FERMILAB-SLIDES-24-0076-SQMS

Cryostat Options for 9.4 Tesla x 800 mm Solenoid

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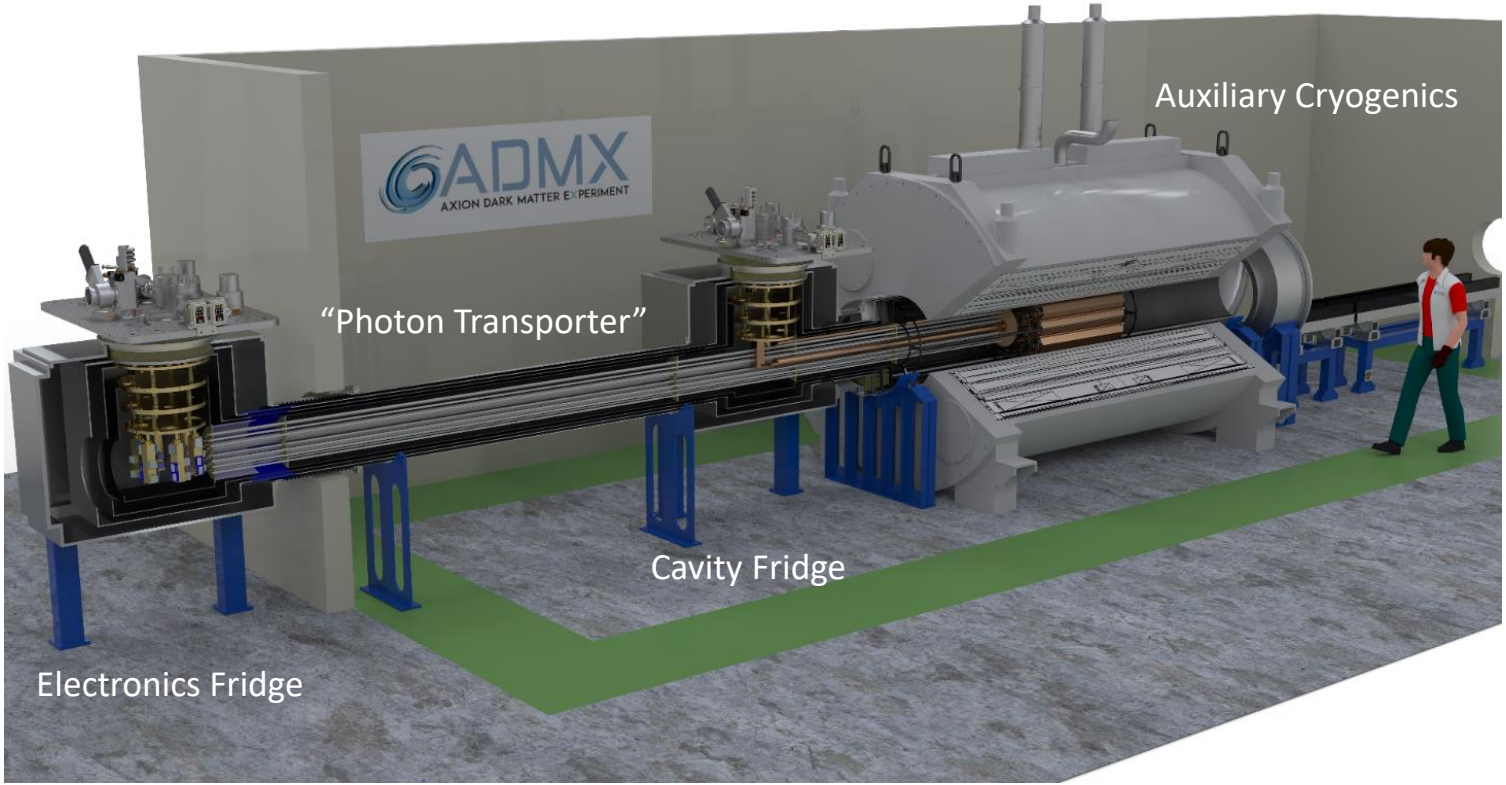
Integration with the MRI Magnet

- MRI magnet has an 800 mm warm bore (i.e. non-vacuum).

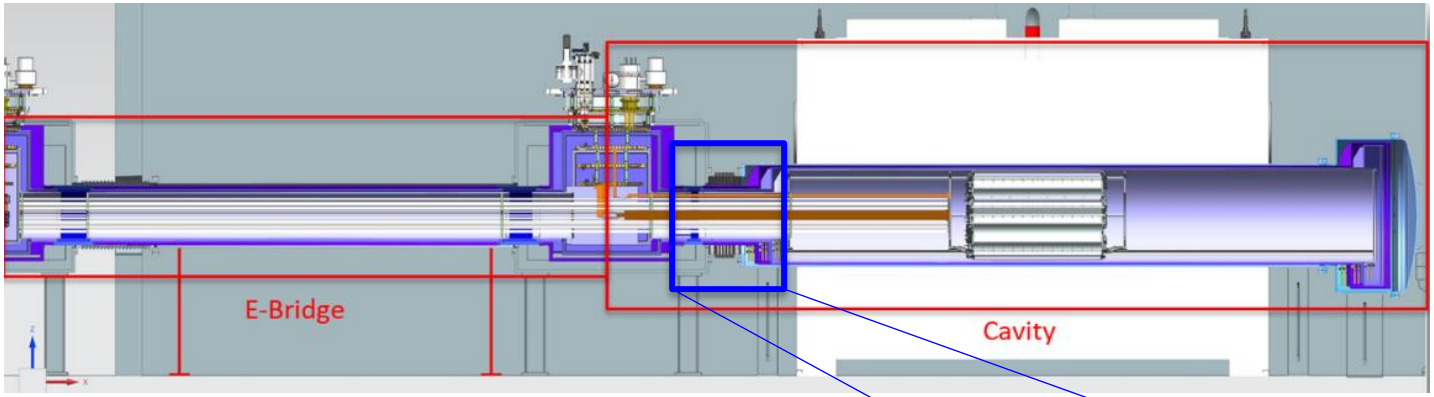
- Early integration designs used a vacuum tube inserted through the bore
  - Requires no modification of the vacuum shell
  - Cuts significantly into the available bore diameter

- Re-evaluation of pulling vacuum on the bore itself
  - Will require modification of the end plates to provide an o-ring sealing surface
  - Need to determine that the bore can withstand the external pressure loading
  - Maximizes the available bore diameter

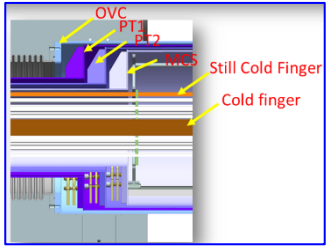
ADMX-EFR mK Cryogenic System



ADMX-EFR mK Cryogenic System

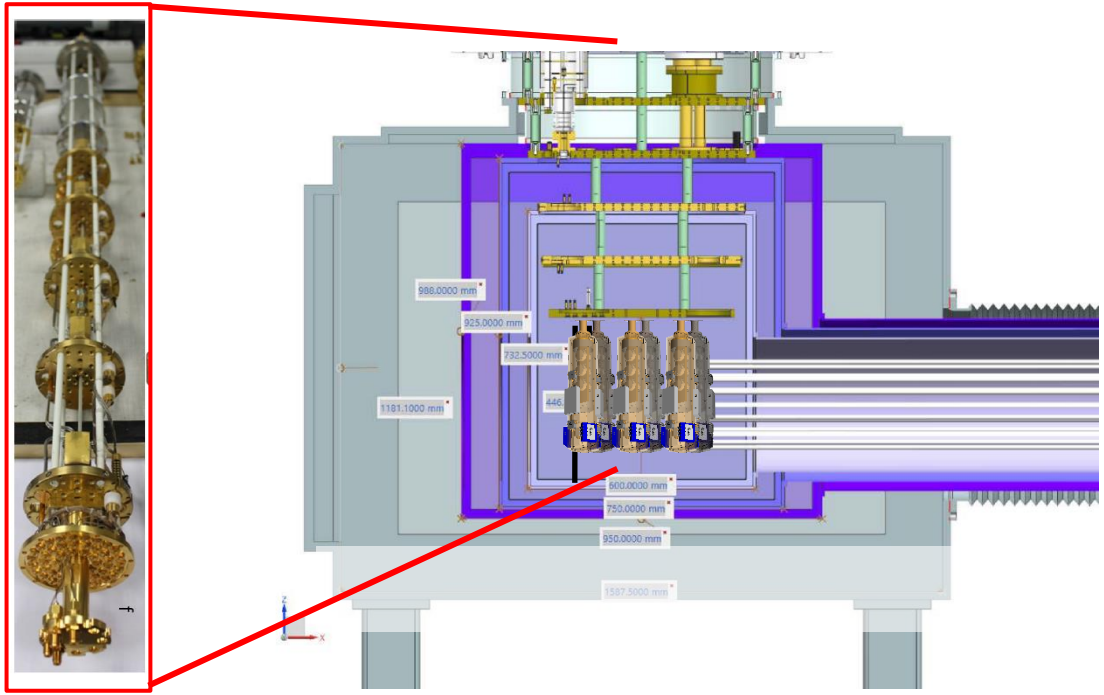


- Thermal shield layers at 70-K and 4-K through the magnet bore and between the two dilution fridges.
- Close-in fridge running at 100-mK, provides 1-K cooling.
- Far fridge (outside shielding) running at <25 mK to cool electronics.



Cold Electronics System

- Cold-insertable probe systems (aka “load locks”) are available from several DR vendors, but the particular system from Leiden Cryogenics allows an entire “stick” of cables and components to be installed into a cold fridge rather than the small sample puck one typically sees.



- Allows Parapet cold electronics module to be removed from the E-Fridge to room temperature in 12-24 hours **<u>while the fridge remains < 4K</u>**
- Large Leiden Cryogenics fridge can accommodate 6-8 modules.
- New electronics module can be inserted and cooled back to mK operating temperature in 24-48 hours.

Dark Wave 4-K Cryogenic System

- Since funding for the full mK cryostat system is likely several years out, we are exploring the possibility of constructing a 4-K cryostat to make use of the MRI magnet in the near term.

- Logical path here is to construct the warmer stages of the cryostat combined with the magnet so that minimal changes would be required to “upgrade” to the full EFR cryostat.

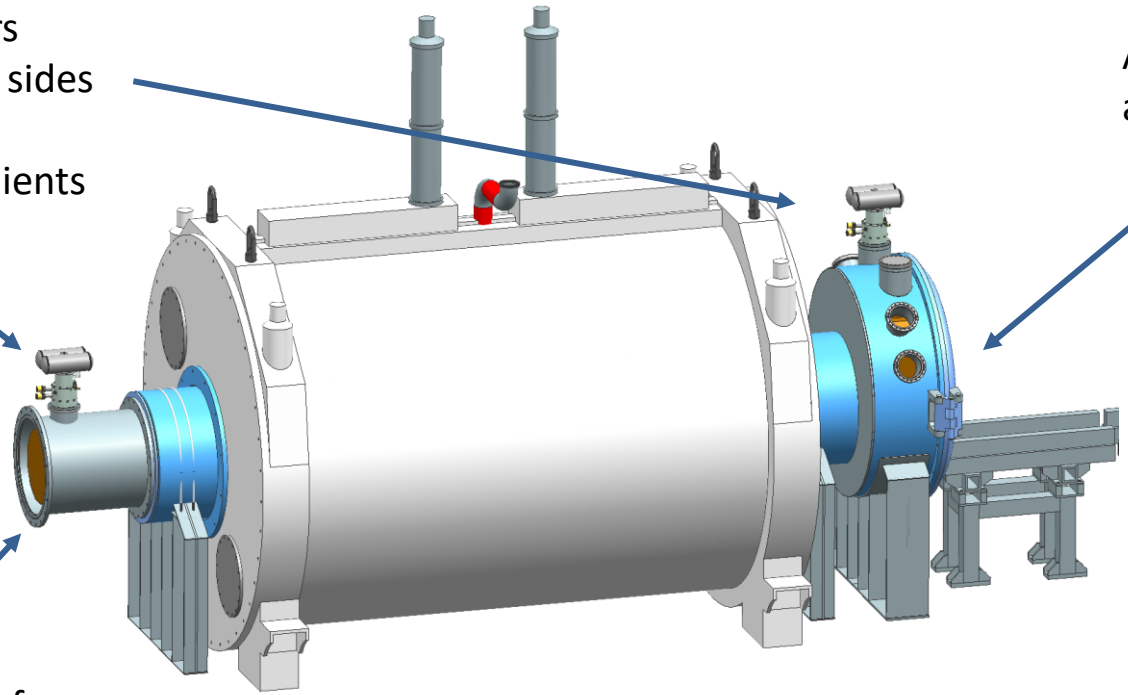
- Baseline plan is to construct the PT-1 and PT-2 shields inside the magnet bore, add the vacuum can with the access hatch and a modified vacuum endcap on the near end of the magnet.

- One of the 4-K coolers will be moved so that the shields are cooled from both ends.

Dark Wave 4-K Cryogenic System

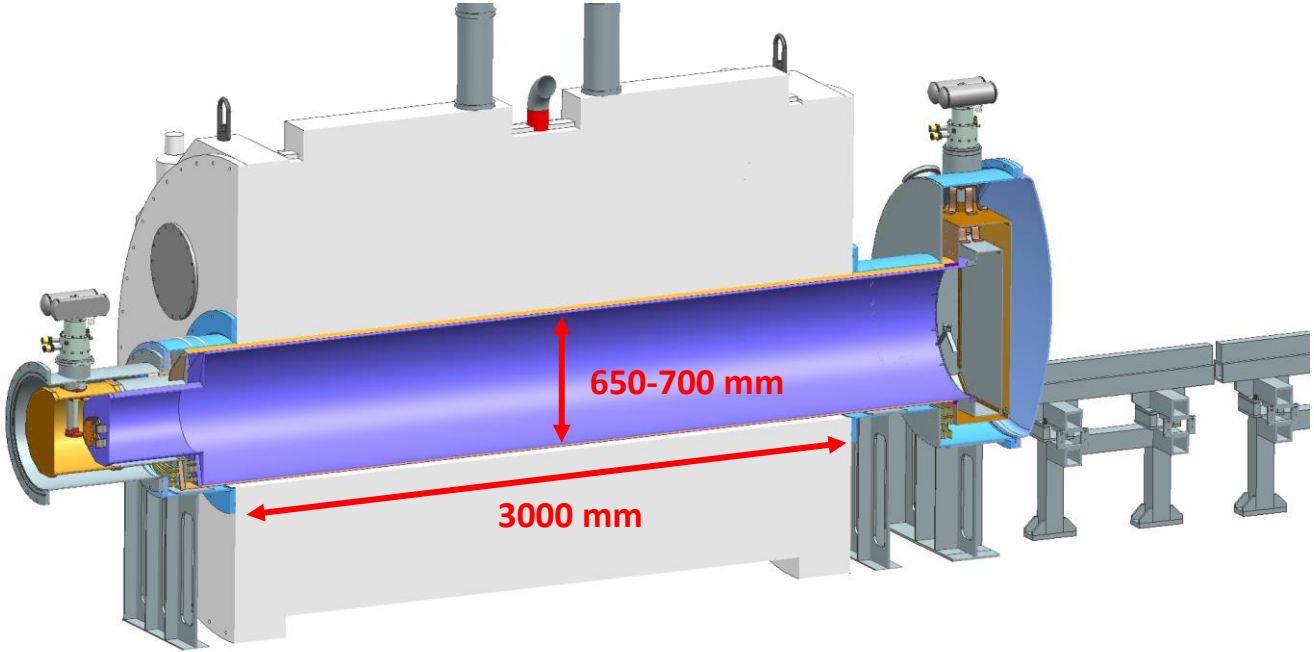
PT1 and PT2 layers cooled from both sides to minimize temperature gradients

Access hatch to access payload



Ports at this side for readout cable access

Dark Wave 4-K Cryogenic System



Cryogenic System Alternatives

- Mechanically, not expecting to make any major changes in the magnet volume at this point

- One issue we're looking at in more detail is the operation of cryocoolers in proximity to the magnet.
  - If this does prove to be a problem, we have the option of moving the cryocoolers further away and using fluid circulation cooling or adding additional shielding

- Also evaluating the possibility of combining the two dilution refrigerators into a single system with staged cooling for the cavity and electronics.

Summary

- Reviewed the cryogenic systems under consideration for use with the 9.4 T magnet.
- Millikelvin system can provide cooling of payloads to <100 mK with electronics at <25 mK in a low-field region.
- Initial 4-K version of the cryostat planned as a near-term objective to enable early science with the magnet.
- Payload diameter of 650-700 mm inside the 4-K shield (for the mK configuration, this diameter would include 1-K shielding and thermally-isolating supports). These dimensions are still being finalized since the available space is dictated by the straightness of various shield cylinders.

Acknowledgement

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