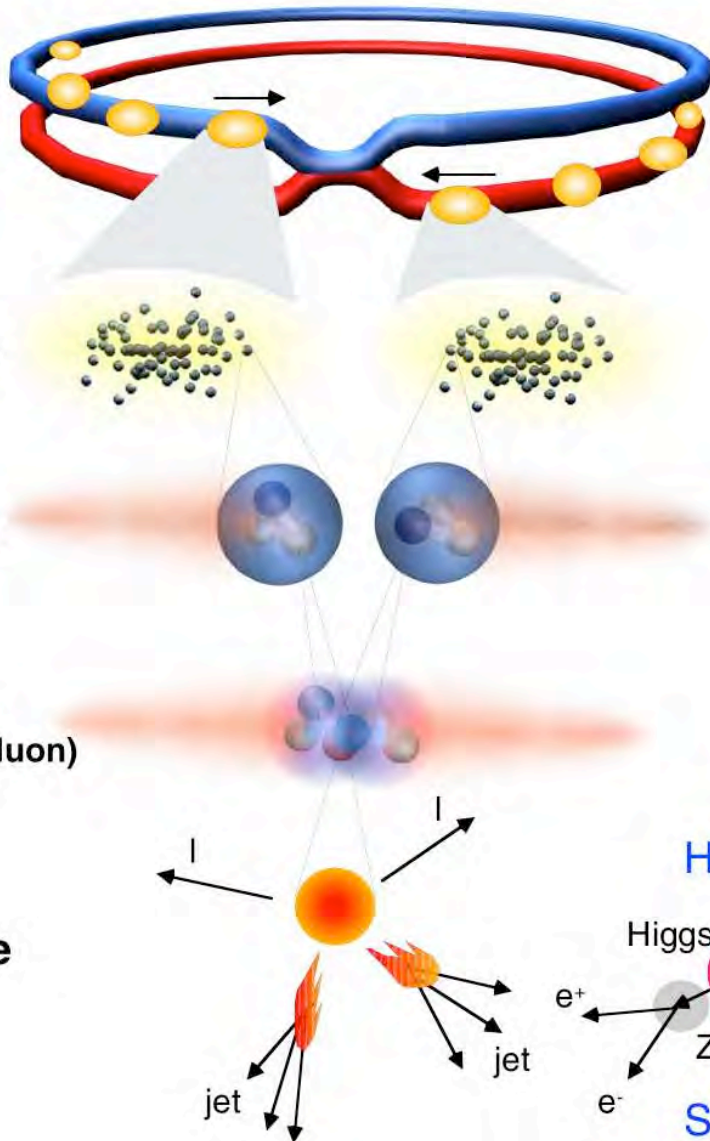




LHC Collisions



Bunch

Proton

Parton
(quark, gluon)

Particle

Proton-Proton
Protons/bunch
Beam energy
Luminosity

2835 bunch/beam
10¹¹
7 TeV (7x10¹² eV)
10³⁴ cm⁻² s⁻¹

Crossing rate

40 MHz

Collisions ≈

10⁷ - 10⁹ Hz

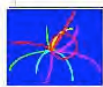
**Selection of 1 in
 10,000,000,000,000**



Trigger & DAQ at the LHC



40 MHz
COLLISION RATE



Energy



Tracks

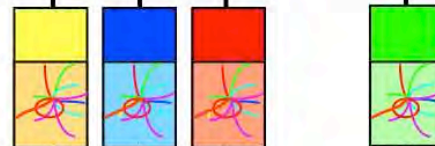
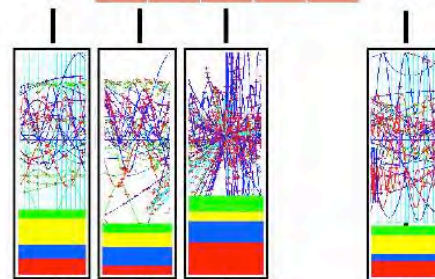
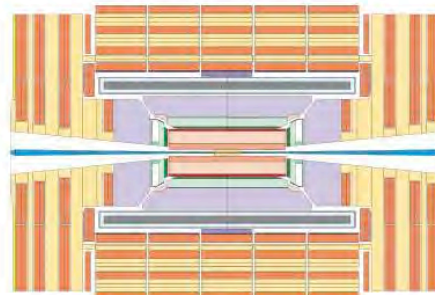
100 kHz
LEVEL-1 TRIGGER

1 Terabit/s
(50000 DATA CHANNELS)

500 Gigabit/s

100 Hz
FILTERED EVENT

Gigabit/s SERVICE LAN



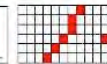
16 Million channels
3 Gigacell buffers



Charge



Time



Pattern

1 Megabyte EVENT DATA

200 Gigabyte BUFFERS
500 Readout memories

EVENT BUILDER. A large switching network (512+512 ports) with a total throughput of approximately 500 Gbit/s forms the interconnection between the sources (Readout Dual Port Memory) and the destinations (switch to Farm Interface). The Event Manager collects the status and request of event filters and distributes event building commands (read/clear) to RDPMs

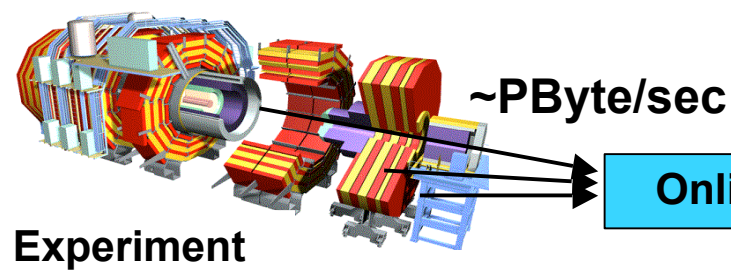
5 TeraIPS

EVENT FILTER. It consists of a set of high performance commercial processors organized into many farms convenient for on-line and off-line applications. The farm architecture is such that a single CPU processes one event

Petabyte ARCHIVE

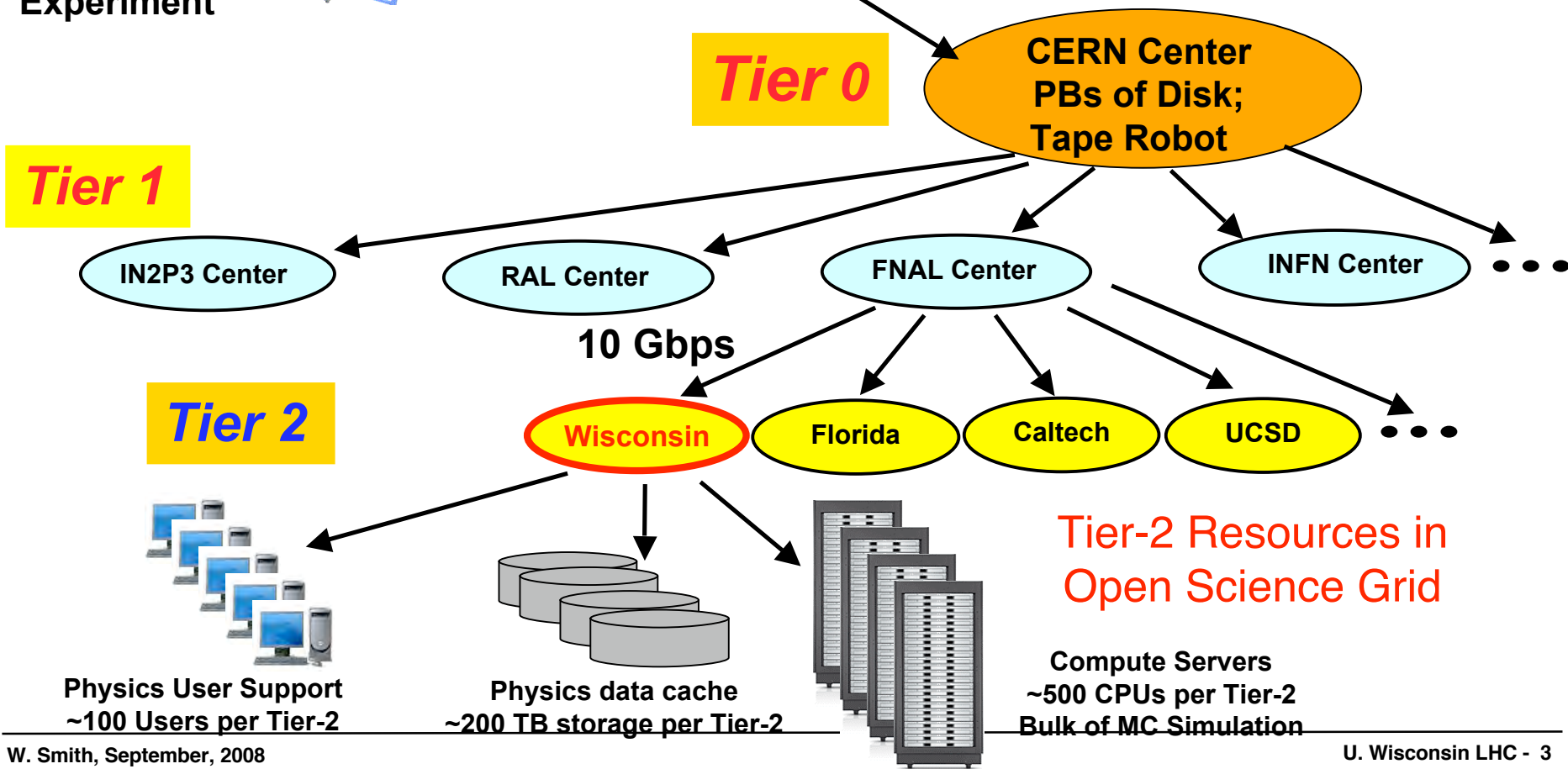


CMS Computing - Tier-2



CERN/Outside Resource Ratio \sim 1:2
 Tier0/(Σ Tier1)/(Σ Tier2) \sim 1:1:1

\sim 100-1500 MBytes/sec





CMS Detector



37 Countries, 155 Institutes, 2000 scientists (including about 400 students) October 2006

TRIGGER, DATA ACQUISITION & OFFLINE COMPUTING

Austria, Brazil, CERN, Finland, France, Greece, Hungary, Ireland, Italy, Korea, Poland, Portugal, Switzerland, UK, USA

TRACKER

Austria, Belgium, CERN, Finland, France, Germany, Italy, Japan*, Mexico, New Zealand, Switzerland, UK, USA

CRYSTAL ECAL

Belarus, CERN, China, Croatia, Cyprus, France, Italy, Japan*, Portugal, Russia, Serbia, Switzerland, UK, USA

PRESHOWER

Armenia, CERN, Greece, India, Russia, Taiwan

RETURN YOKE

Barrel: Czech Rep., Estonia, Germany, Greece, Russia
Endcap: Japan*, USA

SUPERCONDUCTING MAGNET

All countries in CMS contribute to Magnet financing in particular:
Finland, France, Italy, Japan*, Korea, Switzerland, USA

FEET

Pakistan China

FORWARD CALORIMETER

Hungary, Iran, Russia, Turkey, USA

HCAL

Barrel: Bulgaria, India, Spain*, USA
Endcap: Belarus, Bulgaria, Georgia, Russia, Ukraine, Uzbekistan
HO: India

MUON CHAMBERS

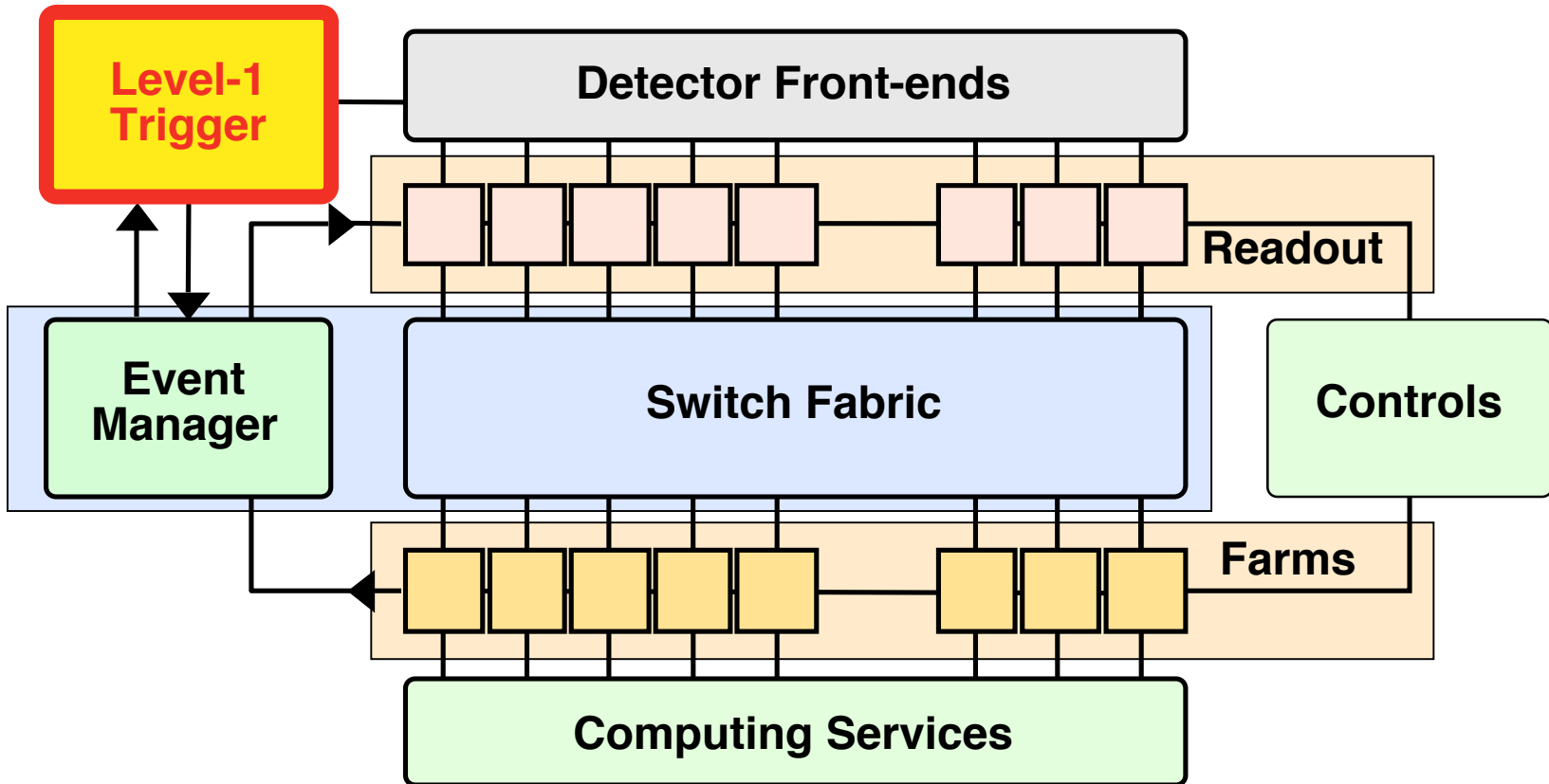
Barrel: Austria, Bulgaria, CERN, China, Germany, Hungary, Italy, Spain,
Endcap: Belarus, Bulgaria, China, Colombia, Korea, Pakistan, Russia, USA

* Only through industrial contracts

Total weight : 12500 T
Overall diameter : 15.0 m
Overall length : 21.5 m
Magnetic field : 4 Tesla



CMS Trigger & DAQ Systems



Level-1 Trigger

- LHC beam crossing rate is 40 MHz & at full Luminosity of $10^{34} \text{ cm}^{-2}\text{s}^{-1} \rightarrow 10^9$ 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



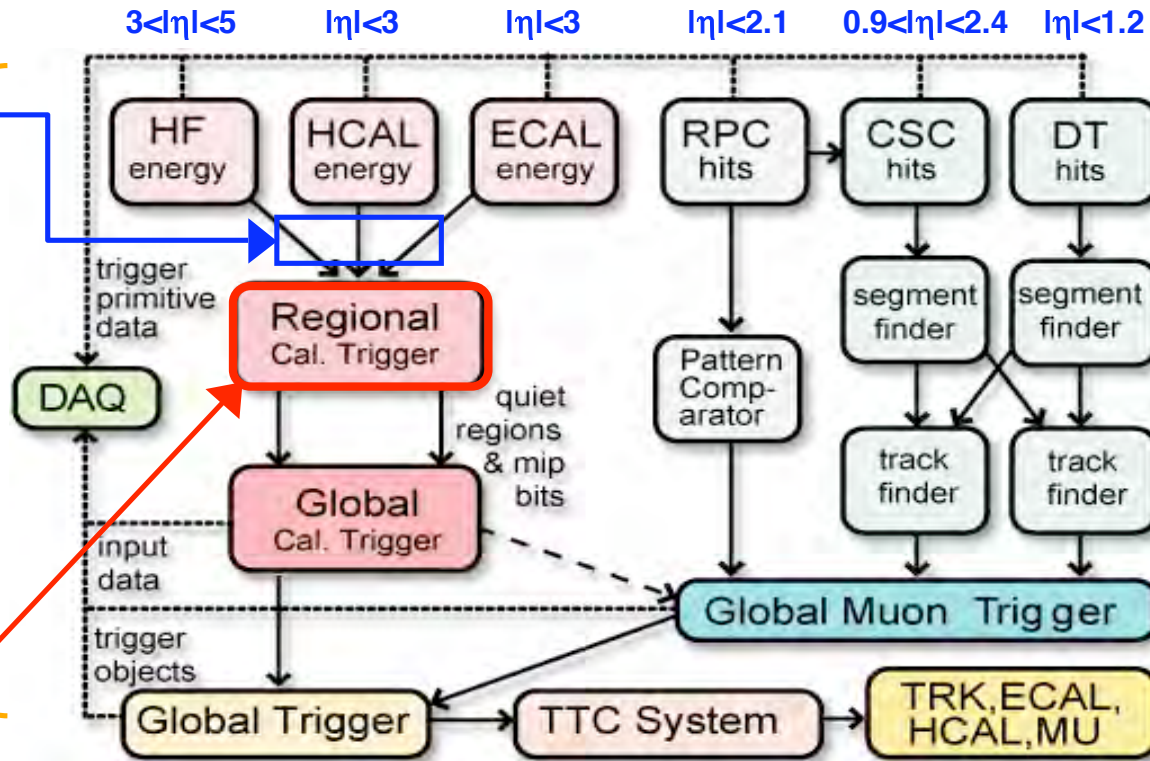
The CMS Level-1 Trigger & Regional Calorimeter Trigger



Only calorimeter and muon systems participate in CMS L1

4K 1.2 Gbaud serial links Cu cables

e/γ, jets, E_T, H_T, jet counts



muons

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

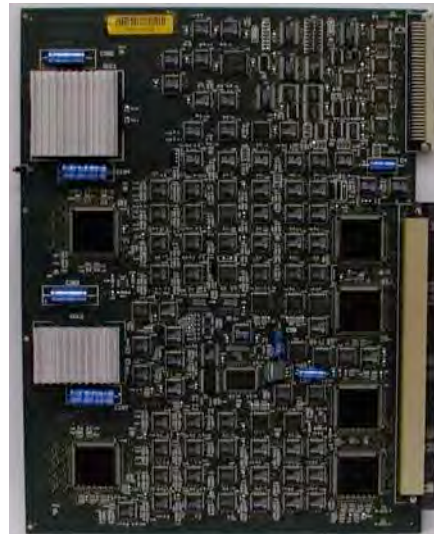


Calorimeter Trigger Crate

built by U. Wisconsin



One of 18 160 MHz systems processing 0.4 Tbits/s.





UW Designed Endcap disks support muon chambers and calorimeters



UW Tier-2 Computing Center

