ALFA Detector for ATLAS

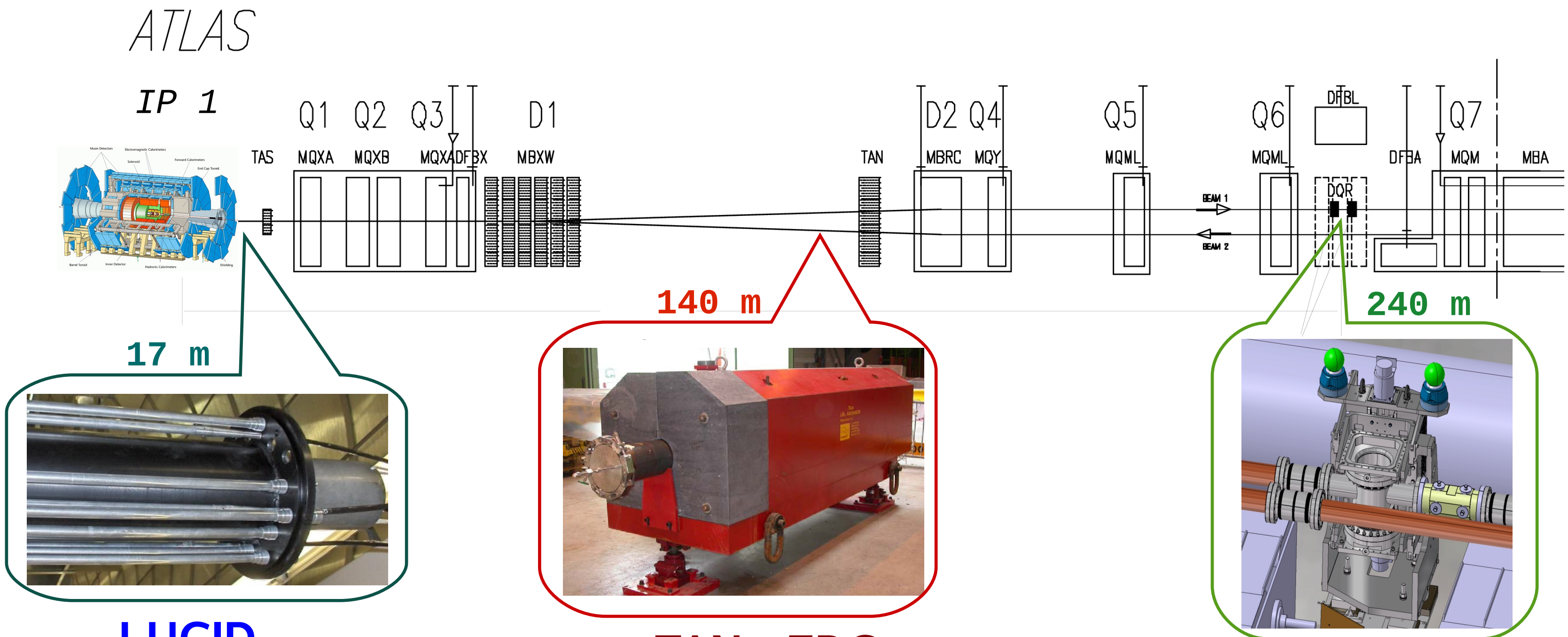
- *ALFA in rank of ATLAS forward detectors*
- *Construction of ALFA fiber modules*
- *Luminosity Measurement*
- *Gießen Group Activity in ALFA*

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

2nd Annual Workshop
Physics at the Terascale
27.11.2008, Aachen

Anatoli Astvatsatourov
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

Forward Detectors at ATLAS



LUCID | **TAN: *ZDC*** | **ALFA Roman Pots**

Luminosity monitoring

Čerenkov tubes, pointing to the IP, placed around beam at ~17 m from IP.

Forward neutral particles

W^{74}/Quartz calorimeter in beam-pipes junction point at 0° to IP.

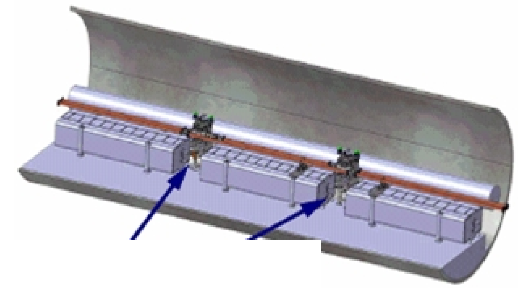
Elastic scattering & Luminosity

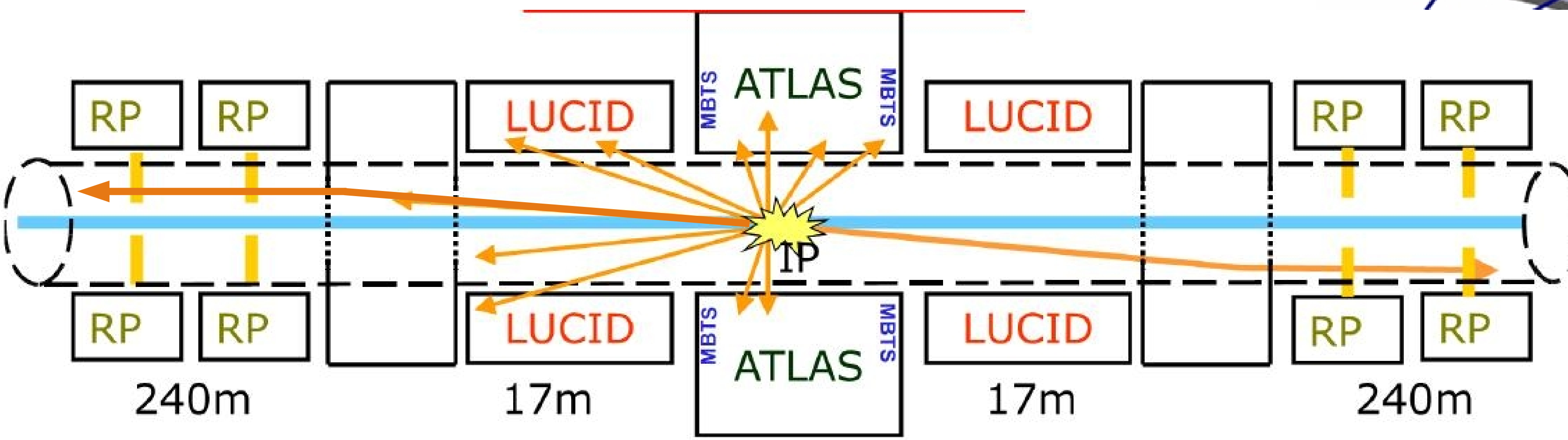
Moveable fiber planes trackers in "Roman Pot" inside the beam-pipe at 240 m from IP.

AFP: Additional forward detectors considered at a distance of ~ 220m, 420m

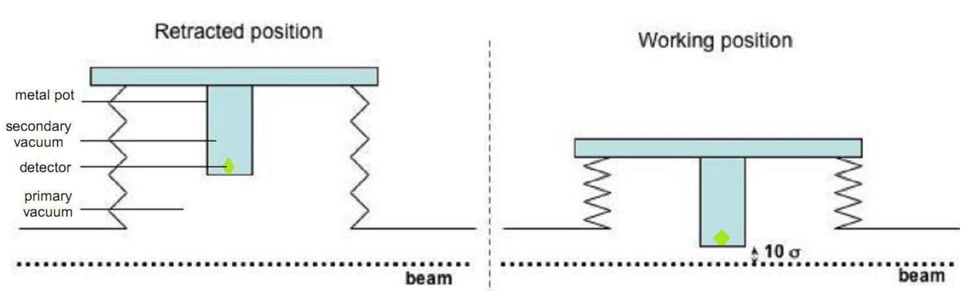
ALFA: Roman Pots

Absolute Luminosity For ATLAS

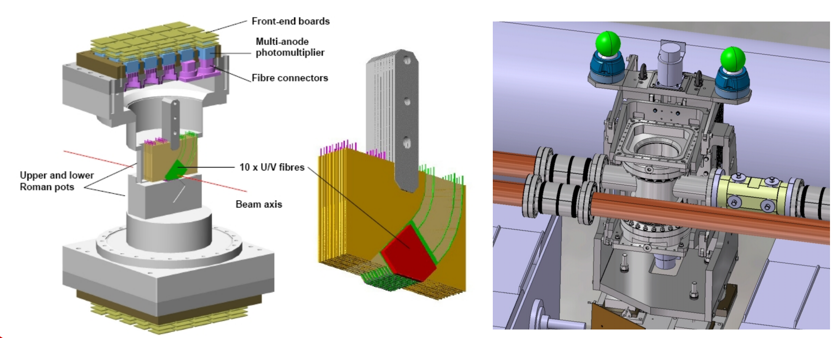




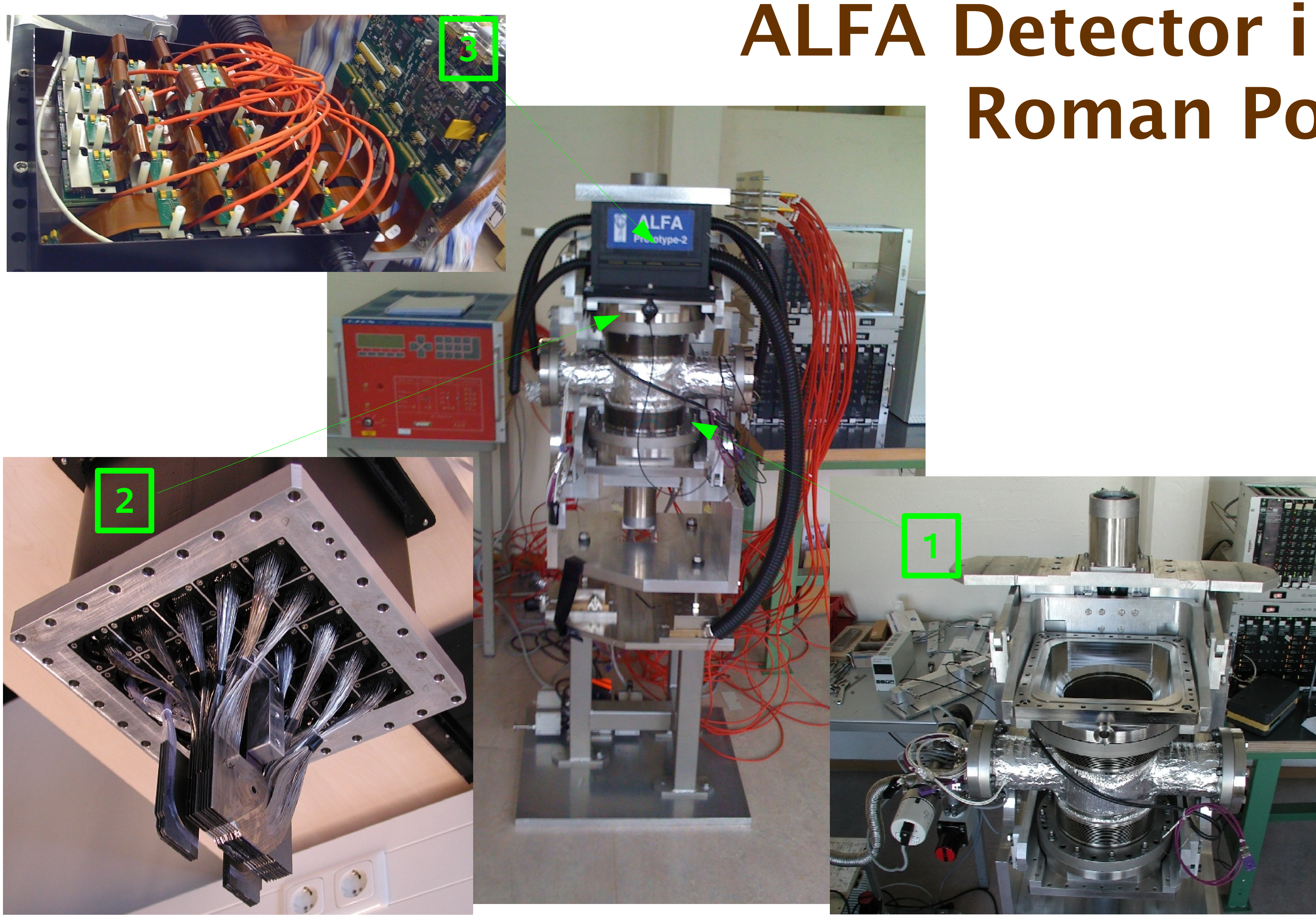
* **Luminosity from forward elastic rate**
* **Calibrate LUCID luminosity monitor**



ALFA detector + Roman Pot

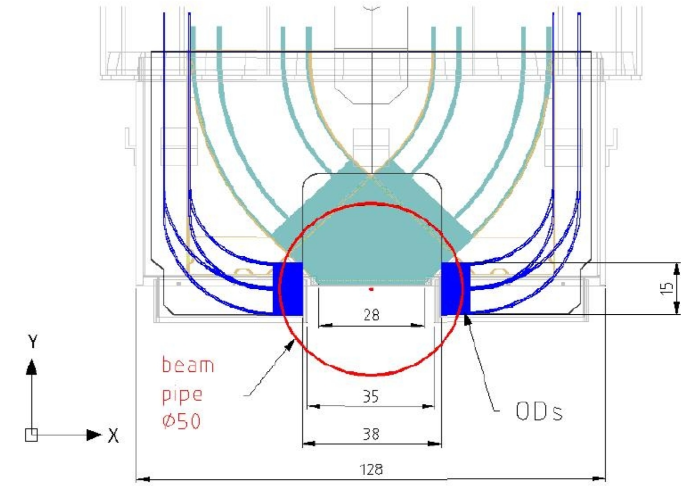


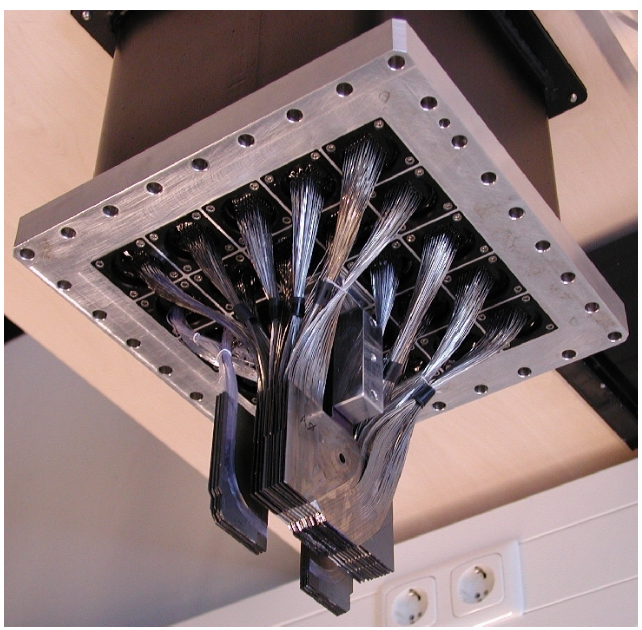
ALFA Detector in Roman Pot

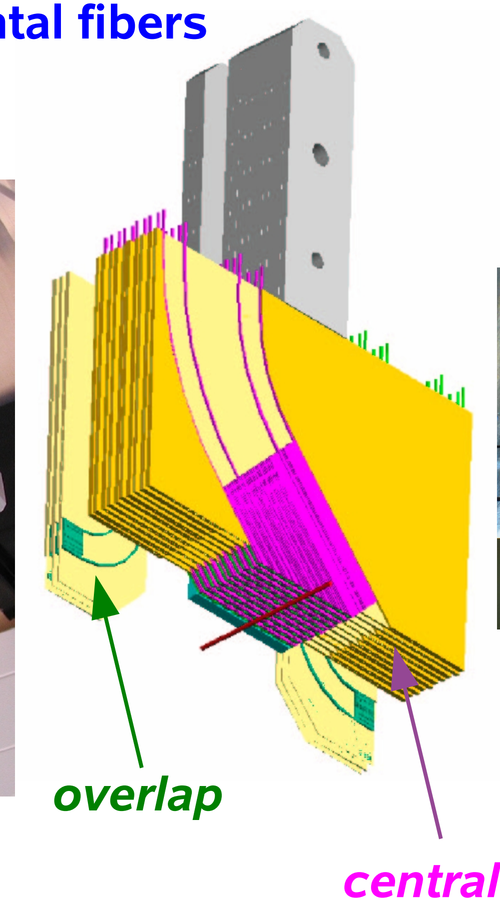


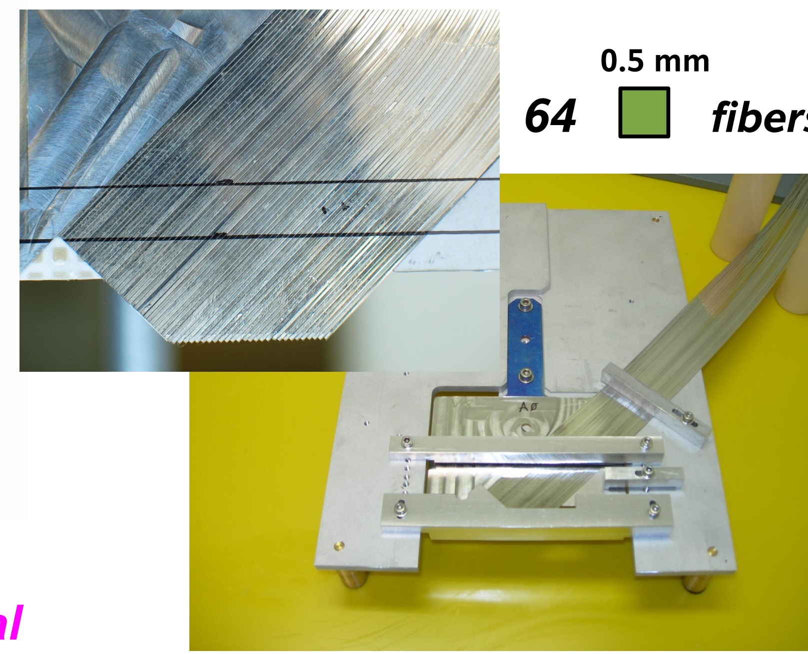
Construction: ALFA Fiber Detector

- **10 central fiber detector modules**
  each 2 sides U/V x 64 fibers at ± 45⁰
- **3 overlap fiber modules**
  for relative vertical alignment
  3 plates x 30 horizontal fibers









ALFA Simulation in Giessen

PYTHIA: ***elastic scattering (ES)***
single diffraction (SD)

MADX:
scattered proton transport through the beam pipe from IP to the ALFA

proton momentum transfer:

$$t \approx -p^2 \cdot \left(\theta_x^2 + \theta_y^2\right)$$

proton energy fraction in pp interaction:

$$\xi = 1 - \frac{E'}{E_0}$$

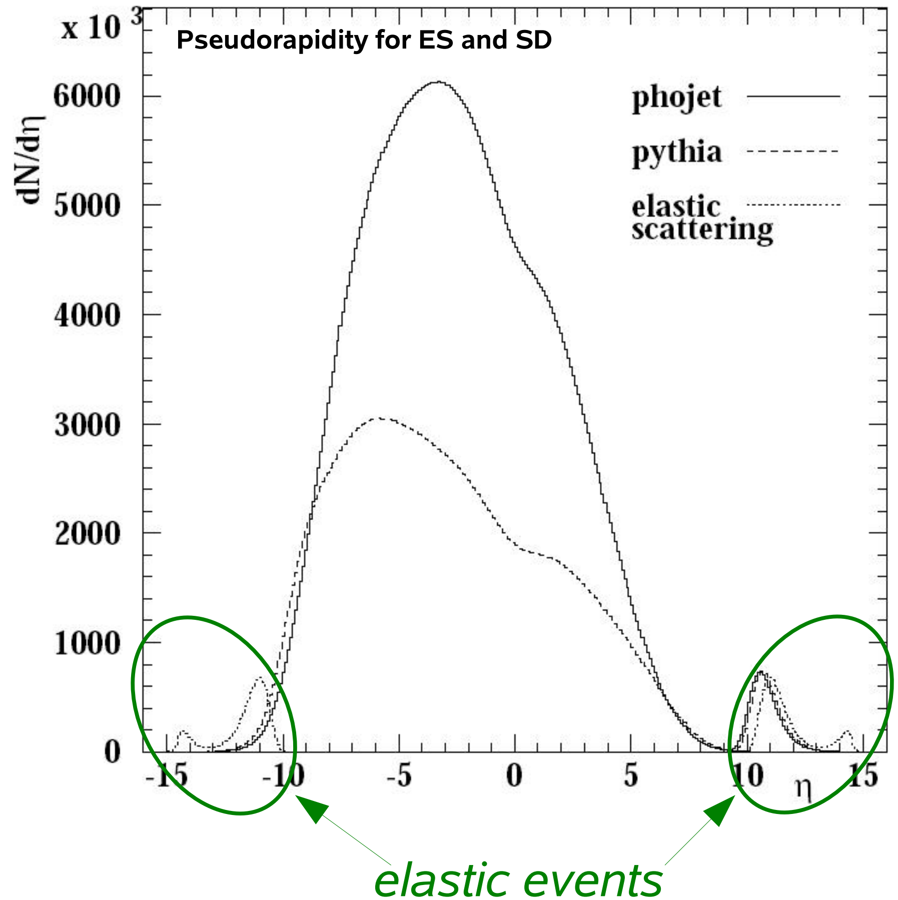
pseudorapidity:

$$\eta = -\ln\left(\tan\left(\frac{\theta}{2}\right)\right)$$

Bachelor thesis 2008

Daniel Pelikan

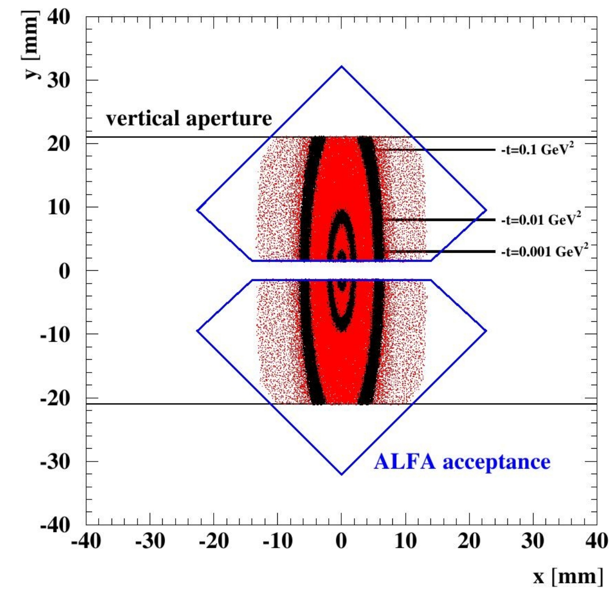
Marcel Werner



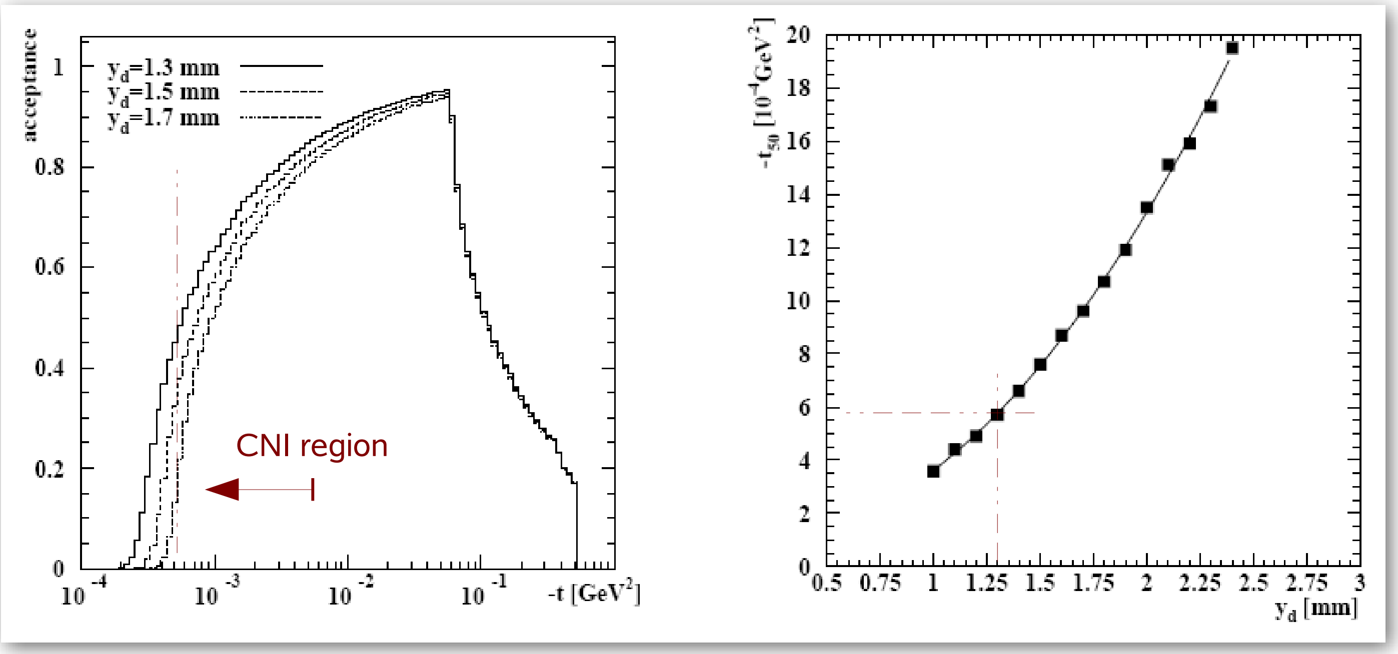
Elastic Scatttering
Simulated with ALFA

ALFA may be able to reach Coulomb nuclear interference region (CNI)

$|t| \sim 6\text{x}10^{-4}\ \text{GeV}^2$; $\Theta \sim 3.5\ \mu$ rad



Acceptance for Elastic Rate



detector position closer to the beam

$$t \approx -p^2 \cdot \left(\theta_x^2 + \theta_y^2\right)$$

Simulation of Lumi Measurement

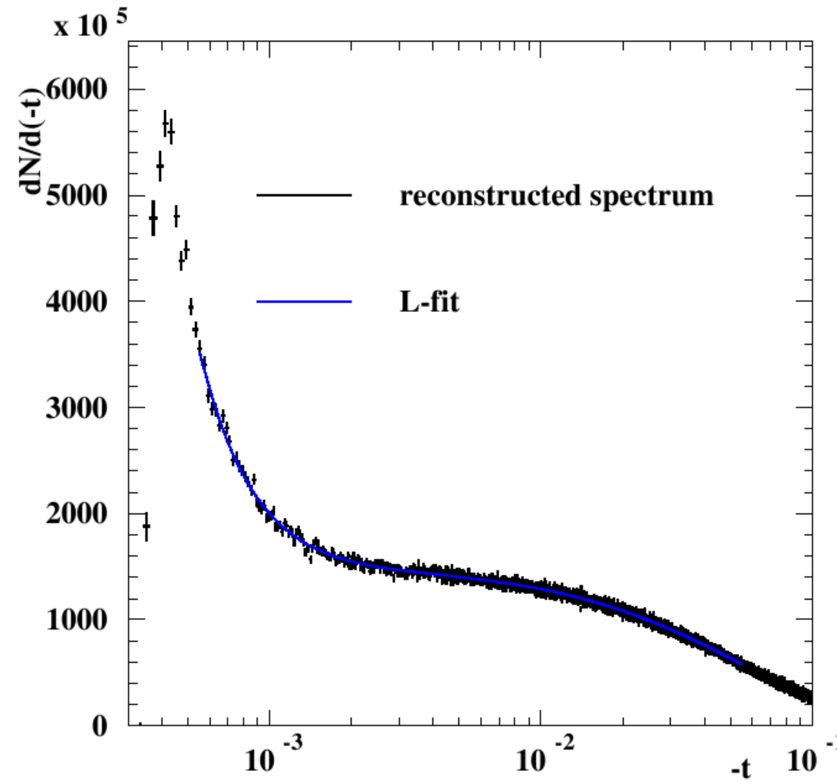
Elastic scattering fit: to the reconstructed ***t*** diistribution with **four** free parameters

$$\frac{dN}{dt} \approx L\cdot\left(\underbrace{\frac{4\pi\alpha^2}{|t|^2}}_{CS} - \underbrace{\frac{\alpha\cdot\rho\cdot\sigma_{tot}\cdot e^{\frac{-B\cdot|t|}{2}}}{|t|}}_{CNI} + \underbrace{\frac{\sigma_{tot}^2\cdot(1+\rho^2)\cdot e^{-B\cdot|t|}}{16\pi}}_{NS}\right)$$

CS ***– Coulomb scattering***
CNI **– Coulomb-nuclei interference**
NS **– nuclear scattering**

1) ***L*** -- *luminosity*
2) ***ρ*** – *ratio of* ***Re*** *to* ***Im*** *part of the scattering amplitude*
3) σ_{tot} – *total cross section* ***pp*** → ***X***
4) ***B*** – *nuclear slope*

Paramter	Fit Value	Units	StatError
L	8.15	[cm^{-2} s^{-1}]	1.77%
ρ	0.14		4.30%
σ tot	101.14	[mb]	0.90%
B	17.9	[GeV^{-2}]	0.25%

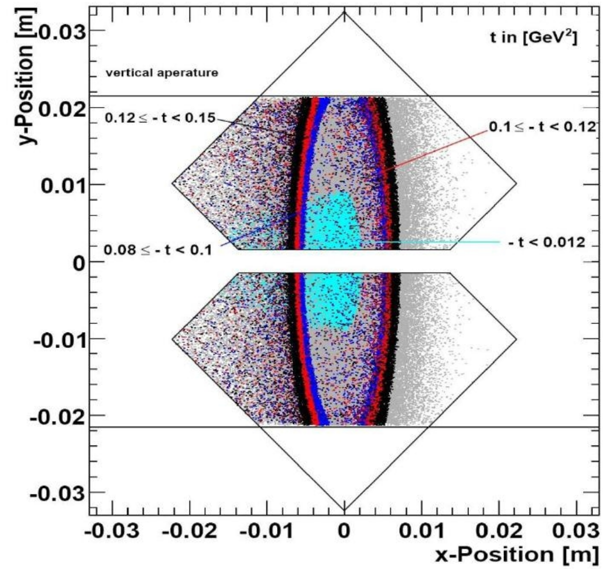


Systematic error of lumi measurement: ~ 2.2%

Total lumi error including systematics : ~ 3%

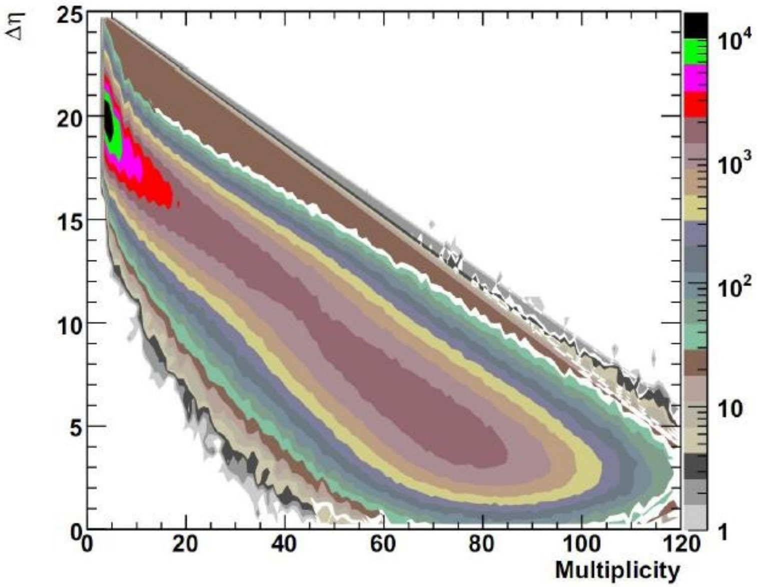
Single Diffraction $pp \to Xp$

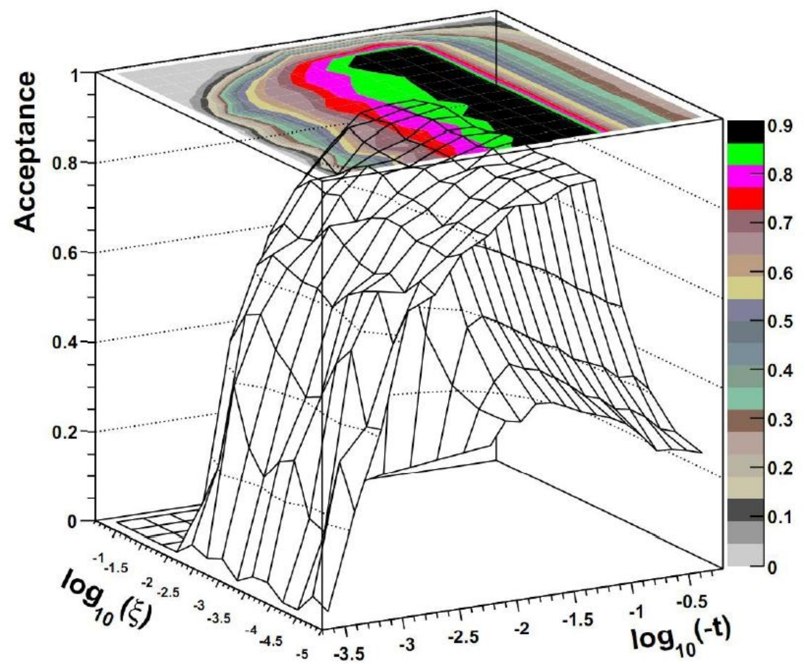
Simulated with ALFA



t and ξ bins: $t \approx -p^2\left(\theta_x^2 + \theta_y^2\right)\,;\ \xi = 1 - \frac{E'}{E_0}$

Rapidity gap $\Delta\eta$ represents θ_{min} or η_{max}





Clear liner dependence $\Delta\eta$ vs Multiplicity

Gießen Activity in ALFA 2008

1) **Construction:**

   ALFA Fiber Detector

2) **Simulation:**

   elastic scattering and single diffraction

3) **Academic:**

   1 diplom and 3 bachelor theses in 2008

4) **Test beam August 2008:**

   preparation and data quality

Plans

1) ALFA fiber modules:

serial production

contribution in installation & commissioning

2) Simulation:

elastic scattering, single diffraction, ...

3) Test beam August 2008:

data analysis

4) Luminosity measurement at ATLAS

data taking & analysis software development

BACK UP

Background to Lumi: Non-elastic Interactions

absollute domination of single diffraction $pp \to X\,p$ (SD)

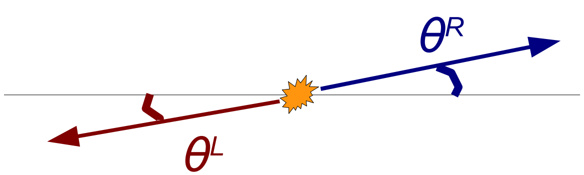
Cuts:

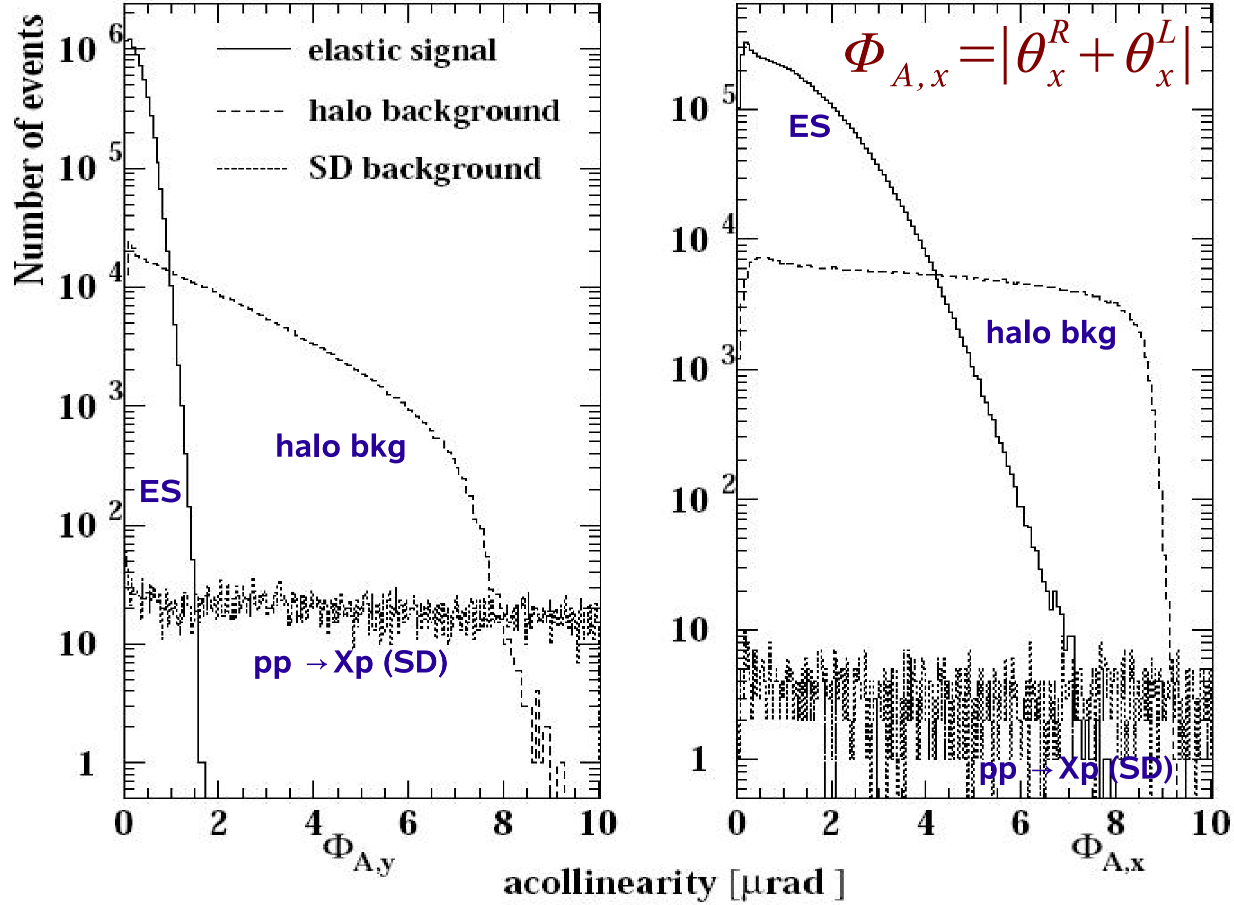
- **E'p ≥ 5 TeV**
- **Vertex cut:** ***ellipce***
  a = 4mm, b =14mm
- $\Phi_{A,x} < 5\ \mu rad$
- $\Phi_{A,y} < 1\ \mu rad$

99.7% elastic events

$$\Phi_{A,x} = |\theta_x^L + \theta_x^R|$$

$$\Phi_{A,y} = |\theta_y^L + \theta_y^R|$$





Background to Lumi: Beam Halo

beam gas + betatron and momentum collimation survivals

<u>**Cuts:**</u>

(the same as for SD)

- **E'p ≥ 5 TeV**
- **Vertex cut:** ***ellipce***
  a = 4mm, b =14mm
- $\Phi_{A,x} < 5\ \mu rad$
- $\Phi_{A,y} < 1\ \mu rad$

essential for small *t*
i.e. for the most
important kinematic region

$$t \approx -p^2 \cdot \left(\theta_x^2 + \theta_y^2\right)$$