The AHCAL dead regions and interfaces: some updates

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ILD Software and Technical Meeting Meeting, Lyon April 27, 2017

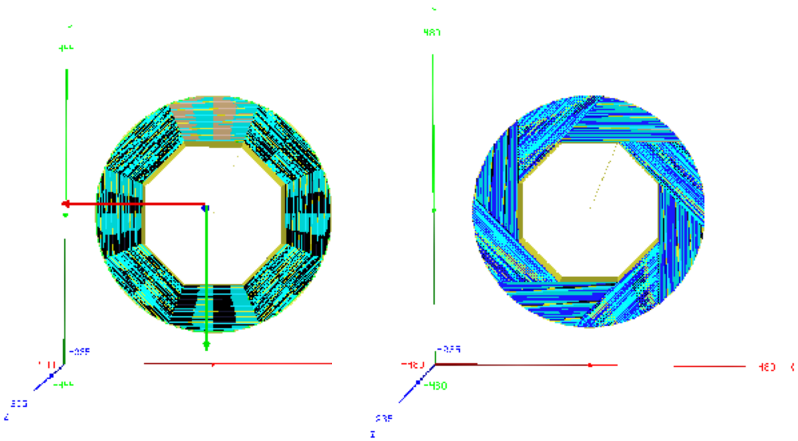
Outline

- Reminders
- Update on dead region study
- Update on signal and service routing

General on "cracks"

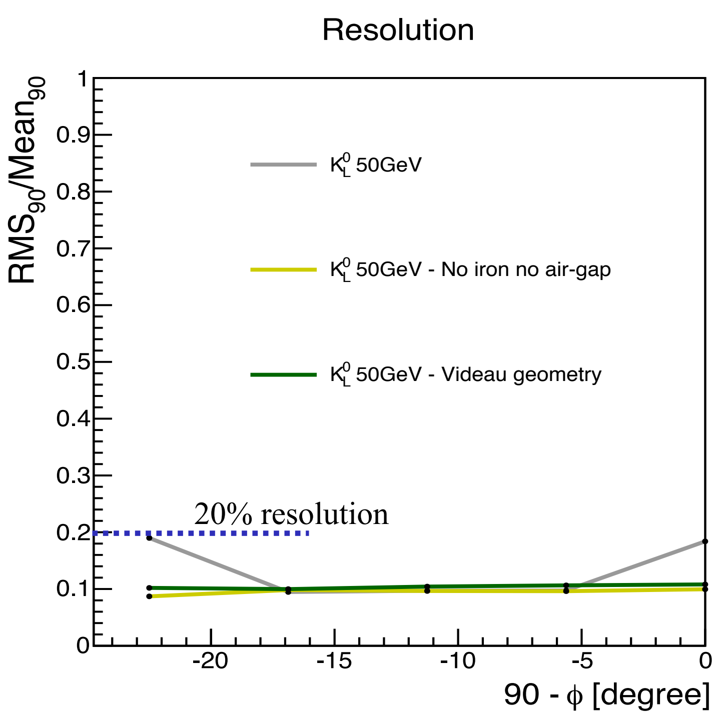
- It is important to note the difference between an air gap and an un-instrumented region in the massive absorber
  - At phi boundaries side walls touch
  - At z=0 the inner end walls touch
- There are no air gaps in ILD through which neutrals - or stiff charged tracks - from the IP could escape
  - Pion muon separation not compromised
- Since the walls are not instrumented with active material, detector response is lowered
  - in realistic calorimeters corrected for using “dead material corrections” at particle or jet level
  - not yet implemented here ⇒ all effects are conservatively over-estimated
- The barrel end-cap transition regions not yet considered here
  - no design yet for “HCAL ring"; needed in both structures

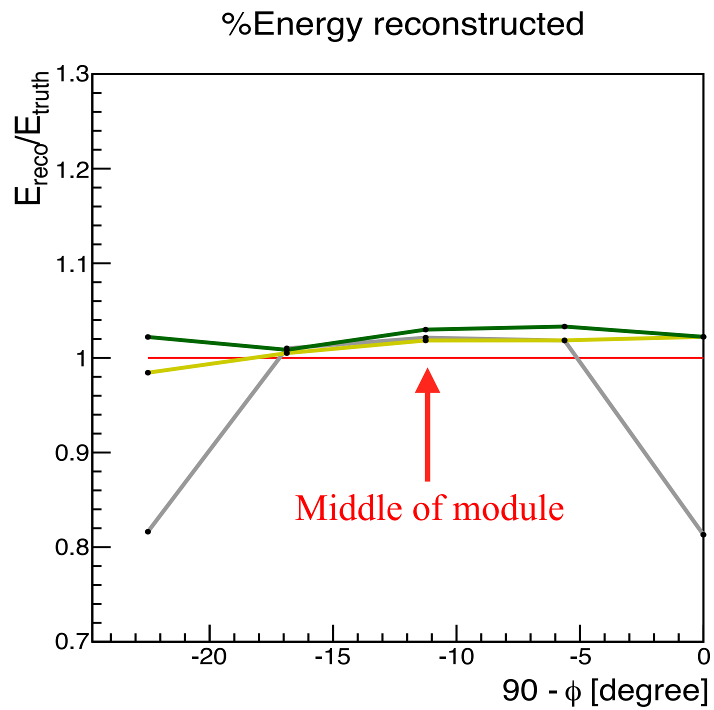
Compare AHCAL and SDHCAL geometries



- Reconstructed energy comparison of 3 geometries:
  - AHCAL geometry
  - Ideal AHCAL geometry w/o iron and air gap in Phi
  - SDHCAL geometry

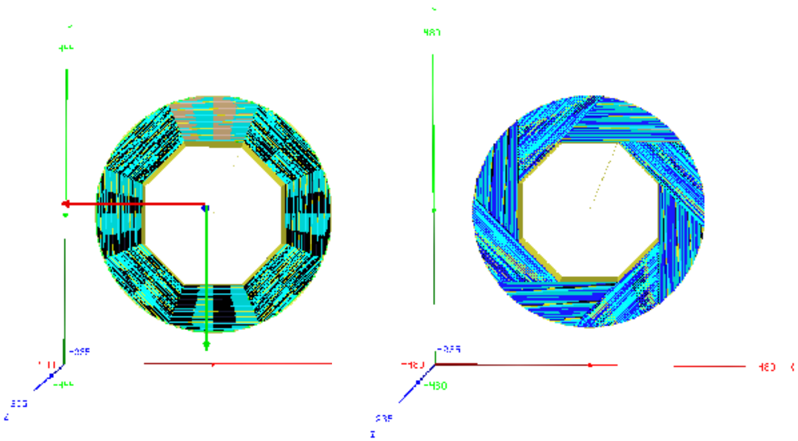
➢ Clear loss of energy response and resolution due to iron crack for AHCAL geometry





But phi steps are large (!)

Compare AHCAL and SDHCAL geometries



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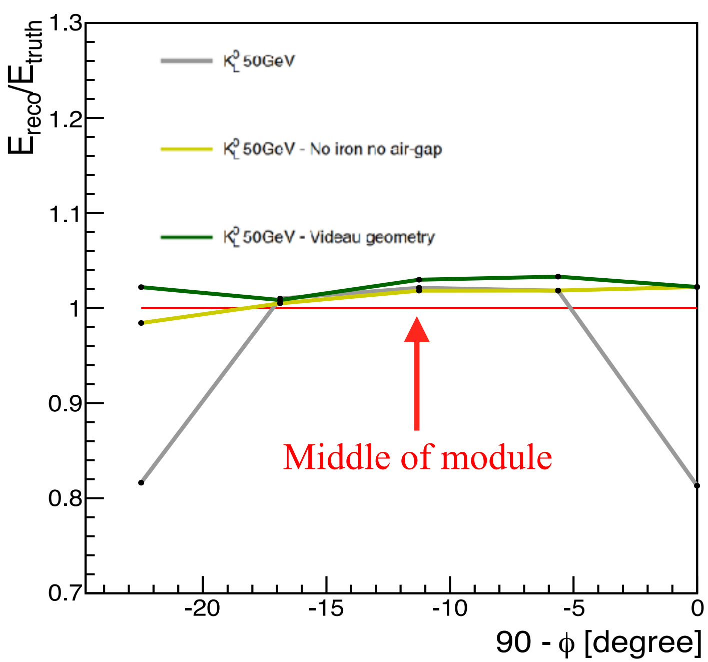
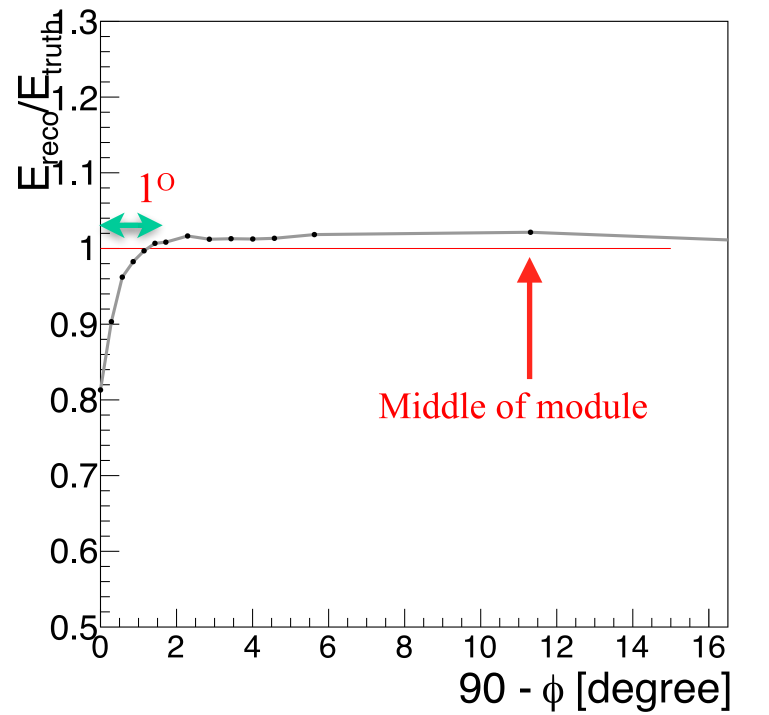
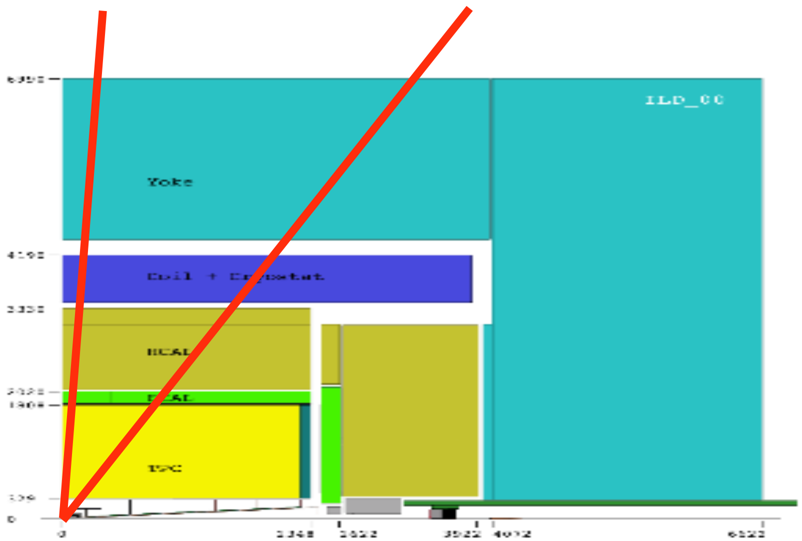
%Energy reconstructed



Finer phi steps

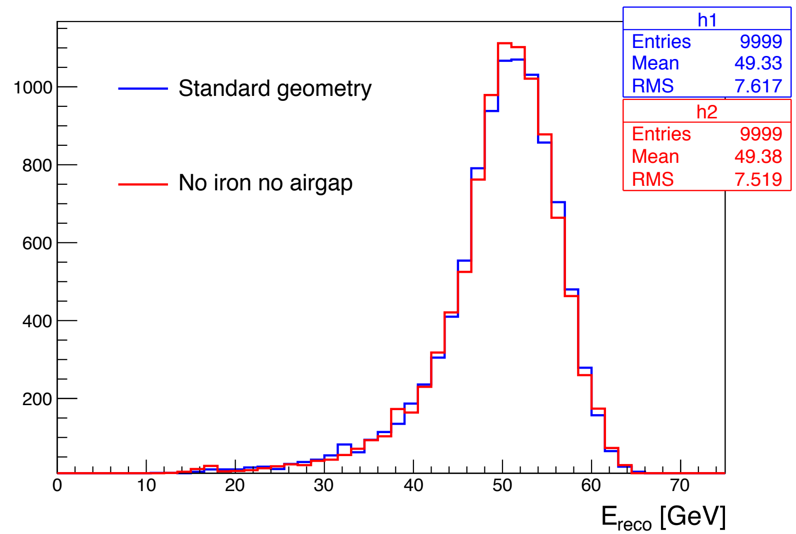


Average effect of supporting structure (*r*,phi) plane



- Cut on Theta to avoid iron support at z = 0 and barrel-endcap gap
- Look at energy distribution ***integrated over all phi***:
  - Standard geometry
  - Standard geometry w/o iron and air gap in Phi

For single particle



Fit Gaus90

Mean: 50.6938
Sigma: 5.07267
Res(Gaus90) = 10%

Mean: 50.7438
Sigma: 5.15704
Res(Gaus90) = 10.2 %

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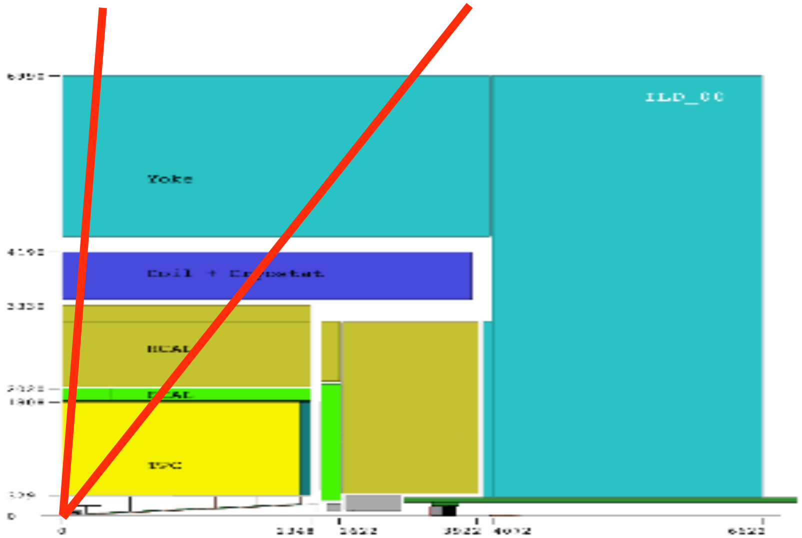

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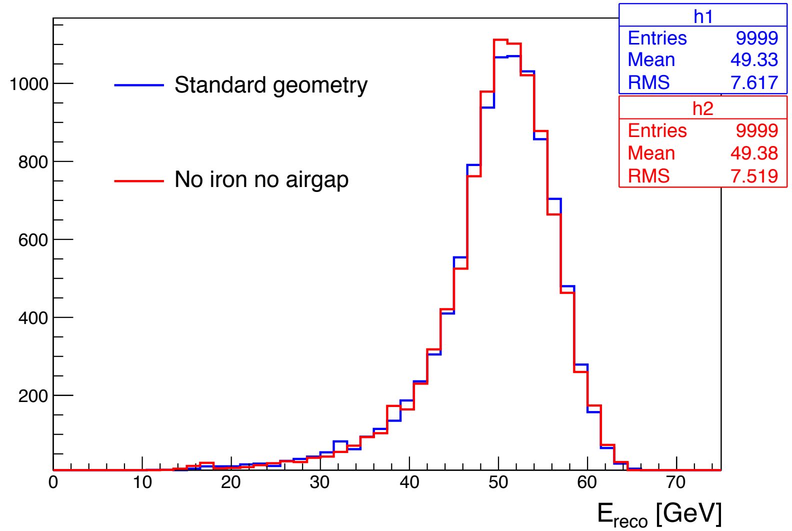


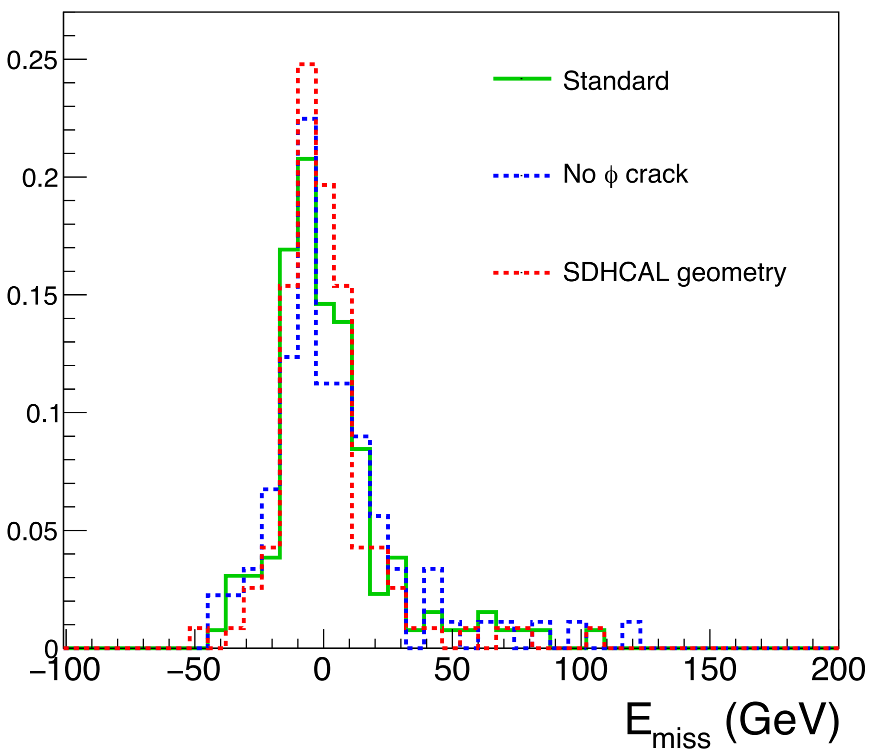
➢ Effect of iron support on energy reconstruction is very small when integrating over all phi

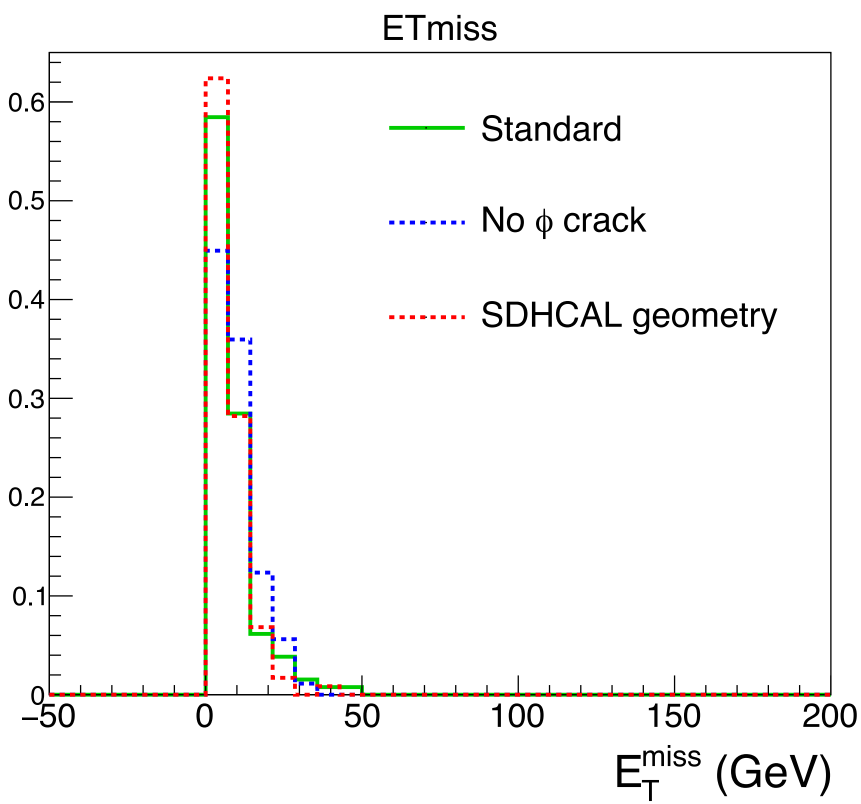
- Can be further mitigated by dead material correction
- Probably not sufficient to motivate a design modification

Multi-particle final states

- In multi-jet events it is unlikely that no particle comes clear to any of the boundaries
- Could in principle affect missing (transverse) energy resolution
- N.B.: MET not well studied for ILC since in general kinematic fits are possible, and missing 4-momentum is reconstructed
- Study using e+e- → WW → hadrons
  - all jets in barrel
  - found that one W → c s-bar in each event, rejection of events with neutrinos at generator level
- Same geometry variants as for single particle study

Missing E_T performance





- Tools and samples at hand
- no significant effects
- small statistics at time of November meeting, now updated

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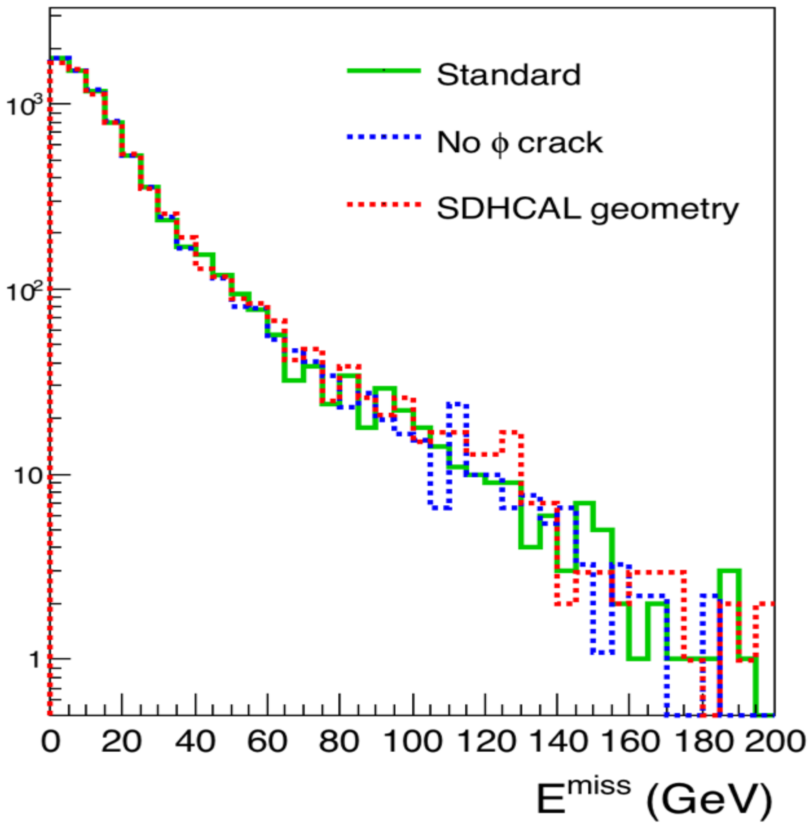

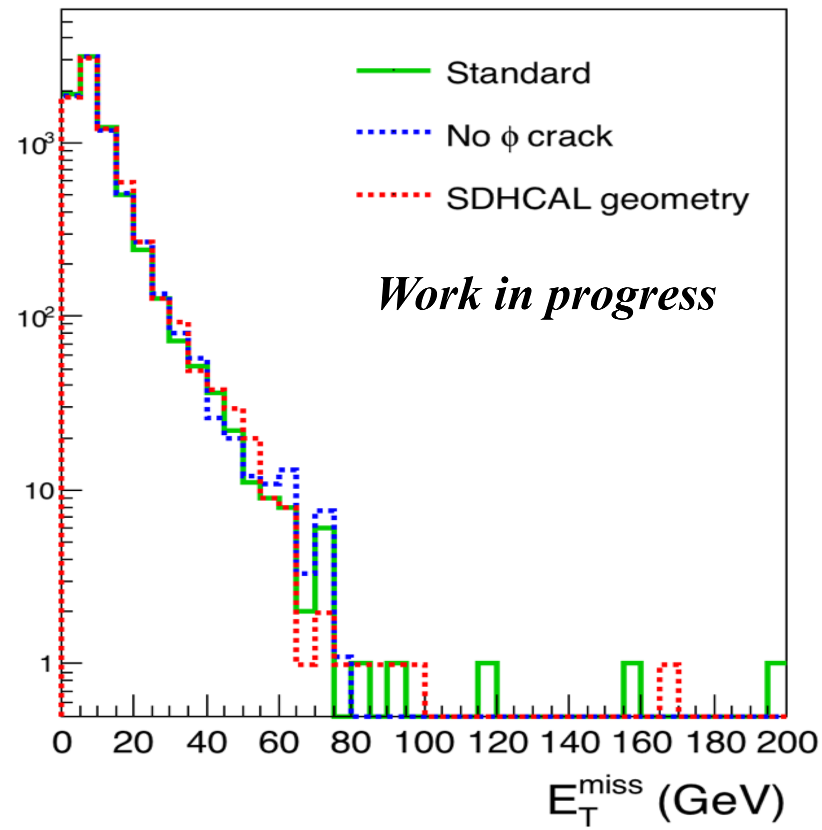

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Summary (dead regions)

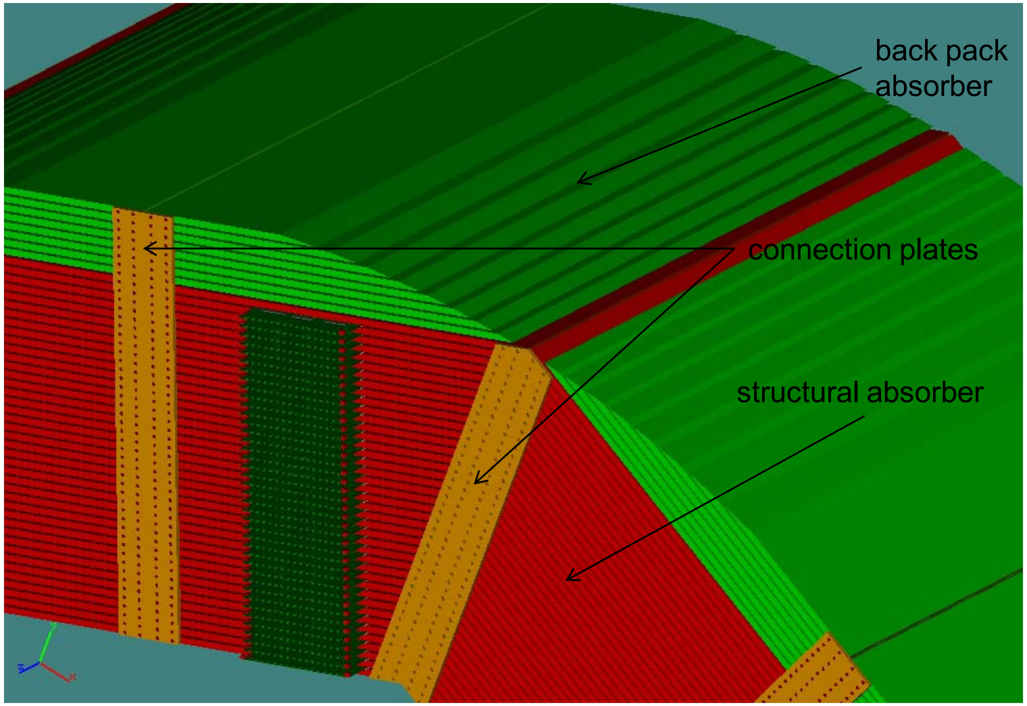
- No “lines of escape”, only decrease of response which can be corrected for because un-instrumented regions are much smaller than single hadron showers
- Studies are made without such corrections
- Effects in phi:
  - single particle: only very small region, negligible on average
  - missing E_T: no significant effects, either
    - and no kinetic constraints applied yet
- Effects in z:
  - should find common approach with TPC
  - in standard design, without corrections, effects are signifiant
  - with staircase design, only small effects left,
    - dead material corrections to be done

- Altogether no noticeable effects in final performance expected

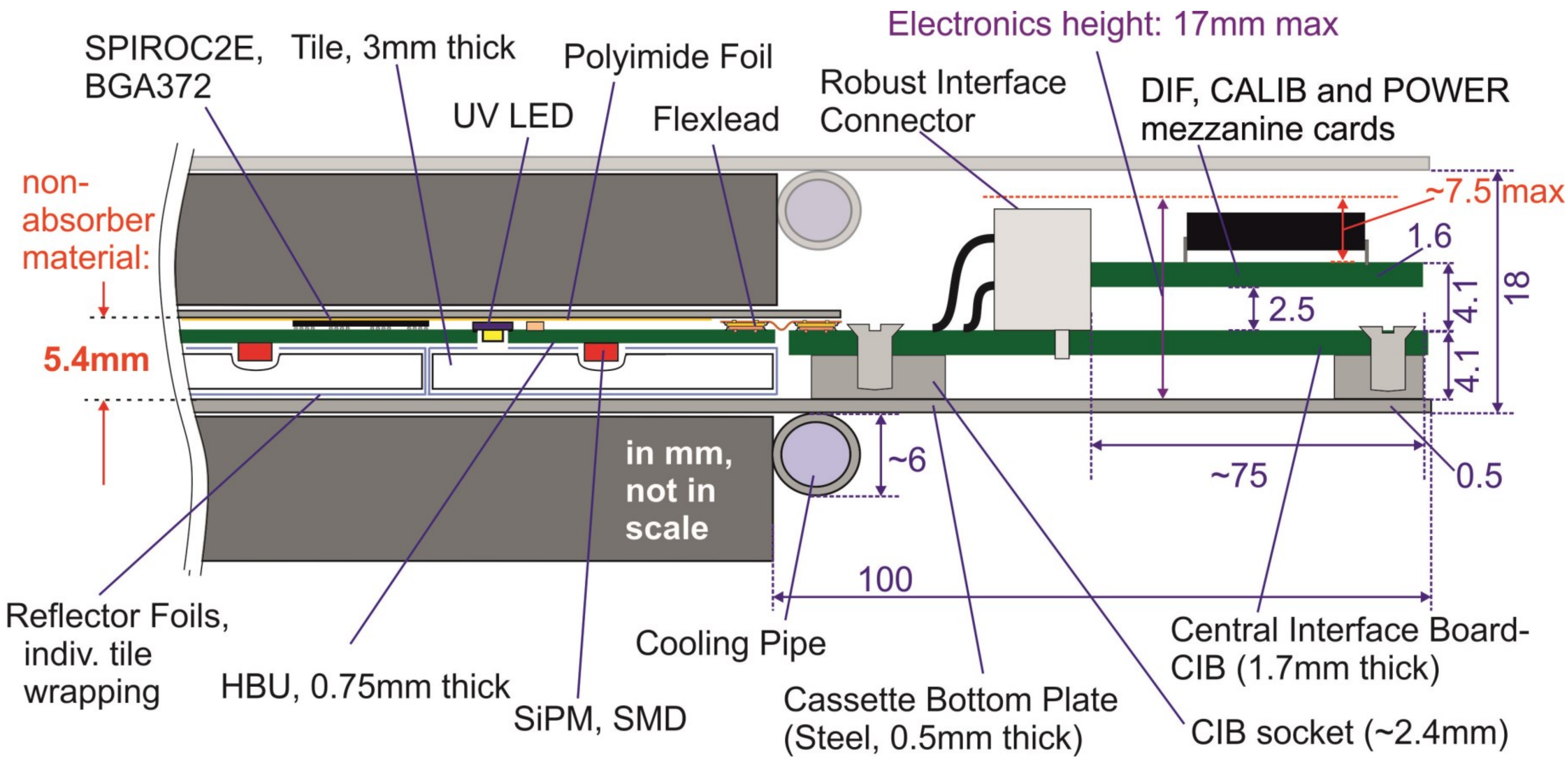
Update on interfaces

Design challenges

- Stainless steel
- Fine longitudinal sampling
  - 2cm plate thickness
- No cracks, minimal un-instrumented regions
- Inside coil radius:
  - compact design to maximise no. of hadronic interaction lengths
  - tight tolerances over large dimensions
- Accessible electronics
  - external: short access
  - internal: longer shutdown or upgrade
- Earth quake stability
  - computational challenge



Layer cross section



(location of cooling pipes not final)

HCAL base unit and interfaces

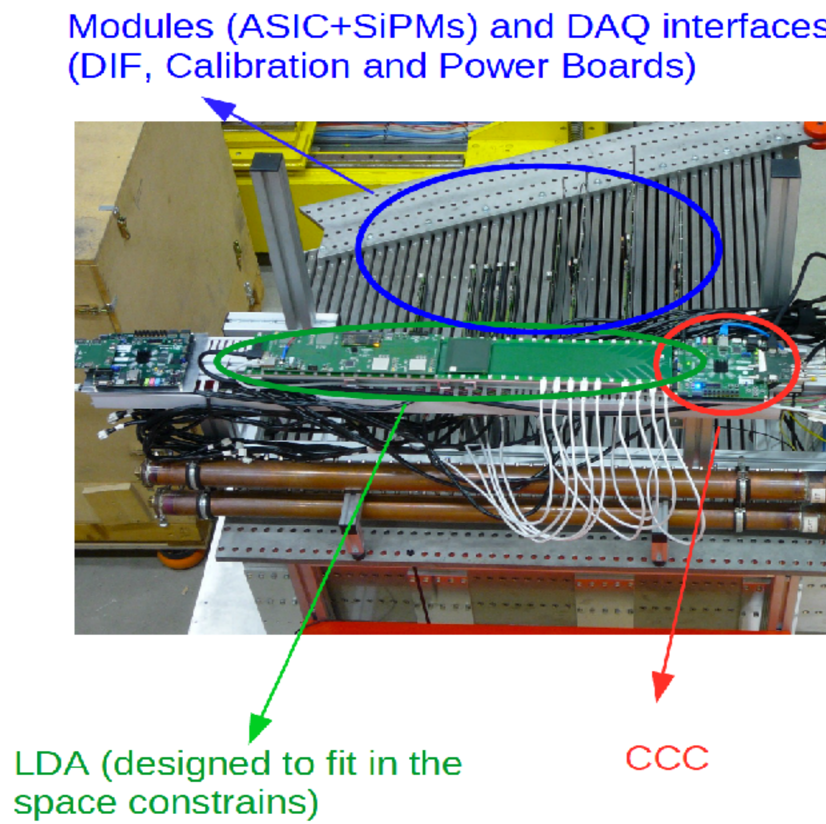
- POWER board
  - regulators
  - common SiPM bias adjustment
  - capacitors for power pulsing
- CALIB board
  - microprocessor steering the LED system
- DIF board
  - DAQ interface
  - ZYNC chip

Central Interface Board 36x10 cm^2

heat sources

System integration

- Interface boards POWER, DIF, CALIB
  - can handle full layer of large detector
  - POWER board equipped with capacitor bank for power pulsing, active temperature compensation possible
  - DIF board uses more advanced FPGA to communicate with the ASICs
- Data concentration:
  - Wing-LDA designed for ILD-AHCAL successfully operated
  - Thanks to power pulsing mode, water-cooling only for interface boards needed (leak-less design)
- Data acquisition:
  - Integrated into EUDAQ system (chosen by LC community and actively supported by AIDA-2020): successful operation



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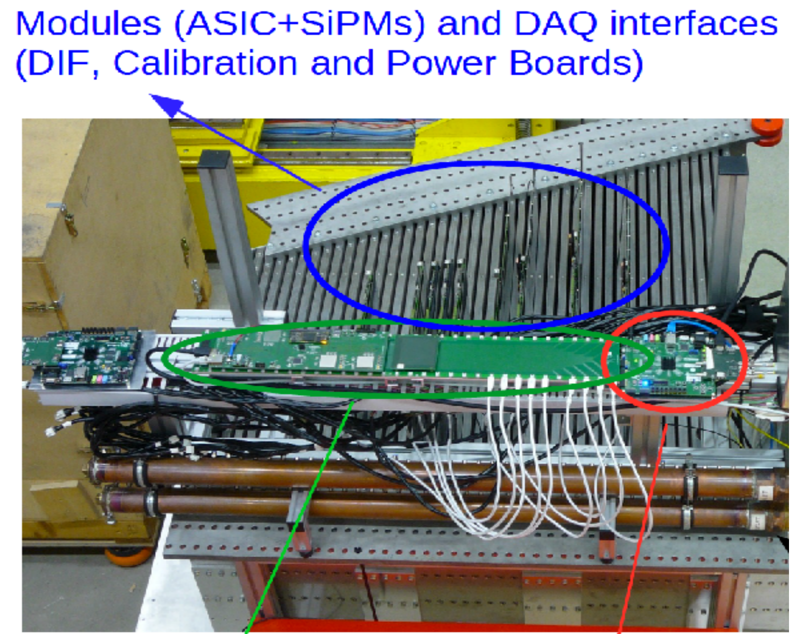
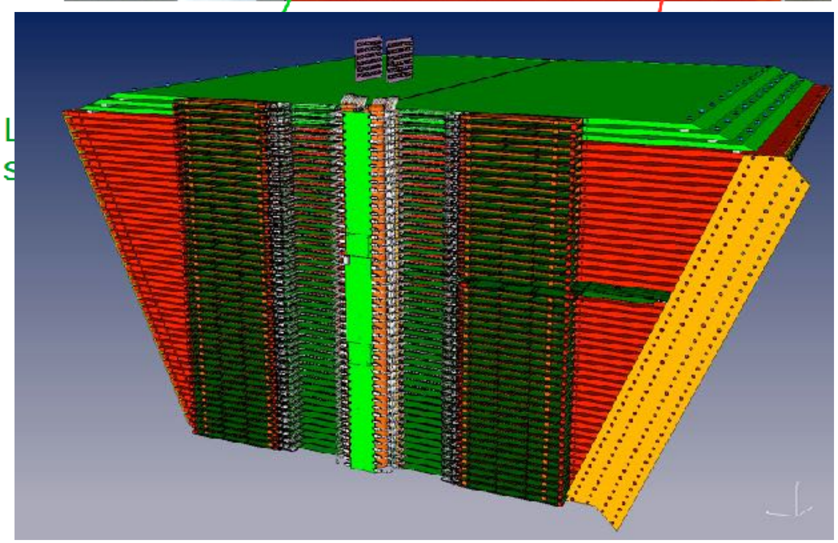
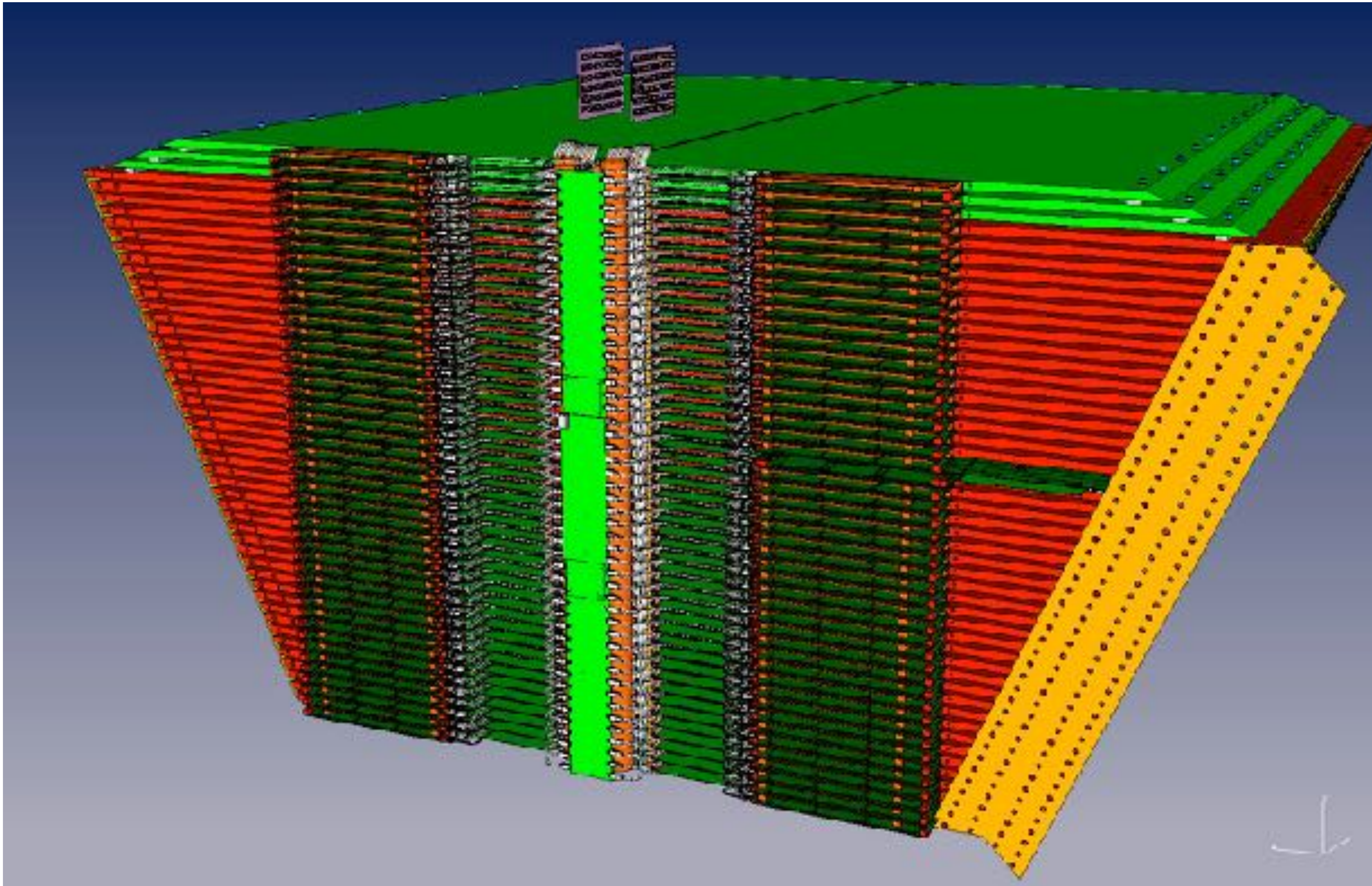




Connections



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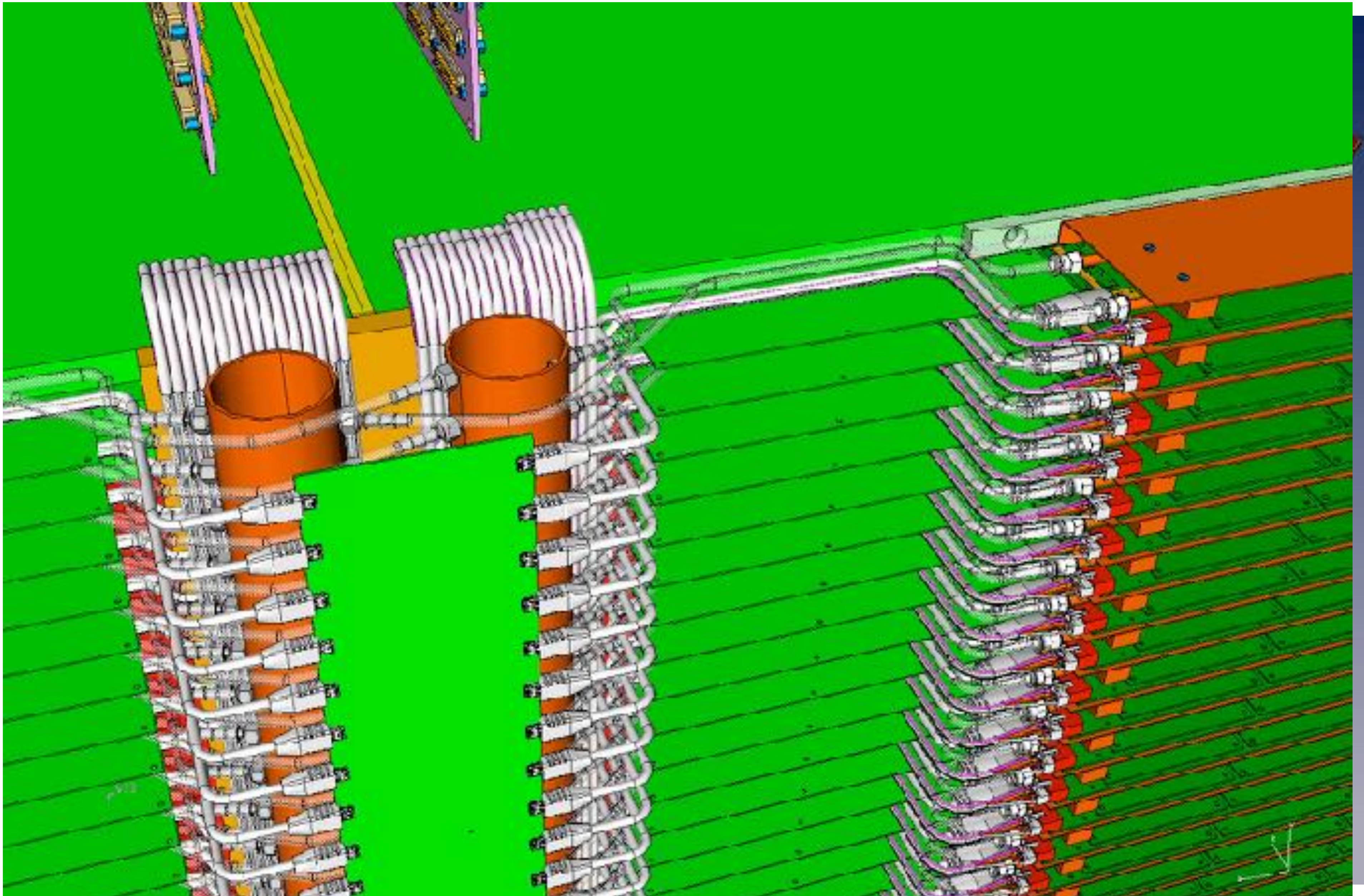


Concluding remarks

- This is a proof-of-principle design
- Now being realised on the test beam prototype

- Will not be redone for every LDC, ILD large, ILD small, ILD small with larger ECAL and all the many future versions that we may be discussing

- Active layers can in principle be done with only 4 different HBU sizes: 8, 9, 10, and 12 tiles wide

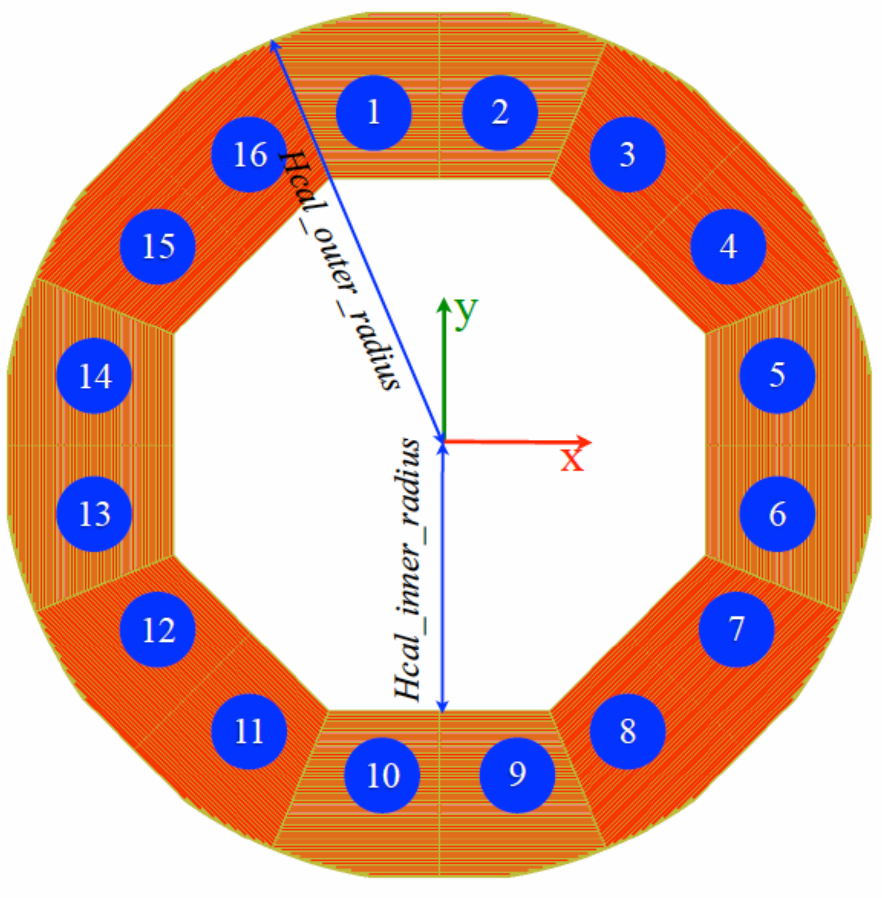
- Constraints on position of central interface board may increase required number of HBU sizes

- This can only be optimised once detector size is fixed

Backup

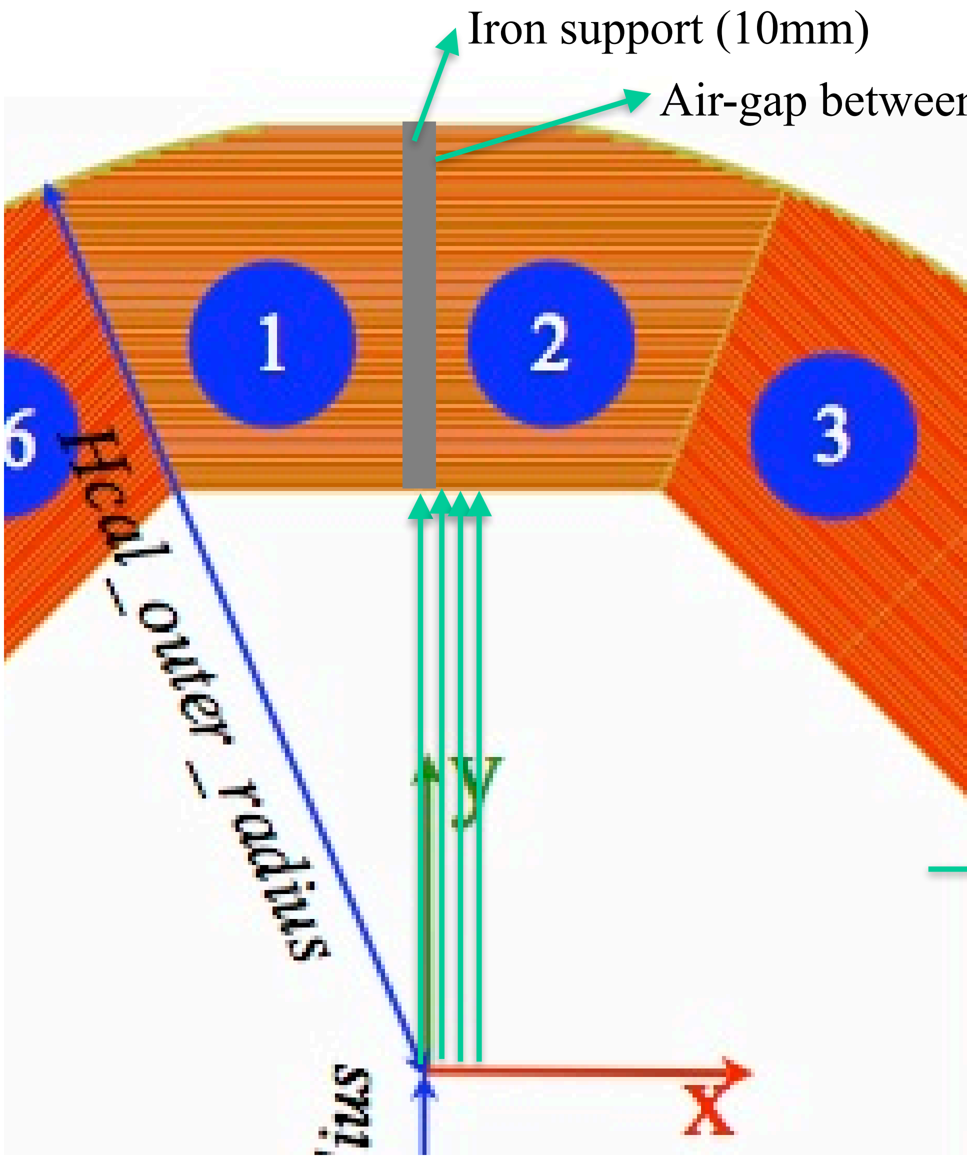
Effect of supporting structure (*r*,phi) plane

ILD-AHCAL view (*r*,phi)

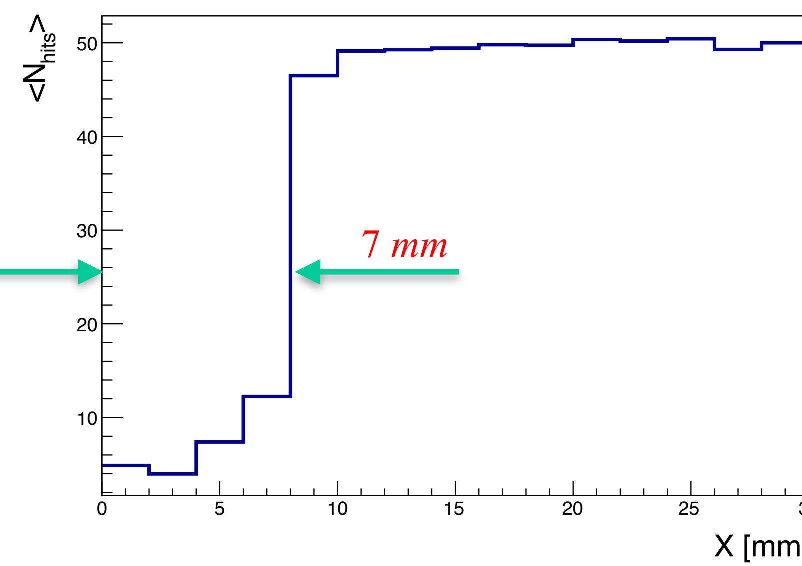


- Highly symmetric structure: 16 sectors of identified shape, but pointing cracks (filled with steel)
- Can be made non-pointing, but less simple construction
- Question: How big is the effect?

Simulation at supporting structure and neighbouring area



- Shooting muon parallel to iron support in 2mm step to check boundary modelling (0-30mm range)
  - At X>7mm (=10mm/2 + 2mm) muon should leave hits on 48 layers



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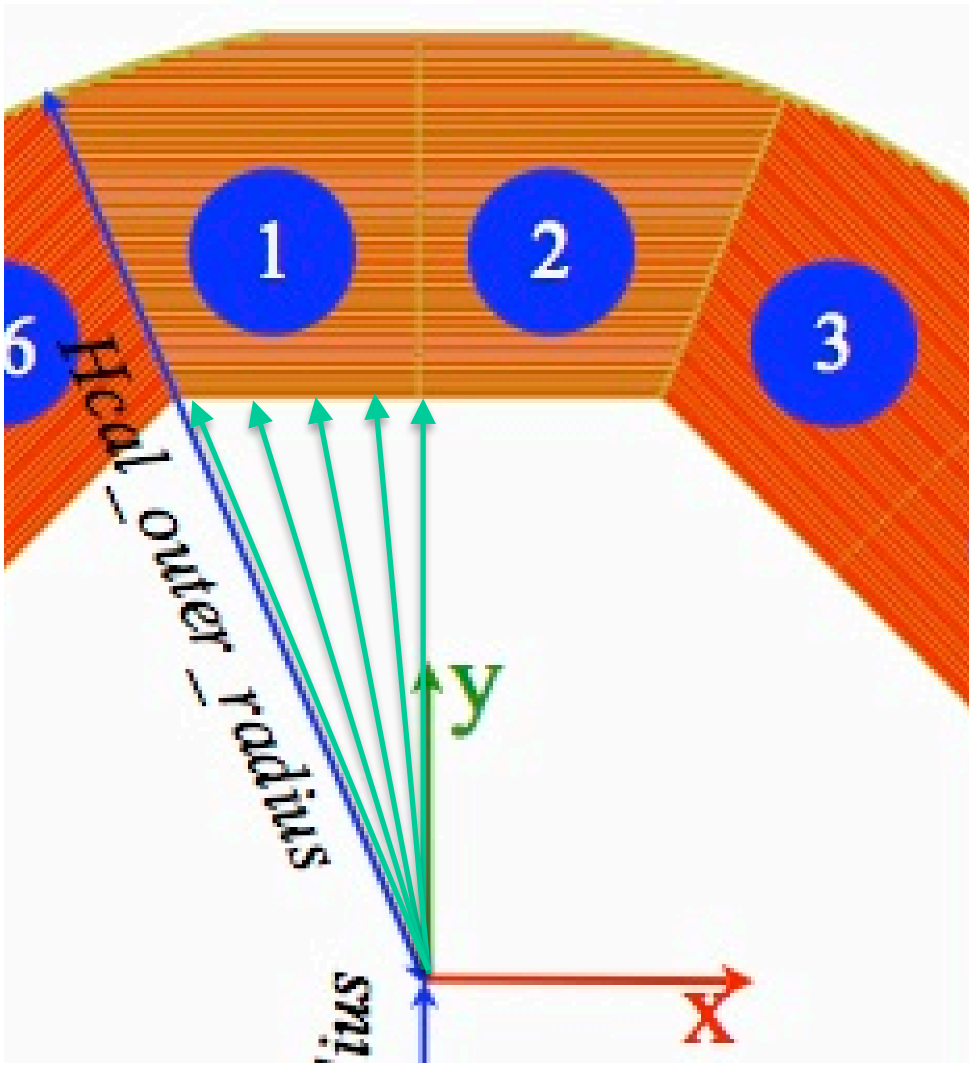
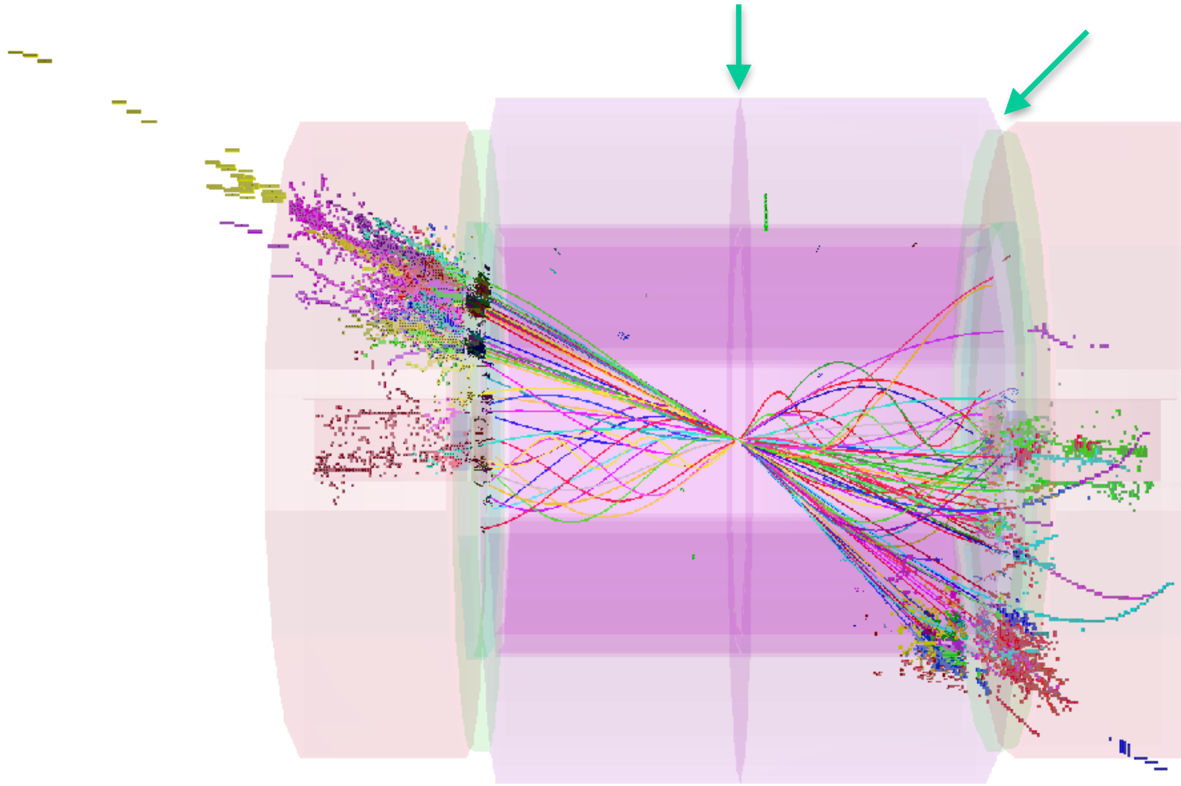


- Shooting Kaon0L in 5 different directions:
  - Avoid iron support at z = 0
  - Direction 1 and 5 correspond to iron support between modules
  - Compare with other geometry designs to estimate the effect

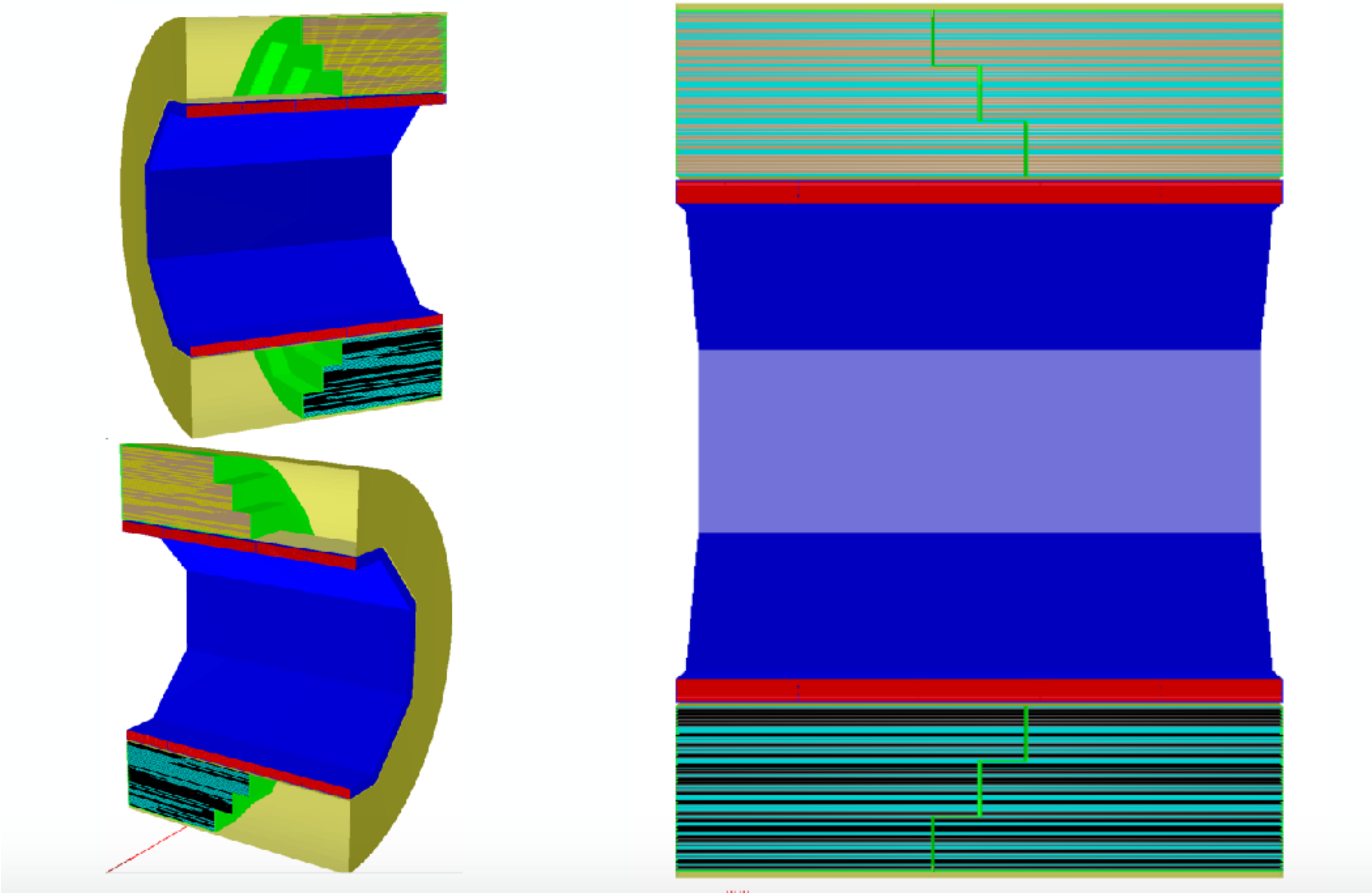
The z = 0 region

In principle should be considered together with TPC



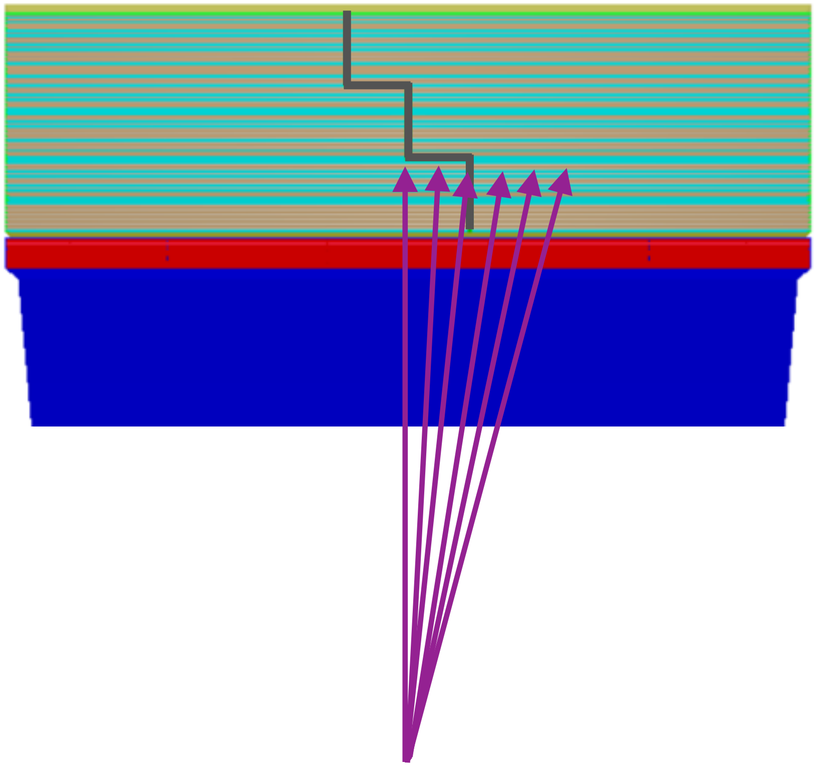
New AHCAL Barrel design

- AHCAL-Barrel driver with staircase-like support at theta=90° implemented in DD4hep
  - Study the influence of this new structure on energy reconstruction

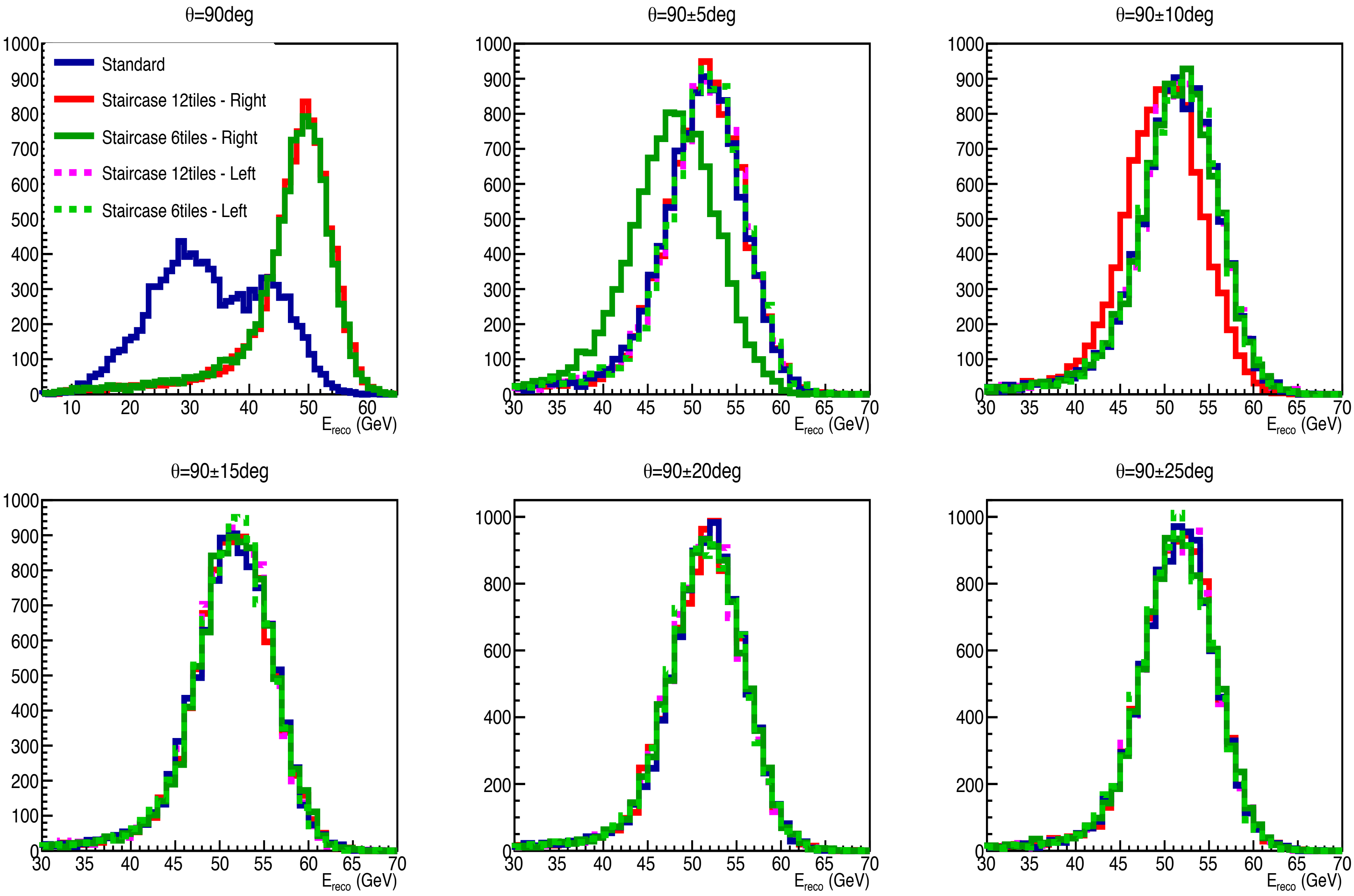


New AHCAL Barrel design

- Shoot Kaon0L at theta = 90, 85, 80, 75, 70, 65 degree
  - Also study left side effect (theta = 95, 100, 105, 110, 115)
  - Expect some degradation at theta = 90 & 80 degree



Reconstructed energy

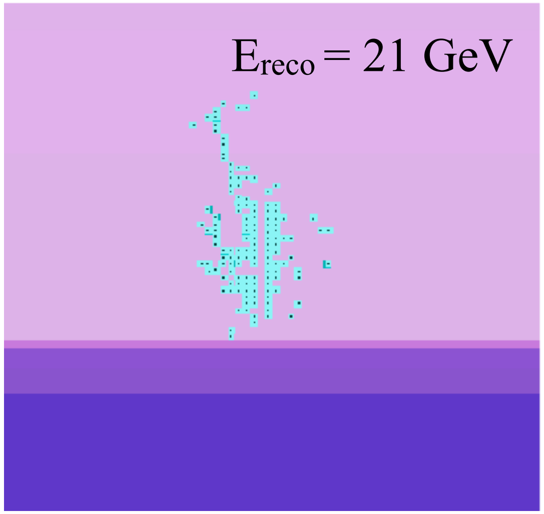


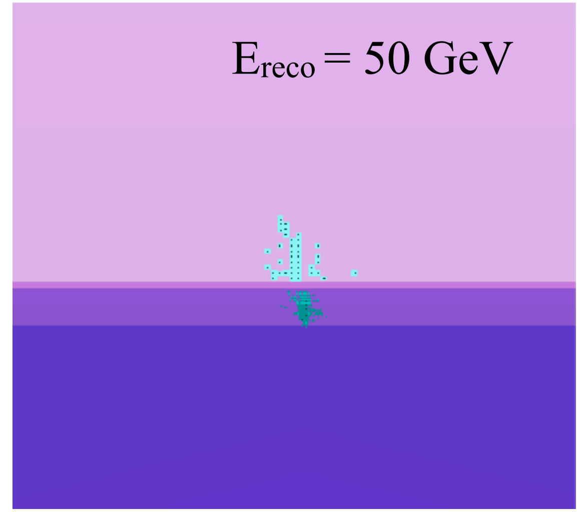
Staircase vs standard

- Effect at z = 0 disappeared
- Small effect (w/o correction) at 5^{o} (10^{o}) for 6 (12) tiles wide step on the side with the boundary closer to the IP
  - only shift, no tails: correction should work well
- No effect for the other side

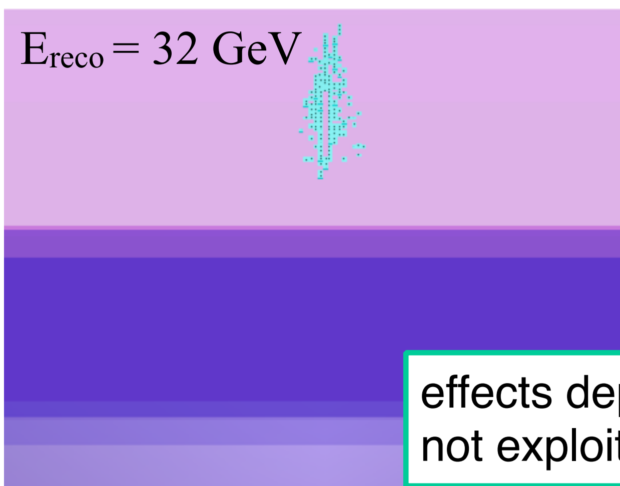
Events

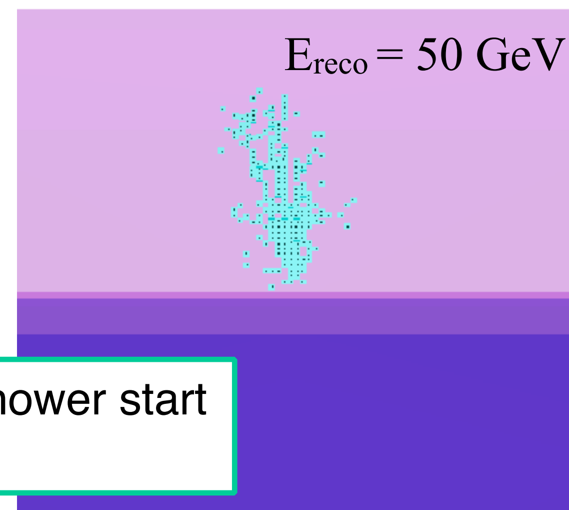
Standard design





Staircaise design





effects depend on shower start
not exploited yet