Double Pomeron Exchange Jet Production Feasibility Studies

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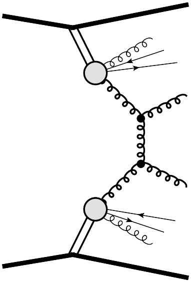
DPE Jet Production

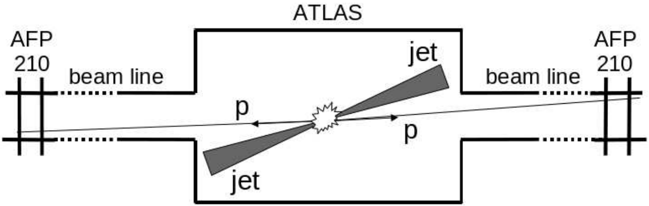
DPE – Double Pomeron Exchange

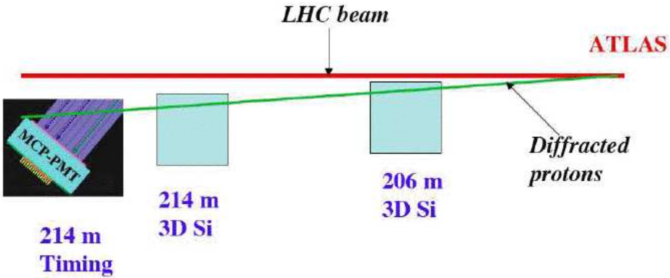
Signature: two jets in central region + two intact protons.



- Studies performed at high values of pile-up ($\mu \sim 23$) reveal that the purity was very small.
- Studies performed at generator level at low values of pile-up ($\mu \sim 1$) show that DPE JJ are possible to be measured using AFP detectors.
- How the situation change when timing and one vertex requirements are considered separately?
- Will this conclusion change when full simulation is considered?

Measurement Idea

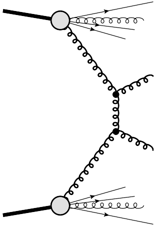




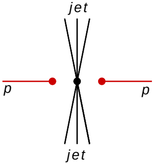
- Detector located close to the beam – Roman Pots.
- Proton position measurement (3-D Pixel detectors, SiD).
- Precise time of flight measurement (QUARTIC timing detector, TD).

- highest cross section among all hard DPE processes – no other DPE process that is a background,
- background due to non-diffractive (ND) and single diffractive (SD) jets overlaid with pile-up protons

non-diffractive jets + pile-up

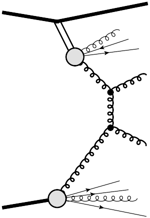


Non−difftactive Production

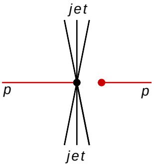


$\sigma \sim 10^4$ times higher than DPE

single diffractive jets + pile-up



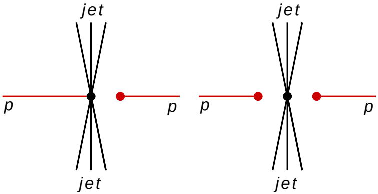
Single Diffractive Production



$\sigma \sim 10^2$ times higher than DPE

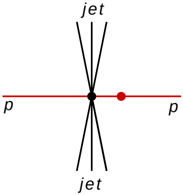
Probability of Single and Double Tag

Single Tagged Soft Interaction(ST)



SD JJ + ST   ND JJ + ST + ST

Double Tagged Soft Interaction(DT)



ND JJ + DT

Single Tag (ST) Interactions					
probability					
default	0.18	0.045	–	0.0055	0.038
MBR	0.12	0.040	0.42	0.0054	0.030
cross section [mb]					
default	2.3	0.40	–	0.32	3.0
MBR	1.3	0.38	0.34	0.30	2.3
	SD	DD	CD	ND	MB

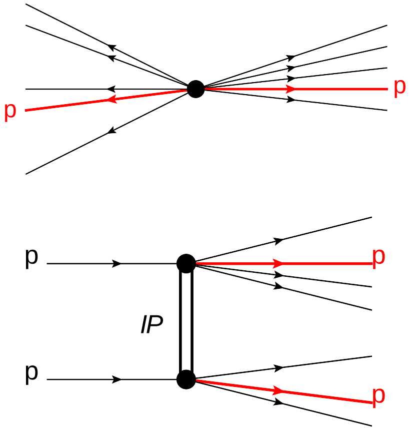
Double Tag (DT) Interactions					
probability $[10^{-3}]$					
default	0.47	0.37	–	0.014	0.13
MBR	0.31	0.36	26.0	0.012	0.37
cross section [μb]					
default	6.1	3.3	–	0.81	10
MBR	3.5	3.4	21	0.67	28
	SD	DD	CD	ND	MB

default – Schuler and Sjöstrand (PomFlux = 1)

MBR – Minimum Bias Rockefeller (PomFlux = 5)

Double Tagged Soft Interaction(DT)

E.g. Double Diffractive Dissociation with protons from hadronisation propagating in forward direction.



Large differences between MC generators and tunes!

(discussed in my last presentation about DPE JJ analysis)

LHC Run Conditions

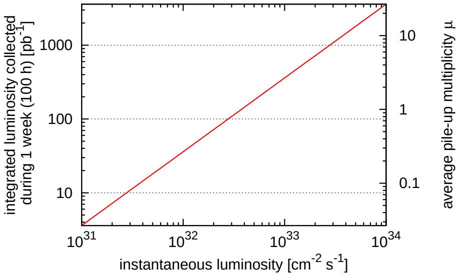


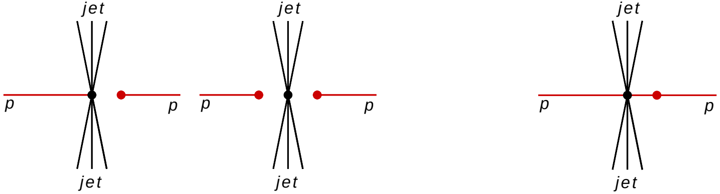
Figure: dependence between the instantaneous luminosity of the machine, the average pile-up multiplicity and the integrated luminosity collected in 100 hour of data taking (2808 bunches).

Signal selection:

- jets in ATLAS central detector,
- double tag in AFP,
- AFP timing (30 ps resolution, 1σ cut),
- one reconstructed vertex.

One Vertex Requirement (I)

- Background removed due to the presence of (at least) one additional soft interaction:

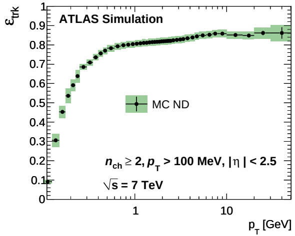


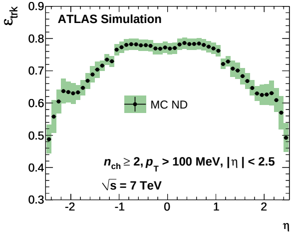
- Signal events accompanied by pile-up will also be rejected.

- Two inefficiency sources:
  - soft vertex is merged with a hard one (in this analysis distance of 2 mm was considered),
  - not enough reconstructed tracks pointing to the soft vertex.

One Vertex Requirement – Reconstruction Efficiency

- ATLAS track reconstruction efficiency:

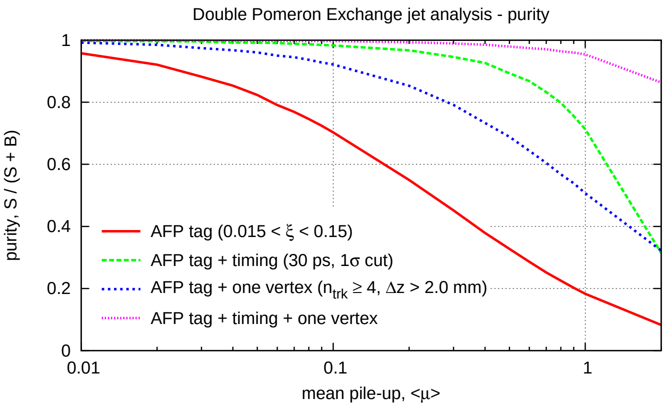




- **table**: prob. of the vertex reco. for a given number of tracks,
- weight considers cross sections and probabilities of having a proton with $0.015 < \xi < 0.15$

Min. number of tracks	Probability SD	DD	ND	MB
2	0.917	0.546	0.987	0.870
3	0.909	0.498	0.967	0.855
4	0.894	0.450	0.932	0.833
5	0.870	0.404	0.881	0.803

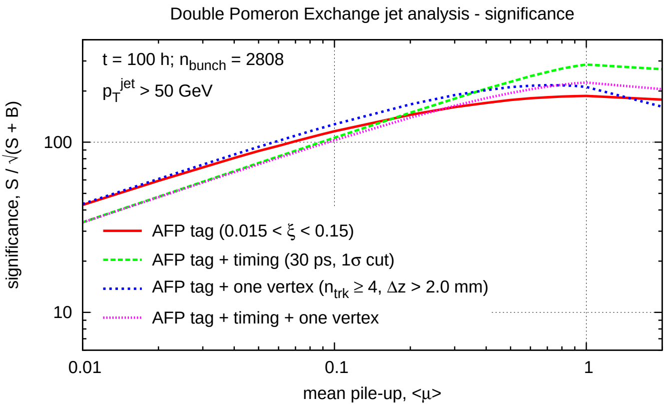
DPE JJ Analysis – Purity



Purity of 0.9 (0.5) is achieved for:

- $\mu < 0.03$ ($\mu < 0.3$) and AFP double tag,
- $\mu < 0.4$ ($\mu < 1.5$) and AFP double tag + timing,
- $\mu < 0.1$ ($\mu < 1$) and AFP double tag + one vertex,
- $\mu < 1.5$ ($\mu < 5$) and AFP double tag + timing + one vertex.

DPE JJ Analysis – Significance



- Highest significance for $\mu \sim 1$.
- For this μ differences between various requirements are smaller than factor 2.

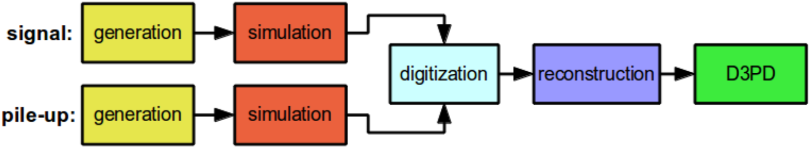
Past:

- generator level studies + proton transport* **or**
- full simulation of ATLAS central detector + proton transport*.

* – protons were transported using MAD-X or FPTracker

Present (in addition) – Geant4 simulation of whole forward region:

- Beam elements (beampipe, magnets, collimators) and forward detectors were implemented.
- Full simulation of event: ATLAS central detector AND proton transport.
- Need to write everything from scratch and to include AFP in all steps in simulation chain.



Full simulation studies confirmed that the DPE JJ production is possible to be measured once the AFP detectors are installed.

Public note in preparation.

Summary

- DPE jet analysis can be performed only with AFP double tag requirement and additional timing or one vertex constraint. Purity of 0.9 (0.5) is than achieved for:
  - $\mu < 0.4$ ($\mu < 1.5$) and AFP double tag + timing,
  - $\mu < 0.1$ ($\mu < 1$) and AFP double tag + one vertex.
- Obviously the bast way is to use all constraints if possible. In this case purity of 0.9 (0.5) is obtained for $\mu < 1.5$ ($\mu < 5$).
- Full simulation studies confirmed that the DPE JJ production is possible to be measured once the AFP detectors are installed.
- Public note based on full simulation of ATLAS detector is in preparation.

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