Optimization of Reconstruction Algorithm for BeamCal (ILC)

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on behalf of FCAL-collaboration

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Search parameters for reconstruction Algorithm

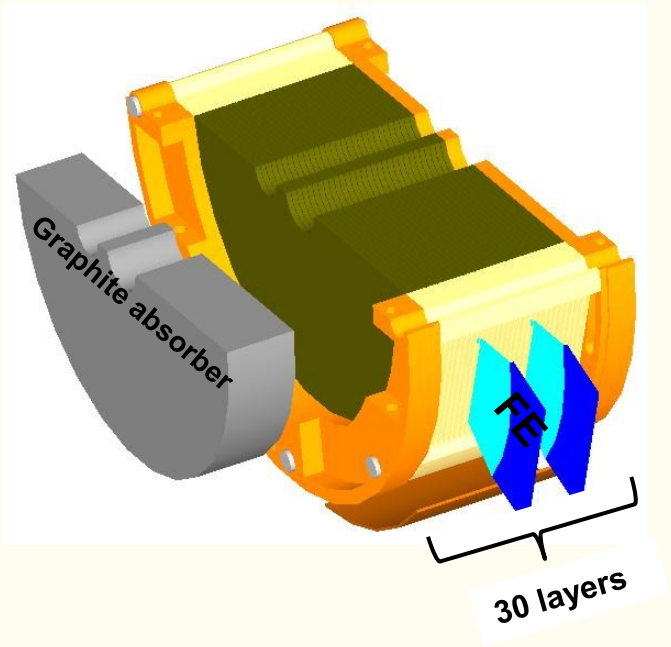
The goal: find optimal parameters of reconstruction algorithm

In my hands: deposited energy in each cell of calorimeter from shower and RMS of background(BG)

Parameters to apply:
- how many sigma(RMS) to apply
- which layers should be considered
- how many cells in a row

Requirements:
- fake rate < 2% (strictly!)
- increase: --efficiency of reconstruction
  --energy resolution
  --spatial resolution

Beam Calorimeter for ILC



- Tungsten absorber
- Diamond sensor
- Readout plane/air gap

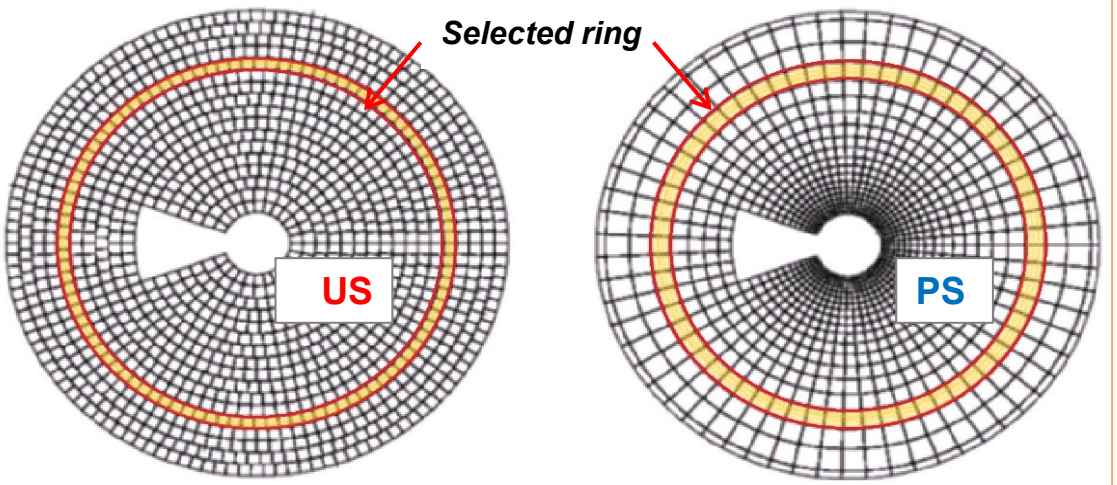
} $1\ X_0$

Size of pads:

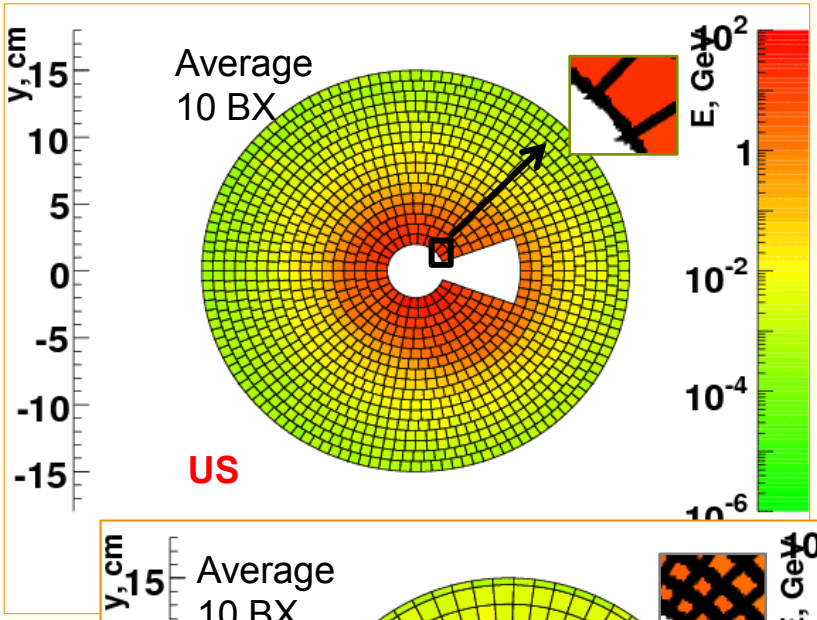
- US - similar, ≈7.65x7.65 mm
- PS - ~R, min 2.2x2.2, max 14.4x14.4mm

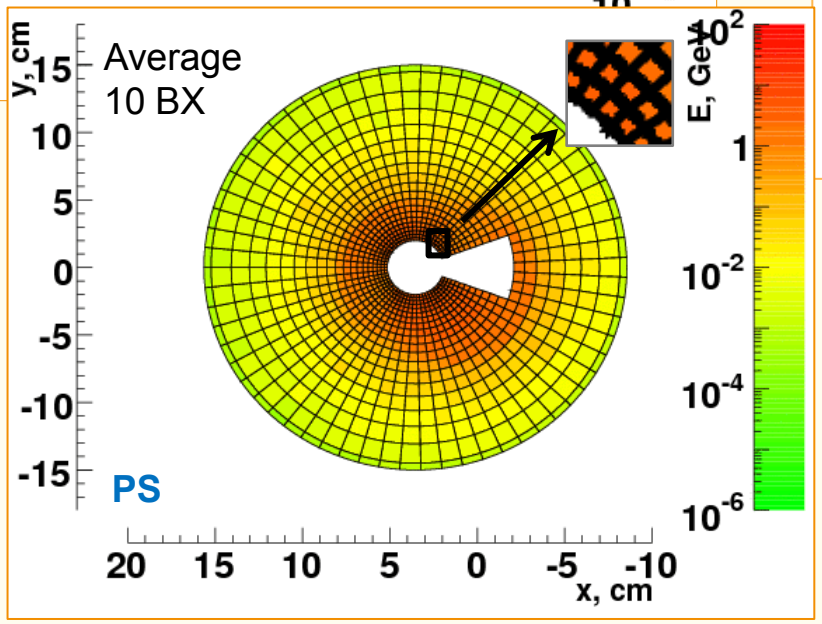
Number of pads:

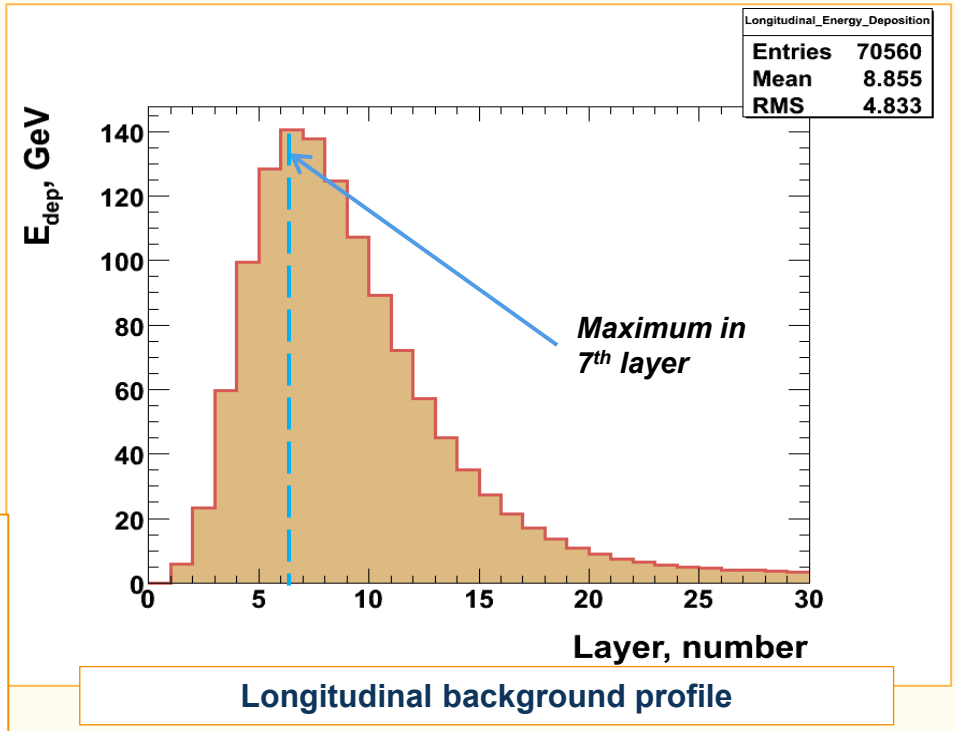
- For US and PS similar



Energy Deposition due to Beamstrahlung





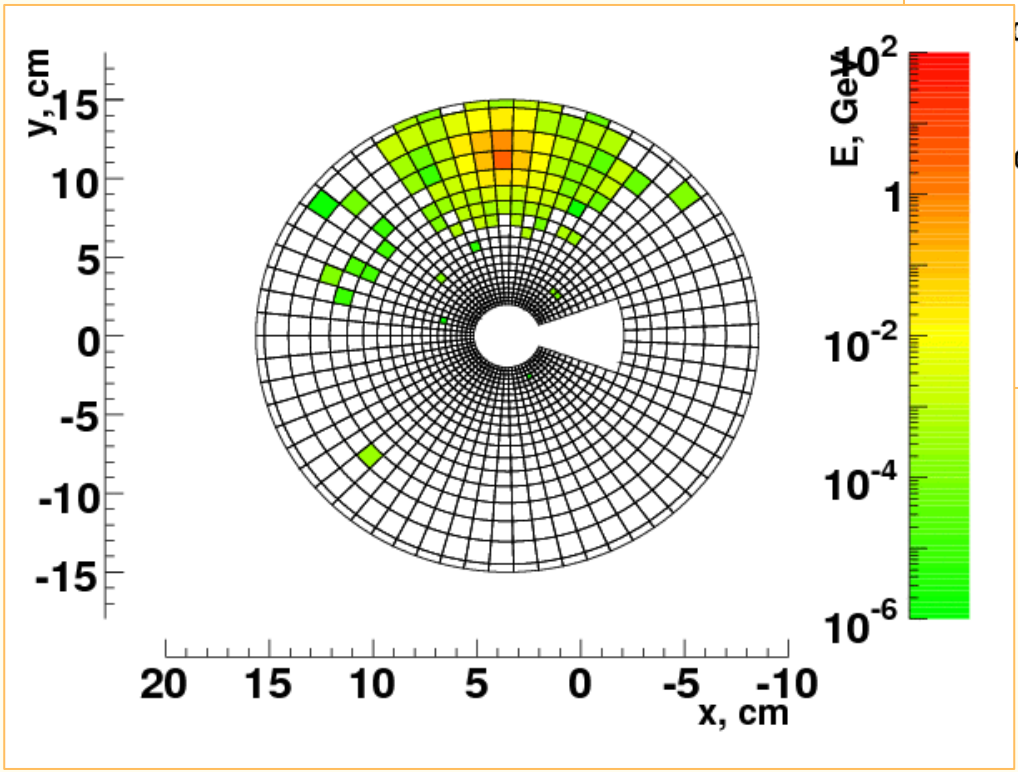


Longitudinal background profile

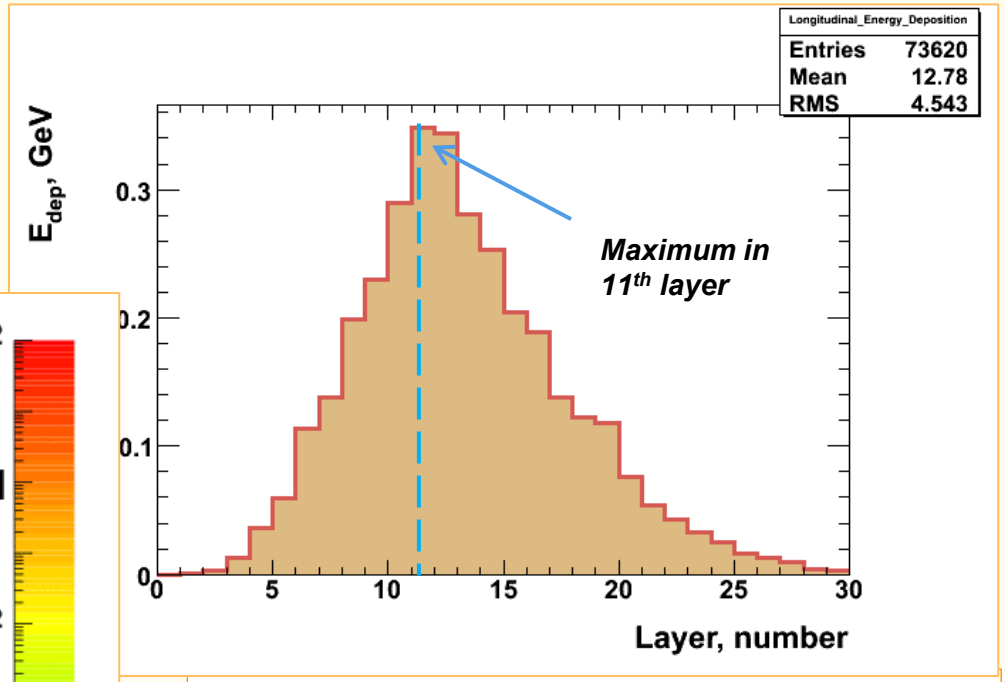
- Beamstrahlung (BS) pairs generated with Guinea Pig
- Energy deposition in sensors from BS simulated with BeCaS (Geant4) ⟶ *considered as background (BG)*

Shower from Single High Energy Electron

Example for 200 GeV electron:



Shower from 200- GeV electron



Longitudinal shower profile

Electron energy	Shower maximum
10 GeV	7 layer
20 GeV	8 layer
50 GeV	9 layer
100 GeV	10 layer

Situation with showers distribution

All the time before I was working with showers which was distributed next way:

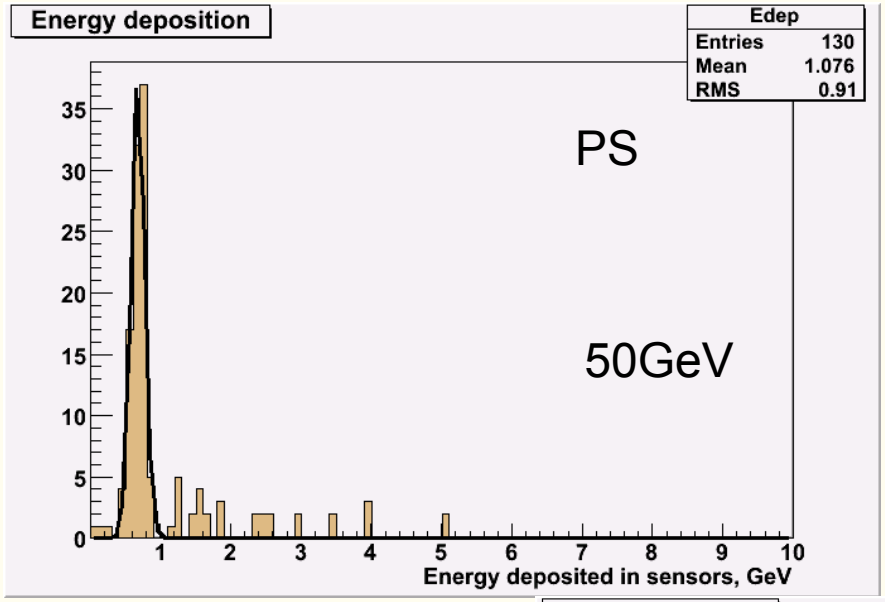
- for uniform segmentation **(US) distribution** of electrons hitting is **uniform**, concerning the radius
- for proportional segmentation**(PS)** density of hittings is $\sim\frac{1}{r}$ inversely proportional to the radius

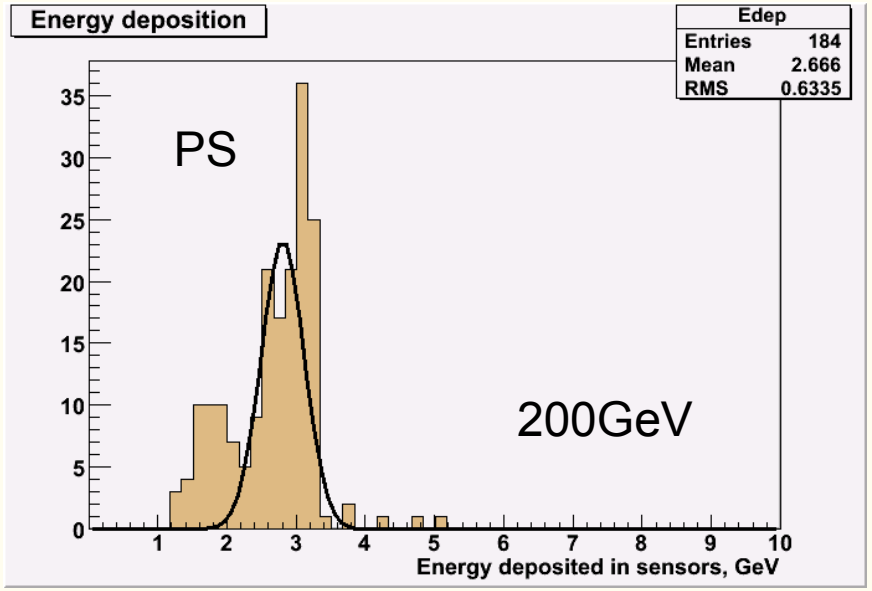
Use: to investigate and compare the characteristics of two segmentations according to the radius. (signal in cell for each ring, RMS, SNR,…)

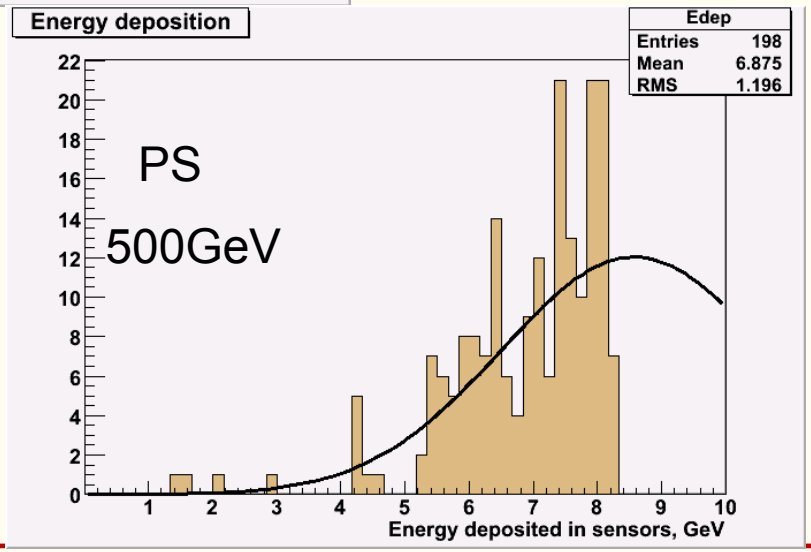
But for such parameters as **fake rate, resolutions, efficiency** – the results from that distributions **are not comparable**. (PS give more events on small radii)

Therefore I simulated for PS “another showers” with uniform distribution.

E deposition. Moliere Radius. With BG.





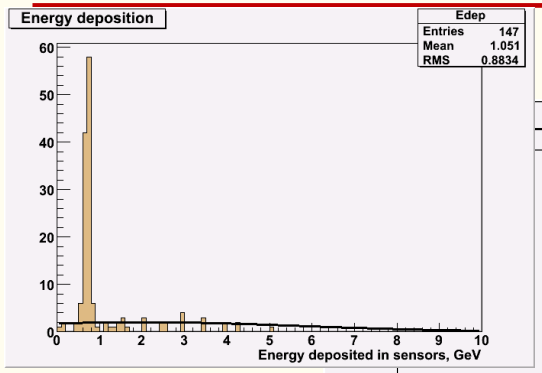


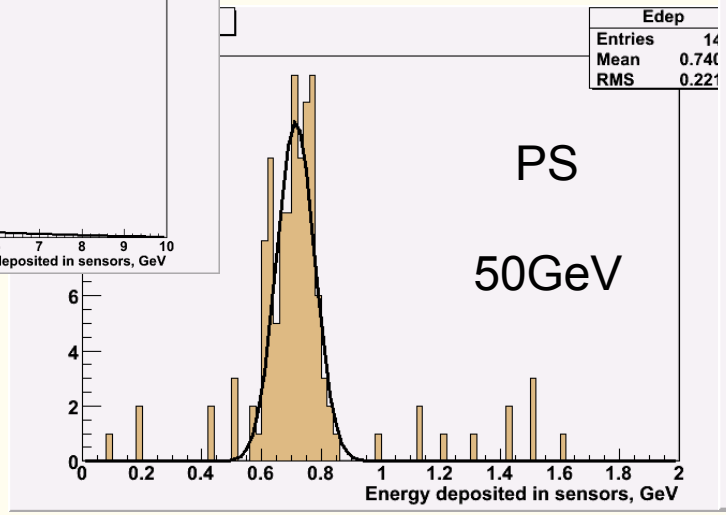
Condition:

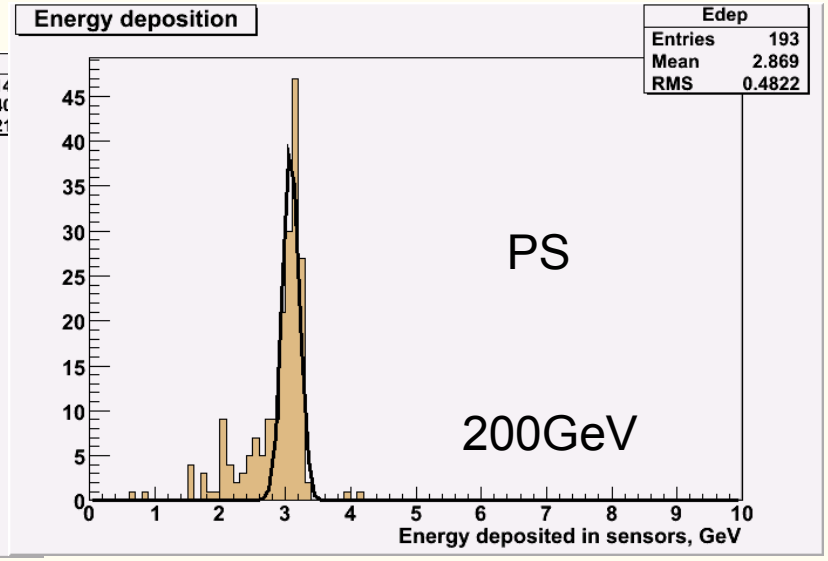
- after 5th layer 10 sequent pads in tower with Edep>σ

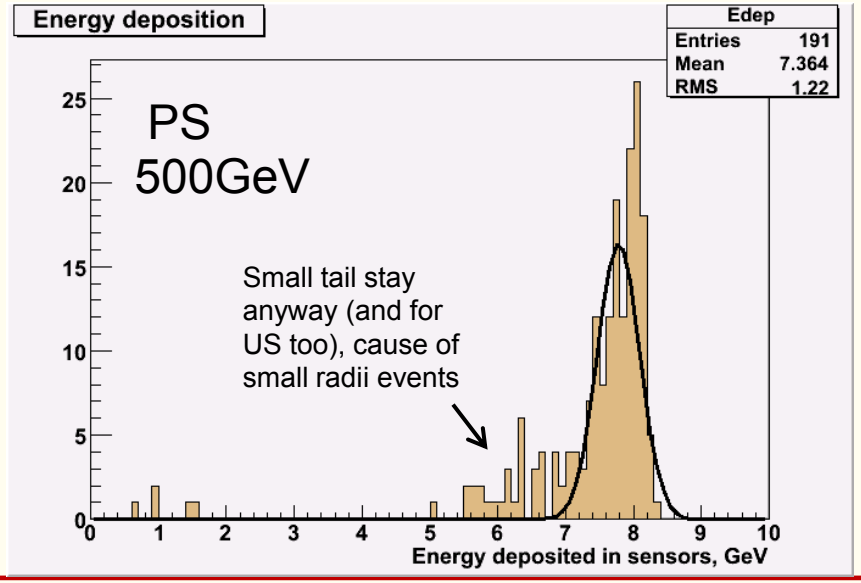
Radial distribution of hits

E deposition. Moliere Radius. With BG.









Condition:

- after 5th layer 10 sequent pads in tower with Edep>σ

Uniform distribution of hits

New showers

Algorithm

1. SH + BG – average_BG
2. Layers from ... to ...
3. Energy threshold ... RMS
4. Combine to towers
5. Search Max energetic tower
   * if there ≥ … cells (not necessarily sequent), search for neighbor towers
   * if in neighbor ≥ … cells & at least 1 neighbor

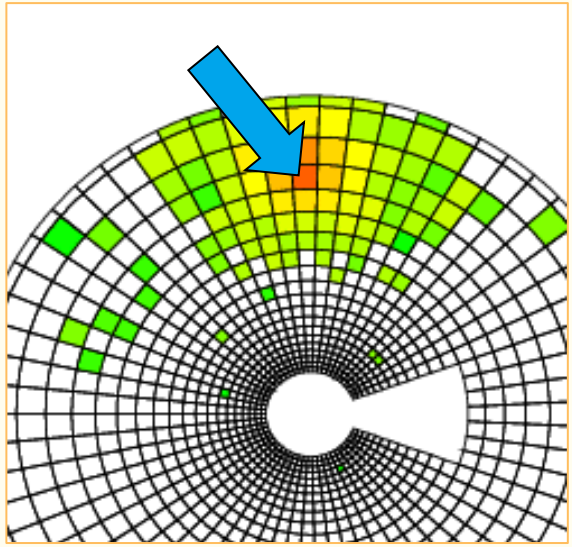
   => shower defined
   * Consider candidate towers to shower within Rm=1.2 cm or at least 8 pads around max energetic tower

   => shower created
6. Next shower: repeat 5
7. For each shower calculate
   - R COG
   - Energy

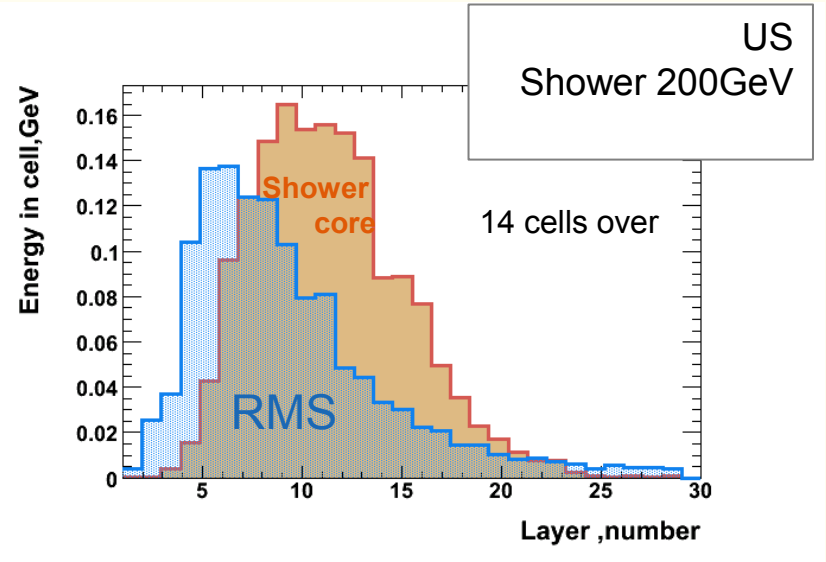
Idea

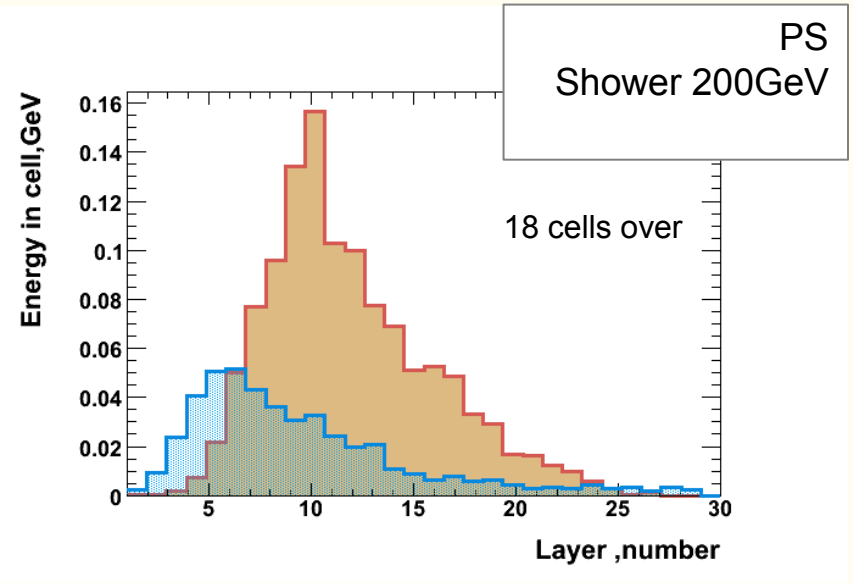
Compare energy deposition on small radii (most problematic area for reconstruction) along Z-axis for:

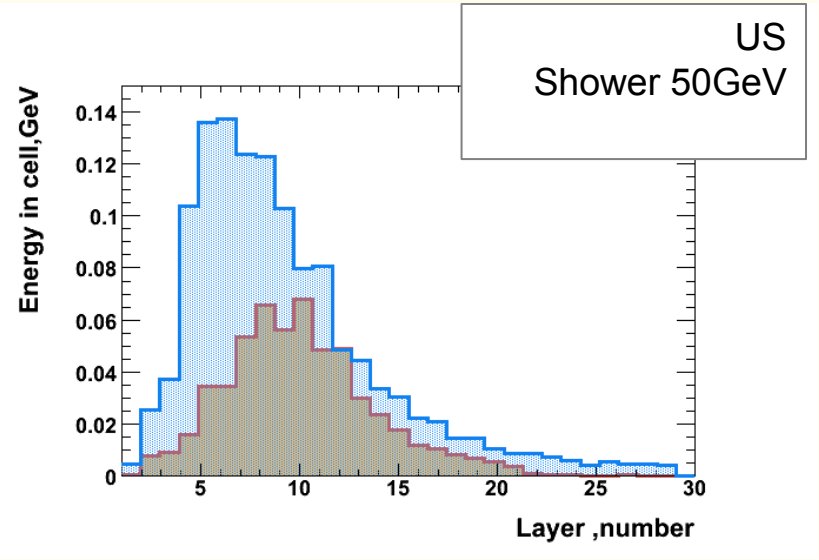
- tower of the shower core and tower of the RMS on small radii
- max energetic tower of (BG – average_BG) and
  tower of the RMS

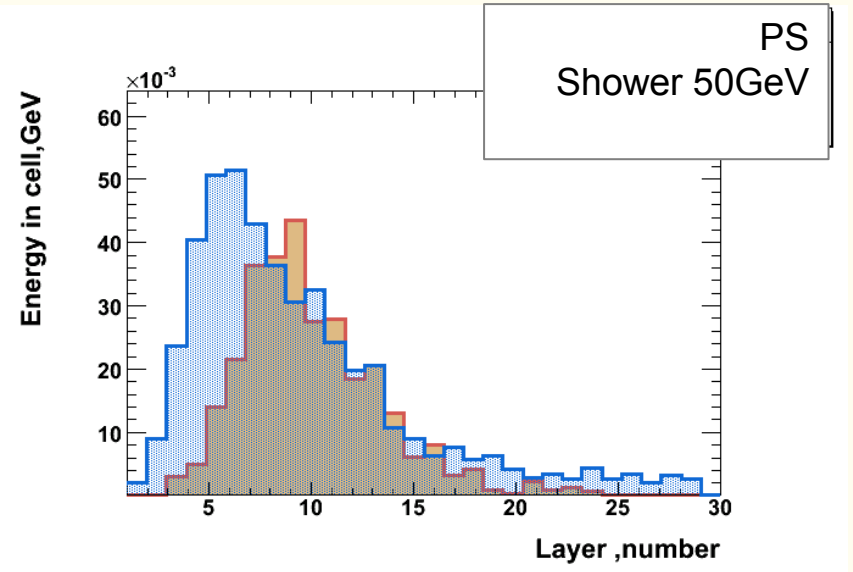


Tower profiles from Shower core and RMS on small R

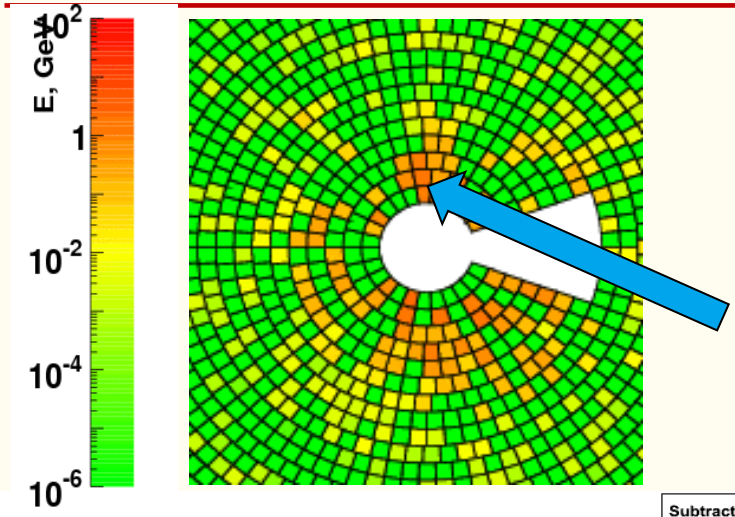




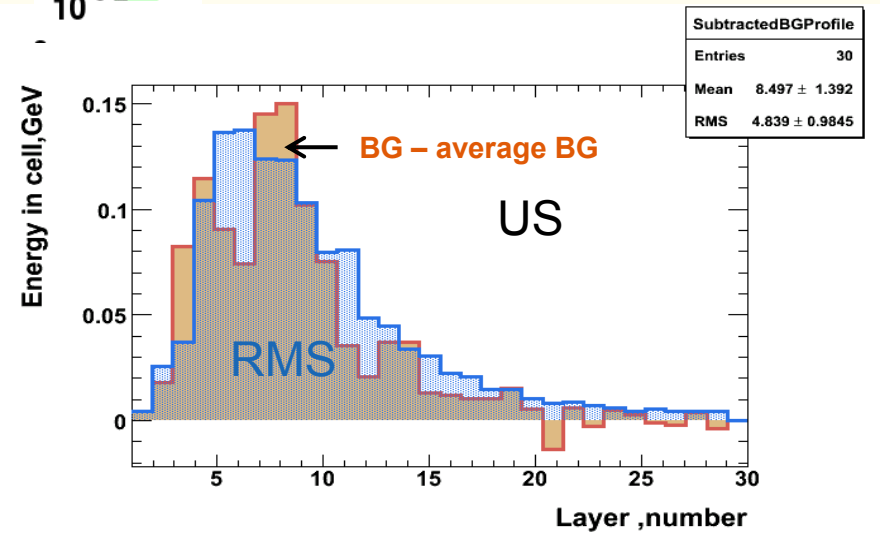


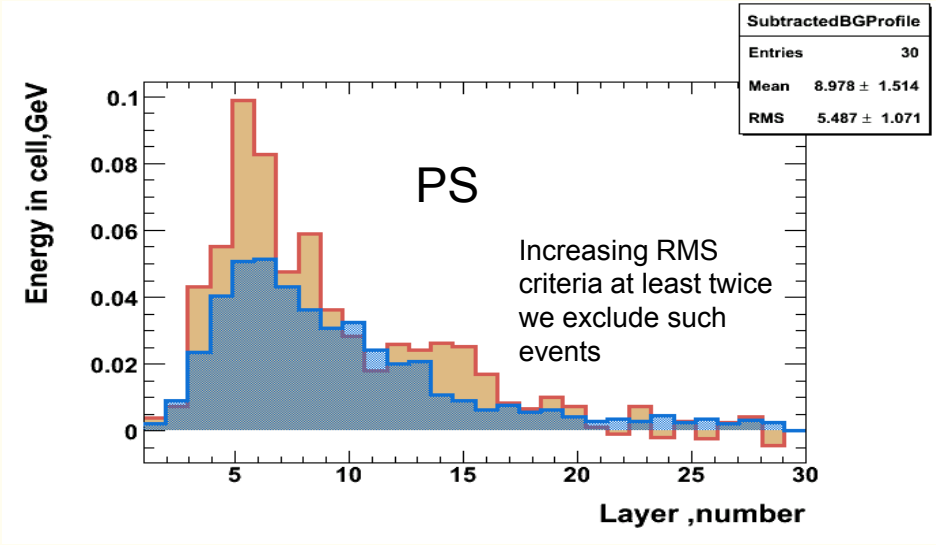


Tower profiles from Subtracted BG and RMS on small R



The tower with maximal energy deposition was chosen(the worst case)





But for showers(previous slide) we still have possibility to reconstruct, especially going further with radius

Choosing parameters. Fake Rate.

Source	Difference in conditions	Layers to be considered	RMS applyed	Min number of cells in a row	
				In SH max	In neighbor
Max SH Tower and RMS along Z comparison (previous slides)	**1 Tev**	**5-20** (25?)	**>2 RMS** (chosen 5 RMS)	**13**	**9**
Thesis of Katharina Kuznetsova, 2006	**500GeV ,** diff size of pads, type of segmentation - US	**4-17**	**3 RMS**	**10**	**6**
FCAL Paper, 2004	**500 GeV**	**2-20**	**5 RMS**	**9**	**6**

Checking fake rate (100 files were used)

	Layers to be considered	RMS applyed	Min number of cells in a row		Fake rate	
			SH max	Neighbor	US	PS
Case 1 (suitable)	**5-20**	**5 RMS**	**13**	**9**	**2 %**	**0 %**
Case 2 (relaxed)	**5-20**	**5 RMS**	**10**	**6**	**3%**	**3%**

Efficiency

1. Reconstruction showers on top of BG -> Number of ring Rreco
2. Reconstruct showers, no threshold applied (0*RMS,
   cause not all SH on small radii reconstructing) -> Rtrue
3. If number of Rreco and Rtrue are equal,
   or if | Rtrue- Rreco| < Rm – then shower reconstructed correctly
3. Ratio Rreco/Rtrue = efficiency
4. If | Rtrue- Rreco| > Rm - fake shower

-Problem:

Detecting several showers from one (mostly for 500GeV)

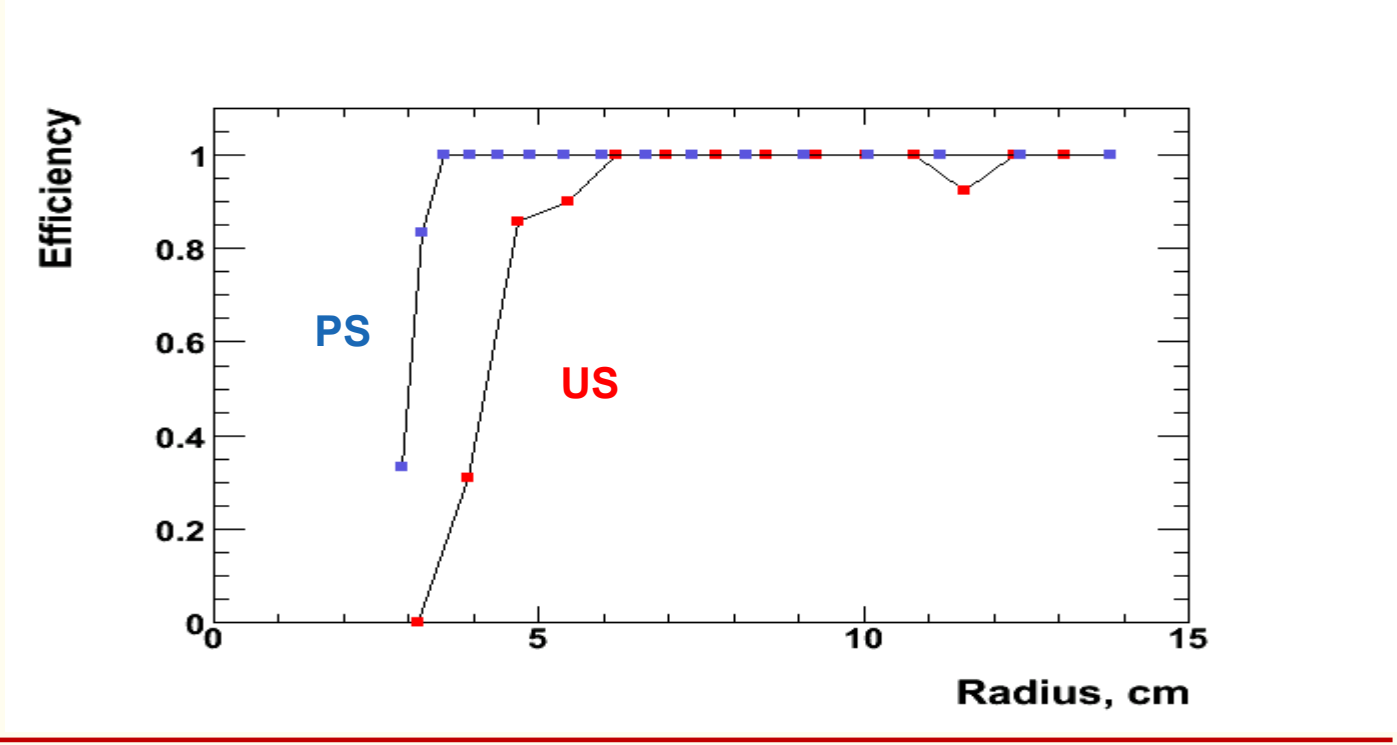
Efficiency 500 GeV

PS

TOTAL EVENTS=200
NUMBER NOT CREARTED SHOWERS=12
EQUAL_EVENTS=183
EQUAL WITHIN R_ MOLIERE EVENTS=0
NUMBER FAKE SHOWERS=2
NUMBER NOT RECONSTRUCTED EVENTS=3

US

TOTAL EVENTS=194
NUMBER NOT CREARTED SHOWERS=11
EQUAL_EVENTS=155
EQUAL WITHIN R_ MOLIERE EVENTS=0
NUMBER FAKE SHOWERS=2
NUMBER NOT RECONSTRUCTED EVENTS=26



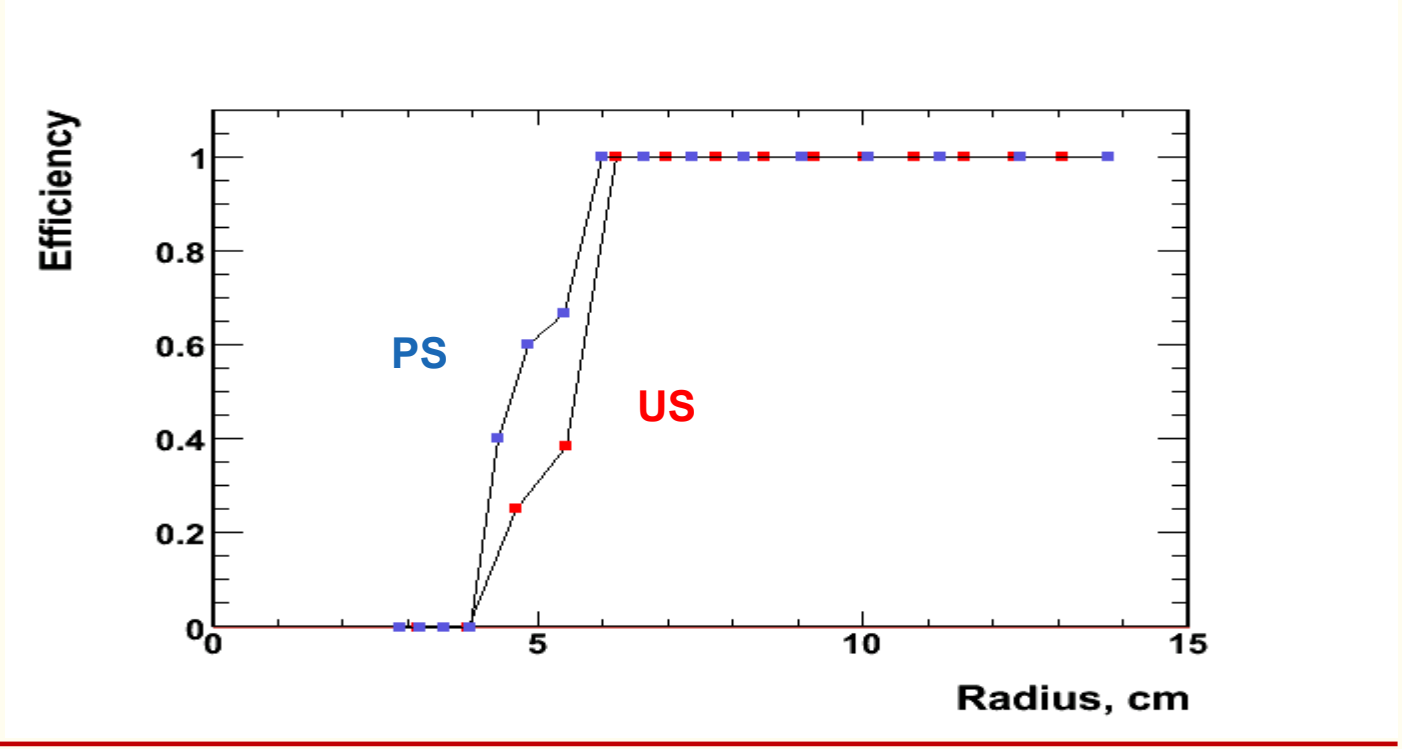
Efficiency 200 GeV

PS

TOTAL EVENTS=199
NUMBER NOT CREARTED SHOWERS=10
EQUAL_EVENTS=152
EQUAL WITHIN R_ MOLIERE EVENTS=0
NUMBER FAKE SHOWERS=2
NUMBER NOT RECONSTRUCTED EVENTS=35

US

TOTAL EVENTS=199
NUMBER NOT CREARTED SHOWERS=9
EQUAL_EVENTS=144
EQUAL WITHIN R_ MOLIERE EVENTS=1
NUMBER FAKE SHOWERS=1
NUMBER NOT RECONSTRUCTED EVENTS=44



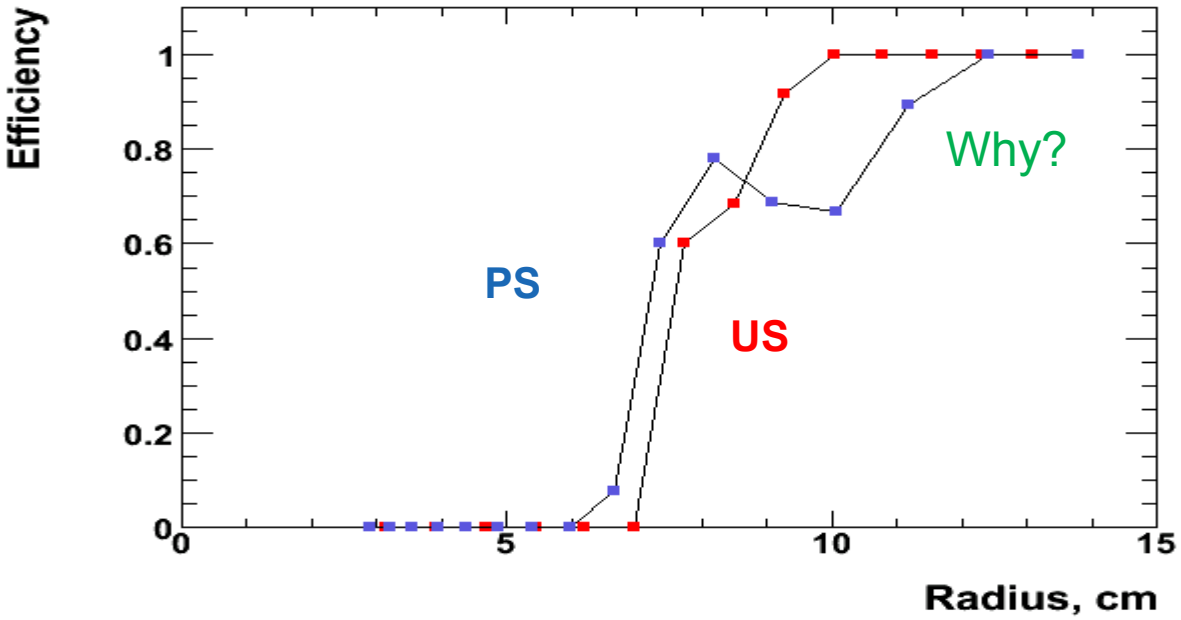
Efficiency 50 GeV

PS

TOTAL EVENTS=200
NUMBER NOT CREARTED SHOWERS=15
EQUAL_EVENTS=85
EQUAL WITHIN R_ MOLIERE EVENTS=0
NUMBER FAKE SHOWERS=0
NUMBER NOT RECONSTRUCTED EVENTS=100

US

TOTAL EVENTS=196
NUMBER NOT CREARTED SHOWERS=14
EQUAL_EVENTS=88
EQUAL WITHIN R_ MOLIERE EVENTS=0
NUMBER FAKE SHOWERS=3
NUMBER NOT RECONSTRUCTED EVENTS=91



Problems

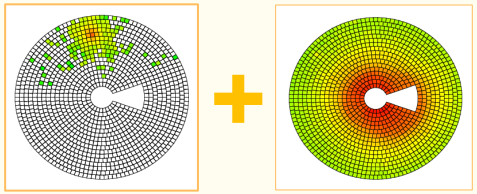
- Access to NAF2 LC group - to get more BG files
- Detecting several showers from one (mostly for 500GeV)

Back up

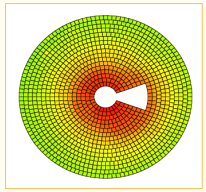
Old Algorithm

with BG

1. SH + BG

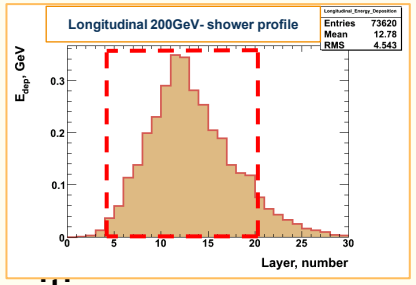


2. - average BG by 10th previous BX

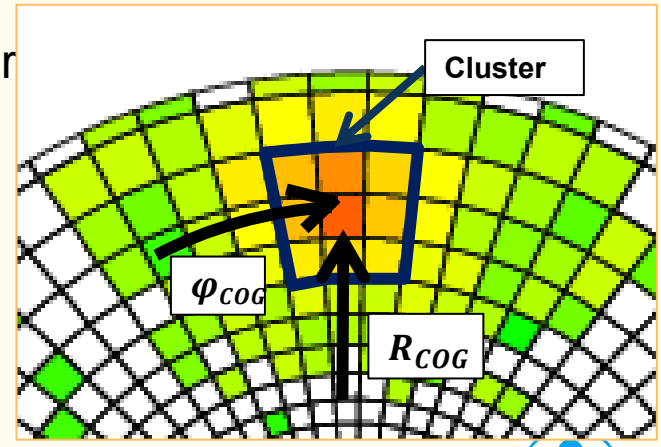


wo BG

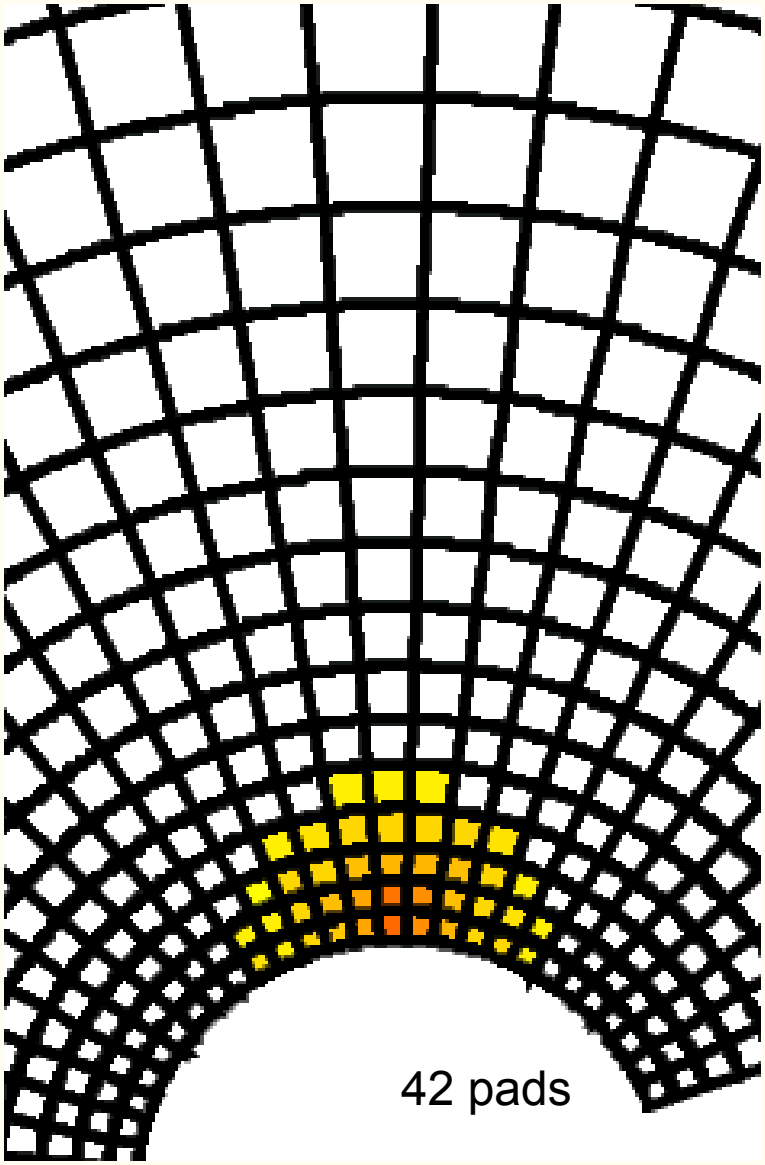
3. Select layers from 5th to 30th. Search for towers contains at least 10 sequent pads with Edep>0 along Z axis.



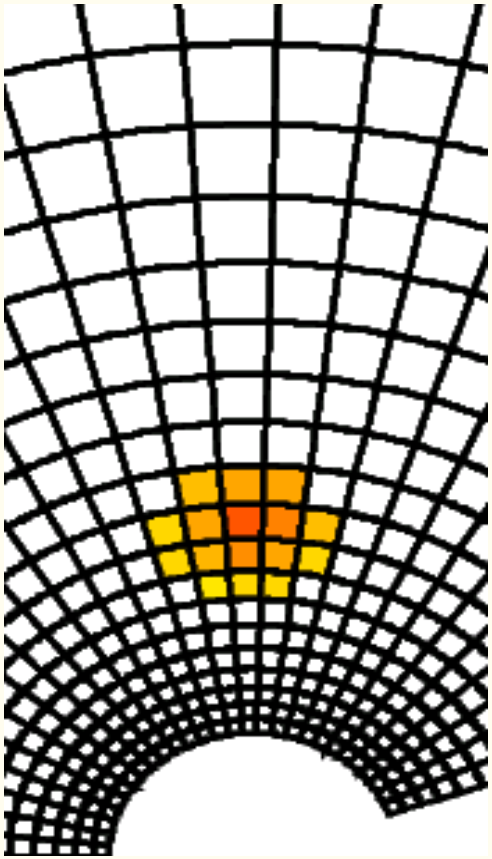
4. Searching in that towers tower with maximum energy deposition
5. Look on to 8 neighbor towers around that tower
6. Get output: $\mathbf{R_{COG}}$, $\boldsymbol{\varphi_{COG}}$, $\mathbf{E_{clu}}$



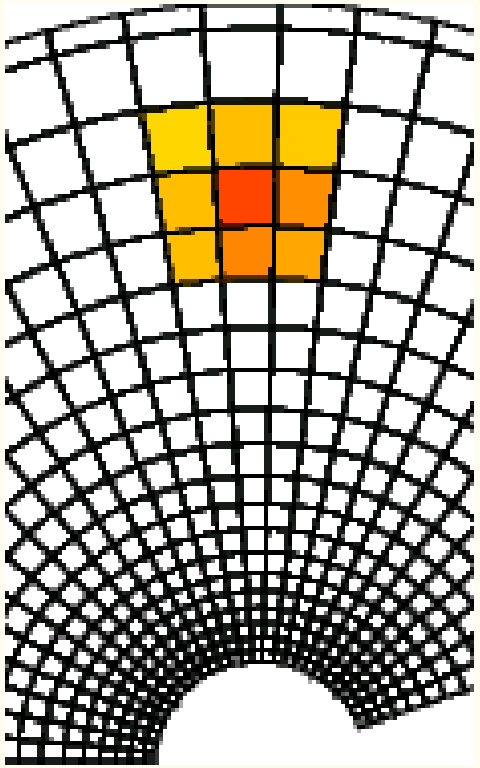
Moliere Radius



42 pads

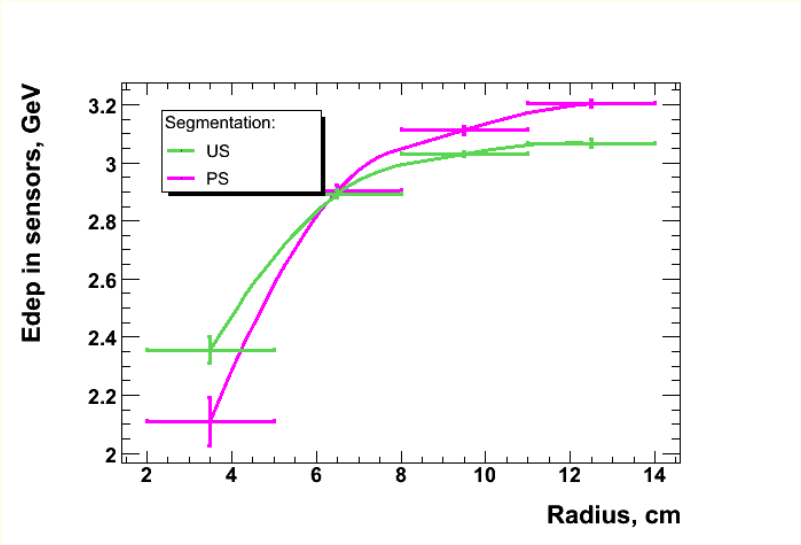


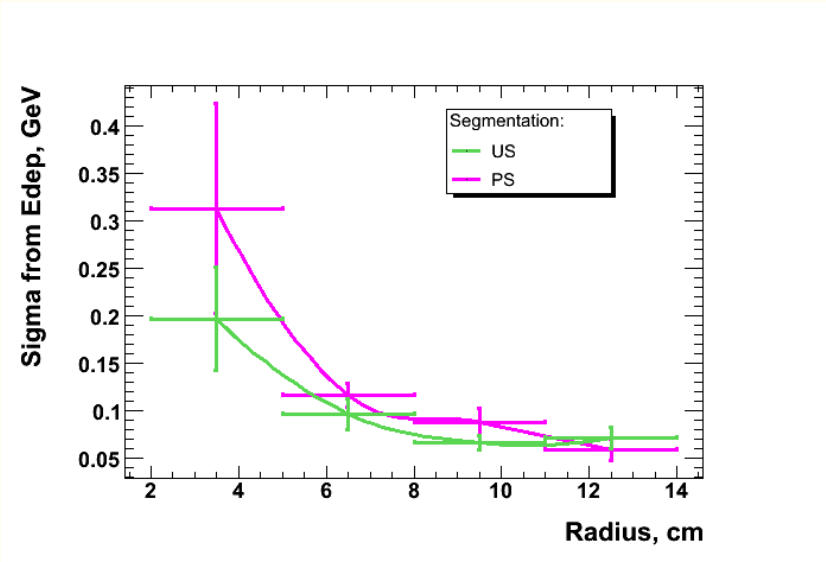
16 pads



8 pads

Energy resolution vs Radius





For 200Gev