VTX Offline Software

Sasha Lebedev, ISU

PHENIX Silicon Vertex Upgrade Review, June 2, 2009

Review Homework

a) Tracking performance

- *Details of the simulation, what assumptions are used*
- *Hit efficiency for each layer*
- *Acceptable level of Signal/Noise*

b) VTX Material budget

- *Document level of details of the simulation*
- *Material budget as a function of eta and phi*
- *Are albedo particles included in simulations?*
- *Is current VTX material budget tolerable by PHENIX?*

c) Jet/Photon measurement

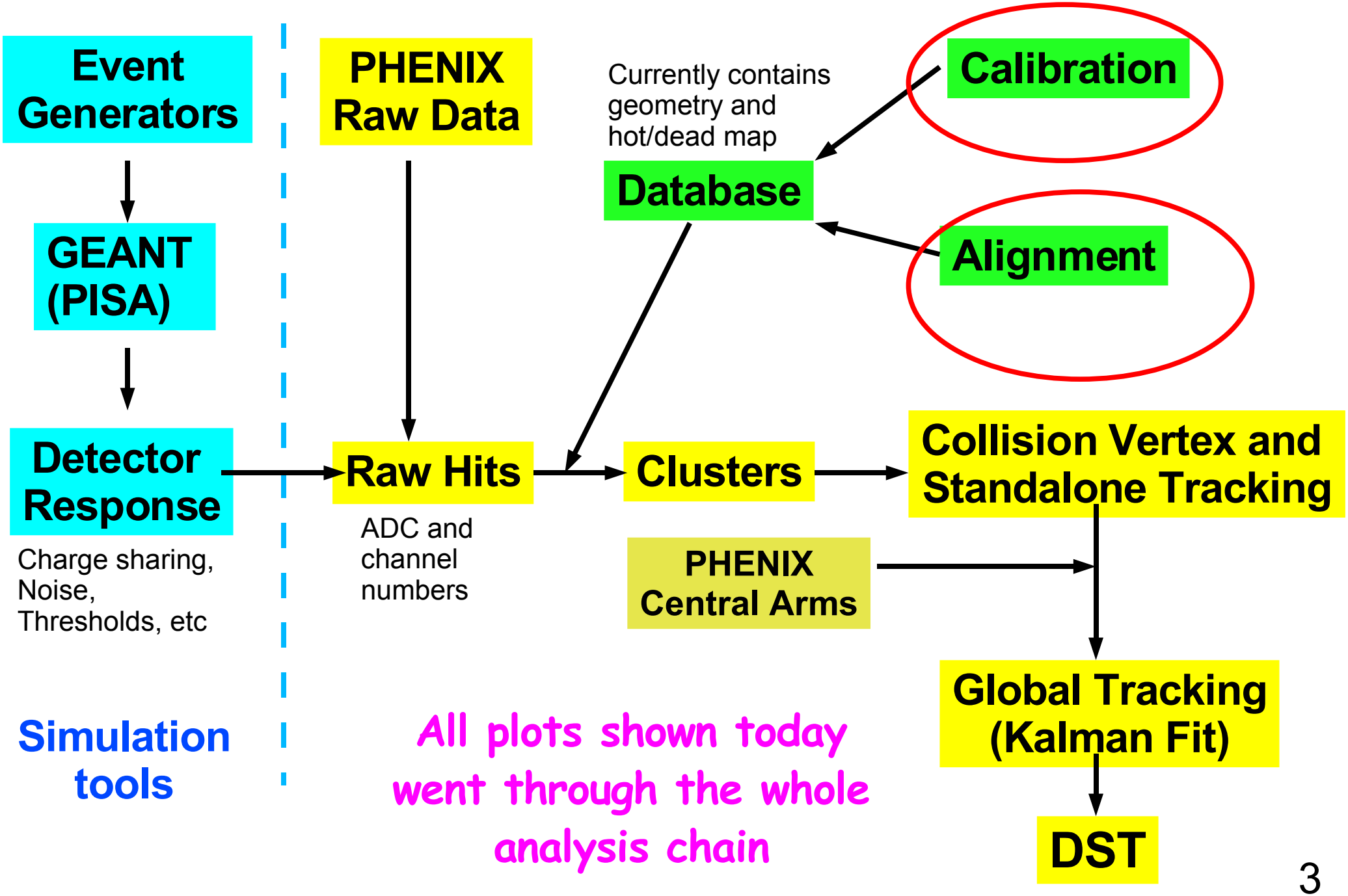
- *Jet resolution in pseudorapidity*
- *pT reach of jets*
- *Efficiency of photon-jet reconstruction*

d) Heavy flavor measurements

- *DCA resolution with full VTX material*
- *Demonstrate heavy flavor electron measurement*
- *What is efficiency of heavy flavor measurement and accuracy of RAA/v2?*

I will describe VTX offline software, and then address items b) and c), while Alan will talk about a) and d)

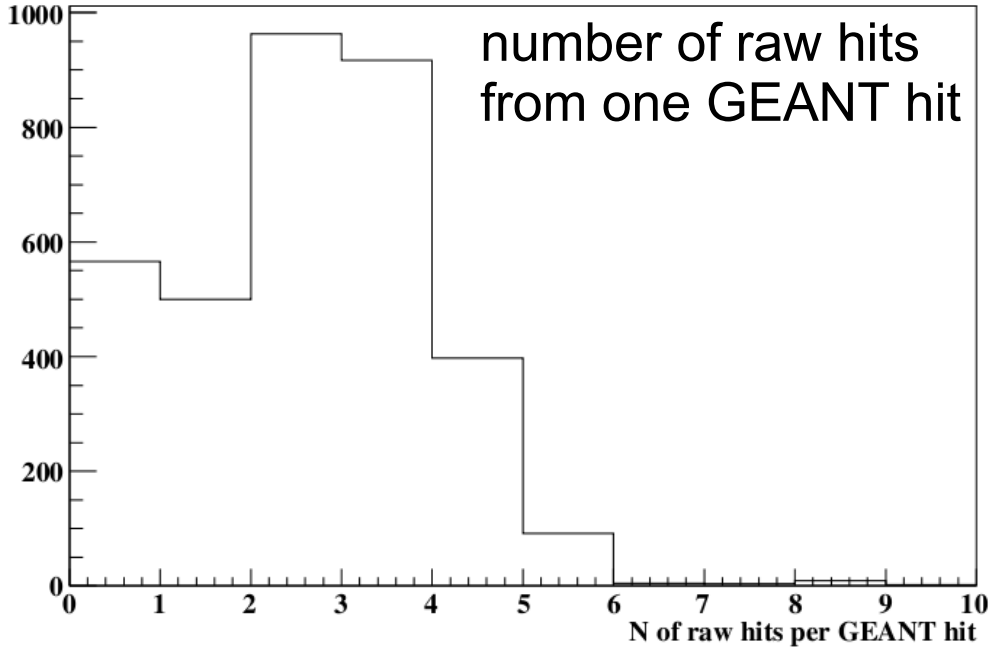
VTX Offline Software Flow Chart



Detector Response: Charge Sharing and Noise

From beam test at Fermilab:

- MIP (most probable value) 100 ADC channels
- Noise 1/10 of a MIP, Gaussian
- Threshold for raw hit production (20 channels default)



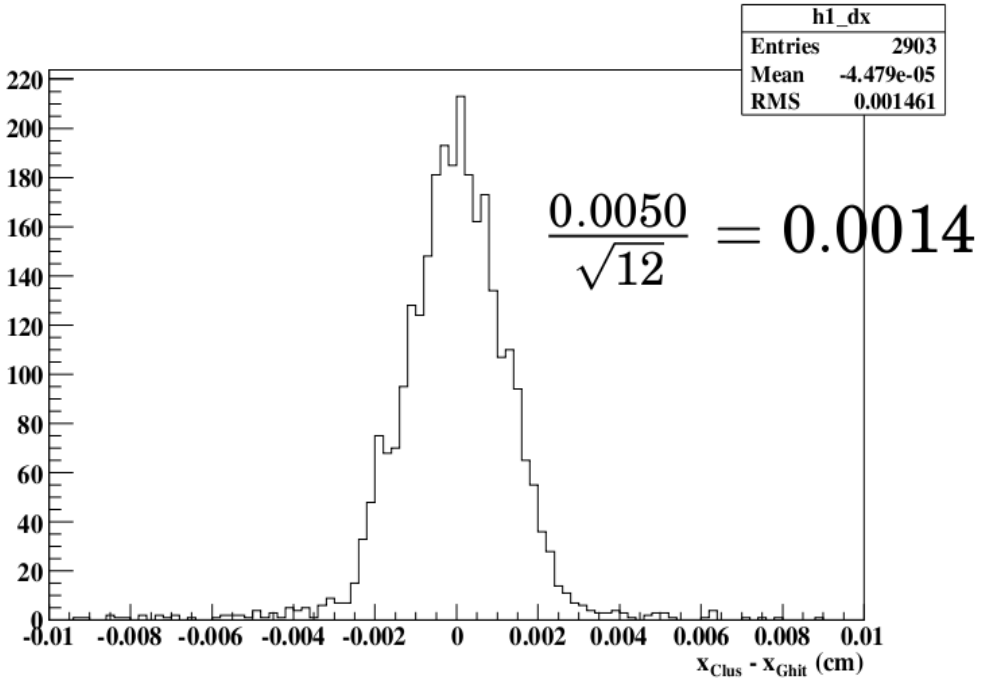
- Charge sharing between adjacent pixels/strips proportional to path length
- Charge sharing between and X and U stripixel channels Gaussian with σ=0.1

Clustering

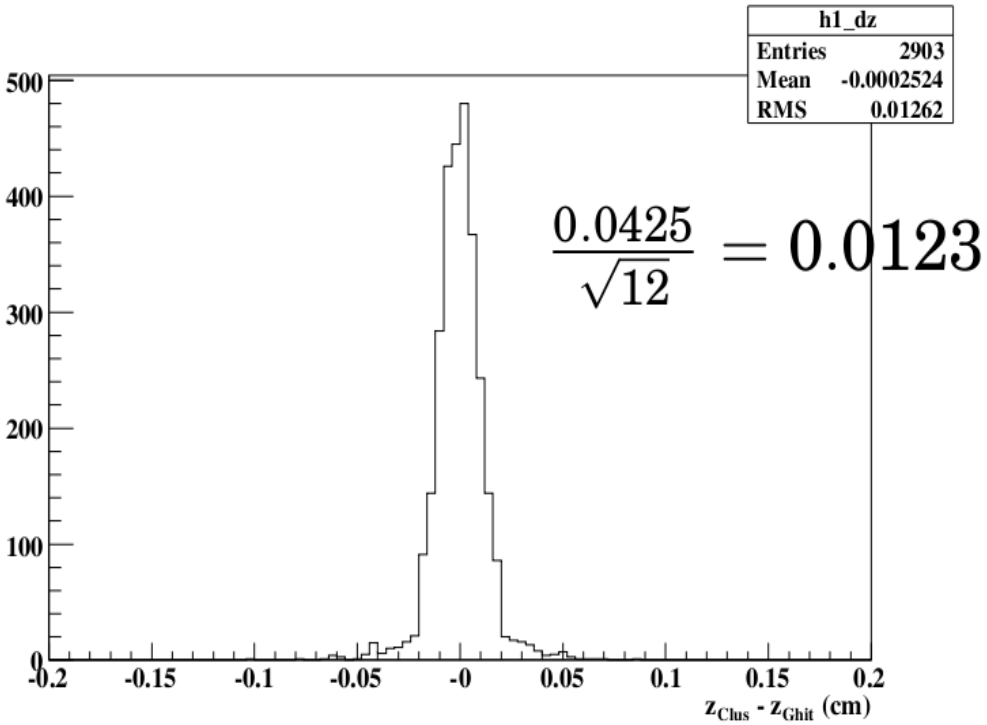
- Adjacent raw hits are combined into clusters

- Clustering done with zero suppression at 20 channels

- Cluster coordinate calculated using ADC as weight



space resolution in X and Y



space resolution in Z

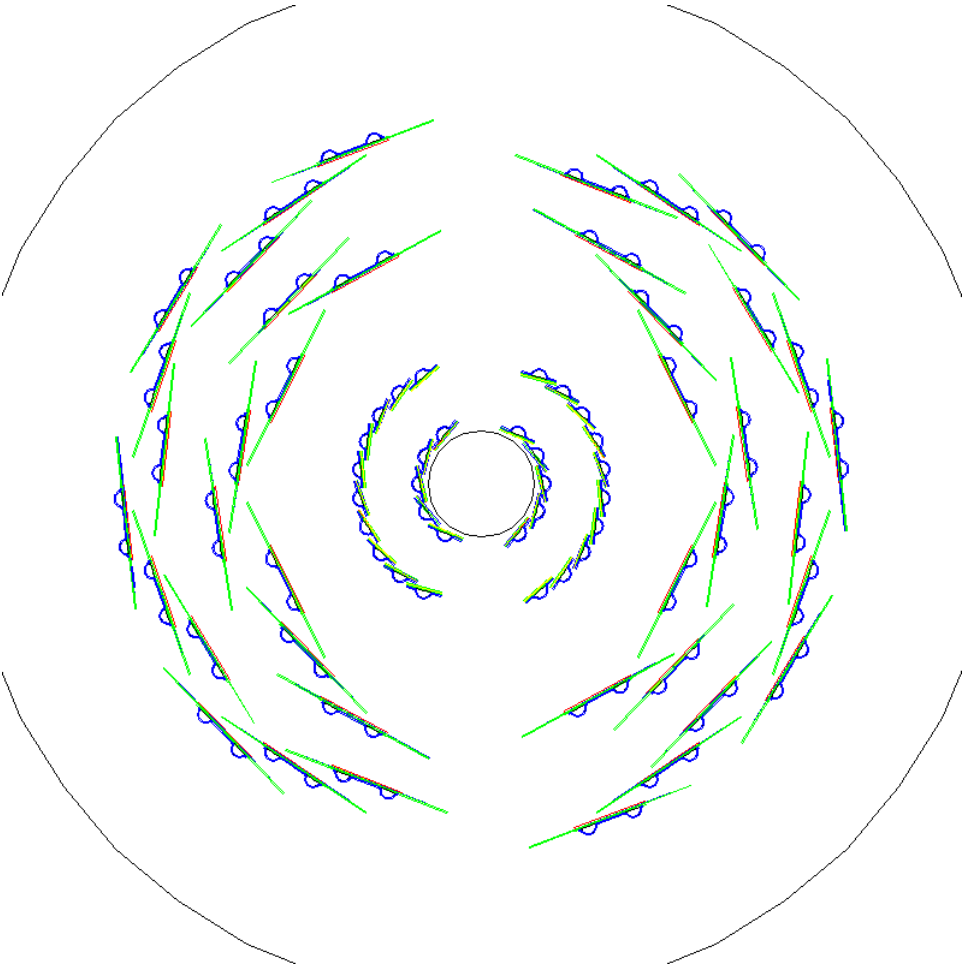
The rest of the analysis chain will be described by Alan

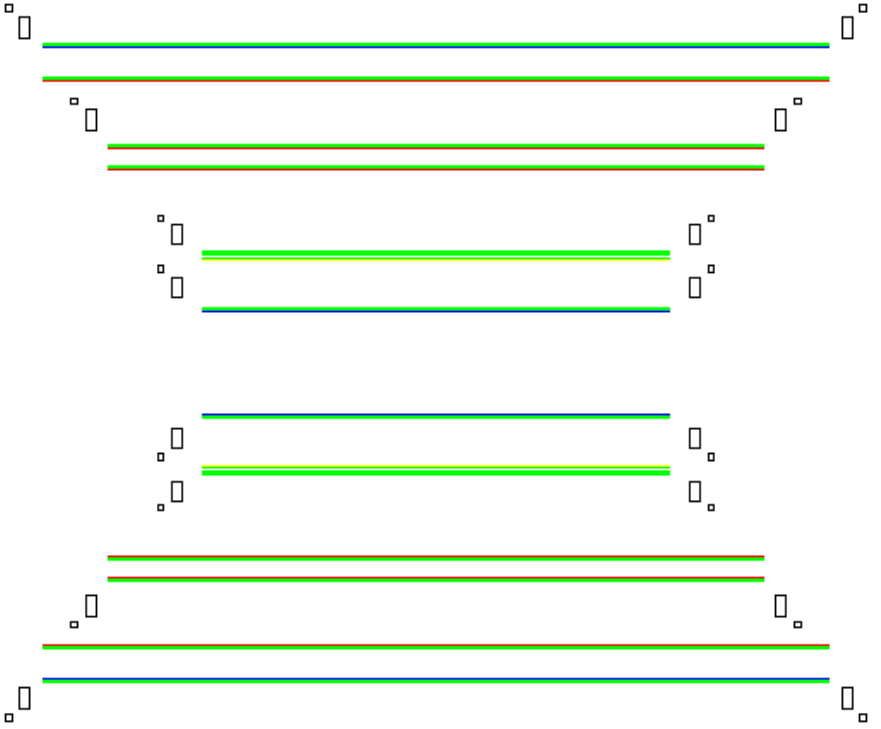
VTX in GEANT

Review homework: b) VTX Material Budget

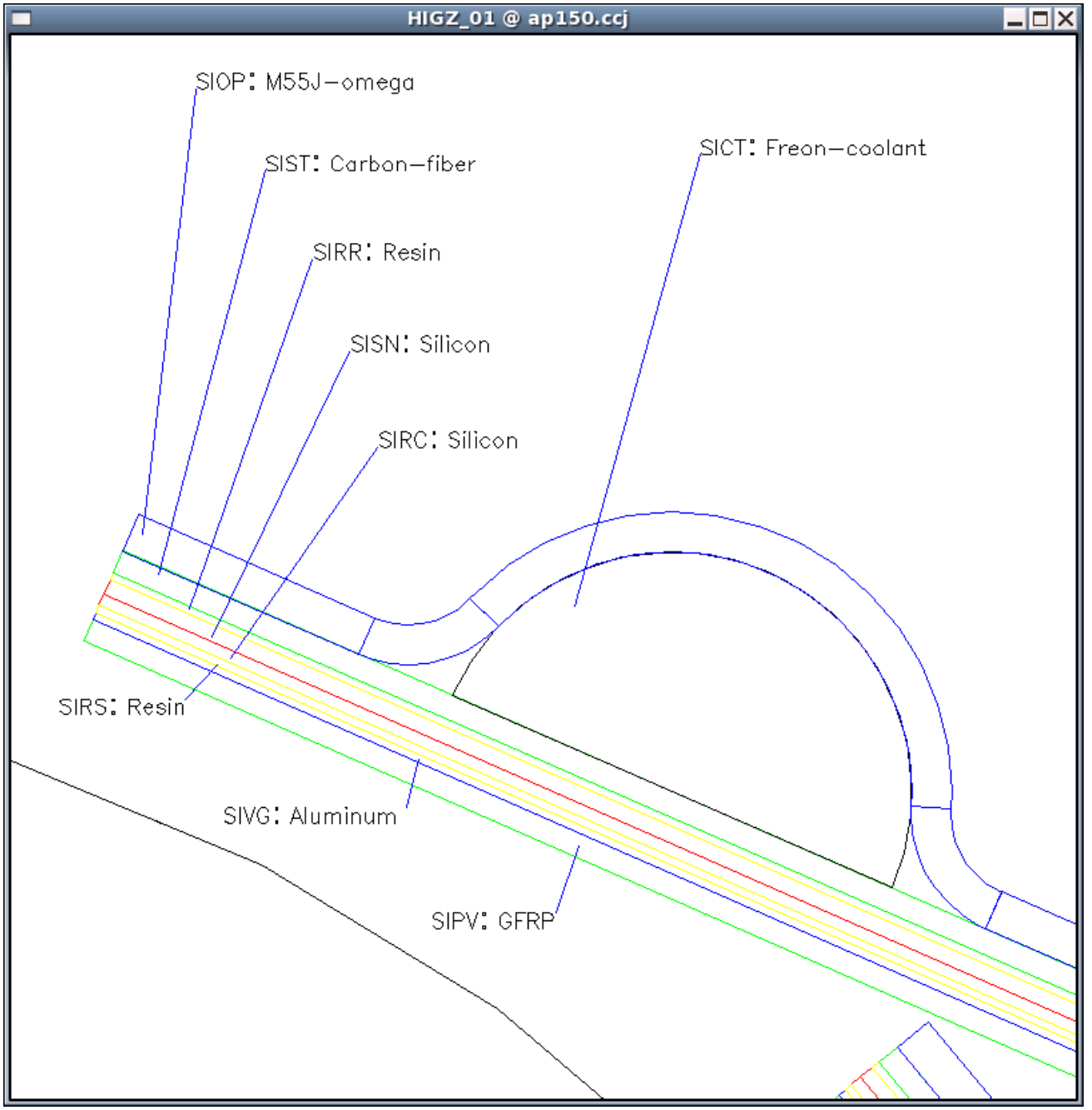
- Document the level of details that has been included for each tracking layer and the mechanical support structure.

VTX description in GEANT is very detailed and realistic



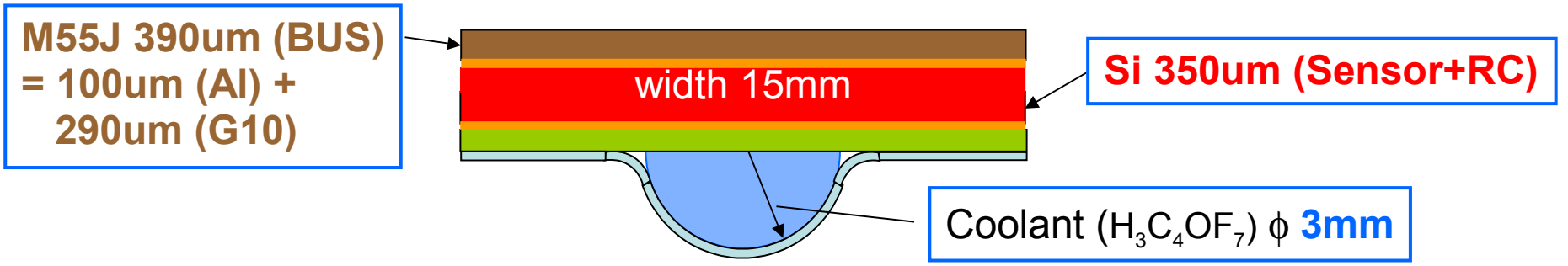


Pixel Layers in GEANT



Pixel Layers Material

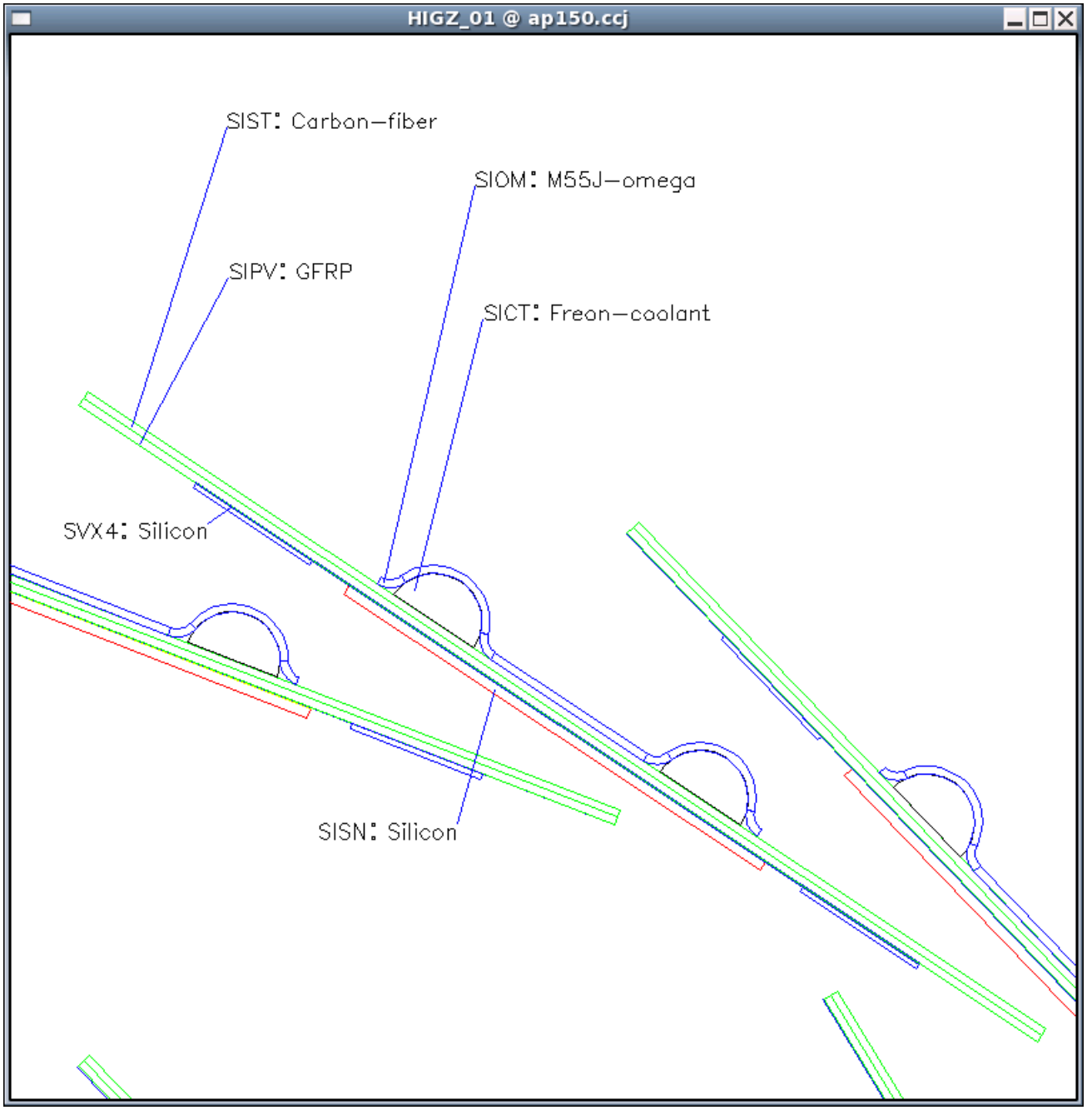
picture not to scale



Material (radl(cm))	Radiation Length (%)
Al (radl:8.9)	0.11 (100um)
G10 (radl:19.4) → polyimide (radl:28.6)	0.15 (290um) → 0.11 (290um)
Resin (radl:35.5)	0.06 (100+100um)
Si (radl:9.36)	0.37 (200um+150um)
Carbon Fiber (radl:26.6)	0.11 (300um)
M55J (radl:25.86)	0.19 (500um)
$H_3C_4OF_7$(radl:30.84) (ϕ2mm → ϕ3mm)	average 0.31 (940um)
Sum	1.30 → 1.26

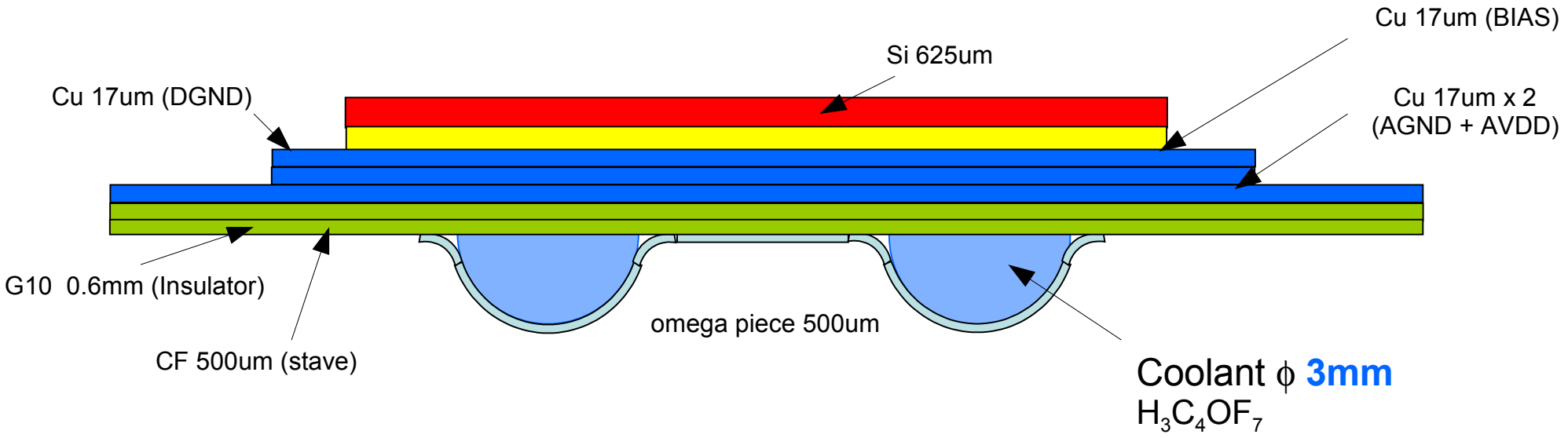
Total estimate = 1.26 (%)

Stripixel Layers in GEANT



Stripixel Layers Material

picture not to scale



Material (radl(cm))	Radiation Length (%)
Si (radl:9.36)	0.67 (625um)
Cu (radl:1.43)	0.48 (68um)
G10 (radl:19.4)	0.31 (1.2mm → 0.5mm)
CF (radl:26.6)	**0.19 (500um)**
$H_3C_4OF_7$(radl:30.84)	**average 0.13 (350um → 393um)**
M55J (radl:25.86)	0.19 (500um)
Sum	**1.97**

multiple crossings

Total estimate = 1.95 + 1.25*1.3 ~ **3.6 (%)**

Radiation Length Study vs θ

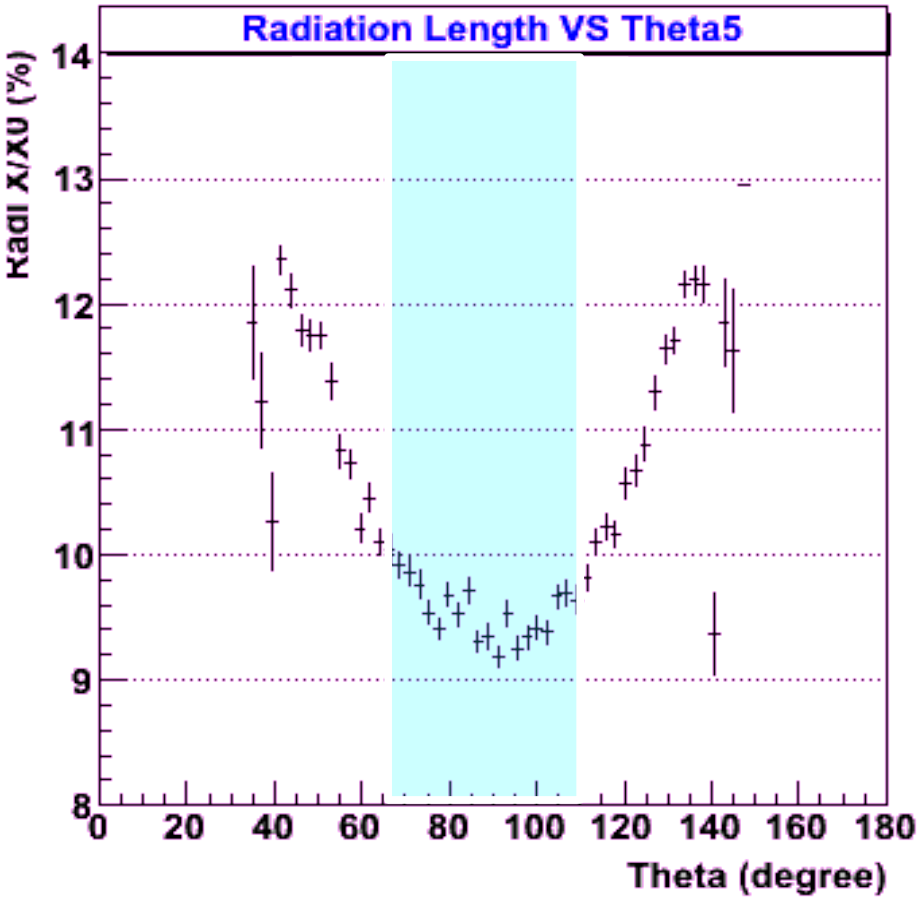
b) VTX Material Budget

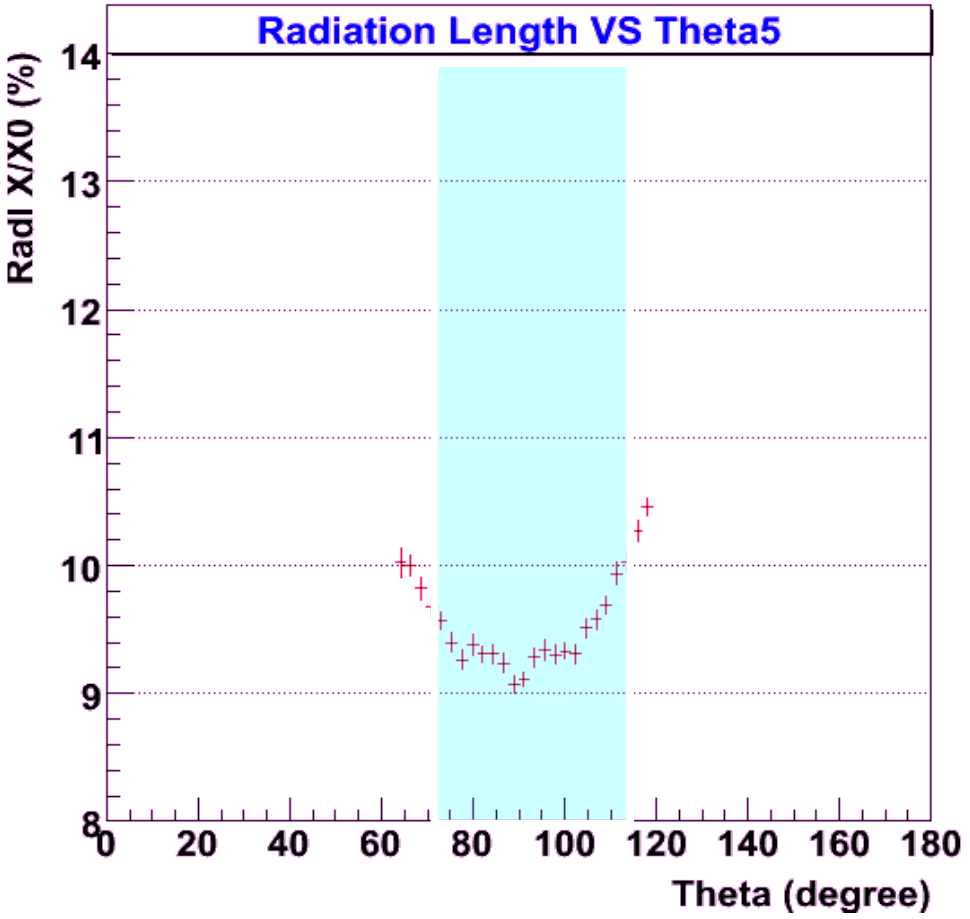
- Show the VTX material budget as a function of pseudo-rapidity and azimuthal angle.

Two different approaches, both give the same result

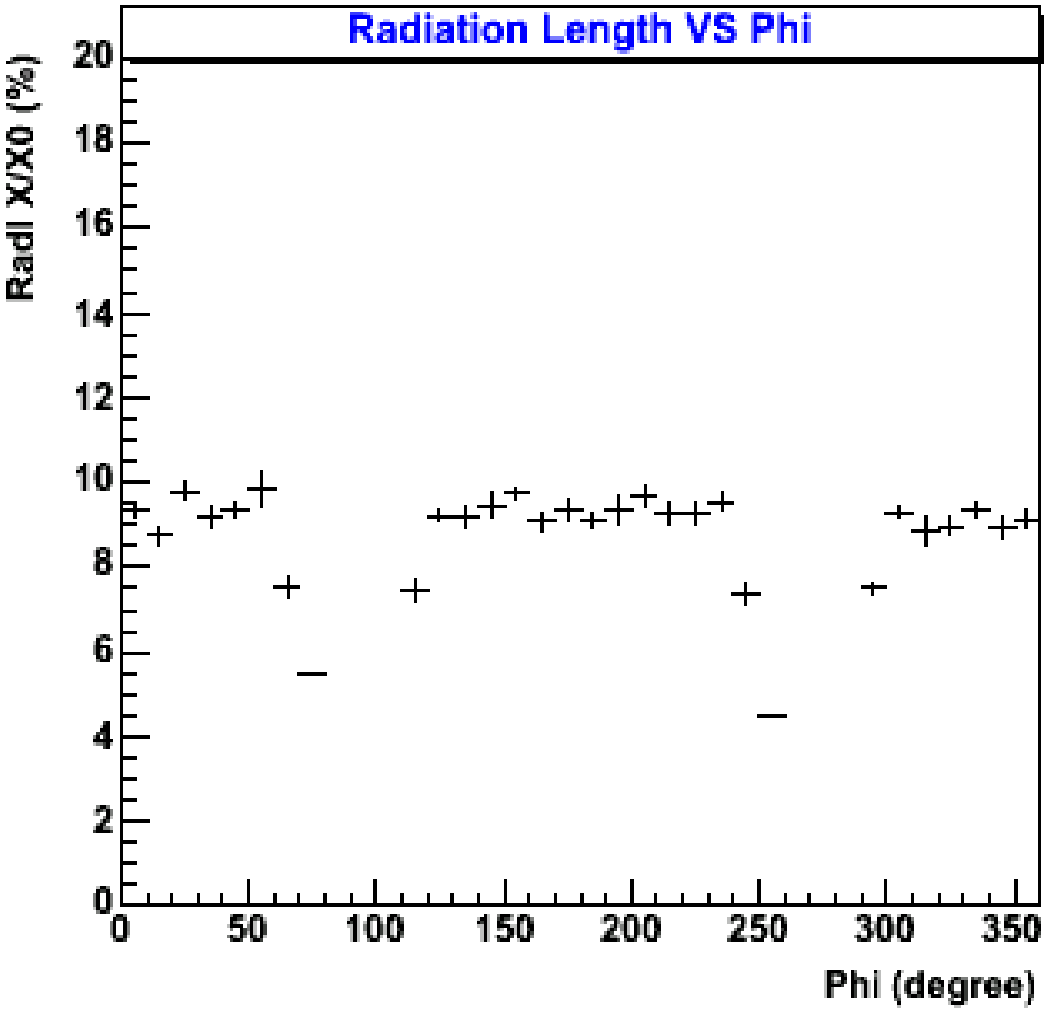
1) For each step in GEANT multiply step length by material rad. length

2) LSCAN tool in GEANT (right plot)





Radiation Length Study vs ϕ

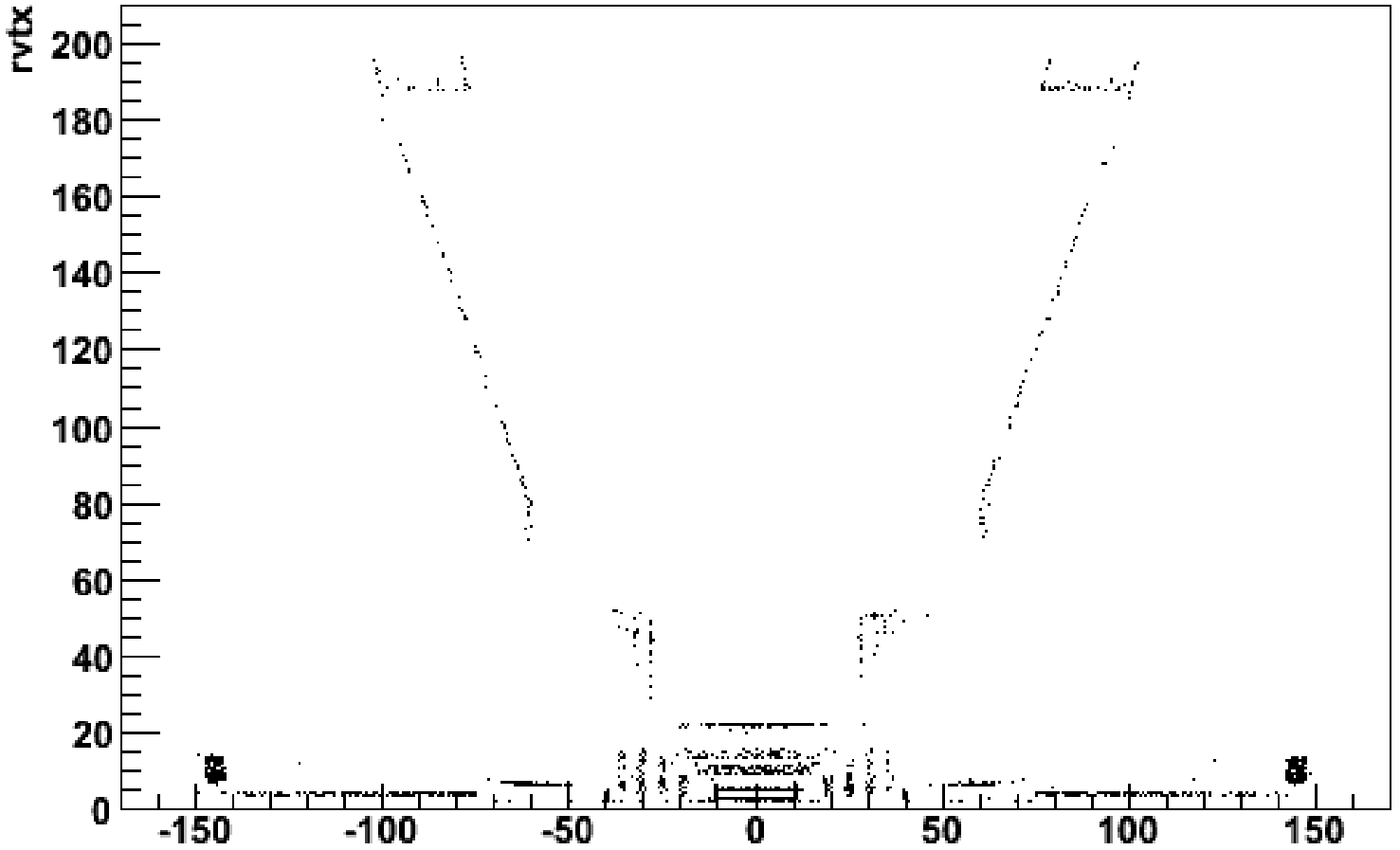


Radiation Length is shown for the PHENIX Central Arms acceptance ~ 70^{o} - 110^{o}

Albedo Particles

Review homework: b) VTX Material Budget

- *To what extent has the impact of albedo particles been taken into account in simulations, such as albedo particles from the NCC?*



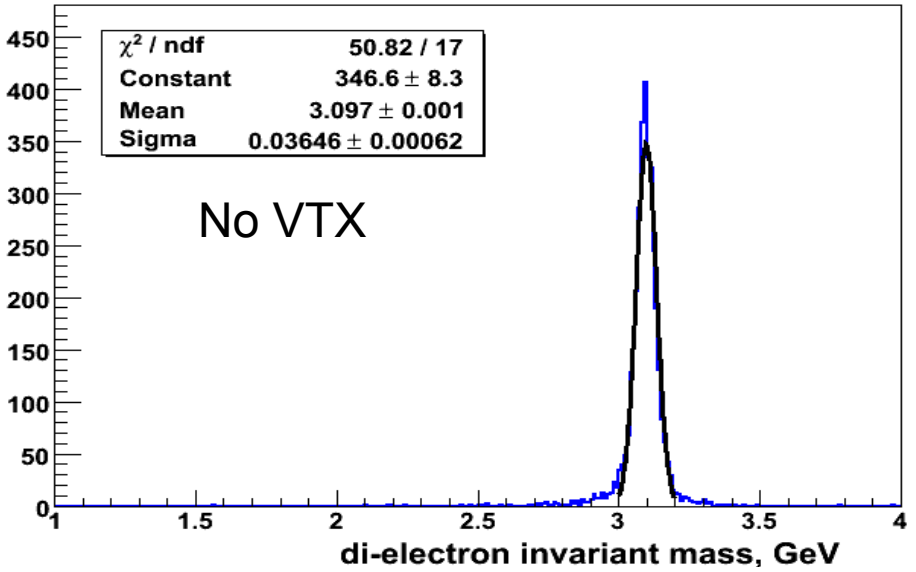
Impact on physics performance: J/ψ reconstruction

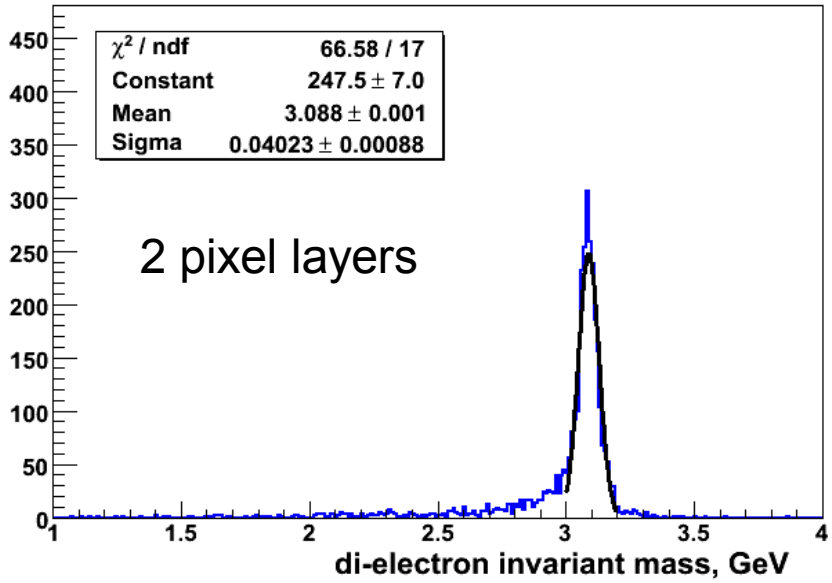
Review homework: b) VTX Material Budget

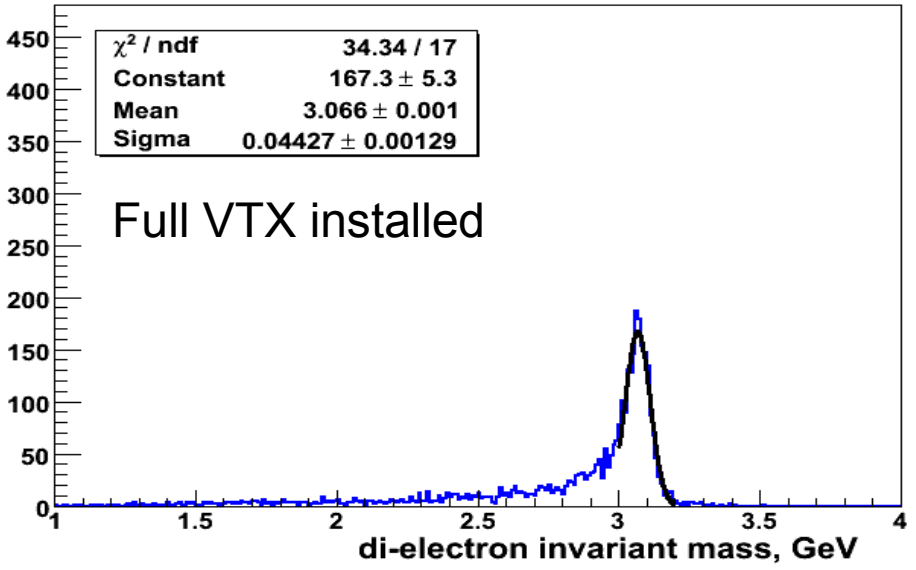
- What is the VTX material budget that is tolerable by the PHENIX collaboration as a whole: J/Psi program, non-photonic electrons and DCA resolution....

Efficiency for:	2 layers	full VTX
Within 3 σ	82.2%	64.5%
Above 2.5 GeV	92.1%	83.3%

Most of the radiative tail can be recovered by exact measurement of the angle at the vertex







Summary of Review Homework item (b) VTX Material Budget

- VTX material budget is well understood, implemented in GEANT, and documented

- In PHENIX Central Arms acceptance it is ~9% of radiation length, while at the extreme edges it can reach up to ~12%

- Albedo particles are fully taken into account in simulations.

- Current VTX material budget is acceptable for the PHENIX experiment as a whole

From internal BNL "PHENIX Review of the Silicon Veterx Barrel" Report:

"...The studies suggest that the amount of material in the current VTX design is acceptable and fits the PHENIX detector performance goals."

(October 1st 2008).

Jet Reconstruction using VTX in p+p events

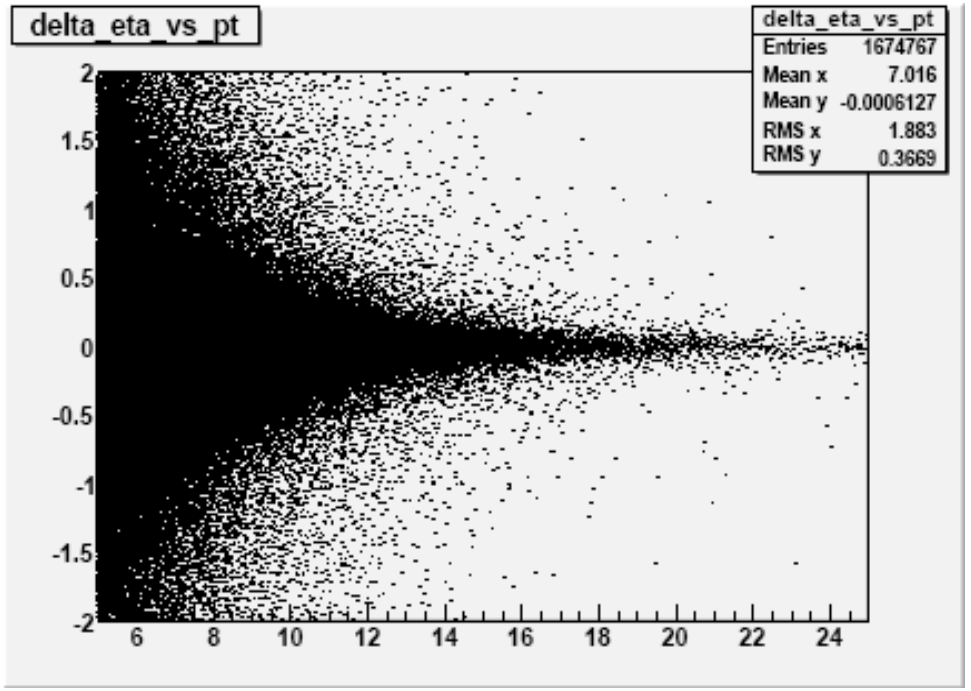
Review homework: Photon-jet measurements / Jet measurements:

- What is the resolution of the jet pseudo-rapidity for jets for which only the VTX is used...

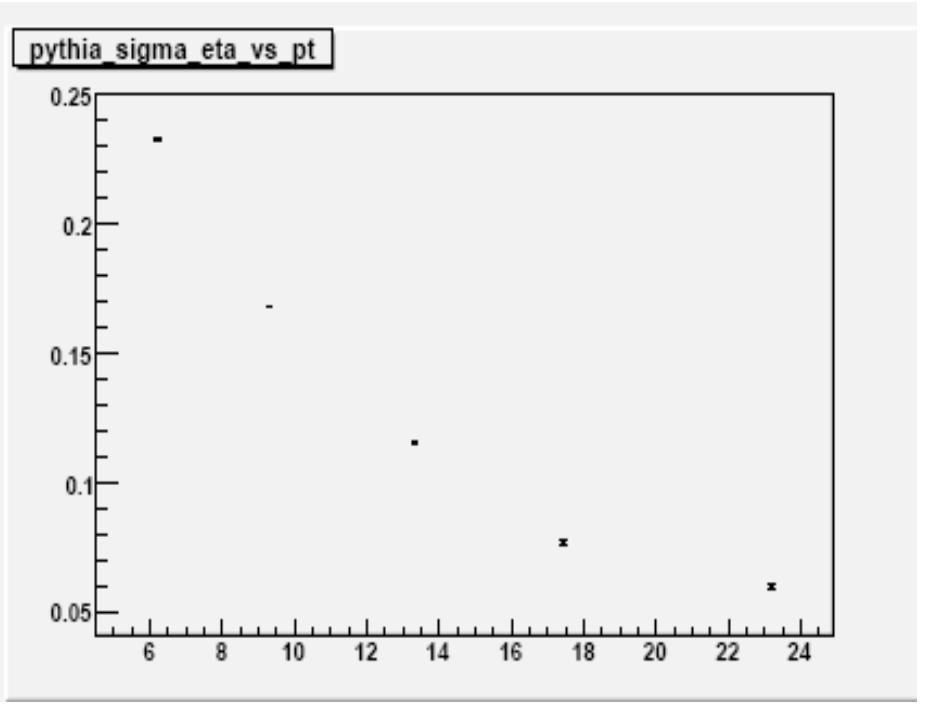
PYTHIA -> GEANT -> Standalone tracking -> FastJet

Working on reconstructing jets in AuAu

reconstructed jet η minus parton η



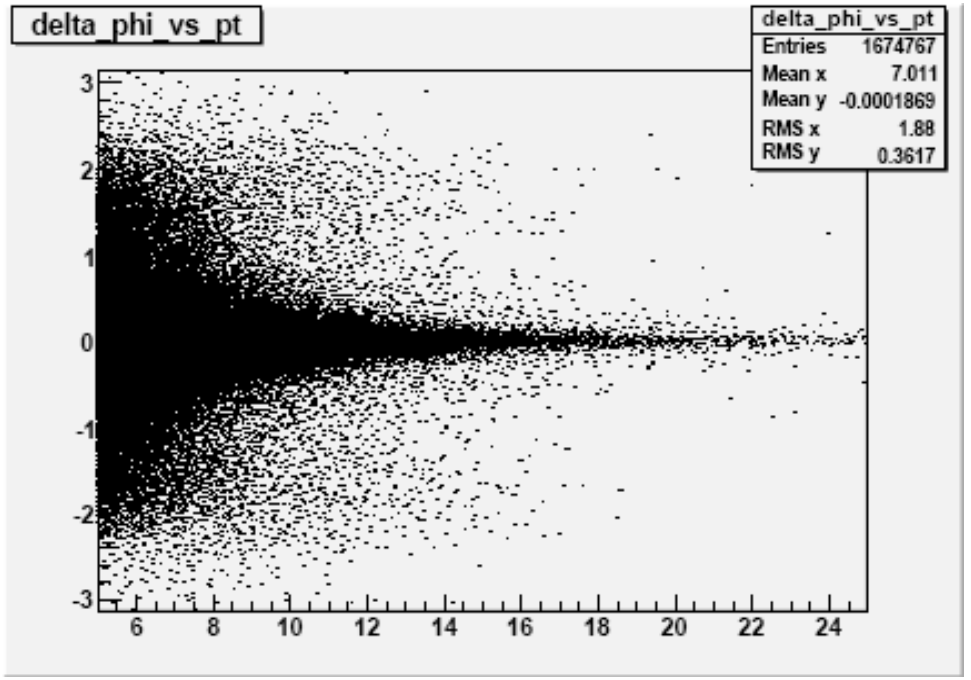
jet transverse energy



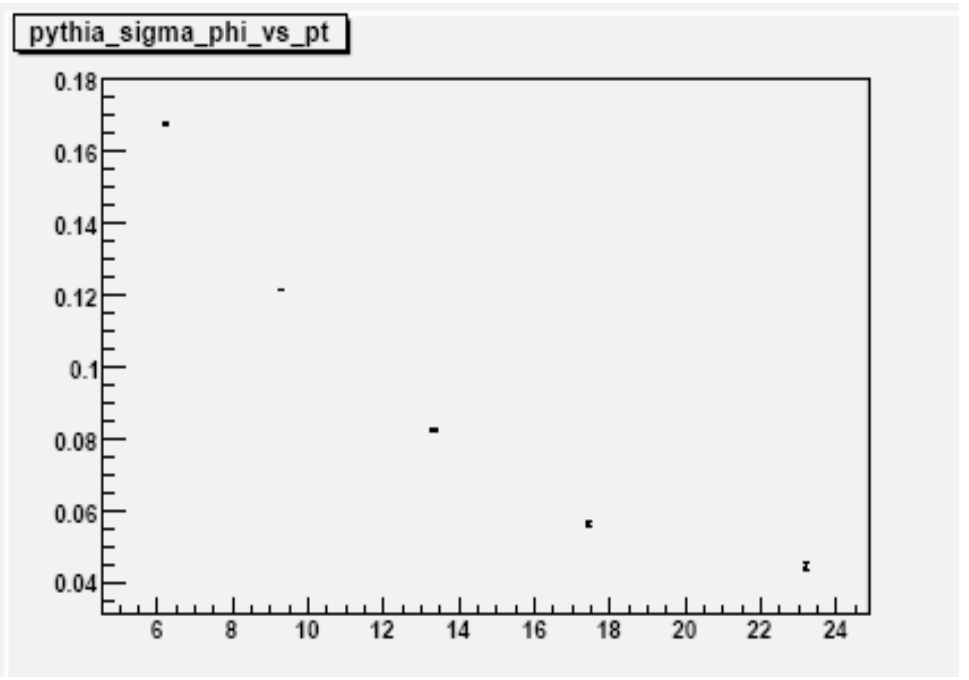
jet transverse energy

Jet Reconstruction using VTX in p+p events (2)

reconstructed jet ϕ minus parton ϕ



jet transverse energy



jet transverse energy

Summary of Review Homework item (c) Jet/Photon Measurements

- Jet reconstruction using VTX standalone have been done for p+p

- Jet resolution in η improves from ~0.25 at low E_T (~6GeV) to ~0.06 at high E_T (~24 GeV)

- Jet reconstruction in Au+Au events have been started, studies in p+p will be continued.

Manpower

Sasha Lebedev – software coordinator, infrastructure

Alan Dion - tracking

Maki Kurosawa – GEANT

Kenichi Nakano – detector response

Manabu Togawa – detector response

Matthew Lockner, Alexander Shaver – ISU students
Benjamin Bannier – SUNY SB student

Software To-Do List

- Alignment and Calibration tools (later this year)

- Optimizing Standalone and Global Tracking (ongoing)

- Blind Analysis Challenge (this summer)

- VTX event display incorporated in PHENIX framework

- On-line monitoring, preparation for data taking (next year)

Conclusions

VTX simulation analysis chain is very realistic, with detailed detector description in GEANT, detector response tuned using beam test, and both standalone and global track reconstruction.

Item b) from Review Homework fully answered.

- Amount of material in PHENIX Central Arms acceptance is ~9%.
- J/ψ mass resolution and reconstruction efficiency is still reasonable with full VTX detector installed.

Item c) partially answered, work is ongoing.

- Jet η resolution in p+p events is ~0.24 at low jet E_T, and improves to ~0.06 at high E_T.

Backup Slides

b) VTX Material Budget

- Document the level of details that has been included for each tracking layer and the mechanical support structure.
- To what extent has the impact of albedo particles been taken into account in simulations, such as albedo particles from the NCC?
- Show the VTX material budget as a function of pseudo-rapidity and azimuthal angle.
- What is the VTX material budget that is tolerable by the PHENIX collaboration as a whole: J/Psi program, non-photonic electrons and DCA resolution necessary for a successful discrimination of charm / bottom? It appears that the total material budget for the current VTX design is ~16% X_0. This is an issue that has to be addressed as soon as possible to allow for potential re-direction of efforts on the actual VTX layout for layer 3/4.

c) Photon-jet measurements / Jet measurements:

- What is the resolution of the jet pseudo-rapidity for jets for which only the VTX is used? How does this change when including the existing central tracking system? How is this dependent on p_T in particular for the case of VTX only tracking?
- What is the p_T reach of jet reconstruction in general for VTX only tracking?
- What is the efficiency for photon-jet reconstruction and therefore the impact on the accuracy of various observable measurements involving photon-jet measurements for an assumed integrated luminosity?