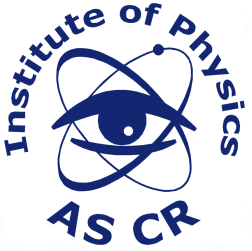

Rapidity gaps in diffractive dijets (with proton tag)

Monte Carlo feasibility studies

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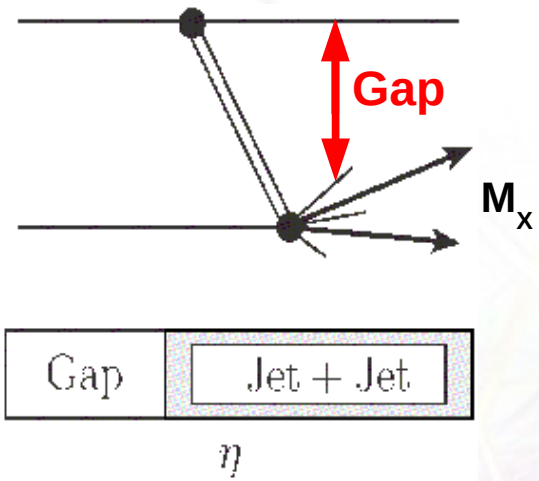
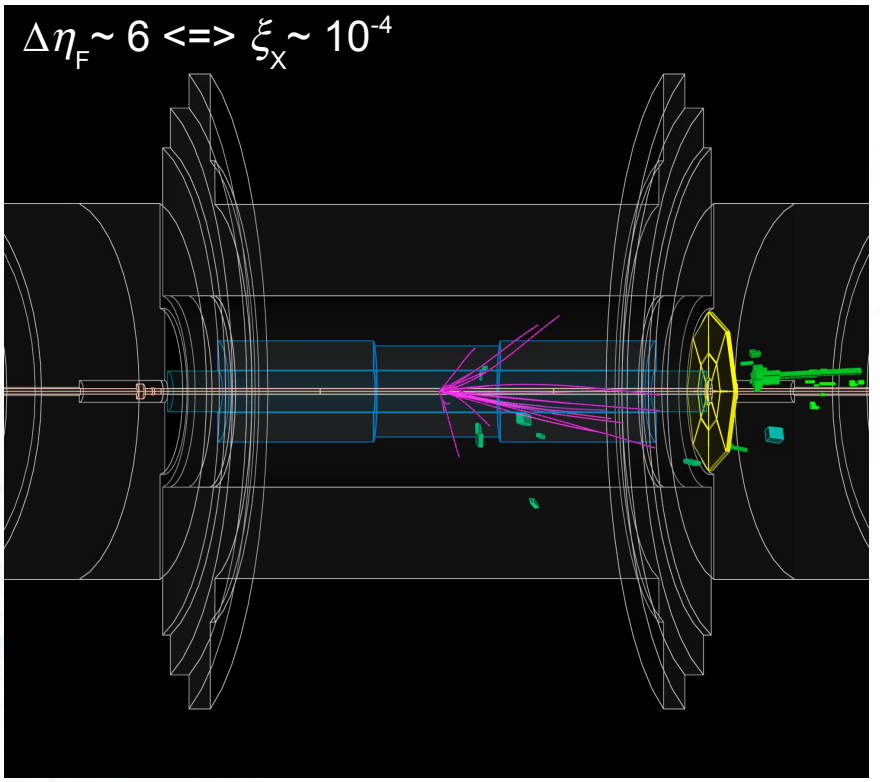
III Workshop on QCD and Diffraction at the LHC

Diffractive dijets



Single diffraction (SD)



- **Single diffraction** – processes of the form … **pp->pX**
  Exchange of colorless object with vacuum quantum numbers (Pomeron) => only dissociated-proton's remnants, no other hadronic activity in large areas of η
- Typical signature ⟶ **rapidity gaps** ($\Delta\eta_F$) … $\Delta\eta_F \sim -\ln\xi_X$, $\xi_X = M_X^2 / s$
  A bigger distance from the edge of the detector (η=4.9) to the closest cluster or track with p_T>200 MeV.
- Low pile-up required for gap recognition, proton tagging could help

Goals and motivations

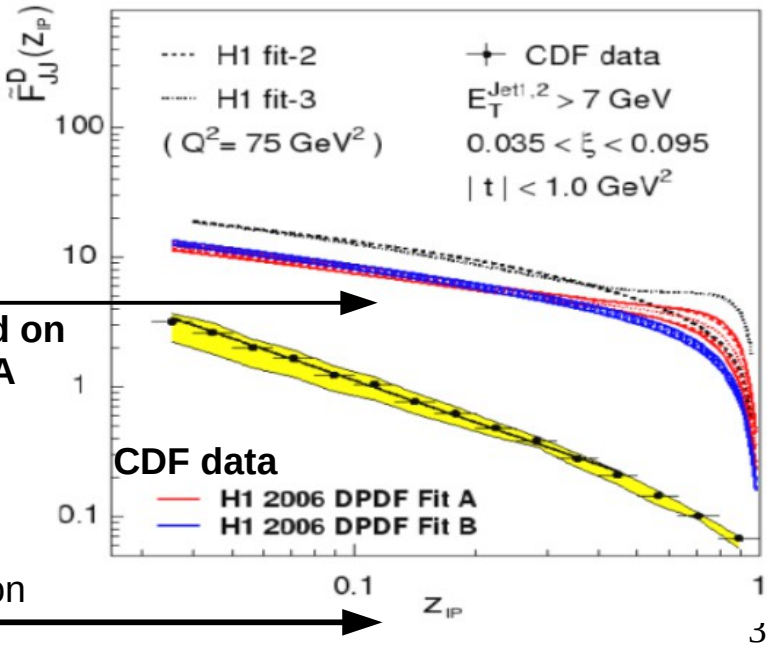
- Main motivation

  Diffraction first observed at HERA (*ep* collisions). Diffractive PDF measured.

  Then studied at Tevatron (*pp*_bar collisions). Structure function measured **~10x smaller** than HERA's dPDFs predictions for *pp*_bar collisions (rescattering of dissociated system *X* with intact proton) → Gap Survival Probability

- Goals

  - **gap survival probability** (S^2) in *pp* collisions (theoretical prediction for LHC 7TeV is **5-7%**)
  - measurements of diffractive structure function **dPDF**
  - to study effects of proton tagging by AFP/ALFA



Predictions based on dPDFs from HERA

Momentum fraction of parton in Pomeron

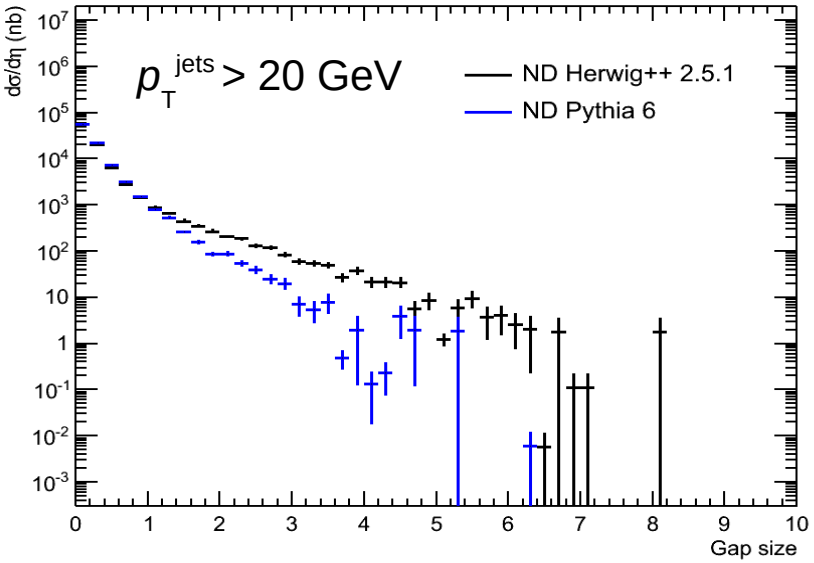
MC truth studies

- Truth studies of Pythia 6, 8, Herwig++ and Pomwig based on private production
  - Herwig++ … versions 2.4.2 and 2.5.1 (tunes UE-EE-3 and UE7-2)
  - Pythia … versions 6.4.23 (tune AMBT1) and 8.150 (AUET2B)
  - Pomwig … version 2.0.2
- Event selection – dijet events, $p_T^{jets} > 20$ GeV
  (jet reconstruction algorithm – FastJet 3.0.0)
- **Gap definition – largest gap in η (with no stable truth particle with p_T>200 MeV) to the edge of detector (|η|<4.9)**
- Significant differences between ND Herwig and Pythia observed
  - ND Herwig provides much slower gap spectrum fall

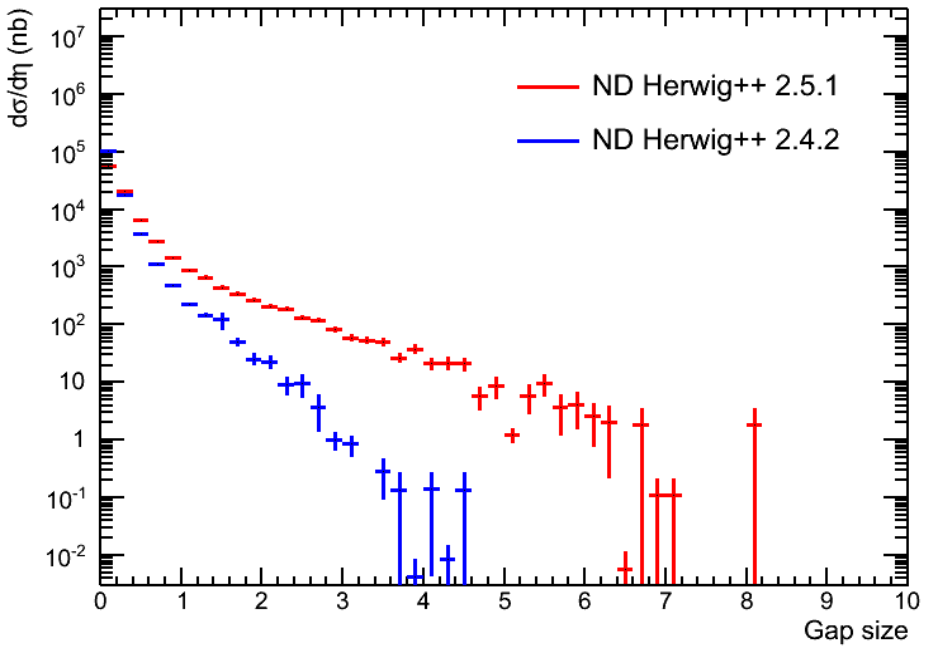
Due to the difference in hadronisation models.

Herwig++: *clustering hadr.* (smaller p_T/multiplicities in fwd region)

Pythia: *string hadronization*



Discrepancies in ND gap spectra



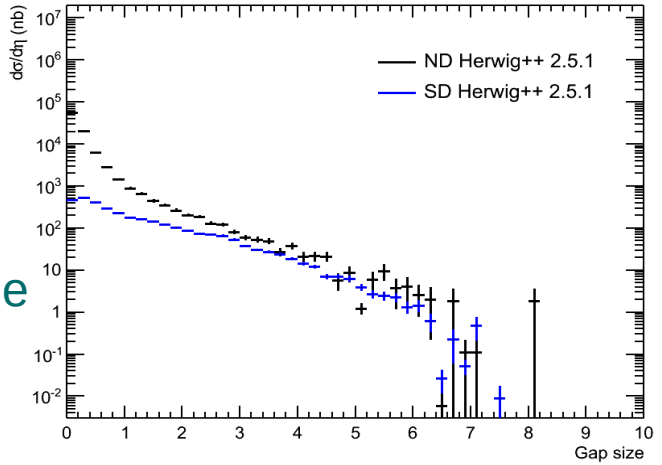
Gaps calculated by taking into account particles with p_T > 200 MeV only.

Jet p_T > 20 GeV cut applied to leading and sub-leading jets.

- Herwig++ 2.4 doesn't describe non-diffractive ATLAS data well
  → newer version (2.5) and tunes should be used

- … however, gap-spectra give unexpected predictions
  (big gaps created by ND events)
  → hard single diffraction would be hardly observable

  This behavior also observed for soft diffraction
  (Eur. Phys. J. C72 (2012) 1926)

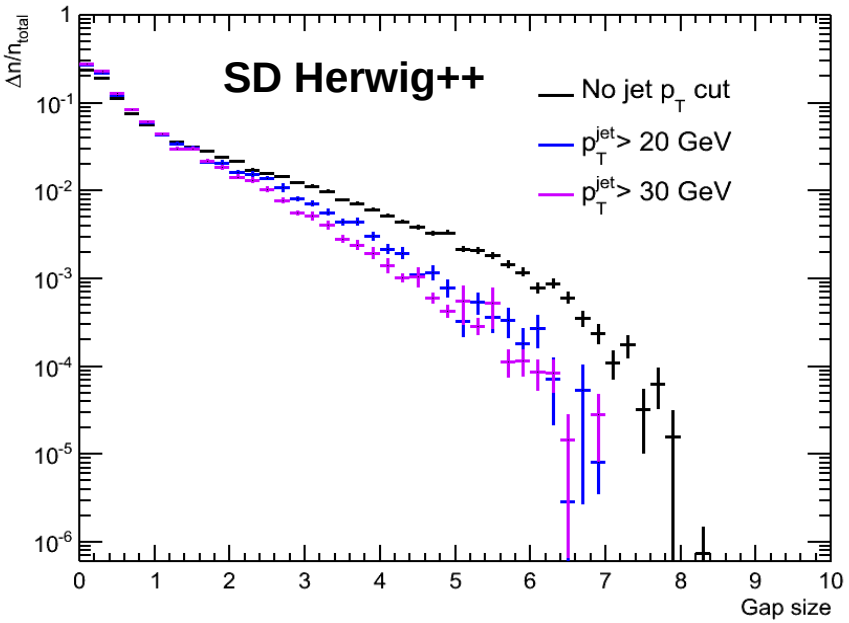


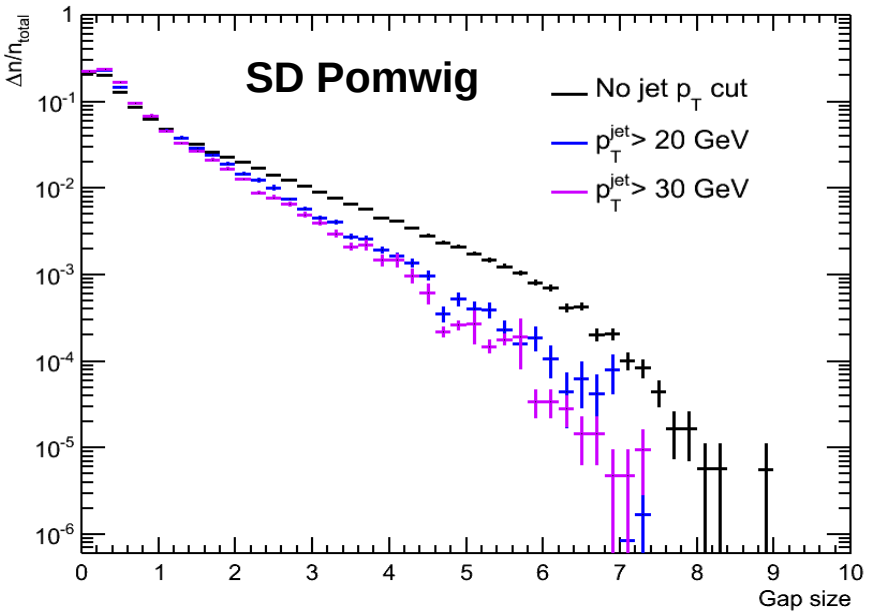
Influence of jet momentum cut

- The intention is to study single diffraction in hard dijet events
  → requirement on presence of at least 2 jets with $\boldsymbol{p_T^{jet} > 20}$ **GeV**

- Due to this p_T^{jet} requirement we loose the diffractive plateau in gap-size distributions

- In plots below, we can't see any plateau even for histograms with no jet p_T cut as these events were generated with $p_T^{parton} > 7$ GeV requirement



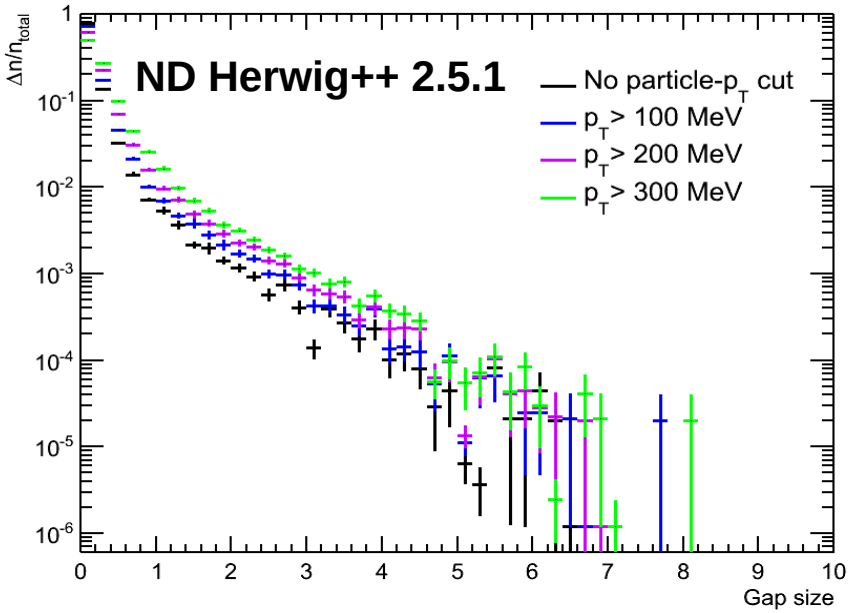


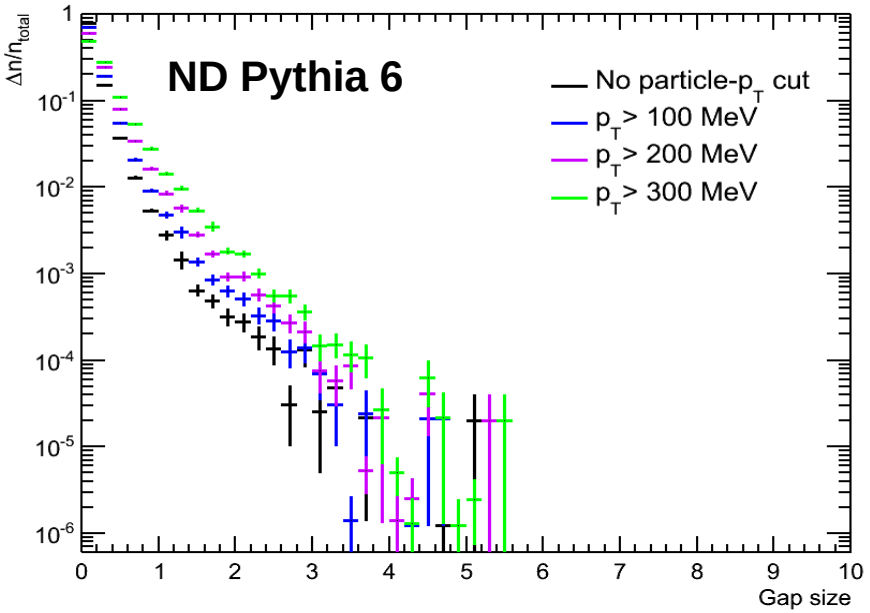
Influence of p_T^{min}-particle cut

- The tracker and calorimeter have limited resolution – we can't see particles that are too soft
  → need to set some **min. p_T cut** on particles to mimic these conditions

- By considering only particles above certain threshold we arbitrarily increase gap-sizes

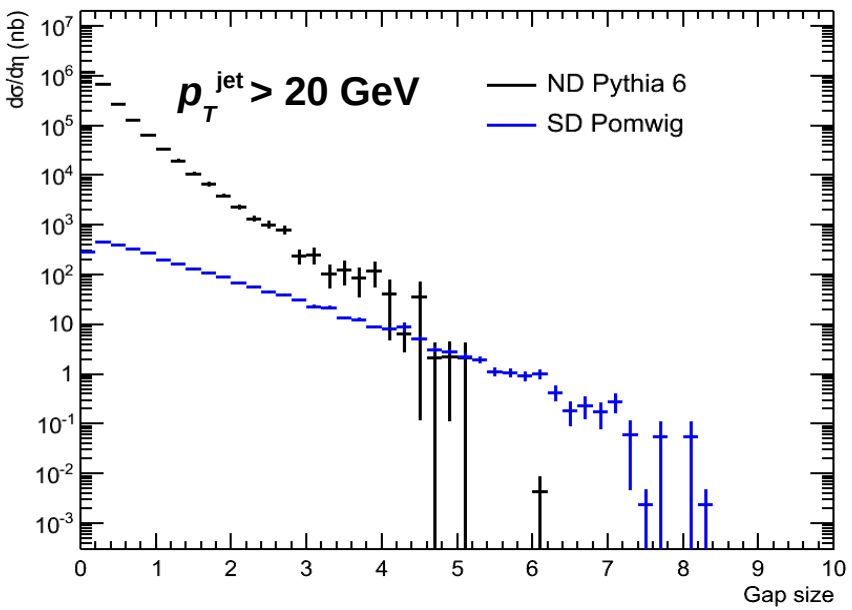
- Tests with several p_T thresholds to estimate this influence …
  ND Herwig++ … ~ 2x-2.5x bigger yields for $\Delta\eta_F > 1$ in p_T>200MeV case
  ND Pythia 6 … ~ 2.5x-3x bigger yields for $\Delta\eta_F > 1$ in p_T>200MeV case

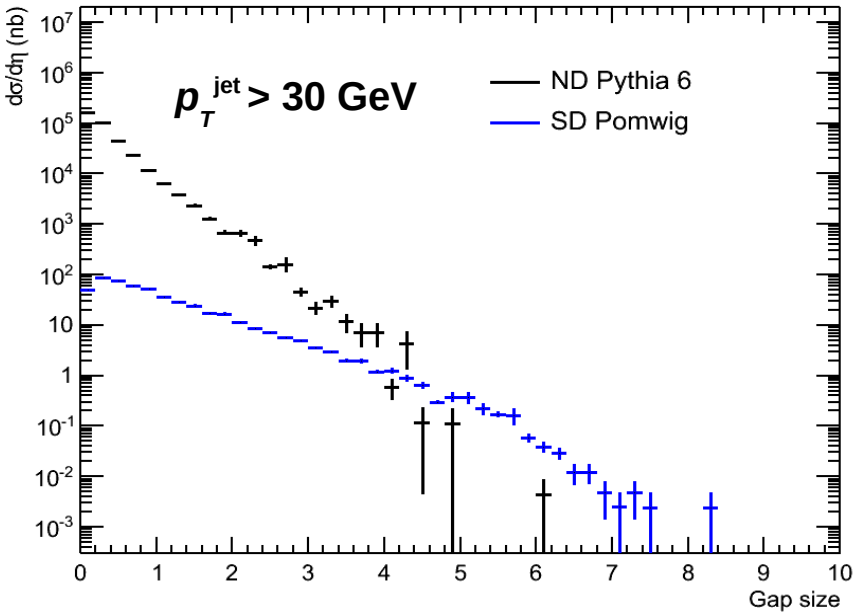




Gap spectra

Generator level





Plots **include KMR prediction of S^2** (gap survival probability) for CMS energy 7 TeV proton-proton collisions … **S^2 = 6 %**

Significant gap spectra fall with increasing p_T cut, no plateau observed due to the presence of hard dijet system.

By using 20 GeV jet cut we gain about one order of magnitude in σ compared to 30 GeV cut. Not possible to go below 20 GeV – no JES available.

Gap spectrum - summary

Generator level

Cross-sections (nb) for different gap sizes $\Delta\eta_{gap}$ and p_T^{jet}>20GeV, S^2 = 0.06

	$\Delta\eta_F > 3$	$\Delta\eta_F > 4$	$\Delta\eta_F > 5$
ND Pythia	**155**	**18**	**0.4**
SD Pomwig	**394**	**127**	**33**
SD Pomwig * S^2	**1.2**	**0.4**	**0.1**

In total … $\Delta\eta_F > 3$: **SD*S^2 / ND = 0.15**

$\Delta\eta_F > 4$: **SD*S^2 / ND = 0.42**

$\Delta\eta_F > 5$: **SD*S^2 / ND = 5**

For measurement, improvement could be achieved by proton tagging by forward detectors.

Current work and future prospects

- This was a 7TeV feasibility study before looking at data

  Significant discrepancies in ND modeling between Herwig++ and Pythia, no diffractive plateau observed due to the requirement on presence of hard dijet system, SD/ND ~ 0.4 for gaps bigger than 4 (gap survival probability included)

- Currently working on hard SD measurement of rapidity gaps on ATLAS low-pileup data (early 2010 data periods)

  Tuning triggers, selection cuts, getting a handle on ATLAS sensitivity to large gap events, getting a gap survival probability

- Will look with Tim Martin on AFP related extension of dijet diffractive analysis
  - MC feasibility study at 13TeV with addition of an intact proton tag in AFP/ALFA (based on acceptance in t, ξ variables)
  - will be based on current 7TeV analysis and cut definition tuning
  - aiming for LPCC report in Spring 2014