



Status of the Forward Physics Projects in ATLAS



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DIS 2007

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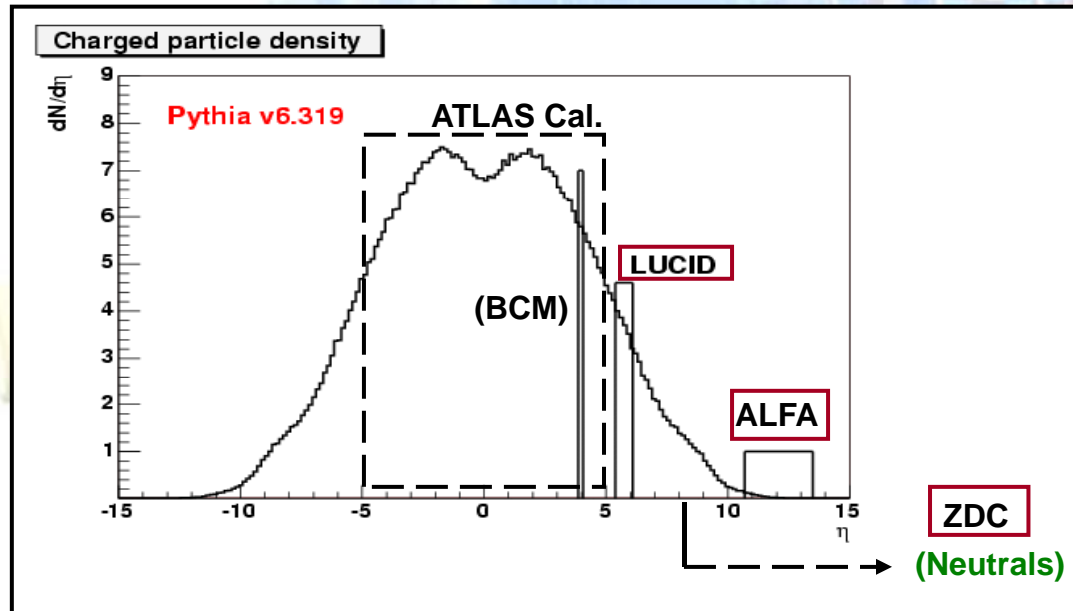
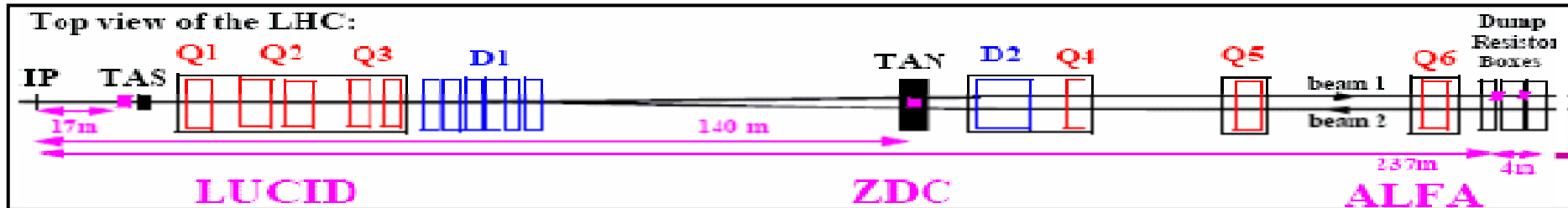
on behalf of the **ATLAS Luminosity
and Forward Physics Working Group**



XV International Workshop on Deep-Inelastic Scattering and Related Subjects



Forward Detectors in ATLAS



- **LUCID**,
Cherenkov integrating detector
- **ZDC**,
Zero degree calorimeter
- **ALFA**,
Scintillating fiber tracker (Roman Pot)

For the upgrade plans of the ATLAS Roman Pot program with stations at 220m and 420m, see talks by C. Royon and A. Pilkington.



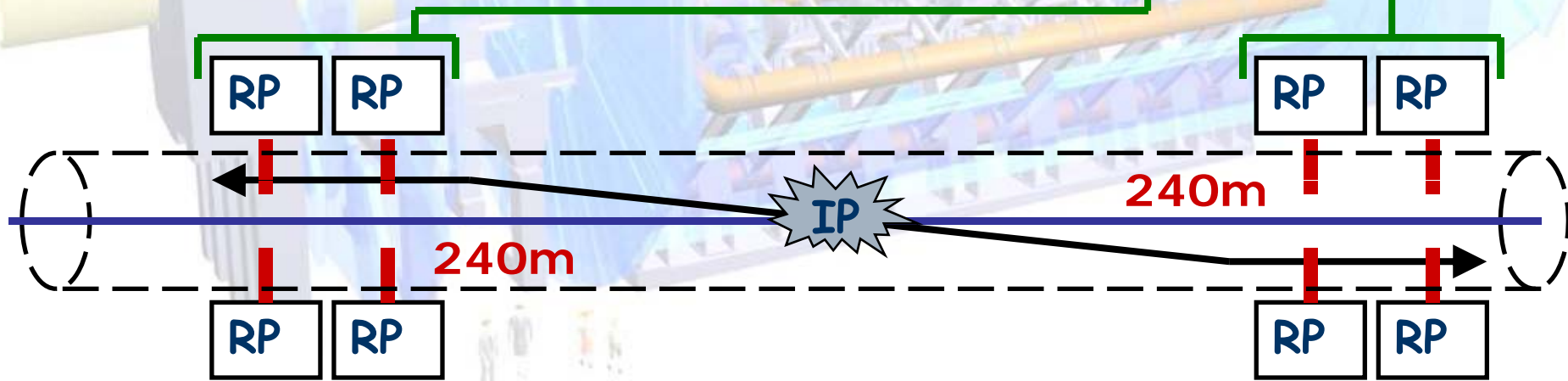
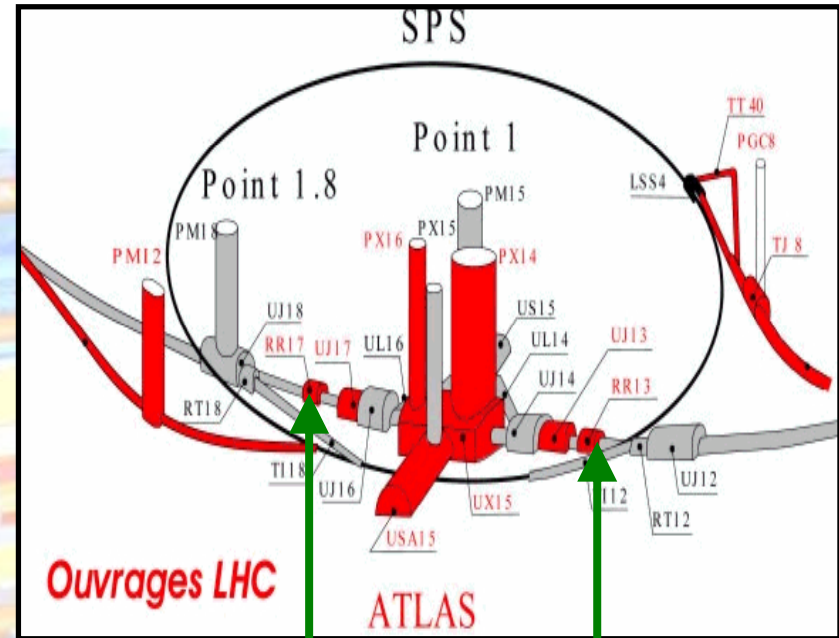
ATLAS Roman Pot Detectors A Scintillating Fiber Tracker (ALFA)



ALFA = **A**bsolute **L**uminosity **F**or **A**TLAS

Elastic proton scattering

1. Determine the Absolute Luminosity in ATLAS
2. Physics Measurements
 - σ_{tot} and elastic scattering parameters
 - Tag protons for single diffraction...





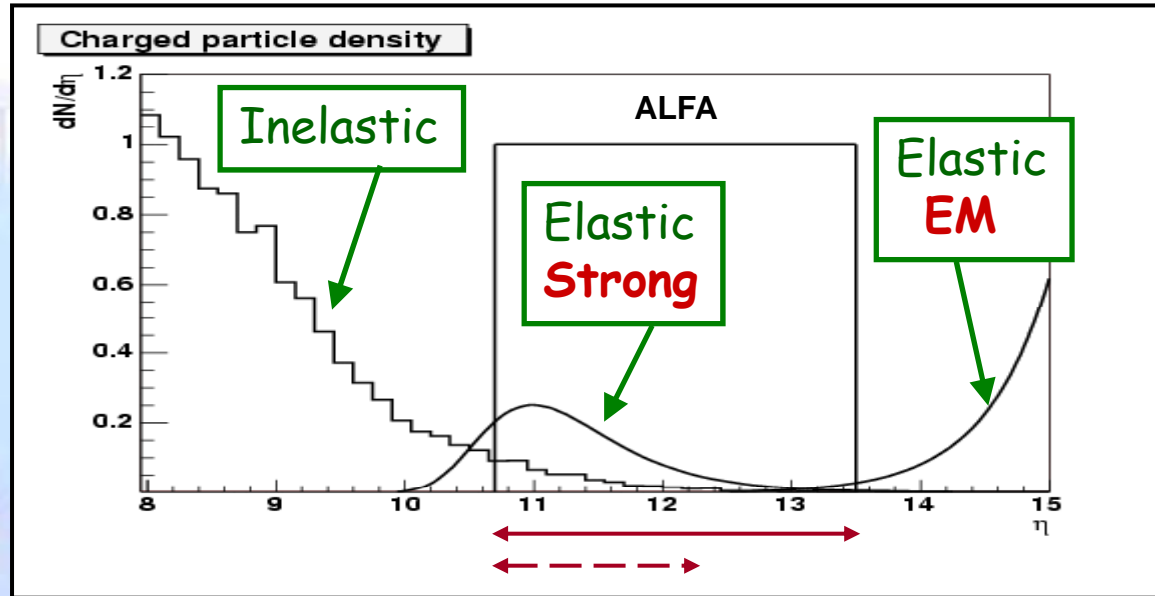
ATLAS Roman Pot Detectors A Scintillating Fiber Tracker (ALFA)



Luminosity

Primary Method:
Coulomb Normalization

Secondary Method:
Optical Theorem



ALFA Coverage:

$$\theta_{\min} = 2.7 \mu\text{rad}$$

$$\theta_{\max} = 44.7 \mu\text{rad}$$

Large β^* LHC Optics:

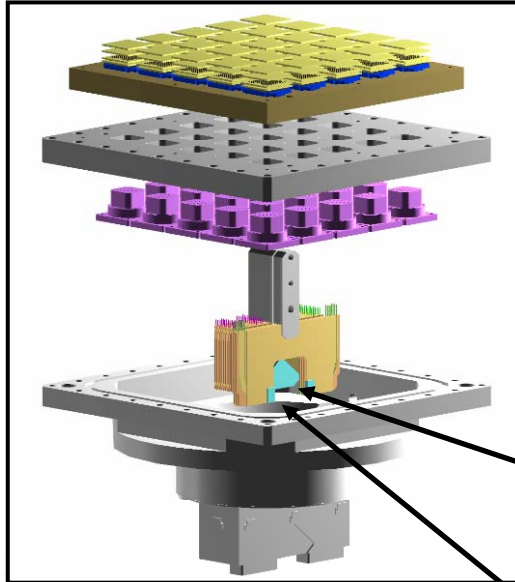
- Parallel to point focusing
- Distance wrt beam = **1-2mm**
- Low-luminosity

ALFA Design Goals:

- $\sigma_{x,y} \sim 30 \mu\text{m}$ ($< 130 \mu\text{m}$)
 - No significant non-active edge region ($< 100 \mu\text{m}$)
 - Insensitive to RF from LHC beam
- **Scintillating Fiber Tracker**



ATLAS Roman Pot Detectors A Scintillating Fiber Tracker (ALFA)



Front-End Elec.

24 MAPMTs

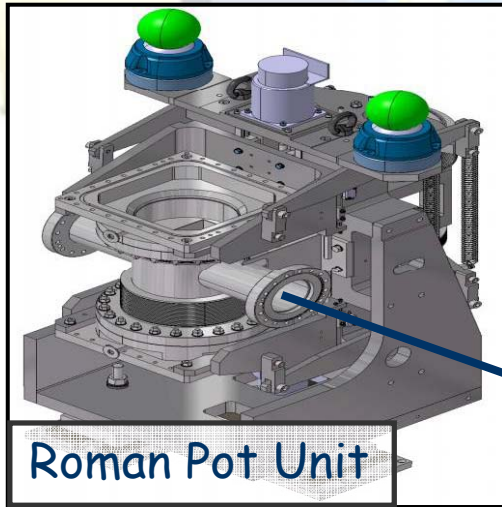
Shielding

Vacuum Flange

Fiber Connectors

20 x 64 Fibers
(Tracker)

Overlap Fiber
Detector



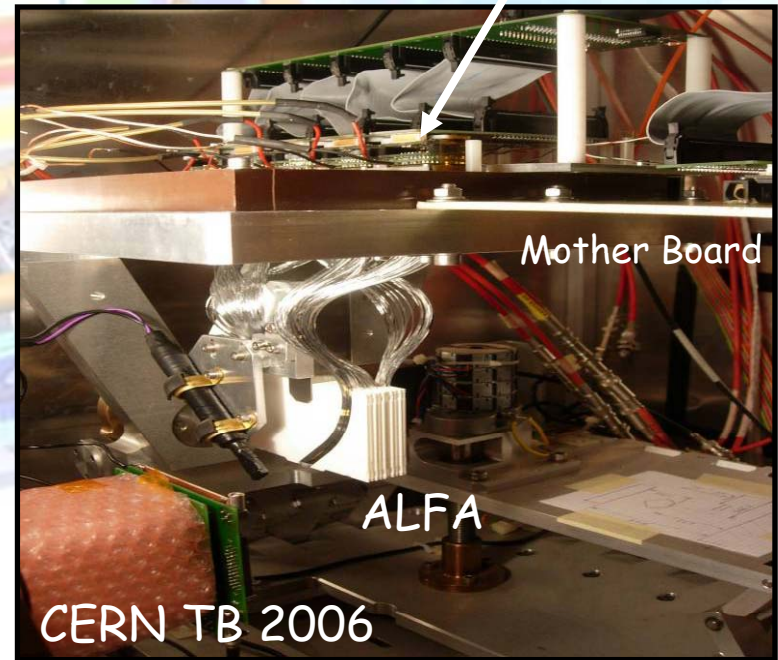
Roman Pot Unit

LHC Beam

Tracker Concept:

- 10 U fiber planes (per Pot)
- 10 V fiber planes (per Pot)

planes are horizontally staggered by multiples of 70.7 μm .



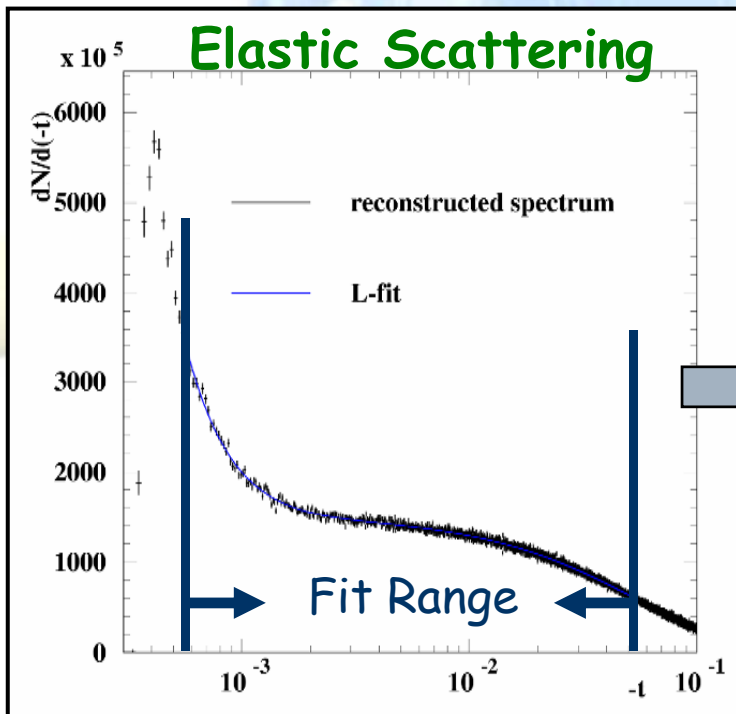


ATLAS Roman Pot Detectors A Scintillating Fiber Tracker (ALFA)



ALFA Measurement Goals

$$\frac{dN}{dt} = L\pi|F_C + F_N|^2 = L \left(\frac{4\pi\alpha^2 (\hbar c)^2}{|t|^2} - \frac{\alpha\rho\sigma_{tot} e^{-B|t|/2}}{|t|} + \frac{\sigma_{tot}^2 (1+\rho^2) e^{-B|t|}}{16\pi(\hbar c)^2} \right)$$



B = Nuclear el. scattering slope parameter
 ρ = Ratio of Re. and Im. part of nuclear amp.

Luminosity Error	Value
Stat. error	$\pm 1.77\%$
Divergence + 10%	$\pm 0.31\%$
Alignment $\pm 10\mu\text{m}$	$\pm 1.3\%$
Acceptance $\pm 10\mu\text{m}$ (edge)	$\pm 0.52\%$
$\beta \pm 2\%$	$\pm 0.69\%$
$\Psi \pm 0.2\%$	$\pm 1.0\%$
Detector resolution	$\pm 0.29\%$
Total exp.syst. error	$\pm 1.9\%$
Total error	$\pm 2.60\%$

$$\frac{\Delta\sigma_{tot}}{\sigma_{tot}} = O(1\%)$$

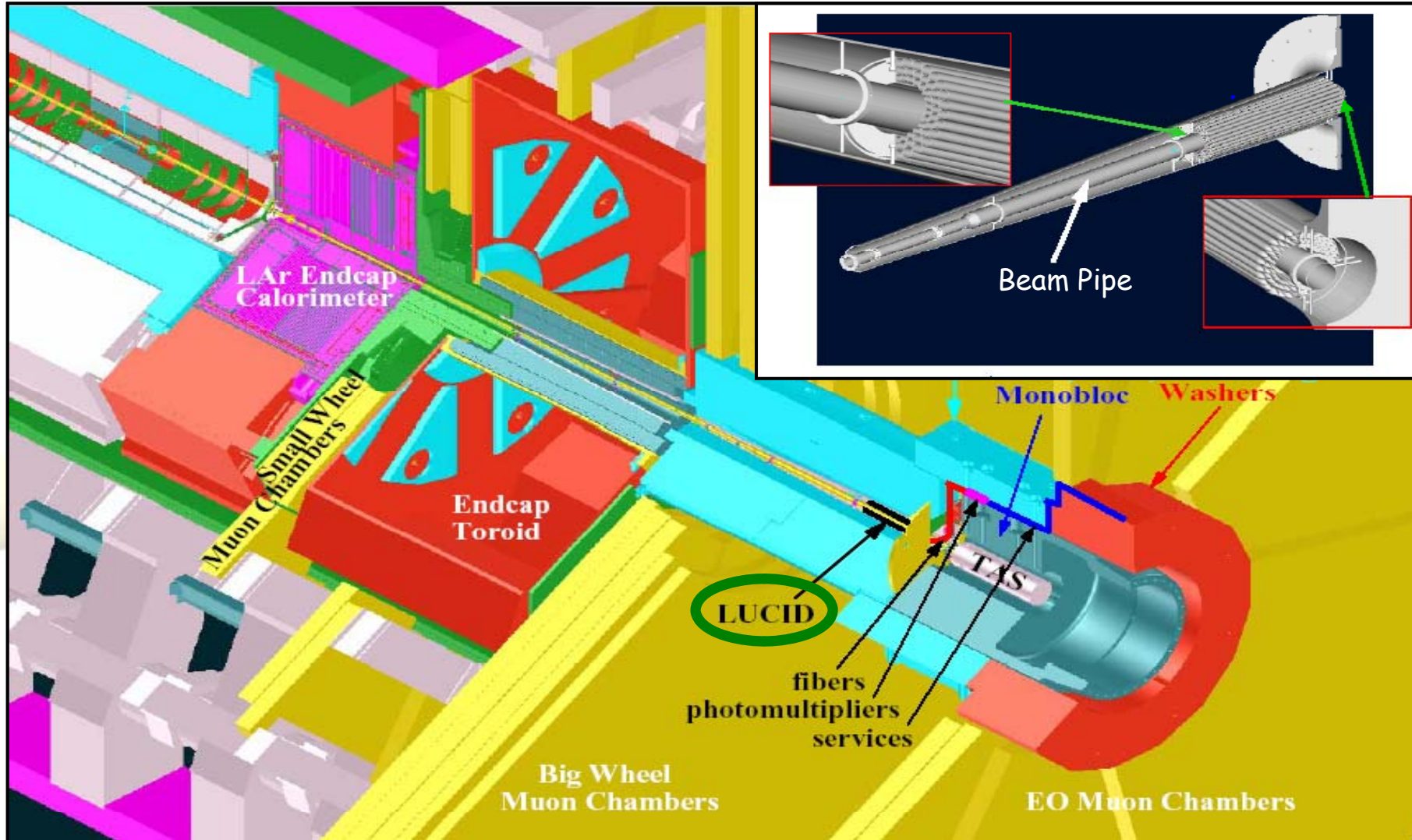
$$\frac{\Delta B}{B} = O(0.5\%)$$

$$\frac{\Delta\rho}{\rho} = O(4\%)$$

(Stat. Only)



The ATLAS Luminosity Monitor (**LUCID**)





The ATLAS Luminosity Monitor (LUCID)

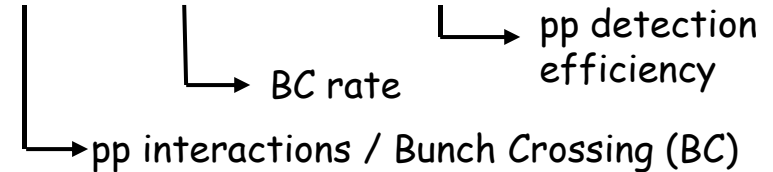


Inelastic pp Scattering

1. Monitor the ATLAS Luminosity
 - Integrated (Relative) luminosity
 - Luminosity (Beam) Monitoring
2. Diffractive Physics (Rapidity Gap Veto)

The pp int. rate seen by LUCID is prop. to L

$$R_{pp} = \mu_{LUCID} \cdot f_{BC} = \sigma_{pp} \cdot \epsilon_{LUCID} \cdot L$$



Zero Counting:

$$\mu_{LUCID} = -\ln \left(\frac{N_{ZeroBC}}{N_{TotBC}} \right)$$

Hit Counting:

(Particle counting, but limited by detector granularity)

$$\mu_{LUCID} = \frac{\langle N_{Hits / BC} \rangle}{\langle N_{Hits / pp} \rangle}$$

Particle Counting:

$$\mu_{LUCID} = \frac{\langle N_{Particles / BC} \rangle}{\langle N_{Particles / pp} \rangle}$$

Requirements:

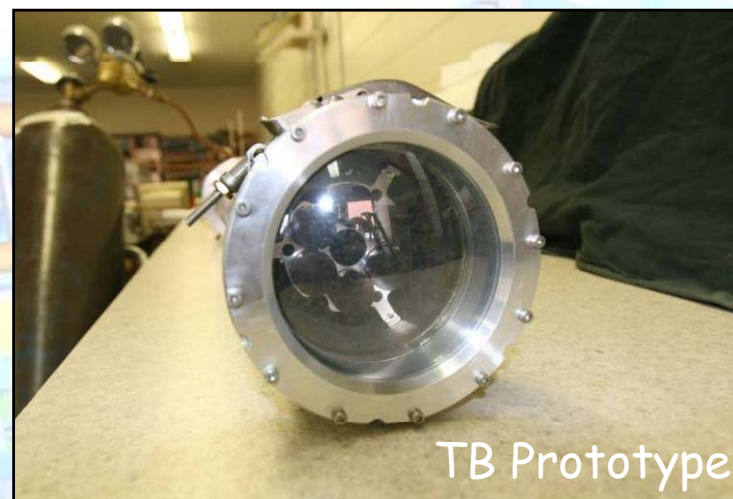
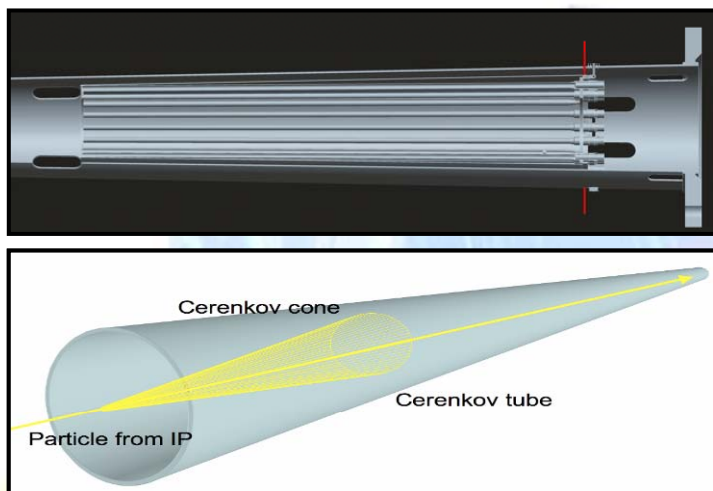
- Acceptance for min. bias events
- Time resolution to measure individual BCs
- Capable of counting particles



The ATLAS Luminosity Monitor (LUCID)



LUCID = LUminosity measurement using Cerenkov Integrating Detector



- Polished **Aluminum tubes** ($\text{\O}=1.5\text{cm}$), filled with **C4F10**, surrounding the beam pipe and pointing at the IP ($Z\sim 17\text{ m}$)
- Fits in available space and has low mass ($< 25\text{ kg/end}$)
- **Cherenkov light** reflected down the tube and **read out by PMTs**
- **Pointing** of the Al-tubes **reduce** signal from particles entering at large angles
- PMT signal **Amplitude** used to **distinguish multi particles** per tube
- **Fast response** from PMT allows to measure **individual BCs**



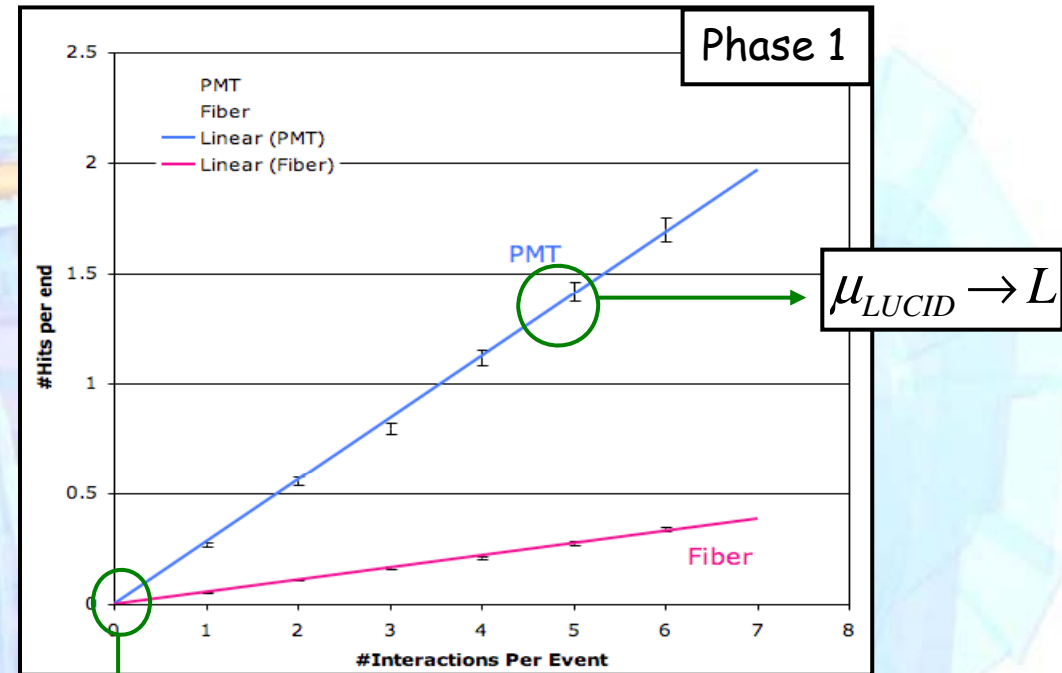
The ATLAS Luminosity Monitor (LUCID)



Run LUCID in parallel with absolute measurement

- Initially, **LHC Machine Parameters** (Precision: ~10-15%)
- Medium term **Physics processes, W/Z & $\mu\mu/ee$** (Precision: ~5-10%)
- During 2009 **Roman Pot (ALFA) measurement** (Precision: ~2-3%)

Calibrate to independent measurements, e.g. TOTEM...



Calibrate LUCID

$$\mu_{LUCID} = A \cdot L$$

Given by calibration method (ALFA)

Measured by LUCID

Calibration Constant:

$$A = \epsilon_{LUCID} \times \sigma_{pp}$$



The ATLAS Zero Degree Calorimeter (ZDC)



Neutral particles at 0° polar angle

Heavy Ion physics program

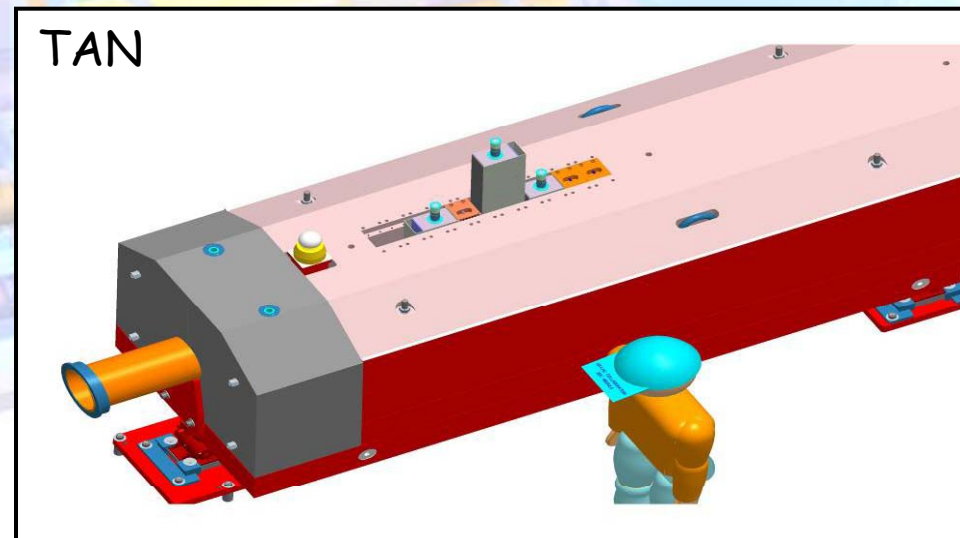
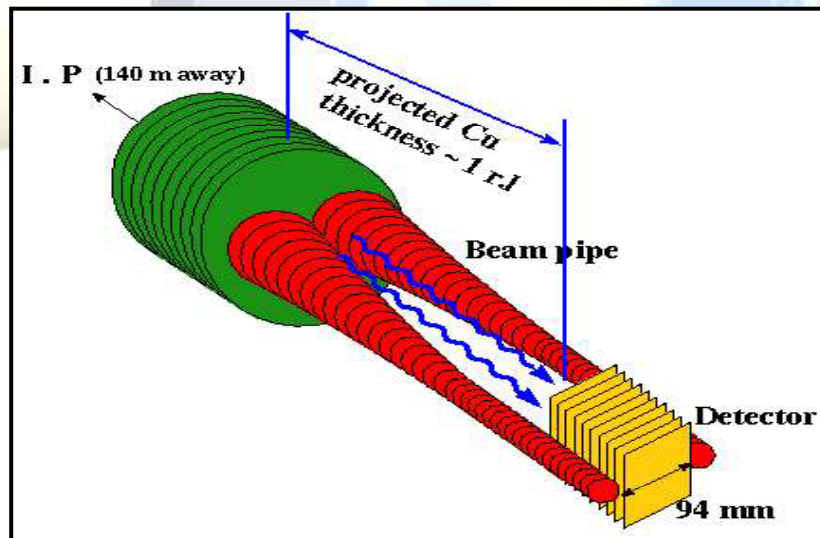
- Impact parameter (Event Centrality), Luminosity, Trigger input

pp physics program

- Forward cross sections

Accelerator tuning

- Van der Meer scan, IP position, beam crossing angle

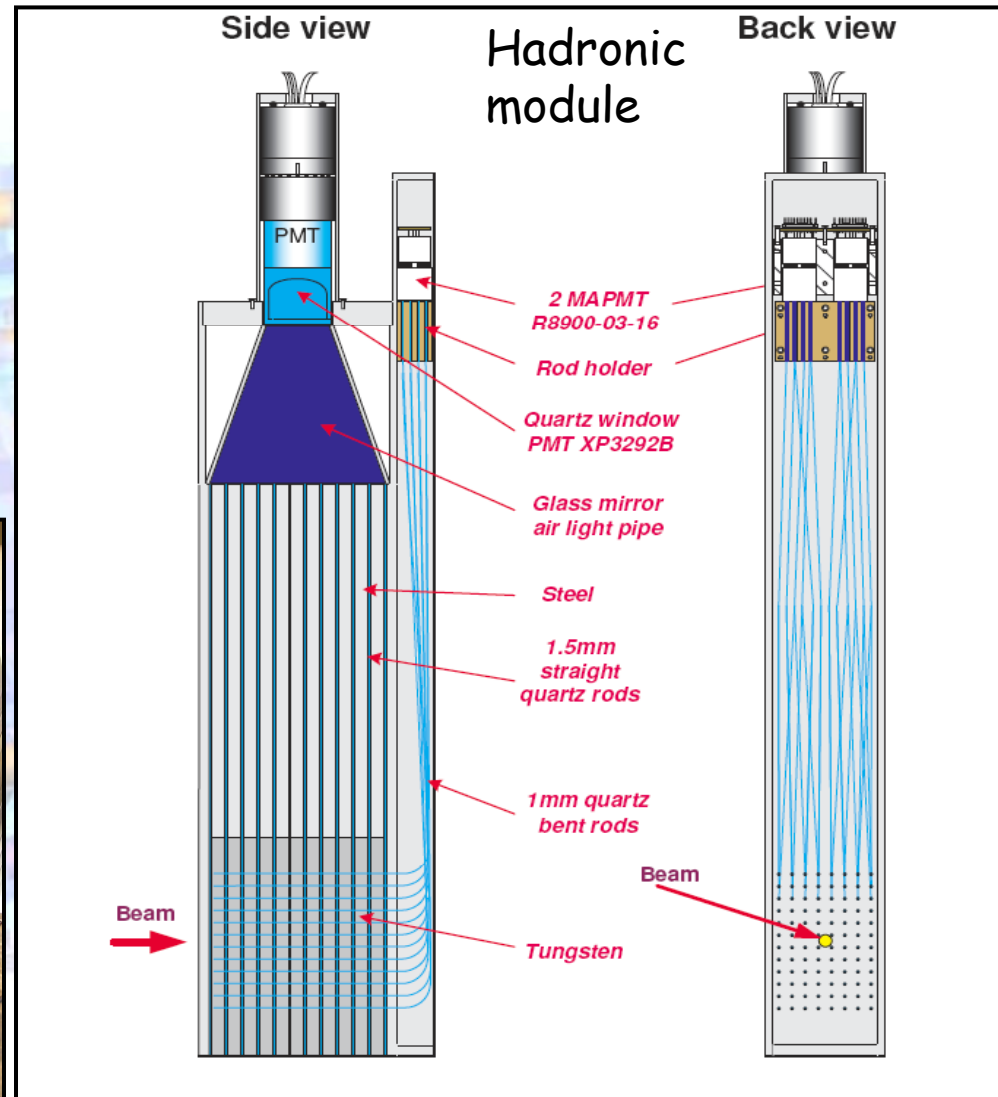




The ATLAS Zero Degree Calorimeter (ZDC)



- Tungsten / Quartz Calorimeter
- Vertical quartz strips for main energy and timing
- Horizontal quartz rods for coordinate read-out





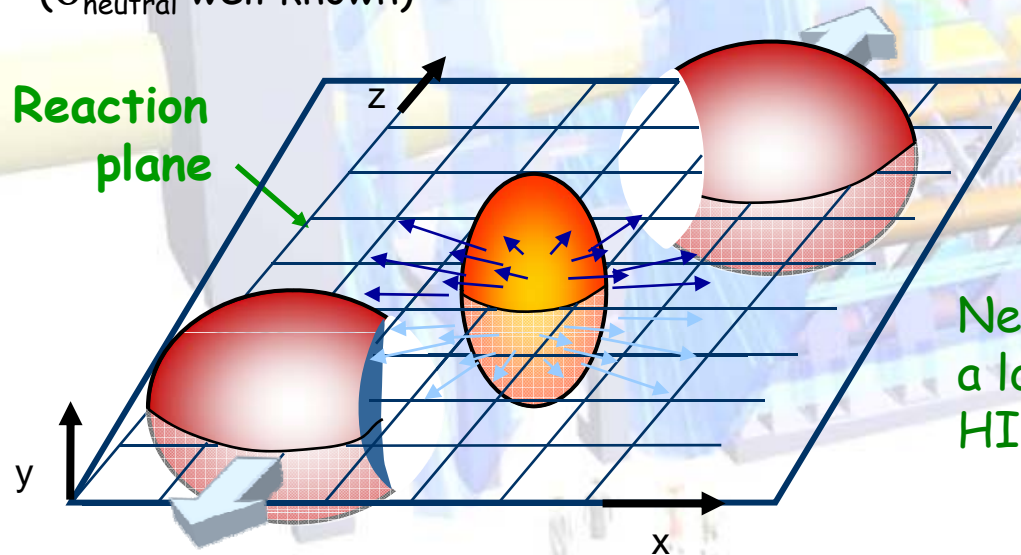
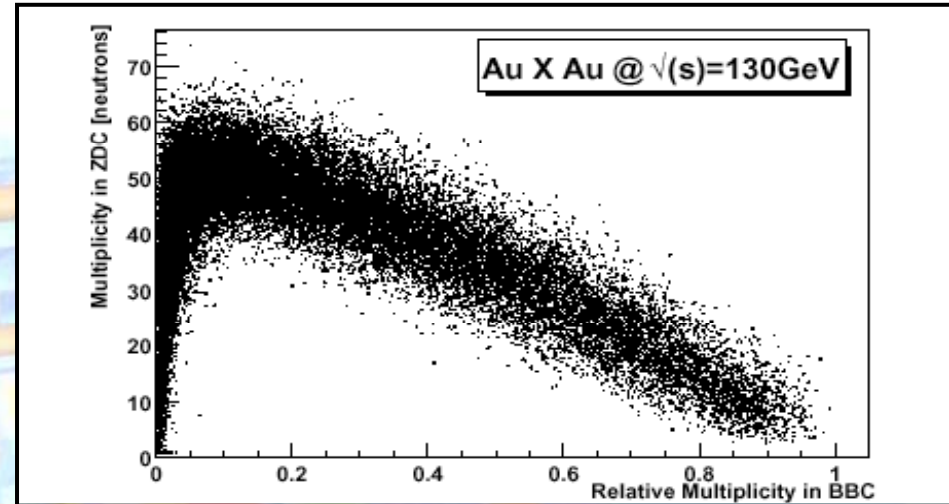
The ATLAS Zero Degree Calorimeter (ZDC)



Heavy Ion physics program

Spectator neutrons

- Measure centrality (magnitude and direction of impact parameter)
- Minimum bias trigger (Acceptance $\sim 100\%$)
- Luminosity, $\Delta L/L < 5\%$ (σ_{neutral} well known)



Magnitude from complementary Parameters: $N_{\text{participant}} = 2 * A - N_{\text{spectator}}$

Neutron tagging essential to design a low rate trigger for ultra-peripheral HI events



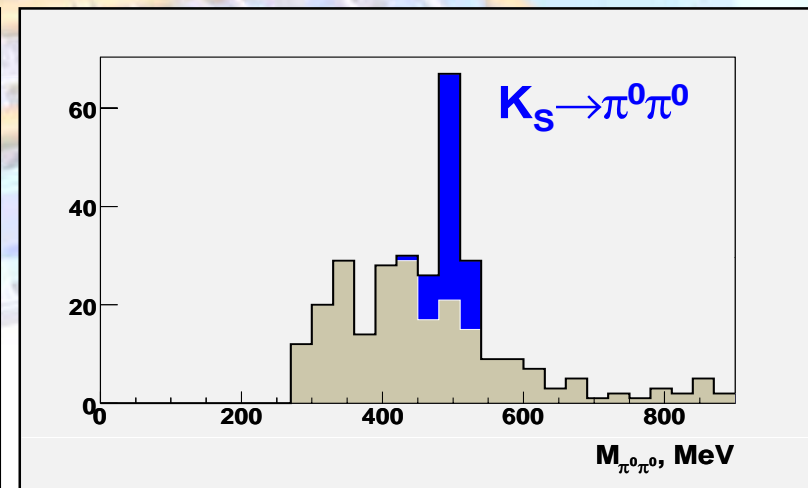
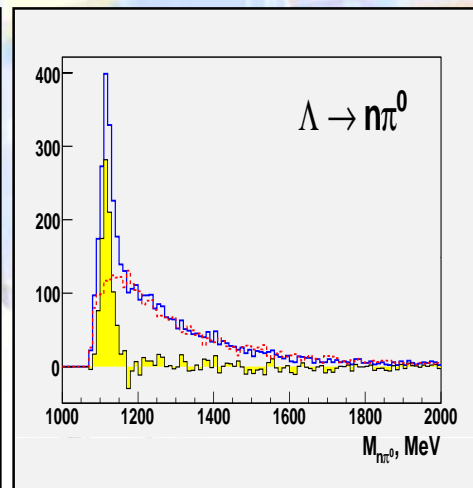
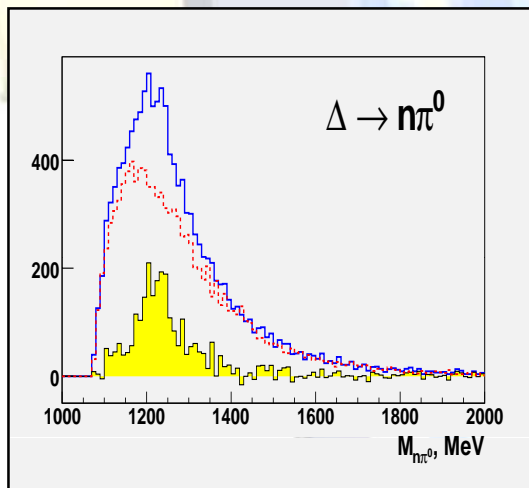
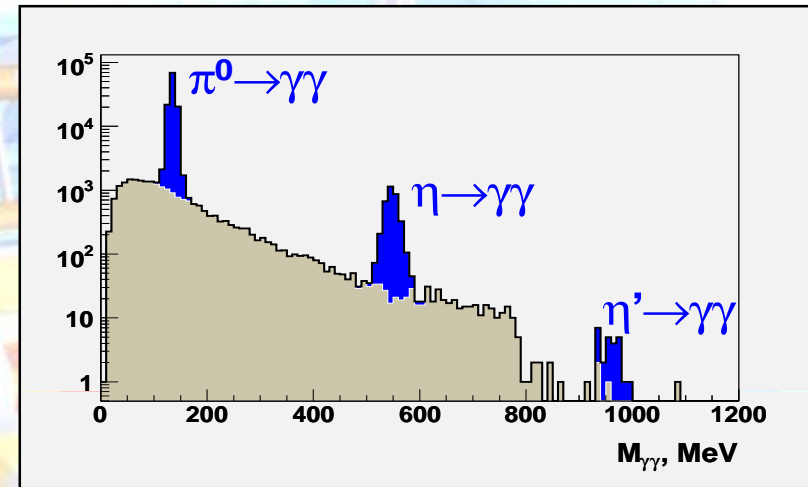
The ATLAS Zero Degree Calorimeter (ZDC)



pp physics program

Forward particle production

- Cross sections in new energy domain
- Large interest from High Energy Cosmic Ray Community
(Modeling air showers from protons entering the atmosphere \rightarrow Forward physics with proton energies of, $E_{\text{lab}} = 10^{17}$ eV)
- Additional ATLAS hermeticity
(e.g. for diffractively produced Higgs...)





Conclusions



- **ALFA**
 - Absolute Luminosity from Elastic Scattering
 - Proton Tagging in Diffractive Events
 - Installation 2008-2009
- **LUCID**
 - Luminosity Monitor
 - Forward Inelastic Scattering
 - Installation Fall 2007 (Upgrade ~ 2009)
- **ZDC**
 - HI Event Characterization and Luminosity
 - HI/pp Forward Physics
 - Accelerator Tuning
 - Installation Fall 2007 (Upgrade ~ 2009)