Noble Liquid Calorimeter EM EndCap concept: Geometry and Simulation

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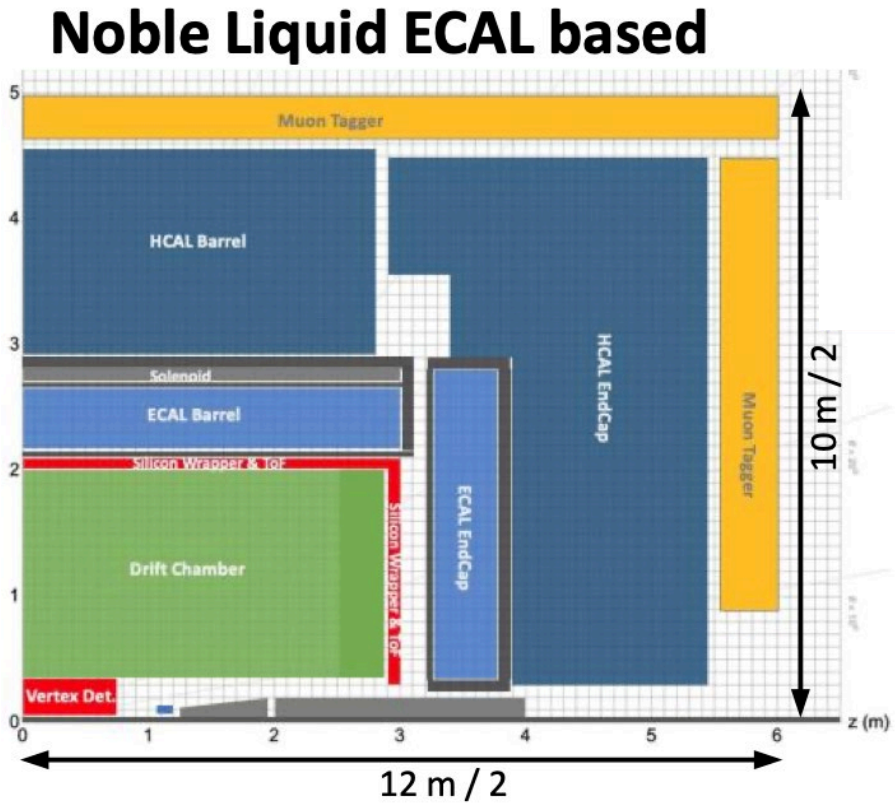
Motivation

- Noble liquid-based (NL) calorimetry is a proven successful technology
- Very likely to be chosen for an FCChh detector because it can withstand the extreme radiation environment
- Desire to maintain NL expertise provides a strong motivation for building an NL based calorimeter for the FCCee
  - nominally this would be part of the ALLEGRO detector concept
- We explore a possible design for the EndCap EM calorimeter
  - Similar to the barrel EM concept which Nicolas Morange presented yesterday
- This is a status report, not a proposal

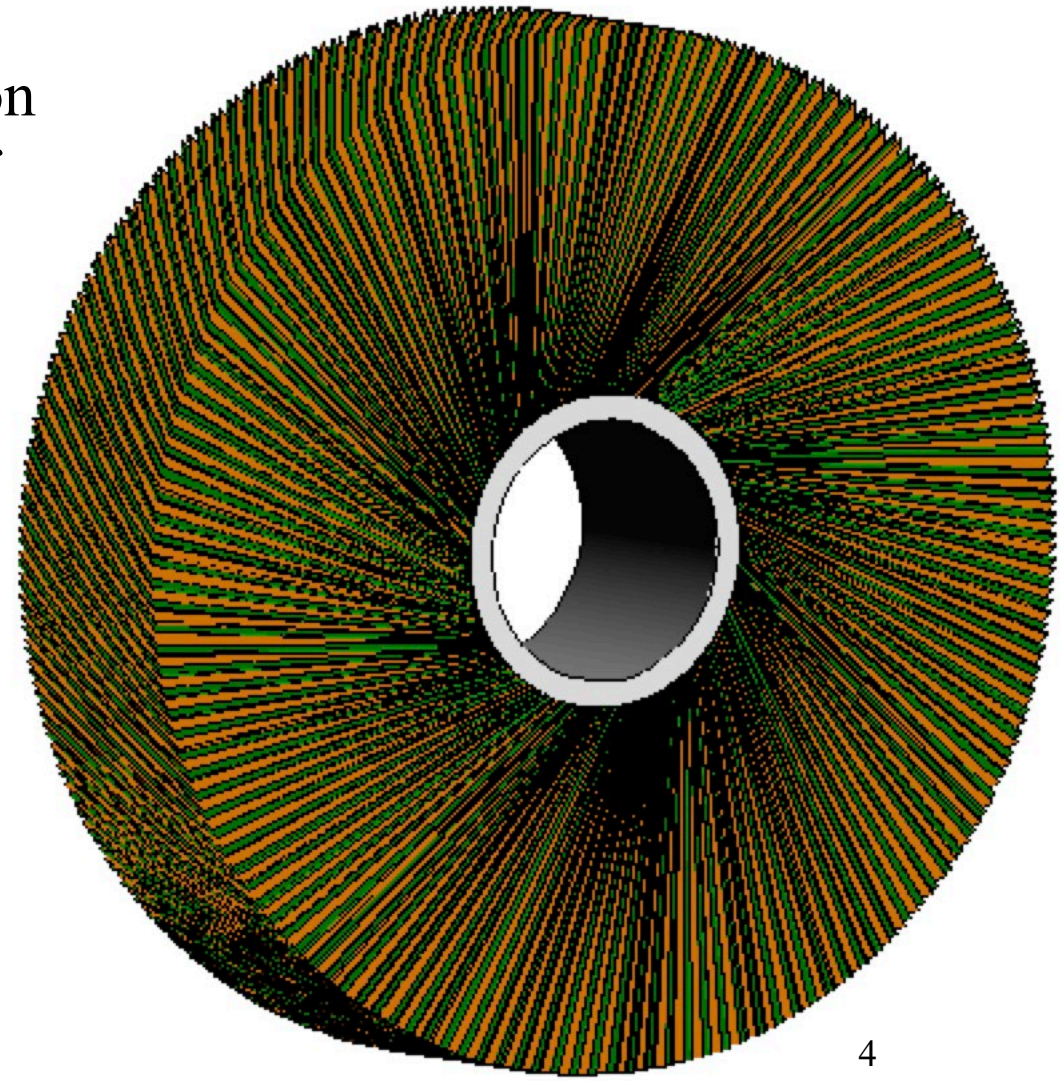
General considerations

- The endcap EM calorimeter is assumed to be a disk with inner radius 42 cm and outer radius 275 cm
  - midplane at z = 348 cm
  - depth in *z* is 45 cm
- Sketch of ALLEGRO subsystems (link):

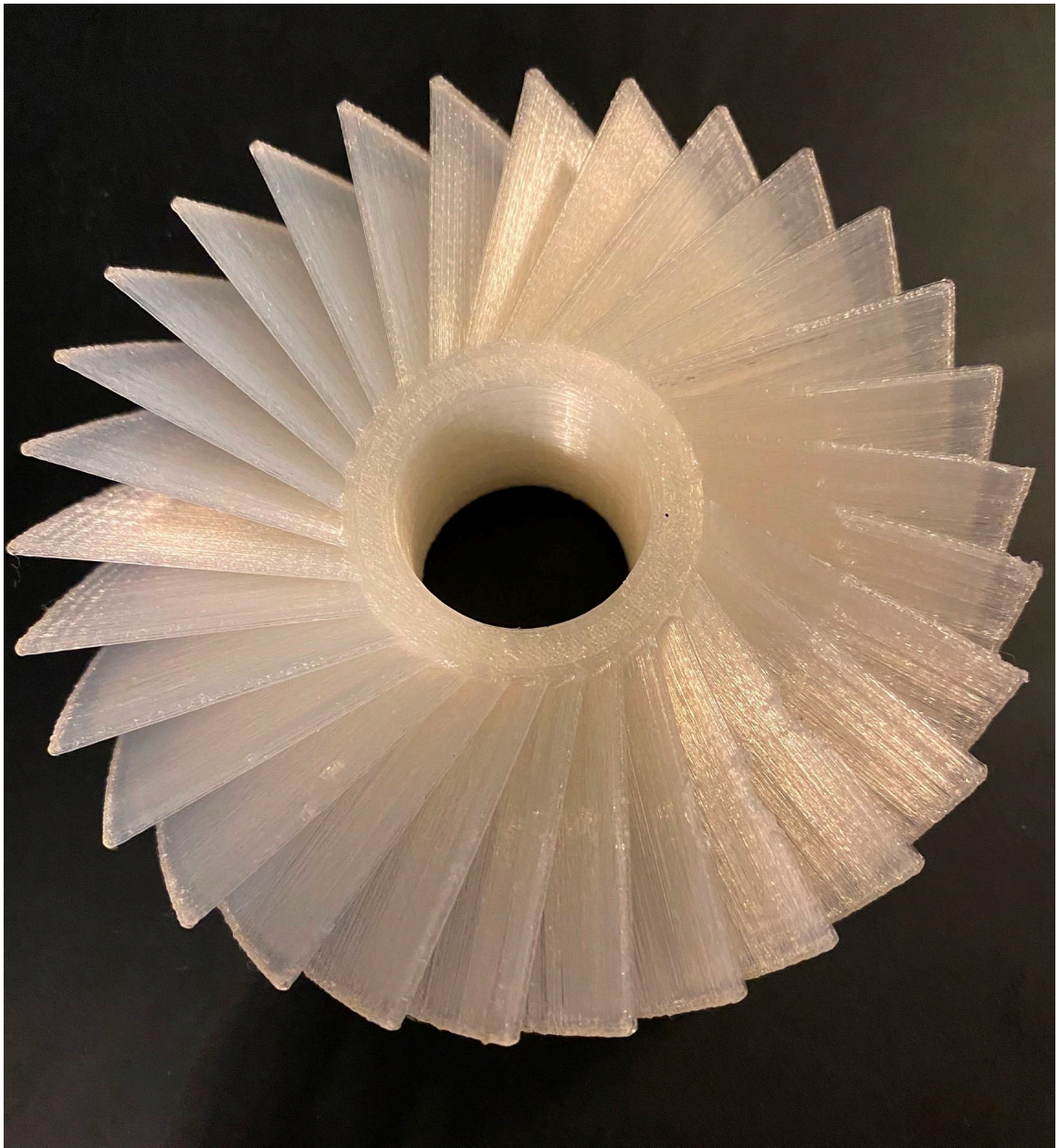


Turbine Concept

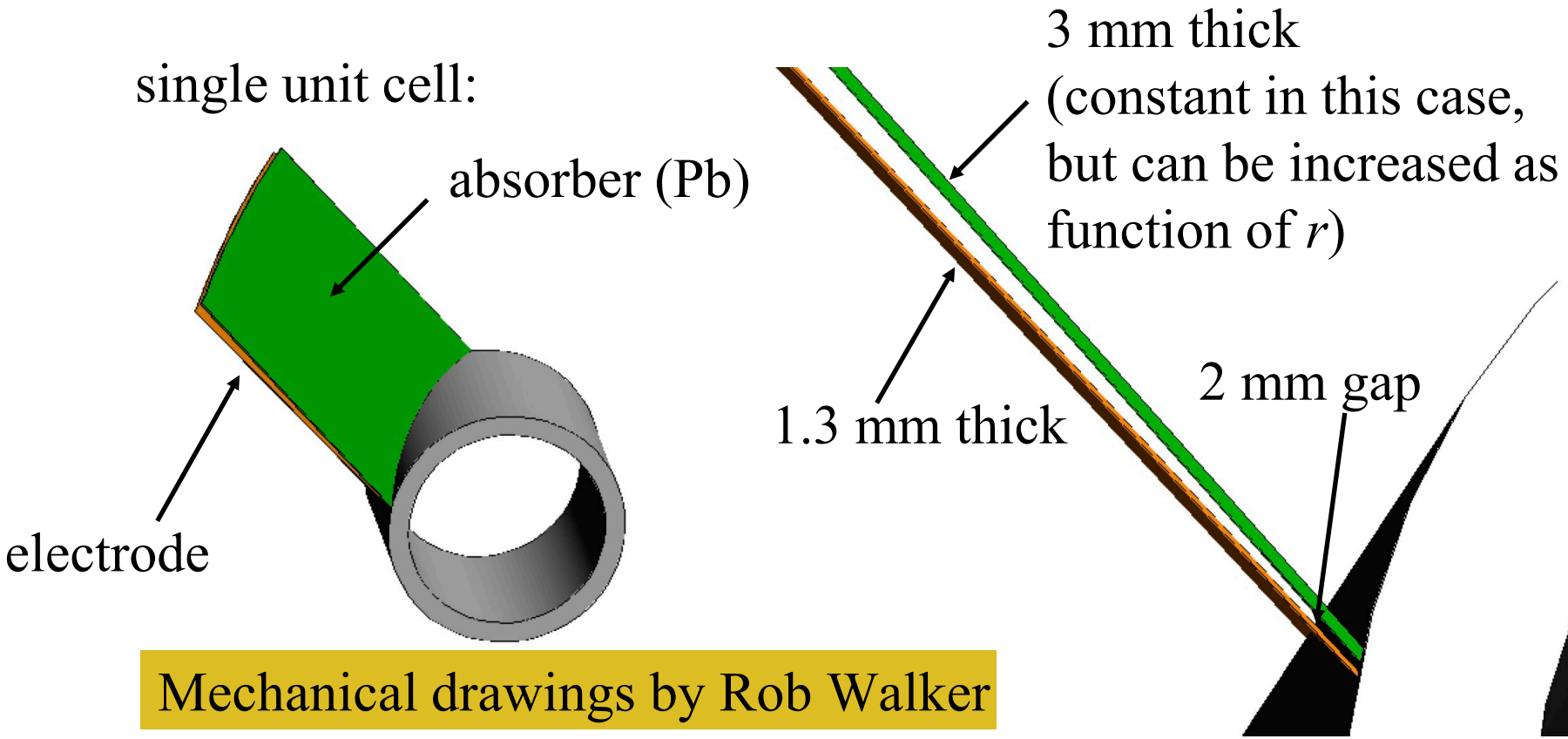
- Inner radius portion with the full set of absorbers and electrodes (~240 of each):



Simplified model from 3D printer

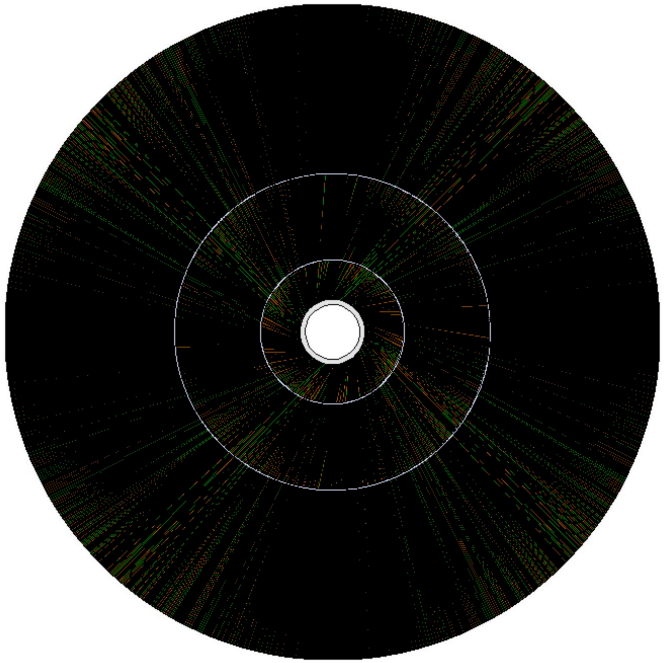


- Tentative absorber geometry motivated by
  - desire to have many thin absorber plates (for spatial and energy resolution)
  - desire to have readout directly from high-$|z|$ edge of electrodes
  - desire for uniformity in ϕ



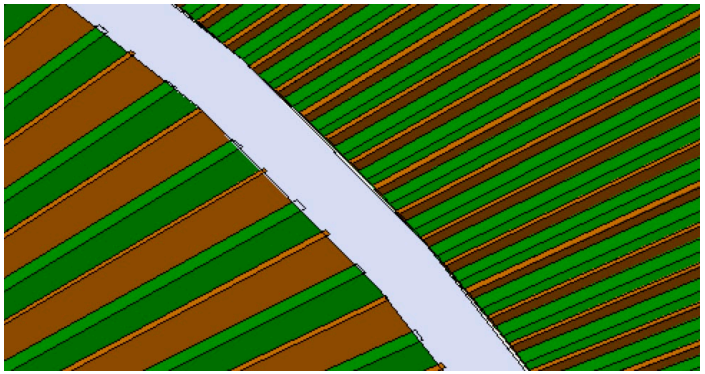
Mechanical drawings by Rob Walker

- One consideration is the variation of the gap with radius
  - means that response is very different at the inner and outer radii (42 cm and 275 cm)
- To mitigate this, the detector can be subdivided into a set of nested cylinders:

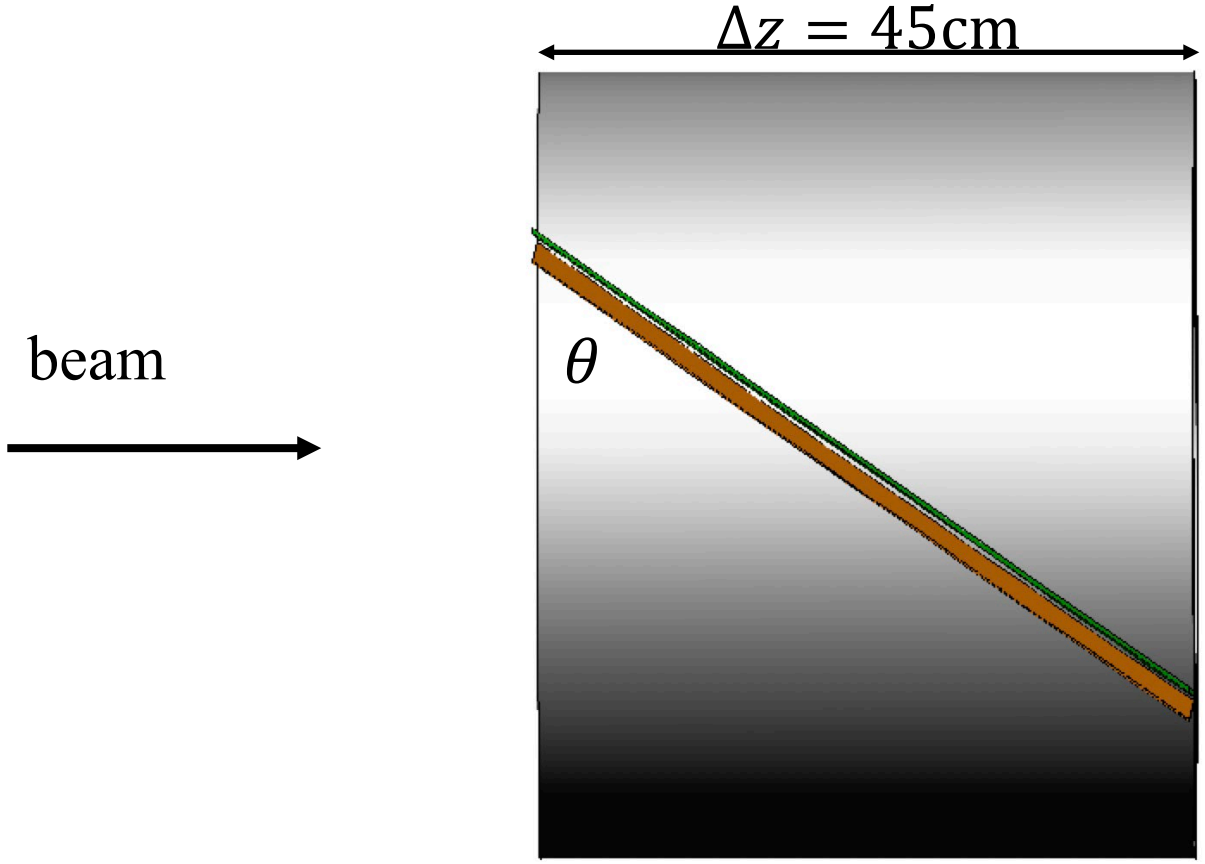


Tradeoff between minimizing variation in gap width vs. minimizing transitions/dead areas

In this example, each cylinder has $r_o/r_i \approx 1.9$



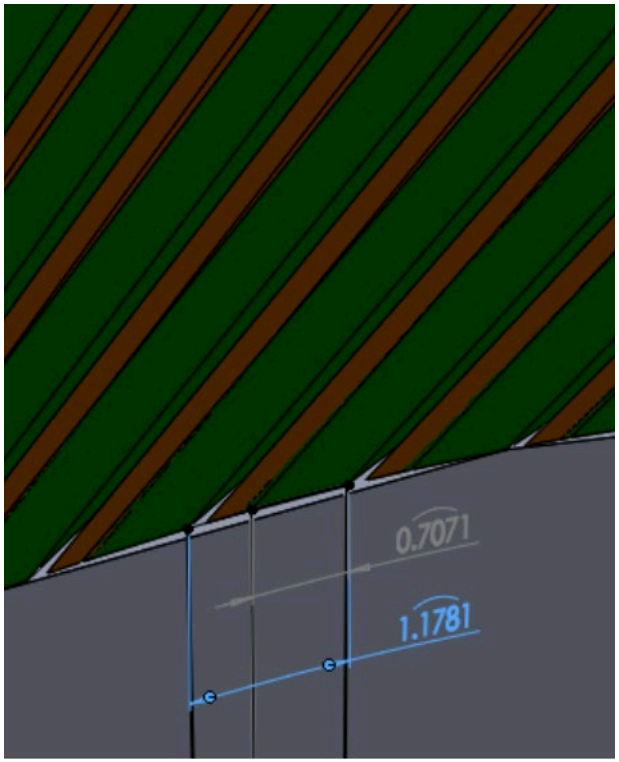
- Some notable parameters:
  - angle of plates wrt face of the cylinder:



- Optimization studies indicate that θ should be as small as possible
  - theoretical minimum is $\tan^{-1}(\Delta z/2r_i) = 28.2^\circ$

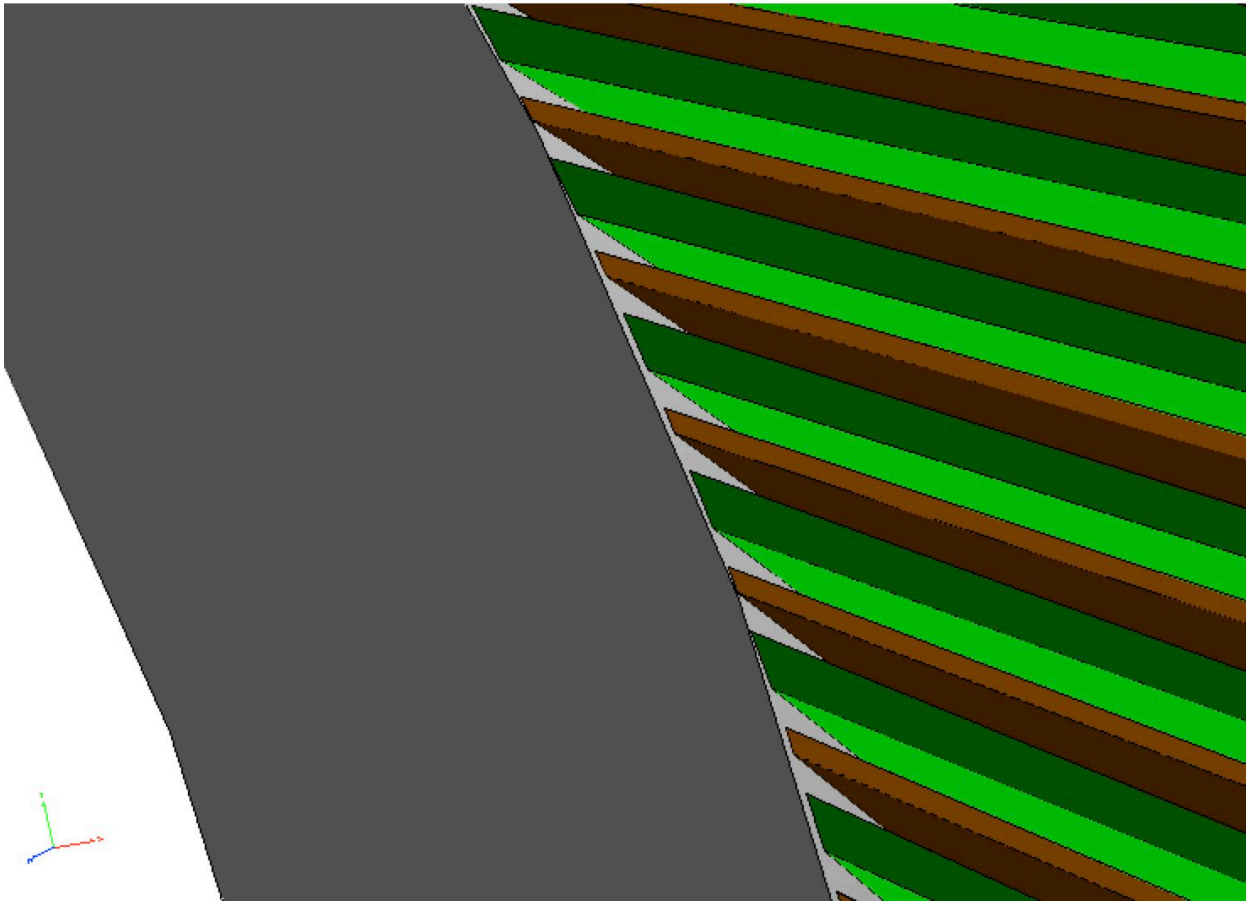
- But there are practical problems with an angle too near that minimum
  - leads to tiny gap or even interference between plates at inner radius

Example for $\theta = 45°$



- θ is set to $55°$ for the studies shown here

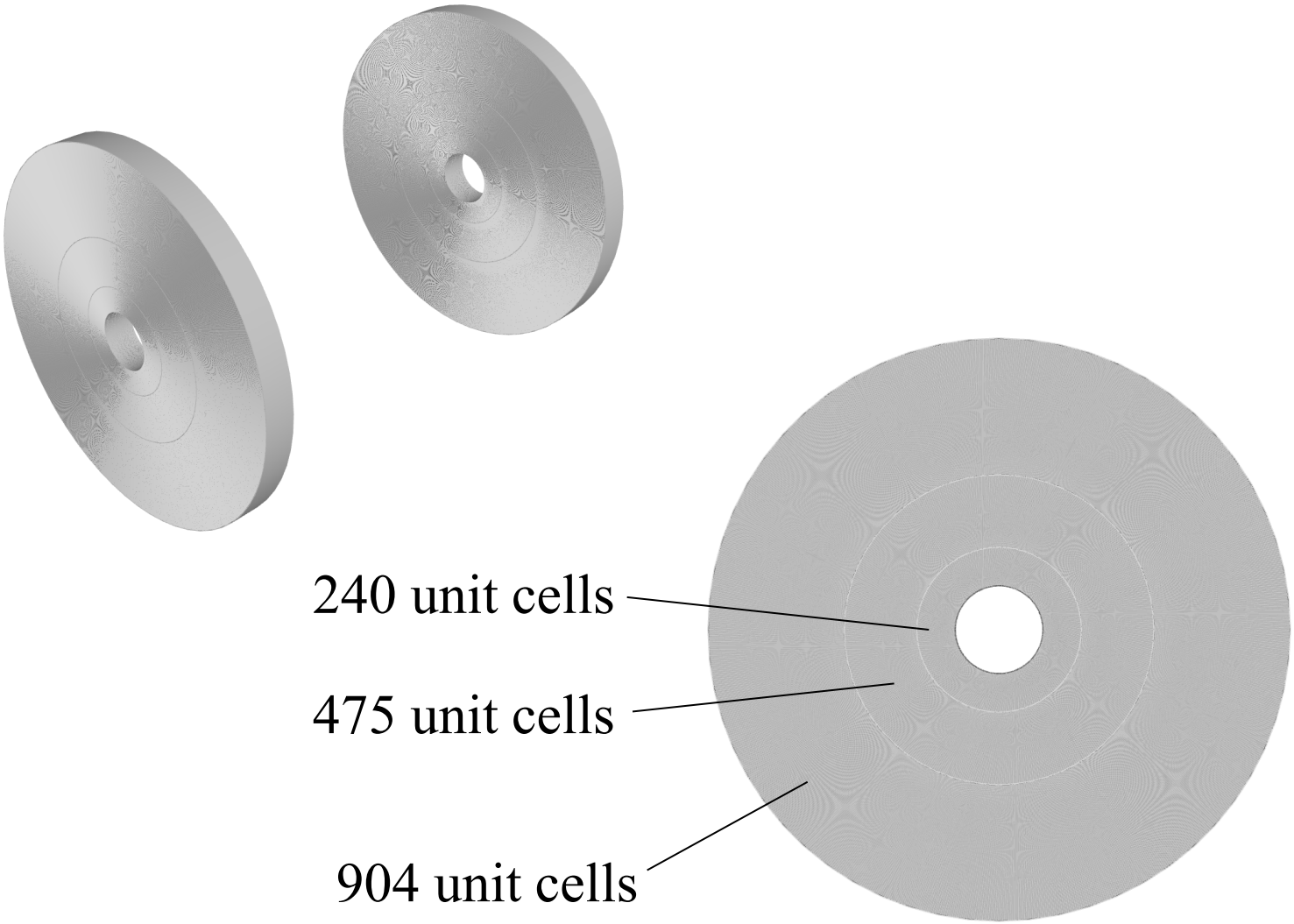
- This avoids “pinching” the NL gap at the inner radius while keeping a relatively large number of plates
  - necessary to allow frequent sampling, and to contain the EM shower



Simulation Status

- Initial exploration of the geometry was done with a standalone Geant simulation
- We are at the point now where a more realistic simulation (including actual reconstruction, etc.) is needed
  - so progress on integrating into the ALLEGRO simulation framework is in progress
- Development in k4geo at https://github.com/varnes/k4geo
  - xml to set parameters
  - cpp file to define the geometry

Geometry used in the simulation

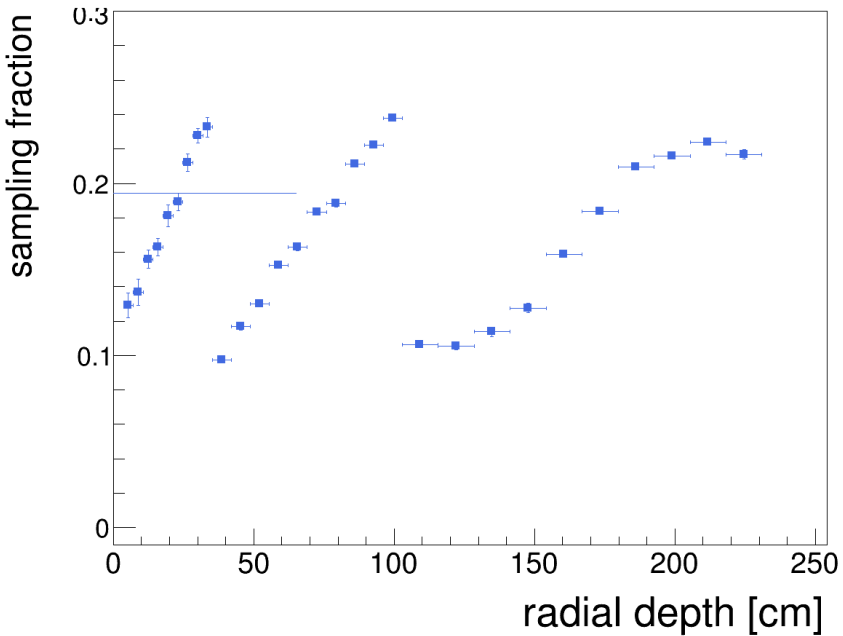


Initial Study: Sampling Fractions

- It is expected that the sampling fraction will vary with distance from the beam line
  - due to the variation in LAr gap size
- In principle, absorber thickness can be varied to compensate, but at the moment this is not implemented in the simulation
- Radial "layers" created to allow the sampling fraction calculation
  - each sub cylinder divided into 10 layers, equally spaced in *r*
  - examples of the layers on a single turbine blade are shown in green below:

Sampling Fraction Results

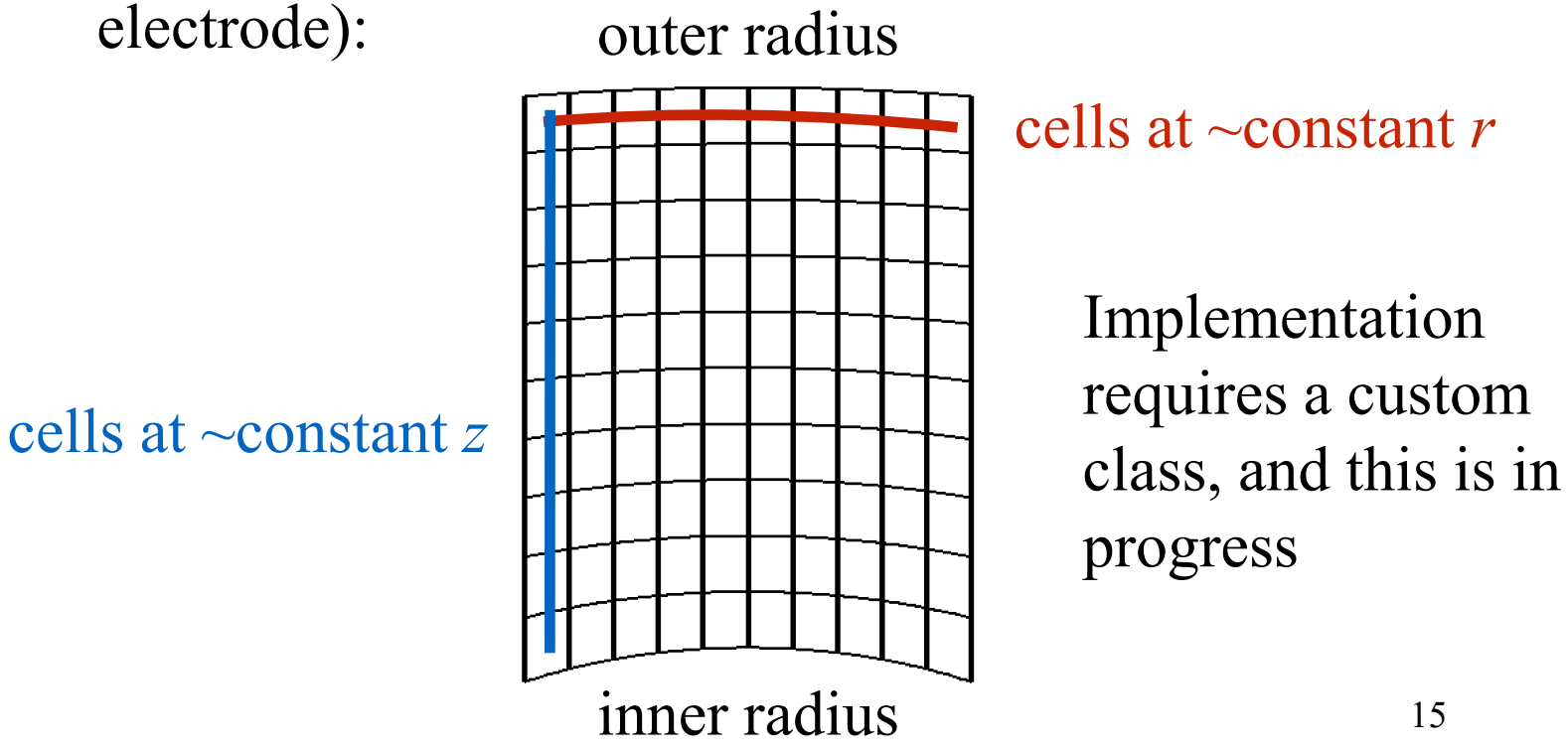
- For the initial study, 1000 electrons of 10 GeV each were generated with the particle gun and distributed uniformly across the calorimeter
- Standard procedures and tools were then used to calculate the sampling fraction
  - e.g. setting the absorber and electrode to be active as well as the LAr
- Result:



Conclusion:
We need to taper the absorber thickness with radius

Next Steps

- Once refined, the sampling fractions will be used as input to the reconstruction
- Reconstruction will also require the definition of a readout segmentation and a corresponding positioning tool
- Initial concept for segmentation (looking face-on at an electrode):



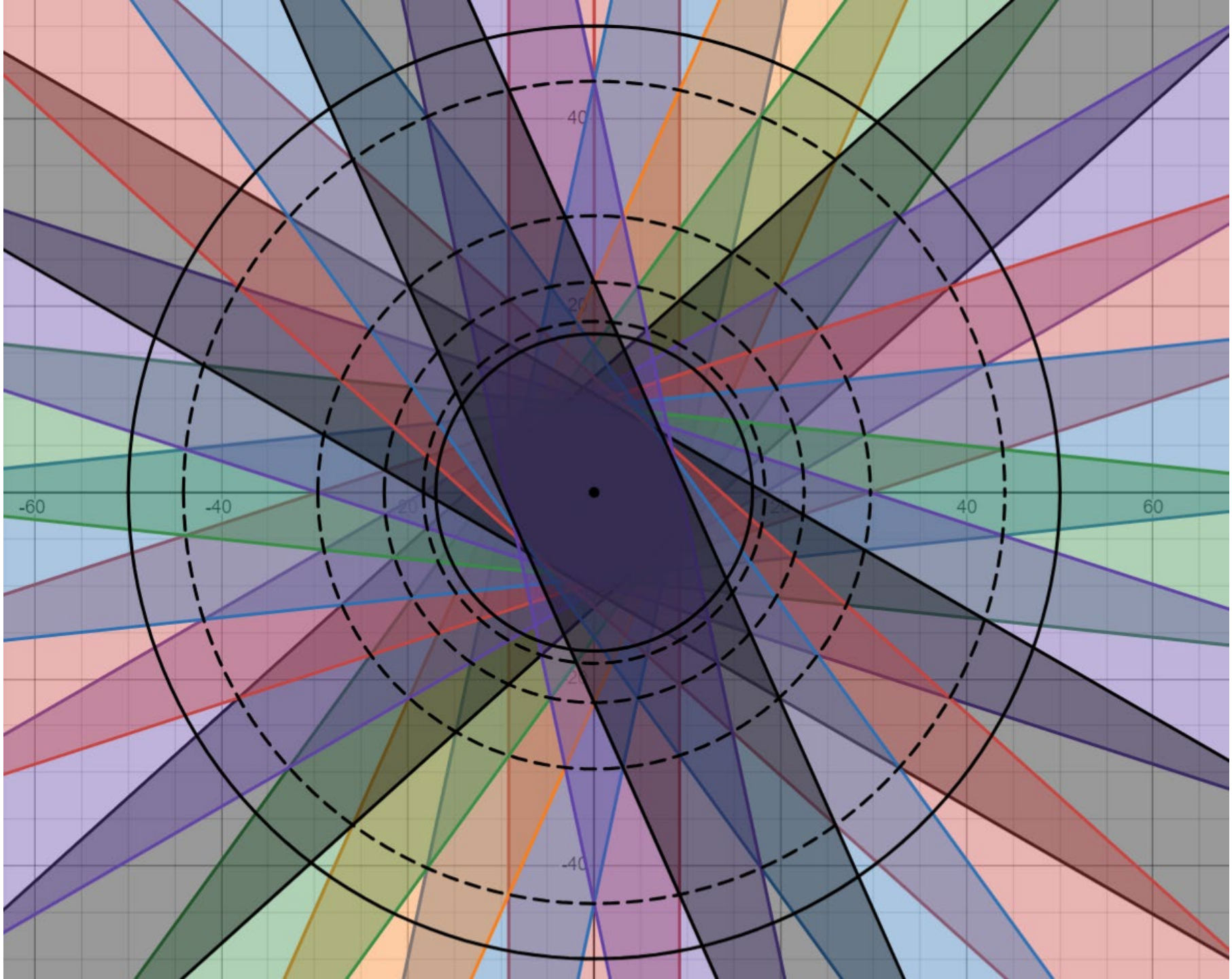
Implementation requires a custom class, and this is in progress

- Once the model is fully integrated into the reconstruction, a complete set of studies will be done to:
  - optimize absorber thickness, noble liquid gap, blade angle
  - study LKr vs LAr
  - assess the effect of varying absorber thickness with radius
- Need FEA analysis for structural integrity studies
- Need to work out how to construct the wheels
- Plan to build one to three electrodes
- Foresee testbeam studies with barrel and endcap

Summary

- A “turbine” geometry concept for the ALLEGRO endcap EM calorimeter has been developed and integrated into the ddsim framework
- At this early time we don’t foresee any show-stoppers

Backup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