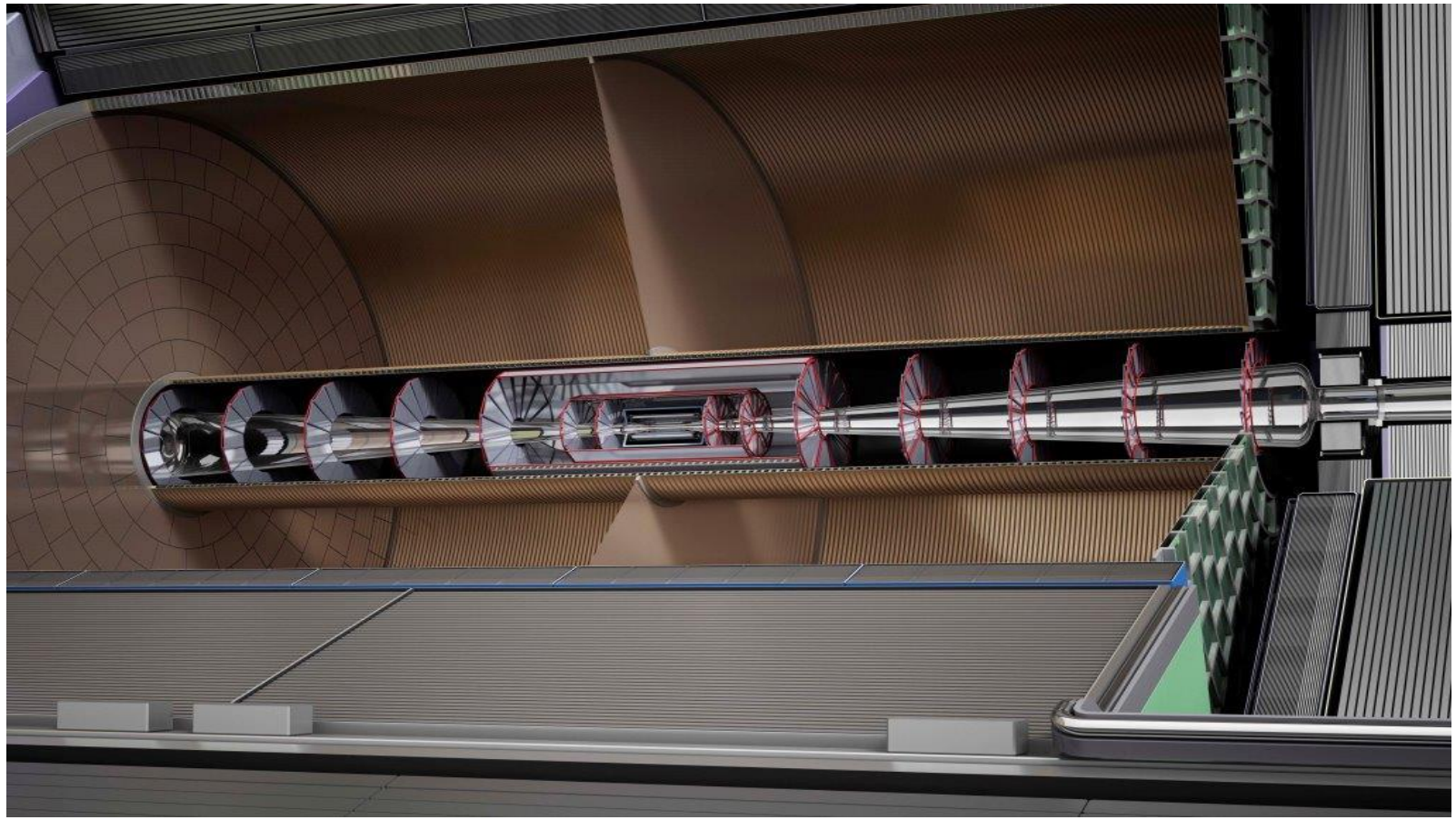
# How to build the ILD TPC?

INTEGRATION MEETING
DESY,
Feb.11,2019

From design to reality



P. COLAS, A. SUGIYAMA

# OVERVIEW

Gravitational loads

- Self-weight of structure : 895 kg
- Weight of the modules : 1176 kg (84 modules / endplate and 7 kg / modules)

→ Total weight of 2 000 kg

Overpressure of 3 mbar

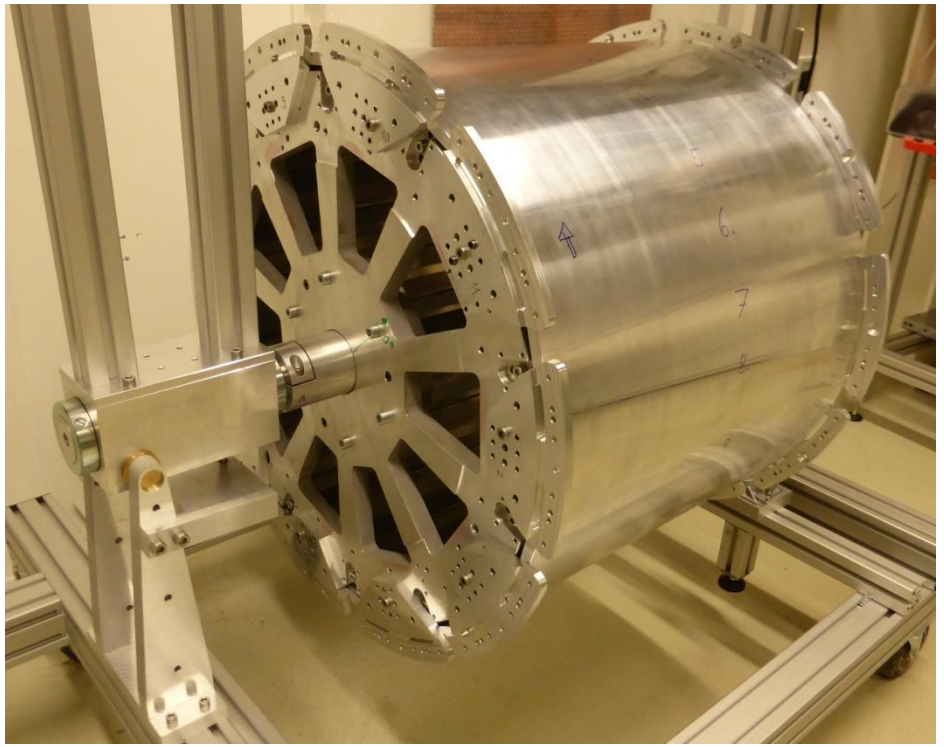
- Pressure applied on the cages
- Forces applied on each endplate by taking into account the pressure on modules

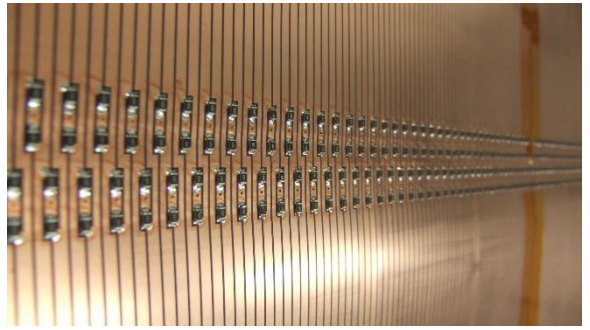
N.B.: what is called modules here (400x400 mm²) can be seen as supermodules consisting of 4 smaller modules

# FIELD CAGE

Requires a mandrel to shape the composite material
Kapton with copper strips
Installation of flanges

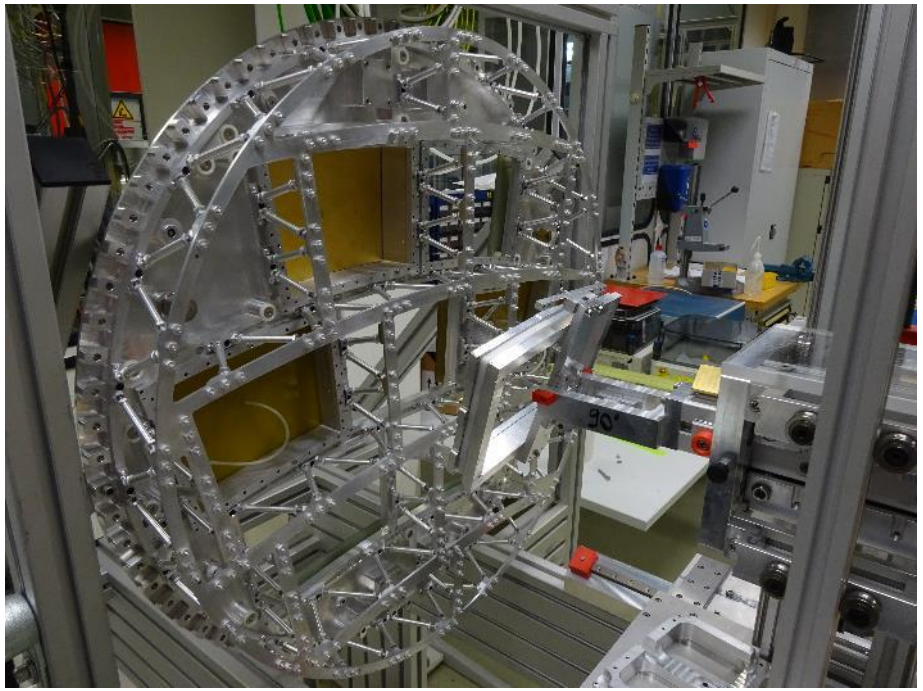
A construction on site looks preferable to a remote construction followed by a travel. Requires space in the surface.

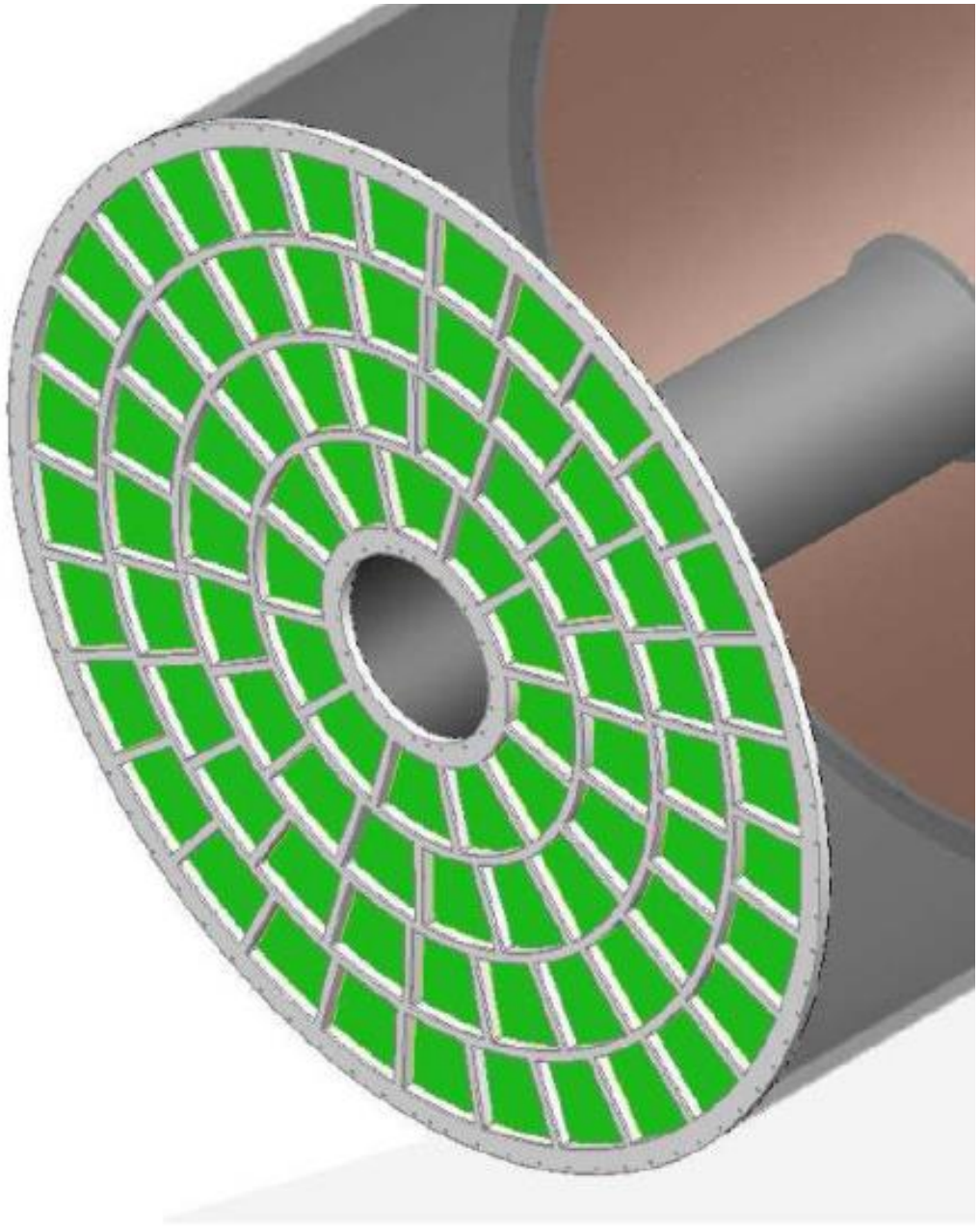


# ENDPLATES

One piece, mold? Space frame?
Which material? Stainless steel?
Aluminum+carbon fibre? (O(50 µ) accuracy) of the module positionning
Need to fill windows by dummy modules to keep the stiffness and exchange them one by one in the grey room after assembly.





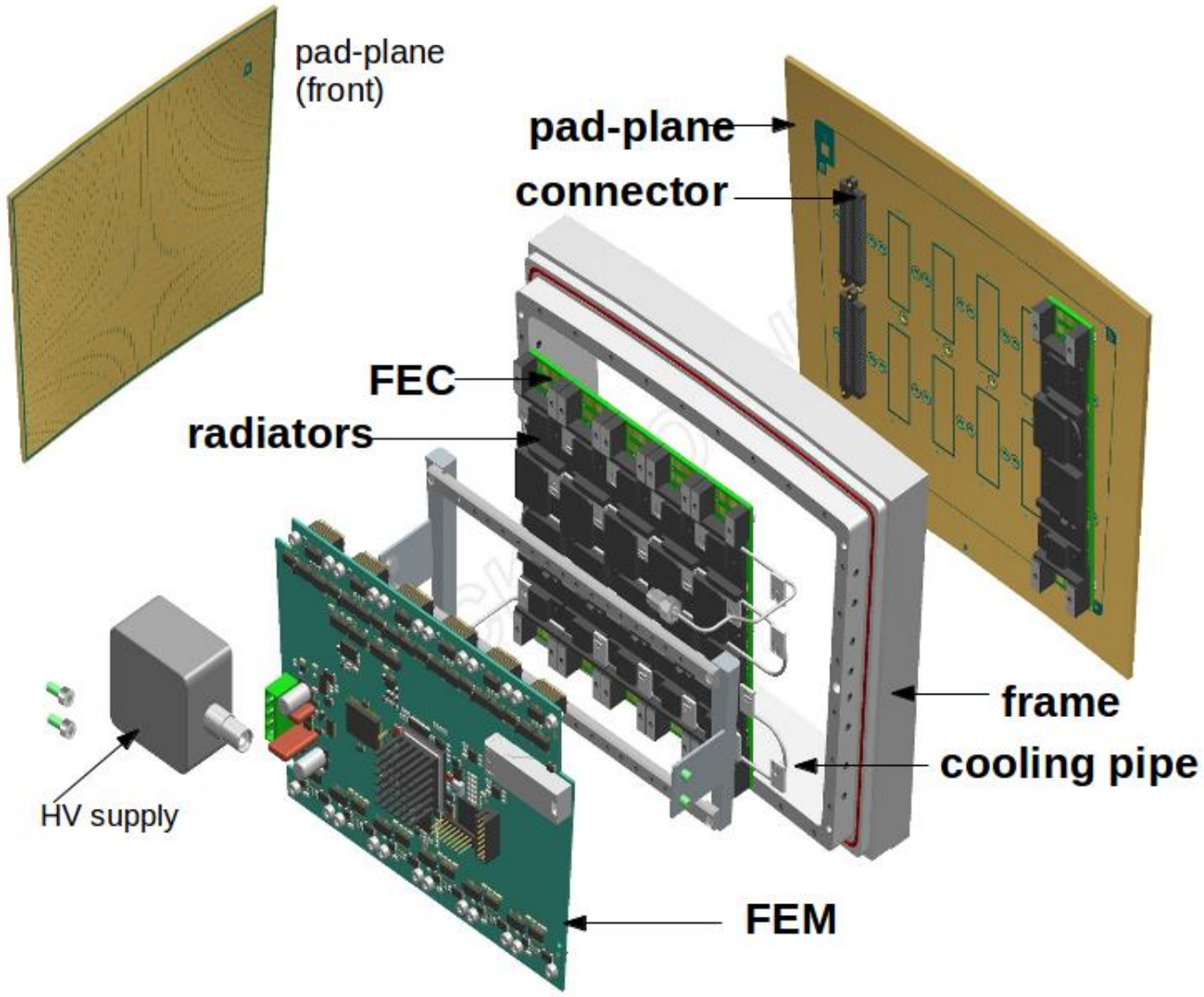
# MODULES

Modules include frame, PCB, amplification system, Front-end electronics (FECs and concentrator), cooling.
3 cables (HV, LV, Signal) and one pipe per module.
They must be shipped after full testing and re-tested after reception at Kitakami.
A special tool is necessary to mount them

*Example of a price estimate for a T2K upgrade module (Rui de Oliveira)*

| | |
|---|---|
| File preparation cost : | 800 CHF |
| Tooling: | 1800 CHF |
| Protection box: | 500 CHF/box (to be returned after each delivery) |
| Price for 1 detector: | 4970 CHF with +/- 10% accuracy |
| | 5370 CHF with +/- 3% accuracy |
| Price for 32 detectors: | 3976 CHF/detector with +/- 10% accuracy |
| | 4296 CHF/detector with +/- 3% accuracy |
| Connector assembly: | to be defined |

Delivery: approximately 4 to 5 detectors every 6 weeks after order reception
CERN is the producer of these parts.
Price don't include VAT.

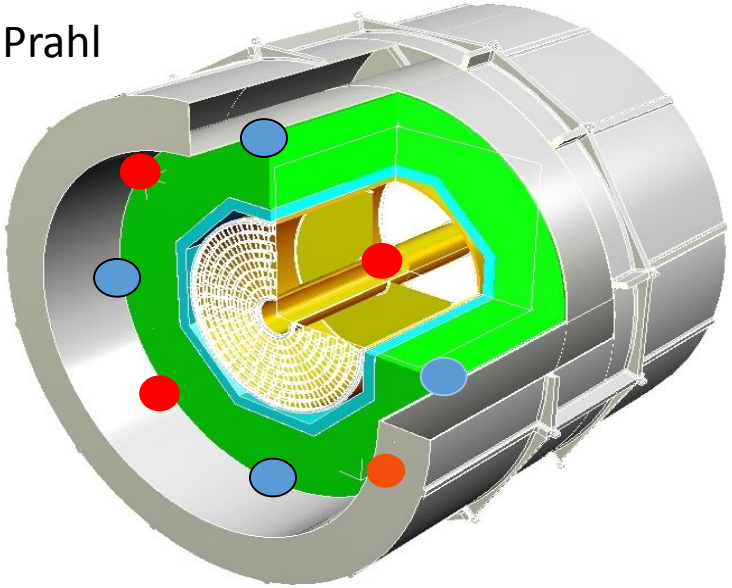



ALICE GEM modules being assembled at CERN

# SUPPORT

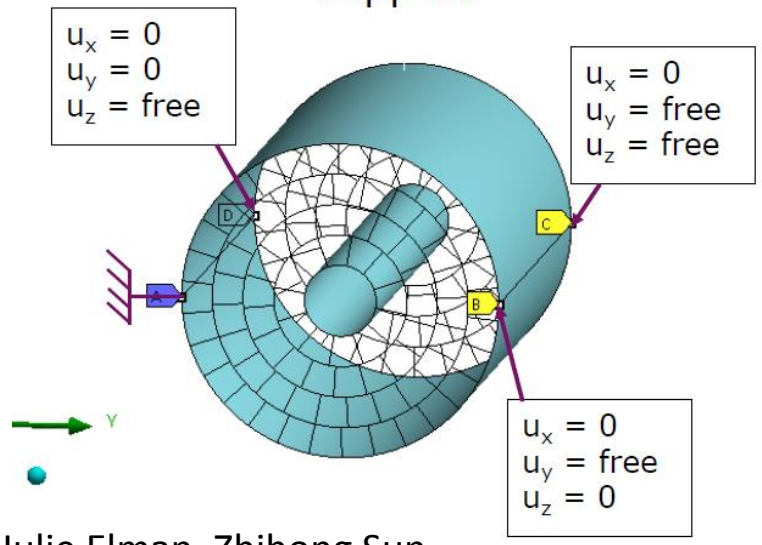
To the cryostat or to the HCAL?
Best for deformations: isostatic median support to the HCAL (shorter 'ribbons')
Damping to be studied.

V.Prahl

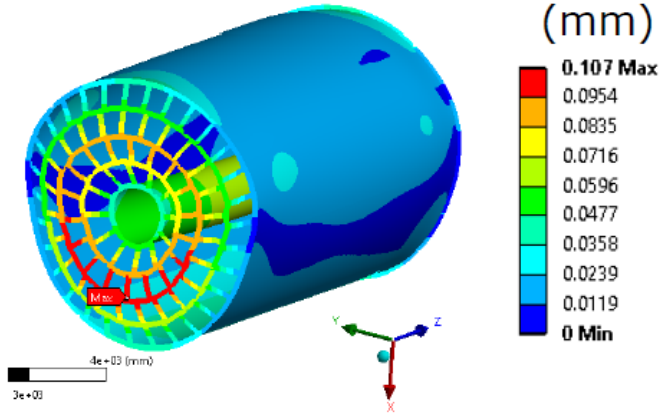


Various possible fixing points

Isostatic median support

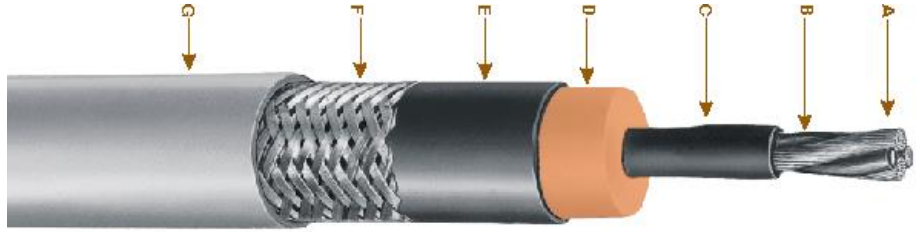


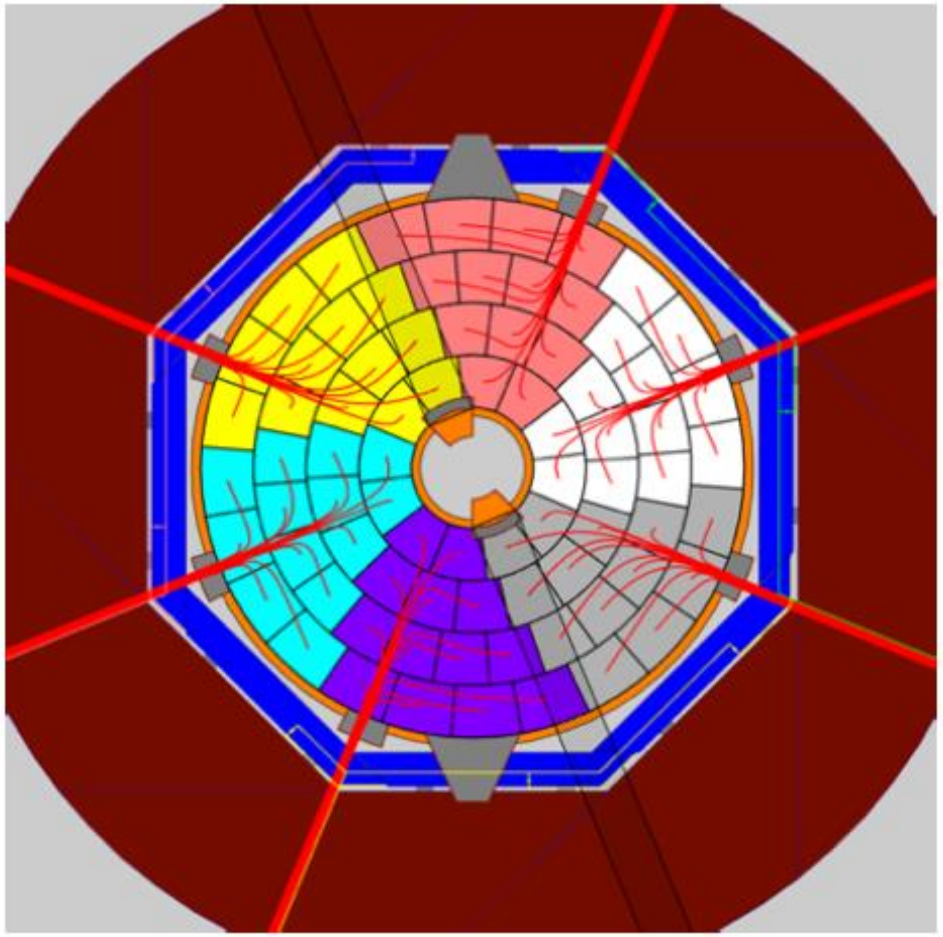

Julie Elman, Zhihong Sun




Shape factor x3000

# INTERFACES





Very High Voltage for the central cathode : Very big cable (insulation), curvature radii 70mm to 280mm. Or make it onsite (needs space also)

Low-voltage power: bundles of 10 copper cables
6 mm² section (32 A).
6 sectors per end-plate : 120 cables, 12kW(100 W per cable).
With 20 m cables (R=O.06 Ω) 60 W loss.
Can we accept this such a loss (60% of the useful power?)
Need cable cooling? DC-DC converters?

Detector HV and fibres for readout less demanding

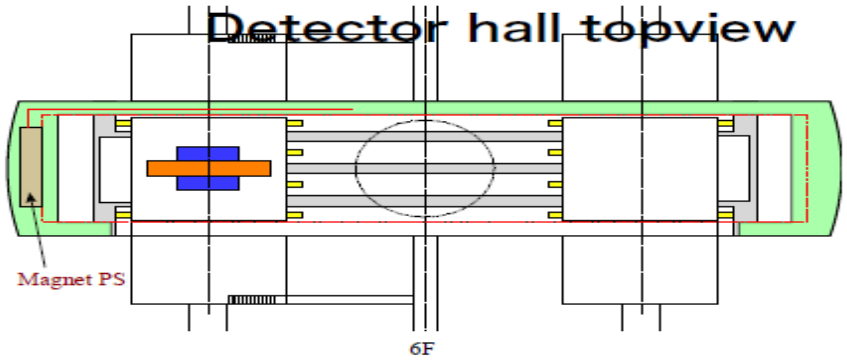
Patch panels on each sector to allow disconnecting the TPC

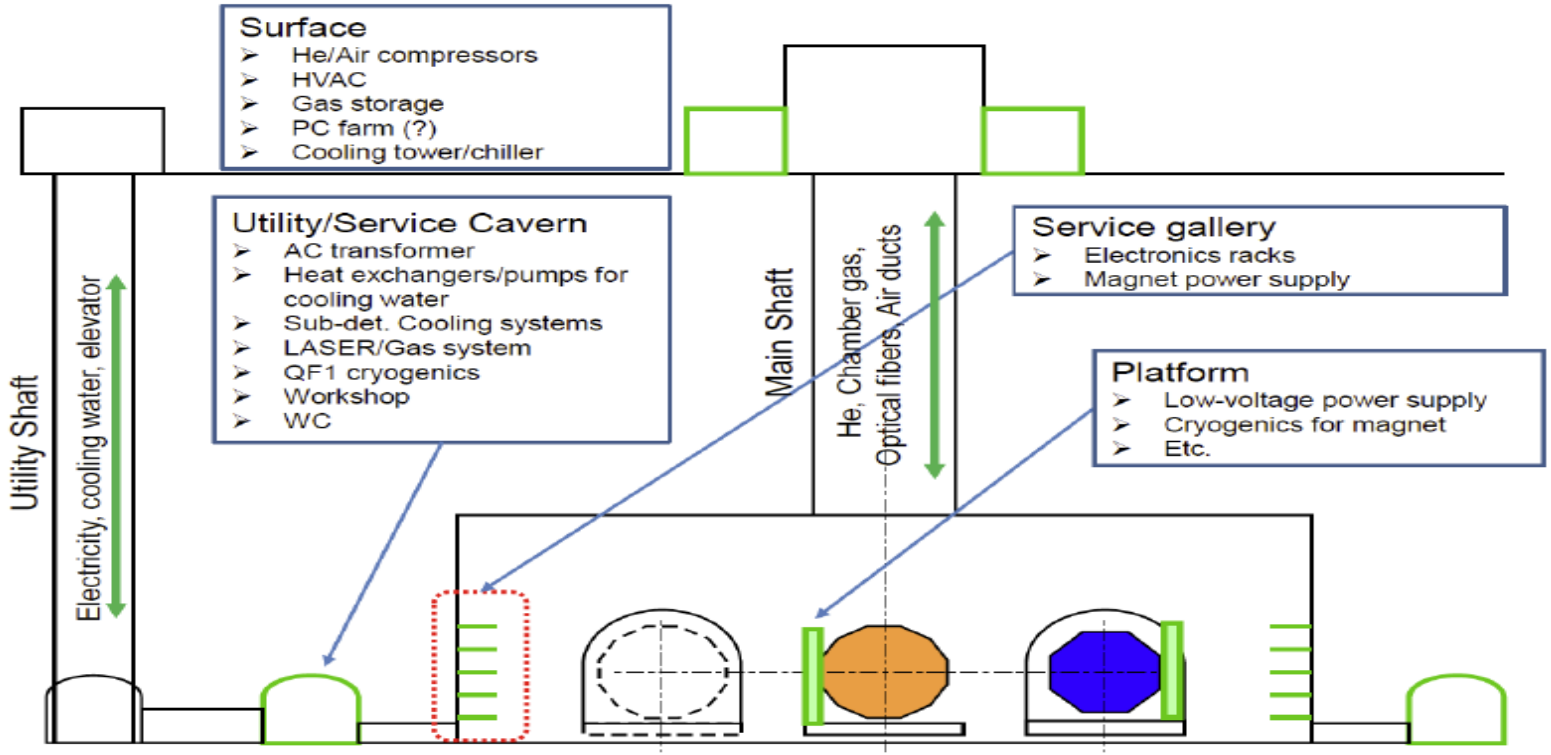
Do we need a jacket against heat from the ECAL?

# CONVENTIONAL FACILITY REQUIREMENTS

Utility Space

| | |
|---|---|
| Platform | ~20-30 m |
| Service Gallery | + 50 m |
| U/S Cavern | + 30 m |
| Surface | +100 m |



# CONVENTIONAL FACILITY REQUIREMENTS

| Sub-detector name | | TPC | |
|---|---|---|---|
| Number of 19-inch electronics racks | Platform | | |
| | Service gallery | | |
| | Utility/Service Cavern (USC) | 4 | |
| Sub-detector cooling system | Floor in USC | Don't mind | |
| | WxDxH | 12x(0.8x0.7x1.5) | m^3 |
| Gas system | Space on surface (WxD) | 8x4 | m^2 |
| | Space in USC (WxD) | | m^2 |
| | Space on service gallery (WxD) | | m^2 |
| | Space on platform (WxD) | 2x2 | m^2 |
| Laser system | Space in USC (WxD) | 1x0.6 | m^2 |
| Other requirements | | | |
| | | | |
| Comment by Y.Sugimoto | Laser system has to be placed in an isolated room in USC for safety reason. | | |

for LV supply
for HV(+VHV) supply

Big tank

gas circulation
purification/removal O2,H2O
gain monitor

Do we need any other space?

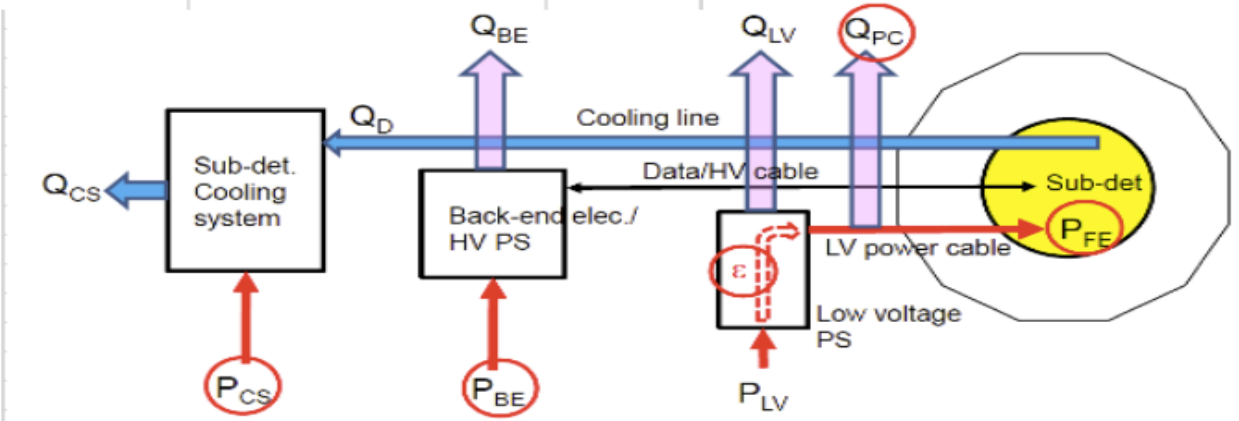
monitor(temperature, , )
controll, interlock,,,  somewhere near detector

# CONVENTIONAL FACILITY REQUIREMENTS

| | Sub-detector name | TPC | |
|---|---|---|---|
| P_FE | Power consumption of Front-end Electronics | 12 | kW |
| Q_PC | Heat loss in Power Cables | | kW |
| e | Efficiency of low voltage power supply | 80% | |
| P_BE | AC Power input to Back-end Electronics | | kW |
| P_CS | Electric power to drive Cooling System | 1.2 | kW |
| | Type of cooling water for cooling system | Normal temperature | |
| | | | |
| P_LV | AC Power input to Low Voltage power supply | 15 | kW |
| Q_LV | Heat loss in Low Voltage power supply | 3 | kW |
| Q_BE | Heat loss in Back-end Electronics | 0 | kW |
| Q_CS | Heat to be extracted from cooling system | 13.2 | kW |

Assumption
1.5M channel/EP
PConsumption 4mW/ch
=> 12 kW

HV Power consumption
~5W from LP1 extrapolat

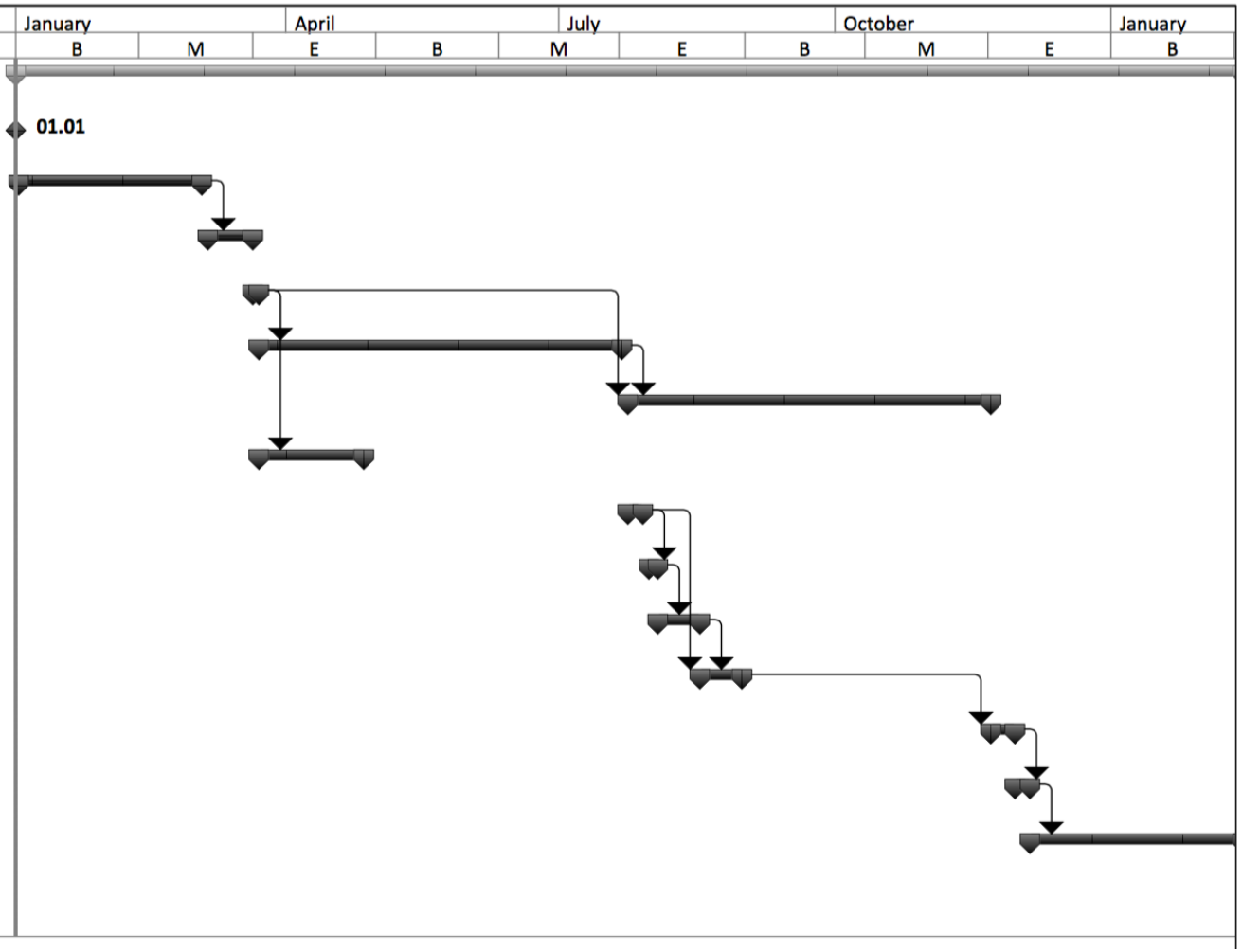



- $P_{FE}$ : Power consumption of sub-detector Front-end Electronics
- $Q_D$ : Heat loss in sub-det. (= $P_{FE}$ )
- $Q_{PC}$ : Heat loss in power cables
- $P_{LV}$ : AC power input to LV PS
- ε : Efficiency of LV PS ($P_{LV}$*ε= $P_{FE}$ +$Q_{PC}$)
- $Q_{LV}$ : Heat loss in the LV PS (=(1-ε)*$P_{LV}$)
- $P_{BE}$ : AC power input to back-end elec./HV power supply
- $Q_{BE}$ : Heat loss in the BE/HV PS (=$P_{BE}$)
- $P_{CS}$ : Electric power to drive the cooling system
- $Q_{CS}$ : Heat to be extracted from cooling system (= $Q_D$ +$P_{CS}$)

# ASSEMBLY

V. Prahl, Th. Schörner-Sadenius

| ID | Task Name | Duration | Start | Finish | Predecesso |
|---|---|---|---|---|---|
| 0 | **TPC Assembly** | **292 day...** | **Sun 01.01.17** | **Tue 13.02.18** | |
| 1 | Start of Assembly | 0 days | Sun 01.01.17 | Sun 01.01.17 | |
| 2 | **Greyroom setup** | **45 days** | **Mon 02.01.17** | **Fri 03.03.17** | |
| 6 | **Trolley installation and test** | **11 days?** | **Mon 06.03.17** | **Mon 20.03.17** | **2** |
| 13 | **End-plates on trolleys** | **2 days?** | **Tue 21.03.17** | **Wed 22.03.17** | **12** |
| 16 | **End-plate mounting R** | **87 days** | **Thu 23.03.17** | **Fri 21.07.17** | **13** |
| 20 | **End-plate mounting L** | **87 days** | **Mon 24.07.17** | **Tue 21.11.17** | **13;16** |
| 24 | **Field cage assembly** | **25 days** | **Wed 22.03.17** | **Wed 26.04.17** | **13** |
| 31 | **Marriage field cage + end-plate R** | **5 days?** | **Mon 24.07.17** | **Fri 28.07.17** | **19;30** |
| 35 | **Inner vessel setup on platform** | **3 days?** | **Mon 31.07.17** | **Wed 02.08.17** | **31** |
| 39 | **Marriage of inner vessel + sail** | **10 days?** | **Thu 03.08.17** | **Wed 16.08.17** | **35** |
| 44 | **Marriage of inner vessel / sail + field cage** | **10 days?** | **Thu 17.08.17** | **Wed 30.08.17** | **31;39** |
| 50 | **Marriage of end-plate L + field cage** | **6 days?** | **Wed 22.11.17** | **Wed 29.11.17** | **44;23** |
| 55 | **Removal of trolleys** | **3 days** | **Thu 30.11.17** | **Mon 04.12.17** | **50** |
| 60 | **TPC tests** | **51 days** | **Tue 05.12.17** | **Tue 13.02.18** | **55** |
| 63 | TPC ready | 0 days | Tue 13.02.18 | Tue 13.02.18 | 62 |




Is one year enough? How much manpower needed?