Task T – CMS at LHC

Wesley H. Smith

DOE Site Visit, Madison, WI, August 26, 2010

Subtasks:

- Trigger: Regional Calorimeter Trigger, Higher Level Triggers, Trigger Coordination (W.S.)
- Computing: CMS Tier-2, US CMS Production Management (Talk by Dasu w/Physics)
- Endcap Muon: Project Management, Chambers & Infrastructure, Alignment (Loveless)

Task T Personnel

- ***Professors:*** **Duncan Carlsmith, Sridhara Dasu, Matt Herndon, Wesley Smith**
- ***Distinguished Scientist:*** **Richard Loveless**
- ***Electronics Engineer:*** **Tom Gorski** (CMS project)
- ***Associate Scientists:*** **Pam Klabbers, Armando Lanaro, Sascha Savin**
  Jim Bellinger (50%, 25% CMS Project, 25%Task E - CDF)
- ***Assistant Scientist:*** **Monika Grothe**
- ***Postdoc:*** **Jonathan Efron**
- ***Software Engineers:*** **Dan Bradley, Ajit Mohapatra, Will Maier** (CMS project)
- ***System Manager:*** **Steve Rader, Matt Radtke** (50 %, 50% UW)
  -- Support all HEP Computing
- ***Grad. Students:*** **Mike Anderson** (NSF-computing)**, Michail Bachtis, Lindsey Gray, Kira Grogg, Christos Lazaridis, Jeff Klukas, Jessica Leonard, Will Parker, Ian Ross, Joshua Swanson, Marc Weinberg**
- ***Grad. Summer Students:*** **Austin Belknap, Isobel Ojalvo, Bethany Reilly**
- ***Technician:*** **Robert Fobes** (CMS project)
- ***PSL* Engineers:*** **F. Feyzi, P. Robl, D. Wahl, D. Wenman, A. White** (CMS project)
- ***PSL* Draft/Tech:*** **B. Dana, G. Gregerson, D. Grim, J. Johnson, A. Riley, T. Sailor, R. Smith** (CMS project)

(*UW Physical Sciences Lab: world-class electronic & mechanical engineering & construction)

ACTIVE GROUP: over 600 Talks in CMS Meetings between Jan. '08 – May '10

Wisconsin Senior Personnel Official CMS Responsibilities

Prof. Wesley Smith

- CMS Trigger Coordinator (07-), CMS Trigger Project Manager (94-07) , CMS Executive Board
- CMS Management Board, CMS Electronics Systems Steering Committee
- SLHC Upgrade Management Board, SLHC Peer Review Board Chair
- US CMS Trigger Level 2 Manager, Project Management Group
- US CMS Institutional Advisory Board Member, Technical Advisory Board Member

Prof. Sridhara Dasu

- CMS Electroweak Physics Co-Convener (07-09), Upgrade Physics Coordinator (10-)
- Online Selection Physics Co-Convener (06-07), Computing Tier-2 Manager (Wisconsin)
- SLHC Upgrade Management Board, US LHC Users Organization Secretary
- US CMS Calorimeter Trigger Level 3 Manager, Institutional Advisory Board Member

Prof. Duncan Carlsmith

- US CMS Endcap Muon Alignment Task Manager, Elections Committee Co-chair (07-09)

Distinguished Scientist Richard Loveless

- CMS Endcap Muon Technical Coordinator (09-), CMS EMU Project Manager (07-09),
- CMS Muon Upgrade Co-Convener (TBC), US CMS EMU Deputy Operations Project Manager
- US CMS Common Projects Manager (98-07), US CMS EMU Project Manager (02-07)

Associate Scientist Pam Klabbers

- CMS Calorimeter Trigger Technical Coordinator, Regional Calorimeter Trigger On-site Operations Manager

Associate Scientist Armando Lanaro

- CMS Deputy Convener, EMU Detector Performance Group, EMU Upgrade Chamber Construction Mgr. (TBC)
- CMS EMU Safety Officer, US CMS Level 3 EMU On-site Operations Manager

Associate Scientist Sascha Savin

- CMS Trigger Performance Group Co-convener

Assistant Scientist Monika Grothe

- CMS Conference Comm. (10-), CMS Forward Physics Convener (07-08), Electroweak Physics Data Validation

Wisconsin CMS Contributions

Endcap Disks (EMU)

- 6 disks ~3500 tons
- UW Design & Contract

Chamber Installation

- 400 EMU Chambers & infrastructure
- Gas, Power, Cooling & Signal Cables

Calorimeter Trigger

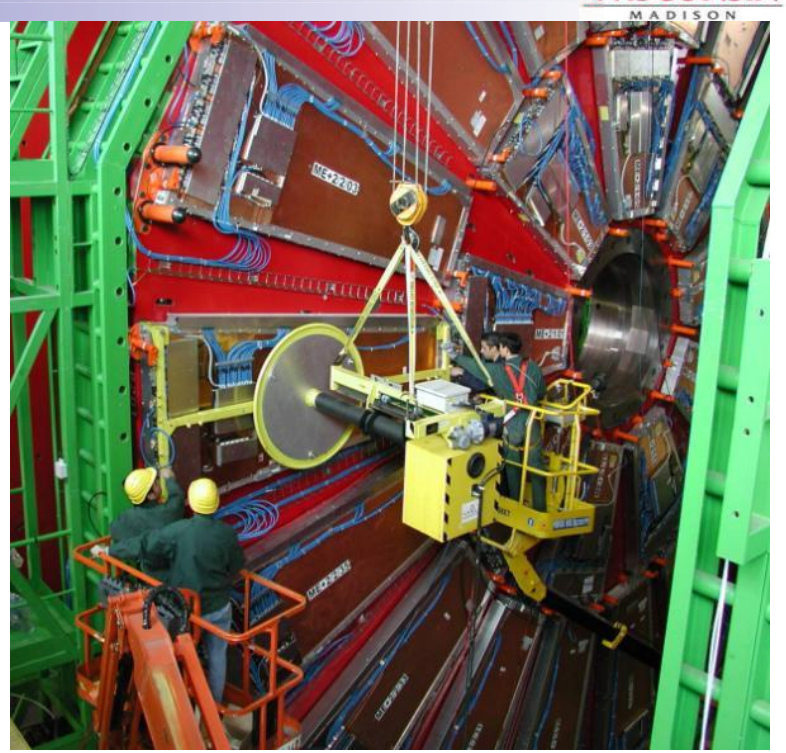
- 19 Crates, 2000 boards
- Custom ASICs
- Sorts objects w/coords

Tier-2 Computing Center

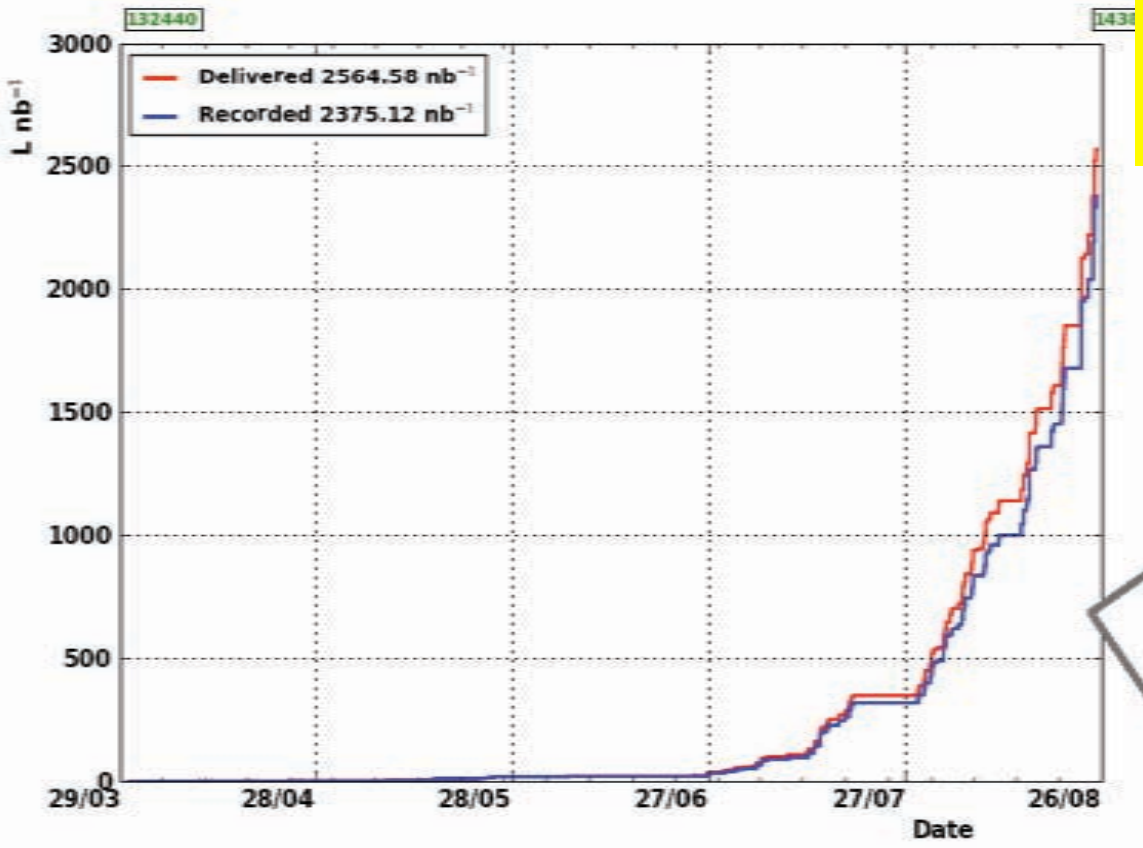
- Large UW Investment
- Leverages GLOW -- Grid Laboratory of Wisconsin

CMS Software

- Collaboration with UW Condor group to develop CMS Grid Tools



CMS & LHC Performance



Tuesday night (Aug. 24): 352 nb^{-1} delivered in one fill – more than our ICHEP data sample!

Since end of March (7 TeV):
2565 nb^{-1} delivered (*)
2375 nb^{-1} recorded
Data taking efficiency (~93%)

Reached L=10^{31} on Aug. 24. Expect 10^{32} by end 2010 Run. Expect 1 fb^{-1} by end of 2011.

Task T: CMS Physics

Leadership and Responsibility for Early Physics with LHC

- Supervision of a large group of postdocs & students across CMS (many institutes)

Physics Trigger Studies (CMS Trigger Coordinator: Prof. Smith)

- Thresholds at L1T and object ID refinement at HLT determines physics reach
- e/γ trigger validation and DQM (Leonard+Lazaridis+Anderson/Grothe+Klabbers)
- τ trigger algorithm improvements and DQM (Bachtis+Swanson/Savin+Dasu)
- μ trigger: HLT development, validation, and DQM (Klukas/Herndon)
- Calorimeter Trigger Calibration (Efron)

Electroweak Physics Analyses (CMS Electroweak Co-convener: Prof. Dasu)

- W and Z reconstruction, especially with jet activity, key for new physics search
- Drell-Yan e^+-e^- Production on & off Z peak (Leonard/Klabbers+Grothe)
- γ+Jets Measurement (Anderson/Dasu)
- W($\rightarrow e\nu$)+Jets Measurement (Grogg/Efron)
- Z($\rightarrow e^+e^-$)+Jets Measurement (Lazaridis/Grothe+Klabbers)
- Z($\rightarrow\tau\tau \rightarrow \mu^+\tau_h$-jet) Measurement (Bachtis/Savin)
- Z($\rightarrow\tau\tau \rightarrow e^+\tau_h$-jet) Measurement (Swanson/Savin)
- SM Zγ Production and Search for Anomalous Couplings (Gray/Lanaro+Dasu)
- SM Top Production and Search for SUSY in dilepton channel (Weinberg/Savin)
- SM WZ Production and Search for W'$\rightarrow$WZ, Technicolor (Klukas/Herndon)
- SM ZZ Production and Upgrade Simulations (Ross/Grothe+Klabbers)

Forward Physics Analyses (CMS Forward Physics Convener: Dr. Grothe)

- Completed Exclusive di-lepton (pp $\rightarrow$ppl^+l^-)production (luminosity measurement) & Exclusive W production (collaboration with Electroweak)

Task T: Trigger I

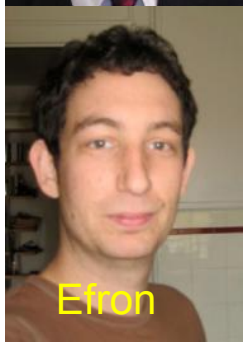
Leadership & Responsibility for Trigger Operations & Upgrades

- **CMS Trigger Coordinator & US CMS Trigger L2 Manager (Smith)**

CMS L1 Regional Calorimeter Trigger

- **US CMS L3 Manager for Calorimeter Trigger (Dasu)**
- **Operations, Hardware, On-Site Management (Klabbers)**
  - UW Hardware diagnostics & repair (Gorski, Fobes -- CMS Project)
  - CERN Maintenance & testing facilities (Klabbers, Grothe, Savin)
- **Online Diagnostics (Klabbers)**
  - Downloading detailed test patterns (Efron, GS: Grogg, Ross, Ojalvo)
  - Trigger Emulator (Dasu, GS: Bachtis, Swanson)
- **Online Configuration & Control (Klabbers & Grothe)**
  - Trigger Supervisor (Grothe, GS: Lazaridis, Ross)
  - Memory Lookup Tables (Dasu,GS: Bachtis, Swanson)
  - Configuration & Conditions Data Bases (Efron, GS: Swanson)
- **Detector Controls System (Grothe)**
  - Monitor temperatures & voltages (Grothe, GS: Grogg, Ross)
- **Data Quality Management (Savin)**
  - Online Histograms & Alarms (Savin, GS: Weinberg, Parker)
  - Offline Histograms & Run Certification (Savin, GS: Weinberg, Parker)

UW Trigger Scientists/Postdoc



Task T: Trigger II

CMS Higher Level Triggers, Trigger Coordination

- **CMS Trigger Coordinator (Smith)**
- **CMS Trigger Performance Co-convener (A. Savin)**
- **UW Trigger Developers/DQM:**
  - Muon: Herndon, Klukas,
  - e/γ: Dasu, Anderson,
  - τ: Dasu, Bachtis

SLHC Trigger Upgrade

- **Trigger Upgrade Chapter Editor (W. Smith)**
- **New Algorithm Design & Simulation**
  - Dasu, Grothe, Bachtis, Ross
- **Hardware design & prototyping**
  - Smith, Klabbers, Gorski, Fobes




UW CMS Trigger Students (RCT unless otherwise): T-B➔: Anderson (γ HLT), Grogg, Klukas (μ HLT), Weinberg ←L-R: Ross, Swanson, Leonard, Lazaridis, Bachtis (RCT & τ HLT)





Task T: Endcap Muon - I

Operations – during running

- EMU Technical Coordinator & US CMS Deputy Manager (Loveless)
- EMU Detector Performance Group Deputy Coordinator (Lanaro)
- EMU Detector Performance (Lanaro, Gray)
- EMU Field Technical Coordinator & Safety Officer (Lanaro)
- Keep infrastructure (cooling, gas, LV, HV, etc.) running (Lanaro, Loveless)
- Fix detector mechanicals (leaks, cables, etc.) (Lanaro, Loveless, PSL team)
- EMU Field Technical Coordinator, EMU Safety Manager (Lanaro)

Maintenance -- during shutdowns

- Fix detector mechanicals (includes removing chambers for board replacements) (Lanaro, Loveless, PSL team)

CMS Endcap Alignment

- Management of EMU alignment task force (Carlsmith)
- Analysis of alignment data (Bellinger)

Task T: Endcap Muon - II

EMU Simulation

- J. Bellinger

Upgrade -- build 72 ME4/2 chambers

- Editor CMS Muon Upgrade Proposal (Loveless)
- Proposed Upgrade Chamber Factory Manager (Lanaro)
- Preliminary plan for ME4/2 chamber production
  - Project engineer at PSL (F. Feyzi - PSL)
  - Parts procurement, QC, shipping (from US) (Feyzi, Loveless)
  - Management of Assembly at CERN (Lanaro)

UW CMS Muon Team:

Task T: Computing

Task-T operates general purpose HEP and CMS specific computing

- **Dasu provides scientific leadership for the team**
- **Rader and Radtke supported at 50% each for HEP computing**
- **Summer Students and RA based in Madison keep Tier-2 validated for physics**

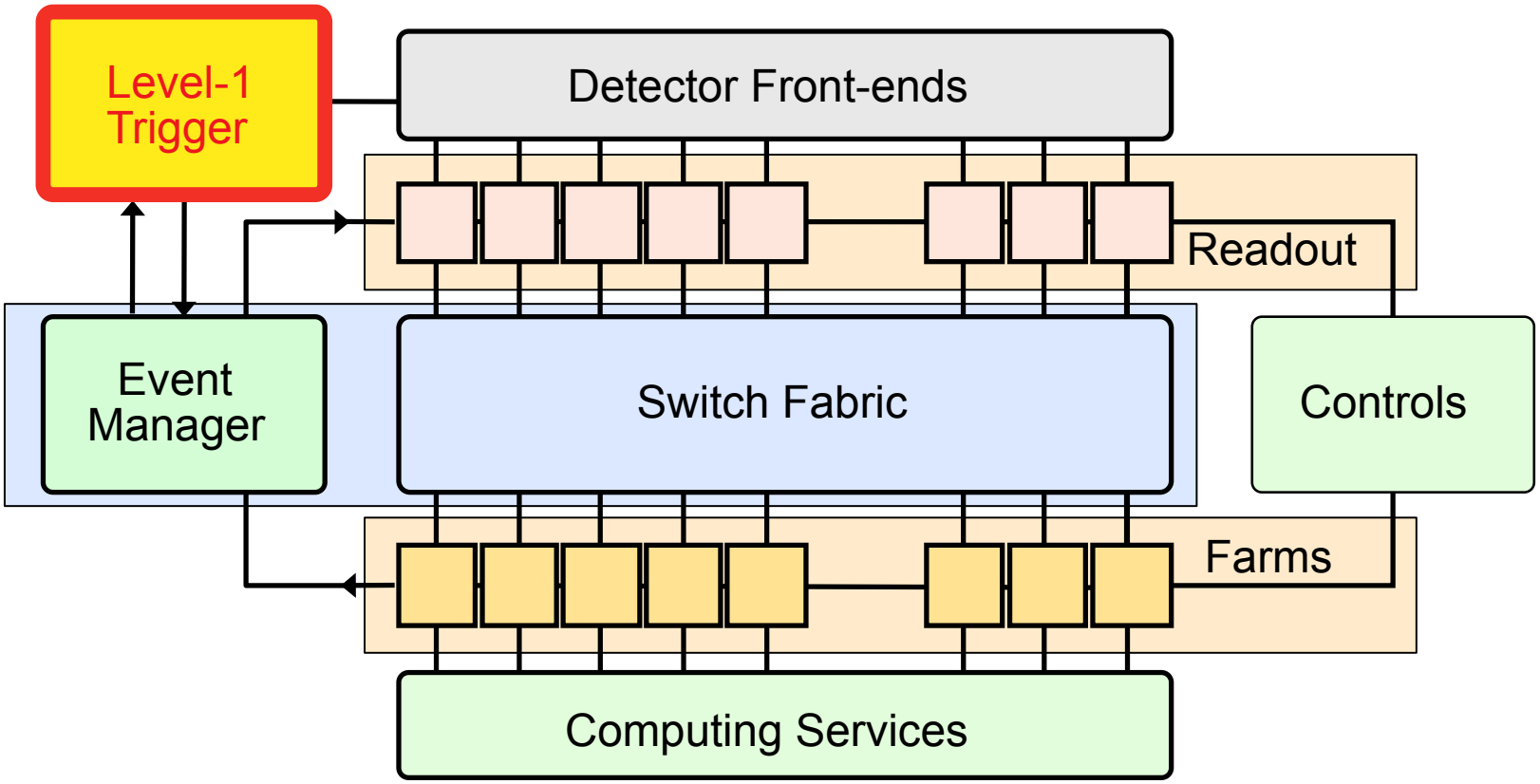
HEP Computing (Director of Computing: Rader, Desktop & Login Support: Radtke)

- **Serve > 250 users (150 remote/guest users)**
- **Mail, AFS storage, desktop, network, backup, printing services**
- **24/7 coverage for core services**

CMS Tier-2, Grid Laboratory Of Wisconsin, Open Science Grid (Manager: Dasu)

- **Most productive Tier-2 center in all CMS (System Manager: Maier, NSF)**
  - 3000 MSI2k, 500 TB useable storage, Over 20 M CPU hours served since 2005
  - Seamless integration with GLOW and OSG
- **Responsible for all CMS simulation production (Manager: Mohapatra, NSF)**
  - Responsible for world-wide CMS production
  - More than half the production done on OSG through 2010 (Mohapatra, Anderson)
- **Innovative software development (Lead: Bradley, Support: Anderson, NSF)**
  - New tools for analysis (Rapid-response Adaptive Computing Environment)
  - Smooth scaling of Condor farms to very large sizes, helping all grid facilities
  - Works within Condor team addressing concerns of FNAL (Tier-1) and Tier-2 sites
- **CMS Analysis Support (Summer Students, Reilly from Fall 2011 -- Task T Activity)**
  - Wisconsin is primary Tier-2 for Electroweak, Forward Physics and Trigger Studies

CMS Trigger & DAQ Systems

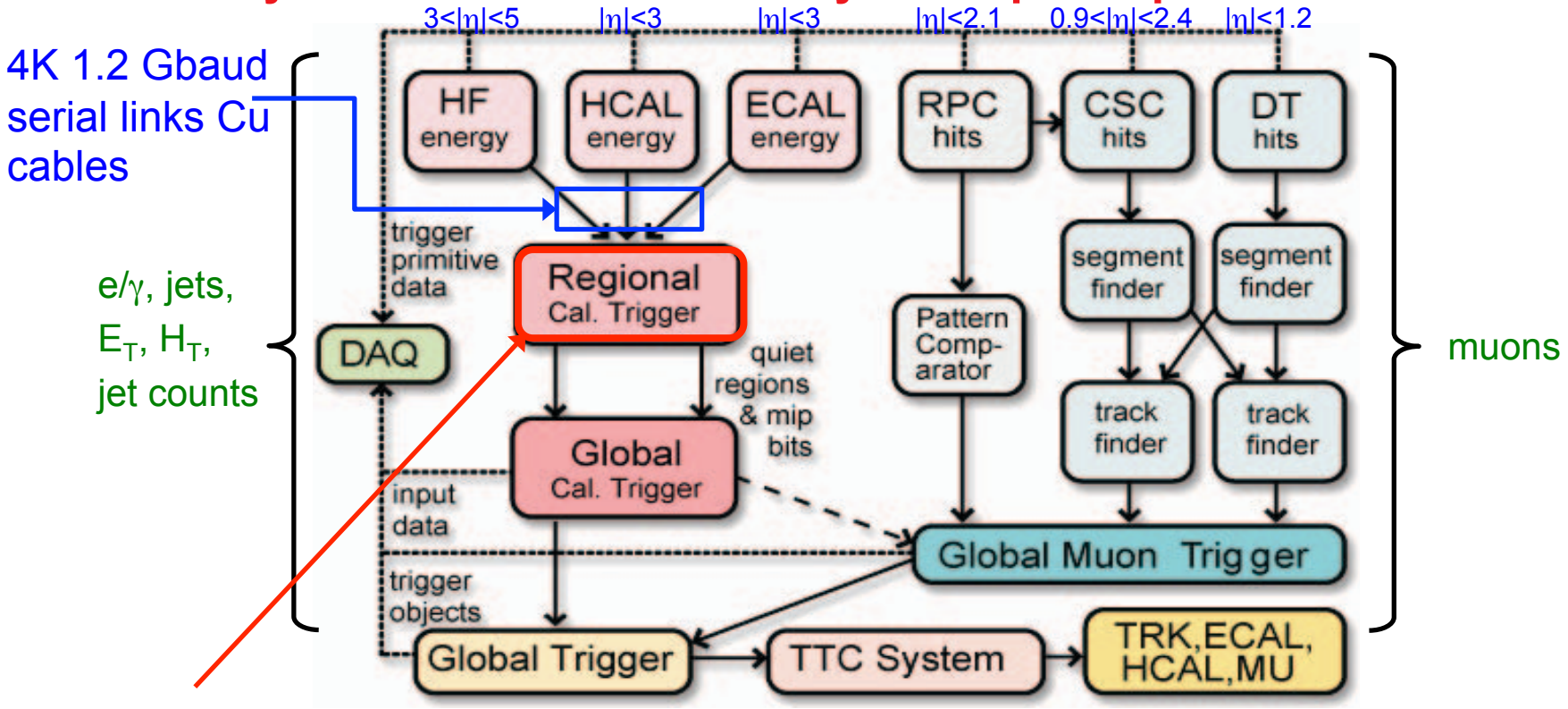


Level-1 Trigger

- LHC beam crossing rate is 40 MHz & at full Luminosity of 10^{34} $cm^{-2}s^{-1}$ → 10^{9} collisions/s
- Reduce to 100 kHz output to High Level Trigger and keep high-P_T physics
- Pipelined at 40 MHz for dead time free operation
- Latency of only 3.2 μsec for collection, decision, propagation

The CMS Level-1 Trigger & Regional Calorimeter Trigger

Only calorimeter and muon systems participate in CMS L1



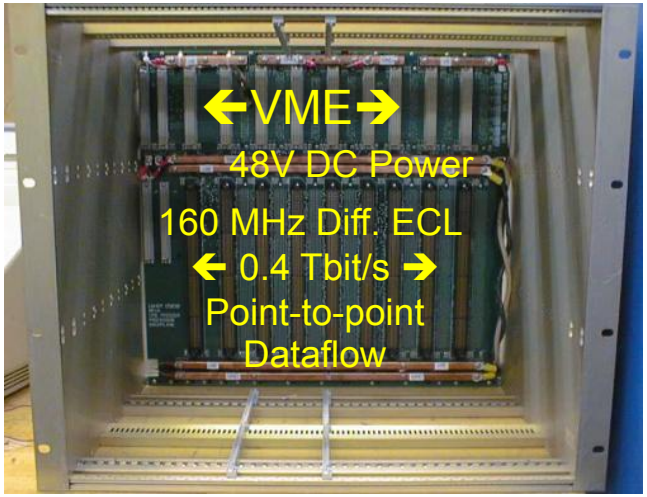
Regional Calorimeter Trigger

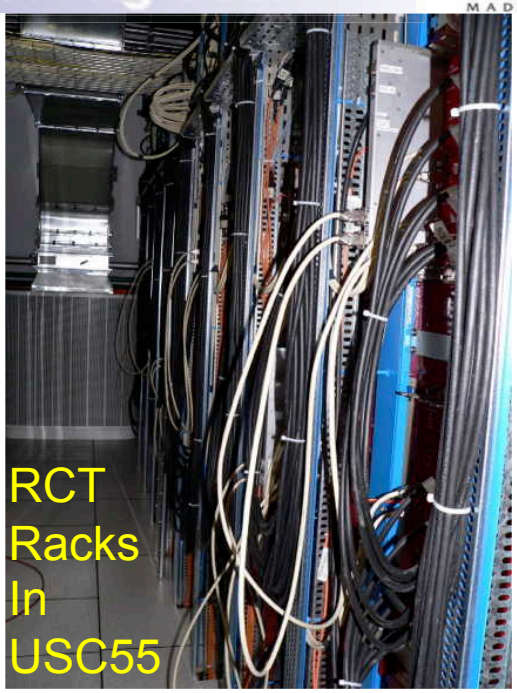
- Receives Trigger Primitives (TPs) from 8000 ECAL/HCAL/HF towers
- Finds 28 e/γ candidates, creates 14 central tower sums, 28 quality bits, and forwards 8 HF towers and 8 HF quality bits
- All sent to Global Calorimeter Trigger at 80 MHz on SCSI cables

Regional Cal. Trigger Crates

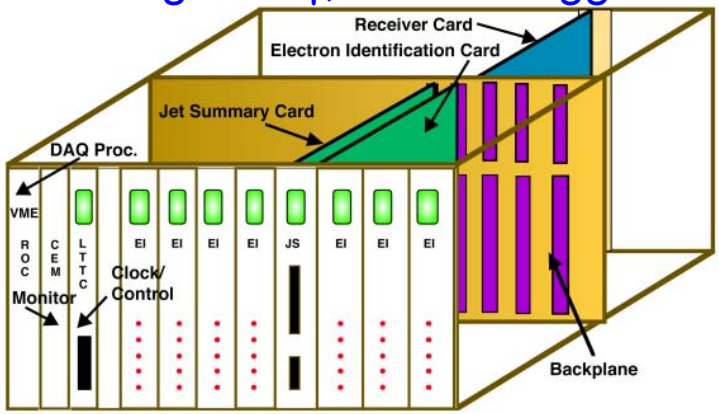
UW Scientist Pam Klabbers, CMS Cal Trig Coord.

Main RCT Crate

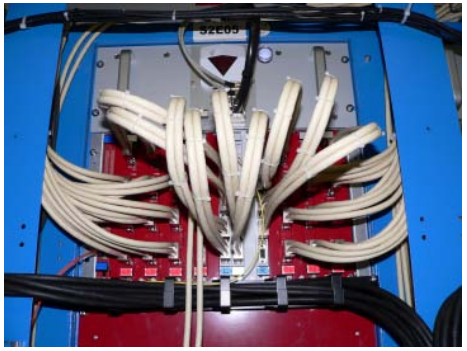




18 Operating (26 incl. Spare & Test) crates with custom backplane incorporate algos: e/γ, τ & Jet Triggers



Master Clock Crate (MCC):

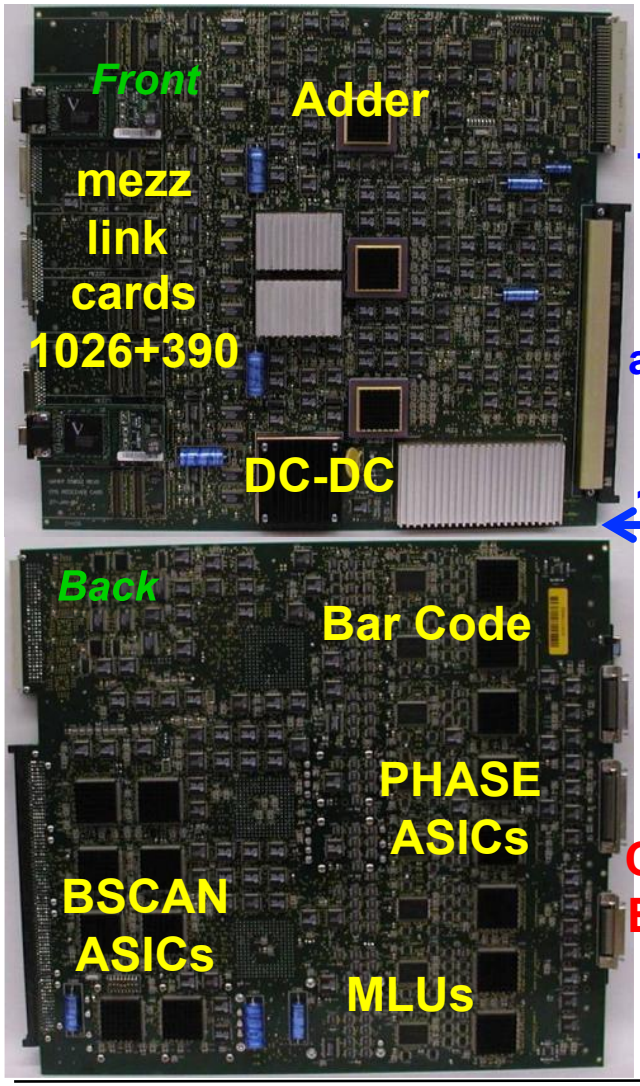


One crate with 3 custom cards to create & fan-out 60 & 120 MHz clocks, ReSync, & Bunch Crossing 0

Regional Cal. Trigger Cards

2000 Cards built by U. Wisconsin using 5 UW Custom ASICs

Receiver Card:

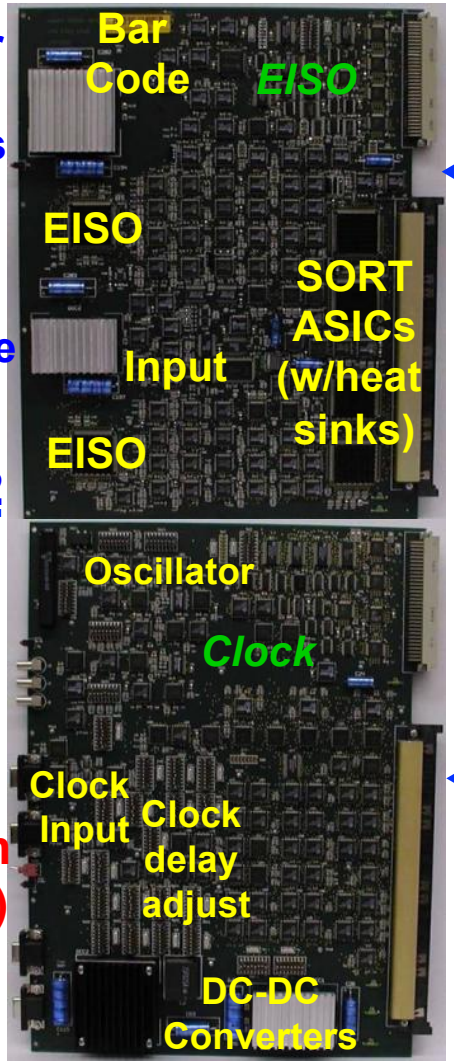


number needed +spares (incl. test setups) available

128+32

(18+9 Custom Backpl)

Electron Isolation & Clock:

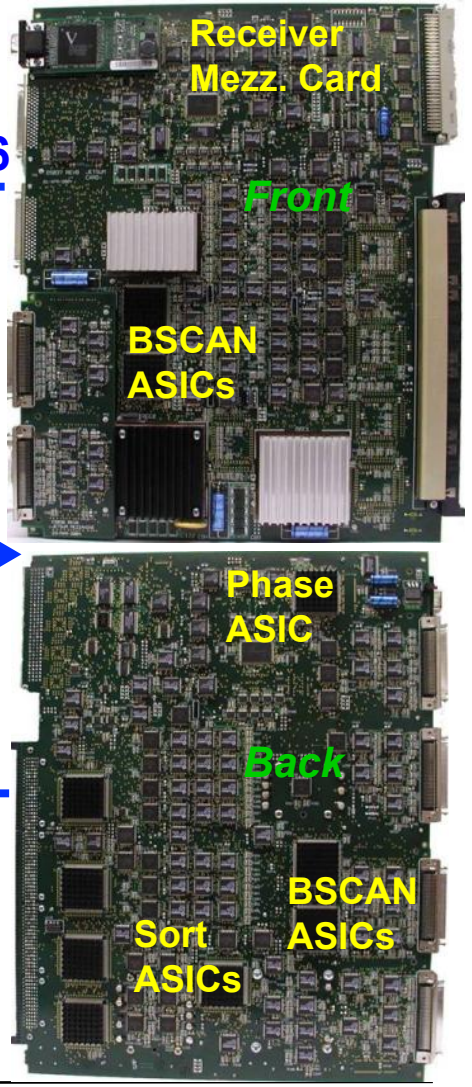


128+26

18+7

18+7

Jet/Summary:



Trigger Lab Setup at CERN

Repair & Test Facility – Prevessin 904

- Stores boards, crates, cables.
  - Power up and run system tests
  - Operate in water-cooled rack for extended tests

Integration tests

- Racks with cooling on a raised floor nearby
- Will be used for upgrade tests

Storage and Repair

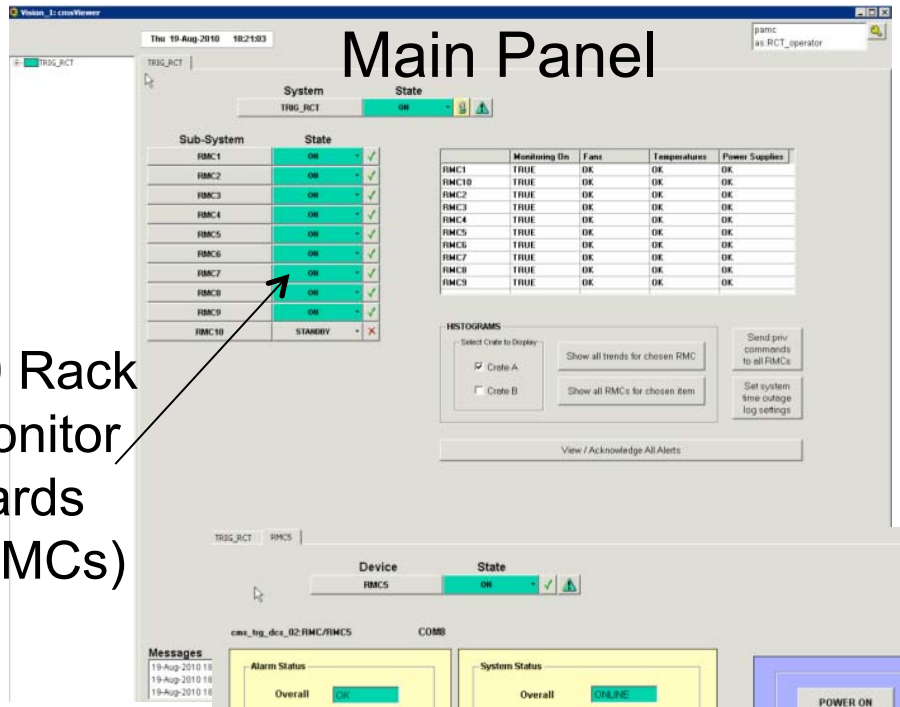
- Spare Crates and cards also available for use in testing and replacement of suspect cards
- Soldering station, scope, and tool storage
- Spare component storage

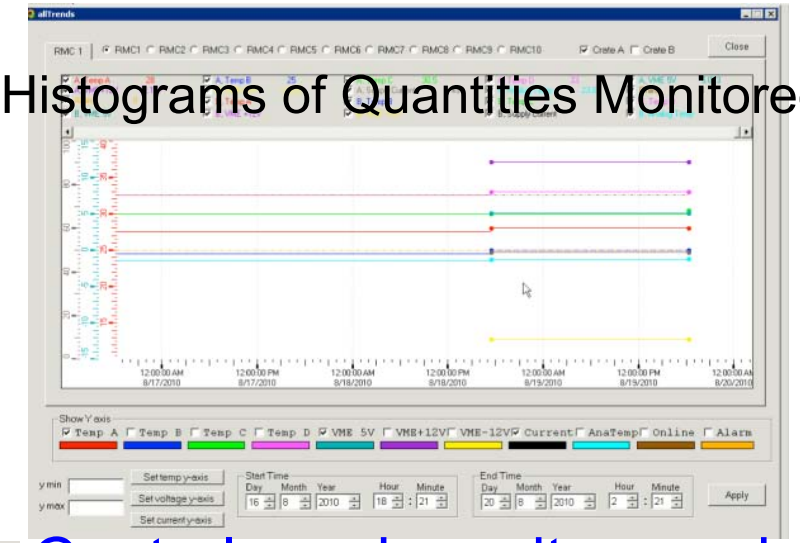
Responsible:

- P. Klabbers & M. Grothe

Detector Control System (DCS)

Scientist M. Grothe, GS: K. Grogg, I. Ross



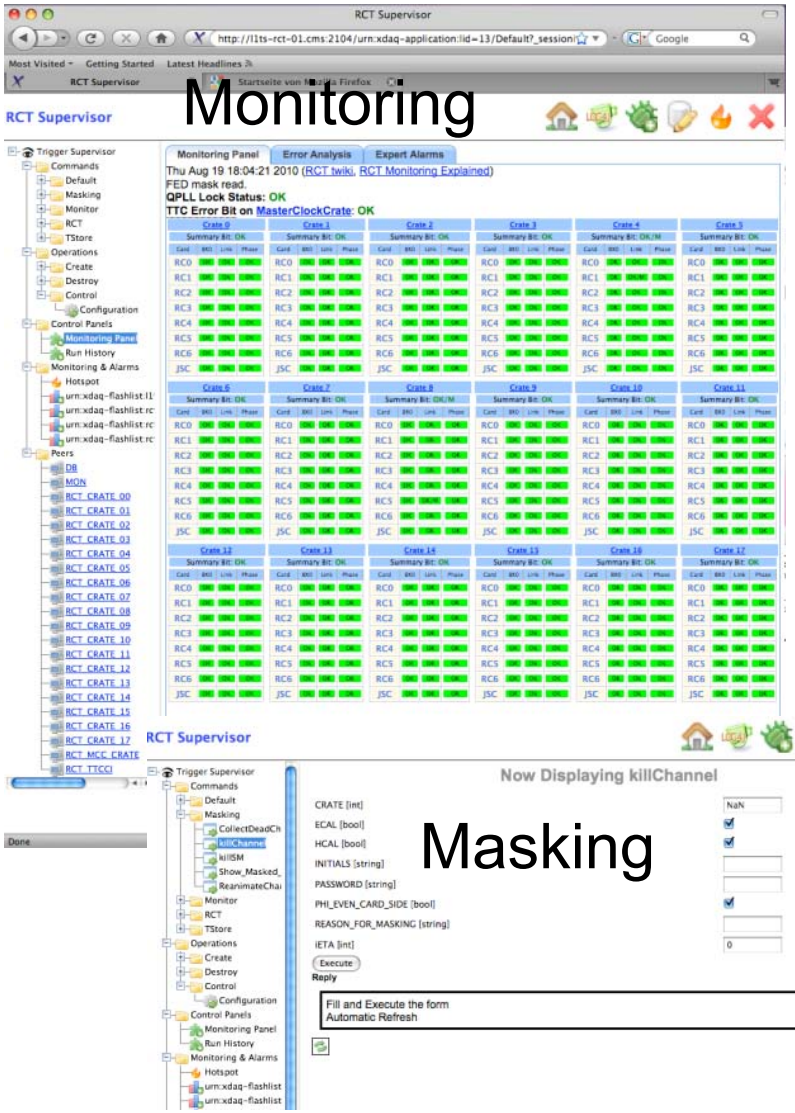


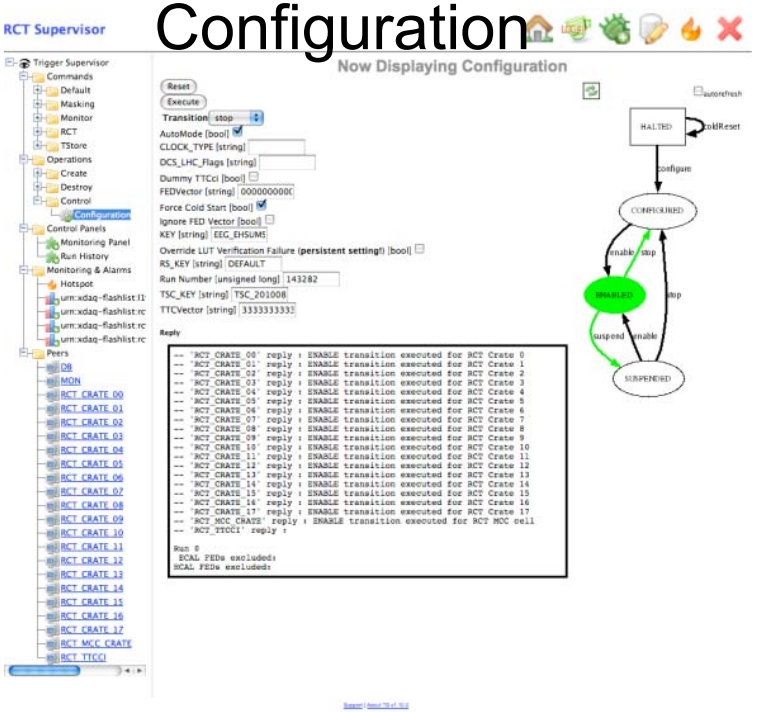
Controls and monitors rack power, current, voltage, temps, and fans:

- Auto-off for cooling, voltage, current failures, sends SMS/e-mail to experts.
- Protects Electronics

Trigger Supervisor (TS)

Sci.: M. Grothe , PD: J. Efron, GS: C. Lazaridis, I. Ross





Configures and monitors RCT & interface to CMS Run Control

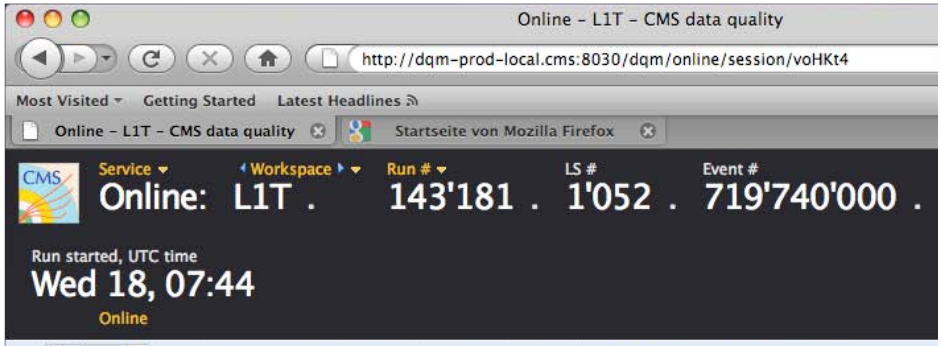
Can mask bad channels, monitor links and clocks, view current configuration

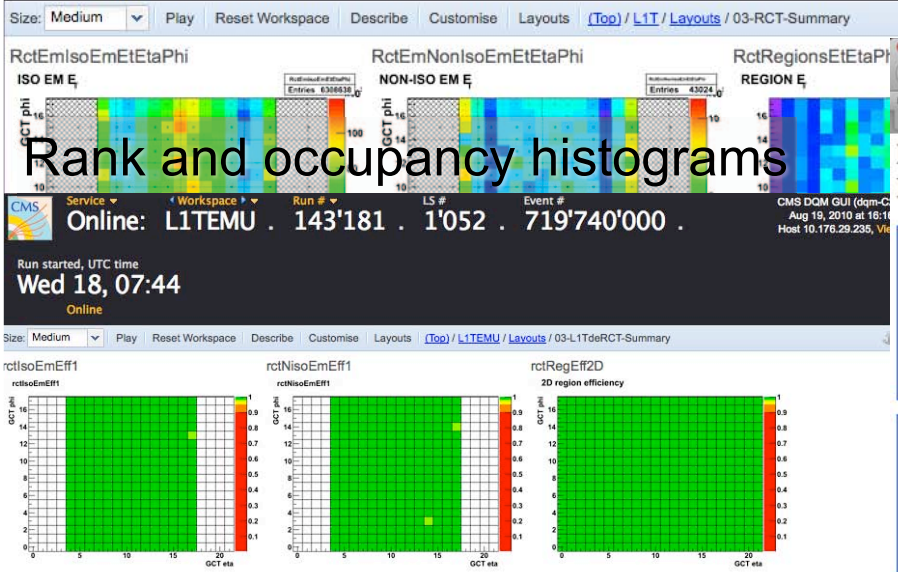
Data Quality Monitoring (DQM)

Sci: A. Savin, GS: M. Weinberg, W. Parker

Online DQM – Live and Archived

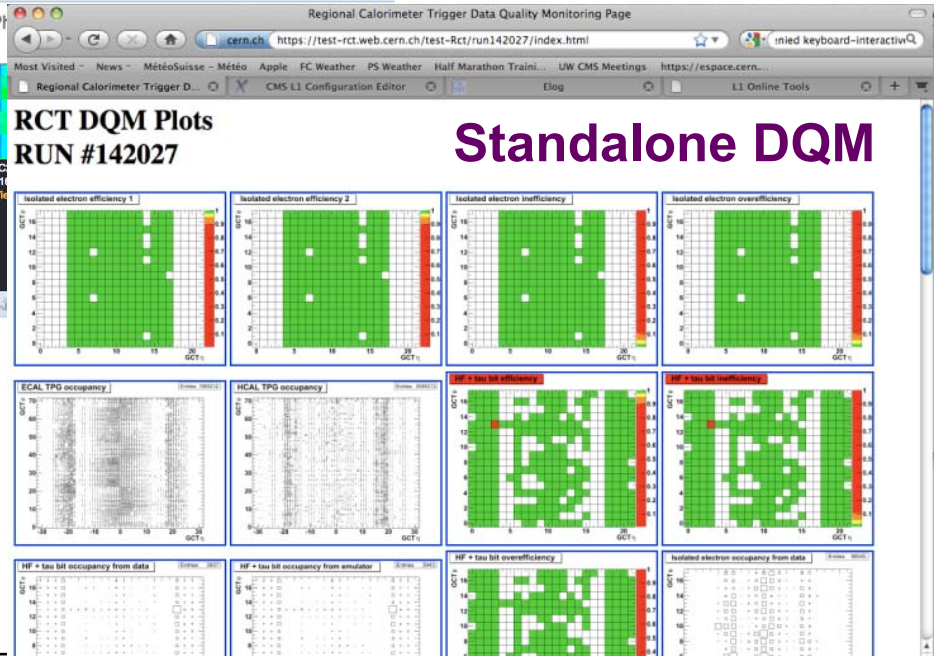
Online DQM: current data to catch real-time problems (and archived)
Offline DQM: post-running, used for data certification (not shown)
Standalone: run by RCT on call, larger datasets possible





Rank and occupancy histograms

Real time data/emulator compare



RCT Emulator and Pattern Testing

PD: J. Efron, GS: K. Grogg, I. Ross

Emulator

- Simulates all RCT data paths – Trigger Primitive input to GCT output
- Part of CMSSW, used by DQM, pattern testing, etc.

Pattern tests use the input LUTs on the Receiver cards to send 64 BX

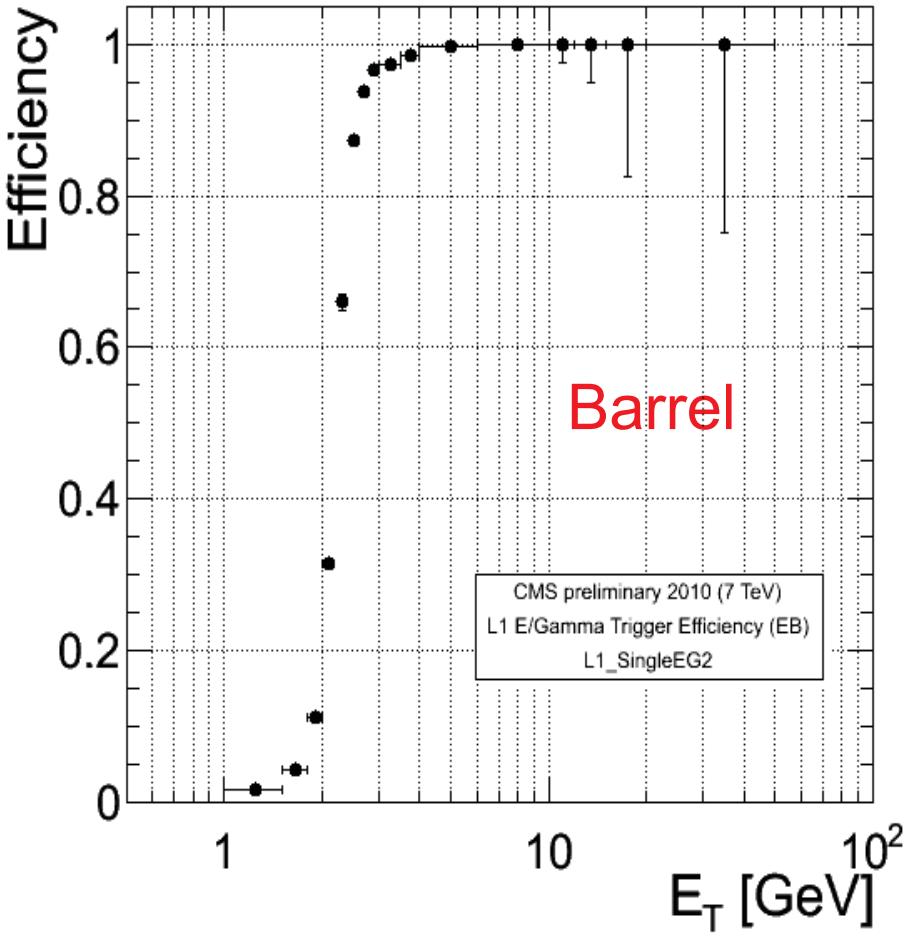
- All 18 RCT crates + GCT Source Cards to capture output
  - Emulator predicts output
  - compared with captured data
- Patterns
  - Walking zeros & ones, random, ttbar simulated data
    - ttbar: Partial output at right
  - Problems found and fixed
  - Checks RCT-GCT connections
- Being integrated into Trigger Supervisor
- Developing tests using patterns injected at TPG level
  - Tests SLB-RCT link, algos.

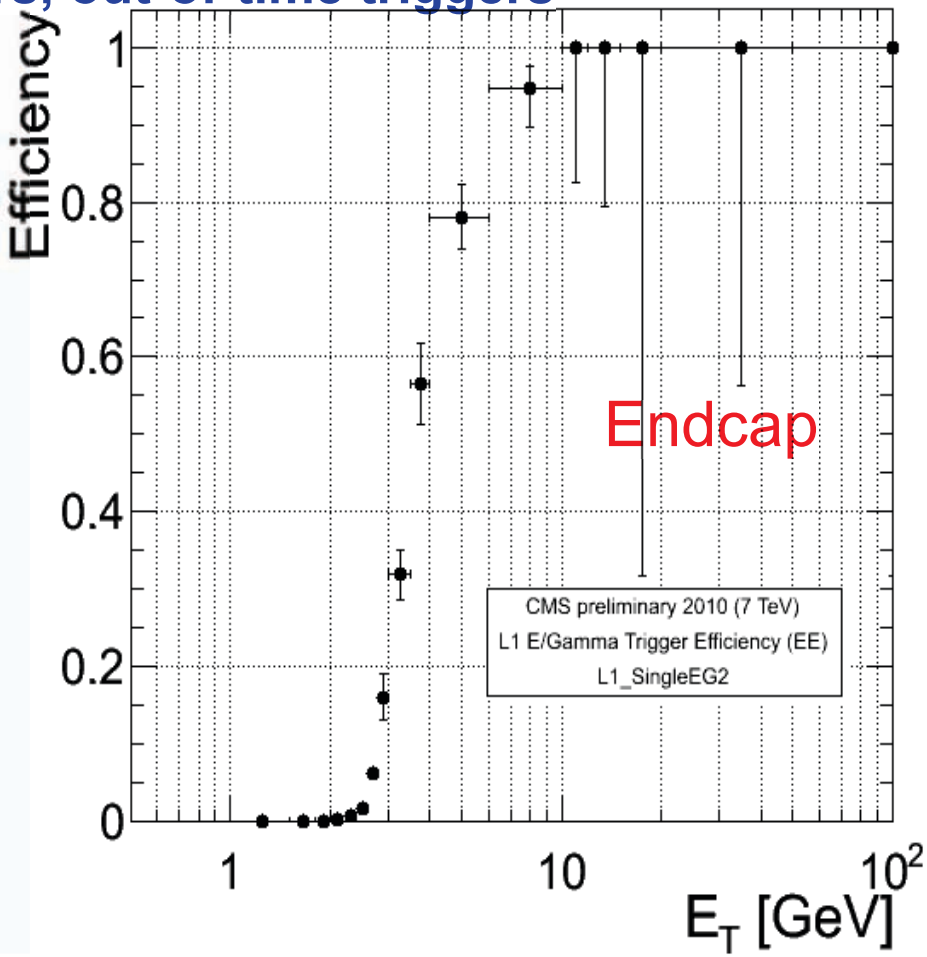
```
Test Name: outputTtbar
Test Date: 01/09/08

source card files
/nfshome0/gctdev/TriDAS/trigger/gct/SourceCardController/patt
/nfshome0/gctdev/TriDAS/trigger/gct/SourceCardController/patt

crate 12 card 2 region 0
scrd: Rank 939 mip 1 tau 0 qbit 0 ovfl 0
emul: Rank 1023 mip 0 tau 1 qbit 0 ovfl 1

Summary of errors
        Crate  0                    Crate  1
         rk crd iso rgn ord  TOT     rk crd iso rgn ord  TOT
        --- --- --- --- --- ----    --- --- --- --- --- ----
Card 0
Card 1
Card 2
Card 3
Card 4
Card 5
Card 6

        Crate  4                    Crate  5
         rk crd iso rgn ord  TOT     rk crd iso rgn ord  TOT
        --- --- --- --- --- ----    --- --- --- --- --- ----
Card 0
Card 1  142  16          128  126
Card 2
Card 3   63  16          376   47
Card 4   16                     16
Card 5
Card 6
```

L1 e/γ Trigger Efficiency

Egamma 2 GeV trigger intrinsic efficiency for 7 TeV Data:

- Require energy deposit ~~in 2~~ towers of L1 Candidate
- Remove effect of masked towers, out-of-time triggers





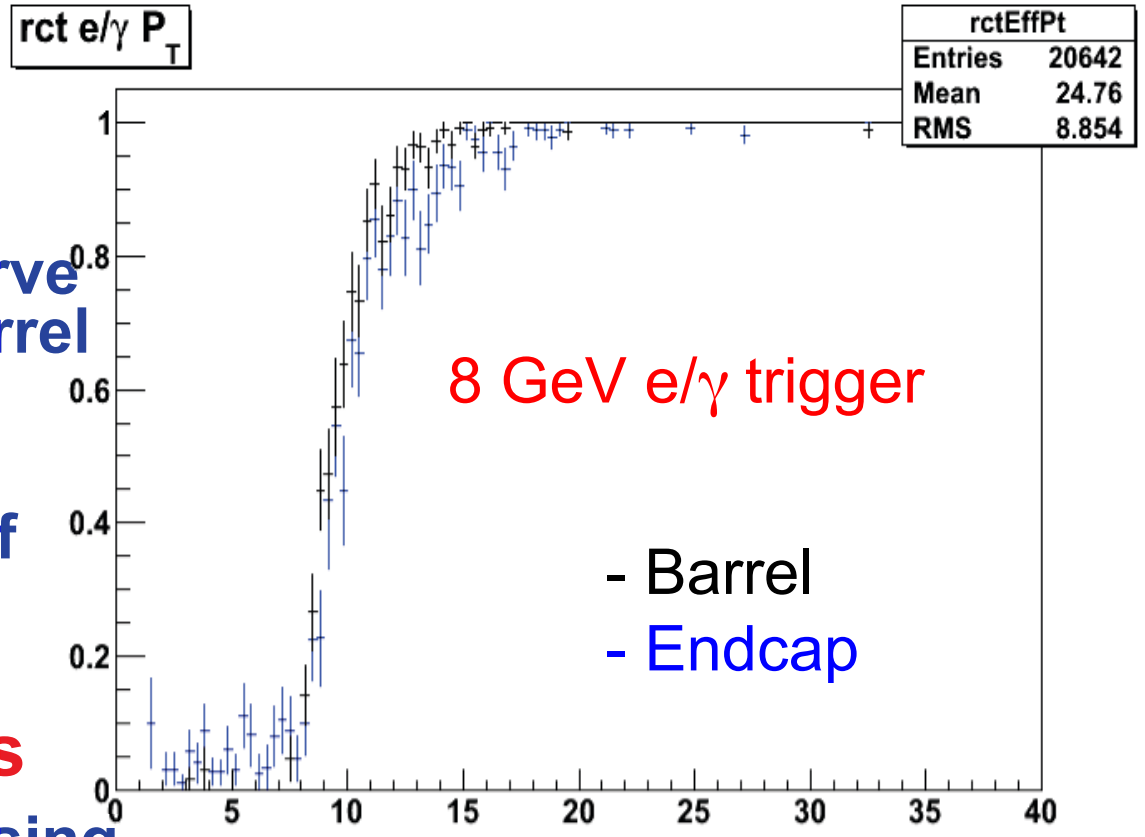
RCT Calibration

L1 physics object calibration for Electrons

- Unified turn-on curve for electrons in barrel and endcap
- Compensates for different amount of material in front of barrel and endcap

Working on hadrons

- Sharpen Jet & Missing Energy threshold curves
- Postdoc Jonathan Efron



Physicist Trigger M&O Tasks
(all from core program)

Change trigger Configuration
- Respond to changing beam/detector conditions & physics priorities

Study new trigger configurations
- Test runs, Monte Carlo studies, data studies

Trigger Physics Analysis
- Understand detailed impact of trigger on physics

Preparation for luminosity increases
- Monte Carlo studies of new conditions, validate with present data

Operations - 24x7 support during running
- Rapid Response to problems at point 5
  - RCT is first to detect problems with ECAL, HCAL, HF
- Write, test & maintain electronics test programs
- Maintain & update bad channel list & run daily checking programs
- Run Control maintenance
- Trigger data validation and calibration
  - Online & Offline analysis of rates & efficiencies
- Monte Carlo & data trigger simulation maintenance
  - Continuous validation of trigger using simulation & readout data

Higher Level Triggers

Reduce 50 kHz L1 output to 200 Hz running algorithms averaging 40 ms/event on event filter farm.

- **Responsibility of Trigger Coordinator (W. Smith)**
- **Optimize HLT & L1 triggers for any given time/luminosity**
  - Integration of algorithms and code provided by detector physics groups and physics object groups into the trigger code
  - Creation of trigger tables via representatives from each detector group, each physics group and run coordination
  - Monitoring of physics performance of the combined online selection
    - **Photon Triggers: Prof. Dasu, GS: M. Anderson**
    - **Muon Triggers: Prof. Herndon, GS: J. Klukas**
    - **Tau Triggers: Prof. Dasu, Assoc. Sci. Savin, GS: M. Bachtis, J. Swanson**
- **Operational Responsibilities**
  - Study efficiency, purity, acceptance, execution time, data unpacking.
- **UW Scientist A. Savin is Co-Convener of Trigger Performance Group**
  - Online Trigger DQM: Determine if actions needed to fix data-taking
  - Offline Trigger DQM: Certify trigger for each run usable for physics
  - Release Validation: Check HLT function in each new SW release
  - Algorithm Evaluation: Check physics performance, samples used for efficiency calculation, monitoring histograms, expected rates

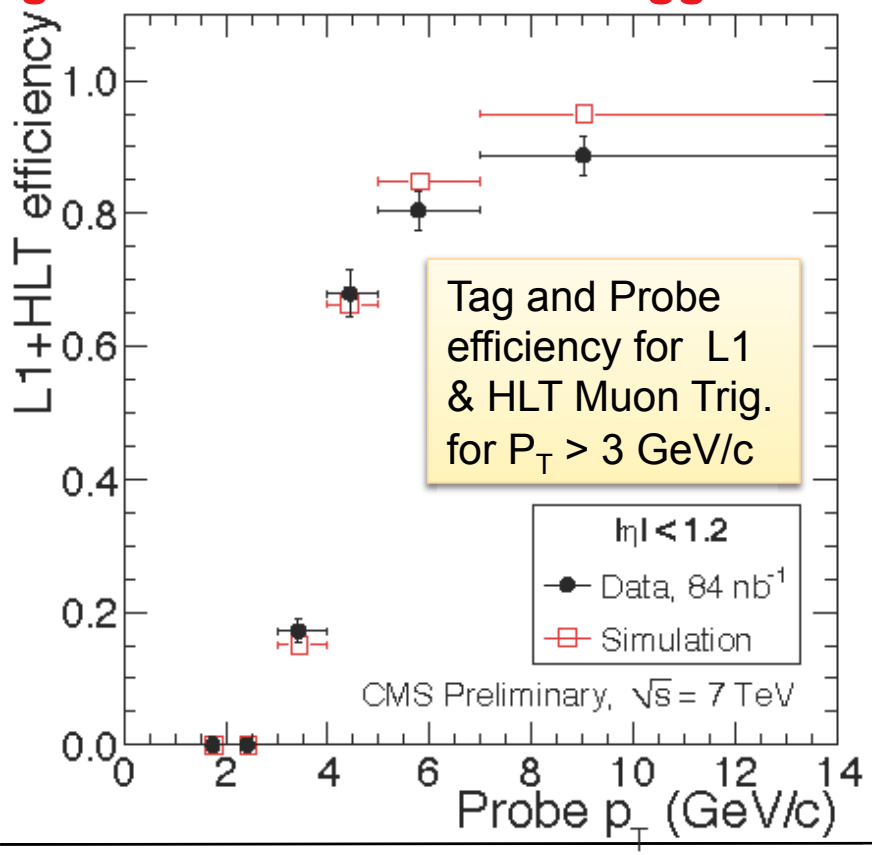
Trigger Performance

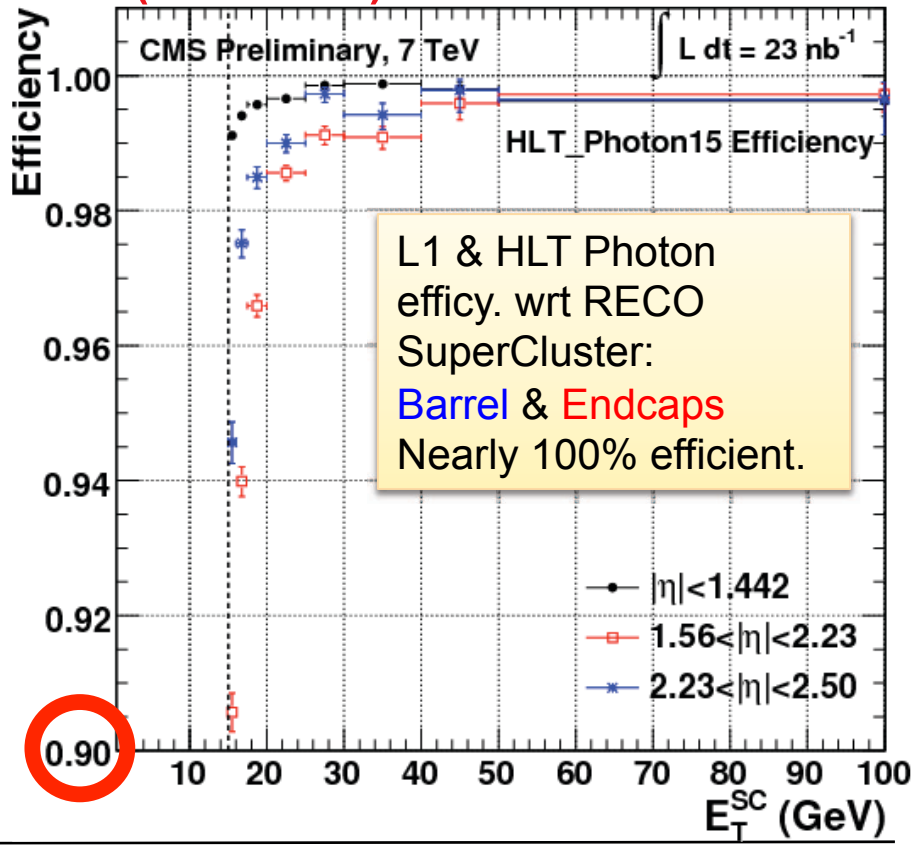
W. Smith Trig. Coor, A. Savin Trig. Performance Co-Convener

Smooth evolution of trigger menus with luminosity

- Successfully deployed 2E29, 4E29, 8E29,1E30, 3E30 L1 & HLT menus
- Rates reliably predicted with data extrapolation & MC within 20%
- L1: 90 kHz (30 kHz physics), HLT: 200 - 400 Hz (50 msec CPU/evt)

High and well understood trigger efficiencies (L1 & HLT):





Upgrade Trigger Strategy

Constraints

- Output rate at 100 kHz
- Input rate increases x2/x10 (Phase 1/Phase 2) over LHC design (10^{34})
  - Same x2 if crossing freq/2, e.g. 25 ns spacing → 50 ns at 10^{34}
- Number of interactions in a crossing (Pileup) goes up by x4/x20
- Thresholds remain ~ same as physics interest does

Strategy for Phase 1 Calorimeter Trigger (operating 2016):

- Present L1 algorithms inadequate above 10^{34} or 10^{34} w/ 50 ns spacing
  - Pileup degrades object isolation
- More sophisticated clustering & isolation deal w/more busy events
  - Process with full granularity of calorimeter trigger information
- Should suffice for x2 reduction in rate as shown with initial L1 Trigger studies & CMS HLT studies with L2 algorithms

Potential new handles at L1 needed for x10 (Phase 2: 2020)

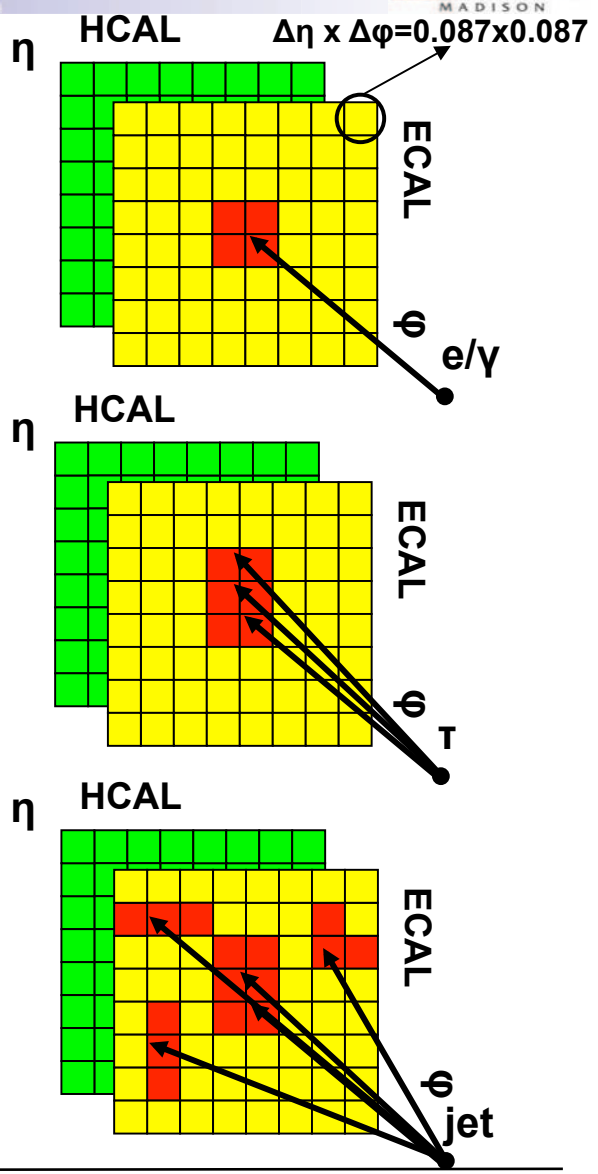
- Tracking to eliminate fakes, use track isolation.
- Vertexing is useful to ensure that the multiple trigger objects come from the same interaction
- Requires finer position resolution for calorimeter trigger objects for matching (provided by use of full granularity cal. trig. info.)

Upgrade Trigger Algorithm Development

- Prof. Dasu, Sci. Grothe, GS Michalis Bachtis & Ian Ross

- **Particle Cluster Finder**
  - Applies tower thresholds to Calorimeter
  - Creates overlapped 2x2 clusters
- **Cluster Overlap Filter**
  - Removes overlap between clusters
  - Identifies local maxima
  - Prunes low energy clusters
- **Cluster Isolation and Particle ID**
  - Applied to local maxima
  - Calculates isolation deposits around 2x2,2x3 clusters
  - Identifies particles
- **Jet reconstruction**
  - Applied on filtered clusters
  - Groups clusters to jets
- **Particle Sorter**
  - Sorts particles & outputs the most energetic ones
- **MET,HT,MHT Calculation**
  - Calculates Et Sums, Missing Et from clusters

Synthesize these algorithms in FPGA →



FPGA Synthesis Results

Collaboration with group of UW EE Professors Katie Compton & Michael Schulte

- **Synthesis includes RocketIO, buffers, particle cluster finder, overlap filter, and cluster weighting for Xilinx Virtex 5 series TX240T FPGA. Resource usage & latency:**

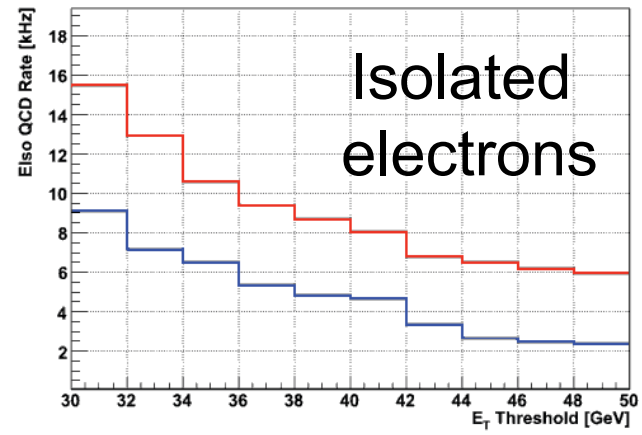
Resource	8 x 8 Grid	8 x 16 Grid	16x 16 Grid
RocketIO Links	25%	46%	83%
Virtex-5 Slices	27%	54%	105%
Block RAMs	14%	27%	53%

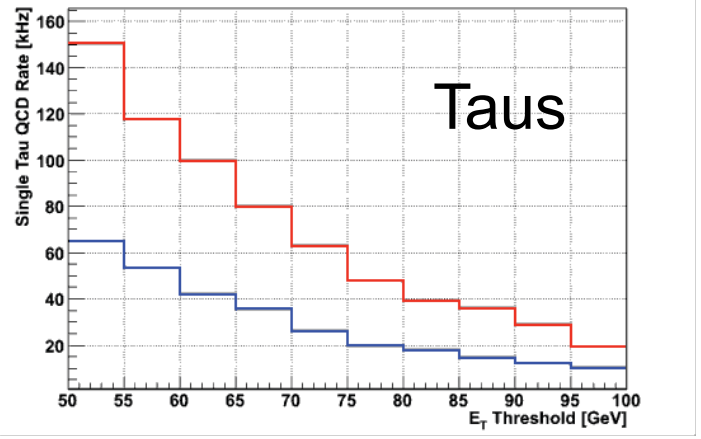
Component	Latency (cycles)	Latency (ns)
Input RocketIO and Buffers	15	75
Particle Finder, Overlap Filter, Cluster Weighting	12	60
Output Rocket IO and Buffers	10	50
Total Estimated Latency	**37**	**185**

Upgrade Algorithm Performance: Factor of 2 for Phase I

Prof. Dasu, Sci. Grothe, GS Michalis Bachtis & Ian Ross

QCD Rate (kHz)

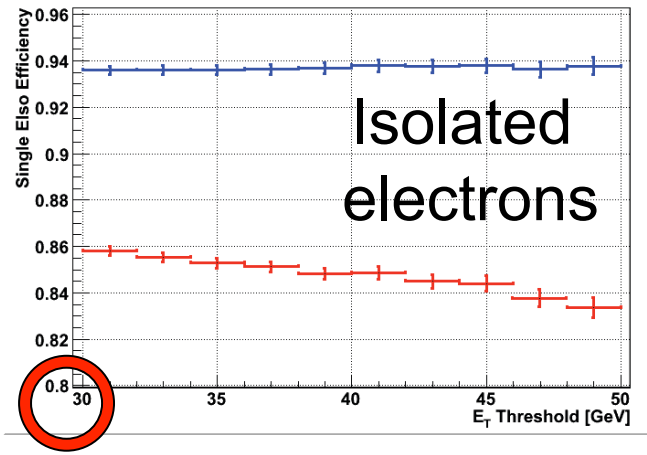


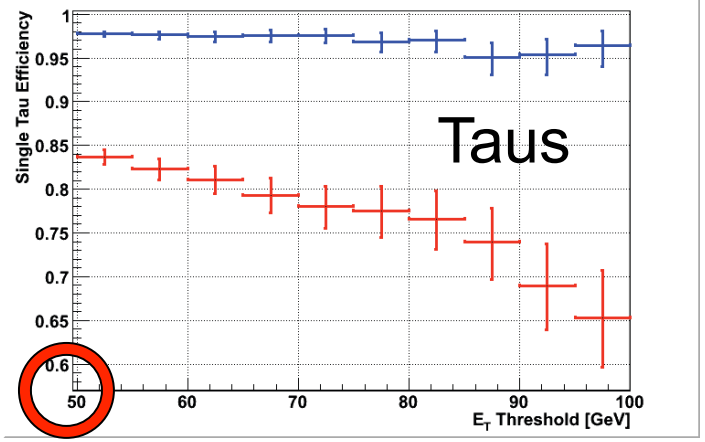


QCD Rate (kHz)

Factor of 2 rate reduction

Efficiency

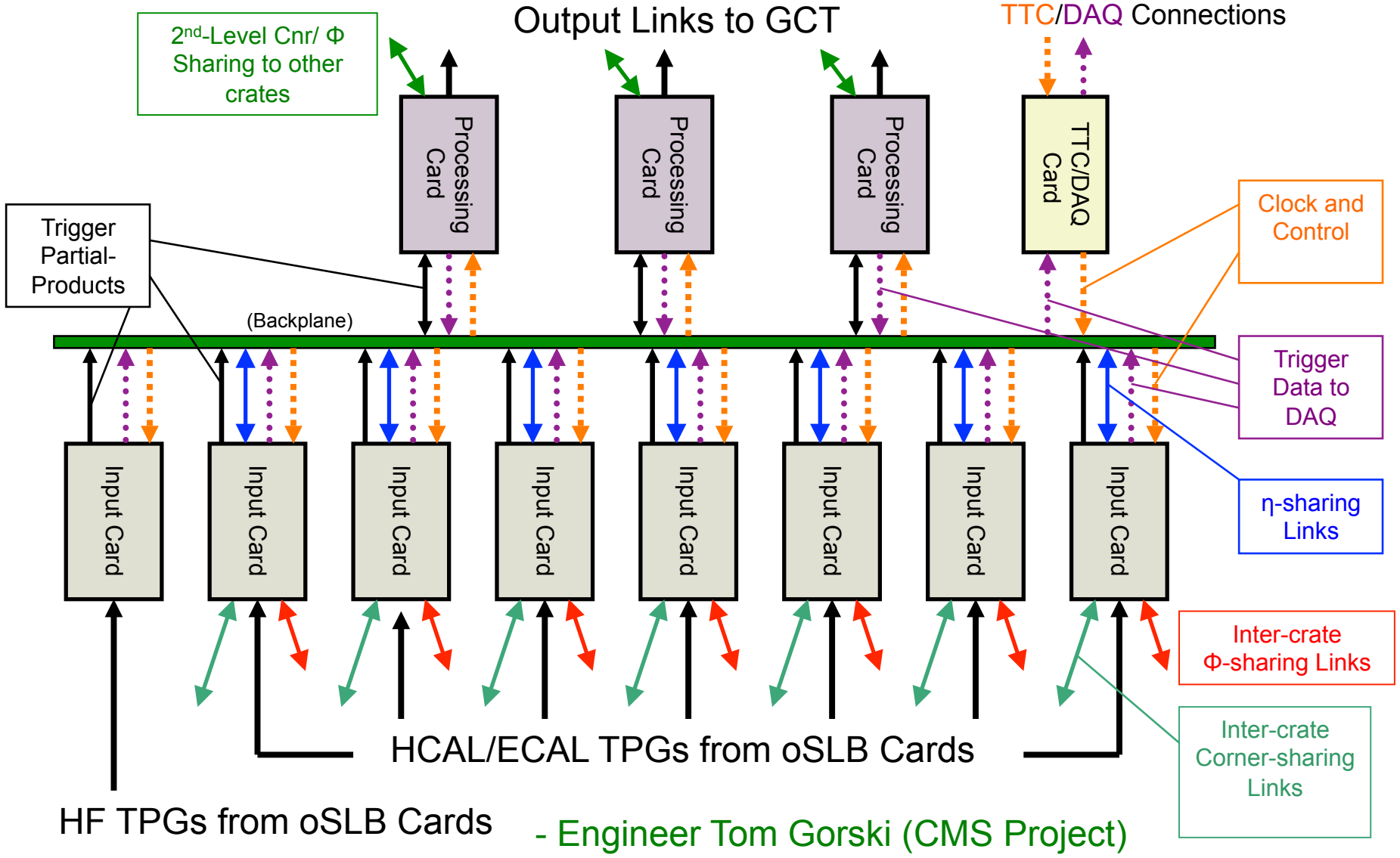




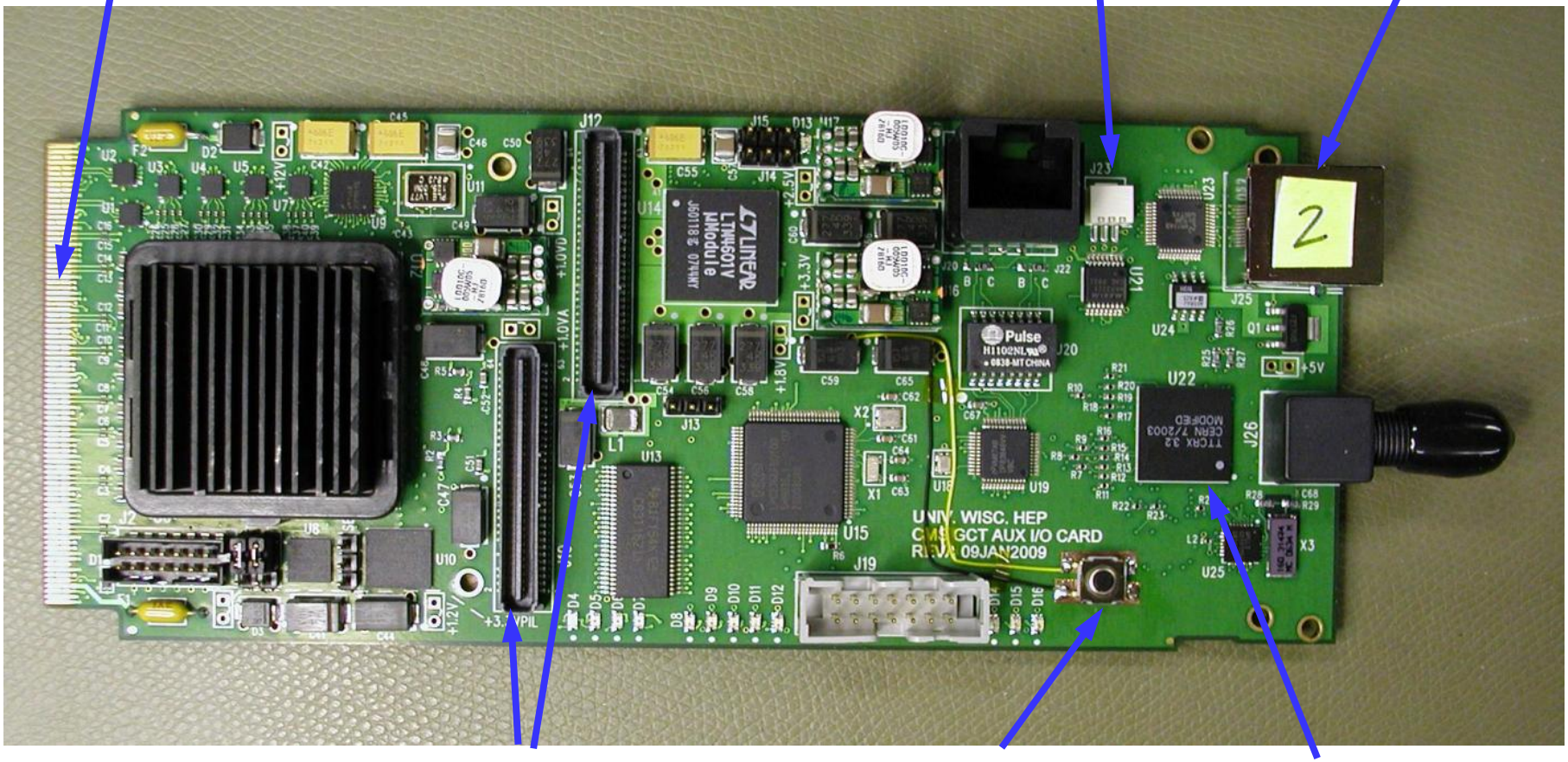
Efficiency

Higher Efficiency

Upgrade RCT Block Diagram
(56η×12φ B/E slice + 24η×12φ HF Slice)

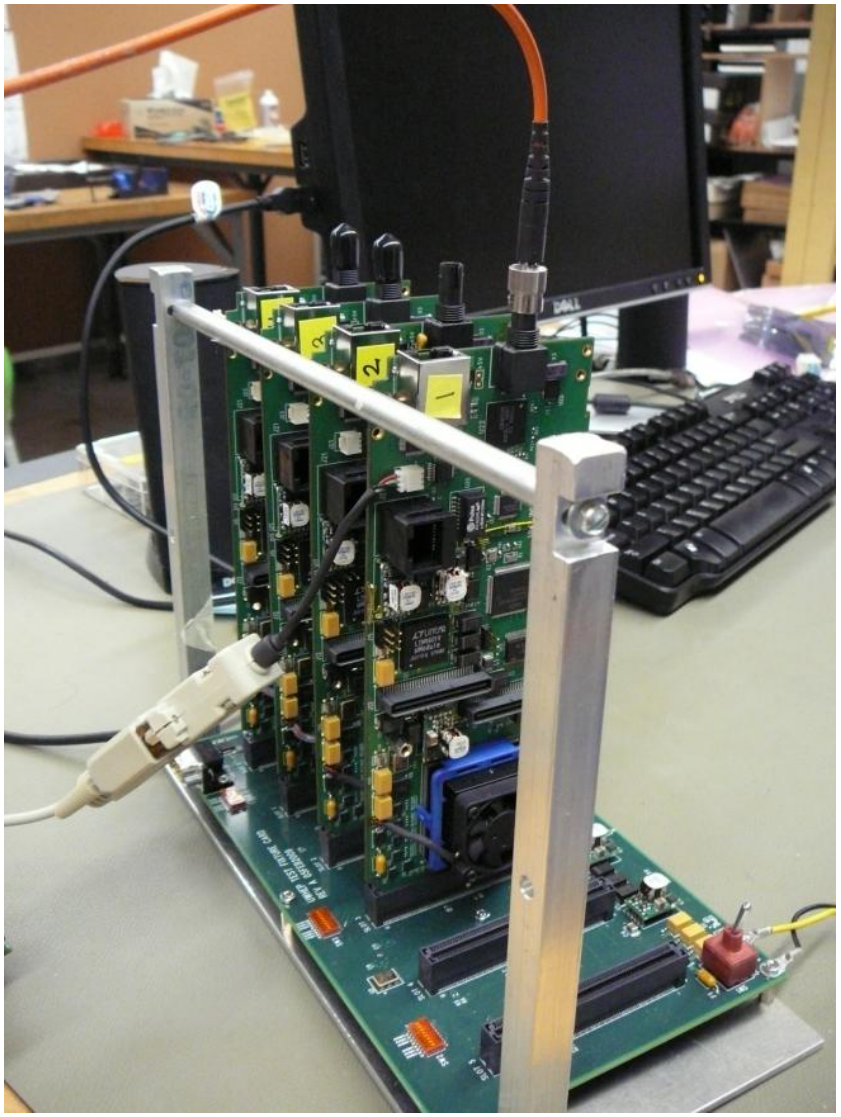


First Prototype: Aux I/O Card



- Engineer Tom Gorski

Trigger Algorithm R&D: 2x2 Firmware Test Bed



- 4 Aux Cards in a 2x2 test fabric
- TTC-based timing and link synchronization test bed
  - Prototype Test Bed for Rocket I/O *"Channel Bonding"* for latency management
- For Testing Trigger Algorithms *with Data Sharing*
- C source code for test pattern generation
- RS-232 Hyperterminal interface

- Engineer Tom Gorski

Upgrade Trigger FY11 Activities

- Engineer Tom Gorski, Tech. Bob Fobes, EE GS: Amin Farmahini-Farahani, Dan Seemuth (CMS Project Support)

Develop Trigger System & UTCA crate infra-structure to allow control & programming of trigger cards &FPGAs to distribute timing & control signals

Design Optical Serial Link Prototypes with Lisbon Group to transmit trigger data from ECAL & HCAL

- **System will also transmit data to present RCT through new mezzanine cards so old and new calorimeter triggers can operate in parallel.**

Produce Calorimeter Trigger Prototype Board

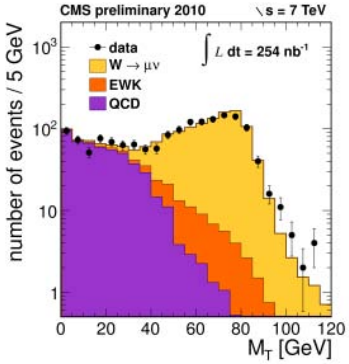
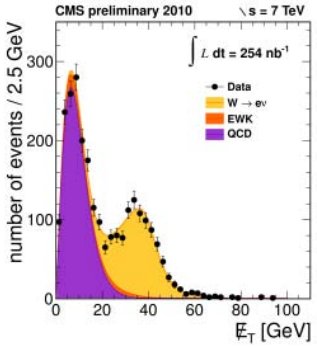
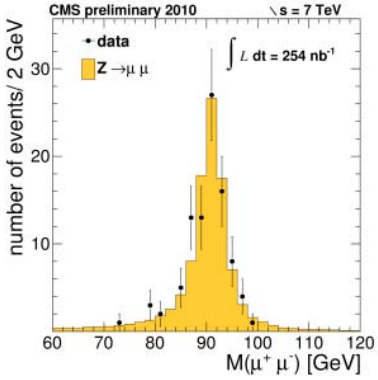
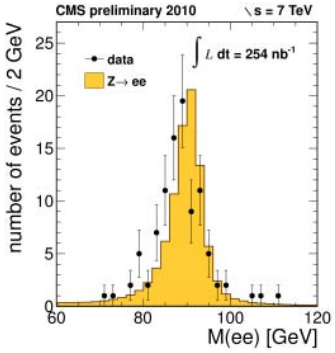
- **Integrate & test with new link prototype**

Continue detailed algorithm simulation & FPGA synthesis studies

Task T Physics Activities
(Talk by S. Dasu)

Early CMS physics analyses

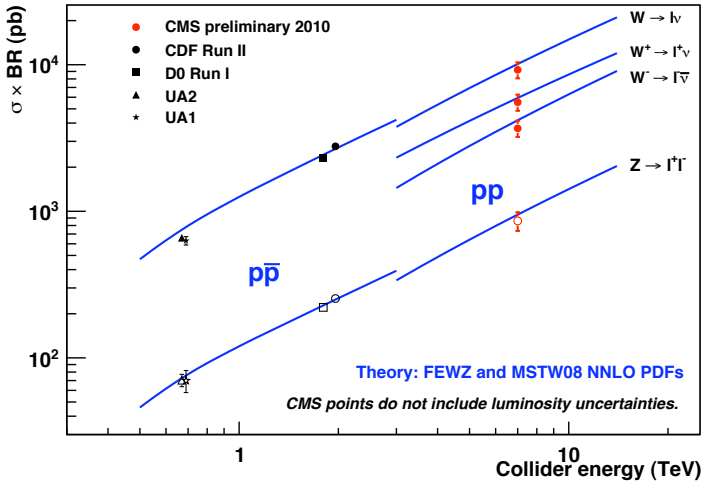
- New energy regime ⇒ rapid discoveries (but, first re-establish SM at 7 TeV CMS)
- Excellent Detector Response, Reconstruction and Analysis highlighted at ICHEP
- Crucial UW contributions to electron trigger, PF/τ reconstruction, W, Z analyses …

	muon	electron
W		
Z		

Sample ICHEP Work

EWK boson cross section measured @ 7 TeV

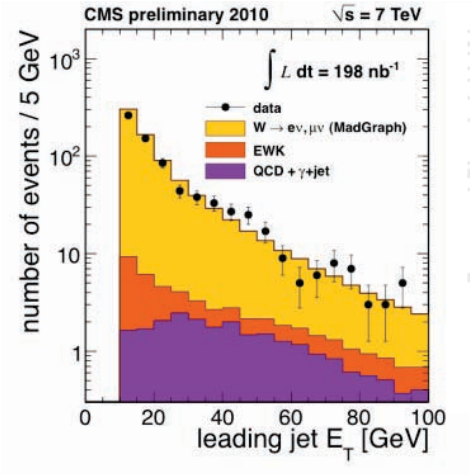
UW Contributors to this Analysis:
Lazaridis, Leonard, Grothe, Klabbers



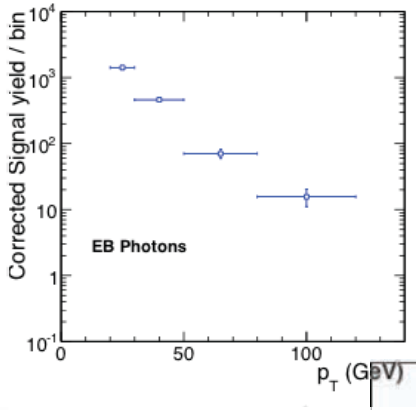
More ICHEP Examples

All senior students and scientists contributed to ICHEP analyses

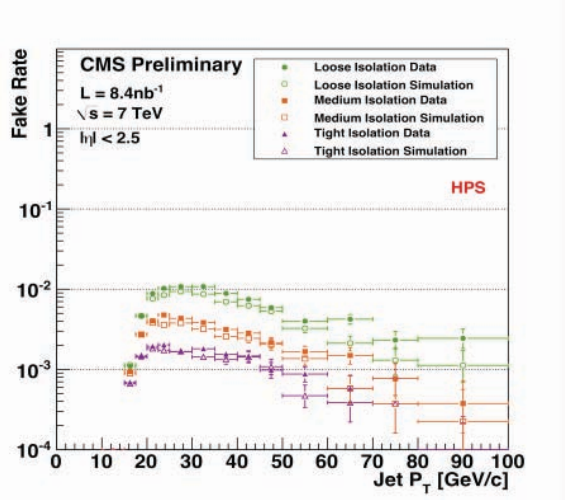
Efron and Grogg studied W+Jets



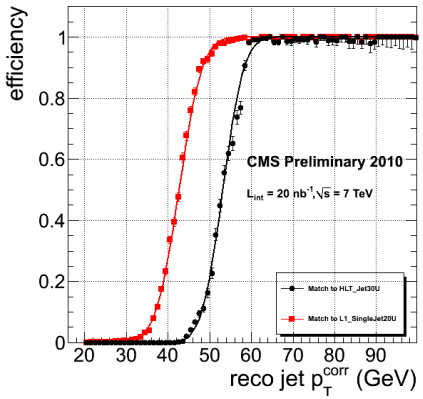
Anderson measured isolated photon yield

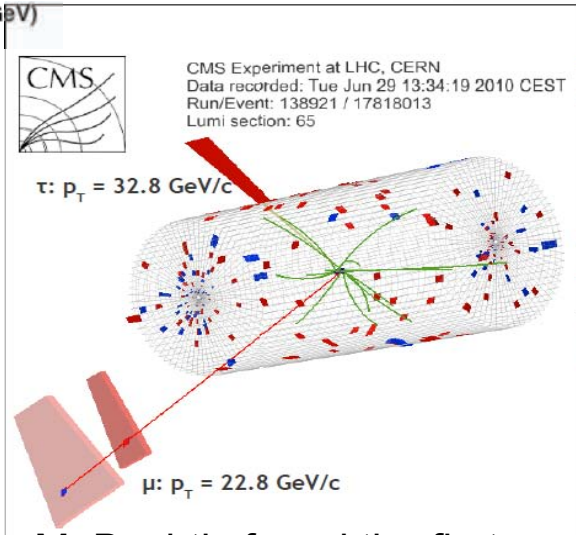


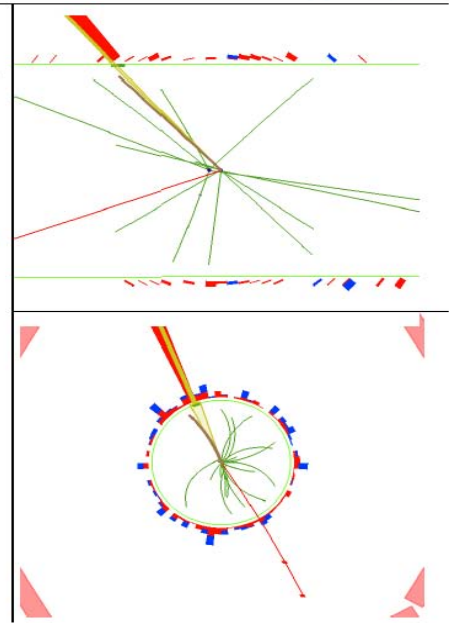
Swanson, Bachtis and Savin determined τ fake rate from data



Weinberg measured jet trigger efficiency turn-on







M. Bachtis found the first $Z \rightarrow \tau\tau \rightarrow \mu\tau_h$ candidate

UW Computing Activities
(Talk by S. Dasu)

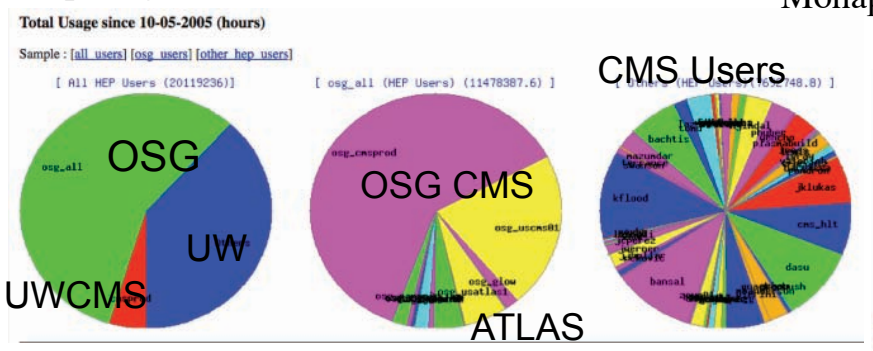
Rader, Radtke [DOE Univ.] & Bradley, Maier, and Mohapatra [NSF] Support

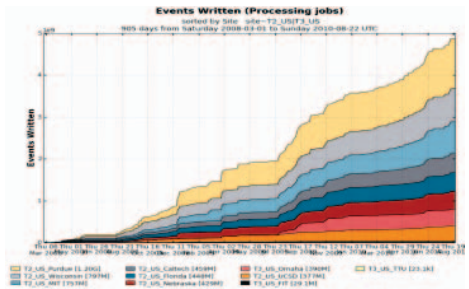
- **A CMS Tier-2 computer center from FY2005**
  - Data-Intensive Science University Network (DISUN) institute
- **Leadership in Grid Community**
  - OSG - Open Science Grid (develop tools and provide cycles)
  - GLOW - Grid Laboratory of Wisconsin (Lead role in development and implementation with CS Condor group to benefit entire UW campus: CMS, ATLAS, IceCube, CS, Genomics, Chem. Eng., Med. Phys., etc.)
  - Benefits both CMS and ATLAS + Computing support for all HEP tasks
- **Simulation production using local UW resources**
  - UW is one of the largest CMS institutes producing MC events since 2002
    - **>20 M CPU hours served since 2005, 500 GB CMS data hosted (refreshed regularly)**
    - **~ 5 B events produced with CMSSW since commissioning in 2008 (on OSG, ~1 B @ UW)**

Rader: UW Physics Director of Computing

>10 k HS06 CPU
>1200 batch slots
>1 PB raw storage
10 Gbps bandwidth
24h/7d operation
~200 user accounts

Radtke: HEP desktop support
Maier: Tier-2 systems support





Mohapatra : CMS MC production czar
Bradley: Software expert

UW Software Activities (Talk by S. Dasu)

Trigger Controls SW

- Prof. Dasu: Core VME software and framework
- Dr. Klabbers: Testing and operations software
- Dr. Grothe: Integration with CMS Trigger Supervisor

Trigger Emulator SW

- UW Students: RCT emulator in new CMS software framework

Trigger Monitoring SW & Physics Studies

- Dr. A. Savin and graduate students, Weinberg (RCT), Anderson (Photon), Klukas (Muon), Bachtis (Tau), Swanson (Tau) and Parker (Jet/MET)

Tau Trigger & Reconstruction SW Development (Particle Flow)

- Graduate Student Bachtis

Upgrade SW Development

- Dr. M. Grothe, Prof. S. Dasu and graduate students Bacthis and Ross

Computing Resources Management Software

- SW Engineer Bradley (NSF): New scheduler, Scalability, Computing-On-Demand
- Contributions to Condor, OSG and ROOT projects

Task T Endcap Muon Activities (Talk by R. Loveless)

Project Management: Dick Loveless

- Construction, test, integrate, install & commission 468 CSCs, electronics & infrastructure

Endcap maintenance

- UW responsibility -- led by UW scientist A. Lanaro, assisted by PSL engineering team

ME4/2 Upgrade

- Editor of Muon Upgrade Proposal, Project Manager? -- R. Loveless
- B904 Factory Manager – A. Lanaro
- Parts procurement – led by Wisconsin

Beam Pipe Support & Shielding

- Design & production of parts

Endcap Alignment

- Alignment Reconstruction & Corrections
  -- D. Carlsmith, assisted by J. Bellinger

Wisconsin CMS Task Support
(over past decade)

UW Computing Support

- > $ 700K
- 5 Servers, 2 TB Disk, 1 GB/s network, Grad. Student RA
- 70 CPU system for simulation with Condor
- 10 Gbps WAN network upgrade
- Two new Computer Rooms with power & AC
- Matching for "GLOW" shared computing facility
- Matching for "Tier-2"

Sabbaticals:

- Dasu (2 Semesters), Carlsmith (1 Semester), Smith (3 Semesters*)

  *Smith 3rd semester partially supported by DOE and UW

Graduate Student Support (07-10):

- 2 years RA support (Mike Anderson, Ian Ross)