ALFA – Absolute Luminosity For ATLAS

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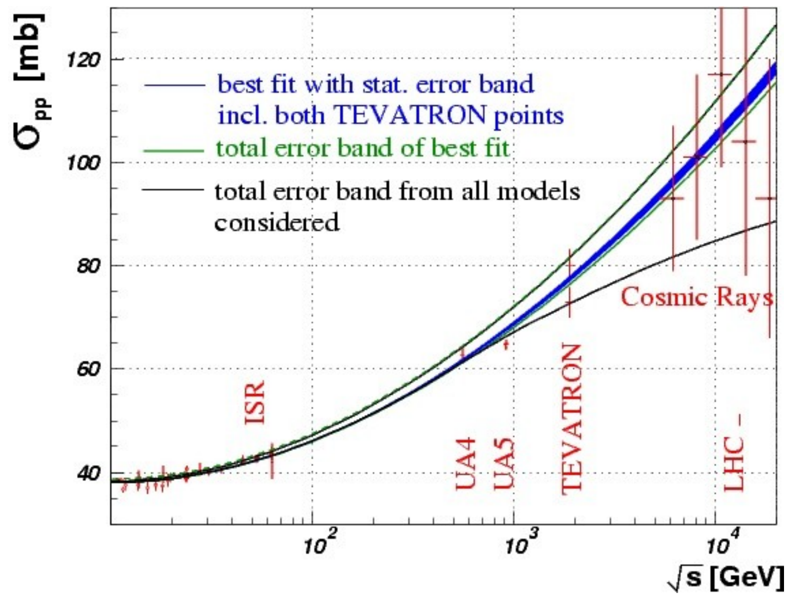
Presentation plan

- Overview on the ALFA physics program and requirement
- ALFA in the ATLAS experiment
- ALFA detectors technology
- ALFA special optic conditions
- First physics run conditions
- Experimental challenges
- Some approved plots
- Summary and outlook

ALFA physics program

ALFA main goals:

- Measurement of the total proton-proton cross section at the LHC
- Measurement of the Absolute luminosity for the ATLAS experiment

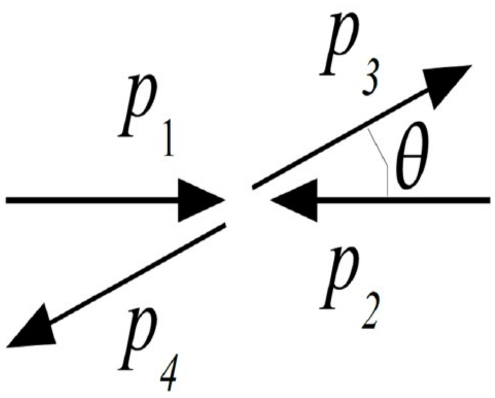


ALFA strategy & analysis key:

- Track elastic scattered protons from the interaction point
- The momentum transfer spectrum (*t-spectrum)* which can be written at small *Θ* as:

  $$t=(p_1+p_3)^2=p^2\Theta^2$$

  p is known if we consider the elastic case, what we still need to calculate is *Θ*



- Once we have the distribution dN_{el}/dt it will be linked to the luminosity and the $d\sigma_{el}/dt$

ALFA physics program

$$\frac{dN_{el}}{dt} = \mathscr{L}\frac{d\sigma_{el}}{dt} = \mathscr{L}|F_c + F_n|^2 = \mathscr{L}\left(\frac{d\sigma_c}{dt} + \frac{d\sigma_{cn}}{dt} + \frac{d\sigma_n}{dt}\right)$$

luminosity

Elastic cross section

Coulomb interaction amplitude

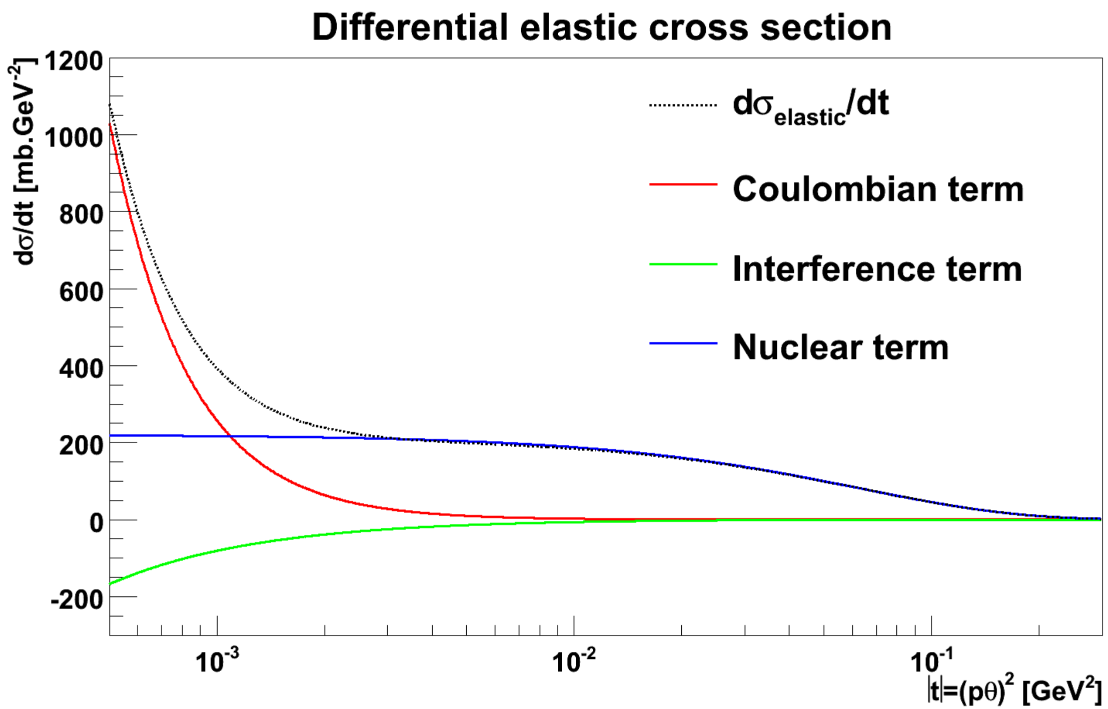
Nuclear interaction amplitude

Nuclear term $\propto \sigma_{tot}^2 \exp(|-t|)$

Coulombian term $\propto \frac{1}{t^2}$

Interference term $\propto \sigma_{tot}\frac{\exp(|-t|)}{|t|}$

Use this equation to parametrize σ_{tot} and the absolute luminosity.

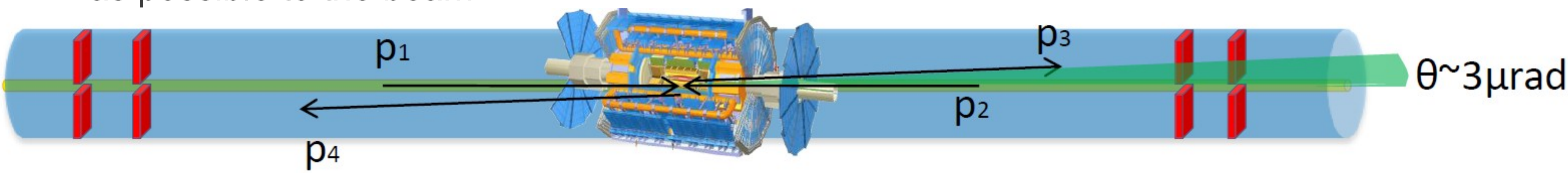


Note that:

- Coulombian term is the cleanest one and will allow the determination of the absolute luminosity
- This term is the dominant one at small *t* values

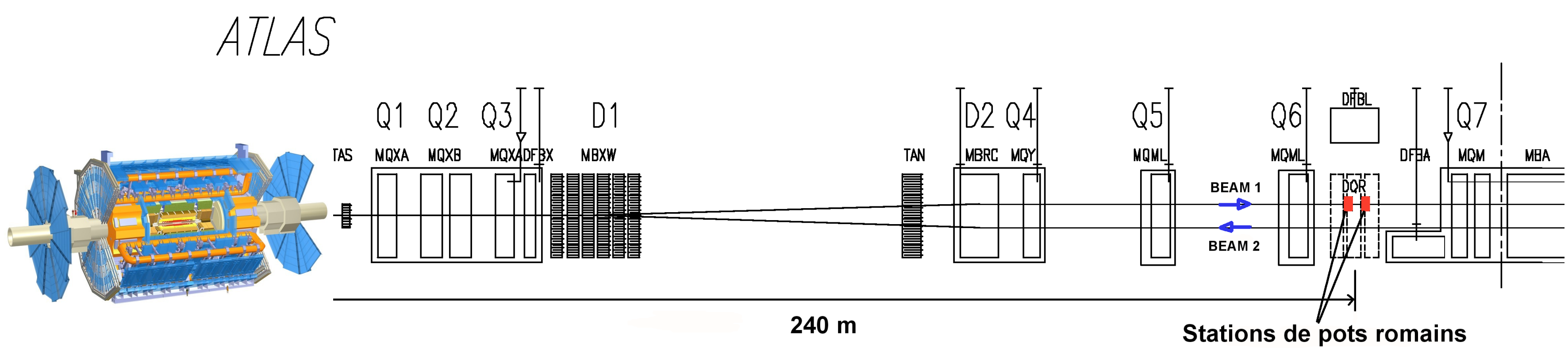
LHC tunnel and ALFA requirement

- Small *t-values* → small *Θ* values → we ask for a tracker system which can go as close as possible to the beam



- In regular case one can put detectors far away from the interaction point where the elastic will be separated from the beam

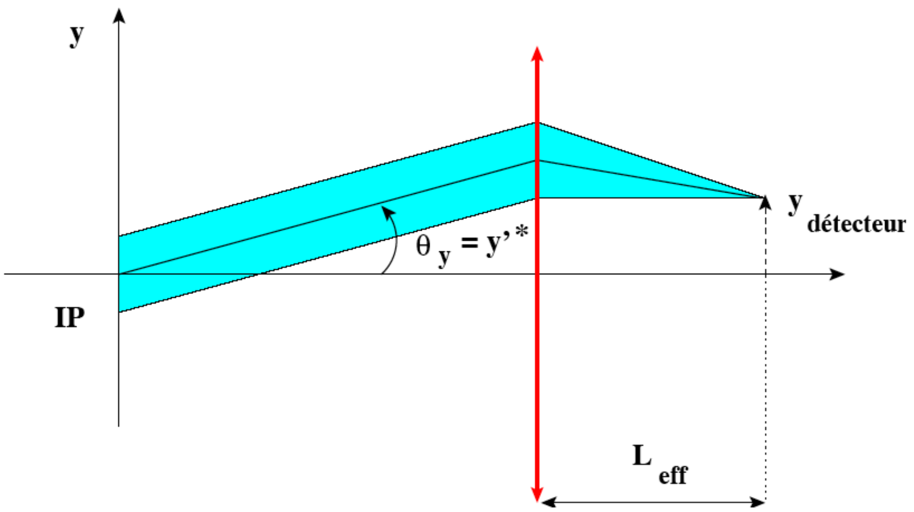
- *This is not the case in the LHC!!* Where we have some optics components to focus and curve the beam in the tunnel → for this reason optics need to be taken into account



Special optic is needed!!

LHC tunnel and ALFA requirement

Dedicated « Parallel to point » focusing optics ensures that a diffusion angle at the IP translates into vertical displacement at the detector



*β** = the beam focusing parameter at the interaction point.

t α *1/β** → increasing *β** is important to reach the coulombian region

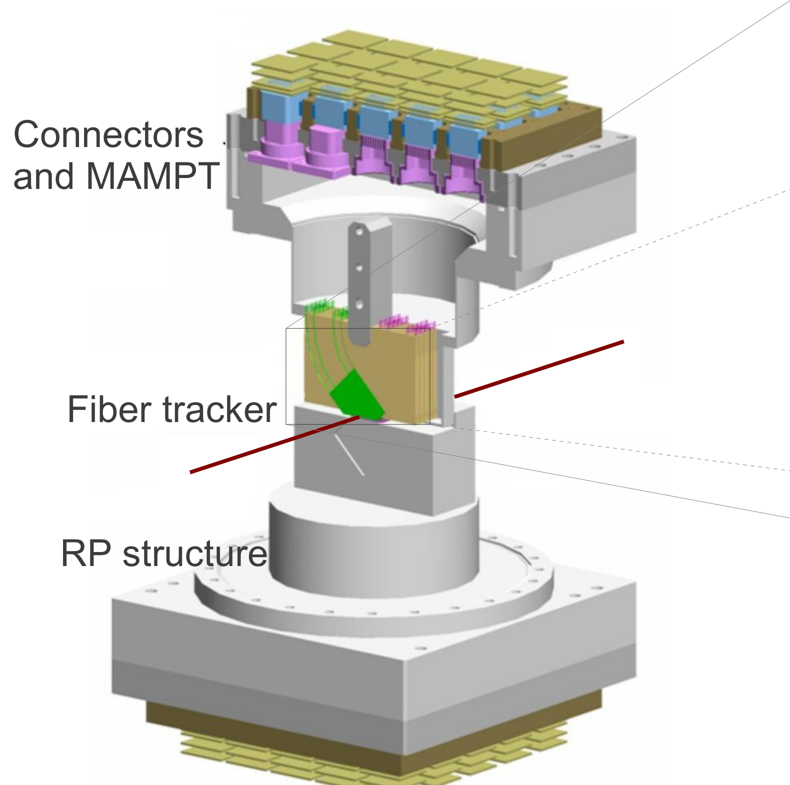
All we need for this experiment is a tracker system with this requirements:

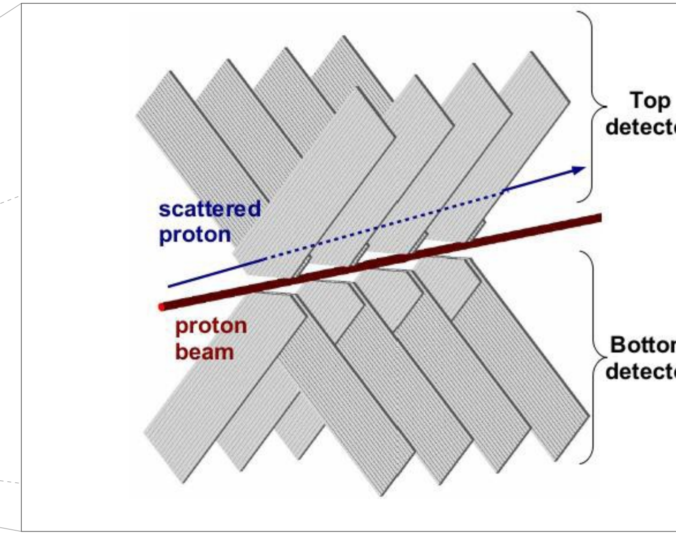
- Good radiation hardness
- High spacial resolution up to ~ 30 microns
- No dead space at the edge where we will be close to the beam, implies to the small *t-values*
- Use the fact that the optic spread elastic protons in the vertical plan where we can think to place our detector (see next...)
- Cover upper and lower sides around the tunnel, with a good measurement of the distance between these 2 sides

This is what we require, now let's take a quick tour of the detector (see next slide ...)

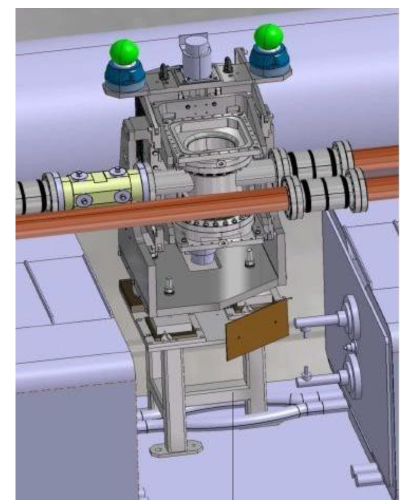
ALFA detector and stations

ALFA detector is a tracking system based on scintillating fibres and will be located in Roman Pots above and beyond the LHC beam axis

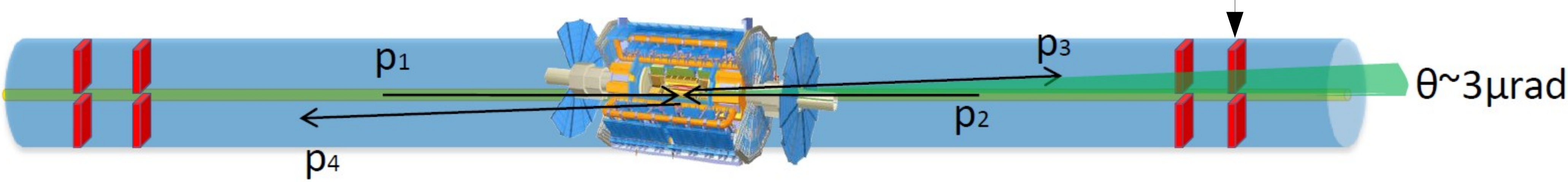




- Fibers have a good radiation hardness.
- 20 layers of fibers ensure the 30 μm of resolution
- Fibers have been cut with 45° for to reduce the dead space at the edge.
- An overlap system between upper and lower detector to reach 10 μm precision on the distance

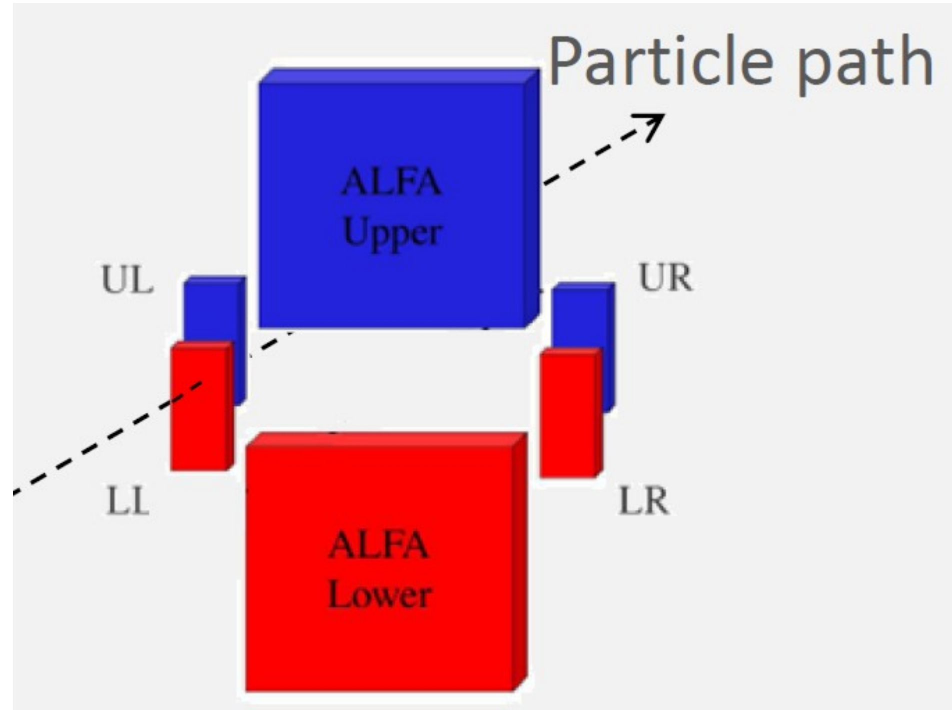


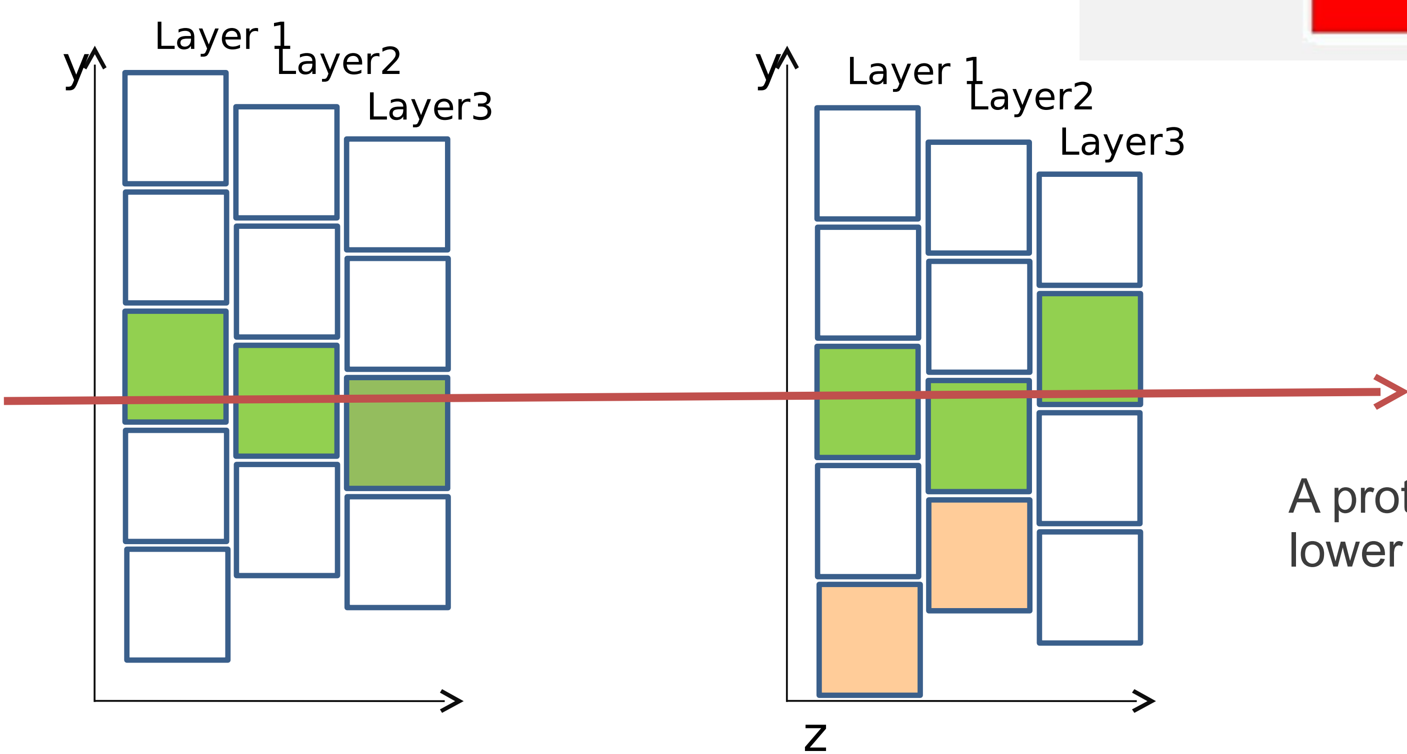
Station in the tunnel



ALFA detector and stations

2 overlap detectors are dedicated to the distance measurement between upper and lower station and the local rotation angle





A proton comes through upper and lower overlap in one side

z

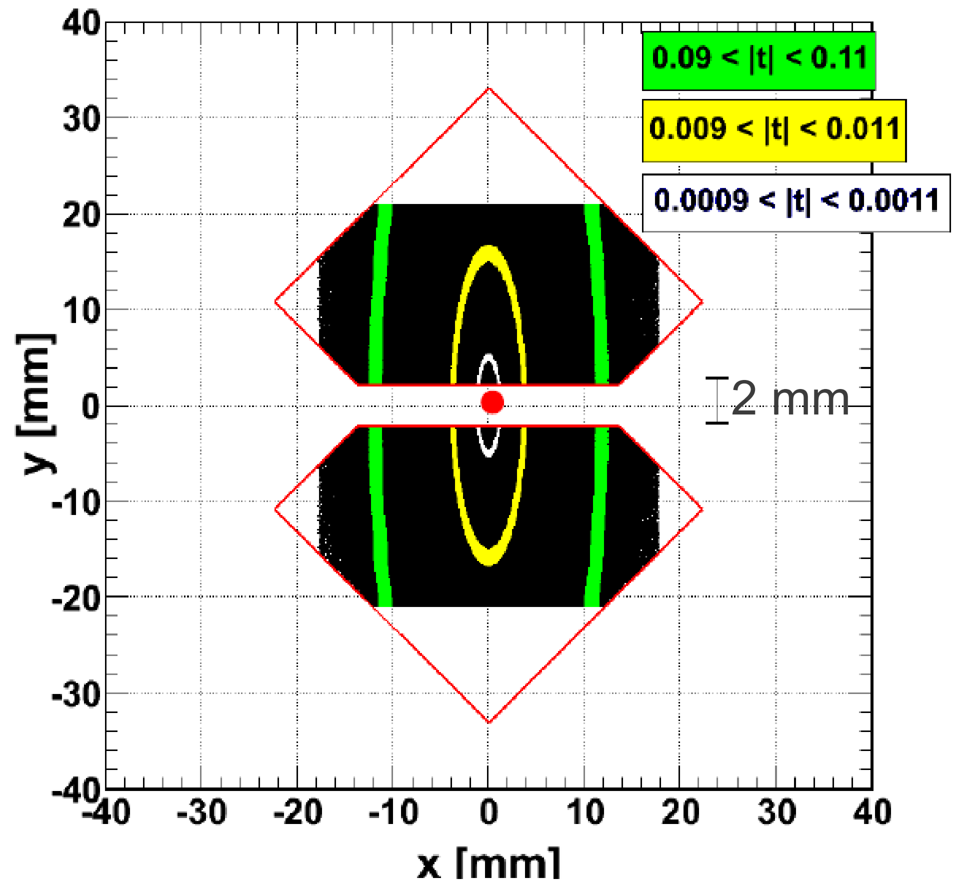
ALFA detector acceptance

The impact position on the ALFA detector acceptance where one can see that small *t-events* are close to the beam center

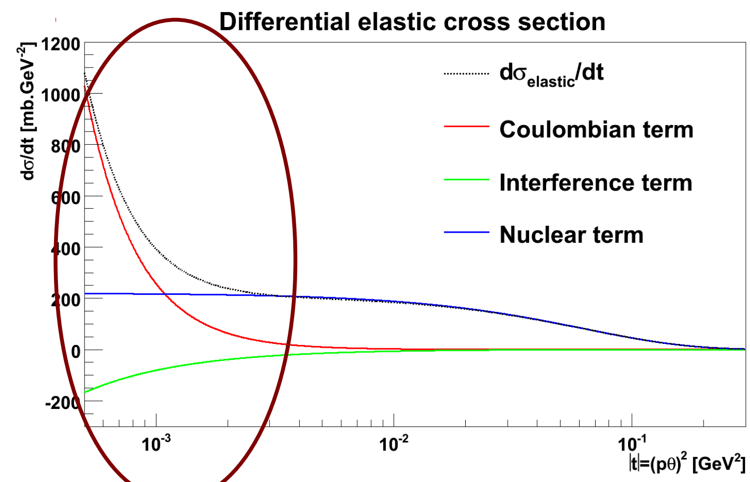
2 acceptance limitation :

- Beam pipe
- Detector edge

→ the fit region will be $10^{-2} > |t| > 10^{-3}$

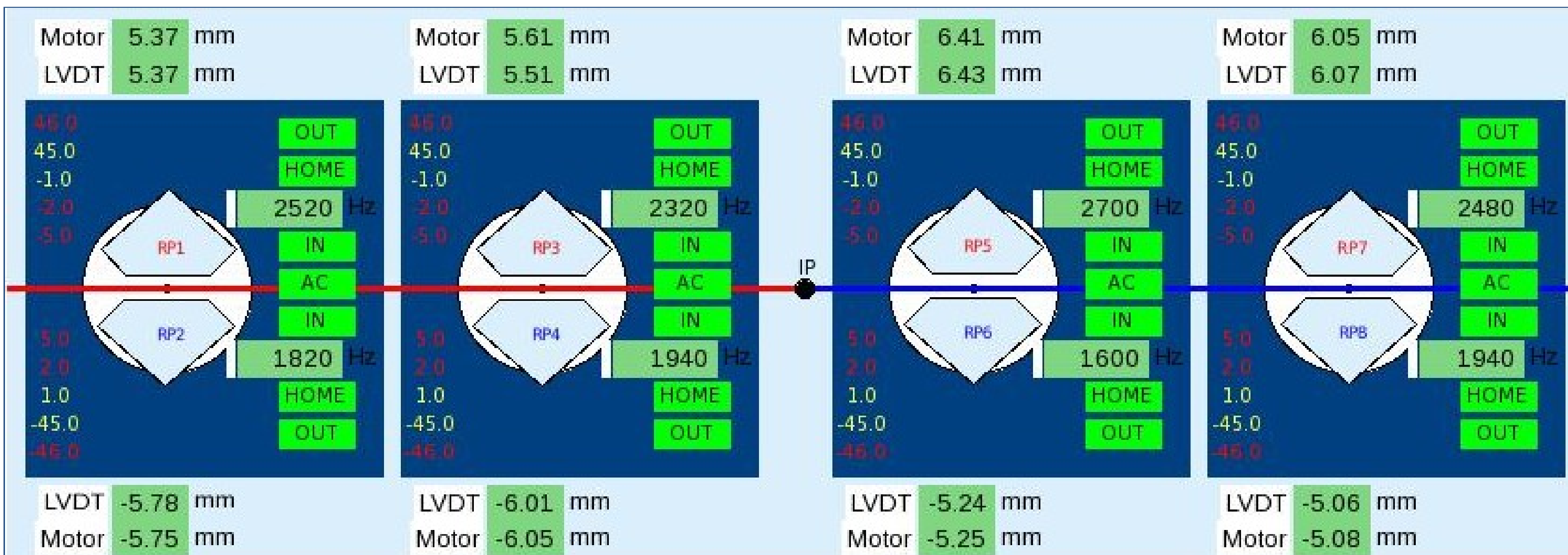


Events close to the low acceptance area will be corrected by the simulation

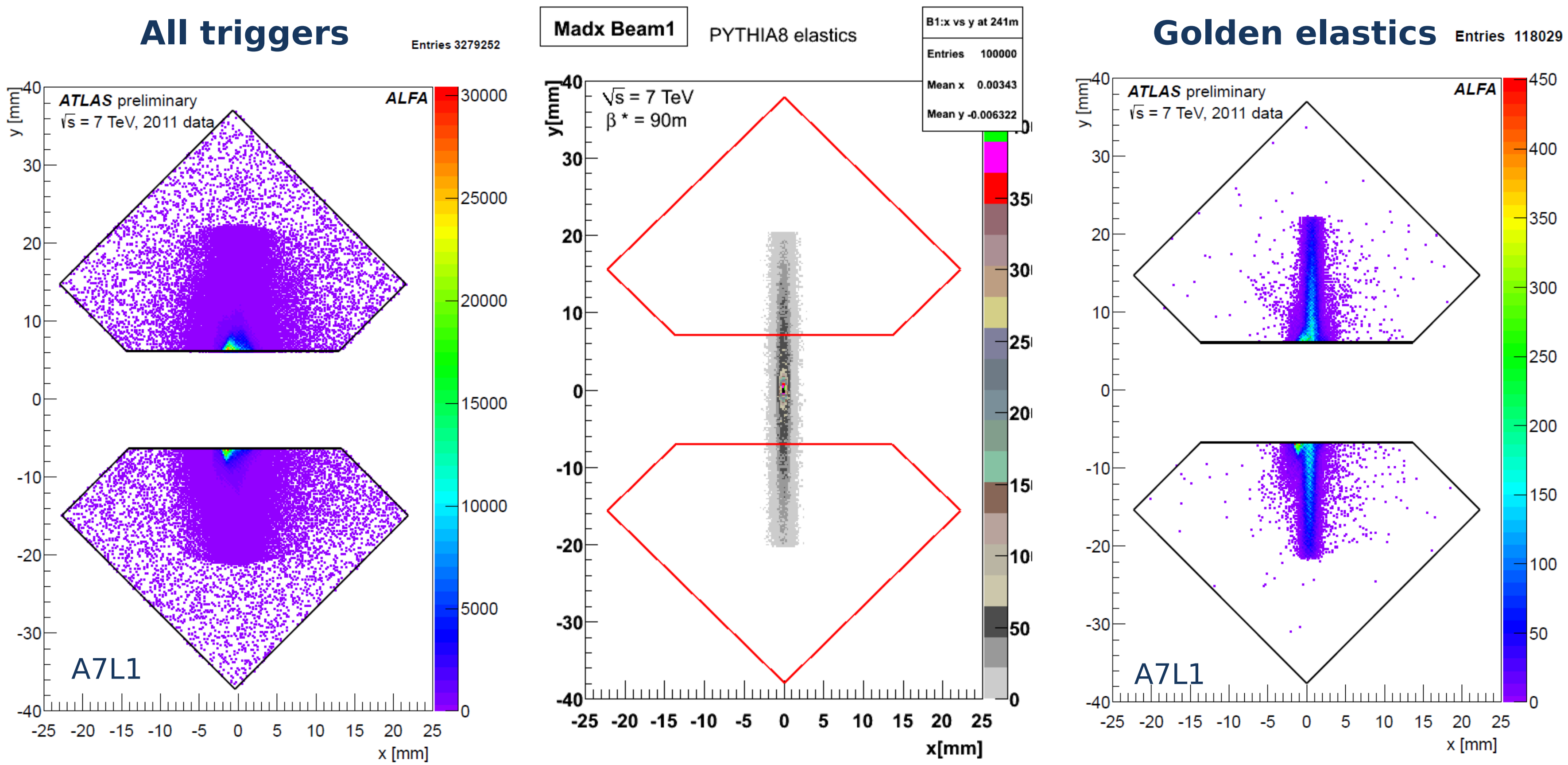


Historical view of the ALFA experiment

- ALFA subdetector was approved in January 2008
- 7 institutes and 25 members
- January 2011 all detectors were installed in the tunnel
- 20th of September, ALFA made a successful physics run with the special LHC optic β^*=90m (remind you that the nominal LHC β^*~1-2m)
- In this run detector edges go to 5mm from the beam center for the first time



Preliminary data

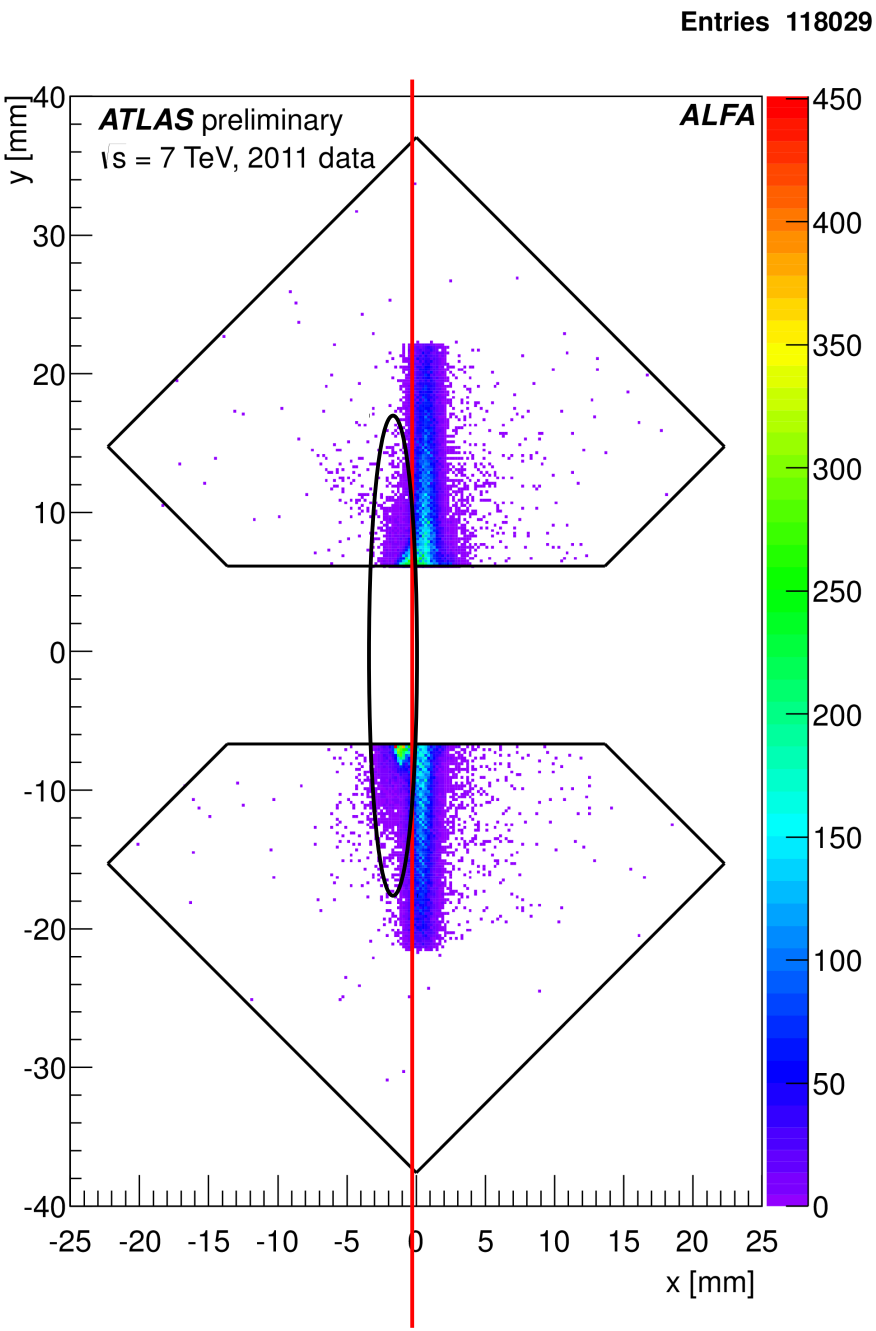


M.Heller, H.Stenzel, P.Hamal

Left and right plots were made by a standalone run with ~10M trigger.
~1% of trigger is considered as elastic
In the middle a pure simulation plot using PYTHIA 8

This is the golden elastic trigger configuration

Challenges come with first data



Each detector has an independent coordinate system, so several points need to be checked:

- Vertical alignment
- Horizontal alignment (see red line)
- Local rotation angle
- Precise distance measurement between upper and lower station

At the end the aim is to put all detectors in one system of reference.

It seems that the elastic trigger is not enough to remove all background or no-back to back events, so additional cuts will be needed (see the black circle)

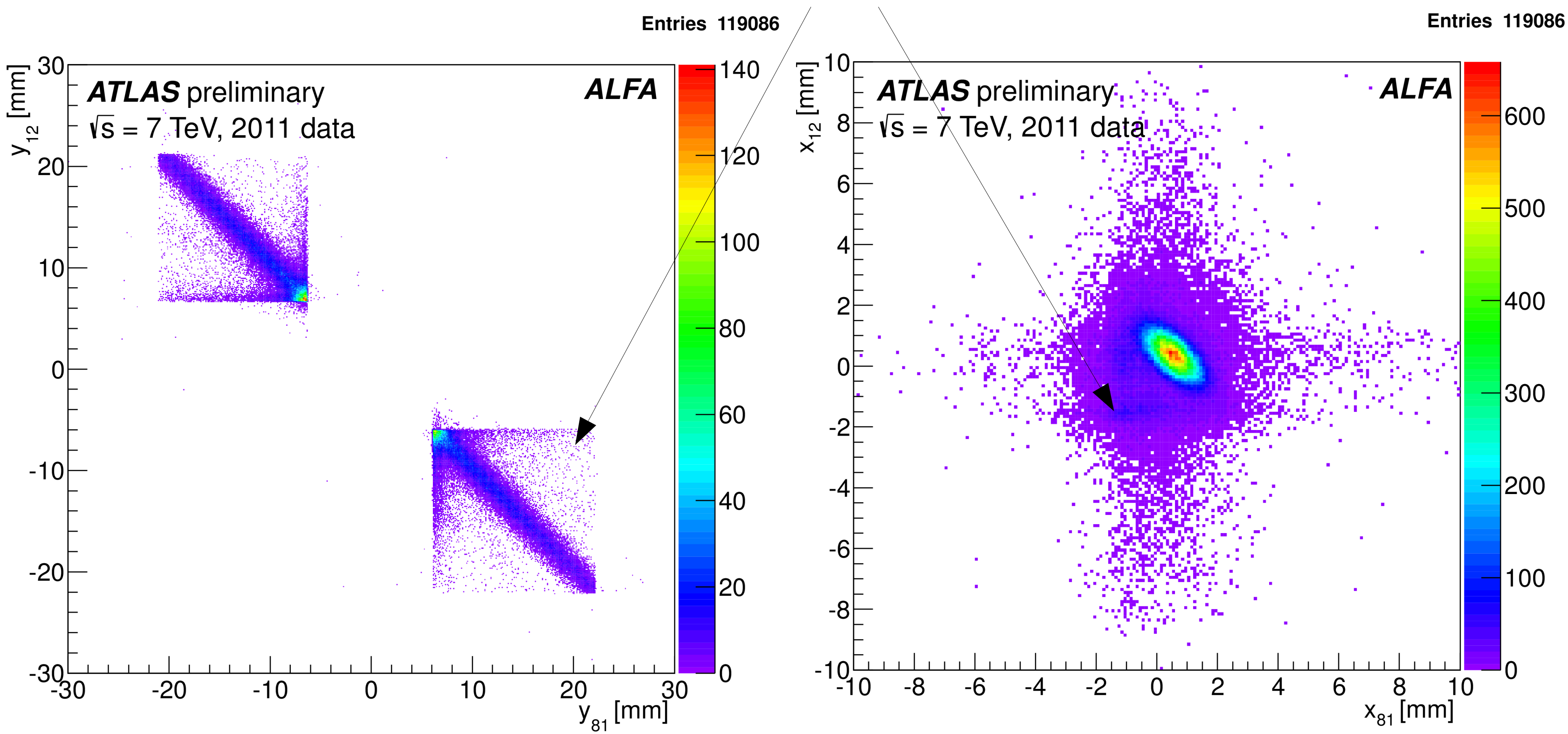
Note that I can show just approved plot...

Challenges come with first data

This is a basic example to how we separate elastic from background

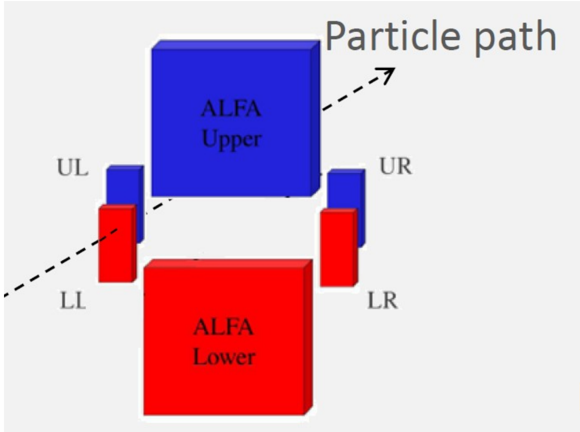
The no-correlated events can be removed

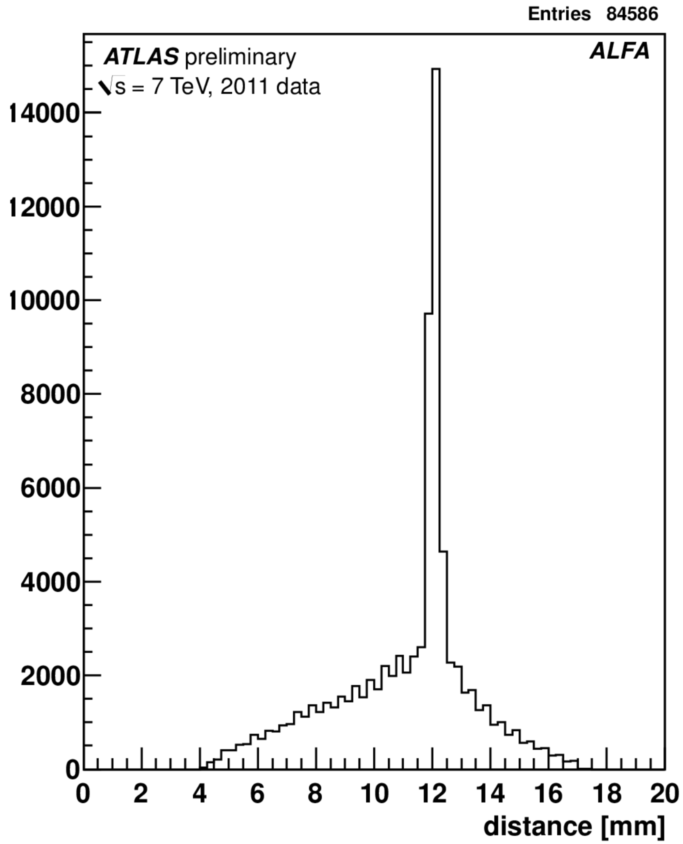
Some background

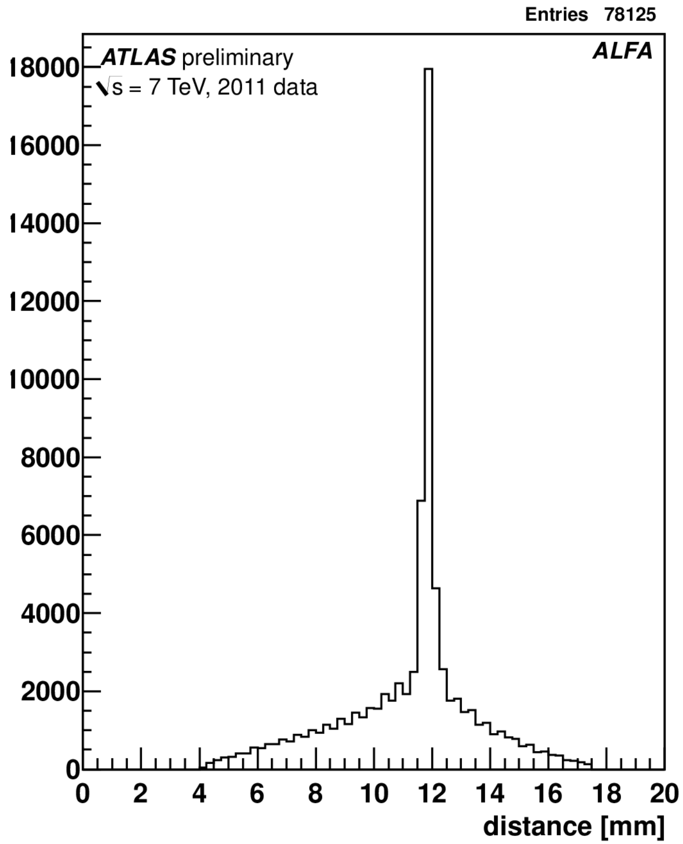


Overlap detector data

Overlap data distribution shows a distance peak which can be used to determine the distance between upper and lower detector







Summary and outlook

- ALFA is dedicated to get the absolute luminosity for ATLAS (calibration of relative measurements)
- This is should be done once we have a high β^* run (not the case for 90m run)

- A lot of achievement was done in this first year:
  - ✓ A successful test beam for all detector before the installation
  - ✓ Installation in the tunnel
  - ✓ Calibration and tunning with ATLAS
  - ✓ First physics run with plenty of data, output will be σ_{tot} value in a few weeks

- Focus now in physics analysis:
  - ✓ Understanding and fine tuning the optics
  - ✓ Good alignment of the stations
  - ✓ Distance measurement with low systematic effect
  - ✓ Analysis of the luminosity measurements

- Concerning my work, I'm focusing now in the distance measurement by the overlap detector, and also to understand the background, which will let me move then to the *t*-spectrum fit and beyond.

Backup