

The logo for the LHCf experiment is centered in the background. It features the letters 'LHCf' in a stylized font where the 'L' is green, 'H' is grey, 'C' is red, and 'f' is blue. Behind the text are several thin, light blue lines radiating outwards from a central point, resembling particle tracks or a detector layout. The entire logo is enclosed within a thick yellow oval border.

*The status and preliminary results  
of the LHC forward experiment:  
LHCf*

*Hiroaki MENJO  
INFN Firenze, Italy*

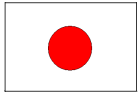
*for the LHCf collaboration*

**DIS2010, Florence, 21 April 2010**

*LHCf = “LHC forward”*

- Introduction.
  - ✓ Detector : calorimeters covering  $\eta > 8.4$  in IP1.
  - ✓ Measurement : energy spectra and  $P_T$  distributions of energetic neutral particles.
- Preliminary results in 900GeV collisions
- Very preliminary results at 7TeV collisions
- Operation plan in this year and in future.

# *The LHCf collaboration*



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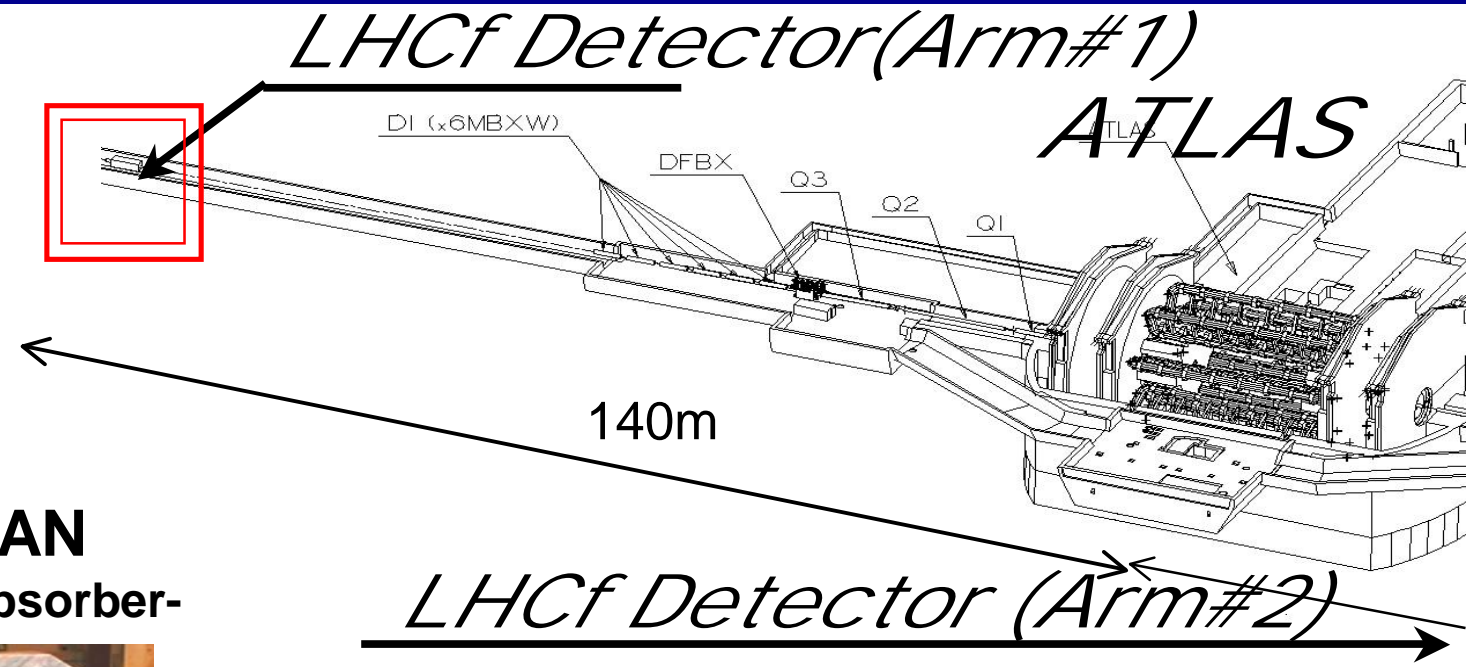
**J.Velasco, A.Faus**

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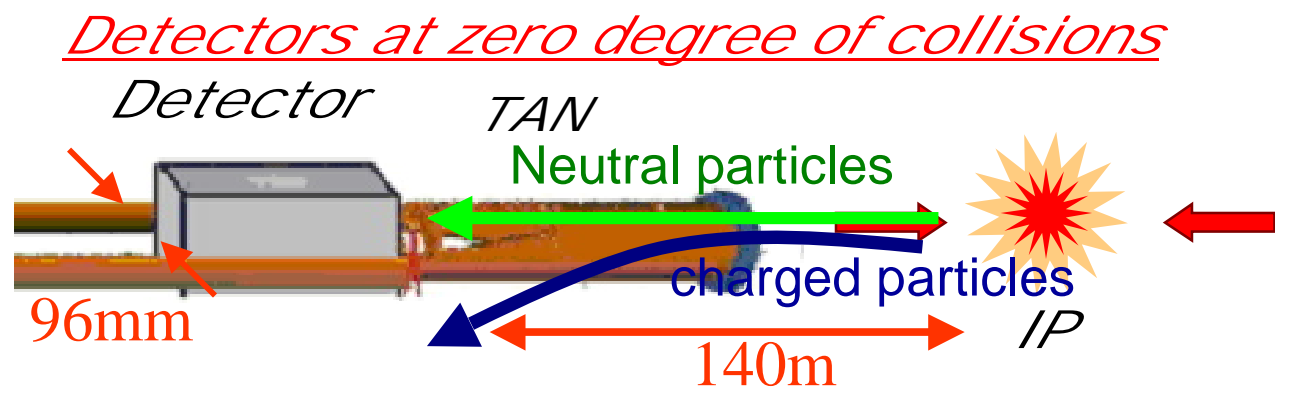
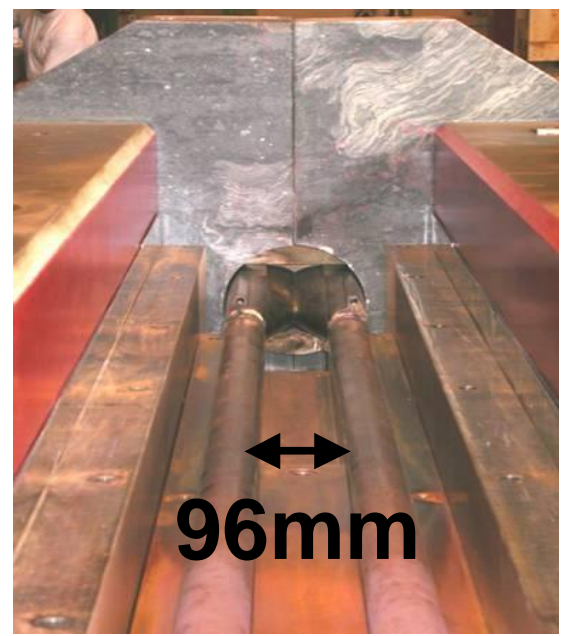


**D.Macina, A-L.Perrot** *CERN, Switzerland*

Location



**Inside of TAN**  
 -Neutral particle absorber-



The detector has been installed in 96mm gap of the beam pipes.

# The LHCf detectors

## Sampling and Positioning Calorimeters

- W (44 r.l , 1.7  $\sigma_I$ ) and Scintillator x 16 Layers .
- 4 positioning layers  
XY-SciFi(Arm1) and XY-Silicon strip(Arm#2)
- **Each detector has two calorimeter towers, which allow to reconstruct  $\pi^0$**

### Expected Performance

Energy resolution ( $> 100\text{GeV}$ )

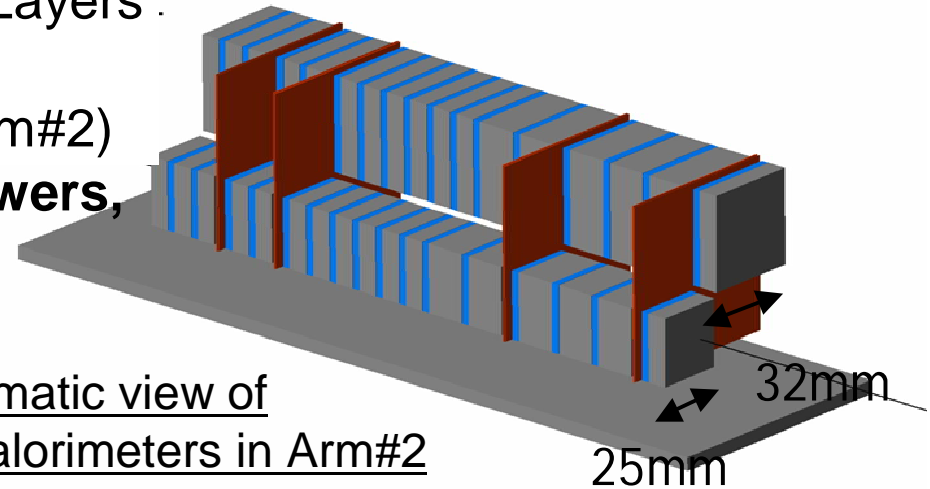
< 5% for photons

30% for neutrons

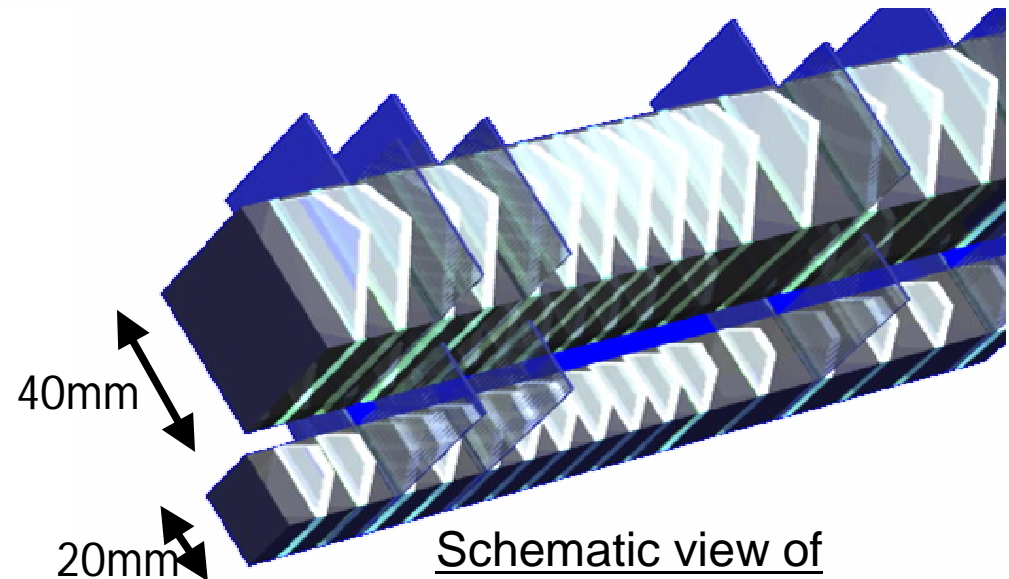
Position resolution

< 200 $\mu\text{m}$  (Arm#1)

40 $\mu\text{m}$  (Arm#2)



Schematic view of the calorimeters in Arm#2



Schematic view of the calorimeters in Arm#1

## Front Counter

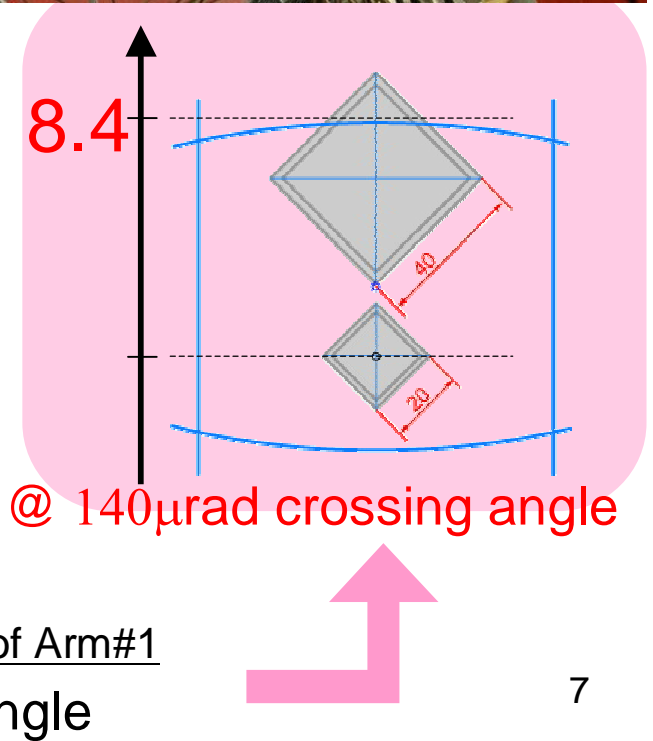
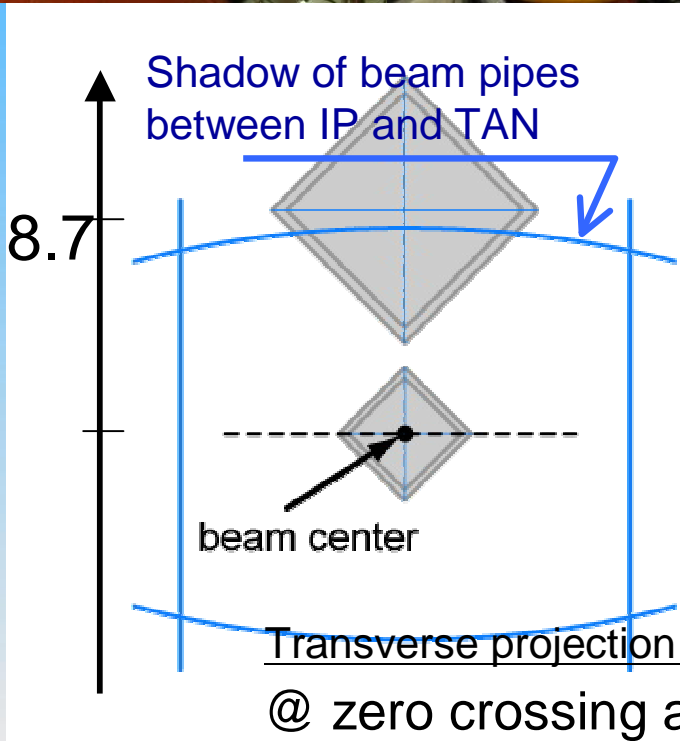
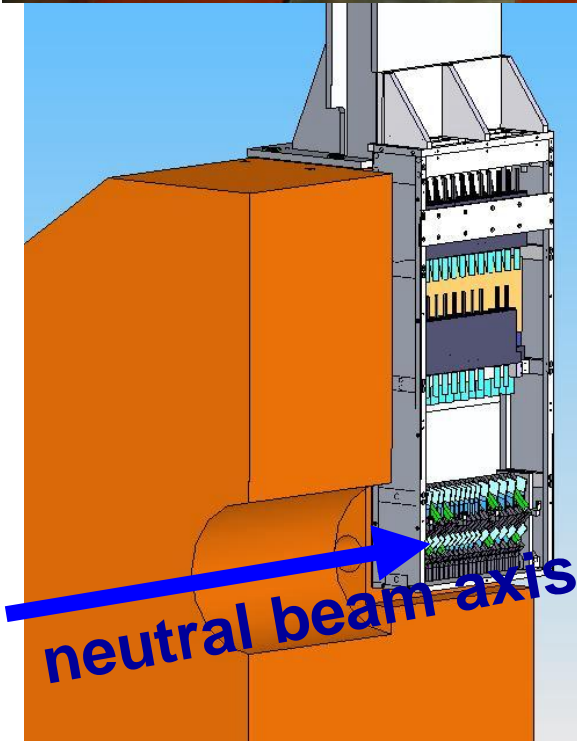
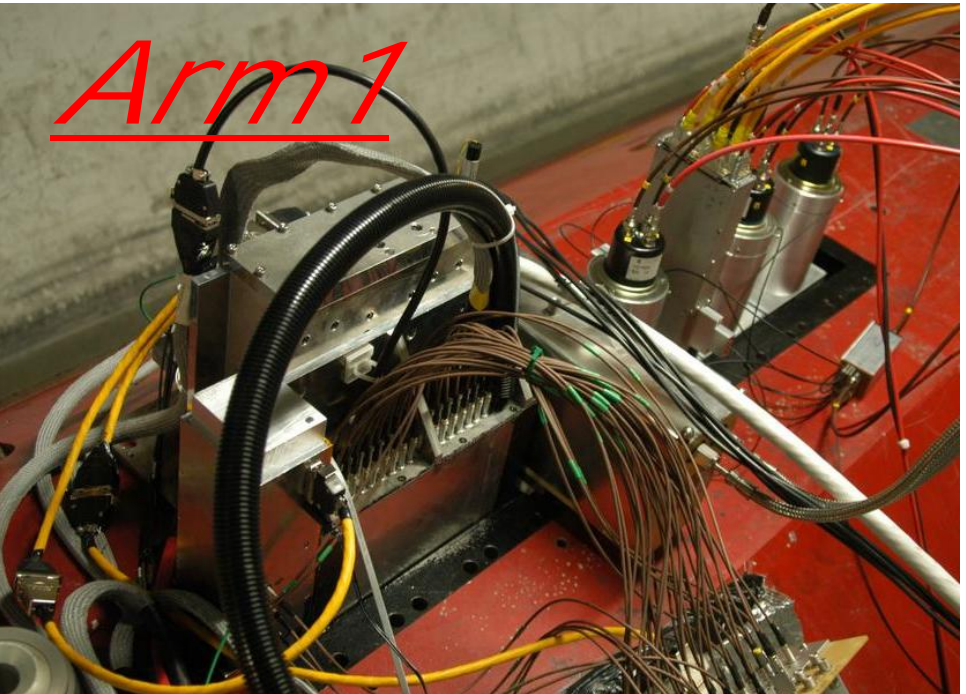
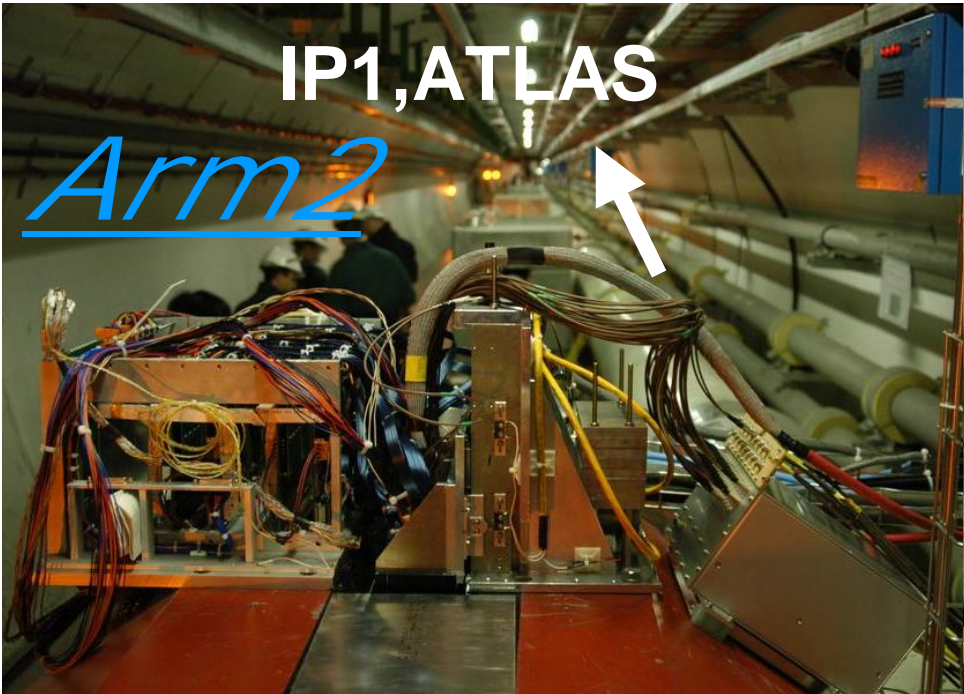
- thin scintillators with 80x80mm<sup>2</sup>
- **To monitor beam condition.**
- **For background rejection of beam-residual gas collisions by coincidence analysis**

# Arm#1



# Arm#2



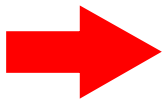


■ *LHCf can measure*

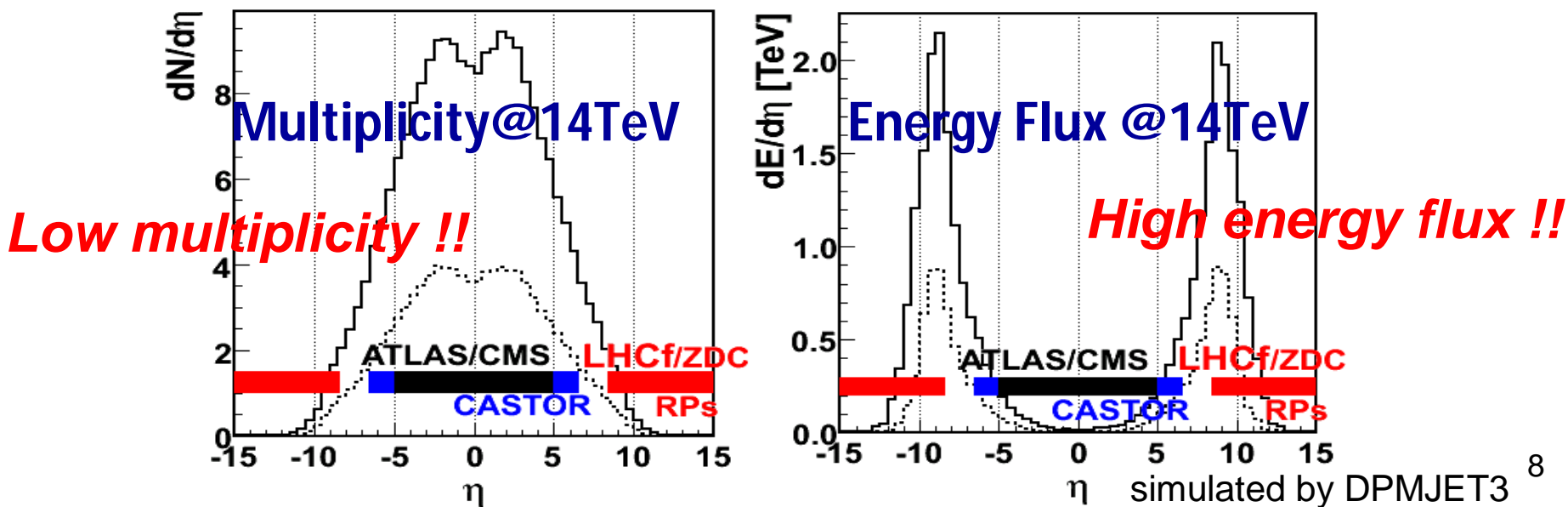
Energy spectra and  
Transverse momentum distribution of

- Gamma-rays ( $E > 100 \text{ GeV}, dE/E < 5\%$ )
- Neutral Hadrons ( $E > \text{a few } 100 \text{ GeV}, dE/E \sim 30\%$ )
- Neutral Pions ( $E > 700 \text{ GeV}, dE/E < 3\%$ )

at pseudo-rapidity range  $> 8.4$



The Aim is to calibrate hadron interaction models for ultra high energy cosmic ray physics.





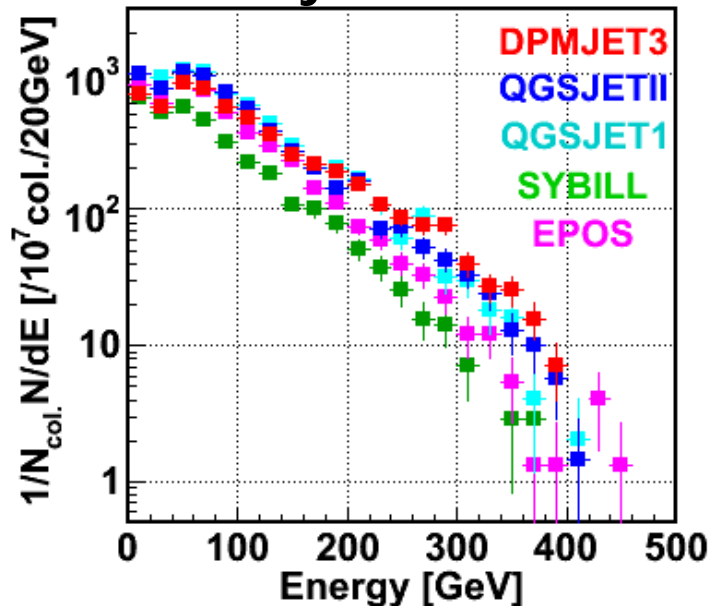
# = Operations in 2009 =

With stable beams at 900GeV, 06.Dec. – 15.Dec  
2.6 hours for commissioning  
27.7 hours for physics

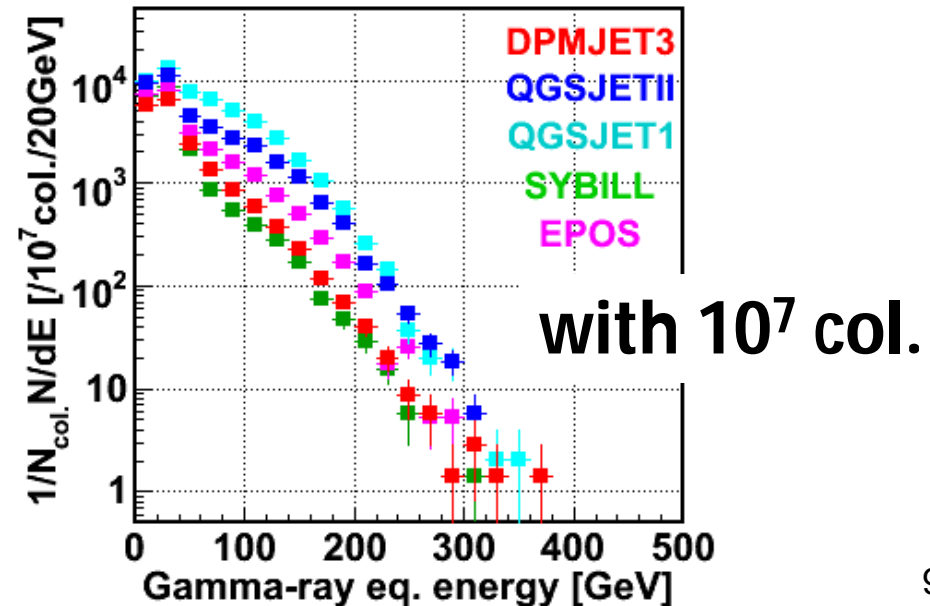
~2,800 shower events in Arm1  
~3,700 shower events in Arm2  $\longleftrightarrow$  ~5x10<sup>5</sup> collisions at IP1

## Expected spectra with each hadron interaction model

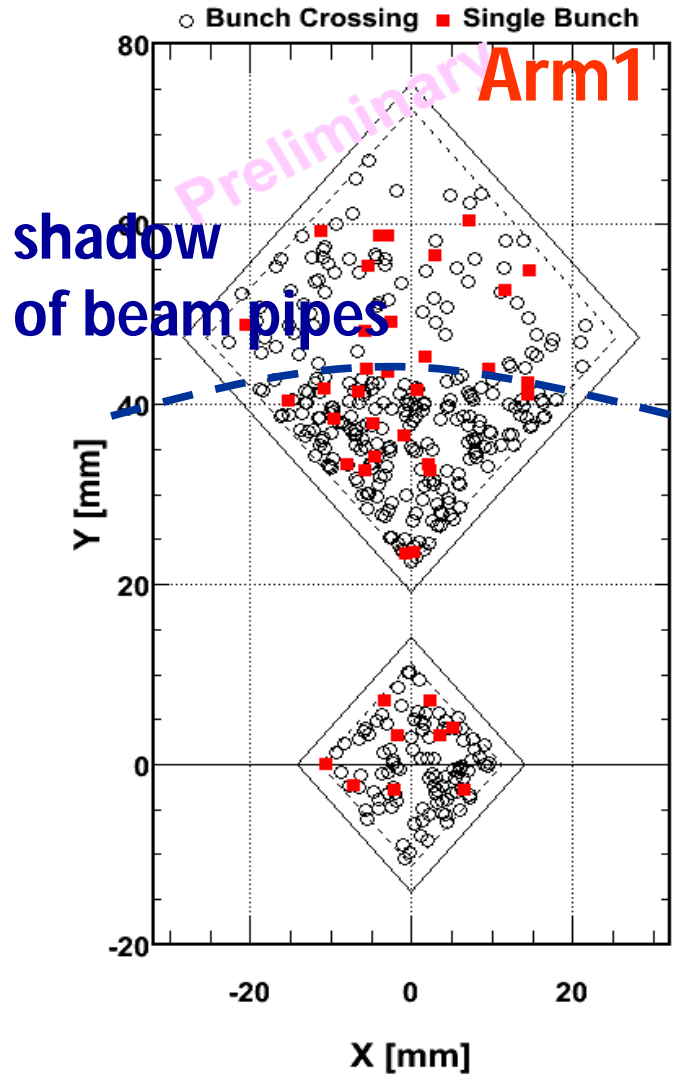
Gamma-ray like @ Arm2



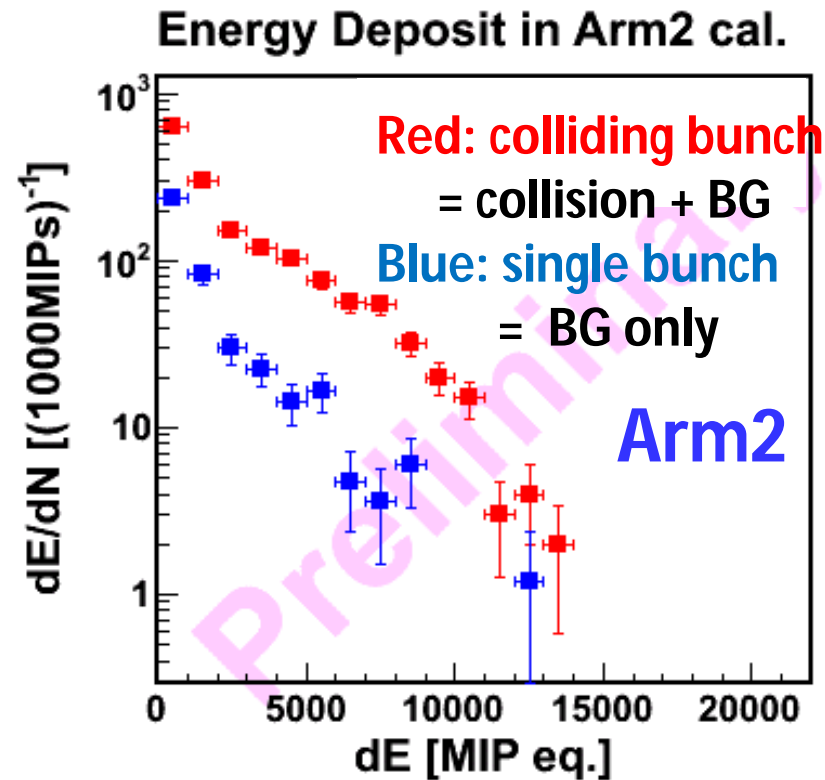
Hadron like @ Arm2



## Hit map of Gamma-rays

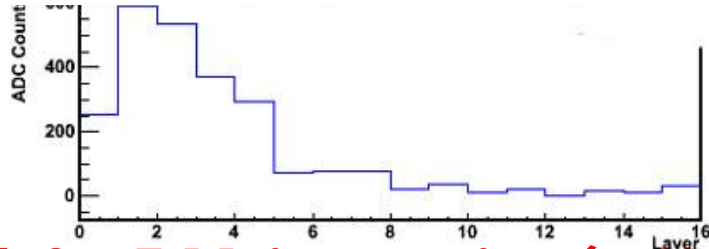


Background due to beam-residual gas collision is about 10%



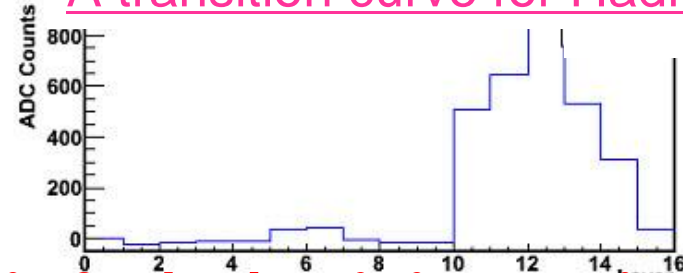
# Particle Identification

A transition curve for Gamma-ray



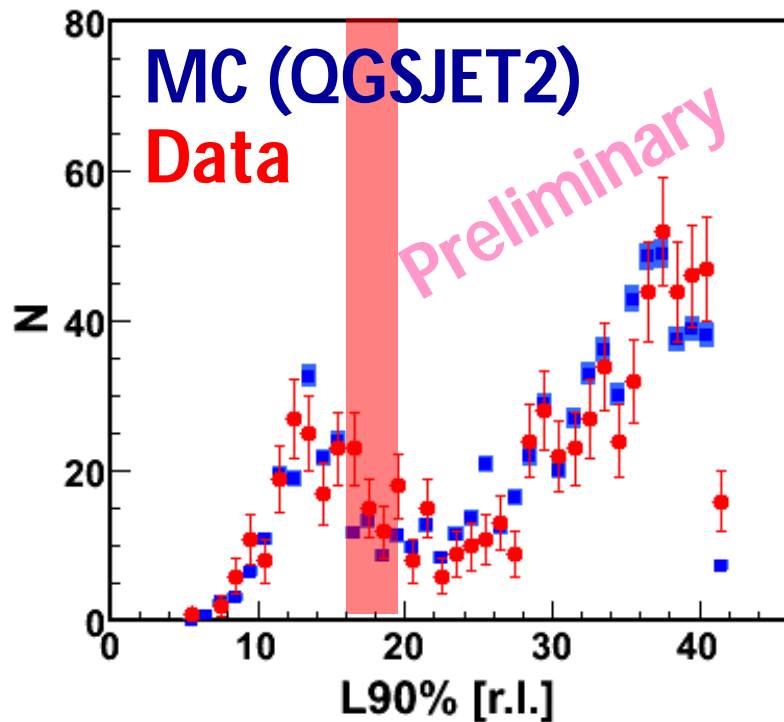
Thick for E.M. interaction ( $44X_0$ )

A transition curve for Hadron



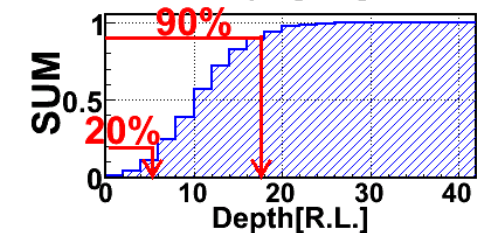
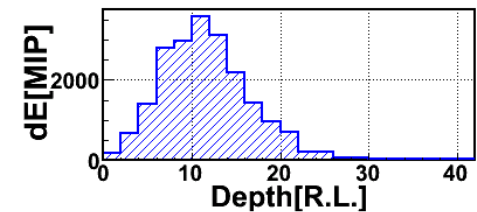
Thin for hadronic interaction ( $1.7\lambda$ )

L90% @ 20mm cal. of Arm2



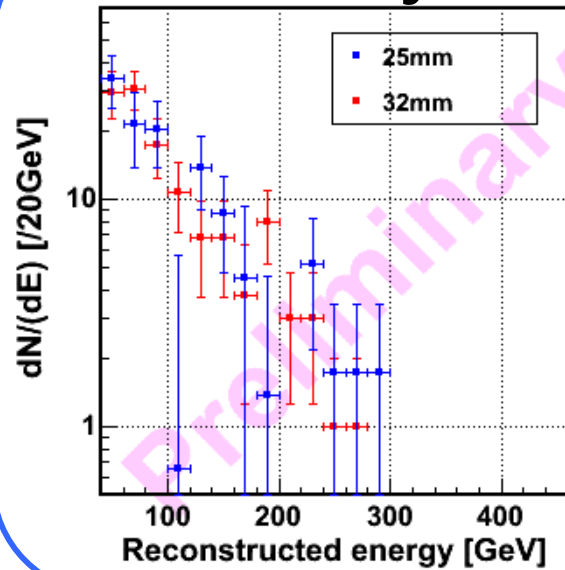
Criteria  
for gamma-rays  
 $16 \text{ r.l.} + 0.002 \times \Sigma dE$

Definition of L90%

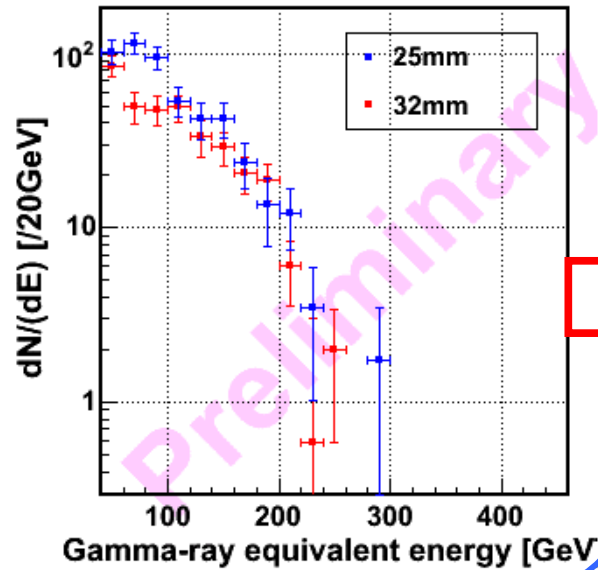


# Comparison between calorimeter towers of Arm2

## Gamma-ray like



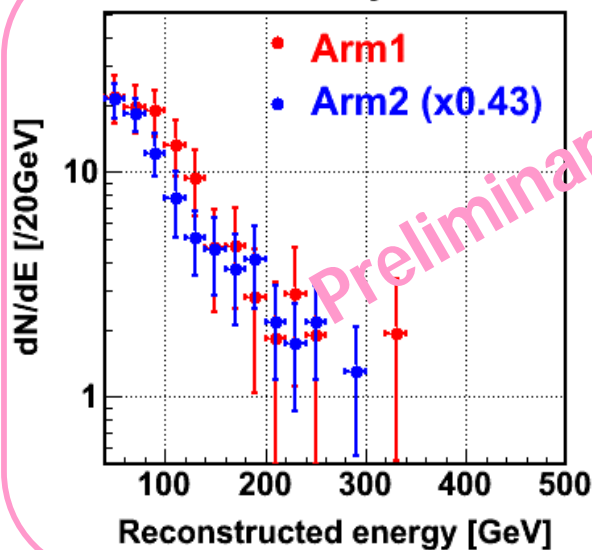
## Hadron like



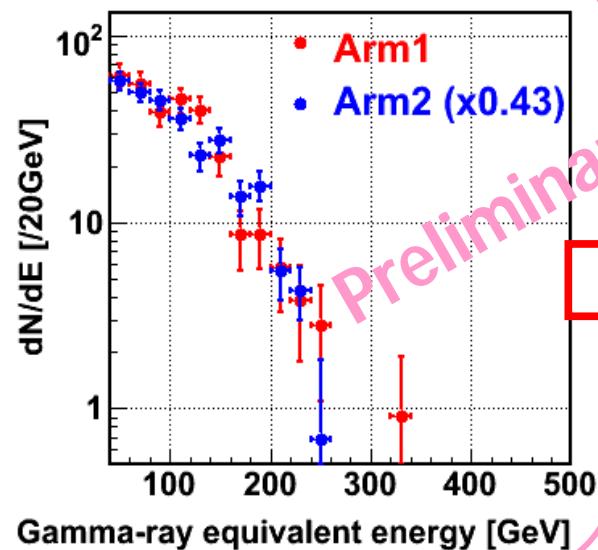
**Spatially flat profile in  $\eta > 8.7$  at 900 GeV**

# Comparison between two Arms

## Gamma-ray like



## Hadron like

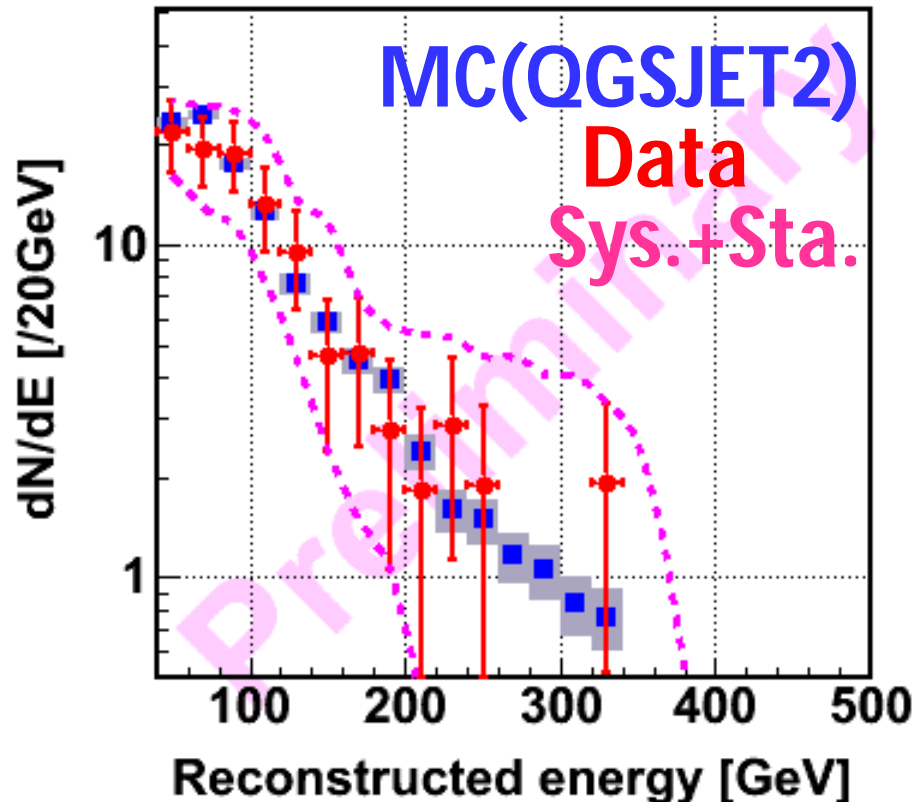


**Both detectors give consistent spectra**

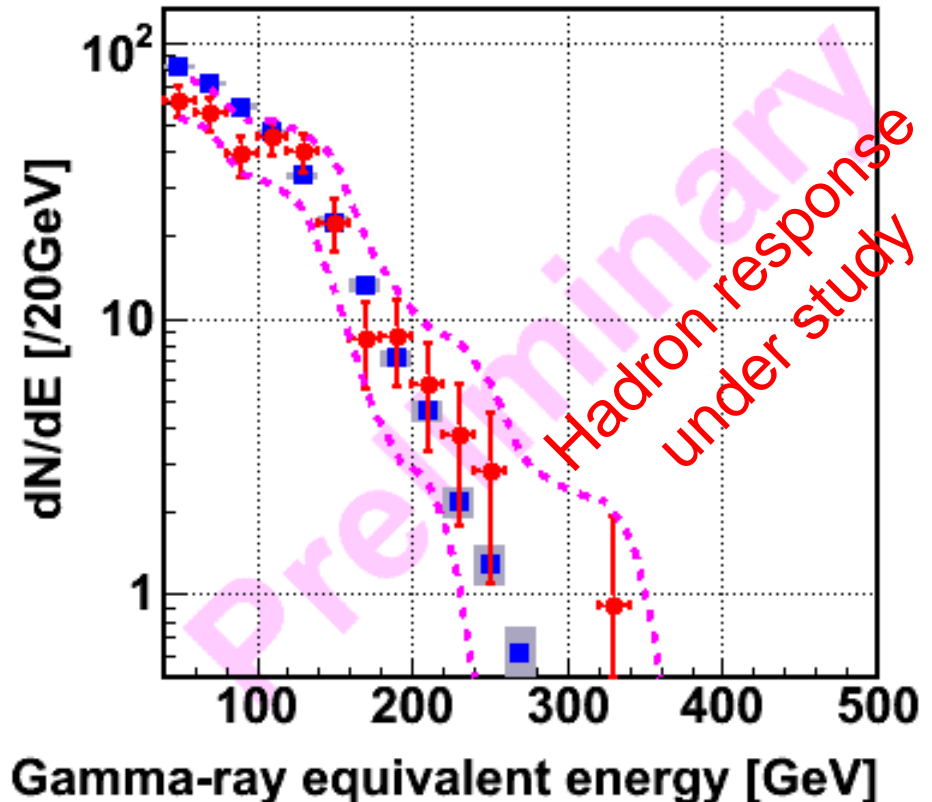
# Comparison with MC @ Arm1

LHCf

Gamma-ray like @Arm1



Hadron like @Arm1

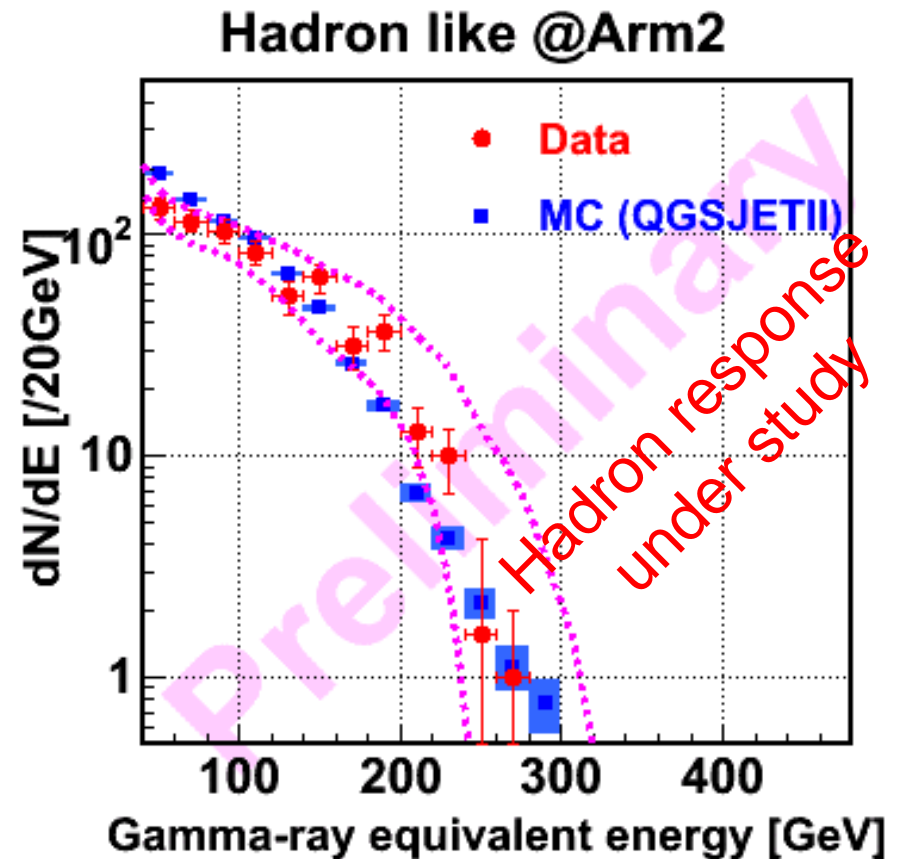
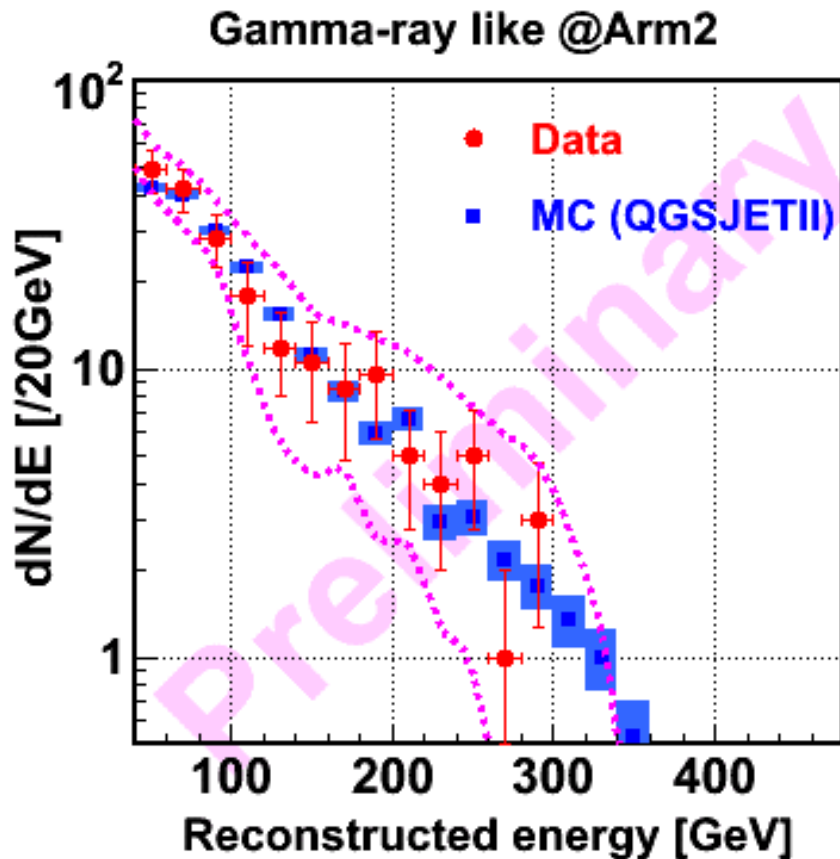


Spectra of MC are normalized by the entries of gamma-ray spectra

**Data is in good agreement with MC**

- Checking detector response for hadrons carefully by beam test data with 150 GeV, 350 GeV protons.
- Studying systematic errors. for the moment. Sys. of Energy scale (+11% / -5%)

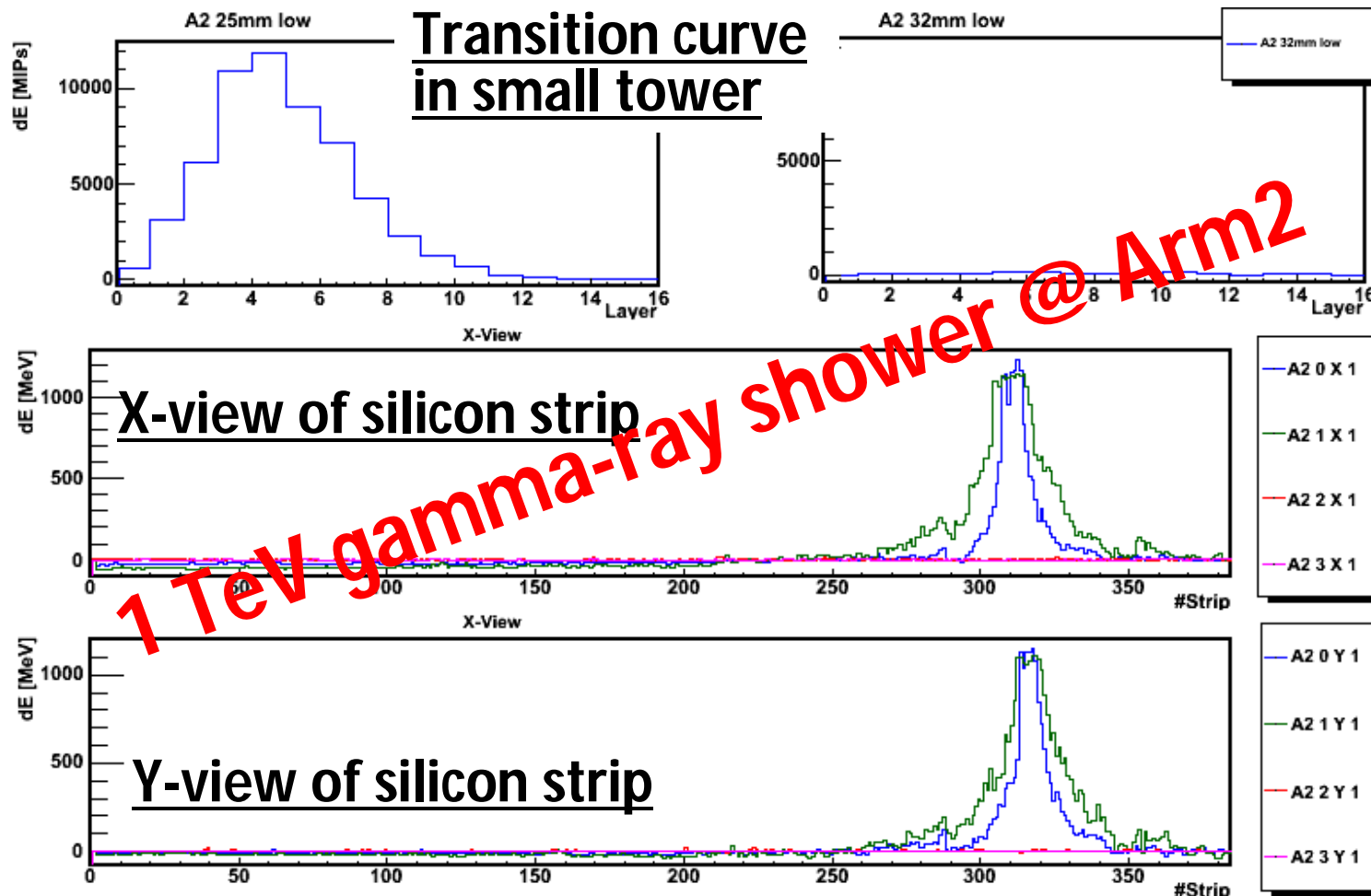
# Comparison with MC @ Arm2



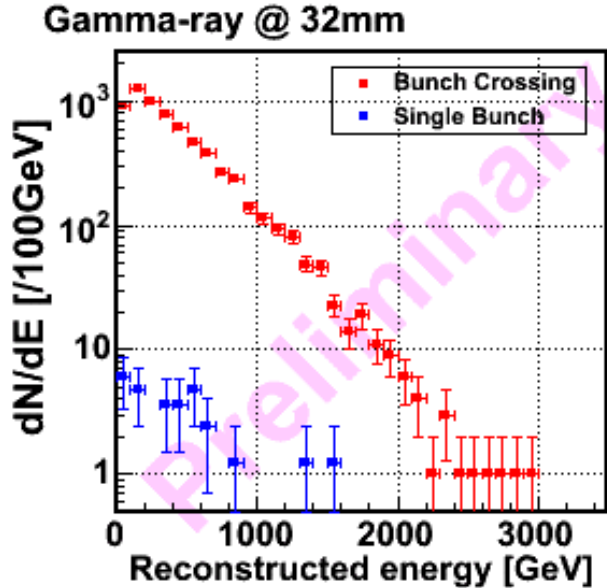
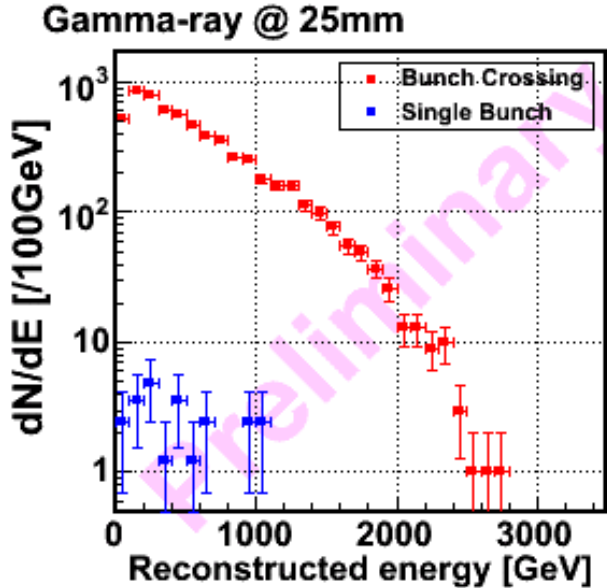
More statistics by data taking at 900GeV soon

# = Operations in 2010 =

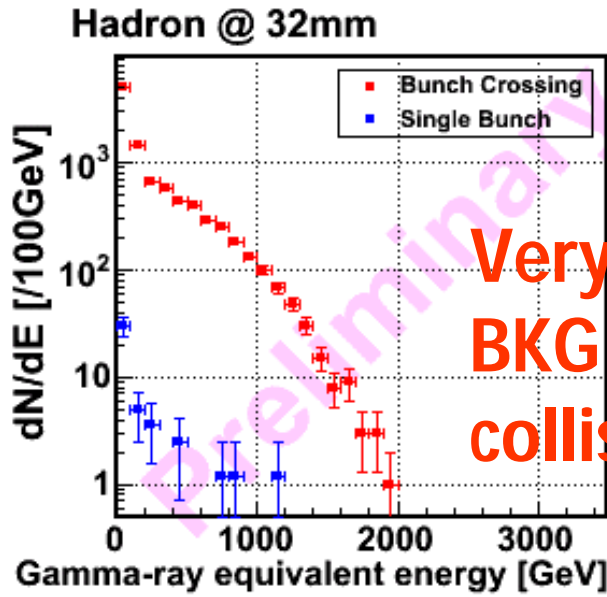
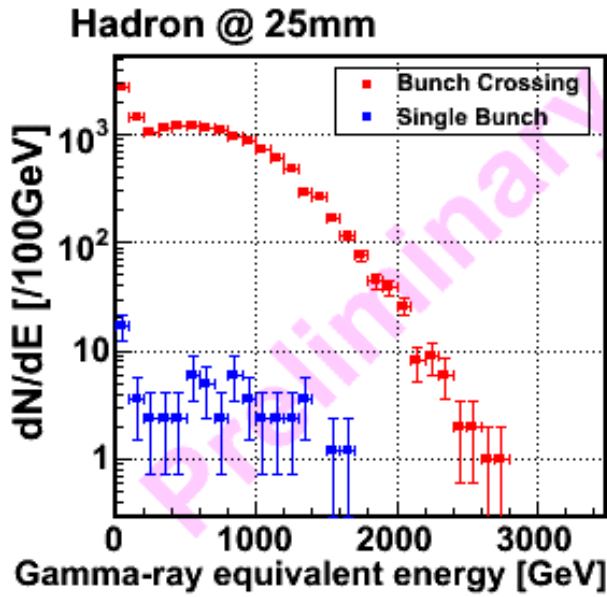
Data taking at 7TeV collisions is ongoing !!!  
Already  $7 \times 10^6$  shower events in Arm1 and Arm2  
have been collected (30<sup>th</sup> Mar. - 19<sup>th</sup> Apr. 2010)



# Very preliminary results



High statistics !!  
Only 1.5% of total data are used



Very clean data!!  
BKG due to beam-gas collisions is ~ 1%



# ■ *Operation Plan*

We will take data in LHC commissioning phases with low luminosity at every collision energy.

<i>2009</i>	Took data at 900GeV collision. ~6,000 shower events
<i>2010</i>	Take data at 900GeV again. Operation at 7TeV until 2 pb <sup>-1</sup> . Then remove detectors and upgrade them.
<i>2013</i>	Install detectors again. Operation at 14TeV

- + we want to measure at intermediate energy ~3TeV, if LHC has.
- + we want to measure at light ions collisions in some future.

## ■ *Summary*

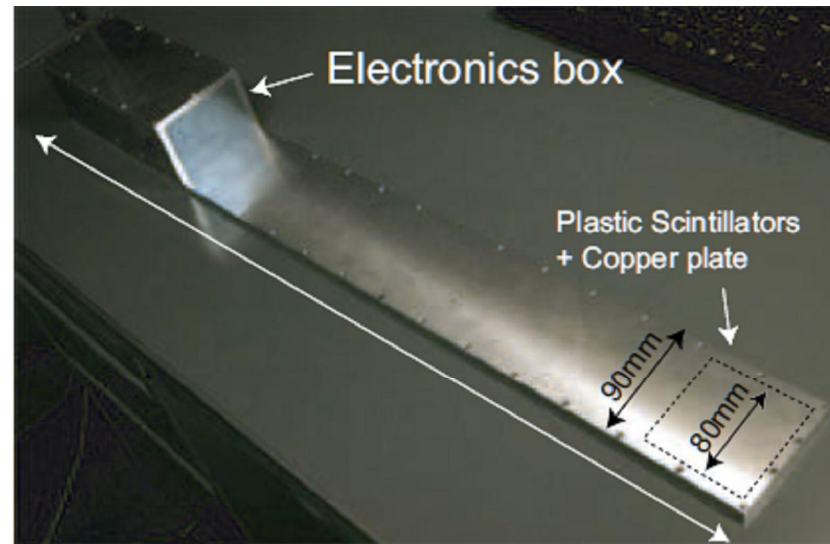
- The LHCf experiment is
  - ✓ a forward experiment of LHC with calorimeters at zero degree.
  - ✓ measuring energy spectra and transverse momentum distributions of very energetic neutral secondaries at the very forward region of IP1 ( $\eta > 8.4$ ).
- At 900GeV pp collisions,
  - ✓ We successfully took 6,000 shower events in the last year operations.
  - ✓ Measured gamma-ray energy spectra are in good agreements with MC within statistics and systematic errors.
  - ✓ We are checking hadron response of the detectors and systematic errors.
  - ✓ More statistic data will be taken in operations soon.
- At 7TeV pp collisions,
  - ✓ Data taking is ongoing successfully.
  - ✓ We will operate until  $2\text{pb}^{-1}$  Integral luminosity (for a few months)

*Buck up*

# ■ *Sub detectors -Front Counter-*

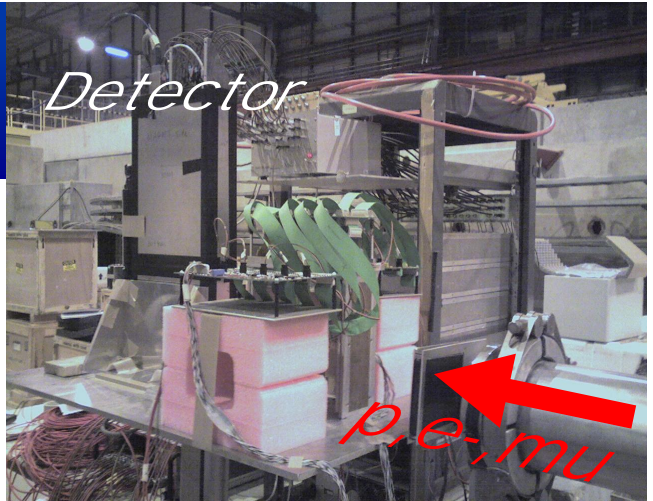
- Thin scintillators with  $8 \times 8 \text{ cm}^2$  acceptance, which have been installed in front of each main detector.

Schematic view of Front counter

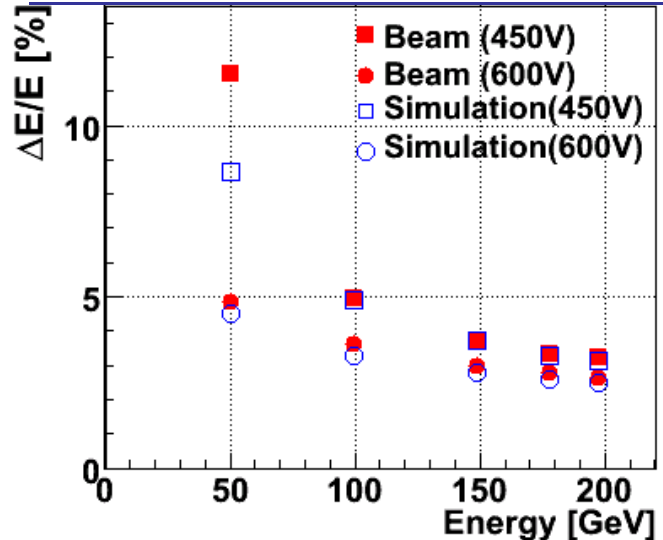


- To monitor beam condition.
- For background rejection of beam-residual gas collisions by coincidence analysis

# Beam test at SPS

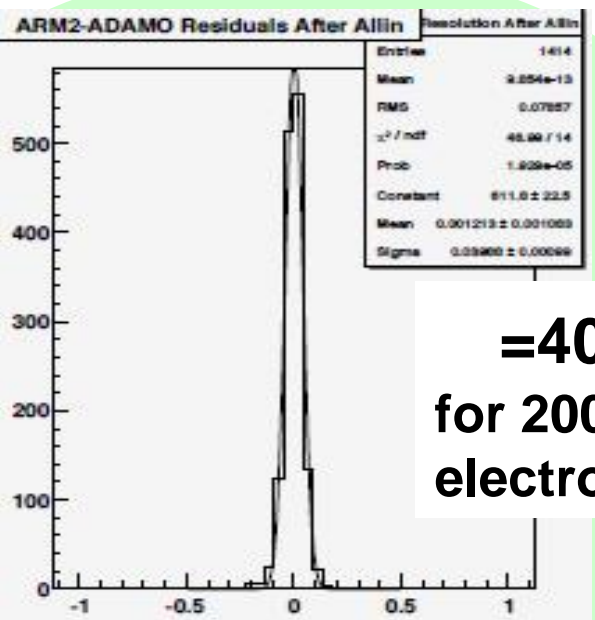


## Energy Resolution for electrons with 20mm cal.



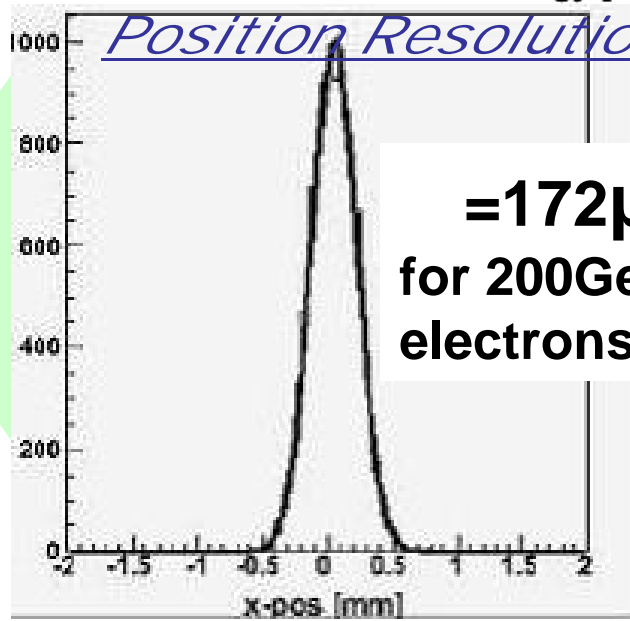
- Electrons 50GeV/c – 200GeV/c
- Muons 150GeV/c
- Protons 150GeV/c, 350GeV/c

## Position Resolution (Silicon)



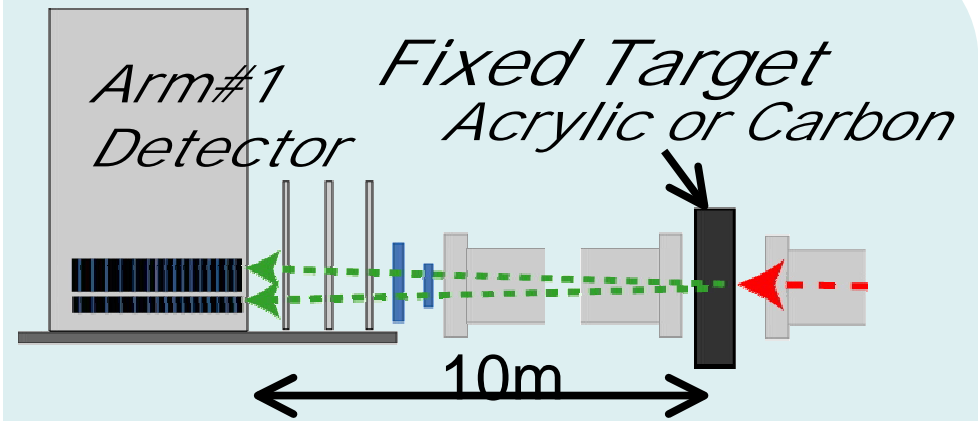
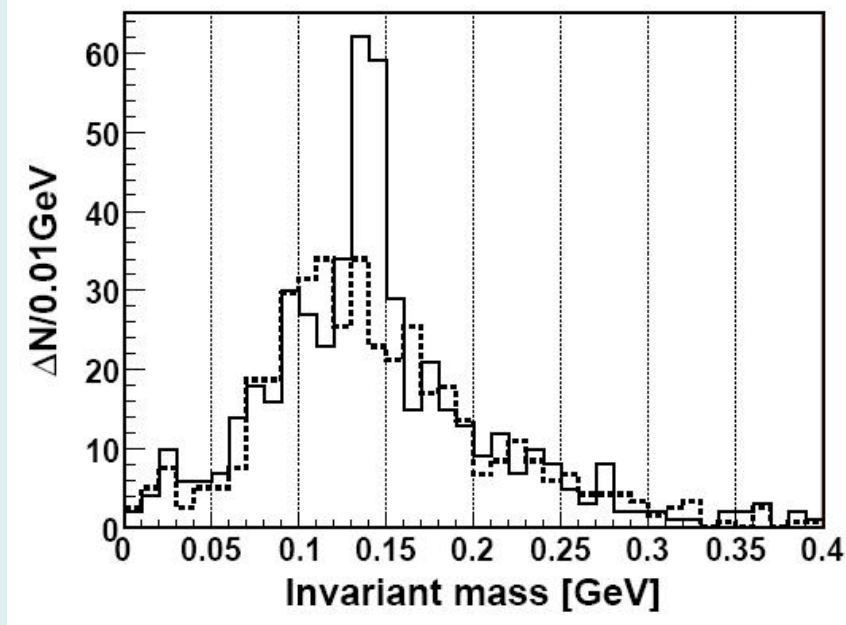
**=40 $\mu$ m**  
for 200GeV electrons

## Position Resolution (Scifi)



**=172 $\mu$ m**  
for 200GeV electrons

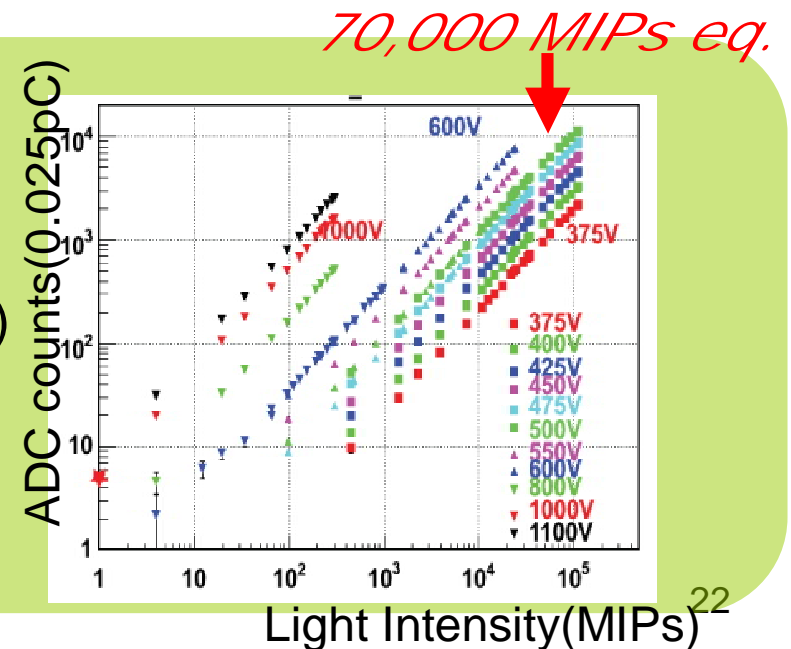
# $\pi^0$ reconstruction at the beam test



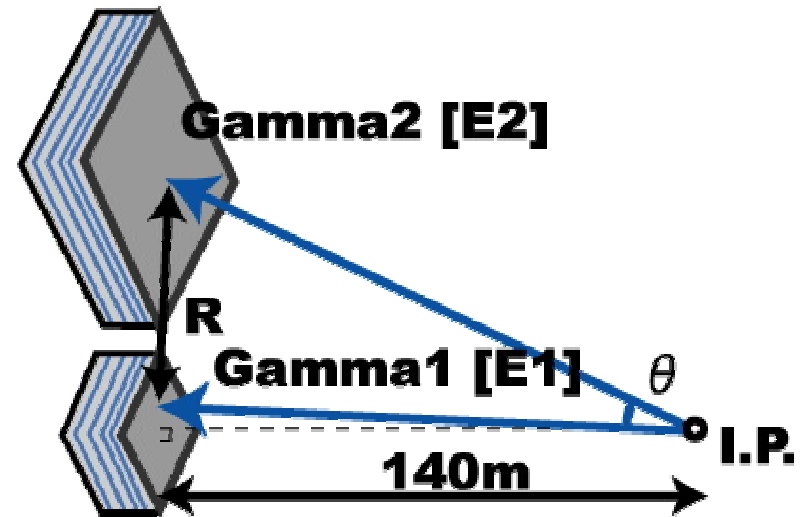
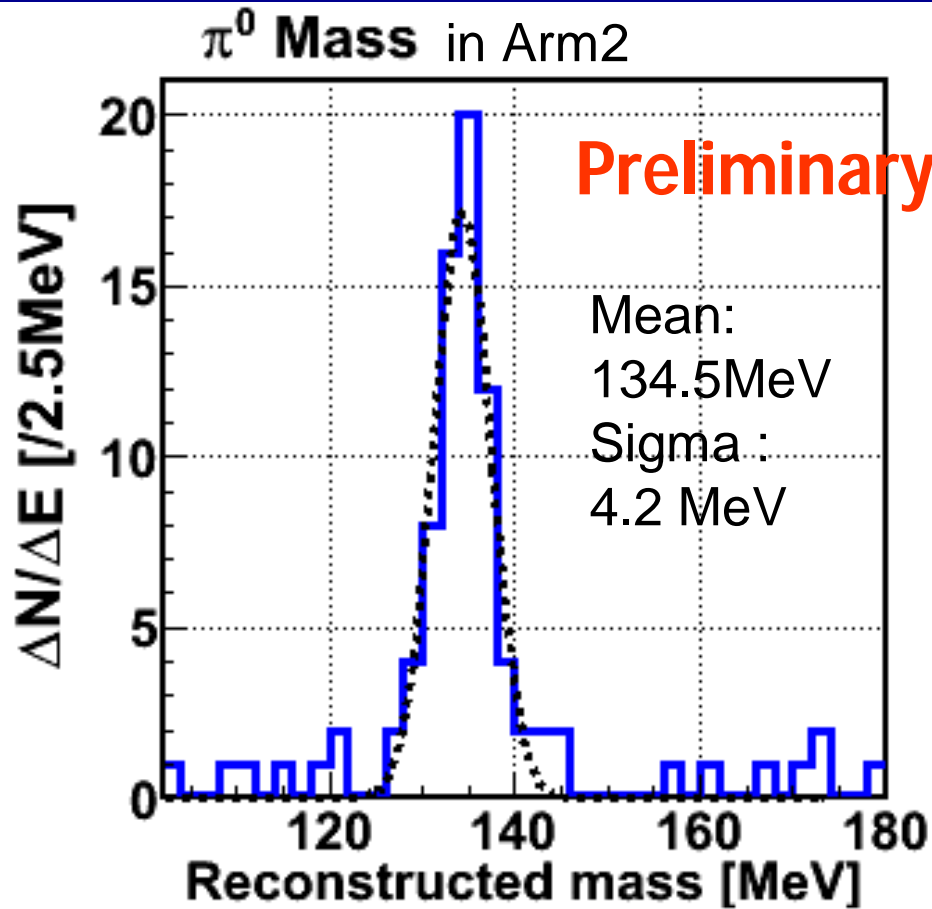
$\pi^0$  mass was reconstructed from gamma-ray pair measured by the both two calorimeters

## Calibration over SPS energy

Response of all PMTs for large amount of light over SPS energy upto 70,000 MIPs eq. (7TeV elemag shower) has been calibrated by a fast  $\text{N}_2$  laser.



# *$\pi^0$ mass at 7TeV*



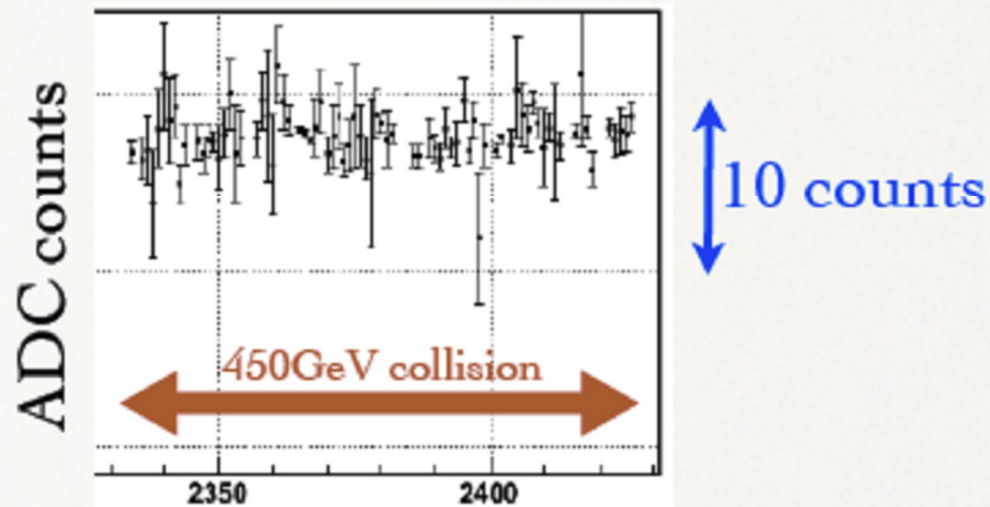
Data taken at 30. March is used (~1.5% of total)

**Good estimator of systematic errors**

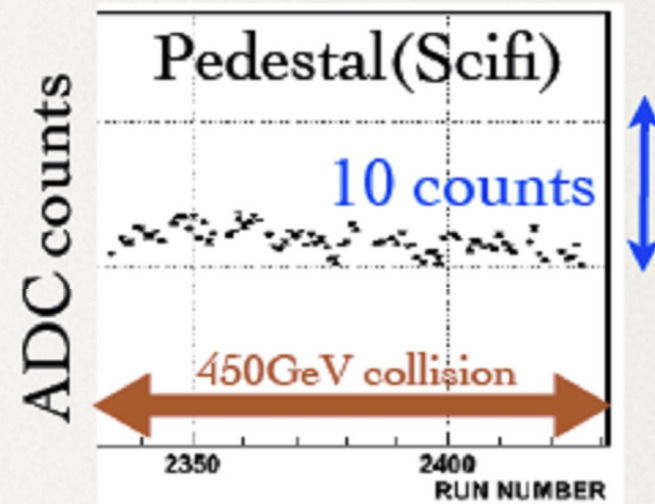
# Detector Stabilities

## Calorimeter

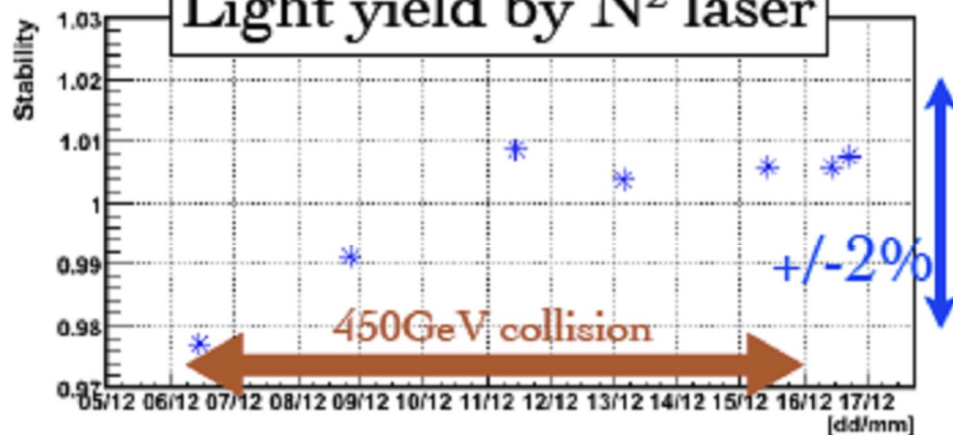
### Pedestal fluctuation



### Pedestal(Scifi)



### Light yield by N<sup>2</sup> laser



### Pedestal(Silicon)

