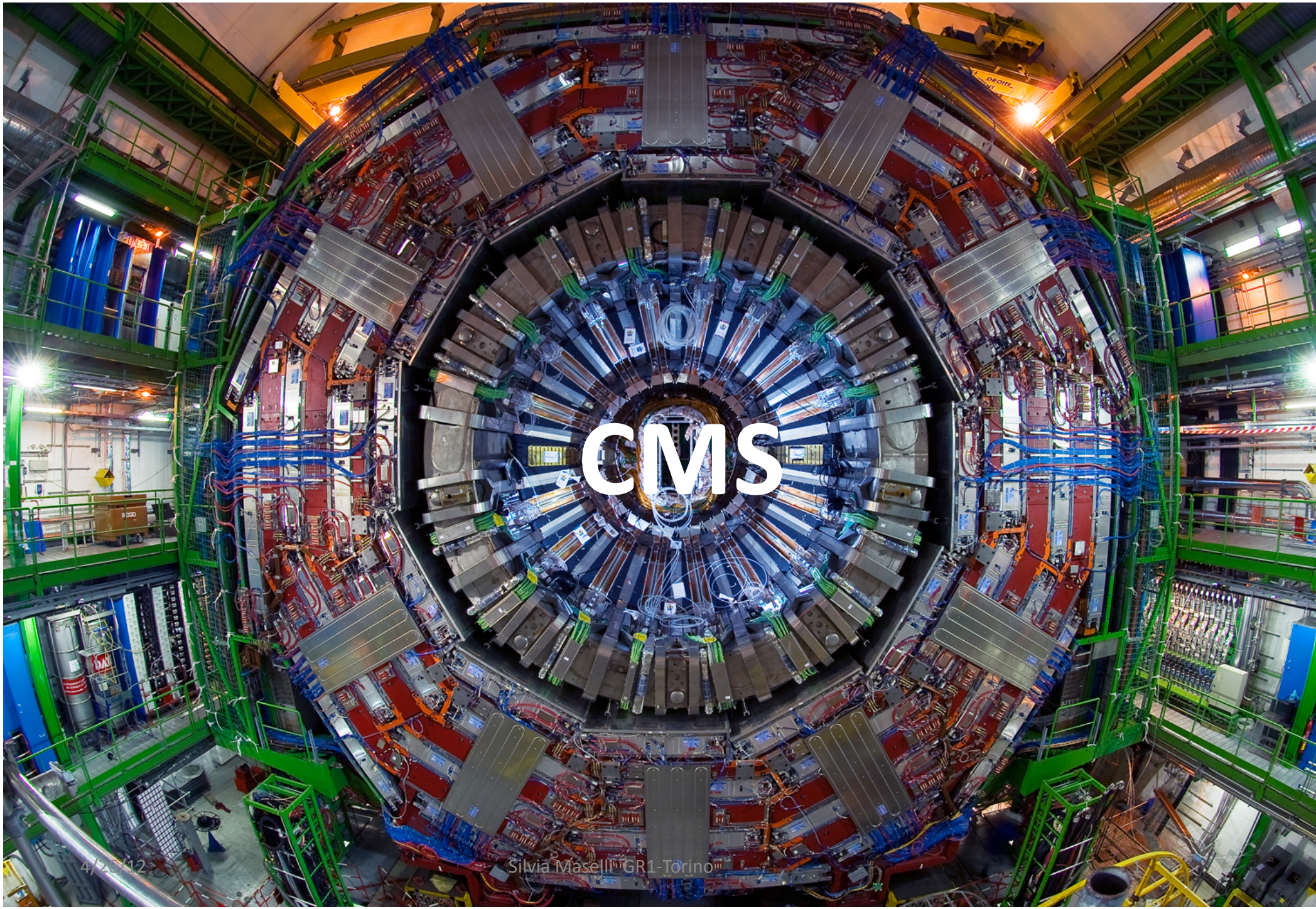
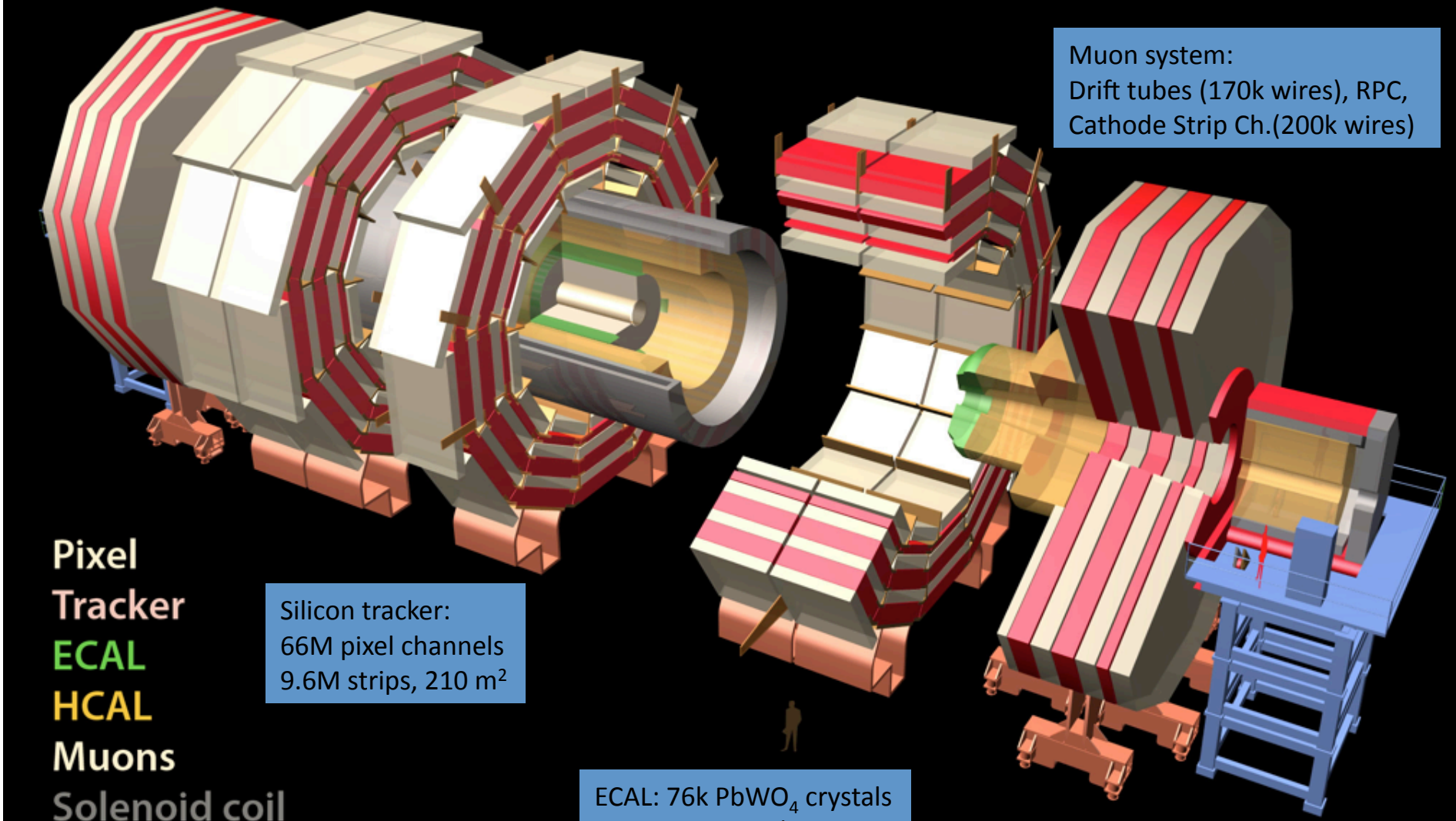

CMS

The CMS Detector



Outline

- Short review of last year operation
- Highlights of Physics Results
- Upgrade Plans

I will focalize:

- Contributions connected to CMS-Torino group
- Hardware activity connected to the maintenance/consolidation/upgrade of CMS detector

People: 3381 Physicists and Engineers (including 720 PhD Students), 40 countries, 173 institutions

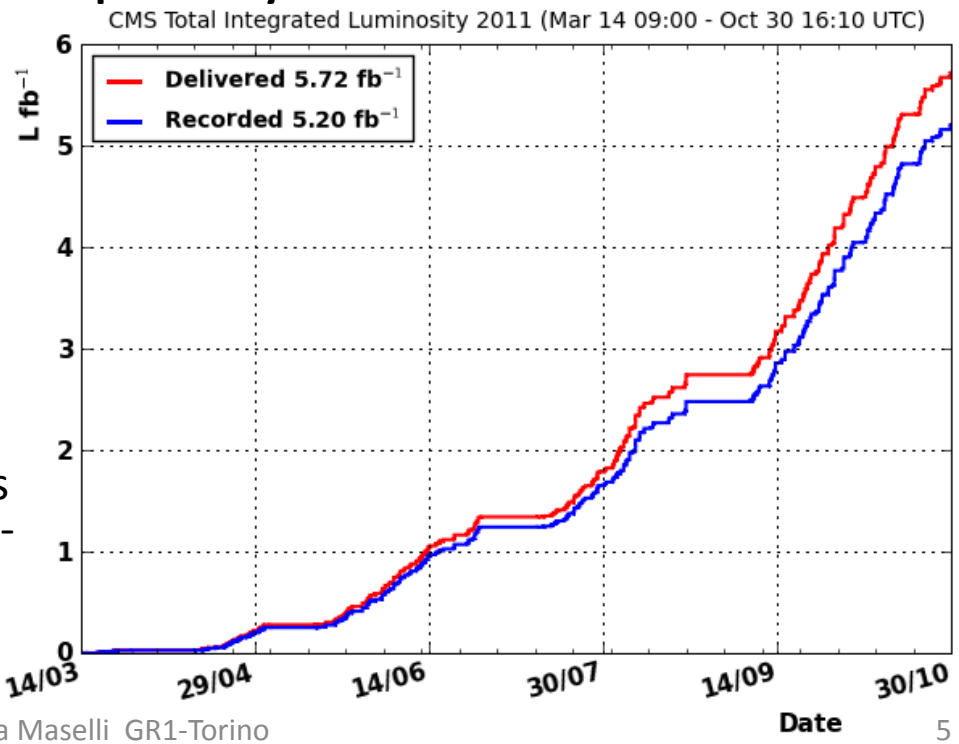
2011 run Review

- LHC delivered high-quality, high-intensity data
- Smooth running conditions, smooth curve in instantaneous luminosity
  - Allowed experiments to gradually understand triggers / tune them / tighten thresholds
  - Optimal turnaround in terms of studies of high-xs phenomena, then "rediscovery" of known EW physics, and finally searches of rare processes
  - Also collected small dataset of pp collisions at 2.76 TeV for xs comparisons to PbPb data
  - End-of-year heavy-ion running (Pb-Pb, 2.76 TeV/nucleon) allows to extend measurements in high-energy nuclear collisions
    - 150/μb: x20 statistics wrt2010

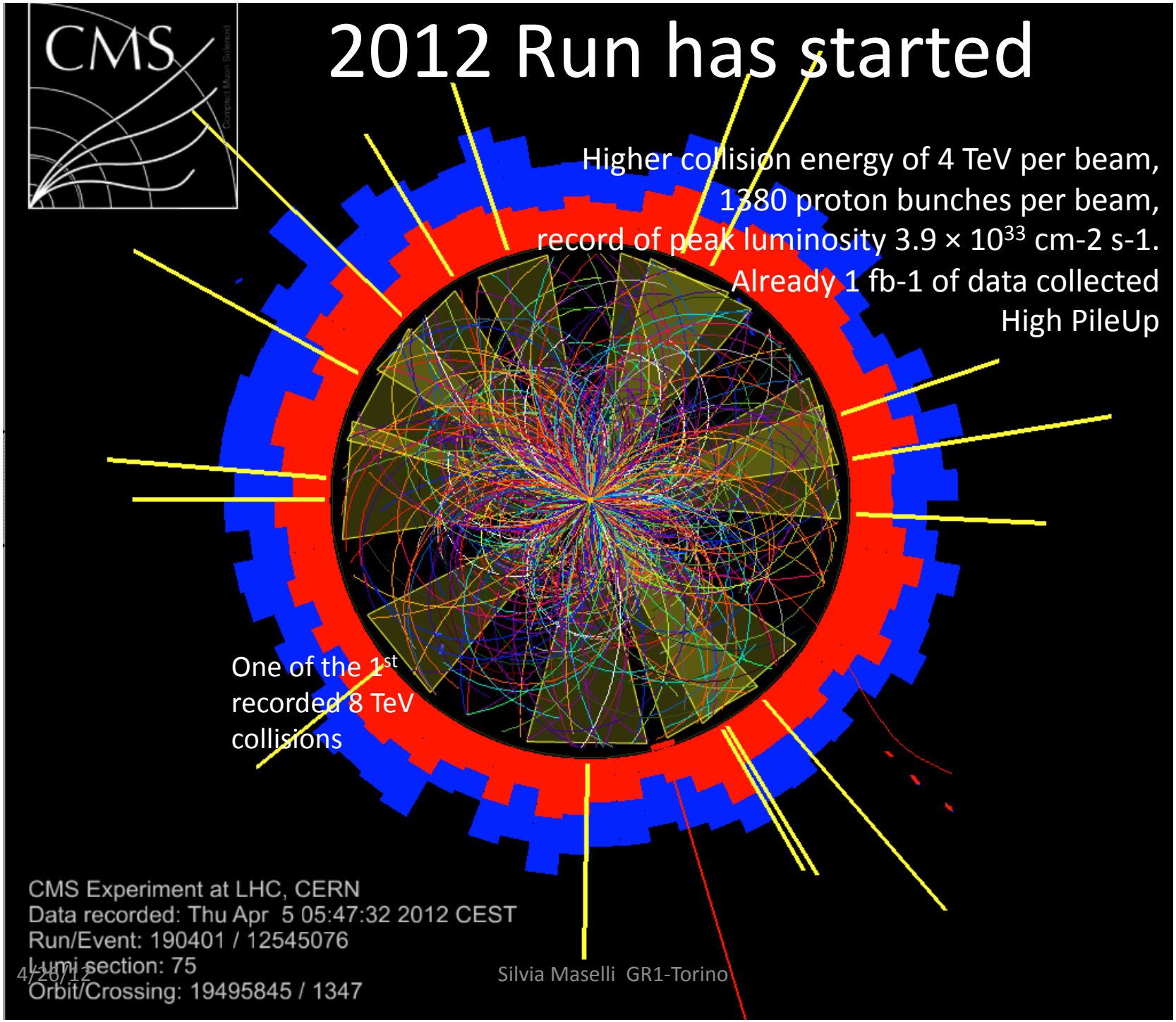
5.72 fb^{-1} delivered by LHC
5.2 fb^{-1} recorded by CMS.
→140 times more data than 2010 !

Tevatron in 8 years ~10fb-1

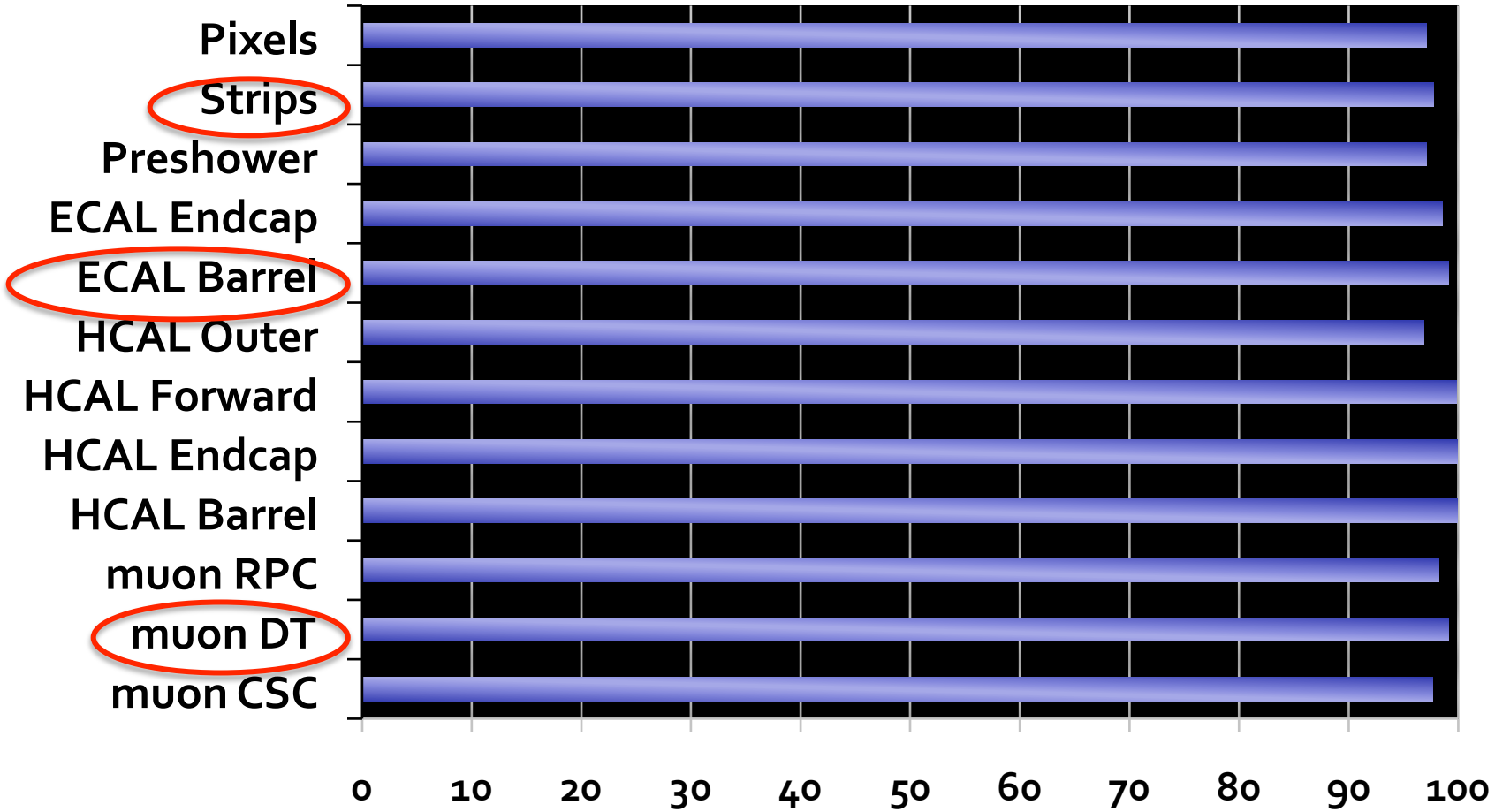
Average fraction of operational channels per subsystem >98.5%



2012 Run has started



Current Operational Status



Pixel Tracker	Strip Tracker	ECAL Barrel	ECAL Endcaps	HCAL Barrel	HCAL Endcaps	HCAL Forward	HCAL Outer	Muon DT	Muon CSC	Muon RPC
97.1%	97.75%	99.16%	98.54%	99.92%	99.96%	99.88%	96.88%	99.1%	97.67%	98.2%

Huge Effort in operation and maintanence

CMS-Torino has fundamental responsibilities in many field :
coordination, operations, physics, upgrade. Some of the recent contributions:

- Responsabile Nazionale CMS
- Detector Performance Group
- DDU read out
- Calibration /Alignment
- Upgrade
- Operation Coordination
- Reconstruction Software
- Run Coordination
- Trigger/DQQ

The excellent performance
has been possible thanks to the contributions of Torino engineers and technicians .
They have given in the past years support to construction, test, and maintenance
more recently they are involved in design and realization of upgrade CMS projects

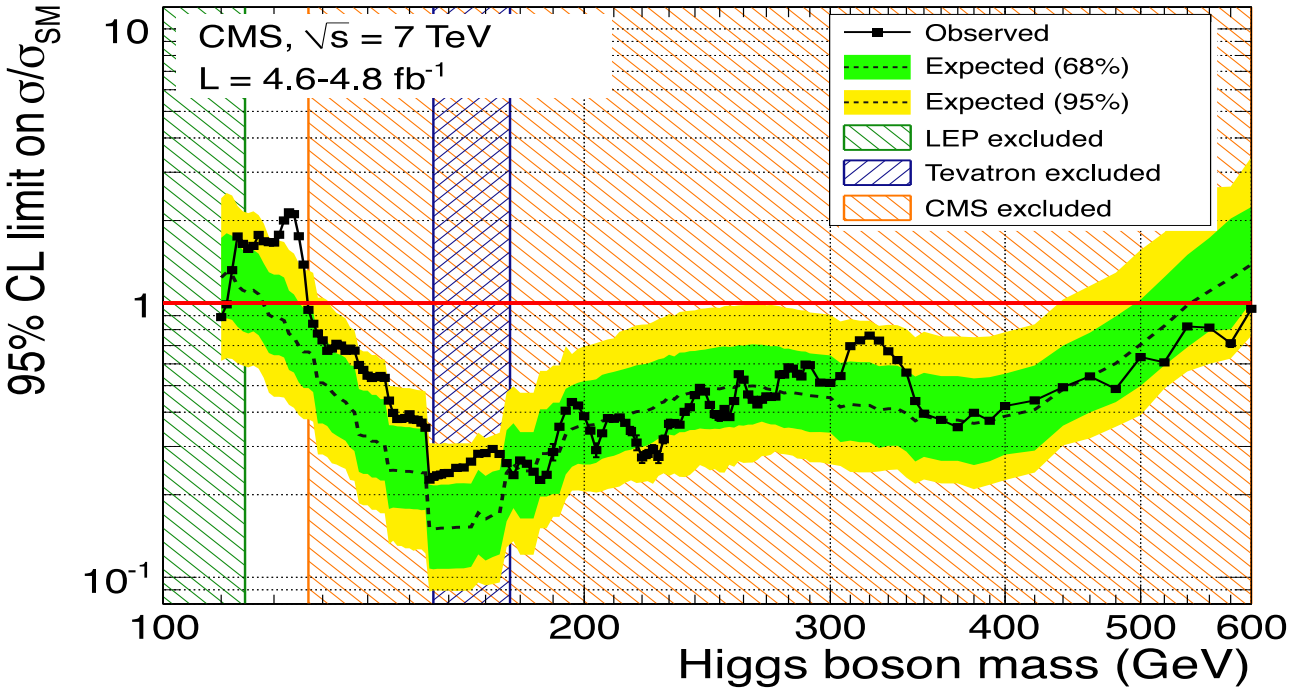
2011/2012 commitments: Expert support in HV and LV supply for ECAL, DT, TK
Expert and responsibility in Mechanical CMS Integration, Upgrade DT Fibers design and realization and Upgrade of Beam Pipe drawings for Very Forward LHC detectors
Expert and responsibility in DT Upgrade Optical Links project
Expert and responsibility in design of New ROC for Pixel Upgrade

Highlights from Physics

Only small subset of all results

Enphasize Torino Activity

Higgs Exclusion Limits: Combined Results



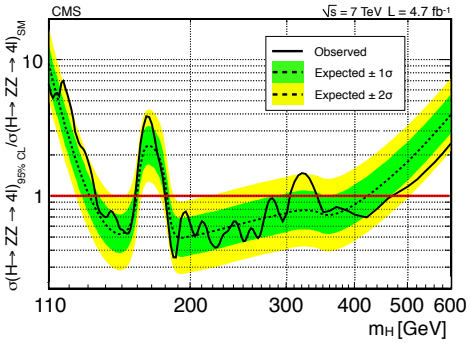
•Only a very narrow mass range [114.4 – 127 GeV/c^2] remains compatible in CMS with the existence of the SM Higgs boson.

• An excess of events is observed, most significant in the 4ℓ and $\gamma\gamma$ channels, in the range 119 – 125 GeV.

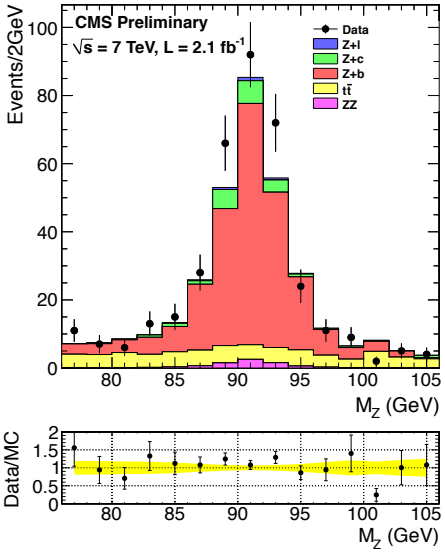
- Largest local excess at 124 GeV with a significance of 3.1σ
- If it thereby the end of 2012 CMSwill have enough data to discover the SM Higgs

CMS-Torino is heavily involved in Physics Analysis from Hard to Soft Regime

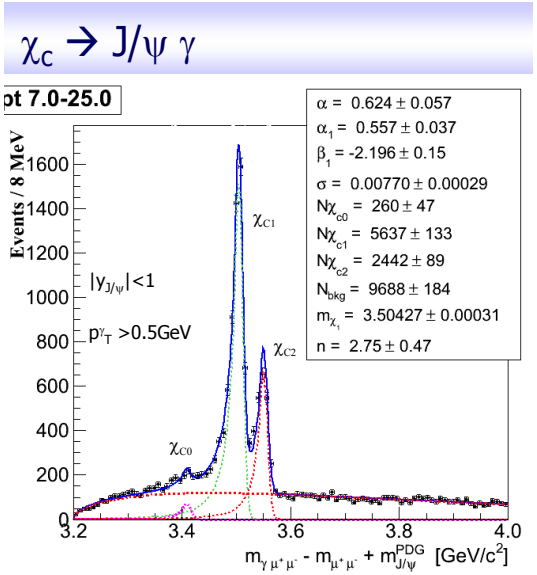
Higgs Searches: H→4l



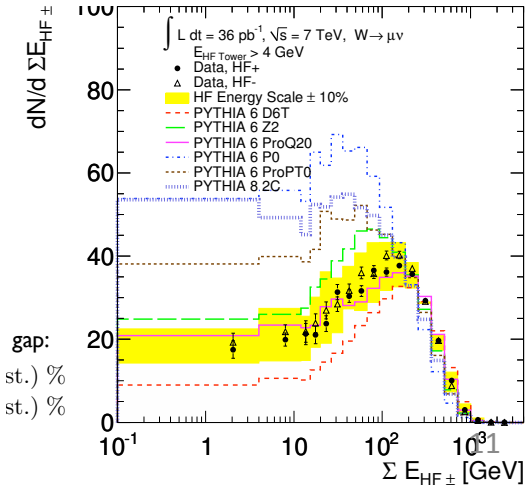
Elettroweak Physics:
Measurement of Z+bb/Z+c cross section



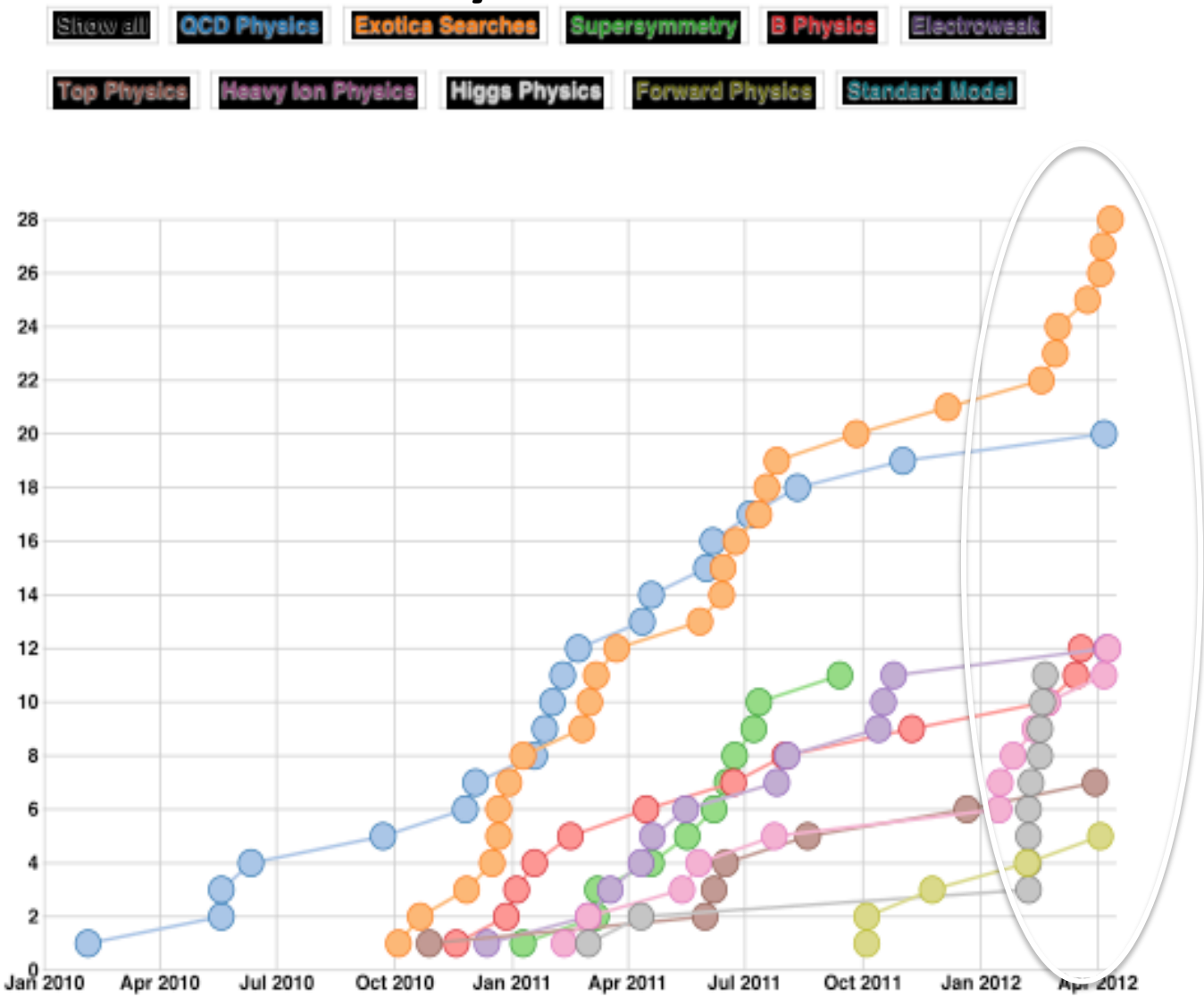
Quarkonium and spectroscopy χc/ χb



Diffractive di-jets production,W/Z events with rapidity gaps



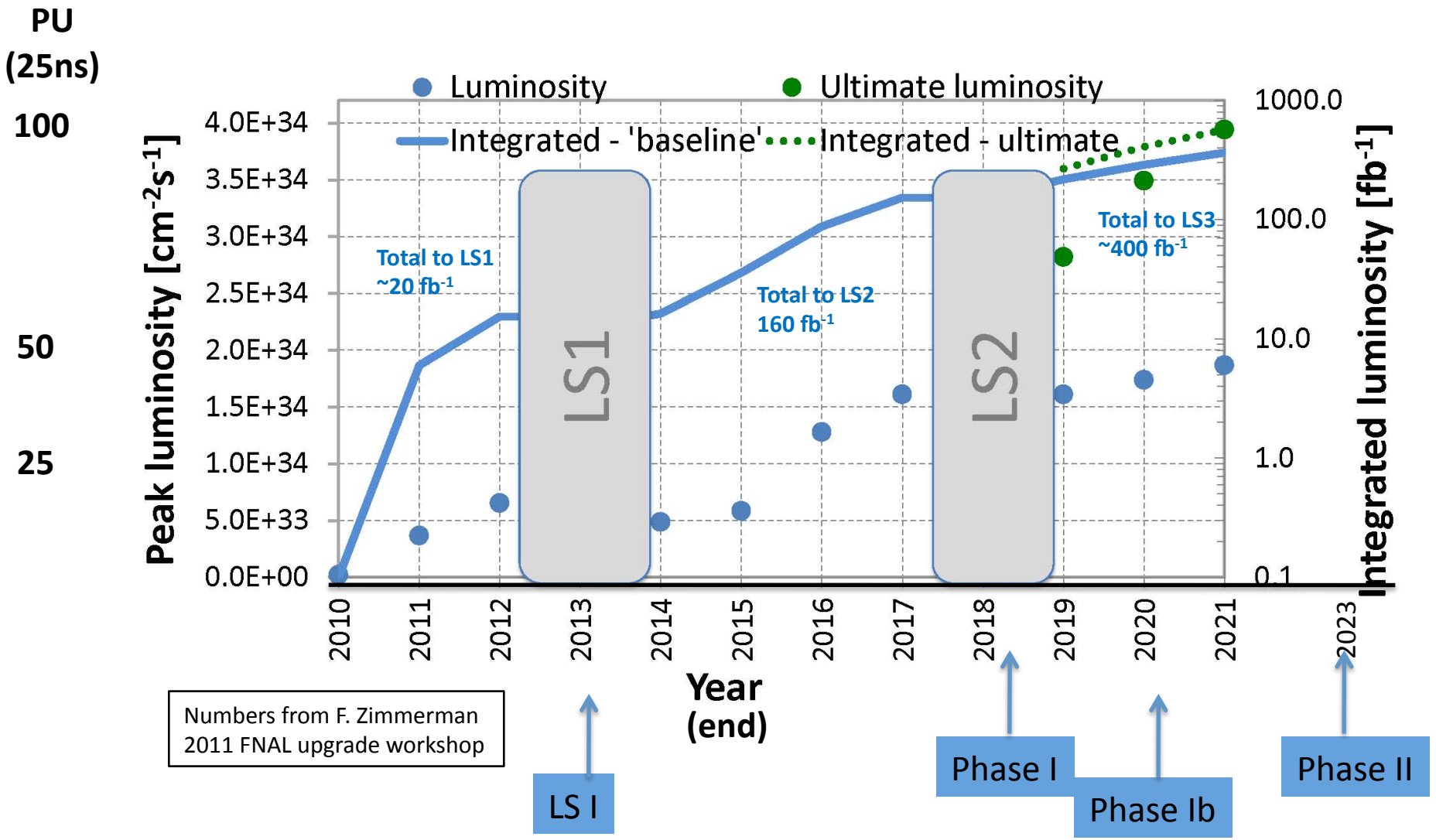
CMS Physics Publications



A wave of up to ~150 pubs on full 2011 dataset has begun to rise

We are only at the beginning …

LHC Long Term Perspectives



CMS Upgrade Plans

Phase 1 Upgrade < 2020 : LS1, LS2

No big changes of the LHC machine in this decade

Long Shutdown 1: LS1 (2013/2014)
machine reach nominal (E=14TeV/ L=10^{34}cm^{-2}Hz)
19 months, physics not before end 2014
CMS: New beam pipe; DT maintenance; TK Cold; New muon endcap CSC/RPC
(TK COLD: Improvement in Humidity seal THIP = Tracker Humidity Improvement Project)

Technical Stop winter 2016/2017:
CMS: new Pixel, HCAL FE electronics, Trigger

Phase 1b Upgrade

CMS: possibility to insert New ROC Pixel

Phase 2 Upgrade >2021 – HL-HLC

Will take place after a LS3
Significant changes to the machines and detectors

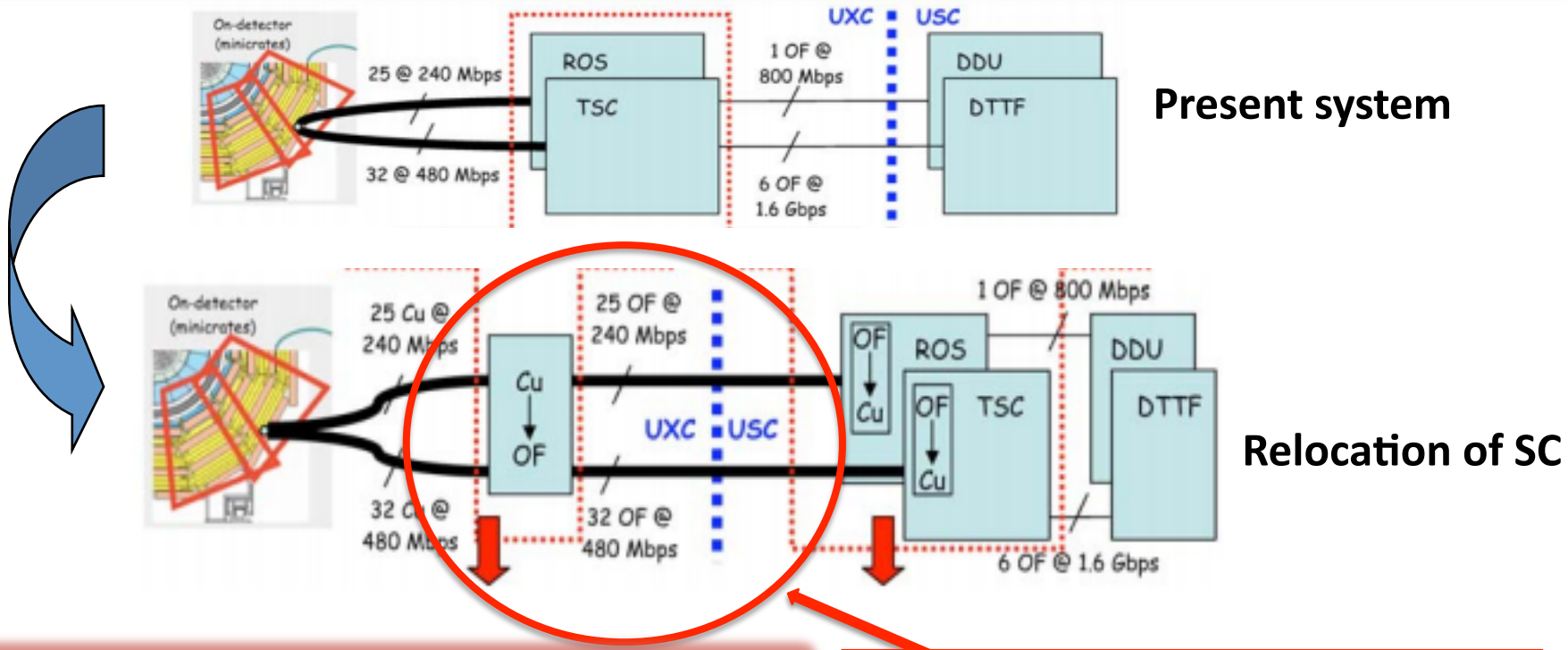
Upgrade Plans for CMS-Torino

Muon Upgrade
Tracker (Pixel) Upgrade
Very Forward High Precision Spectrometer

Relocation of the Sector Collector

- **Relocation of DT SC electronics in the USC counting room**
- **Make a robust copper to OF conversion at SC level**
- **Modify input mezzanines of ROS and TSC**

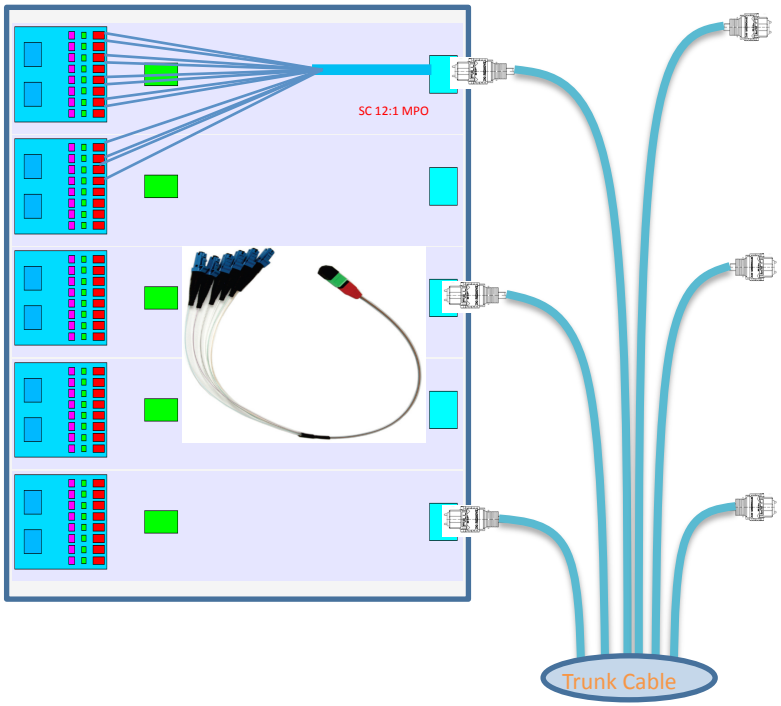
Low impact modifications: compatible with present system and with possible future upgrades

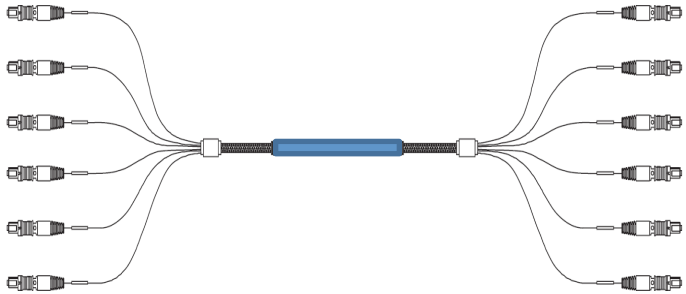


A malfunction in one board of SC or ROS imply the loss of ~2% of apparatus

Torino commitment: CuOF project

DT Upgrade. UX-US Optical Fibre.
Proposal with Trunk Cables 72 Fibre terminated by 6 MPO



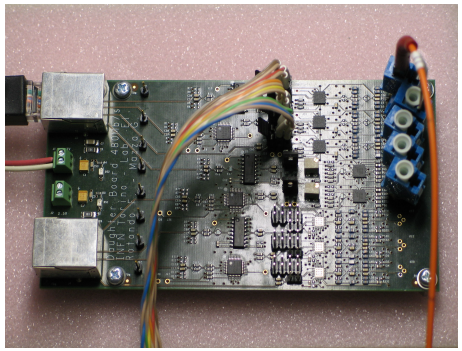


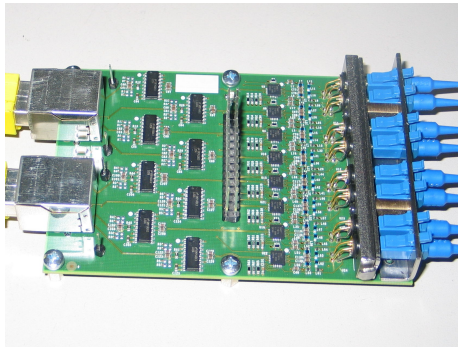
Fibers layout

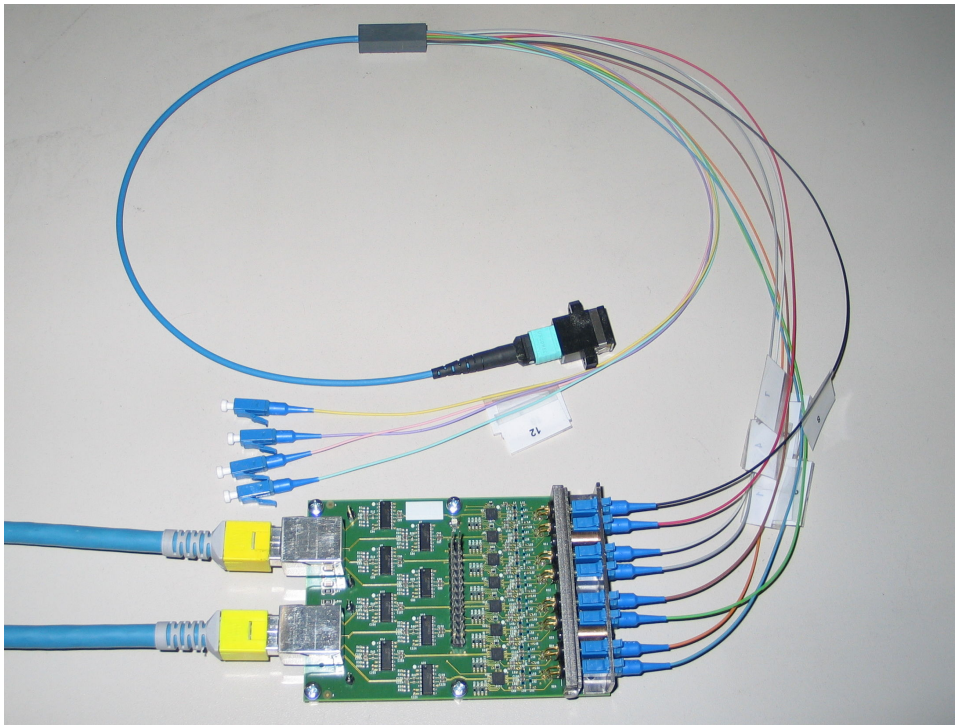
* Space available for routing the fibers is tight but existing

* Passing of connectorized fibers imposes constrains on the fiber selection

Test board and first prototype for the CuOF







The test board was designed for the evaluation of several combinations of cable equalizers and laser drivers; while the CuOF prototype is ready for the testing of the system behaviour together with the 60 m long optical fibres and the VME prototype of the OFCu module.

Pixel Upgrade: Objectives and Scope

- Handle luminosity of at least 2 x 10^{34}
  - at 2x 10^{34} Hz/cm^2 and 25ns (or 10^{34} Hz/cm^2 and 50ns)

  Expect ~16% data loss for BPIX layer-1
  - at 2x 10^{34} Hz/cm^2 and 50ns

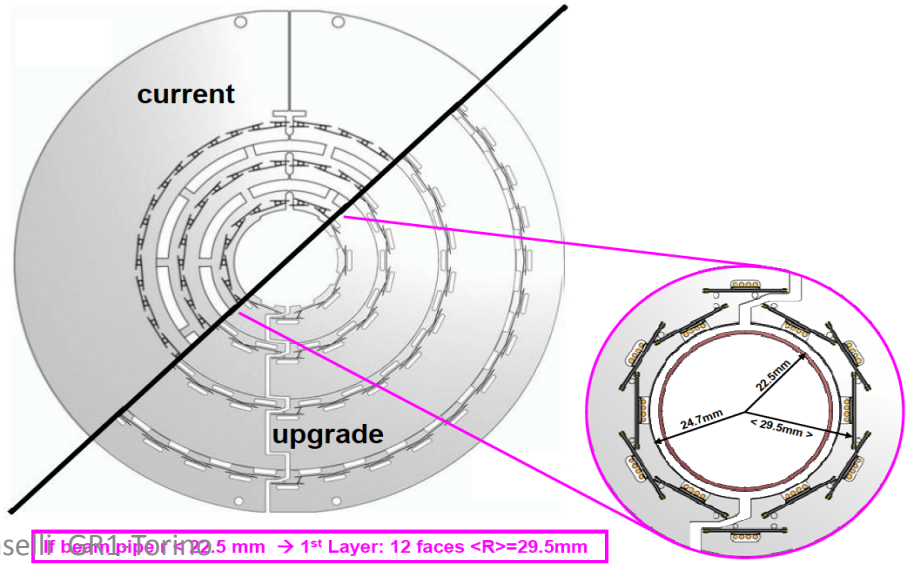
  Expect >50% data loss in BPIX-L1, and large losses for L2 and L3 also.
  - R&D on rad-tolerant sensors & new pixel readout electronics (chips, optohybrids, front end drivers)
- Maximize hit coverage
  - Providing 4 hits with coverage up to eta of 2.5 to increase the physics performance
- Reduce material
  - Light-weight mechanical support
  - CO_2 cooling

Total 79 million pixels

1.6 x *present* BPIX

- **Goal: detector ready mid-2016**
- **5 months to install and commission**

BPIX Upgrade Mechanics



Pixel “Phase 1b” Development

- Motivation
  - Luminosity is expected to be above $2x10^{34}$ before 2020
  - Innermost layer for the upgrade pixel detector will need to be replaced at least once or even more
  - Improve sensor radiation tolerance (e.g. thin Si, 3d sensor, diamond)
  - New pixel readout chip with rate capability to handle luminosity well above $2x10^{34}$ $cm^{-2}s^{-1}$
  - Support for (region of interest) intermediate level trigger
- Goal
  - a new pixel layer with better performance and longer lifetime ready for installation when the pixel inner layer needs to be replaced
  - **Development towards the requirements for the HL-LHC pixel detector**
- Work plan
  - Collaboration of institutes in Europe and US
  - Assess requirements and determine what can be done in time to have significant improvements during the operational lifetime of phase 1
  - Working groups being formed on Readout chip, Sensor, Simulation, System architecture, Trigger. Initial steps for the next two years defined

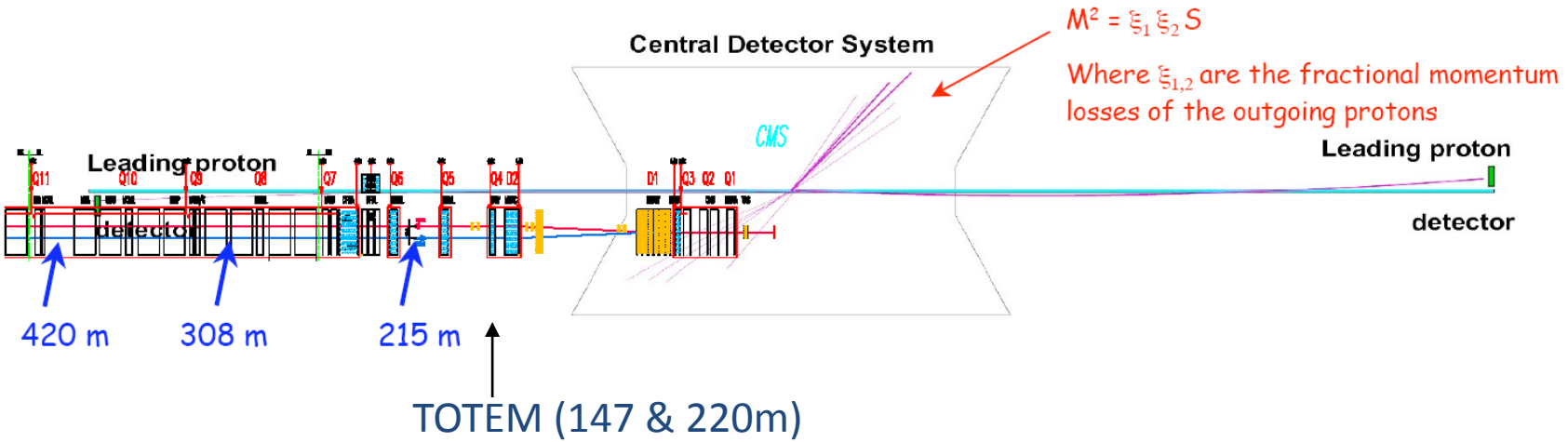
The New Pixel ROC for Phase 1b

- The Phase 1 ROC is the main baseline (2016)
  - Good conservative approach but it limited precisely by that (250nm; PUC/architecture unchanged)
  - Problems foreseen for Layer 1 already with R=3.9cm; they will not improve at 2.98cm
- The New Pixel ROC for Phase1b should set our technical specs above phase 1, studying phase 2 regime already
- We should profit from CMS case: same performance as Atlas (or better) with larger PUC
- Technology wise we should start with 130nm but in future we should not forget larger integration scale (90/60/35 nm)
- Sensor will be an important ingredient to be taken into account
  - Thickness could allow better segmentation or higher rates

Torino is the center in Italy where there is most expertise in micro-electronics INFN has invited Torino people to pursue the project.

HPS: High Precision Spectrometer @ CMS

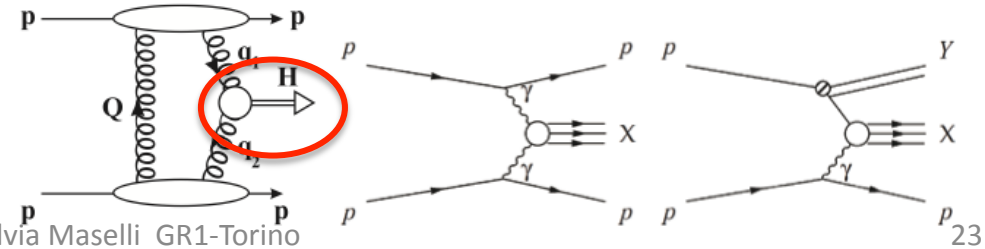
Aim is to install **precision forward proton tracking** (~ 10μm; ~1μrad), and **timing** with resolution ~10 ps, at **±240 m (±420 m)** on both sides of CMS for
p p → p + X + p physics, at normal high luminosity lowβ^* pp running.



HPS420 (Stage2)

HPS240 (Stage1)

Physics Case: Diffraction Physics



HPS future plans

Il **Management di CMS** ha richiesto al gruppo HPS un **documento entro metà maggio**. Questo documento conterrà la **proposta di upgrade** di CMS nella regione in avanti, con **rivelatori di tracciamento** per la misura di protoni di alto impulso e **rivelatori di timing** per la soppressione del pile-up, da posizionare in una '**movable beampipe**' a **±240m** dall'IP (Stage1).

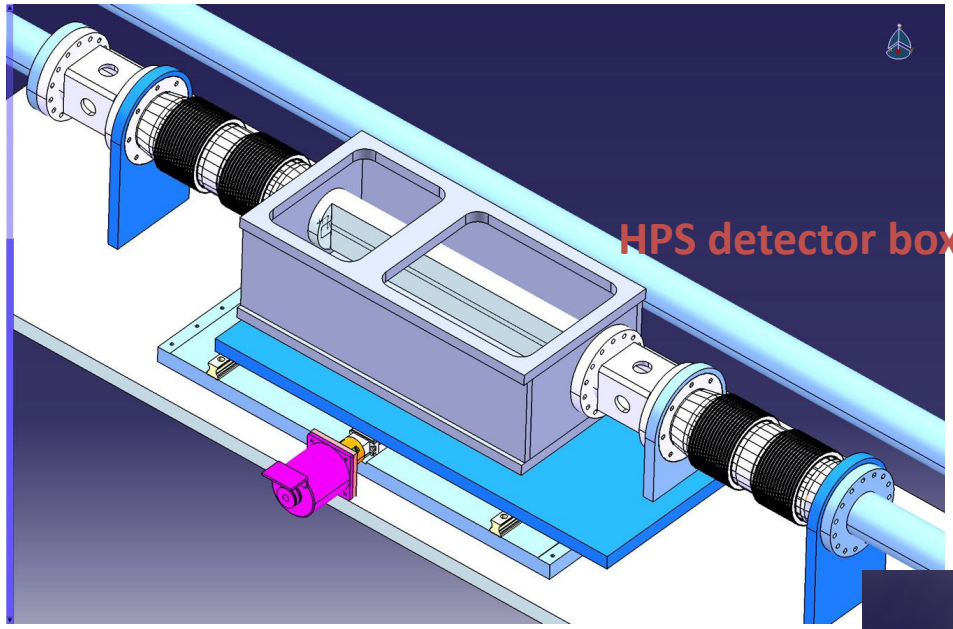
Il documento include la prospettiva di un'installazione successiva a **±420m** (Stage2), che necessita però di un cryo-bypass sulla linea di fascio.

Le **attività di Torino** in questo progetto riguardano:

- il disegno e la prototipizzazione della '**movable beampipe**' (Mimmo Dattola)
- lo **studio dei rivelatori di tracciamento a pixel 3D**
- la coordinazione della **simulazione**

In questo contesto va citato il recente sviluppo di una più stretta **collaborazione tra CMS e TOTEM**, che stanno esplorando la possibilità di lavorare insieme per un **upgrade comune della regione in avanti** e per il 2012 avranno periodi di presa dati insieme.

HPS and Pixel 3D



Movable beampipe

HPS and Pixel 3D

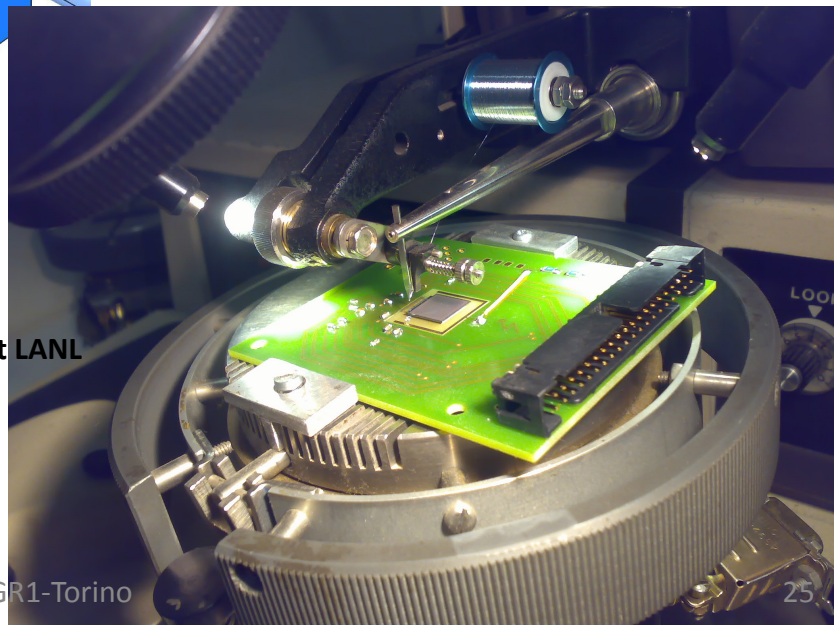
2011

- **14 detectors wire-bonded and characterised in Torino**

Testd on with a 120 GeV proton beam at FNAL, and irradiation test at LANL

2012

- **1 ATLAS09 FBK wafer** bump-bonded at Selex: **3 detectors 1E**
- **Wire-bonded and characterised in Torino**
- **Tested at FNAL** in April with a 120 GeV proton beam



Extra Funds in Torino 2010 – 2012
PRIN/FIRB submission

FIRB (Responsabile Scientifico dell'Unità di Ricerca M.Pelliccioni) : "Studio dell'utilizzo di rivelatori monolitici innovativi in applicazioni ad elevato rate ed elevata densità di tracce in fisica delle alte energie"

PRIN : " Sviluppo di rivelatori innovativi per lo studio della nuova fisica a collisori di alta luminosita" (miglioramento prestazioni RPC, SiPM (scintillatori letti da matrici di photodiodi)PRIN)

PRIN: "Sviluppo di rivelatori di radiazione a semiconduttore di nuova concezione sensibili alla posizione" (sensori 3D con bordo attivo accoppiati con un chip di R/O; sensori epitassiali assottigliati e con bordo attivo accoppiati con un chip di R/O; integrazione verticale di sensori a pixel attivi assottigliati)

Progetto di Ateneo vinto:

Collaborazione fra teorici, sperimentali ed informatici sulla ricerca dell'Higgs a LHC
"Metodi innovativi per la Fisica delle Particelle con collider alla scala del Tera-electronvolt"

Technological support 2011 -2012

- **Electronics**:
  - Progetto scheda trasmissione dati (Mazza)
  - Progetto architettura sistema CuOF (De Remigis)
  - Realizzazione e layout scheda trasmissione (Rotondo)
  - Preparazione e realizzazione Test Beam irraggiamento CuOF (De Remigis, Rotondo)
  - Installazione nuovo firmware DDU (Dellacasa)
  - Progettazione nuovo ROC Pixel (Rivetti)
  - Studi simulazione VHDL nuovo ROC Pixel (Dellacasa)
  - Bonding HPS e Tracker
  - Manutenzione HV/LV ECAL/TK/DT durante run (Trapani)
- **Mechanics**:
  - Responsabilita'/ Progetto stesura e installazione fibre ottiche Upgrade DT (Dattola)
  - Preparazione e realizzazione Test Beam irraggiamento CuOF (De Remigis, Rotondo)
  - Disegni Nuova Beam Pipe HPS (Dattola)
  - Interventi manutenzione rivelatori durante il run (Dughera, Panero)