Soft Physics with a Proton Tag, Report plans
LPCC Forward Physics, Kracow

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Introduction

Utilise kinematics of diffractive event topologies.

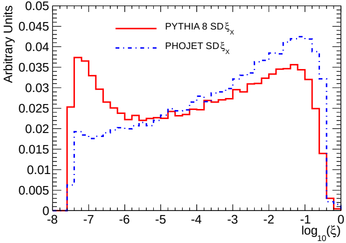
Look at what soft physics can also be tagged in the forward detectors: AFP210.

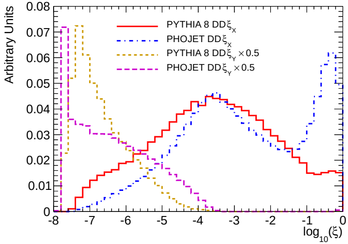
Work towards generator studies for the report.

Today: Plans and first look at some studies.

Diffractive Kinematics: Pomeron Flux

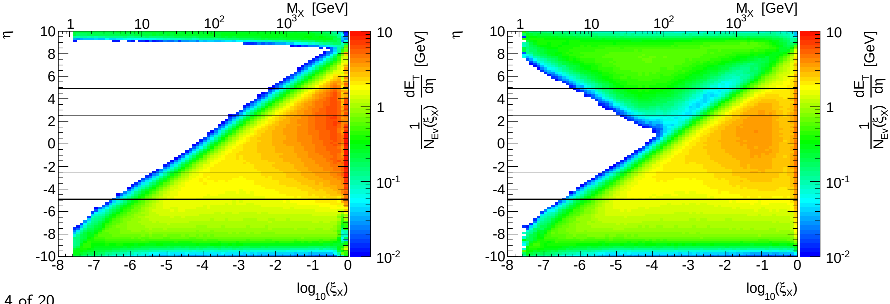
- Parameterised by ξ parameter. $\xi = M_X^2/s$ where M_X is the invariant mass of the larger diffractive system (c.f. M_Y).
- For a diffractivly scattered proton, ξ is equivalent to the fractional energy loss of the proton.
- Flux is $\approx$ flat in $\log(\xi)$ due to $1/M_X^2$ dependence on cross section from Regge theory.
- Many different flux models in different generators.





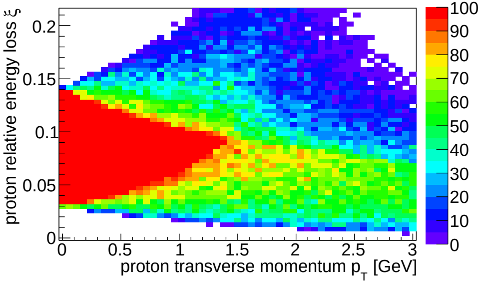
Diffractive Kinematics: Generator Energy Flow

- Kinematics of diffractive dissociation results in asymmetric particle production in the (M_X, p) or $(M_X, M_Y$ systems.
- Aim to use proton tagging to enhance the diffractive selection, probe the particle correlations and dynamics of the diffractive systems.



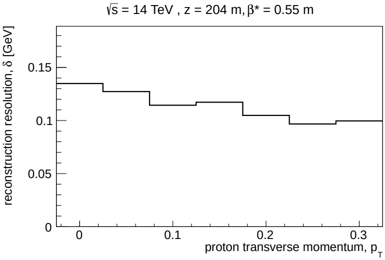
AFP Acceptance

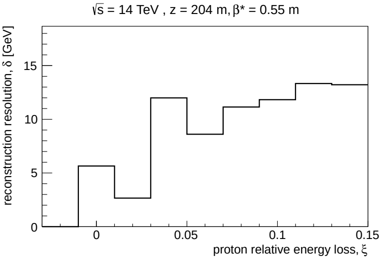
- Apply proton tagging to standard MinBias measurements.
- Use acceptance maps kindly provided by M. Trzebinski.
  - ATLAS Forward Physics detector at 210 m from IP.
  - Collision optics, $\beta^* = 0.55$ m.
  - $\sqrt{s} = 14$ TeV.
  - Distance from beam 0–4 mm ($\approx 20\sigma$).



AFP Reconstruction

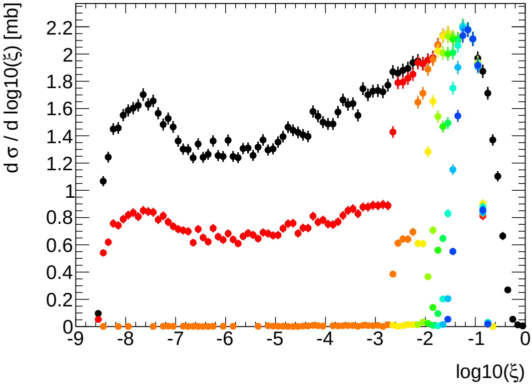
- Mainly driven by detector resolution, little dependence on $\sqrt{s}$.
- $p_{\rm T}$ resolution typically 0.1 GeV.
- ξ resolution 5 – 10 GeVfor $\xi = 0.04 - 0.14$.





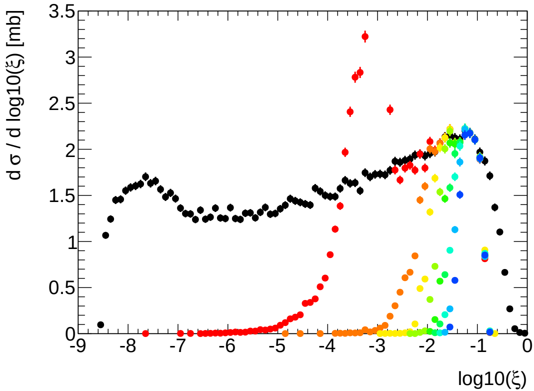
ξ Acceptance - Truth

- Pythia 8 4C Single Diffractive at $\sqrt{s}$14 TeV.
- Black, generated. Red, 0mm from beam - Blue, 4mm from beam.
- True diffractive proton ξ.



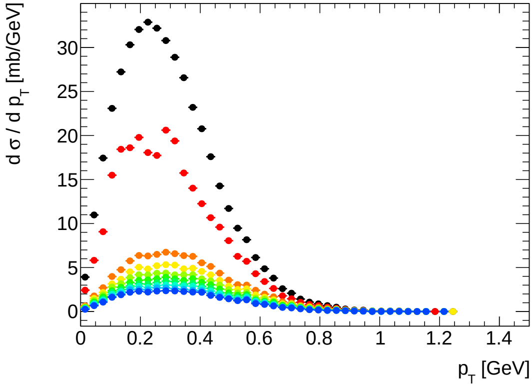
ξ Acceptance - Resolution Smeared

- `Pythia 8 4C Single Diffractive` at $\sqrt{s}14$ TeV.
- Black, generated. Red, 0mm from beam - Blue, 4mm from beam.
- Diffractive proton ξ smeared by AFP resolution.



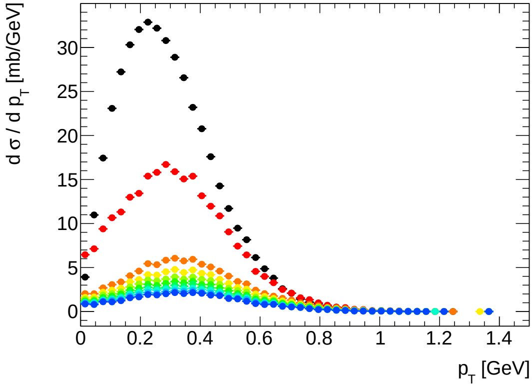
p_T Acceptance - Truth

- `Pythia 8 4C Single Diffractive` at $\sqrt{s}$14 TeV.
- Black, generated. Red, 0mm from beam - Blue, 4mm from beam.
- True diffractive proton p_T.



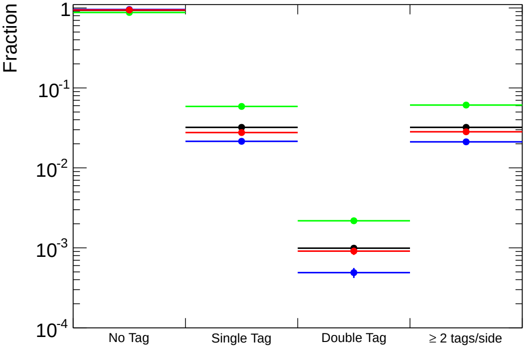
p_T Acceptance - Resolution Smeared

- `Pythia 8 4C Single Diffractive` at $\sqrt{s}$14 TeV.
- Black, generated. Red, 0mm from beam - Blue, 4mm from beam.
- Diffractive proton p_T smeared by AFP resolution.



Protons reaching AFP

- Diffractive protons are not the only *p* reaching the forward detectors. Black=Inelastic, Green=SD, Blue=DD, Red=ND.
  - Forward shower particles, forward proton remnants
  - More detials in previous talk, R. Staszewski.

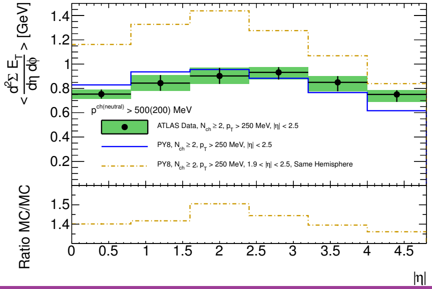


Plans for report

- Revisit some past ATLAS studies with early data.
- Use AFP acceptance maps for trigger and (optional) reconstructed ξ to enhance diffractive contribution to MinBias studies.
  - Charged particle multiplicities. Extra diffractive enhancement at low N_{ch}?
  - Diffractive gap spectra. Distinguishing power between SD and DD?
  - Energy Flow. Asymmetric flow with reference to proton tag?
  - Identified particle spectra. Different Λ and K_{s} spectra in tagged events?

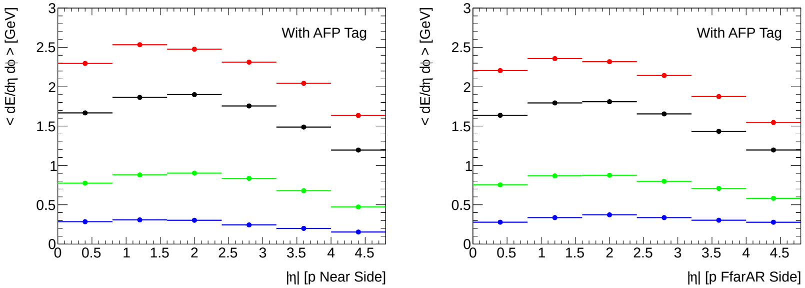
Forward Energy

- We have discussed previously how a common definition could allow us to historic and future energy flow measurements.
  - Treat each hemisphere separately, 1/event for `LHCb`, 2/event for others.
  - Require $N_{\mathrm{ch}} \geq 2$, $p_{\mathrm{T}} \geq 200$ MeV within $\pm 1.9 < \eta < \pm 2.5$.
  - Correct to E flow of charged(neutral) particles with $p > 500(200)$ MeV.



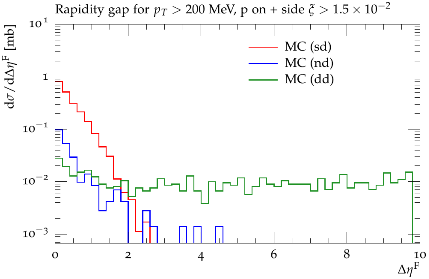
First Look - EFlow with a proton tag

- Require exactly 1 ASide proton, 0 CSide protons (AFP210, $\beta^* = 0.55m$, d=3mm, $\sqrt{s} = 14$ TeV).
- Shape comp: Black=Inelastic, Green=SD, Blue=DD, Red=ND.
- Split into hemispheres **near**est and **far**thest from p-tag.
- No significant shape change observed yet - more study needed.



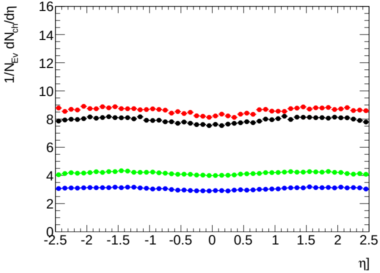
Diffraction with a gap

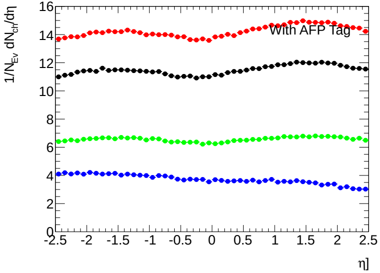
- As observed in studies by O. Kepka, shape differential between SD and DD.
- SD falls away as expected due to large diffractive mass needed for proton-tag ($M_X > 1.7$ TeV).
- Interesting behaviour of forward dissociated systems in DD, looks to give uniform trigger - independent of mass. More investigation...



First Look - Charged Particle Multiplicities: η

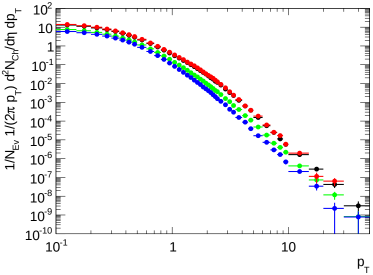
- Tag exactly 1 ASide proton, 0 CSide protons (AFP210, $\beta^* = 0.55m$, d=3mm, $\sqrt{s} = 14$ TeV).
- Shape comp: Black=Inelastic, Green=SD, Blue=DD, Red=ND.
- Look at standard analysis ($N_{\text{ch}} \geq 2, |\eta| < 2.5, p_{\text{T}} > 100$ MeV) with/without tag.
- Interesting slope for DD, no obvious diffractive enhancement.

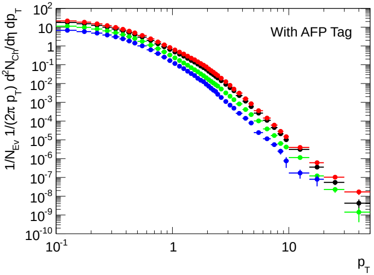




First Look - Charged Particle Multiplicities: p_T

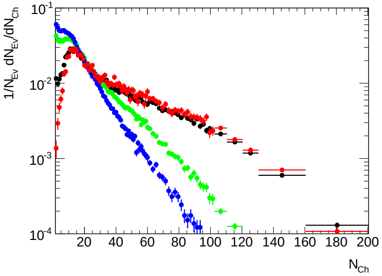
- Tag exactly 1 ASide proton, 0 CSide protons (AFP210, $\beta^* = 0.55m$, d=3mm, $\sqrt{s} = 14$ TeV).
- Shape comp: Black=Inelastic, Green=SD, Blue=DD, Red=ND.
- Look at standard analysis ($N_{ch} \geq 2, |\eta| < 2.5, p_T > 100$ MeV) with/without tag.
- Little to see in $p_T$spectrum.

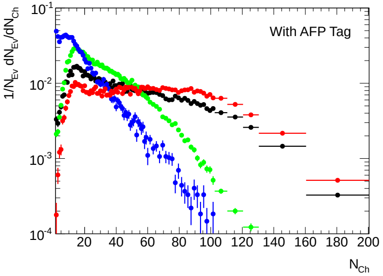




First Look - Charged Particle Multiplicities: N_{ch}

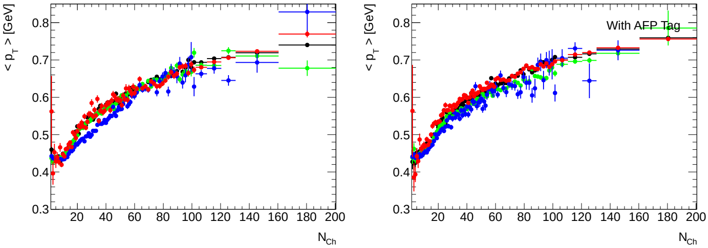
- Tag exactly 1 ASide proton, 0 CSide protons (AFP210, $\beta^* = 0.55m$, d=3mm, $\sqrt{s} = 14$ TeV).
- Shape comp: Black=Inelastic, Green=SD, Blue=DD, Red=ND.
- Look at standard analysis ($N_{\mathrm{ch}} \geq 2, |\eta| < 2.5, p_{\mathrm{T}} > 100$ MeV) with/without tag.
- Nice additional enhancement visible at low N_{ch}.





First Look - Charged Particle Multiplicities: N_{ch} vs. $< p_T >$

- Tag exactly 1 ASide proton, 0 CSide protons (AFP210, $\beta^* = 0.55m$, d=3mm, $\sqrt{s} = 14$ TeV).
- Shape comp: Black=Inelastic, Green=SD, Blue=DD, Red=ND.
- Look at standard analysis ($N_{ch} \geq 2, |\eta| < 2.5, p_T > 100$ MeV) with/without tag.
- May also hold interesting sensitivity at low N_{ch}.



Conclusion

- Proton tagging should yield regions of phase space with enhanced diffractive contributions.
- Need to study the origin of protons which will reach AFP.
- Investigate sensitivity as a function of the distance of the detector from the beam.
- Investigate gains to be made in standard MinBias analyses at $\sqrt{s} \approx 14$ TeV.