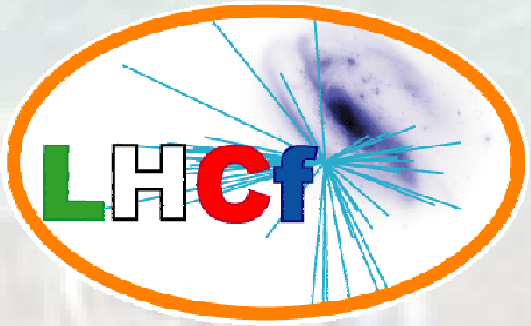
CERN, February 17th, 2010

LHCf status report



Oscar Adriani
Università degli Studi di Firenze
INFN Sezione di Firenze

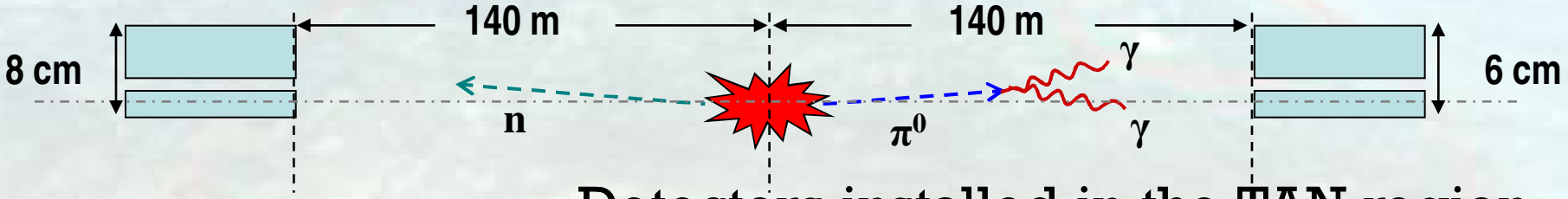
On behalf of the LHCf Collaboration

Experimental set-up

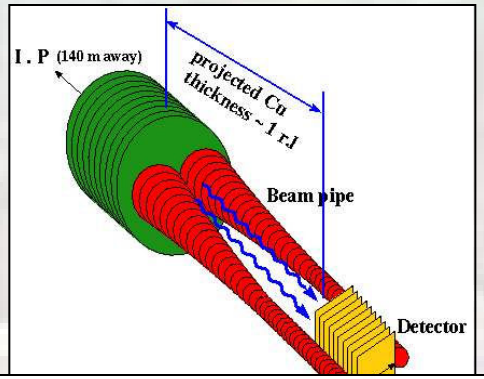
Detector I
Tungsten
Scintillator
Scintillating fibers

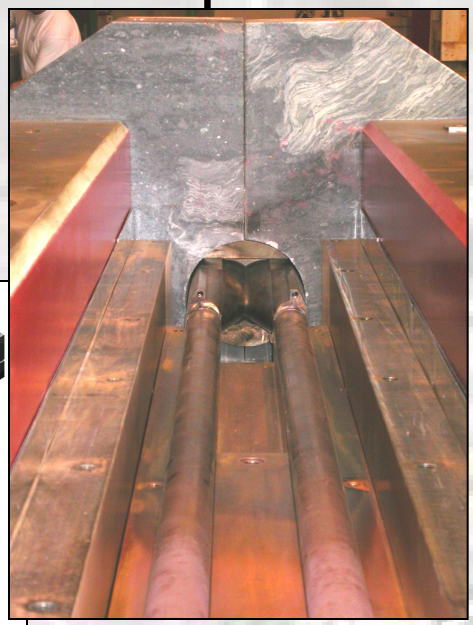
INTERACTION POINT
IP1 (ATLAS)

Detector II
Tungsten
Scintillator
Silicon μstrips

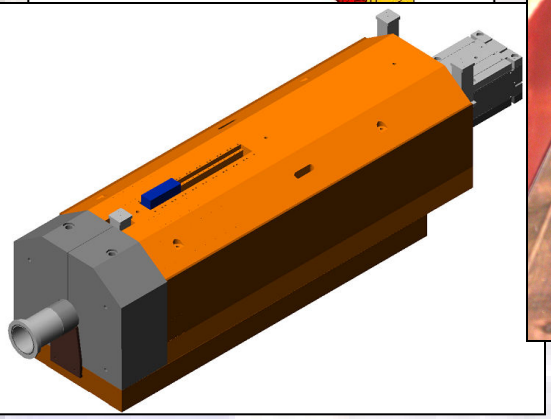


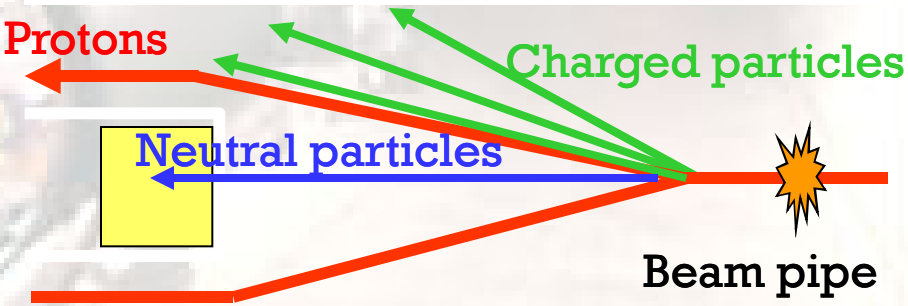
Detectors installed in the TAN region, 140 m away from the Interaction Point



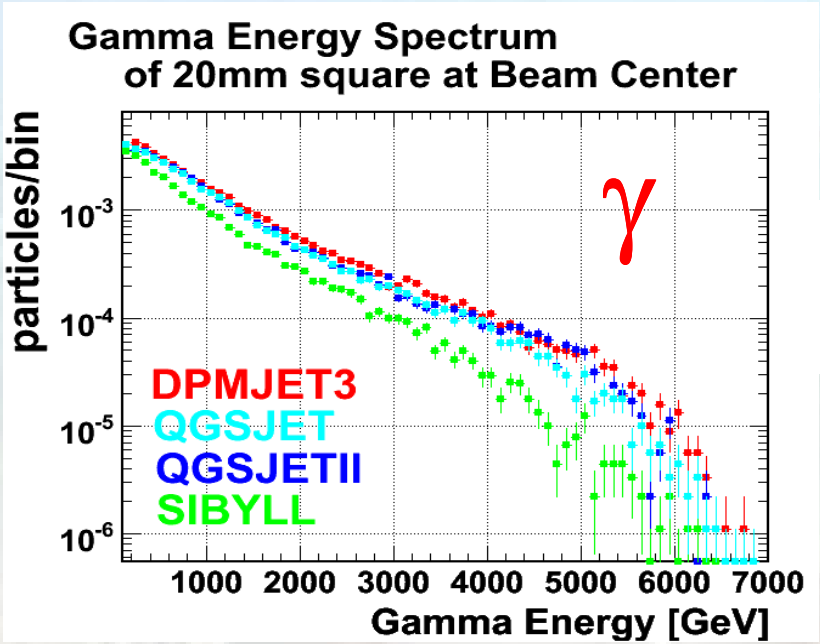


- Here the beam pipe splits in 2 separate tubes.
- Charged particle are swept away by magnets
- We cover up to y→∞



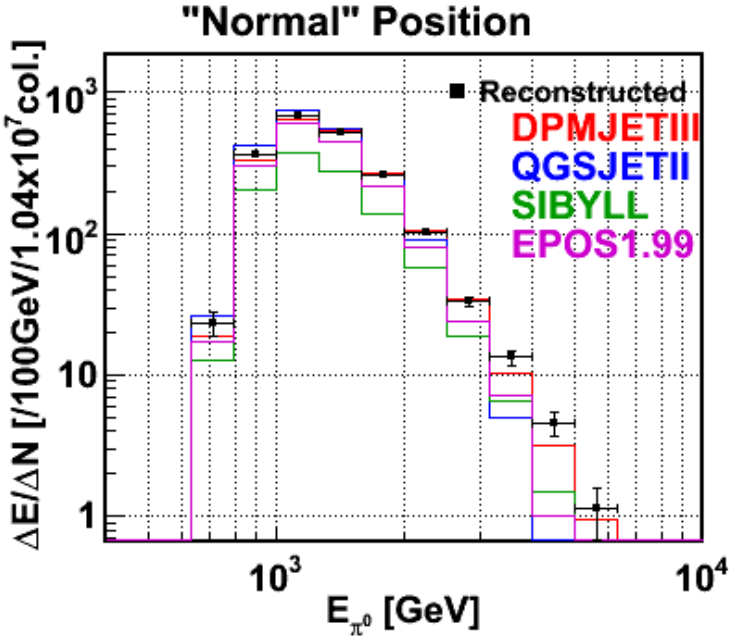


LHCf : Monte Carlo discrimination

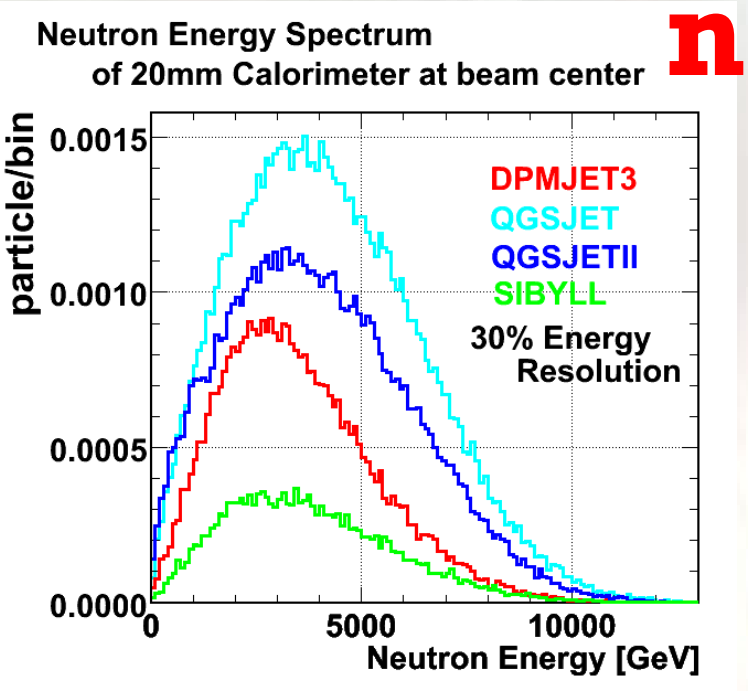


γ

$10^6/10^7$ generated LHC interactions at 7+7 TeV→
1 minute exposure@10^{29} $cm^{-2}s^{-1}$ luminosity



π^0

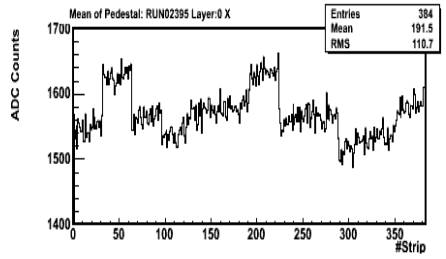


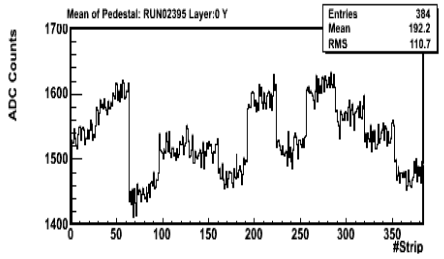
n

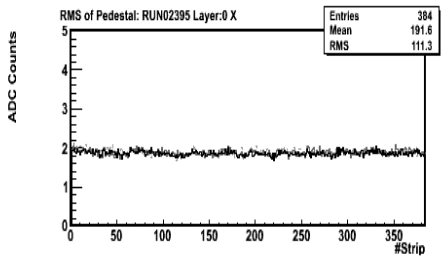
2009 LHC Operation: Very Good News!

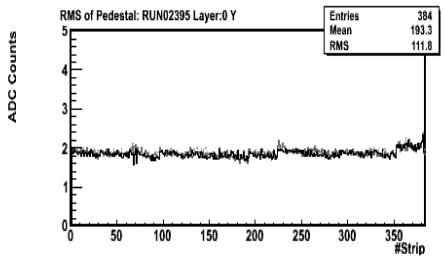
- From End of October 2009 LHC restarted operation
- 450 GeV + 450 GeV → 1.2 TeV + 1.2 TeV
- Exceptional effort and success from LHC!!!
- Few weeks of 'smooth' running allowed LHCf to collect some statistics at 450+450 GeV in stable beam conditions (Moving from garage to running position) ☺ ☺ ☺ ☺
- Extremely useful period to debug all the system
- No particular problem came out from the run
- Detectors are working very well and in a stable way

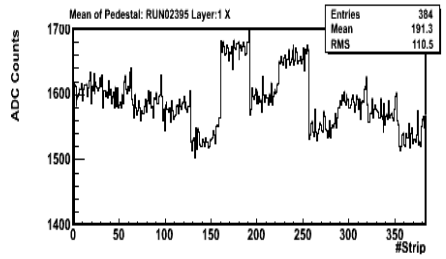
Pedestals and Sigma for silicon

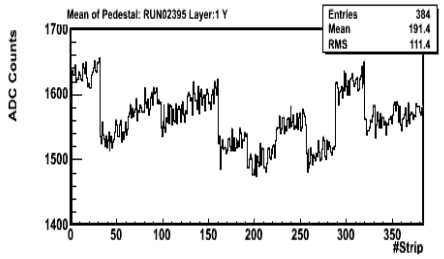


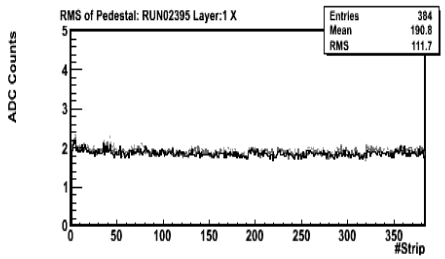


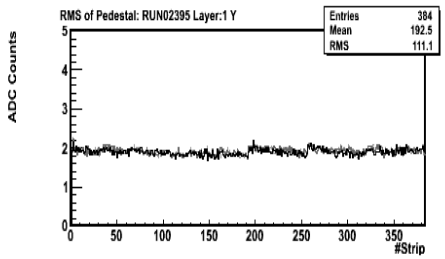


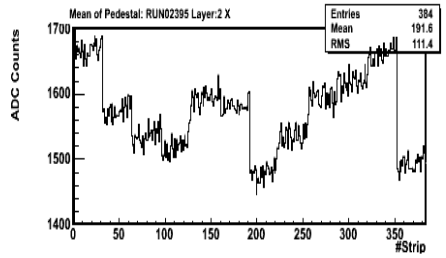


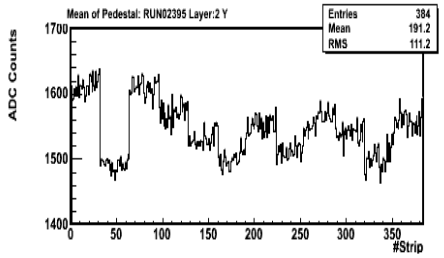


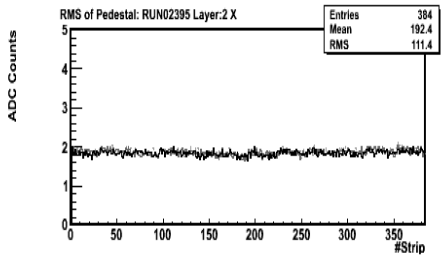


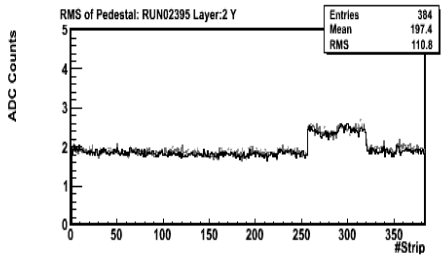


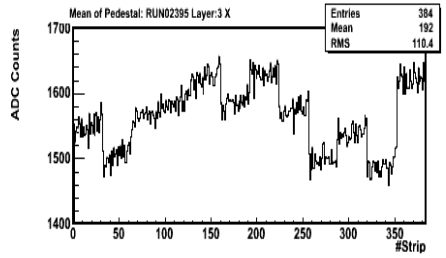


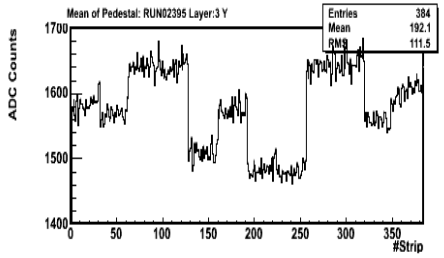


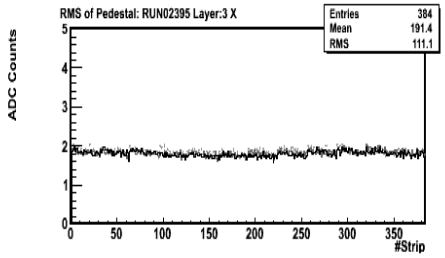


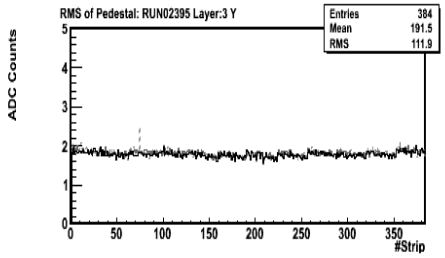








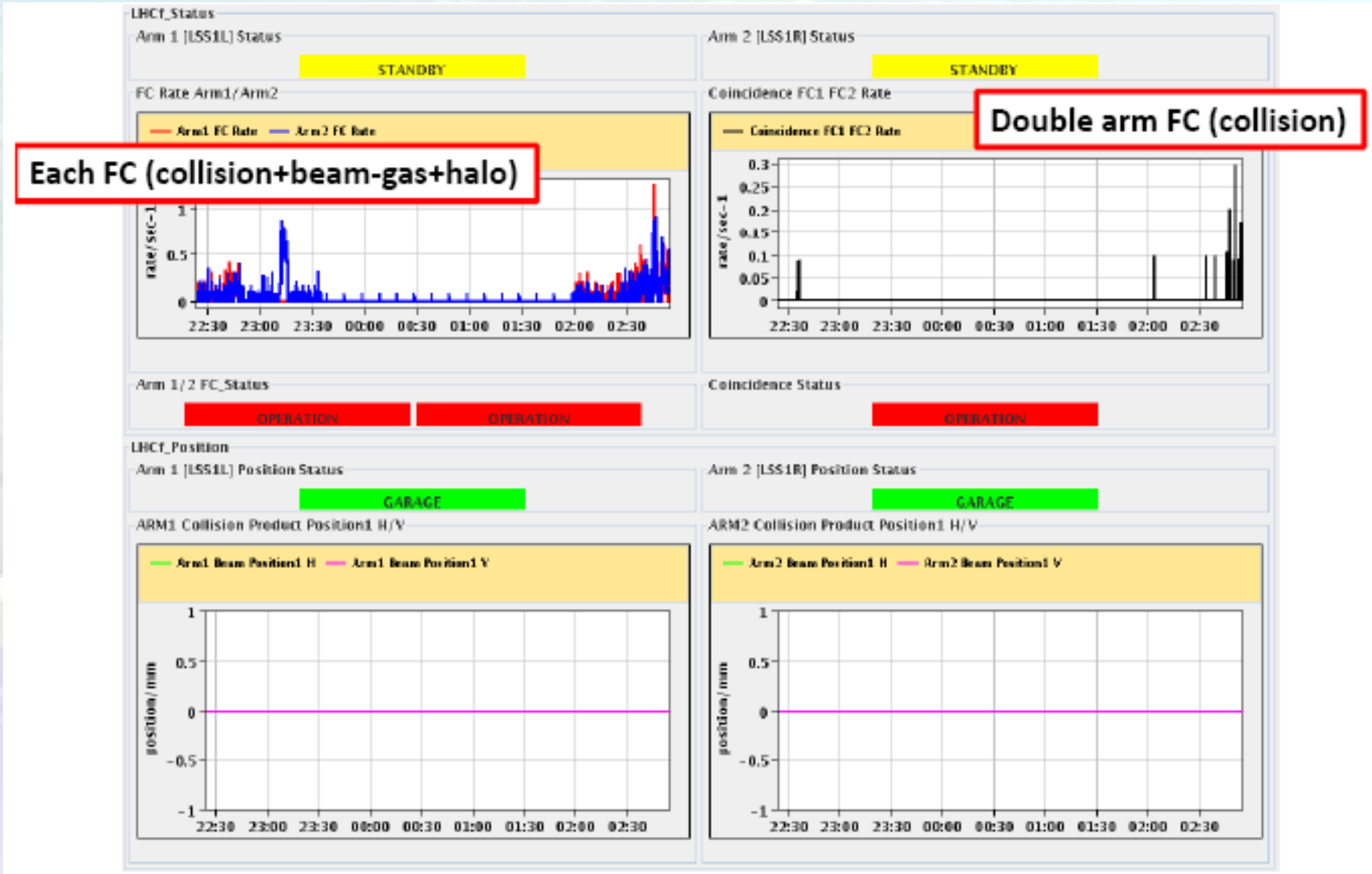




2009 LHC Operation: Not so good news…

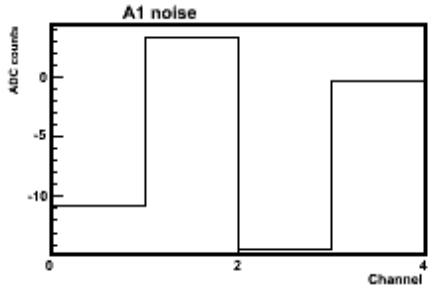
- No stable beam at 1.2+1.2 TeV → No data at this energy for this year ☹
- No π^0 reconstructed in LHCf ($E_{cm}^{thr} \sim 2$ TeV)
- Neutral particle flux in LHCf region scale as E^2
  - Flux is reduced by $(7 \text{ TeV}/450 \text{ GeV})^2 \sim 2.10^3$ wrt to 7+7 TeV expectations
- Luminosity ~ 10^{26} $cm^{-2}s^{-1}$
  - 3 orders of magnitude below 'optimal LHCf low luminosity')
- 20 minutes lost at beginning of stable beam to allow moving from garage to operating positions (already improved for 2010 run)
- → Very low statistics
- → 24 hours data taking
- → 10^3 particles less than 'usual LHCf plot'
- → 6000 Shower Triggers acquired on disk

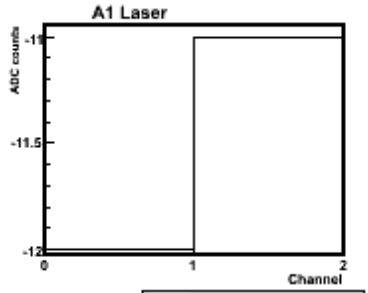
Dedicated LHCf page on VISTAR

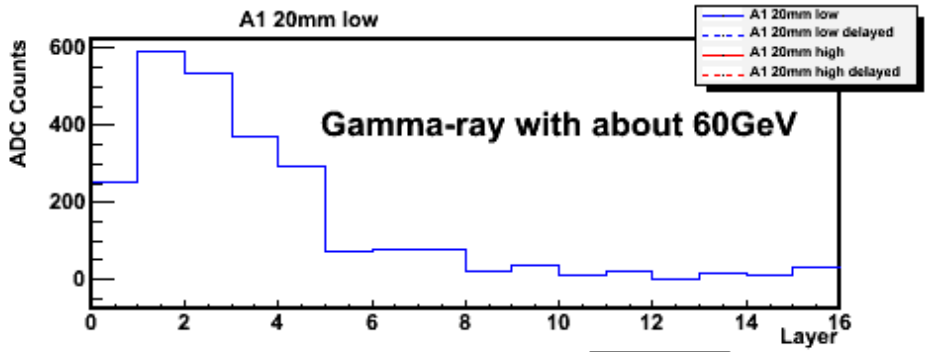


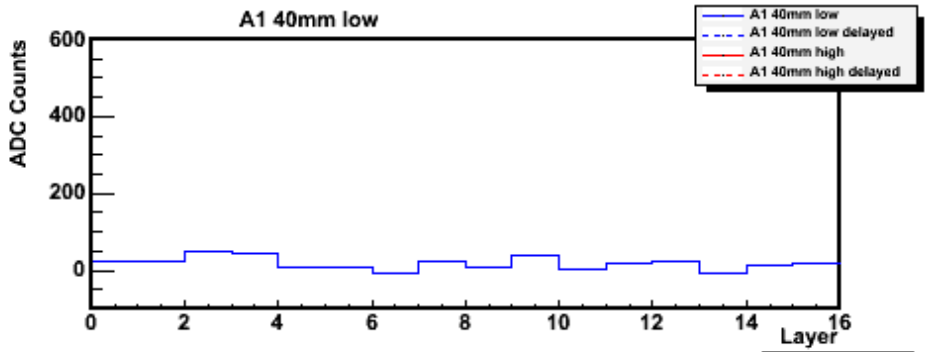
Arm1 γ event

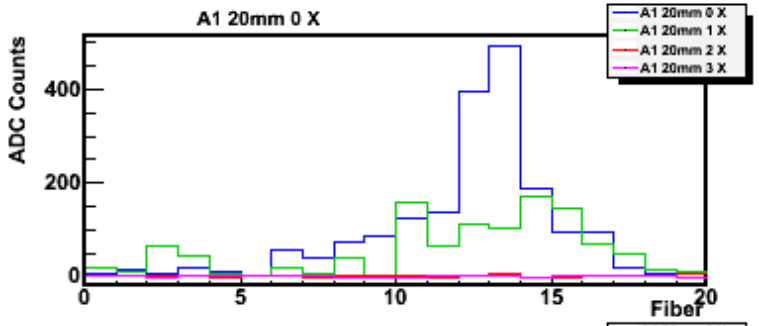
RUN: 2342
NUMBER: 223
GNUMBER: 423
TIME: 1260084266
FLAG0: 00009557
FLAG1: 0000007£
FLAG2: 000£1317

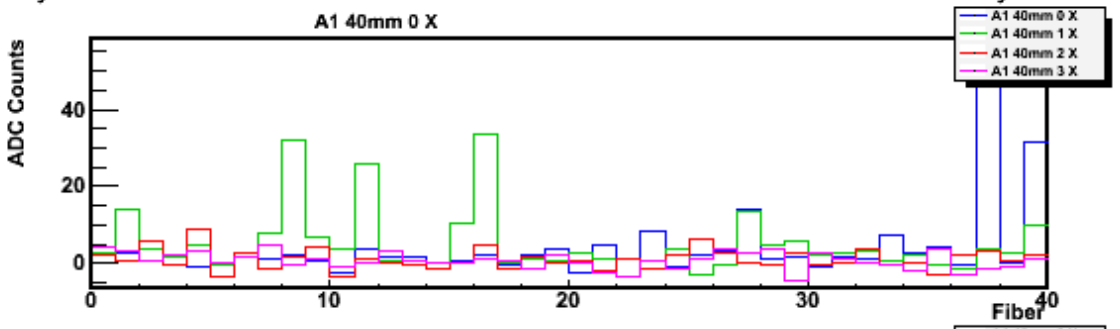


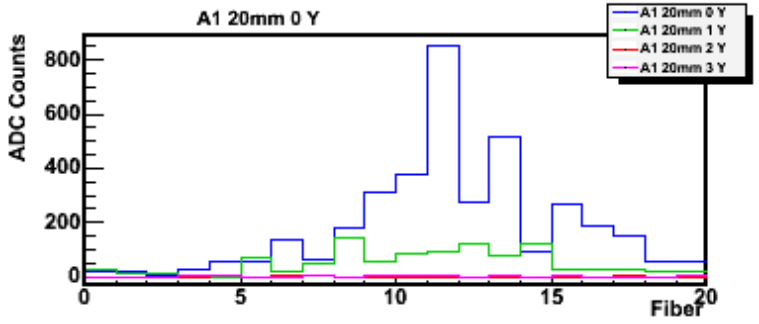


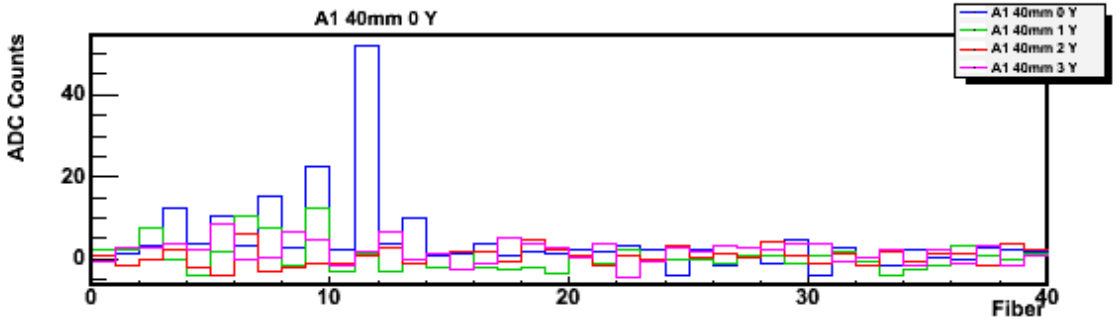






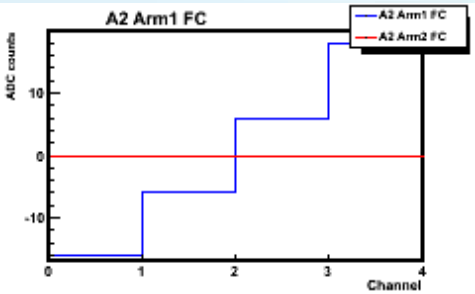


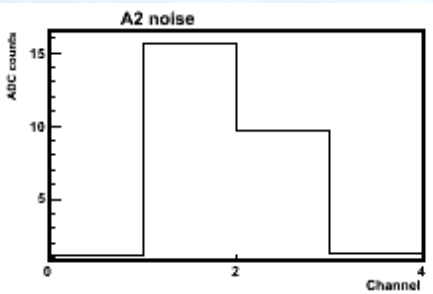


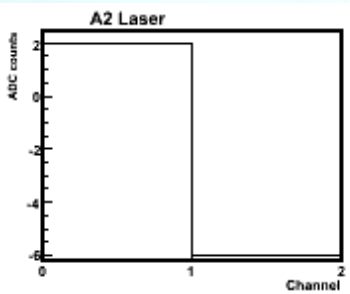


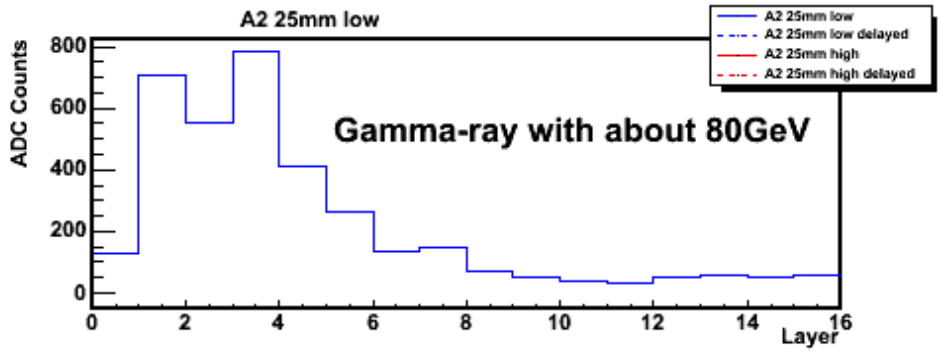
Arm2 γ event

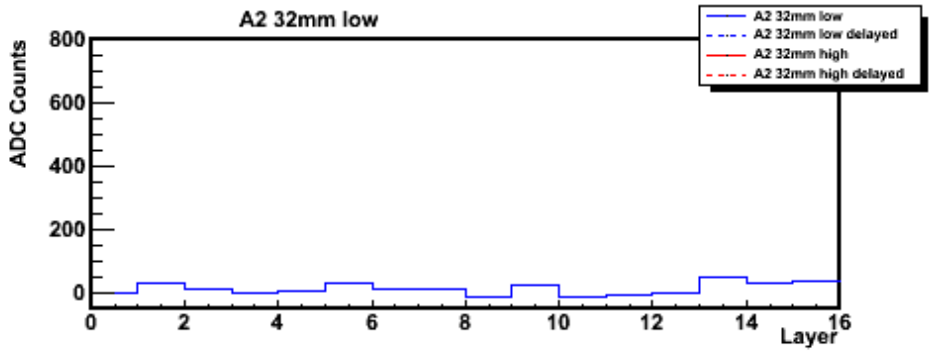
RUN: 2342
NUMBER: 506
GNUMBER: 1154
TIME: 1260085179
FLAG0: 00009557
FLAG1: 000009ff
FLAG2: 00a02371

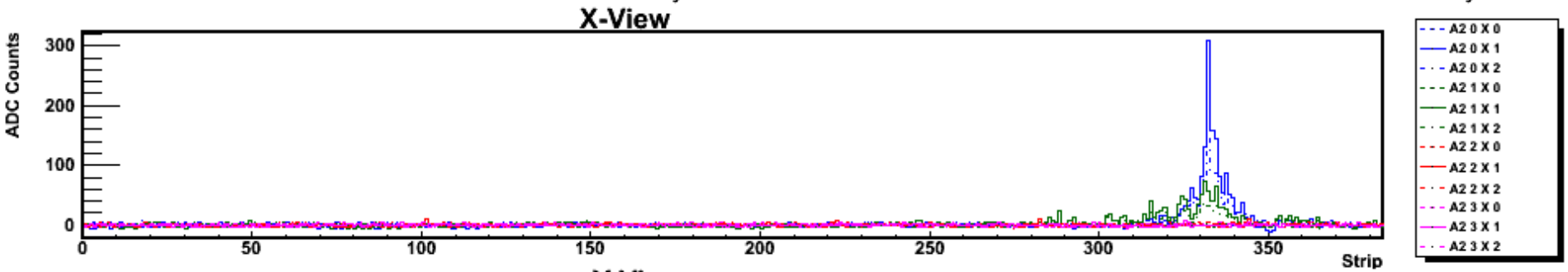


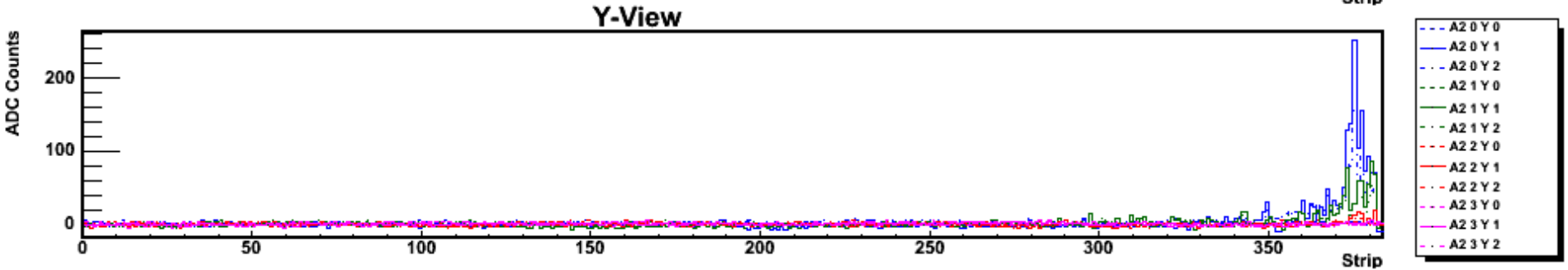




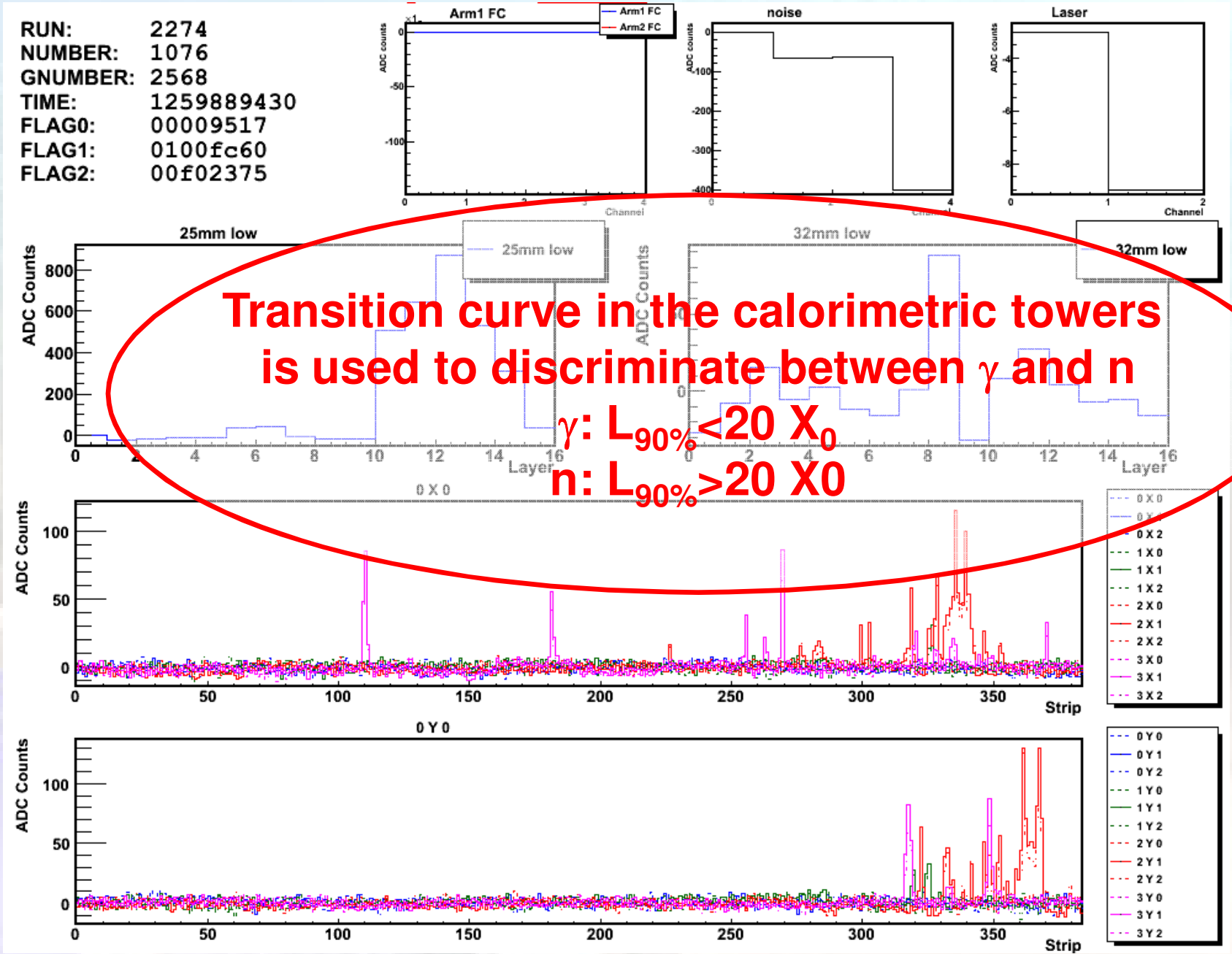








Arm2 neutron event



2009 Arm1 and Arm2 analysis

- Results are preliminary
- Big effort to understand the LHC beam (DIP signals)
  - Intensity bunch by bunch
  - Not colliding bunches vs colliding bunches to estimate Beam Gas rate
  - Timing of the bunches
  - Etc etc etc
- Quite few problems found during the analysis
  - Timing problems in Atlas (BPTX not synchronized)
  - Displaced bunches
  - Missing DIP information
  - Etc etc etc

Statistics

- Integrated Intensity after bad runs cuts= (Σ_{bunch} Intensity) x time [sec]

	Bunch Crossing	Non-B.C.	Displaced B.C.
Beam1	9.0 E14	7.5 E14	1.0 E14
Beam2	8.5 E14	6.7 E14	0.9 E14

- Number of Events in Arm2

Before cuts : 3,656 L2TA events, After bad run cuts : 2,000 L2TA events (55% efficiency)

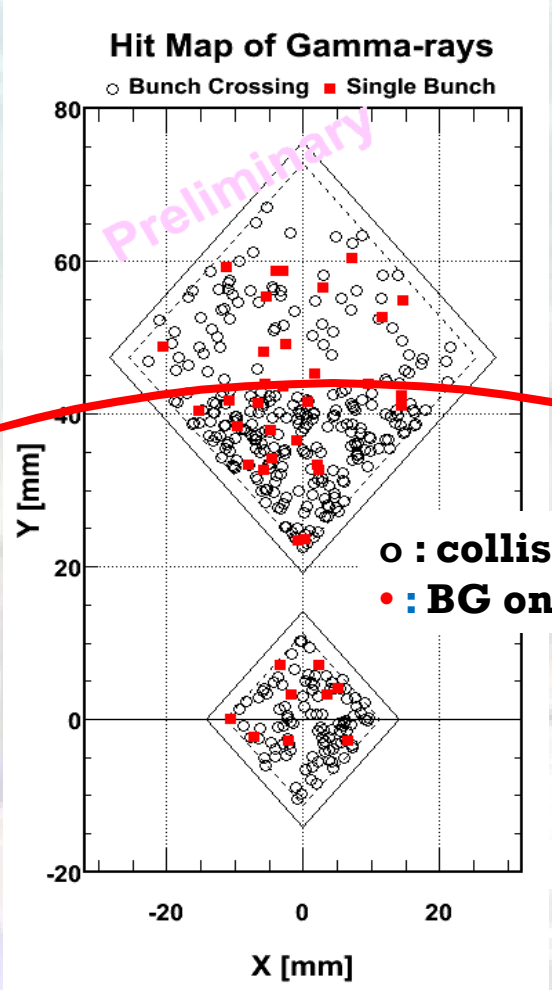
	Bunch Crossing	Non-B.C.	Displaced B.C.
L2TA *	1,585	361	54
25mm (γ/h) *	133 / 301	18 / 27	3 / 9
32mm (γ/h) *	231 / 674	44 / 190	7 / 25

*) L2TA : Hardware Trigger for showers
*) Criteria : integrated energy deposit in calorimeter > 400MIPs
γ : L90 < 20r.l., h: L90 > 20r.l

- Livetime during stable beam time: 80% (mainly due to manipulator moving)

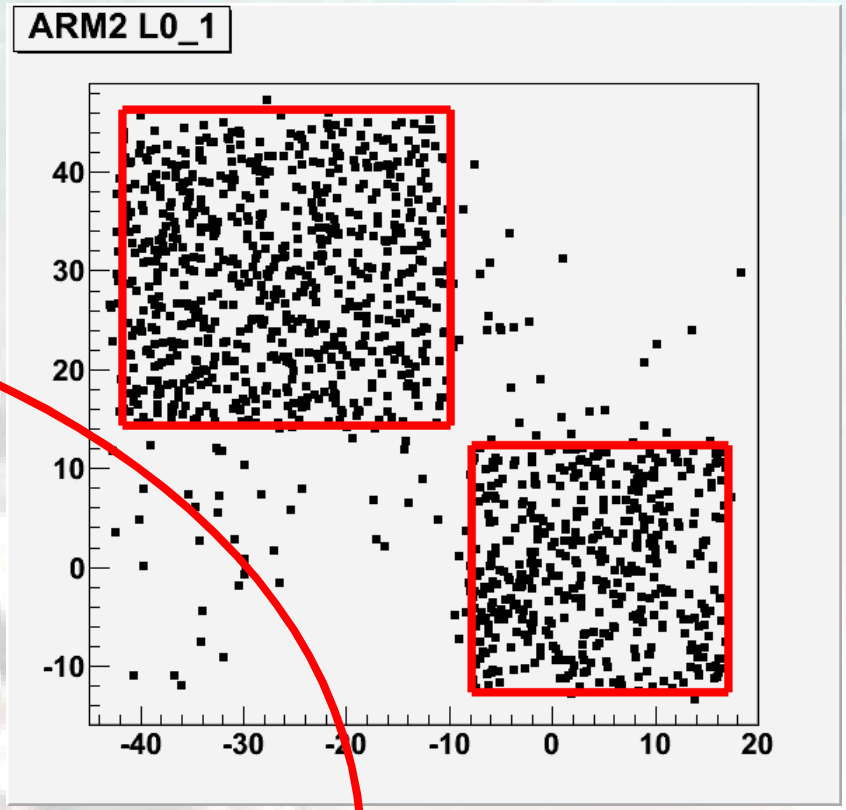
We expect to recover some statistics by the new publication of the DIP data foreseen in the next few weeks

Hit map on ARM1 and ARM2



o : collision + BG

• : BG only

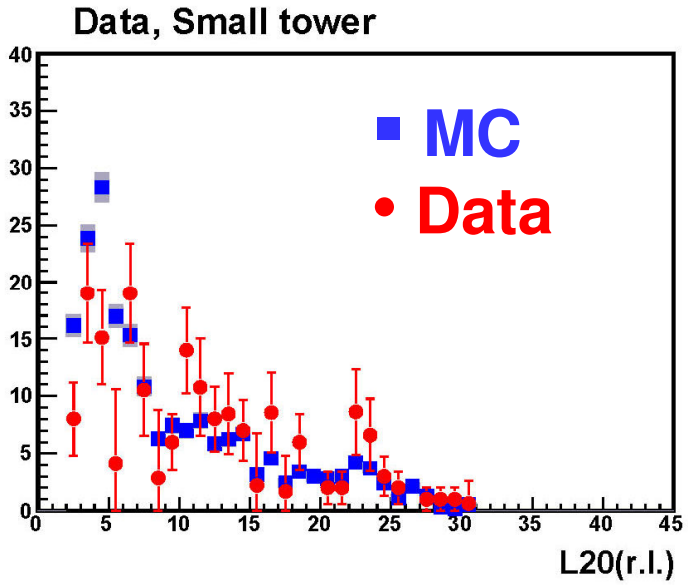


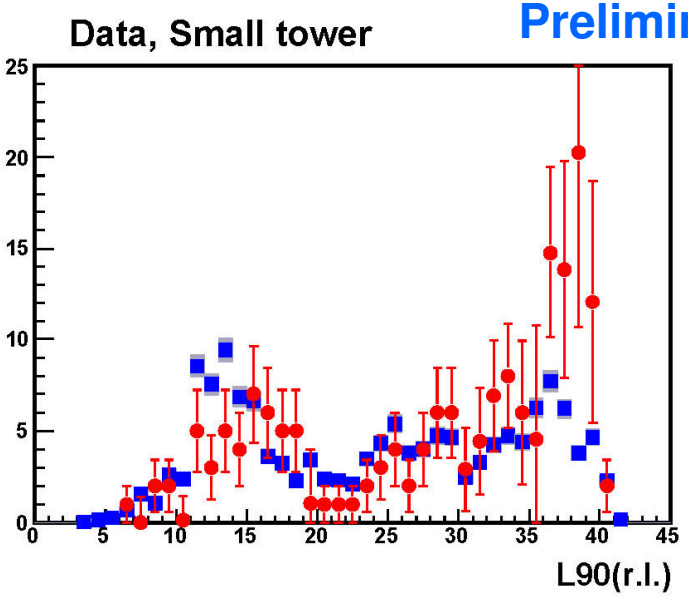
Analysis cuts

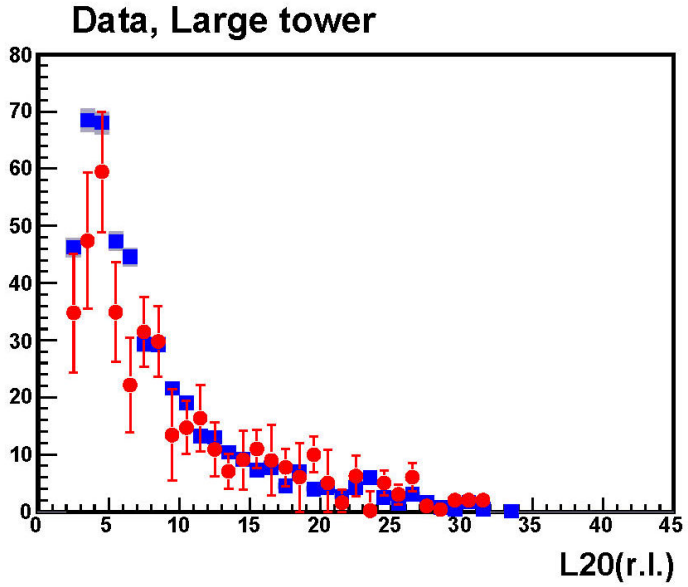
- **Energy cut:**
  - Integral energy deposit in one tower > 400 MIPS (~ 10 GeV γ energy deposit)
- **Fiducial volume cut for γ:**
  - 2 mm inside from the tower edges.
- **PID Cut:**
  - Gamma-rays: L90 < 20 r.l.
  - Hadrons: L90 > 20 r.l

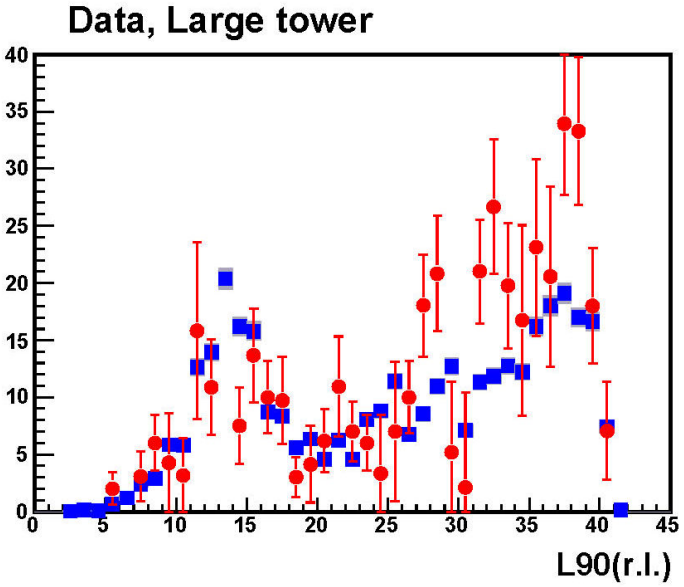
Arm1 Results: L20 and L90

Preliminary



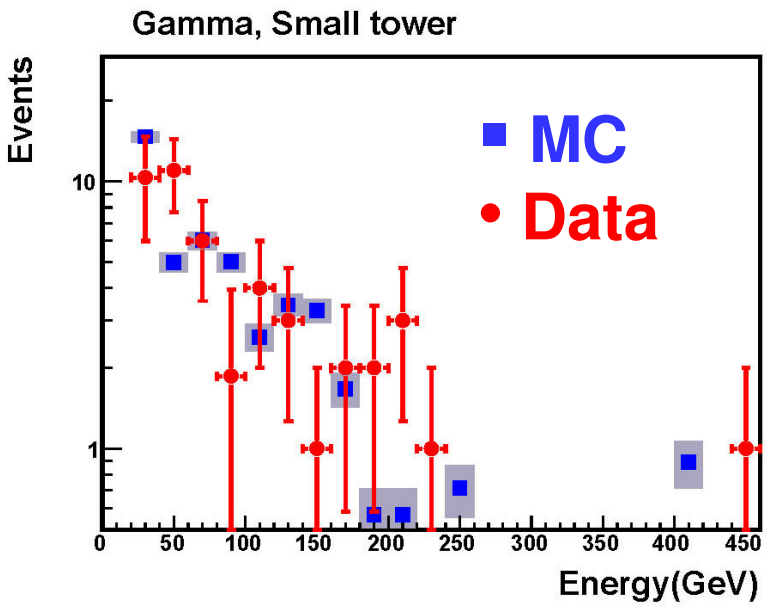


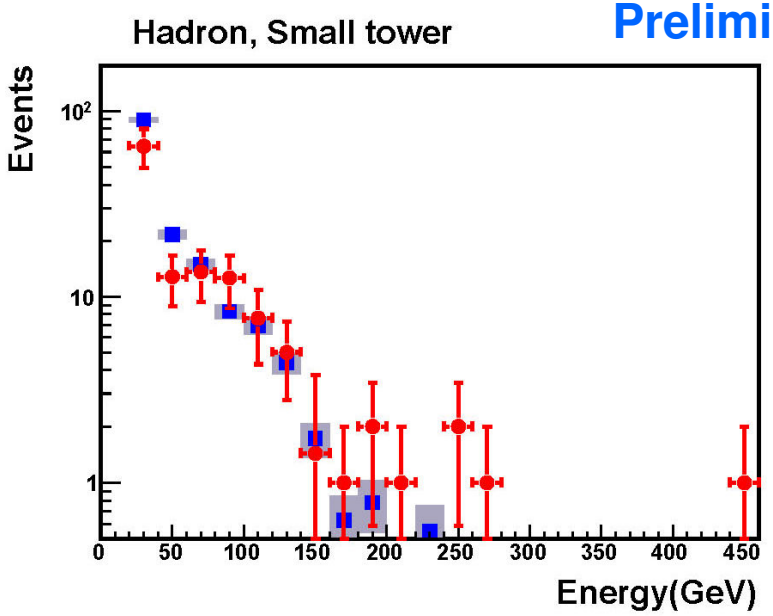


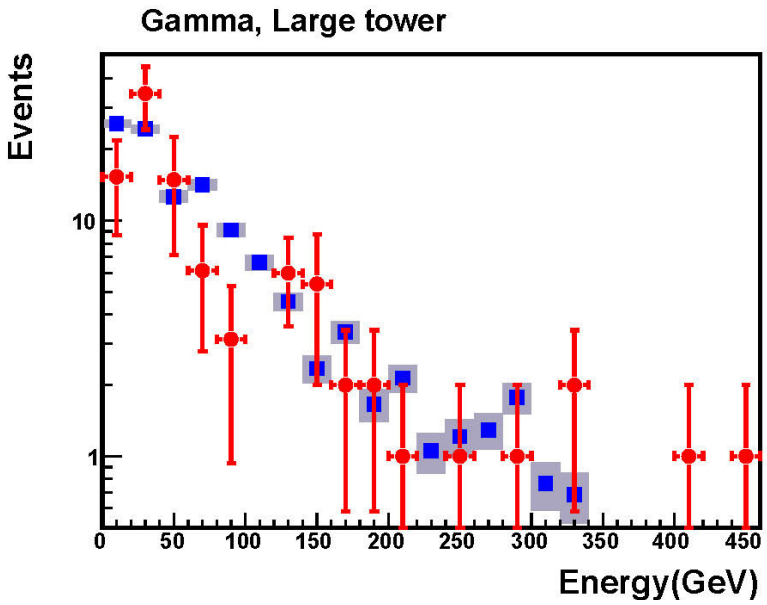


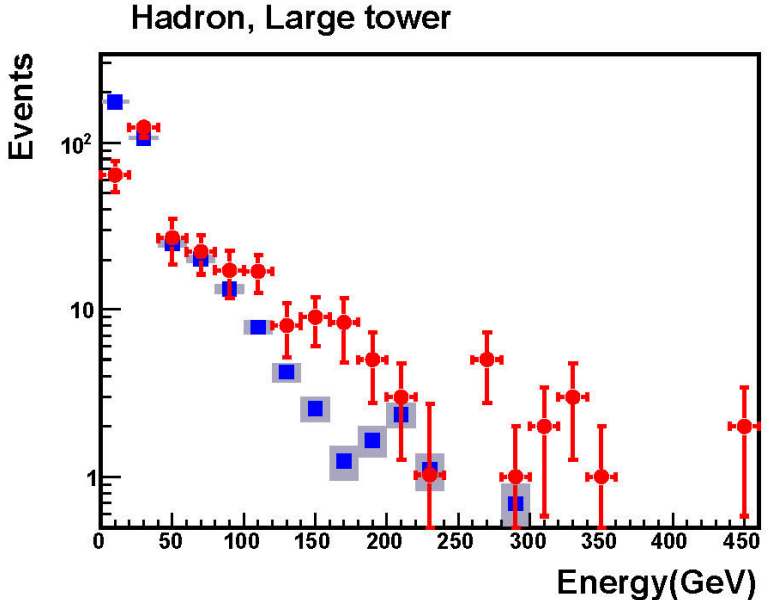
Arm1 Results: γ and n spectra on the 2 towers

Preliminary



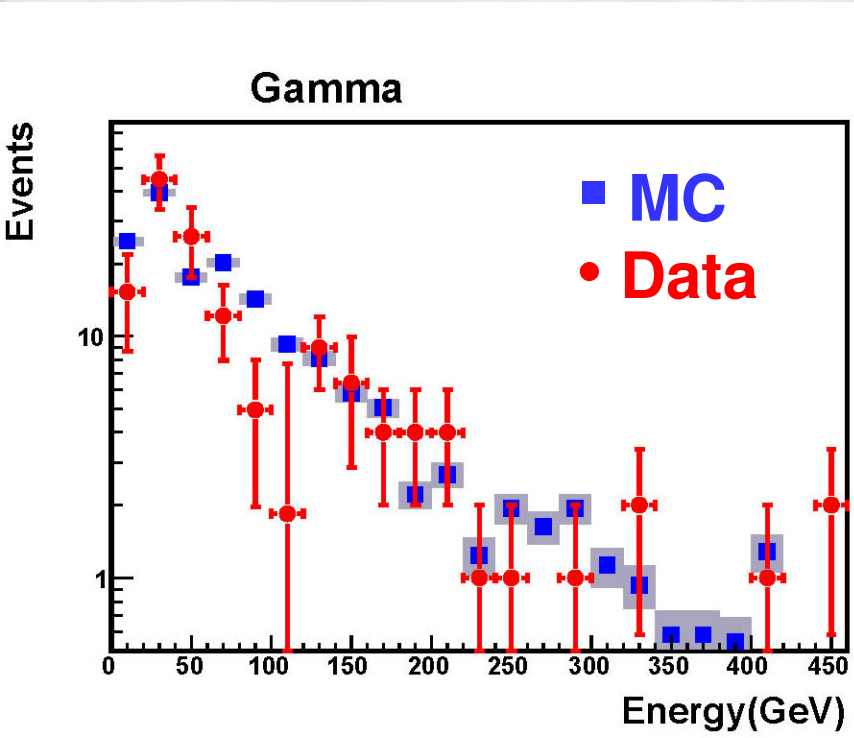




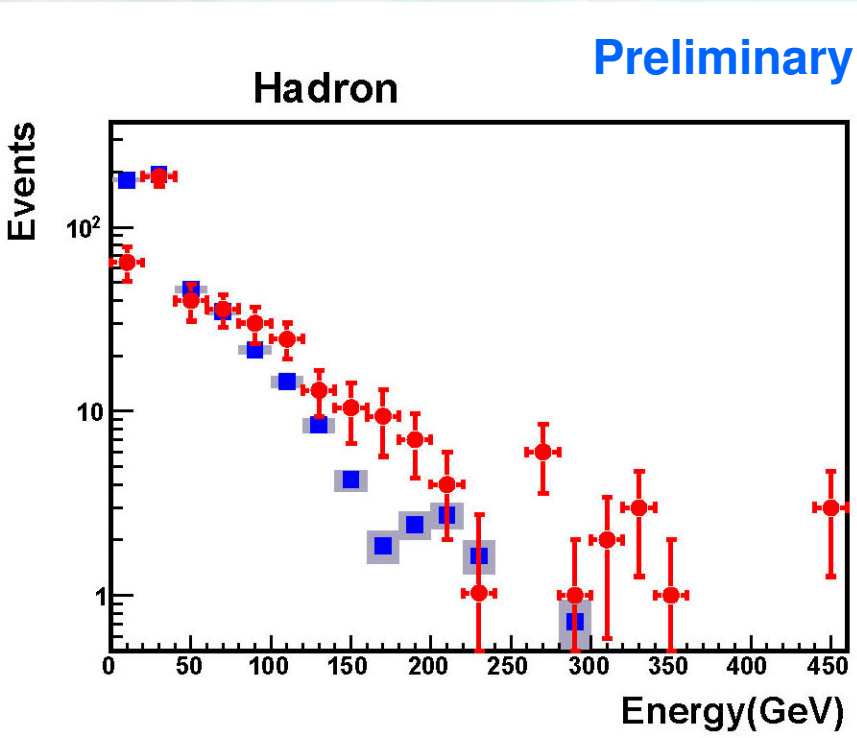


After the subtraction of the Not Colliding Bunches properly normalized

Arm1 Results: combined γ and n spectra

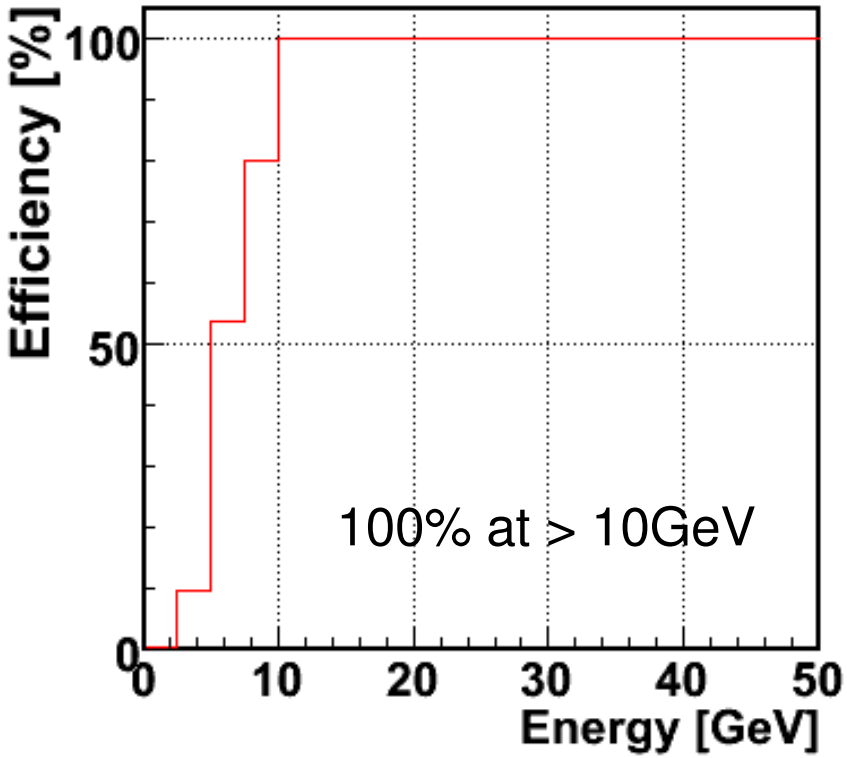


Preliminary

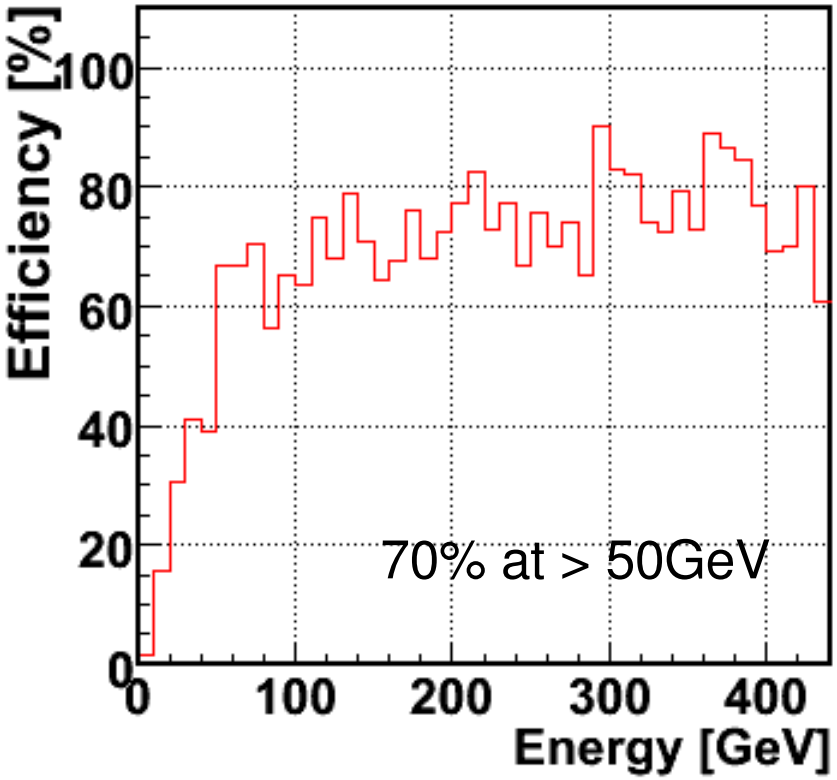


Arm2 Results: Efficiency of Shower Trigger

For Gamma-rays

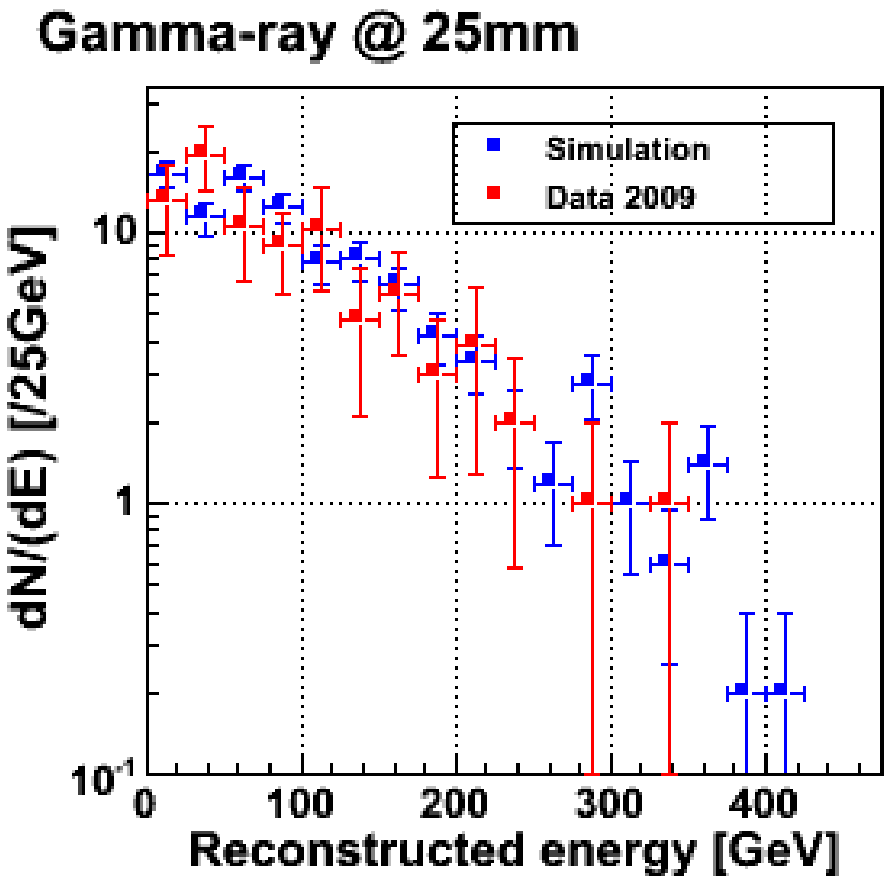


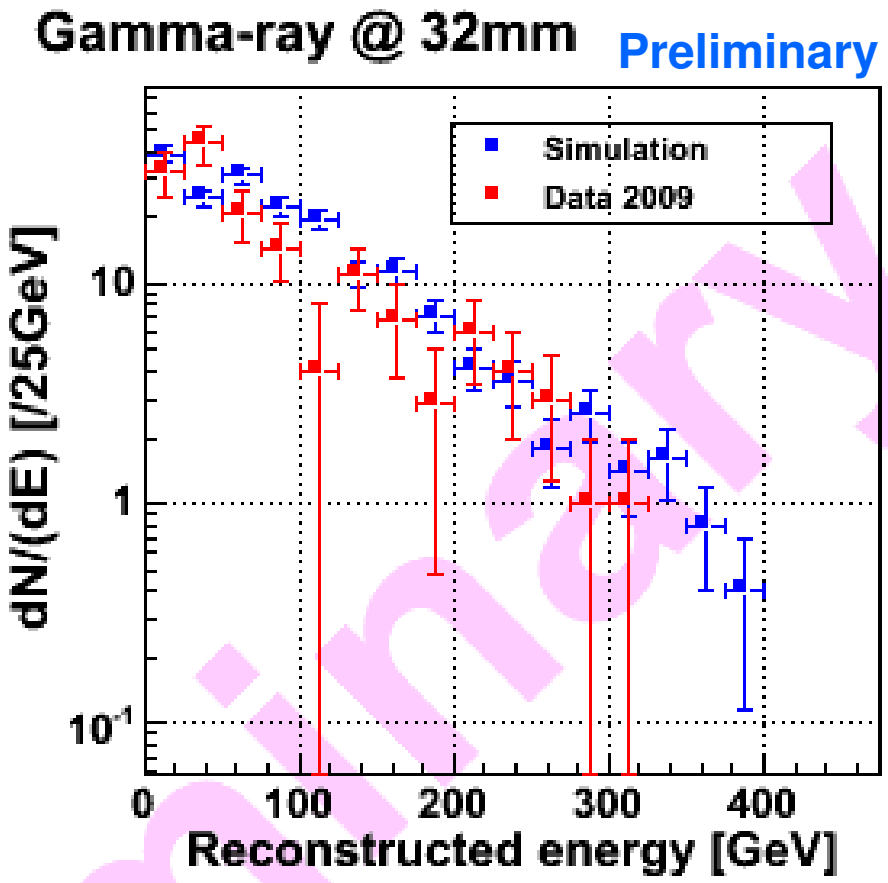
For Neutrons



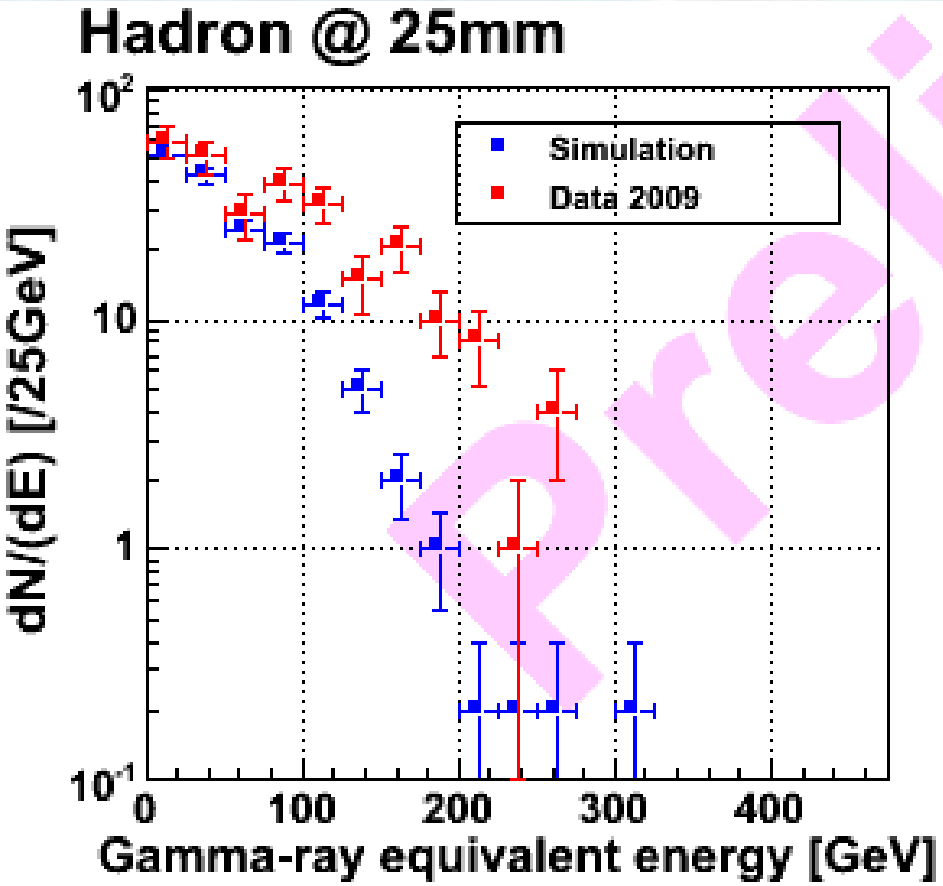
Studied by MC data

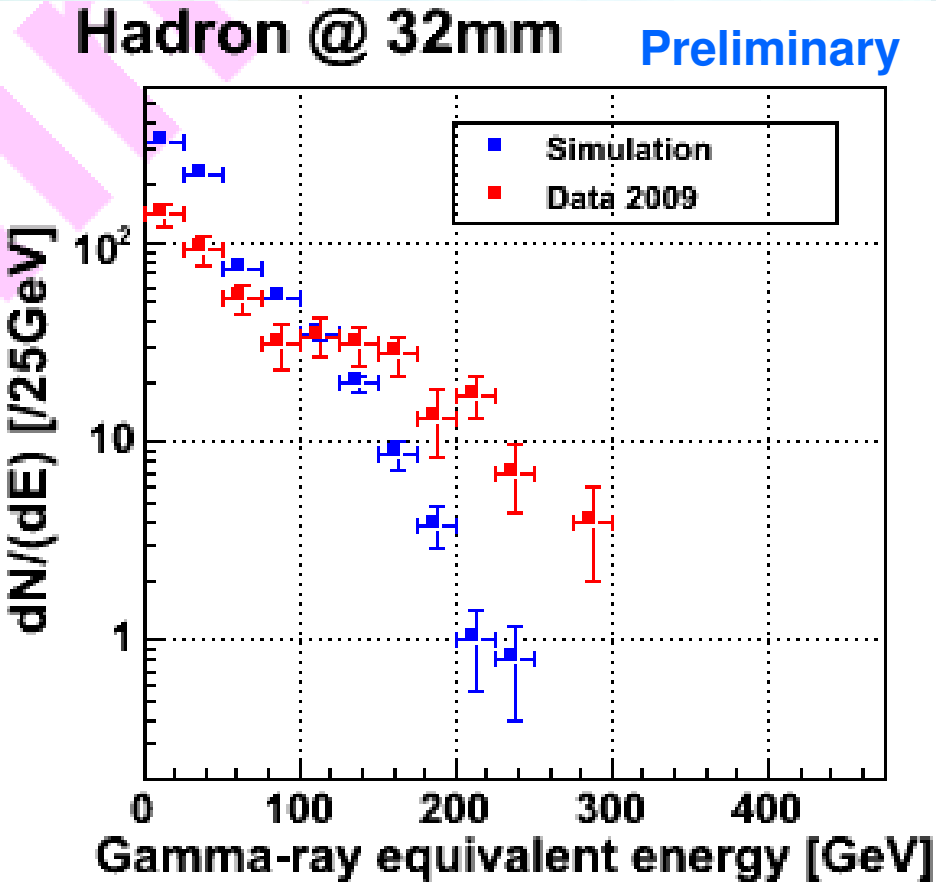
Arm2 Results: γ spectra on the 2 towers



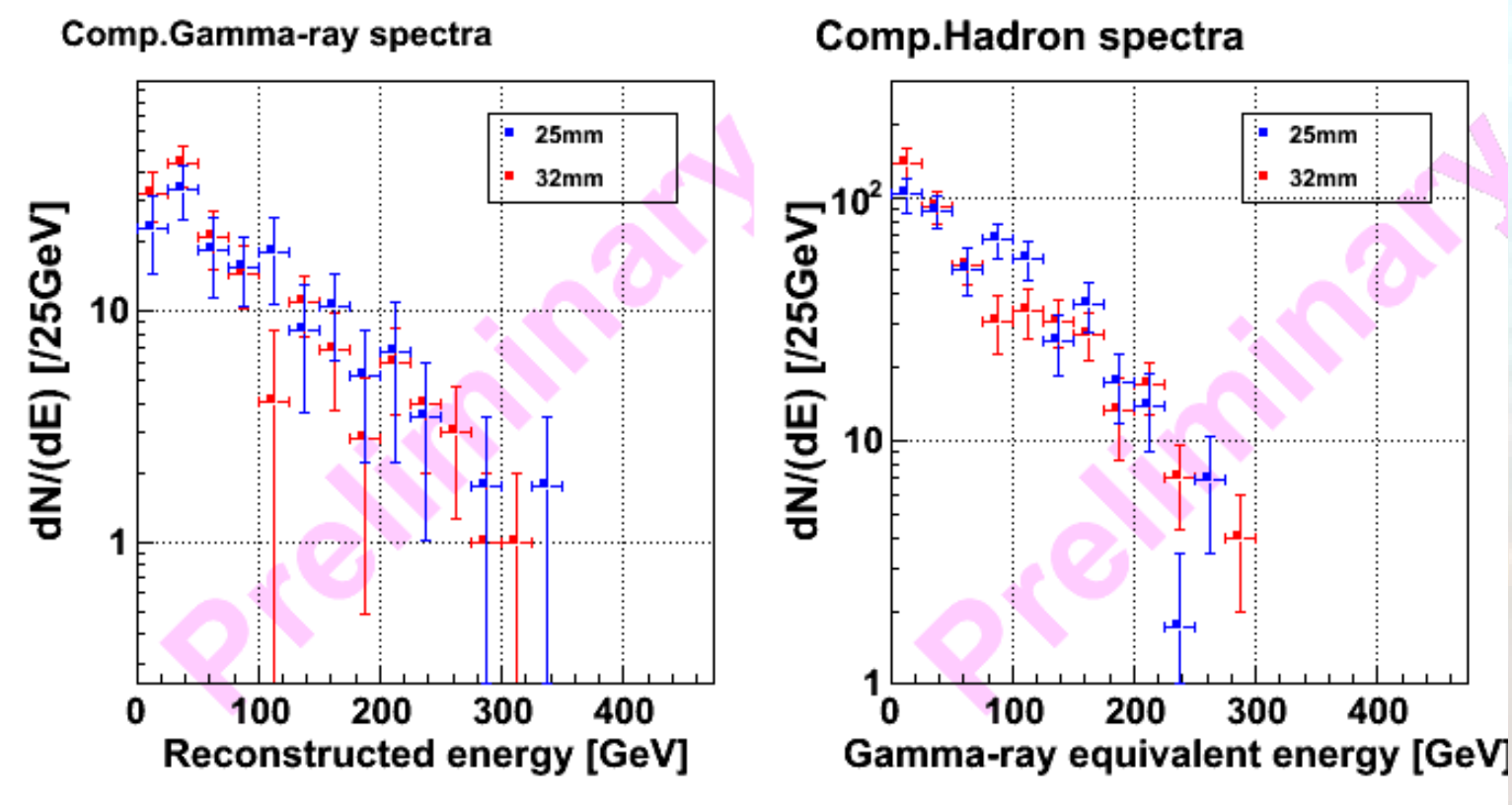


Arm2 Results: n spectra on the 2 towers





Arm2 Results: Comparison of 25mm and 32mm



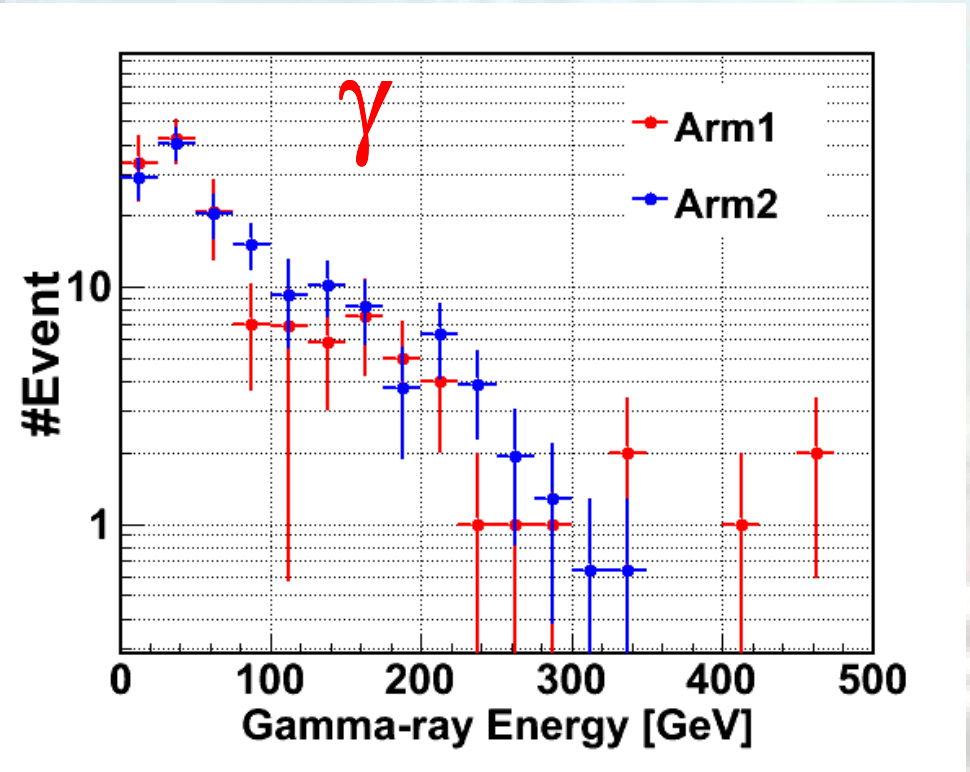
Chi2 : 13.3 (DOF=10)

Chi2 : 7.7 (DOF=10)

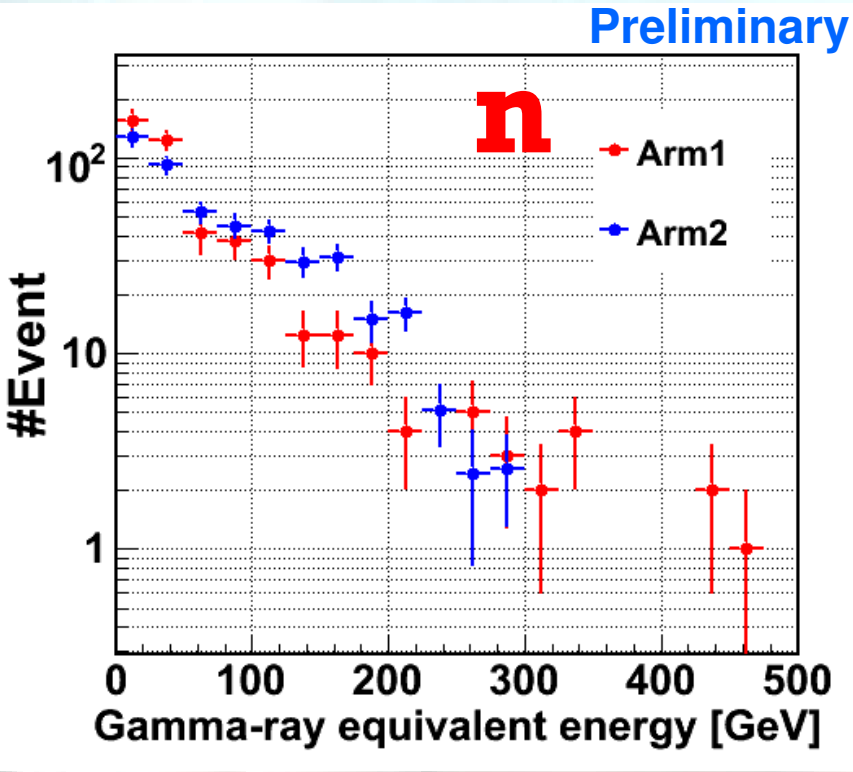
The spectra of 32 mm are normalized by the relative acceptance (factor 1.77)
No significant difference between 25mm and 32mm spectra.
It is consistent with the expectation by simulation:

Flat distributions at 450 GeV

Arm1 & Arm2 comparison



Preliminary



Arm1 and Arm2 γ spectra are normalized to the ratio of the fiducial volumes surfaces

Summary

- Good agreement between Data and MC for γ both for Arm1 and Arm2
- Some discrepancy for hadrons → Still to be investigated

- γ and n spectra are practically flat
- Very nice agreement between Arm1 and Arm2 data!

- Statistics can be improved by re-analysis of bunch intensities in the DIP data

Plans for the future

- At beginning of 2010, after the LHC restart, we will take data
  - 0.45+0.45 TeV
  - 3.5+3.5 TeV

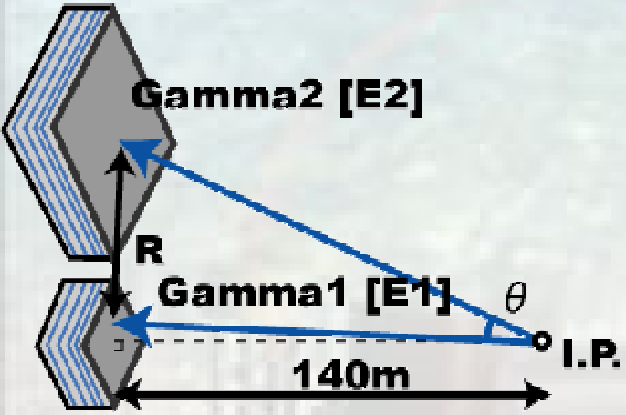
- When luminosity will become too high ($>10^{31}$ $cm^{-2}s^{-1}$, 2 pb^{-1}) we will go out from the TAN (Radiation damage of the plastic scintillator is significant, LHCf has been designed to run at low luminosity/high energy!)
- Test beam for calibration with the 'old' LHCf
- Replace Plastic Scintillator with GSO + Change position of silicon layers
- Test beam with 'new' LHCf
- Re-install LHCf when LHC will increase energy

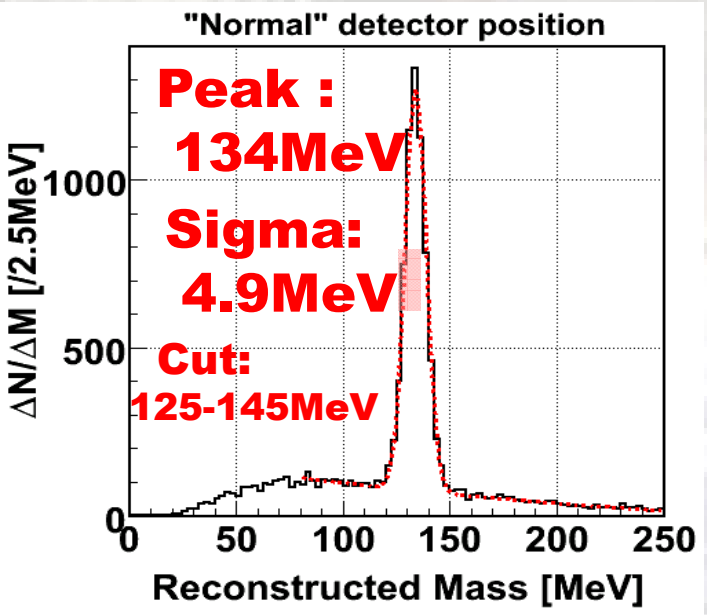
Backup slides

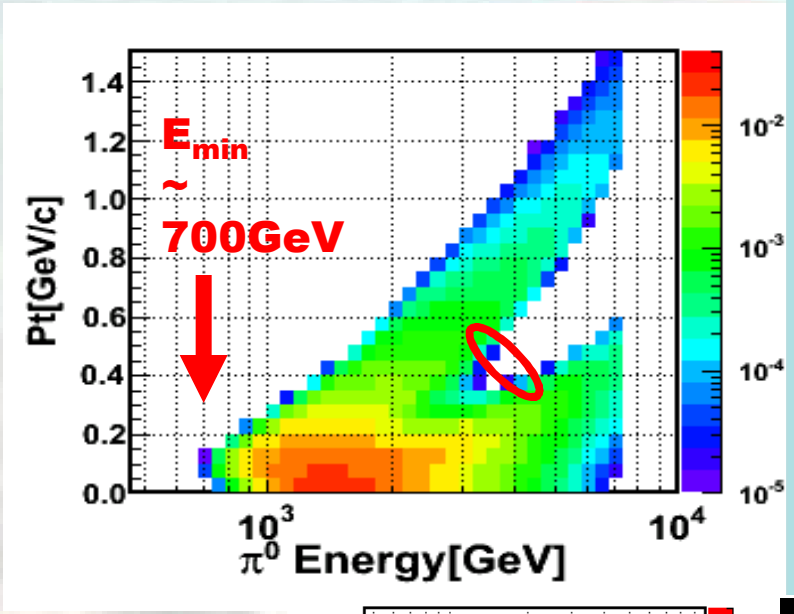
π^0 spectra

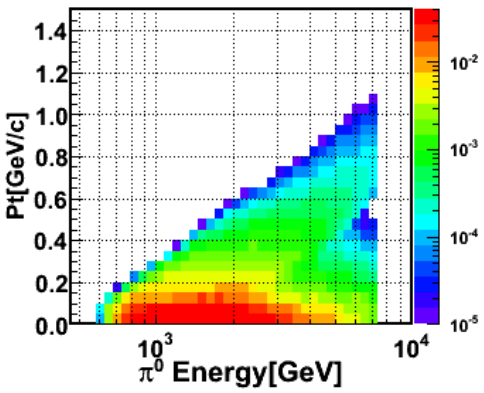
π^0 produced at collision can be extracted by using gamma pair events

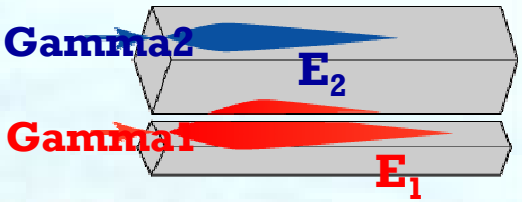
Powerful tool to calibrate the energy scale and also to eliminate beam-gas BG



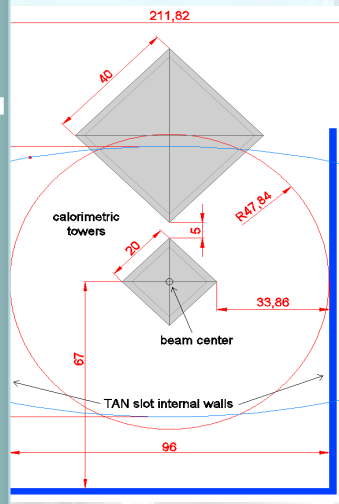


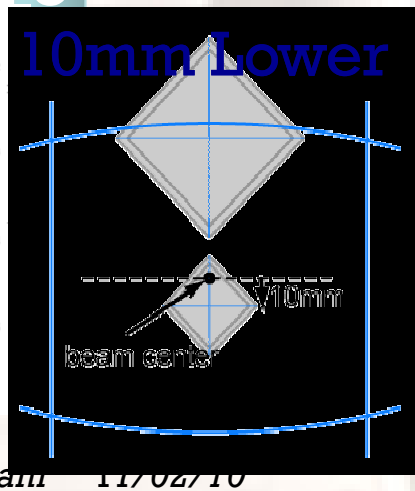




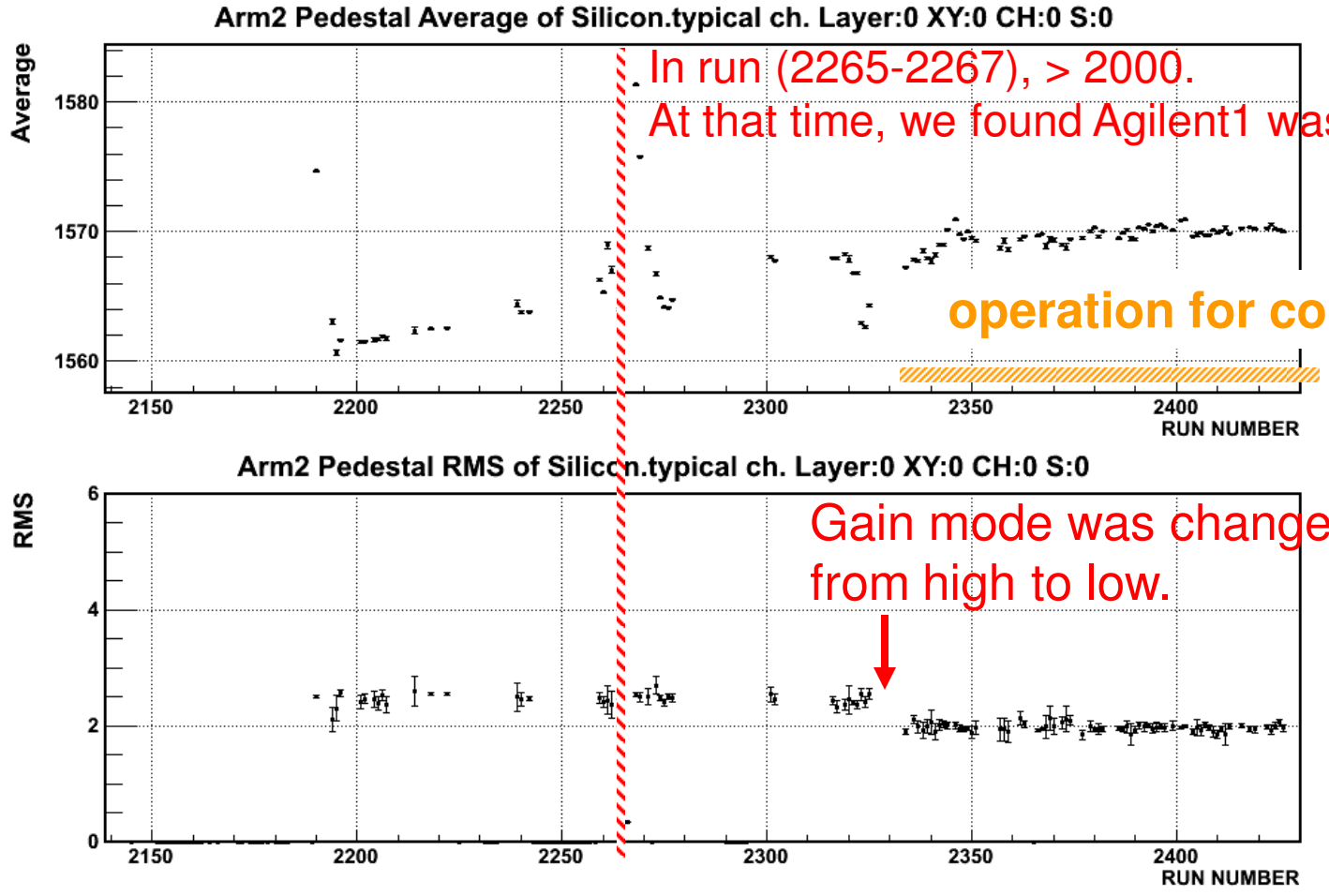


Geometrical Acceptance





Stability of pedestal of Silicon

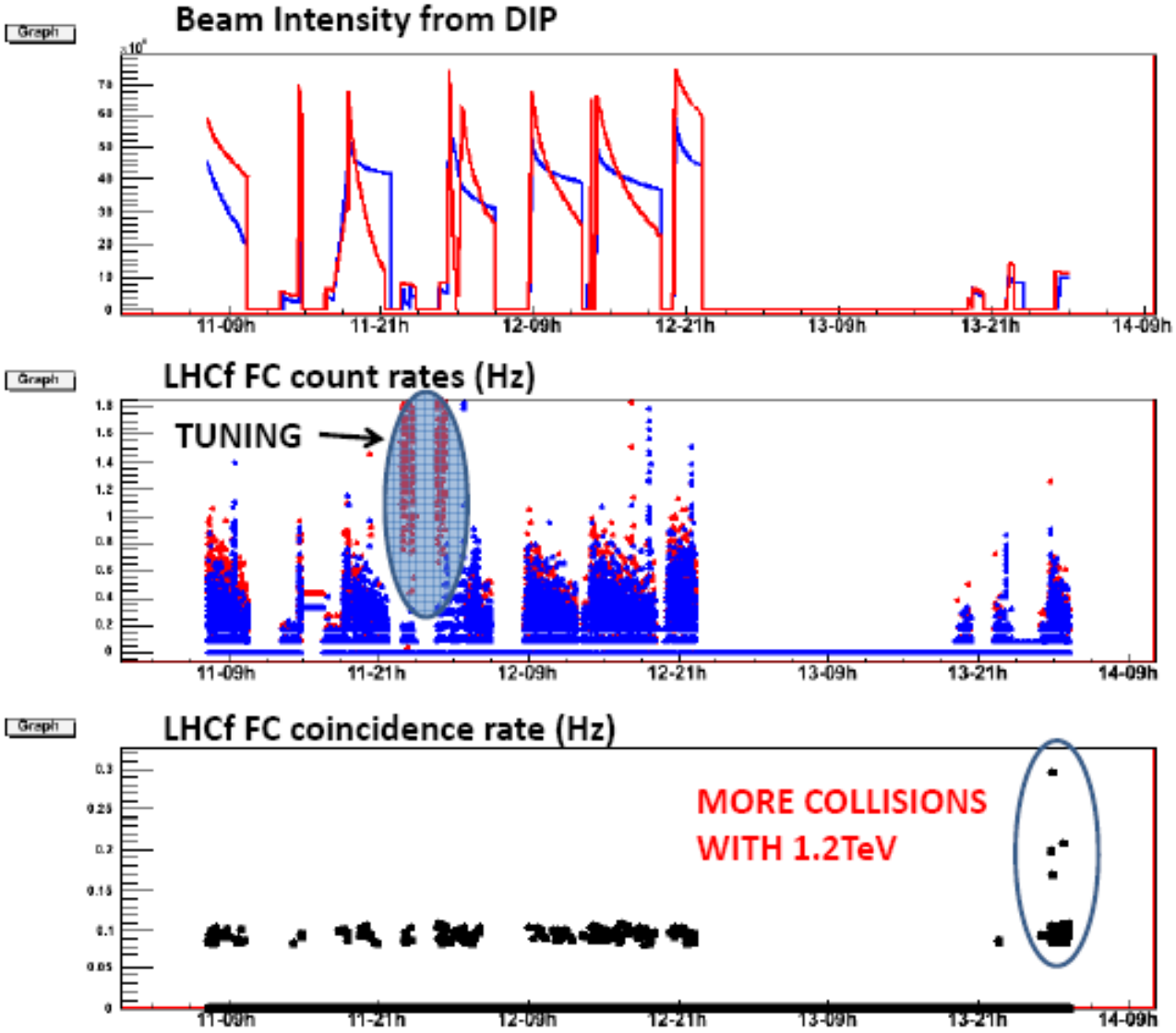


Very stable during the stable operation.

Run table for 2009 (Stable beam)

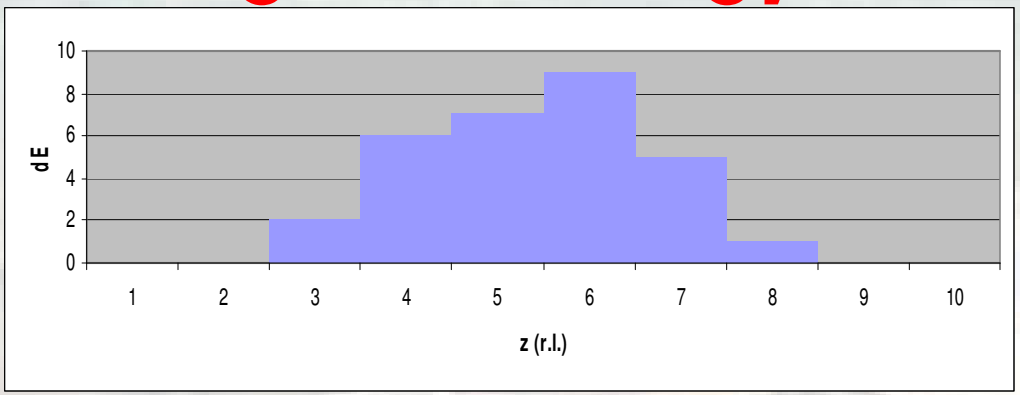
RUN	DATE	START	END	GAIN	#L2TA Arm1	#L2TA Arm2	BUNCH
02347	06/12/2009	23:17	00:25	Normal	65	86	4x4 (3*)
02349	08/12/2009	02:17	05:49	Normal	184	239	4x4 (3*)
02379	11/12/2009	02:06	02:43	Normal	102	103	5x5 (4*)
02380	11/12/2009	02:43	06:03	Normal	323	335	5x5 (4*)
02382	11/12/2009	07:34	10:34	Normal	335	411	5x5 (4*)
02387	11/12/2009	18:56	21:22	Normal	196	301	5x5 (3)
02391	12/12/2009	04:03	06:18	Normal	157	244	4x5? (2)
02393	12/12/2009	09:33	13:00	Normal	321	447	5x5 (3)
02395	12/12/2009	14:21	15:17	Normal	146	208	5x5 (3)
02396	12/12/2009	15:20	18:24	Normal	337	472	5x5 (3)
02399	12/12/2009	20:42	22:21	Normal	310	444	5x5 (3)
02412	15/12/2009	01:09	01:59	Normal	330	365	17x17? (9+3*)

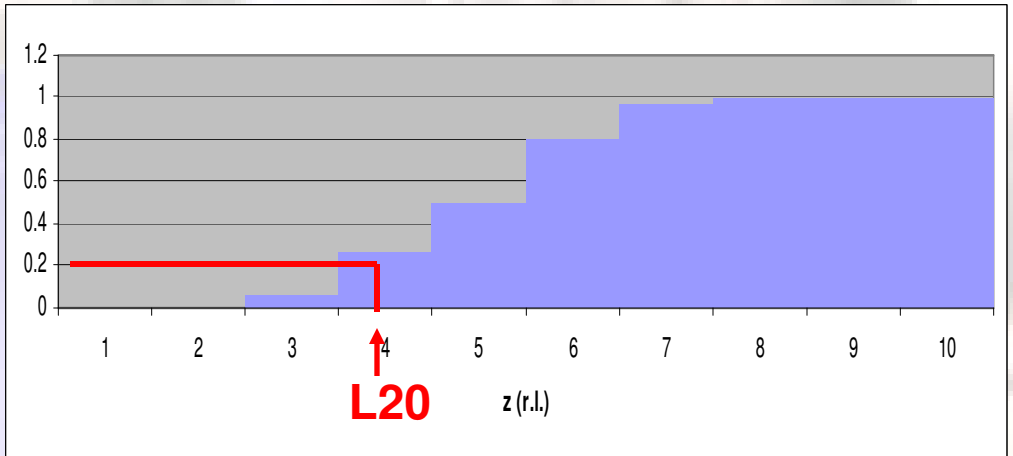
Number of detected showers > 6000!

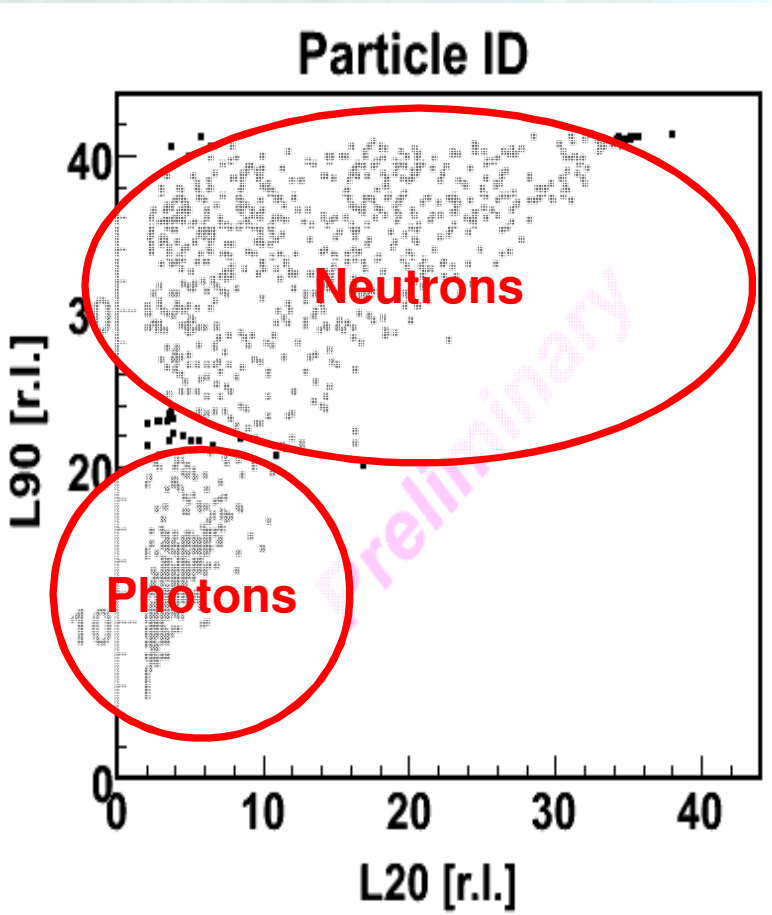

Graph
Beam Intensity from DIP
11-09h
11-21h
12-09h
12-21h
13-09h
13-21h
14-09h
Graph
LHCf FC count rates (Hz)
TUNING
11-09h
11-21h
12-09h
12-21h
13-09h
13-21h
14-09h
Graph
LHCf FC coincidence rate (Hz)
MORE COLLISIONS
WITH 1.2TeV
11-09h
11-21h
12-09h
12-21h
13-09h
13-21h
14-09h

L20 and L90

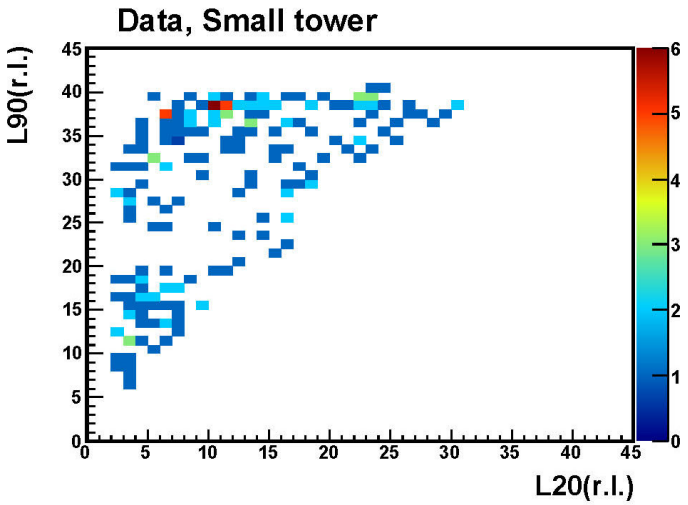
- Integrate the energy loss in the calorimeter layers, normalized to the total energy
- L20 (L90) depth at which we have 20% (90%) of integrated energy

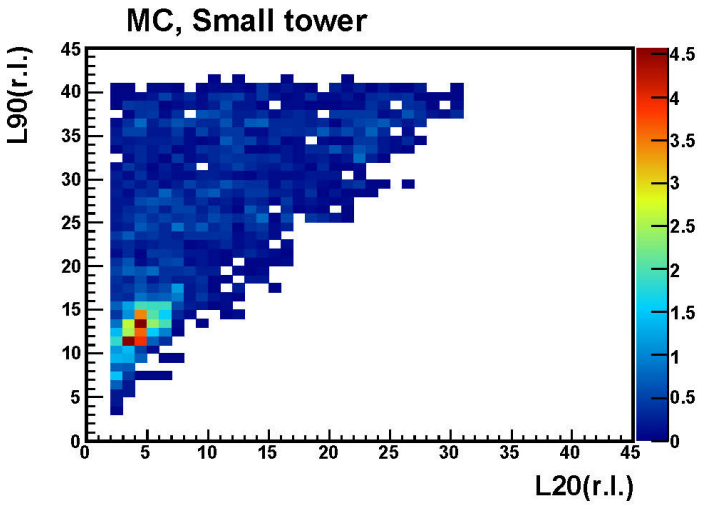


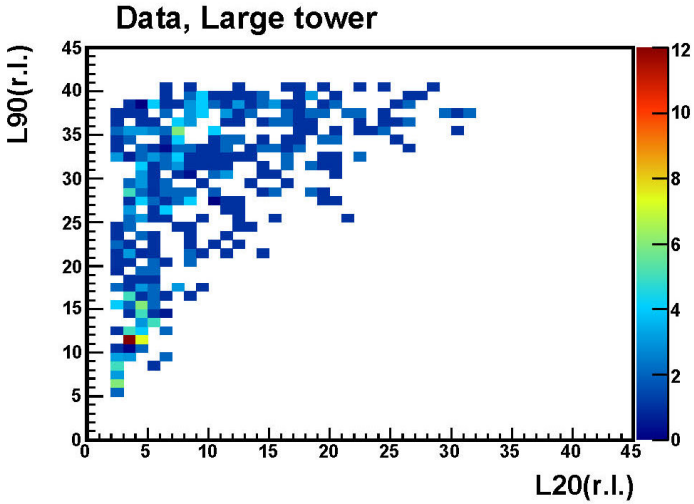


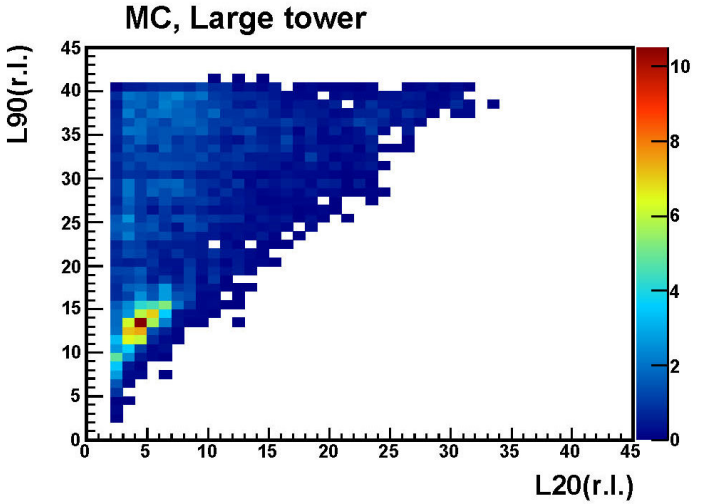


Arm1


Data, Small tower
L90(r.l.)
L20(r.l.)

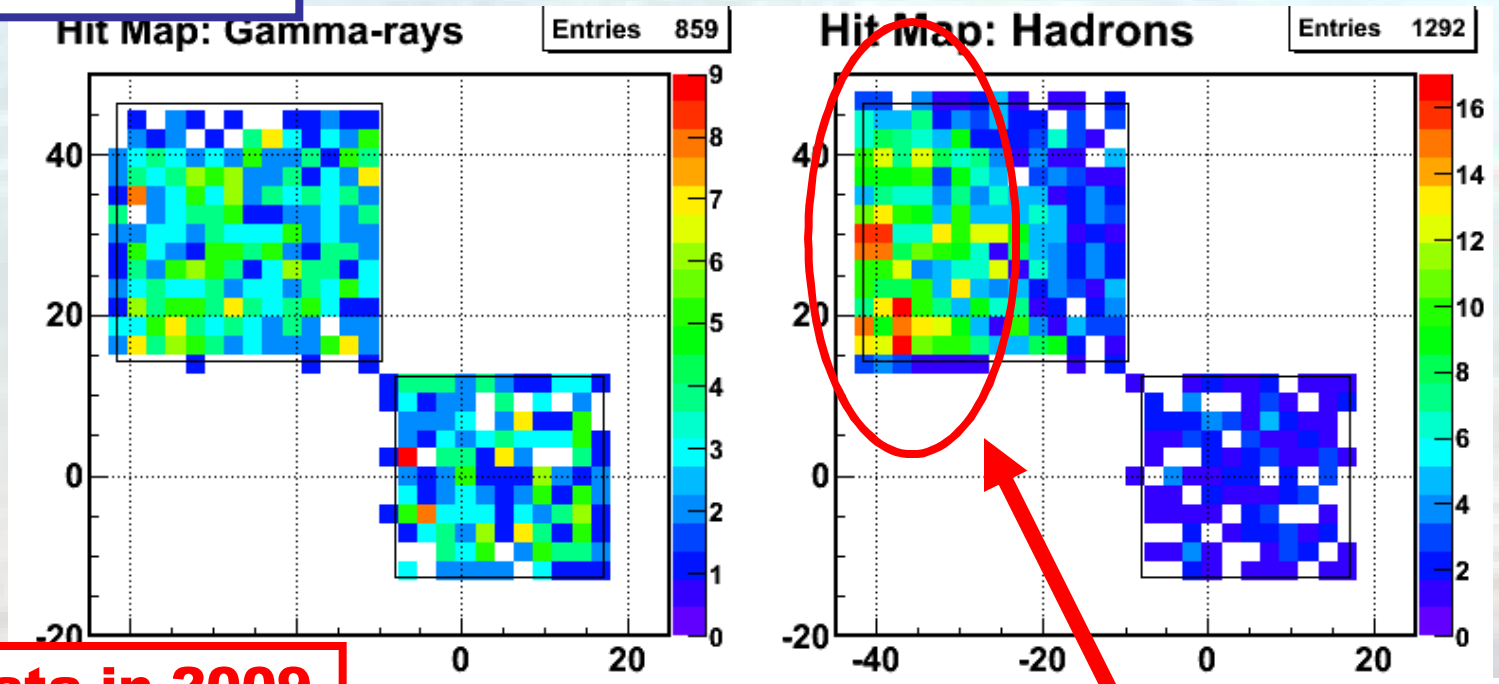

MC, Small tower
L90(r.l.)
L20(r.l.)


Data, Large tower
L90(r.l.)
L20(r.l.)

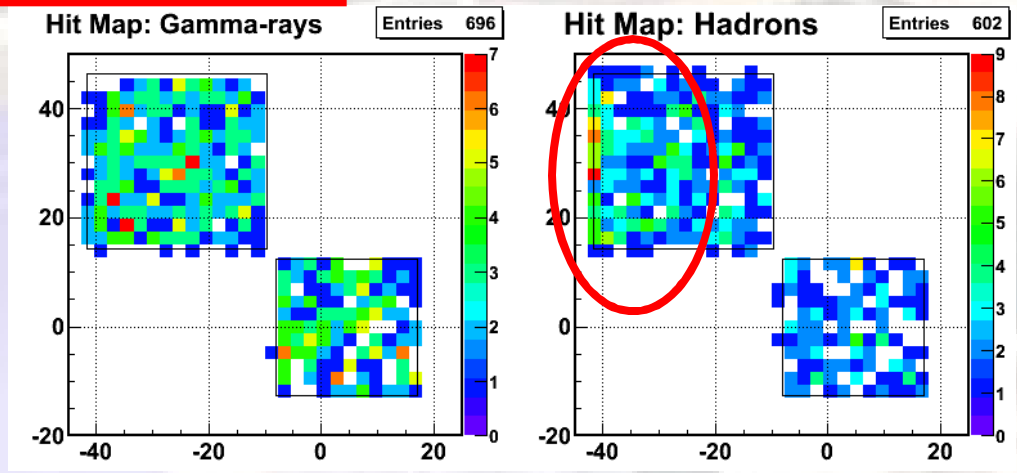

MC, Large tower
L90(r.l.)
L20(r.l.)

Hit Map of Simulation results

Simulation



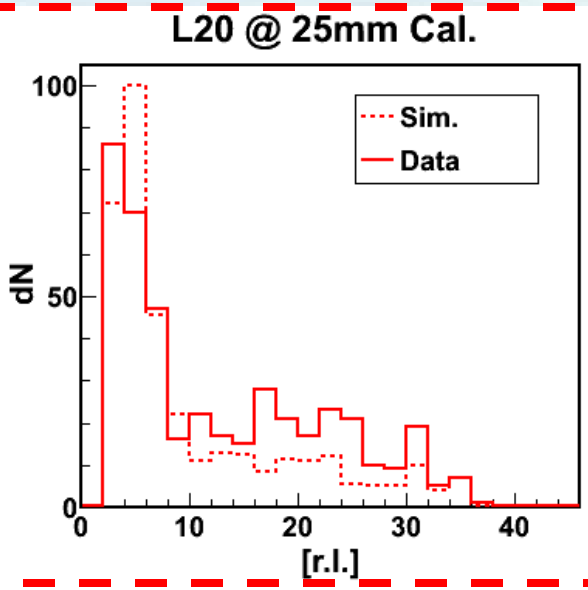
Data in 2009

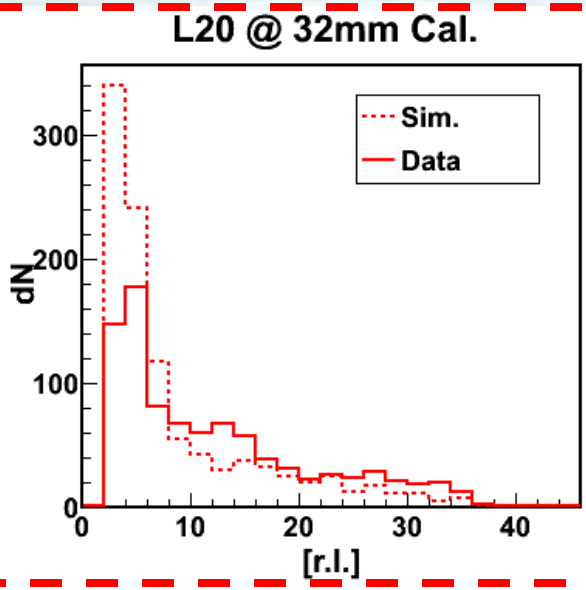


Scattered Proton
(High Energy ~450GeV)

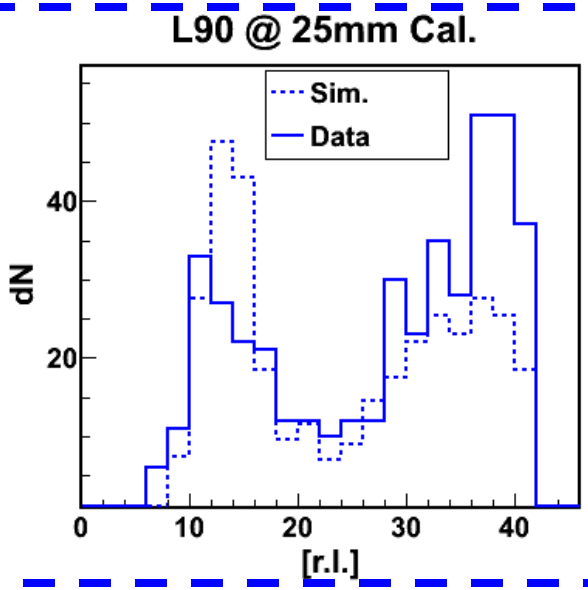
data seems not to have clear proton incidences !!

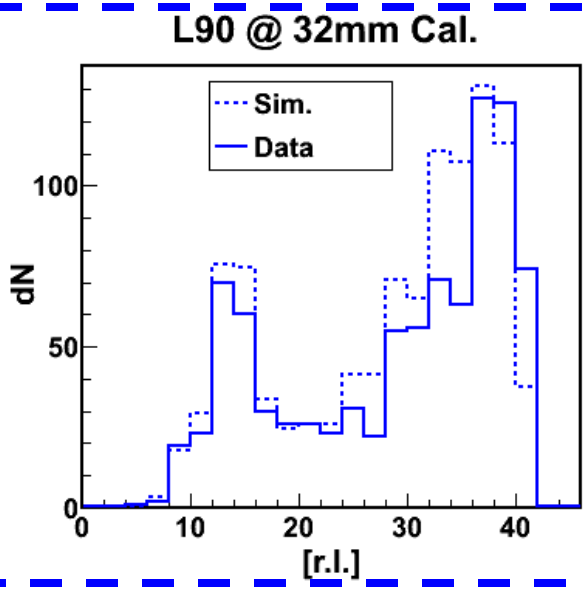
Arm2 PID L20 v.s. L90 (w/ P cut)





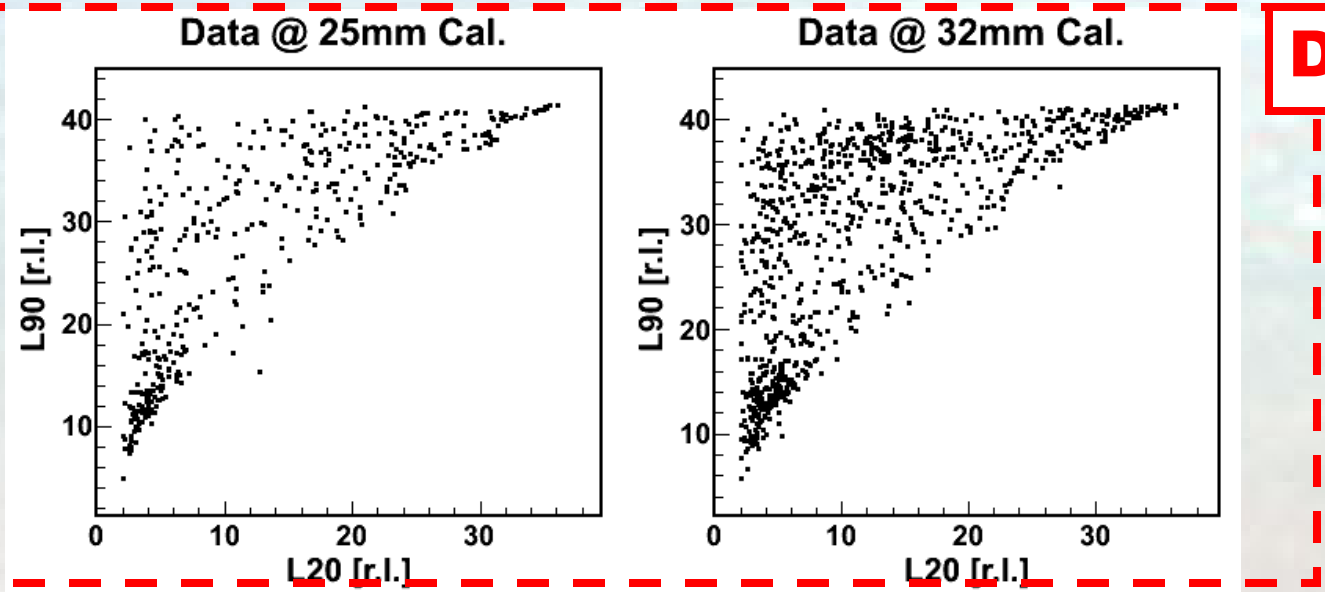
L20



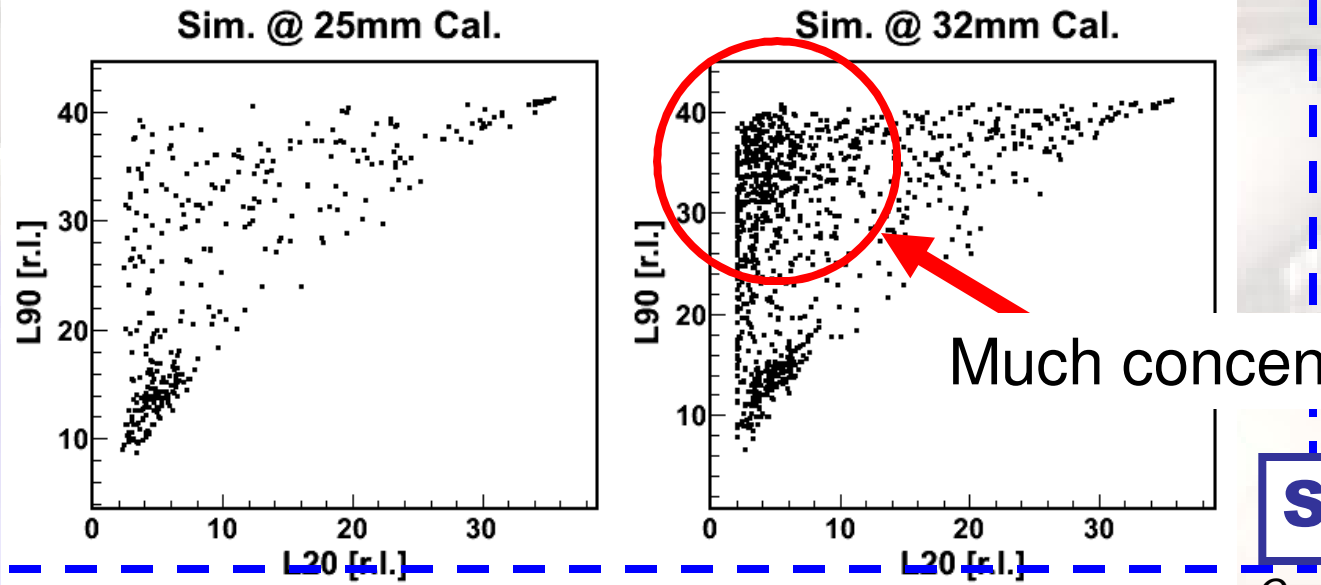


L90

Arm2 PID L20 v.s. L90 (w/ P cut)



Data

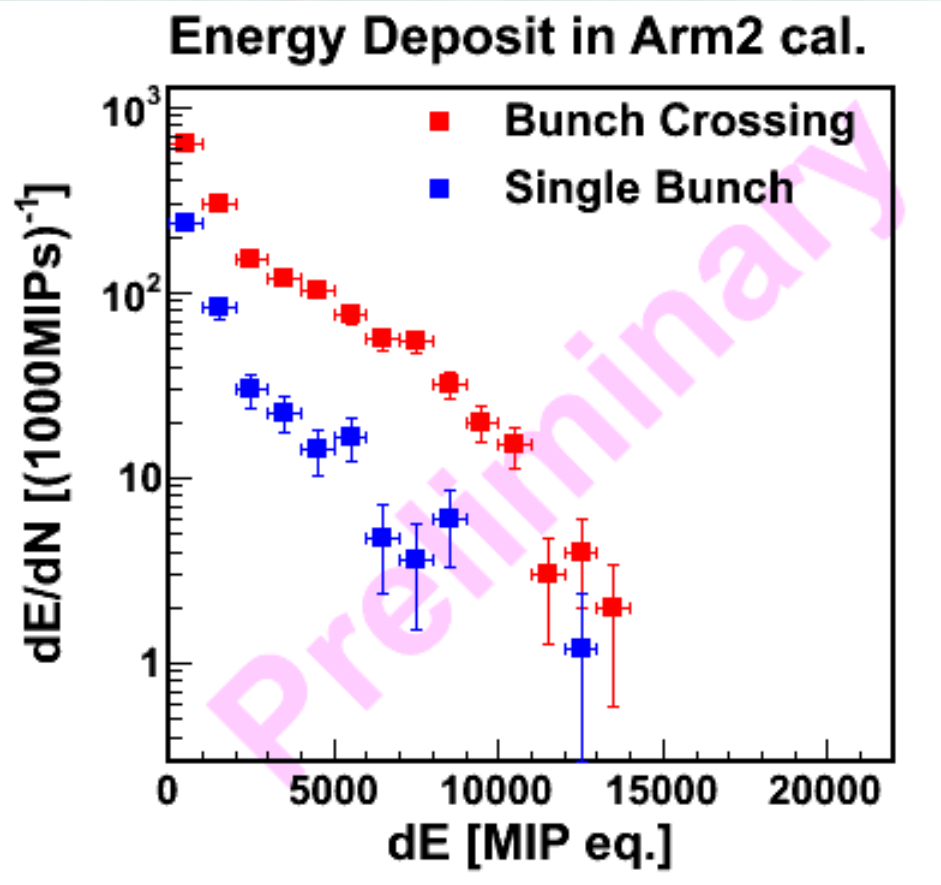


Much concentrated than data

Simulation

Arm2 Results: Distribution of integrated dE

- Raw level spectra
  (no PID and combined 25mm and 32mm)

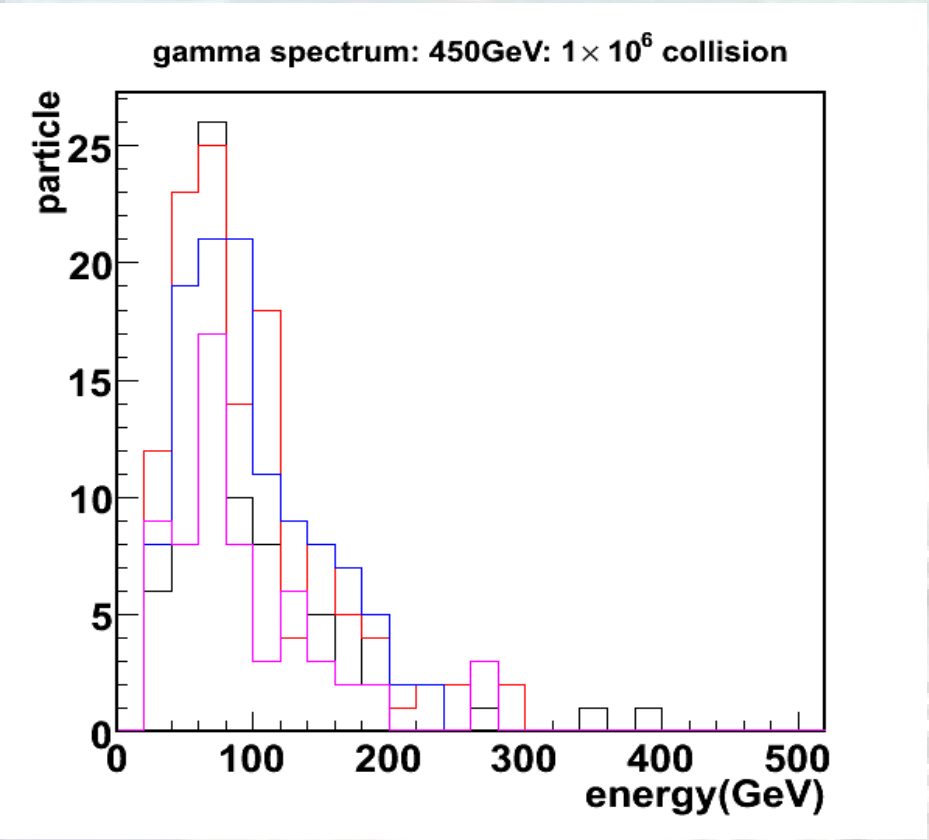


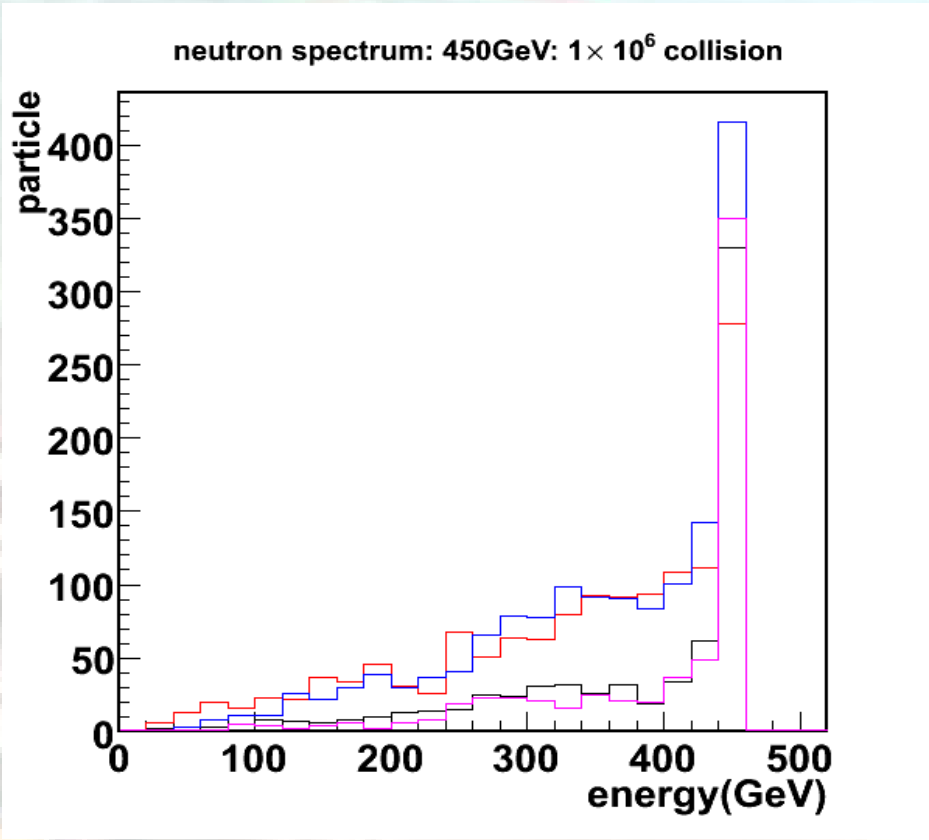
Bunch Crossing :
No normalization

Non-Bunch Crossing:
Normalized
by Integral Intensity.
(normalization factor
= 9.0E14/7.5E14)

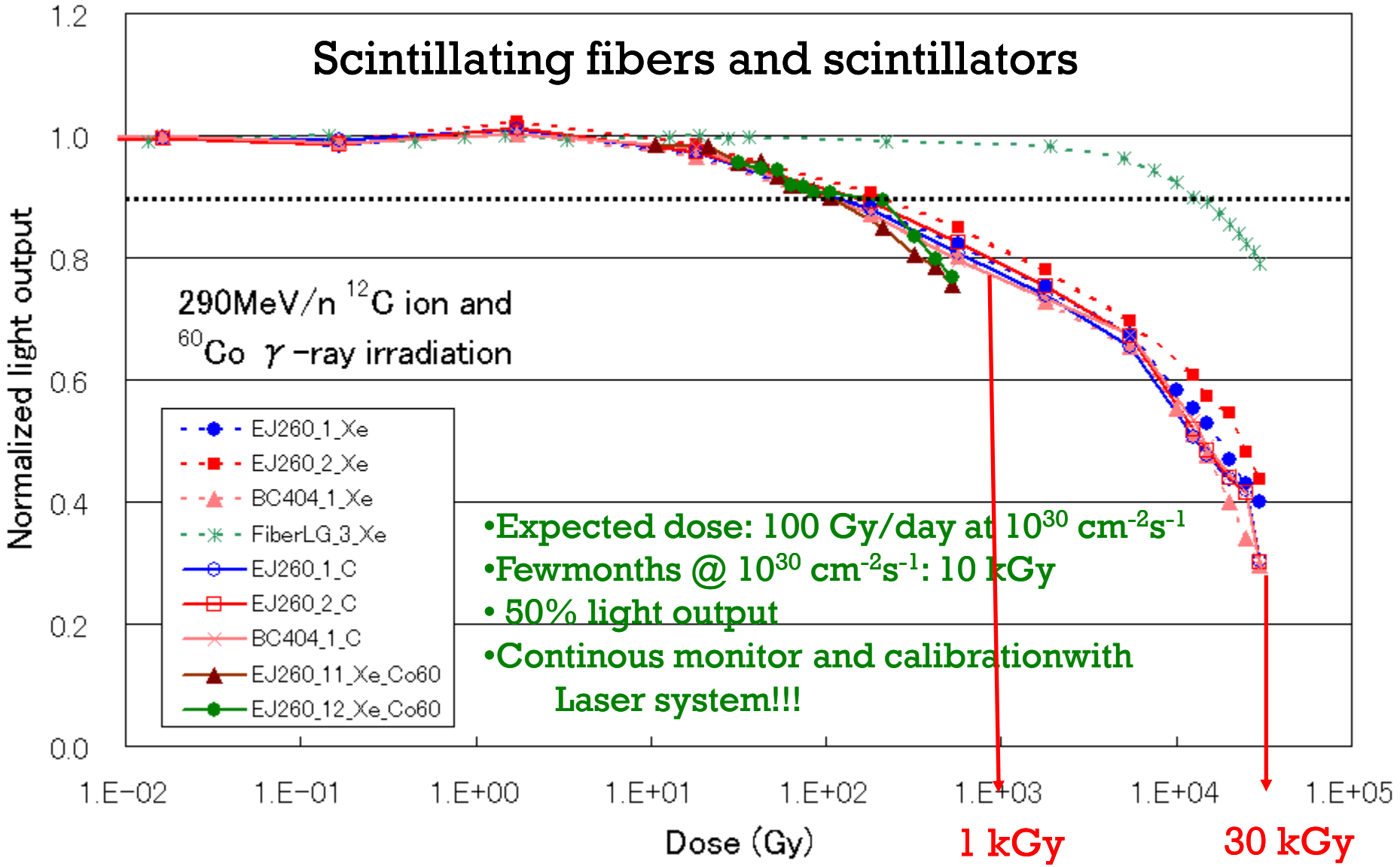
450GeV:
1x10^6 inelastic collision

DPMJET3
QGSJET2
QGSJET1
SIBYLL





Radiation Damage Studies



Results on radiation damage

The dose approximately scale as E^3

Energy (TeV)	Dose rate (Gy/hour at $10^{29}cm^{-2}s^{-1}$)	Dose rate (Gy/nb^{-1})	Time to reach 1KGy at $10^{29}cm^{-2}s^{-1}$ (days)	Integrated lumi to reach 1KGy (nb^{-1})
0.45+0.45	$4.6 \cdot 10^{-4}$	$1.27 \cdot 10^{-3}$	9140	$7.9 \cdot 10^{5}$
3+3	$1.3 \cdot 10^{-1}$	0.35	330	$2.9 \cdot 10^{3}$
5+5	$6.1 \cdot 10^{-1}$	1.7	68	590
7+7	1.6	4.3	27	230