LHCf status report

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for the LHCf collaboration

LHCf Collaboration

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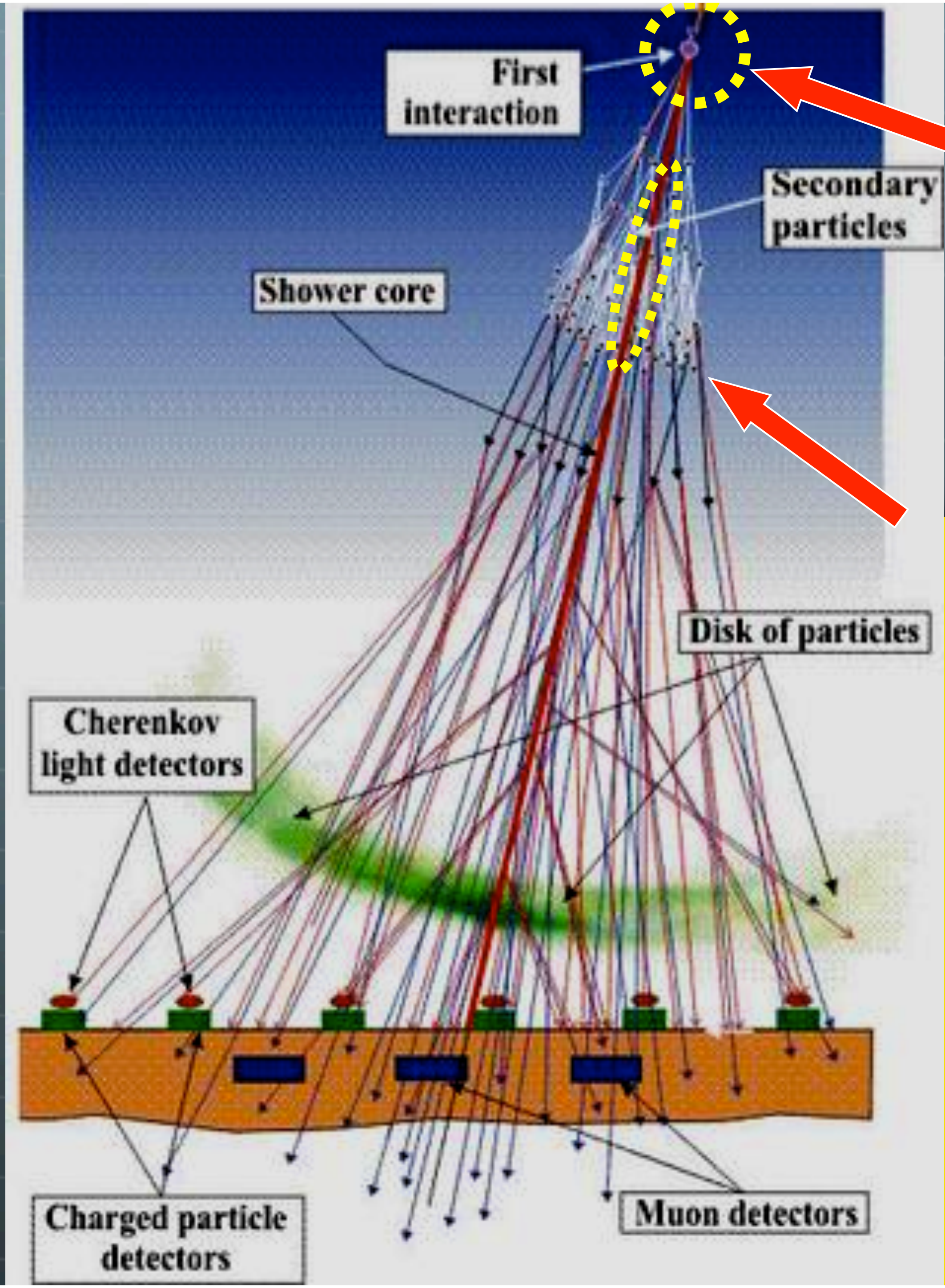
Contents

- What is LHCf ?
- High-lights in past 6 months
  - p-Pb operation (2.76TeV p-p)
  - Neutron analysis of 7TeV data
- Preparation for 13TeV p-p
- Summary



① Inelastic cross section

If large s
rapid development
If small s
deep penetrating

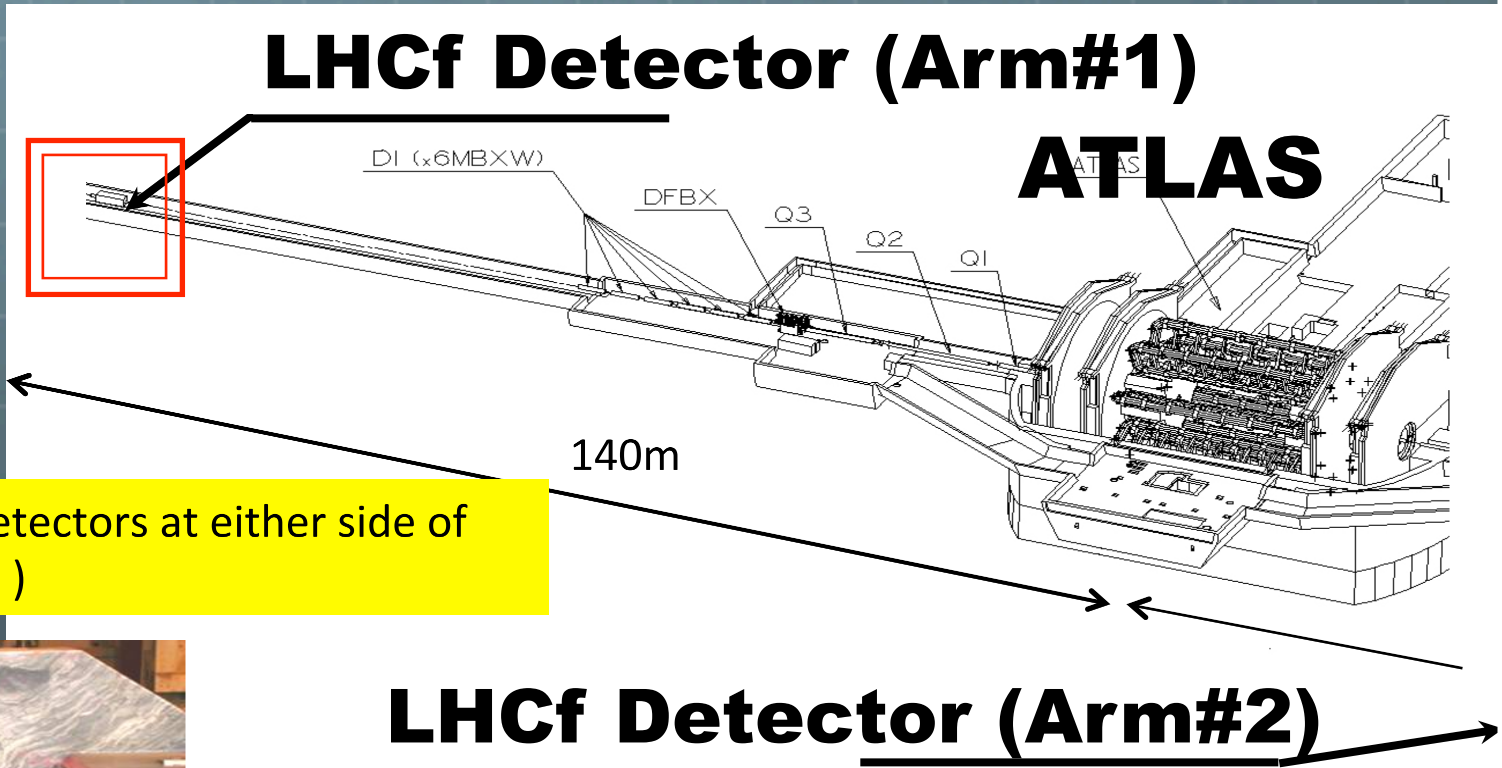
② Forward energy spectrum

If softer
shallow development
If harder
deep penetrating

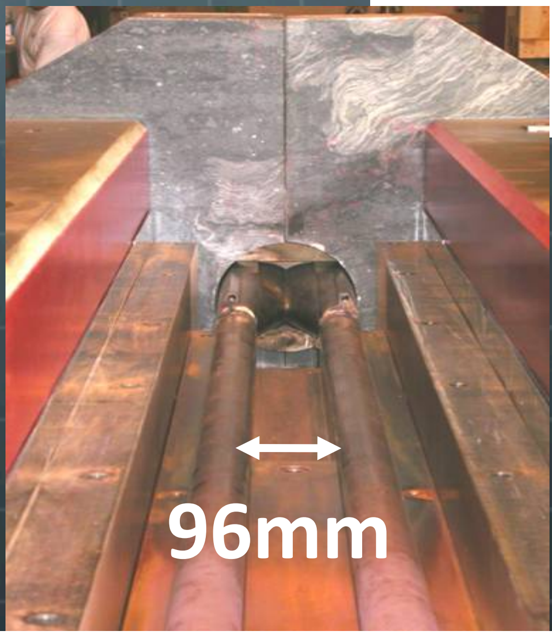
③ Inelasticity $k= 1-p_{lead}/p_{beam}$

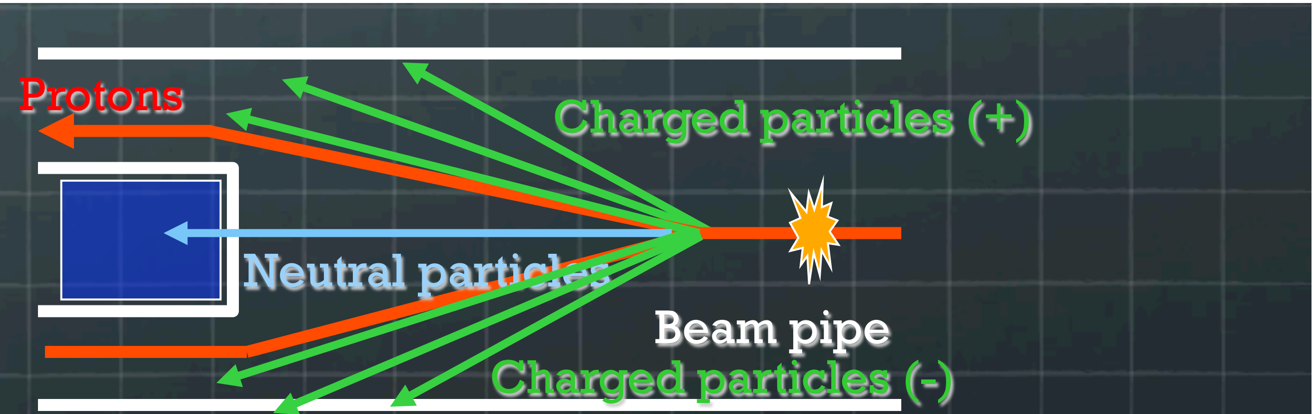
If large k
rapid development
If small k
deep penetrating

Detector Location



Two independent detectors at either side of IP1 (Arm#1, Arm#2)

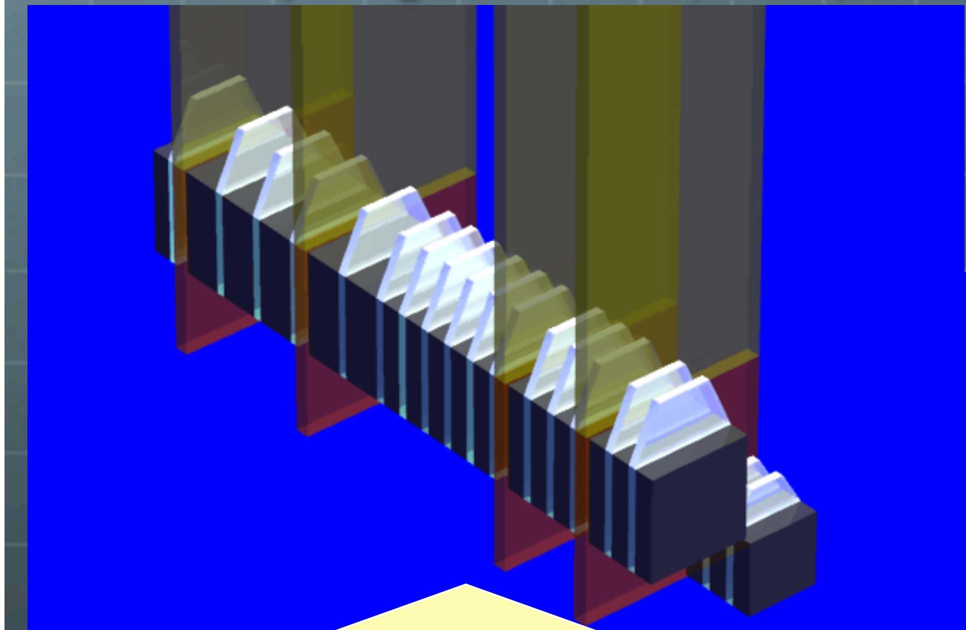




Neutral particles at η>8.4 are measured

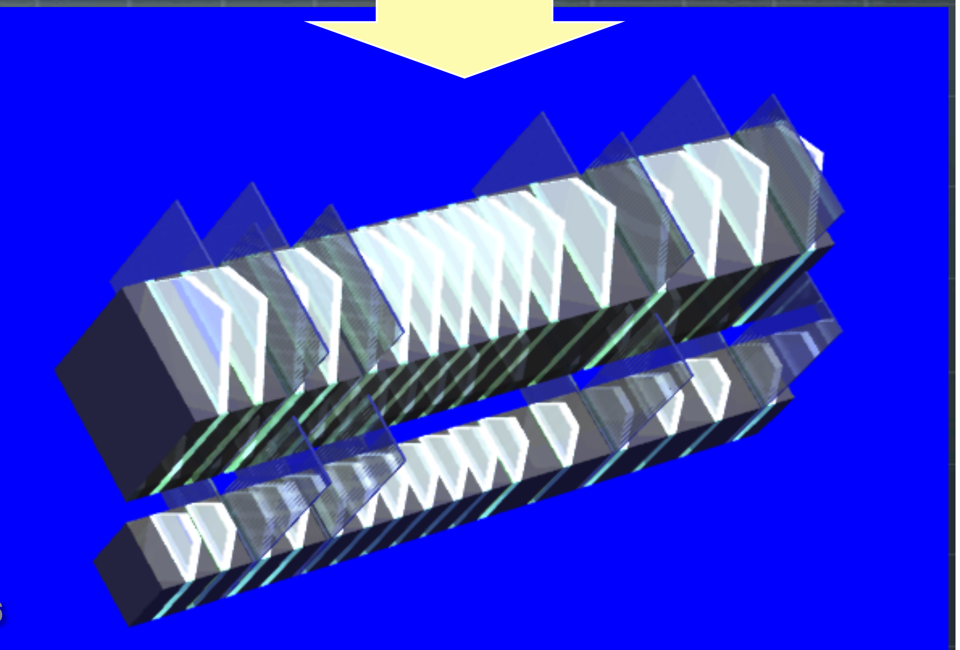
LHCf Detectors

- **Imaging sampling shower calorimeters**
- **Two independent calorimeters in each detector (Tungsten 44r.l., 1.6λ, sample with plastic scintillators)**

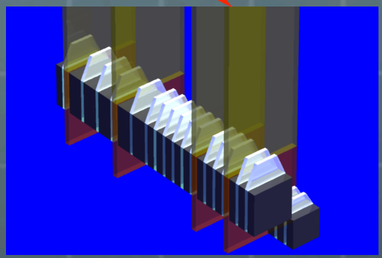


Arm#2 Detector
25mmx25mm+32mmx32mm
4 XY Silicon strip detectors

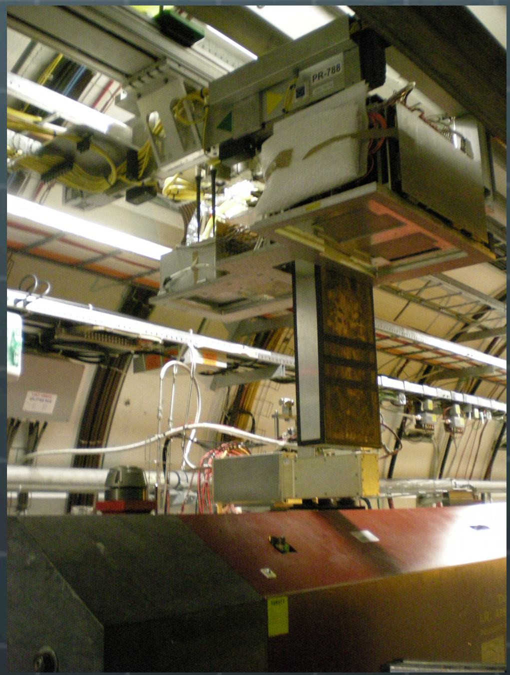
Arm#1 Detector
20mmx20mm+40mmx40mm
4 XY SciFi+MAPMT



Operation in Jan-Feb 2013

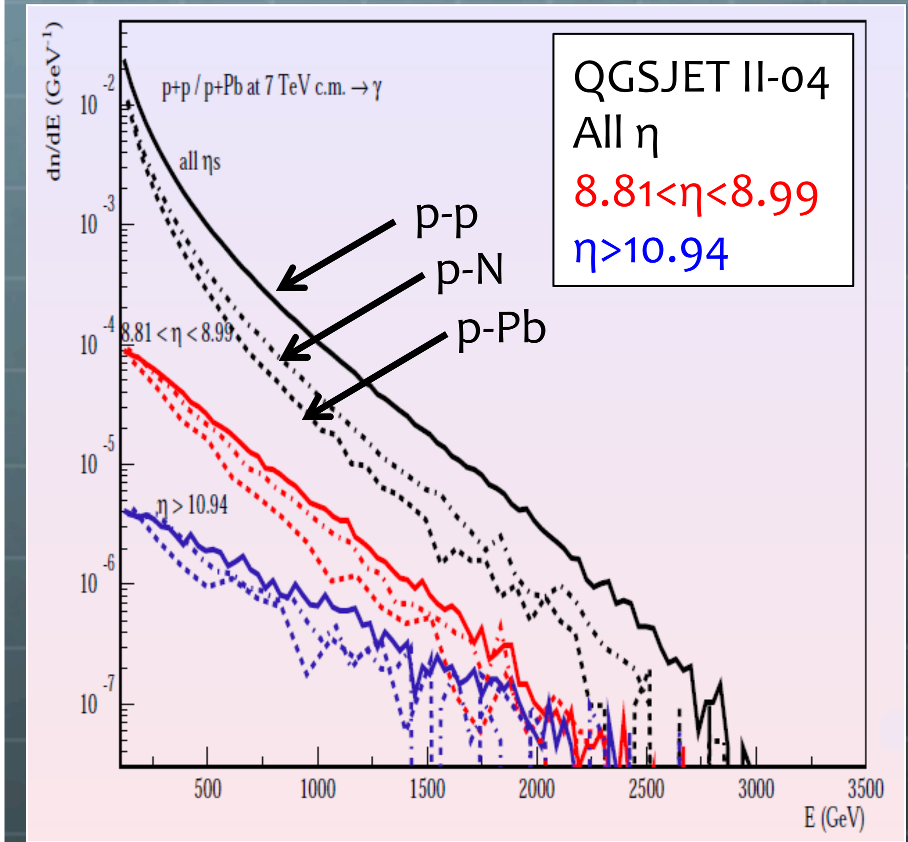


- p-Pb/Pb-p operation
  - One arm (Arm2) observation
  - p-remnant side (little Pb remnant)
  - Common trigger with ATLAS
- 2.76 TeV p-p operation
  - Unscheduled, but thanks to the other groups and accelerator team

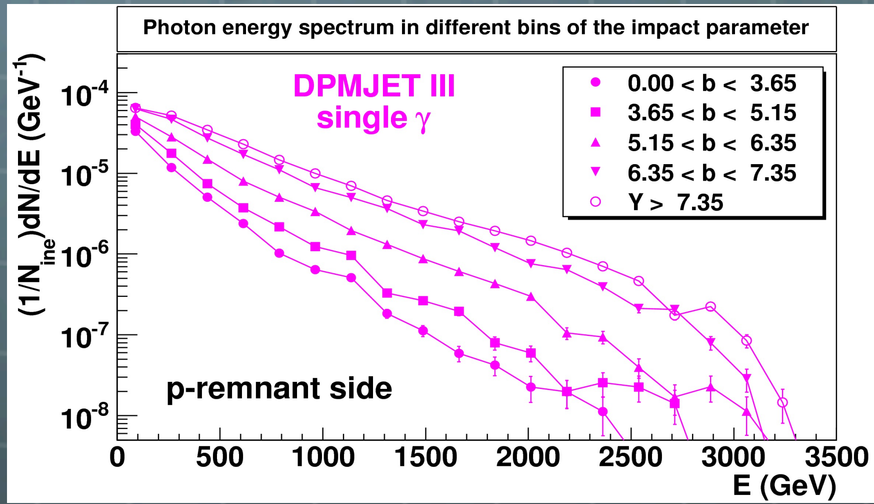


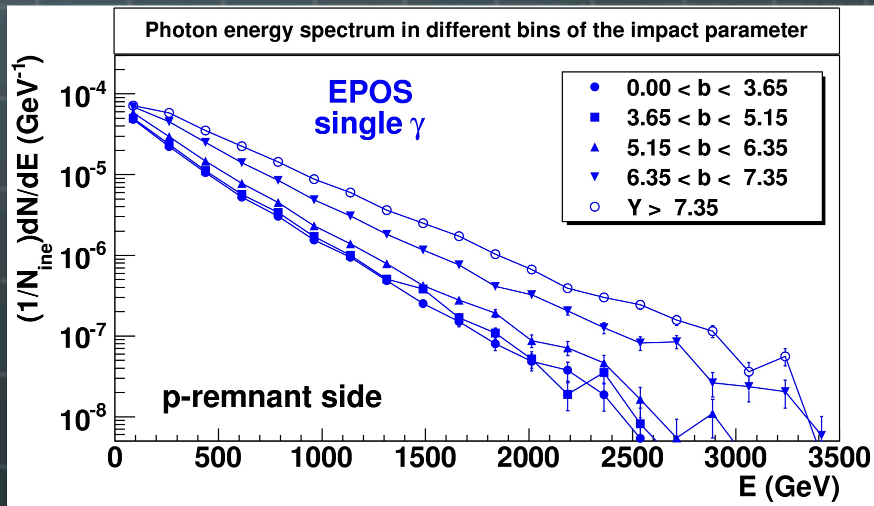
Successful reinstallation on 18-Dec-2012

Physics in pA



Photon spectra at different η in p-p, p-N and p-Pb collisions
Is p-Pb good test for p-atmosphere?
(Courtesy of S.Ostapchenko)

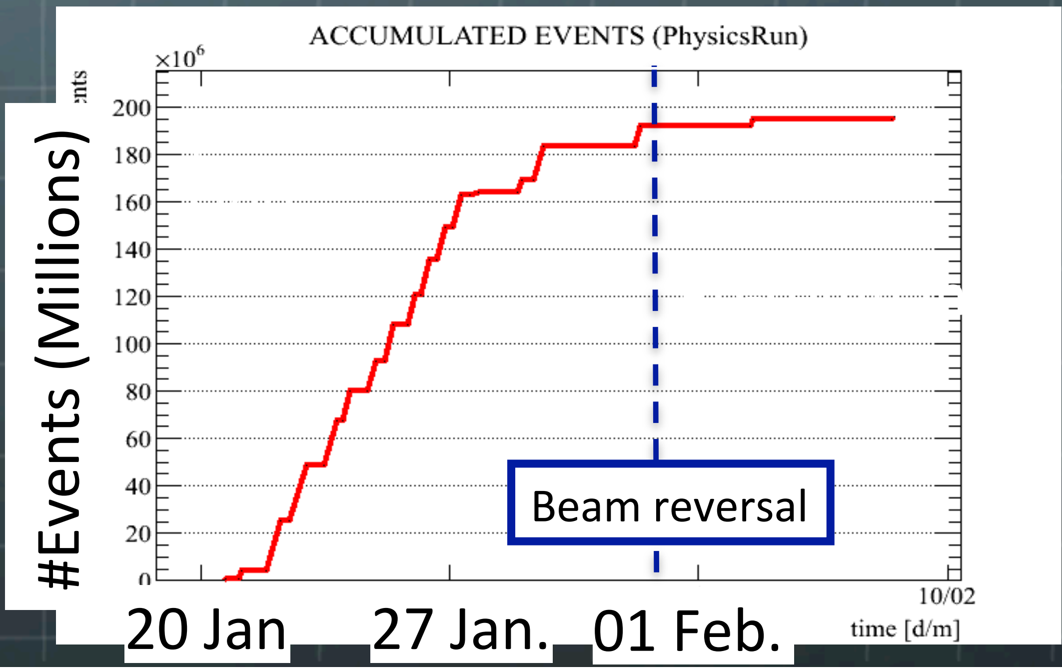


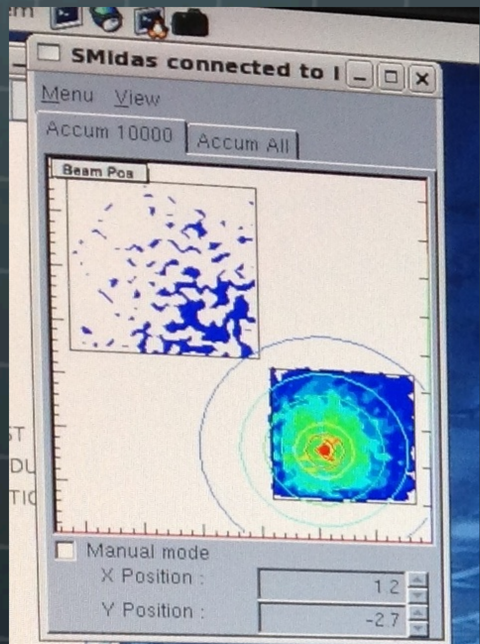


Nuclear effect in the forward particle production
Photon spectra for different impact parameters

Run summary and Statistics

- L = $1x10^{29} – 0.5x10^{29} cm^{-2}s^{-1}$
- b^* =0.8m, 145μrad crossing angle
- 338p+338Pb bunches (min.ΔT=200ns), 296 colliding at IP1
- 10-20kHz trig rate downscaled to ~700Hz
- 20-40Hz ATLAS common trig. Coincidence seems successful





Run summary (detail)

LHCf - Summary table for data taking in 2013		Beam crossing angle (urad)		Detector vertical position (mm, 0=center)							Thresholds (mV)					PMT HV (V)		BPTX only (min bias)	Events	ATLAS filters for LHCf trigger
		290	170	0	-3	+5	+10	+15	+35	+40	-11	-13	-18	-24	-36	Normal	600			
p-Pb (p-remnant) 4 TeV/n	Pilot run	x		x								x				x			5.4 ´ 10^{5}	NoAlg
	Nominal run	x		x							x					x			2.4 ´ 10^{6}	NoAlg
		x		x								x				x			1.3 ´ 10^{8}	NoAlg + mbSpTrk
		x		x									x			x			2.4 ´ 10^{6}	NoAlg
		x		x										x		x			2.4 ´ 10^{6}	NoAlg
		x		x											x	x			2.4 ´ 10^{6}	NoAlg
		x		x								x					x		9.4 ´ 10^{6}	NoAlg + mbSpTrk
		x			x							x				x			9.2 ´ 10^{6}	NoAlg + mbSpTrk
		x				x						x				x			8.7 ´ 10^{6}	NoAlg + mbSpTrk
		x					x					x				x			6.9 ´ 10^{6}	NoAlg + mbSpTrk
		x						x				x				x			5.9 ´ 10^{6}	NoAlg + mbSpTrk
		x		x								x				x		x	2.2 ´ 10^{7}	NoAlg
Pb-p (Pb-remnant) 4 TeV/n	Nominal run	x								x		x				x			1.4 ´ 10^{6}	NoAlg + mbSpTrk
		x								x				x		x			4.8 ´ 10^{5}	NoAlg + mbSpTrk
		x								x					x	x			6.3 ´ 10^{5}	NoAlg + mbSpTrk
		x							x						x	x			3.2 ´ 10^{6}	NoAlg + mbSpTrk
p-p 1.38+1.38 TeV	Nominal run		x	x								x				x			9.7 ´ 10^{6}	NoAlg + mbSpTrk

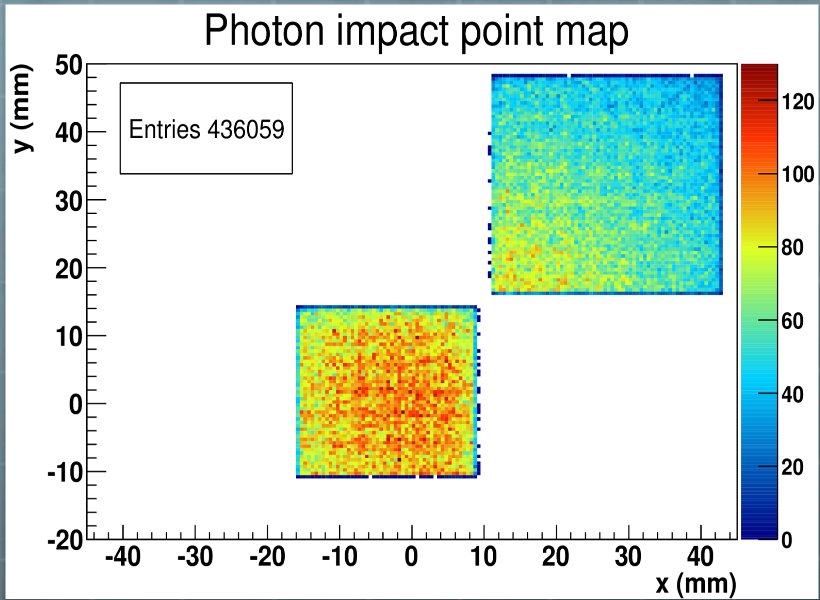
Position scan for p_T coverage

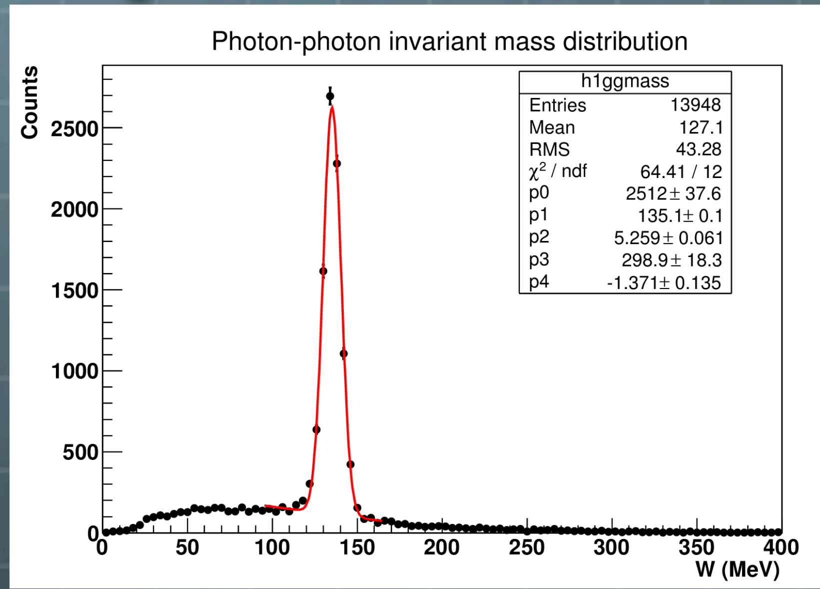
Threshold scan

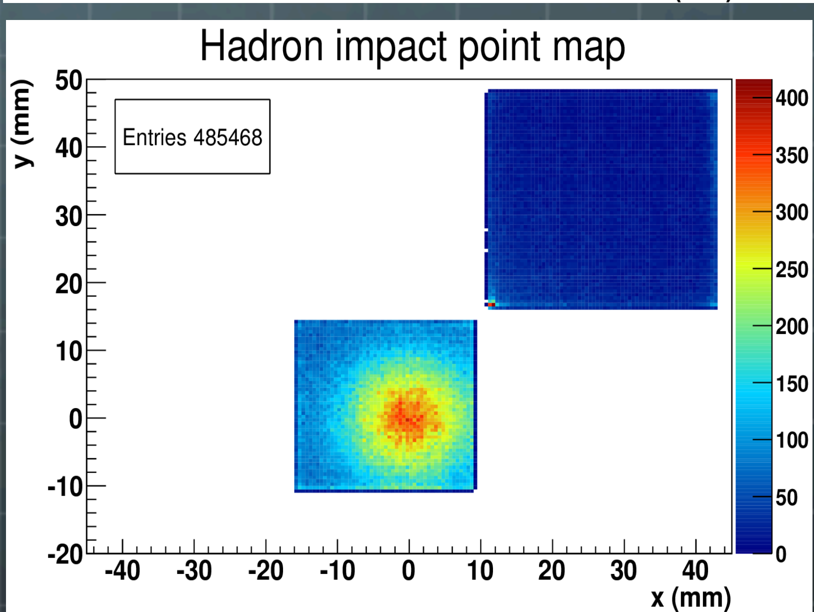
Gain scan

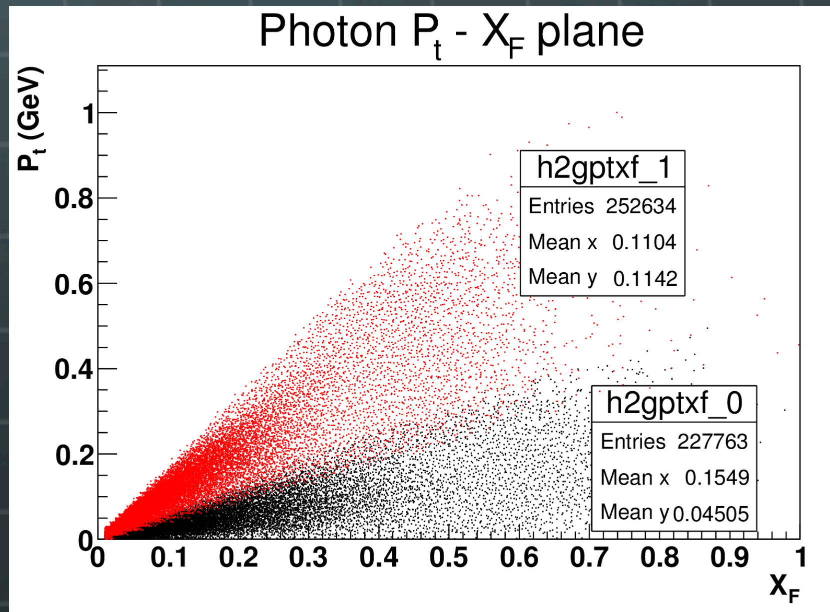
MB trigger

Data sample


Photon impact point map
Entries 436059
y (mm)
x (mm)

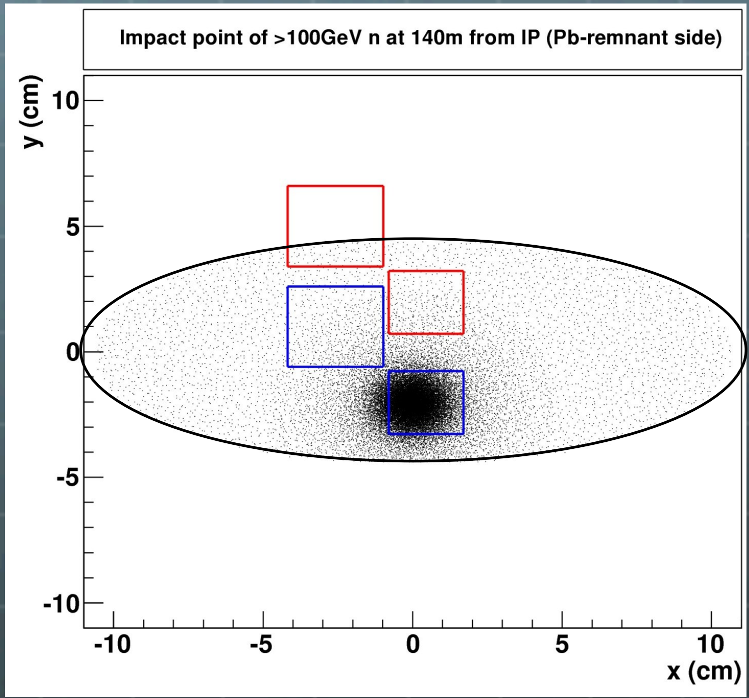

Photon-photon invariant mass distribution
h1ggmass
Entries 13948
Mean 127.1
RMS 43.28
χ^2 / ndf 64.41 / 12
p0 2512± 37.6
p1 135.1± 0.1
p2 5.259± 0.061
p3 298.9± 18.3
p4 -1.371± 0.135
Counts
W (MeV)

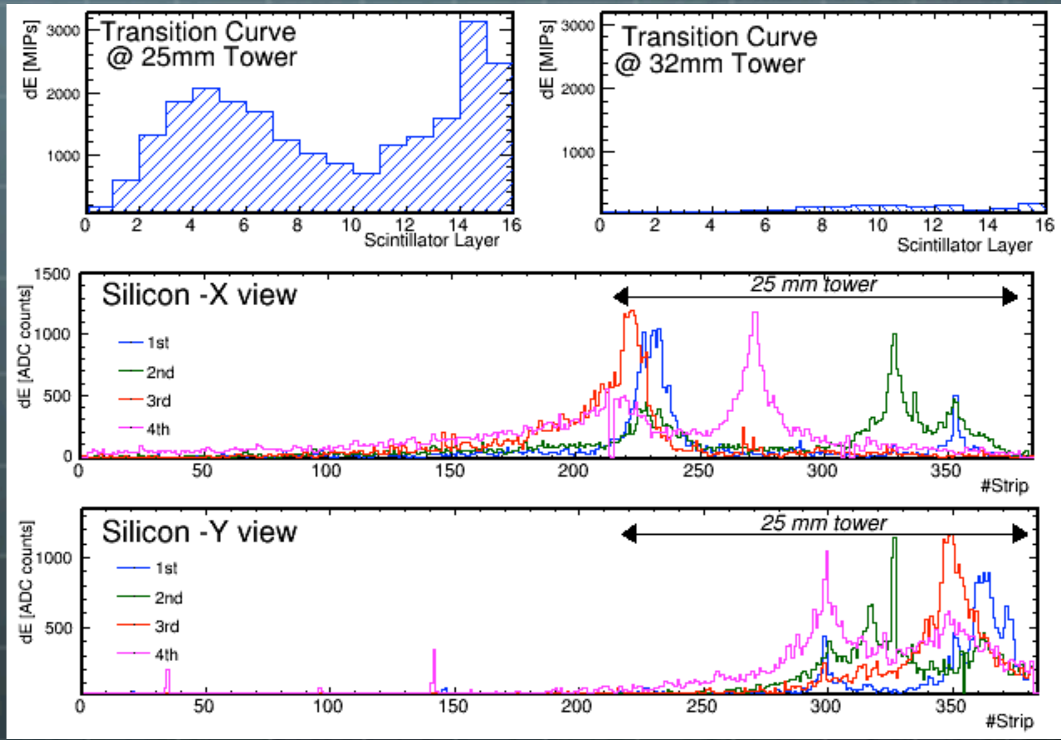

Hadron impact point map
Entries 485468
y (mm)
x (mm)


Photon P_t - X_F plane
h2gptxf_1
Entries 252634
Mean x 0.1104
Mean y 0.1142
h2gptxf_0
Entries 227763
Mean x 0.1549
Mean y 0.04505
P_t (GeV)
X_F

High-multiplicity event sample (in Pb-p)

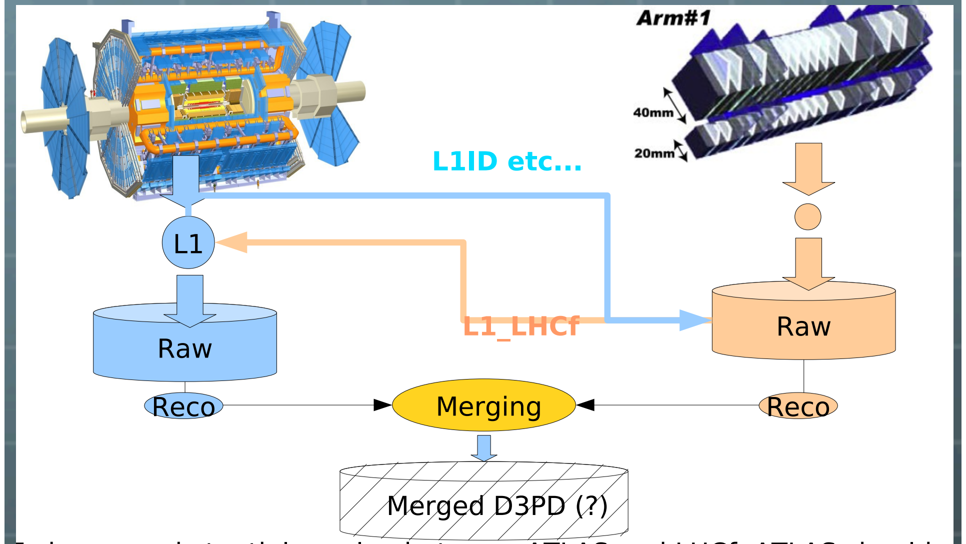
MC (Pb-remnant)

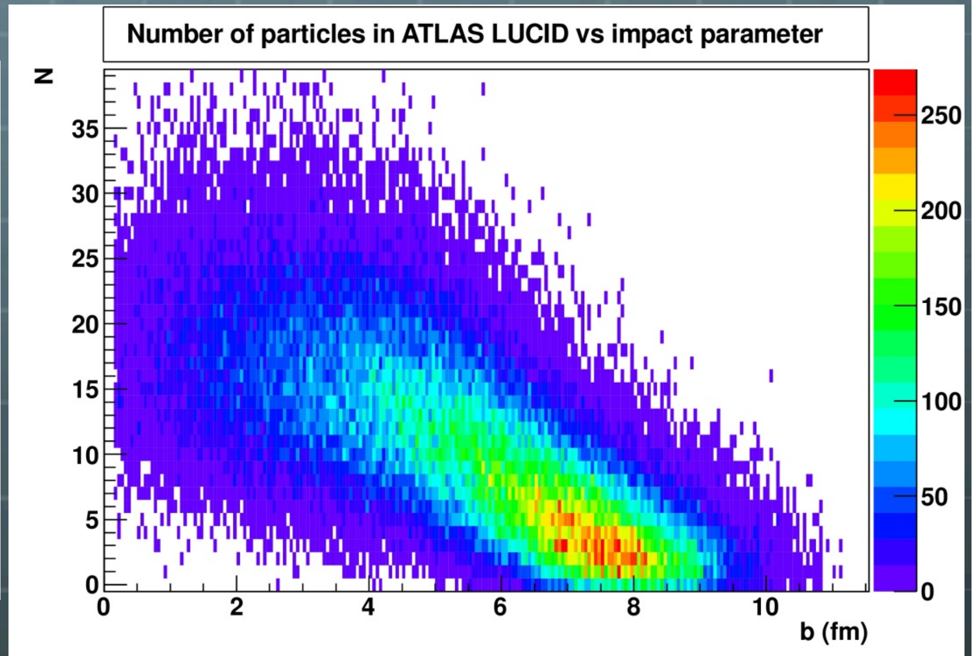




- **Analysis, coming …**

Common trigger with ATLAS





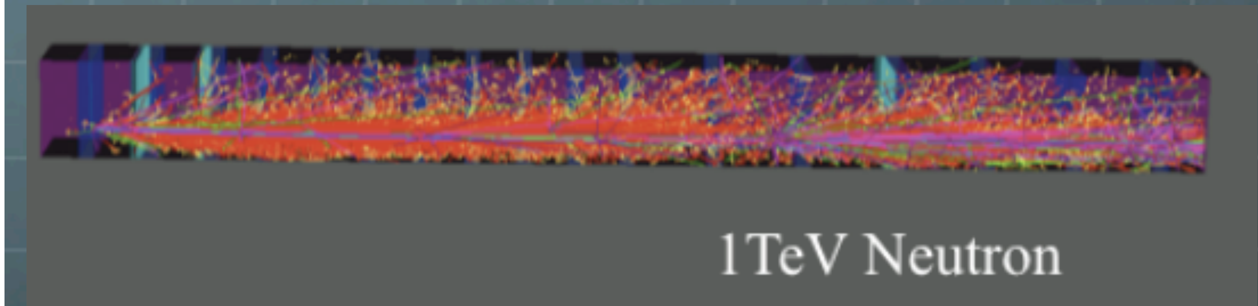
MC; impact parameter vs. # of particles in LUCID

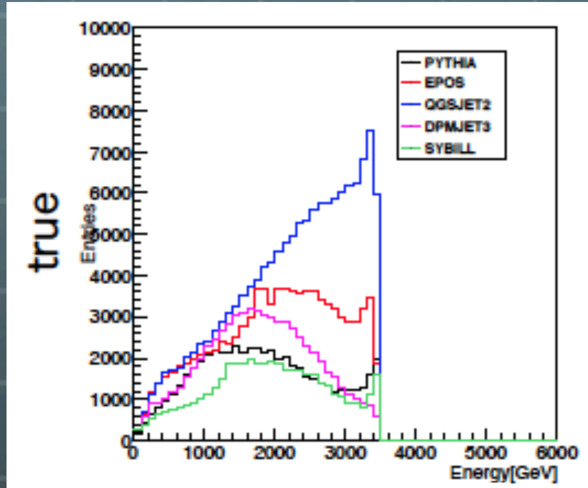
- **LHCf forced to trigger ATLAS**
- **Impact parameter may be determined by ATLAS**
- **Identification of forward-only events**

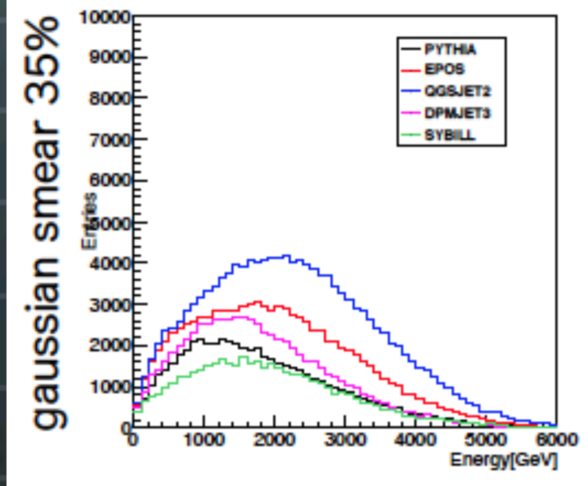
Neutron analysis

- Analysis of 7TeV p-p data obtained in 2010 (using 1 nb^{-1} data)
- Constrain 'elasticity' in the air shower development
- Detector response study (Arm1 here)
  - MC validation at SPS energy
  - Resolution (energy, position)
  - Preliminary results (folded)
- To do list before publication

LHCf as hadron calorimeter

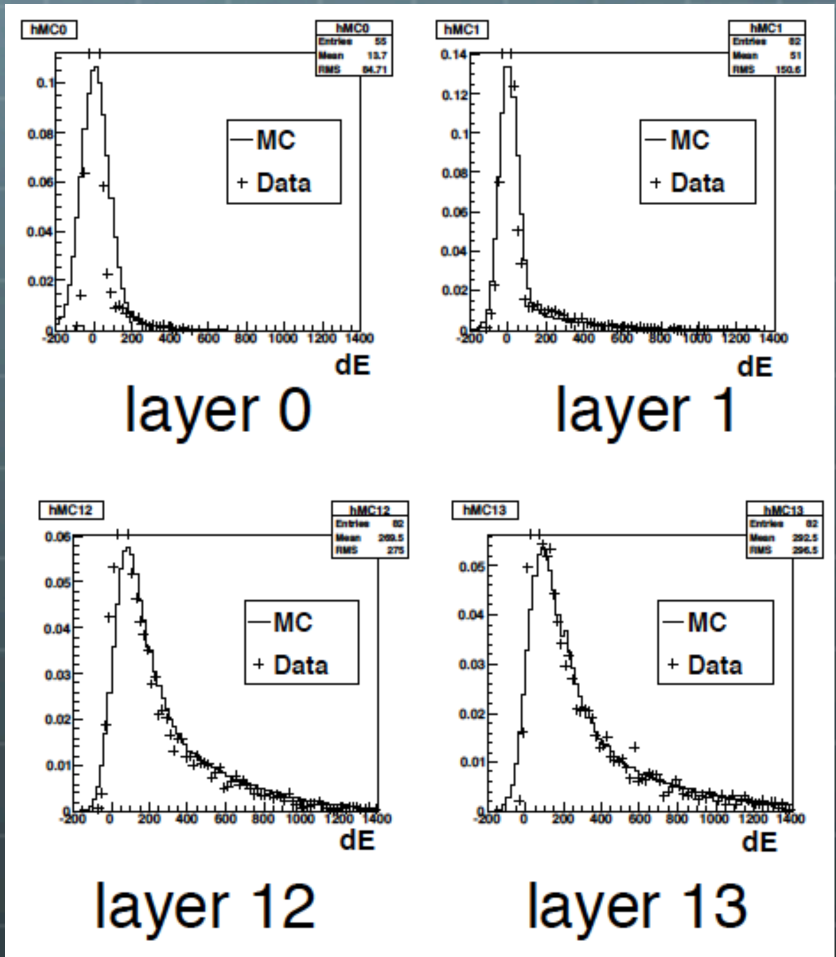




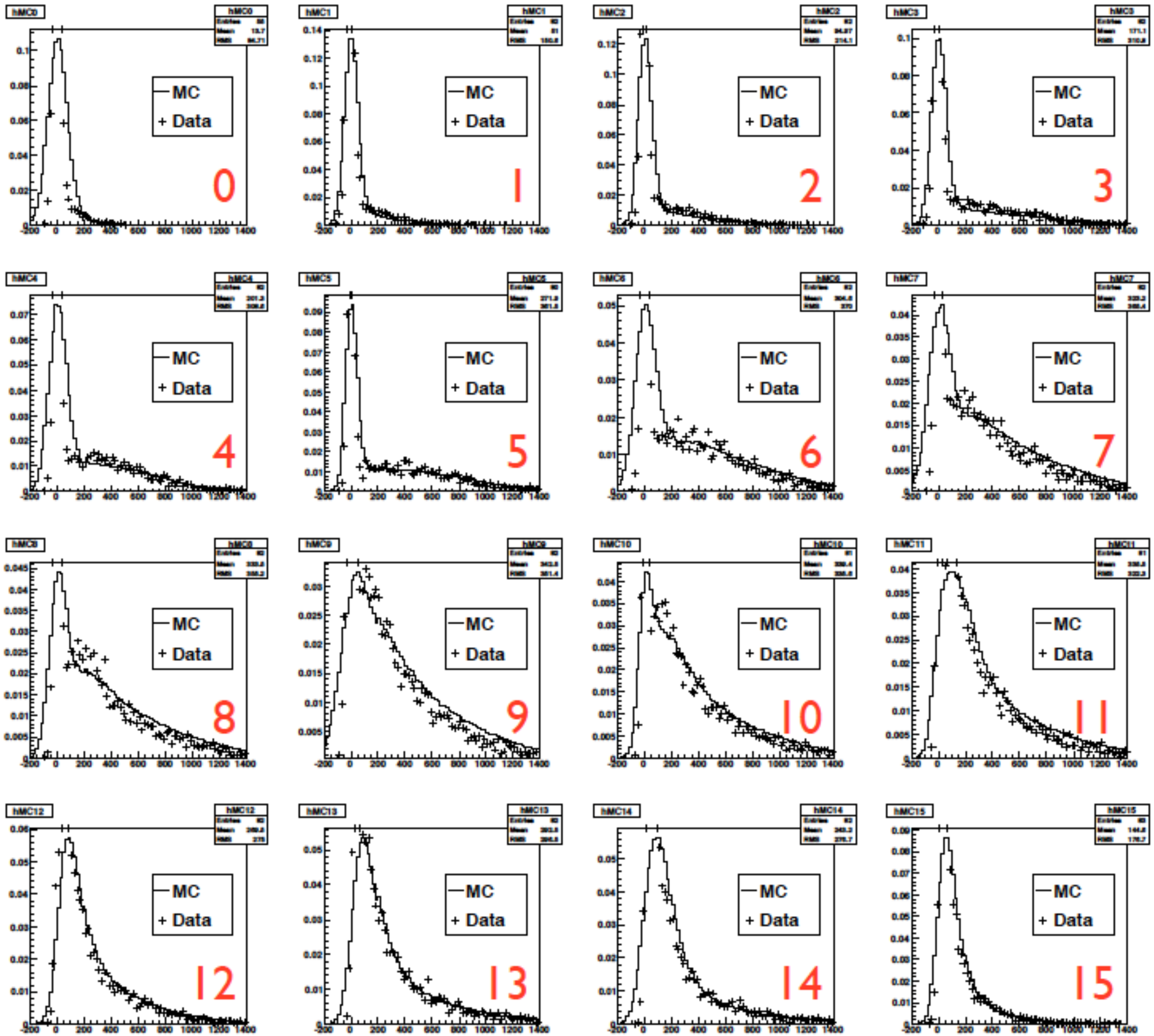


- **44 r.l. of tungsten = 1.6 hadron int. lengths**
- **Large leakage of shower particles; ~35% energy resolution**
- **Detector response is also model dependent**

Detector simulation
SPS data vs MC

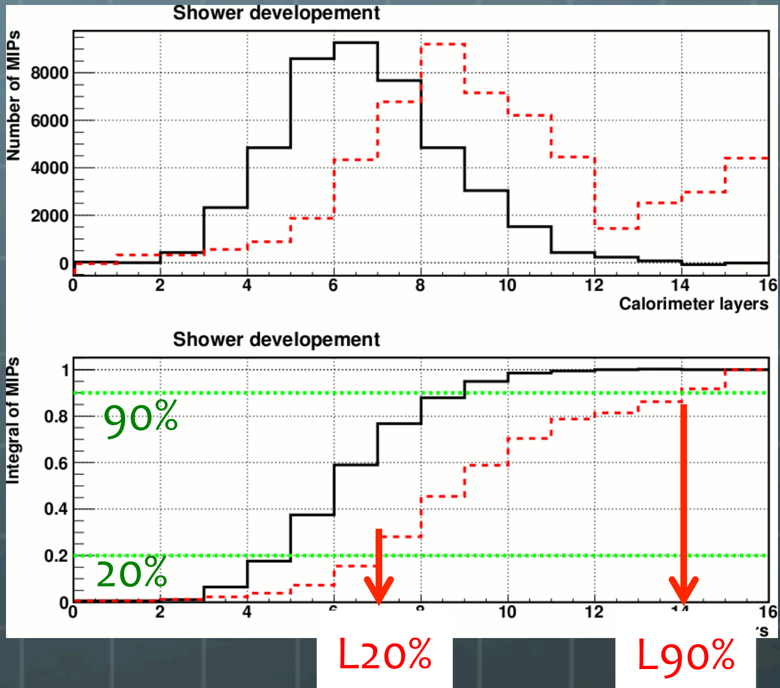


- **Data; SPS 350GeV proton shower**
- **Absolute energy was calibrated with electron shower data**
- **MC; Detector simulations using QGSJET II model**
- **Layer-by-layer comparison of dE** (all layers next slide)

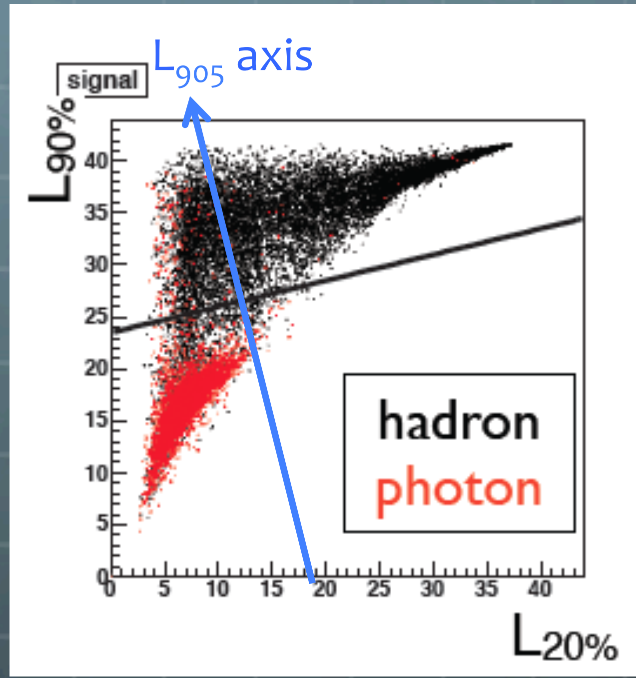


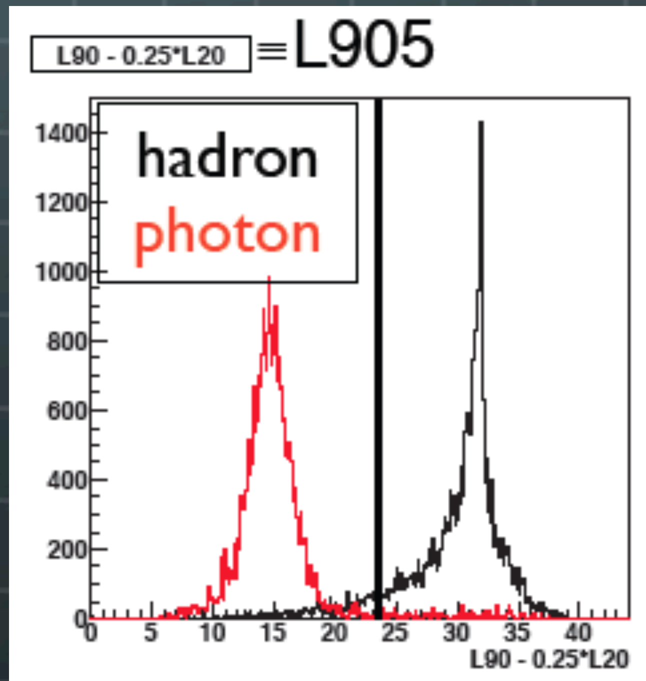
hMC0
MC
Data
0
hMC1
1
hMC2
2
hMC3
3
hMC4
4
hMC5
5
hMC6
6
hMC7
7
hMC8
8
hMC9
9
hMC10
10
hMC11
11
hMC12
12
hMC13
13
hMC14
14
hMC15
15

Particle ID (EM vs. hadron)

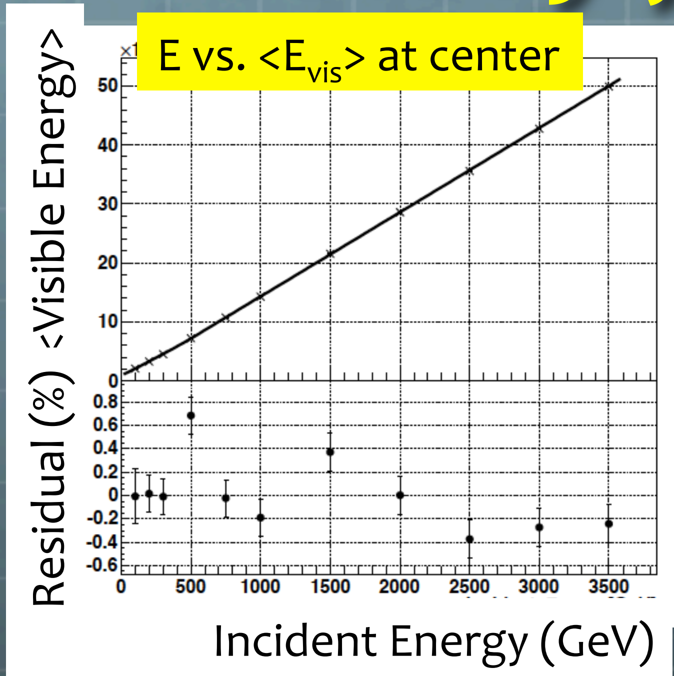


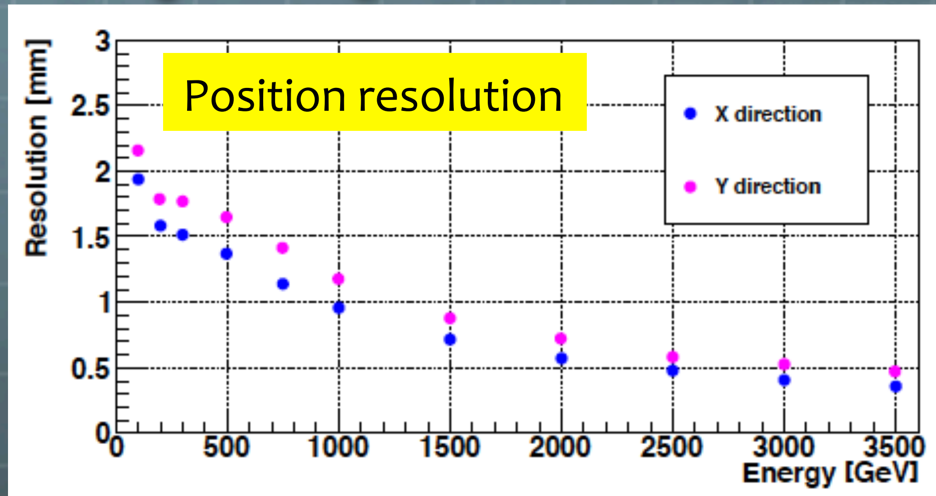
- Shower depth is parameterized by L20%, L90%
- Event selection in L20%-L90% plane

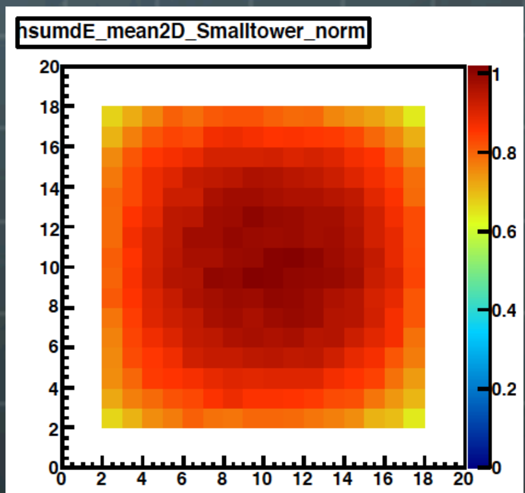




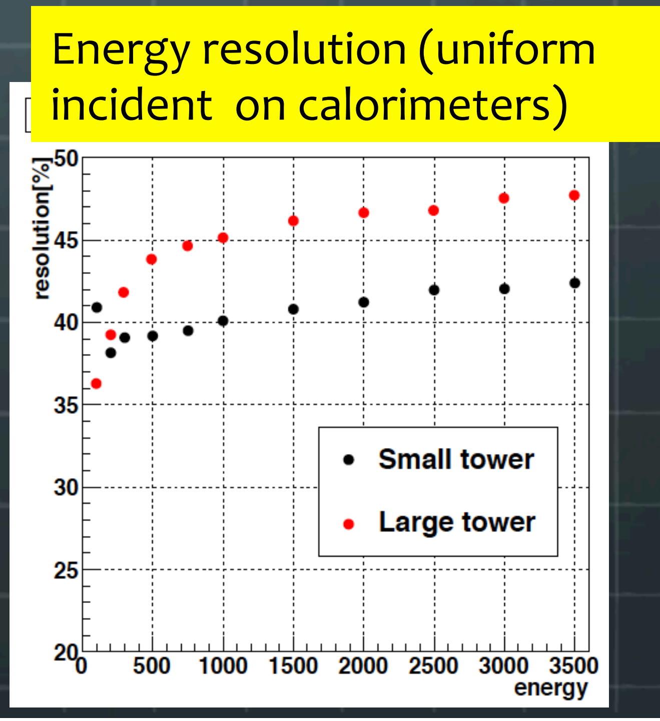
MC study for performance





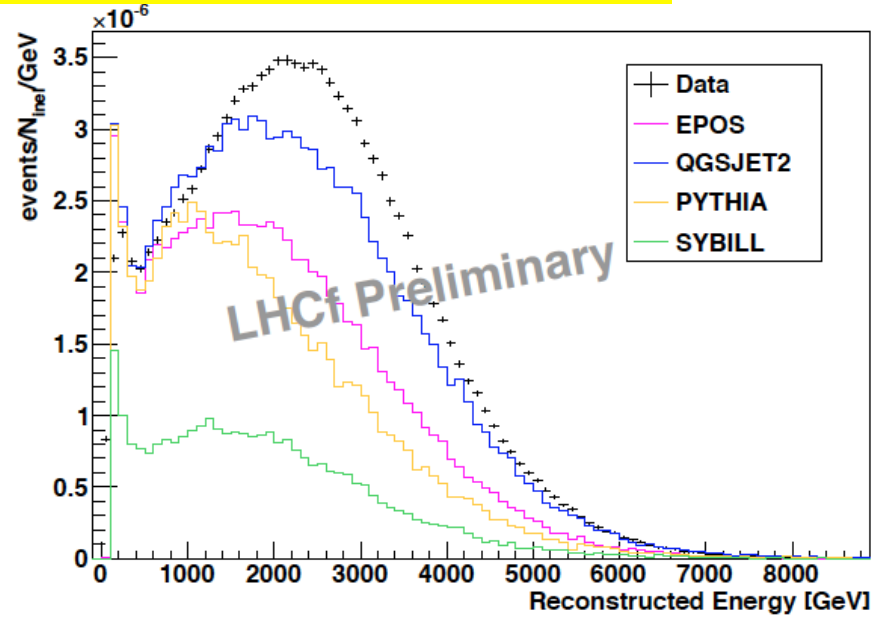


Correction for position dependent shower leakage

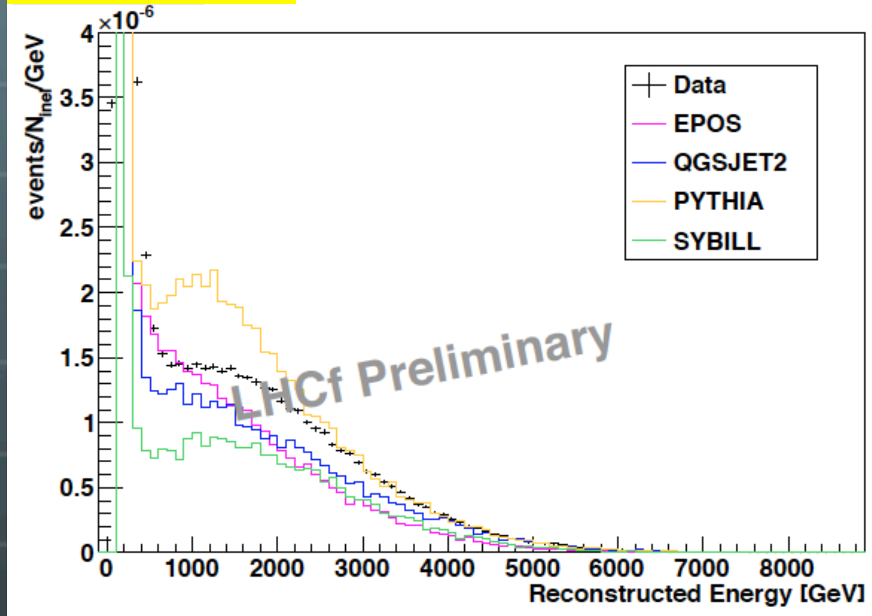


Neutron spectra, LHC 7TeV results (preliminary)

Small tower including 0 degree



Large tower



- Arm1 results only
- Models; full detector simulation using QGSJET II and same analysis as data are applied
- Detector response NOT unfolded
- Stat. error only

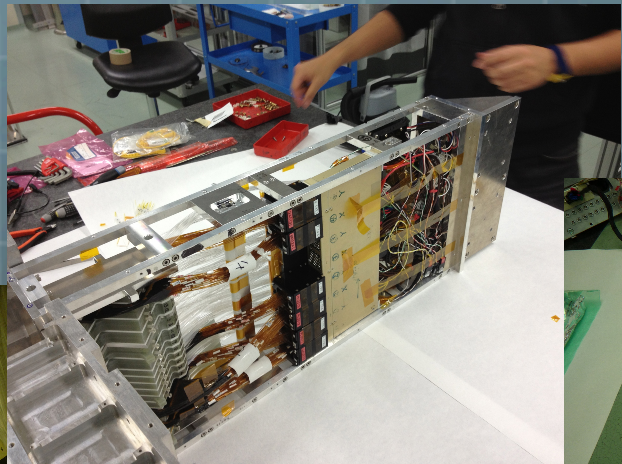
Neutron analysis to do

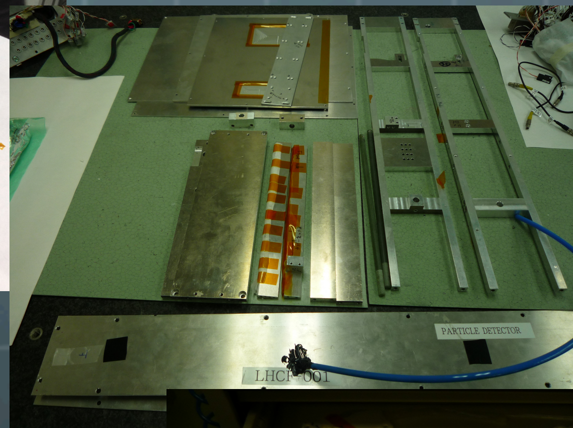
- Arm2 analysis
- Select best model for detector MC (based on SPS)
- Unfolding detector response
- Systematic error estimate

Upgrade for 13 TeV

- Basic Ideas
  - Plastic scintillators => GSO scintillators
  - SciFi => GSO bars
  - Silicon strip => Doubling dynamic range, relocation for better energy measurement
- Arm1
  - All scintillators, 5/8 of GSO bar channels were ready to test for shower measurements at SPS in 2012 summer
  - 100% ready and to be tested at HIMAC (heavy ion beam facility) in 2013 winter
- Arm2
  - Component 100% ready and to be tested at HIMAC in July
- Early 2014, final assembly in Florence
- End of 2014, beam test at SPS => install to LHC

Dismounted detector





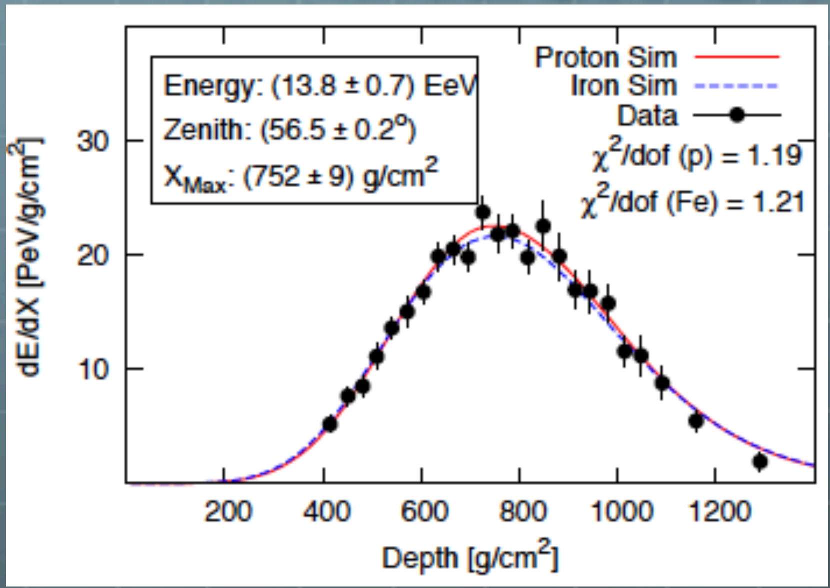
- Reassembly with GSO
- Heavy ion beam exposure in 2013
- Final assembly and SPS beam test in 2014 (end of LS1)

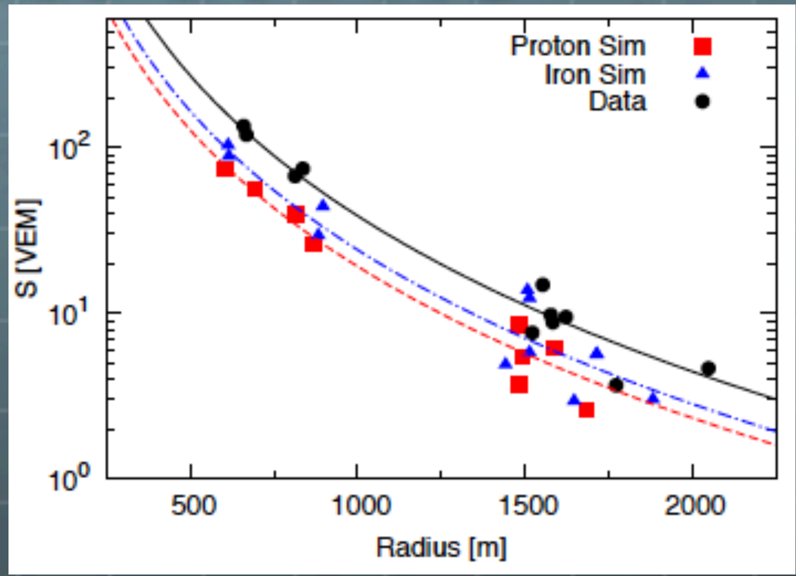
Summary

- LHCf took data at p-Pb collision in Jan-Feb 2013 with the Arm2 detector
  - First forward measurement at p-A collision
  - Combined data with ATLAS allows analysis for b-dependence and diffractive events.
- LHCf is analyzing forward neutron spectra from the 7TeV p-p data
  - Analysis chain is established and first comparison between data and generator predictions is presented
  - Analysis of Arm2, unfolding, systematic error estimation will be done
- LHCf is preparing for 13TeV p-p run after LS1
  - All tests of GSO scintillators will be finished in 2013
  - Last beam test at SPS and reinstallation to LHC in the end of 2014

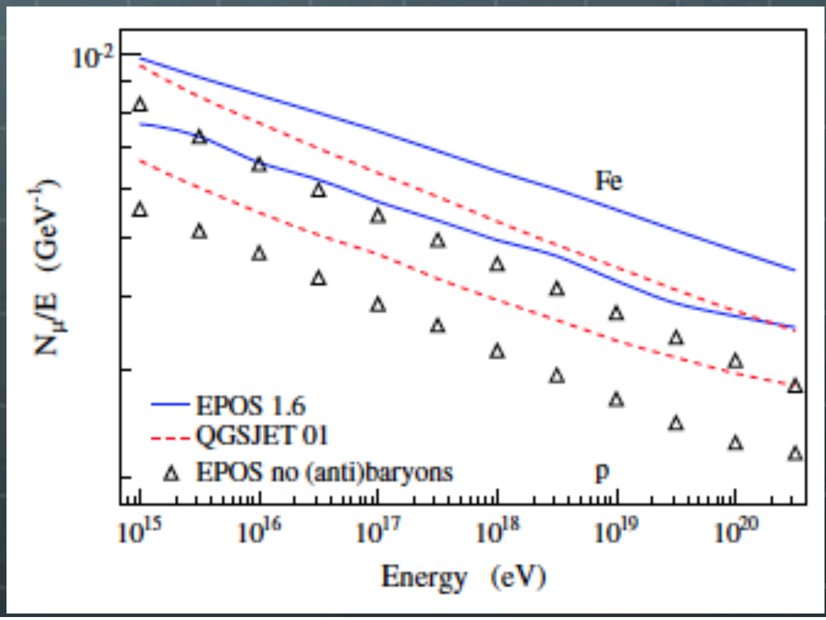
Backup

Muon excess at PAO





Pierre Auger Collaboration, ICRC 2011 (arXiv:1107.4804)



PAO hybrid analysis

event-by-event MC selection to fit FD data (top-left)

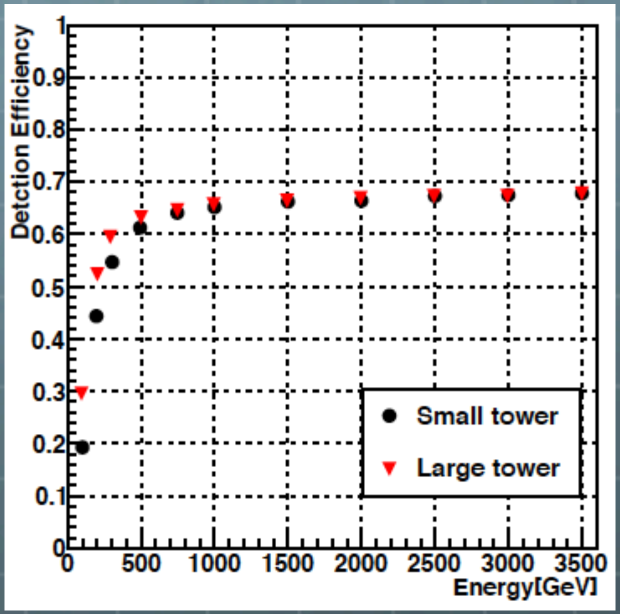
comparison with SD data vs MC (top-right)

muon excess in data even for Fe primary MC

EPOS predicts more muon due to more baryon production

=> importance of baryon measurement

Pierog and Werner, PRL 101 (2008) 171101


Detction Efficiency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 500 1000 1500 2000 2500 3000 3500
Energy[GeV]
Small tower
Large tower