# US CMS TriDAS 2006

## US CMS Meeting

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CMS Trigger Project Manager

April 8, 2006

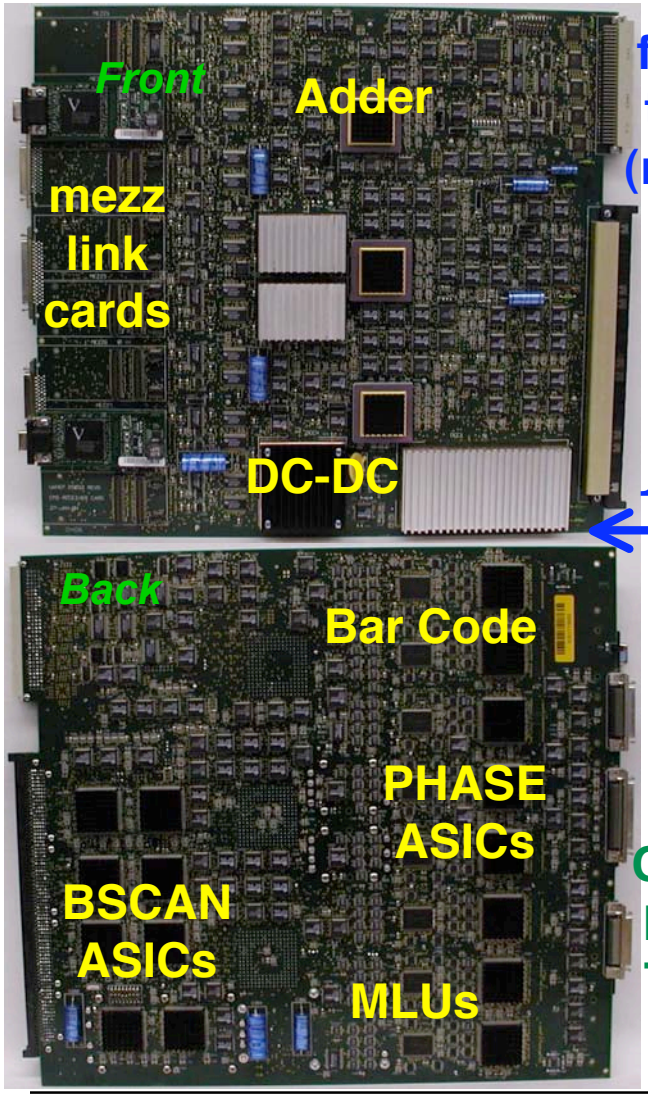
**Outline:**

- Calorimeter Trigger Status
- Endcap Muon Trigger Status
- US DAQ Status
- Installation/Commissioning Plans
- Preparations for Physics
- Upgrade R&D

This talk is available on:
http://hep.wisc.edu/wsmith/cms/doc06/smith_trig_USCMS_apr06.pdf

# Regional Cal. Trigger Milestone: Production & Testing Complete

## Receiver Card:



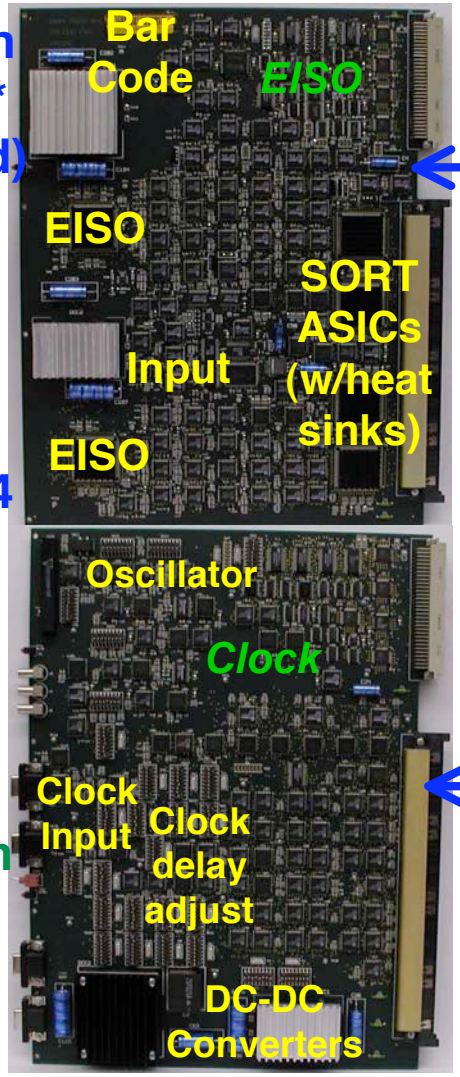

fraction tested* (needed)

*will test rest for extra spares

158/164 tested (126)

27/28 Custom Backpl Tested (18)

## Electron Isolation & Clock:

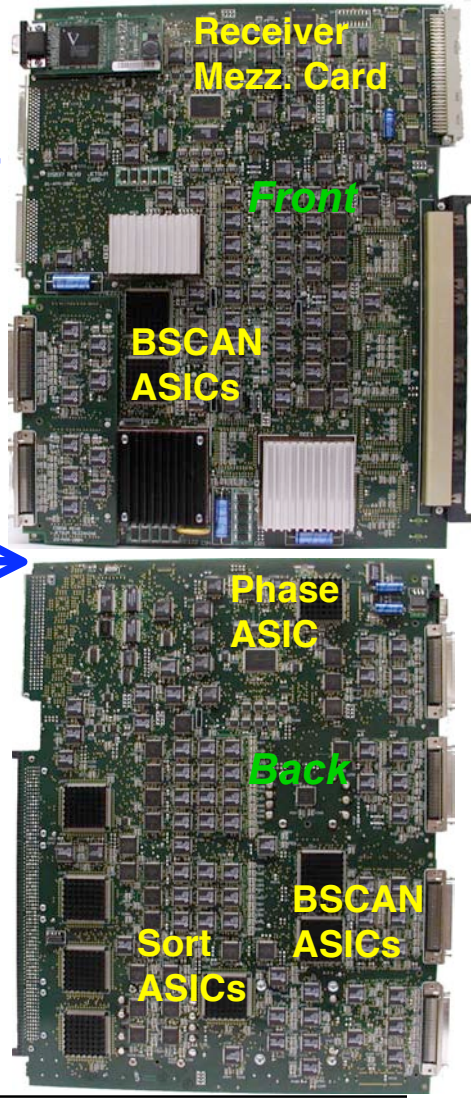



153/154 Tested (126)

23/25 tested (18)

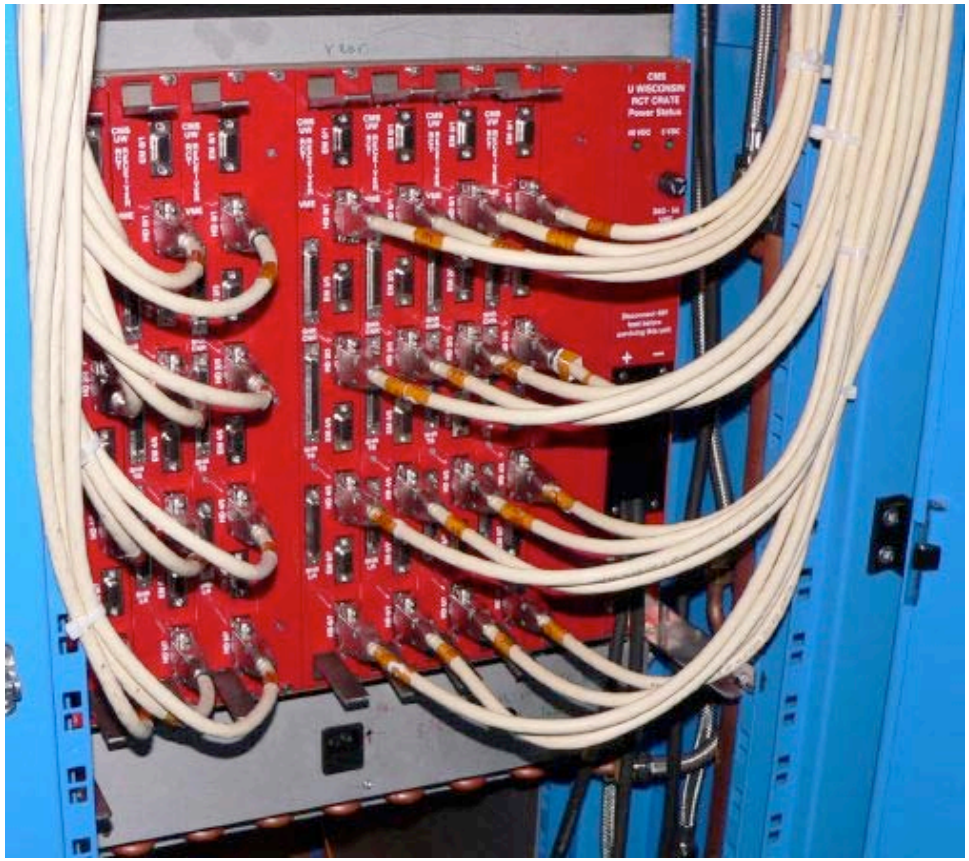
25/25 tested (18)

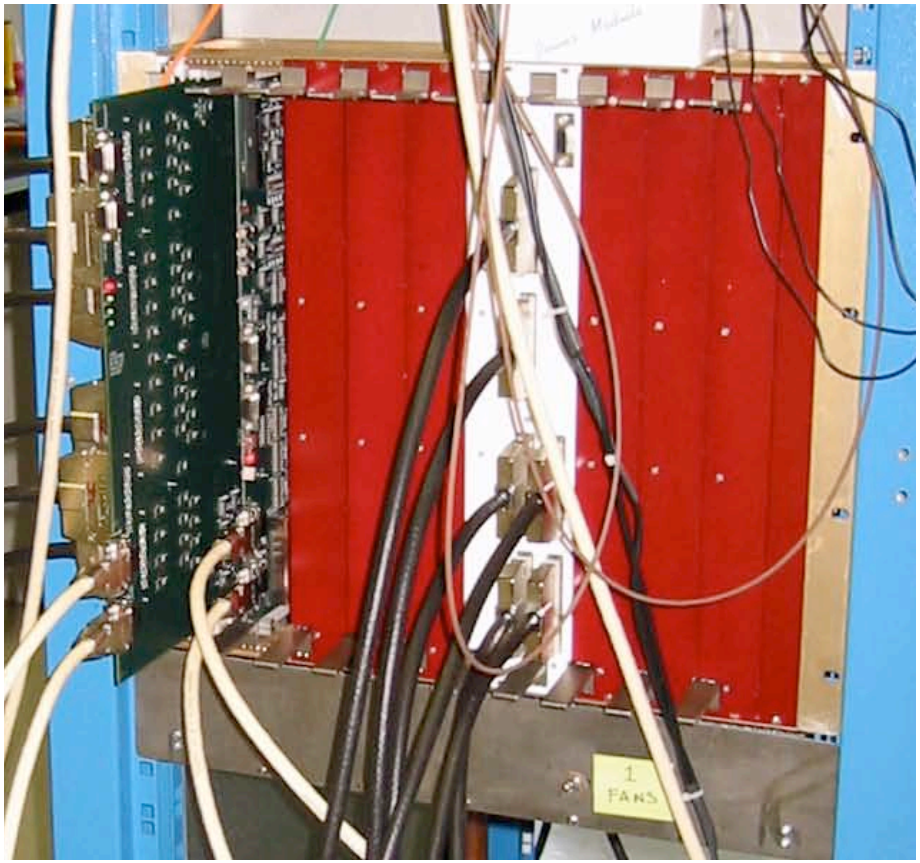
## Jet/Summary:



# 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

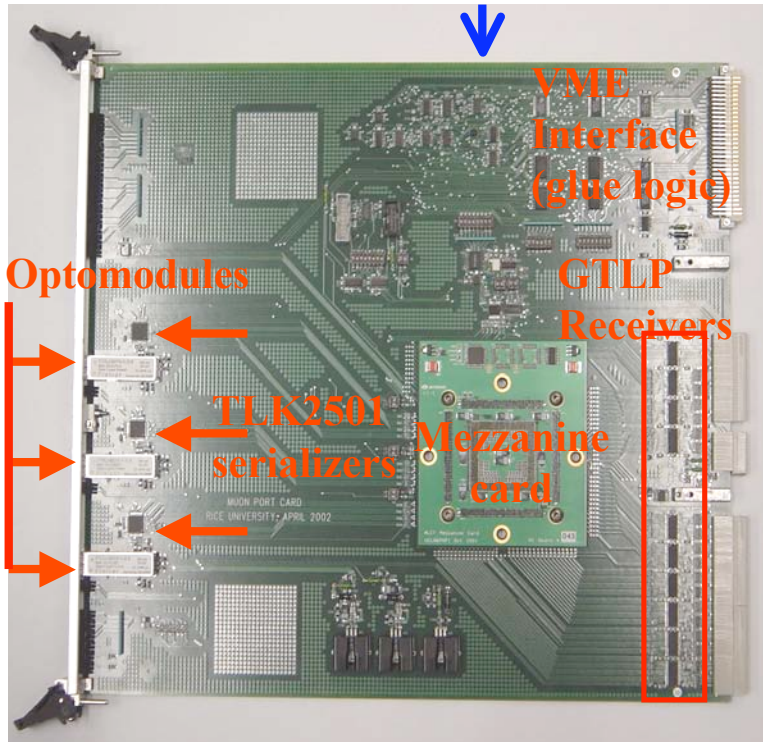
# Endcap Muon Trigger Milestone: Production & Testing Complete

## Muon Sorter (Rice):

- Sorter produced (1 needed)

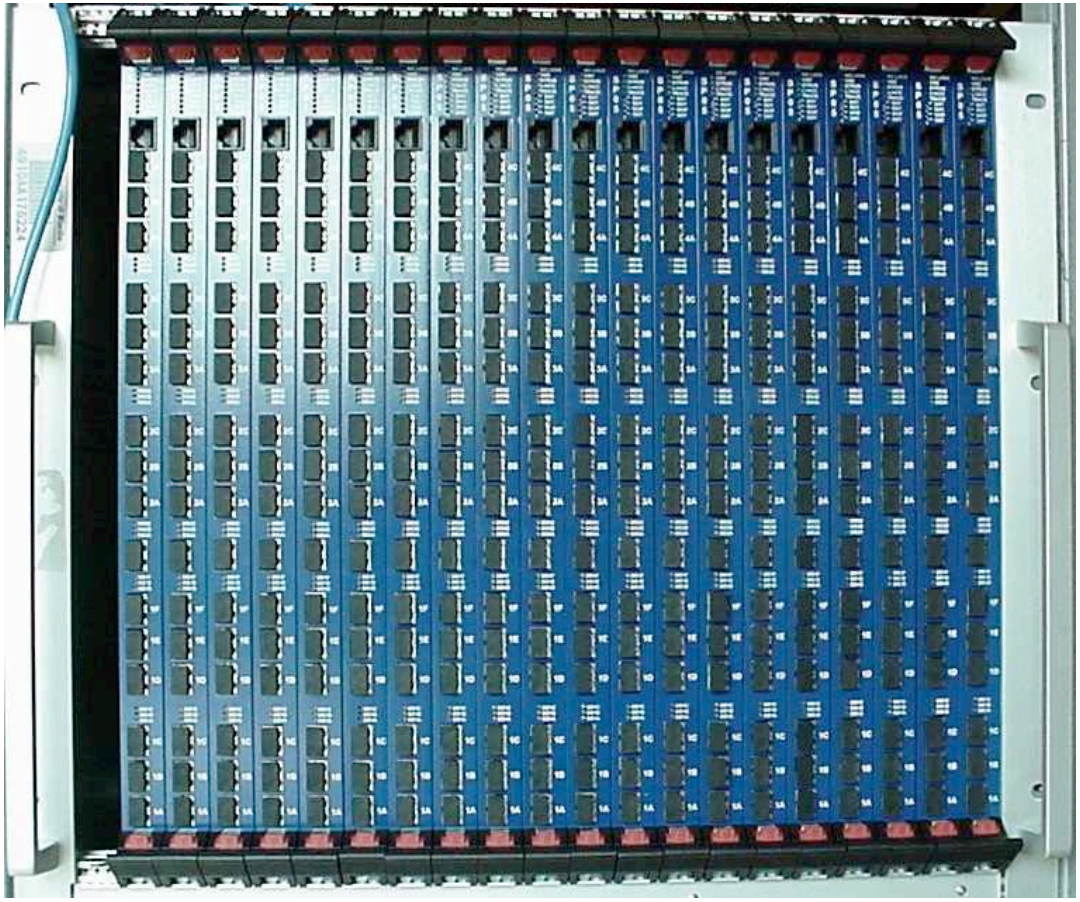
## Muon Port Card (Rice):

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




## Sector Processor (Florida):

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



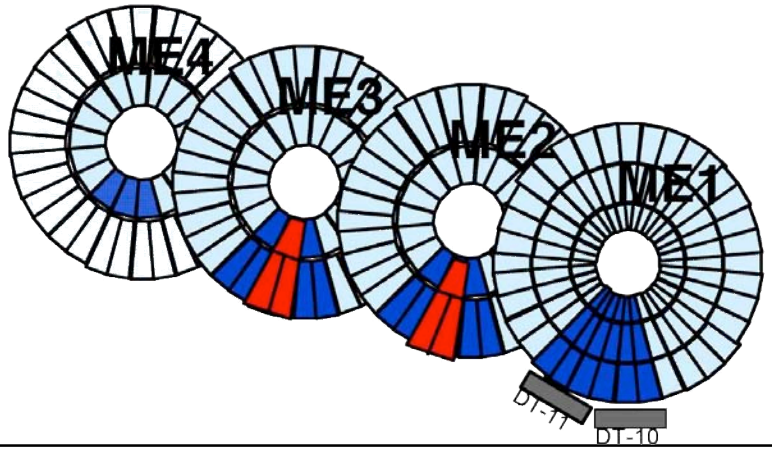
# CSC trigger operations:
## Preparing for Cosmic Challenge

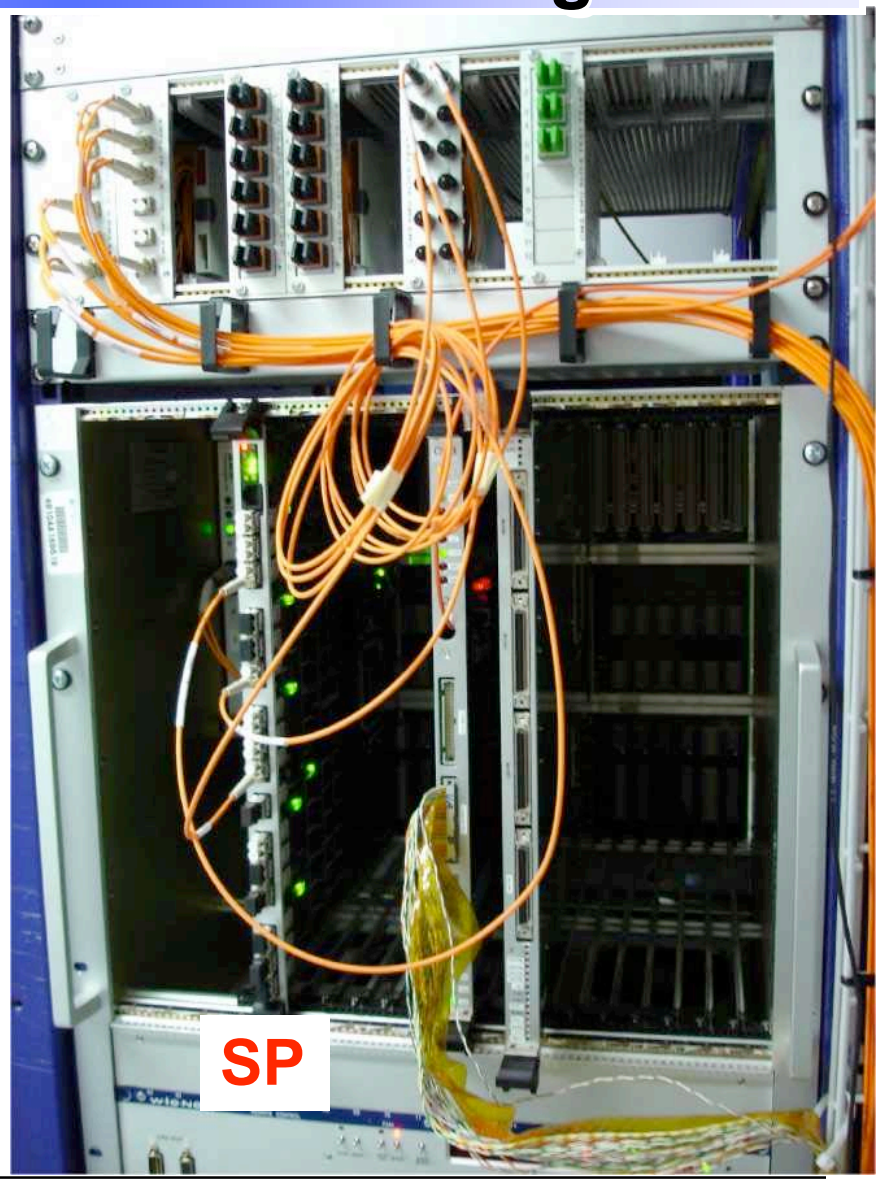
**Currently set-up in SX5 and operating continuously with CMS DAQ**

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

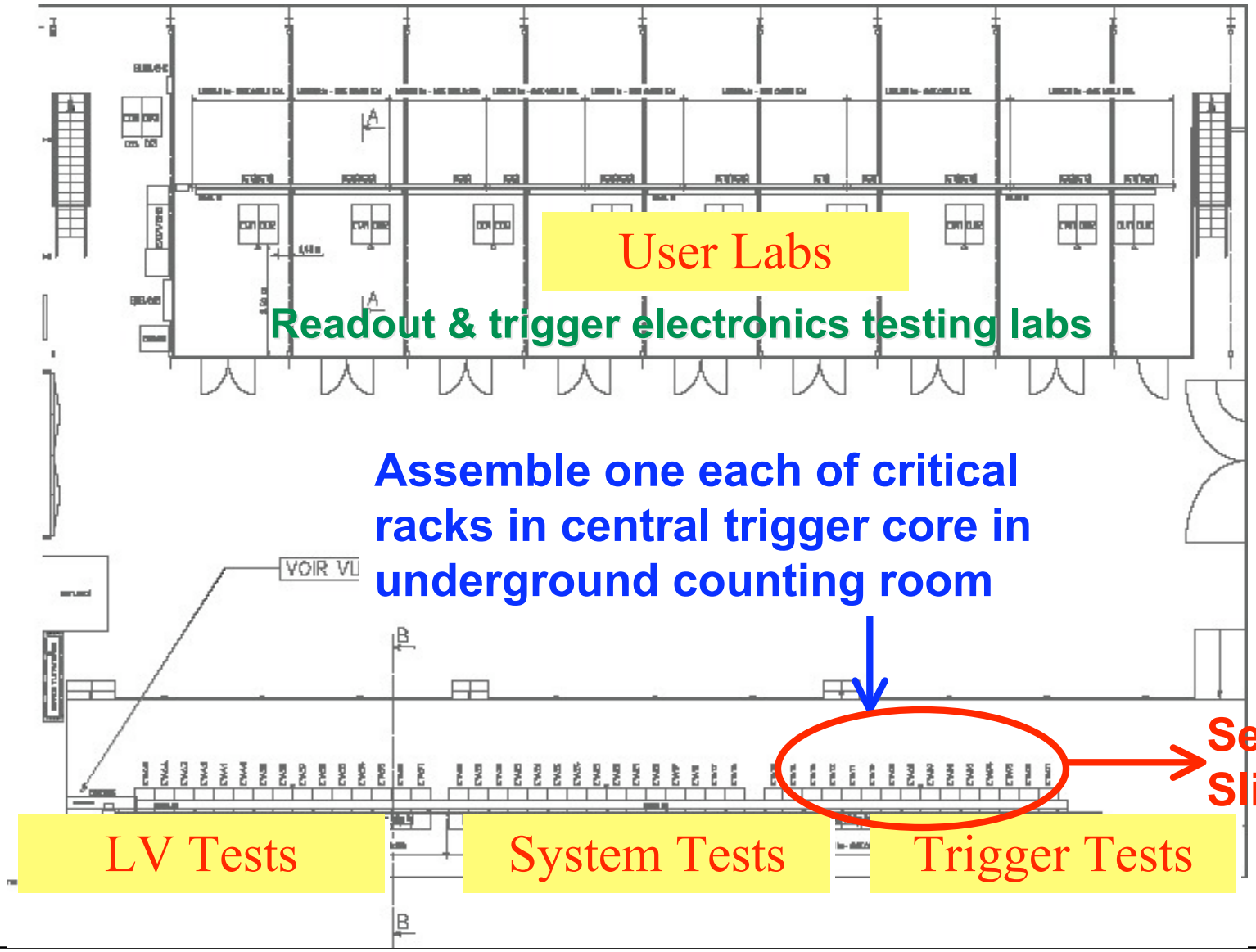
**CSC Track-Finder will provide cosmic muon trigger based on a coincidence of LCTs in two or more disks**

- Currently triggering @ 50Hz with 2-station coincidence
- CSC track finder has already provided triggers used to pass data from CSCs to global DAQ using Local Trigger Control and Fast Monitoring Modules.



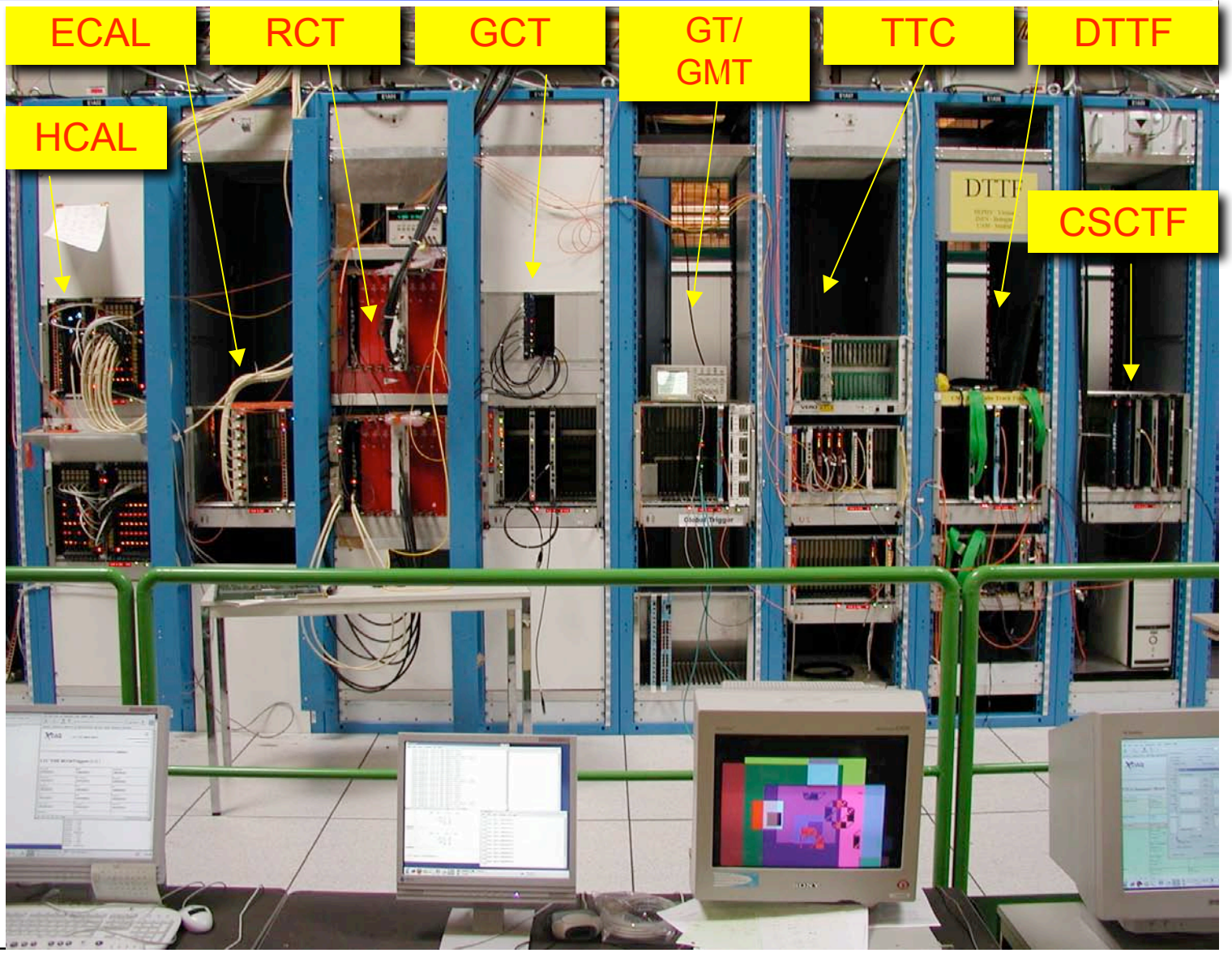
# Electronics Integration Center
## (Building 904)



# Central Integration Racks
## in Electronics Integration Center

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

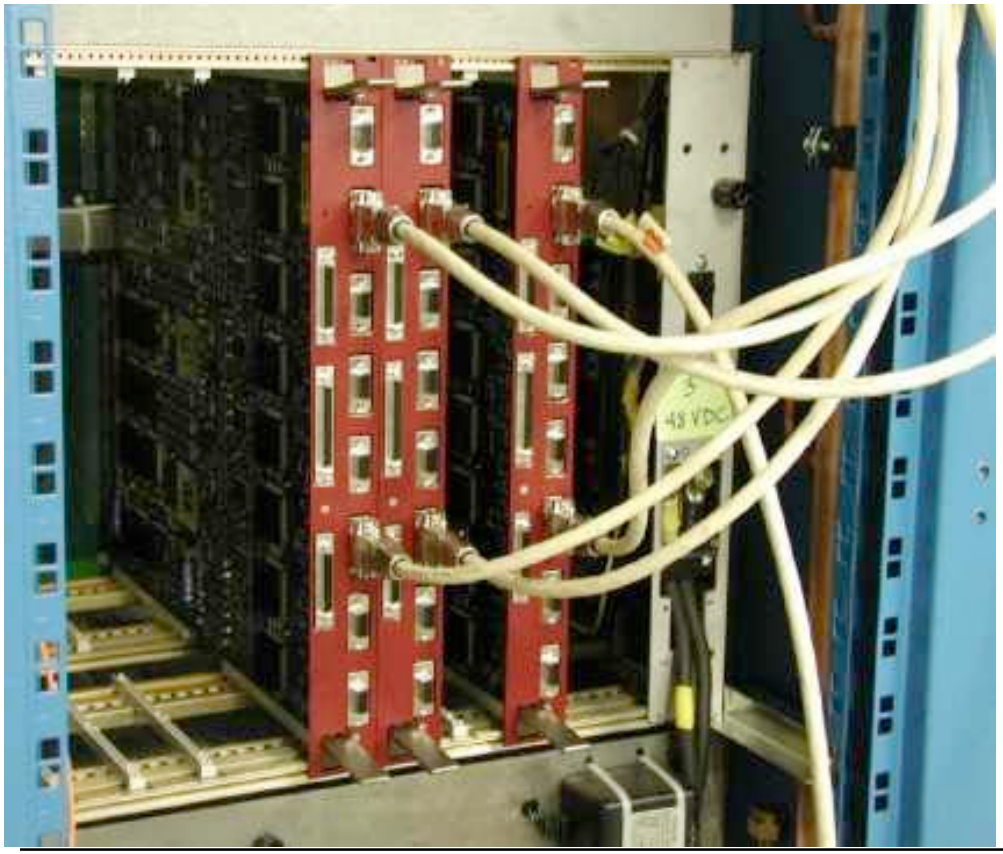
- **Example: Calorimeter trigger operating with CMS timing & control system**
  - **Successful integration tests with regional calorimeter trigger, global calorimeter trigger, HCAL and ECAL trigger primitive logic**

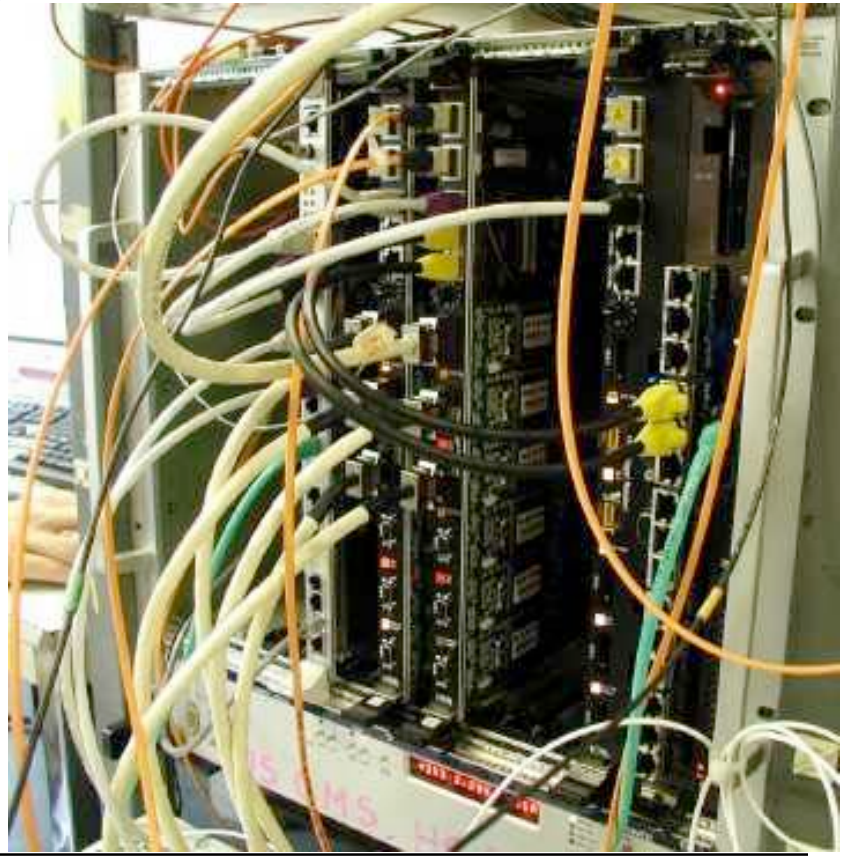


# HCAL-SLB-RCT Integration in EIC

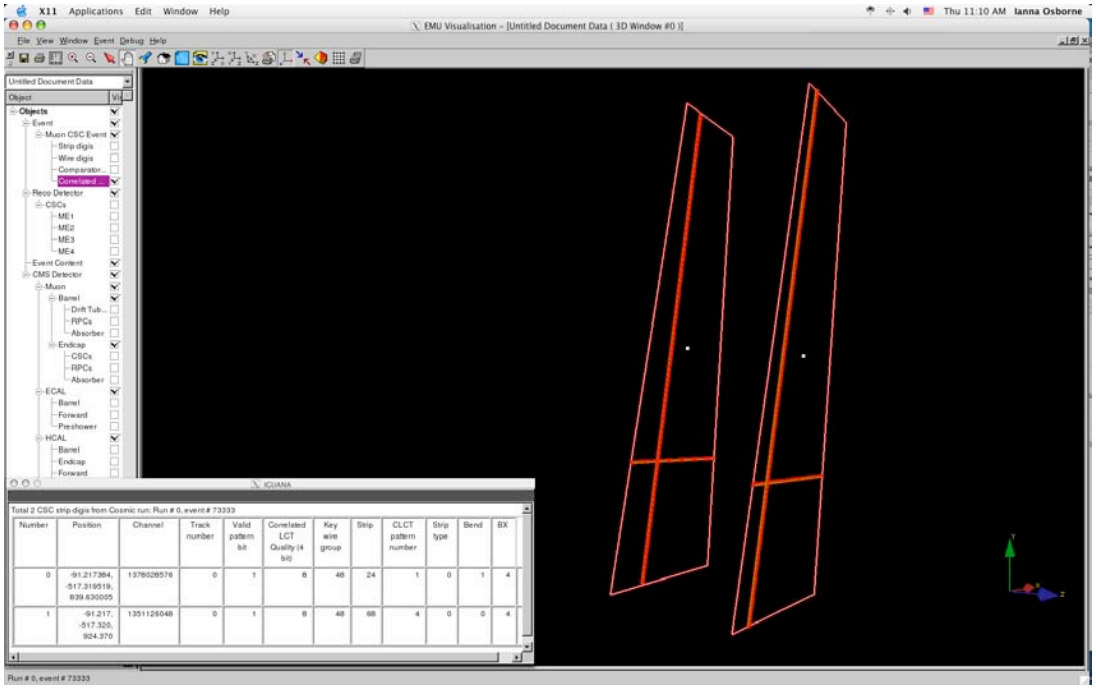
## - Maryland, Lisbon, Wisconsin

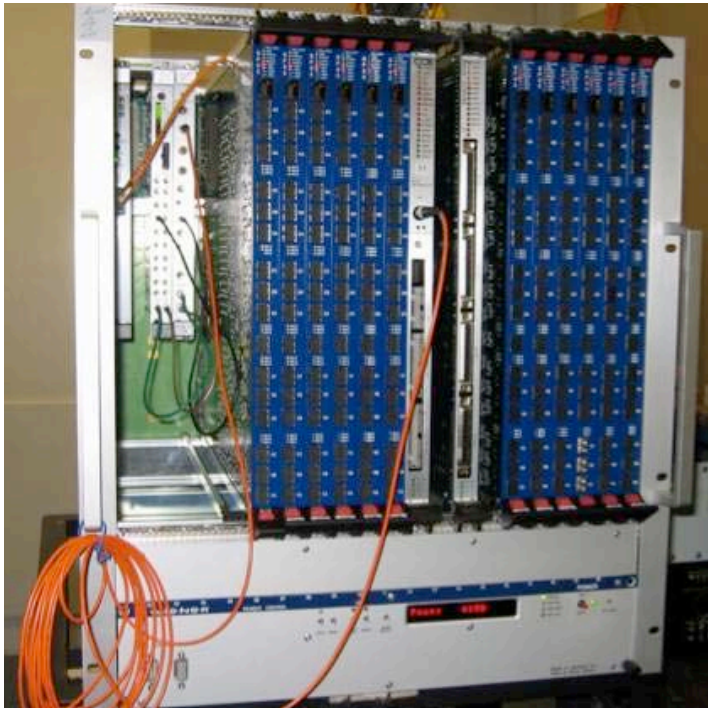
**Sent synchronous jet data from HCAL HTR's thru 6 SLB via 10m cu 4Gb/s Vitesse Links to 6 Regional Cal.Trigger Receiver Mezzanine cards, thru Receiver Cards, Backplane & Jet Summary Card to Jet Capture Card that records the output of 256 crossings. Observe output jets on all channels in expected crossings.**





# 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 June '05 self-triggering with as close to nominal CMS setup as possible
  - used to pass data CSCs to global DAQ.
  - Above: visualization of correlated LCTs recorded by the SP at the slice test, stored and read back using CMSSW

## EIC Integration

- Integration tests with Drift Tube Track Finder underway
- Have CSC TF crate running in EIC
  - Full Florida TF crate operating at Rice (above)

# Global Calorimeter Trigger

## New GCT project launched

- **Project schedule challenging but technical risks modest**
- **Modular design can be staged & installed in 3 steps**
  - Electron, Jet & Muon Trigger
- **Already tested the most critical part of the design**
  - Jet finder on leaf card demonstrated to work at full speed.
- **Have a team of excellent engineers with proven records**
- **Schedule and costs include adequate contingency.**
- **Good progress as of first review in March**
- **ESR in May**

## Fallback RCT direct to GT trigger scheme

- **Uses existing hardware, initially without any modifications**
  - Sent via RCT Jet Capture Card originally used for diagnostics
- **Can be ready in 2 months for integration purposes**
  - Trigger data from RCT to GCT already tested & works
- **Operational trigger available by end of 2006**

# Trigger Software

## Configuration data

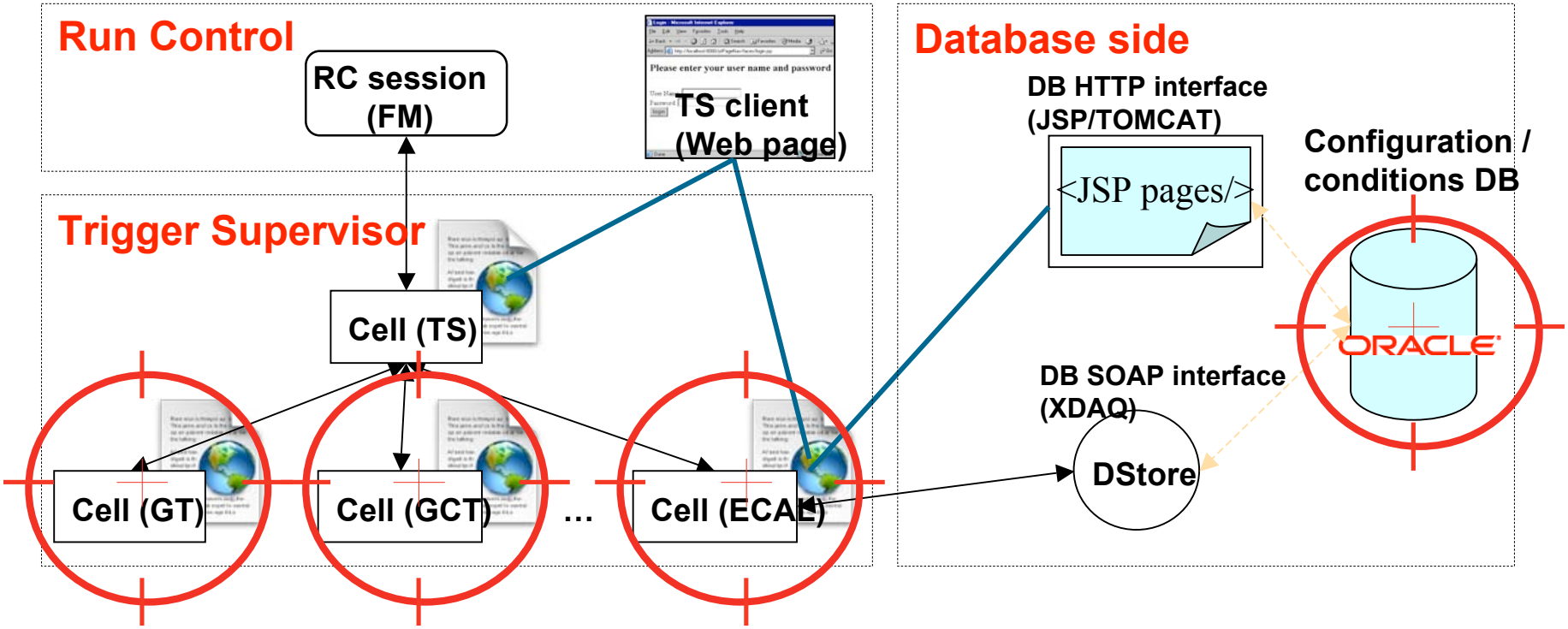
- Use CMS Configuration DB Infrastructure

## Trigger Supervisor (see below)

- Integrate with Run Control and trigger sub-systems

## Trigger testing and monitoring

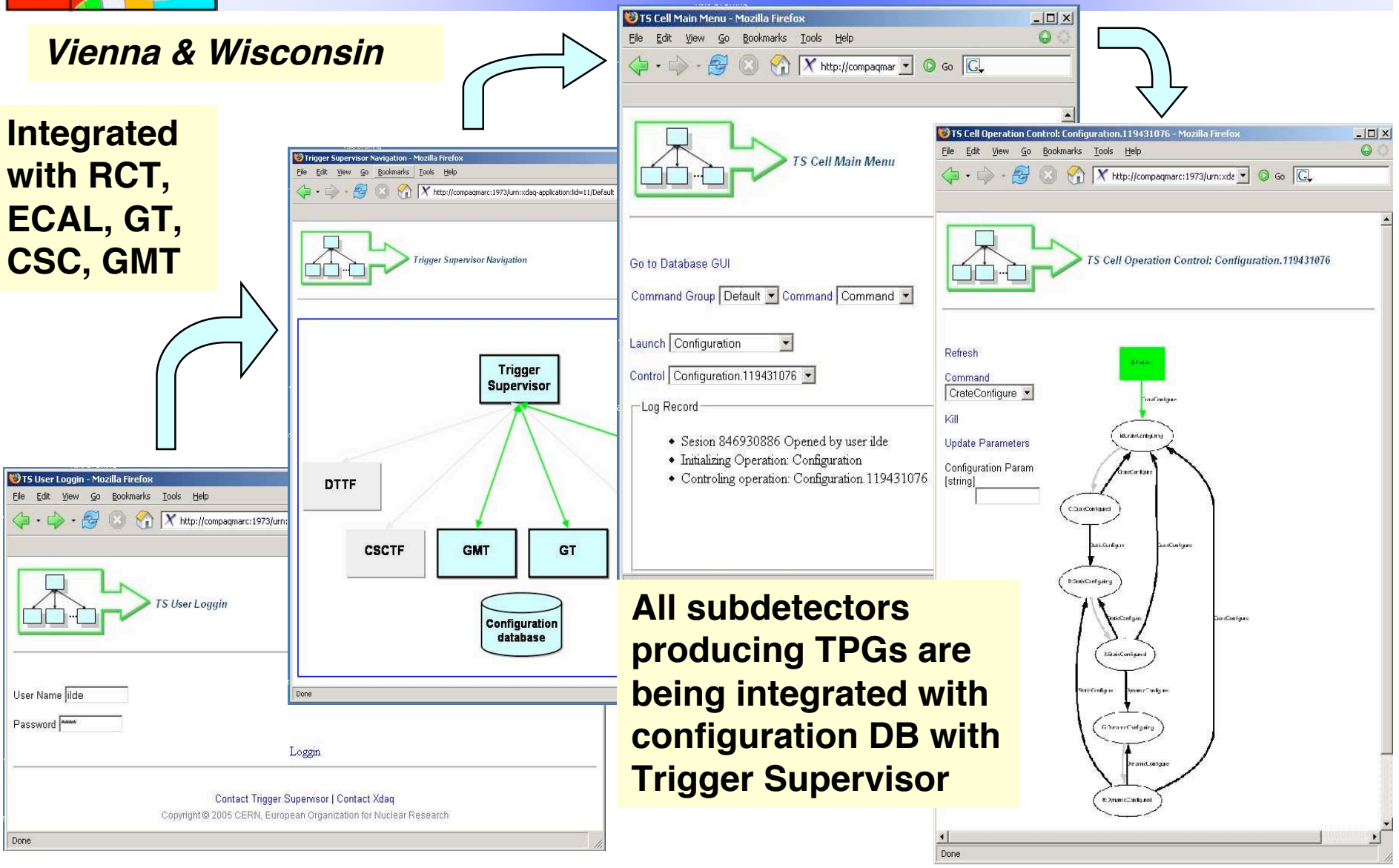
- Translate Integration Test Plans into Software ⇒ Bldg 904 setup
- Trigger Online Monitoring → Use DAQ Monitoring Infrastructure



# Trigger Supervisor GUI

***Vienna & Wisconsin***

**Integrated with RCT, ECAL, GT, CSC, GMT**




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

# Trigger Supervisor Demonstrator

*Philipp, HEPHY*

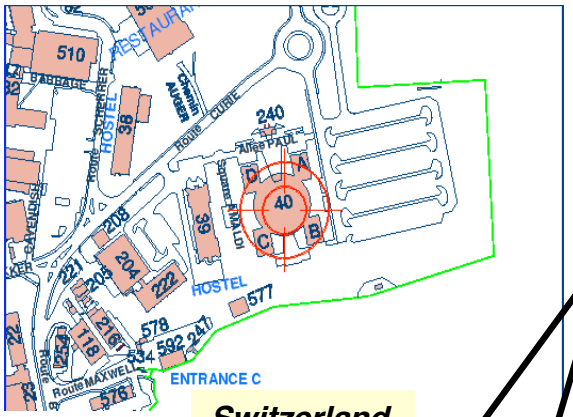
*Tobias, HEPHY*

*Monika, Wisconsin*

*Marc, Wisconsin*

*Ildefons, HEPHY*

*3 nations, one trigger supervisor!*

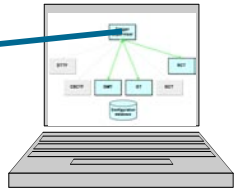


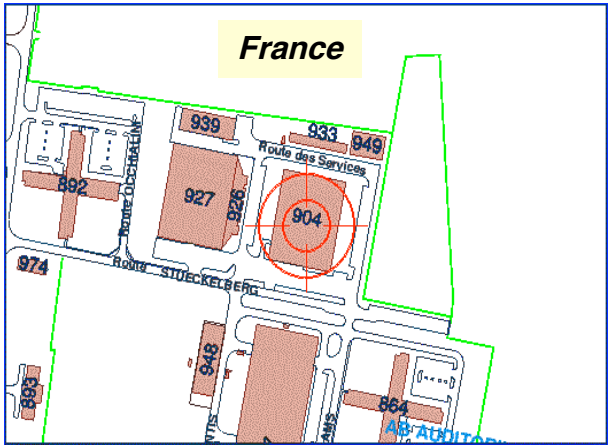

*Switzerland*

*gtswpc1.cern.ch:1972*

Central Cell

Web browser





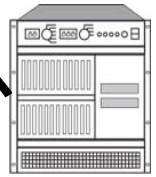

*France*

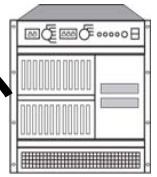
*Pcyestercm.cern.ch:1972*

*Pcwiscms.cern.ch:1972*

GT Cell

RCT Cell





*Austria*

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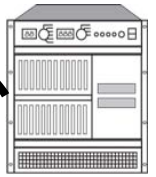
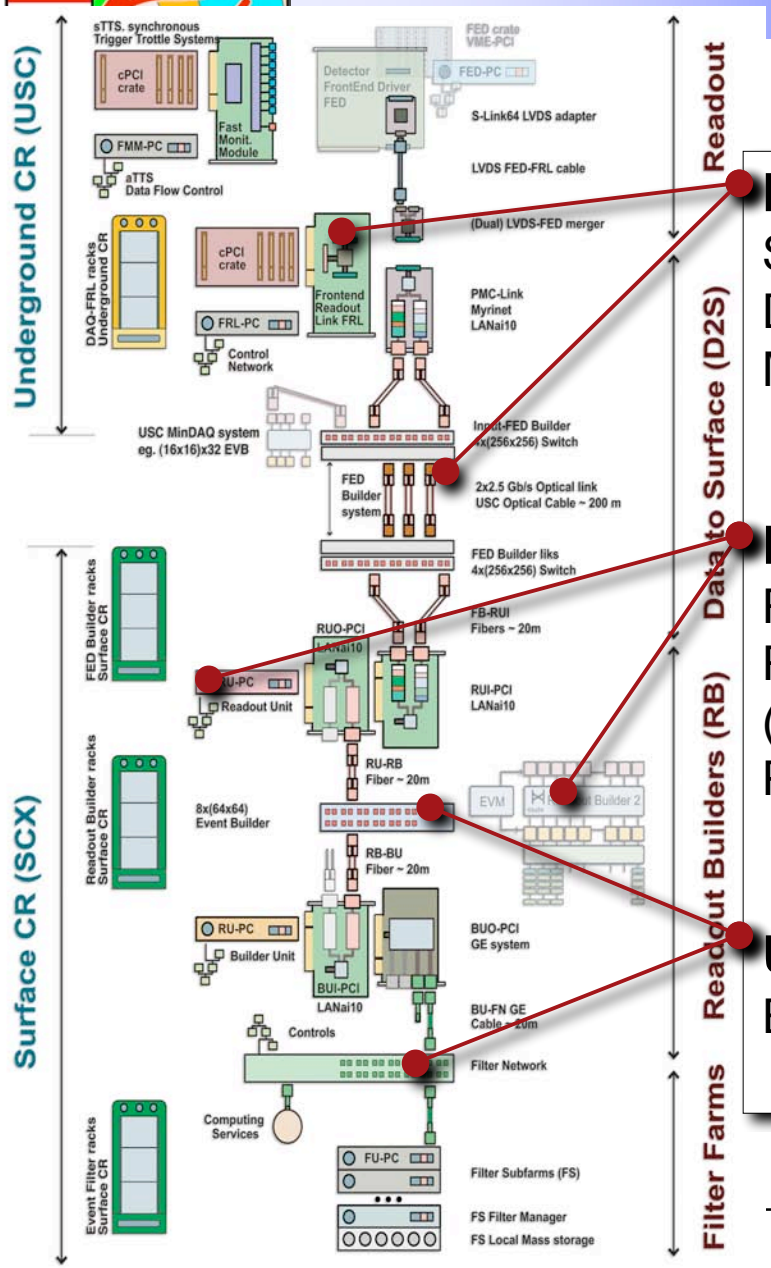
GMT Cell



# US groups in central DAQ




**MIT**

SLINK-FRL production test & commission

D2S installation & commission (people @ CERN)

Mini-DAQ: RUs, switch, BUs, FUs, mass storage

**FNAL**

Readout Builder applications

RCMS MTCC and sub-detectors integration (**UCLA**)

Page1 experiment status summary

**UCSD**

Event Builder GBE technology evaluation

# Central DAQ RU Builder

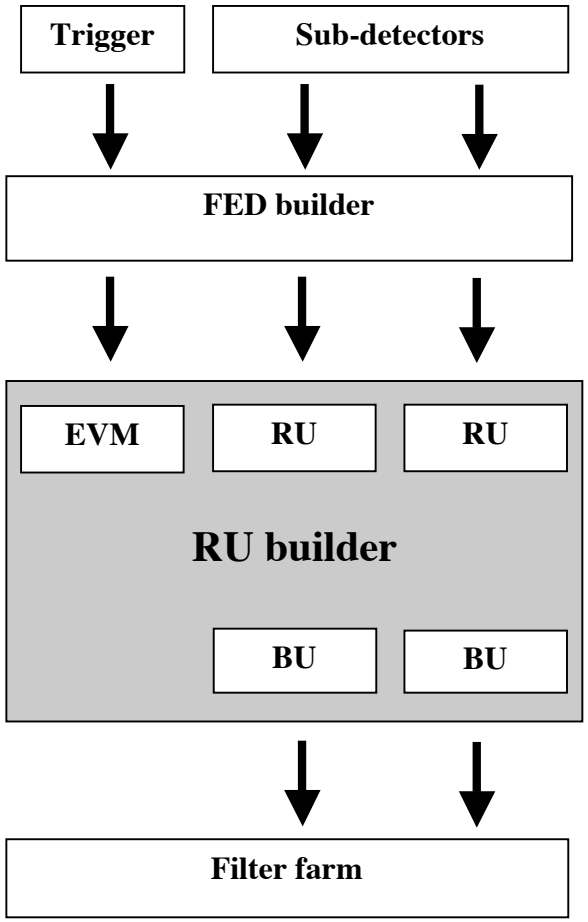
**Latest release**
Version 3.8

**Incorporated into XDAQ worksuite**
worksuite_G_28176 V1.5

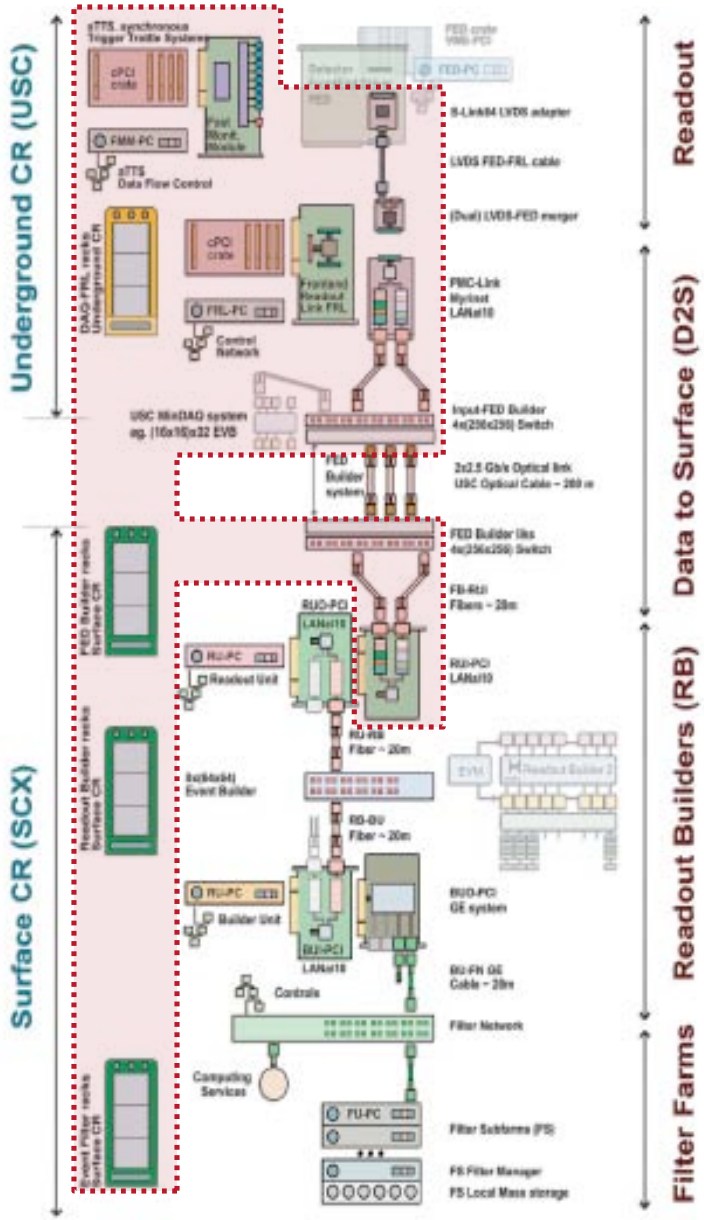
**Documentation**
http://xdaqwiki.cern.ch/index.php/Event_builder

**Project website**
http://smurray.home.cern.ch/smurray

**Contact person**
Steven Murray (Fermilab)
E-mail: Steven.Murray@cern.ch



# DAQ Progress




## USC:

- D2S FRL-FMM production&test **completed**
- D2S Myrinet (FB switches, FRL-interfaces) **delivered**
- 41 FRL/PCs racks installation well **advanced**
  - Start to learn S-link routing sometime next week
- 80 PCs (FRL, FMM, MTCC and miniDAQ) **delivered**
  - 50 PCs (FRL/FMM) installed in USC
- 211 PCs (VME controllers, DCS + spares) **delivered**
  - 24 VME PCs delivered to tracker, CSC and MTCC
- DAQ cable trays ready in USC
  - Slink routing (FED-FRL) **started**
- First optical cable (18 ribbons, 200m) arrived at CERN
  - All safety documents approved by TIS
  - Tested in DAQ preseries. **Final Order out**

## SCX:

- Myrinet (FB switches, RU-interfaces) **delivered**
- 106 PC racks **delivered** (stored at first floor of SCX5)
- 600 PCs first RUN DAQ. **Market survey out**
- GBE event builder switch. **Test Started**

# DAQ Integration: Pre-series

## Green Barrack

**Readout Builder PCs**

- 64 dual Xeon 2.6 GHz RU-BU PCs
- Myrinet +GbE interfaces
- 16 dual Xeon 2.6 GHz Filter nodes
- OS Linux 2.4

## Current activities

DAQ integration and MTCC

Online services preseries

Detector readout integration

First Run EVB technology

**GbE with a FORCE10 E1200 switch**


# Trigger Install/Commission

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

- **Muon Barrel Trigger:**
  - YB+2 sectors 10, 11 & YB+1 sector 10 for DT's & RPCs
  - DT's use Sector Collector, Phi Track-Finder, Barrel/Wedge Sorters
  - RPCs use RPC Barrel Collector connected to Link Boards
- **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 May 2006**
- **All trigger systems first tested in Prevessin 904**
  - Nothing is installed in a rack for the first time in USC55

# Trigger Commissioning in 2006:
## Task List

## 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
- **US CMS Concern: Sustaining the team needed for these tasks**

## Physicists:

- **Diagnostics, emulators, simulation code, interfaces and integration with other CMS systems.**
- **US CMS Concern: Sufficient postdoctoral support to enable those working on these tasks to also be able to do physics**

# Trigger Install Schedule - I

## Install/Commission Crates: May '06 - Sep '06

- Tested Trigger Crates installed in USC55, re-tested, interconnected, inter-synchronized
- Regional and Global Detector trigger systems integrated with each other and Global Trigger

## Integrate w/Detector Elect.: June '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

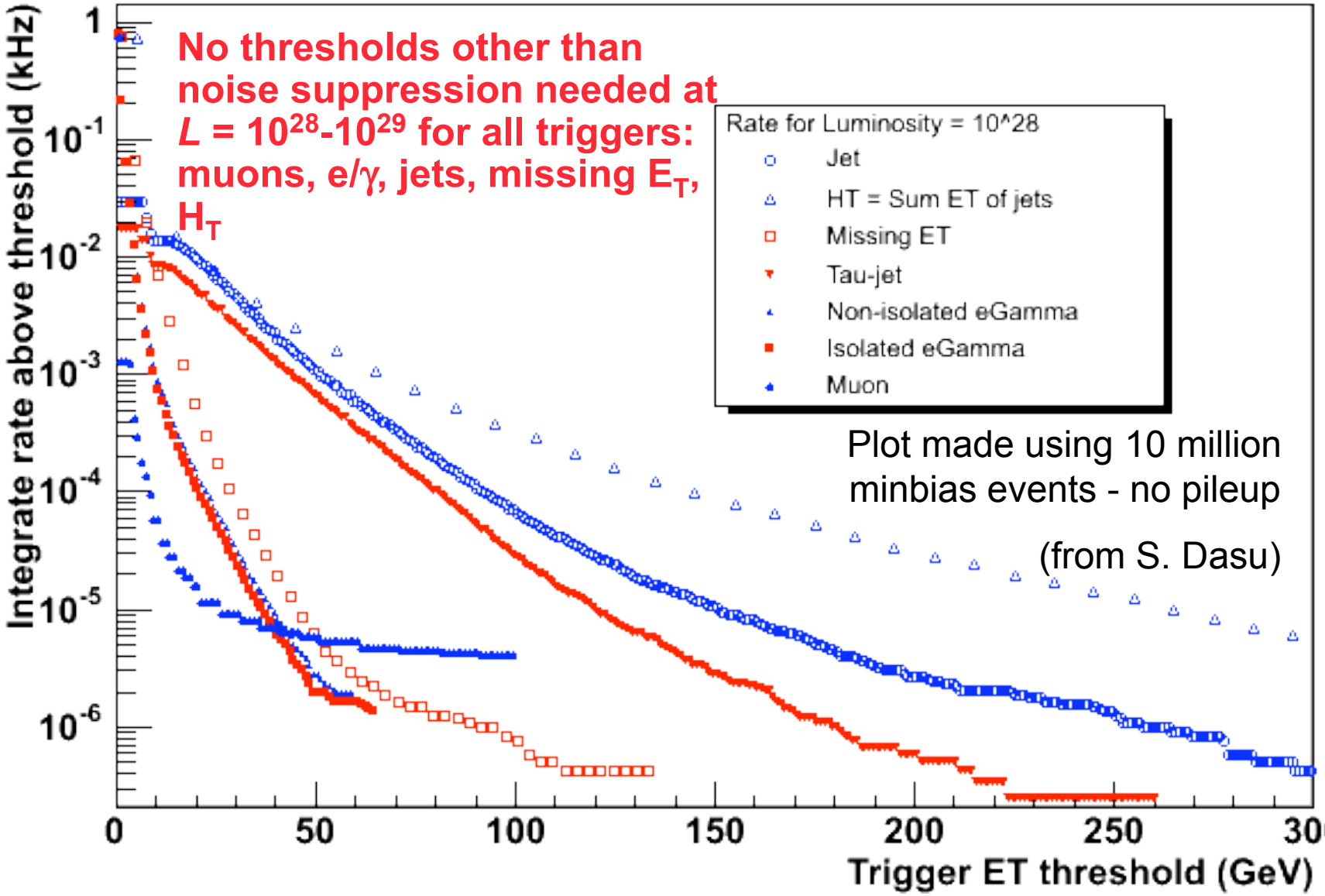
- Subset of triggers available to detectors in UXC55
- Dedicated testing with individual detectors
- Detailed synchronization testing of all systems
- Testing with Central DAQ

## 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

# Simulated L1 rates at $10^{28}$
## Collaboration with Online Selection PRS



# Initial Trigger Menu

## Turn On: Level-1 Trigger Totally Open @ 12.5 kHz

- Calorimeter low $\Sigma E_T$ or any muon (no $P_T$ cut)
- Other candidate triggers for later running are active for diagnostic and study purposes (efficiency)

## Test Triggers

- Dedicated runs and possible operation during abort gaps to verify detector function & synchronization.

## Start Luminosity ($10^{28\text{-}29}$): First Trigger @ 12.5 kHz

- Calorimeter low $E_T$ Electron ($\geq$ 5 GeV) or Jet ($\geq$ 10 GeV)
- Any muon (effectively $\geq$ 3 GeV $P_T$ cut)
- Other candidate triggers for later running are active for diagnostic and study purposes (efficiency)

## Need HLT from beginning

- Reduce Level-1 12.5 kHz output rate to 100 Hz to tape
- Diagnostic for Level-1 Trigger
- All L1 trigger algorithms first tested/validated in HLT

# Evolution of Initial Trigger Menu

## Simultaneous strategies as luminosity & rates rise:

- **Keep thresholds low by adding conditions**
  - Electrons: add isolation at lower thresholds
    - **Longitudinal: H/E**
    - **Transverse: HCAL Isolation, ECAL Isolation (Fine-Grain bit)**
  - Jets: add $\tau$-bits to preserve thresholds for $\tau$'s.
  - Muons: add quality conditions at lower thresholds
    - **more hits on muon tracks of individual muon trigger systems**
    - **Require coincidence between RPC and either DT or CSC**
  - Muons: add isolation at lower thresholds
    - **Calorimeter quiet region associated with muon**
- **Raise thresholds for "unrestricted" triggers**
  - Above lowest possible thresholds do not impose conditions
    - **Calorimeter: no isolation above higher threshold or $\tau$-bits**
    - **Muon: remove coincidence & isolation, relax hit requirement**
- **Depends on HLT requirements (thresholds, conditions)**
  - Triggers first validated in HLT, then migrated to L1

# Trigger Monitoring

## Pipeline alignment

- Check bunch crossing 0 alignment for changes (pipeline jumps)
- Check pattern in occupancy histograms

## Trigger Function

- Test processing of online data through trigger emulation vs. trigger output on a dedicated stream of level-1 pass-through events. Flag discrepancies.
- Process L1 accepted events through HLT & compare with result of comparison with DAQ data.
- Use overlapping triggers to produce online trigger efficiency turn on curves and compare to previous runs and “ideal” templates using automatic statistical tests
- Repeat above offline (where possible)

# SLHC Upgrade Planning

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

- 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
- Set up by CMS Management Board & approved by Collaboration Board

## April Workshop just held

- April 3/4 2006 Perugia

## Next Meetings During Electronics & CMS Weeks

# SLHC TriDAS 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**
- **Use L1 calorimeter & muon trigger data as seeds for trigger tracks**
- **Transmit L1 physics objects made from tracking, calorimeter & muon regional trigger data to global trigger**
  - Cal/Mu: ID (needs good acceptance, *e.g.* ME4/2), Track: $P_T$
- **Implication: perform some of tracking, isolation & other regional trigger functions in combinations between regional L1 triggers**
  - New "Regional" cross-detector trigger crates
- **Leave present L1+ HLT structure intact (except latency)**
  - No added levels --minimize impact on CMS readout
- **DAQ: Merge Global L1 & Event Manager to perform event building with new enhanced TTC system**
  - Readout directly into filter farm nodes using addresses communicated along with level-1 accept signal to front end readout

# USCMS TriDAS 2006 Summary

## Good Progress on all fronts:

- CAL & EMU Triggers finished production
- DAQ installation started
- 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 next month

## Upgrade R&D:

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