MEBT Water to Vacuum Leak

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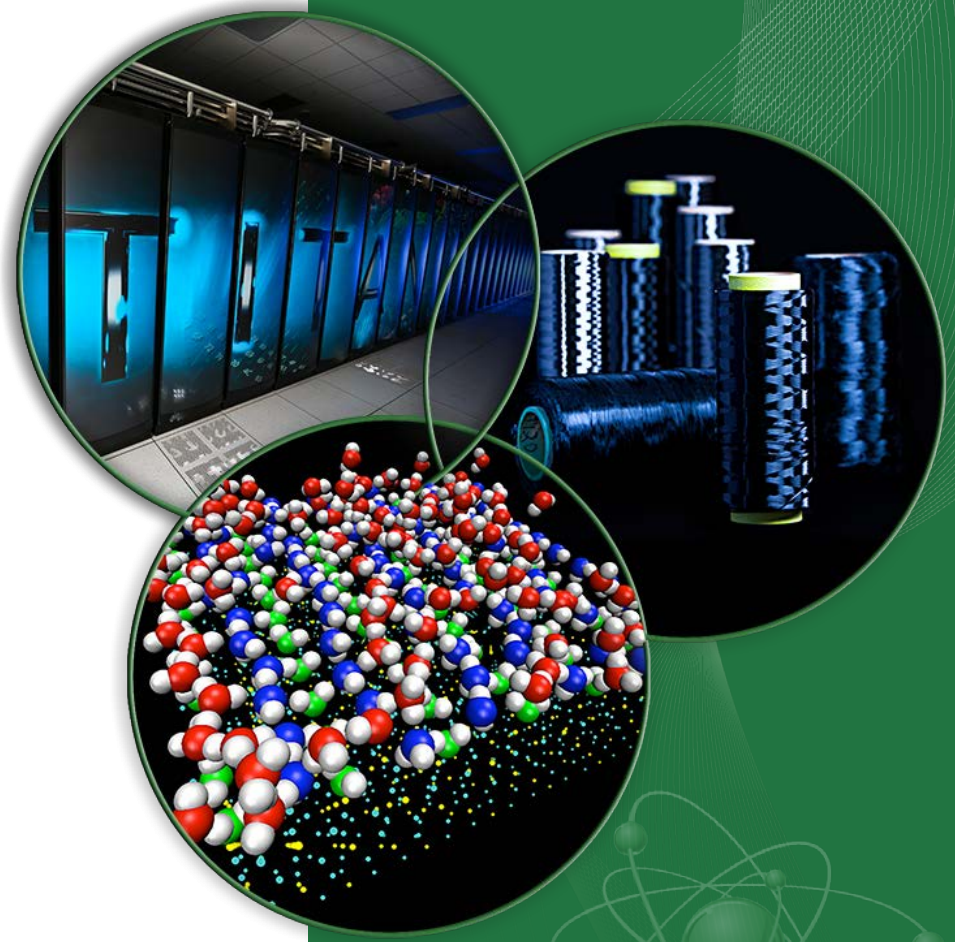
SNS Operations



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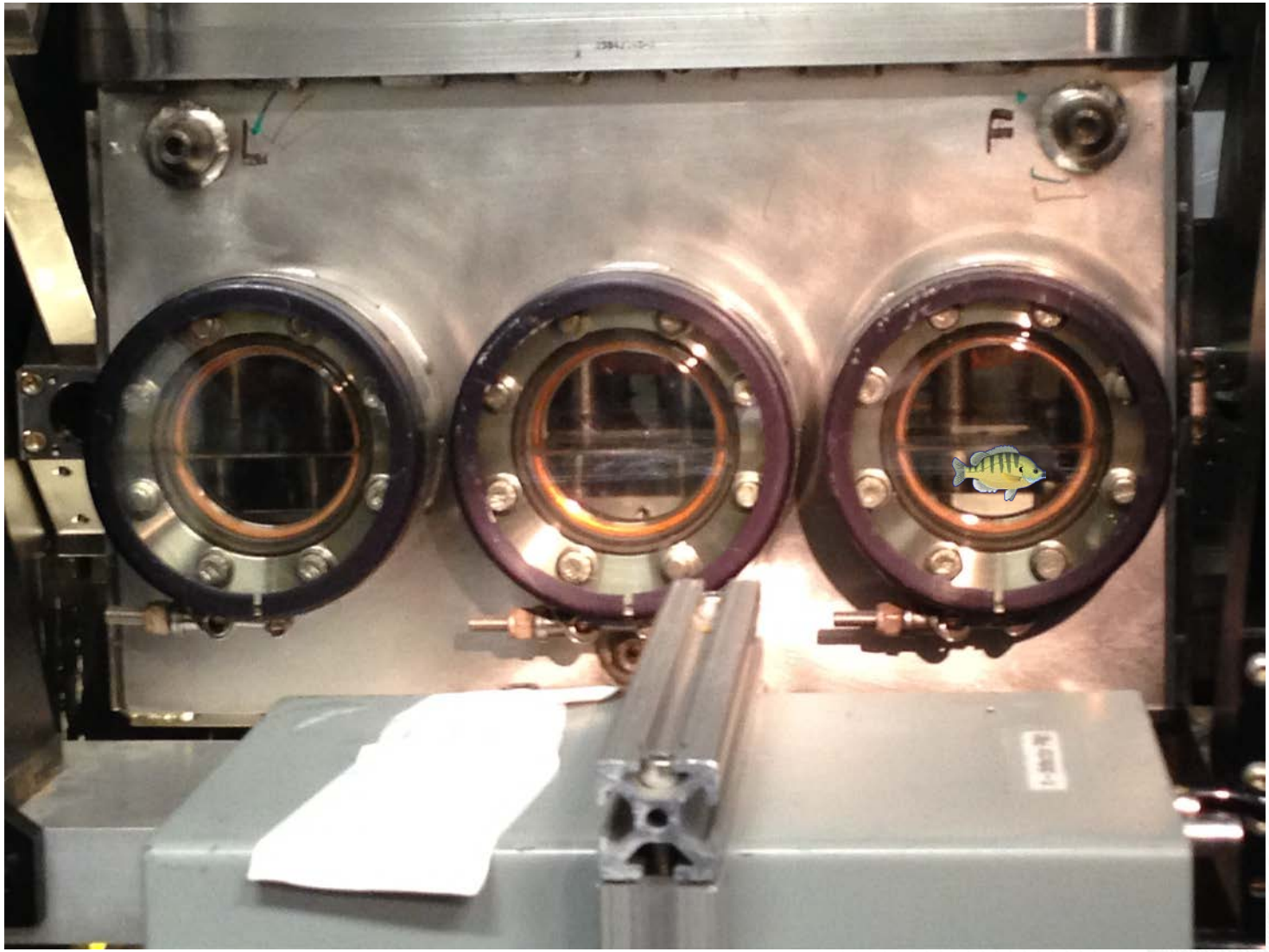
On 15 Sep 2014...

- Accelerator off for unplanned target change
- Routine maintenance and RF conditioning in progress
- Events quickly became non-routine at 12:28

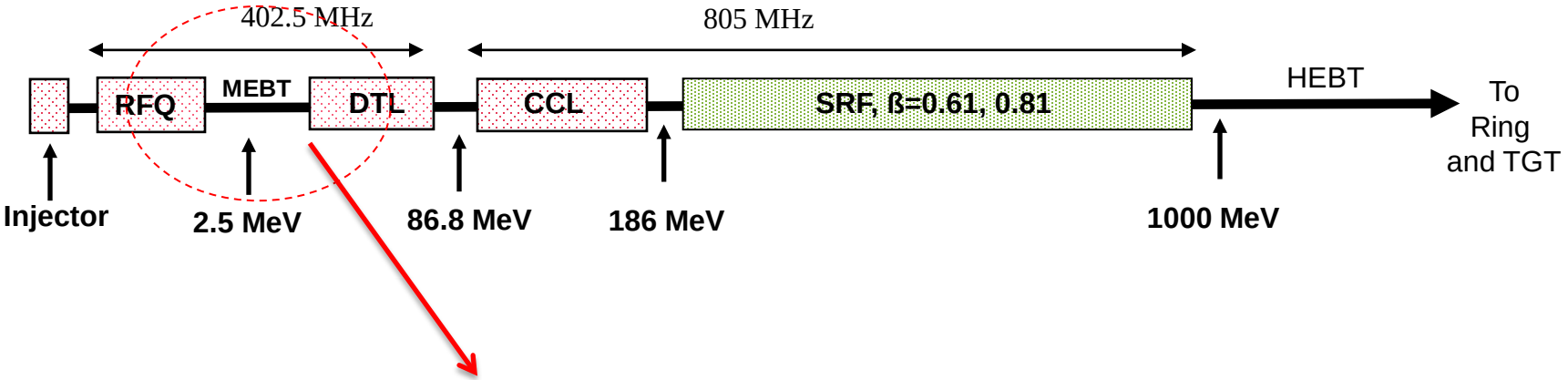
Operator Response to Alarms

- 12:28 – Vacuum alarms from front end
- 12:29 – Water system alarms from front end
- Investigating vacuum remained top priority for ops.
- Water techs were called about water system.
- When report of water leaking onto floor near beampipe came in, operators shut off water system (15 minutes)
- Water to vacuum leak is (thankfully) an extremely rare occurrence!

Uh-oh!



MEBT Layout



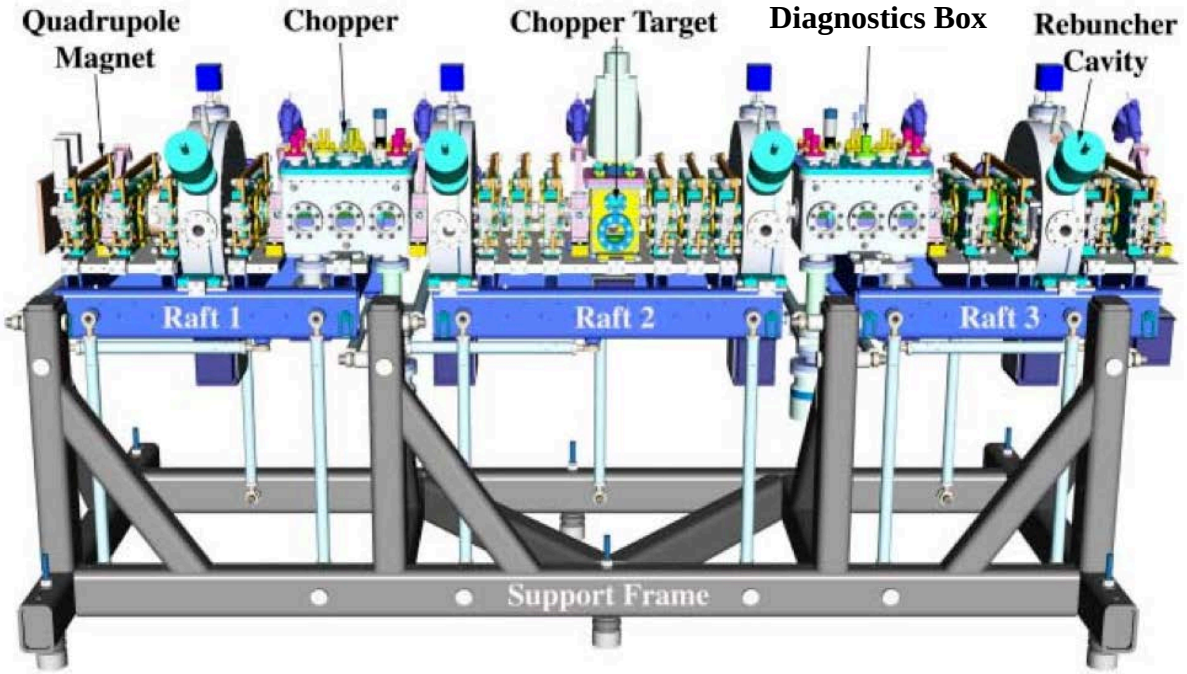


Figure 1: The MEBT beamline layout.

MEBT Layout

- Arrived pre-assembled from LBNL
- No as-built drawings, no people involved in assembly at SNS

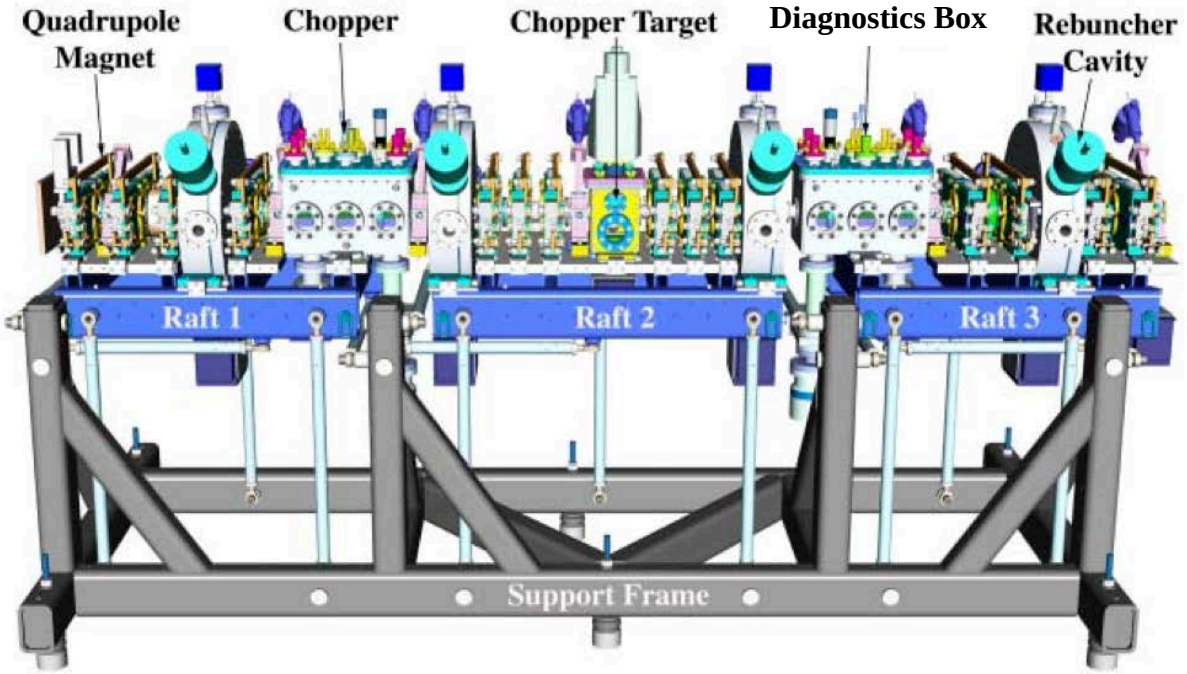
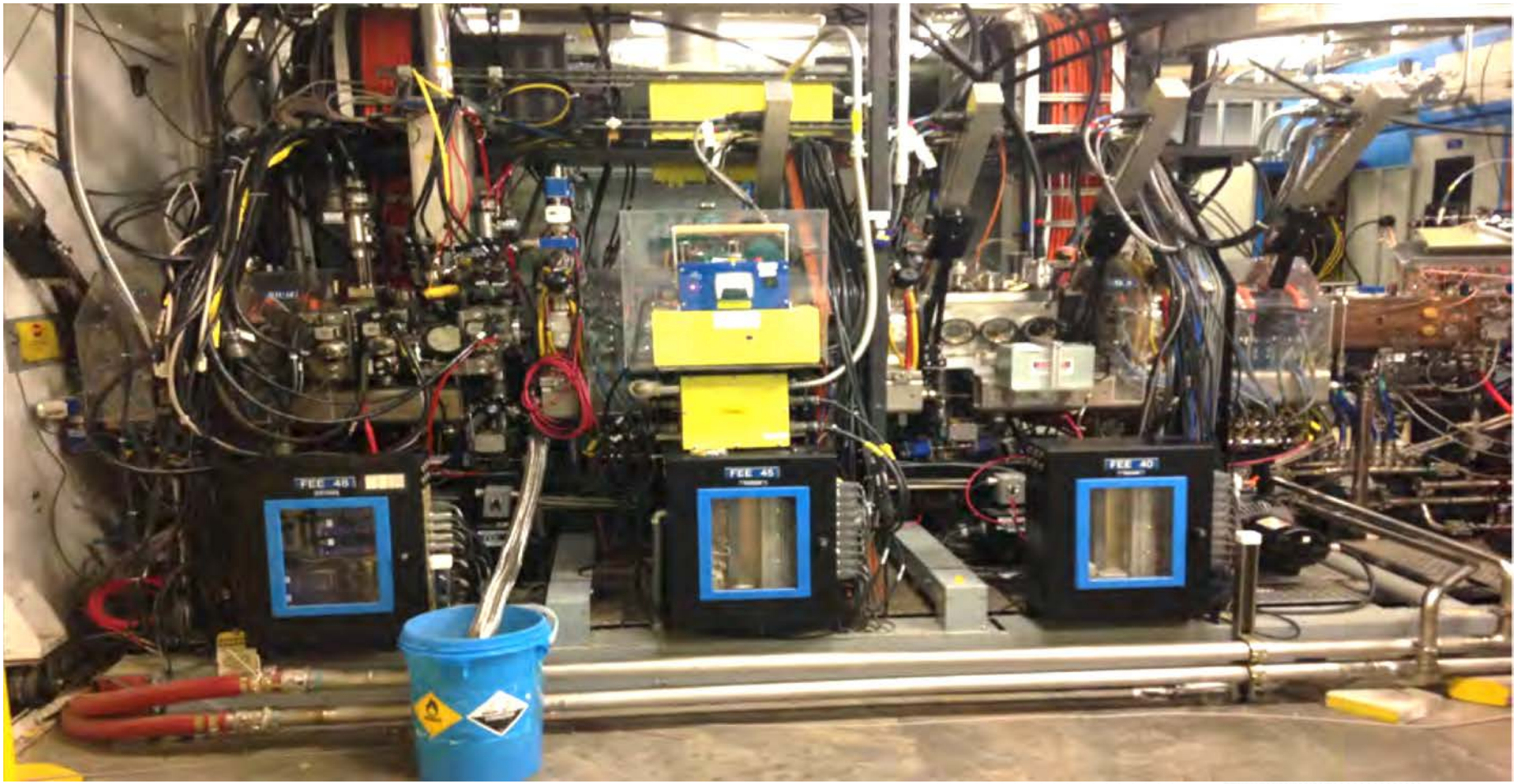


Figure 1: The MEBT beamline layout.

MEBT Before Disassembly



Safety

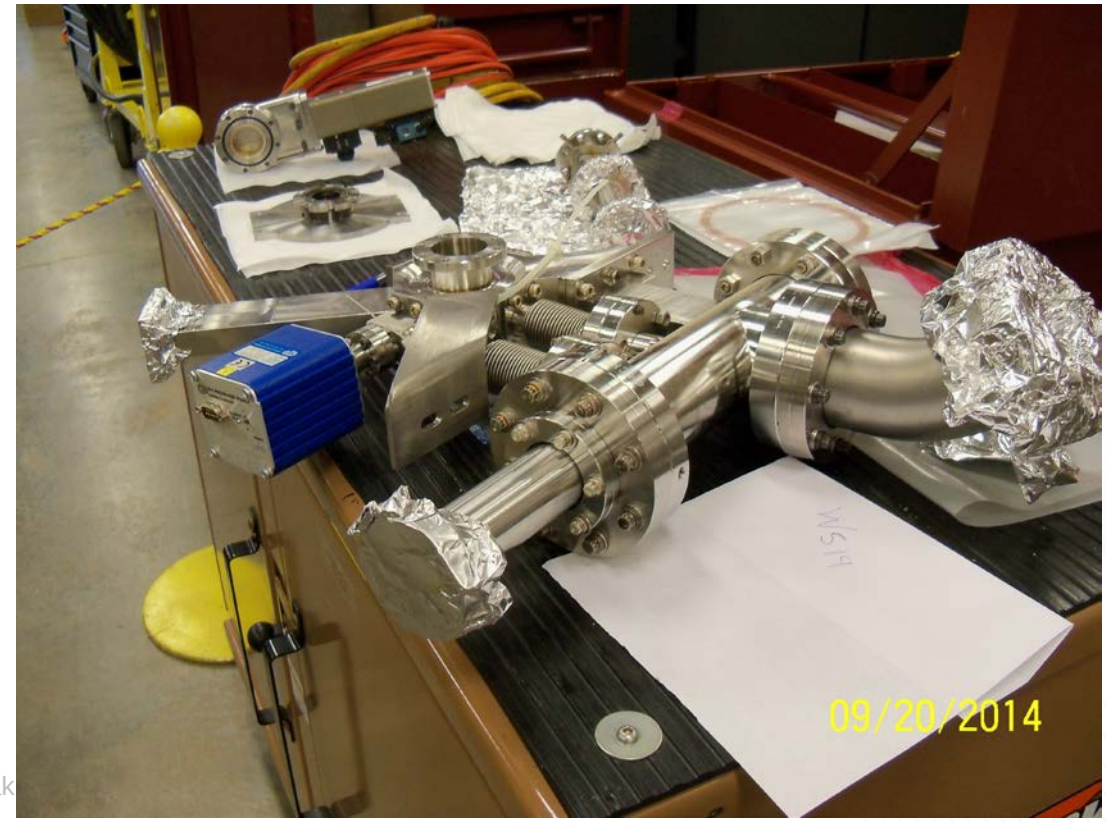
- Initial response: immediate action! Vacuum and water groups already on site.
- RAD division director paused work, even with water present in the structure, to permit a careful hazard assessment and development of an energy control and LO/TO plan to mitigate the hazard.

Safety

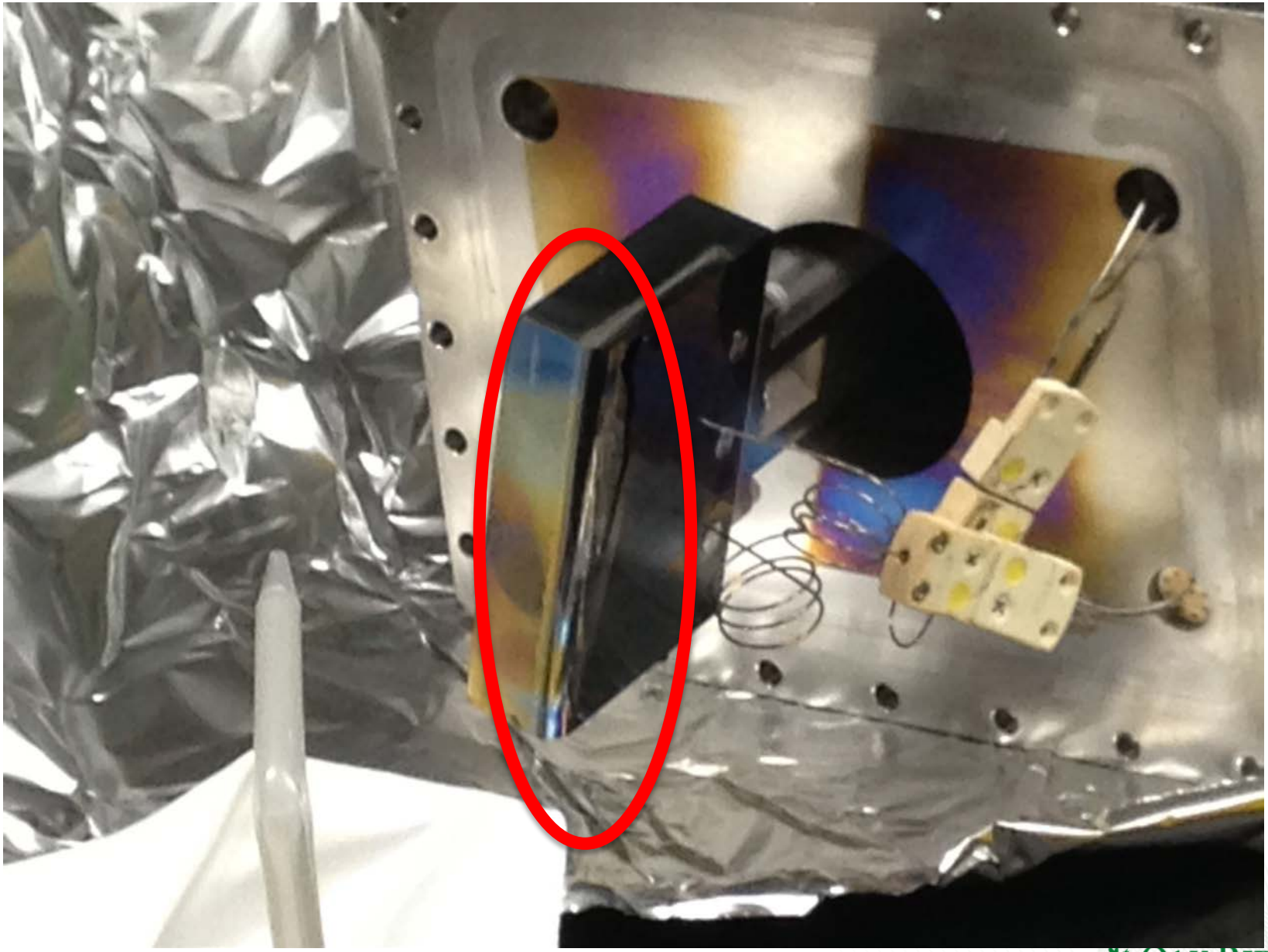
- LOTO: Examined all unusual sources of energy that could arise from water in the beam pipe. Changed LOTO as required to support work.

Safety

- Radiation: Initial survey of water found no issues. Buffer area established near work zone to store parts. Surveyed parts if removed from buffer area.



Chopper Target Failure



Chopper Target Design

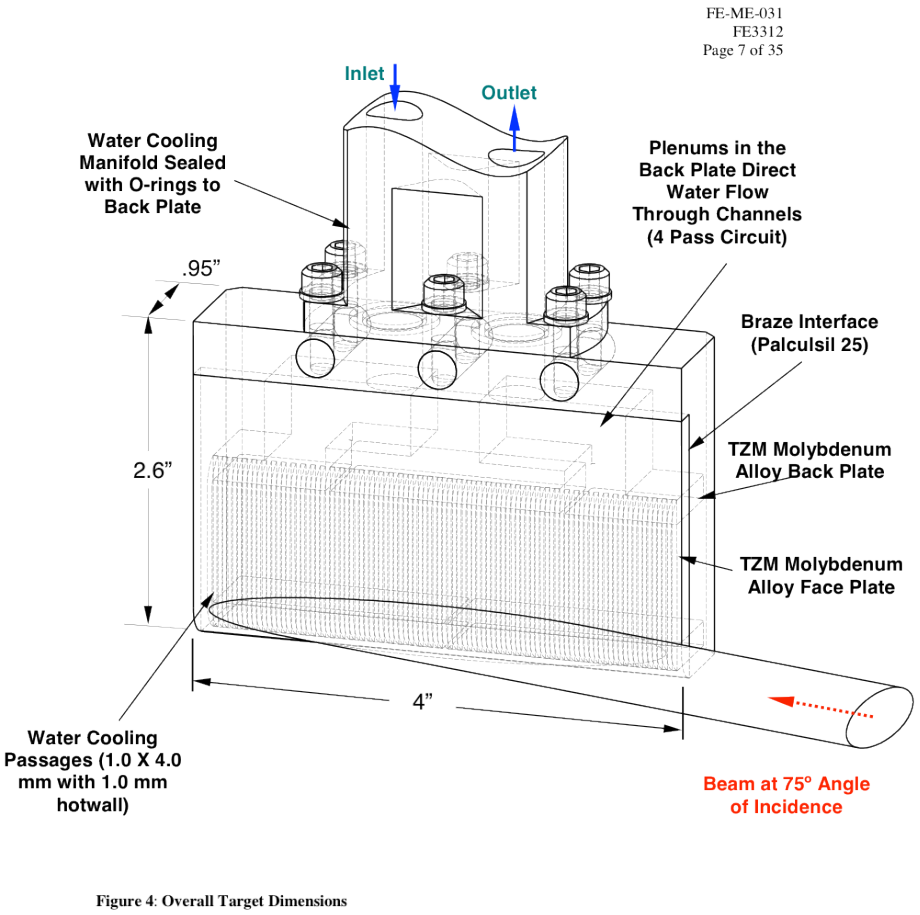


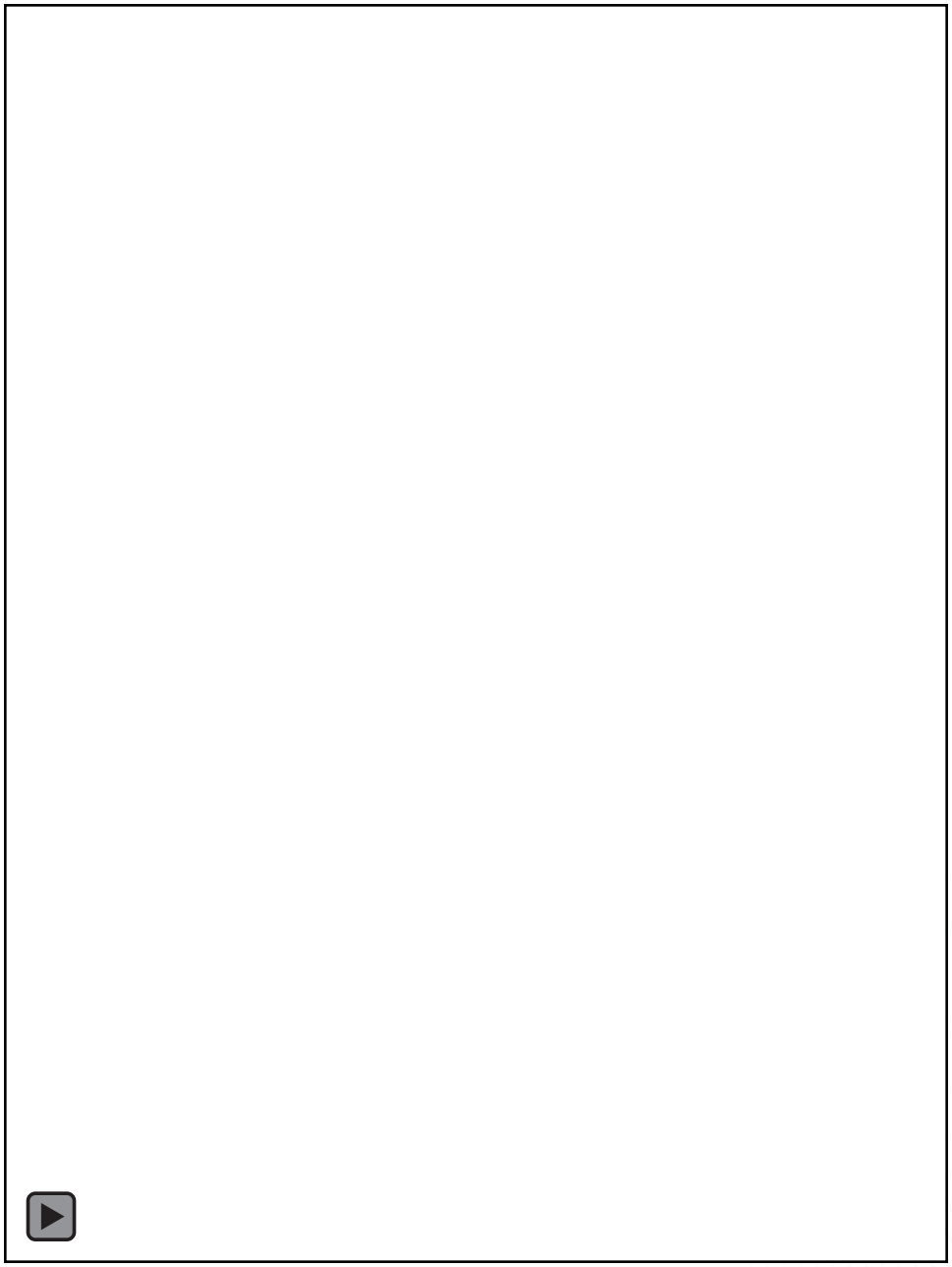
Figure 4: Overall Target Dimensions

- Front plate: TZM (molybdenum alloyed with titanium and zirconium)
- with 0.5 mm water-cooling micro channels
- 1 mm thickness between the water channels and the front plate
- Design max power 500 W
- Beam power in MEBT at 1 MW on target is 2500 W
- Usually scraping 1-2%, < 50 W
- May be the heating-cooling cycles affected the front plate + “hydraulic hammer”

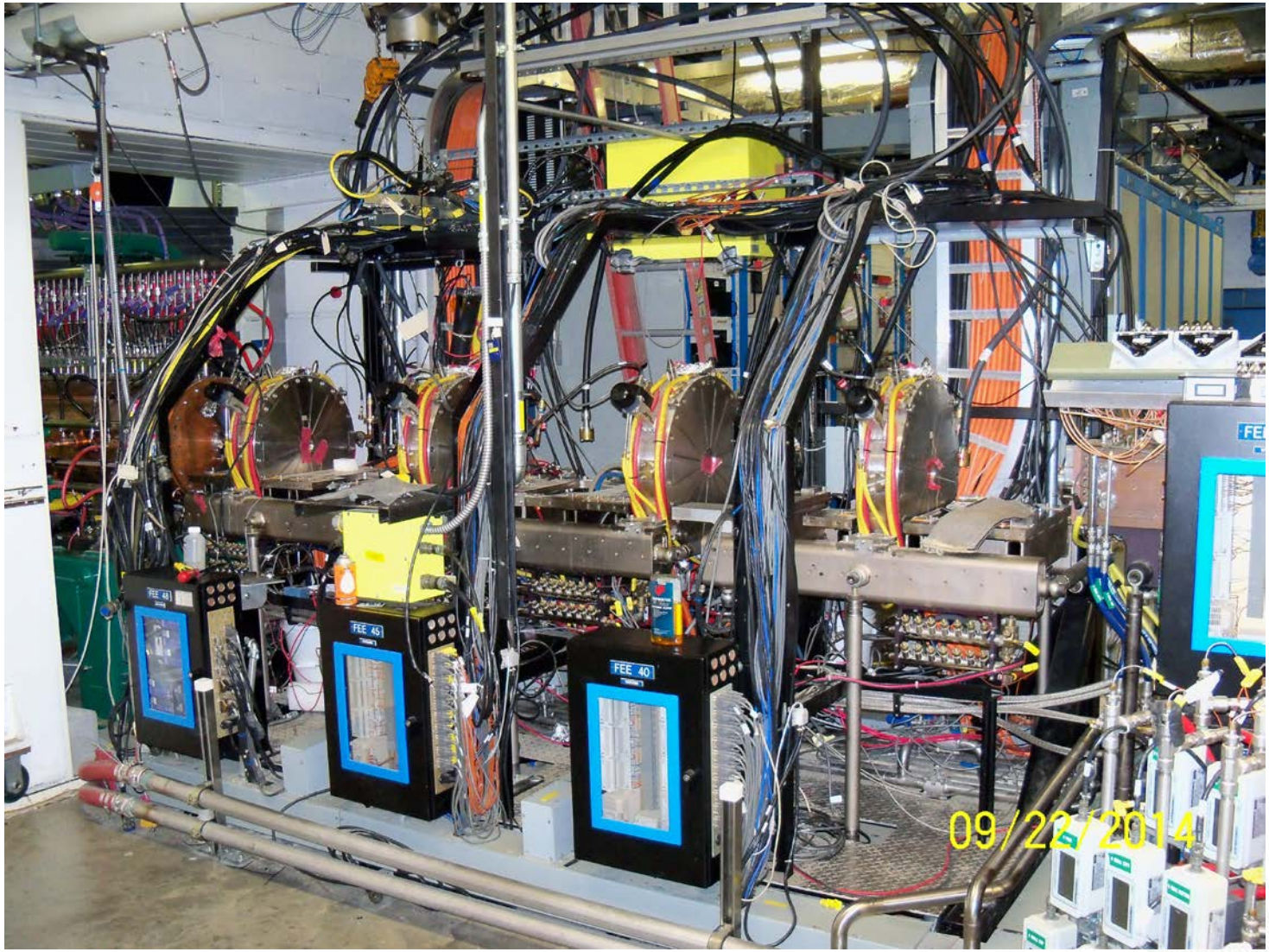
MEBT Recovery

- Vacuumed out as much water as possible
- Took off vacuum pumps at bottom of beampipe
- Disassembled entire beam line except for rebuncher cavities to remove water from inaccessible bellows, o-rings, etc.
- Vacuum baked all equipment to be put back in

Document Parts

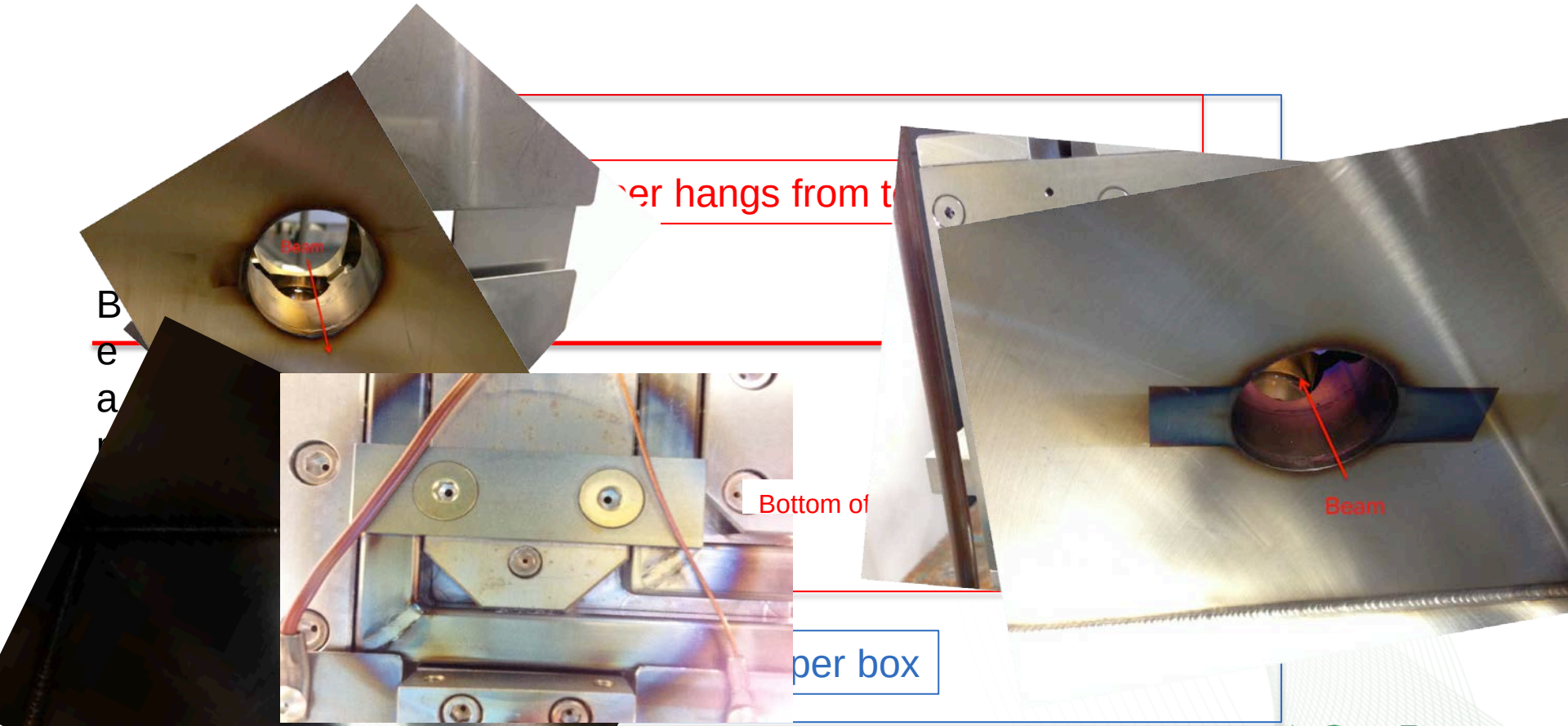


MEBT Disassembly



Unexpected Finding

- Chopper box (before target) showed unusual heating



Courtesy of C. Peters

Dewatering Rebunchers

- Wanted to keep on beamline, some critical seals unavailable, long lead time to manufacture
- Decided to raise temp and keep under vacuum to pump out water, but not too hot to protect seals
- Tried heat lamps and heated nitrogen gas, but ineffective
- Heated water through cooling channels effective to raise cavity temperature ~ 95 C

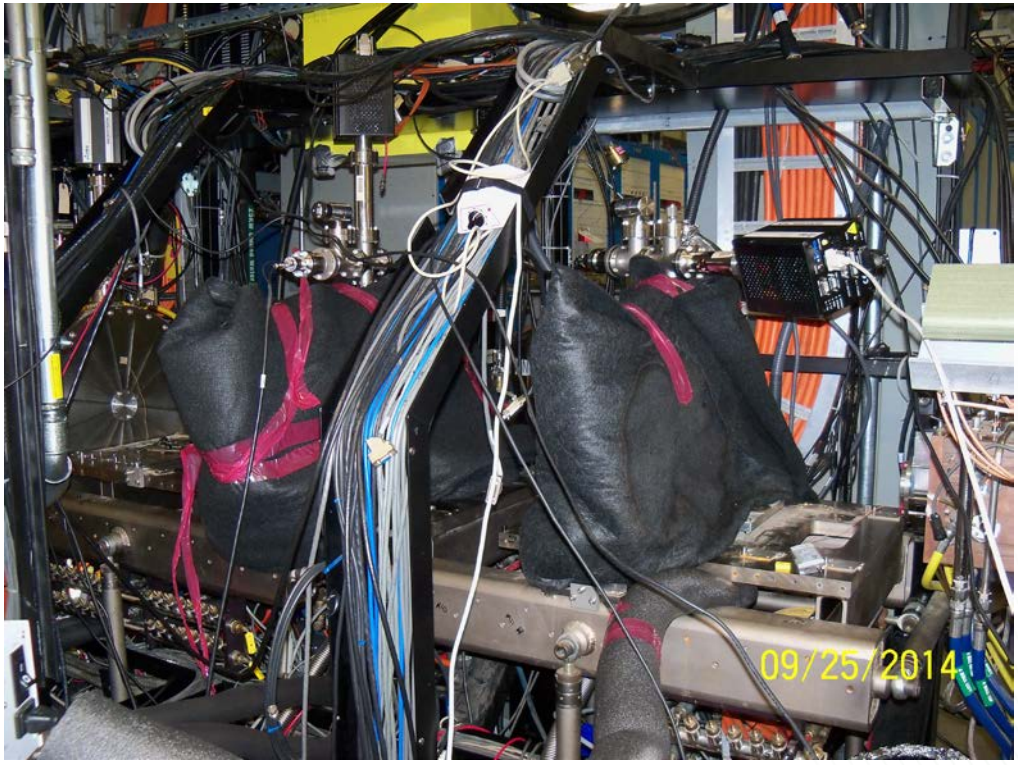
Dewatering Rebunchers

But!

- Our Vacuum Engineer computed that it would take ~ 4 days to pump 1 cc of water, and estimated ~ 5 cc could be trapped in the cavity
- TOO SLOW!

Solution!

- Change to a glycol mix and raise temp > 100 C
- Rebunchers 2-4 processed to good vacuum in 5 days.
- Rebuncher 1 took 8 days



Reassembly

- Low power tests of rebunchers to verify operation.
- Conditioned RF (with extra shielding) before reassembling beam line.
- Reassembly is simply the reverse of disassembly.
- Everything reinstalled except chopper target.

Timeline

- 15 Sep 14 – Water leak
- 22 Sep 14 (7 days) – All components removed
- 25 Sep 14 (10 d) – Rebuncher temps > 100 C
- 1 Oct 14 (16 d) – All components baked out, ready
- 3 Oct 14 (18 d) – Rebuncher dewatering complete
- 8 Oct 14 (23 d) – RF tested, first RF conditioning complete
- 13 Oct 14 (28 d) – Mechanical reassembly complete
- 17 Oct 14 (32 d) – RF processed again, ready for beam!

Lessons Learned

- Remove legacy equipment from beamline
- Keep drawings up to date, make drawings if you don’t have them, capture knowledge
- More space is always better (between equipment, for storage, etc.)
- Interlock for water cooled devices inside beam line
- Heated glycol/water bath for rebunchers – Brilliant!