Soft diffraction at CMS

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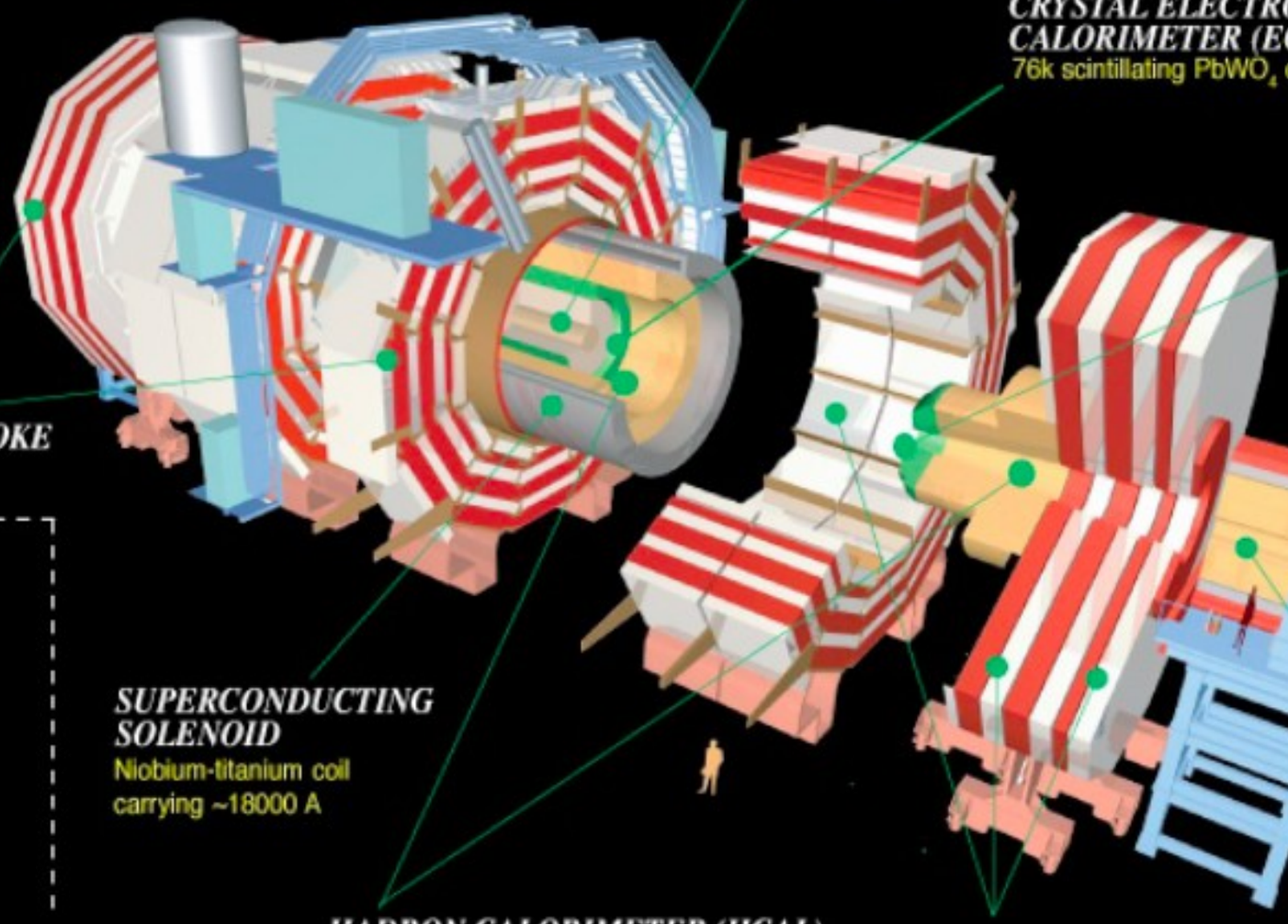
for the CMS collaboration

Outlook

- Observation of diffraction in *pp* collision at 900, 2360 and 7000 GeV at LHC
- Total inelastic *pp* cross section at $\sqrt{s}$ = 7 TeV

CMS Detector

Pixels
Tracker
ECAL
HCAL
Solenoid
Steel Yoke
Muons



SILICON TRACKER
Pixels (100 x 150 μm²)
~1m² 66M channels
Microstrips (50-100μm)
~210m² 9.6M channels

CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
76k scintillating $PbWO_4$ crystals

PRESHOWER
Silicon strips
~16m² 137k channels

CASTOR CALORIMETER
Tungsten + quartz plates

STEEL RETURN YOKE
~13000 tonnes

ZERO-DEGREE CALORIMETER

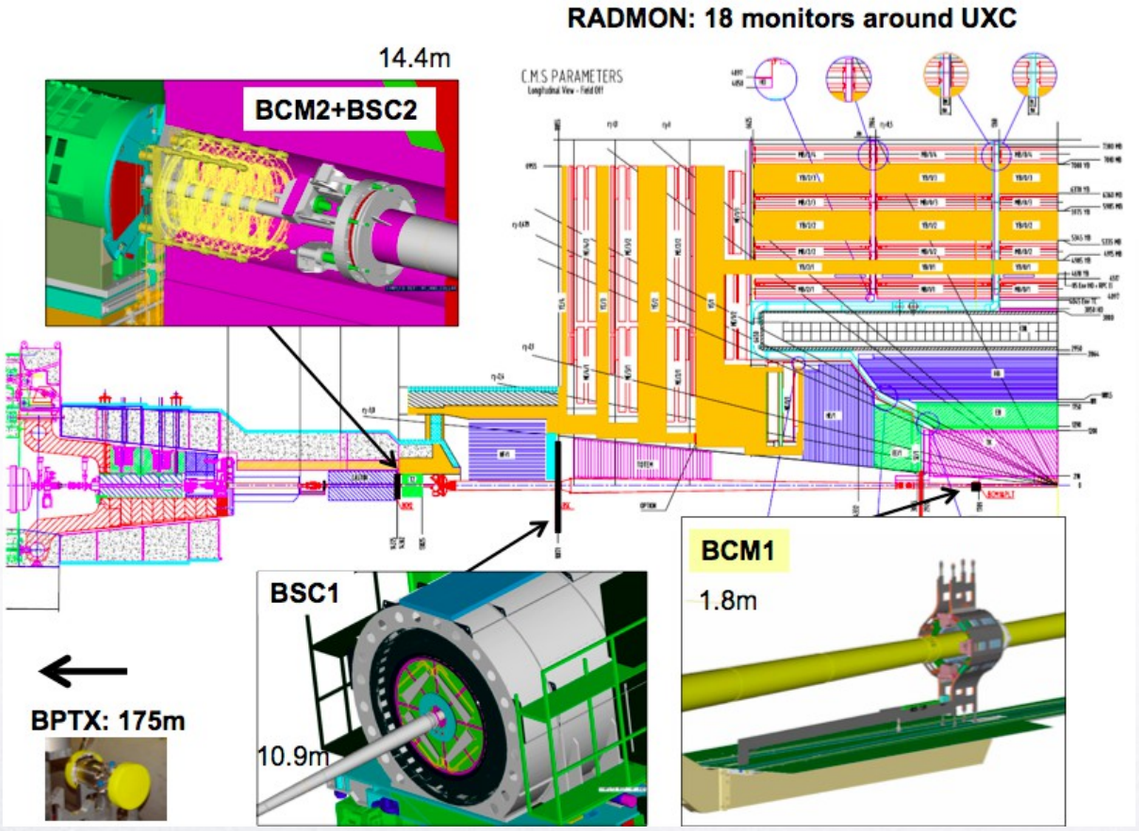
SUPERCONDUCTING SOLENOID
Niobium-titanium coil carrying ~18000 A

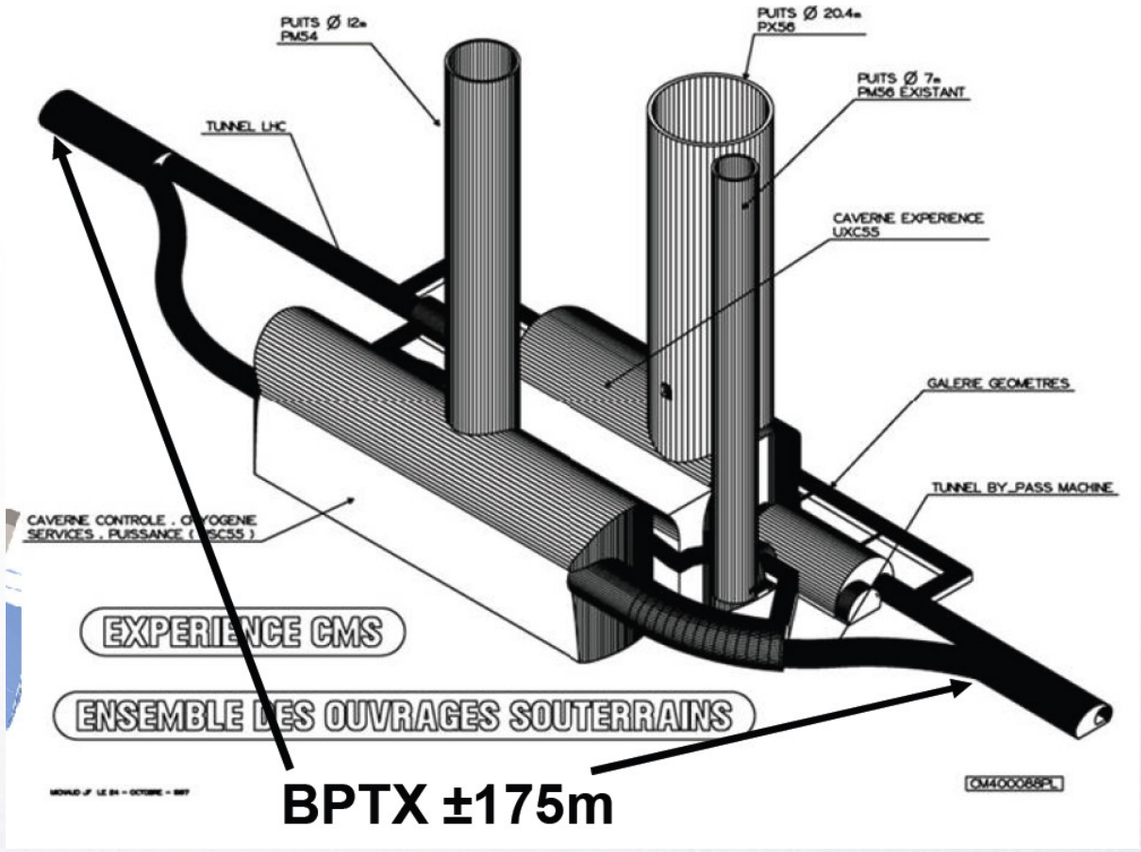
HADRON CALORIMETER (HCAL)
Brass + plastic scintillator

FORWARD CALORIMETER
Steel + quartz fibres

MUON CHAMBERS
Barrel: 250 Drift Tube & 500 Resistive Plate Chambers
Endcaps: 450 Cathode Strip & 400 Resistive Plate Chambers

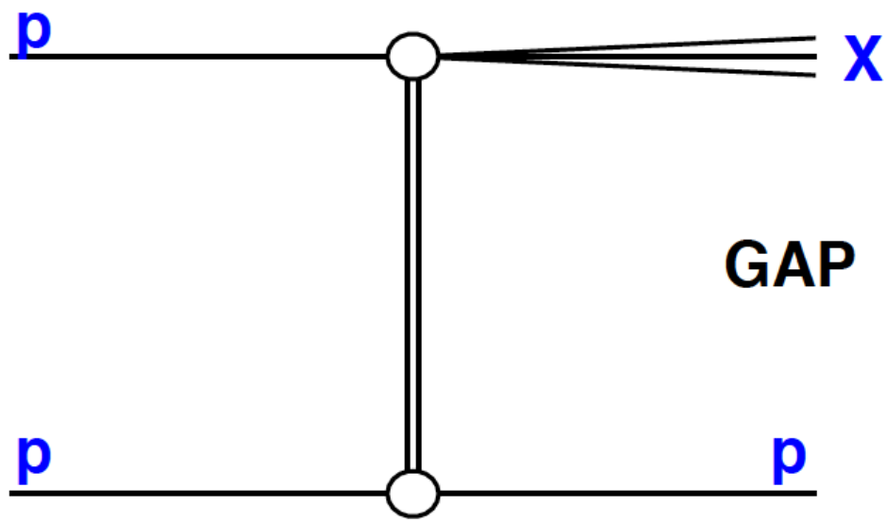
Total weight	: 14000 tonnes
Overall diameter	: 15.0 m
Overall length	: 28.7 m
Magnetic field	: 3.8 T


RADMON: 18 monitors around UXC
14.4m
BCM2+BSC2
C.M.S PARAMETERS
BSC1
10.9m
BCM1
1.8m
BPTX: 175m


PUITS Ø 12m
PM54
PUITS Ø 20.4m
PX56
PUITS Ø 7m
PM56 EXISTANT
TUNNEL LHC
CAVERNE EXPERIENCE
UXC55
GALERIE GEOMETRES
TUNNEL BY_PASS MACHINE
CAVERNE CONTROLE . CRYOGENIE
SERVICES . PUISSANCE (USC55)
EXPERIENCE CMS
ENSEMBLE DES OUVRAGES SOUTERRAINS
OM4000688PL
BPTX ±175m

Observation of diffraction in proton-proton collisions at 900, 2360 GeV and 7000 GeV centre-of-mass energies at the LHC.

Topology



$$\sqrt{s} = \left\{ \begin{array}{r} 900\,GeV\,(2009) \\ 2360\,GeV\,(2009) \end{array} \right\} \; CMS\ FWD-10-001$$

$$7000\,GeV\,(2010) \quad CMS\ FWD-10-007$$

Event selection

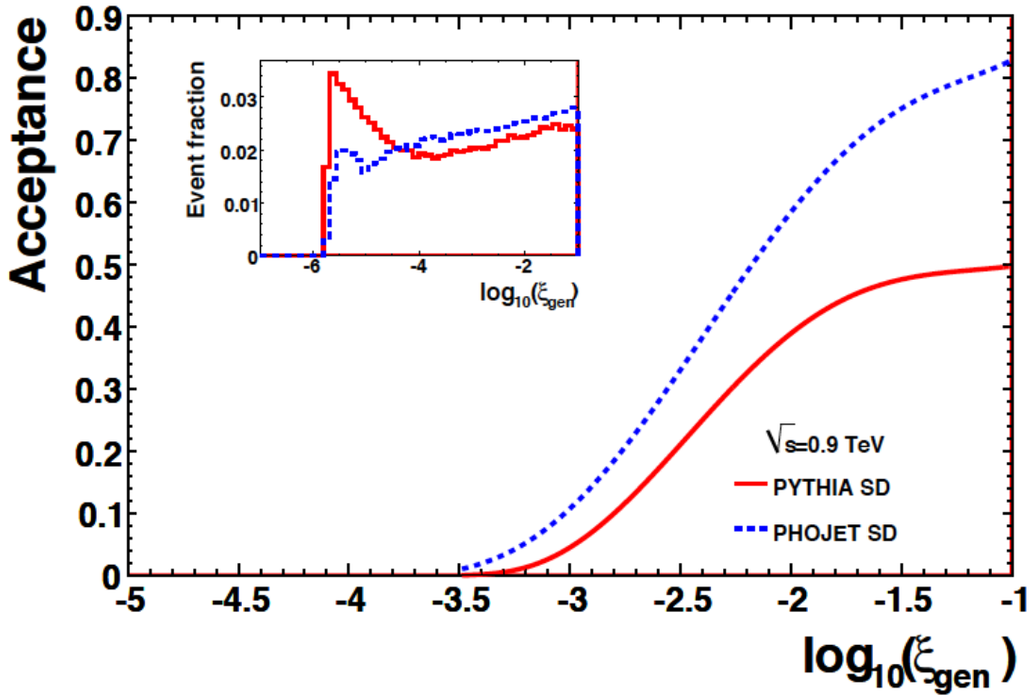
- Trigger:
  - BSC OR & BPTX OR
- Offline:
  - BPTX AND + BSC OR
  - Vertex with $|z|<15cm$, $R_{xy}<2cm$, at least 3(4) tracks
  - Hallo rejection (BSC)
  - $N_{Trk} > 10$ and $Fraction_{HqTrk} > 25\%$
  - HCAL noise rejection

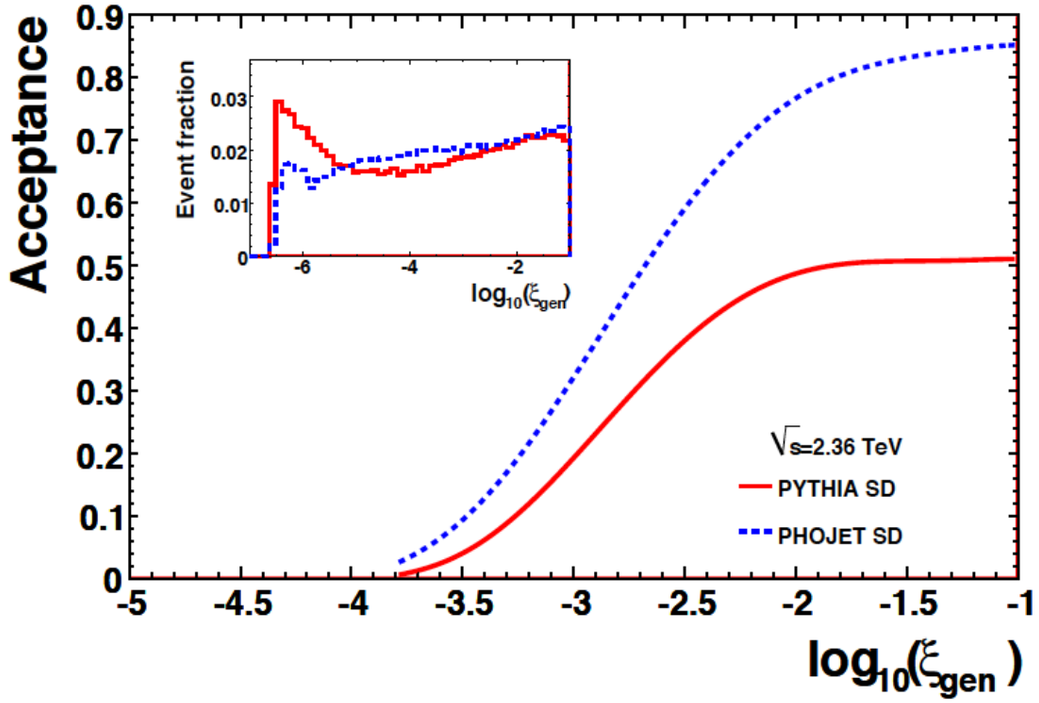
two bunch crossing

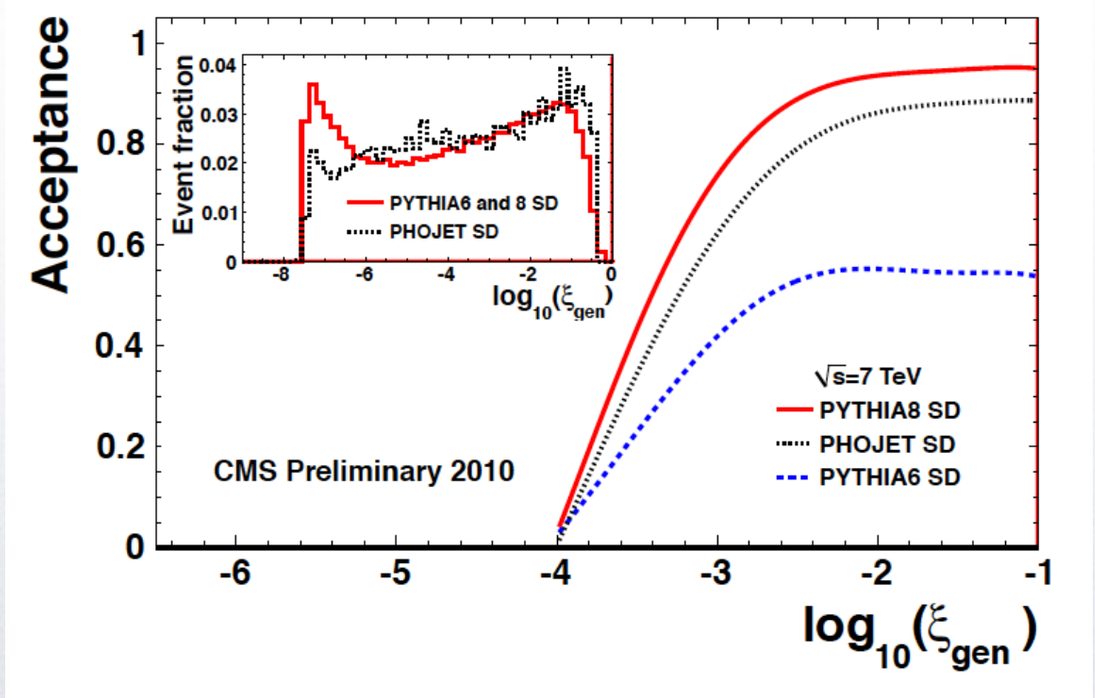
SD interaction

3 GeV (2009)
1.5 GeV(B)/2 GeV(E) (2010)
4 GeV (HF)

SD acceptance







Data Sample & MC

$\sqrt{s}$	900 GeV	2360 GeV	7000 GeV
# Events	207345	11848	1030752
MC	PYTHIA6 (D6T,CW,DW) PHOJET		PYTHIA6 (D6T,CW,DW,PO,Z1) PYTHIA8 PHOJET

Pile up probability ~ 0.5%

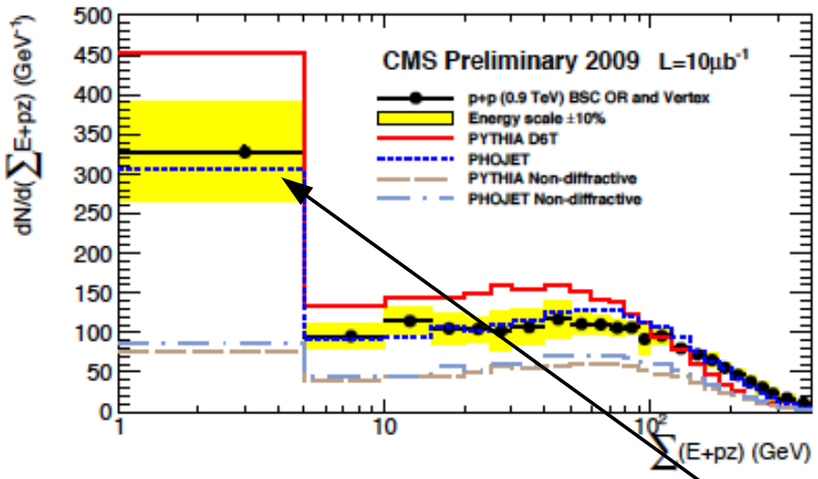
Results

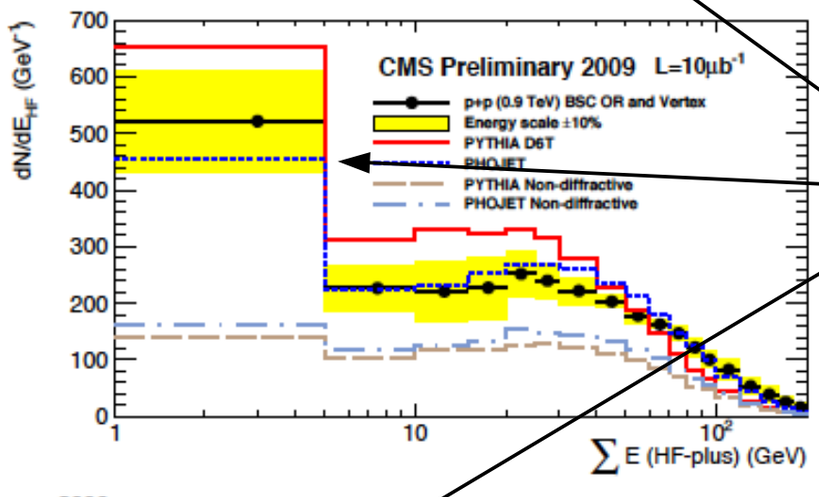
Diffractive sample

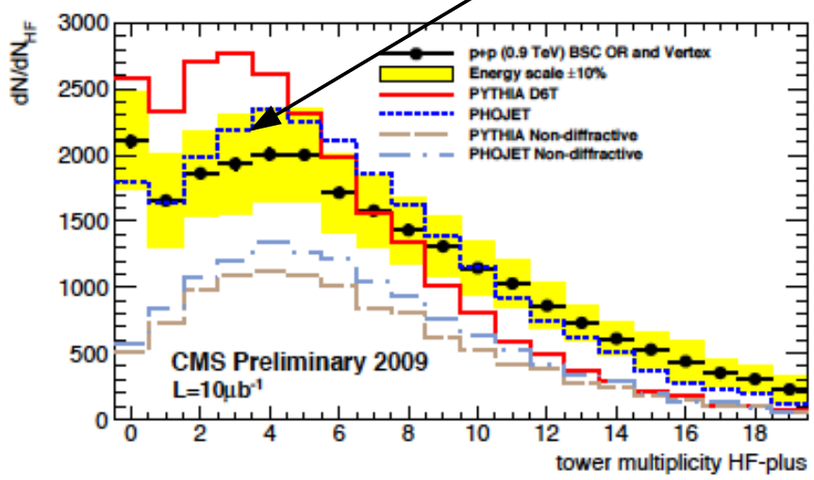
$$\sum E_{HF\pm} < 8\,GeV$$

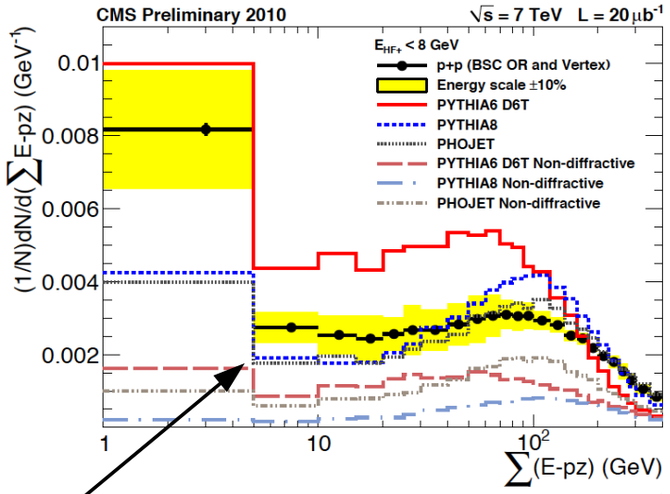
PHOJET

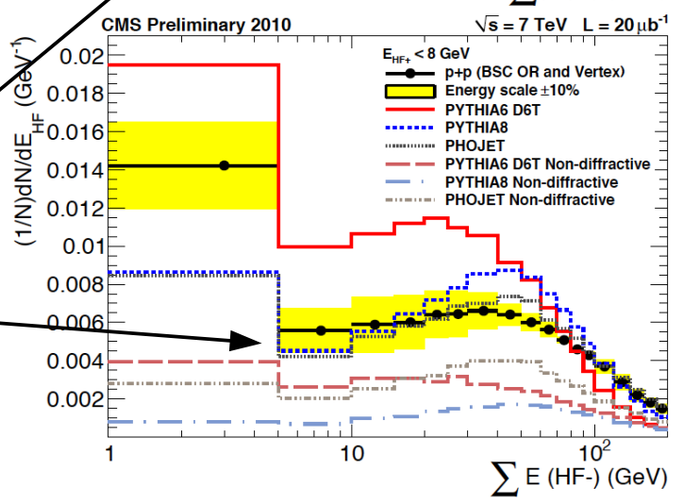
PHOJET
PYTHIA8

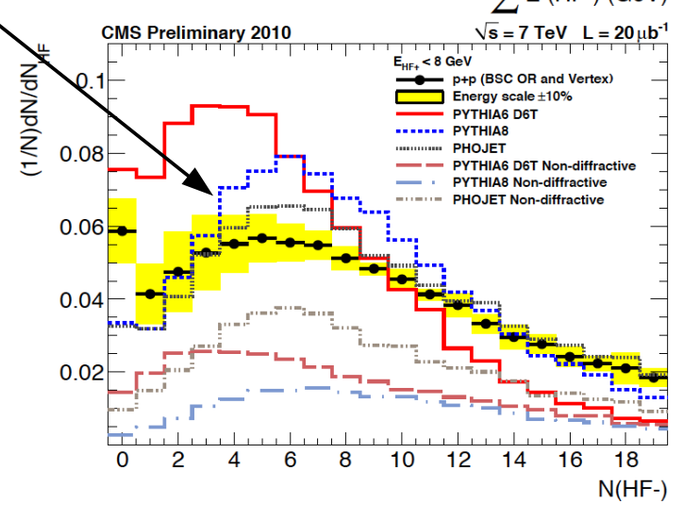












Measurement of inelastic cross section at $\sqrt{s} = 7$ TeV, using two complementary methods:

1 - energy in the HF calorimeter $\longrightarrow$ total

2 - vertex-counting (Si tracker) $\longrightarrow f$(#tracks)

1 $\longrightarrow$ forward

2 $\longrightarrow$ central

CMS FWD-11-001

Event selection

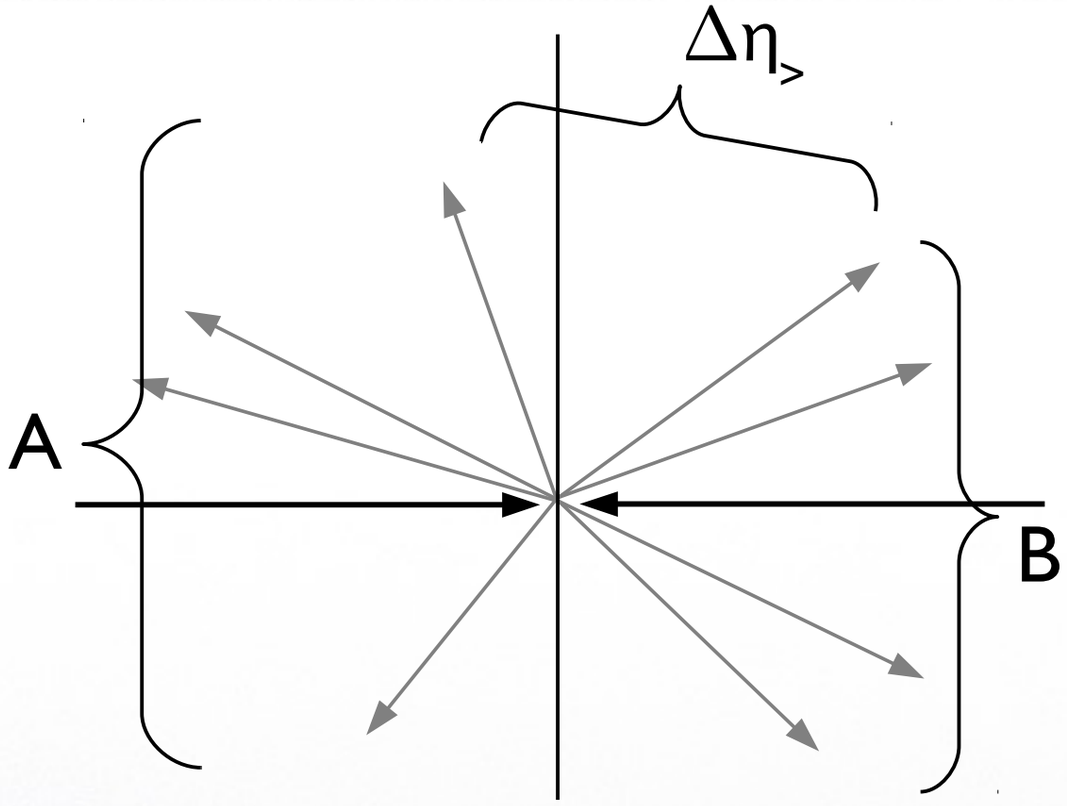
Method 1

- Trigger:
  - BPTX AND → zero-bias trigger
  - BPTX XOR → background
  - Random (empty) trigger → noise estimation
- Offline
  - $\sum E_{HF} \geq 5$ GeV

Method 2

- Inclusive samples of:
  - two electrons (3.6×10^6)
  - Single muons (1.5×10^6)
  - Particles with $p_T > 200$ MeV/c
  - $|\eta| < 2.4$

Analysis strategy



A,B $\xrightarrow{>M}$ $M_X \rightarrow \xi=(M_X c)^2/s$

MC

⇩

$\sigma(\xi>5\times10^{-6})$

Based on a Poisson distribution for the number of collision/trigger

Simultaneous collision

$$P(i,\lambda)=\frac{\lambda^i e^{-\lambda}}{i!}$$

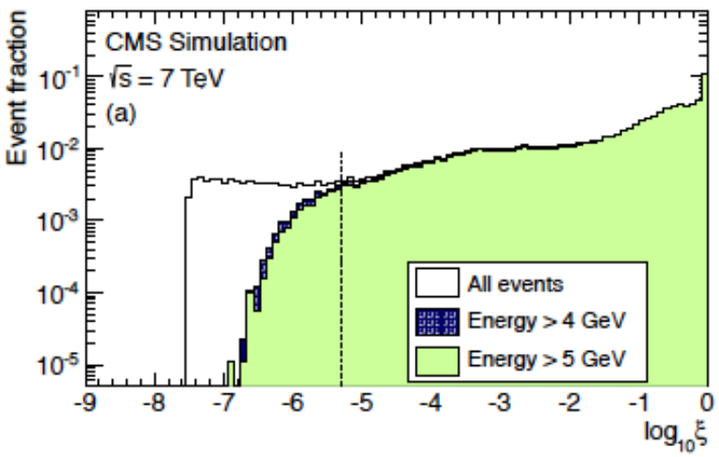
$$\lambda = L\cdot\sigma_{inel}$$

Mean # of interactions

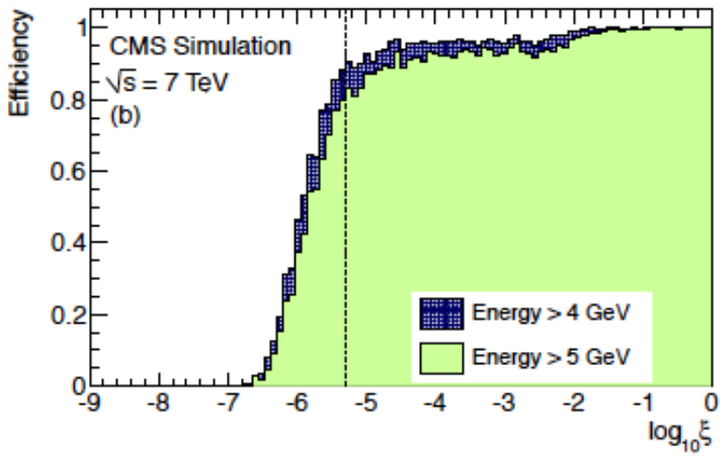
Instantaneous luminosity

Selection efficiency (method 1)

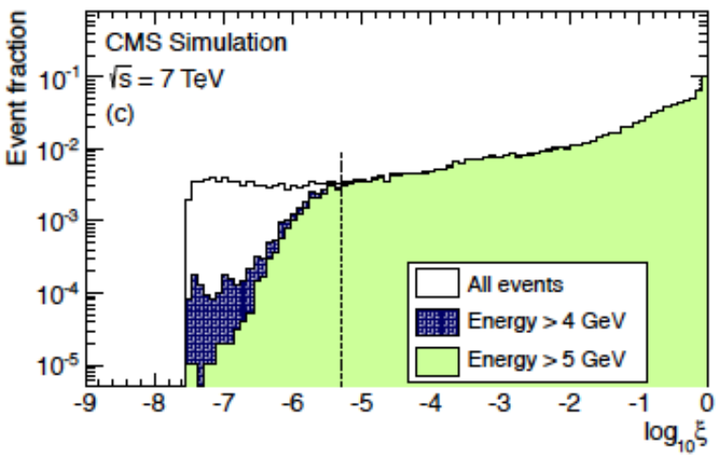
PYTHIA 6



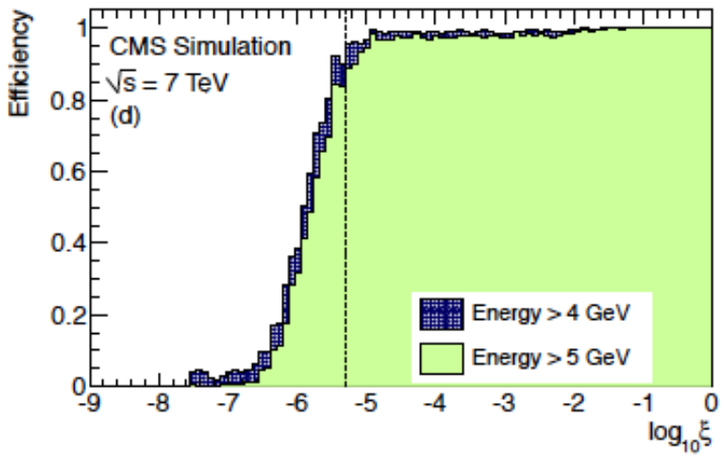
PYTHIA 6



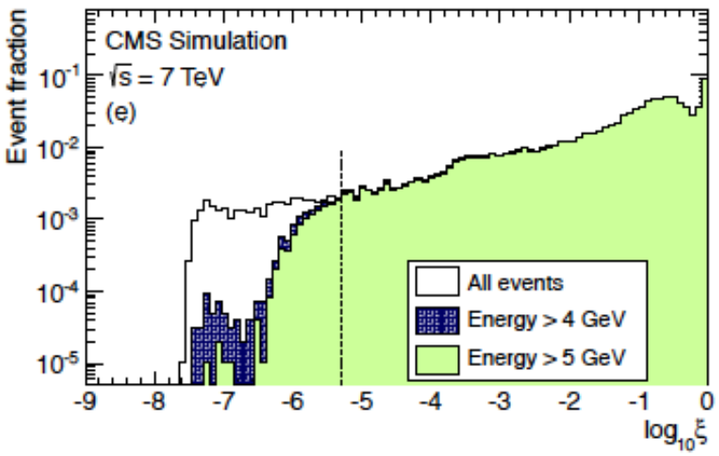
PYTHIA 8



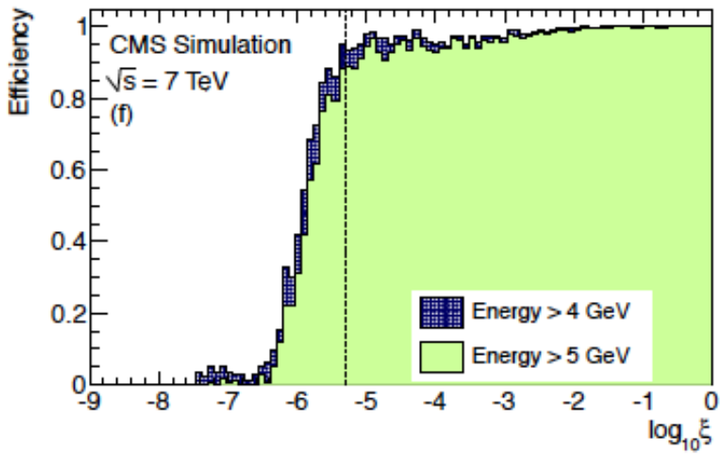
PYTHIA 8



PHOJET

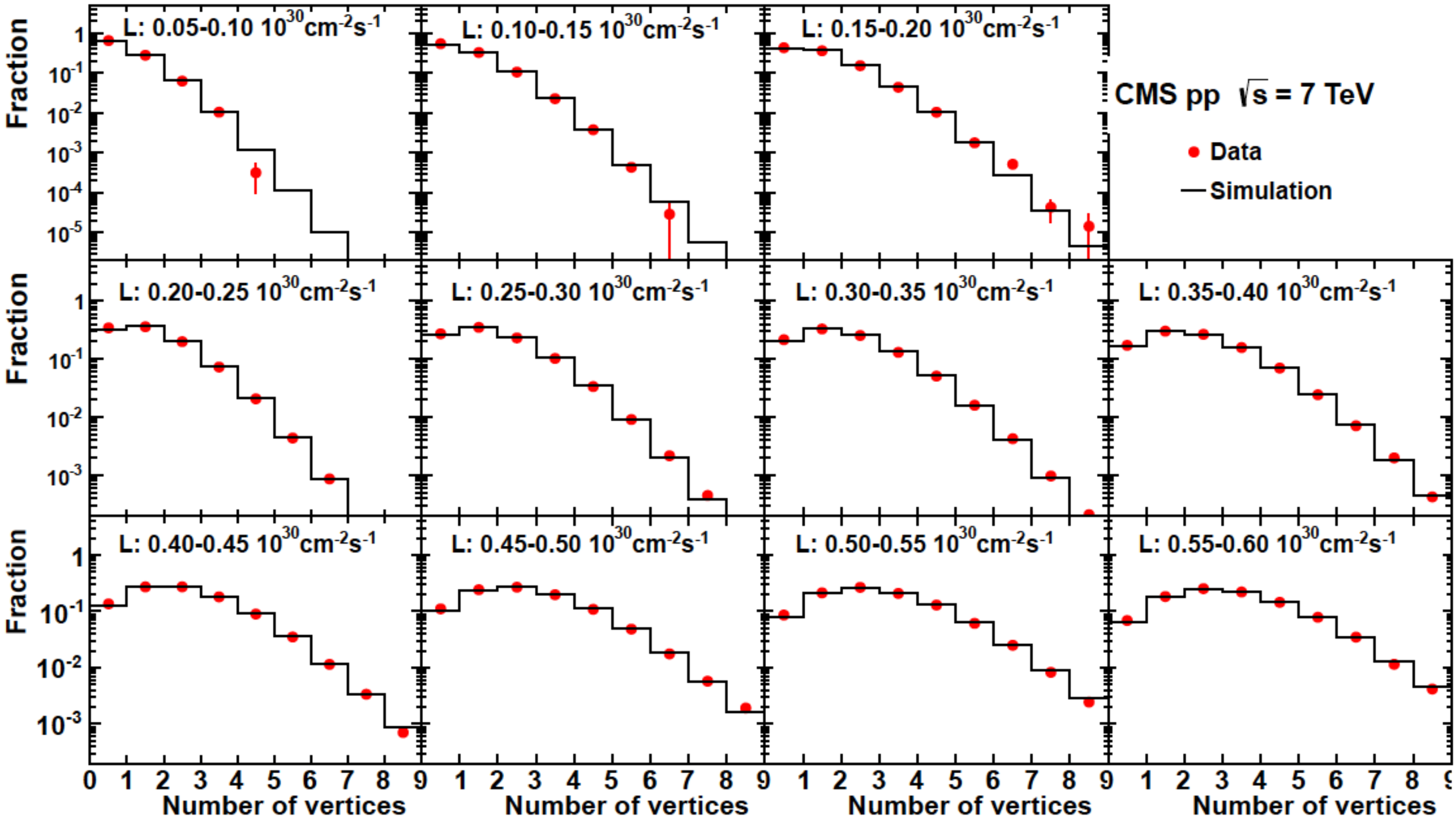


PHOJET

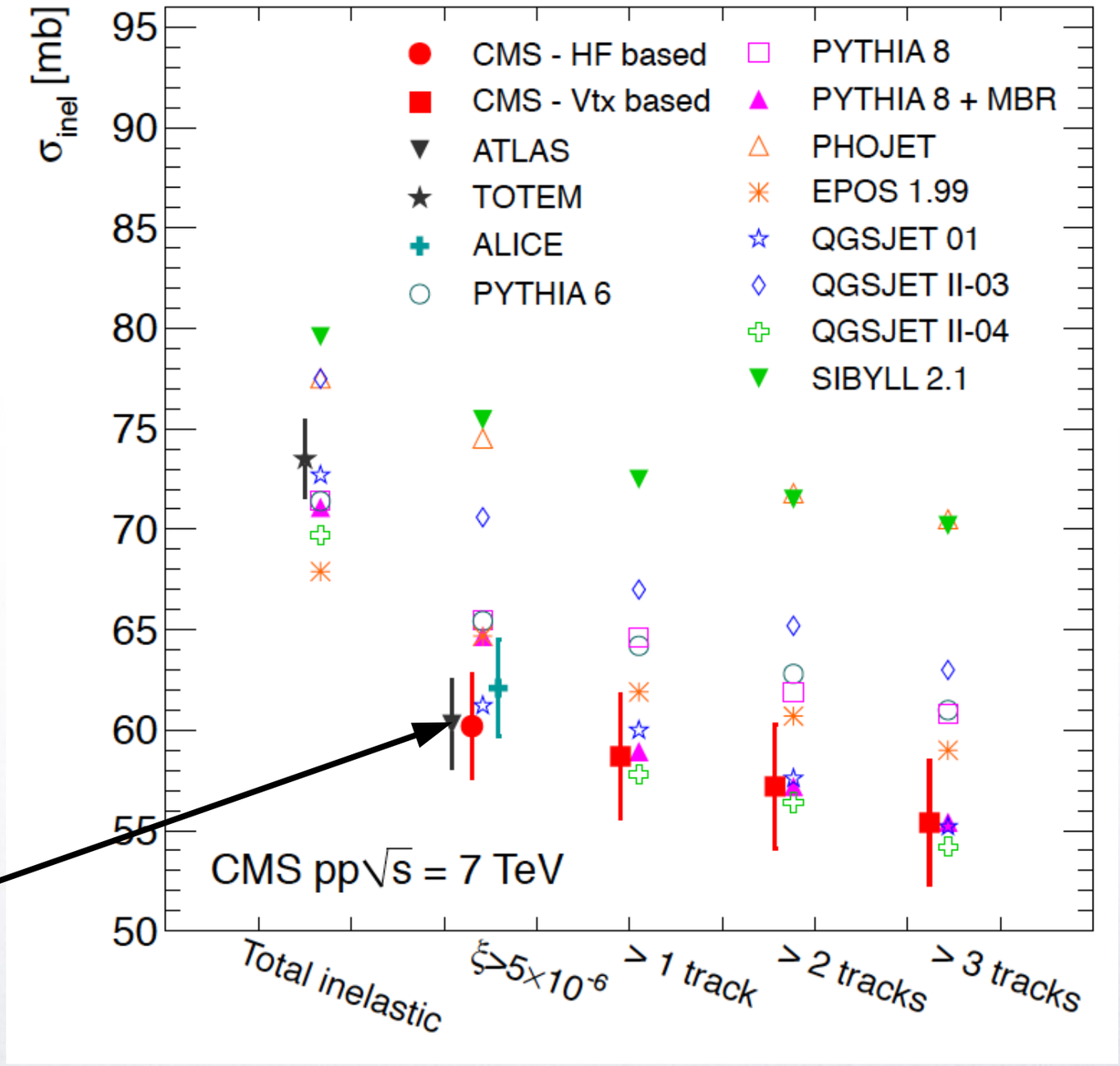


$\xi > 5 \times 10^{-6}$

Pileup distributions: Poisson fits (method 2)



Inelastic cross section



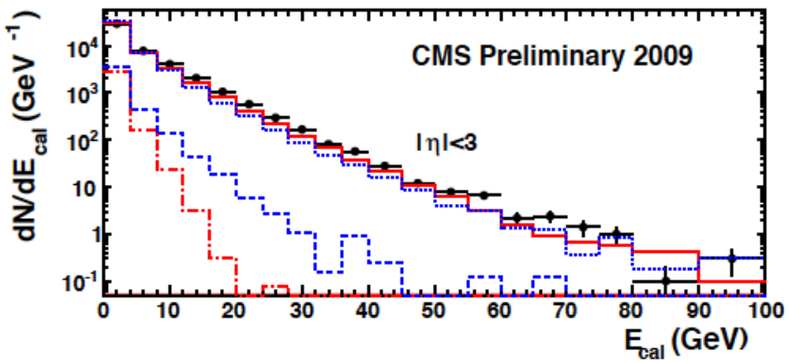
$$60.2 \pm 0.2^{stat} \pm 1.1^{syst} \pm 2.4^{\mathcal{L}}\ mb$$

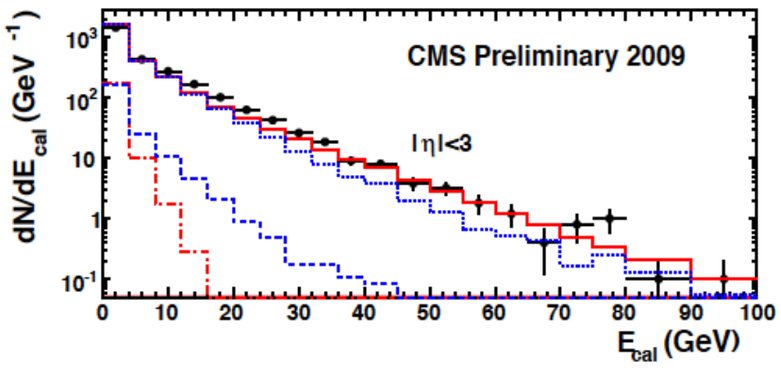
Conclusion

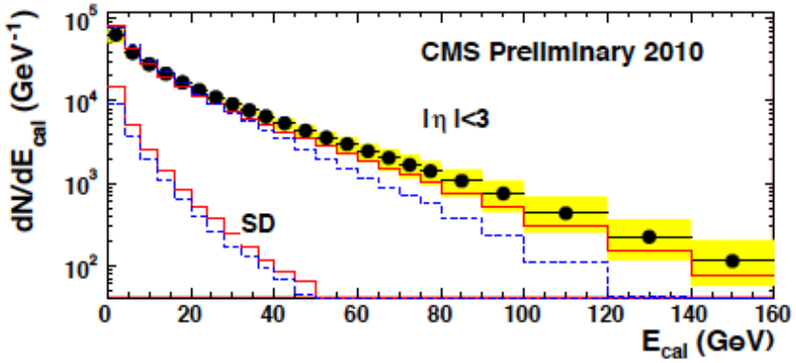
- Evidence of diffraction in *pp* collisions at $\sqrt{s}$ = 0.9, 2.36 and 7 TeV was shown;
  - The data can only be (fairly well) described by MC with a diffractive components in most of the cases;
- The inelastic cross section was measured by two independent and complementary methods, showing good agreement with other recent measurements.

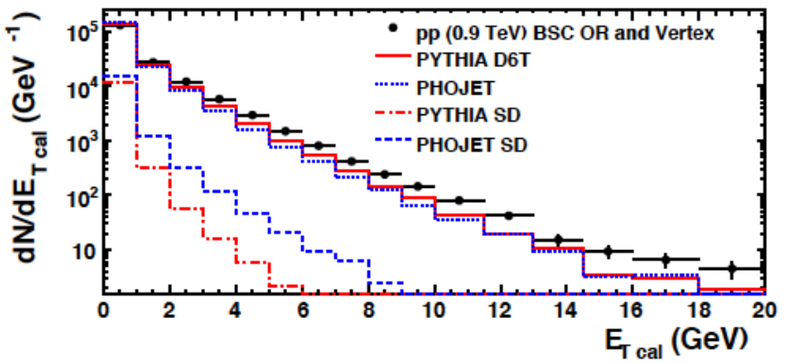
BACKUP

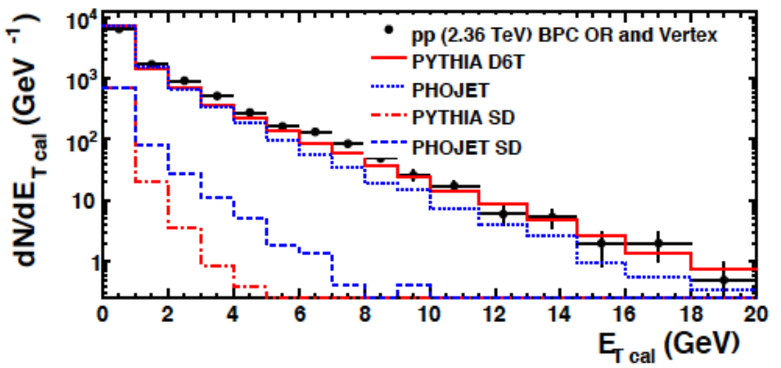
Data-MC match

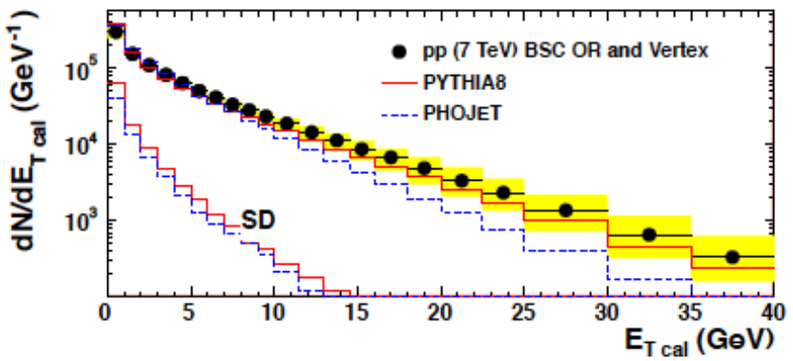


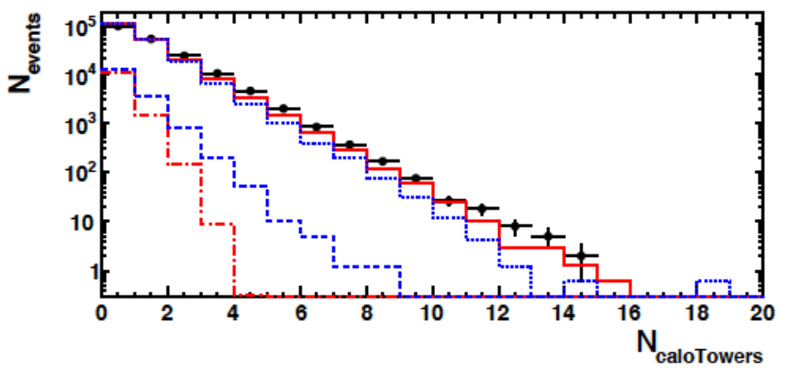


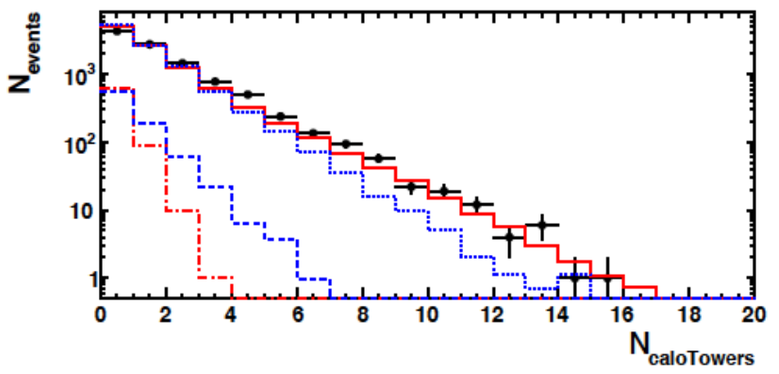


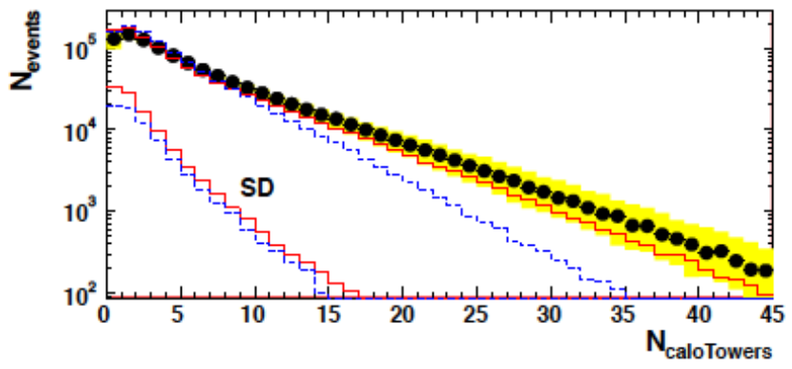




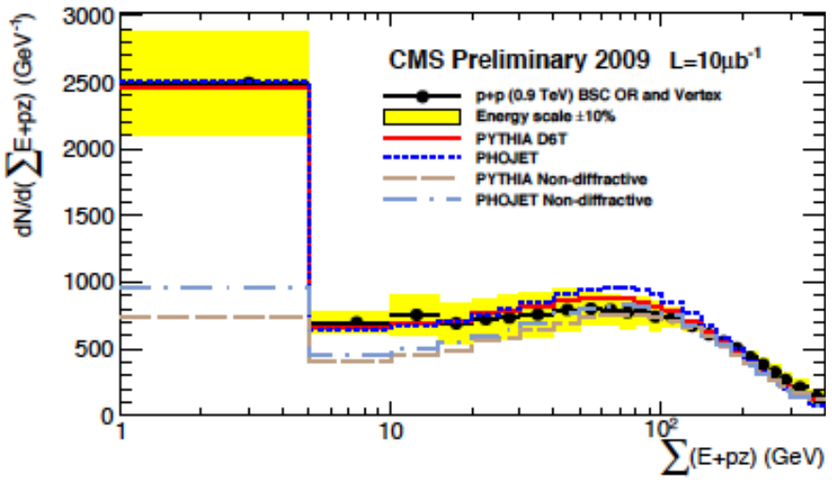


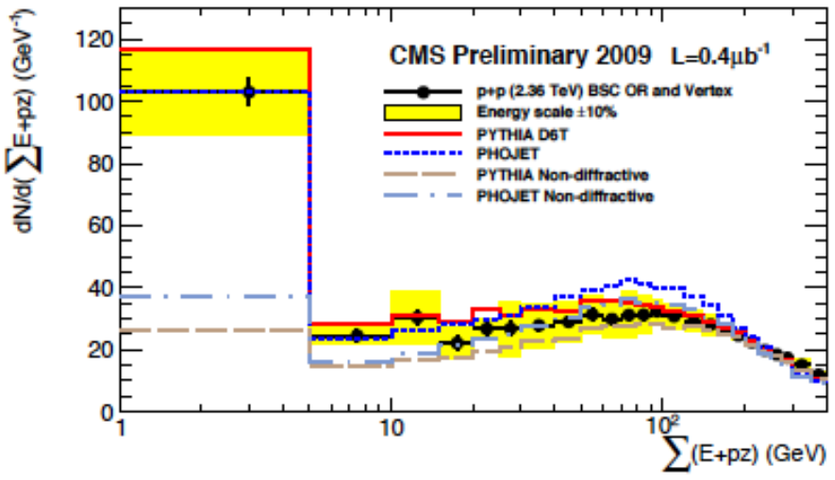


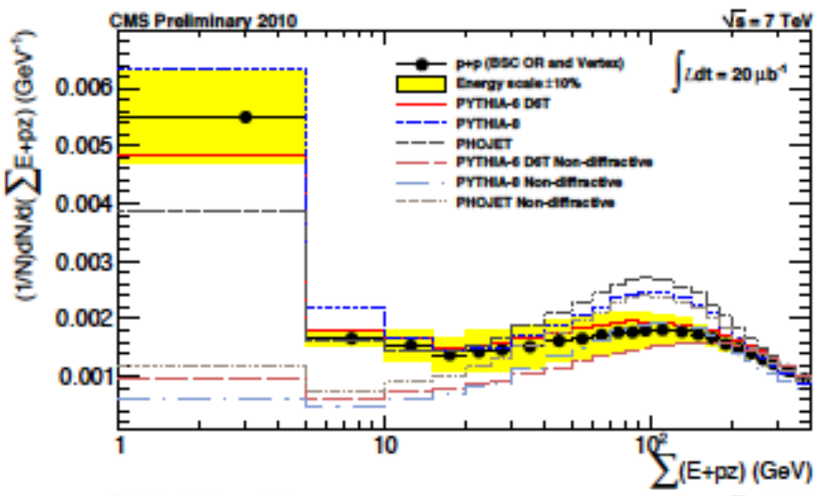


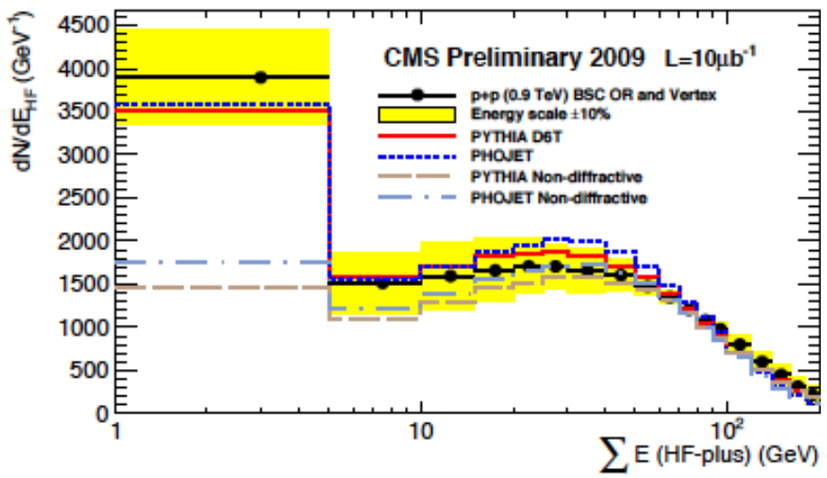


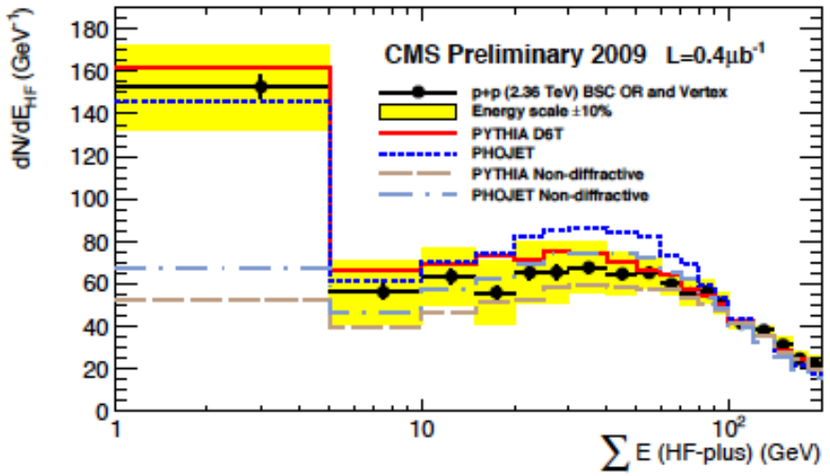
Data-MC match

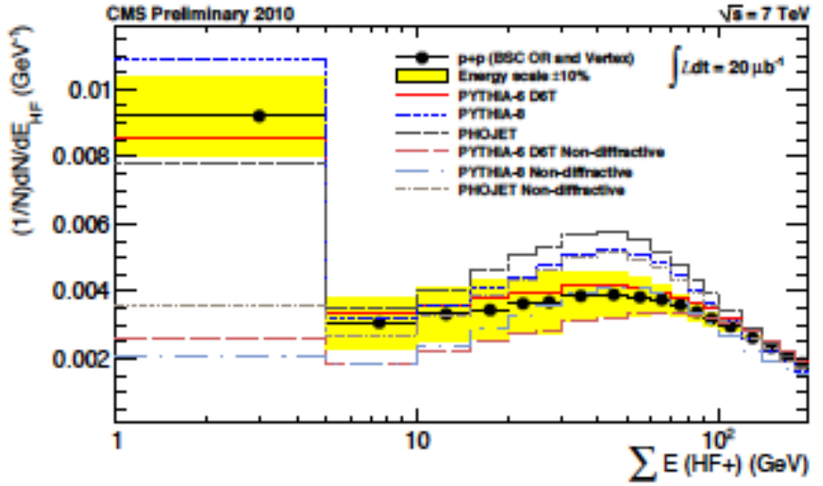


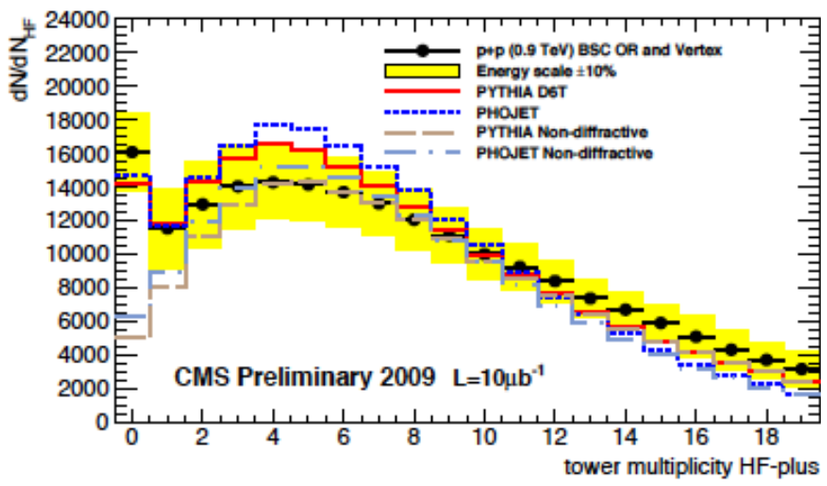


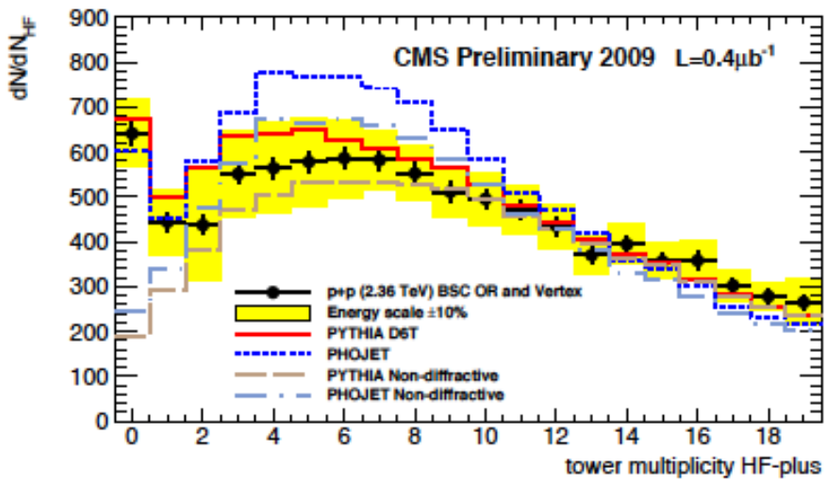


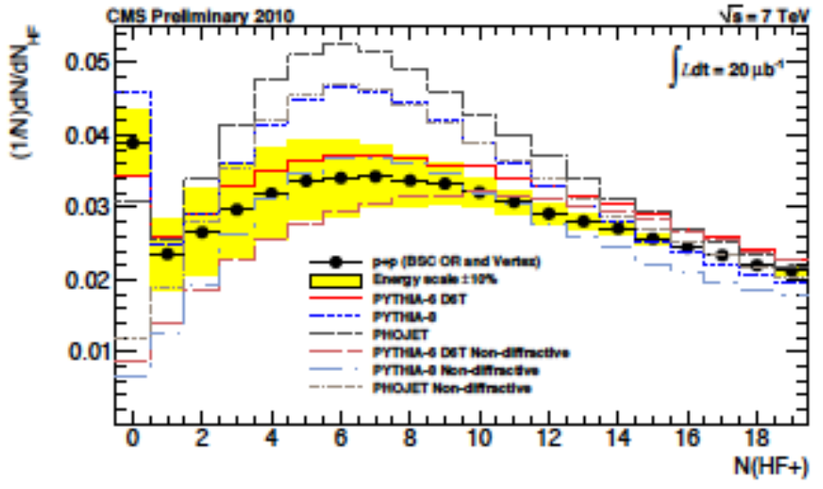












Pileup Poisson fits as $f(\mathscr{L}_{\text{inst.}})$