The status of the CMS pixel upgrade detector

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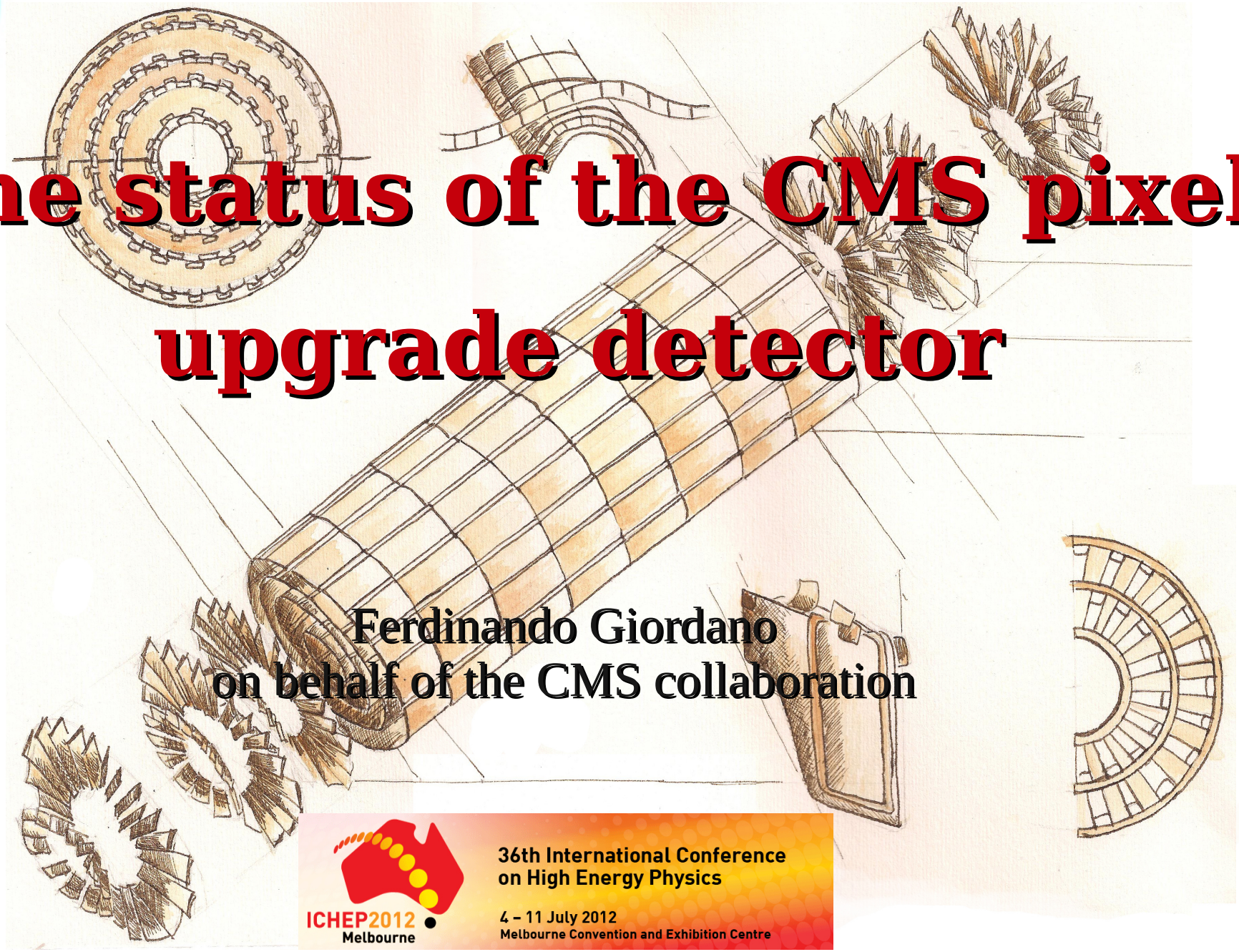
on behalf of the CMS collaboration



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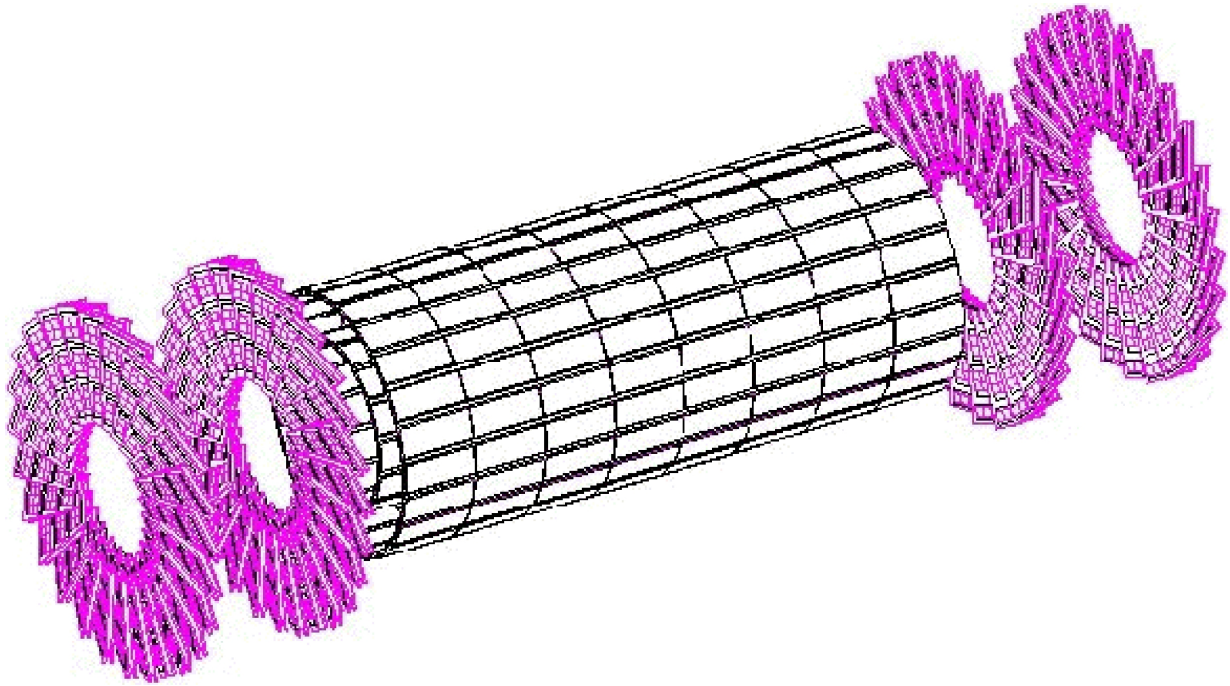
Outline

- Short summary of current detector
- Proposed Pixel Upgrade
- Performance comparison
- Project plan and timeline

Current detector

- Designed to cope with luminosities up to 10^{34} $cm^{-2}s^{-1}$
- 25 ns beam crossing time



- 2 disk end-caps
- 3 barrel layers, with the innermost layer at 4.4 cm.
- C_6F_{14} cooling system and about 60 millions pixels.
- 3-hits coverage up to pseudorapidity 2.5
- readout system was design to work up to 100 kHz.

Efficiency limitations

- Dynamic inefficiencies increase with instantaneous luminosity and trigger rate due to limitations in the buffers of the Red-Out Chips (ROCs).
- Single Event Upset (SEU) may cause the temporary loss of a module and also increase with luminosity.
- Radiation damage becomes more important with integrated luminosity, decreasing measurement precision and eventually making the detector difficult to operate.

Proposed Upgrade

BPix 3 layers → 4 layers
FPix 2x2 disks → 3x2 disks

→ 4-hits coverage up to $|\eta|<2.5$

CO_2 cooling
Shift material to high η

→ Significant material budget reduction

Minimization of the innermost layer radius

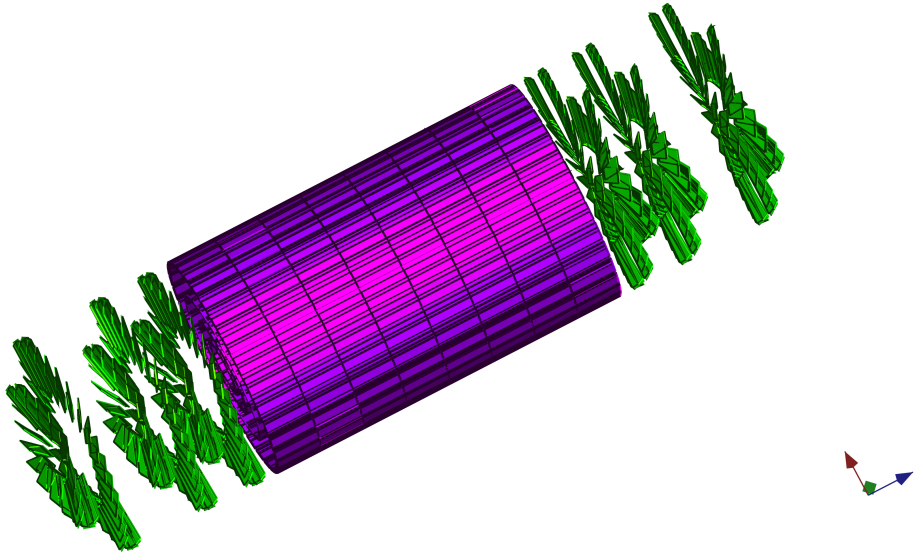
→ Reduction of the impact parameter errors

Modification of the current ROC design

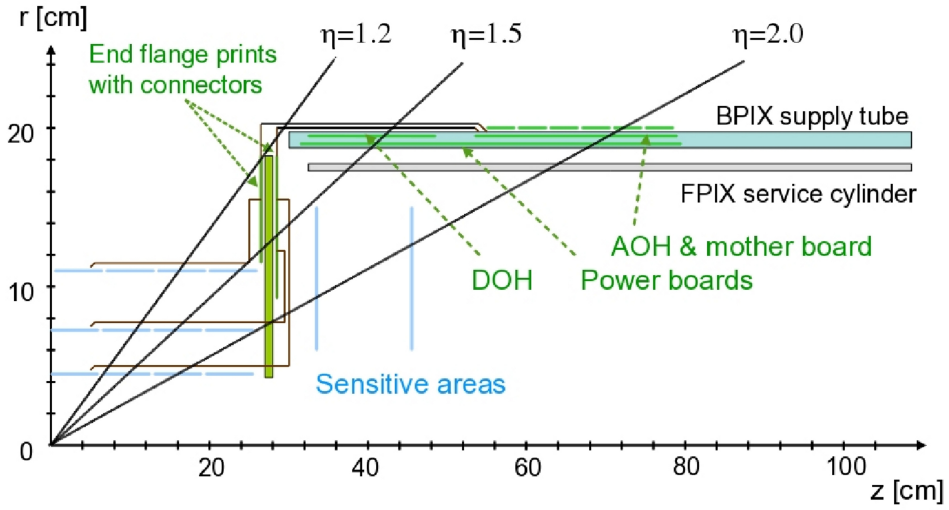
→ Reduced data loss at high luminosity

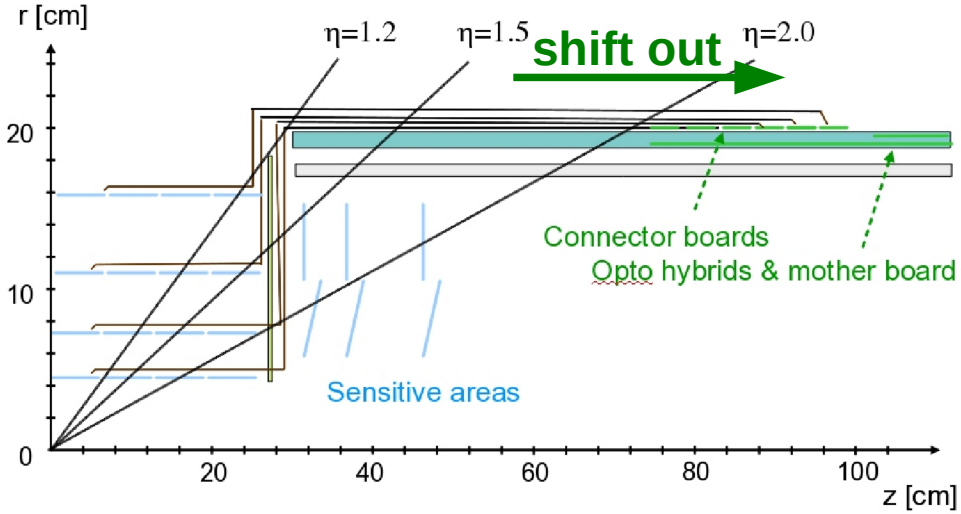
New design

The new design has four barrel layers and three end-cap disks on each side to make the system more robust against pileup.

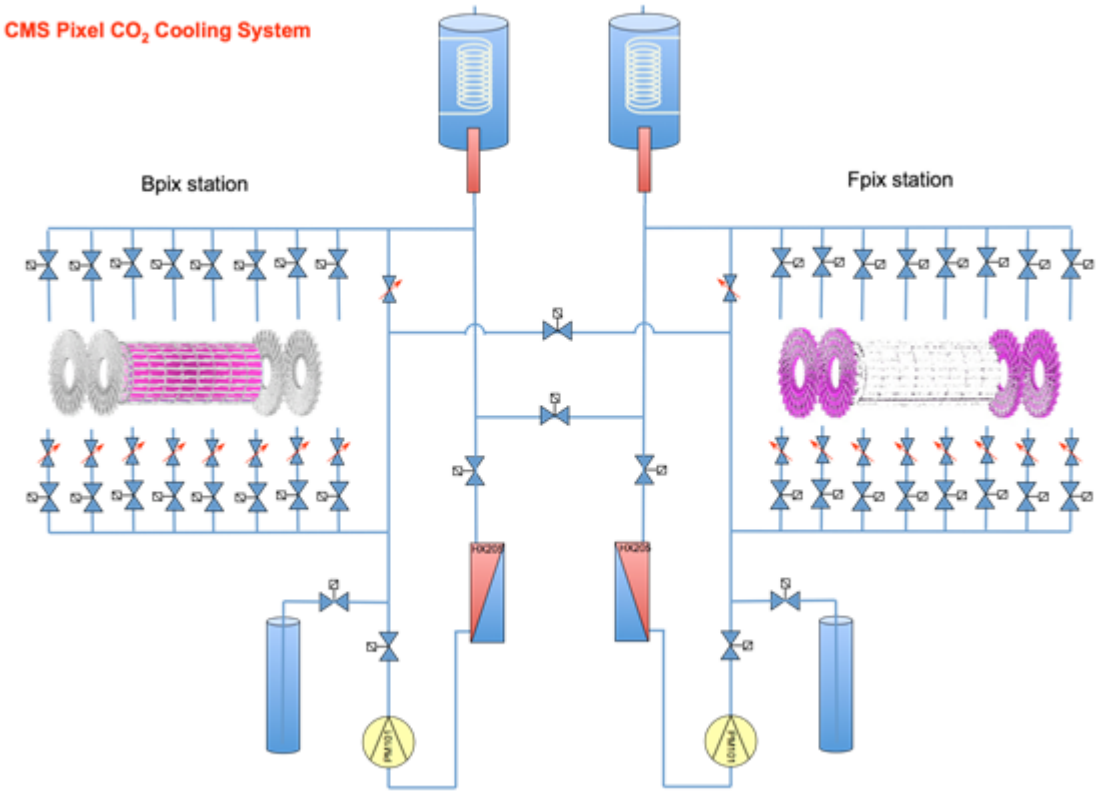


Services moved at high η to decrease the amount of material in the tracking region.





CO_2 cooling



The new cooling system will be installed during the first long shutdown (LS1).

It will be a two phase CO_2 system.

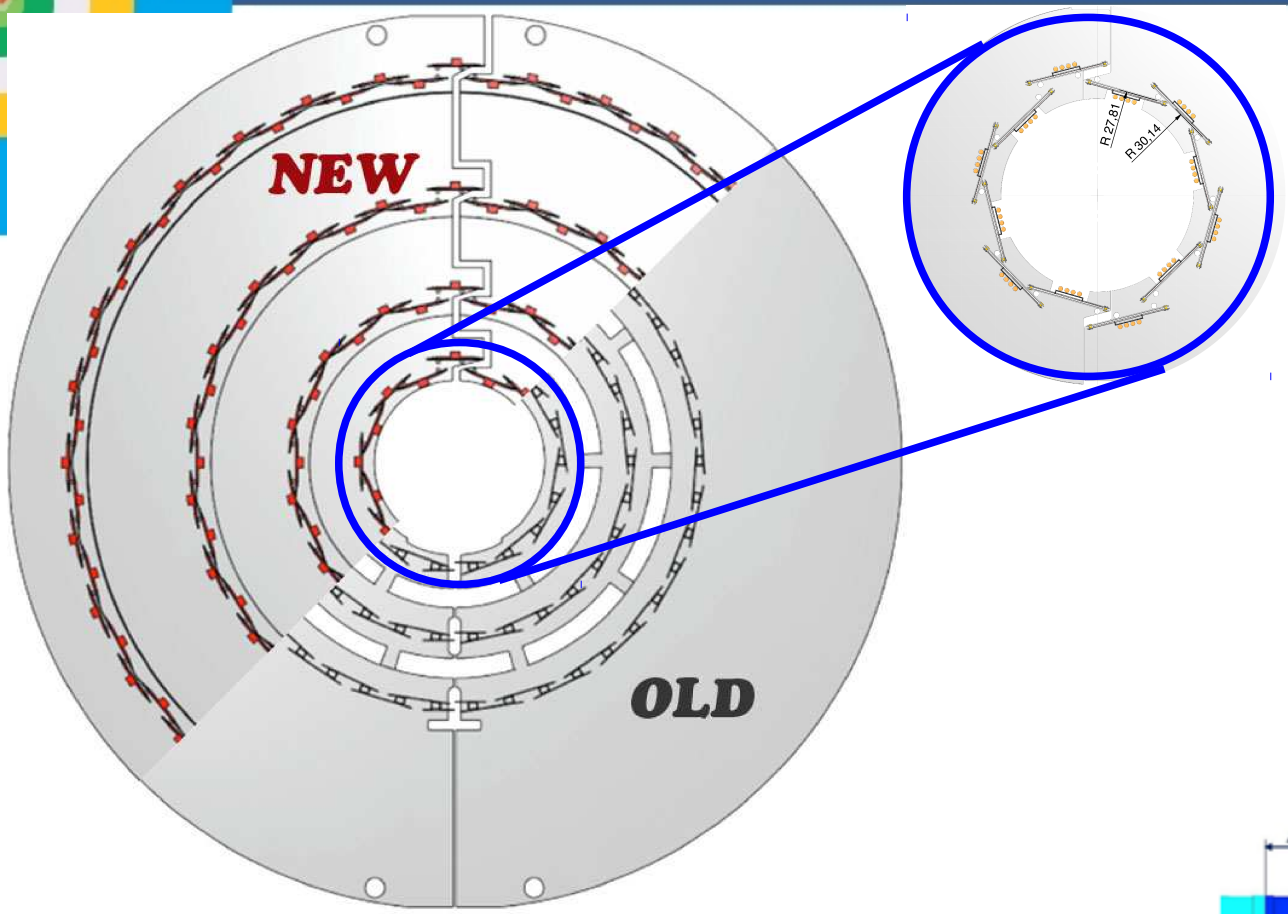
Two twin systems will be installed, 1 BPix and 1 FPix.

BPix and FPix can be operated at different temperatures.

If needed each system is capable of cooling the whole detector.

Lighter infrastructures for CO_2 compared to C_6F_{14}.

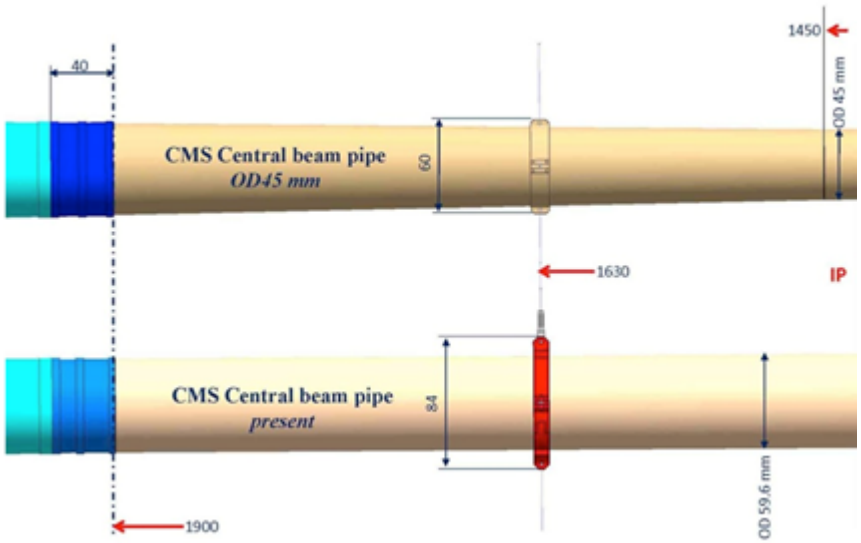
BPix and beam-pipe



A new layer will be added to improve performance with pileup.

The innermost layer will be made with the smallest possible radius to increase the precision of the impact parameter measurement.

New beam pipe with lighter material (AlBeMet) and smaller radius will be installed during LS1.

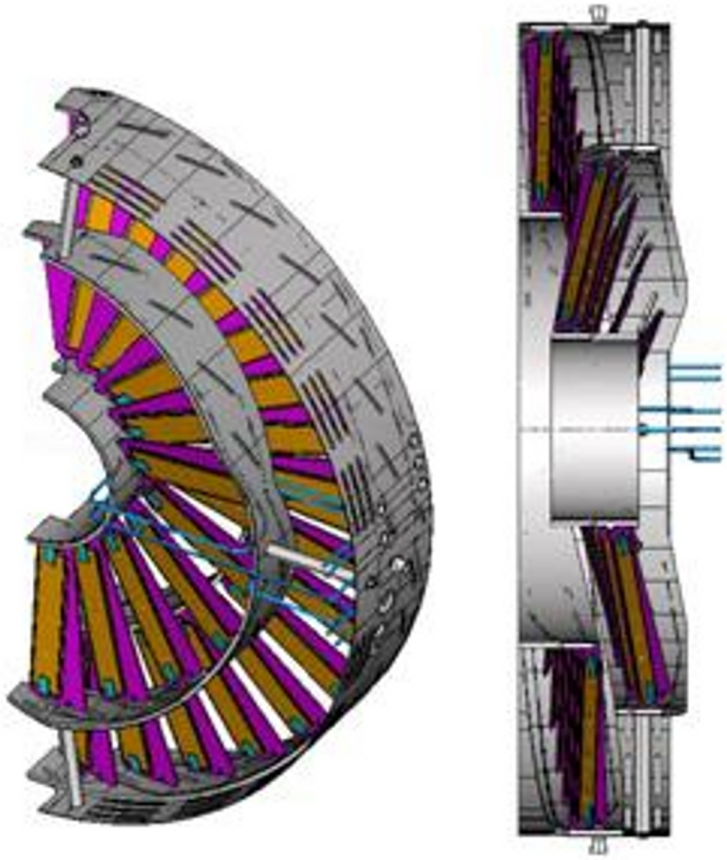


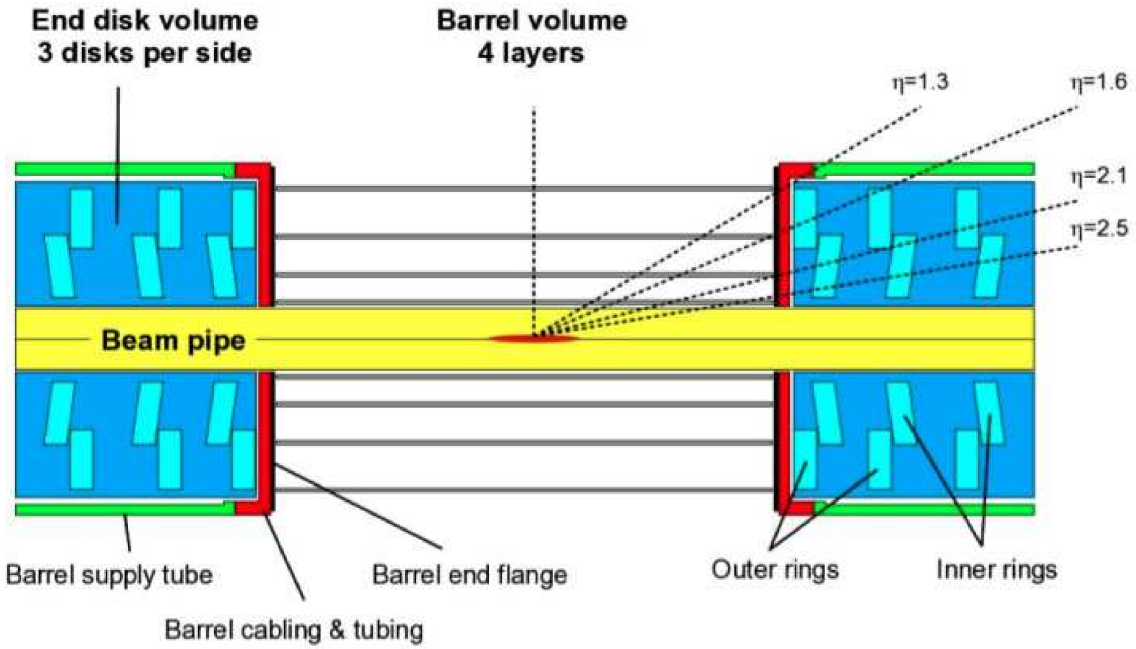
FPix

Substantially lighter structure.

Blades use same ROC modules.

Inner blades are tilted inward to optimize hit coverage and all blades are rotated 20° to enhance charge sharing and hit resolution.

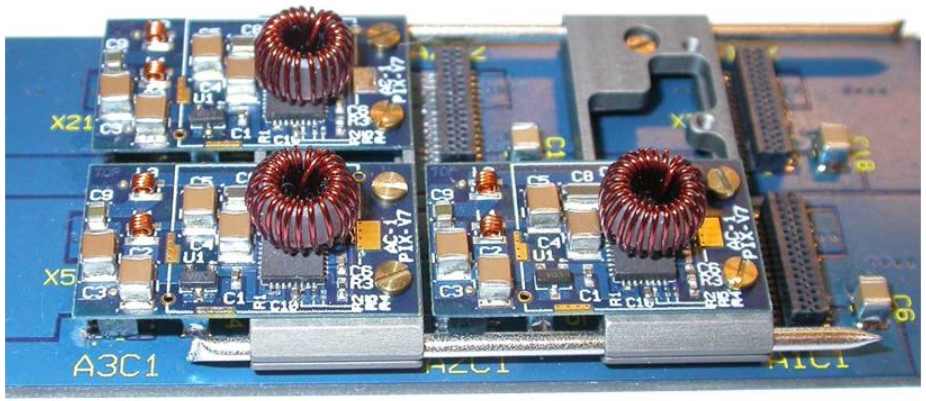




DC-DC and ROCs

Substantially more channels.

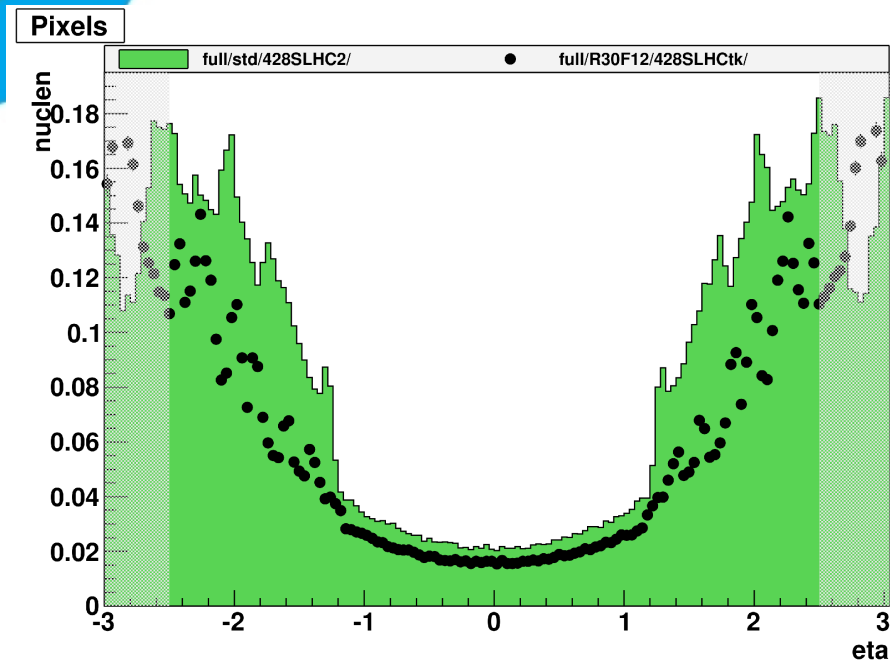
- Existing power system leads to large cable losses.
- Solution is to use higher voltage on the power supplies.
- DC-DC converters provide low voltage current close to the detector.

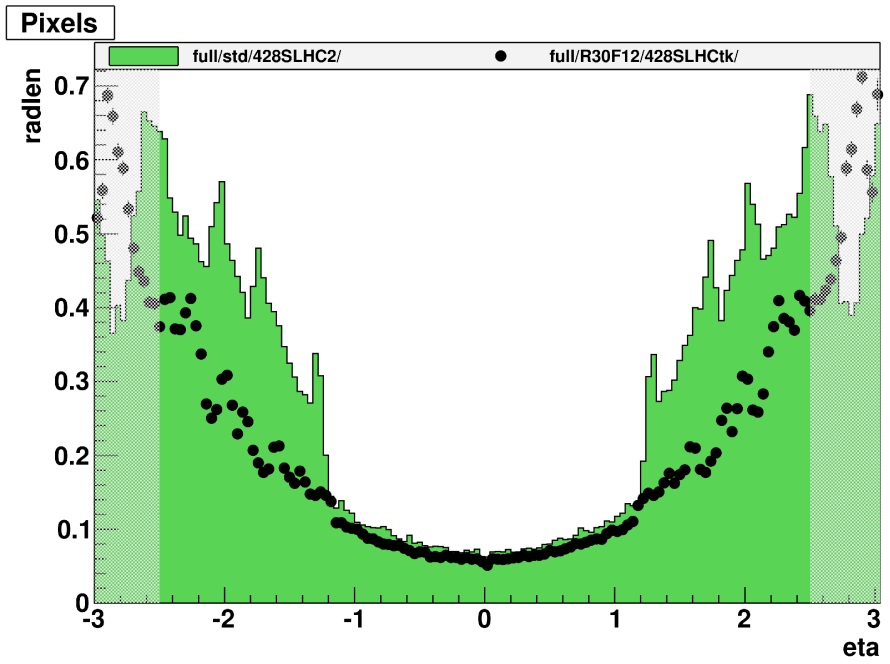


Data acquisition system upgrades.

- New ROCs with a larger buffer size to decrease data loss.
- Modified readout chain with digital signals at higher rate to cope with higher luminosities.

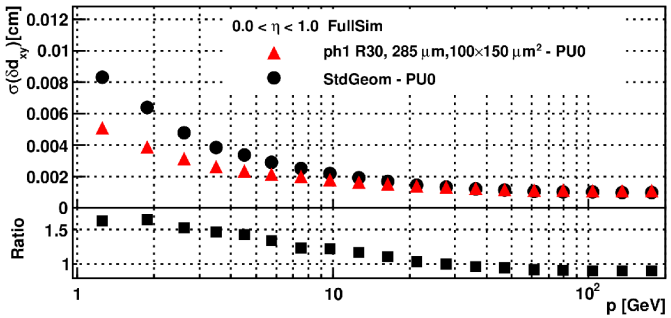
Material budget

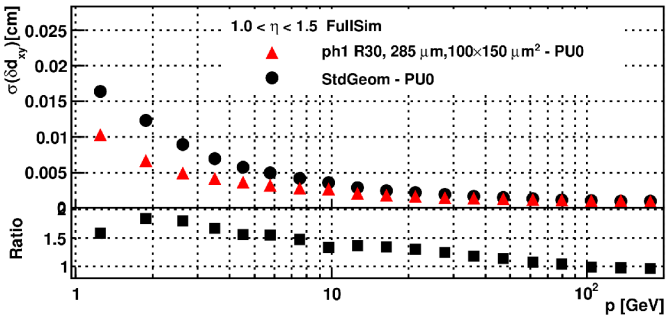


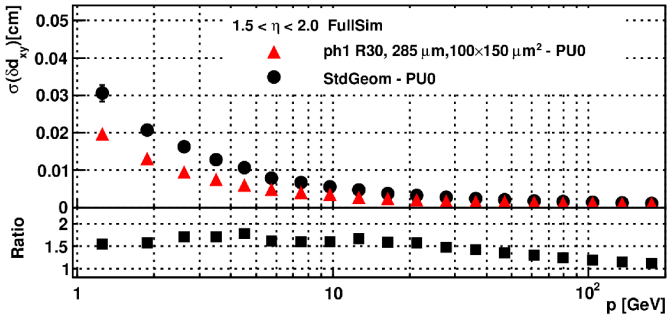


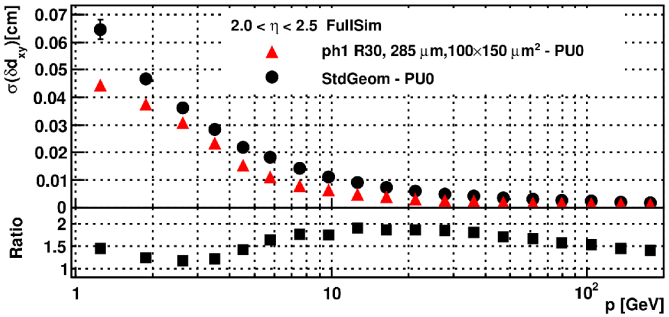
More layers but less material thanks to lighter supports, new cooling and shift of the services out of the tracking region $|\eta|<2.5$.

Impact parameter





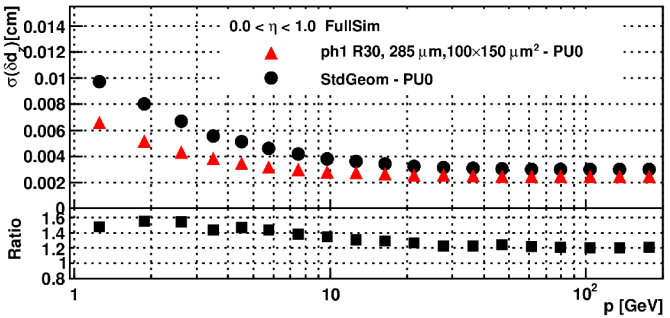


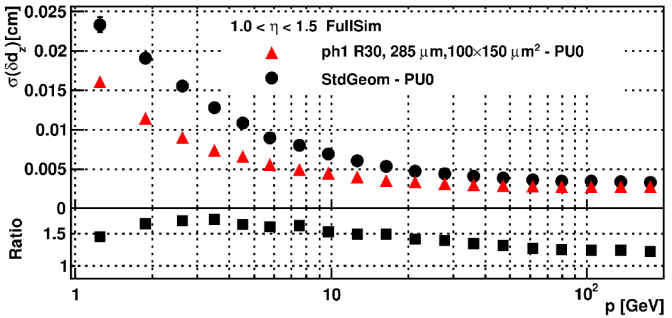


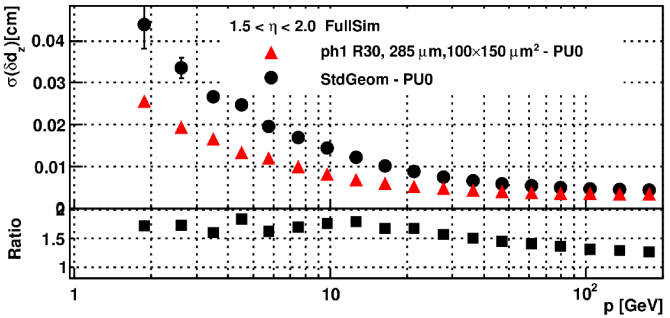
Less material and smaller radius for the innermost layer mean better impact parameter resolution.

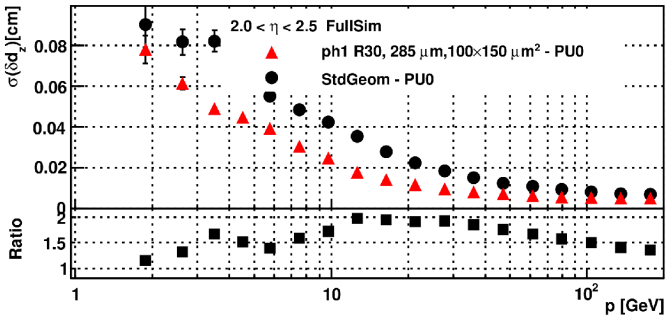
Top plots: transverse impact parameter resolution for different eta regions measured with muon Montecarlo.
Bottom plots: longitudinal impact parameter.

Red upgrade and **black** current geometry.





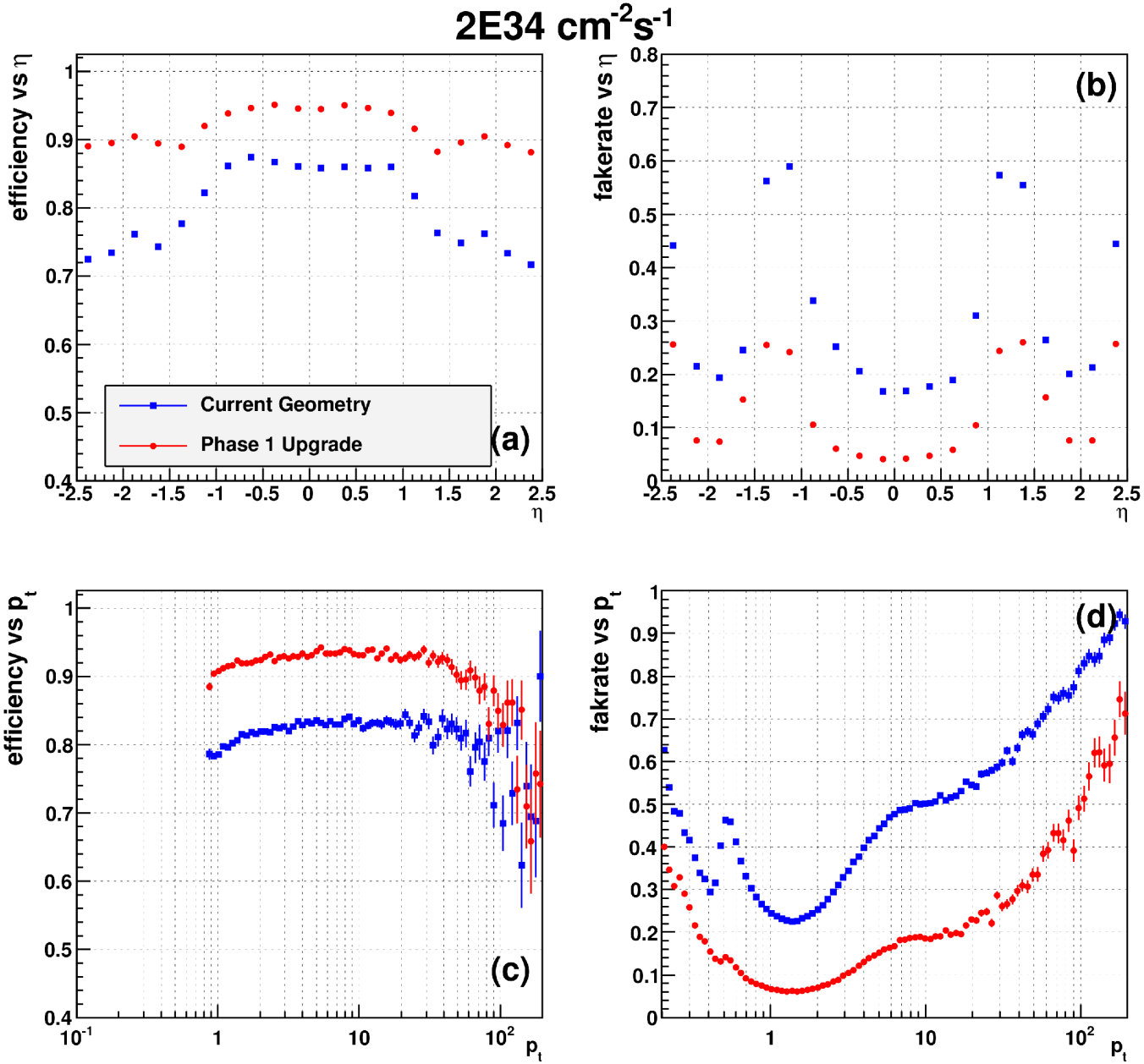




Tracking performance

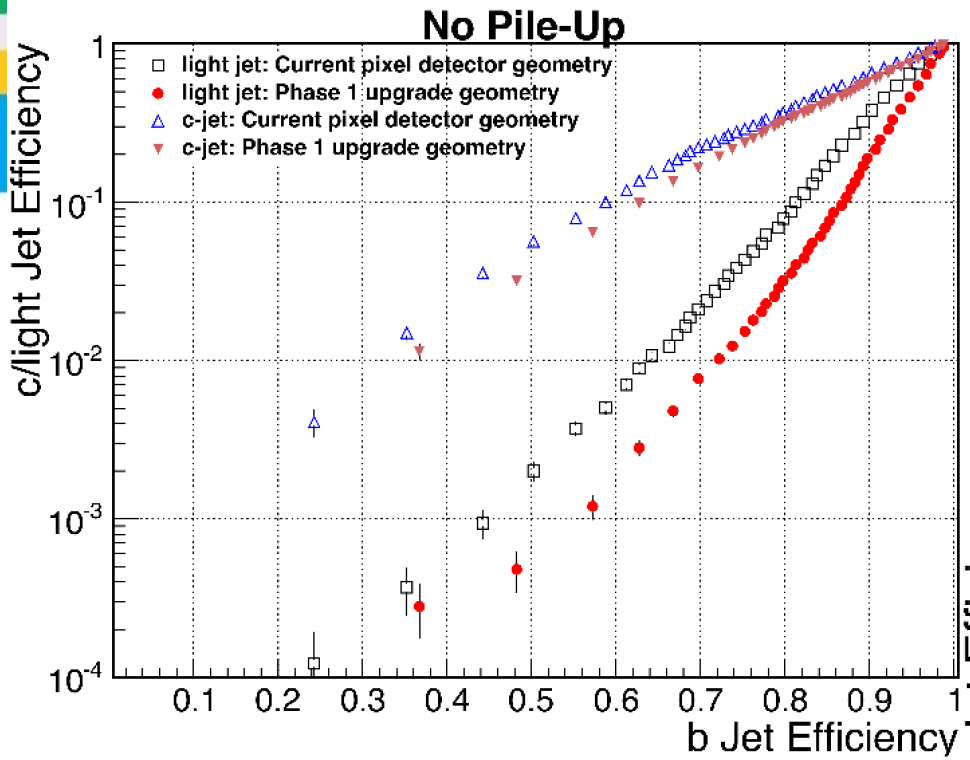
Geometry studied:

- Different pileup scenarios
- Different dynamic inefficiencies

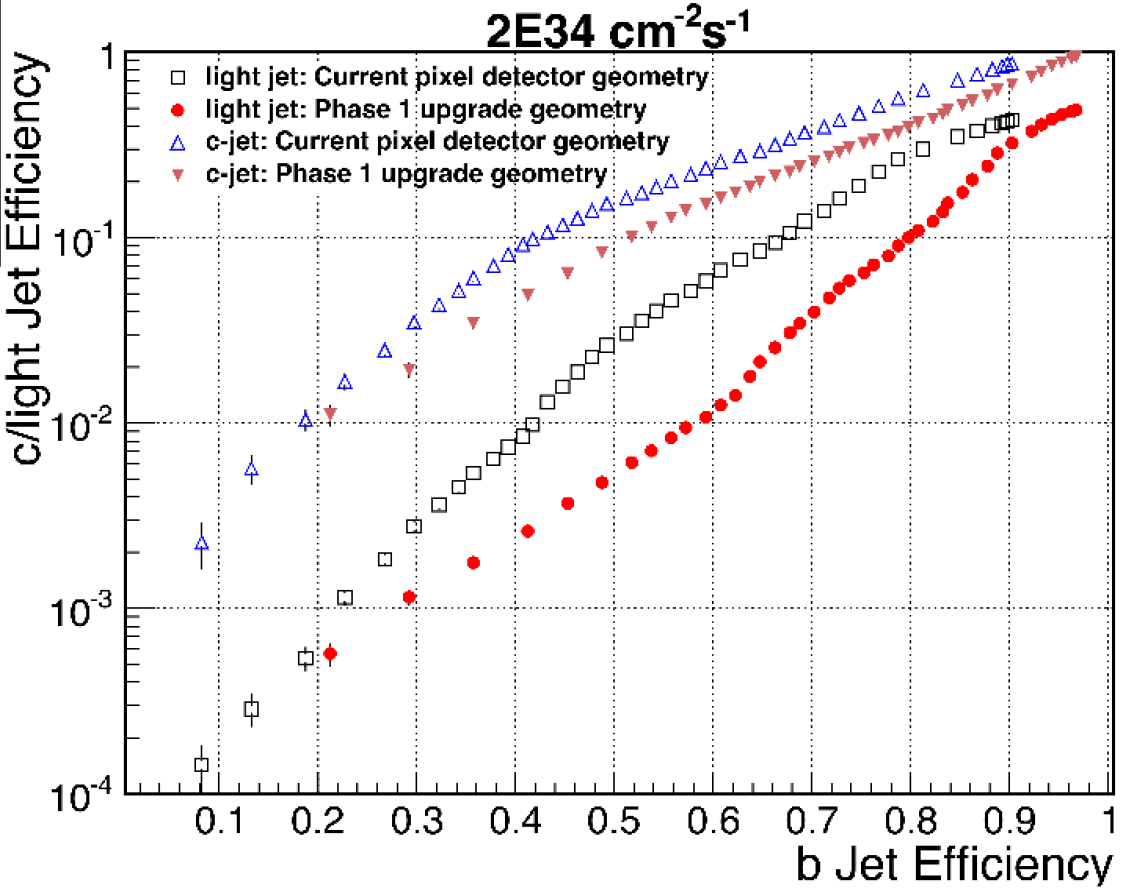


Right plots: the efficiency and fakerate for ttbar events for the **current** and **upgrade** geometries with pileup 50 and data loss.

b-tagging



The proposed upgrade has the same performance as the current detector but with higher occupancy.

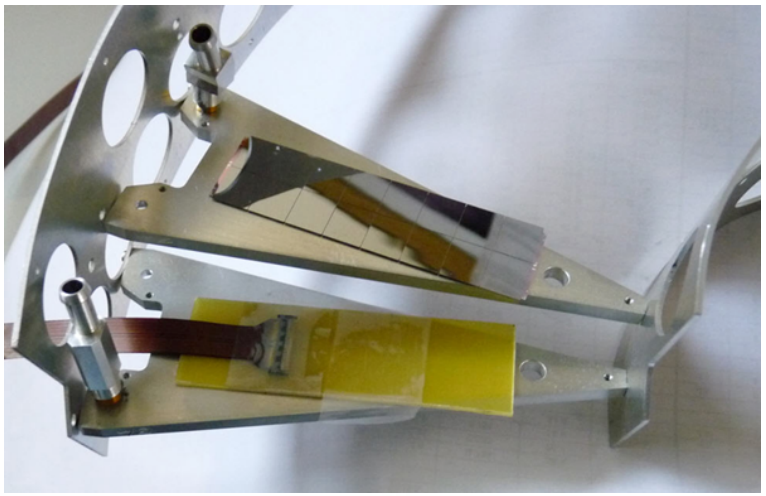


b-tagging efficiencies are calculated in ttbar events without pile up (top plots) and for pileup 50 with data loss (bottom plot).

Project plan and timeline

The current schedule matches the current LHC plan:

- LS1 (~~2012~~ 2013?-2014)
  - new beam-pipe
  - new CO_2 cooling
  - installation of a pilot system
  - production of new modules
- Between LS1 and installation
  - continue production of the new modules
  - system assembly and tests
- Installation of the new detector during an extended year end technical stop (foreseen in 2016)



Pilot system blades that will be installed in place of a third FPix disk and used to test the new DAQ system.

Conclusions

- Pixel upgrade to 4-hits system significantly improves pixel track seeding & vertexing.
- Reduced and displaced material budget significantly improves impact parameter resolution, vertexing, b-tagging and the performance of the whole tracking system.
- Changes of the present pixel readout chain to tackle data flow limitation.
- The 4 hit upgrade will boost the HLT triggering capability of CMS.
- The upgrade system will have a better resistance to radiation damage.
- The new pixel detector will cope LHC operations beyond the standard mode (25 ns) and luminosities of $10^{34}cm^{-2}s^{-1}$.