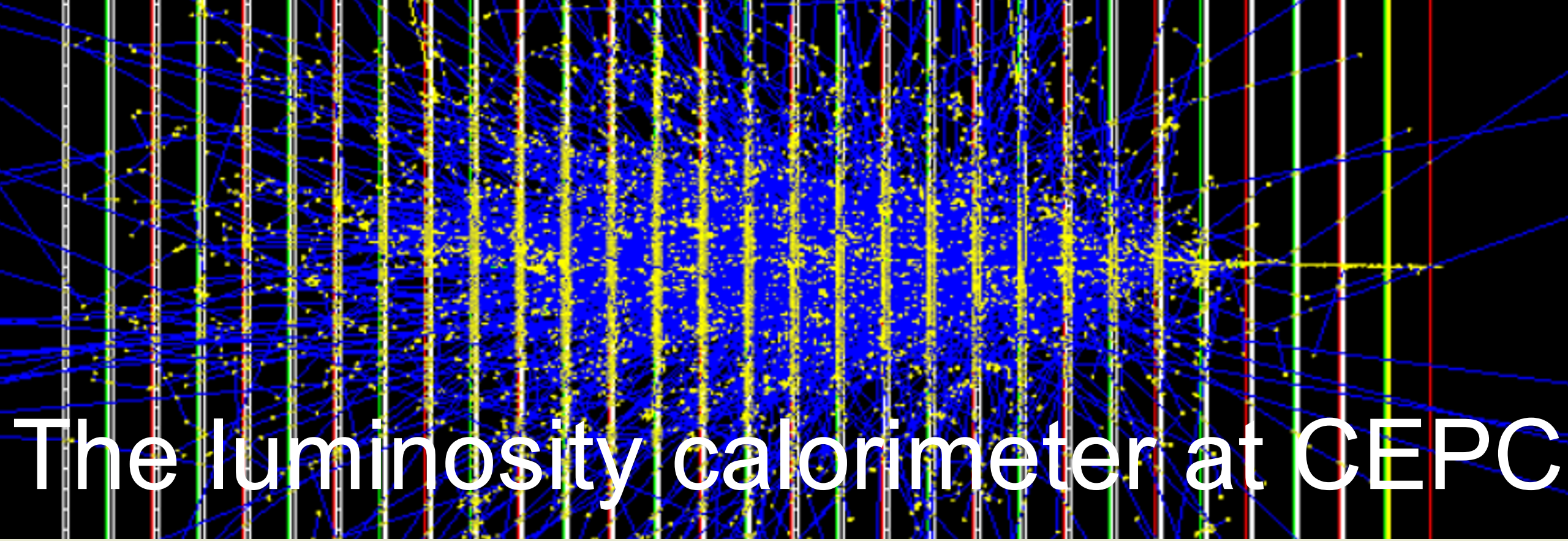


The luminosity calorimeter at CEPC

Cheng-Wei Shih[1]

Supervisor : Chia-Ming Kuo[1], Suen Hou[2], Cheng-Dong Fu[3]

[1]National Central University, Taiwan
[2]Academia Sinica, Taiwan
[3]Institute of High Energy Physics, China

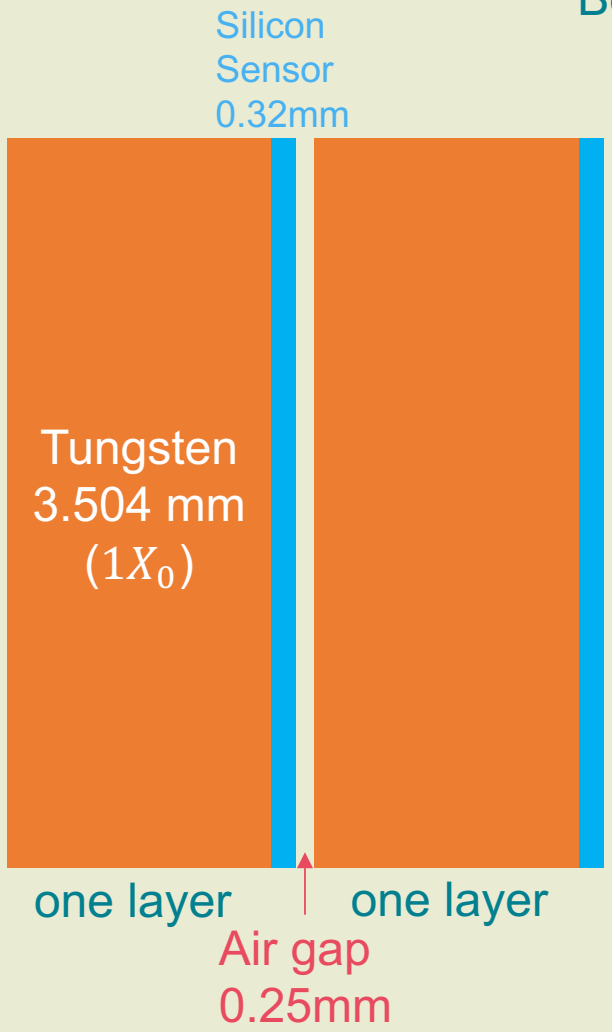
outline

- Case – 1 LumiCal :
  - angular resolution
  - LumiCal position change comparison
  - material test
- Case – 2 LumiCal :
  - angular resolution

Case – 1 LumiCal

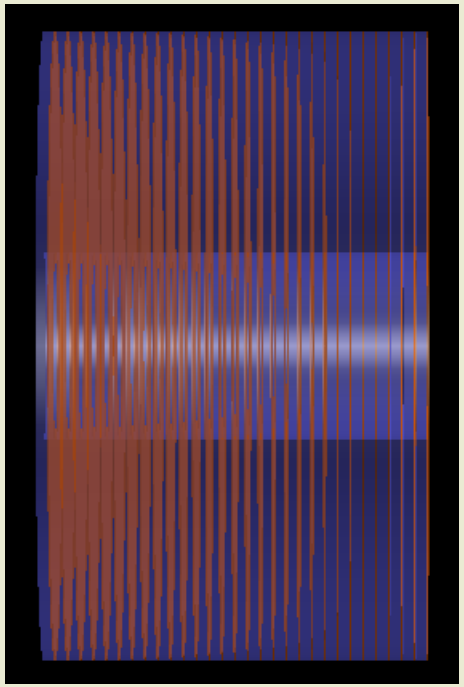
Geometry – hollow circle shape detector

Beam pipe code in macro file : /Mokka/init/EditGeometry/addSubDetector tube_cepc_v4

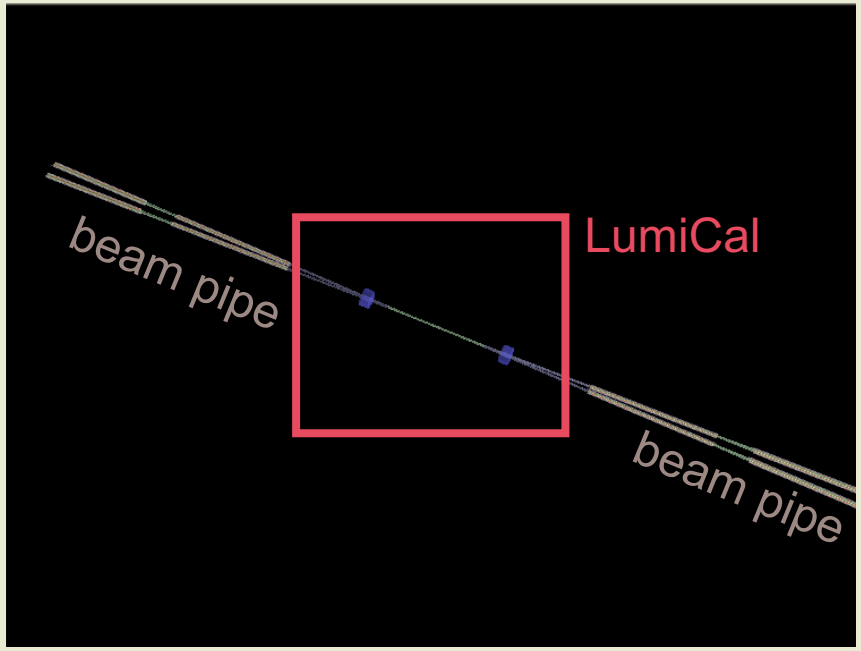


x 30 layer

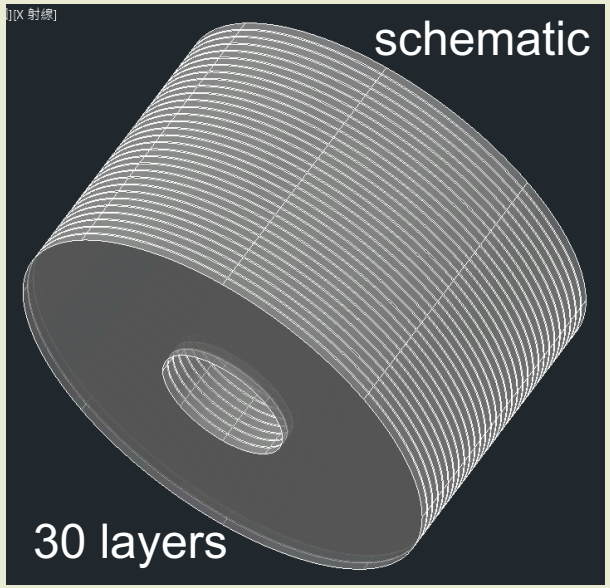
● ● ●



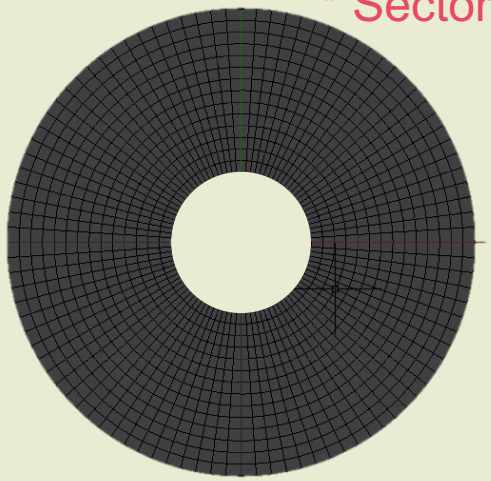
30 layers (one side)



Geometry – hollow circle shape detector

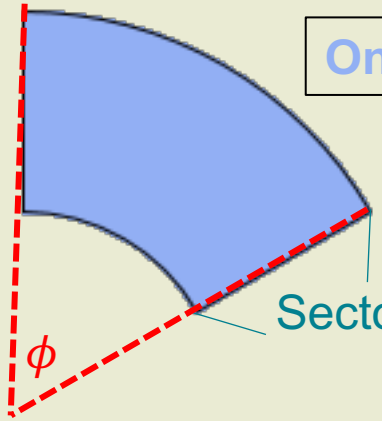


* Sector width not to scale



LumiCal front view

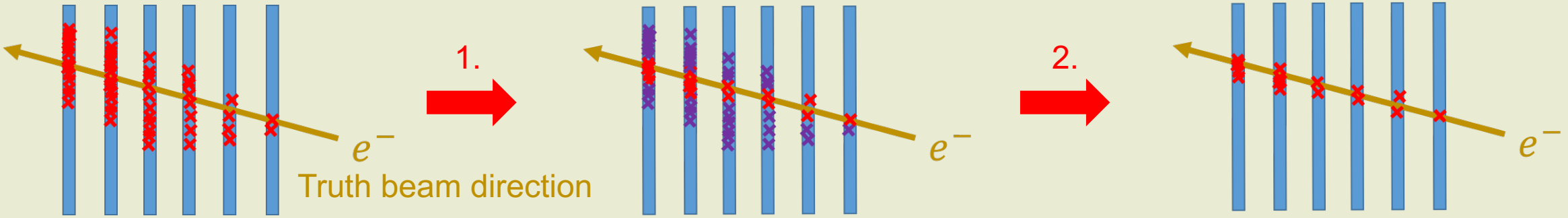
One sector shape pad



Element	Value	Unit
Tungsten thickness	3.504	mm ($1X_0$)
Silicon thickness	0.32	mm
Inner radius	30	mm
Outer radius	100	mm
Sector ϕ rotate	3.75	degree
Sector width	0.3 - 1.6	mm
Air gap	0.25	mm
LumiCal position	$\pm$500, 970	mm

Method to reconstruct θ angle

Energy cut method : if the cell energy deposit < energy cut, eliminate this cell



✖ : Energy deposit cell

✖ : cell energy deposit < energy cut

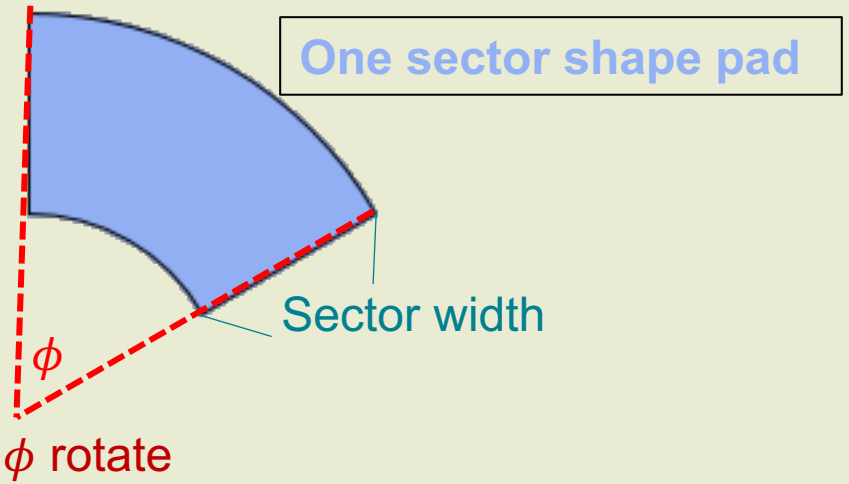
After energy cut

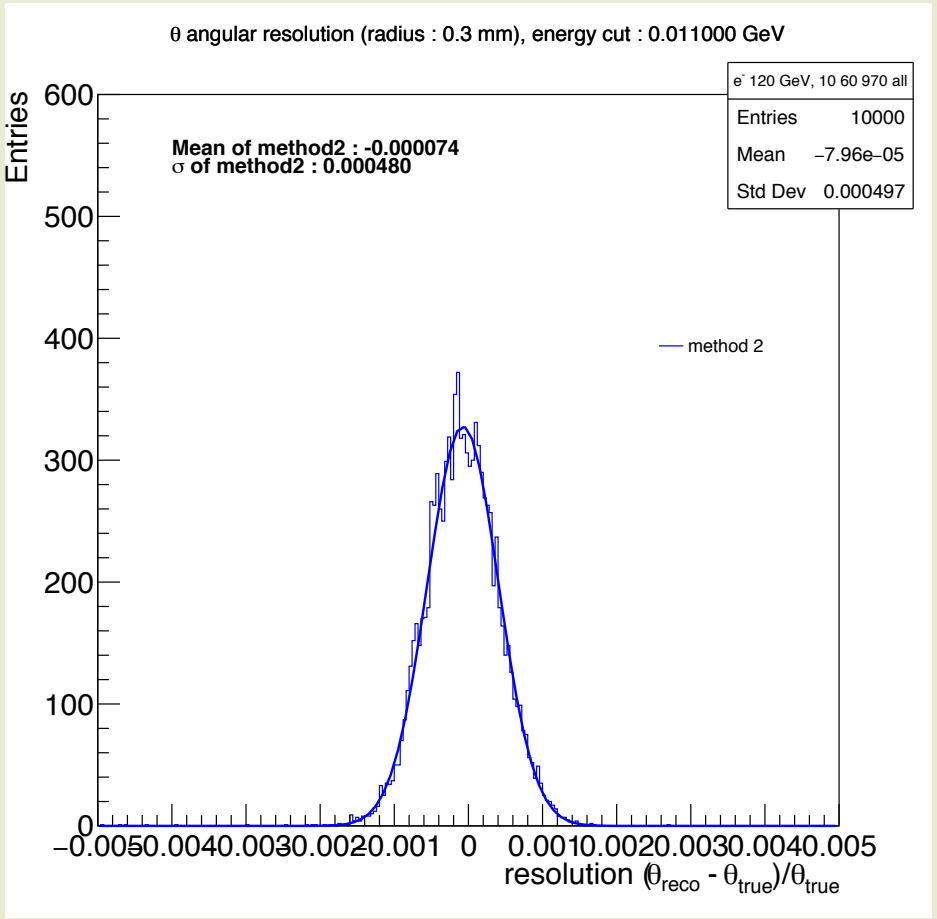
3. → Energy weight method to reconstruct angle

Geometry : fine the sector width

LumiCal position : 970

IP : 0 0 0, Fixed θ : 3.58^0
Sector width : **0.3** mm,
σ : $4.8 * 10^{-4}$
Energy cut : 0.011 GeV
Resolution : $\frac{\theta_{reco}-\theta_{true}}{\theta_{true}}$

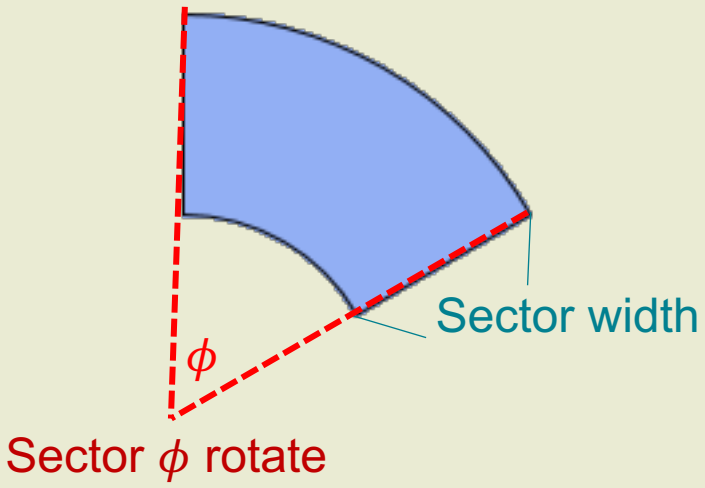


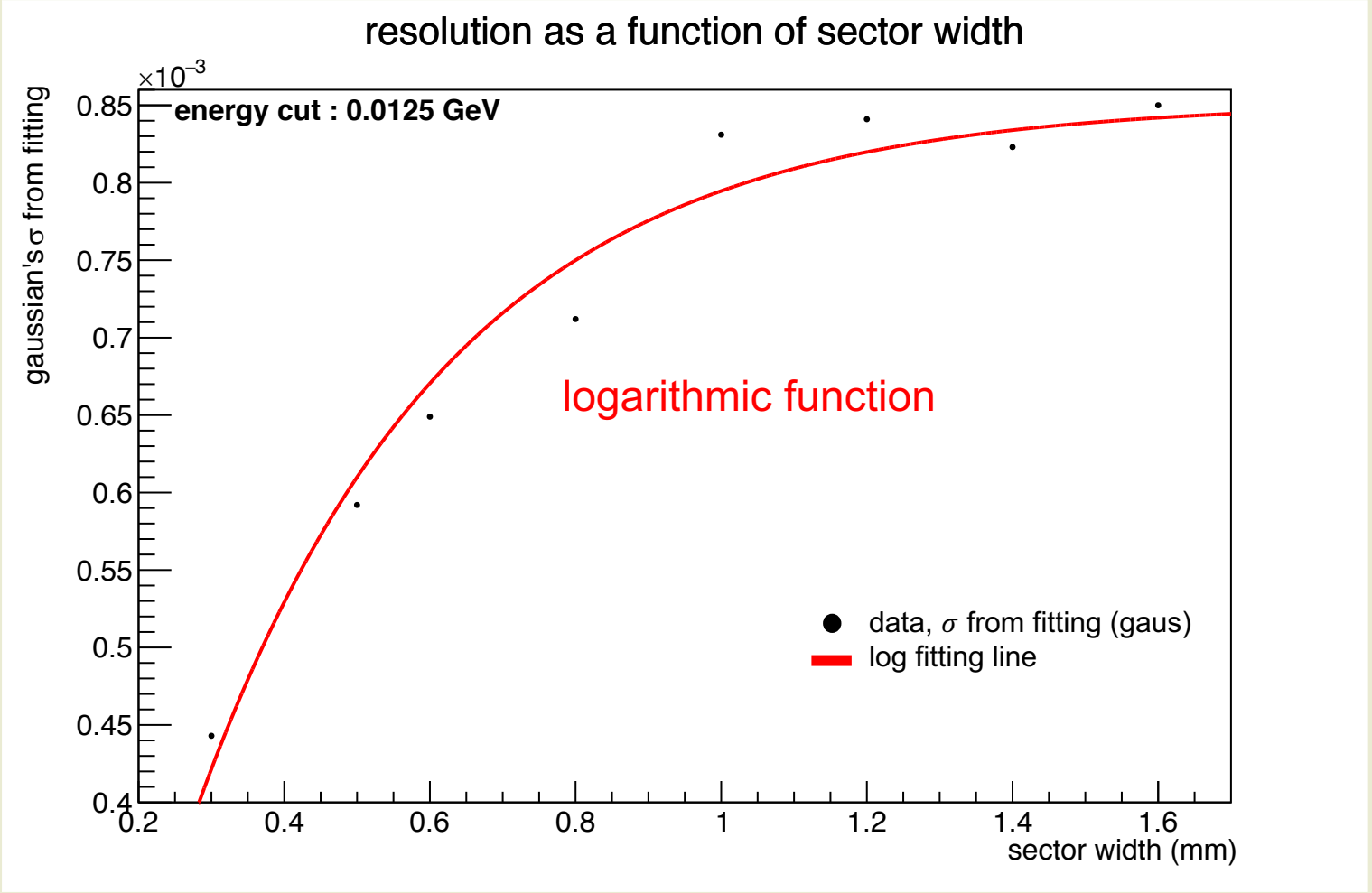


Angular resolution as a function of sector width

LumiCal position : 970

Sector width :
1.6, 1.4, 1.2, 1.0, 0.8, 0.6, 0.5, 0.3 (mm)





Preliminary events count test

LumiCal position : 970

Electron, 120 GeV, One side, doesn't consider FSR photon

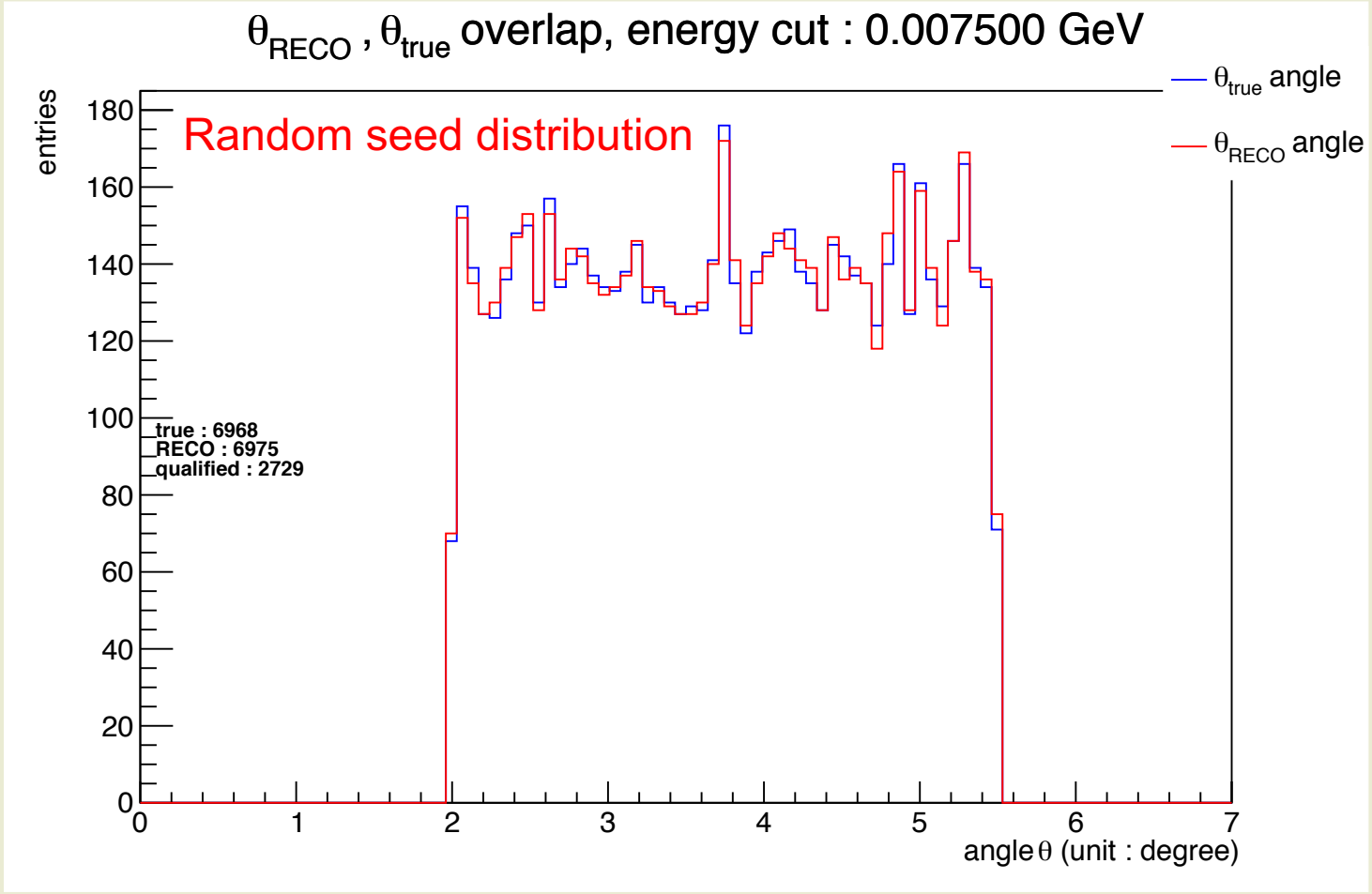
$\frac{\Delta N}{N_{true}}$: - 10^{-3}, reached (higgs)

ΔN : $N_{reco} - N_{true}$

Exclude edges (poor reconstruct region)

Sector width : 1.4 mm

Acceptable θ : 2.0^0 to 5.5^0

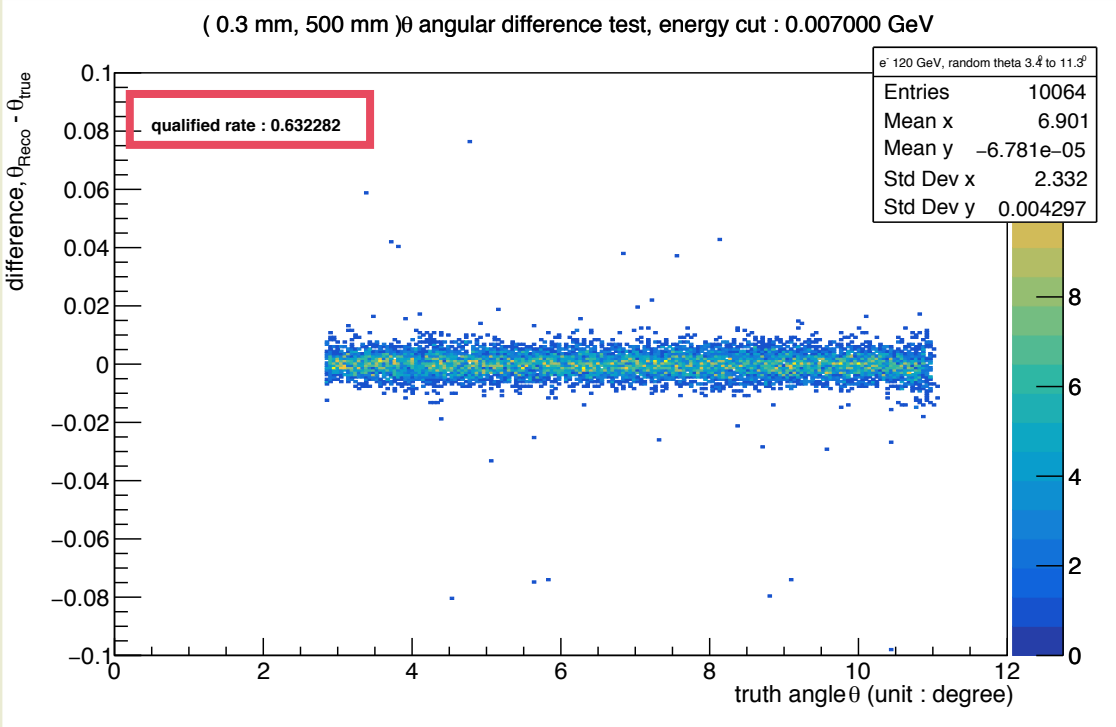


LumiCal change position comparison

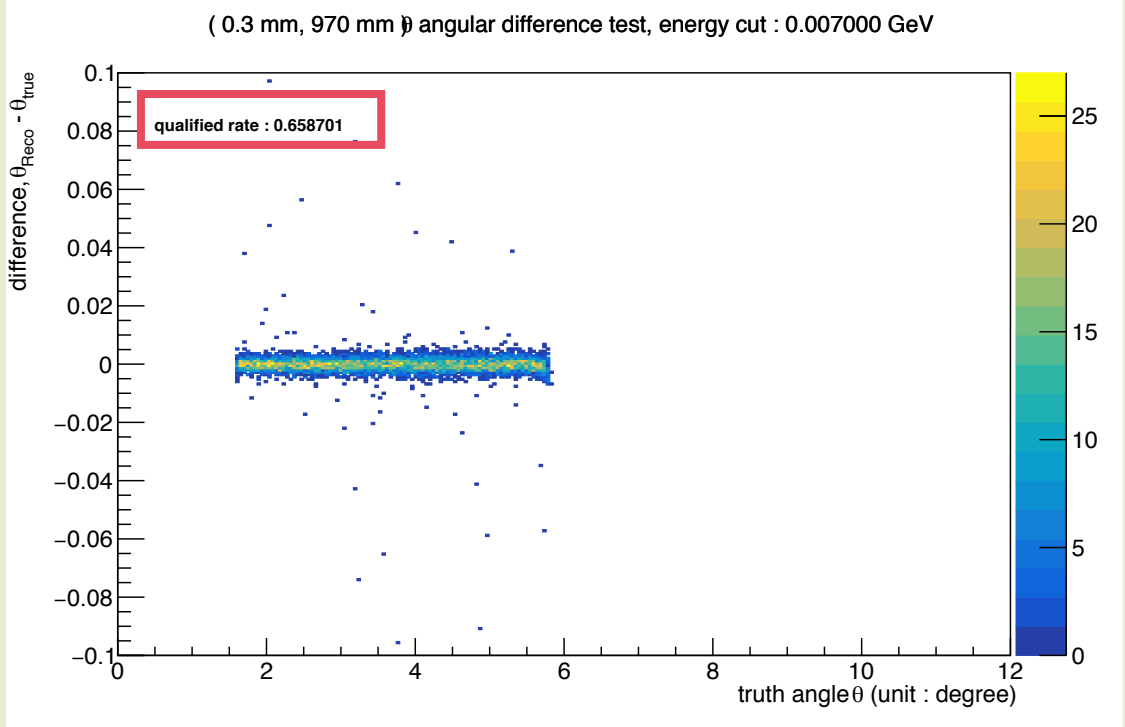
Sector width : 0.3 mm, energy cut : 0.007 GeV, difference : $\theta_{reco} - \theta_{true}$

500 mm with 4.17% worse

Position : 500 mm



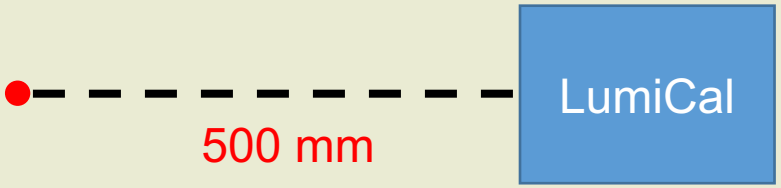
Position : 970 mm

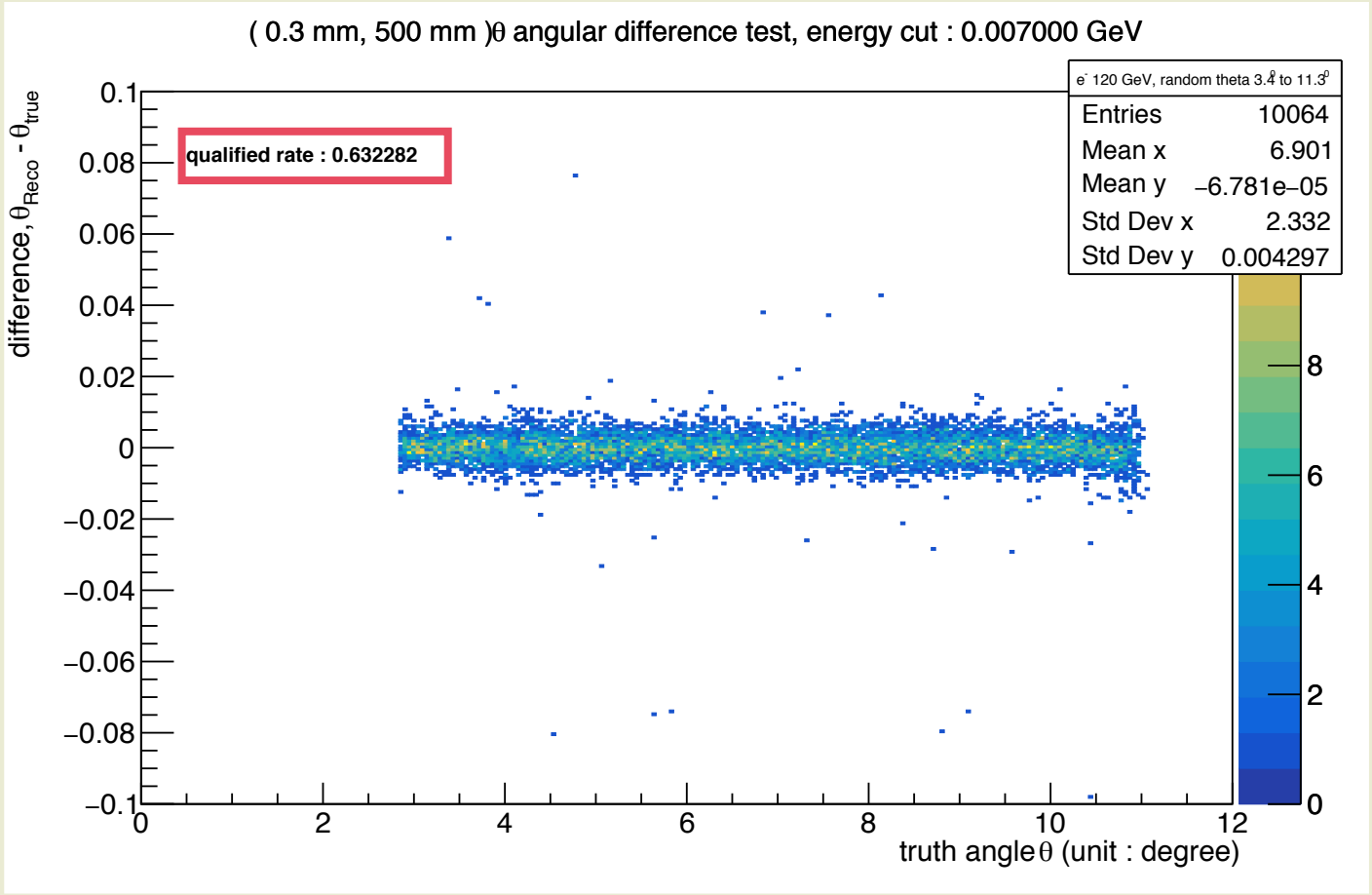


Material test : LumiCal only

LumiCal position : 500

Sector width : 0.3 mm
Energy cut : 0.007 GeV

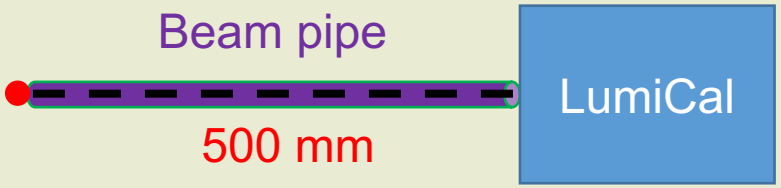


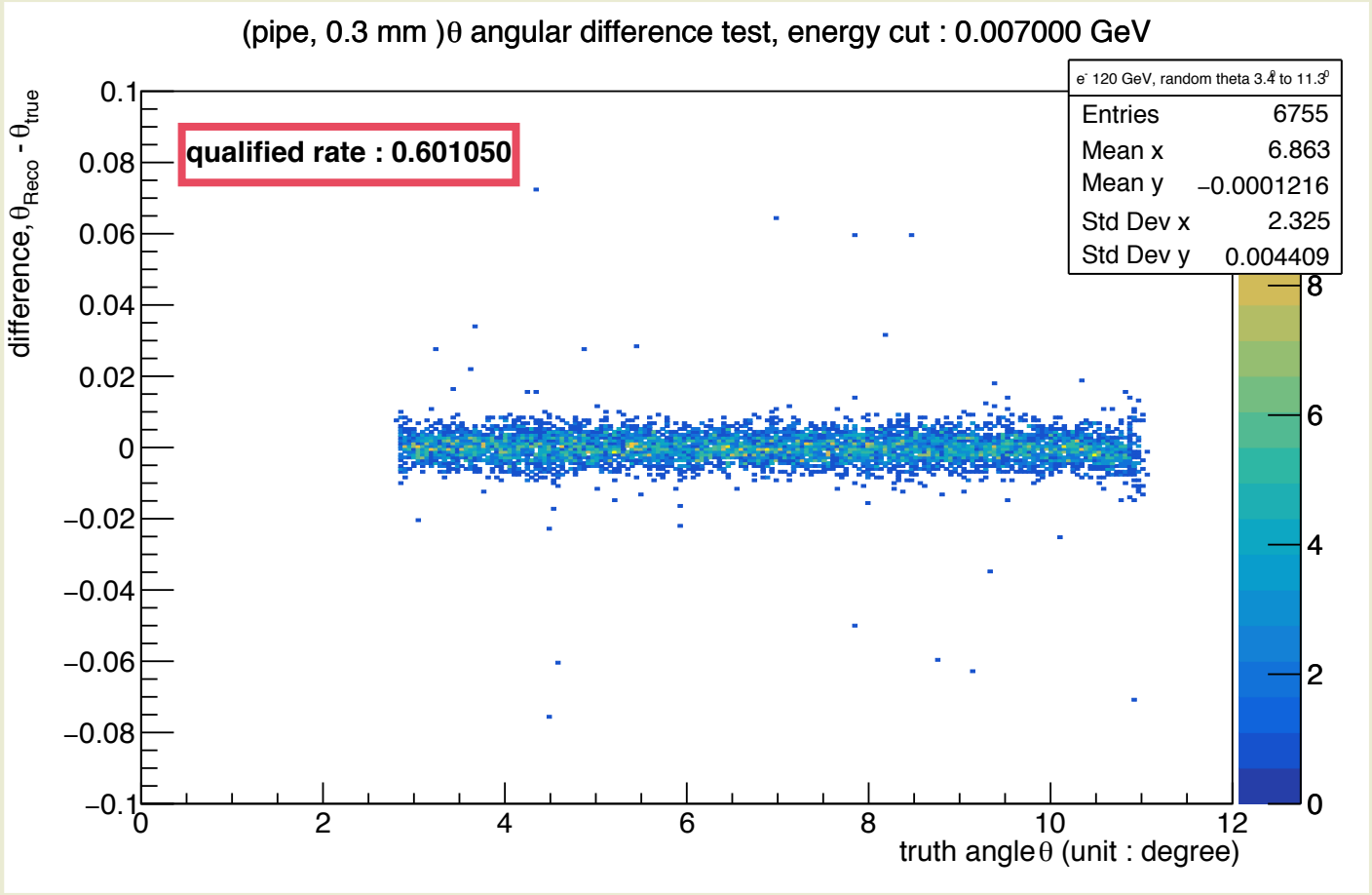


Material test : LumiCal + pipe

LumiCal position : 500, Beam pipe code in macro file : /Mokka/init/EditGeometry/addSubDetector tube_cepc_v4

Sector width : 0.3 mm
Energy cut : 0.007 GeV
With beam-pipe : 5% worse

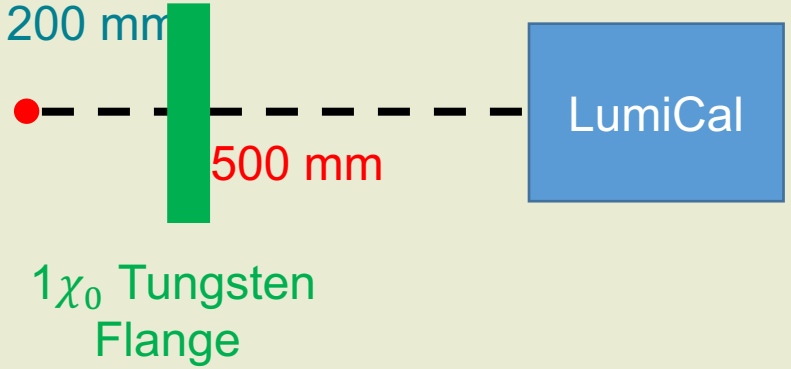


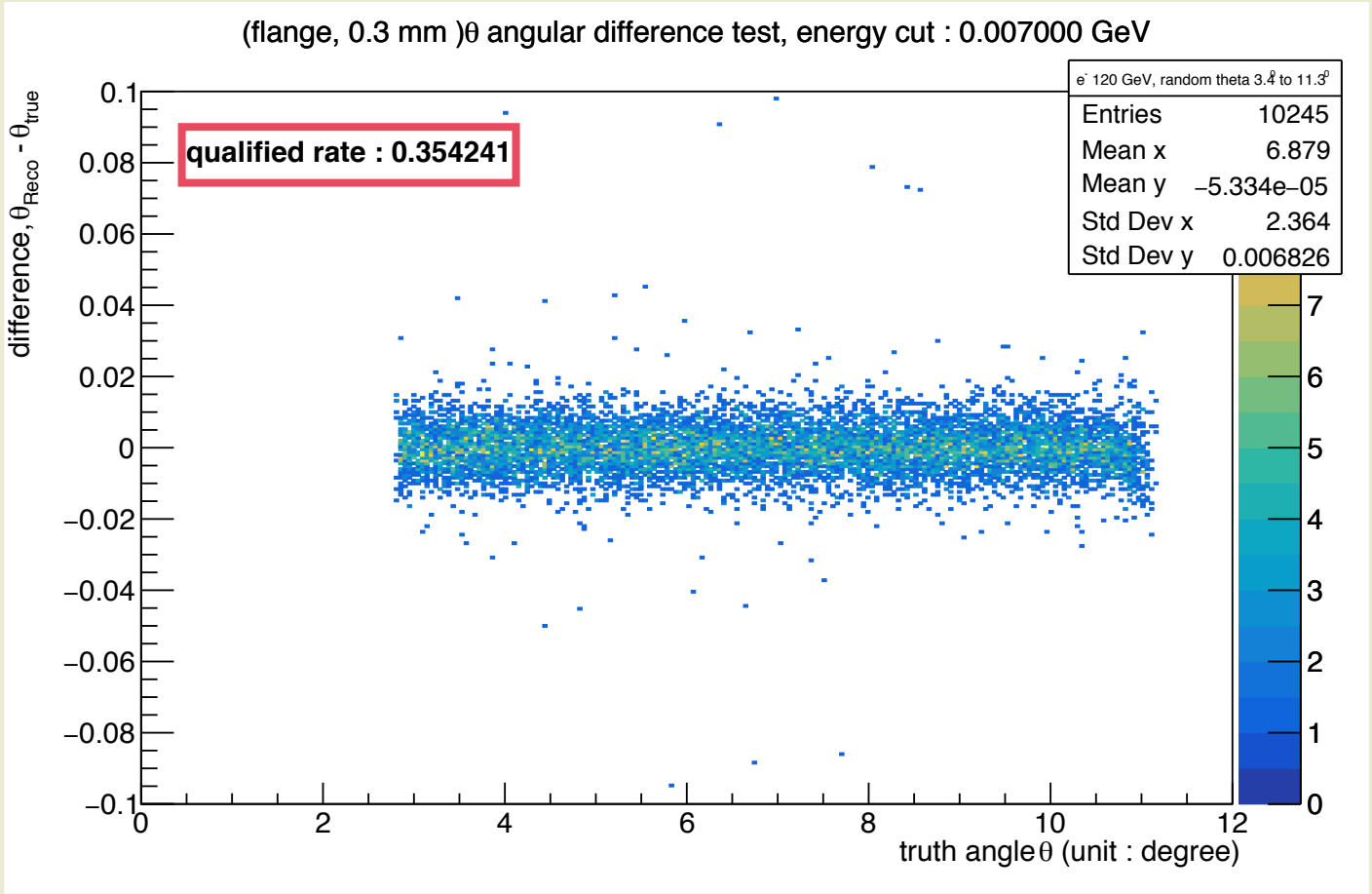


Material test : LumiCal + flange

LumiCal position : 500

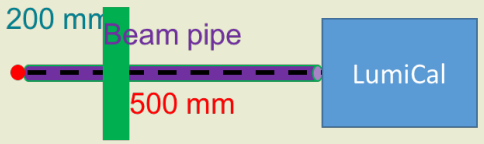
Sector width : 0.3 mm
Energy cut : 0.007 GeV
With flange : 44% worse





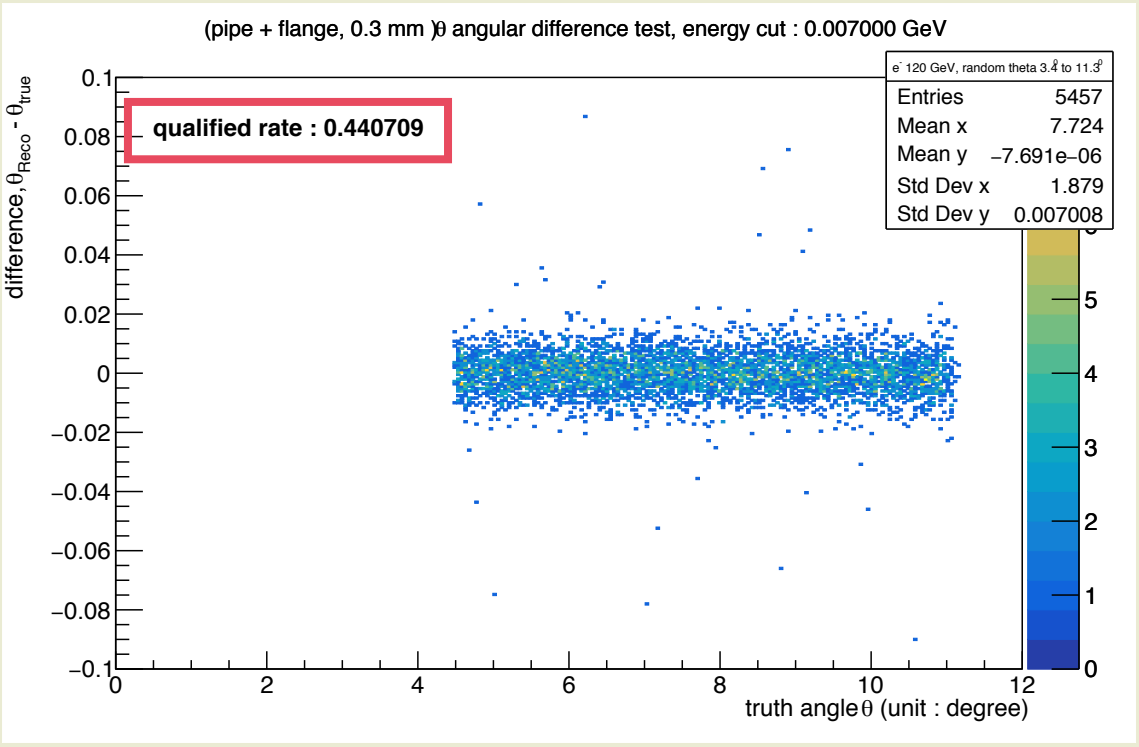
Flange with / without beam-pipe

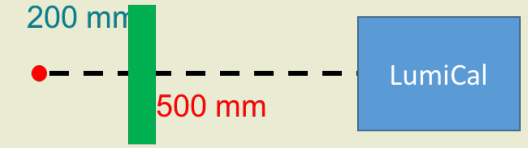
LumiCal position : 500
Energy cut : 0.007 GeV



$1\chi_0$ Tungsten Flange

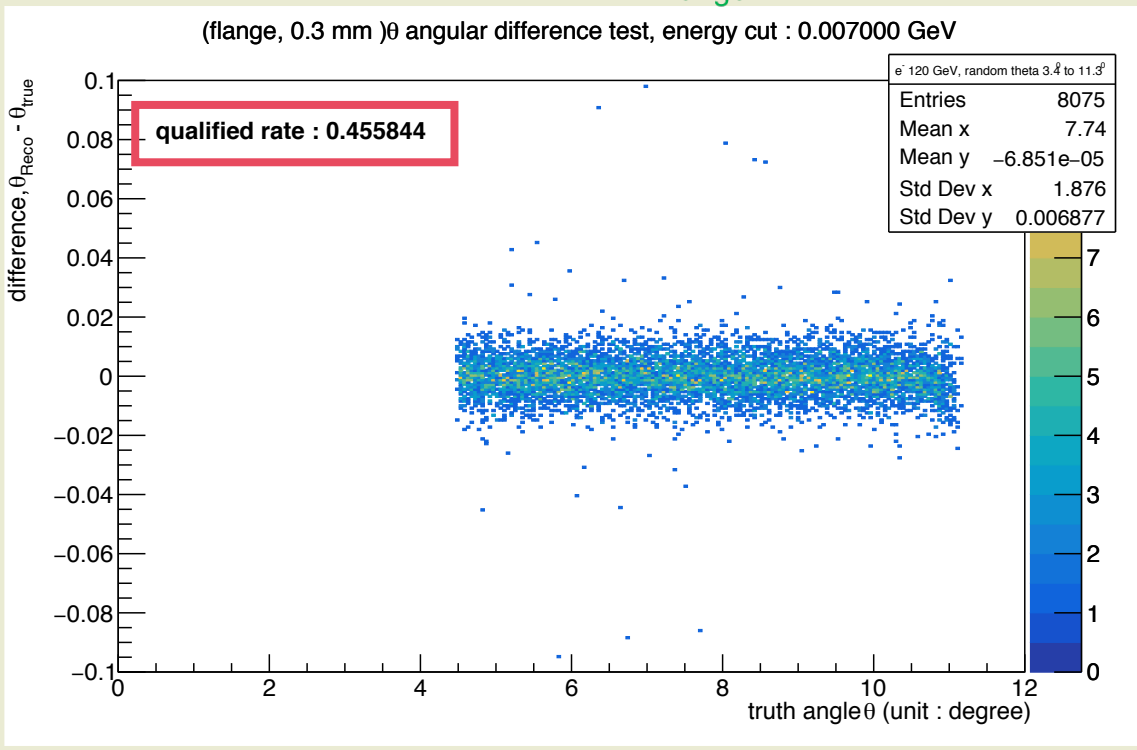
With beam-pipe





$1\chi_0$ Tungsten Flange

Without beam-pipe

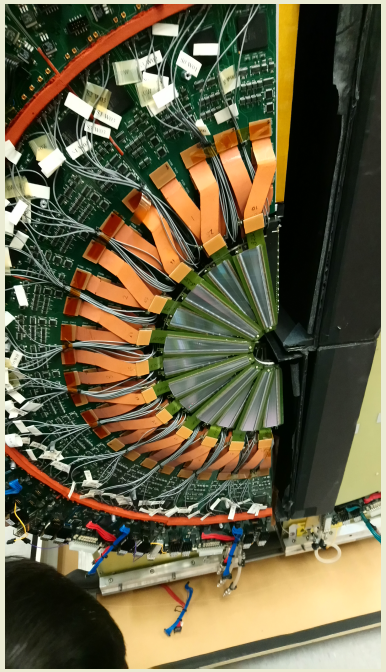


With beam-pipe : 3% worse -> multiple scattering effect dominated : flange

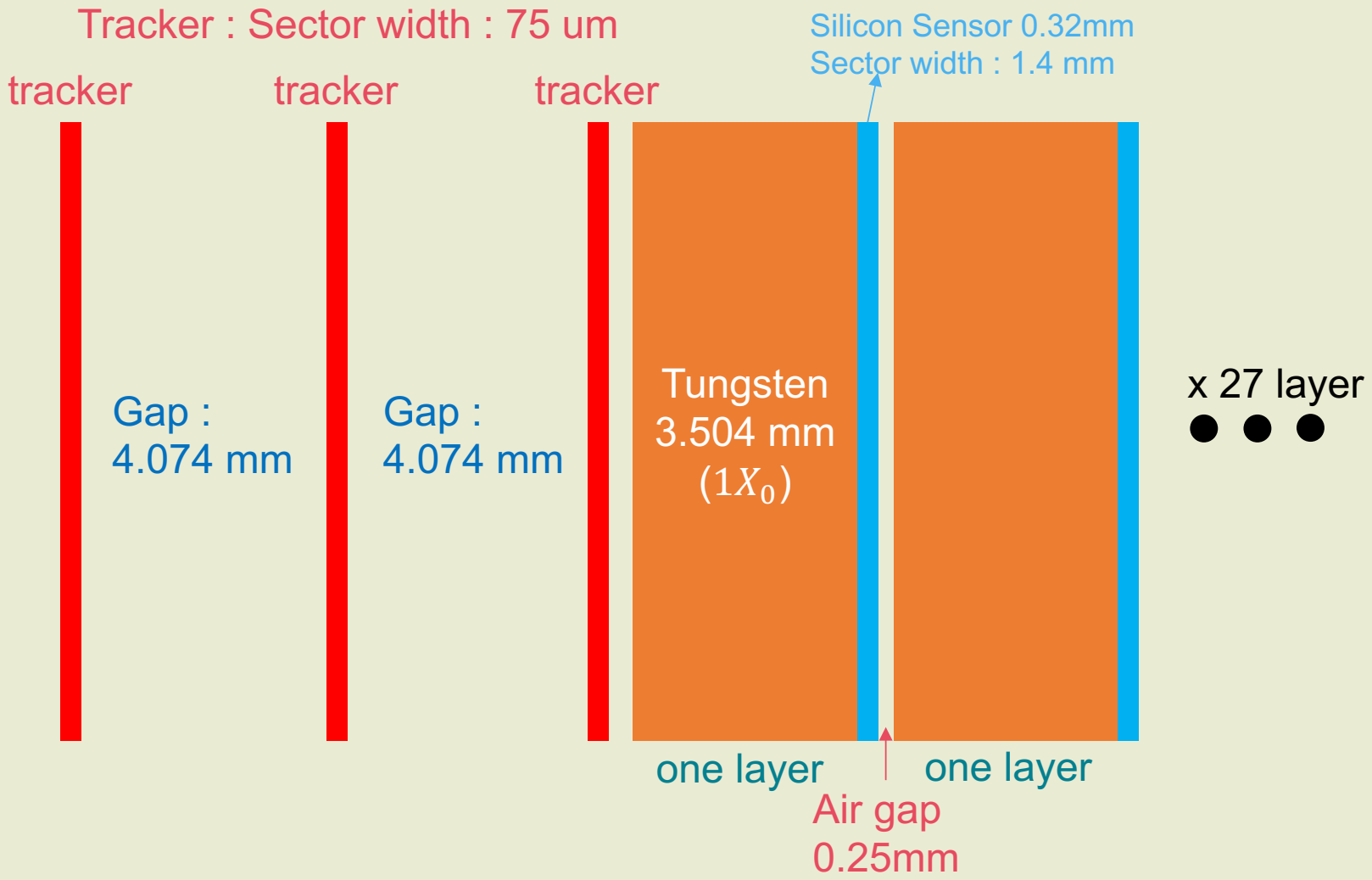
Case – 2 LumiCal

Geometry : 3 layers tracker + sampling calorimeter

LumiCal position : 500
Sector ϕ rotate : 3.75^0



PHENIX detector : FVTX
FVTX detail

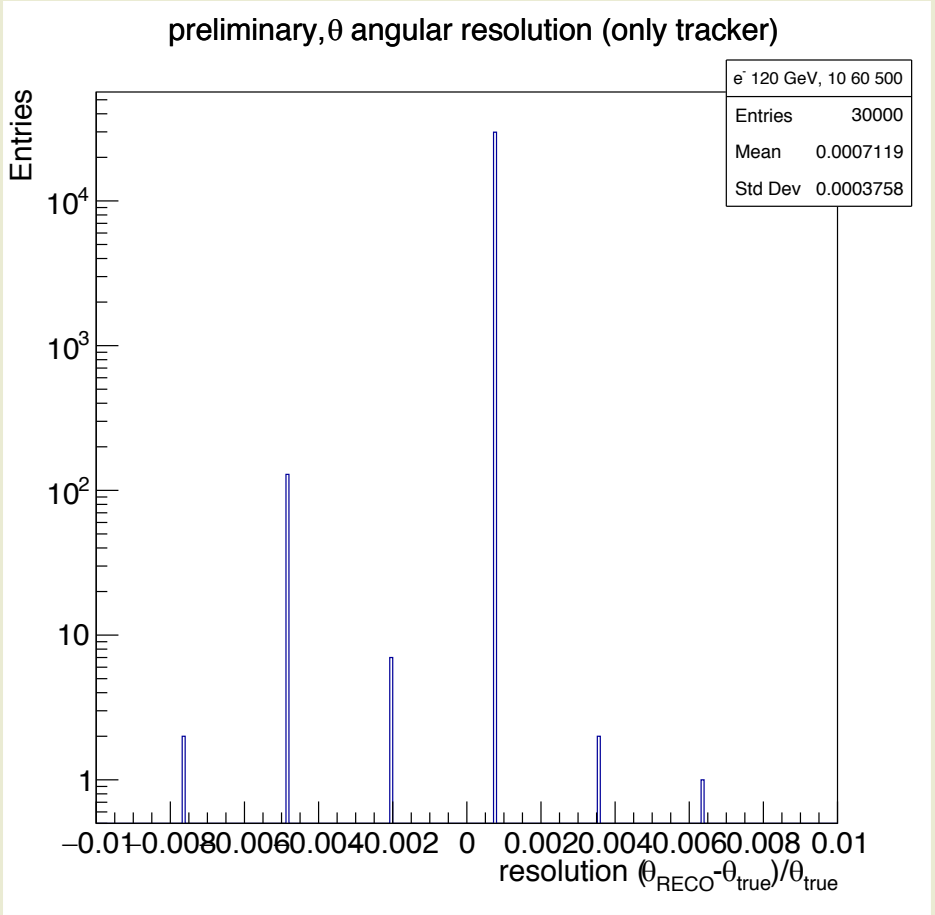


Angular resolution (only tracker)

LumiCal position : 500

IP 0 0 0, direction θ : 6.93^0 (fix angle)

New angle reconstruction method
(the one with smallest χ^2/NDF is used)



Preliminary events count test (only tracker)

LumiCal position : 500

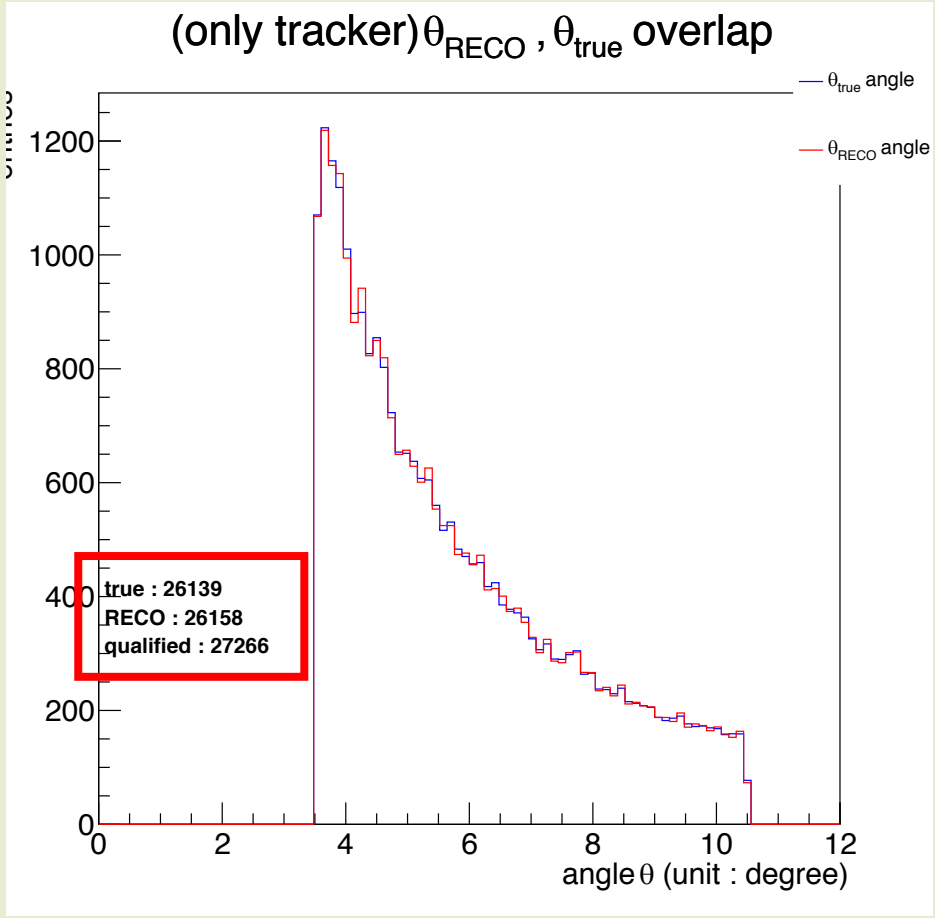
Electron, 120 GeV, One side, doesn't consider FSR photon

$\frac{\Delta N}{N_{true}}$: 7.3*10^{-4} , requirement : 10^{-3}

Reweight function : $\frac{1}{2(\frac{x}{180}*\pi)^2}$, x : degree

IP 0 0 0,
Random ϕ angle : 360 degree.
Used range : 3.5 to 10.5 degree.

New angle reconstruction method
(the one with smallest χ^2/NDF is used)



Summary

- In case-1, energy cut method works well to reconstruct angle.
- LumiCal position (from 970 to 500) doesn't effect resolution a lot.
- Flange dominate multiple scattering effect.
- Case – 2 detector may be more realistic, the angle reconstruction method need to be optimized.

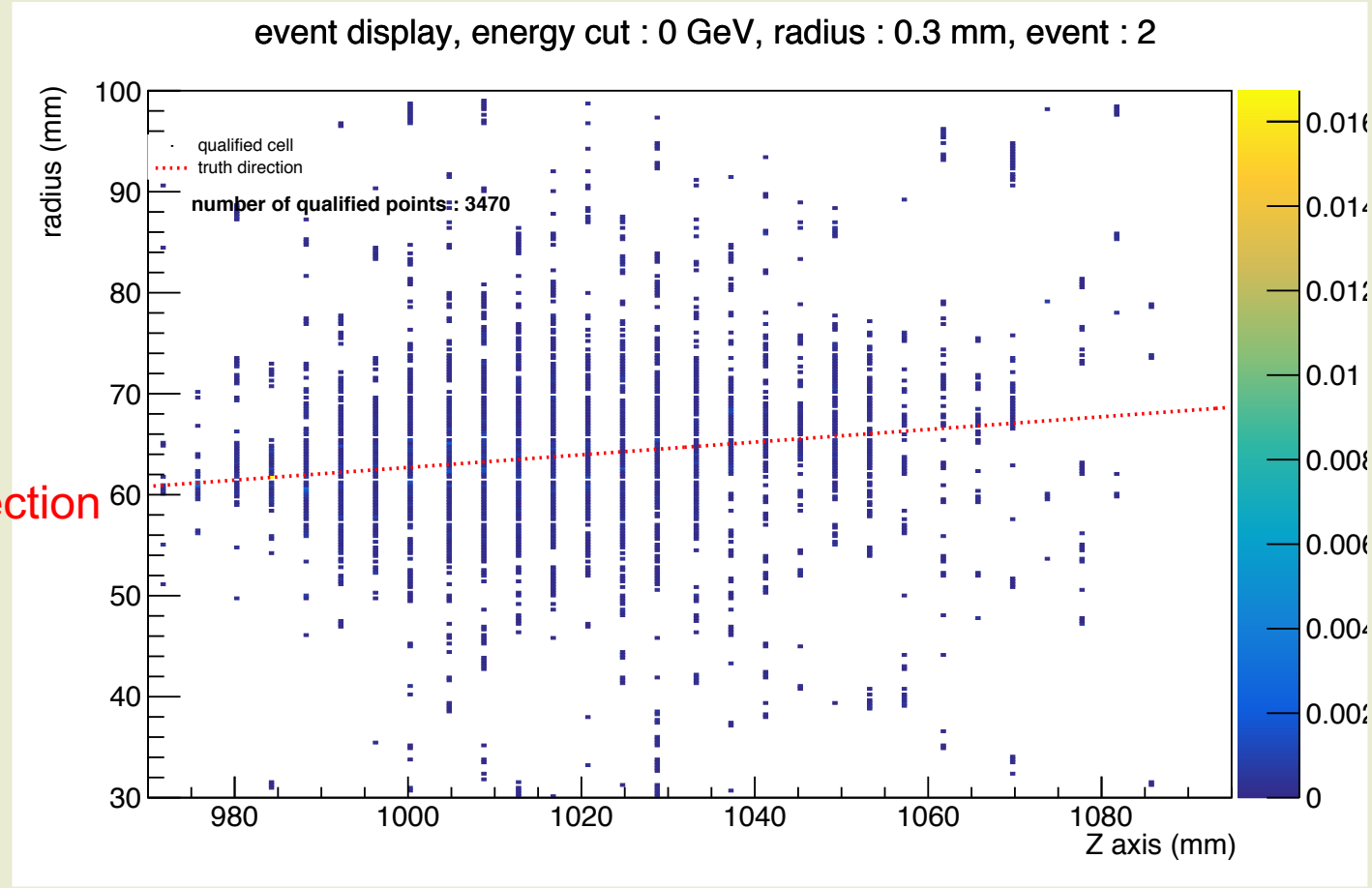
Back up

Energy cut method, before energy cut

LumiCal position : 970

Sector width : 0.3 mm

Truth direction

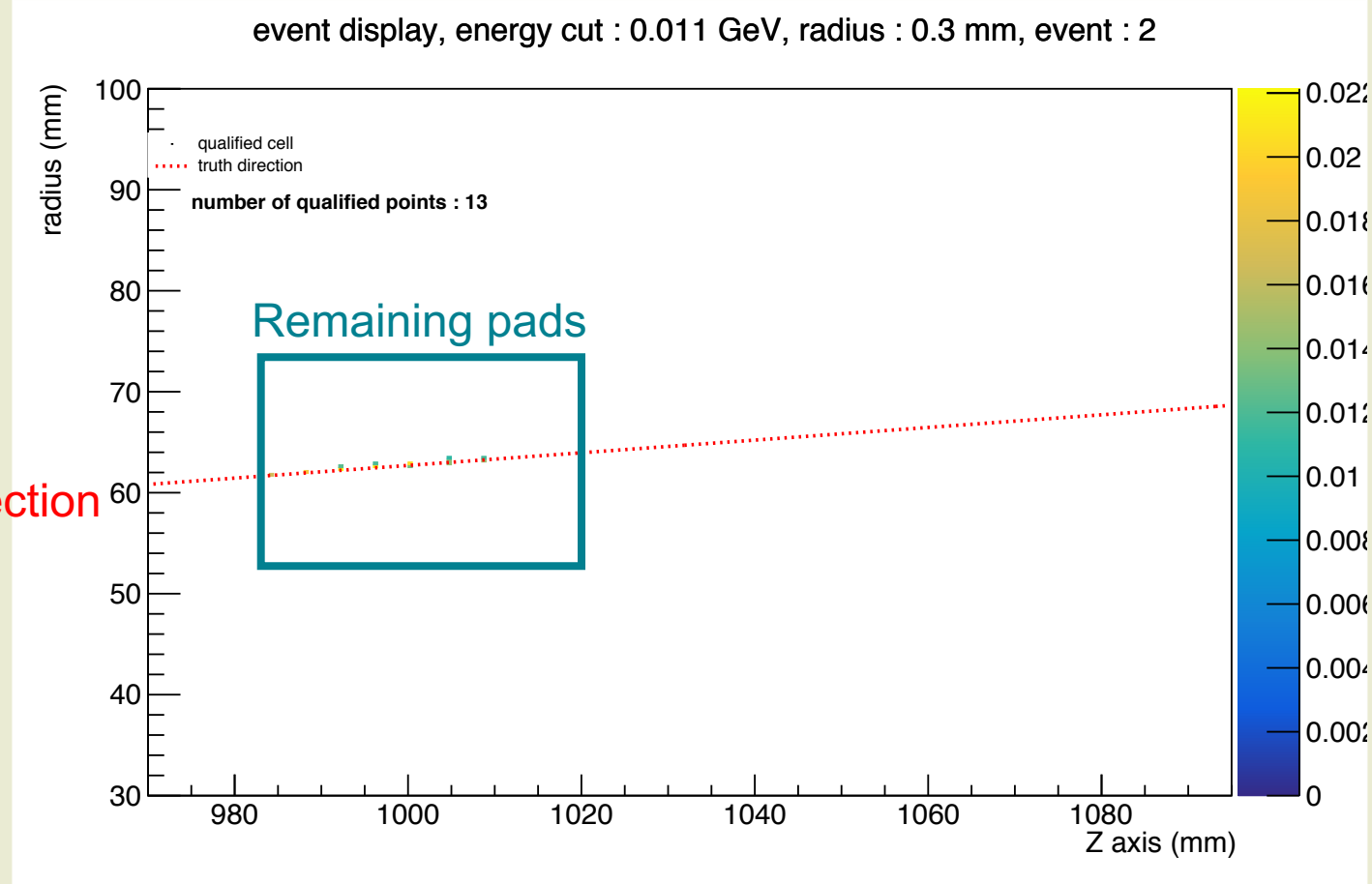


Energy cut method, after energy cut

LumiCal position : 970

Sector width : 0.3 mm

Truth direction



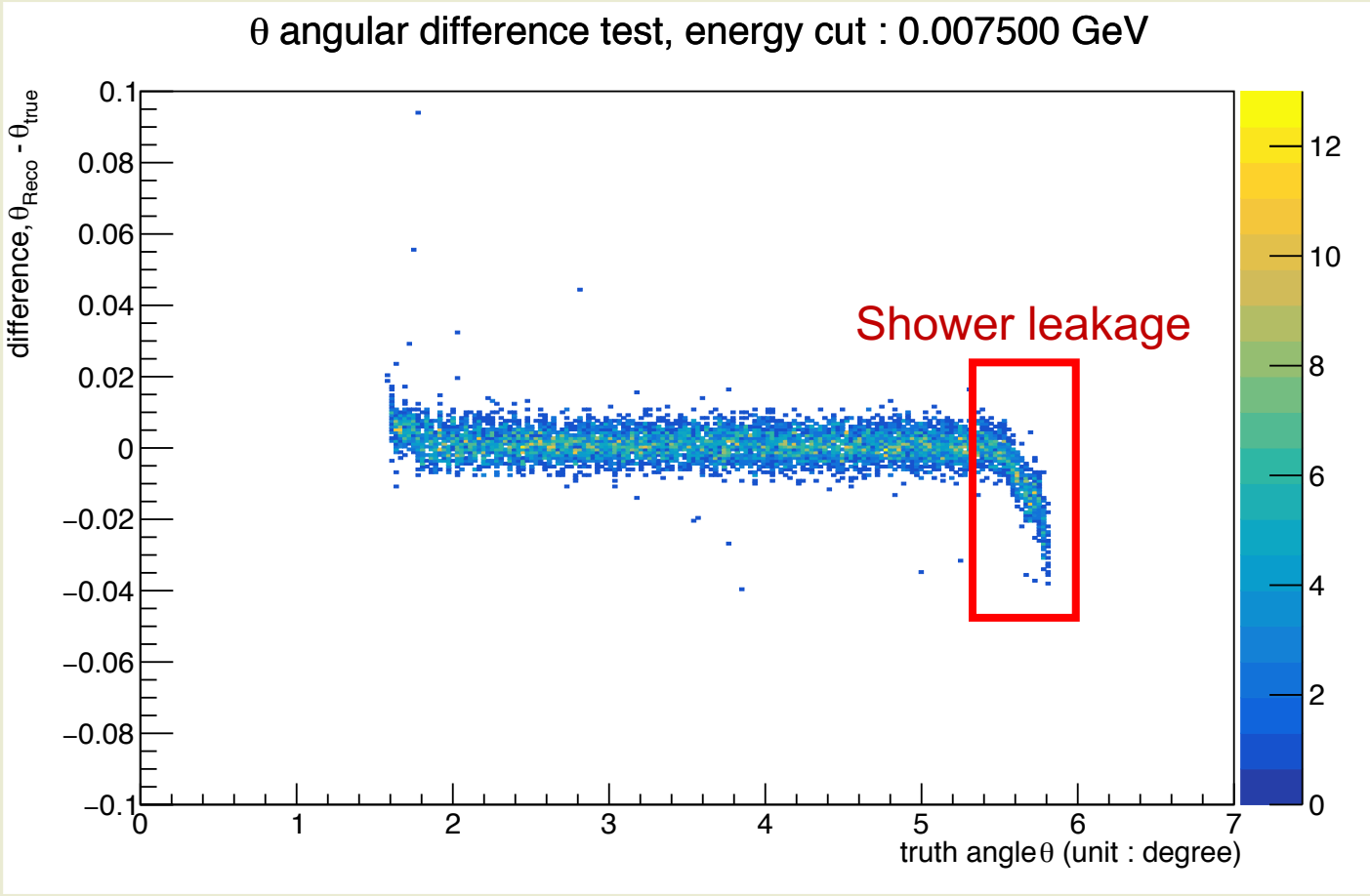
Angular difference as a function of random θ angle

LumiCal position : 970

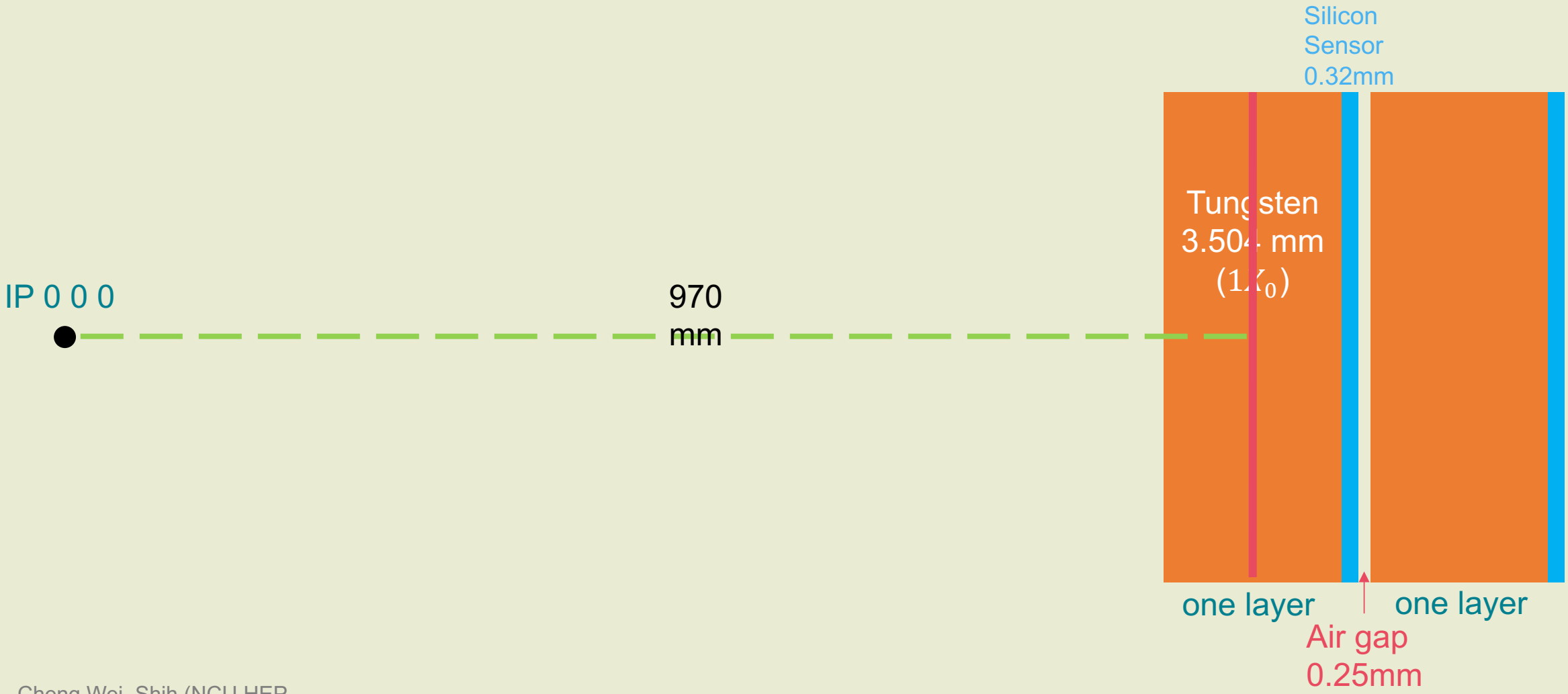
Energy cut : 0.0075 GeV for each sector cell (the best)
Sector width : 1.4mm

Acceptable θ : 1.77^0 to 5.88^0

Energy cut method can work



Identification of LumiCal position



Change position performance test

*Red mark : better one

Performance check

IP : 0 0 0,
LumiCal position : 500, 970
Only calorimeter
Sector width : 0.3 mm
Phi 3.75 degree
Energy cut method : 0.007 GeV

4^0 region	970 mm	500 mm	500 mm case-2
Truth angle (degree)	3.99968	4.00072	3.99962
RECO angle (degree)	3.99966	4.00247	3.99781
difference	$-2.072*10^{-5}$	0.001745	-0.00181

4.5^0 region	970 mm	500 mm	500 mm case-2
Truth angle (degree)	4.50011	4.49905	4.49995
RECO angle (degree)	4.50231	4.50193	4.49611
difference	0.002199	0.002882	-0.00384

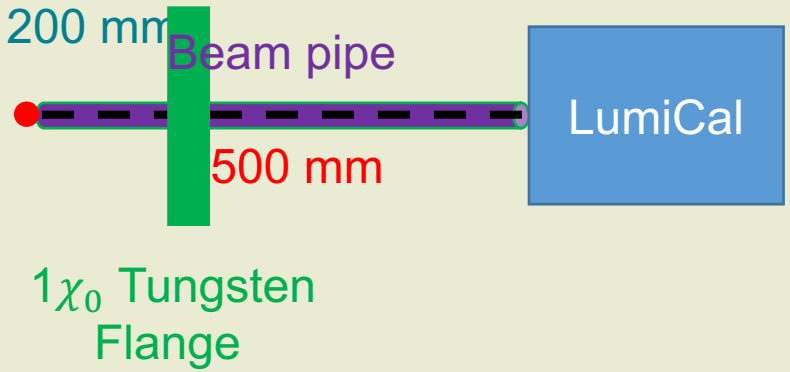
5^0 region	970 mm	500 mm	500 mm case-2
Truth angle (degree)	5.00009	4.99982	4.99987
RECO angle (degree)	5.00172	5.00469	4.99937
difference	0.00163	0.00487	-0.000506

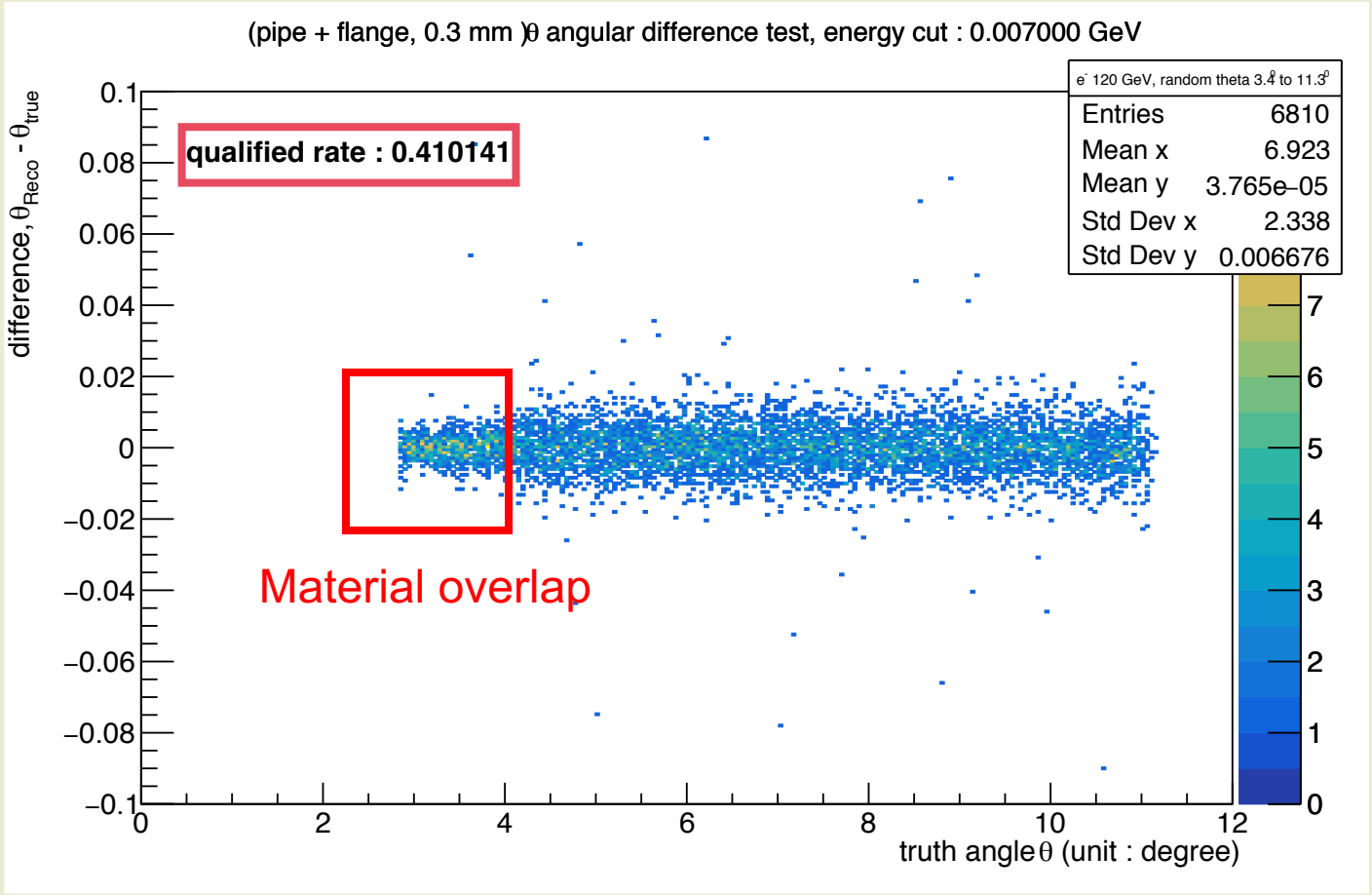
Conclusion : consider case -1, LumiCal position at 970 mm has more chance to reconstruct better

Material test : LumiCal + pipe + flange

LumiCal position : 500

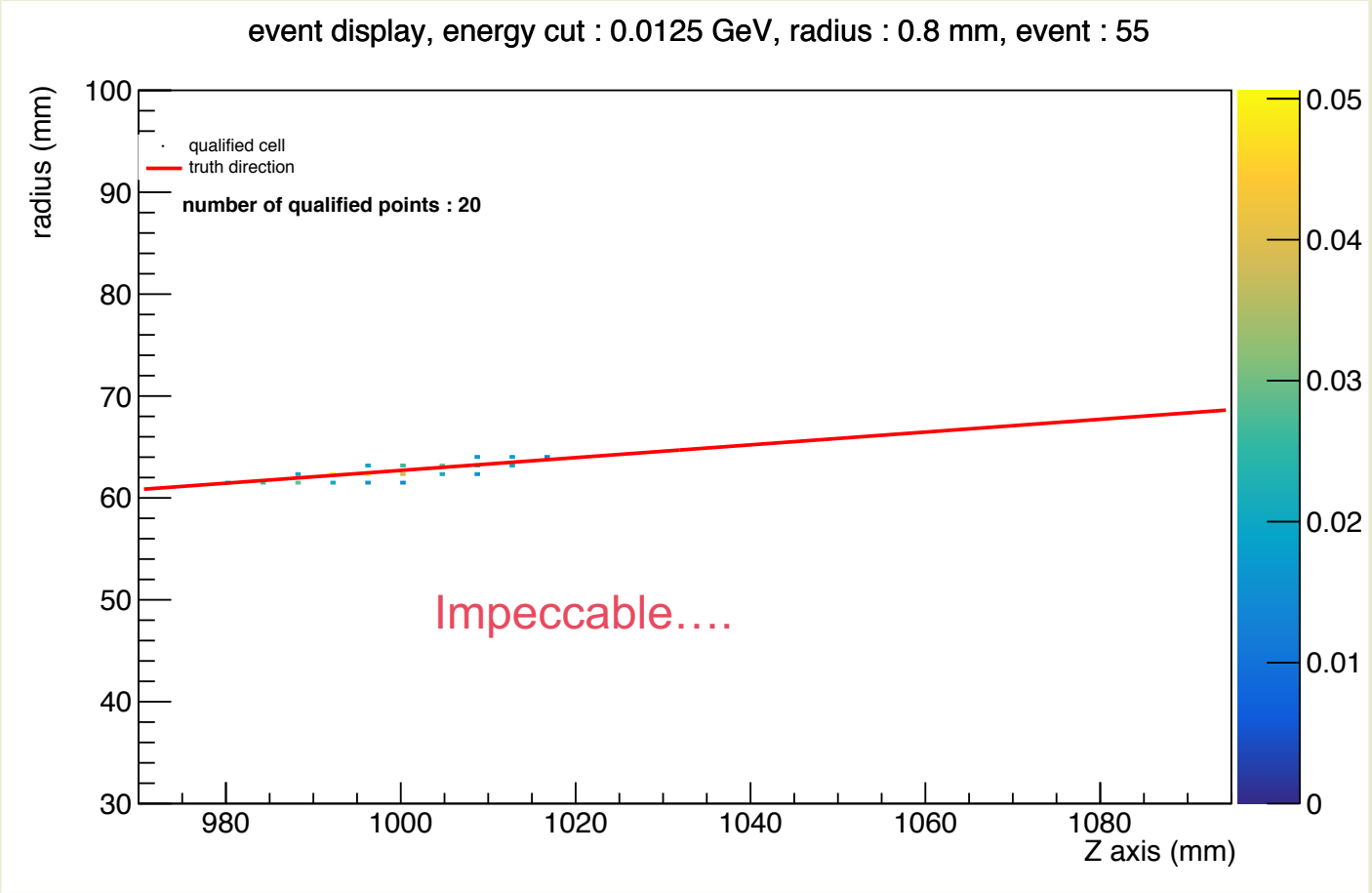
Sector width : 0.3 mm



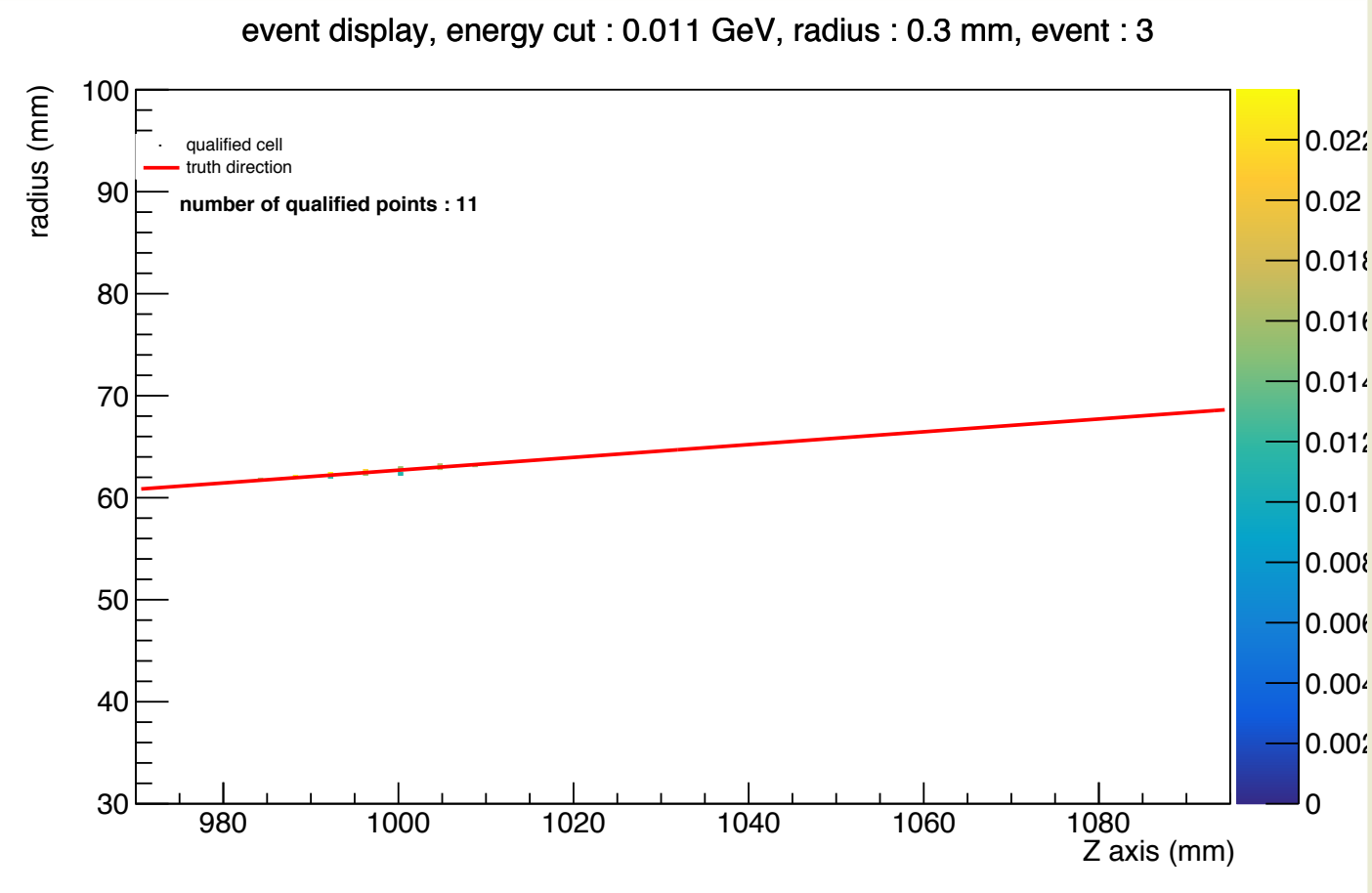


Cluster optimize

Still thinking other good method….



Event display with energy cut : 0.011 GeV , sector width : 3 mm



sPHENIX INTT

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