



# SSR1 Cryomodule String Assembly

Leonardo Ristori – on behalf of the SSR1 team

Slides by Mattia Parise

*International Workshop on Cryomodule Design and Standardization*

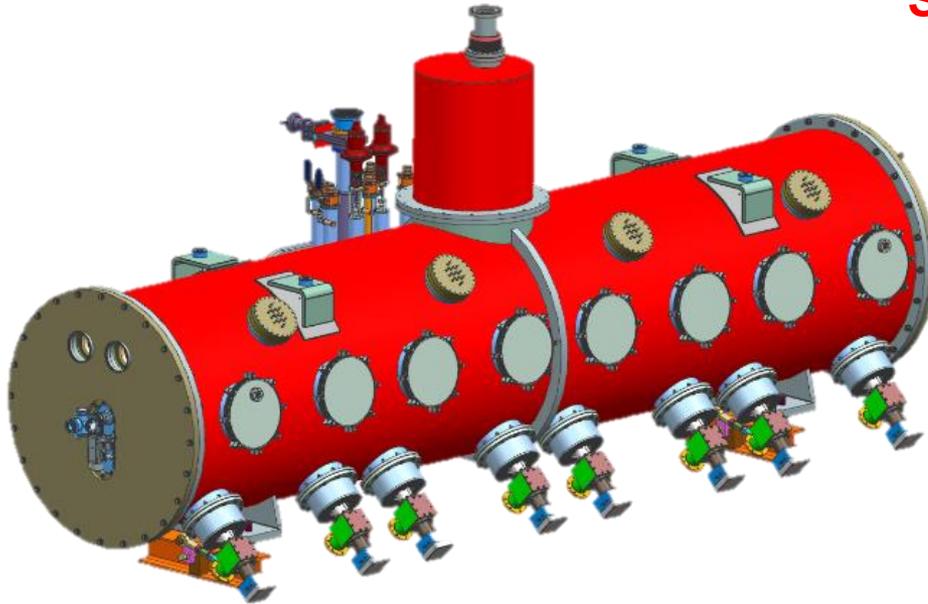
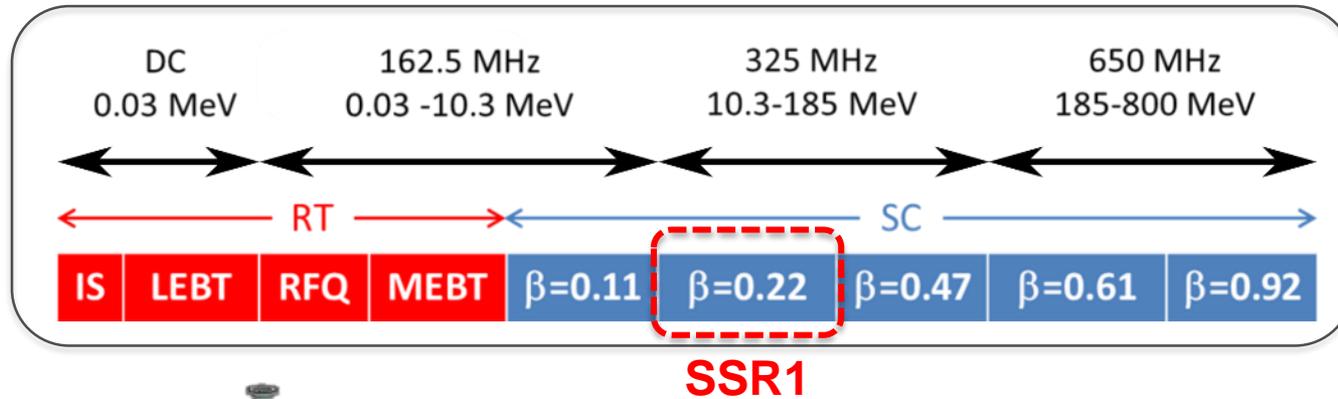
BARC, Mumbai 4-7 September 2018

# Outline

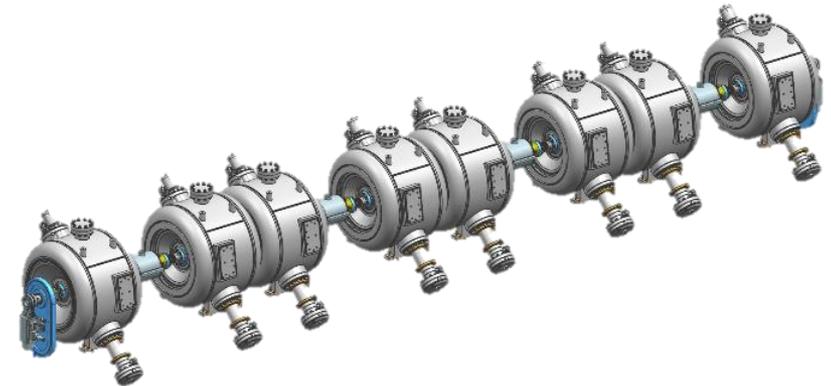
- String overview
- Rail system
- Beamline bellows
- Assembly of solenoid-BPM group
- Nitrogen purging studies
- Recent improvements

# SSR1 cryomodule for PIP-II

## PIP-II Linac



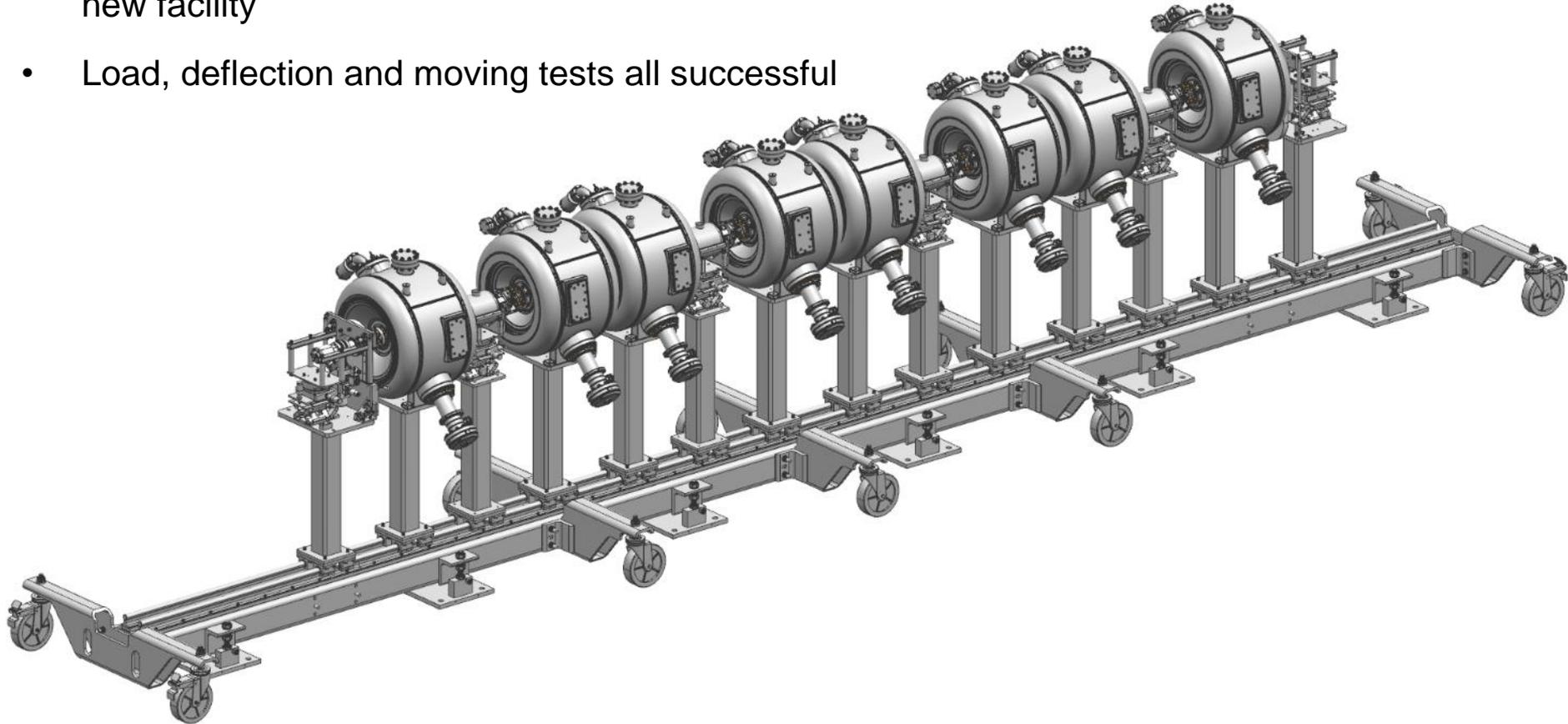
SSR1 cryomodule



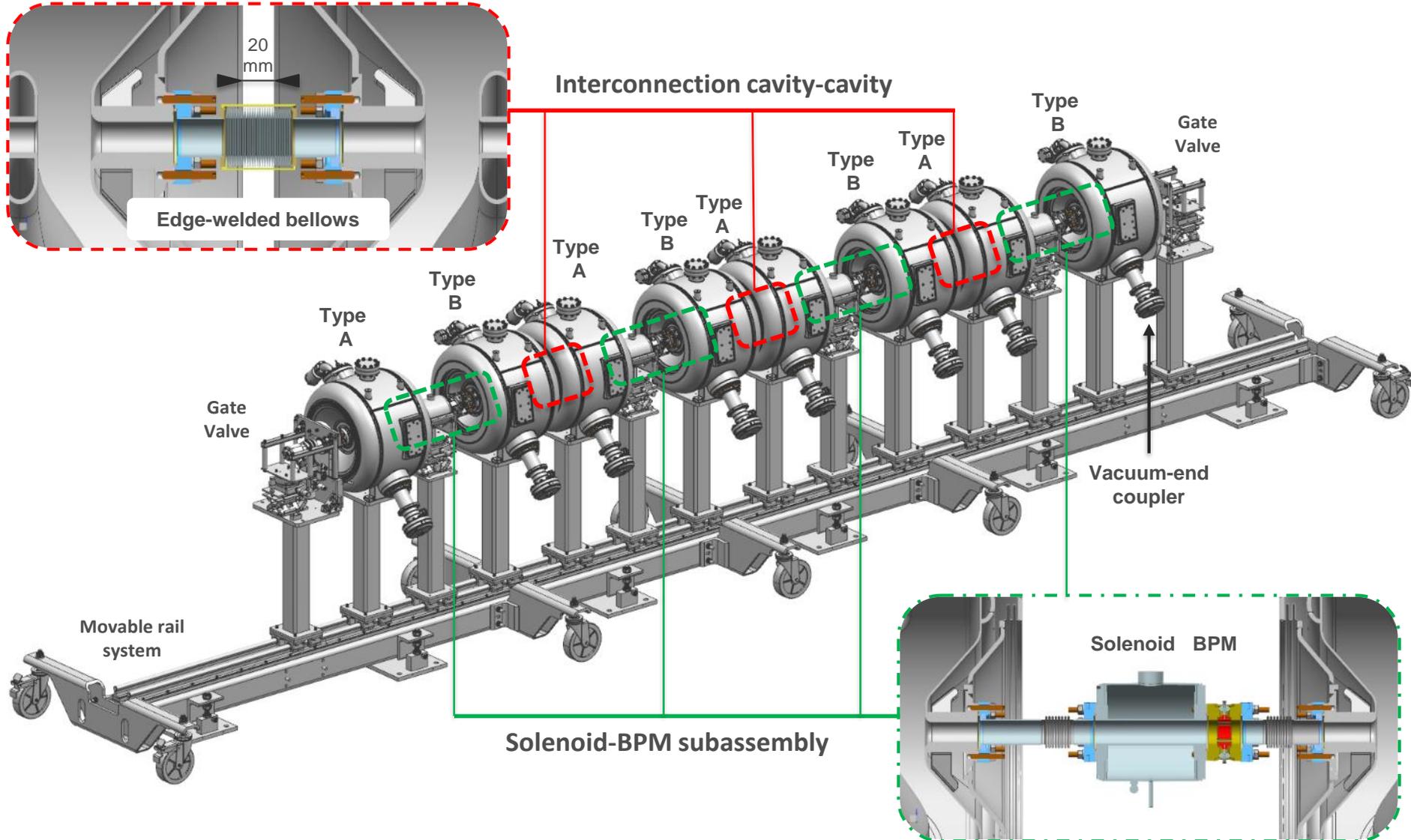
SSR1 cavity string

# SSR1 string overview – Rail system

- Completed string ready to roll out of cleanroom
- Rail system is new design adapted for SSR and new facility
- Load, deflection and moving tests all successful



# SSR1 string overview – Assembly oriented design

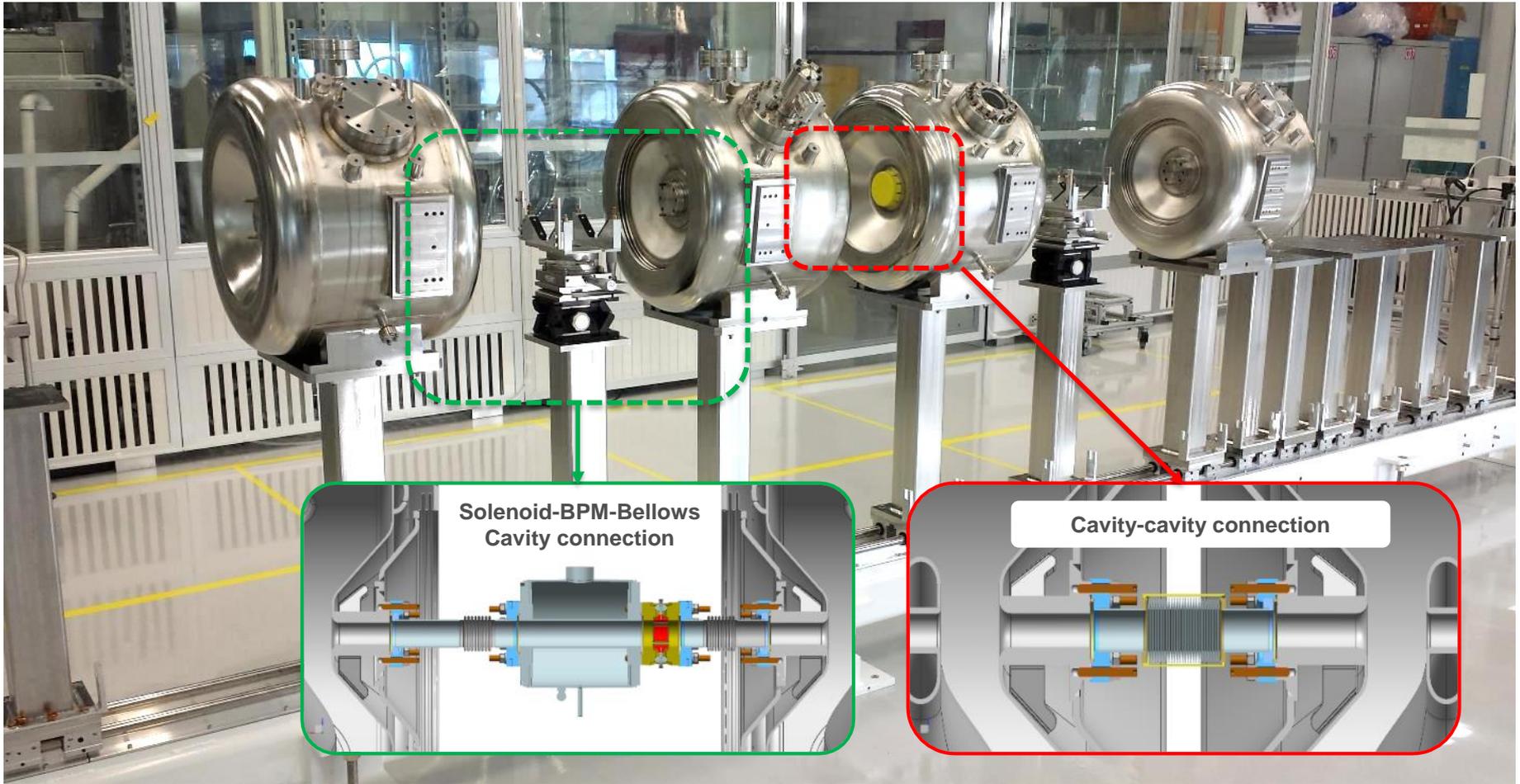


# SSR1 string assembly dry-run



- Dry-run of SSR1 string assembly is carried out on a half cavity string
- The goal is to assess the feasibility of a cleanroom-compatible assembly

# SSR1 string assembly dry-run



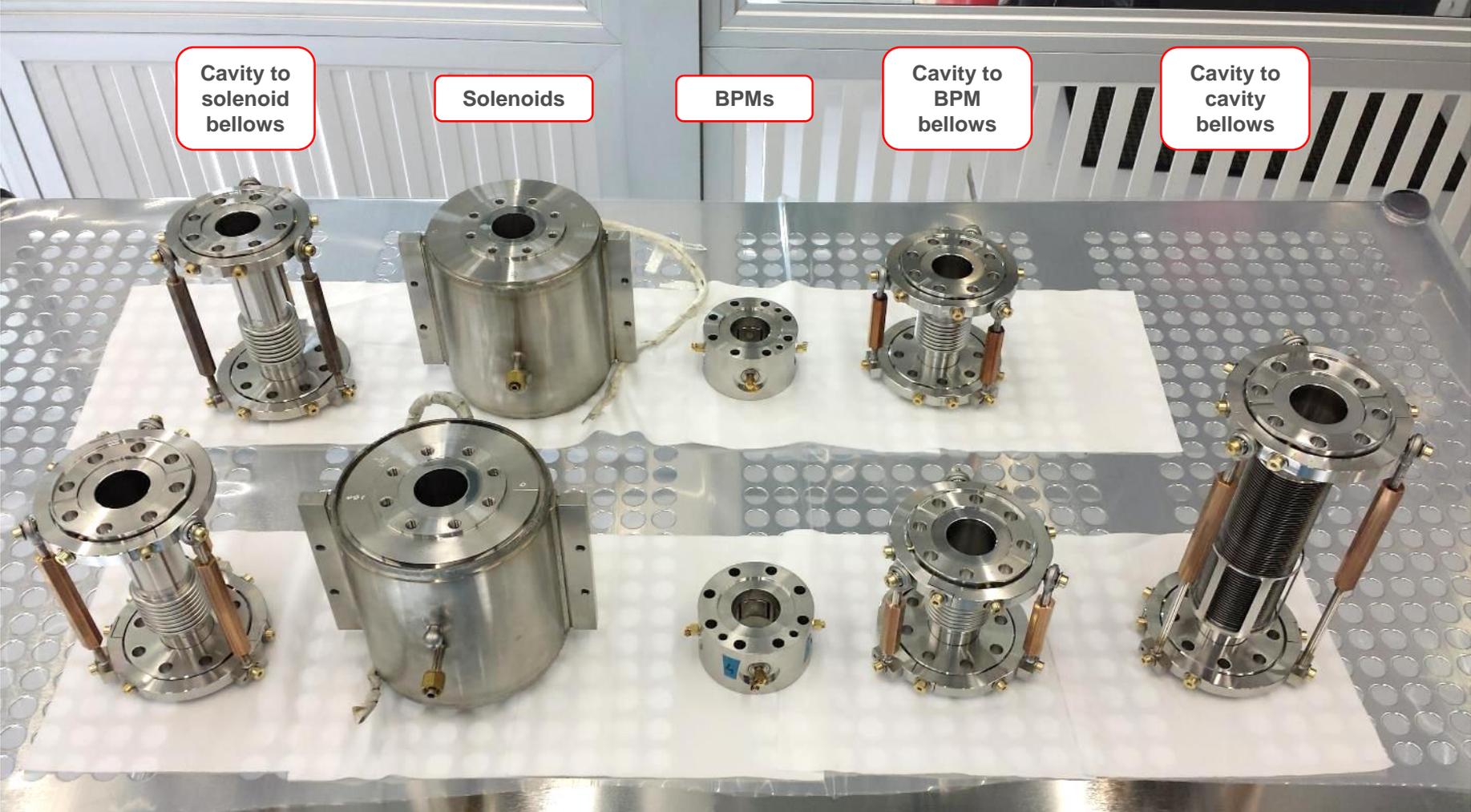
- Dry-run of SSR1 string assembly is carried out on a half cavity string
- The goal is to assess the feasibility of a cleanroom-compatible assembly

# SSR1 string assembly dry-run – Movable Rail System



- ✓ Rail system with string weight can be successfully moved to the desired location. The process has been repeated 5 times and final position can be achieved with an uncertainty of  $\sim 5$  mm

# SSR1 string assembly dry-run



# Edge welded bellows particle counts

- Edge welded bellows was cleaned and brought inside class 10 cleanroom:
  - 30 min Liquinox (1%) + DI water ultrasonic cleaning at 50 °F
  - 30 min Citranox (2%) + DI water ultrasonic cleaning at 50 °F
  - 30 min DI water ultrasonic cleaning at 50 °F
  - Handheld HPR
- Particle counts of the nitrogen dried bellows approach 0 particles > 0.3  $\mu\text{m}$  in less than 1 minute

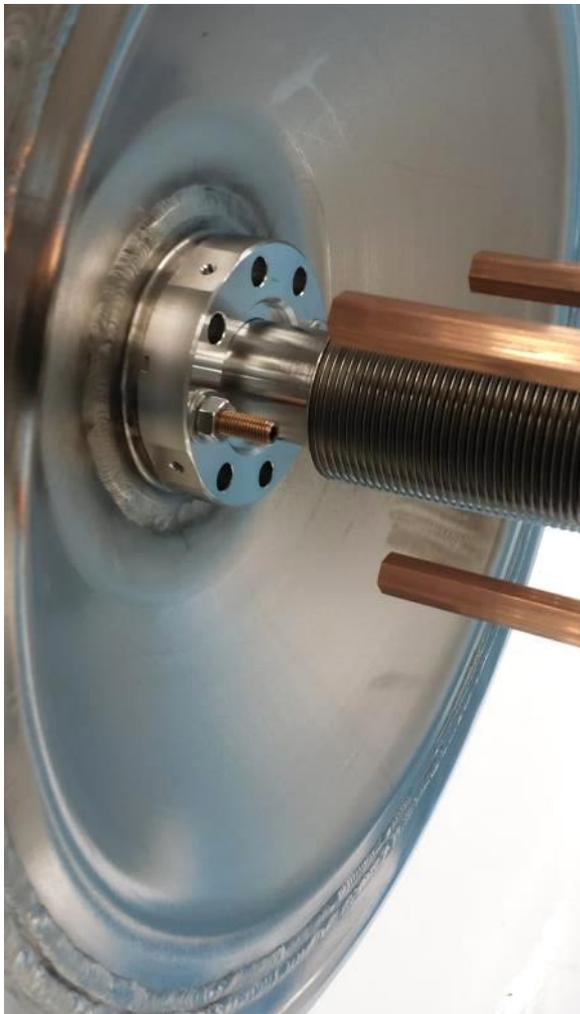
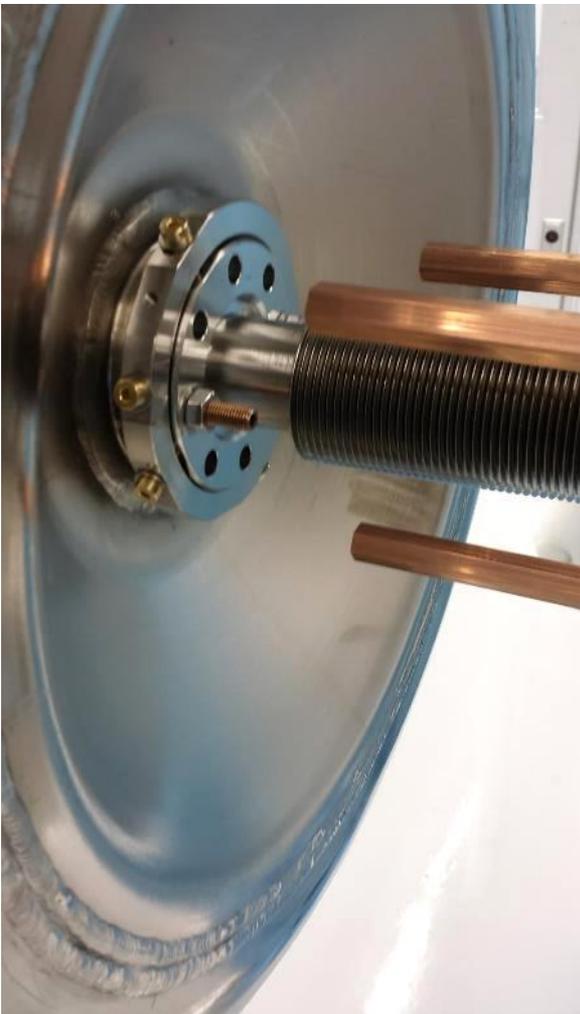
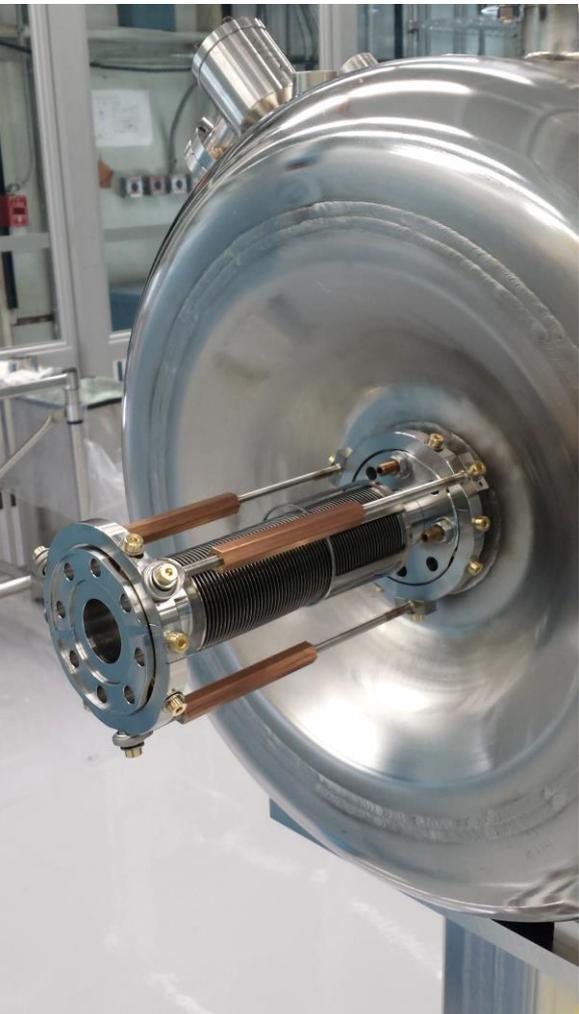


3 cycles compression and extension (10 liters sample)			
Time [s]	> 0.3 $\mu\text{m}$	> 0.5 $\mu\text{m}$	> 1 $\mu\text{m}$
7	2	0	0
14	2	1	0
21	3	1	0
28	1	0	0
35	3	0	0
42	1	0	0
49	1	0	0
56	1	0	0
63	1	0	0
70	1	0	0
77	1	0	0
84	0	0	0
91	2	1	0

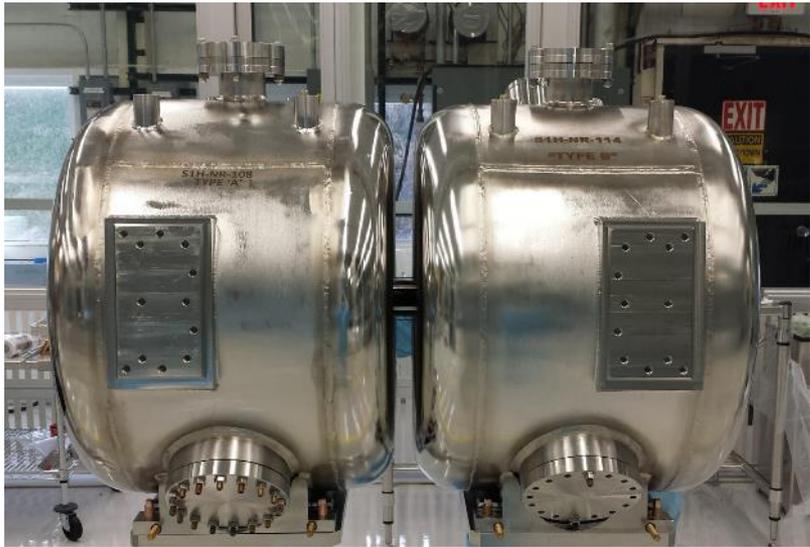
✓ Particle counts during contraction are acceptable

# SSR1 string assembly dry-run

Bellows cage is disassembled once the cavity-cavity connection is completed



# SSR1 string assembly dry-run



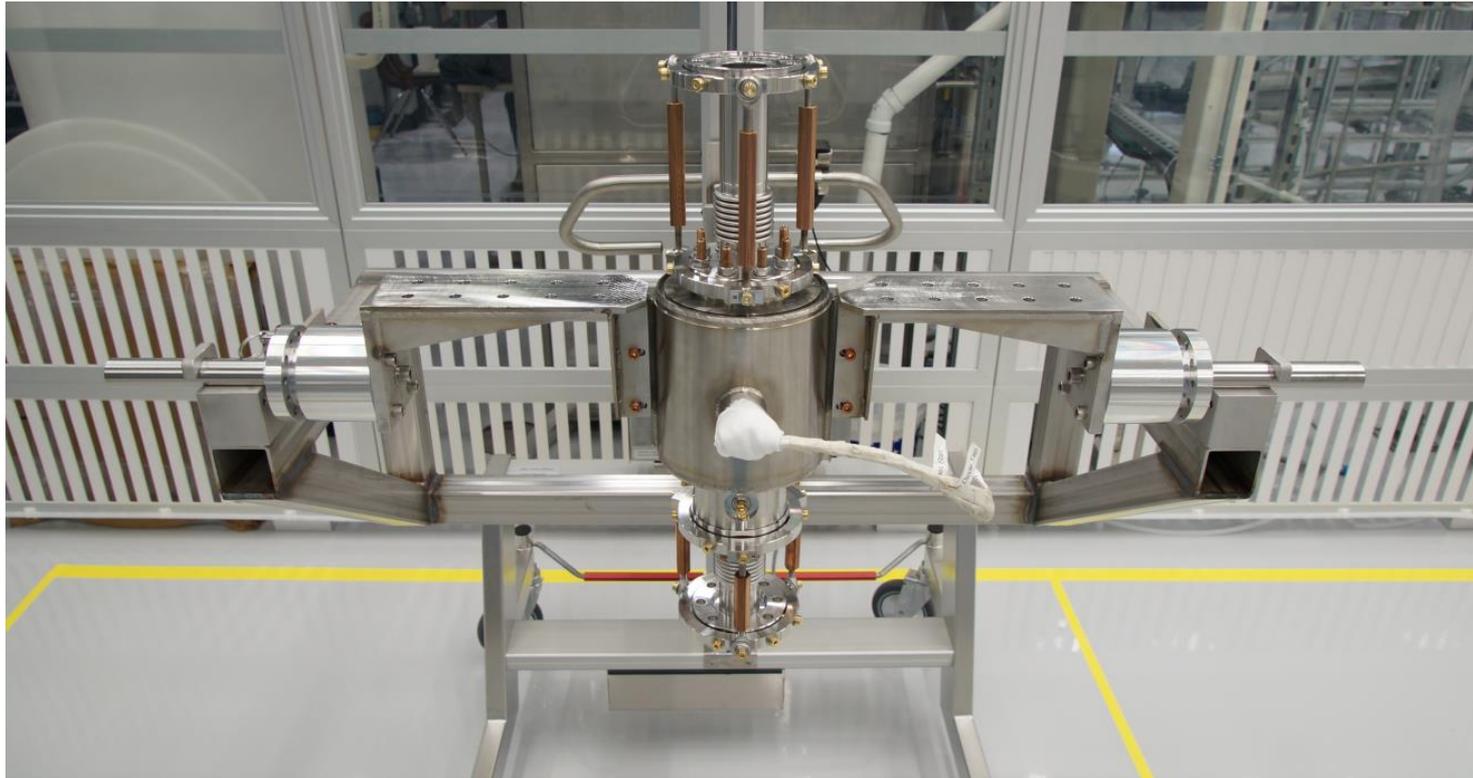
✓ Edge welded bellows can be successfully assembled and bellows cage can be removed

# SSR1 string assembly dry-run



- ✓ Bellows cages provides 2 rotational degrees of freedom at the end flange
- ✓ Can be splitted in 2 halves so that can be removed prior cryomodule assembly

# Solenoid-BPM Group

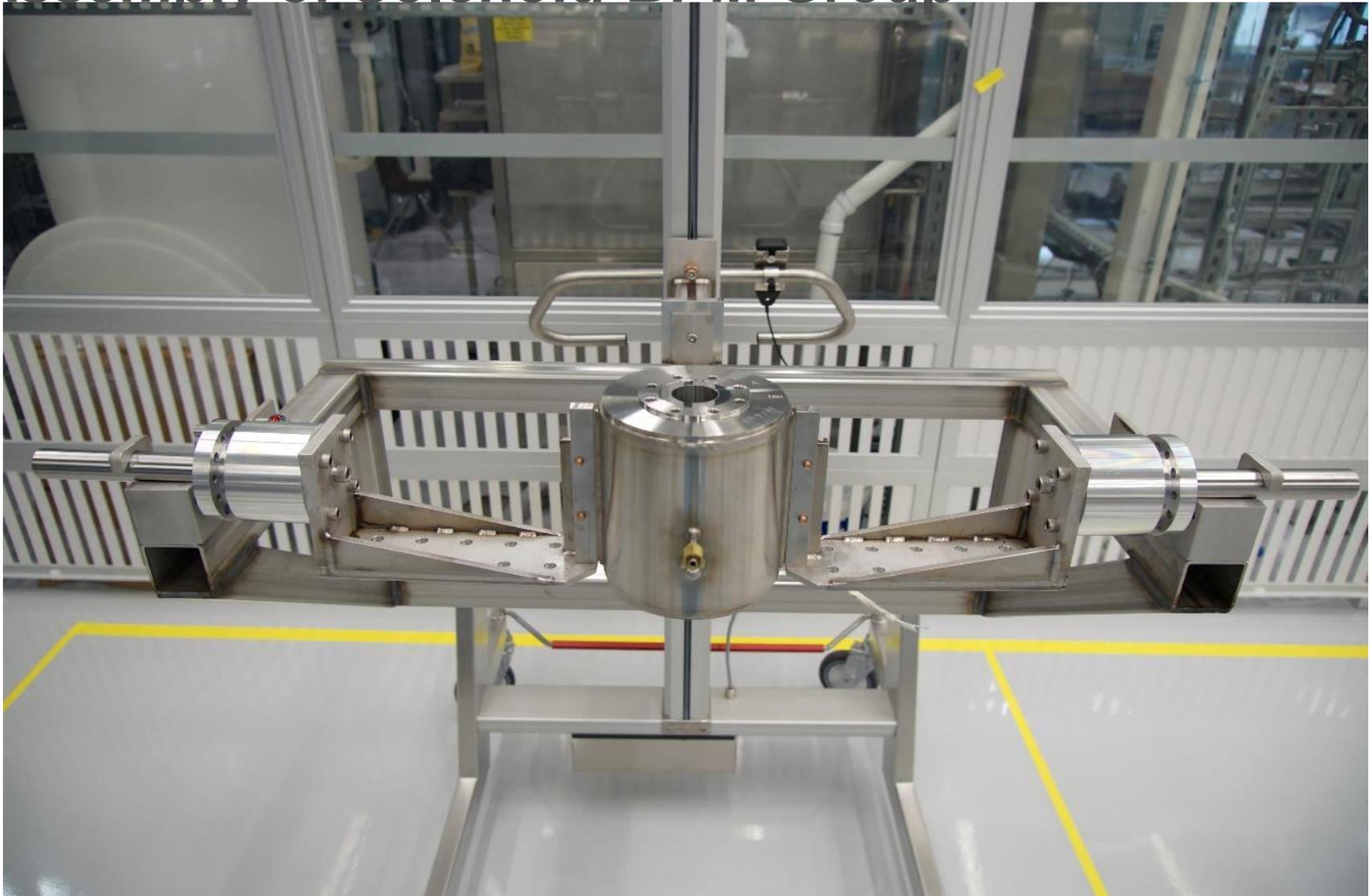


- ✓ Vertical assembly facilitates handling of components
- ✓ Sub-assembly can rotate 360 degrees for an easy assembly
- ✓ The movable cart allows easy handling of the heavy sub-assembly

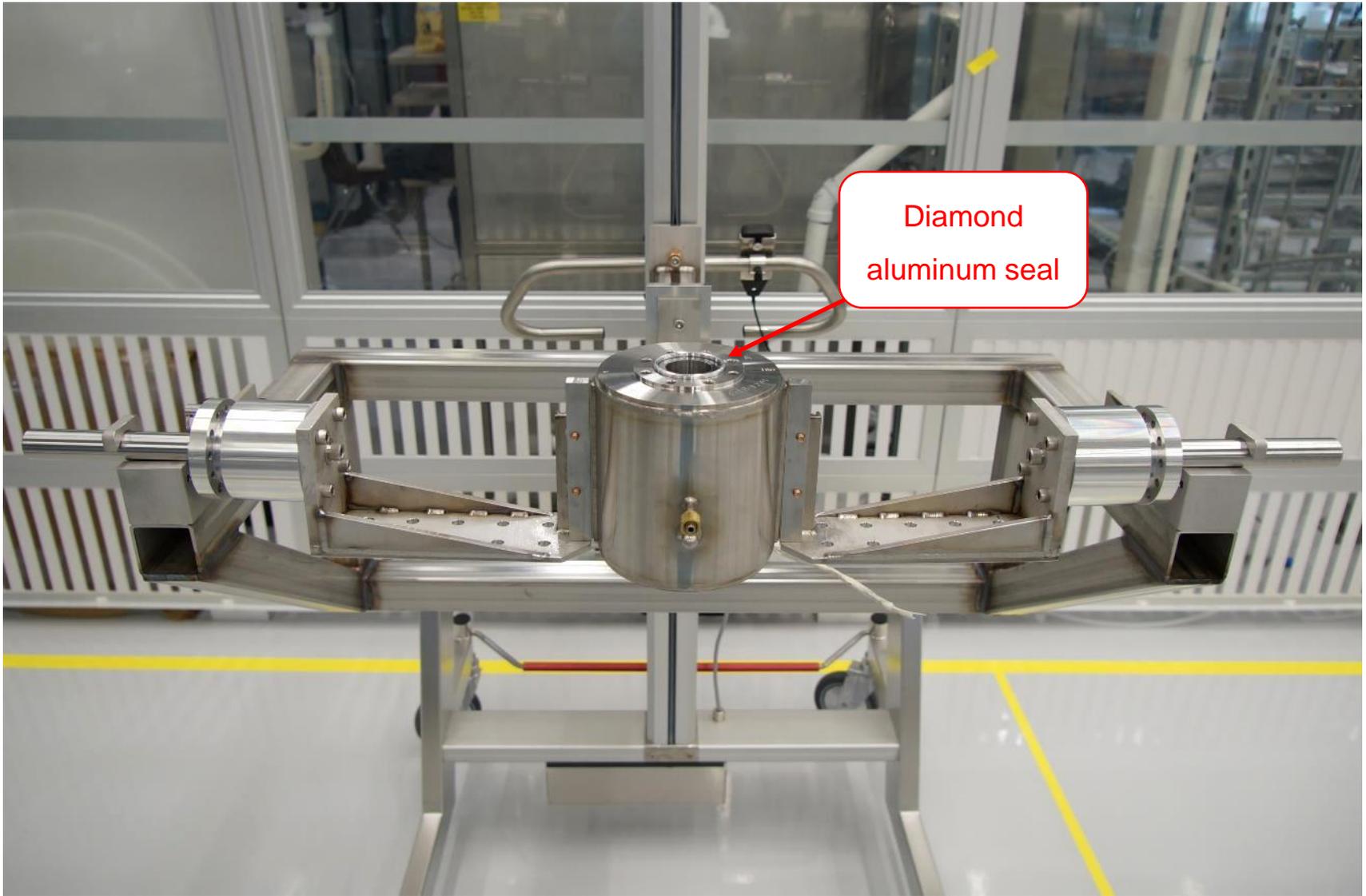
# Assembly of Solenoid-BPM Group



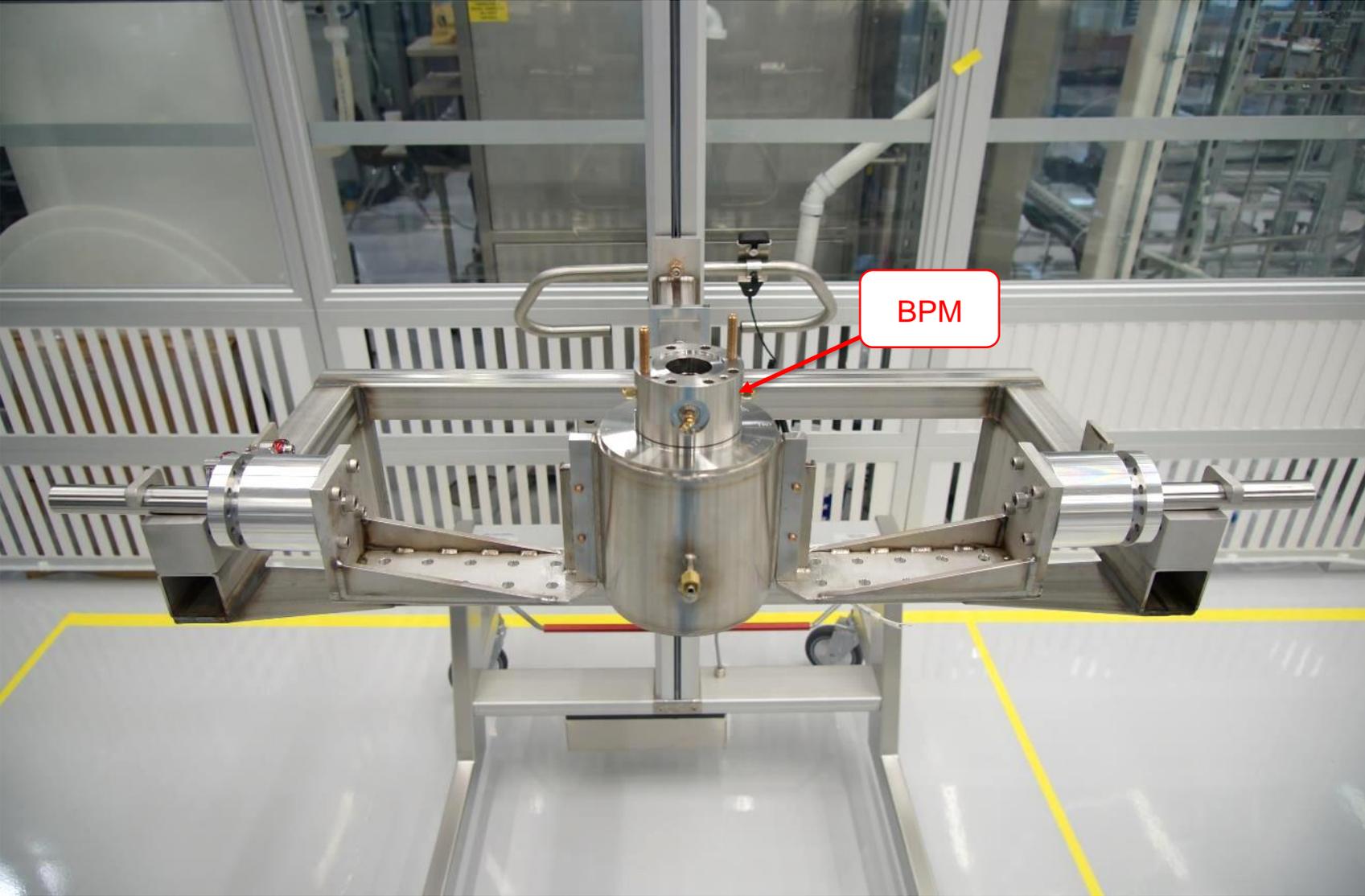
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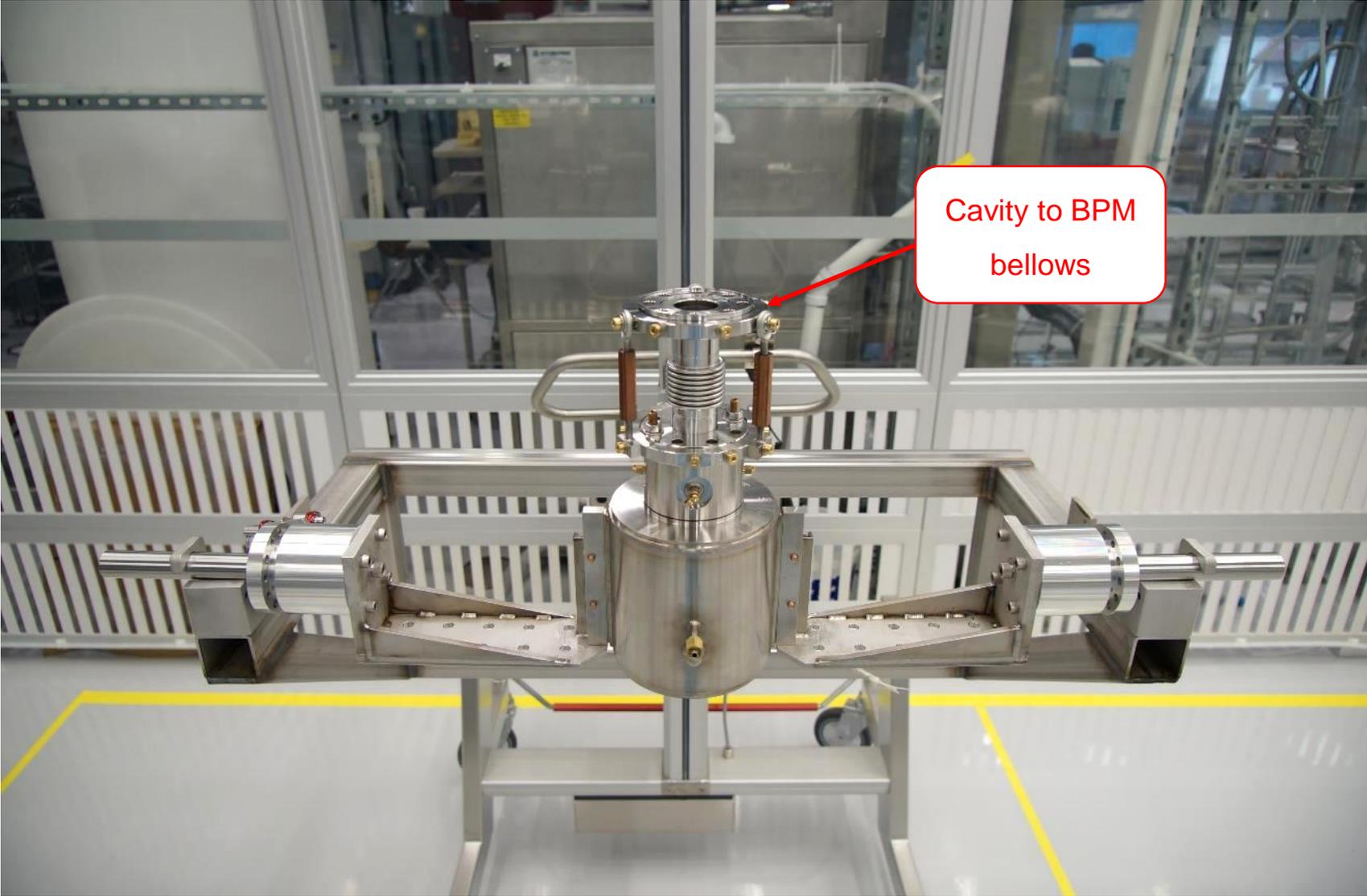
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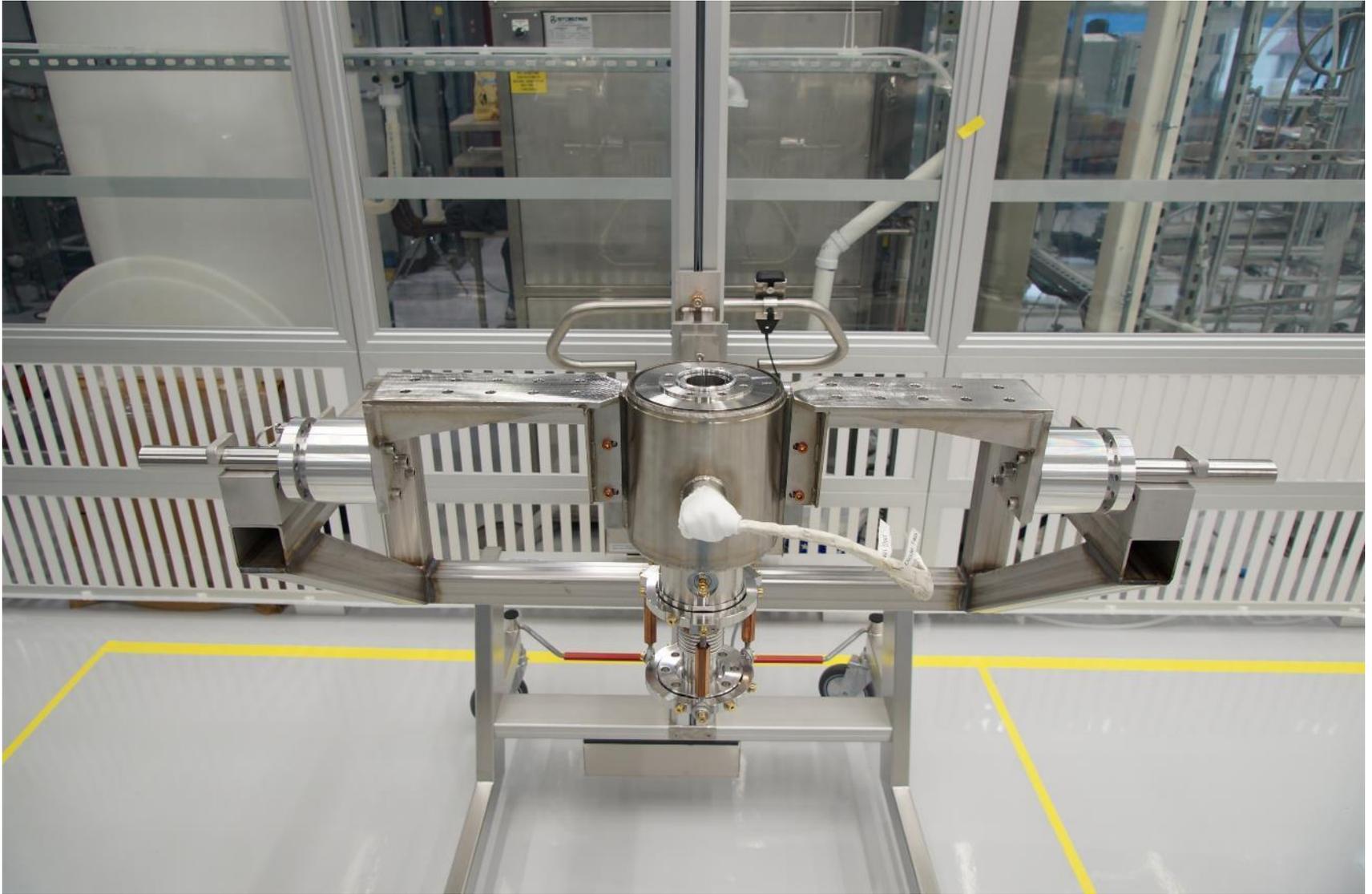


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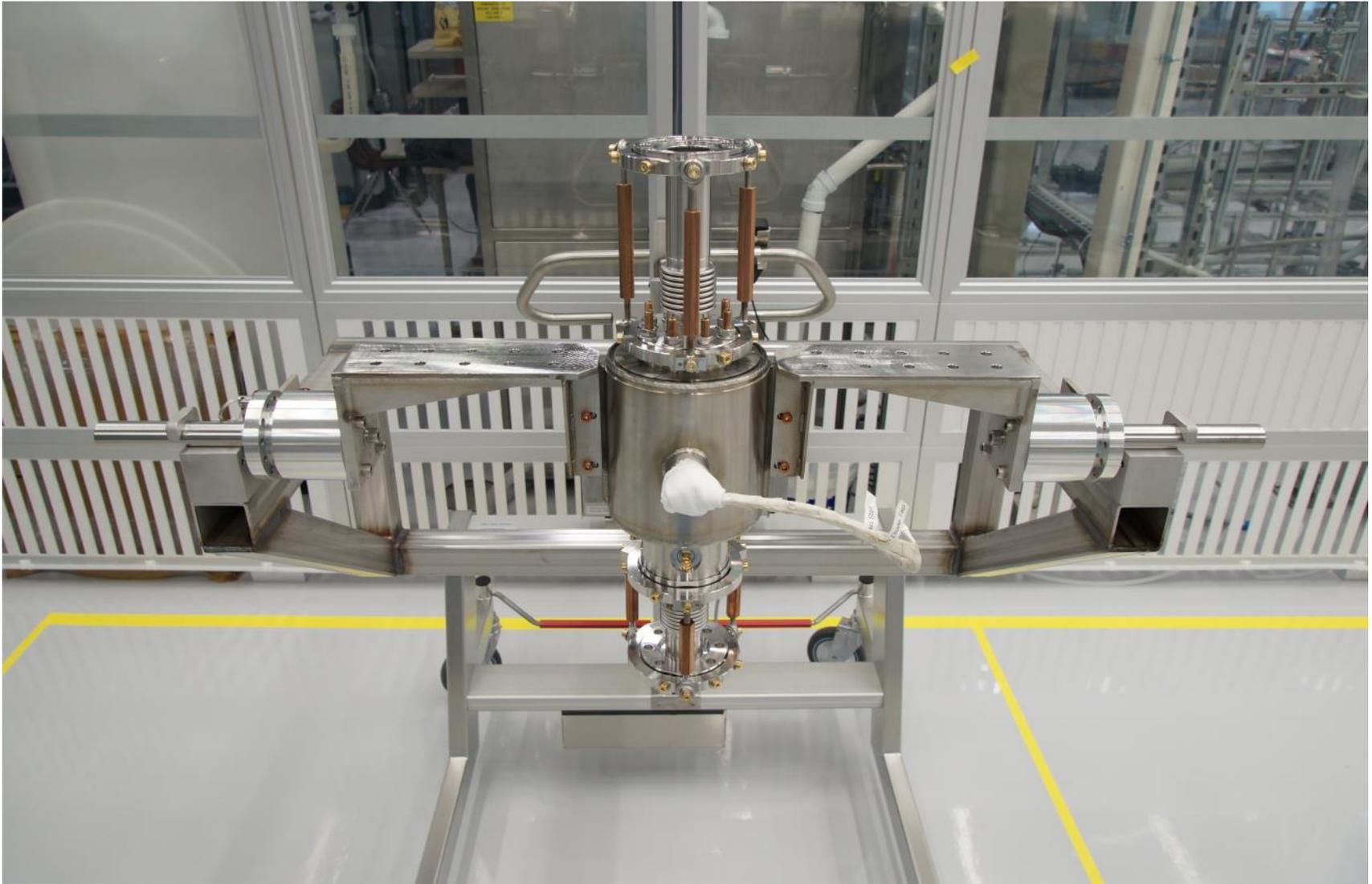


Cavity to BPM  
bellows

# Assembly of Solenoid-BPM Group



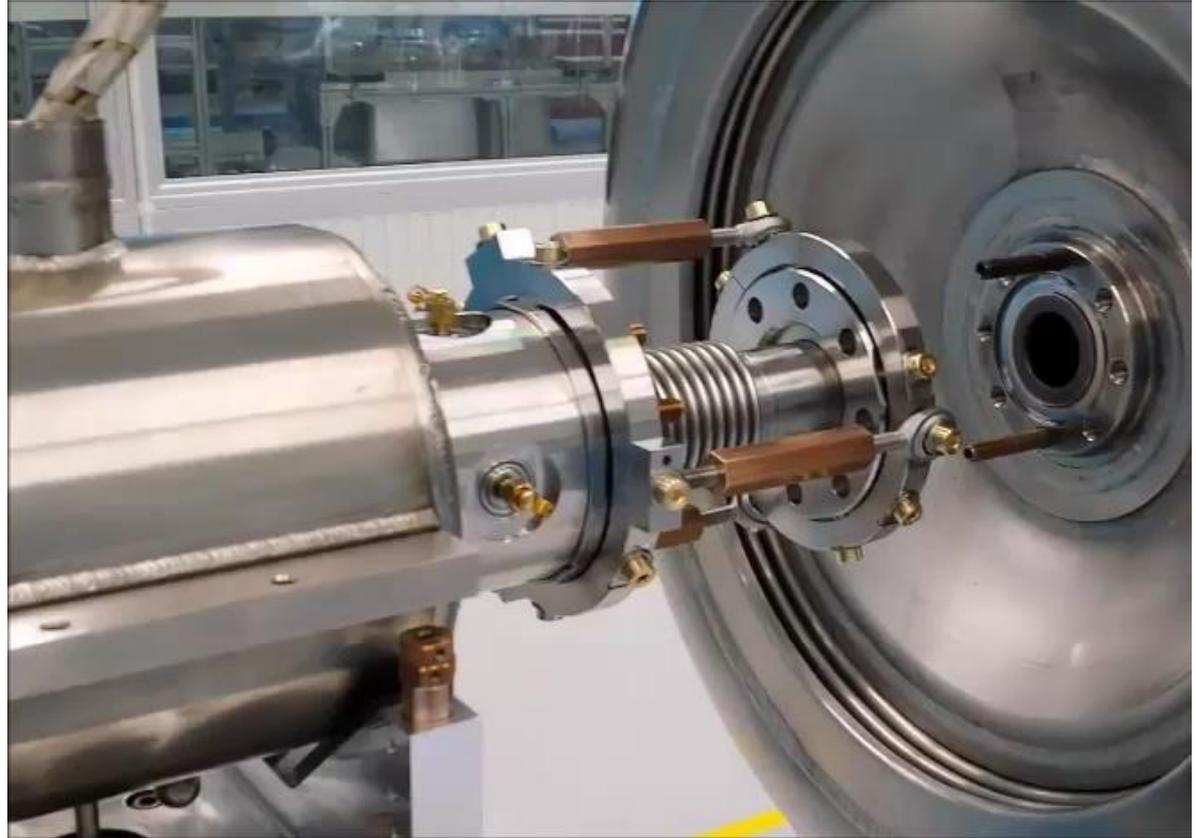
# Assembly of Solenoid-BPM Group



# Preparation of the SSR1 string assembly dry-run



# Preparation of the SSR1 string assembly dry-run



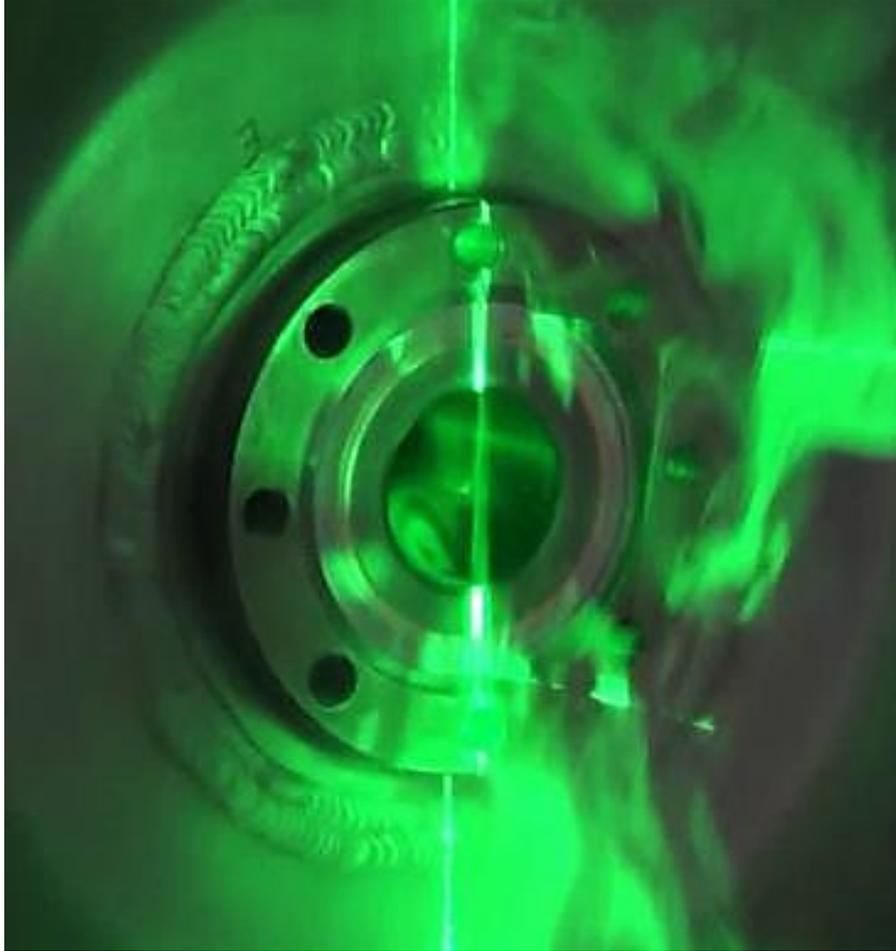
- ✓ Sub - millimeter precise and reliable alignment
- ✓ Easy to use system

# Nitrogen purging studies

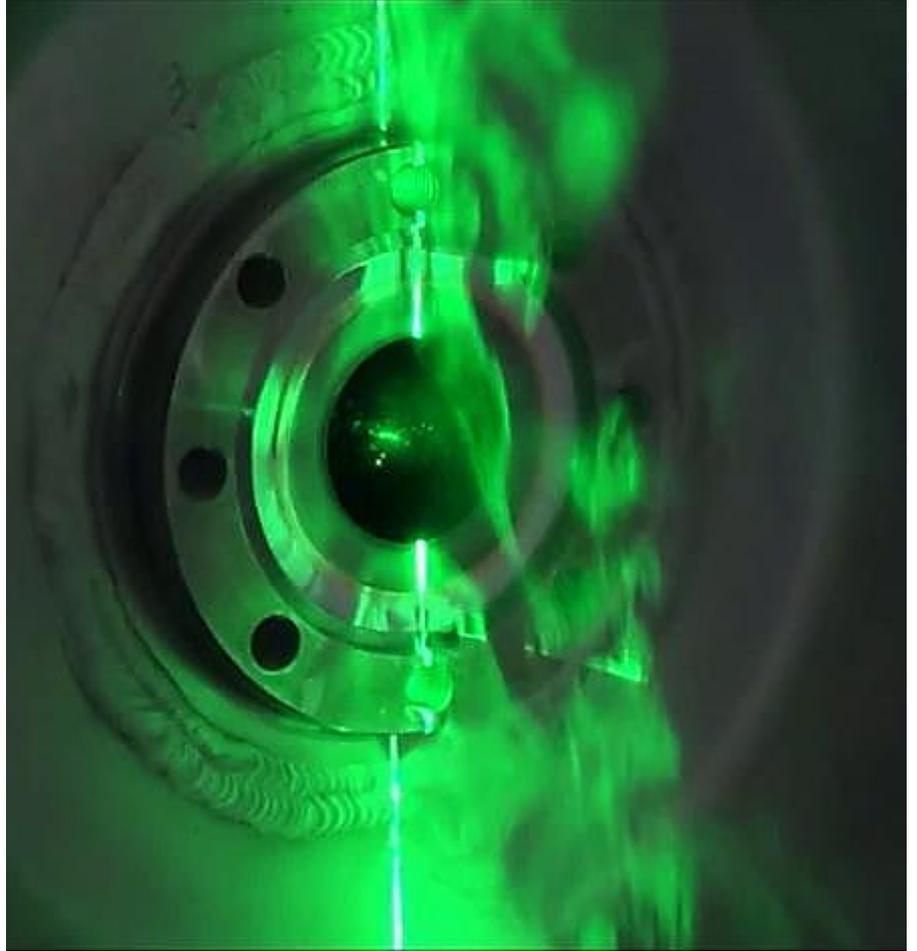


# Nitrogen purging studies

No Nitrogen purging applied

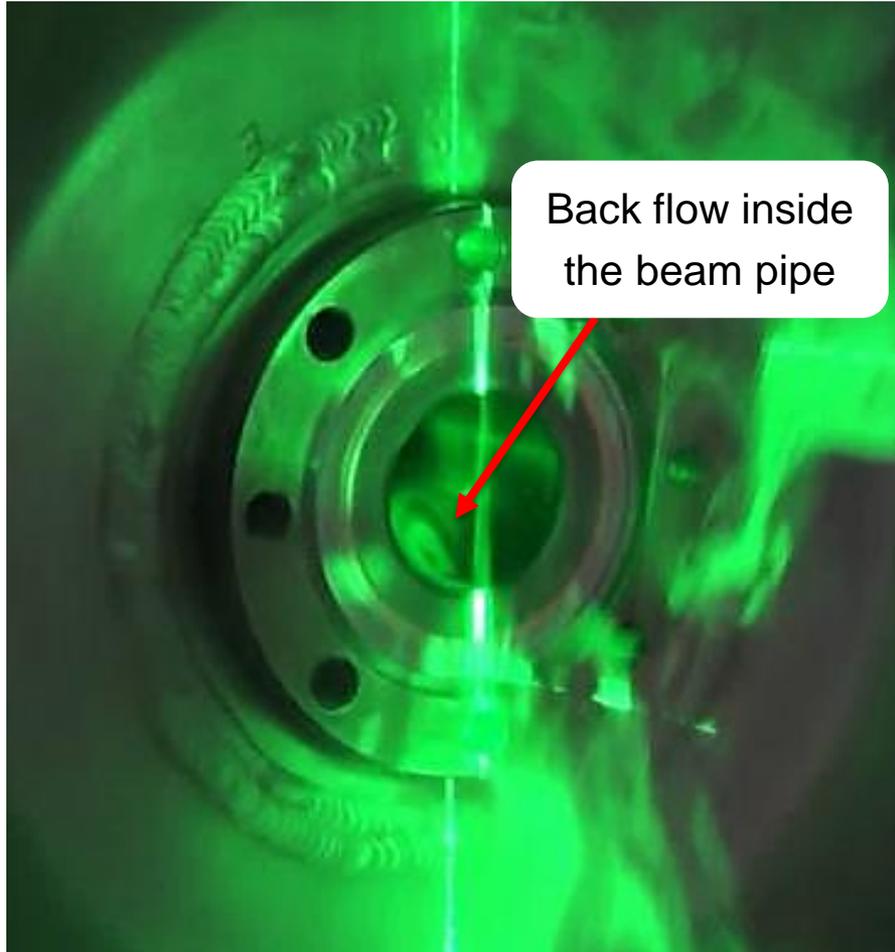


Nitrogen purging at 4 SLPD  
purge flow speed 0.1 m/s

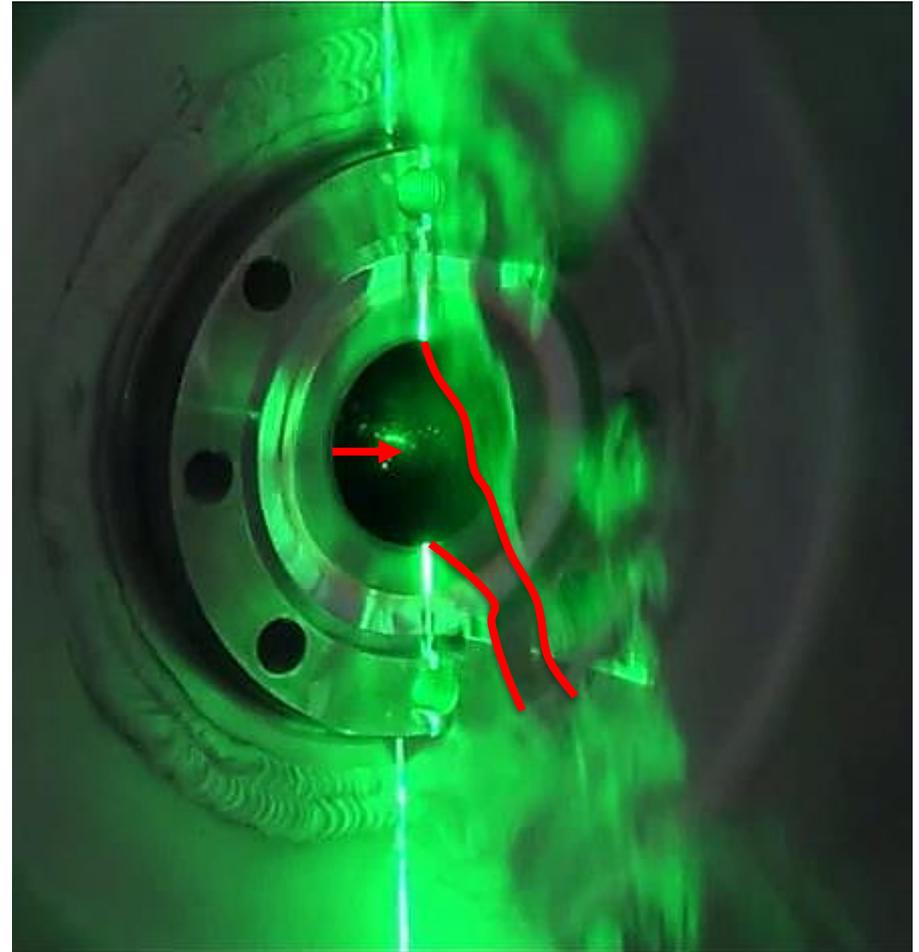


# Nitrogen purging studies

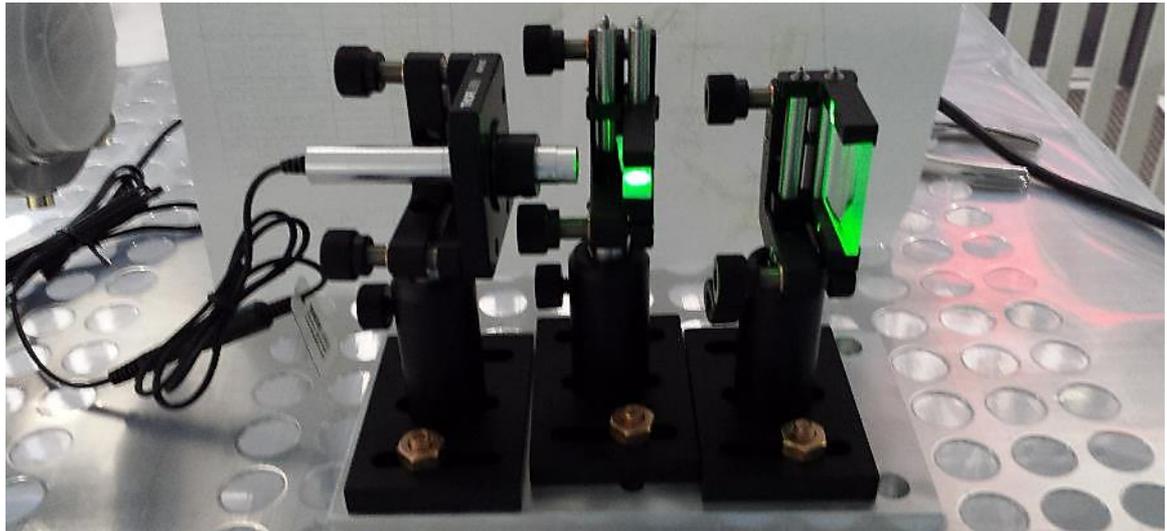
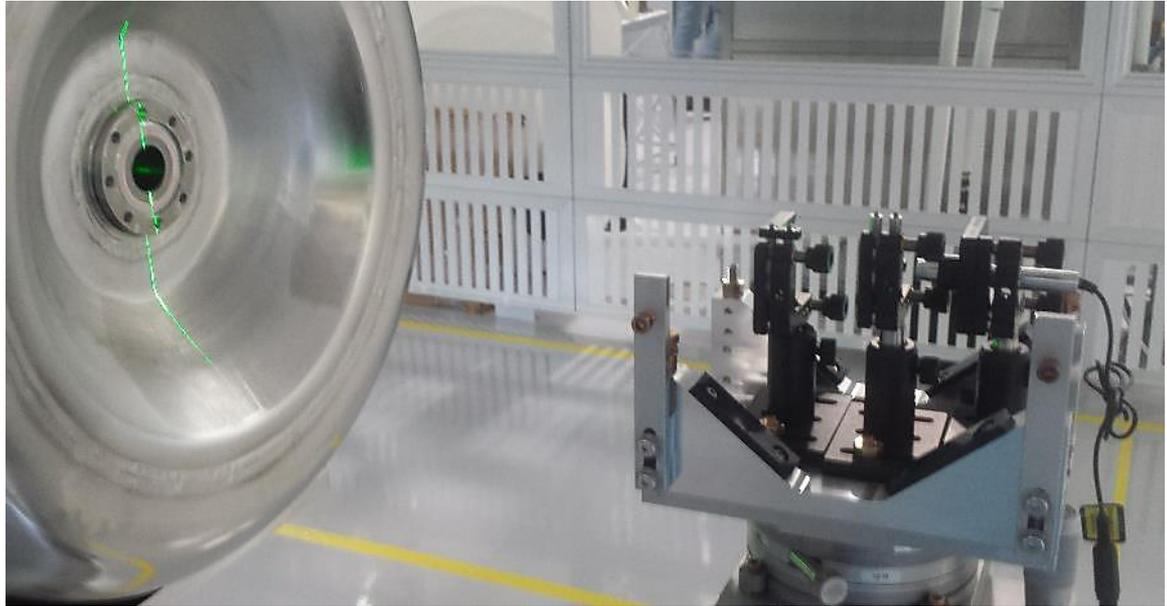
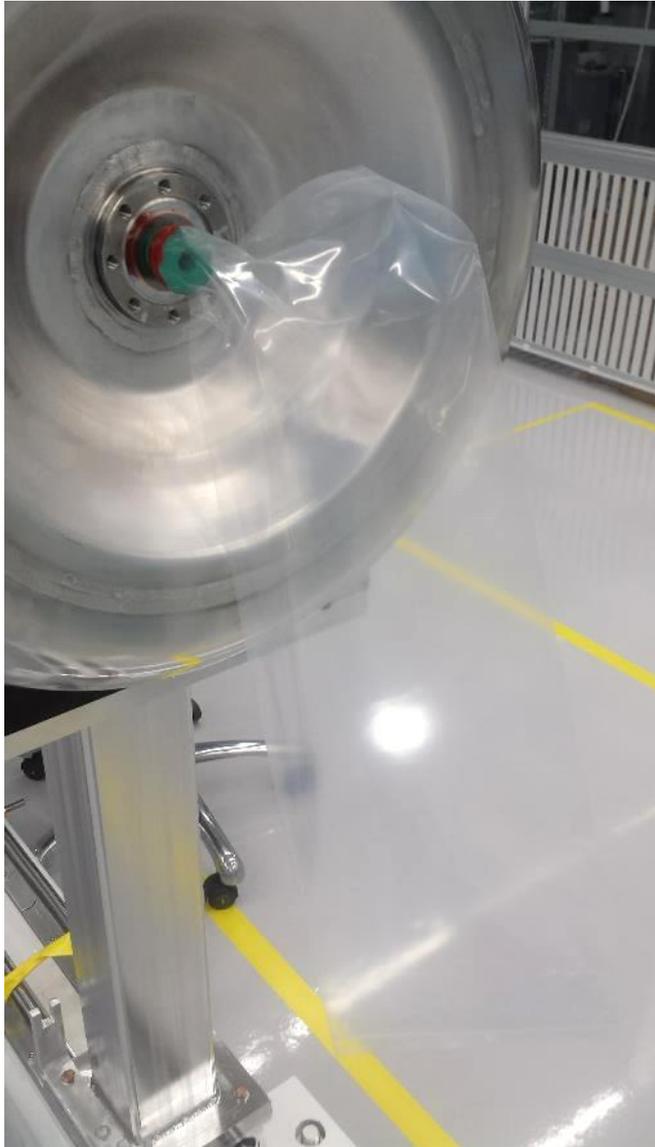
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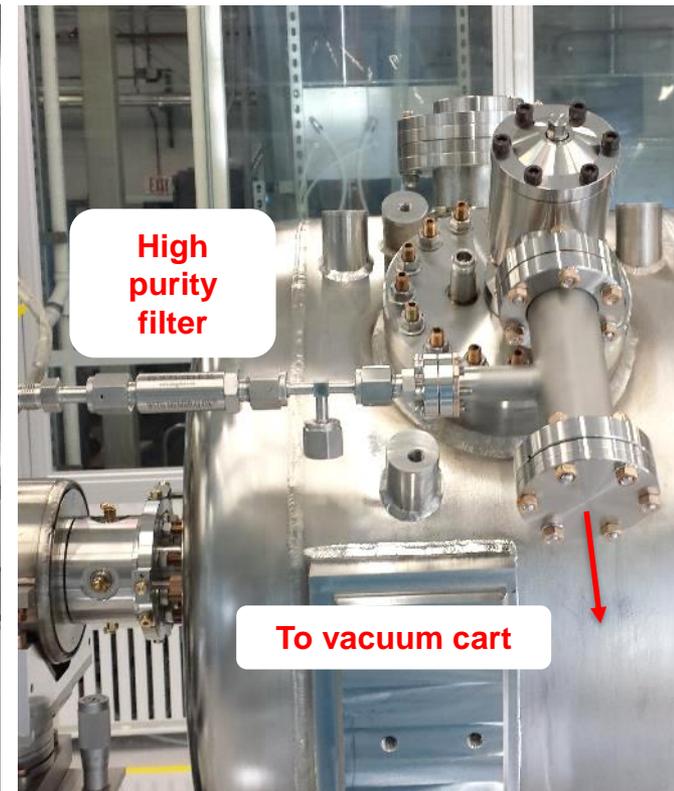
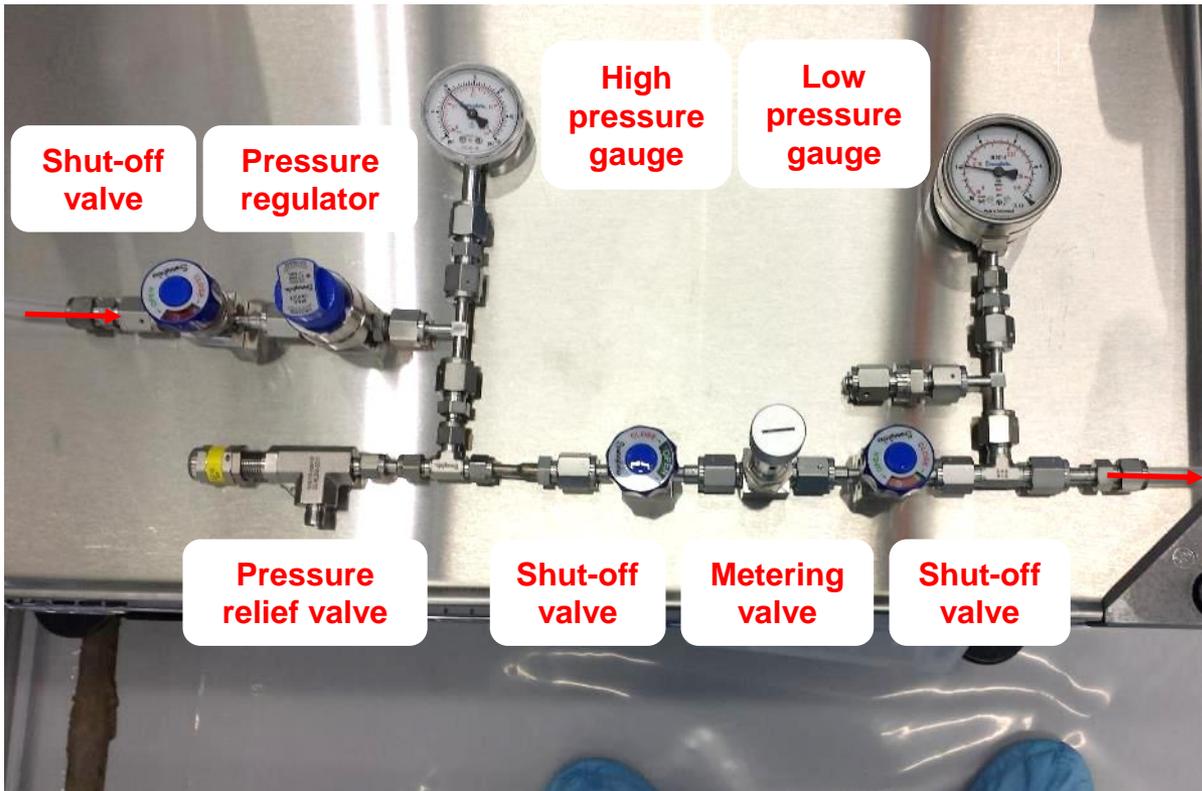


# Experimental setup for purging studies



# Nitrogen purging line

- Nitrogen purging line can provide up to 20 SLPM
- Filter is located on the cavity as last element to avoid cavity contamination
- Can be manually operated
- Mass Flow Controller can substitute the metering valve for a reliable soft start



# Gate valves particle counts: all metal vs Viton sealed

## SSR1 GATE VALVE



- Viton sealed
- Pneumatic actuation (<1 sec for opening and closing)
- Viton may degrade due to radiation

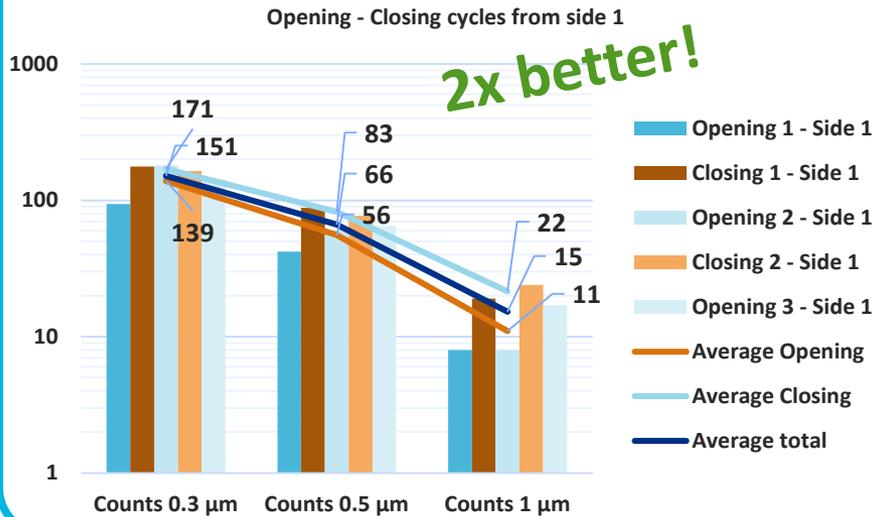
## LCLSII ALL-METAL GATE VALVE



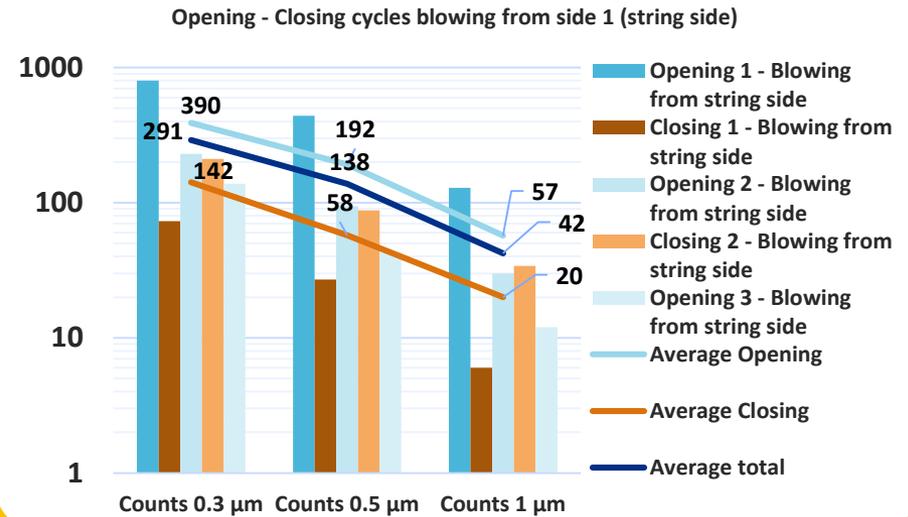
- All metal construction
- Manual actuation (~ 5 min for opening and for closing)
- Radiation resistant

# Gate valves particle counts: all metal vs Viton sealed

## SSR1 GATE VALVE



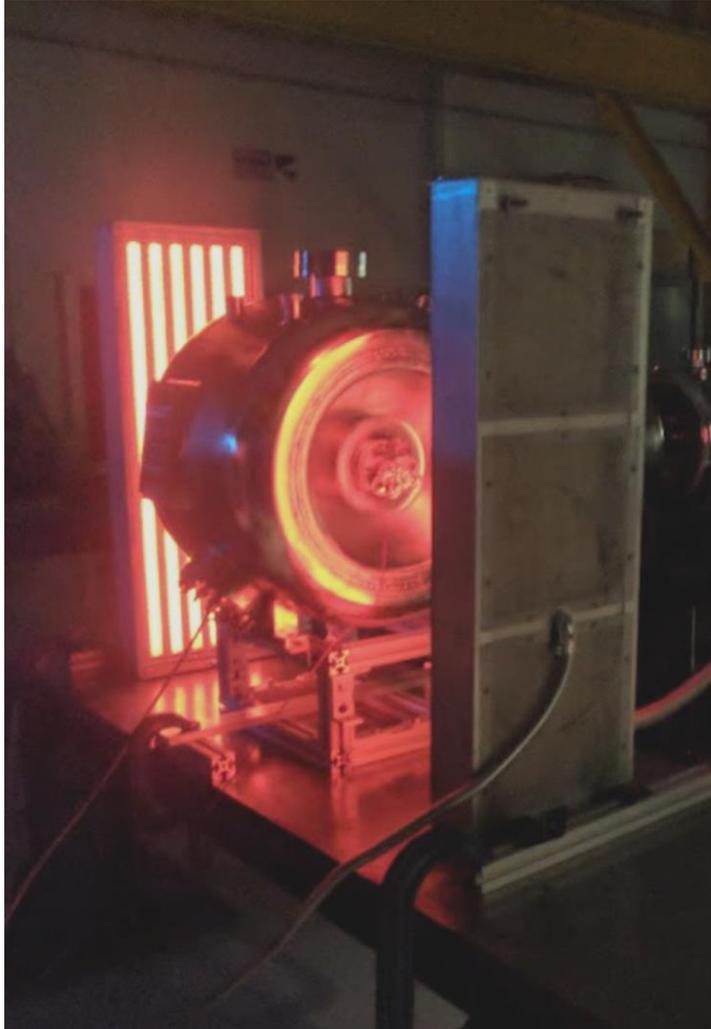
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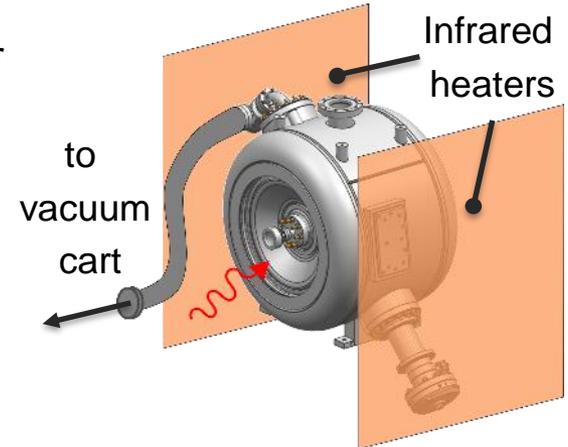
- SSR1 Viton sealed pneumatic actuated gate valve performed better than the all-metal gate valve in terms of particle counts
- SSR1 cryomodule is located at the early stage of the LINAC
- Damaging of the Viton due to beam radiation is limited at this stage

- ✓ SSR1 Viton sealed gate valve is compact, generate less particulate, reliable (does not depend on the operator to be actuated) and can be opened/closed in <1 sec

# Low-Temp bake with Space Heaters: a new approach



Quartz fabric Faced Heater



- Able to reach 120°C in 2 hours
- 90% energy efficient
- Can reach 815°C
- Output power can be controlled through cavity temperature
- Cavity never leaves the cleanroom facility

# Avoid active pumping: burst disk

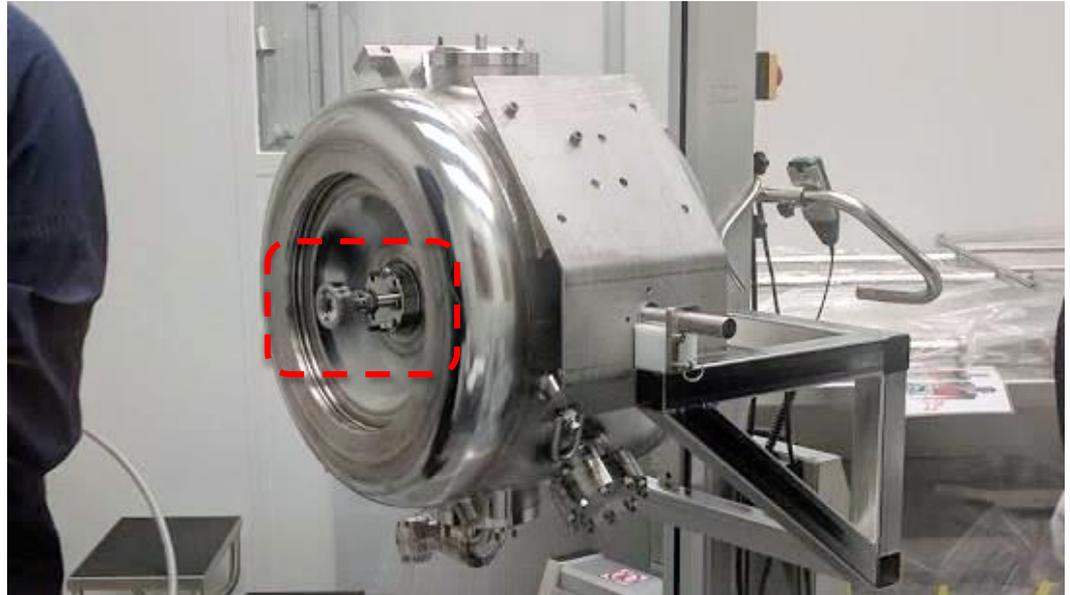
## With active pumping:

- Connection to the vacuum cart was done in a portable glove box
- 2 days required
- Environment is not ideal for a clean connection



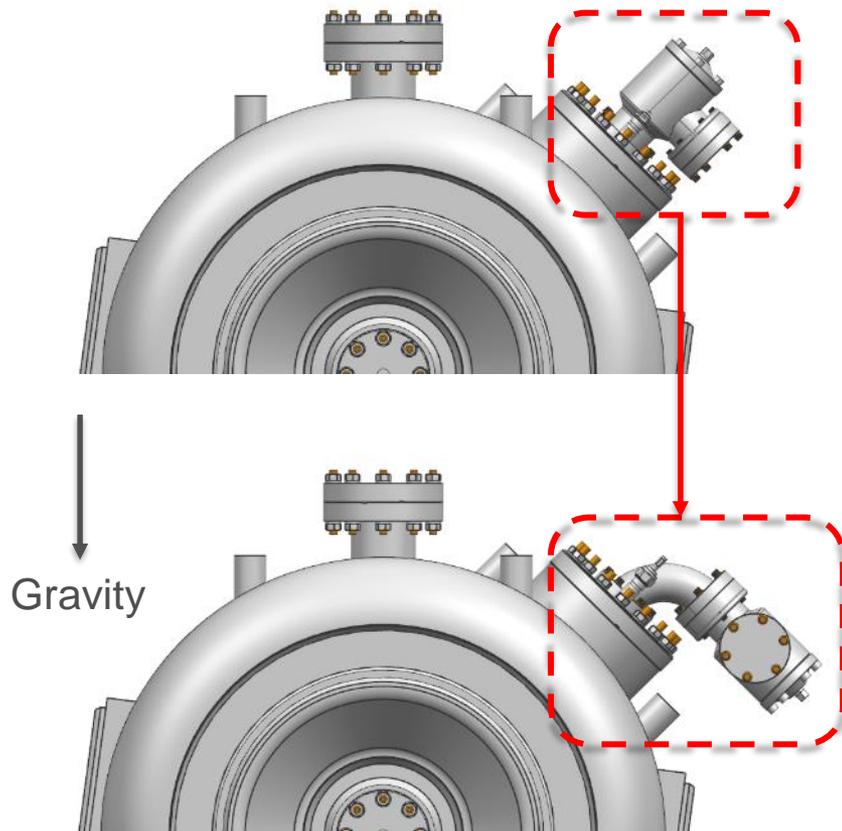
## Without active pumping: Burst Disk

- ✓ Avoid potential contaminations during the connection and from the vacuum cart
- ✓ Installation time into the test cave is substantially reduced



# Right Angle Valve (RAV) to cavity connection

- RAV was directly located on top of the cavity beam volume
- High risk of particles generated during valve actuation. Gravity force or bad venting procedure can move such particles inside the cavity beam volume



# Summary

- SSR1 String designed with assembly in mind
- String is segmented in sub-systems for particle-free assembly
- Edge-welded bellows a necessary and understood risk
- 6 degree supports for all components
- Nitrogen purging optimized for SSR1 reentrant walls
- Several improvements adopted during R&D and dry-run
- String assembly of pSSR1 CM to start soon!

This work would not be possible without contribution of many people of the powerful SSR I Team!

