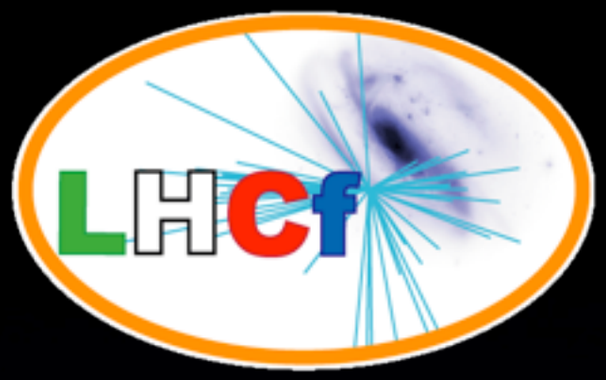


First year results from LHCf

K.Kasahara in place of Alessia Tricomi

for the LHCf collabortion.

Waseda Univ.

UHECR2010 @Nagoya: Dec.11 2010

Purpose of LHCf

★To select better nuclear interaction models

or

★To afford basic information for constructing a better nuclear interaction model

by observing forward energetic neutral particles at LHC for cosmic-ray physics

Excerpt from CERN Courie/Bulletin 2006

LHCf: a tiny new experiment joins the LHC
While most of the LHC experiments are on a grand scale, LHC forward(LHCf) is quite different. Unlike the massive detectors that are used by ATLAS or CMS, LHCf's largest detector is a mere 30 cm.

Most of the LCHf collaborators in one photo!

K.Kasahara, M.Nakai, Y.Shimizu, T.Suzuki, S.Torii

WasedaUniversity, Japan

K.Fukatsu, Y.Itow, K.Kawade, T.Mase, K.Masuda, Y.Matsubara, G.Mitsuka, K.Noda, T.Sako, K.Suzuki, K.Taki

Solar-Terrestrial Environment Laboratory, Nagoya University, Japan

K.Yoshida

Shibaura Institute of Technology, Japan

T.Tamura

Kanagawa University, Japan

Y.Muraki

Konan University

M.Haguenauer

EcolePolytechnique, France

W.C.Turner

LBNL, Berkeley, USA

O.Adriani(1,2), L.Bonechi(1), M.Bongi(1), G.Castellini(1,3), R.D'Alessandro(1,2), M.Grandi(1), H.Menjo(1), P.Papini(1), S.Ricciarini(1),

1) INFN, Sezione di Firenze, Italy, 2) ∪niversit`a degli Studi di Firenze, Florence, Italy,3) IFAC CNR, Florence, Italy

A.Tricomi, G.Sinatra

INFN, Sezione di Catania, Catania, Italy

J.Velasco, A.Faus

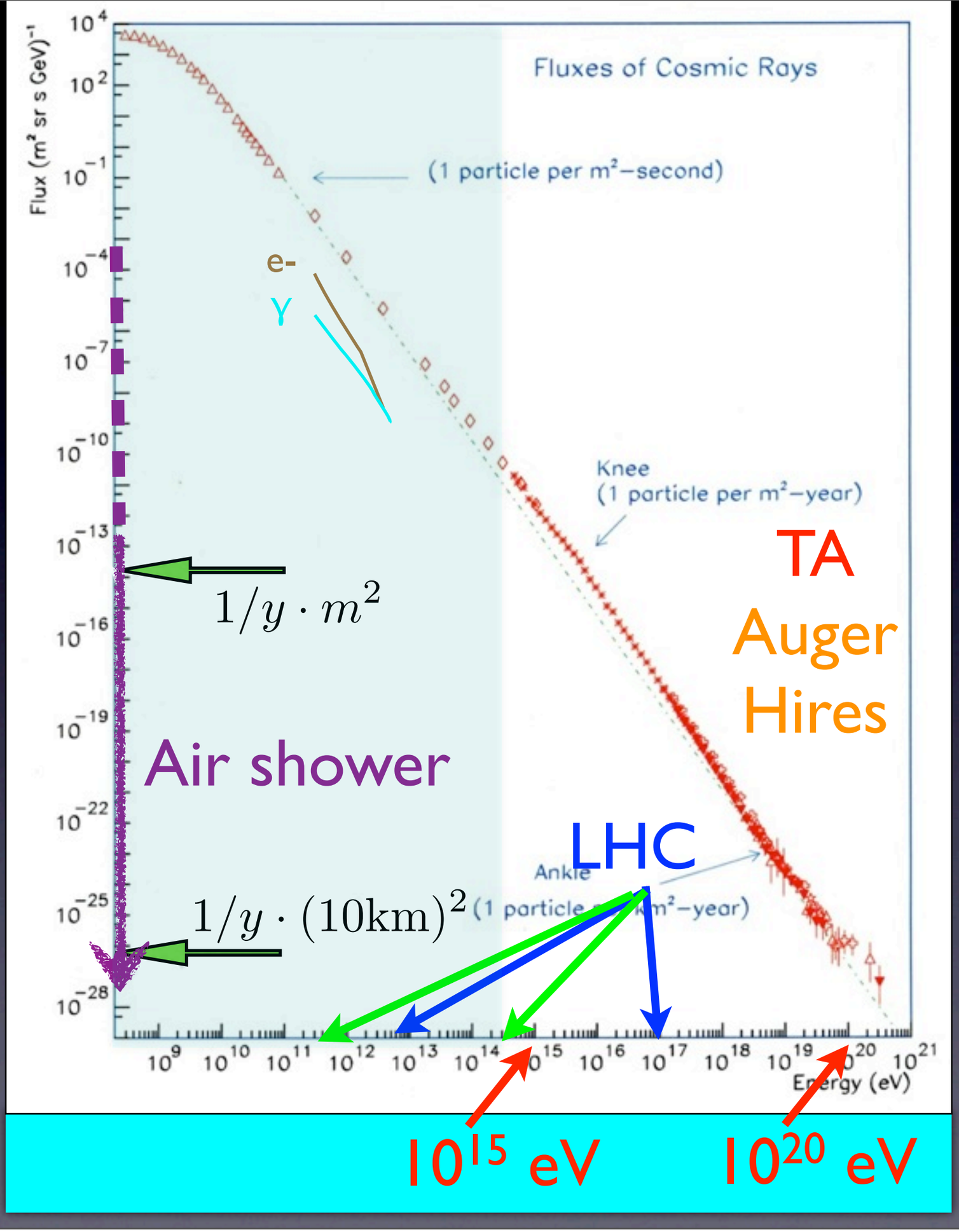
IFTC, Universitat de Val`encia, Valencia, Spain

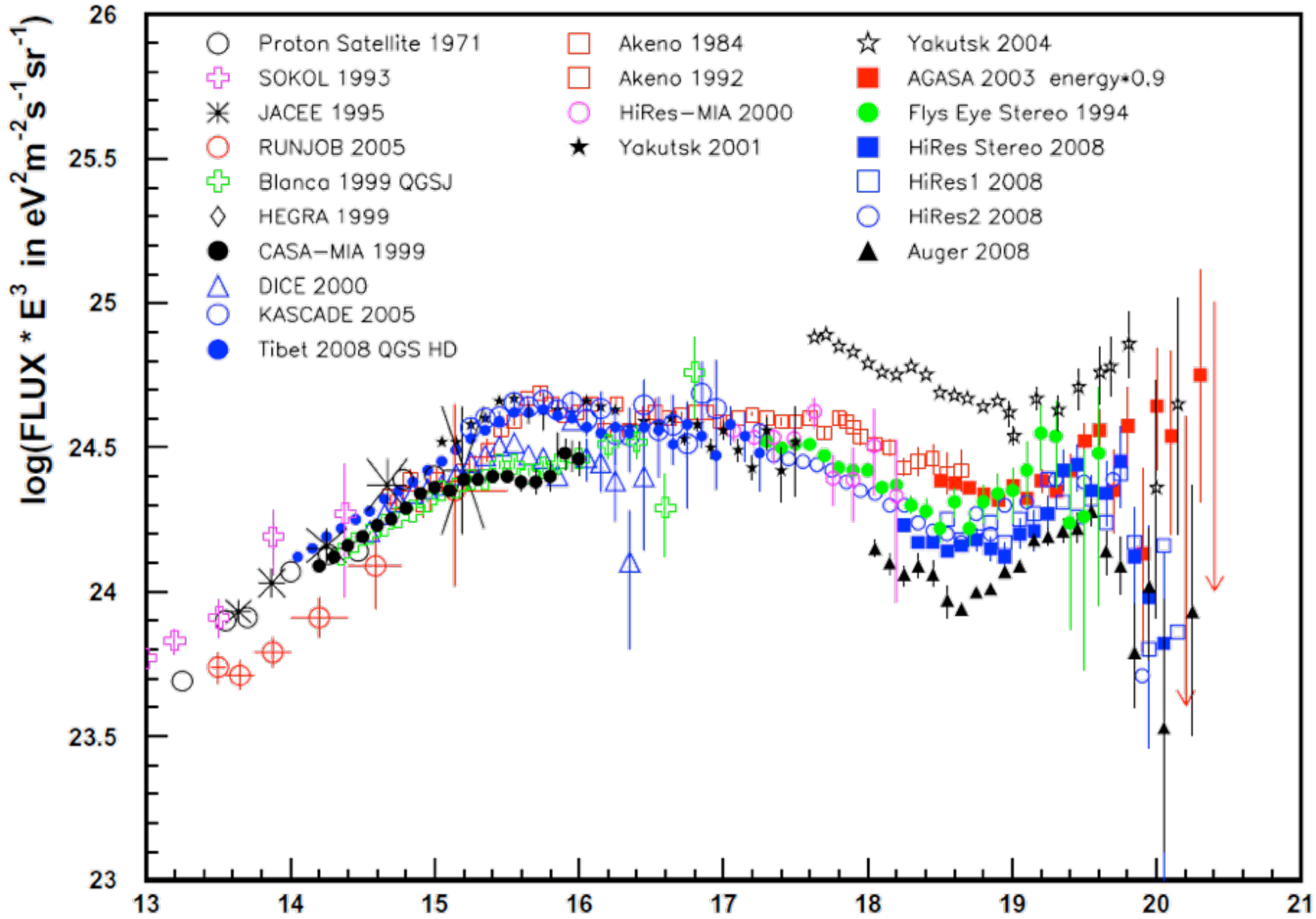
D.Macina, A-L.Perrot

CERN, Switzerland

Cosmic-Ray Energy Spectrum

- < *10^{14}eV:accel.SNR
- near-by e- source?
- dark mater ?
- B/C ratio ...





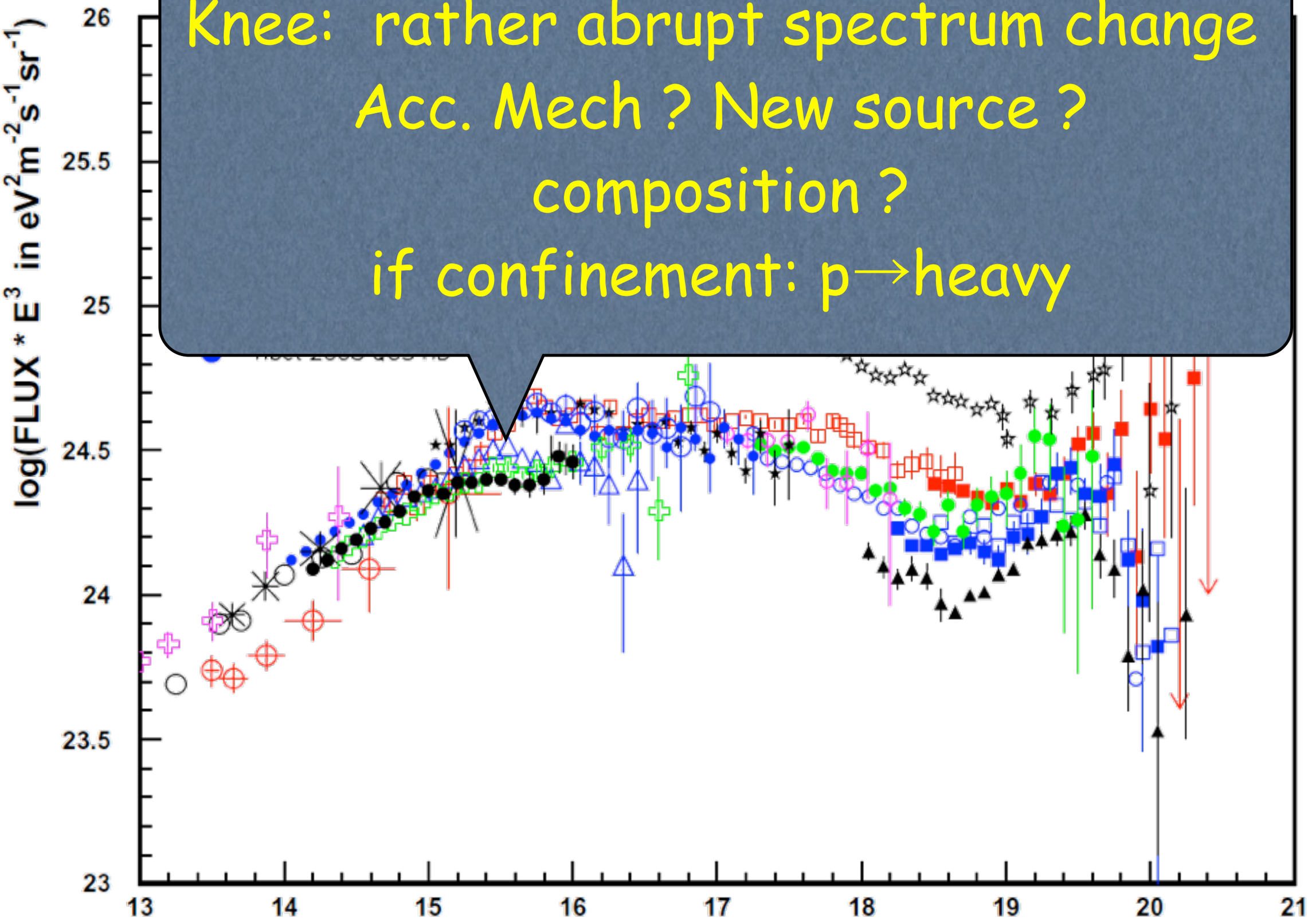
Form M.Nagano: New Journal of Physics 11 (2009)

Knee: rather abrupt spectrum change

Acc. Mech ? New source ?

composition ?

if confinement: p→heavy

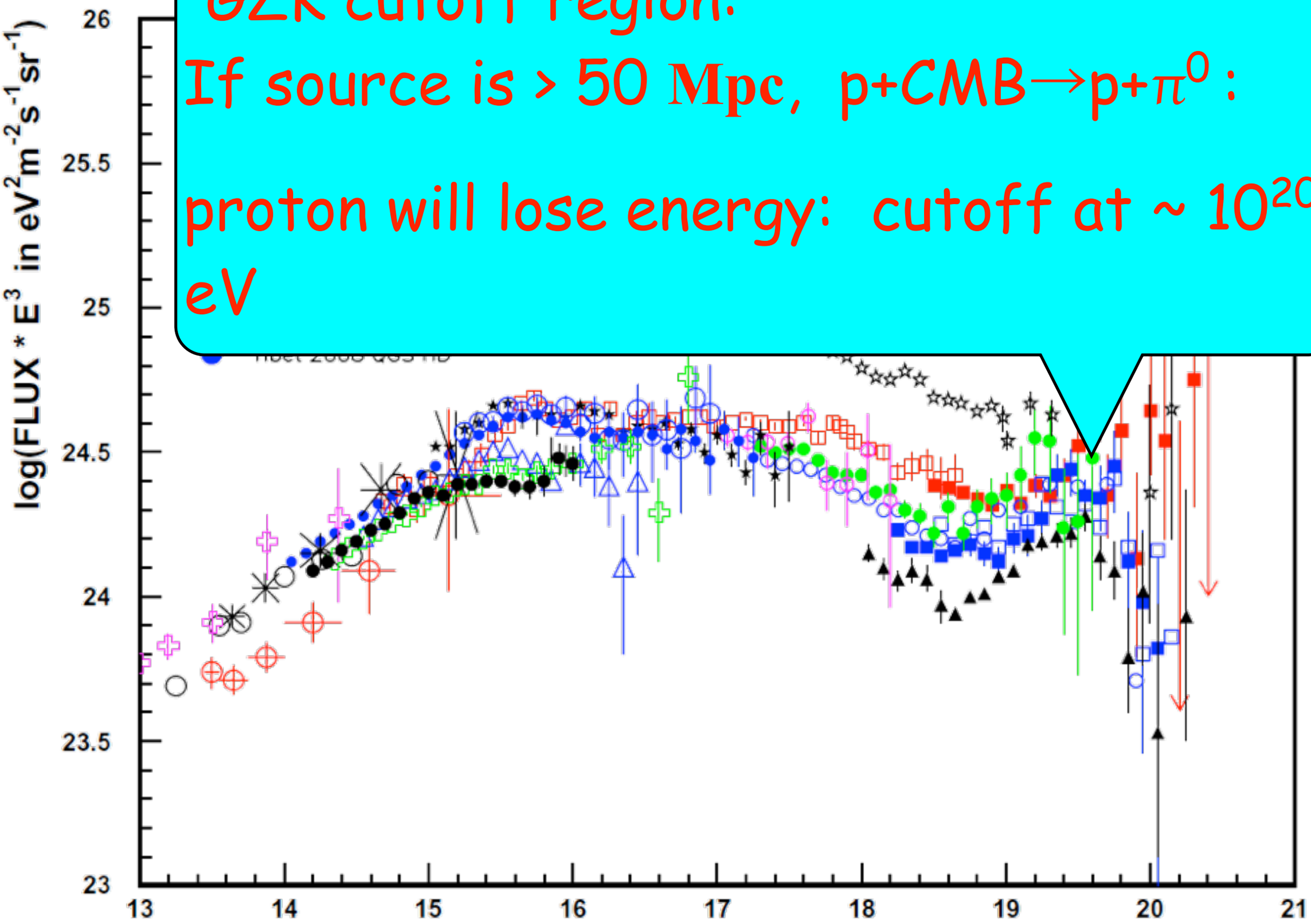


Form M.Nagano: New Journal of Physics 11 (2009)

GZK cutoff region:

If source is > 50 Mpc, $p+CMB \rightarrow p+\pi^0$:

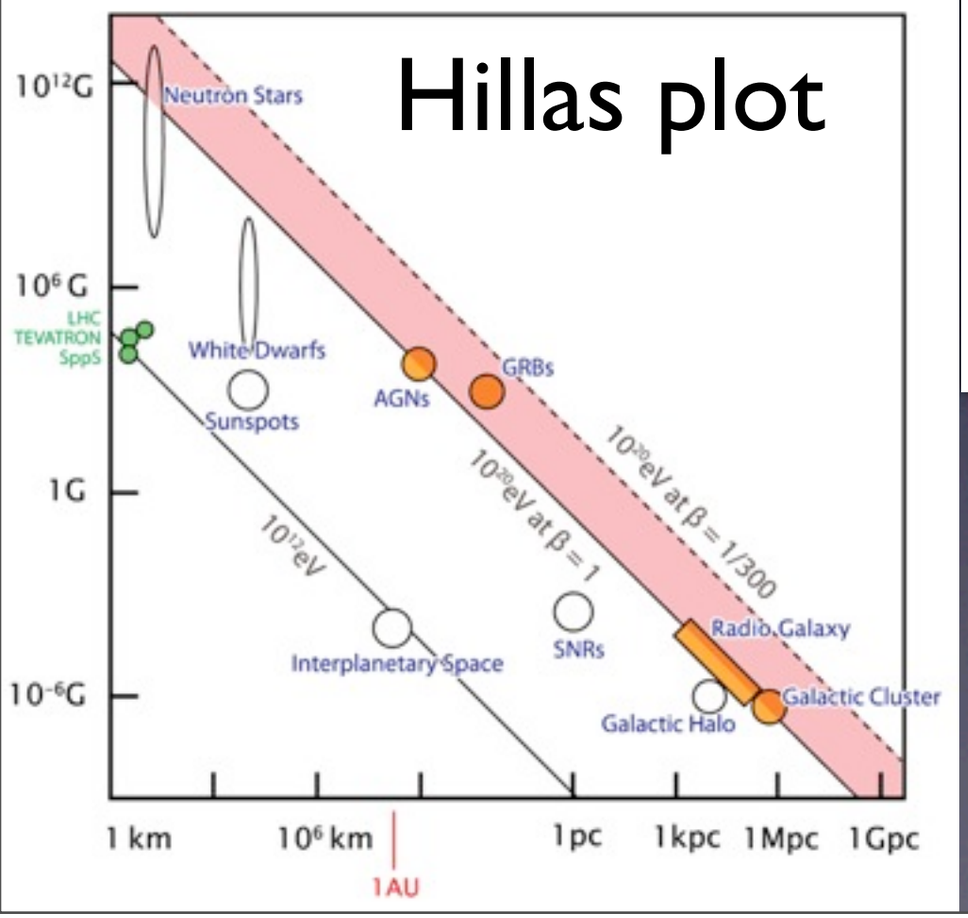
proton will lose energy: cutoff at ~ 10^{20} eV



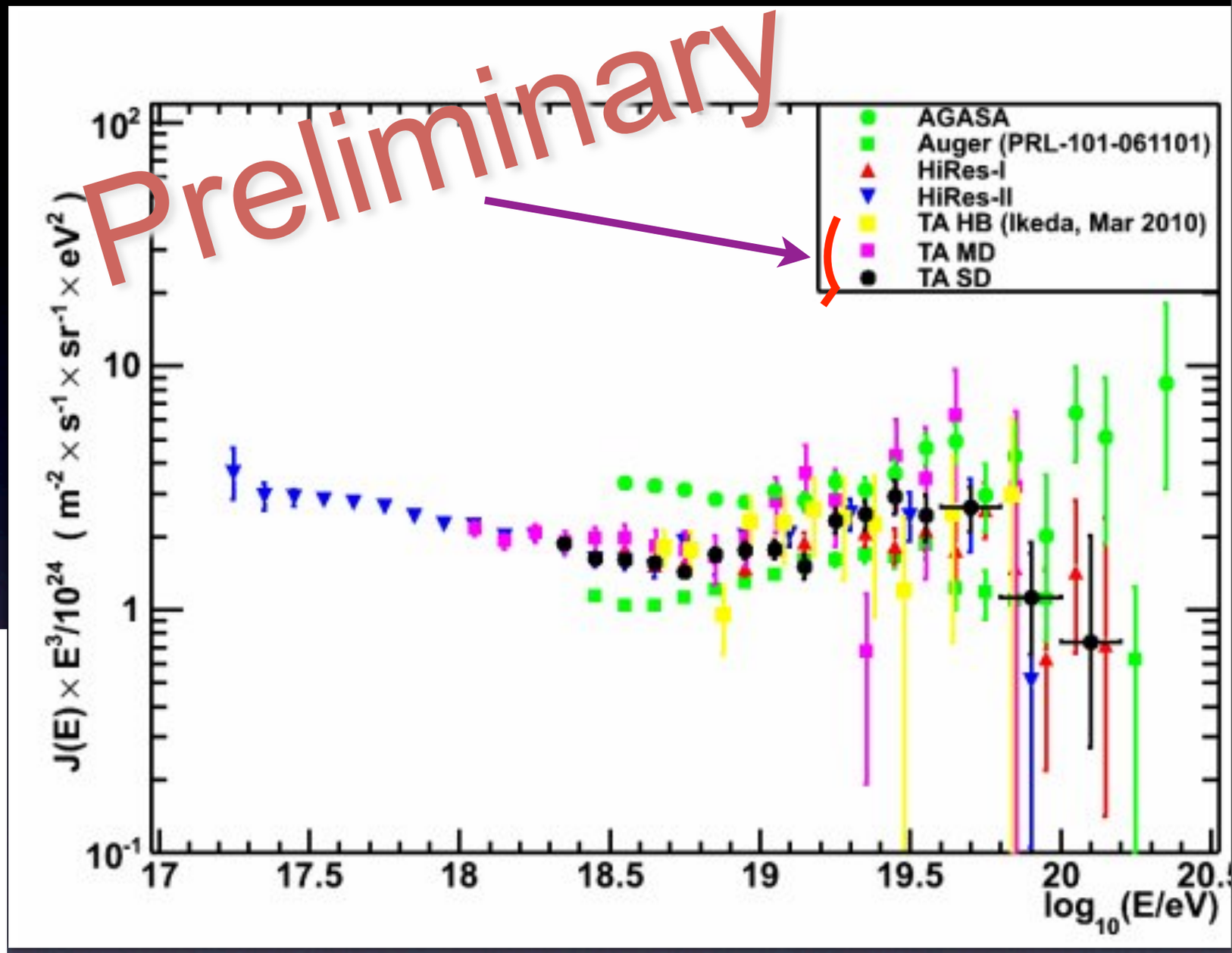
Form M.Nagano: New Journal of Physics 11 (2009)

If Super GZK:
various interesting scenarios:

New results: GZK cutoff



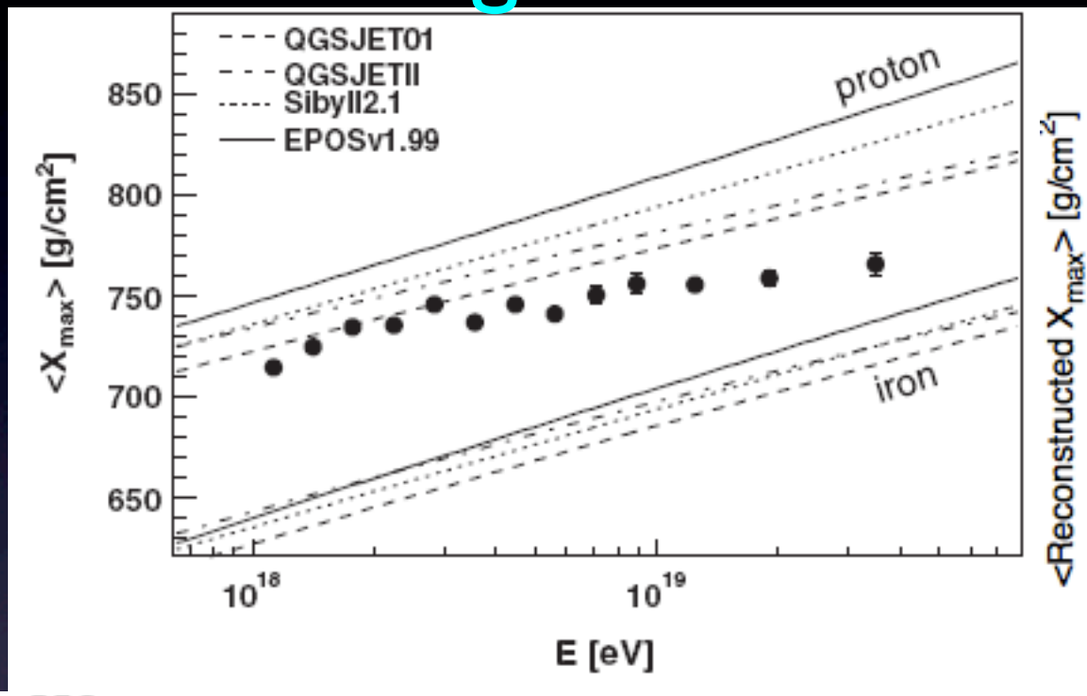
Recent TA result



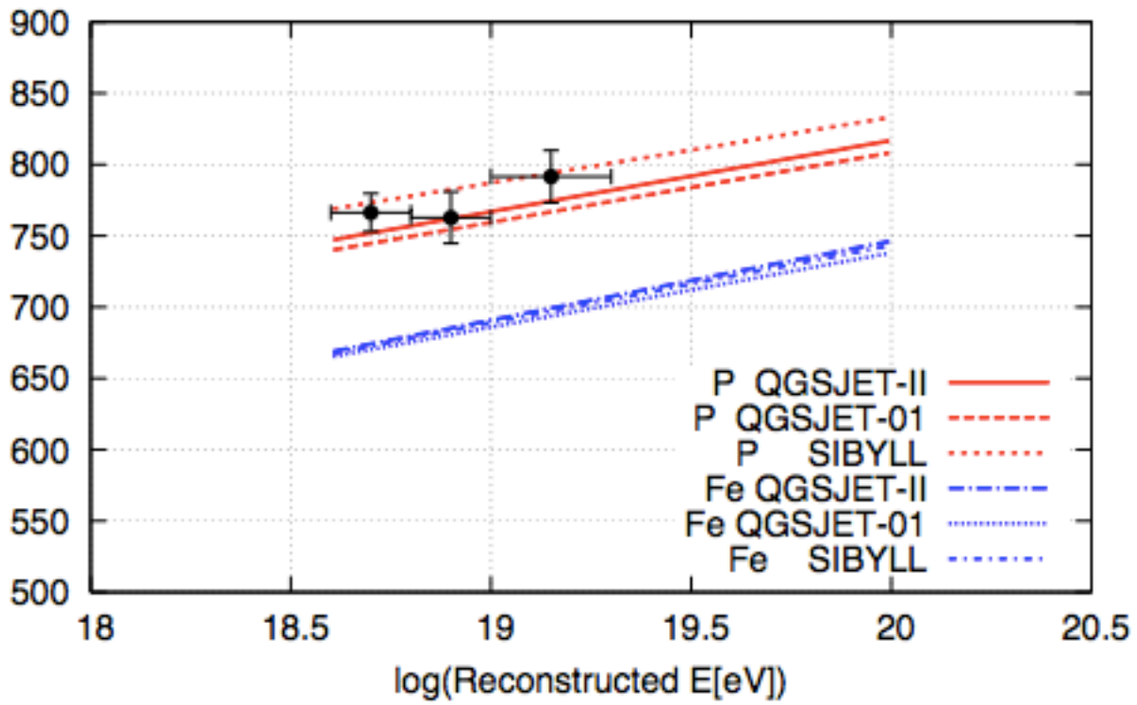
There still remain lots of problems:
source: AGN ? GRB ? .Composition ?
near-by source → super GZK recovery

Composition

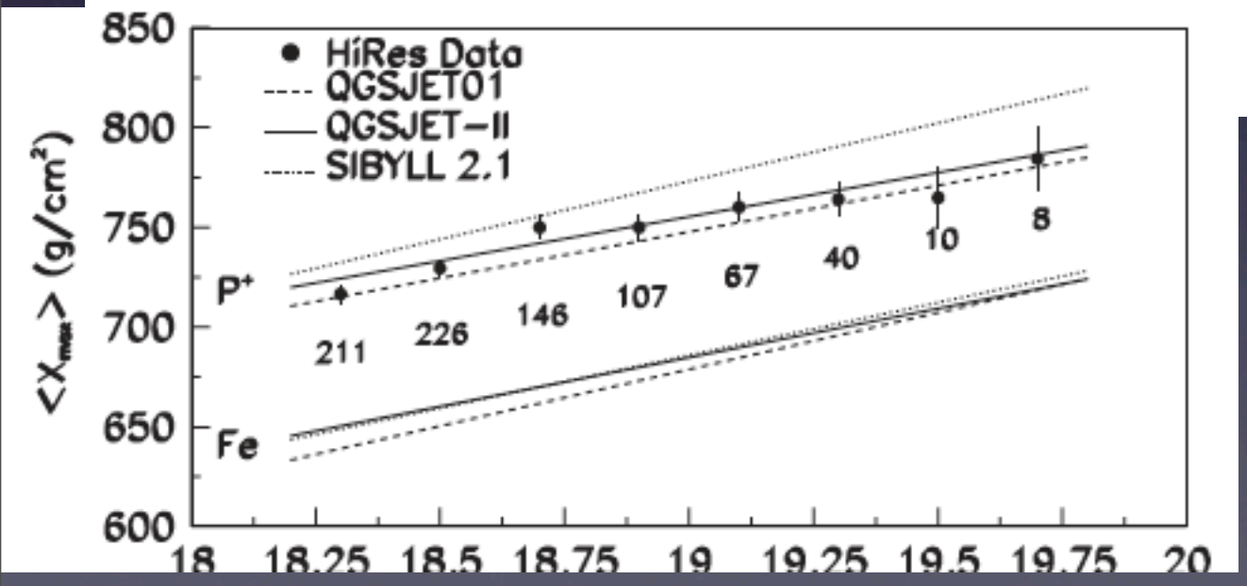
Auger



TA

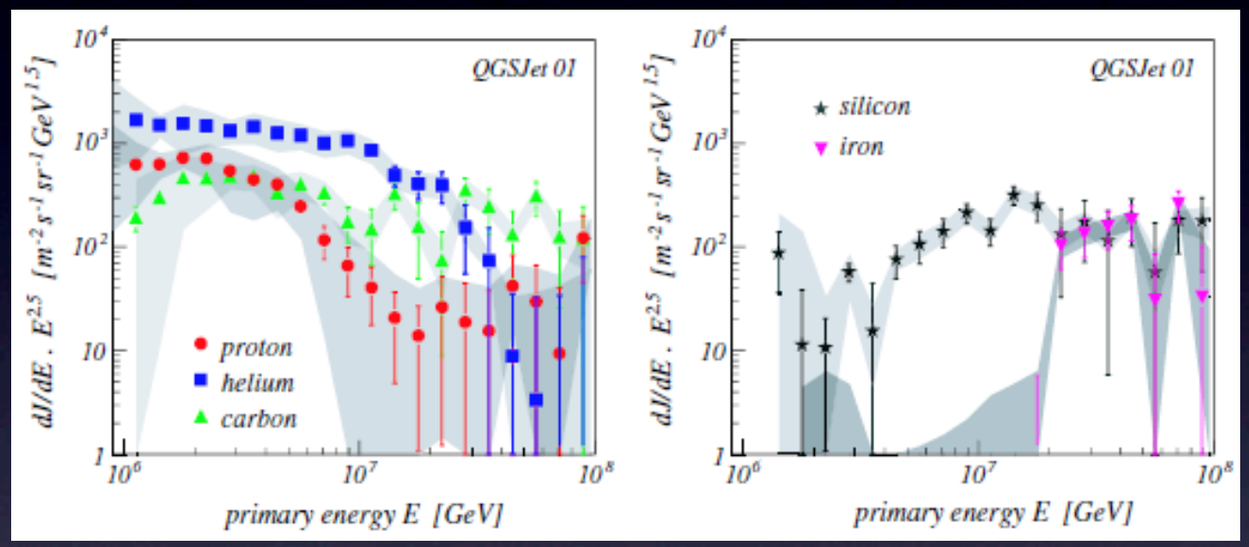


HiRes



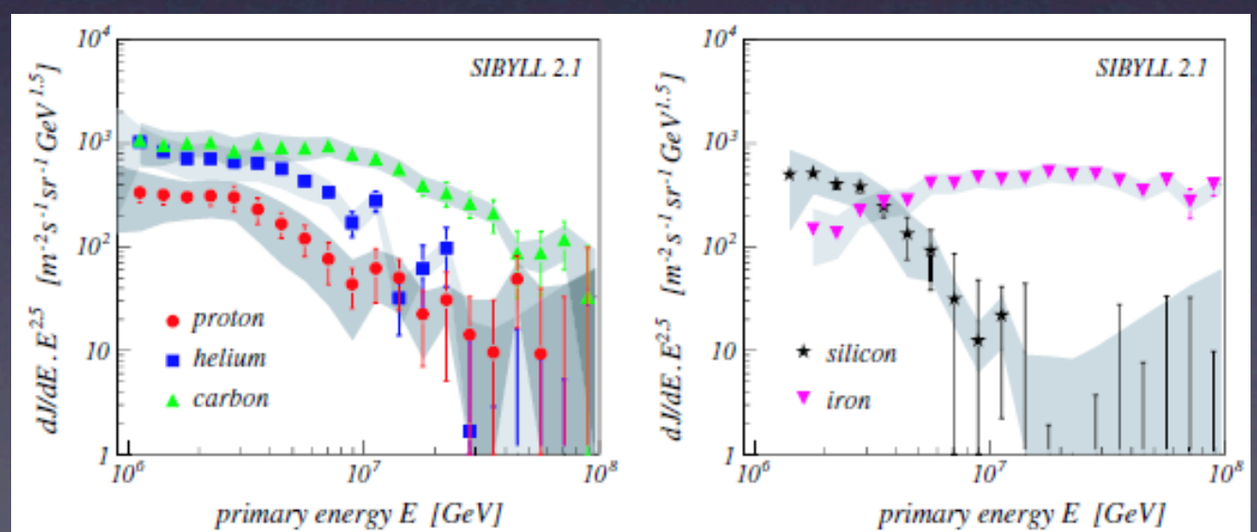
Not only UHECRs

composition (@ ~10^{16} eV) by KASCADE



qgsjet I

Sibyll2.1



- SD: Surface array Detectors
- FD: Fluorescence Detectors

- Cherenkov
- Radio

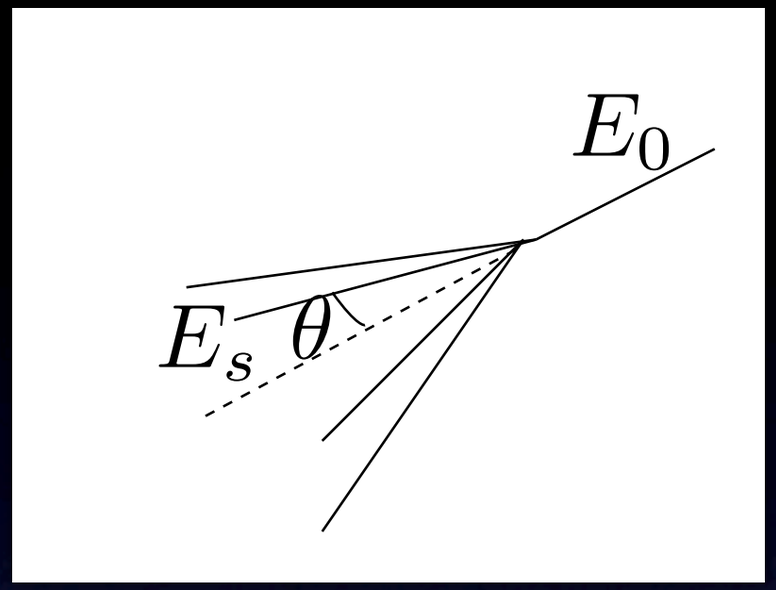
M.C: Indispensable tool

- Energy scale
- Composition
- Trigger efficiency, SΩ

* Problems:
  * Hadronic interaction model
  * Computation time at >10^{16}eV

- Hadronic Interaction model
- Several interaction models in cosmic ray field
  - qgsjet1
  - qgsjet2
  - dpmjet3
  - sibyll
  - EPOS

Imortant variables for AS development



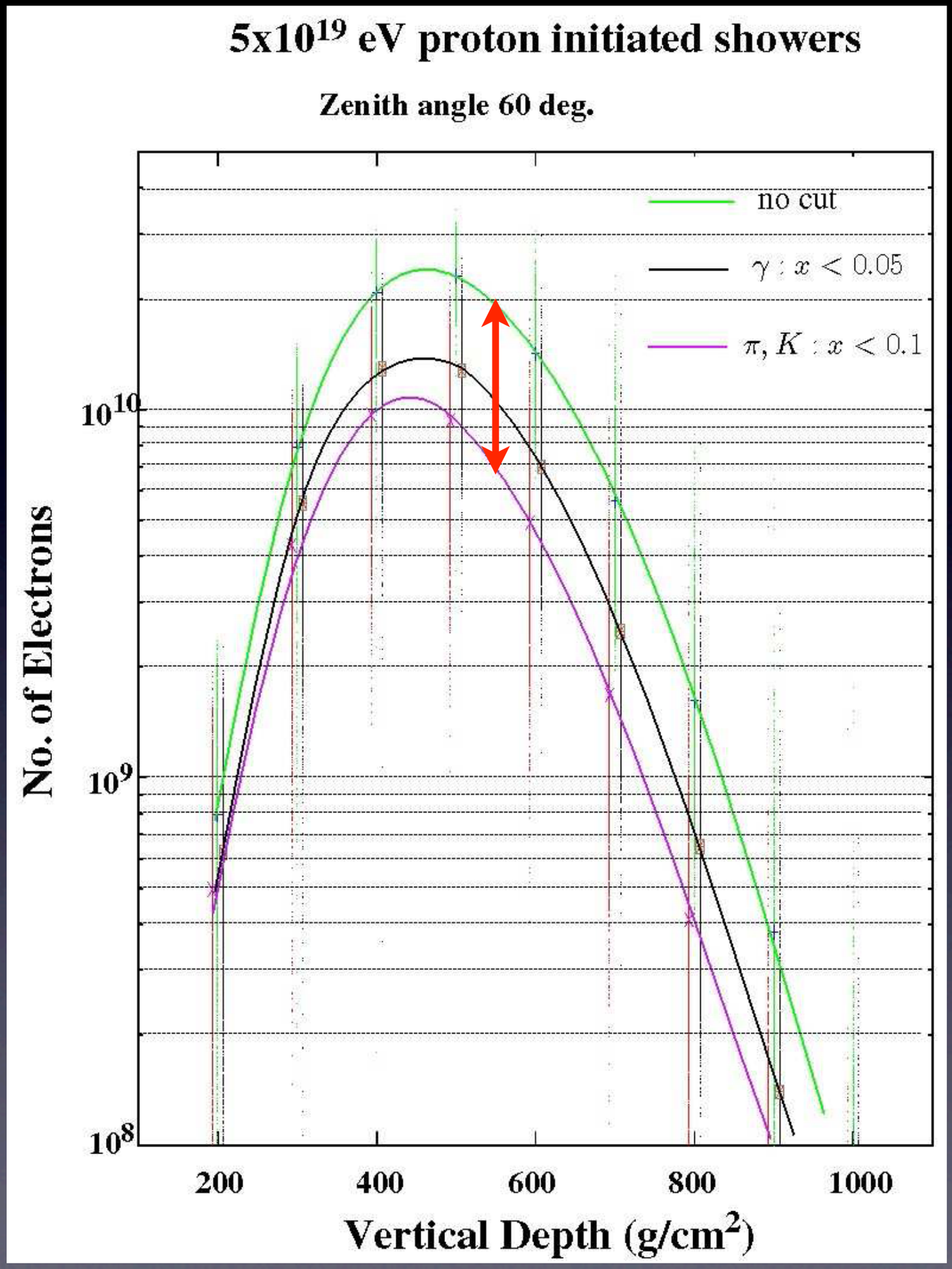
$$\frac{1}{\sigma}\frac{d\sigma}{dx} \qquad x = \frac{E_s}{E_0}$$

$$\frac{1}{\sigma}\frac{d\sigma}{d\eta} \qquad \eta = -\log(\tan(\frac{\theta}{2}))$$

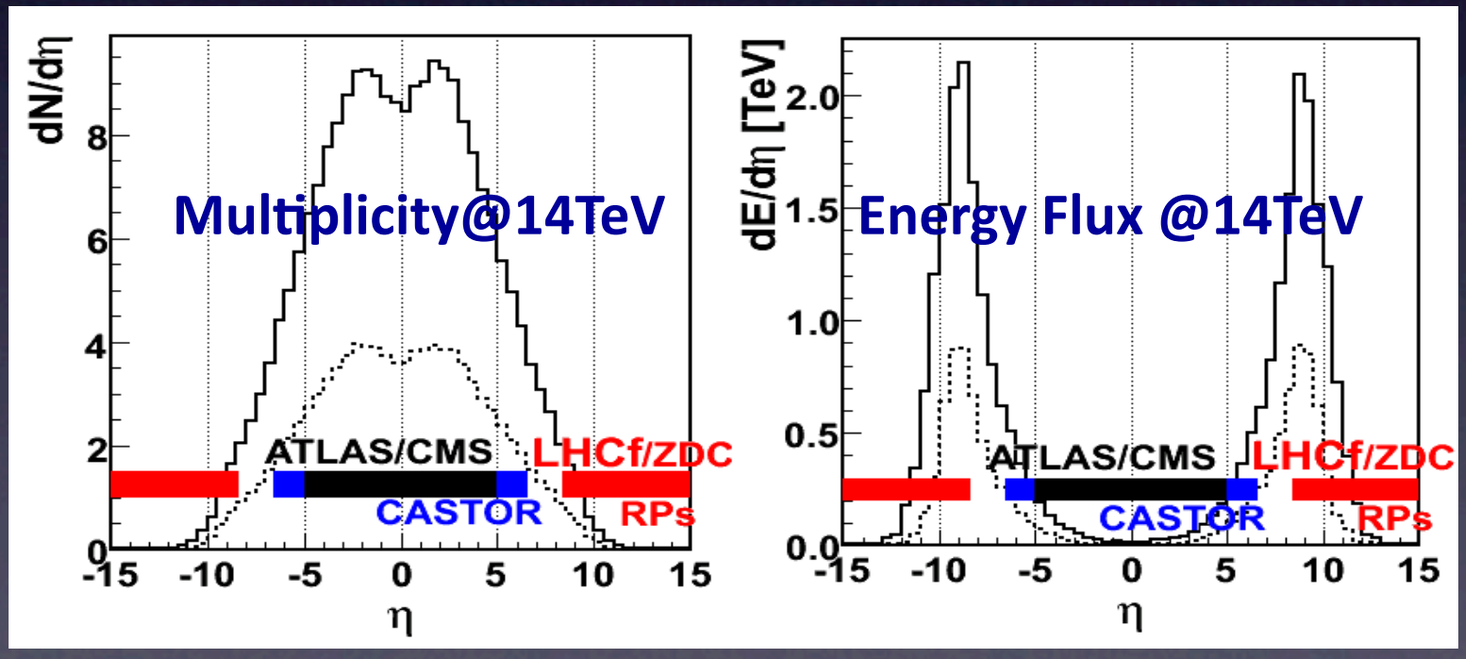
- For Ne and N γ
  - large x is important
- For N μ
  - small x (or η_{cms} ~0) is also important

electron/
gamma in AS

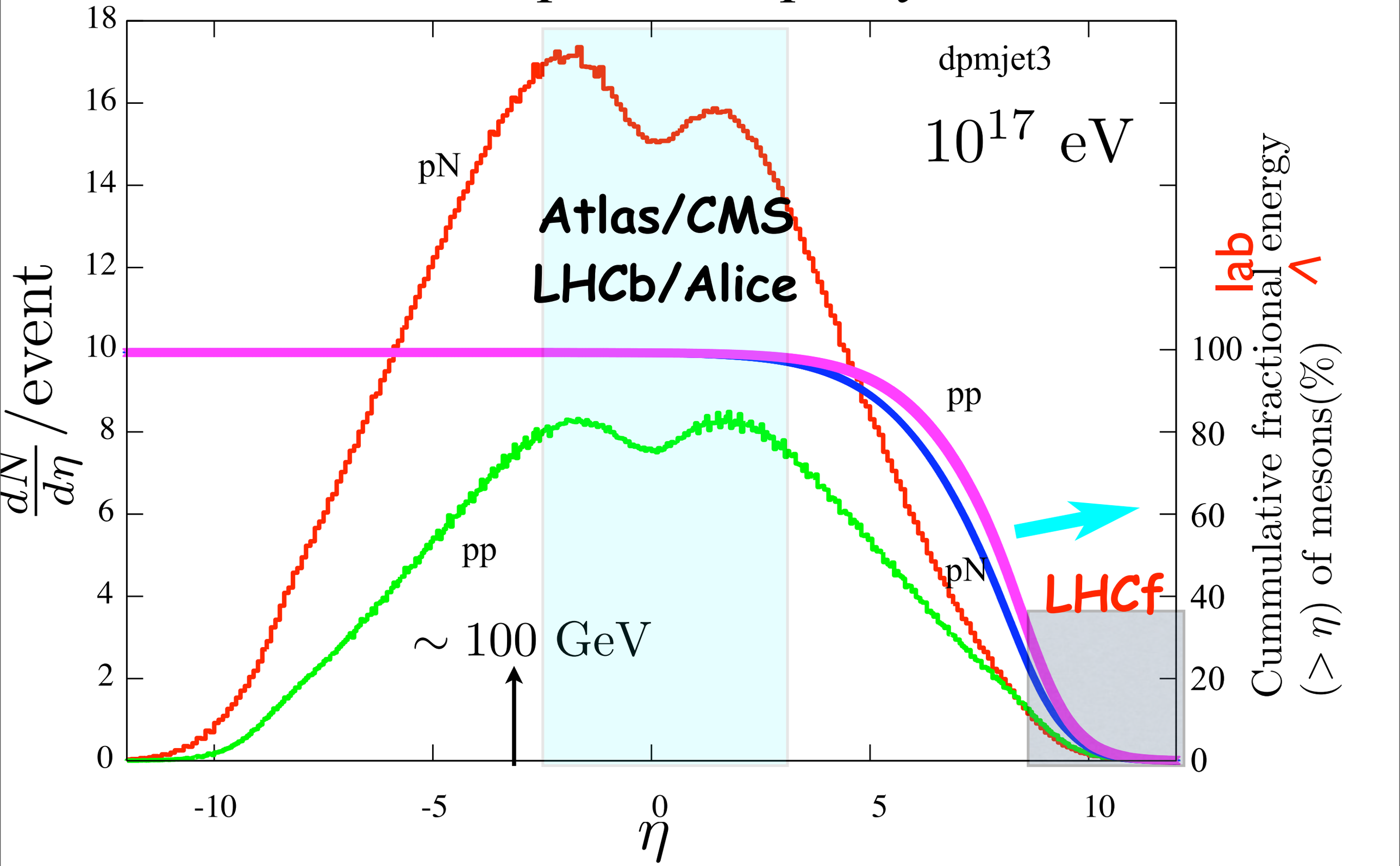
50~60 % are
from pi, K with
x>0.1
or
~40 % from
γ with x>0.05

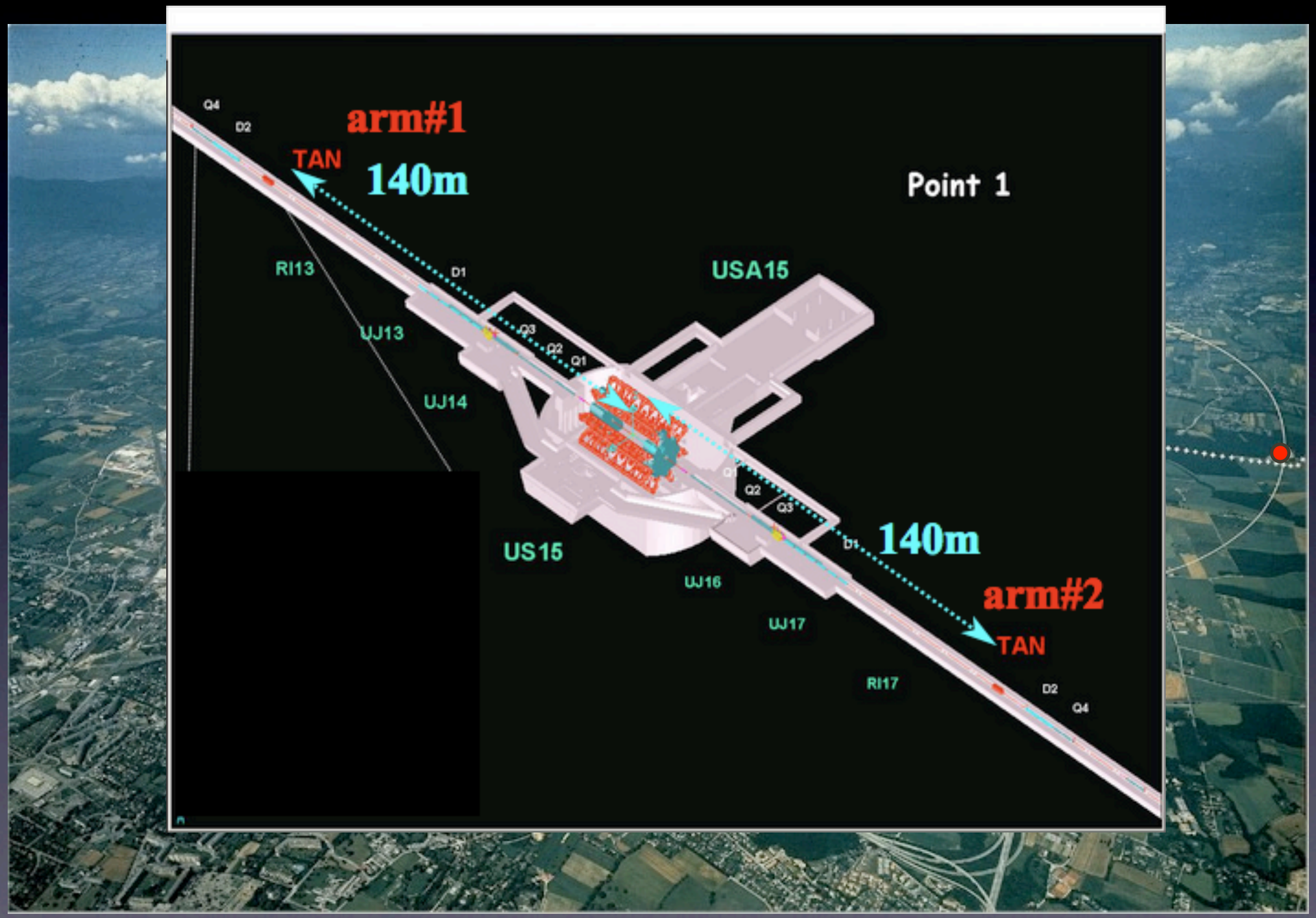


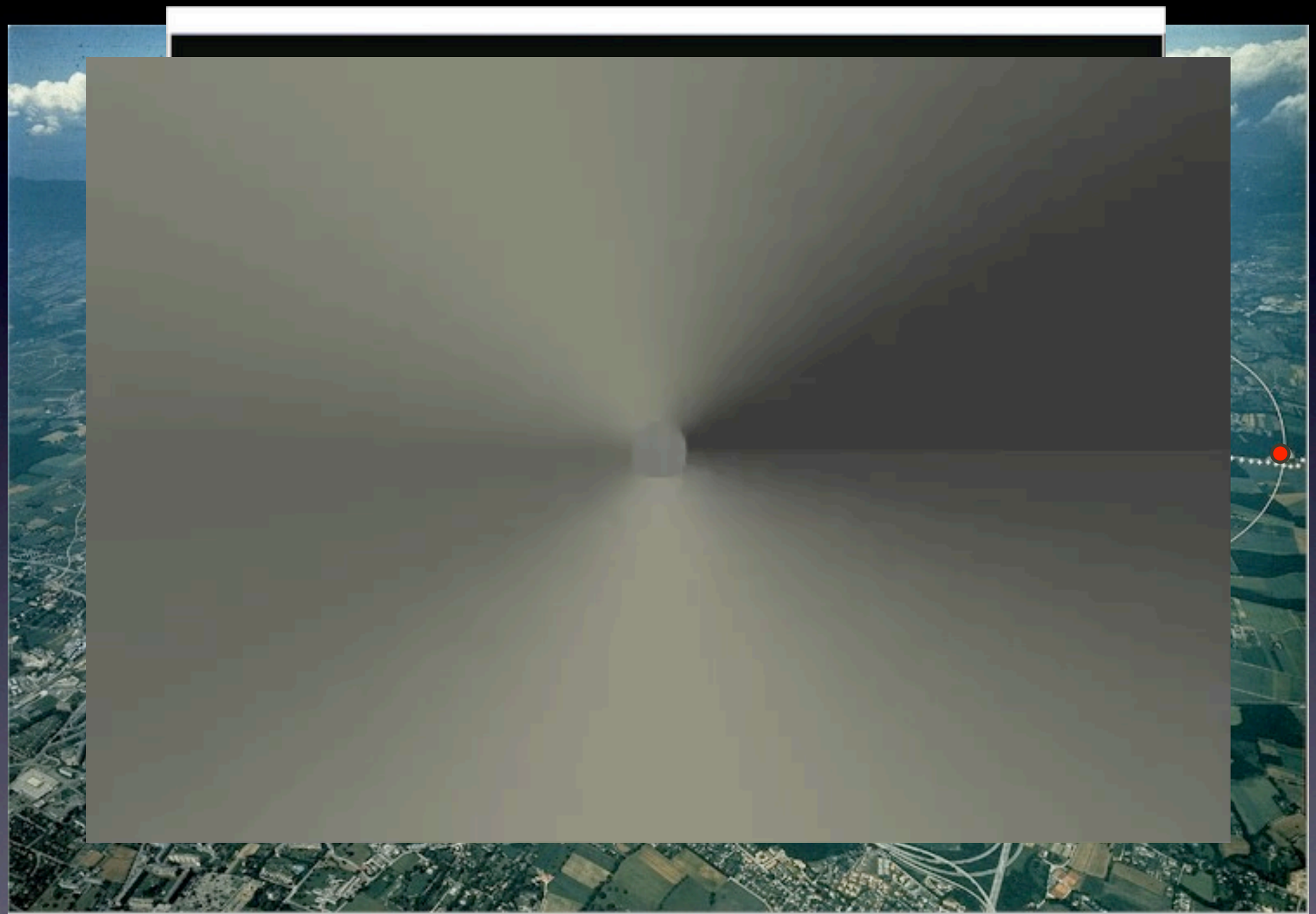
In terms of number and energy in CMS

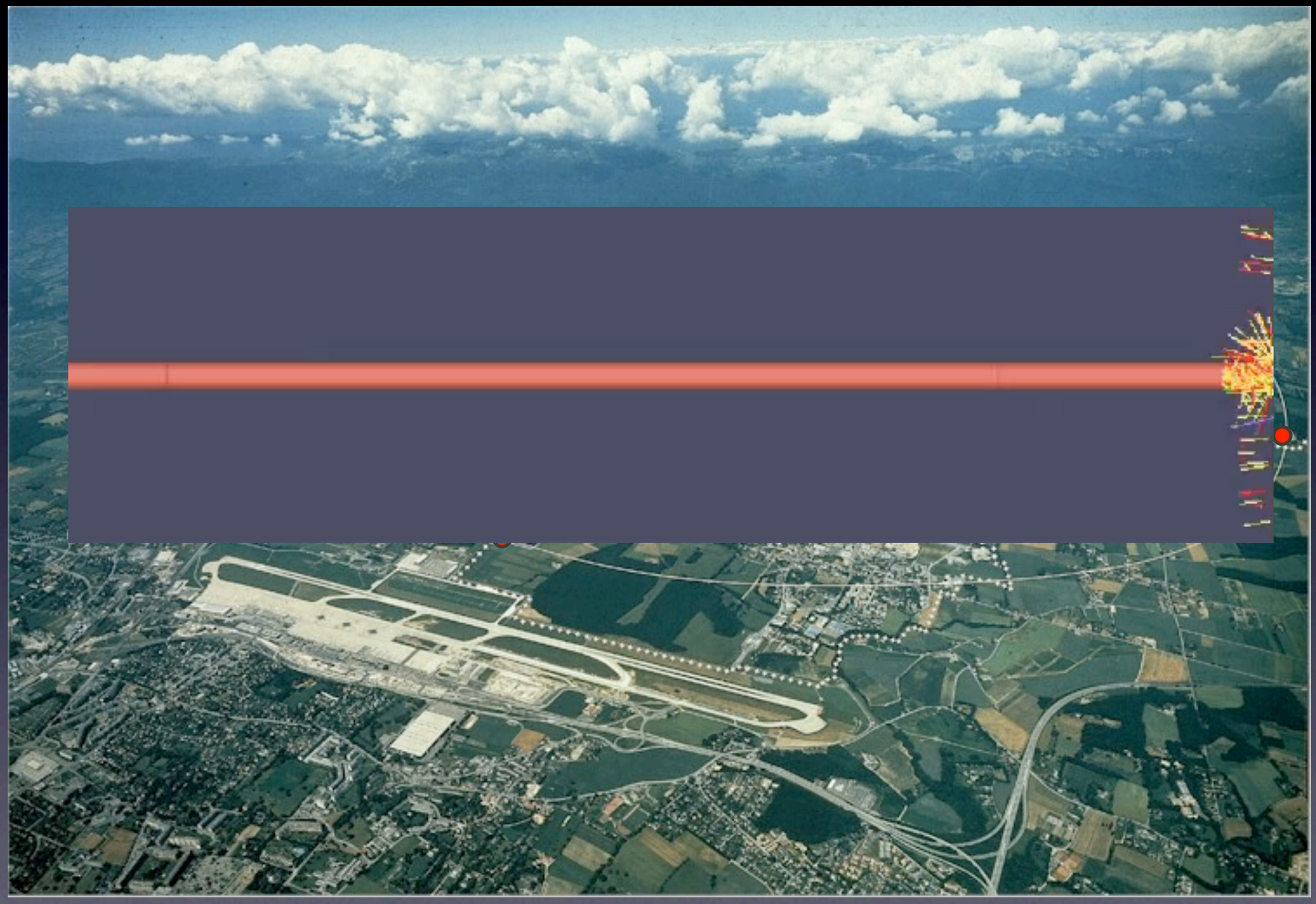


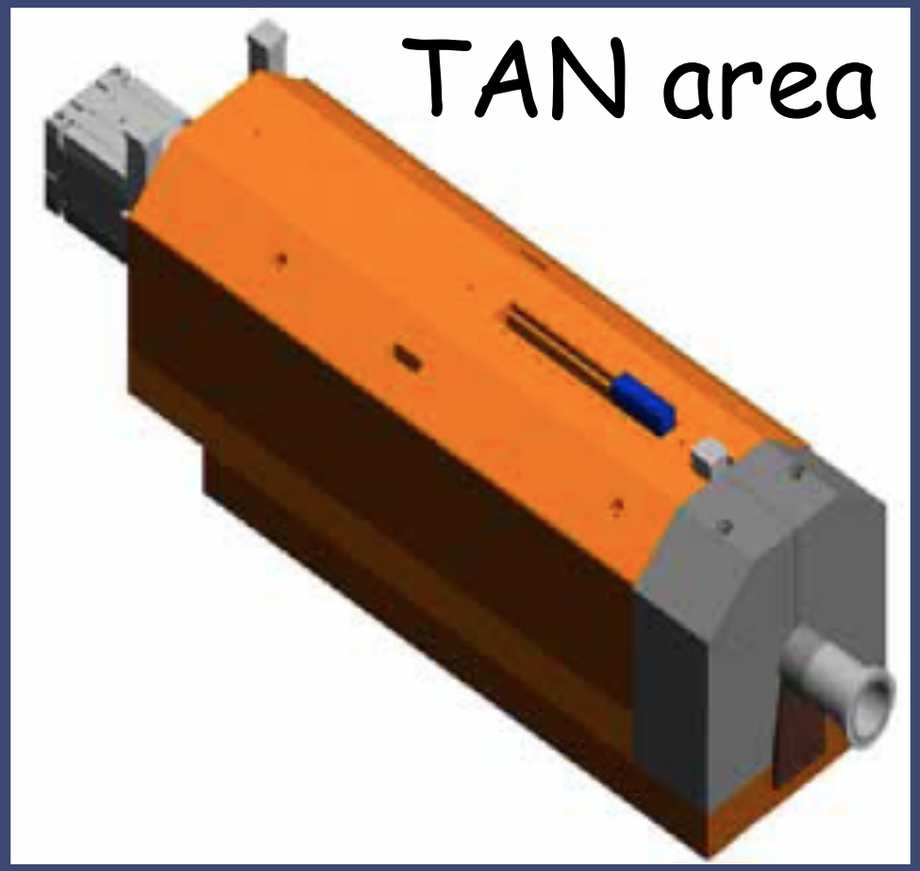
Meson pseudo rapidity

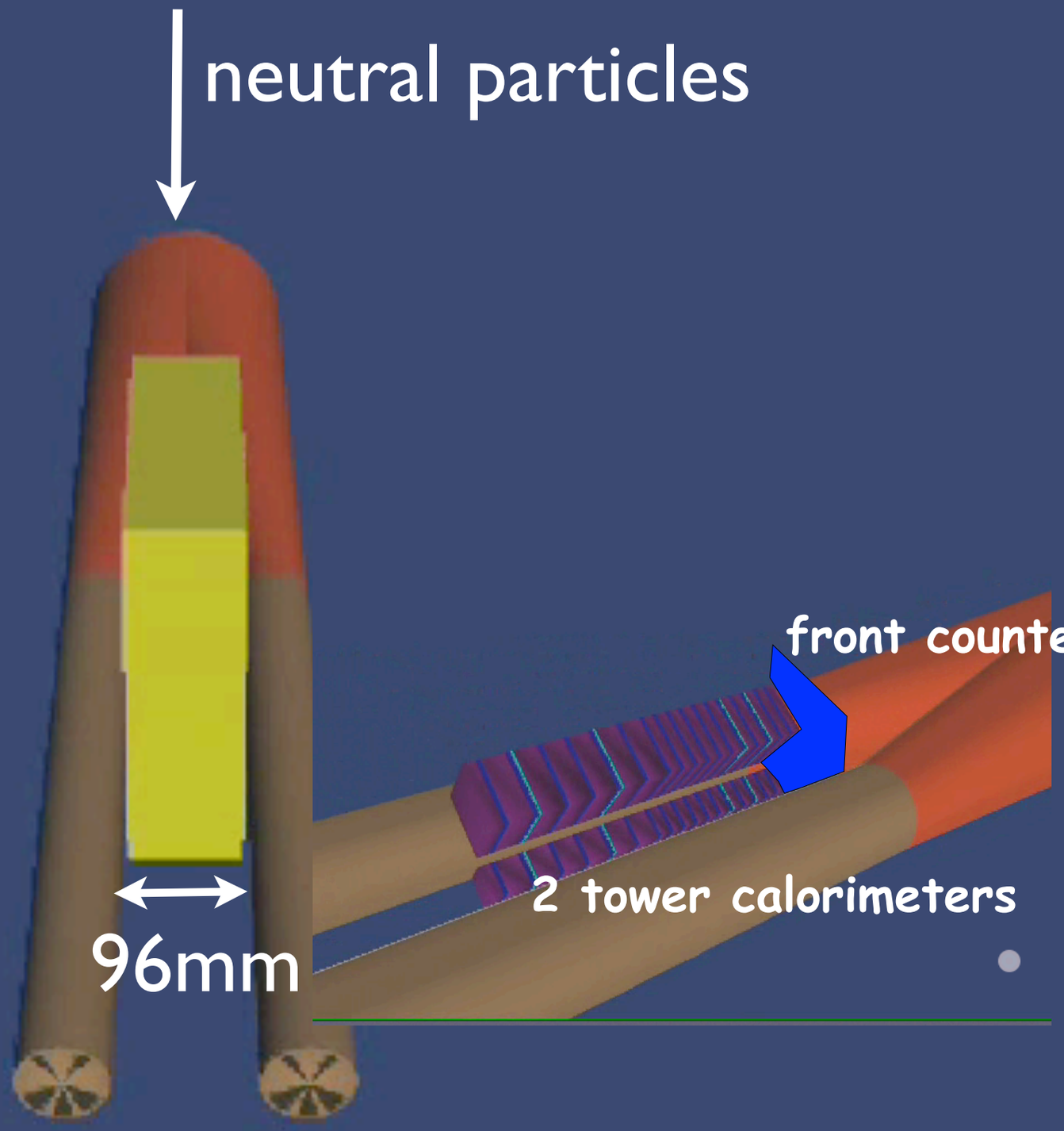



arm#1
140m
TAN
Point 1
Q4
D2
RI13
D1
USA15
UJ13
Q3
Q2
Q1
UJ14
Q1
Q2
Q3
D1
140m
arm#2
TAN
D2
Q4
US15
UJ16
UJ17
RI17

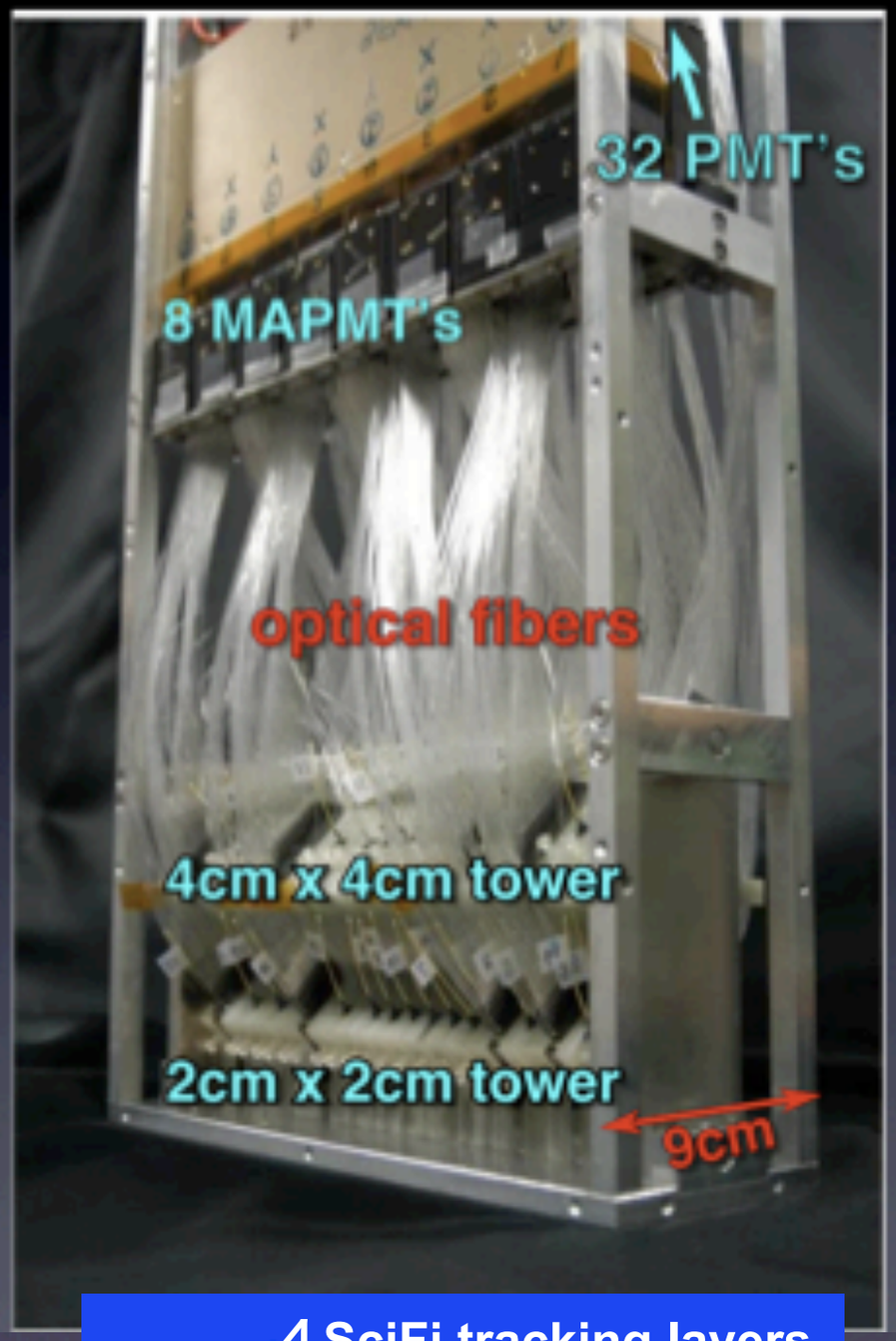





TAN area

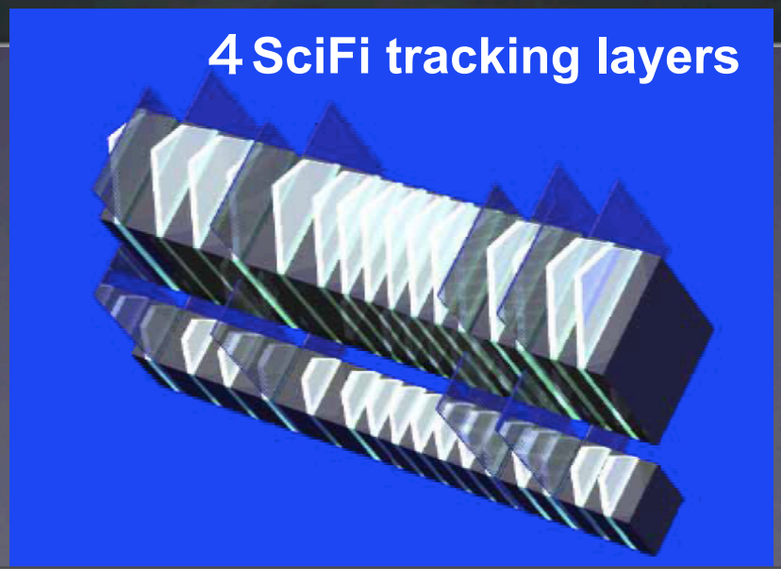

neutral particles
front counter
2 tower calorimeters
96mm

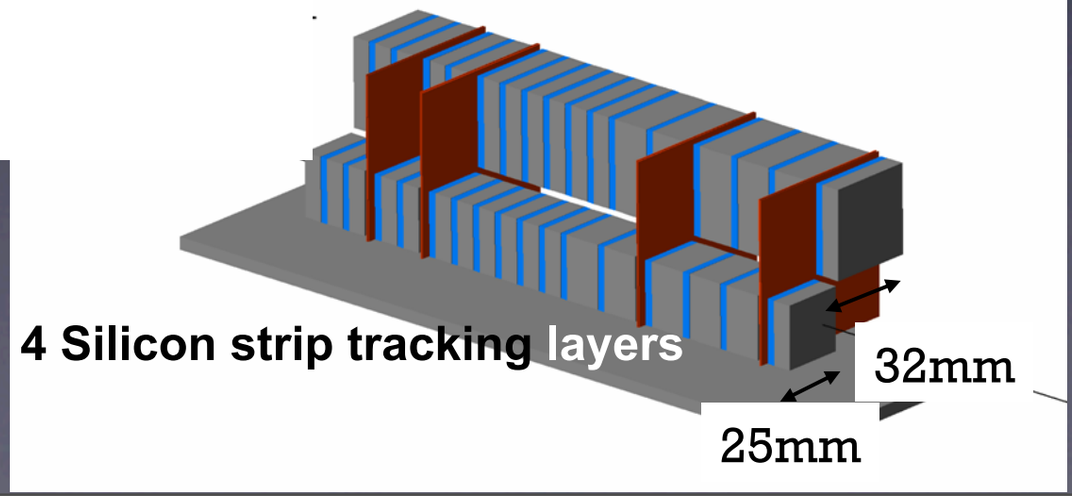
Arm #1



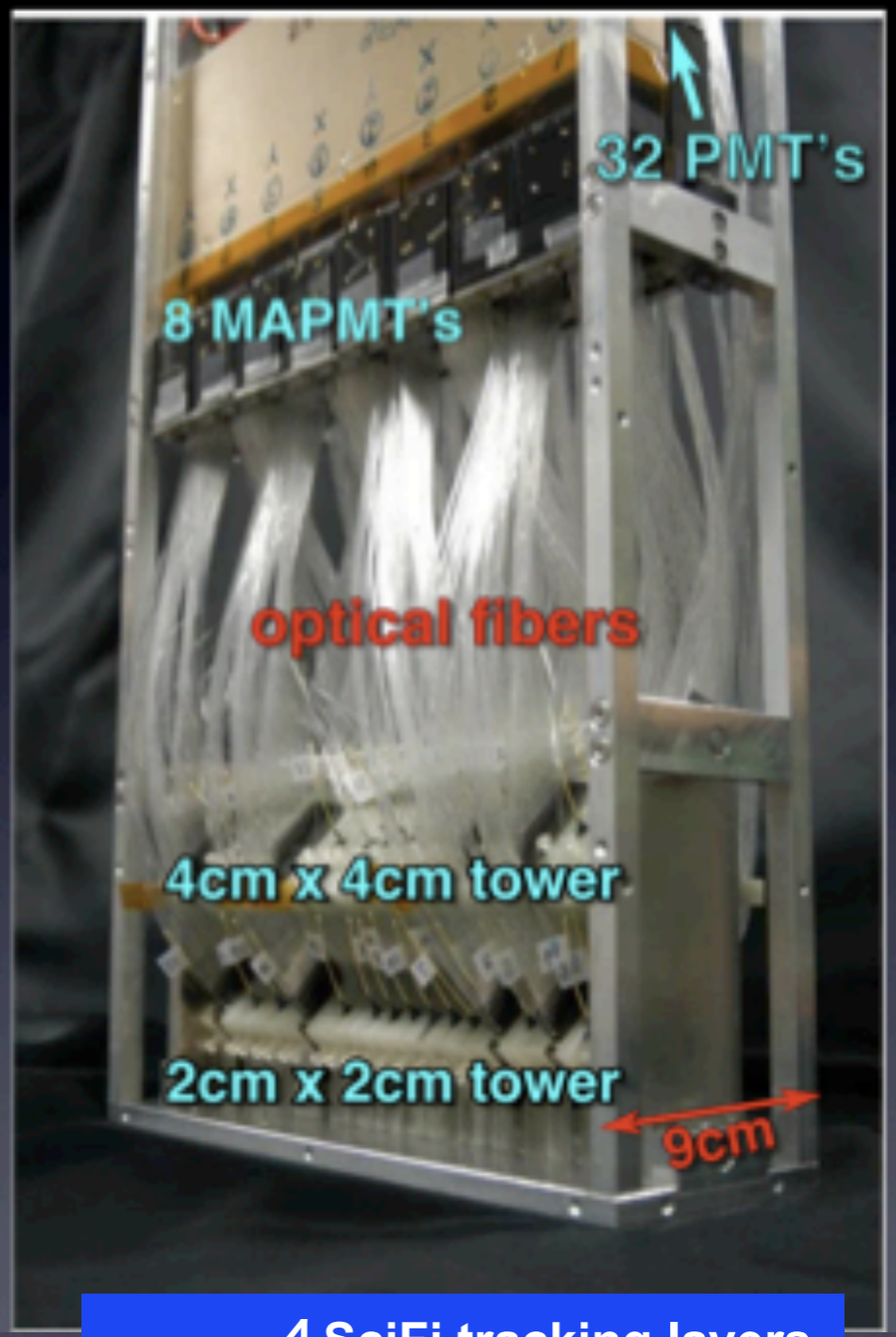
Arm #2

W 44X0
1.7λc





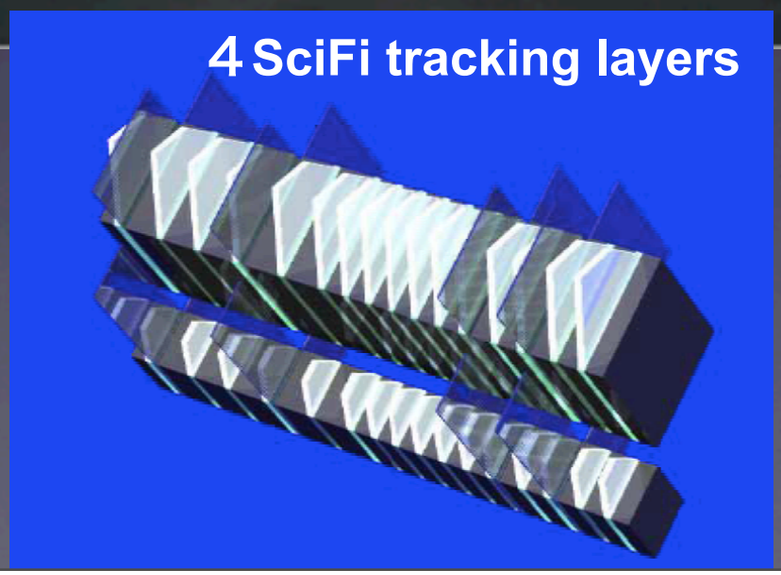
Arm #1

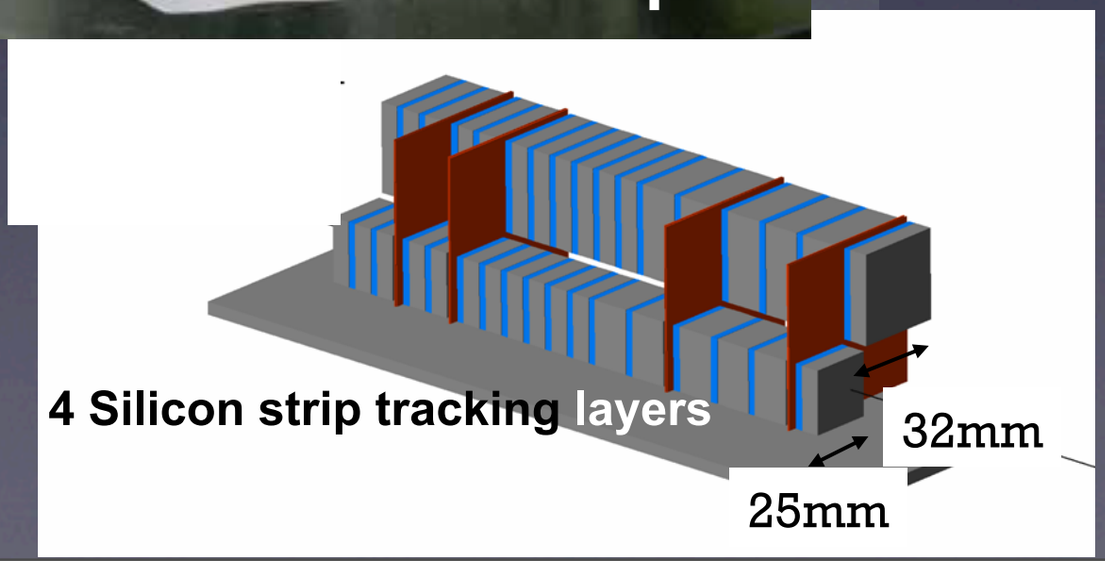


Arm #2

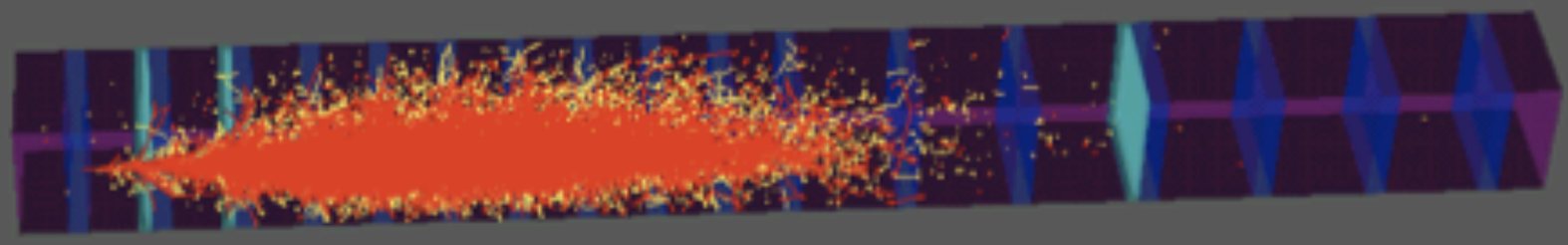
W 44X0
1.7λc

Sampling calorimeter
W of 44 X0
Plastic scinti.
4 pos. sensitive layers:
Arm I: SciFi
Arm2: Si strip

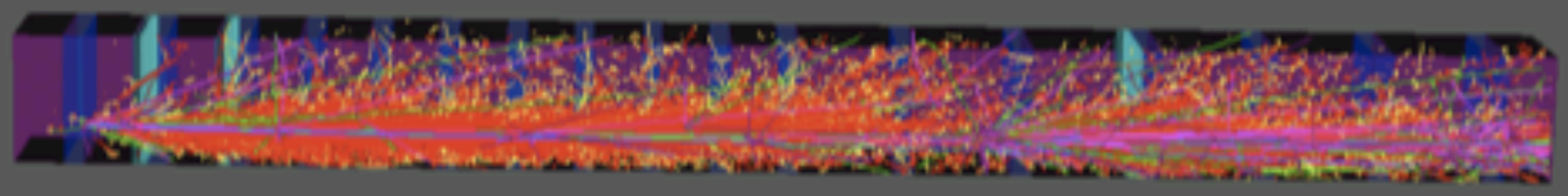




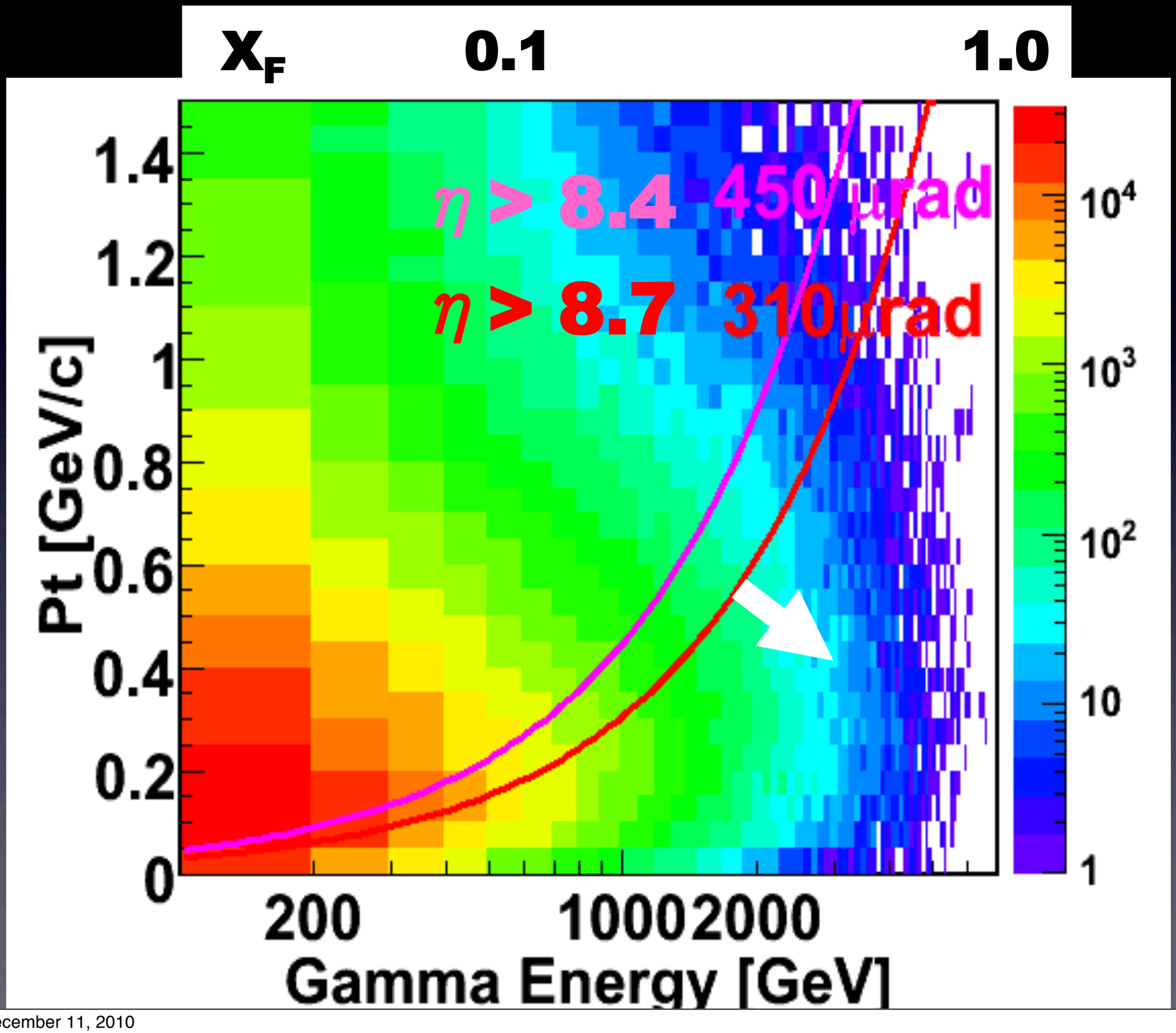
Photon vs Neutron



400 GeV photon

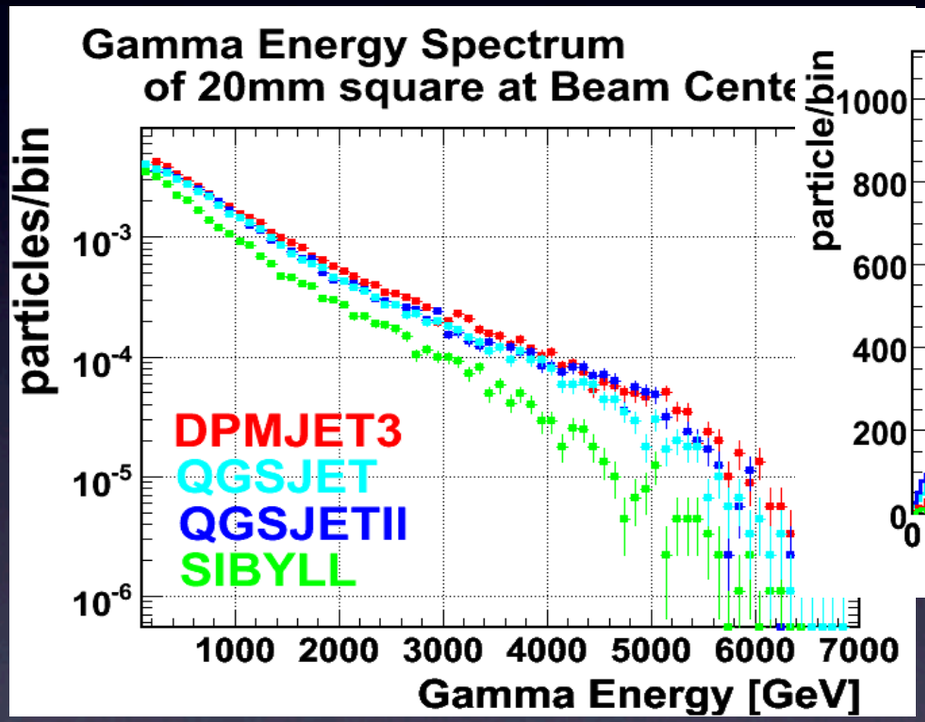


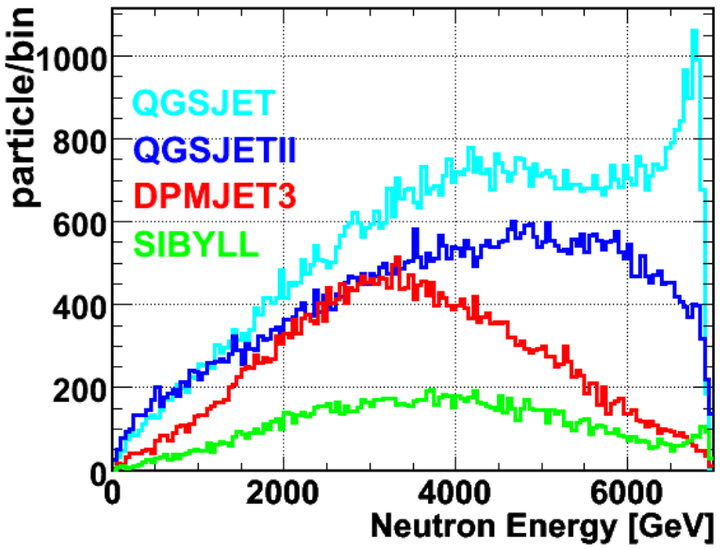
1TeV Neutron

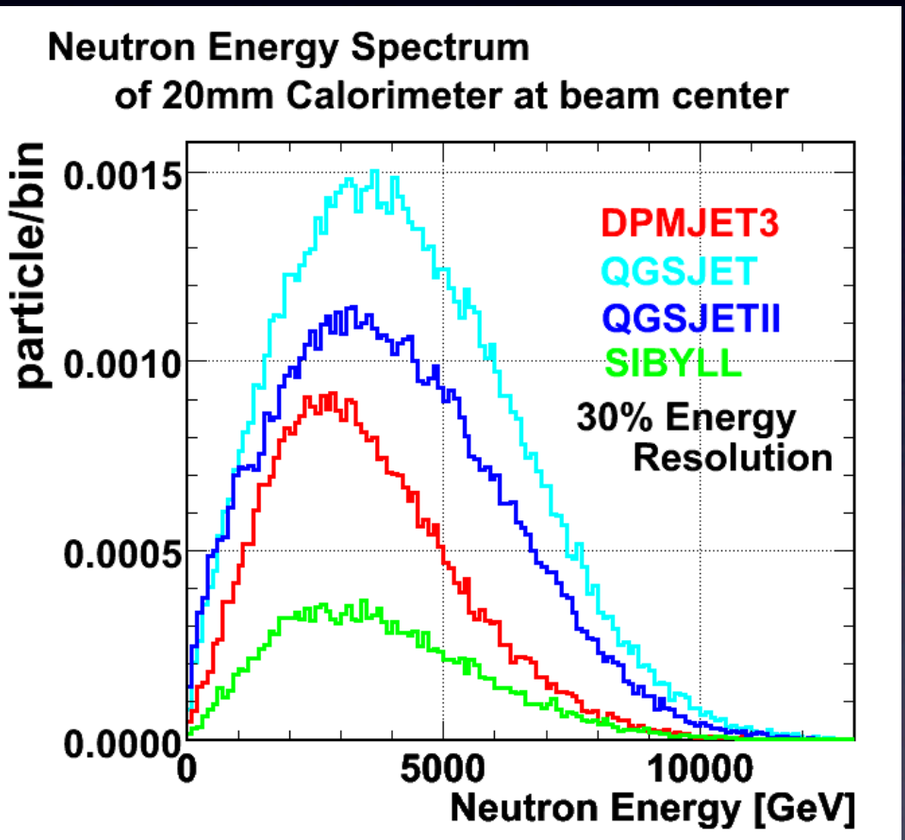

x_F
0.1
1.0
$\eta > 8.4$ 450 μrad
$\eta > 8.7$ 310 μrad
Pt [GeV/c]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
200
1000
2000
Gamma Energy [GeV]
10^4
10^3
10^2
10
1

Detector performance: SPS test and M.C

Gamma-rays (E>100GeV, ΔE/E<5%)
Neutral Hadrons (E>a few 100 GeV, ΔE/E~30%)
Neutral Pion (E>700GeV, ΔE/E<3%)
at psudo-rapidity range >8.4







at 7TeV + 7TeV pp

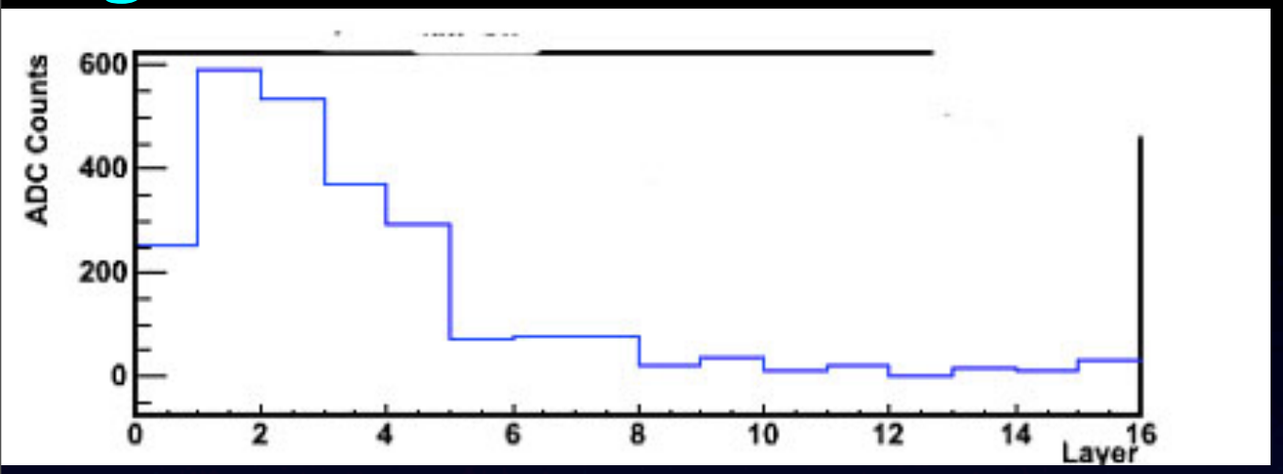
We can see the difference !

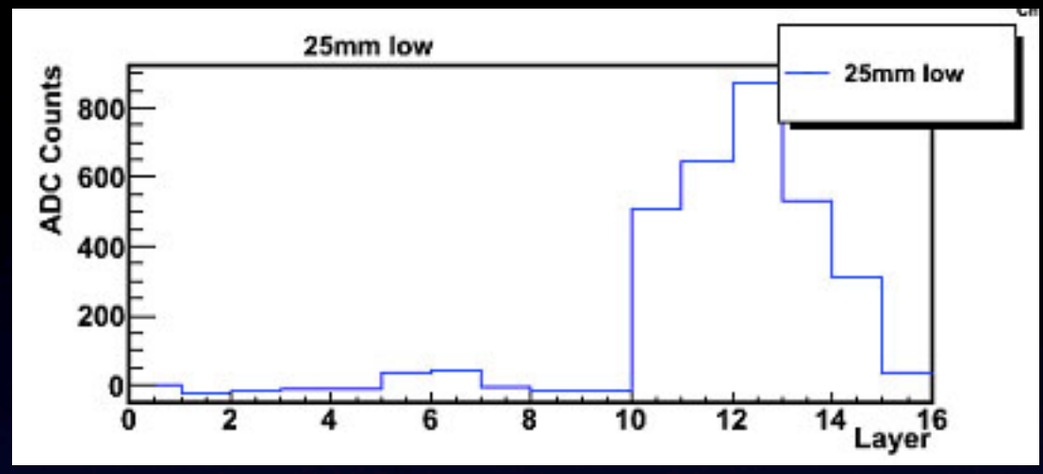
2009-2010 run summary

- $\sqrt{s} =$ 900 GeV run (no crossing angle)
  - 06 Dec.- 15Dec. 2009(27.7 hrs, 500k collisions
    - 2.8k/3.7k single showers at Arm1/Arm2
  - 02 May-27 May 2010(15 hrs. 5.5M collisions)
    - 44k/63k single showers at Arm1/Arm2
- $\sqrt{s} =$ 7TeV run (0 and 100 μ rad crossing angle)
  - 30 Mar.- 19 July, 2010(~150 hrs.)
    - 172M/161M single showes at Arm1/Arm2
    - 345k/676k Pi0's at Arm1/Arm2
- Detectors were removed at 20 Jul. 2010

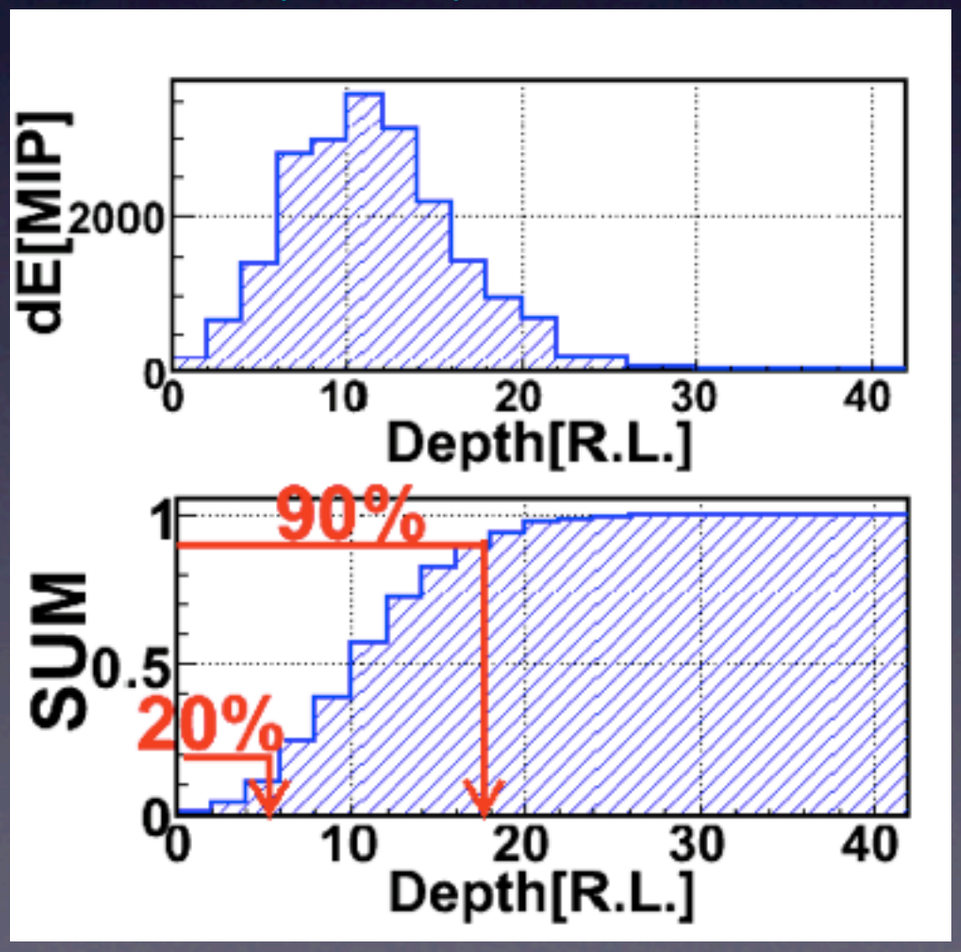
Partilce ID

gamma like shower transition curve hadron like

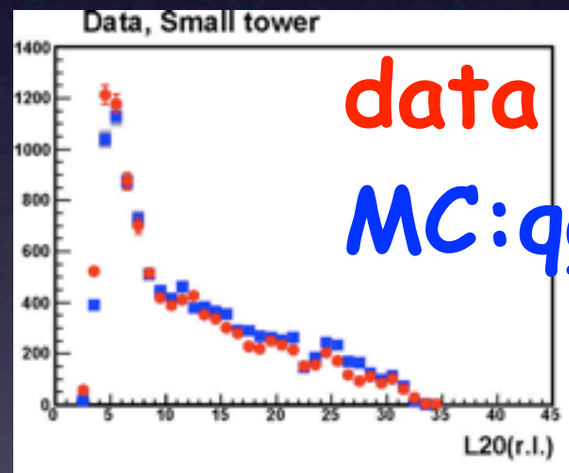




Def. of L90%

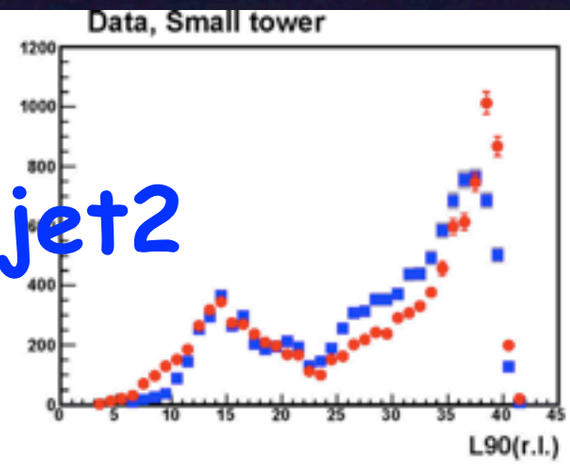


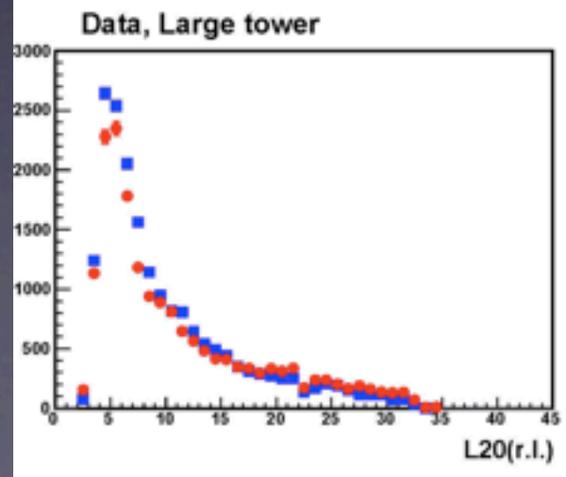
L20 & L90%: Data vs MC

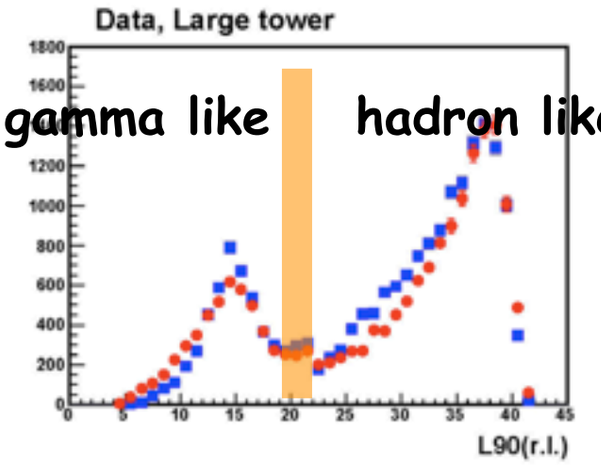


data

MC:qgsjet2





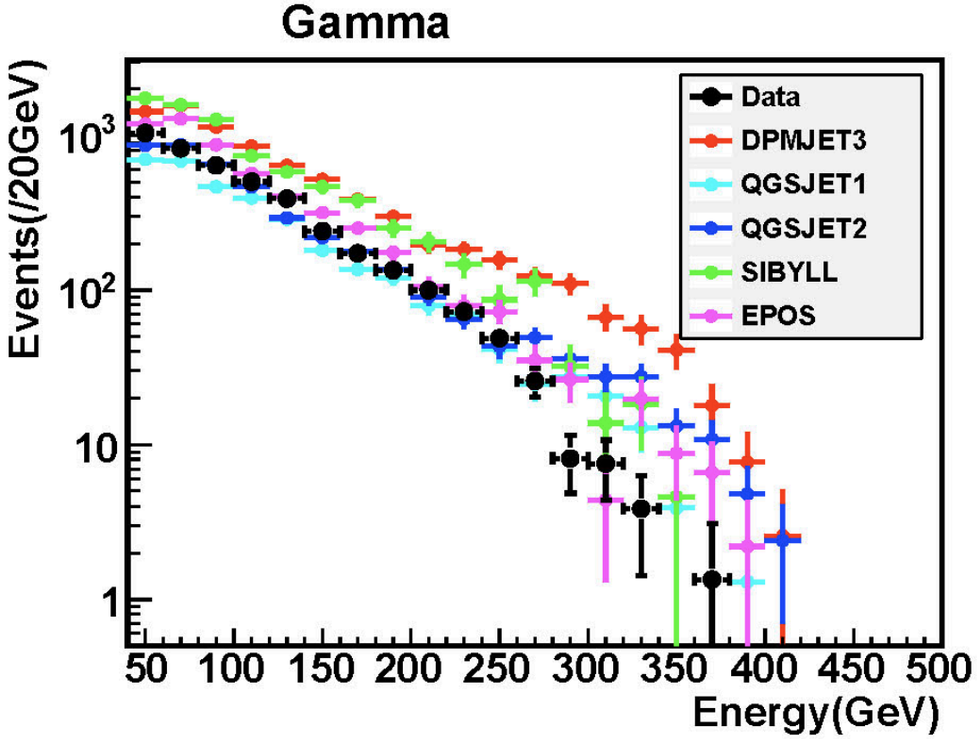


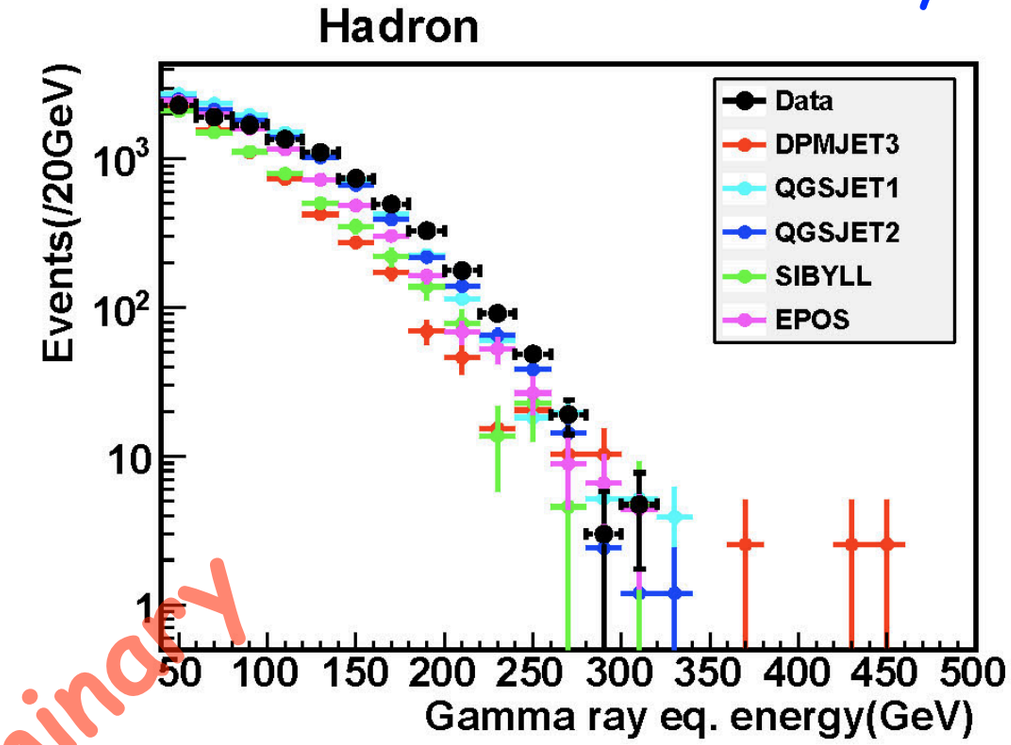
- Changing PID criteria:
  - We get the same energy spectrum

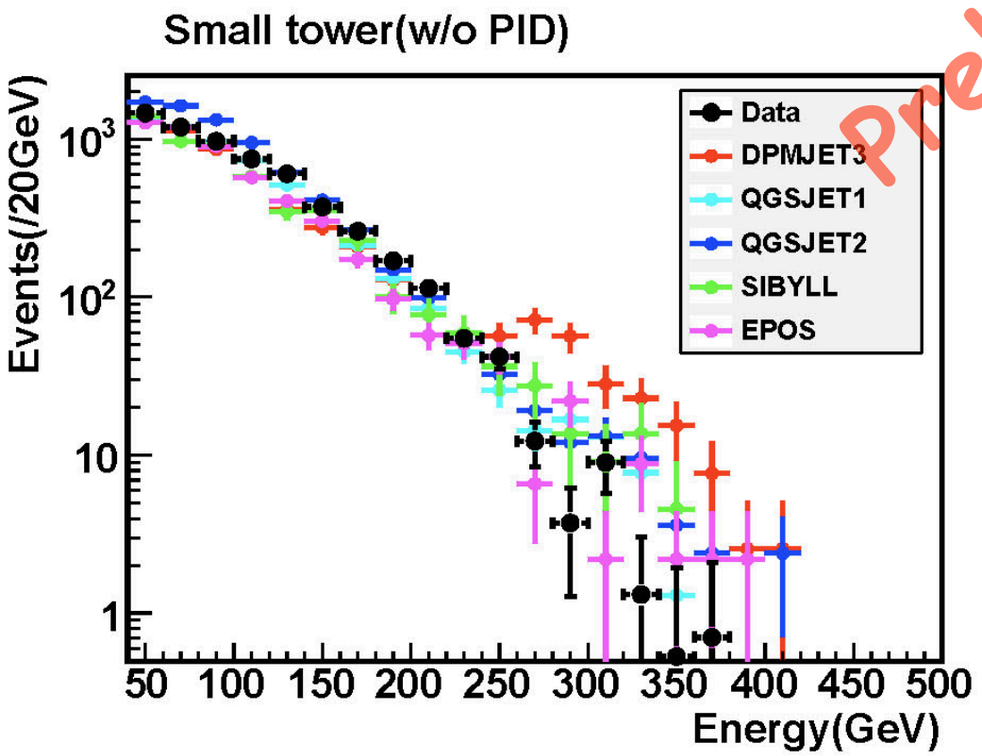
900 GeV collisions

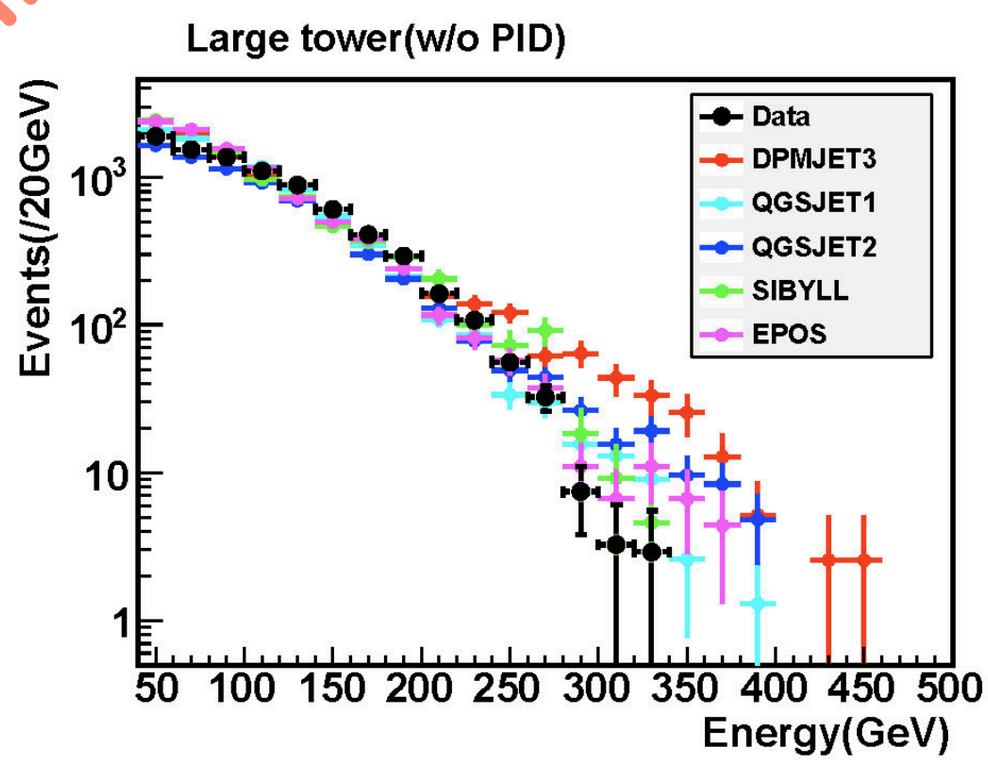
Arm 1

Normalization: by total number
stat. error only

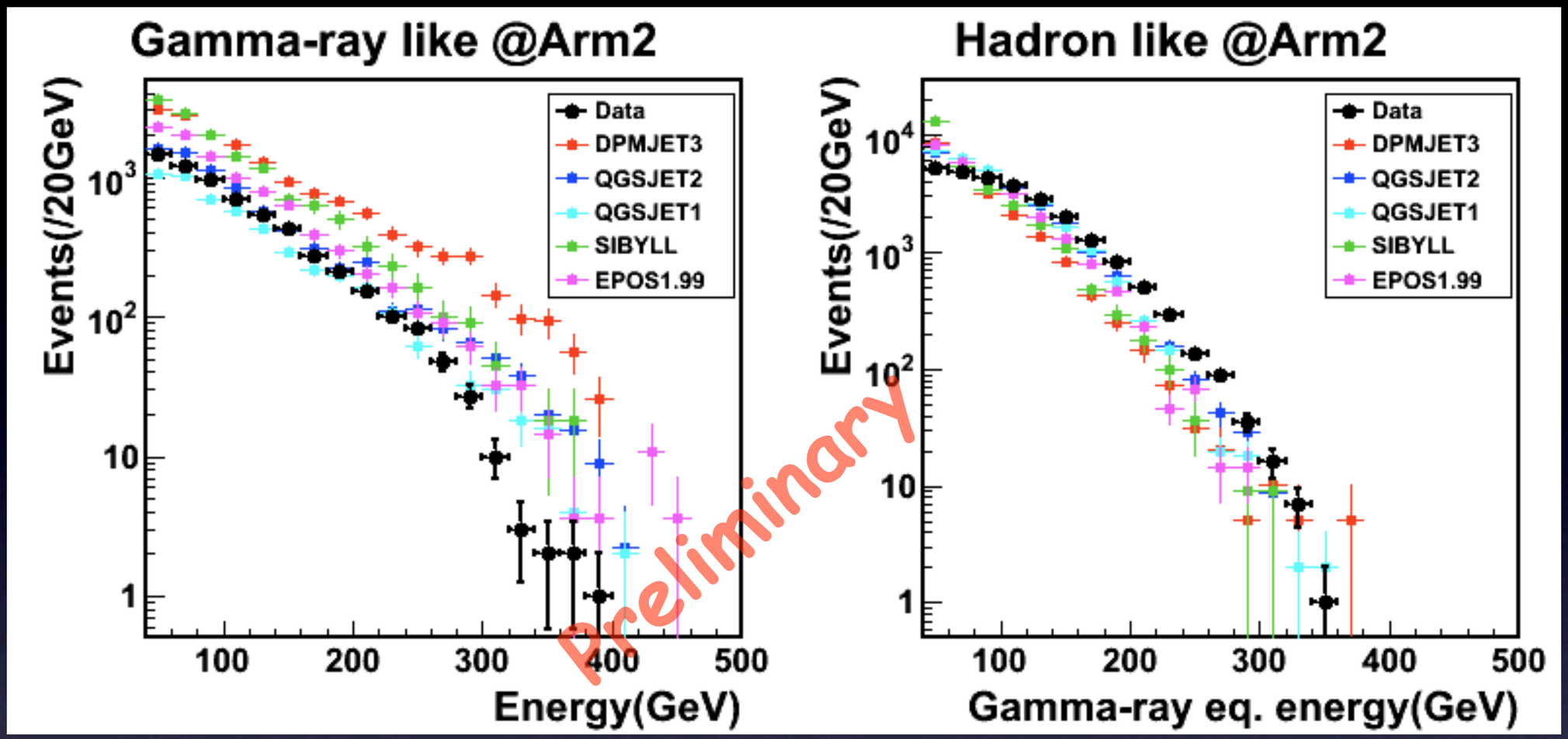








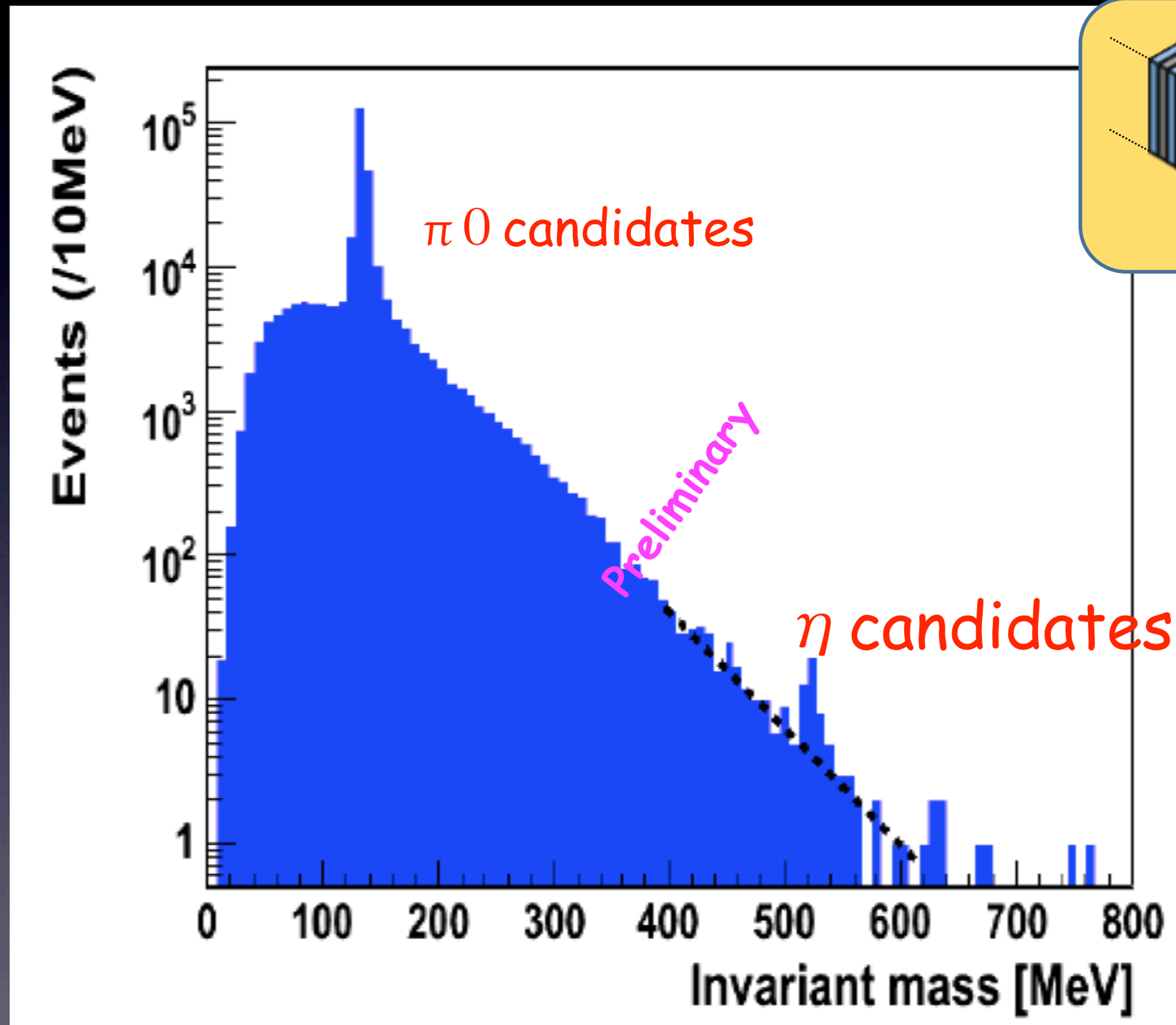
Arm2

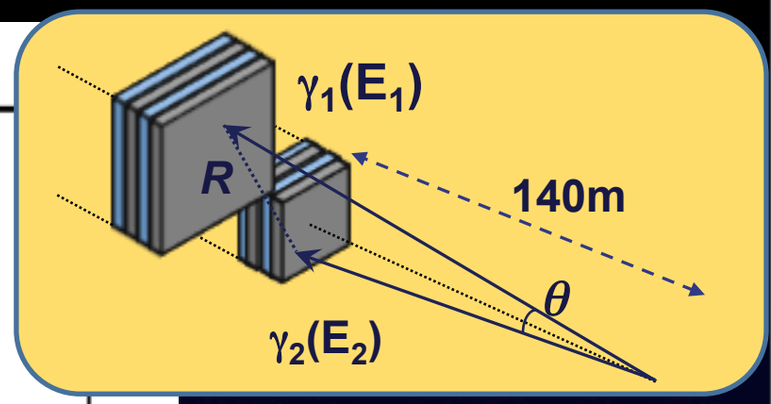


- Arm1 and Arm2 are quite consistent
- Preliminary conclusion at 900 GeV:
  - qgsjet2 is most consistent with the data
  - hard neutron spectrum is favored

(NOTE: not yet in absolute scale)

7TeV(3.5 TeV + 3.5TeV)
Energy calibaration by π^0 is possible



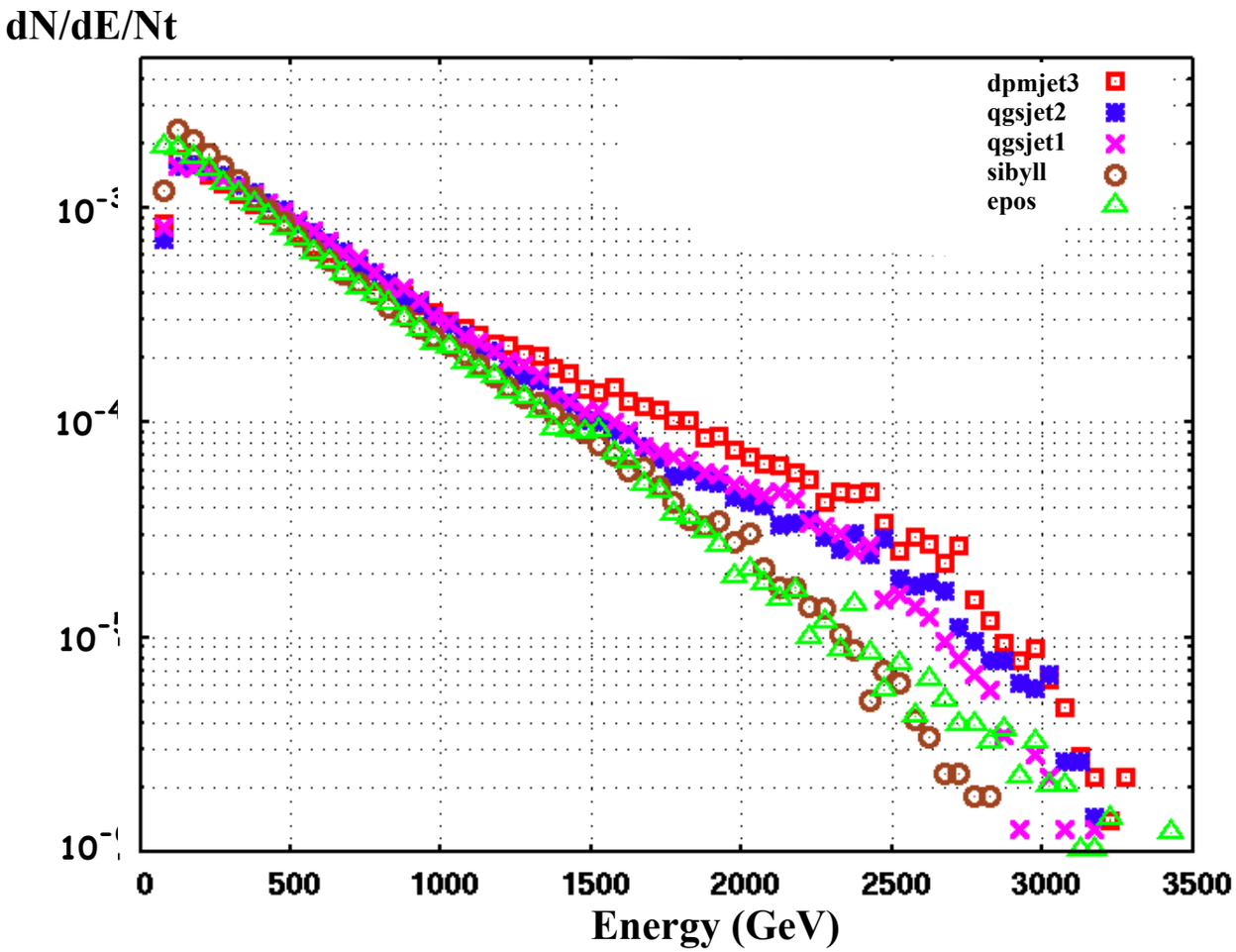


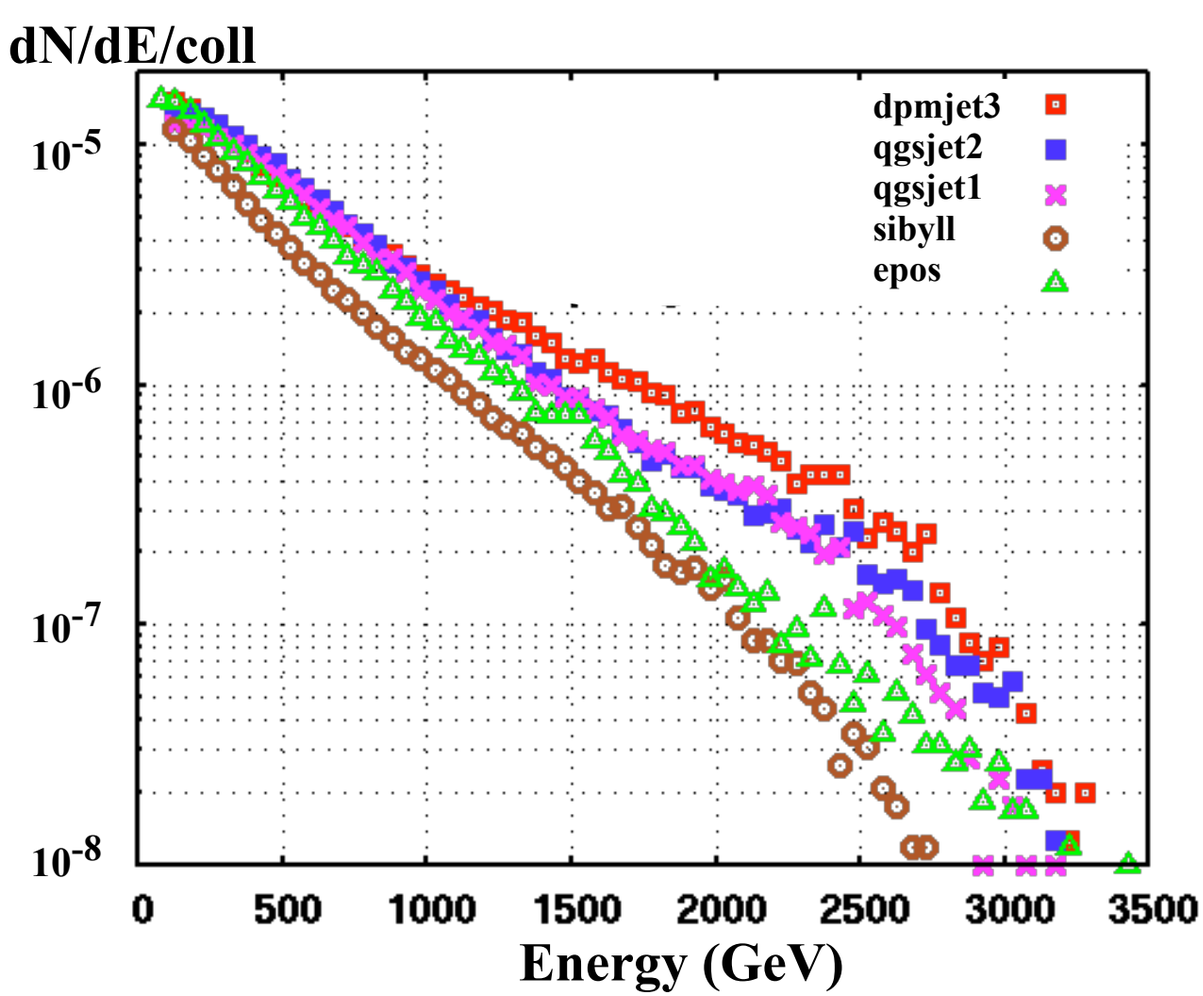
η / π^0 would be useful for model selection

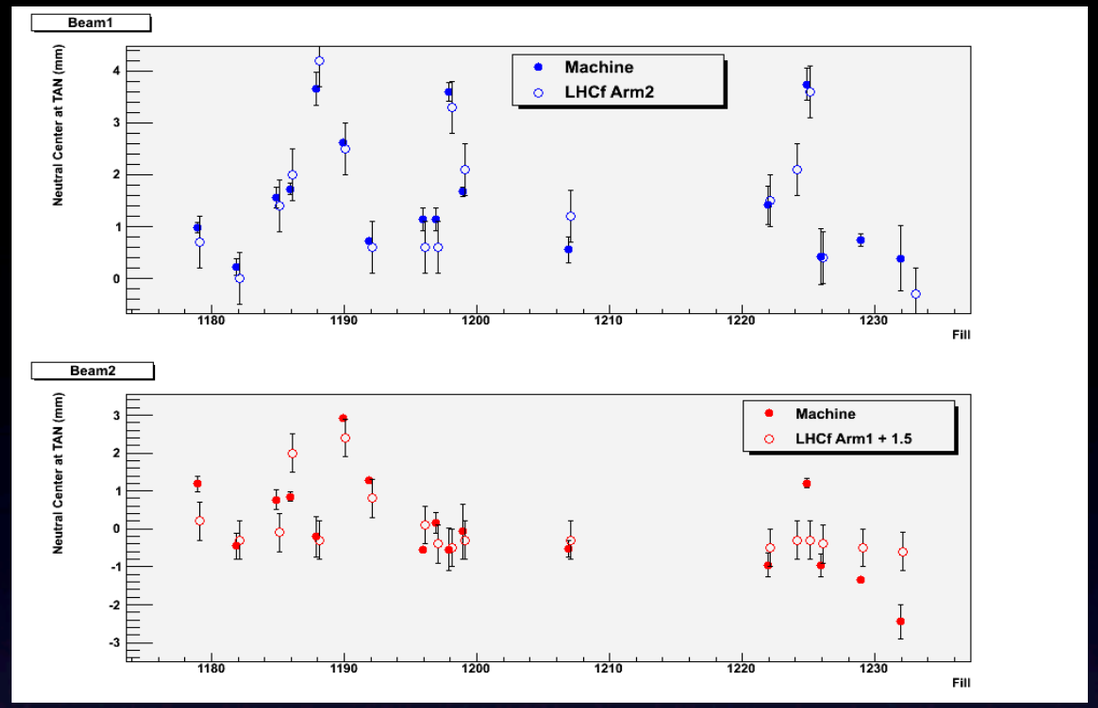
7TeV (3.5TeV + 3.5TeV)
Single gamma on 2cmx2cm tower:

Prediction by various models

area normalization /collision







- Beam position
- Front count rate vs Luminosity
- Inelastic cross-section

Wait a bit for comparison with experiment

Summary

- LHCf has completed 0.9 and 7TeV runs
- Performance is as expected
- 7 TeV run result will appear soon and we will be able to tell the best models
  - Data in absolute scale
    - soft photon spectrum and hard neutron spectrum seems to be preferred
- We will be back to the tunnel when 7(or >5) TeV beam will be ready

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We thank CERN and all the related staff at CERN for the successful LHCf operation

Thank you for your attention