



Diamond particle detectors systems in high energy physics

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for the RD42 Collaboration

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Outline

- Why diamond?
- ATLAS Diamond Beam Monitor (DBM)
- CMS Pixel Luminosity Telescope (PLT)
- Summary



Curse and Cure of Diamond

- Band gap is 4 x that of silicon
 - ⇒ need larger energy to display an atom
 - ⇒ less leakage current
 - ⇒ less susceptible to radiation damage
- Need 4 x more energy than silicon to create an e-h pair
 - ⇒ smaller signal
- Faster signal than silicon
 - ⇒ ideally suited for bunch-by-bunch luminosity measurement

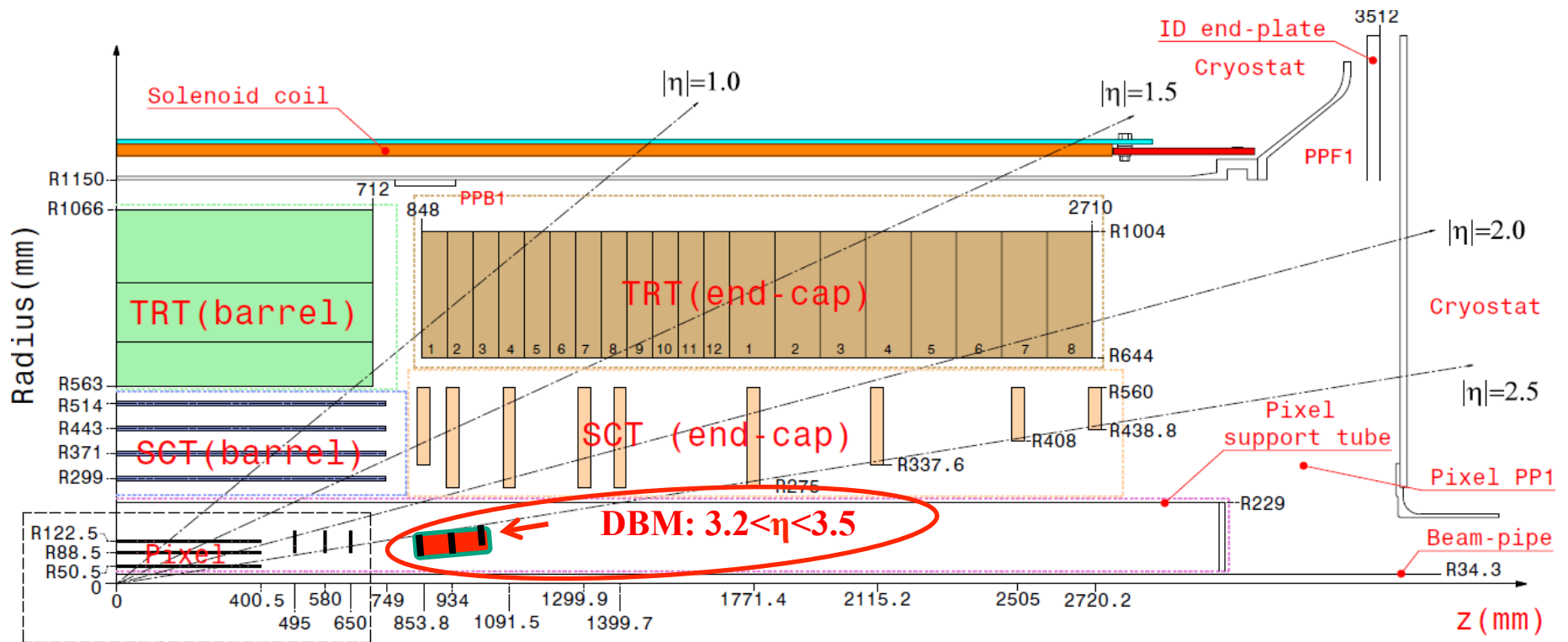


ATLAS Diamond Beam Monitor

- Build on success of Beam Condition Monitor (BCM)
 - Build diamond modules similar to pixel module for the Insertable Barrel Layer (IBL)
 - Four 3-plane stations on each side of ATLAS
 - Installed during Fall 2013



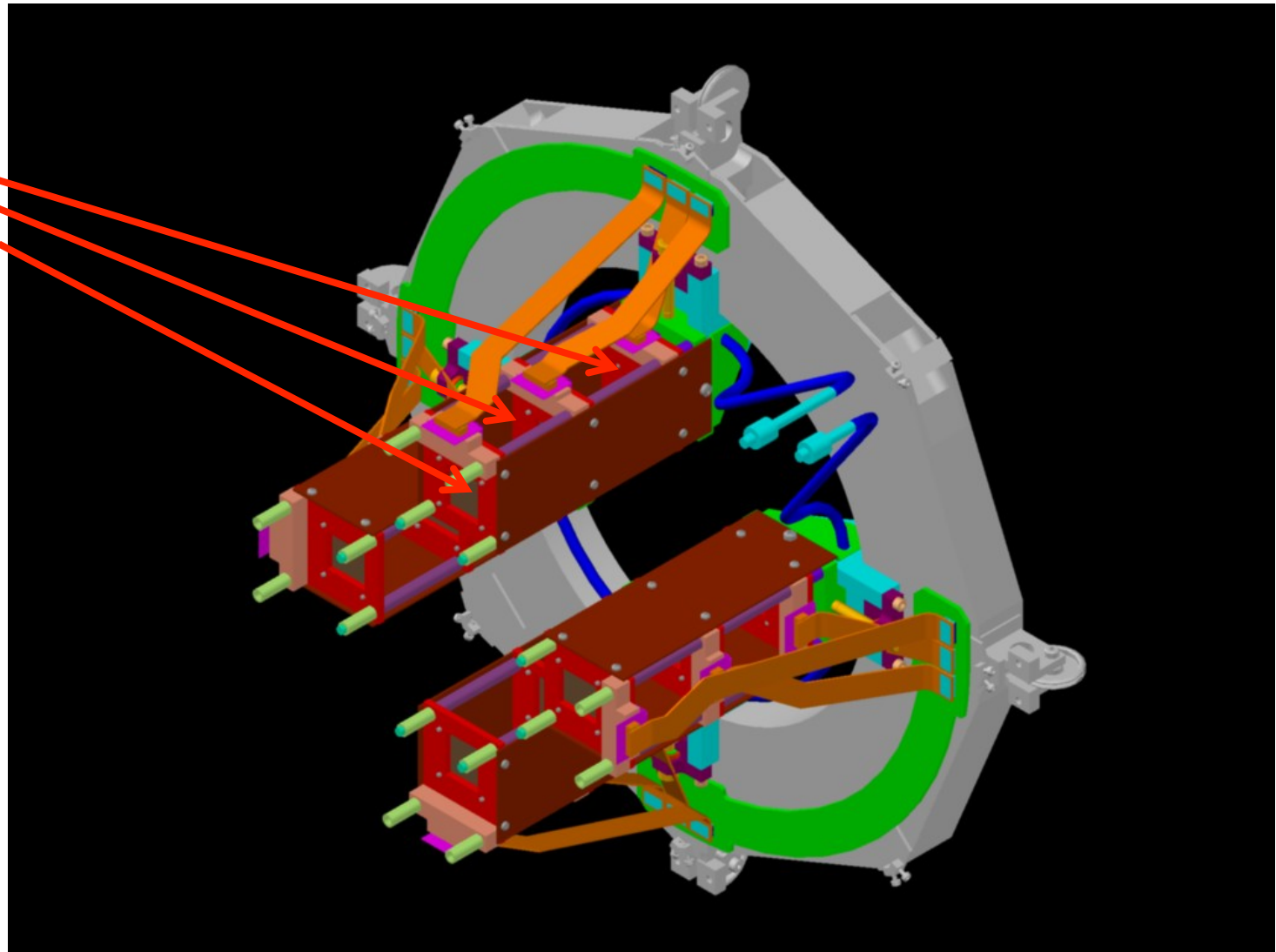
ATLAS Diamond Beam Monitor





ATLAS Diamond Beam Monitor

Diamond
pixel module

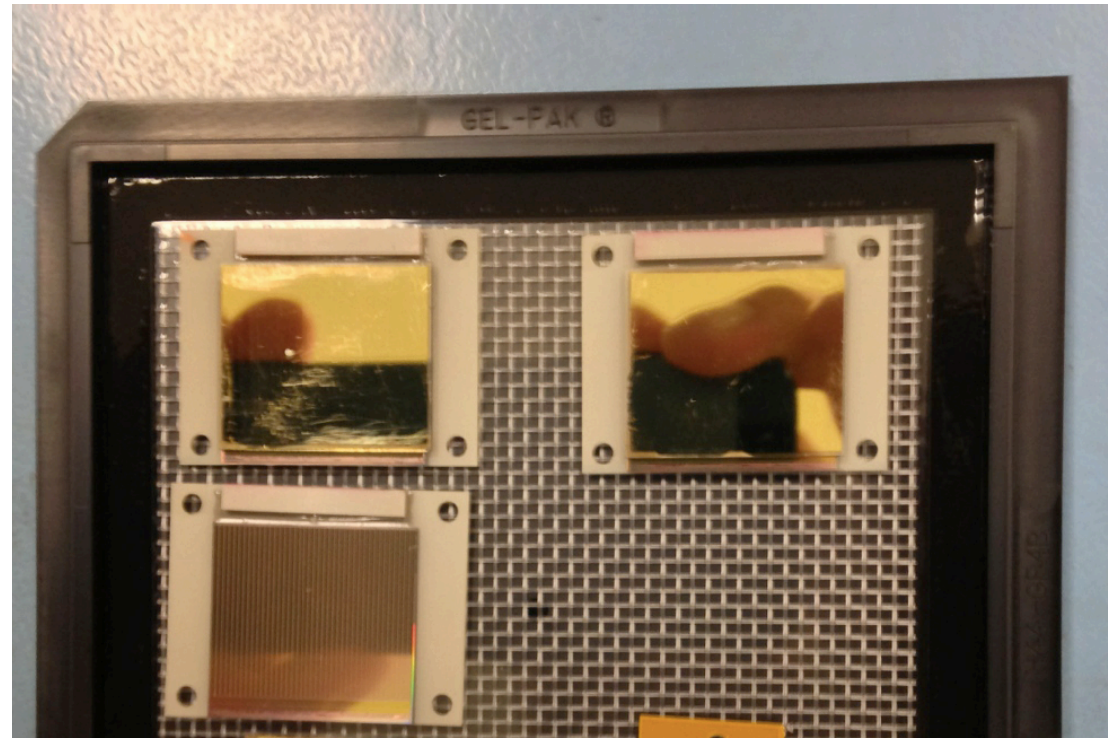




TIPP '14

ATLAS DBM Module Production

- All modules bump bonded at IZM
 - Still learning to bump-bond reliably
 - 50% of modules reworked
 - ◆ diamond supplied by two vendors

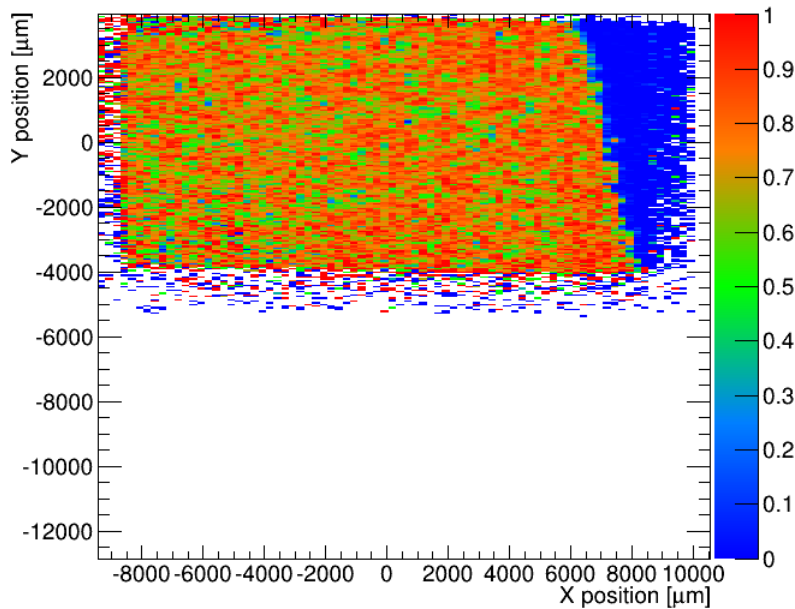




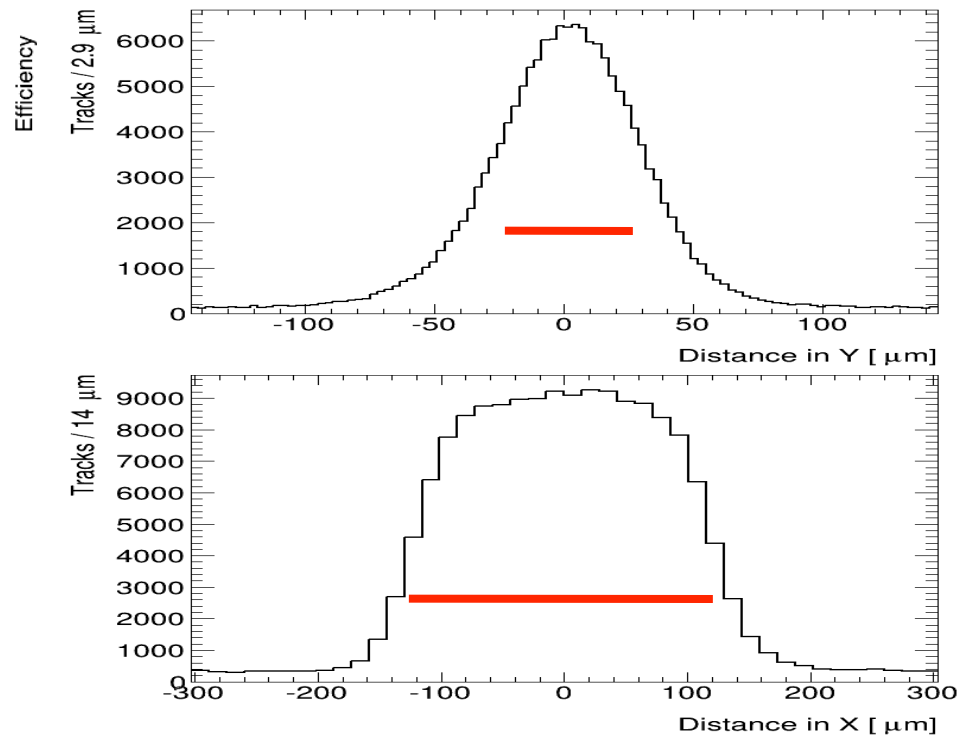
ATLAS DBM DESY Testbeam

- MDBM-01 in 5 GeV electron test beam at DESY
 - Operated at 600 V with 1100e threshold
 - Beam/trigger populated top half of the detector

Efficiency



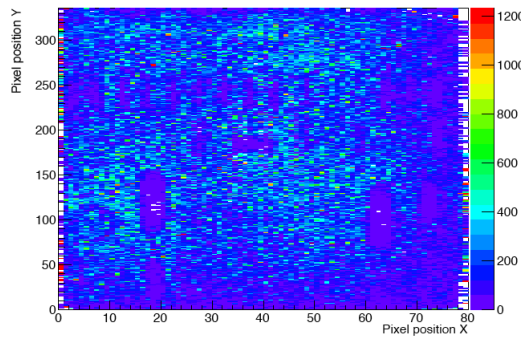
Hit residuals (pixel width)



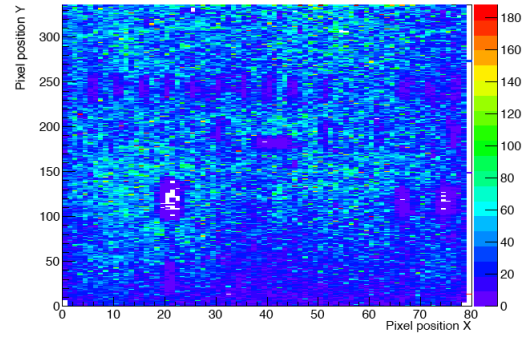


Module Connectivity Issues

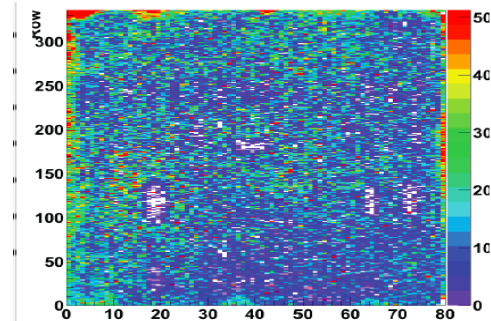
MDBM03 (TDBM01)



MDBM09 (TDBM01)

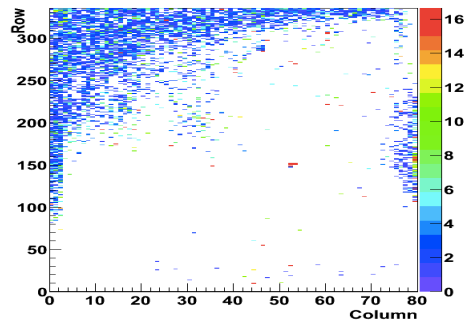


MDBM10 (re-worked)

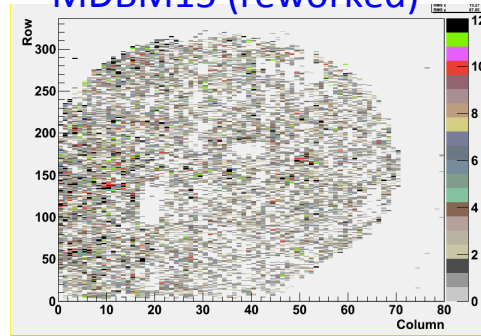


Bonded prior to May 2013

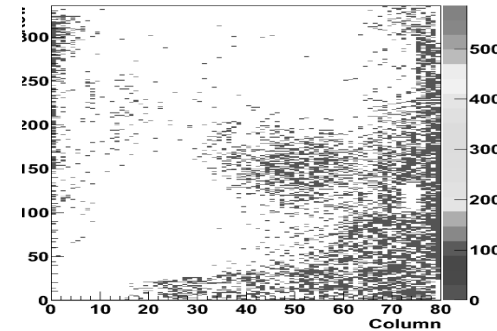
MDBM17 (reworked)



MDBM15 (reworked)

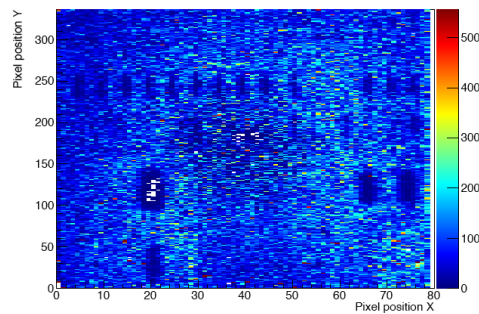


MDBM18 (reworked)

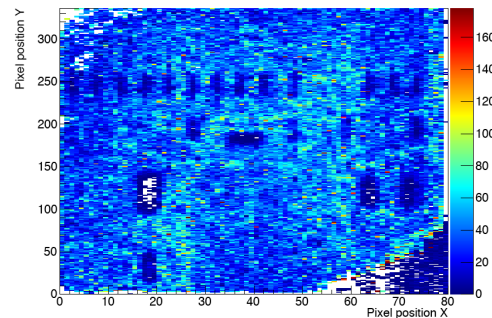


Bonded in June/July 2013

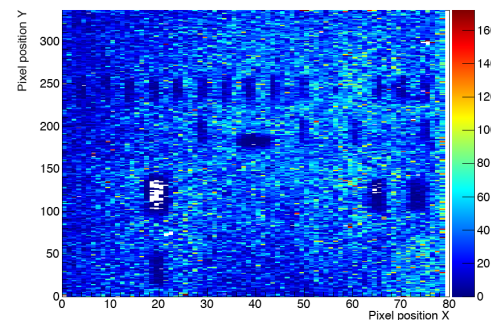
MDBM17 (not used)



MDBM30 (not used)



MDBM31 (TDBM05)

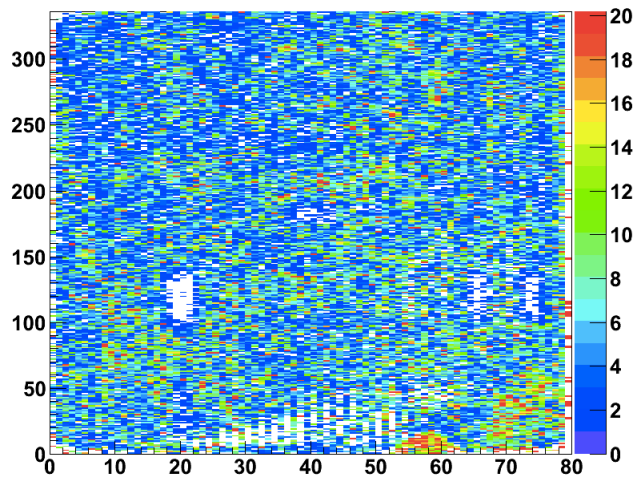


Bonded in September 2013

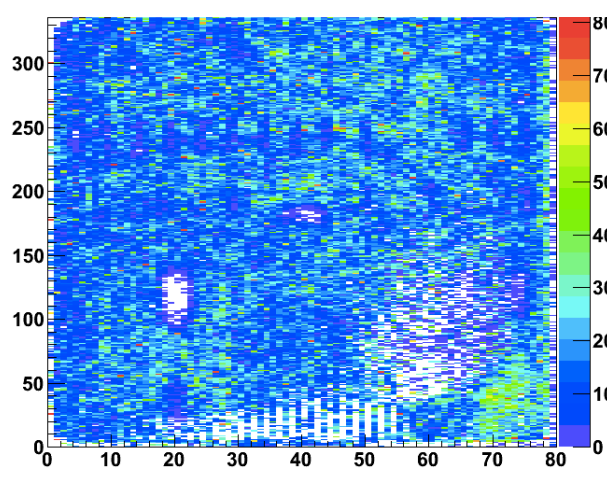
Thermal Cycling Issues

- QA included thermal cycling
 - 10 cycles: +20C → +40C → -20C → +20C
 - All modules installed showed no thermal sensitivity
 - Three modules were rejected

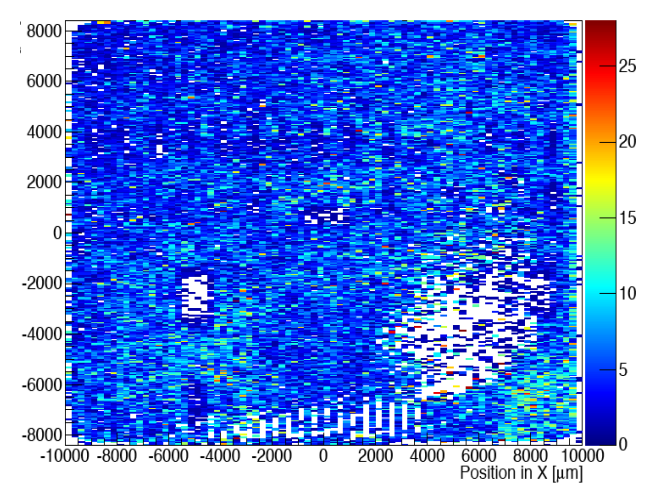
MDBM-08



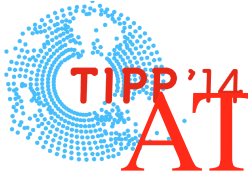
Before Thermal Cycling



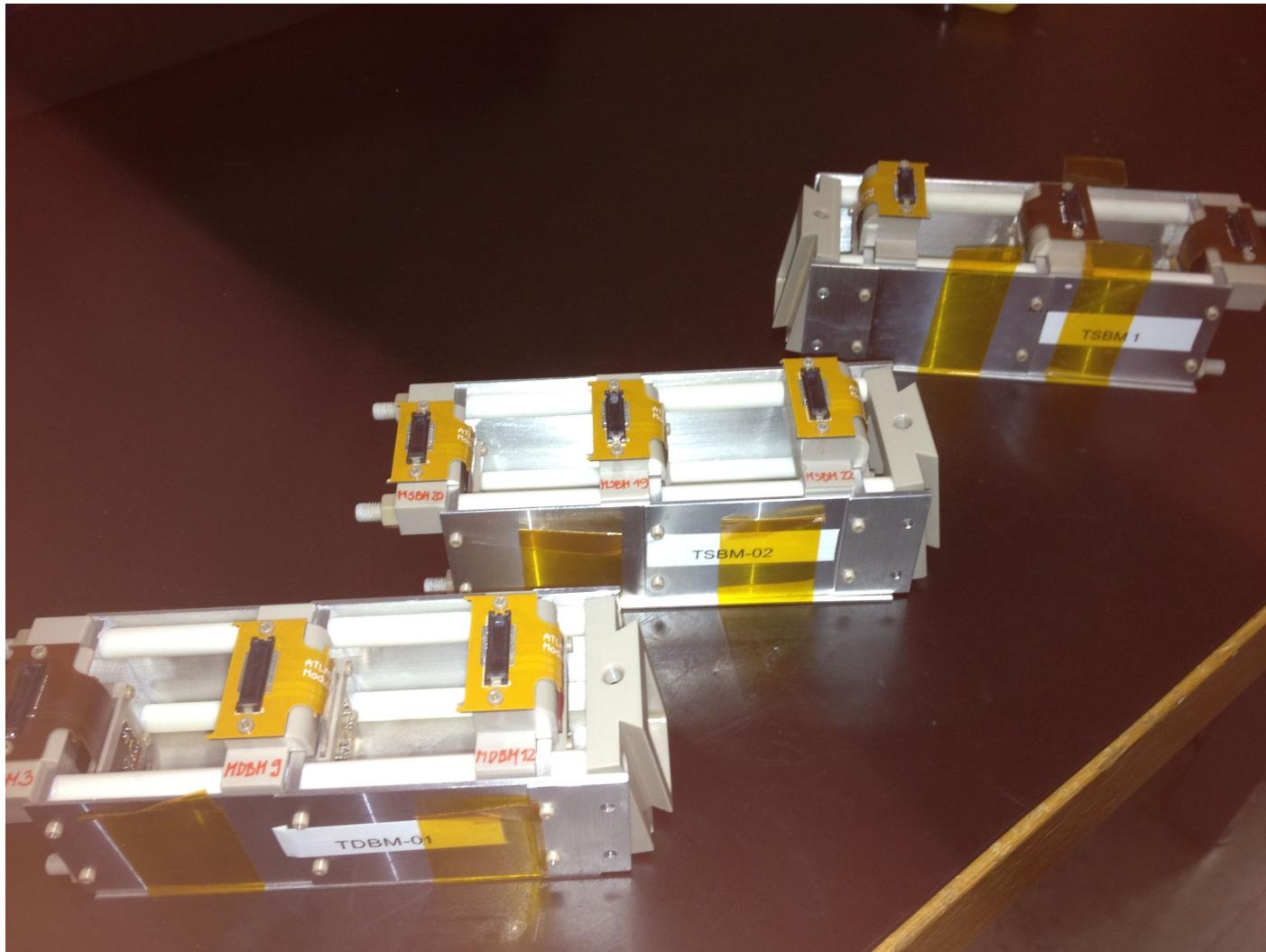
After One Thermal Cycle



After Two Thermal Cycles

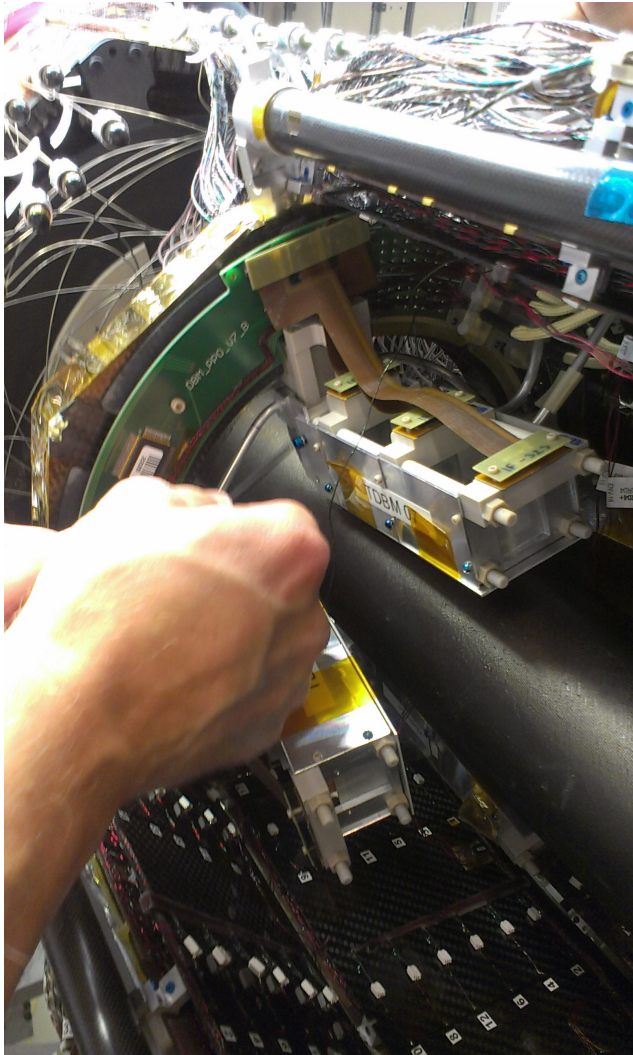


ATLAS DBM Telescopes Assembled

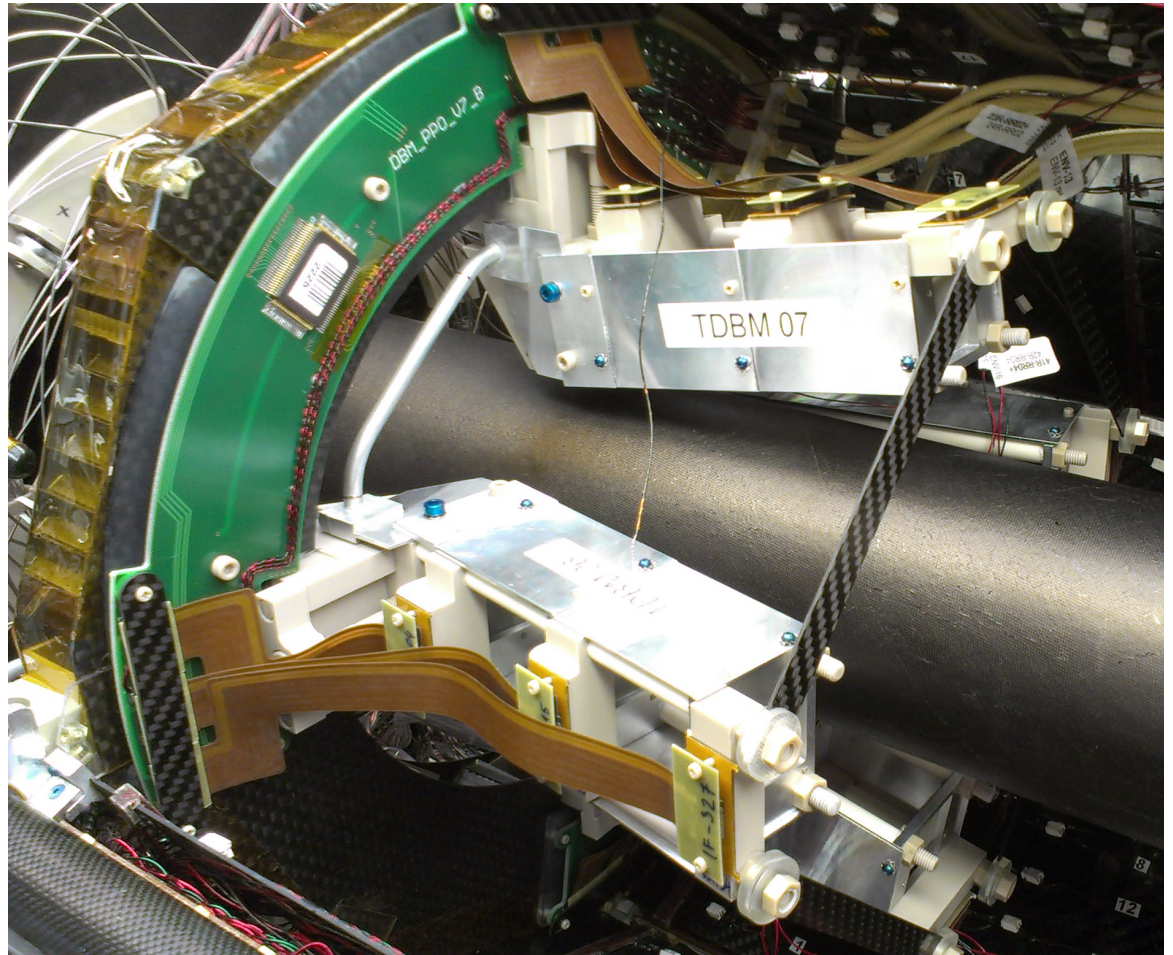




ATLAS DBM Telescopes Installed



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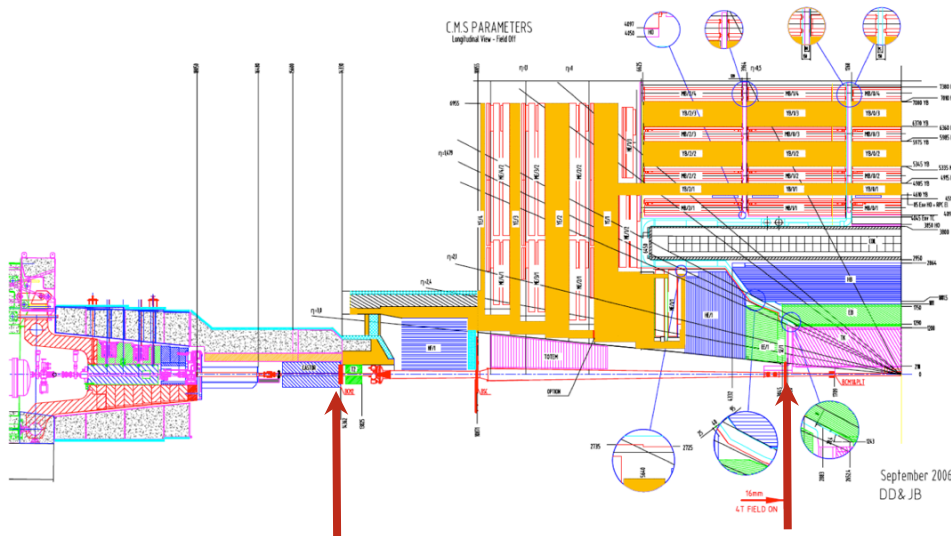
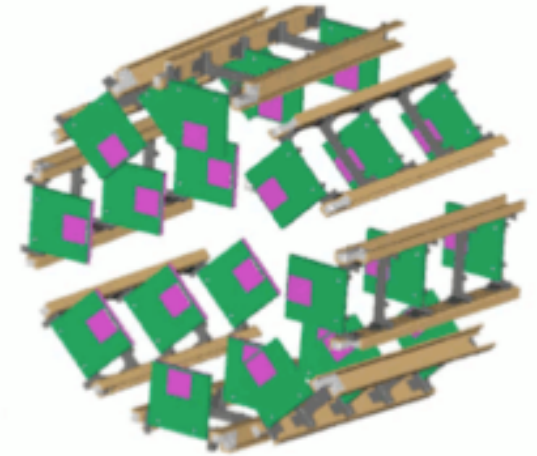


TIPP2014



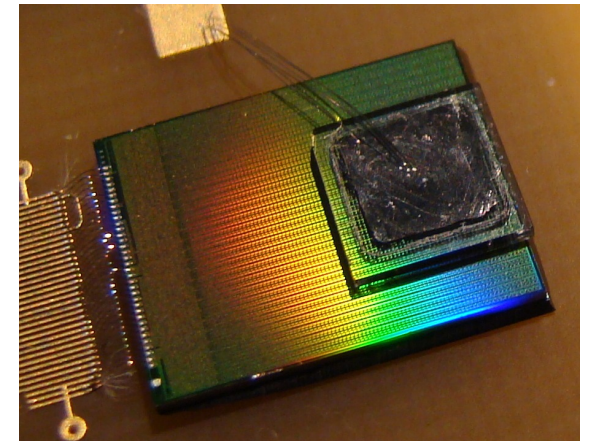
CMS Pixel Luminosity Telescope (PLT)

- Array of eight 3-plane telescopes
- Single-crystal diamond pixel sensors
- Pixel readout for tracking and diagnostics
- Pilot run in Castor region: 14.5m from IP
 - Total exposure 20 fb^{-1}



Pilot run location

Final location

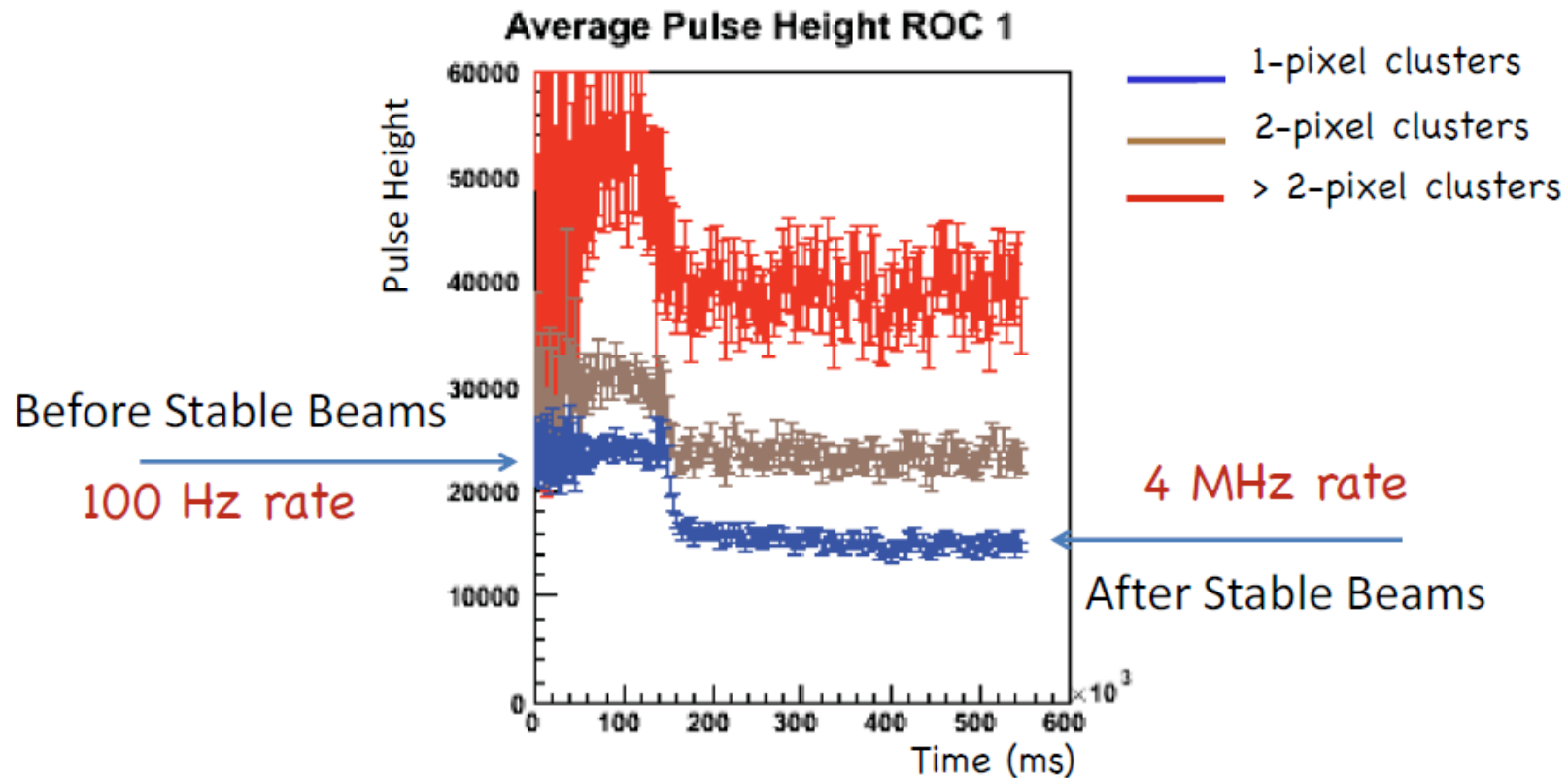




Observations from the PLT Pilot Run



Shift in pulse heights with rate

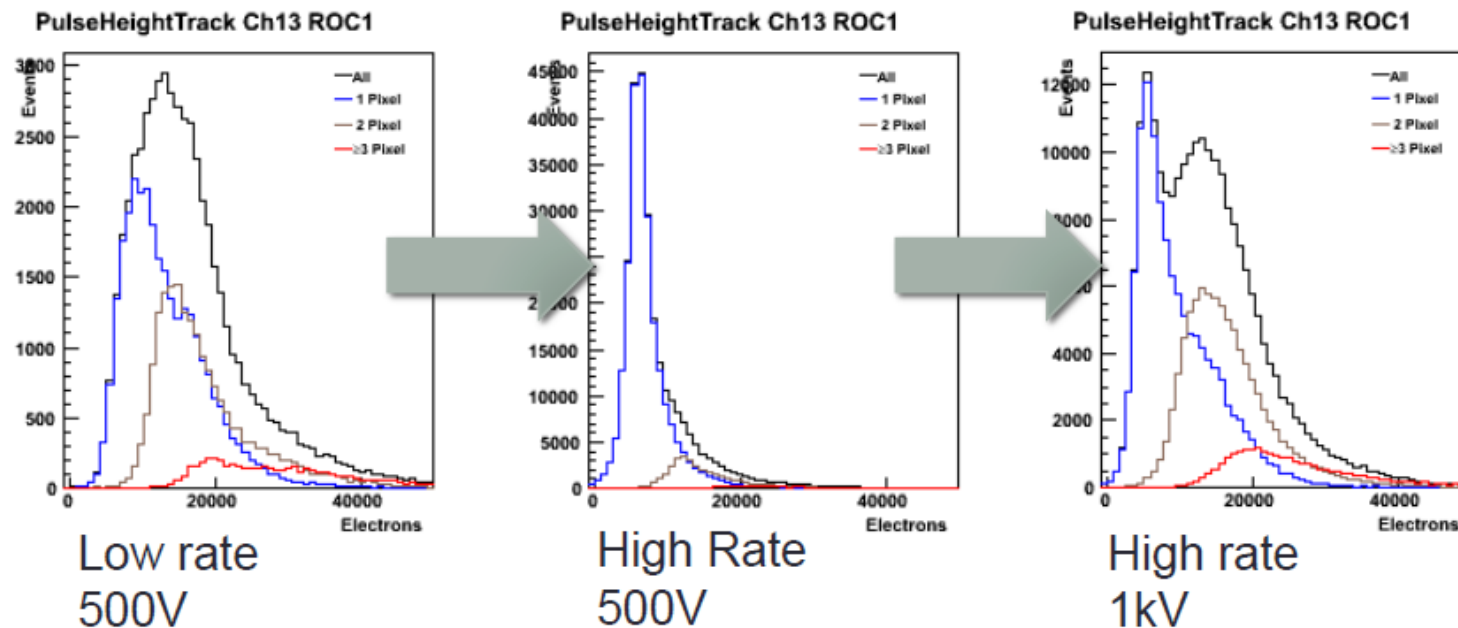




Indication of Polarization



- On Castor we see what we believe is a polarization effect
 - This effects the charge collection
 - Raising the HV brings back charge collection even at full luminosity
 - Turning on and off HV seems to reset this as well





CMS PLT Status

- These effects led CMS to decide the PLT baseline would be silicon instead of scCVD diamond
 - must install cooling!!
- Performed a series of irradiations/tests
- See Talk by D. Hits for details



Summary

- First diamond pixel projects nearing completion
- ATLAS DBM complete and installed
 - commissioning underway
- CMS PLT scCVD diamond had issues
 - PLT now silicon
 - Tests underway to understand scCVD diamond manufacturing issue