



# US CMS Trigger 2006



## LPC Meeting

Wesley H. Smith, *U. Wisconsin*  
CMS Trigger Project Manager  
February 17, 2006

### Outline:

Calorimeter Trigger Status  
Endcap Muon Trigger Status  
Installation/Commissioning Plans  
Upgrade R&D

This talk is available on:

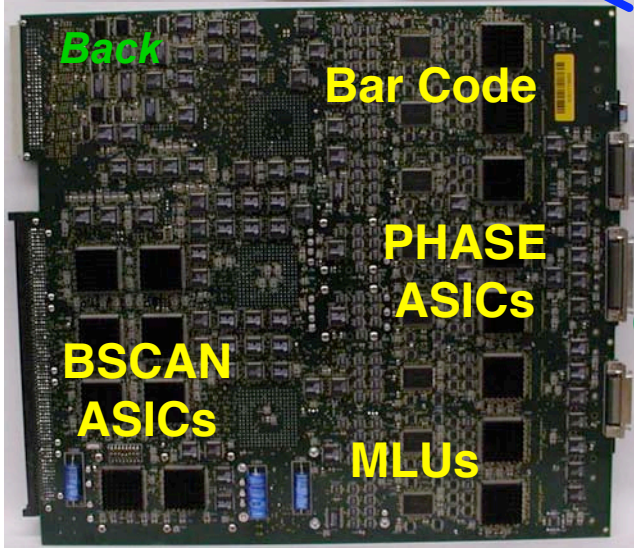
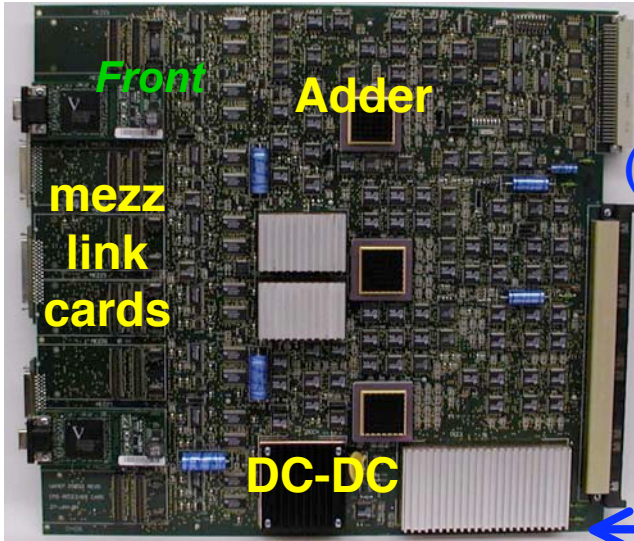
[http://hep.wisc.edu/wsmith/cms/doc06/smith\\_trig\\_LPC\\_feb06.pdf](http://hep.wisc.edu/wsmith/cms/doc06/smith_trig_LPC_feb06.pdf)



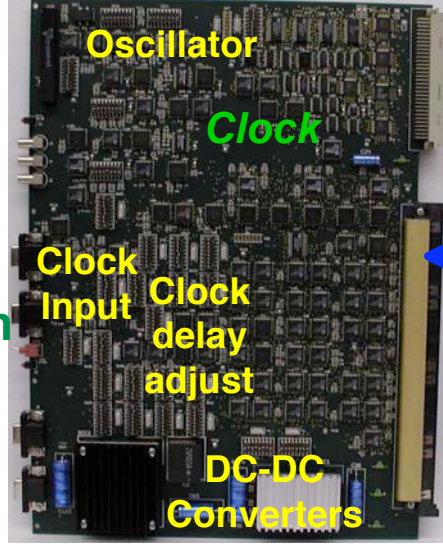
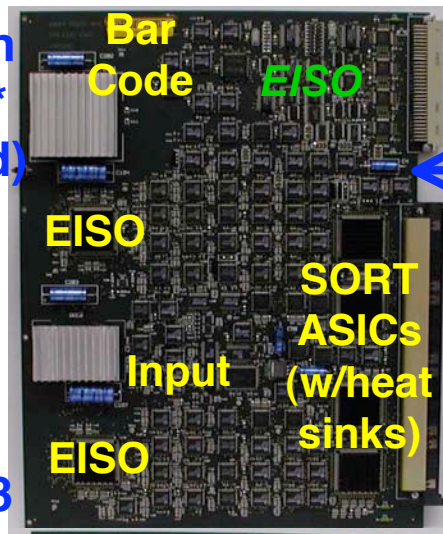
# Regional Cal. Trigger Milestone: Production & Testing Complete



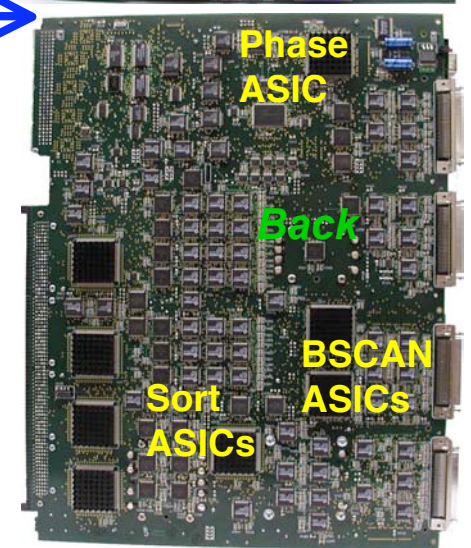
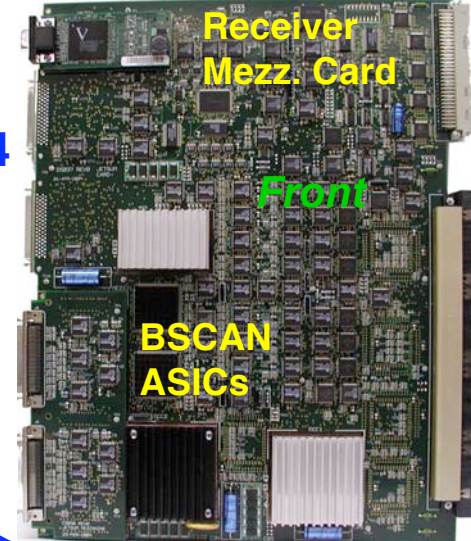
## Receiver Card:



## Electron Isolation & Clock:



## Jet/Summary:



**fraction tested\* (needed)**

*\*will test rest for extra spares*

**132/153 tested (126)**

**26/28 Custom Backpl Tested (18)**

**153/154 Tested (126)**

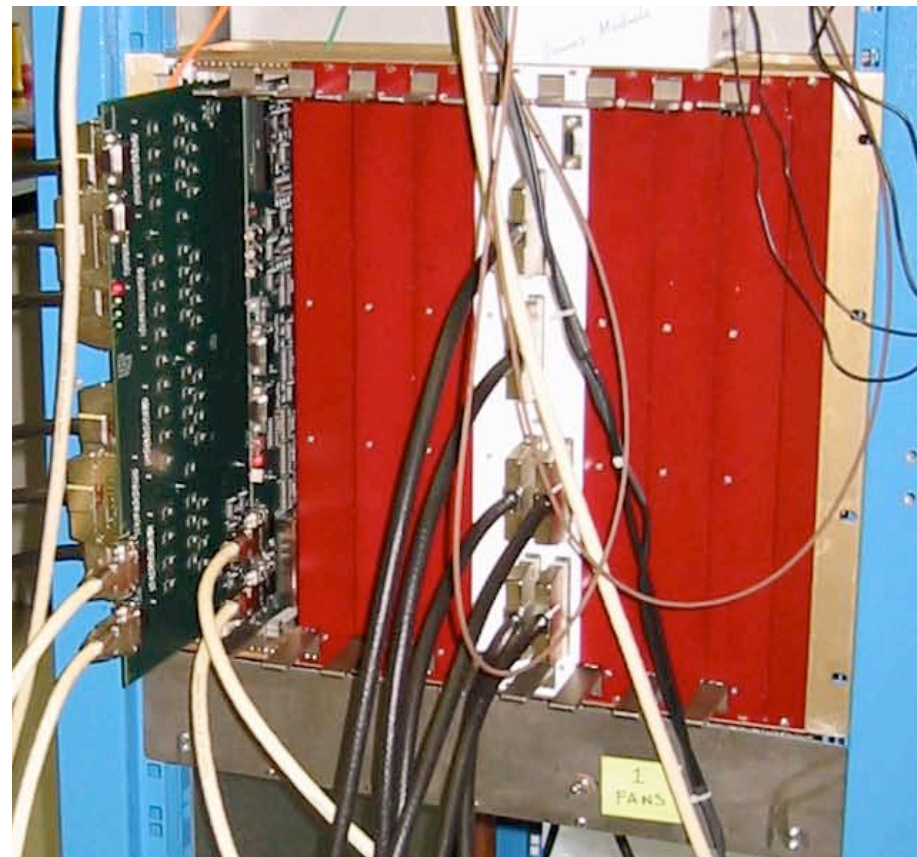
**22/25 tested (18)**

**23/25 tested (18)**



# 3 RCT Full Crates Operating at CERN

- U. Wisconsin



Rear of Full RCT crate fully cabled to HCAL trigger primitive logic

Used for integration tests & board checkout after shipment

Front of Full RCT crate with Jet Capture Card that continuously samples output, checks on the fly for errors and provides readout of 256 crossings



# Endcap Muon Trigger Milestone: Production & Testing Complete



## Muon Sorter (Rice):

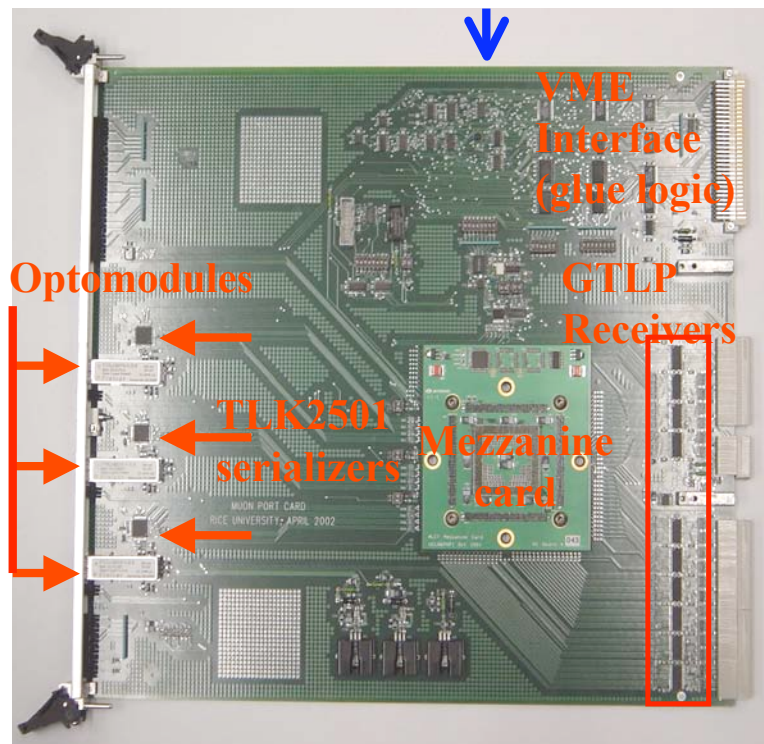
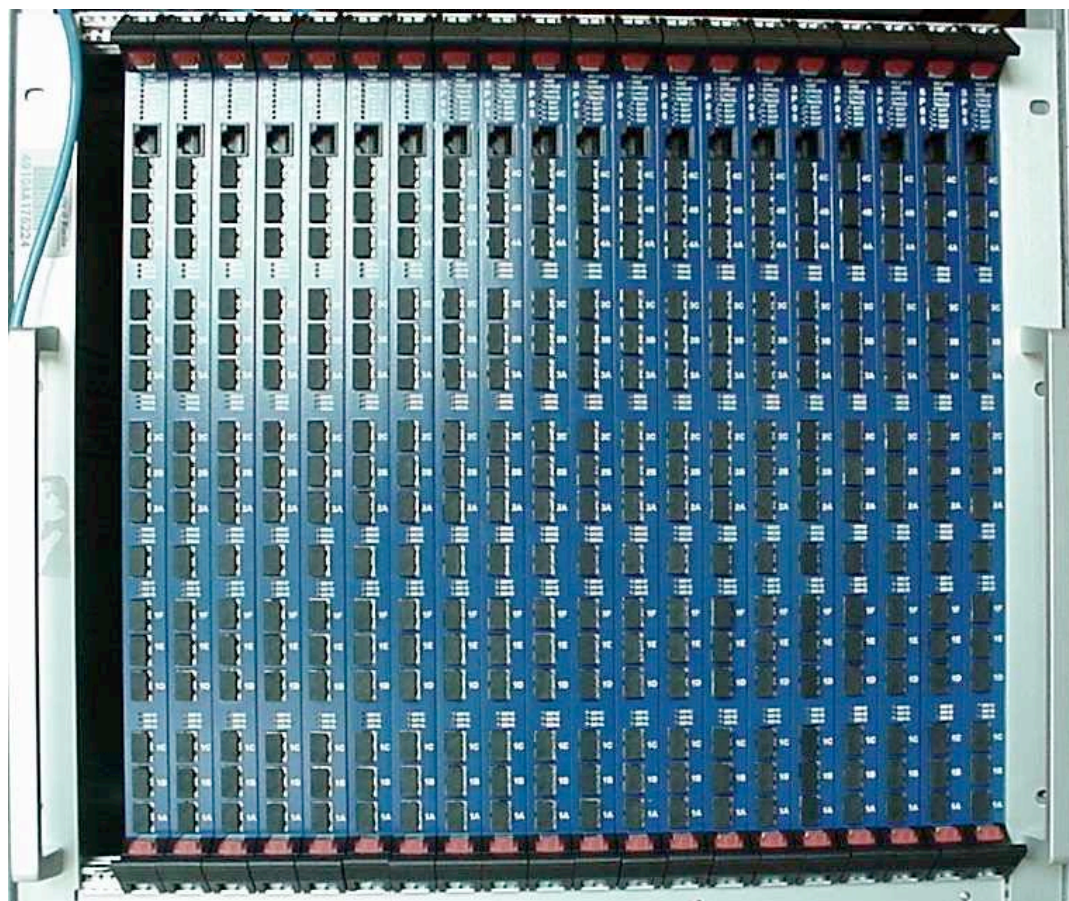
- Sorter produced (1 needed)

## Muon Port Card (Rice):

- Final production done (tested 67)
- Total needed: 60 (75 incl. spares)

## Sector Processor (Florida):

- Backplane produced (1 needed)
- 20 SP produced (12 needed):





# CSC trigger operations

## Preparing for Cosmic Challenge

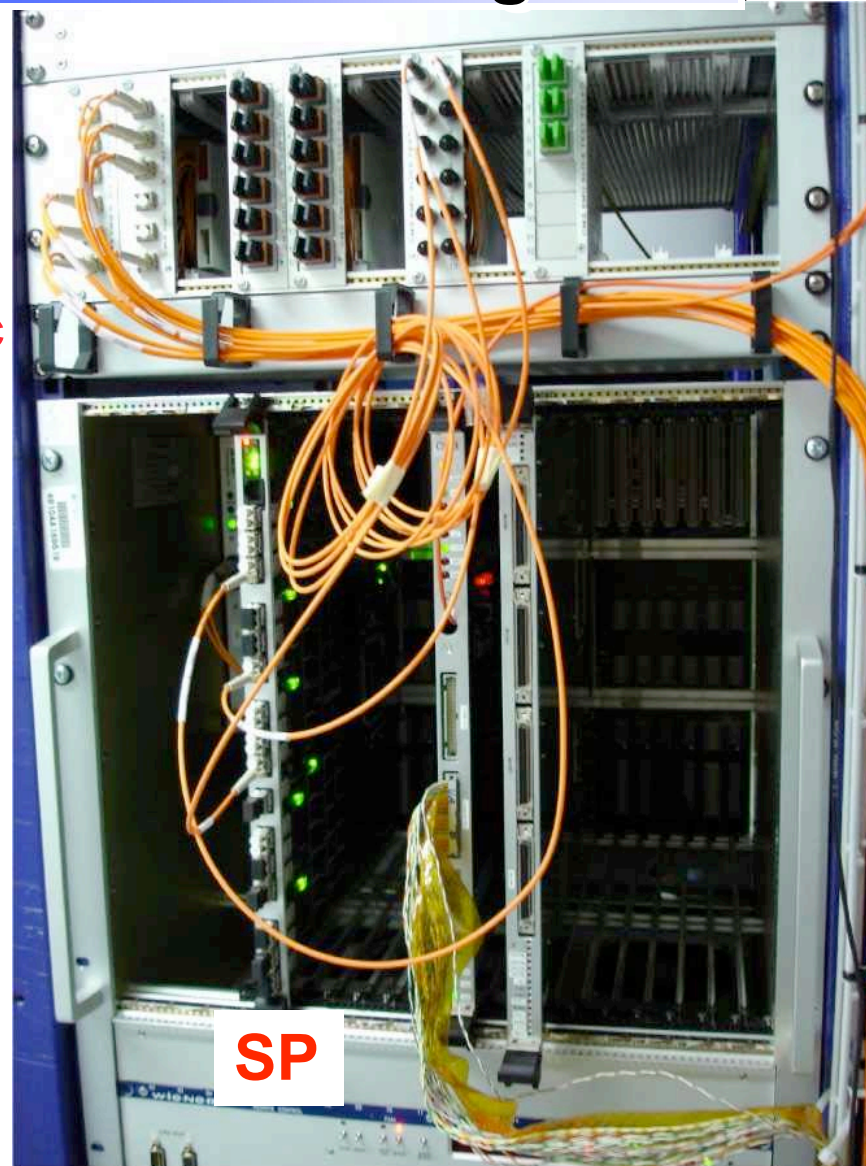
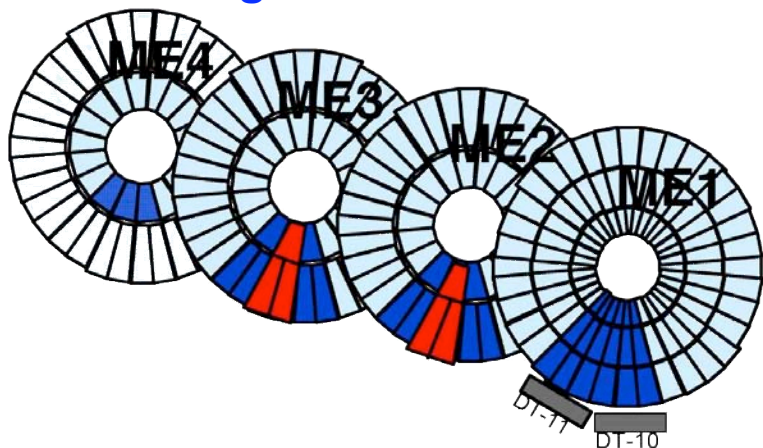


Currently set-up in SX5 as operated in 2004 beam tests

- Connected 10 chambers in ME+2 & ME+3 → 20° full slice on YE+2

CSC Track-Finder will provide a cosmic muon trigger based on a coincidence of LCTs in two or more disks

- Currently triggering @ 50Hz with 2-station coincidence
- CSC track finder has already provided triggers used to pass data from the CSCs to the global DAQ.





# Trigger Activity in 2006



## Operate fully functional trigger electronics at CERN

- Employed in myriad tests & preparation activities

## Tests in Electronics Integration Center

- Labs & row of racks for electronics subsystems
- Test interfaces & integration as much as possible before move to USC55

## Surface & “Magnet” tests in SX5

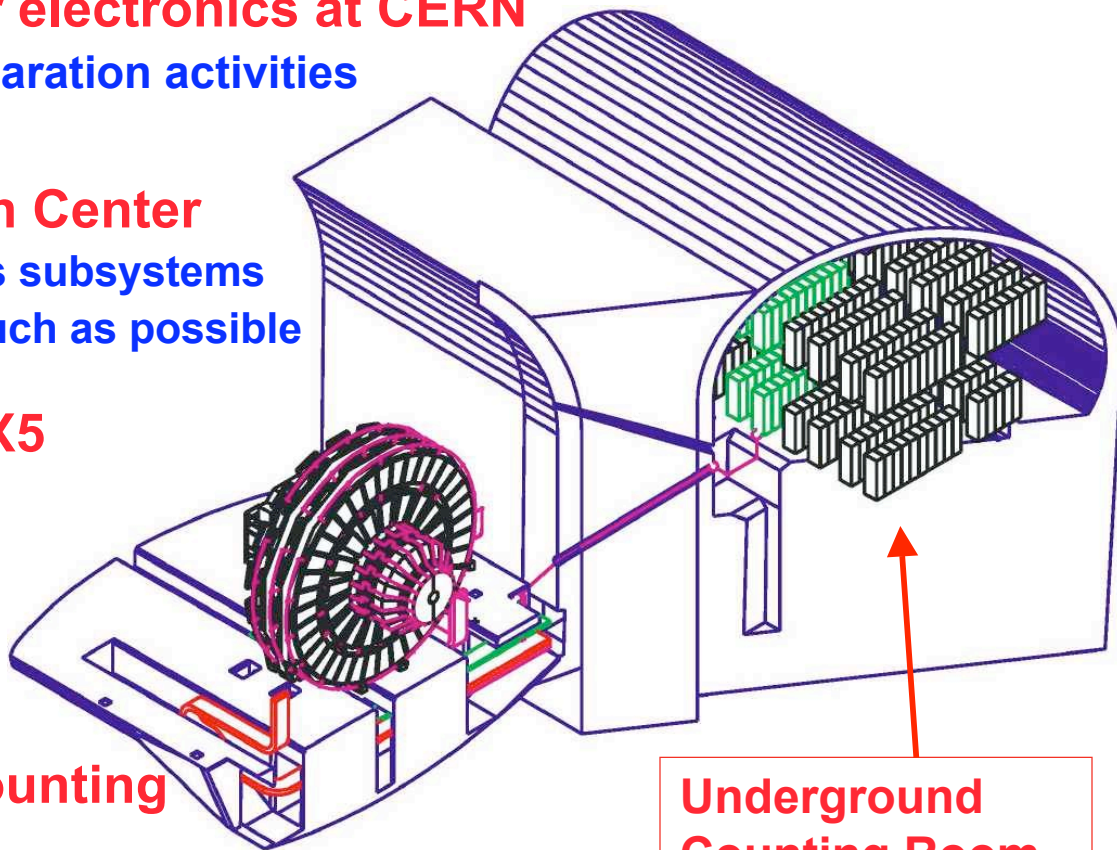
- With both HCAL and EMU
- More during magnet test
- Verify trigger functions & interfaces w/detectors on surface.

## Installation in Underground Counting Room (USC55)

- Expect start by April '06 --”ready for crates”
  - Racks, Infrastructure installed & operational

## Trigger Upgrade R&D

- Start initial design work & technology investigations

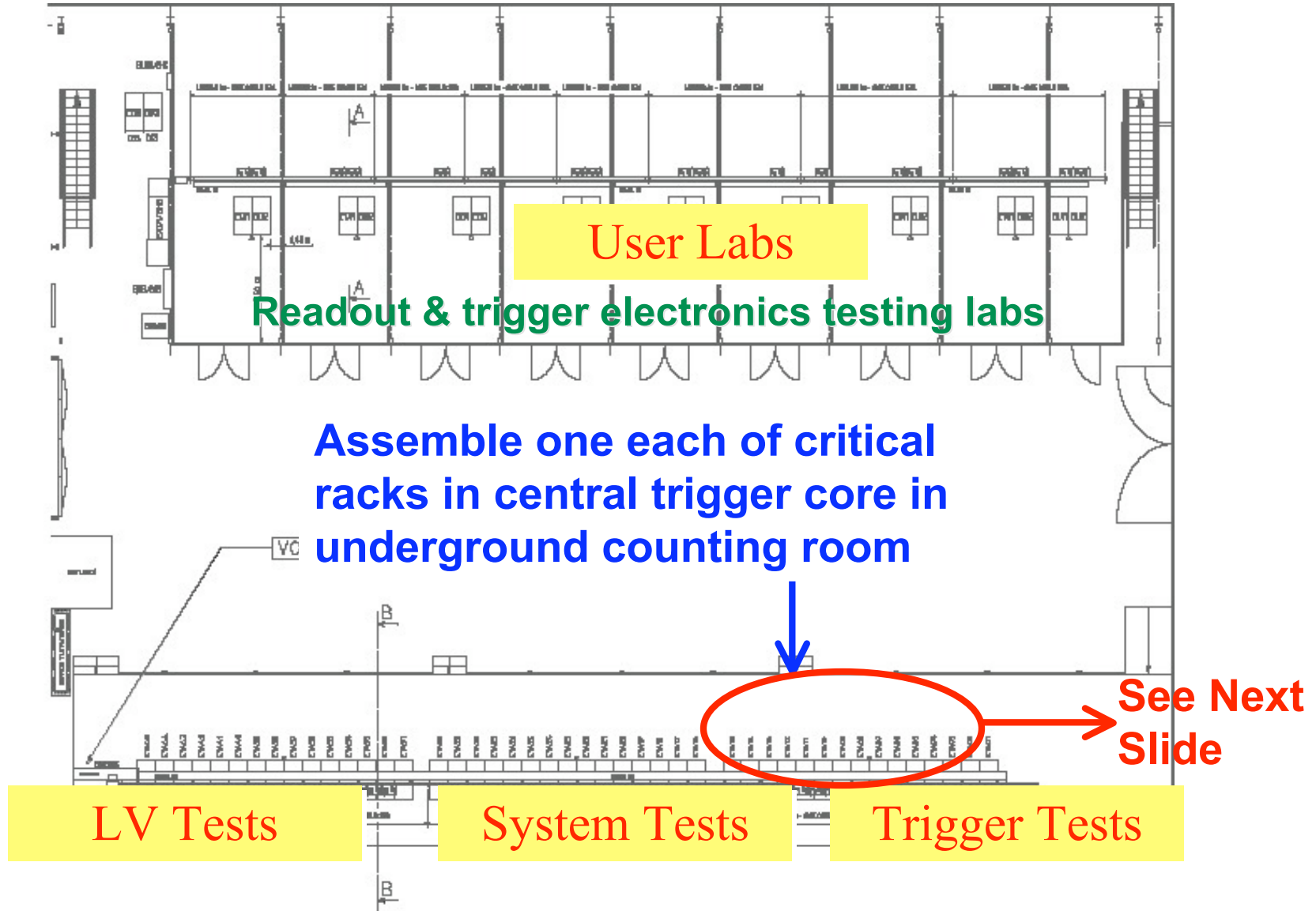


Underground  
Counting Room





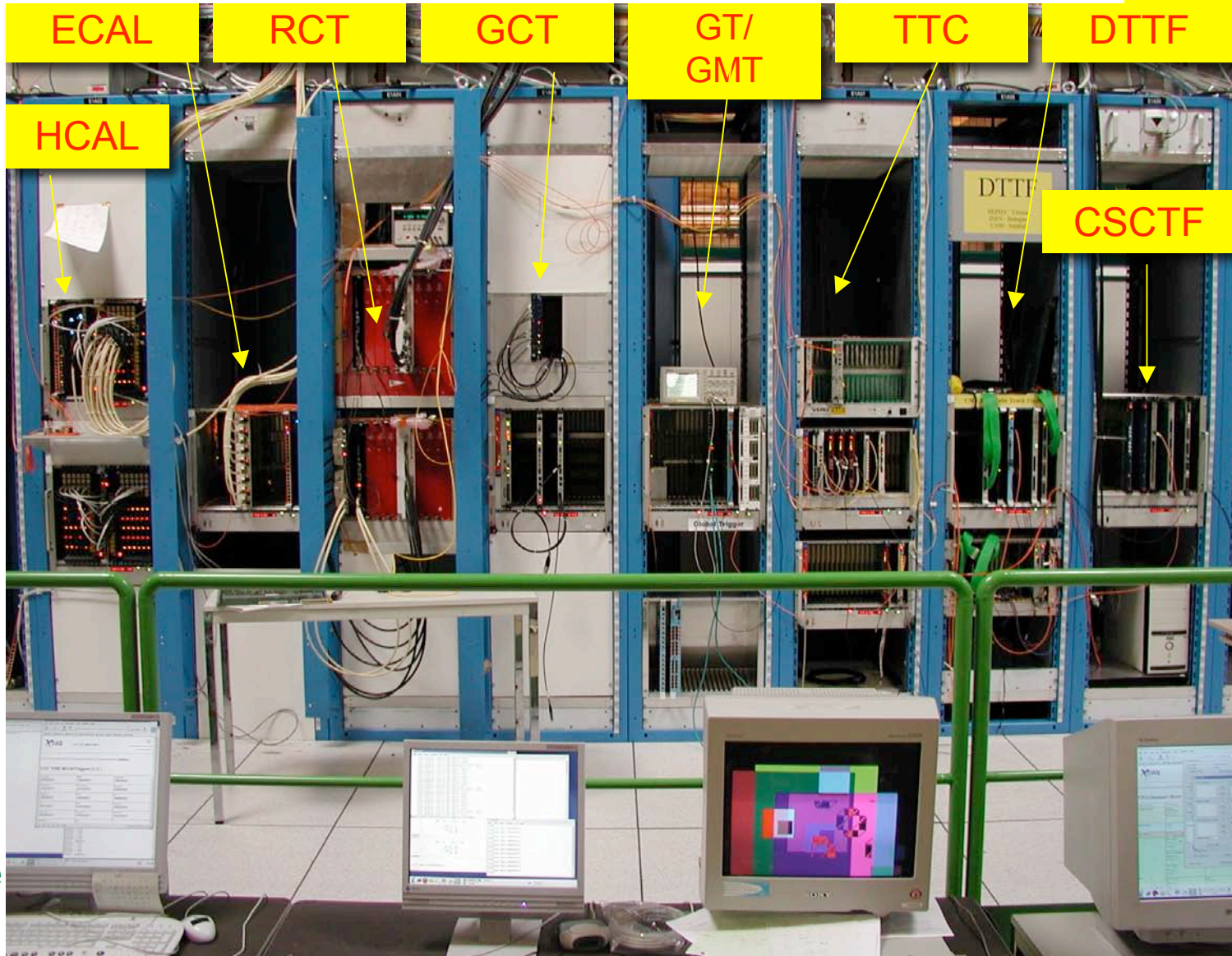
# Electronics Integration Center (Building 904)







# Central Integration Racks in Electronics Integration Center



**Large scale integration tasks in central racks:**

- Example: Calorimeter trigger operating with CMS timing & control infrastructure

- Successful integration tests with regional calorimeter trigger, global calorimeter trigger, HCAL and ECAL trigger primitive logic



# Bldg. 904 Integration Tests





# Status of 904



## All users in place

- Safety system validated. 24/7 operation
- Procedures in place for DSS/DCS operation

## Integration in central racks now focus of work

- DAQ burn-in
- Integration of TTC/RCT/ECAL/HCAL/GCT/GT
- Integration of GMT/CSCTF/DTTF/GT/RPC

## Extensive burn-in debugging taking place in labs

- HCAL/ECAL/RCT/TTC/GCT/GT/TKR/EMU/RPC

## Subsystems have been profiting from the availability and gaining valuable experience in integration/commissioning

- Problems are being found - and fixed
  - Often subtle problems which only show up in the integration environment of trying to run many systems at once.

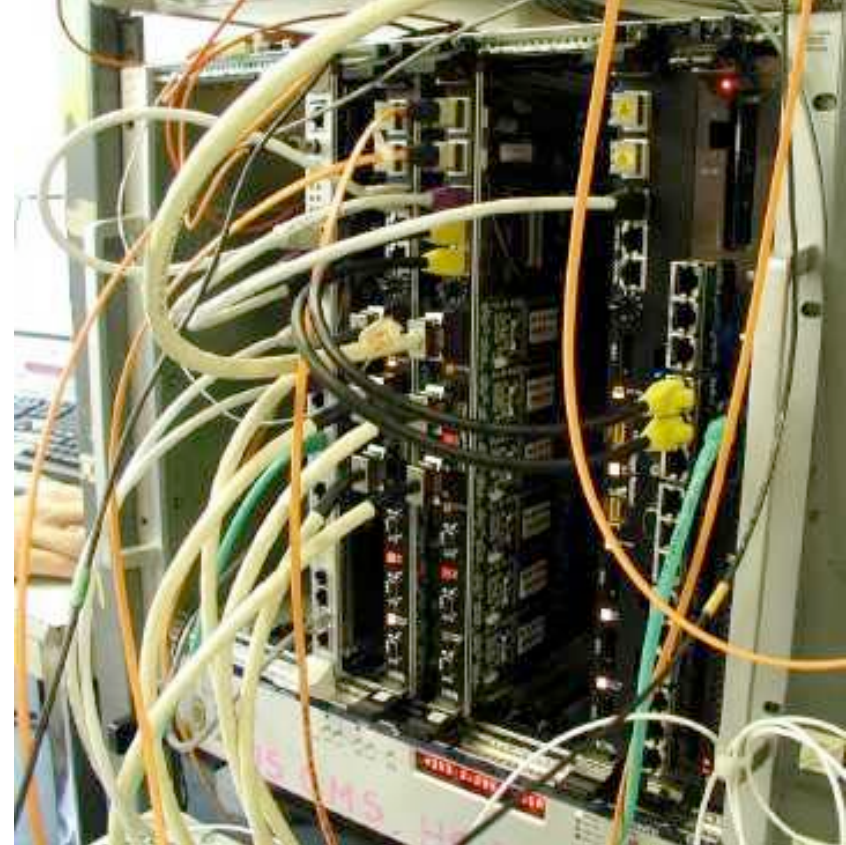
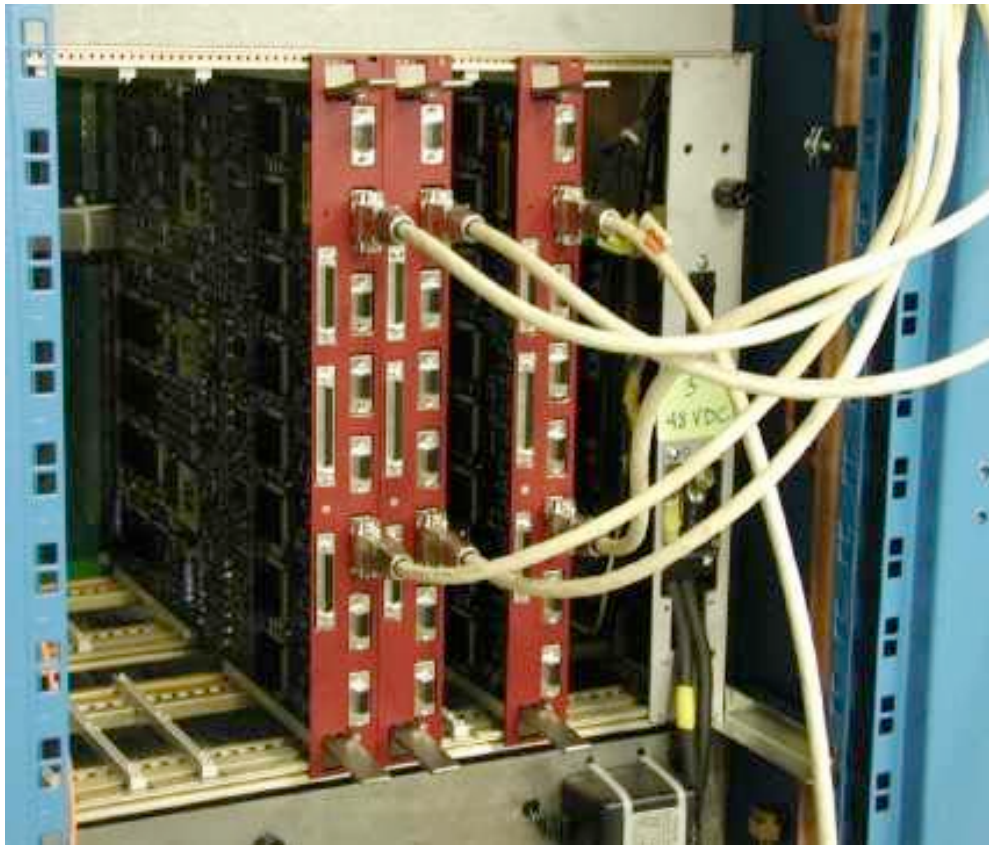


# HCAL-SLB-RCT Integration in EIC

- Maryland, Lisbon, Wisconsin



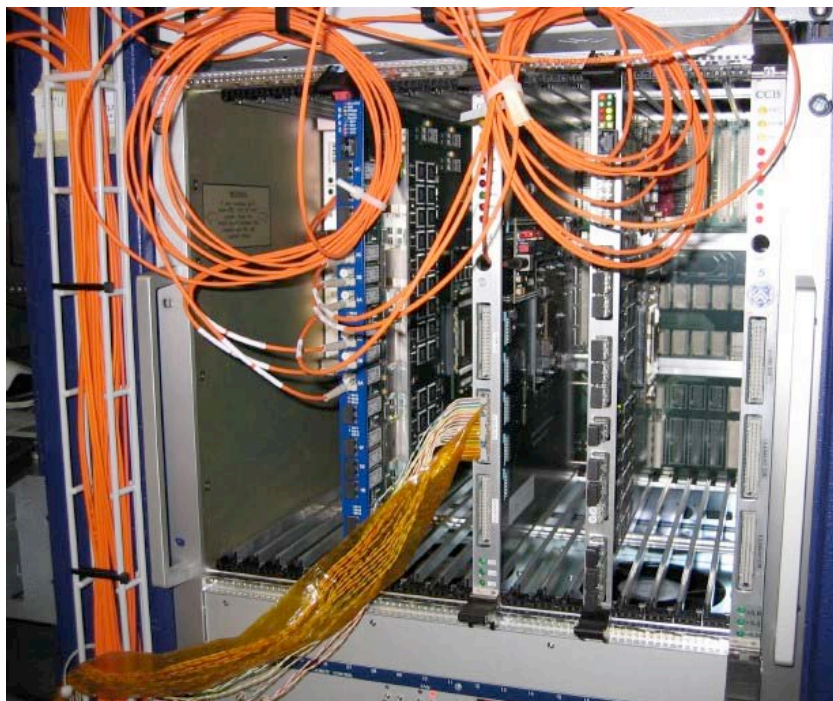
Sent synchronous jet data from HCAL HTR Cards thru 6 SLB over 10m copper 4Gb/s Vitesse Links to 6 Regional Calorimeter Trigger Receiver Mezzanine cards, thru Receiver Cards, Backplane and Jet Summary Card to Jet Capture Card that records the output of 256 crossings. Observed output jets on all channels in expected crossings.





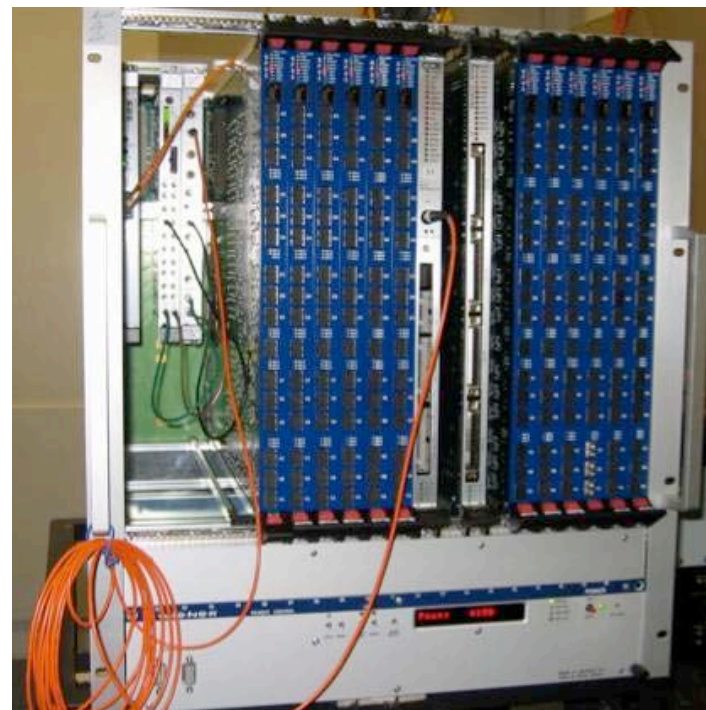
# CSC Track Finder Integration

- Florida, Rice, UCLA



## Slice Test: cosmics running now!

- preparing full readout and self triggering of a whole trigger sector (60°).
- Since April 05 self-triggering with as close to nominal CMS setup as possible
  - used to pass data CSCs to global DAQ.
- Goal: magnet test with 1/12th of the fully functioning CSC detector system

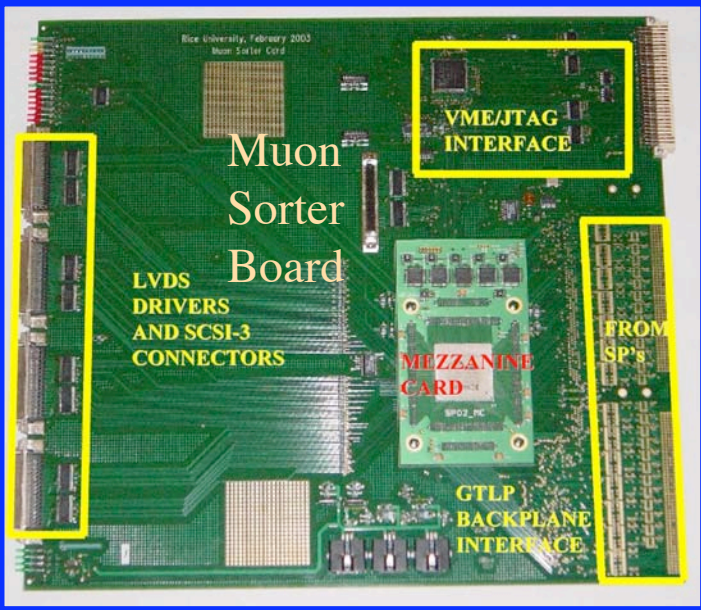


## EIC Integration

- Integration tests with Drift Tube Track Finder underway
- Have CSC TF crate running in EIC
  - Now have full crate working at Florida (above)



# CSC Trigger Integration with Global Muon & Global Triggers



Rice Muon Sorter sorts Sector Processor muons & transmits to Vienna Global Muon Trigger:  
**Integration Test successful**



# Trigger Software



## Configuration data

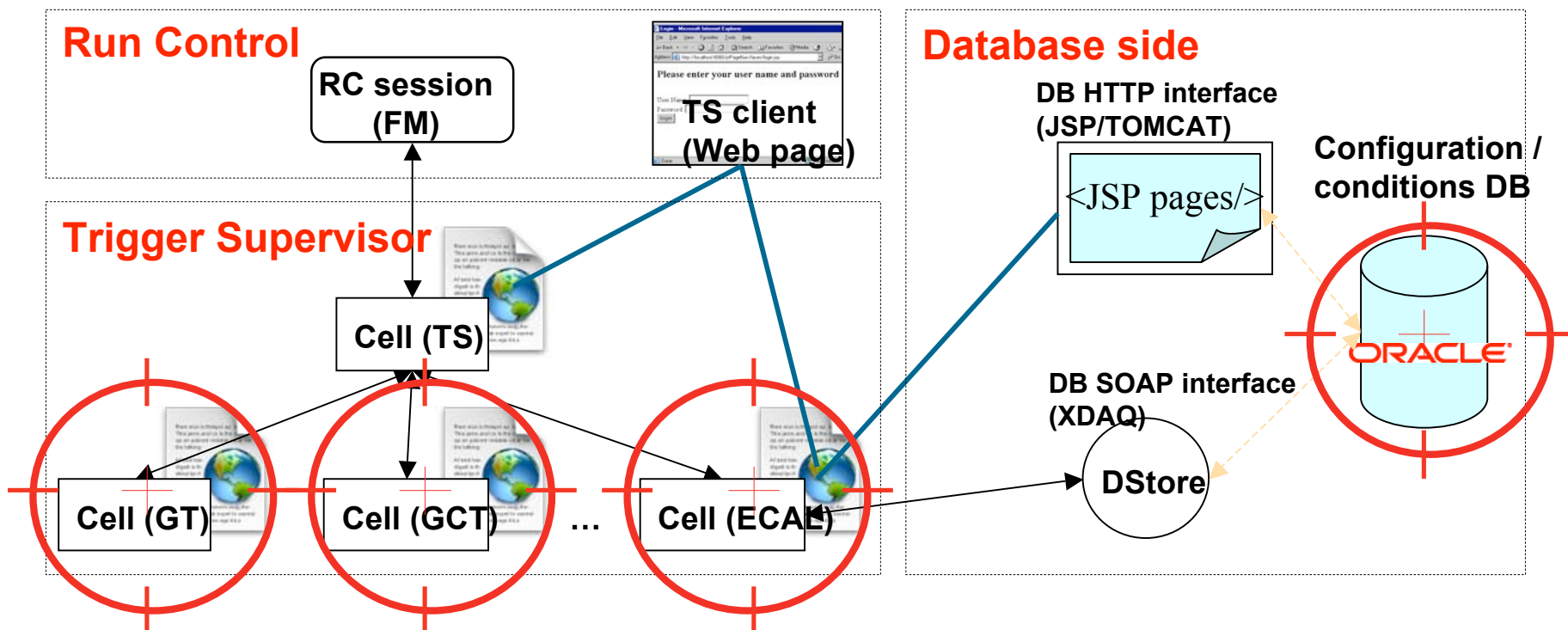
- Use CMS Configuration DB Infrastructure

## Trigger Supervisor (see below)

- Integrate with Run Control and trigger sub-systems

## Trigger testing and monitoring

- Translate Integration Test Plans into Software  $\Rightarrow$  Bldg 904 setup
- Trigger Online Monitoring  $\rightarrow$  Use DAQ Monitoring Infrastructure





# The Trigger Supervisor GUI



Vienna & Wisconsin

Integrated with RCT, ECAL, GT, CSC, GMT

**TS User Login - Mozilla Firefox**

File Edit View Go Bookmarks Tools Help

http://compaqmar:1973/urn:...

TS User Login

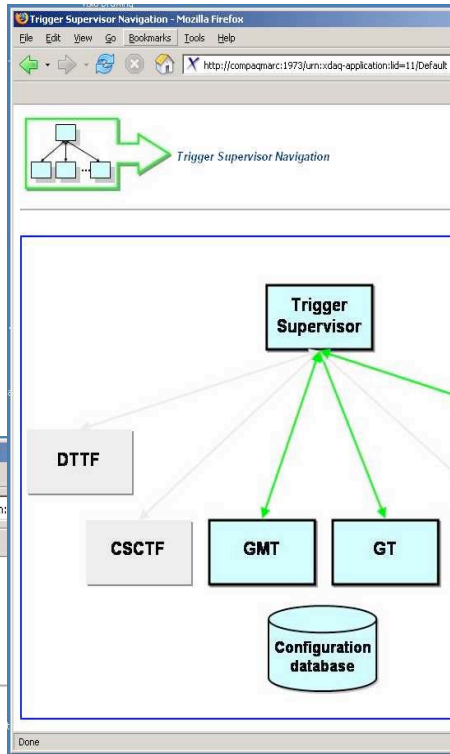
User Name

Password

Loggin

Contact Trigger Supervisor | Contact Xdaq

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**TS Cell Main Menu - Mozilla Firefox**

File Edit View Go Bookmarks Tools Help

http://compaqmar

TS Cell Main Menu

Go to Database GUI

Command Group  Command

Launch

Control

Log Record

- Sesion 846930886 Opened by user ilide
- Initializing Operation: Configuration
- Controlling operation: Configuration.119431076

**TS Cell Operation Control: Configuration.119431076 - Mozilla Firefox**

File Edit View Go Bookmarks Tools Help

http://compaqmar:1973/urn:xde

TS Cell Operation Control: Configuration.119431076

Refresh

Command

Kill

Update Parameters

Configuration Param [string]

All subdetectors producing TPGs are being integrated with configuration DB with Trigger Supervisor





# Trigger Supervisor Demonstrator



Philipp, HEPHY

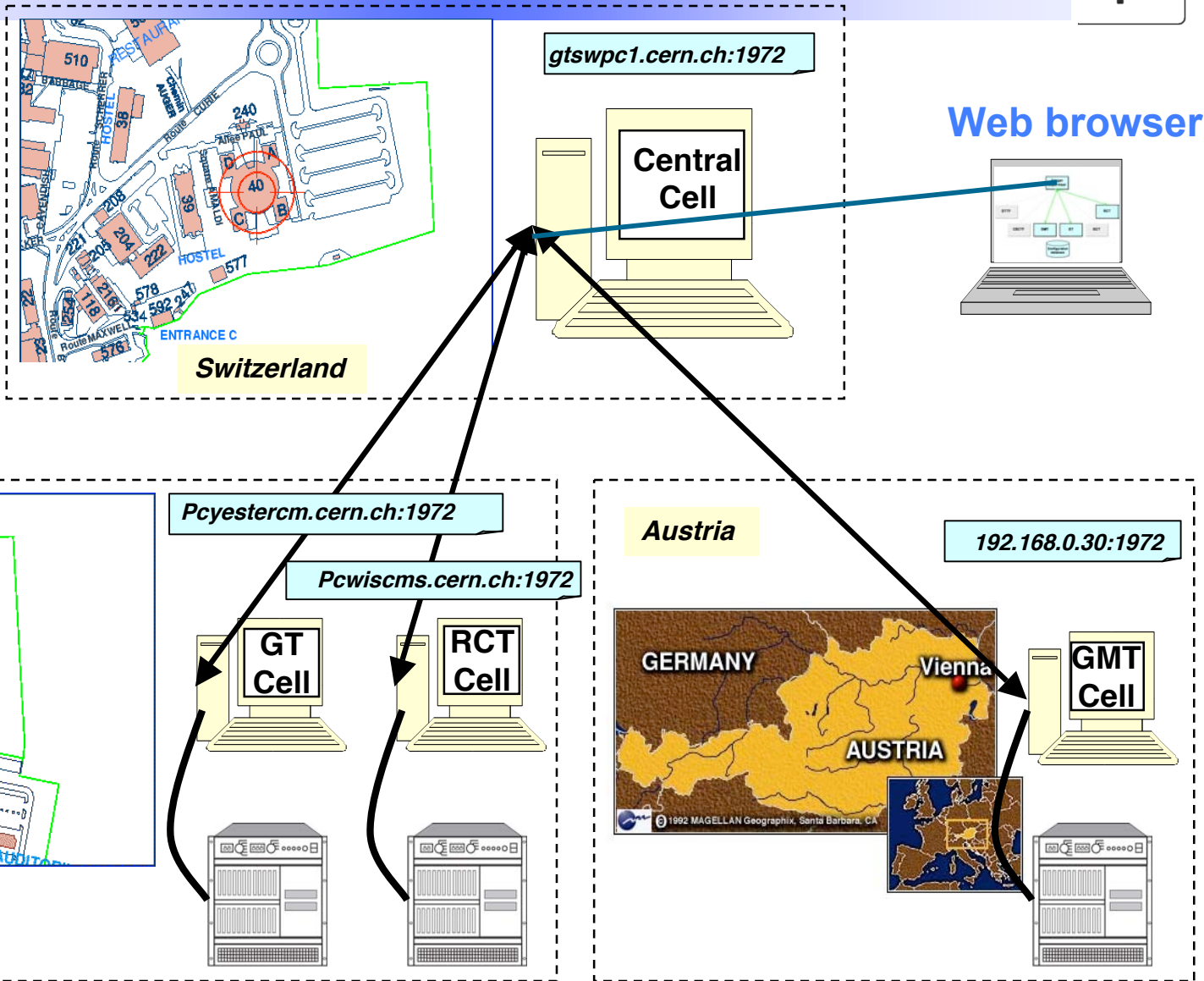
Tobias, HEPHY

Monika, Wisconsin

Marc, Wisconsin

Ildefons, HEPHY

3 nations, one trigger supervisor!





# Install/Commission



## Magnet Test (a.k.a. Cosmic Challenge) :

- **Drift Tube Trigger:**

- Main trigger along with RPC Trigger with dedicated logic

- **CSC Trigger:**

- 40° (or 60°) Slice: 24 CSCs from Sector 5, overlaps DT sectors 10, 11
- SP → Clock & Control Board → Local Timing Controller

- **Calorimeter Trigger:**

- Existing HCAL → RCT → JCC system brought to point 5 on demand
  - provides full HCAL module trigger

- **Trigger provided to all participating subsystems**

## USC55:

- **Planned start April 2006**

- **All trigger systems first tested in Preveessin 904**

- Nothing is installed in a rack for the first time in USC55



# Commissioning Tasks in 2006



## Engineers:

- **Revise firmware**
  - Replace testing firmware with operations firmware
- **Monitoring**
  - Implement voltage/temperature detector controls
- **Timing & Control**
  - Build up timing & control signal distribution systems
- **Software**
  - Develop APIs for integration with software

## Physicists:

- **Diagnostics, emulators, simulation code, interfaces and integration with other CMS systems.**



# Trigger Install Schedule - I



## Install/Commission Trig. Crates: Apr '06 - Sep '06

- Tested Trigger Crates installed, re-tested, interconnected, inter-synchronized
- Regional and Global Detector trigger systems integrated with each other and Global Trigger

## Integrate w/Detector Elect.: May '06 - Oct '06

- Phase 1 in USC55, Phase 2 in UXC55
- Cal Trig connected to E/HCAL USC55 electronics
- Muon Triggers connected to optical fibers carrying trigger data from detector in UXC55
- Global Trigger connected to TTC distribution system
- Operation with Local DAQ



# Trigger Install Schedule - II



## Integrate w/Central Trig. & DAQ Oct '06 - Mar '07

- Subset of triggers available to detectors in UXC55
- Dedicated testing with individual detectors
- Detailed synchronization testing of all systems
- Testing with Central DAQ

## System Commissioning Apr '07 - Aug '07

- Full capability of trigger system available
- Tests with all detectors and trigger operating simultaneously together and partitioned
  - Trigger and DAQ can operate in 8 separate partitions

## Ready for Data Taking August, 2007



# SLHC Upgrade Planning



**Luminosity upgrade x10 – SLHC :  $L = 10^{35} \text{cm}^{-2}\text{s}^{-1}$**

- Extends LHC mass reach by ~ 20-30% with modest changes to machine
- Detector upgrades needed -- especially the trigger & tracker
- Time scale ~ 2015

**Attempt to restrict upgrade to post-Trigger Primitive electronics as much as possible where detectors are retained**

- Only change where required -- evolutionary -- some possible pre-SLHC?

**SLHC Upgrade Committee Members -**

- Tracker: G. Hall, ECAL: P. Busson, HCAL: A.Baden, Muon: C. Wilmott, Trigger: W. Smith, Computing/Physics: D. Acosta, Microelectronics: A. Marchioro, Opto-electronics: F. Vasey, Electronics Coordinator: J. Nash, Spokesperson, Deputy Spokesperson, Technical Coordinator, Deputy Technical Coordinator

**Meeting During Electronics & CMS Weeks**

- Next Meeting:
  - CMS Week March 2006

**Planning for April Workshop**

- April 3/4 2006 Perugia
  - [http://bilei.home.cern.ch/bilei/Doc/SLHC\\_in\\_Perugia.html](http://bilei.home.cern.ch/bilei/Doc/SLHC_in_Perugia.html)



# SLHC Trigger Upgrade



## LHC:

- Level 1: Regional to Global Component to Global

## SLHC Proposal:

- Combine Level-1 Trigger data between tracking, calorimeter & muon at Regional Level at finer granularity
- Transmit physics objects made from tracking, calorimeter & muon regional trigger data to global trigger
- Implication: perform some of tracking, isolation & other regional trigger functions in combinations between regional triggers
  - New “Regional” cross-detector trigger crates
- Leave present L1+ HLT structure intact (except latency)
  - No added levels --minimize impact on CMS readout



# SLHC L-1 Trigger R&D



## New Features:

- **80 MHz I/O Operation**
- **Level-1 Tracking Trigger**
  - Inner pixel track & outer tracker stub
  - Reports “crude”  $P_T$  & multiplicity in  $\sim 0.1 \times 0.1 \Delta\eta \times \Delta\phi$
- **Regional Muon & Cal Triggers report in  $\sim 0.1 \times 0.1 \Delta\eta \times \Delta\phi$**
- **Regional Level-1 Tracking correlator**
  - Separate systems for Muon & Cal Triggers
  - Separate crates covering  $\Delta\eta \times \Delta\phi$  regions
  - Sits between regional triggers & global trigger
- **Latency of 6.4  $\mu$ sec**

## R&D program & technologies motivated by needs:

- **Complicated Algorithms & Low Latency:**
  - FPGA's: faster, more logic -- less custom logic -- programmable
  - Faster and larger memories
- **Moving more data at higher speed:**
  - Link technology: speed & integration
  - Backplane technology: connectors & newer interconnect technology
- **Higher Crossing Frequency:**
  - High speed clocking: low jitter - design for links
- **Overall Complexity:**
  - Design for test, diagnostics, algorithm validation





# Trigger 2006 Summary



## Good Progress on all fronts:

- CAL & EMU Triggers finished production
- Operations at CERN underway
- Integration tests complete or underway
- Software is in use and development continues

## Main Activity in '06-7: Installation:

- Time is tight to accomplish the necessary tasks
- Steps taken, planning established to meet schedule
  - Tests: Surface Tests in SX5, incl. Magnet Test in Spring '06
  - Extensive use of Electronics Integration Center
  - Careful layout and plan for USC55 starting Apr. '06

## Upgrade R&D:

- Design work: build on evolving concepts for higher luminosity
- Investigate enabling technologies to understand implementation