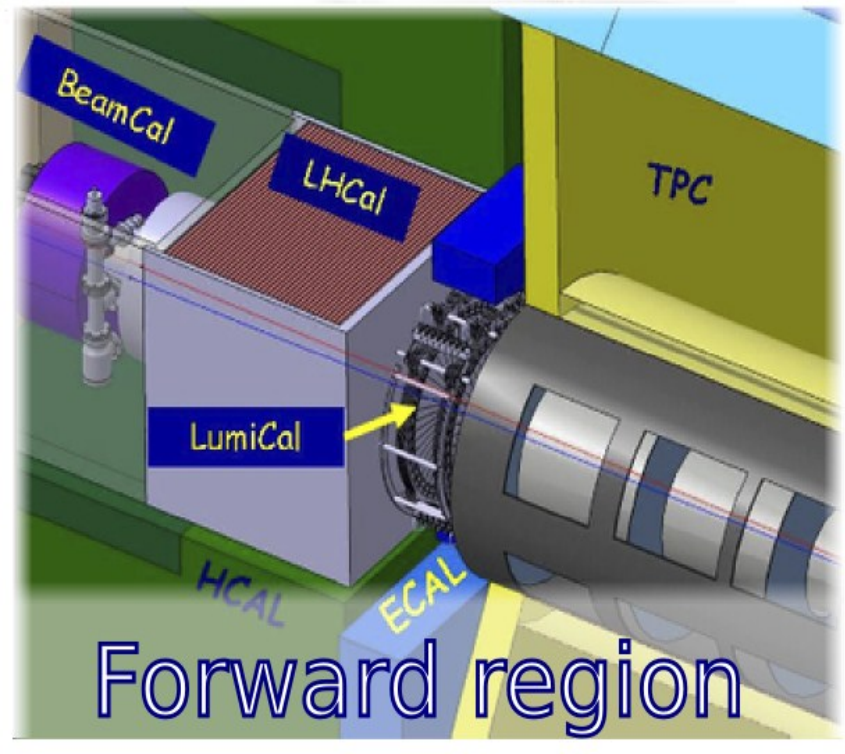
BeamCal Reconstruction Algorithm Simulations for TB

Lucia Bortko, DESY

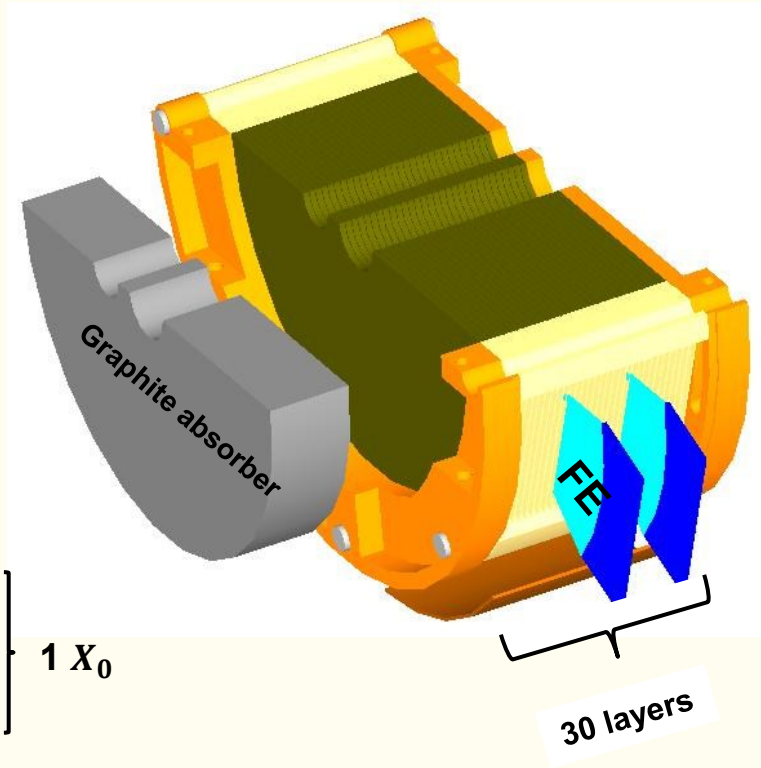
1st FCAL Clustering Meeting | 14 July 2014

Beam Calorimeter for ILC



BeamCal aimed:

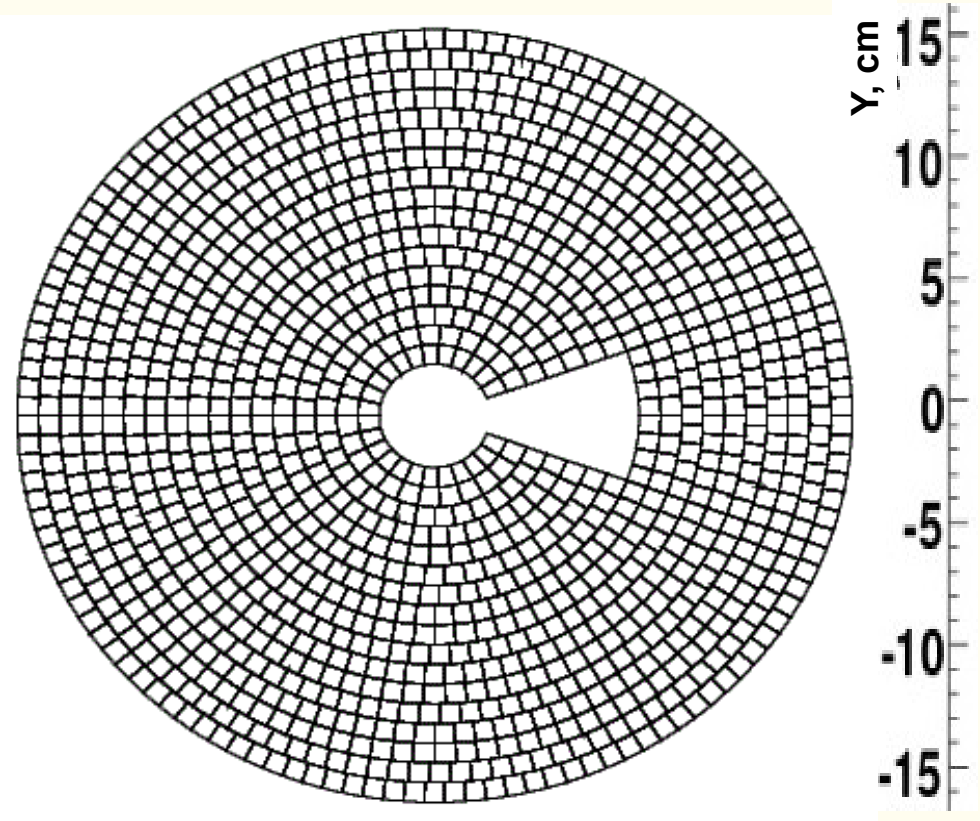
- Detect sHEe
- Determine Beam Parameters
- Mask backscattered low energetic particles



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

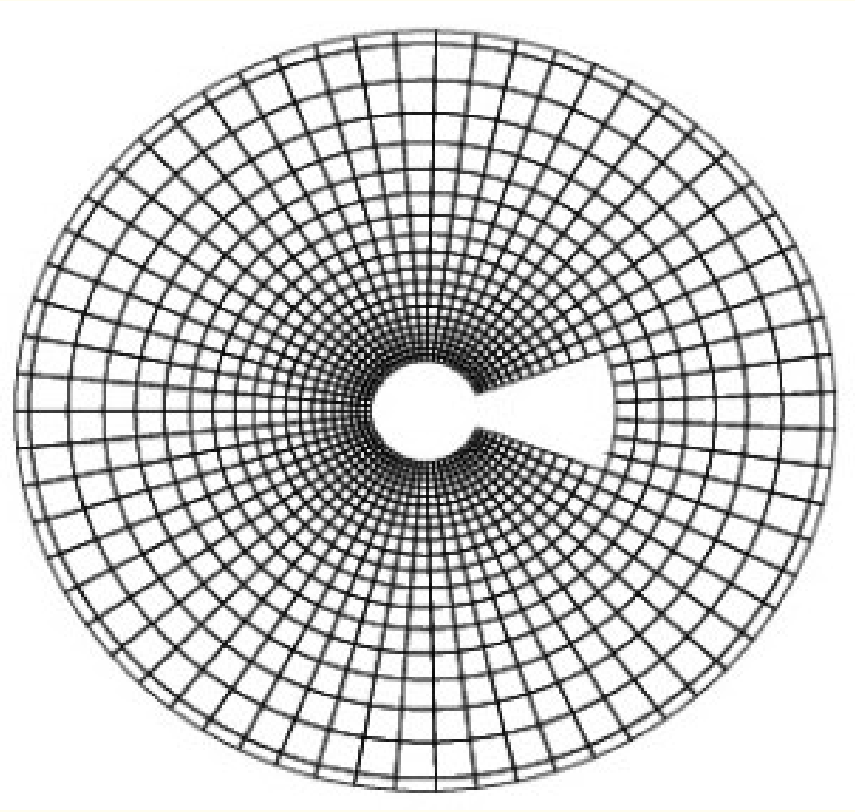
} **1 X_0**

BeamCal Segmentation



Uniform Segmentation (US)

pads size are the same



Proportional Segmentation (PS)

pads size are proportional to the radius

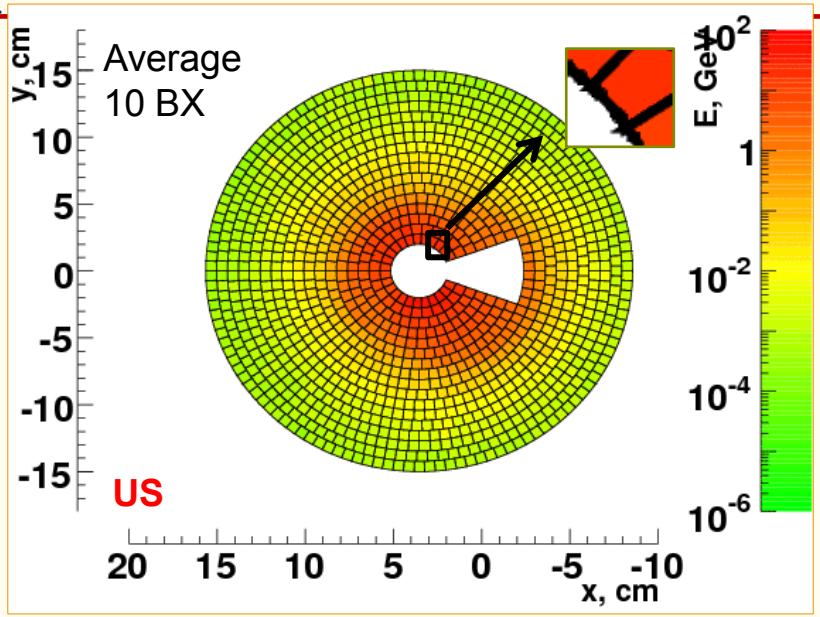
Similar number of channels

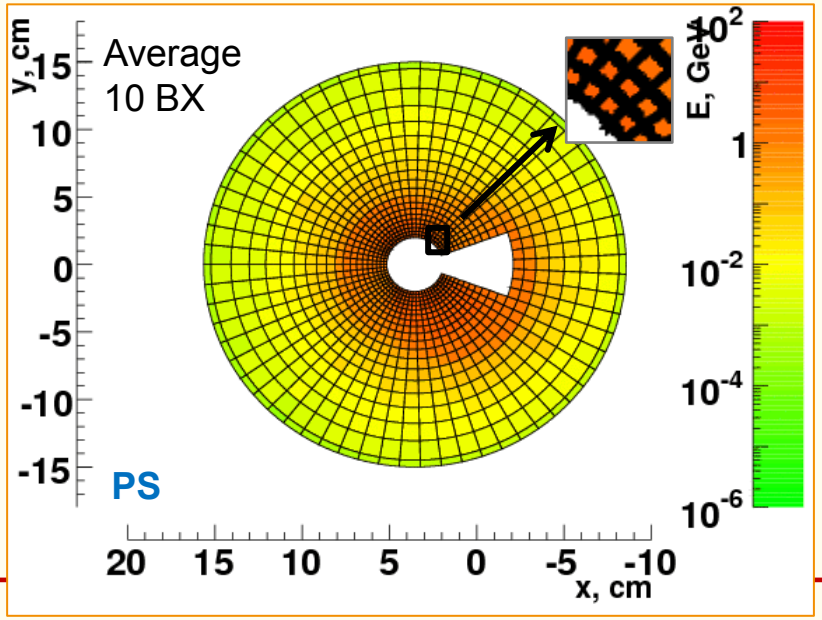
Energy Deposition due to Beamstrahlung

- **Beamstrahlung pairs generated with Guinea Pig**
- **Beam parameters taken from the ILC TDR Nov 2012**
  - *Nominal parameter set*
  - *Center-of-mass energy 1 TeV*
- **Energy deposition in sensors from beamstrahlung simulated with BeCaS (Geant4)**

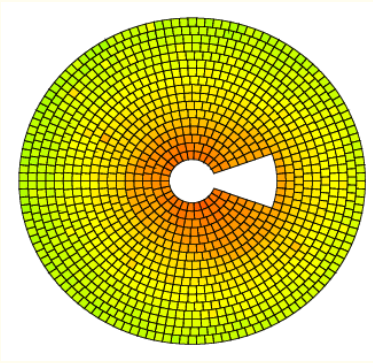
  → ***considered as Background (BG)***

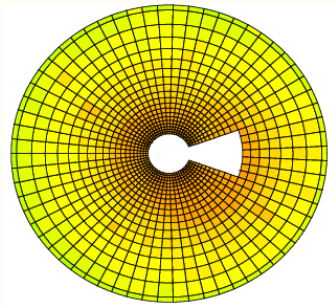
PS decrease deposited energy per pad in a high BG area





RMS of the averaged BG





Figures show sum by all layers

Algorithm

With BG

Without BG

1. SH + BG – average by 10th previous BXs BG
2. Select layers from 5th to 20th
3. Applying energy threshold 5 RMS
4. Combine to towers, calculate its energy
5. Search shower core (max energetic tower)

   * if there ≥ 13 cells (not necessarily sequent), search for neighbor towers

   * if in neighbor ≥ 9 cells & at least 1 neighbor

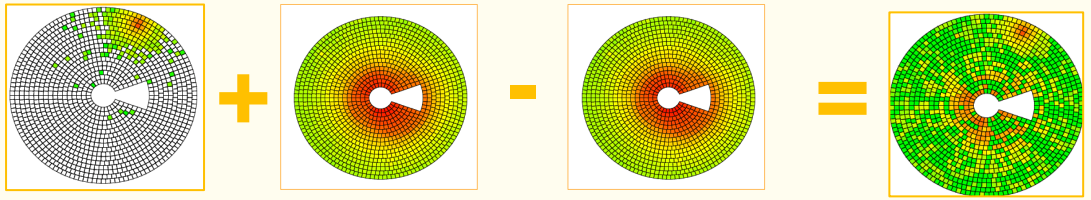
   => shower defined

   * Candidate towers are considered to shower within Rm=1.2 cm or at least 8 pads around shower core

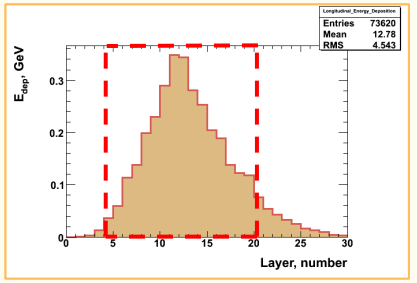
   => shower created
6. Next shower: repeat step 5
7. For each shower calculating

   - R_{COG}, φ_{COG}, E_{sh}

1

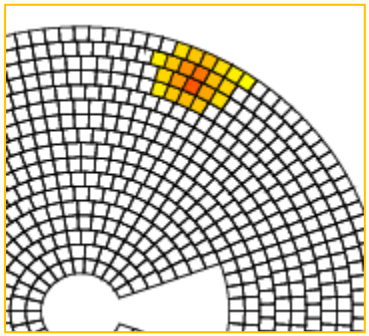


2



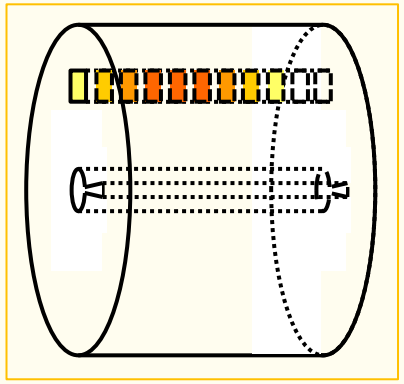
Reconstructed SH

5



Tower

4



Fake Rate. Efficiency of Shower Reconstruction

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:

If *rTrue, phiTrue - original coordinates of electron*

rReco, phiReco – COG coordinates from reconstructed showers on top of BG

then If | rTrue - rReco| < Rm

and |phiTrue – phiReco| < Rm

=> shower reconstructed correctly

$$\text{Efficiency} = \frac{\text{rReco}}{\text{rTrue}}$$

Else (| Rtrue- Rreco| > Rm) - fake shower

Efficiency of shower reconstruction for 500 GeV electron

PS

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 89.2%

NUMBER FAKE SHOWERS = 1.2%

NUMBER NOT RECONSTRUCTED SHOWERS = 9.6%

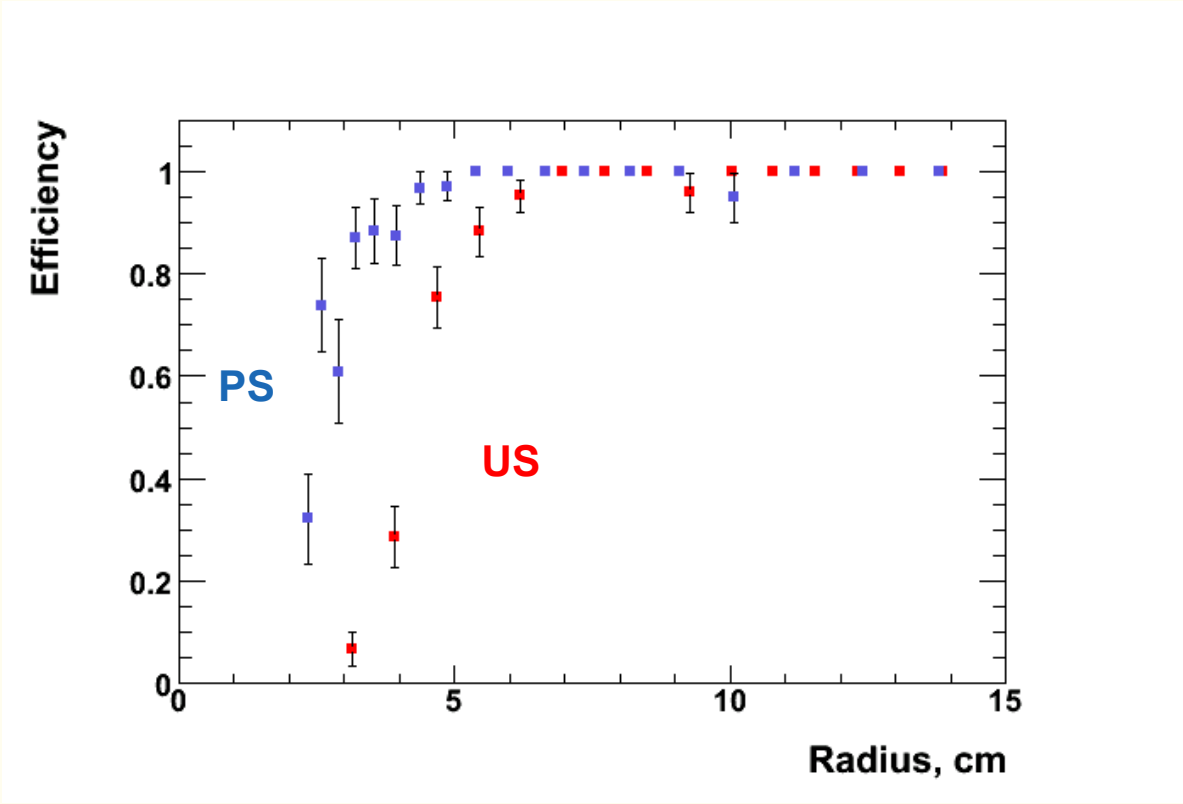
US

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 64.9%

NUMBER FAKE SHOWERS = 0.6%

NUMBER NOT RECONSTRUCTED SHOWERS = 34.5%



Efficiency of shower reconstruction for 200 GeV electron

PS

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 55.1%

NUMBER FAKE SHOWERS = 0.8%

NUMBER NOT RECONSTRUCTED SHOWERS = 44.1%

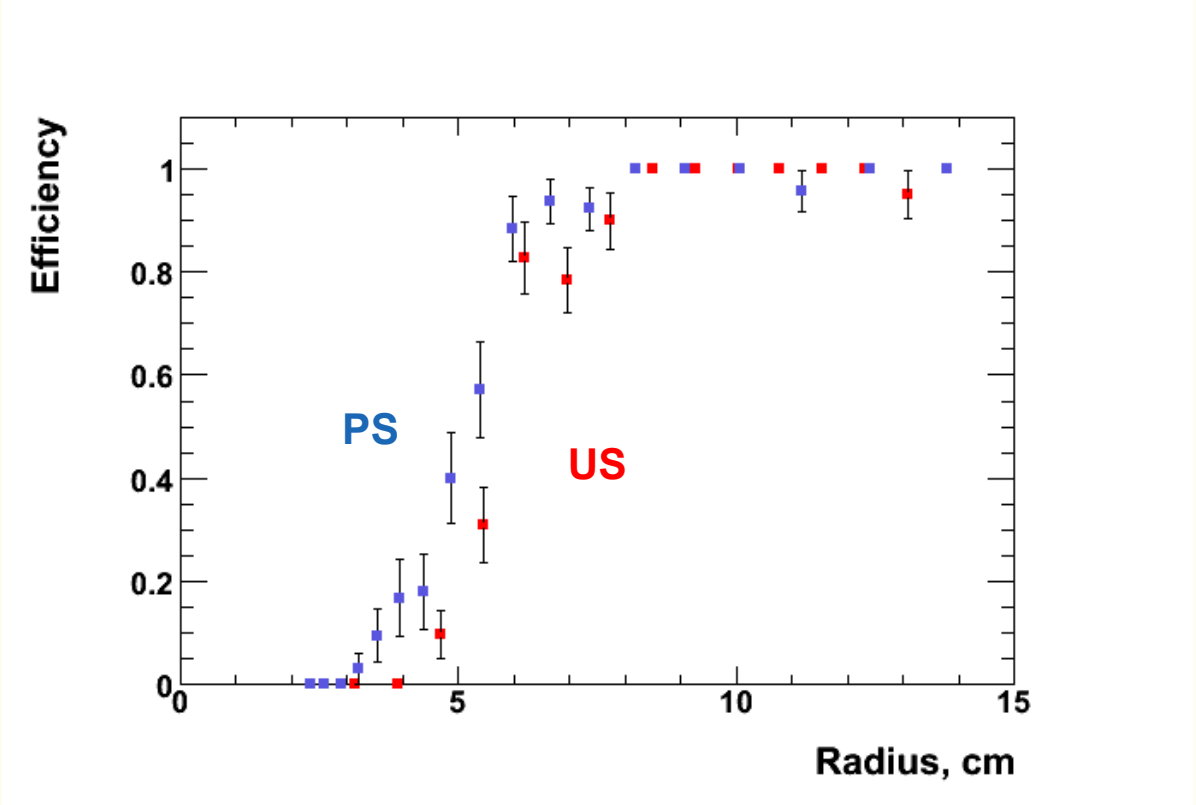
US

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 46.0%

NUMBER FAKE SHOWERS = 1.4%

NUMBER NOT RECONSTRUCTED SHOWERS = 52.6%



Efficiency of shower reconstruction for 50 GeV electron

PS

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 29.5%

NUMBER FAKE SHOWERS = 0.4%

NUMBER NOT RECONSTRUCTED SHOWERS = 70.1%

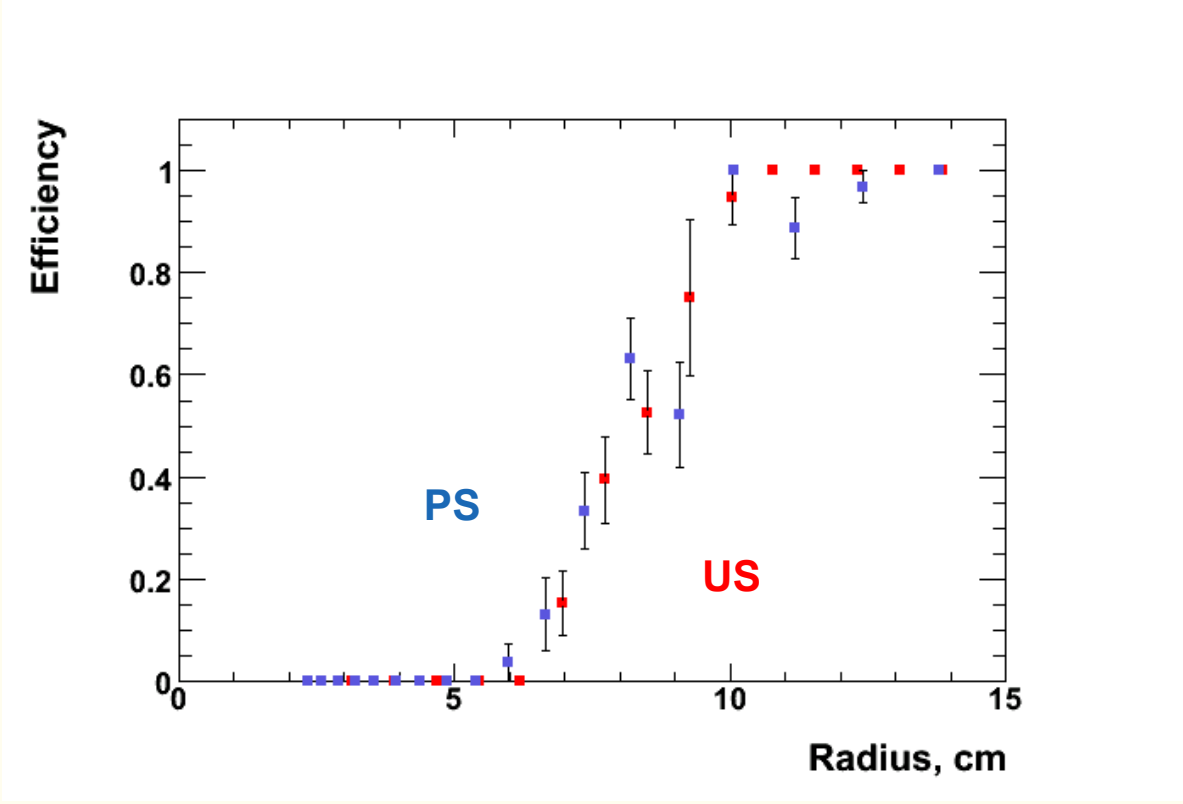
US

TOTAL EVENTS≈500

NUMBER RECONSTRUCTED WITHIN R_MOLIERE SHOWERS = 27.9%

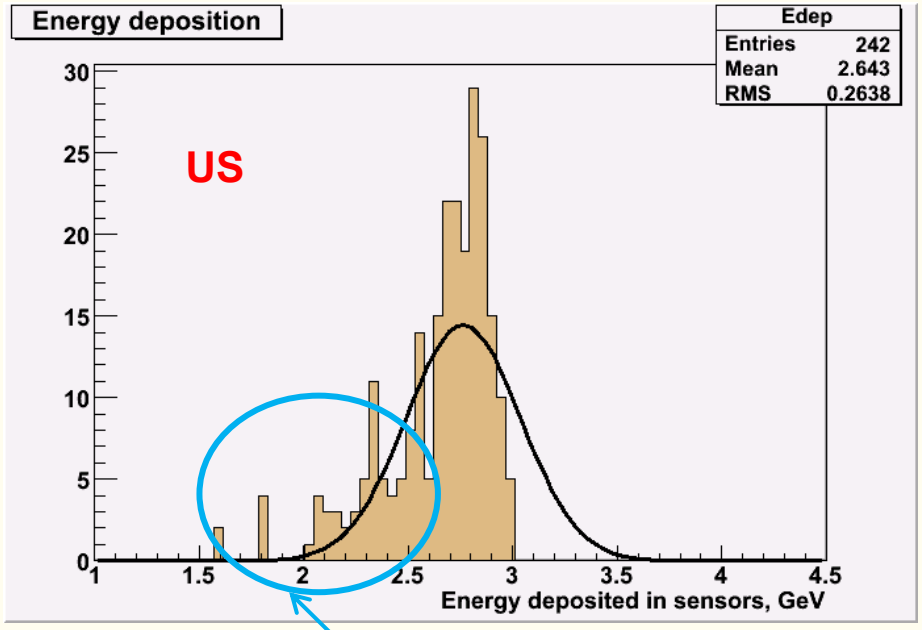
NUMBER FAKE SHOWERS = 1.6%

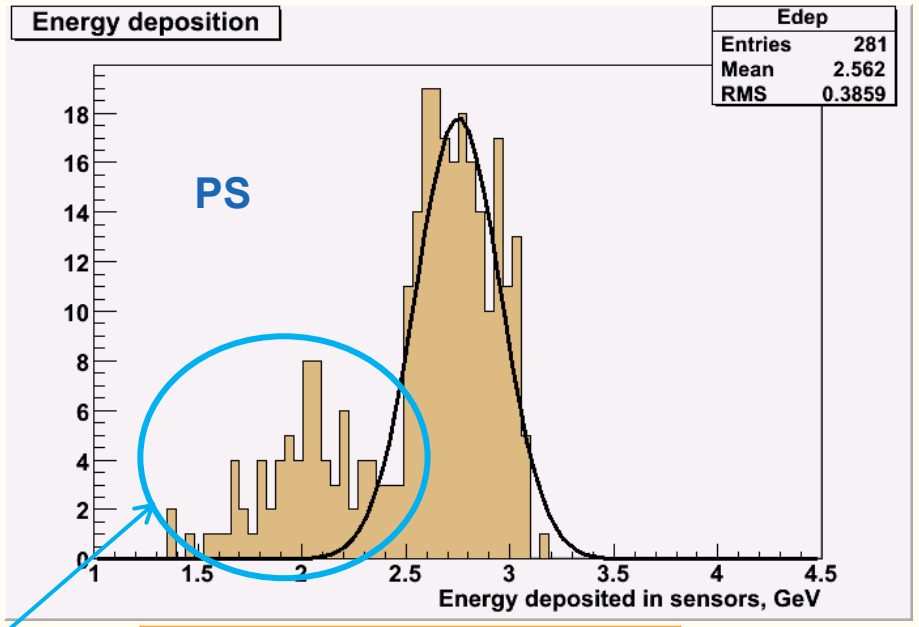
NUMBER NOT RECONSTRUCTED SHOWERS = 70.5%



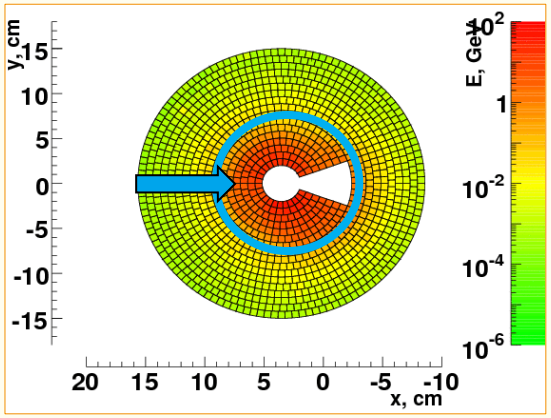
Energy deposition from 200 GeV electrons

Deposited energy over the all radii of calorimeter:





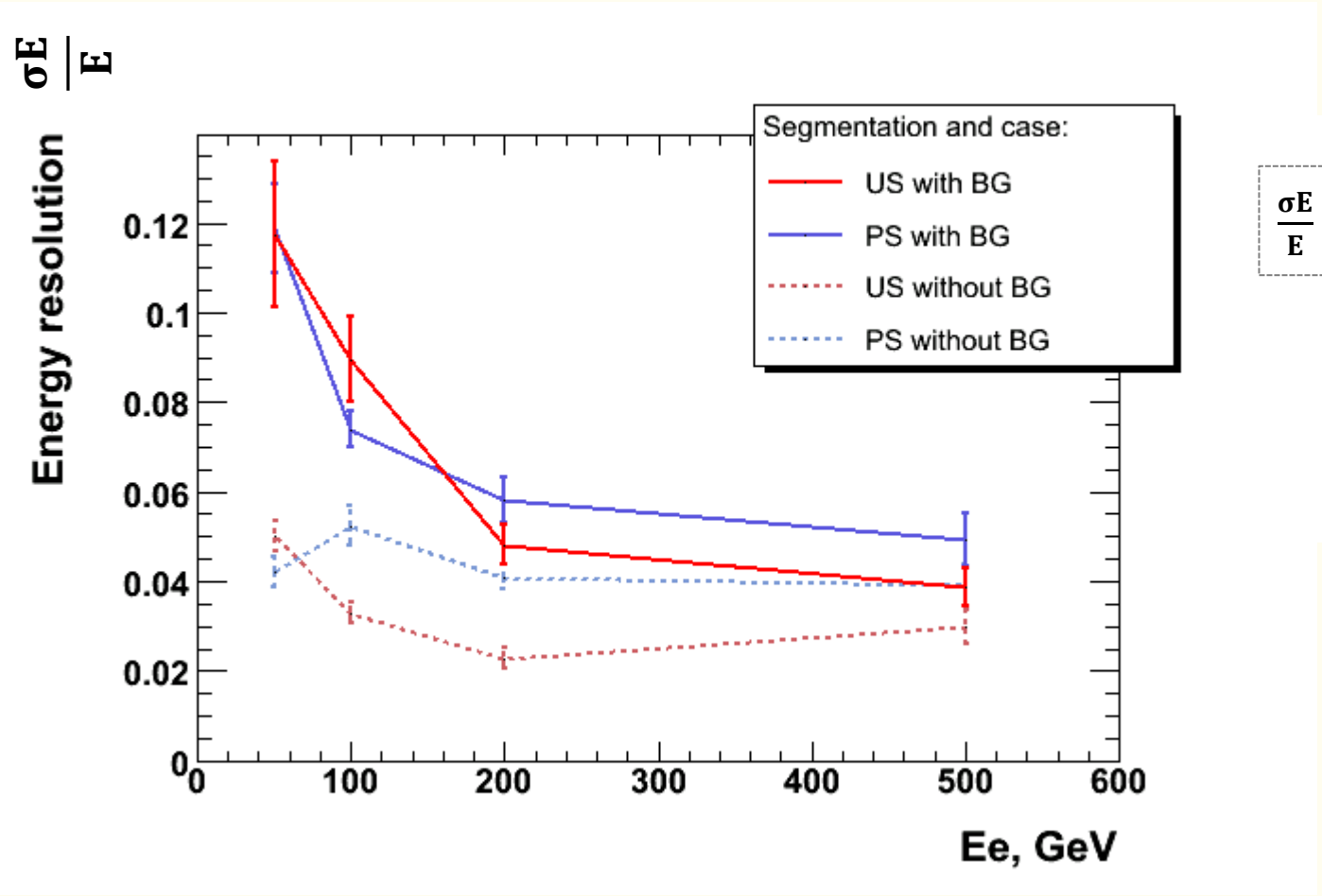
Events from high BG area



⇒ Consider separately 2 areas:
Low BG and High BG

Energy resolution vs Energy of Electron for low BG area

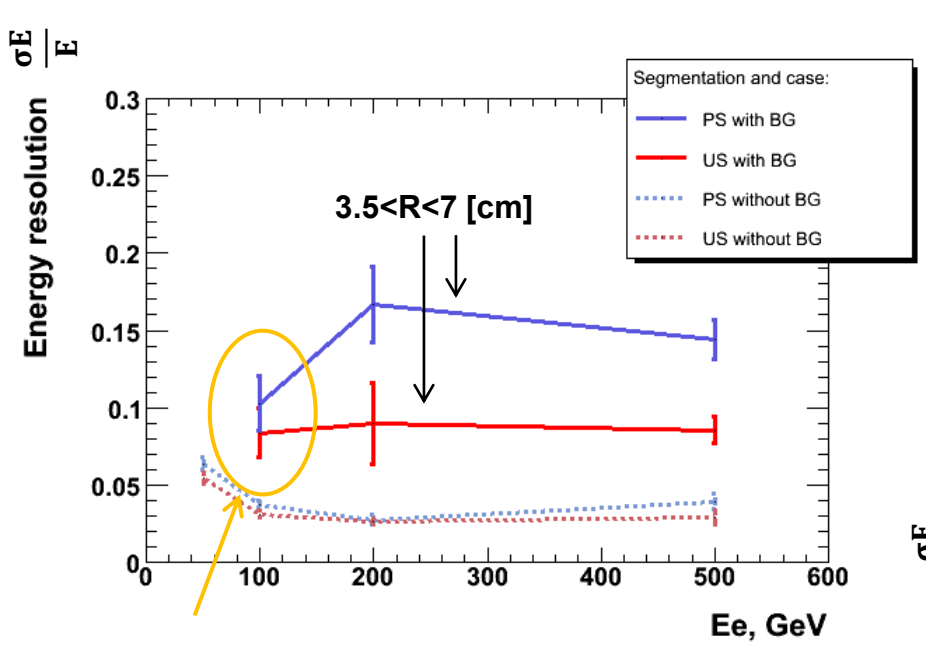
7<R<12 [cm]



$$\frac{\sigma E}{E} = \frac{p_0}{\sqrt{E}} \oplus \frac{p_1}{\sqrt{E}} \oplus p_2$$

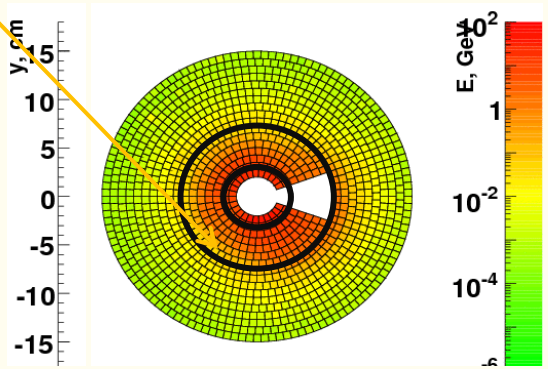
$$\frac{\sigma E}{E} > \frac{40\%}{\sqrt{E}}$$

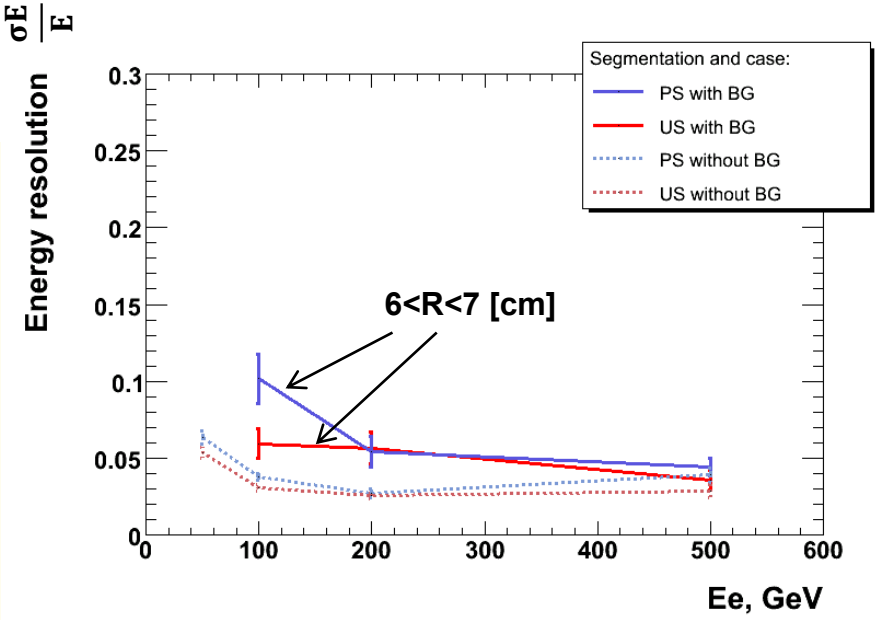
Energy resolution vs Energy of Electron for high BG area



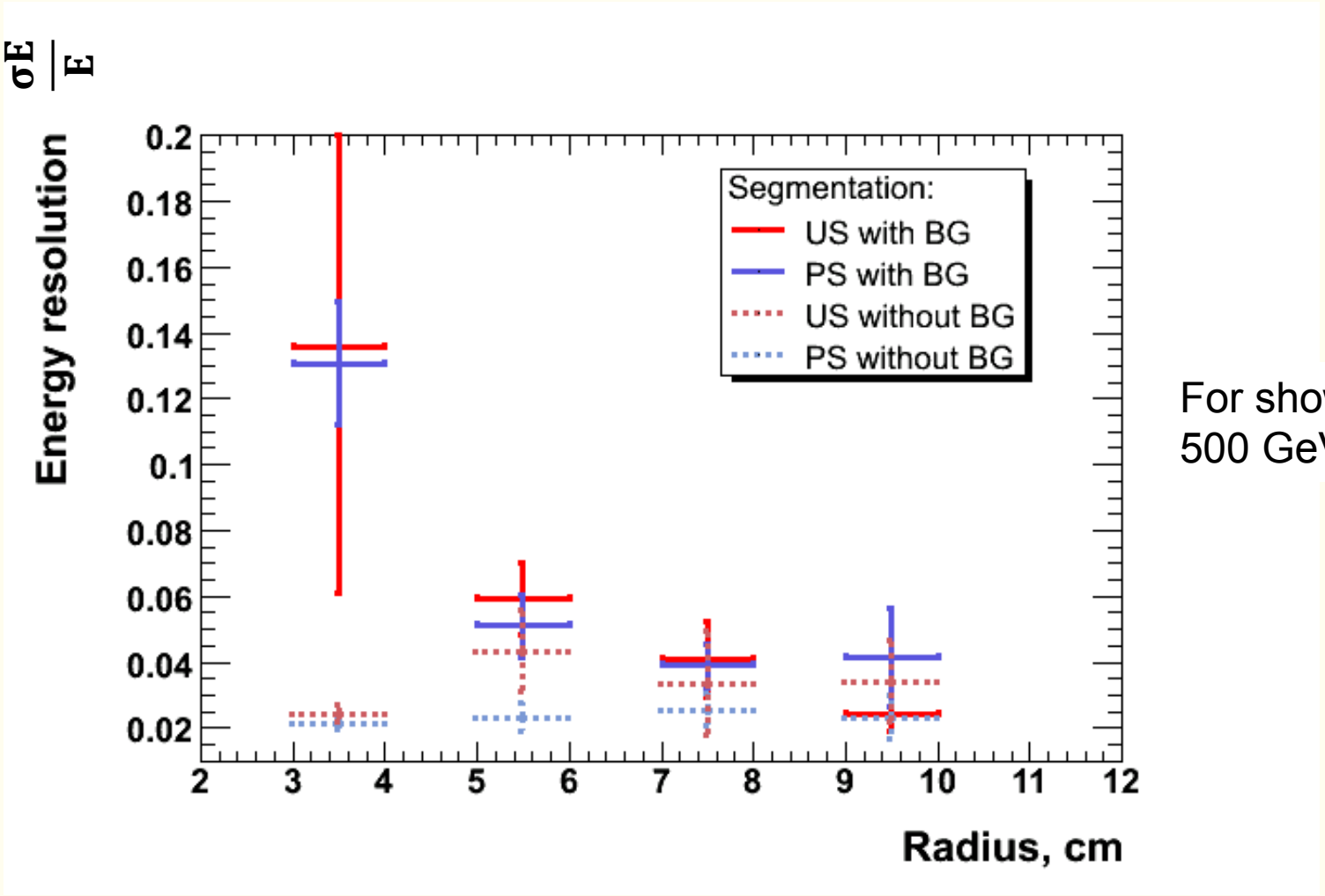
3.5<R<7 [cm]

100 GeV electrons reconstruct only
on outer part of range 3.5-7 cm, i.e. only on 6-7 cm





E resolution vs Radius



For showers from 500 GeV electrons

Current work

-> Check algorithm for fake rate with 1000 BG files (PS and US), which I recently simulated

-> Adjust algorithm, if fake rate is too high

-> Get energy and spatial resolution for this algorithm

-> Writing report about simulations for BeamCal

-> Simulations for TB

Preparations to the Test Beam

Beam Parameters

Konrad kindly provided information about beam parameters and thesis, where details can be found

* Thesis: TB 2010 on T9 beam line, W-HCAL prototype, 30 layers, 1-10 GeV

Beam composition on T9 beam line, estimated by Cherenkov counters:

Positive polarity

	Fraction in beam (%)		
p_{beam} (GeV)	e^+	$\mu^+ + \pi^+ + p$	
1	76	24	
2	28	72	
	e^+	$\mu^+ + \pi^+$	p
3	10	69	21
4	3	67	30
5	1	63	36
6	< 1	60	39
7	< 1	55	43
8	< 1	48	51
9	< 1	39	60
10	< 1	31	68

Negative polarity

	Fraction in beam (%)	
p_{beam} (GeV)	e^-	$\mu^- + \pi^-$
-1	85	15
-2	40	60
-3	16	84
-4	6	94
-5	4	96
-6	2	98
-7	2	98
-8	1	99
-9	1	99
-10	1	99

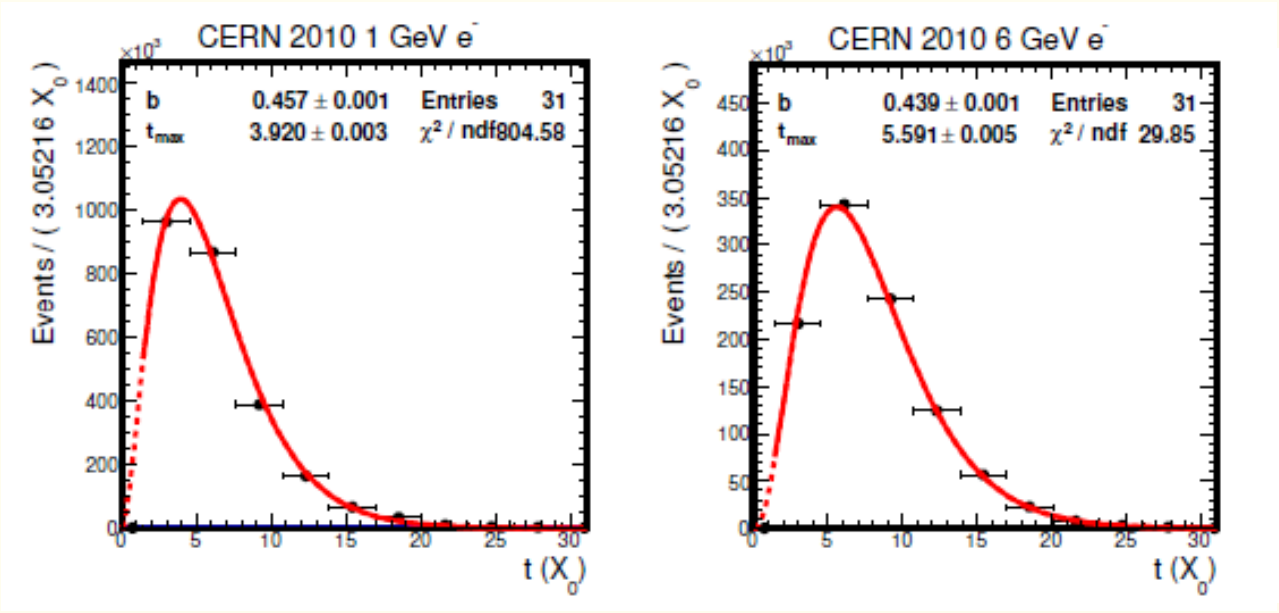
Events amount:

-> Supercycle - 30 sec
-> Inside this - 2 x 400msec beam spills
-> intensity is constant

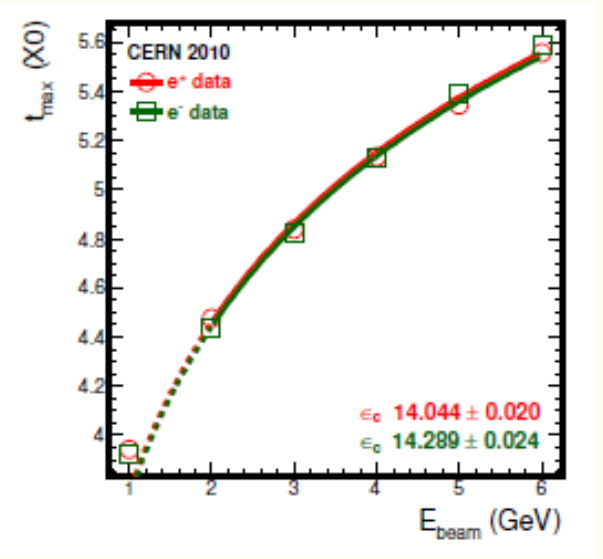
⇒ Can record 10events per minute due to the DAQ speed
⇒ 10k events per day (17 hours)

Beam Parameters

Longitudinal shower profile

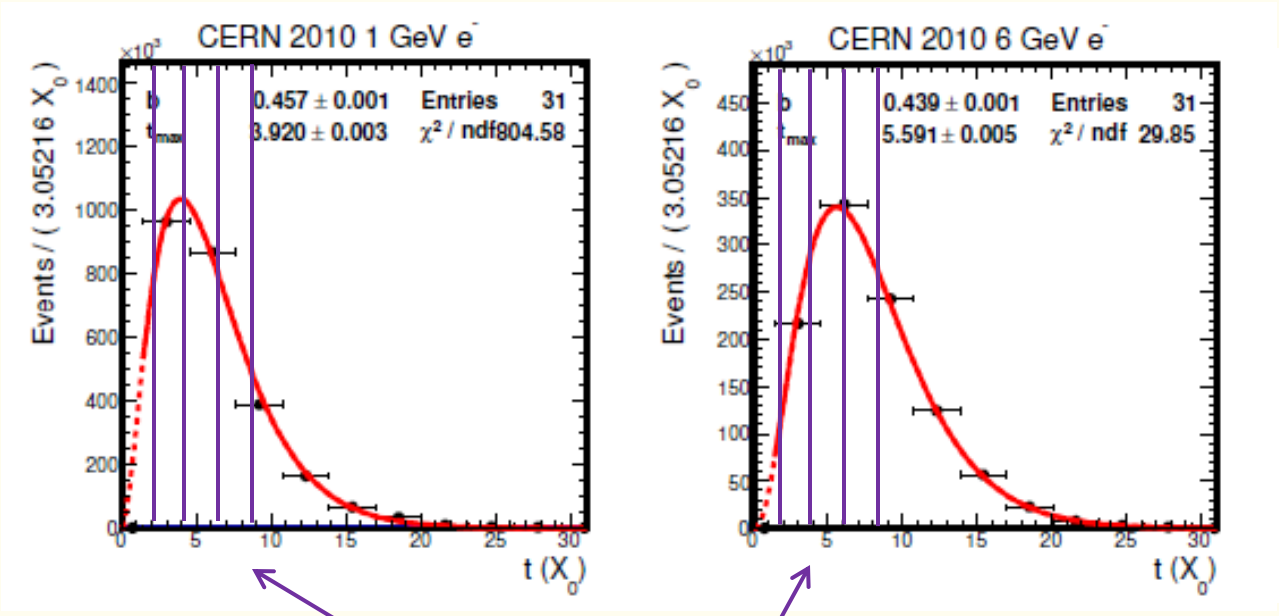


Shower max vs beam energy

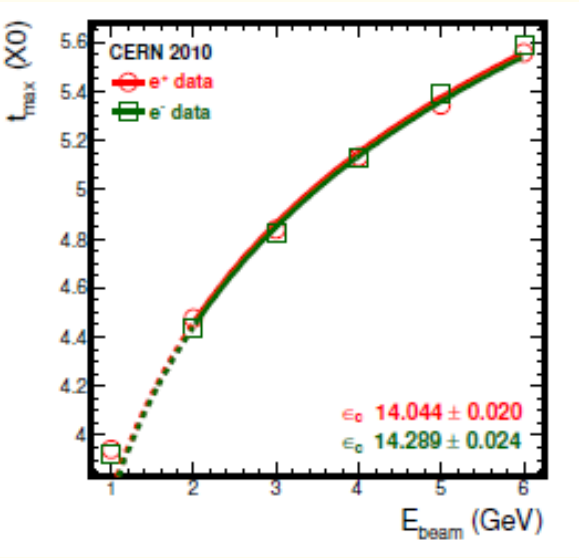


Beam Parameters

Longitudinal shower profile

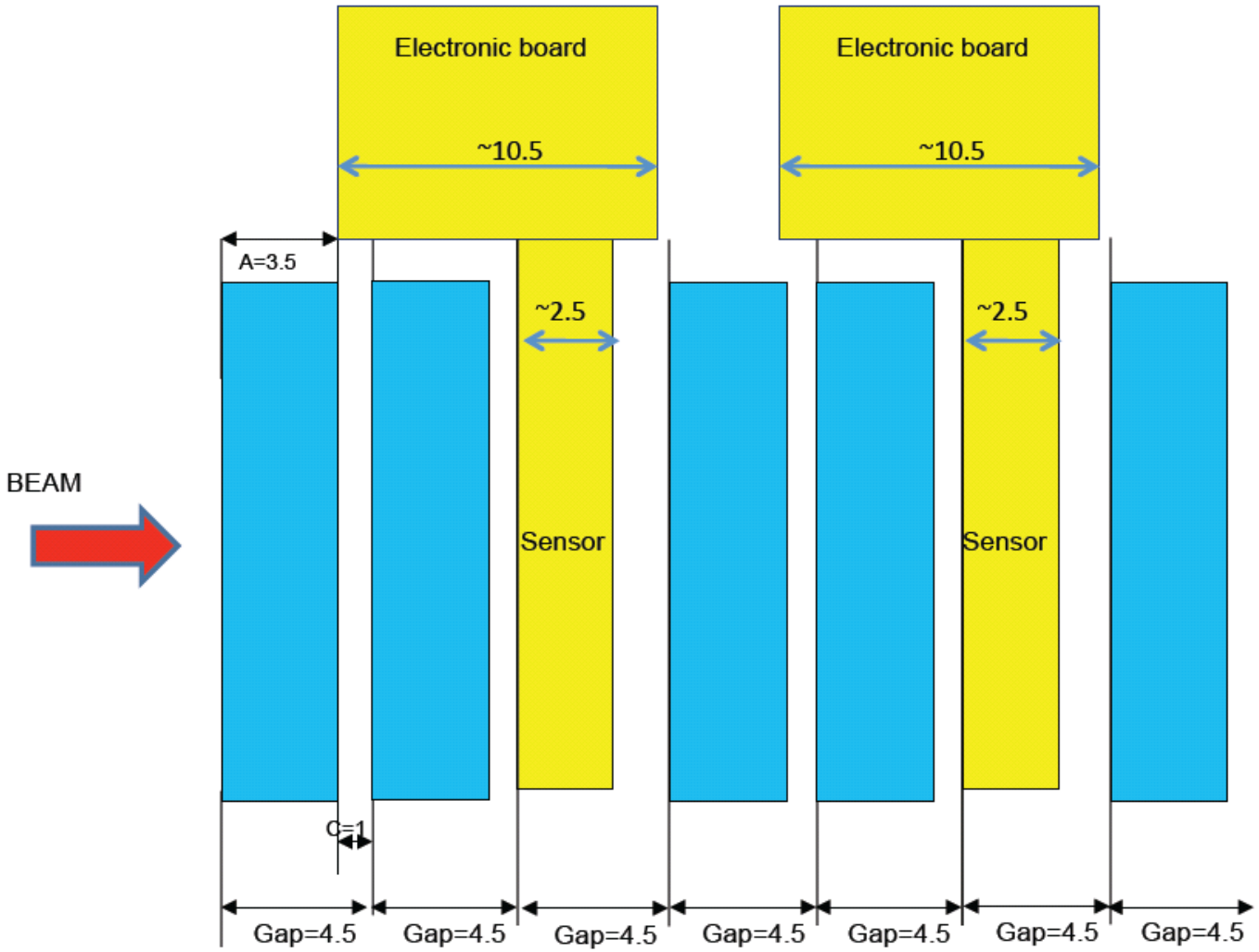


Shower max vs beam energy



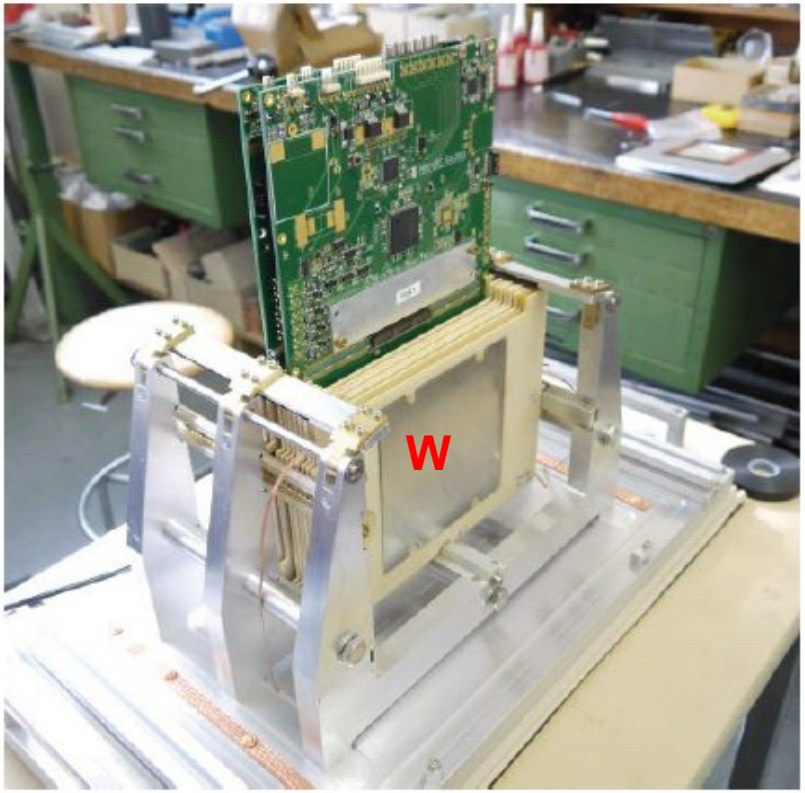
Reasonable position of sensor planes:
after 2, 4, 6, 8 Xo

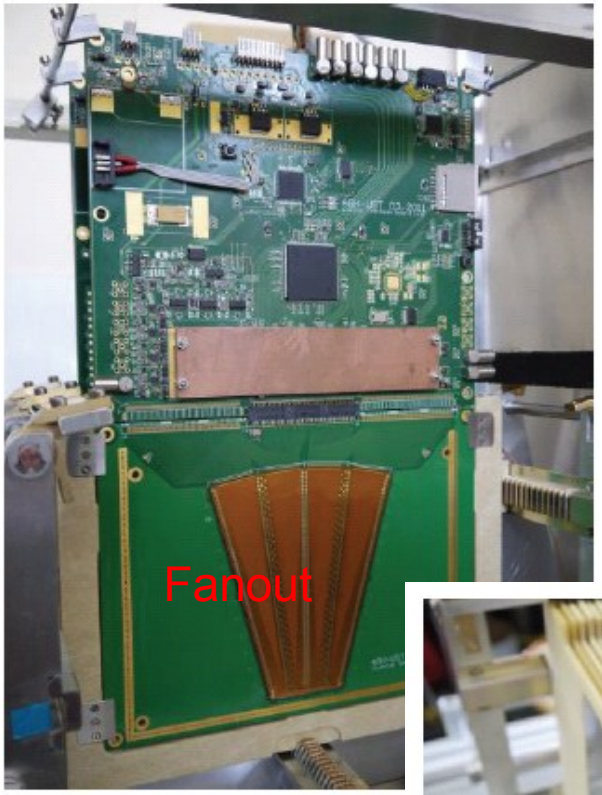
Current test beam configuration

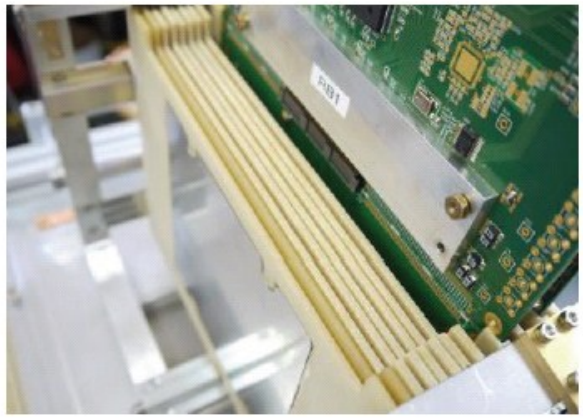


In the current configuration the sensor planes are placed in a 4.5 mm interspace (one tungsten layer removed)

Setup Pictures







Issues

-> What we want to get on TB => simulate?
> energy resolution, longitudinal shower profile, shower radius,…?

-> Which statistics on which energy BeamCal and LumiCal need (how many days who will need for measurements)?
> In total we have 5 days of measuring time:
1day-adjusting + 2days LumiCal + 2days BeamCal
> 2days = 1day: 1GeV + 1day: 6GeV
> 10k events per day

-> Who considering to make simulations for BeamCal and Lumical for TB prototypes? Are any of them already done?
> BeamCal: Lucia, Veta?, …
> LumiCal: Bogdan?, ...