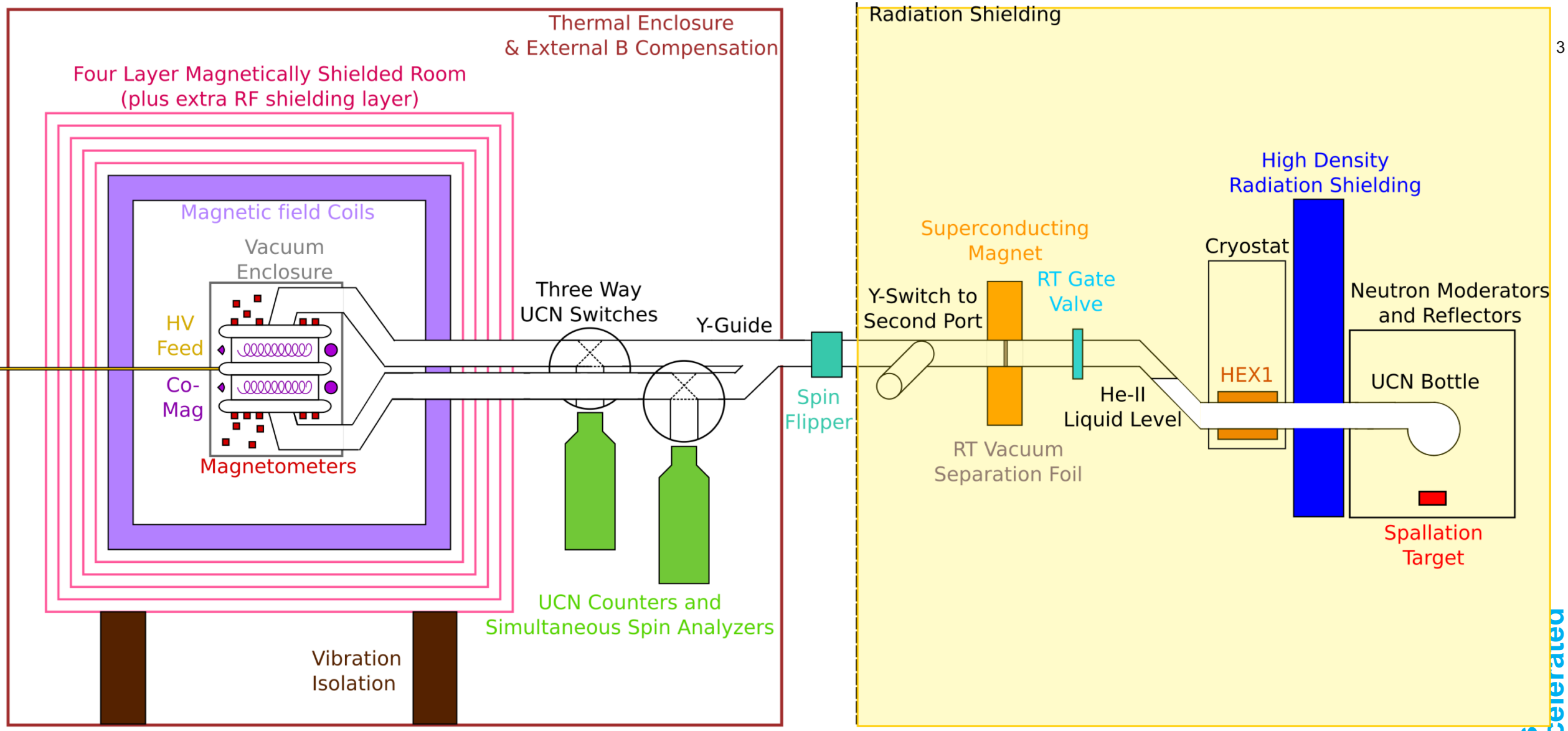
The TUCAN EDM experiment - overview

TUCAN EDM measurement concept

- construct a neutron EDM spectrometer based on a room temperature (RT) apparatus
- perform Ramsey cycles with spin polarized UCN stored in two measurement cells
- within which they will be exposed to vertically aligned, parallel and anti-parallel magnetic and electric fields.

- The objective of the TUCAN collaboration is to search for a permanent EDM of the free neutron d_n with a sensitivity of $\sigma(d_n) = 1 \cdot 10^{-27}$ $e$cm within 400 measurement days.



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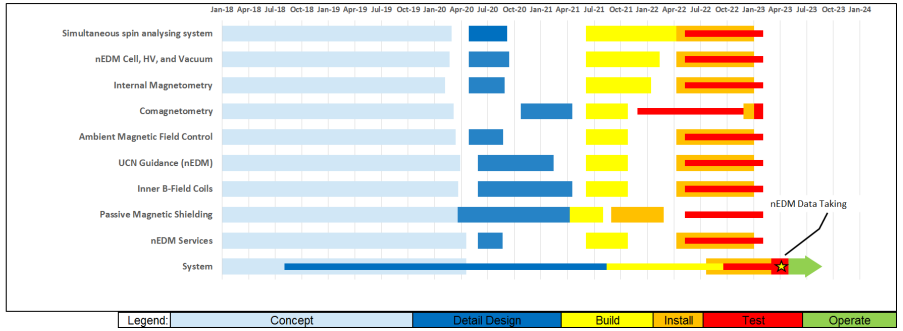


nEDM status overview

- We have a general plan based on our available human and financial resources
- We need to develop a more detailed schedule, it's very 'vertical' at the moment for nEDM subsystems (= everything happening at the same time)
- The development status of our subsystems differ: some are more advanced than others (which is not compatible with a vertical schedule…)
- UCN source design is taking precedence over EDM design at the moment
- Despite this, significant progress has been made in various subsystems (see next slides)

A TRIUMF gate 2 review on nEDM is scheduled for this calendar year. We hope that a sufficiently detailed report from the EAC review committee can be considered to contribute to the TRIUMF gate review process.

Staged approaches

- We have started a collaboration internal discussion about nEDM related milestones – and how staged approaches to subsystem performance could allow us to accommodate potential bottlenecks in resources while still moving forward toward a fully operational spectrometer.

We consider two complementary approaches to an EDM experiment:

A) taking every subsystem to their final and required performance and then only installling and combining them to an EDM experiment

B) installing whatever subsystem we have available (even if not fulfilling requirements) to put something on the floor as early as possible

- We are working on developing the middle ground between the two since A) causes delays in the schedule and takes away the ability to learn about the interplay of systems and their interfaces B) can be more expensive (installing that extra prototype costs) and also might distract from the necessary developments required for each subsystem
- Our collaboration tends to follow approach B) while keeping a balance with respect to potential disadvantages. We appreciate the EAC's comments on this.

Highlights & status overview: Magnetics

- NEW: **Extensive magnetic field mapping** of the nEDM area during end of January! Important information for MSR vendors, and for compensation coil design
- We want to move forward with purchasing the **MSR**: we are ready for tender
- **High precision magnetometers** - two theses completed, students graduating; nuclear magneto-optical rotation (NMOR) sensor prototypes measure the magnetic field stability in the pico Tesla range and progress towards sub pico Tesla magnetometry is being made, buy 5 to start with
- **Main magnetic holding field coil** - new design concept for self shielded coils with reduced coupling to the magnetic shielding, this reduces magnetic field fluctuations as consequence of temperature variations or vibrations of the magnetic shielding; hired expert as new postdoc: M. McCrea

Magnetics, Russ Mammei, 30’ + 30’

MAGNETICS SUMMARY

MSR:
- Ready to begin working with a Vendor

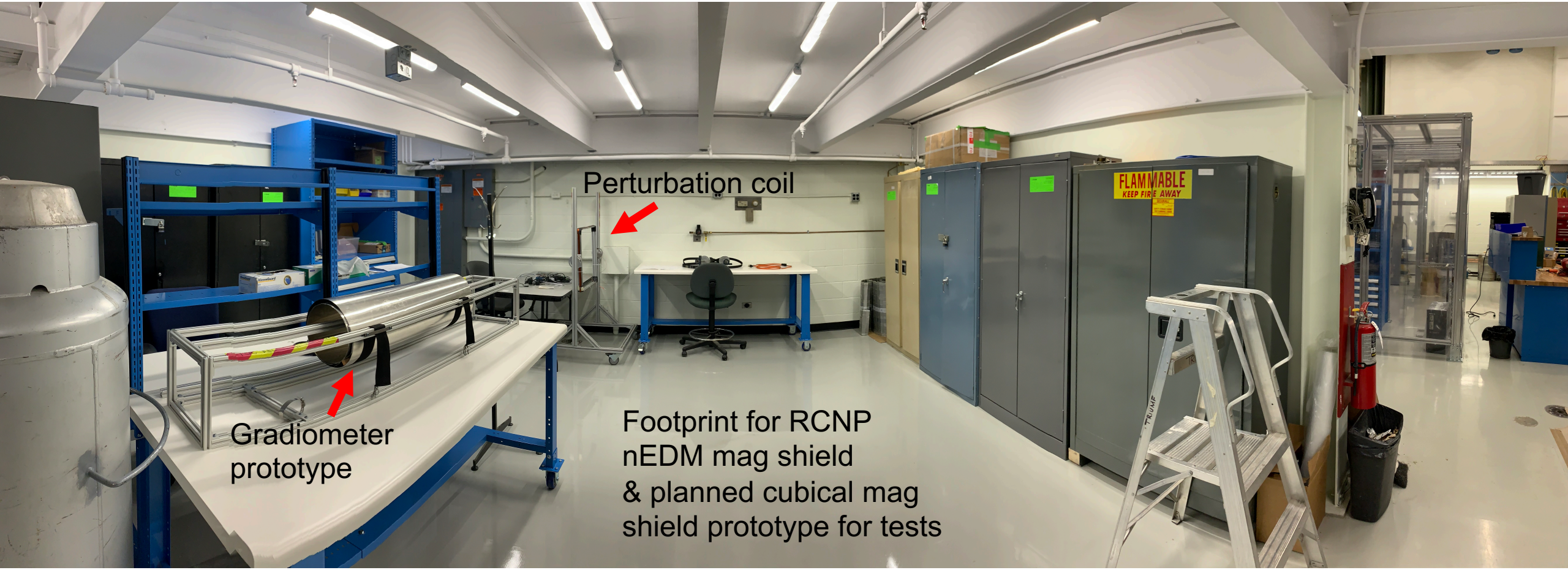
AMC:
- We have/are measuring the B field around the site for the MSR
- AMC static coil design progress begun

Internal Coils:
- We have explored a few different design concepts. We will have a review this year to pick one.
- Hired an expert as a postdoc.

Internal Magnetometers:
- Placement positions and constraints well understood.
- Will start with a 5 sensor based system that is scalable

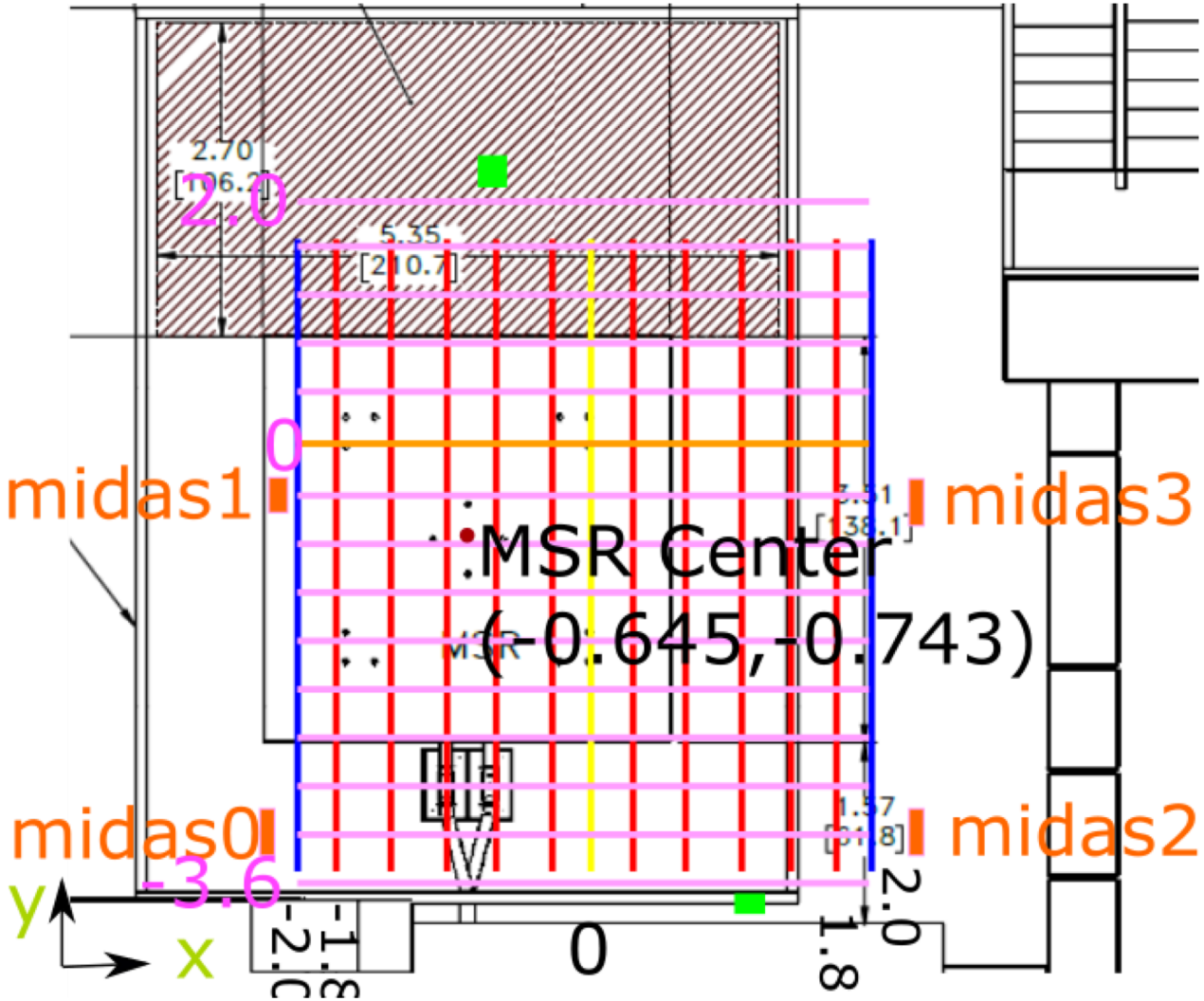
Highlights & status overview: Magnetics

NEW: R&D lab space for magnetics related projects at TRIUMF (magnetrometer tests, guiding fields, etc)

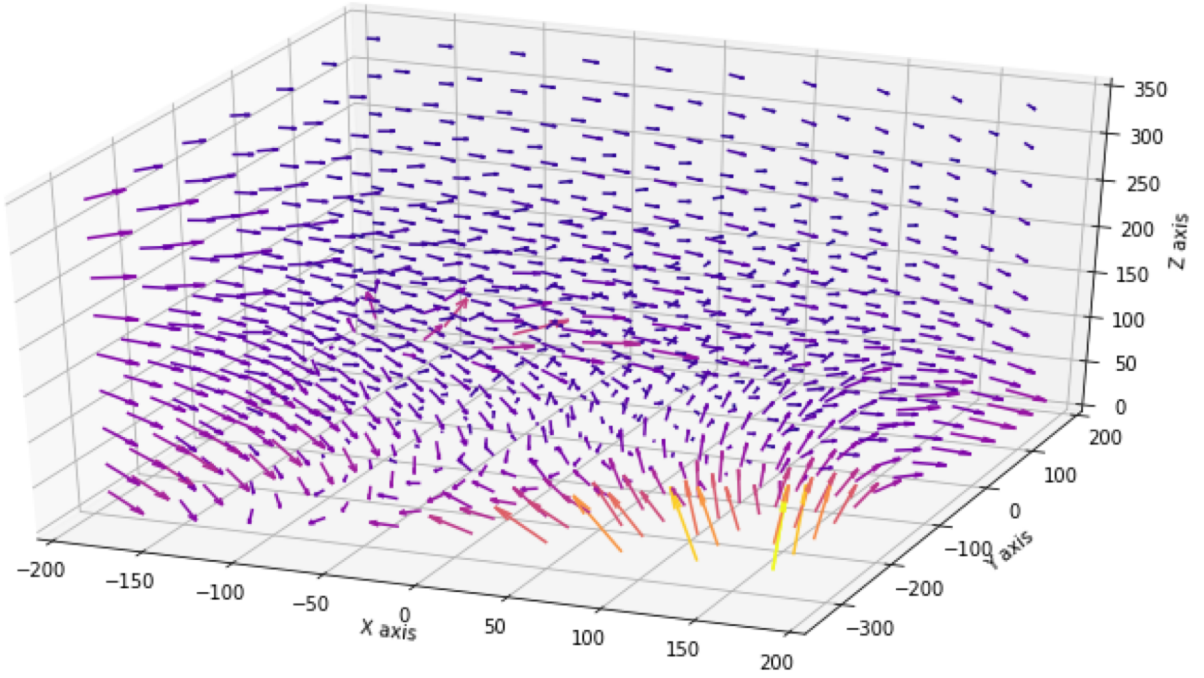


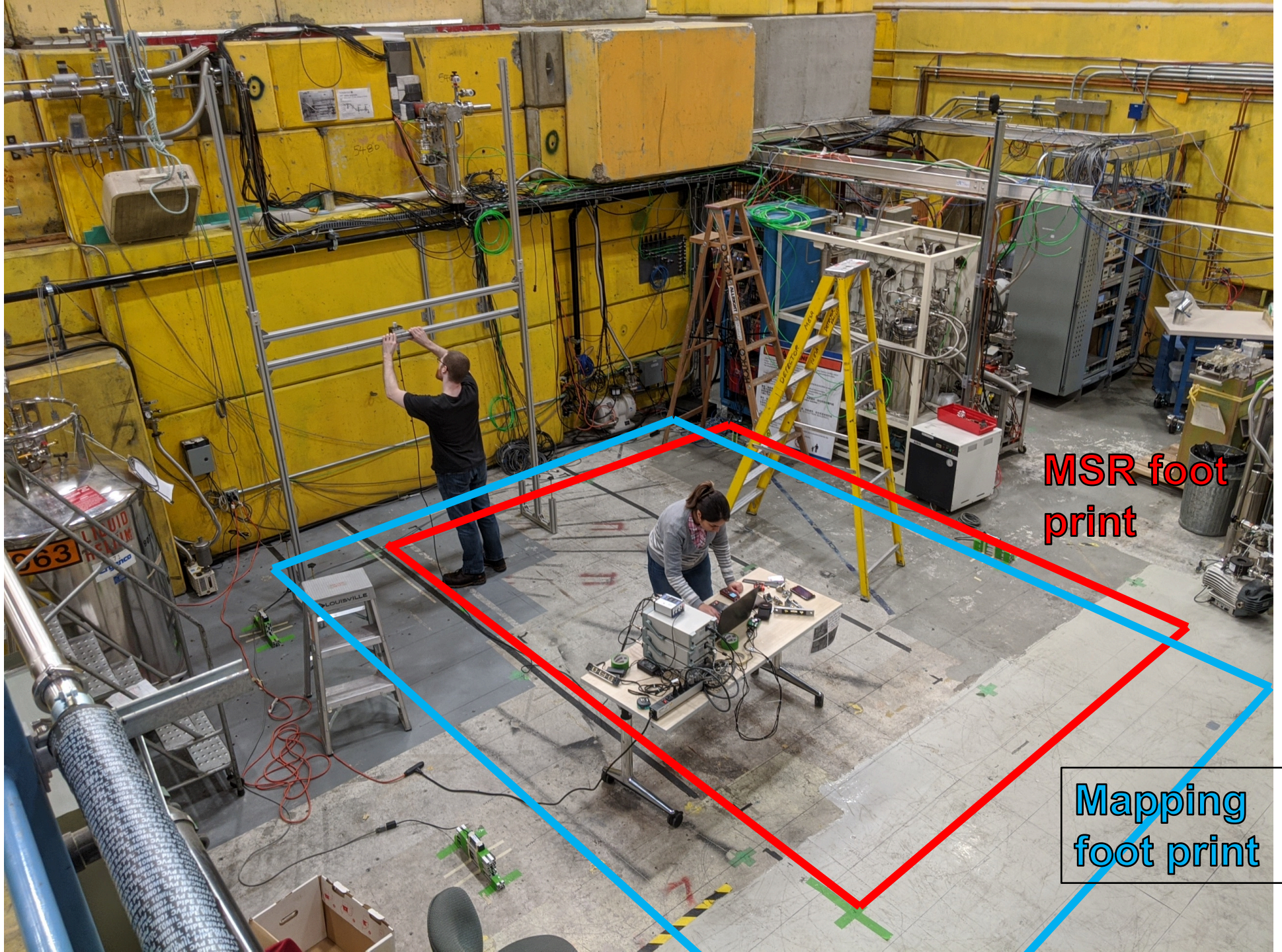
Highlights & status overview: Magnetics

NEW: Mapping of the nEDM area with TRIUMF cyclotron OFF (reduced stray field)



Preliminary field map
(xyz axes == area coordinates in cm;
Arrow heat map == mag field in arbitrary relative units)



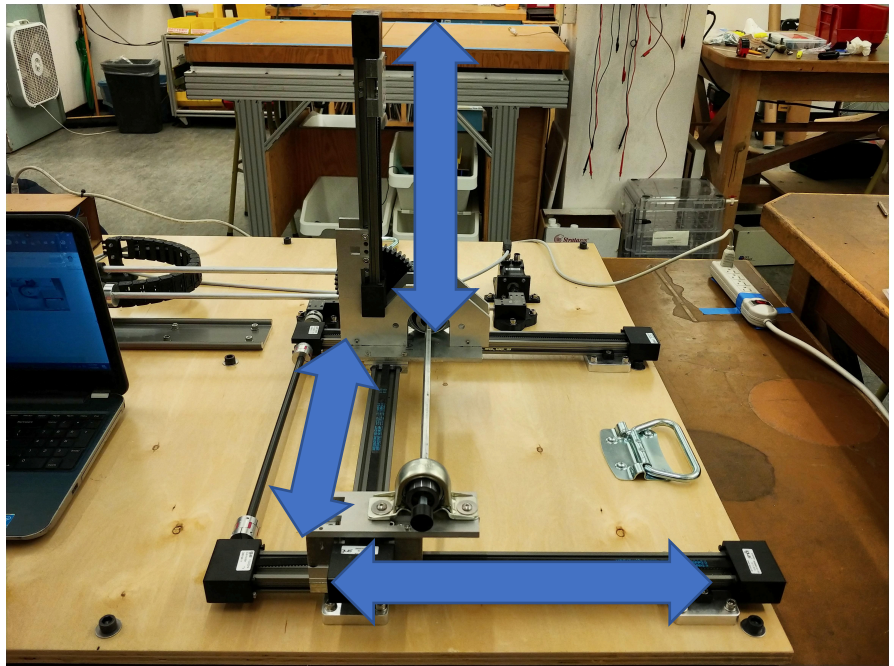

MSR foot print
Mapping foot print

Highlights & status overview: EDM cell, comagnetometer, inner mapper

- **nEDM main cell (including HV & surrounding vacuum)** - compatibility with AC fields for neutron spin flipping, prototype EDM cell built including non-magnetic valve which is tight to UCN and comagnetometer gases, coating facility ready for first coating tests, breakdown measurements with different gases incl. Xenon
- **Comagnetometer** - progress towards interfaces and implementation within the actual nEDM apparatus, i.e. prepolarizing & filling of comagnetometer gases as well as light transport for optical precession frequency readout. This also provides input for necessary penetrations in magnetically shielded room. New results in Xenon spectroscopy!
- **non-magnetic mapping robot for nEDM magnetic holding field** - UBC engineering physics Capstone project completing first prototype; knowledge of absolute magnetic field homogeneity crucial for systematics control in nEDM; video in backup slides

EDM cell & HV, Florian Kuchler, 20’ + 5’

Comagnetometer, Eric Miller, 15’ + 5’



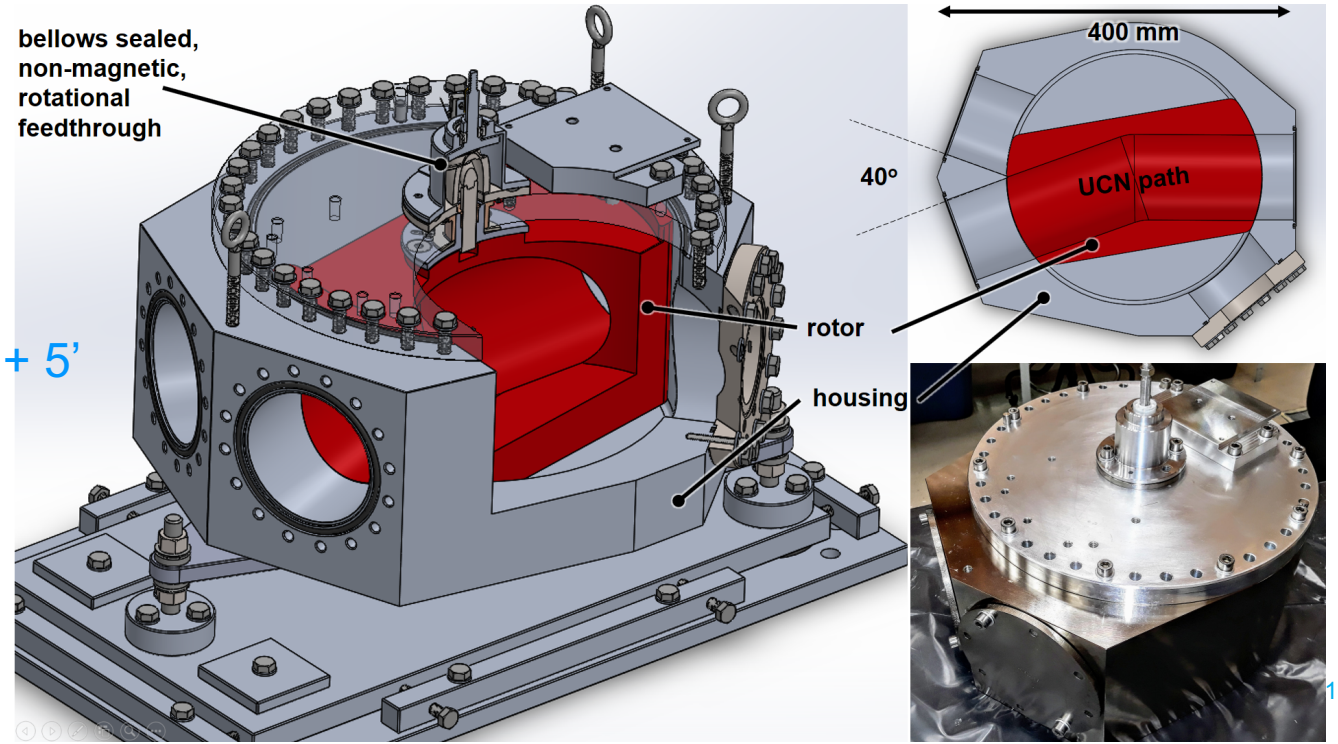
Highlights & status overview: neutron handling & detection/spin analysis

- **Neutron handling** – lots of components have been designed, manufactured, (and partly characterized):
  UCN source Y-switch, vent/relief/pump port for UCN source, gate valve, etc -> solid baseline for UCN guide elements

- **UCN detection and spin handling & DAQ** – advanced testing of MIDAS interface and experiment sequencer, continuous and reliable operation of our 6Li and 3Helium detectors and R&D towards improvements or substitute detectors (SiPM light readout for 6Li detector, or CASCADE-U), improvements in the design and efficiency of the simultaneous spin analyzer, R&D towards guiding fields started

Neutron handling, Ruediger Picker, 15’ + 5’

UCN detection SSA DAQ, Pietro Giampa, 15’ + 5’



Summary

EAC: please endorse our following plans

Purchasing and commissioning the MSR is a crucial step and will enable us to move forward:
to characterize its performance we will need a variety of magnetometers and magnetic field related tools

We solicit approval from the EAC on our approach to prioritize completing the source
over nEDM R&D efforts

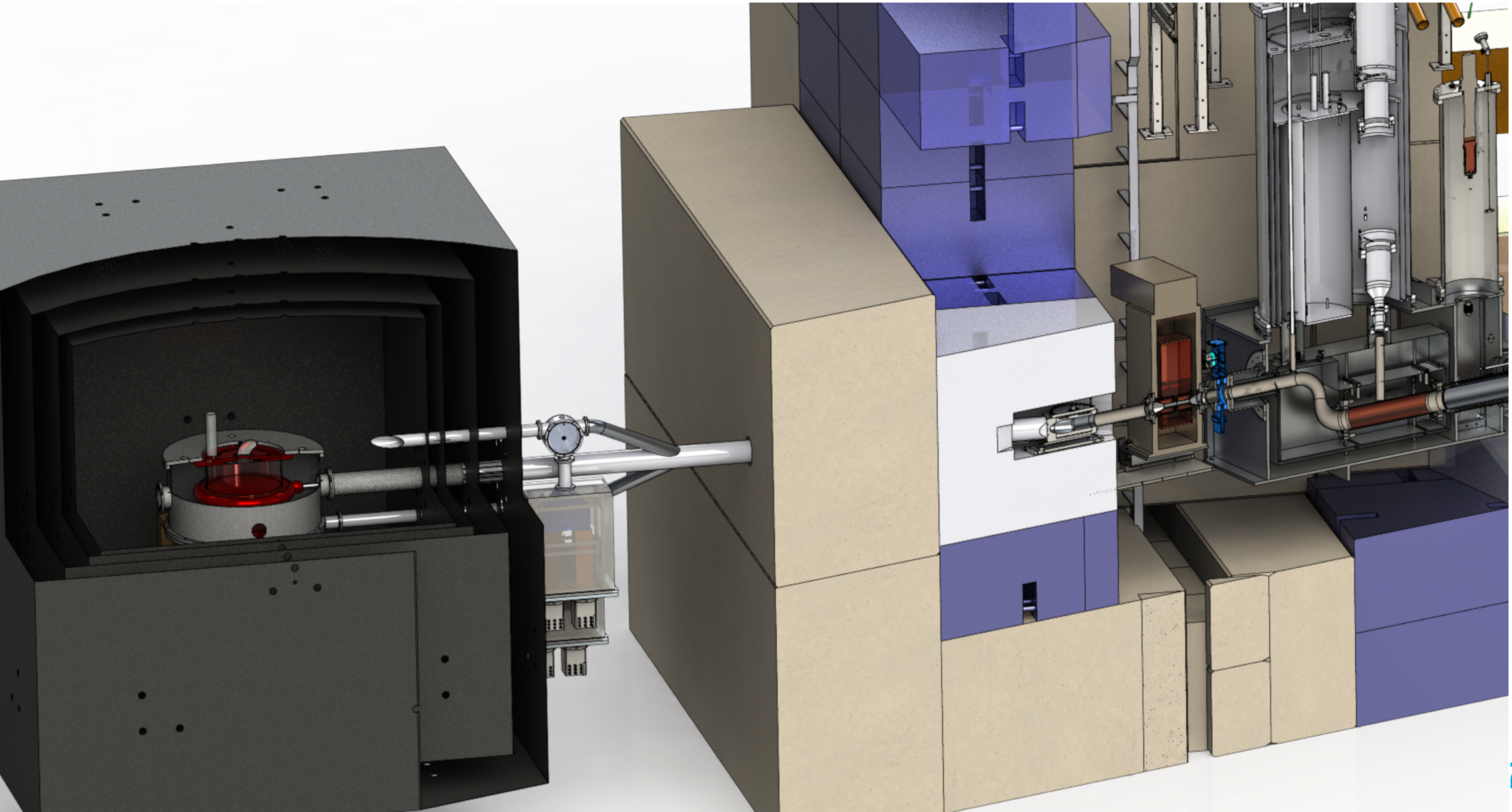
We solicit detailed assessment from the EAC on the readiness and next steps forward of each subsystem

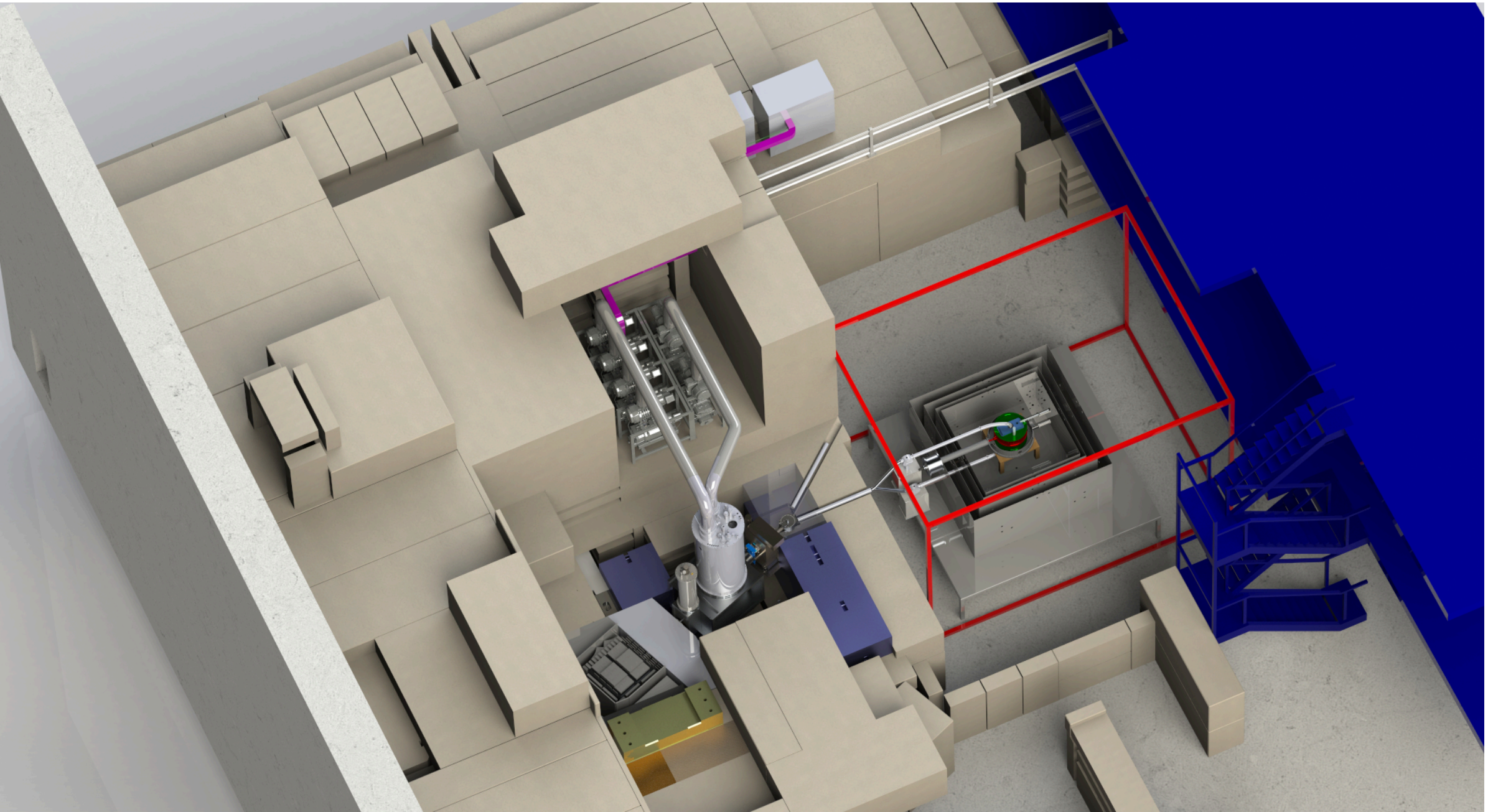
- Start building the AMC (our ‘insurance policy’ for MSR performance)
- Buy a first set of 5 NMOR magnetometers as soon as funding is released
- Have a collaboration internal review to decide on a final design for internal coils, technical input welcome
- And others as presented during this review, and in the nEDM CDR

It is our goal to ‘put something on the floor’ so that we can start learning
how to operate an nEDM apparatus
(as compared to pushing for the ‘perfect’ design because we will learn that we need upgrades anyways)

Back-up slides

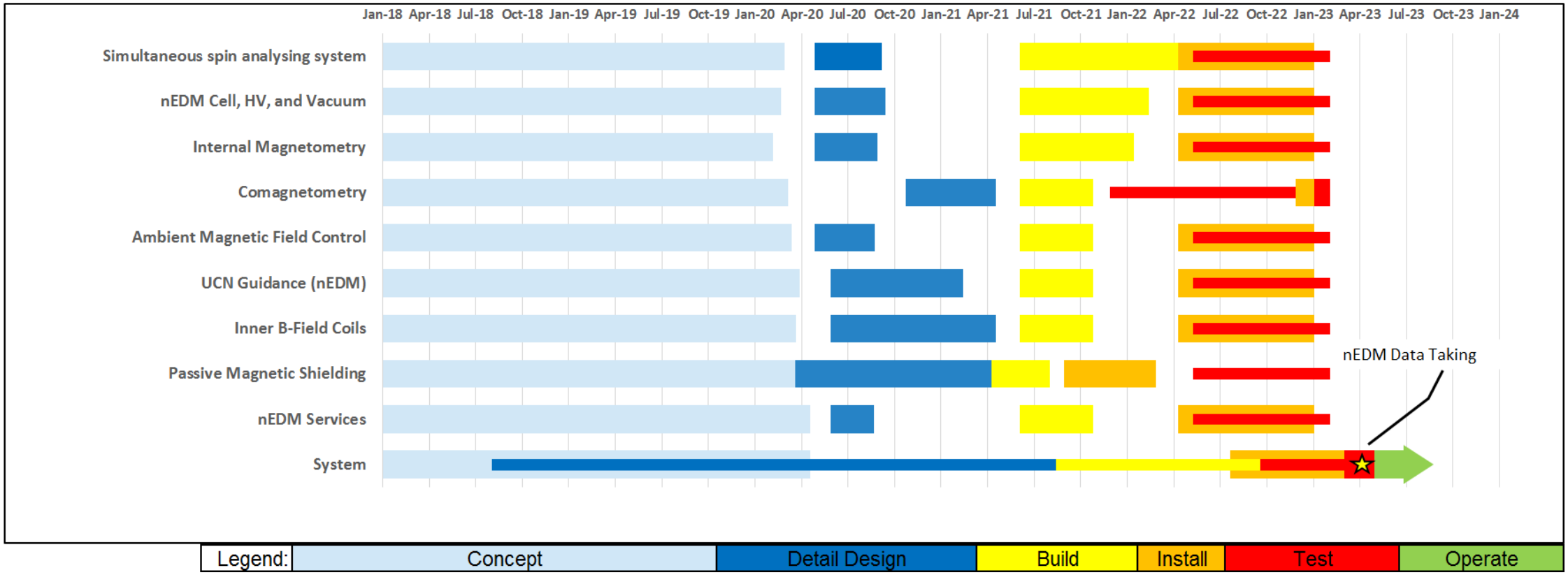
Screenshot of the location of master slides





Discovery, accelerated

Schedule



Screenshot of the location of master slides

Staged approaches – some simple examples

- AMC: start with static/DC component to buck cyclotron field, add dynamic/AC component later
- Thermal enclosure: start with (passive) housing only, which can be upgraded to active AC/temperature control
- Vibration control/damping: passive rubber feet; potential upgrades to active system or air pads

Mapper robot - video

Designed to be actuated through MSR penetrations via angled Drives, thus only penetrations On one side of MSR are necessary