dRICH Geometry

acceptance, snout length, aerogel size

C Chatterjee and C Dilks

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Outline

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2. dRICH Geometry implementation in ePIC
3. Interdependency of sensor placement and aerogel cone
4. Visualization of photon paths and hits from simulation
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    - Intermediate cone depths
5. Estimation of the sensor sector surface
6. Comments and Questions from our side

Standing issues with the dRICH simulation

Currently, we are working mainly on two standing issues with the dRICH.

- dRICH Cherenkov angle resolution depends greatly on particle pseudo-rapidity. Spherical aberration needs to be handled with dual mirror configuration. Work in progress.
- The loss of photons (mainly from gas radiator) for high pseudo rapidity particles. Description of the sensor placement depends on the description of the aerogel cone. Hence, the parameters of the aerogel cone description is under scrutiny.

In this update we focus on the second issue.
Last time, we reported that 110 cm inner radius was conflicting extension of the photon-sensor to allow the photons to get detected. We were told to stick to 90 cm to avoid conflict with other sub-detectors. Aerogel cone inner radius changed from 110 cm to 90 cm, a git PR is under evaluation.

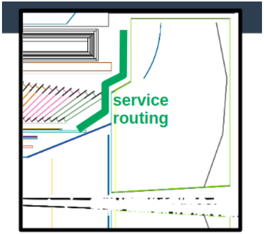
For more information of the problem please look into Chris's update in GD/I Jan 30

Description of dRICH Geometry in ePIC stack

1. The dRICH geometry is described in ePIC with several free and constrained parameters in an .xml file.
2. These parameters are very much interrelated. For every geometrical or optical tuning a set of multidimensional adjustments are made.
3. We do not change any constrained parameters for the tuning purpose (e.g. distance of dRICH entrance from IP).
4. Few recent updates in the dRICH geometry has been implemented related to the placement of sensor positioning and reduced aerogel inner radius (from 110 cm to 90 cm). Here we are reporting all the studies using 90 cm inner radius of the aerogel.

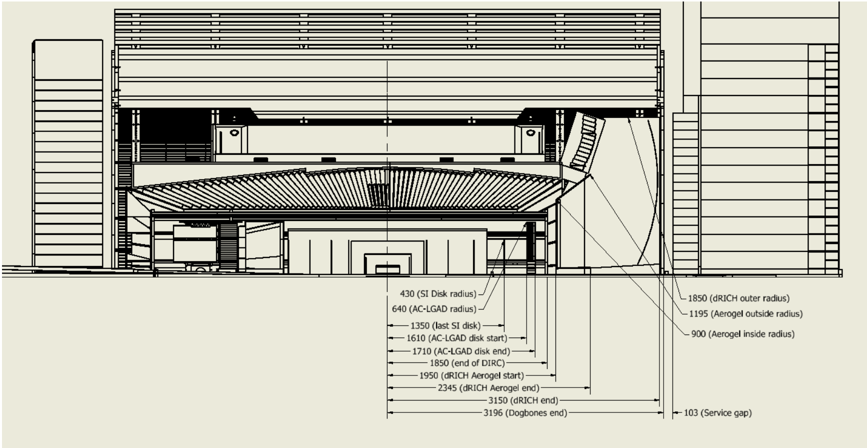
Aerogel cone and sensor placement

- The sensor coverage is dependent on the outer-radius of aerogel cone. Therefore, on the depth. Assuming a projective nature the outer radius of the aerogel cone is: $tan(atan(r/L) + 0.2) * d$
- Where, r (inner radius of the cone) = 90 cm, L (distance of dRICH entrance from IP) = 195 cm; d (cone depth) = open question to us. The radius has to be big enough to contain the full ring of the aerogel, therefore 200 mrad added to the projective slope of the aerogel cone. But, not so much that it shadows the photons.
- The spherical patch of the sensor starts after the end of the aerogel cone. The lowest value of the placement in X dimension has to be greater than the outer radius of the cone.



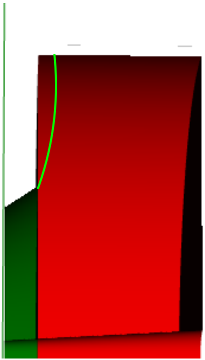
- The effective size of the sensor-surface essentially reduces due to outer radius of the aerogel cone. The outer radius is a function of:
  1. The inner radius. (Last time 110 cm caused the issue. Fixed by changing to 90 cm)
  2. The slope of the aerogel cone. (So far never created a problem)
  3. The depth of the cone. (Today's concern)

Geometry drawing

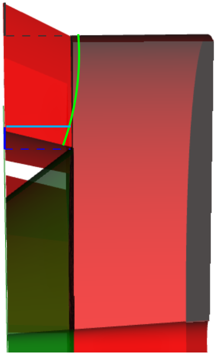


We have implemented the geometrical parameters as followed in the diagram. Namely, 90 cm aerogel, 39.5 cm aerogel cone and 119.5 cm of aerogel cone outer radius, we have also extruded the vessel to accommodate the sensor box. **And checked possible effect of shadows**.

Envelope for simulation: Visualization of Extrusion



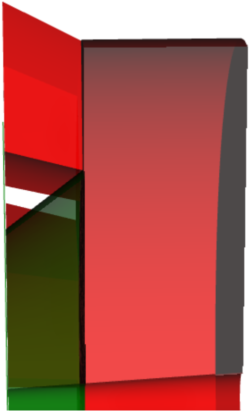
W/O Extrusion

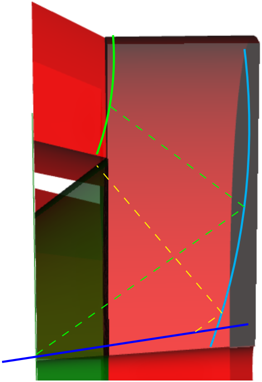


Extruded

- Aerogel cone inner radius : 90 cm (We are treating this as a constraint parameter)
- Aerogel cone depth : 39.5 cm (Parameter we want to test)
- Aerogel cone outer radius : 119 cm (Constrained by depth and inner radius)
- Extrusion Implemented. Length : 39.5 cm (The cyan line)
- Extrusion R_{min} : 10.0 cm (Defines the blue line)
- Extrusion R_{max} : 20.0 cm (Defines the thick black line)

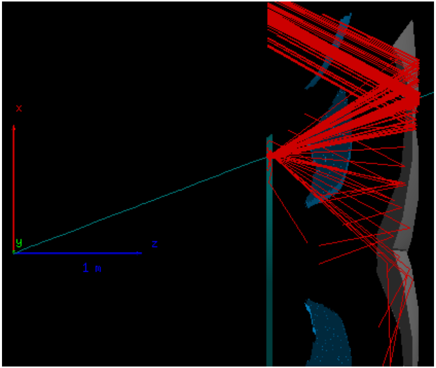
Envelope for simulation: Visualization of photon-path (intuitive)

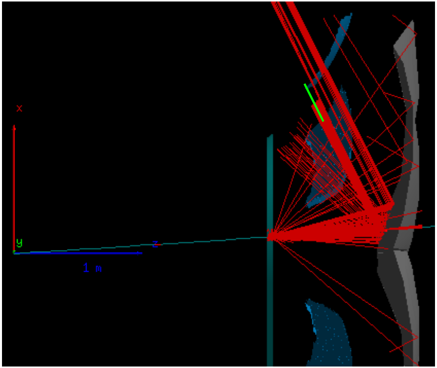




1. If the aerogel cone is too large it can block the reflected photons. The gas photons of high pseudo rapidity will suffer the most due to their small angle. The aerogel photons (due to large angle) and also gas photons coming small pseudo rapidity particle will be less affected .
2. We can imagine to play with the mirror radius to recover the photons. Shortens the gas length for high pseudo-rapidity particles. Causing reduced number of photons for high pseudo rapidity particles. Critical for PID.

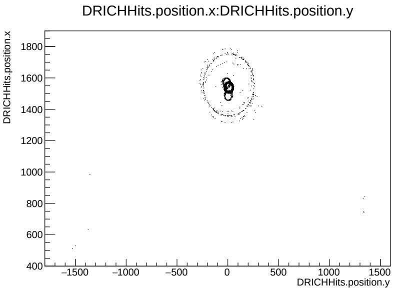
Visualization of Cherenkov photon propagation: 40 cm aerogel cone

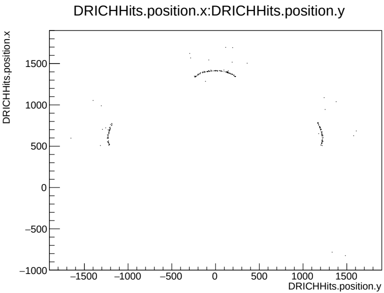




The right hand plot shows that the aerogel cone of length 40 cm(outer radius 119 cm) shadows the gas photons coming from particles with high pseudo rapidity. The extrusion length is same as the aerogel cone length. With maximum and minimum offset 20 cm and 10 cm.

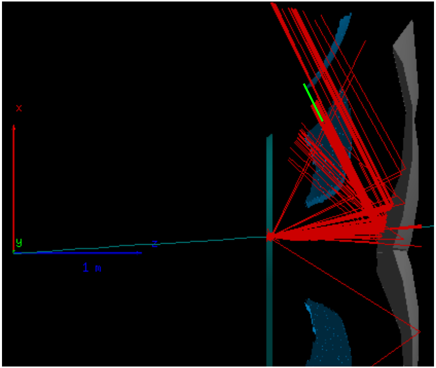
Hit display

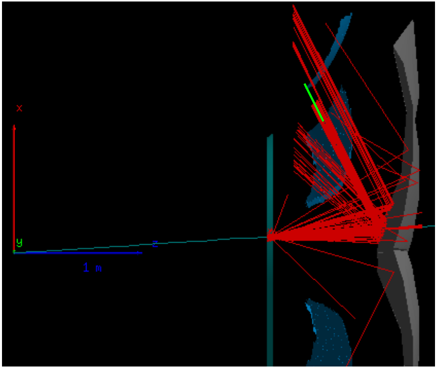




At highest eta (right plot) the photon hits generated in the gas are missing due to the vessel of the 40 cm cone.

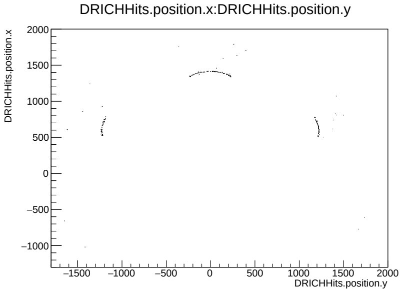
Visualization of Cherenkov photon propagation: Changing extrusion box parameters

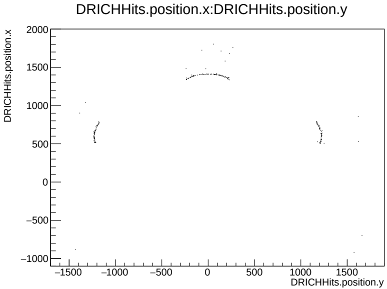




The design of the extrusion size and shape is immaterial to recover the photons given the cone length is 40 cm. Left plot: offsets are reduced by half; Right plot: extrusion length and offsets are reduced to half.

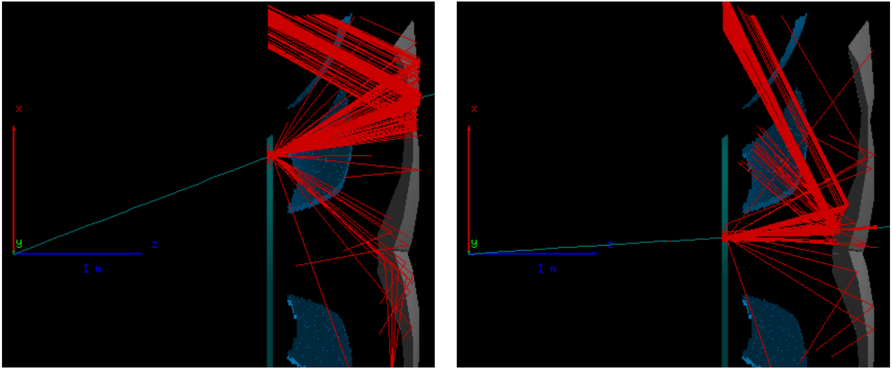
Hit display: Changing extrusion parameters





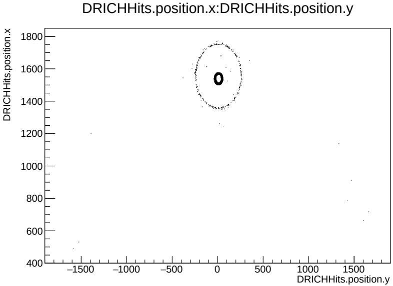
The lesson we have learned: the cone depth or the outer radius is critical for the detection of the photons of high pseudo-rapidity. It reduces the available space for sensor placement and shadows the photon. The sensor extrusion box length or offset values have no effect in photon detection for critically long cone depth.

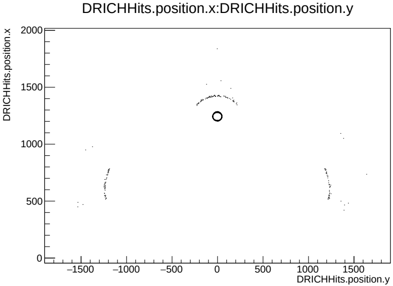
Aerogel cone depth set to 20 cm: photon path visualization



With 20 cm aerogel cone depth (outer radius 105 cm) we can recover the full gas ring for high pseudo-rapidity particles.

Visualization of Cherenkov hits

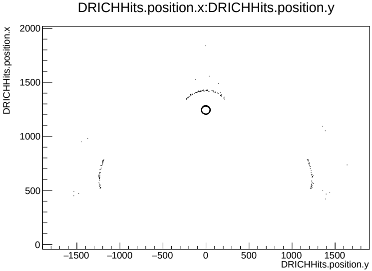




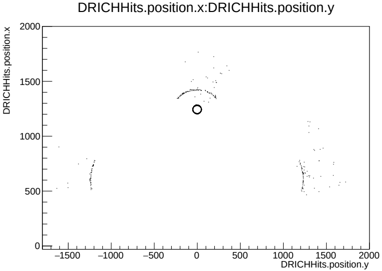
We can notice the full ring at the highest eta generated in the gas. The 20 cm cone depth reduces the outer radius to 105 cm and this allows the photons to reach the sensor. Given this shape has no conflict with other sub-detector system, we can recover the acceptance in very forward pseudorapidity.

Effect of intermediate cone depths

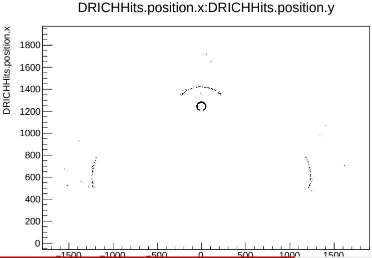
cone : 20 cm



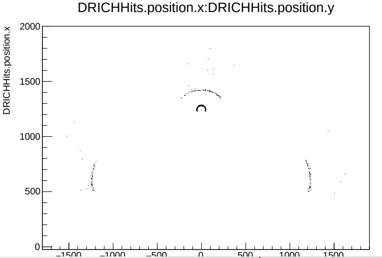
cone : 25 cm



cone : 30 cm



cone : 32 cm



Estimation of the required sensor-sector surface

We tried to estimate the requirement for sensor-surface. In simulation, we use 25.8 X 25.8 mm^2 of sensor units. We are just estimating the total area for a given configuration.

Depth (cm)	R_{Out} (cm)	NSensors	Area (m^2)	Remarks
20	**105**	**825**	**0.55**	**Full Ring**
25	**108**	**799**	**0.53**	**Full Ring**
30	112	754	0.50	Shadow starts
32	113	737	0.49	Half Ring
40	119	666	0.44	No Ring

We at least need to have single sensor-sector surface larger than 0.5m^2. We have 6 sectors.

Questions and comments we have

Comments:

1. The extended **aerogel cone length of 40 cm, will shadow** the photons of high pseudo-rapidity particles generated in the gas. Our standard **20 cm cone is better** from this perspective.
2. For each sensor sector we estimate little larger than 0.50 m^2 per sector of sensor surface to contain full rings in extreme pseudorapidity values.
3. The **effect of the shadow** from the wall of the cone, **starts if its length is around 30 cm**. The **outer radius** of the cone **has to be smaller than 110 cm** to contain the full rings.
4. Titling the mirror can be thought as an option. But we may end up paying heavy price in terms of detected number of photo electrons. In particularly affecting the high momentum particles in very forward rapidity. A detail simulation will be done in the coming weeks.

Questions:

1. What should be the minimum length of the aerogel cone to have no conflict with the other sub-detector systems? Can we stick to **20 cm** aerogel cone depth? We can provide a constraint on the upper limit of the length. Around 30 cm, we will get shadows from the cone wall.
2. What constraints do we have in azimuthal directions? Can we get some CAD modeling or something similar instead of tables? A 3D visualization of the constraints will be more helpful for the geometry description in the simulation.
3. How much space we need to provide for the extrusion boxes? Is 20 cm sufficient?