

Evaporator Status and Mirror Coating Work at SBU

**Wenliang Li (Bill), on behalf of SBU CFNS
June 21, 2024 at SoLID Collaboration Meeting at Argonne**



The Evaporator at SBU



e-Gun

Turbo

Chiller 2

Chiller 1

- **Where did it come from?**
 - Made in INFN
 - Arrived at JLab in 1990s.
 - Came to SBU in early 2000s
- **System consists:**
 - Three pumping stages: rough (10^{-3} Torr), turbo (10^{-6} Torr), cryo (high 10^{-8} Torr)
 - Gauges
 - Electron gun
 - Thickness monitoring system
 - Rotation motor
 - Cooling system
 - ...

The image shows the interior of a vacuum furnace chamber. At the top, a mounting fixture holds several test samples. In the center, a quartz crystal monitor is positioned. On the floor, an electron gun is surrounded by numerous filled crucibles. A small object wrapped in aluminum foil is also visible on the floor. The chamber walls are metallic and feature various ports and fixtures.

Mounting Fixture +
Test Samples

Quartz Crystal
Monitor

Electron gun +
filled crucibles

Where are we? How ready are we?

- **Water cooling system Stability** ✓

- 24 hour continuous operation

- **Vacuum quality** ✓

- 3×10^{-6} Torr (current configuration limit)

- **Tape stability** ✓

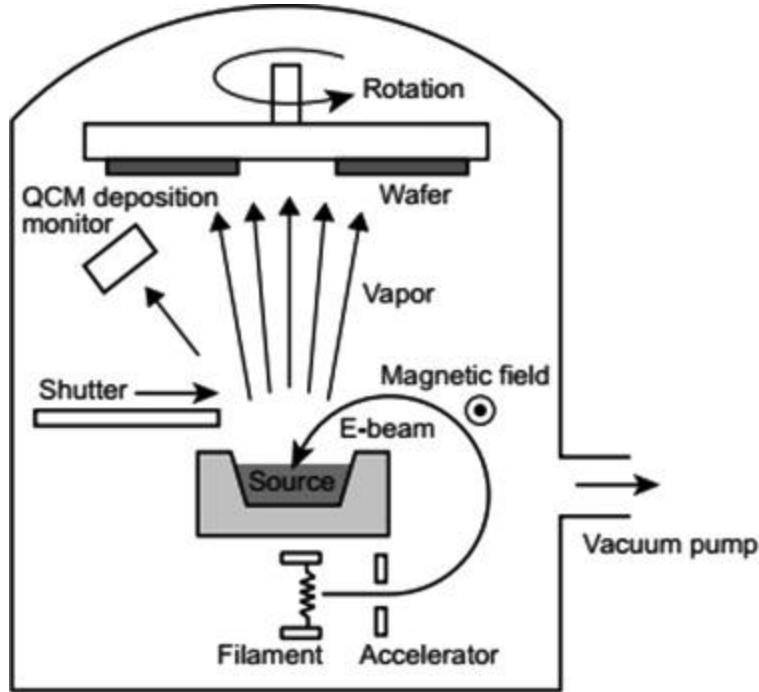
- Stickiness and outgassing test

- **Rotation Motor** ✓

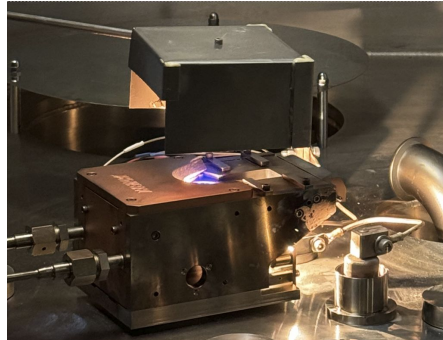
- Continuous 1 hour operating ~ 1 rev/s



How does an evaporator work?



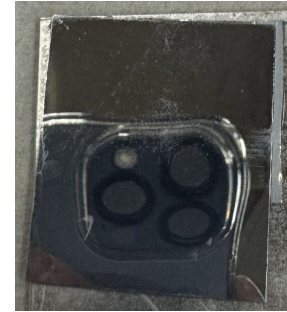
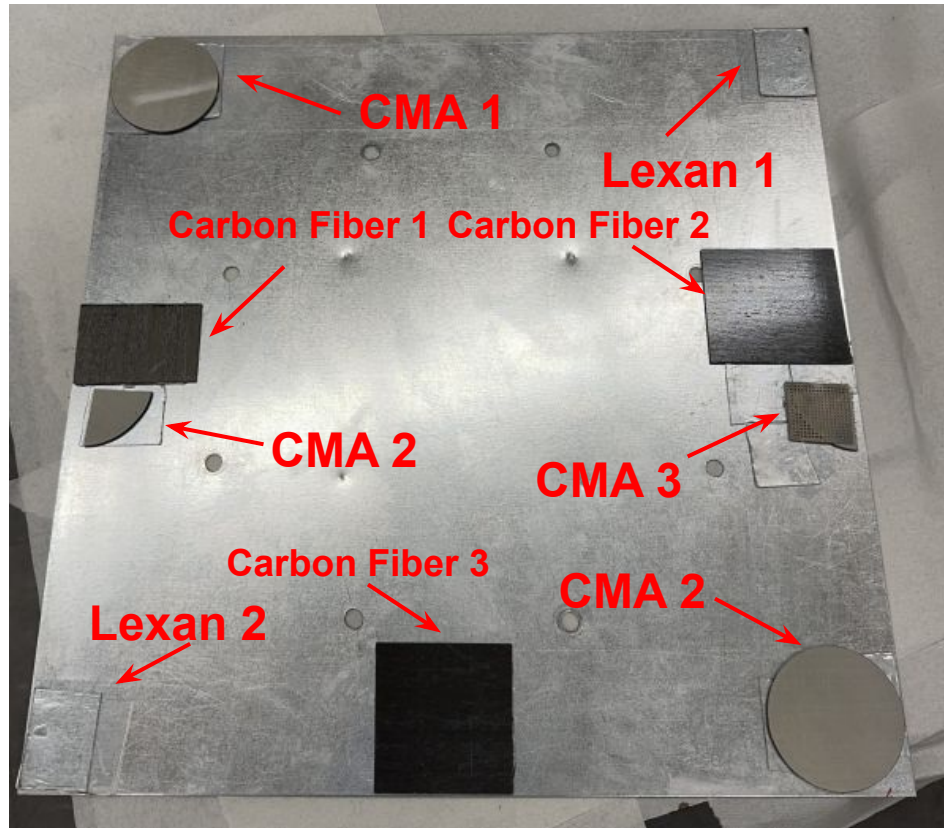
- **Substrate mount**
- **Pump down (6 hours)**
 - **Vacuum: 10^{-6} Torr**
- **Ramp the electron gun (20 mins)**
 - **6.6kV @ 100 mA**
- **Evaporate**
 - **Cr as primer base (100 nm in 10 mins)**
 - **Al (300 nm in 30 mins)**



Coated samples from 2nd Evaporation



Surface roughness:
200 nm (ISO N4
polished surface)

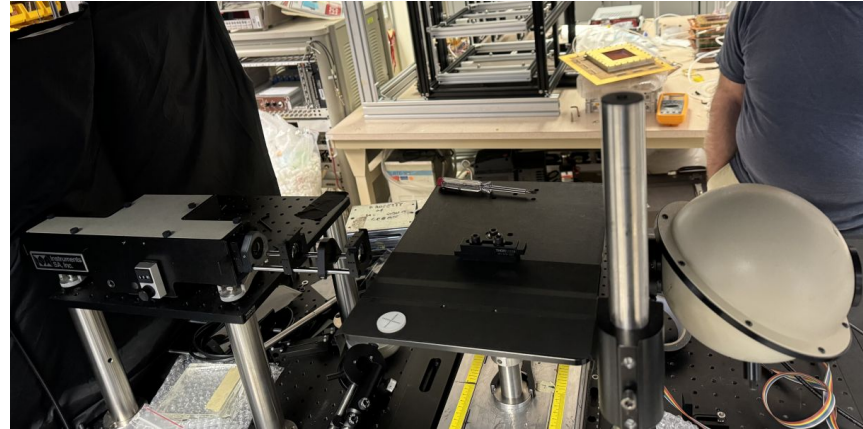


Surface roughness:
20 nm (ISO N1 polished
surface)



Timeline

- **2023 Summer, Preparation and equipment refurbishment**
- **2023 Nov, first coating, reflectivity ~75% at 300 nm**
- **2024 March, coating #7, reflectivity ~90% at 300 nm with small samples**
- **2024 Summer upgrade: ion source installation, mounting scheme.**
- **2024 Oct, Mirror characterization setup and test at Mississippi state**
- **2025 Summer upgrade: cryopump installation and commission**
- **2025 Transferring mirror characterization setup to SBU**



Evaporation Condition for Different Requirement

Requirement	SoLID LGC	ePIC dRICH	SoLID HGC	ePIC pfRICH
Wavelength	> 180 nm	> 200 nm	> 220 nm	> 300 nm
Vacuum	High 10^{-8} Torr (Cryopump)			10^{-6} Torr
Material	Cr + Al + MgF_2			Cr + Al
Substrate heating	Yes, 300°C			Not needed
Surface smoothing	Ionized Gun			Ionized Gun
	Beyond current capability			

Documentation, monitoring, prediction and Q&A

- Estimating the evaporation depth


$$\Phi_e = \frac{\alpha_e N_A (P_v - P_h)}{\sqrt{2\pi MRT}}$$

- Depth measurement at SBU











- Smooth measurement
- Documentation: a dedicated elog server
 - <https://elog.cfnsbu.physics.sunysb.edu>

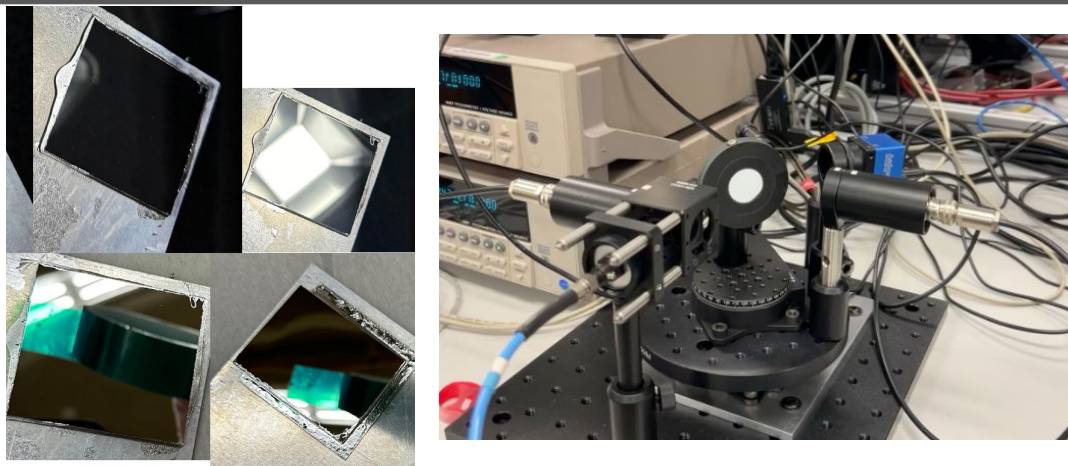
Welcome to the CFNS Logbook



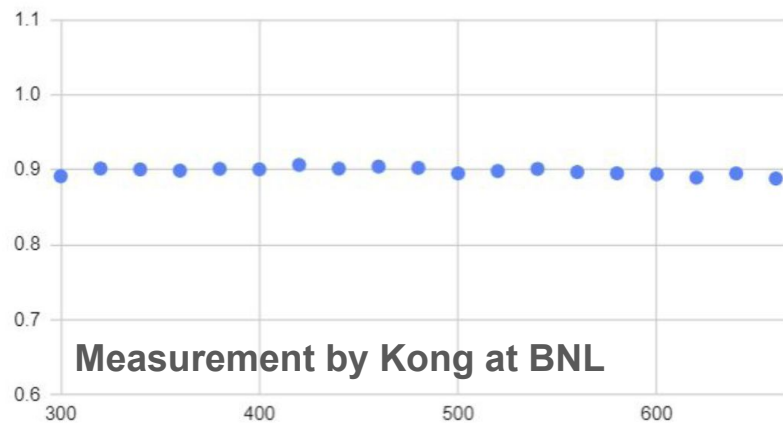
**Center for Frontiers
in Nuclear Science**

Logbook	Entries	Last submission
General CFNS  General CFNS Operation	10	Sat Dec 2 18:57:50 2023 by bill
Moller  Moller Experiment R&D	15	Tue Nov 21 17:44:39 2023 by Sourav T
SoLID  SoLID Experiment R&D	21	Thu Nov 30 14:32:15 2023 by Pre
pFRICH  EIC pFRICH R&D	6	Wed Nov 15 10:12:00 2023 by Muqing
DIRC  EIC DIRC R&D	8	Wed Nov 8 10:34:33 2023 by Nathan Sh
Generic ePIC  Generic EIC ePIC R&D	0	-
2nd IR  EIC 2nd Detector R&D	0	-
Pioneer  Pioneer experiment at PSI	0	-

Mirror Reflectivity Characterization

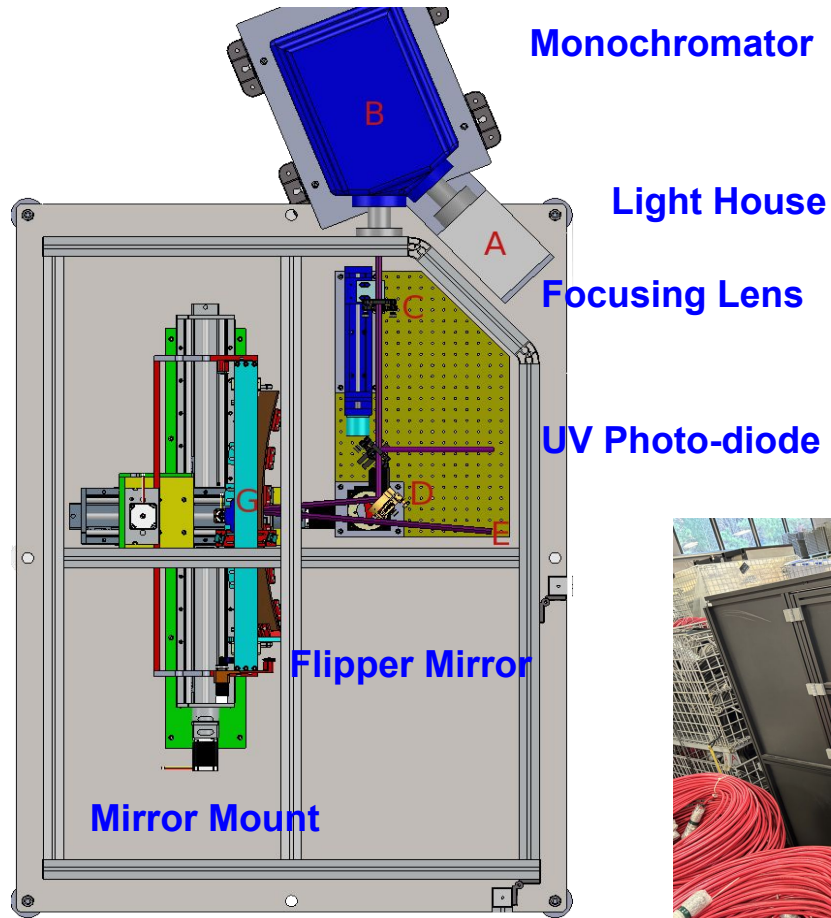


Evap. #7 ("THICK")



- Measurement performed by Kong, Sean at BNL (March 11, coating # 11)
- Winning recipe:
 - Thinner Cr (<50nm)
 - Thick Al (2-3 layers of 200nm)
 - Leave samples in chamber overnight
- Reflectivity 90% at 300 nm (achieved requirement for the pfRICH)

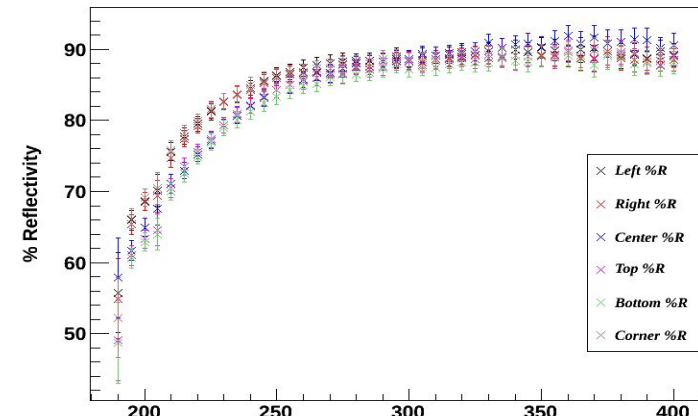
Mirror Characterization at $< 200\text{nm}$



- Current status: parked at ESB building at JLab
- Negotiated equipment loan: monochromator from WM, setup from JLab, lock-in amplifier from Shukui
- Need to transported to Mississippi State for refurbishment work

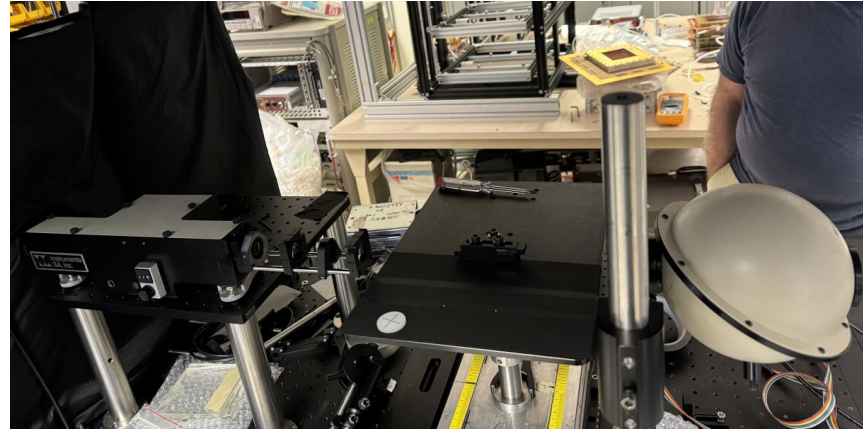


Mirror #8 % Reflectivity



Timeline

- 2023 Summer, Preparation and equipment refurbishment
- 2023 Nov, first coating, reflectivity $\sim 75\%$ at 300 nm
- 2024 March, coating #7, reflectivity $\sim 90\%$ at 300 nm with small samples
- 2024 Summer upgrade: ion source installation, mounting scheme.
- 2024 Oct, Mirror characterization setup and test at Mississippi state
- 2025 Summer upgrade: cryopump installation and commission
- 2025 Transferring mirror characterization setup to SBU



Next Small Step

- **Gradual improvements towards MgF_2 coating**
 - Installing ionized Gun
 - Heat test: Can the substrate take heat? How to cool down?
 - Coating PETG
 - Installing the heater

What do the mirror project need?

- **Low wave coating requires cryopump**
 - Equipment coat: \$56k
 - Student labour

- **Mirror test setup ground transportation**
 - Equipment refurbishment: \$23k
 - Student labour

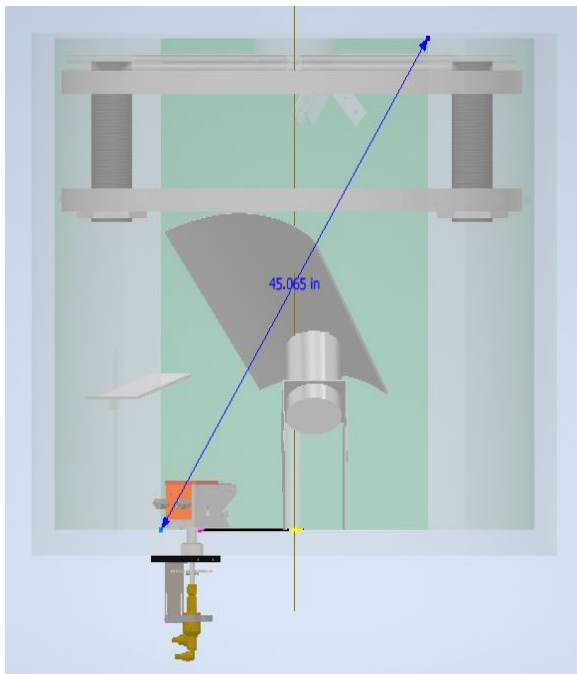
Acknowledgement

- **Stony Brook team: Charles (postdoc), Jaydeep (postdoc), Kong Tu (BNL staff scientist), Preet Mann (undergraduate), Muqing Wang (undergraduate).**
- **Thanks to the help from sPhenix colleagues from SBU: [Ross Corliss \(SBU contact person\)](#), Vassu Doomra (Ph.D. student).**
- **Thanks to the help from former CFNS members: Klaus and Prakhar.**

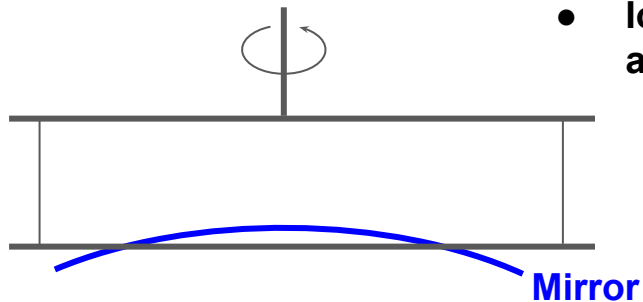


To-do List

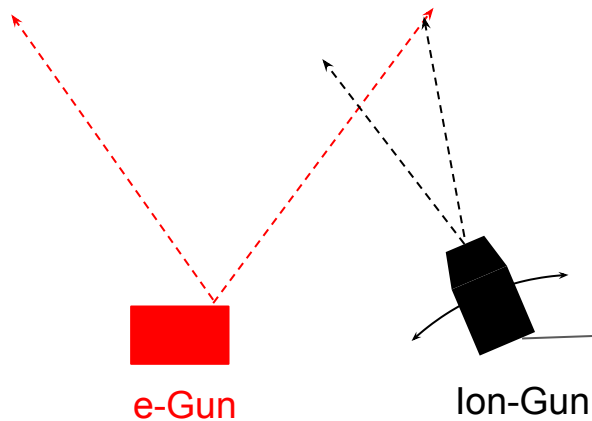
A Clean Space for Staging and Mount/Dismount Mirrors



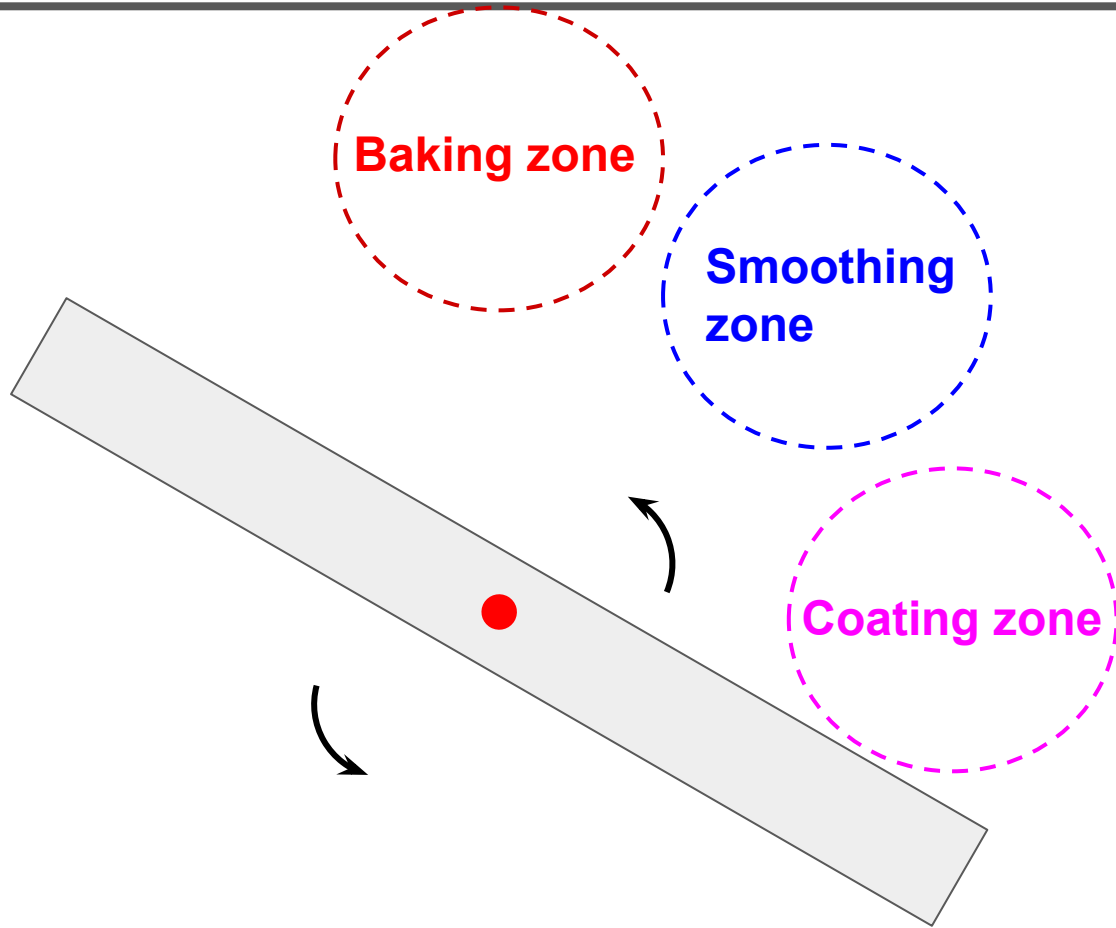
Rotating axel



- **Ion source required pitch adjustment under high vacuum**
 - A remote control vacuum compatible stage is a must for large size mirrors
 - Thanks to mirror rotation, yaw angle is not needed



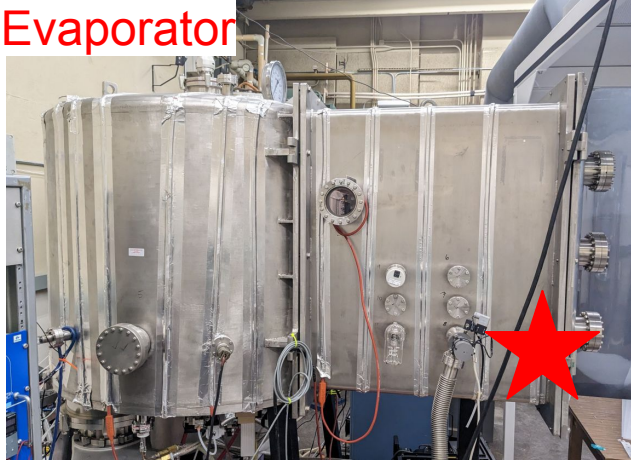
A Cartoonish view on deposition process



Sample Surface Roughness

Facility at SBU

Evaporator



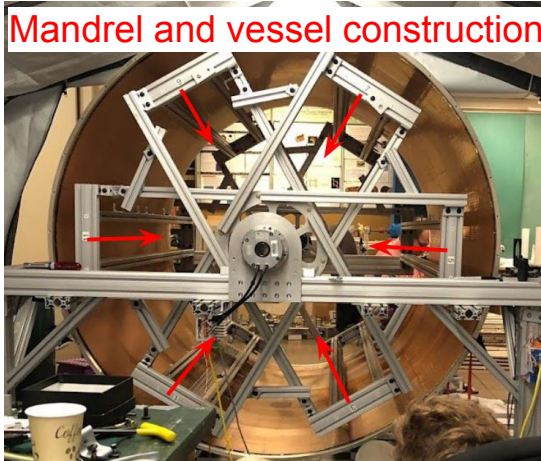
GEM Facility



Additional High bay area



Mandrel and vessel construction



A special gratitude to Klaus in setting up many of these facility