Diffractive and Low-X Physics at ATLAS.

MPI 2010

2nd December 2010

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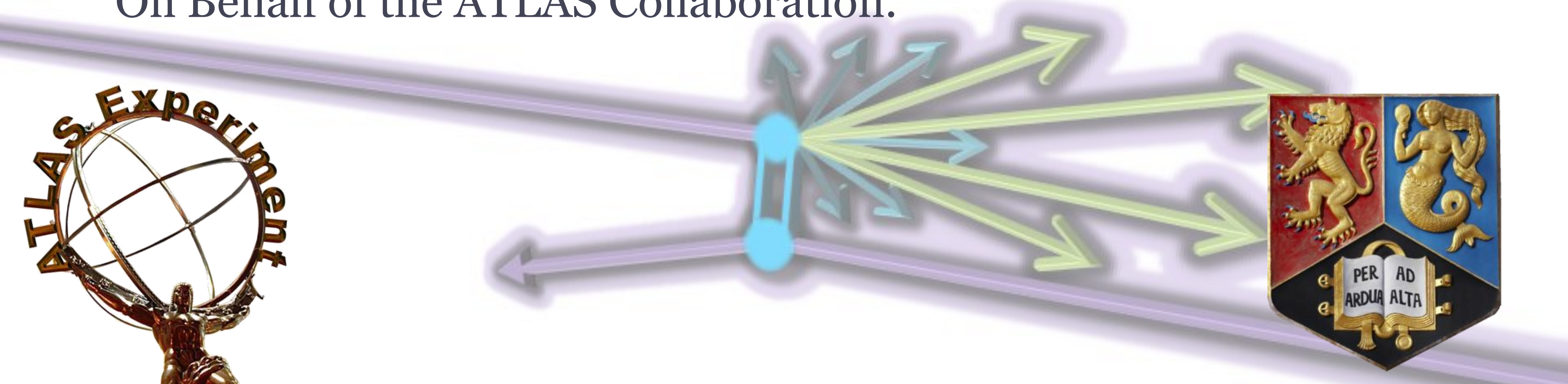
On Behalf of the ATLAS Collaboration.



ATLAS Experiment

UNIVERSITY OF BIRMINGHAM

Overview

Diffraction in ATLAS

Detector Performance

Soft Gaps in the Tracker

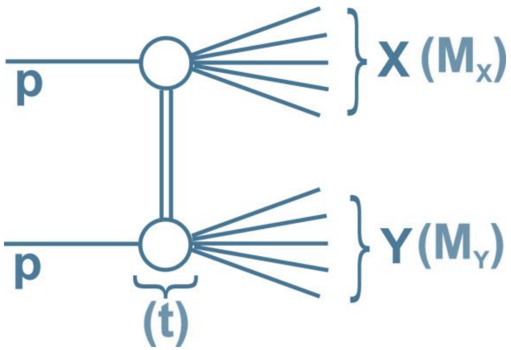
Gaps Between Jets

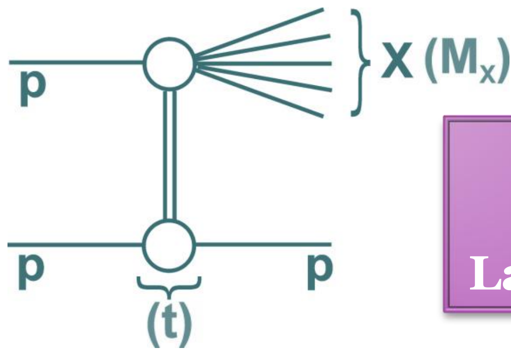
ATLAS-CONF-2010-048

ATLAS-CONF-2010-085

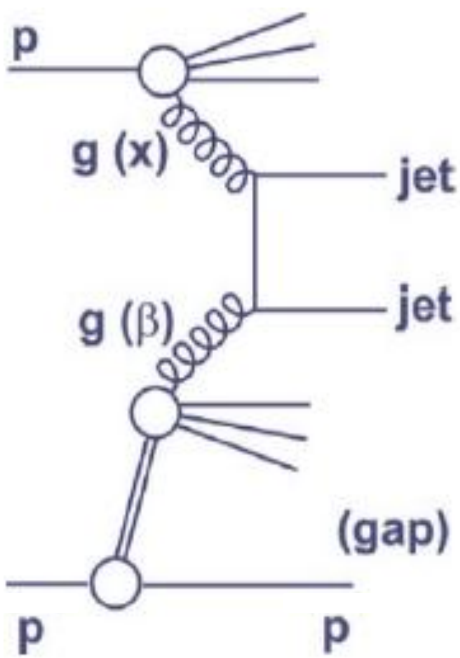
LHC Diffraction

$$\xi = \frac{M_X^2}{s}$$





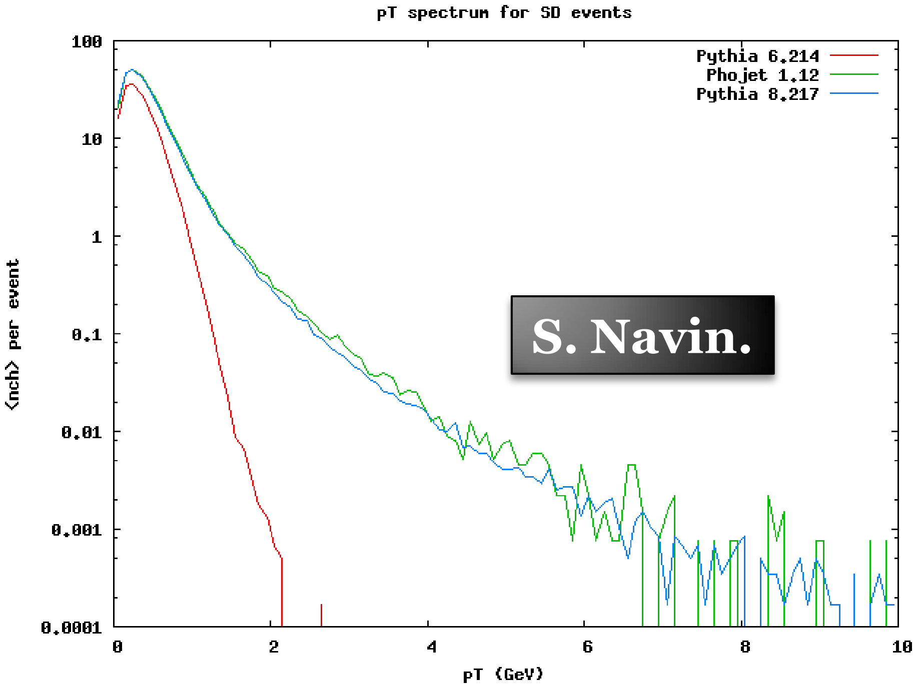
$\sigma_{\text{Diffractive}}/\sigma_{\text{Total Inelastic}}$
$\approx 20 - 30\%$
Large theoretical uncertainty.



- **Colour singlet** exchange between the protons.
- Leads to possibility **of large rapidity gaps**.
- Formulated in terms of **a pomeron flux** and **pomeron distribution functions**.
- Can be expressed in terms **of the kinematic variable, ξ**.
- **Hard interactions** possible **within diffractive systems**, such as diffractive di-jet production.
- **Gap survival in events with hard scale linked to MPI**.

Generator Differences

- Pythai6 uses only a soft fragmentation model, it **does not easily generate high p_T** particles.
- **Phojet** utilizes a **dual-parton model** to simulate the hard component.
- **Pythia8** includes pomeron parton distribution functions, allowing for a hard diffractive component.

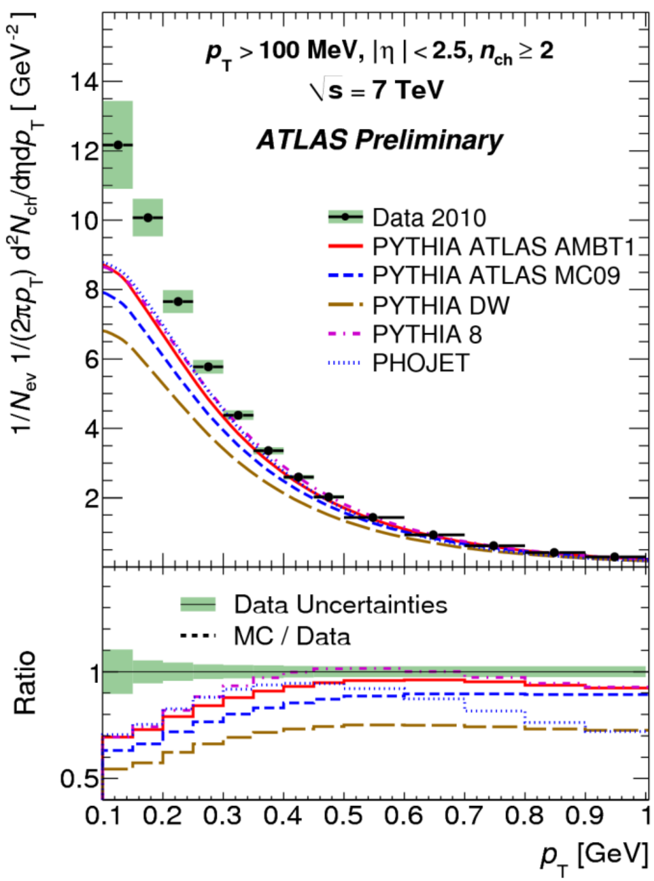


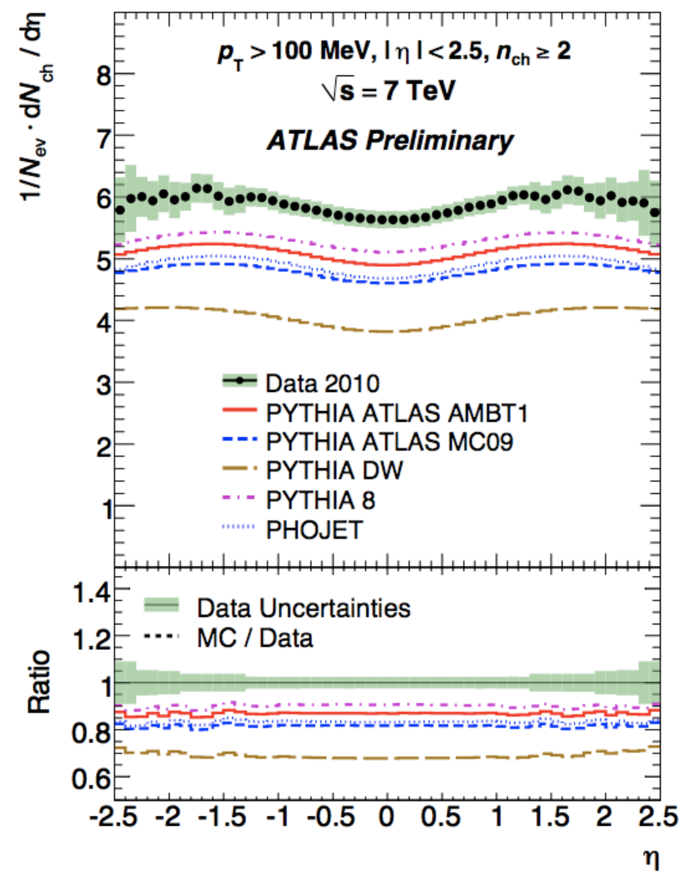
In ATLAS, we only see events where M_X > 10 GeV

- In **Pythia8**, diffractive mass (**M_X**) and momentum transfer **(t)** chosen with **Pomeron flux model**.
- Particles generated in **pomeron-proton** interaction **using pomeron PDFs from HERA**.
- Pythia handles **MPI, parton showers and hadronisation**.
- For **M_X < 10 GeV**
  - **Old, non-pertubatitive**, longitudinally stretched strings
- **For M_X > 10 GeV**
  - **New, pertubatitive**.

Low p_T Charged Particle Discrepancies

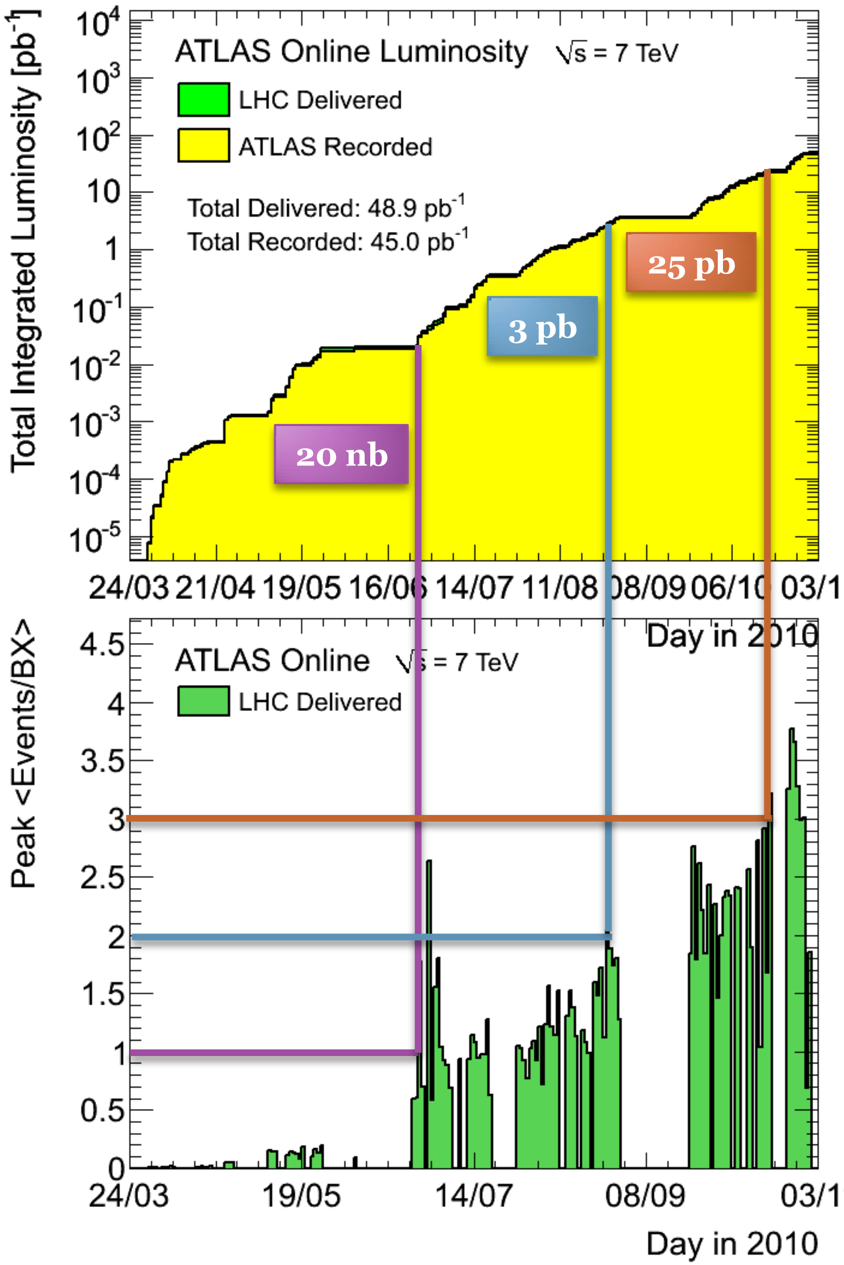
- **ATLAS** has studied events with 2 or more charged particles of **> 100 MeV** within **|η| < 2.5**. Tunes are **Non Diffractive Only**.
- See an **excess of low p_T** particles not described by MC.





2010 Pileup Profile

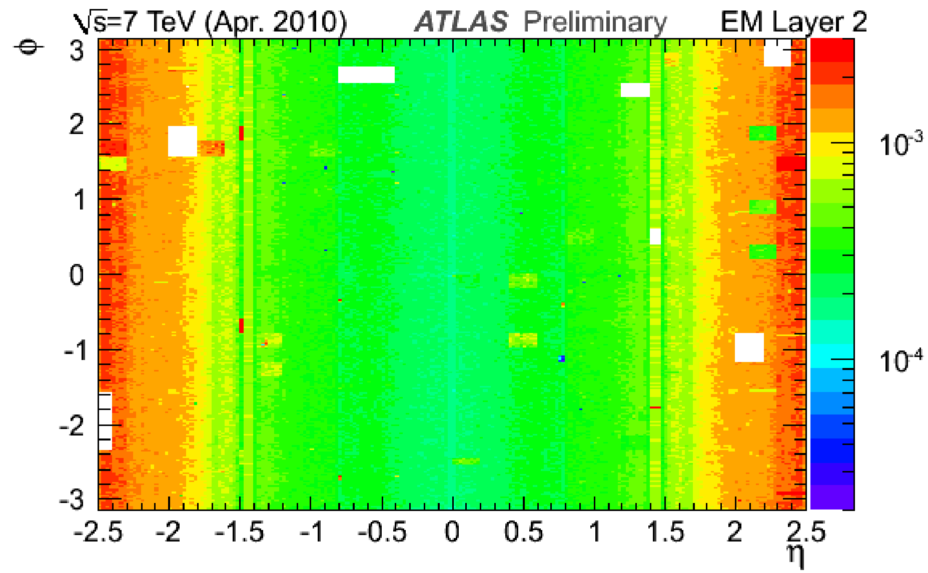
- Pileup quantified by counting **primary vertexes**.
- Predominantly a function of the **bunch current**.
- We have good sized data samples with **manageable pileup**.
- Lots of potential for **soft physics** requiring **clean environments**.

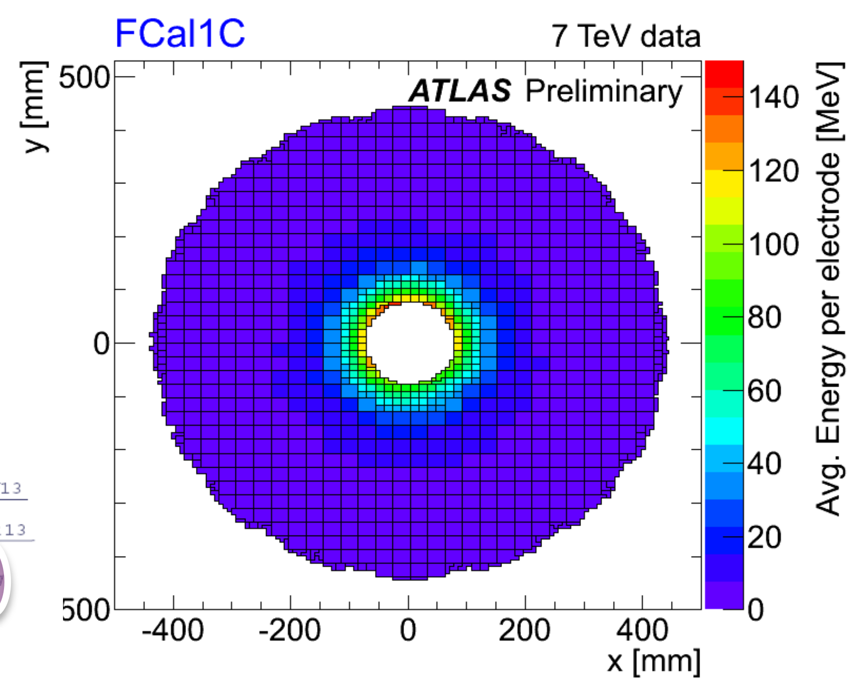


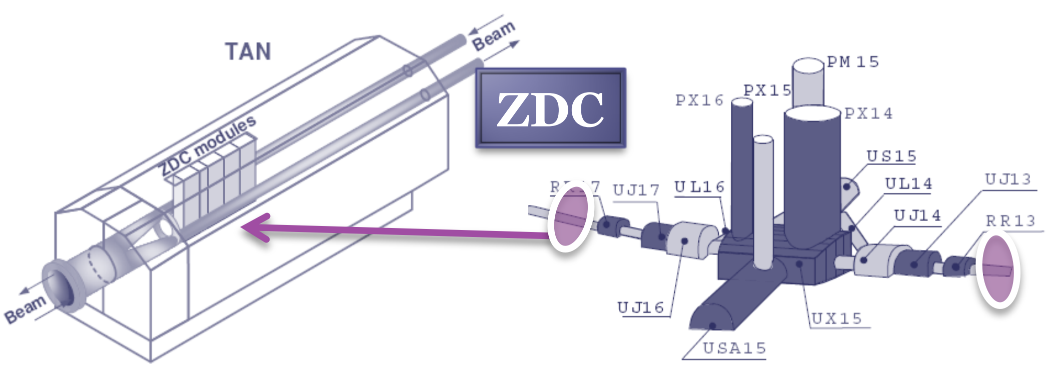
Energy Flow

- **LAr** Energy Flow with 5m **MBTS triggered** Minimum Bias events.
- Occupancy in cells ~**5σ above noise peak**.
- 1.3% **Dead**.
- 6% **Non-nominal HV**.
- 0.1% **Masked**, problematic cells.

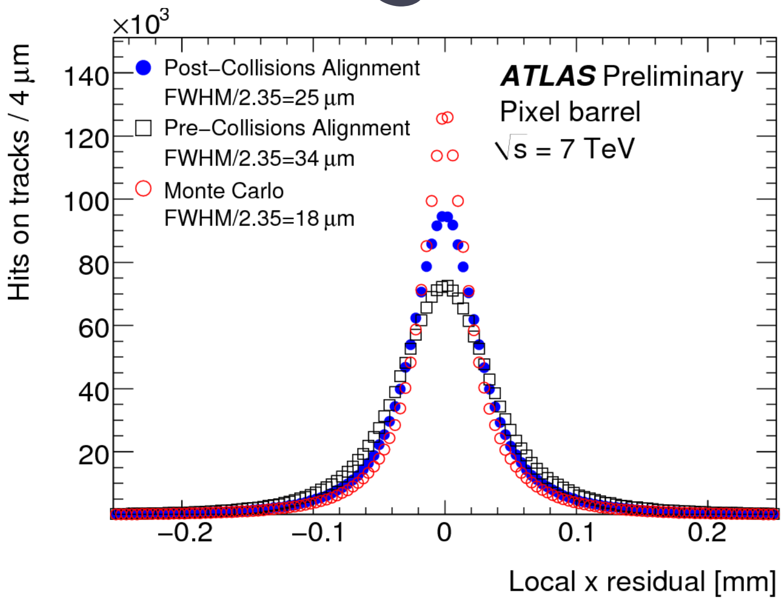
- **Forward calorimeter**, coverage up to **η 4.9**.
- Energy flow from first stable 7 TeV run.



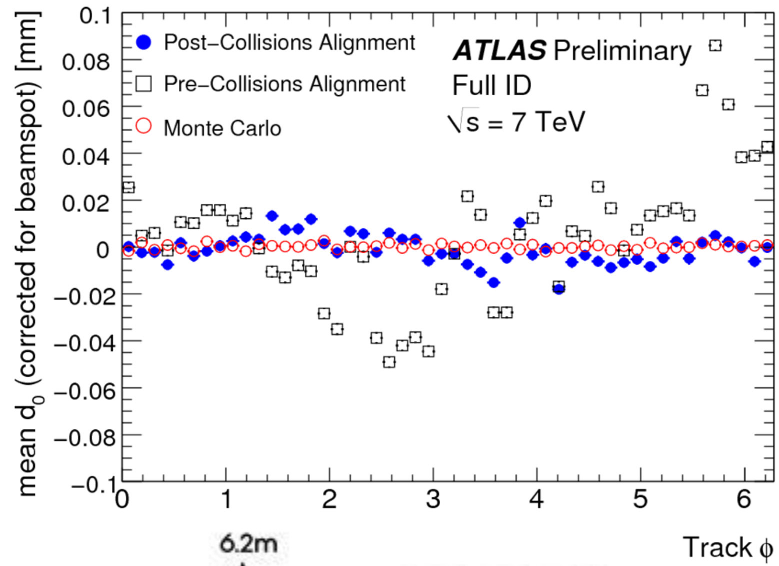


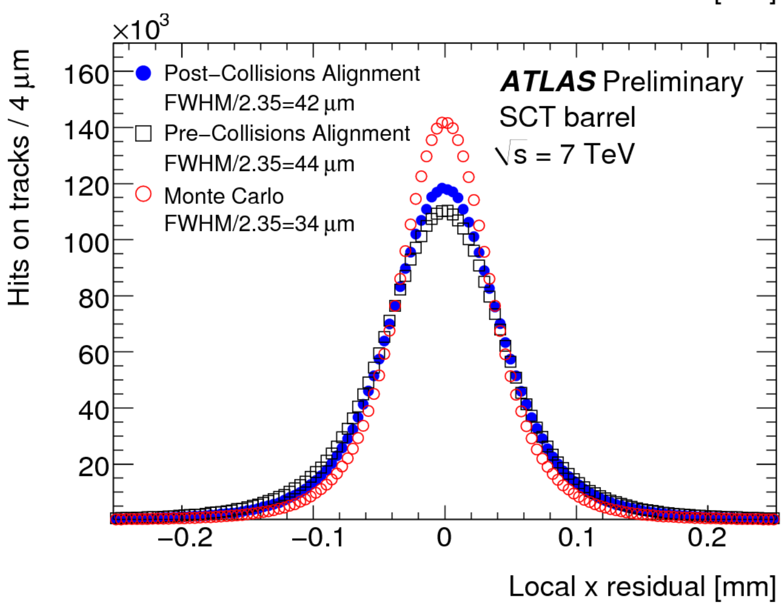


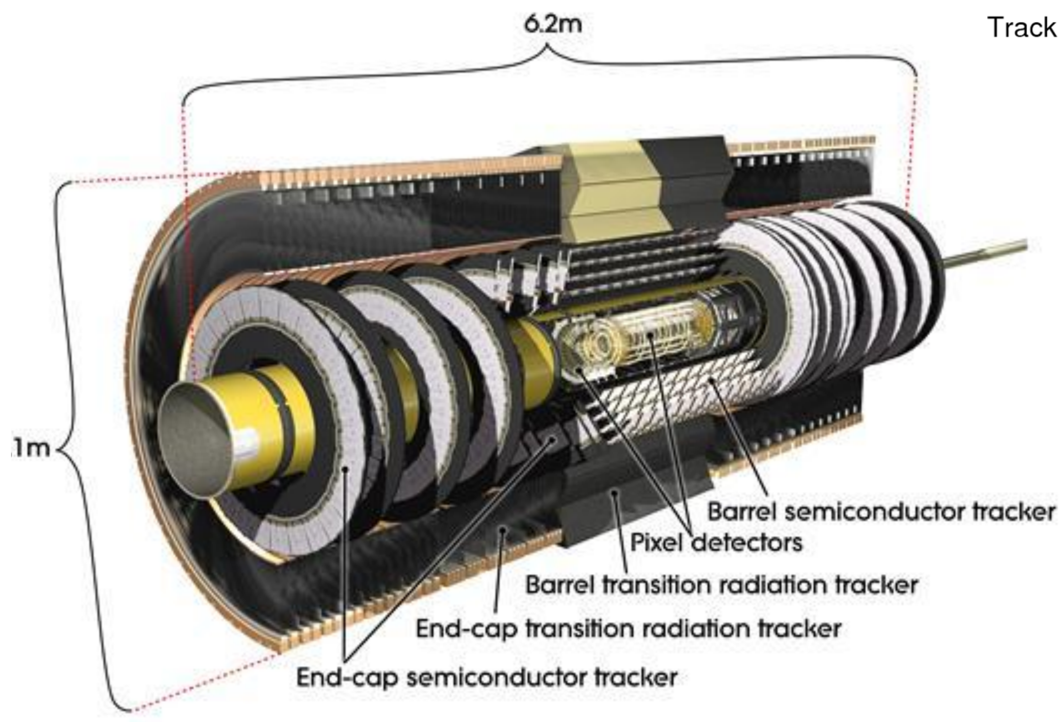
Tracking Performance



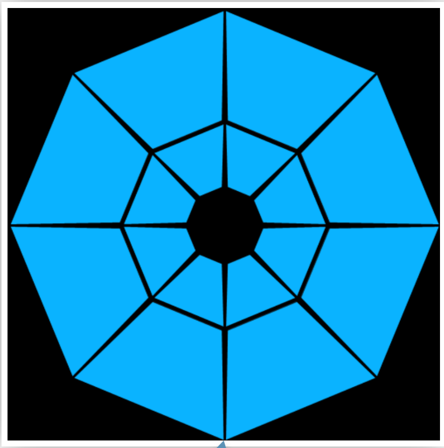
Inner detector alignment from collision data.



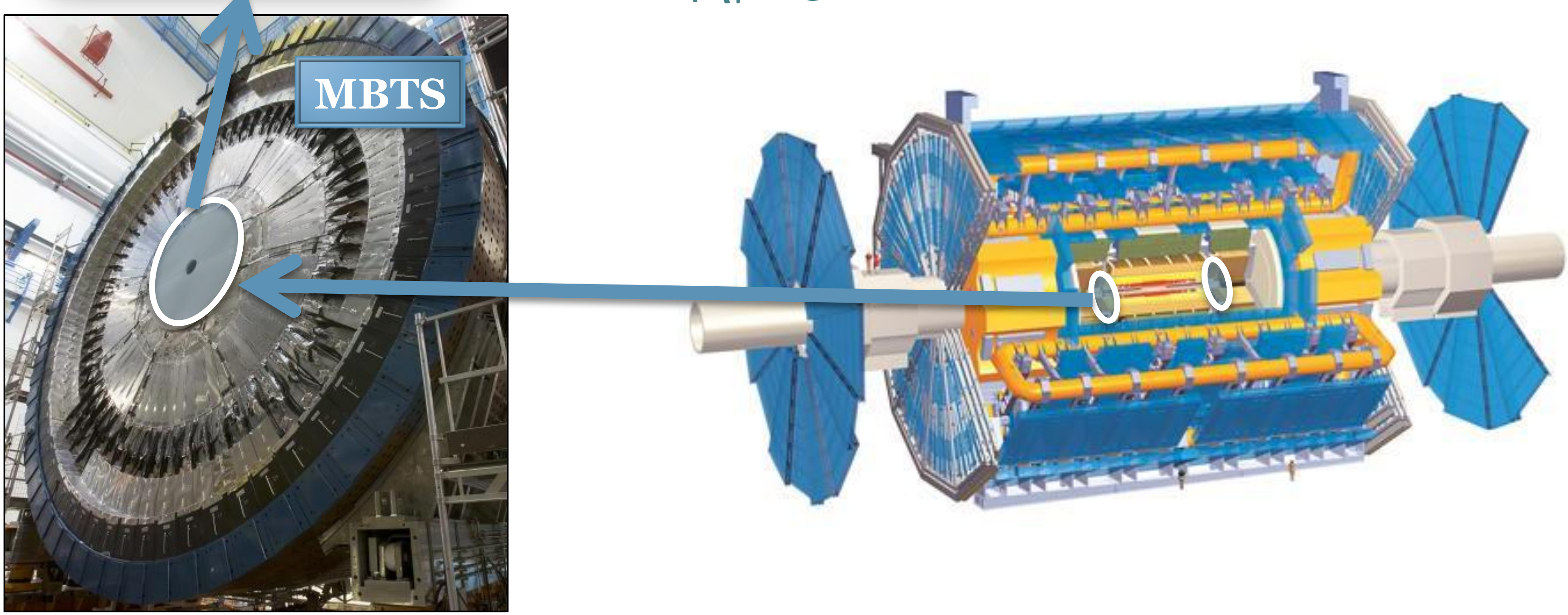




MBTS Trigger



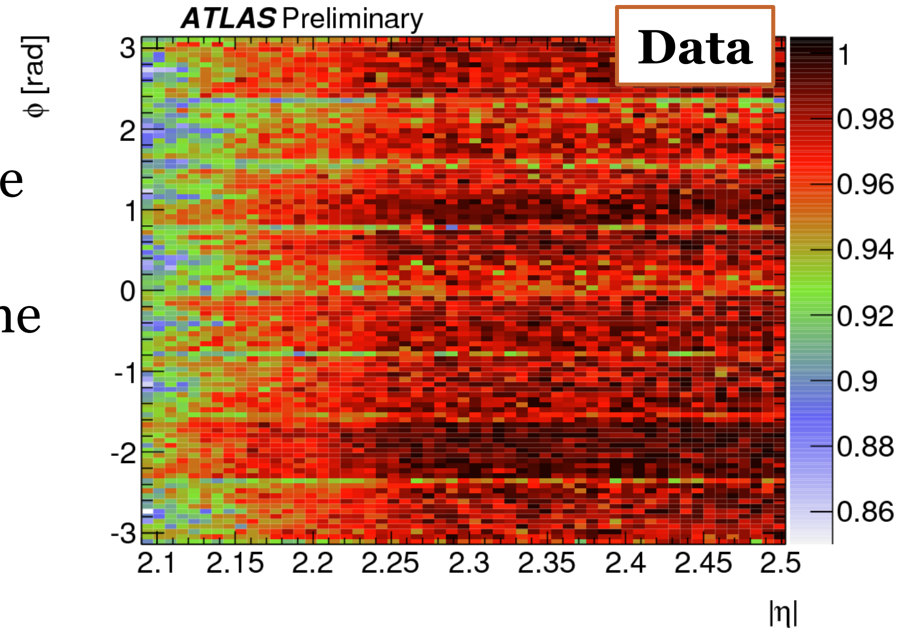
- **Segmented** into **16 counters** on **each side.**
- Plastic scintillator planes connected to photomultiplier tubes via wavelength shifting fiber.
- Highly efficient trigger on charged particles.
- Generally trigger on the **Inclusive Or** of both sided.
- **MBTS** is **the primary** Minimum Bias trigger.
  - **$2.1 < |\eta| < 3.8$**

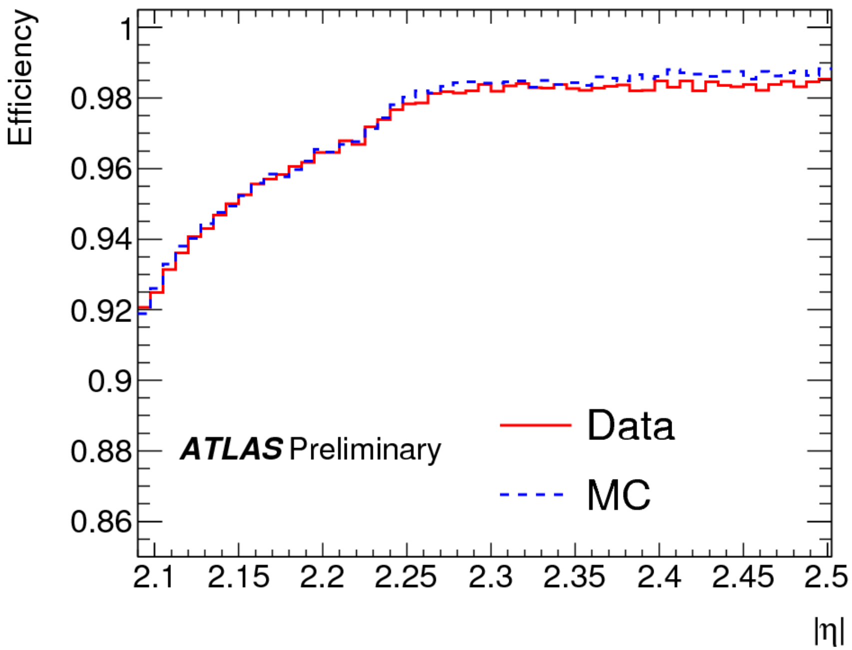


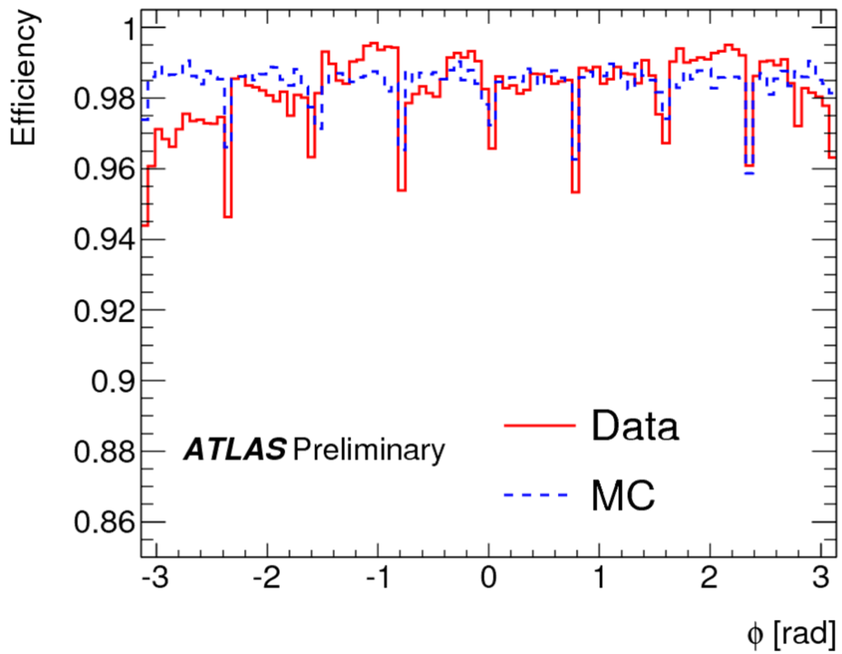
A MinBias Triggered MBTS Event

MBTS Efficiency

- **MBTS Efficiency** calculated in in the Inner Detector overlap region.
- Efficiency calculated when **exactly** one track is **extrapolated** to the **MBTS.**
- High **efficiency is vital** when triggering **small mass diffractive systems**.





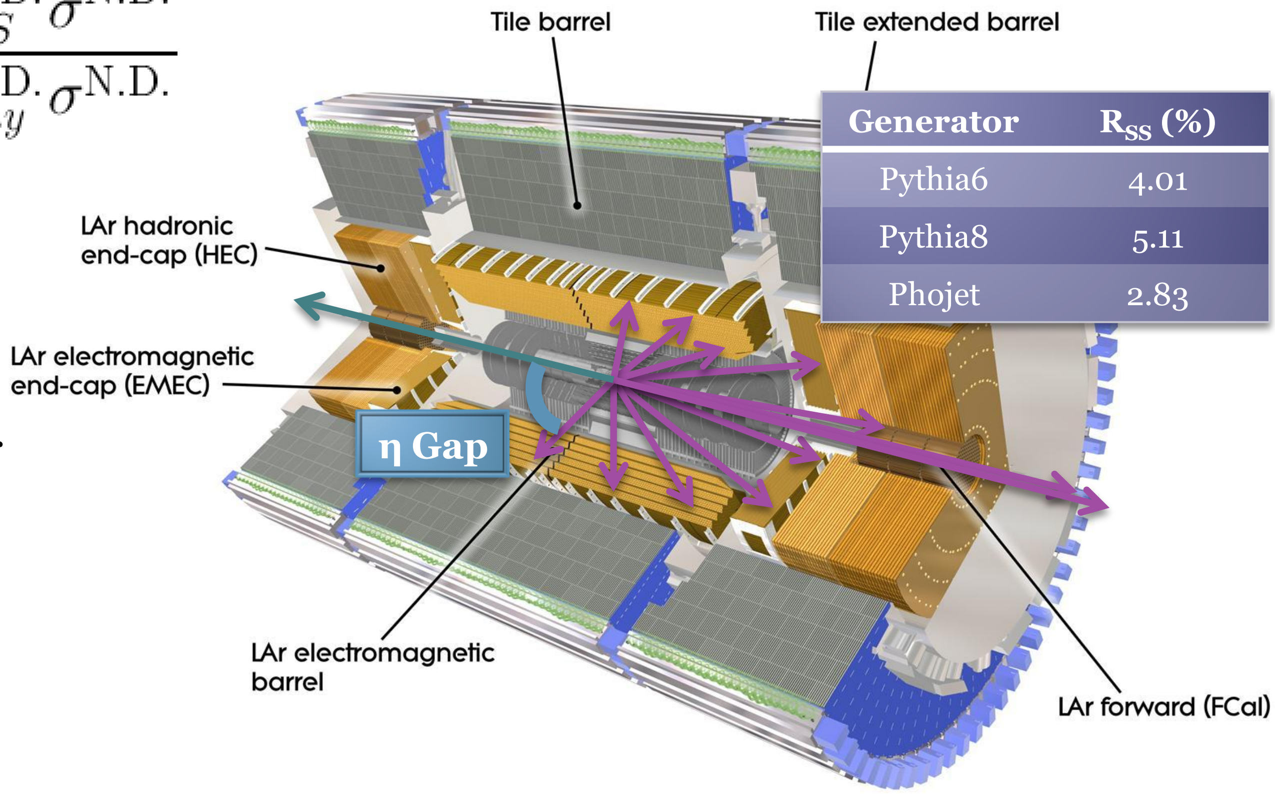


Inner Detector Measurement

- Form an **enhanced diffractive sample** using an **exclusive single sided MBTS Trigger**.
- R_{SS} is the **ratio** of **exclusive single sided MBTS Triggers** to **all MBTS Triggers**.

$$R_{SS} = \frac{A_{SS}^{\text{Diff.}}\sigma^{\text{Diff.}} + A_{SS}^{\text{N.D.}}\sigma^{\text{N.D.}}}{A_{any}^{\text{Diff.}}\sigma^{\text{Diff.}} + A_{any}^{\text{N.D.}}\sigma^{\text{N.D.}}}$$

- A_{SS} is the acceptance for the single sided requirement.
- A_{any} is the acceptance for the requirement of 1 MBTS hit anywhere.
- ***Diff.*** refers to the combined Single and Double Diffractive cross sections.



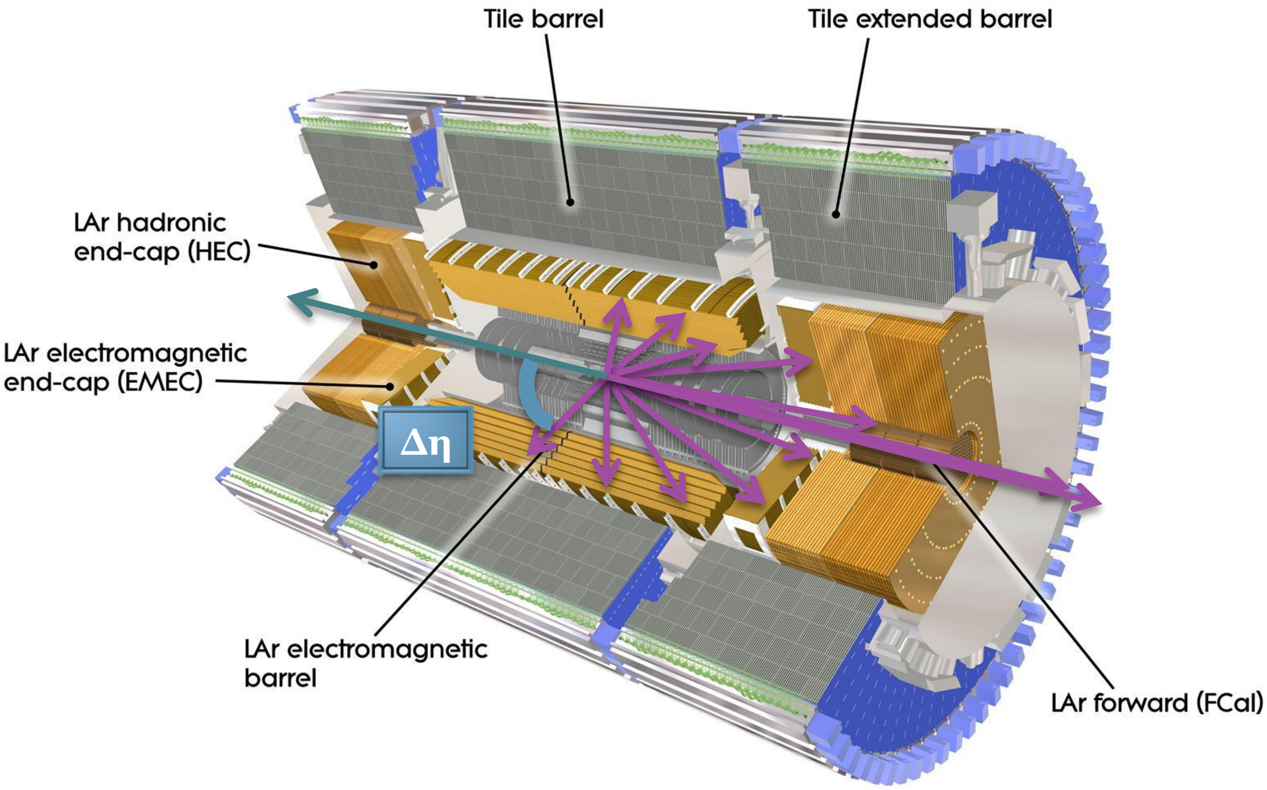
Generator	R_{SS} (%)
Pythia6	4.01
Pythia8	5.11
Phojet	2.83

Inner Detector Measurement

- For events passing the **exclusive single sided MBTS** requirement.
- Select tracks satisfying quality parameters.

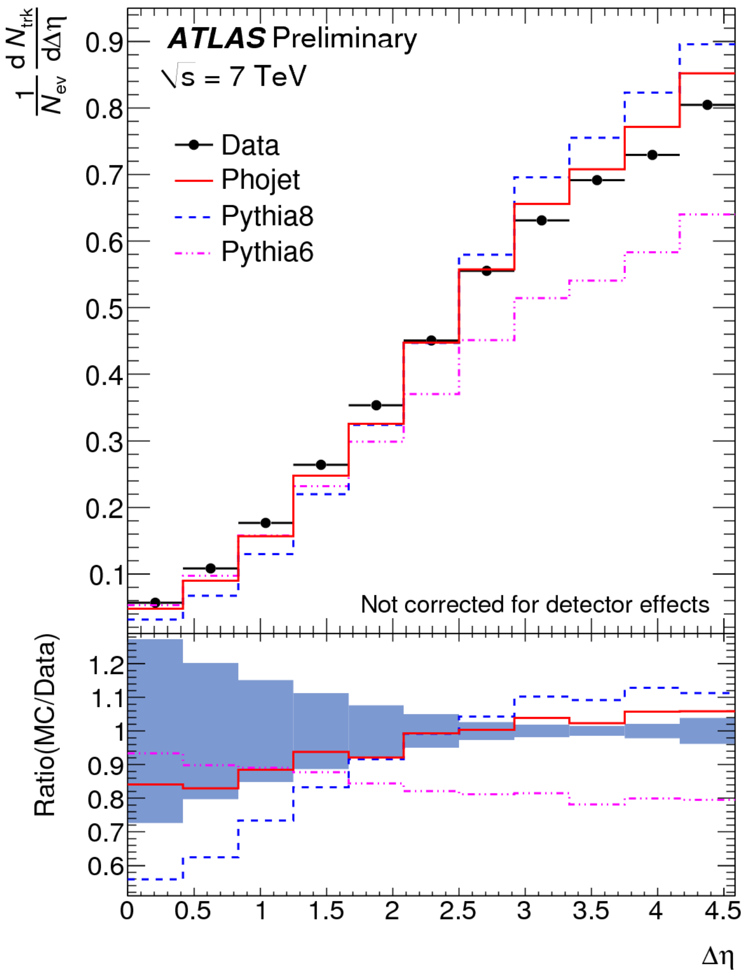
$p_T > 500$ MeV	N_{sct} Hit ≥ 6
$\|\eta\| < 2.5$	$\|d_0^{bs}\| < 1.5$ mm
N_{pix} Hit ≥ 1	$\|z_0\| < 100$ mm

- **Δη** is the difference in **η** between the MBTS (**η_{MBTS}**) side with ***no*** hits and the track.
- **η_{MBTS}** is **+/- 2.08 η**
- Tracking efficiency for charged prompt hadrons:
- **87%** at **η=0**
- **65%** at **|η|=2.5**

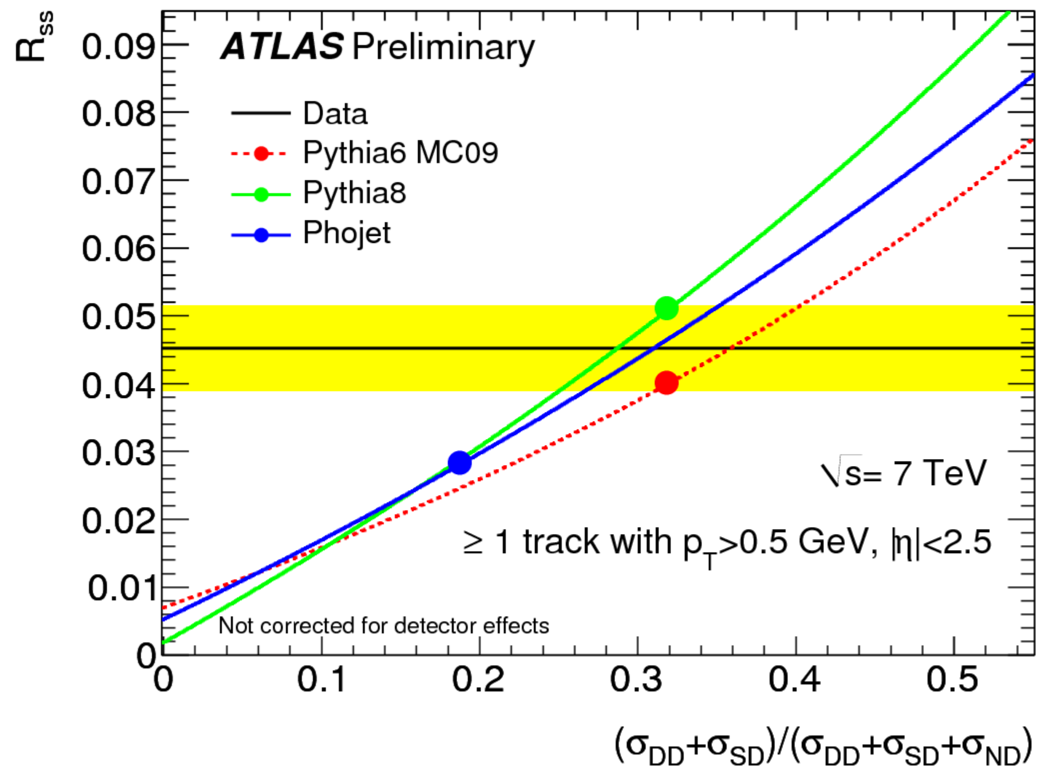


Single Sided Event Fraction

- **R_{SS}** is calculated for events with **at least one selected track**.
- **Ratio of SD to D.D** cross sections **fixed** to generator prediction.

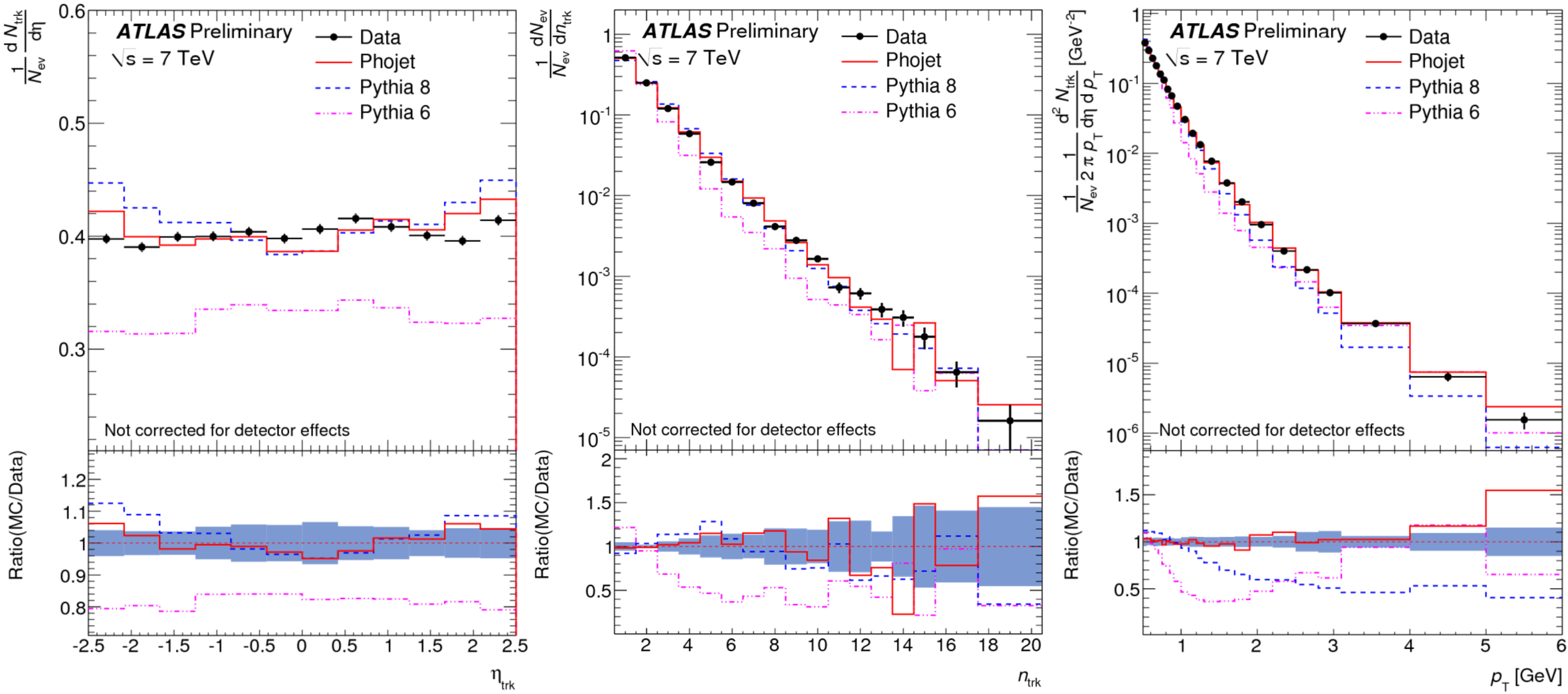


Diffractive cross section not well known, even at Tevatron CoM energy



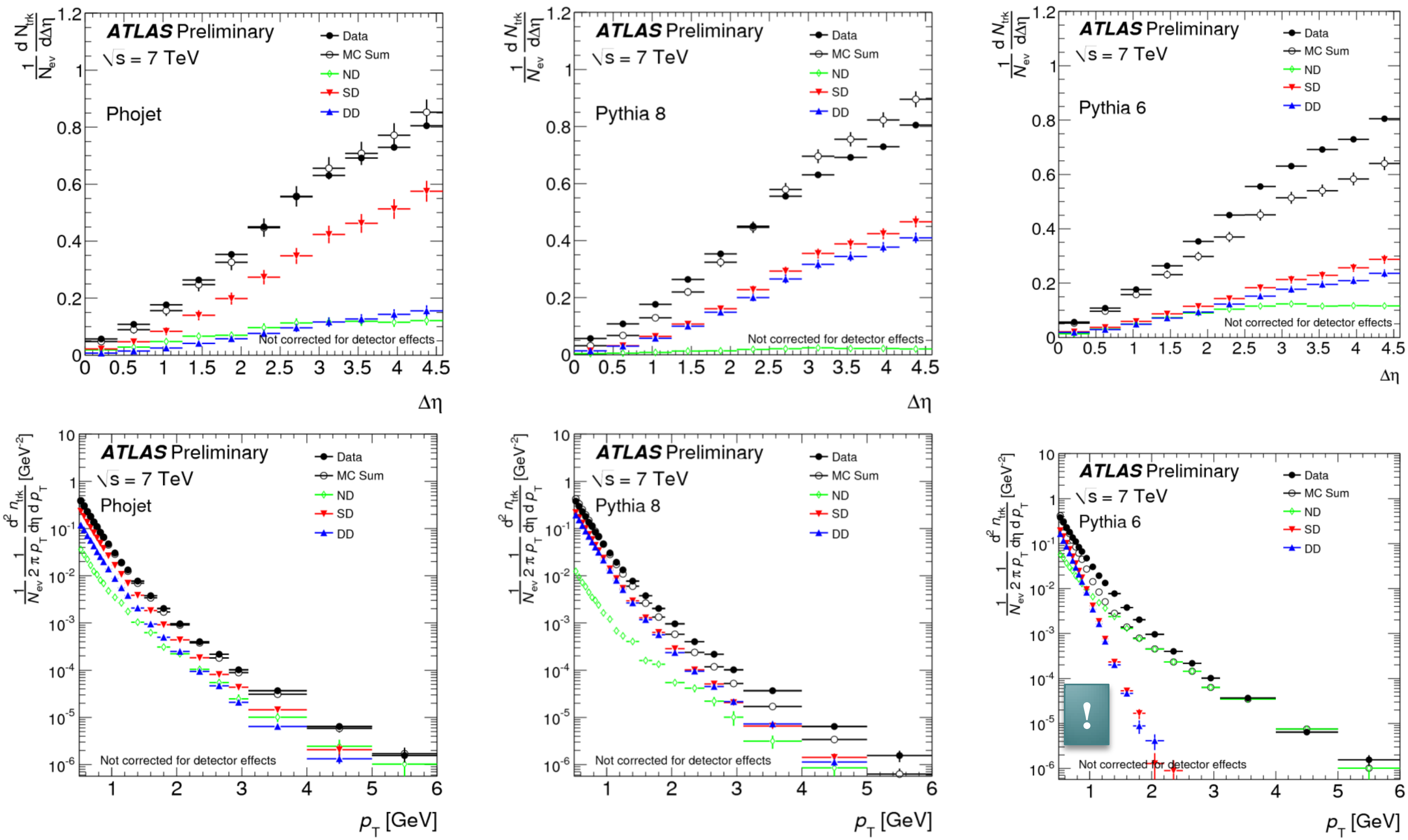
Track Distributions

- **Pythia8** and **Phojet** provide best description.
- Both would describe it better with an **increase of the ND component**.
- Detector effects **determined to be the same** for **data** and **MC** to within **systematic error**.



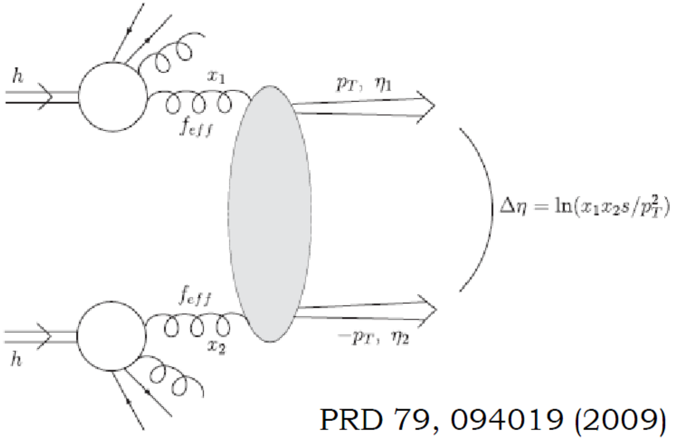
Distribution Breakdowns

- **Broken down into sub components.**



Gaps Between Jets

- Fraction of **di-jets** with **no additional jet structure** in the bounded rapidity region.
- Sensitive to **QCD** such as **colour singlet exchange**, **soft gluon radiation in the gap**, **BFKL-like dynamics**.



PRD 79, 094019 (2009)

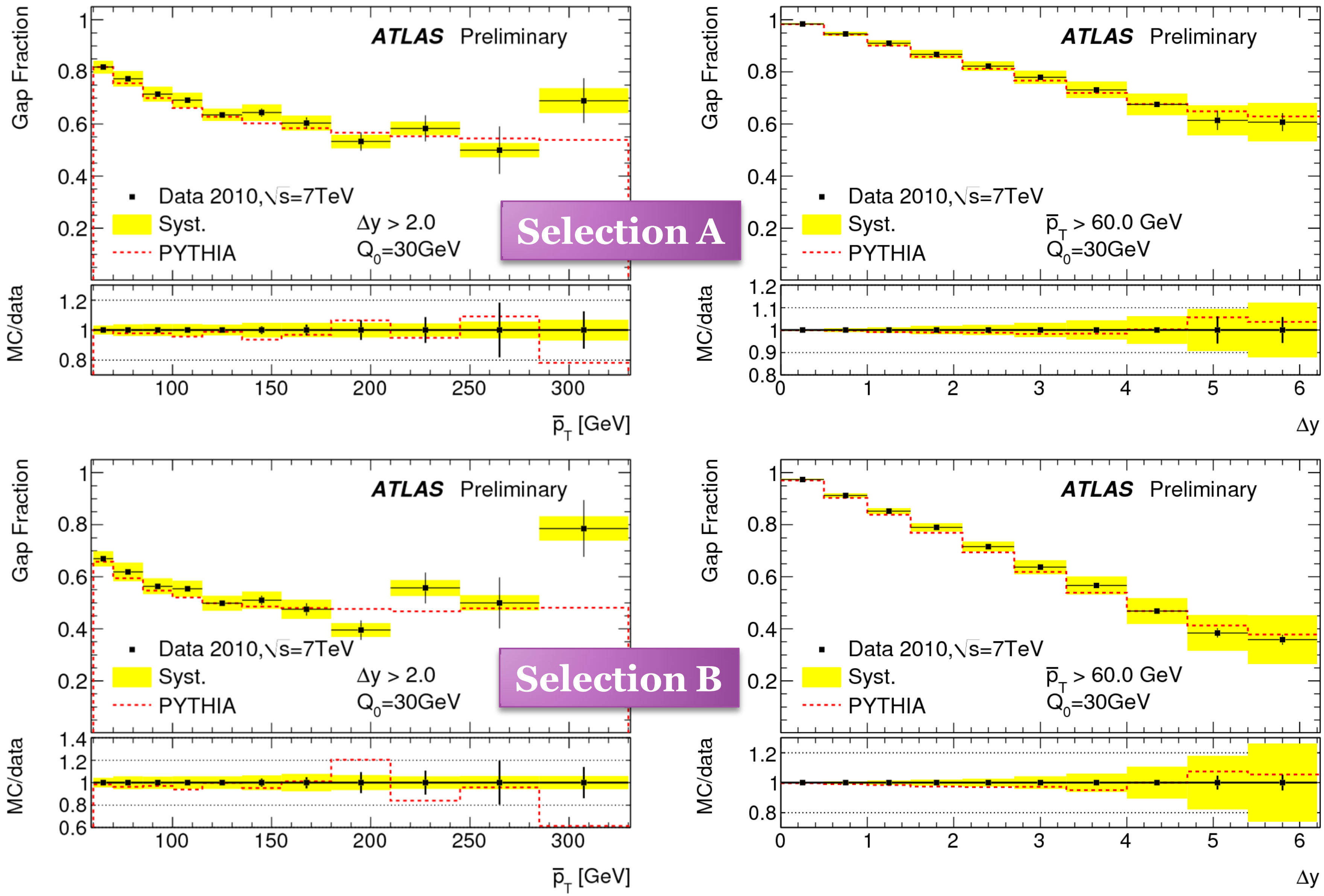
Jet Requirements:
2 good anti-kt Jets (**R=0.6**)
Average p_T > 60 GeV
Individual jet p_T > 30 GeV
Within $|y| < 4.5$
With $|\Delta y| > 2$

- Look at **fraction** of events **without a third jet** with p_T above the veto scale (**Q_0=30GeV**). Two jet selections used.

Selection A: The two highest **transverse momentum** jets in the event.
Selection B: The most **forward** and most **backward** jets in the event.

Gaps Between Jets

Good agreement between Pythia 6 (MC09) and Data.



Conclusion

- Much opportunity to study the **dynamics of hard and soft diffraction** at a muti-TeV collider.
- Work is ongoing to **investigate diffractive kinematics** in the **ATLAS tracking systems and calorimeters**.
- **Tuning** of the **diffractive part of MC models** will allow a **better description of minimum bias data**.
- **MPI and gap survival probabilities** will be an important factor in upcoming studies of **hard interactions within diffractive masses**.