Clean assembly of the warm section and cryo-module in the RAON accelerator tunnel

Jangwon Kwon

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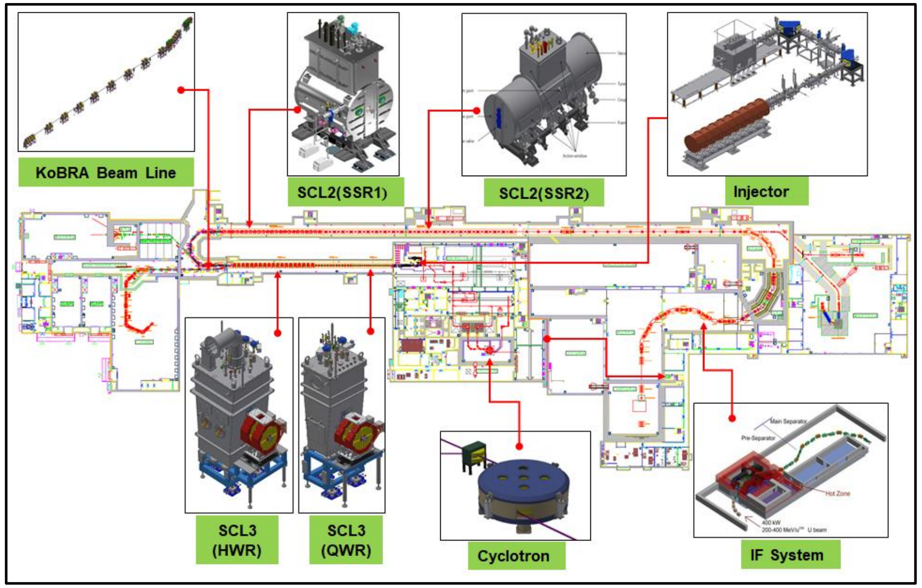
Institute for Rare Isotope Science

RAON Accelerator

- Cavity and cryomodule



RAON acclerator

QWR

HWR

SSR1

SSR2

EM Parameter of QWR and HWR

	QWR	HWR
β_{opt}	0.047	0.12
f [MHz]	81.25	162.5
L_{eff}	173.5	221.5
R/Q [Ω]	469	295
E_p/E_{acc}	5.7	5.2
B_p/E_{acc} [mT/(MV/m)^2]	10.4	9
E_{acc} [MV/m]	6.1	6.6
V_{acc} [MV]	1.06	1.46
QR_s	18.1	36.8

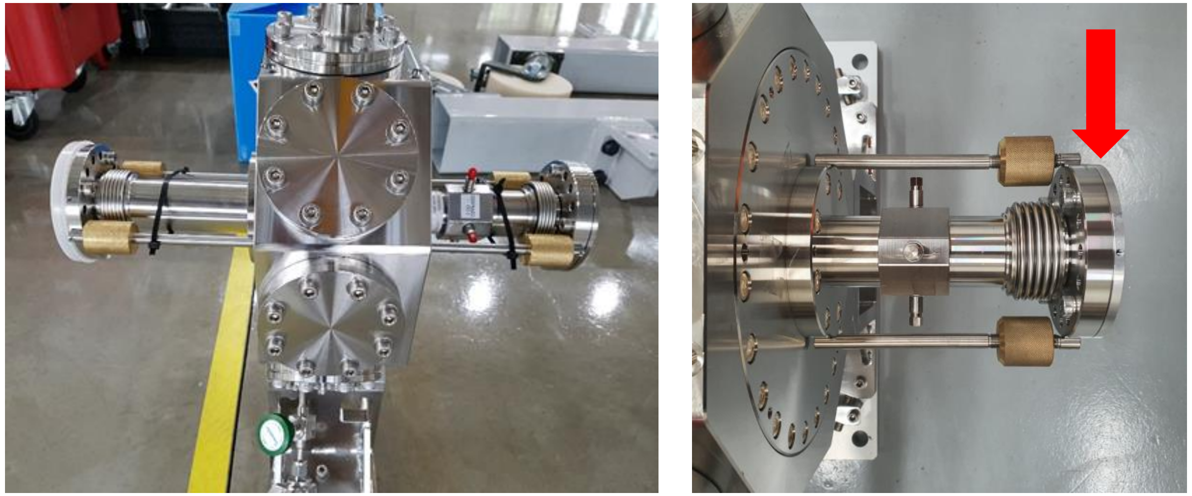
	Cavity	# of cav.	# of CM	Cav. Op. T (K)
SCL3	**QWR**	1	**22**	4.5
	HWR	A-2	**13**+2	2.05
		B-4	**19**	2.05
SCL2	SSR1	3	23	2.05
	SSR2	6	23+2	2.05

RAON Accelerator

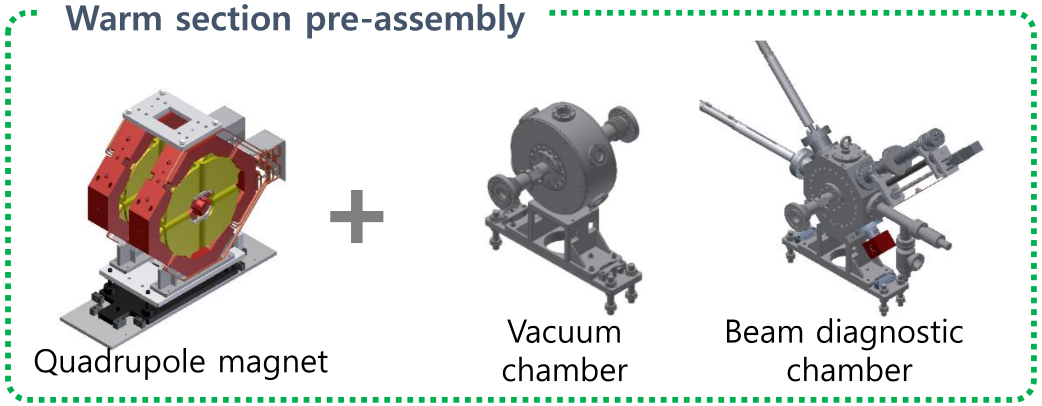
- Warm section with Quadrupole Doublet
  - 1 chamber (beam diagnostic device as option)
  - 1 BPM, 1 BLC(36 mm Nb Ring), 1 Beam Pipe

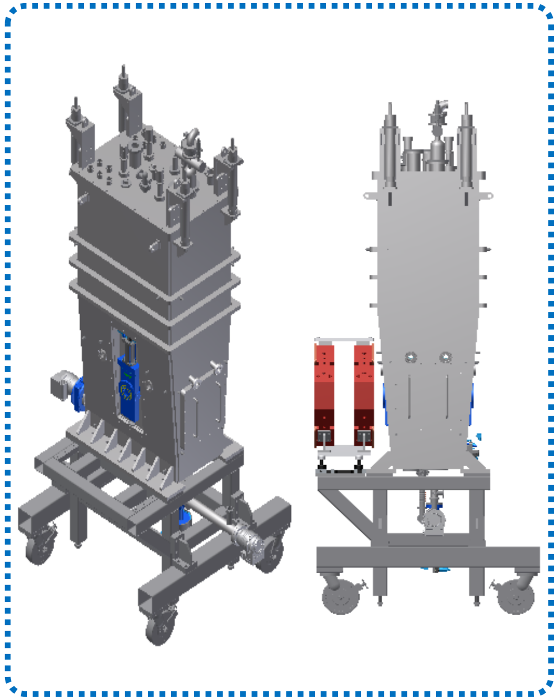
  - Assembly at class 10 clean room

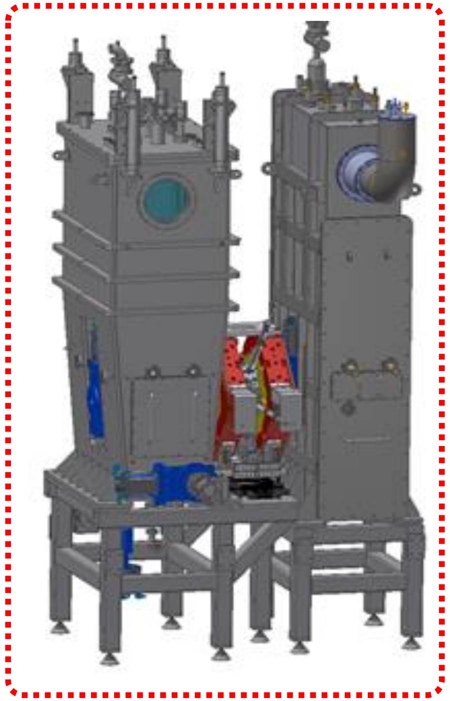
  - Length adjuster for shrinking and expanding
  - 6 mm thickness plate with 23 mm cut bolt



<u>Clean Assembled chamber for SCL3</u>



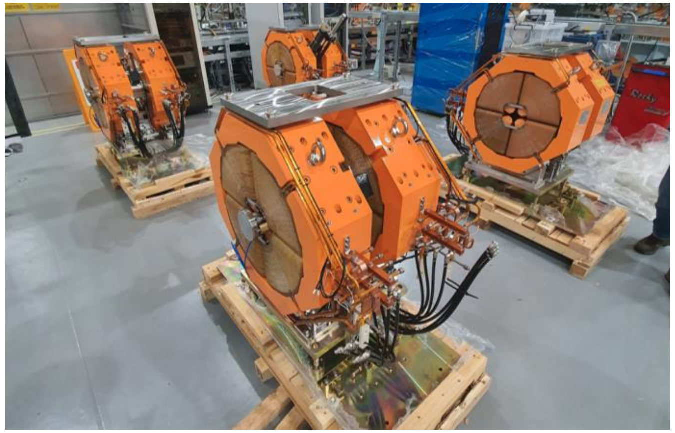




Installation of cryomodule

① SRF building → ISOL loading area

② Magnet top-bottom separation/height adjustment



③ Magnet + vacuum(beam diagnostic) chamber assembly/alignment

④ Place the warm section on the cryomodule

⑤ Alignment between warm sections and cryomodule

⑥ Moving CM into the tunnel, then install it

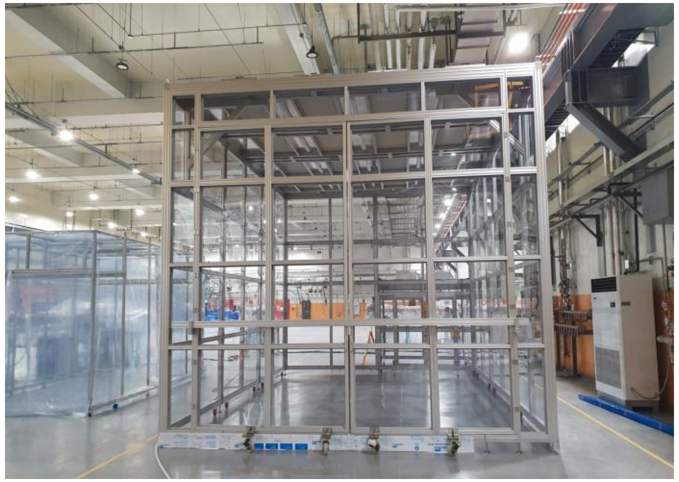
Clean booth

- 1st version of clean booth at injector section
  - **Assemble BPM side to CM gate valve**

  - Big scale of clean booth
  - House 2 CMs in the booth

  - 😢 It took so long time to satisfy assembly condition
  - 😢 It must be moved for ECR installation






Clean booth

- 2nd version of clean booth at the SCL3 tunnel
  - **Assemble Beam pipe to 'next' CM gate valve**
  - Big size
  - 😢 It cannot be left in the accelerator tunnel
  - 😢 There are contamination probability at a gap between booth-CM
    : near the gate valve is complex
  - 😢 Long support wheels underneath the CM
    : lots of interference, especially moving in the tunnel

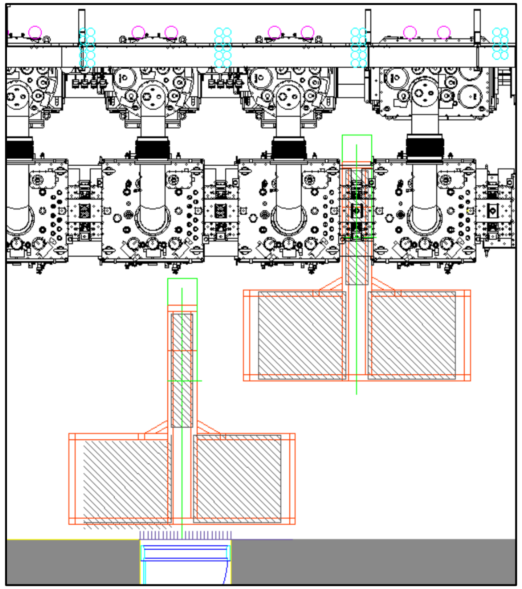
4.2m height
Over the cryomodule

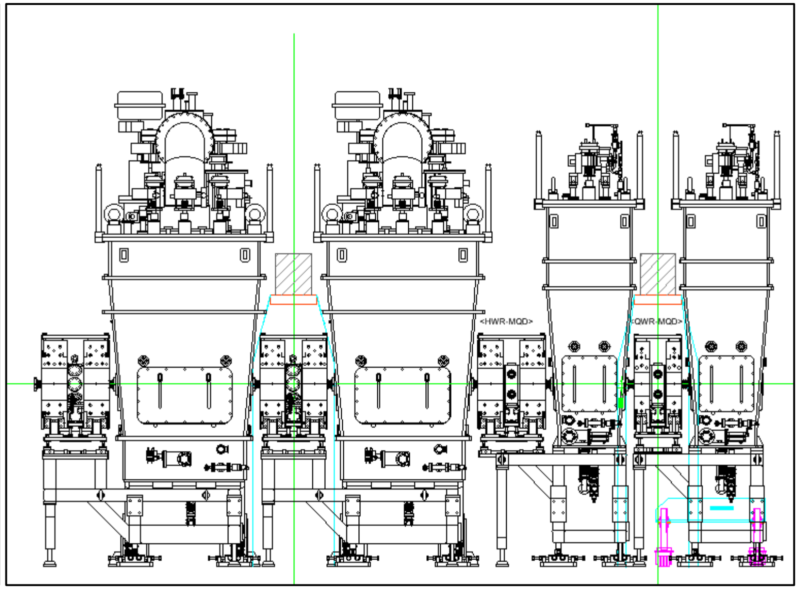
Clean booth

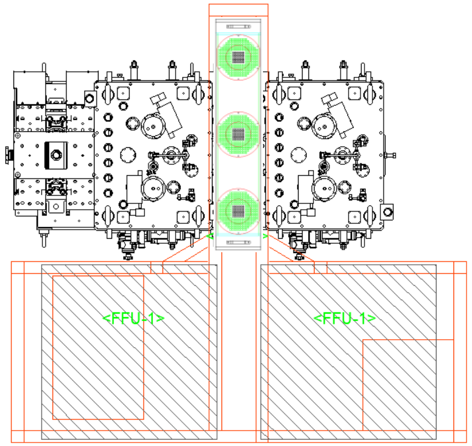
- 3^{rd} (current) version of clean booth
  - HEPA FILTER
    - 2 * 1172-1172-200H
    - 1 * 350-1000-200H (**3 fans**)

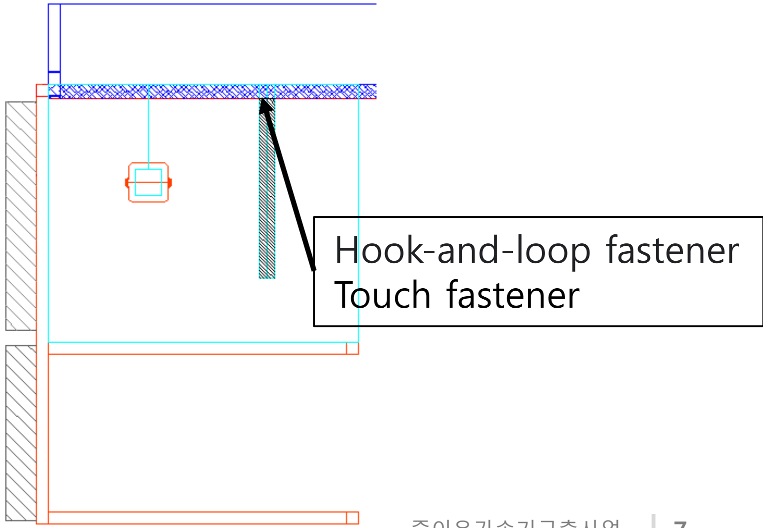
  - Length 2900 mm (expandable 3430 mm)
    - The width of entrance 3000 from injector section
  - Width : 3000 mm
  - **Antistatic PVC** sheet around the booth

  - ☺ Easy to move around & out of tunnel
  - ☺ No support bar (CM side) required
    : Fits all (QWR, HWR-A, HWR-B)



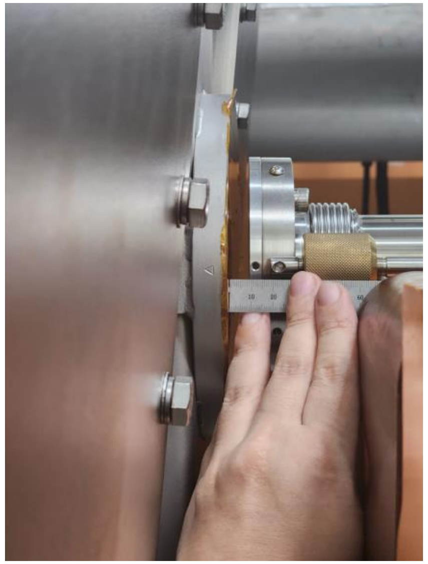






Clean booth

- 3rd (current) version of clean booth
  - ☺ **Assembly the both sides, BPM & Beam pipe**
  - Compact size (2.2 m height)
  - Vacuum Pumping cart can be easily moved in/out
  - ☺ Exposed area around CM gate valve is minimized
  - It takes less time to reach a clean assembly condition



<u>10 mm between assembly parts, working area less than 10 cm</u>

<u>Making plane using split Board</u>

<u>2.2m height</u>
Between the cryomodule

Installation of clean booth

- Clean Booth installation procedure
  - Blow compressed air into the warm section.
  - Wipe down the warm section with a wet wiper
  - Bolting the board to the CM gate value

  - Clean booth is placed between CMs
  - Turn on the fans (HEPA filters).
  - Attach the booth to the board.
  - Move the vacuum pumping cart into the booth.

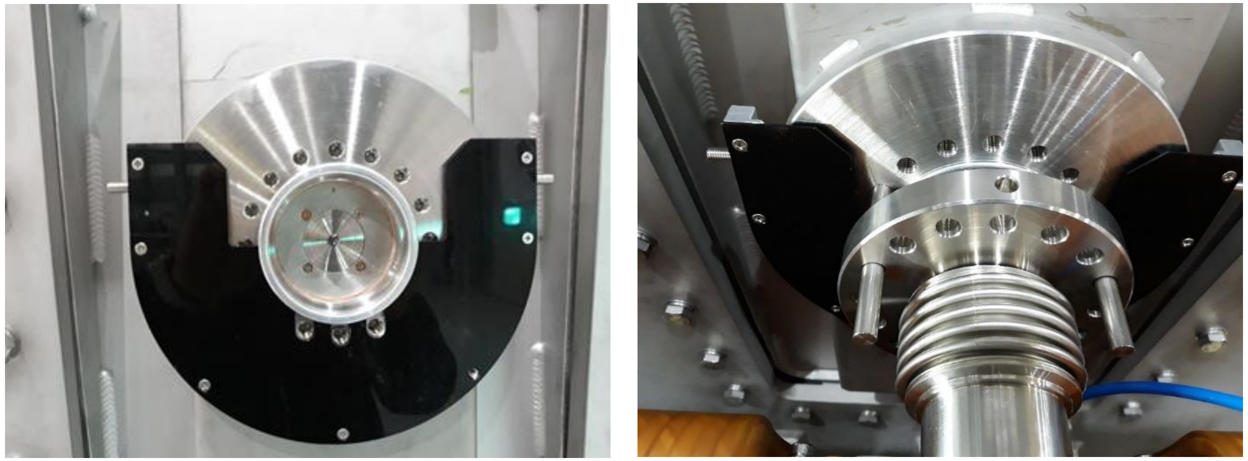
  - Clean Booth zip closure.
  - Blast compressed air into the warm section.
  - Wiping down the clean booth, warm section, floor and pumping cart with a wet wiper
  - Wipe again with ethyl alcohol except the floor.

  - Particle counts around warm section and pumping cart.
  - Wait a few hours until it reaches to clean condition.

There is a person behind the module

Clean booth

- Tools for assembly

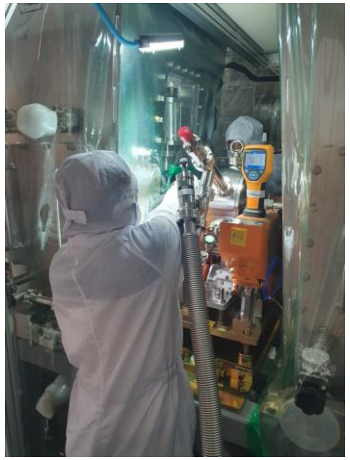


Helicoflex seal and seal guide

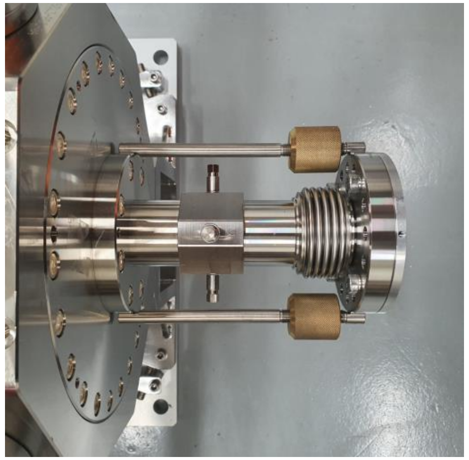
Torque wrench

purging line

Cloth and gloves



Particle counter



Length adjuster

Clean assembly

- Beamline assembly (Warm section to CM Gate valve) procedure
  - Wearing clean gowns and shoes.
  - Wiping down booths, chambers and tools with ethyl alcohol.
  - Nitrogen gas is sprayed on to the assembly area using an "ion gun."
  - Assemble angle value of vacuum pumping cart to chamber.
  - Open AV and pressurize with nitrogen gas to 1.05 bar slowly with mass flow controller.

  - Assemble as quickly as possible after particle inspection

  - Nitrogen gas is sprayed onto the assembly area using an "ion gun."
  - Approach towards the gate valve using an length adjuster.
  - Remove tape attached to CM gate valve
  - Remove bolts and plates (of Warm Section beam pipe).
  - Dropped the Vition O-ring with awl.
  - Preparation includes installation of seal (Helicoflex) using seal guide.
  - Attach the seal to the GV.
  - Use the length adjuster to bring the plate closer to the GV and seat the seal.
  - Tighten a few bolts by hand.
  - Remove Seal guide
  - Add more bolts, then remove the length adjuster.

From here N2 gas is purged out of the chamber.

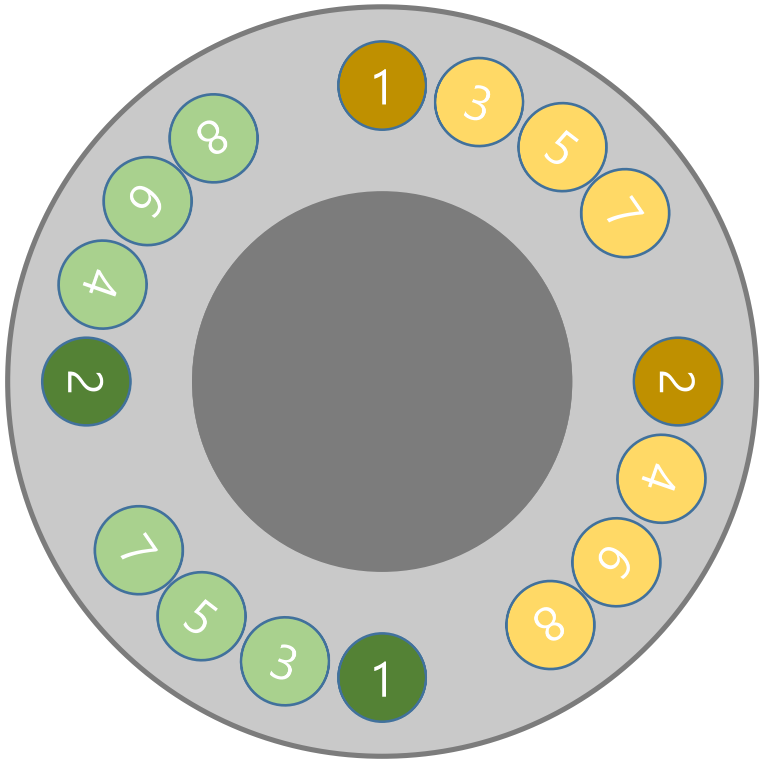
Clean assembly

- Tightening procedure
  - There are 16 M8 25 mm silver bolts.
  - Two workers use two torque wrenches to tighten opposite sides at the same time.

  - <u>If the bolt rotates even slightly when tightening, tighten it again with the same torque until it stops rotating.</u>

  - Torque strength start with $40\ kgf.cm$ (~15 times)
    "If pressure reach 1.05 bar Close the MFC "
  - $50\ kgf.cm$ (~7 times), $60\ kgf.cm$ (~2 times)
  - $70\ kgf.cm$ (1 time), $80\ kgf.cm$ (1 time)

  - $90\ kgf.cm$ (1+1 switching the torque wrench)



<u>Bolt for tightening flange</u>

Vacuum leak test

- After assembly ..
  - Vacuum the chamber slowly at 80 ccpm using MFC (takes about 5 hours).
  - Helium Leakage Test
  - SIP and NEG pump degassing & activation
  - Close and disassemble the angle valve
  - pumping cart out
  - clean booth out
  - Connect BPM cables
  - Install the top side of quadrupole magnet.
  - Connect remaining signal cables

Movable crane for lifting
the top side of quadrupole magnet

Conclusion

- A compact clean booth applicable to RAON's 3 different type modules has been developed.
- Using "Length adjuster" helps a lot; Chamber assembly, moving, assembly to CM
- An optimized helico-flex seal installation and assembly procedure was established.
- All of "warm section" and "module" of SCL3 successfully clean assembled.

- Lessons learned
  - Because the O-ring is installed on the pipe side and is removed using an awl, there is a risk of damage to the device.
  - If the O-ring is installed with a groove on the plate side, it will be easier to remove.

  - Concerns about "claustrophobia" among workers.
  - Consider enough passage to go the other side of module.