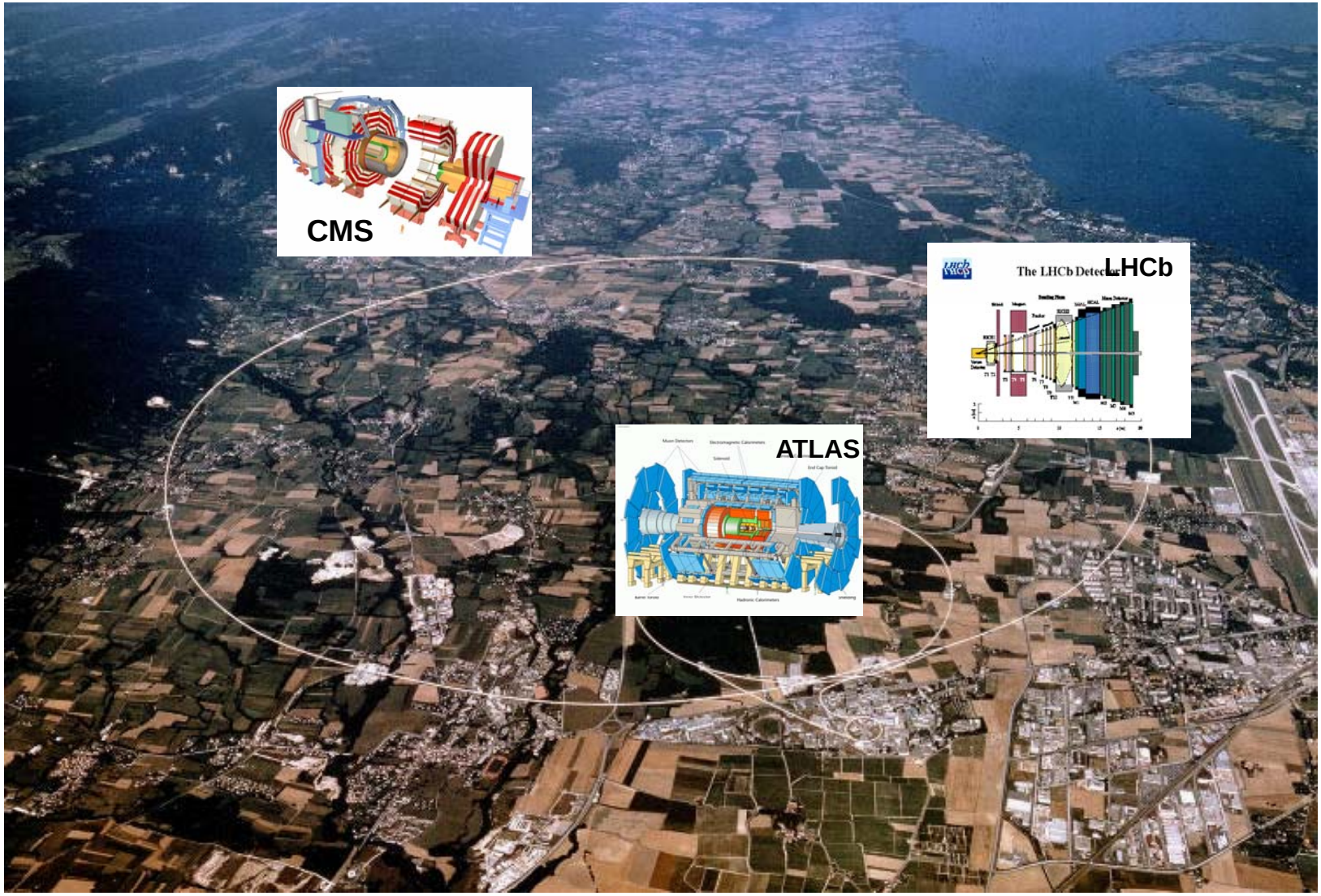
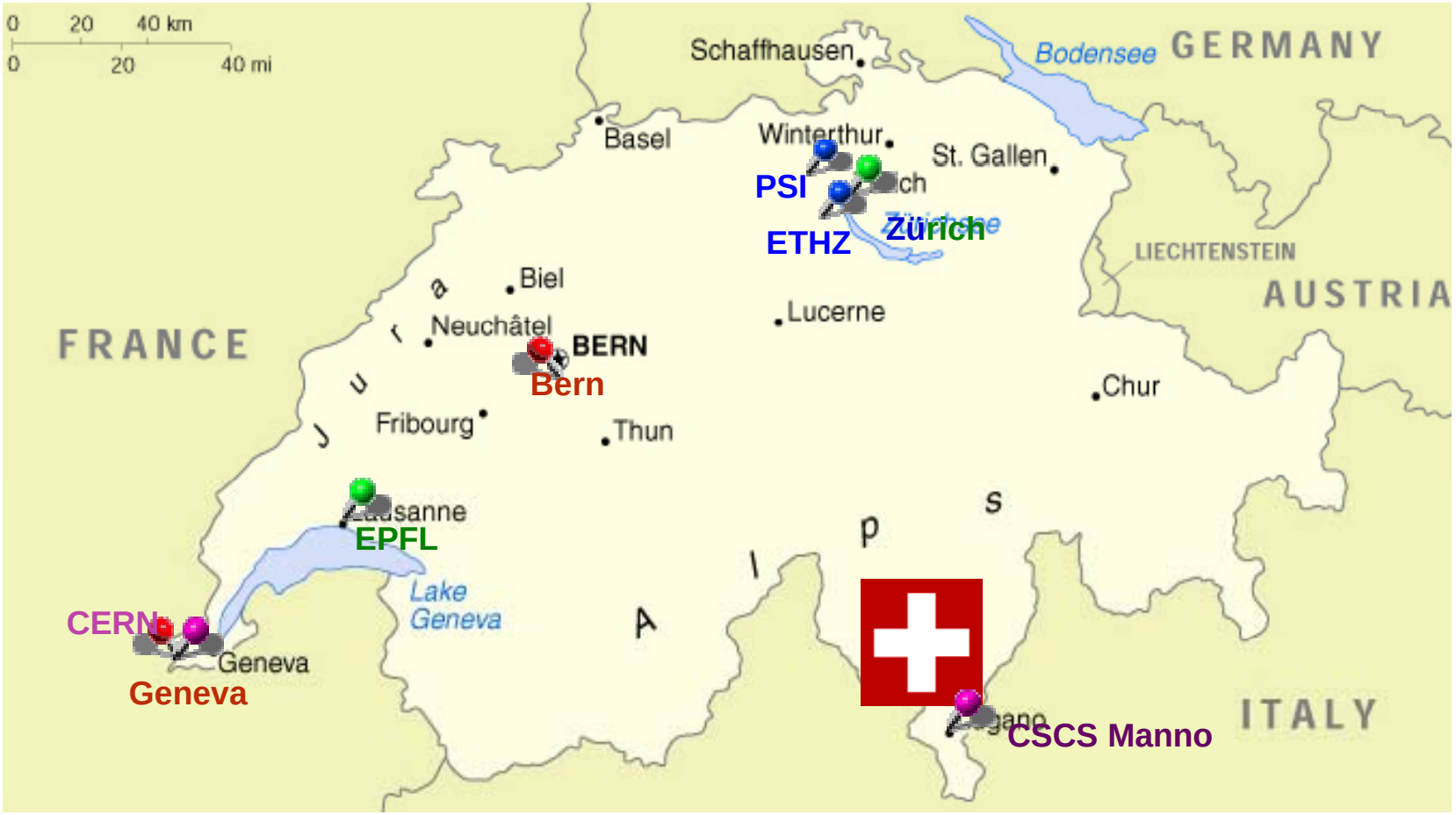
The LHC and Swiss Participation



Large participation by Swiss institutes in machine and 3 of the LHC experiments
ATLAS, CMS and LHCb

The LHC and Swiss Participation – support at federal and cantonal level



ATLAS – Geneva, Bern

CMS – ETHZ, PSI, Zürich

LHCb – EPFL, Zürich

Other – CERN, CSCS Manno

Why Manno?

Why Manno?

Vast CPU and disk requirements for LHC experimental analysis *beyond the scope of individual institutes* – requires international collaboration on extended timescale

Particle physics implementation of GRID (LCG)

- Decision by CHIPP LHC institutes to work together on computing issues
- Agreement with CSCS to provide infrastructure in "T2+T3" framework

Switzerland as co-host to the CERN LHC

- **CERN is now the leading world accelerator laboratory**
  - LHC experiments will dominate particle physics research in next decade
  - LHC experiments expect to collect first data (10 TeV) in Summer 2008
  - Tremendous opportunity for Swiss research groups (~350 physicists and doctoral students associated to CHIPP in Switzerland)

- **The benefits for Switzerland are scientific, cultural and economic**
  - Investment in contracts and services in Switzerland
  - Technology transfer to industry and training
  - Association with new technologies (e.g. GRID)
- **LHC machine and LHC experiments are strongly supported**
  - Federal, cantonal and institute level
  - Financial, advisory and "in-kind" support
  - This has enabled substantial contributions to both LHC and Swiss LHC groups Hopefully an effect on quality of research
  - **Support includes that of CSCS**

A. Note some contributions to the LHC machine in addition to CH budget contribution to CERN
B. CH contribution to and status of the experiments
C. Analysis and computing in CH for LHC

Switzerland as co-host to the CERN LHC

- **Special financial contributions (non-inclusive) related to LHC**
  - 25 MCHF (transfer tunnels)
  - 11 MCHF (indexation 1998-05)
  - 12 MCHF (LHC test beam at PSI) 12 MCHF
  - 14 MCHF (loan interest redemption)
  - 28 MCHF (infrastruction, upgrade, CLIC etc

  } 90 MCHF

- **Contracts (4.4% of 2936 MCHF total construction machine)**
  - 43 MCHF (magnet elements)
  - 19 MCHF (cryogenics)
  - 13 MCHF (accelerator components)
  - 55 MCHF (civil eng + exp. services)

  } 130 MCHF

- **Companies involved (non-inclusive)**
  - ABB Power Automation
  - Forbeton Bohr SA
  - MGC Ltd
  - Zschokke SA
  - Cicorel SA
  - KabelwerkeBrugg
  - Nexans (Cortaillod)
  - EMPA
  - Casutto&Co
  - Leica SA
  - Huber &Suhner AG
  - Luwa SA
  - Cryogenic SA
  - …….

Enormous contributions and benefits

The LHC experiments – contribution of Swiss Groups

Experiment	Institute	# physicists	# doctoral students	~ # technical support	CORE[1] construction (MCHF)
CMS 38 countries 184 institutes	ETH Zürich PSI UniZh	15 12 5	13 7** 4	22 3 2	92
ATLAS 37 countries 167 institutes	UniGe UniBe	15 7	10 3	9 4	23
LHCb 15 countries 49 institutes	EPF Lausanne UniZh	10 5	10 3	8 2	8
Total		69	50	50	123

In addition :

- CUS has created a « CHIPP Priority Program for LHC Physics Analysis » with 10 post-doctoral positions in the period 2008-2012
- Rules of FNRS PRO*DOC program modified to be compatible with practical requirements of the LHC program.
- Request made to FNRS for ~10 doctoral positions.

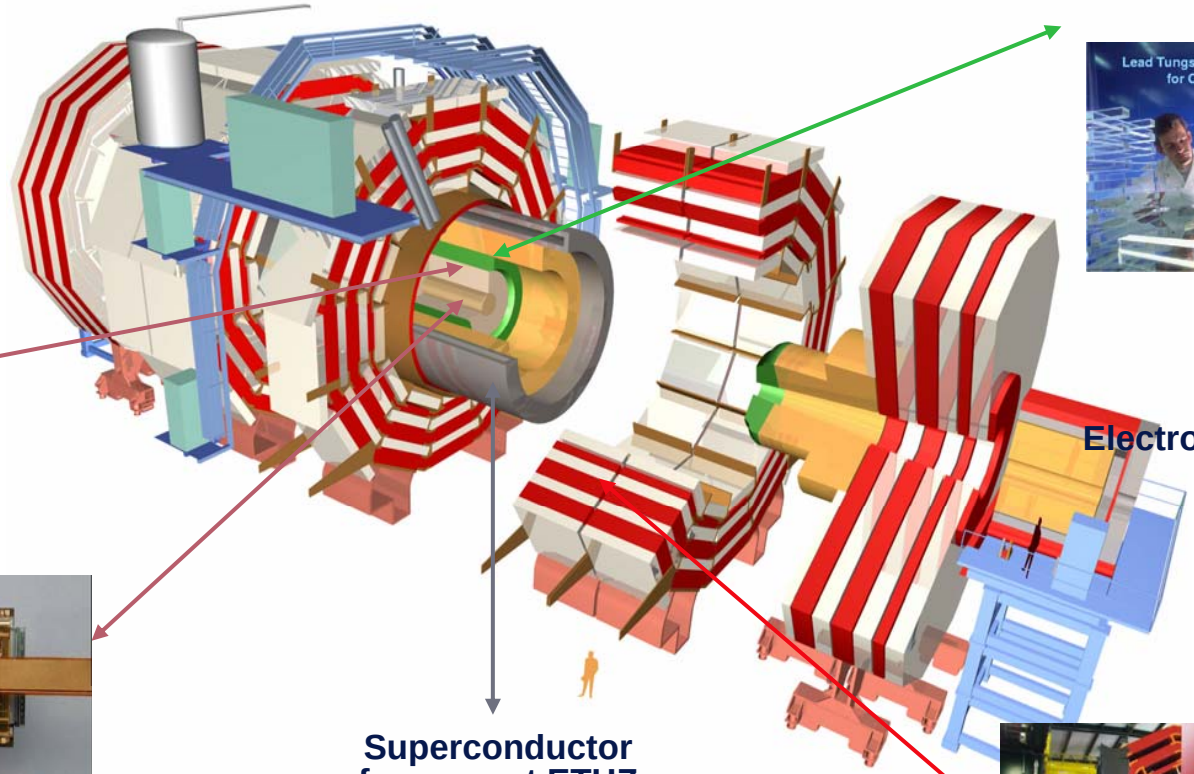
[1] Federal and Cantonal funding – computing not included

** 5 students co-financed with ETHZ, 2 students co-financed with UniZh

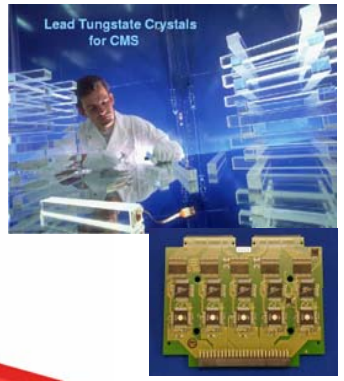
The LHC experiments – CMS

CMS Detector:
Weight: 12'500 t
Diameter: 15 m
Length: 21.6 m

Magnetic field: 4 T

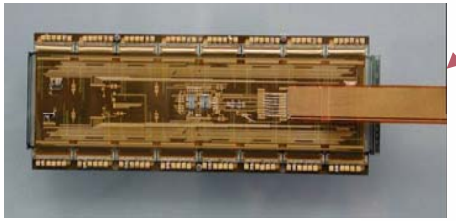


Crystal calorimeter ETHZ



Electronics ETHZ, PSI

Silicon strips ETHZ



Pixel detector
PSI, ETHZ, UniZh

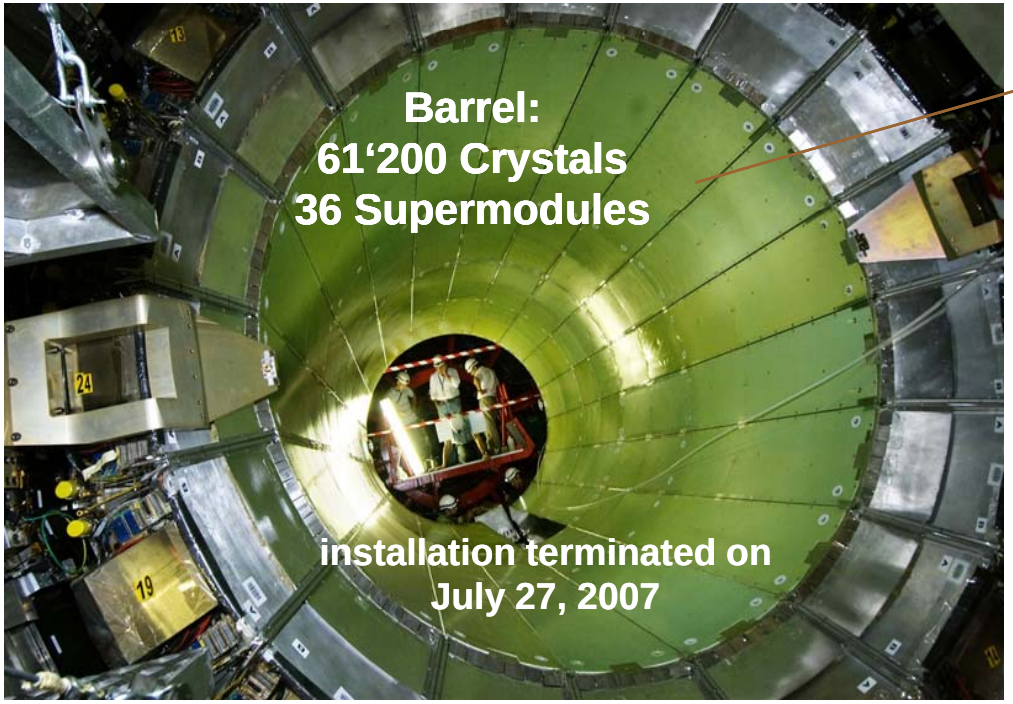
Superconductor for magnet ETHZ

Organization of magnet procurement ETHZ

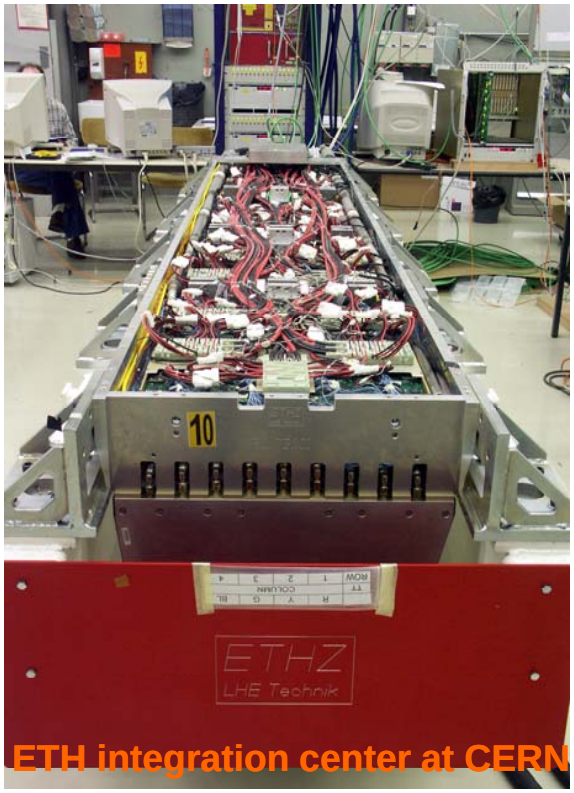
Software & Physics

ETHZ, PSI, UniZh

ETH Zurich: crystal, electronics and electronics integration
PSI: Photo detector for barrel (APDs)



1 Supermodule:
1‘700 $PbWO_4$ crystals



Lead Tungstate crystals ($PbWO_4$)
Front face. 2.2x2.2cm^2 , Length 23 cm

CMS – Lowering magnets into the cavern

Lowering of central and heaviest element (~ 2000 t) on February 28, 2007

Central part including magnet (2000 tons) (as heavy as 5 Jumbo jets)

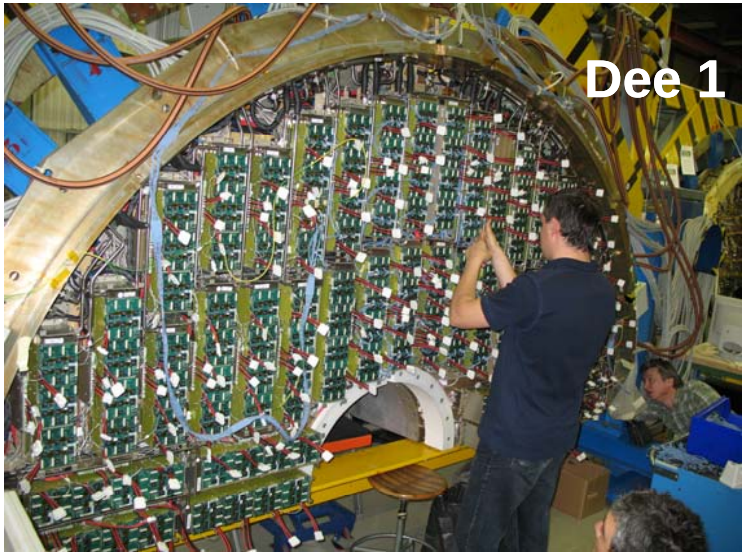
Cool-down and mapping of the 4Tesla magnet completed

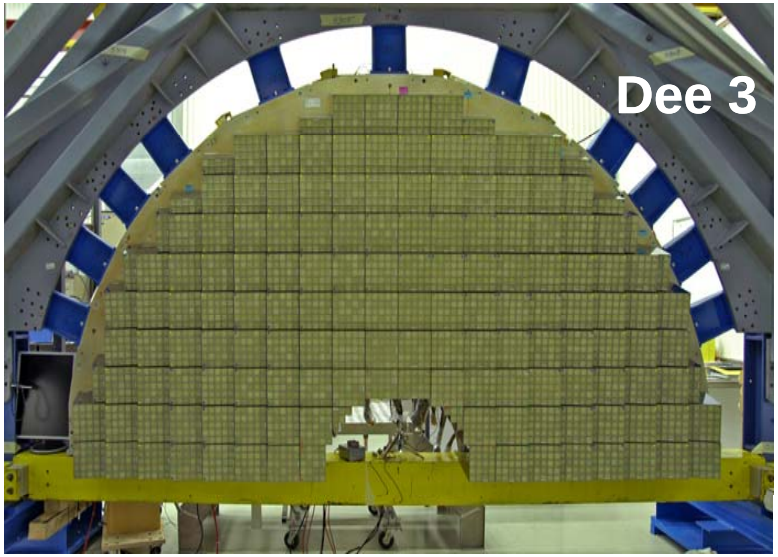
Last element lowered on 22 Jan 2008.

CMS – ECAL Endcap Construction

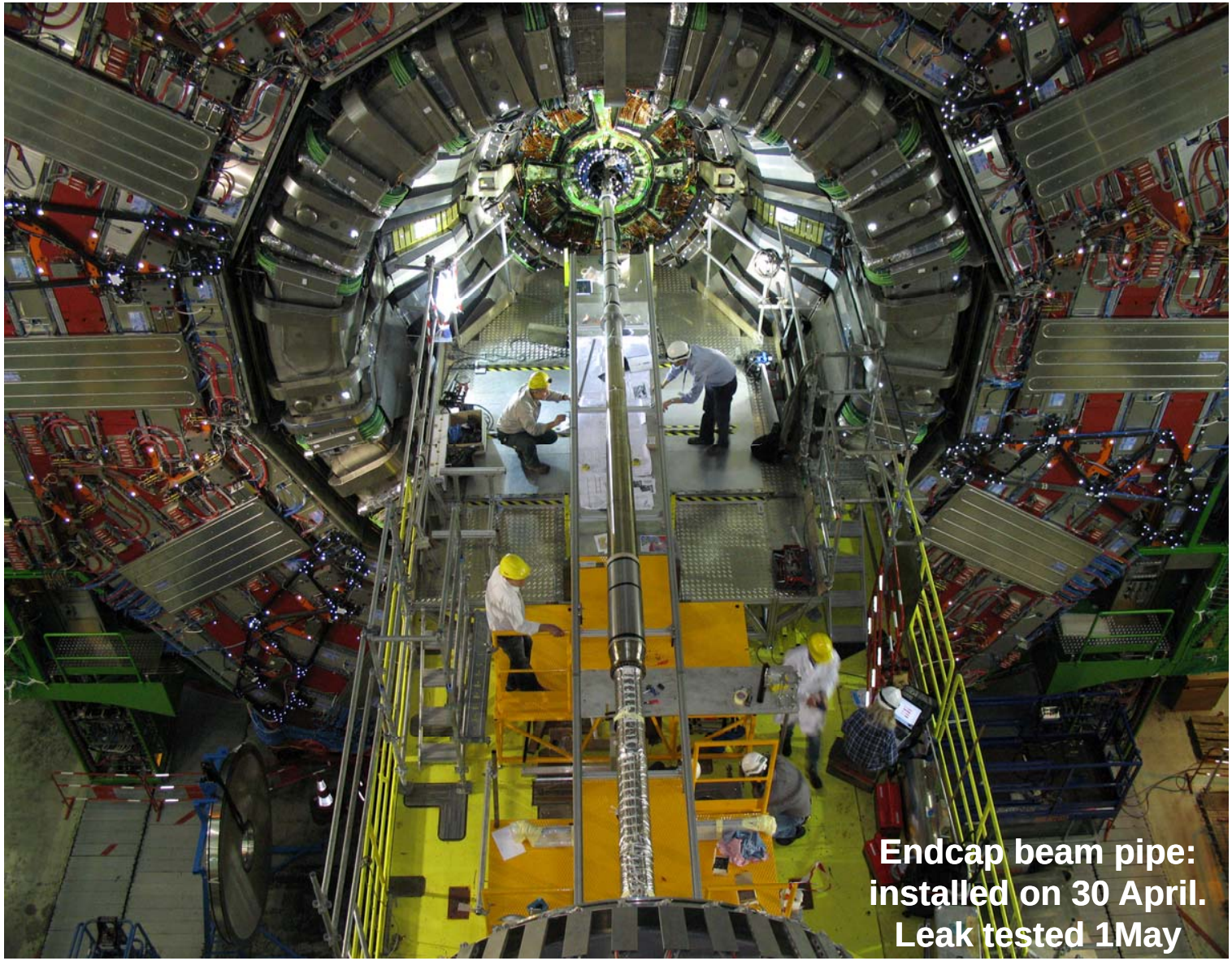
ETH Electronics Integration Center (bld 867):

1st EE ready for installation by mid-June.
Last EE Dee scheduled for week 30.



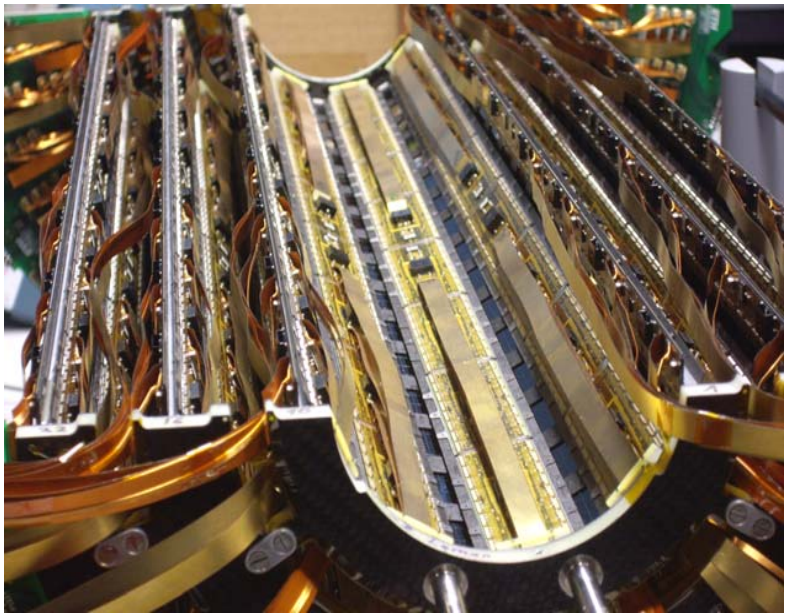


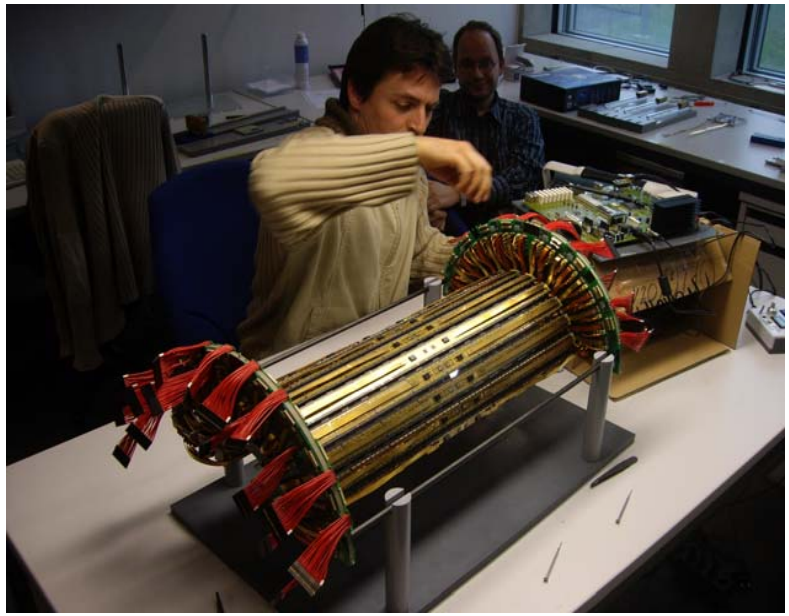
CMS – Endcap beam pipe installation



CMS – Barrel Pixel Mechanics and Assembly

- Collaboration UniZh and PSI
- Silicon pixel detector close to the beam interaction region
- Mechanics and assembly completed 12 March 2008





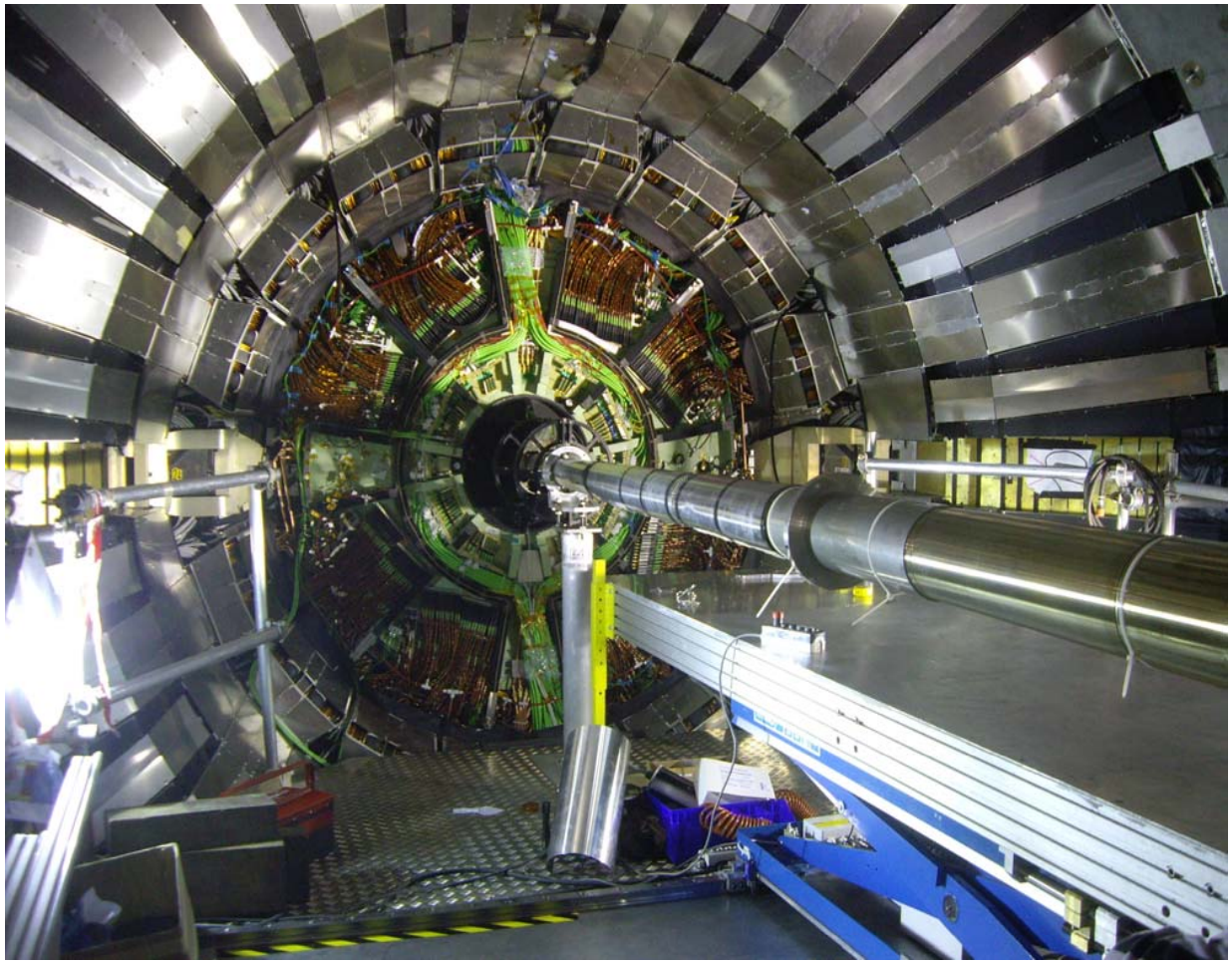
Emphasis in CH contributions on silicon-based tracking detectors

CMS – Pixel Detector

Pixel detector at PSI May 2008

- Fully assembled after the supply tube and the services added
- Installation time of ~1 week prior to beam closure
- Installation of mockup detector into CMS made
- In parallel development of DAQ, DCS etc ongoing

CMS – Barrel Pixels

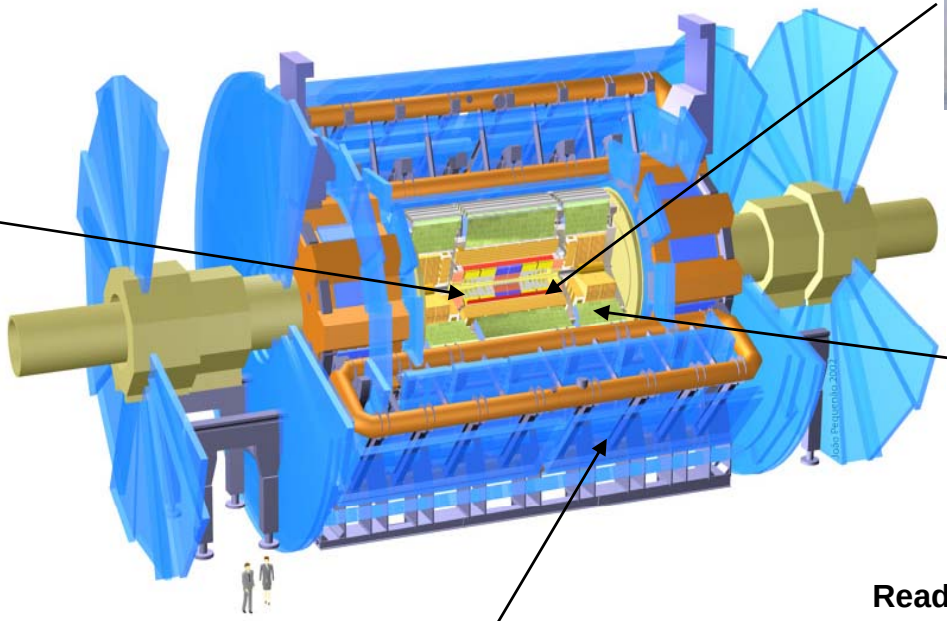


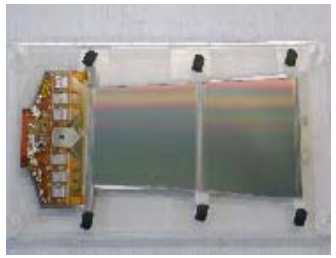
Close-up of PPO, beam pipe and installation table during mockup installation procedure for the barrel pixels.

The LHC experiments – ATLAS

The ATLAS Detector
Weight: 7000 tons
Dimensions: 46m x 22m x 22m
Magnetic Field: 2.6 T (solenoid) and 4.1 T (toroid)

Tracker Support Structure Geneva





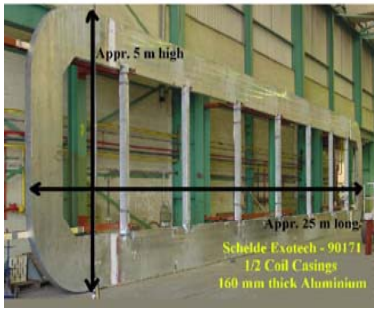
Semiconductor Tracker Geneva

TDAQ- Trigger and Dataflow Bern and Geneva

Readout Electronics (ROD) for Calorimeters Geneva

Online and Offline Software

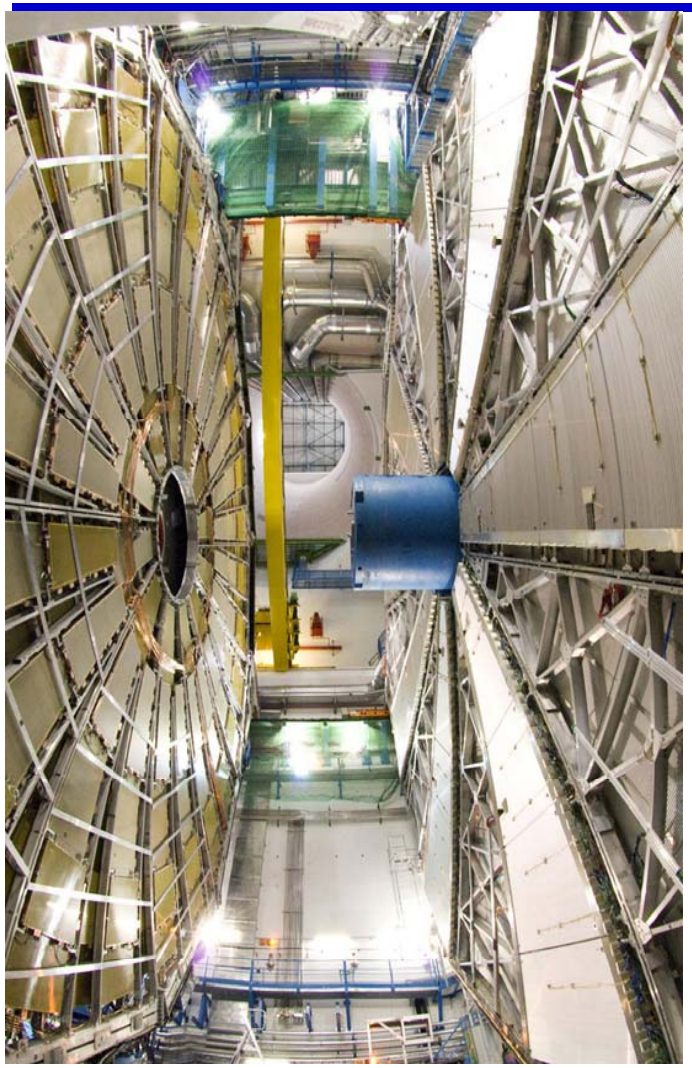
Bern and Geneva



Superconductor and Casings for Barrel Toroid Coil Bern and Geneva

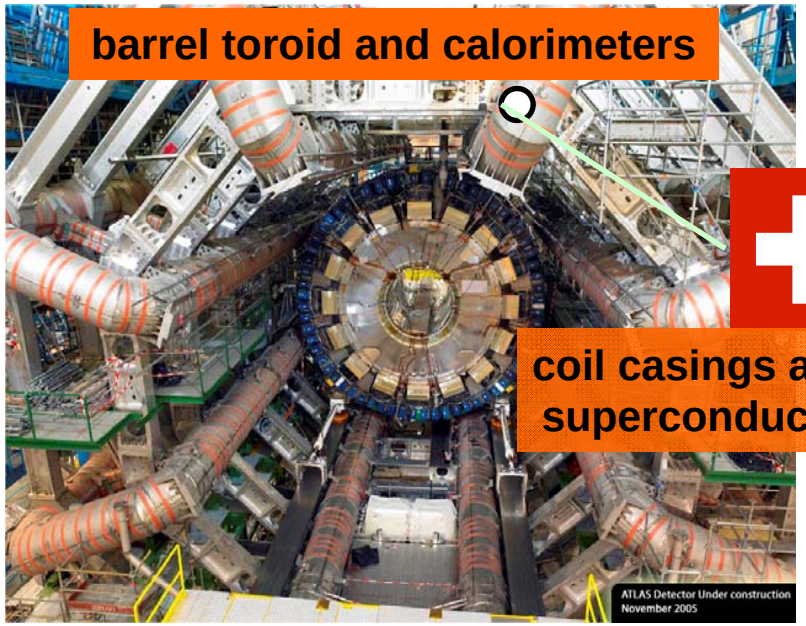
Physics and Computing Preparations

The LHC experiments – ATLAS integration



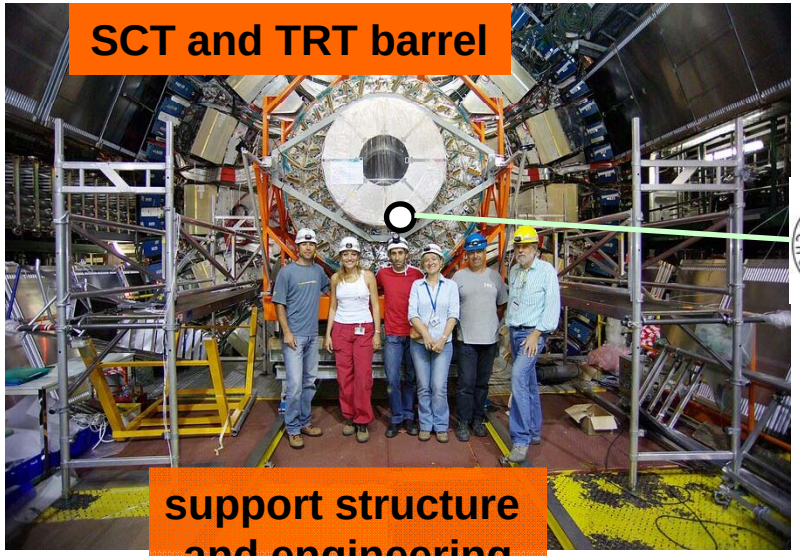
big TGC and MDT muon wheels

barrel toroid and calorimeters



coil casings and superconductor

SCT and TRT barrel



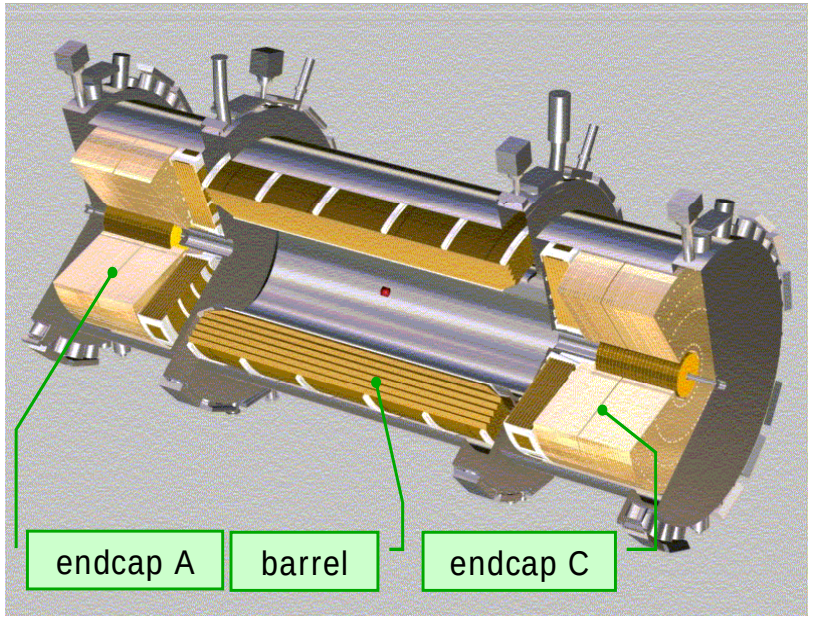
support structure and engineering

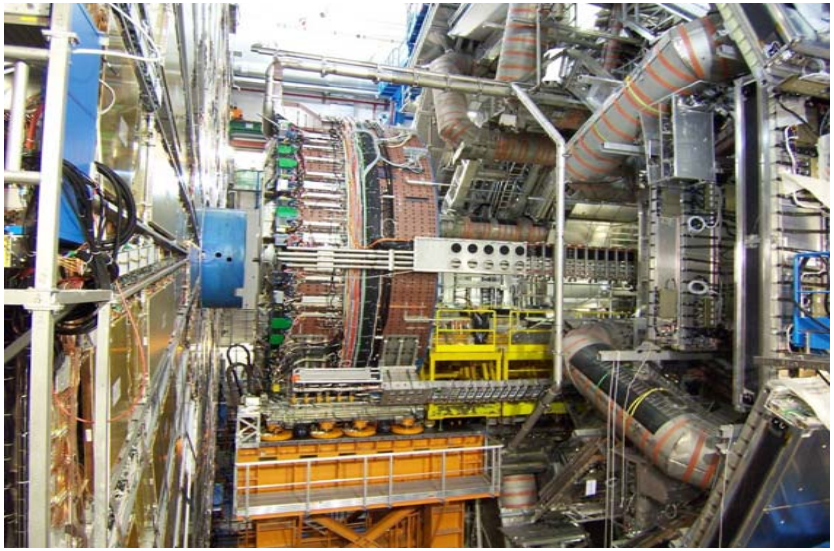
MDT=Monitored Drift Tubes

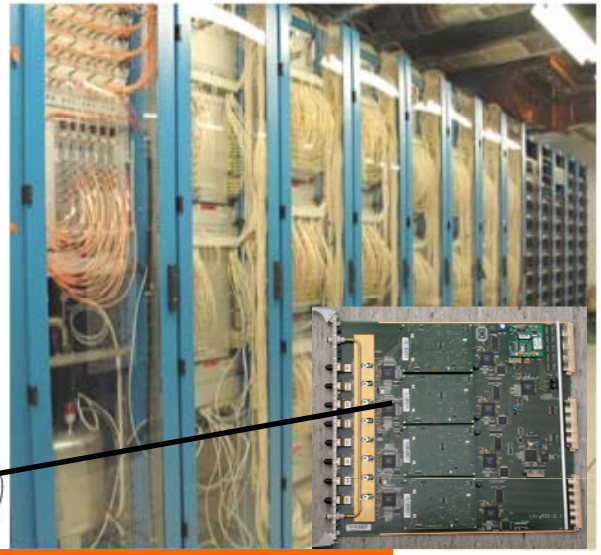
bers

The LHC experiments – ATLAS Liquid Argon calorimeter

- All 3 cryostats cold
- Temperature stable in time, mean <20 mK
- Liquid purity stable and<<0.5ppm(barrel <210 ppb, EC <150 ppb)
- Controls, safety systems operational

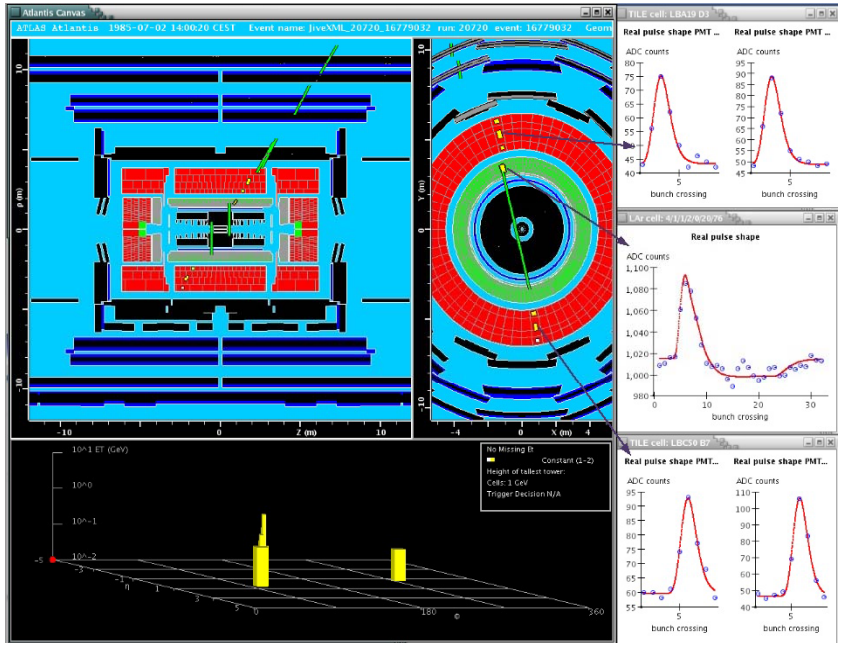




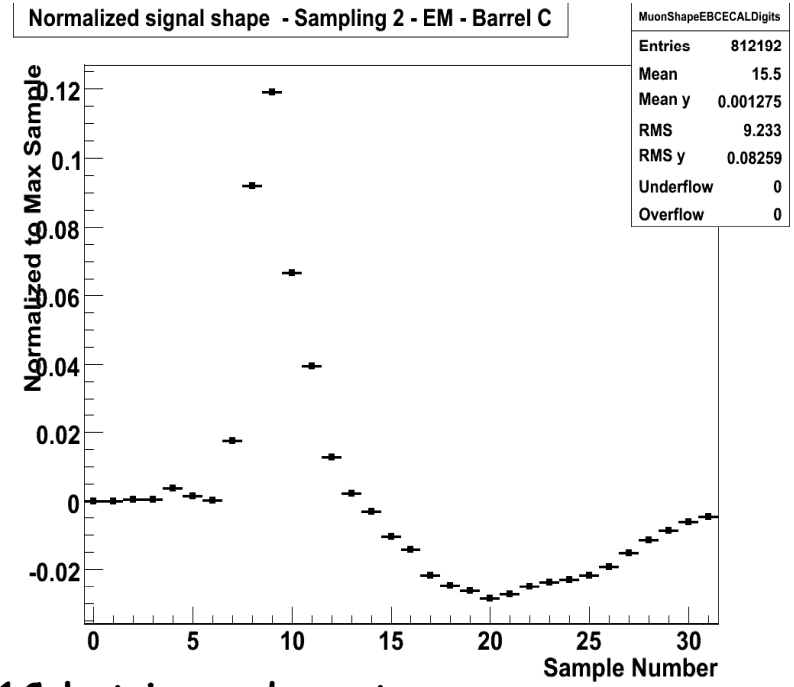


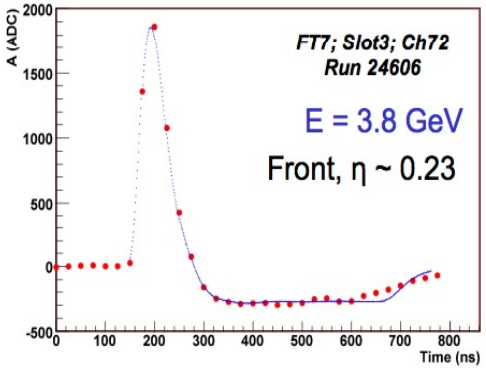
245 ROD boards for LArand tile calorimeters

ATLAS – LAr calorimeter cosmic tests



- First data taking with the full LAr detector (100%)
- Many parameters already available in the online monitoring
  - Digits, Noise, Timing, Cells, Clusters





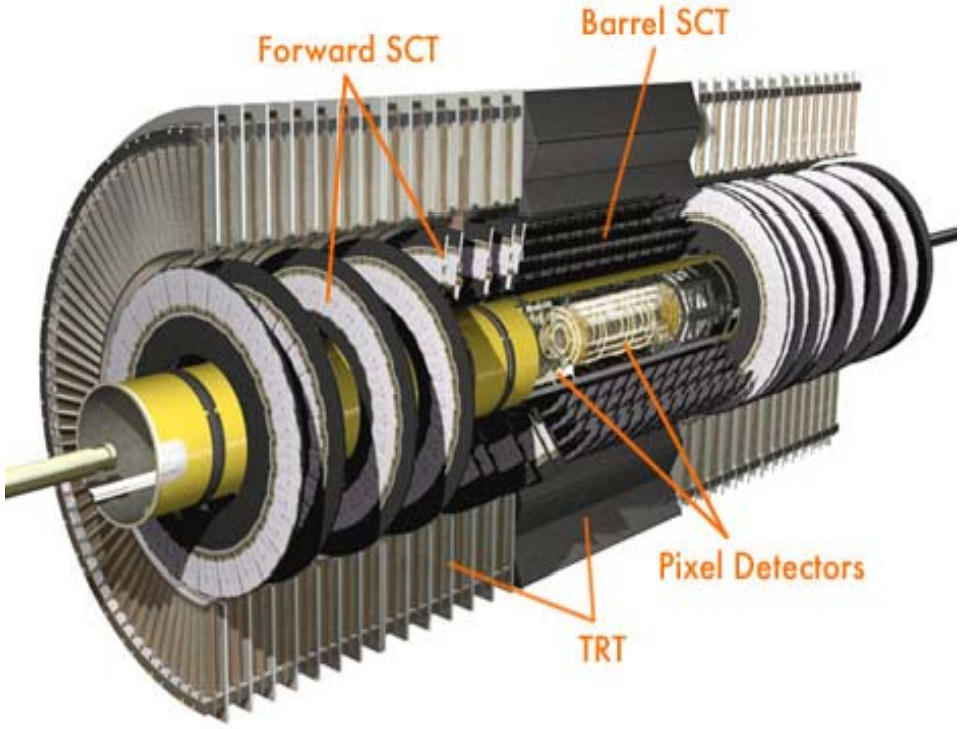
Single cosmic muon pulses fitting very well to the predicted pulse shape

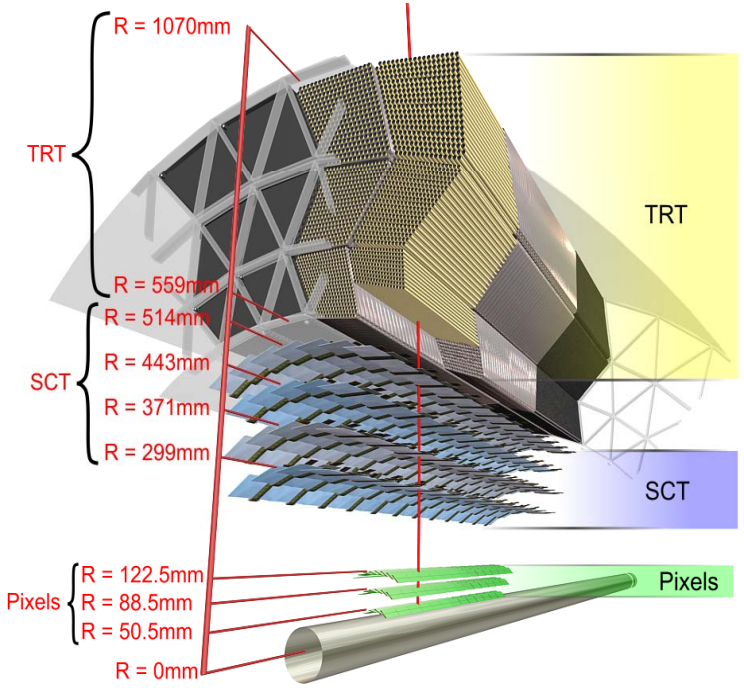
LVL1Calo triggered events:

Averaged cosmic muon pulse shapes (online monitoring plot, full Barrel C averaged)

Shows good timing achieved over the whole detector

ATLAS – Inner Detector and Silicon Tracker (SCT)

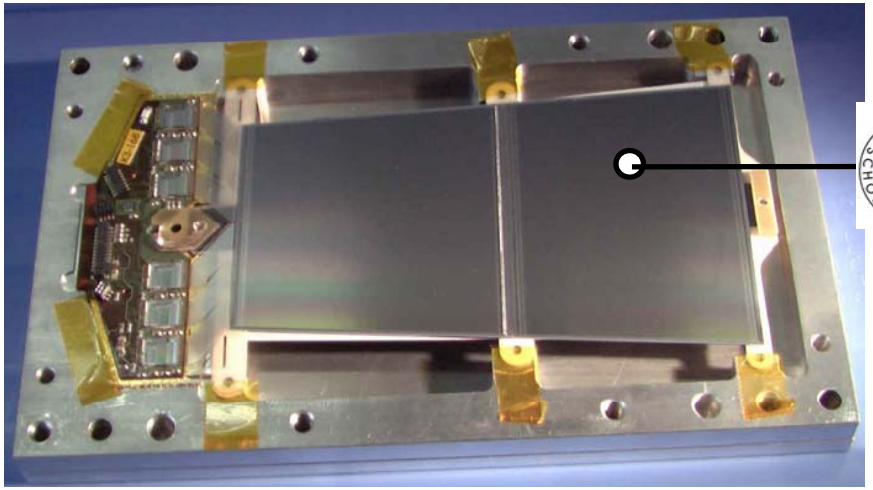




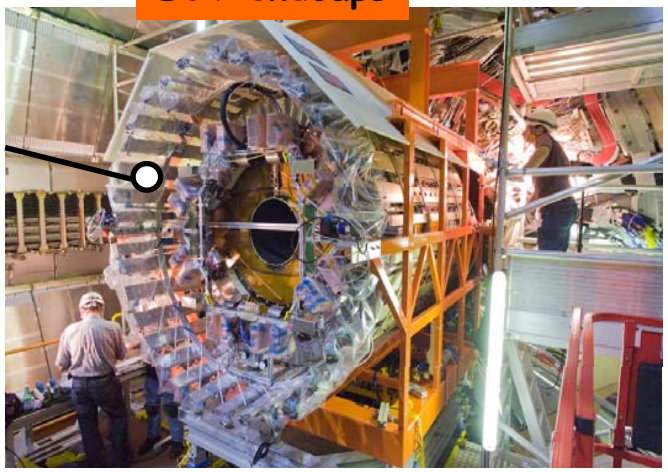
All detector components installed:

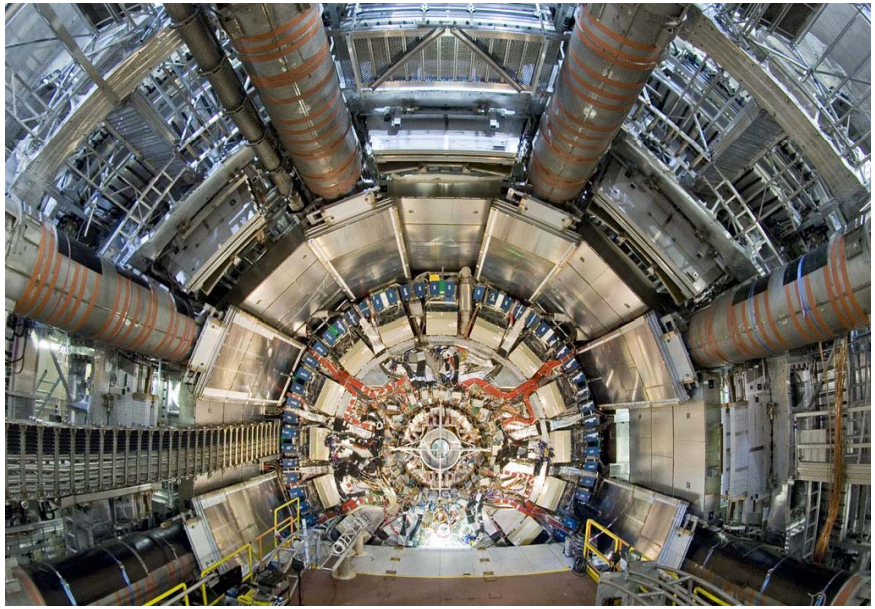
- **Barrel SCT + TRT**
- **2 End-Caps SCT + TRT**
- **Full pixel detector + Be beam pipe**
- **Commissioning of ID in progress**

ATLAS – Inner Detector and Silicon Tracker (SCT)



SCT endcaps

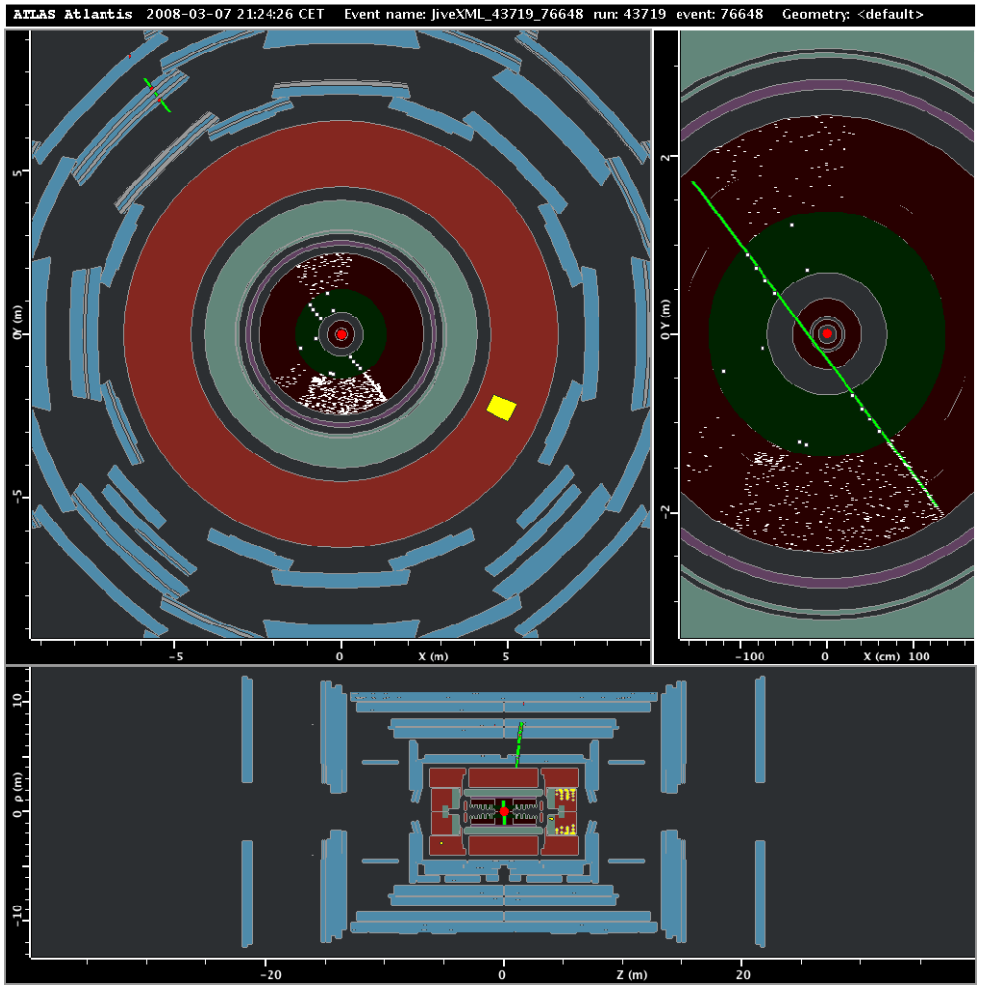


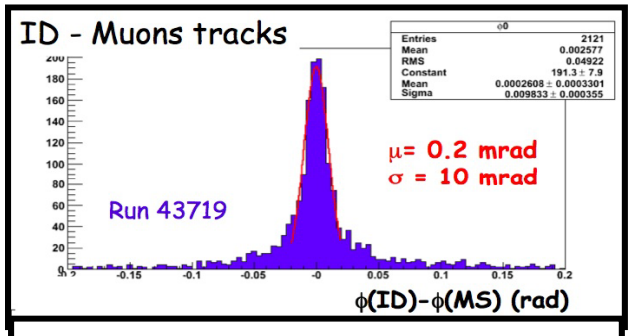


650 out of 2000 forward silicon modules
mechanical engineering detector slow control

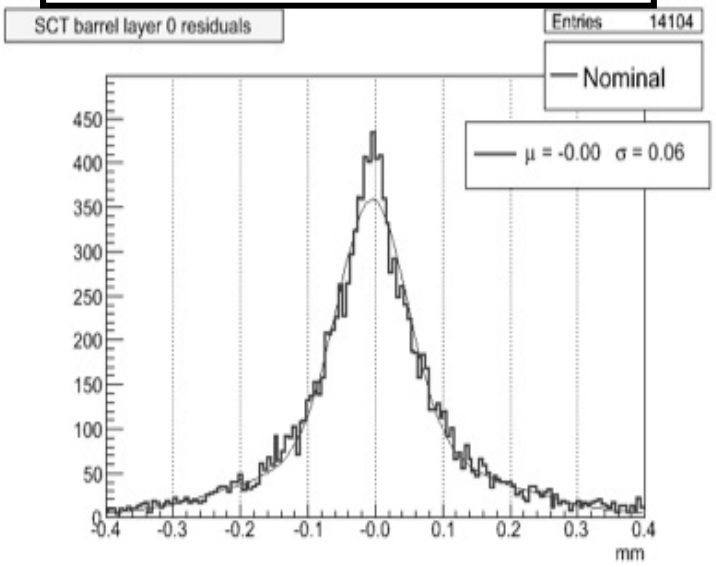
SCT surface commissioning:
only 0.3% dead channels

ATLAS - SCT Commissioning





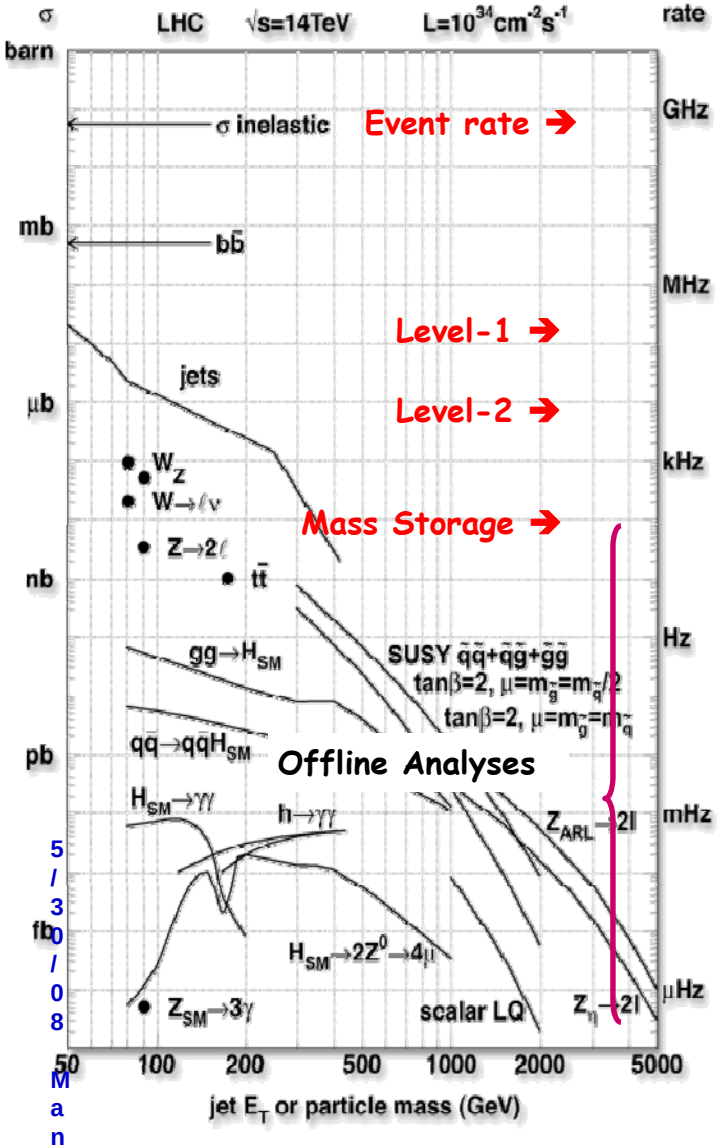
Phi difference SCT+TRT, RPC track segment



Run first alignment checks ~ 5000 tracks

SCT residuals (GlobalChi2)σ~65μm without alignment.

ATLAS and CMS – Expected Trigger Rates



Manno

- ⌘ Bunch crossing 40 MHz
- ⌘ σ total 70 mb
- ⌘ Event rate ~1 GHz
- ⌘ Number of events/BC ~25
- ⌘ Number of particles/event ~1500
- ⌘ Event size ~1.5 MB
- ⌘ Mass storage rate ~200 Hz

- Need to have trigger of high performance
  - 6 orders of rate reduction
  - complex events and 140 M channels

- Level-1: hardware based at 40 MHz
- Level-2: software based at 100 kHz
- Level-3: event filter at 3 kHz
- Storage at 100-200 Hz

} PC farms

- 3 Petabytes per year raw data for ATLAS
- Similar for CMS and LHCb

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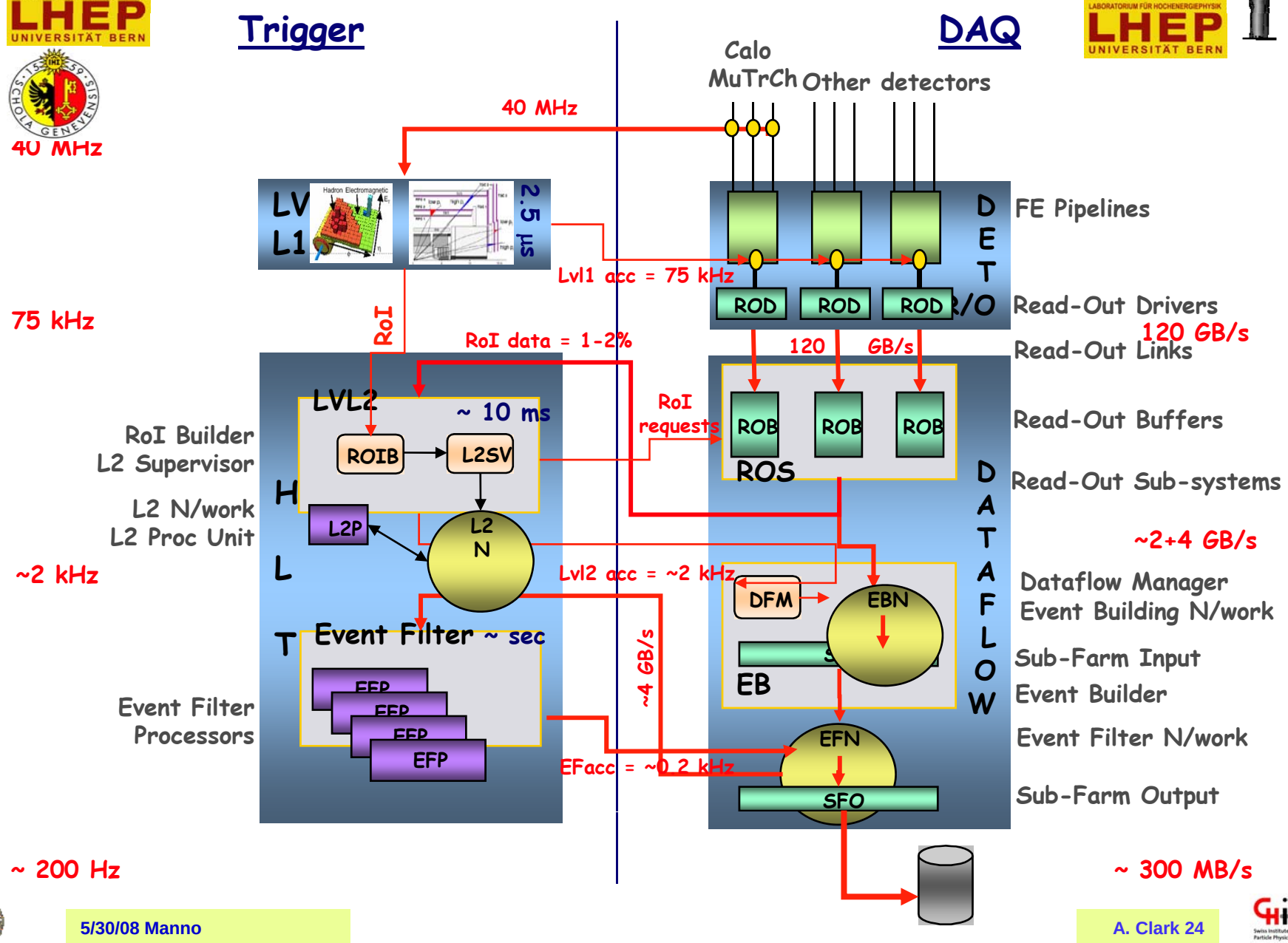
} strongly involved in trigger

ATLAS – Trigger and Data Acquisition



ATLAS – DAQ and Event Filter Hardware

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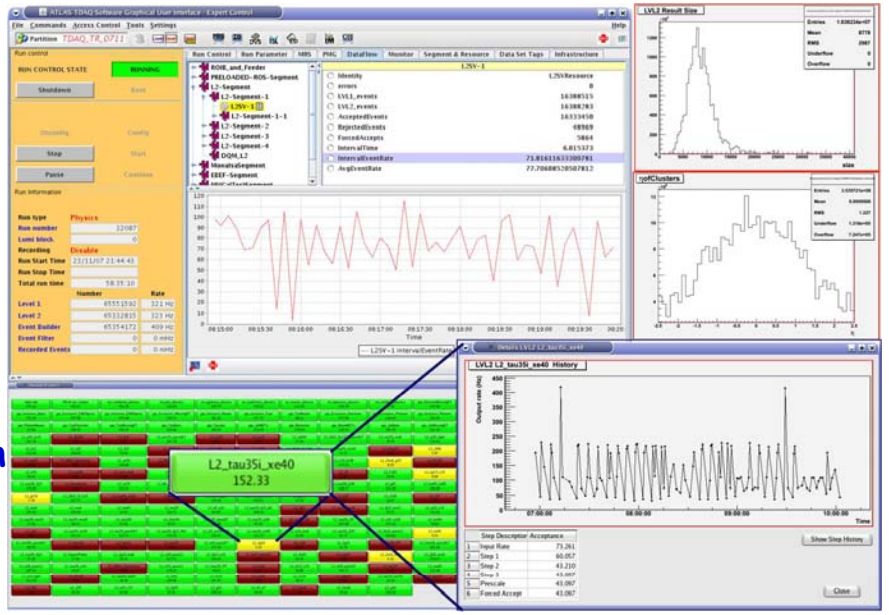
Hardware Installation and Thru-put



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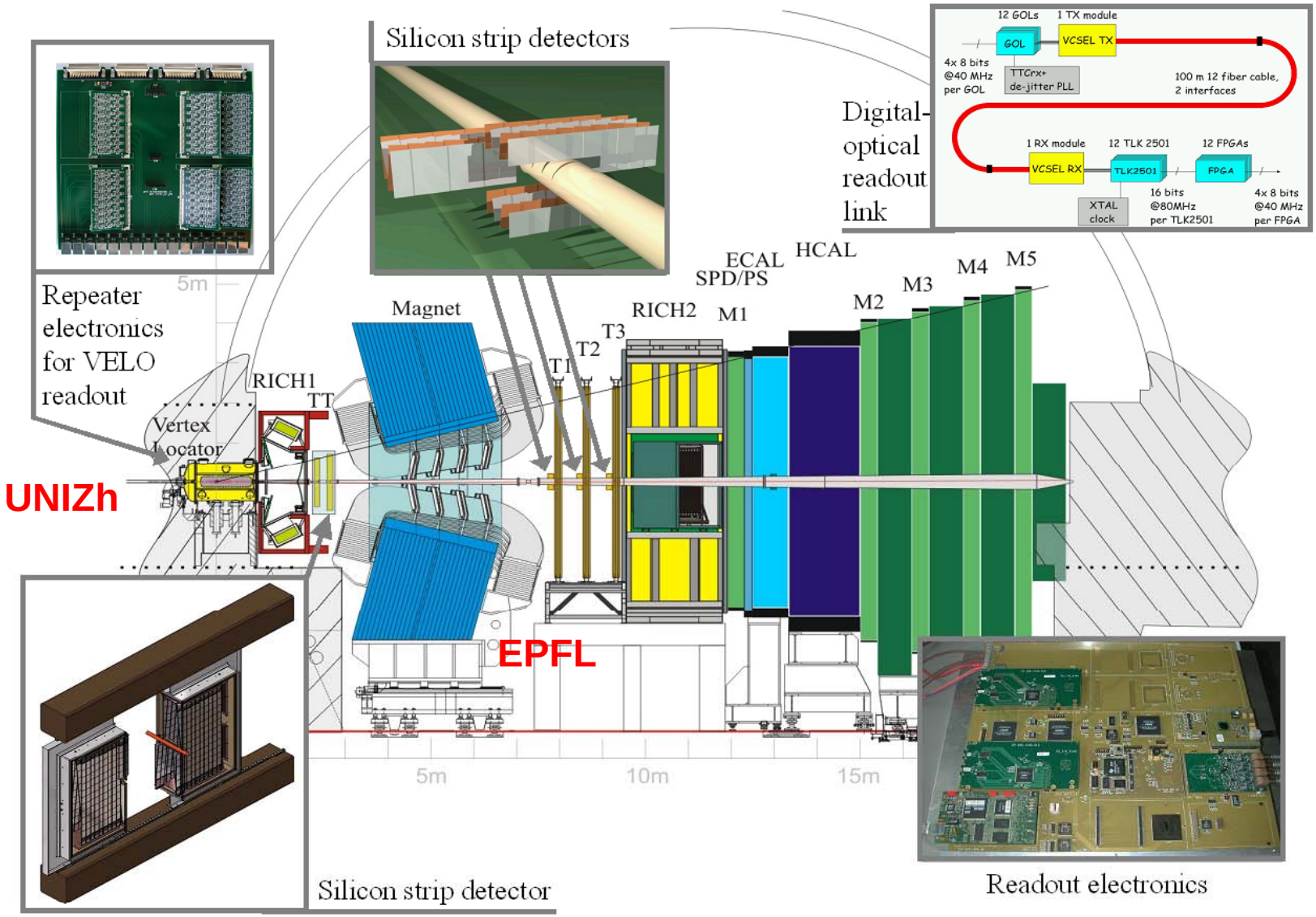
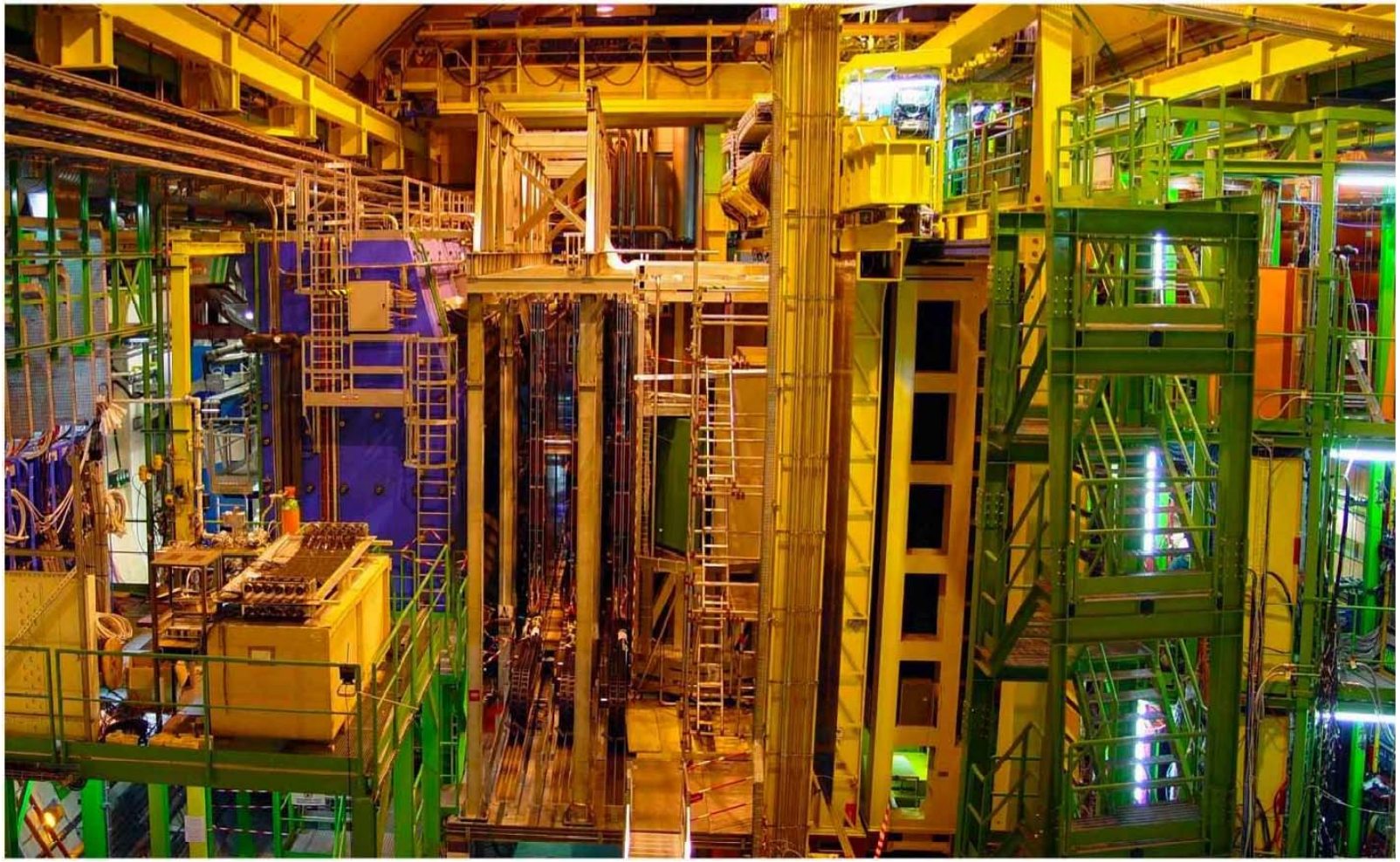
- Many Swiss HLT activities:
  - steering framework development
  - persistency of trigger information
  - level-2 calorimeter trigger calibration
  - $E_T$miss trigger development
  - trigger menus for physics in "express stream"
  - online integration of HLT algorithms

The LHC experiments – LHCb

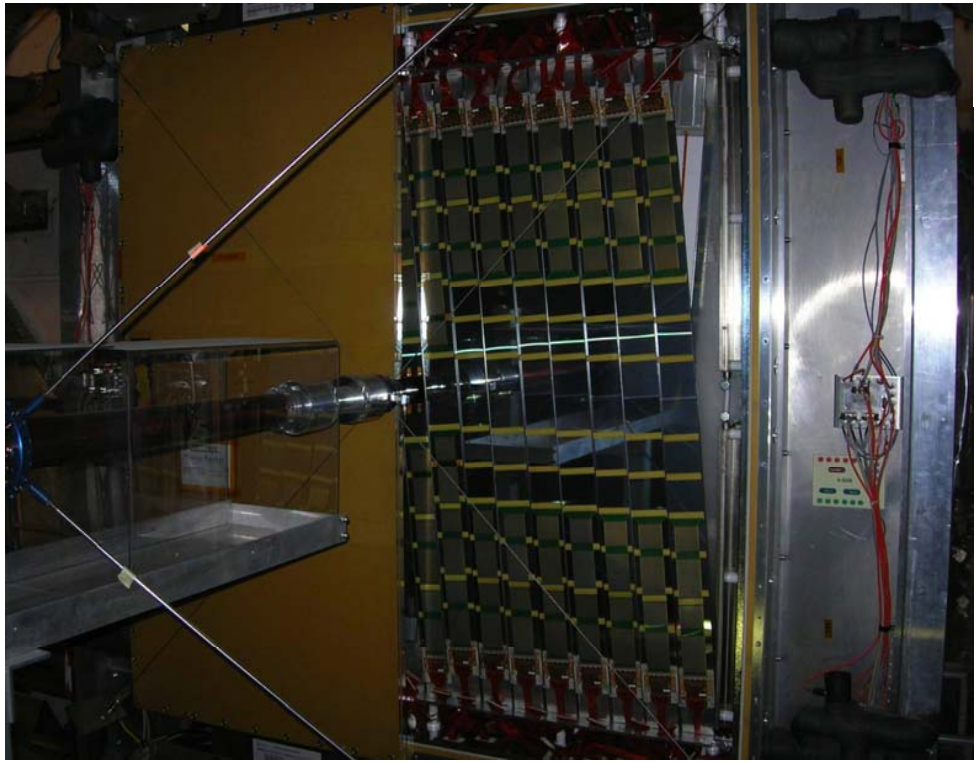


The LHC experiments – LHCbExperimental Area IP8

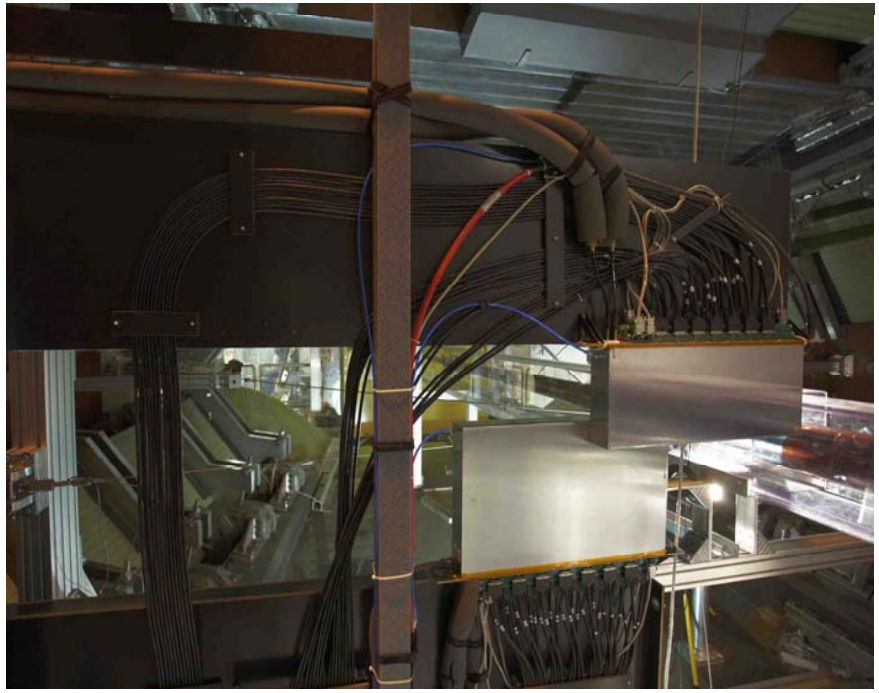


Detector installation completed
(except the first Muon Station not needed for the 2008 run)

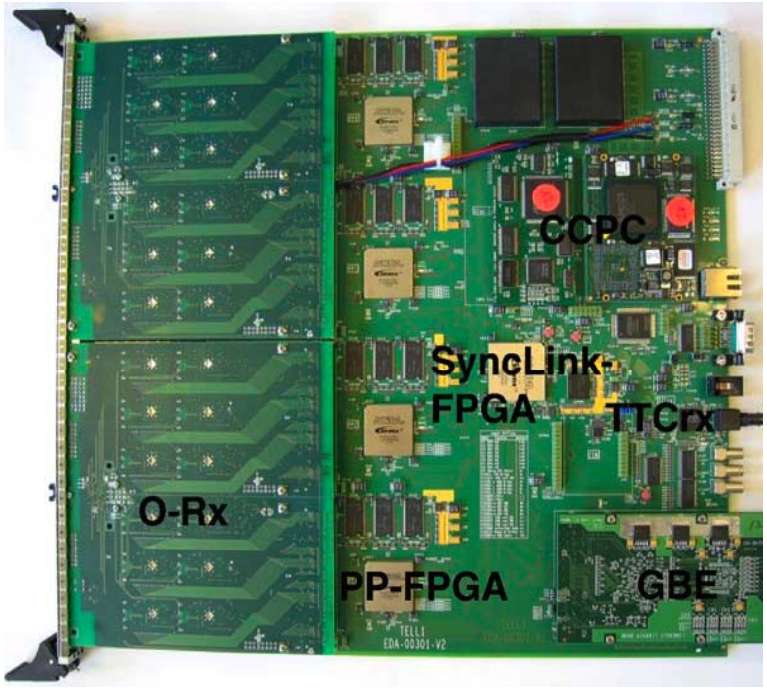
LHCb – TT large surface silicon tracker by UniZh



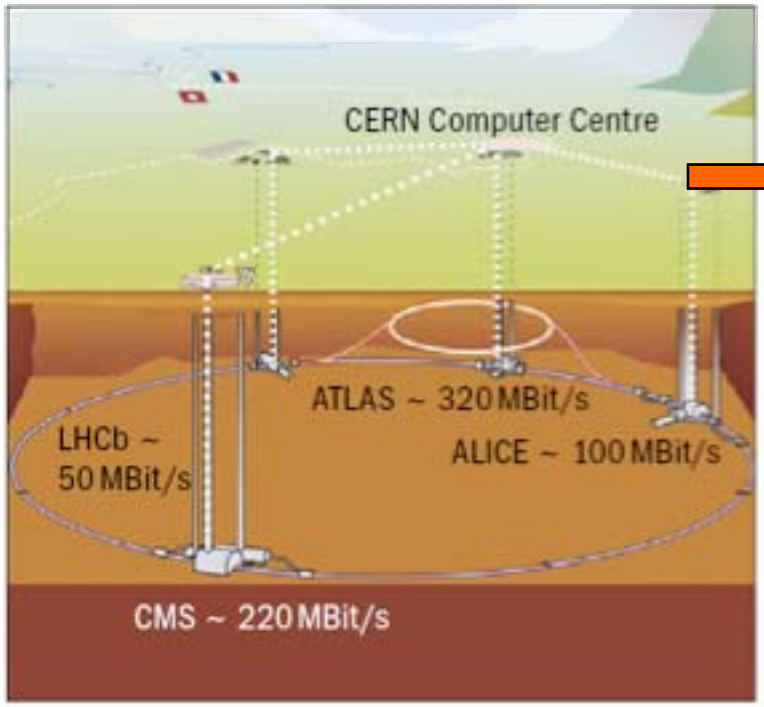
IT and Telle-1 inner silicon tracker



LHCb common readout boards

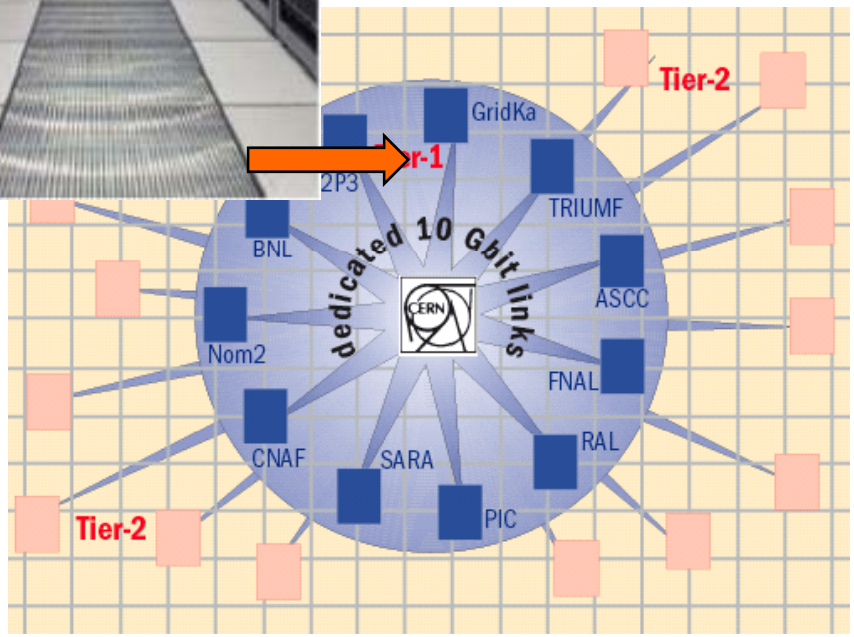


The LHC experiments – the LCG computing challenge



Tier-0 at CERN

Tier-1 a large computer center (11 work for LHC, none in Switzerland) (work with Karlsruhe)



Tier-2 a regional center, e.g. CSCS in Manno (Ti).

Tier-3 at an institute (not shown)

The LHC experiments – the Swiss T2 at Manno

Phase-A installed in Dec 07

(225 TB, ~800 kSI2k, 400 cores)

For the three LHC experiments in which Swiss groups participate

- **CMS**
- **ATLAS**
- **LHCb**

Swiss Institute of Particle Physics

The LHC experiments – typical T3 at institute

- CMS – T3 at PSI
- ATLAS – T3 at Bern and Geneva
- LHCb – T3 at Zurich and Lausanne

Example – ATLAS T3 in Geneva

- ATLAS Grid site since 2005
- local computing facility for the Geneva group
- development and testing of trigger code
- interactive and batch analysis
- free CPU cycles used for ATLAS Monte Carlo production

- current size
  61 machines, 188 CPU, 75 TB
  hardware used for 1st ATLAS data this Summer

The LHC experiments – ramp-up of Phoenix cluster

- Actual ramp-up schedule ; calculations based on Q2/07 pricing, installed in collaboration with SUN (phase-A completed 1/08)

Phases	Latest installation time	Minimum *aggregate* compute capacity [kSi2000]	Minimum *available* disc space [TB]
existing + CSCS GRID cluster	2006/07	214	52
Phase A	Operational: 1/08	~800	225
Phase B	End 2008	1500	420
Phase C	End 2009	2600	800
Operation+repl. /a	>= 2010	2600	800

- WAN: need > 3 Gbps in 2008/09
  already 1 Gbps, can get 2x10 Gbps☺

- Personnel
  physicist-informaticienat Manno attached to each experiment desirable

* 1 XEON 3 GHz ≈ 1.5 kSI2

Conclusions

- **The LHC will start in coming months and will be the leading scientific instrument in particle physics in coming 10-15 years**
  - **The coming 12 months will be an exciting but chaotic period for the CH groups and for the first analysis of data at Manno**

- **The CH contribution to the LHC is important and the T2 centre in Manno is an essential element of support for the physics community**

- **CHIPP is grateful to the CSCS for their strong collaboration in developing the T2 GRID capability for CH**

- **We look forward to a continuing fruitful collaboration in the coming 15 years**