TRIUMF

Current ISAC Target Infrastructure Strategy

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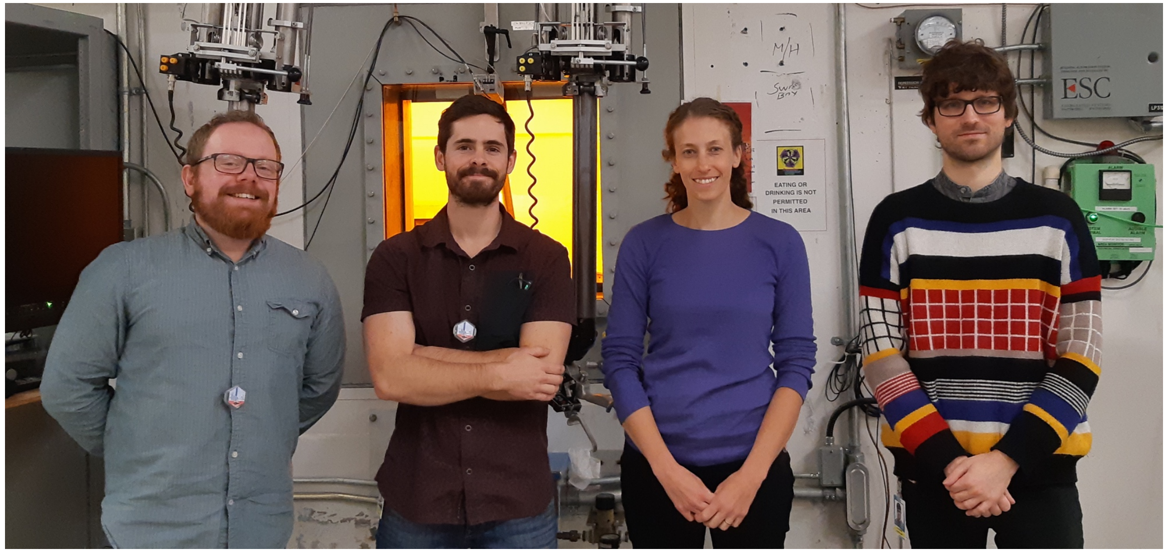
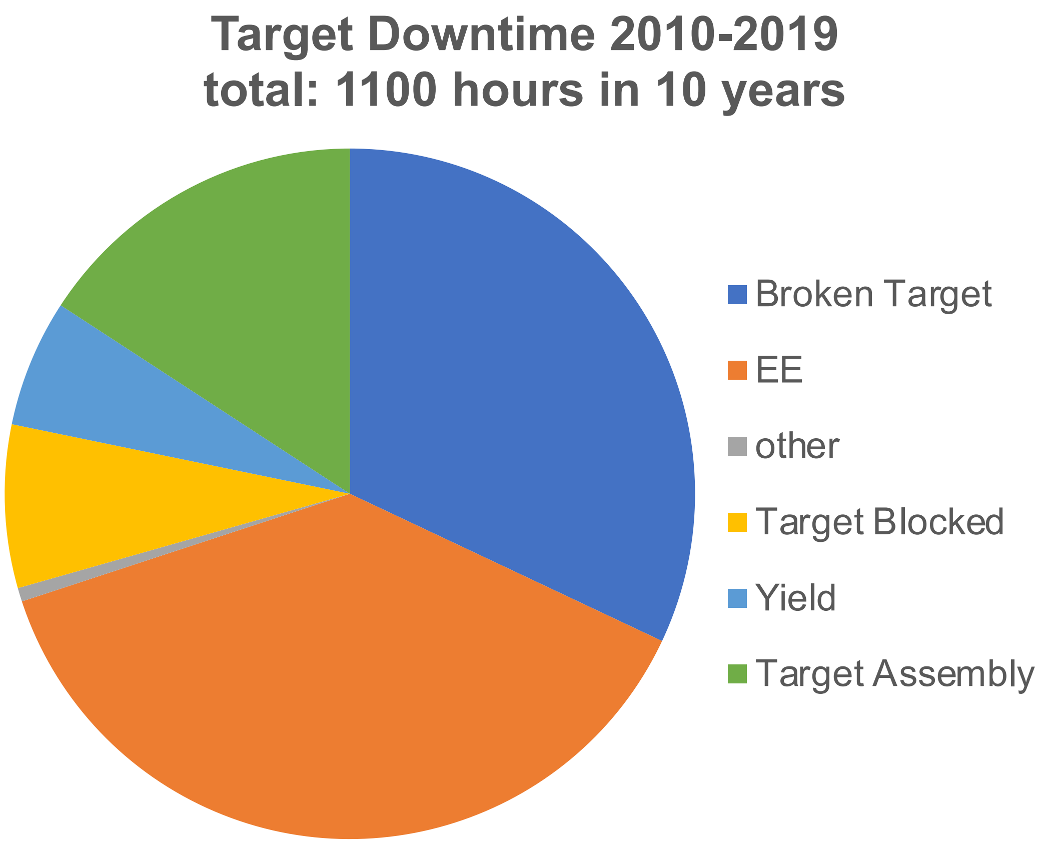
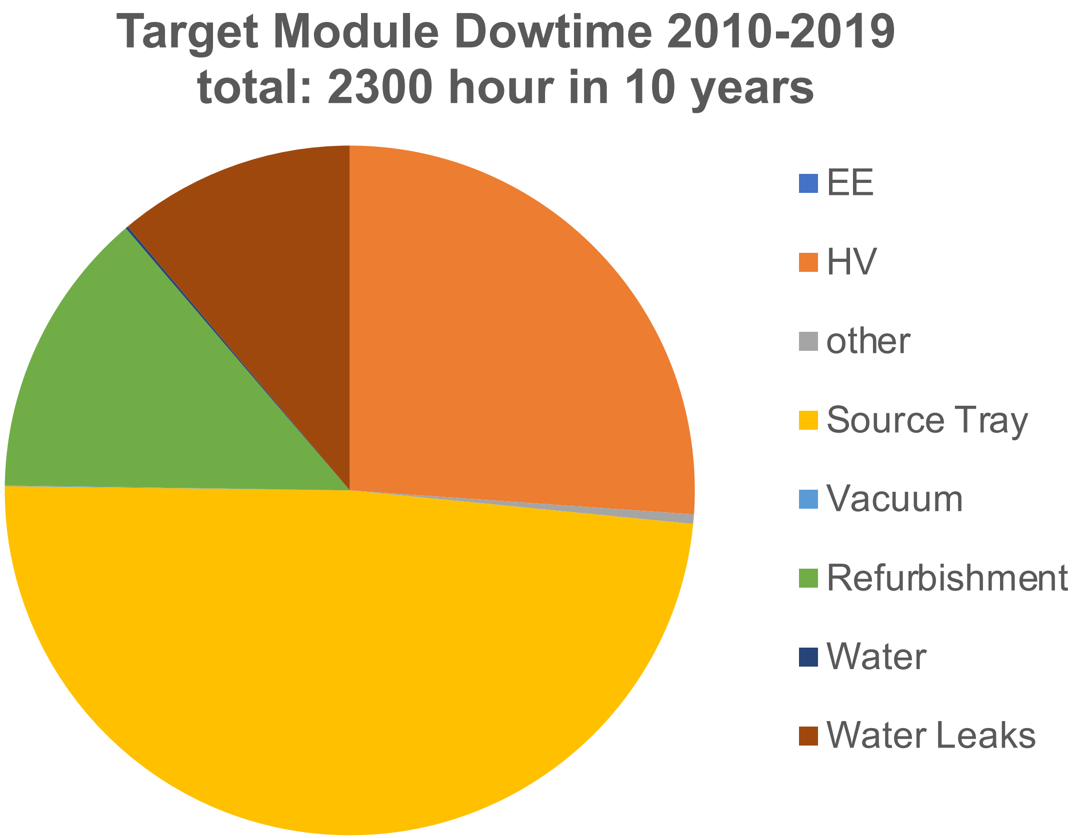
ISAC Strategy Workshop
November 08, 2019



Discovery, accelerated

Performance Statistics 2010 – 2019





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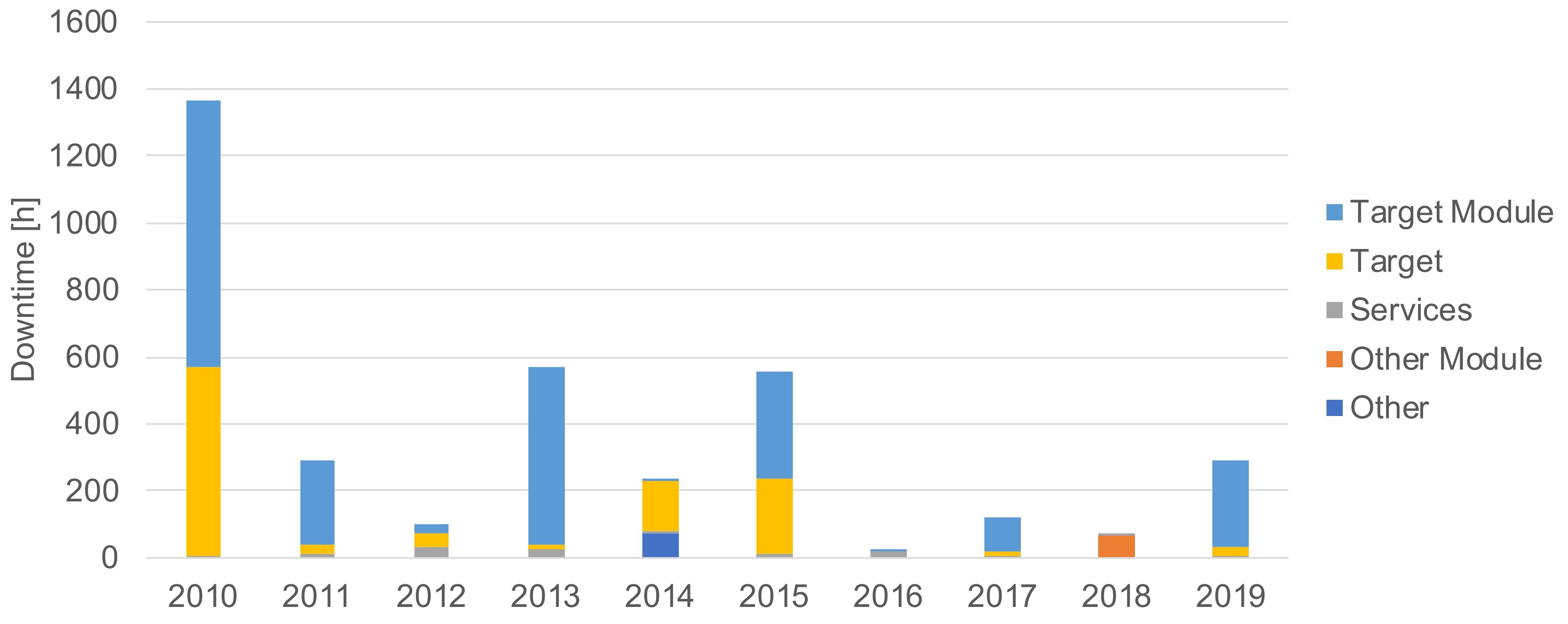

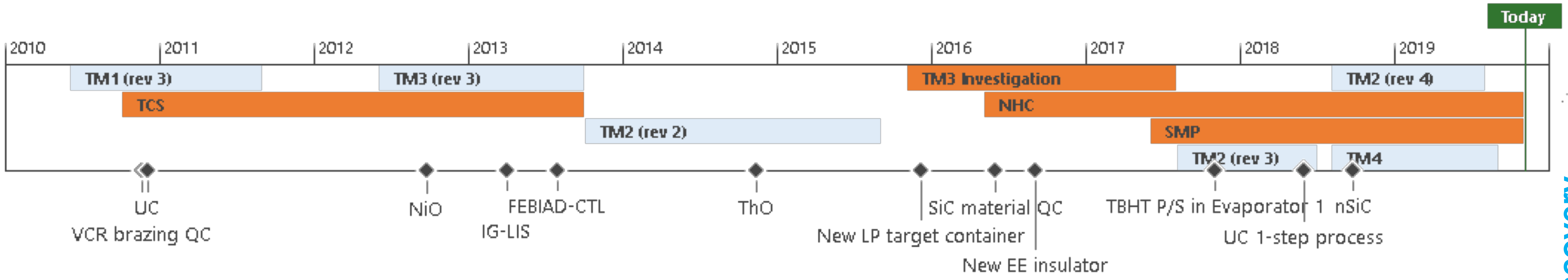

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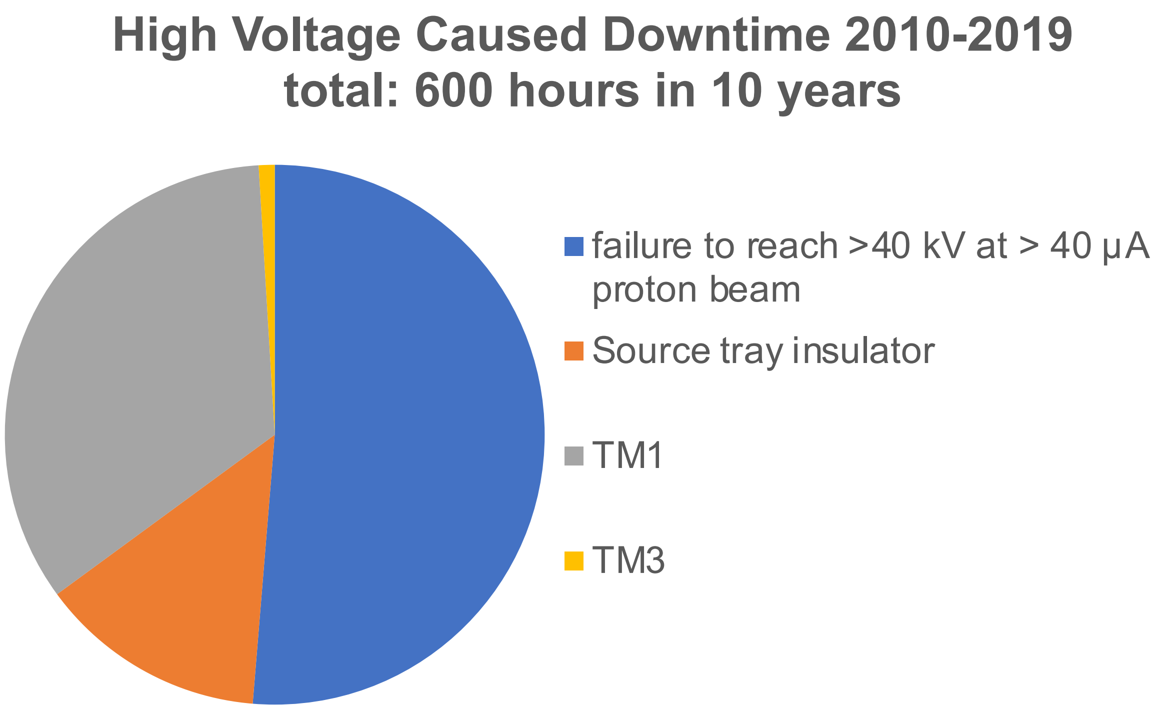
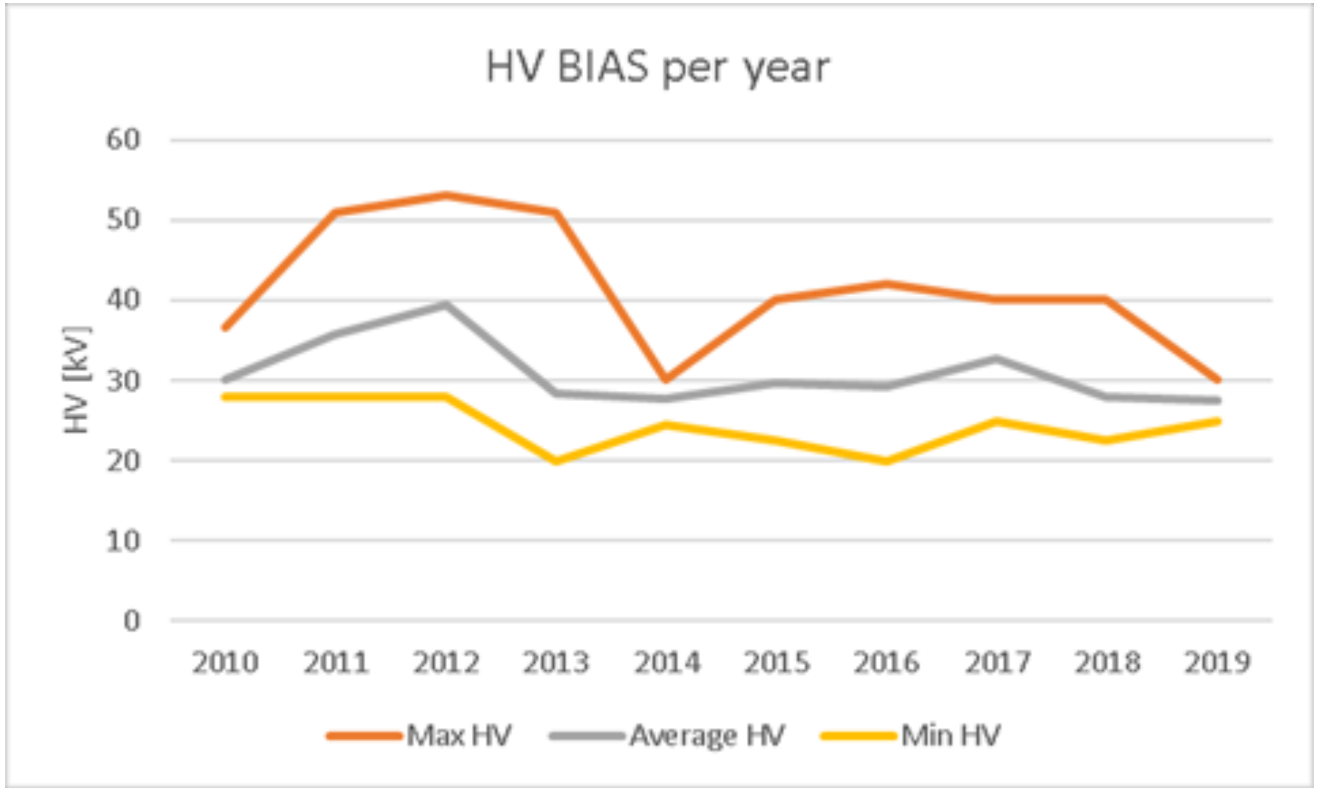
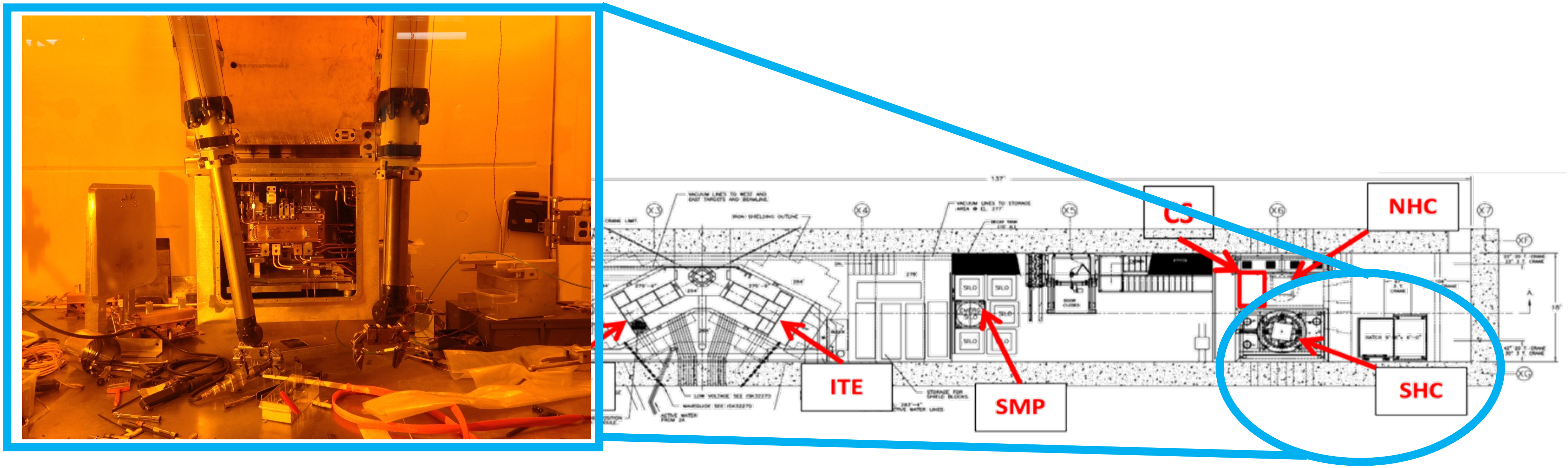


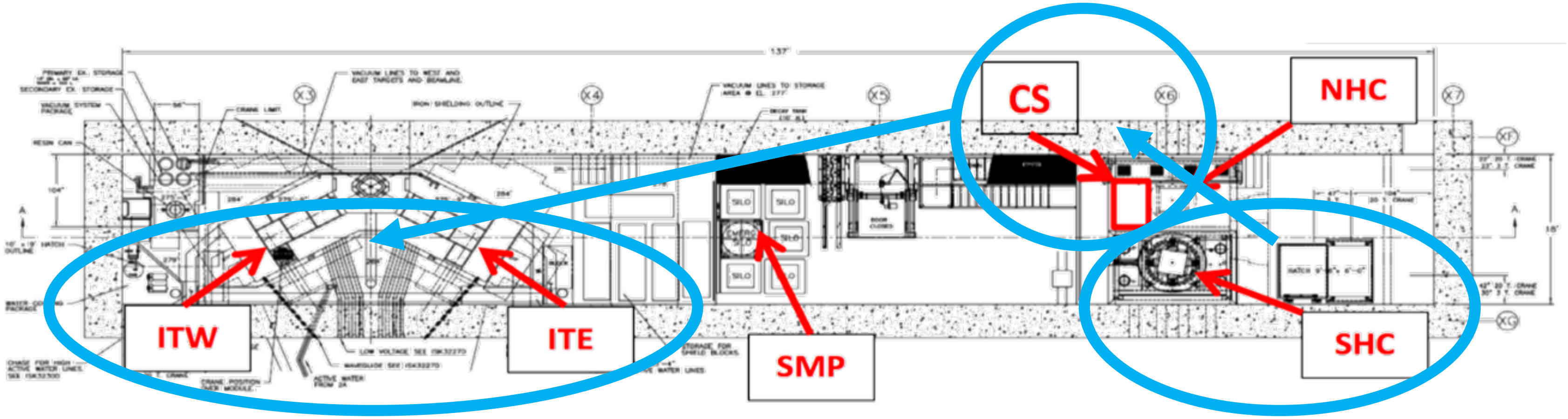


- Target assembled in the hot/cold lab then introduced into the south hot cell
- Module craned into the hot cell and target installed with manipulators



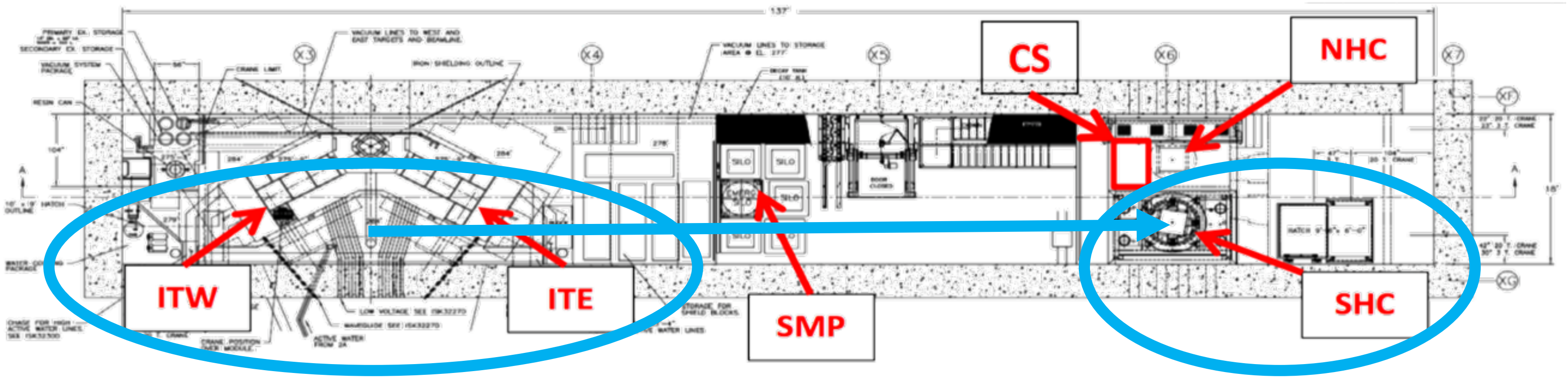
Infrastructure Overview

- Target assembled in the hot/cold lab then introduced into the south hot cell
- Module craned into the hot cell and target installed with manipulators
- Module craned into the conditioning station for testing, then into the target pit



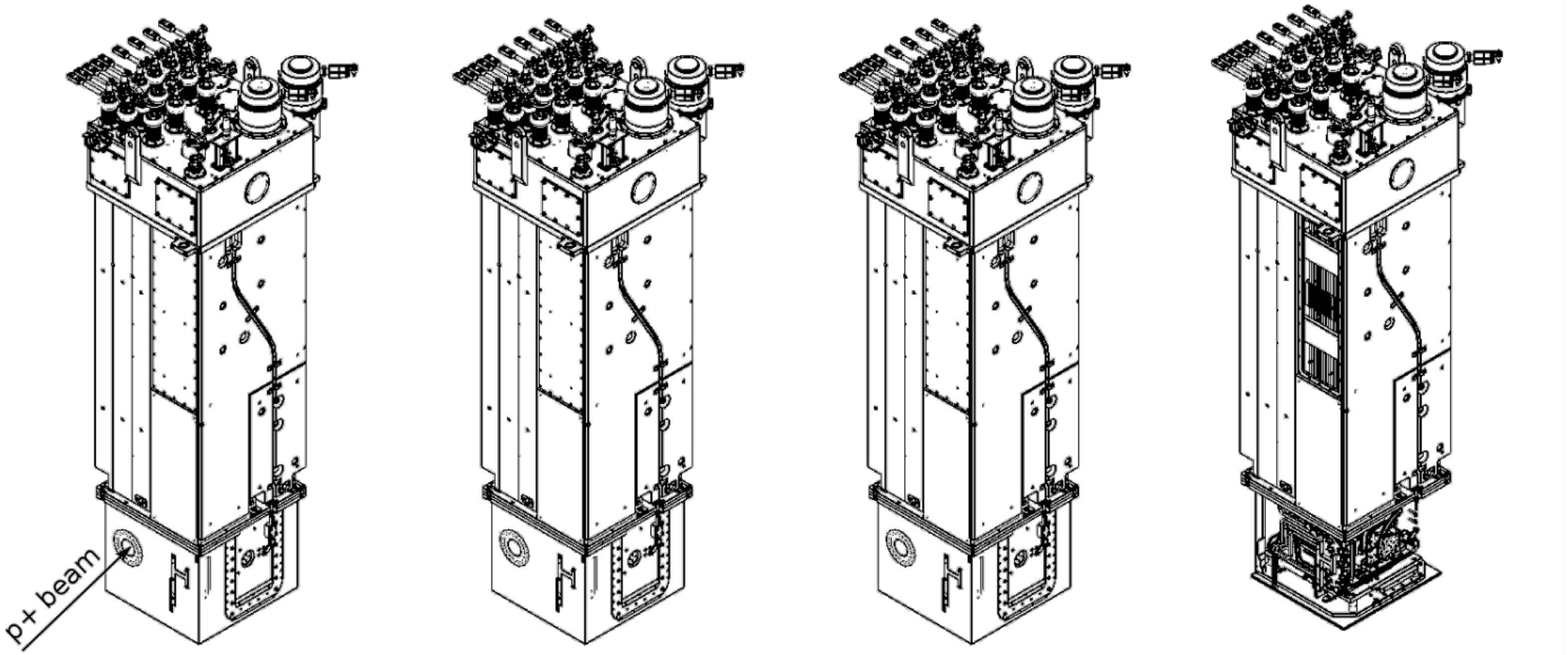
Infrastructure Overview

- Target assembled in the hot/cold lab then introduced into the south hot cell
- Module craned into the hot cell and target installed with manipulators
- Module craned into the conditioning station for testing, then into the target pit
- After the run, the module is craned back to the south hot cell for target removal



Ultimate Target Module Vision

Four operating target modules required for reliable and sustainable operation of two ISAC target stations.



Running Module | Module in prep/cool down | Spare Module | Module in refurbishment

Constant upgrades and two-module operation with a spare module in reserve for emergencies

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Current Status of ISAC Target Modules

TM #	HV	SIS	FEBIAD	IGLIS	Protons	Notes
~~1~~	~~25 kV~~	~~Yes~~	~~No~~	~~No~~	~~10 uA~~	~~Window water line broken, possibility to use TM1 as a last resort~~
2	55 kV offline 35 kV online	Yes	Yes	No	100 uA	Plans to retrofit module for IGLIS operation during winter shutdown 2019-2020
3	< 20 kV	No	No	No	-	Not functional (in refurbishment)
4	55 kV offline 35 kV online	Yes	No	No	100 uA	Plans to pull wires to run IGLIS and FEBIAD during winter shutdown 2019-2020

Running with two modules in rotation presents a major vulnerability.
In first order: If one module fails unexpectedly we lose half of RIB delivery for the year.

Consider intermediate one-module rotation to mitigate this risk.

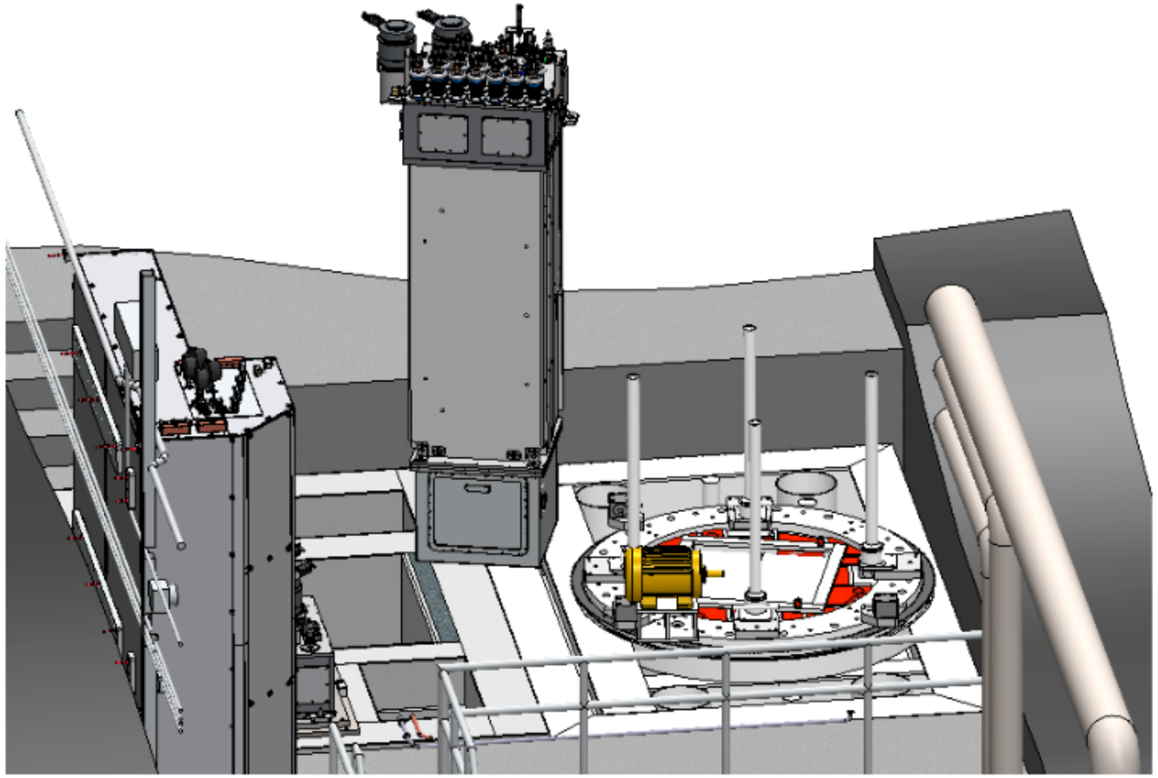
Two Reasons for Existing Module Deficiencies Until Now: 1. Infrastructure Limitations

- South hot cell must be empty during module moves, meaning refurbishment projects are difficult to schedule

- South hot cell also used primarily for target exchanges

➔ Long-term module repair and refurbishing very difficult.

Initiation of new several infrastructure projects in 2016 to make South Hot Cell available for target module work.



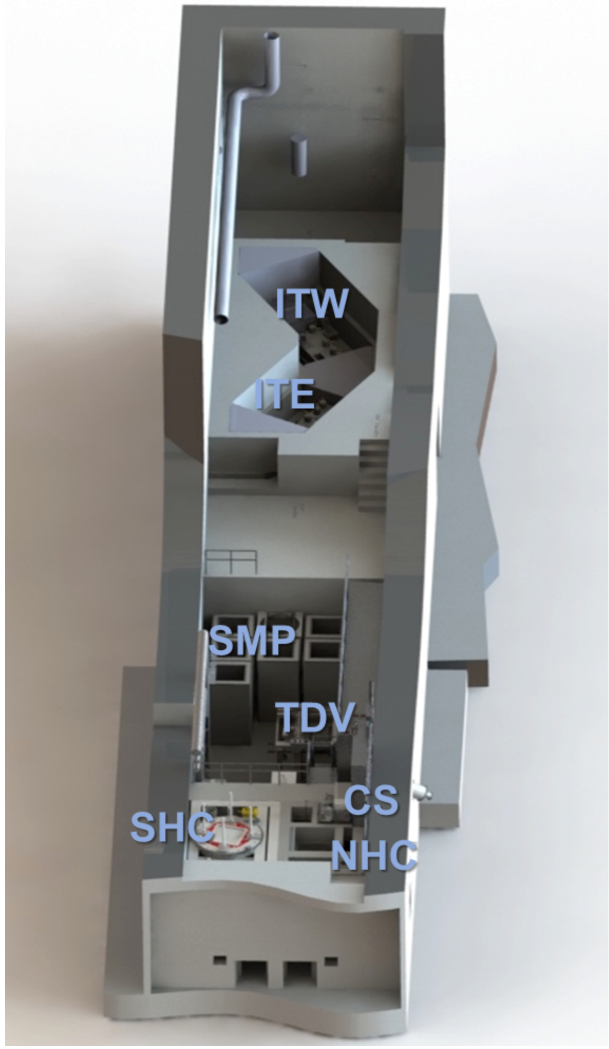
Previous ISAC Reliability Upgrade Paradigm

Projects for an integrated approach to ISAC reliability upgrade:

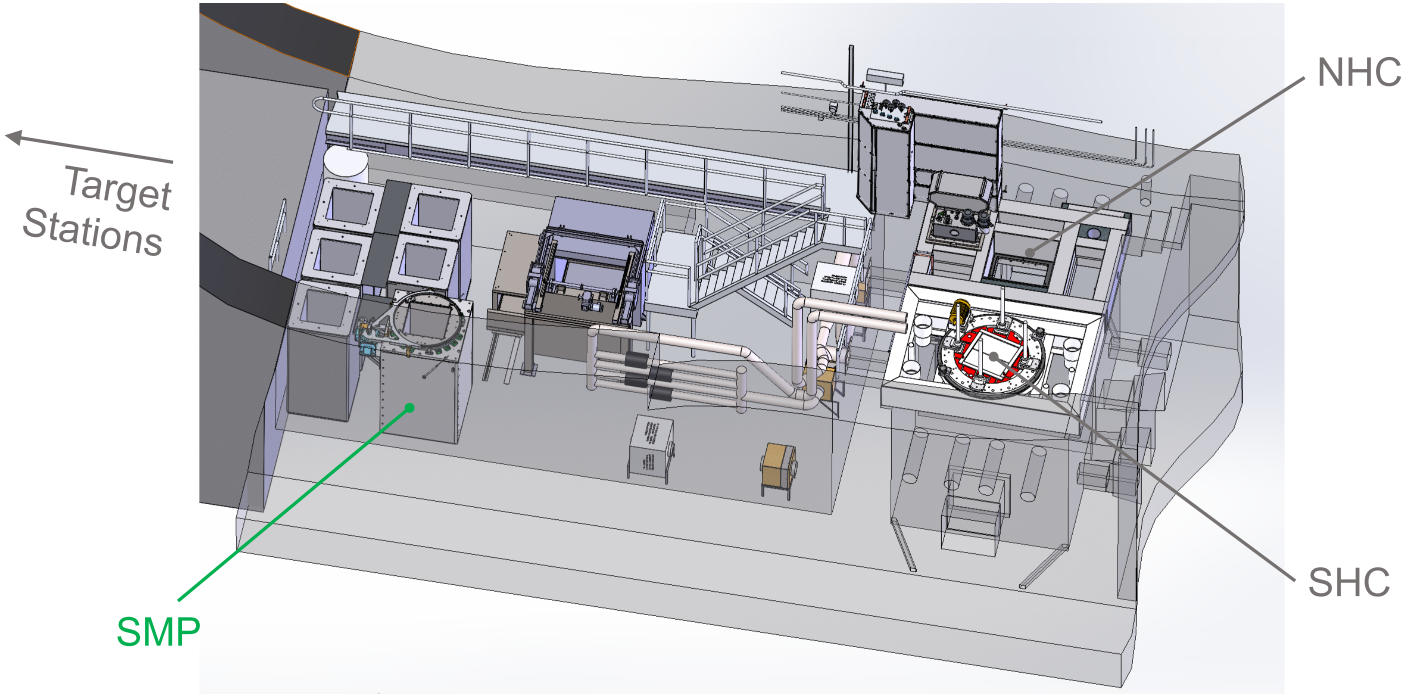
1. **North Hot Cell Project (P426)**
   A dedicated target exchange hot cell, freeing up the SHC for extended refurbishment and repair activities.
2. **Safe Module Parking Project (P421)**
   A shielded landing site that supplies rotational redundancy that is missing at the target hall crane. This allows that the hot cell does not have to be empty during every module move.
3. **TM3 Investigation Project (P416)**
   An offline inspection of target module 3 that will provide design guidelines for designing a sustainable TM refurbishment strategy including the capability of meeting the technical TM requirements.
4. **TM5 Project (P432)**
   A new (cold) version of the existing TM design that addresses known issues and that can be procured relatively quickly with minimum TRIUMF personnel in order to provide an interim solution until periodic refurbishment program launches.

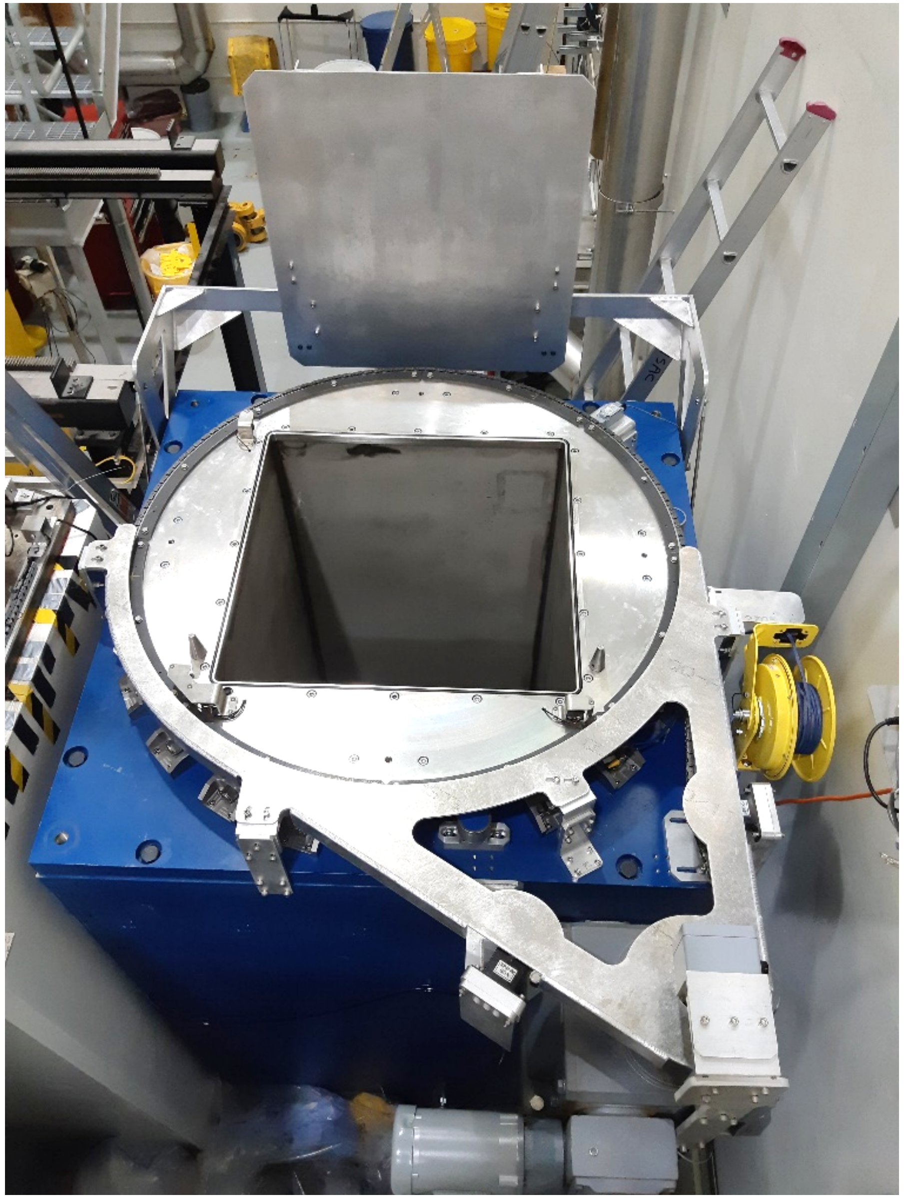
Prioritize

Previously postponed until SMP + NHC available and level with ARIEL resource demand



Safe Module Parking – Completed October 2019





- Dedicated module landing spot to provide target hall crane rotation redundancy
- Project duration: June 2017 – October 2019

- On budget
- 1 year delay due to personnel availability

Discovery, accelerated

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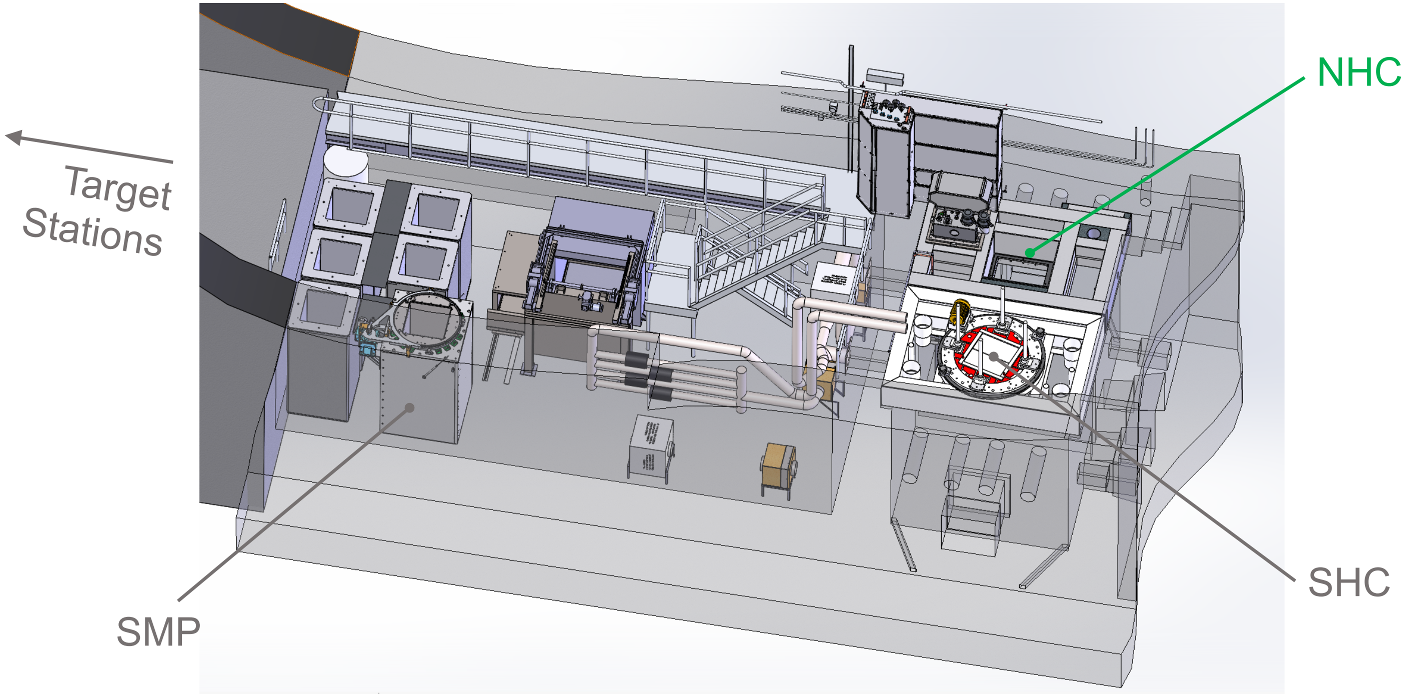
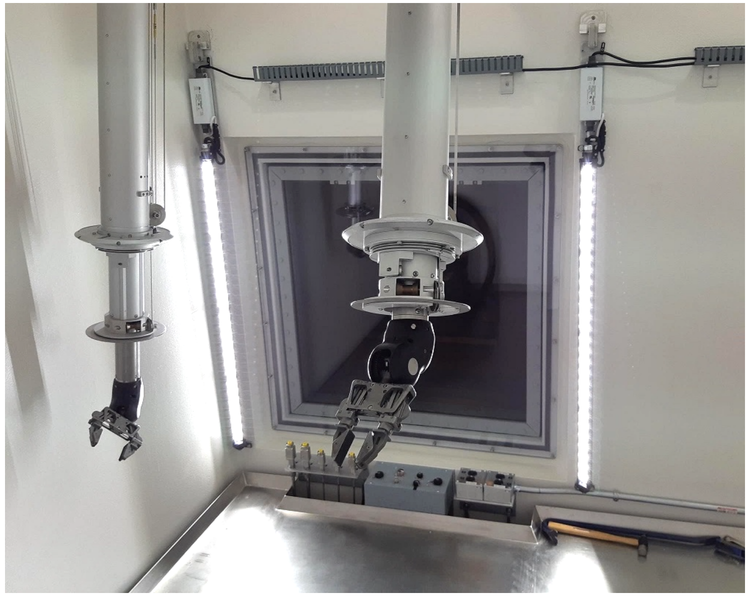
North Hot Cell – Completed April 2019





- Dedicated target exchange hot cell
- Project duration: May 2016 – April 2019

- On budget
- 1 year delay due to personnel availability

Discovery, accelerated

Two Reasons for Existing Module Deficiencies Until Now:
1. Infrastructure Limitations

- South hot cell must be empty during module moves, meaning refurbishment projects are difficult to schedule

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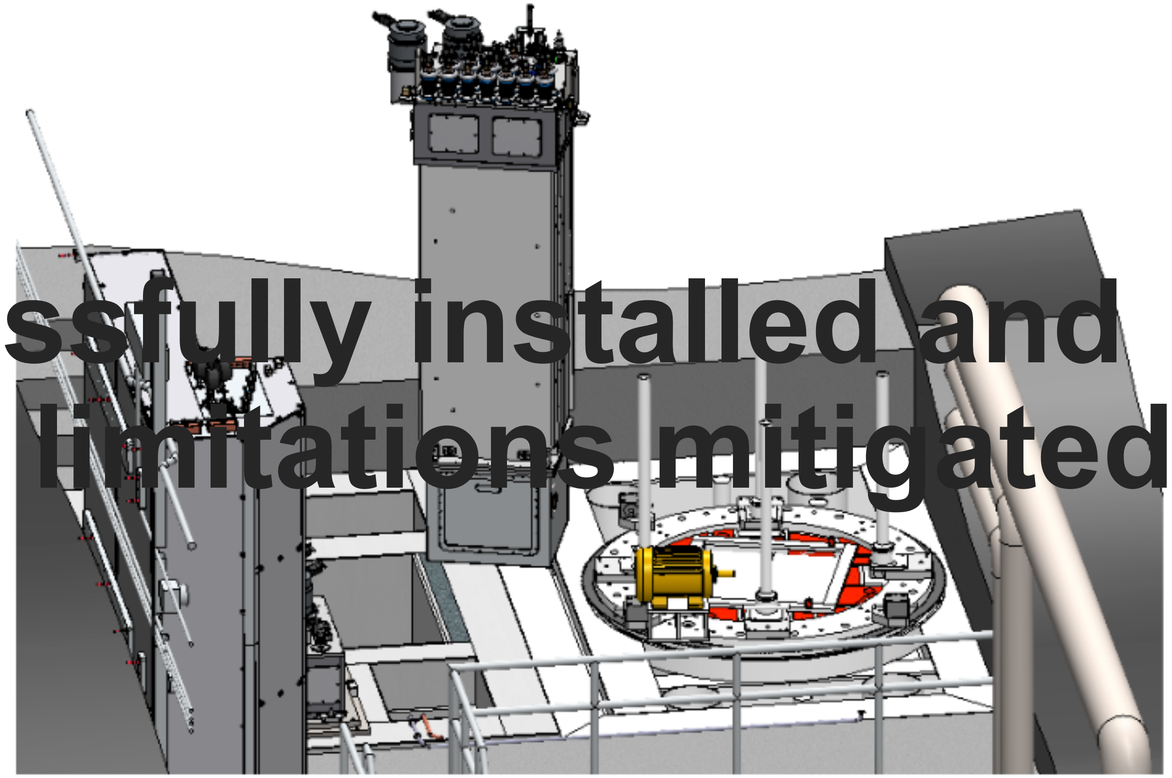


Infrastructure successfully installed and dominating technical limitations mitigated

Discovery, accelerated

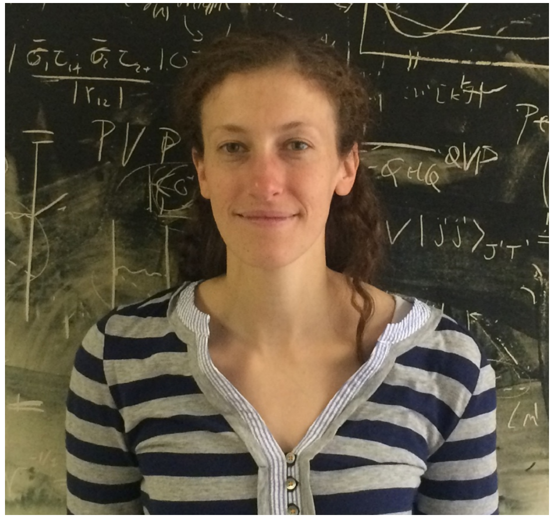
Two Reasons for Existing Module Deficiencies Until Now: 2. Resources

- Another bottleneck to refurbishment projects has been the operational responsibilities of remote handling/target and ion source personnel.

- TRIUMF has now committed to a dedicated team to work on ISAC module development projects.

- This team has defined responsibility to drive ISAC reliability projects, taking priority over responding to online emergencies and ARIEL.

Dedicated Team



Carla Babcock

Target and Ion Source Postdoc

Project Leader

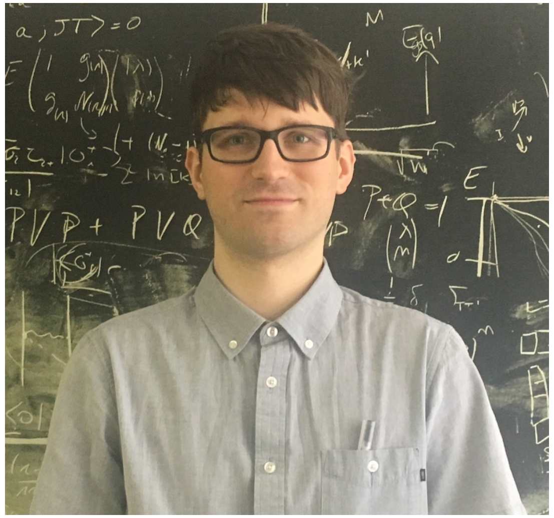
60%

Matthew Kettle

Target Operation and Production Engineer

Project engineer

60%

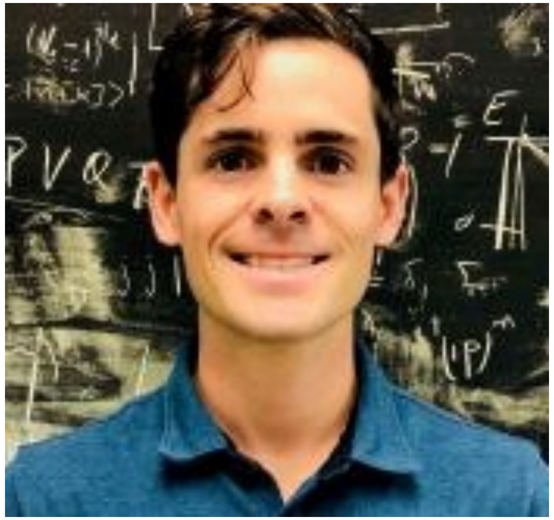


Alexander Shkuratoff

TIS Development Engineer

High-voltage design, engineering physics

100%



Sam McEwen

Vacuum Engineer

Mechanical engineering

80%

With support from Design Office, Target Operation Group, Remote Handling Group
Competition with ISAC operation, fire fighting, ARIEL project

Developed Mid-Term Strategy

2019-2020:

Keep TM2 and TM4 alive with critical spare parts on hand.

2019:

Develop improved and 60 kV capable service tray design.

2020:

Consider one-module rotation to mitigate impact of critical TM failure.

2021:

Refurbish TM3 completely.

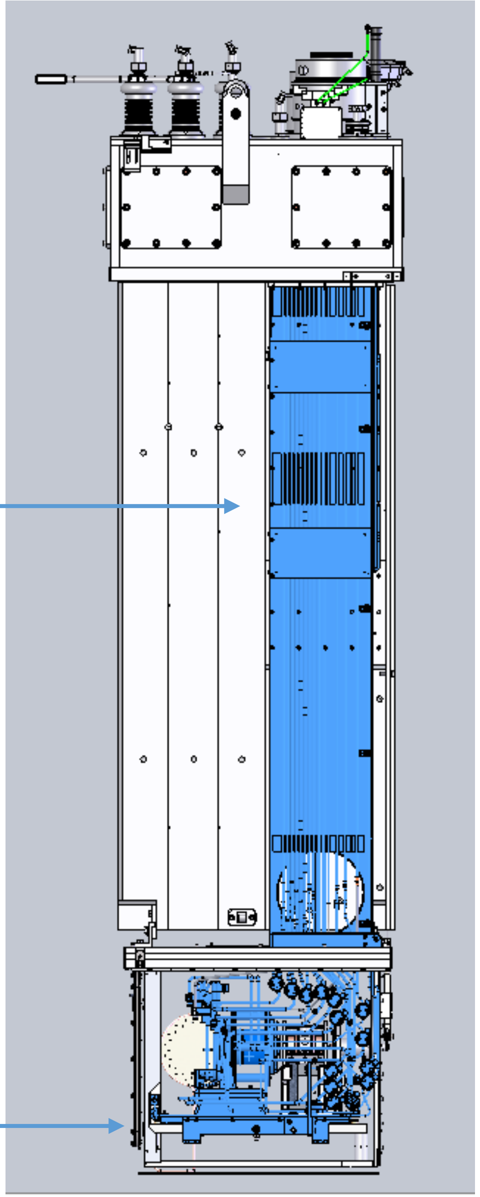
Develop strategy for unprecedented exchange of service tray.

2022:

TM4 full refurbishment and upgrade.

2023:

TM2 full refurbishment and upgrade.

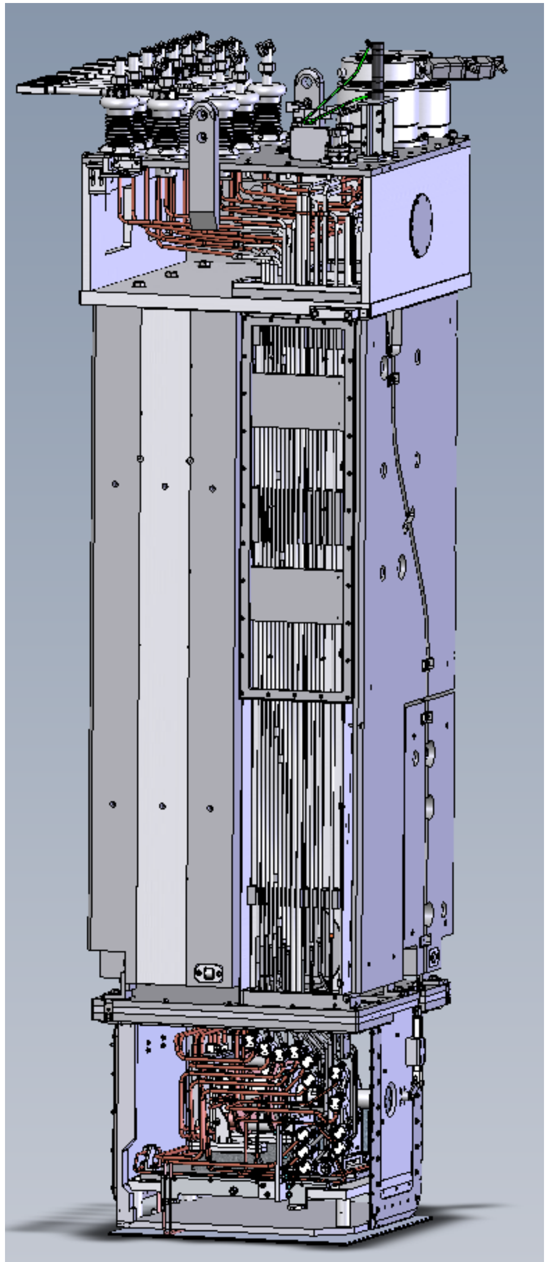


Discovery, accelerated

Developed TM Design Requirements

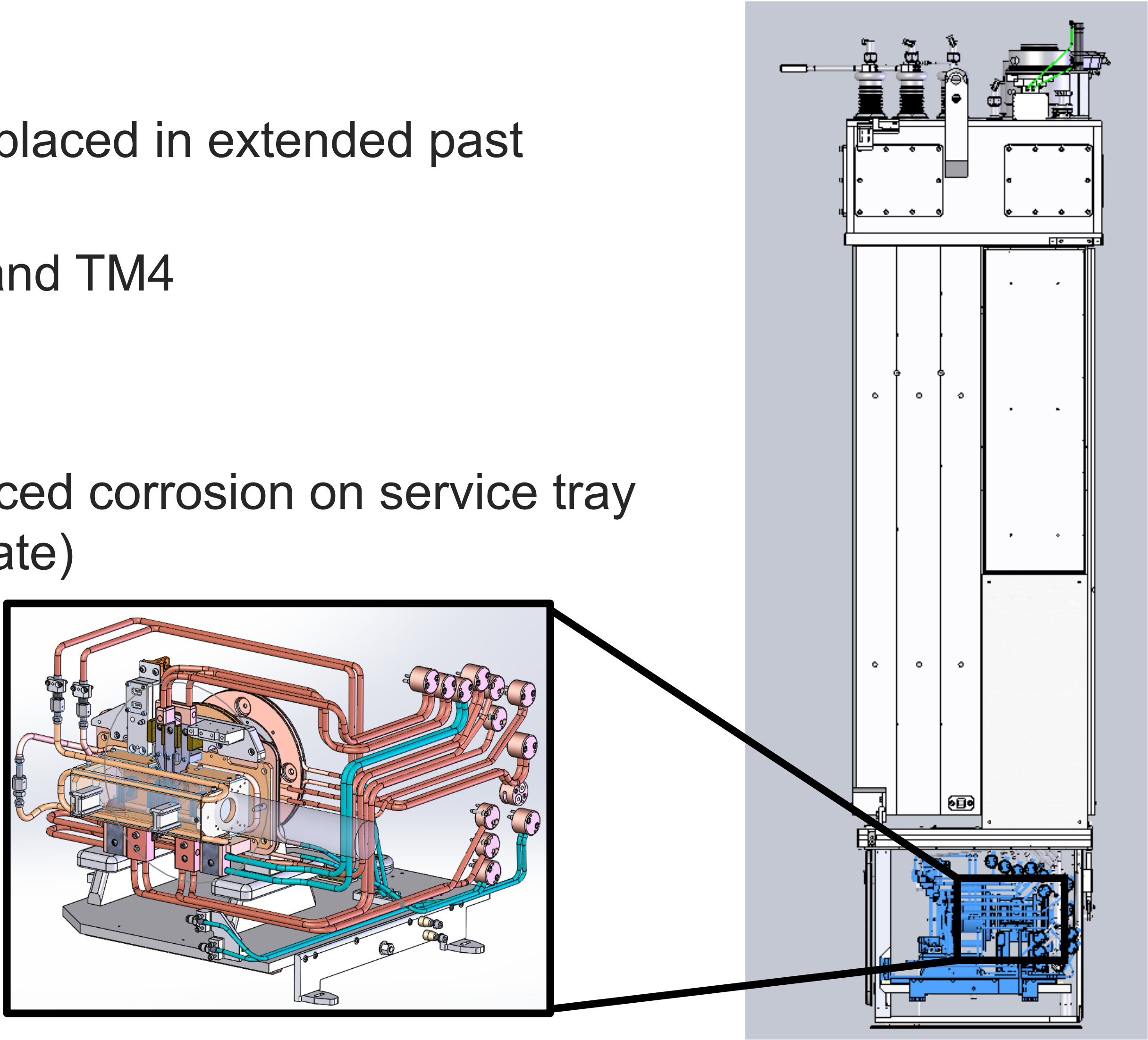
High-level summary:

1. The service tray must hold 75 kV offline.
2. The new service tray must deliver all services required for running any of TRIUMF’s target/ion source combinations.
3. The new service tray must fit in the current shield plug void.
4. The new service tray must be remotely installable, in hot cell or using the remote crane.
5. Should be compatible with TM2 and TM4 designs.



TM2 and TM4 Source Tray Refurbishment

- Source trays in TM2 and TM4 have been replaced in extended past winter shutdown:
  - Replaced damaged insulators on TM2 and TM4
  - TM2 source tray in operation now.
  - TM4 source tray exchange:
    - Some difficulties with radiation-induced corrosion on service tray side! (no maintenance concept to date)
    - Patch applied and module back in operation.
- Source tray design has been improved to lower the risk of HV breakdown



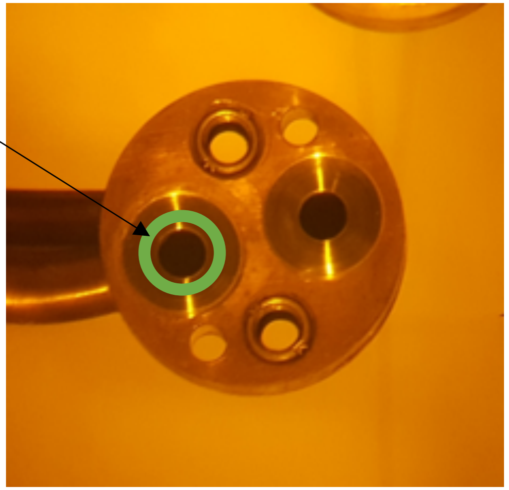
Recent Target Module Issues

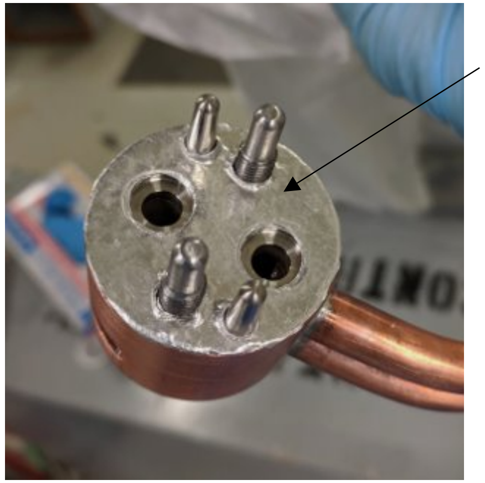
Age, radiation and chemistry contributed to corrosion on the TM4 water blocks, causing leaks in three of them during this last source tray replacement

- This was solved using a temporary but so far effective sealing method

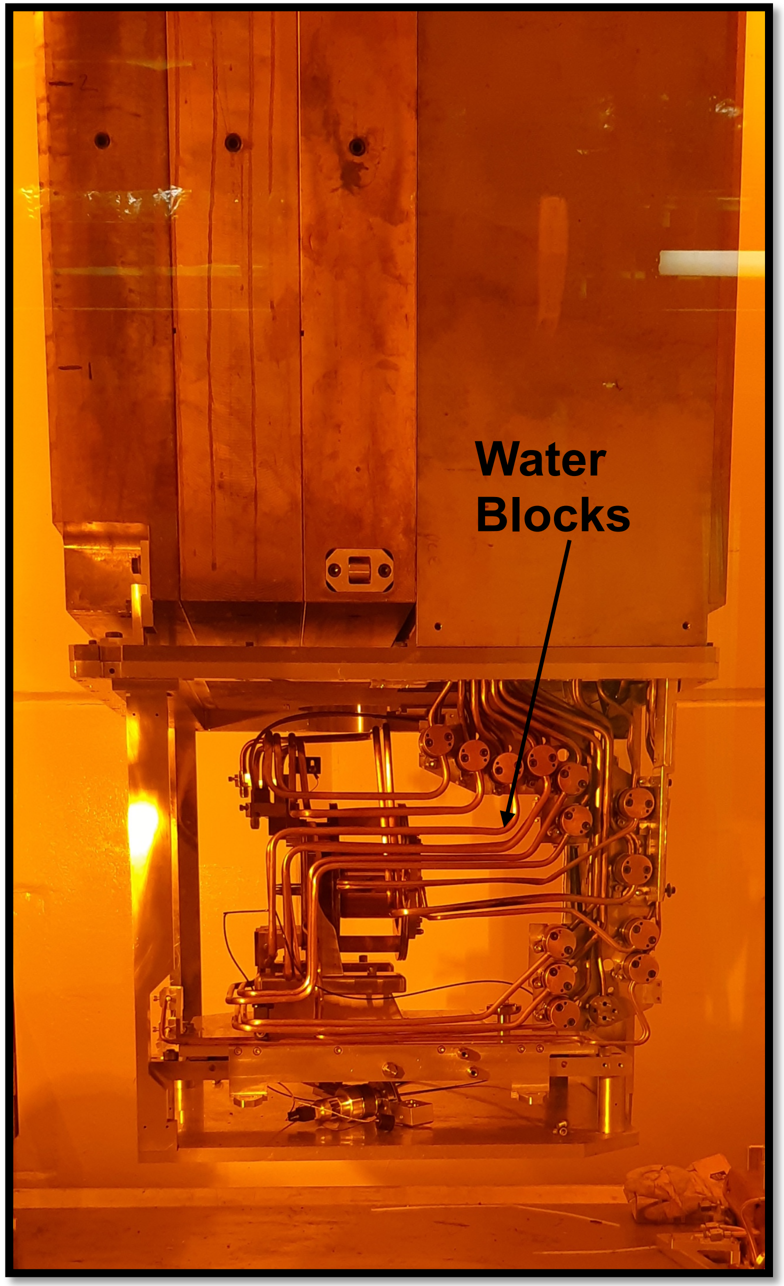
➔ Development of service tray exchange required!

Normal sealing surface





New sealing surface



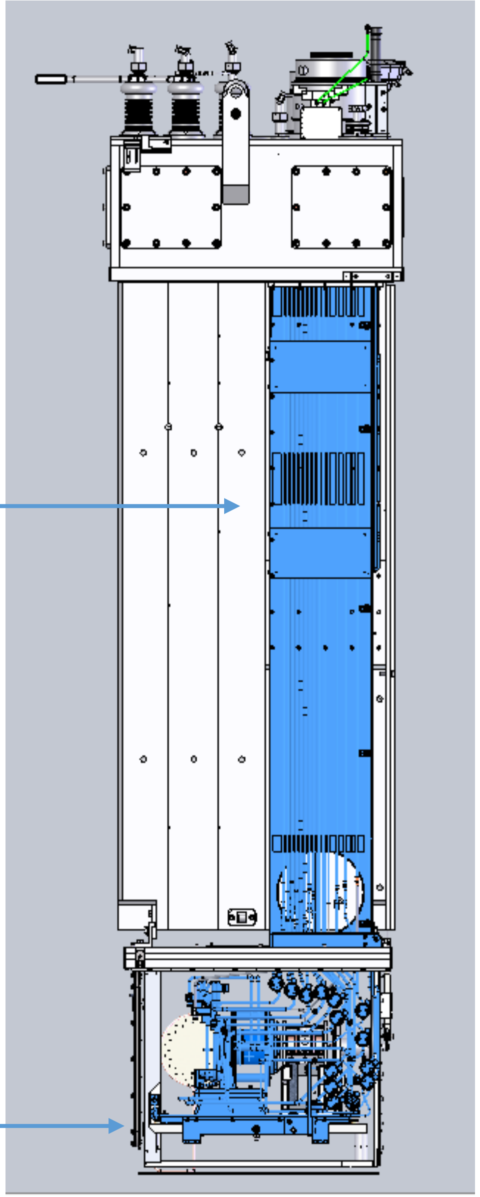
Recent Target Module High-Voltage Issues

High voltage operation continues to be problematic, current operating voltages are around 30 kV.

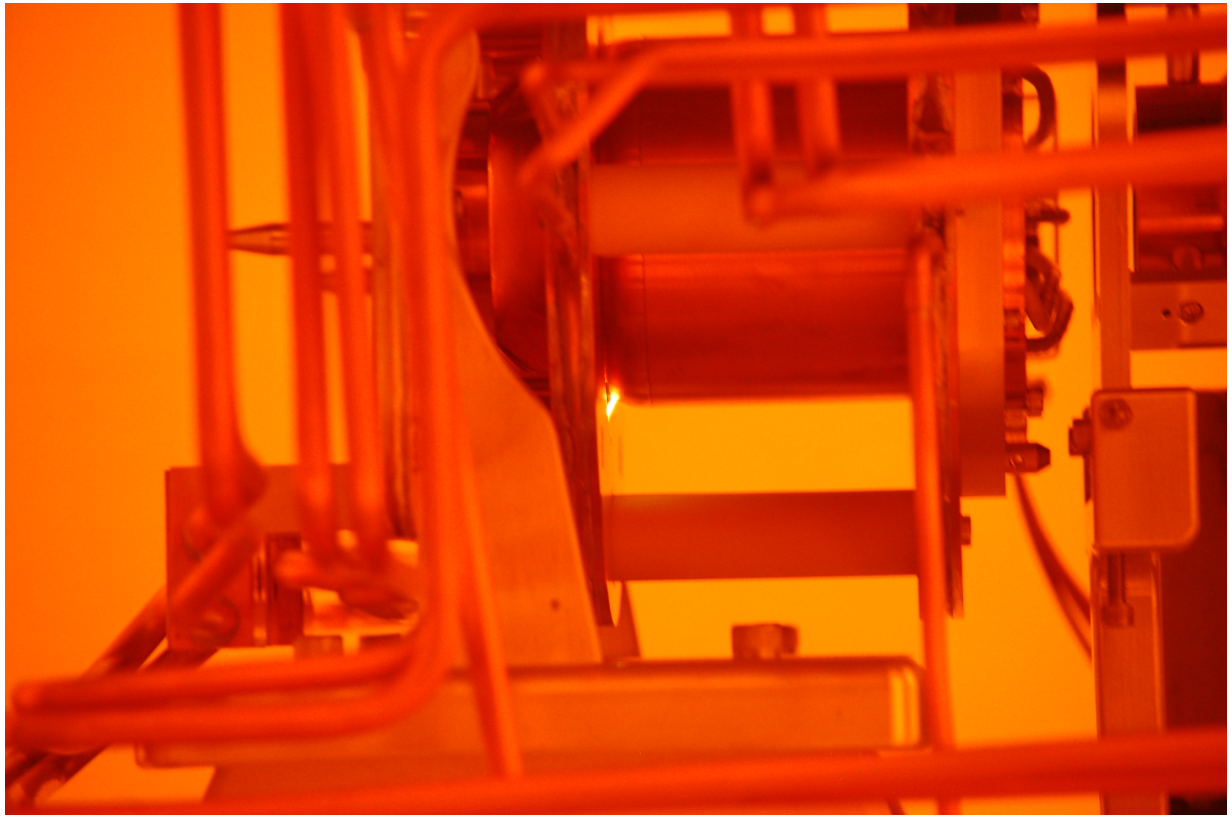
- There have been incremental upgrades to the source tray to eliminate that as a source of problems.
- Online testing is on-going to set a baseline for performance.
- Replacement of service tray should allow module to function at full bias.

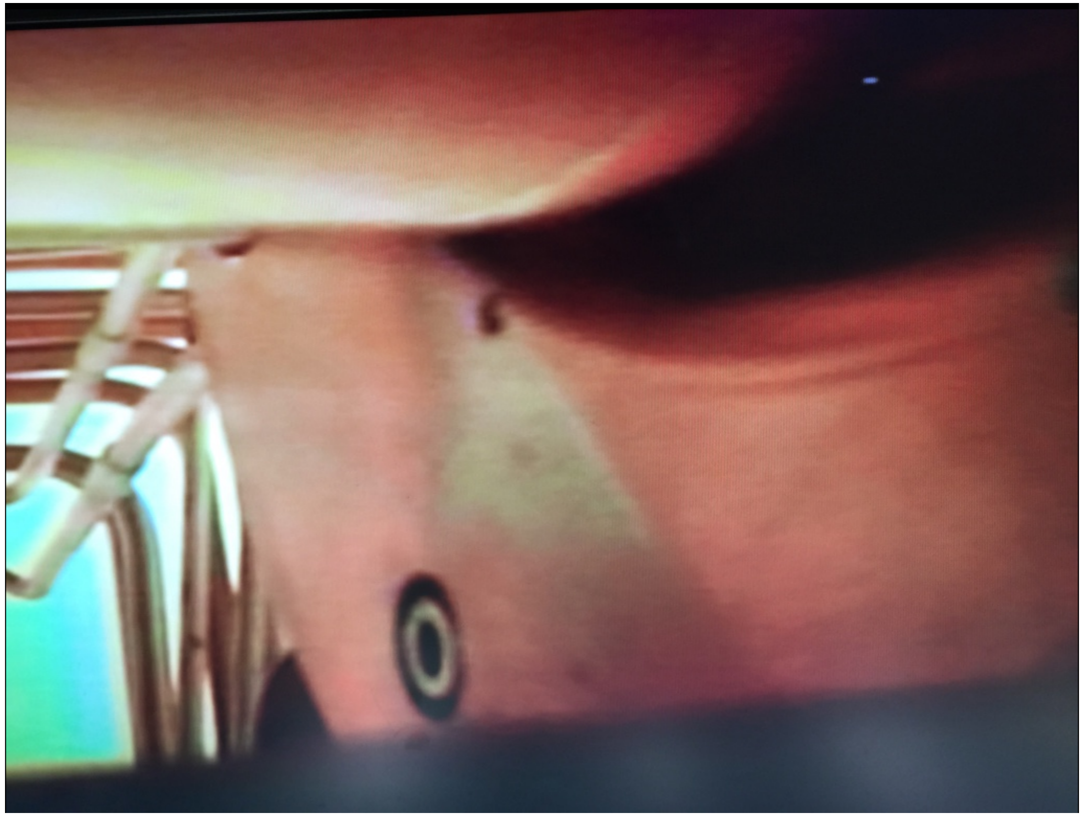
Service tray
Delivers all HV services from the module cap to the source tray

Source tray
Holds the target assembly and extraction optics



Example: Target Module Source Tray Discharges

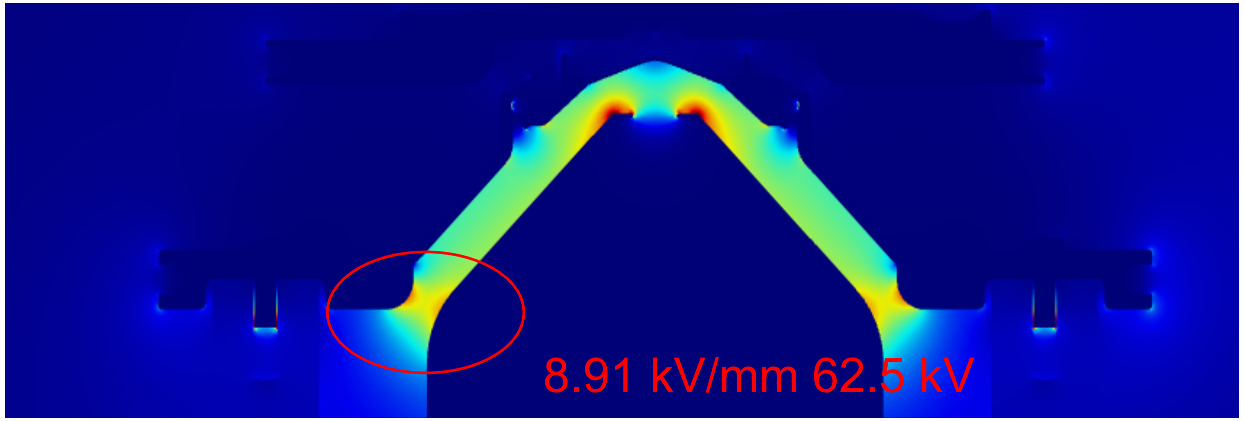


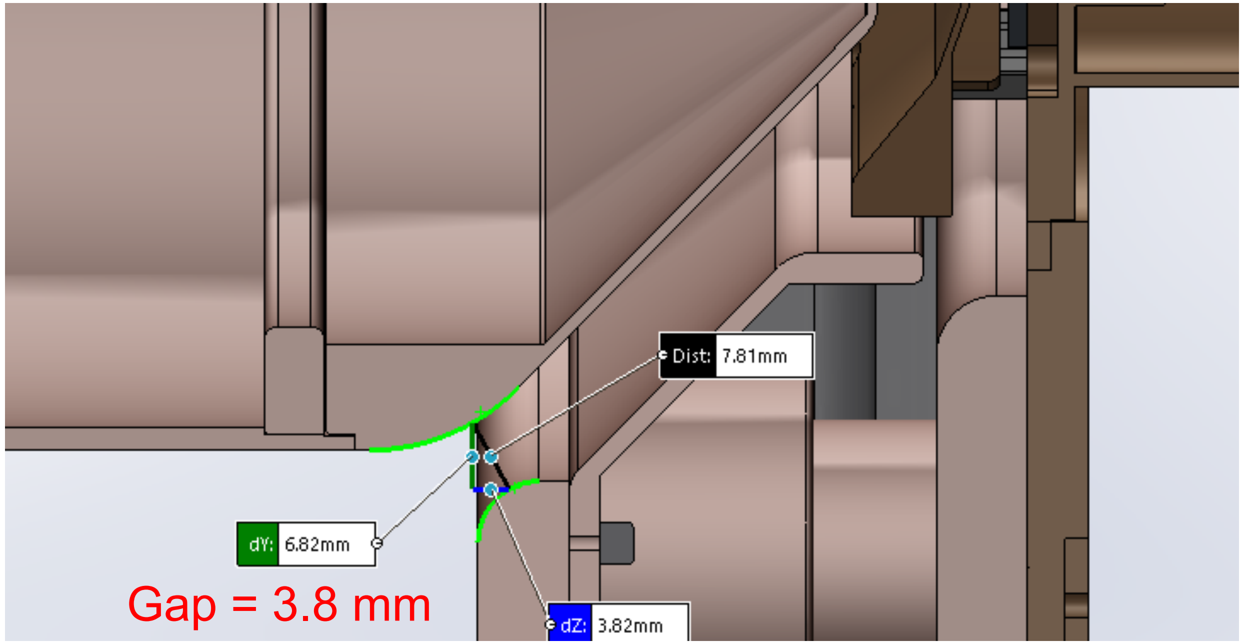


Discovery, accelerated

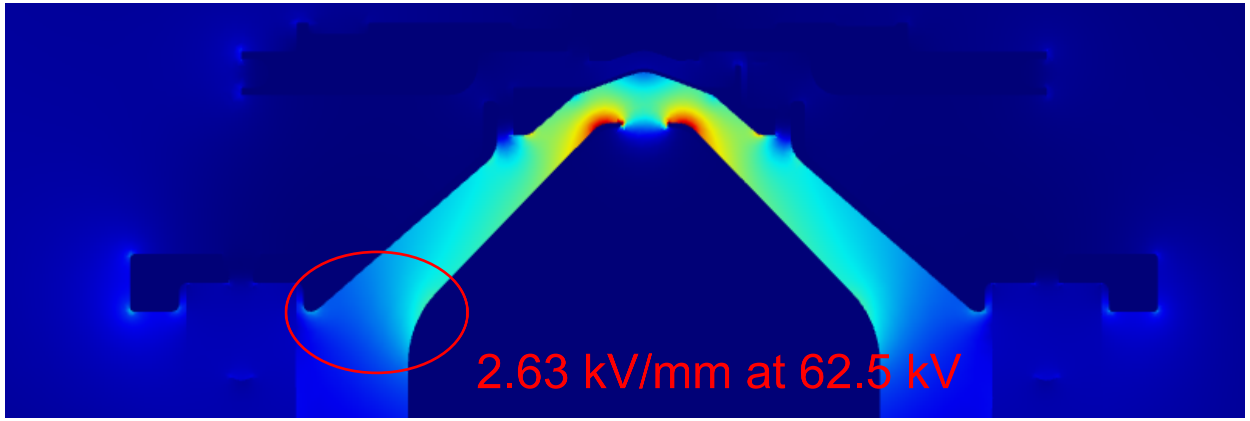
Field Strength at Extraction Electrode – TM2/TM4 Redesign

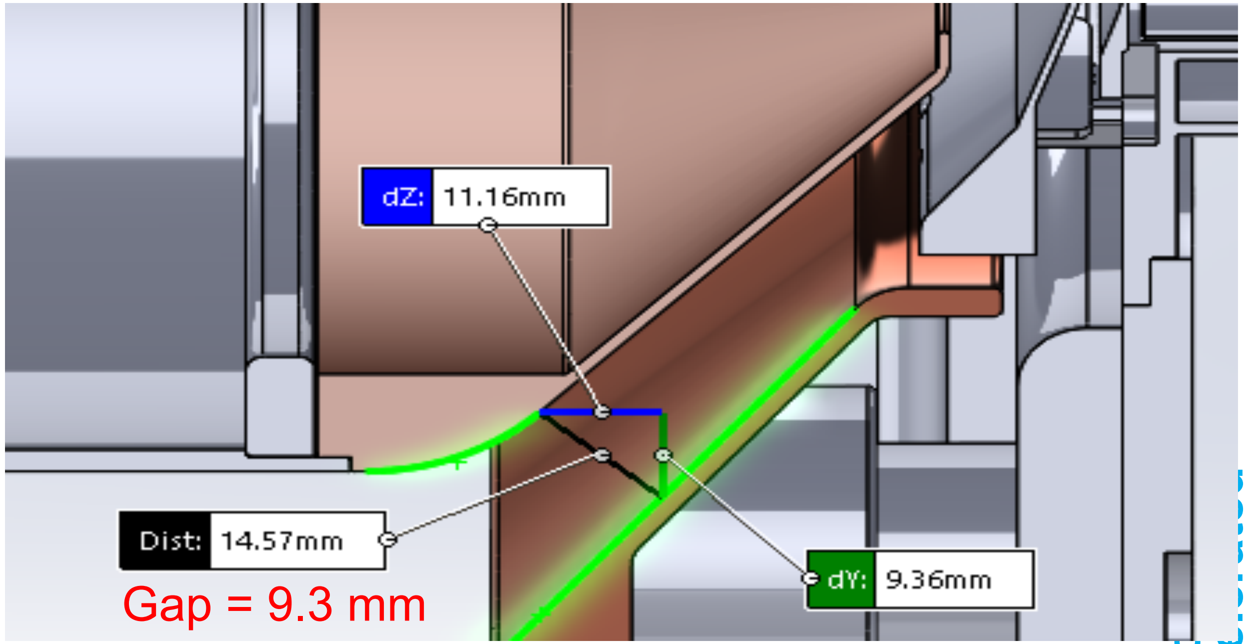
Previous Design





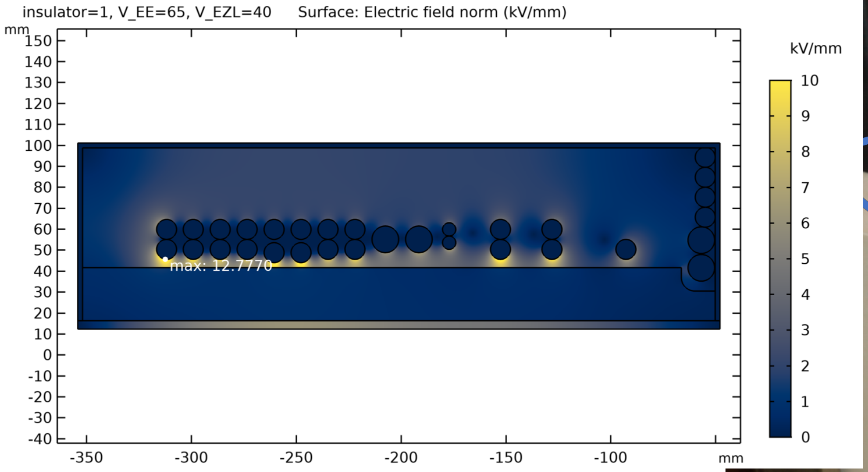
New TM2 Source Tray

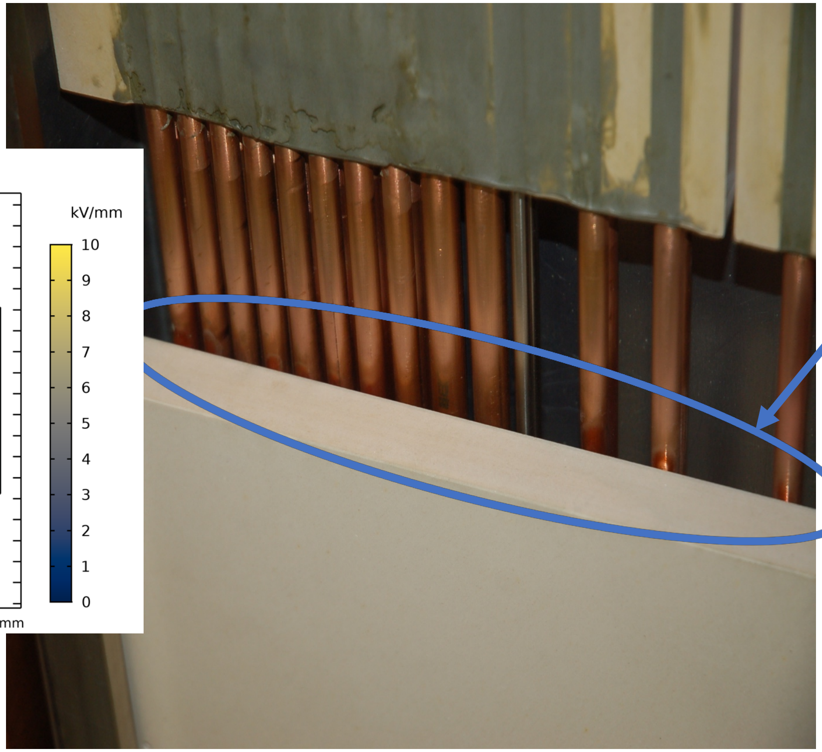




TM3 Service Tray Inspection

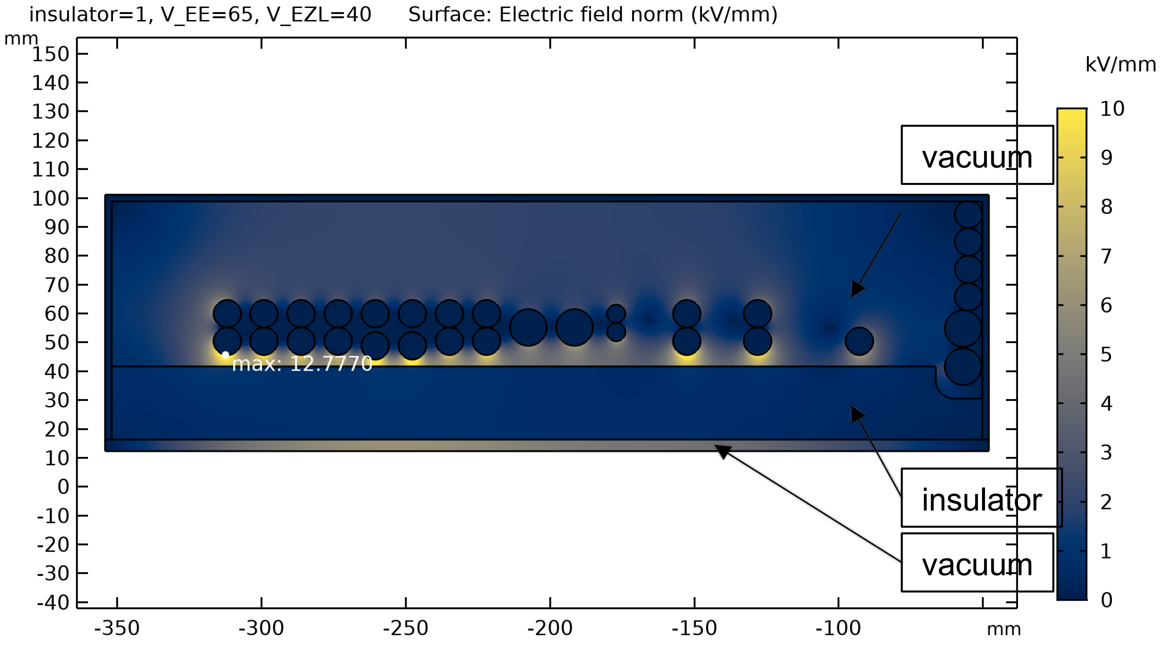
- Signs of sparks at both edges of the flat Mykroy insulator plates.
- Copper lines and Aluminum cover plate indicate sparking at the same location.





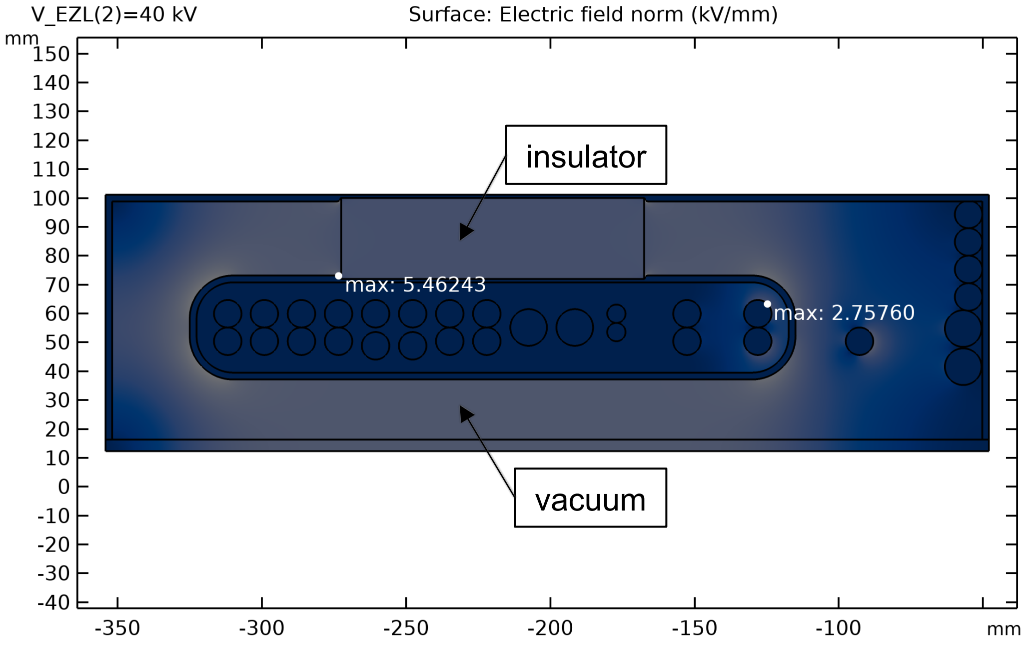
Current design

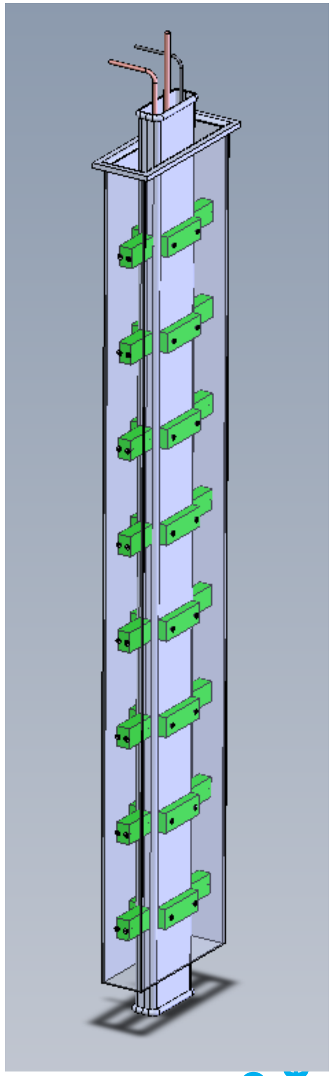
Maximum field strength: 13 kV/mm



New concept

Maximum field strength: 5.5 kV/mm





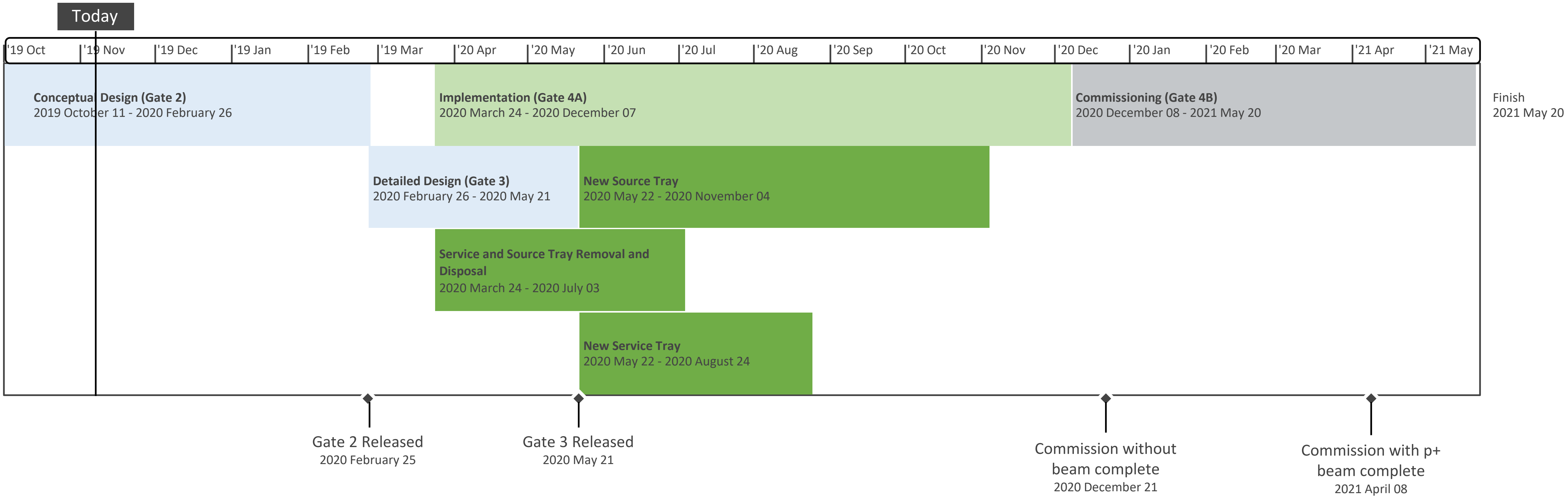
Cross section of current model

- Bias = 75 kV, EE = -10 kV, EZL = 40 kV
- High field strengths occur between service lines and insulator plate

Cross section of unoptimized proposed design

- Bias = 75 kV, EE = -10 kV, EZL = 40 kV
- Enclosing service lines at high voltage significantly reduces field strength
- Detailed design finished in beginning 2020

TM3 Refurbishment Schedule

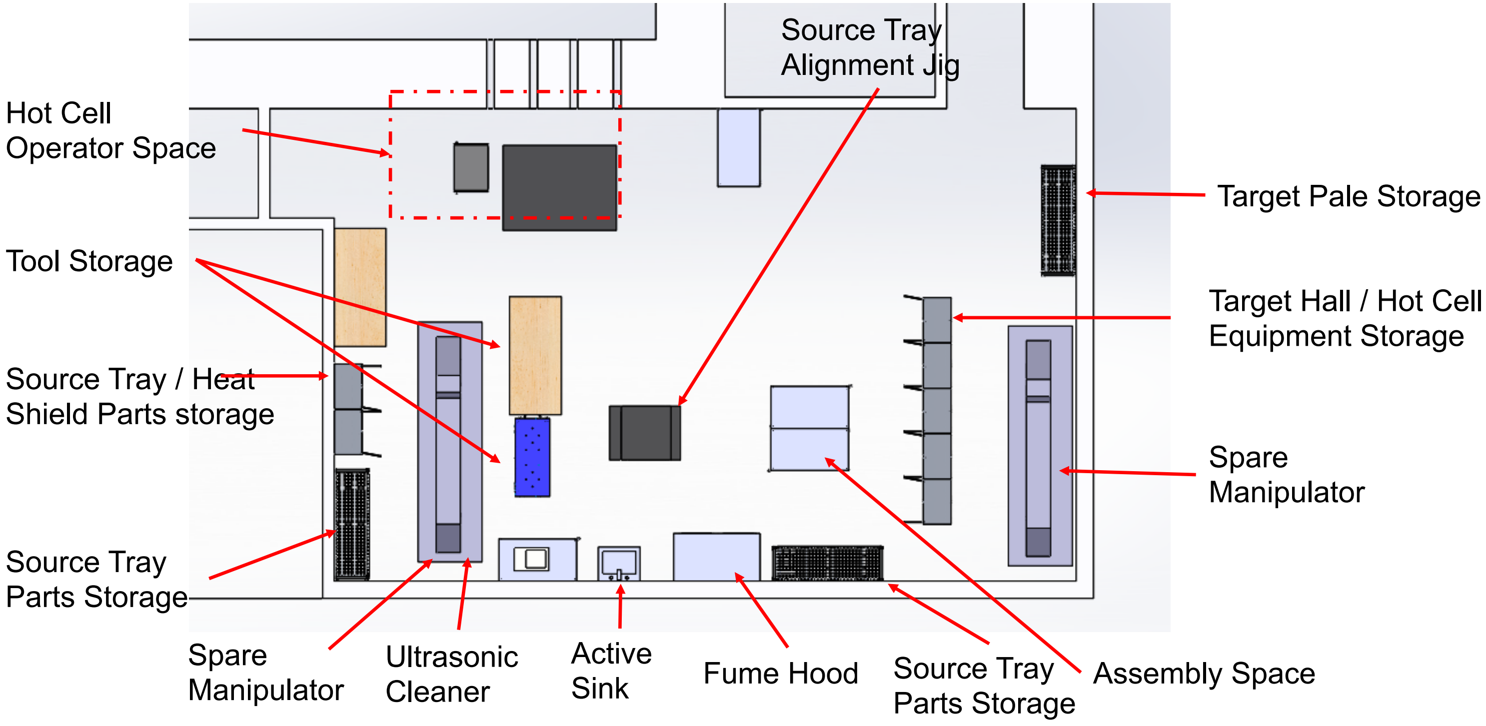


Towards Sustainable TM2/TM3/TM4 Refurbishment Cycle

- SMP and NHC allow south hot cell availability for TM work
- Design of future source trays and service trays that are applicable to all target modules
- New radiation tolerant and hot cell friendly interfaces between source tray and service tray
- Effective use of resources required to manufacture spare parts
- Availability of TM spare parts for next refurbishment and in case of failure

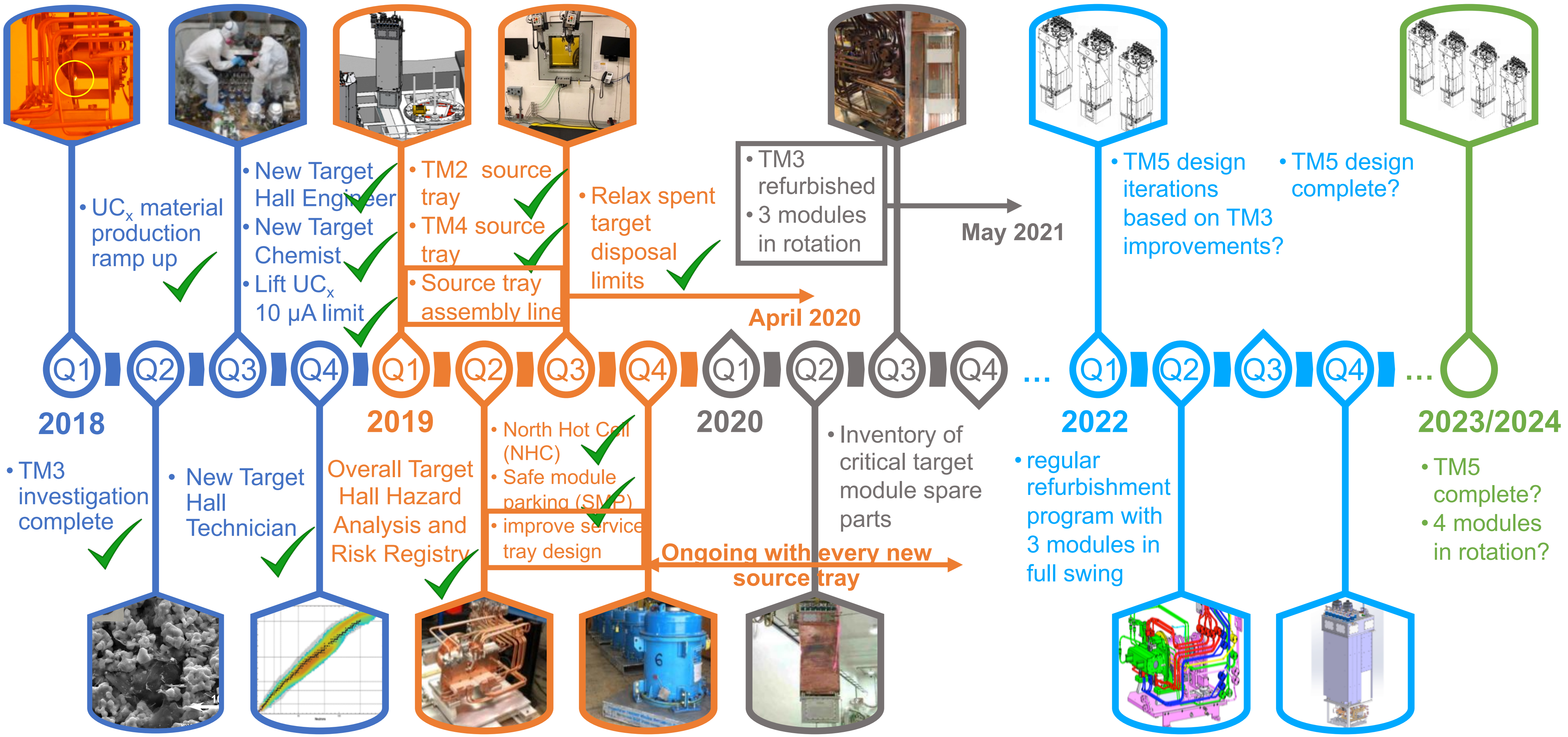
➔ Full refurbishment of one module every 5-7 years

Dedicated spare part assembly area



Operational in April 2020

Target Infrastructure Improvement Strategy – Est. Q2 2018, progress compared to initial time line



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Summary:

- Performance statistics shows that targeted reliability campaigns are successful.
- Remaining:
  Service tray exchange, preventative TM refurbishment cycle
- Infrastructure (NHC, SHC, TCS, SMP) finally in place
- Dedicated resources with right skill sets assigned
- TM3 refurbishment including first service tray exchange on track, completion 2021
- Systematic refurbishment cycle of TM2/3/4 as of 2022
- TM5 under consideration

Thank you!
Merci!