Flexibility of LHC optics for forward proton measurement

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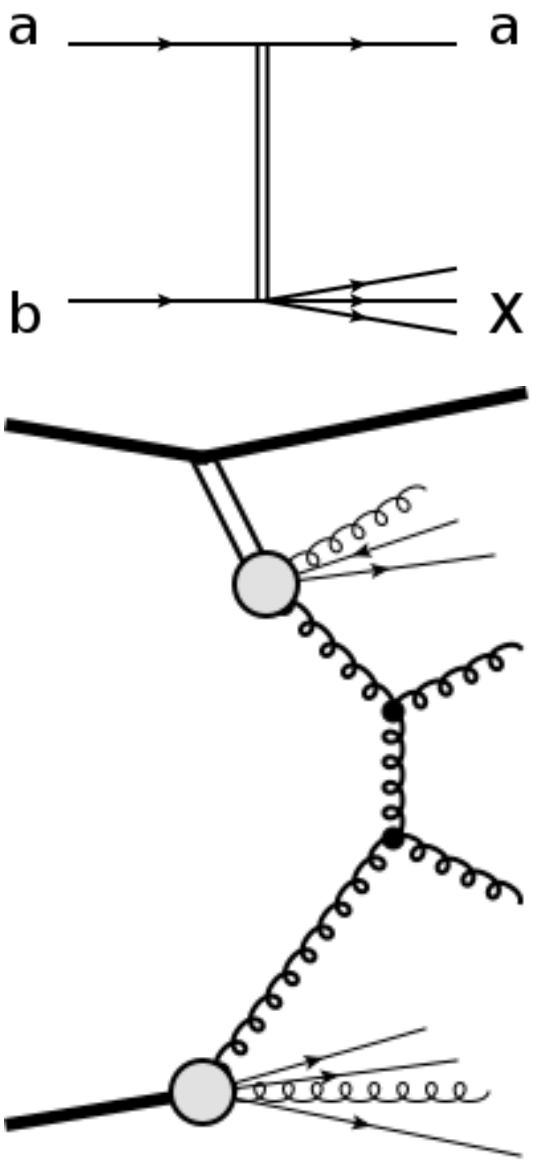
Forward physics

Soft diffraction and hard diffraction (e.g. diffractive jet production)

Colour singlet (Pomeron) exchange

Large rapidity gap

Intact forward proton



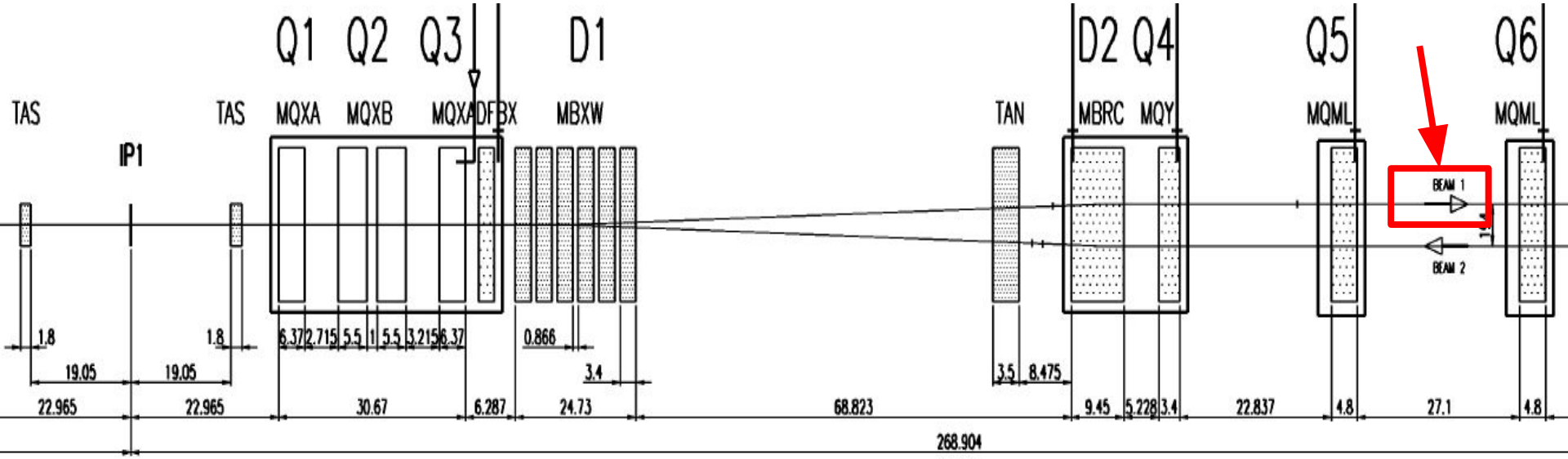
An example: AFP (ATLAS Forward Proton) detectors

Motivation:

Measurement of very forward protons, which are outside of the central detector acceptance.

Setup:

- 204 and 212 m from IP
- few milimeters from the beam
- 4 stations (2+2)
- near stations - Si pixel
- far stations - Si pixel + ToF

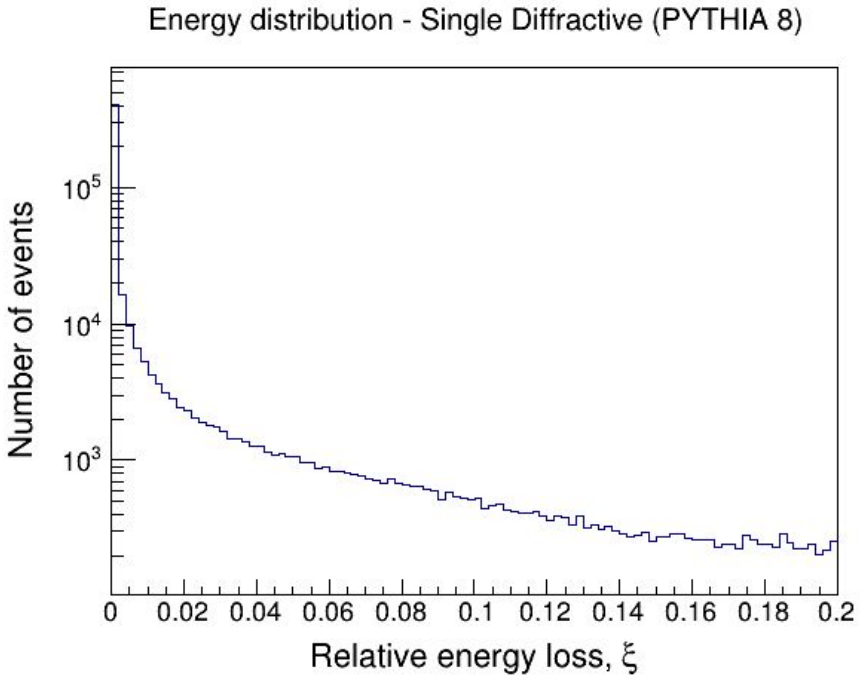


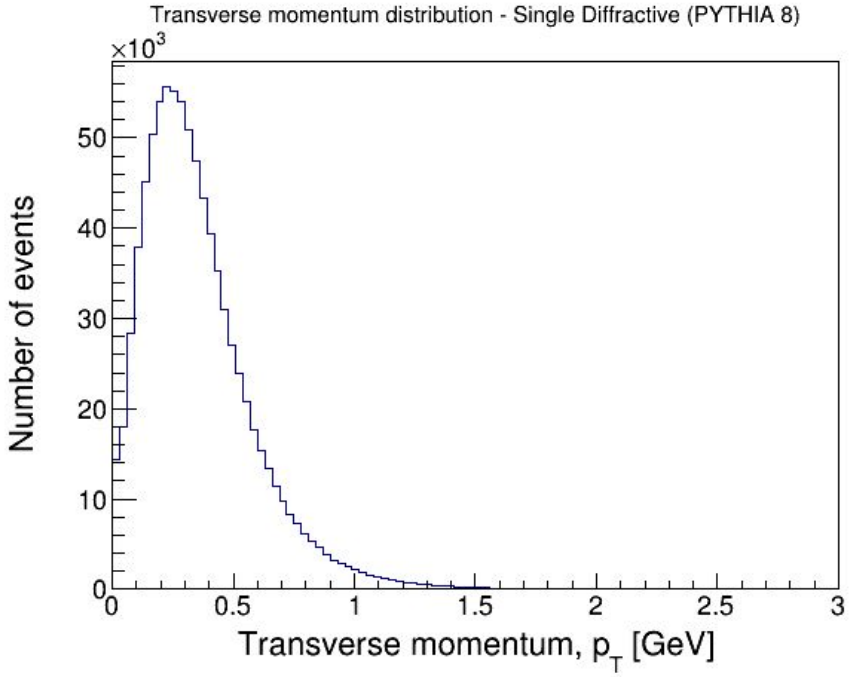
ATLAS(AFP) taken as example, but results qualitatively relevant also for CMS/TOTEM

Kinematics of forward protons

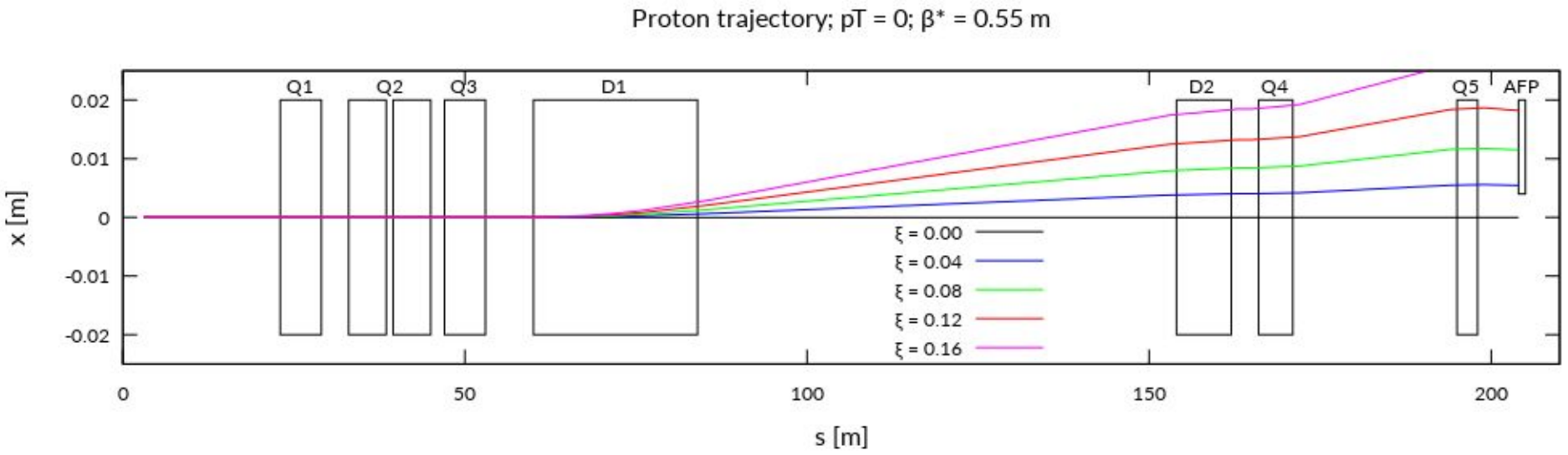
Usefull variables:

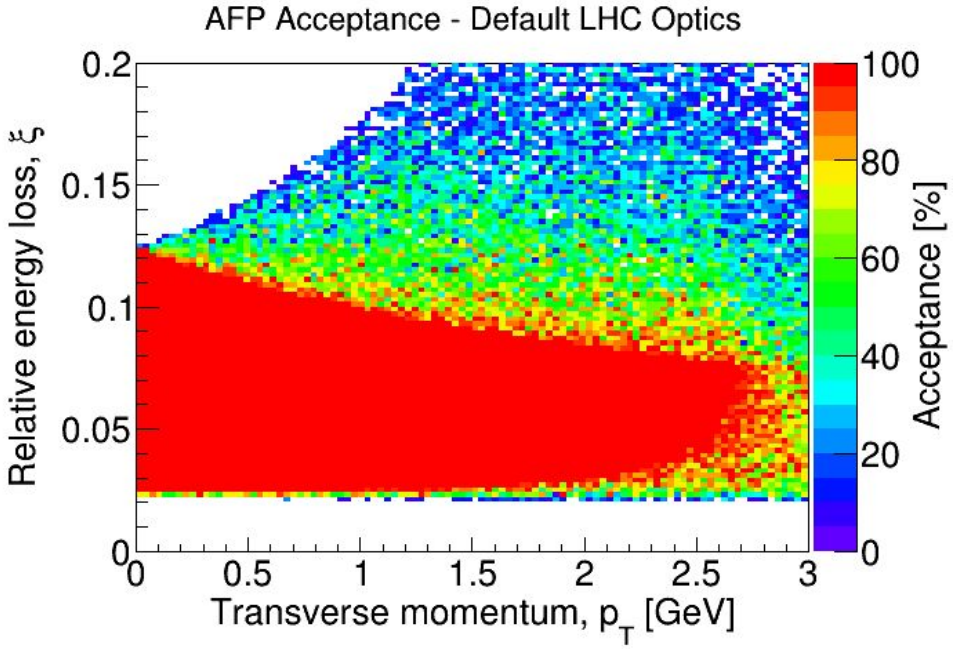
- Transverse momentum: p_T
- Azimuthal angle: φ
- Relative energy loss: $\xi = (E_{beam} - E_{proton})/E_{beam}$





AFP detectors acceptance



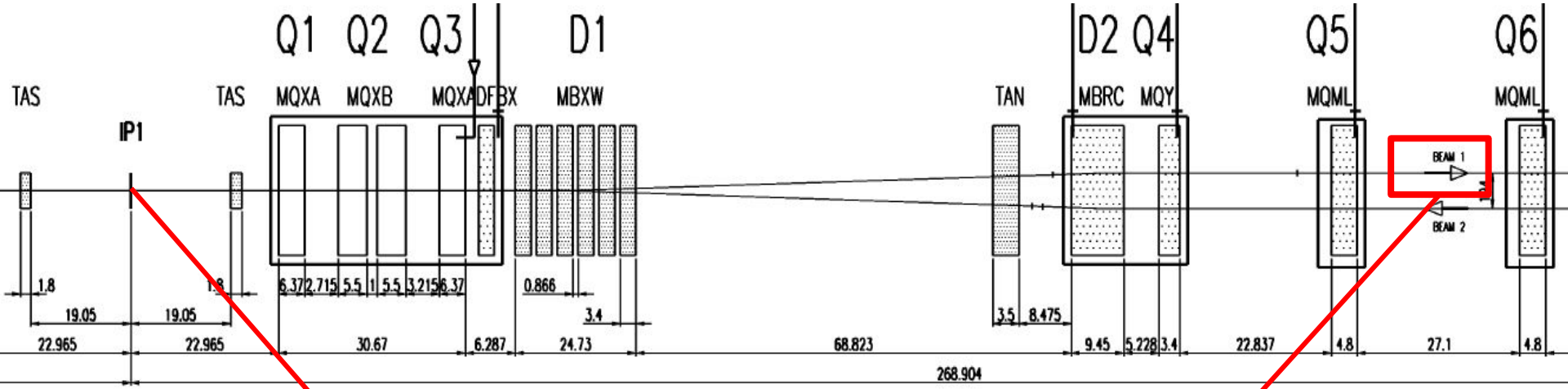


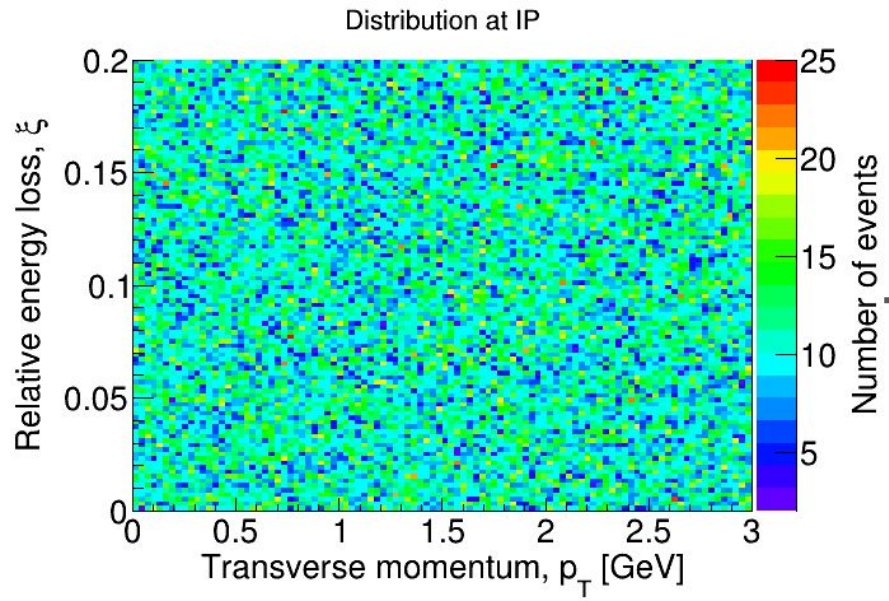
Not all protons can be registered

Acceptance - probability of detecting a proton with a given kinematics

Proton transport through LHC lattice

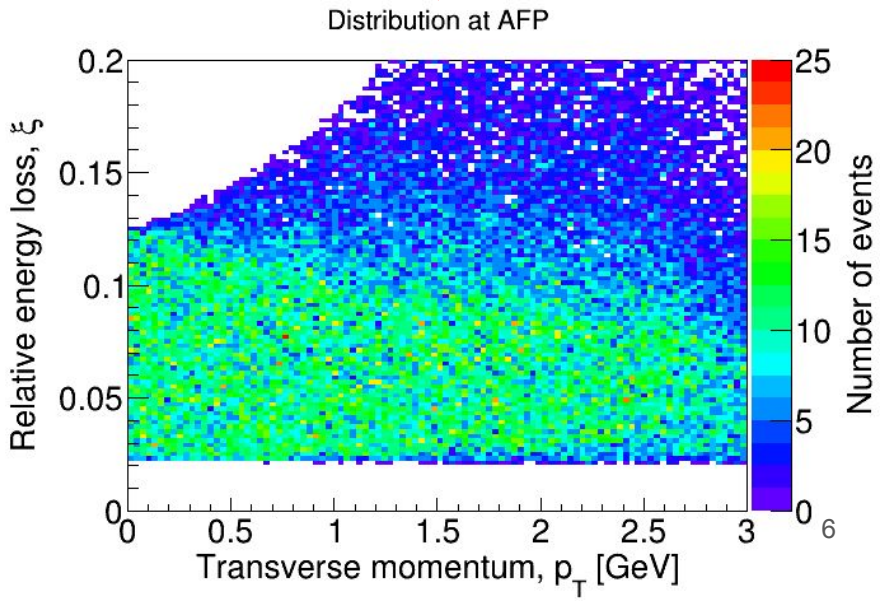
Simulation of proton trajectories in the fields of accelerator magnets



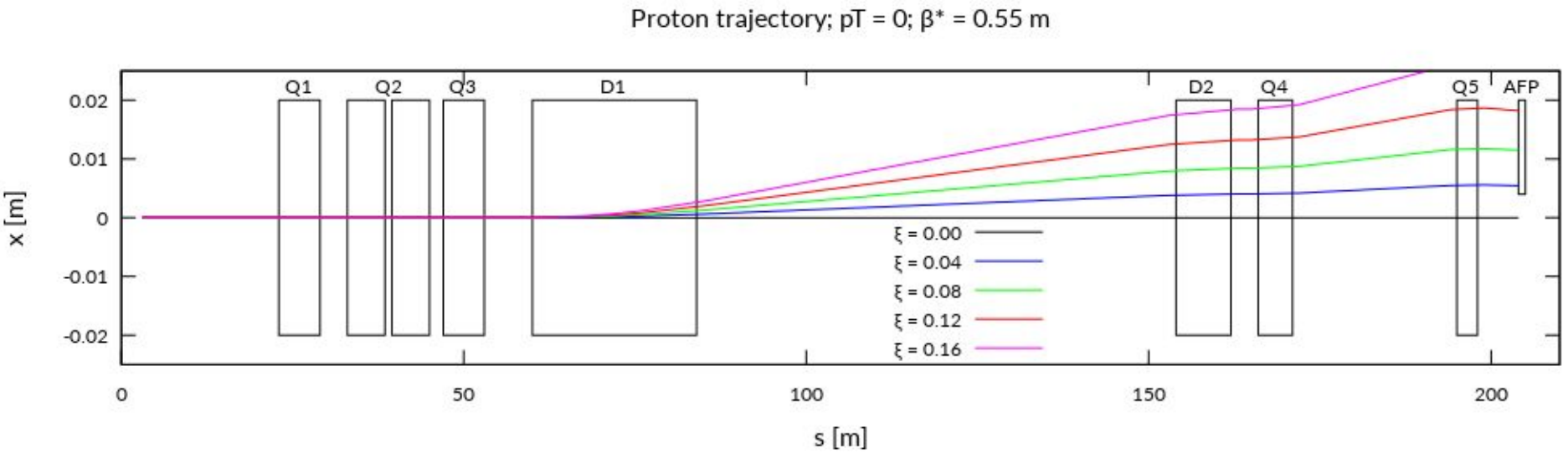


MAD-X

β*=0.55



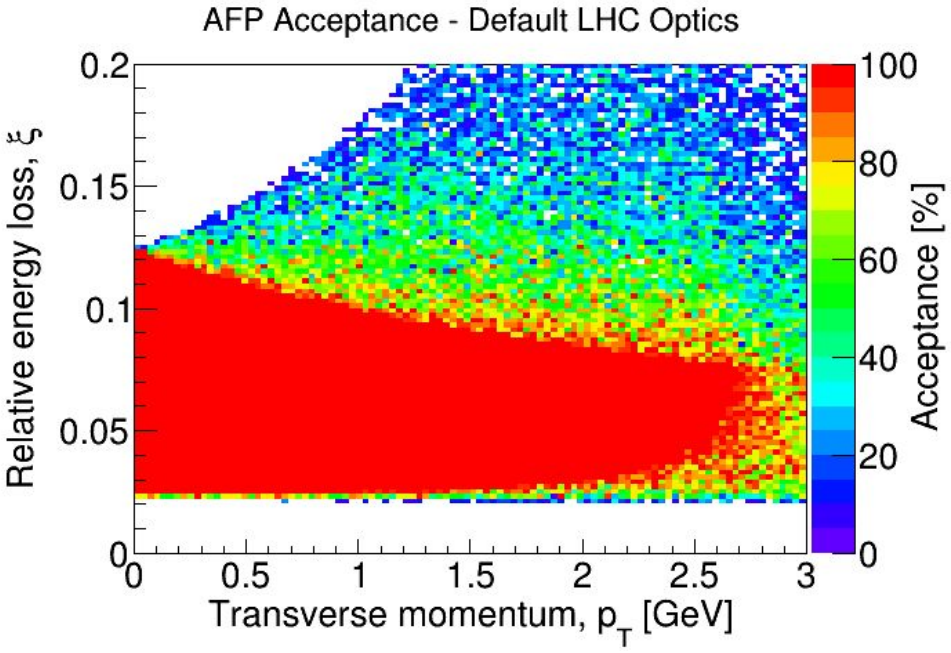
Optics modifications



- Acceptance determined mainly by the dipole magnets D1 and D2
- Dipole magnets define the orbit - they cannot be modified
- Quadrupoles Q4 and Q5 also have an effect
- **Goal of the study: check how much Q4 and Q5 influence the acceptance**

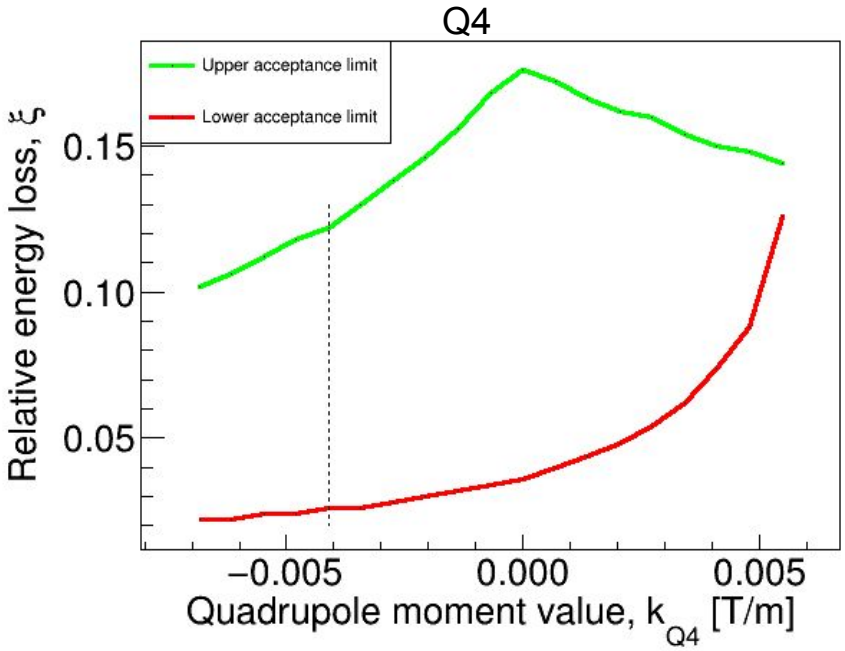
- Default values of quad. moment, k: -0.0041 (Q4), +0.0030 (Q5)
- Allowed range: (-0.00015, -0.0069) (Q4), (+0.00016, +0.0069) (Q5)
- In this study: (-0.0069, +0.0069)

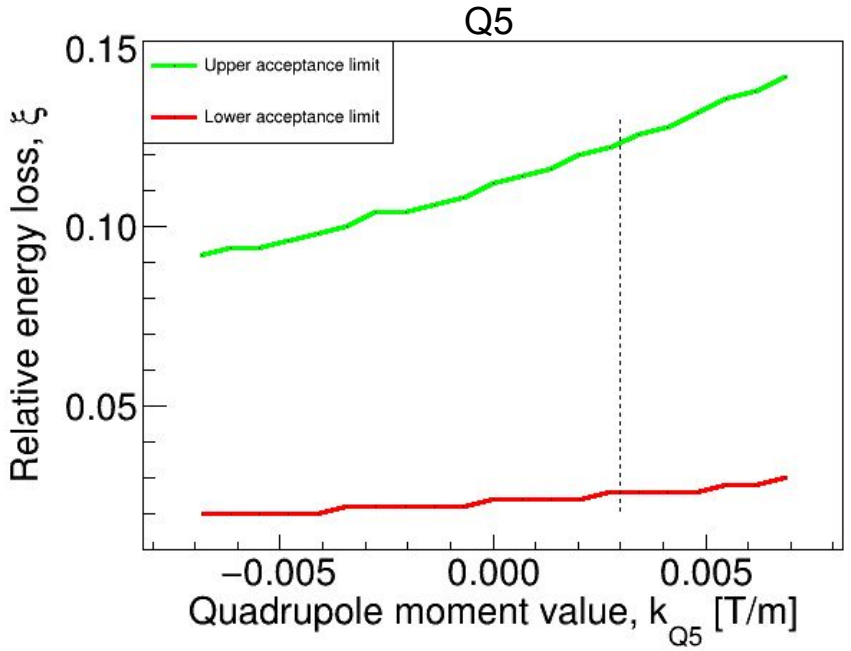
Results



- Diffractive protons have small p_T
- Checking how ξ range for low p_T changes with optics modification

- Q4 has greater impact (further from the detectors)
- Lower and upper limits change in the same direction





Summary

- Diffractive physics - intact forward protons
- Dedicated detectors: AFP/TOTEM
- Not all protons can be detected -> acceptance
- MadX simulation used for acceptance calculations
- Effects of Q4 and Q5 modification studied

- Gain in low ξ always accompanied by loss in high ξ
- Physics: steep ξ dependence
- It may be worth increasing the acceptance at low ξ