CEPC MDI Mechanics Issues

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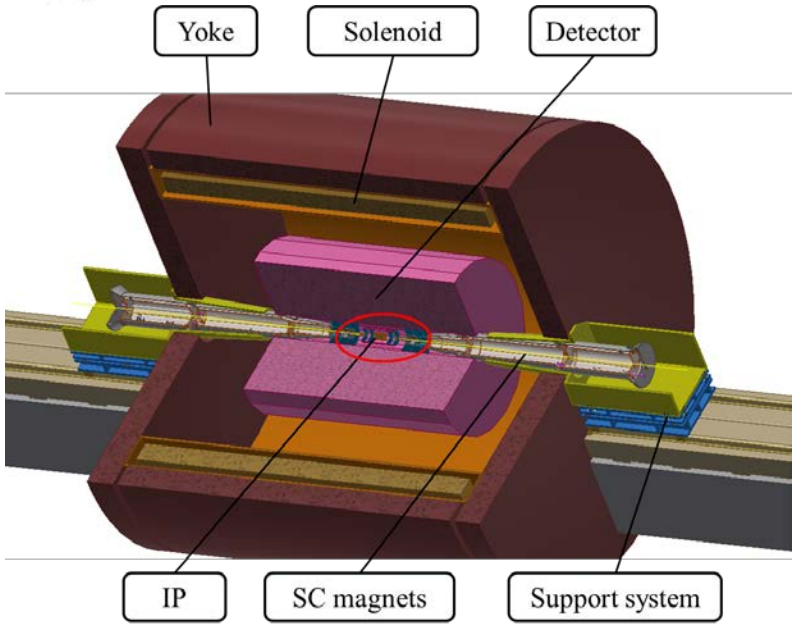
The Hong Kong University of Science and Technology

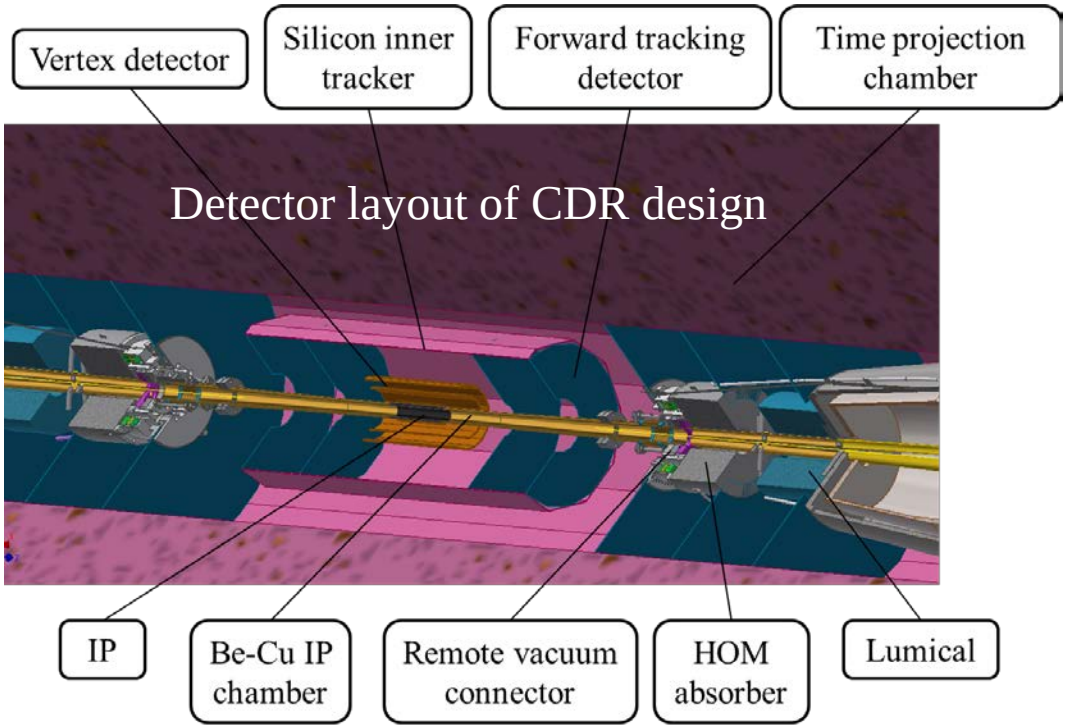
Mini-Workshop on MDI for Future Colliders

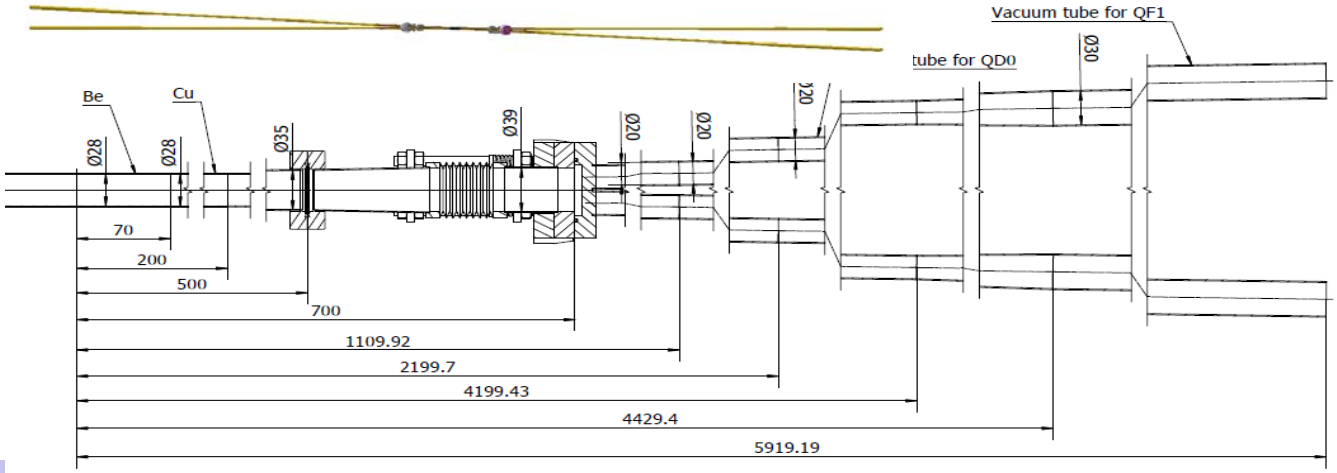
Outline

- Overview
- Preliminary installation scenario
- Remote vacuum connection methods
- Support system of SC magnets
- Lists to be done

Overview

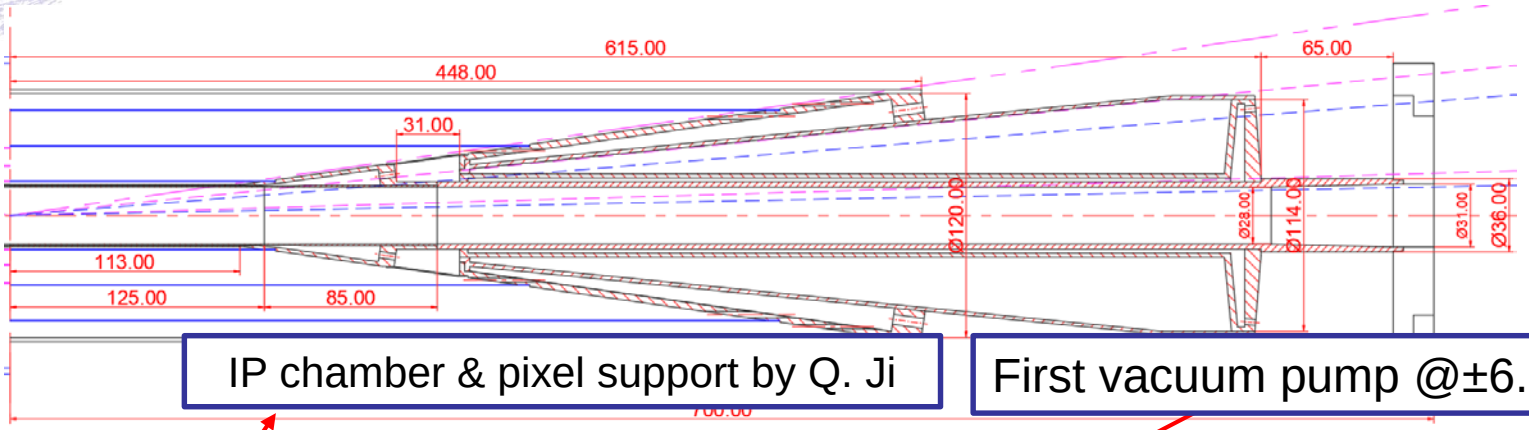






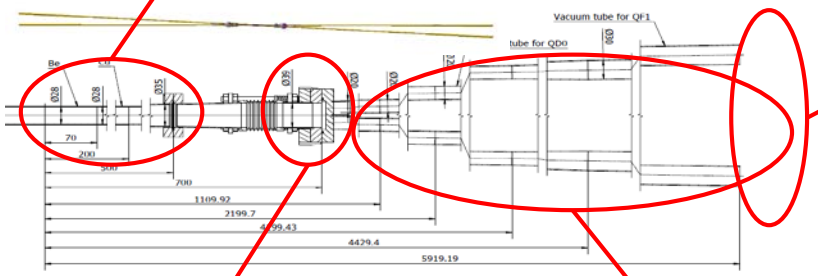
For the layout above, the length of yoke is 9.2 meters. The length of yoke should be discussed further.

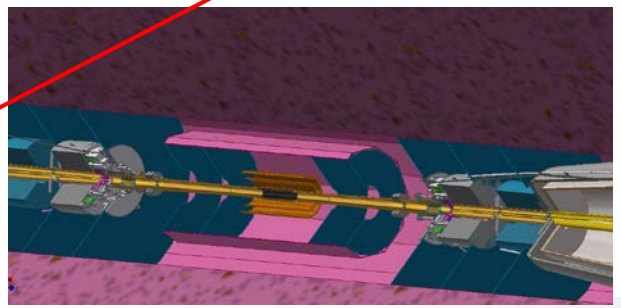
Overview

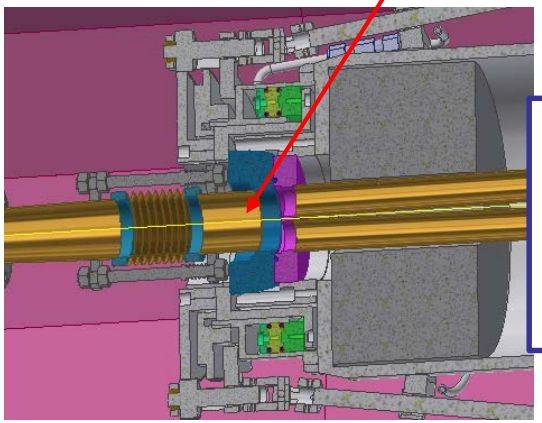


IP chamber & pixel support by Q. Ji

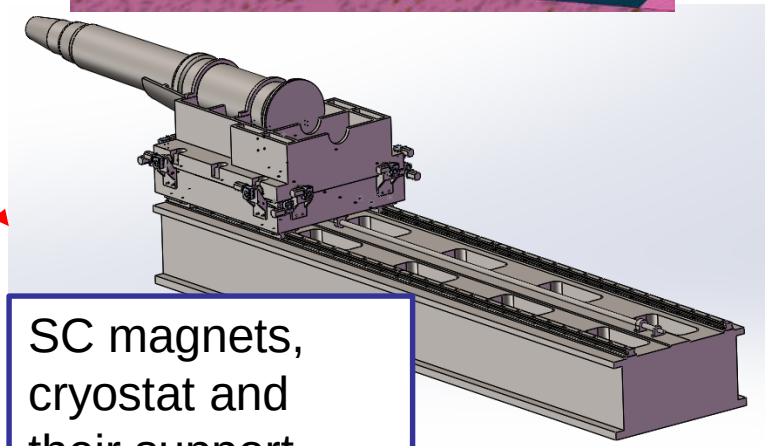
First vacuum pump @±6.5m







Connection interface of detector and accelerator

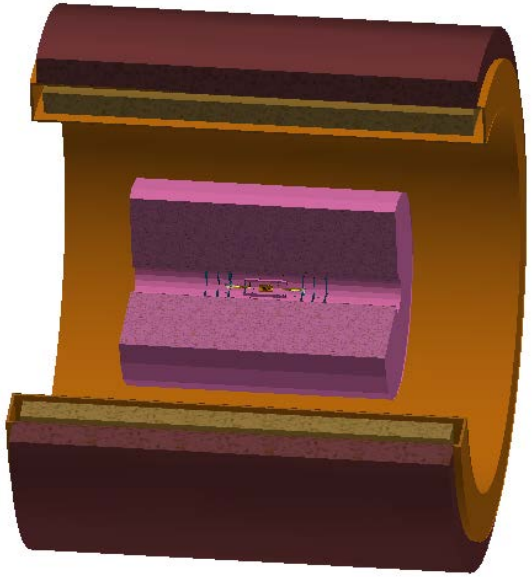


SC magnets, cryostat and their support

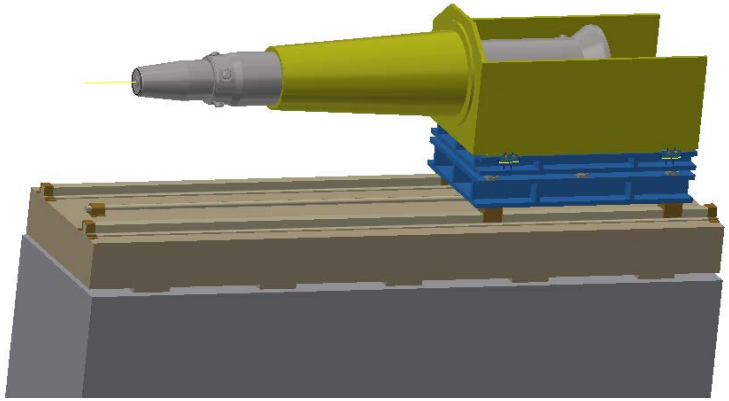
Preliminary installation scenario

Basic conditions

- The IP chamber and relative detectors have been assembled together as one assembly.
- The assembly can be supported and aligned.



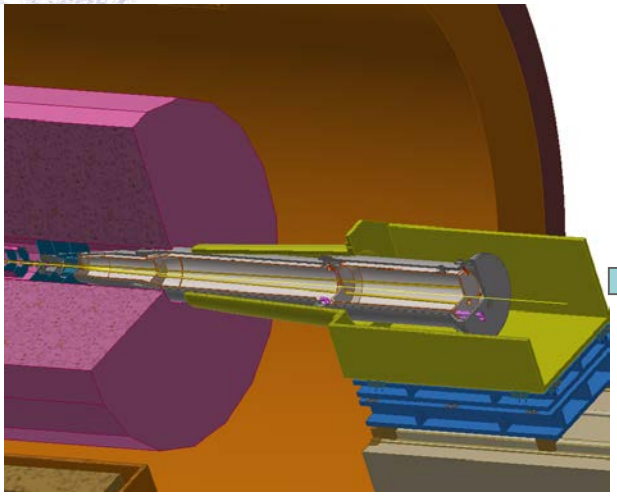
- Preliminary design of IP assembly.
- The detailed design is on-going.

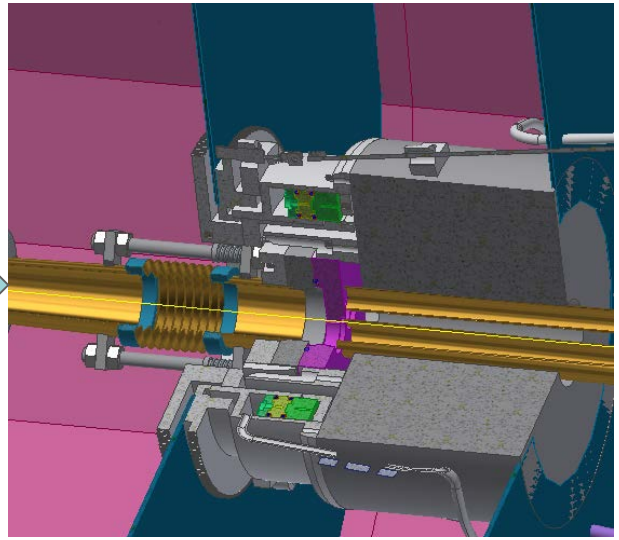


- **Pre-alignment of SC magnet: cryostat in working condition.**

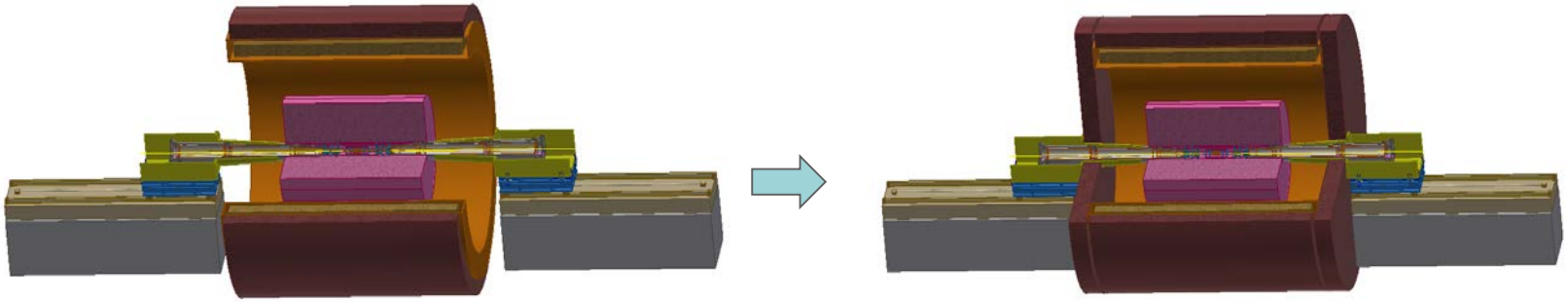
- **Installation of BPM, HOM absorber, RVC and relative support mechanism.**

Preliminary installation scenario



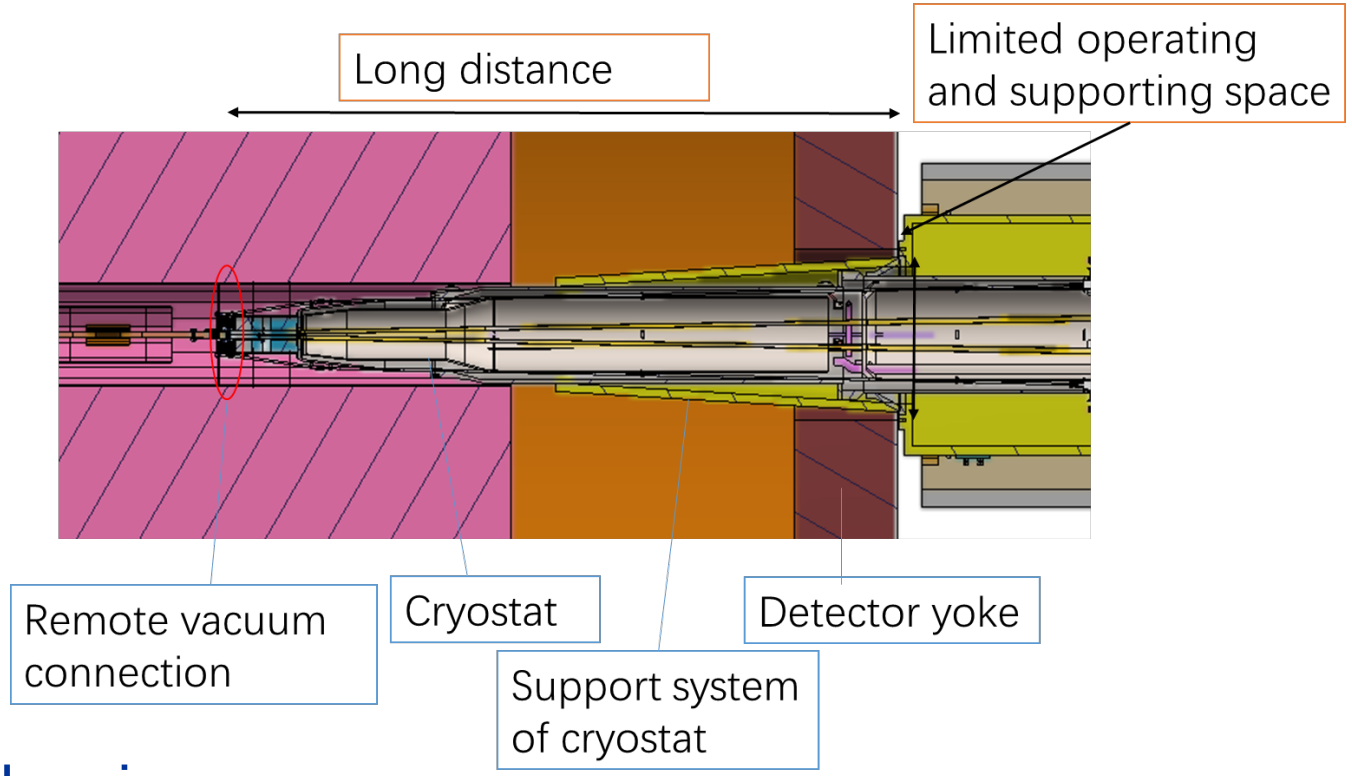


- Move the SC magnet to working location.
- Connect the flanges.
- Do the alignment.



- Finish the connection and alignment for both sides, install the yoke walls.

Preliminary installation scenario



- Two key issues:
  - Vacuum connection method at MDI to fulfill the vacuum requirement. Leak rate: ≤2.7e-11Pa.m3/s
  - Support system of cryostat to fulfill the alignment requirement. Alignment error: ≤30 μm, at least ≤50 μm.

	Distance from yoke boundary to connection location (m)	Alignment requirements of SC/ deformation of cryostat (μm)
BEPCII	~2.3 (has manual operation space)	Tested deformation: 960
SuperKEKB	~3.5 (the longer side) [1]	Analyzed deformation: 900 [2]
FCC-ee	~3 [3]	Alignment error: ≤50 [3]
CEPC	~3.8-6.1 *	Alignment error: ≤30

[1] Hiromi linuma, SuperKEKB status. Report, Nov, 2013。
[2] Hiroshi Yamaoka, et al, The mechanical and vibration studies of the final focus magnet-cryostat for SuperKEKB. Proceedings of IPAC 2014, Dresden, Germany.
[3] Future Circular Collider Study. Volume 2: The Lepton Collider (FCC-ee). Conceptual Design Report. V0.20, 8 Nov, 2018

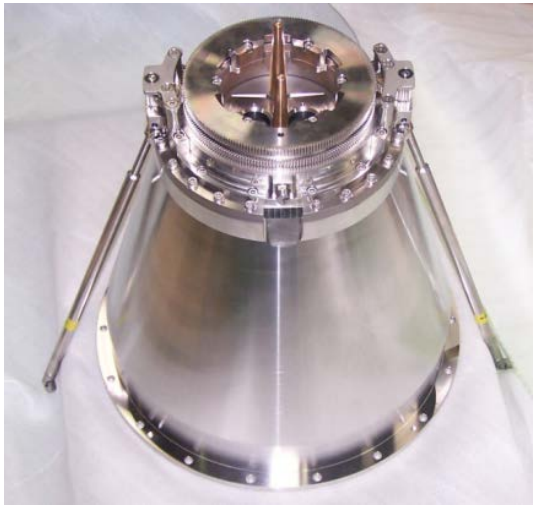
*: The distance needs to be discussed further. The current design is based on the shortest version.

Difficult question!

Remote vacuum connection methods

Difficulties	Limited operation space	Anti-radiation	High leak rate requirement	Special location
Solutions	Remote connection	All-metal sealing	Leak rate test	High safety and reliability

RVC similar to SuperKEKB as baseline, and studying other schemes at the same time.

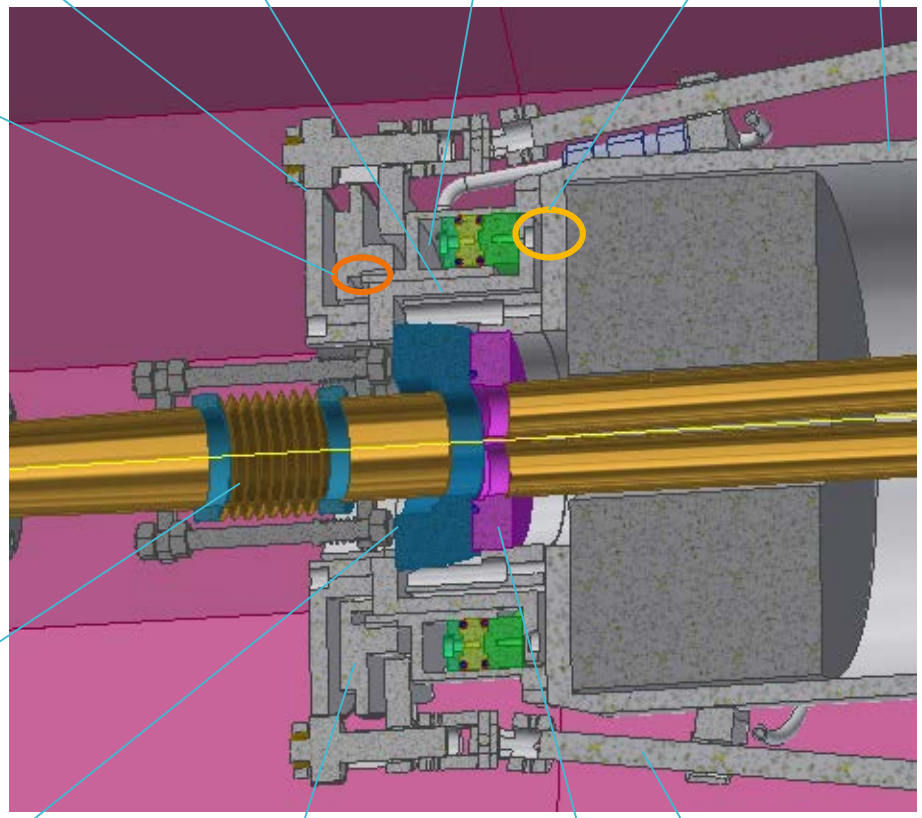


RVC of SuperKEKB

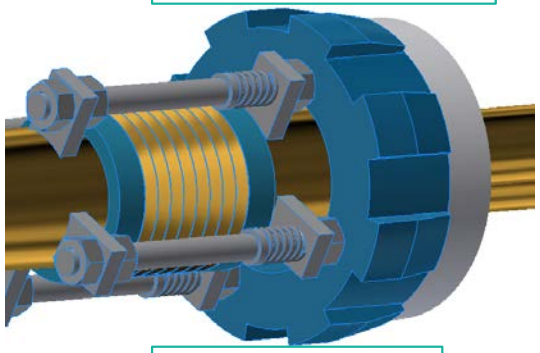
Ken-ichi Kanazawa, the 2019 international workshop on CEPC

Remote vacuum connection methods

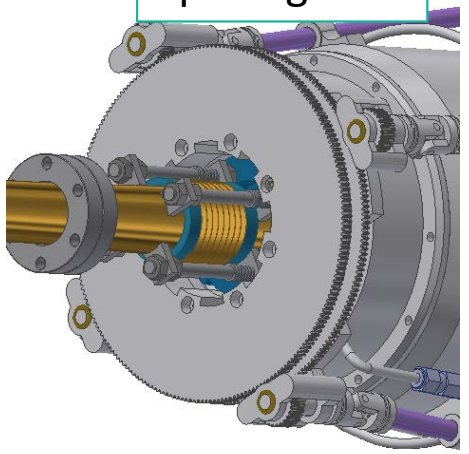
RVC Design



Spline flange



Spline gear



Dimensions:

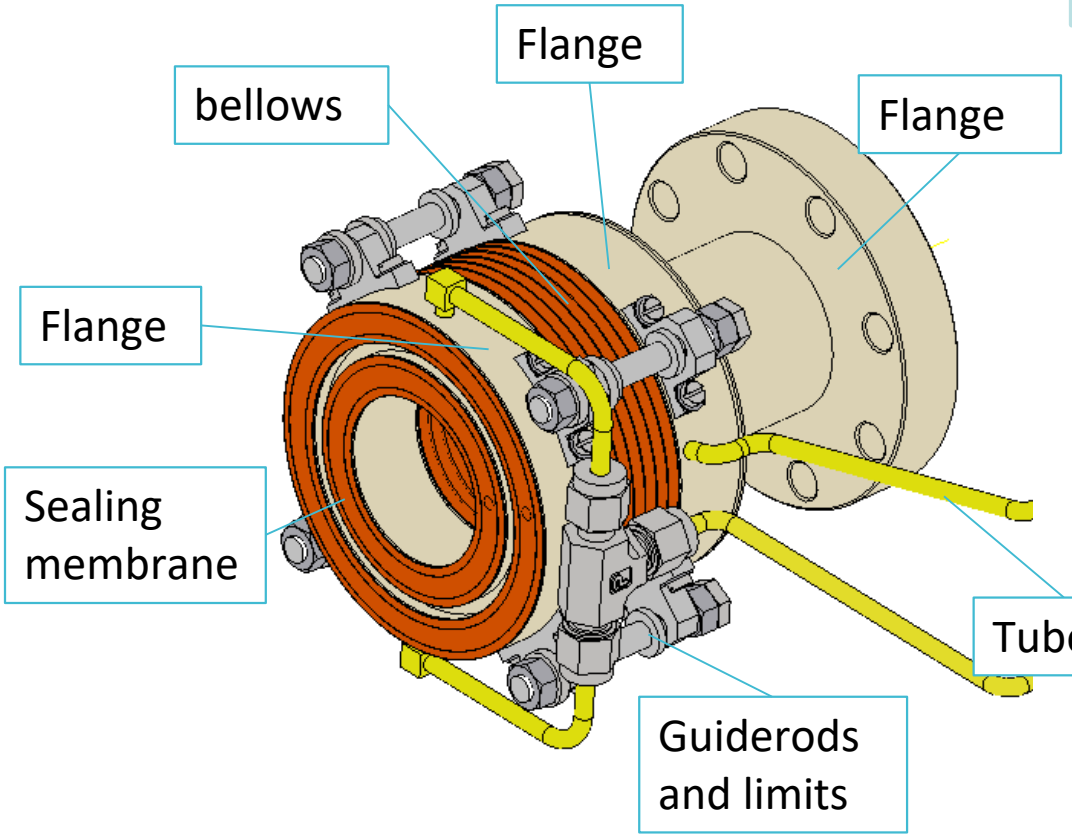
- Transversal: Max. ϕ264mm
- Longitudinal: ~223mm

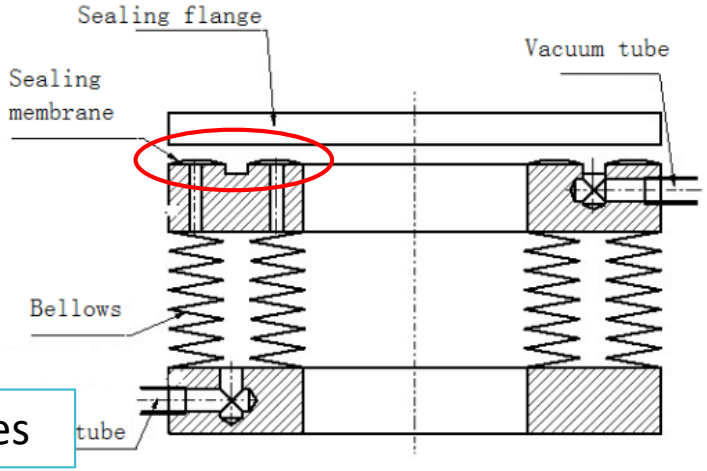
** Cooperate with Shenyang Huiyu vacuum technics co., Ltd.*

Remote vacuum connection methods

Inflatable seal design

- Experience from CSNS: leak rate ~10-7 Pa.m3/s level, four levels higher then CEPC requirement.





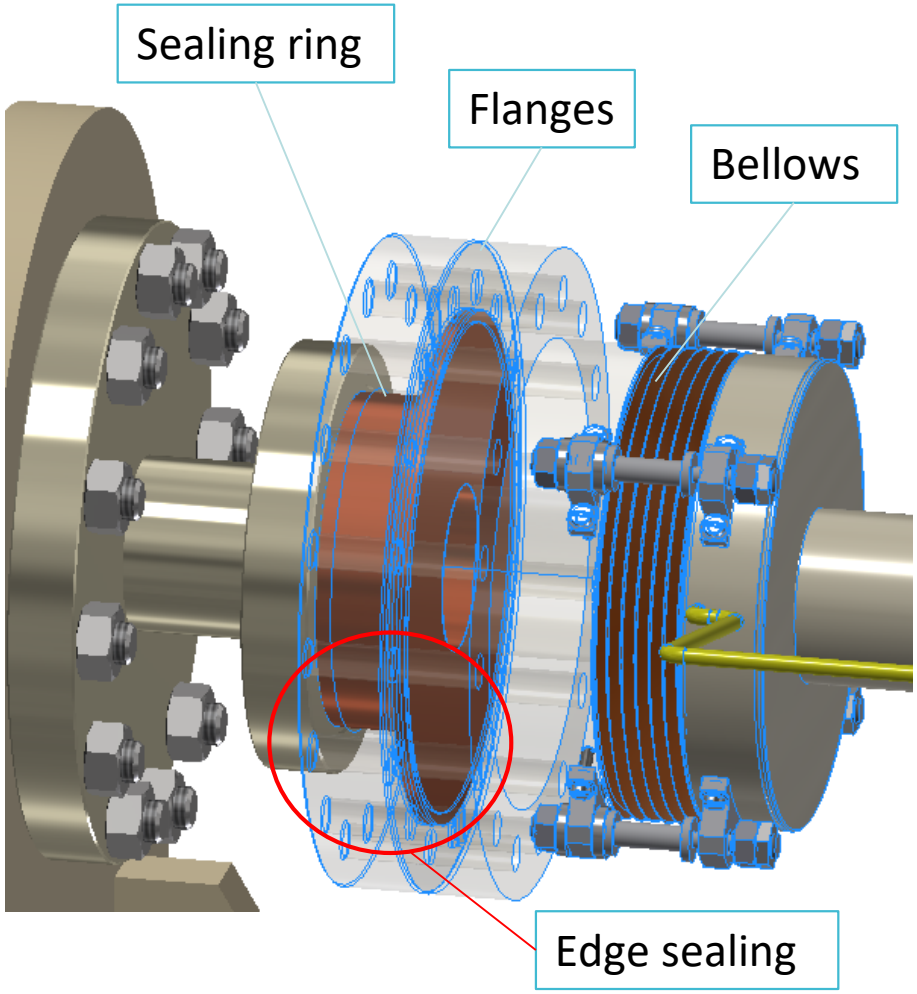
Dimensions:

- Transversal: Max. ϕ112mm
- Longitudinal: ~120mm

Remote vacuum connection methods

Inflatable seal design

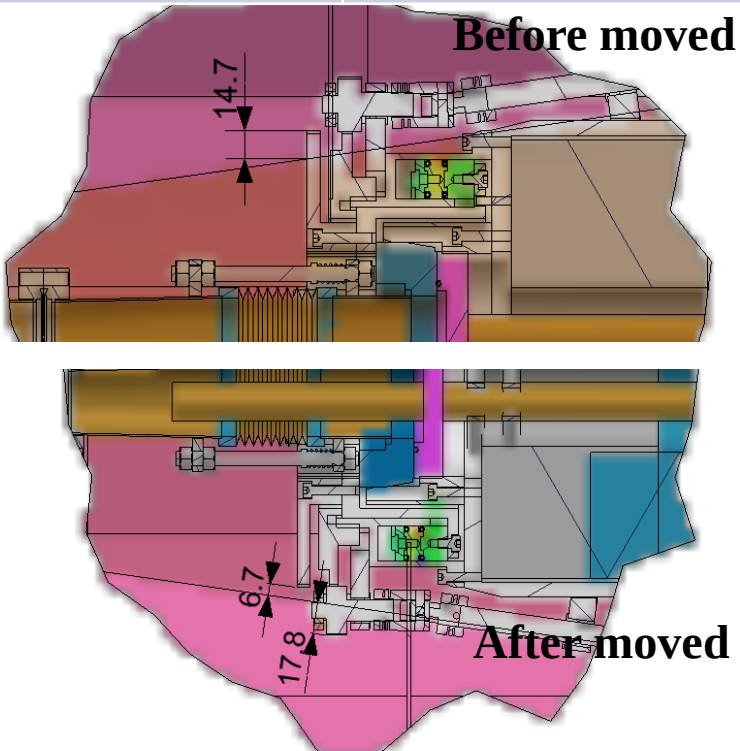
- Improved methods
  - Precision machining of sealing membrane and flange.
  - Different materials of sealing membrane and flange.
  - Using edge sealing instead of membrane sealing.
  - …



Remote vacuum connection methods

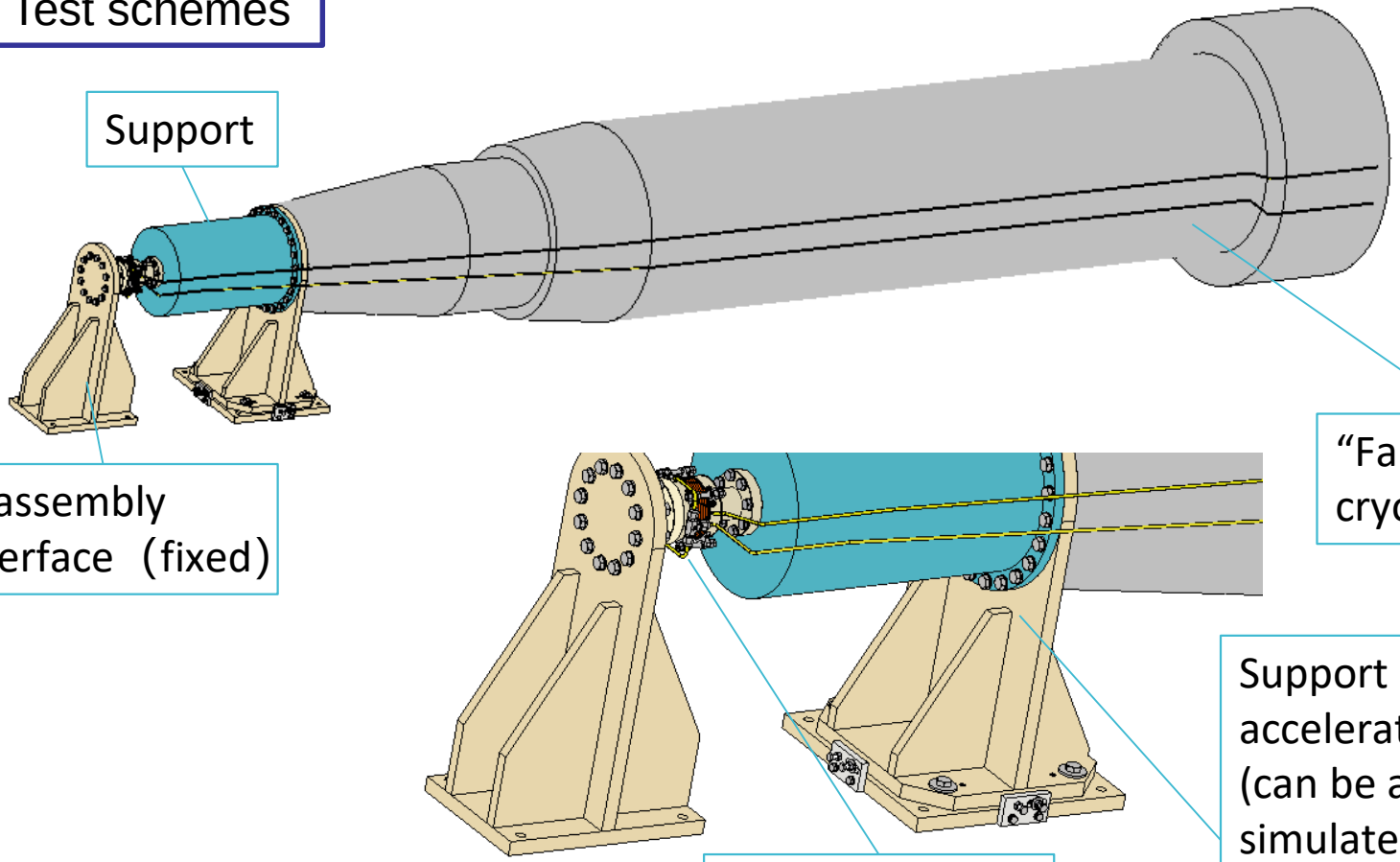
	RVC	Inflatable seal	Long tools
Sealing methods	Pneumatic clamping with auxiliary locking	Pneumatic clamping	Screws clamping using long tools
Advantages	Successful experience from SuperKEKB	Successful experience from CSNS; Small and simple; Bellows at accelerator side	Simple and small
Disadvantages	Big and complex; Bellows at IP chamber side	Difficult for leak rate requirement	Difficult in operation

- The bellows of all methods have RF fingers.
- Physics requirements: all accelerator devices are within acos0.99.
- RVC design exceeds the boundary.
- New consideration is that main body of Lumical move to IP assembly, thus the space is better.



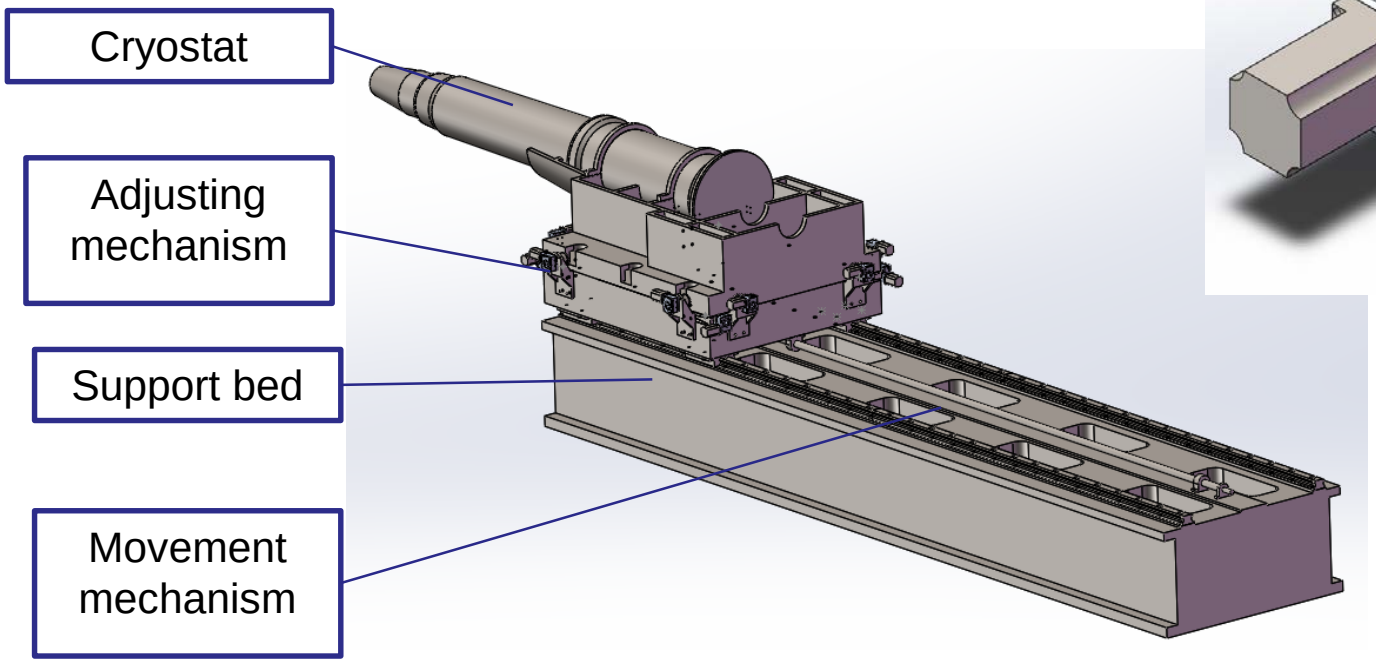
Remote vacuum connection methods

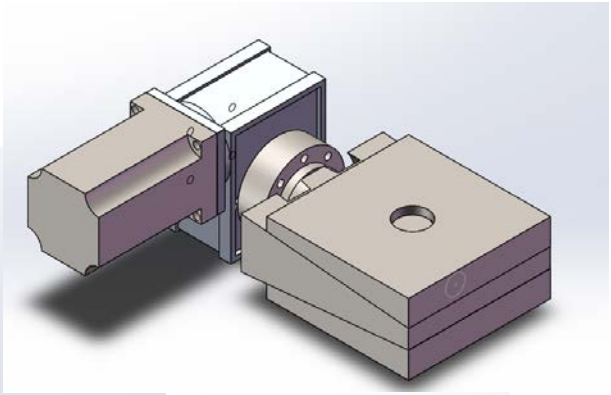
Test schemes

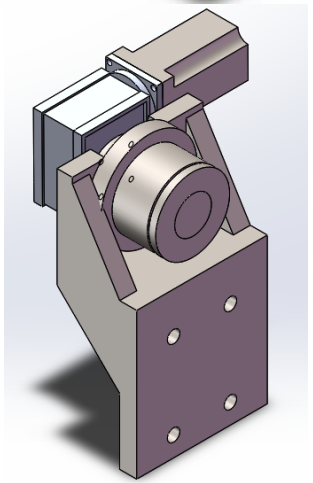


Support system of SC magnets

- Support system of SC magnets
  - The alignment accuracy of SC magnets: ≤30 μm, at least ≤50 μm.
  - Movement mechanism: high precision track & rack.
  - Adjusting mechanism: motor driven wedges jacks for vertical direction, motor driven screw jacks

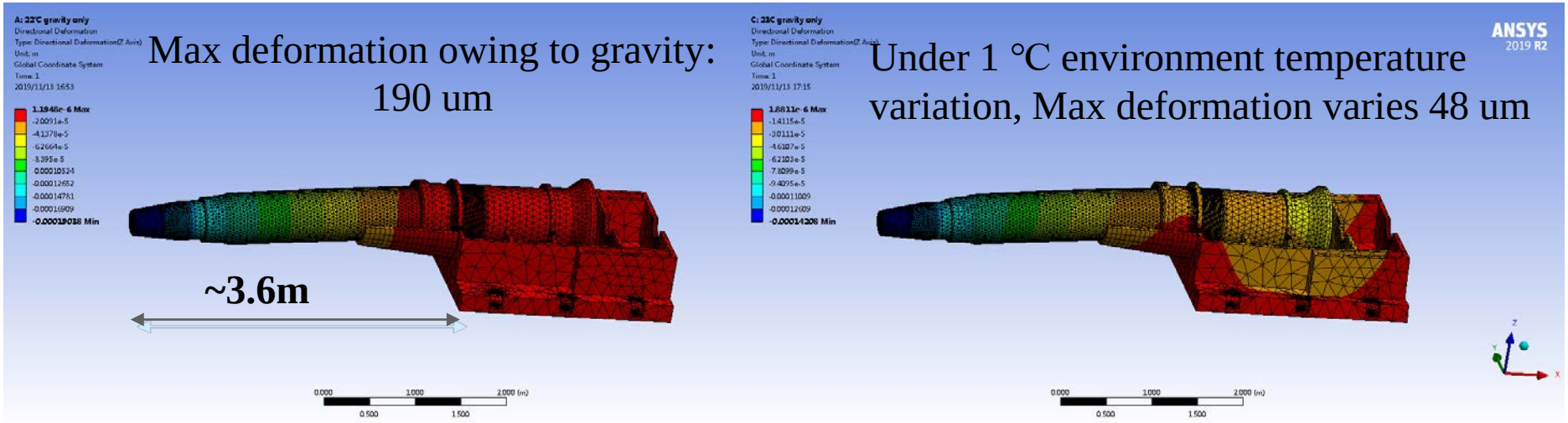






** Cooperate with Beijing Institute of Space Mechatronics*

Support system of SC magnets



- The current design of cryostat is 5 meters long with18 mm thick stainless walls. The weight of the cryostat is about 2 tons.
- Only the cryostat itself is considered in the calculation above.
- If the yoke length gets larger, the deformation will be even larger, which is proportional to the 4^{th} power of length.
- If the weight of components inside the cryostat and the magnetic field forces are considered, the deformation will be much larger.

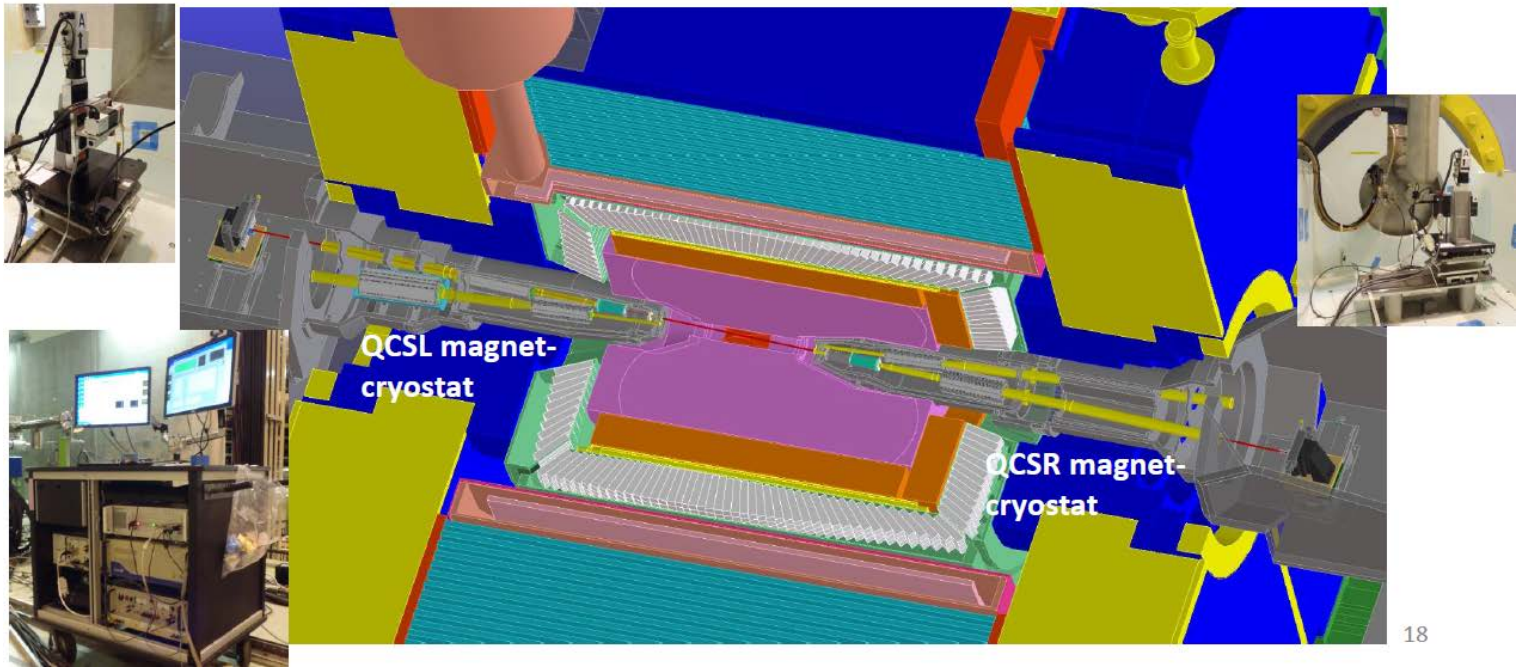
No clear solution right now!

- Sensors will be used for deformation monitoring.
- We are considering to pre-align the SC magnets to “certain location” to compensate the effect of loads. It may work, but needs complex stiffness design and has risk, especially for the stability and repeatability.
- The magnetic field forces in Z, H, and W operations are different. The pre-alignment should fulfill all the cases.
- The design will be adjusted with detector design, dynamic design and alignment design.
- We will learn the successful experience from other facilities.

SSW measurement

SSW measurement system in the IR

- Two magnet-cryostats of QCSL/R were aligned to the beam lines with the targets of the cryostats.
- A BeCu single wire of ϕ0.1 mm, which was aligned to the design beam line, was stretched through QCSR and QCSL cryostat bores.
- The measurements were performed with operating the Belle SC solenoid at 1.5 T, and ESL and ESR1 solenoids.
  - The measured data include the displacement by the electro-magnetic forces between solenoids and magnetic components in the cryostats.



N. Ohuchi, IPAC2018

SSW measurement summary

- Measured magnetic center shifts to the design values and field angles to the horizontal planes of the 8 main quadrupoles as follows:

	QC1LP	QC2LP	QC1RP	QC2RP
Δx, mm	0.01	-0.34	0.68	0.49
Δy, mm	-0.21	-0.69	-0.30	0.04
$\Delta\theta$, mrad	-1.67	-4.05	2.02	-1.73

	QC1LE	QC2LE	QC1RE	QC2RE
Δx, mm	-0.21	0.13	0.25	0.08
Δy, mm	-0.29	-0.54	-0.37	-0.58
$\Delta\theta$, mrad	-1.60	-1.54	-0.14	-0.73

- Every alignment errors are able to be corrected by the corrector magnets.

N. Ohuchi, IPAC2018

Lists to be done for the MDI mechanics

- We have done some preliminary design of the layout, installation scenario and the support system of cryostat, as well as some vacuum connection methods. We will do:
  - 3D layout of all the components of accelerator, find and solve the space problems.
  - More detailed design of the connection methods and the prototype developing.
  - Detailed analyses of the cryostat & support assembly, including the deformation and vibration, considering gravity, temperature, magnetic field force.
  - The vacuum tubes and cooling methods.
  - Integration of accelerator and detector, and the installation and replacement scenarios.

Thanks for your attention!