LHCf results on forward particle production at the LHC

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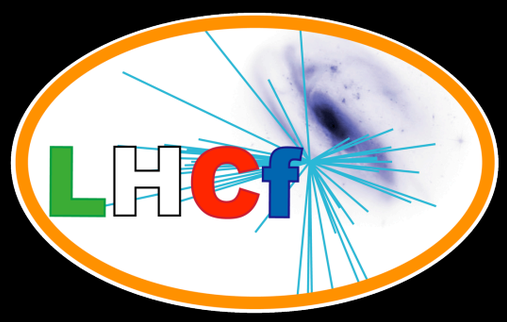
for the LHCf collaboration



Winter workshop on Recent QCD Advances at the LHC
Les Houces, Feb. 14th, 2011

Outline

- Introduction and Physics motivation
- The LHCf detectors
- Status of the LHCf experiment
- Results at $\sqrt{s}$=900GeV and 7TeV
  - All data at $\sqrt{s}$=900GeV
  - Fill#1104(May 2010) at $\sqrt{s}$=7TeV
- Conclusions and Future prospects

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Introduction

The LHCf experiment...

- observes neutral particles produced in p-p collisions emitted into the very forward (including zero degree, $\eta > 8.4$), equivalent to cosmic-ray air showers.
- , by means of energy spectra, tests the existing hadronic interaction models(e.g. Sibyll, QGSJET, etc...) which are mainly used in cosmic-ray experiments.
- aims to provide training data for building future models and reduce the uncertainty of hadronic interaction models around a TeV energy scale.
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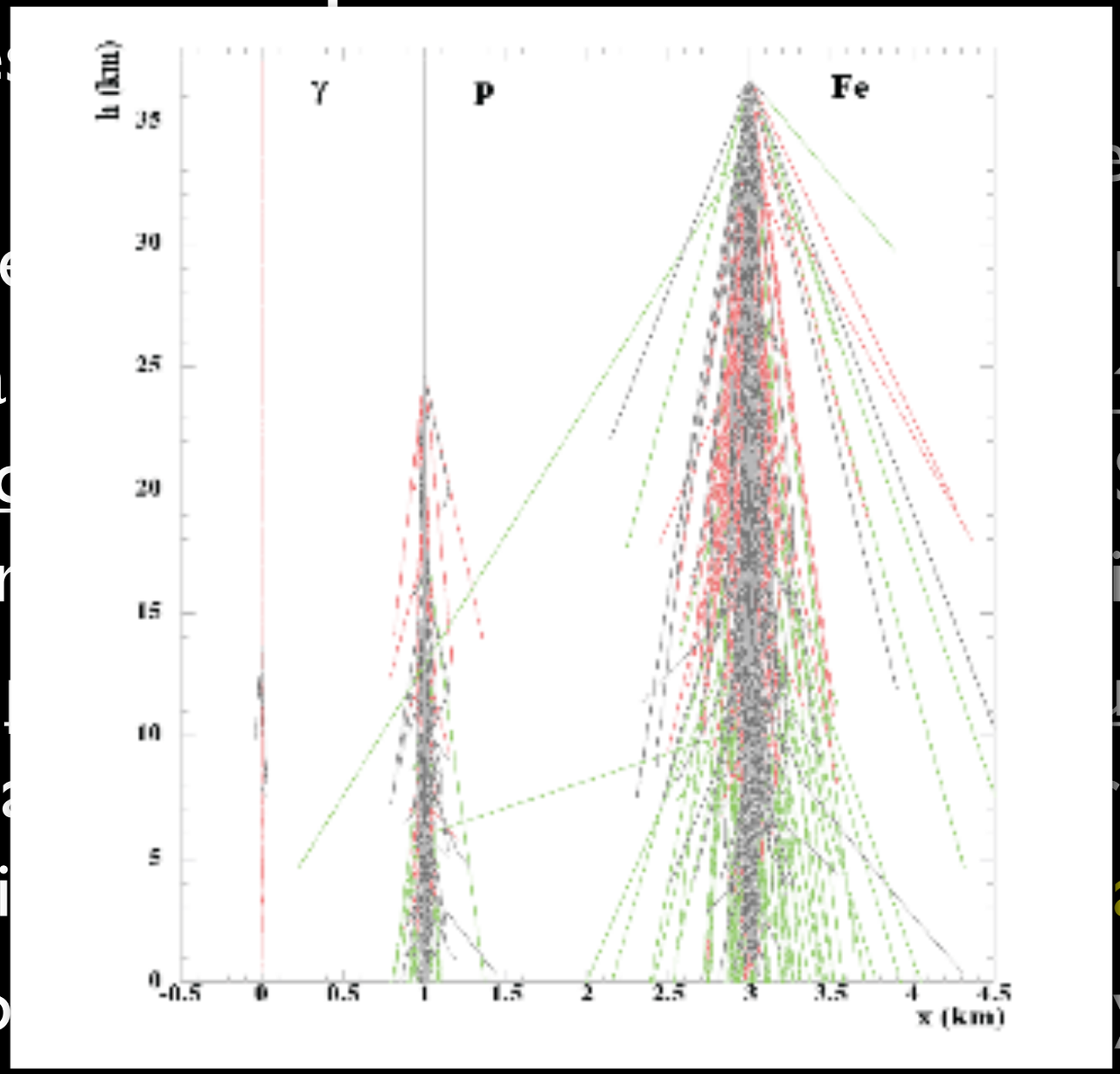

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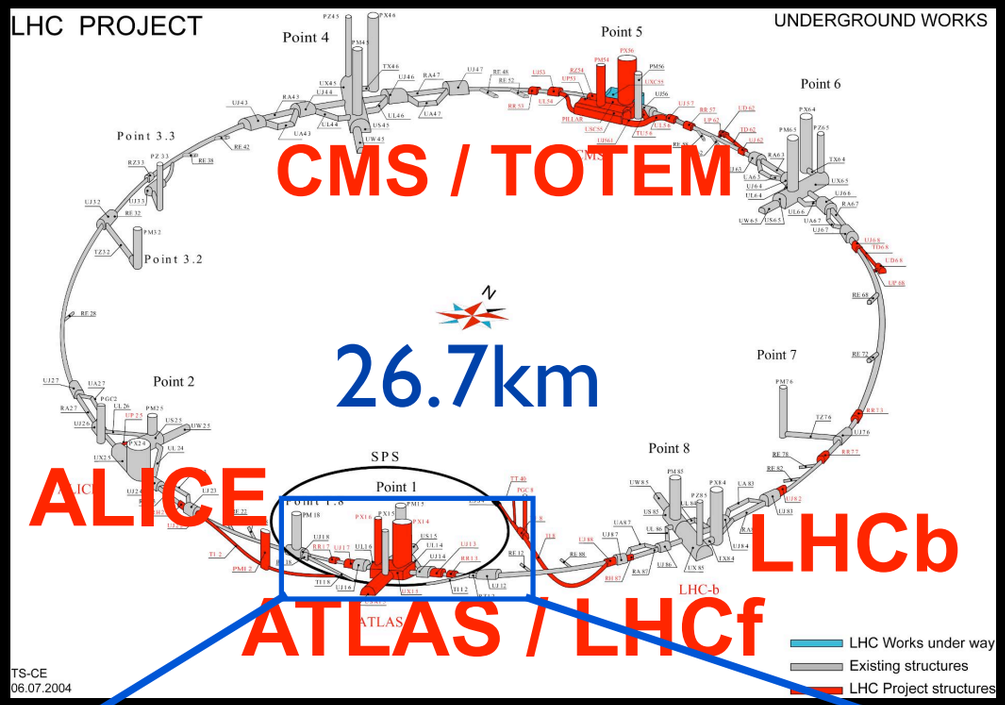
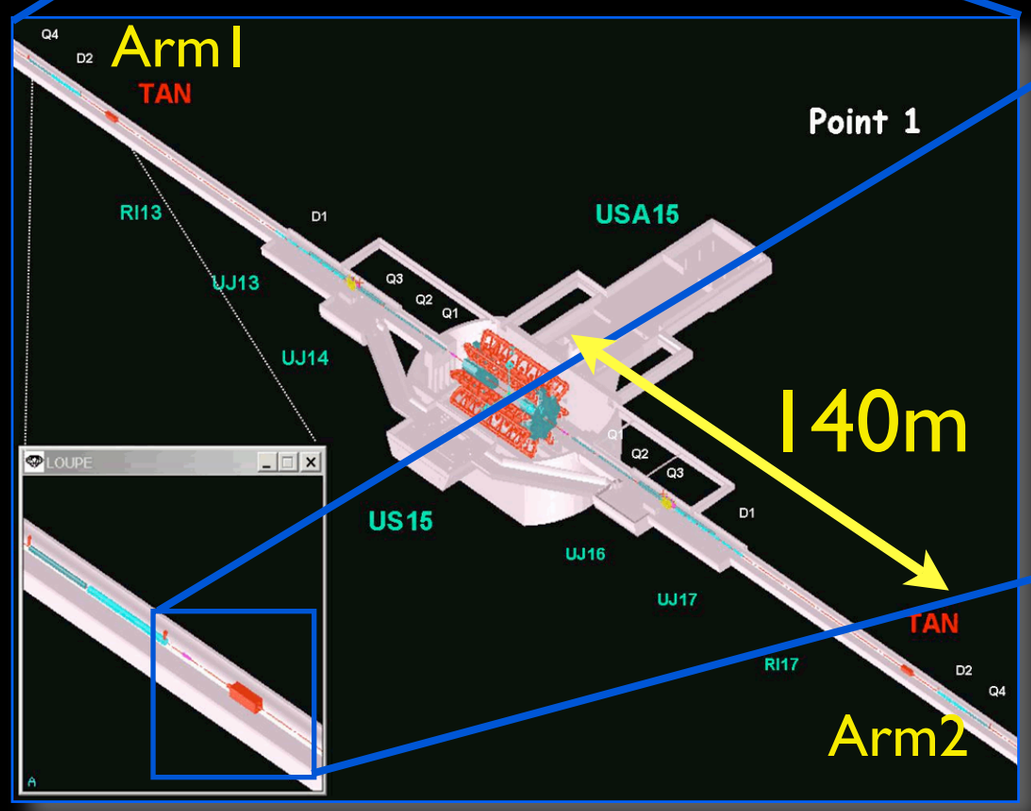
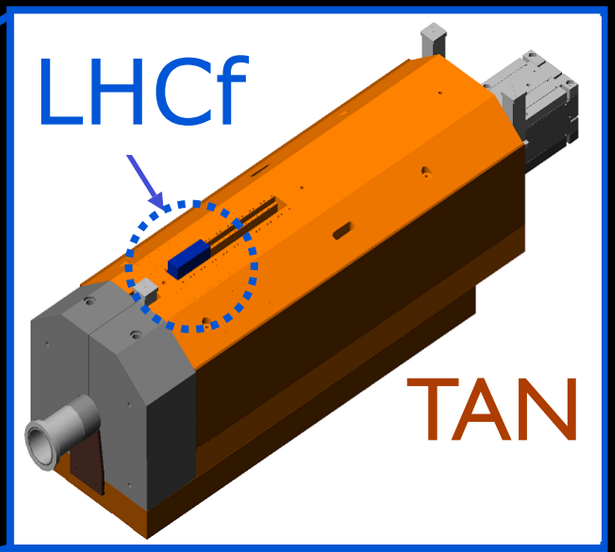
Forward measurements

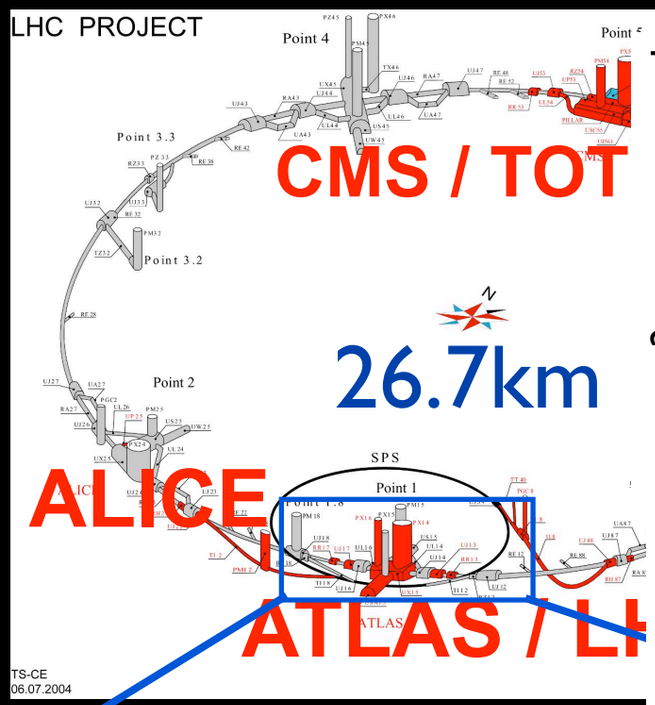


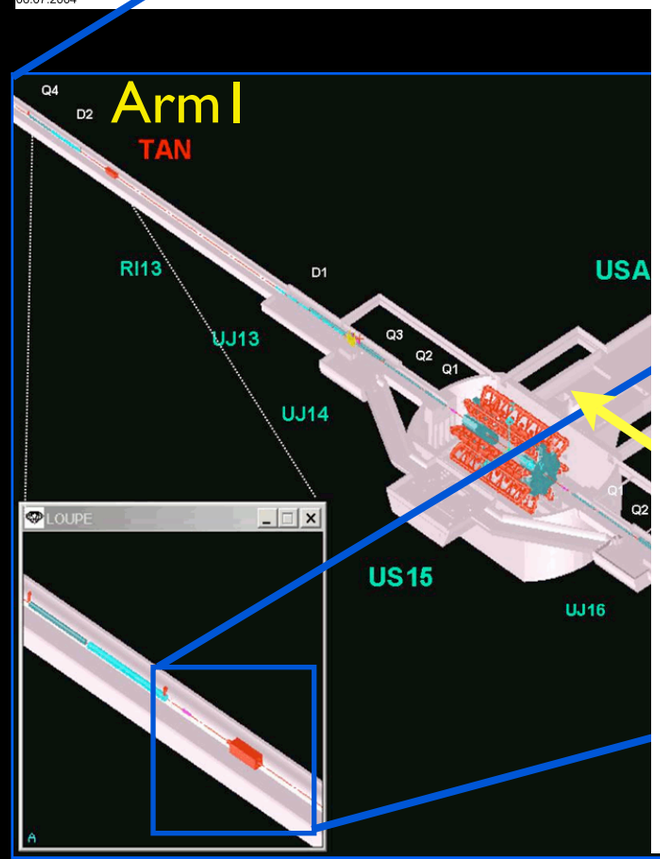
- Zero degree instrumentation slot at 140m away from IP1(ATLAS).
- p-p collision at $\sqrt{s}$=14TeV corresponds to $E_{lab}=10^{17}$eV.

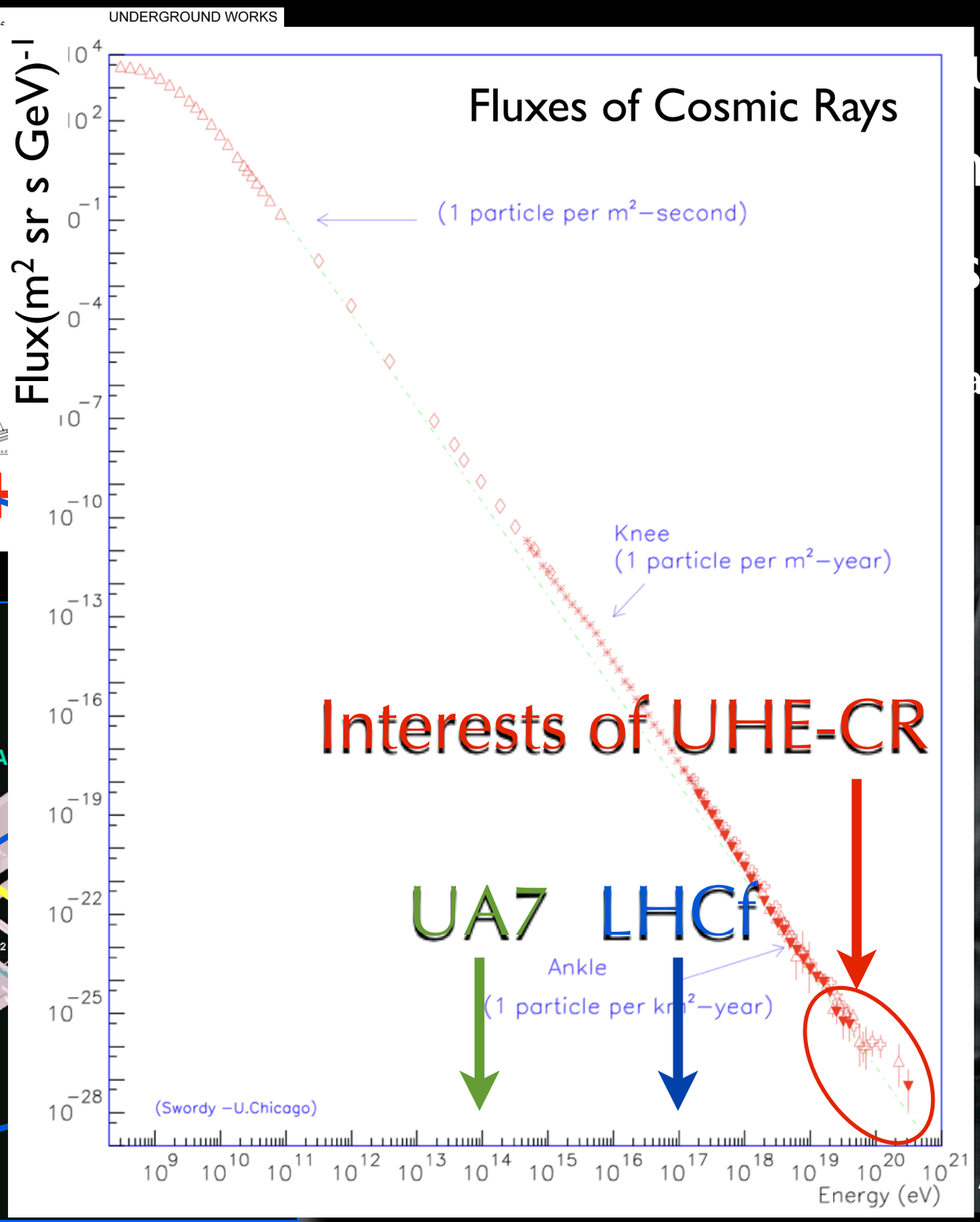




Forward measurements







umentation slot

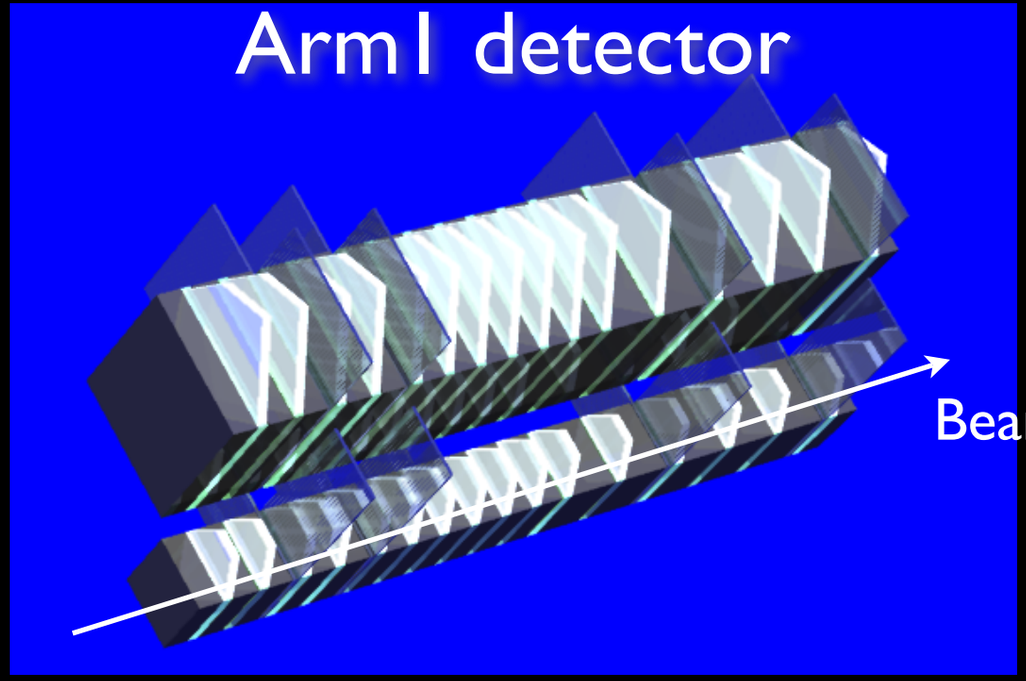
n IP1(ATLAS).

s=14TeV

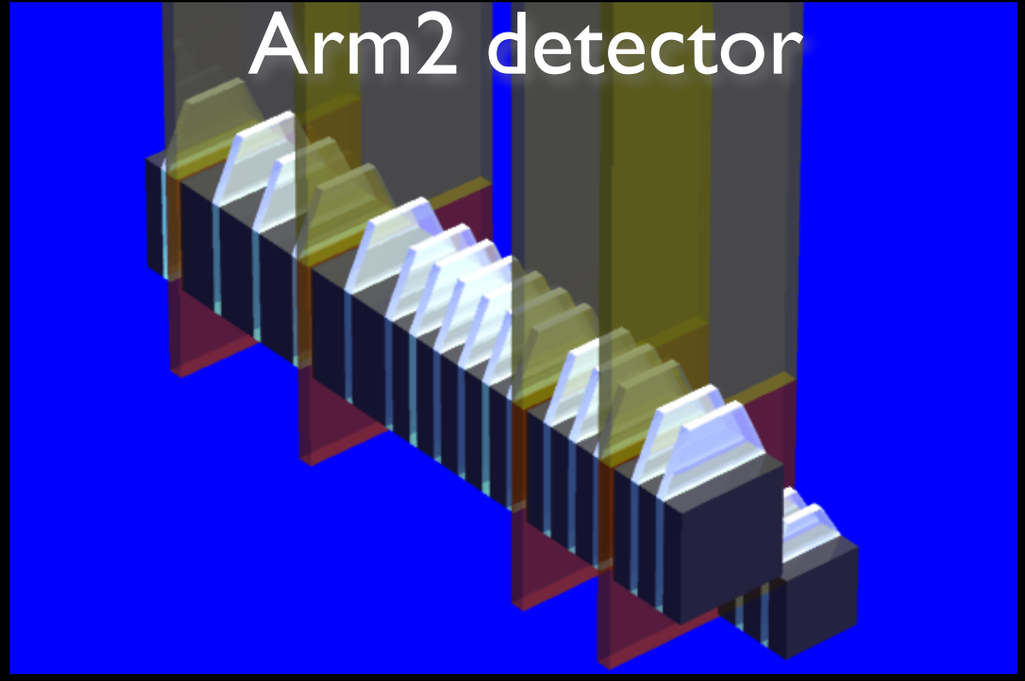
ab=10^{17}eV.

The LHCf detector

- Sampling & imaging calorimeters either side of IP1.
- Two compact towers in both detectors.
  - Tungsten absorbers: 44r.l., 1.7λ
  - 16 plastic scintillator sampling layers
  - 4 position sensitive layers



20mmx20mm + 40mmx40mm
Consists of scintillation fibers
Located at 6, 10, 30, 42 r.l.



25mmx25mm + 32mmx32mm
Consists of silicon strip detector
Located at 6, 12, 30, 42 r.l.

Operation in 2009-10

Run in 2009

- From End of October 2009 LHC restarted operation.
  - 450 GeV + 450 GeV → 1.18 TeV + 1.18 TeV
- Stable operation at $\sqrt{s}$=900GeV, while no data was obtained at $\sqrt{s}$=2.36TeV.

Run in 2010

- Data taking at 7TeV since March to July.
  - 400M showers and 2M π^0s were obtained (arm1+arm2).
  - Energy scale calibration with a π^0-mass peak.
- Statistics improved at 900 GeV >10times larger than 2009.
- Uninstallation of the detectors on July.

SPS in 2010

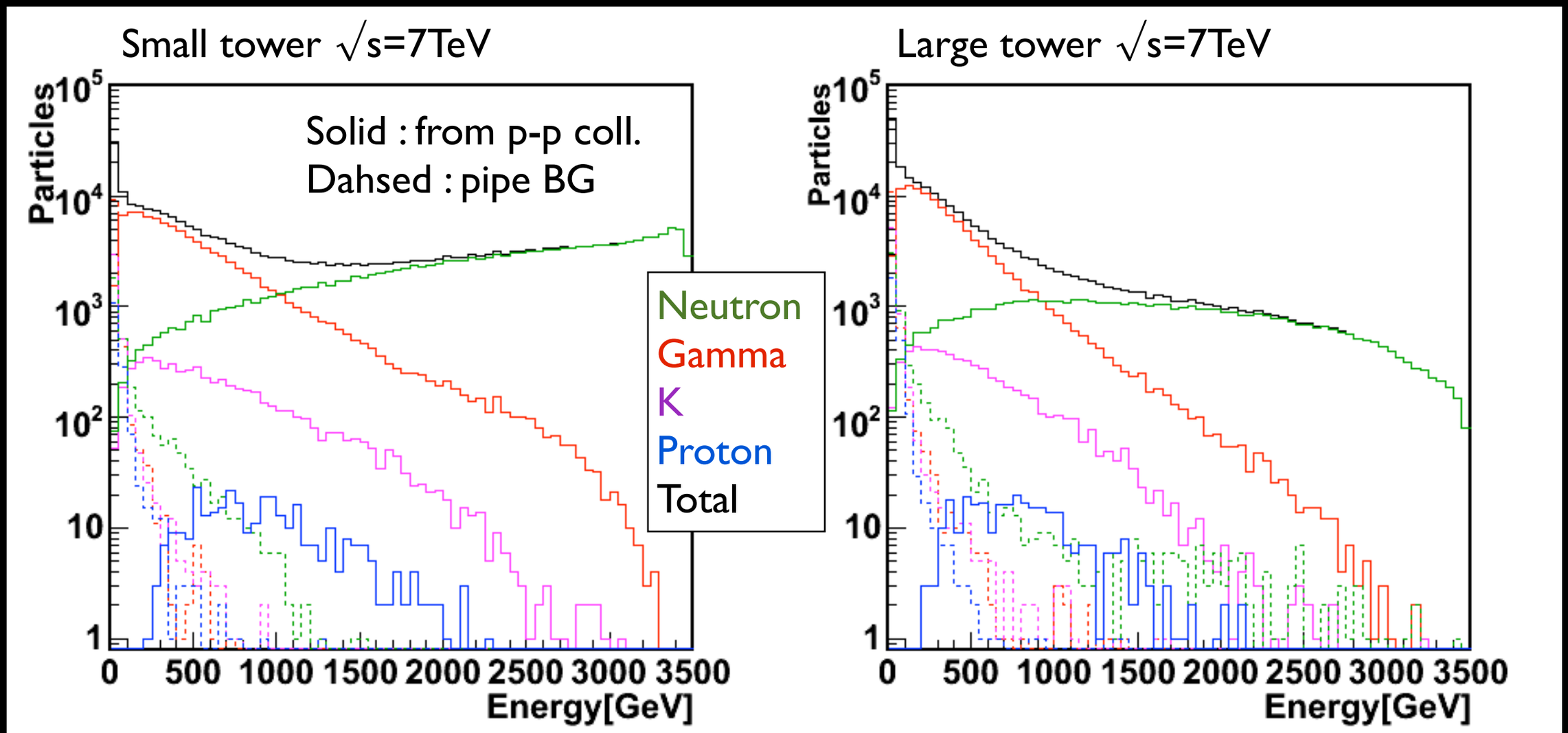
- Post-calibration was done at SPS on Oct-Nov.
- Calibration results in 2007 and 2010 will be published soon.

Detector upgrade is planed this summer for $\sqrt{s}$=14TeV run.

Expected spectra

All figures assume
10^7 collisions@$\sqrt{s}$=7TeV

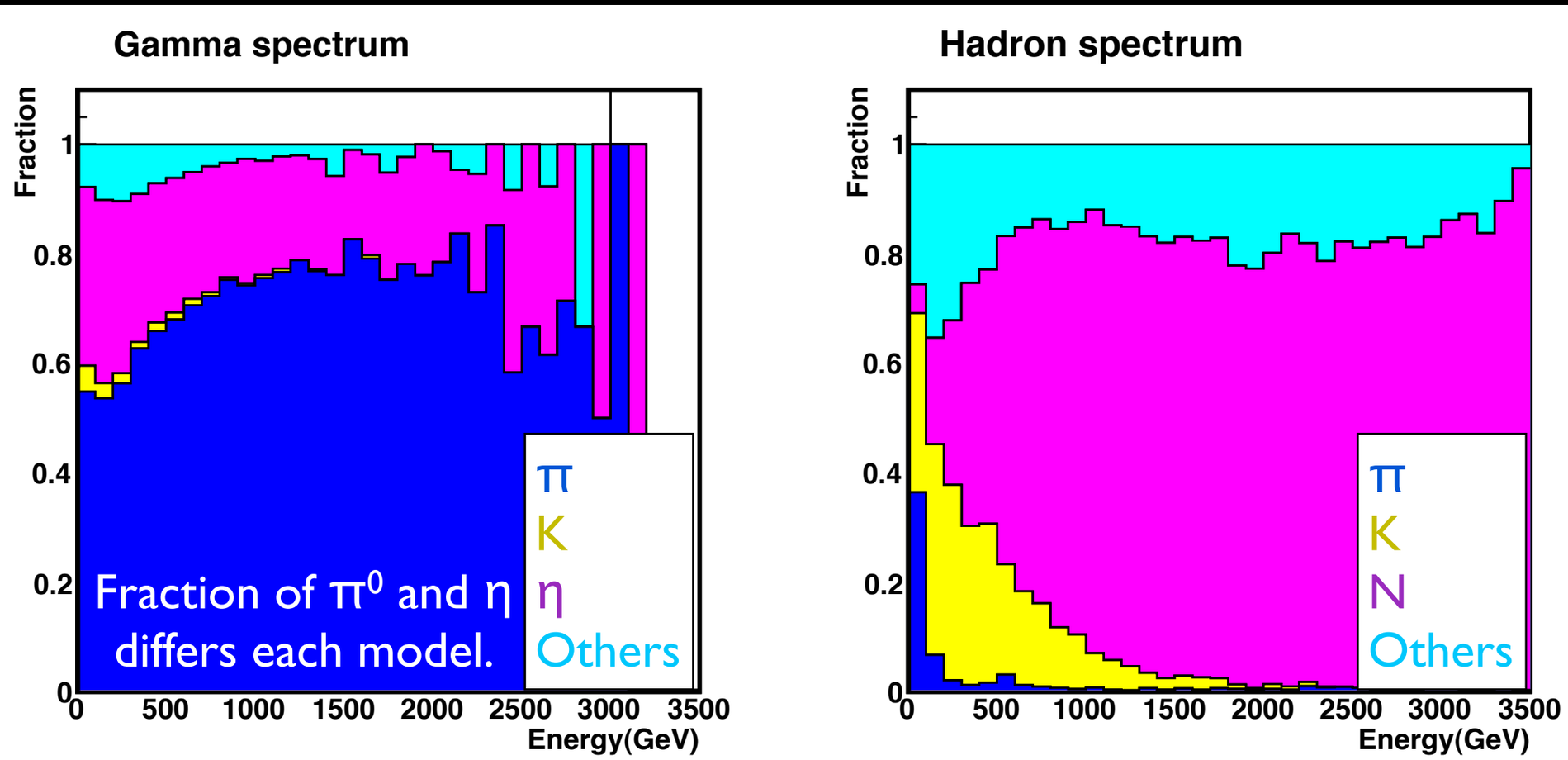
- Spectrum in the forward region at 140m away from IP1 (i.e. LHCf site).
- No detector simulation is applied.
- Neutron/Gamma ratio is also important from the cosmic-ray point of view.



Description in Sibyll

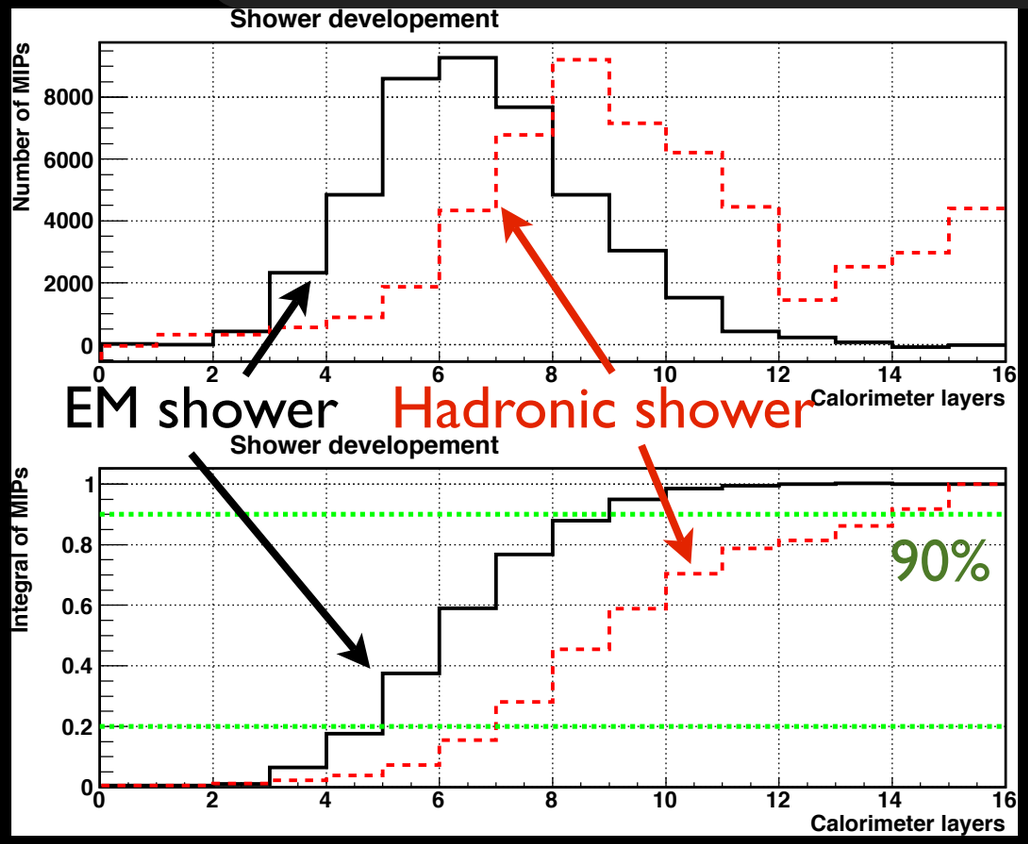
- "Sibyll 2.1" has been released 1999 and widely employed in many cosmic-ray experiments.
  - relatively simple than other models(i.e. fast)
  - based on Lund model
  - energy dependent Pt cutoff to separate soft/hard process
  - includes the tuning by HERA data and tested against Tevatron

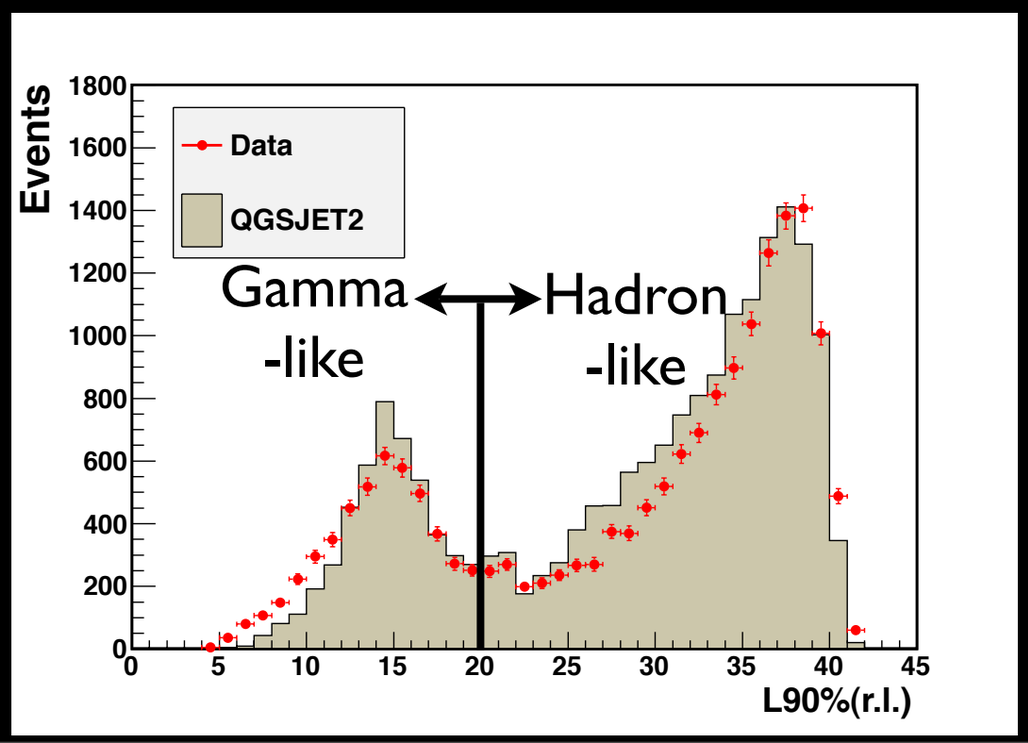
Fraction of parent particles



Analysis@900GeV

Particle Identification



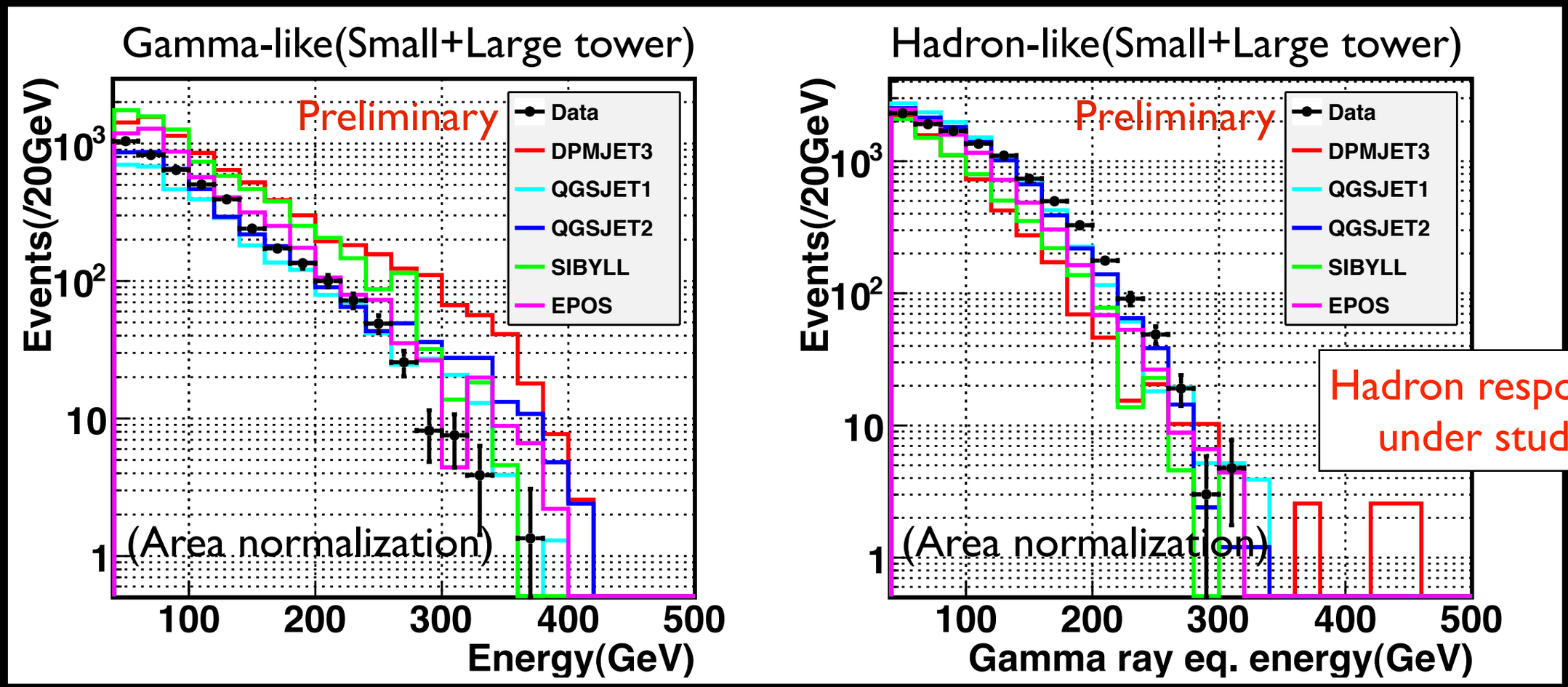


- EM and hadronic showers can be discriminated by the difference of the longitudinal shower development.
- Longitudinal development is parametrized as L90%(r.l.).

$$\frac{\int_0^{L90\%} E_{dep}}{\int_0^{44 r.l.} E_{dep}} = 90\%$$

- ~90% efficiency and >80% purity for gamma-like events.
- PID correction is applied in the testing hadronic interaction models.

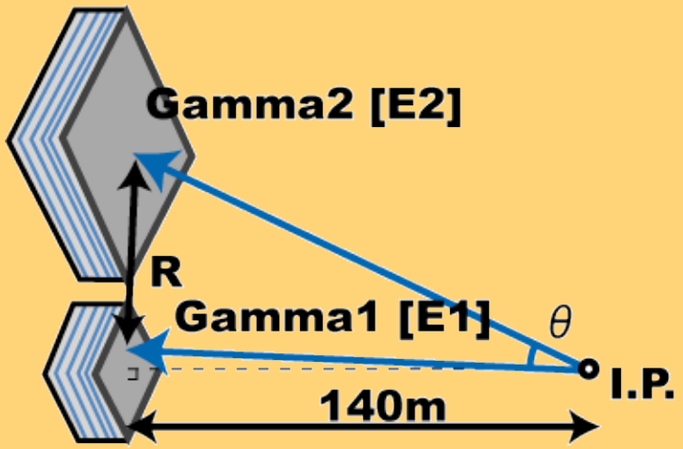
Spectra at $\sqrt{s}$=900GeV



- Focusing on only shape Sibyll seems better agreement, while QGSJET2 has similar gamma/hadron ratio with data.
- For the moment very conservative systematic uncertainty must be taken into account for energy scale +10%-2% both for gamma and hadron-like events.
- We'll soon back to $\sqrt{s}$=900GeV data analysis.

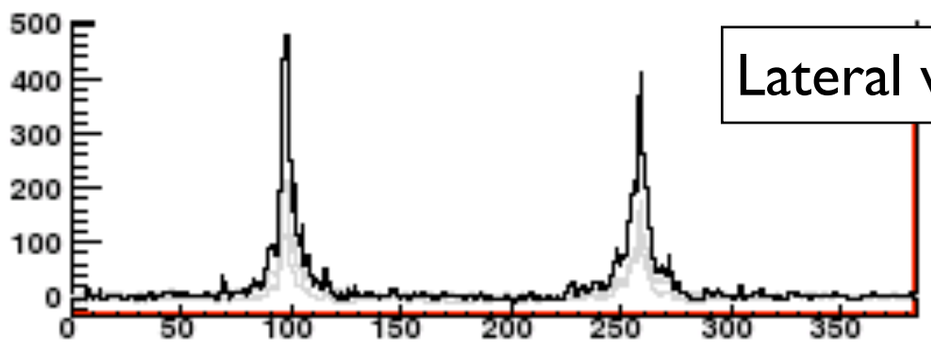
Analysis@7TeV

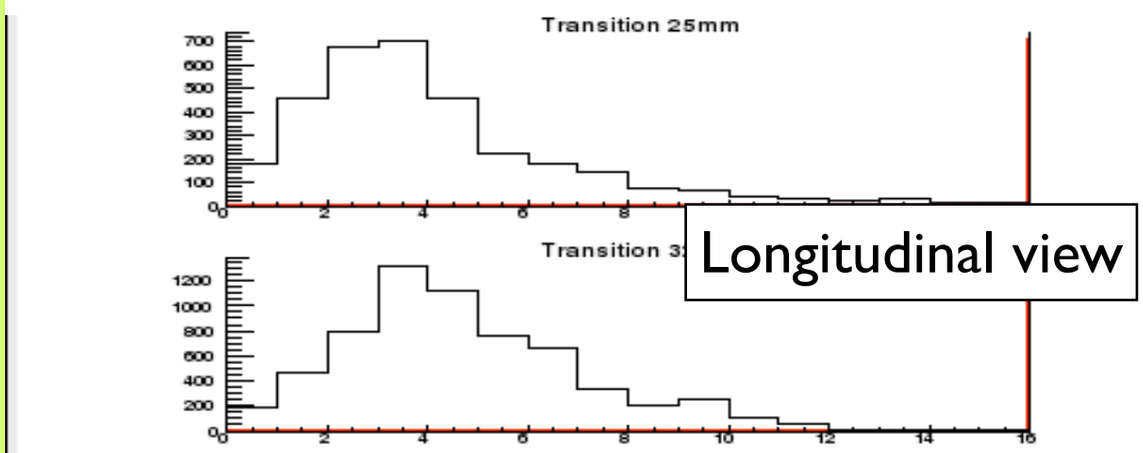
π^0 measurement

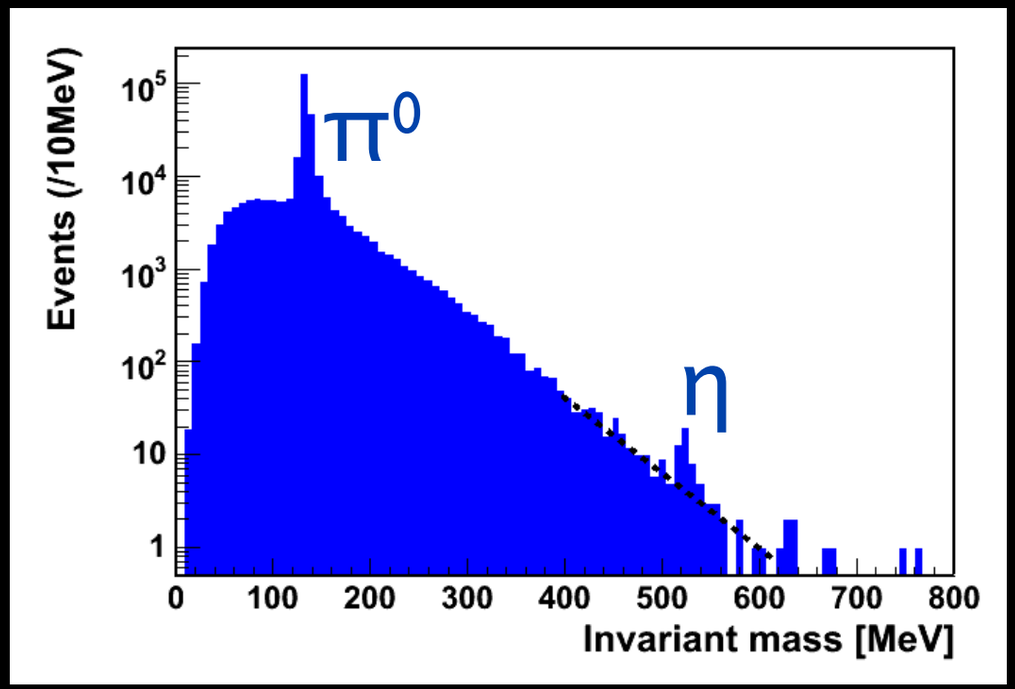


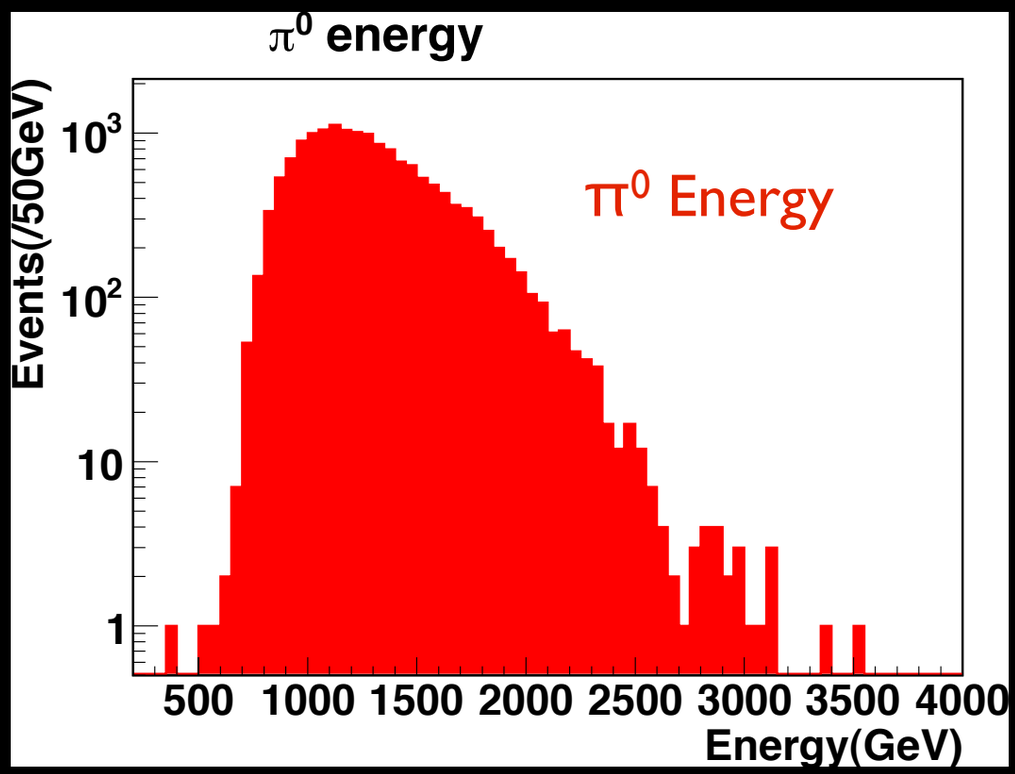
$$\theta = \frac{R}{140\mathrm{m}}$$

Event display of π^0(2-gamma)

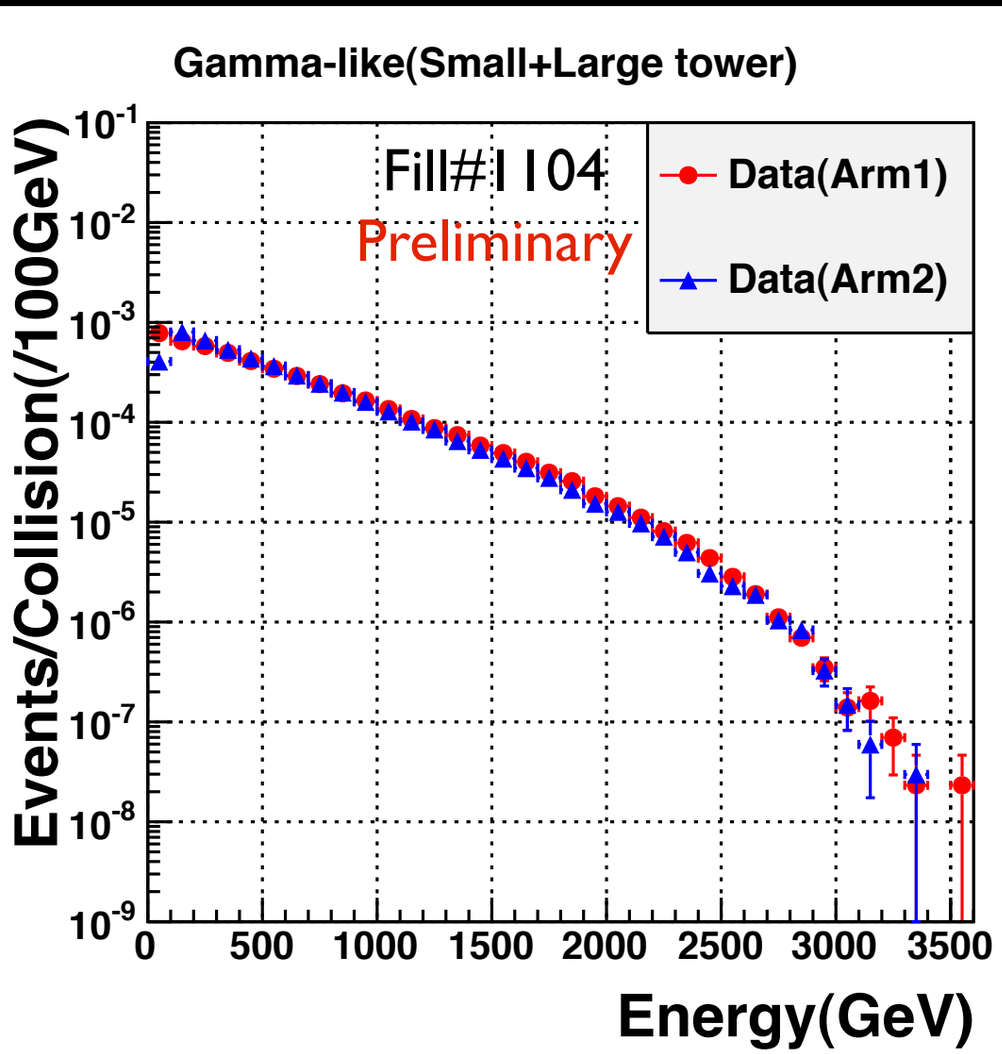


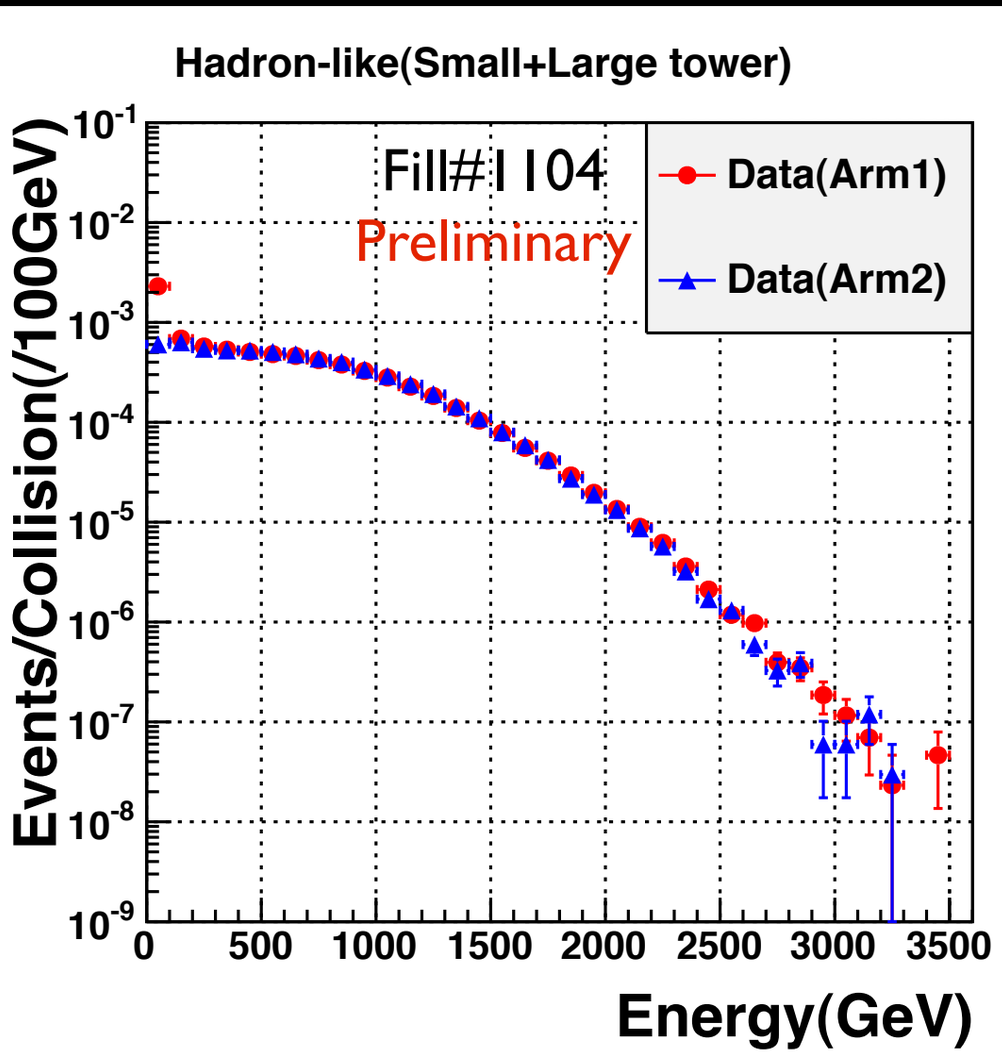






Spectra at 7TeV





- To check the consistency btw. Arm1 and Arm2, events in common rapidity range are selected($\eta>10.9$, $8.81<\eta<8.99$).
- Normalization is based on the number of collision determined by vdM scan(σ_{inel}=71.5mb).
- Slight difference is within the systematic uncertainty related to energy scale.
- Comparison with hadronic interaction models will be presented at CERN next month.

Conclusions

- LHCf finished 1st physics program quite successfully.
  - 100K showers at 900GeV (Run2009 + 2010)
  - 400M showers and 2M π^0 at 7TeV (Run2010)
- Detectors had worked fine and stably.
  - π^0 mass peak demonstrates good performance
  - Consistent results are given from independent analysis at Arm1 and Arm2
- First analysis results will be published soon.
  - Test of hadronic interaction models at 7TeV by gamma-ray energy spectra
  - SPS beam test data (detector performance)