The ATLAS Forward Physics Program

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On behalf of the ATLAS collaboration

DIS 2010
April 2010, Florence, Italy

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- ATLAS Forward Detectors
- Diffraction using rapidity gap
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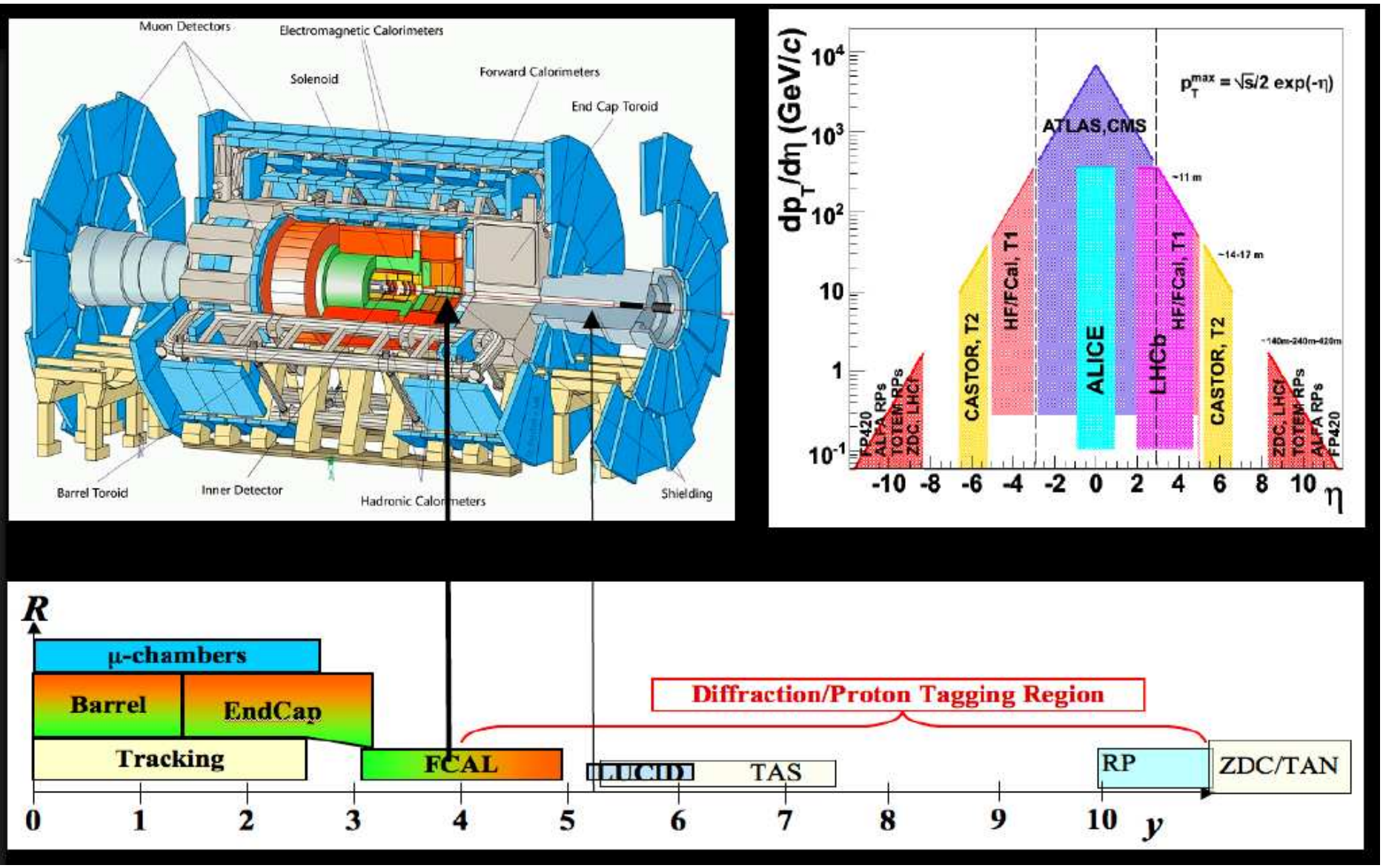
- ATLAS Forward Physics project (AFP)

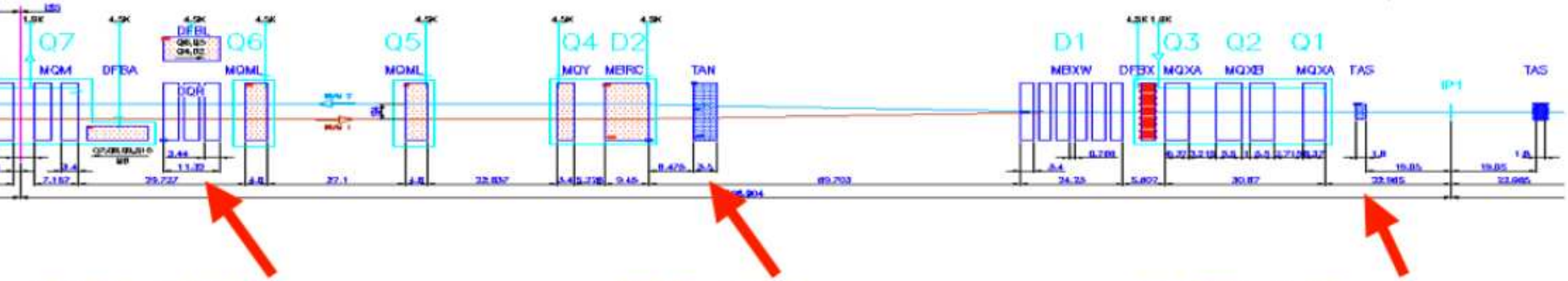
ATL-PHYS-SLIDE-2010-072
20 May 2010

ATLAS detector



See talk by Andrew Brandt for more details

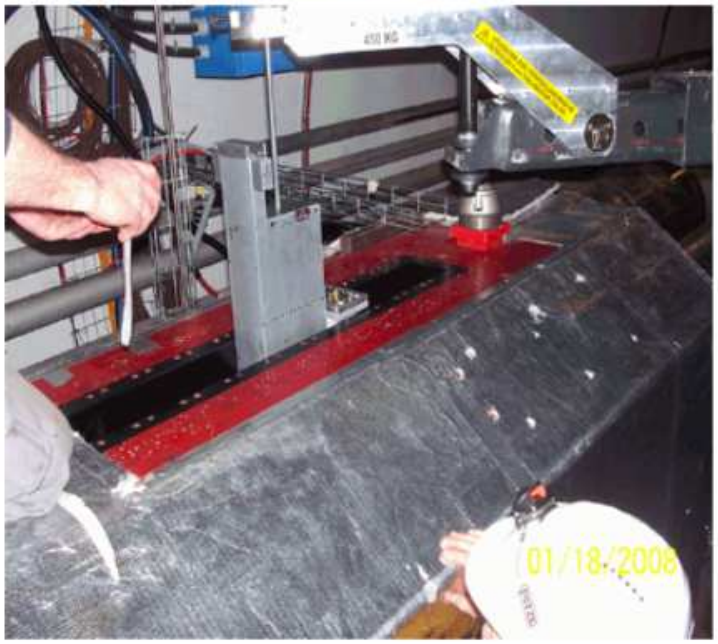
ATLAS forward detectors



ALFA at 240 m

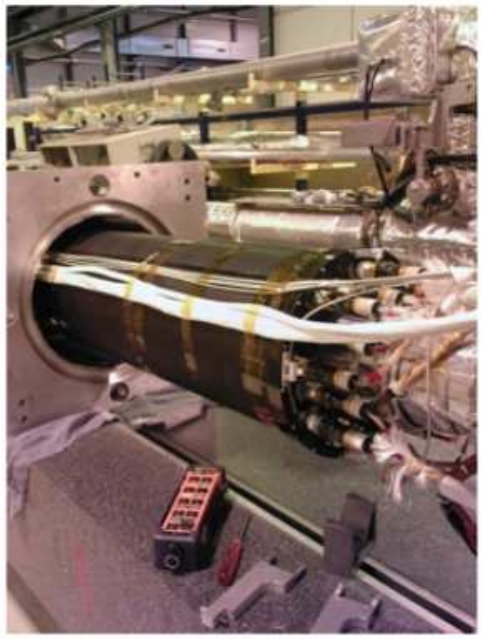
Absolute Luminosity for ATLAS

ZDC at 140 m



Zero Degree Calorimeter

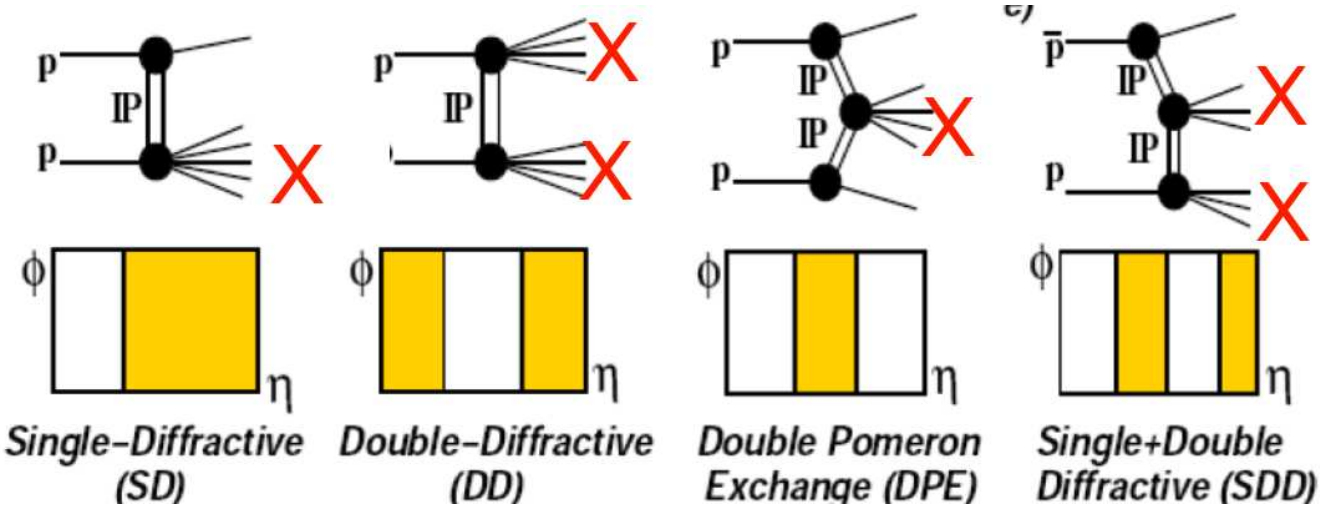
LUCID at 17 m



Luminosity Cerenkov Integrating Detector

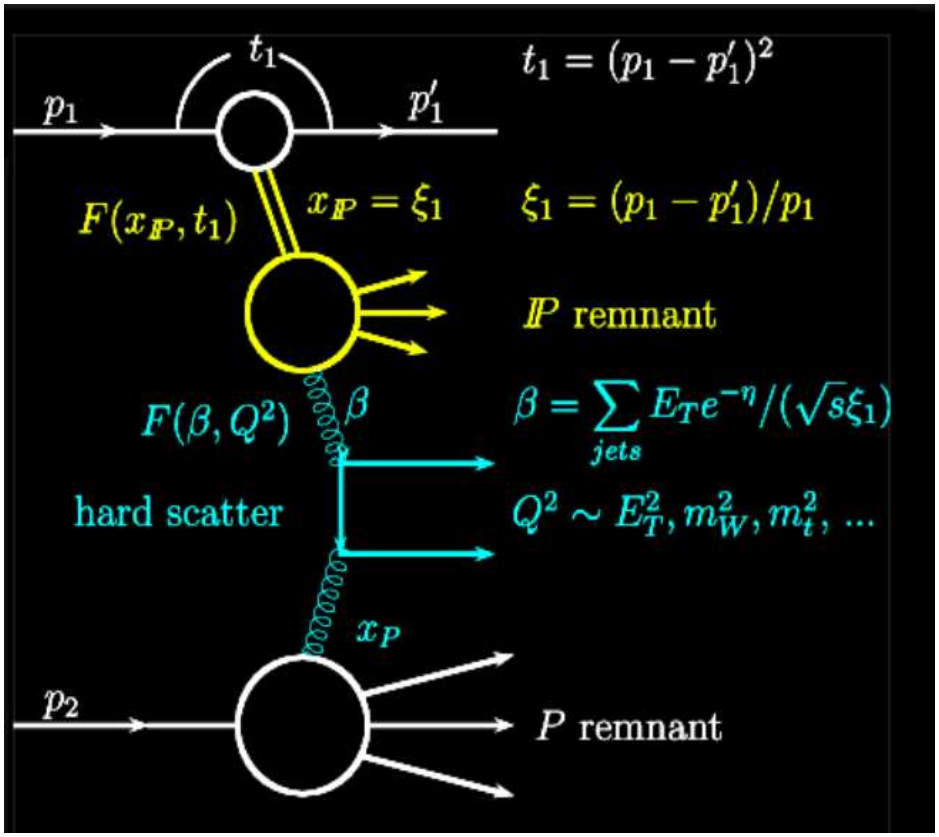
See talk by Andrew Brandt for more details

ATLAS Diffractive physics



- Diffractive studies:
  - Study of diffractive events using forward rapidity gap method at low luminosity (or in dedicated runs): low pile-up; forward rapidity gap in FCAL ($3.2 < |\eta| < 4.9$), LUCID ($5.6 < |\eta| < 6.0$) and ZDC ($|\eta| > 8.3$)
  - Central gaps: Hadronic calorimeter ($|\eta| < 3.2$) and inner detectors ($|\eta| < 2.5$)
  - Diffractive measurements at low luminosity using ALFA
  - Diffractive measurements at high luminosity: ATLAS Forward Physics project
- Hard diffraction: jets, Z, W, Higgs..., hard processes calculable in pQCD, info on Pomeron structure, discovery physics
- Soft diffraction: total cross section, gap survival probability...

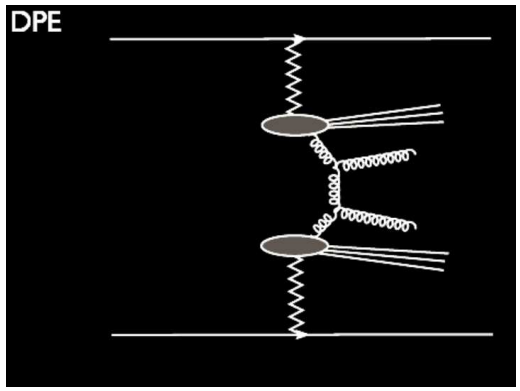
Hard single diffraction

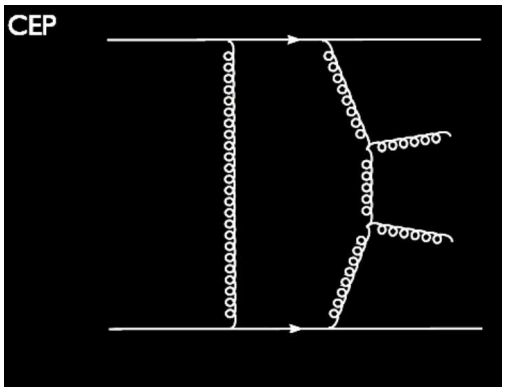


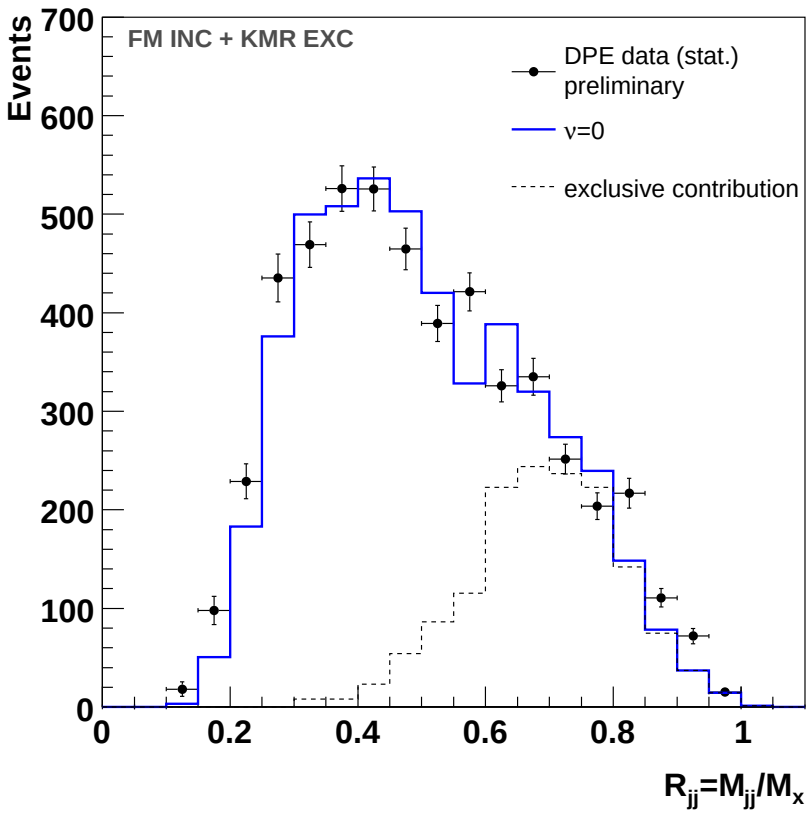
- Look for hard scatter events (jets, W...) with gap on one side of the detector
- Gap defined using LUCID/ZDC and FCAL
- Compare gap/non-gap ratio to determine soft survival probability
- As an example, approximately 5000 (8000) SD dijet events in 100 pb^{-1} with jet transverse energy above 20 (40) GeV after trigger prescale

DPE and Central Exclusive Processes measurements

- Request two central jets in central ATLAS detector ($|\eta| < 2.5$) and gap on both sides using FCAL, LUCID and ZDC
- Measure DPE and CEP and compare with CDF results using dijet mass fraction for instance

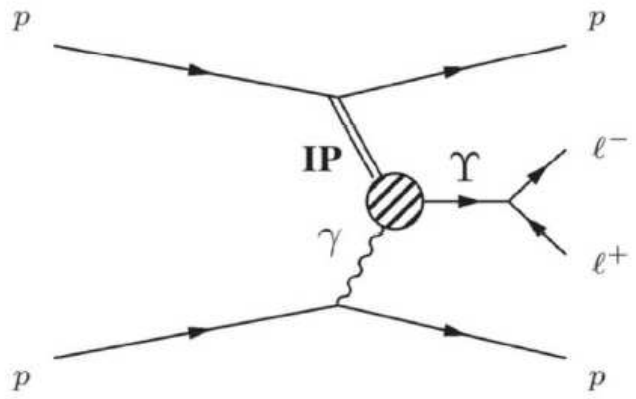


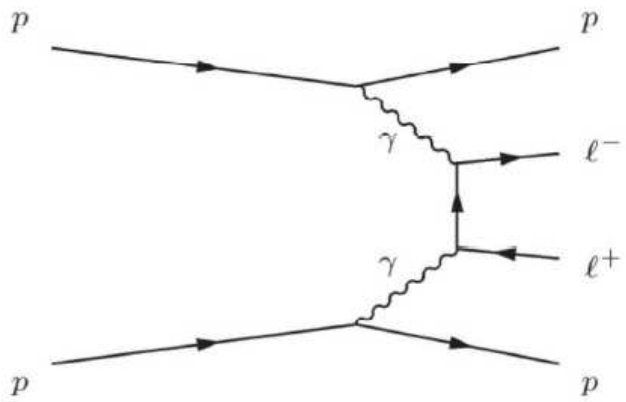




Photon induced lepton pair production

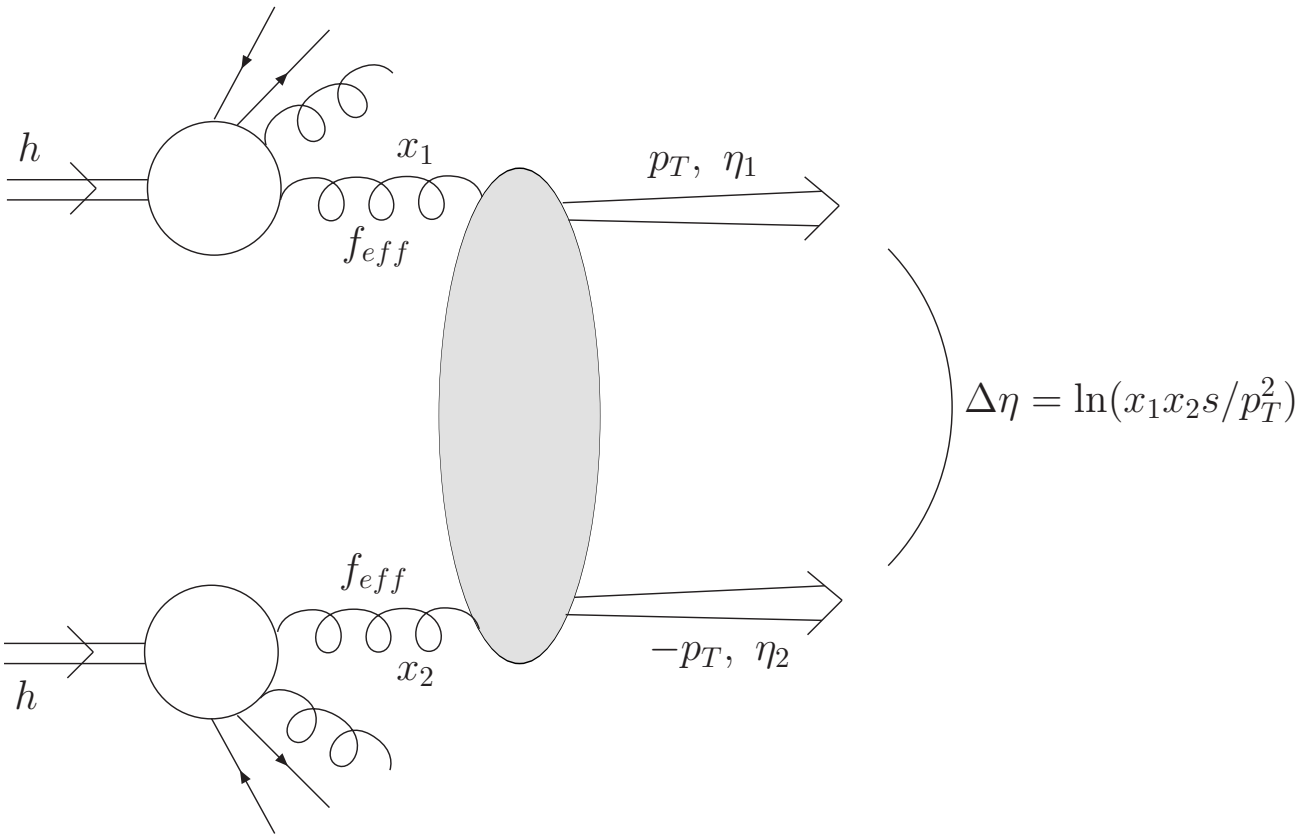
- Exclusive dilepton production: two isolated leptons back-to-back, gaps in forward region, exclusive vertex (no other tracks than from leptons), $\sigma \sim 10$ pb for $p_T > 2.5$ GeV
- Photon induced dilepton pair production: can be used for luminosity calibration, low p_T lepton ID studies, standard candle at high luminosity for BSM phsyics ($\gamma\gamma \rightarrow$ sleptons, Higgs, WW..)
- Photoproduction processes: J/Ψ, Υ resonances ($\sigma \sim 10$ pb) which can be used to constrain the unintegrated gluon distribution (important for Exclusive production)





Jet gap jet events

- Dijet production via single exchange: require two jets and a central gap
- Test of BFKL NLL cross section: Implemented in HERWIG (C. Marquet, C. Royon)
- Complementary tests for BFKL in Mueller-Navelet jets (see ...)

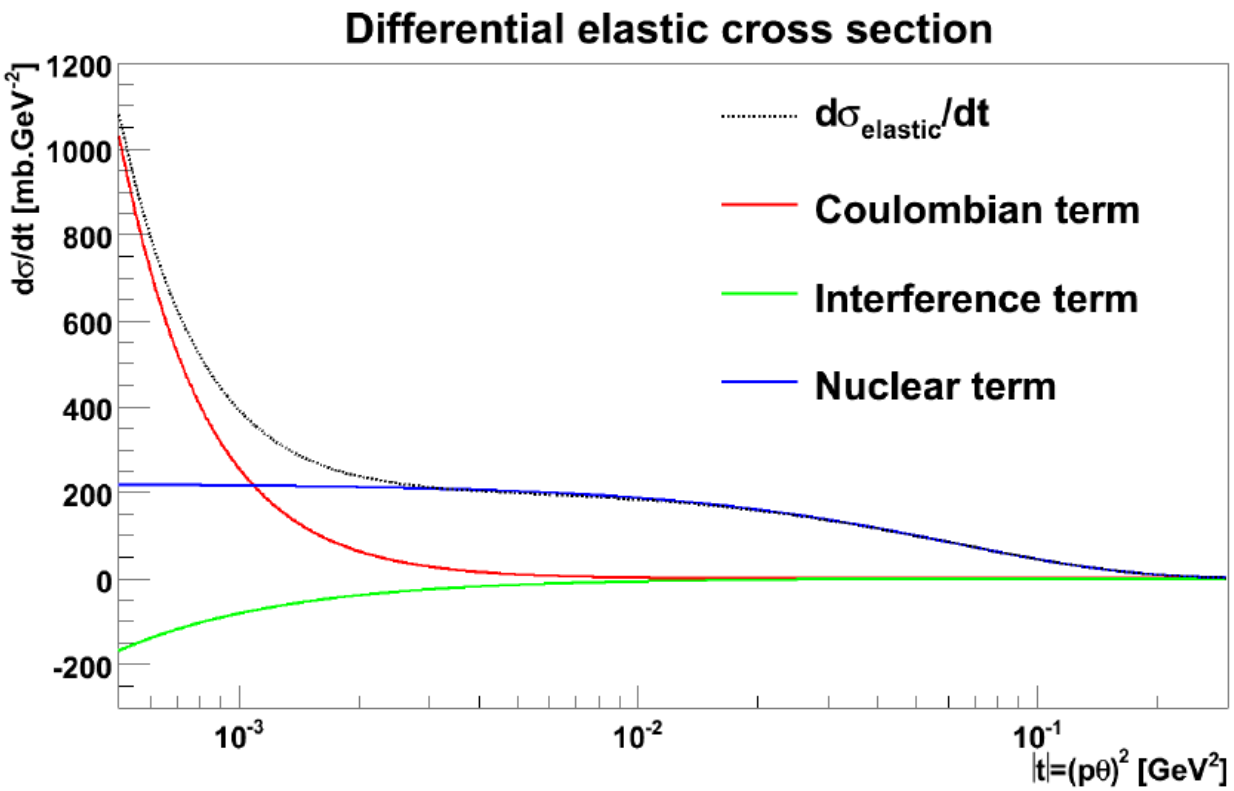


Total cross section measurement using ALFA

- Measurement of the elastic cross section in the Coulomb and interfernce region
- Coulombian term, Interference term, Nuclear term:

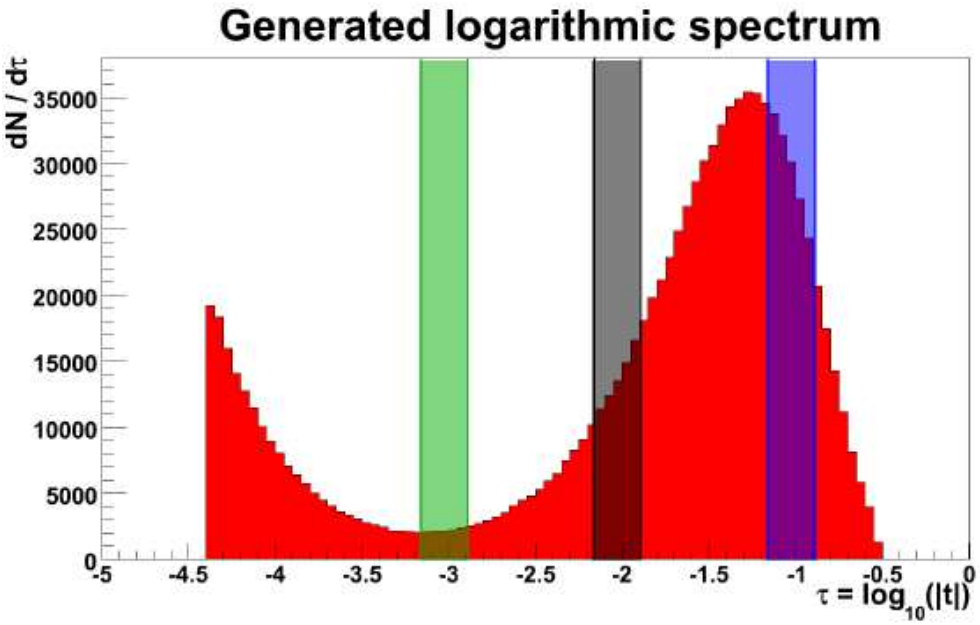
$$\frac{dN}{dt} = L\left(\frac{4\pi\alpha^2 G^4(t)}{|t|^2} - \frac{\alpha\rho\sigma_{tot}G^2(t)e^{-B|t|/2}}{|t|} + \frac{\sigma_{tot}^2(1+\rho)^2 e^{-B|t|}}{16\pi}\right)$$

- Requires a measurement of elastic cross section down to $t \sim 3.7\ 10^{-4}$ GeV^2, which means an angle down to 3 μrad. using ALFA roman pots and dedicated high β^* runs



Measurement procedure and results

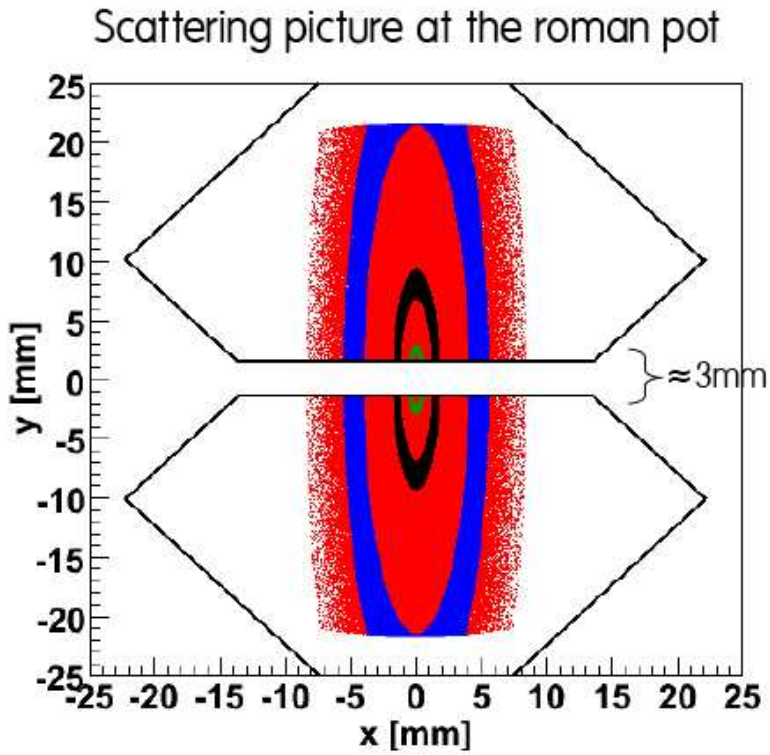
- Luminosity, total cross section, B, ρ are determined by fitting the dN/dt spectrum in the interference, nuclear regions
- Total uncertainties estimated to be less than 3% (bea, properties: 1.2%, detector properties: 1.4%, background substraction: 1.1%, stat error: 1.8% for 100 hours of measurement at a luminosity of 3.6 10^{32}



$0.0007 < -t < 0.0013$ GeV^2

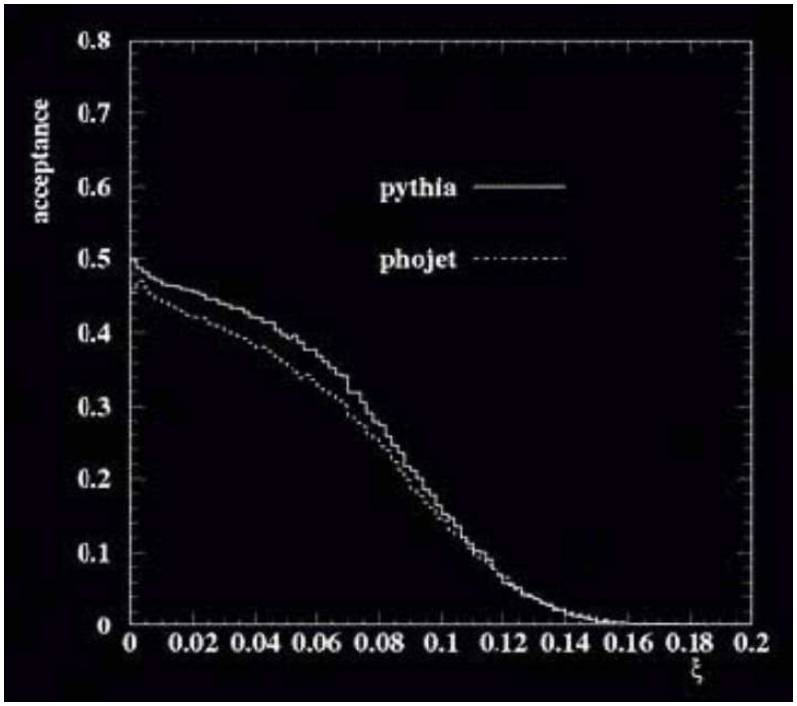
$0.007 < -t < 0.013$ GeV^2

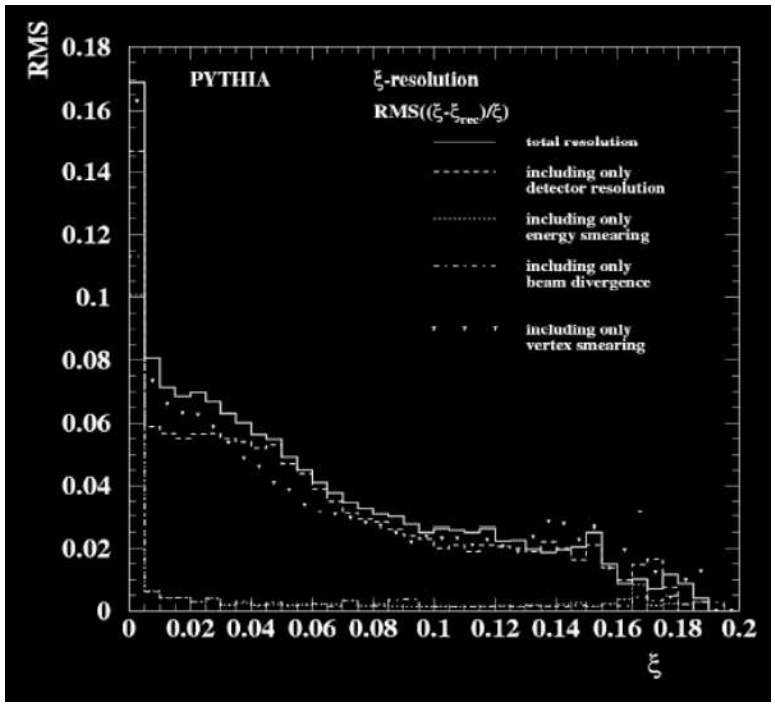
$0.07 < -t < 0.13$ GeV^2



Soft single diffraction with ALFA

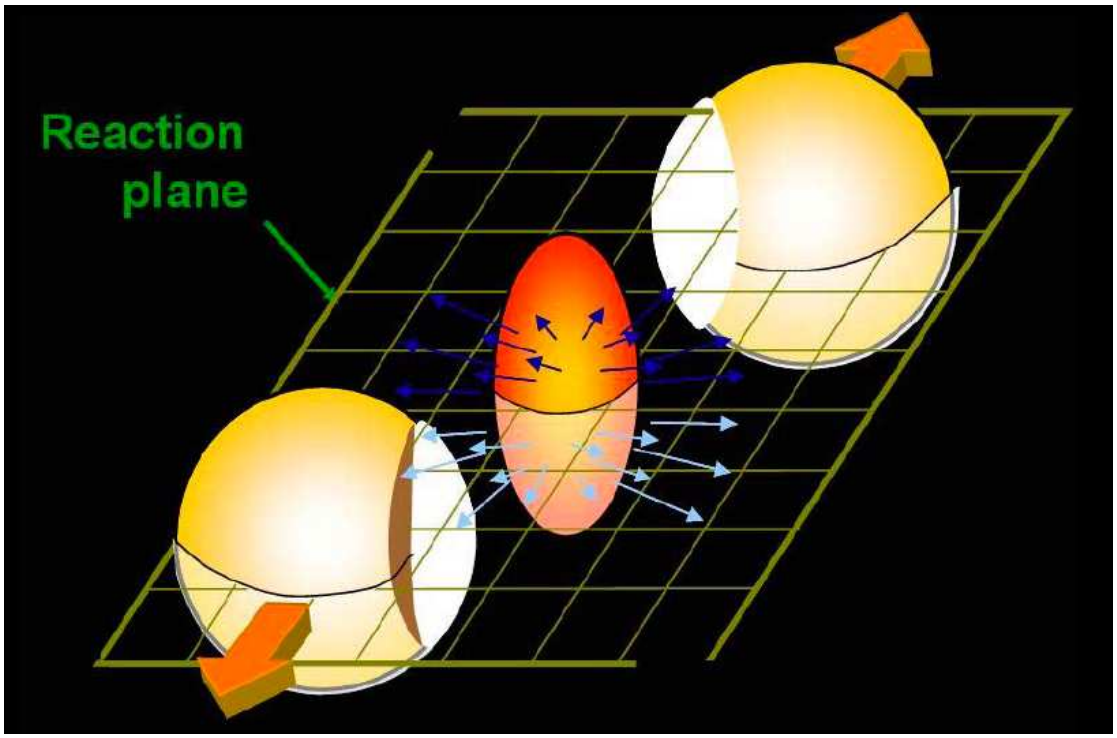
- ALFA has good acceptance for single diffractive events in dedicated runs
- Measure forward proton spectrum in the region: $6.3 < E_{proton} < 7$ TeV
- SD measurements for $\xi < 0.01$ and non-diffractive proton measurements for $0.01 < \xi < 0.1$
- Expect $\sim$1.5 million events in 100 hours at 10^{27} cm^{-2}s^{-1}

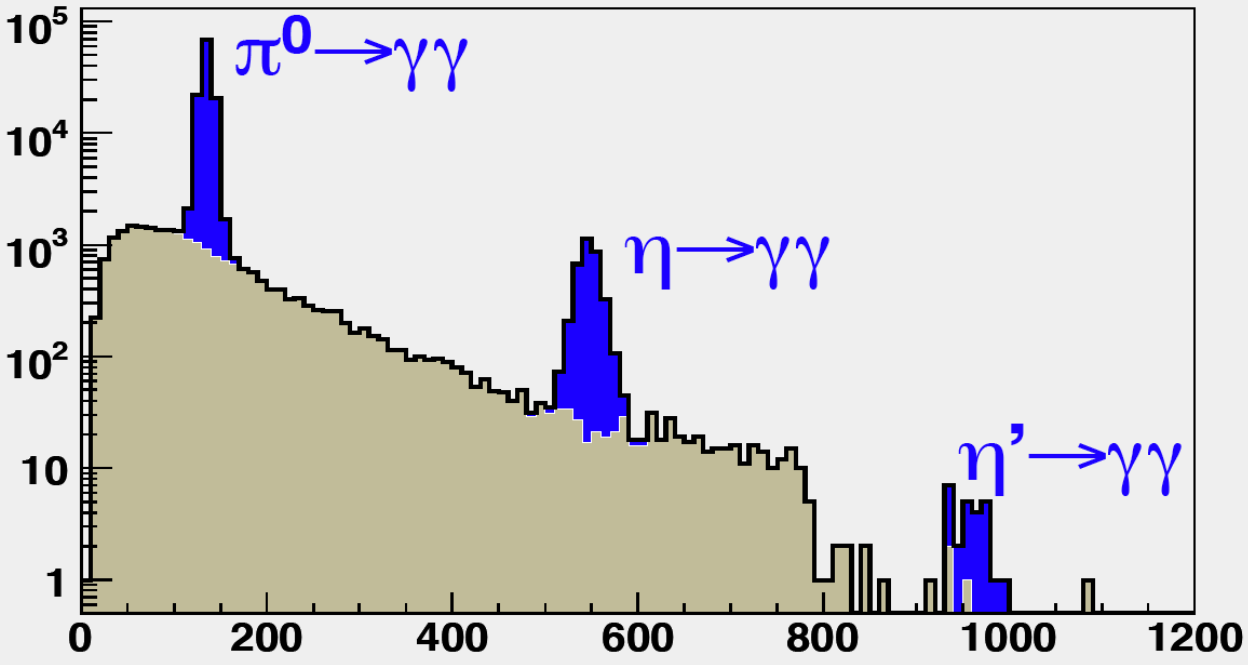




ATLAS ZDC

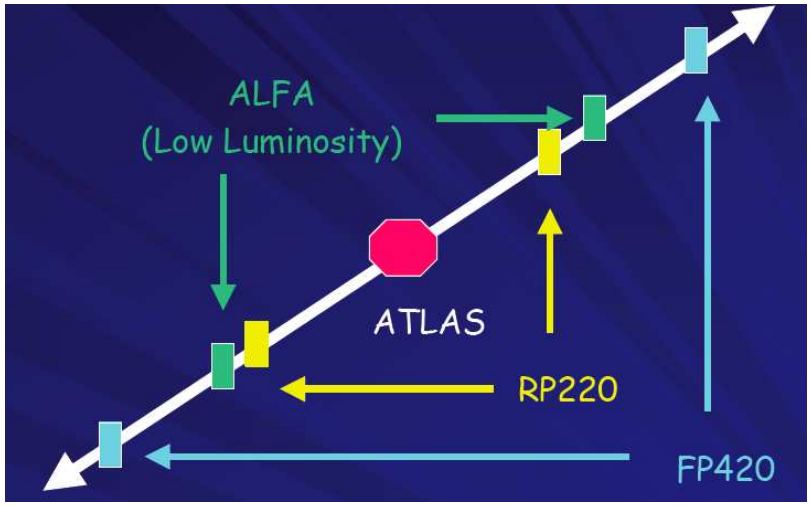
Will perform studies both in heavy ion and pp collisions to measure neutral particles at 0 degree (n, γ, π^0)

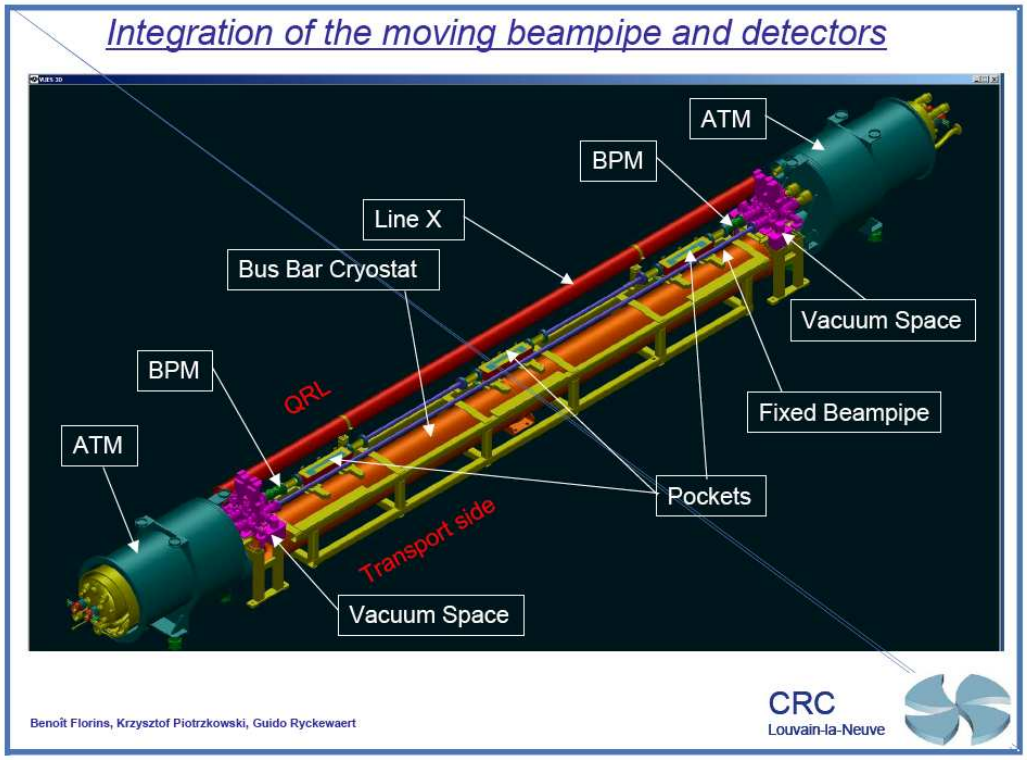




The ATLAS Forward Physics Project (AFP)

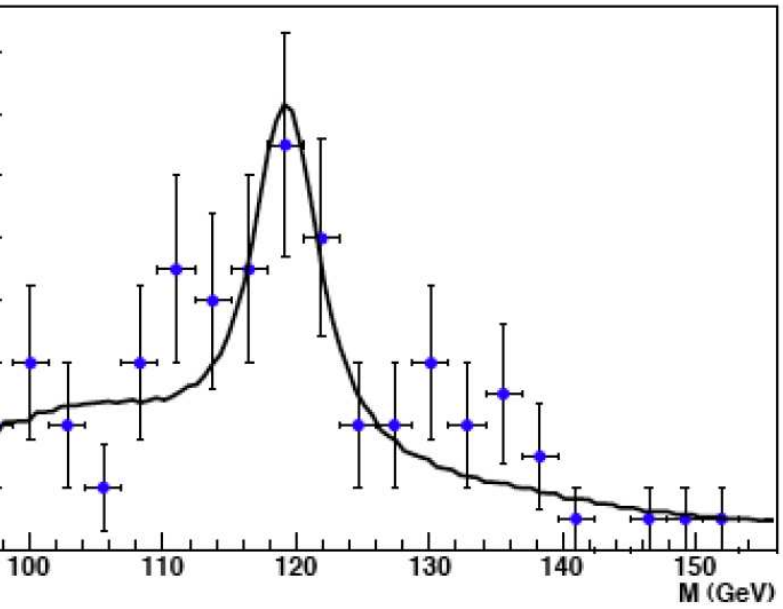
- Additional proton detectors located at 220 and 420 m
- Movable beam pipes (lack of space at 420 m in cold region of LHC
- Measure proton position (3D Si) and time of flight (GASTOF, QUARTIC)

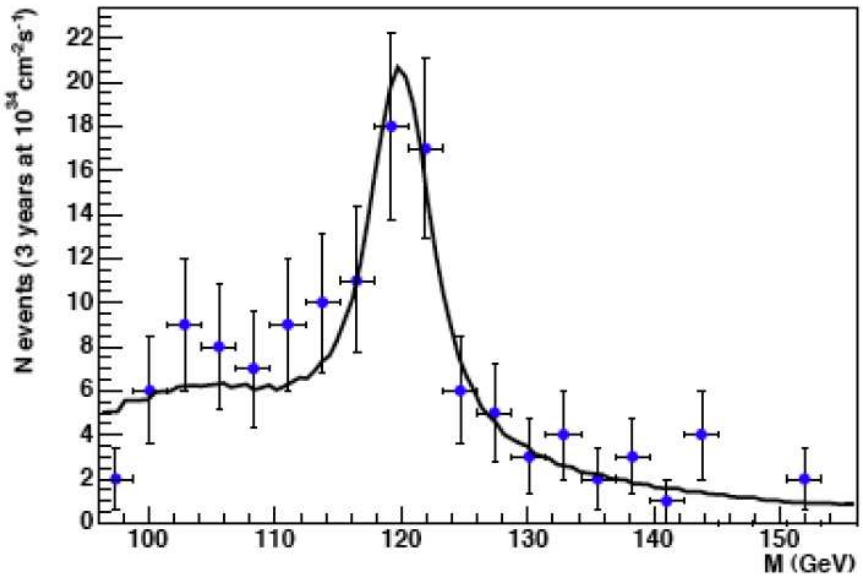




SUSY Higgs Signal significance using AFP

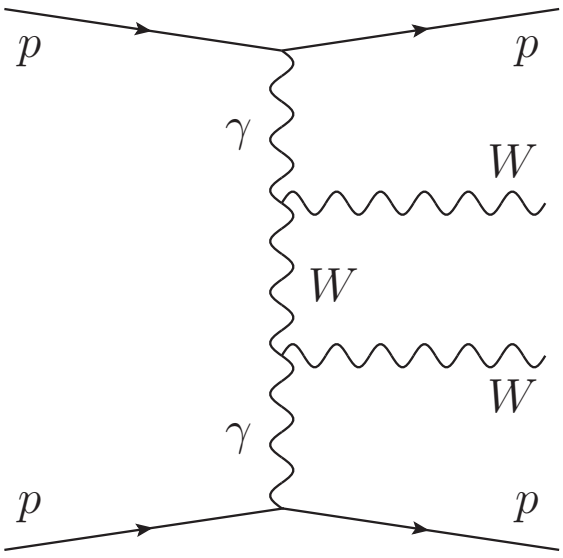
- Signal and background full simulation, pile up effects taken into account for h production at $\tan\beta \sim 40$, 8 times higher cross section than SM
- Significance $> 3.5\sigma$ for 60 fb^{-1} after detector acceptance
- Significance $> 5\sigma$ in 3 years at 10^{34} with timing detectors
- Diffractive Higgs boson production complementary to the standard search

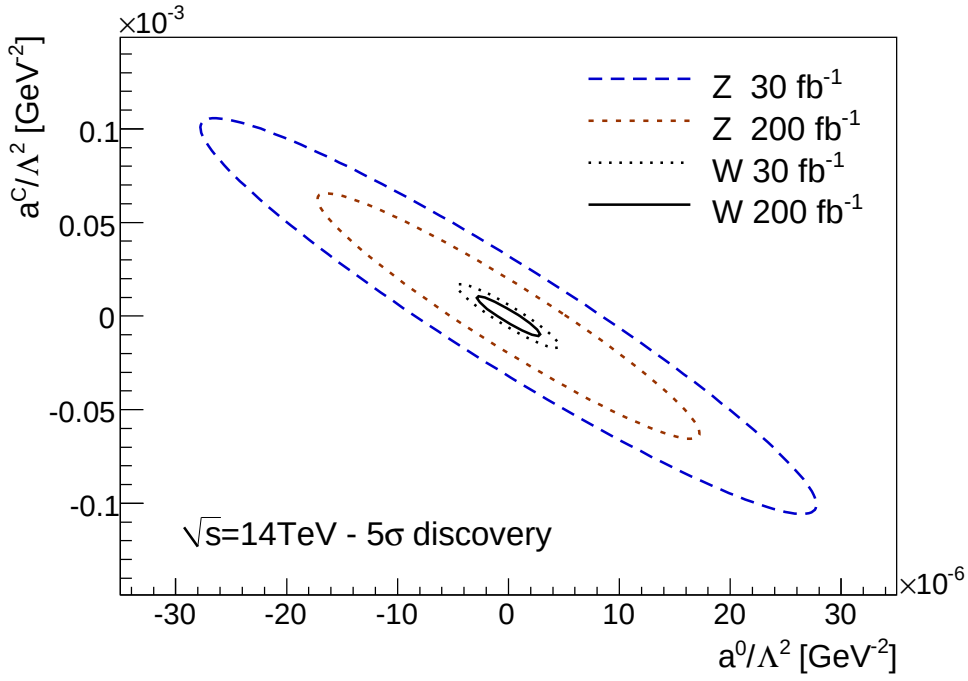




WW production via photon exchange at the LHC

- Study of the process: $pp \rightarrow ppWW$
- Clean process: W in central detector and nothing else, intact protons in final state which can be detected far away from interaction point
- Study of anomalous $W\gamma$ couplings predicted by Higgsless / extradim models
- Present LEP limits can be improved by up to four orders of magnitude reaching the expected values for Higgsless models (see talk by C. Royon about anomalous coupling)





Conclusion: Diffractive program in ATLAS

Luminosity	Possible measurements
10 pb^{-1}	Jet gap jet (Mueller Navelet) Soft single diffraction total cross section (ALFA) Hard Single diffraction (jets, b jets...)
10-100 pb^{-1}	Central exclusive production (jets) Single diffractive W/Z
100-200 pb^{-1}	WW via photon exchange dilepton production CEP $\tau\tau$
30 fb^{-1}	Higgs (with AFP) Anomalous $W\gamma$ couplings (with AFP) Test of Higgsless / extradim models (with AFP)

Many different possible measurements using rapidity gap method (low luminosity), ALFA, and AFP project