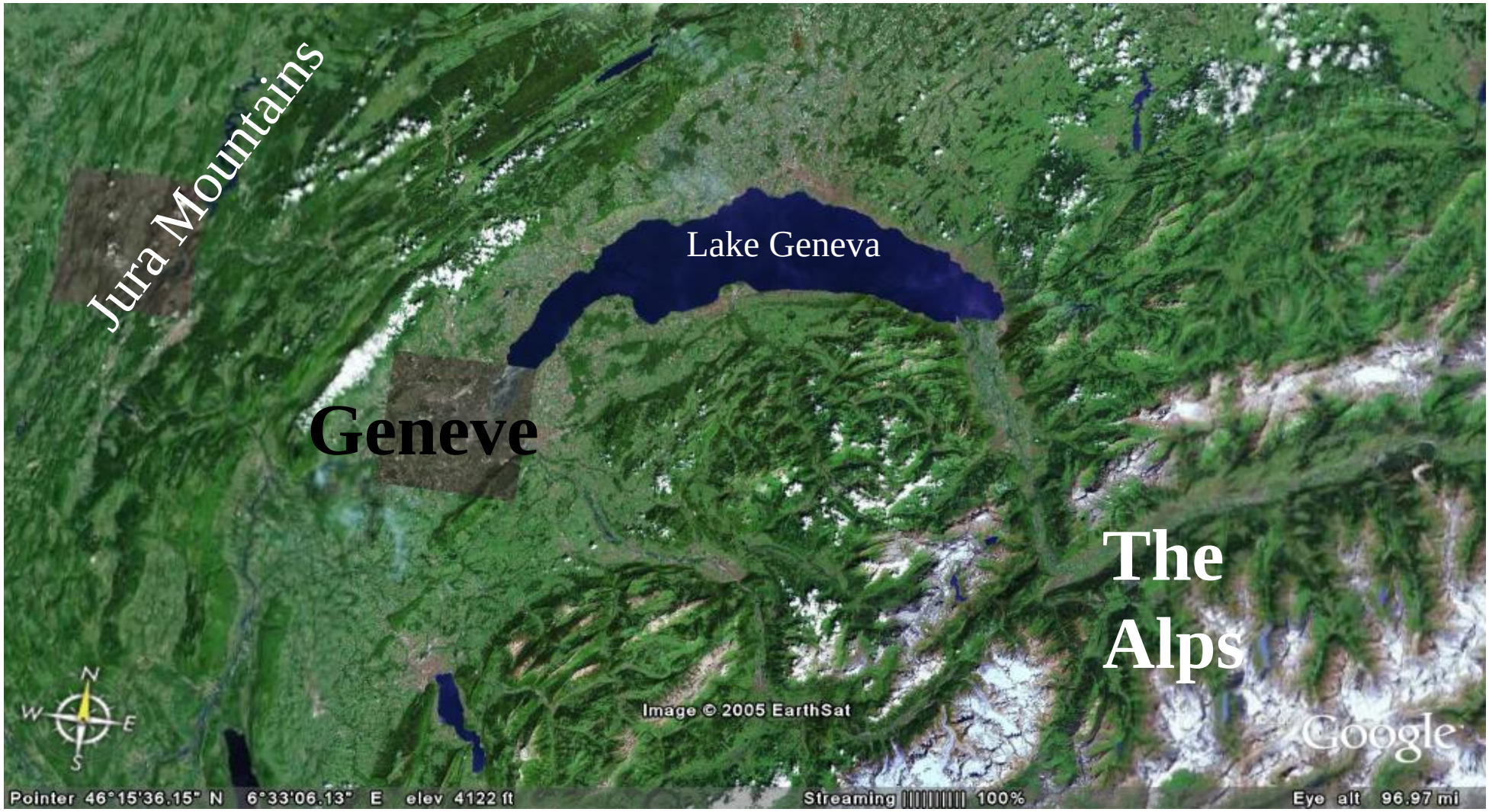
Where is CERN?

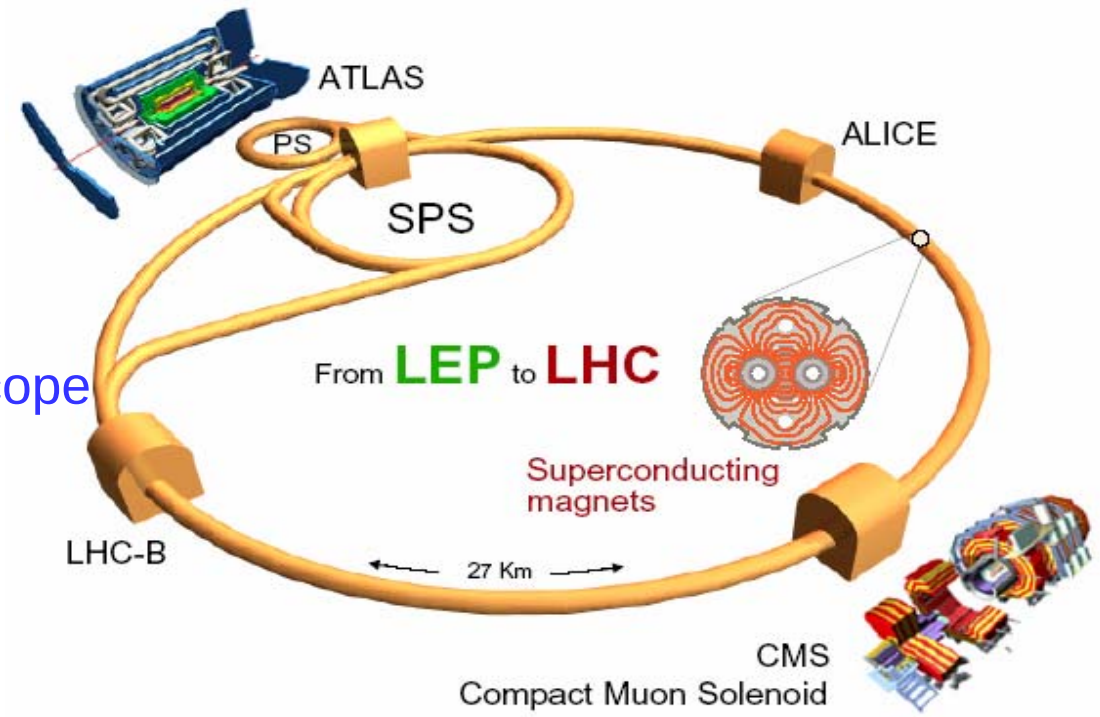


Angels and Demons?

- CERN's very own X-33 space plane!

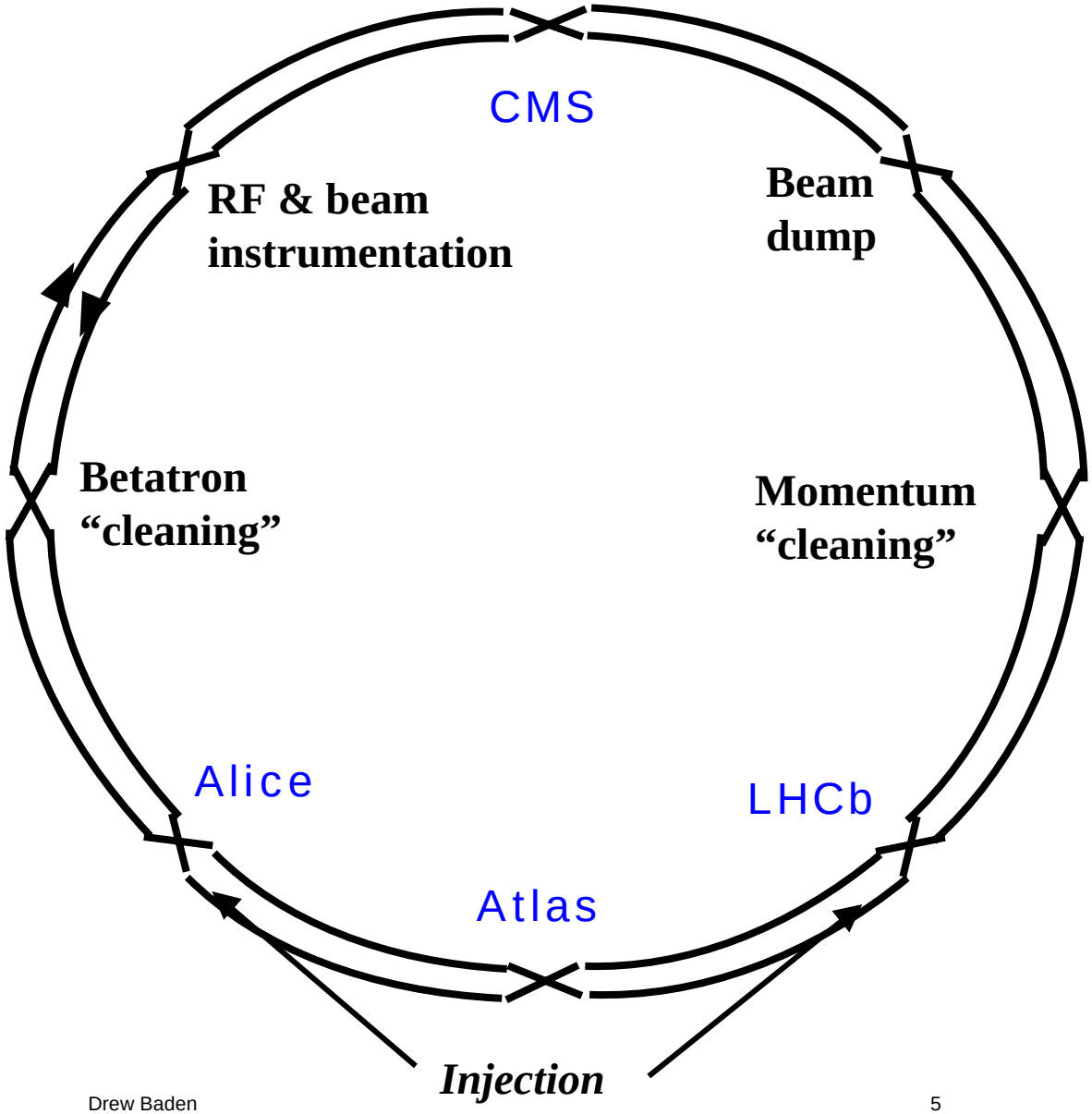
LHC

- 27km proton-proton ring at CERN
- Reuse the tunnel previously home for the LEP collider
- Dig new collision areas for new experiments
  - ATLAS & CMS
    - All high p_T physics, hermetic, large, general purpose
  - LHCb & Alice
    - Smaller in size and physics scope



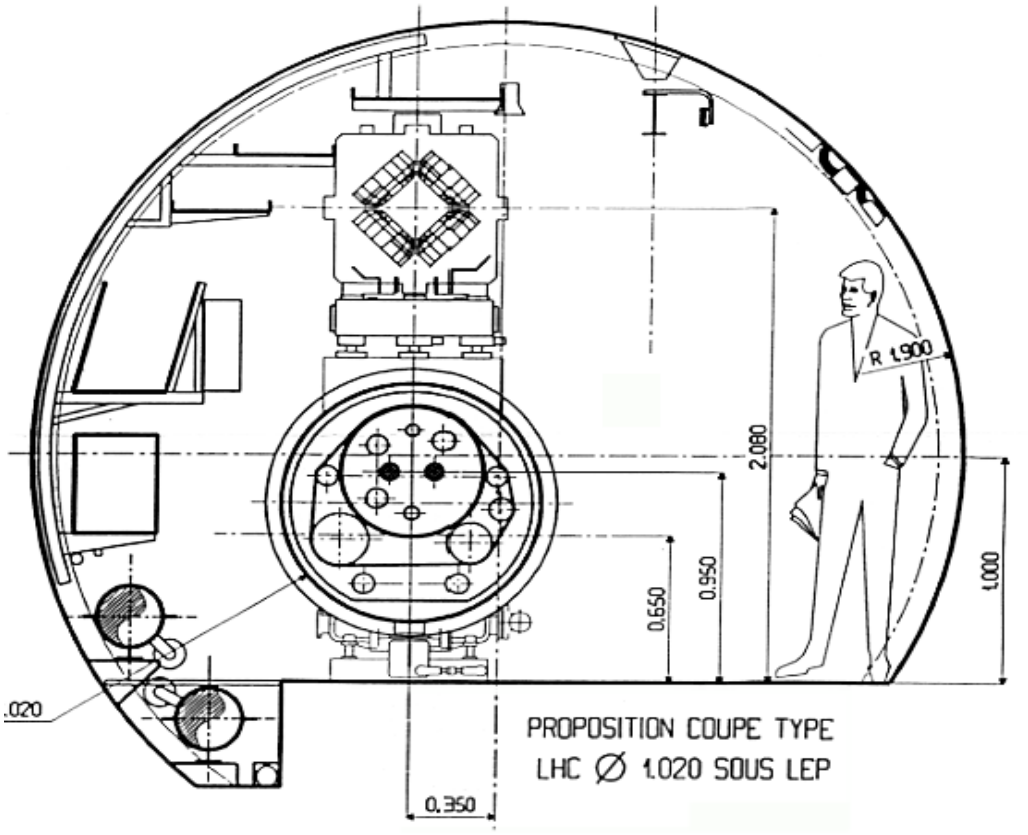
LHC Layout

- 8 arcs + 8 straight sections
  - 4 intersections have experiments
    - CMS, Atlas, Alice, LHCb
  - 4 have instrumentation, beam dump, beam focusing, etc

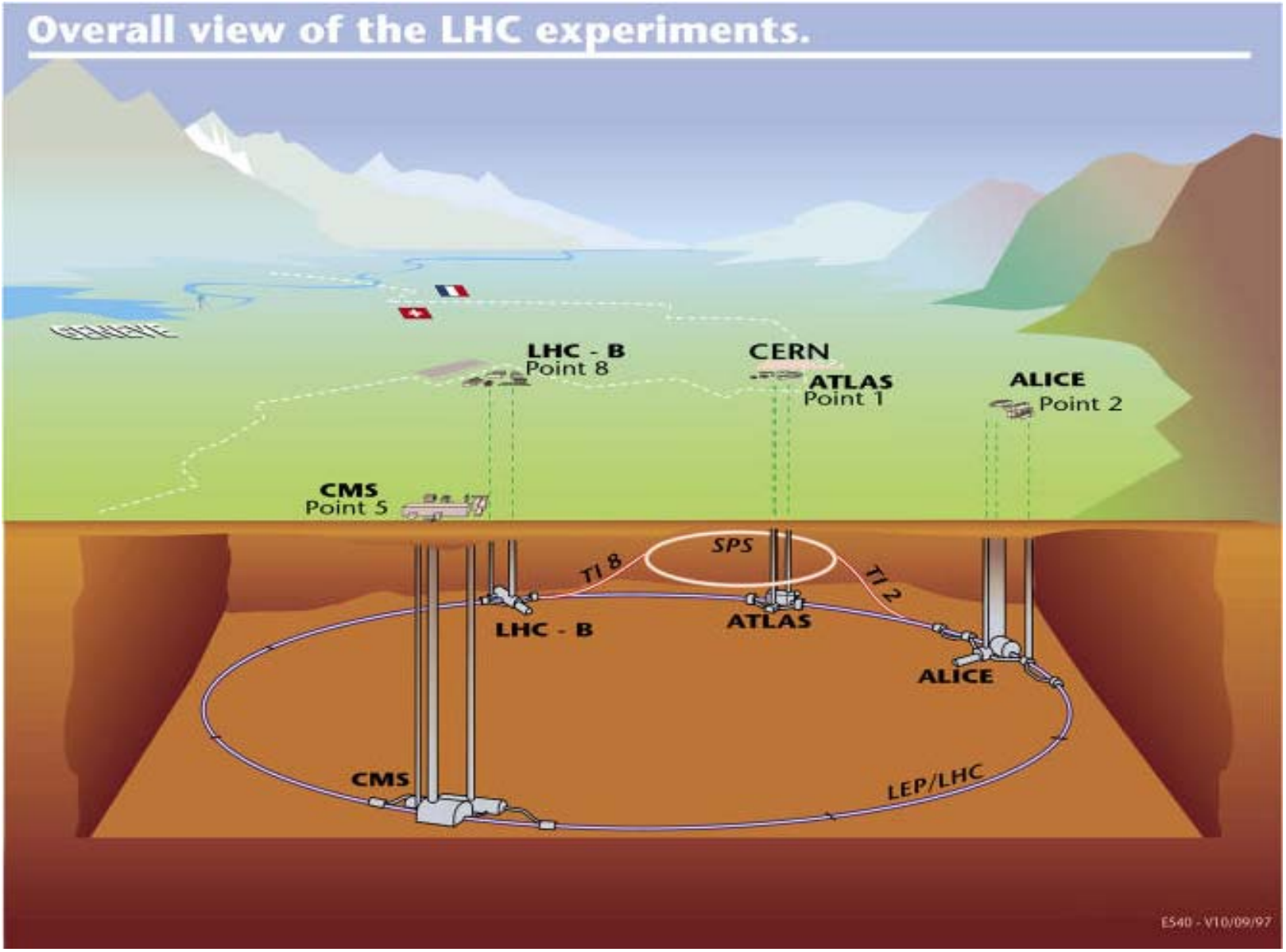


LHC/LEP Tunnel

- 27km long bored deep underground tunnel
  - Boring is more stable than cut/fill or blasted tunnels
  - 3km are actually under the Jura mountains
- Diameter 4 - 6m
- Depth 50 - 175m depending on location
- 1.4 x 10^6 m^3 ~ $(100m)^3$ soil extracted to dig it



LHC (cont)

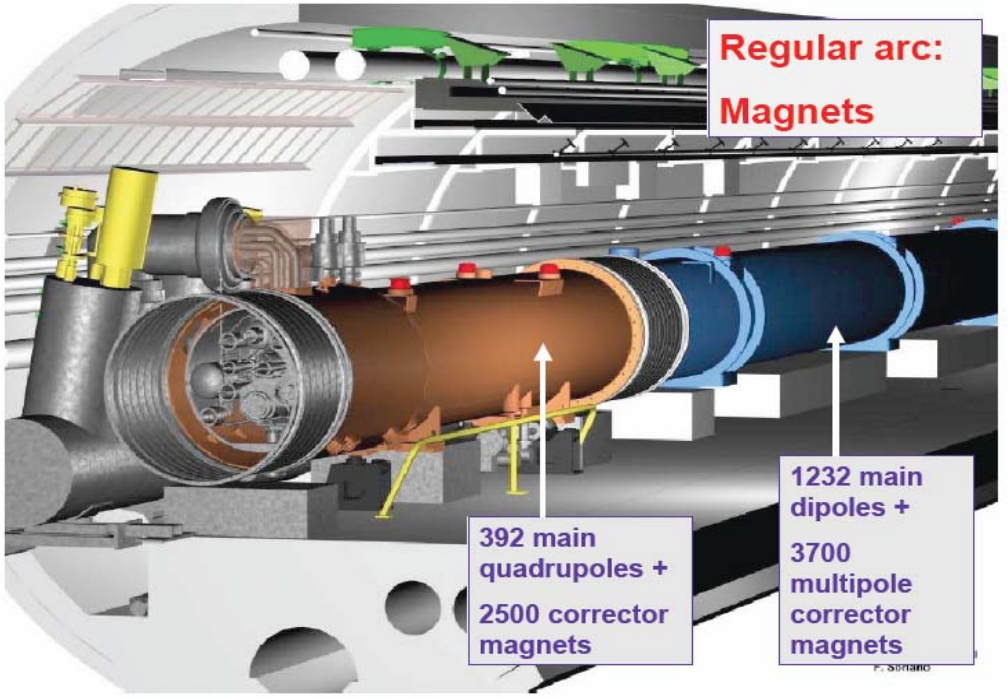

Overall view of the LHC experiments.
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
ES40 - V10/09/97

LHC Progress

…27 km of dipoles…whew!

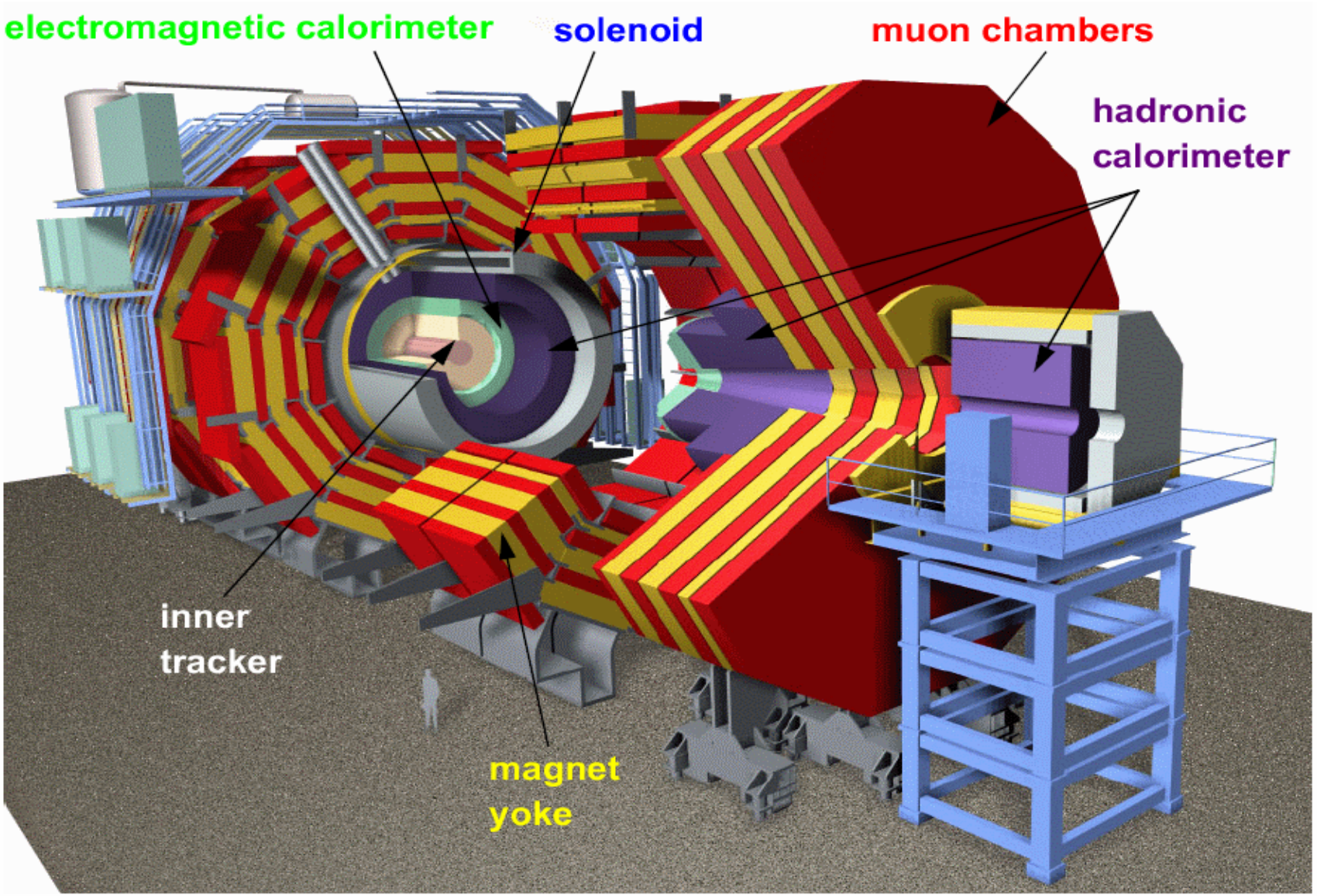
LHC Stats

- E_{beam} = 7 TeV, 2 counter-circulating proton beams
- Bunched beam structure
  - Crossing every 25ns
  - Number of bunches 3654
  - 1.1×10^{11} particles/bunch
- DC beam current .56Amps



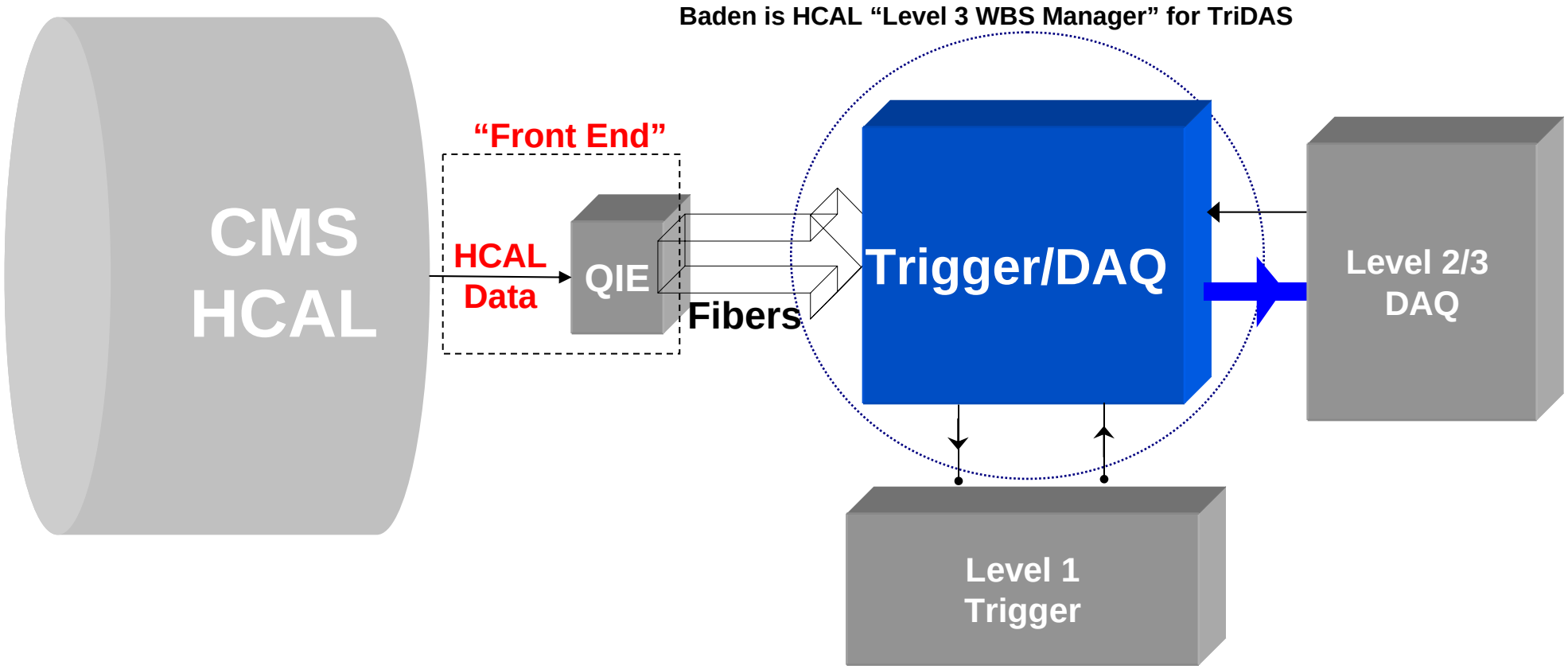
- Stored beam energy 350 MJoules
  - Equivalent to ~100 kW-hrs Superconducting NbTi magnets @ 1.9K
  - Dipole field 8.33T @ 7 TeV full beam energy

CMS (cont)

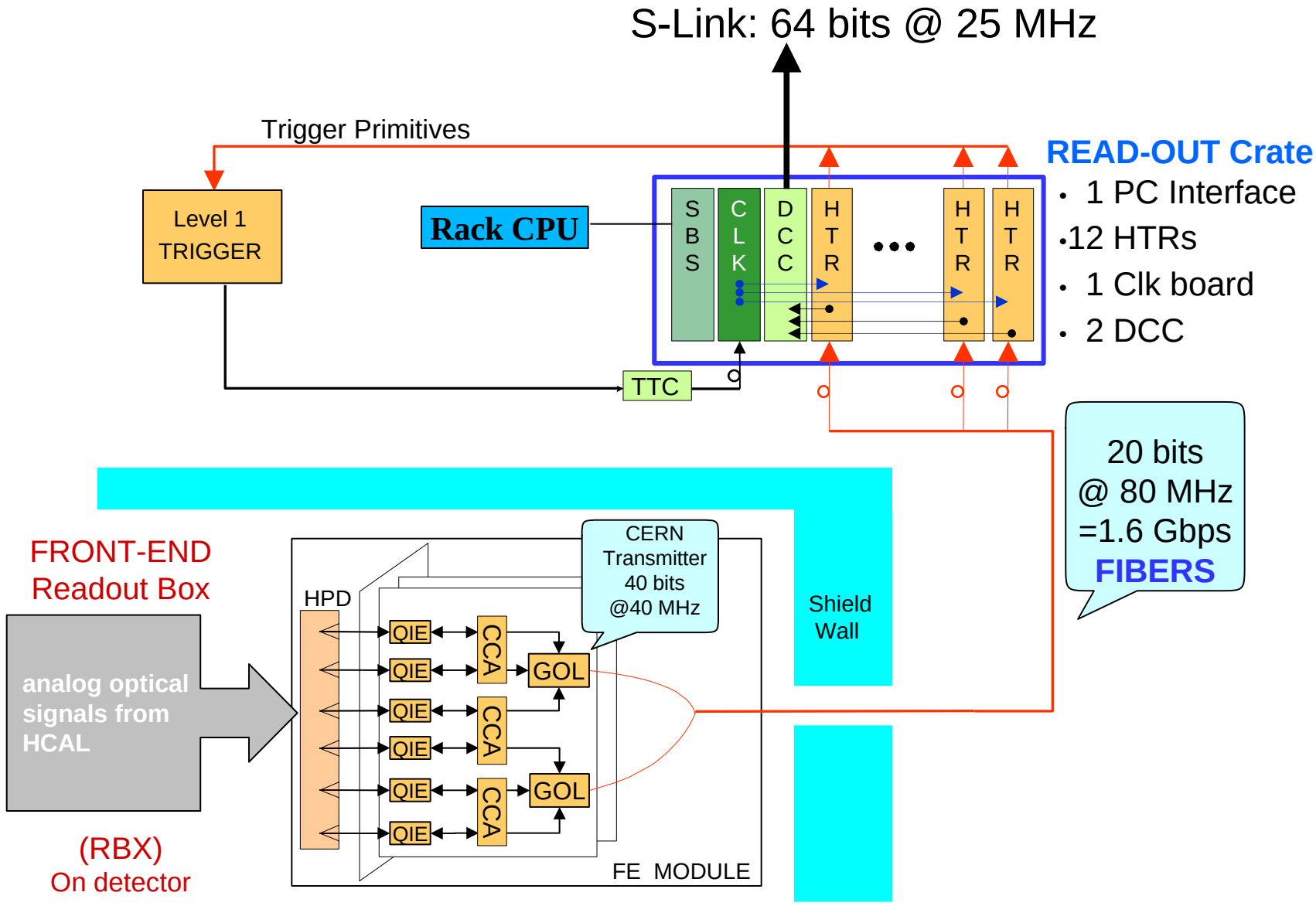

electromagnetic calorimeter
solenoid
muon chambers
hadronic calorimeter
inner tracker
magnet yoke

TriDAS Overview

- CMS Trigger: Emphasis is on bandwidth and commercial processors
- Level 1
  - 3 μs latency inside L1 trigger
  - 100 kHz average L1 accept rate (1/400)
  - 100 Gbyte/sec into Level 2



HCAL Electronics Overview

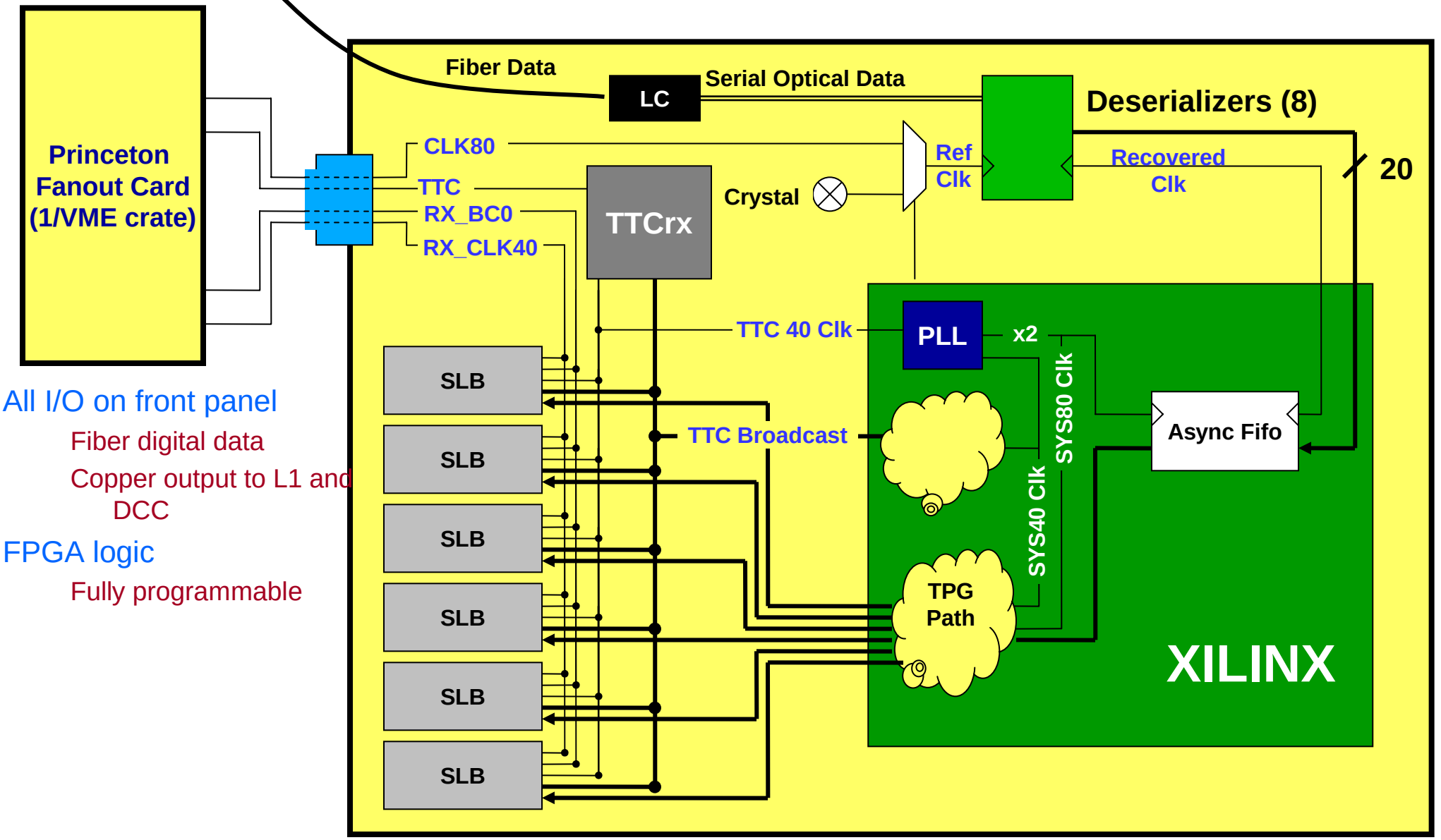


HTR Principal Functions

1. Receive HCAL data from front-ends
   - Synchronize optical links
   - Data validation and linearization
   - Form “trigger primitives” and transmit to Level 1 at 40 MHz
   - Pipeline data, wait for Level 1 accept
     – Upon receiving L1A:
       » Zero suppress, format, & transmit raw data to the concentrator (no filtering)
       » Transmit all trigger primitives along with raw data
       » Handle DAQ synchronization issues (if any)
2. Calibration processing and buffering of:
   - Radioactive source calibration data
   - Laser/LED calibration data
3. Support a VME data spy monitoring

- Data: total of approximately 650 TB/sec flowing through our boards!!!

HCAL Trigger/Readout (HTR) Board



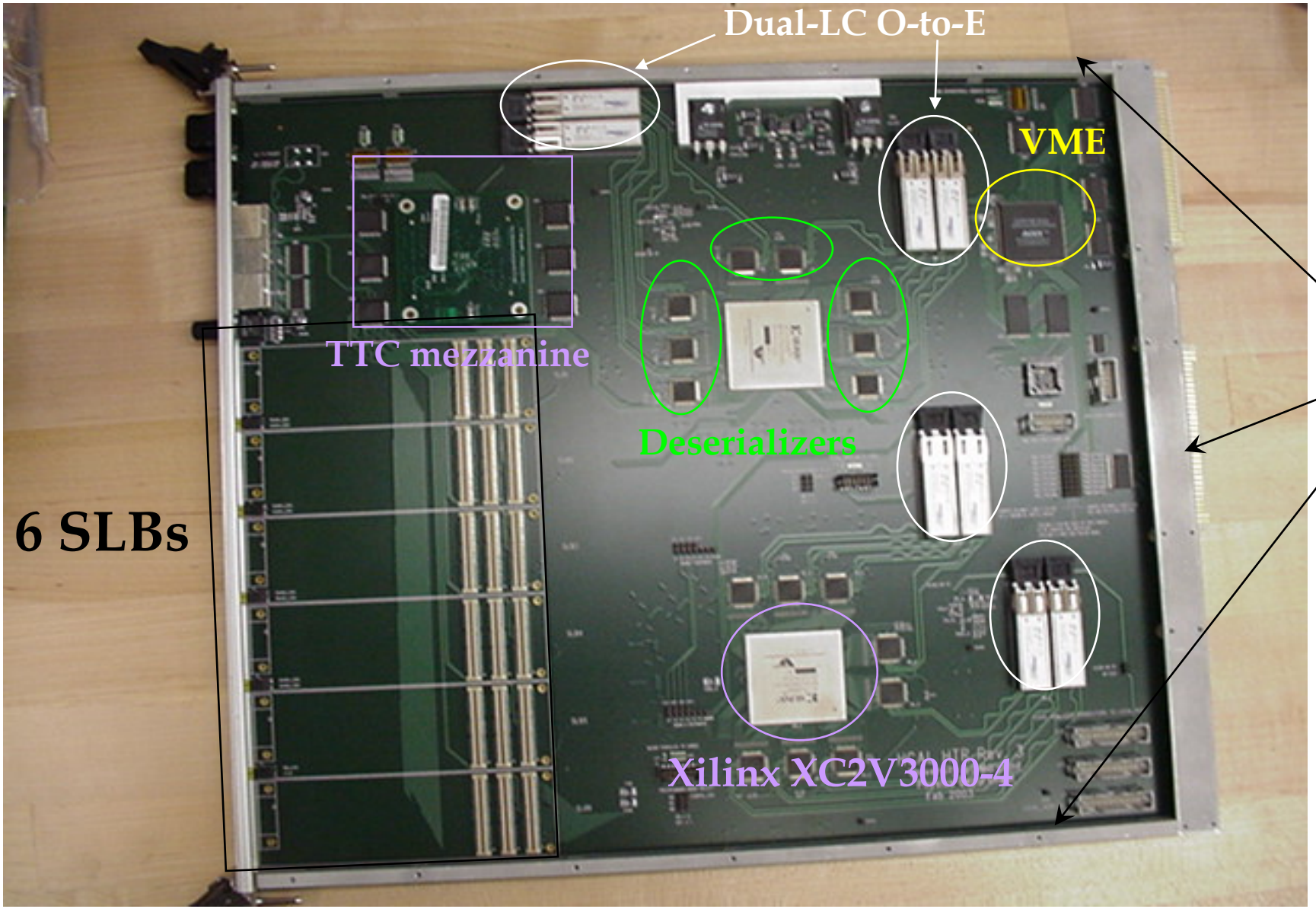
All I/O on front panel

- Fiber digital data
- Copper output to L1 and DCC

FPGA logic

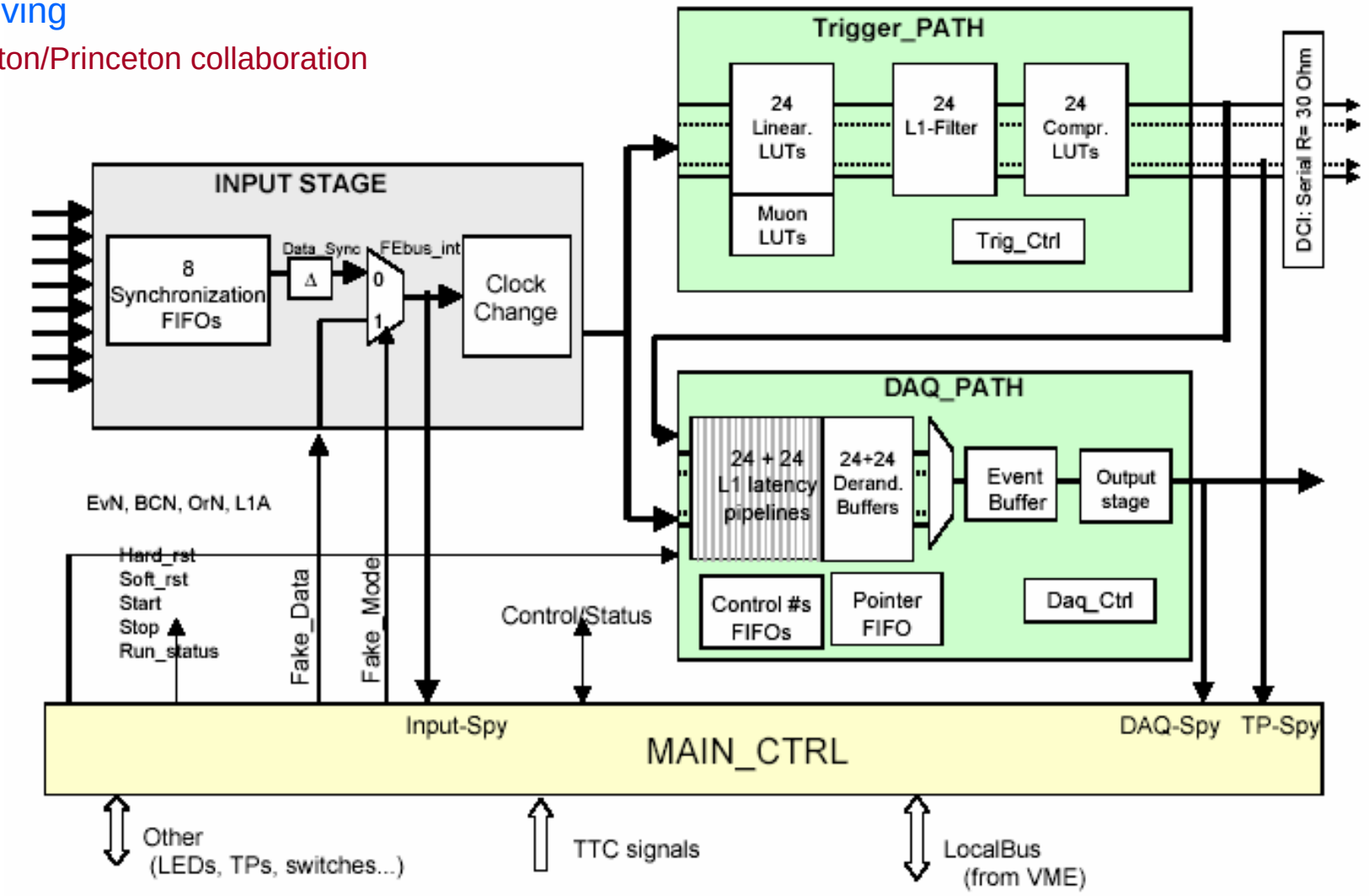
- Fully programmable

HTR Card Production Version (Rev 4)



Firmware

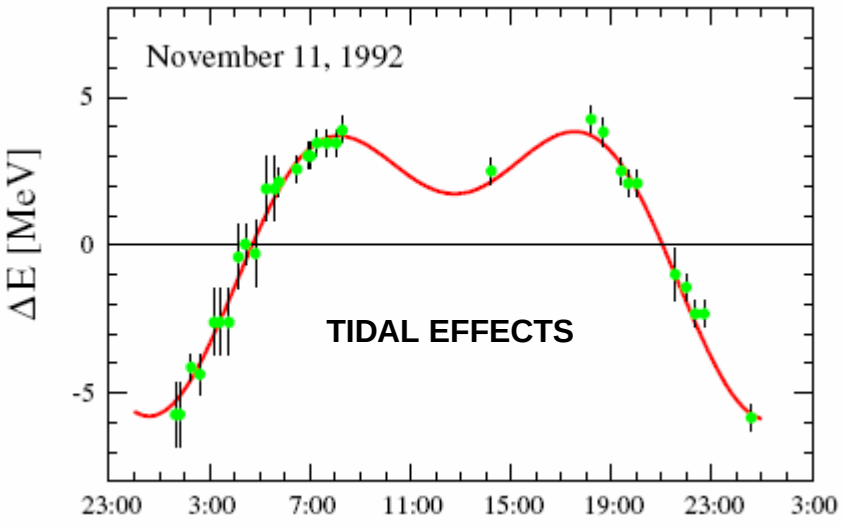
- DAQ format evolving
  - Maryland/Boston/Princeton collaboration
- Top-level view:

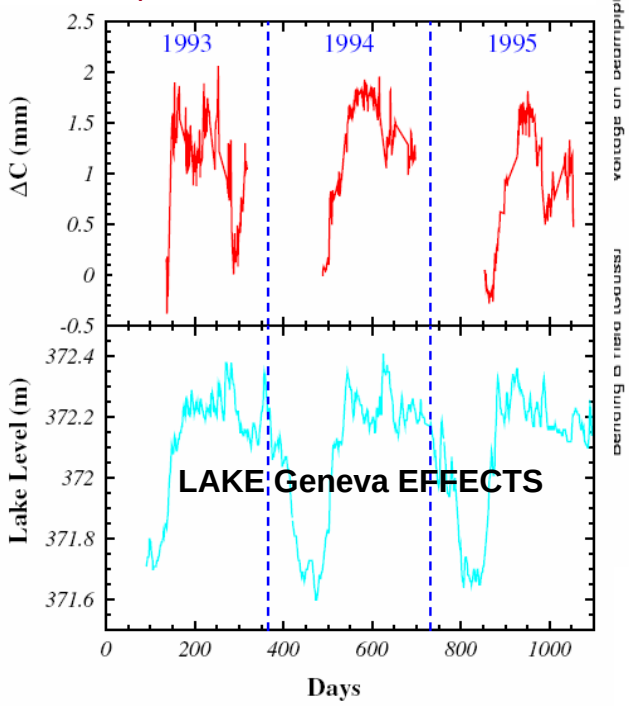


- See http://cmsdoc.cern.ch/cms/HCAL/document/CountingHouse/HTR/design/Rev4MainFPGA.pdf

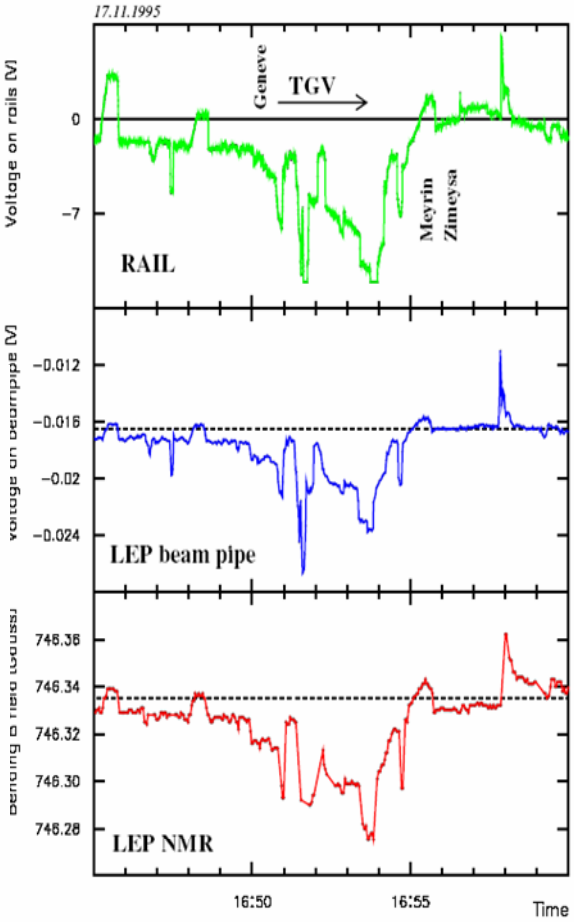
LHC Clocking

- LEP ring is sensitive to:
  - Distortions in the large (27 km) circumference
    - Tidal distortions
    - Pressure from Lake Geneva
  - Return currents from DC trains running nearby
- LHC RF clock keeps 3564 buckets of protons circulating
  - CMS must remain synchronous with this clock
  - LEP was concerned about ΔE~few MeV, LHC will be concerned with Δf ~ 25 ppm
- We have learned to handle this…

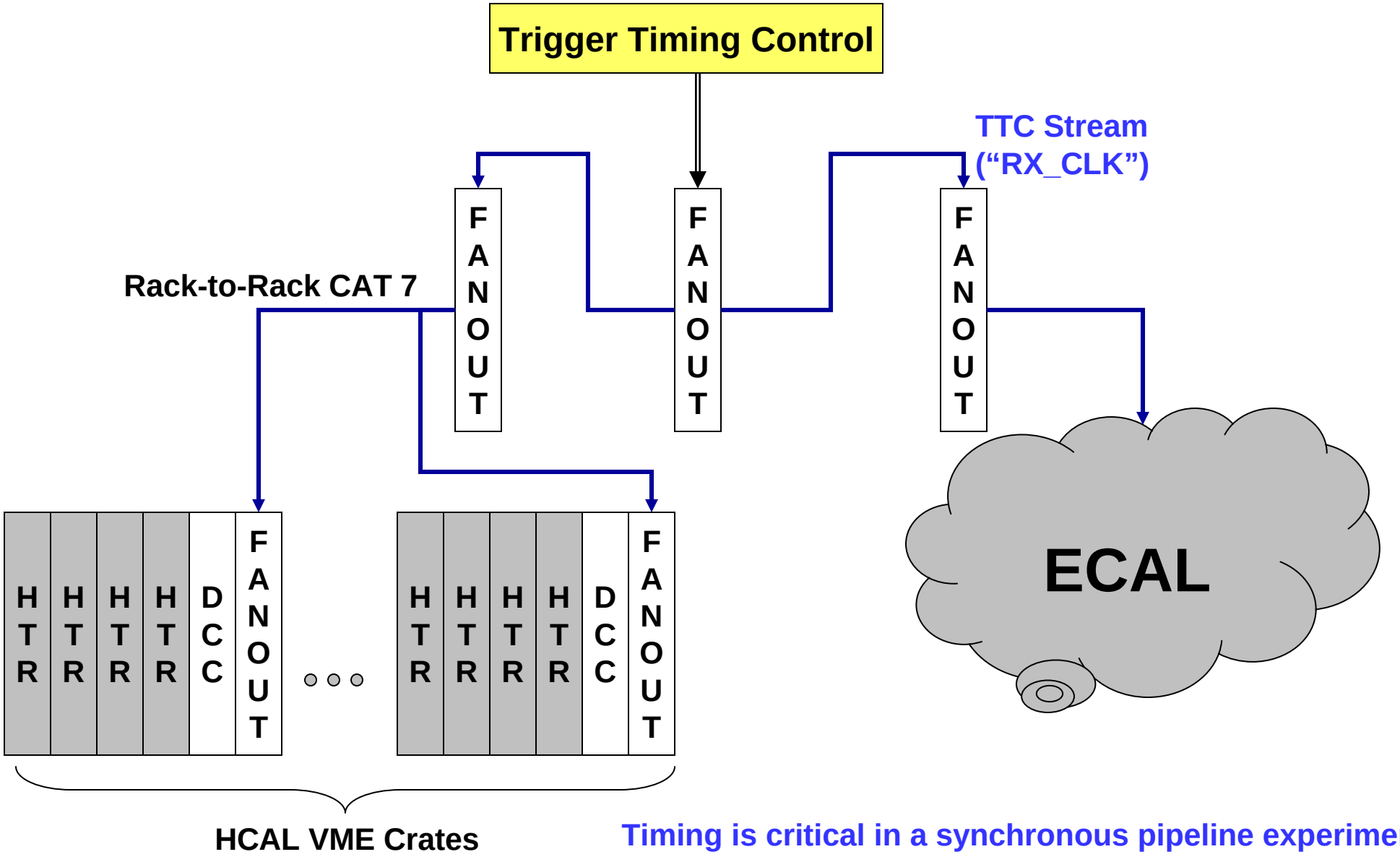




Train to Bellgarde EFFECT



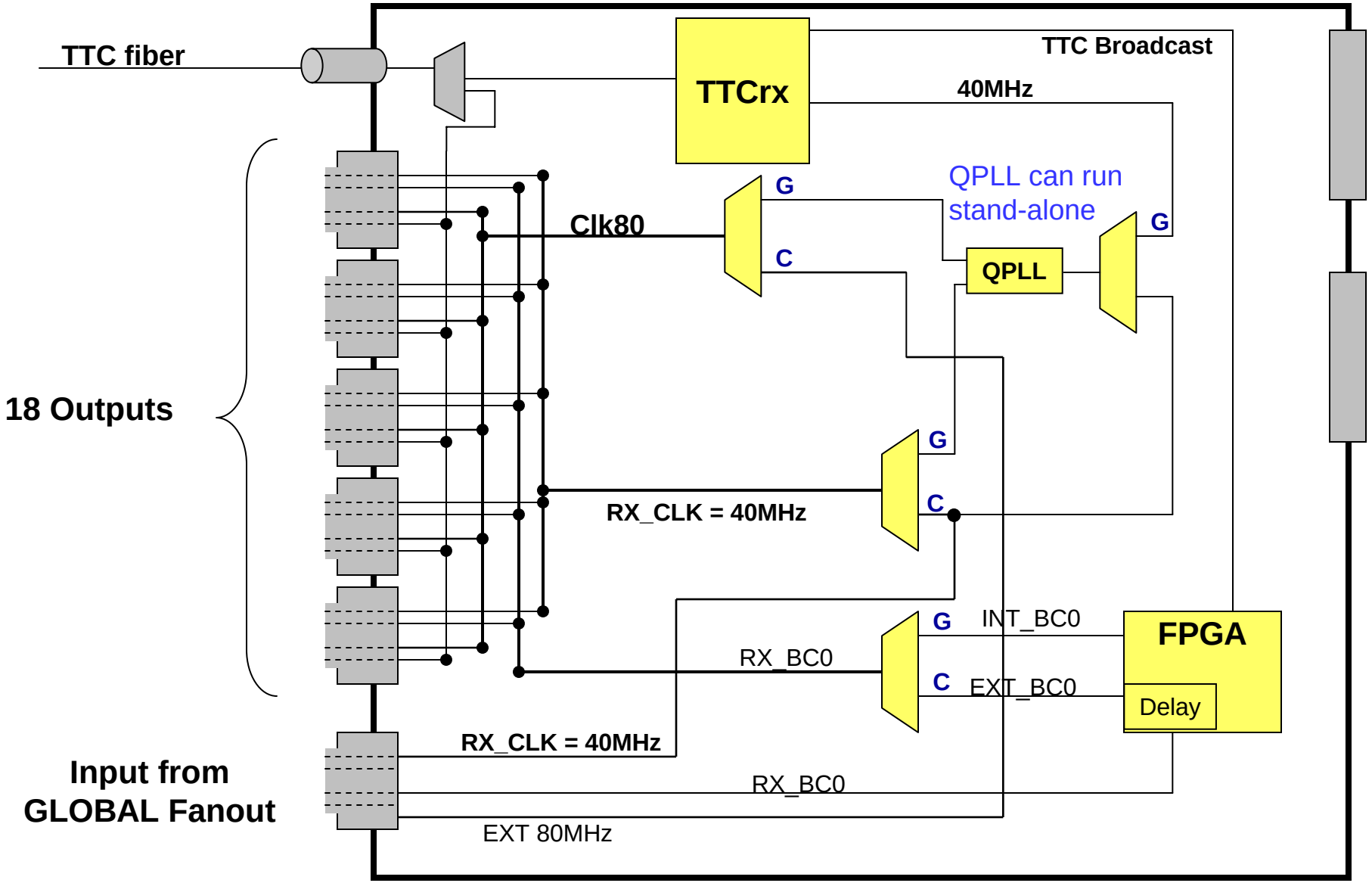
Timing Signal Distribution



Timing is critical in a synchronous pipeline experiment!

Fanout board

2 operating modes: Global or Crate



Overall TriDAS Project Cost

- Contingency:
  - Effort: 50%
  - M&S: 75%
  - Based on the uncertainty in the requirements, which will certainly change over time.

Item		Cost
Effort:	Engineering	$802,669
	Technician	$138,684
	Total	**$941,353**
M&S:	R&D	$ 218,100
	Production	$1,929,374
	Total	**$2,147,474**
Misc:		$45,000
	Grand Total	**$3,133,827**