SiW-ECAL optimisation

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for the SiW-ECAL group

ILD SW & Optimisation meeting
DESY, 24/02/2016

What is (still) needed for ILD ?

Most studies already done, some needs to be refined:

- Radius studies with realistic models **<= issue for cost**
  - Wafers thickness ⇒ Energy resolution
- Lateral granularity (cell size)
  - Dependent on the (HCAL/ECAL correlation) ⊗ SW
- Radial granularity (number of layers): to be continued. **<= issue for cost**

What about other correlation ?

Threshold studies ?

Timing ?

- Do we have time for time ?

Cost / performance optimisation
Current situation (~correct)

Const[ly] refined

New since Sept 2014

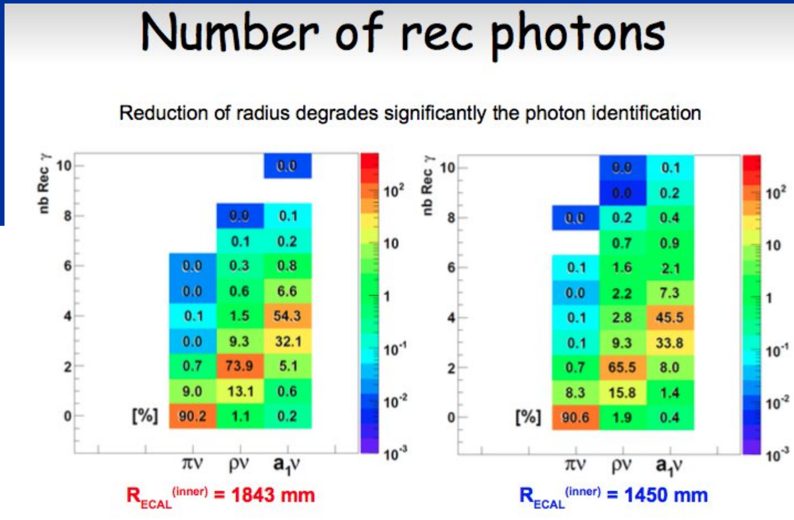
Study Param. Details	HCAL		Author
Global geometric parameters			
(W thickness ≡ constant); cell size = 5×5mm²		RMS_{90}	
R_{TPC}	AHCAL; SDHCAL AHCAL	single JER	Trong Hieu Tran, LLR Green, Marshall, Thompson, UCAM
@ constant (R/Half-z)	AHCAL	tau reconstruction	
Cell size	AHCAL	single JER	Green, Marshall, Thompson, UCAM
	SDHCAL		Trong Hieu Tran, Dan Yu, LLR
Number of layers		single JER	Trong Hieu Tran, Dan Yu, LLR
@ constant W thickness (not Si thickness)			
Construction Parameters			
PCB thickness		single JER	D. Jeans, Tokyo U.
@ 45.5, 180, 250 GeV			
Si Guard Ring Thickness		(homogeneity) & singe JER	A. Suhail, LAL
@ constant wafer size; unique global correction			
Resilience			
Amount of dead pixels		single Photons & JER	D. Jeans, Tokyo U.
random removal of hits ; unique global correction			
Raw performances.			
JER on uds events @ 45.5, 100, 250, … GeV.			
Separation power (π/γ ; γ-γ, $m_{\pi 0}$) σ(E)/E (γ) ; Single γ (3, 10, 100, 500 GeV).			D. Jeans, Green/Thompson, Kostya Shpak

On going

based on V. Balagura review for the CALIIMAX ANR

⚠ on-going work

Radius studies with Jets & Tau's

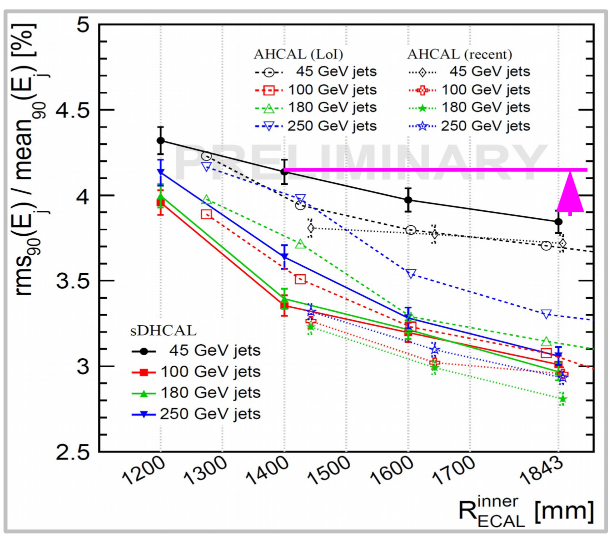


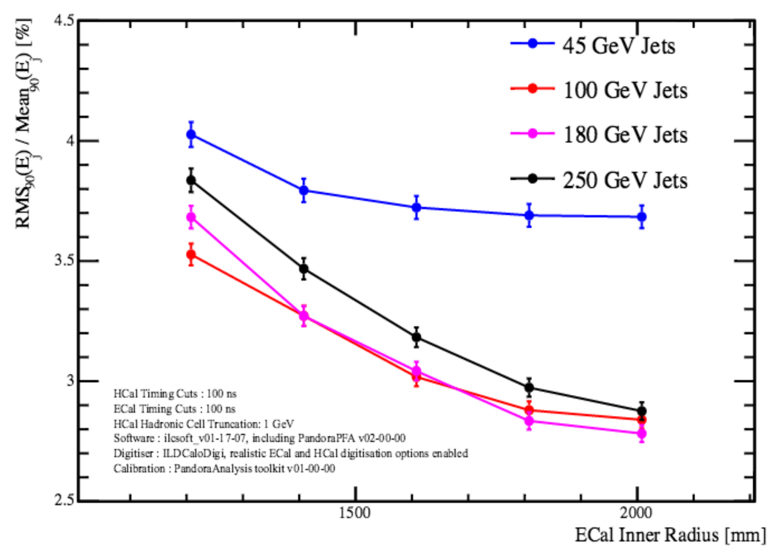
Latest results from T. H, Tran presented on sept 2015

- Paper submitted to EPJC arxiv.org/abs/1510.05224
- Using GARLIC and 3 radii, and B Field

a reduction of the SiW ECAL radius by about 20% and with the same granularity, ILD can still provide a measurement of the π0 mass with a resolution of better than 10% while the tau reconstruction efficiency degrades compared to the baseline design by at most 2%. The improvement of the efficiency does not justify to increase the magnetic field from 3.5 to 4 T.

Jet Energy Resolution:

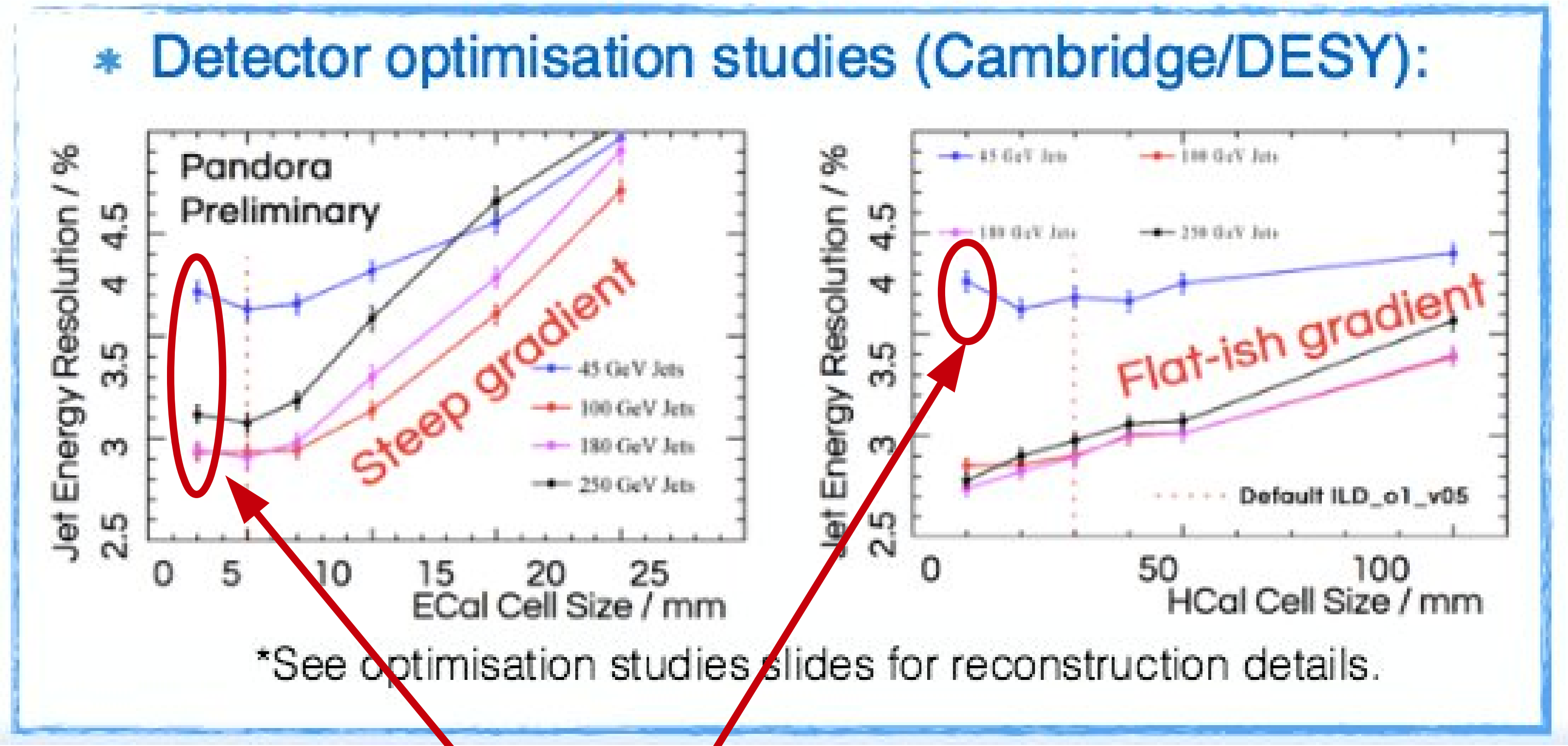




Lateral granularity (cell size)

(HCAL/ECAL correlation) ⊗ SW:

(PandoraPFA & AHCAL) vs (ARBOR & SDHCAL)



Threshold &
Dead zone ?

Is a threshold at ½ mip sufficient ?
¼ of mip seems technically feasible...

Radius studies with realistic models.

Should we restrict to 3 sizes for realistic simulation ?

SiW-ECAL wafer is a quantum for ILD dimensions *(not true for Scintillator opt.)*

Wafer size standard + Price ⇒ cassettes dimensions
R from Endcaps,
$z_{½}$ from Barrel

Make things complicated for simulation
to go in step of 26 or 13 cm (1 cassette, ½ cassette)

≠ the standard inner→outer onion construction of dimensions (à la Mokka)

⇒ Cost / Perf optimisation

- Wafers thickness ⇒ Energy resolution

Realistic parameters: on-going

From preliminary mechanical model ⇒ in simulation & cost

Reduced radius $\mathbf{R_{INNER}}$**= ~1600 and~ 1400mm**.

Base unit = Wafer size

- Largers Wafers: 6” ⟶ **8”** (OK from HPK, LFoundry); smaller wafers (4”) in 2nd part ?
- Wafer side: ~90 ⟶ **126–130** mm; Alveola ~200mm⟶ 253,8 mm – 263mm (132.3mm for single SLAB)

Barrel: **5 modules of 3 alveola**

- L_{Barrel} = 3829mm (Z_{endcap} = 3929mm).

Preliminary numbers
(and not necessarily consistent)
Enginering plans on-going

Endcaps: **Quadrants of 2 modules of 2 and 3 alveola**

- with R(ECAL Ring) = 40cm + Integer number of Wafers + ½ Wafers

  ⇒ R_{Endcap} = 1676mm

N_{layers} = 22 = **14 + 8** (single and double W thickness)

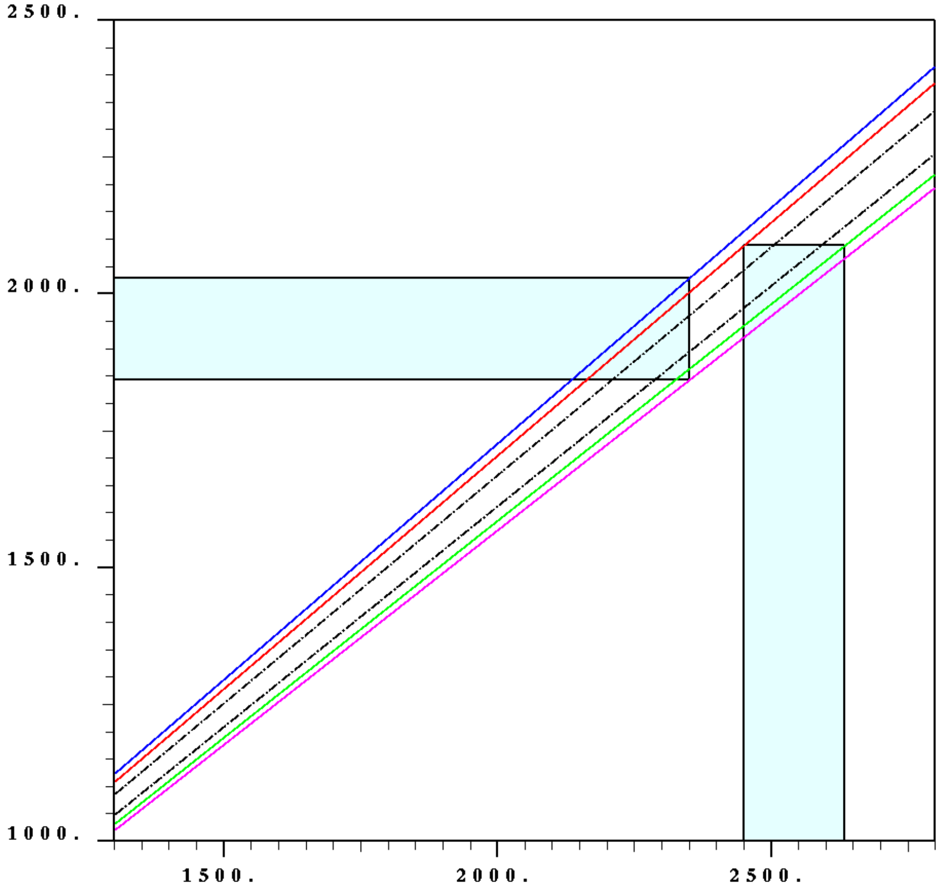
Wafer thickness 500⟶ **~725µm**

- Improved $\sigma(E\gamma) \propto \sqrt[5]{t}$ ⇒ ~recovery of N_{layers} effect. ⇒ compensation of N_{Layer} loss.
- ECAL thickness = 223,85 mm

Geometry studies

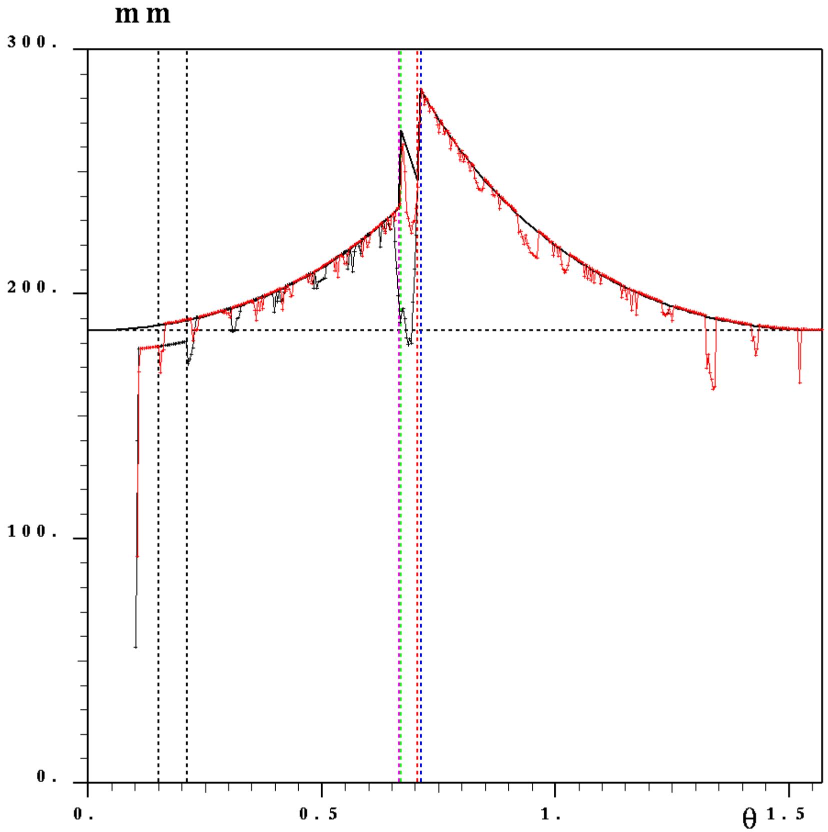
Henri Videau

Overlap corner



Baseline design

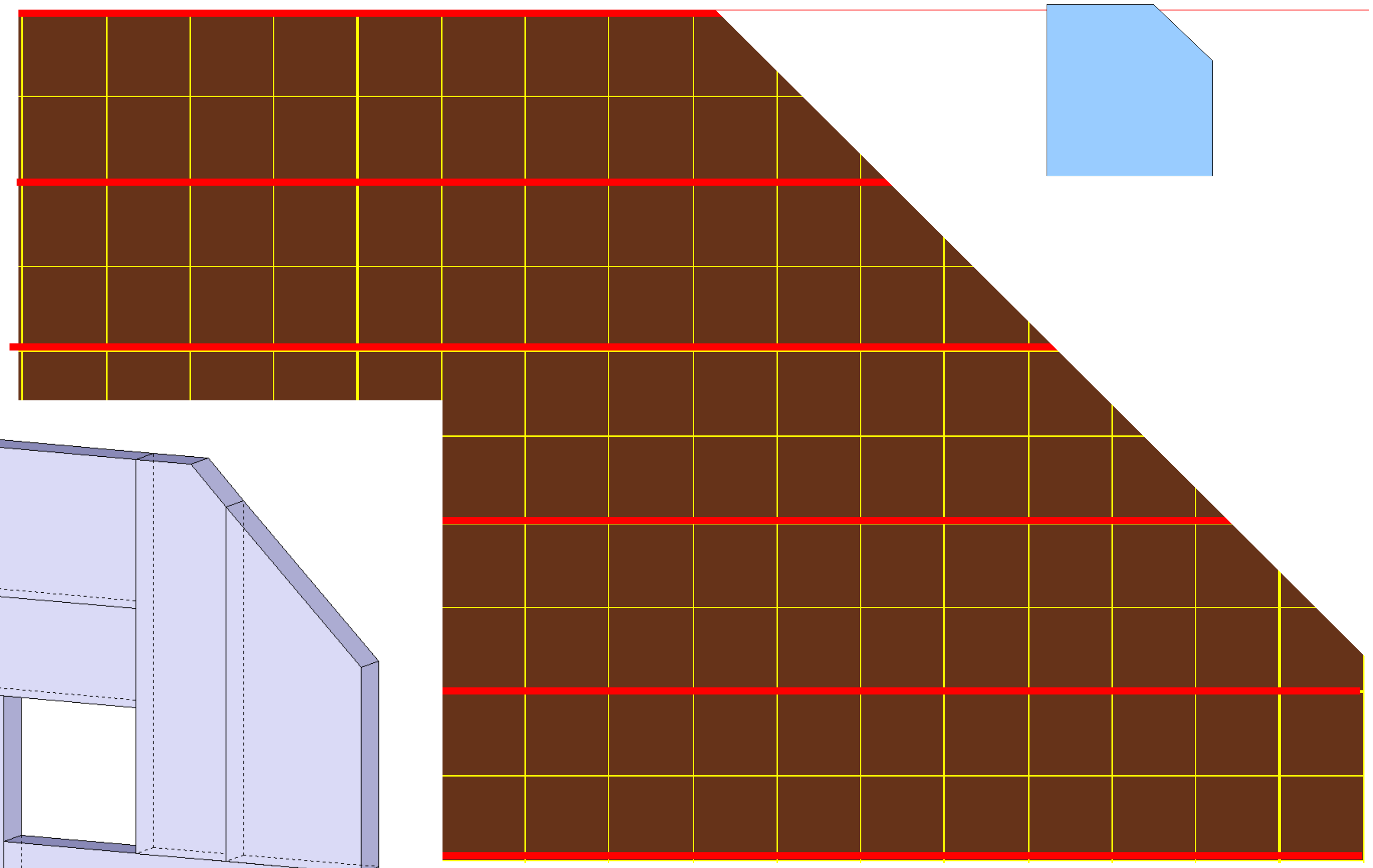
Depth of the calorimeter as a function of angle
+ L(X_0) @ **φ=0** **@ φ=π/4**

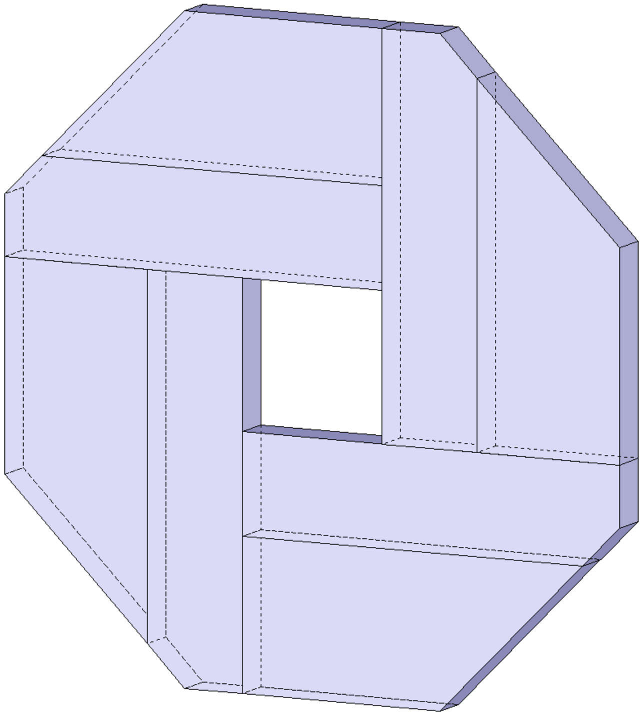


Geometry of endcaps

Magic numbers for limited types of wafers

- linked with size of the ECAL Ring. (⇔ QD0 size)

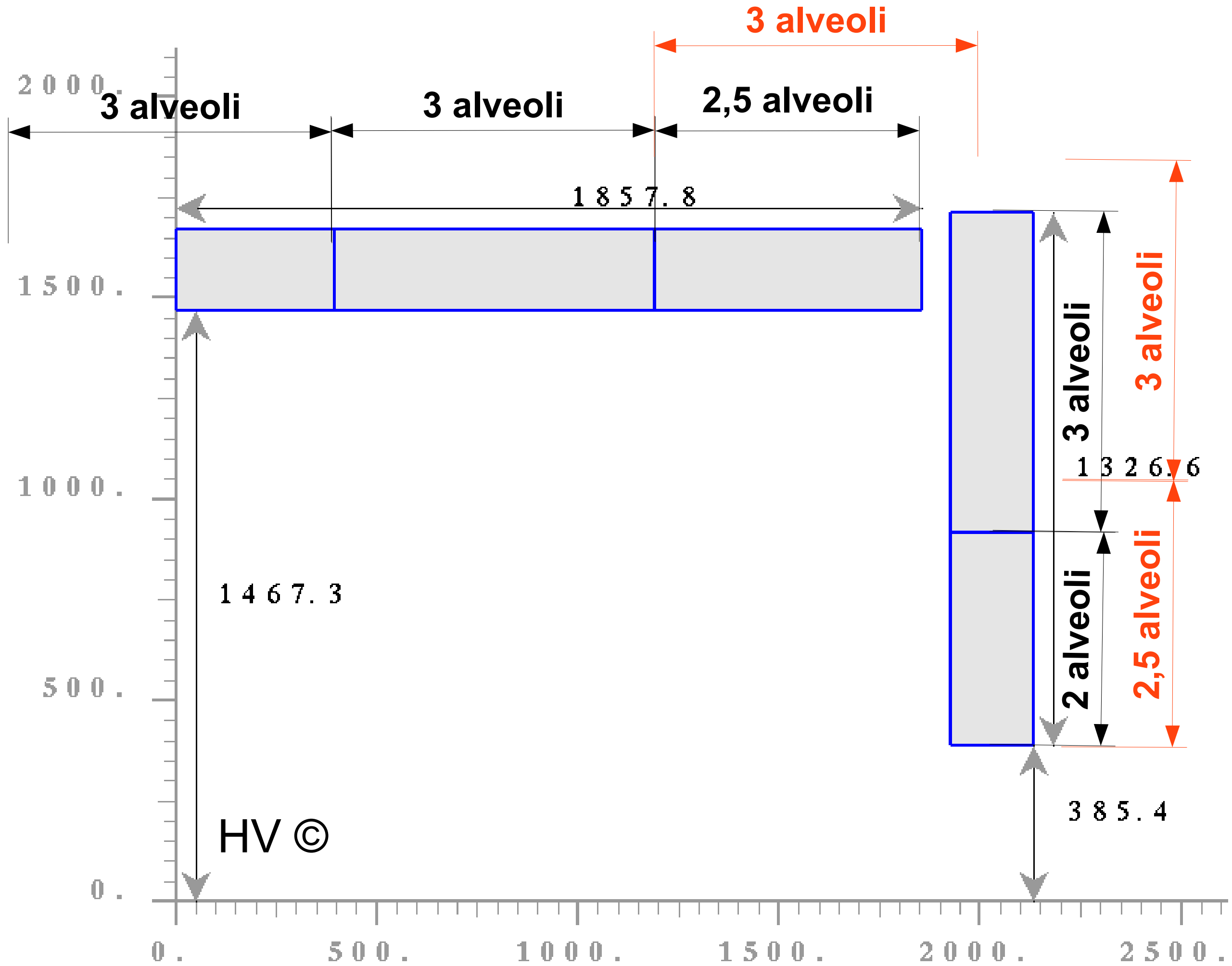




Example of geometry

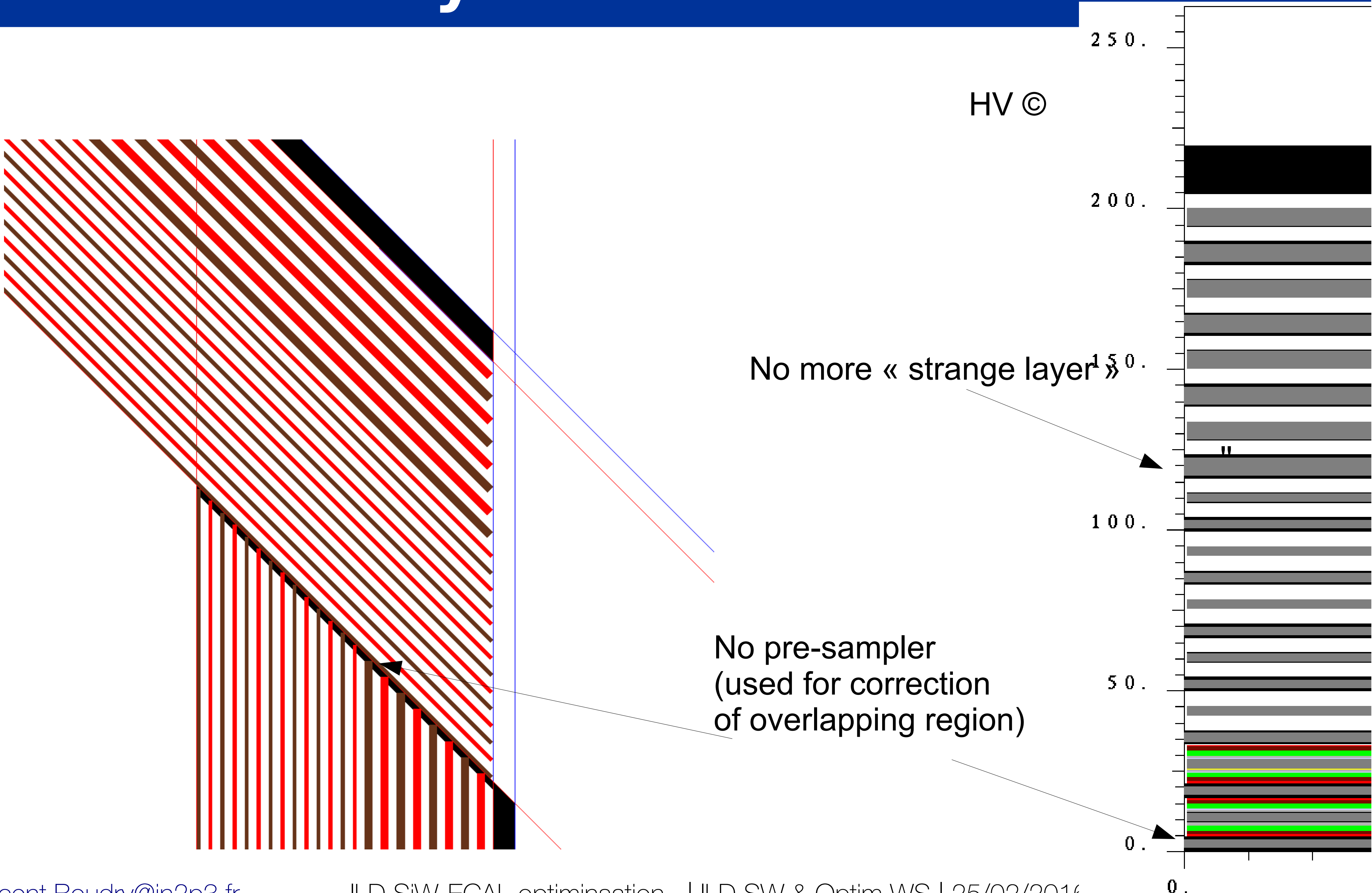
Model 3 (~1400mm)

+ Model 1 (~1600mm)



Preliminary numbers
Enginering plans on-going

Internal structure with reduced number of layers



Simulation modifications

Slide from Sept 2014

Cleaning & adapatation of ECAL Mokka drivers:
[D. Jeans + J. Marshall + E. Becheva + V. Boudry + Dan Yu]

- Many cleaning made by D. Jeans ⇒ SECal05
  - Bugs, improved GEAR output, handling of pre-shower
- Documentation being reviewed
- ~~TBD:~~ Implementation of SEcal05 in DDHEP
  ~~(based on S. Lu implementation of SEcal04 + tests)~~
  - Done for CLICdp by D. Protopopescu & M. Petric
    Needs to be review / adapted for ILD vs SECal04

Status of Sept 2014

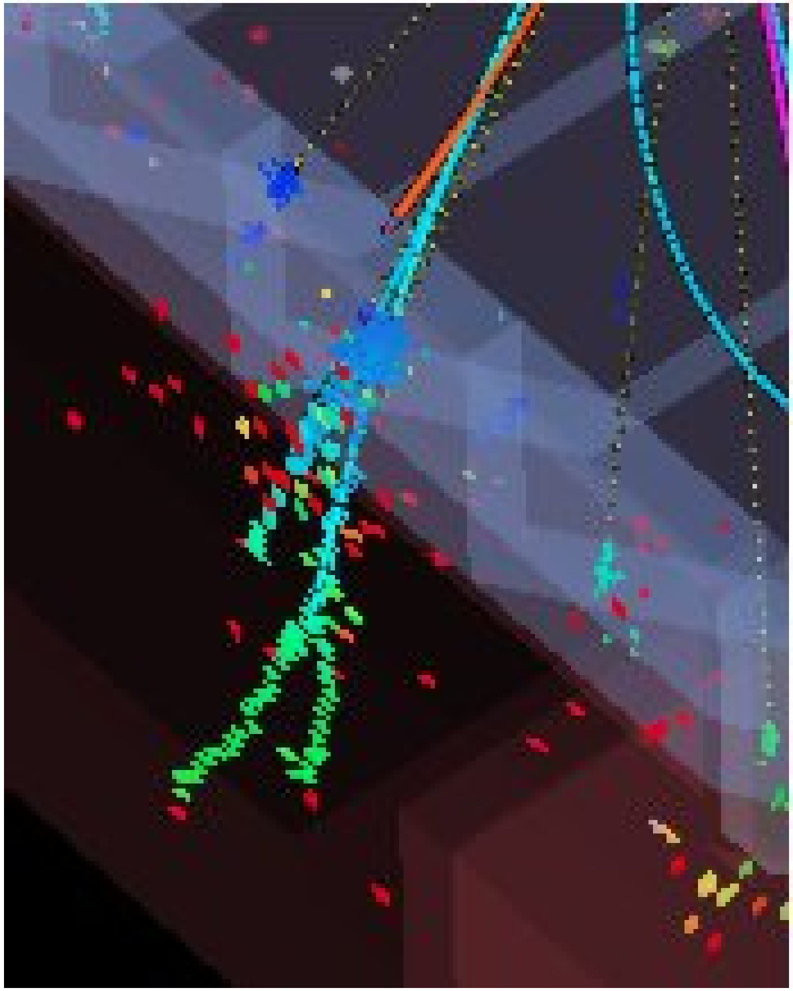
New ECAL Driver (SEcal06) to correct defects (mostly in Endcaps).

- Missing dead materials, “corners”
- Consistant treatment of Barrel/Endcaps
- Better handling of Layers, optionnal pre-shower

Timing ?

CMS-HGCAL and ATLAS-HGTD are investigating precise time for vertex separation

- 50ps timing precision for single cells
- ➘ ~10 ps for EM shower
- electronics (CEA / Omega) is being developped for this



Benefits in terms of PFA ?

- Certainly in HCAL

  in SiW-ECAL ?

But do we have time for time ?

Conclusions

Most studies done with «flexible models» of sim.

- Fine for barrel, be aware of |cosθ| > 0.7
- Correlations and holes to be scanned for… (+ threshold, wafer thickness)

Lower radius models being looked at

- Engineering “safe” in barrel-endcap region
- Larger wafers wrt to baseline,
- Thicker wafers
  - Study of 725µm vs 500µm vs 320µm needs to be completed
- Calculations “almost” there…

Simulation needs to be adapted (with model in DDSIM)

...Timing...

Extras

Variation of N_{Layers}

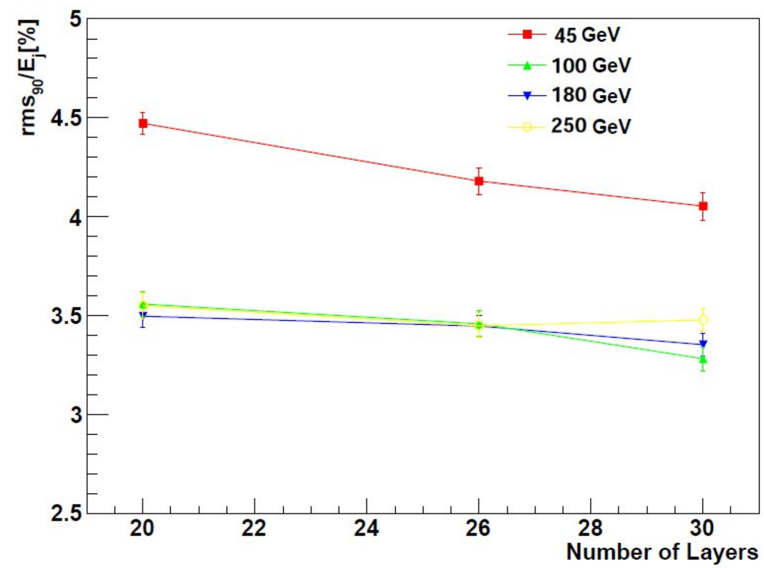
Shown @ 6th ILD Optim meeting (16/07/2014) [Internship work of Dan Yu (LLR)]
https://agenda.linearcollider.org/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=6435

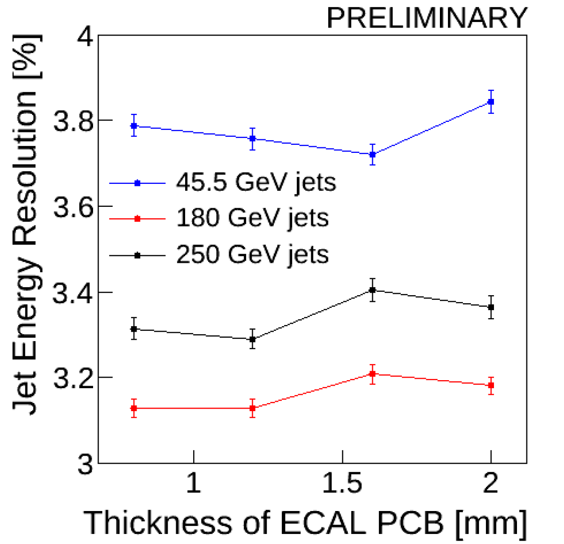
- Variation of ECAL's N_{Layers} for R=1450mm, HZ_{Barrel}=1848mm on ILD_o2_v05
- Exact Same procedure as previous study
  - Non-Linearity ≤ 1%
- For |cosθ| ≤ 0.7

number of Si layers	W layers (1st section)	Thickness (mm)	W layers (2nd section)	Thickness (mm)
20	13	3.15	6	6.3
26	17	2.4	8	4.8
30	20	2.1	9	4.2

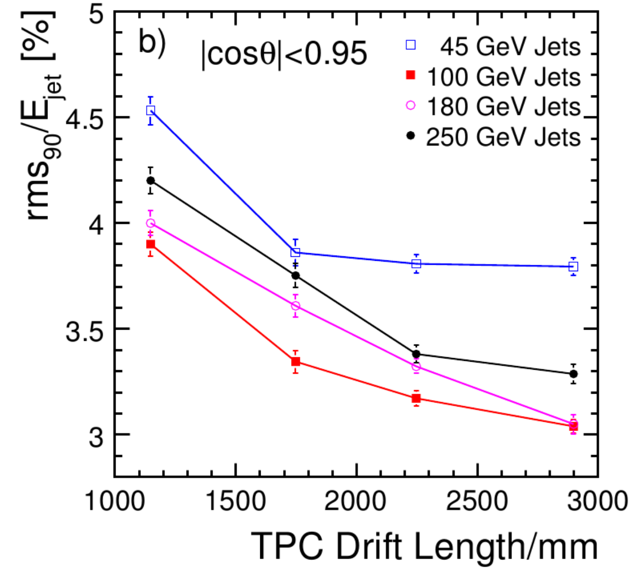
Results

- JER + ≤6% @45 GeV

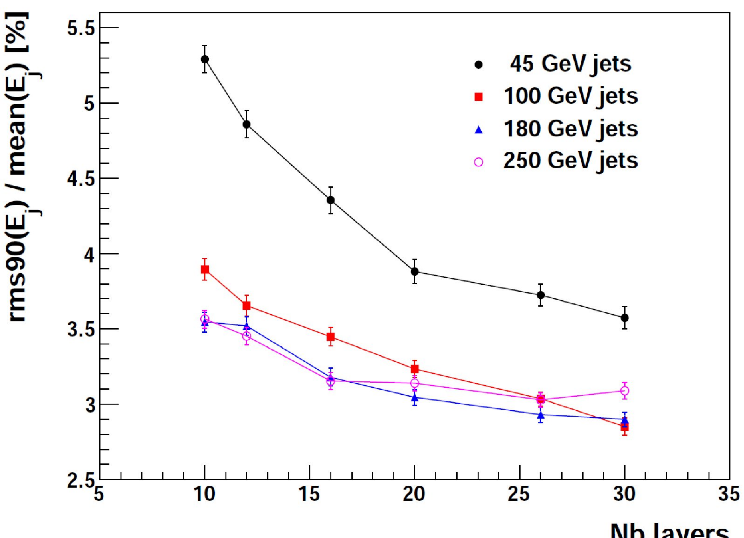




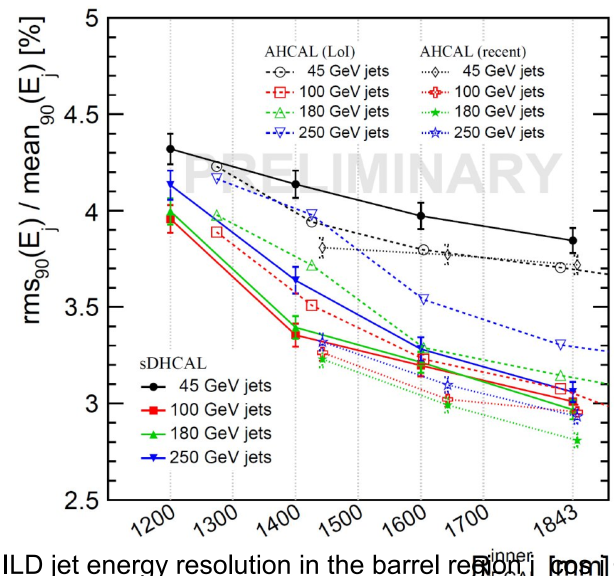
Single jet energy resolution as a function of the thickness of PCB with embedded electronics.



Single photon energy resolution as a function of the number of silicon layers for four photon energies.

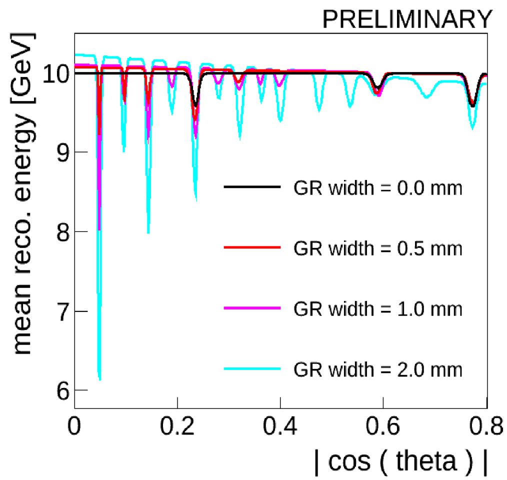


Single jet energy resolution (rms90=E) in the barrel region (j cos j < 0: 7) as a function of the number of ECAL silicon layers in events e+e- → ZX → usd

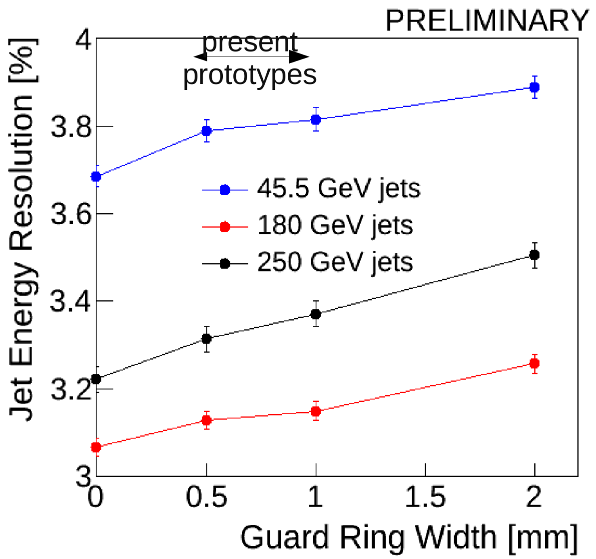


ILD jet energy resolution in the barrel region j cos j < 0: 7 as a function of its radius.

Guard Ring studies

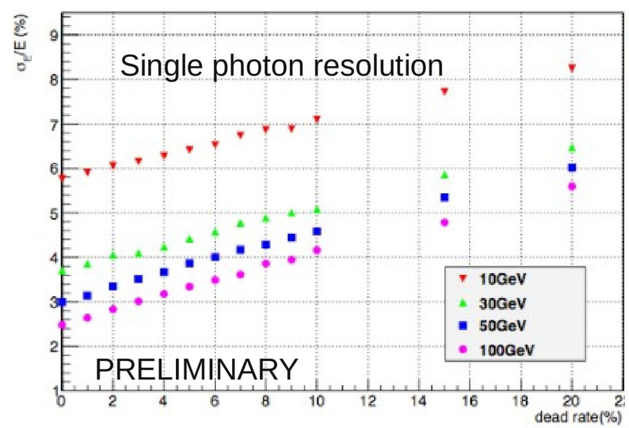


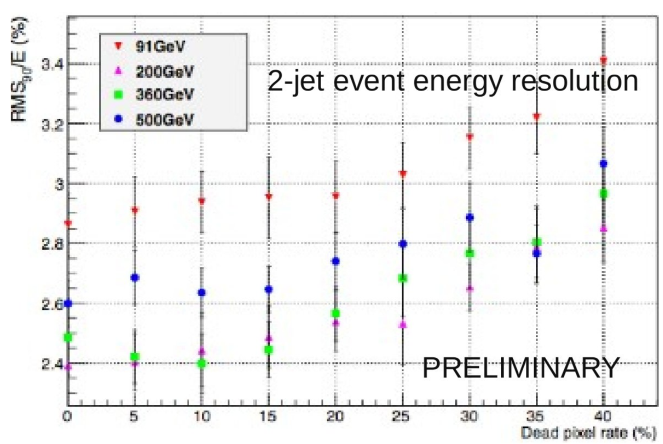
An ECAL average signal versus azimuthal angle. The loss in inter-sensor dead areas is visible (between barrel modules, barrel and endcap
and between the sensors, the latter depends on the guard ring).

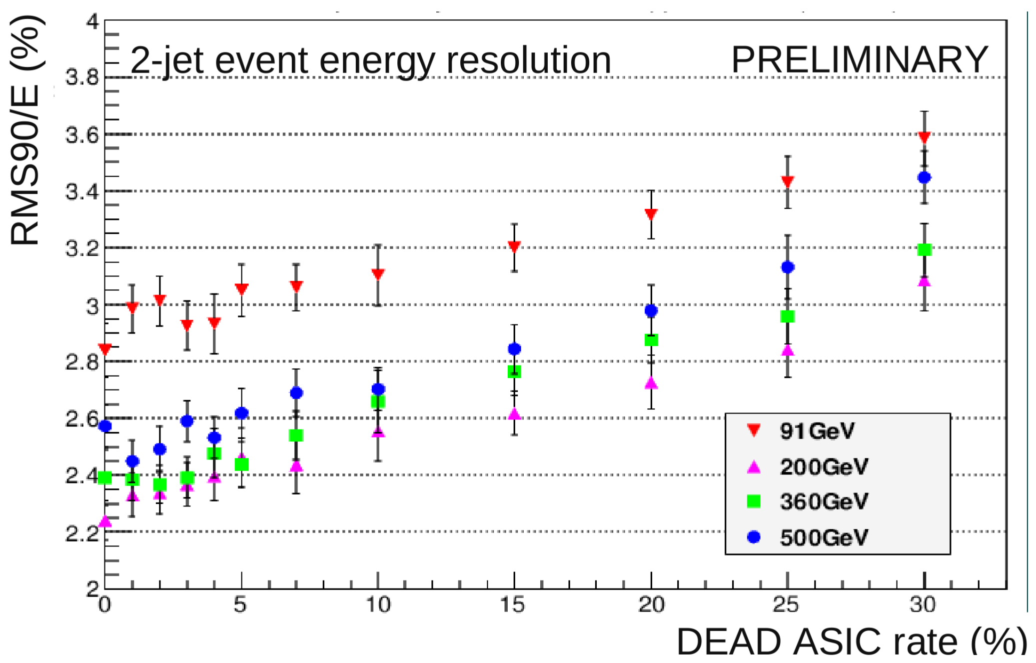


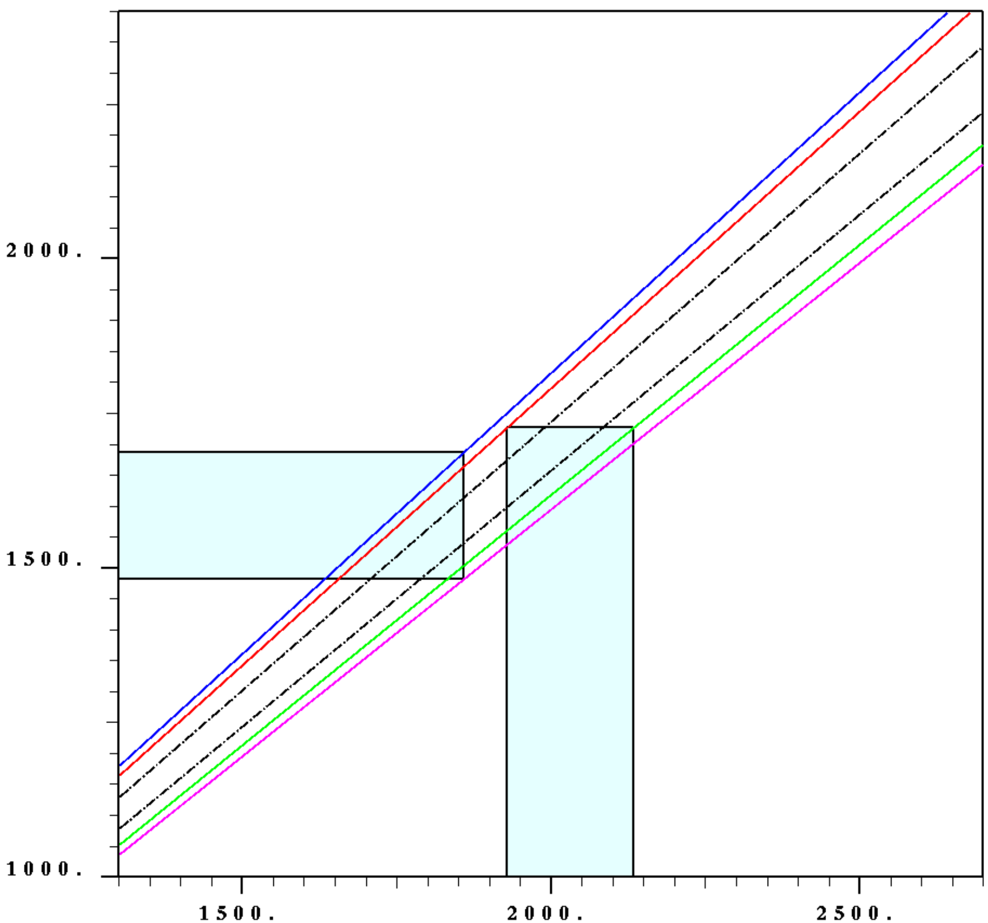
the single jet energy resolution after a simple dependent correction as a function of the guard ring thickness.

Resilience


Single photon resolution
PRELIMINARY
10GeV
30GeV
50GeV
100GeV
dead rate(%)


2-jet event energy resolution
PRELIMINARY
91GeV
200GeV
360GeV
500GeV
Dead pixel rate (%)


2-jet event energy resolution
PRELIMINARY
RMS90/E (%)
91GeV
200GeV
360GeV
500GeV
DEAD ASIC rate (%)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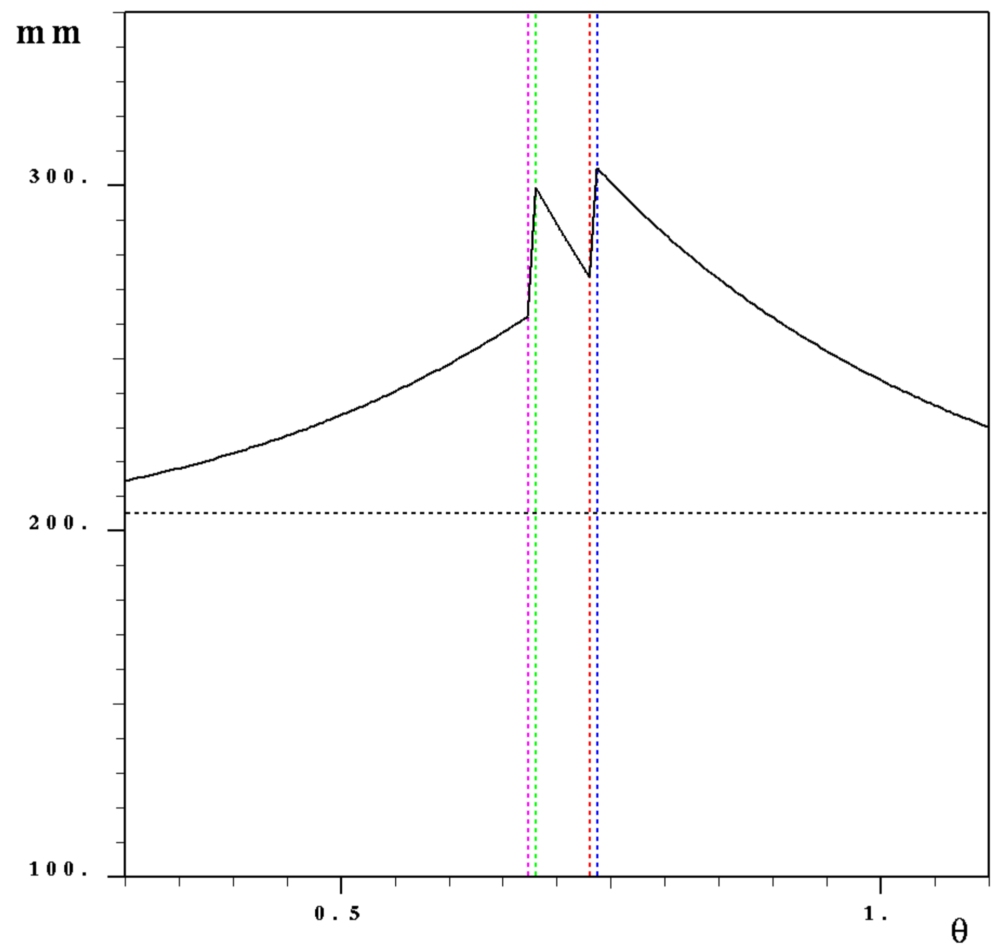
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