Final Status of WP4

J. Nash – SLHCPP Annual Meeting 2011 Saclay

Outline

- Review of status on Milestones/Deliverables
- Highlights from the Technical Proposal

Task 4.1

Description of work

Task 4.1 Coordination and organisation of CMS2

Overall coordination task for managing the upgrade of the experiment for SLHC; identification of participating institutes and their contribution, including activities related to seeking and integrating new partners; definition of the organisational project structure needed to manage the consortium of institutes participating in the construction and modification work; negotiation with institutes and funding agencies to establish collaboration agreements, cost books and reporting methods; exchange and dissemination of scientific and technical information (CERN, Imperial)

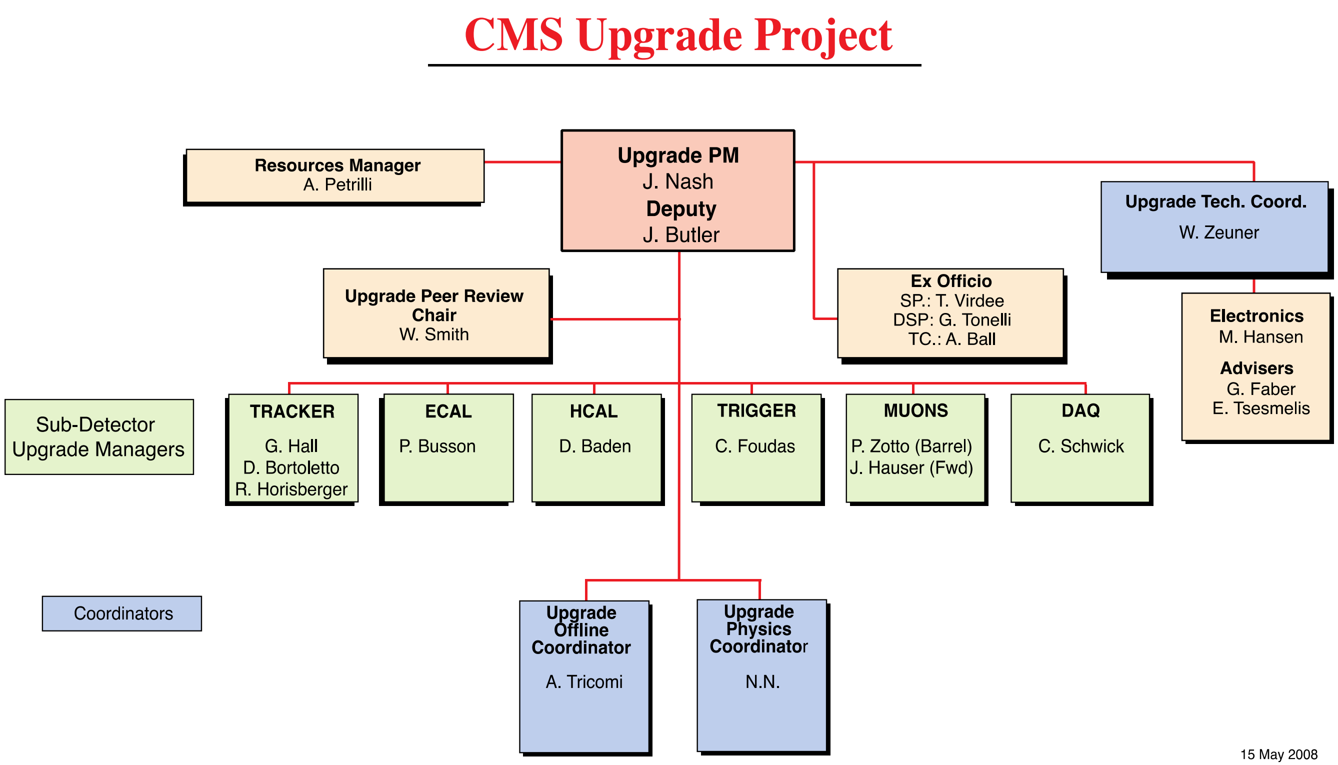
Deliverables task 4.1	Description	Nature	Delivery date
4.1.1	Project Structures for construction of systems and sub-systems	O, R	M12
4.1.2	Cost book and MoU for the upgrade and installation phase	R	M36

Milestone	Description	Nature	Expected date
4.1	Upgrade Project Scope defined	R	M18

Task 4.1.1 – Management Structure

- Project management structure defined
- Management team put in place
- Team and mandate approved by CMS
  - Now a "project" (ala Tracker/ECAL…)
- Regular meetings of management team
- Monthly meetings of overall upgrade team
  - Regular meetings of many subgroups within sub-detector upgrade projects
- Two Workshops held each year
- Report published to EU

Upgrade project organization

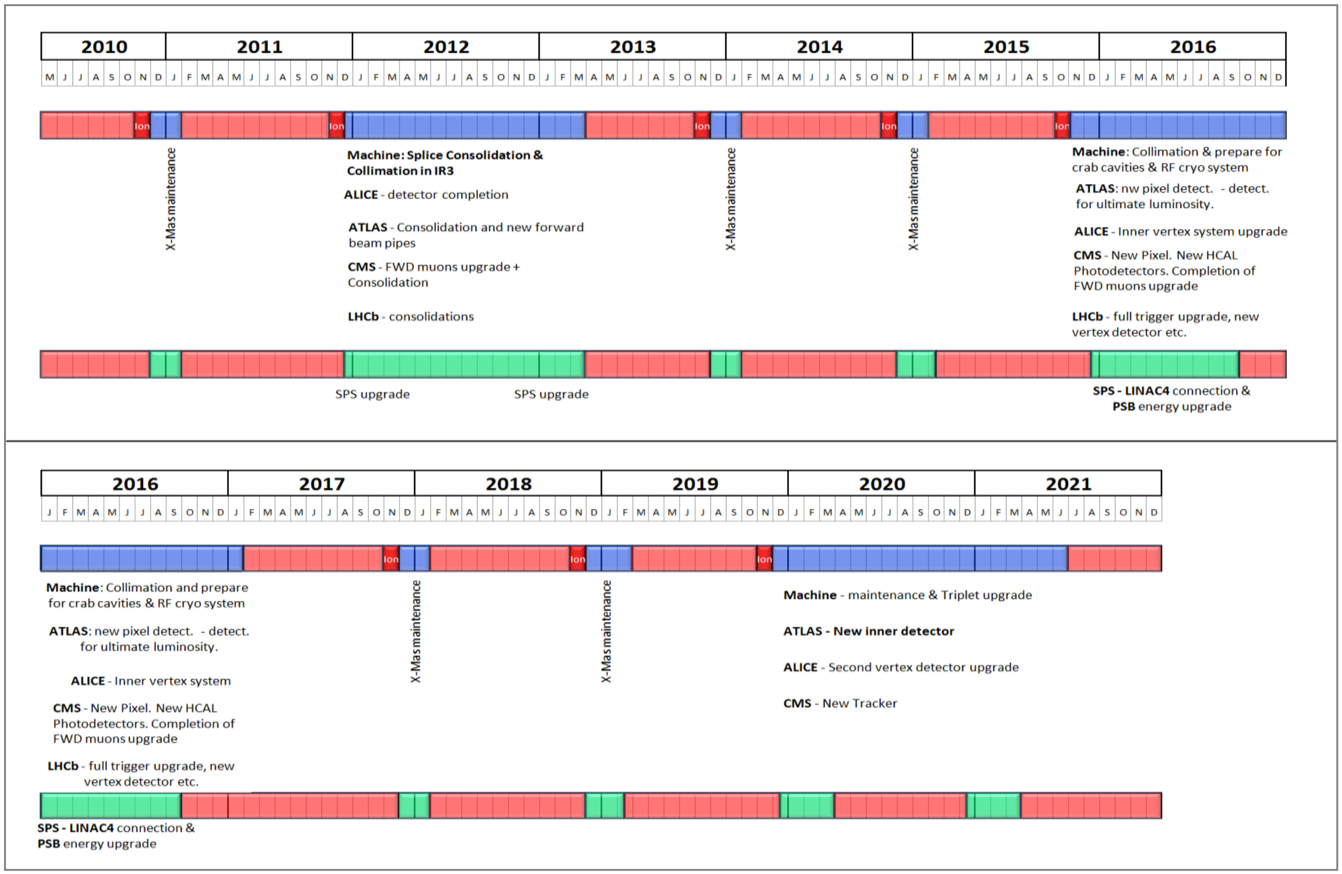


Milestone 4.1 – Upgrade Scope

- Workshop in May 2008 at CERN to define the scope of upgrades
  - What needs to be done in Phase I, Phase 2
- Follow up workshop held November 2008 in FNAL (150 participants) to track progress, and prepare work plan for the following six months
  - Goal prepare TP for phase I upgrades
- Workshop held in May 2009 to present, approve plans for phase I upgrades, and also progress towards a "Strawman" for phase 2 upgrades.
- Follow on Workshops held in Oct 2009 at FNAL, May 2010 at CERN, October 2010 at CERN
- Report published to EU – Milestone passed
  - Explicitly break out phase I and phase 2

CERN has announced the plan for shutdowns over the next 10 years

The 10 year technical Plan



This plan is very consistent with what CMS had been planning for upgrades

Agreed at the May 2008 Upgrades Workshop
http://indico.cern.ch/conferenceDisplay.py?confId=28746

CMS Upgrade Scope

2016

2012

2016

2012
/2016

2016

CMS Upgrades ideal scenario

- 2012(now 2013) Shutdown
  - Begin Installing forward muon systems
  - HO SiPMs (Hadronic Calorimeter Tail Catcher)
  - HF PMTs (Forward Hadron Calorimeter eta 3-5)
  - Pixel Luminosity Telescope
- 2016 (now 2017?) Shutdown
  - Install new beampipe
  - Install new pixel detector
  - Install HB/HE photo-detectors
  - Install new trigger system
- 2020 (now 2022??) Shutdown
  - Install new tracking system
  - Major consolidation/replacement of electronics systems
    - Including potentially ECAL electronics
  - ECAL Endcaps (subject of a task force)
  - DAQ system upgrade

Requirements for the phases of the upgrades: ~2010-2020

- This decade will see the initial operation of the LHC and the increase of energy and luminosity towards the design luminosities.
- Goal of extended running in the second half of the decade to collect ~100s/fb
  - 80% of this luminosity in the last three years of this decade
  - About half the luminosity would be delivered at luminosities above the original LHC design luminosity
- Motivation for upgrades during this phase
  - may be based on required performance for higher luminosity, better physics performance, better reliability of operation

WP 4.2 Deliverables

Deliverables task 4.2	Description	Nature	Delivery date
4.2.1	Personnel and working practices of the Technical Coordination unit in place	O, R	M12
4.2.2	Key structural requirements (information repository, tools, coordination framework, safety and quality systems, integration office) and scheduling and reporting mechanisms in place	O, R	M18
4.2.3	Pilot design and schedule for the upgrade project published.	R	M36

Task 4.2.1 – Upgrade TC Unit established

- Upgrade TC named
- Working within the current technical coordination unit.
- working methodology defined
- Planning for work in 2012/2016 shutdowns well advanced
- Meetings between Executive Board, and Project Managers to discuss procedures for reviews, TC needs for upgrades, engineering support issues
- Report published

Task 4.2.2 – Upgrade TC methodology defined

- Working within the current technical coordination methodology.
- Examined potential changes for future operation
- Report published

Technical Proposal – “pilot design”

- We have finished the Technical Proposal.
  - >300 page report
- This has been submitted to the LHCC
  - Is under review, should be “approved” at LHCC March meeting
- R/D for HL-LHC is also going on and appears as an appendix to the TP

CMS U1TDR
2010/11/15

2010/11/15
Head Id: 16688
Archive Id: 0:21642M
Archive Date: 2010/08/31
Archive Tag: trunk

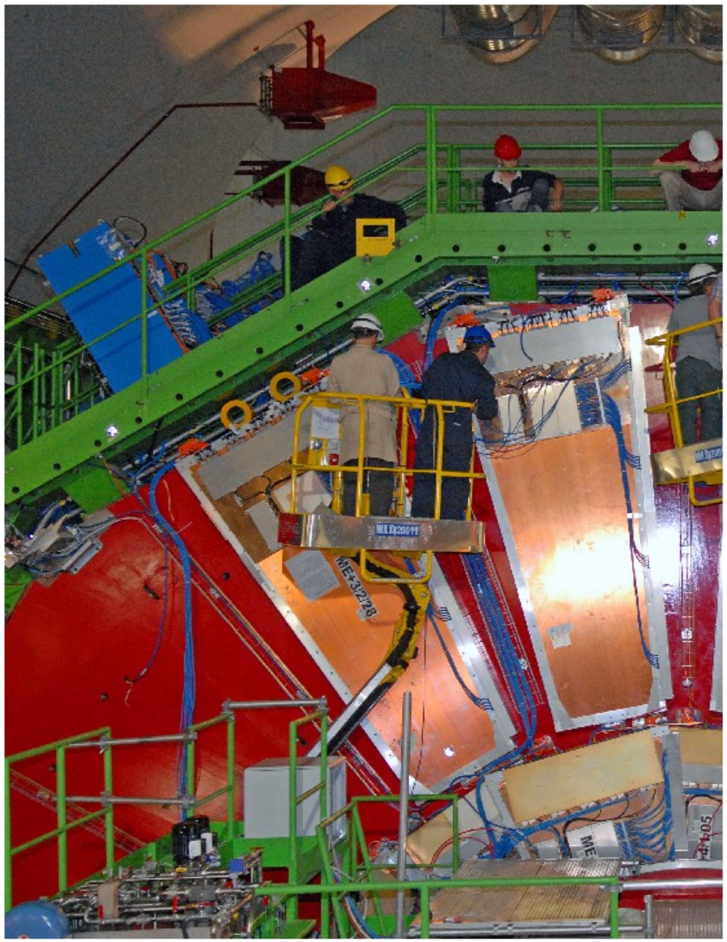
TECHNICAL PROPOSAL FOR THE UPGRADE OF THE CMS DETECTOR THROUGH 2020

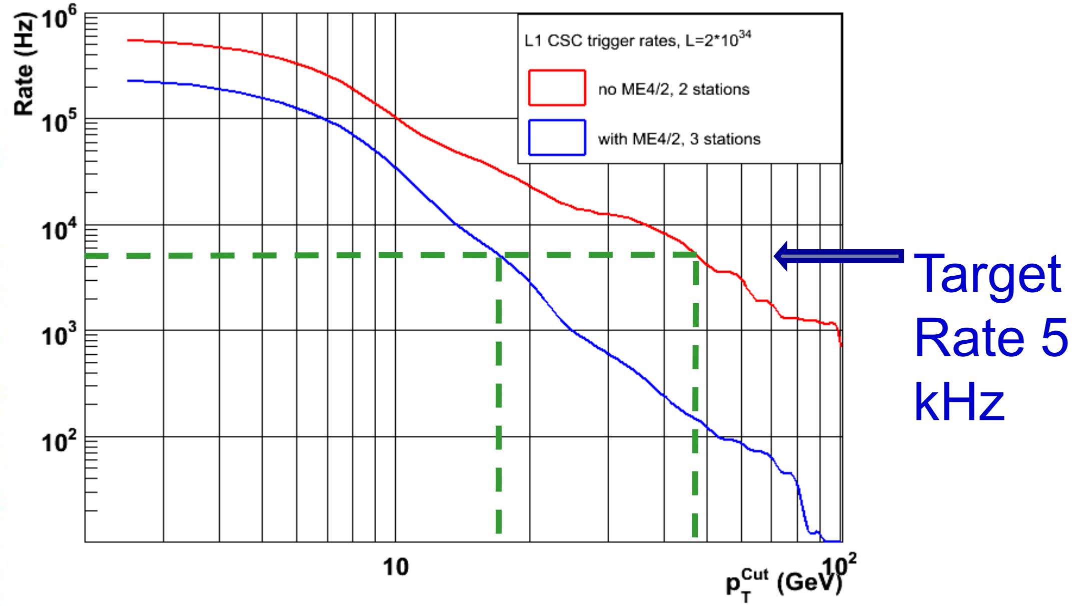
The Large Hadron Collider at CERN has begun operations at 7 TeV center of mass energy. CERN plans to run at this energy until the end of 2011 with the goal of providing an integrated luminosity of 1 fb^{-1} to the CMS and ATLAS experiments. The LHC will then shut down for 1 to 1.5 years to make the revisions necessary to run at ~14 TeV. Operation resumes in 2013. In 2016, there will be another long shutdown to prepare the LHC to operate at and eventually above the design luminosity of 10^{34} $cm^{-2}s^{-1}$. Operation will then resume with the luminosity rising gradually during this period to 2×10^{34} $cm^{-2}s^{-1}$. The two long shutdowns provide CMS an opportunity to carry out improvements to make the experiment more efficient, to repair problems that have been uncovered during early operations, and to upgrade the detector to cope with the ultimate luminosity that will be achieved during this period. The detector work involves the hadron calorimeters, the muon detectors, the pixel detector, the beam radiation monitoring and luminosity measurement system, the trigger, the data acquistion system, and the CMS infrastructure and facilities. The purpose of this report is to explain the need for these improvements, repairs and upgrades and the plans for carrying them out and installing them in the two shutdowns forseen in 2012 and 2016.

Some highlights from the TP

- Upgrades to the Muon System
- Upgrades to the Hadronic Calorimeter
- Upgrades to the Pixel Detector

Phase 1 : Muons ME4/2 upgrade motivation



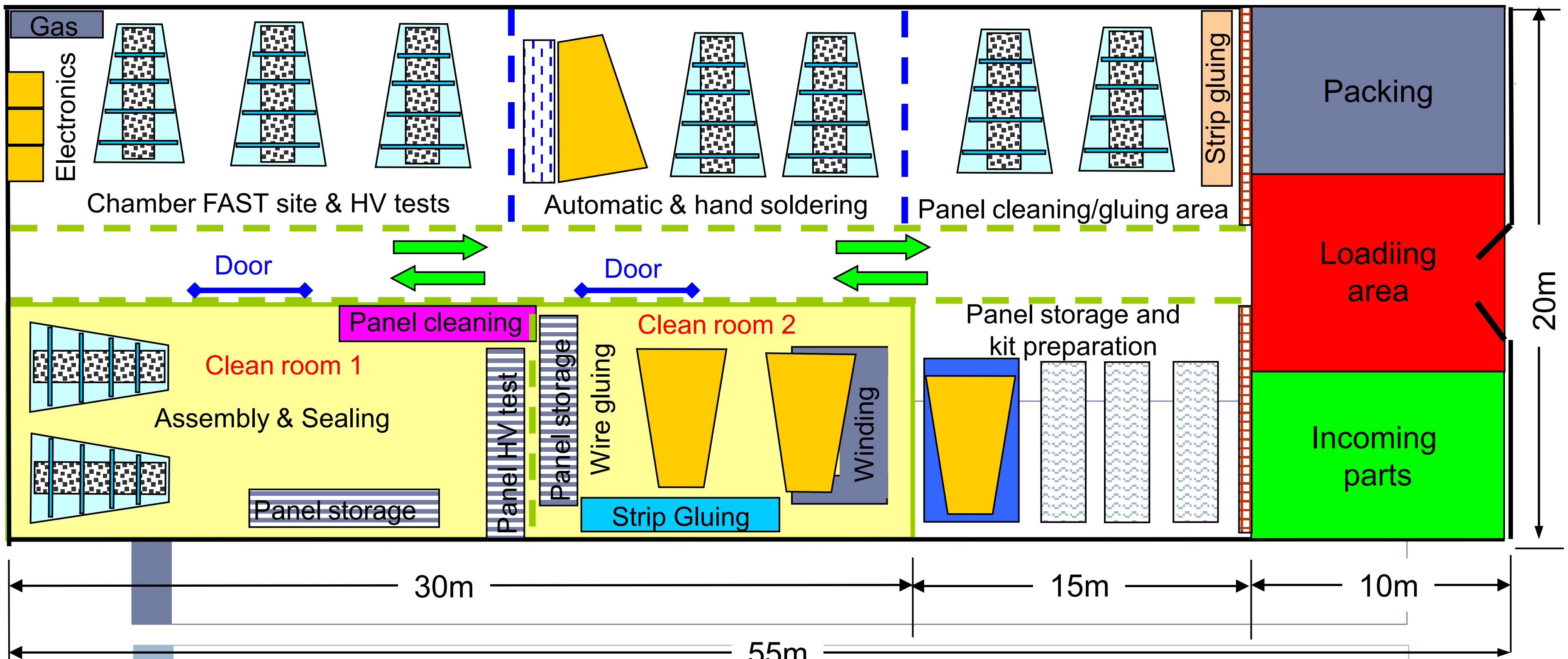


5 chambers already installed

- Compare 3/4 vs. 2/3 stations:
  - (Triggering on *n* out of *n* stations is inefficient and uncertain)
- Recent simulation with & without the ME4/2 upgrade:
  - The high-luminosity Level 1 trigger threshold is reduced from 48 → 18 GeV/c

CSC Factory Production Site at CERN

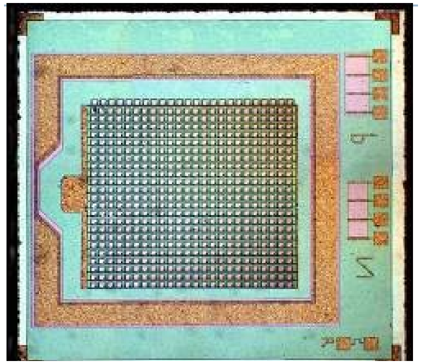
Floor plan layout at Bldg 904 (Draft)

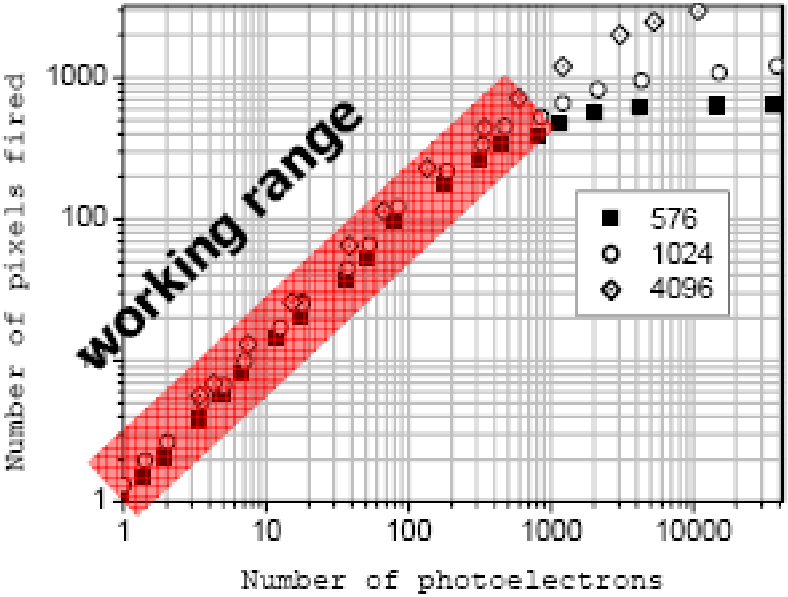


Based on experience of ME4/2 prototype production the proposed area at 904 of ~ 1000 m2 should be enough to place a factory production and FAST test site. For the completed chambers we need additional storage area of ~ 250m^2.

New photo-detectors for Hadronic Calorimeter

- Array of avalanche photo diodes ("digital" photon detection)
  - Array can be 0.5x0.5 up to 5.0x5.0 mm^2
  - Pixel size can be 10 up to 100µ
- All APDs connect to a single output
  - Signal = sum of all cells
- Advantages over HPDs:
  - 28% QE (x2 higher) and 10^6 gain (x500 higher)
  - More light (40 pe/GeV), less photostatistics broadening
  - Very high gain can be used to give timing shaping/filtering





SiPMs already being installed in the HO

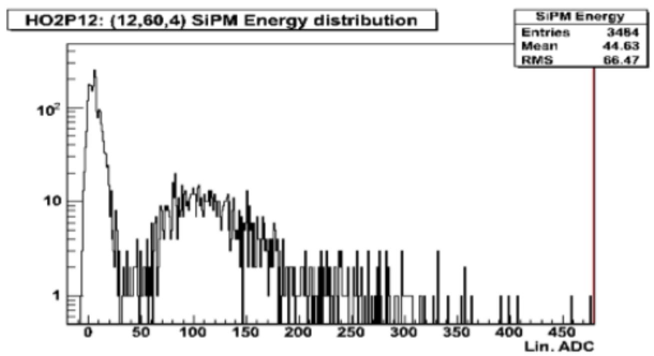


Figure 10a: Individual energy distribution, mwgr18, for a single HO channel, HO(ieta=12, iphi=60). Here energy E_{μ} is not corrected for muon angle of incidence.

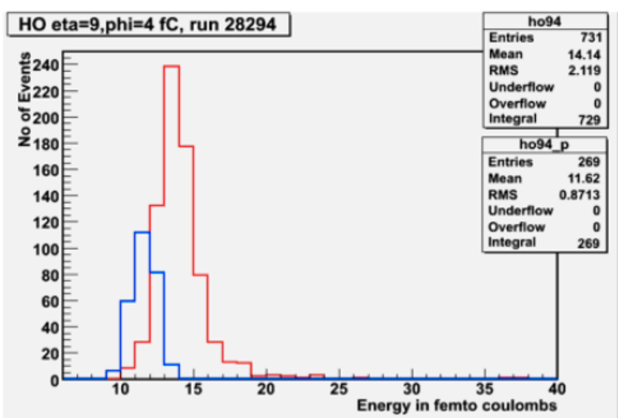
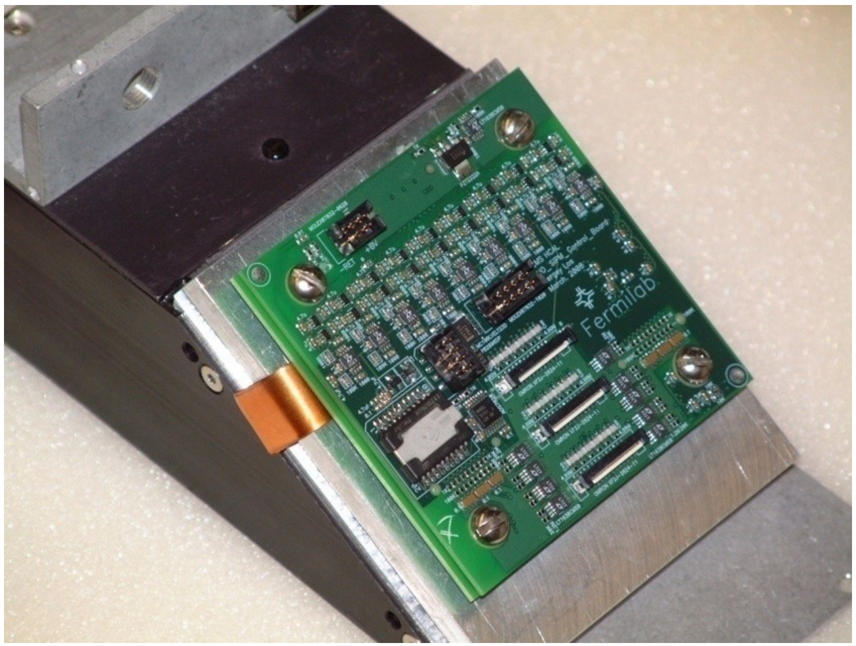
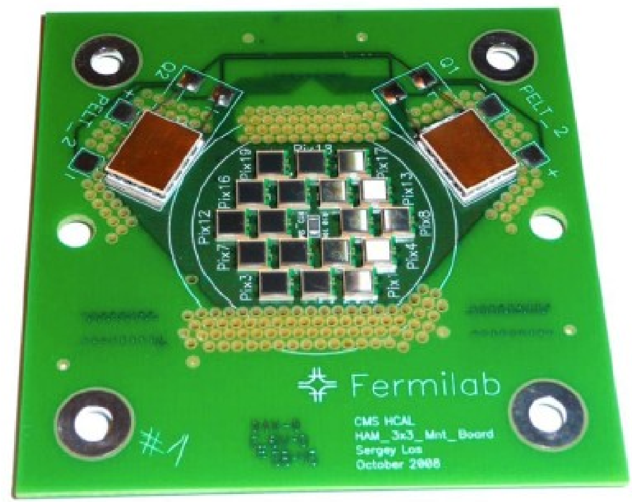


Figure 10b: For comparison, individual energy distribution, single HO channel read out with HPD, TB2007 data. Blue line: pedestal events, red line: muon signal.

- HPDs show increased noise in the magnetic field region where HO is operated
  - They show this effect much less at full field or at 0 field
- Decided to replace the HPDs in HO with SiPM
  - Have already installed some modules
- SiPM Signal/Noise is a factor of 10 better than with the HPDs currently on the detector

HO SiPMS

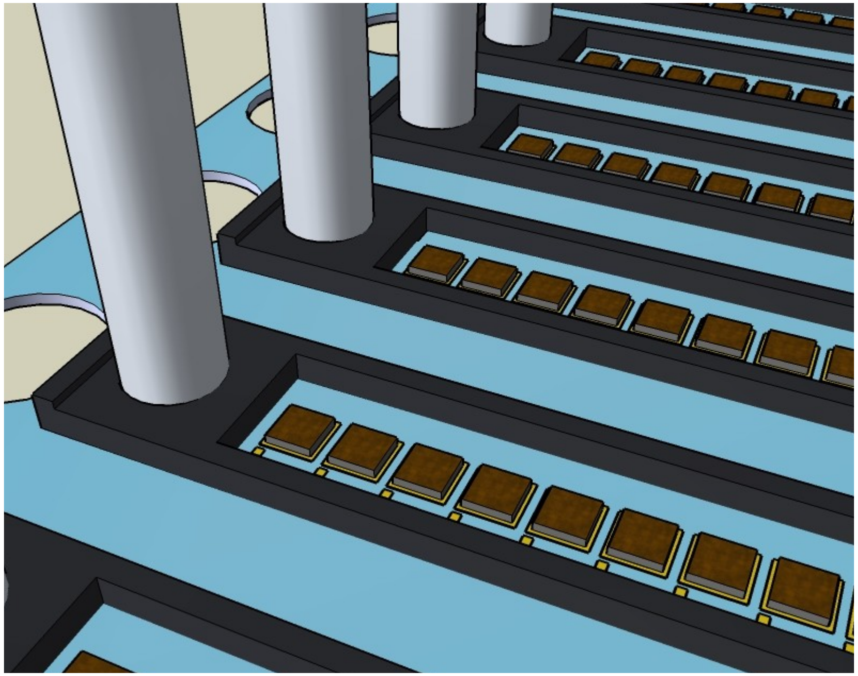




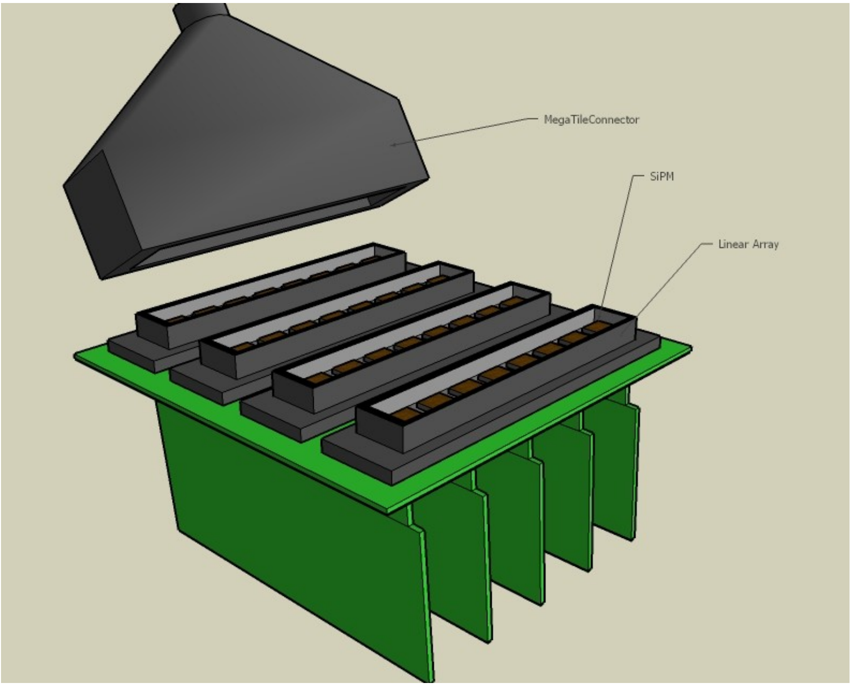
Plug in replacement for HPD

SiPMs in the Barrel HCAL

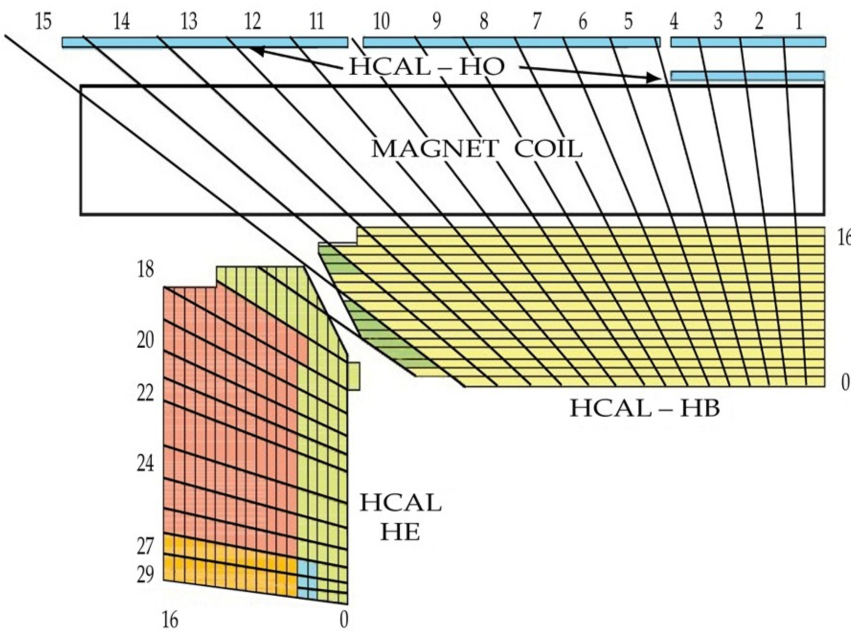
One SiPM per fibre

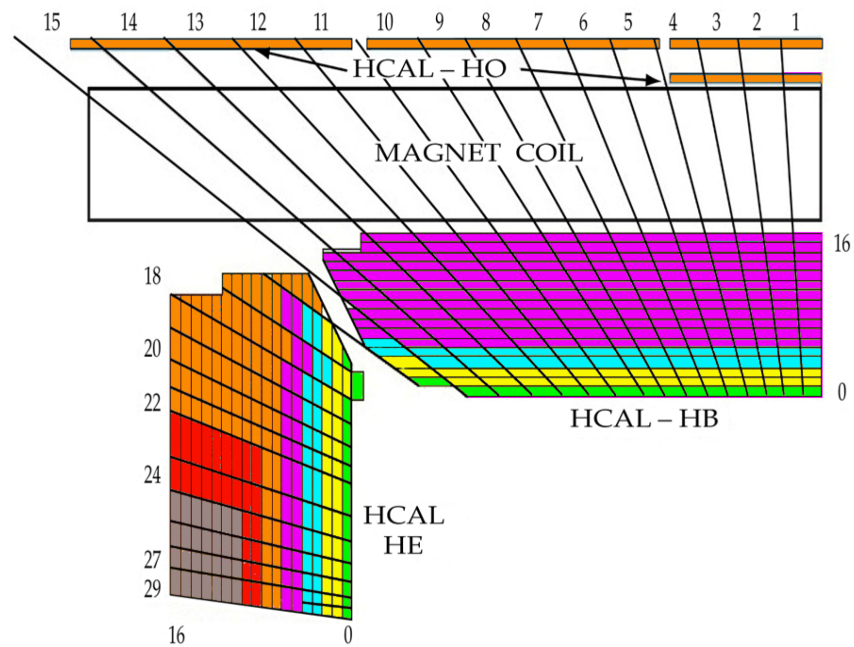


Plug compatible with current optics



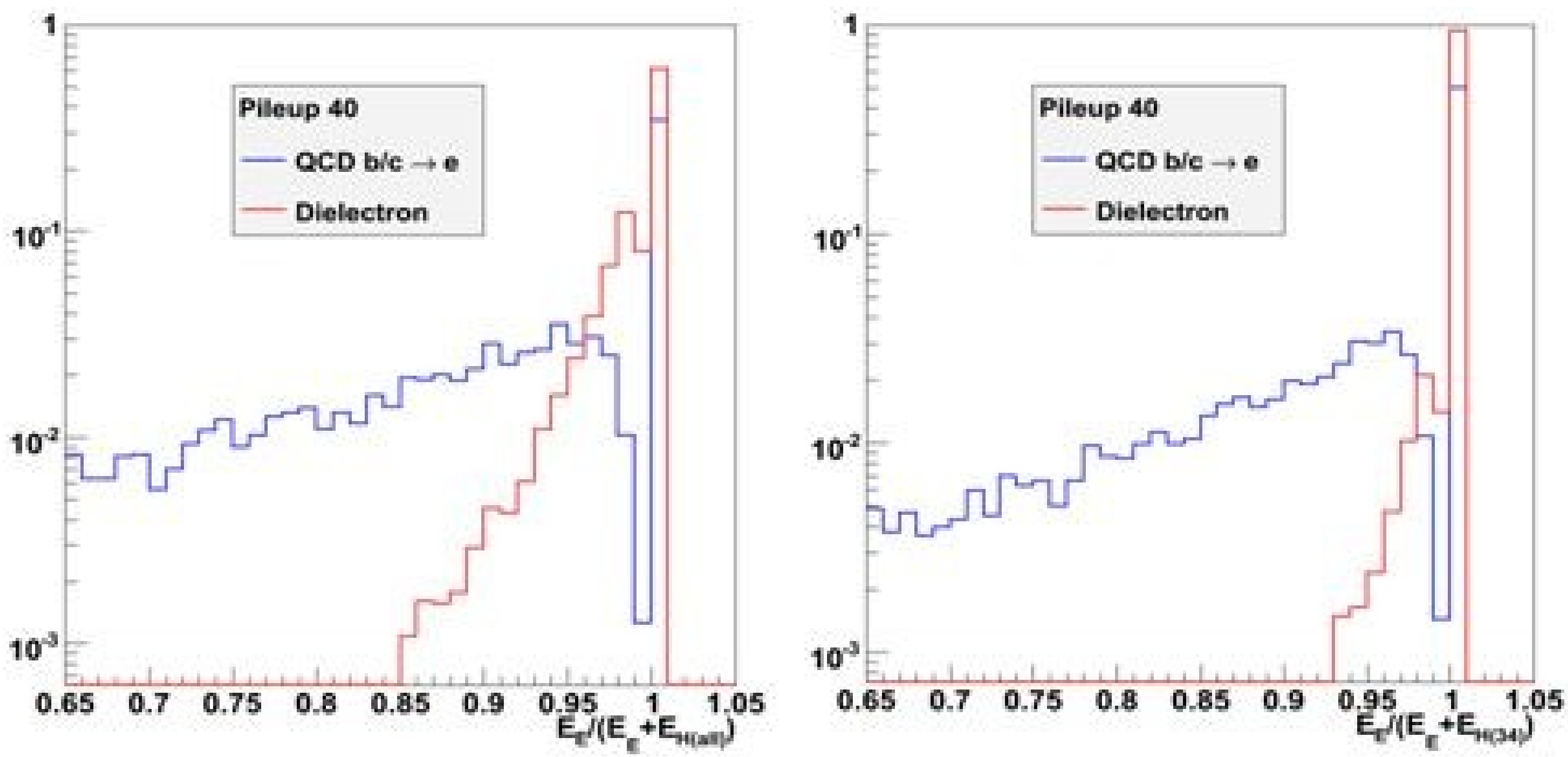
New Photodetectors allow finer segmentation of readout in depth





New segmentation – more robust against damage to inner scintillator layers

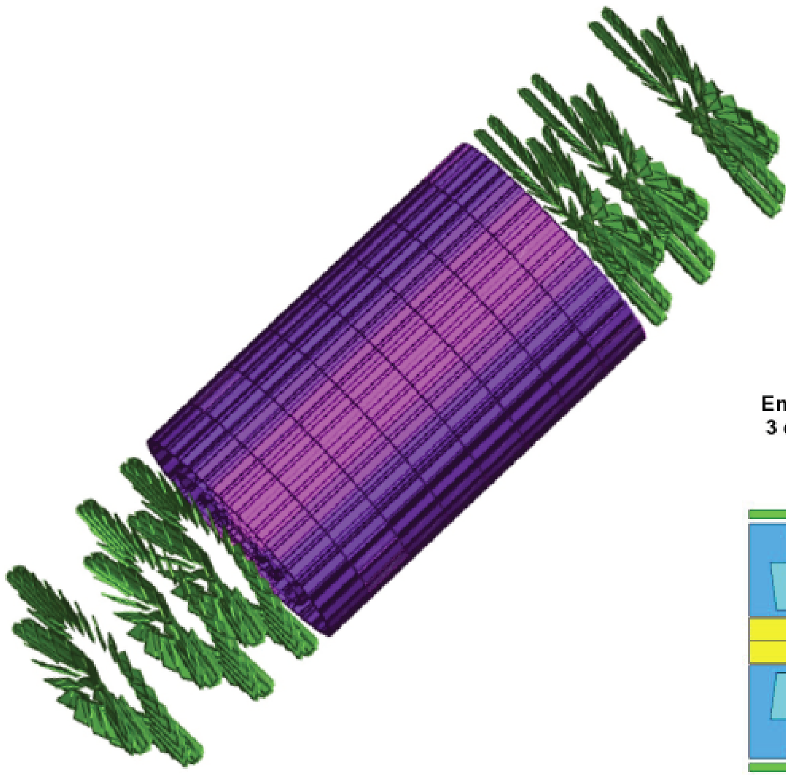
Segmentation – Electron isolation



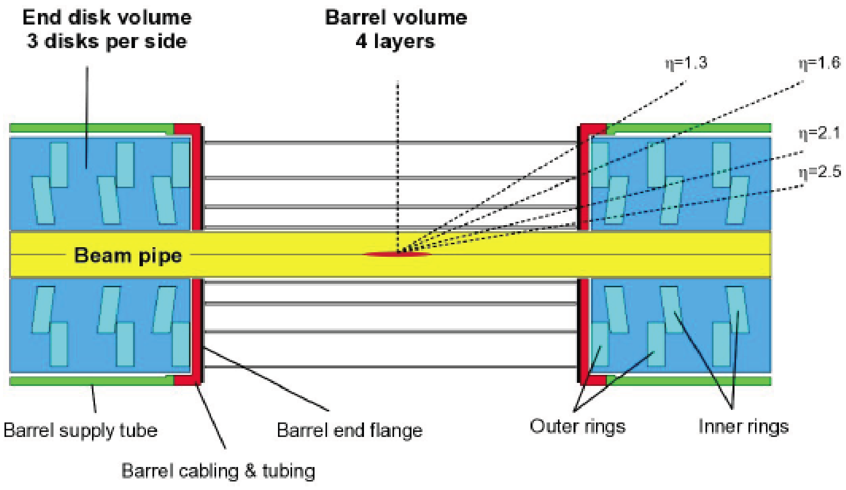
2nd Shutdown: A new Pixel detector

- Well developed plan for a new 4 Barrel layer, 3 end disk low mass pixel detector
- Main Issues for Pixel replacement
  - Radiation hardness, reparability of the inner layer(s)
  - Buffer sizes (data loss at higher luminosities)
    - Including the case where we achieve luminosity using 50ns bunch spacing – giving higher number of interactions/bunch
    - Current detector first layer has very large dead time with ultimate luminosity (worse with 50ns bunches)
  - Extra seeding layer for tracking gives better tracking performance in higher luminosity environment
  - Improved B tagging capabilities – gives much improved physics performance

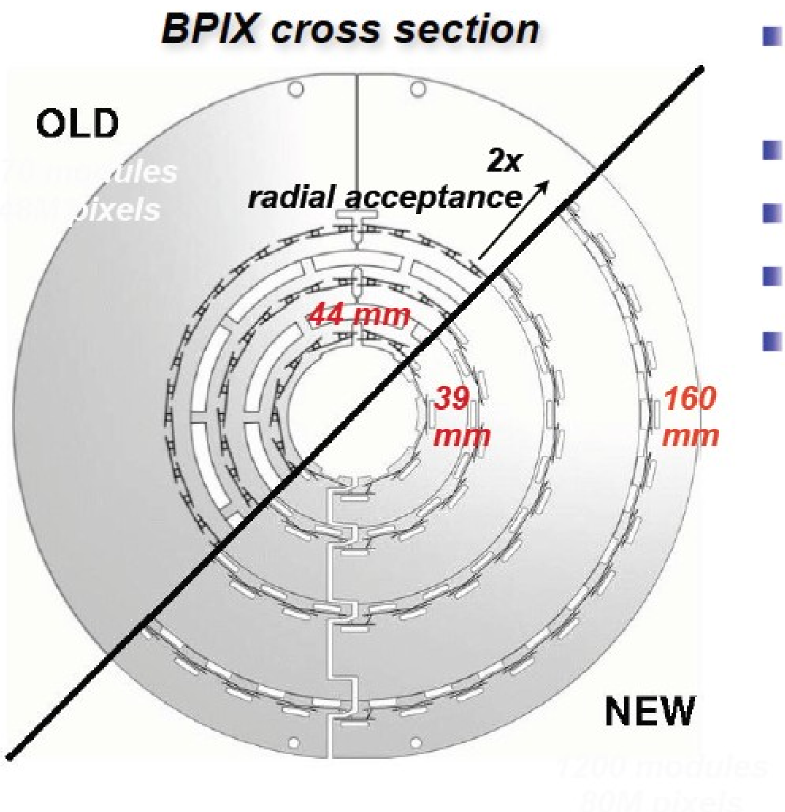
New Pixel detector overview



- **Main features of the new detector:**
  - 4 barrel layers and 3 endcap disks at each side
  - New readout chip with expanded buffers, embedded digitization and high speed data link
  - CO_2 two-phases cooling and displaced optical transceivers
  - Powering based on DC-DC converters

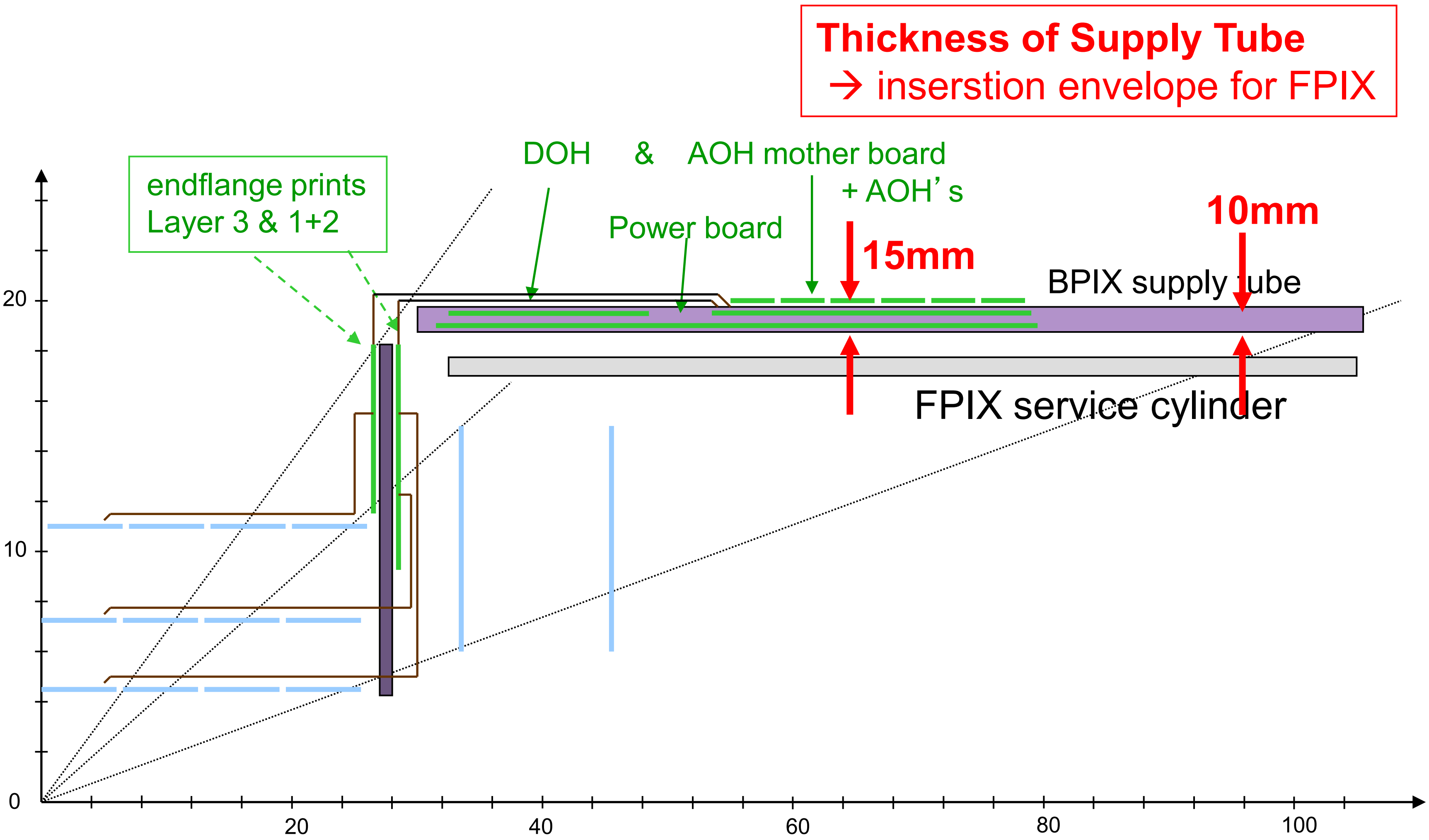


New Barrel Pixel design

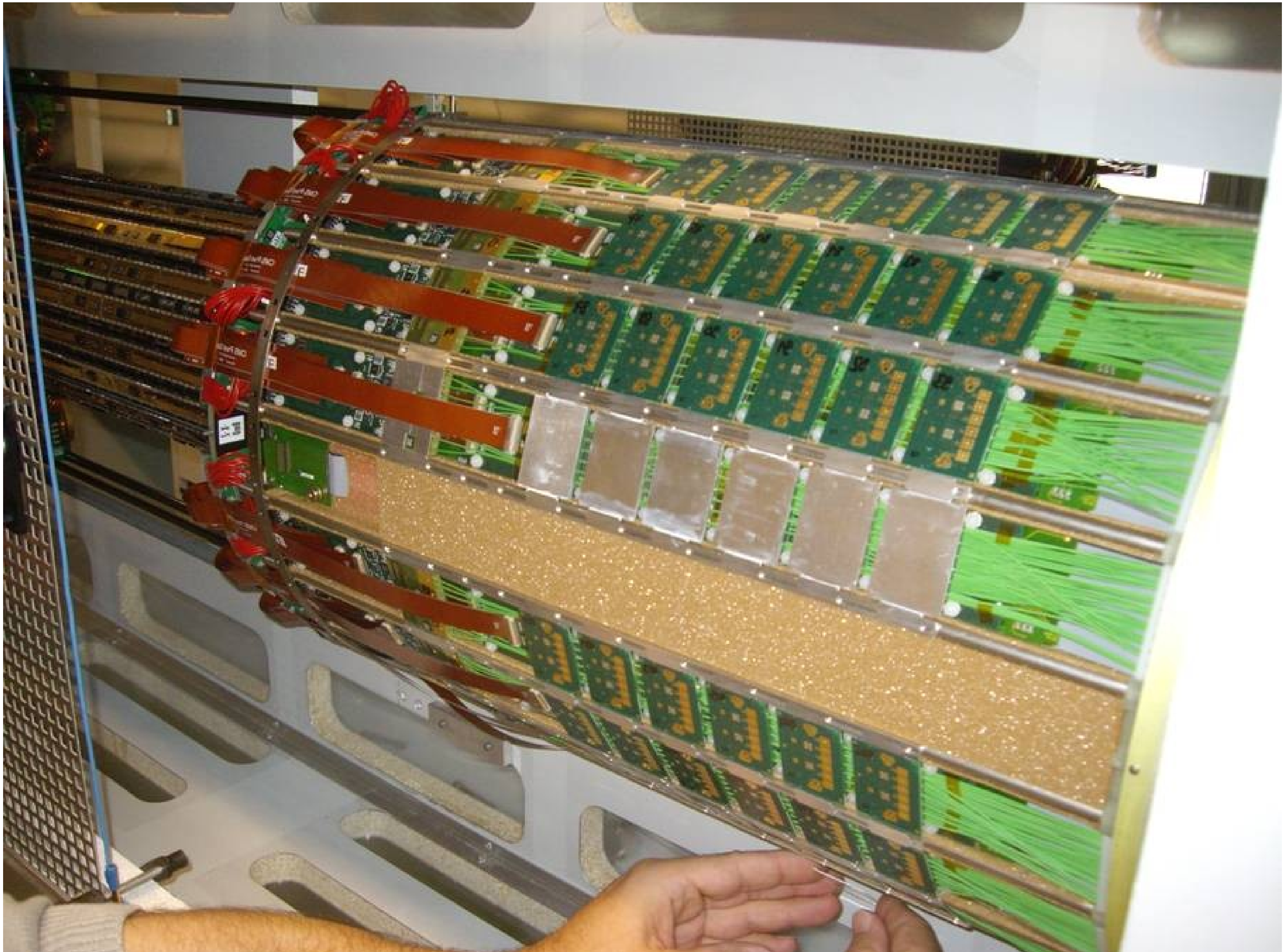


- Innermost layer with reduced radius (39mm)
- Additional outermost layer at 160mm
- ~2x radial acceptance
- ~65% more pixels
- Only one module type

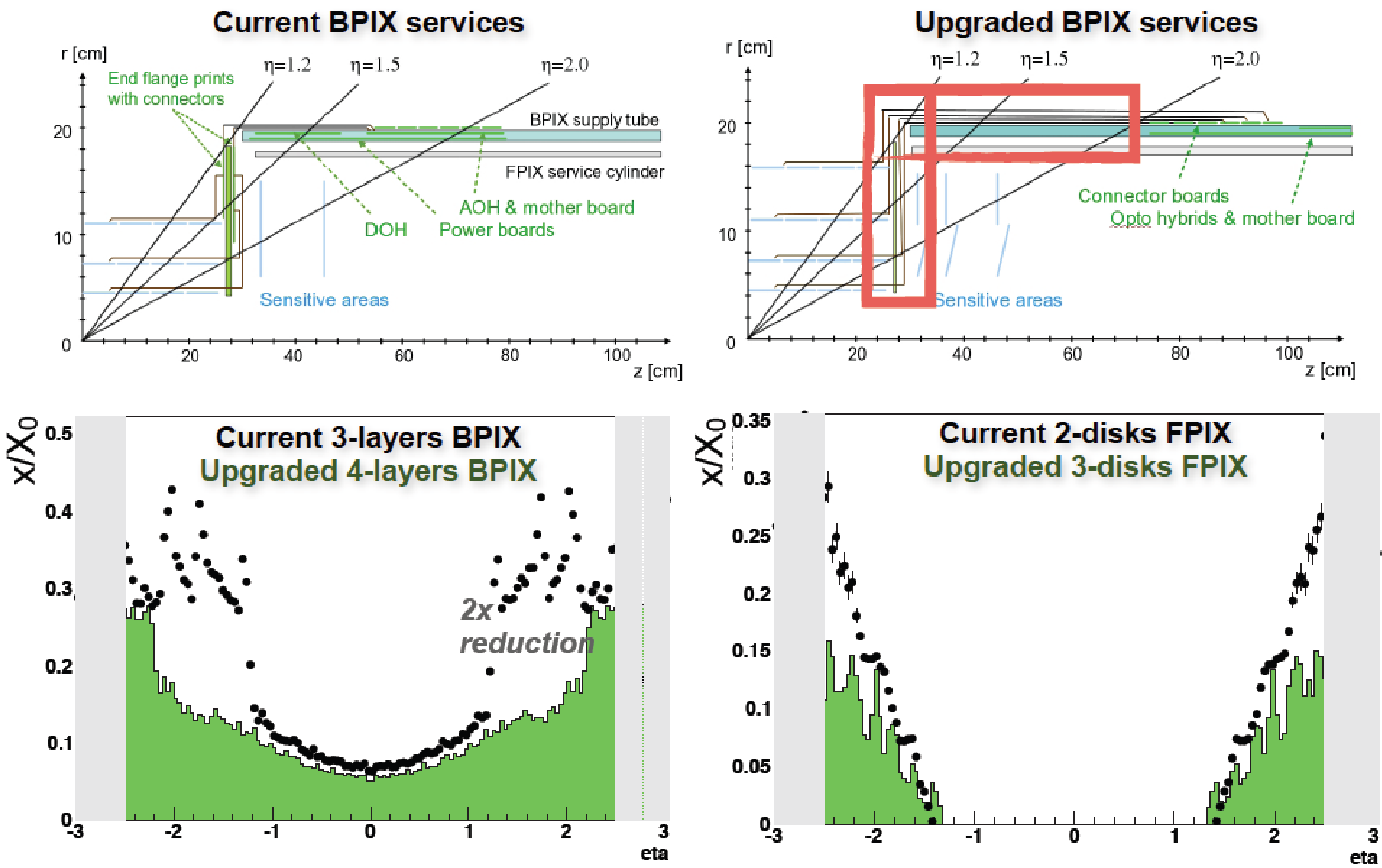
Current Pixel System with Supply Tubes / Cylinders



BPIX & Supply Tube with AOH, DOH, PCBs & Fibres

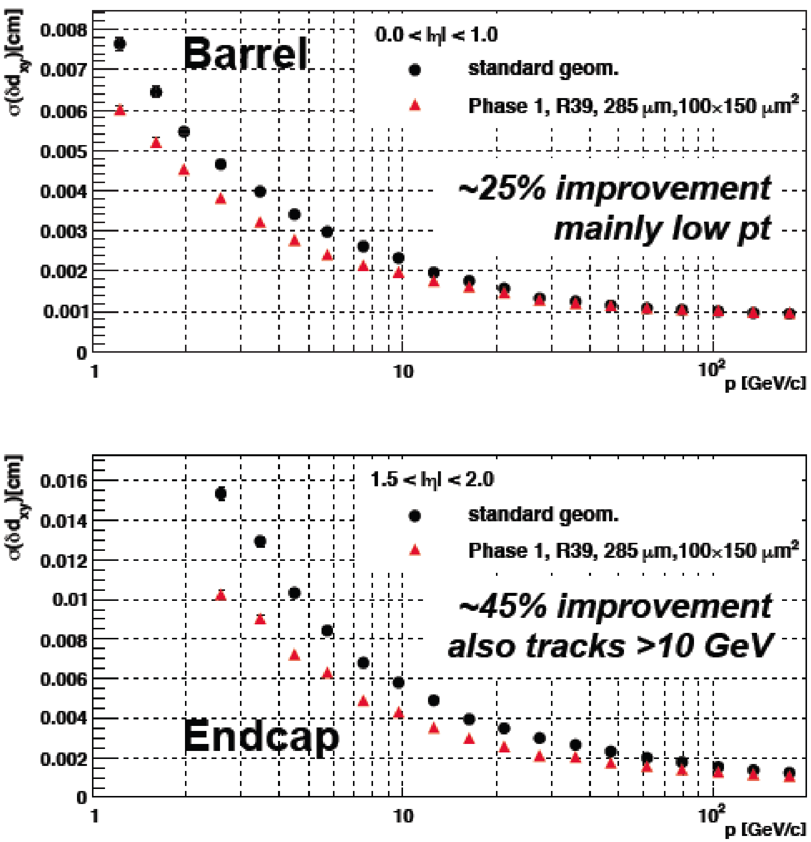


Pixel Material budget improvement

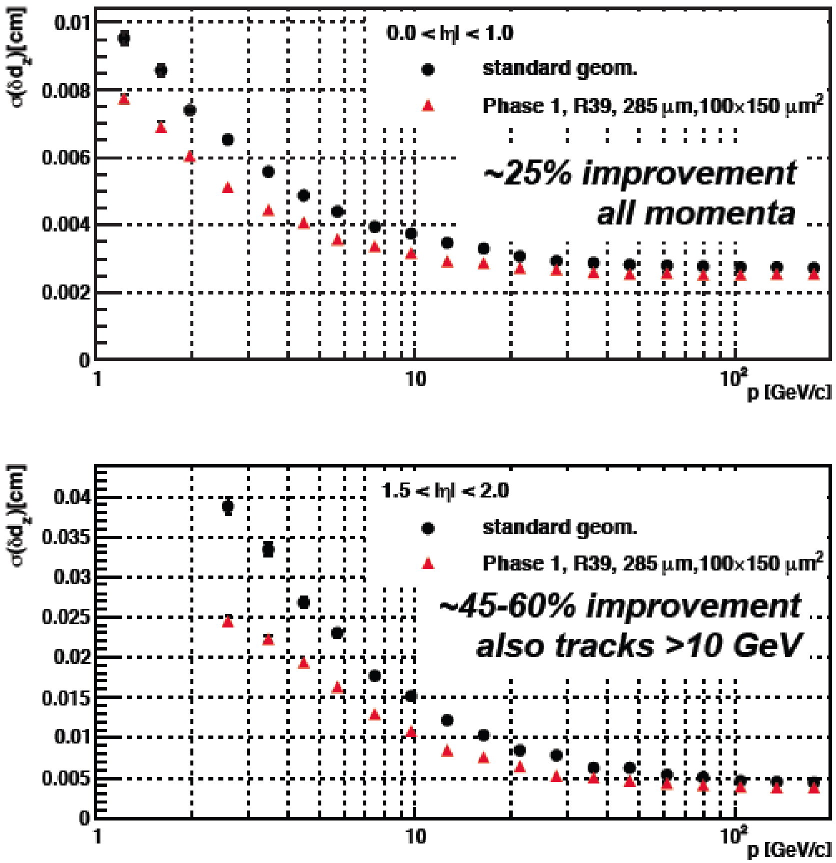


Improved impact parameter resolution

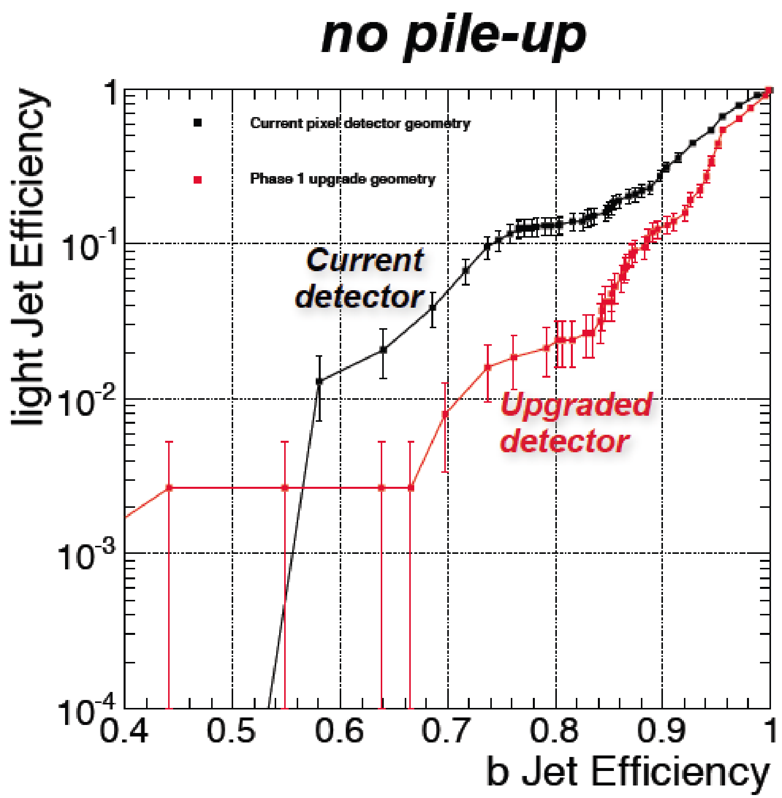
Transverse IP resolution

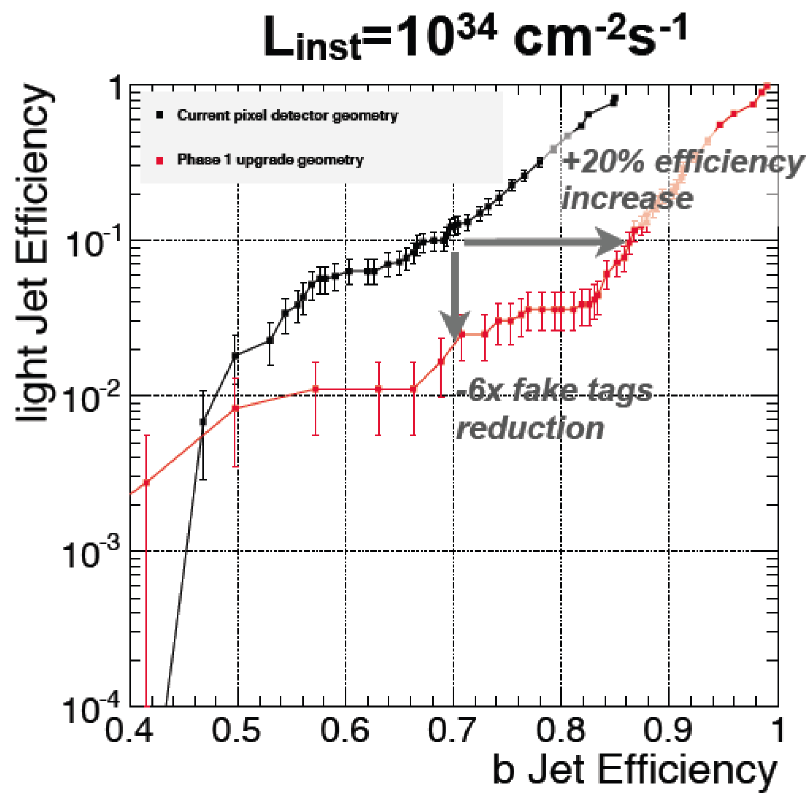


Longitudinal IP resolution



Improved B tagging

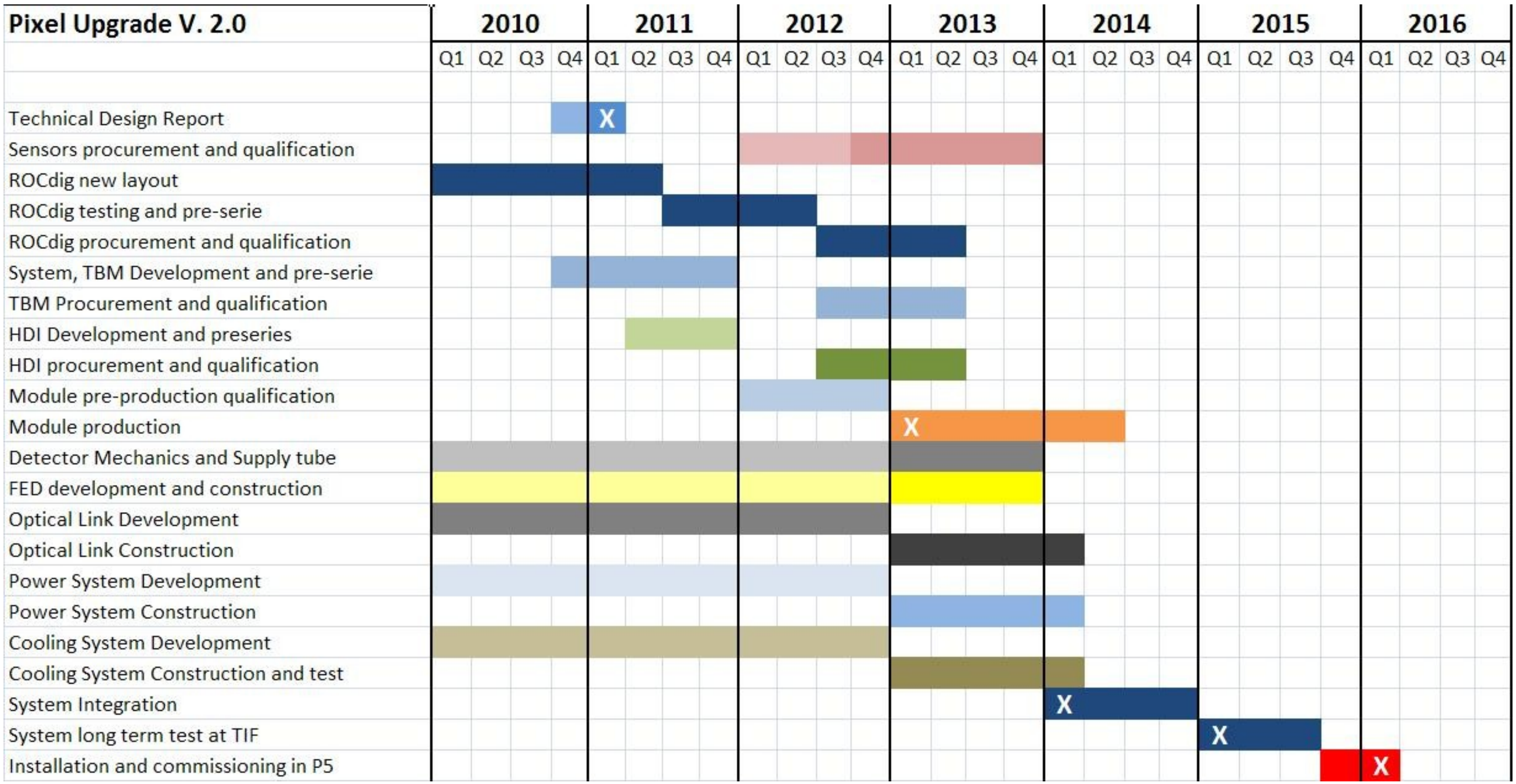




Improved efficiency and fake rate contributing exponentially with the number of b-tagged jets (e.g. Top, Susy, etc.)

QCD $80<p_t<120$ GeV
Combined Secondary Vertex tagger

Pixel detector schedule



Conclusions

- Good progress on tasks/Milestones
  - have essentially completed all of them
- Phase I/Phase 2 split actually allowed us to deliver a complete upgrade plan (for the first phase of upgrades) during the course of this FP7 project
- Full Technical proposal for the first phase of the upgrade submitted to LHCC
- Preliminary cost books and schedules have been prepared – a first draft of the project costing have been shown to the CERN RRB. The Lab management has been deciding how to prepare the MOAs for these.