FCC-ee detector integration in experiment caverns

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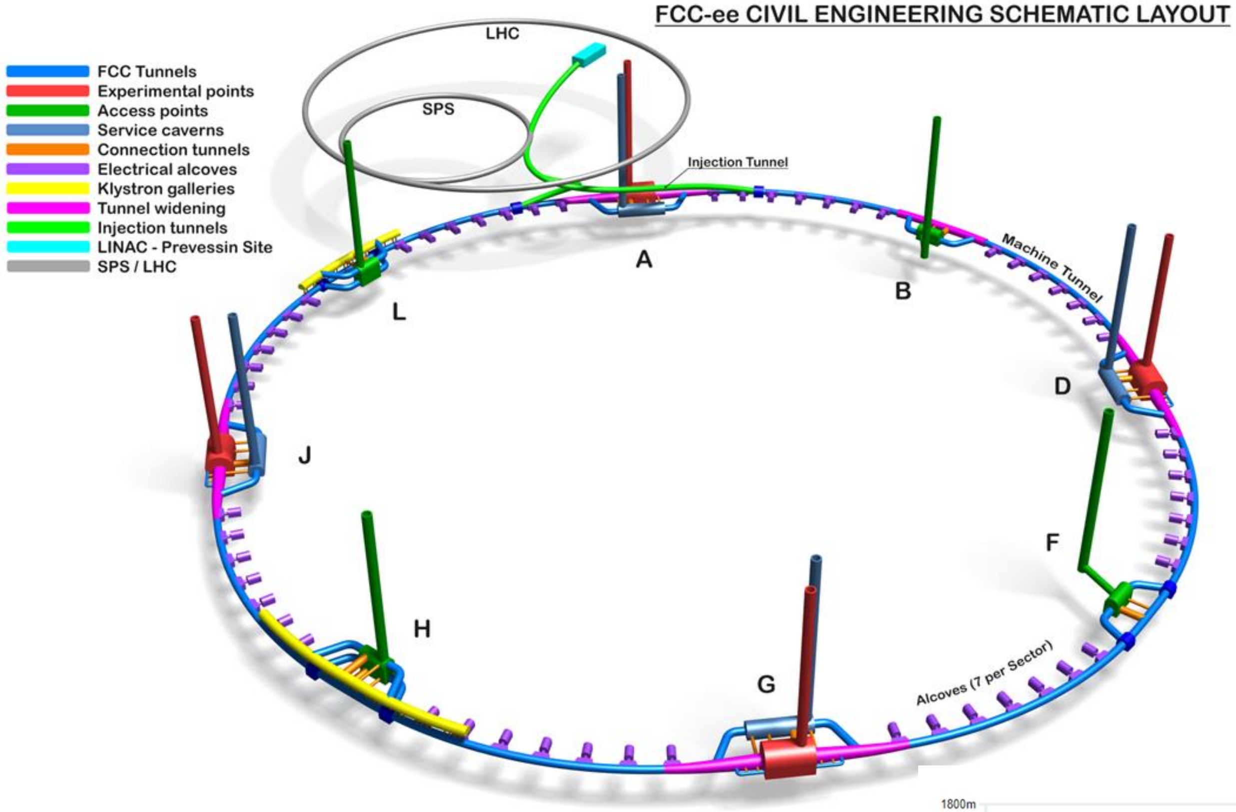
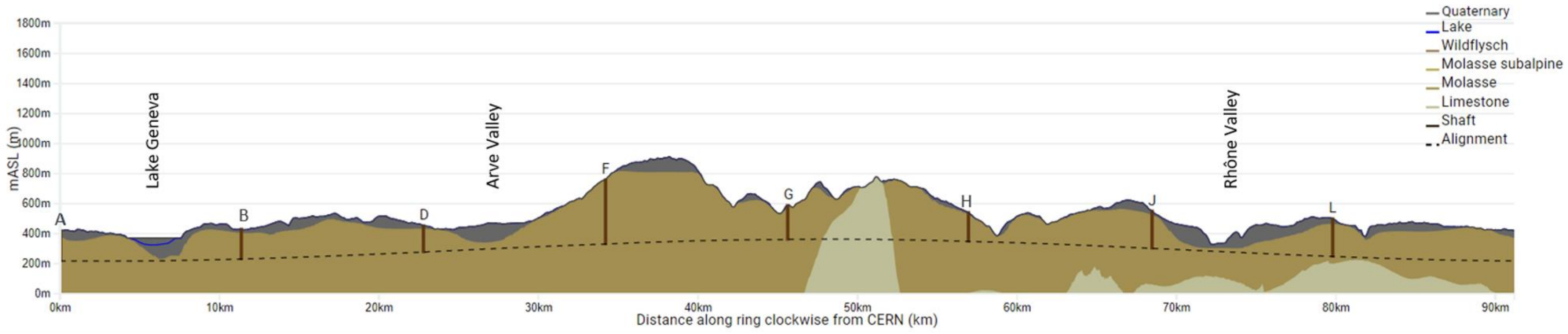
Content

- Size of experiment caverns vs dimensions of detectors
- Beam-line hight issue in experiment caverns
- Detector assembling
  - Assembling on surface vs underground
- Detector opening scenarios
  - Accessibility during long shutdowns vs year-end technical stops
- Outlook

Size of experiment caverns vs detectors



A & G sites – Large experiment caverns
D & J sites – Small experiment caverns

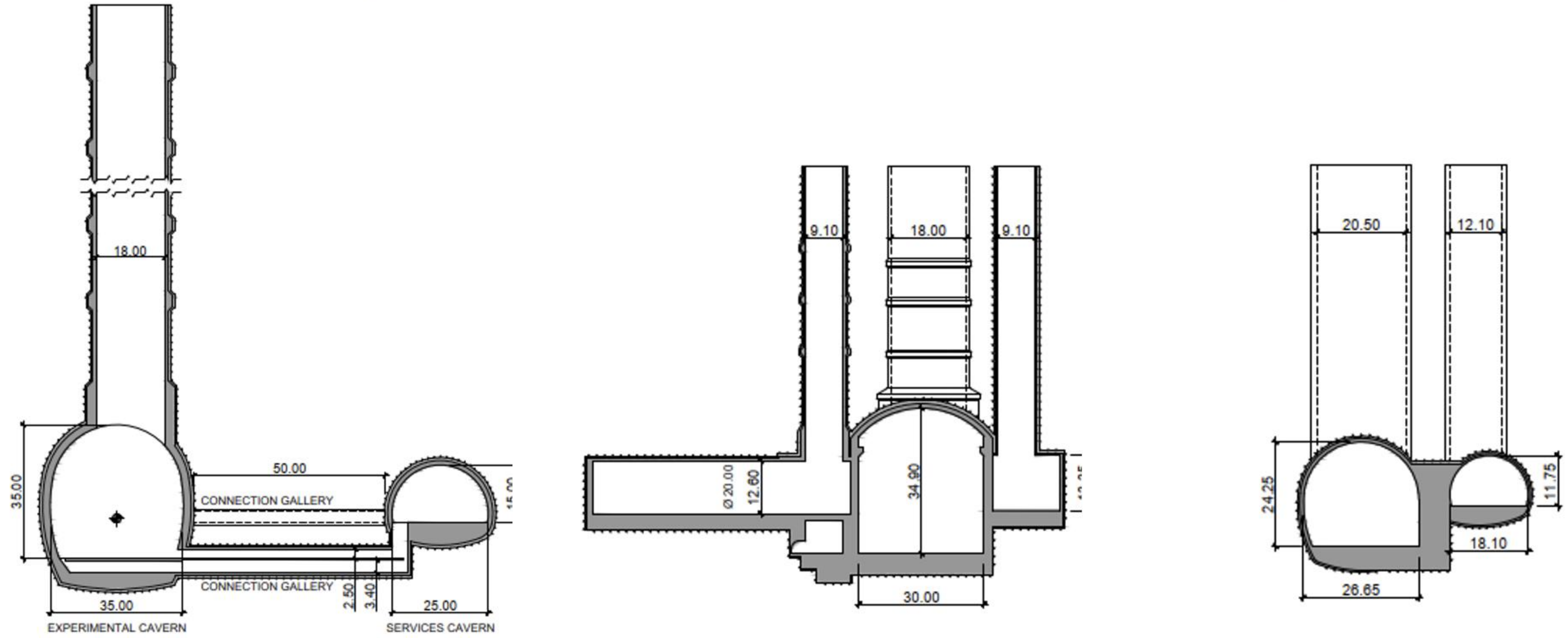


Shaft depths:

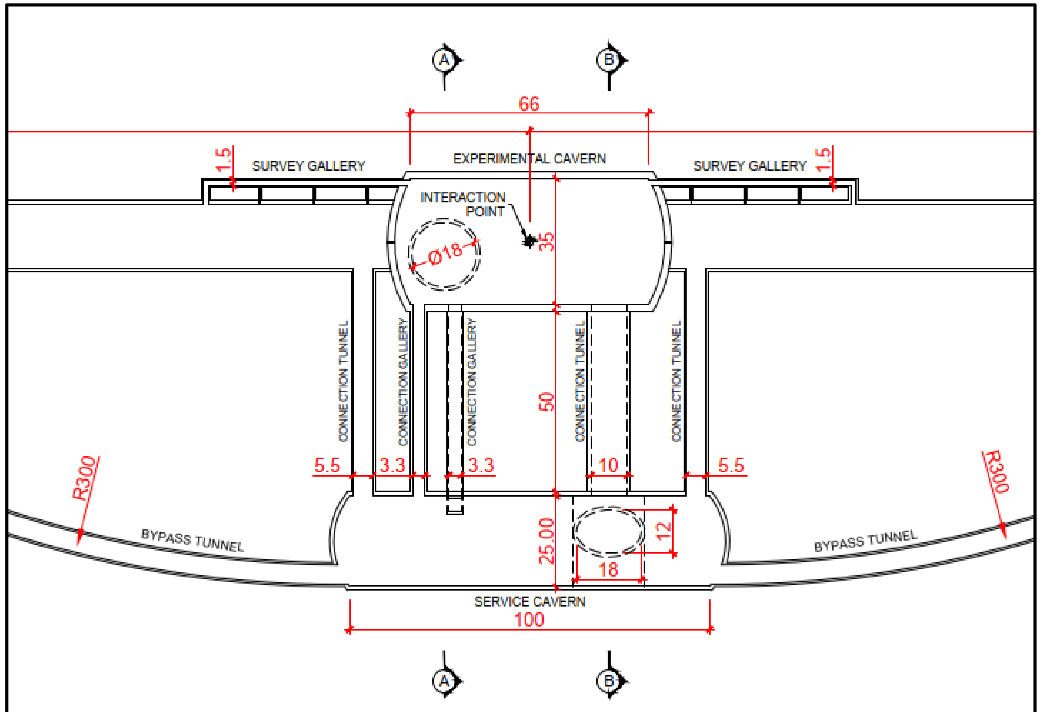
A: 201 m B: 201 m D: 181 m F: 400 m G: 226 m H: 235 m J: 253 m L: 250 m

Size of experiment caverns vs detectors

Comparison FCC to ATLAS and CMS Cavern Complexes

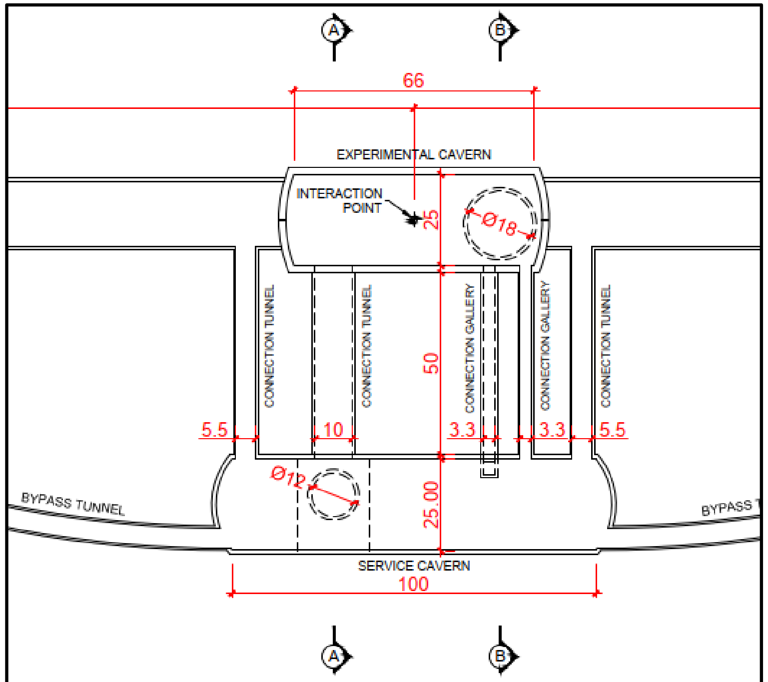


FCC **ATLAS** **CMS**

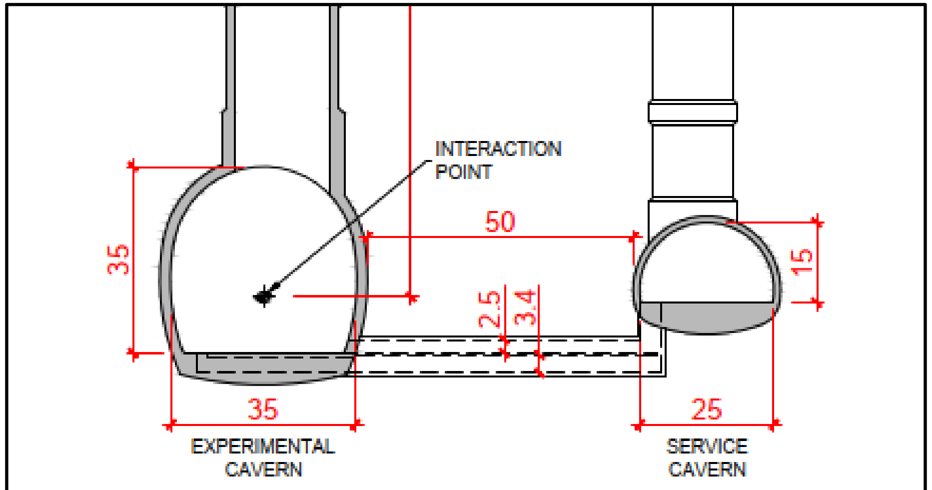


PLAN VIEW
1:1000

Small D & J sites
Cavern dimensions comparable with CMS site.
Smaller shaft diameter.

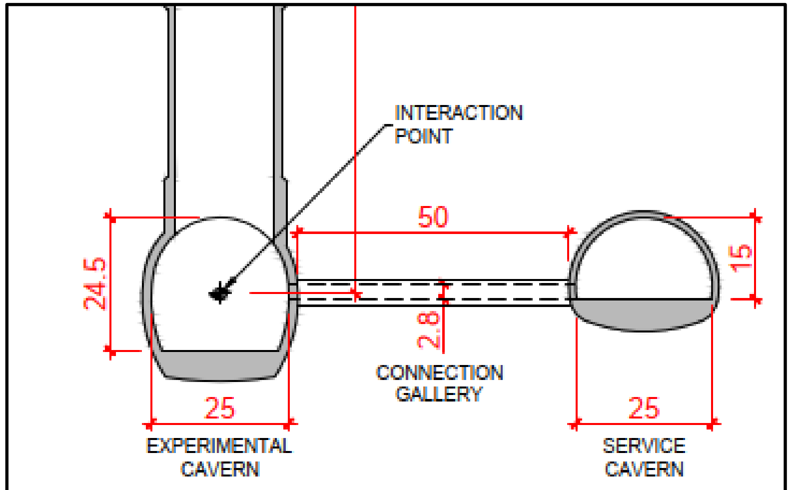


PLAN VIEW
1:1000



SECTION A-A
1:1000

Large A & G sites
Very large and tall cavern, comparable with ATLAS site and sized for h-h detector.
Just one shaft.



SECTION B-B
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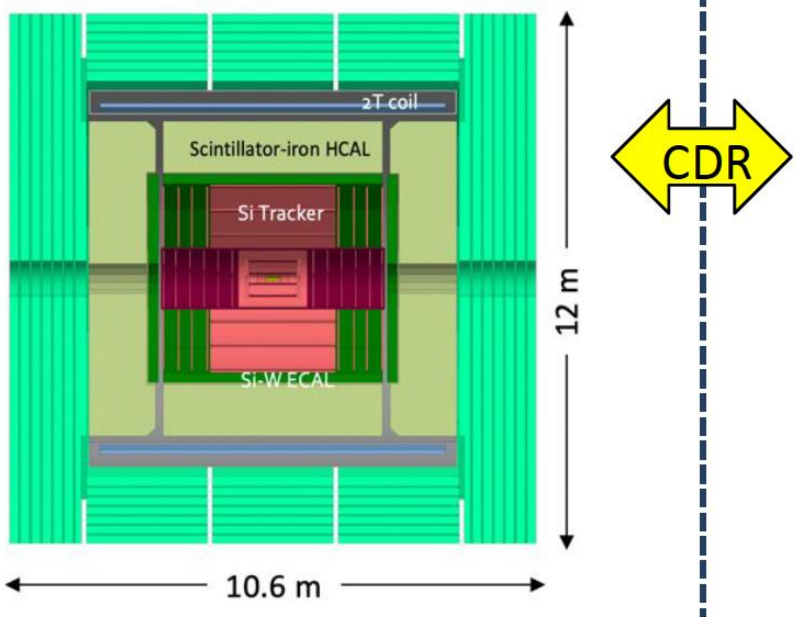
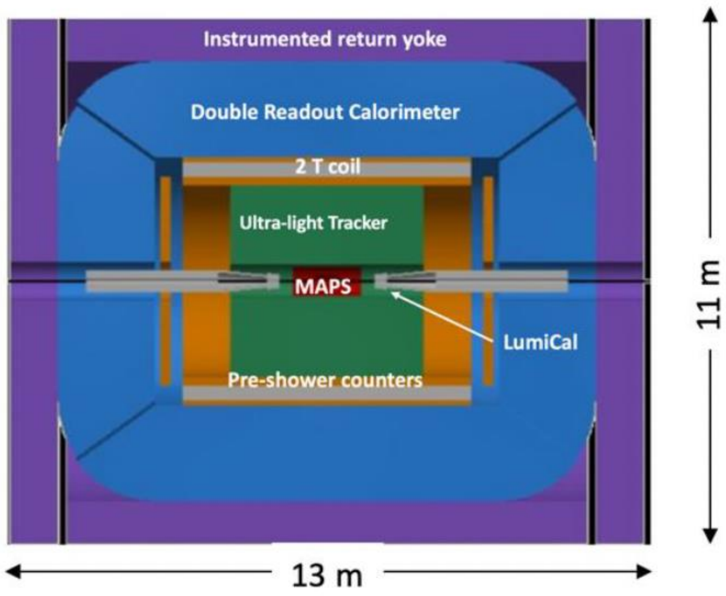
Size of experiment caverns vs detectors

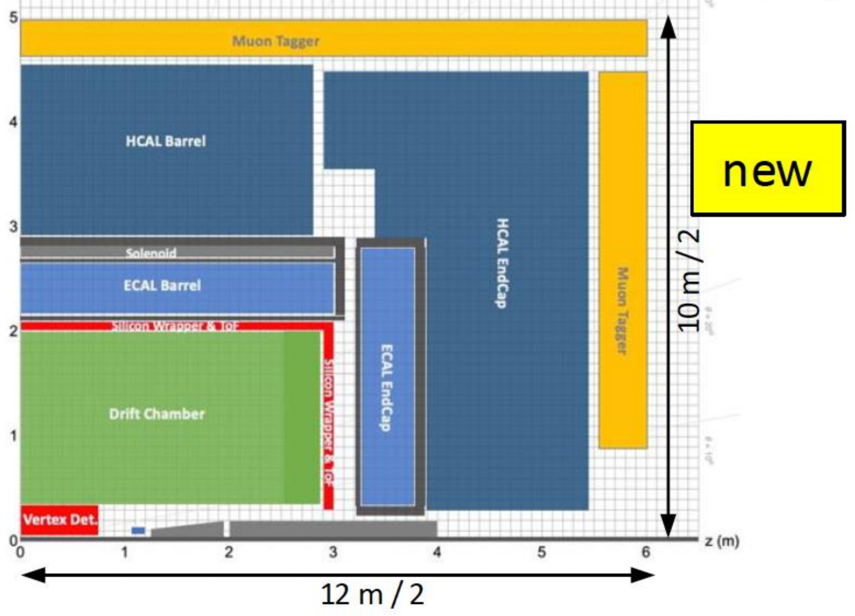
CLD



IDEA

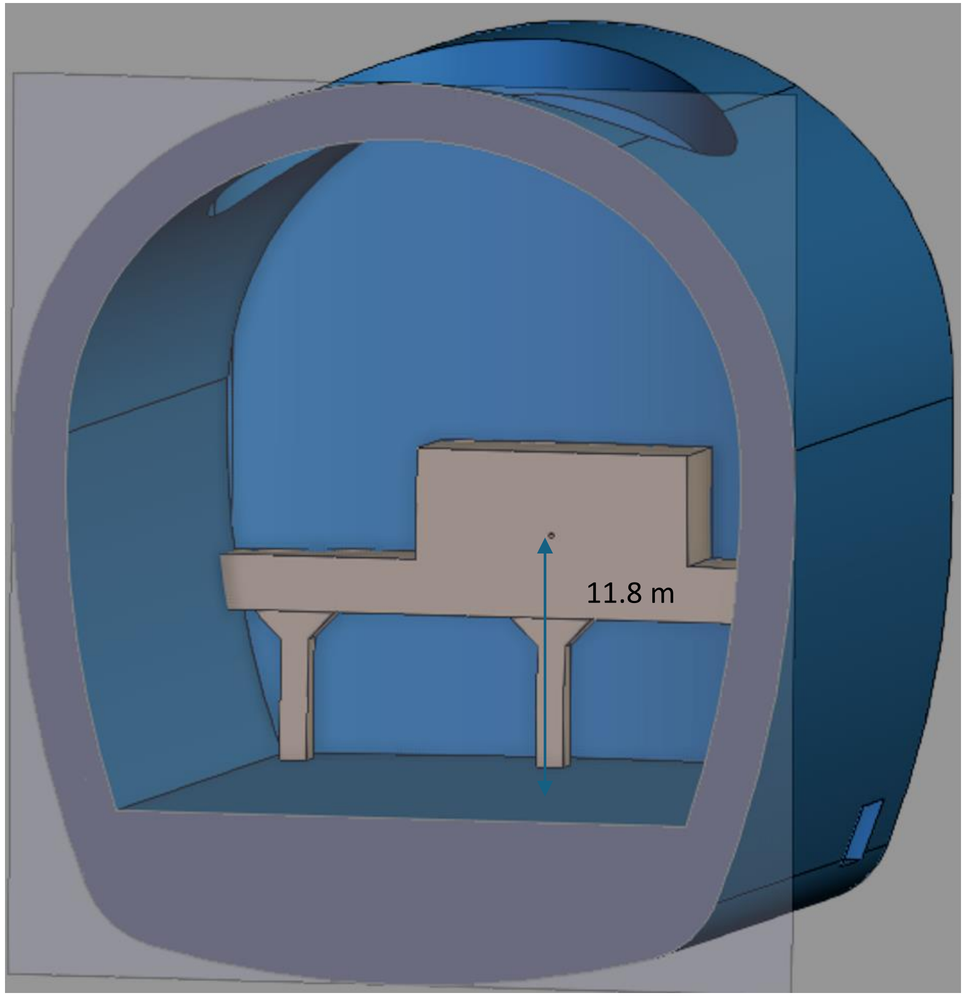


ALLEGRO (Noble Liquid ECAL based)

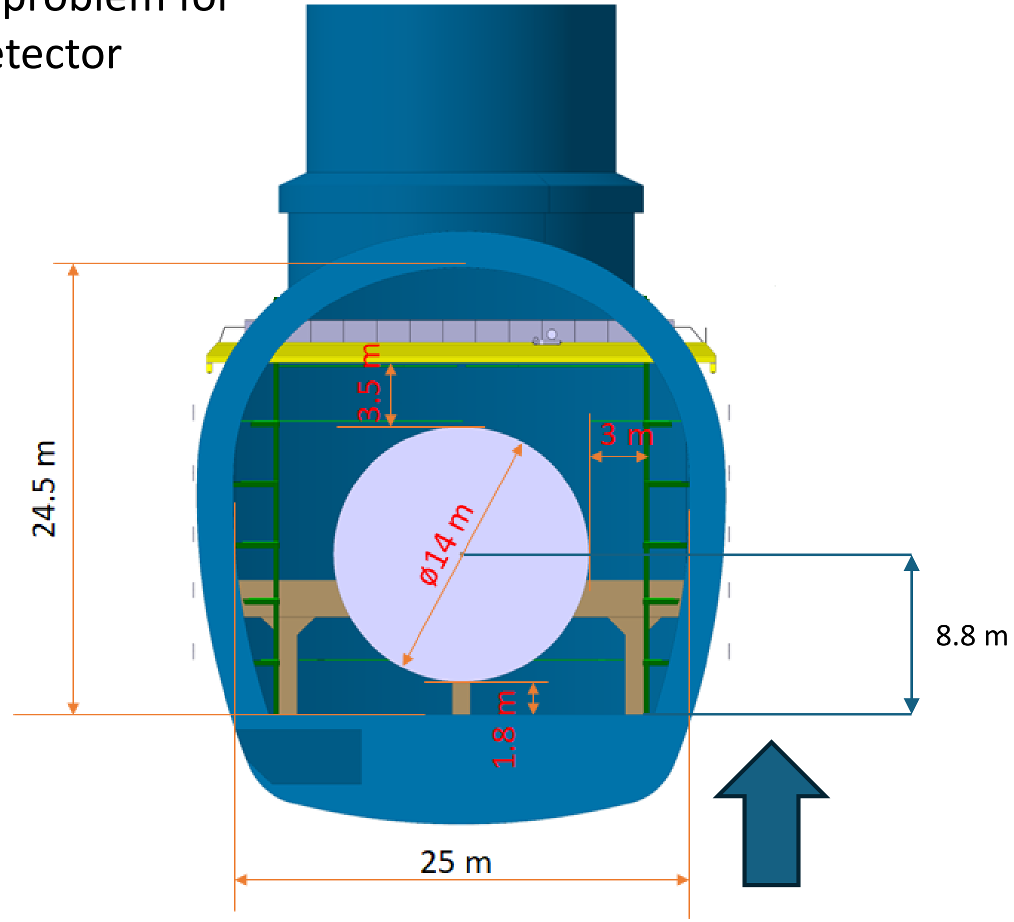


The three detector proposals show comparable dimensions, this facilitate the integration study.
The largest monolithic object is the superconducting coil within its cryostat, or the IDEA's barrel Calorimeter.

Beam-line hight in experiment caverns



Excessive beam high is a problem for both FFQ stability and detector assembly



Excessive beam hight compared to detector diameter. Requires 3 – 4 m tall heavy-duty platform (see slide 15) , to be removed for h-h detector installation

Cavern floor raised by 3 m in small cavern, compatible with special h-h detector.

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Detector assembly strategy

- The way the detector is assembled on the beamline depends on many factors:
  - The detector segmentation (moving endcaps, fixed barrel)
  - The geometry of the cavern and the shaft(s)
  - The handling tools available on surface and underground (cranes)
  - The MDI layout, that essentially determines the sequence how pieces have to be installed.

Detector assembly strategy

- Assembling the detector on surface has several advantages:
  - Space constrains less critical than underground → large assembly halls
  - Accessibility from all sides
  - Large detector parts tested on surface before lowering
  - Repairs or last-minute changes easier to be implemented
  - Crane underground is mid-size capacity (e.g. 20 tons).
- Cons:
  - It requires a <u>large shaft</u> to lower down pre-assembled detector parts (e.g. full endcap disk).
  - Detector check-out needed after lowering.

Detector assembly strategy

- Assembling underground has the following advantages:
  - The shaft size can be reduced to fit the largest detector component (typically the magnet cryostat) and the hall on surface is smaller.
  - Detector check-out and commissioning at the same time.
- Cons:
  - Timely delivery of detector elements for assembling
  - Requires large capacity crane underground (e.g. 80 – 100 tons).
  - Repair and modification tasks require more time.

Detector opening scenarios

Detector vs machine requirements:

- Detector side:
  - Detector acceptance and hermeticity
  - Simple opening sequence – minimal services disconnection & handling
  - Accessibility to detector inner parts in reasonable time during shut-downs
- Machine side:
  - Stability of the FFQ supports
  - Quick and reliable alignment procedure
  - Beampipe vacuum preserved

Detector opening scenarios

The detector's endcaps could be opened following three different options:

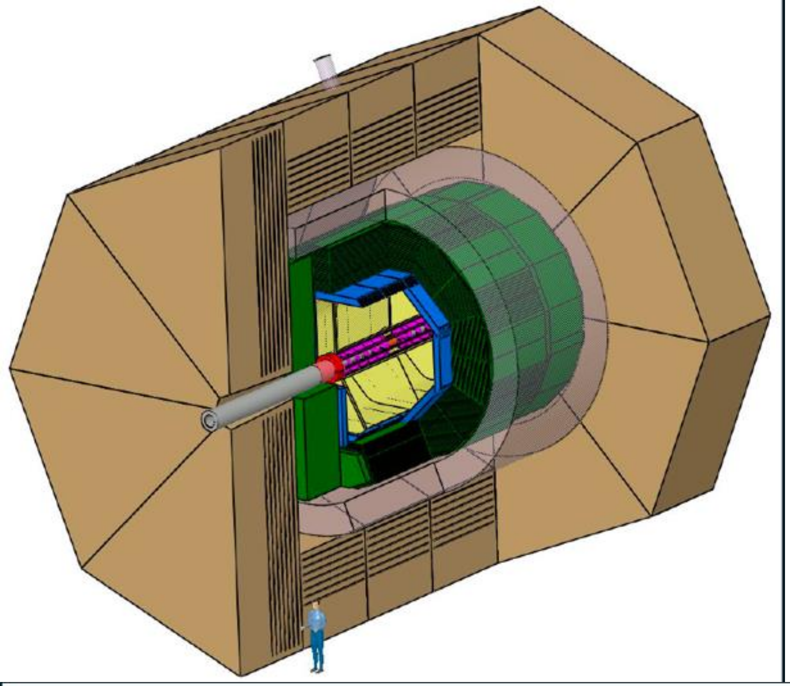
#1. Full longitudinal opening of the two endcaps.

- Detector acceptance in the forward region depends on machine layout
- FFQ and other machine elements beyond detector endcaps shall be removed (with their supports). BP vacuum broken also in cold pipes. Realignment of the machine needed.

#2. Limited longitudinal opening to disengage the detector endcaps plus transversal opening (split endcaps) or diagonal opening of the split endcaps.

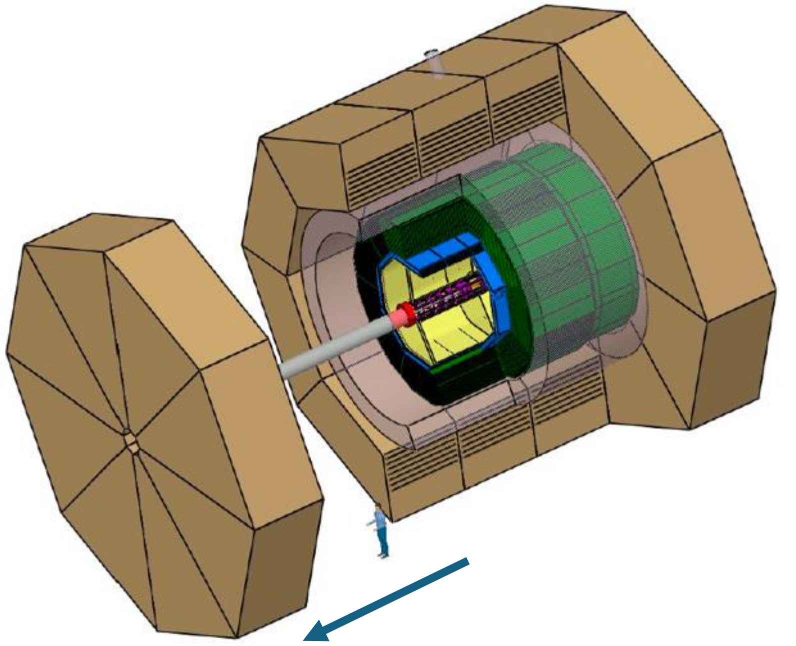
- Split endcaps significantly deteriorate detector precision measurements
- The cross section of the FFQ cryostat determines the envelope into which the machine elements just behind the detector endcap shall ideally stay. This constraint refers specifically to the cryo-services of the FFQ assembly.
- BP vacuum stay (or Ne flushing), no realignment needed.

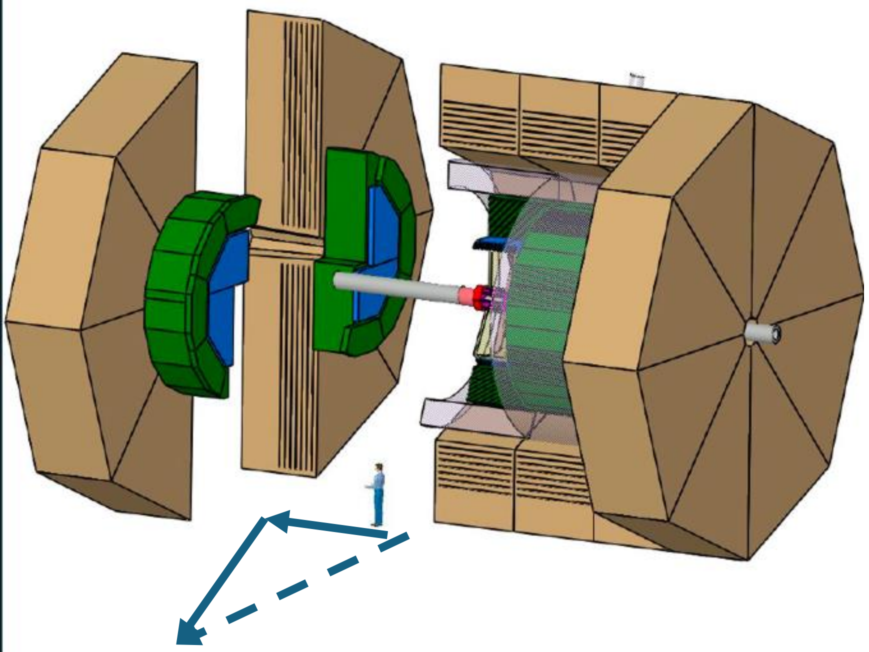
A. Gaddi, F. Valchkova, G. Roy, K. Oide



Scenario #1

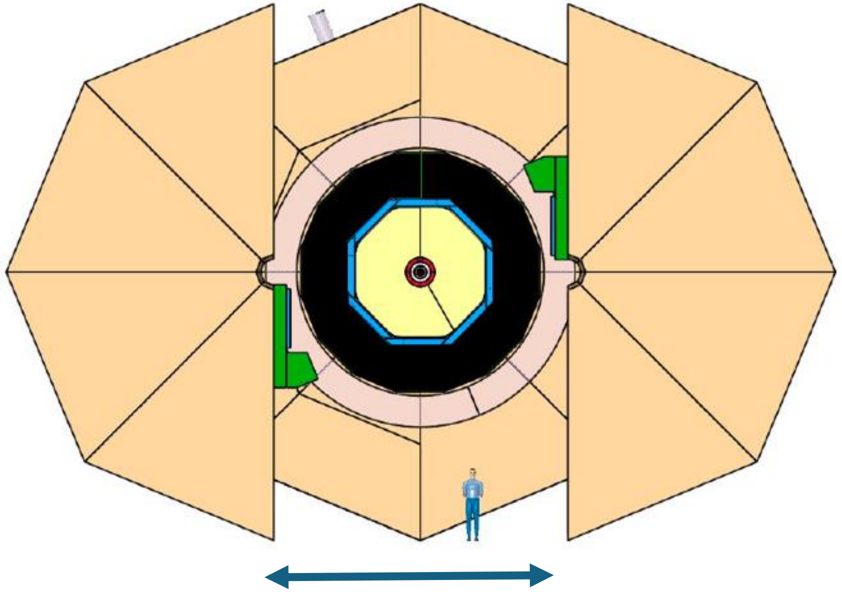
Long (7m) longitudinal stroke to access inner detector elements. Last machine elements cantilevered & removed for opening.





Scenario #2

Combined short (2m) longitudinal stroke + transversal opening.



Detector opening scenarios

- #3a. Transversal shift of the full detector plus the FFQ assembly (parking position), then extraction of the FFQ and full longitudinal opening of the detector endcaps
    - Optimal detector acceptance
    - FFQ assembly stays inside the detector, temporarily supported by the detector's endcaps. Machine elements beyond detector endcaps also stay in place. BP vacuum broken for detector beampipe. Realignment needed.
- #3b.Longitudinal pull-back of the FFQ assembly, followed by a transversal shift of the full detector (parking position), then full longitudinal opening of the detector endcaps
    - Optimal detector acceptance
    - FFQ assembly is mechanically isolated from detector supporting and positioning and extracted before transversal movement. Vacuum is broken for detector beampipe. Realignment needed.

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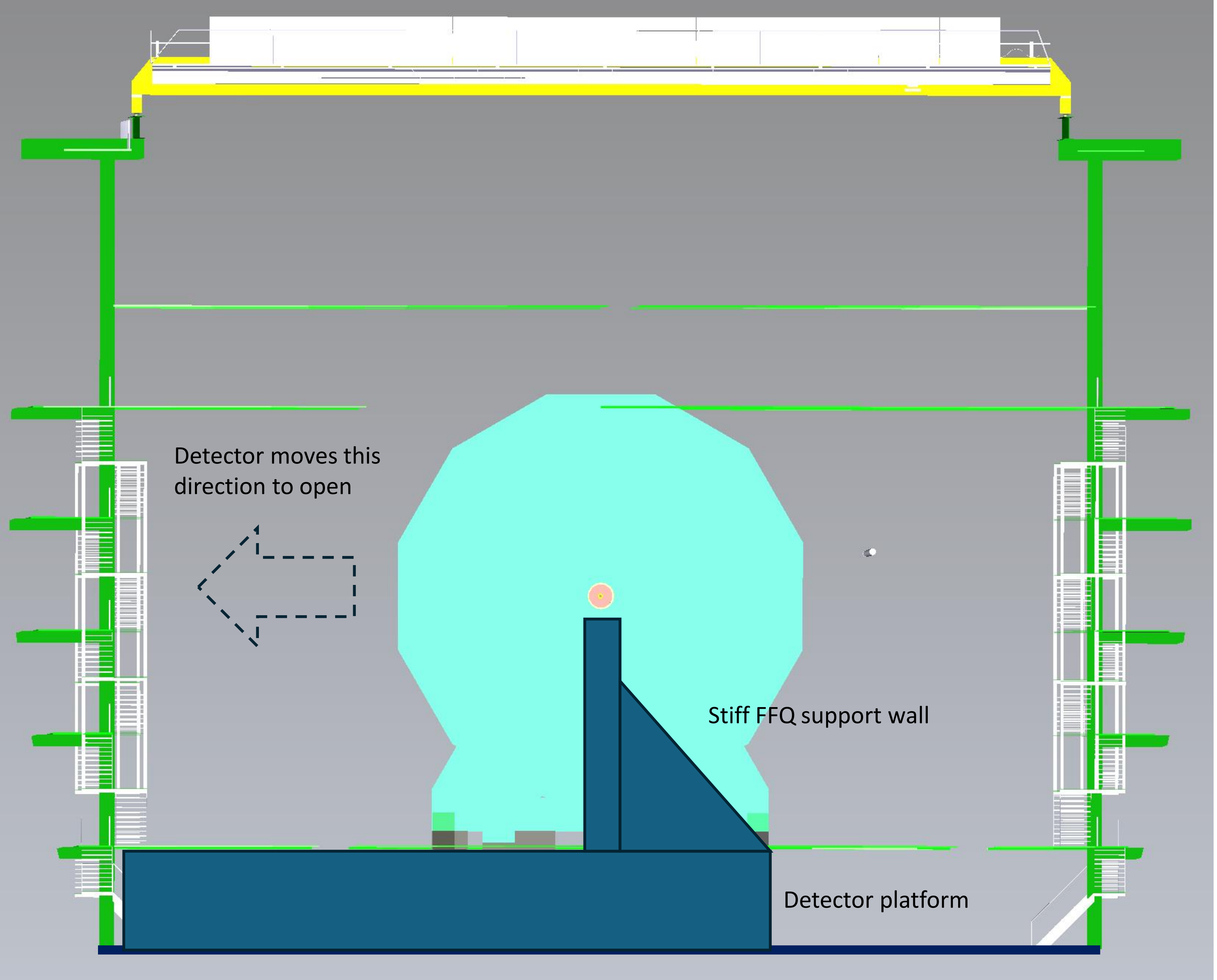


FUTURE CIRCULAR COLLIDER
Innovation Study

Scenario #3

In the large experiment sites A & G there is enough clearance to envisage the scenario to move the detector aside the beamline and get full access to the detector's inner parts.
The FFQ can either be removed before the translation or move with the detector and be removed from the garage position.

Detector opening scenarios

General consideration common to all the detector opening scenarios:

- The design of the FFQ assembly, including their cryo-services, must include the possibility of being disconnected from the conical BP chambers, that are mechanical integrated with the vertex detector, at z = 1190 mm, via a bellow and a remote actuated flange plus one or two vacuum valves to isolate the vacuum pipe of the quadrupoles (cold vacuum pipe).
- The FFQ assembly is supported cantilevered by a removable pillar at the edge of the endcaps from the ground to be mechanically decoupled from the detector (opening option 1). If the pillar supporting the FF assembly cannot guarantee enough stiffness, then the cavern floor on the vertical projection of the beamline, shall be raised to a convenient height to increase the pillar stiffness (this rules out the opening option 1 hereabove). The maximum width of such structure shall be limited to 2m to allow the detector to be opened from the parking position (option 3) in the large cavern site.

A. Gaddi, F. Valchkova, G. Roy, K. Oide

Accessibility to detector internals during long shut-downs vs year end technical stops.

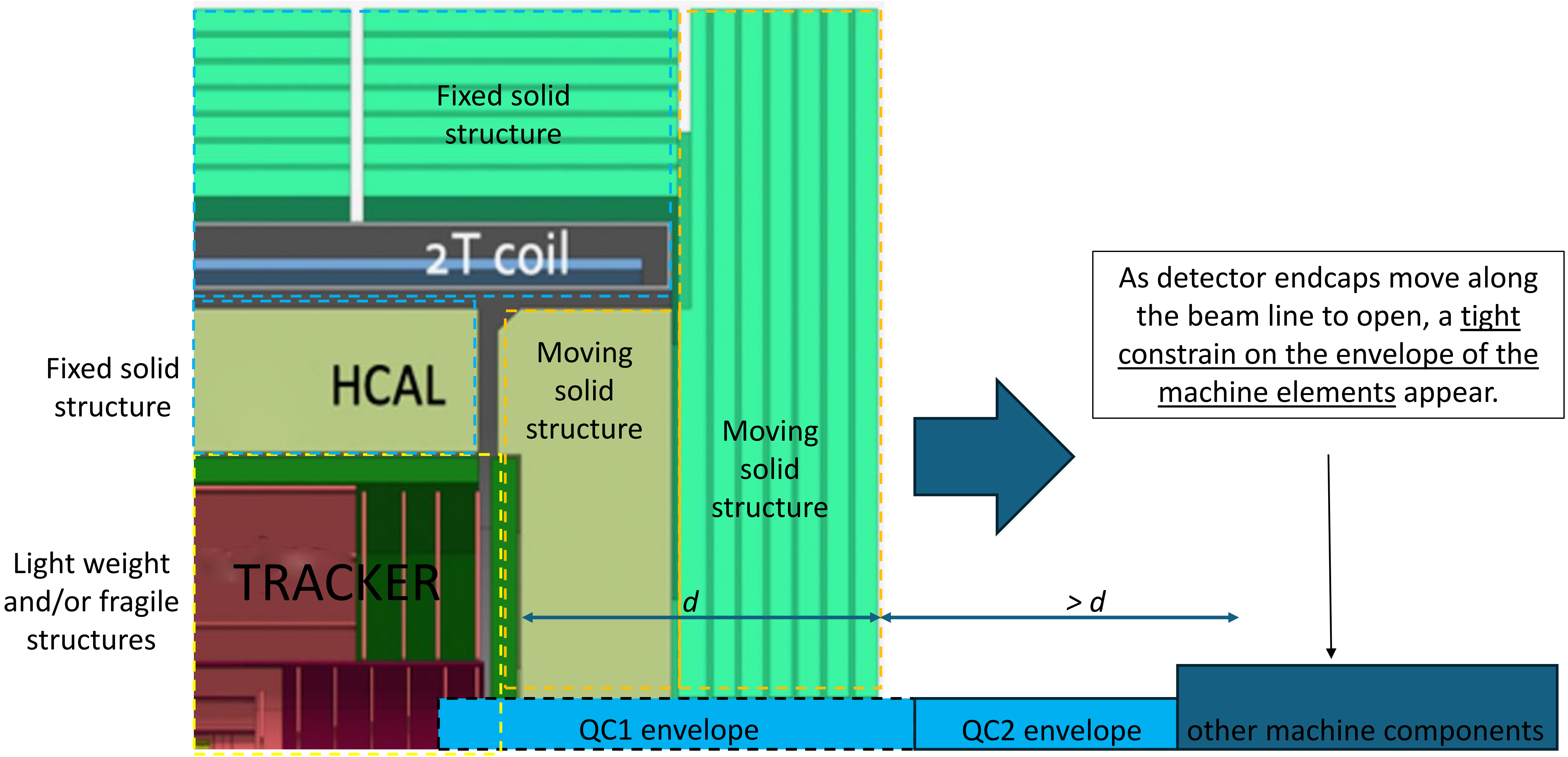
- Whilst during a long shut-down it is reasonable to remove the machine elements (and their services) closest to the detector, the duration of a year-end technical stop of few weeks/months would suggest to try to preserve the alignment of the FFQ and the BP vacuum.
- This is possible only in the scenario #2, thus it is of paramount importance that, for scenarios #1 & #3, the FFQ have a quick and reliable alignment system. If the re-alignment is done at the same time of the BP vacuum pumping, the full operation shall be completed within a week.

Outlook

- Progresses have been made to solve some inconsistency between the civil engineering design and the detector proposals (beam hight). Discussions to be continued on the layout of the service cavern and connecting tunnels.
- Fruitful discussions going on with K. Oide and G. Roy on the MDI layout between +5 and +15m from IP.
- Start looking at the details of detector integration and opening sequence, following the scenarios depicted here before, for both short and long machine shutdowns.

Back-up slides

Typical detector structure.

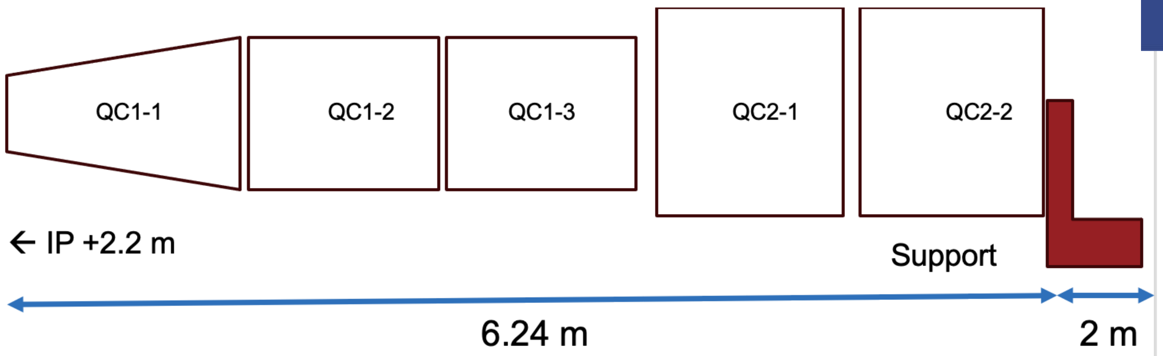


As detector endcaps move along the beam line to open, a tight constrain on the envelope of the machine elements appear.

Possible QCs layouts and their supporting structures

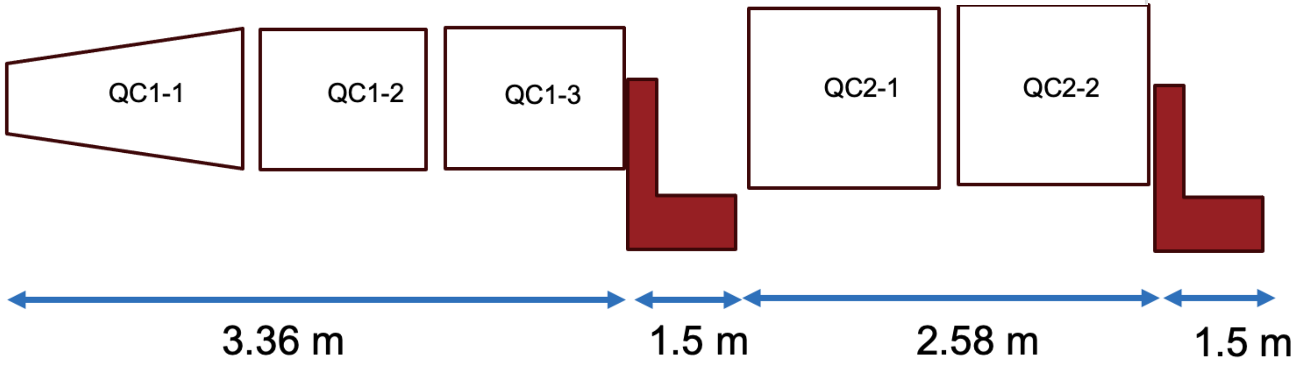
Option 1:
IR QC1 and QC2 in one cryostat and girder.

- minimal cryogenics & powering interconnections
- long & heavy cantilever assembly → stability issues
- complex handling



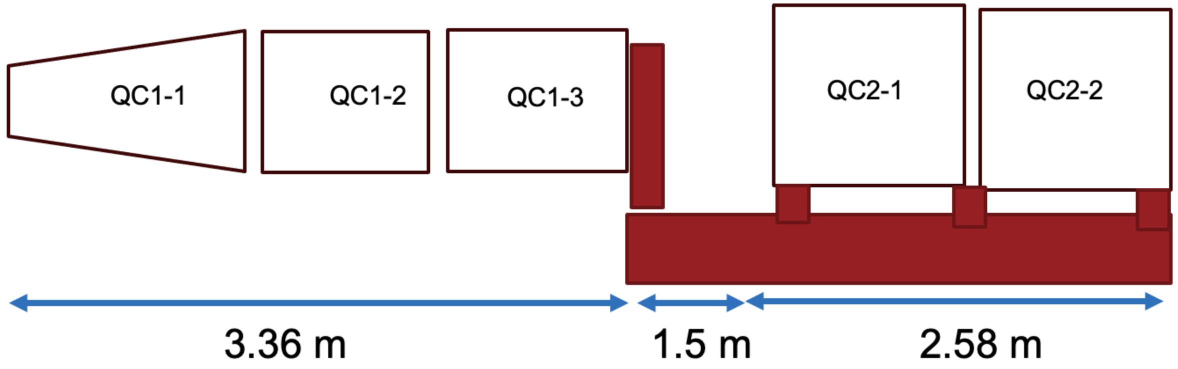
Option 2a:
IR QC1 and QC2 in two different cryostats and girders.

- shorter cantilever → less vibration
- tricky alignment between QC1 & QC2

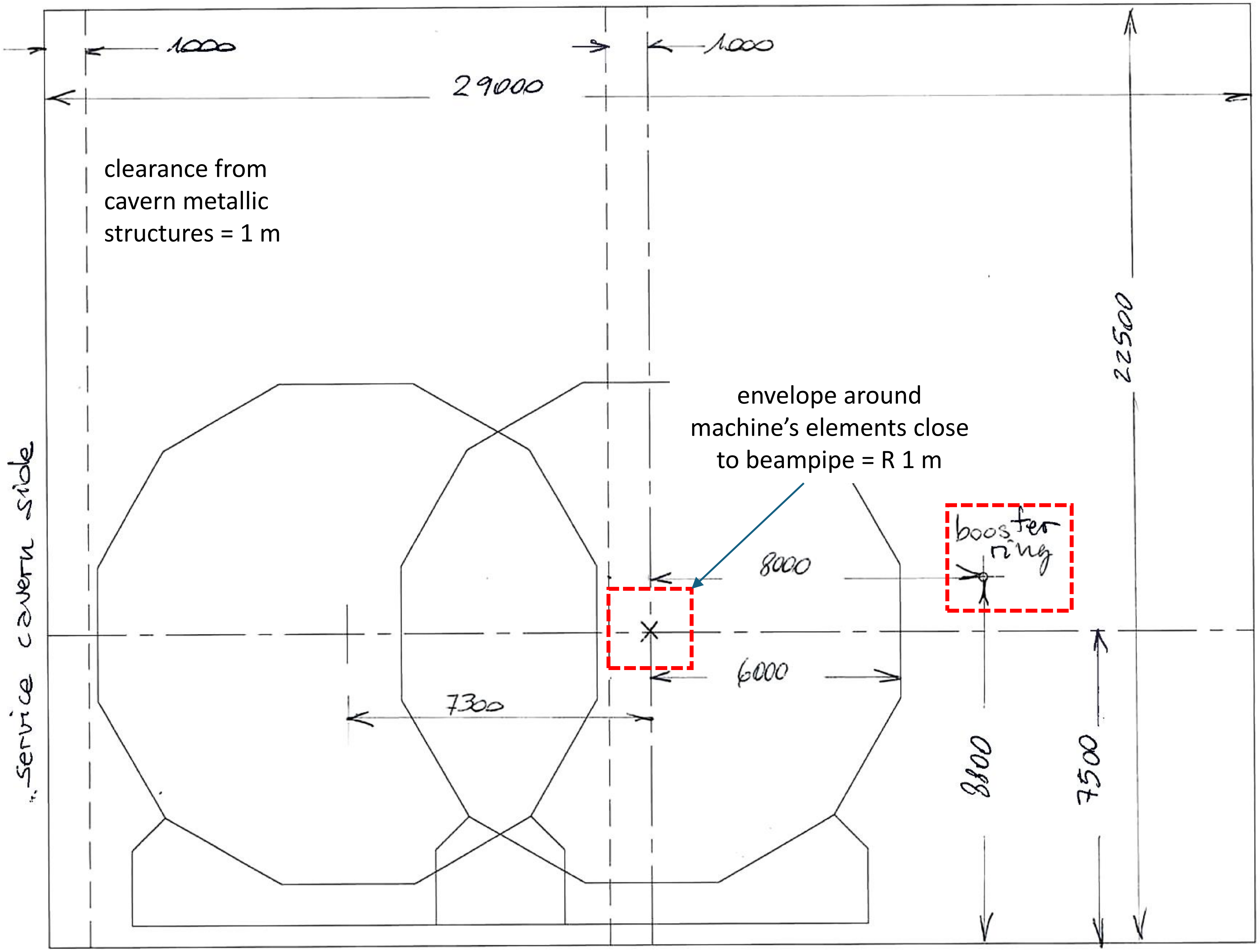


Option 2b:
IR QC1 and QC2 in different cryostats, but one integrated girder.

- same as above, quicker assembly installation & removal
- most interesting to get quick access to detector inner parts

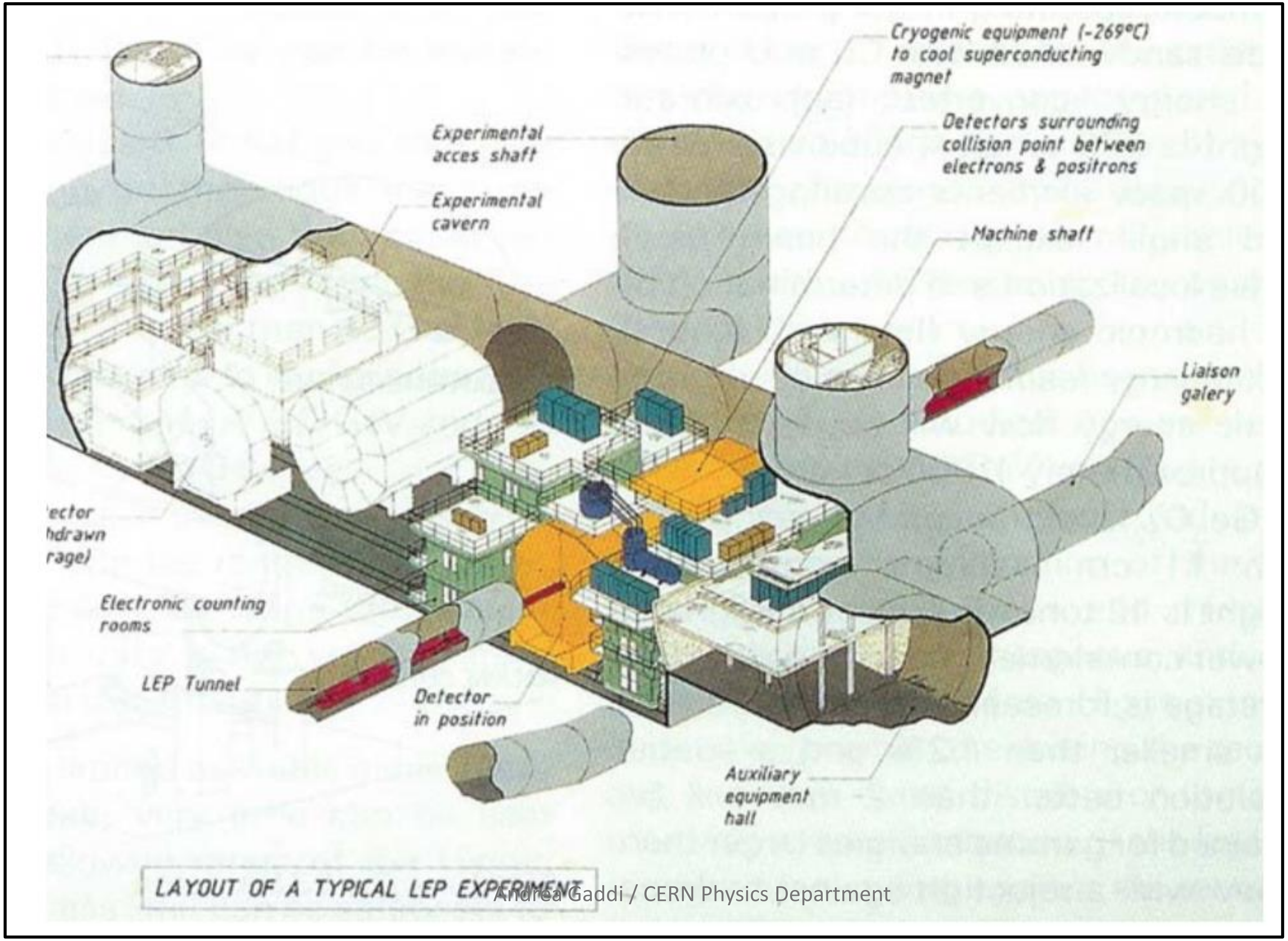


courtesy J. Seeman / SLAC

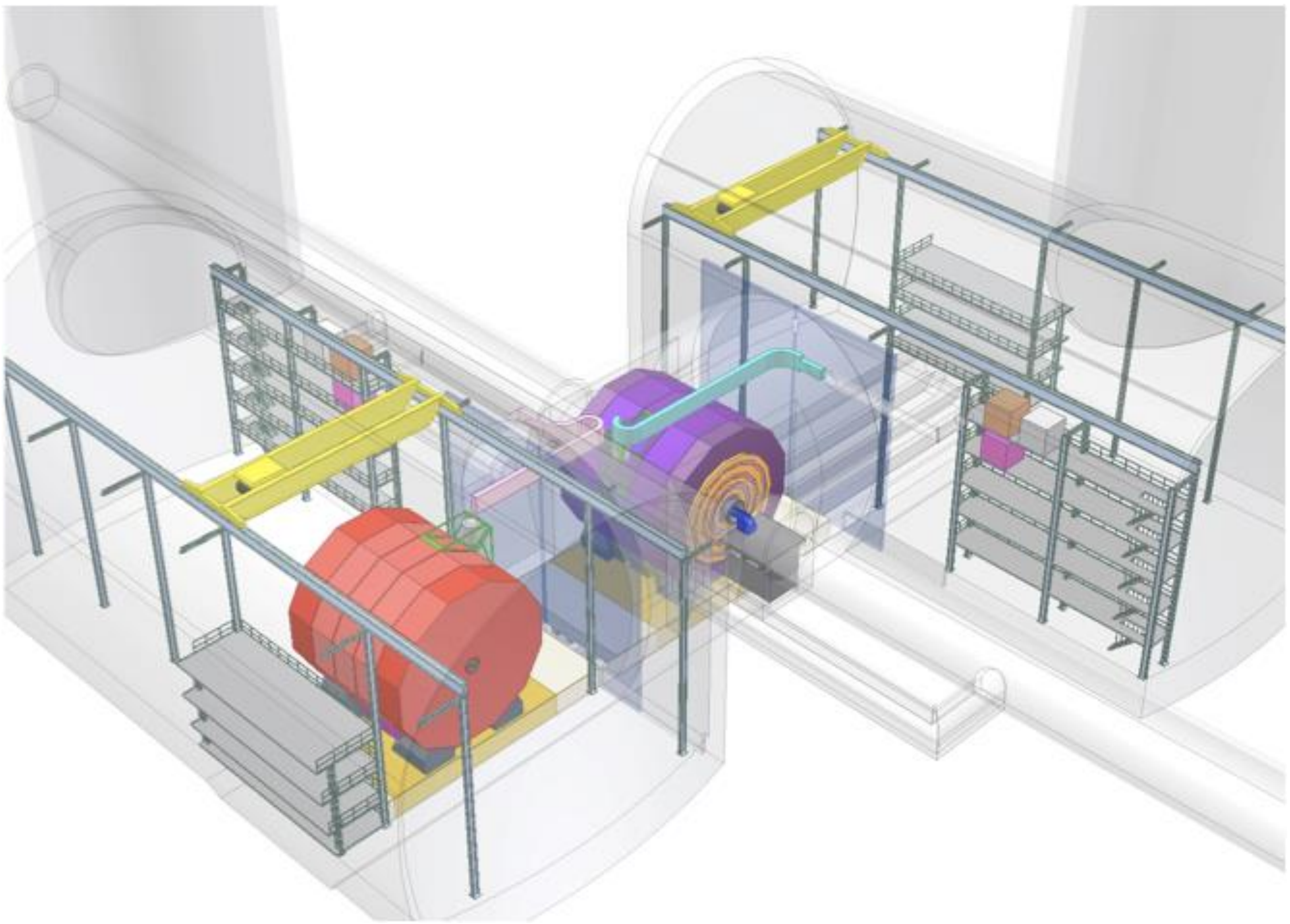


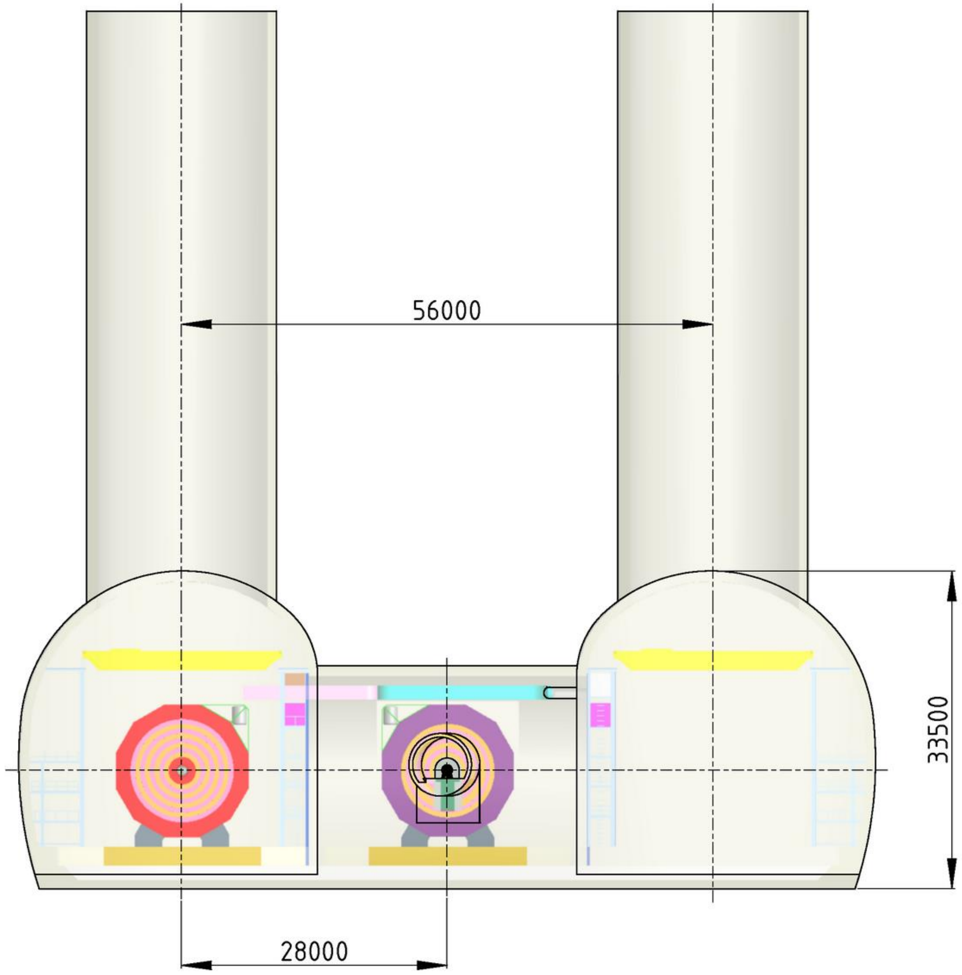
There is enough clearance to envisage the scenario to move the detector aside the beamline and get full access to the detector's inner parts

LEP Cavern Layout for Detector



ILC / CLIC Push-Pull Cavern Layout





by A. Gaddi, H. Gerwig / CERN