CERN, July 7th, 2010

LHCf status report

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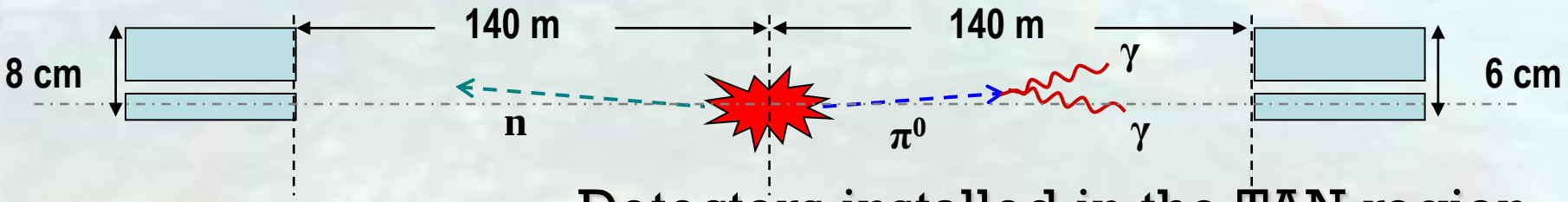
On behalf of the LHCf Collaboration

Experimental set-up

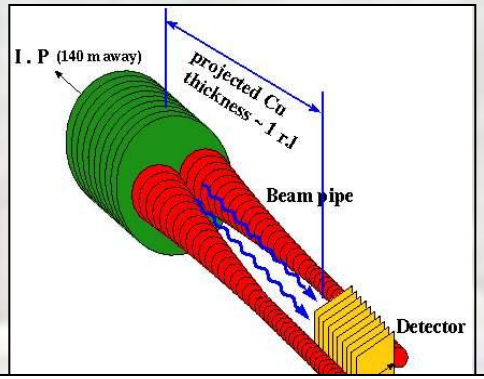
Detector I
Tungsten
Scintillator
Scintillating fibers

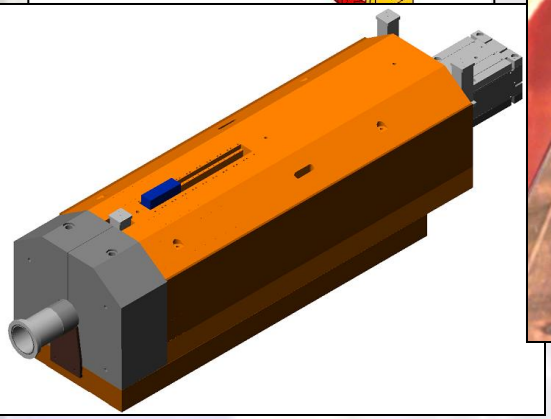
INTERACTION POINT
IP1 (ATLAS)

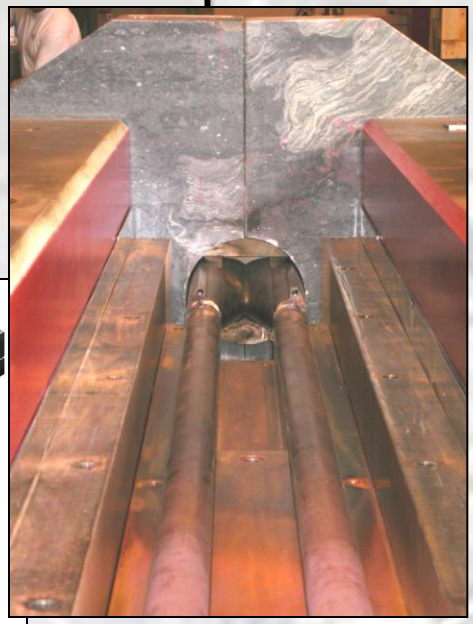
Detector II
Tungsten
Scintillator
Silicon μstrips



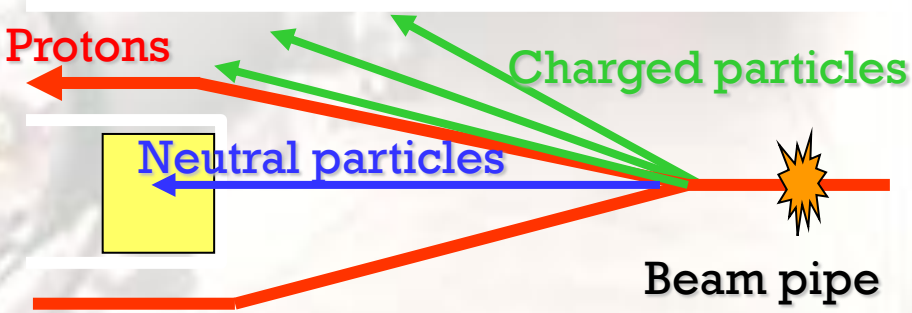
Detectors installed in the TAN region, 140 m away from the Interaction Point



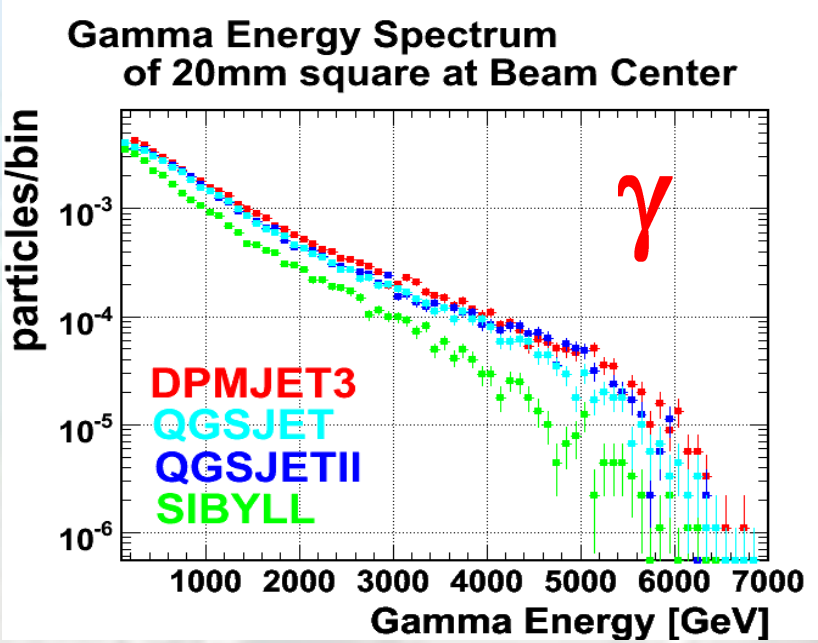




- Here the beam pipe splits in 2 separate tubes.
- Charged particle are swept away by magnets
- We cover up to $y \rightarrow \infty$

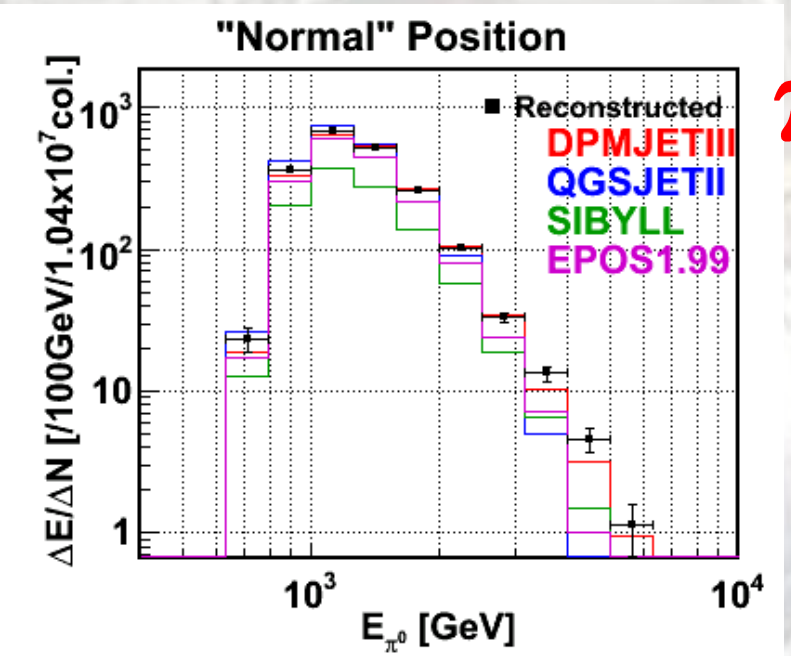


LHCf : Monte Carlo discrimination



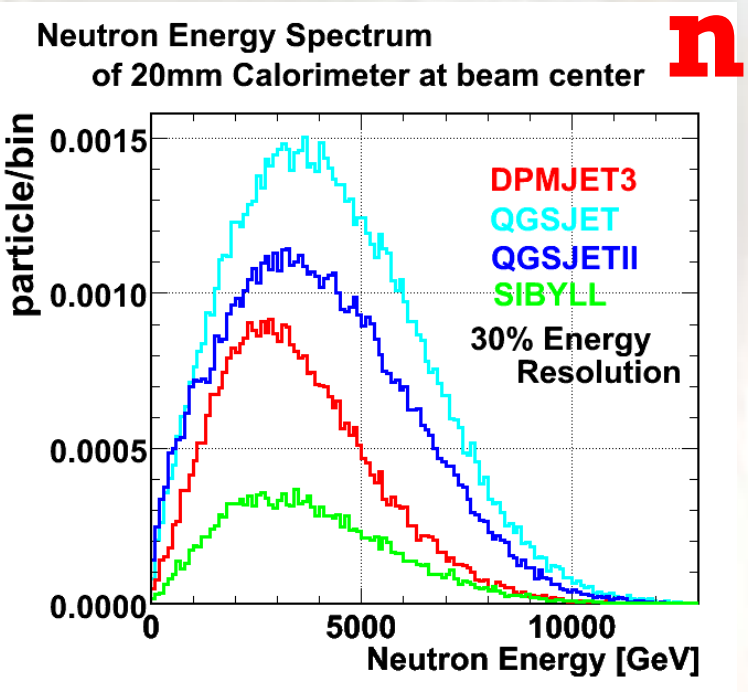
γ

10^6/10^7 generated LHC interactions at 7+7 TeV→
1 minute exposure@10^{29} $cm^{-2}s^{-1}$ luminosity



π^0

n



LHCf Operations at 900 GeV

06 Dec – 15 Dec 2009

27.7 hours for physics

~5×10^5 collisions at IP1

~2,800 shower events in Arm1

~3,700 shower events in Arm2

02 May – 27 May 2010

15 hours for physics

~5.5×10^6 collisions at IP1 (Statistics x 11 wrt 2009)

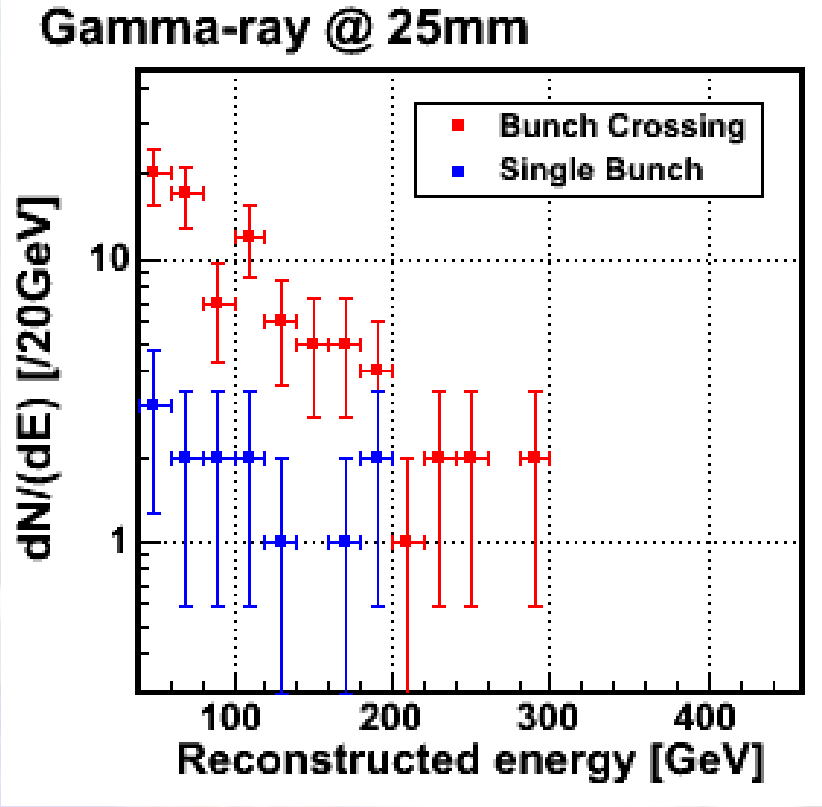
~44,000 shower events in Arm1

~63,000 shower events in Arm2

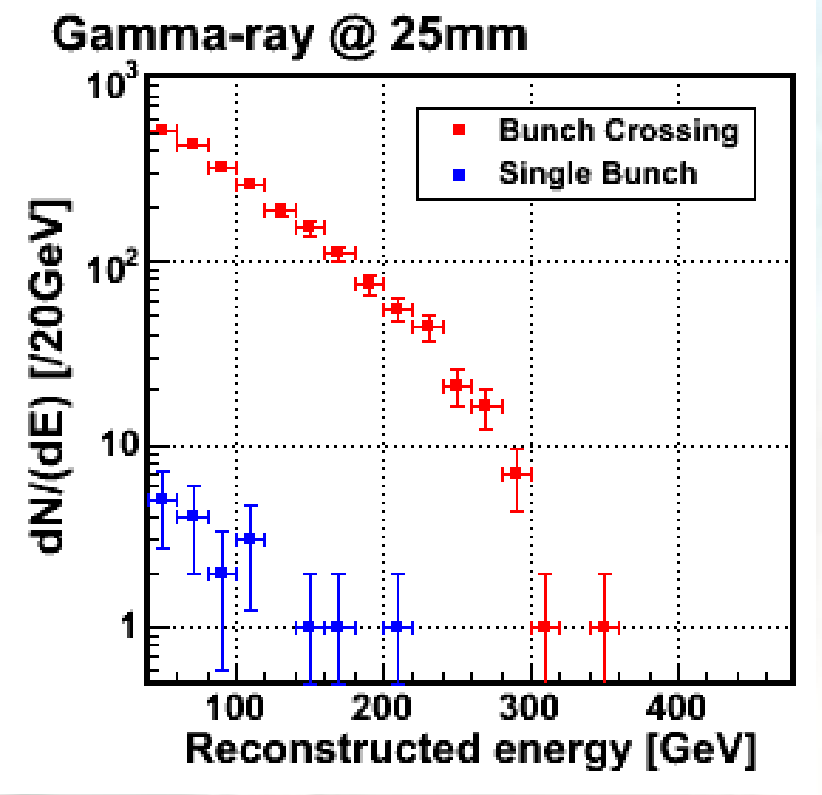
Beam Gas significantly reduced wrt 2009

2009 vs 2010

2009



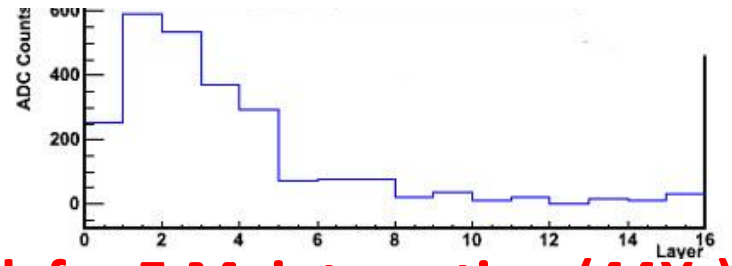
2010



Very big reduction in the Beam Gas / Bunch crossing ratio!!!!
Very big increase of the 'signals/noise' ratio due to higher intensity

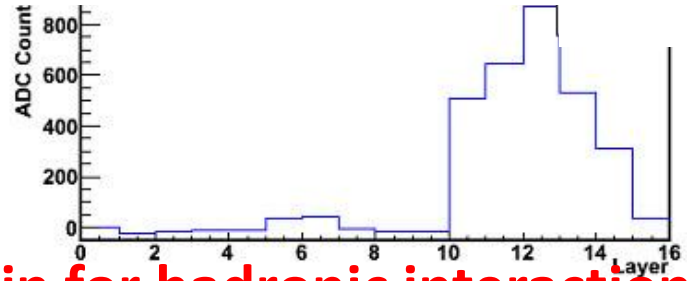
Particle Identification

Longitudinal development of γ shower



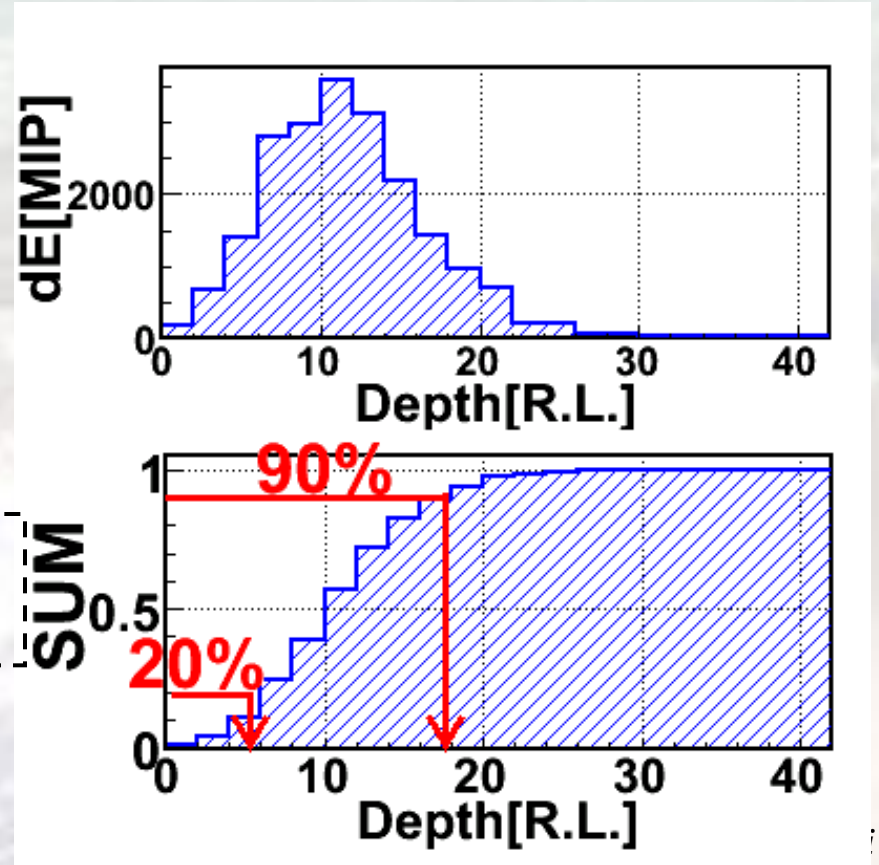
Thick for E.M. interaction ($44X_0$)

Longitudinal development of Hadron shower



Thin for hadronic interaction(1.7λ)

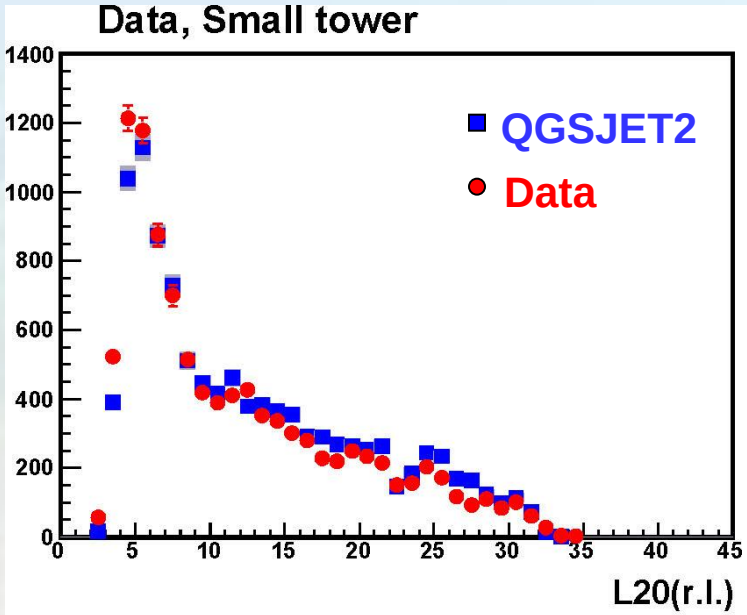
Definition of L90%

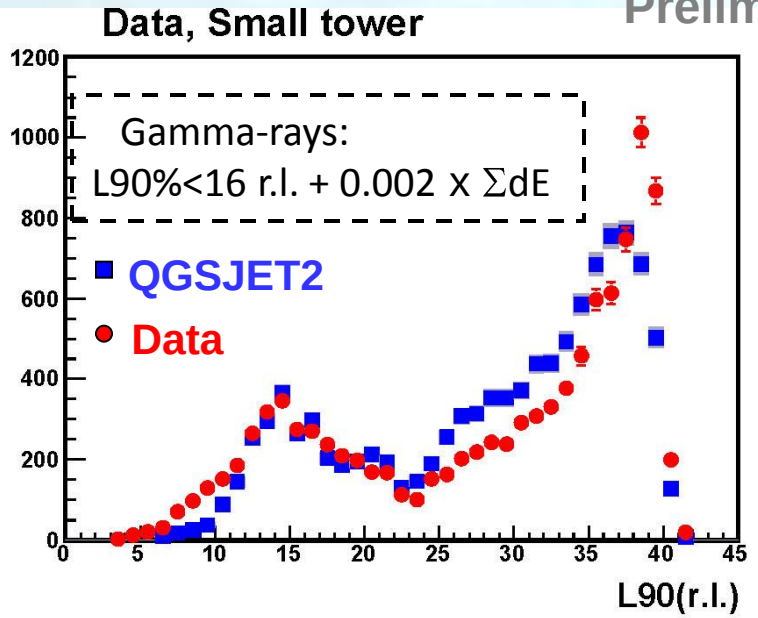


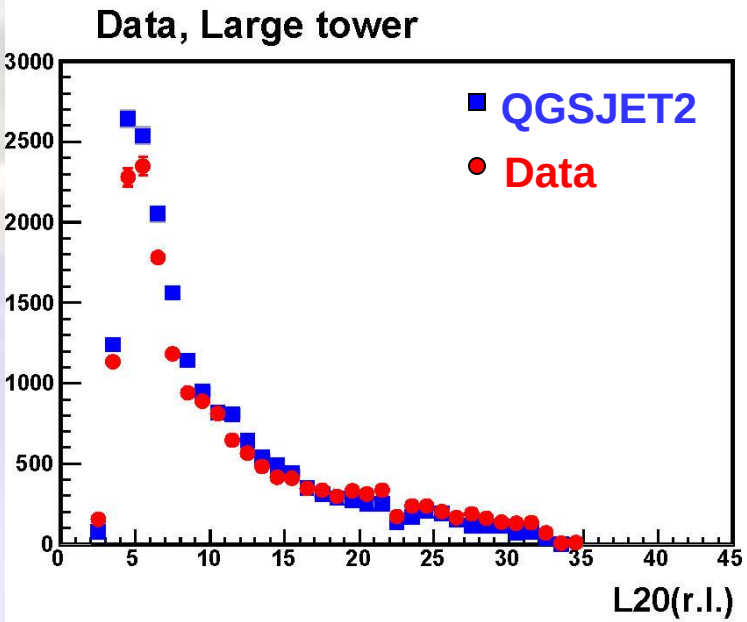
Gamma-rays:
L90%<16 r.l. + 0.002 x ΣdE

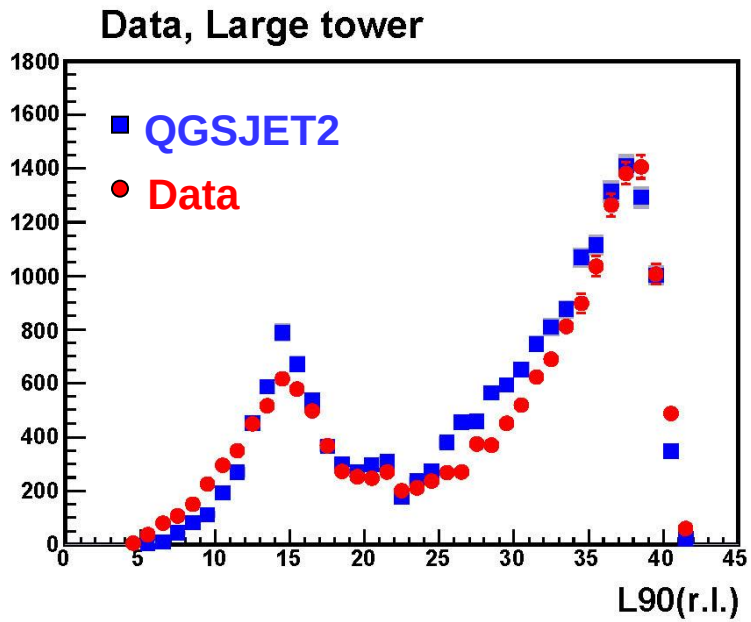
Results at 900GeV: PID

Preliminary



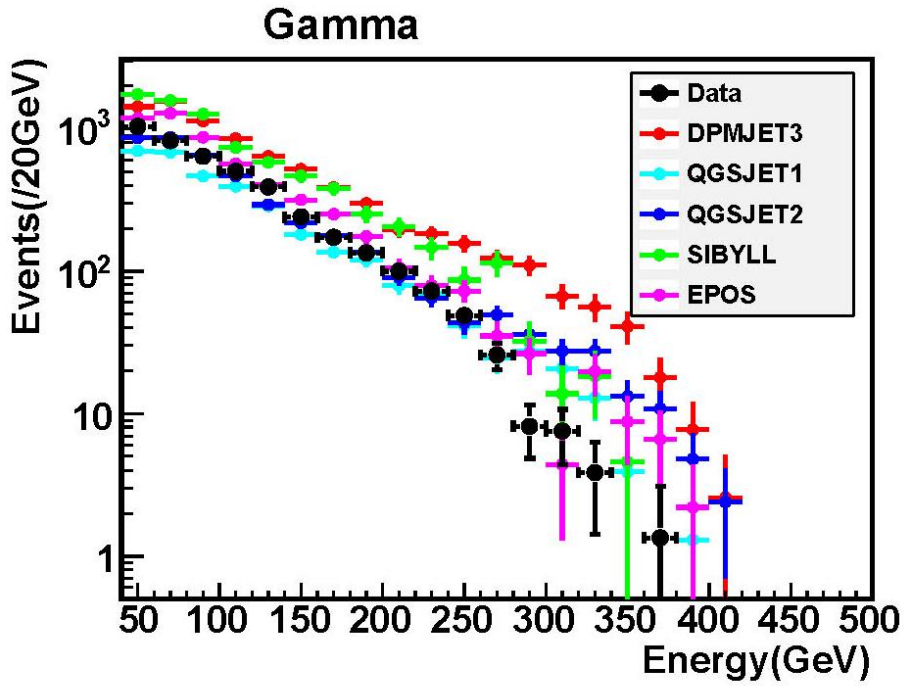


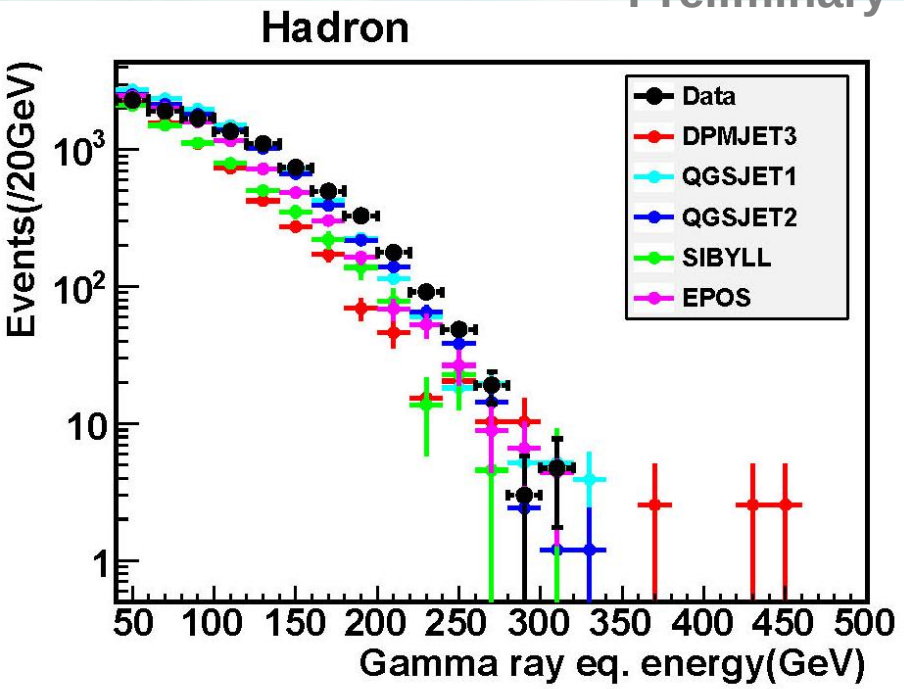




Arm1 Spectra at 900 GeV

Preliminary

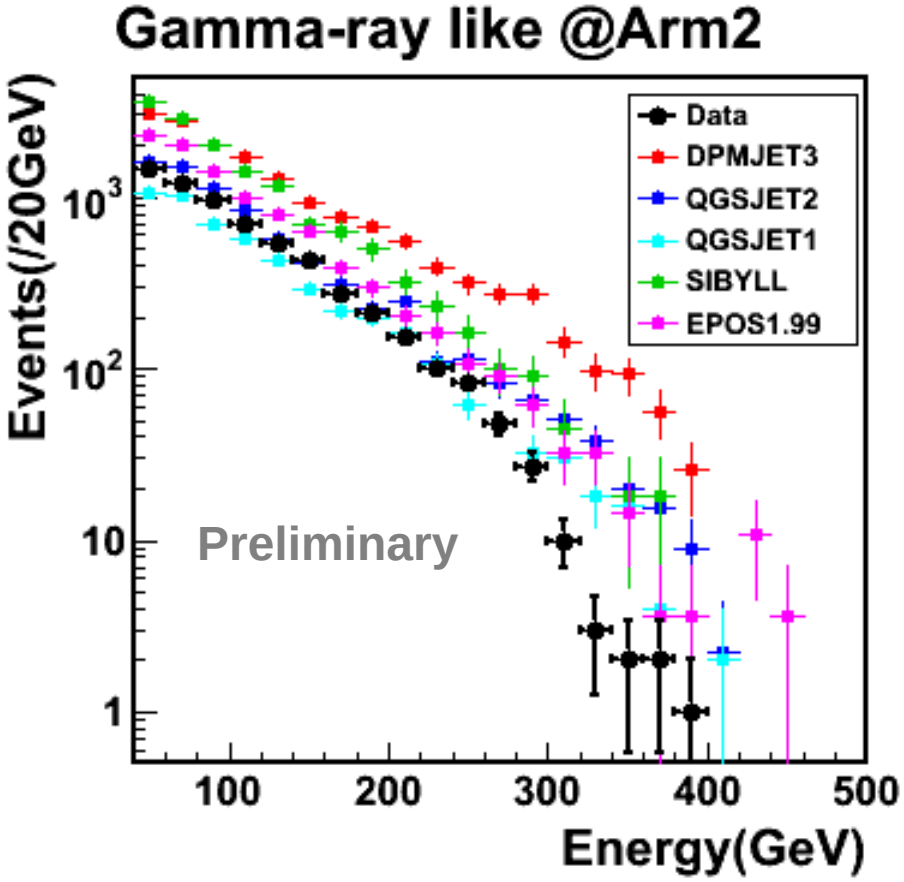


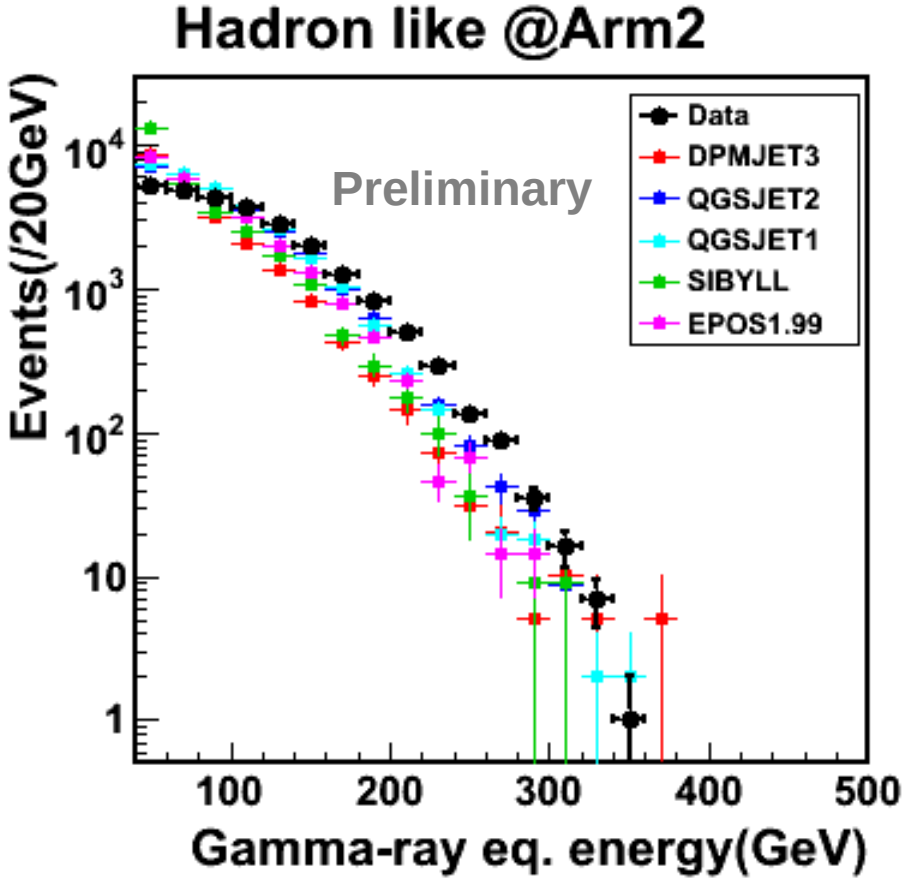


Only statistical errors are quoted

MC normalized to the total number of events in the 2 towers,without PID.
Only one normalization factor common to all models

Arm2 Spectra at 900 GeV





Only statistical errors are quoted

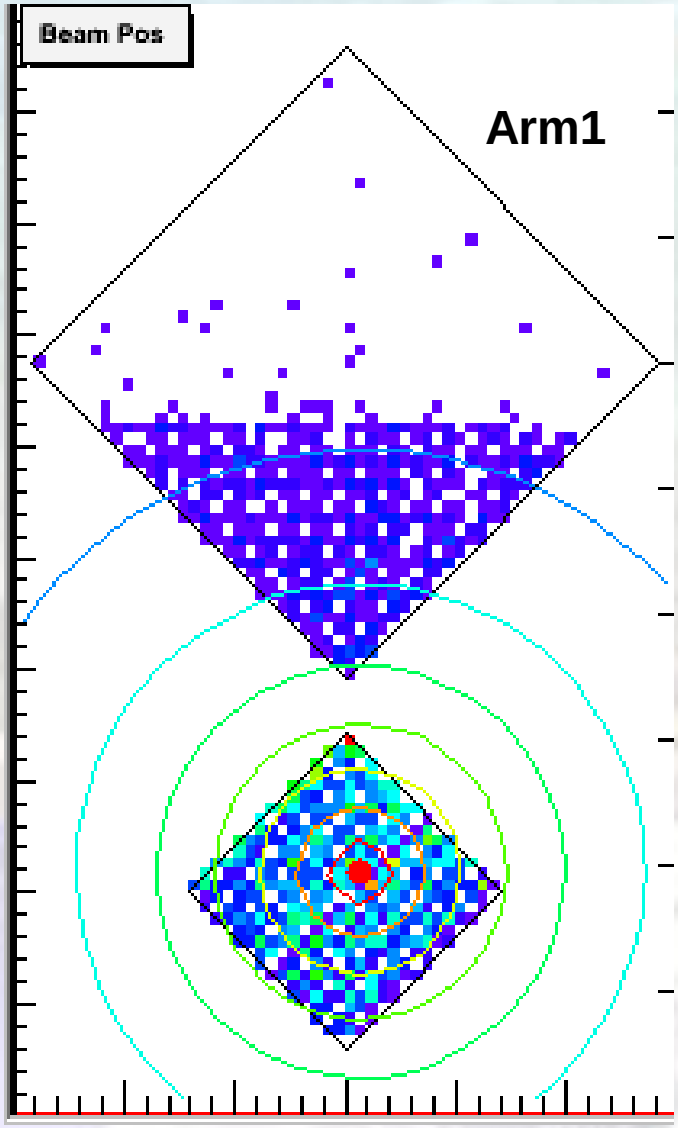
MC normalized to the total number of events in the 2 towers,without PID.
Only one normalization factor common to all models

LHCf 2010 runs (mainly at 7 TeV)

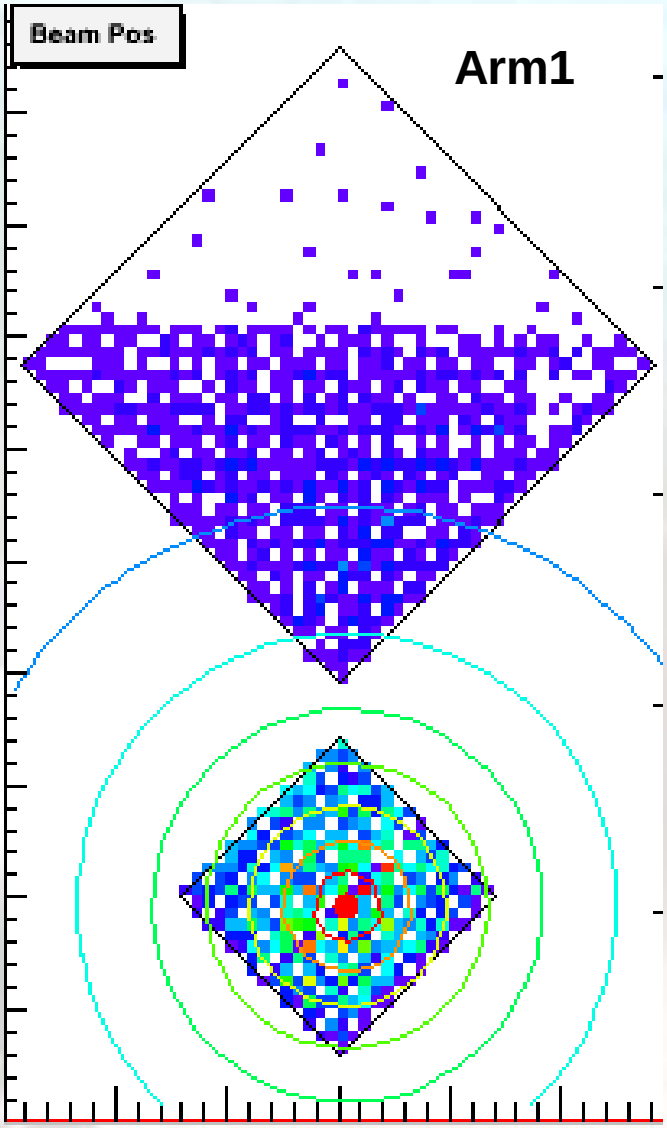
- Detector shows good performance with stable quality.
  - Energy scale calibration with the π^0 peak!!!!
  - Good stability < ±1% level.
  - We start now to have some radiation problem.
- Thanks a lot to all LHC people for providing us 100 μrad crossing angle!!!
  - Very important for physics to enlarge the P_T acceptance
  - Special thanks to Massi for coordinating the efforts!

Acceptance gain due to Crossing Angle

No crossing angle



100 μrad crossing angle



A very significant gain in acceptance is clearly visible!

Operation at 7 TeV

Without crossing angle (30/03 – 05/06)

Vertical Position	Center	-5mm	-8mm	-10mm
Arm1	35,938,286	5,433,952	4,876,170	9,617,205
Arm2	38,873,415	5,709,553	4,256,258	2,459,871

Total : Arm1 51,227,454 events
Arm2 54,957,955 events
in 223 hours operation and about 14 nb^{-1}

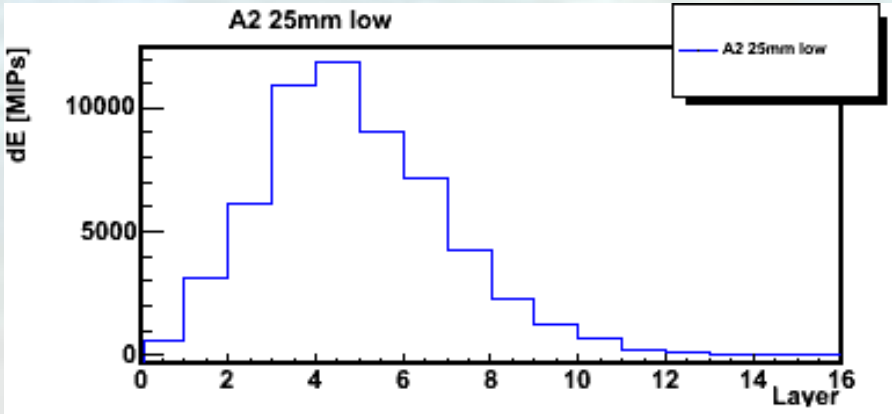
With 100μrad crossing angle (25/06 – Now)

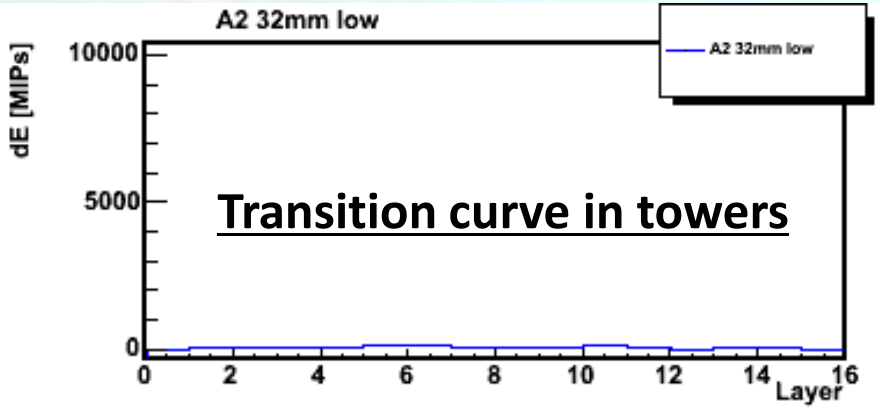
Vertical Pos.	Center	+8mm	+5mm	-5mm	-8mm
Arm1	45,369,562	2,106,042	1,818,097	2,044,387	4,960,483
Arm2	41,001,321	-	1,647,263	4,065,706	2,159,801

Total : Arm1 56,298,571 events
Arm2 48,874,091 events
in 63 hours operation and about ~70 nb^{-1}

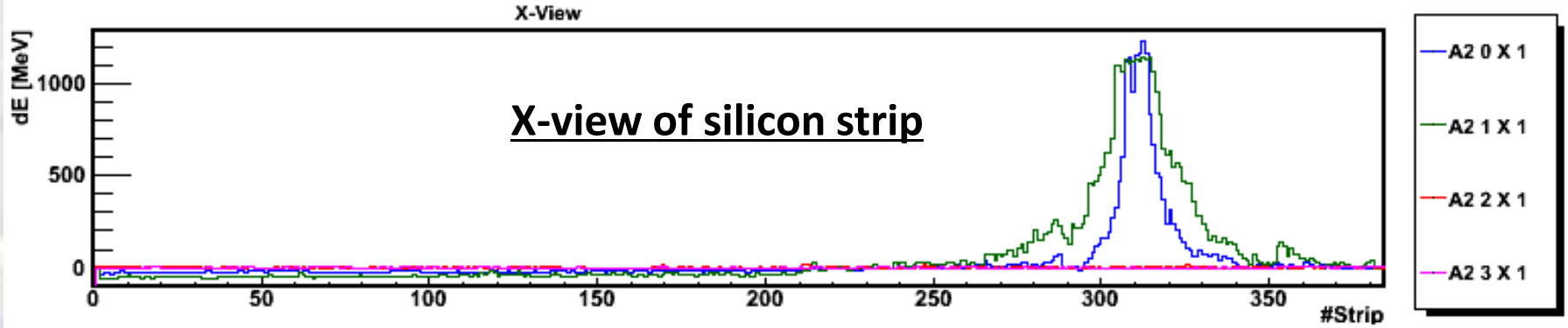
7 TeV collisions

1 TeV gamma-ray shower @ Arm2

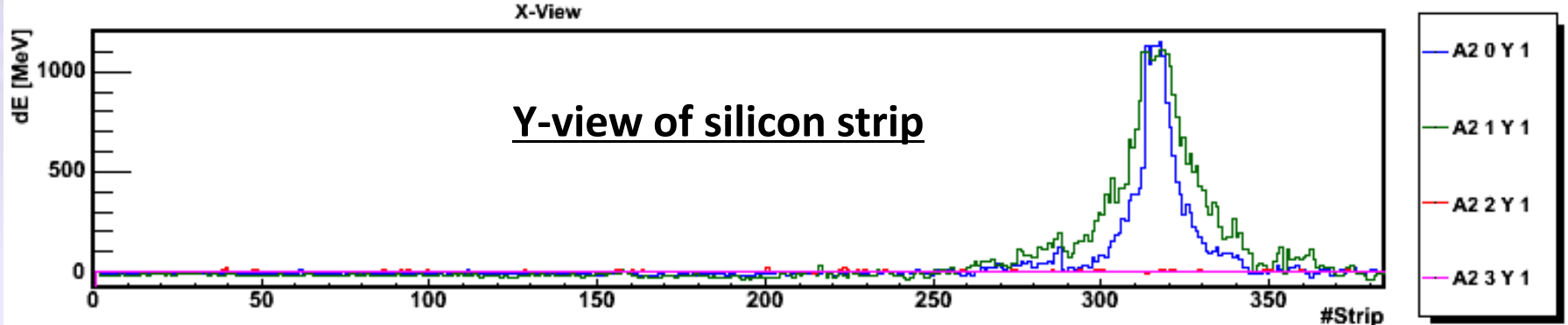




Transition curve in towers

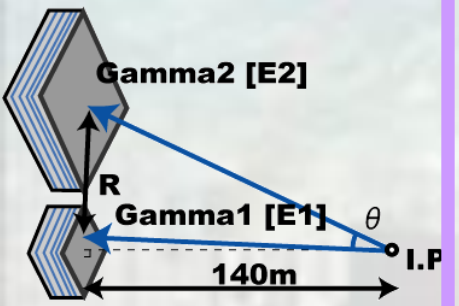


X-view of silicon strip

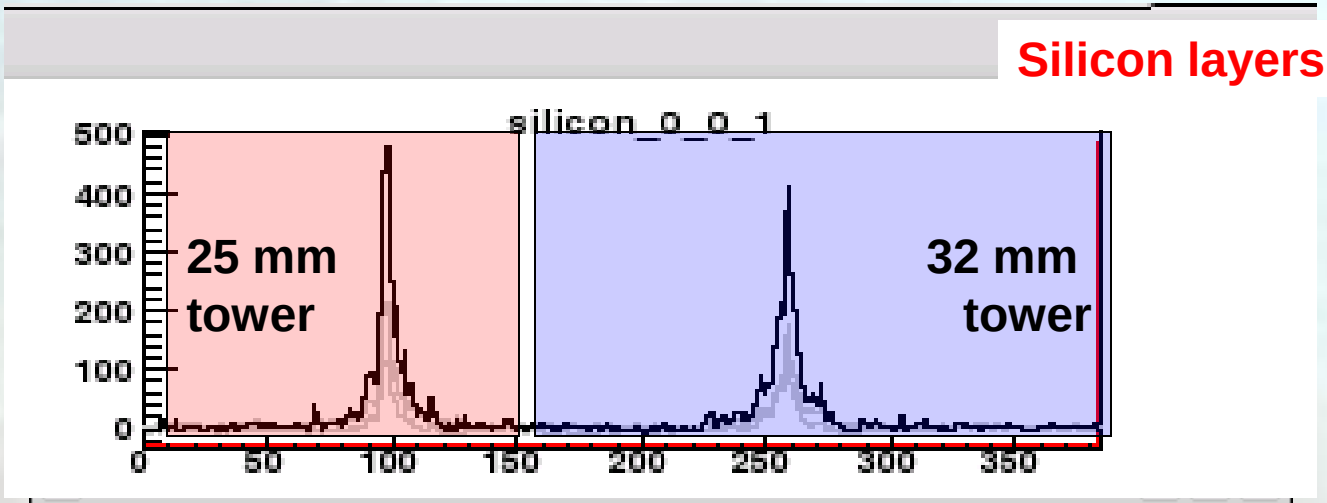


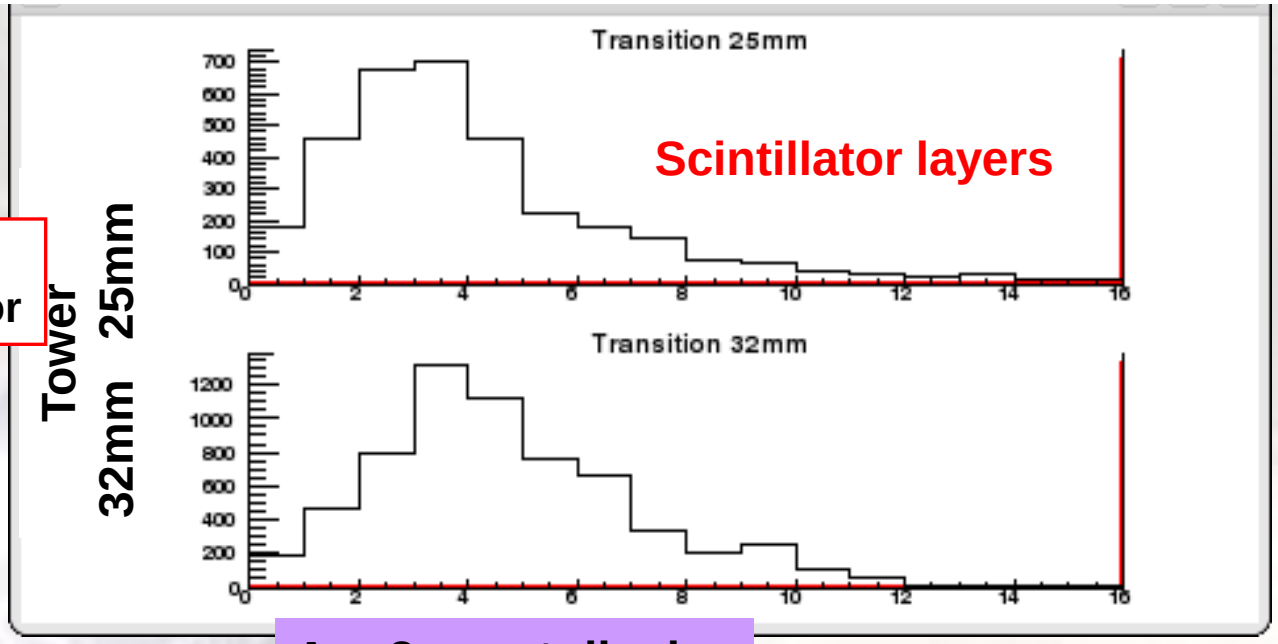
Y-view of silicon strip

π^0 at 7 TeV



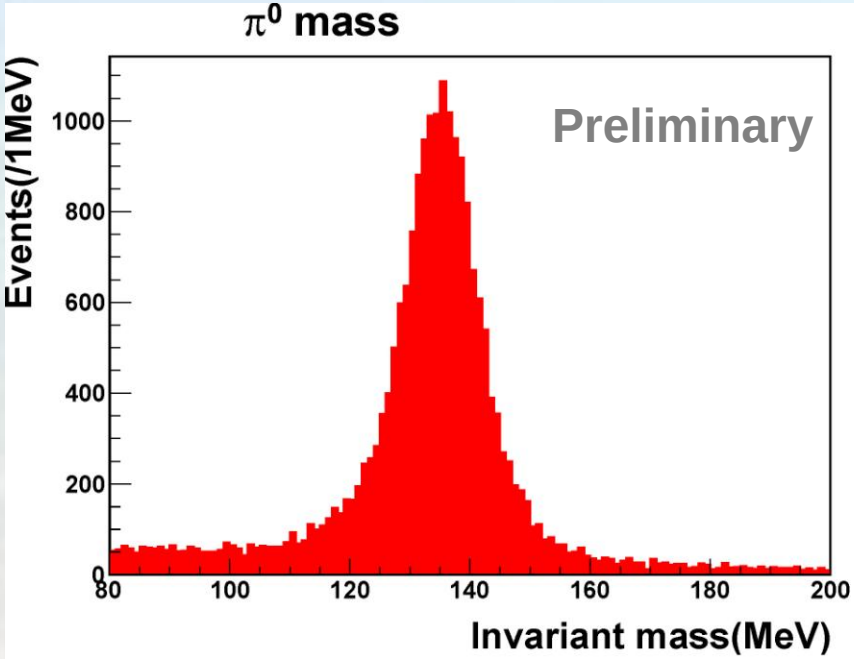
- Robust sample
- Good energy calibrator

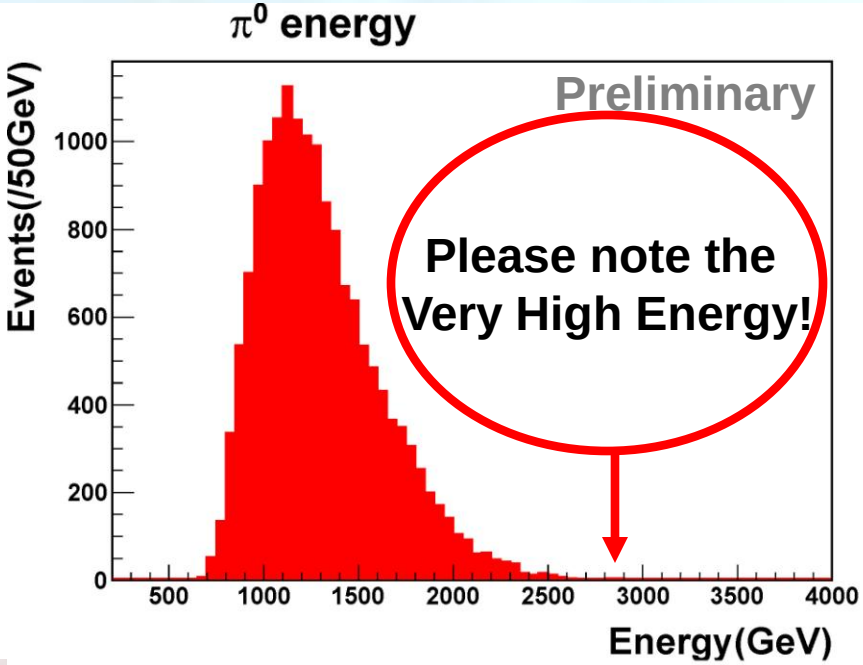




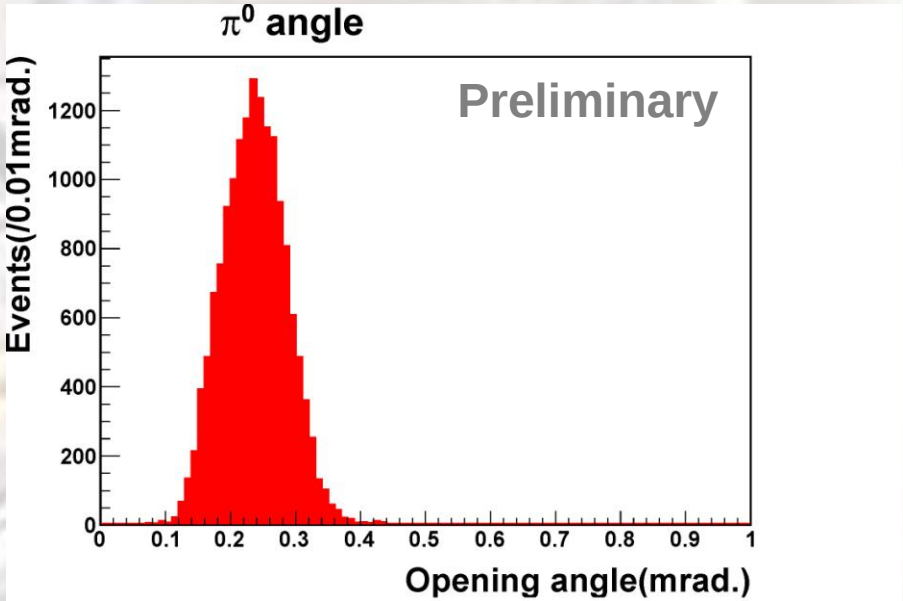
Arm2 event display

π^0 mass and energy spectrum (Arm1)

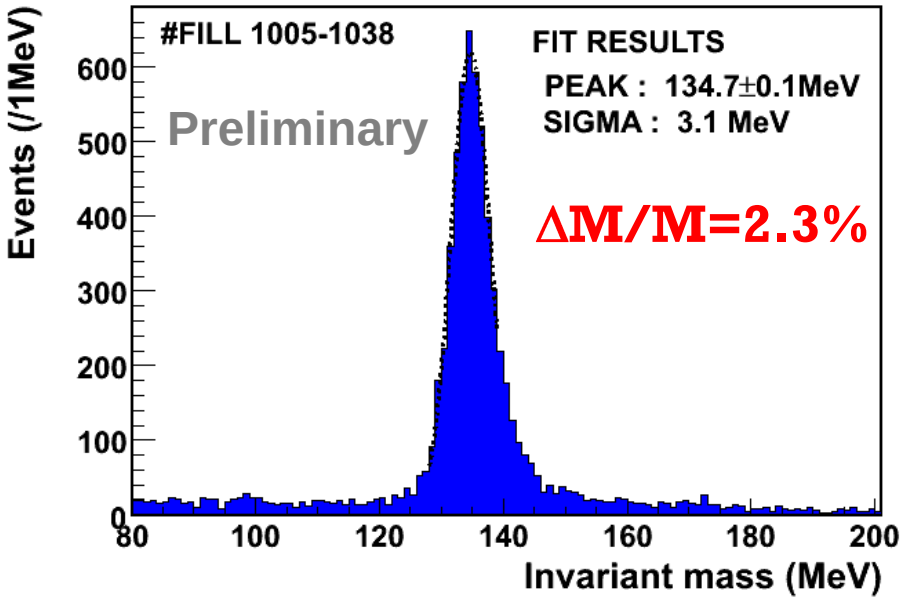




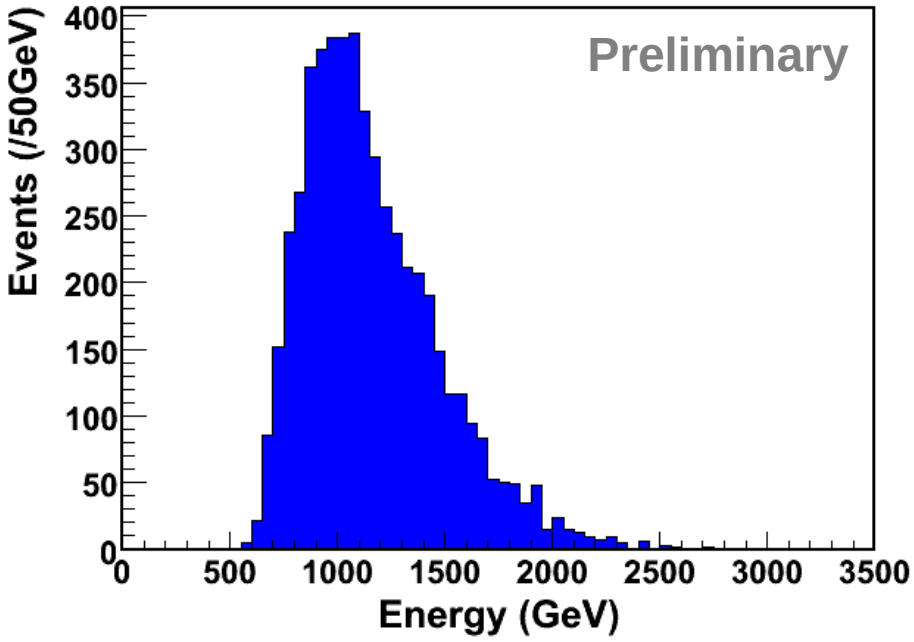
$\Delta M/M = 6.3\text{MeV}/135\text{MeV} = 4.7\%$



π^0 mass and energy spectrum (Arm2)

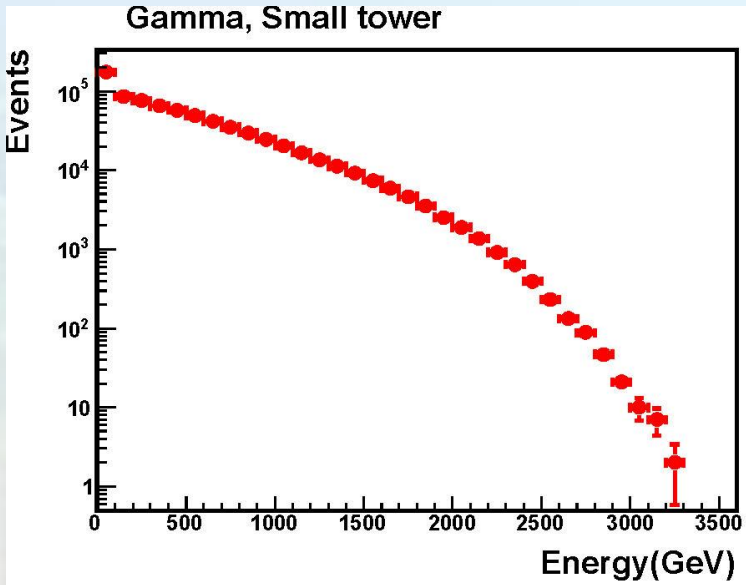


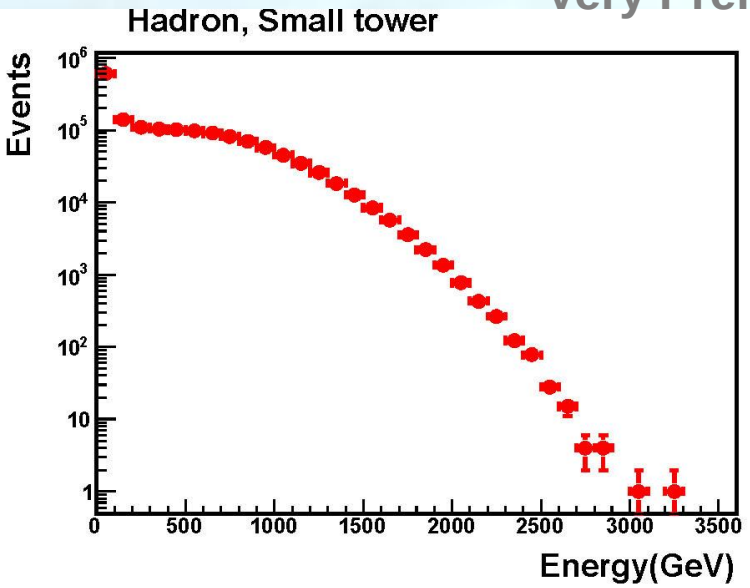
Using only data taken before April 13th

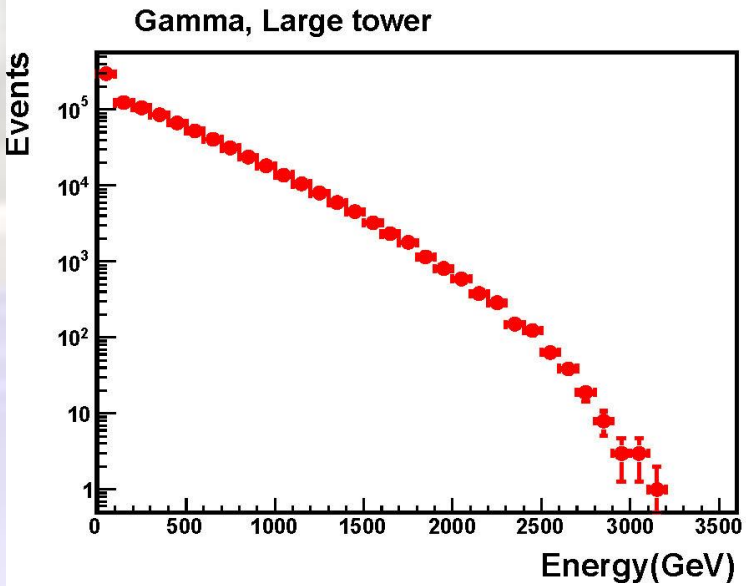


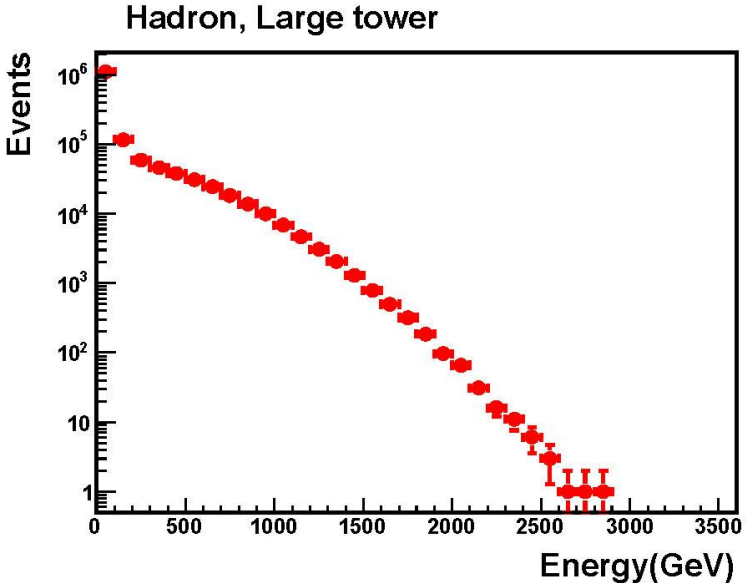
Arm1 spectra at 7 TeV

Very Preliminary





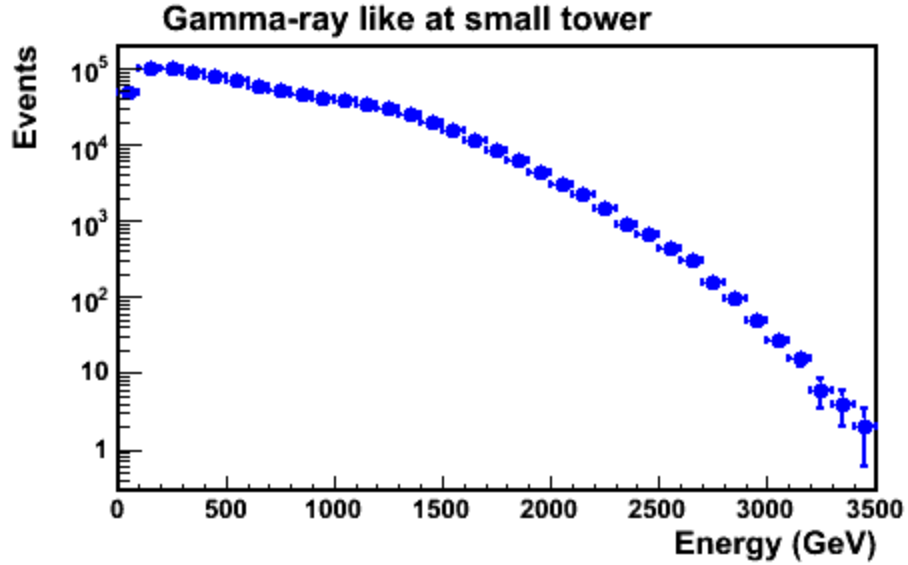


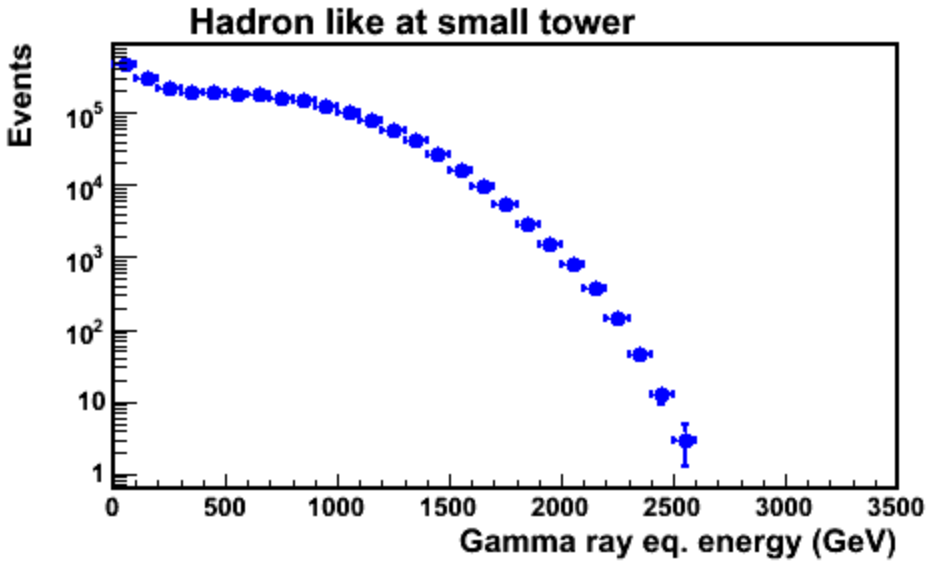


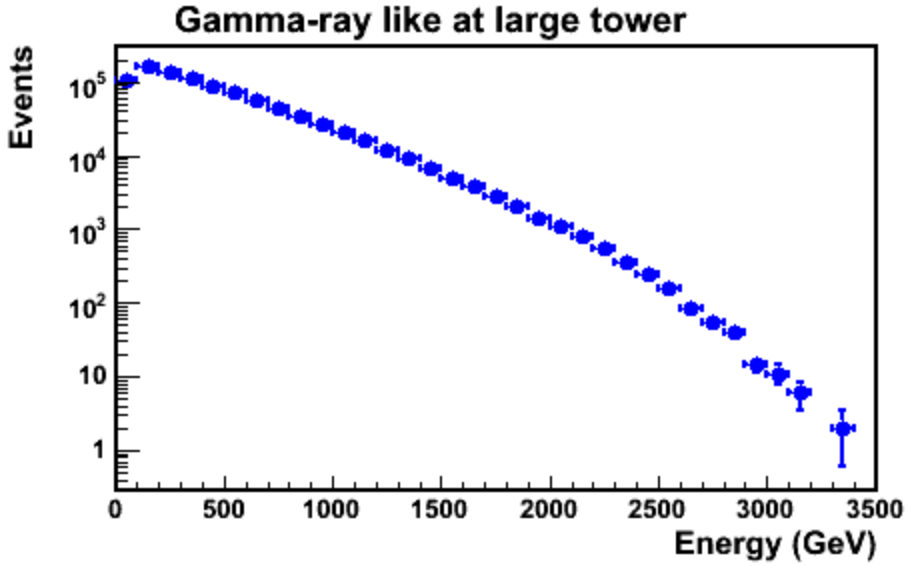
About 10% of all data taken with non-crossing angle

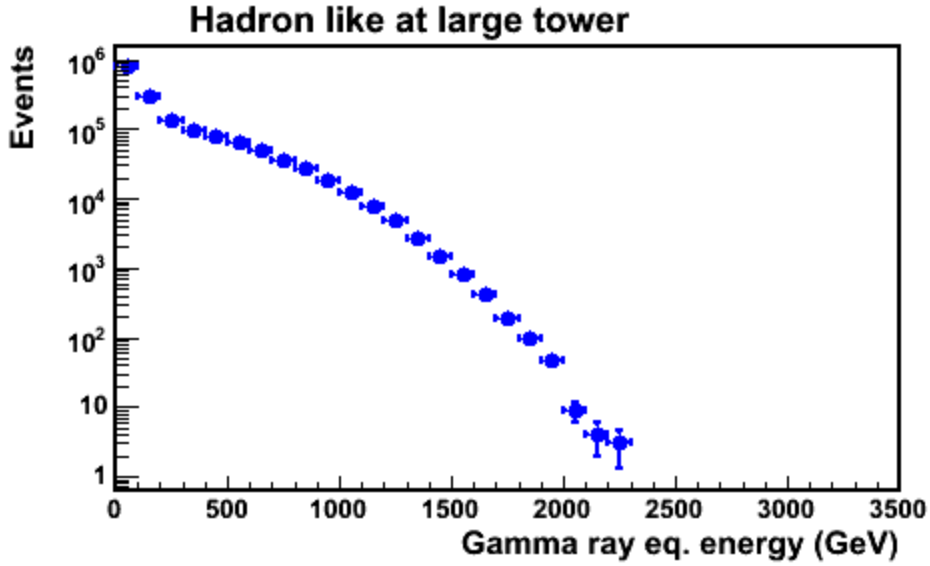
Arm2 spectra at 7 TeV

Very Preliminary



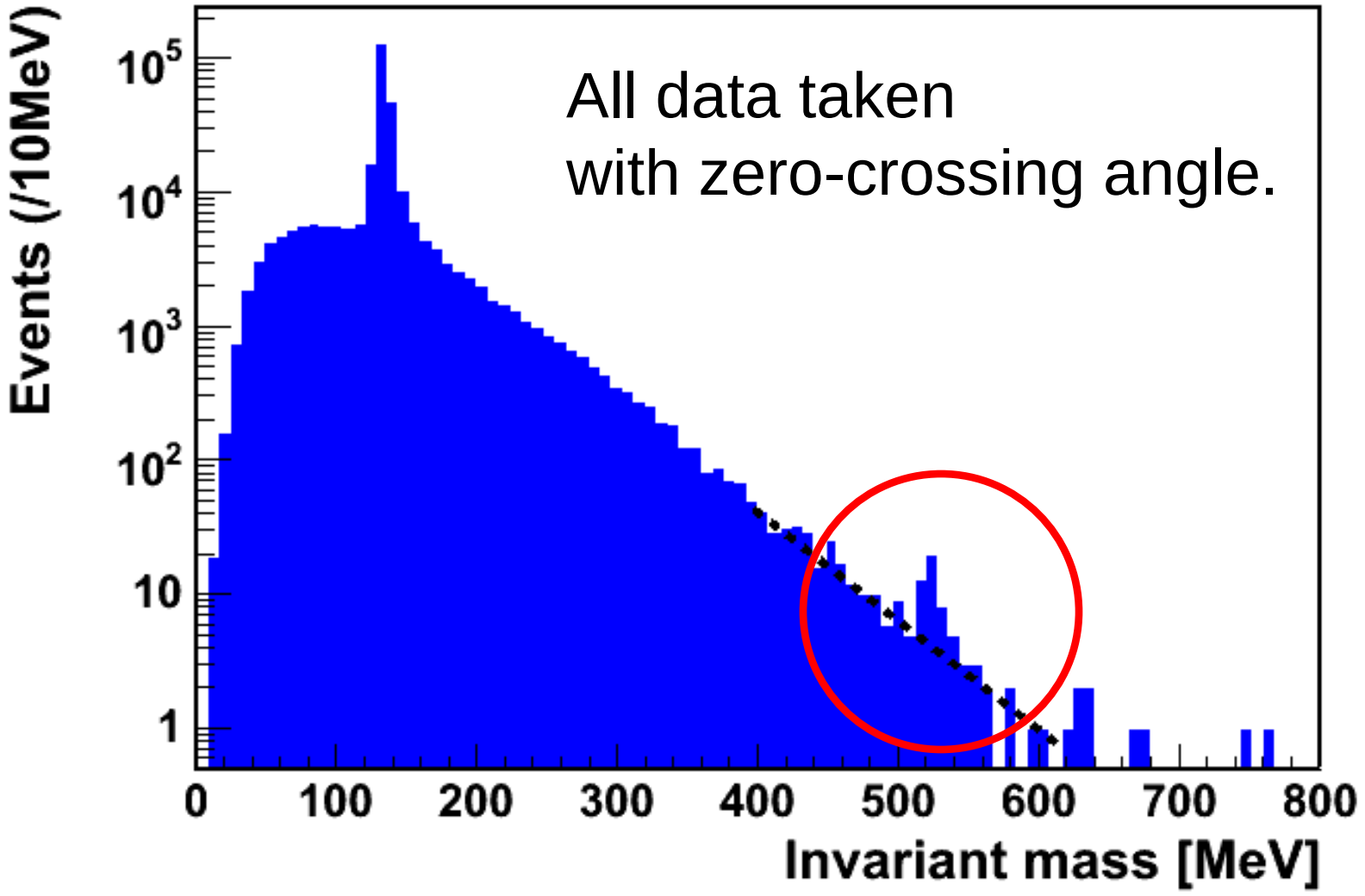




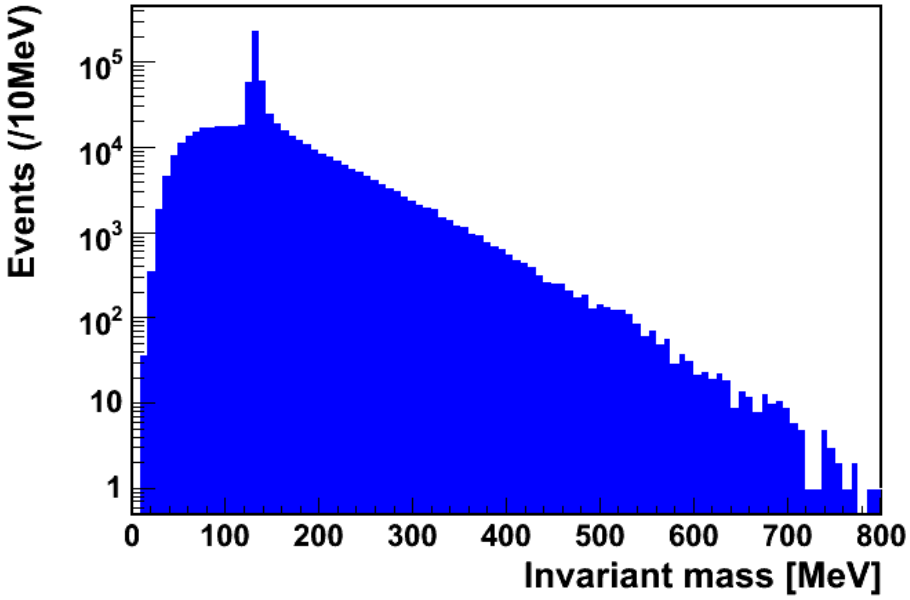


About 10% of all data taken with non-crossing angle.

η search


All data taken
with zero-crossing angle.
Events (/10MeV)
10^5
10^4
10^3
10^2
10
1
0
100
200
300
400
500
600
700
800
Invariant mass [MeV]

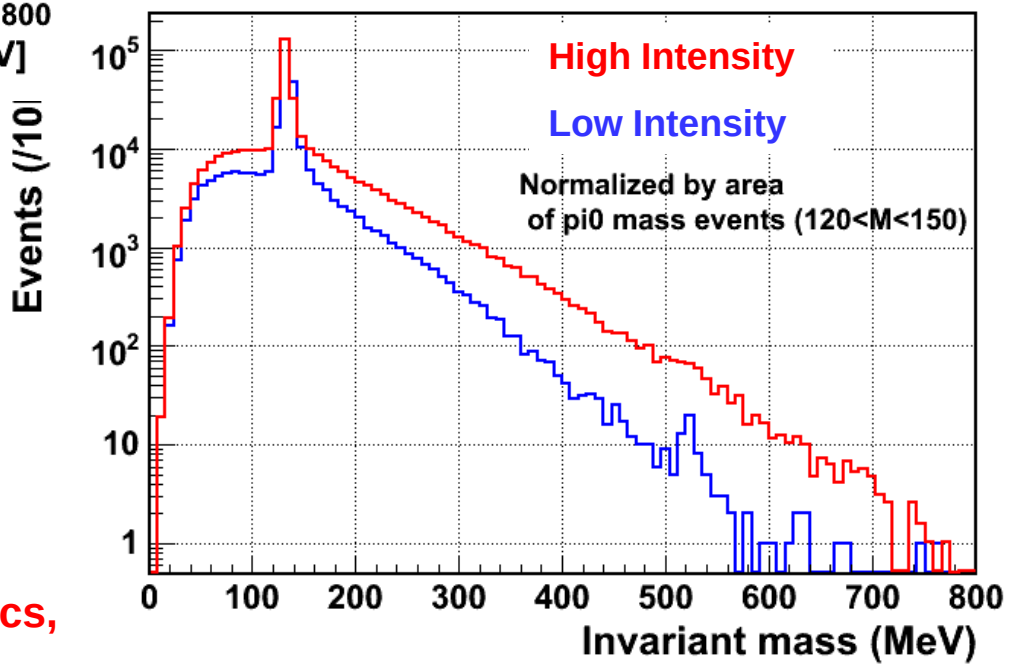
η search at high luminosity operation



A fraction of data taken with 100μrad crossing angle. (operation with nominal bunch intensity and β*=3.5m)
$L \sim 4 \times 10^{29}\ cm^{-2}s^{-1}$

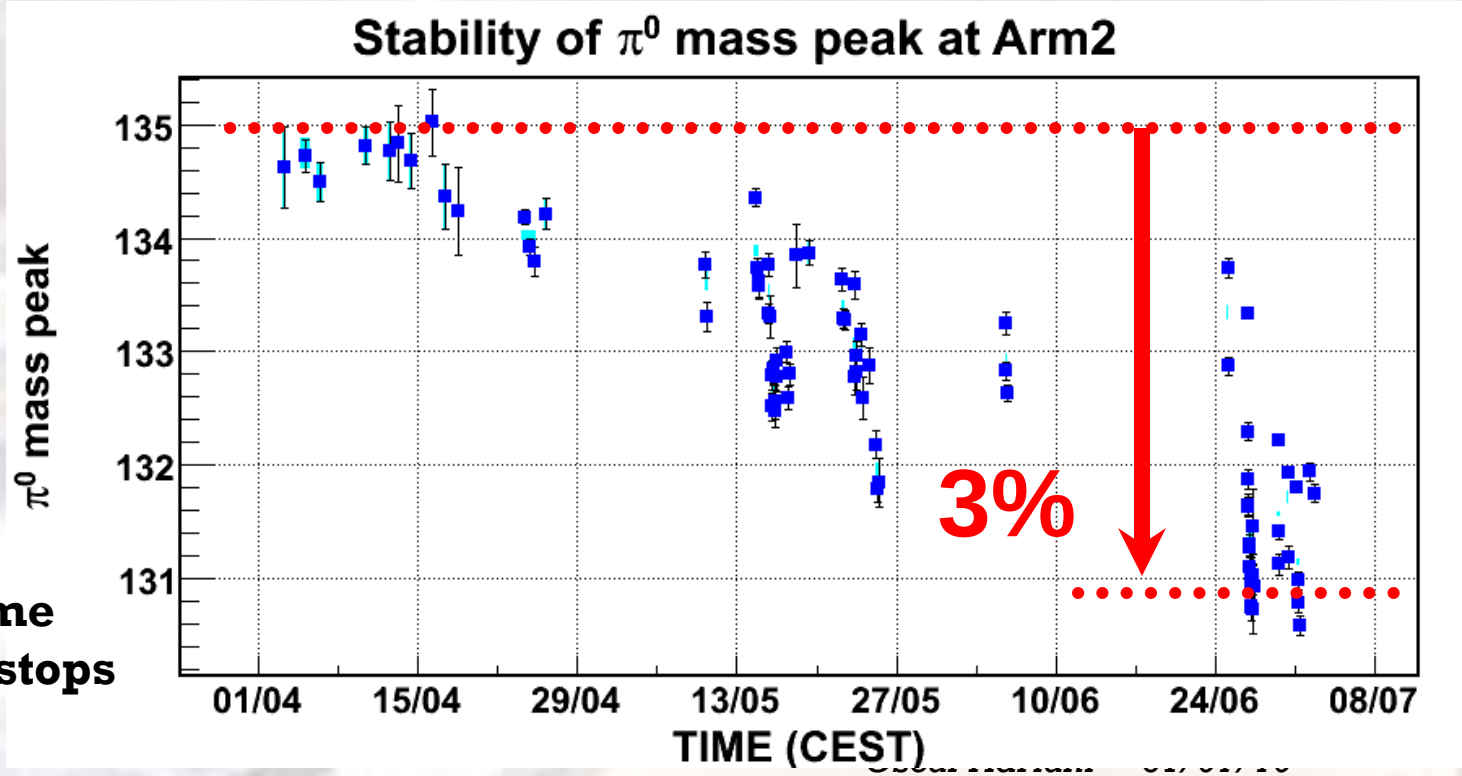
Due to ~2 average number of collisions in one bunch crossing, there is a bigger background due to accidental coincidence of two unrelated particles (Pile Up effect)

Please note:
Pile Up depend on filling scheme and optics, not directly on Luminosity



Radiation Damage

- Light yield of plastic scintillators inserted in calorimeters is decreasing due to the radiation damage, in agreement with what we expect from our irradiation measurements
- We are monitoring light yield by nitrogen laser and π^0 invariant mass.



Slow recovery of light yield with time When irradiation stops (Annealing effect)

Integrated dose measured by dosimeter

3 Gy

In agreement with our expectations for the Integrated Luminosity

LHCf removal

- LHCf has completed the basic physics program at 7 TeV
- We will continue to take data until next technical stop
  - Special dedicated trigger (η, Λ, High threshold, etc.)
  - Special runs (different setting and vertical positions)
- LHCf will be removed during next technical stop (Starting on July 19)
  - 1 day of laser calibration after LHC stop
  - Removal will be done on Tuesday, July 20
- Detailed plan has been defined in agreement with Atlas ZDC, Remote handling expert, Radio Protection team etc.
- Few hours are needed to remove the detectors

Activities after the removal

- The detector will be checked by RP team to measure the activation
  - Detailed procedures have been defined if LHCf will be declared as 'radioactive'
- We will take laser calibration for at least 1 week after the removal (to study recovery time due to annealing)

- Test beam at the SPS is the next step, to confirm absolute energy calibration
- The optimal date for the Test Beam are now under discussion with the SPS coordinator
  - Original beam time slot at beginning of August is too early!
  - We need help from the SPS coordinator to find the best solution!

Conclusion

- LHCf has completed the basic physics program
- LHCf will be removed from TAN on July 20
- Test beam is foreseen later in the year
- The detector will be upgraded during 2011 to improve radiation hardness
  - GSO will replace plastic scintillator
  - More energy measurement oriented silicon arrangement
- We will be ready to come back in the TAN for the 14 TeV run!

And…. Last but not least…

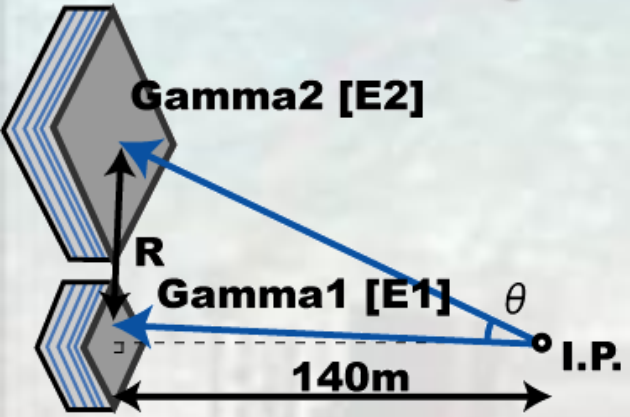
- Many many thanks to all people that contributed to the success of our experiment!
  - Machine people
  - LHCC and LHCC Referees
  - Atlas
  - SPS Coordinator
  - EN/MEF Division
  - Radio Protection
  - Survey
  - Remote handling
  - Etc. etc. etc……

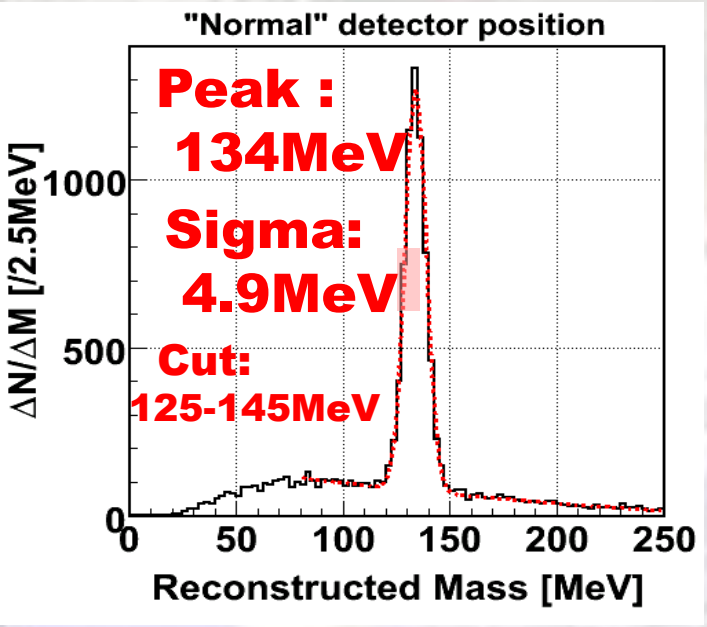
Backup slides

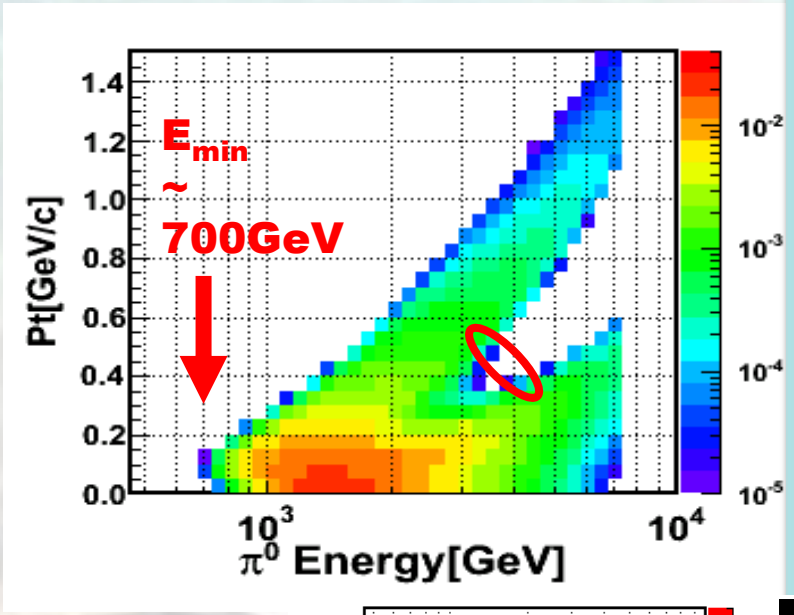
π^0 spectra

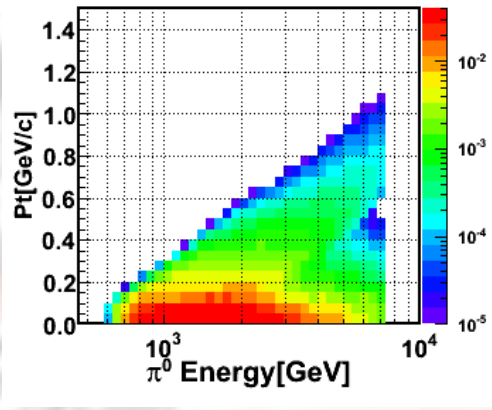
π^0 produced at collision can be extracted by using gamma pair events

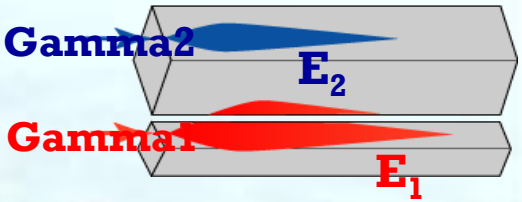
Powerful tool to calibrate the energy scale and also to eliminate beam-gas BG



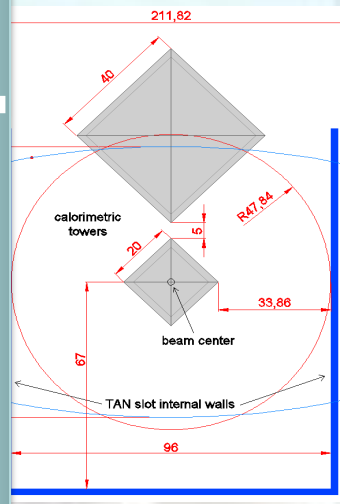


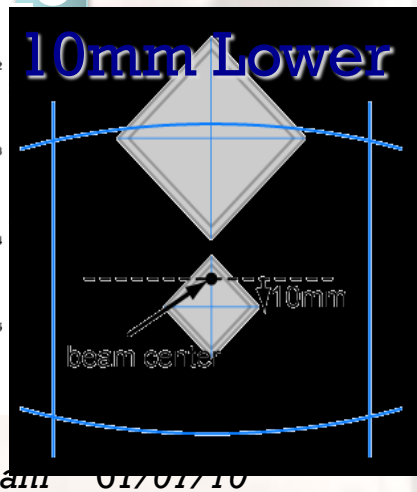






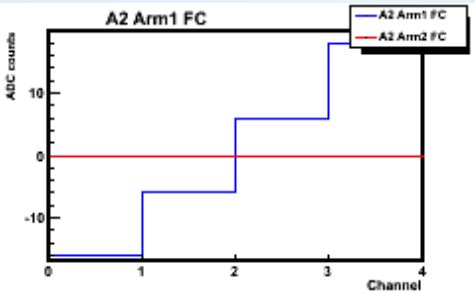
Geometrical Acceptance

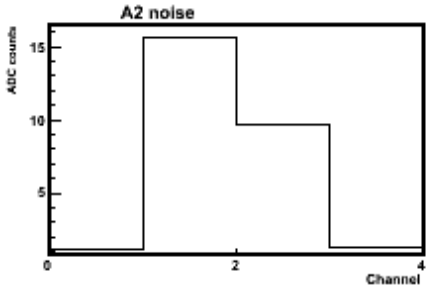


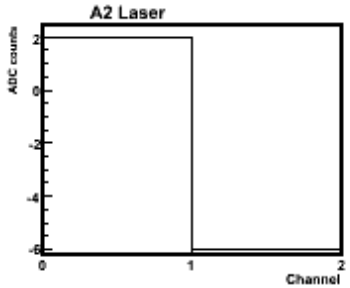


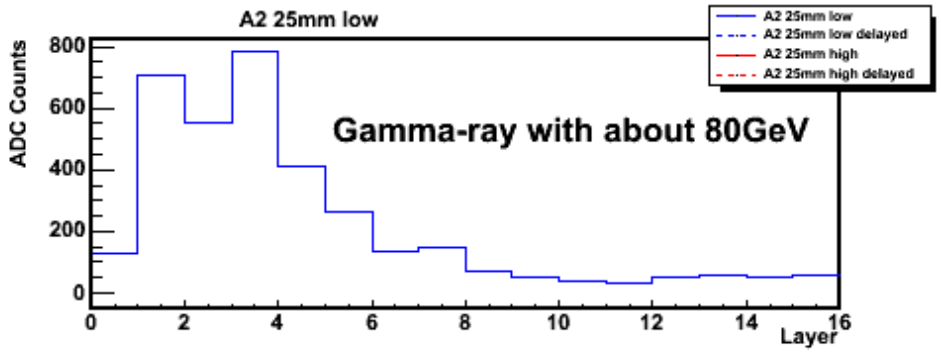
900 GeV Arm2 γ event

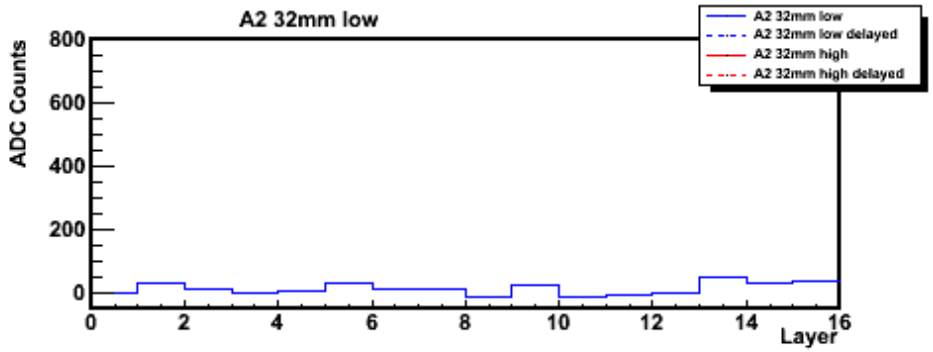
RUN:	2342
NUMBER:	506
GNUMBER:	1154
TIME:	1260085179
FLAG0:	00009557
FLAG1:	000009ff
FLAG2:	00a02371

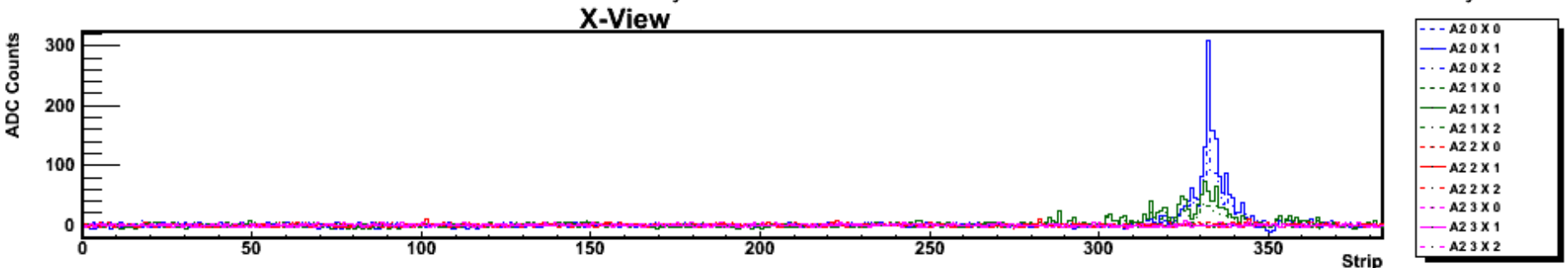


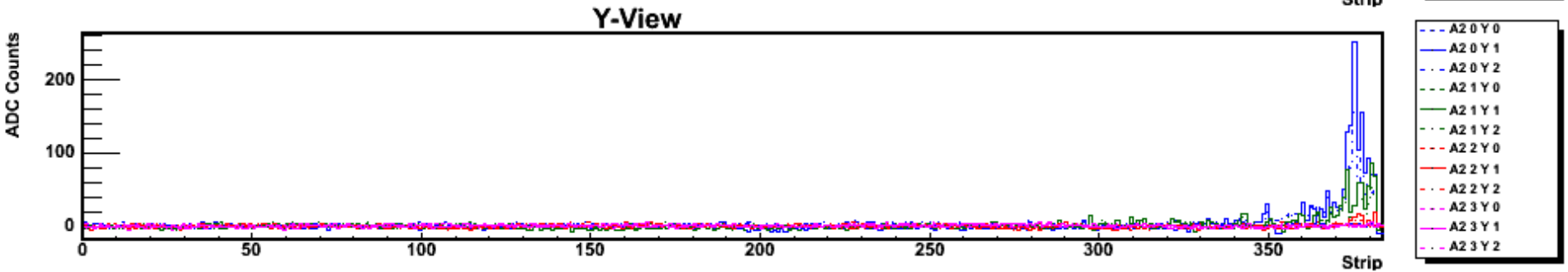




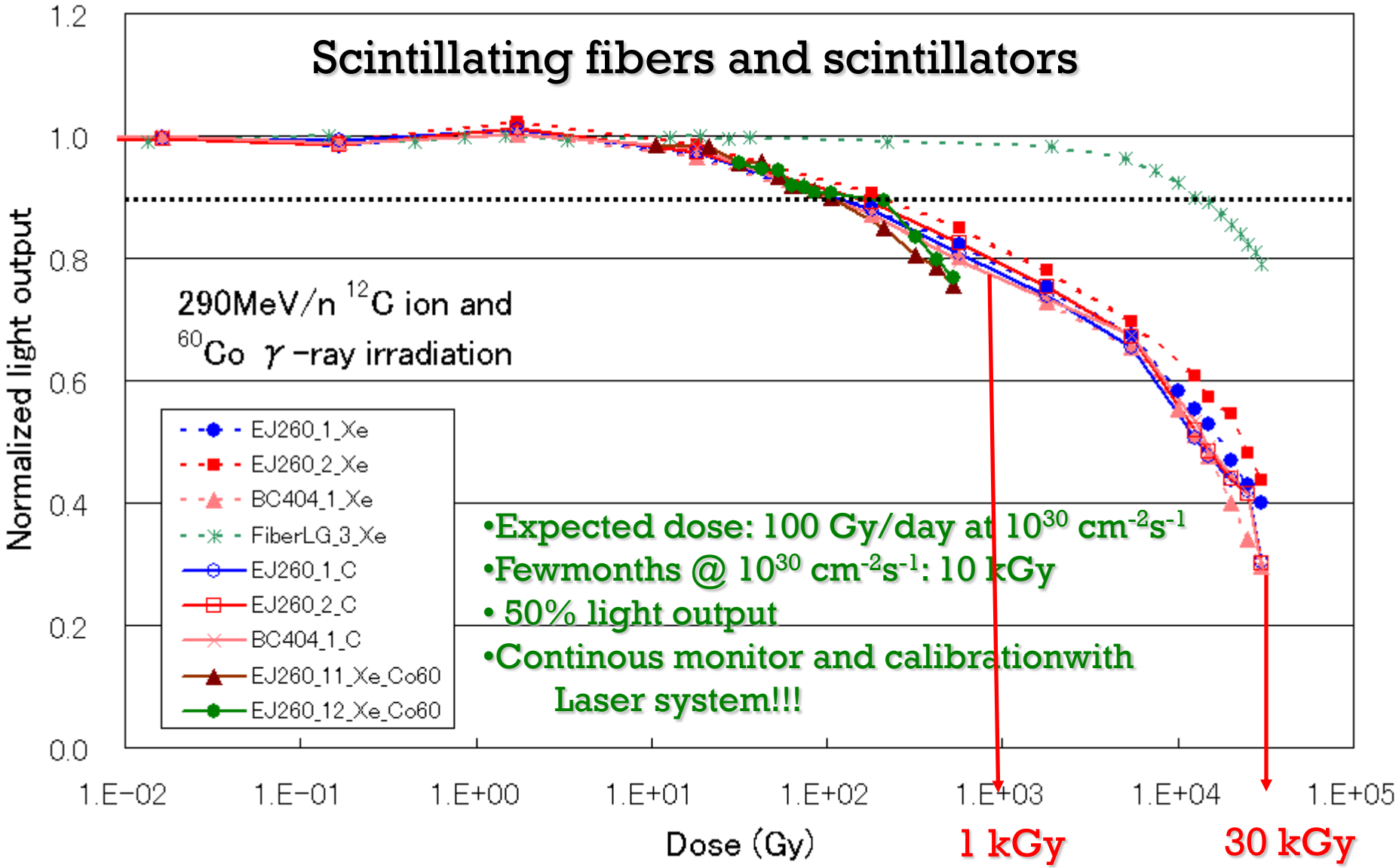








Radiation Damage Studies



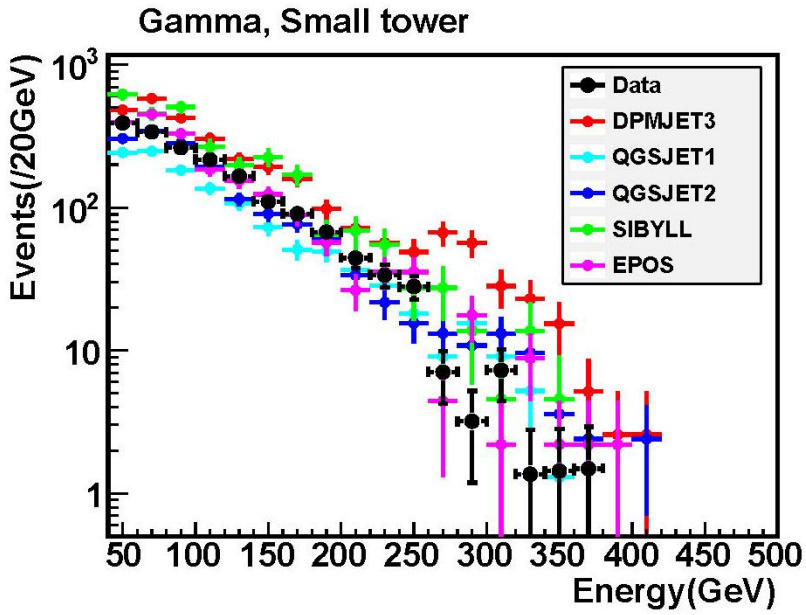
Results on radiation damage

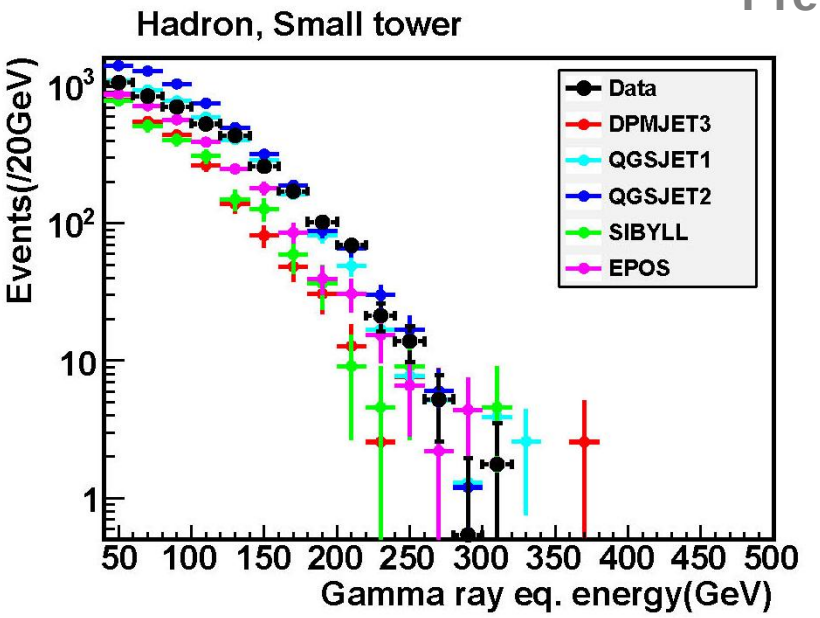
The dose approximately scale as E^3

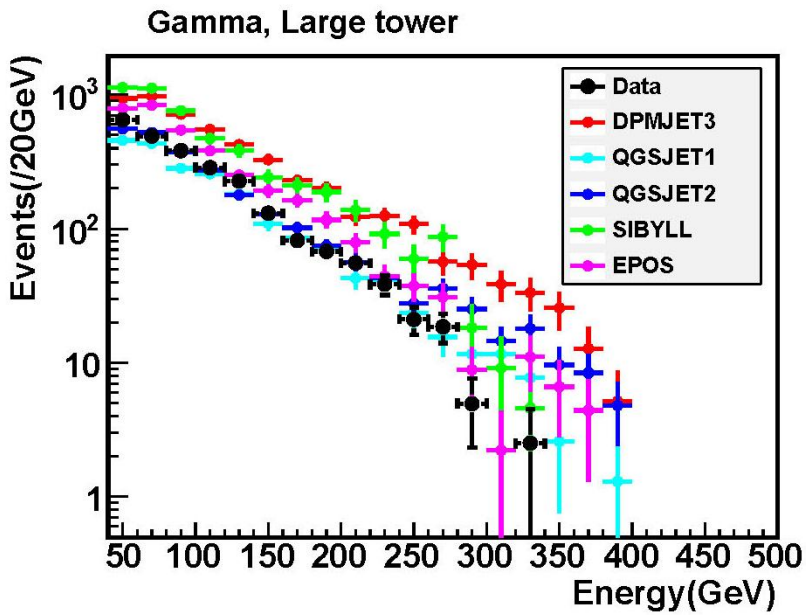
Energy (TeV)	Dose rate (Gy/hour at $10^{29}cm^{-2}s^{-1}$)	Dose rate (Gy/nb^{-1})	Time to reach 1KGy at $10^{29}cm^{-2}s^{-1}$ (days)	Integrated lumi to reach 1KGy (nb^{-1})
0.45+0.45	$4.6 \cdot 10^{-4}$	$1.27 \cdot 10^{-3}$	9140	$7.9 \cdot 10^{5}$
3+3	$1.3 \cdot 10^{-1}$	0.35	330	$2.9 \cdot 10^{3}$
5+5	$6.1 \cdot 10^{-1}$	1.7	68	590
7+7	1.6	4.3	27	230

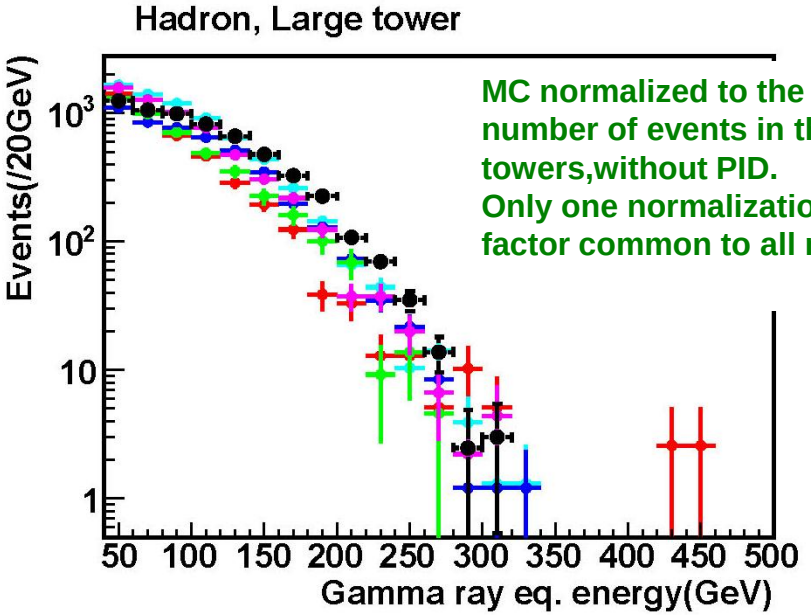
Arm1 Spectra at 900 GeV

Preliminary









MC normalized to the total number of events in the 2 towers,without PID.
Only one normalization factor common to all models

χ^2 values for 900 GeV spectra

	Gamma	Hadrons
DPMJET3	547.6	910.4
QGSJET1	145.8	145.2
QGSJET2	61.9	71.9
SIBYLL	303.4	451.0
EPOS	110.9	222.0

d.o.f. =14

MC normalized to the total number of events in the 2 towers,without PID.
Only one normalization factor common to all models