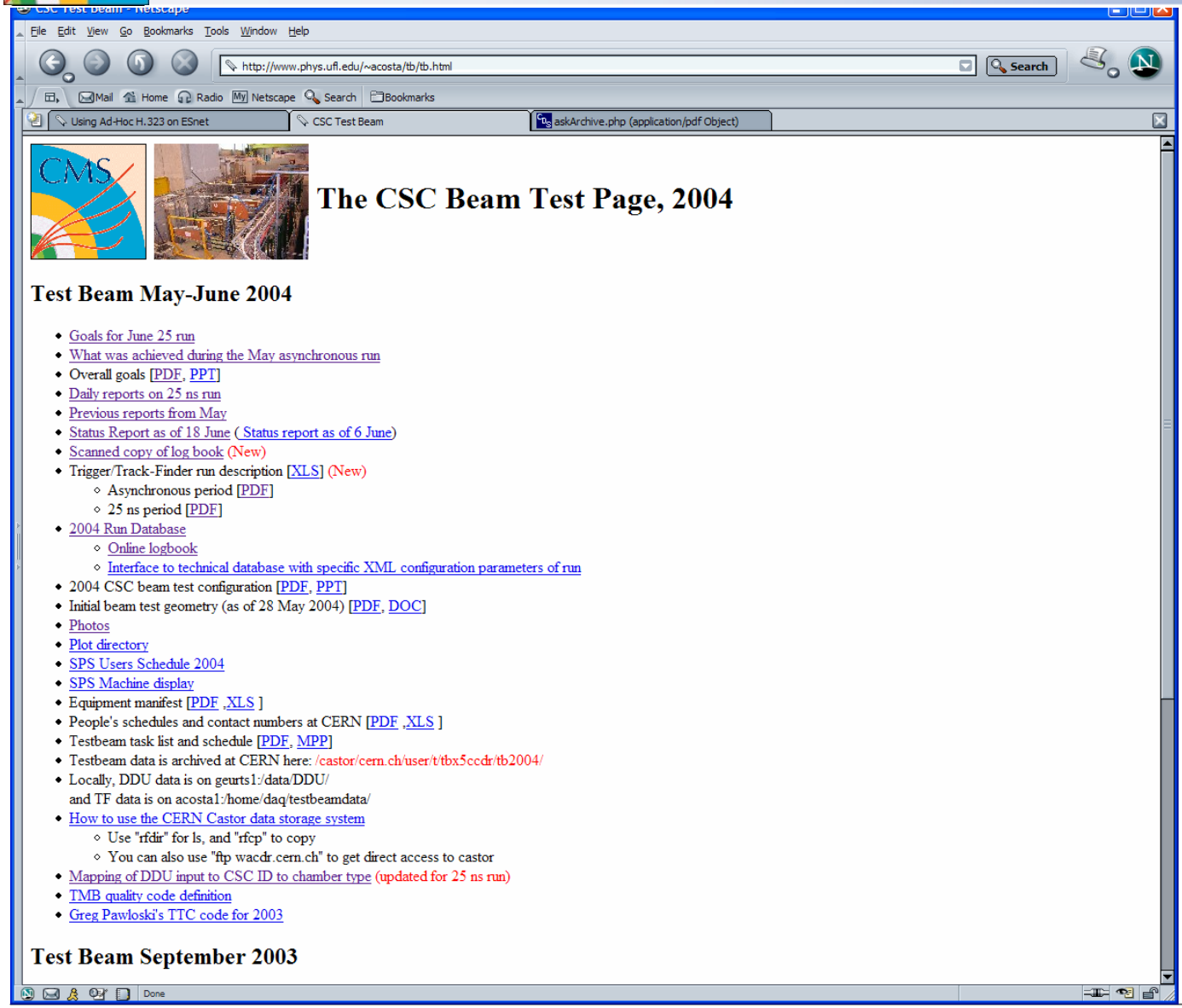
Offline: Simulation

- Michael Case created first XML geometry file for CSC beam test
  - Initial geometry only, chambers were moved around during tests
- Next step is to run OSCAR job around this geometry
  - Tim Cox volunteers to work on this
- Ultimately should inject raw data into ORCA for reconstruction, and compare with simulation
  - Validate CSC digitization
  - Verify multiple scattering in iron
  - Check possible impact of RPC operation on CSC
- Need more volunteers, at least for ORCA-based analyses!

Conclusion

- **130 GB of data logged**
  - **Many analyses still to be done!**
- **May-June 2004 test beam program had many accomplishments**
  - **New fully XDAQ-based run control and data acquisition system tested**
  - **Pre-production prototypes working well**
  - **Trigger system synchronized and self-triggering**
  - **RPC interface tests performed**
- **Some problems crept up:**
  - **Data unpacking robustness (more thorough studies required)**
  - **Anode LCT interface through RAT card**
- **Will return to CERN in September/October at H2**
  - **Continue progress toward a CMS slice test**

http://www.phys.ufl.edu/~acosta/tb/tb.html



Most documentation linked off here

Acosta, Darin	UF
Barashko, Victor	UF
Bondar, Nikolai	PNPI
Breedon, Richard	UCD
Case, Michael	UCD
Chertok, Max	UCD
Cox, Tim	UCD
Drozdetski, Alexei	UF
Durkin, Stan	OSU
Geurts, Frank	Rice
Gilmore, Jason	OSU
Golovtsov, Victor	PNPI
Golunov, Alexander	Dubna
Gray, Lindsey	UF
Gu, Jianhui	OSU
Karjavine, Vladimir	Dubna
Khabarov, S.	Dubna
Korytov, Andrey	UF
Kotov, Kostya	UF
Kraemer, Tami	USCMS
Lanaro, Armando	UW
Lee, Sang-Joon	Rice
Levchenko, Peter	UF
Matveev, Mike	Rice
Moissenz, Peter	Dubna
Movchan, Sergei	Dubna
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Pakhotin, Yury	UF
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Sharma, Archana	CERN
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Tsesmelis, Emmanuel	CERN
Trevino, Andrea	Rice
Tumanov, Alex	Rice
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(apologies to anyone I left off)