ATLAS Forward Detectors

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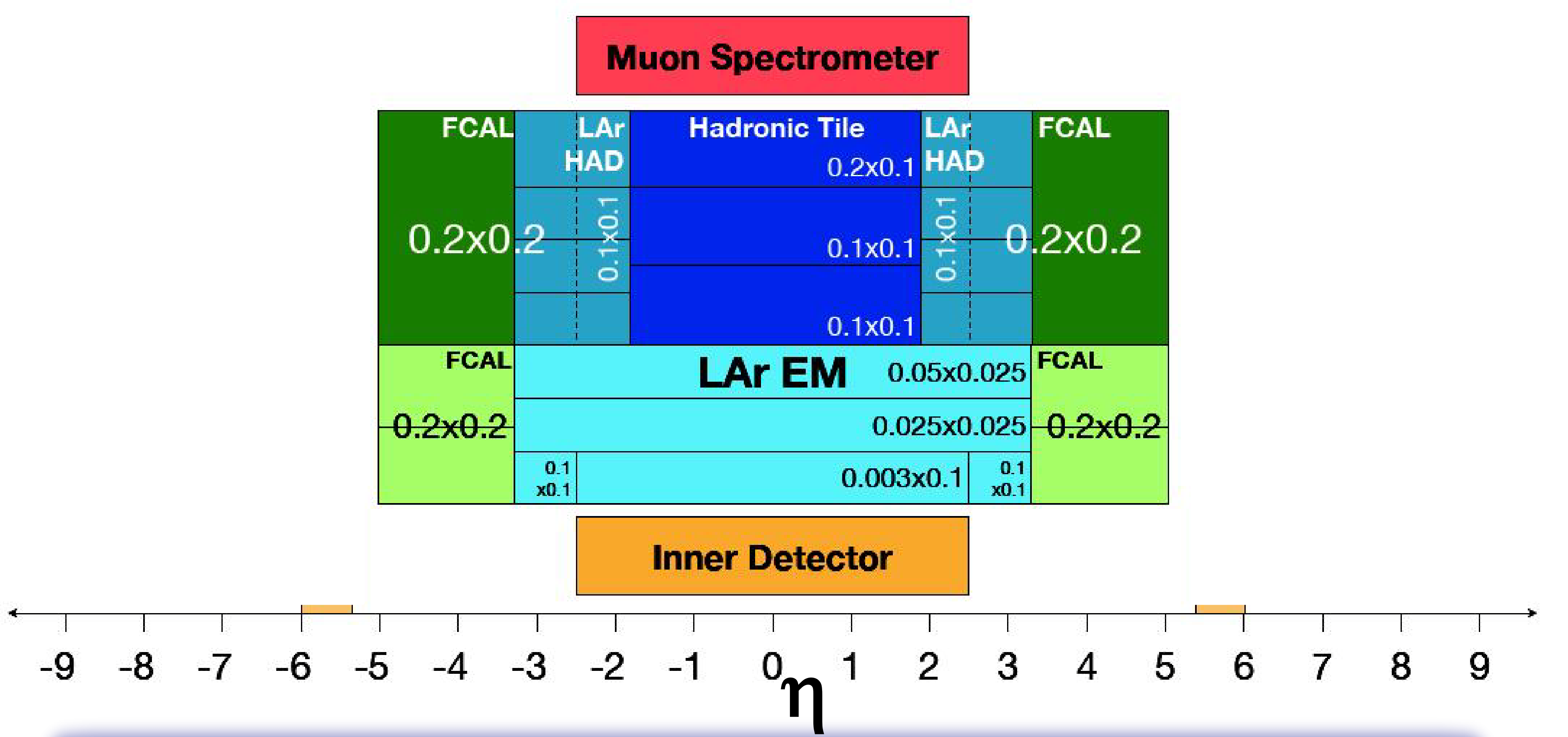
- **ATLAS Forward Detectors**
  - **MBTS**
  - **LUCID**
  - **ZDC**
  - **ALFA**
- **Future Project: AFP**
- **Conclusions**

Thanks to ATLAS Forward group for help with slides, especially Carla Sbarra, Nitesh Soni, Jacob Groth-Jensen, Per Grafstrom, Stephen Watts

ATLAS Central Detector Coverage



Central Detector covers

Inner Tracker $|\eta| < 2.5$ EM calorimeter $|\eta| < 3.2$

Hadronic Calorimeter $|\eta| < 4.9$ Muon Spectrometer $|\eta| < 2.7$

ATLAS FORWARD Detectors

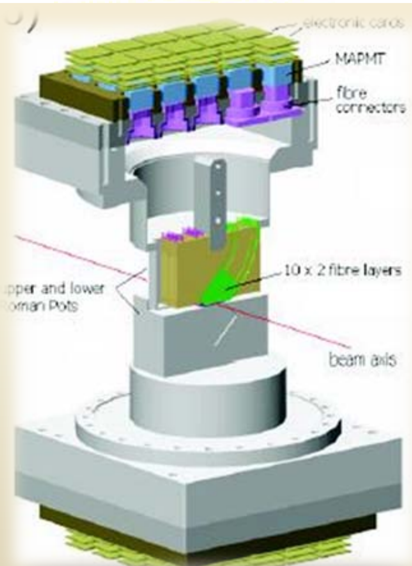
ALFA at 240 m

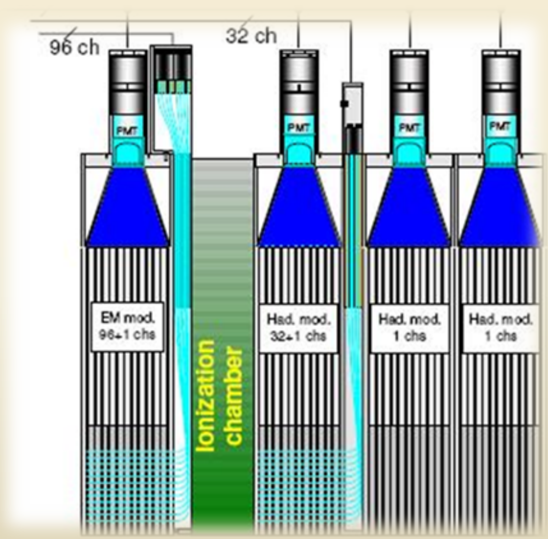
ZDC at 140 m

LUCID at 17 m

MBTS at 3.6 m

Minimum Bias Trigger Scintillator



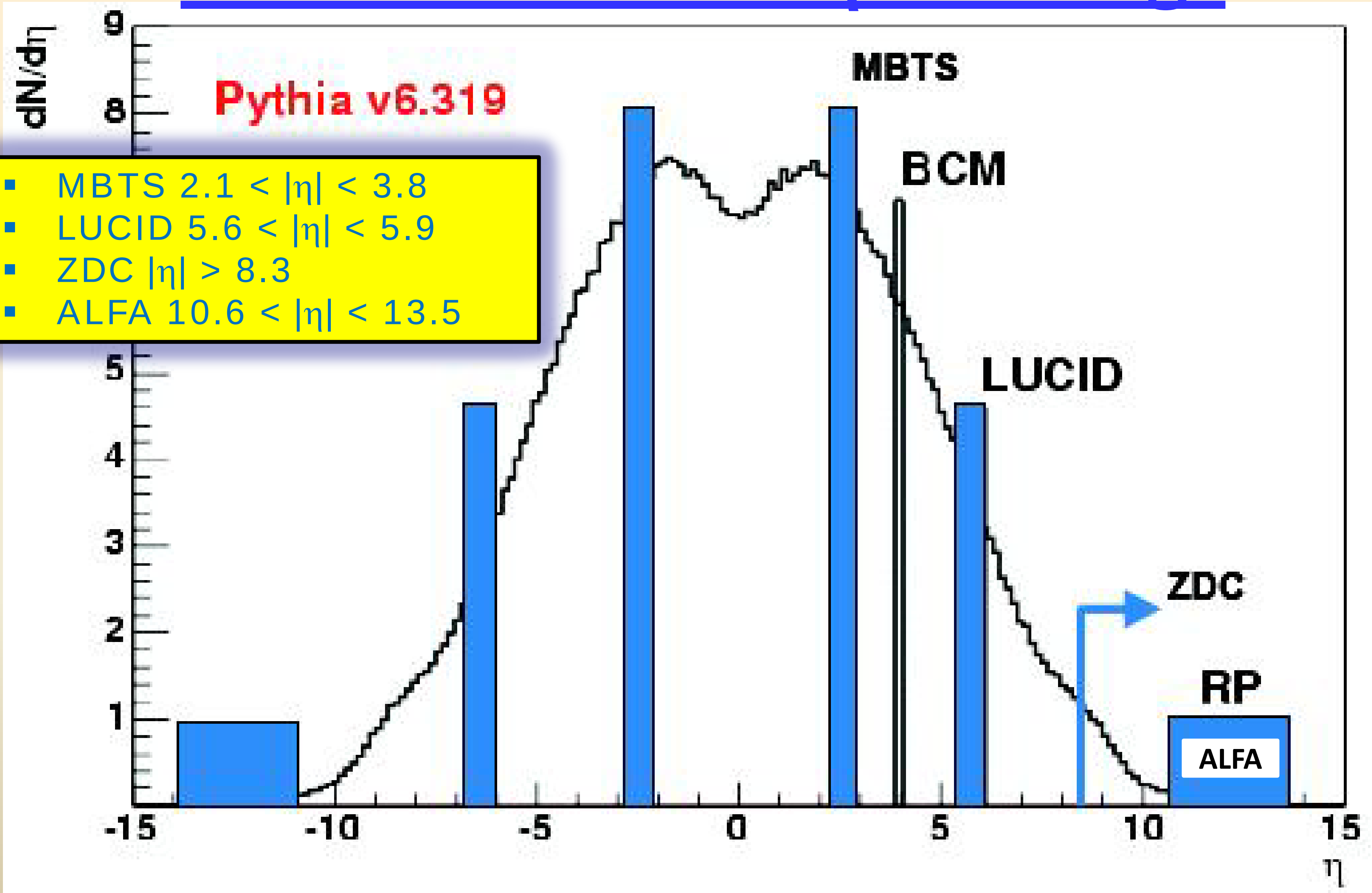


Absolute Luminosity For ATLAS

Zero Degree Calorimeter

Luminosity Cherenkov Integrating Detector

ATLAS Forward η Coverage

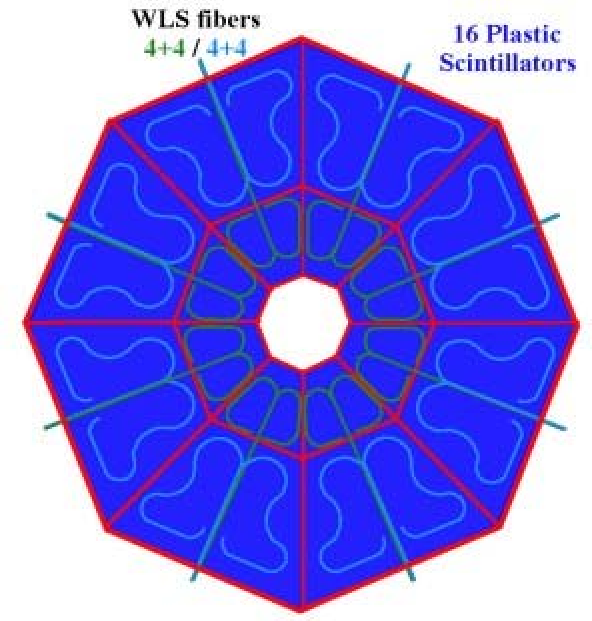


- MBTS 2.1 < |η| < 3.8
- LUCID 5.6 < |η| < 5.9
- ZDC |η| > 8.3
- ALFA 10.6 < |η| < 13.5

MBTS

Minimum Bias Trigger Scintillator

- 32 independent wedge-shaped plastic scintillators (16 per side) read out by PMT's
- Full coverage from $2.1 < |\eta| < 3.8$ in two η bins

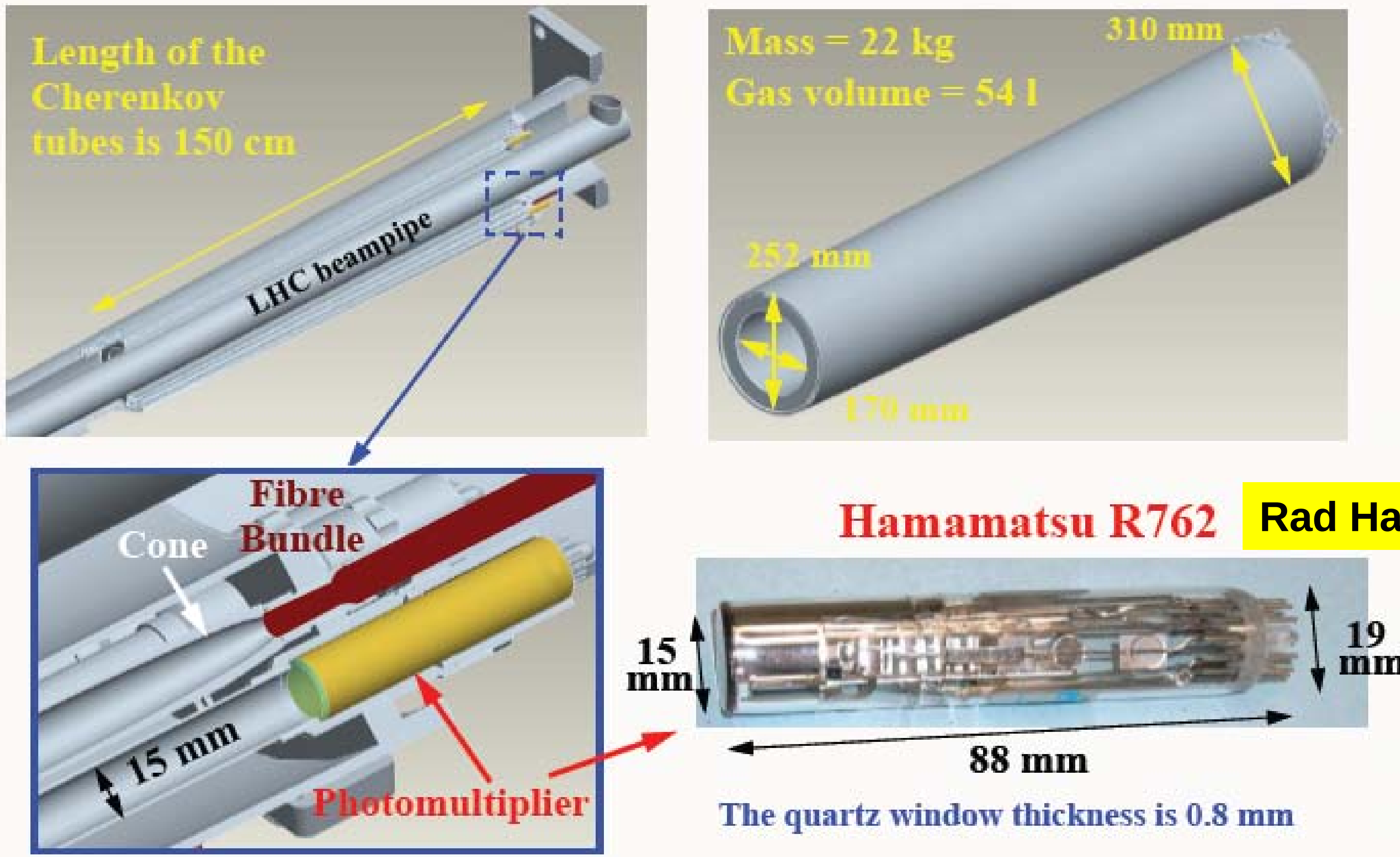


- Designed to provide Level 1 trigger on minimum bias events
- Timing used to veto halo and beam gas events
- Also being used as gap trigger for various diffractive subjects

LUCID

5.6 < |η| < 5.9

LUminosity measurement using Cherenkov Integrating Detector



Rad Hard PMT

Array of 20 Aluminum tubes with C_4F_{10} gas at 1.1 bar as radiator

LUCID Principle

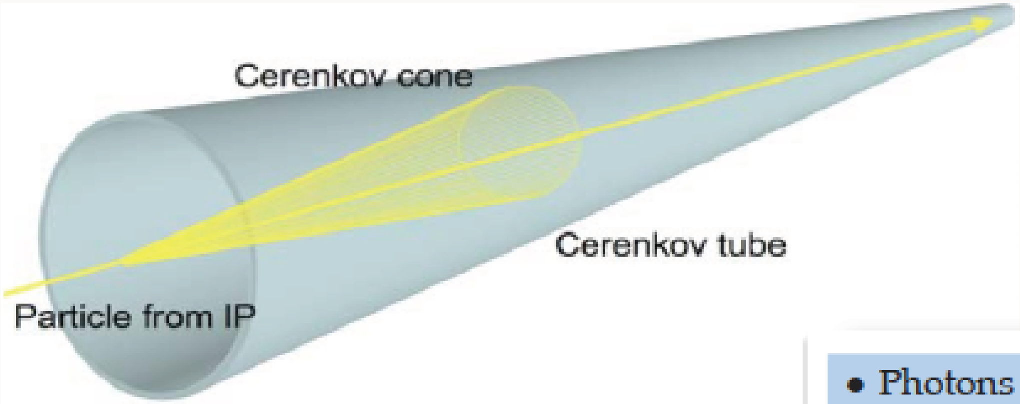
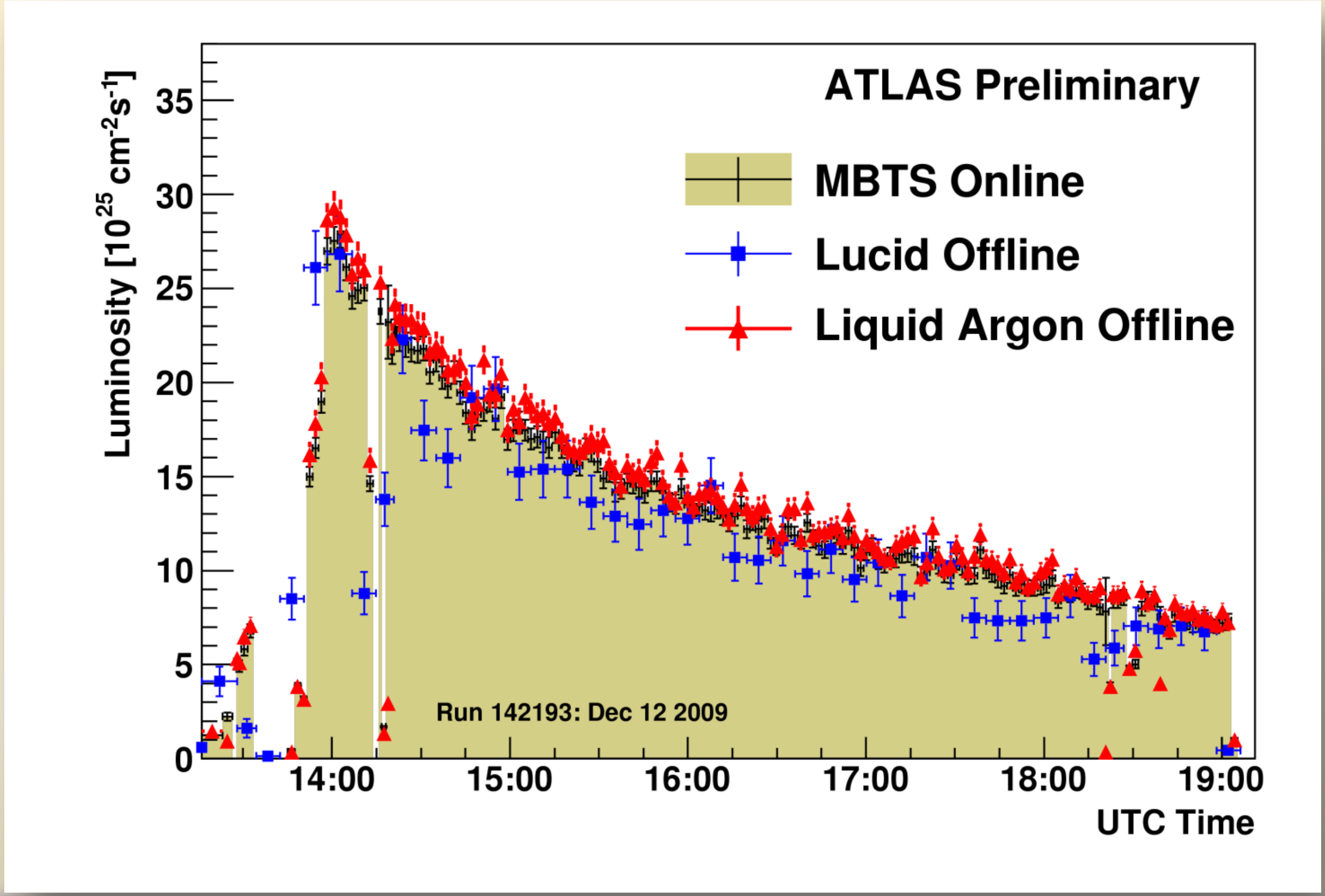


Photo-multiplier tubes (PMT) read-out

- Photons are emitted at 3°
- On the average 3 reflections inside the tube
- Further radiation of photons inside the PMT window

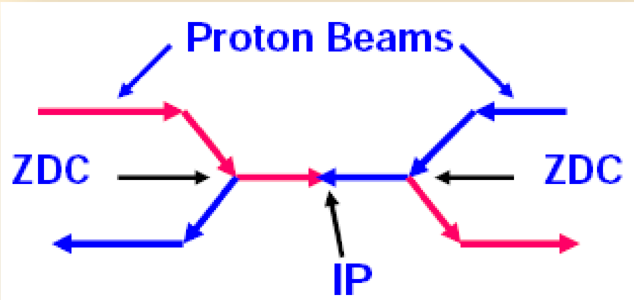
- Background suppression:
  - Cherenkov threshold: in the gas (10 MeV for e- and 2.8 GeV for π)
  - Tubes are pointing to the pp interaction region.
- The fast response (few ns) allows for single bunch crossing detection.

Luminosity Measurements (900 GeV)

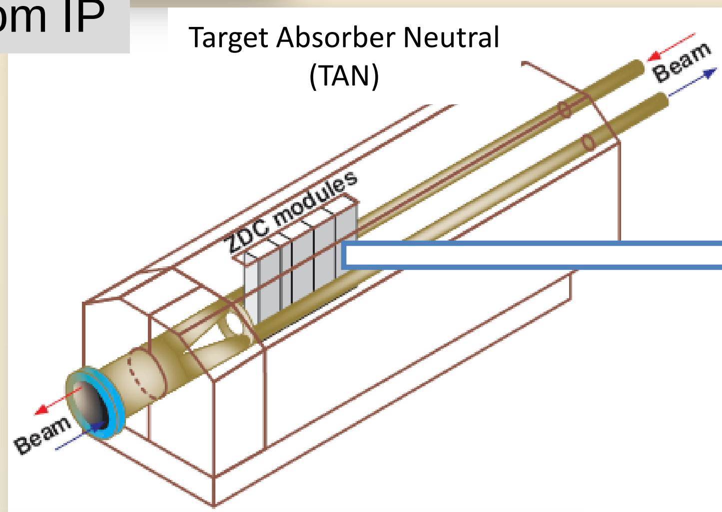


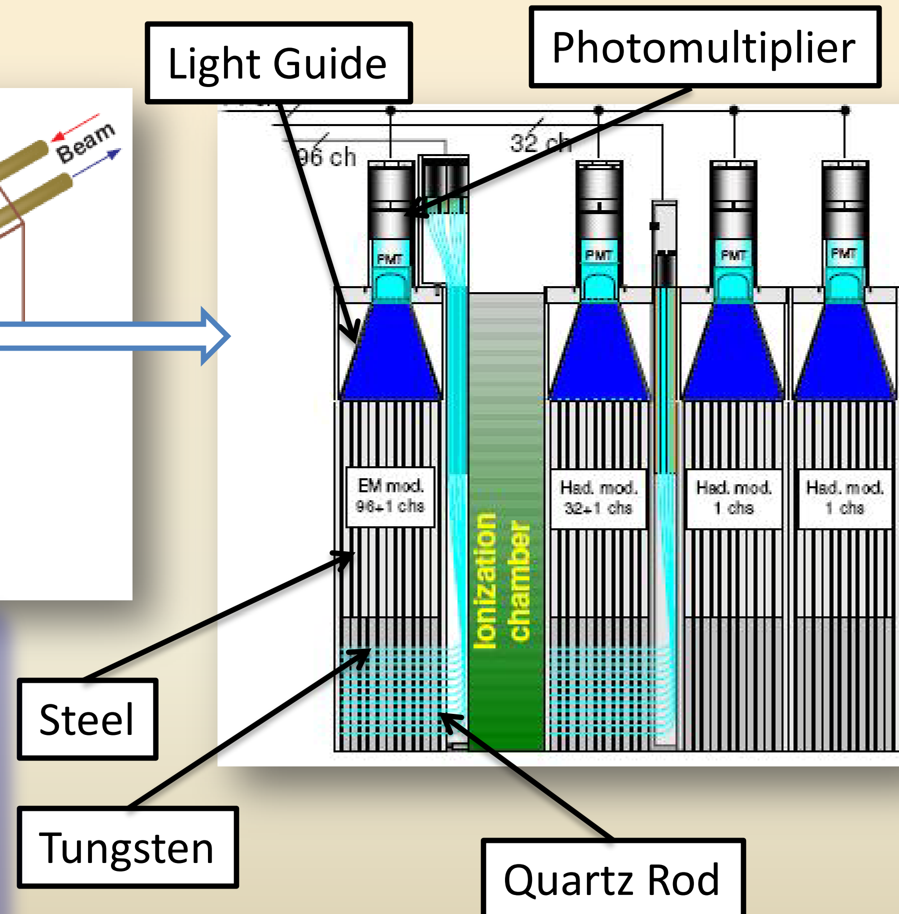
- Integrated Luminosity recorded by ATLAS: 20 μb^{-1}
- Max. Peak Luminosity: 7 X 10^{26} $cm^{-2}s^{-1}$
- Note: LUCID optimized for higher luminosity, but performed well at very low luminosity

ZDC Zero Degree Calorimeter



140m from IP





1 Electromagnetic , 3 Hadronic Modules

- ZDC detects forward neutral particles with |η| > 8.3
- Designed for heavy ion collisions
- Determine Centrality of the events
- Provide Minimum bias Trigger
- Luminosity Measurements

At the moment only Hadronic Part is installed; EM after LHCf removed

LUCID goals achieved in 2009 run

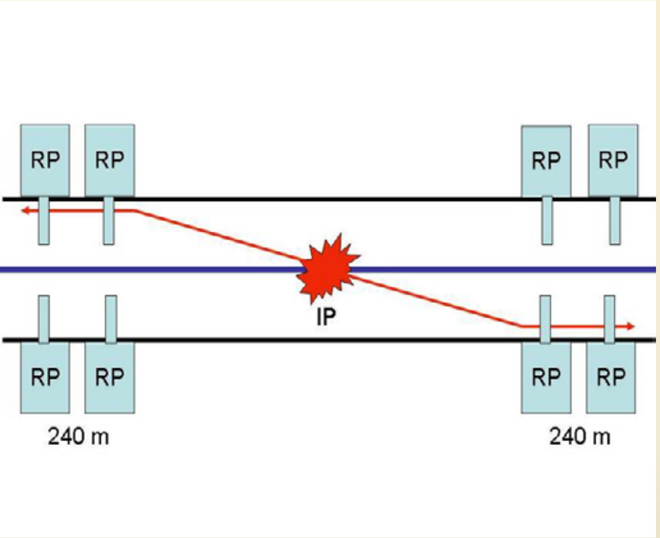
- Stable readout of PMT signals, response equalized within few percent
- Sensitivity to beam background with unstable beams
- Online publication of full set of raw counts for Online Luminosity Calculator
- Coincidence counts (hits in both sides) are background free
- Sensitivity to L already at $L \approx 10^{26}$

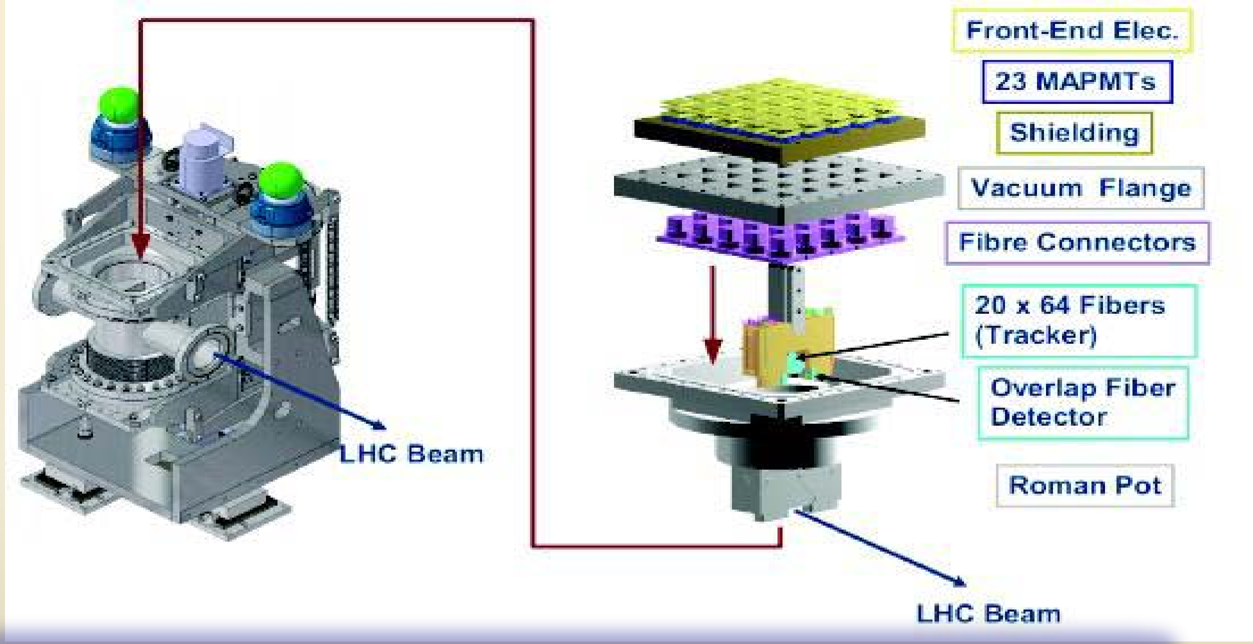
ZDC goals achieved in 2009 run

- PMT readout integrated in DAQ and trigger, working since first beams
- SW infrastructure for luminosity and beam background monitoring
- Collected data useful to understand energy scale, tune timing, gain, thresholds

ALFA Absolute Luminosity For ATLAS

- Main goal to provide absolute luminosity via elastic scattering
- Planned to operate with special beam conditions
  - High -β^* optics
  - Reduced beam emittance (low luminosity ~$10^{27} cm^{-2} s^{-1}$)



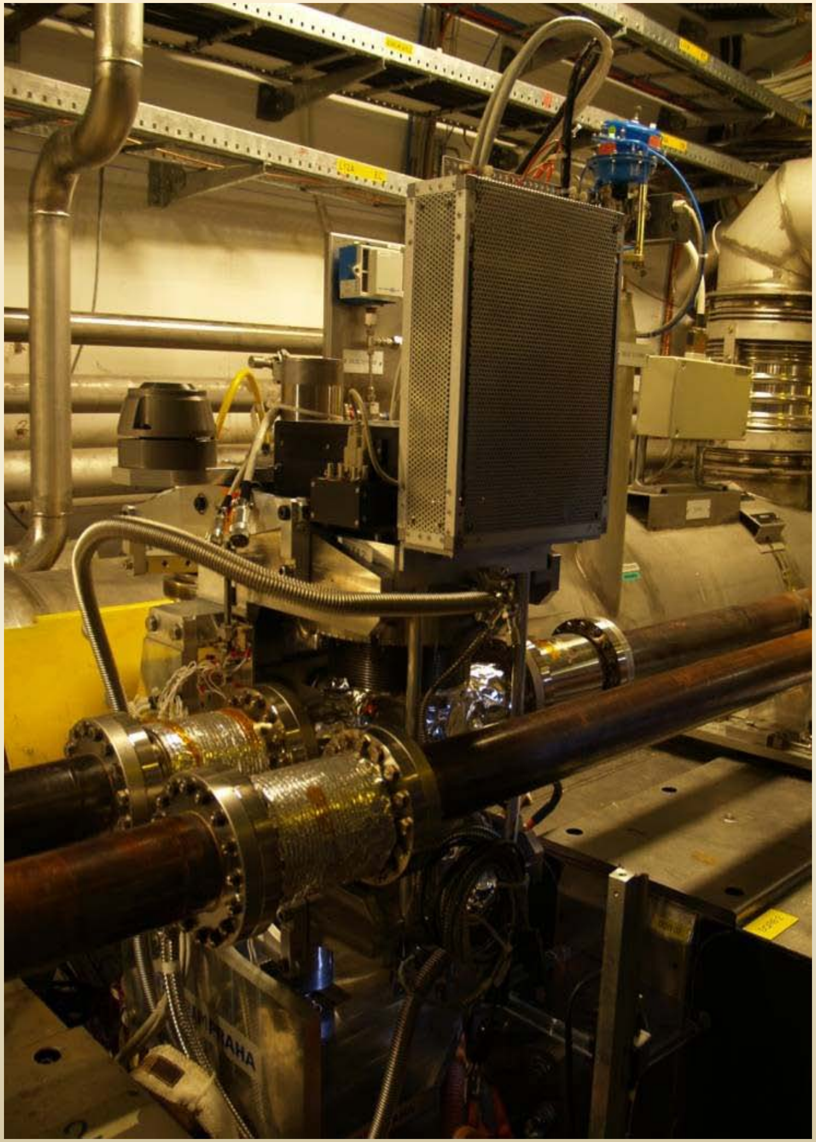


- 4 sets of Roman Pots (2 per side) located ± 240m from IP
- Operating position close to the beam (1mm)
- Spatial Resolution 30 μm
- Scintillating Fibre Tracker

ALFA Recent Progress: August 2009

Photographs of installation of the mechanics for one station (1/4 of total Roman Pot system)

ALFA Recent Progress: January 2010



Installation of first complete detector
(~1500 independent fibers)
inside pot with electronics on top.
(1/8 of total number of detectors)

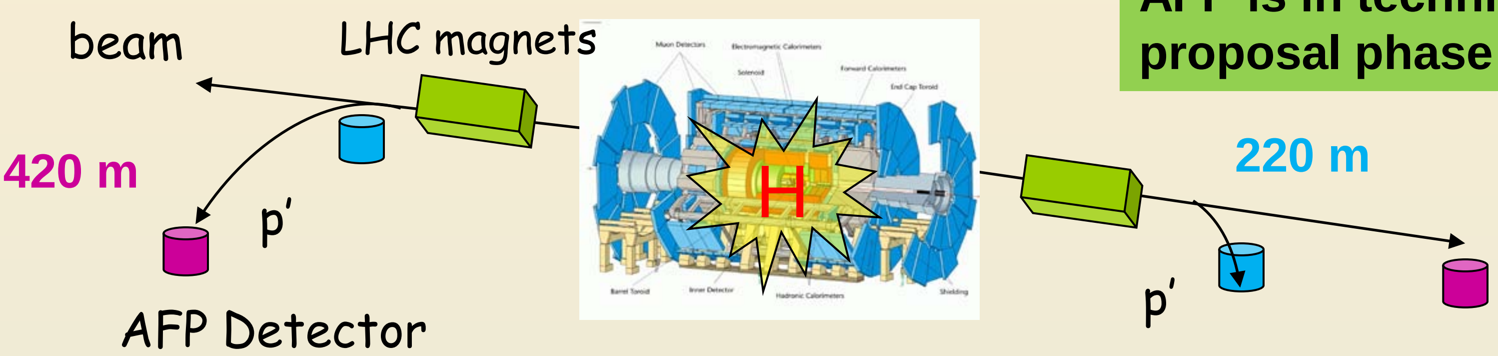
Remaining 7 detectors to be validated in test beam September-October 2010.

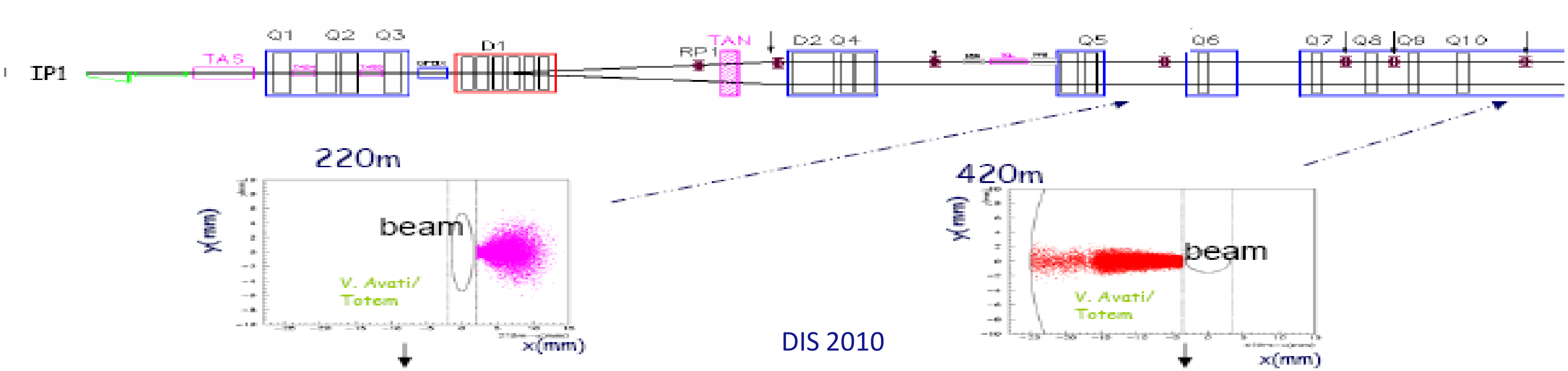
Require a one month shutdown after November 2010 to complete ALFA installation.

ATLAS Forward Proton Upgrade

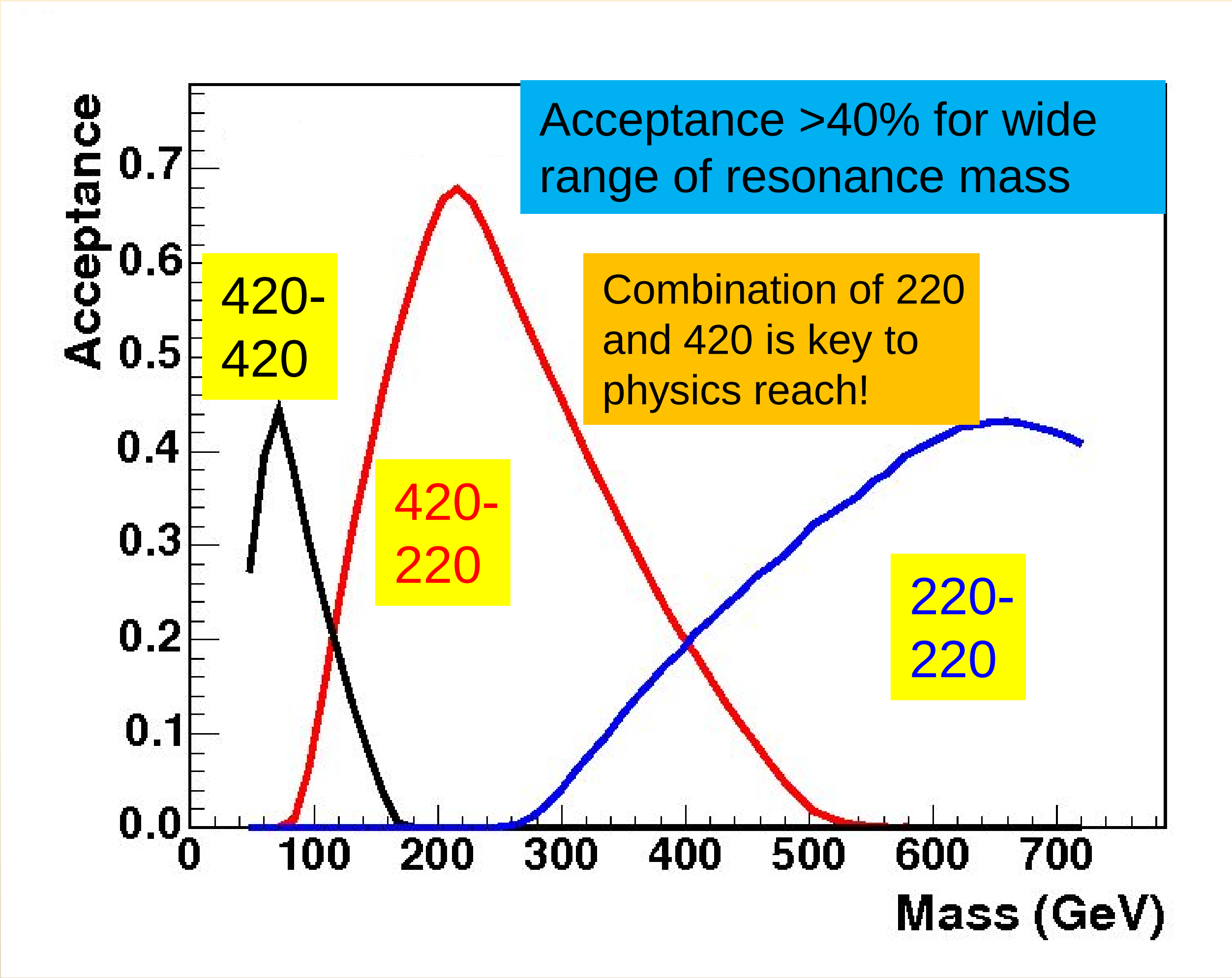
AFP concept: add new ATLAS sub-detectors at 220 and 420 m upstream and downstream of central detector to precisely measure the scattered protons to complement ATLAS discovery program. These detectors are designed to run at 10^{34} and operate with standard optics (need high luminosity for discovery physics)

AFP is in technical proposal phase





What does AFP Provide?



- Mass and rapidity of centrally produced system

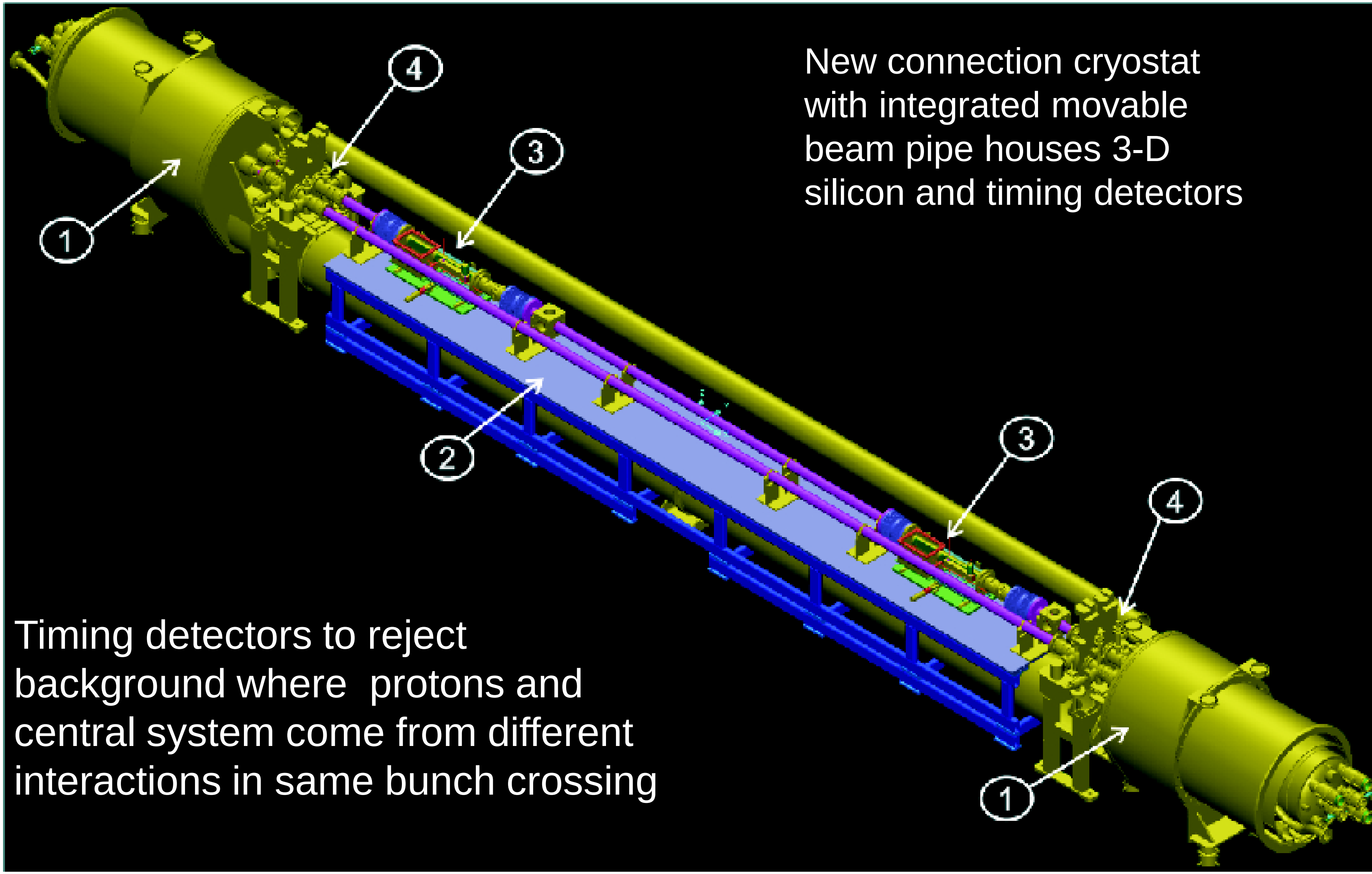
$$M = \sqrt{\xi_1 \xi_2} \bullet \sqrt{s}$$

$$y = \frac{1}{2} \ln(\xi_1 / \xi_2)$$

- where $\xi_{1,2}$ are the fractional momentum loss of the protons
- Mass resolution of 3-5 GeV *per event*

Allows ATLAS to use LHC as a tunable √s glu-glu or γγ collider while simultaneously pursuing standard ATLAS physics program

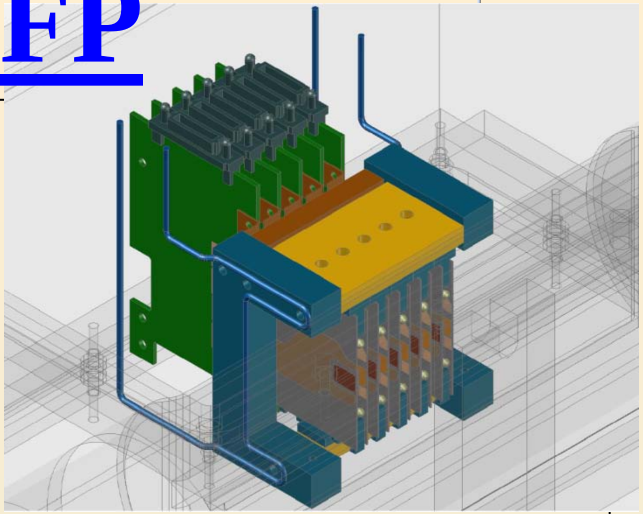
AFP in Pictures



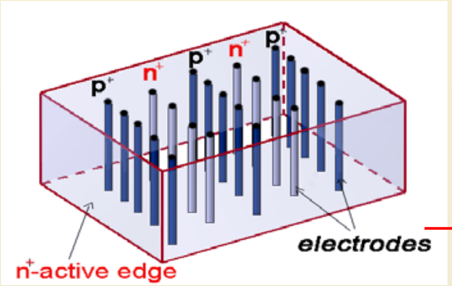
New connection cryostat with integrated movable beam pipe houses 3-D silicon and timing detectors

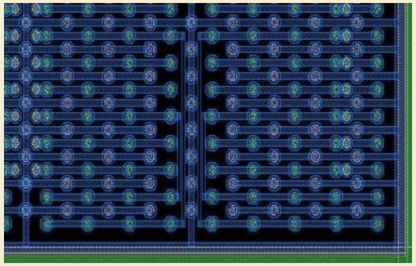
Timing detectors to reject background where protons and central system come from different interactions in same bunch crossing

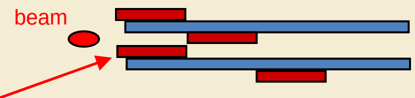
Tracking in AFP



Array of rad-hard active edge 3D silicon detectors with resolution ~11-14 μm/plane and 1μrad angular resolution. 3D technology development which is also an ATLAS R&D Project for Insertable B Layer







Edge response with tracks < 4μm

- Angular Error = (2 x Precision) / (Distance between stations x √(2N))

N = number of planes per station. Two stations eight metres apart per arm.

3D with 50 micron pitch at 10 degree angle gives precision of 11 microns in test beam.

N planes => (2.75 mrad)/√(2N) Around 6 planes needed for specification.

Conclusions

- Just getting started
- Looking FORWARD to completed detectors, new capabilities
- See Christophe Royon's talk about plans to use these detectors