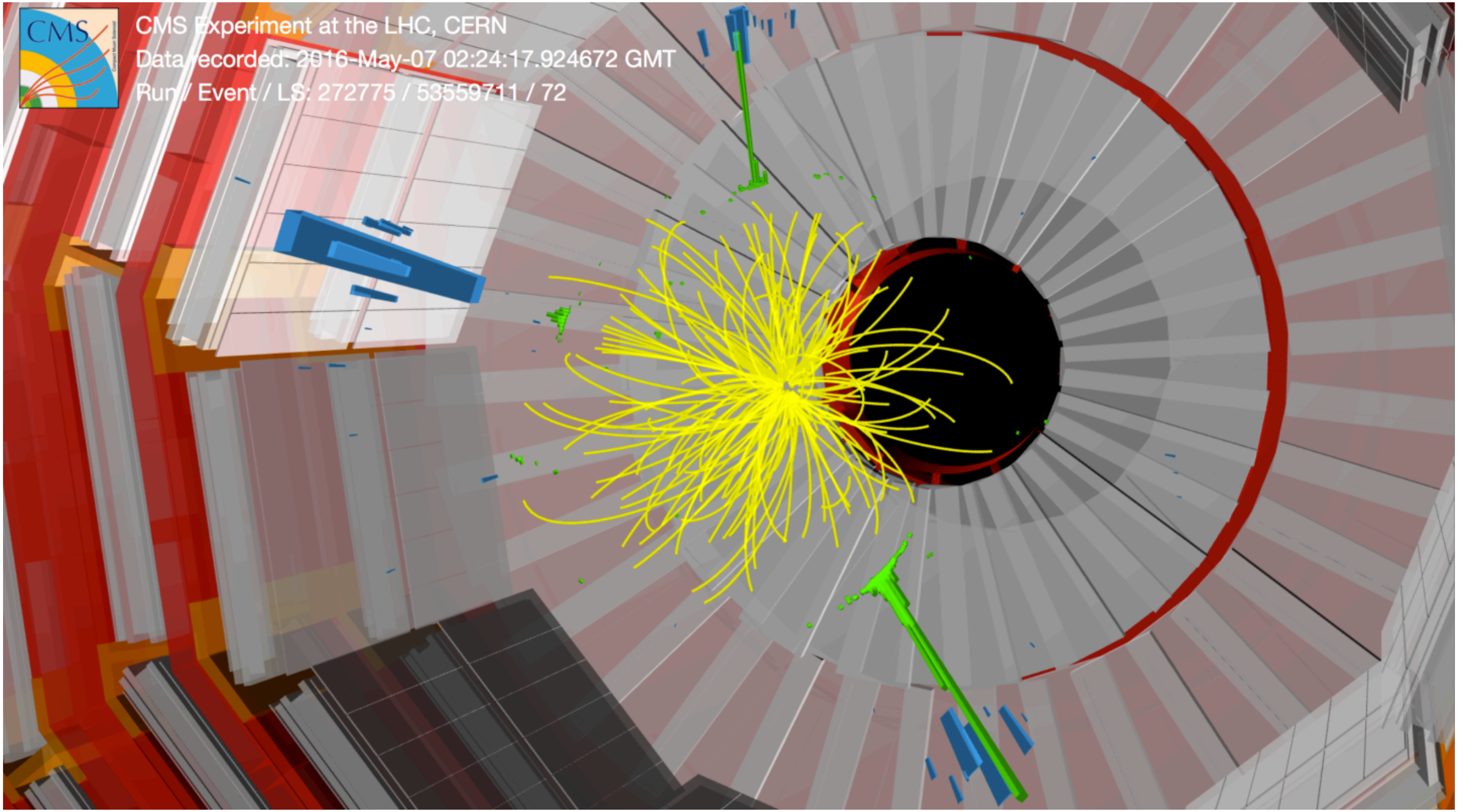


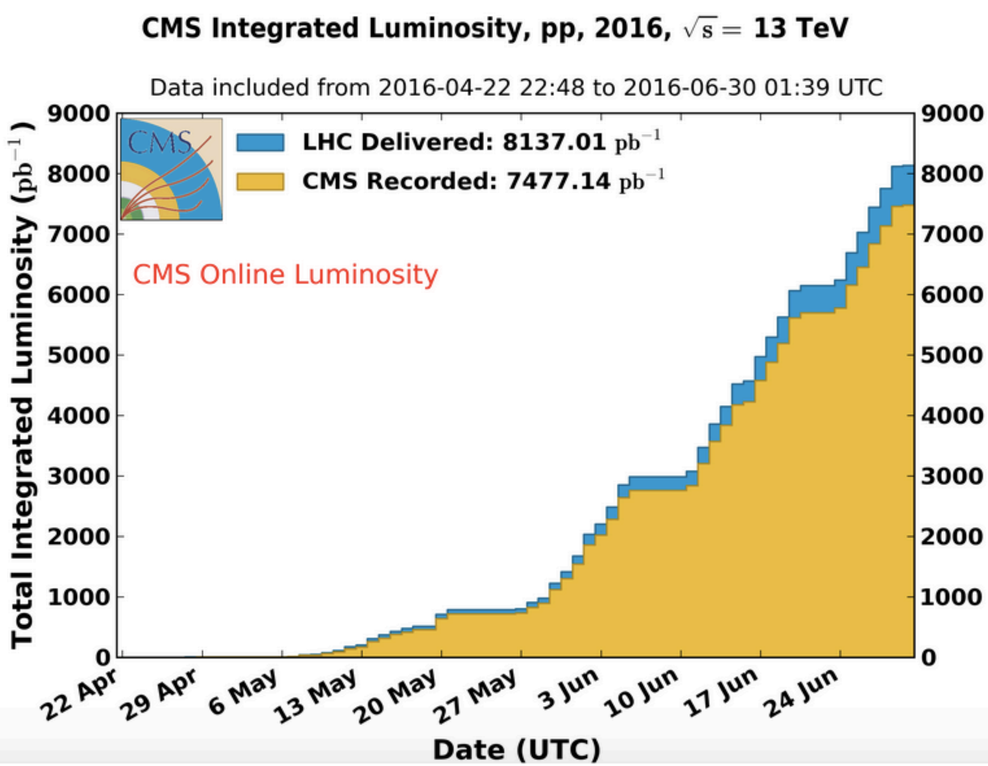
CMS

Consiglio di Sezione – 30/06/2016

CMS status after restart in 2016

Major work accomplished during end-of-the-year shutdown

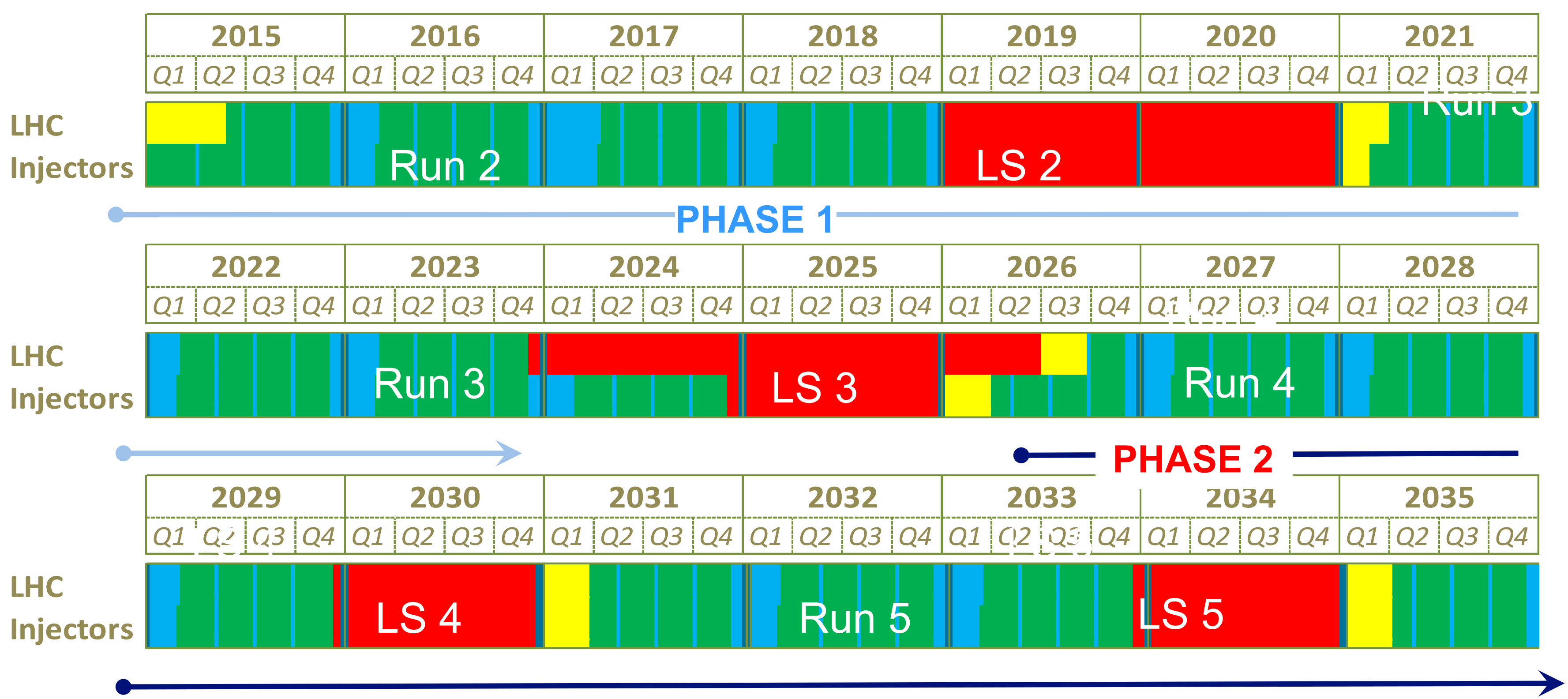
- Solenoid cooling system fixed successfully, magnet stable at 3.8 T
- L1 trigger upgrade completed and commissioned with first data
- Big work on all CMS systems to recover best efficiency: all detectors in excellent shape for data taking
- CT-PPS in accelerated version installed and fully integrated in CMS



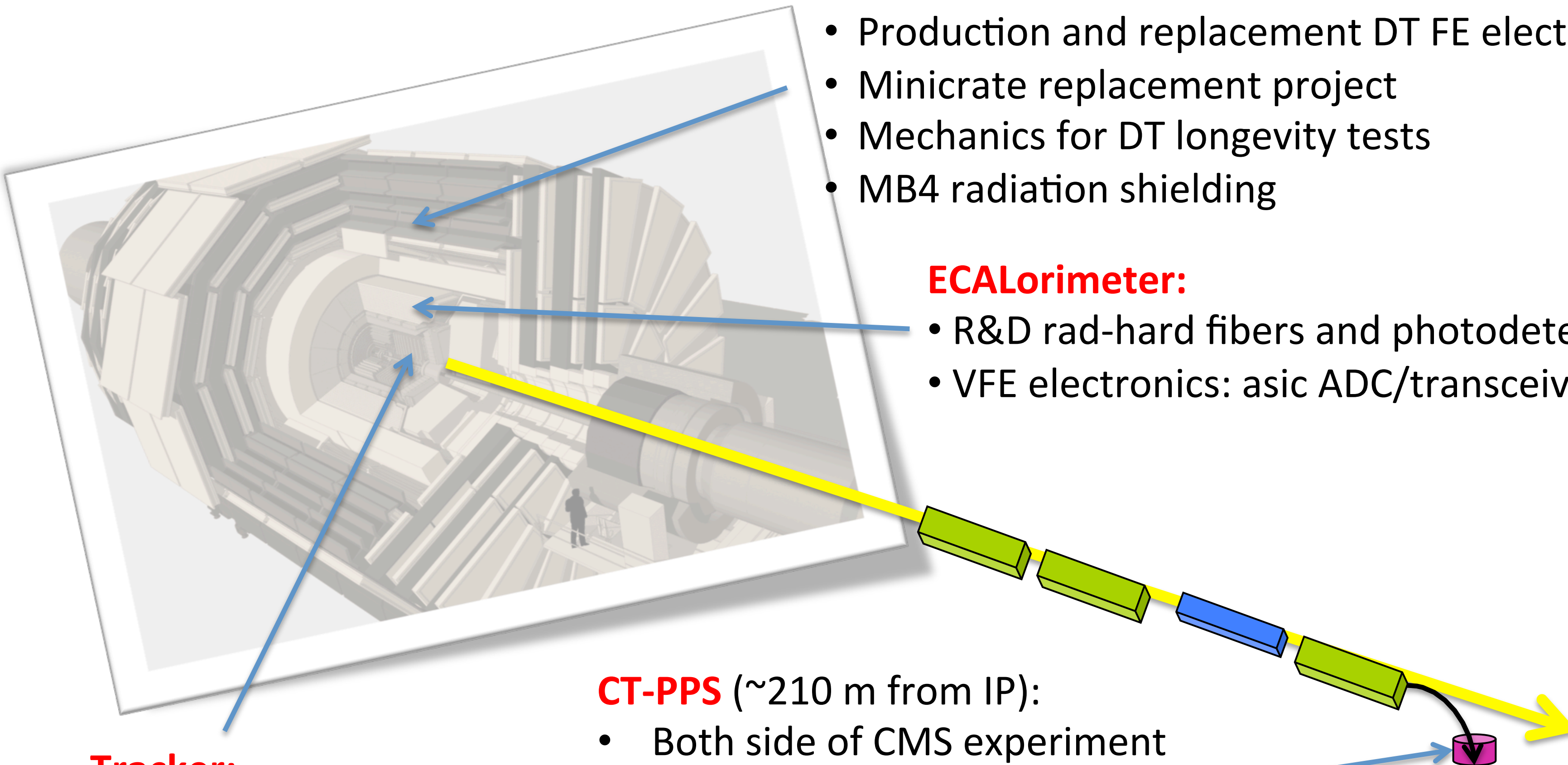
Data taking efficiency:
> 95% live-time,
> 92% collected of delivered luminosity

LHC roadmap to HL-LHC (Phase 2)

- High Luminosity 5x10^{34} cm^{-2}s^{-1}
- High pile-up (average is 140 interactions per bunch crossing, could be higher)



Detector activities in Torino from Long Shutdown 1 towards HL-LHC



Muon Drift Tubes:
- Production and replacement DT FE electronics
- Minicrate replacement project
- Mechanics for DT longevity tests
- MB4 radiation shielding

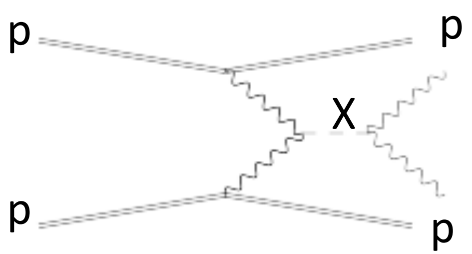
ECALorimeter:
- R&D rad-hard fibers and photodetectors
- VFE electronics: asic ADC/transceiver

CT-PPS (~210 m from IP):
- Both side of CMS experiment
- Production of 3D modules for the tracking stations
- UFSDs for the timing stations

Tracker:
- R&D new chip 65nm
- R&D 3D pixel sensors

Accelerating CT-PPS

- **The results presented by ATLAS and CMS on excess in the diphoton mass spectrum motivated speeding up the CT-PPS 'Physics operation' (initially foreseen for 2017)**
- If 'resonance' decays to $\gamma\gamma$ can also be produced via $\gamma\gamma$ interactions (central exclusive production), and be measured with CT-PPS: **advance data taking to 2016** (decision taken in January)



- For tracking use the TOTEM Si strips already in the Roman Pots
- For timing use the TOTEM diamond detectors – NB timing not necessary for 750 GeV resonance, but useful as extra tracking device

Major effort. **In the past three months:**

- Redesign and installation of the TOTEM **diamond detectors**
- Integration of CMS and TOTEM **DAQs**
- TOTEM proton **reconstruction software** in current version of CMSSW
- Successful Roman Pot insertion tests as beam currents increased
- On June 3rd, **collimation and machine protection groups agreed that CT-PPS pots can be put at 15σ in all fills starting at beginning of fill**
- **Have been taking data since then (> 3 fb-1 collected)**

Towards full CT-PPS: Torino activities

3D pixel tracking detector – to replace TOTEM Si-Strip detector (foreseen to die because of radiation) during the end-of-the-year shutdown

- Production of detector modules, assembly, wire-bonding
- Qualification of modules: X-ray test for bump-bonding check, ROC parameters optimization, threshold trimming, calibration
- Beam tests

Ultra-Fast Silicon Detector – R&D option for timing detectors
Final aim: 10 ps resolution

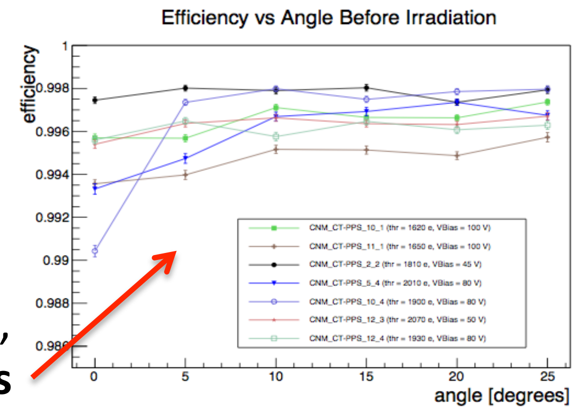
- Production of sensors at FBK and CNM and their lab characterization
- Design of a custom-made FE electronics for CT-PPS (TOFFEE chip)
- Beam tests

Note: UFSD R&D done in Gr5 (see) + ERC-Cartiglia

CT-PPS 3D pixel tracking detector

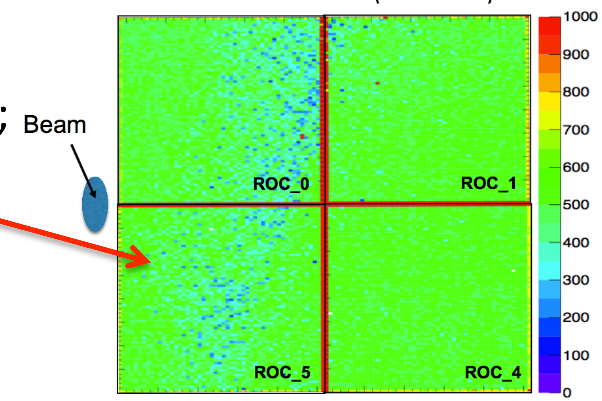
Four Roman Pot stations (2+2) with 6 planes each
Plane sensitive area is 1.6x2.4 cm^2 (2x3 ROCs)

- **3D pixel sensors produced by CNM and PSI46dig ROCs ready** at IZM for module bump-bonding
- **First 10 single-ROC modules** delivered in March, wire-bonded, characterized in lab and **tested at FNAL with 120 GeV protons**
  Very good preliminary results
- **First 10 modules 2x3 and 2x2 delivered by IZM in May**
- **Test of modules started**: prototype flex hybrid and TBM functioning checked; setting of timing delays; ROCs calibration; X-rays to check bump-bonding and sensor answer
- A procedure for testing modules before gluing them to the TPG (final cooling substrate) is being validated
- Remaining module production at IZM starting soon



Efficiency greater than 99.4% at 20°

First 2x2 module (2E sensor)



X-ray test

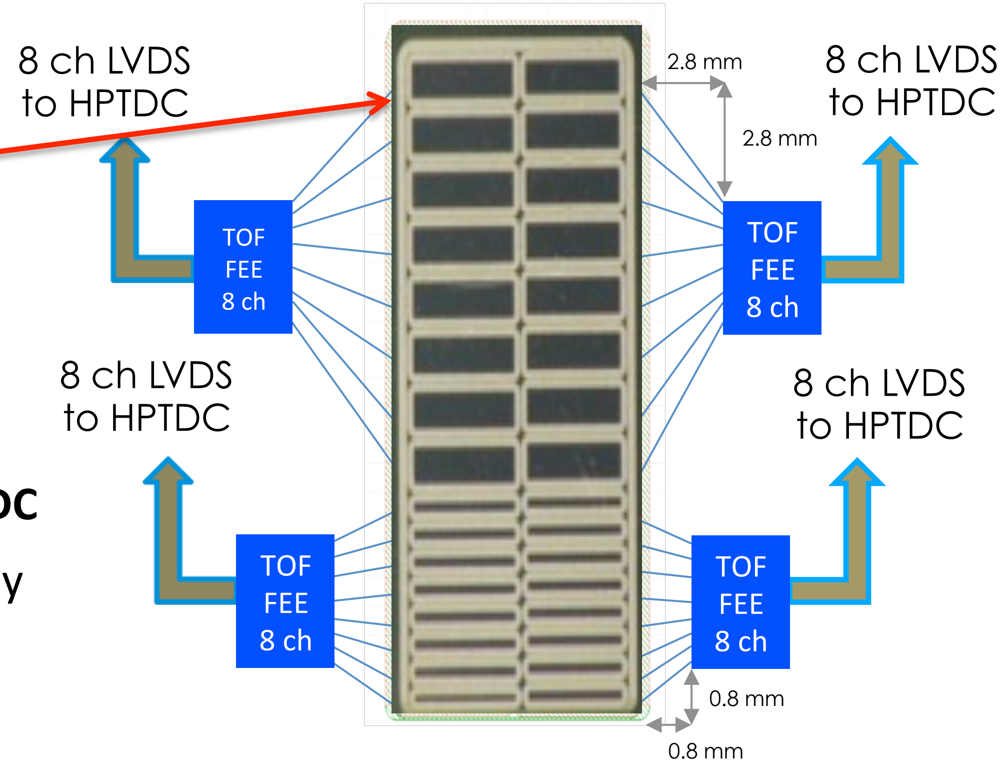
Aim for all 24 modules ready and tested by the end of September
Installation in tunnel during end-of-the-year shutdown

2x3 module

UFSD for CT-PPS

- Sensor production at FBK and CNM.
  50 um sensors with CT-PPS design just delivered by CNM
- Electronics: two possible options
  1) Baseline solution:
     UFSD + pre-amp + NINO + HPTDC
  2) Advanced solution:
     UFSD + custom ASIC (TOFFEE) + HPTDC

     TOFFEE submitted at beginning of May
     Delivery expected in July/August
     Test board design in progress.
     Final readout board design will follow



- **Test beam preliminary results very promising.** Time resolution (one plane):
  300 um FBK sensors: 95 ps
  75 um CNM sensors: 74 ps

Aim for installation during end-of-the-year shutdown

DT for HL-LHC
Torino activities

DT Upgrade program started since Long Shutdown 1 (2012-2015)
Torino main actor for:

- Sector Collector Relocation (2012- 2014)
- Upgrade L1 trigger electronics (2015)

Design and realization by Lab Elettronica (De Remigis, Rotondo)

- Design and realization MB4 radiation shielding (2016-2017)

Design and realization by Lab Tecnologico (Dattola)

Plans for HL-LHC: R&D Phase 2 program (2015-2019):

- Design and realization mechanics for DT Longevity tests

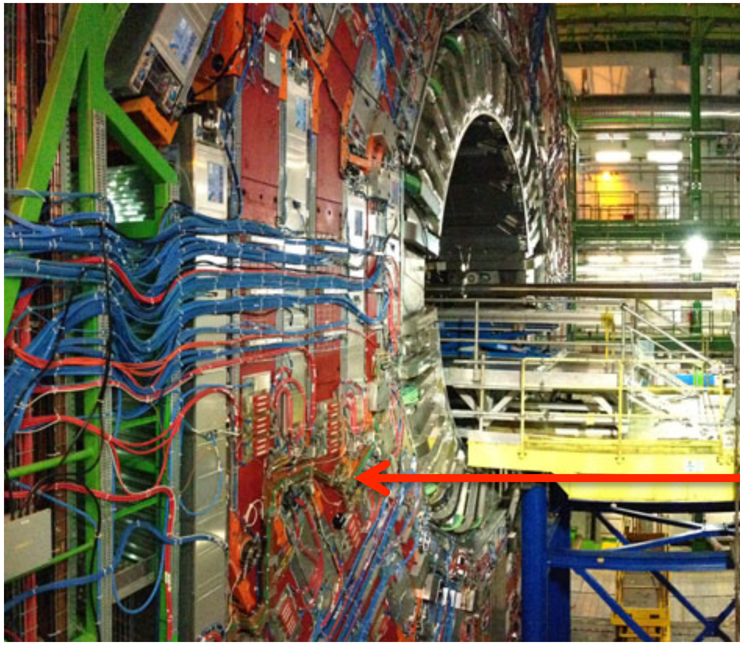
Design and realization by Lab Tecnologico (Dattola)

- R&D optical links for new electronics L1 on chambers (new Minicrates)

Design and realization by Lab Elettronica (De Remigis, Rotondo)

Barrel Muon Drift Tubes Electronics Phase2 LHC Upgrade

- Replace on-chamber electronics (Minicrate)
- Move trigger and readout complexity to USC (outside of radiation environment)



DT system = 250 Minicrates

Original Minicrates

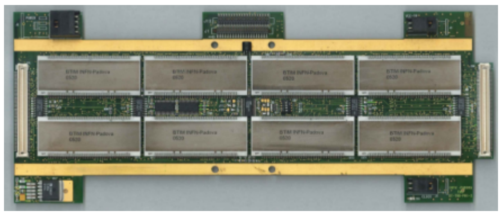
- Highly integrated and complex system
- Many boards with various ASICs for specific tasks
- Trigger primitive generation performed on each chamber
- Filtered information sent to the counting room

Phase2 Minicrates

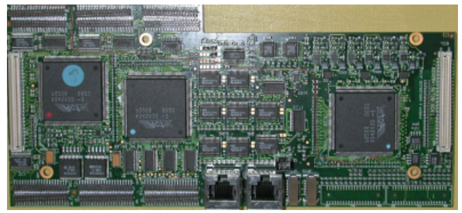
- On-chamber electronics performs time digitization of all chamber signals
- Digital information sent through optical link to the counting room
- Complexity is brought into the counting room

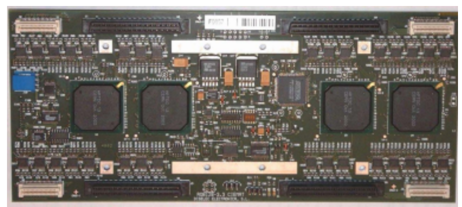
Barrel Muon Drift Tubes Electronics Upgrade Motivation

Original Minicrates



Readout
Time digitization
Event matching





Trigger
segment finding, angle measurement=>
single chamber trigger generation

17 different boards:
Some of them not radiation tolerant for HL-LHC
Limitation in readout bandwidth

Phase-2 Minicrates

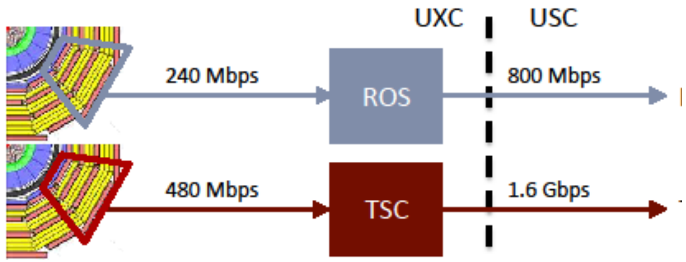
- **On-chamber electronics performs time digitization of all chamber signals**
- **Digital information sent through optical link to the counting room (GBT Links)**
- **Complexity is brought into the counting room**

Radiation tolerant FPGAs which perform 1 ns time digitization (no filtering)

Allows readout at 1 MHz Level 1 and 20 us latency

Trigger primitive generation:
- **maximum chamber resolution**
- **room for pt resolution increase**

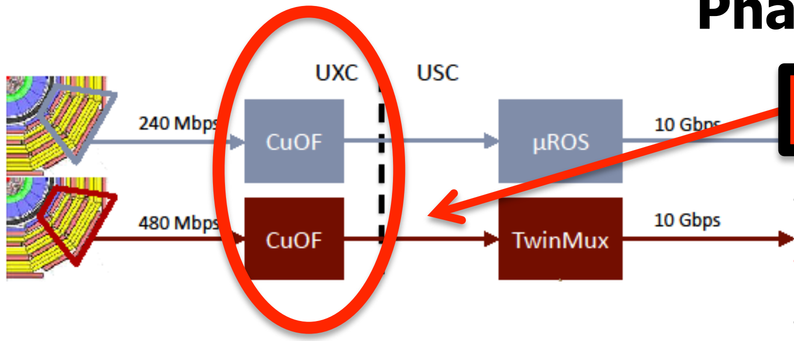
Barrel Muon Drift Tubes Electronics in Torino



DT during LHC RUN1:

- Separate Paths over copper to USC
- Read Out Server (ROS) and Trigger Sector Collector (TSC) electronics in UXC

Phase1 DT Upgrade:

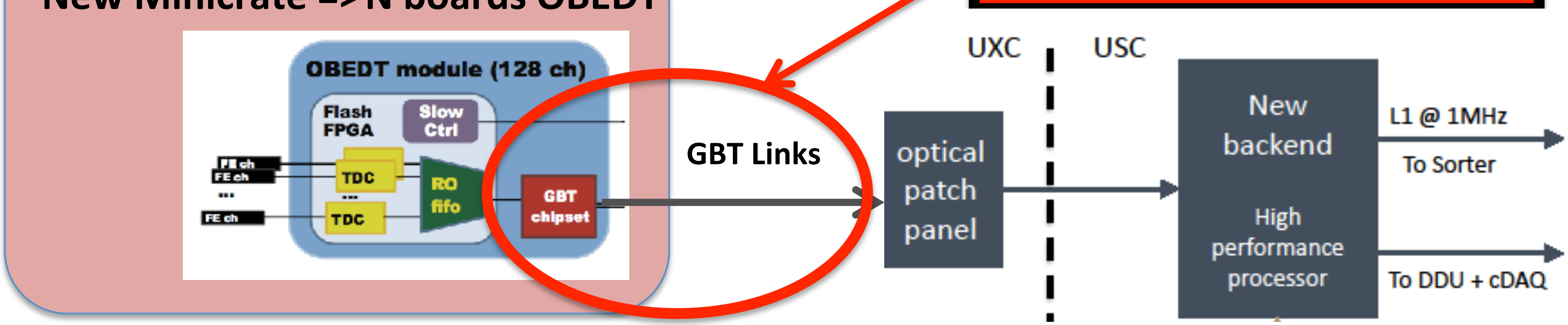


100% Torino 2012-2014

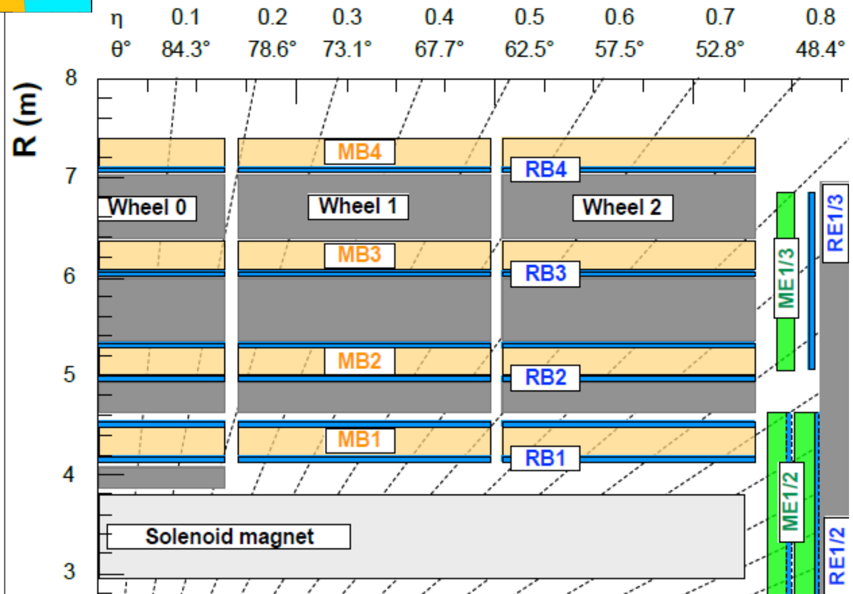
- ROS and TSC moved to USC
- Data converted and transmitted over fiber in USC
- ROS and TSC replaced with µTCA based electronics

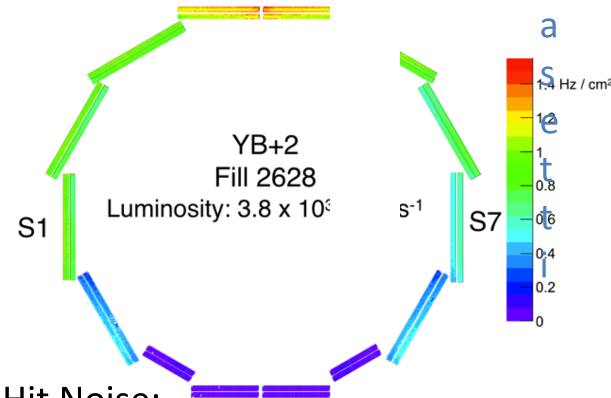
Phase2 DT Upgrade:

Torino 2016-2020

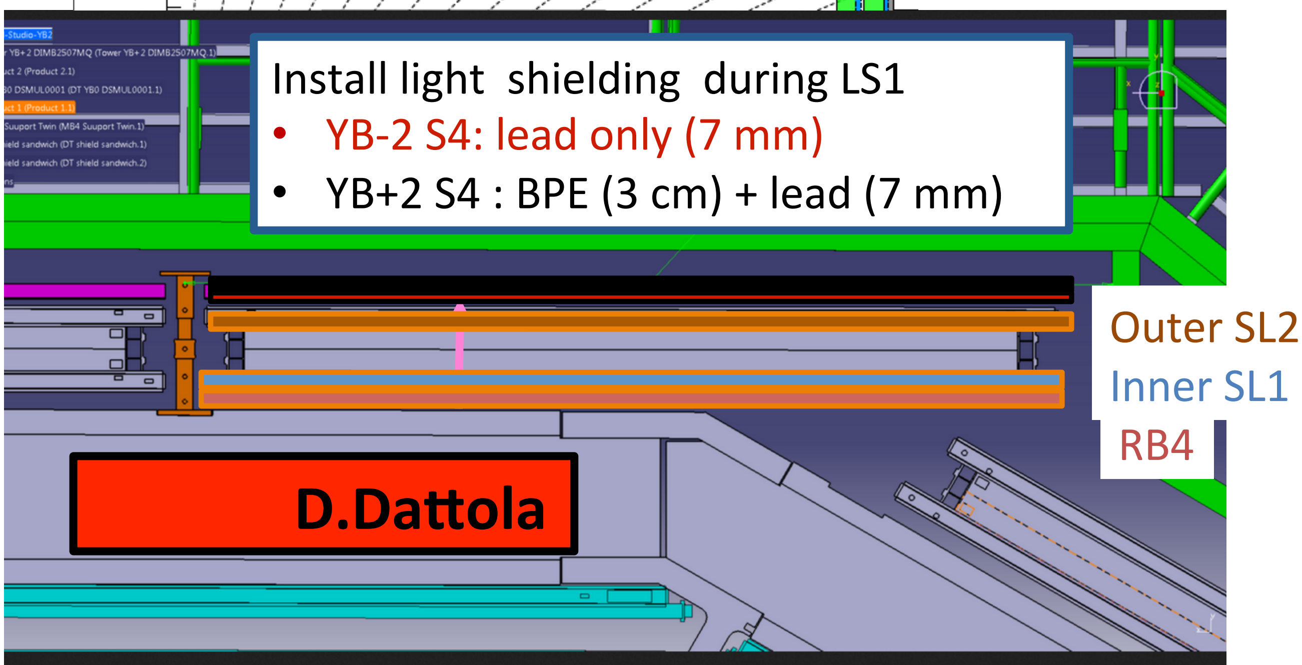


MB4 neutron shielding



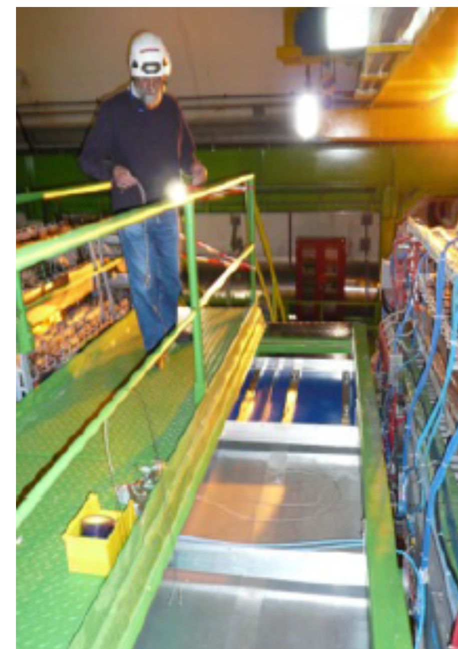


Run I SinglelHit Noise:
ϕ-asymmetry from wheel feet &cavern walls

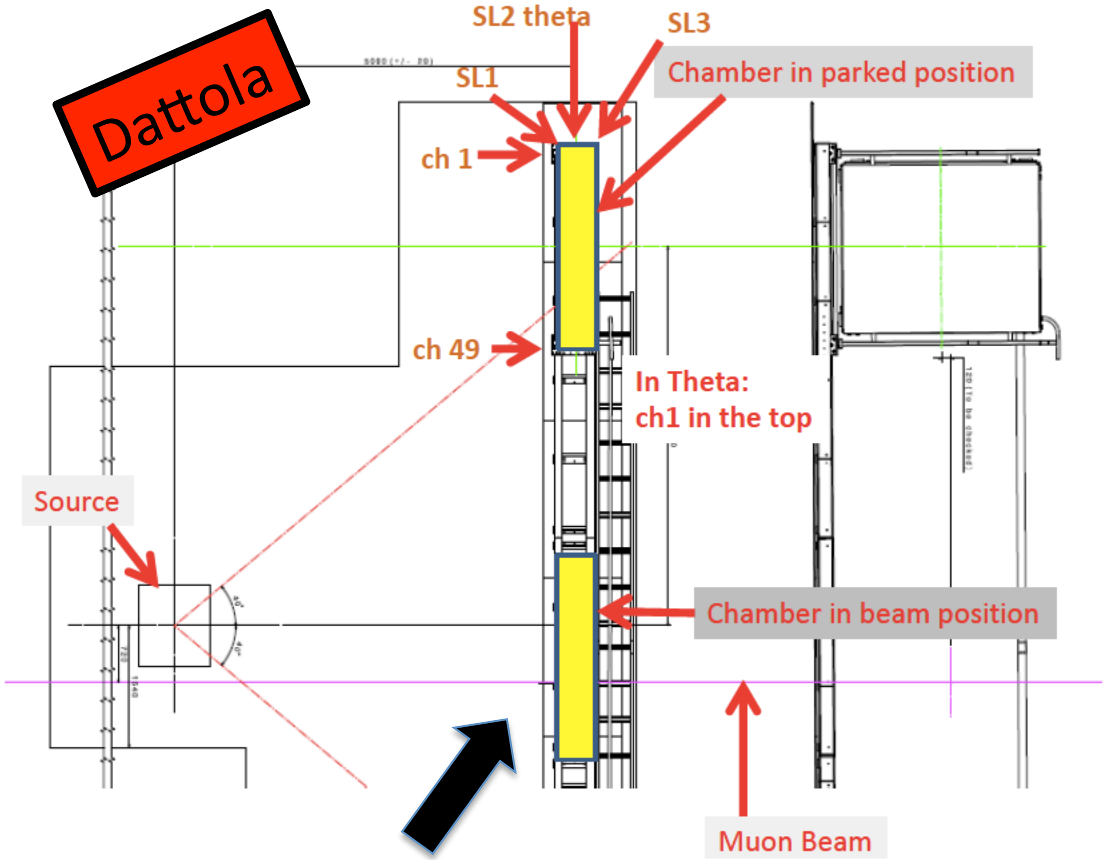


Install light shielding during LS1

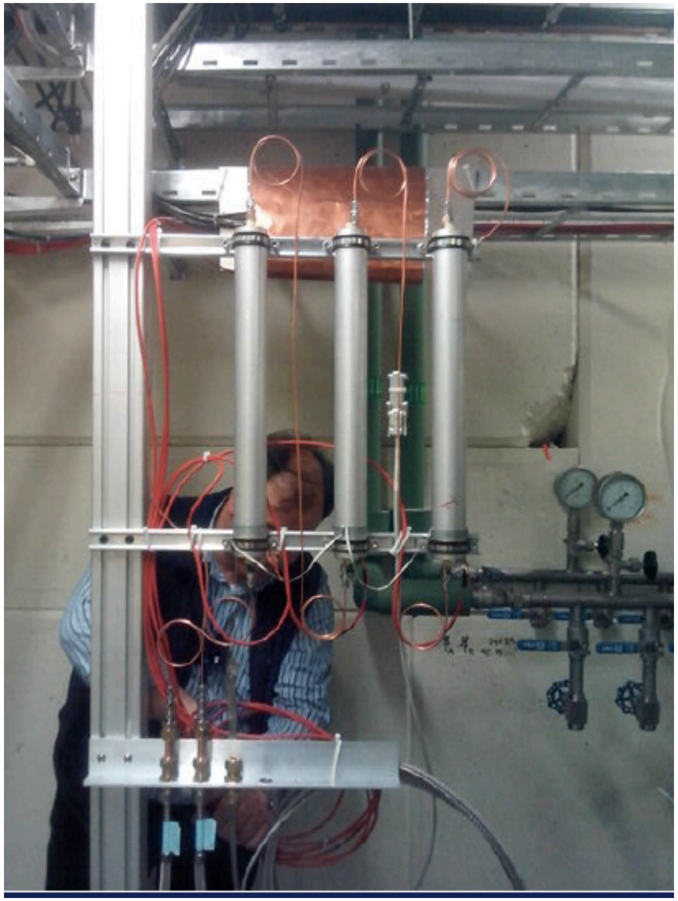
- YB-2 S4: lead only (7 mm)
- YB+2 S4 : BPE (3 cm) + lead (7 mm)



Barrel Muon Drift Tubes Longevity Studies at GIF++ at CERN



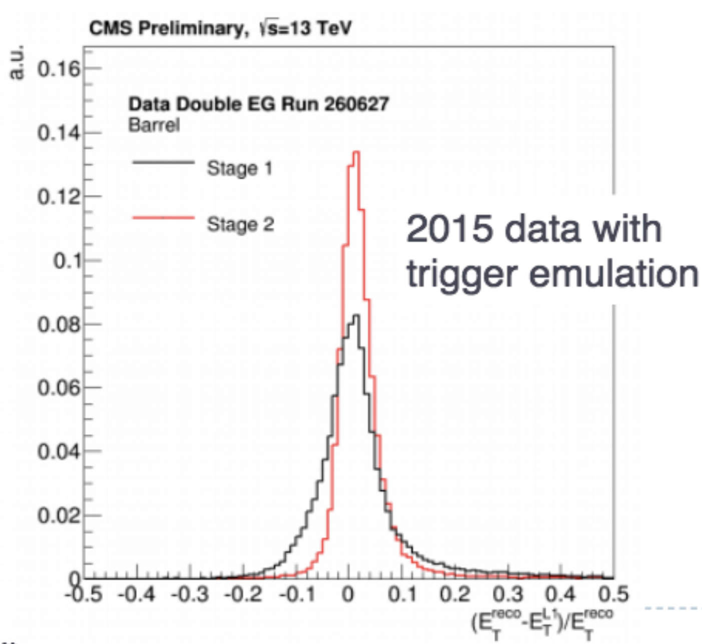
MB1 chamber under test mounted on a rail at GIF++

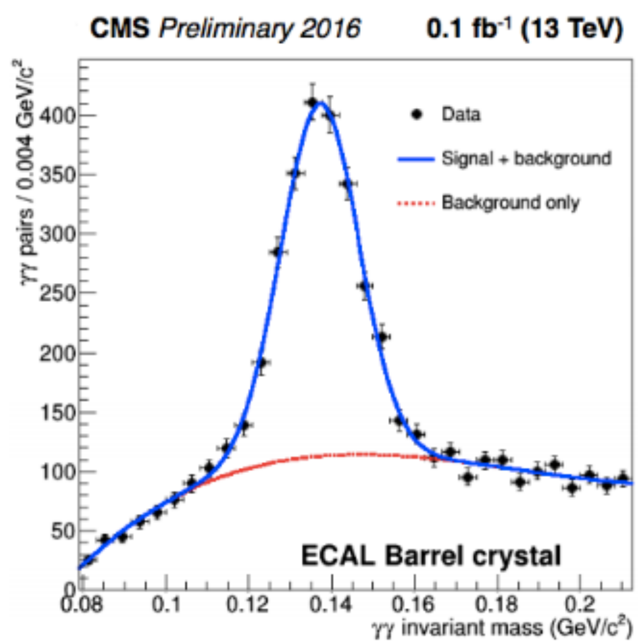


DT tubes test of pollutants generation under radiation

ECAL Past and Present

- ECAL performed a **key role in the discovery of the Higgs boson** ($H \rightarrow \gamma\gamma$, $H \rightarrow 4l$) in Run I
- Much hype connected to the **γγ (750 GeV) excess** (400+ theory papers in arXiv): the detector is *under the spotlight*
- In the 2016 run the detector behaves as expected, including upgraded L1 trigger
- Important involvement of Italian groups (To, Mi, Rm) on construction, operation, reconstruction, calibration





ECAL Future: HL-LHC

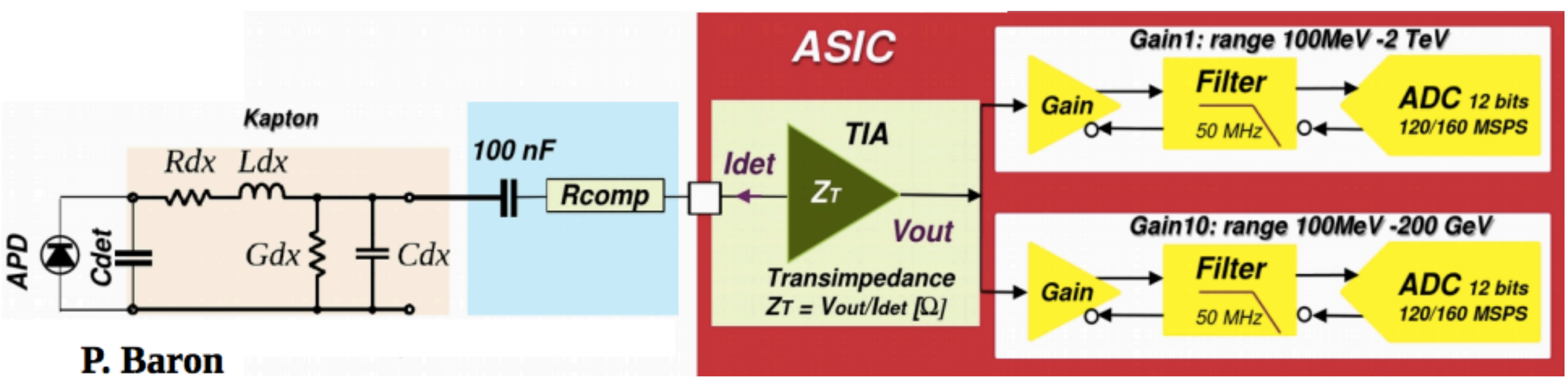
- Replace Front-End (FE) and Very-Front-End (VFE) readout
  - To cope with increased Phase II trigger requirements
  - To cope with HL-LHC conditions (APD current noise, pileup, anomalous APD signals).
  - Precise timing measurements for high energy photons.
- Run colder to mitigate increase in radiation induced APD dark current
- New off-detector electronics to cope with higher output bandwidth from FE: move trigger off-detector, per-channel granularity

ECAL barrel trigger tower (25 crystals)

ECAL for HL-LHC
VFE upgrade: Torino contribution

- VFE re-design:
  - Analog readout chip (Saclay/RAL)
  - **ADC and transceiver chip** ⟶ Torino + Lisbon
    - 160 MHz, 12 bit sampling to allow precise time reconstruction
    - All samples continuously shipped off-detector
    - Lisbon: ADC block,
    - Torino : everything else, including executive design, integration, testing of prototypes

Torino



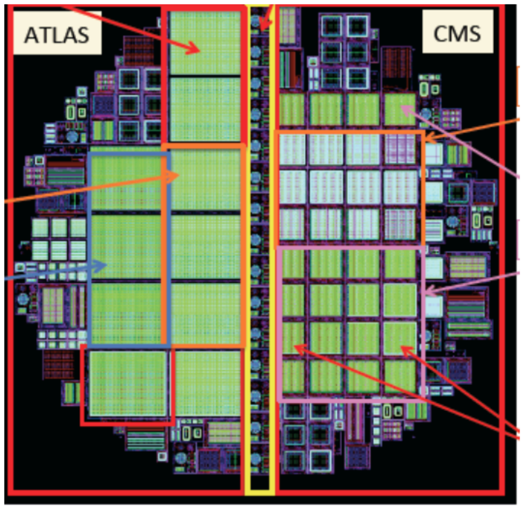
TK for HL-LHC

- TORINO heavily involved in pixel R&D
  - pixel readout ASIC (see CHIPIX65 talk)
  - pixel sensors
  - detector simulation for pixel layout studies
- Tracker plan for HL-LHC
  - TDR foreseen for middle/end 2017
  - discussions on-going within INFN institutes and at TK-MB about sharing of responsibility
- Interests of Torino are in Barrel Pixel Tracker
  - readout chip (procurement, qualification)
  - module calibration and qualification
  - mechanical integration and testing
- For year 2017, requests are for
  - support for the sensor R&D (bonding, test set-ups)
  - Other in CHIPIX65 presentation for chip R&D

TK R&D on pixel sensors

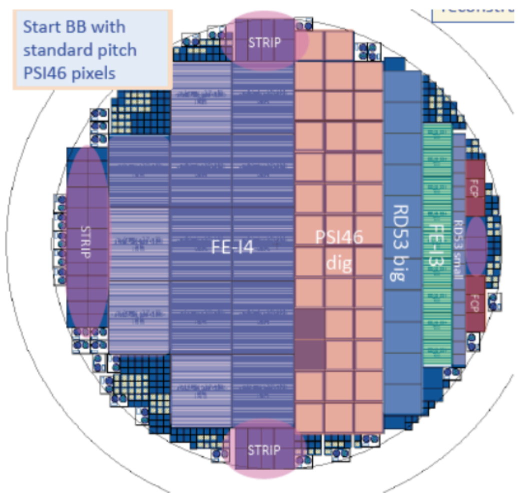
Several submissions ongoing to select technologies and configurations

Finished:



FBK Planar

Detectors went to test beam before and after irradiation



FBK 3D

Sensors just delivered
Bump-bonding in preparation

Foreseen:

INFN

- FBK Planar Active Edge
- FBK 3D Active Edge

CMS

- HPK Planar

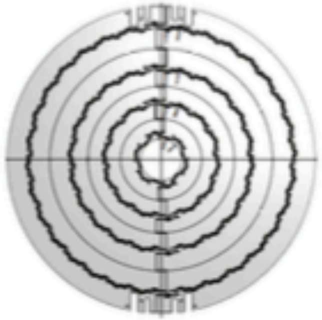
Torino contribution:

- Module assembling, wire-bonding
- Module characterization and calibration
- Beam tests

INFN contribution to HL-LHC Pixel

Deliver Layers 1-2 BPix, mounted, integrated and tested with 324 (3x1 ROC) ultra rad-hard Pix modules (≈ 0.4 m^2 surface detector)

- **Contribution to development, qualification, RD53 ROC, Sensors, Hybrids**
  - **ROC testing**
  - **Sensors testing**
  - **Hybrids testing**
- **Construction and integration of Modules (324 installed) in Pixel Layer 1-2**
  - **bare module testing**
  - **module assembly and bonding**
  - **module burn in and calibration**
  - **module mechanical integration and qualification**



- **Bpix Mechanics development and construction**
- **Contribution to development, qualification of common systems**
  - **Serial power system and Power Supply**
  - **DAQ and Control Systems**
  - **Safety system**

Draft INFN organization for Pixel construction: Barrel L1-L2

WP1 PI

Silicon Sensors Qualification

WP2 TO-PV

Qualification of Pixel Readout Chip

WP3 BA

Front End Hybrid development
Construction and Qualification

WP4 PI

Bumb Bonding qualification
324 Bare Modules testing

WP5 FI

324 Pixel Module Assembly,
wire bonding and testing

WP6 TO

324 Pixel Modules burn in, calibration
Module Integration on Layers and
functional test

WP8 TO-PI

Bpix Mechanical support developments
Bpix mechanical construction and
mechanical qualification

WP7 ALL

Integration, test and
commissioning at CERN

Richieste CMS 2017
Lab. Tecnologico – Lab. di Elettronica

Dattola	12 m	Infrastruttura per studi di longevita' dei DT alla GIF++/ Schermo protezione per MB4 (DT)
Dellacasa	1 m	Aggiornamento FW DDU
De Remigis	40%	Progetto DT nuovo Minicrate
Rotondo	11 m	Progetto DT nuovo Minicrate
Rotondo/Mignone	1 m	Disegno PCB per test prototipi ECAL
Mazza/Dellacasa/Rolo	6 m	ADC/Transceiver ASIC
Zampieri	2 m	Supporto per setup di test rivelatori 3D (CT-PPS e RD_FASE2)
Pini/Dumitrache	3 m	Wire-bonding rivelatori CT-PPS e RD_FASE2