國家同步輻射研究中心
National Synchrotron Radiation Research Center

Progress of Construction of the TPS Vacuum System

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Outline

- Introduction
- Design Considerations for TPS Vacuum System
  - six questions
- Conclusions

Six Questions

Six Questions for Design Considerations

1. How to obtain a good UHV system ?
2. How to design a proper pumping configuration ?
3. How to design low beam impedance ?
4. How to eliminate deformations ?
5. How to manage thermal loads ?
6. How to improve manufacturing processes ?

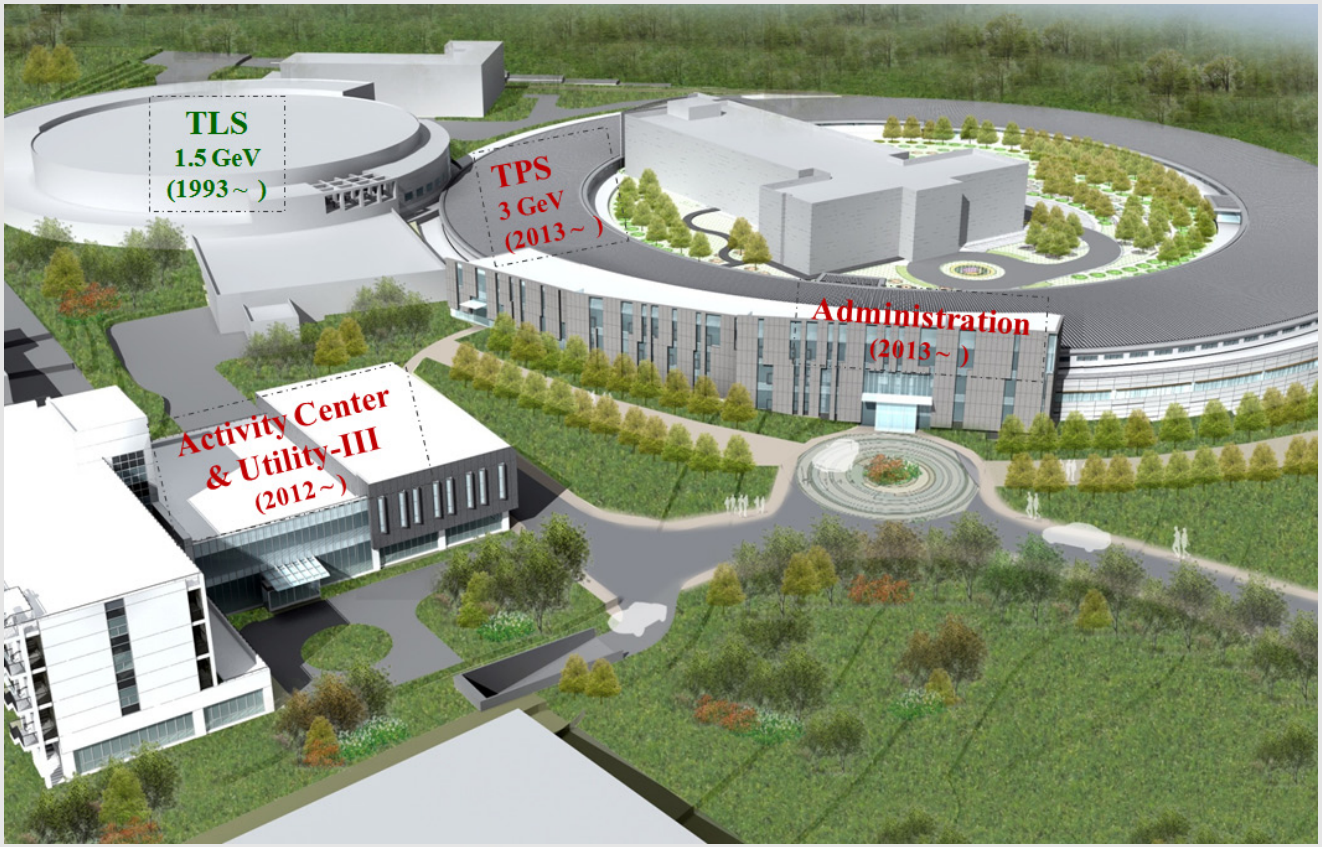
Design Parameters for TPS

Demanding of Taiwan Photon Source (TPS)

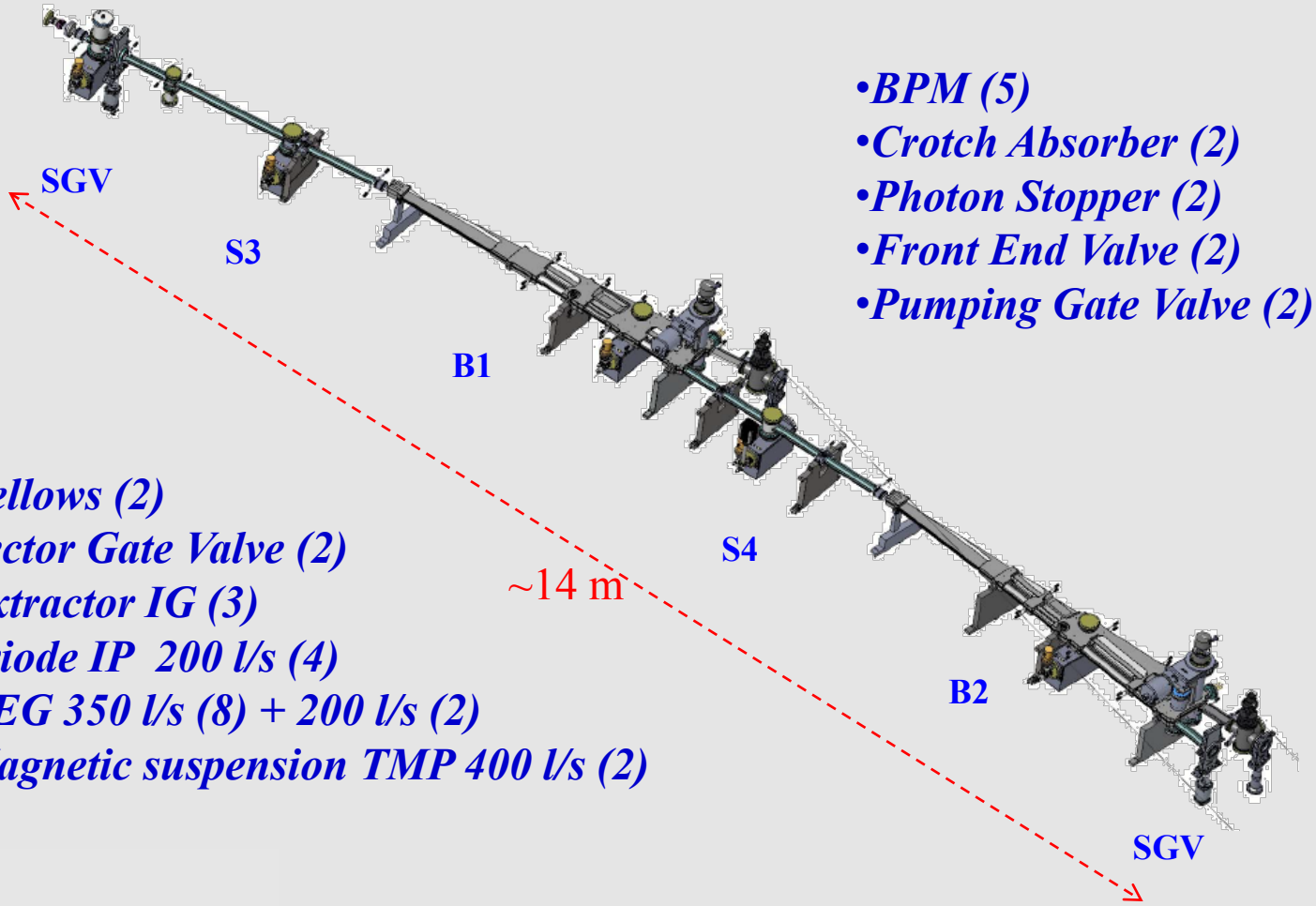
Energy	3 GeV (provides high energy hard X-ray)
Electron beam current	500 mA (Top-up injection) (constant and high flux, brilliance)
Circumference of SR	518.4 m (h = 864 = $2^5 \cdot 3^3$, dia.= 165.0 m)
Circumference of BR	496.8 m (h = 828 = $2^2 \cdot 3^2 \cdot 23$, dia.= 158.1 m)
Lattice	24-cell DBA
Straight Section (Length x Quantity)	12 m x 6 (σ_v = 12 μm, σ_h = 160 μm) 7 m x 18 (σ_v = 5 μm, σ_h = 120 μm)
Bending Magnets	48 (many beam lines, ID+BM)
Beam emittance	1.6 nm·rad at 3 GeV (Distributed dispersion) (high brilliance)
Location	National Synchrotron Radiation Research Center, Hsinchu, Taiwan
Ring Building	Outer Diameter 210 m ; Inner Diameter 129 m

Layout for TLS and TPS

Two synchrotron light sources in Taiwan
- TLS (1.5 GeV, 360 mA Top-up), in operation
- TPS (3.0 GeV, 500 mA Top-up), in construction



Standard 1/24 Unit Cell Vacuum Chamber



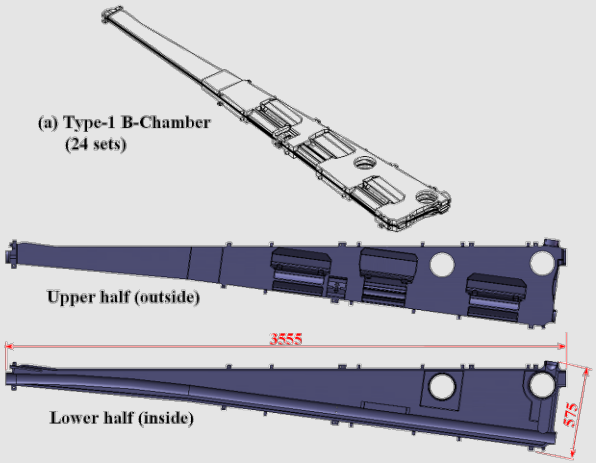
- *BPM (5)*
- *Crotch Absorber (2)*
- *Photon Stopper (2)*
- *Front End Valve (2)*
- *Pumping Gate Valve (2)*

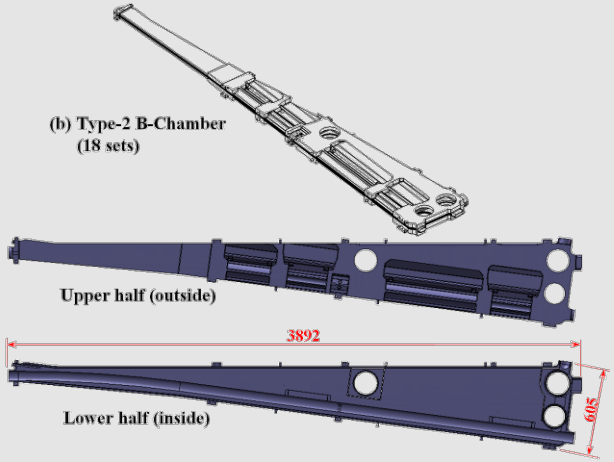
- *Bellows (2)*
- *Sector Gate Valve (2)*
- *Extractor IG (3)*
- *Triode IP 200 l/s (4)*
- *NEG 350 l/s (8) + 200 l/s (2)*
- *Magnetic suspension TMP 400 l/s (2)*

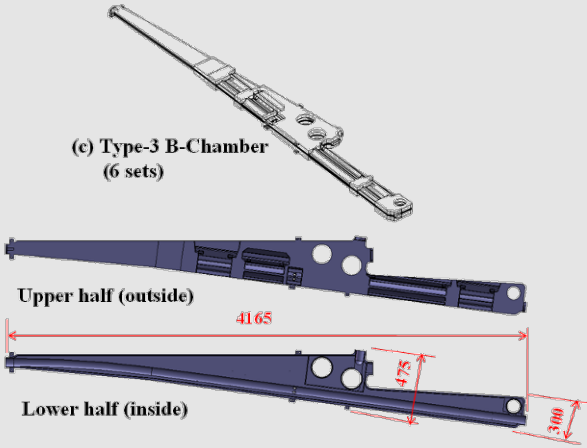
1. How to obtain a good UHV System ?

- Target pressure of TPS to be achieved in the presence of the maximum beam current is $<1X10^{-7}$ Pa
- Chamber's surface cleanliness is the most important factor.
- Solutions for preventing contamination:
  - ✓ Oil-free CNC machining
  - ✓ Ozonated water cleaning
  - ✓ Clean-room TIG welding

Oil-Free CNC Machining Process



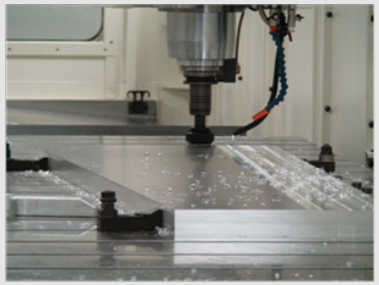




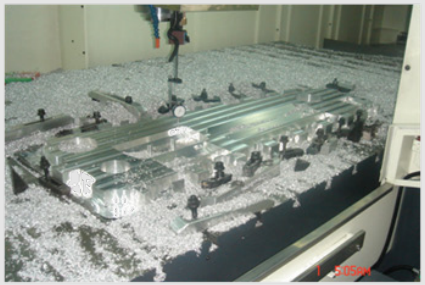
Oil-free CNC Machining in Clean Room

Rough Machining → Wait 3 days → Intermediate Machining → Wait 1 day → Precision Machining

Tool enter increment: 0.3 ~ 0.5mm



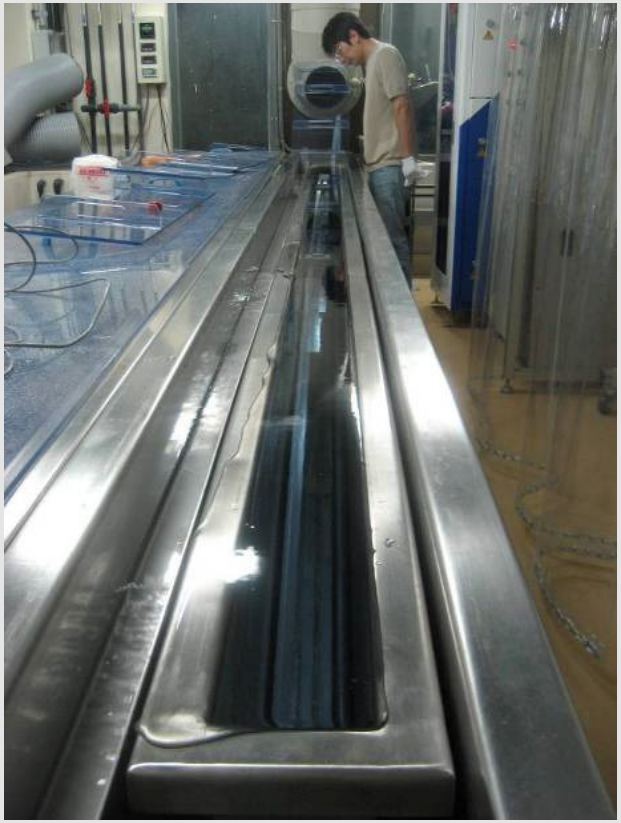
Tool enter increment: 0.1 ~ 0.2mm



Tool enter increment: < 0.05mm

CNC Machining Processes (sprayed with pure alcohol)

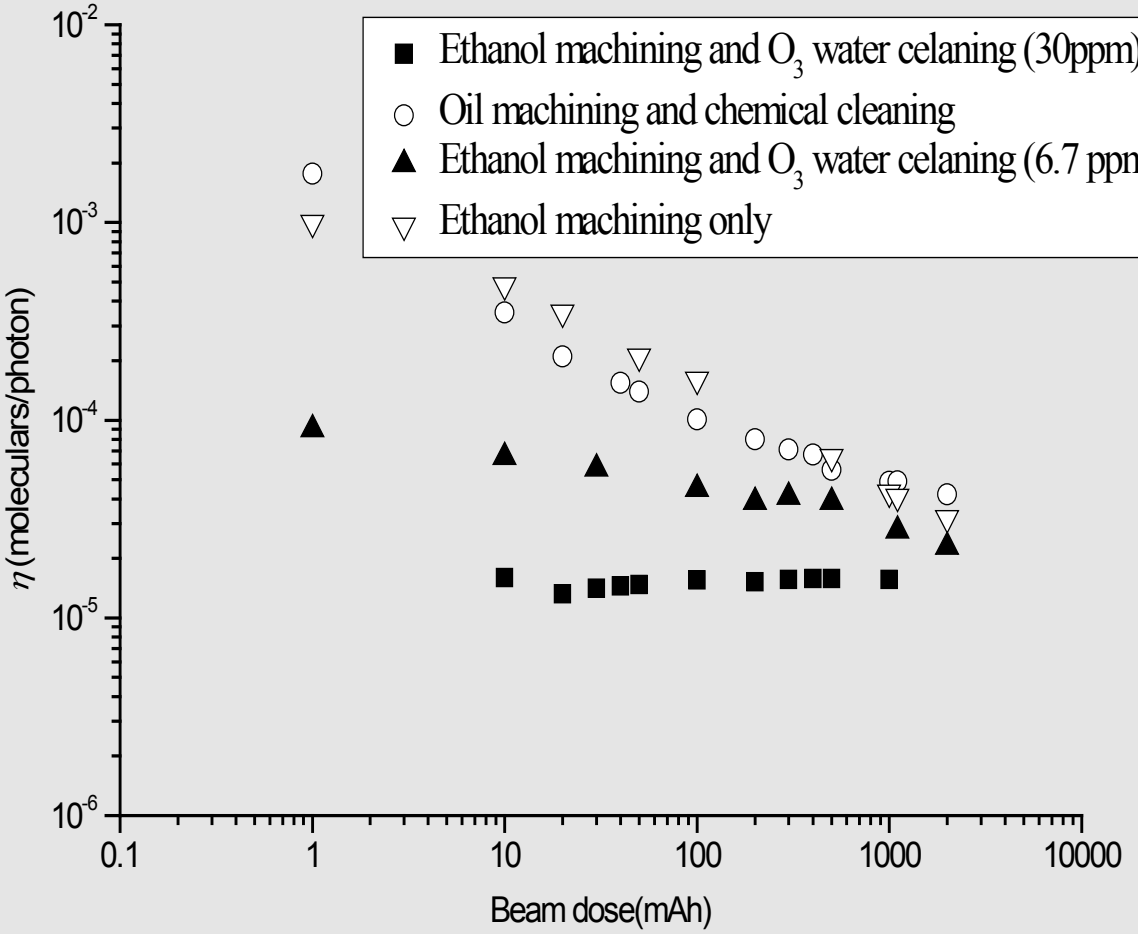
Ozonated Water Cleaning Process



Ozonated Water Cleaning Bath

(> 20 ppm)

Photon-stimulated desorption (PSD) results with various surface treatments [a] [b]



[a] Chan, et al., "Design of the TPS Bending Chamber",APAC'07, THPMA056, p.703 (2007)

[b] T. Momose, et al., J. Vac. Sci. Technol. A13(3) (1995) 515

Sequence of Bending Chamber Welding

Ozonated Water Cleaning

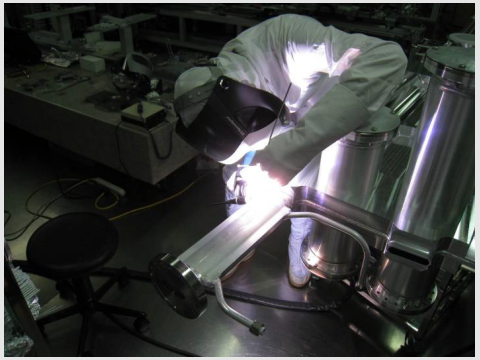
Upper and Lower Halves

Pumping Port Welding

B-Chamber Alignment+ Spot weld seams

Clean Room (Class 1000)
- **Temperature: T = 25±1 ˚C**
- **Humidity: HR < 50%**

Auto-Welding System



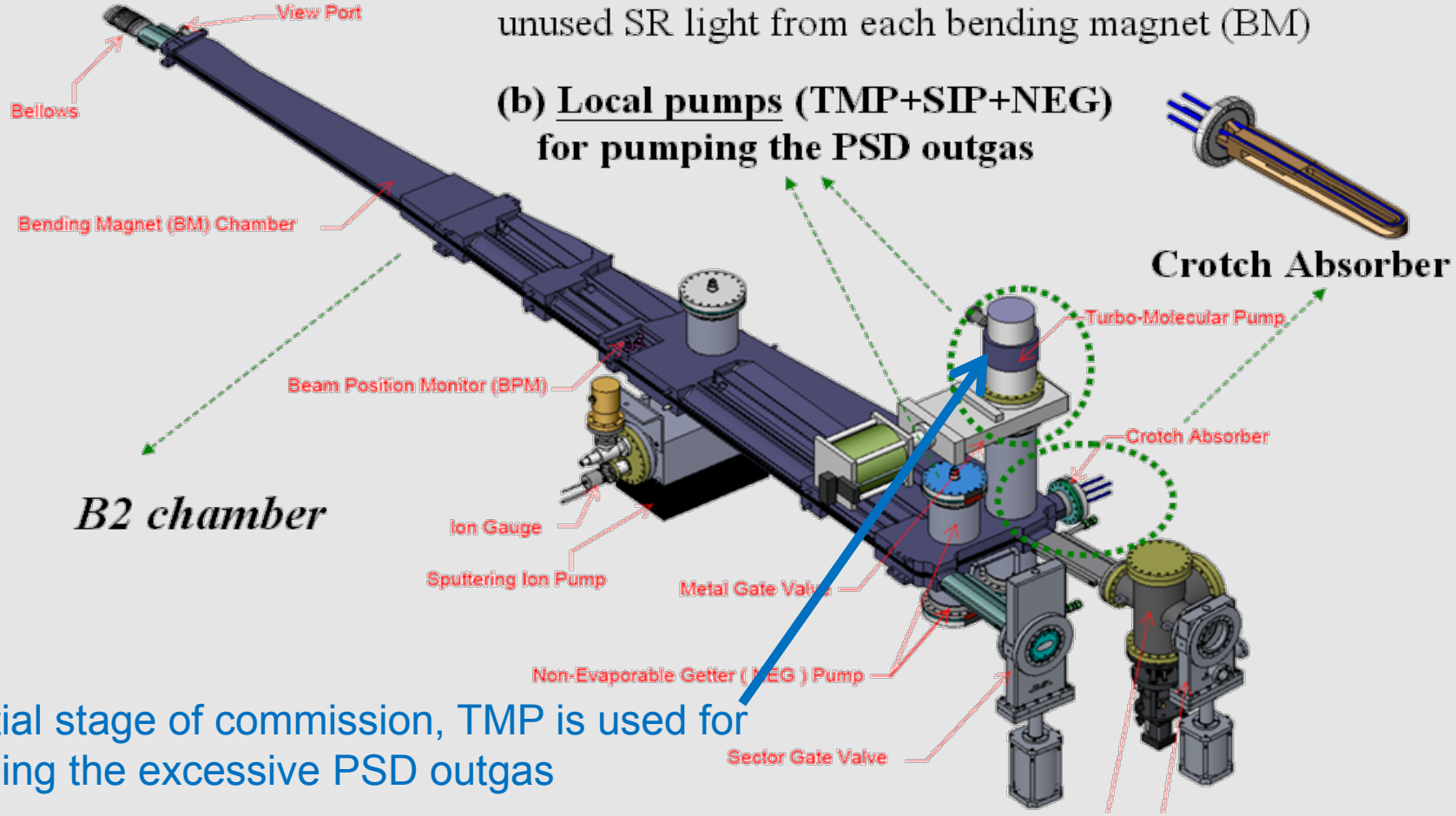
2. How to Design a Proper Pumping Configuration ?

- In order to obtain a pressure under $1X10^{-7}$ Pa
- An optimal pumping design is needed.
- Solutions for pumping system:
  - ✓ Oil-free pumps
    - ***Starcell IP 200 l/s***
    - ***NEG 350 l/s + 200 l/s***
    - ***Magnetic suspension TMP 400 l/s***
  - ✓ Confined pumping with ante-chamber
  - ✓ At initial stage of commission, TMP is used for pumping the excessive PSD outgas
  - ✓ Pumping speed ≈ 200 l/s per meter

Confined Pumping with Ante-Chamber Design

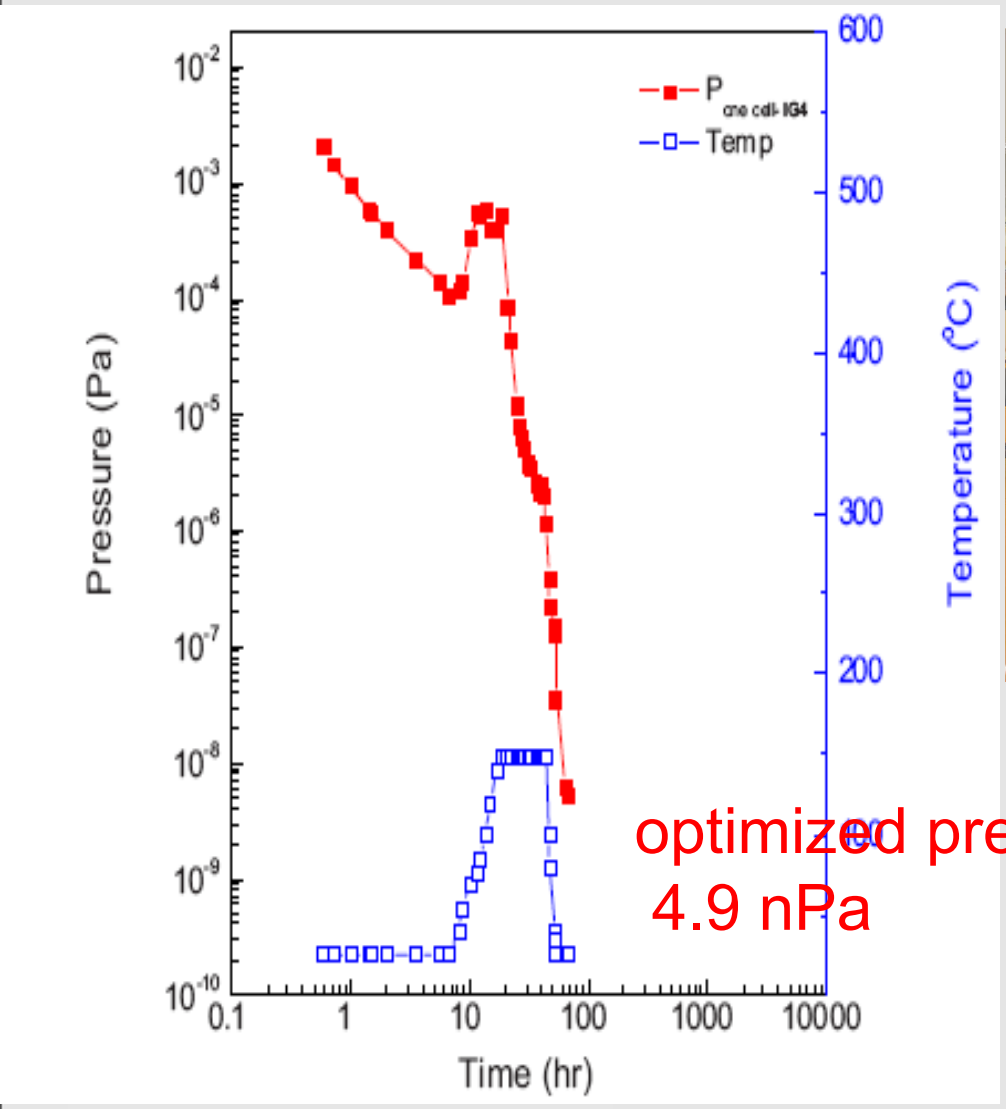
(a) Crotch absorber for absorbing ~ 6.2° (80%) of the unused SR light from each bending magnet (BM)

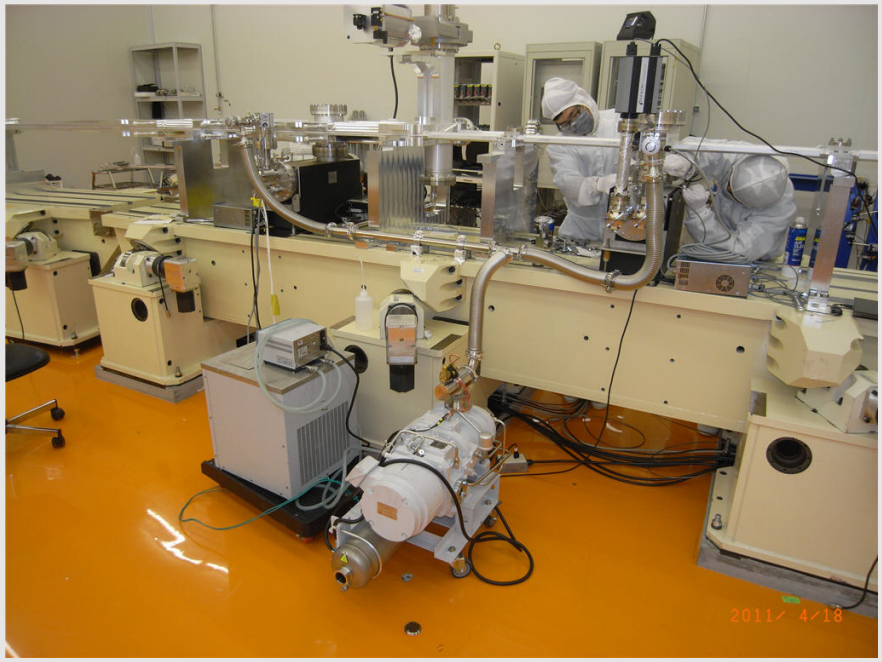
(b) Local pumps (TMP+SIP+NEG) for pumping the PSD outgas

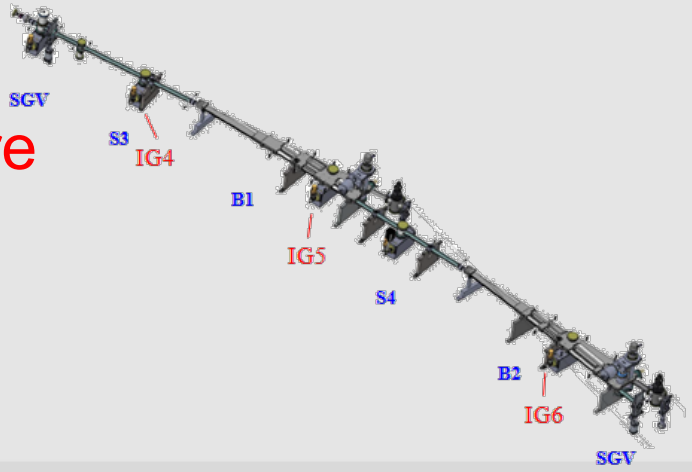


At initial stage of commission, TMP is used for pumping the excessive PSD outgas

Assembly of valves, pumps, gauges, absorbers; leak check; baking (150 °C, 24h)



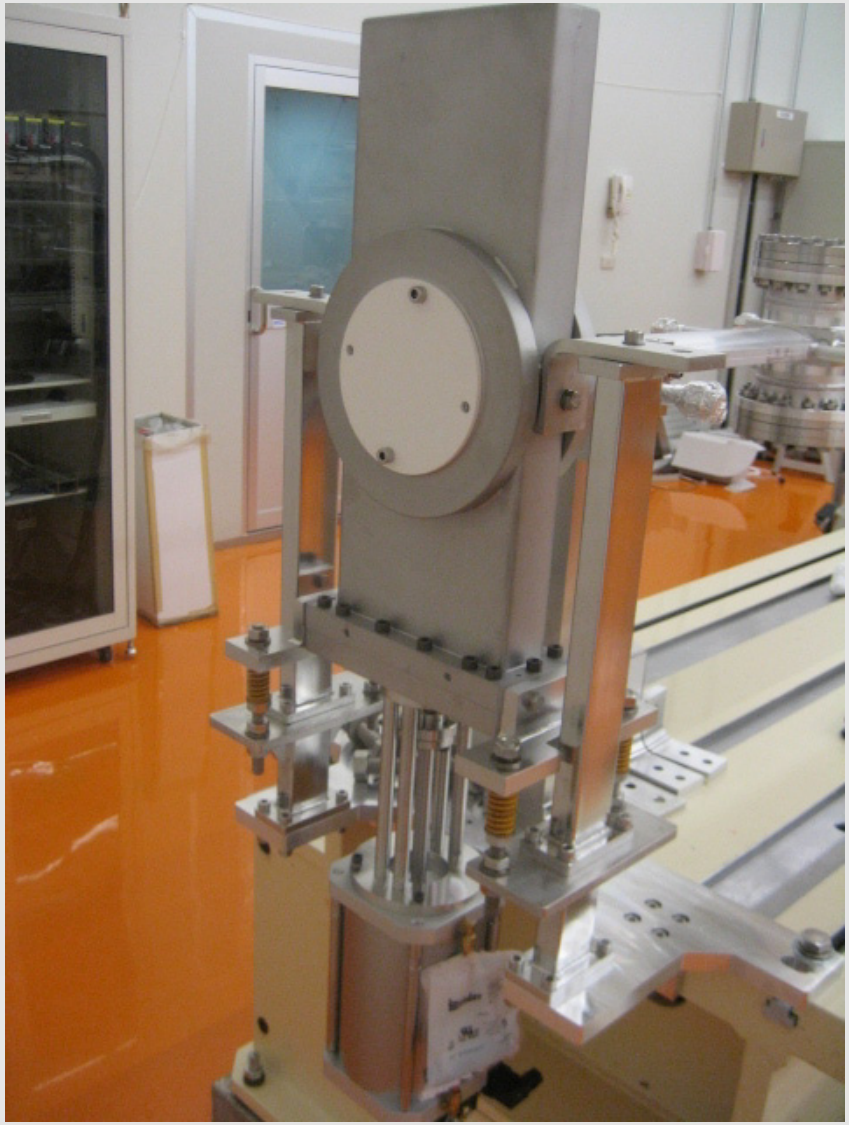




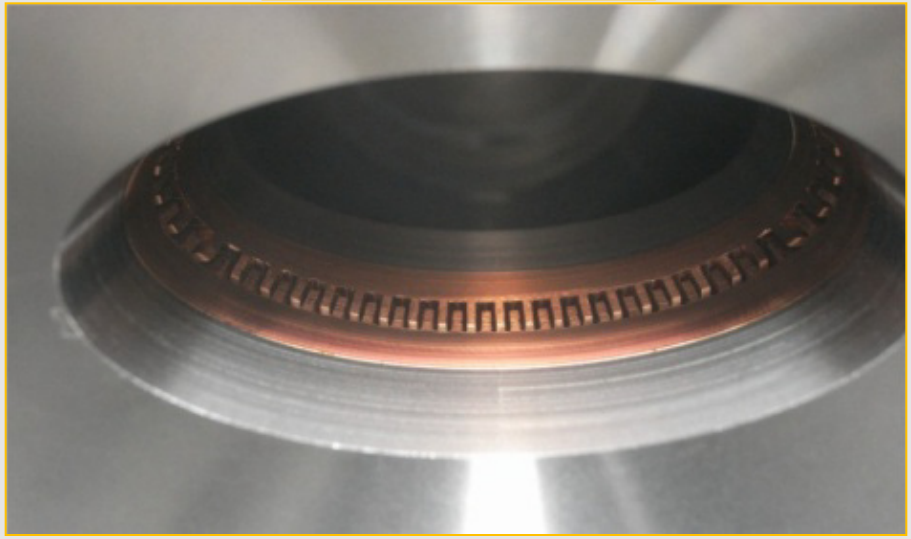
3. How to Design Low Beam Impedance ?

- To decrease the impedance, any possible discontinuous cross sections in the beam duct must be avoided.
- Components induce impedance:
  - All metal gate valves
  - Bellows
  - Flanges
  - Pumping Ports
- Solutions for lower impedance:
  - ✓ Reduce the number of flanges
  - ✓ Reduce the number of bellows
  - ✓ Bellow and gate valves with RF-contact structures

All Metal Sector Gate Valve with Comb-Type RF Fingers

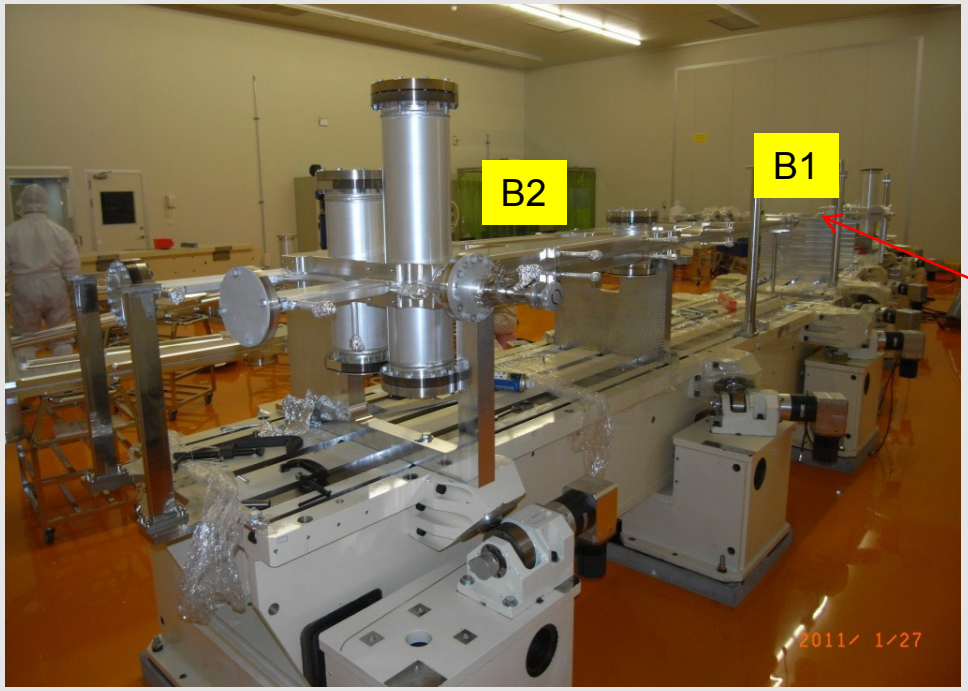


comb-type fingers

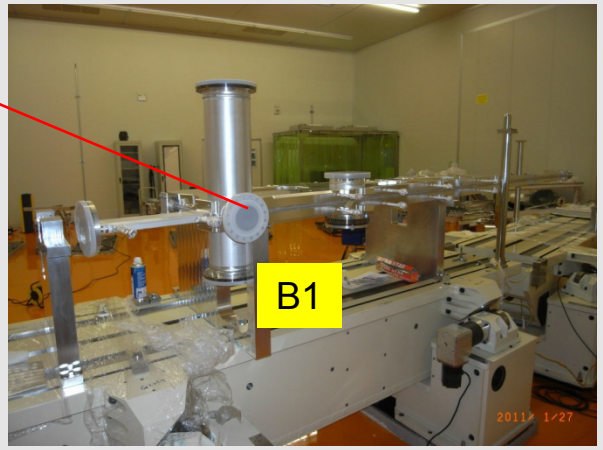


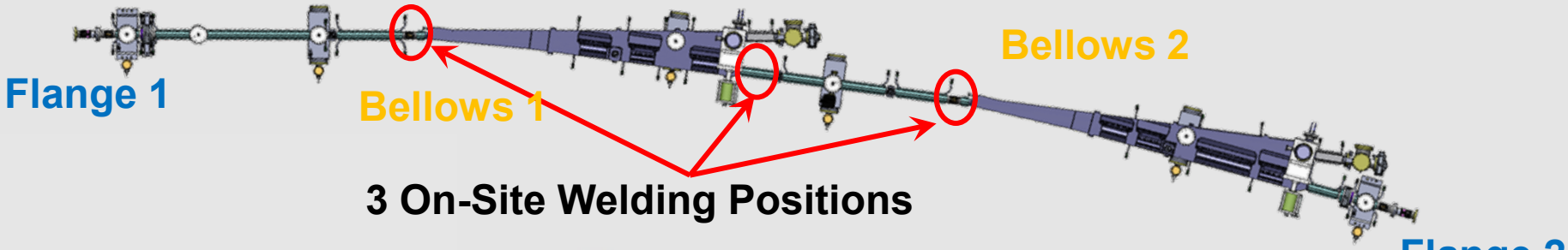
Reduction of Bellows and Flanges

On-site TIG welding the cell chambers (S3-B1-S4-B2) to form a 14 m sector



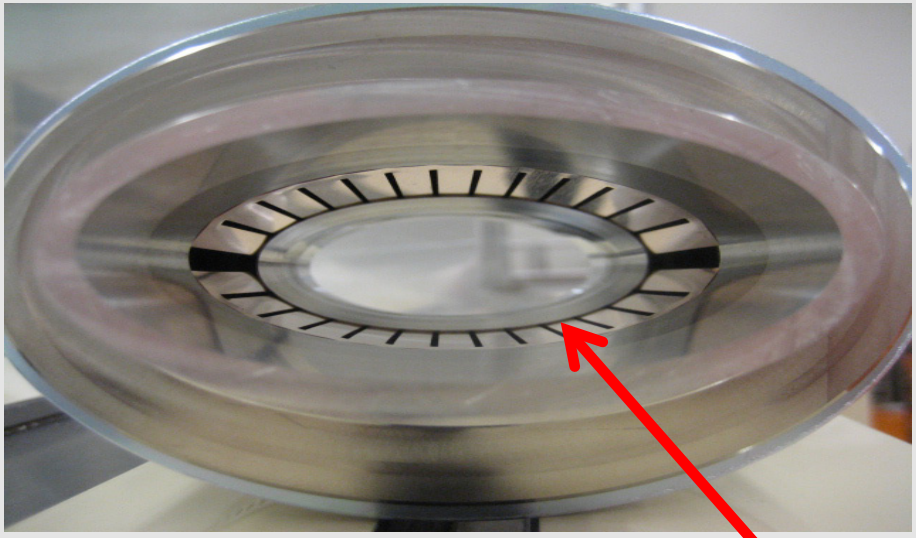
Number of flanges used: 2
Number of bellows used: 2

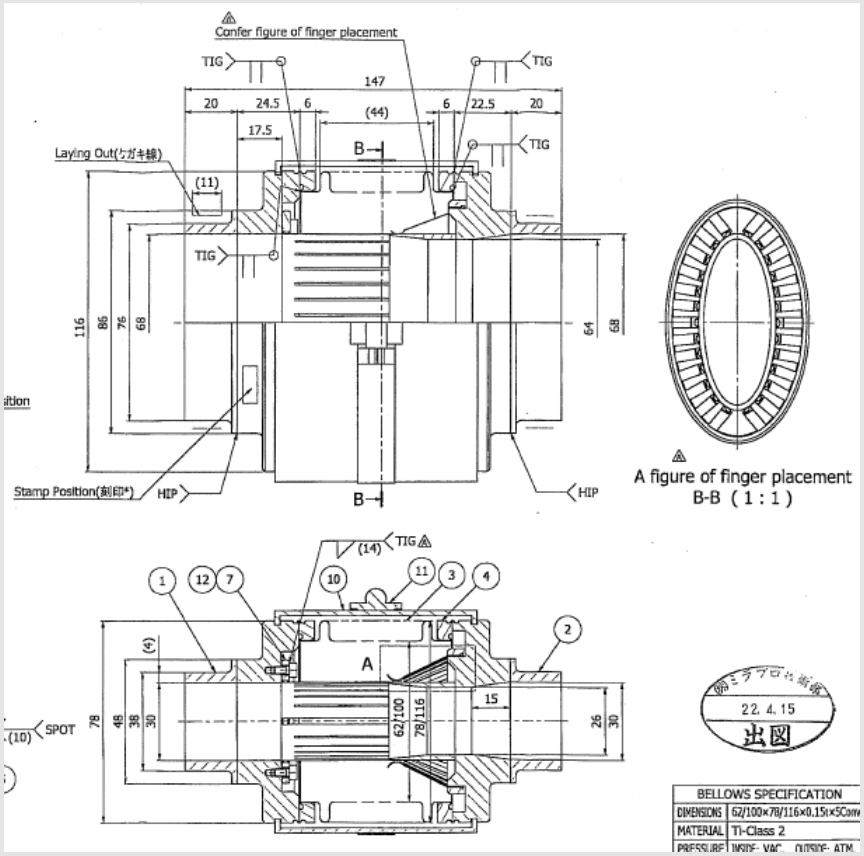




Al/Ti Bellows with RF Fingers

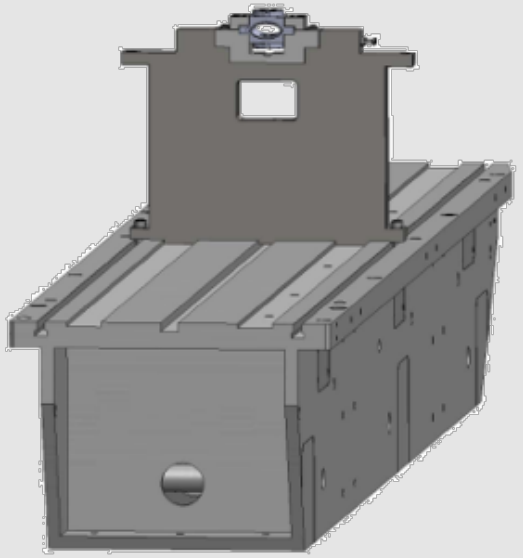
- Ti Bellows with RF fingers
- Al/Ti HIP transition materials for welding to the Al chambers directly





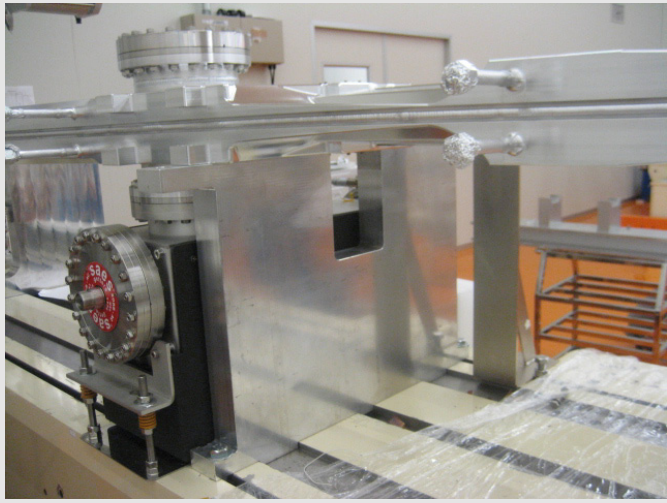
4. How to Eliminate Deformations ?

- TPS magnet and vacuum chamber is individually supported on the girders.



- In order to stabilize BPM position, all BPMs are mounted on a rigid support.

- Solutions for low deformation due to thermal expansion :
  - ✓ Strong supports for the BPM fixed on the girders to position the BPM precisely. BPM shift < 0.3 micron against the thermal stress.



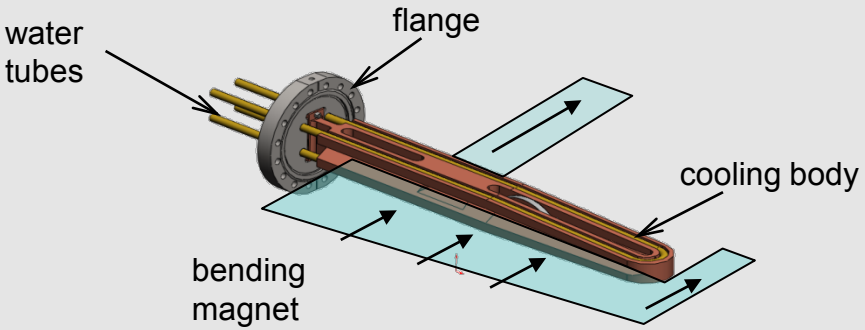
5. How to Manage Thermal Loads ?

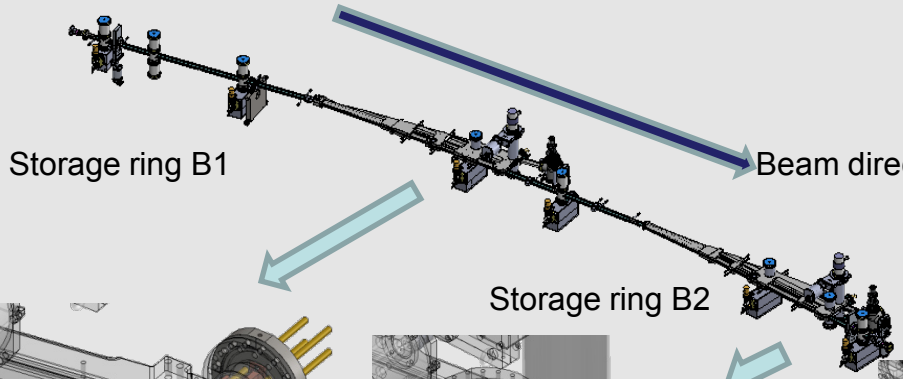
- Vacuum chamber must withstand the radiation loss (7.11 kW per dipole, about 54.3 W/mrad).

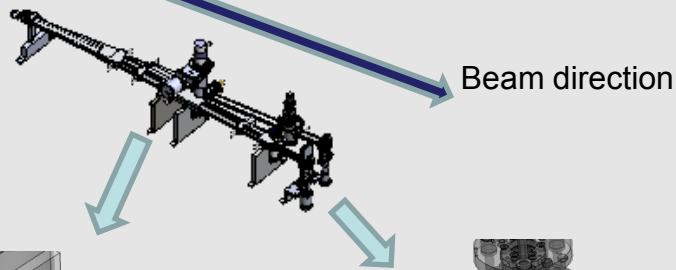
- Solutions for thermal loads:
  - ✓ Crotch absorber (takes away 80% of heat load)
  - ✓ Cooling water channel embedded

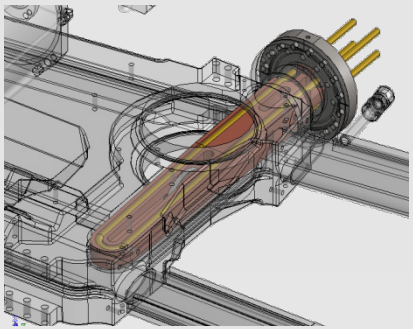
Crotch Absorber Installation

Crotch Absorbers

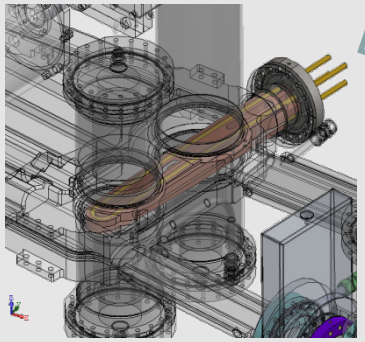




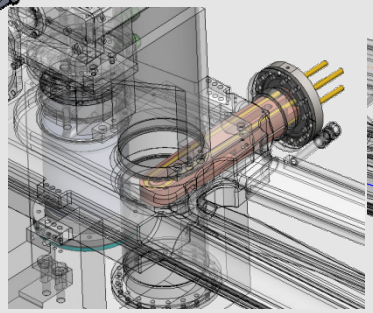




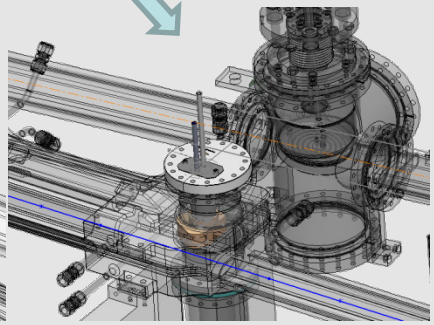
B1 crotch absorber



B2 crotch absorber

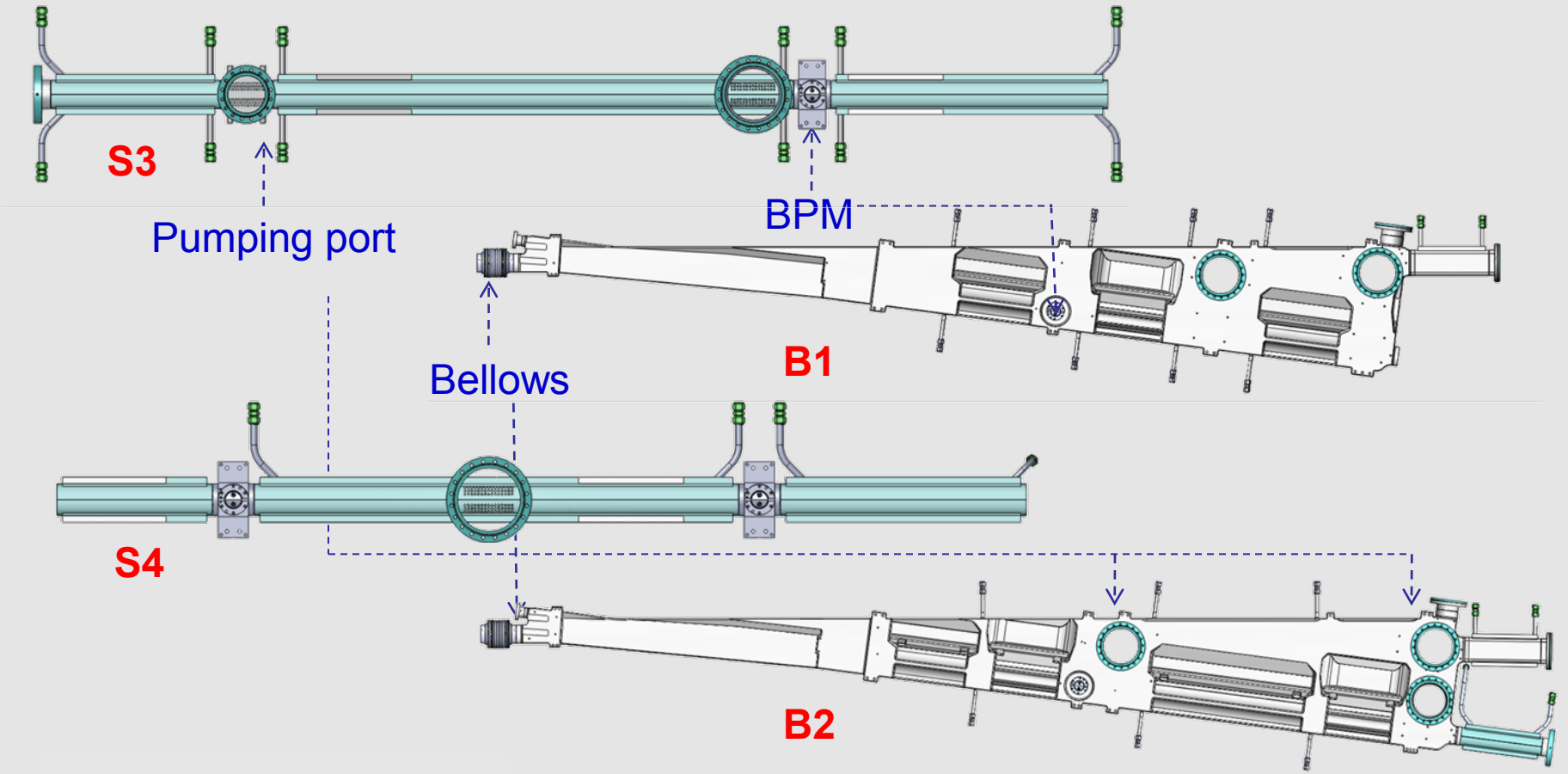


B3 crotch absorber

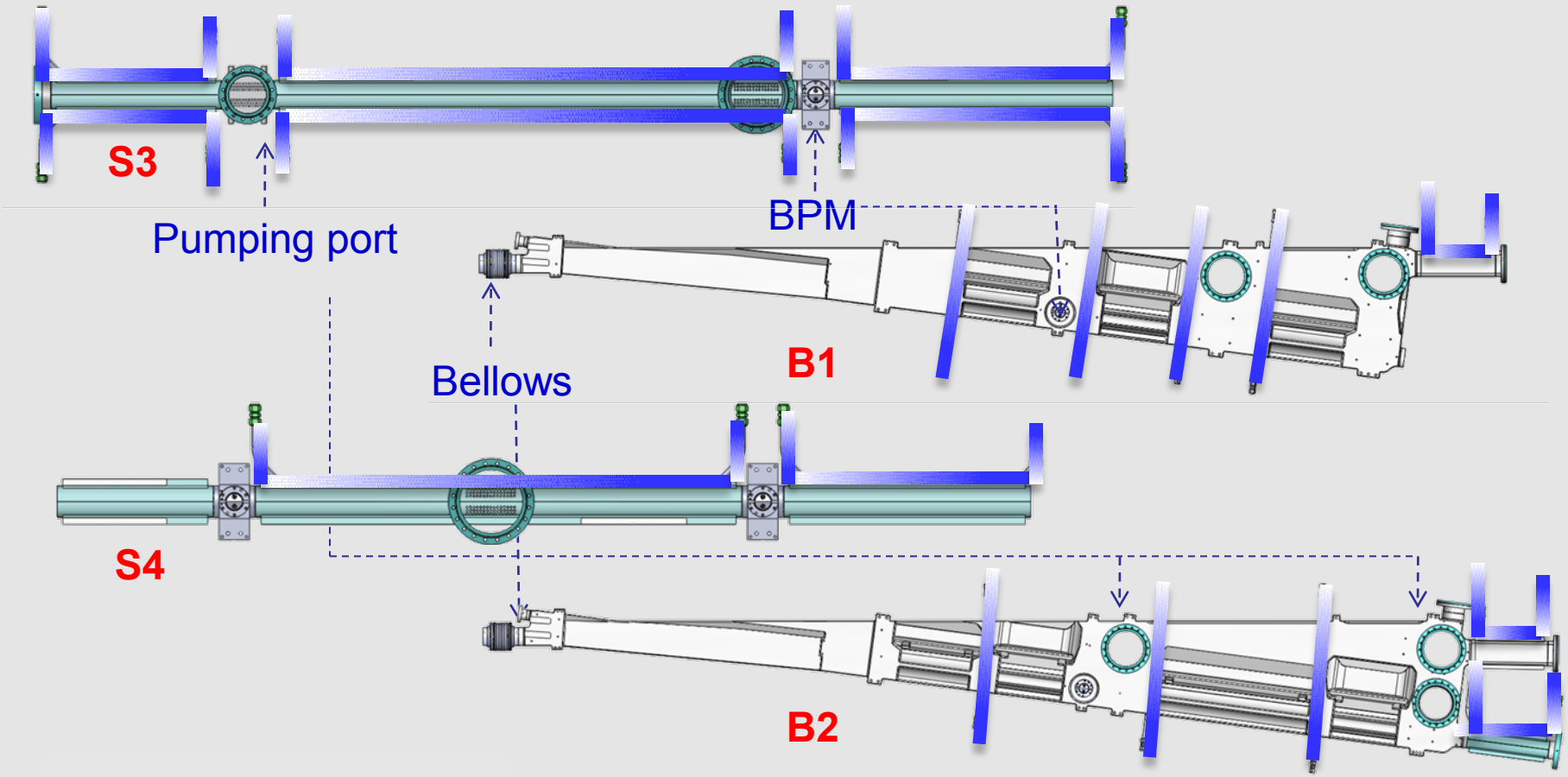


End absorber

Cooling Water Channel Embedded



Cooling Water Channel Embedded

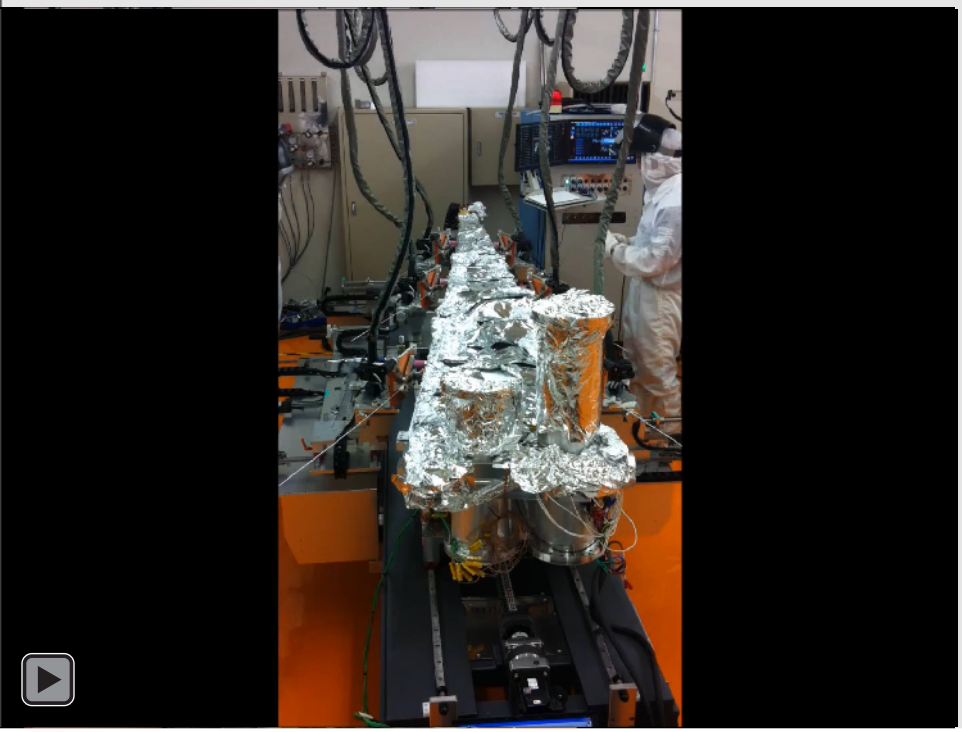


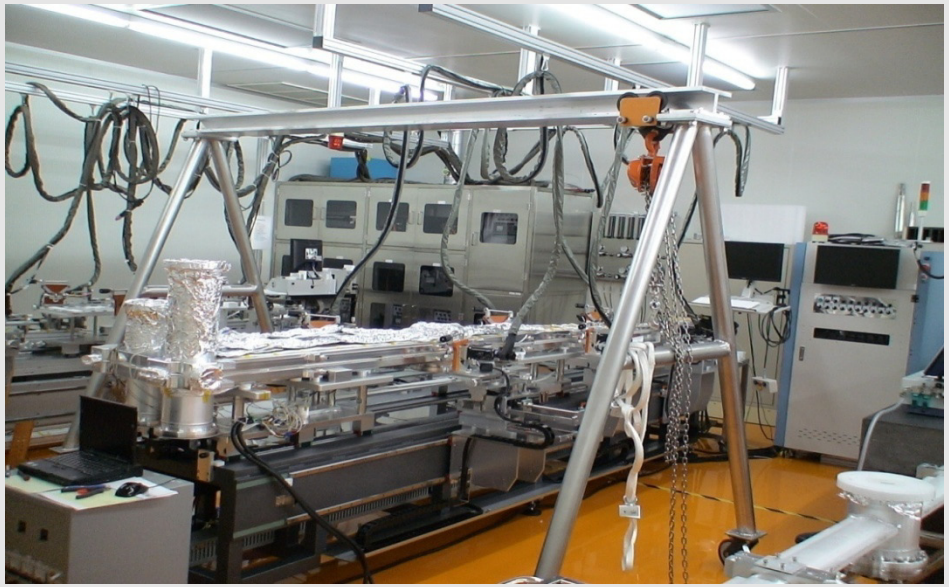
6. How to Improve Manufacturing Processes ?

- Tools have been used to improve the manufacturing processes.

- Solutions for two areas:
  - ✓ Automatic welding system for replacement of manual welding
  - ✓ 14-meter transport carrier for reduce the maintenance time inside the tunnel

Automatic Welding System



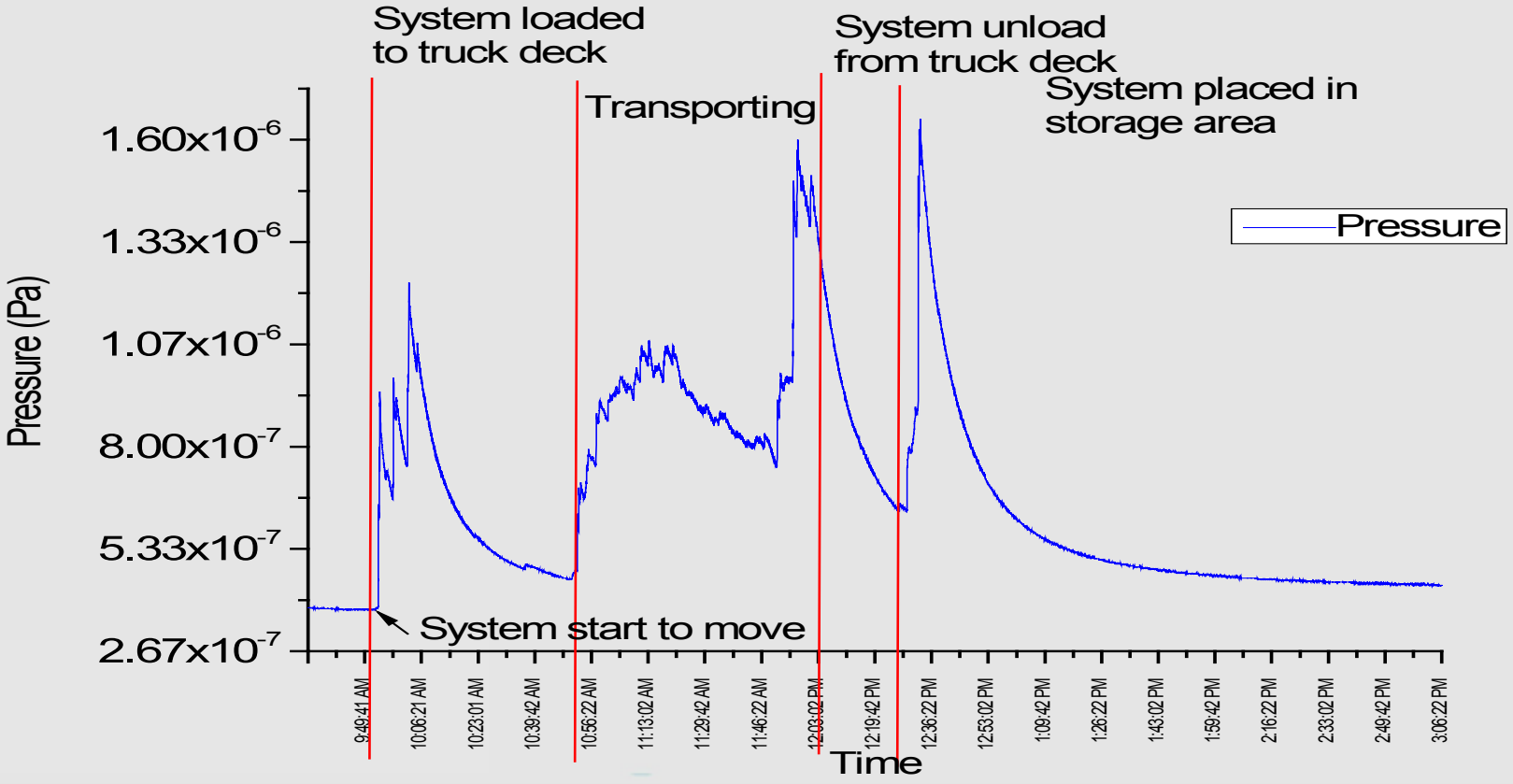


14-Meter Transport Carrier

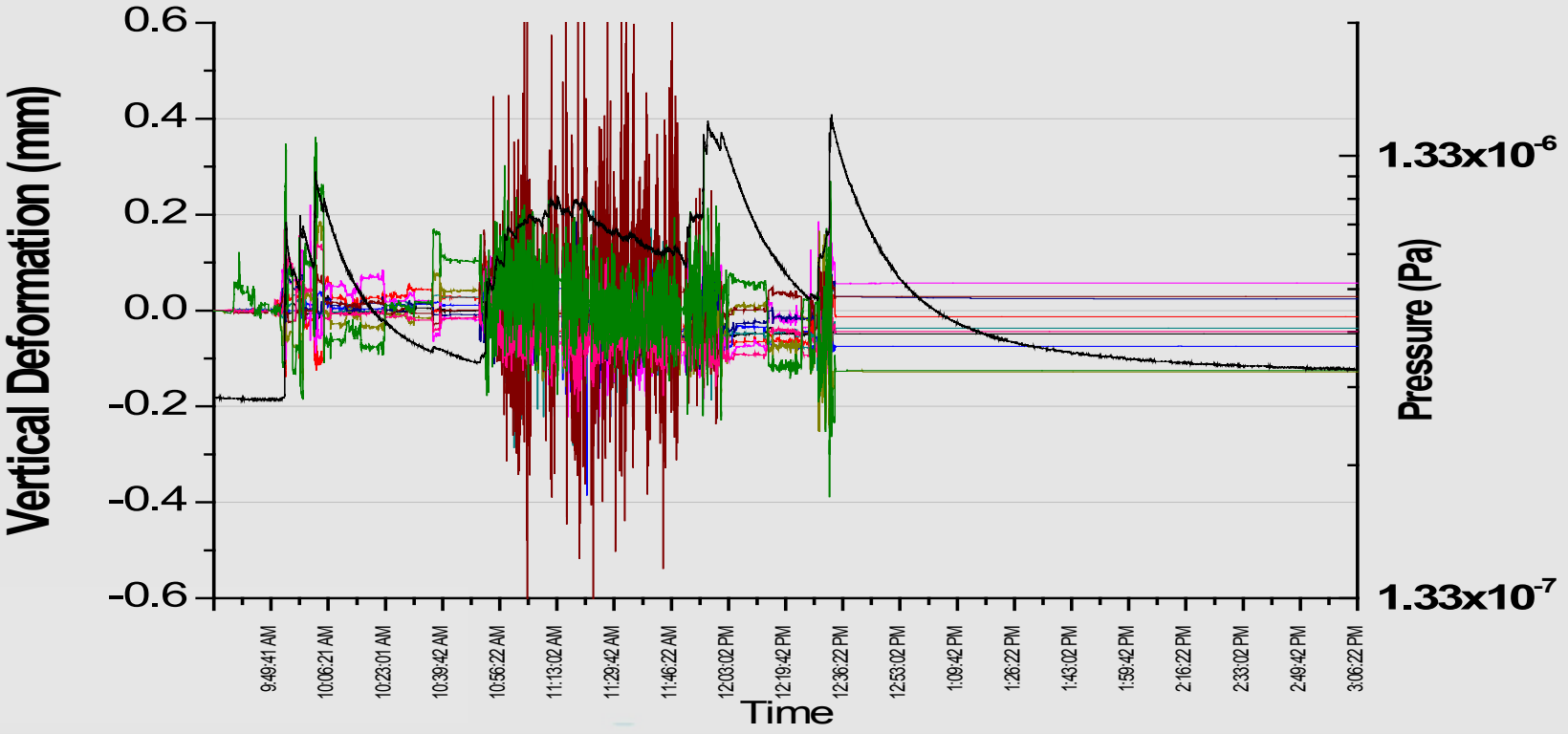
Transportation test of a 14 m cell vacuum system (after baking and sealed)

Limited speed:
10 km/hr

14-Meter Transport Carrier



14-Meter Transport Carrier



Conclusion

These designs features for TPS vacuum system have been described:

- ☑ How to obtain a good UHV system ?
- ☑ How to design a proper pumping configuration ?
- ☑ How to design low beam impedance ?
- ☑ How to eliminate deformations ?
- ☑ How to manage thermal loads ?
- ☑ How to improve manufacturing processes ?

The unit-cell vacuum system can be completely assembled every three weeks, and all 24 cells are expected to be completed by the end of year 2012.

Thank you for your attention!!

Q & A

Check posters today,
Related information in Tuesday Poster Session, start @ 4 pm --- 6 pm

TUPS029 Development of a Feedthrough with Small Reflection for the TPS BPM

TUPS030 Manufacturing and Vacuum Test of Aluminum Bending Chambers for TPS

TUPS031 The Installation of One 14 Meter Cell of TPS Vacuum System