Lawrence Livermore National Laboratory

Design and Prototyping of the ILC Positron Target System

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September 6, 2013 - Posipol 2013, ANL

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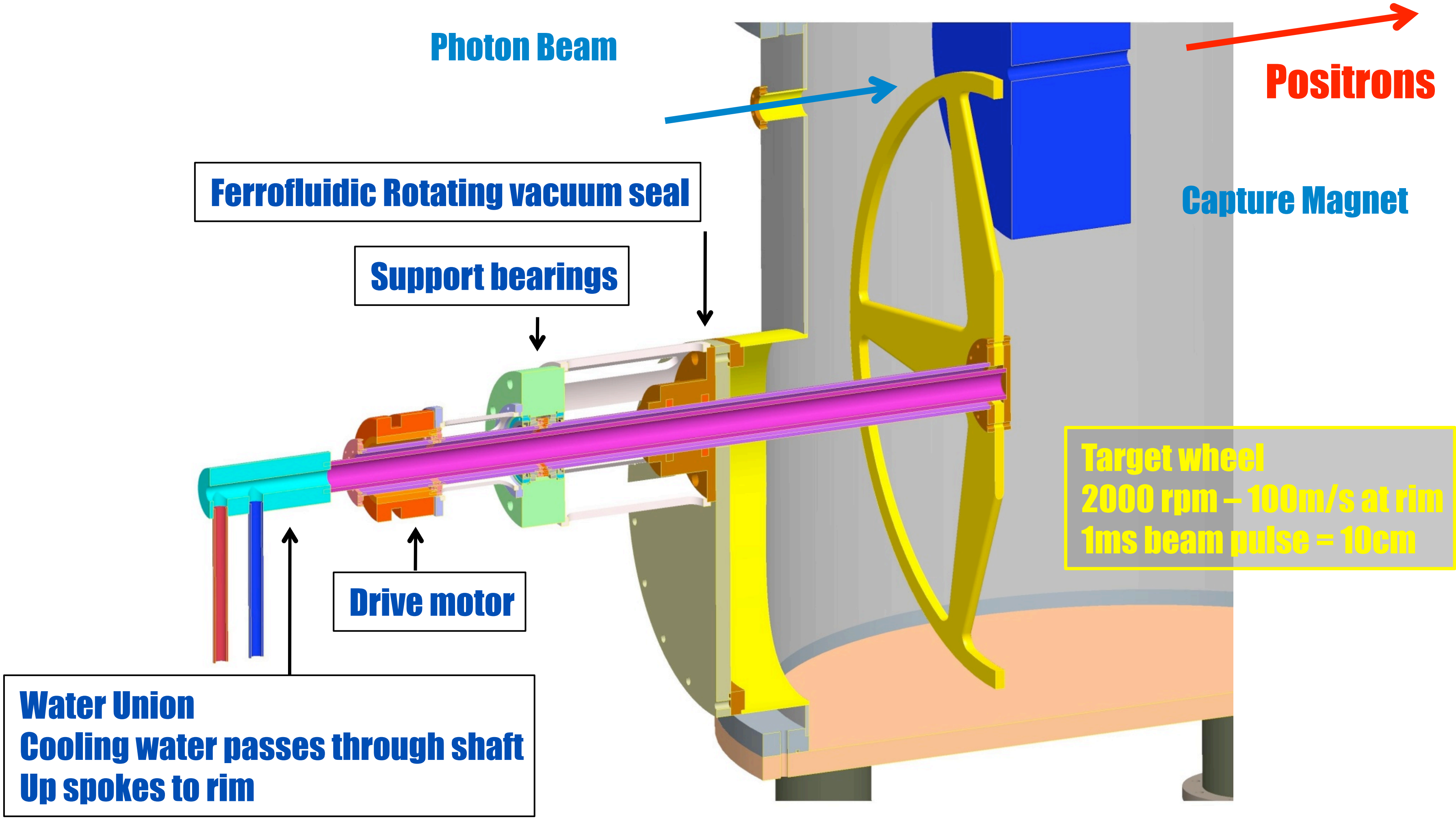
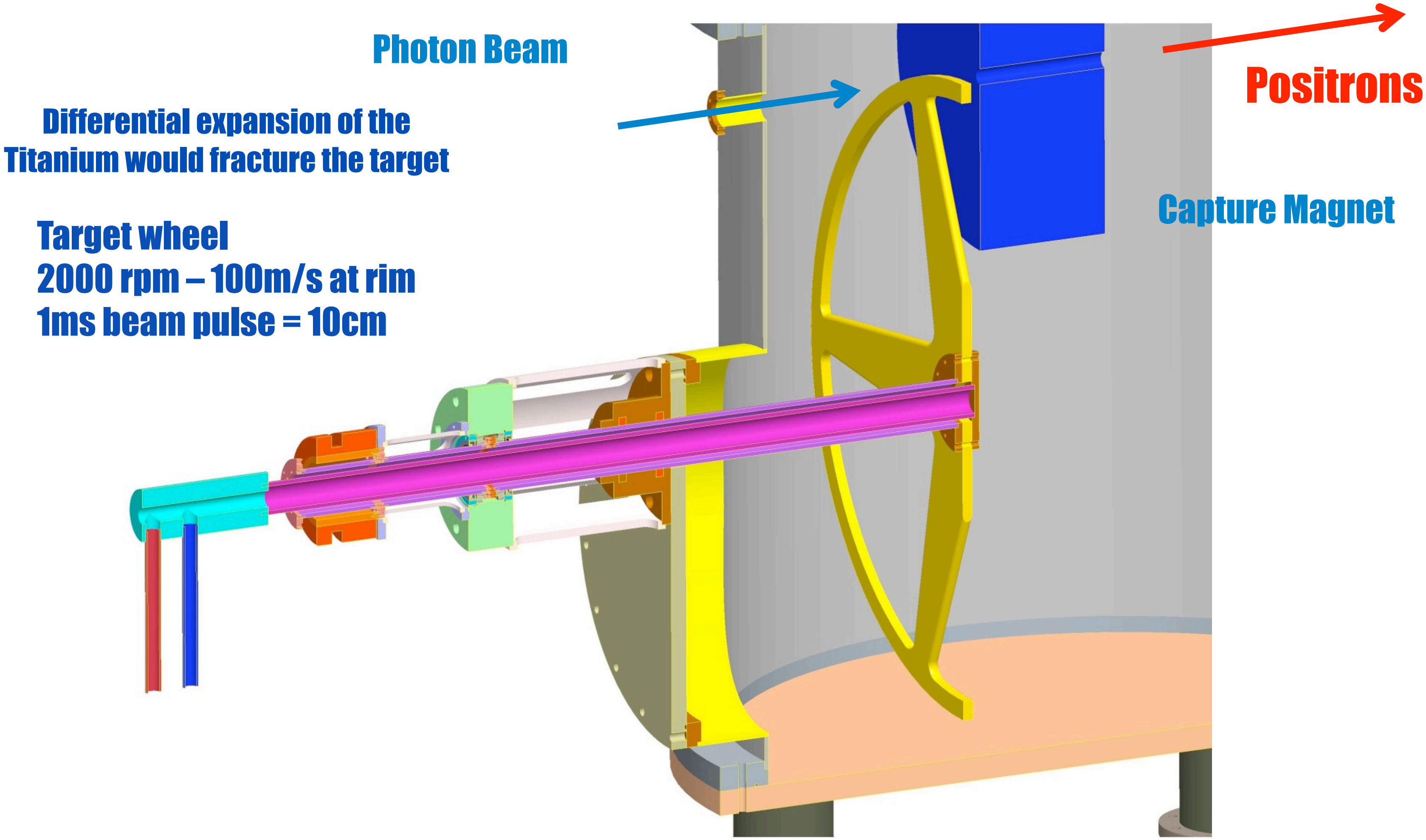
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344

UCRL-XXXX-12345

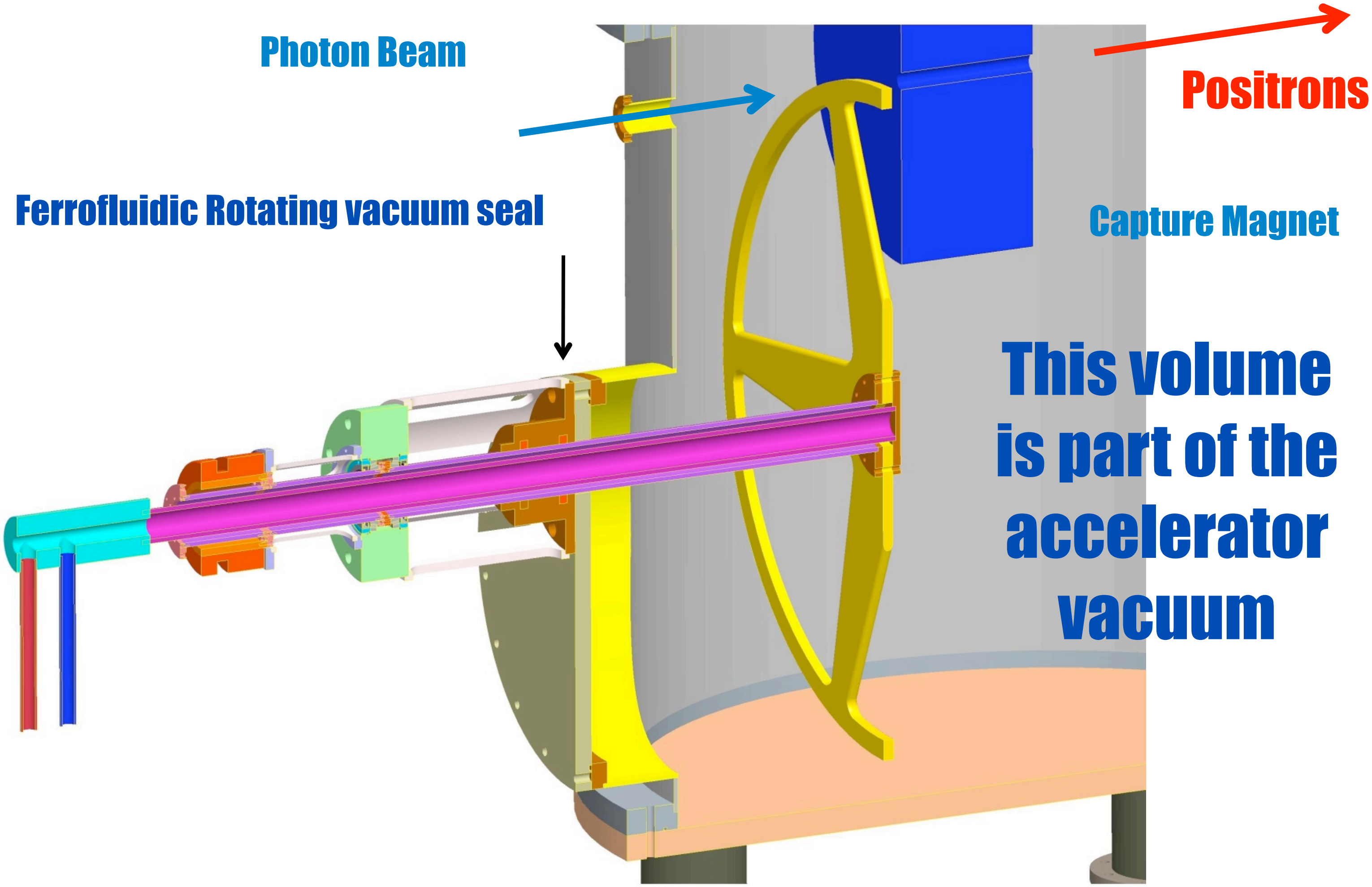
Let's review why the baseline target is the way it is



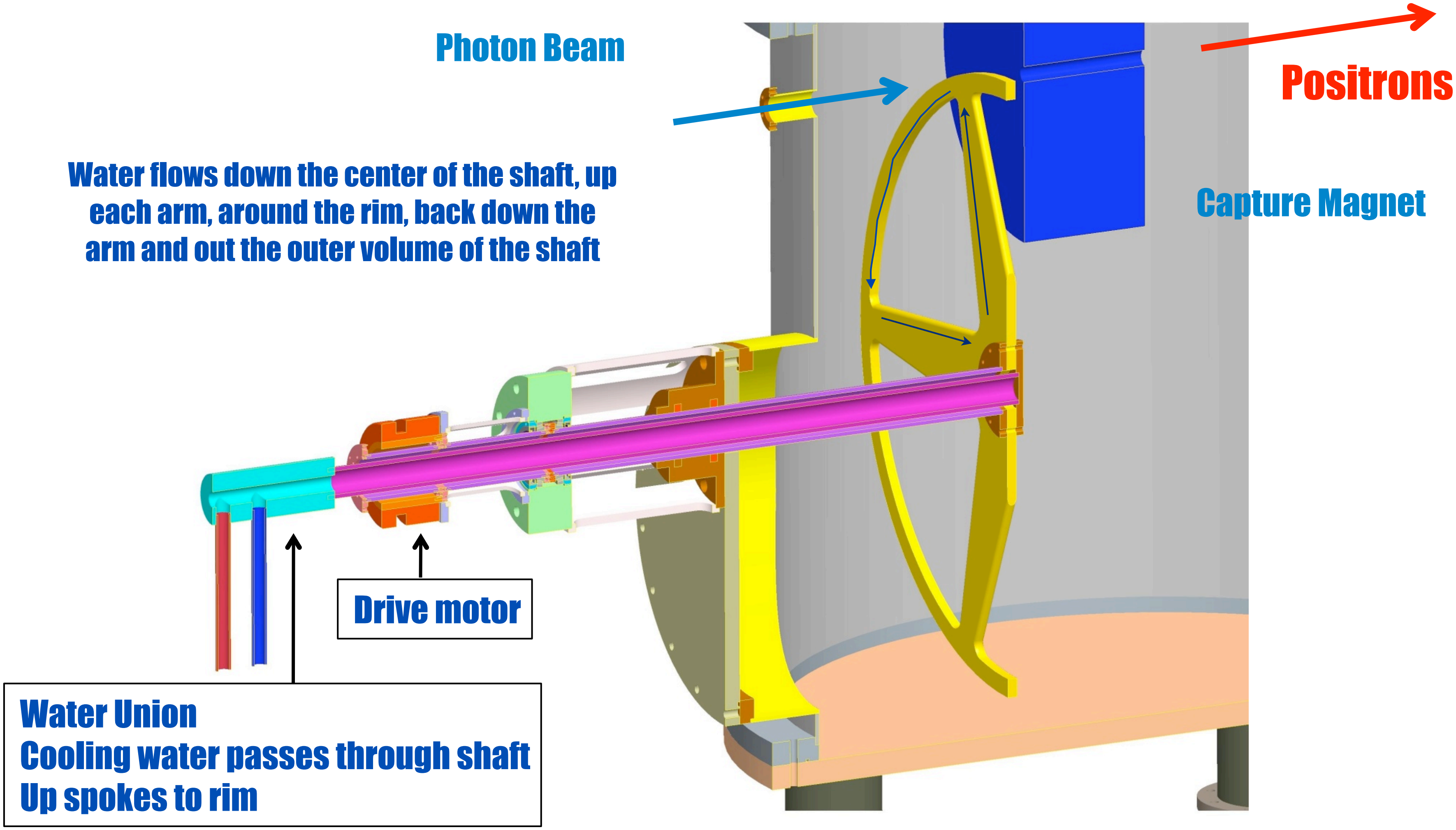
The 1 ms ILC photon beam pulse would fracture a stationary solid titanium target



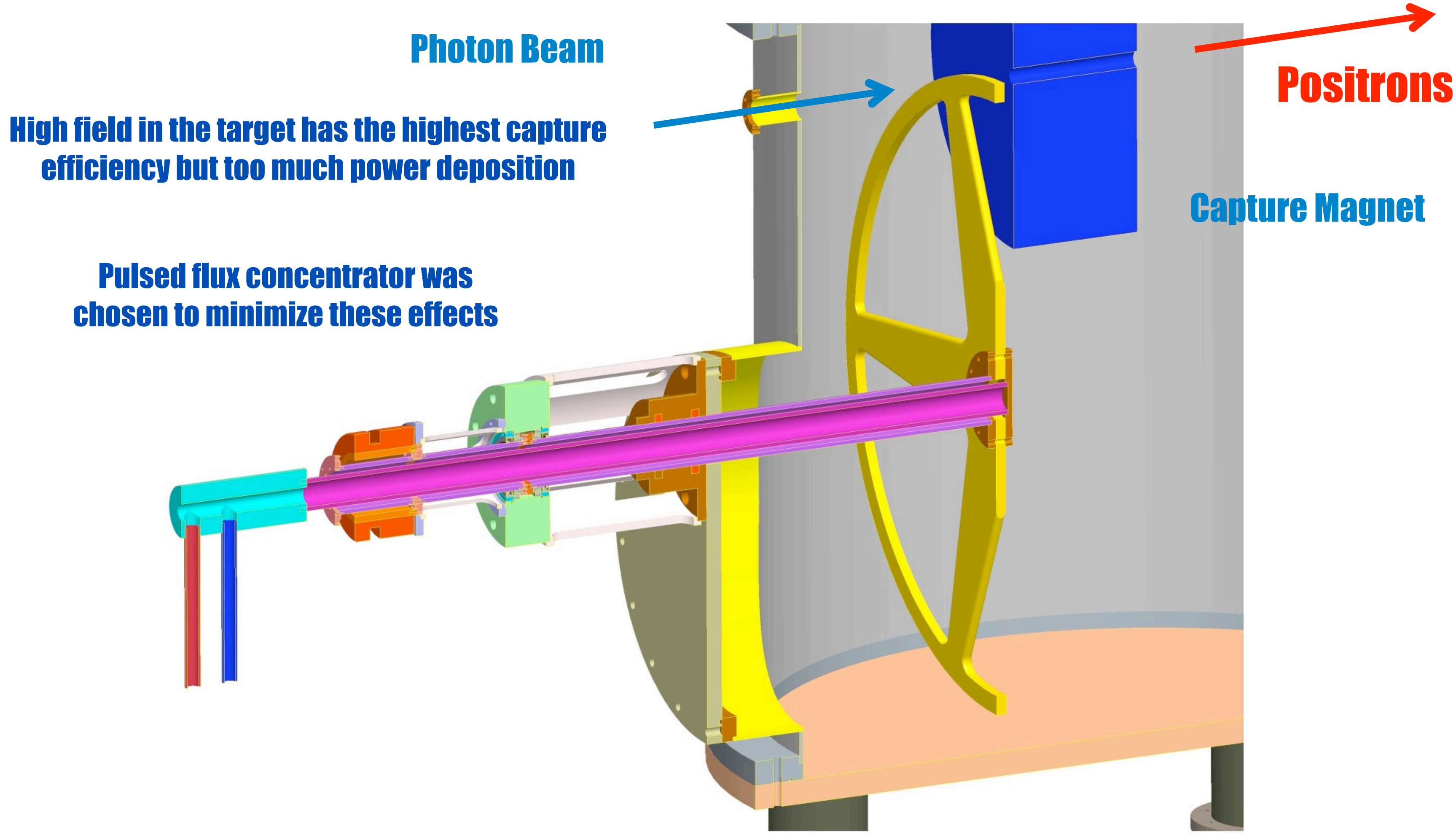
We have never been able to design a window between the target and capture section that can withstand the positron beam



We have to remove the average power in the target

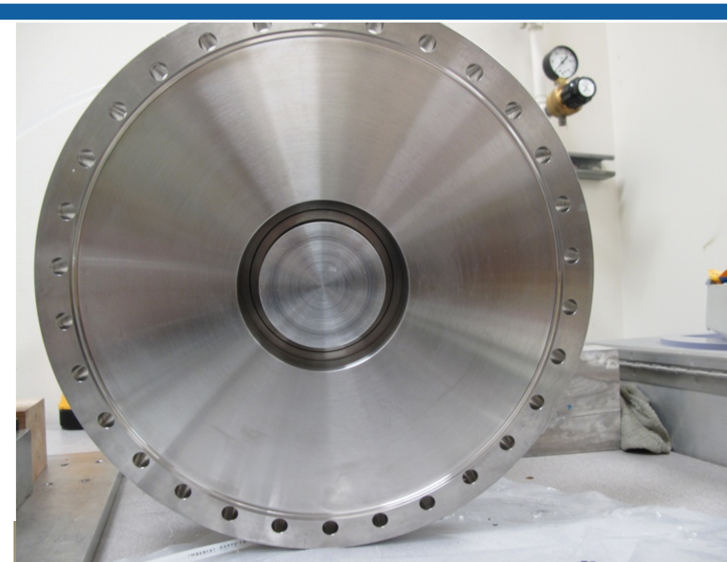


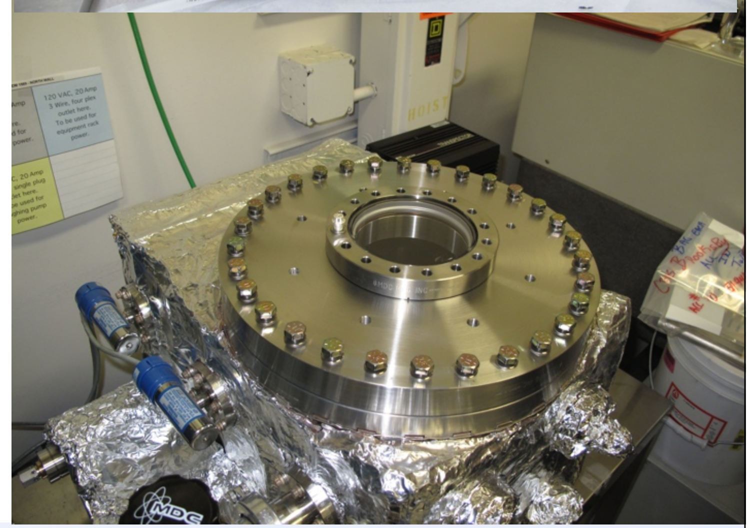
We need a capture magnet that won’t cause excessive eddy currents or stresses in the target



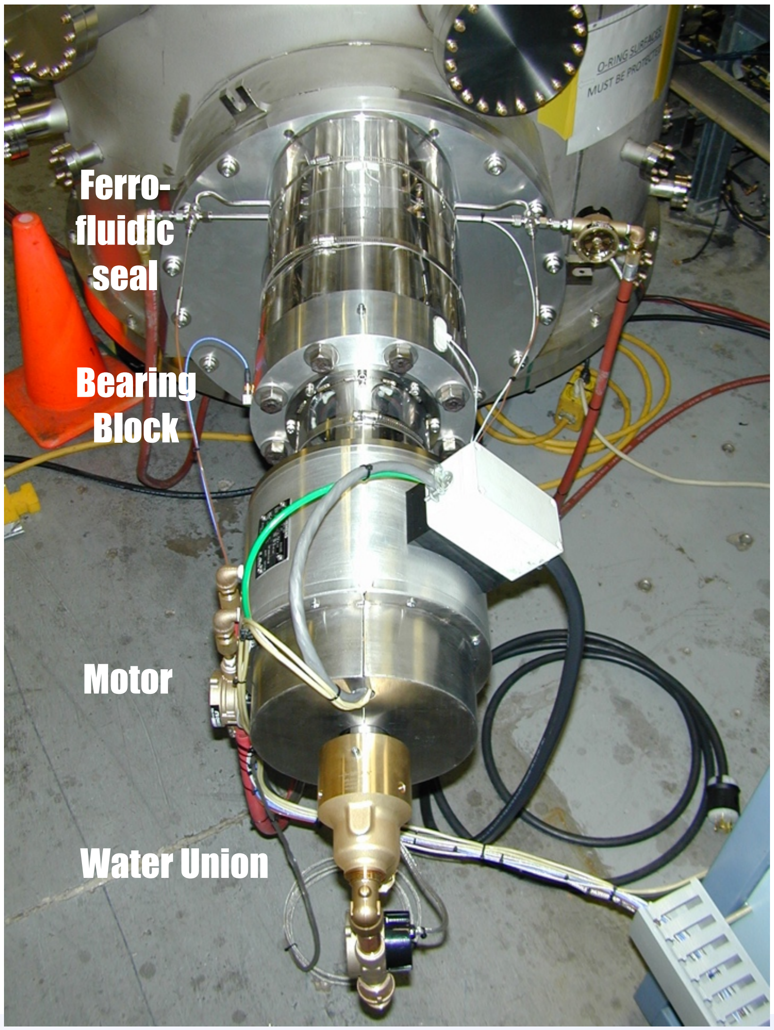
- We wanted to test:
  - the behavior of the ferrofluidic seal
  - the ability of a pulsed flux concentrator to maintain the 1 ms flat top field

We built a small test stand to rotate the seal up to 2000 RPM with pressure and outgassing measurements





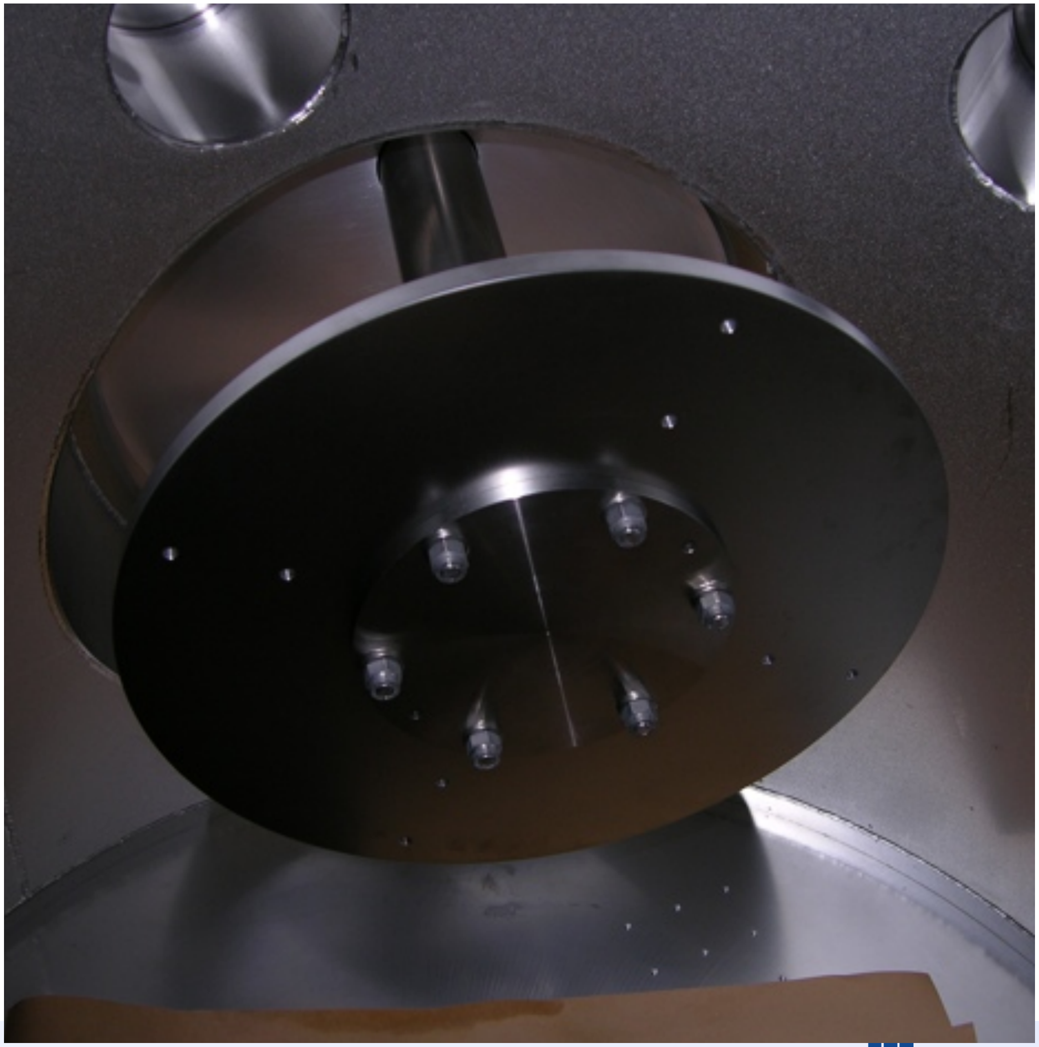
We built a full scale prototype of the shaft



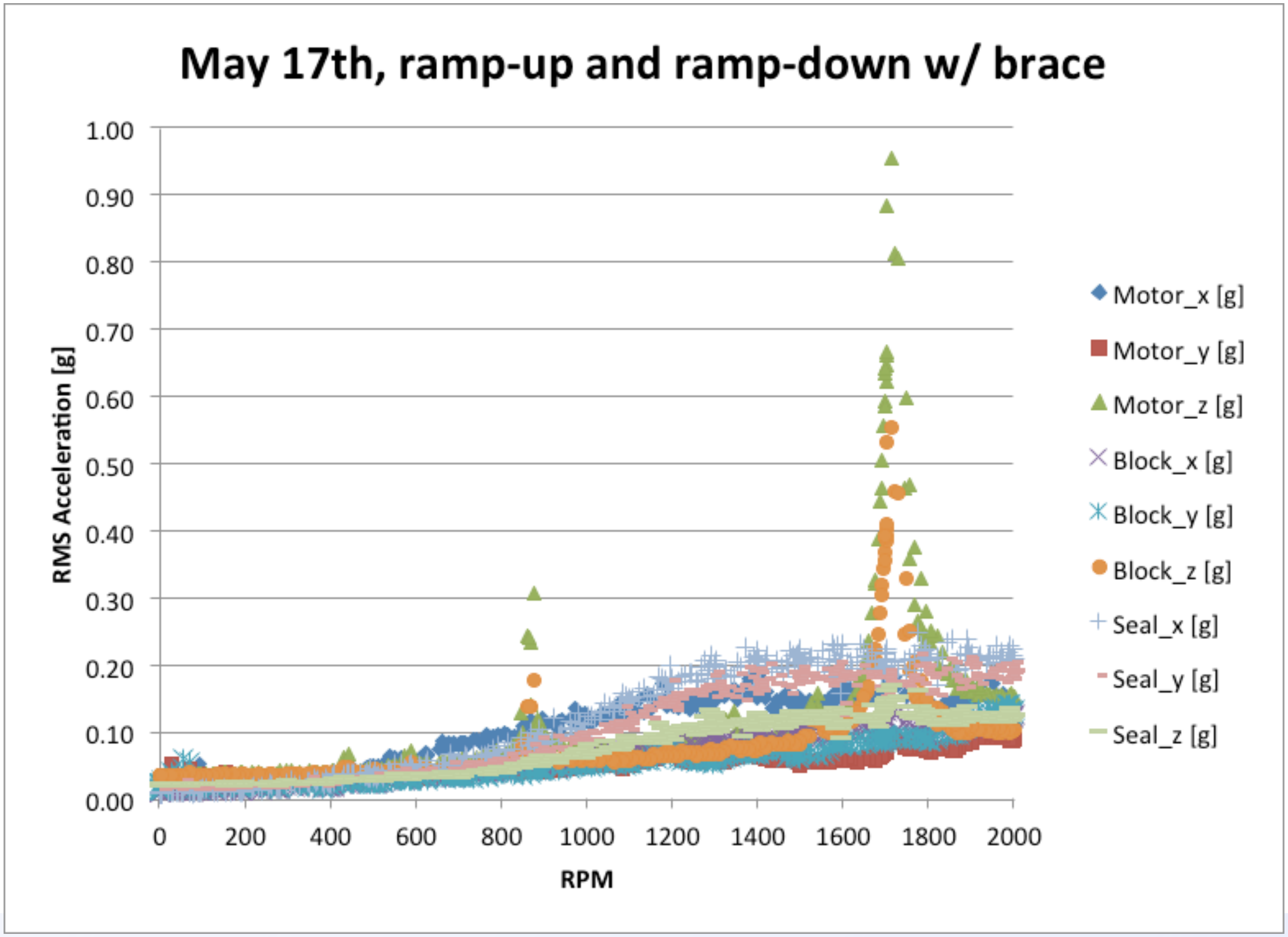
- The DAQ records the system state every 30 seconds.
  - Cooling water flows up and down the shaft
  - Ferrofluidic seal maintains the vacuum with spin at 2000 rpm

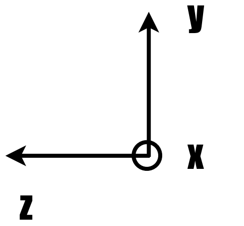
We have the English prototype wheel but have started with the medium disk

- Same weight as titanium wheel but lower moment of inertia
- No shielding required for safety
- Cooling water in the shaft has an effect on the balancing
- Not quite as stable a balance point as a solid shaft would have



Balancing data from the FerroTec seal shows the resonances we expect



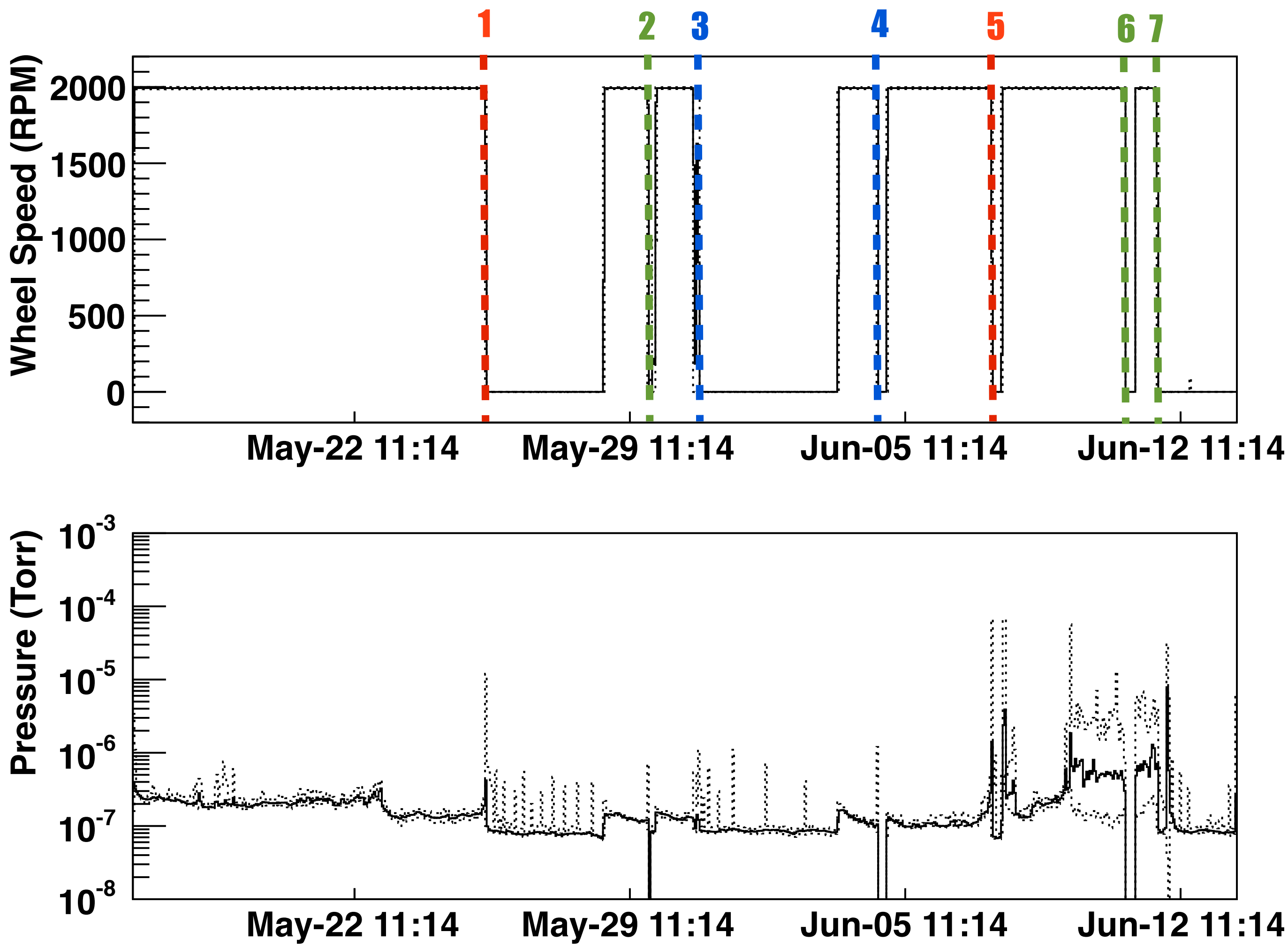


x = along shaft

y = vertical

z = horizontal

FerroTec Seal #1 ran for 1 month (450 hours up)



Pressure Trip

System Trip

Planned Down

1 - Pressure Spike

2 - DAQ software change

3 - Cooling water flow

4 - Vibration Limit

5 - Pressure Spike

6 - Wheel stopped for pressure test

7 - System down for rework

The ferrofluid seal didn't fail

- The collar which is supposed to clamp the seal to the shaft had been left off
- The O-rings became the components that transferred torque from the shaft to the seal
- Eventually the O-rings were destroyed

History and Status of our Available Seals

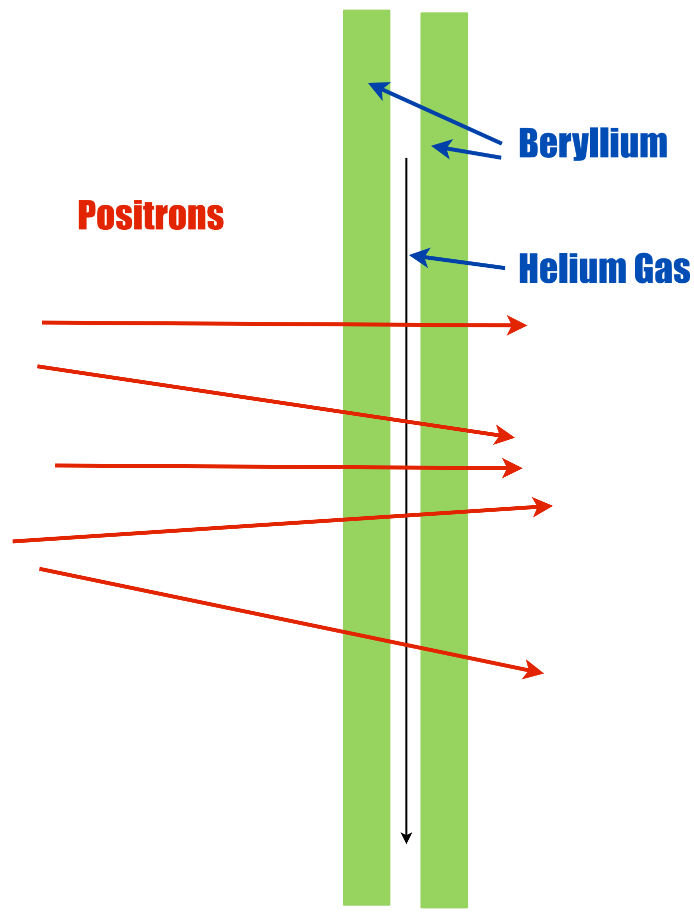
- Rigaku #1
  - Catastrophic failure after 15 minutes at 2000RPM on the outgassing test stand
  - Rigaku analysis indicates differential expansion of components lead to failure
- Rigaku #1 reworked
  - Switched fluid for low viscosity type
  - Unacceptable behaviors seen on the test stand
- Ferrotec #1
  - Low viscosity fluid
  - Normal operation for 38 hours at 2000 RPM on the outgassing test stand
  - Higher outgassing than Ferrotec expected
  - Ran normally on the test stand until O-ring failure, damaged during rework
- Ferrotec #2
  - Ran rough on the outgassing test stand, better outgassing than Ferrotec #1.
  - Returned to Ferrotec for analysis
- Ferrotec #3
  - Currently mounted on the test stand
  - Good vacuum
  - Vibration spikes

Lessons Learned

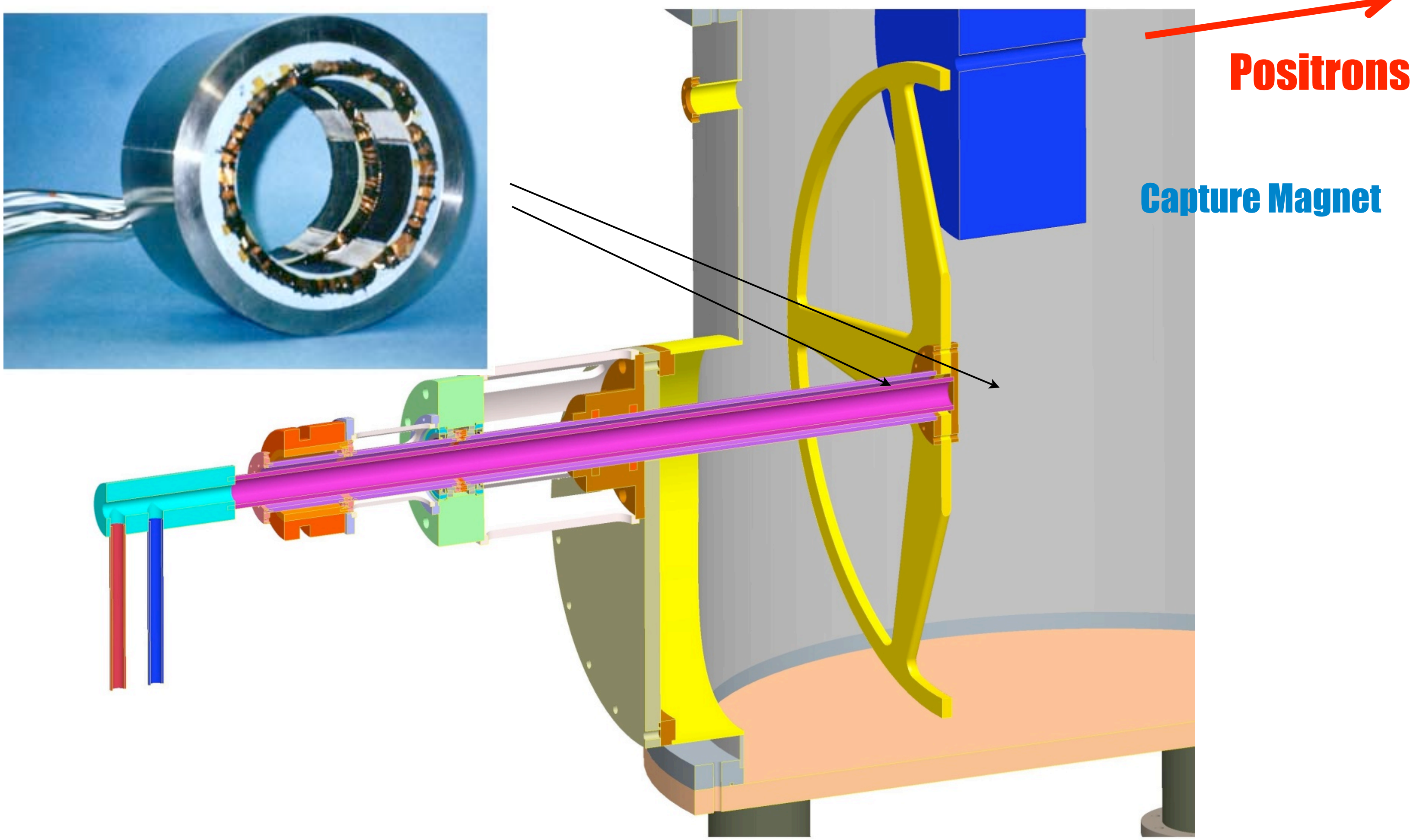
- Ferrofluidic seals are not boring, each one has its own individual personality
  - We would prefer them to be anonymously interchangeable and predictable
- They all have outgassing spikes
  - A differential pumping region just after the seal would be a useful modification
- We are pushing them to speeds at which there is significant heat dissipation
  - Off-the-shelf models do not seem to be well designed for this.
  - Improved cooling design is a must for any future system

Possible window concept - Double walled helium gas cooled window

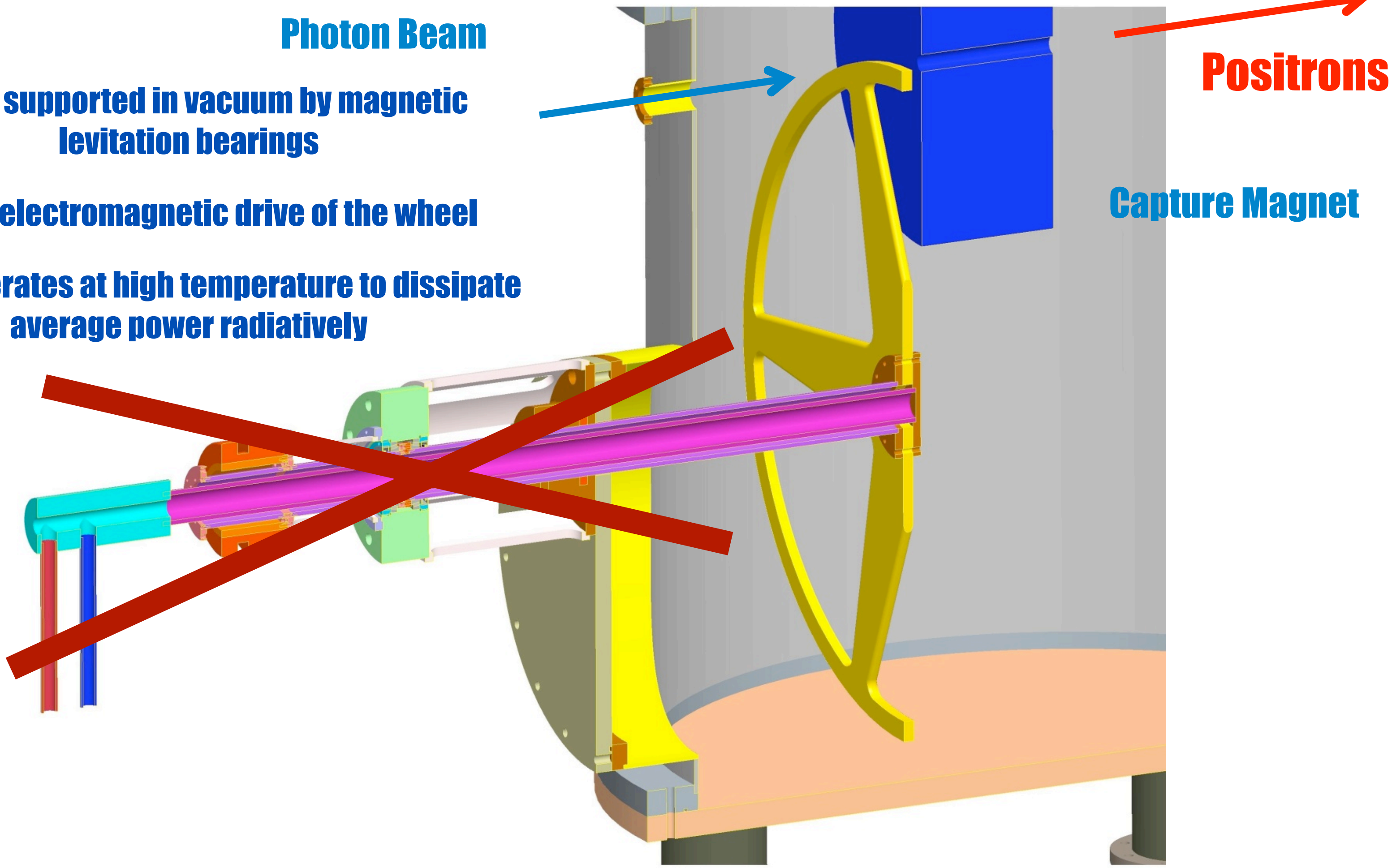
- Never seriously evaluated as I recall
- Energy deposition, thermal stress, gas expansion and cooling calculations would need to be done
- Could greatly simplify the vacuum issues



Magnetic levitation bearings could work in vacuum without friction and stiffen the shaft against beam and magnet induced impulses



Marty Briedenbach suggests radiative cooling to eliminate vacuum feedthrough and water cooling

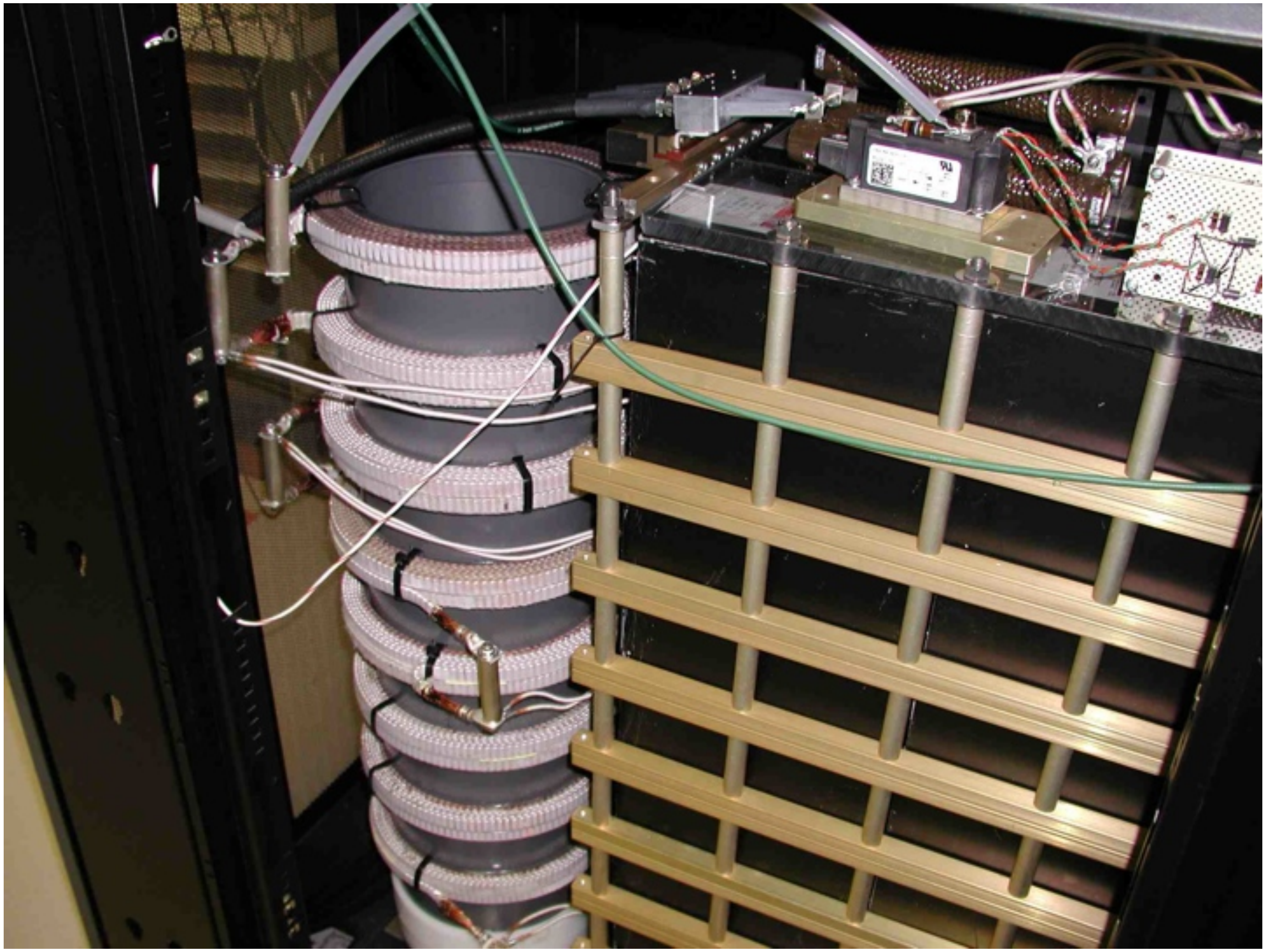


Ferrofluidic seal summary

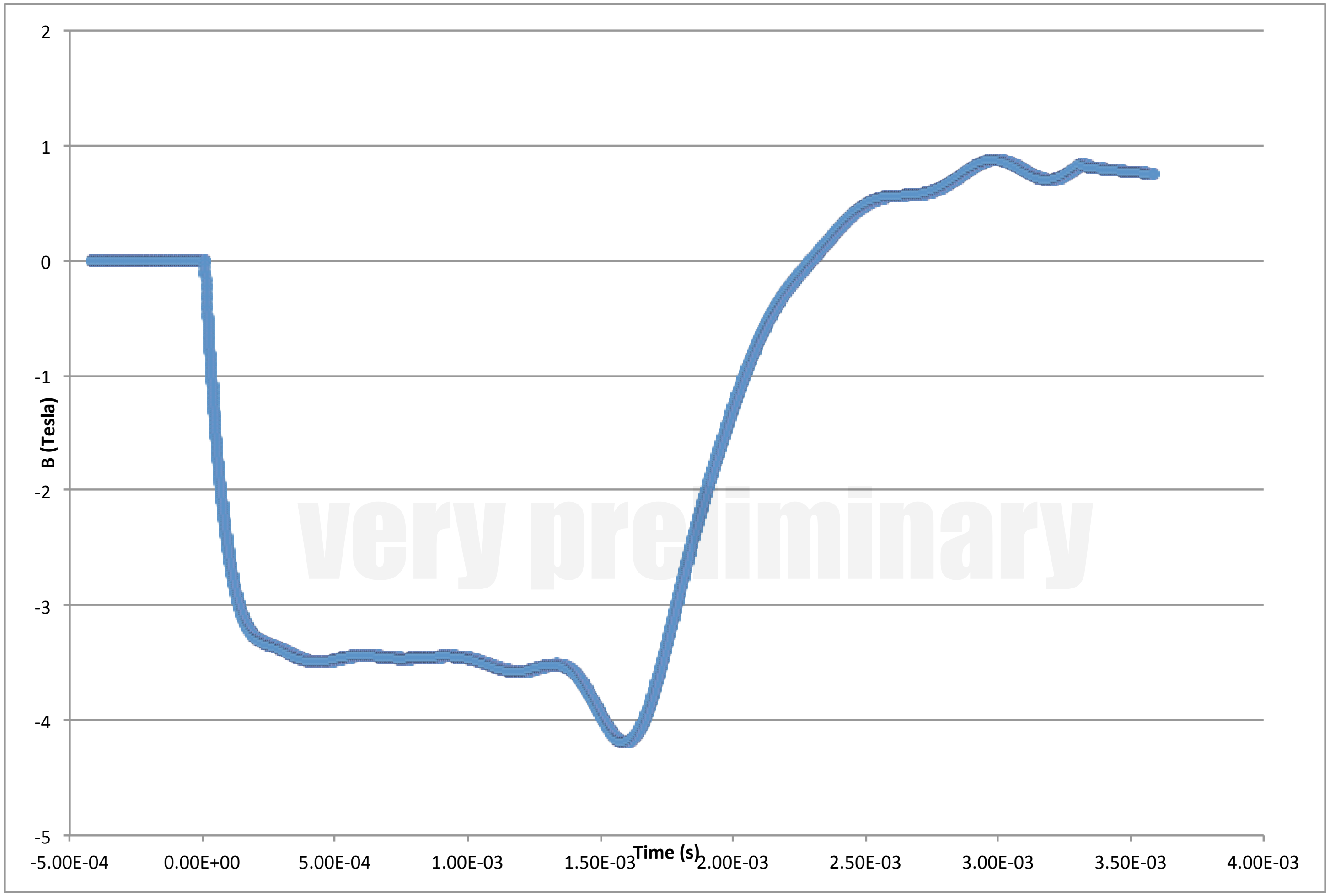
- There are a couple of concepts which should be evaluated that could be game changers
- The current prototype system works ... sometimes ... but not robustly enough for a production system
- Still need to demonstrate full wheel with cooling channels

The 3 copper concentrating plate and 2 center cooled copper coil test stack

Pulse forming network created to form a ramped pulse to maintain the flat top magnetic field



The magnetic field has a 1 ms flat top



Pulsed Flux Concentrator Summary

- We have demonstrated the full field with a 1 ms flat top.
  - Improvements to the pulse forming network should reduce the ripple

- Things we still need to do:
  - Construct and install the ceramic spacing disks
    - metal spacers distort the magnetic field temporal profile
    - we used plastic spacers for the current test
  - Run for an extended period at 5 Hz, full average power with cooling
  - Design the first plate to shield the gap from radiation

Summary

- We have not yet demonstrated a robust solution for the vacuum seal
  - The ferrofluidic seals have been tempermental

- The pulsed flux concentrator seems workable but we still need to demonstrate full average power operation.