Studies of electron reconstruction efficiency for the Beam Calorimeter of an ILC Detector

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On behalf of FCAL Collaboration

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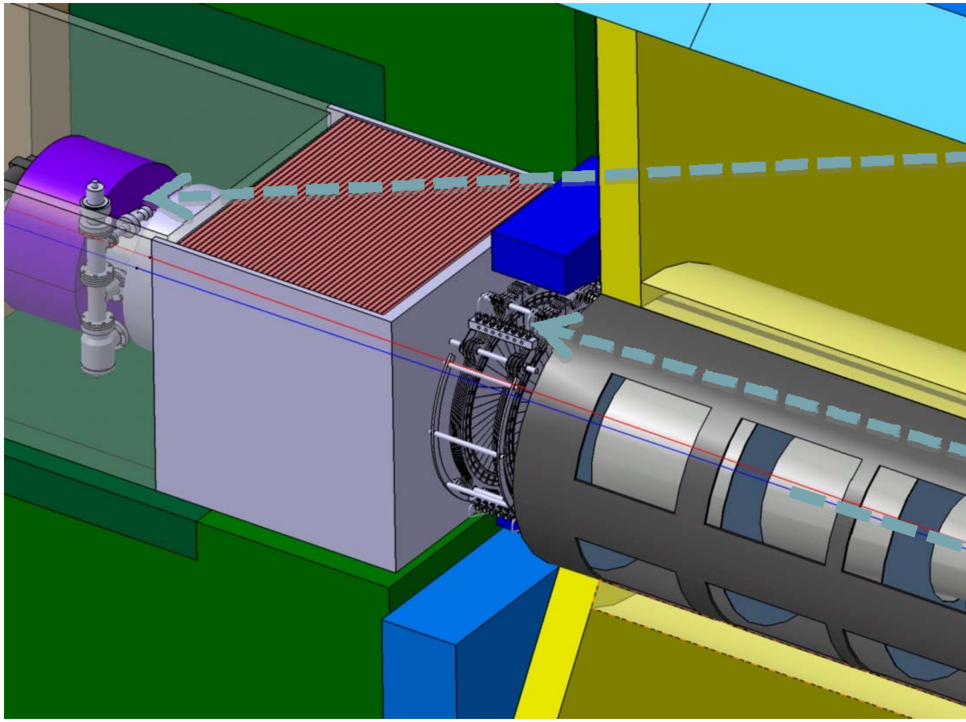
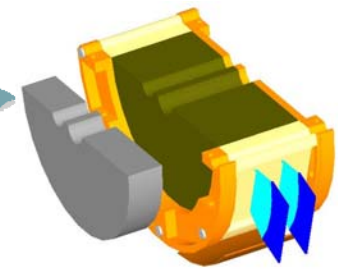
Plan:

- Challenges of Beam Calorimeter for ILC
- Simulation studies
- Single High Energetic electron (sHEe) reconstruction algorithm
- Reconstruction efficiency for nominal and SB-2009 beam parameters

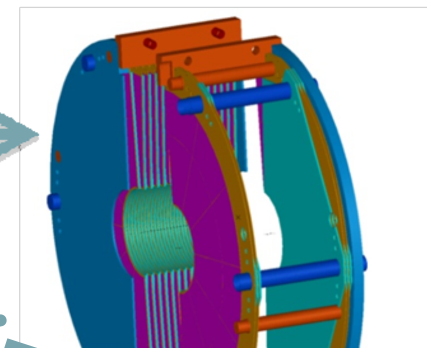
Very forward detectors- challenges :



BeamCal
+ Pair
Monitor



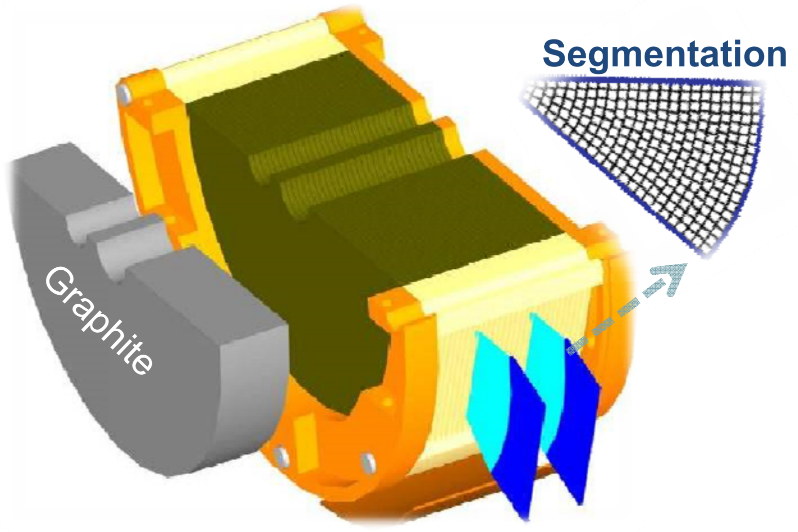
LumiCal



IP

- Ongoing simulations to optimize detector design for
  - precise luminosity measurement,
  - hermeticity (electron detection at low polar angles),
  - assisting beam tuning (fast feedback of BeamCal data to machine)
- Challenges: radiation hardness (BeamCal), high precision (LumiCal) and fast readout (both)

Beam Calorimeter :



Around Beam-pipe

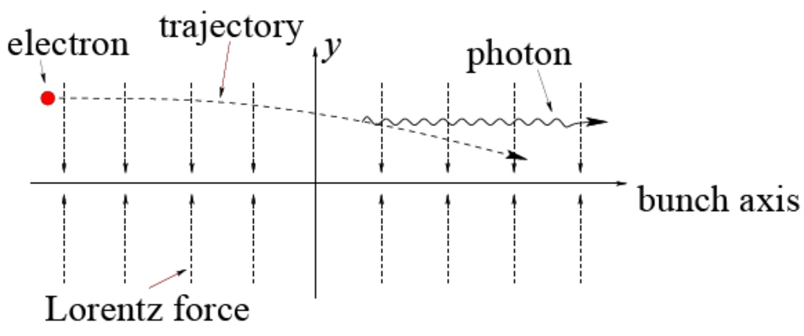
30 Layers → tungsten-sensors → Di, GaAs (harsh radiation environment)

Outer radius 15cm, inner radius 2cm and the depth 12 cm

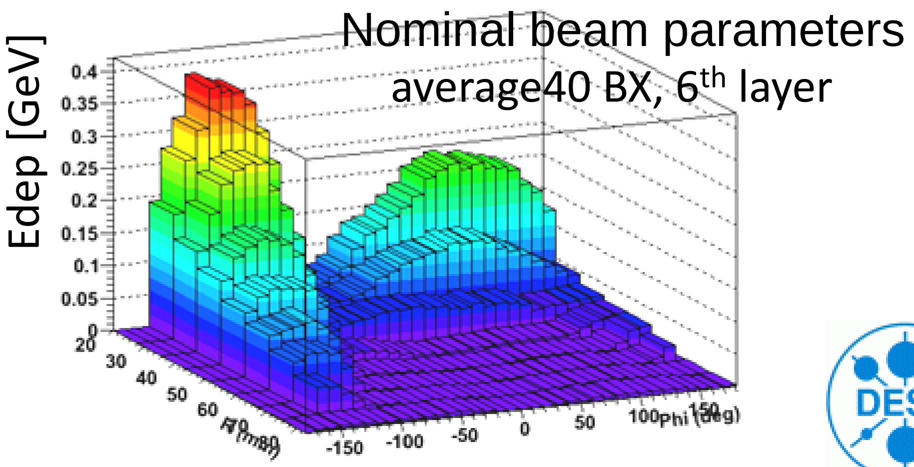
Sensor segmentation 8x8 mm^2

Moliere radius of sHEe $R_m = 11.8 \pm 0.4\,mm$

Beamstrahlung process and pinch effect

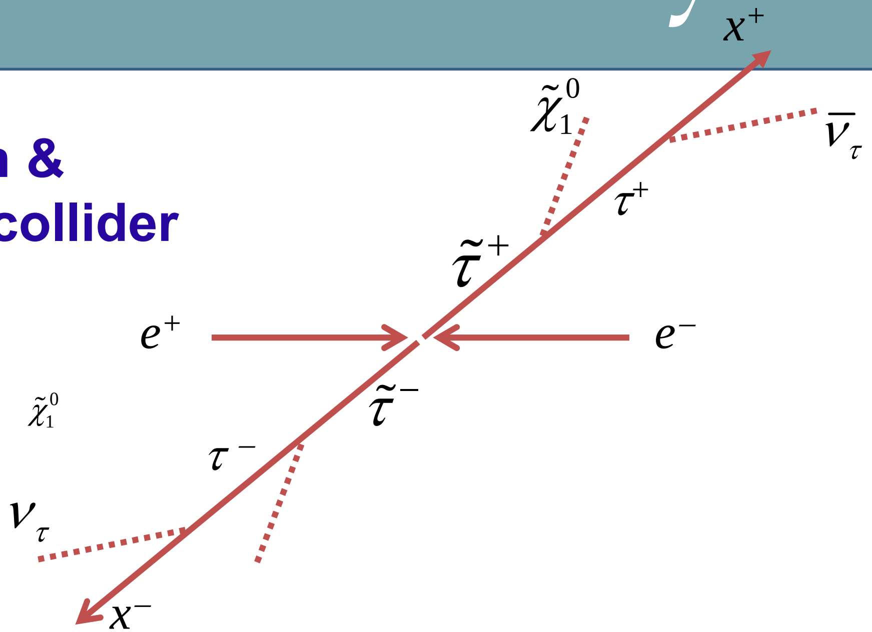


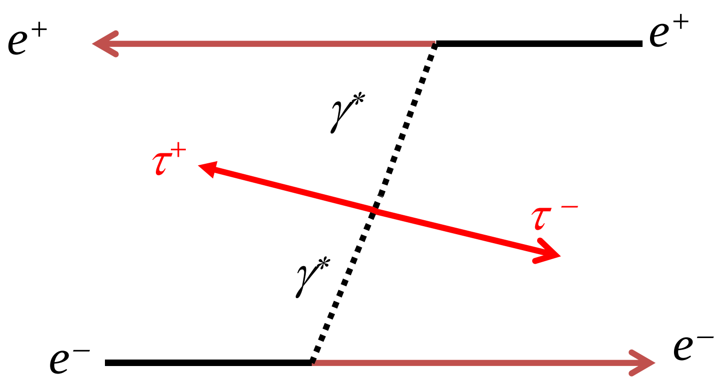
Deposition Energy



Why we need hermeticity?

Stau production & Decays at e+e- collider





- **Difficulty № one:**
  Missing energy from both LSP $\tilde{\chi}_1^0$
  and neutrino(s) in tau decay final state
  Only little activity in the center of detector

- **Difficulty № two:**
  Large SM background contributions

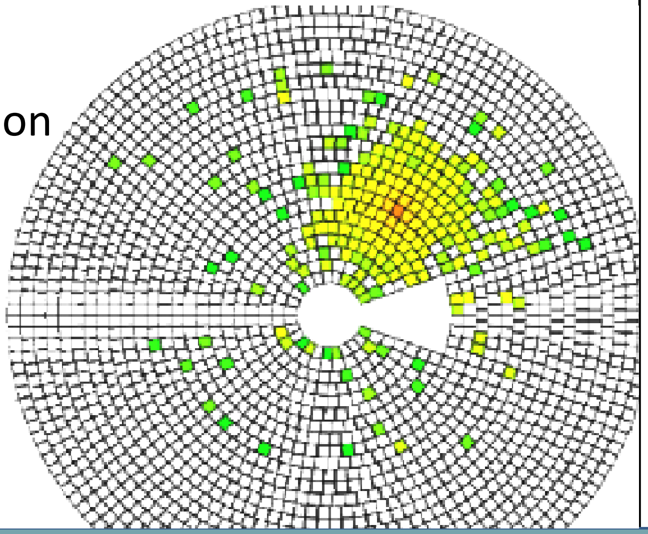
Simulation steps:

A Geant4 BeamCal simulation has been set up BeCaS can be configured to run with:

- different crossing angles (corresponding geometry is chosen) -> 14 mrad
- magnetic field
- detailed material composition of BeamCal
- geometry description
- surrounding detectors

Steps:

- Comparison of different beam parameters
- Writing an algorithm for single electron reconstruction
- Calculation of reconstruction efficiency
- Simulations in Mokka are on the way



Beam Parameters:

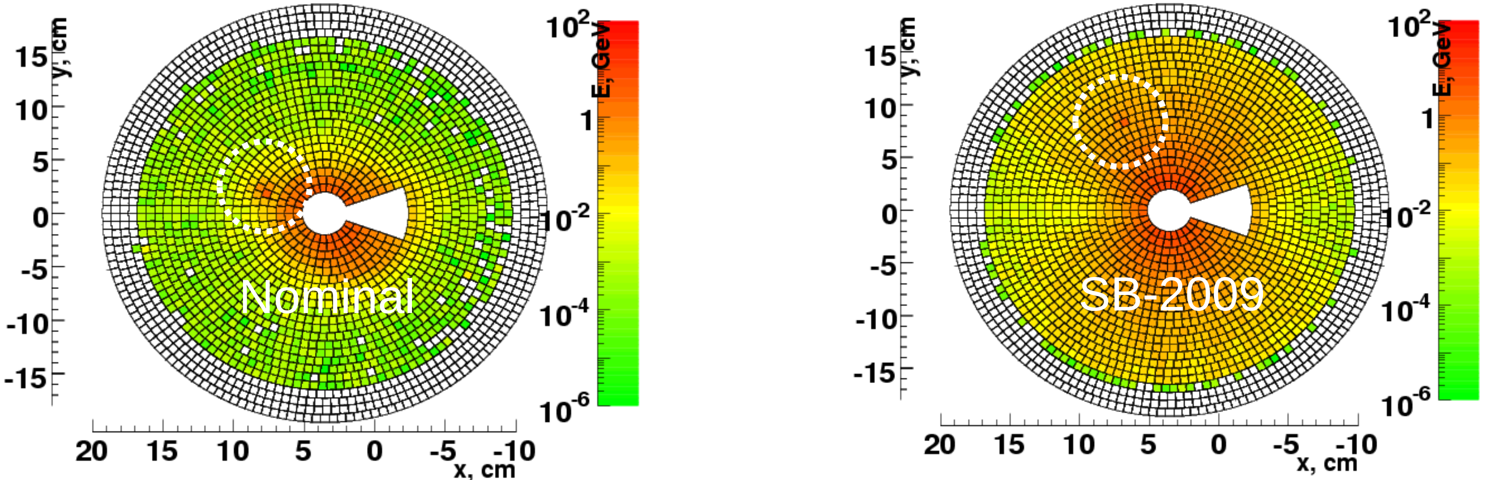
		RDR -Nom	SB-2009	
Beam and RF Parameters				
No. of bunches		2625	1312	
Bunch spacing	ns	370	740	
beam current	mA	9.0	4.5	
Avg. beam power (250 GeV)	MW	10.8	5.4	
Accelerating gradient	MV/m	31.5	31.5	
P_{fwd} / cavity (matched)	kW	294	147	
Q_{ext} (matched)		3×10^6	6×10^6	
t_{fill}	ms	0.62	1.13	
RF pulse length	ms	1.6	2.0	
RF to beam efficiency	%	61	44	
IP Parameters				
Norm. horizontal emittance	mm.mr	10	10	
Norm. vertical emittance	mm.mr	0.040	0.035	
bunch length	mm	0.3	0.3	
horizontal β*	mm	20	11	
horizontal beam size	nm	640	470	
			no trav. focus	with trav. focus
vertical β*	mm	0.40	0.48	0.2
vertical beam size	nm	5.7	5.8	3.8
D_y		19	25	21
dE_{BS}/E	%	2	4	3.6
Avg. P_{BS}	kW	260	200	194
Luminosity	$cm^{-2}s^{-1}$	2×10^{34}	1.5×10^{34}	2×10^{34}

```
$ACCELERATOR:: ilc_SB2009 {
  energy=250.0;
  particles=2.0;
  sigma_x=470.0;
  sigma_y=5.8;
  emitt_x=10.0;
  emitt_y=0.035;
  sigma_z=300.0;
  f_rep=5.0;
  n_b=1312;
  charge_sign=-1.0;
  dist_z=0.0;
  offset_x=0.0;
  offset_y=0.0;
  waist_x=0.0;
  waist_y=0.0; }
```

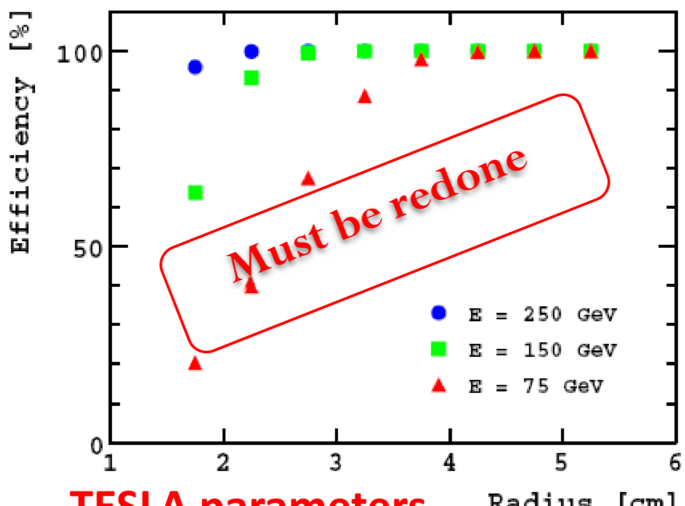
DESY

Straw-man Baseline 2009 (SB2009) parameters are taken from ALCPG09 talk by N.Walker.

Simulation Studies, impact of SB2009:



An example of 1background event with 250GeV single high energetic electron



TESLA parameters

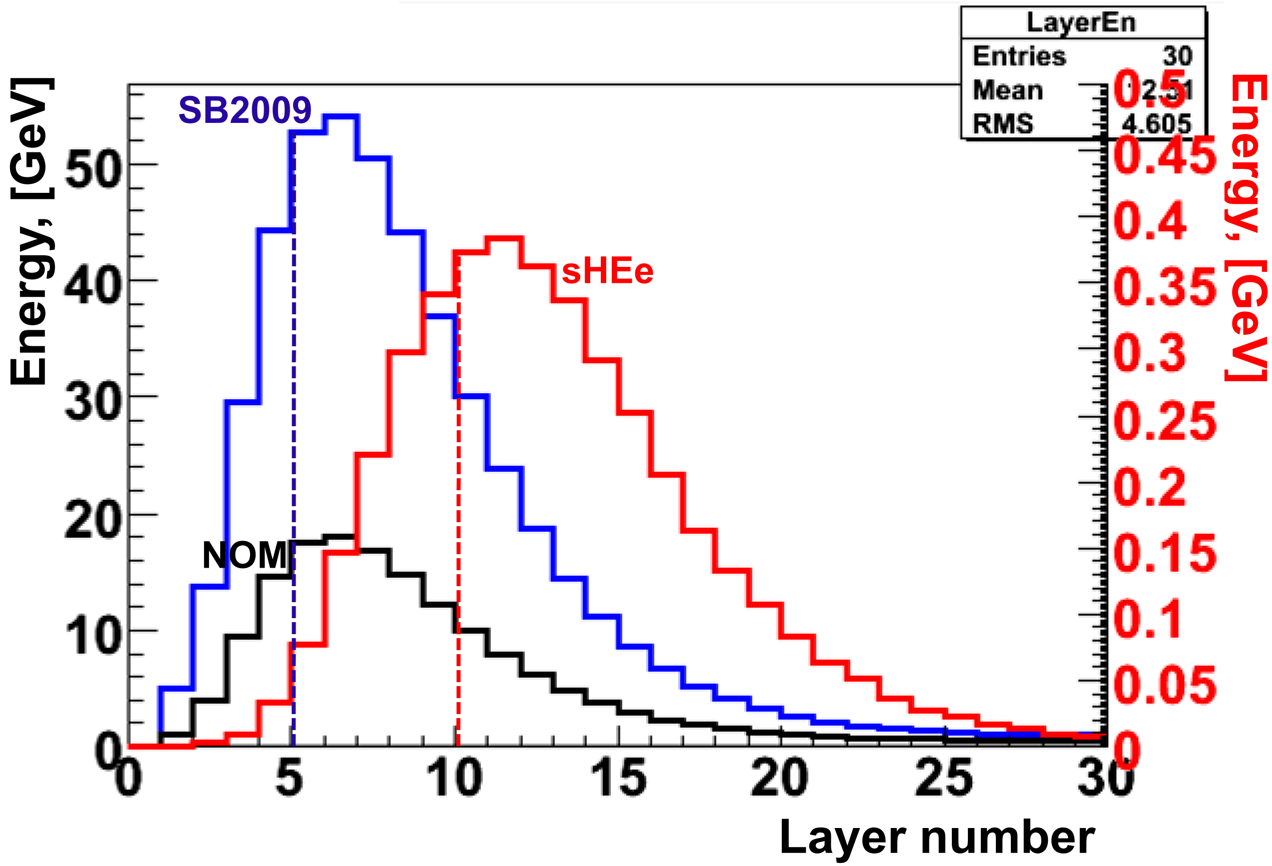
BeamCal load per BX by a factor of ~2 larger

- single high energetic electrons (photons) detection capability will become worse study: how much?

Simulation tools:

- Guinea Pig
- BeCaS

Longitudinal development:



- Background showers-> maximum in **5** layer
- Single e- shower -> maximum in **10** layer

Algorithm development:

Background influence:

- Average background calculations (10BX) + RMS calculation
- Superposition of 1 background + 1 sHEe
- Subtraction of background and collecting cells with energy larger then few times RMS of background
- Searching for clusters

Cluster definition:

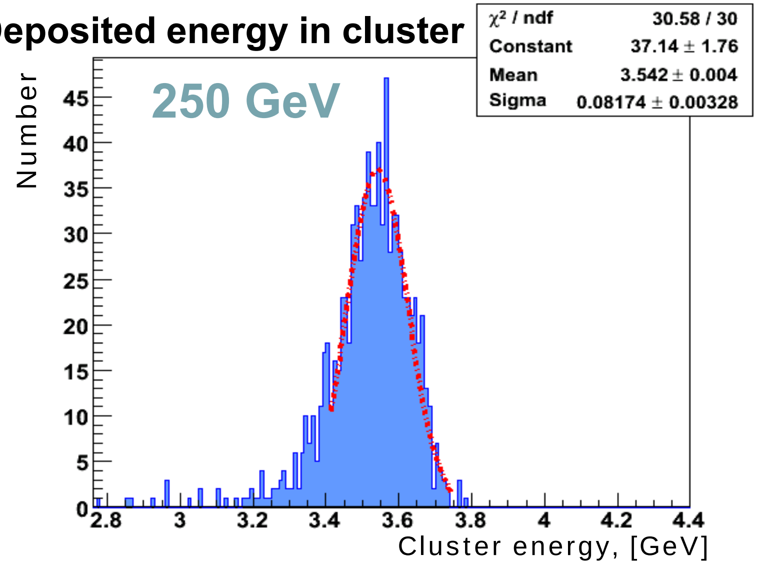
- Towers after 5-th layer with more then 10 consecutive cells

- Around tower with maximal energy (En_{max}) in cells search neighbors towers
- If one of neighbor towers has En>0.9 En_{max}, search neighbors for this tower too

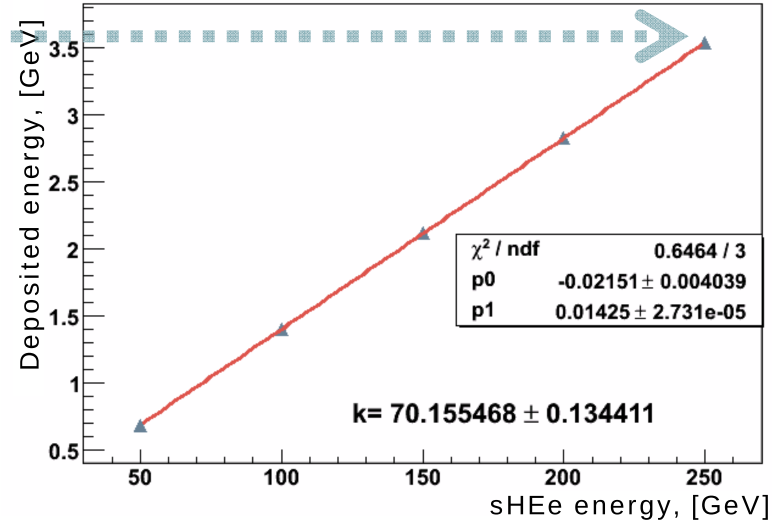
- **Reconstruction efficiency calculation**

Calibration:

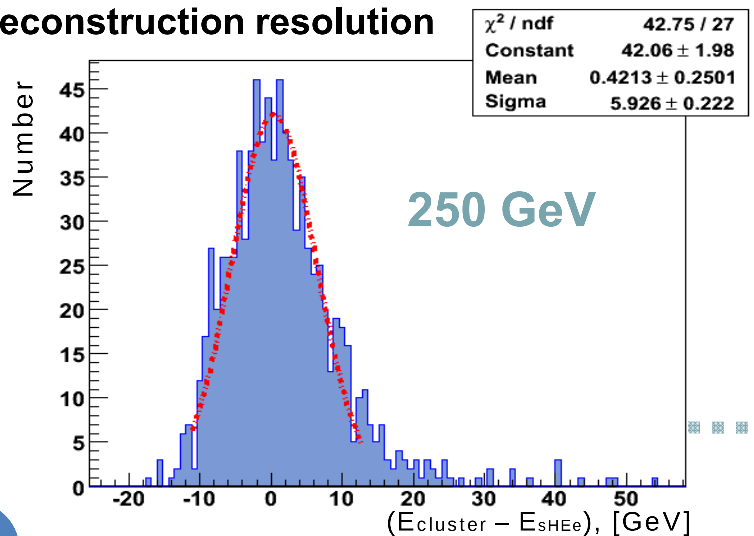
Deposited energy in cluster



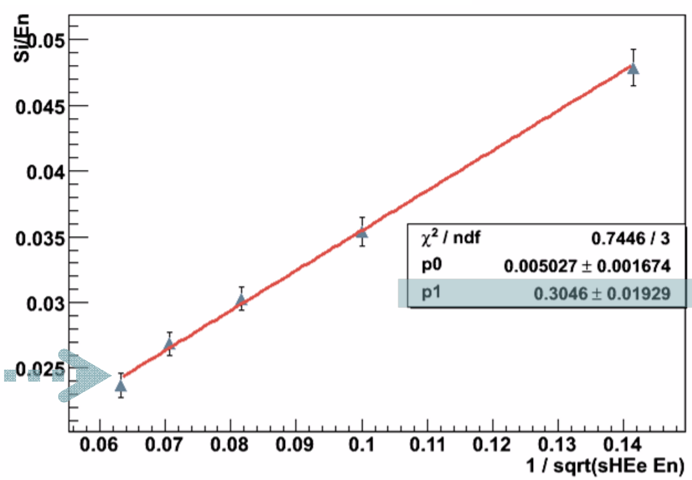
Calibration curve



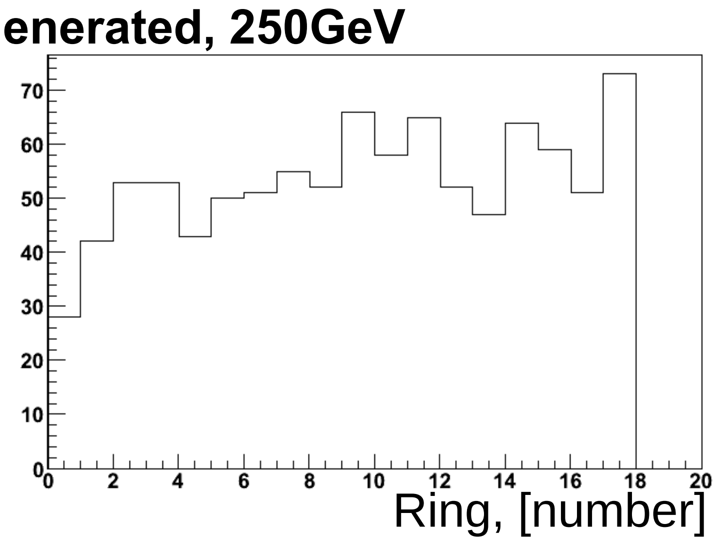
Reconstruction resolution

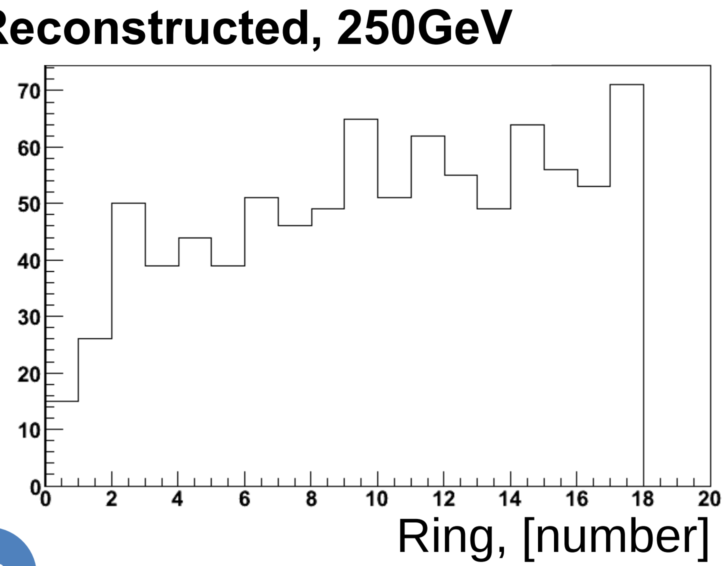


Reconstruction resolution

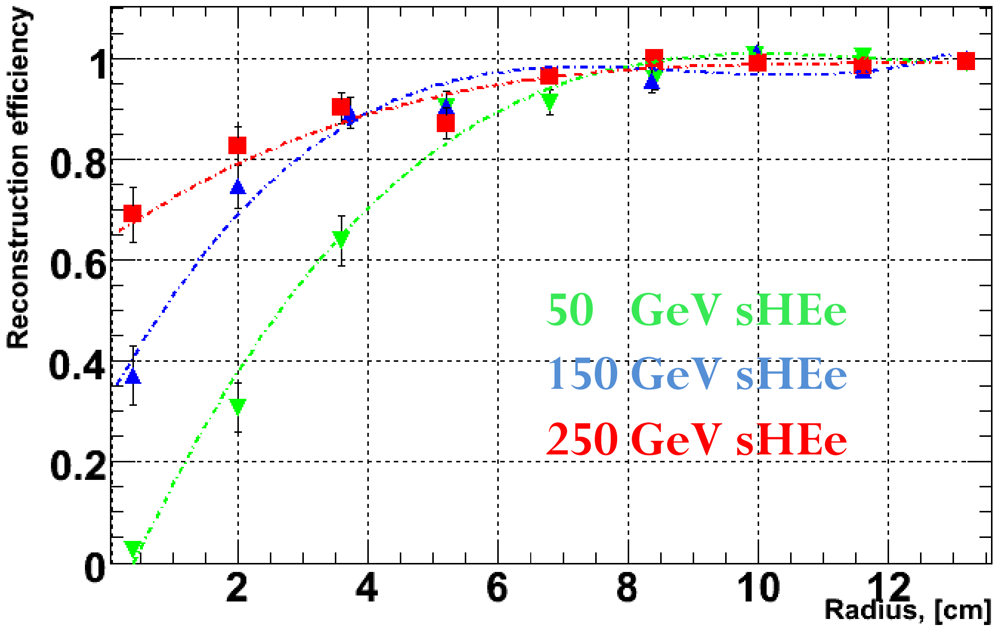


Reconstruction efficiency, Nominal:



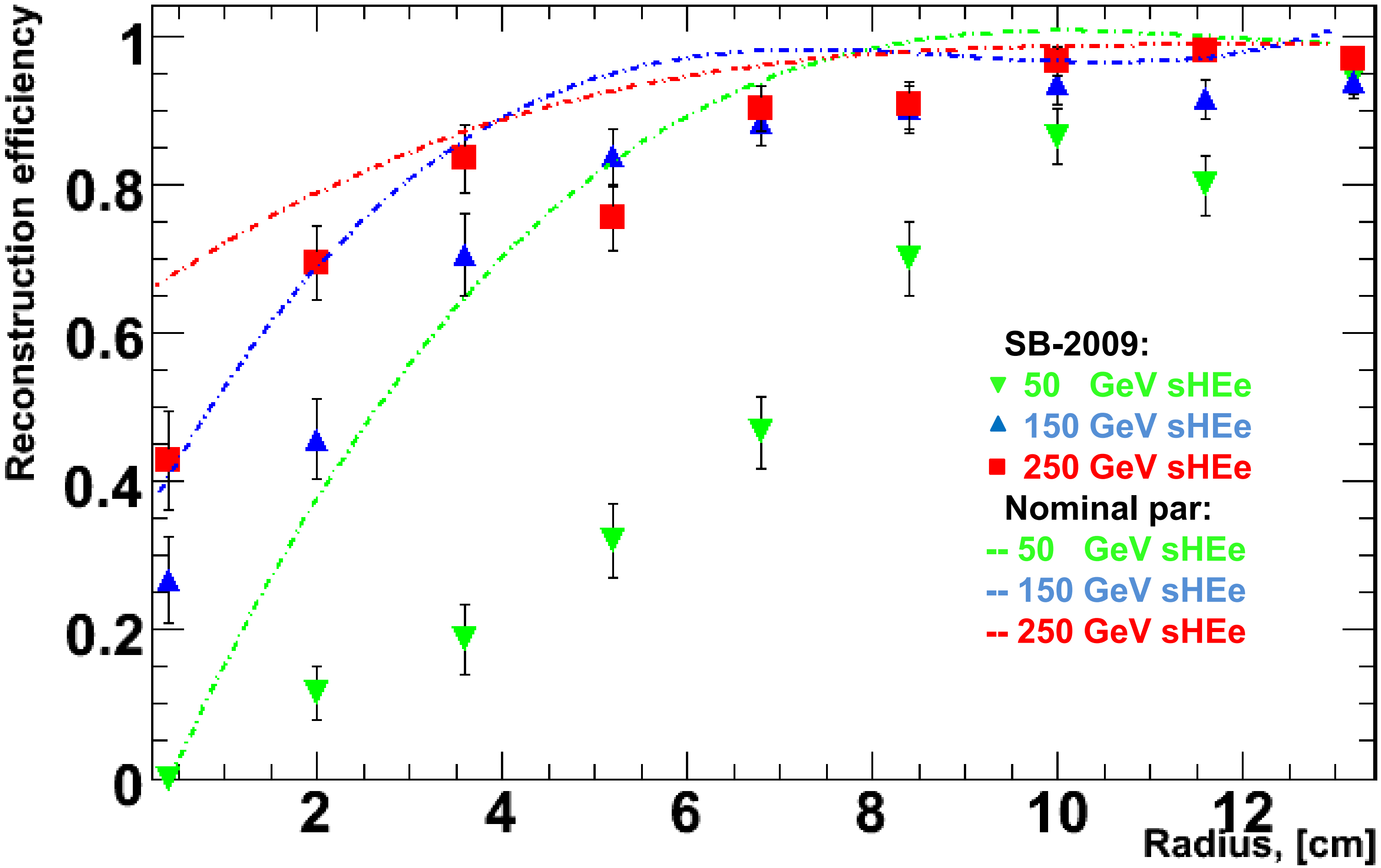


$$\varepsilon = \frac{N_{reconstr}}{N_{generated}}$$



Reconstruction efficiency as a function of Radius (start from beam-pipe) for 50, 150, 250 GeV sHEe and nominal beam parameters

Reconstruction efficiency, SB-2009:



Summary and Outlook:

- Algorithm was developed to reconstruct sHEe on top of Beamstrahlung
- Applied for Nominal and SB-2009 beam parameters
- Optimization for the developed algorithm is needed
- And similar work will be done on Mokka (detailed magnetic field, detector)

Thank You !

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