ATHENA Proposal Committee: Integration & Global Design Subgroup NEWS

Silvia Dalla Torre, Alexander Kiselev, Bedanga Mohanty, Franck Sabatie, Thomas Ullrich & Elke Aschenauer

HOW ARE WE WORKING

Proposal Committee: Integration & Global design

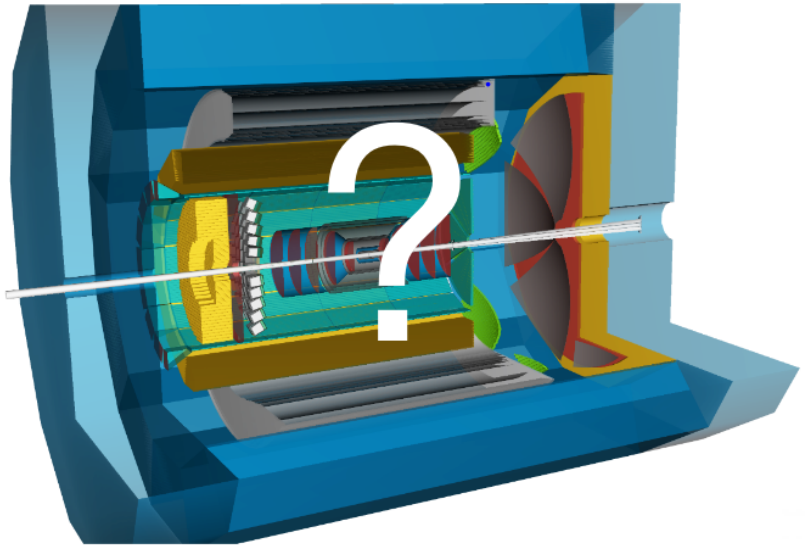
- 13 meetings so far
- each Wednesday, at 11.00 am (EDT)
  - WG conveners invited according to the needs of the agenda of each individual meeting
  - An opportunity to thank all of them for their help and collaborative attitude
  - Material posted in INDICO

- INDICO page: https://indico.bnl.gov/category/378/

Integration & Global Design Subgroup, GOAL

The Goal of the I/GD Subgroup is …

Design this:



and:

- Meet all physics requirements
- Low risk
- Upgradable
- Cost effective
- Superior to other concepts

with:

- Detector Working Groups
- Engineers
- Project
- Software Group
- DD4HEP
- Physics Working Groups
- Patience
- Little Time

In a constructive and friendly way

2

Our report at the previous bi-weekly (9/16), slide by Thomas Ullrich

WHERE ARE WE vs GOAL

INTRODUCTION - The principle that guides us

- Design a detector where:
  - All the essential subdetectors are present in the baseline configuration and no more than that
  - The configuration is realistic from the engineering point of view:
    - The different subdetectors do not interfere one with another
    - The subdetectors can be mechanically supported
    - The subdetectors can be supplied (power, cooling, data transfer)
    - The detector can be assembled

Essential contribution of the project thanks to our project contact person

  - Later, strategic upgrades can be easily accommodated within the baseline configuration

→ Minimize the number of detectors

→ With the help and support of the WG conveners, operate choices

→ Define the R&D's of interest for the base-line and the possible upgrades

WHERE ARE WE vs GOAL

TODAY we report about the CENTRAL DETECTOR

- **Most of our recent activity dedicated to CD**
- **Progress also in defining the design of FF and FB**
  - **Next report**

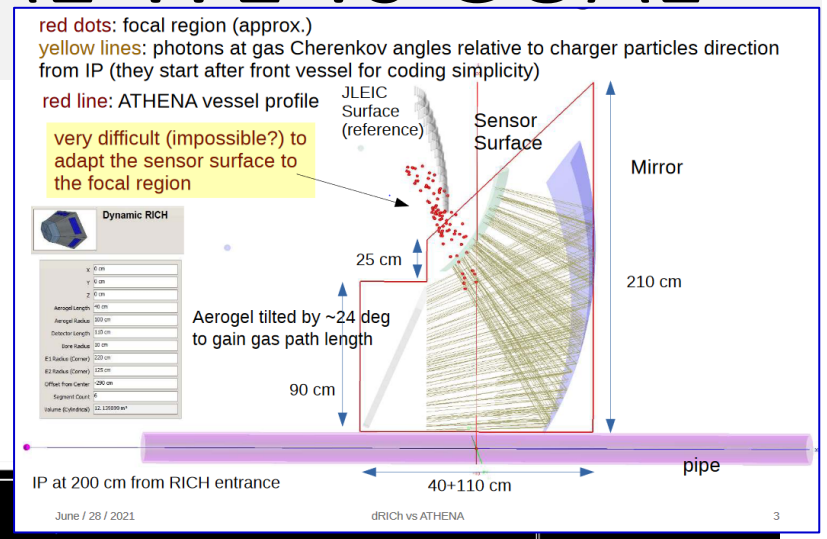
WHERE ARE WE vs GOAL

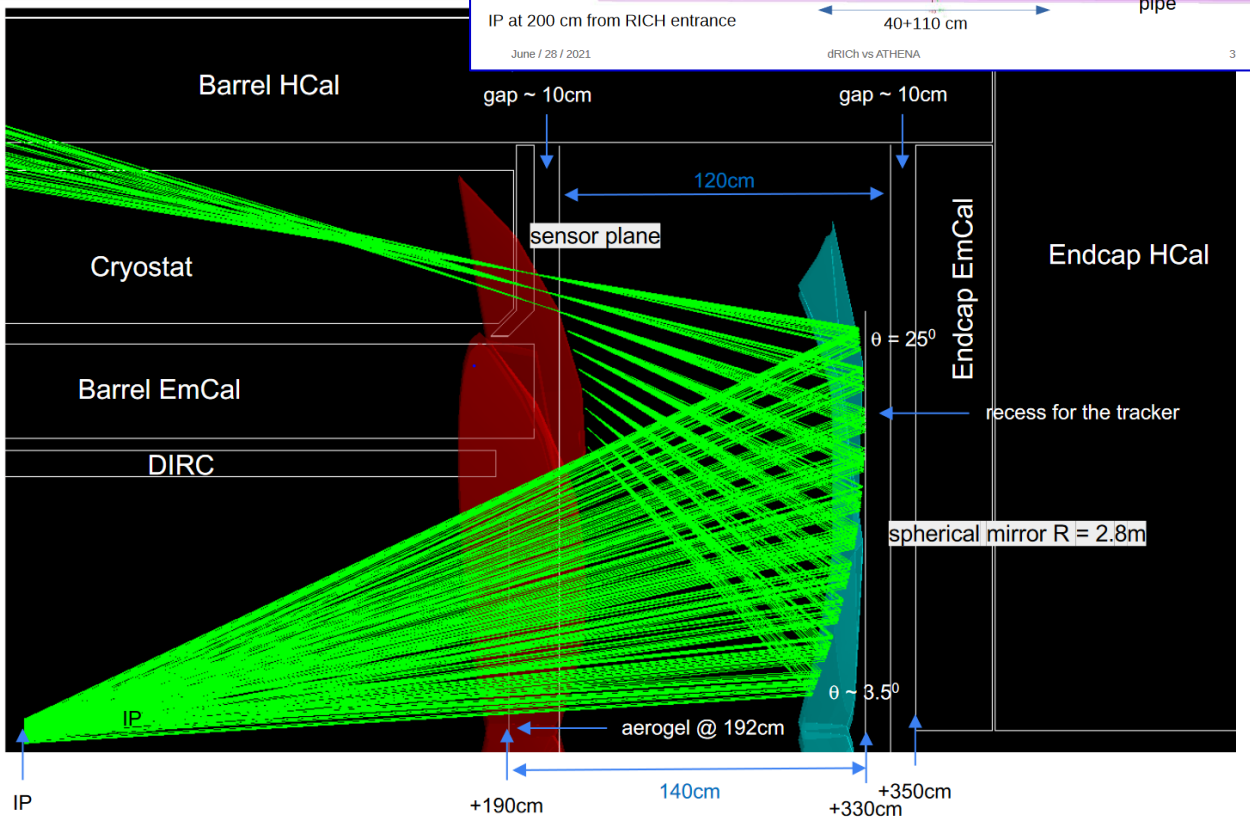
1

CENTRAL DETECTOR, MAJOR DIFFICULTIES ENCOUNTERED

- **Forward endcap, conflicting requirements**
  - **Support of the heavy (~ 100 t) barrel em calorimeter**
  - **Routing out the services for the calorimeter and more inner subdetectors**
  - **Design an effective dRICH optics**
    - **Conflicting:** large angular acceptance, short available space in z, more critical at large radius

Here, examples of the non-successful exercises performed to fit the dRICH optics in the available space (Evaristo Cisbani, Alexander Kiselev)





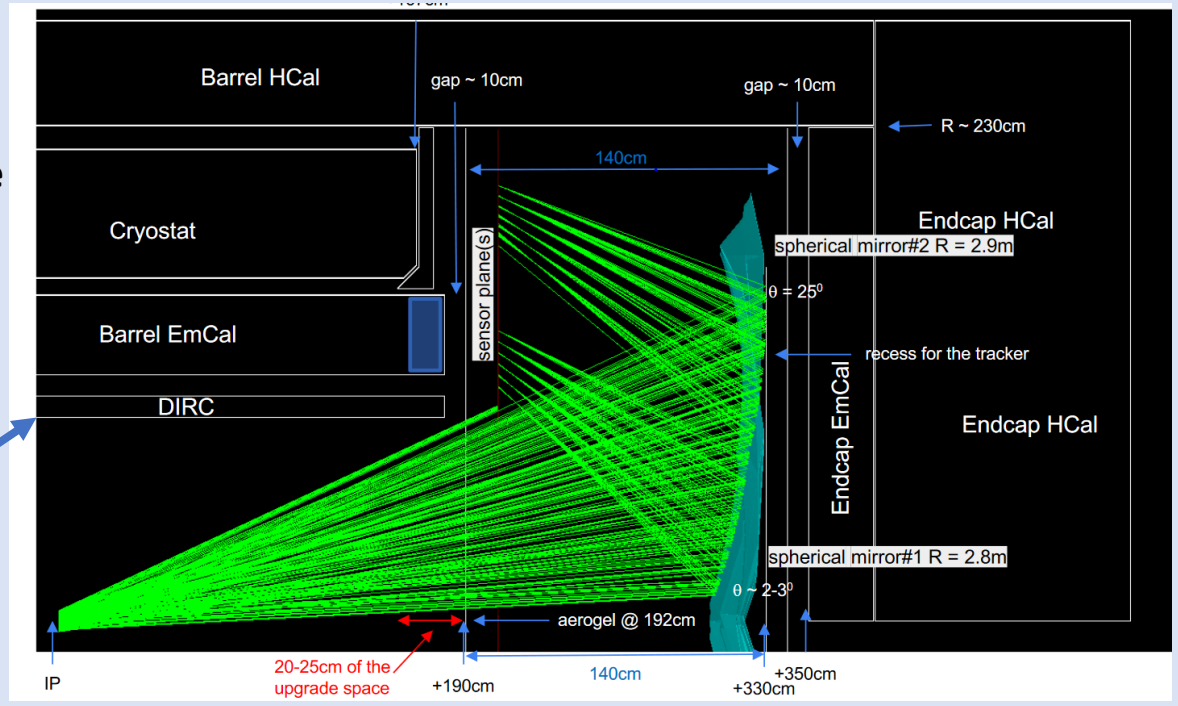
WHERE ARE WE vs GOAL

FORWARD ENDCAP, THE WAY OUT

New field map now available:
https://wiki.bnl.gov/athena/index.php/Project#Magnet

- **Move the solenoid 25 cm backward (thanks, Elke!)**
  - **Correspondingly, make the EC calorimeter shorter in the forward direction**
  - **Obtain more space in z at large radius for dRICH**
  - **Check that an effective dRICH optics can be designed**
  - **STILL IN THE TO DO LIST**
    - **Design an optimized dRICH optics**
    - **Check magnetic field at the DIRC expansion volume**
    - **Check the effect (no surprises expected) of :**
      - **More ∫Bdl for e**
      - **Less ∫Bdl for h**

Here, an example of the dRICH optics by Alexander Kiselev
Not yet an optimized optics: it shows that very reasonable optics are allowed thanks to the more relaxed constrains from integration



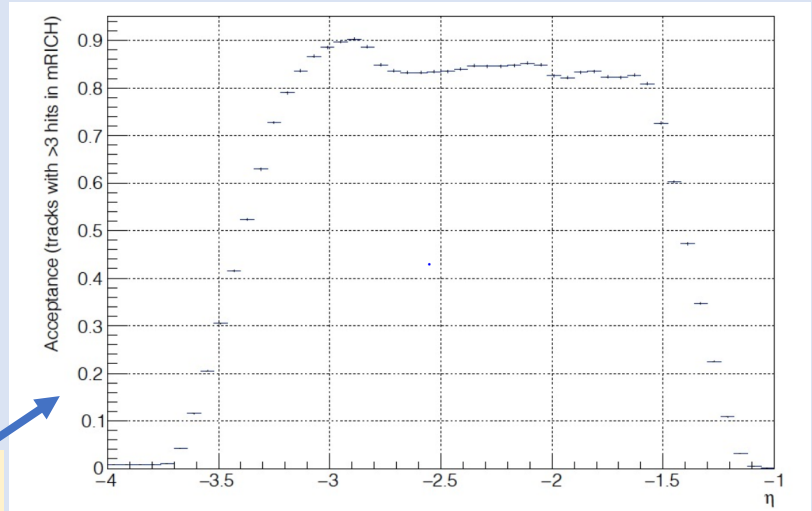
WHERE ARE WE vs GOAL

CENTRAL DETECTOR, MAJOR DIFFICULTIES ENCOUNTERED

2

- **PID by Cherenkov in the backward endcap**
  - **YR default - mRICH, supported by:**
    - Years of R&D
    - two test beam (n. of ph.s, ring size OK; resolution not yet demonstrated)
    - Stand alone simulation, now also GEANT4 in DD4HEP with reconstruction in progress
    - π/K sep. > 3σ up to 10 GeV/c making use of limited space thanks to Fresnel lenses (to be demonstrated)
  - **Problematic aspects**
    - Material budget to be better understood (10-12% X0 ?)
    - Non-homogeneity of the material budget
    - Dead area due to modules at ~ 15-20% level
    - Resolution that can be obtained with Fresnel lenses

From Murad Sandor at PID meeting



π^- p:05-11.5 GeV/c && -4 < η < -1 and full azimuth
vertex(x,y,z) = (0,0,+-35 cm)
Efficiency = (Tracks with at least 3 hit in mRICH)/ (all tracks)

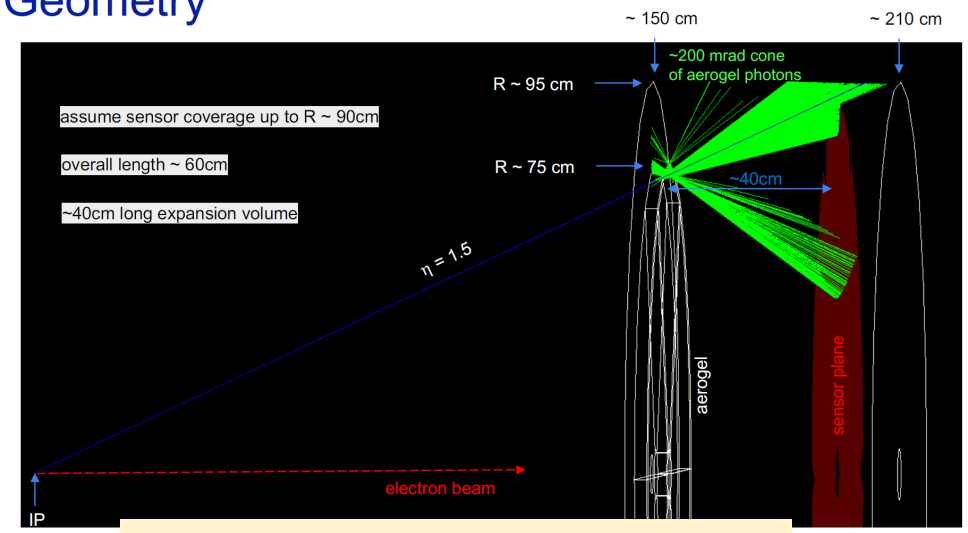
PID by CHERENKOV in the BACKWARD ENCAP, A RECENT ALTERNATIVE

- Starting point: with the evolution of the design of the ATHENA detector, more space along z available
- A proximity focusing aerogel RICH with LONG proximity gap can fit the available space
  - Total length: ~60 cm, proximity gap ~ 40 cm
  - Initial simulation study indicate performance similar to what expected for mRICH (LONG proximity gap)
  - NOTE: initial study do not foreseen Fresnel lenses, that can be added when it demonstrated that the bring further improvements
- ADVANTAGES
  - Better established technology
  - Less material budget
  - More complete coverage
- OPTION TO HAVE PROXIMITY FOCUSING RICH (with Fresnel lense option) AS DEFAULT discussed with mRICH team →
  - Agreed upon also with their help for the new default
  - constructive attitude GREATLY appreciated

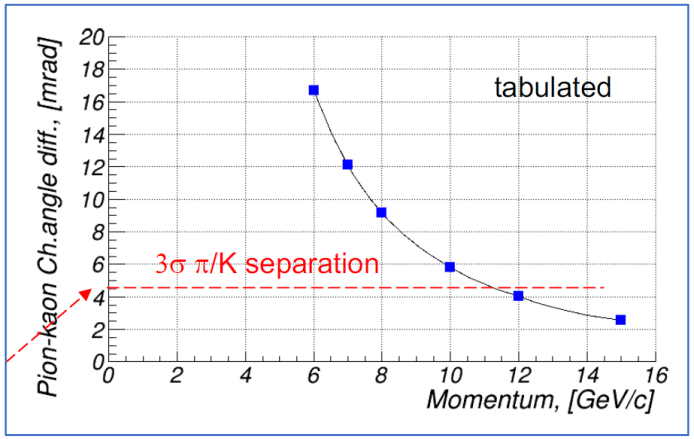
WHERE ARE WE vs GOAL

ATHENA

Geometry



From Alexander Kiselev



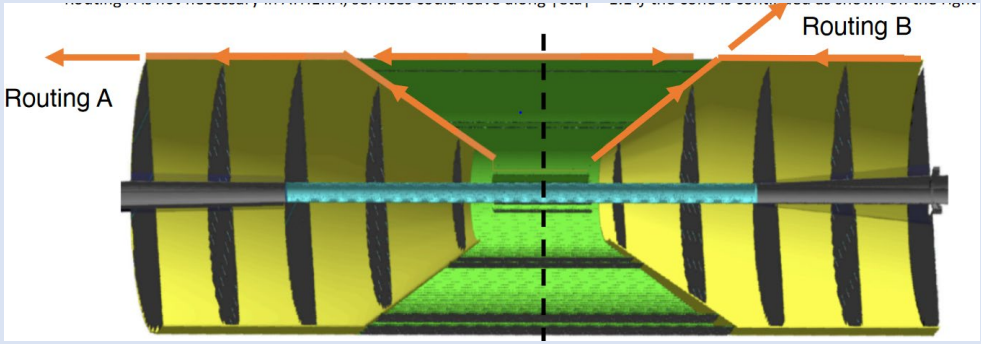
~10 p.e. per track and ~1.5 mrad track-level Cherenkov θ resolution

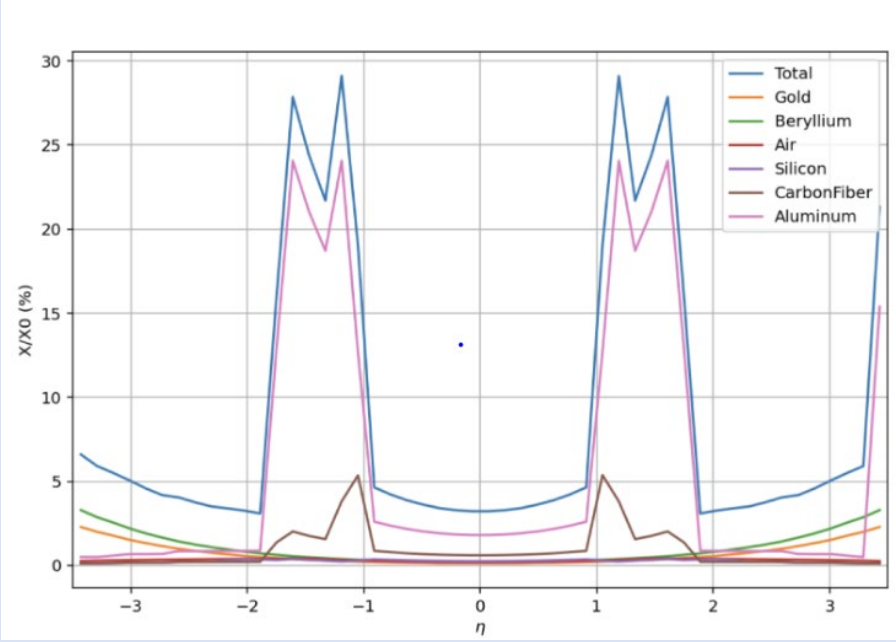
3a

WHERE ARE WE vs GOAL

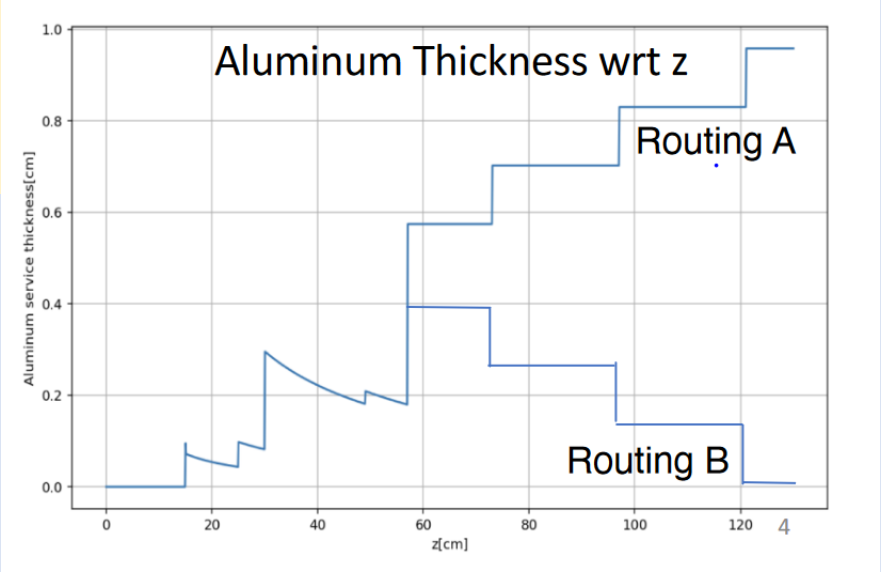
CENTRAL DETECTOR, MAJOR DIFFICULTIES ENCOUNTERED

- **Material Budget spectrum for the whole Si option in end caps**
  - **Main problem coming from the matrial for the services**
  - **Brilliant option of different cable routing**





Material from Ernst Sichtermann at Tracking meeting



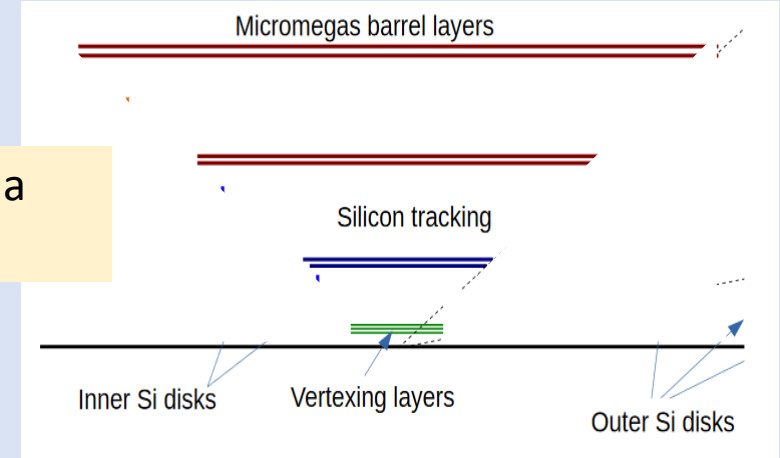
3b

WHERE ARE WE vs GOAL

CENTRAL DETECTOR, MAJOR DIFFICULTIES ENCOUNTERED

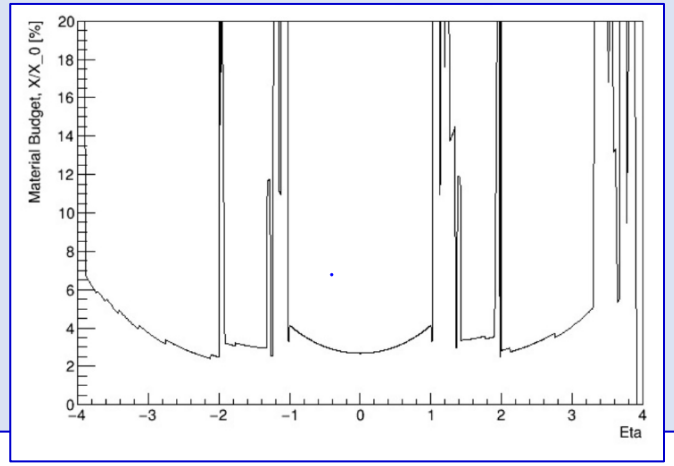
- **Designing the hybrid tracking configuration**

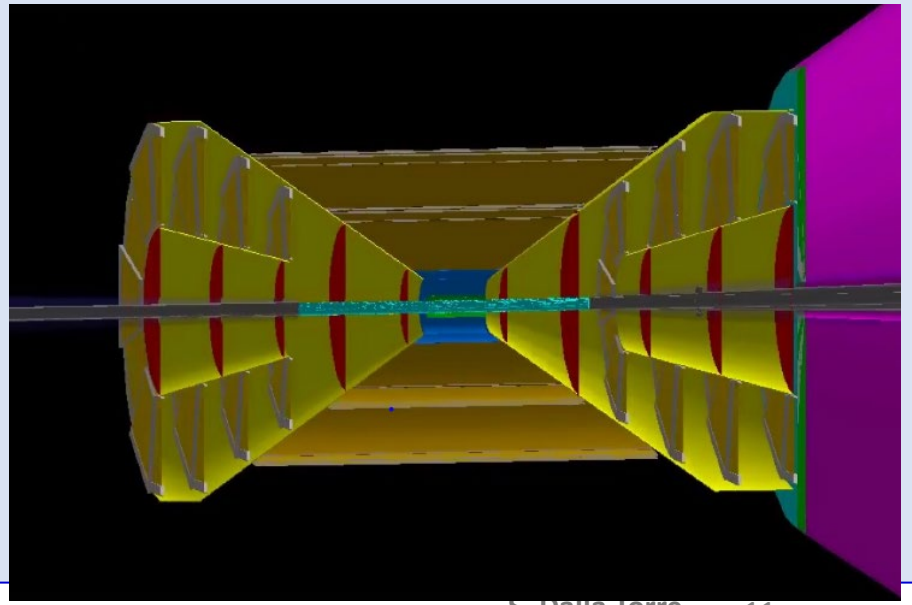
From Laura Gonella at I/GD meeting



  - **Barrel, consolidated design since a while**

  - **Proposed double projective geometry problematic for engineering integration, even if favorable concerning material budget spectrum**



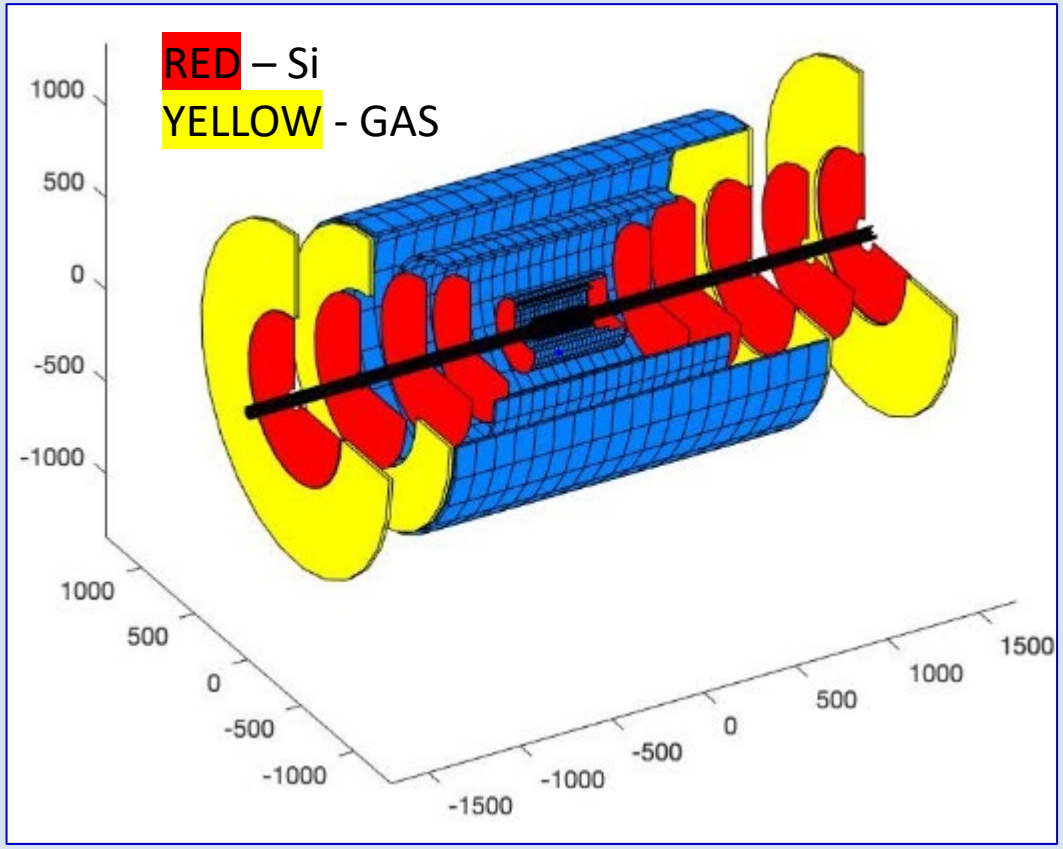


WHERE ARE WE vs GOAL

THE NOVEL DESIGN OF THE HYBRID TRACKING CONFIGURATION

From Laura Gonella
at I/GD meeting

- Fixed for the forward endcap: no major integration problems as some material in front of GEMs to support disks can be tolerated
- With/without GEMs in the backward endcap according to the impact of the disk support material; also option of larger Si disc considered
  - Remaining open points to be fixed by October 6th
- In other words, in 1 w, we will now about these two options:
  - Barrel: Hybrid, Fwd: Hybrid, Bkwd: Hybrid
  - Barrel: Hybrid, Fwd: Hybrid, Bkwd: Si



WHERE ARE WE vs GOAL

CENTRAL DETECTOR, baseline Design in the PROPOSAL

- **Includes**
  - **Tracking, 2 options**
    - Full Si
    - Hybrid
      - Configuration largely defined, frozen within 1 week
  - **Calorimetry (configuration stable since ~July)**
    - YR-like for HCal
    - YR-like for ECal Backward endcap
    - YR-like for ECal forward endcap
    - Novel hybrid concept (imaging layers followed by sampling layers) in the barrel
      - First Imaging layer also providing space point information (res. ~150 um) downstream of the DIRC bars
  - **PID**
    - hpDIRC in the barrel
    - dRICH in the forward endcap
    - Proximity focusing aerogel RICH in the backward endcap
      - Fresnel lenses optional

IMPORTANT !!!
There is still a lot to understand about these baseline detectors:
- With simulation for Proposal
- With R&D for further and complete consolidation

WHERE ARE WE vs GOAL

CENTRAL DETECTOR, baseline Design in the PROPOSAL

- **KNOWN QUESTIONABLE ASPECTS OF THIS DESIGN**
  - **Poor HCal in the barrel due to solenoid material:**
    - **Better than initially:** some replacement of Cu with Al in the solenoid design
    - A choice between 3T field and better h detection/measurement:
    - ATHENA has chosen 3T
    - Waiting to understand from simulation what limited HCal performance in barrel implies for physics (assessment needed)
  - **No PID below the Cherenkov thresholds (aerogel, quartz)**
    - e/π separation in support of ECal (in particular at low p)
      - Understand from experience what Cherenkov devices in threshold mode can provide
    - h-PID
      - Understand from experience what Cherenkov devices can provide for π/K separation below K threshold
      - Deeper understanding of the impact of this limitation on physics potential
    - **Low p PID upgrades considered**

WHERE ARE WE vs GOAL

CENTRAL DETECTOR, UPGRADE OPTIONS

- From the KNOWN QUESTIONABLE ASPECTS OF THIS DESIGN
  - Low p PID upgrades
  - Several development on-going
    - TRD: e/π separation and tracking
      - TRD can replace a tracker in the frontend endcap
    - MiniTPC (gridpix sensors) : Low p e/π separation, h-PID and tracking
      - Space available between the MPGD cylinders in the barrel
    - TOF by LGAD: Low p e/π separation, h-PID and tracking
      - Space available in the barrel, in front of dRICH and in front of Backward ECal
    - LAPPD: TOF and single photon sensors (backward RICH)
      - Replacing SiPMs in backward RICH
      - Other applications ?

Effects of extra material budget
Need to be addressed

- MORE R&D OF POTENTIAL INTEREST
  - μR-WELL as alternative to GEM detectors for large areas