



# Proposal Committee Subgroup: Integration & Global Design Status Report

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

August 19, 2021

# Organization

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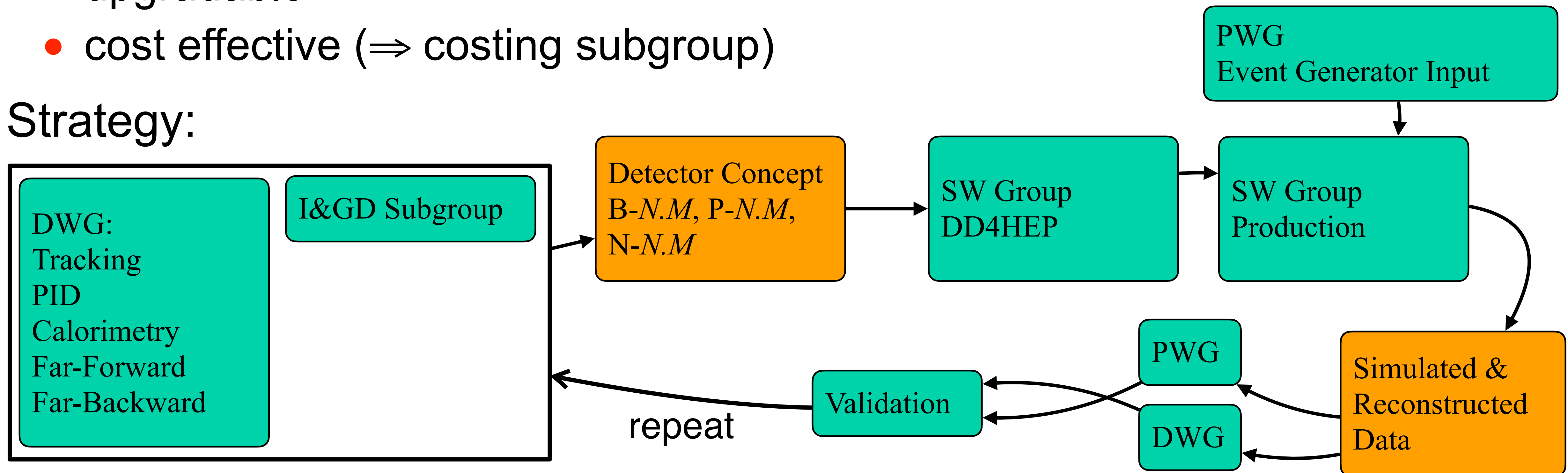
- Weekly Meeting on Wednesday 11:00 EDT
  - ▶ <https://indico.bnl.gov/category/378/>
  - ▶ Committee + Invited Colleagues (varying, DWG & PWG conveners, Software, ...)
  - ▶ General Interest:
    - ⦿ 21 July: 3 T magnet session with Valerio Calvelli and Renuka Rajput-Ghoshal
    - ⦿ 11 August: Status of mechanical integration with Roland Wimmer (engineer)
- Wiki Pages
  - ▶ <https://wiki.bnl.gov/athena/index.php/Integration>
- Project Support/Contact
  - ▶ Elke Aschenauer
  - ▶ See also project relate info at <https://wiki.bnl.gov/athena/index.php/Project>

# Goal & Strategy

Goal: Mature ATHENA detector design that is

- delivering the physics as outlined in WP, NAS report, and YR
- competitive
- low risk
- upgradable
- cost effective ( $\Rightarrow$  costing subgroup)

Strategy:



# Detector Concepts in the Queue

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## Baseline

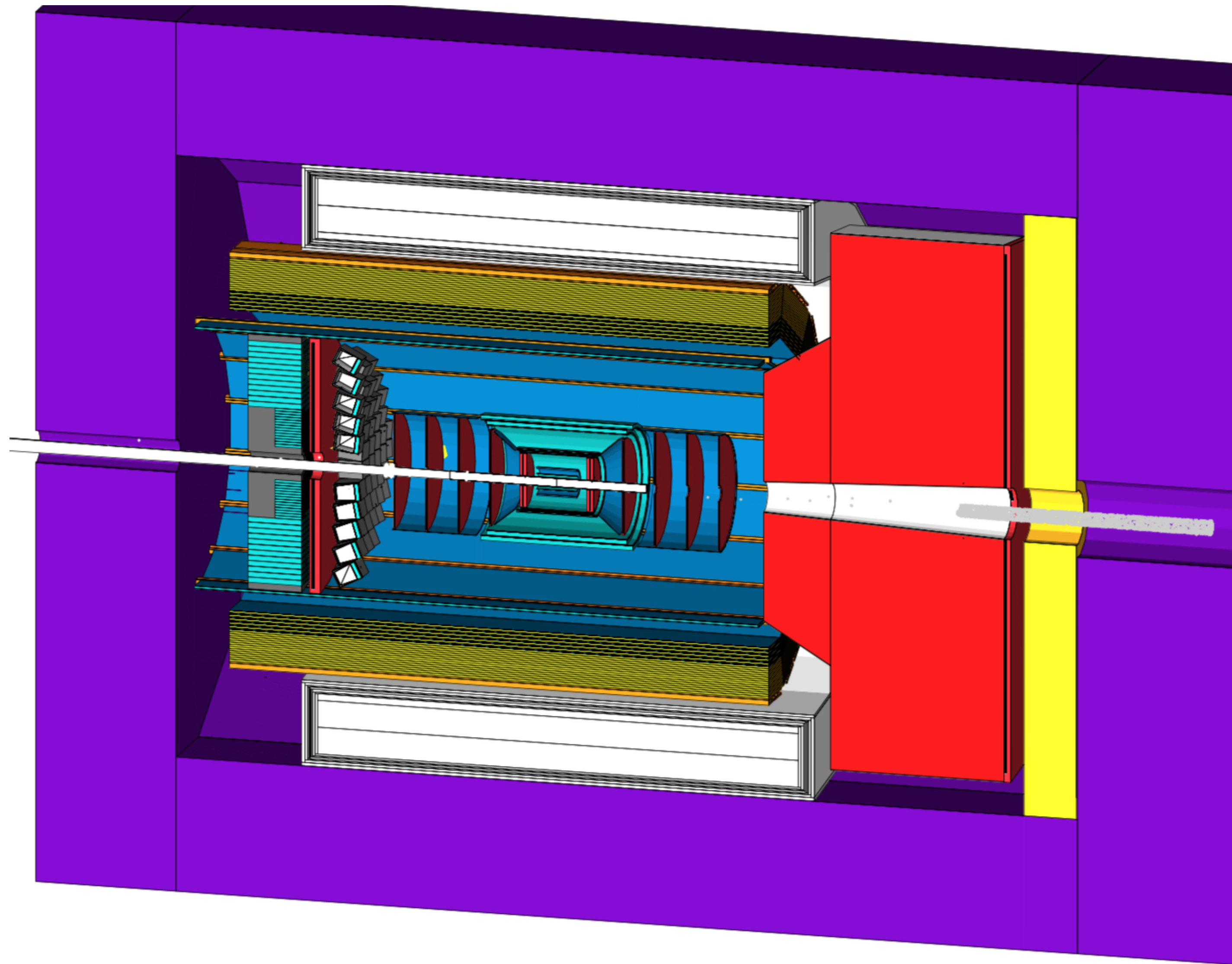
- Purpose: Simple/minimal configuration to get started
  - ▶ Field: Solenoidal
  - ▶ B-0.0 = All-Silicon Tracker (no MPGD) + HP-DIRCEMCAL + HCAL (Fe/Sc)
  - ▶ P-0.0 = Si-Disks + GEM Layer + dRICH + EMCAL (W powder/ScFi) + HCAL (Fe/Sc) + B0 + Off-Momentum + Roman Pots + ZDC
  - ▶ N-0.0 = Si-Disks + GEM Layer + mRICH + iEMCAL (PbWO4) + oEMCAL + HCAL (Fe/Sc) + Low-Q2 Tagger

## Baseline+ (next iteration)

- Purpose: First refinement
  - ▶ B-1.0 = add cylindrical MPGD
  - ▶ P-1.0 = add MPGD (GEM) layer
  - ▶ N-1.0 = add MPGD (GEM) layer



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Backward PID: mRICH  
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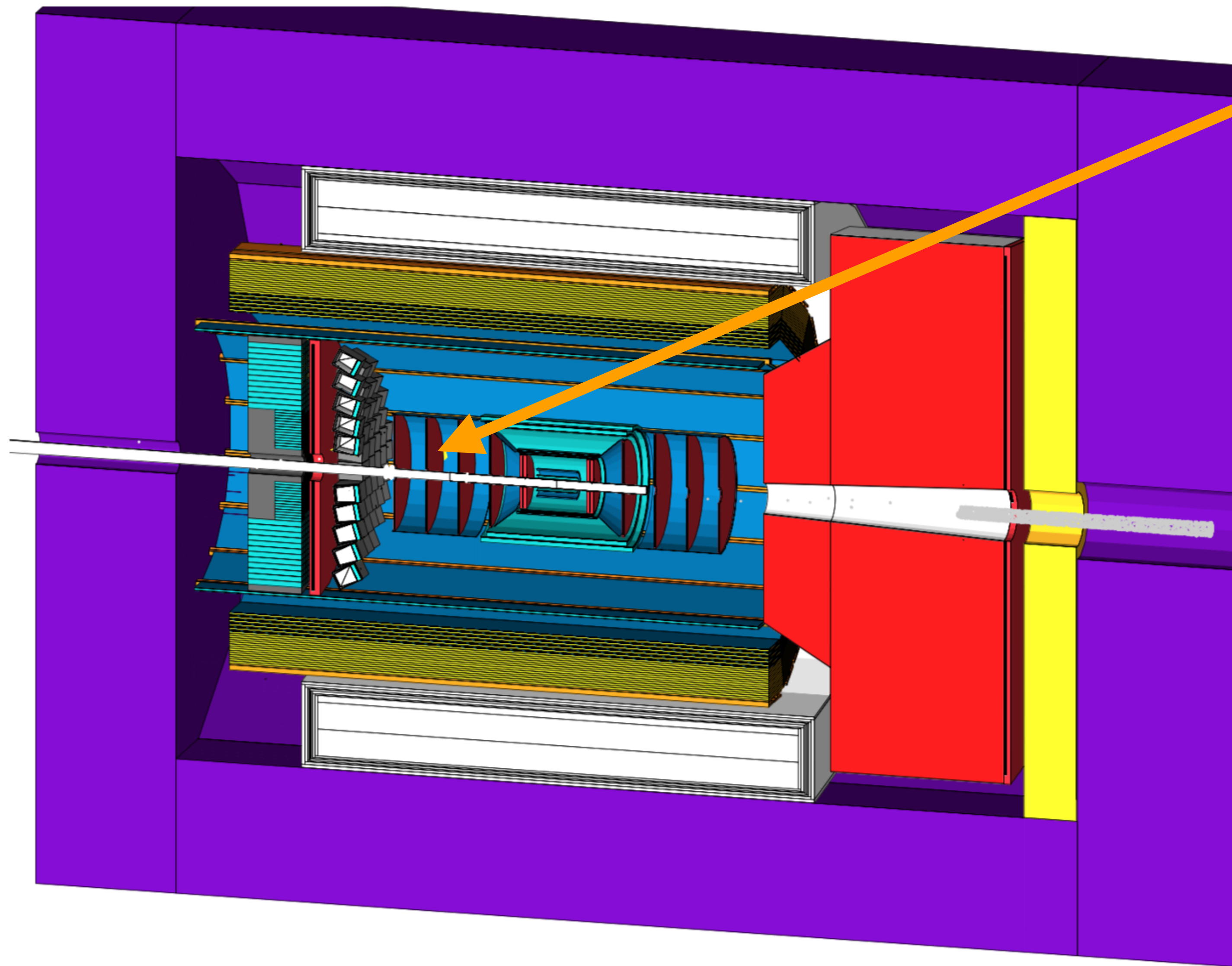
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(40cm glass blocks + 20cm for readout)  
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Empty space  
-245m to -285cm ( $\Delta$ : 40cm)  
30cm for DIRC expansion  
10cm service gap

HCAL  
-285cm to -390cm ( $\Delta$ : 105cm)  
(60cm more available in negative direction)

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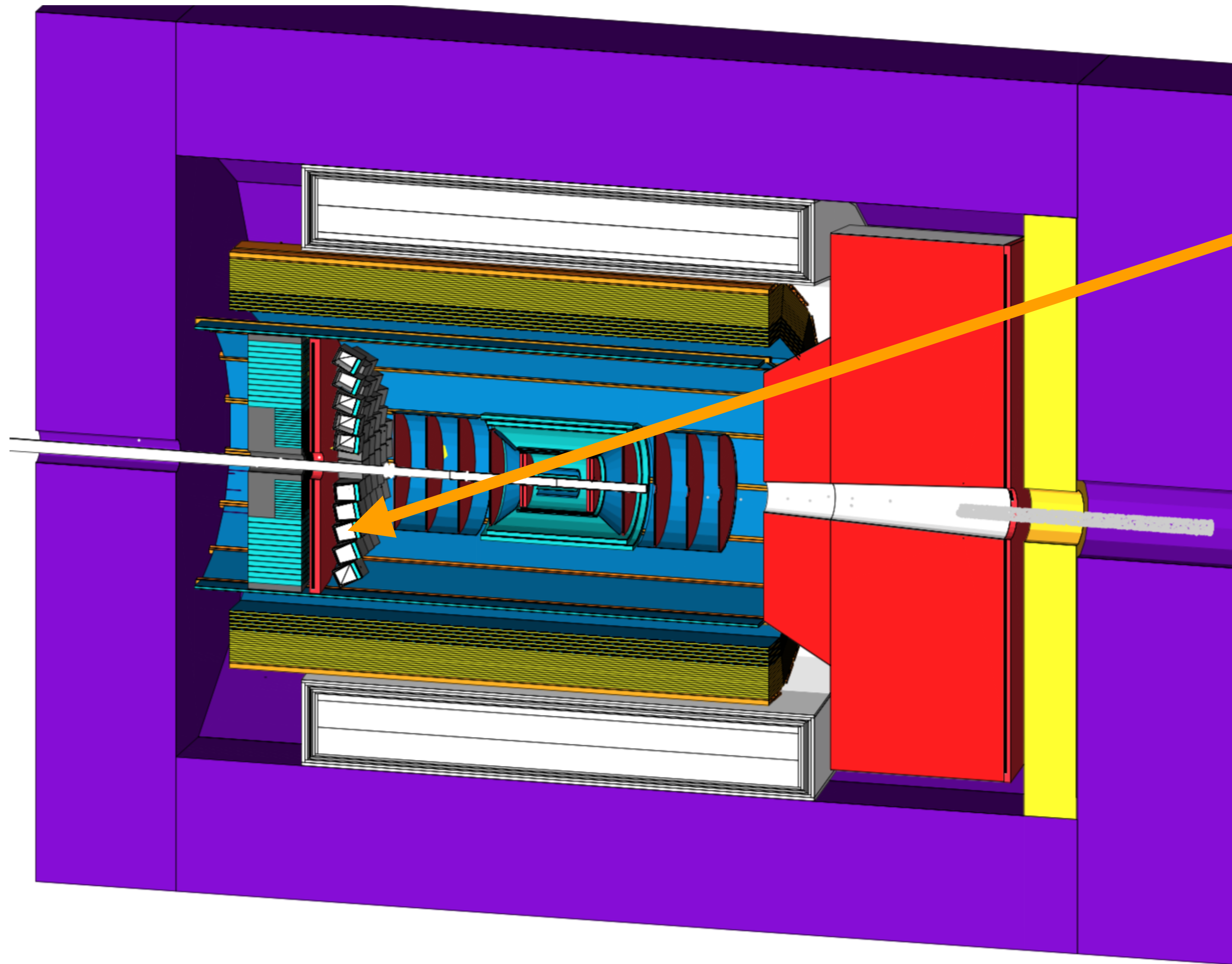
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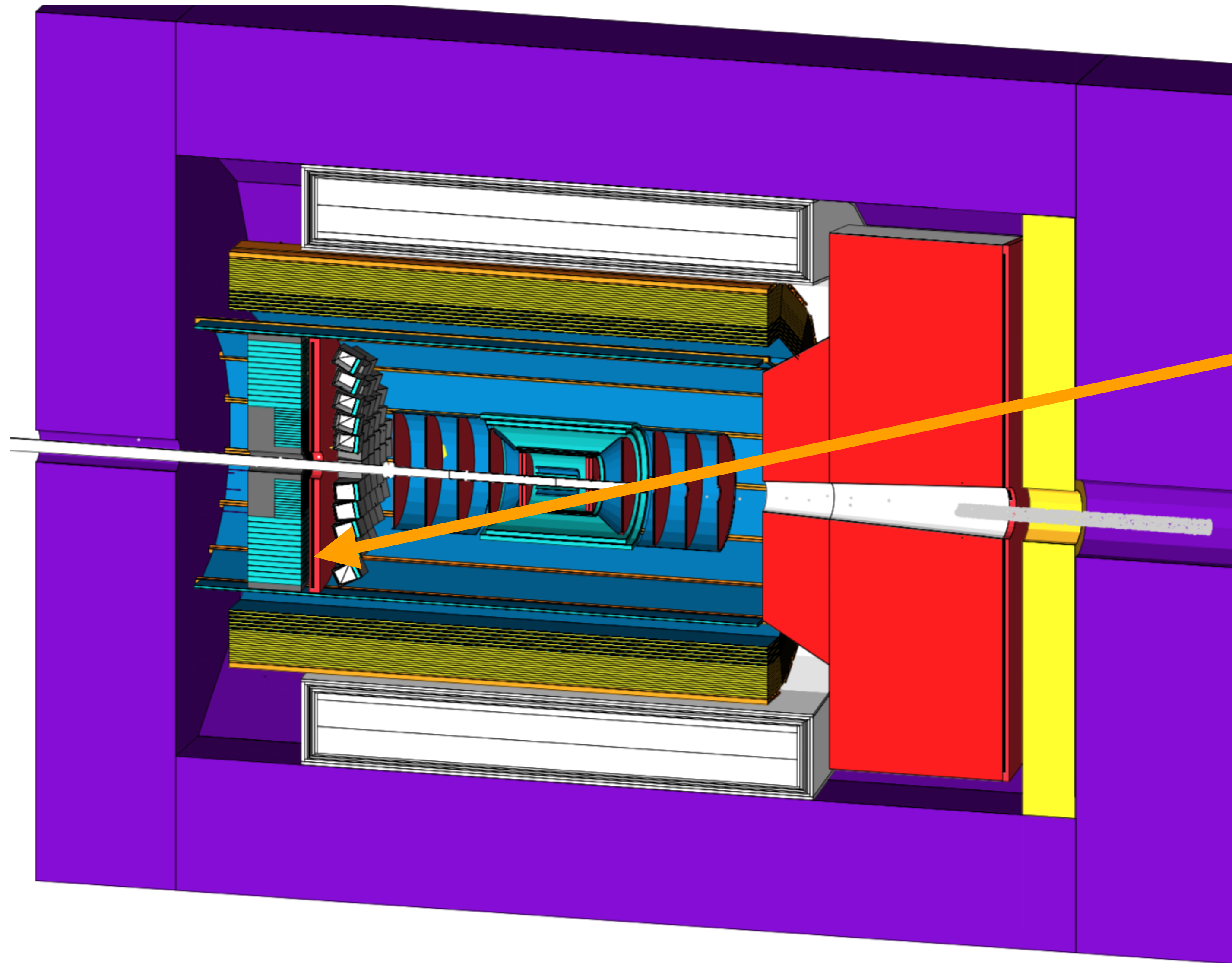
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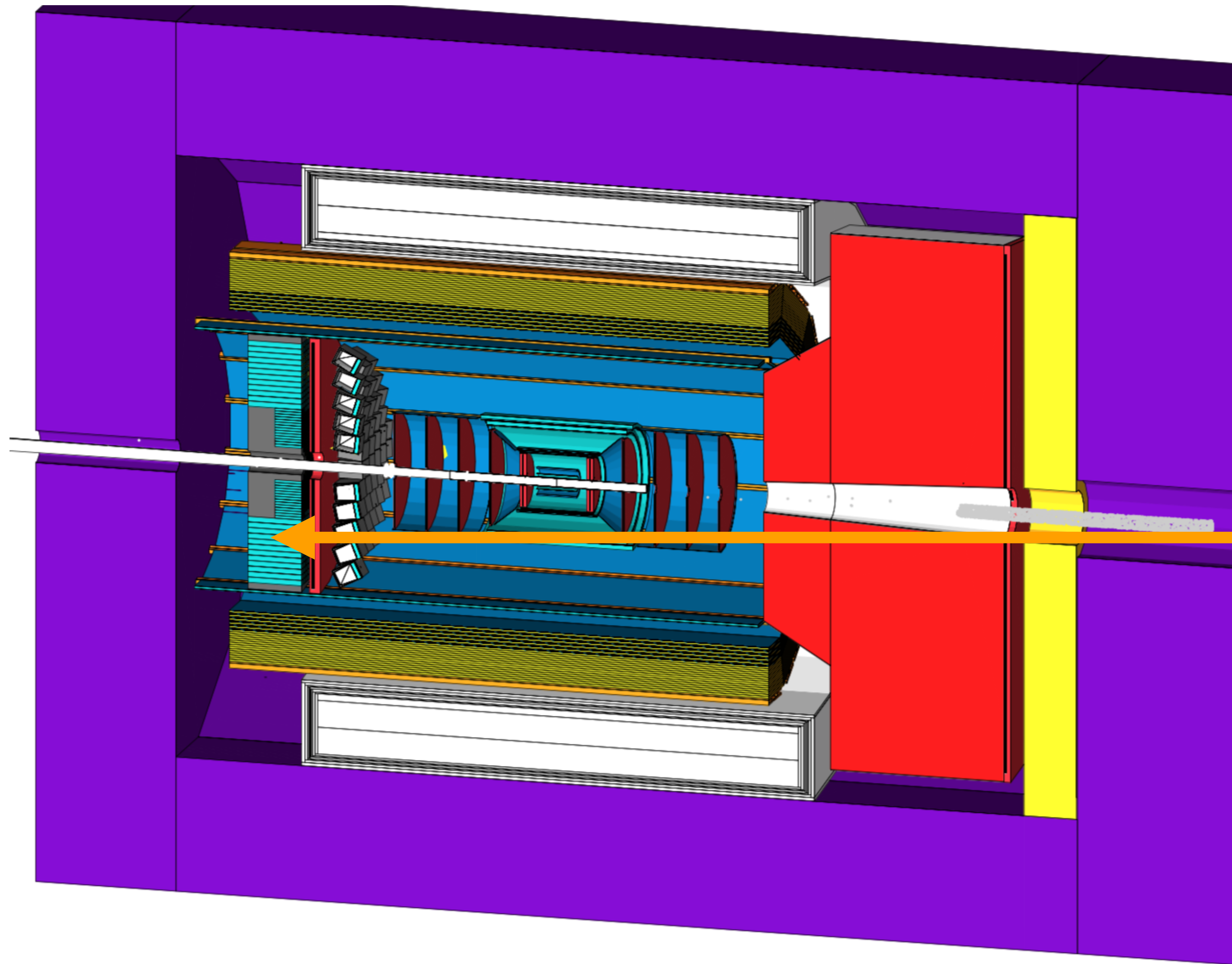
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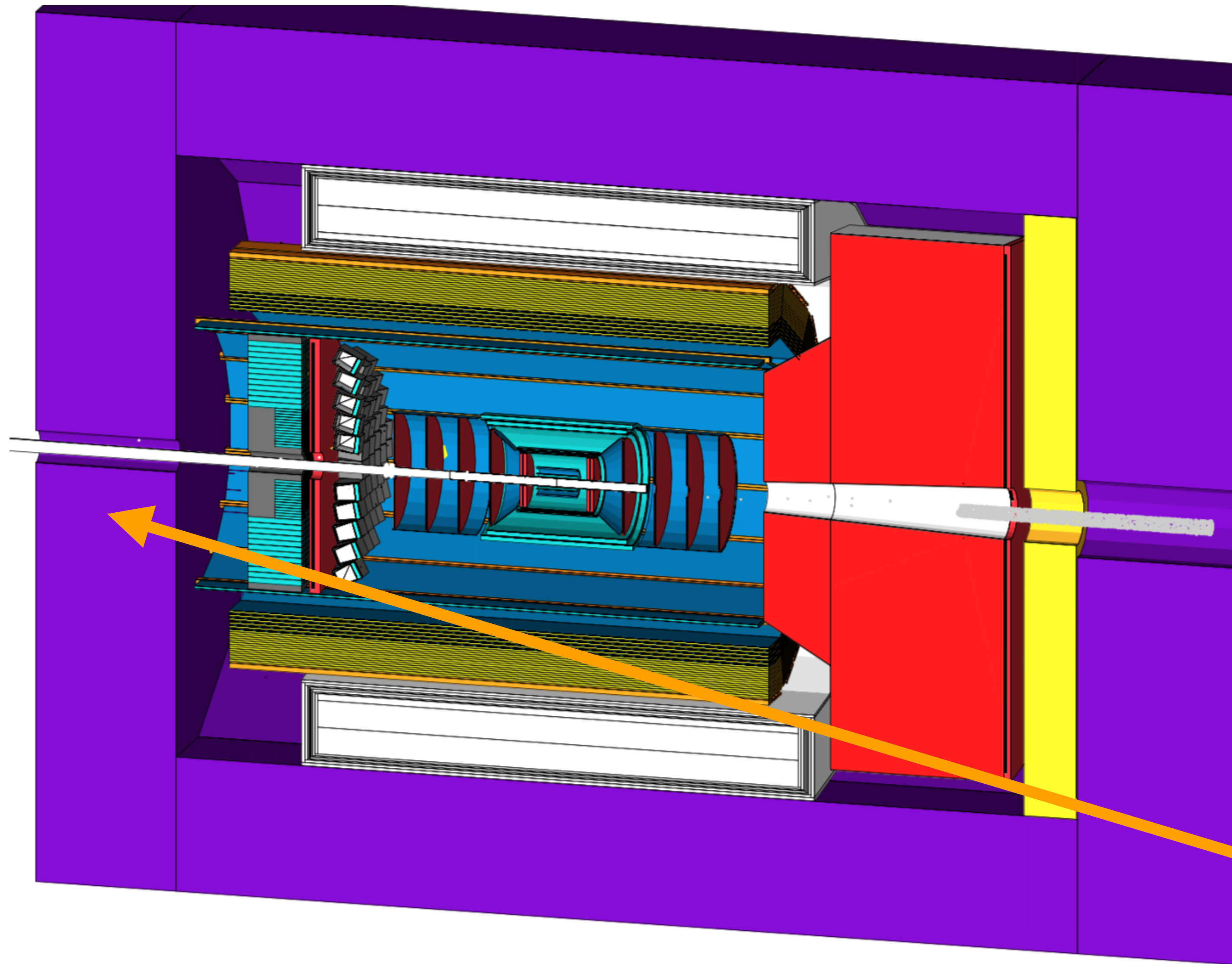
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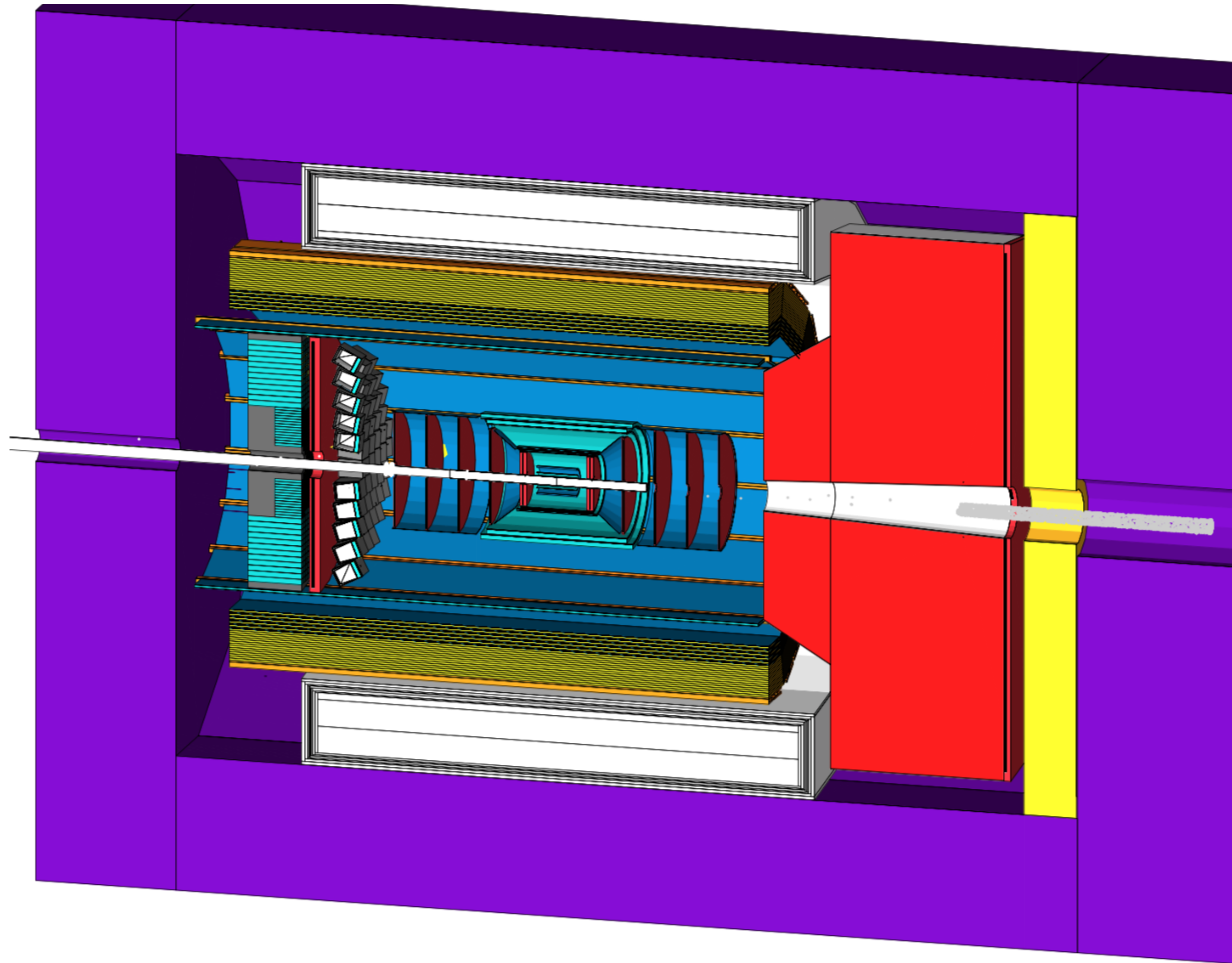
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(same radial parameters for backward region)

## Barrel PID (DIRC, 16 sectors):

-275cm to -155cm ( $\Delta$ : 430cm)

rmin: 95cm, rmax 105cm ( $\Delta$ r: 10cm)

space for expansion volume behind BECAL

Space for 10cm service gap in front of HCAL

## Empty space for upgrades

rmin: 105cm rmax: 112cm ( $\Delta$ r: 7cm)

## Barrel ECAL (including support)

-245cm to -159cm ( $\Delta$ : 404cm)

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## Solenoid

-192 to 192cm ( $\Delta$ : 384cm)

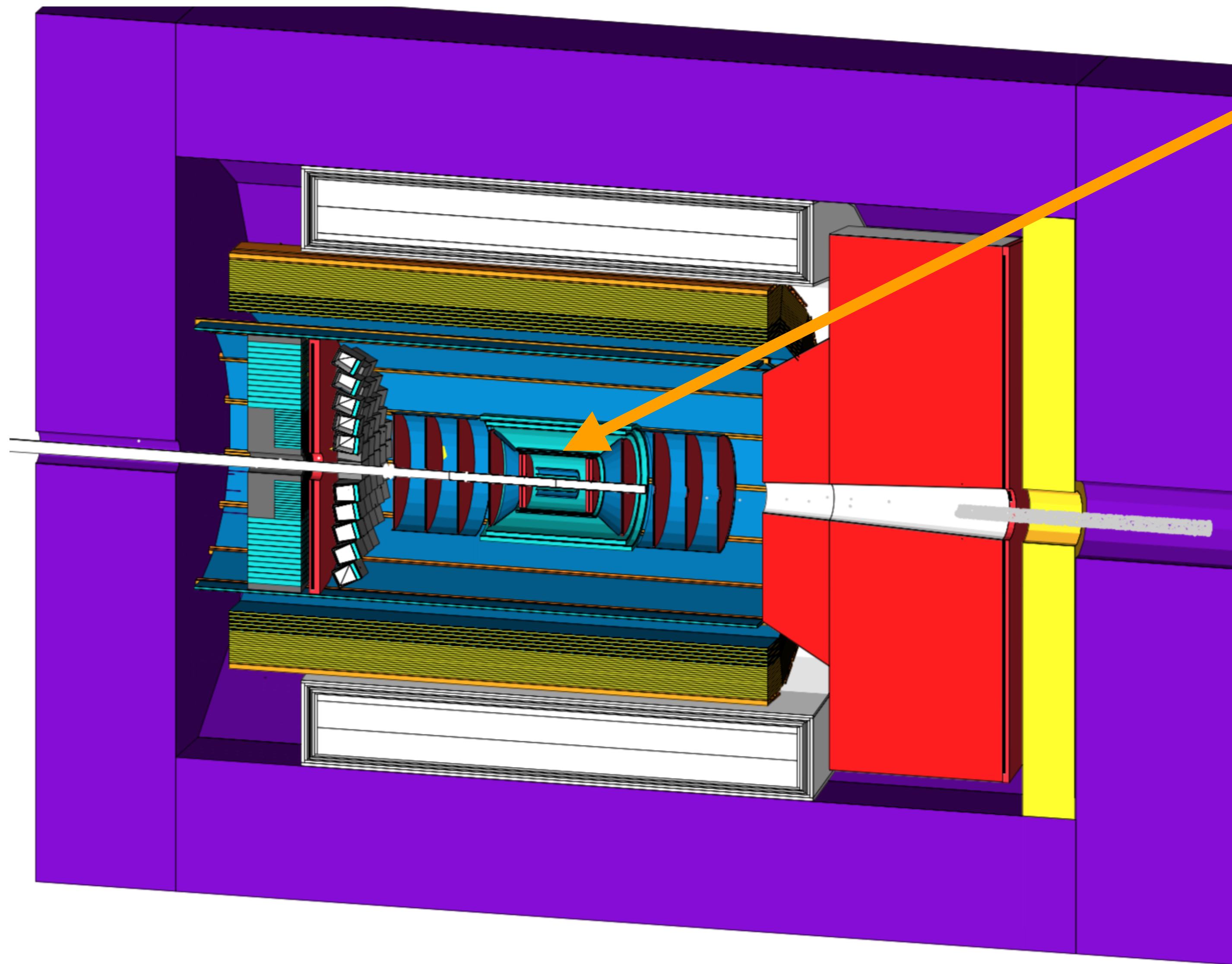
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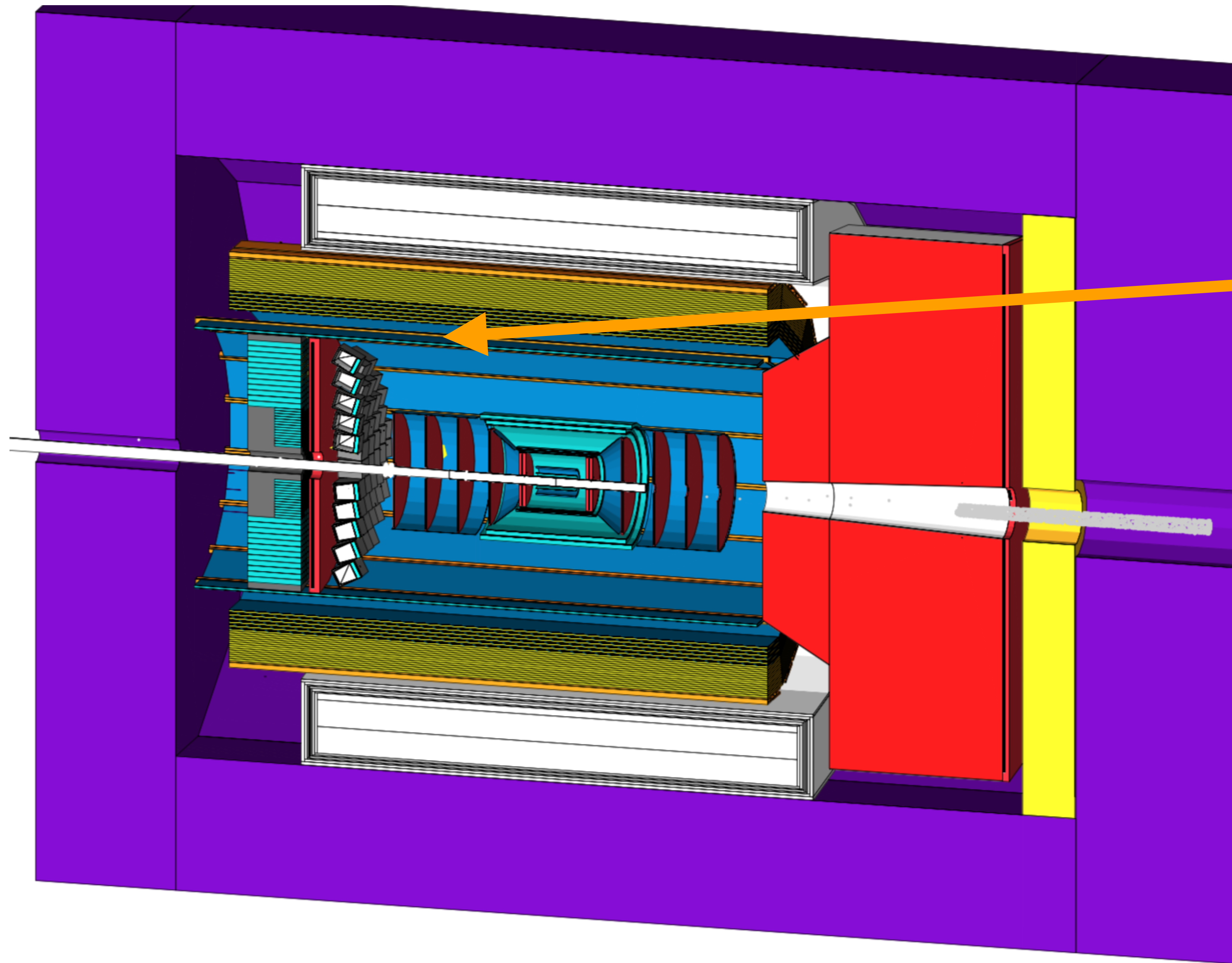
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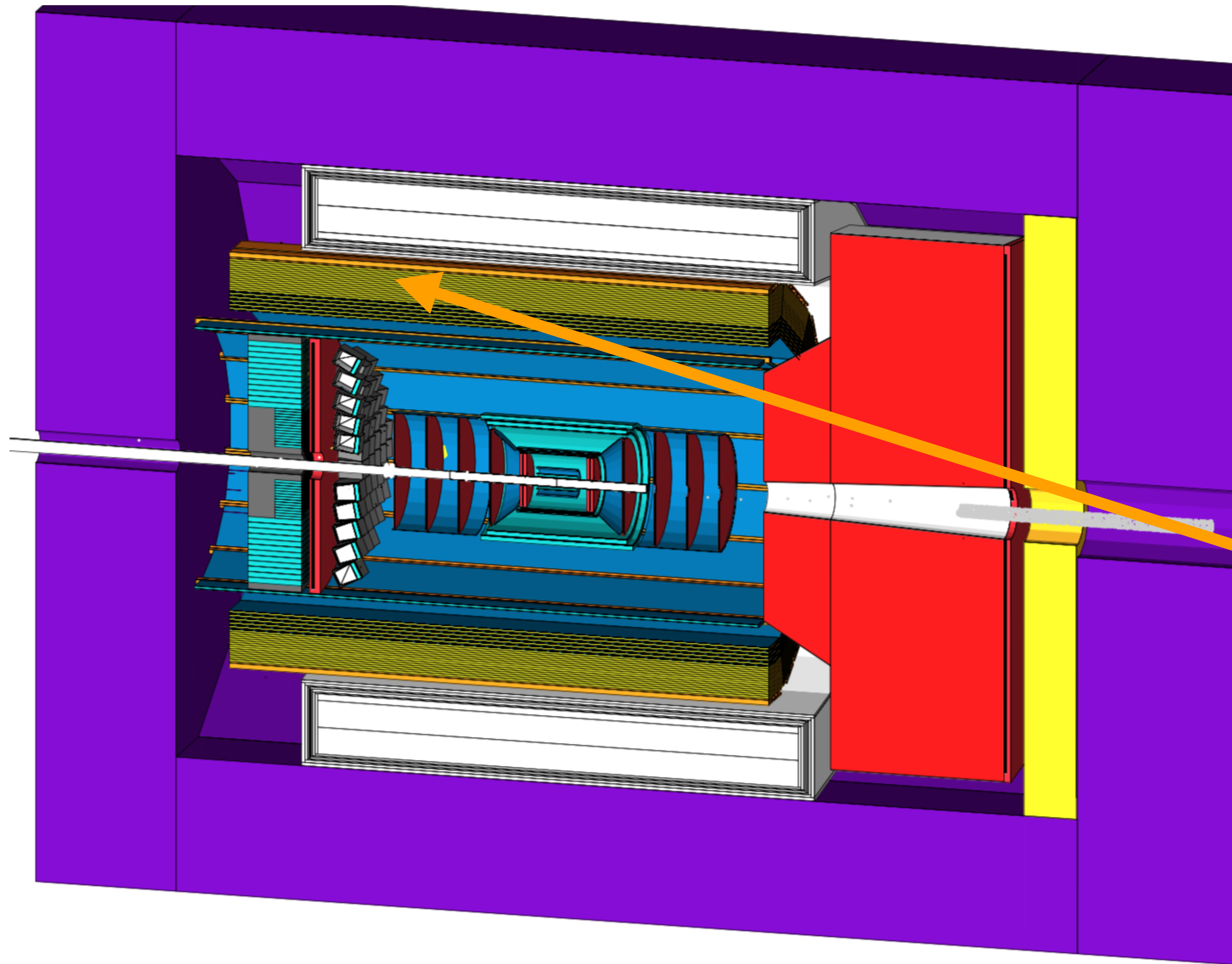
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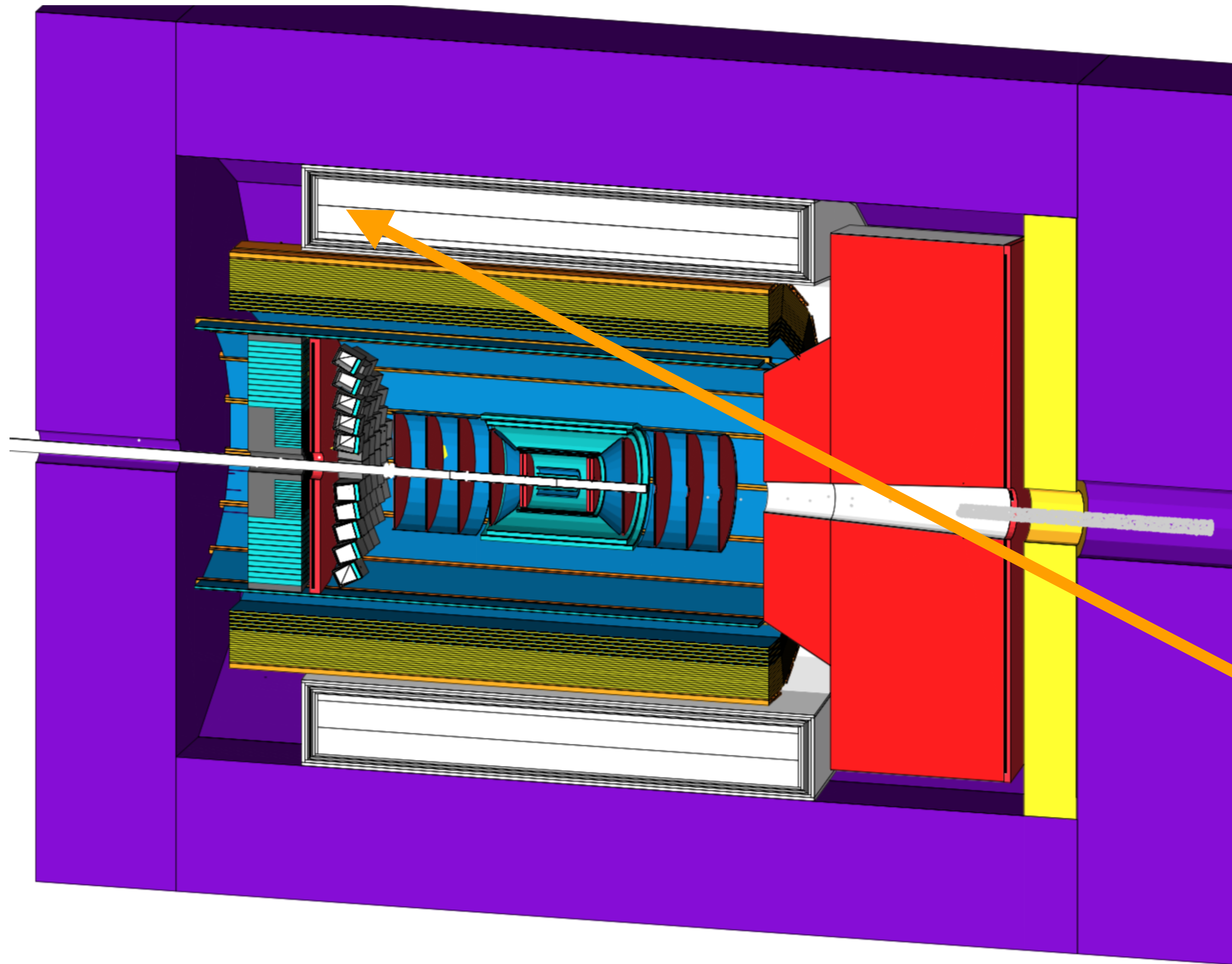
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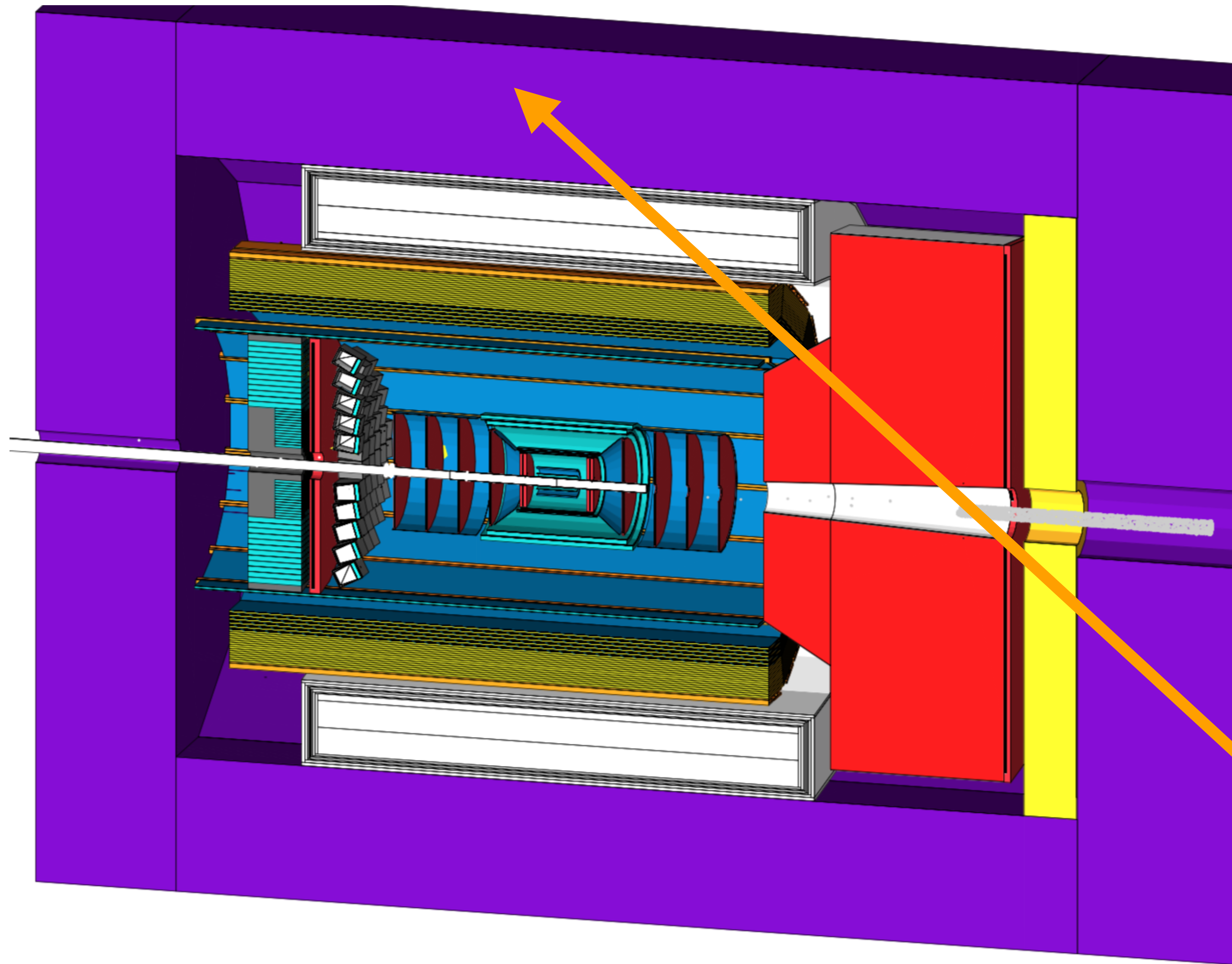
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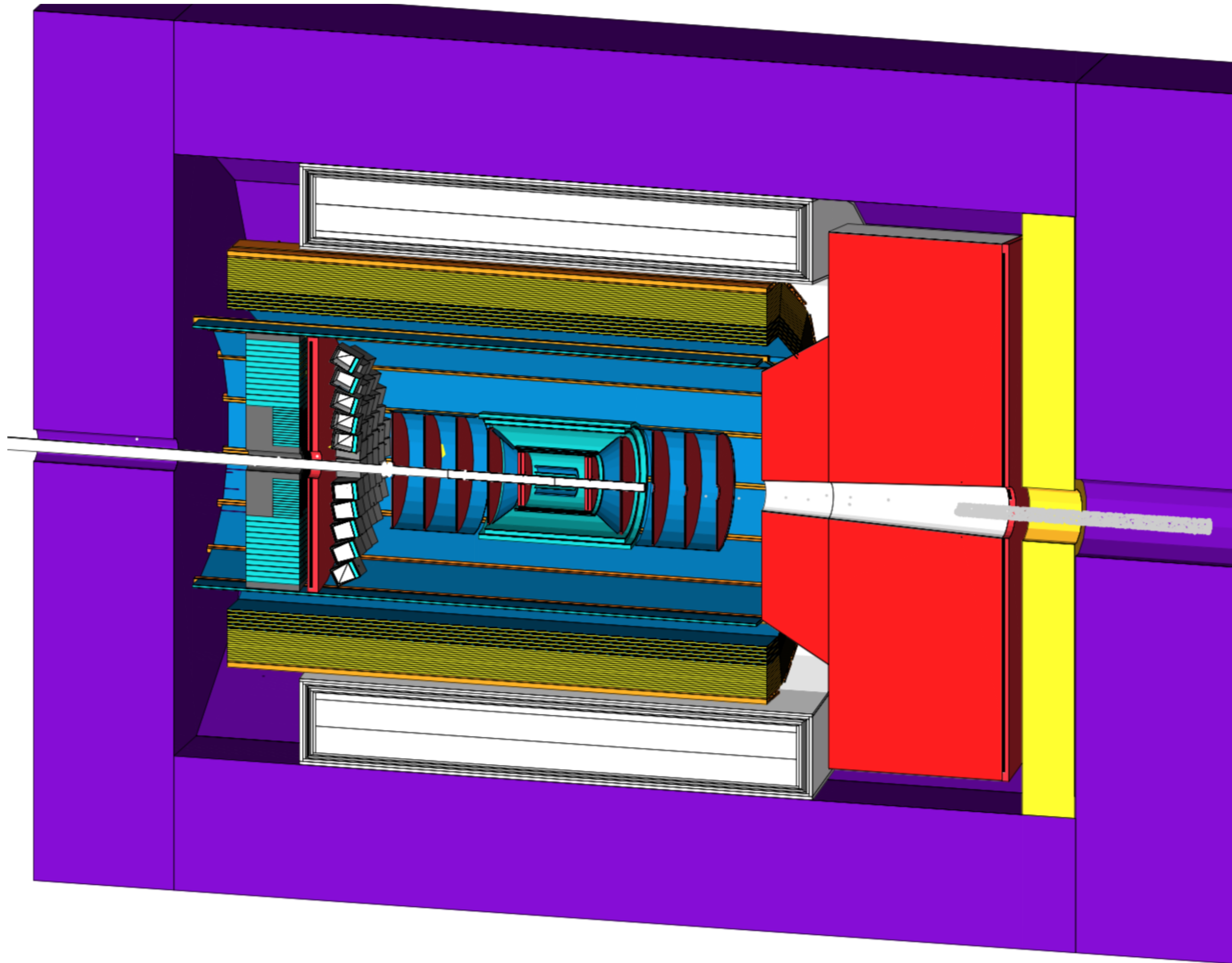
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vessel: rmin: beampipe, rmax 200cm  
snout: rmin: bmpp, rmax 92.5  $\rightarrow$  122.5cm  
Snout length: 50cm. **13cm gap between vessel and solenoid cryostat**

Forward tracking  
(needs more space for upgrades!):  
335cm to 340cm ( $\Delta$ : 5cm)  
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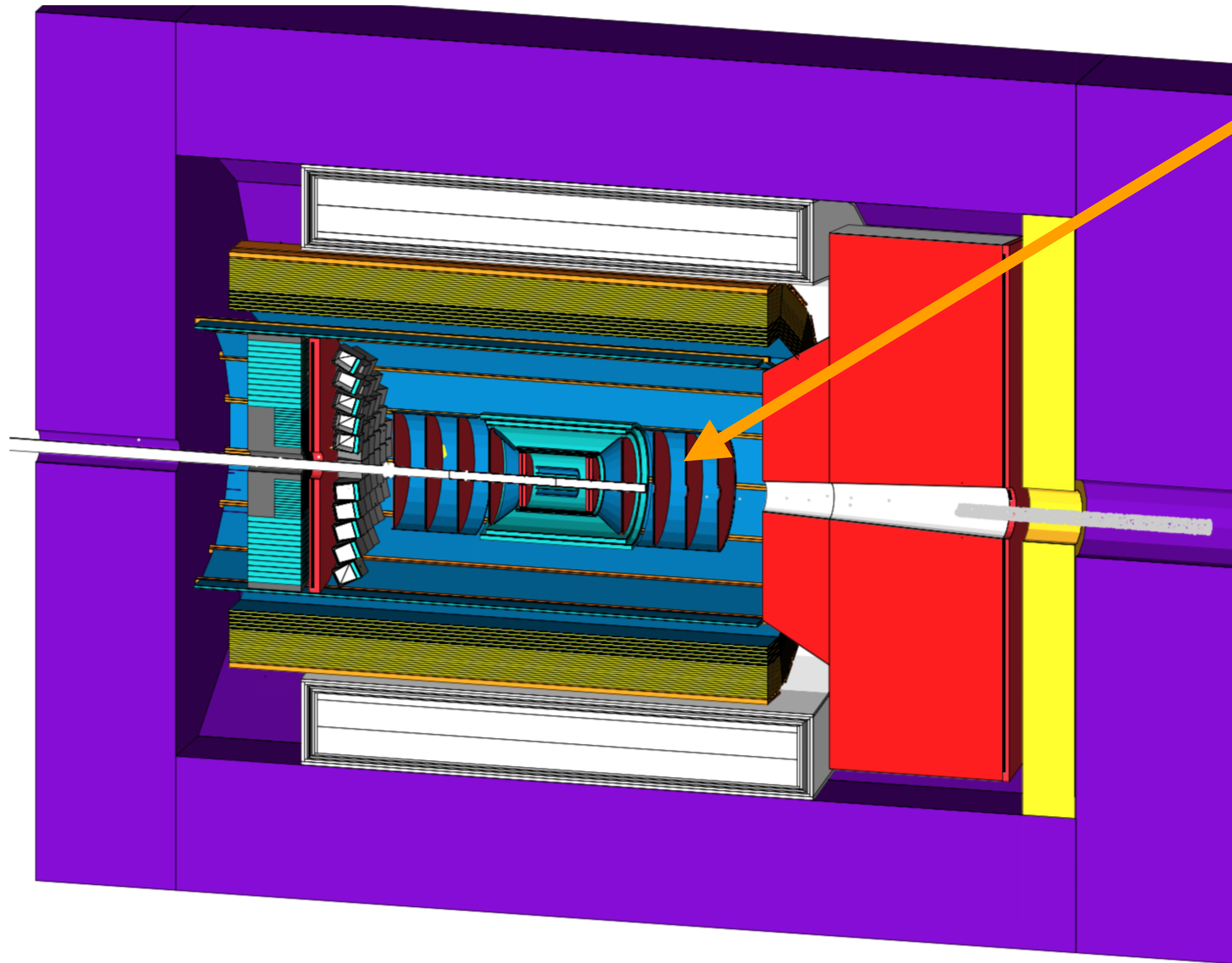
Empty space  
10cm service gap

Forward ECAL  
350cm to 380cm ( $\Delta$ : 30cm)  
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380cm to 500m ( $\Delta$ : 120cm)



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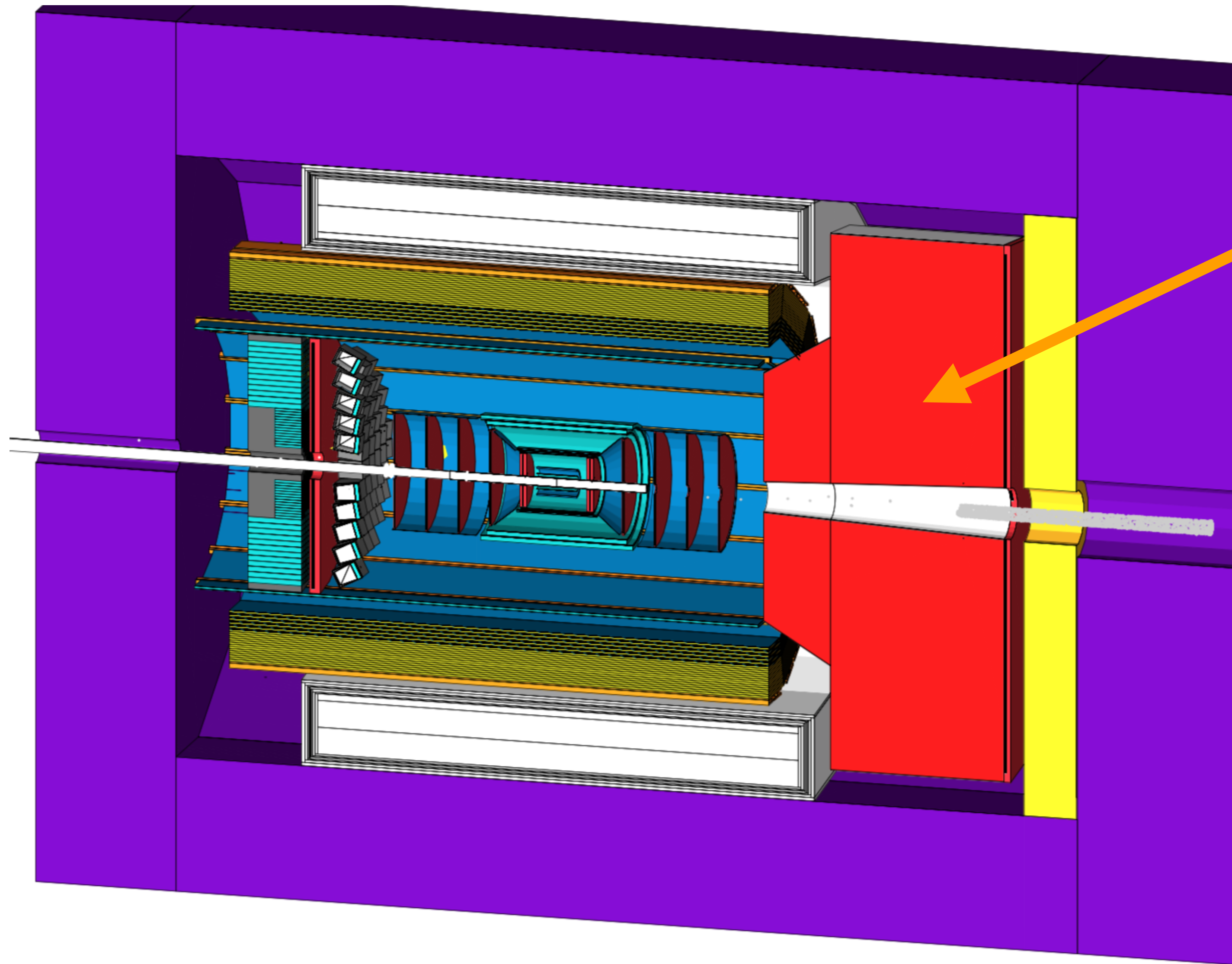
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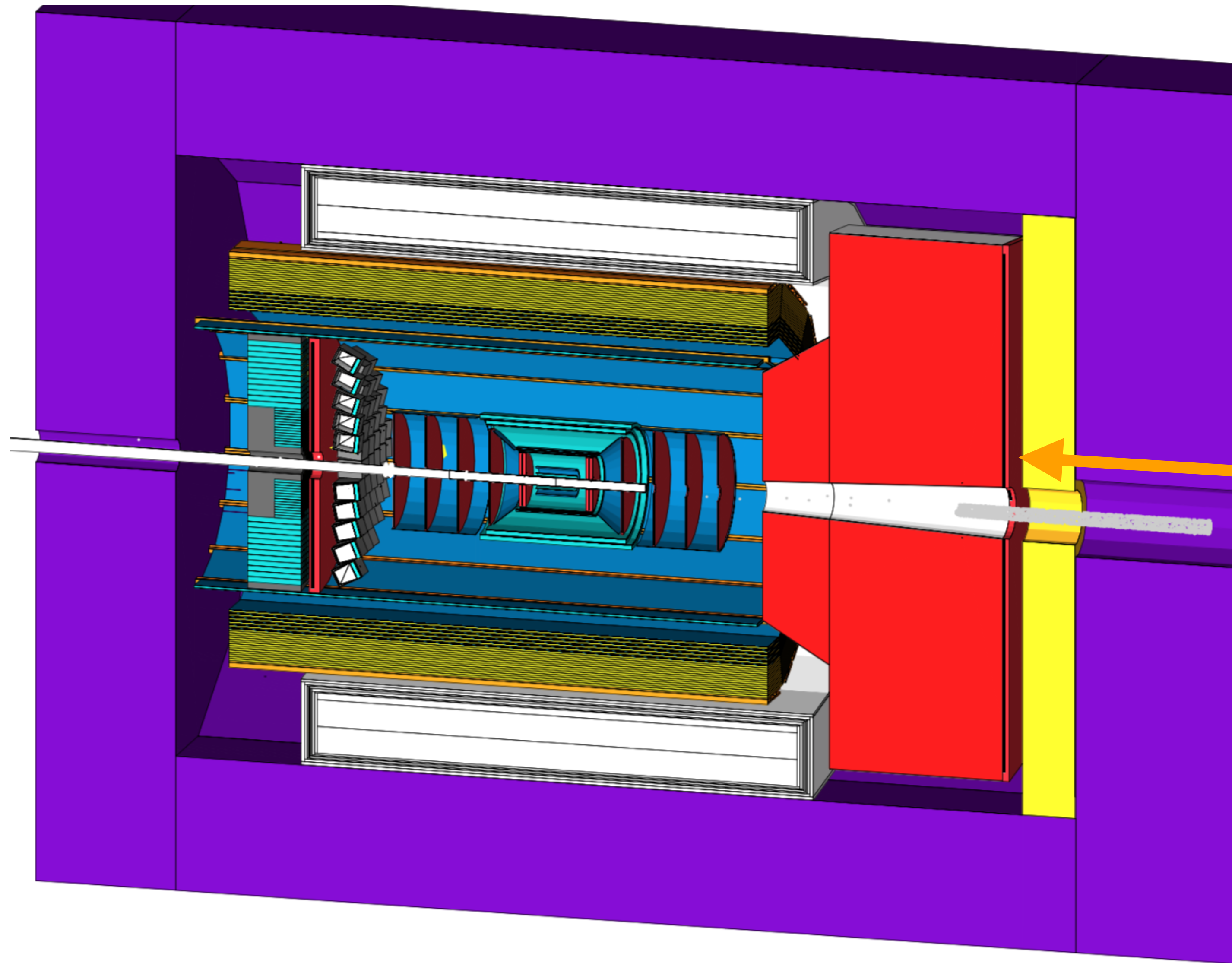
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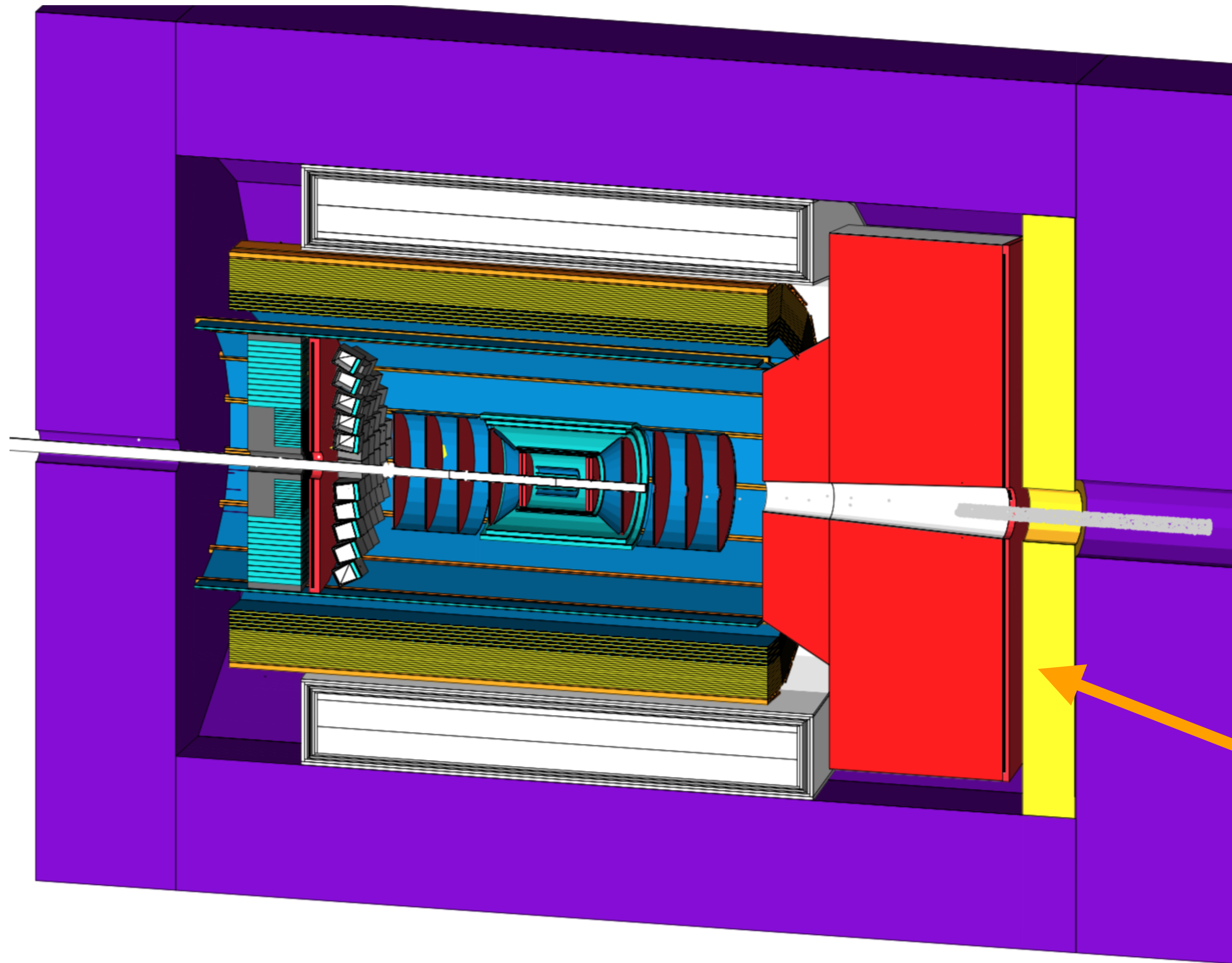
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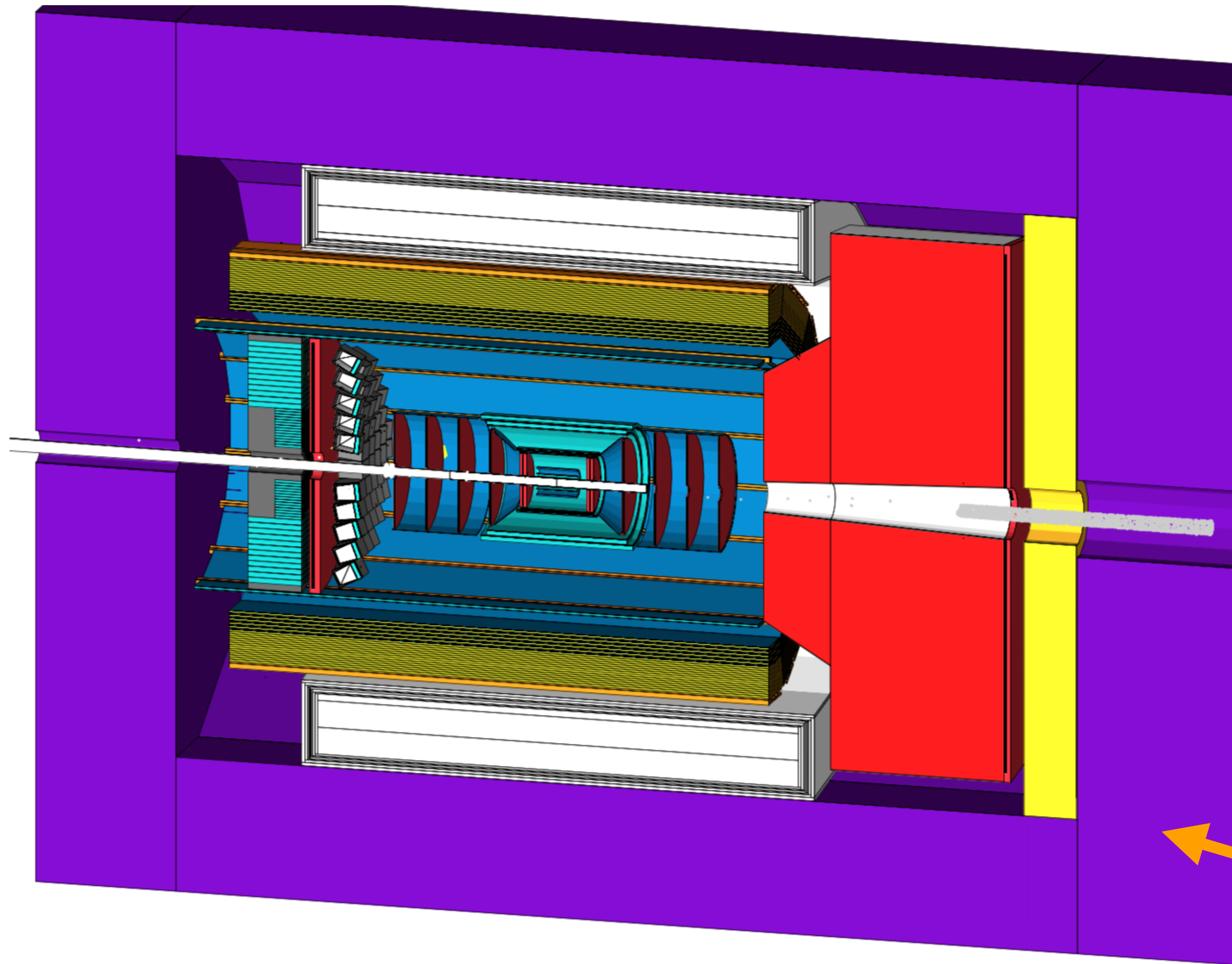
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# Production of Baseline

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**Has started yesterday Wednesday August 18, 2021**





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- This is a big achievement and due to DWGs and **especially** the software group
- Remaining issues (all solvable)
  - ▶ Sartre output needs too be converted to HEPMC
  - ▶ Too few DIS events
- Still
  - ▶ we have to be realistic if we want to succeed
  - ▶ this step was expected earlier - we are  $\frac{1}{2}$ -1 month behind our schedule
  - ▶  $\Rightarrow$  this will affect the next steps



# Validation Process

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Coordinated by Bedanga Mohanty

- Who validates what?
  - ▶ **DWGs** check the detector performance using complete and realistic (= material and services) configurations ( $p/p_T$  resolution,  $\sigma$  separation for PID)
  - ▶ **PWGs** check if and at which extent the configurations match the requirements for physics
- List of key measurements and key plots now on Wiki
  - ▶ **I&GD**: Focus on detector configuration performance
  - ▶ Writing subgroup: Focus on proposal
  - ▶ Expect iterative procedure with pros improving over time
- Important: Feedback to I&GD and DWGs



# Decisions on Magnet Design

## Requirements February 2021

- $B_{IP} = 3.0$  T
- Bore Diameter = 3.2 m
- Length 3.6 m
- Homogeneity
  - ▶ Flat field region = 10%
  - ▶ TPC region\* = 5%
  - ▶ Projectivity RICH for  $1.5 \leq \eta \leq 3.5$
- Possible operation at  $B_{IP} = 0.5$  T

## Homogeneity

[Field lines parallel to main axis]

Flat region:  $H_{Flat} = (B_{max} - B_{min}) / B_{IP} < 10\%$

TPC Region:  $H^2_{TPC} = B_r / B_z < 5\%$

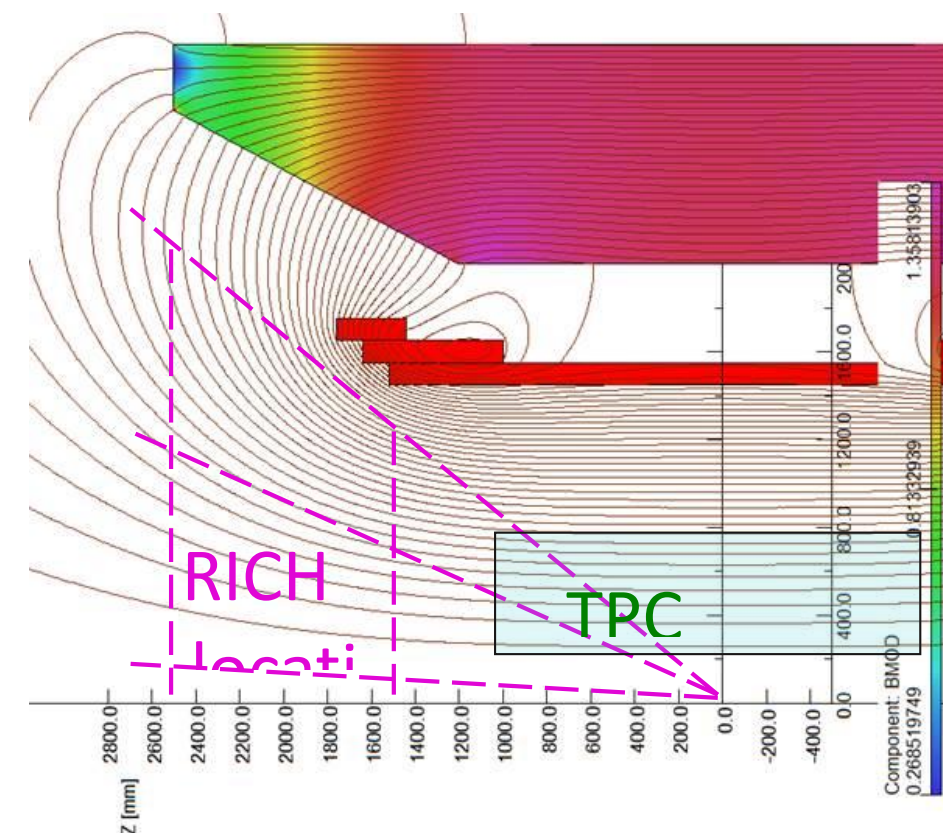
## Projectivity

[Field lines parallel to particle trajectory]

Important in fwd/bwg region

$$Proj = \frac{B_z \tan \Theta - B_r}{J_E}$$

If  $Proj = 0$   
everywhere,  
particles are not  
deflected from the  
original trajectory



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    - ▶ Projectivity RICH for  $1.5 \leq \eta \leq 3.5$
  - Possible operation at  $B_{IP} = 0.5 \text{ T}$
- Projectivity and homogeneities are inversely proportional
  - Note: TPC can be dropped
  - Projectivity vs. homogeneity
  - Every big change in the configurations / criteria will require 2 months before having a design
  - Request from designer (Valerio Calvelli) to decide this week

## Homogeneity

[Field lines parallel to main axis]

Flat region:  $H_{\text{Flat}} = (B_{\text{max}} - B_{\text{min}}) / B_{IP} < 10\%$

TPC Region:  $H^2_{\text{TPC}} = B_r / B_z < 5\%$

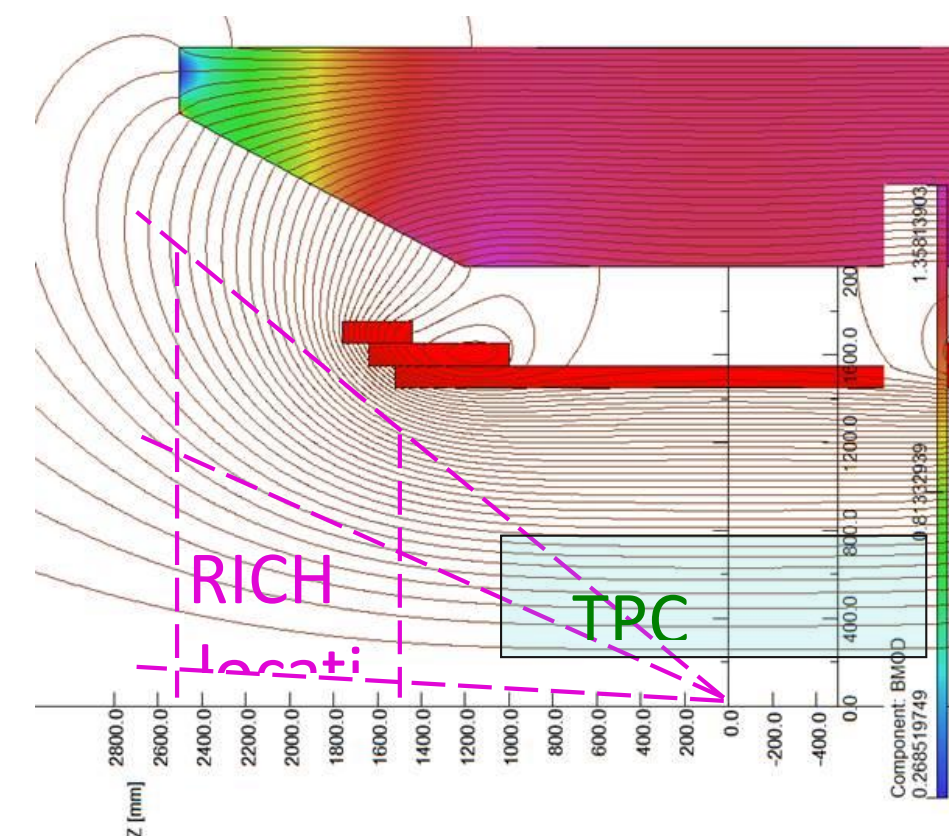
## Projectivity

[Field lines parallel to particle trajectory]

Important in fwd/bwg region

$$Proj = \frac{B_z \tan \Theta - B_r}{J_E}$$

If  $Proj = 0$   
everywhere,  
particles are not  
deflected from the  
original trajectory





# Decisions on Magnet Design

Requirements February 2024

Homogeneity

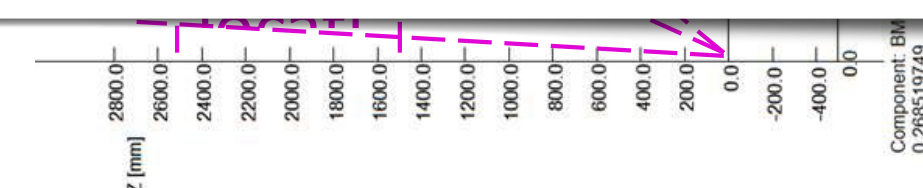
- DWG see no difference between configuration with optimized homogeneity versus configuration with optimized projectivity!?

- Recent configuration entailed an dRICH (150 cm → 180 cm) that might not be needed - discussion with PID group

- Last request to Valerio for configuration with short dRICH design before final decision

- Also check possibility if moving electron-endcap coil further out

decide this week



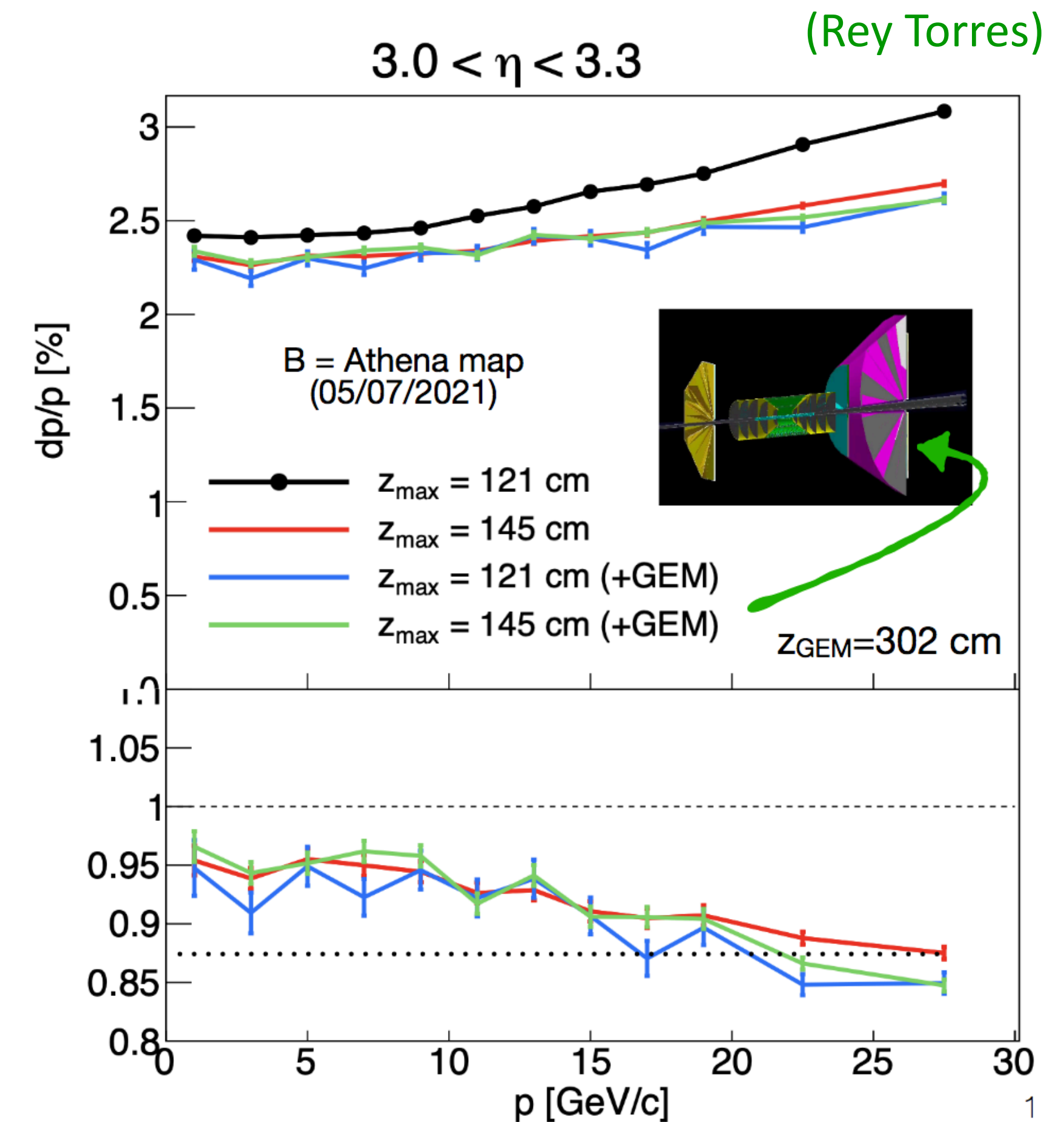
# Tracking WG - Activities (I)

## Tracking Studies

- Studies are on going to improve large  $\eta$  ( $|\eta| > 3$ ) momentum resolutions: See talk at tracking meeting 8/17 by Rey Torres
- Si group has been working with project regarding services
- Work with the software group has led to first implementation of Si support and service materials into the Baseline configuration
  - ▶ Additional iterations will come later

## Costing

- Preliminary GEM detector costing has started
- Quotes for GEM foils, cathodes, readout, ASIC in hand
- Working on support frames and electronics
- Other gaseous and Si costing estimates to come





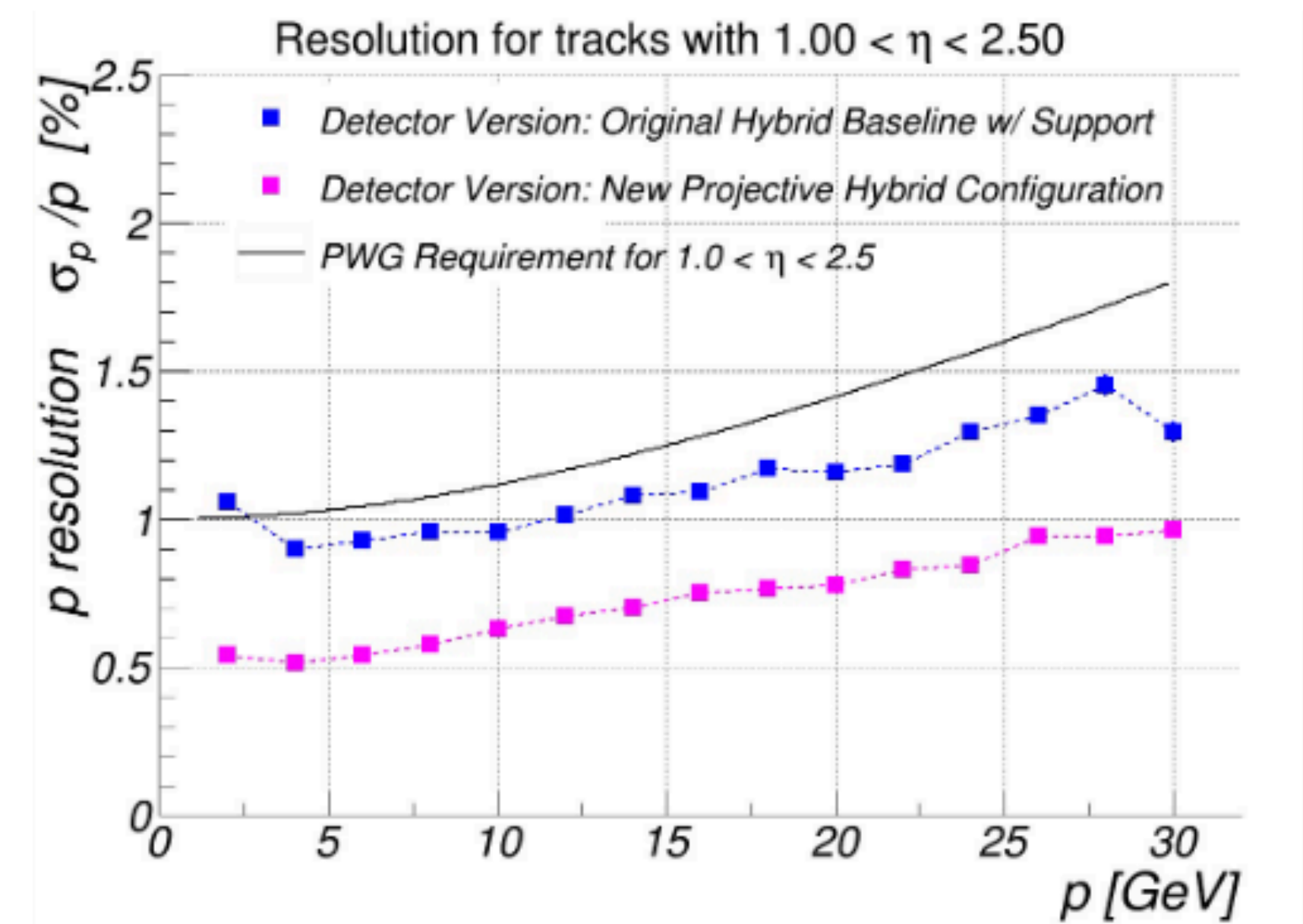
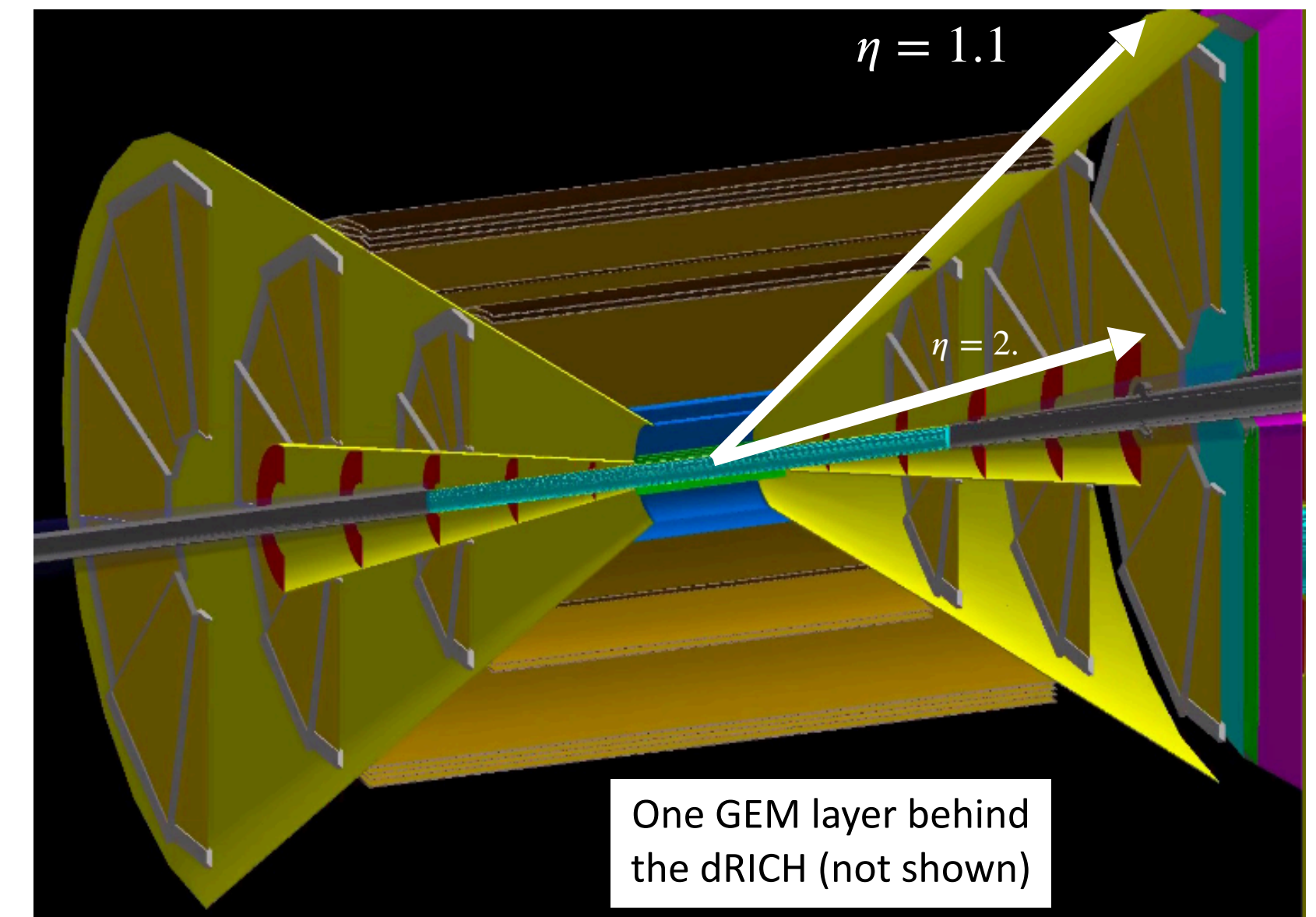
# Tracking WG - Activities (II)

## Evaluation of New Ideas in Projective Design

- Include conical support/services
- Minimize material over large  $\eta$  range
  - ▶ Have conical structures projective along  $\eta = 1.1$  and 2.5
- Has better or comparable performance as original Baseline
- More details: Tracking Meeting 8/17 (Nick Lukow)
- Needs further evaluation

## Institutions

- Hardware
  - ▶ Si Detectors: EIC Si Consortium
  - ▶ MPGDs Detectors: Florida Institute of Technology, Temple and URA, Saclay
- Tracking Simulation Studies (Fun4All)
  - ▶ Berkeley, Birmingham, Temple, and Saclay



# Calorimeter WG - Activities (I)

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## pECAL and pHCAL

- WScFi + Fe/Sc
- Implemented in dd4hep, WScFi being tweaked at this moment
- Description of the technology and detectors are ready to go into proposal

## bECAL

- hybrid design, imaging layers + WScFi (KLOE/GLUEX type)
- Implemented in dd4hep. Both parts under optimization

## bHCAL

- KLM type
- due to thick coils seems sufficient to instrument only two interaction length
- Reusing components from STAR BEMC - sc. Megatiles and re-using passive steel for flux return from STAR Magnet (project engineers started to look at this).
  - ▶ Implemented in dd4hep. Need manpower to do optimizations, currently only one student working on this.



# Calorimeter WG - Activities (II)

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## nECAL

- PWO + SciGlass
- Implemented in dd4hep.
- Large consortia behind this system (9 institutions) - same for ATHENA and ECCE

## nHCAL

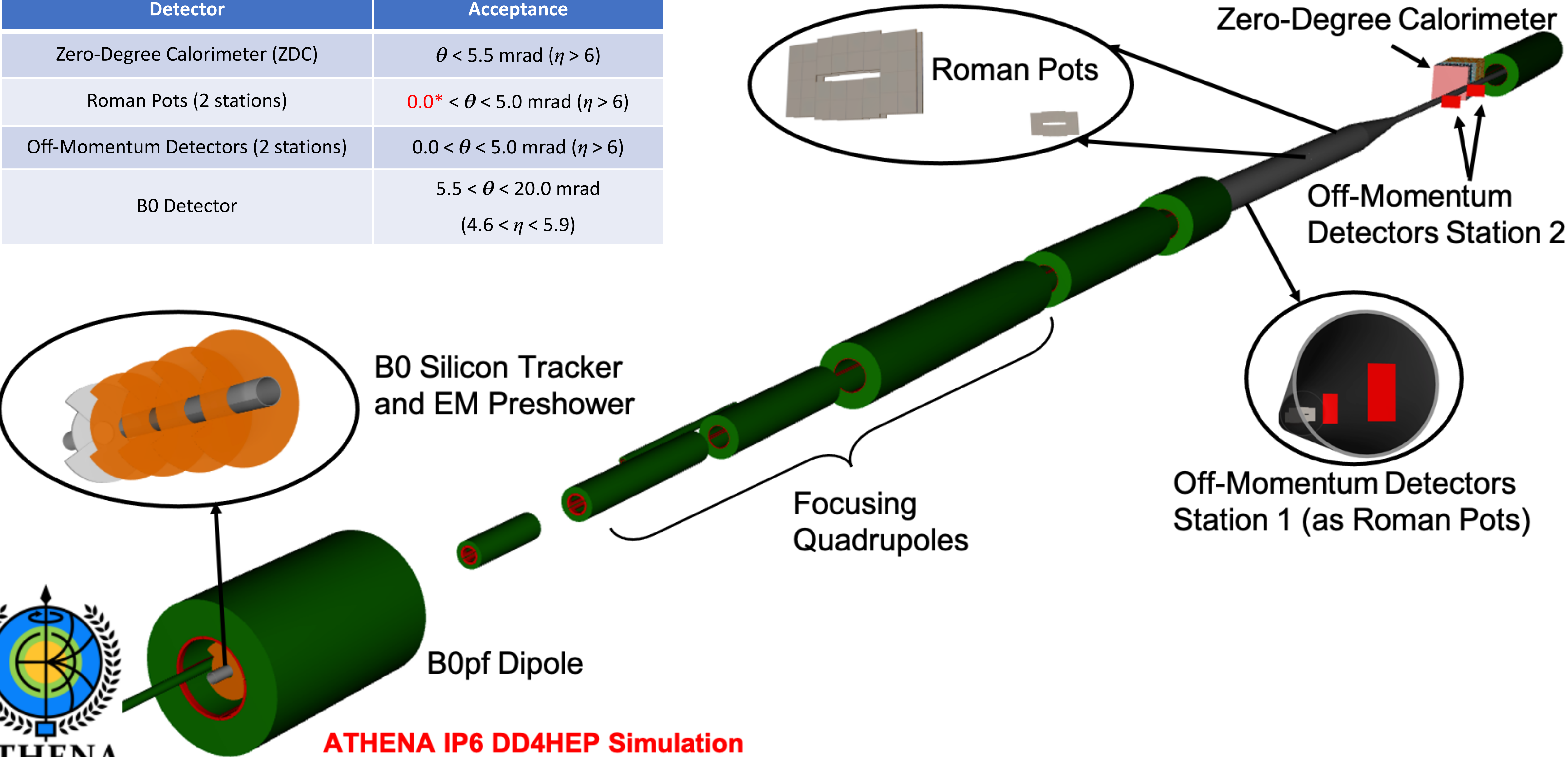
- KLM type. Re-using STAR EEMC Megatiles
- Implemented in dd4hep. Need optimization (reduction of layers).

## Institutions

- pECAL, pHCAL
  - ▶ UCLA, UCR, Fudan U., Shandong U., Tsinghua U., South China Normal U.
- bECAL:
  - ▶ Si tracking component: Argonne National Laboratory
  - ▶ Absorber/SciFi : **None**
- nECAL
  - ▶ CUA, Lehigh U., MIT and MIT-Bates Research and Engineering Center, U. Kentucky, AANL, FIU, Charles U.-Prague, IJCLab-Orsay
- bHCAL,nHCAL
  - ▶ **None**

# Far-Forward Detectors WG - Activities (I)

Detector	Acceptance
Zero-Degree Calorimeter (ZDC)	$\theta < 5.5 \text{ mrad } (\eta > 6)$
Roman Pots (2 stations)	$0.0^* < \theta < 5.0 \text{ mrad } (\eta > 6)$
Off-Momentum Detectors (2 stations)	$0.0 < \theta < 5.0 \text{ mrad } (\eta > 6)$
B0 Detector	$5.5 < \theta < 20.0 \text{ mrad}$ $(4.6 < \eta < 5.9)$



ATHENA IP6 DD4HEP Simulation



# Far-Forward Detectors WG - Activities (II)

## Roman Pots

**eRD24 & LGAD consortium**

- AC-LGADs with modified ALTIROC ASIC for readout are a great candidate to meet requirements.
- Studies underway to understand needed mods to off-the-shelf ASICs to optimize for use with the AC-LGADs.
- Aiming for “potless” system – need to work out cooling, readout, etc.

## Off-Momentum Detectors

- Same AC-LGAD technology can be used as for RP system.
- Looking at a “two-stage” approach to maximize coverage – 1 set of detectors close to B1apf (possibly as a more conventional RP injected horizontally), set close to B2pf, opposite of ZDC.

## Zero-Degree Calorimeter

**U. Kansas and RIKEN**

- Starting concept based on ALICE FoCal.
- Has dedicated EM component (PbW04 and silicon) and hadronic component (Pb scintillator).
- Also working out possibility of same EM technology for the ZDC and Lumi./Low-Q2 tagger. Common technology will reduce cost and risk.

## B0 Tracker

**LANL, BNL, others**

- Need silicon tracking layers for charged particles and timing.
- Possible use of MAPS for spatial resolution, and AC-LGADs for timing.
- EM calorimetry or preshower also envisioned for photon tagging. Must be compact to fit in the B0 space.
  - ▶ PbW04 could be useful here, but we need to look at requirements more carefully to decide. In progress.

# Far-Forward Detectors WG - Activities (III)

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## Current Status

- Coordinate flip and 50cm shift fully implemented.
- All main detectors defined and placed.
- Still an issue with readout/digitization in the off-momentum detectors, which should be solved soon
- Simple, but realistic, beampipe included in the FF drift region.
- Working on solving an issue with the transport of protons through the magnetic fields
- Tracking/reco for B0 to be integrated into forward tracking.
- Reconstruction for other detectors underway.
- Engineering support needed (and in progress) for the RP/OMD station 1/B0 detector. There is active work being already on this front (e.g. beam pipe design).



# Yes, there are issues ...

- Testing of implementation in DD4HEP by DWG needs support from software group that is already stretched thin. Steep learning curve.
  - Geometry and location of the dRICH needs to be settled
  - Barrel: Hybrid likely but details need work
  - PID in Barrel:
    - ▶ Low  $p_T$  PID still an issue
      - ◉ Timing in EMCAL
        - ditto depending on position
        - ◉ Timing with AC-LGAD layer after MAPS
          - would capture low  $p_T$  also at full B
          - needs R&D
      - possible but  $p_T \gtrsim 0.8$  needed to reach EMC
      - would require low B runs
    - ◉ dE/dx in Gridpix
- Support structure for tracking & PID detectors?
  - ▶ Still much missing in DD4HEP
  - ▶ More engineering components needed
  - ▶ Limited people-power for this right now from the project. What we currently have is just enough to estimate the essential performance.
  - ▶ Engineers from universities to the rescue?

# Next Steps

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We are behind: no reason to panic but we need to reschedule things and become more proposal focused

- Cannot iterate over too many detector configurations
- Next iteration needs to get close
  - ▶ DWG and I&GD group need to define “hot” candidate configuration next Wednesday (August 25)
- Need to focus on what is really needed for proposal
  - ▶ Validation has to be timely and concise
  - ▶ Tracking, PID: decisions needed despite different views
    - ◉ there is still plenty of time between proposal and CD-2 and CD-3
- Manpower issues need to be addressed now
  - ▶ Institutions need to help with manpower for the next few months
- ATHENA has many smart people working very hard and it is a joy working with all of you - we can get this done!