A study of Luminosity Estimation in ATLAS using the Minimum Bias Trigger Scintillators (MBTS)

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Luminosity: definition

The interaction rate μ (i.e. the number of interactions per BC) is proportional to the cross section σ; the constant of proportionality is the luminosity L:

μ is the number of interactions per Bunch crossing (BC)

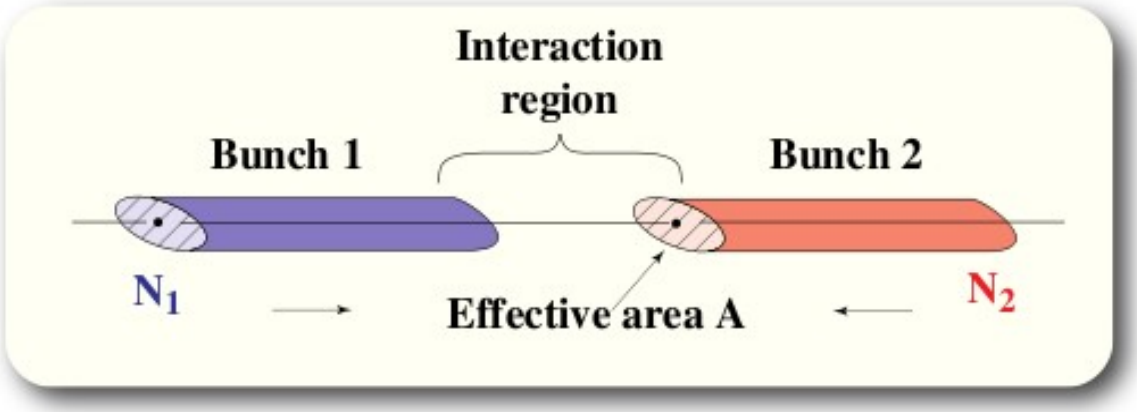
$$\mu = \mathcal{L}\,\sigma$$

σ is cross section of the process

L characterizes the number of collisions in a collider [$cm^{-2}\ s^{-1}$]

If two bunches containing N_1 and N_2 particles collide with frequency *f* then:

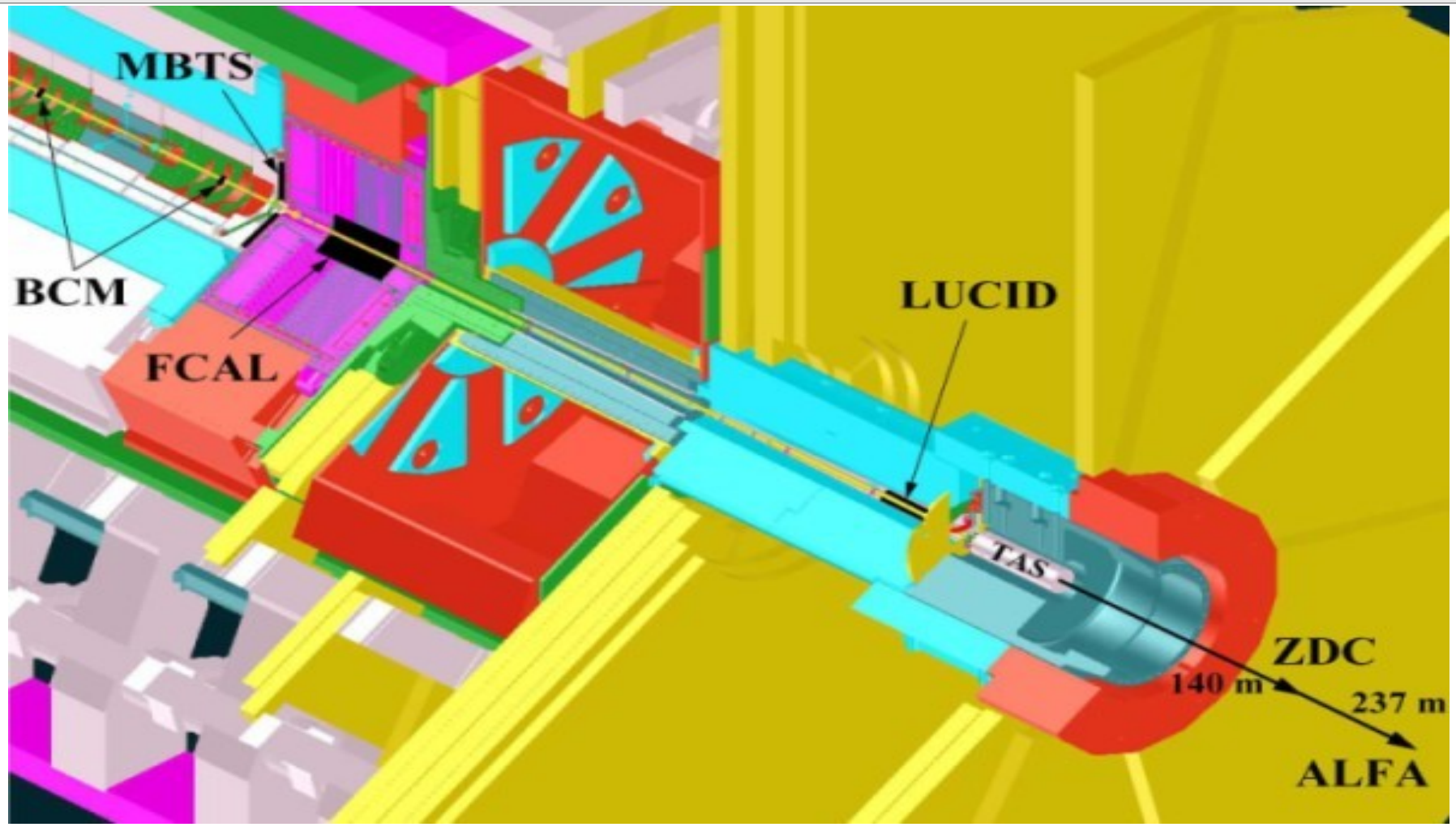
$$\mathcal{L} = \frac{N_1\, N_2\, f}{A_{\text{eff}}}$$

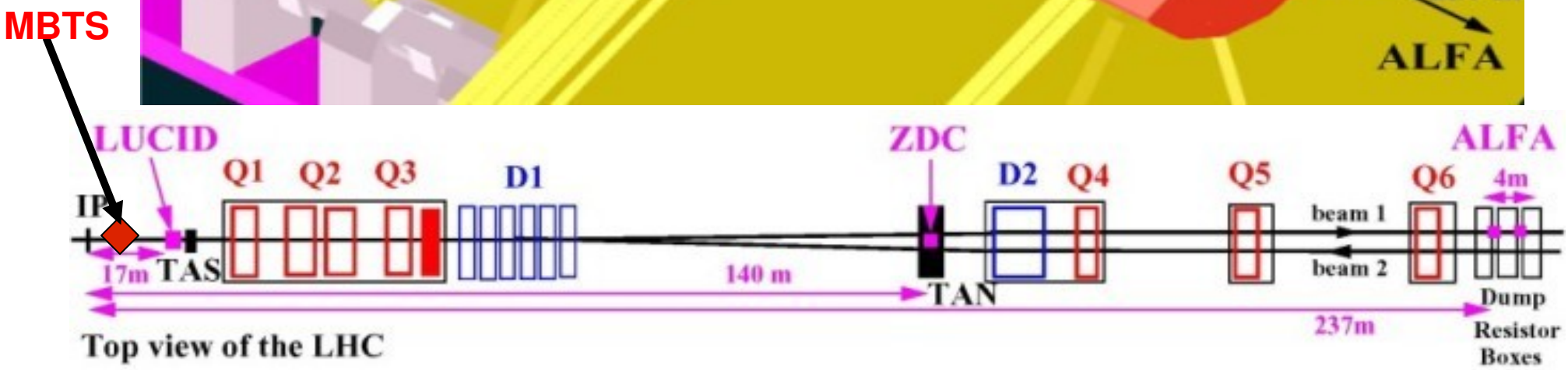


The Luminosity depends only on the beam parameters ⇒ It is independent of the physical reaction

The design luminosity of LHC is $10^{34} cm^{-2}\ s^{-1}$ after 2 or 3 years

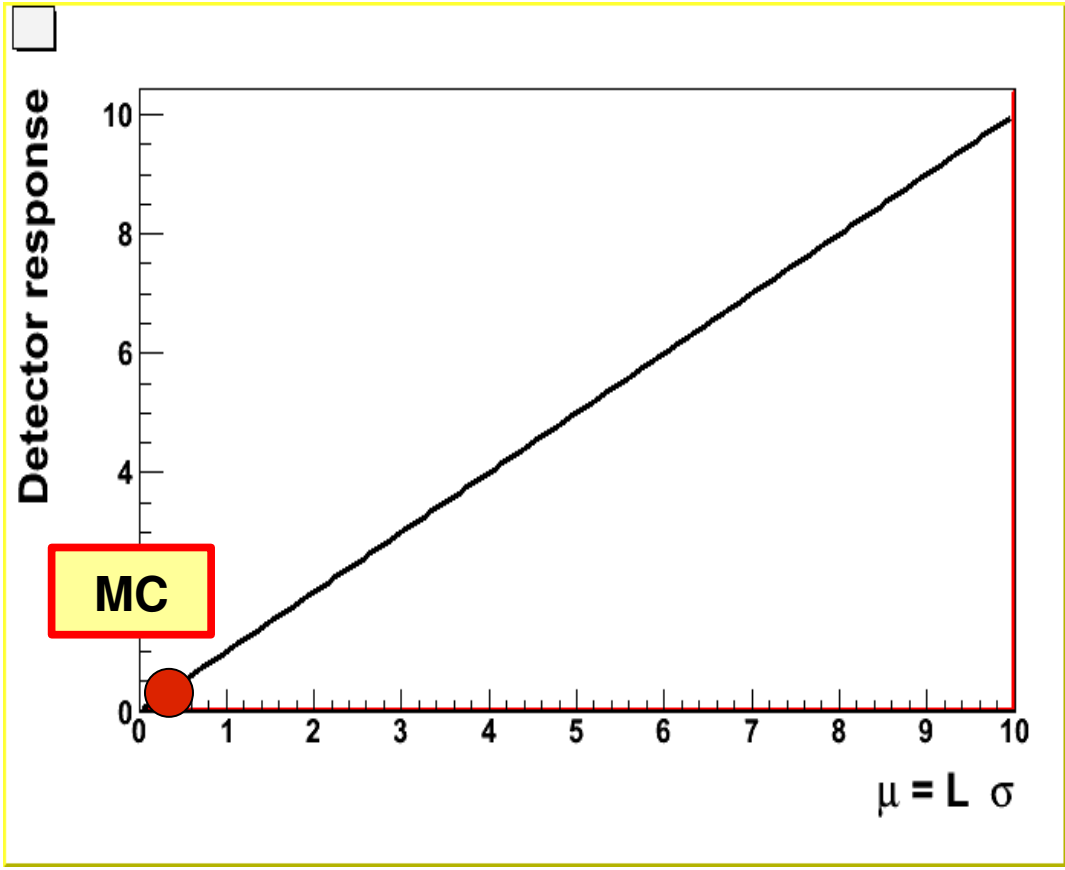
The ATLAS luminosity measurement taskforce





The ATLAS luminosity measurement taskforce

- Identify, document and characterize the performance of the various online luminosity algorithms
- Provide an initial absolute Monte Carlo based calibration
- Identify and quantify the possible systematic errors in the luminosity measurements
- Identify and document the improvements that can be made in an offline analysis;
- Propose offline archiving and accounting strategies.



Here we are interested in make a luminosity estimation using the Minimum Bias Trigger Scintillators (MBTS)

Cross check of estimated luminosities from different subdetectors: BCM, FCAL, LUCID, MBTS, ZDC

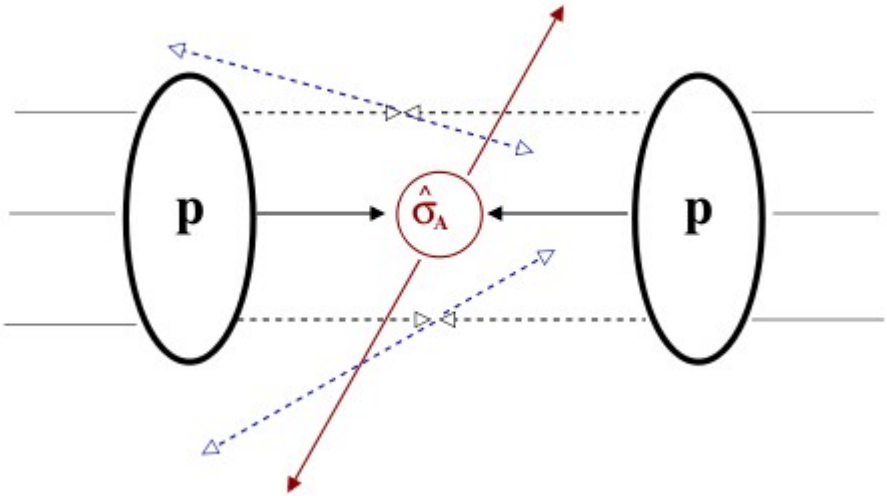
Minimum Bias Trigger Scintillator (MBTS)

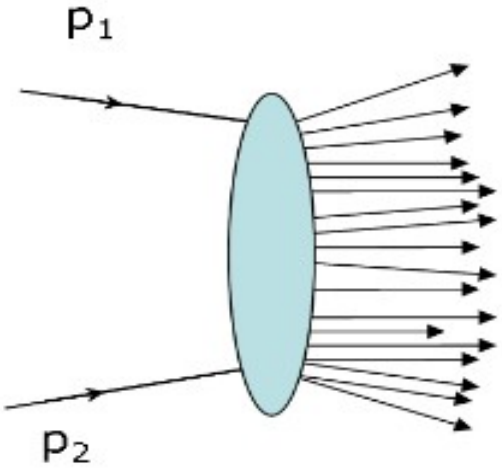
MBTS will be used as a minimum bias trigger in early running (max 1 year)

Minimum bias what??

Most of the time the protons will pass through each other with low amount of momentum (low-pt) being transferred between the interacting partons

Occasionally there will be a "hard" parton-parton collision, resulting in large transverse momentum outgoing particles.





Minimum Bias events = Non diffractive inelastic interaction

Minimum bias events are dominated by soft interactions

No QCD

Modelling with Pythia, Phojet, Herwig

Minimum bias events constitutes unavoidable background, for this reason it's important study them

Minimum Bias Trigger Scintillator (MBTS)

MBTS will be used as a minimum bias trigger in early running (max 1 year)

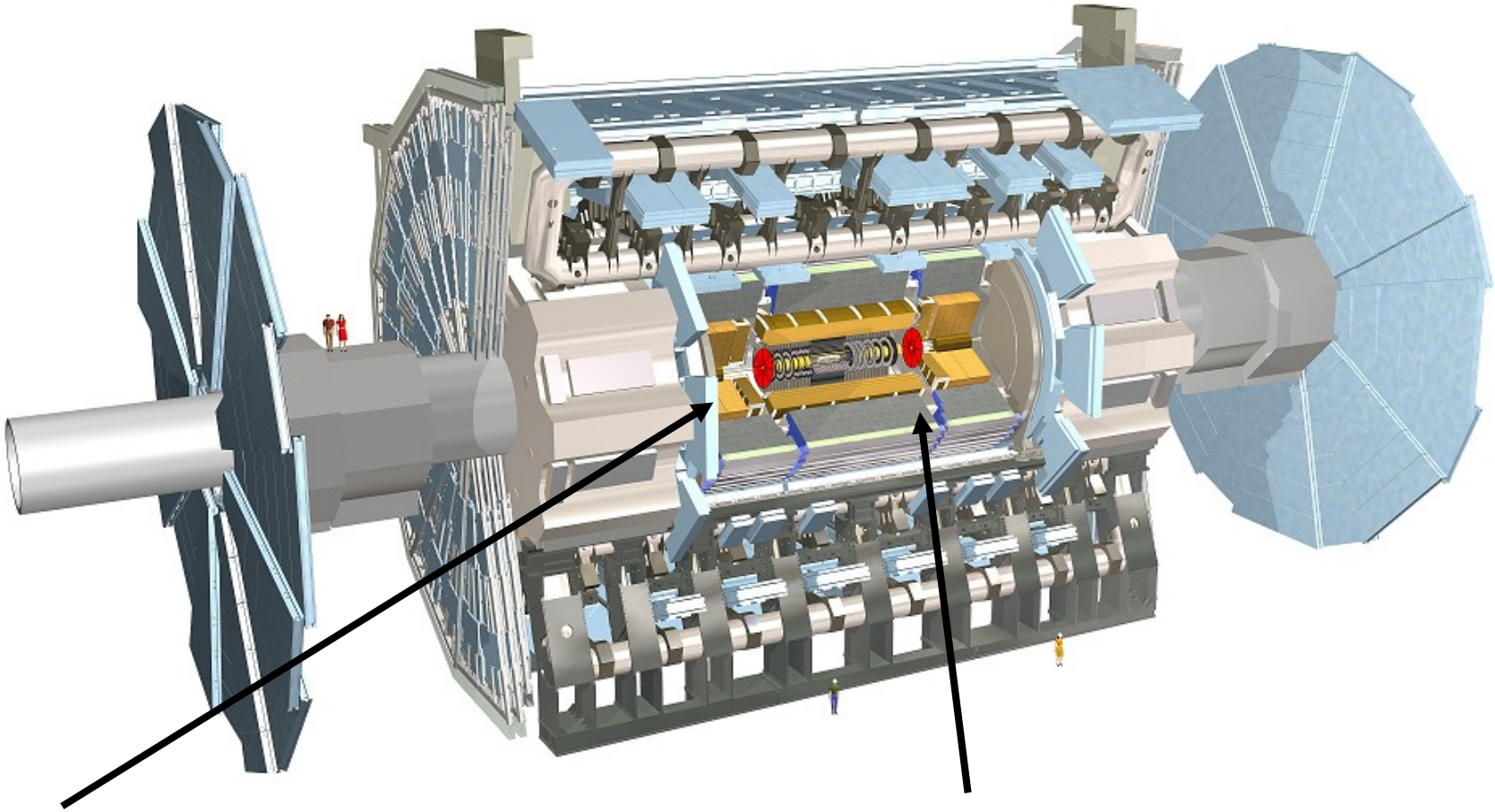
- **Two sets of 2x8 scintillators in front of the endcap calorimeter**
- **Psedorapidity (η) coverage: outer [2.1, 2.8], inner[2.8, 3.8]**
- **High efficiency (almost 100%) for non diffractive *pp* collisions**
- **Located at |z| = 3560 mm from the IP**

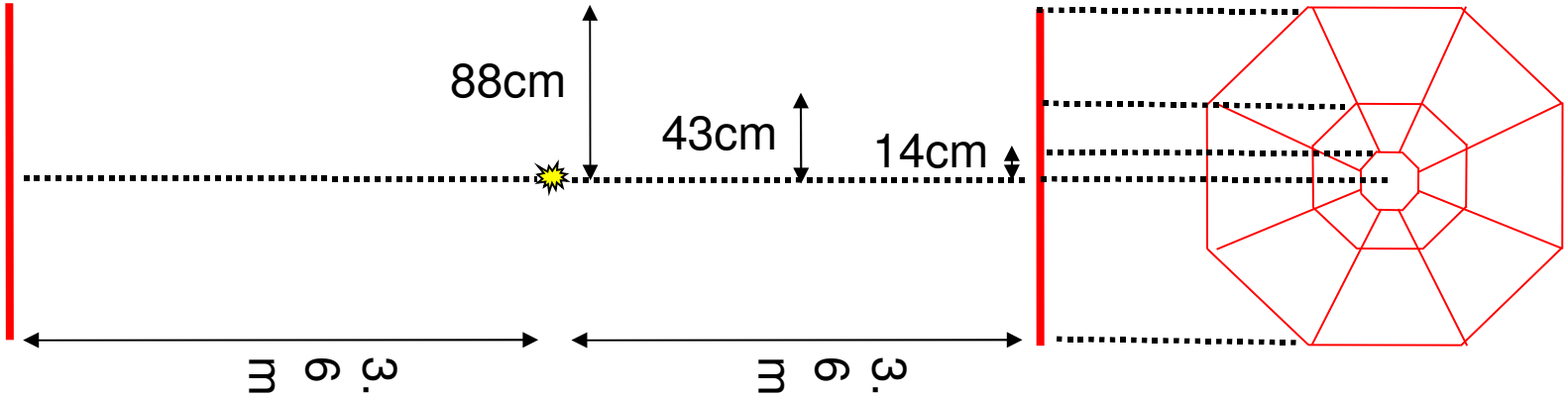
Minimum Bias Trigger Scintillator (MBTS)

MBT

ear)

- Tw
- Ps
- Hi
- Lo





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Interest for luminosity:

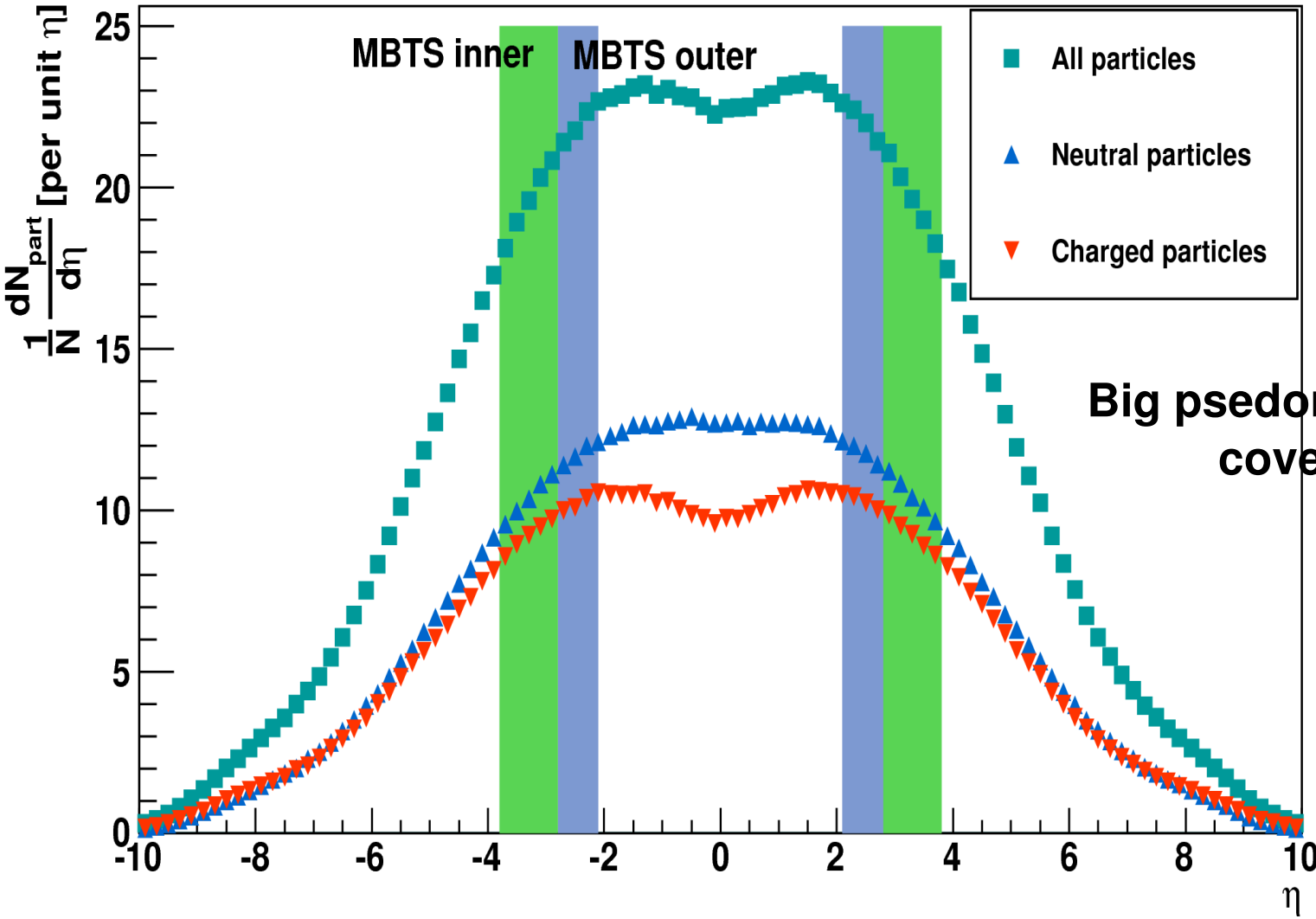
- **Provide calibration samples for other luminosity monitors**
- **Provide a measurement of luminosity in early stages**

Simulation: Full ATLAS in Athena, Pythia non diffractive events at $\sqrt{s}$ = 10 TeV

Average number of particles per *pp* interaction
Response of the detector to a single particle
Hit multiplicity as a function of μ

Pseudorapidity (η) for all primary particles

ParticleEta

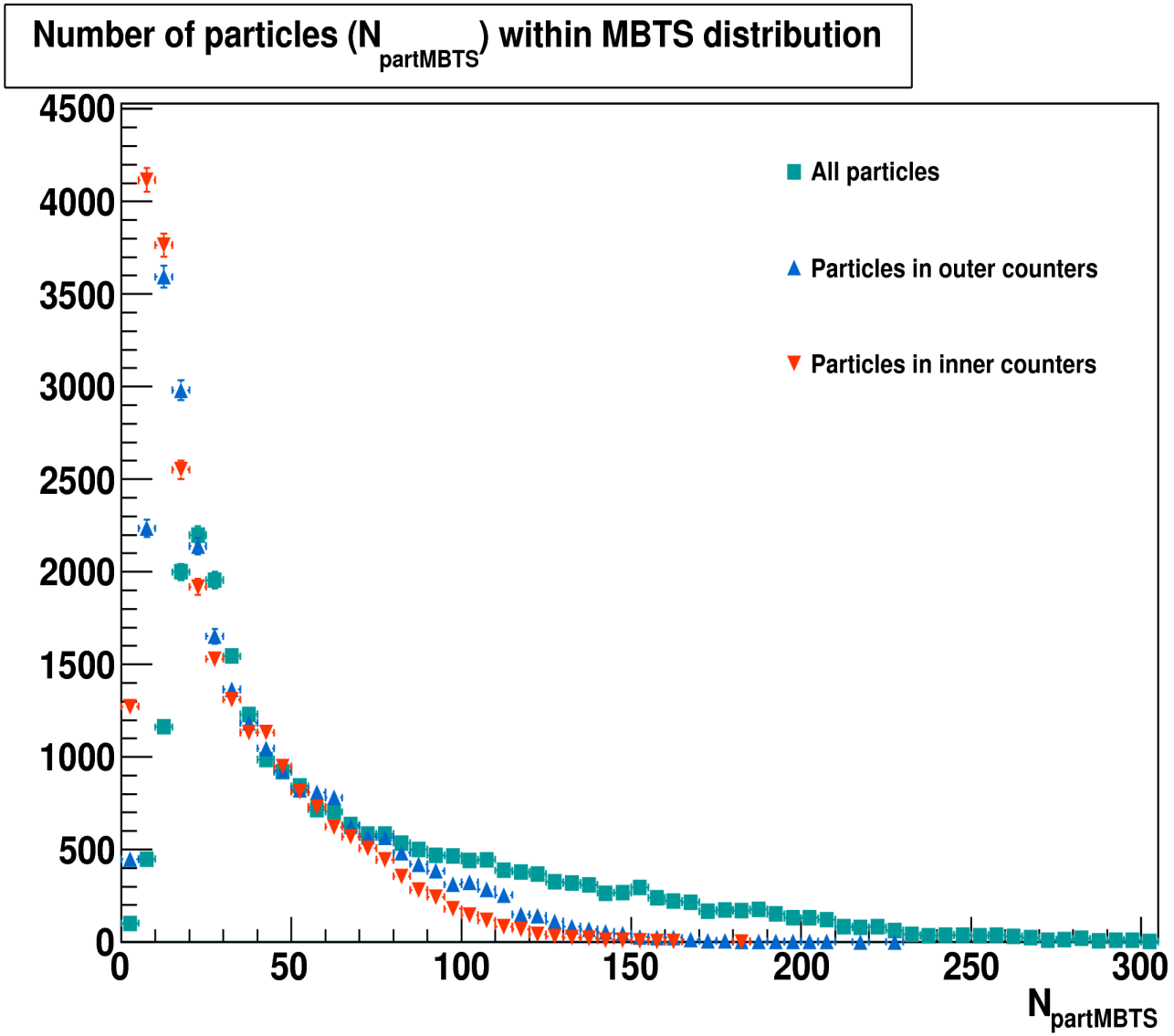


Big psedorapidity (η) coverage

GEANT4 simulation of the ATLAS detector and non diffractive, one interaction per event data generated with PYTHIA (simulation of inelastic pp collisions at $\sqrt{s}$ = **10GeV**).

Only primary particles selected (part_barcode) < 100000

MBTS particles distribution

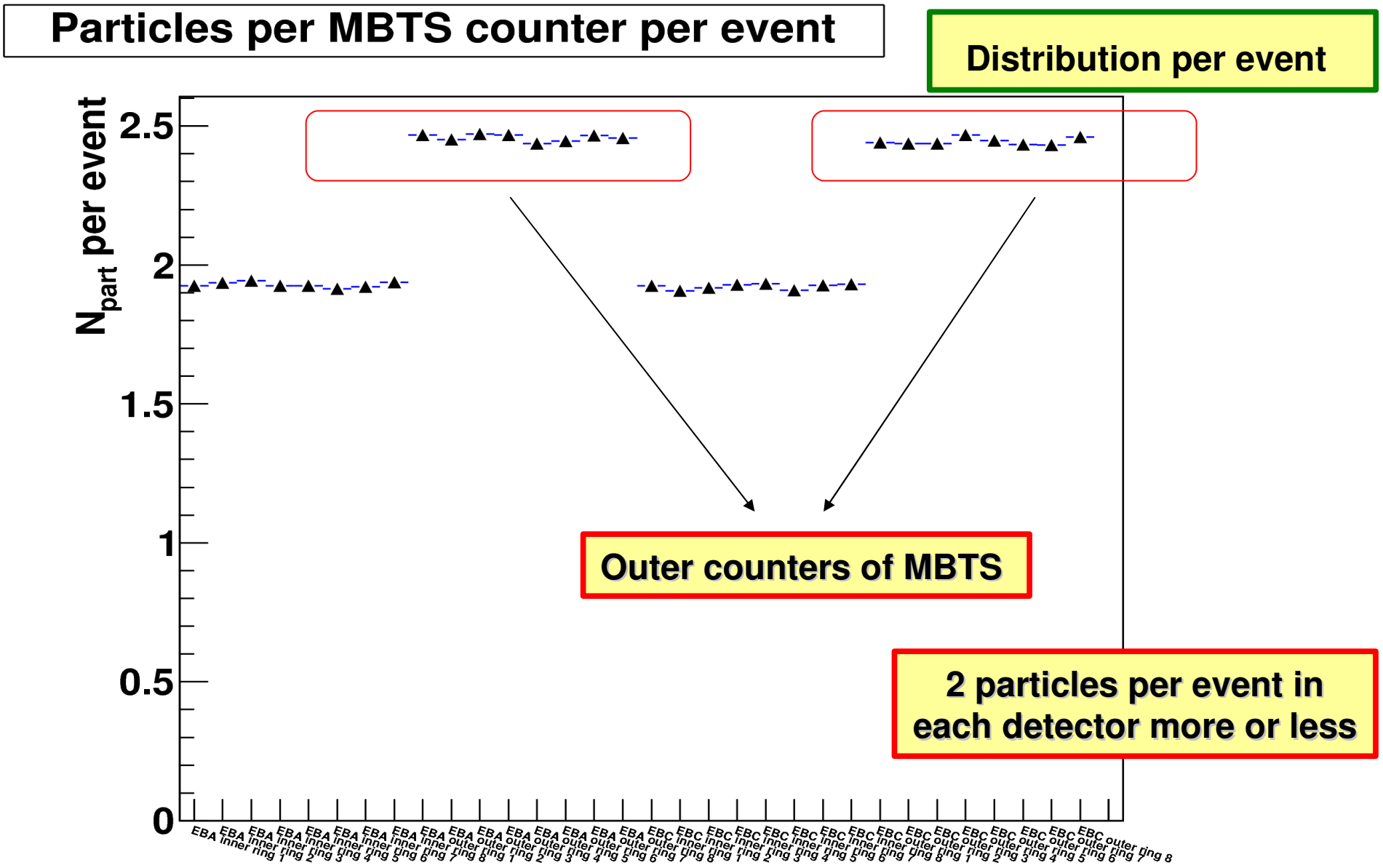


Only primary particles selected (part_barcode) < 100000

The average number of primary particles inside MBTS acceptance is about 25.

Selection criteria:
Inner = 2.8 < | η| < 3.8
Outer = 2.1 < | η| < 2.8

Particles per counter distribution



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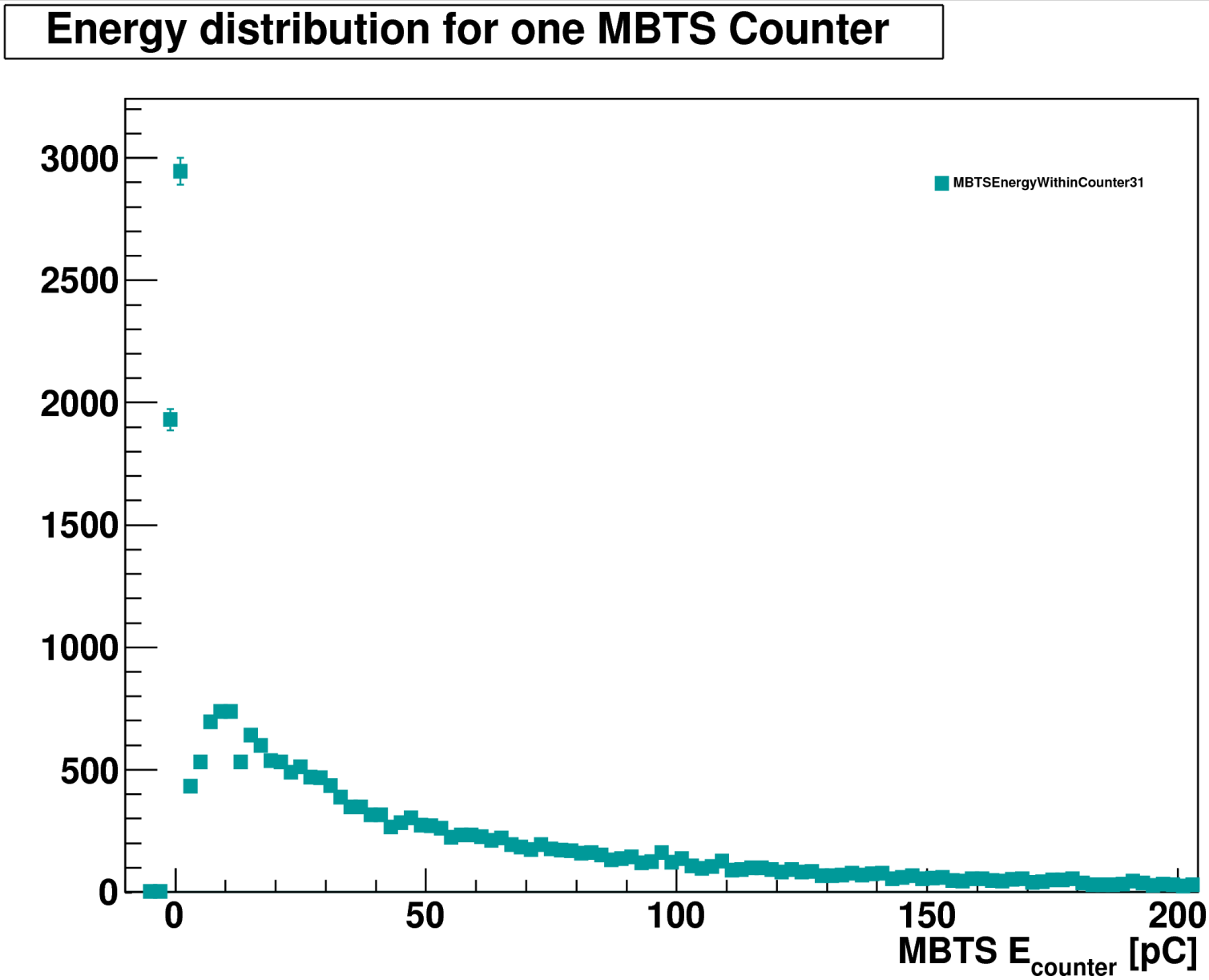
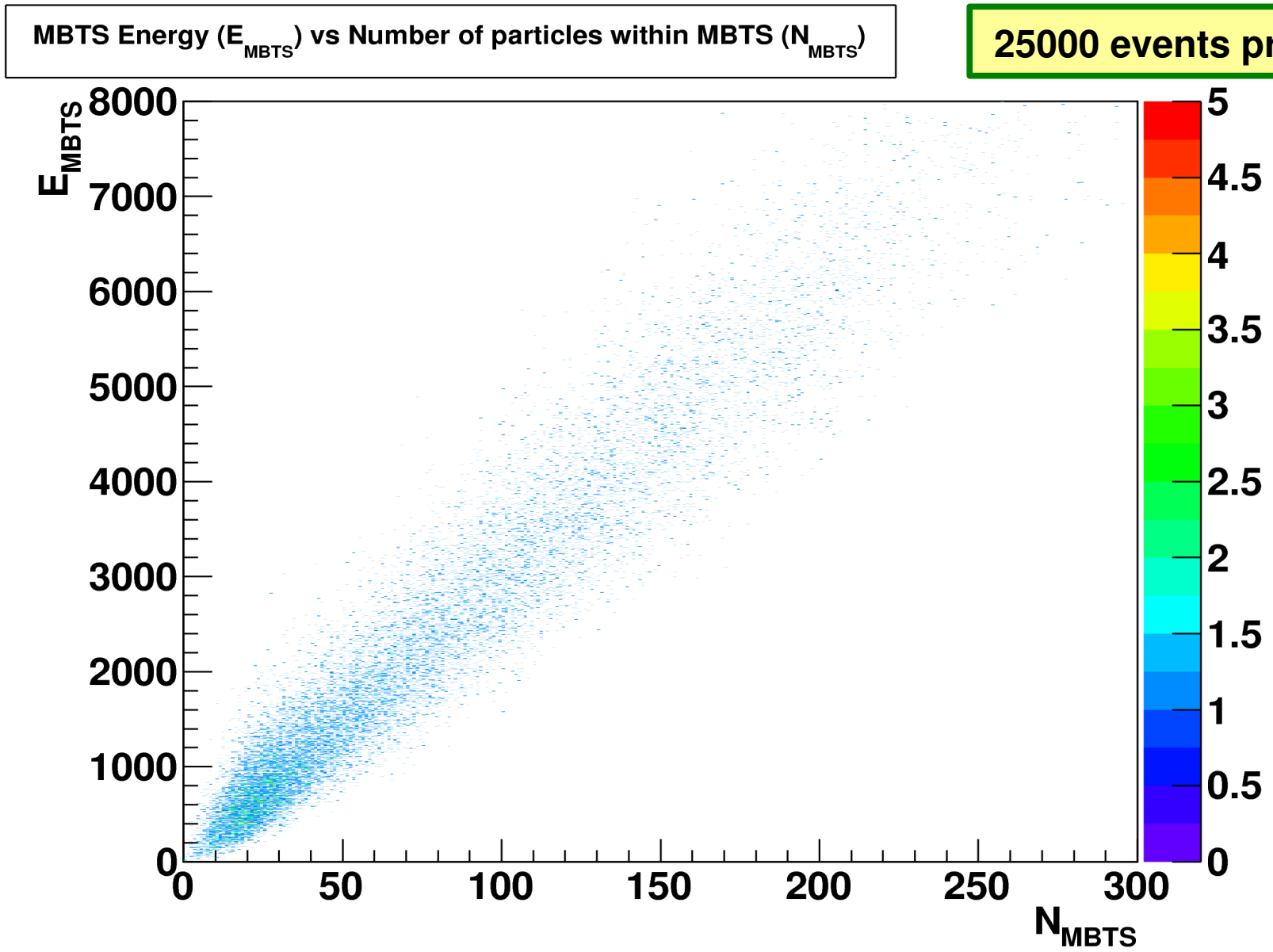
GEANT4 simulation of the ATLAS detector and non diffractive, one interaction per event data generated with PYTHIA (simulation of inelastic pp collisions at $\sqrt{s} = 10$GeV).

Energy distribution for one of the MBTS counter



GEANT4 simulation of the ATLAS detector and one single particle data generated with PYTHIA (simulation of inelastic pp collisions at $\sqrt{s}$ = **10GeV**).

MBTS energy E_{MBTS} vs number of particles inside MBTS



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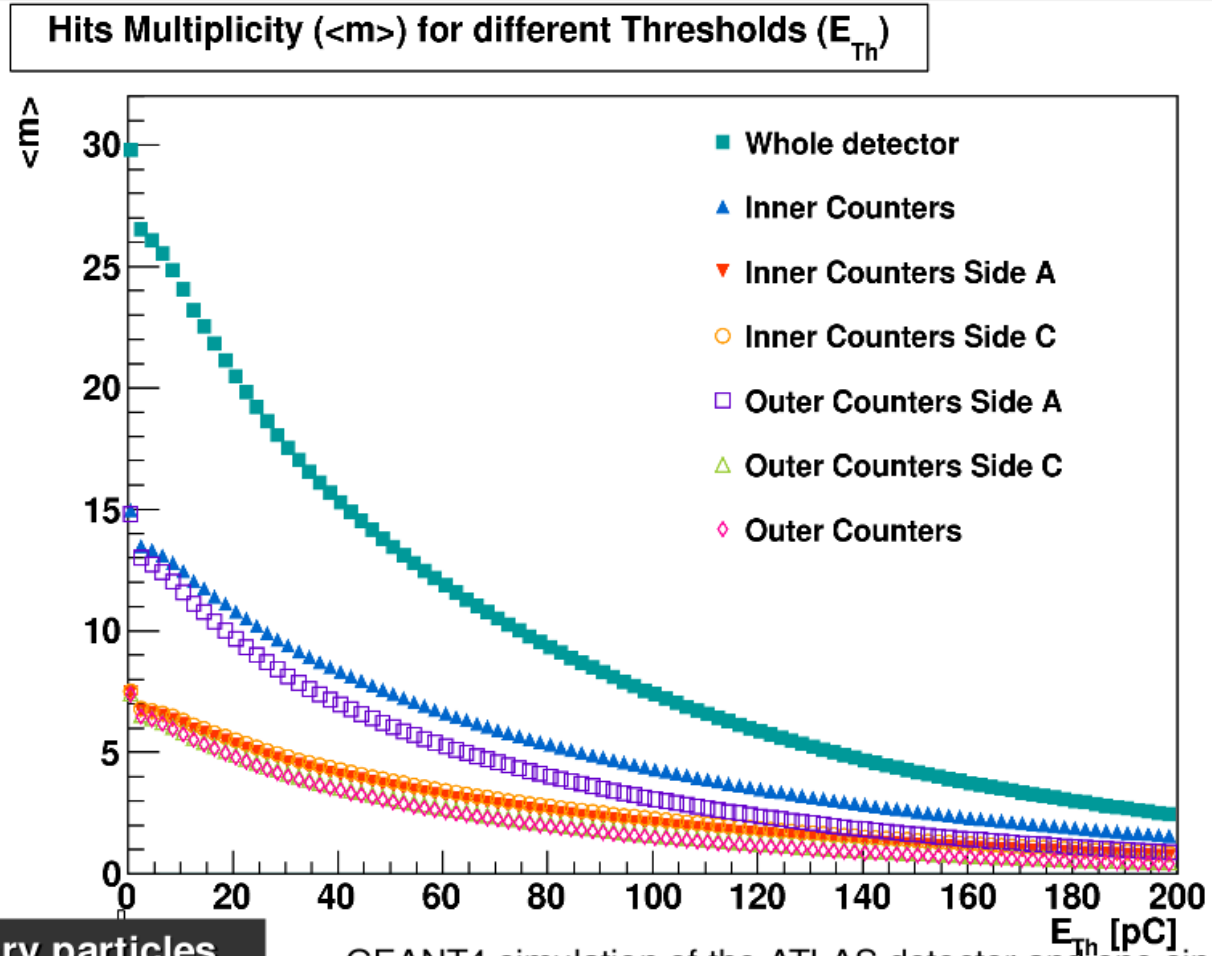
Correlation between the E_{MBTS} and the number of particles that pass through the MBTS

MBTS hits multiplicity

¿How many counters detect a particle as a function of the energy threshold?

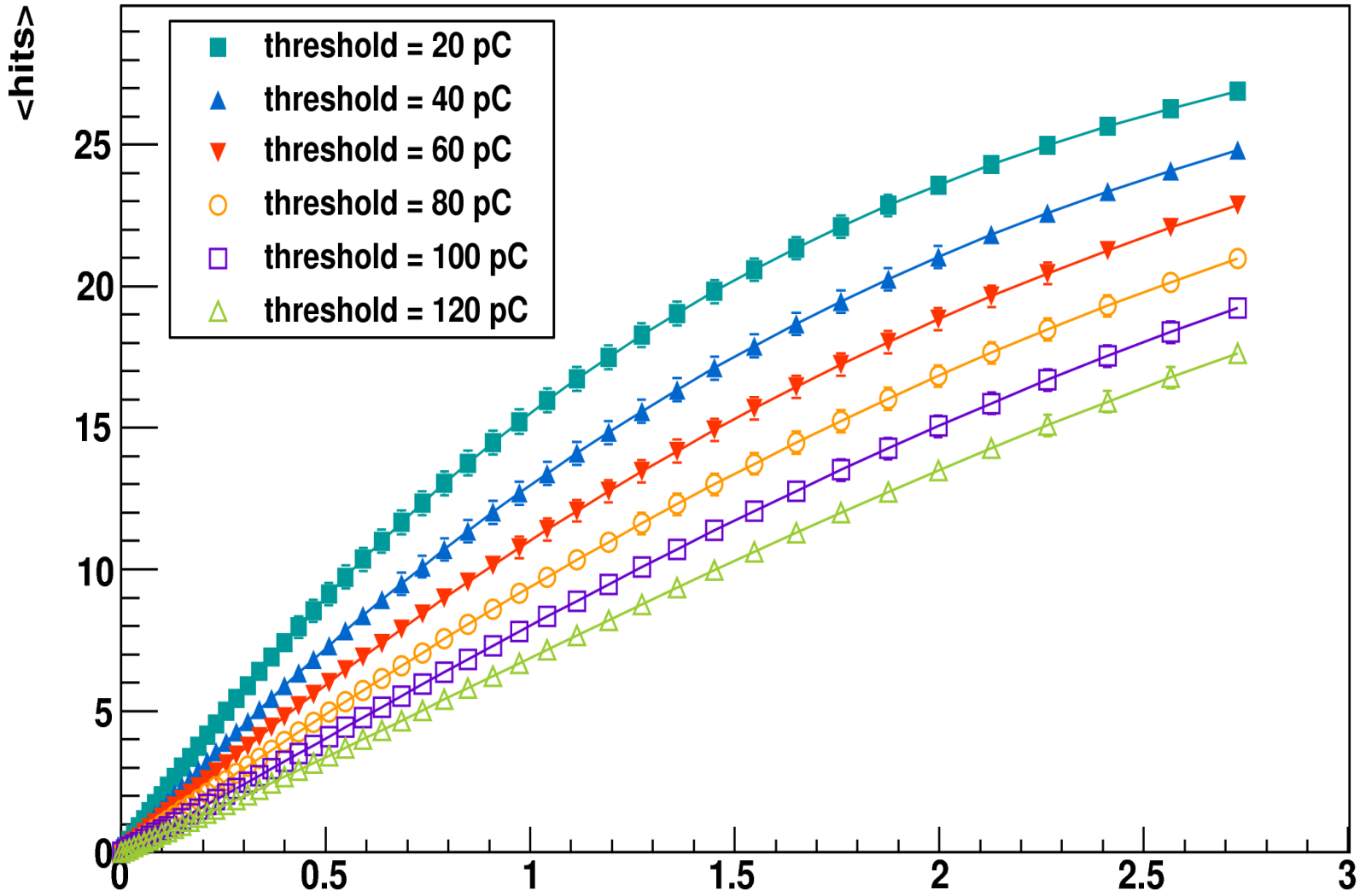


Only primary particles selected
(part_barcode) < 100000

GEANT4 simulation of the ATLAS detector and one single particle data generated with PYTHIA (simulation of inelastic pp collisions at $\sqrt{s}$ = 10GeV).

Smooth behaviour of multiplicity as a function of pulse height threshold. Detector is not fully saturated. Can be used to estimated luminosity.

Hits multiplicity vs Mean number of interactions (μ)



μ is *pp* interactions per Bunch crossing (BC)

$$\mu = \mathcal{L}\,\sigma$$

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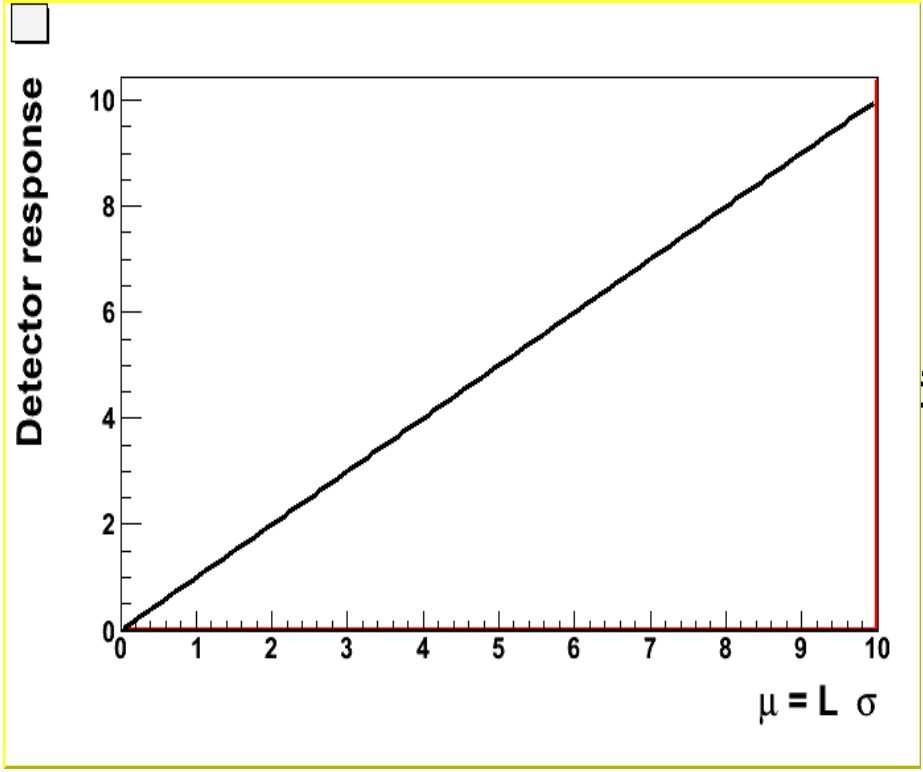

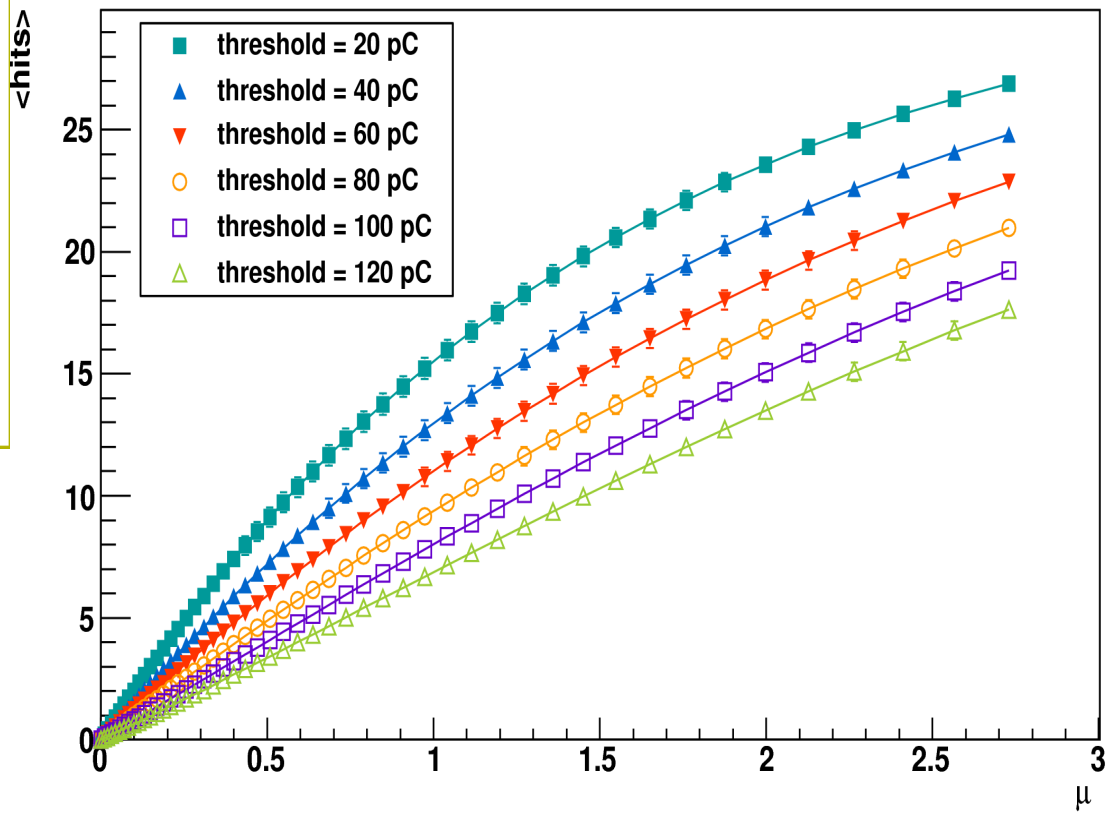

μ is *pp* interactions per Bunch crossing (BC)

$$\mu = \mathcal{L}\,\sigma$$

Conclusions

- A lot of progress in understanding MBTS simulation.

- MBTS machinery are ready to provide systematic uncertainties in luminosity measurements.

- Have a look in another data types: single diffractive, double diffractive, splash data

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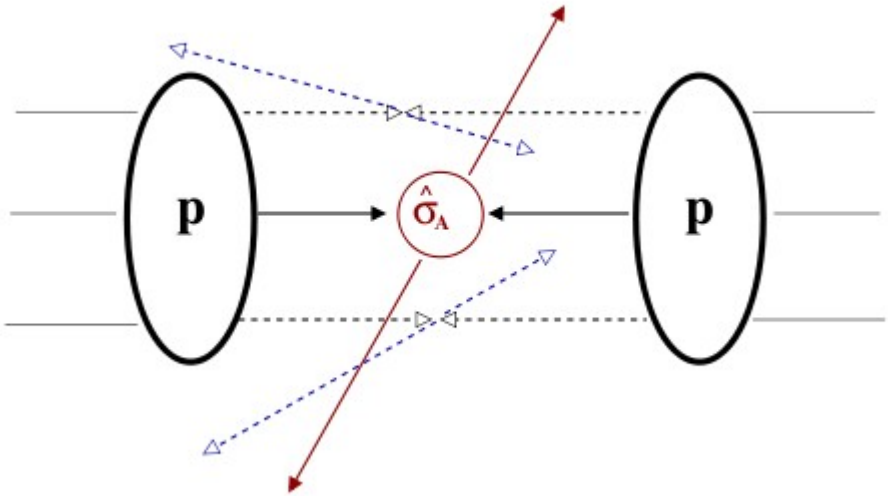
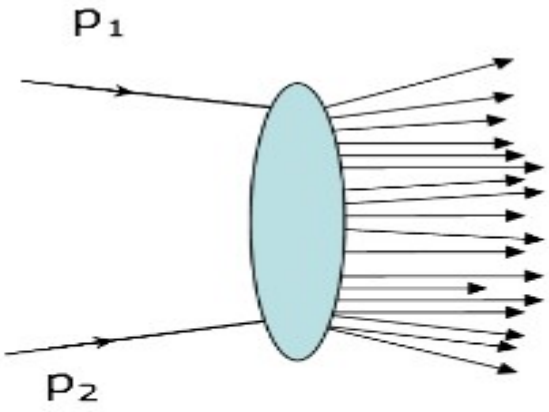
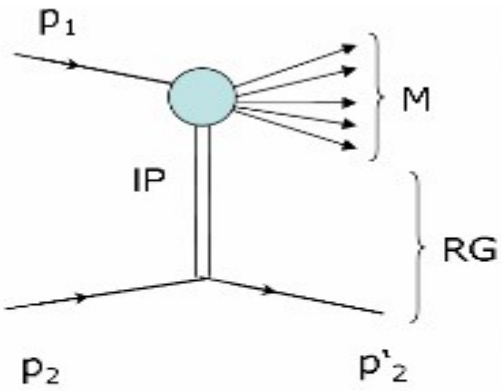
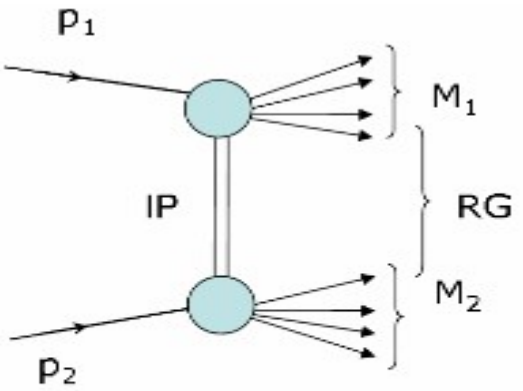




ndiff

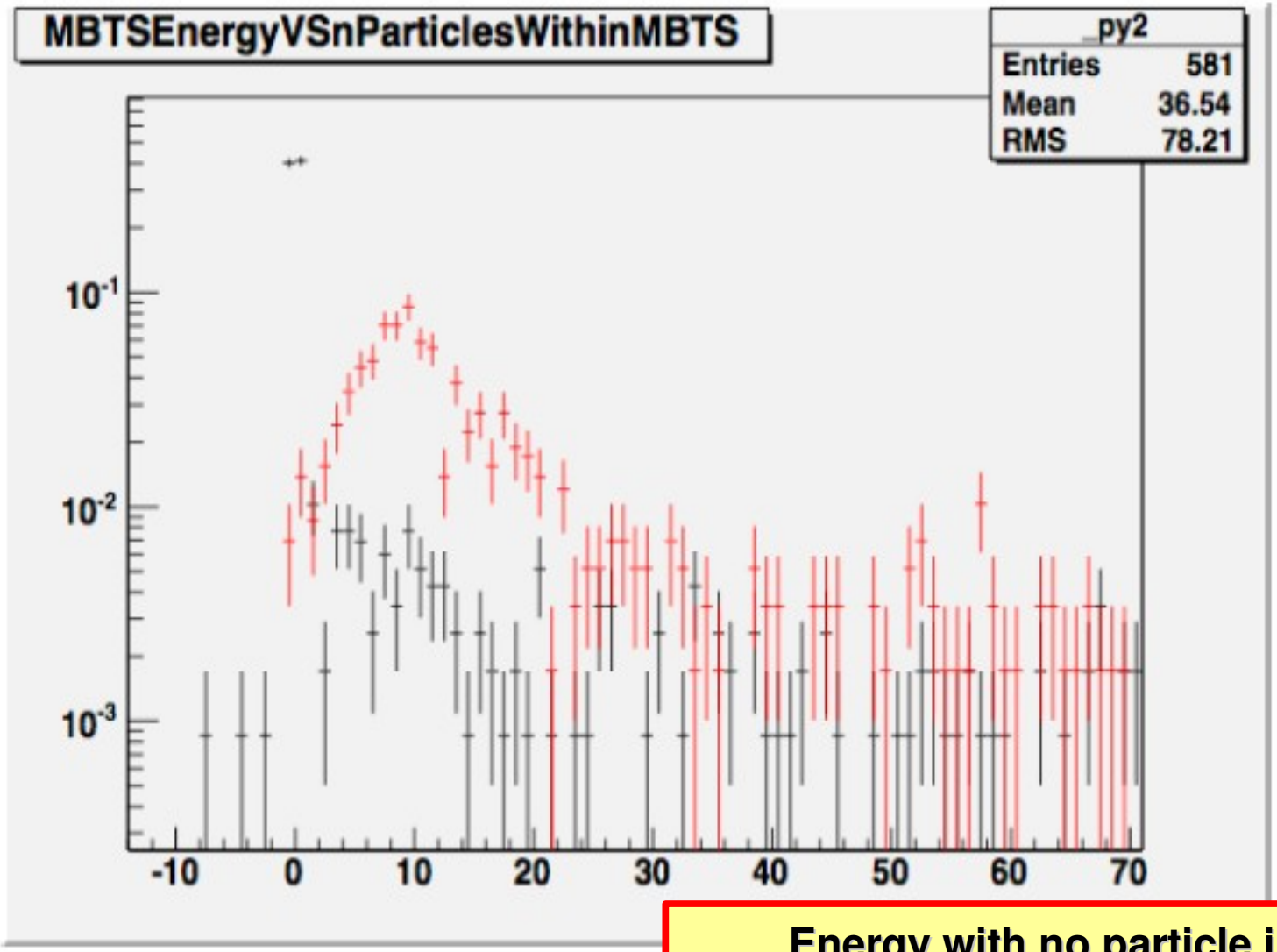


sdiff



ddiff

MBTS single particle peak



___Energy with no particle in counter

___Energy with one particle in counter

Selection criteria:

Outer = 2.8 < | η| < 3.8

Inner = 2.1 < | η| < 2.8

GEANT4 simulation of the ATLAS detector and one single particle data generated with PYTHIA (simulation of inelastic pp collisions at √**s = 10GeV**).