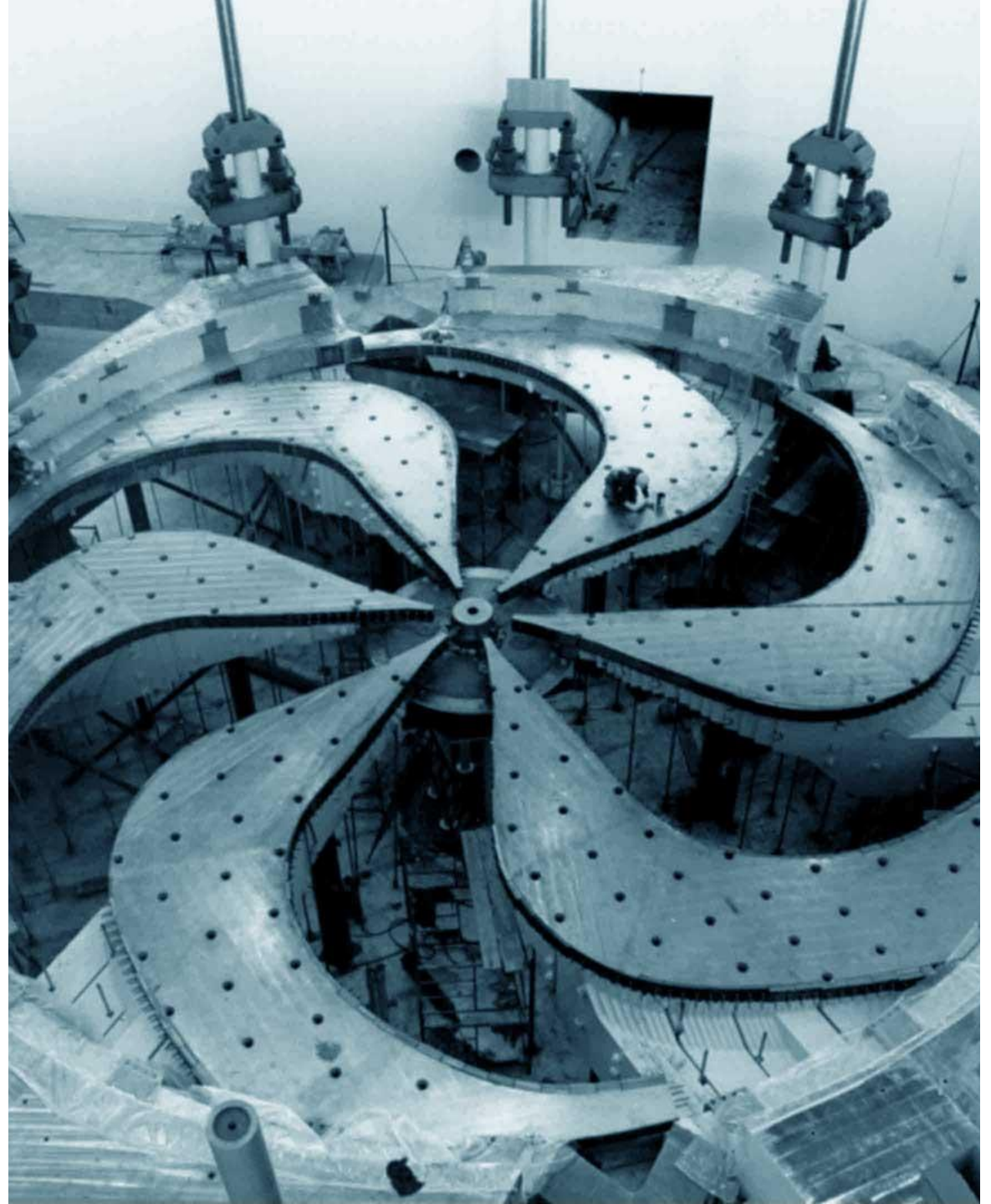
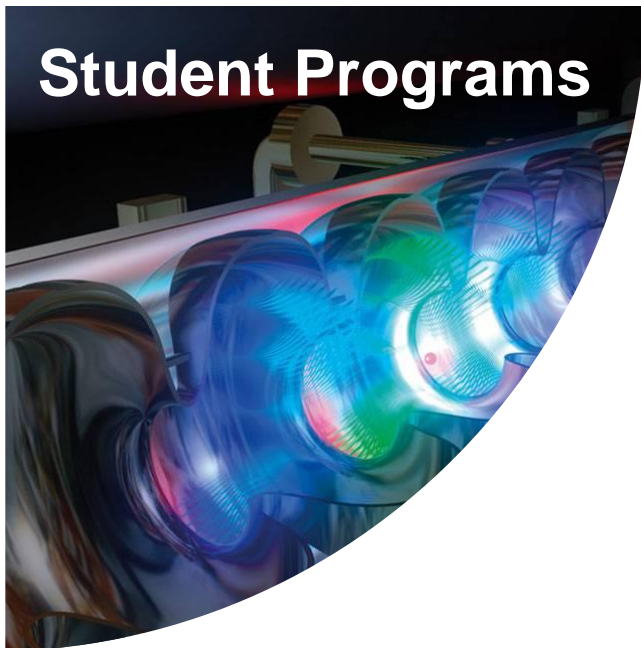
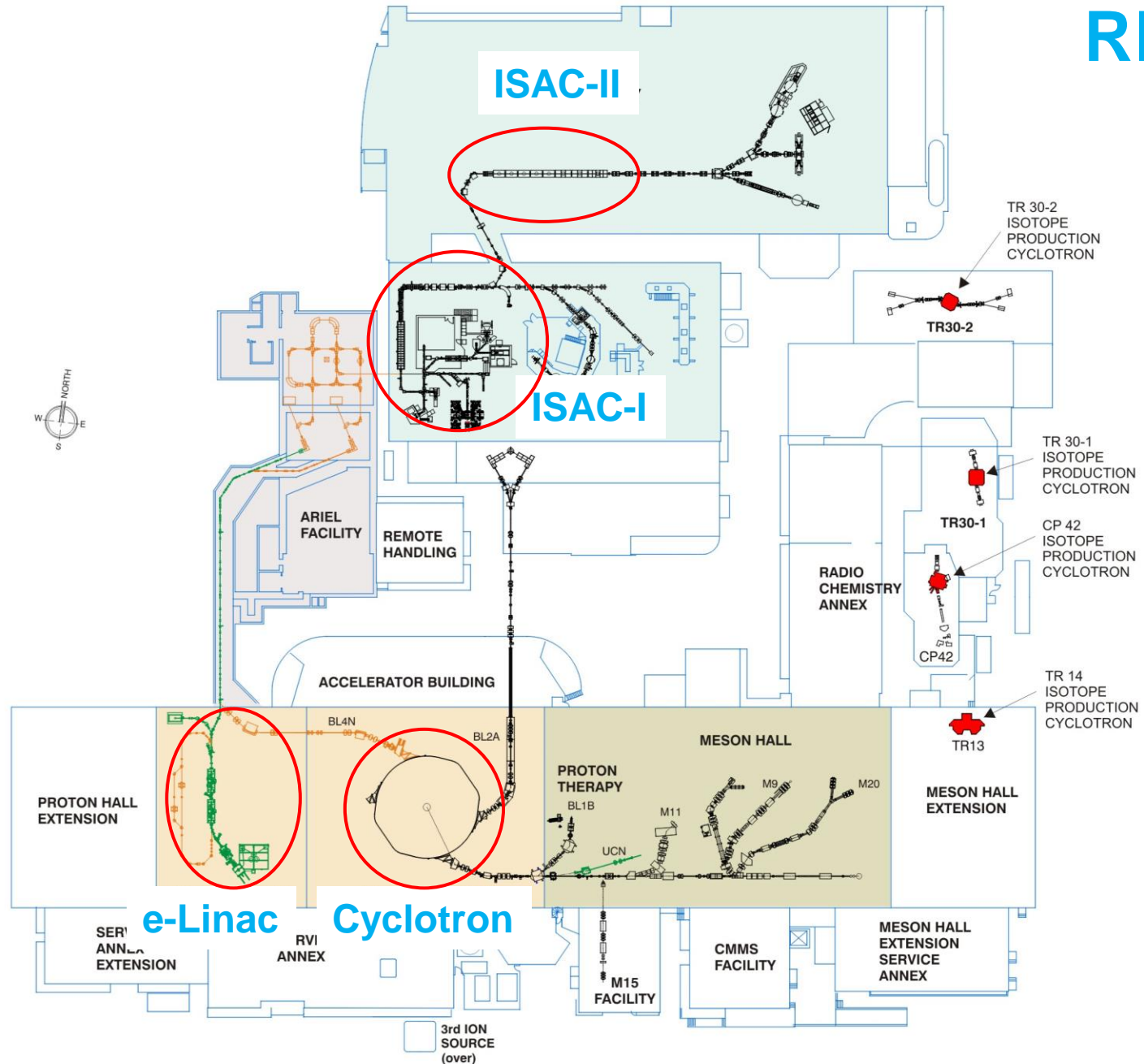


RF/SRF and the next FYP

Zhongyuan Yao
RF/SRF Department
Science Week, Jul. 21, 2022

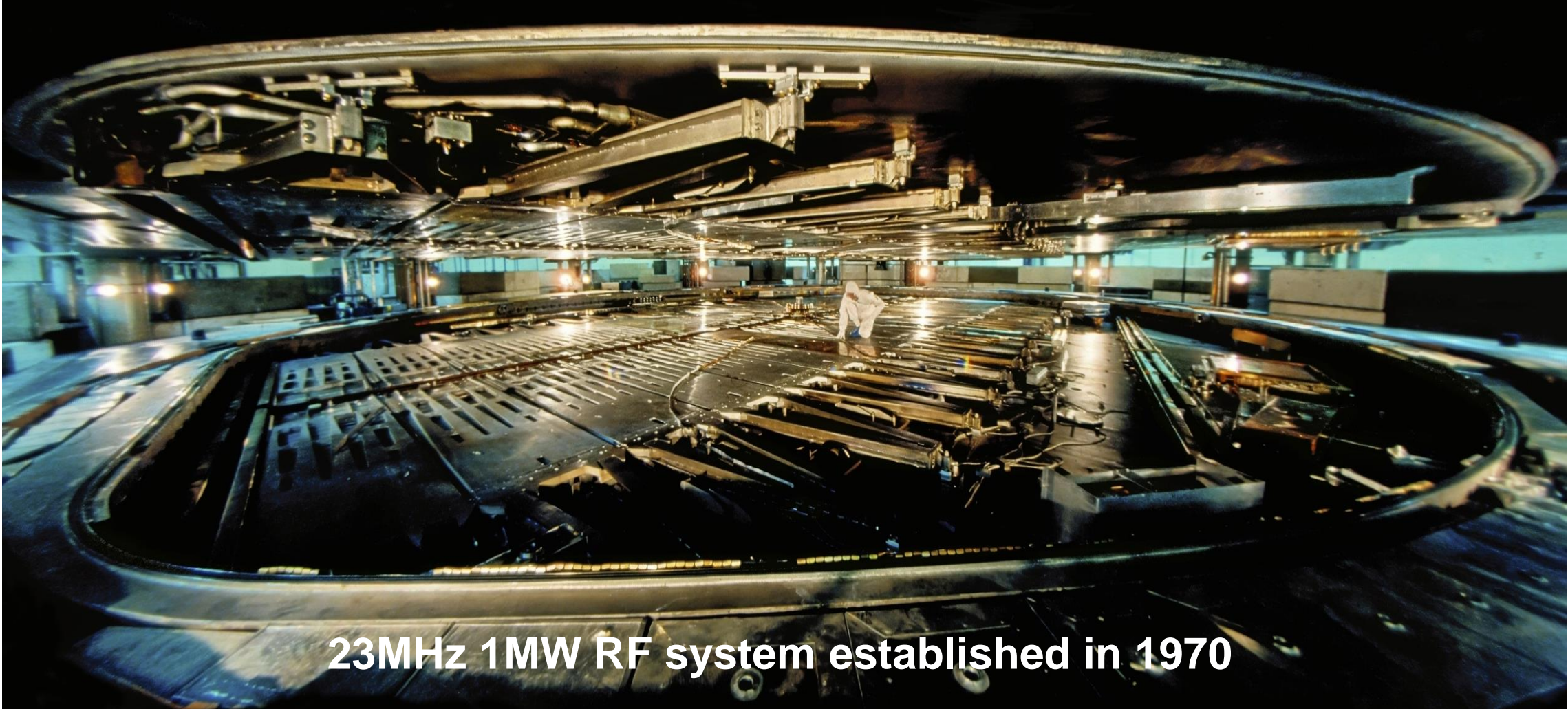






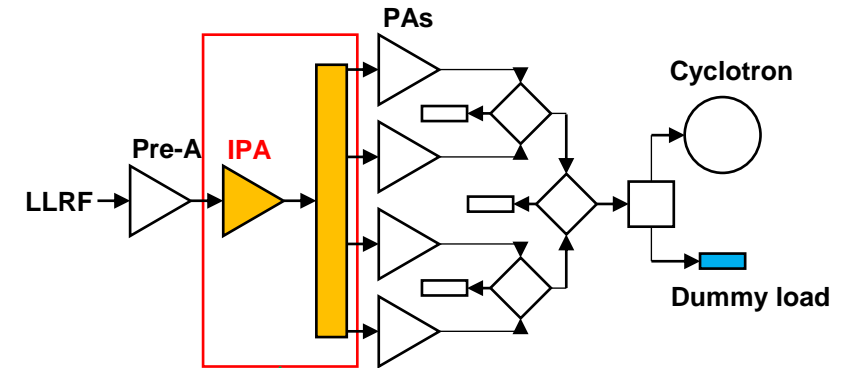
Medical cyclotrons

e-Linac Cyclotron

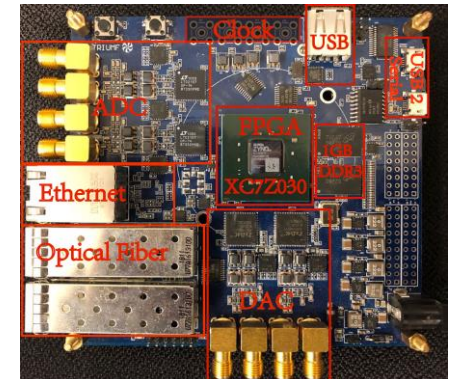
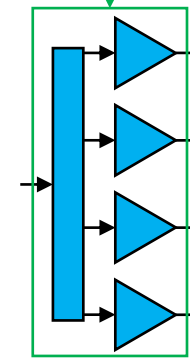


23MHz 1MW RF system established in 1970

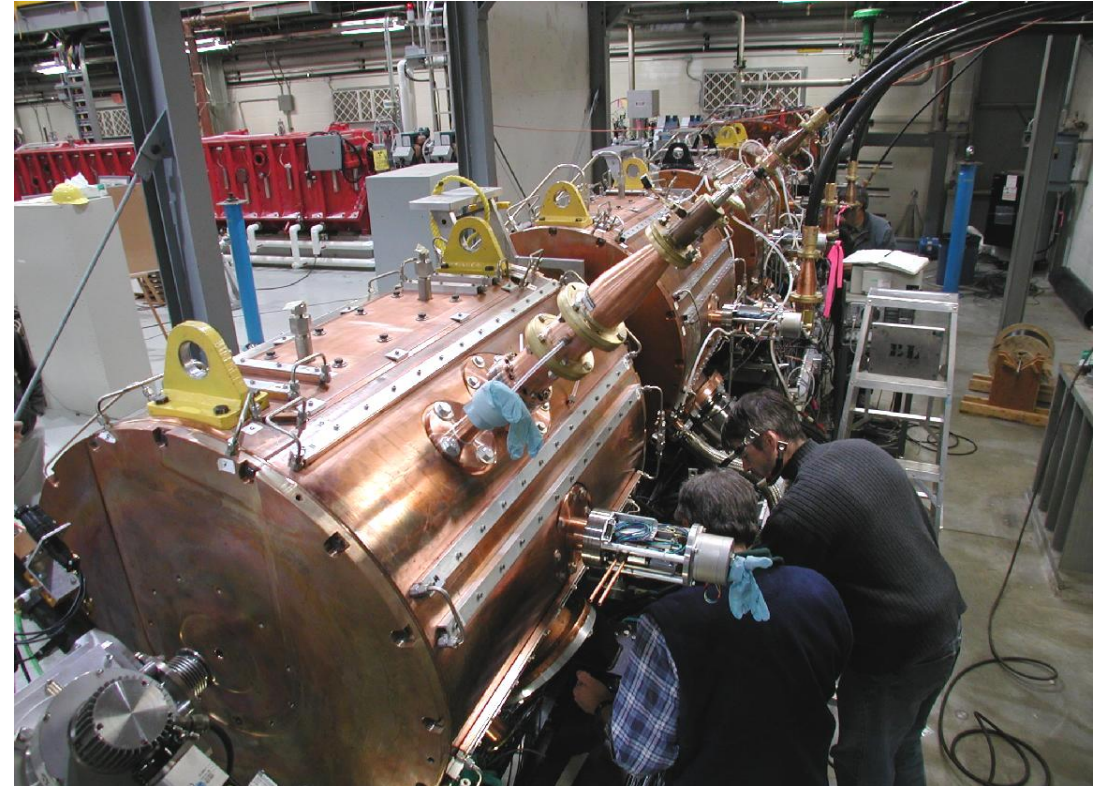
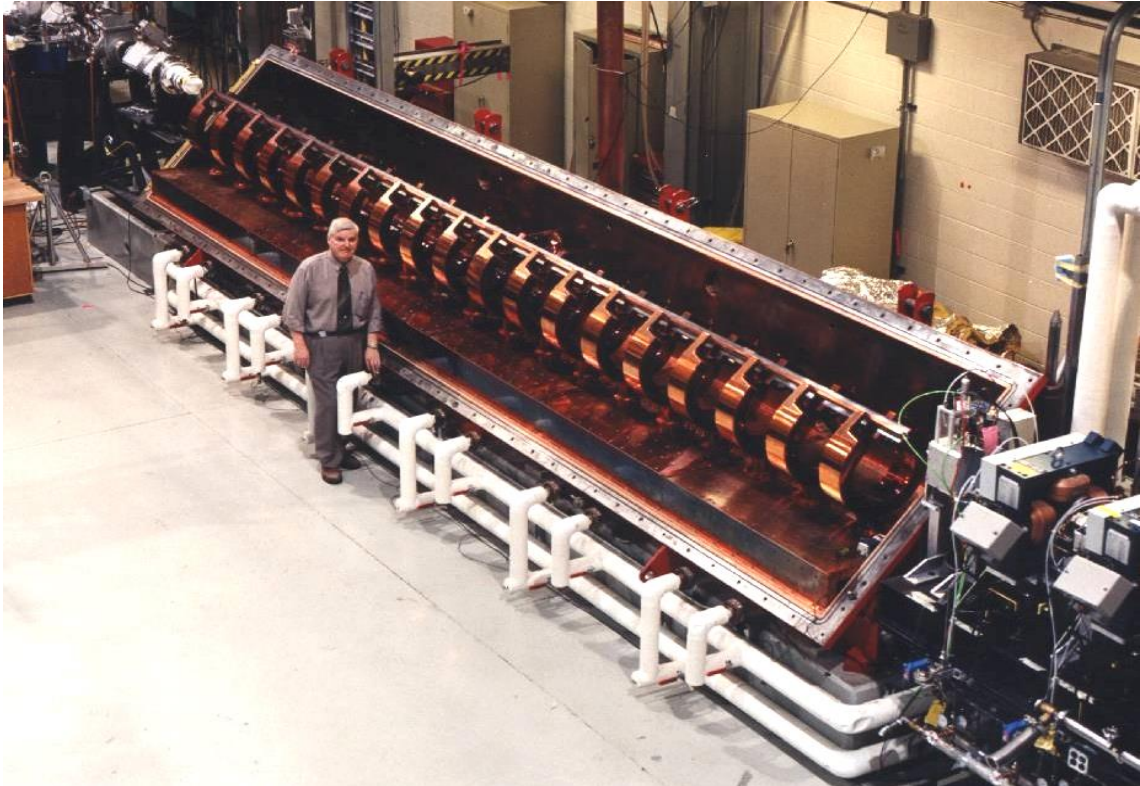
- To reduce downtime and improve reliability with a performance goal of 95kV to allow higher intensities in the cyclotron
- System upgrades
 - Upgrade power amplifiers – Intermediate power amplifier (IPA)
 - Acquire critical spares – tubes and capacitors
 - Update diagnostics – digital LLRF and new event detection
 - See R. Leewe’s talk on Monday for details
 - Move away from obsolete technology



RF schematic



Digital LLRF board



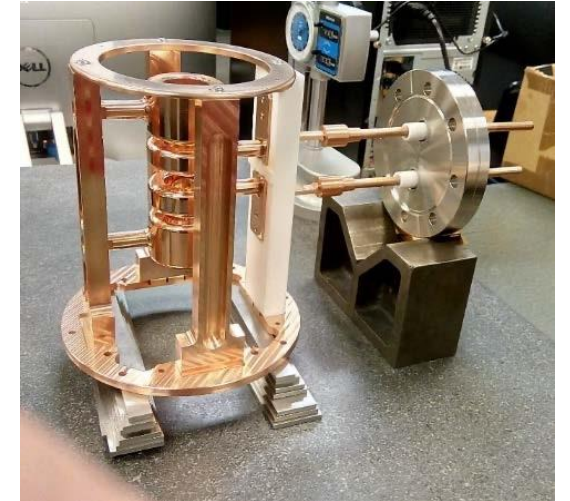
- 35MHz 90kW RF Quadrupole (RFQ)
- 106MHz 5-25kW Drift Tube Linac (DTL)
- Bunchers, rotator, choppers, booster – frequency range 5-106MHz

Service over 20 years

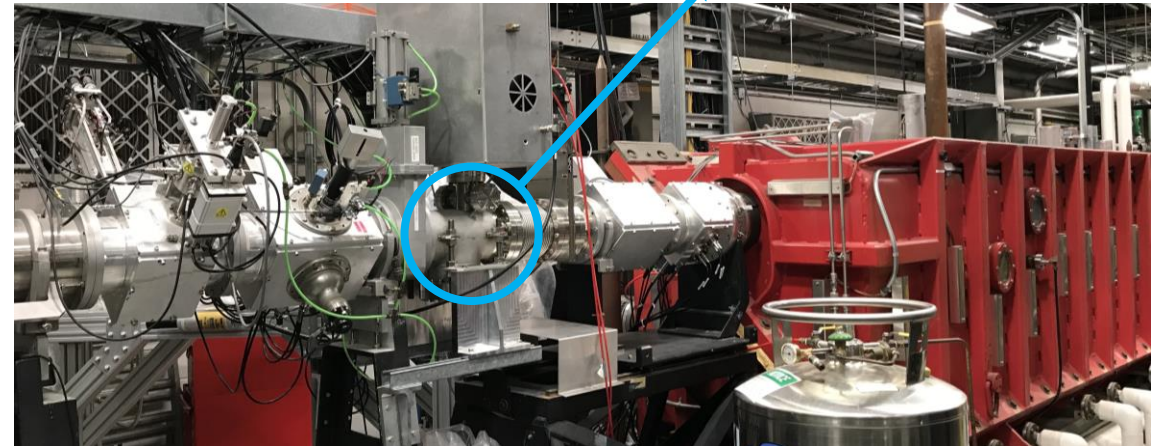
- RF system refurbishments
 - Refurbish the most vulnerable parts in RF chain to improve long-term reliability
 - Upgrade RF amplifiers to solid-state amplifiers
 - Upgrade LLRF to digital system
- 11MHz ISAC booster upgrade
 - Increase voltage from 10kV to 24kV
 - Reduce beam aperture
 - Implement new optics to reduce beam size
 - Increase RF power
 - De-risk Target source bias capability



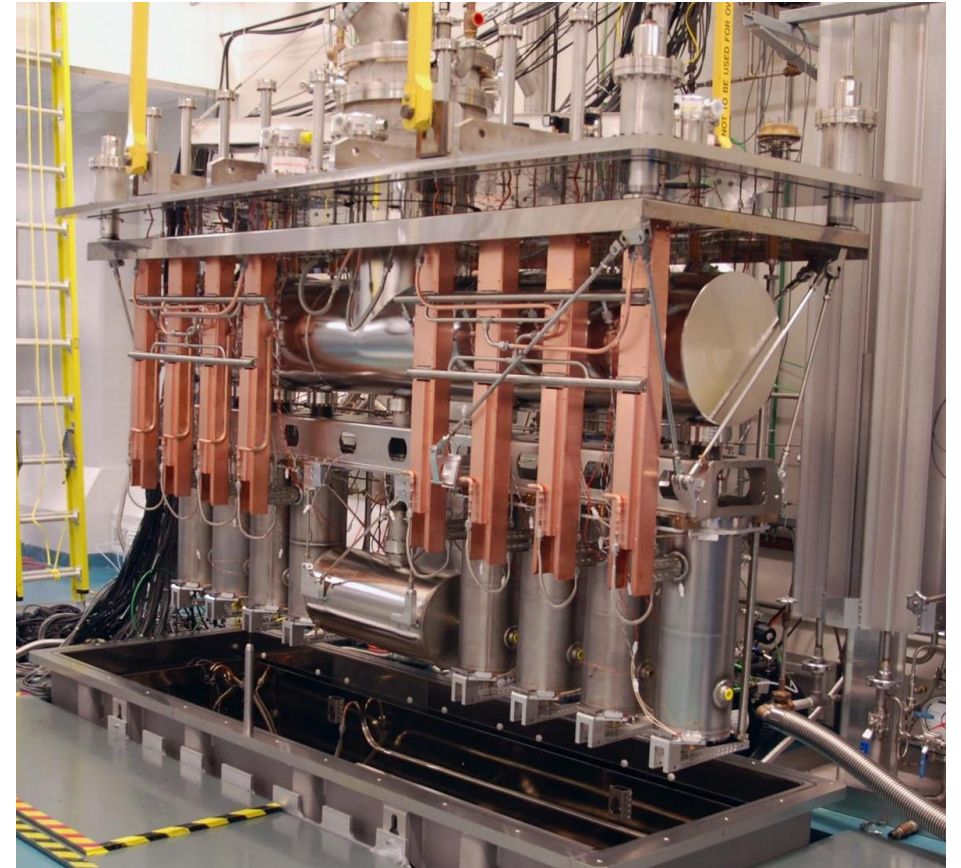
4.8kW 106MHz SS Amp



Booster electrodes



ISAC-II Superconducting Linac



- 40MV SC Linac with 40 106/141MHz Quarter-Wave Resonators (QWRs)
- In operation since 2006

- On-going refurbishment program
 - Upgrade critical components for better reliability
 - Improved Linac performance from 33MV to 39MV (38 cavities) in past 5 years
 - Reduced RF downtime by a factor of 5 since 2014
- To achieve 40MV in next few years
 - 40 cavities available for operation
 - Optimize RF preparation procedure

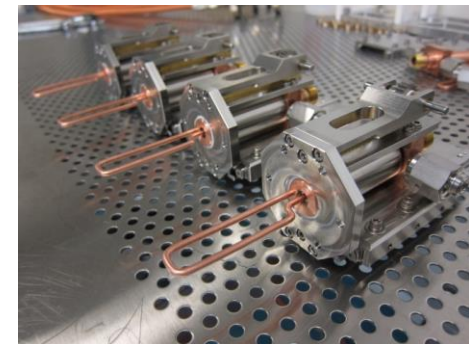
RF feedthrough



Hermetic RF cable



Tuner w/ nut joint

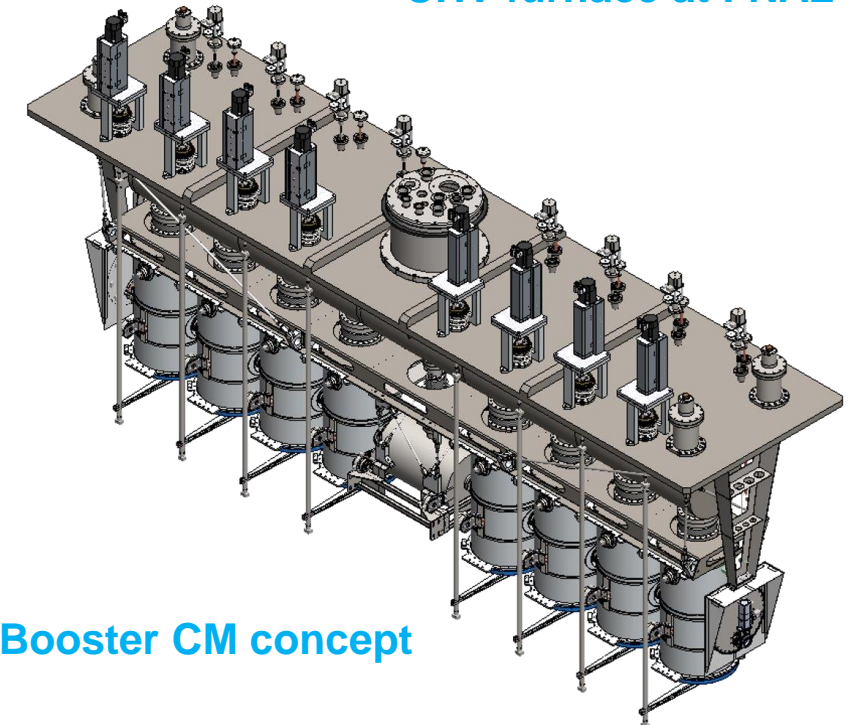
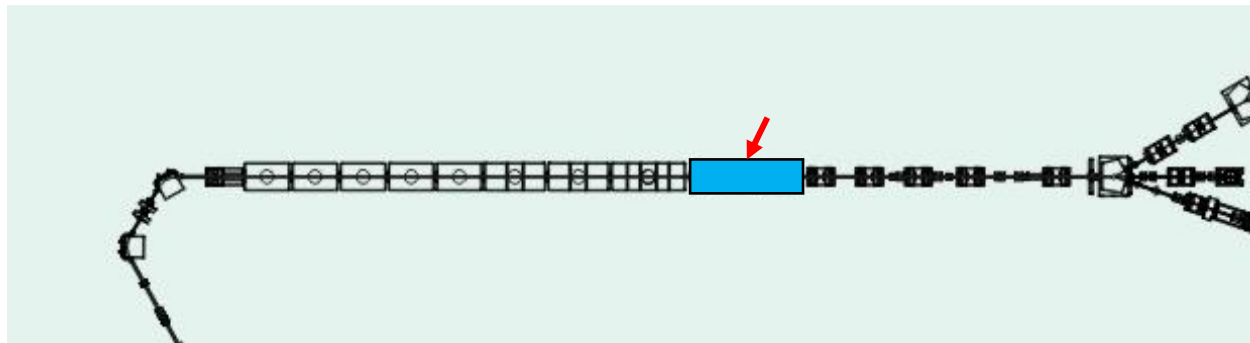


'New' RF coupler

- Improve existing cavity performance
 - Various heat treatments improve cavity performance
 - Hydrogen degassing & low temperature baking
 - Add ~6MV to 40MV
- ISAC-II booster cryomodule proposal
 - Additional cryomodule with 8 QWRs after SCC3
 - Add 16MV to current ISAC-II capability
 - Concept based on separated vacuum system

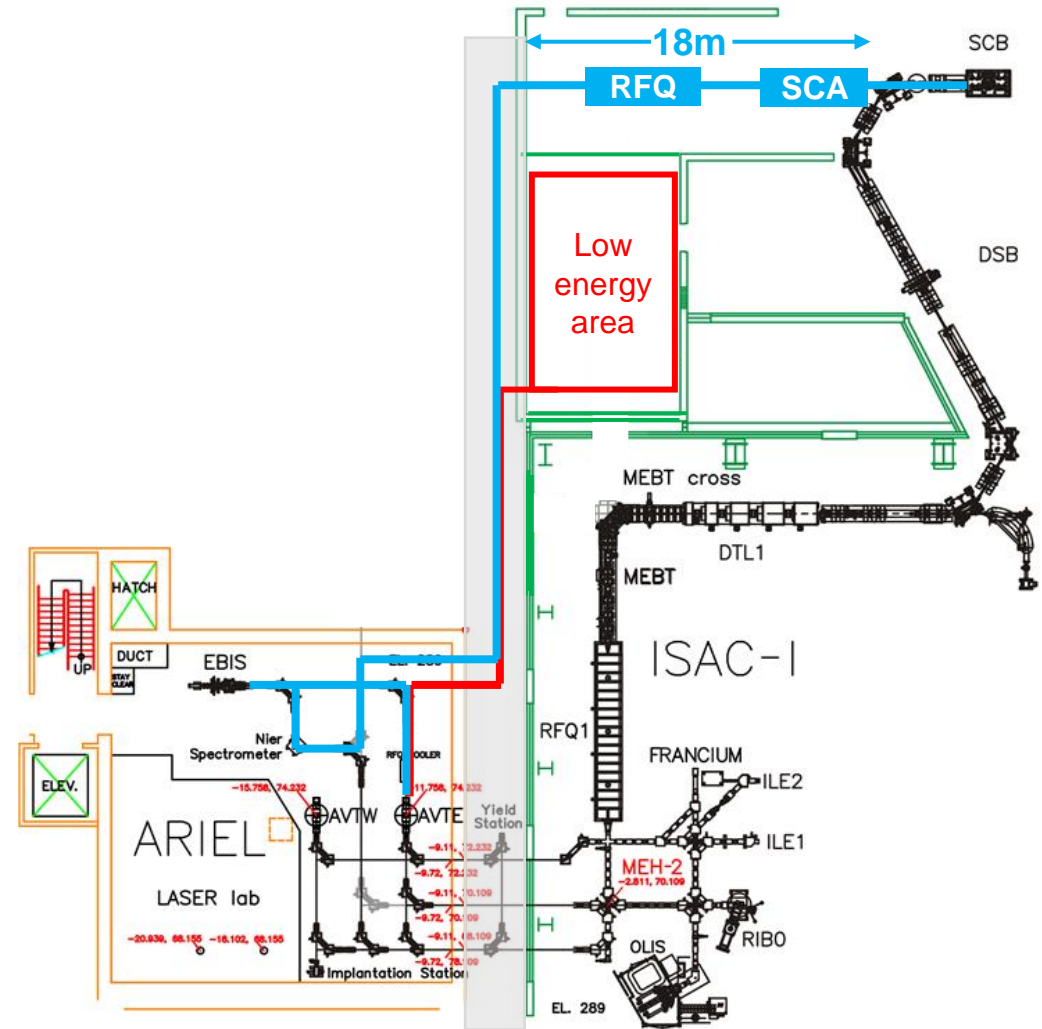


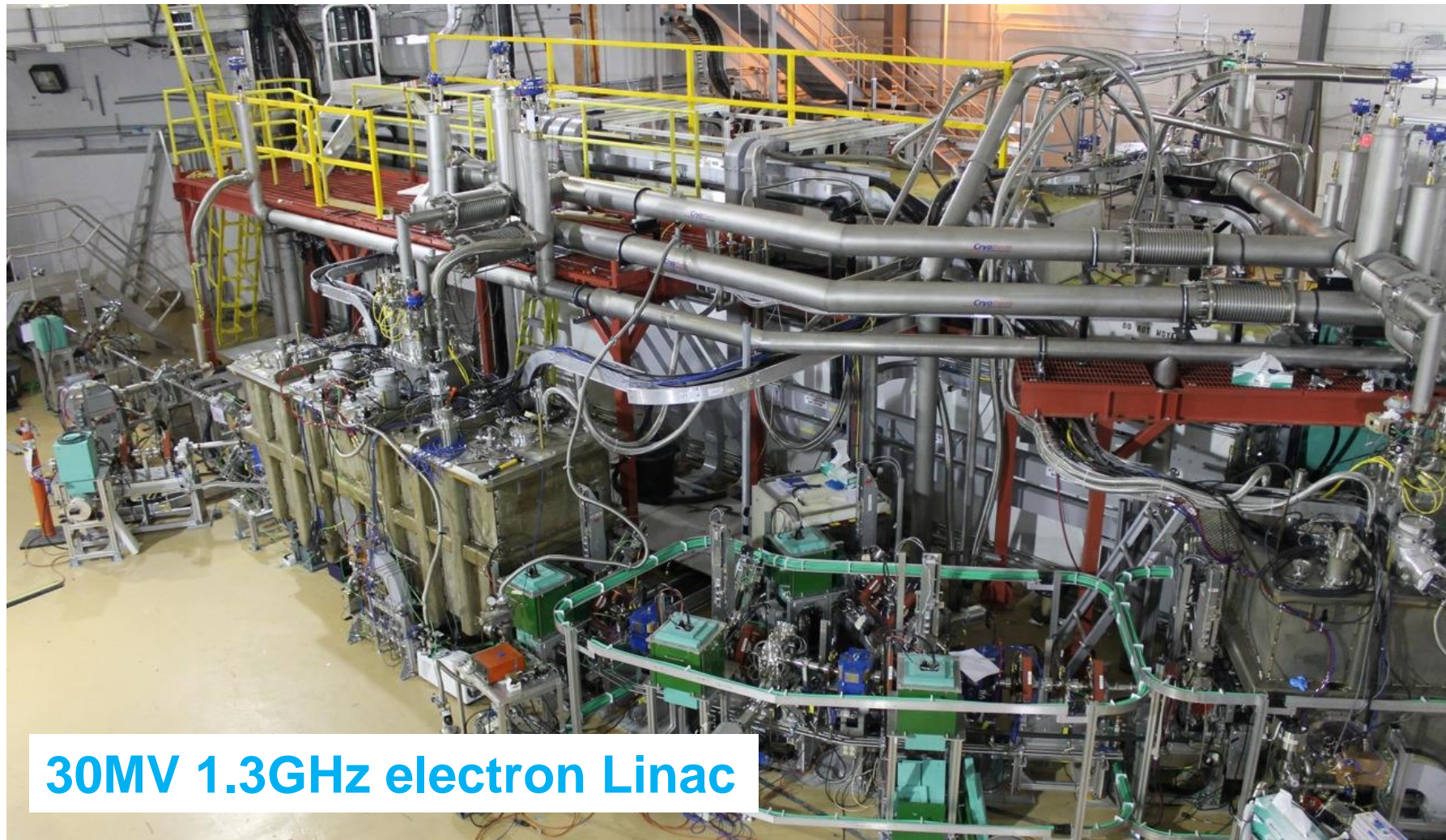
UHV furnace at FNAL



Booster CM concept

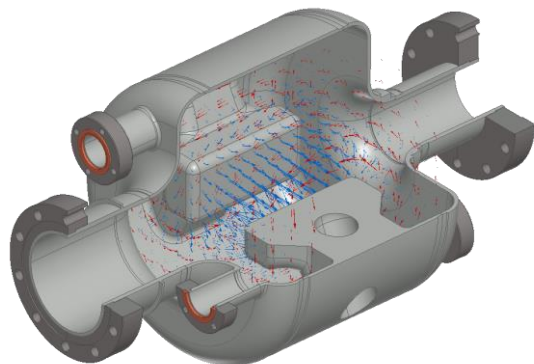
- New RFQ
 - Accelerate RIBs with A/Q 2~7 (EBIS) to energy 400keV/u, compatible with SCA injection
- New SCA cryomodule
 - 7 QWRs @ 70MHz, 0.041 velocity
- With ARIEL completion, ISAC facility could offer 3 simultaneous RIBs to experimental stations (LE /ME/HE)



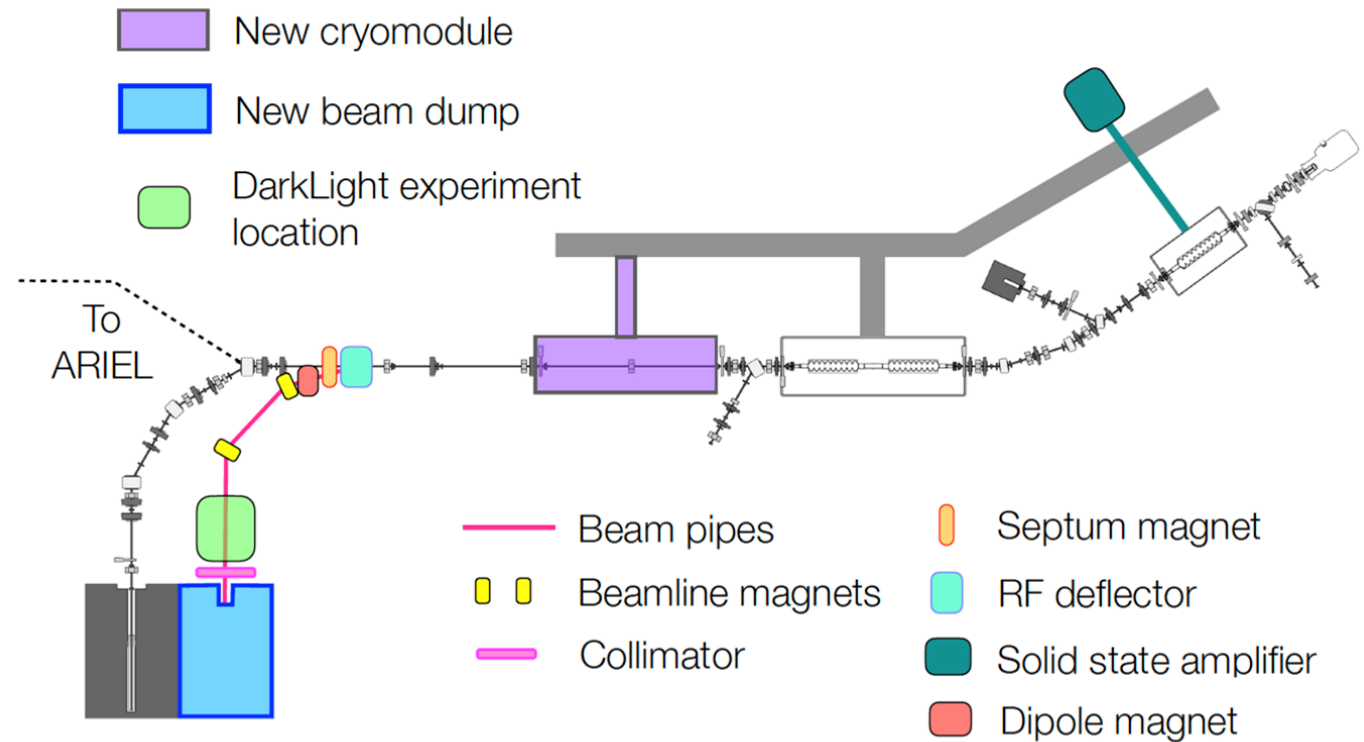


30MV 1.3GHz electron Linac

- Support DarkLight experiment to search particles beyond the Standard Model
 - 50MeV electron energy required to explore X17 uncovered parameter space
 - See K. Pachal’s talk on Tuesday for details
- New RF systems
 - 2nd accelerator cryomodule (EACB)
 - 100kW solid-state RF amplifier
 - 325MHz RF separator
- Provide long-term reliability and flexibility for ARIEL operation



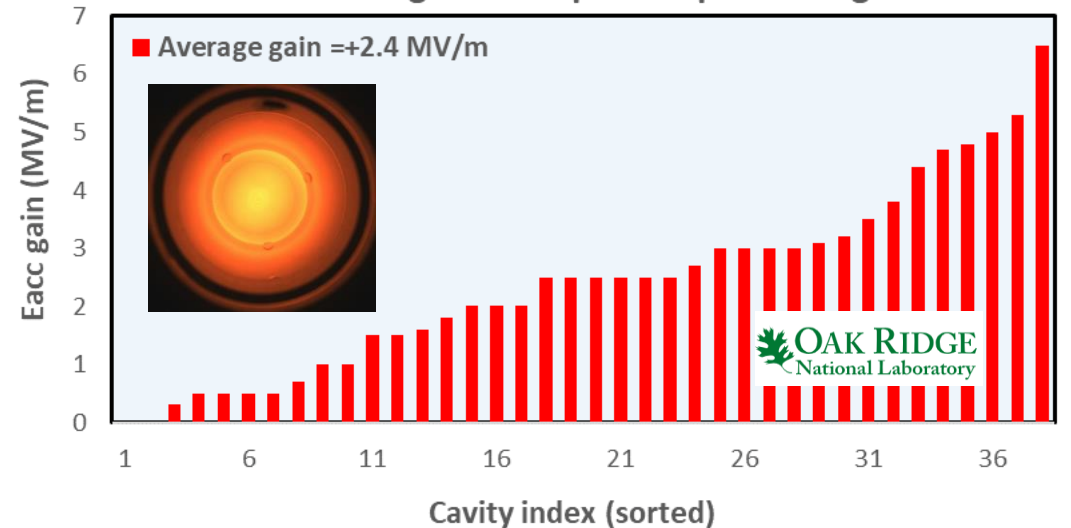
650MHz separator design (demo)



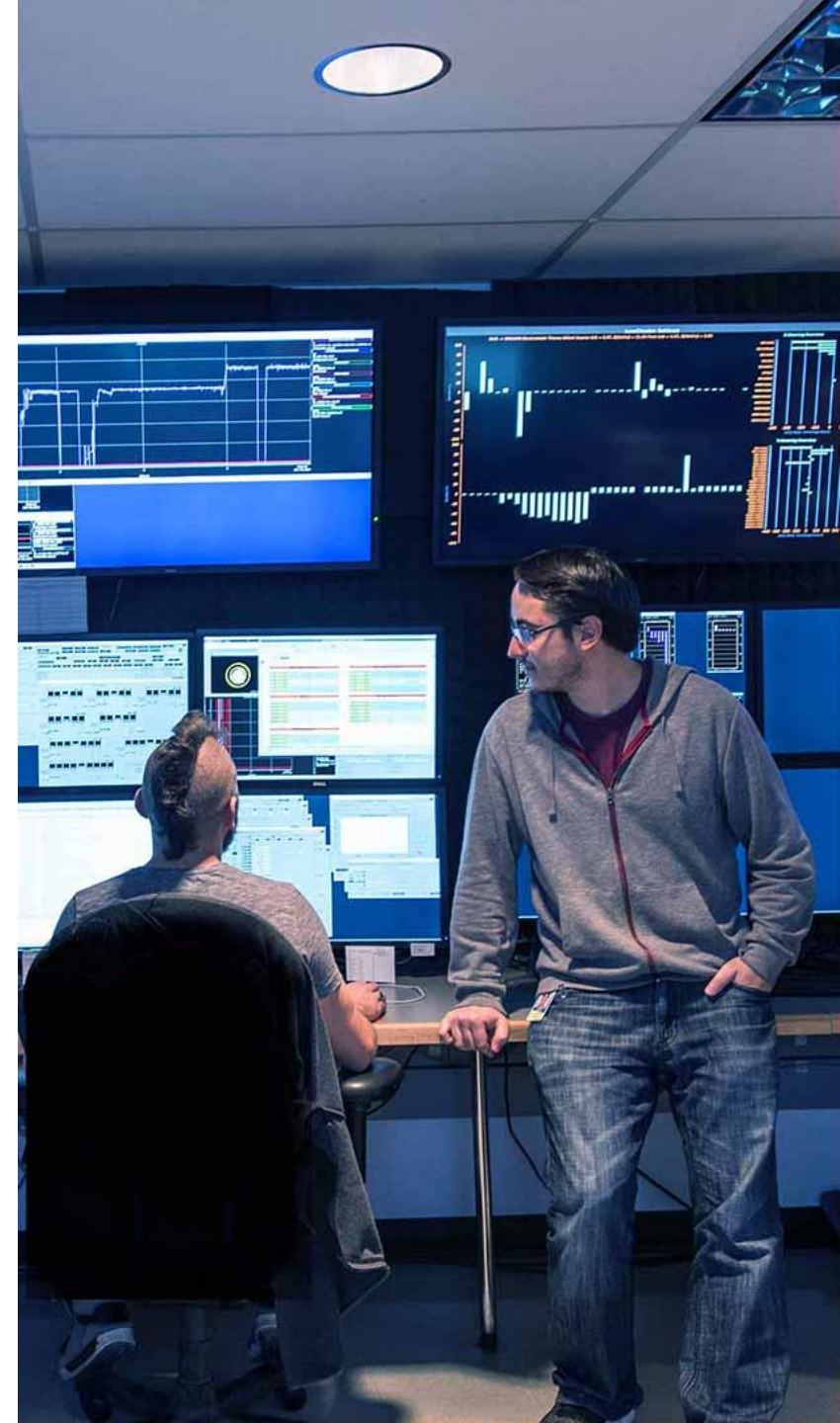
- R&D on particulate contaminations
- Environment cleanness
 - Clean pump and purge system (completed)
 - Mobile cleanroom
 - Particulate migration (PhD program)
- Plasma cleaning (PhD program)
 - In-situ SRF processing
 - Ignite plasma in each cell of a cavity sequentially
 - Remove hydrocarbon surface contaminations
 - Mitigate field emission and multipacting



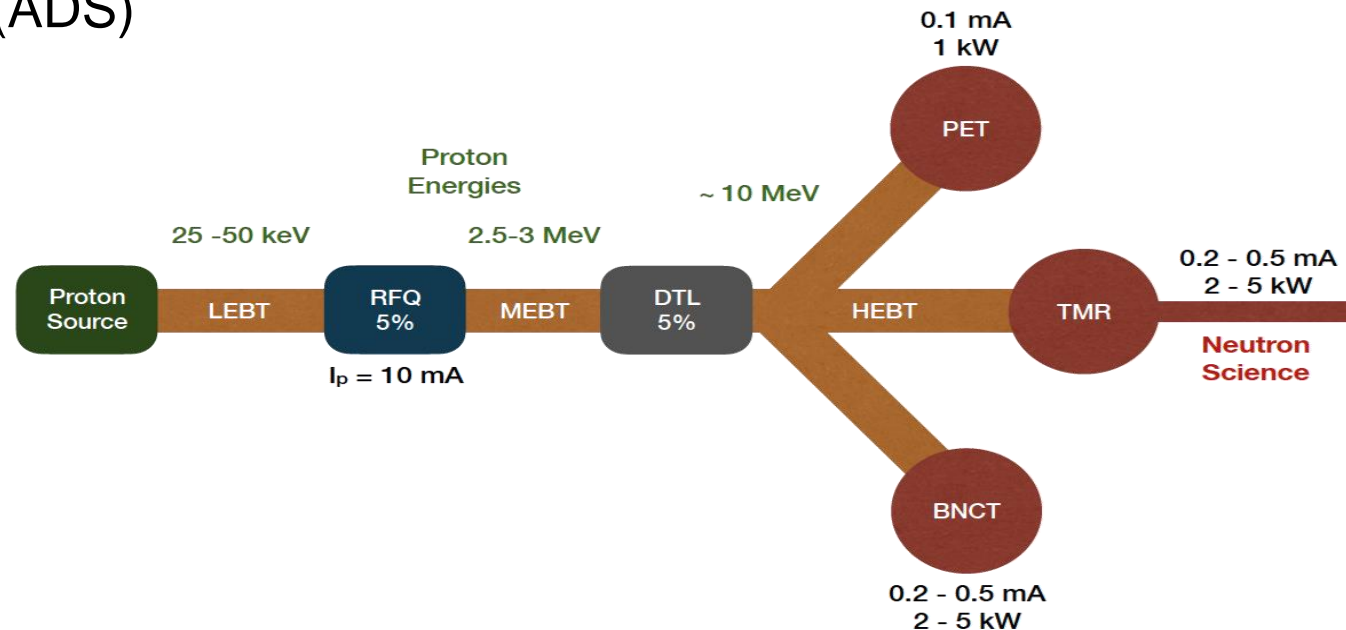
Gradient gain after plasma processing



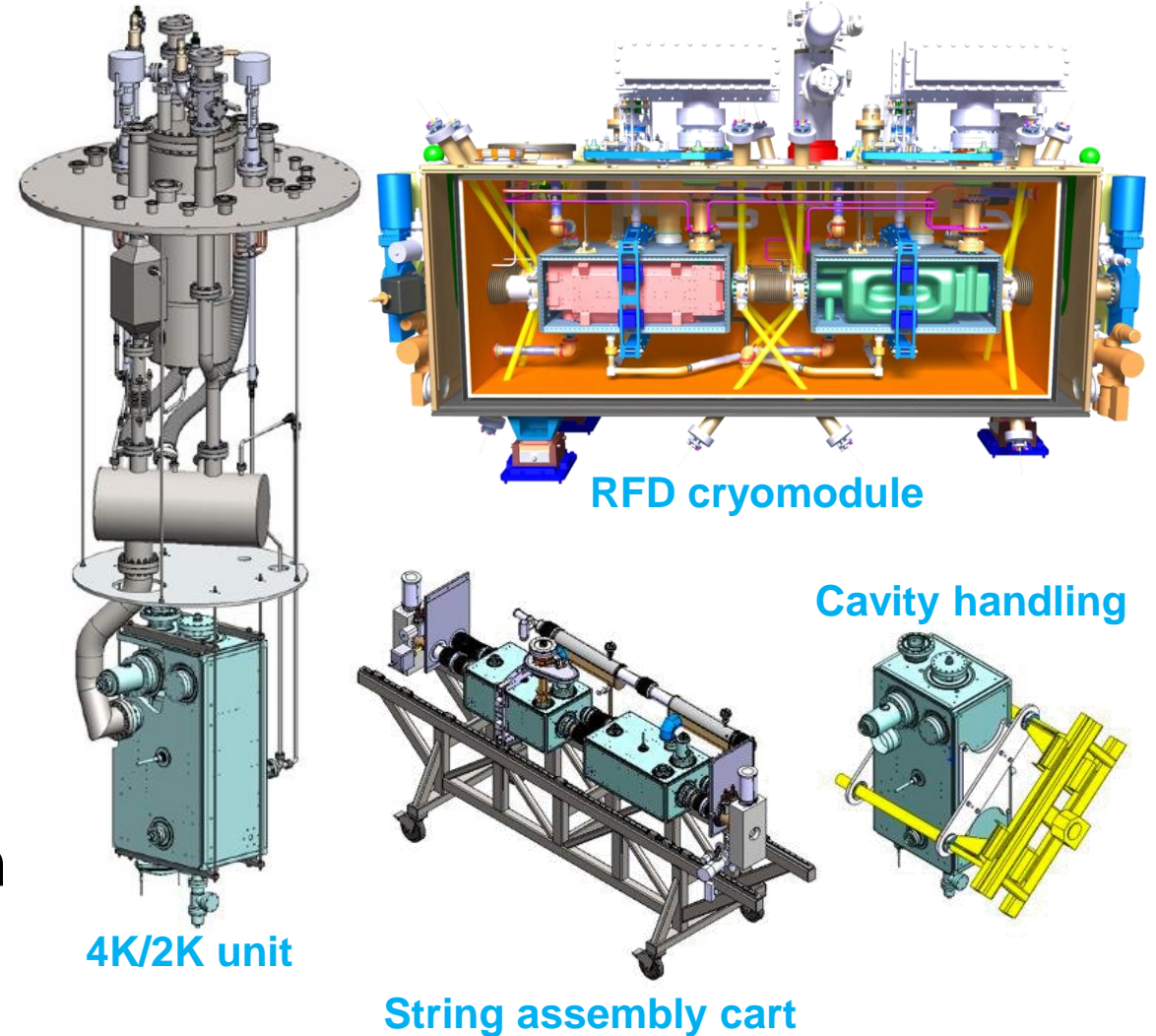
Collaborations



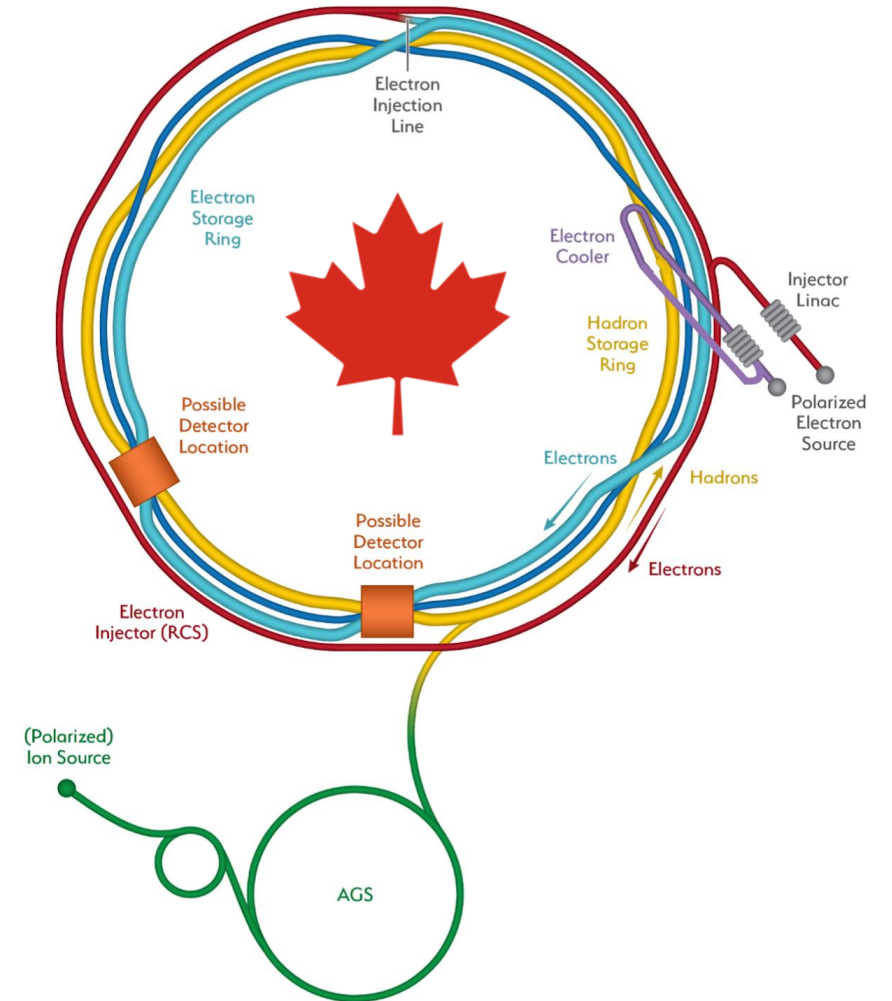
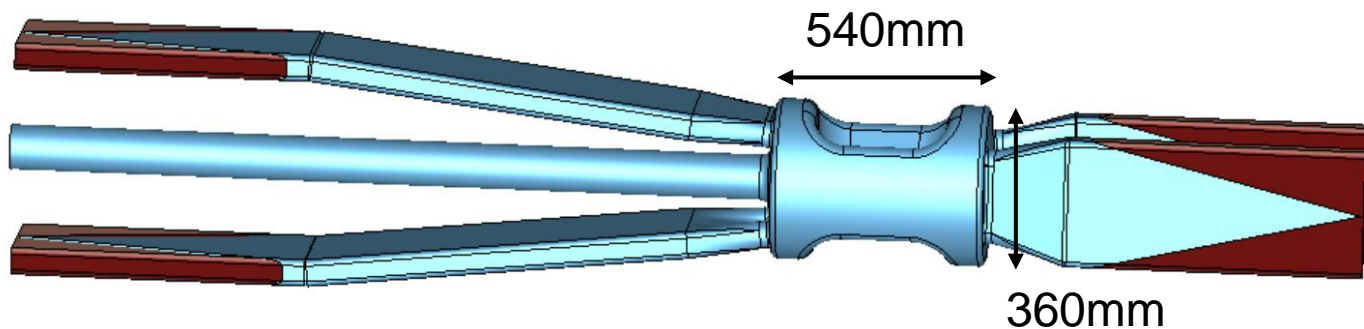
- High demand for high brilliance, pulsed neutron beams in Canada
 - See D. Maharaj’s talk on Monday for details
- TRIUMF would provide linear accelerator, RF and target expertise to realize a high intensity neutron source
- The project will augment and solidify TRIUMF core competence in Linac and target systems
- High intensity proton accelerator technology is well aligned with applications like Accelerator Driven System (ADS)

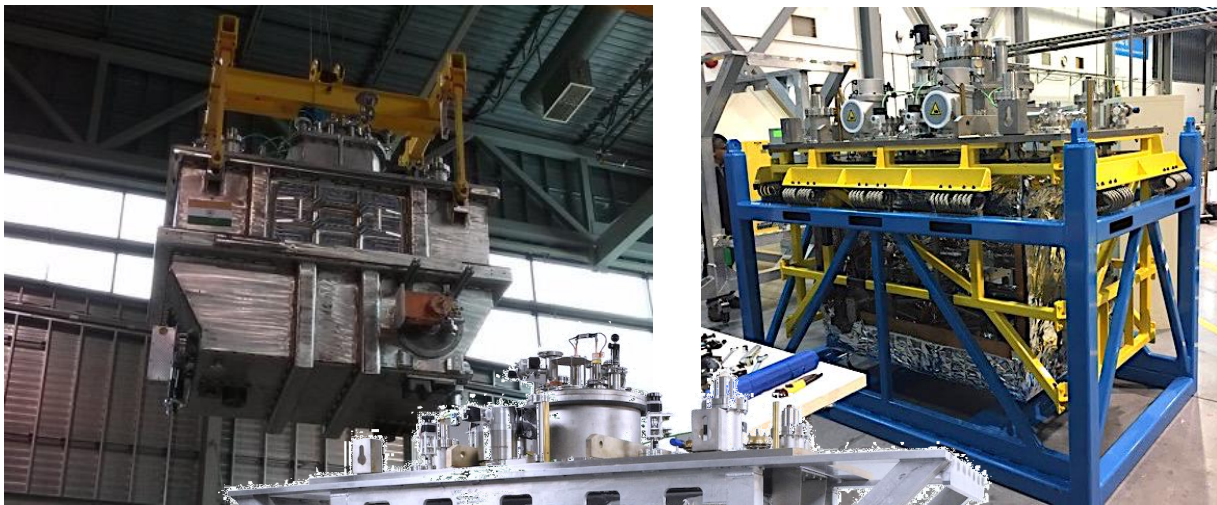


- TRIUMF was funded to produce and qualify 5 RF Dipole (RFD) cryomodules as in-kind contribution
- Preparing to build prototype cryomodule (TCM0) and to receive first cavities in early 2023
- Series production CMs will follow after TCM0 verification
- Last two CMs will be completed in 2025



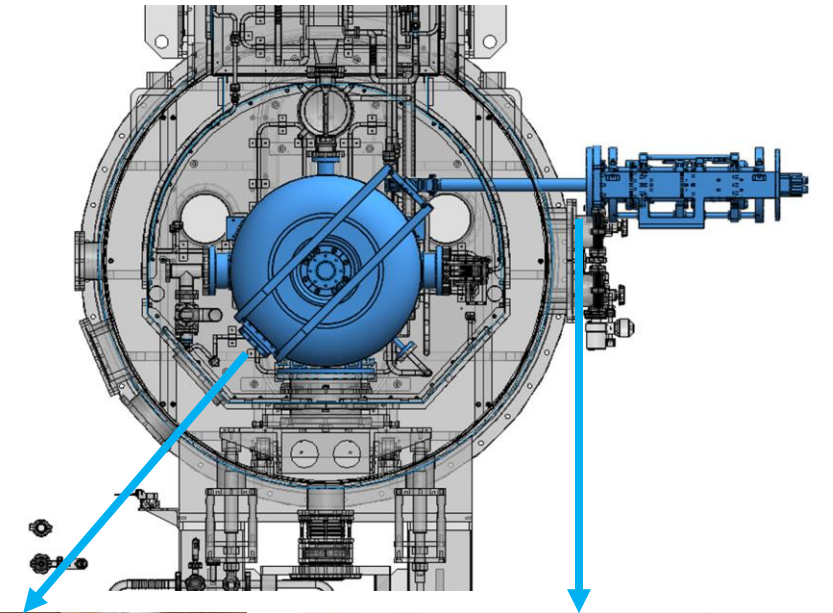
- A major new collider facility scheduled to be built at BNL to explore subatomic physics
- TRIUMF working with EIC-Canada to seek Canadian funding to support in-kind contributions
- Potential for TRIUMF SRF involvement in 400MHz Crab cavity and cryomodule



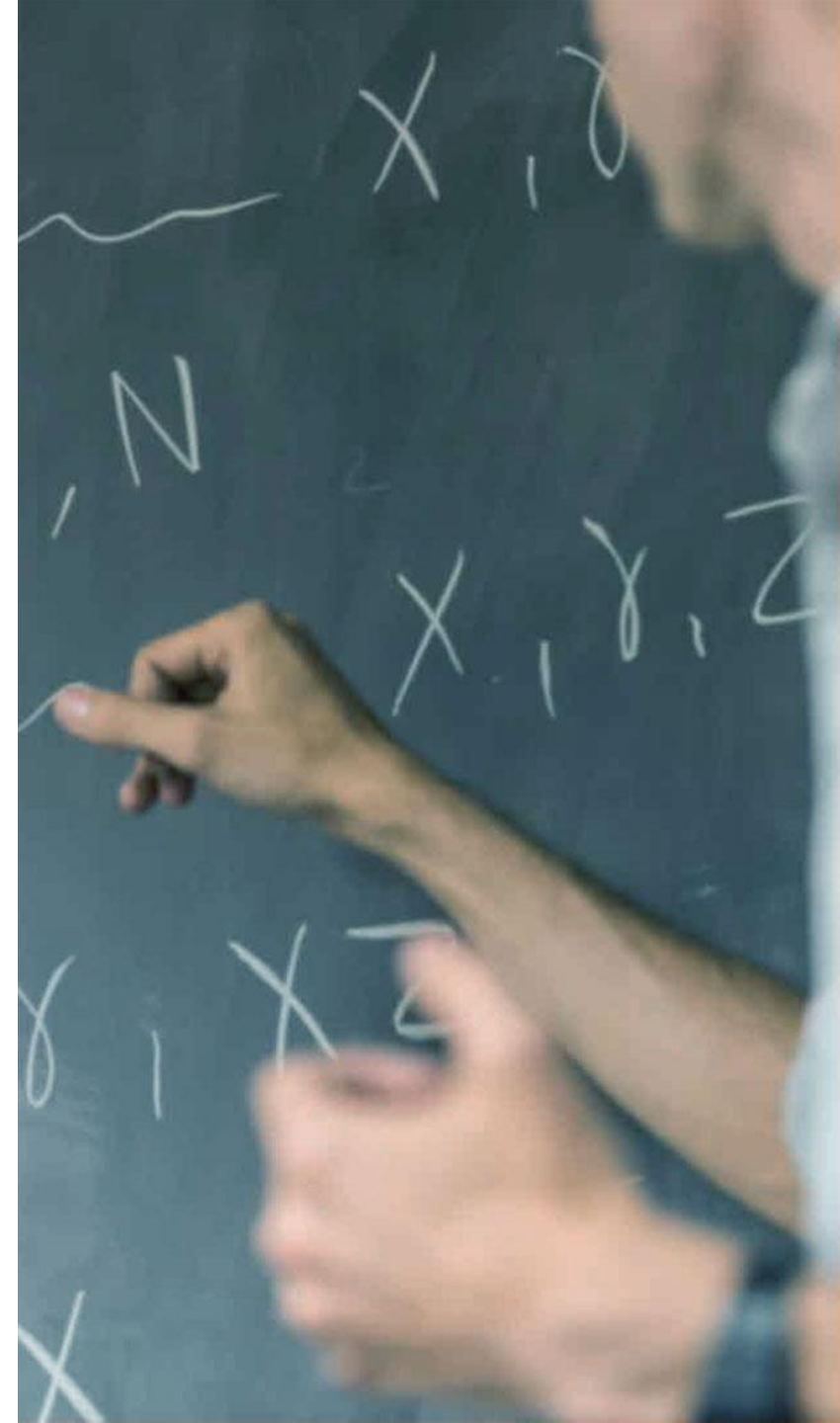


VECC Injector and QWR CMs

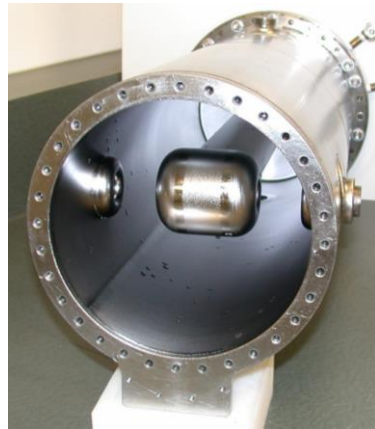
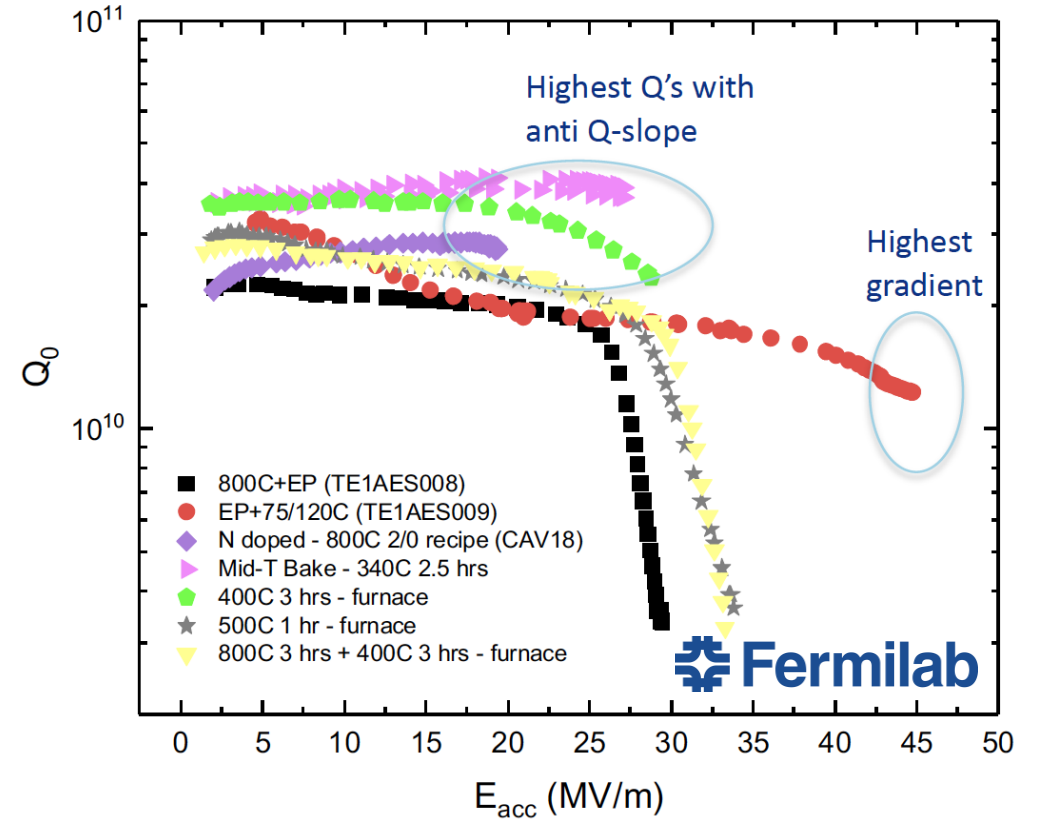
RISP SRF cavity and tuner

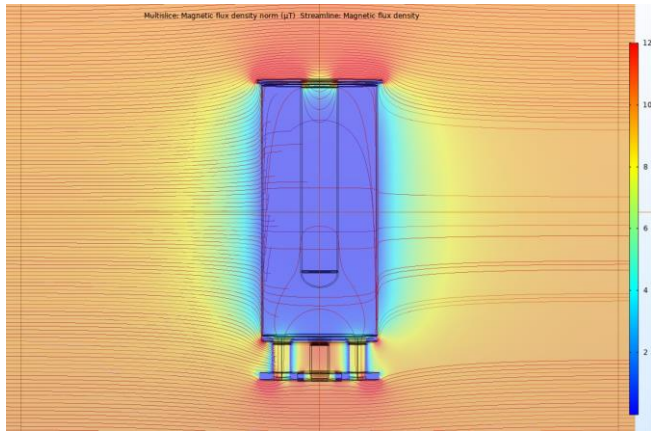


Development & Student Programs

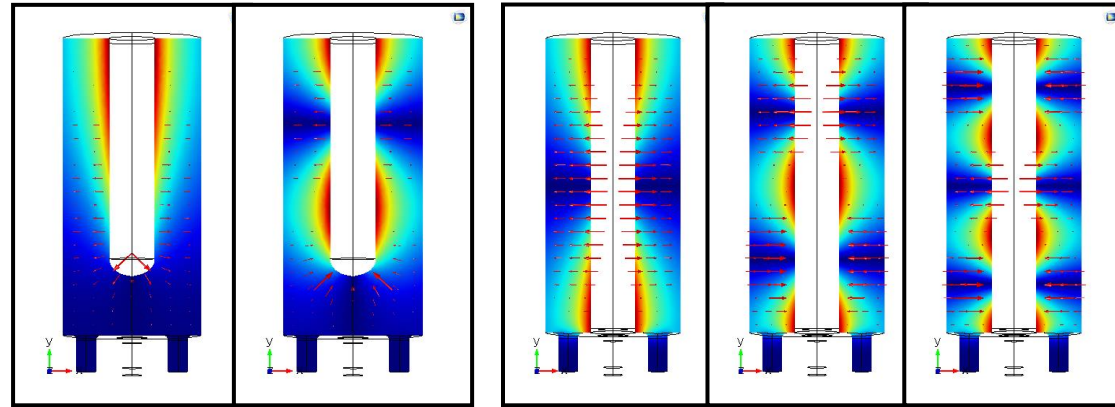


- Recent SRF developments focused on elliptical cavities around the world
- TRIUMF is exploring best treatments to push coaxial cavities' performance
- TRIUMF is implementing unique material diagnostic probes for insight of new SRF developments

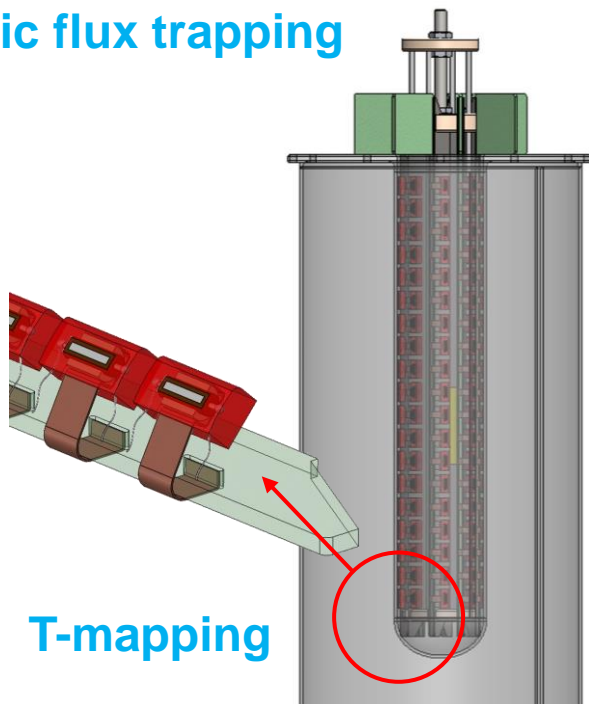




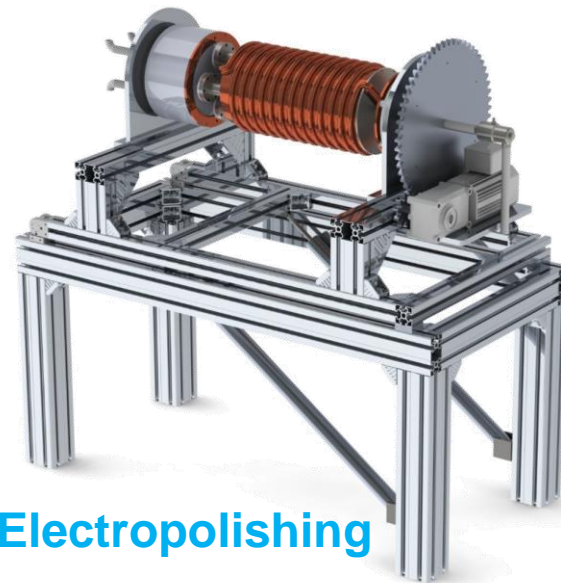
Magnetic flux trapping



220MHz 650MHz 390MHz 780MHz 1166MHz



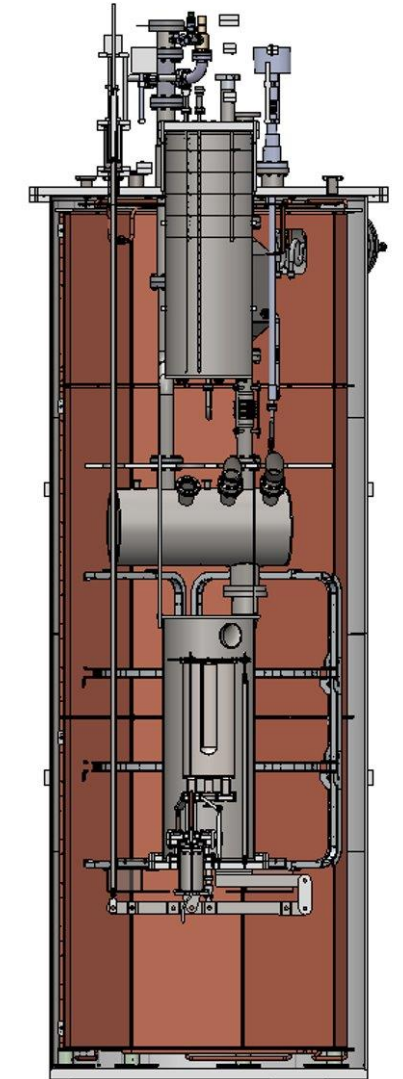
T-mapping



Electropolishing

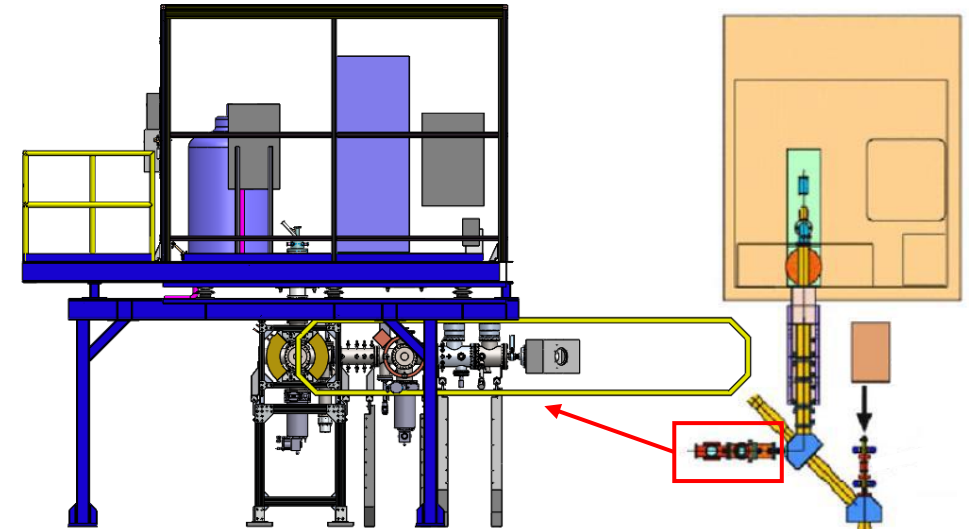
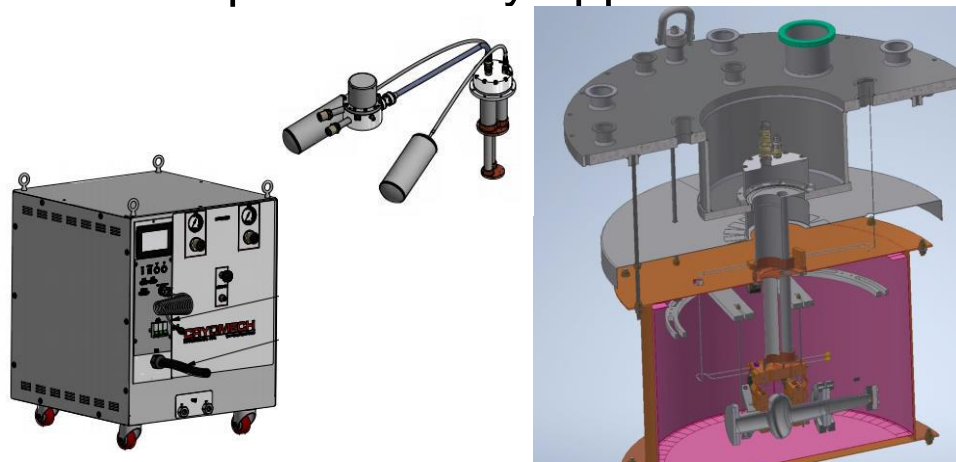


Induction Oven



Cryostat upgrade

- Implant polarized $^8\text{Li}^+$ into sample to detect local magnetic field
- High field spectrometer makes it a unique facility in the world for SRF material studies
- To utilize this facility to characterize existing materials and treatments for new developments
 - Nb_3Sn coated SRF cavity
 - High gradient applications
 - Compact industry applications



High field spectrometer

Heat treatment

N-doped

Thin film

- Operating RF/SRF facilities
 - Improve systems' availability, reliability and capability to support discoveries in science frontiers
- Collaborations
 - Contribute to Canadian and international projects with critical components and expertise
- Development & student programs
 - Leverage infrastructures to deliver cutting-edge research

Thank you
Merci

2022-07-21

