geant4 simulation SVD pixel detector based on SOI pix

BGM geant4 session

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  - construction double layer
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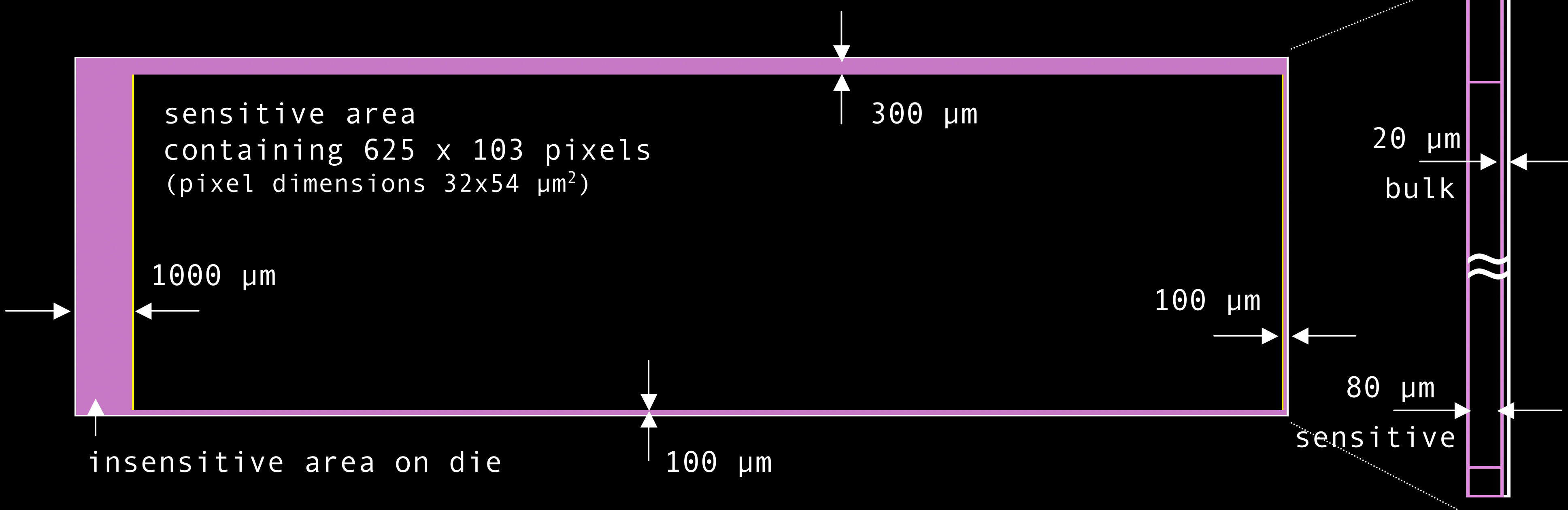
  - material budget
  - cluster size
  - Δ cluster and hit position
  - layer efficiencies
- planning

geometry: single die

die overall dimensions: 21 mm x 6 mm x 0.1 mm



material: G4_Si

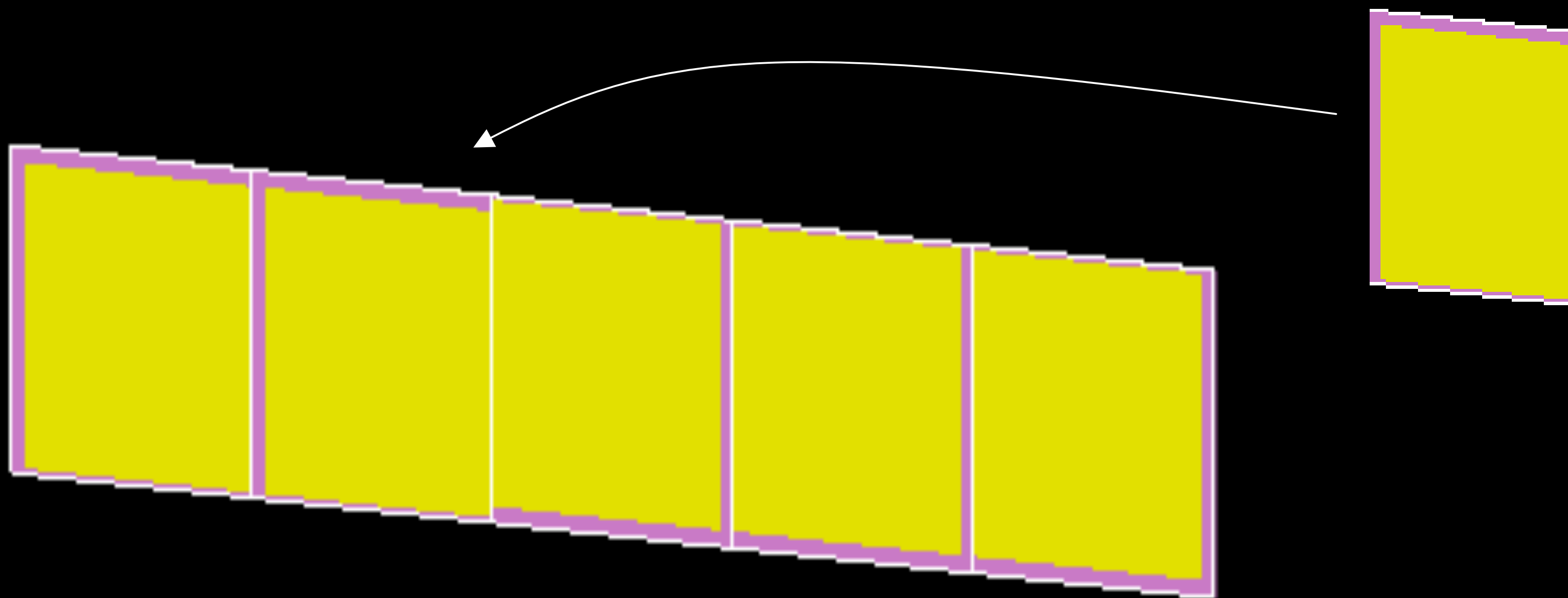
arrangement of 5 units to a ladder (length 105 mm):

some units rotated

geometry: double layer construction

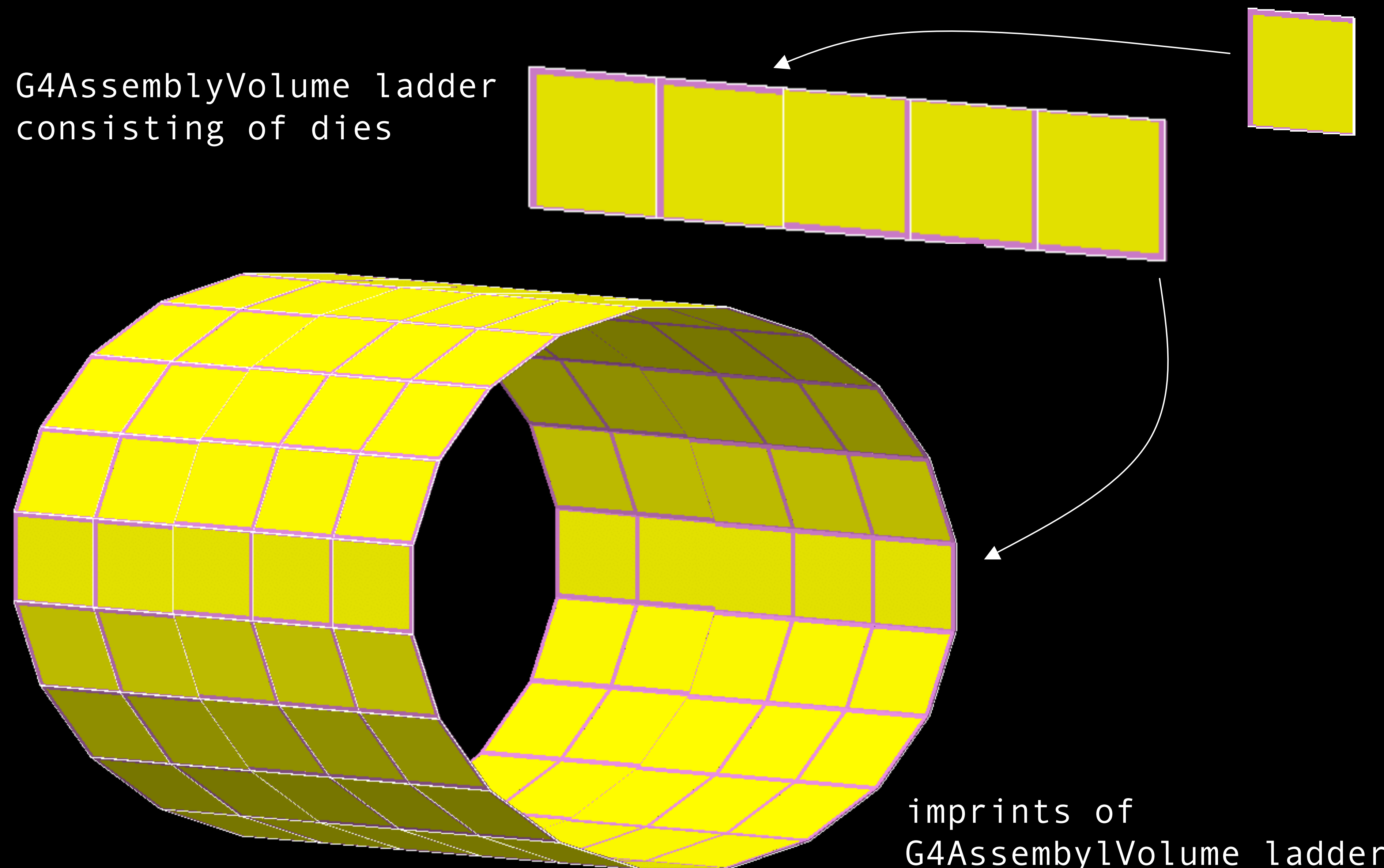
material: G4_Si

G4AssemblyVolume die
consisting of several
G4Boxes



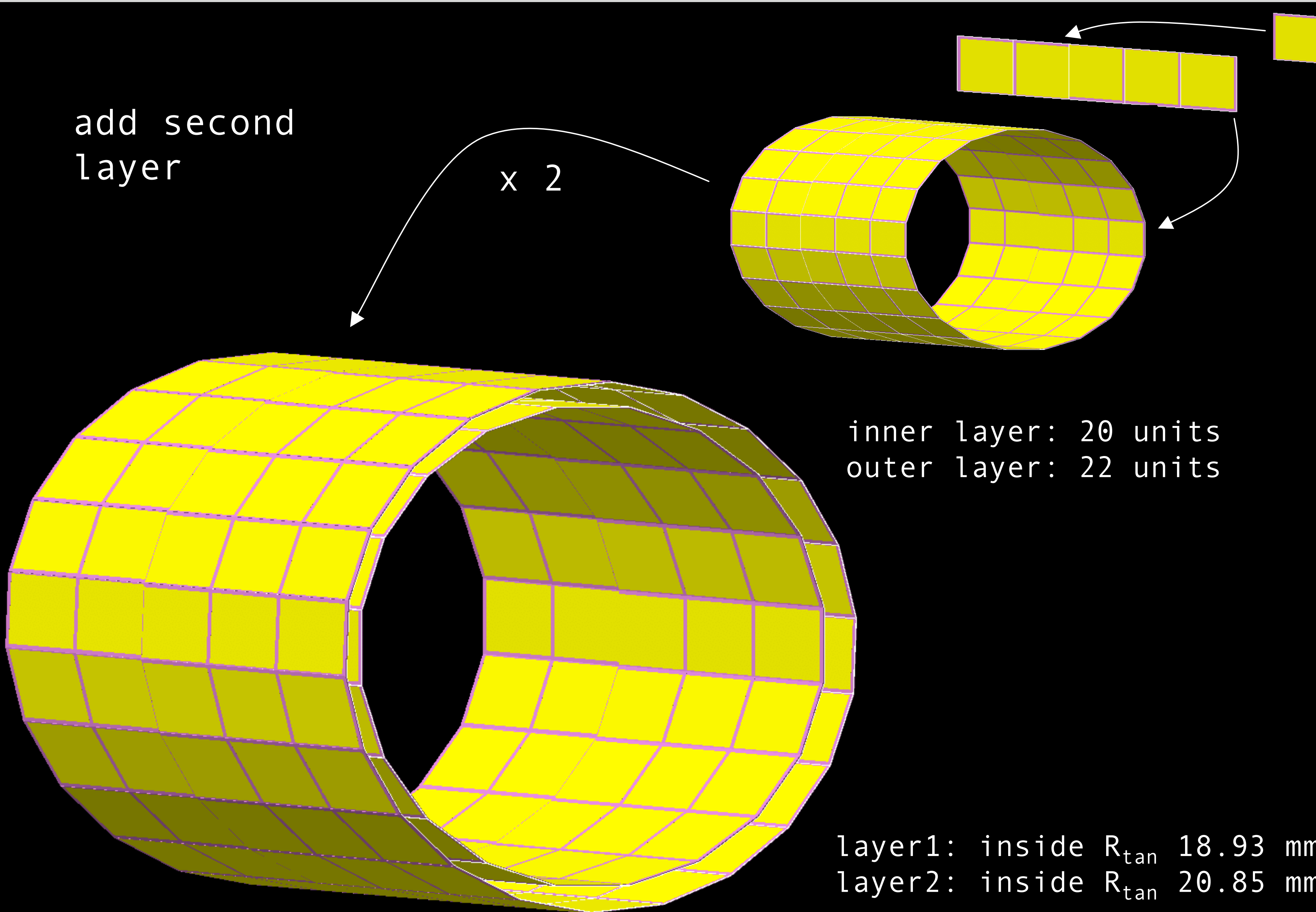
G4AssemblyVolume ladder
consisting of dies

geometry: double layer construction



material: G4_Si

geometry: double layer construction

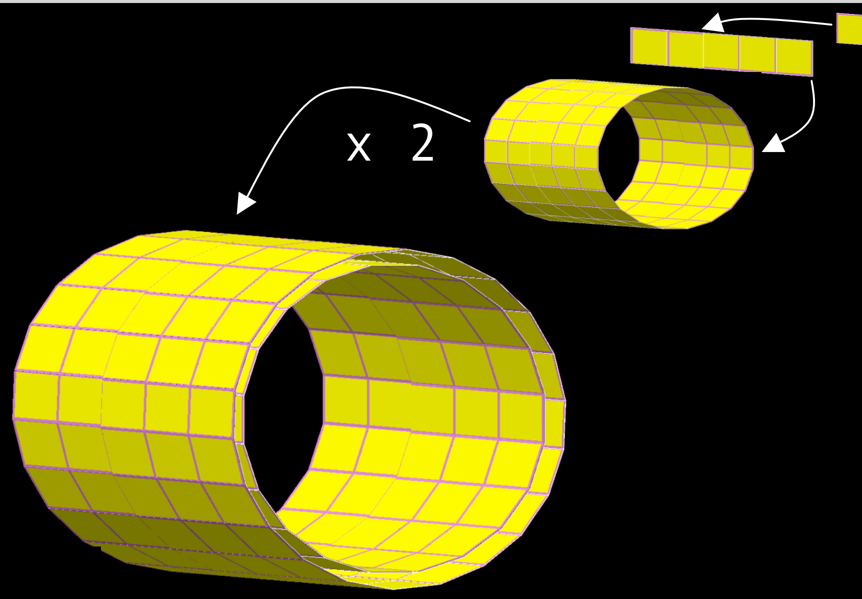


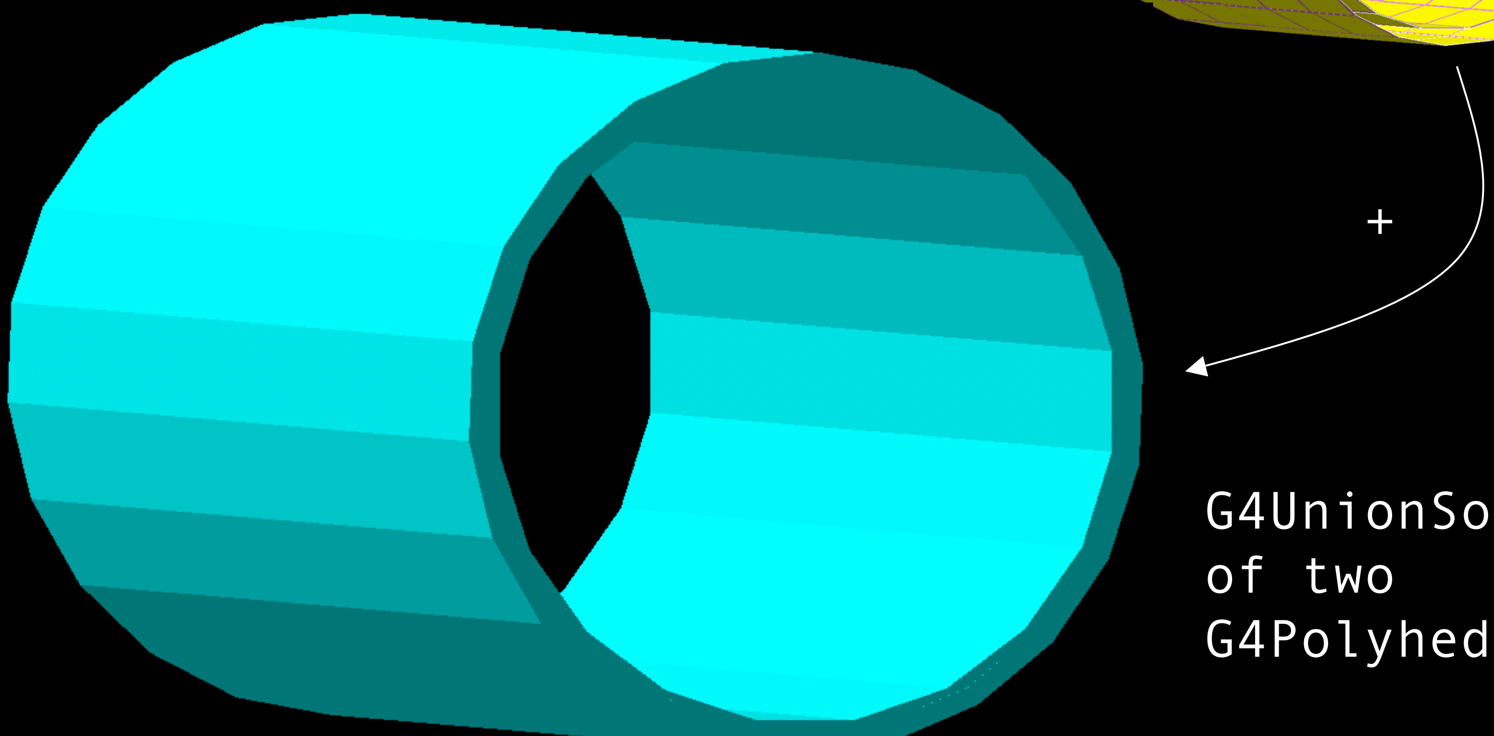
geometry: double layer construction

add support structure

material: 3% RVC

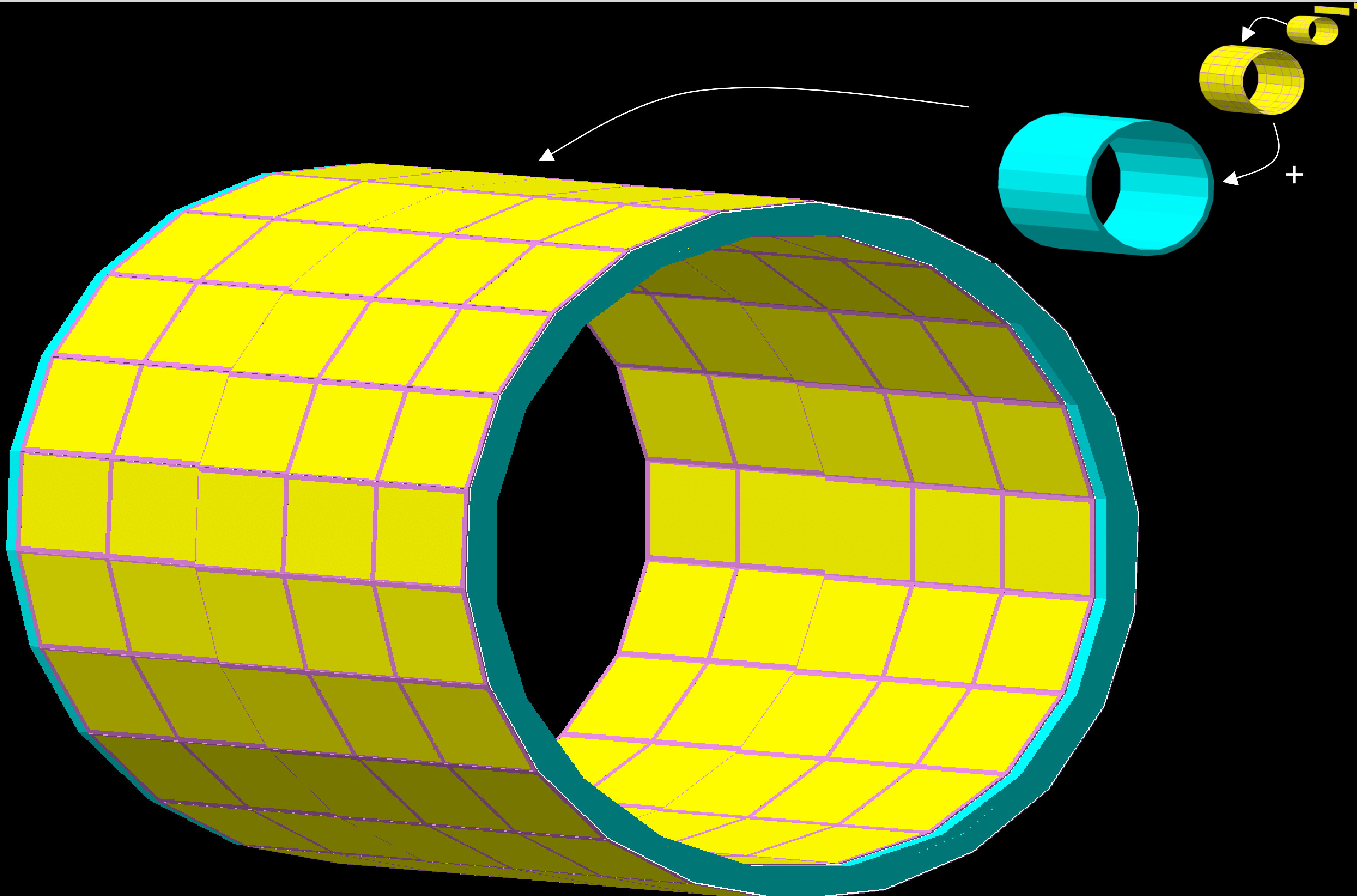
- implemented as C with lower dens.
- can be switched to SiC
- relative densities can be changed



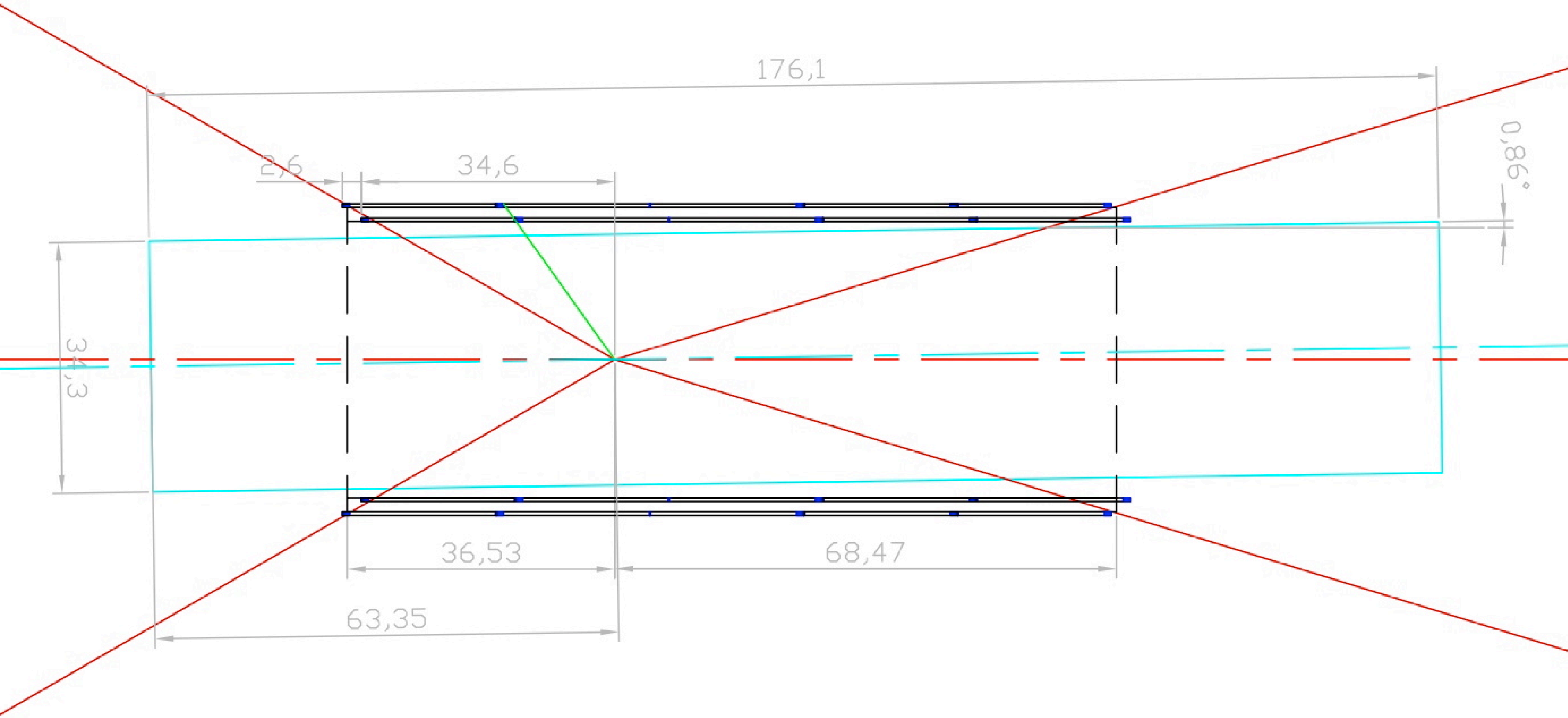


G4UnionSolid
of two
G4Polyhedras

geometry: full detecor view



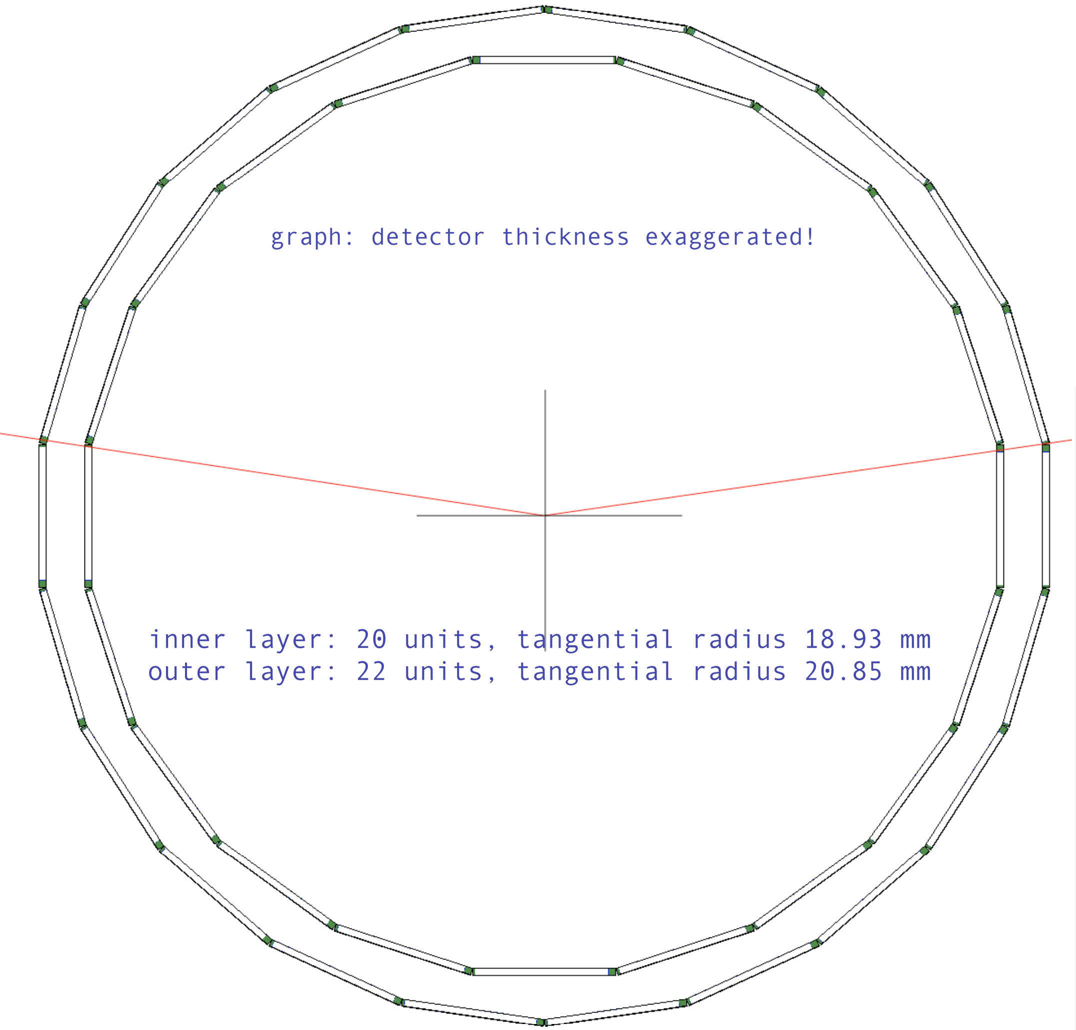
layer arrangement in θ



inner layer: 20 units, tangential radius 18.93 mm
outer layer: 22 units, tangential radius 20.85 mm

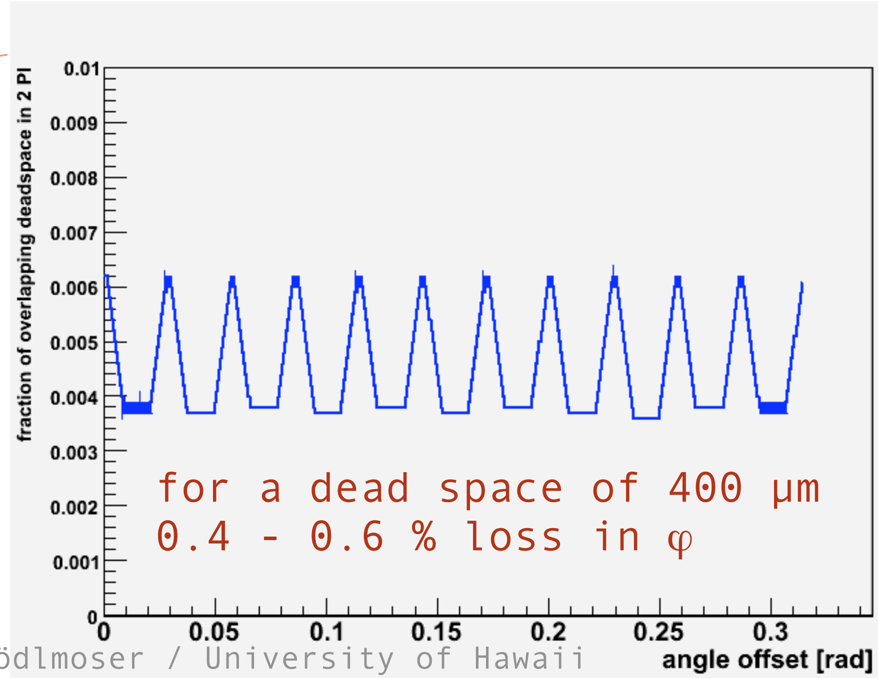
layer arrangement in φ

problem: overlapping deadspaces in inner and outer layer



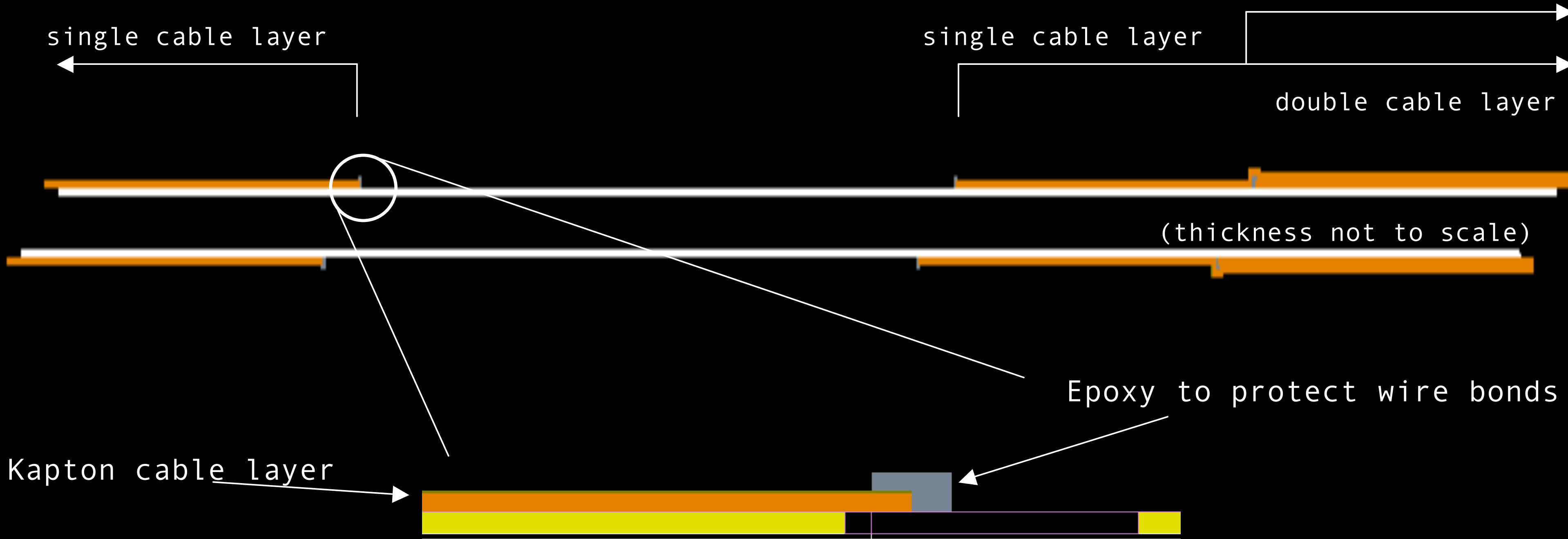
minimize overlap through rotational offset of layer2:

overlap as a function of offset integrated over 2π:

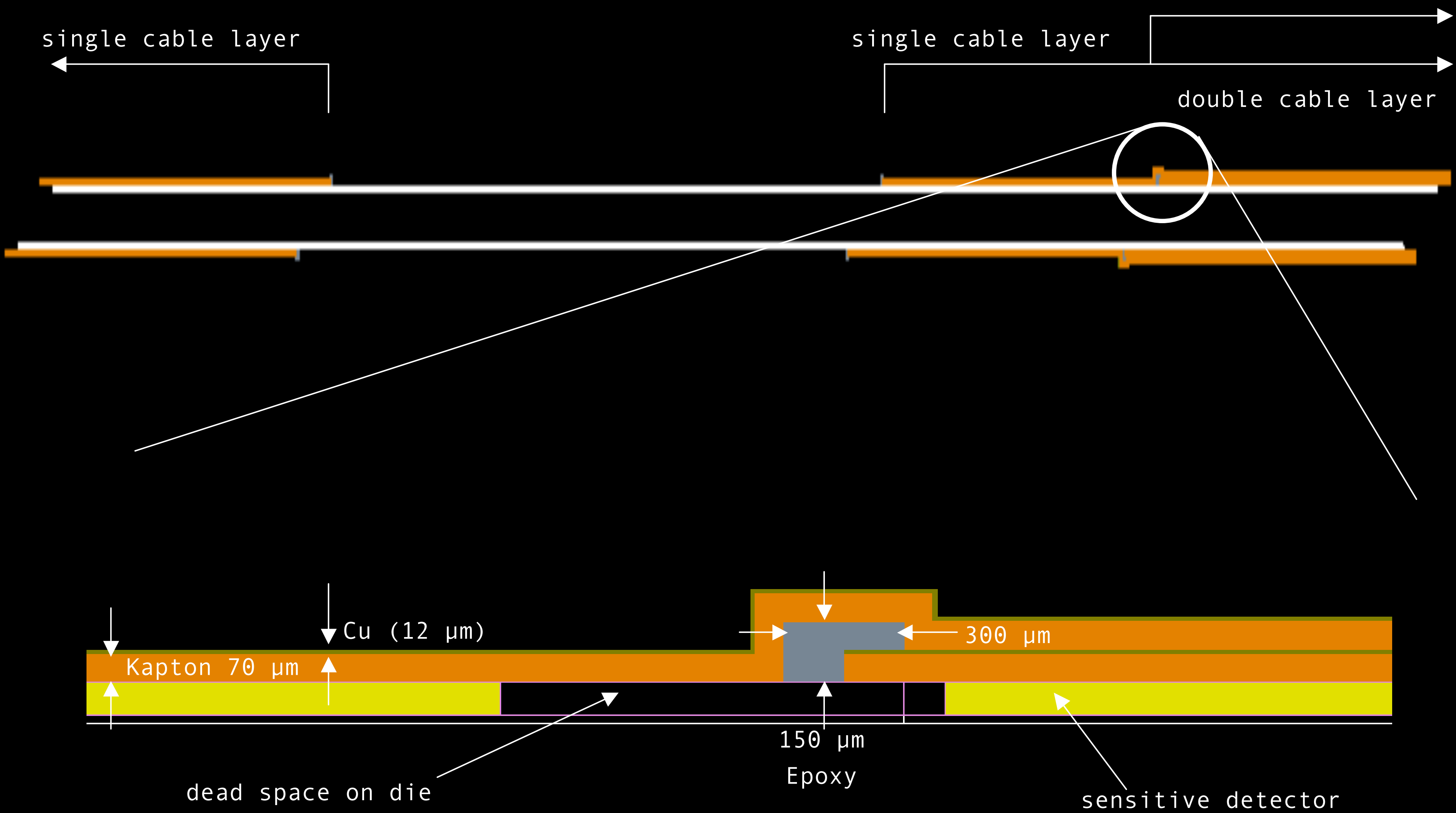


cabling

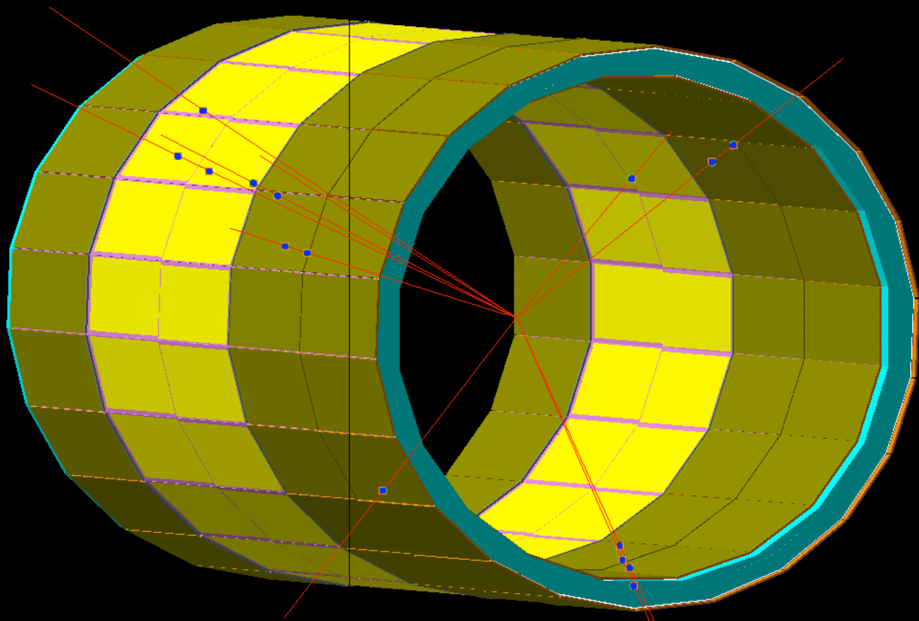
flex circuits:
coming out from 1 mm dead zone on the dies



cabling

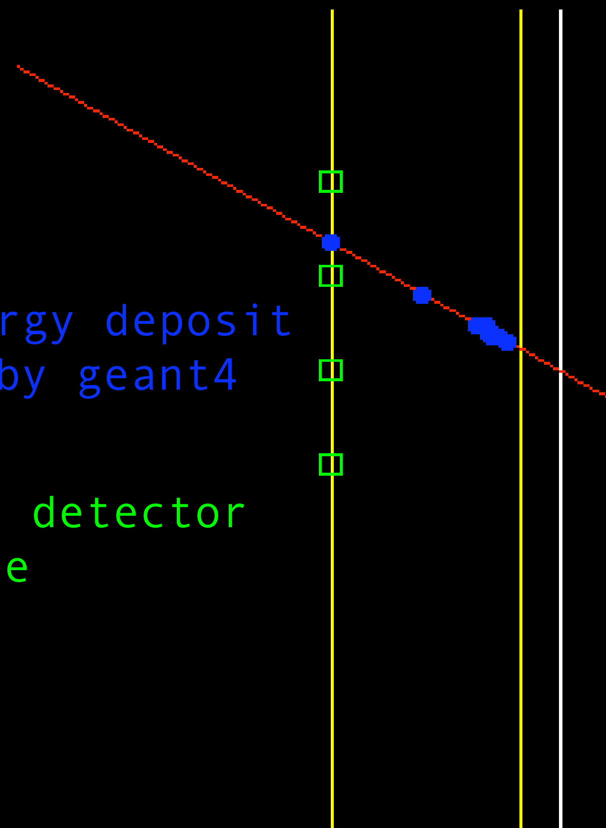

single cable layer
single cable layer
double cable layer
Cu (12 µm)
Kapton 70 µm
300 µm
150 µm
Epoxy
dead space on die
sensitive detector

digitization



● hits: energy deposit provided by geant4

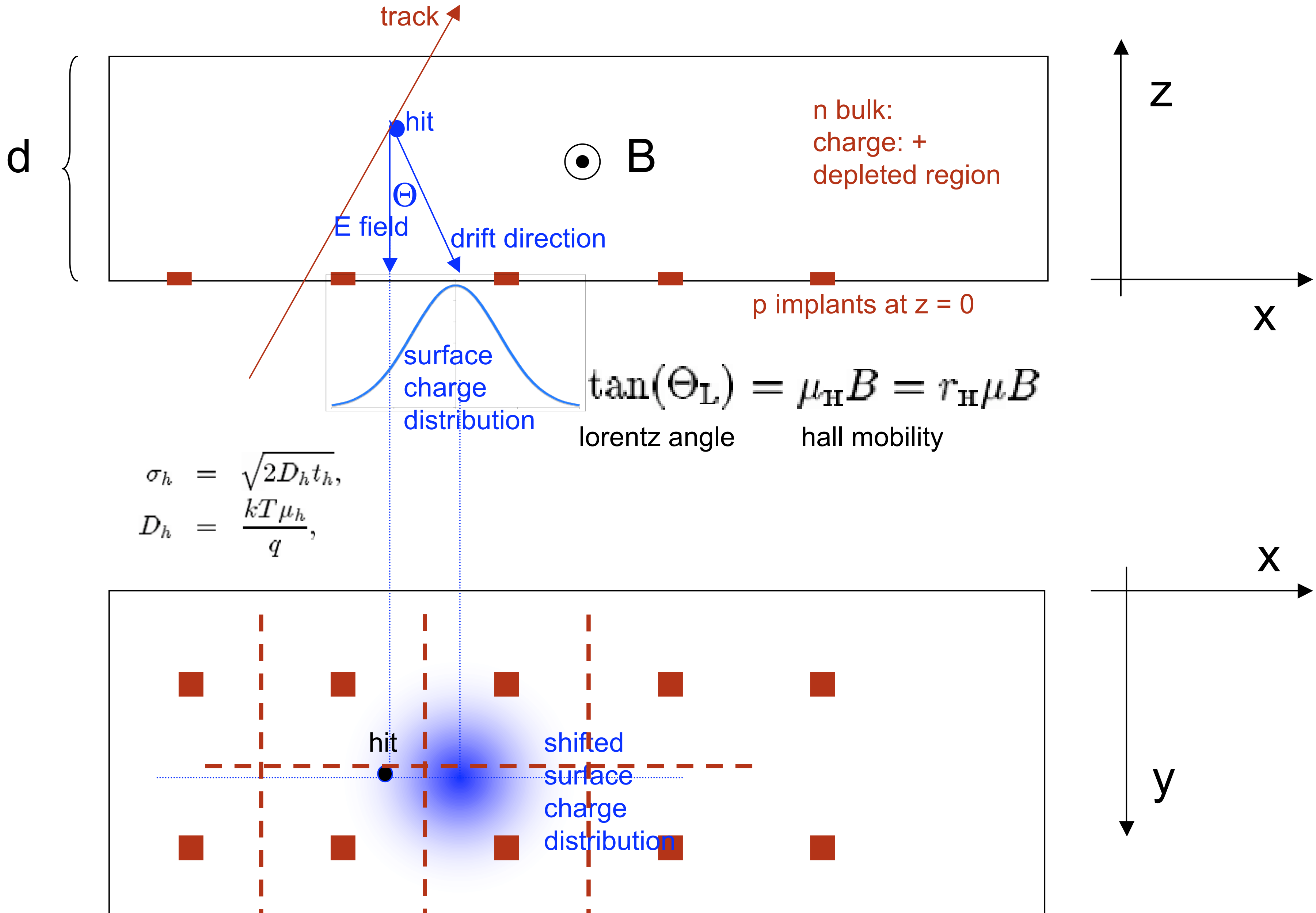
□ digits: detector response



Digitization taking into account:

- drift time
- lateral diffusion
- lorentz angle
- pixel threshold
- channel noise

digitization: details



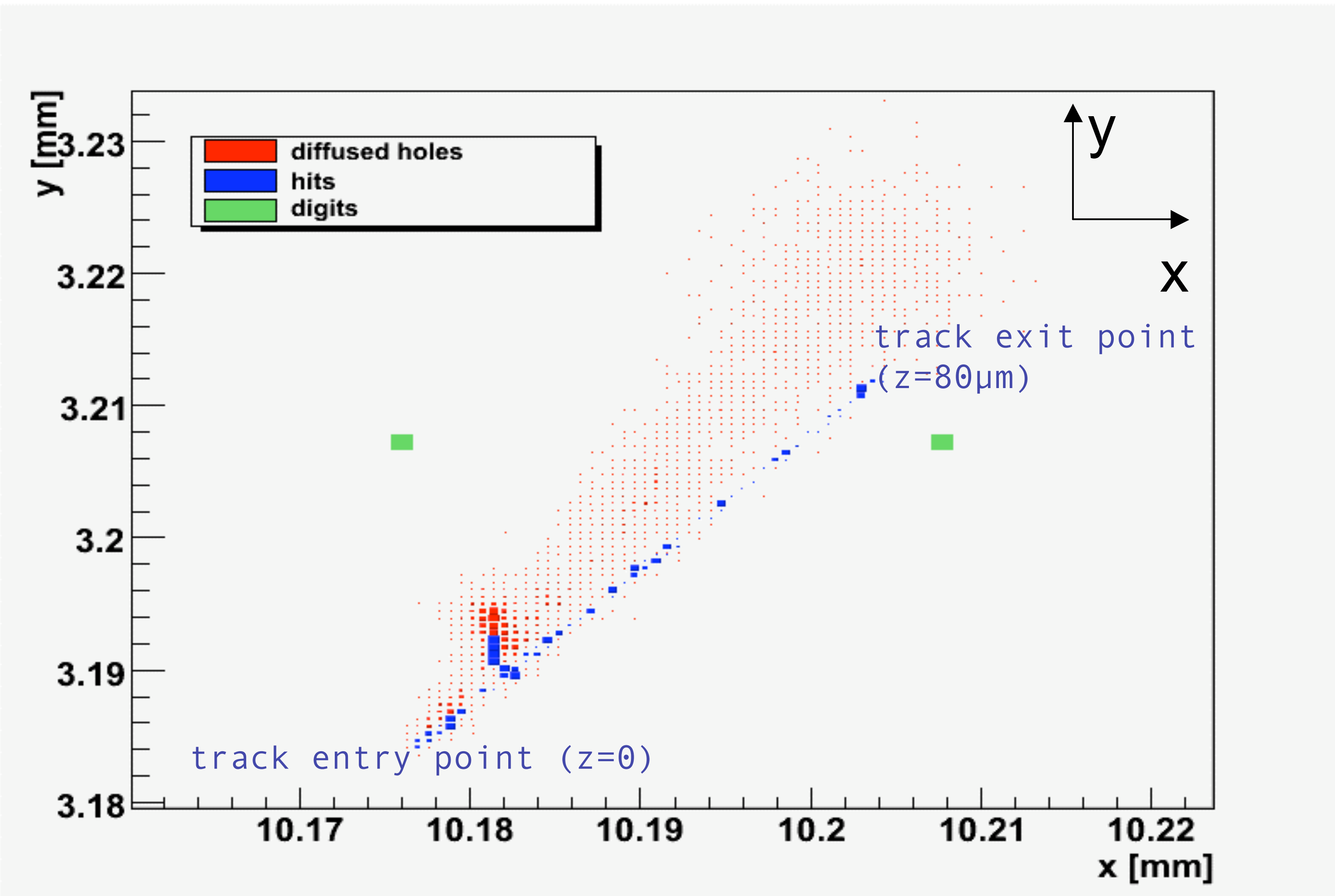
$$\tan(\Theta_L) = \mu_H B = r_H \mu B$$

$$\sigma_h = \sqrt{2 D_h t_h},$$
$$D_h = \frac{kT\mu_h}{q},$$

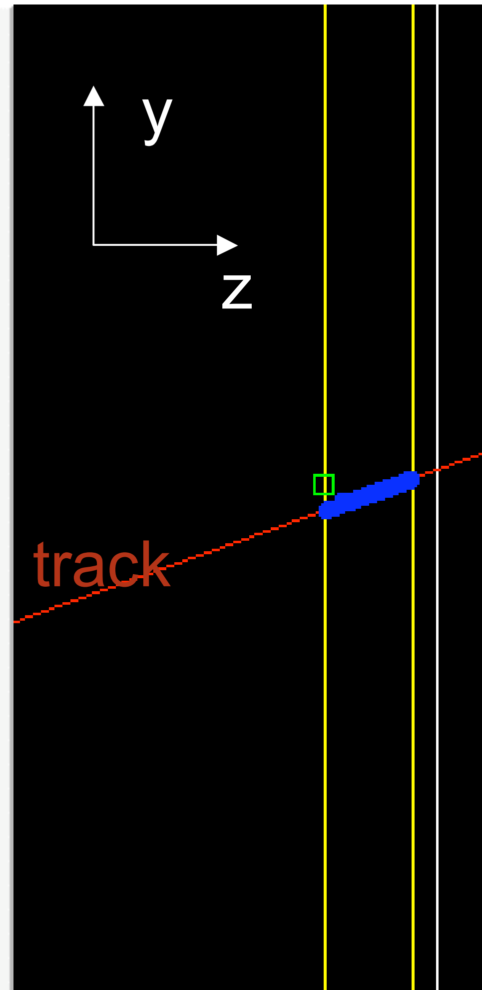
digitization example

1 GeV pi- through one detector building block:

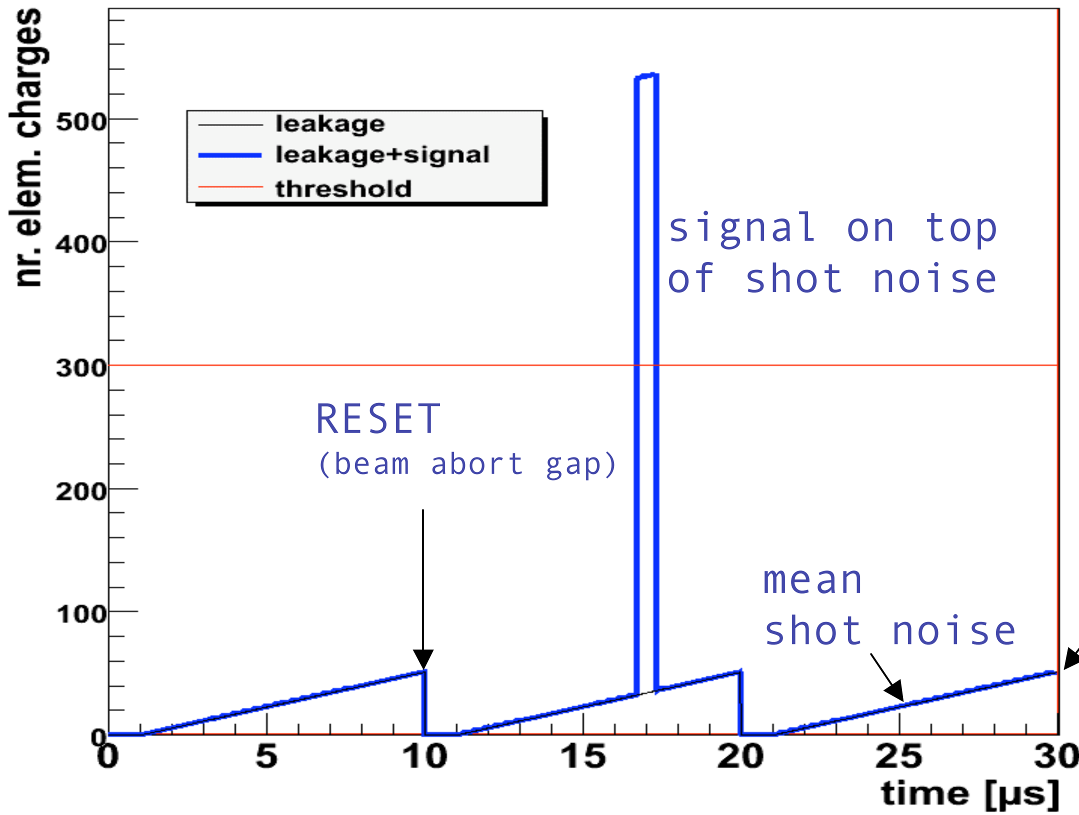
top view



side view



refinement digitization: channel noise

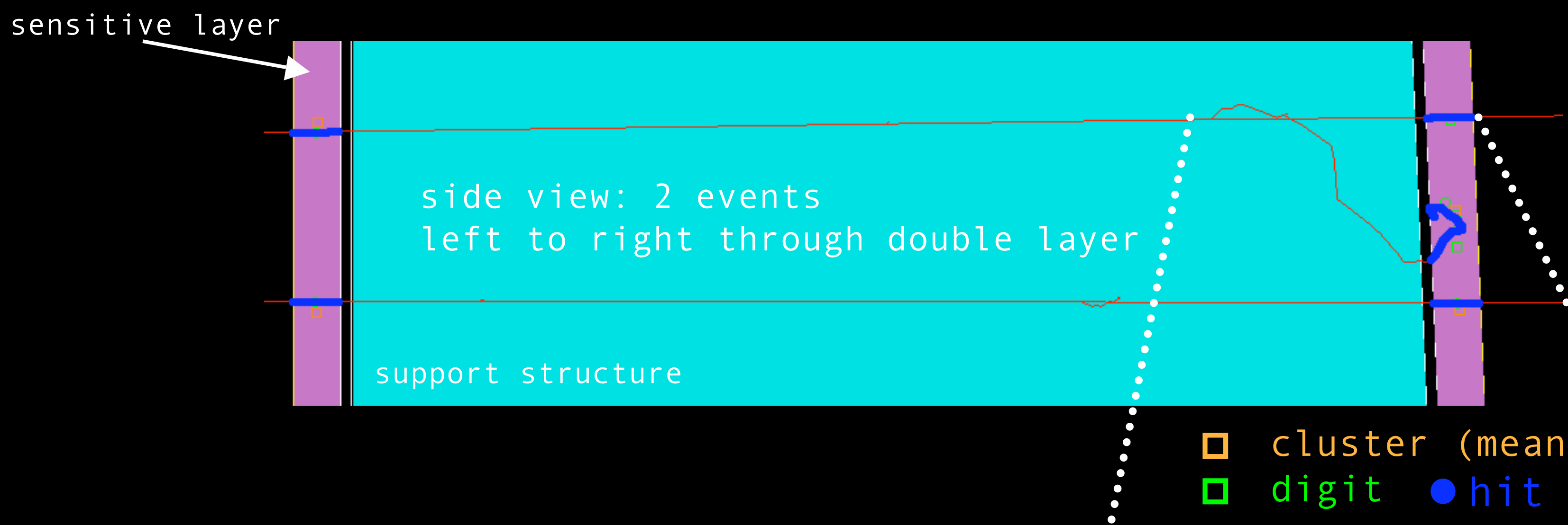


maximum ~ 60 e
calculated from
leakage current
measured with
CAP5

implementation in digitization:

1) for each event pick random time t within reset cycle
2) calculate mean shot noise from leakage current: $\langle Q_{noise} \rangle = I_{leak} * t$
3) for each channel chose random number from poissonian distribution with mean $\langle Q_{noise} \rangle$: $Q_{noise} = RandPoisson(\langle Q_{noise} \rangle)$

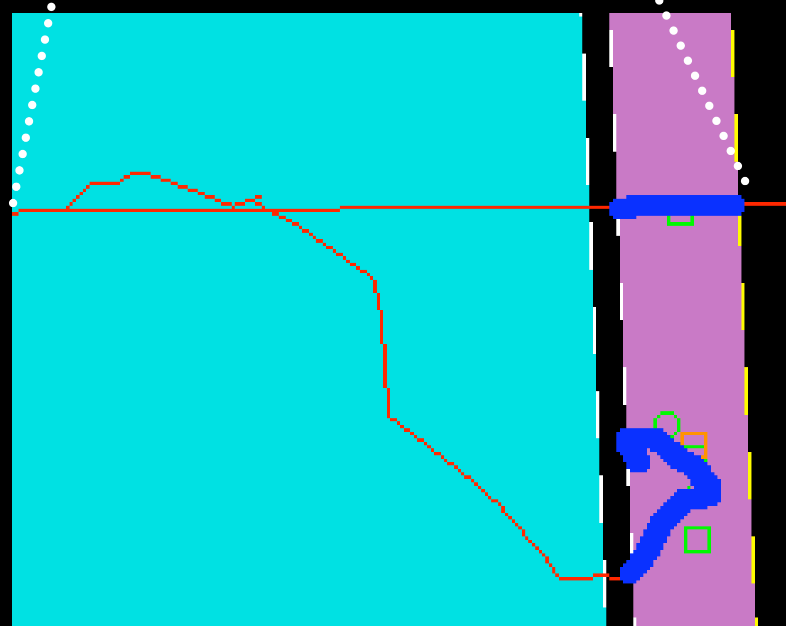
clusters



clusters defined for each event

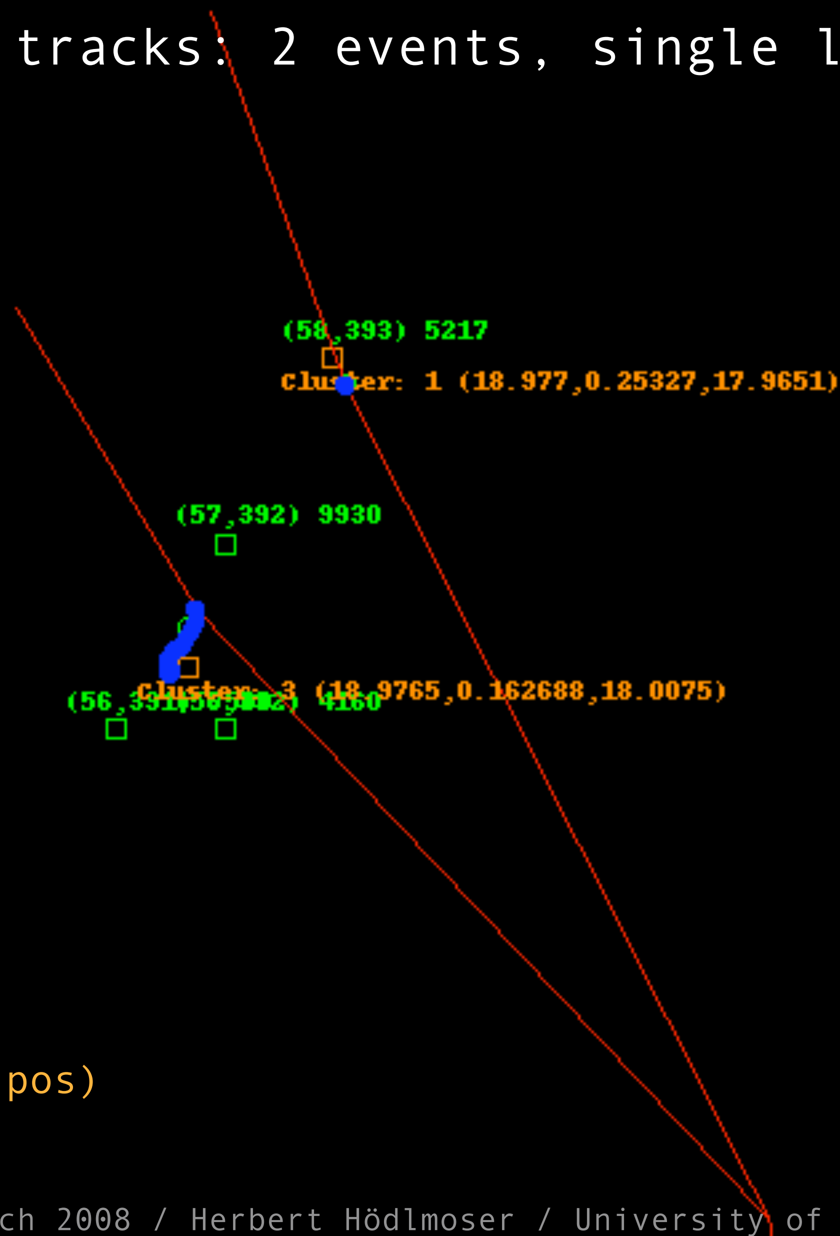
cluster information:

- layer and unit IDs
- cluster size
- cluster global position
- distance to associated mean hit position
- "clean cluster" flag



clusters: examples

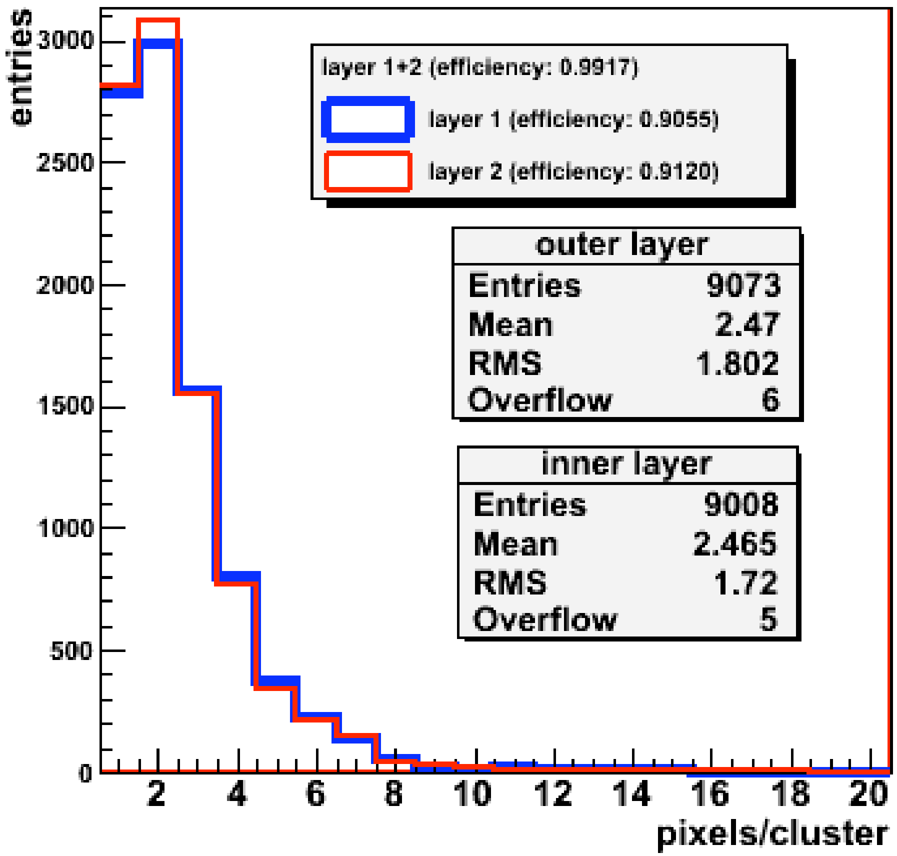
view along tracks: 2 events, single layer



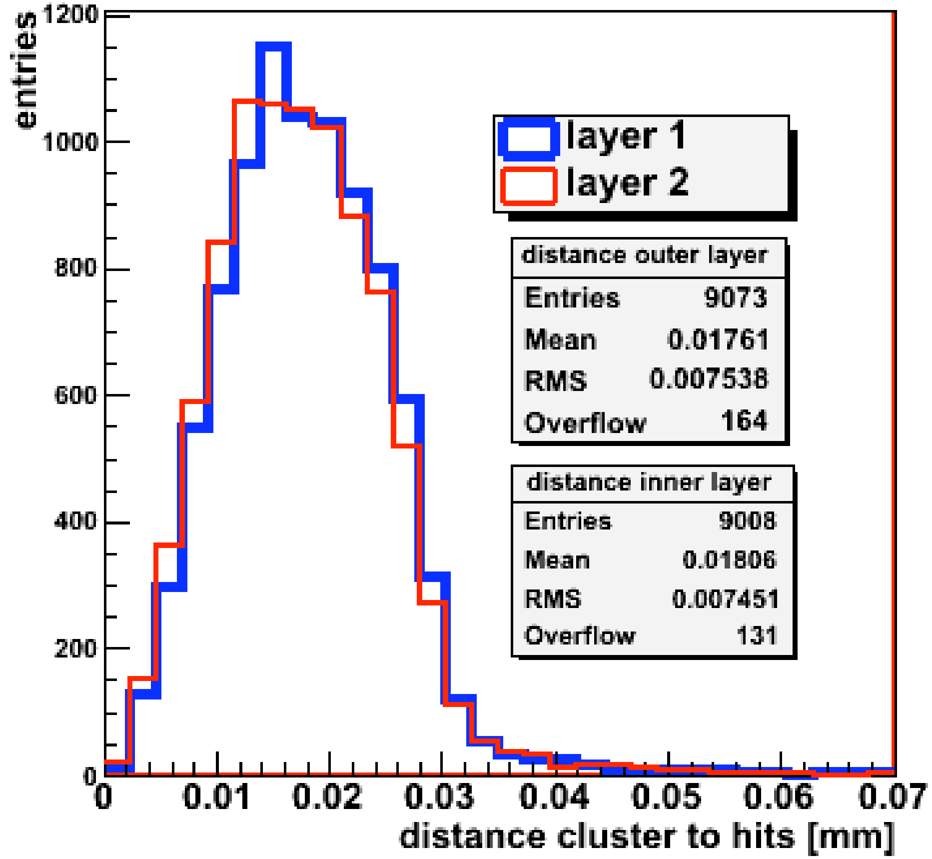
□ cluster: size (mean pos)
□ digit ● hit

cluster-size and distance to hits

cluster-size



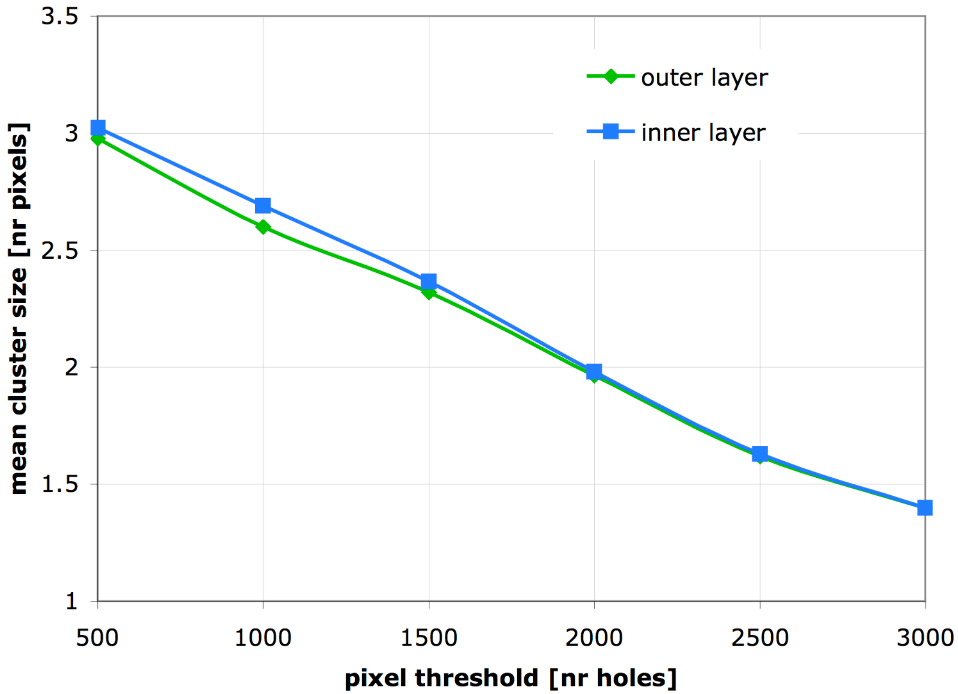
distance cluster - hit



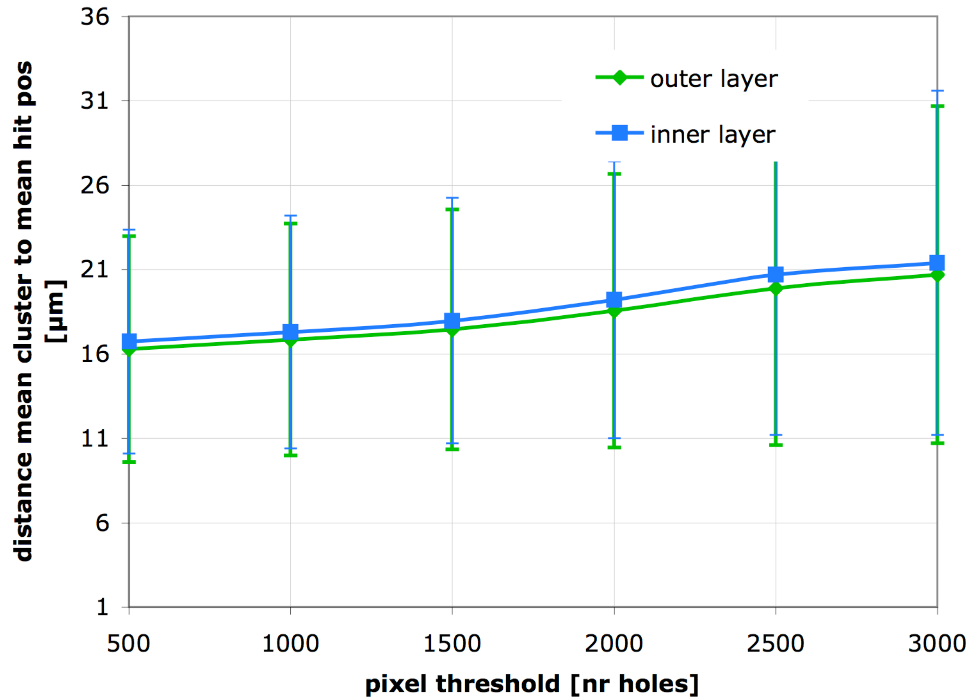
run: 10000 2GeV pi- random within acceptance, threshold 1500 holes

influence digitization threshold

cluster-size

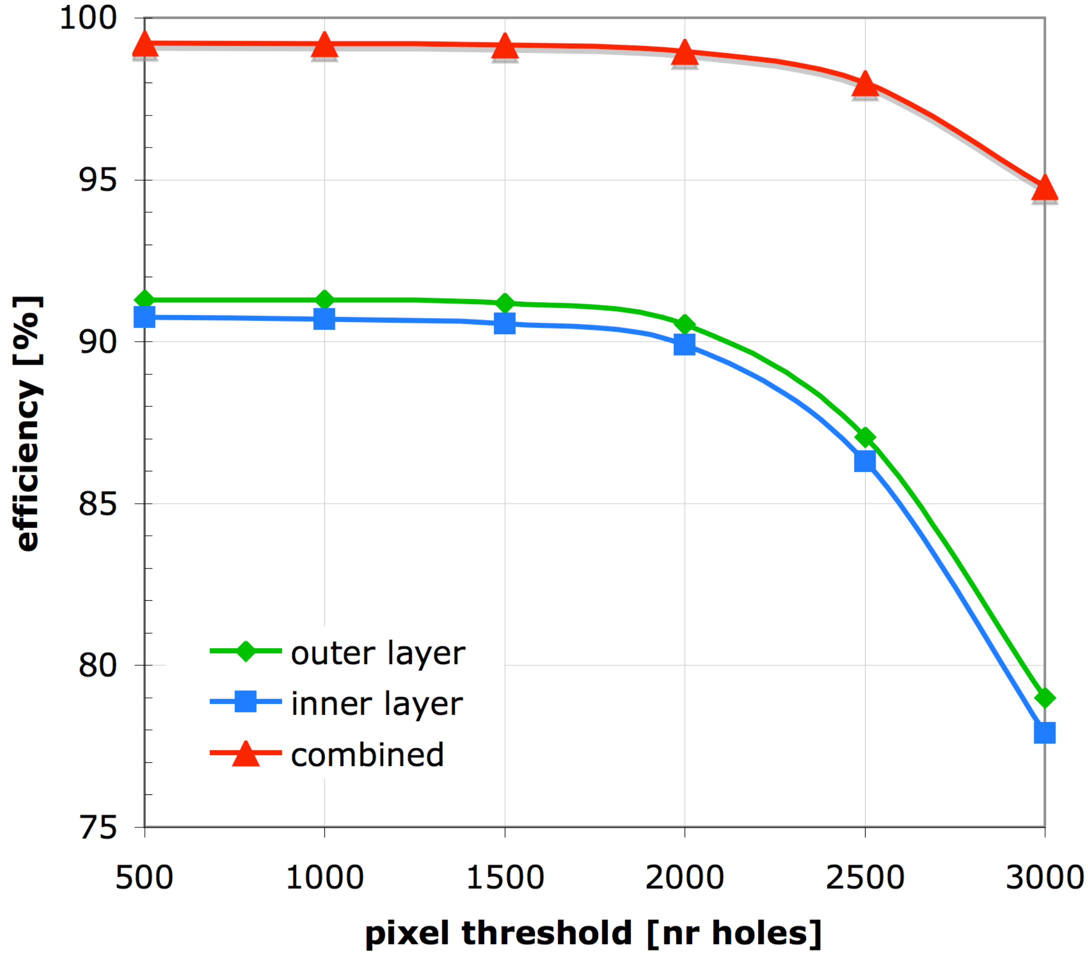


distance cluster - hit



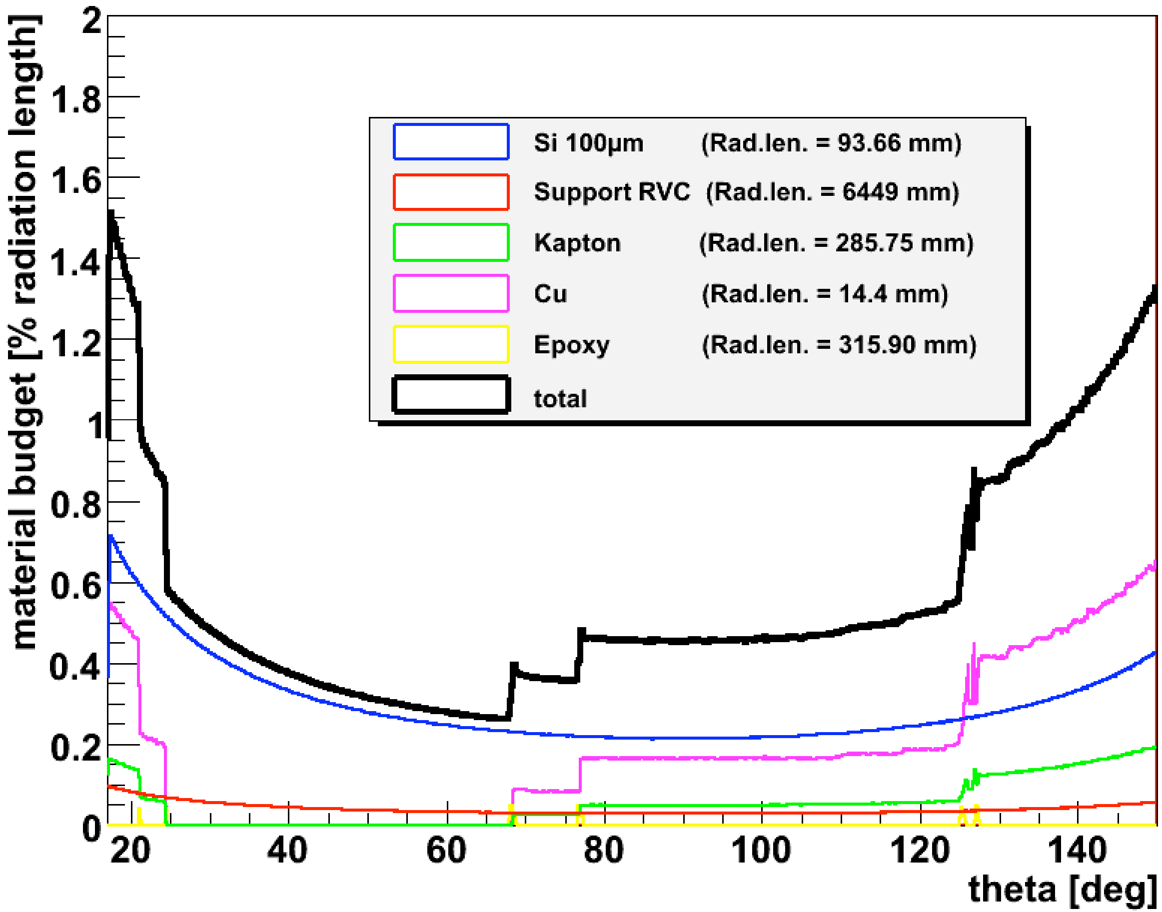
run: 10000 2GeV pi- random within acceptance

layer efficiency (threshold)



run: 10000 2GeV pi- random within acceptance

material budget



- obtained through tracking of geantinos
- possible improvement: thin Si down to 50 µm
- conservative assumption: Cu 12 µm does not cover full area (30%?)
- alternative: remove all cabling and shift data through full array

planning

- simulation runs

```
efficiency(theta,noise)
clustersize(theta,noise)
distance(theta,noise)
...
```

- study influence of pixel dimensions
- study smaller detector (10 mm beam-pipe)
- documentation, debug
- integration blib