



LHCf 2010 Christmas Report

LHC End-of-Year Jamboree

CERN 17 December 2010

*Alessia Tricomi on behalf of the LHCf Collaboration
University and INFN Catania, Italy*





What is LHCf?

Experimental Set-up & Detectors

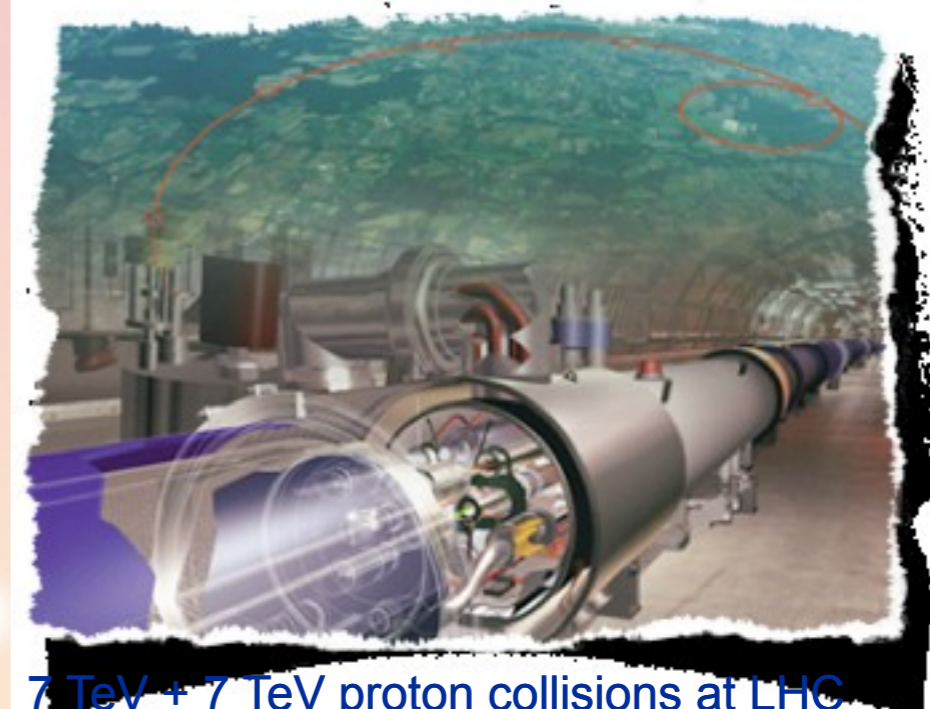
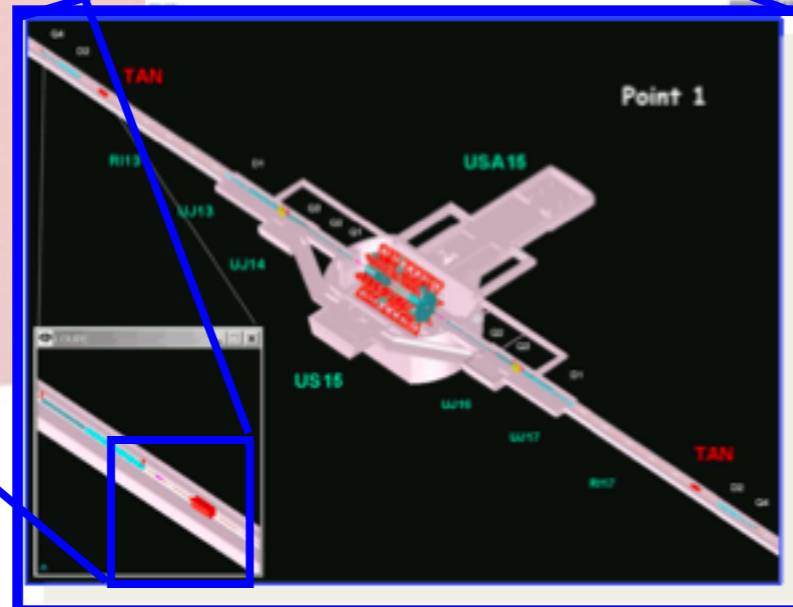
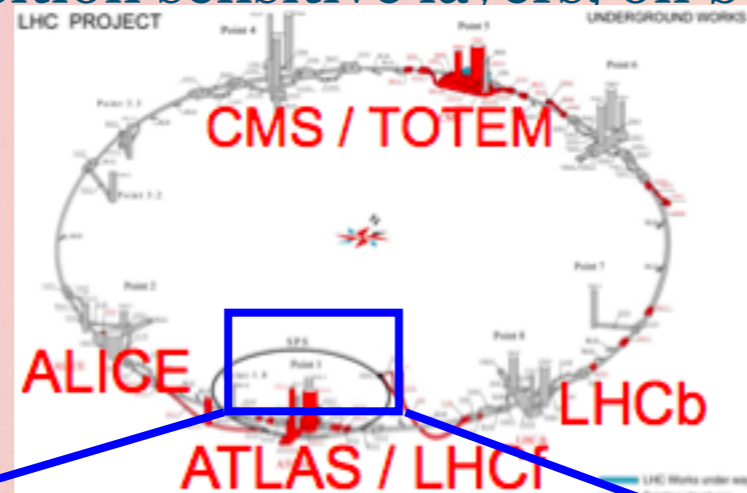
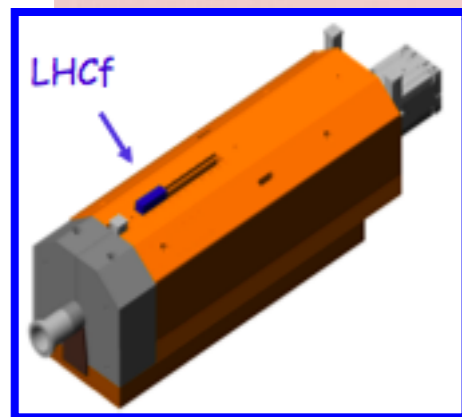





The LHCf experiment at LHC

 LHCf, the smallest LHC experiment, is a fully dedicated collider experiment to HECR Physics

 Two independent electromagnetic calorimeters equipped with position sensitive layers, on both sides of IP1



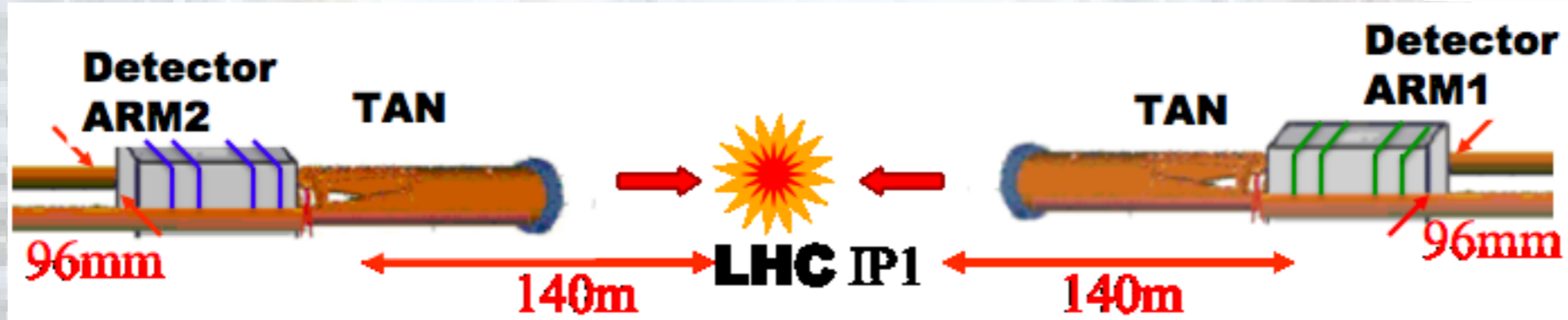
7 TeV + 7 TeV proton collisions at LHC correspond to $E_{LAB} = 10^{17}$ eV

 Measure energy and position for $\eta < 8$ of gamma from π^0 decays and neutrons produced in pp interactions at LHC

 International collaboration mainly Japan-Europe (about 30 members)



Experimental Set-up

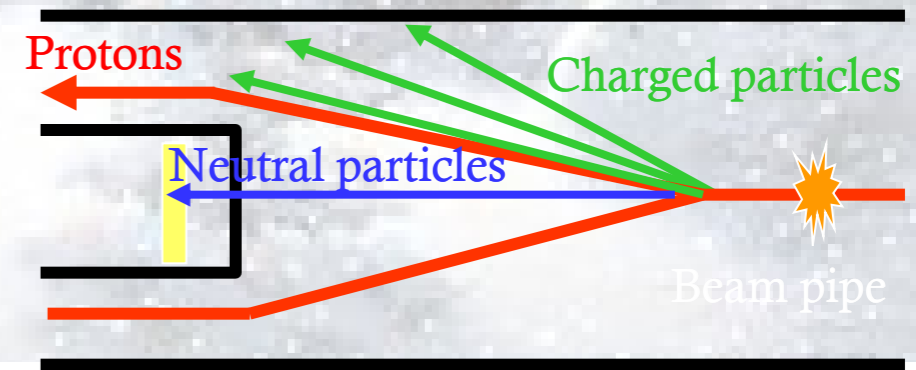
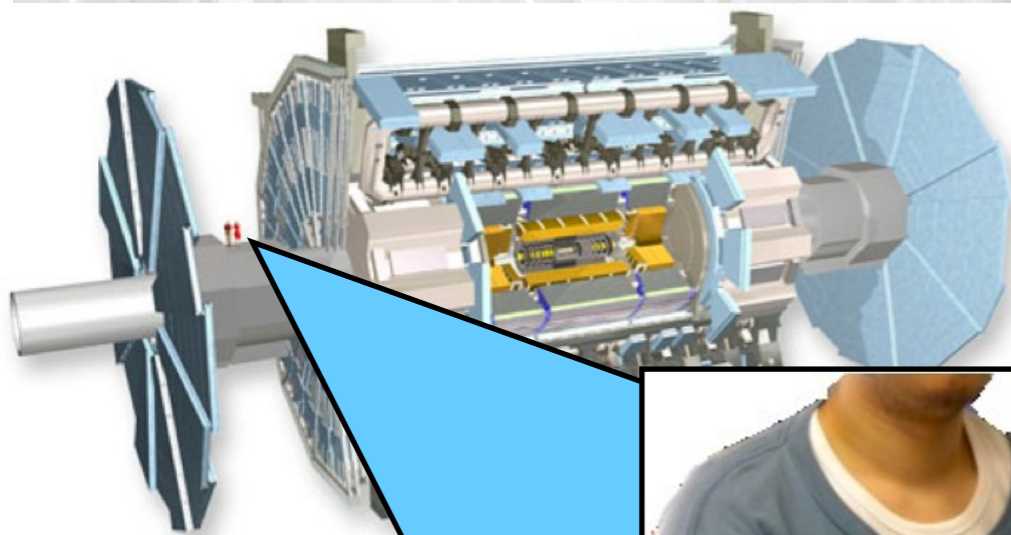


Detectors installed in the TAN region, 140 m away from ATLAS Interaction Point (IP1)

✦ Here the beam pipe splits in 2 separate tubes.

✦ Charged particles are swept away by magnets

✦ We will cover up to $y \rightarrow \infty$





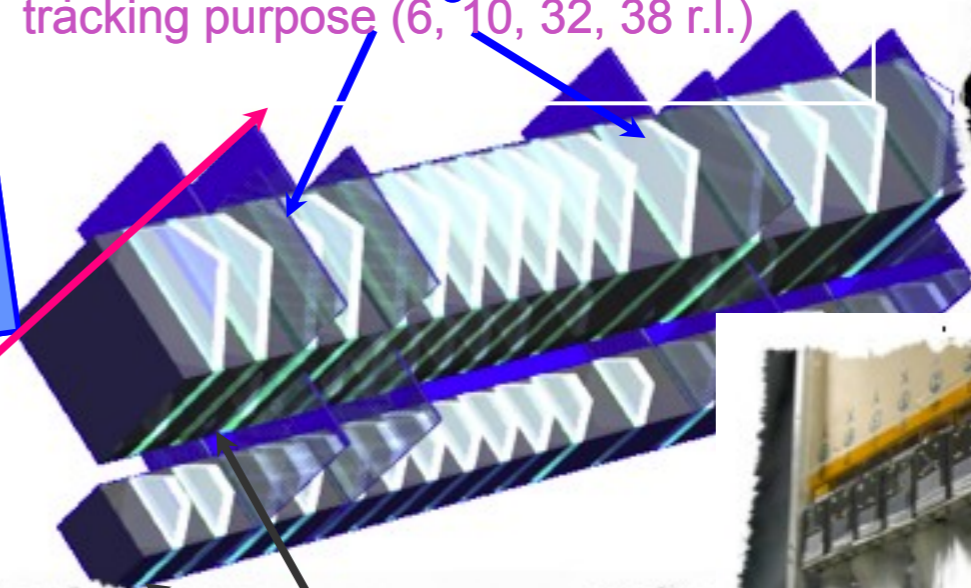
ARM1 & ARM2 detectors



Arm#2

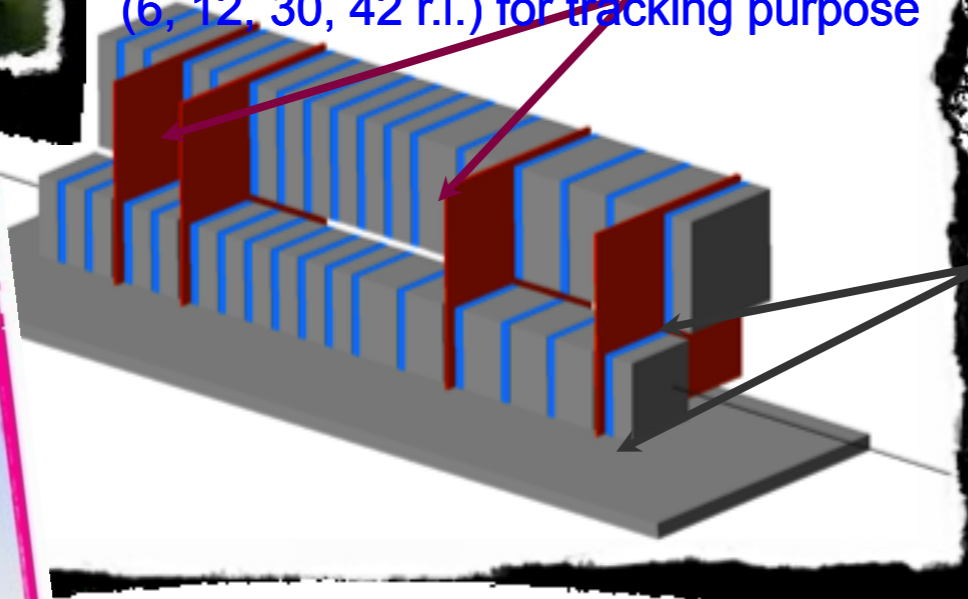
ARM1
2 towers 24 cm long stacked vertically with 5 mm gap
Lower: 2 cm x 2 cm area
Upper: 4 cm x 4 cm area

4 pairs of scintillating fiber layers for tracking purpose (6, 10, 32, 38 r.l.)



Impact point (η)

4 pairs of XY silicon micro-strip layers (6, 12, 30, 42 r.l.) for tracking purpose

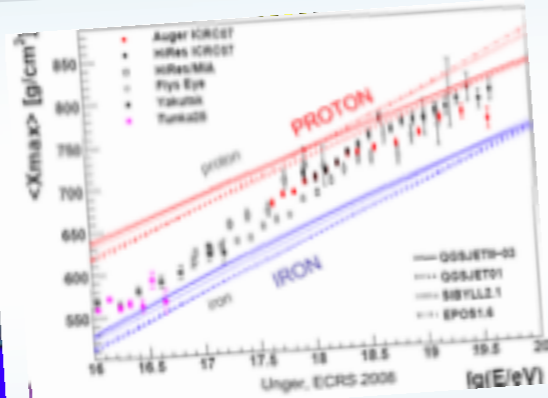
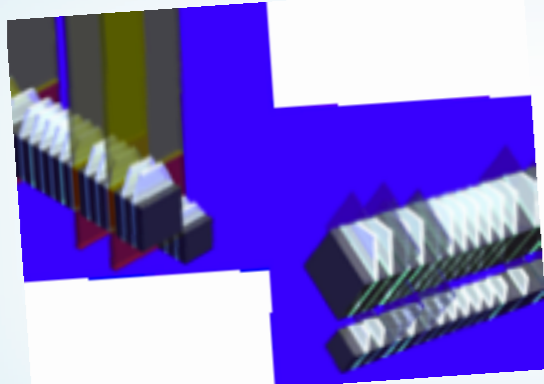


Arm#1

290mm 90mm

Energy

ARM2
2 towers 24 cm long stacked on their edges and offset from one another
Lower: 2.5 cm x 2.5 cm
Upper: 3.2 cm x 3.2 cm



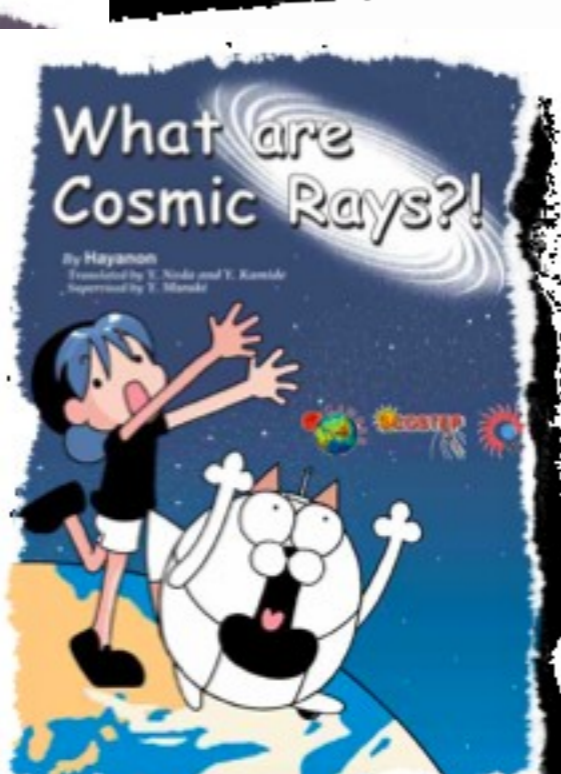
Why LHCf?

Physics goals & motivations

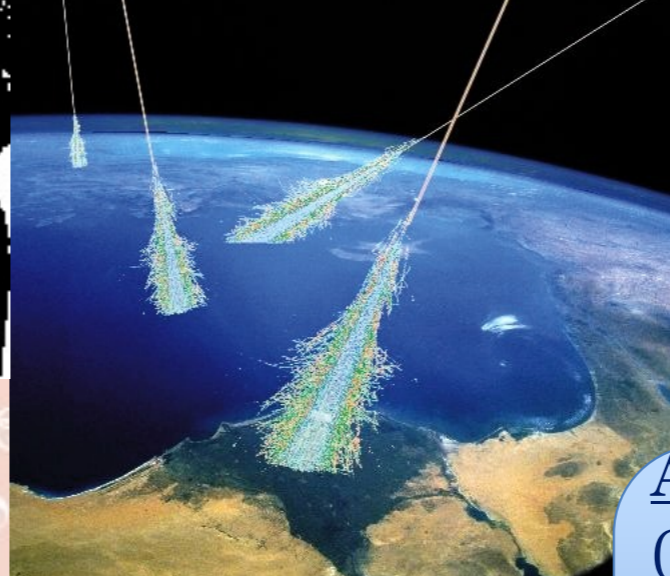




Ultra High Energy Cosmic Rays



Extensive Air Showers



Experimental observations
at $E > 100$ TeV only EAS

(shower of secondary particles)

- lateral distribution
- longitudinal distribution
- particle type
- arrival direction

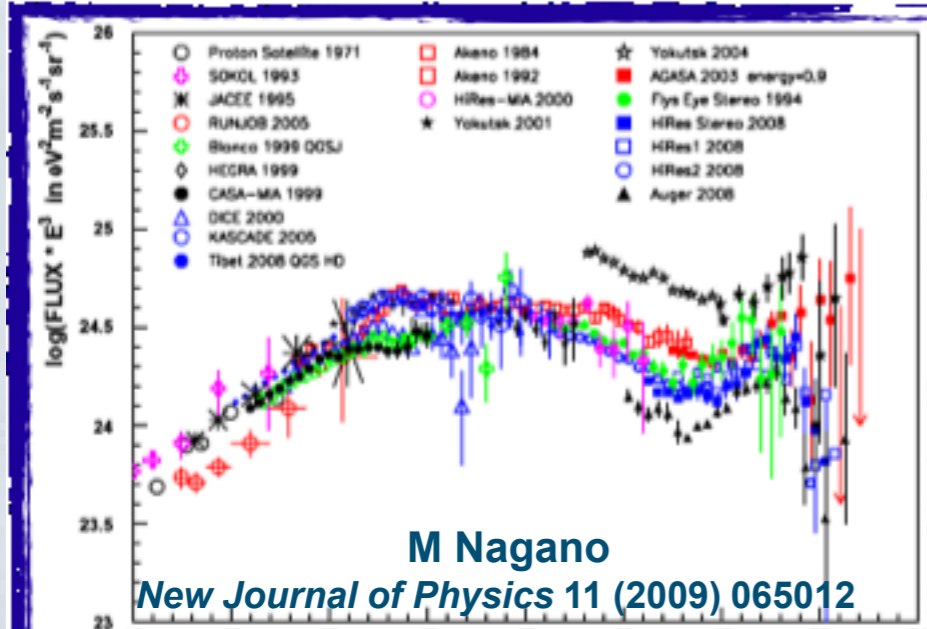
*Air shower development
(particle interaction in the atmosphere)*

Astrophysical parameters:
(primary particles)

- spectrum
- composition
- source distribution
- origin and propagation



HECR Open Issues



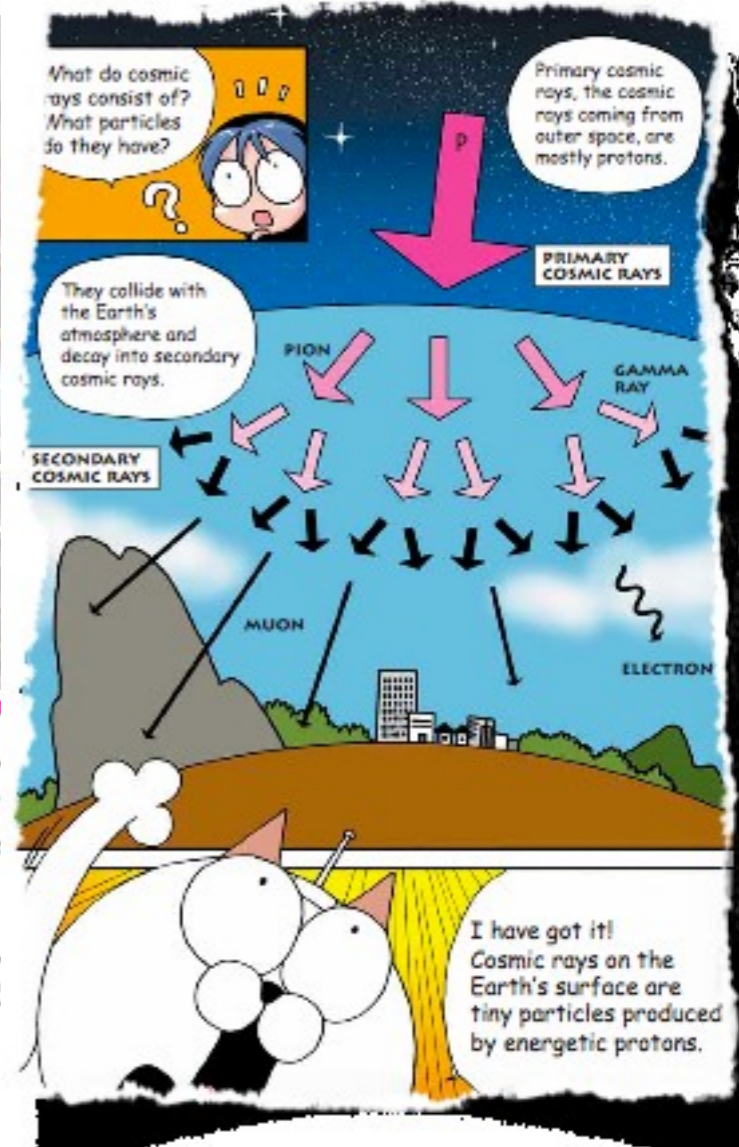
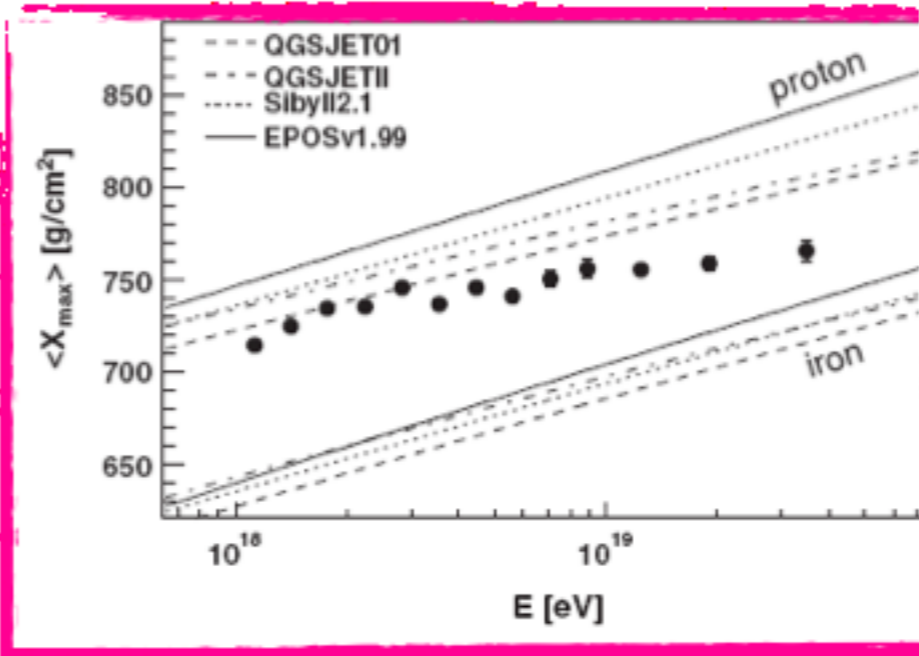
M Nagano

New Journal of Physics 11 (2009) 065012

Difference in the energy scale between different experiments???

Different hadronic interaction models give different answers about the composition of HECR

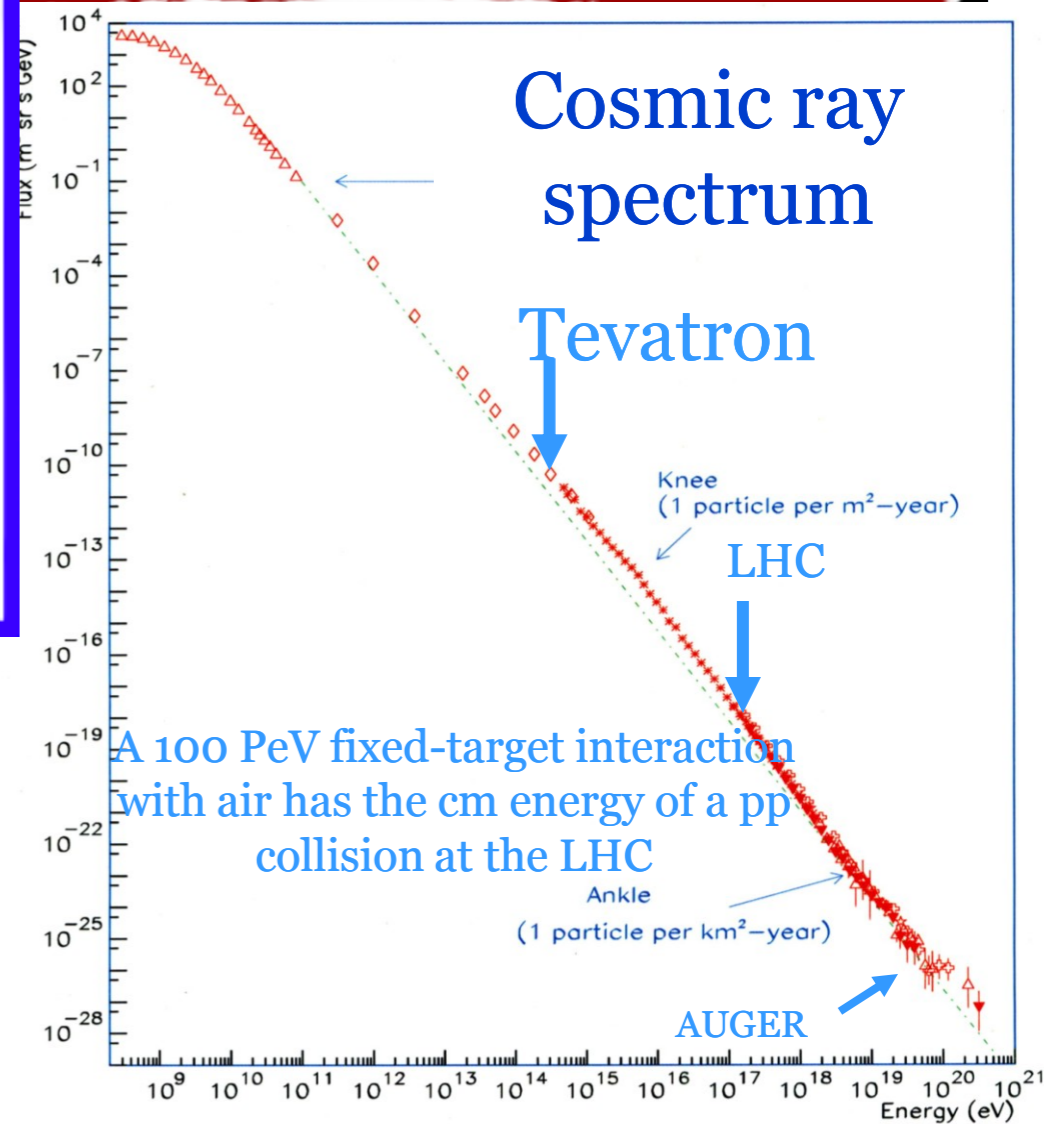
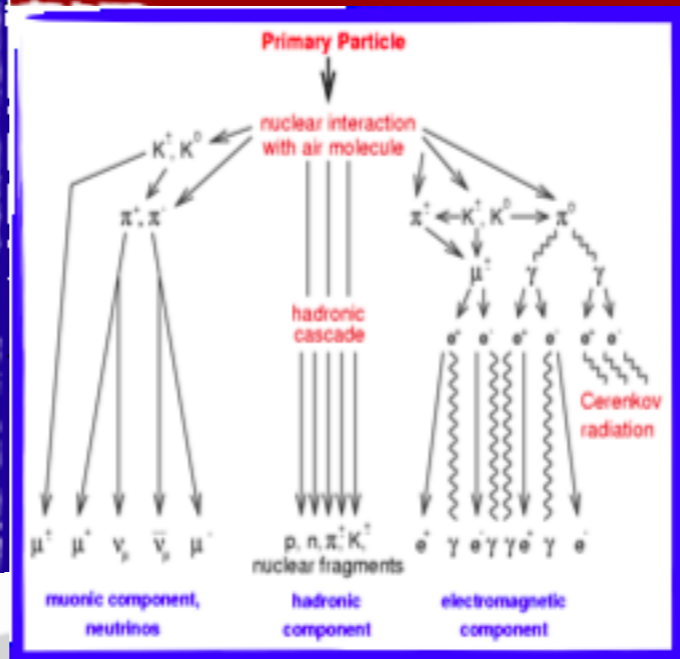
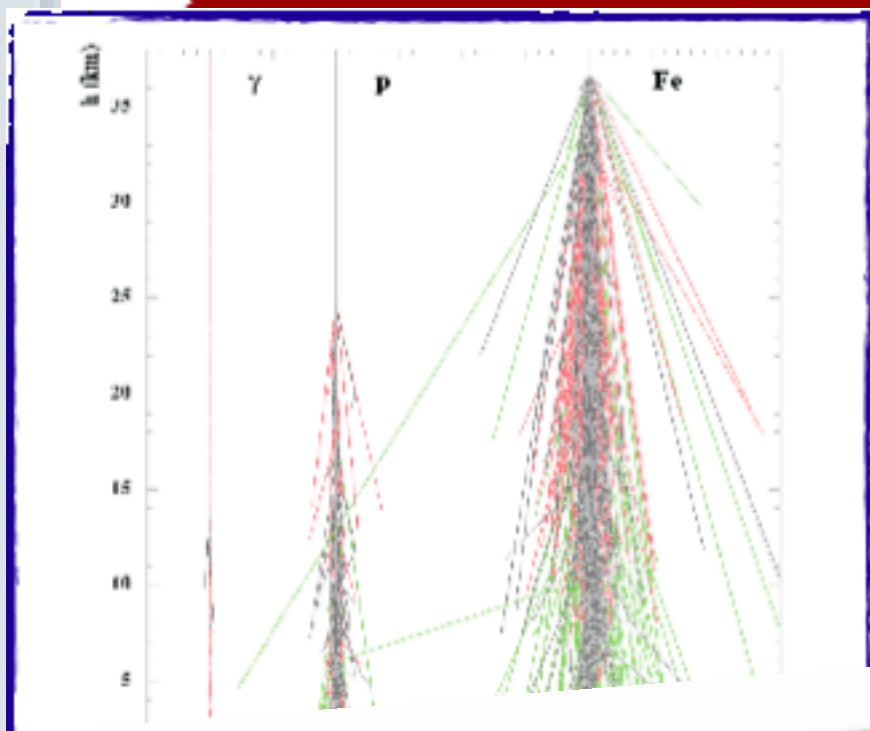
AGASA Systematics
 Total $\pm 18\%$
 Hadr Model $\sim 10\%$
 (Takeda et al., 2003)



maximum of the shower X_{max} depends on energy and type of the primary particle

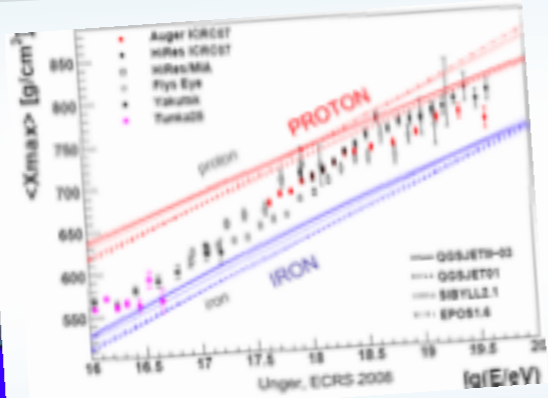
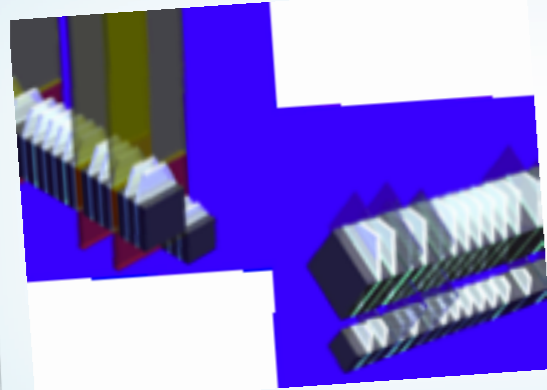


Development of atmospheric showers



Determination of E and mass of CRs depends on description of primary UHE QCD (p+N, O-Fe+N, O) interaction
Hadronic MC's need tuning with data
The dominant contribution to the energy flux is in the very forward region ($\theta \approx 0$)
In this forward region the highest energy available measurements of π cross section done by UA7 ($E=10^{14}$ eV)





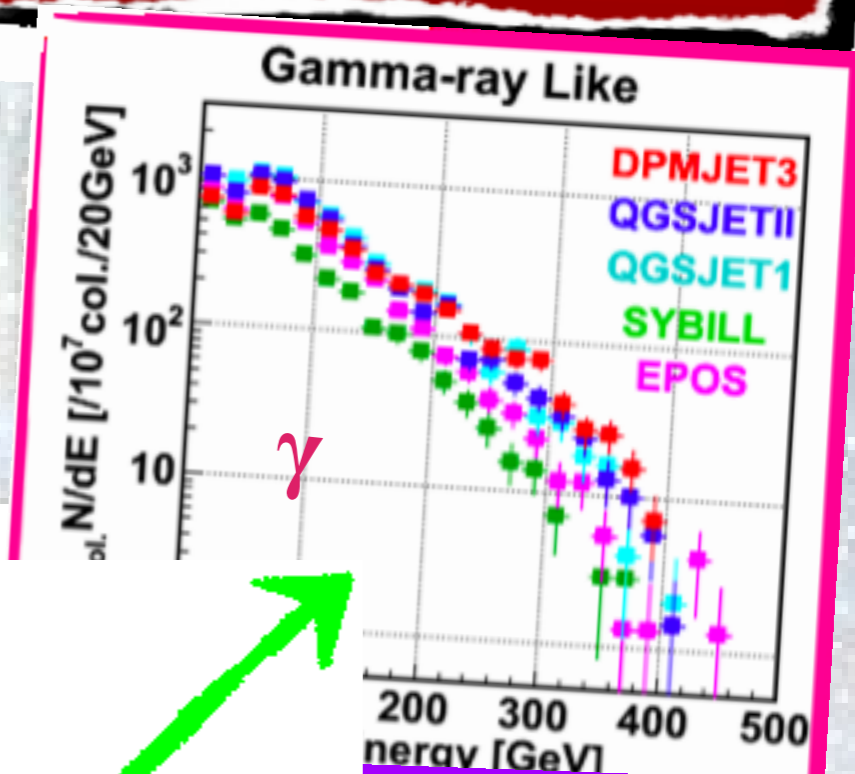
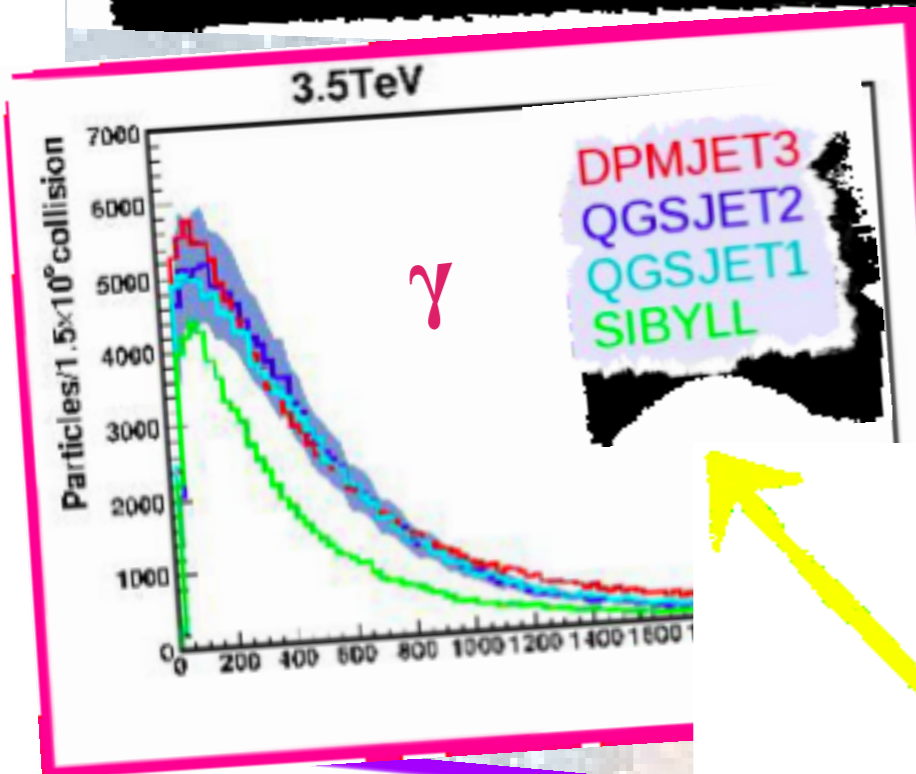
How LHCf can calibrate MC?

Physics Performances

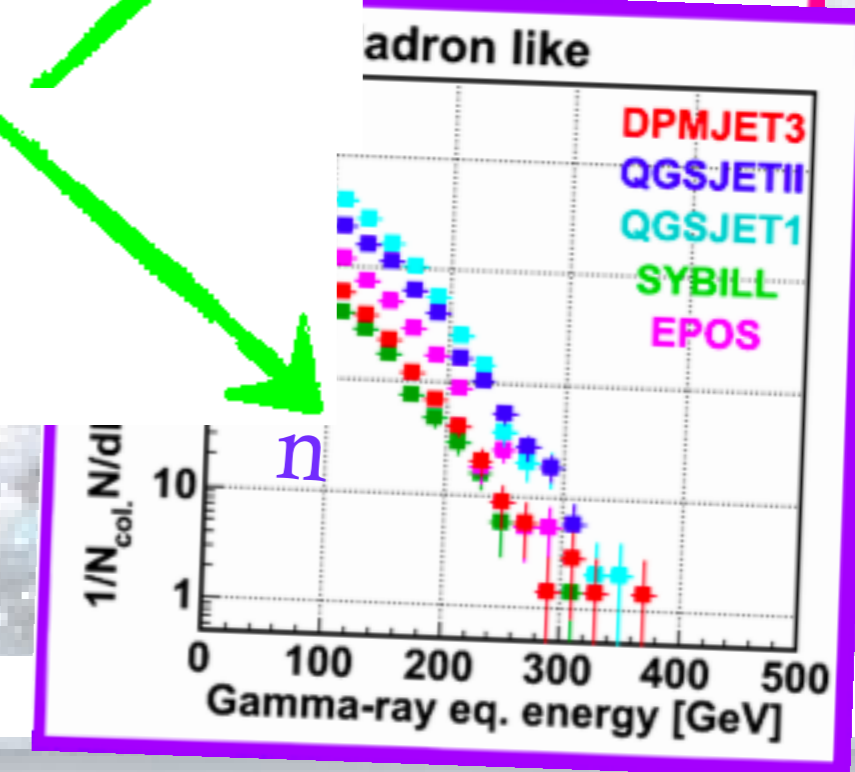
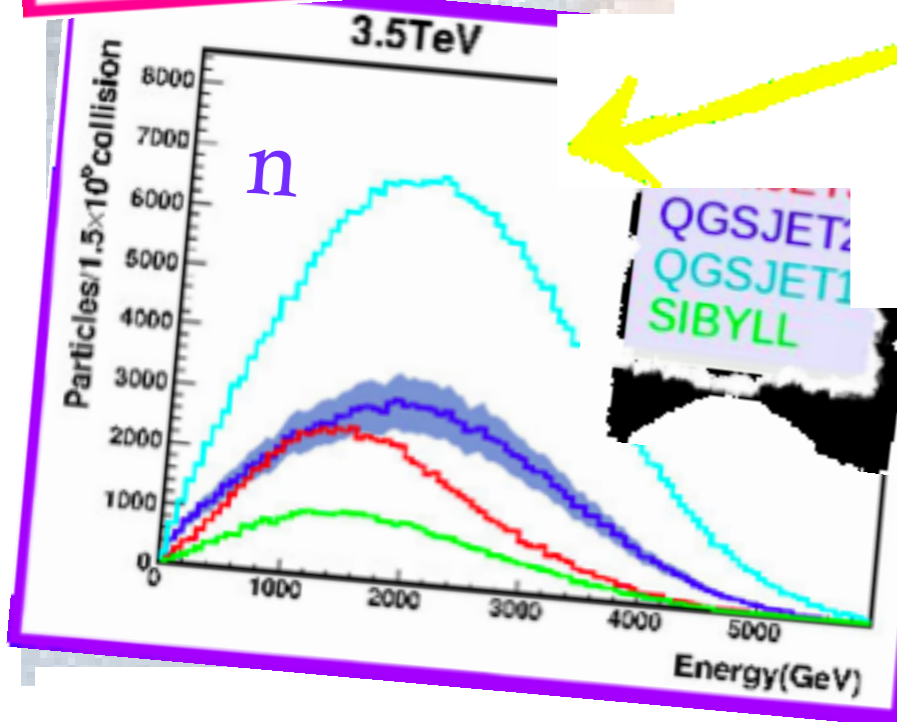


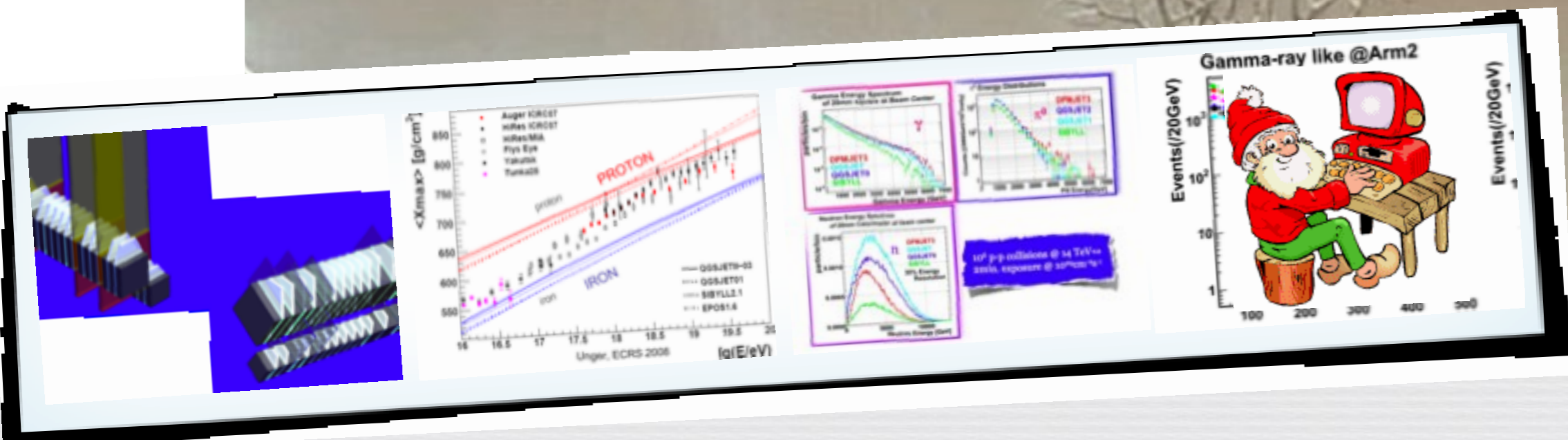


LHcf : Monte Carlo discrimination @ <14 TeV



10^7 p-p collisions
3.5 TeV + 3.5 TeV
450 GeV + 450 GeV





LHCf at work!!!

Data taking & Analysis





LHCf operations @ 900 GeV & 7 TeV

With Stable Beam at 900 GeV Dec 6th – Dec 15th 2009

- With Stable Beam at 900 GeV May 2nd – May 27th 2010

	Shower	Gamma	Hadron
Arm1	46,800	4,100	11,527
Arm2	66,700	6,158	26,094

- With Stable Beam at 7 TeV March 30th - July 19th

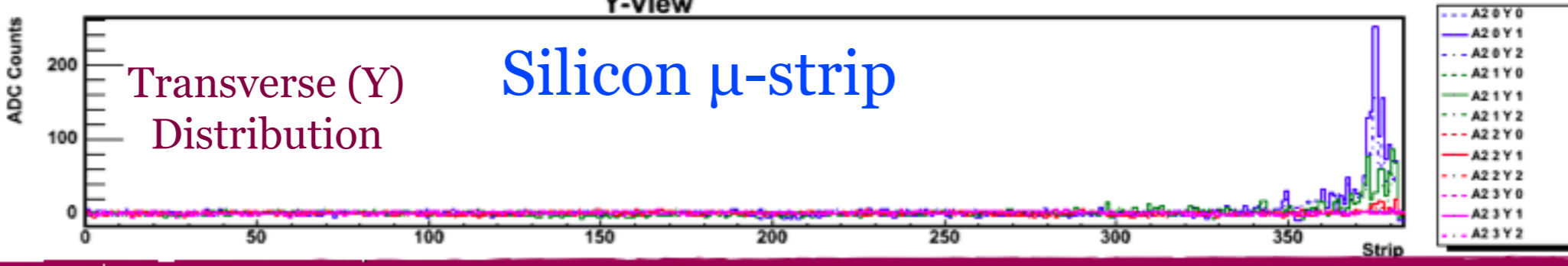
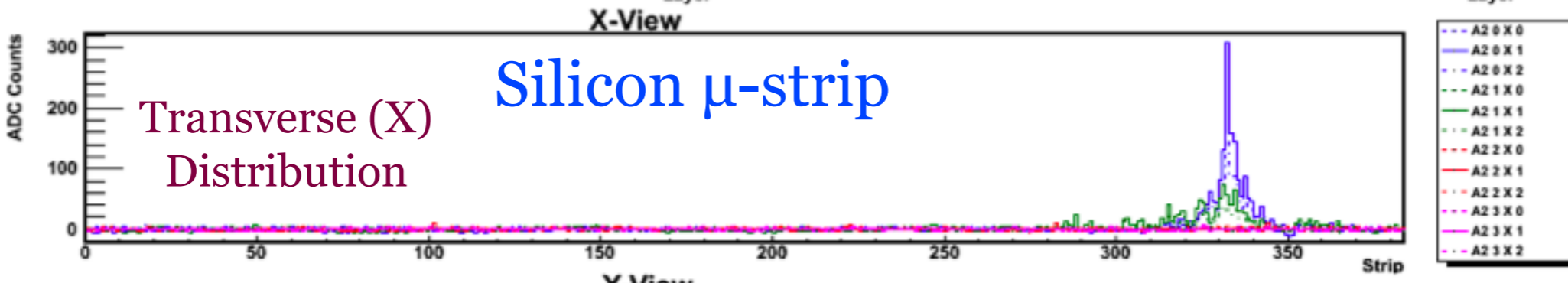
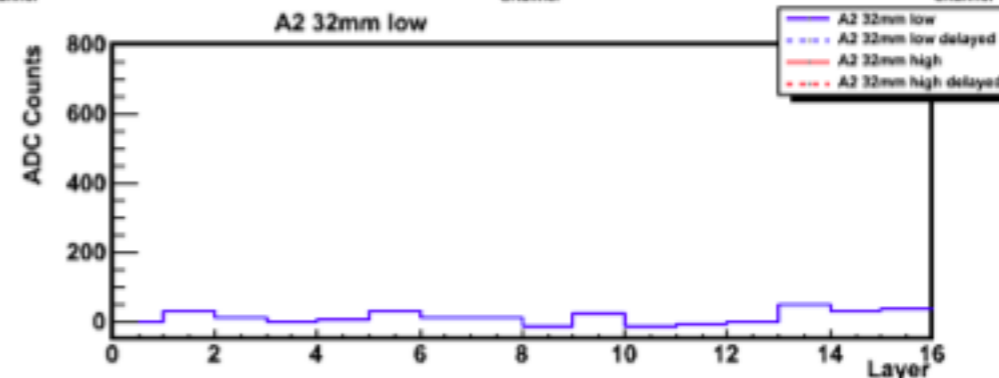
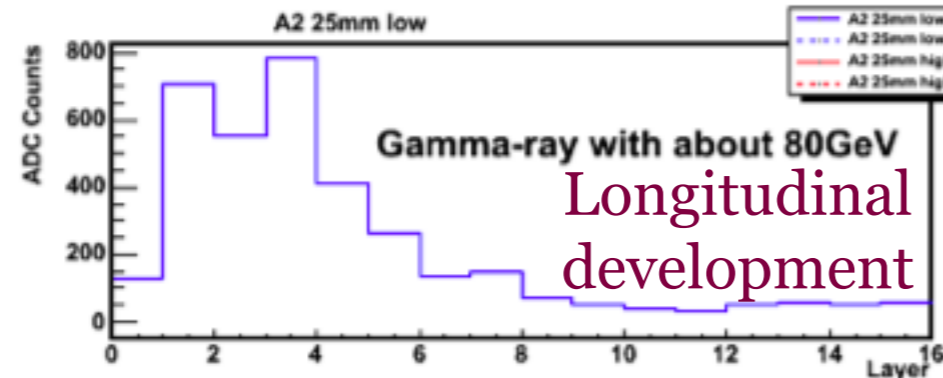
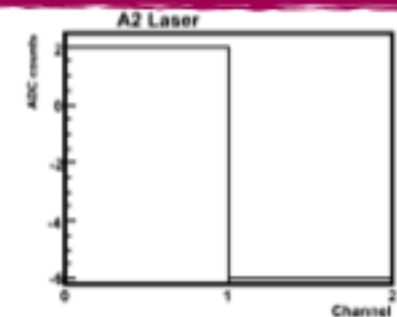
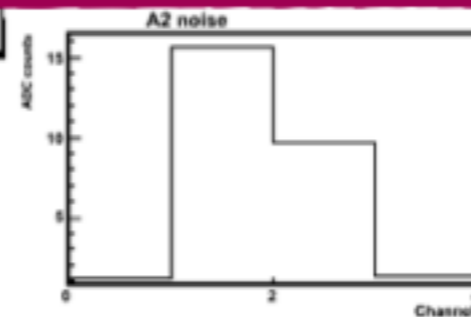
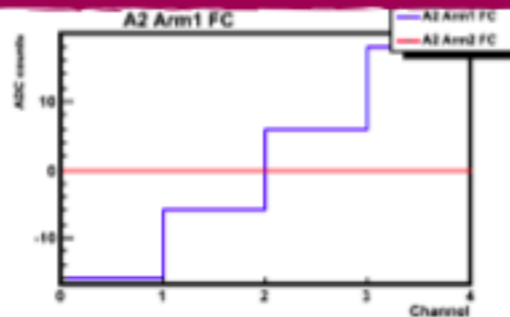
- we took data with and without 100 μ rad crossing angle for different vertical detector positions

	Shower	Gamma	Hadron	π^0
Arm1	172,263,255	56,846,874	111,971,115	344,526
Arm2	160,587,306	52,993,810	104,381,748	676,157



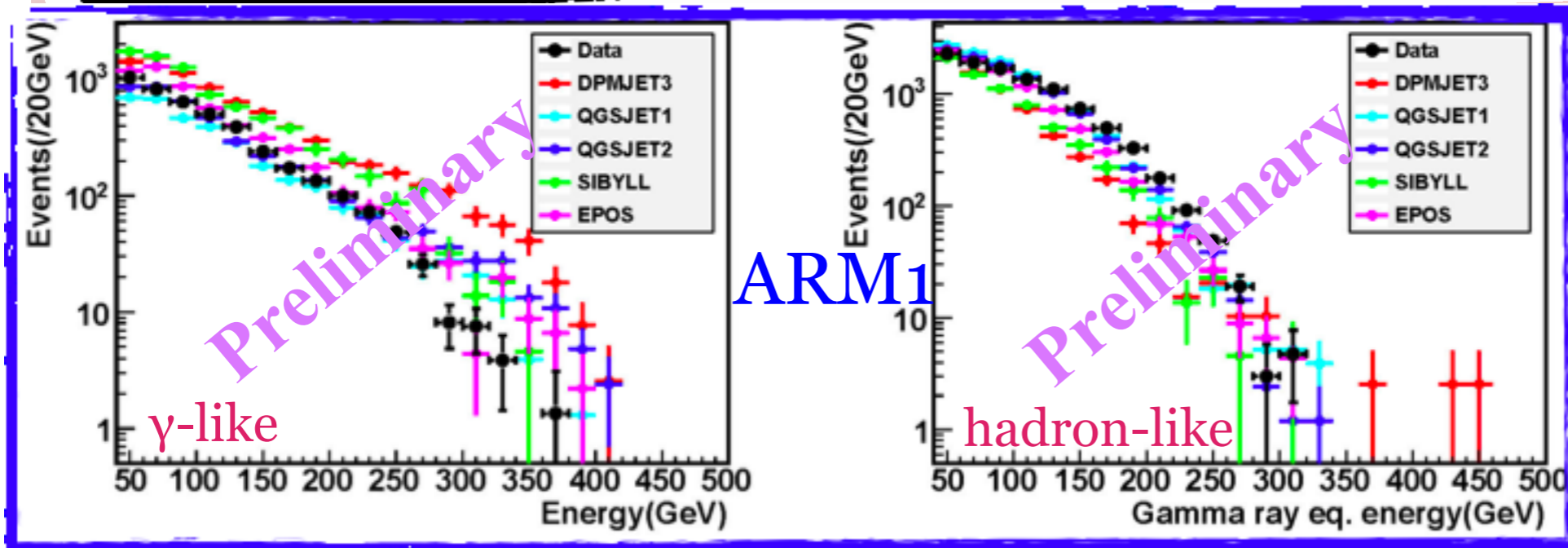
ARM2: γ event at 900 GeV

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





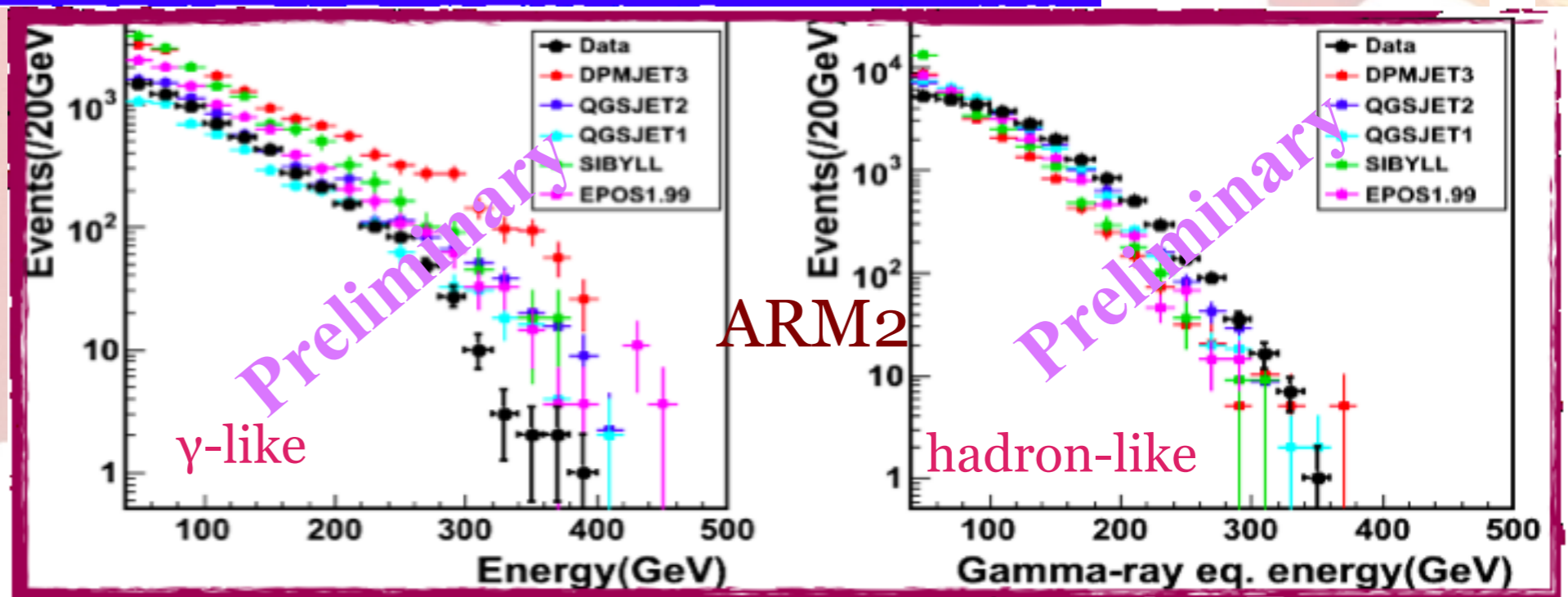
LHCf spectra at 900 GeV



Enough sensitivity to discriminate between models!!!

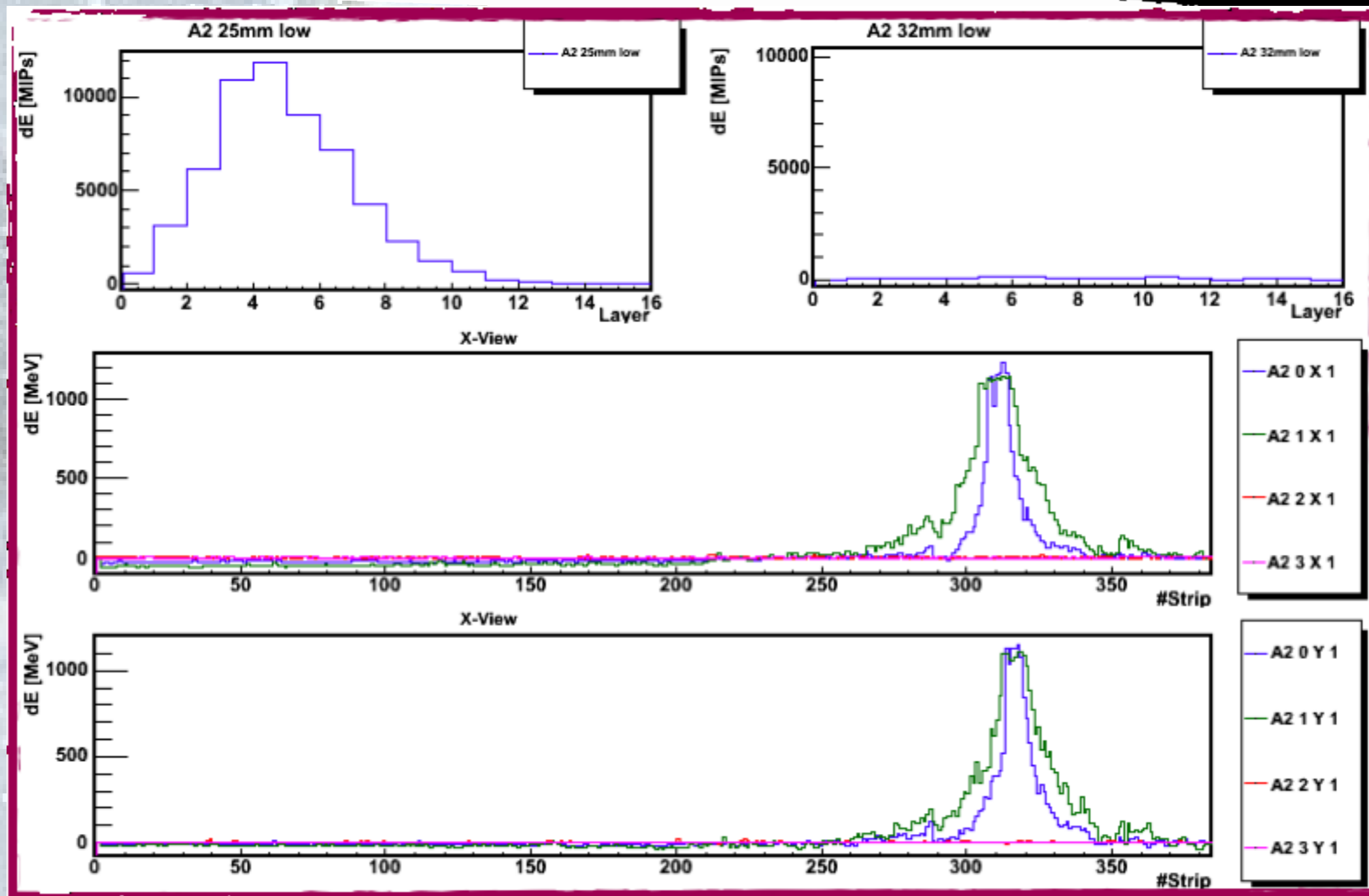
Statistical error only

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



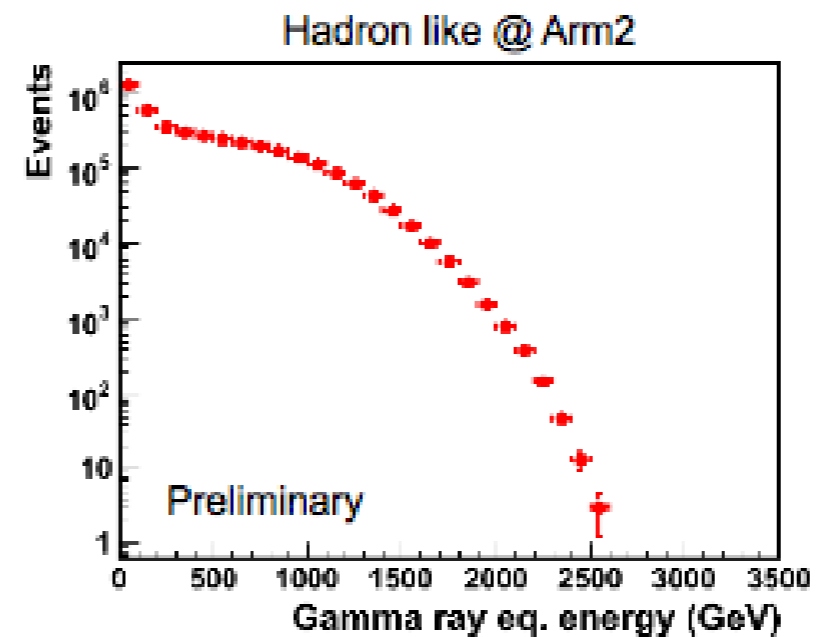
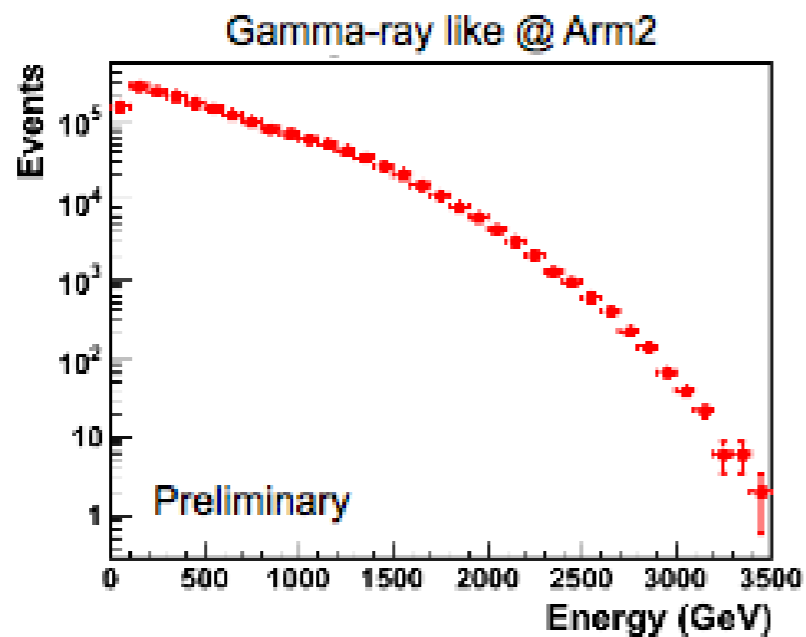
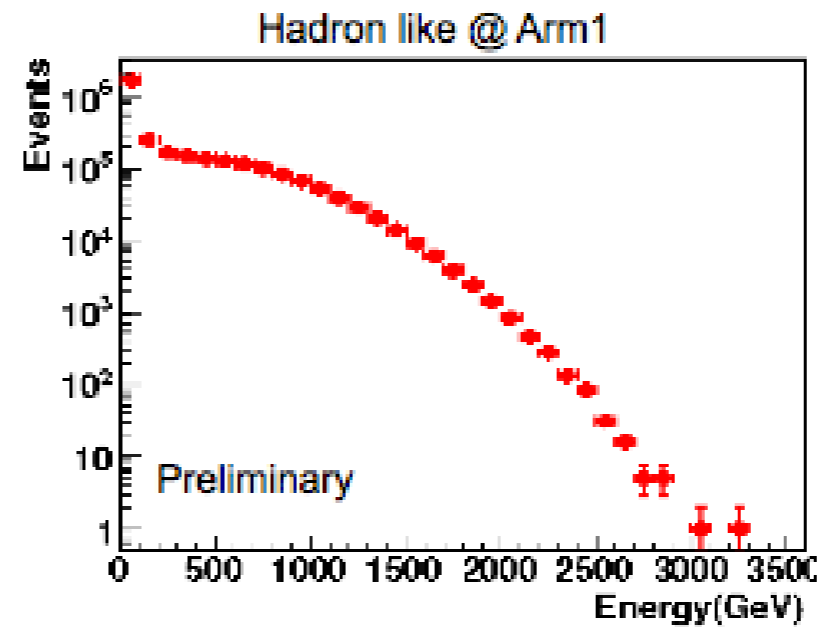
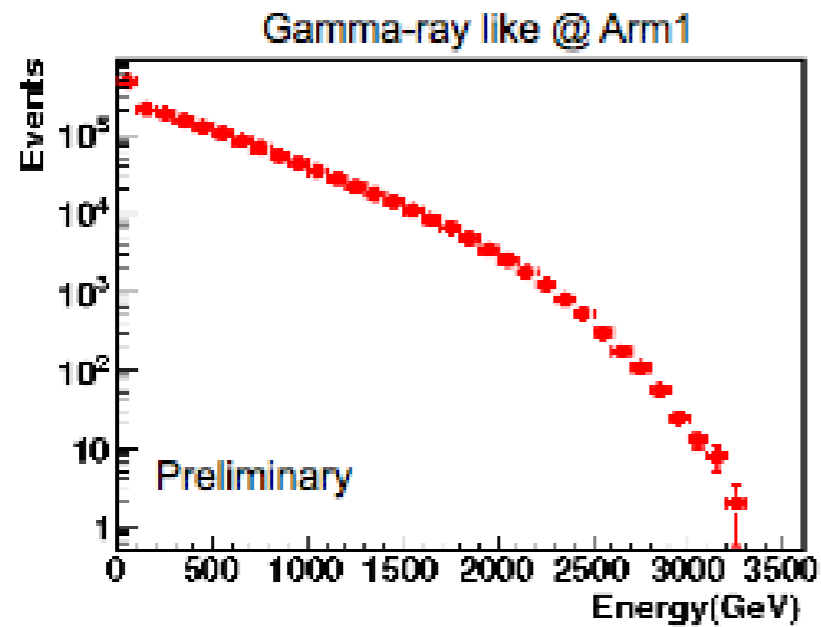


Impressive TeV Showers





Spectra @ 7 TeV

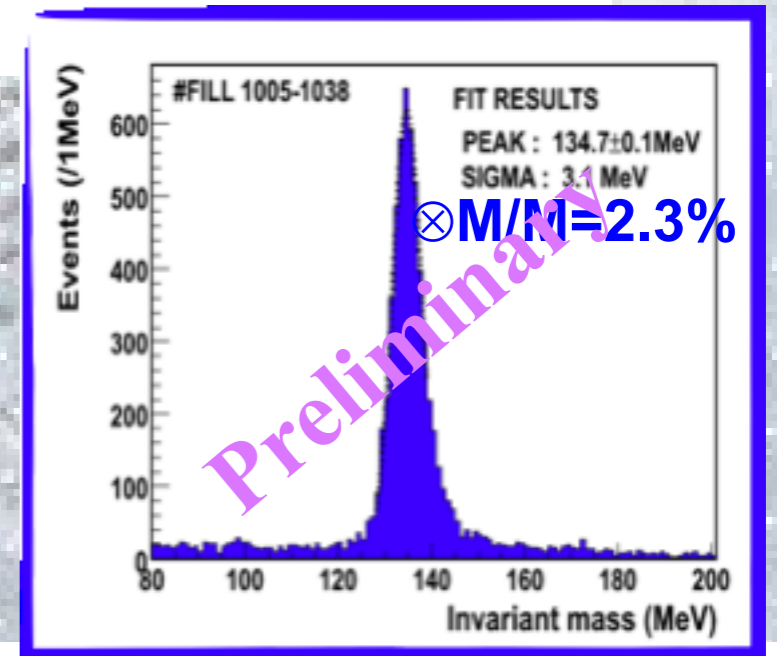
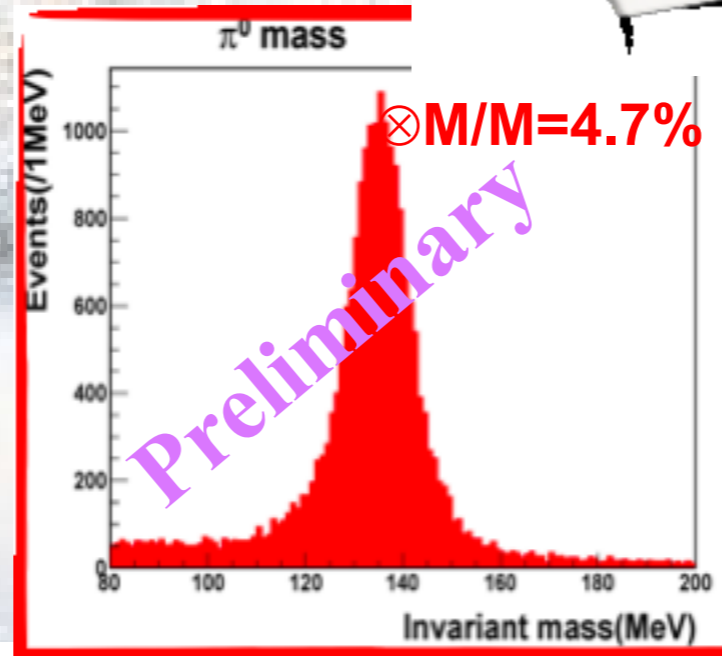
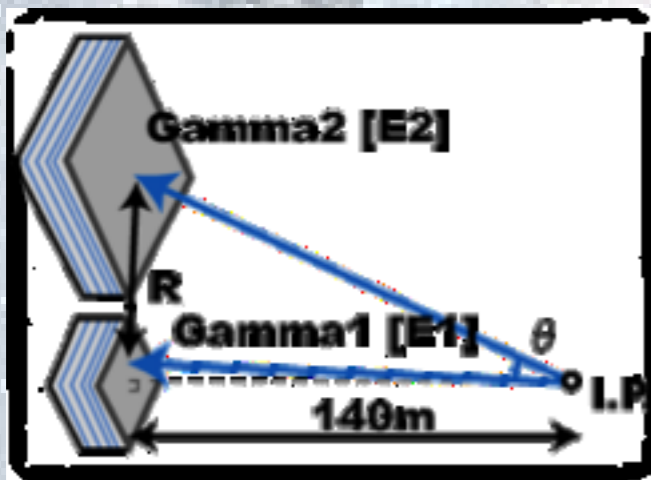
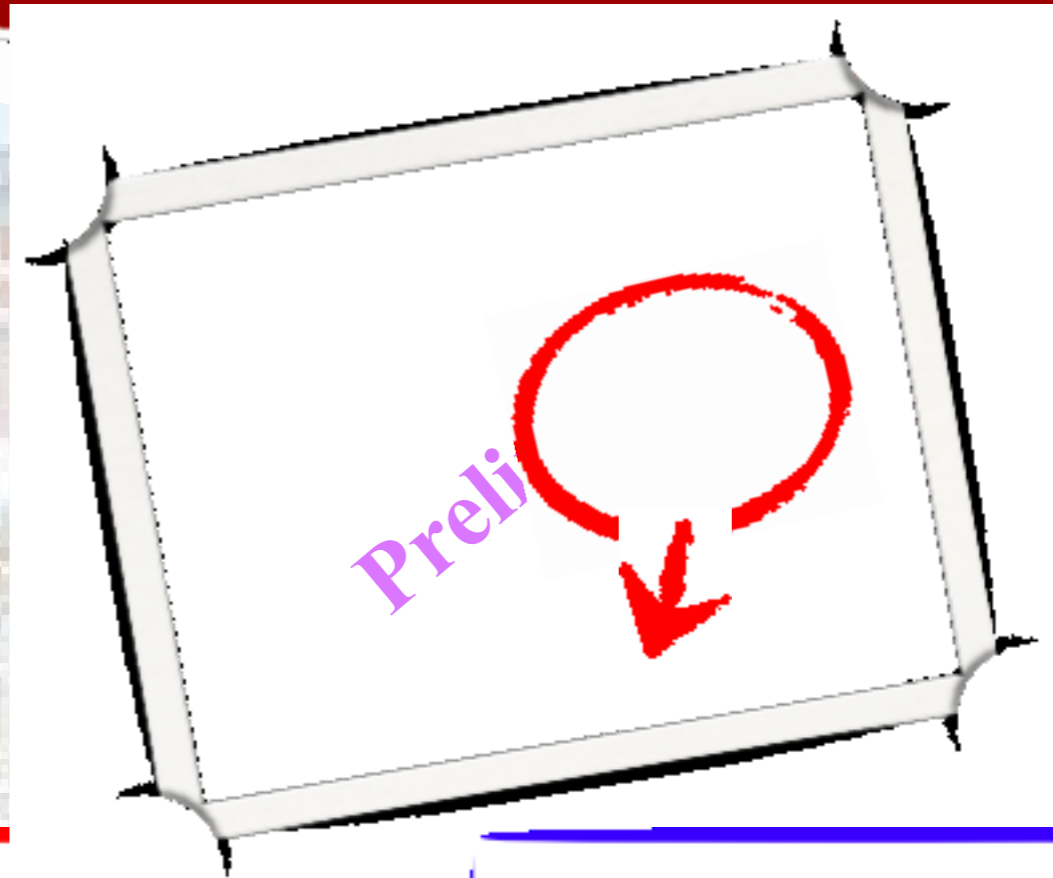
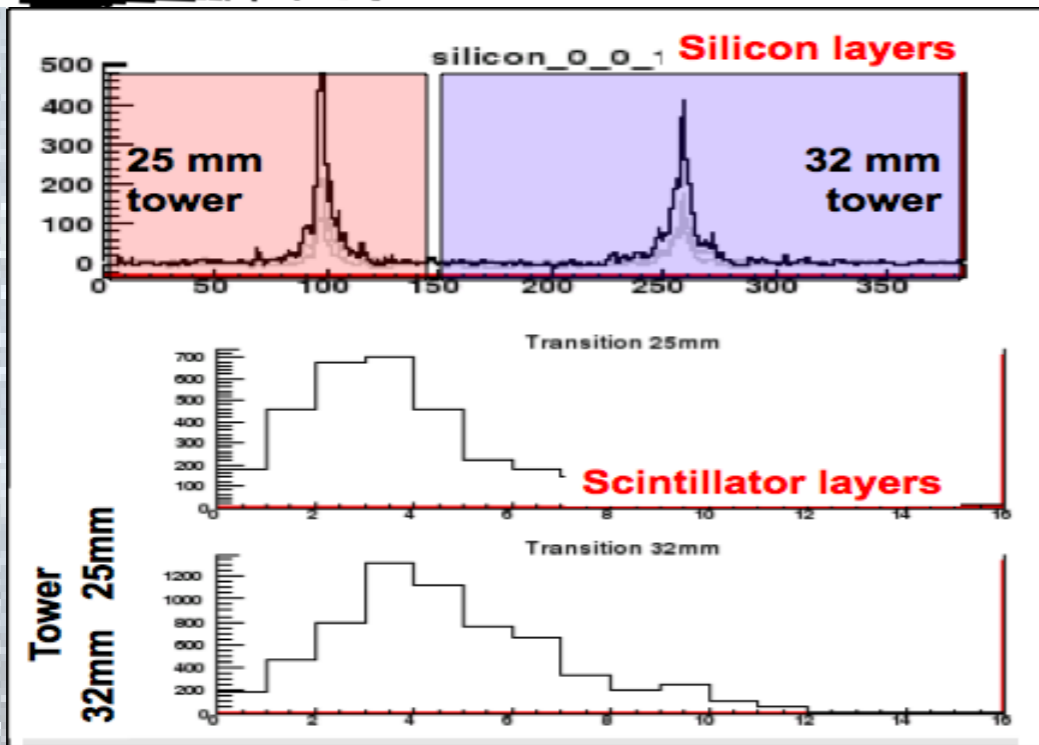


Statistical error only



π^0 reconstruction:

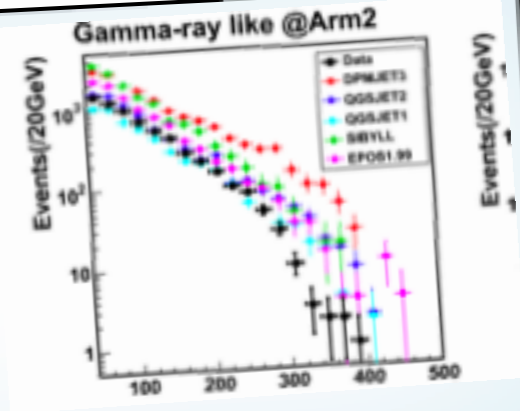
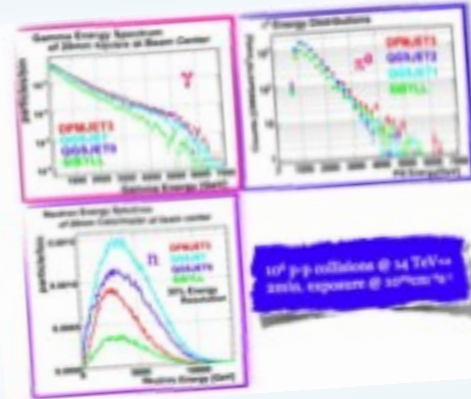
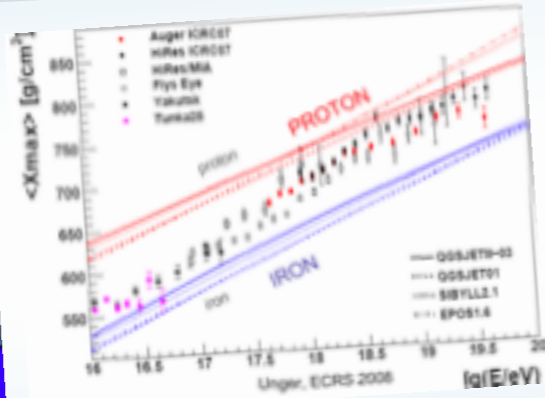
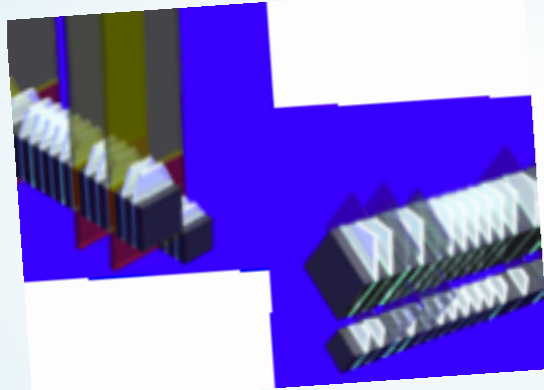
the mandatory tool for energy scale calibration





Summary

- LHCf is a dedicated astroparticle experiment to measure neutral particle produced in the very forward region at LHC
- LHCf successfully completed data taking at 900 GeV and 7 TeV. The detector has been removed from the TAN on July 20
- Both 900 GeV and 7 TeV analyses are almost final and ready to be submitted for publication
- The detector will be upgraded during 2011 to improve radiation hardness
- LHCf will provide crucial calibration of hadron interaction for CR study with the actual and forthcoming data

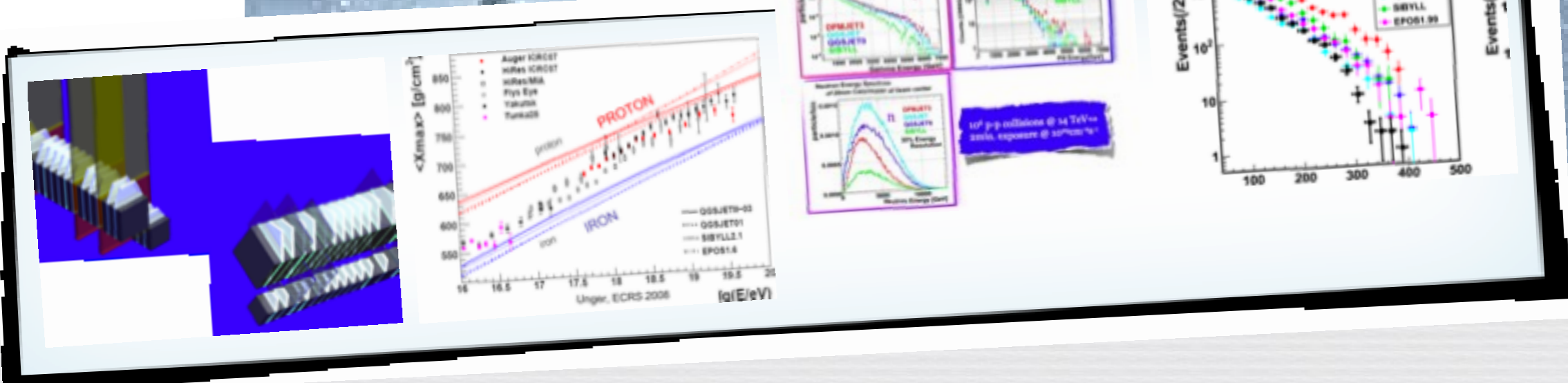


We would like to thank all the people who contributed to this successful first data taking period and say...



Looking forward to come back very soon for 14 TeV data taking!!!





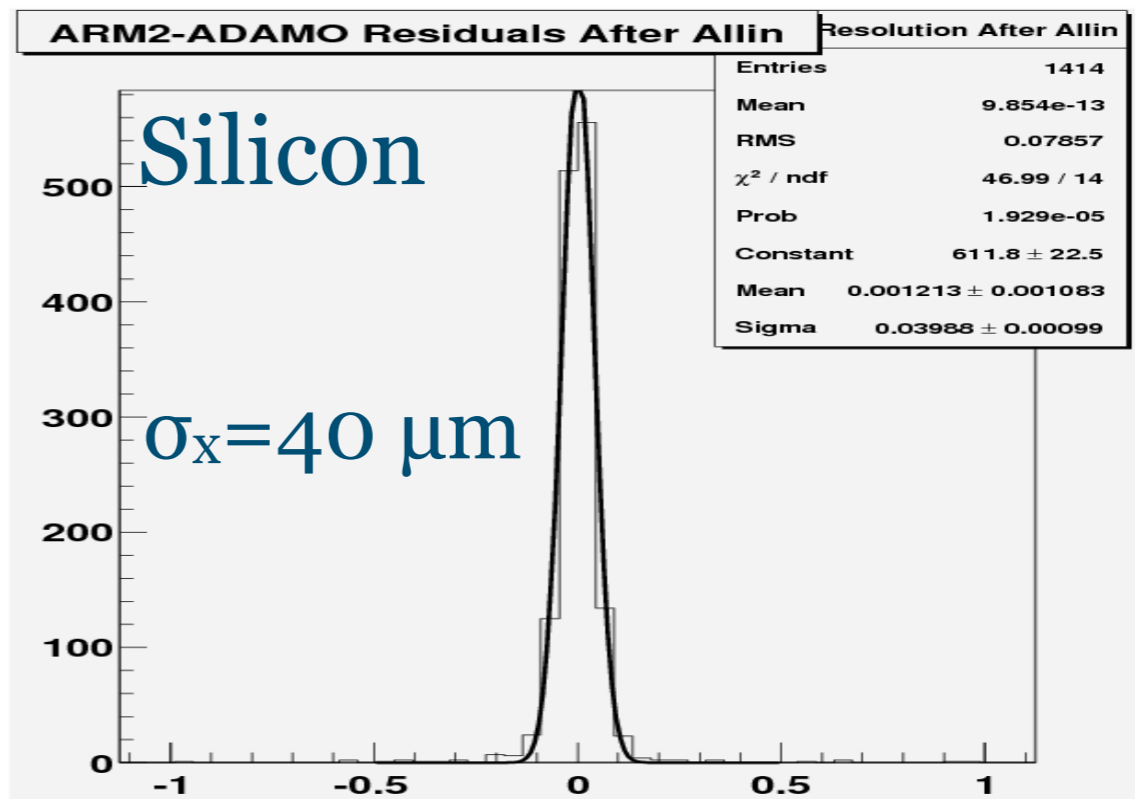
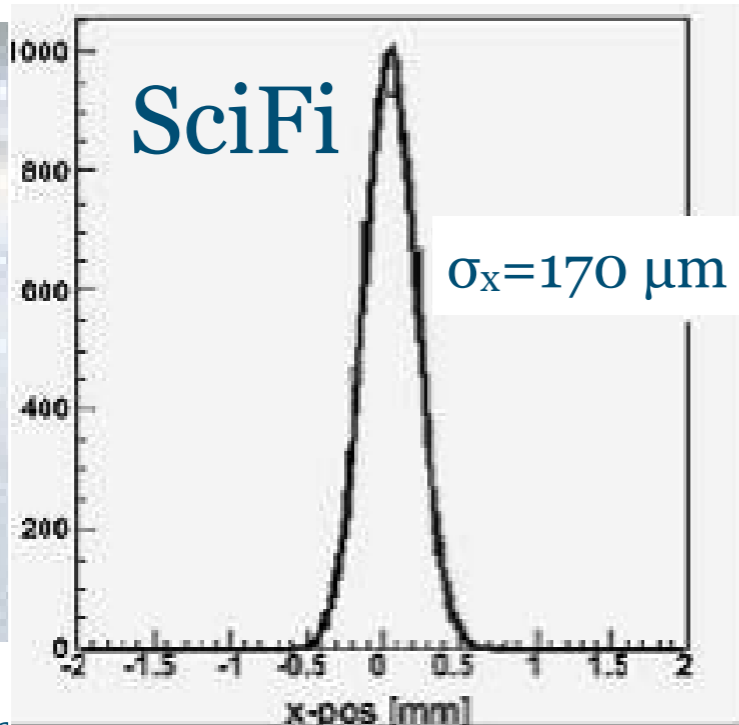
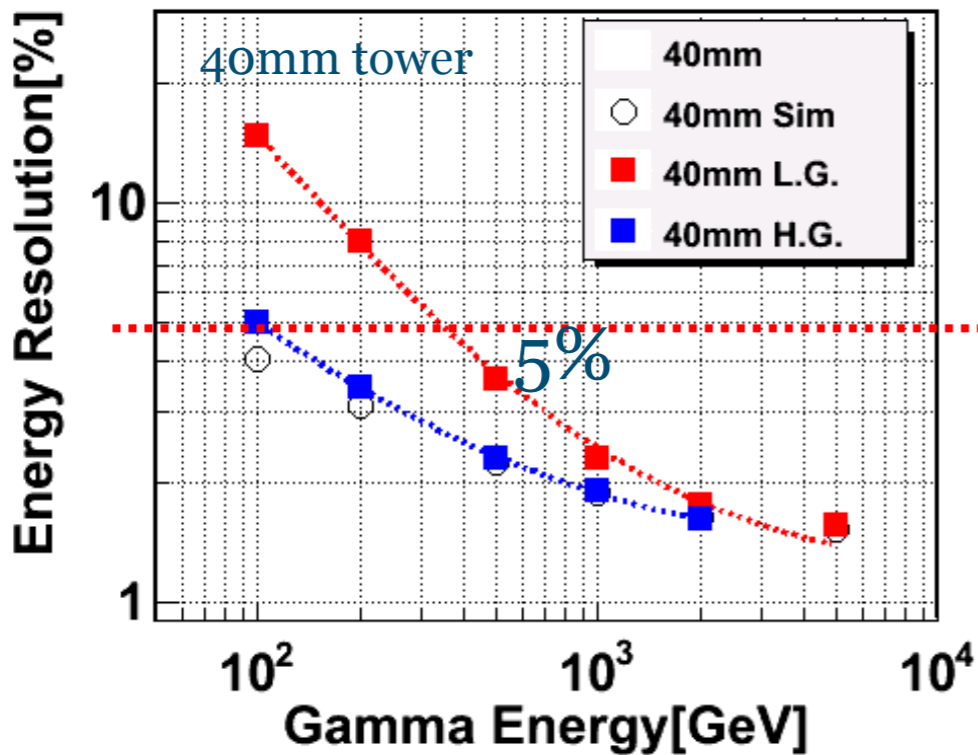
LHCf Backup

Some additional infos...





Physics Performances: Energy and position resolution for γ



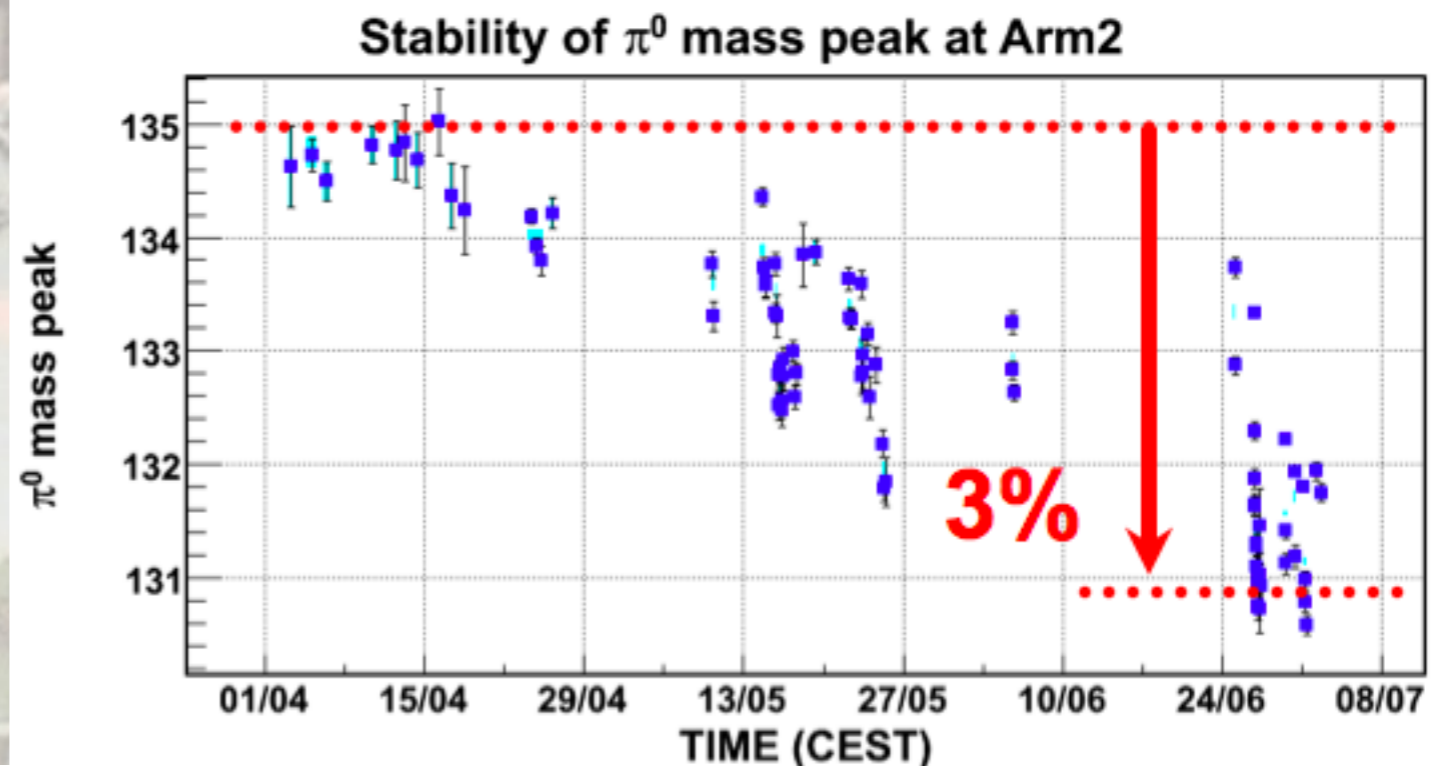


Radiation Damage

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

Timeseries Chart between 2010-03-30 06:34:00 and 2010-07-15 06:34:00 (LOCAL_TIME)

→ SIMA.4L1.1LM18S:DOSE_HS

→ SIMA.4R1.1RM19S:DOSE_HS



The integrated dose for the two sensors is approximately 8 Gy by mid-July 2010.



Radiation Damage studies

