ILD Integration Meeting

TPC Mechanics

11. February 2019, DESY

Volker Prahl on behalf of the TPC Collaboration

Most of the slides presented at:

Mini-Workshop on ILC Infrastructure and CFS for Physics and Detectors

Friday 23 Feb 2018, KEK Tsukuba Campus

https://agenda.linearcollider.org/event/7804/overview

Indebted to many authors from whom I have reused their material

HELMHOLTZ GEMEINSCHAFT

DESY

Over view

- TPC support structure (AHCAL)
  - Requirements of the TPC support structure
  - Pros and cons of various fixing point
  - Various designs of the support structure
  - Design of the support structure
- HV-Cable and routing
- Cathode design
- TPC installation
  - TPC assembly
  - TPC insertion
- Conclusion and outlook

TPC support structure

Requirements of the TPC support structure

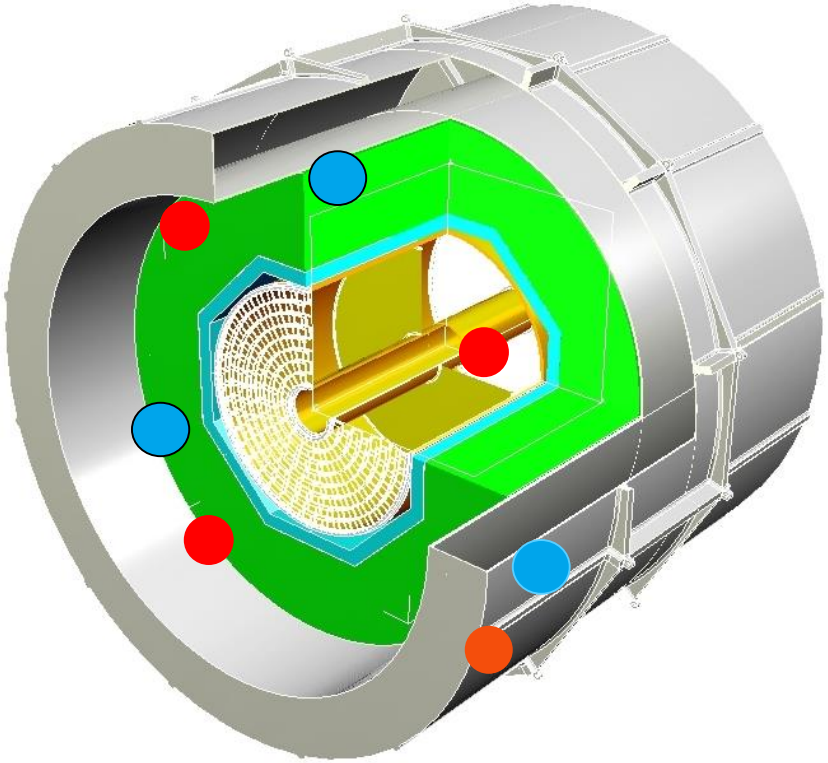
- Non-magnetic material
- Low thermal expansion coefficient

Carbon fiber structure preferred

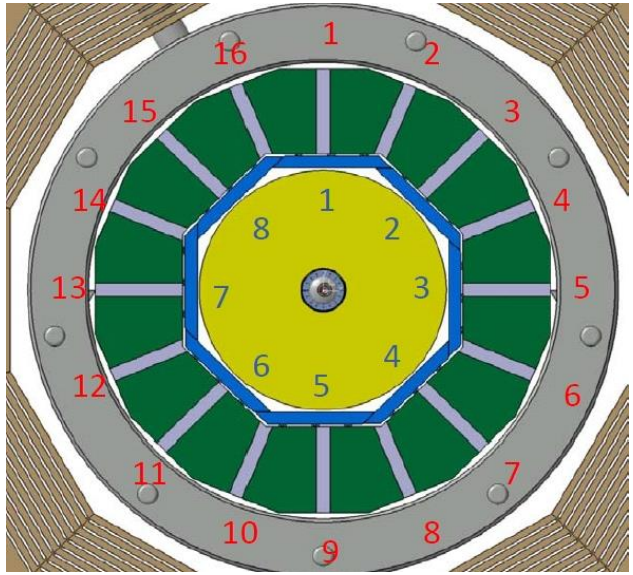
- Robust system in x,y,z,
- Accuracy and stability has to be constant over the lifetime
- Earthquake-safe system
- Short support structure (more a wish than a realistic option)
- Vibration absorption in Z direction
- Required accuracy 100 µm or better for Vertex, SIT, FTD !, realistic?
- Min free space of 10 mm in all directions ! Gaps ! I guess it is too small

TPC Support Structure

Requirements of the TPC support structure, AHCAL around !



Main dimensions of the TPC (outside)
Ø Od = 3616, r=1808
Ø Id = 658, r=329
Length = 4700 incl. endplate and cabling

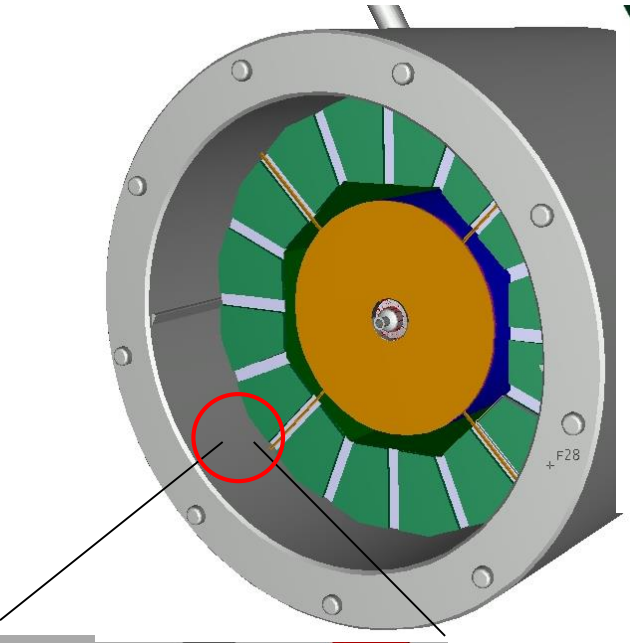


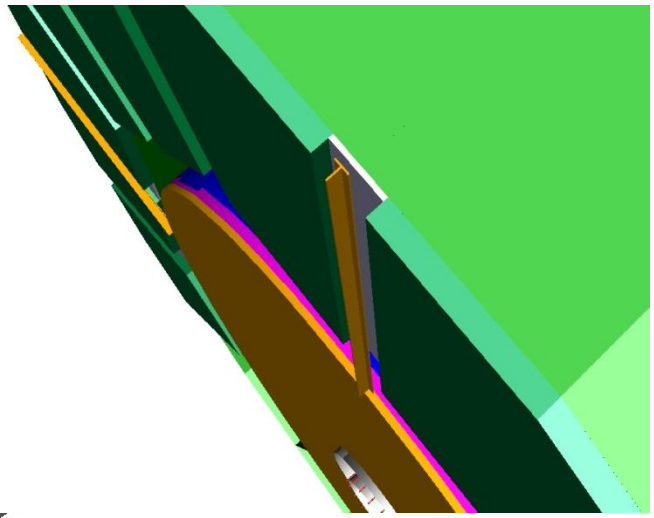
3 Point 3x120°, preferred gaps: 1,12, 6

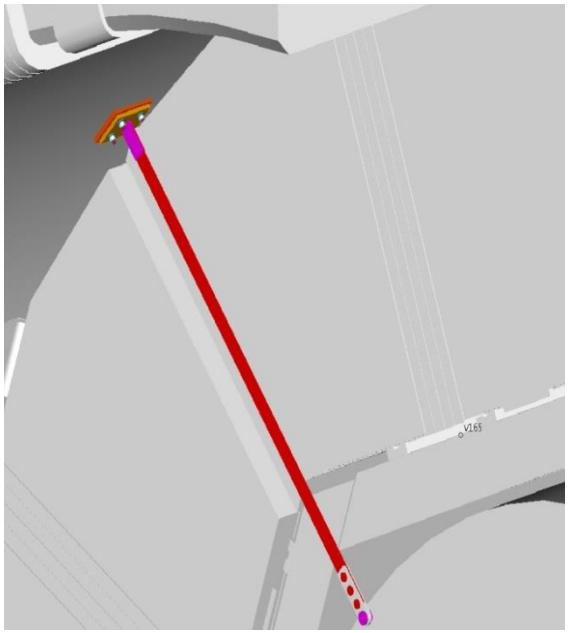
4 Point 4x90°, preferred gaps: 3, 15, 11, 7 but this gaps filled 100%

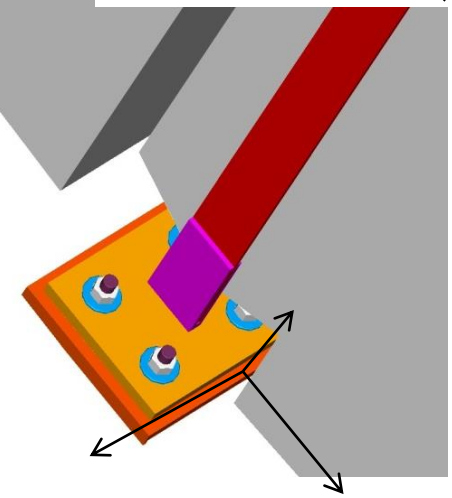
Only the cryostat is foreseen to support the TPC

Flat ribbon support



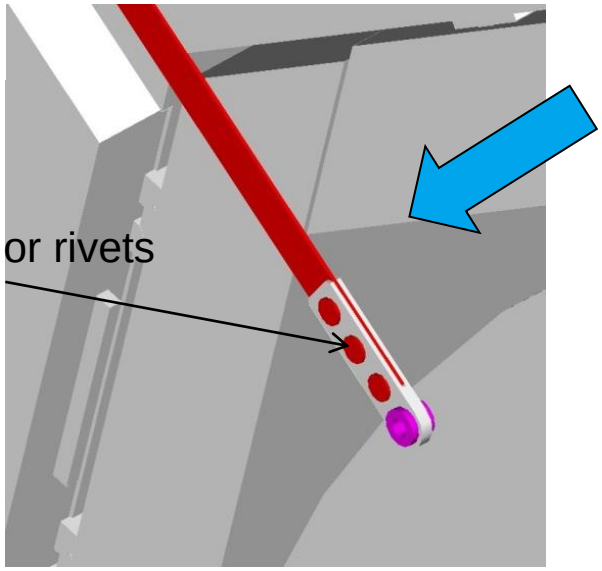






Adjustable in x,y,z

Screws or rivets



An ribbon support takes the smallest space, but a separate support in Z has to be defined

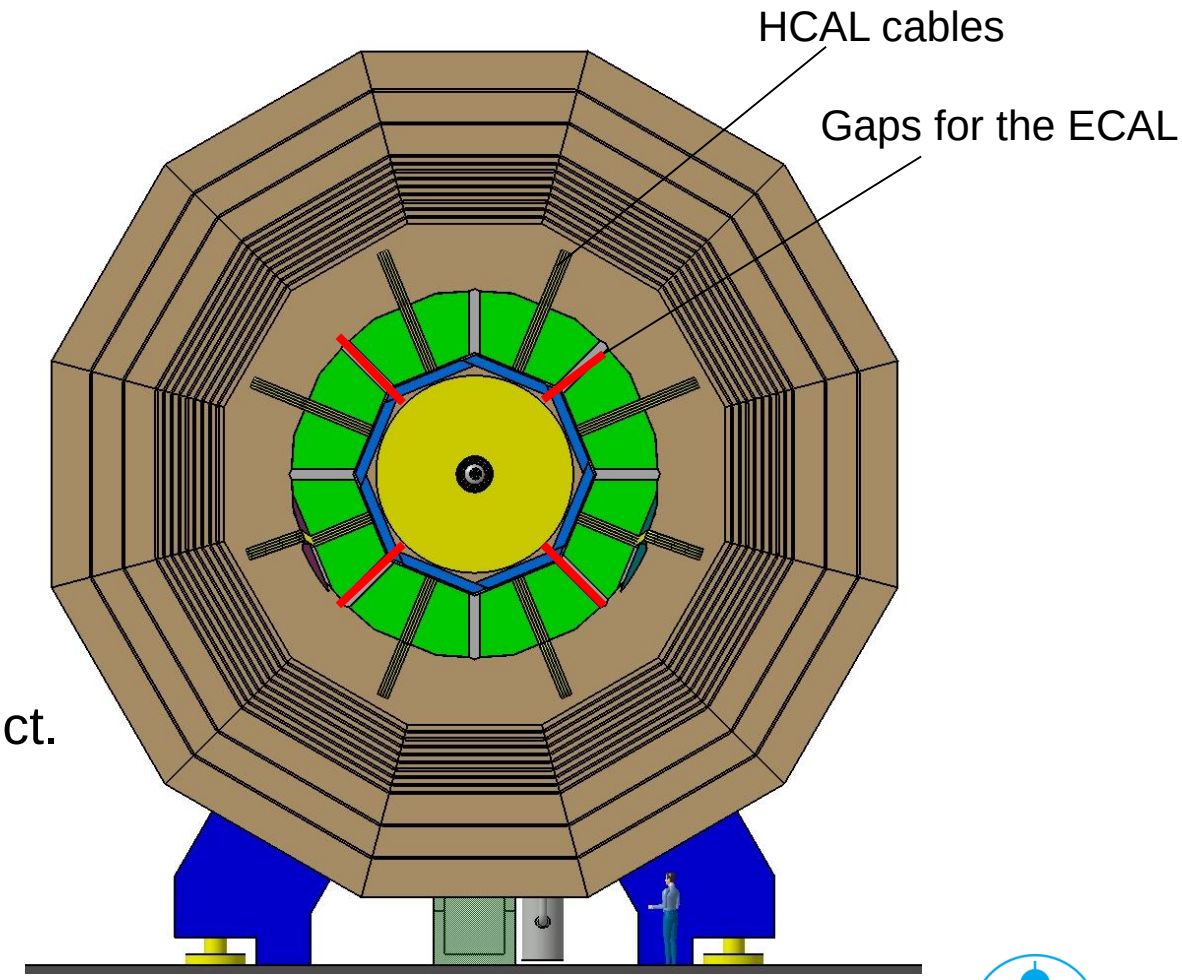
TPC Support Structure

Pros and cons of various fixing points

	AHCAL	Cryostat
3x120°	- Accuracy + Shorter support structure - HCAL deformation -Stability under seismic conditions of the AHCAL	+ Accuracy - Longer support structure + Cryostat deformation +/- Seismic stability
4x90°	See above - More space required	See above - More space required

HV-Cable and routing

- Gap for the HV-Cable (two, incl. one spare?)
- TPC services
- TPC cooling lines
- TPC Support
- Cooling systems of



A lot of cables, coolling lines ect. touting at the same space

Cathode design

Typical cathode design:

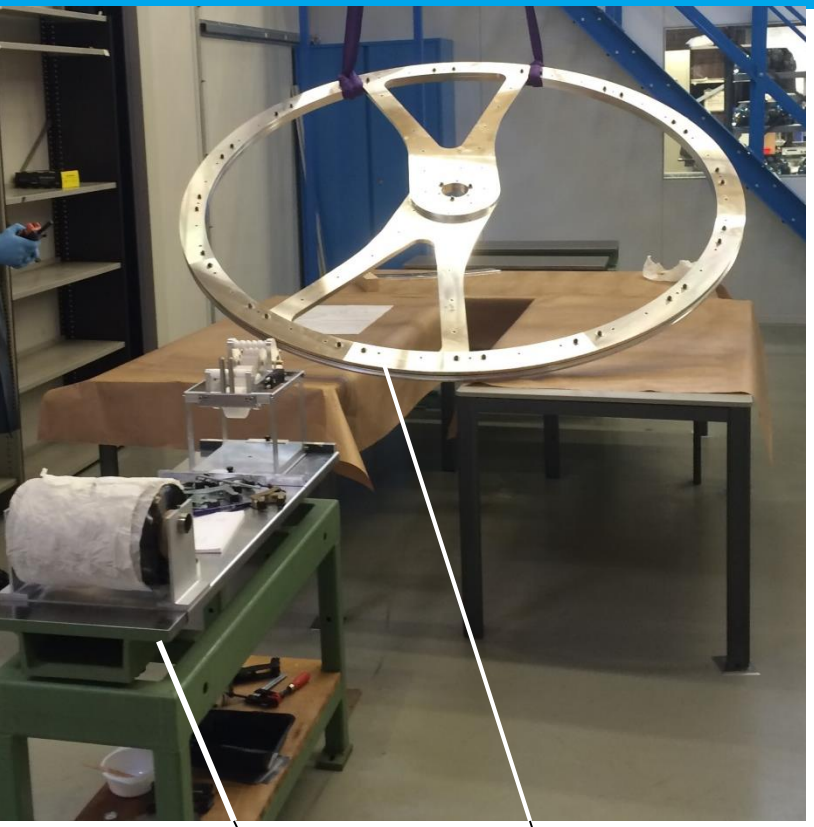
Tensioned foil (mylar, CFC, …) supported by inner and outer ring

STAR-TPC

Design goals and problems:

- Light weight, thin
- Mechanically stable and robust (inaccessible)
- Supply of HV non trivial
- Studies in laboratory support this design: load is about 2kg/10cm outer radius
- HV supply through special HV cable, OD about 14mm for 100 kV

Cathode design



Part of the wetting tool

Mold

Wetting tool and mold for an T-Shape cross section rim from NIKHEF, designed for the Atlas Endcap 2m outer dia

Instance of the outer / inner wheel of the Cathode

Carbon Roving

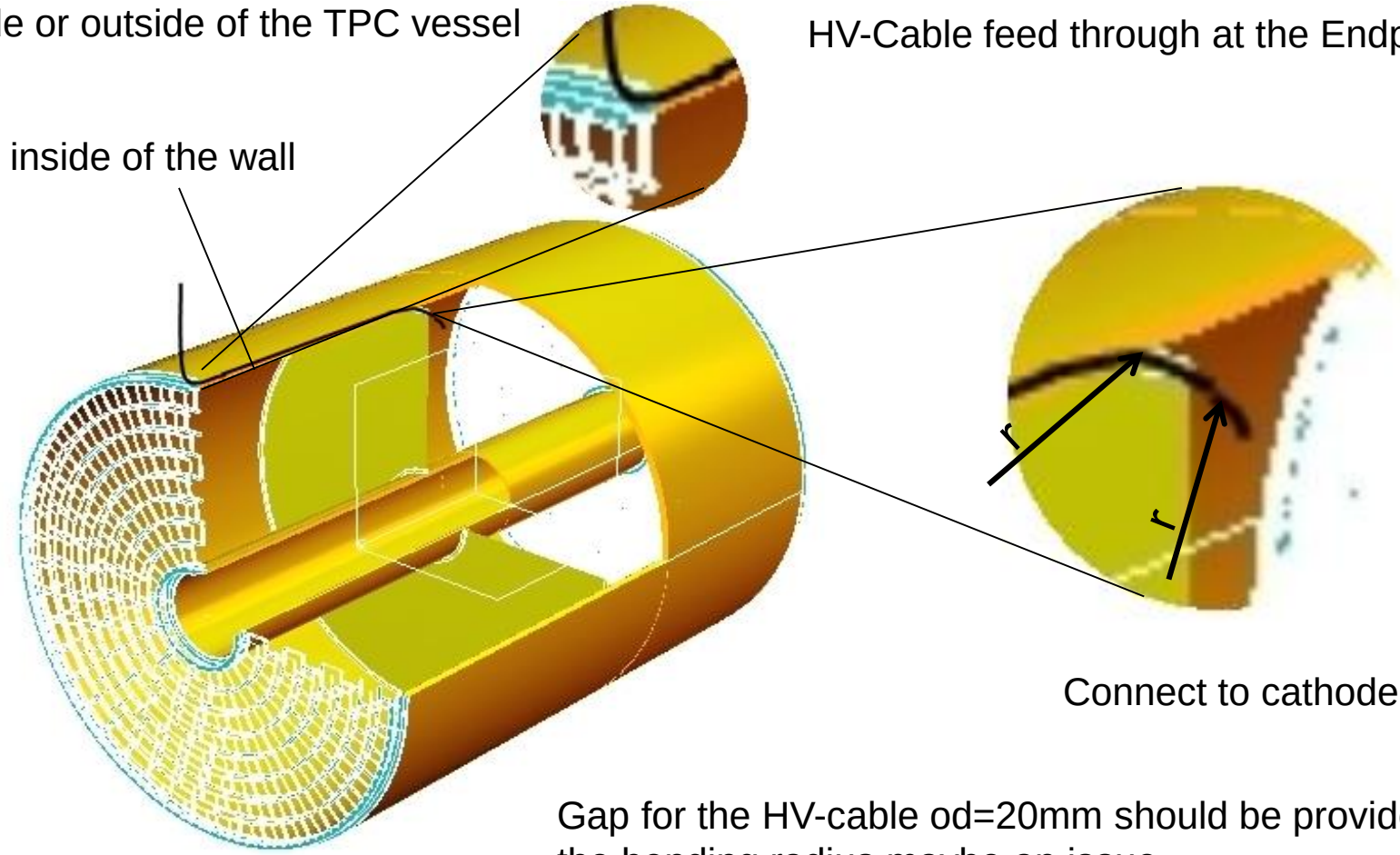
HV Cable and routing

Overview of an first idea of the HV-cable routing

Inside or outside of the TPC vessel

HV-Cable feed through at the Endplate

Laying inside of the wall



Connect to cathode

Gap for the HV-cable od=20mm should be provide, the bending radius maybe an issue

TPC installation

Thomas Schörner-Sadenius
Volker Prahl
Paris, 8/9 October 2015

Some basic assumptions – all to be argued

No (long) transport of full TPC, field cage or fully equipped end-plates → **need to assemble TPC at IP campus**

- Our assumption here: TPC assembly in the AH. Compatible with Yasuhiro's overall plan assuming realistic TPC time scales?
- Then space in AH necessary
- Do it in research office building? But then where full TPC system test (gas!)?
- No TPC assembly in DH.

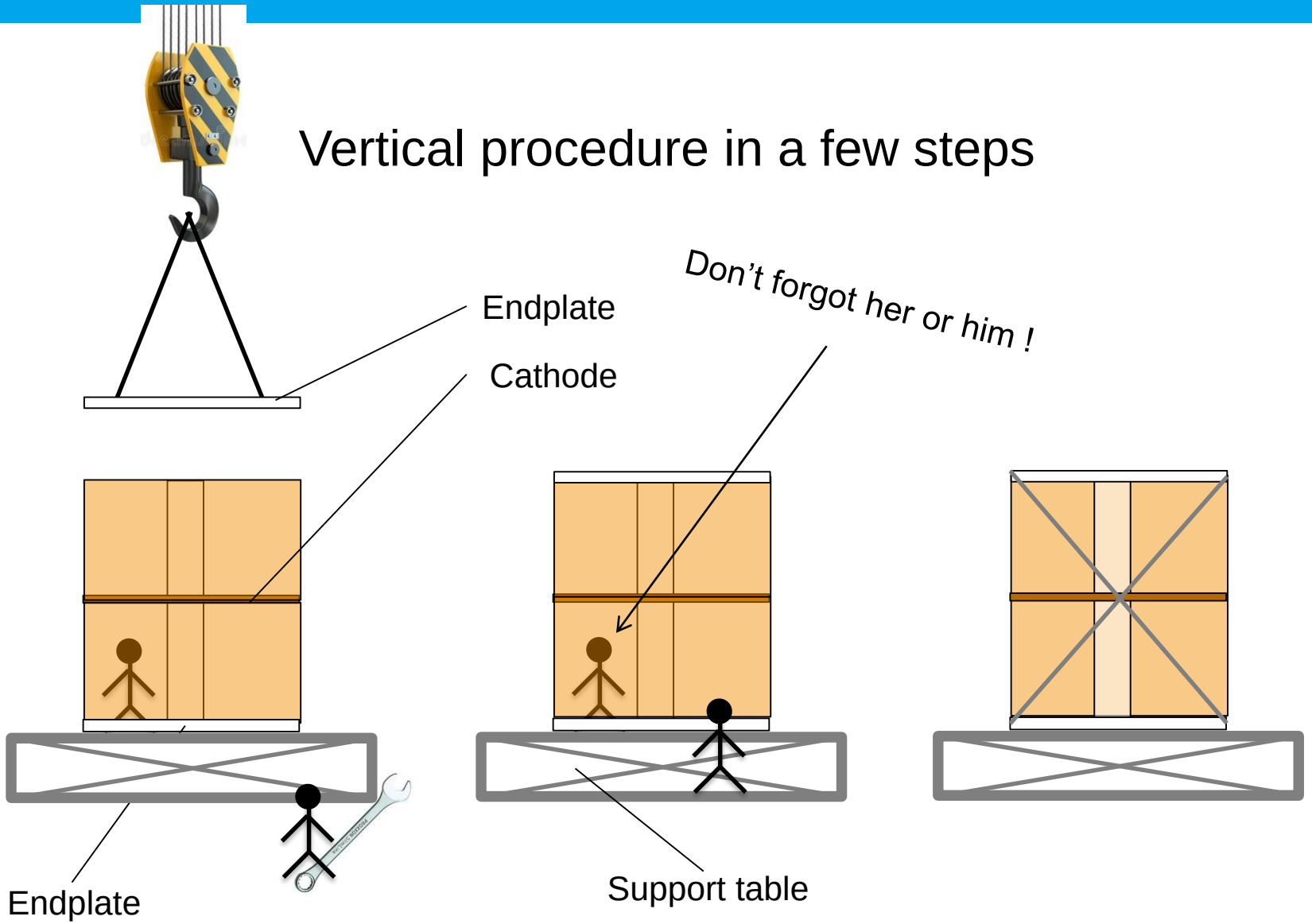
No TPC assembly in DH – sufficient space and possibility to work in parallel with yoke construction, but probably bad timeslot?

Current scenario therefore:

- Horizontal or vertical assembly in AH hall (exact position tbd)
- Space requirement: 100 m^2 (probably 60 m^2 enough, but some contingency), plus storage space (for modules) and test area for modules
- Field cage delivered in one or two big pieces and assembled in AH
- Necessity to create grey-room / ISO7 characteristics around TPC assembly place

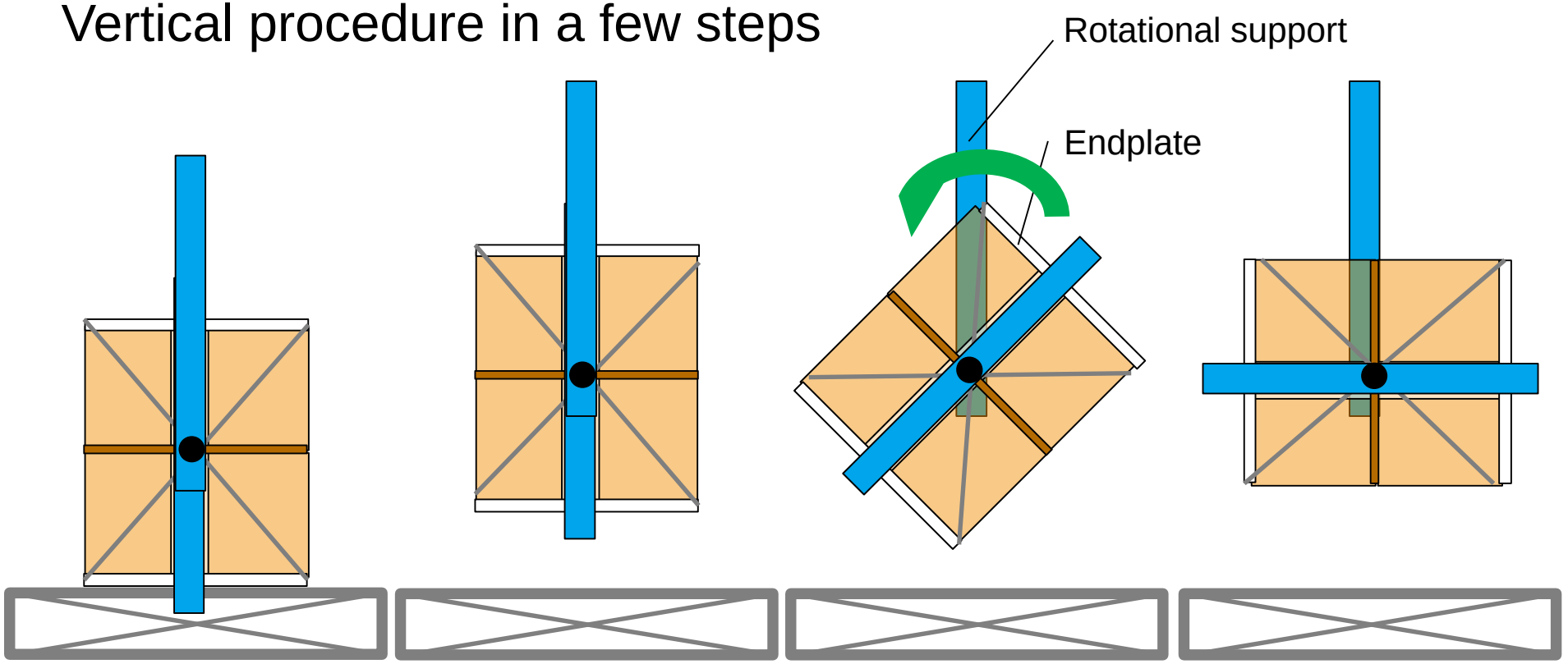
TPC installation

Vertical procedure in a few steps



TPC assembly

Vertical procedure in a few steps



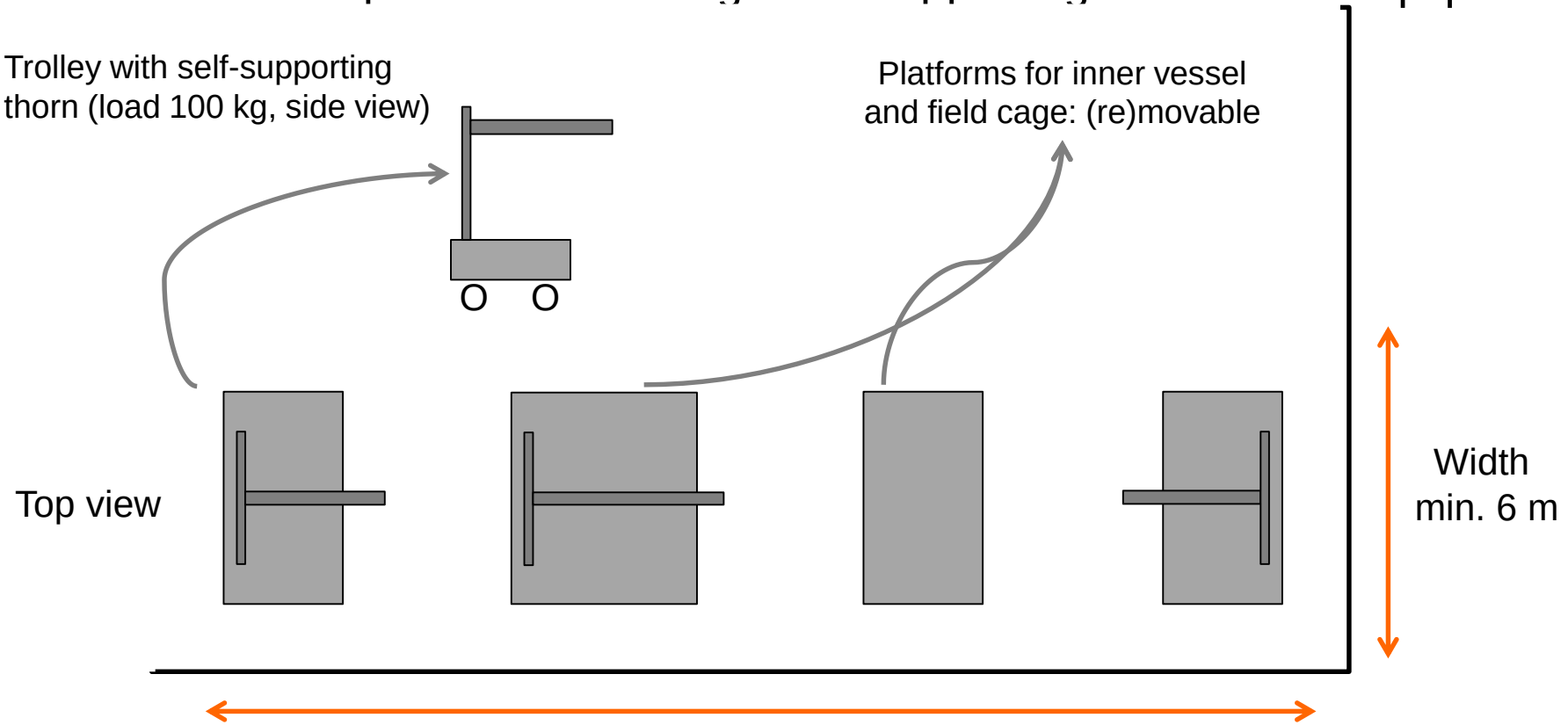
Then

- Cleaning of field cage
- Construction of grey/clean room around TPC field cage (ISO 7)
- Equipping of end-plates with tested modules using robot (petal-like structures in EP quadrant holes).
- System test (in AH)

TPC assembly

Horizontal procedure in a few steps

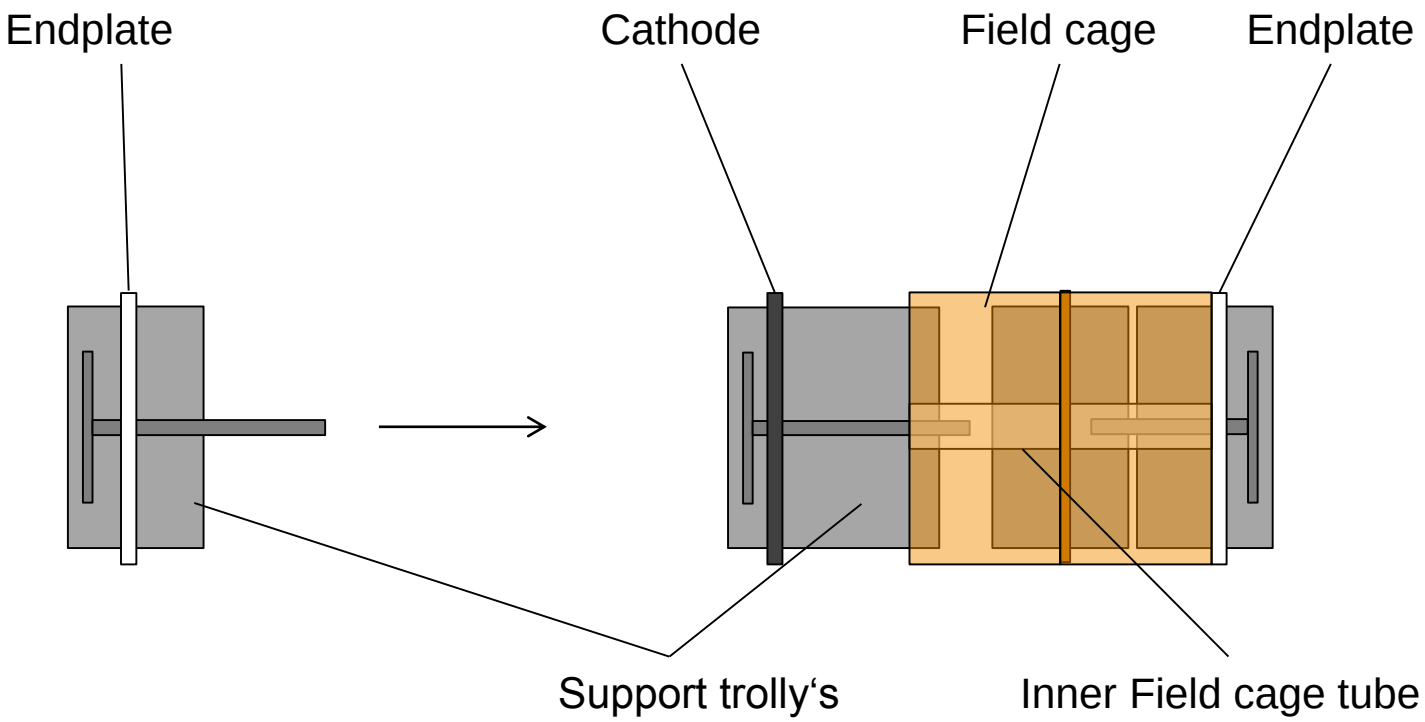
Note: – Grey room / ISO7 with stable T and FFUs needed from start.
– Access to grey room through sliding gate with air lock
– Assumption that field cage self-supporting and first EP equipment



8/9 October 2015
TSS: TPC Assembly

TPC assembly

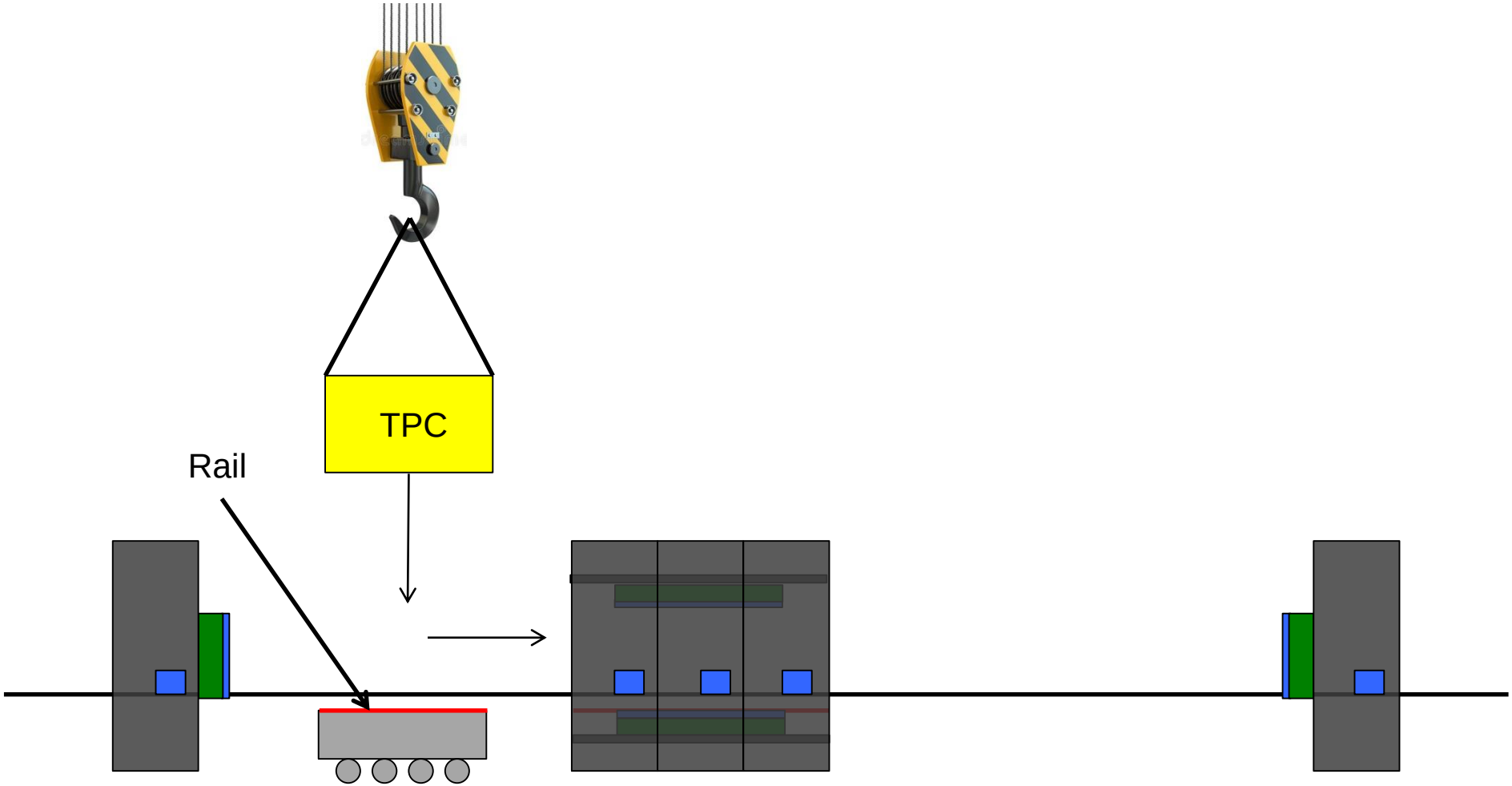
Horizontal procedure in a few steps



Alternative: First fixing of inner vessel in field cage, then installation / spanning of cathode.

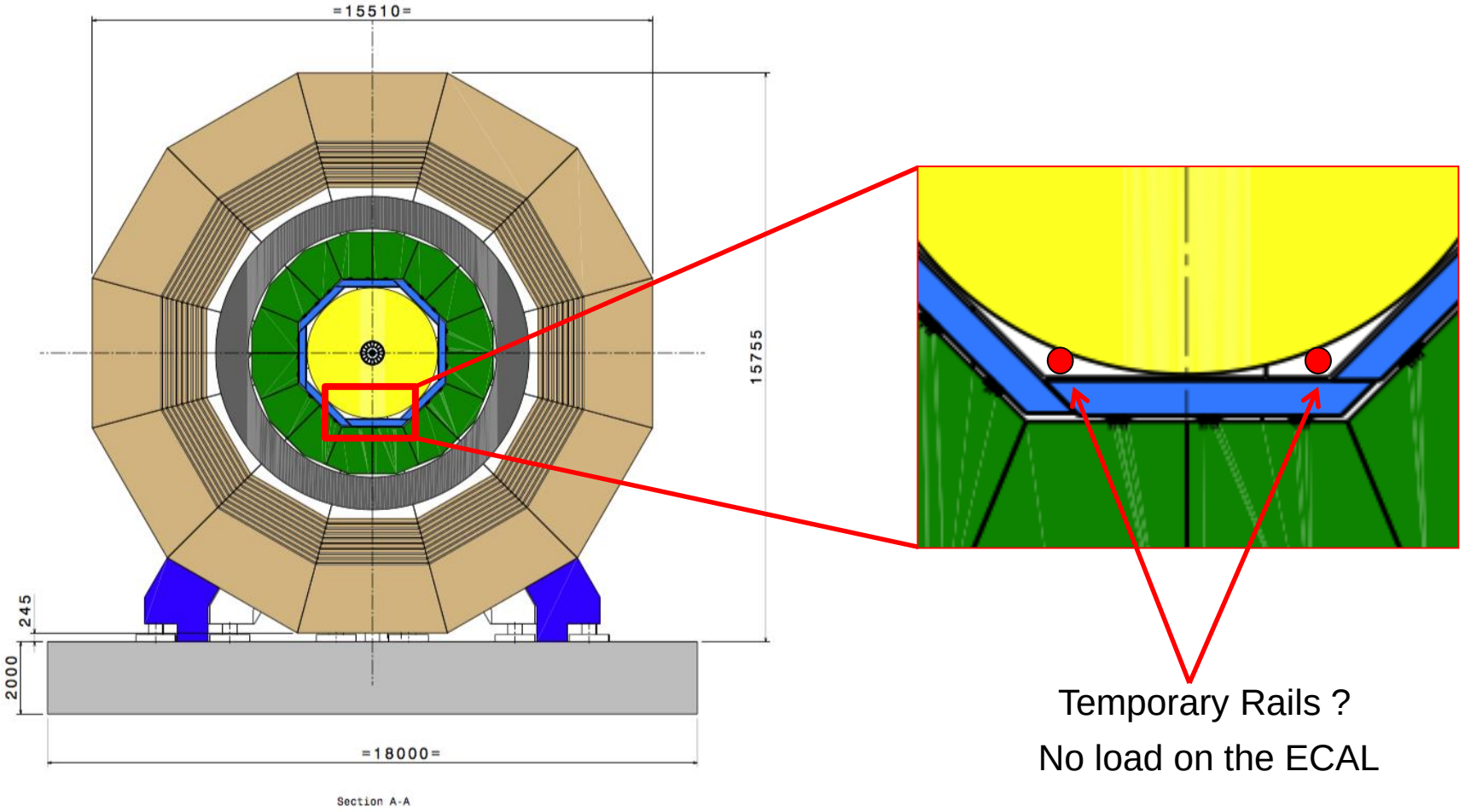
Top view of TPC assembly

TPC inserting



8/9 October 2015
TSS: TPC Assembly

TPC inserting



8/9 October 2015
TSS: TPC Assembly

Conclusion and outlook

Conclusion

- More studies of the support system required
- Required space is an issue with the infrastructure and gaps between and in the middle of the AHCAL / ECAL octagons
- Alternative approaches have to be considered
- Various cross sections and materials of the support bars will be calculated
- Alternative system design maybe required

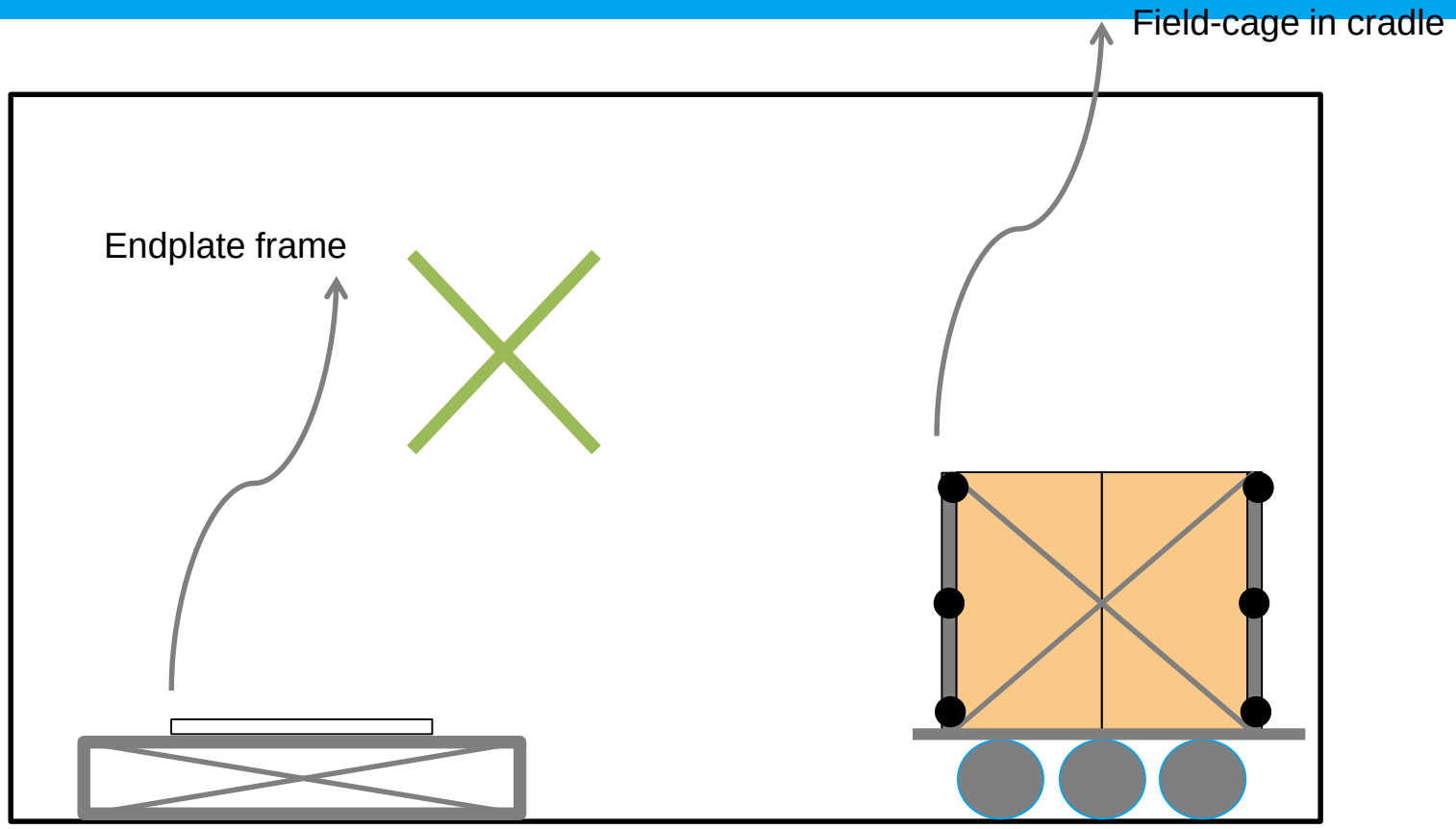
Outlook

- Build the second field cage
- Availability of space in the gaps has to be evaluated
- More FEA studies
- Minimize the cross section of the support bars
- HV-Cable routing
- Field cage electrical insulation
- Cathode, design and inserting
- TPC Assembling and mounting, services
- TPC insertion
- Local regulations (Gas, HV, …)
- And many more…

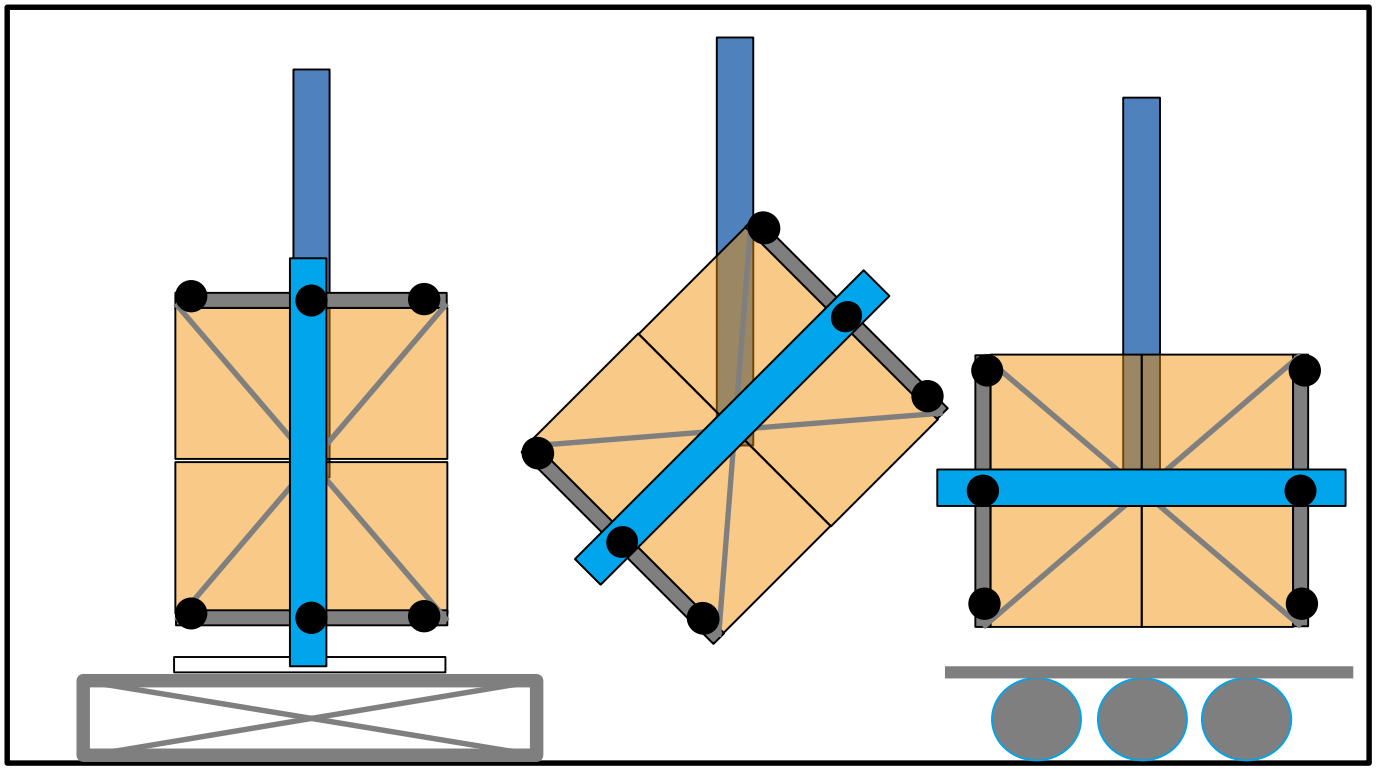
Back up slides

TPC assembly and inserting steps
some ideas from Thomas Schörner-Sadenius, Volker Prahl

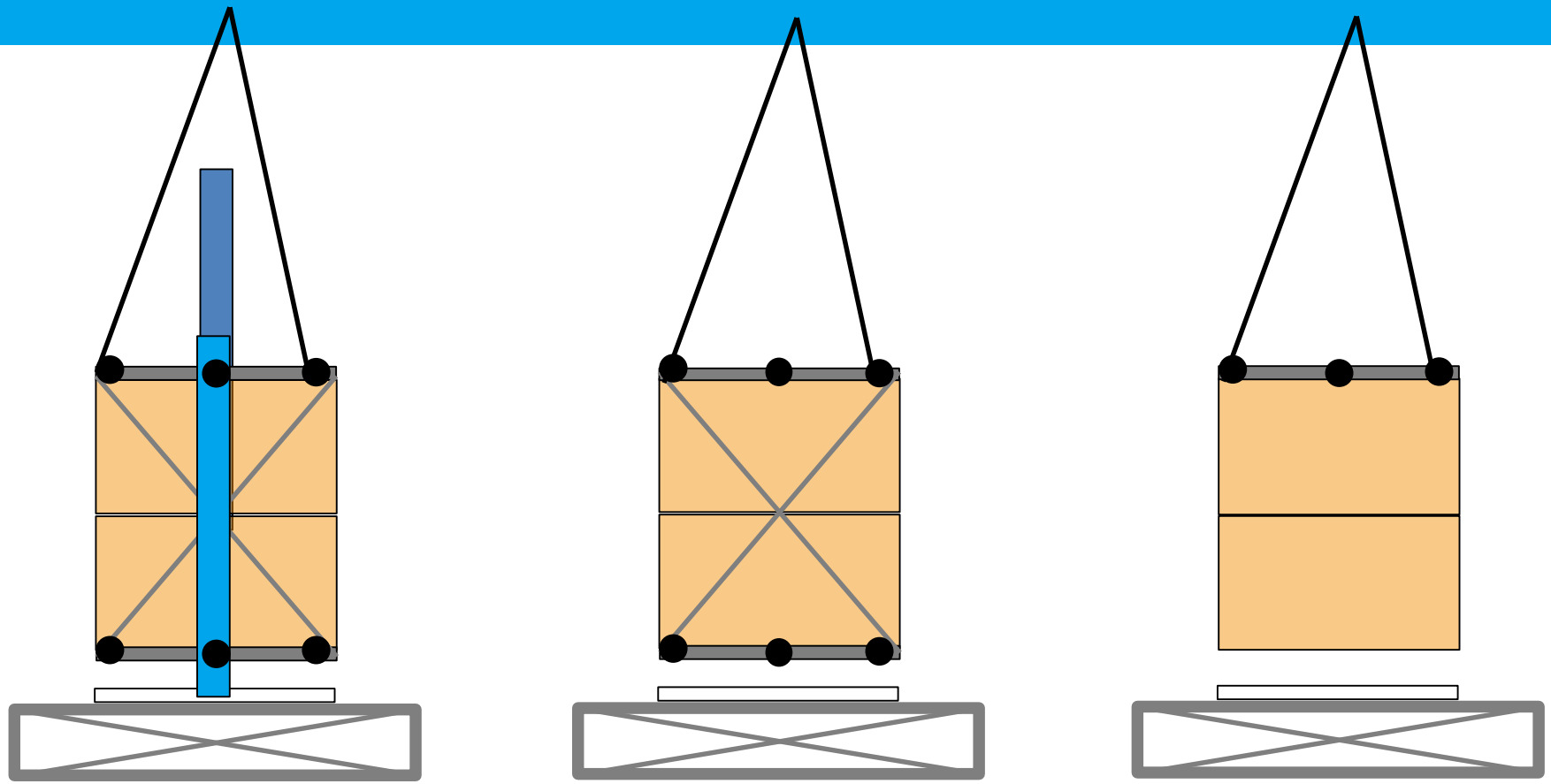
Vertical procedure in a few steps



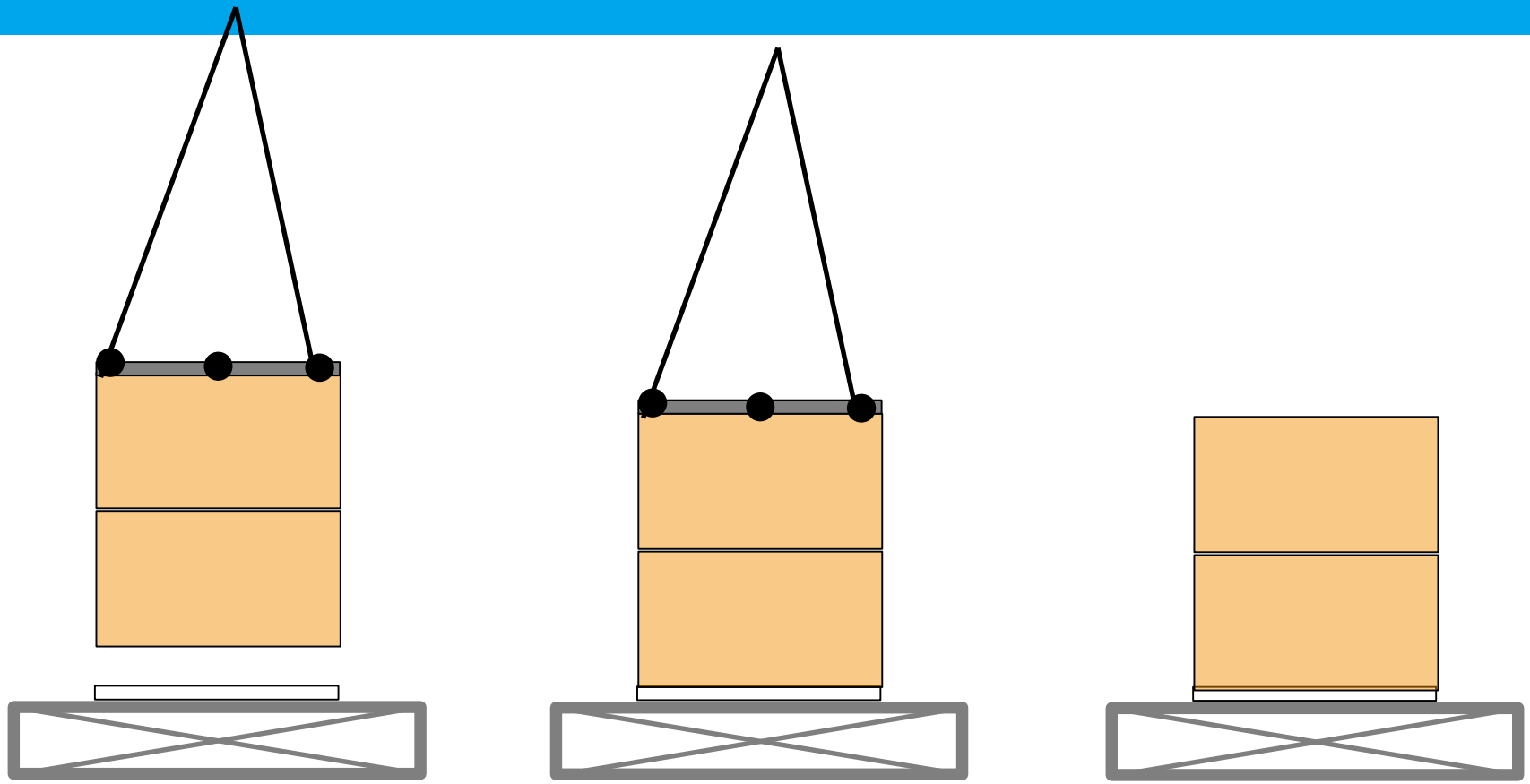
Vertical procedure in a few steps



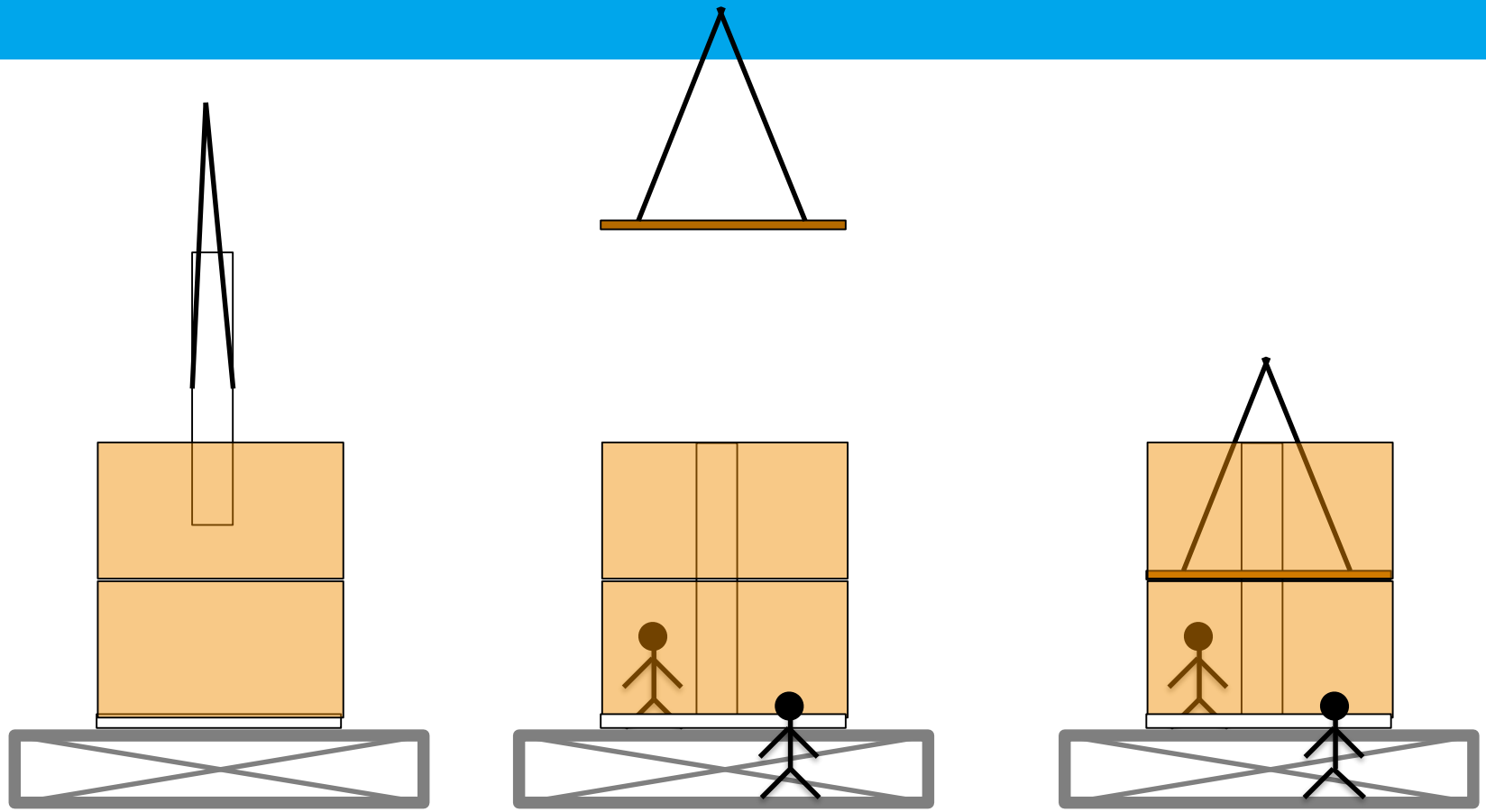
Vertical procedure in a few steps



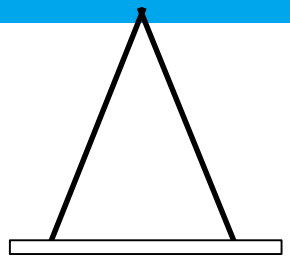
Vertical procedure in a few steps

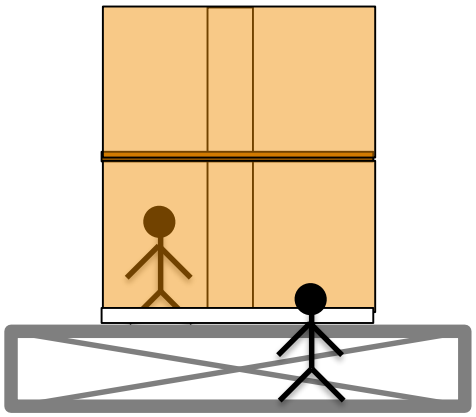


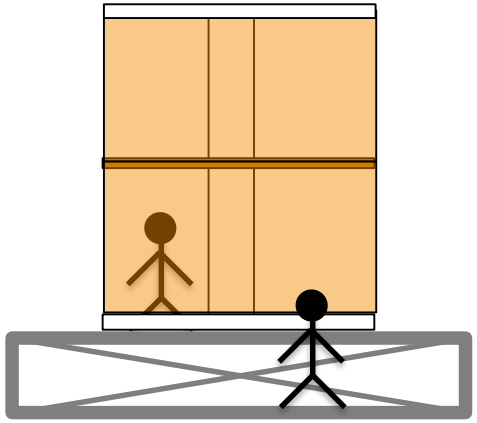
Vertical procedure in a few steps

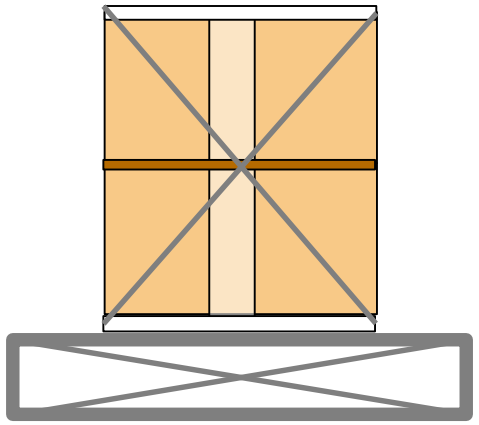


Vertical procedure in a few steps

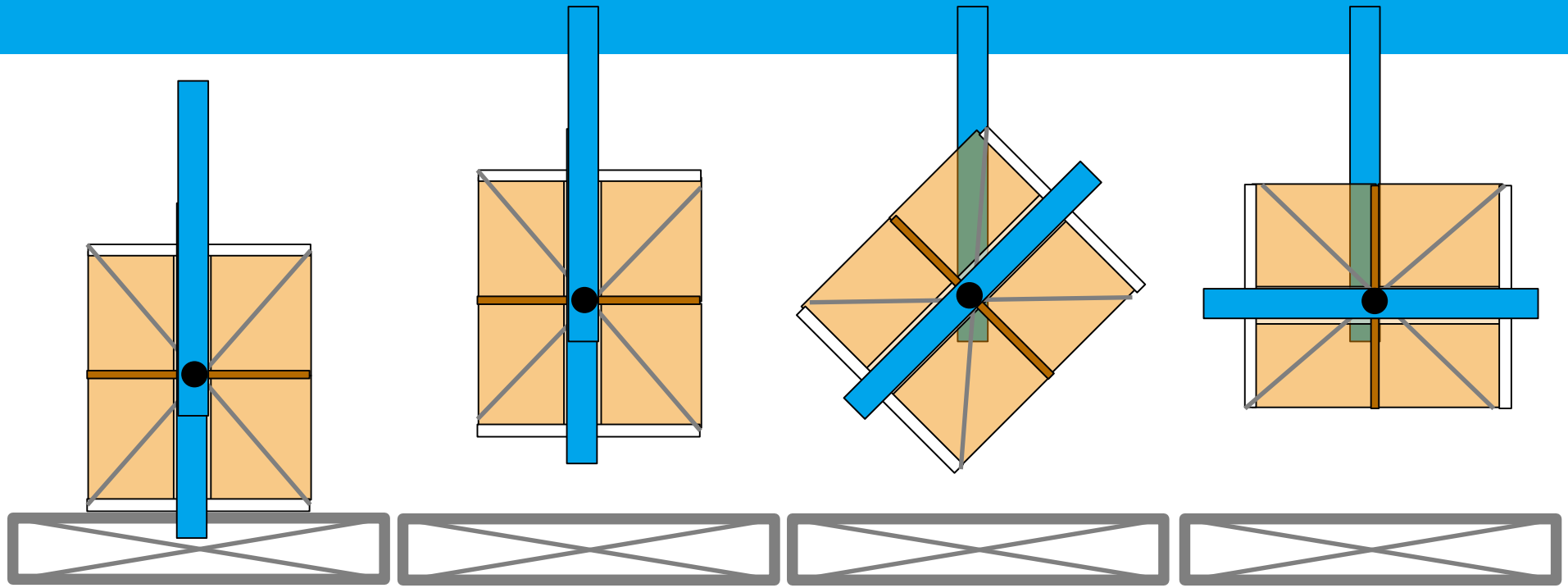








Vertical procedure in a few steps

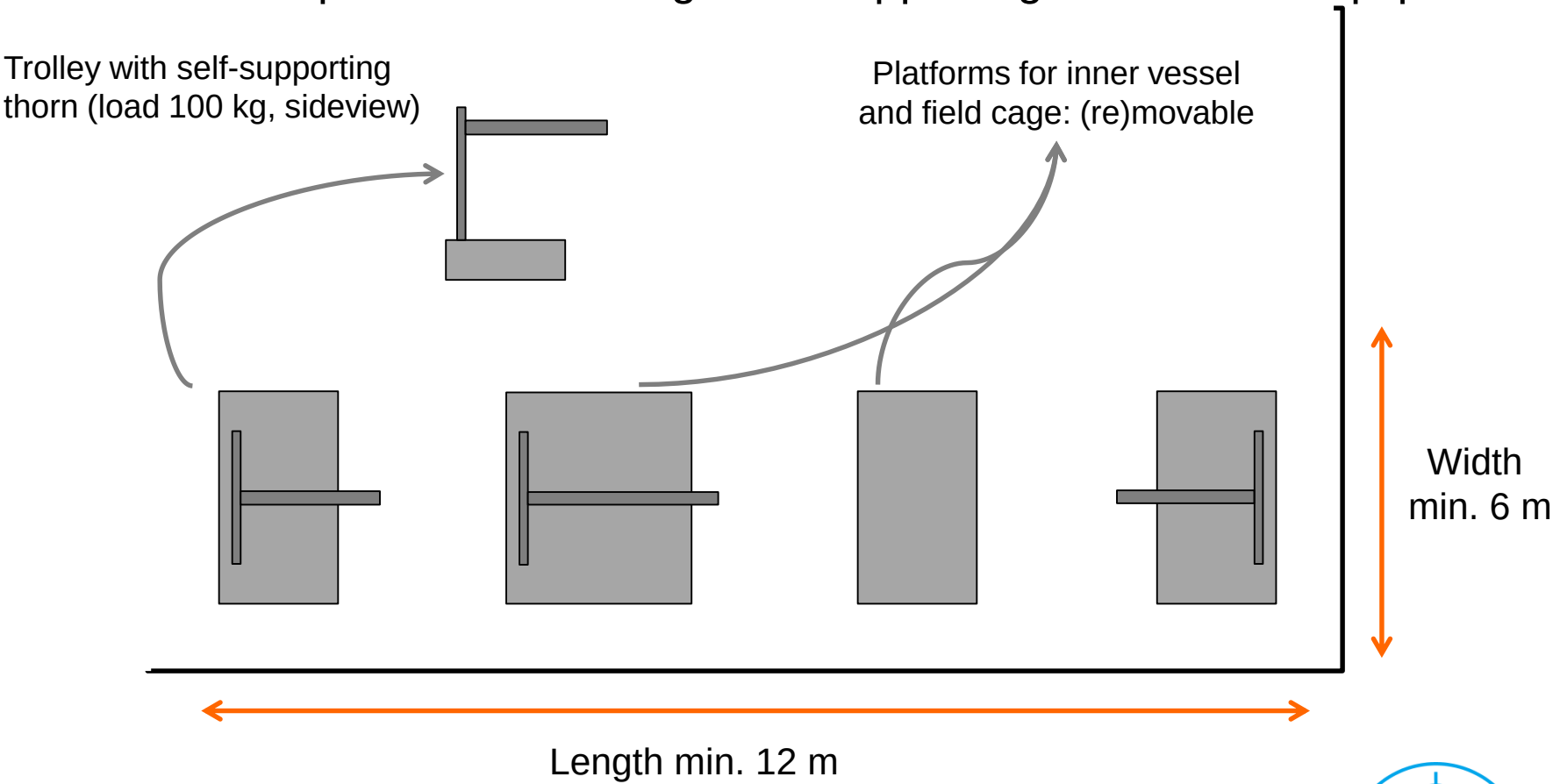


Then

- Cleaning of field cage
- Construction of grey/clean room around TPC field cage (ISO 7)
- Equipping of end-plates with tested modules using robot (petal-like structures in EP quadrant holes).
- System test (in AH)

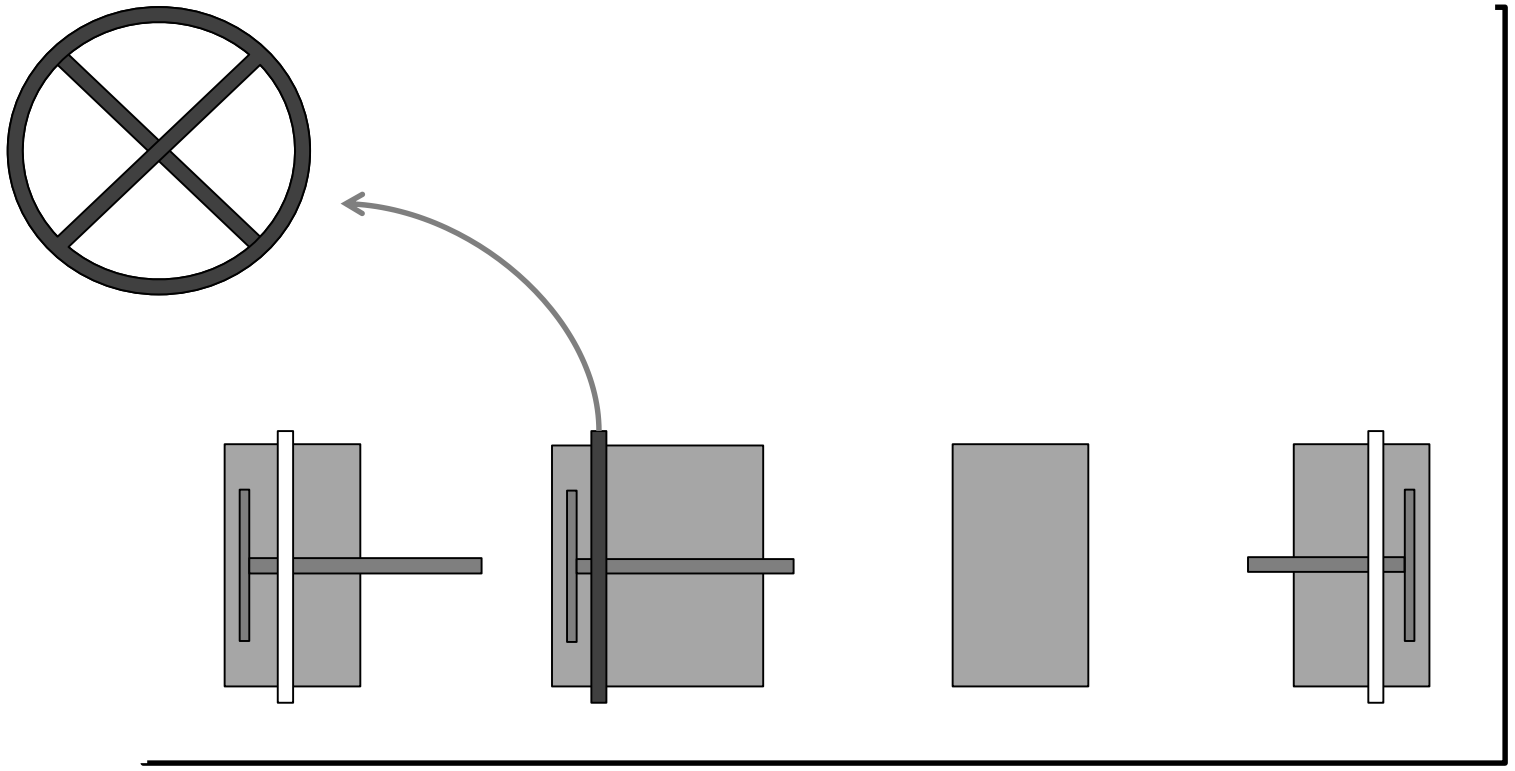
Horizontal procedure in a few steps

Note: – Greyroom / ISO7 with stable T and FFUs needed from start.
– Access to greyroom through sliding gate with air lock
-- Assumption that field cage self-supporting and first EP equipment



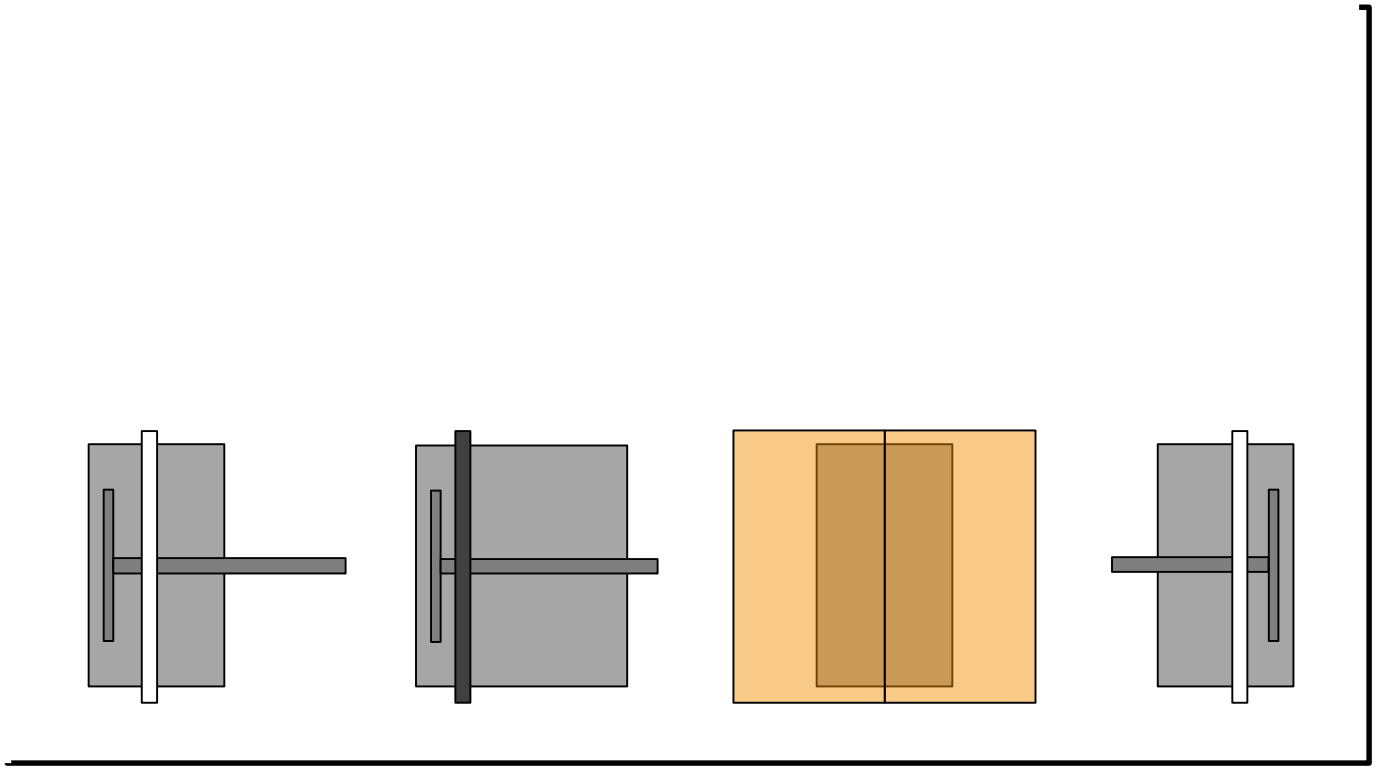
Horizontal procedure in a few steps

End-plate structures on trolleys and beginning of end-plate equipping (R); supporting star on inner-vessel platform



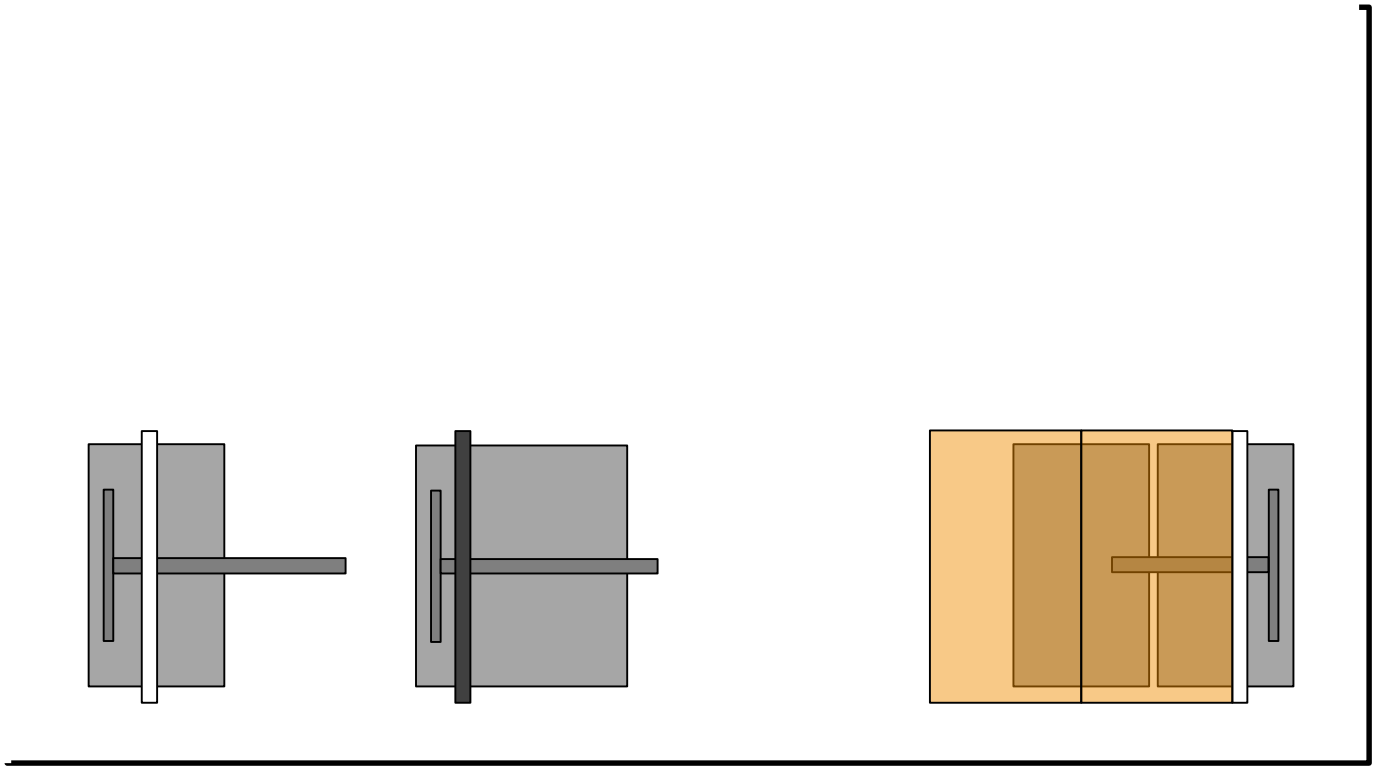
Horizontal procedure in a few steps

Field-cage assembly



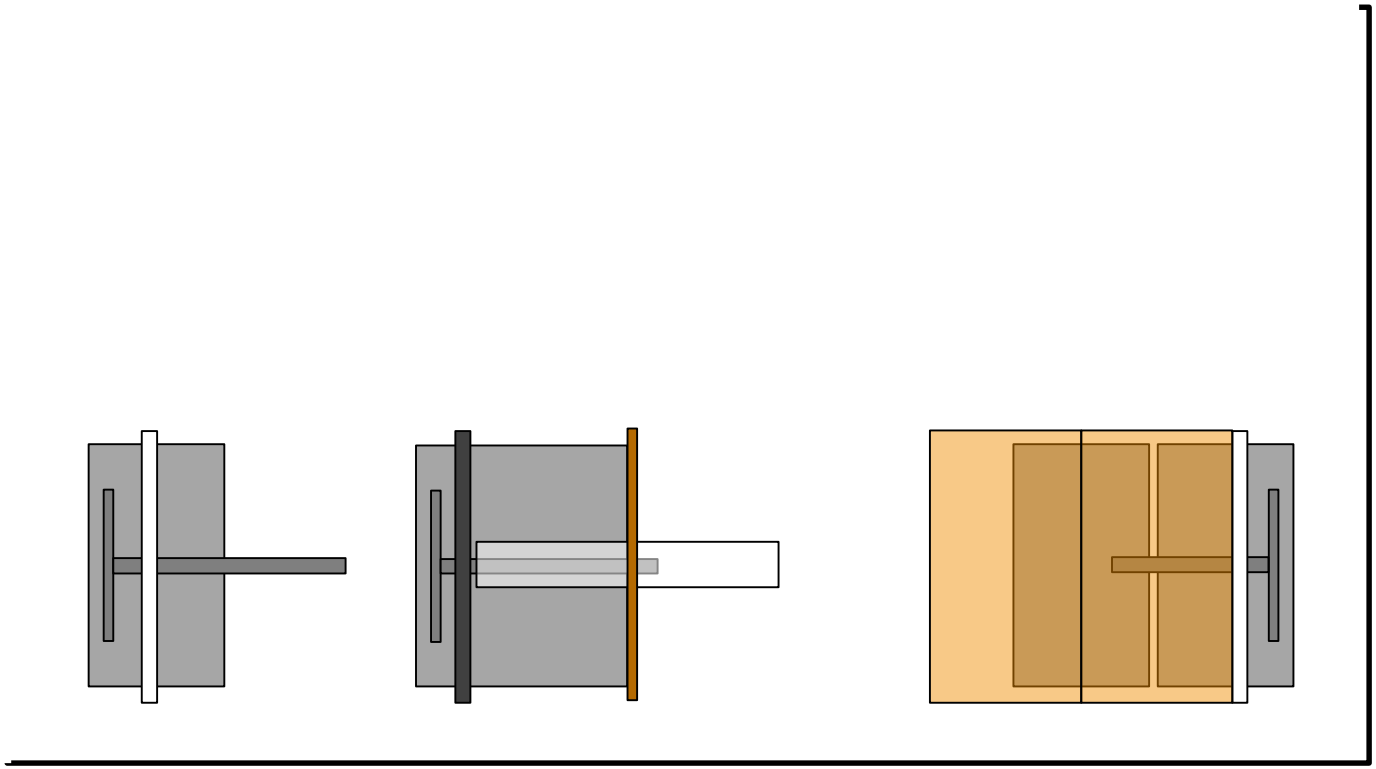
Horizontal procedure in a few steps

Marriage of field-cage and end-plate R



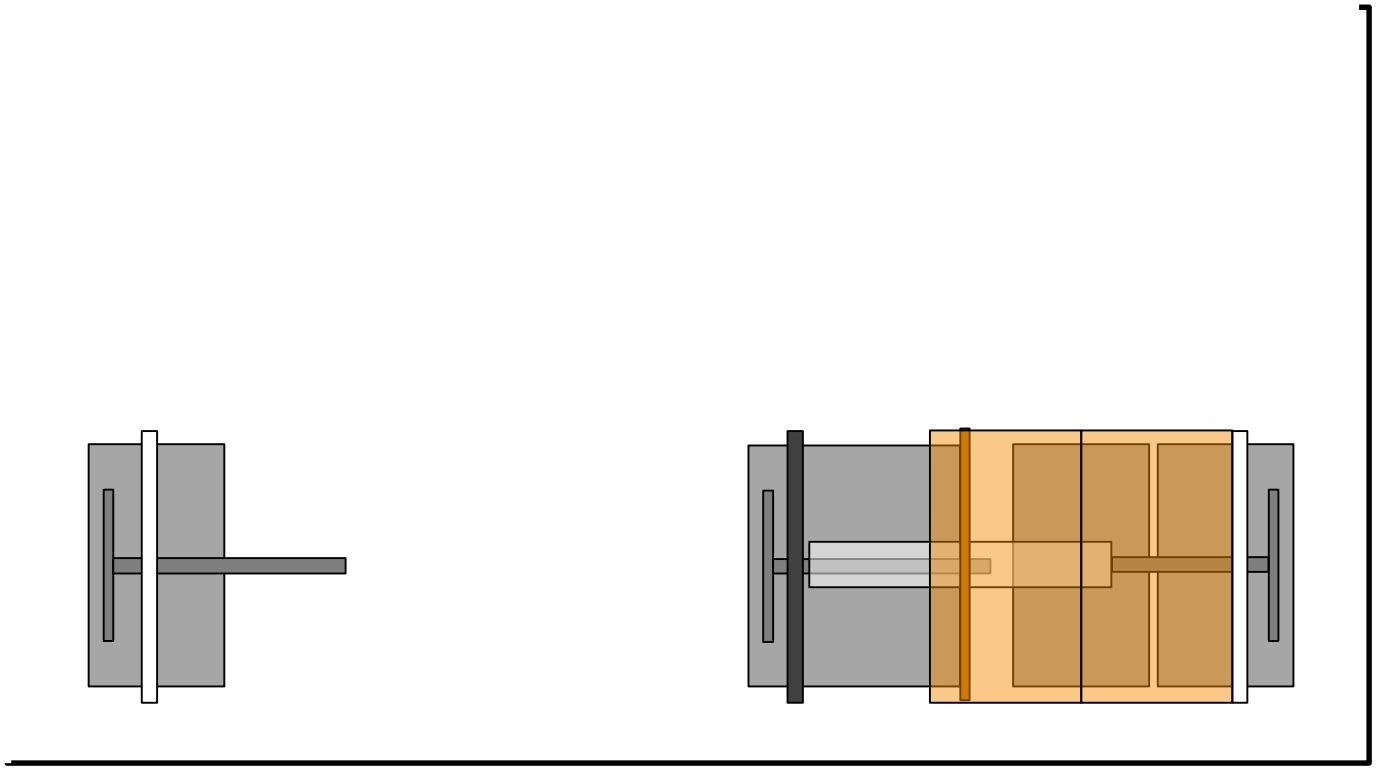
Horizontal procedure in a few steps

Set-up of inner vessel with cathode (“sail”)



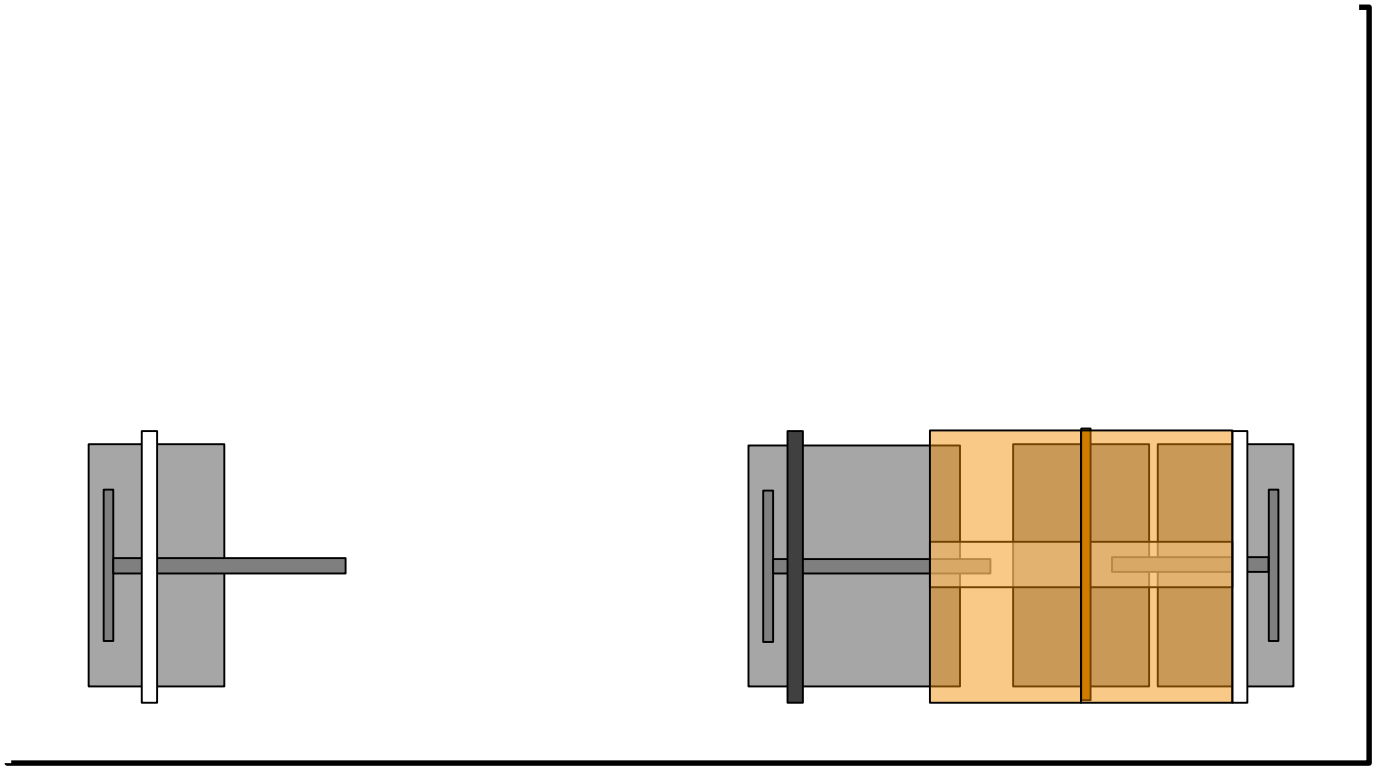
Horizontal procedure in a few steps

Marriage of inner vessel with cathode and field cage



Horizontal procedure in a few steps

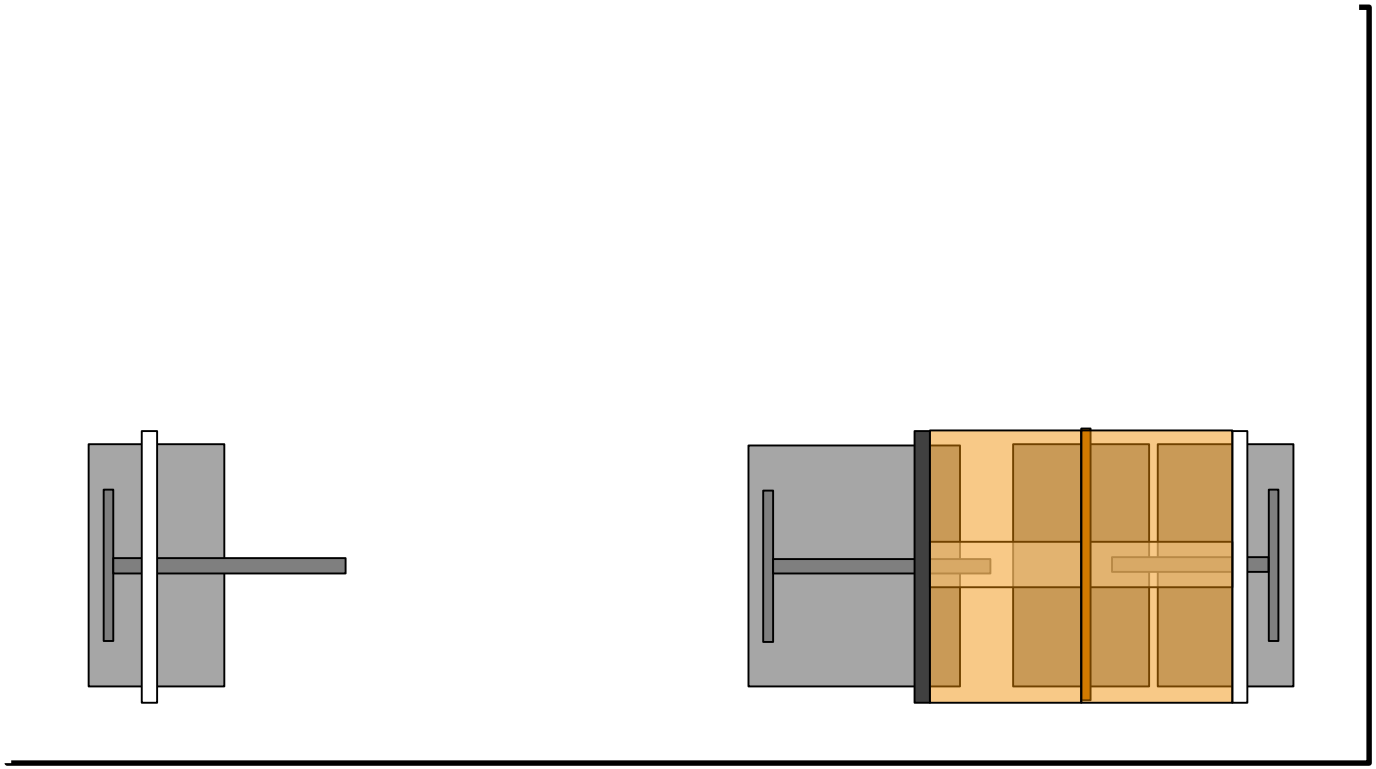
Marriage of inner vessel with cathode and field cage



Alternative: First fixing of inner vessel in field cage, then installation / spanning of cathode.

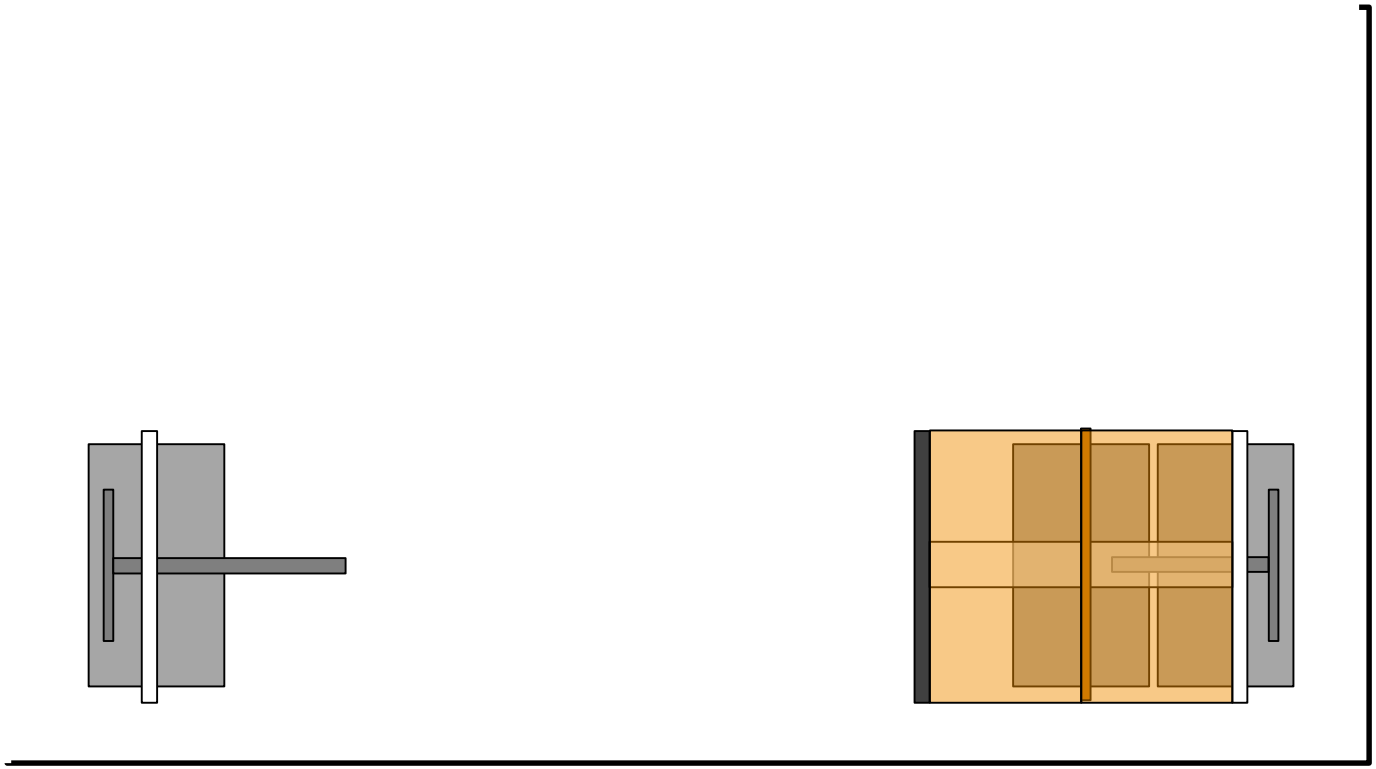
Horizontal procedure in a few steps

Marriage of inner vessel with cathode and field cage.
Fixing the supporting “star” supporting the inner vessel and the sail



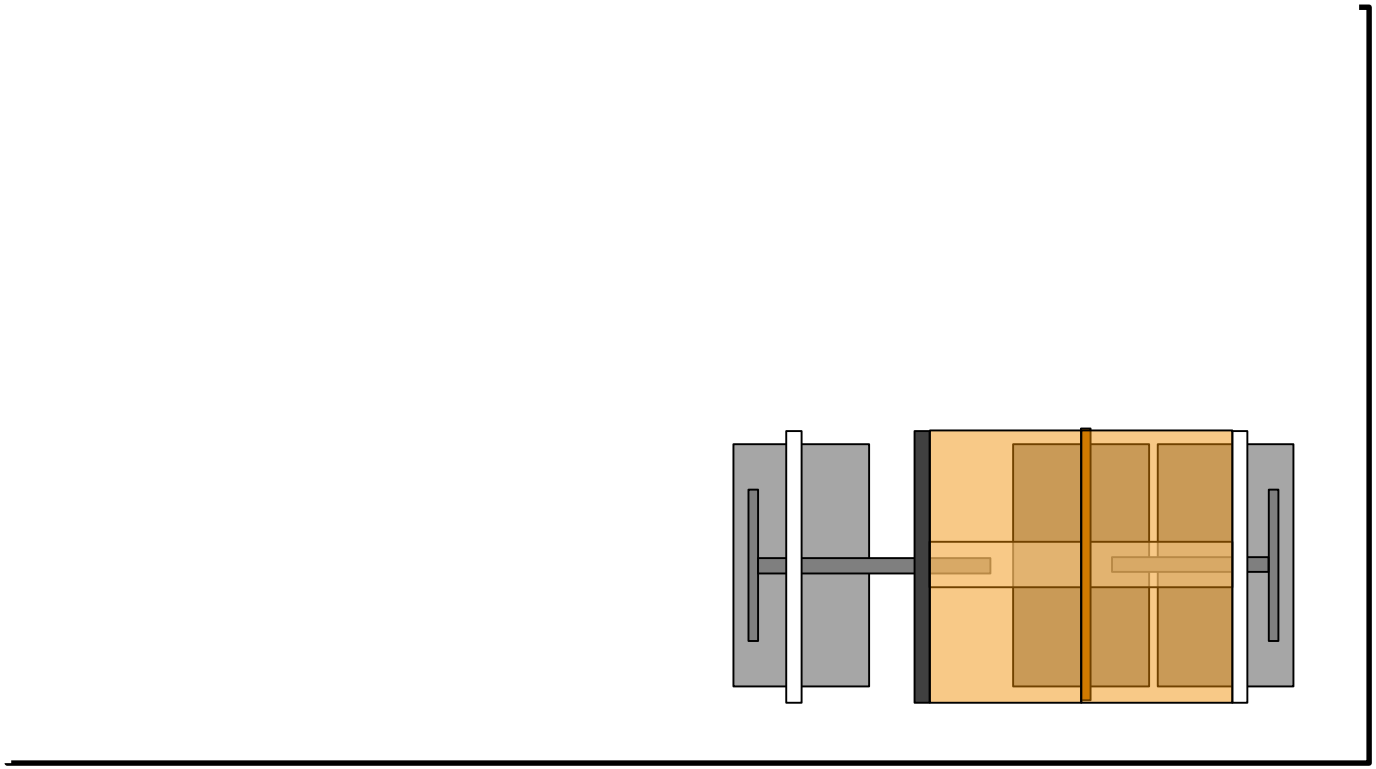
Horizontal procedure in a few steps

Removing inner-vessel platform and finalisation of end-plate L



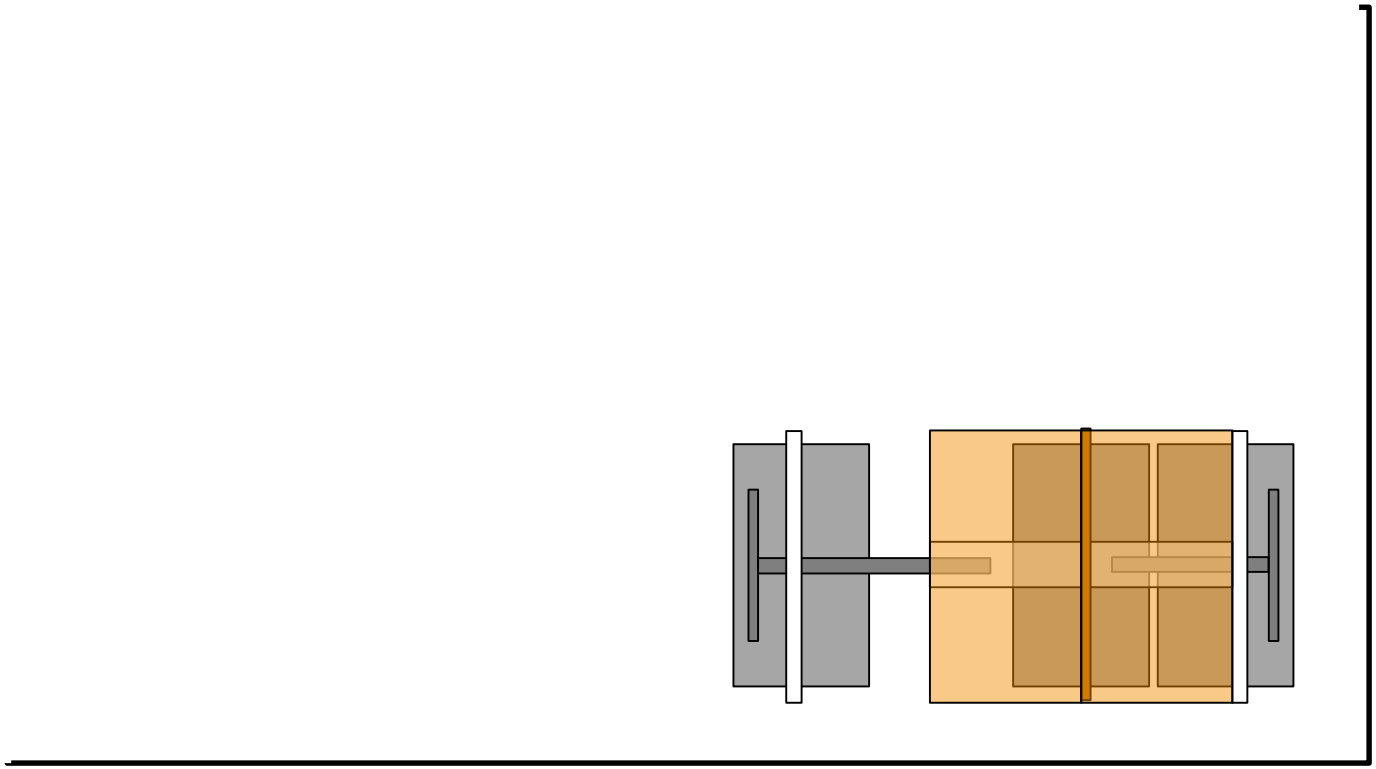
Horizontal procedure in a few steps

Inserting end-plate L: approaching the field cage …



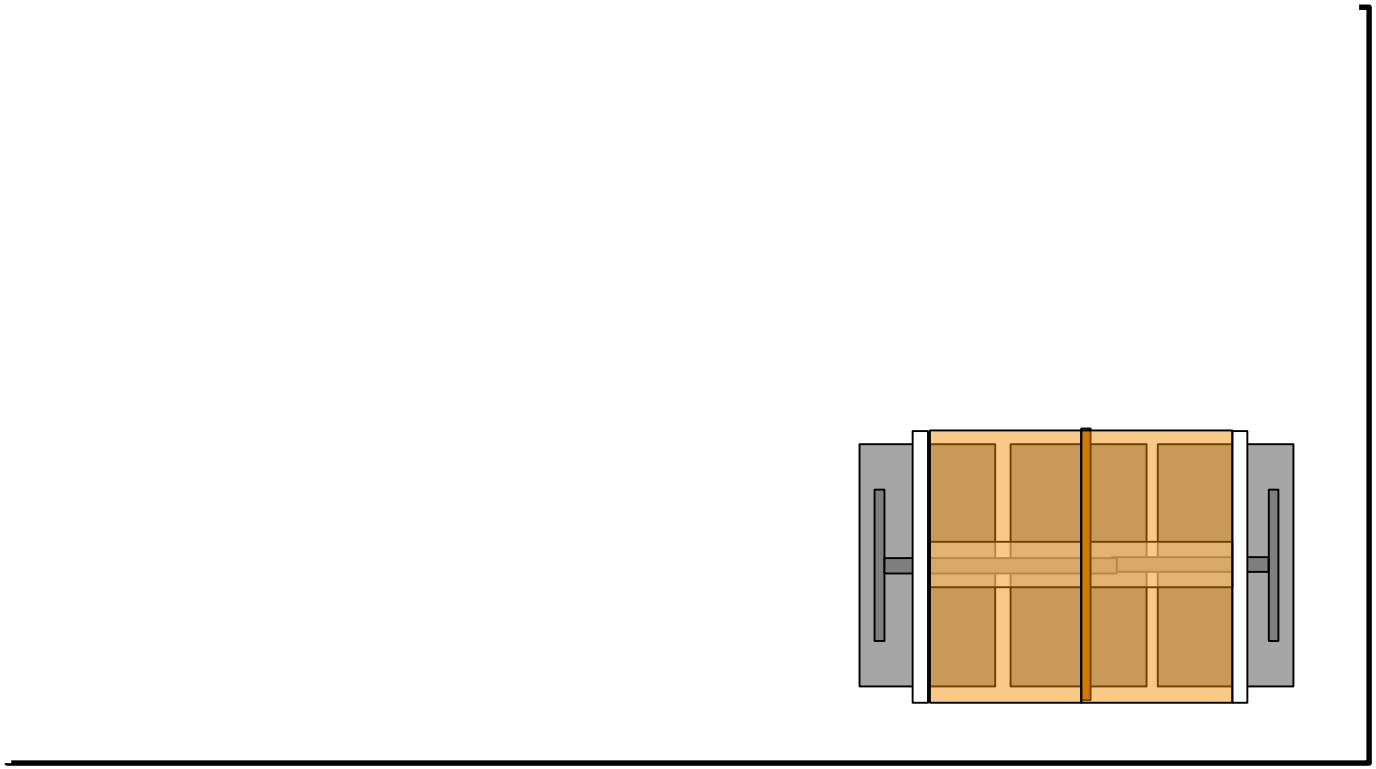
Horizontal procedure in a few steps

Inserting end-plate L: approaching the field cage, supporting the inner vessel and removing the supporting star, …



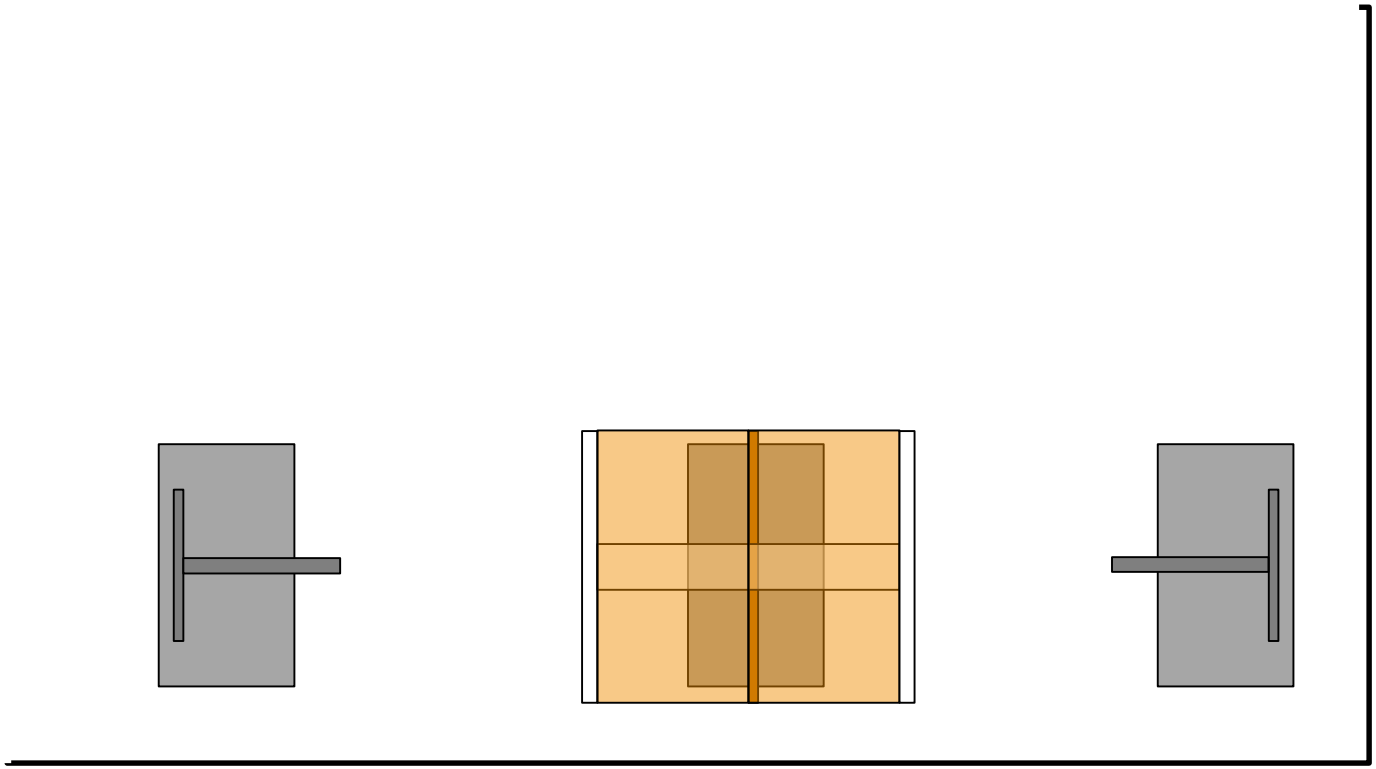
Horizontal procedure in a few steps

Inserting end-plate L: approaching the field cage, supporting the inner vessel + removing the supporting star, pushing in end-plate L



Horizontal procedure in a few steps

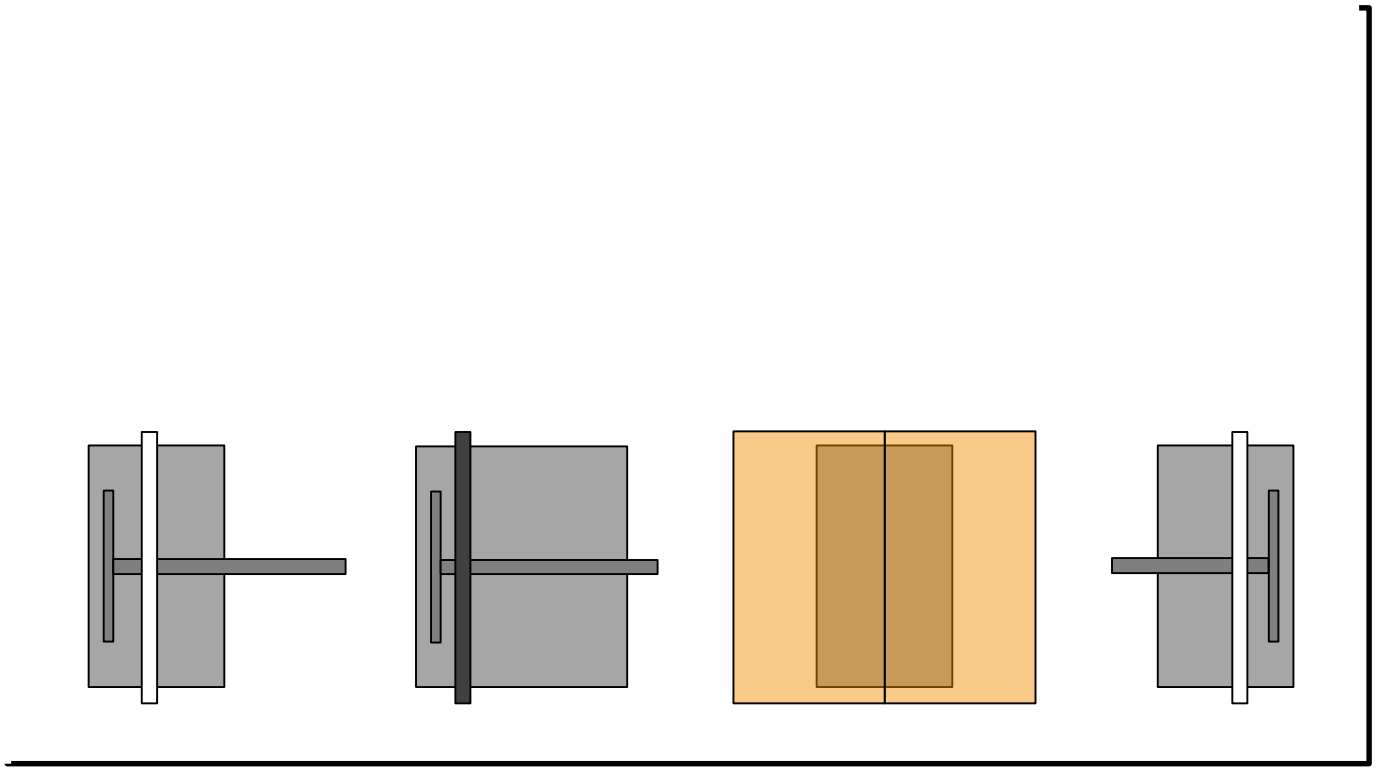
Ready



Alternative horizontal procedure

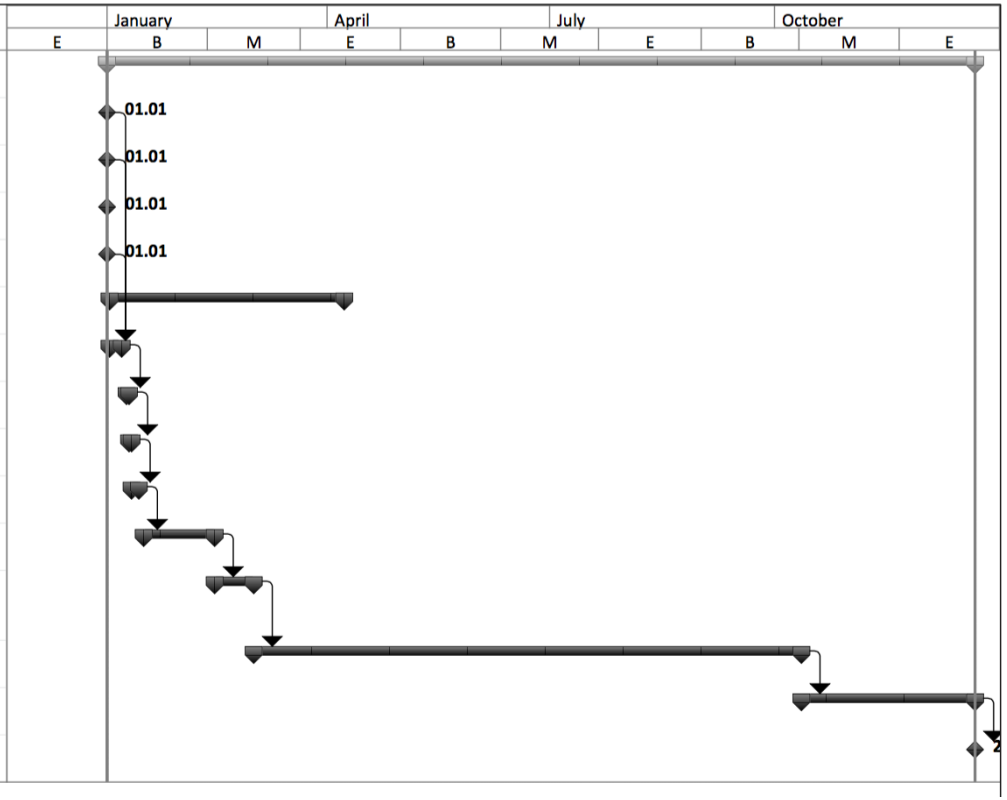
Assumptions: Similar as before, but …

- EP equipment at the end with robot
- Question of overall time planning (end-plate equipment the most time-consuming item



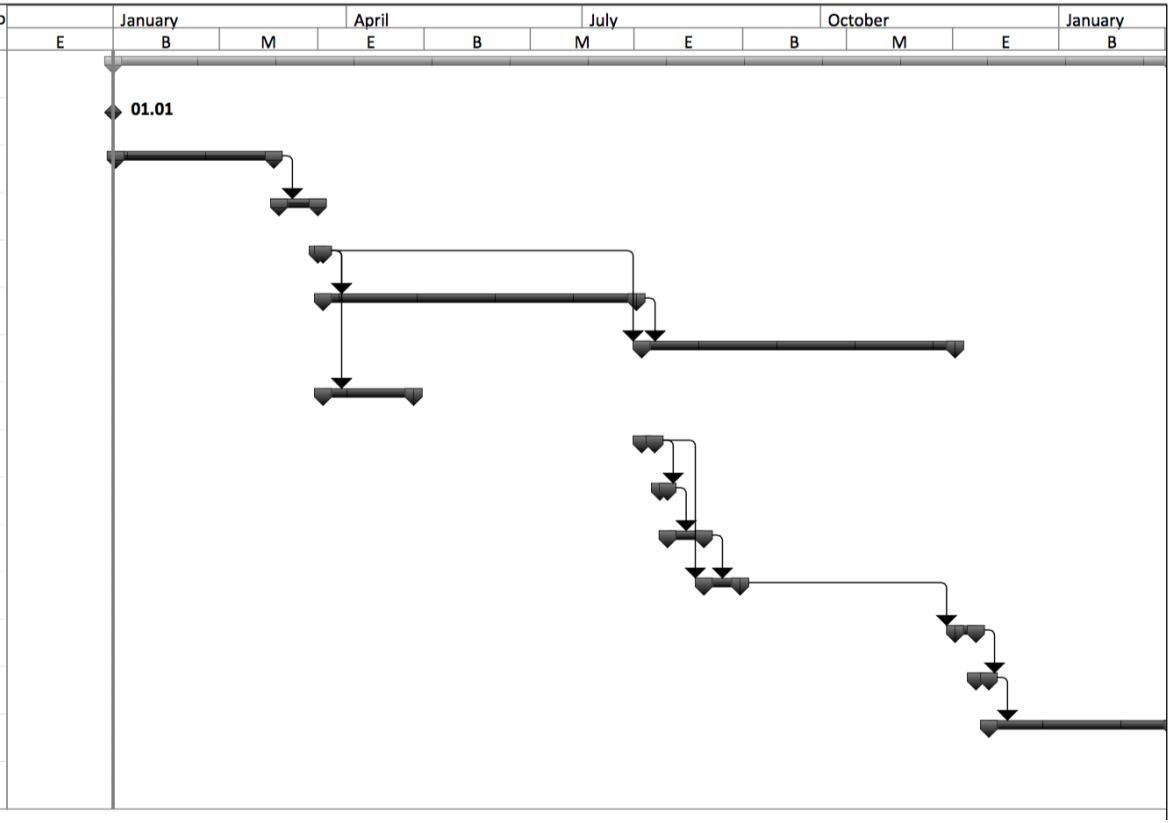
Vertical procedure – time estimate

ID	Task Name	Duration	Start	Finish	Predecesso	Resource Names
0	**TPC Assembly**	**254 day...**	**Sun 01.01.17**	**Thu 21.12.17**		
1	Platform setup	0 days	Sun 01.01.17	Sun 01.01.17		
2	End-plate delivery	0 days	Sun 01.01.17	Sun 01.01.17		
3	Inner vessel delivery	0 days	Sun 01.01.17	Sun 01.01.17		
4	Field cage delivery to hall	0 days	Sun 01.01.17	Sun 01.01.17		
5	**Module testing**	**70 days**	**Mon 02.01.17**	**Fri 07.04.17**		
8	**Placing field cage on end-plate**	**5 days?**	**Mon 02.01.17**	**Fri 06.01.17**	**1;2;4**	
14	**Installation of inner vessel**	**1 day?**	**Mon 09.01.17**	**Mon 09.01.17**	**8**	
16	**Installation of cathode**	**1 day?**	**Tue 10.01.17**	**Tue 10.01.17**	**14**	
18	**Installation of top end-plate**	**3 days?**	**Wed 11.01.17**	**Fri 13.01.17**	**16**	
22	**Cleaning and greyroom installation**	**21 days**	**Mon 16.01.17**	**Mon 13.02.17**	**18**	
25	**Cabling of field cage, inner vessel and cathode**	**12 days**	**Tue 14.02.17**	**Wed 01.03.17**	**22**	
28	**Installation of Modules**	**160 days**	**Thu 02.03.17**	**Wed 11.10.17**	**25;6**	
31	**Final test of TPC**	**51 days**	**Thu 12.10.17**	**Thu 21.12.17**	**28**	
34	TPC ready	0 days	Thu 21.12.17	Thu 21.12.17	31	

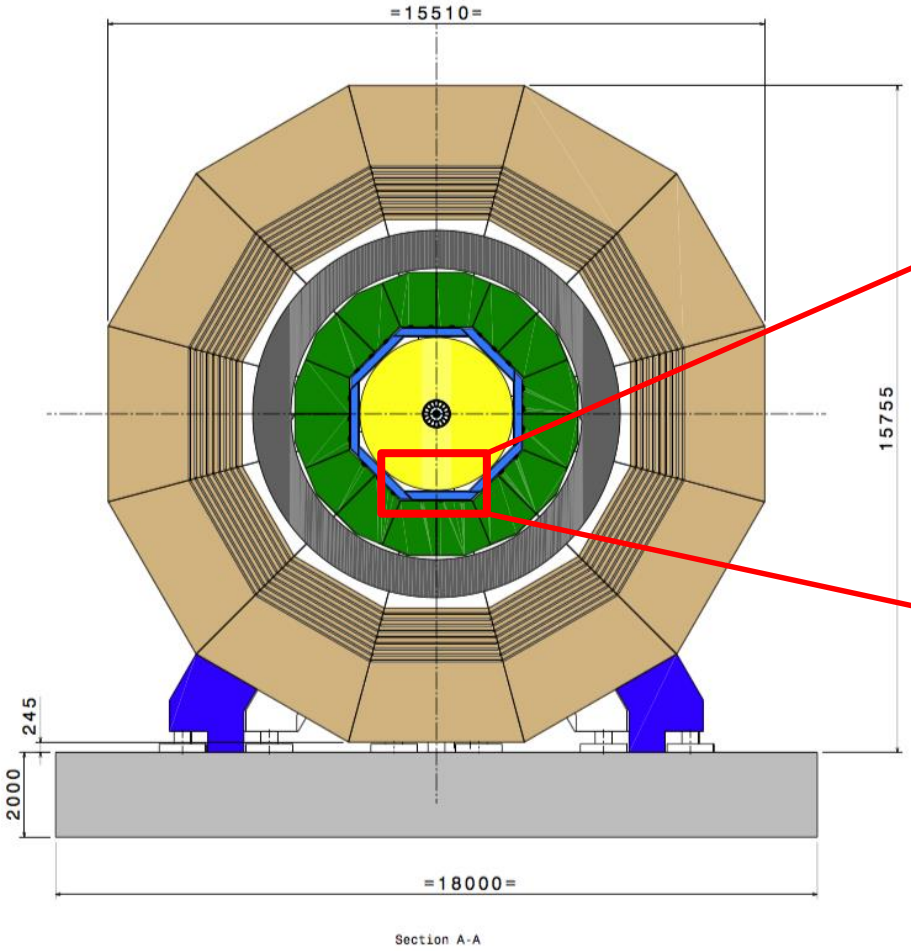


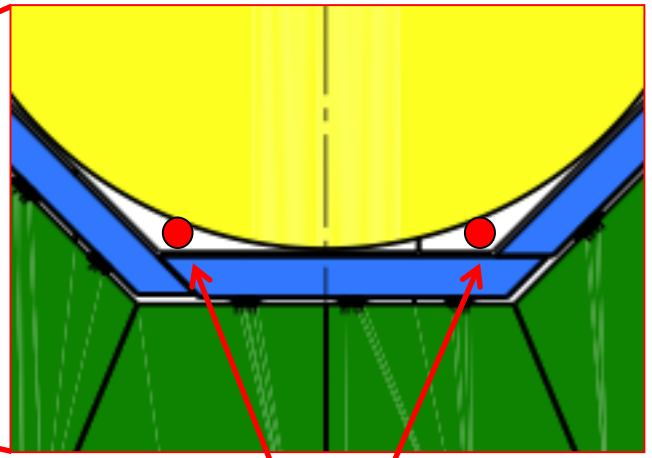
Horizontal procedure – time estimate

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

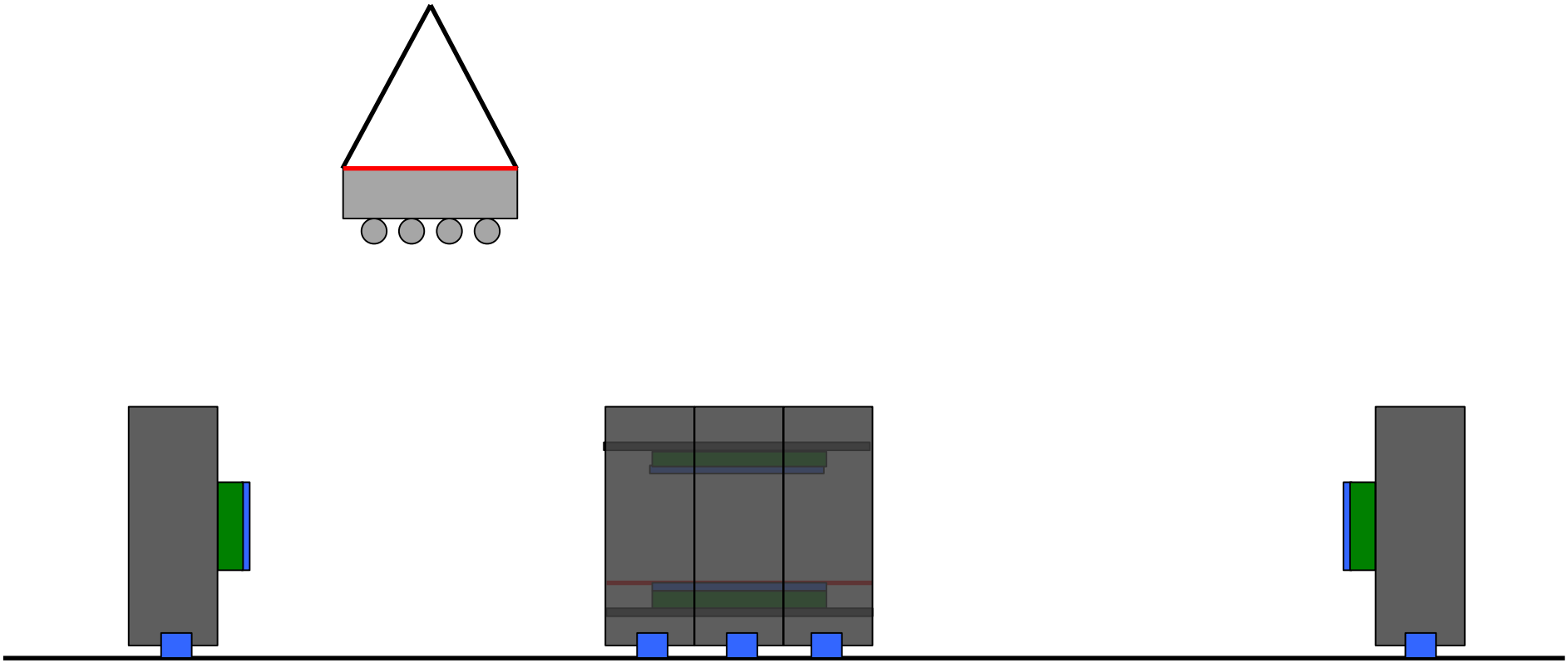


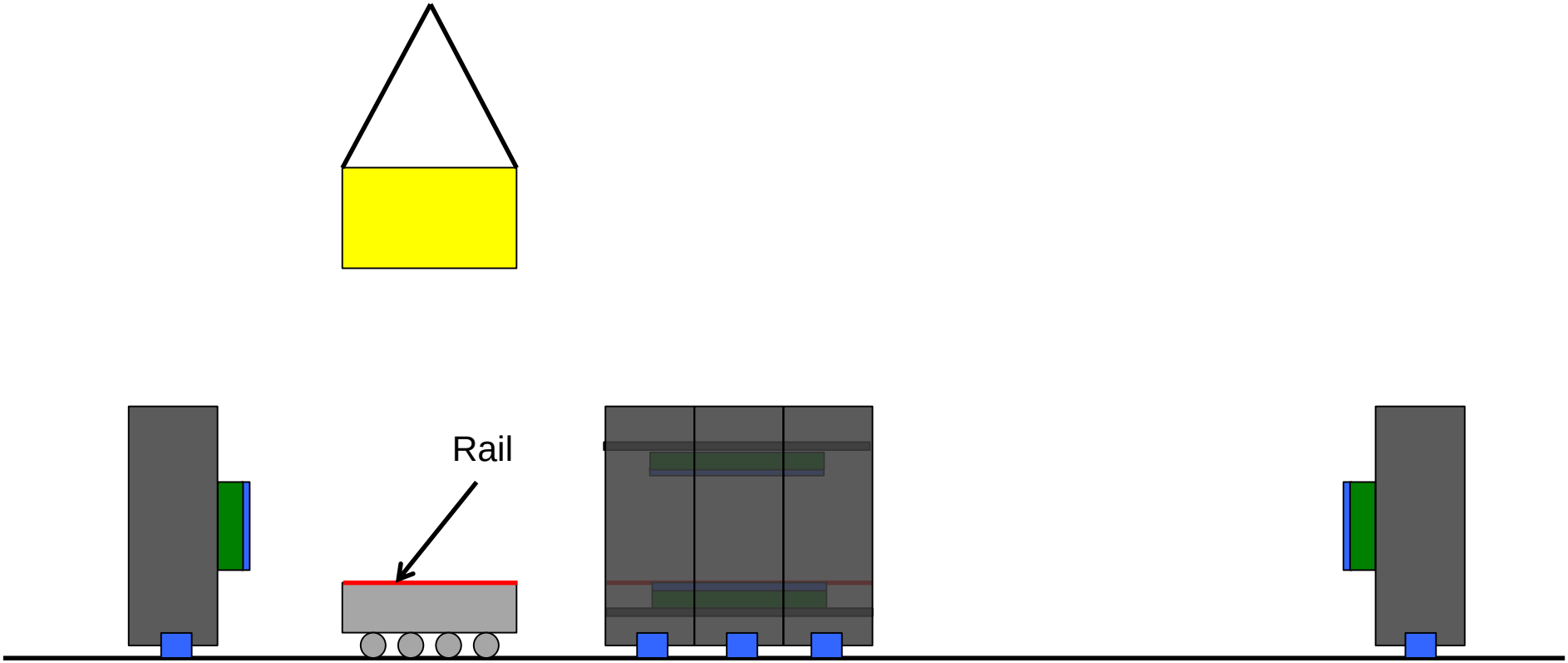
TPC insertion – mechanism?

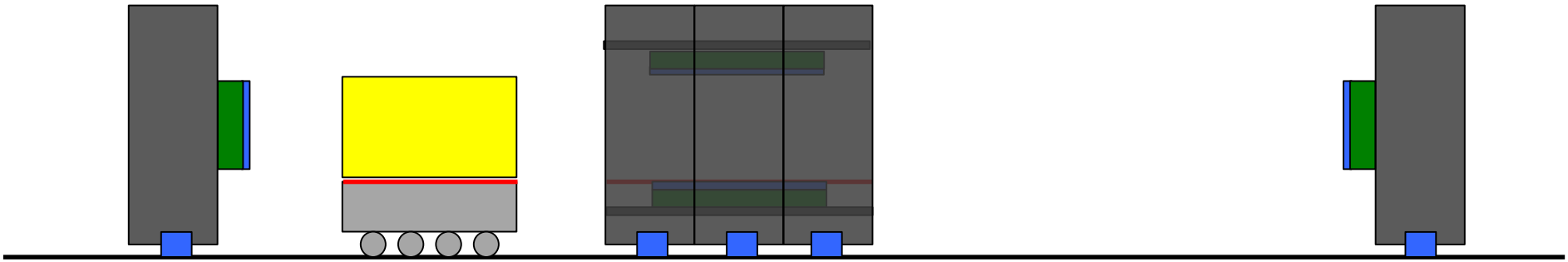


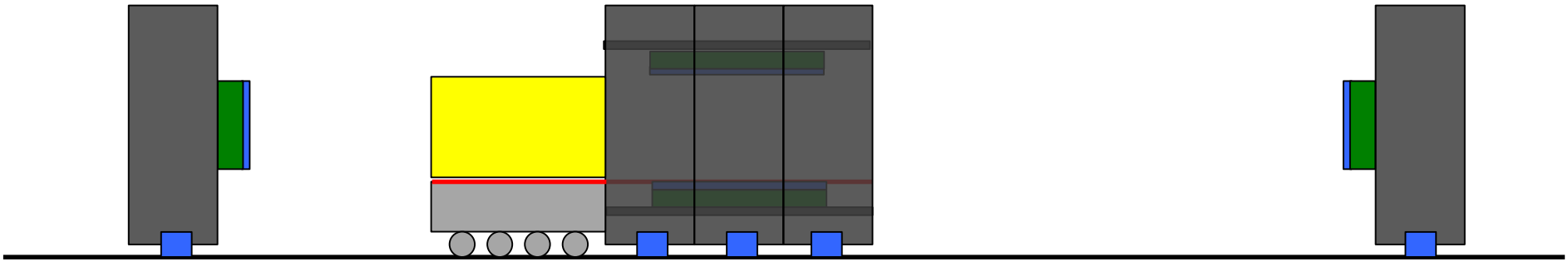


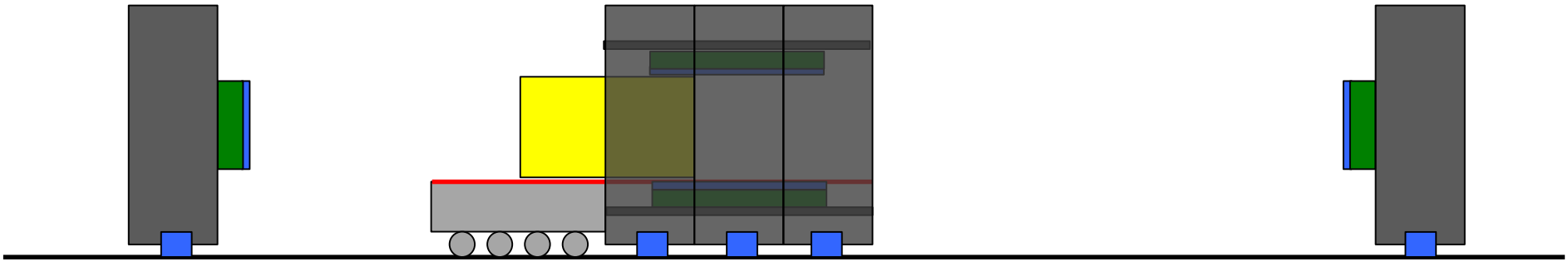
Rails
Space?

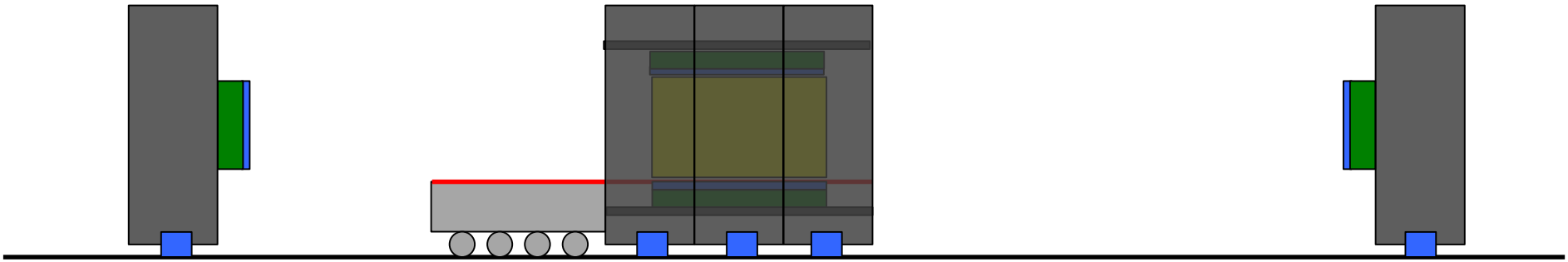


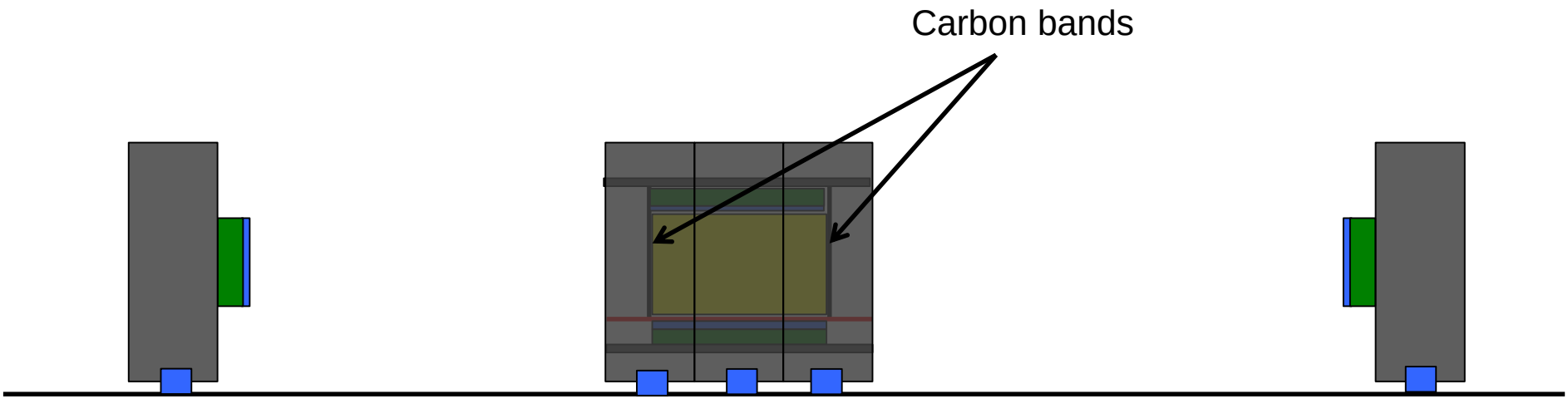

Rail





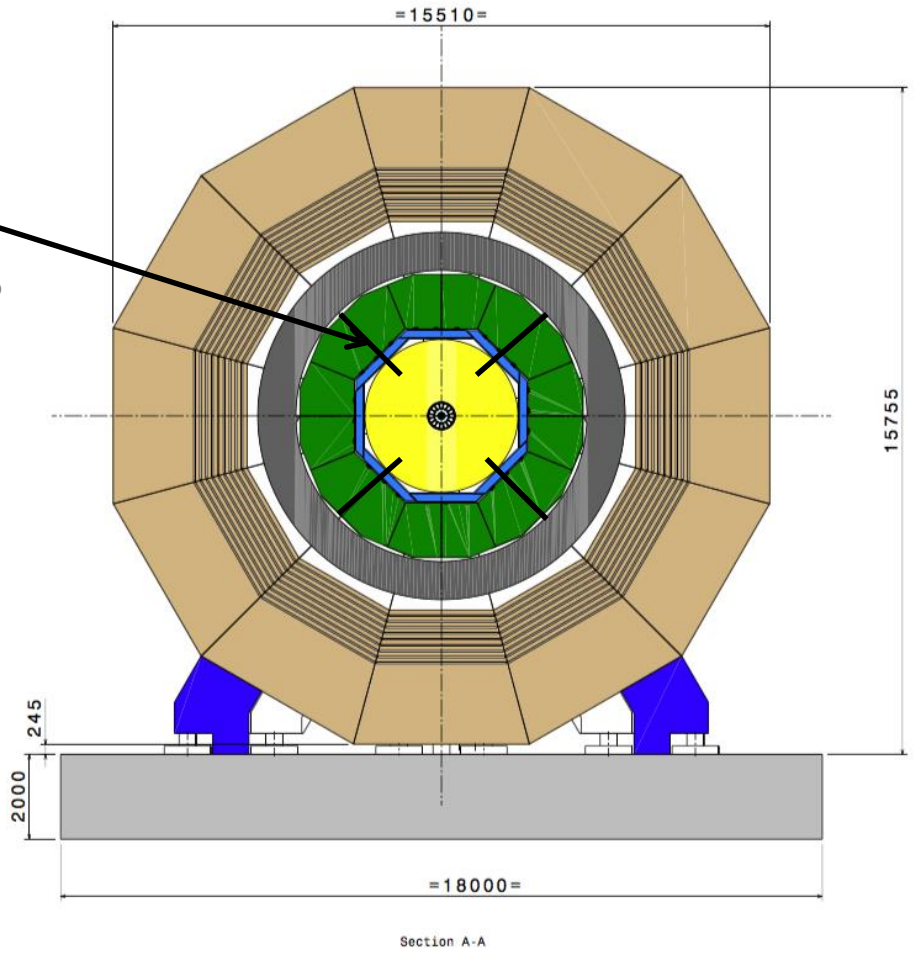


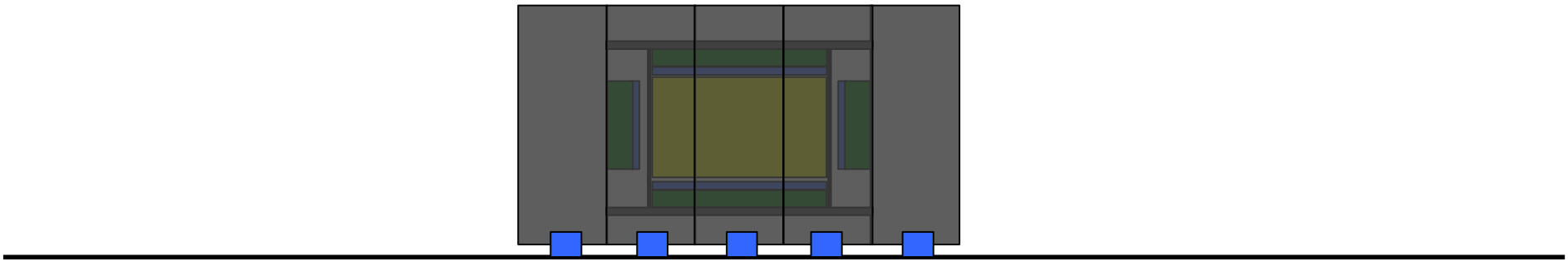



Carbon bands

Carbon bands

- How many?
- Size?
- How about longitudinal strain?





Veeeeery preliminary conclusions

Currently, more in favour of vertical assembly:

- Space requirements
- Time requirements
- Ease of access / logistics
- …

But many steps need thorough planning, and many engineering solutions are still missing.

- Also for insertion of TPC into ILD, and for mounting and suspension

Nevertheless – best current guess:

- Assembly requires one year after delivery of field cage
- Space requirements: 100 m^2 (ISO 7 / grey room quality)
- Plus space for module storage and testing, plus services

Some near-future steps

Continue to work on the models, assumptions and their consequences

- Principal procedures, needs and requirements
- Some important topics:
  - Support of TPC in ILC?
  - Prevention of longitudinal movement?
  - Cathode design?
  - End-plate design?
  - Space and infrastructure in DH (gas, power, electronic hut etc.)

To be decided soon: Where to assemble TPC?

- AH or research office building?
- If research office building, then still full TPC system test before lowering in AH?

Draw on previous experience

- Specifically ALICE → meeting in November at CERN

Get in touch with global integration efforts

- Hope to intensify contact to Yasuhiro