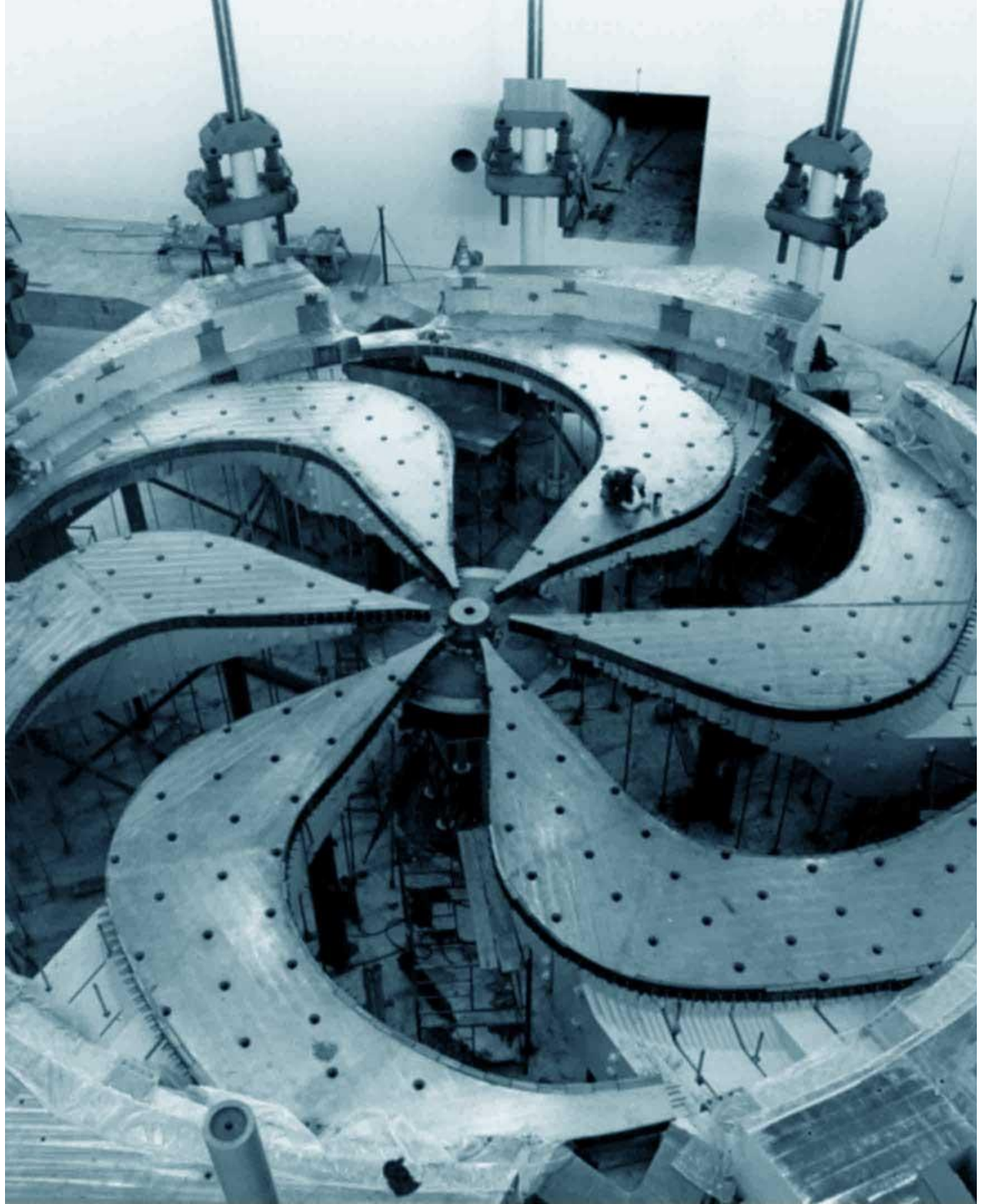
TRIUMF

ISAC-II Availability & Reliability

Zhongyuan Yao

WG-4, TTC meeting, Aomori-city

Oct. 11 – 14, 2022



QST

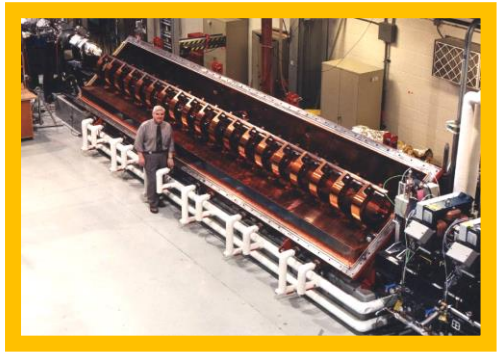
TESLA TECHNOLOGY COLLABORATION

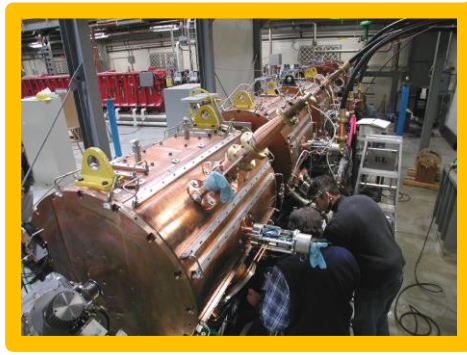
TTC

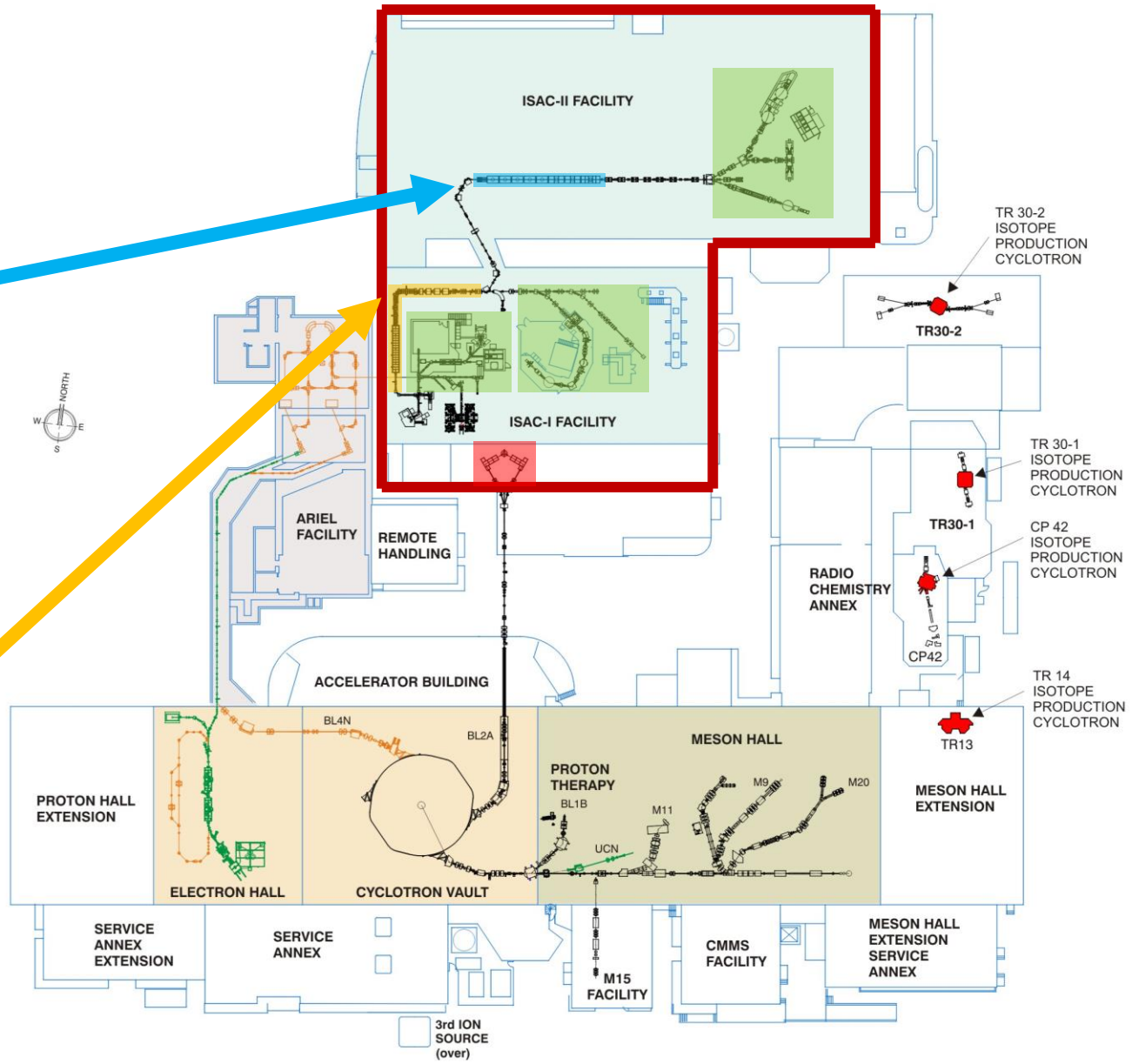
Discovery, accelerated

Isotope Separator & ACcelerator (ISAC)

40MV accel. 2≤A/q≤6 RIB to 6.5–16MeV/u







Discovery, accelerated

ISAC-II Operation

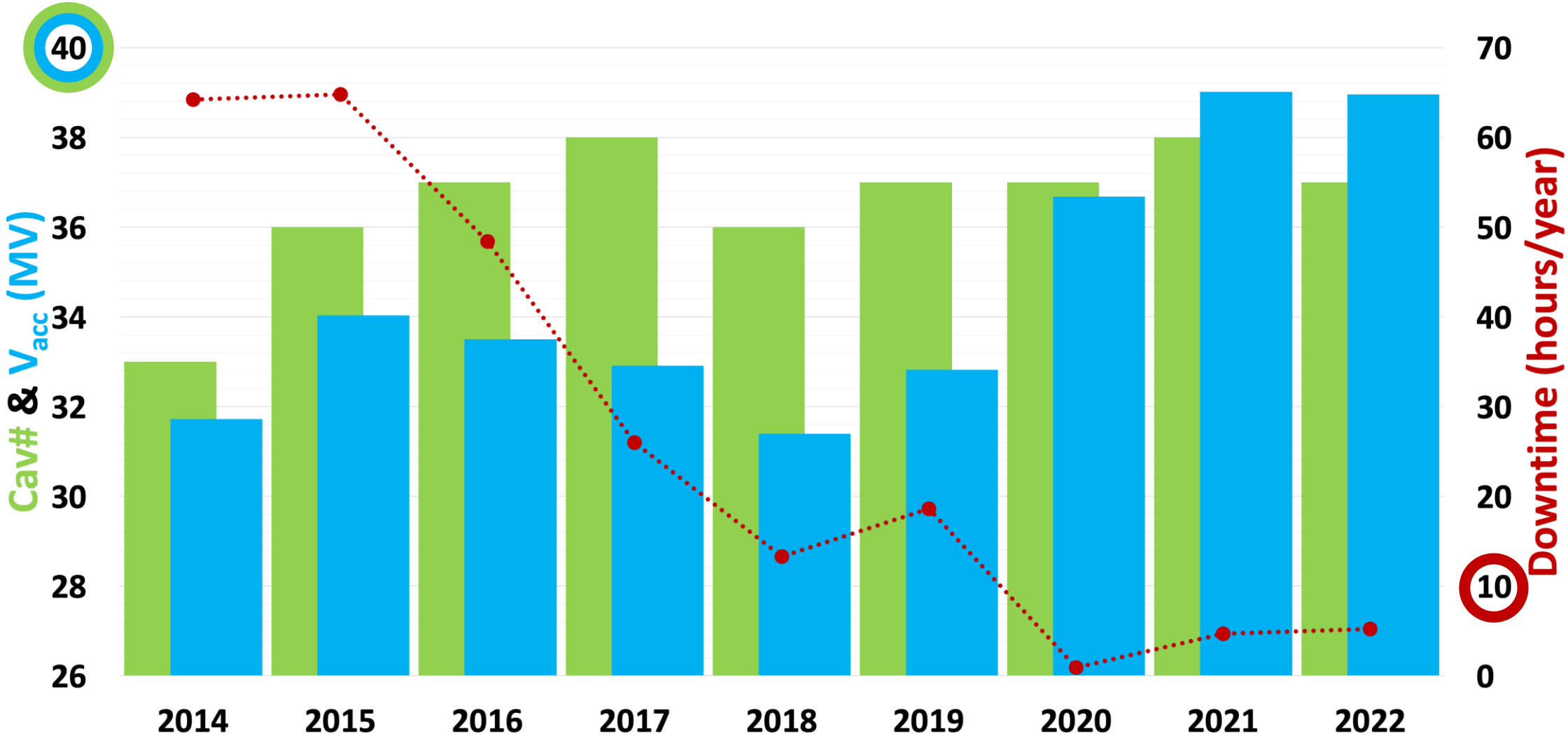
- Post-accelerator for RIB experiments
- System uptime
  - SRF in operation ~2300 hours per year
  - Opportunity to track performance and do maintenance between experiments
- Linac performance
  - Flexible to meet experiments' energy requirements
- Winter shutdown
  - Linac is warmed up to room temperature (Jan. – Arp.)
  - Opportunity to refurbish problem CM
  - Require annual cooldown and RF preparation

Shift	Cyclotron	BL2A	ISAC		OLIS	
	Offline	Offline	Exp. #	Facility	Offline Exp. #	Facility
Sun May 29 OWL		Shutdown			S1758 (*)	EMMA (SEBT3B)
DAY		Shutdown			S1758 (*)	EMMA (SEBT3B)
EVE		Shutdown			S1758 (*)	EMMA (SEBT3B)
Mon May 30 OWL		Shutdown			S1758 (*)	EMMA (SEBT3B)
DAY		Shutdown			S1758 (*)	EMMA (SEBT3B)
EVE		Shutdown			S1758 (*)	EMMA (SEBT3B)
Tue May 31 OWL		Shutdown			S1758 (*)	EMMA (SEBT3B)
DAY	Beam Development				S1758 (*)	EMMA (SEBT3B)
EVE	Beam Development				S1758 (*)	EMMA (SEBT3B)
Wed Jun 1 OWL		Startup			S1758 (*)	EMMA (SEBT3B)
DAY		Startup			S1758 (*)	EMMA (SEBT3B)
EVE			S841	YIELD	S1758 (*)	EMMA (SEBT3B)
Thu Jun 2 OWL			S841	YIELD	Setup (*)	N/A
DAY			Setup	YIELD	S1880	DRAGON (HEBT2)
EVE			Setup (*)	N/A	S1880	DRAGON (HEBT2)
Fri Jun 3 OWL			Setup (*)	N/A	S1880	DRAGON (HEBT2)
DAY			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
EVE			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
Sat Jun 4 OWL			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
DAY			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
EVE			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
Sun Jun 5 OWL			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
DAY			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
EVE			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
Mon Jun 6 OWL			S1795 (*)	TITAN (ILE2T)	S1880	DRAGON (HEBT2)
DAY			S1795 (*)	TITAN (ILE2T)	Setup (*)	N/A
EVE			S1795 (*)	TITAN (ILE2T)	Setup (*)	N/A
Tue Jun 7 OWL			S1795 (*)	TITAN (ILE2T)	Setup (*)	N/A
DAY	Maintenance				Setup (*)	N/A
EVE	Maintenance				Setup (*)	N/A
Wed Jun 8 OWL	Maintenance				Setup (*)	N/A
DAY			S1795 (*)	TITAN (ILE2T)	Setup (*)	N/A
EVE			S1795 (*)	TITAN (ILE2T)	S2138 (*)	IRIS (SEBT2)
Thu Jun 9 OWL			S1795 (*)	TITAN (ILE2T)	S2138 (*)	IRIS (SEBT2)
DAY			S1795 (*)	TITAN (ILE2T)	S2138 (*)	IRIS (SEBT2)
EVE			S1795 (*)	TITAN (ILE2T)	S2138 (*)	IRIS (SEBT2)
Fri Jun 10 OWL			S1795 (*)	TITAN (ILE2T)	S2138 (*)	IRIS (SEBT2)

Example

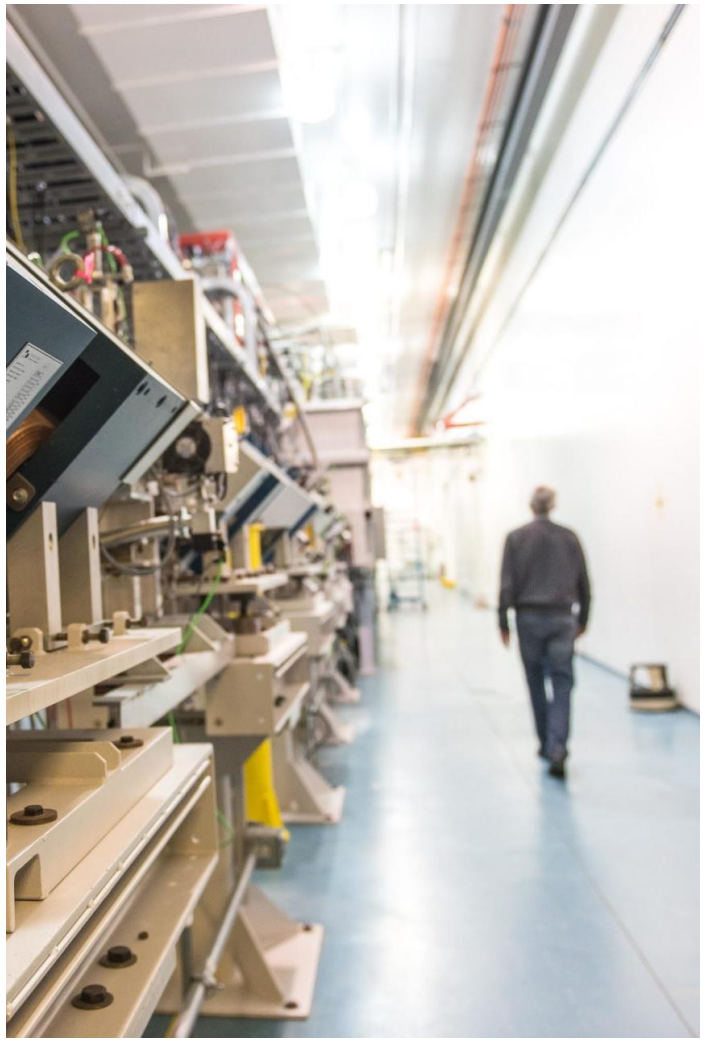
4 days available between high energy experiments in 2 weeks

ISAC-II Performance



Summary

- ISAC-II has been trending to high availability and high reliability
- Key factors
  - Avoid hard failures requiring to remove cavity from operation
    - HPRF – internal transmission line
  - ‘Know’ cavities and optimize operating regime
    - Cavity – change spec. ‘7W’ → stable
    - LLRF – fine tune for unstable cavities
  - Remote access is very helpful
  - Prepare for system aging
- Forward-looking
  - Push cavity ‘limits’
  - Achieve stable operation with less bandwidth
  - Mitigate particulate migration
  - Avoid accident (to be in next session)



Thank you
Merci

Question?

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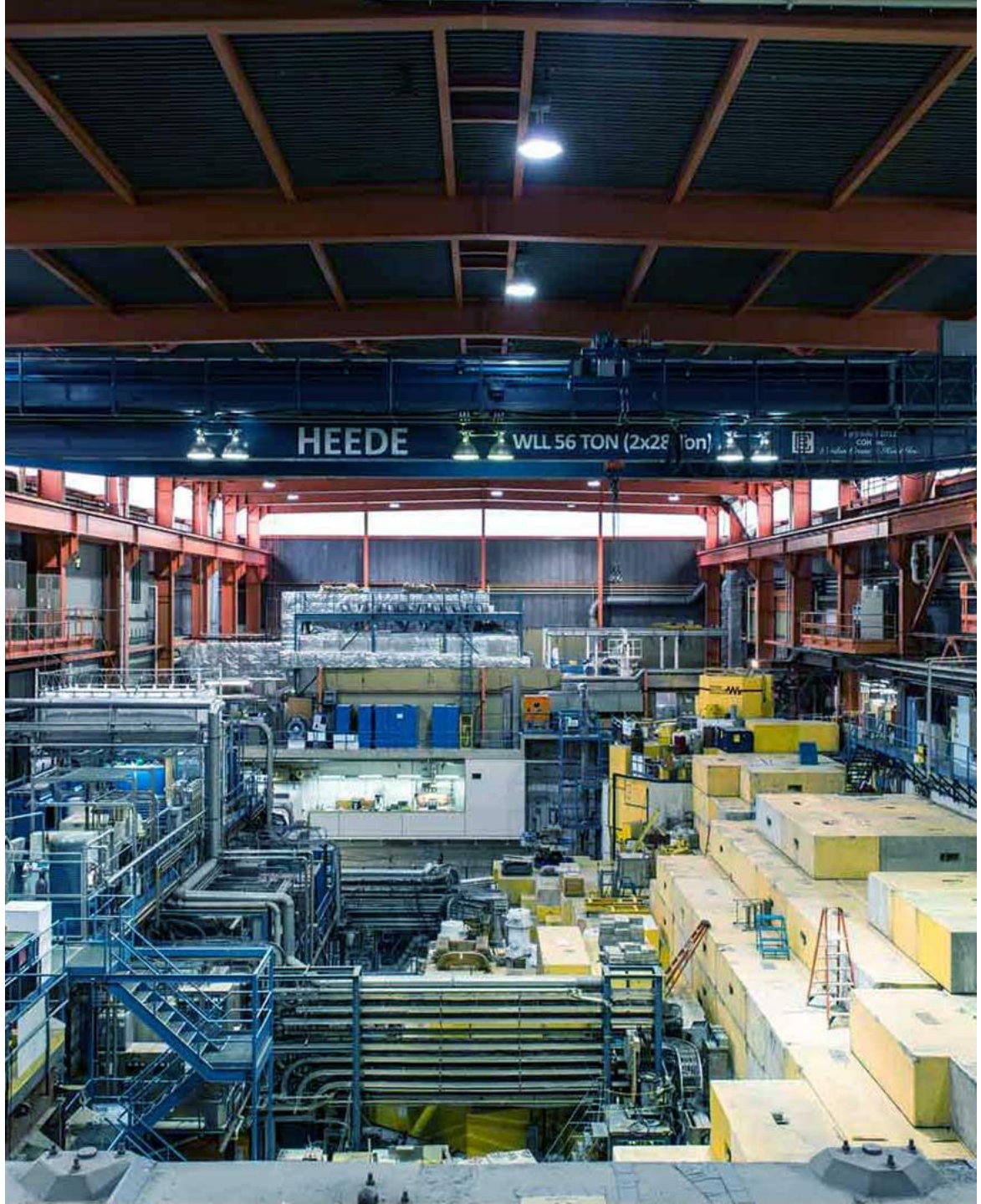


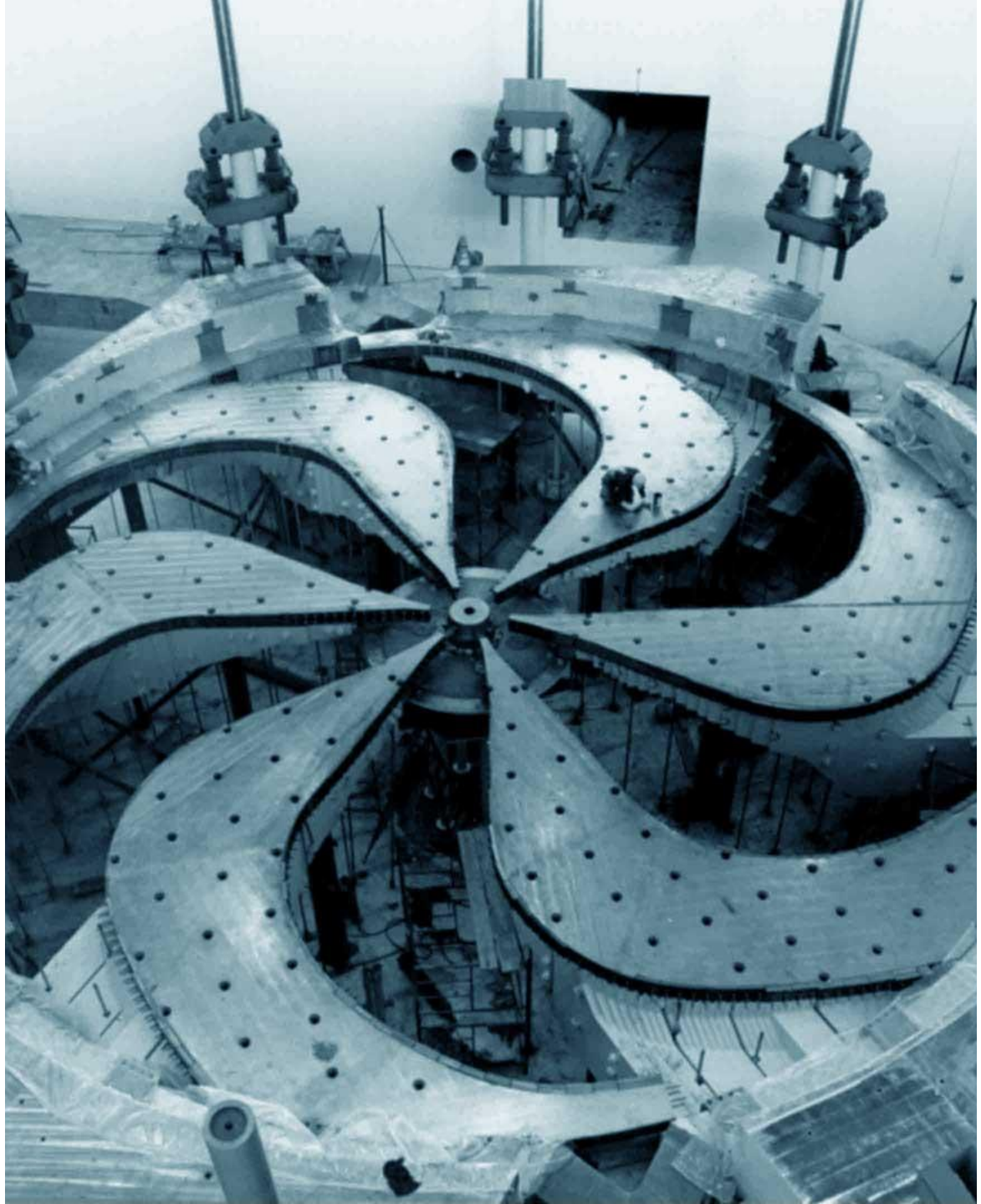
Discovery, accelerated

TRIUMF

Backup

For discussion

Oct. 12, 2022



Discovery, accelerated

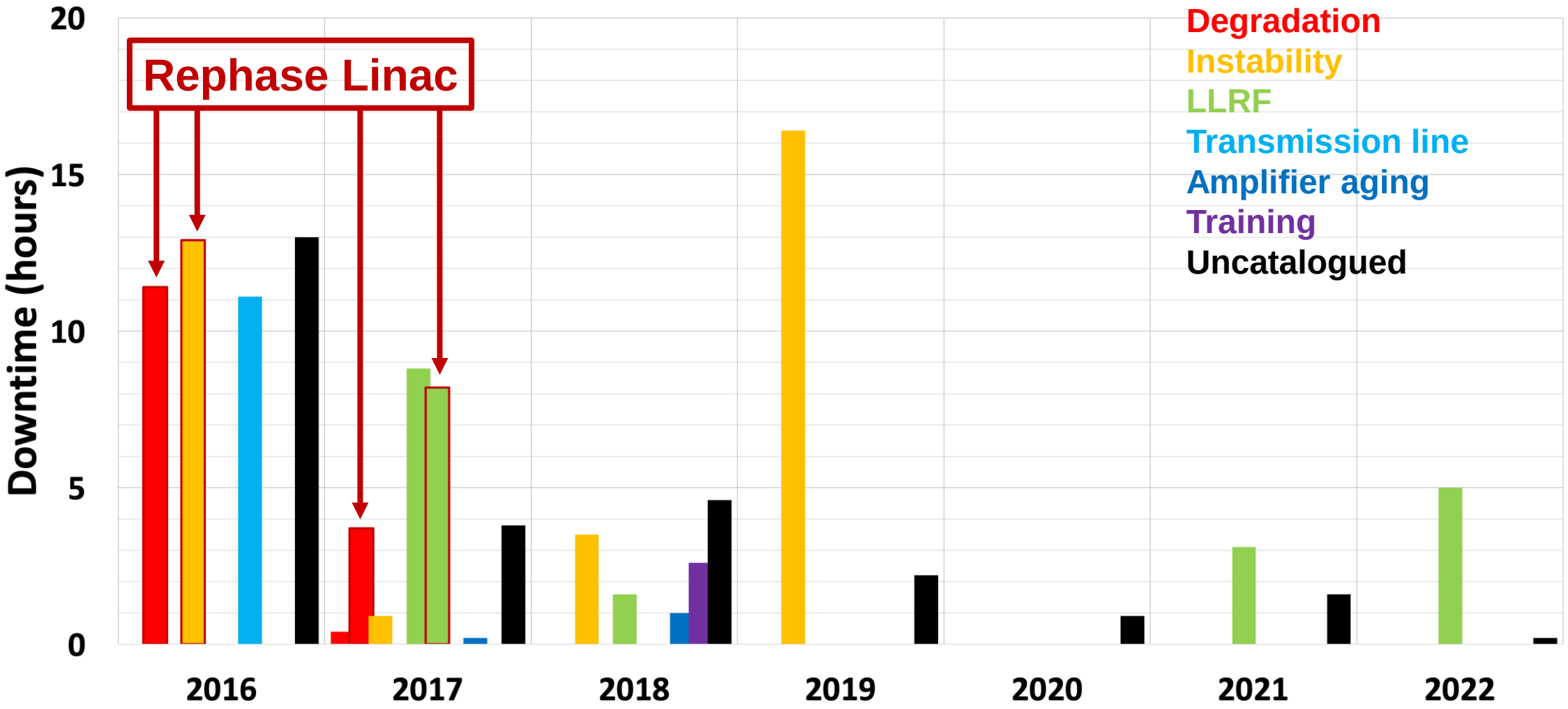
ISAC-II Cryomodules

- 40 QWRs in 8 CMs
  - 20 SCB @ 106MHz, 4 cavities per CM
  - 20 SCC @ 141MHz, 6/6/8 cavities in CM
  - Operating @ 6MV/m w/ 7W cavity loss
  - 200W RF drive power
- One 9T SC solenoid per CM
- Operating temperature @ 4K
- Top load CM design
- Single vacuum system
- 80K thermal shield
- Warm μ-metal shield
- Nb jacket as Meissner shield

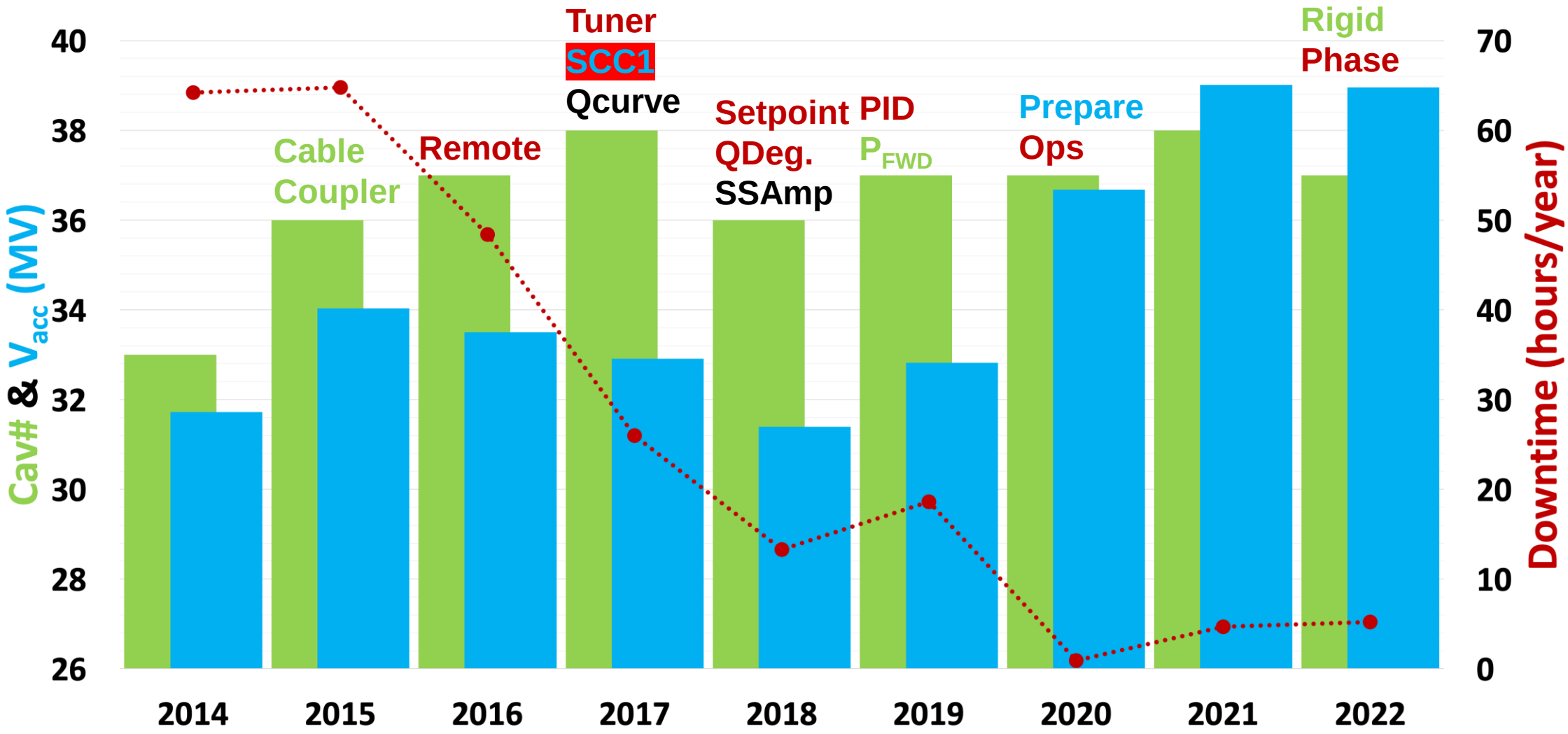
141MHz QWR

SCC3 Cryomodule

Downtime Analysis



ISAC-II Performance



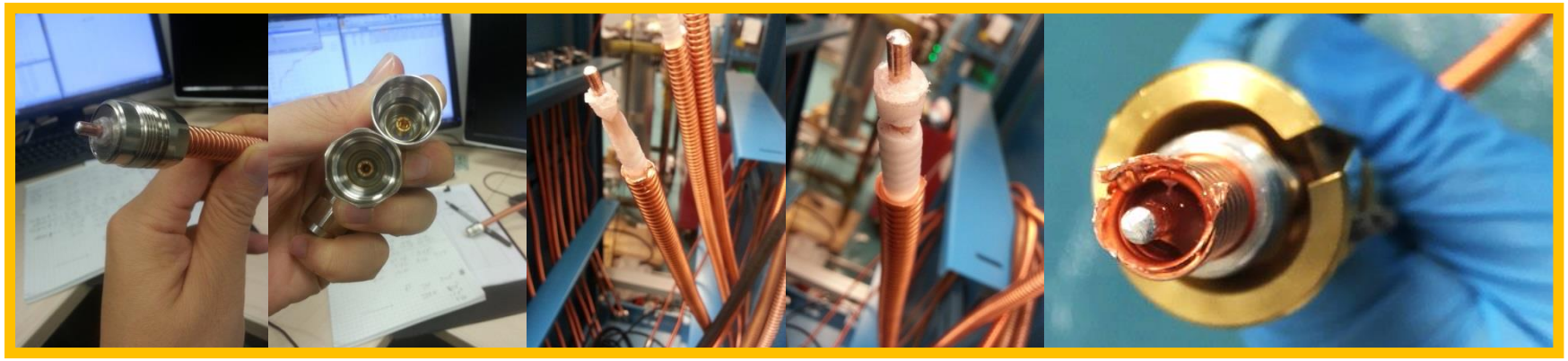
Discovery, accelerated

Internal RF Drive Cable

RF glow discharge in closed space of RF connector

- Drill holes on connector
- Change 3/8” cable to 1/2”
- Then to **rigid cable**
  - Length optimized
  - Loop added

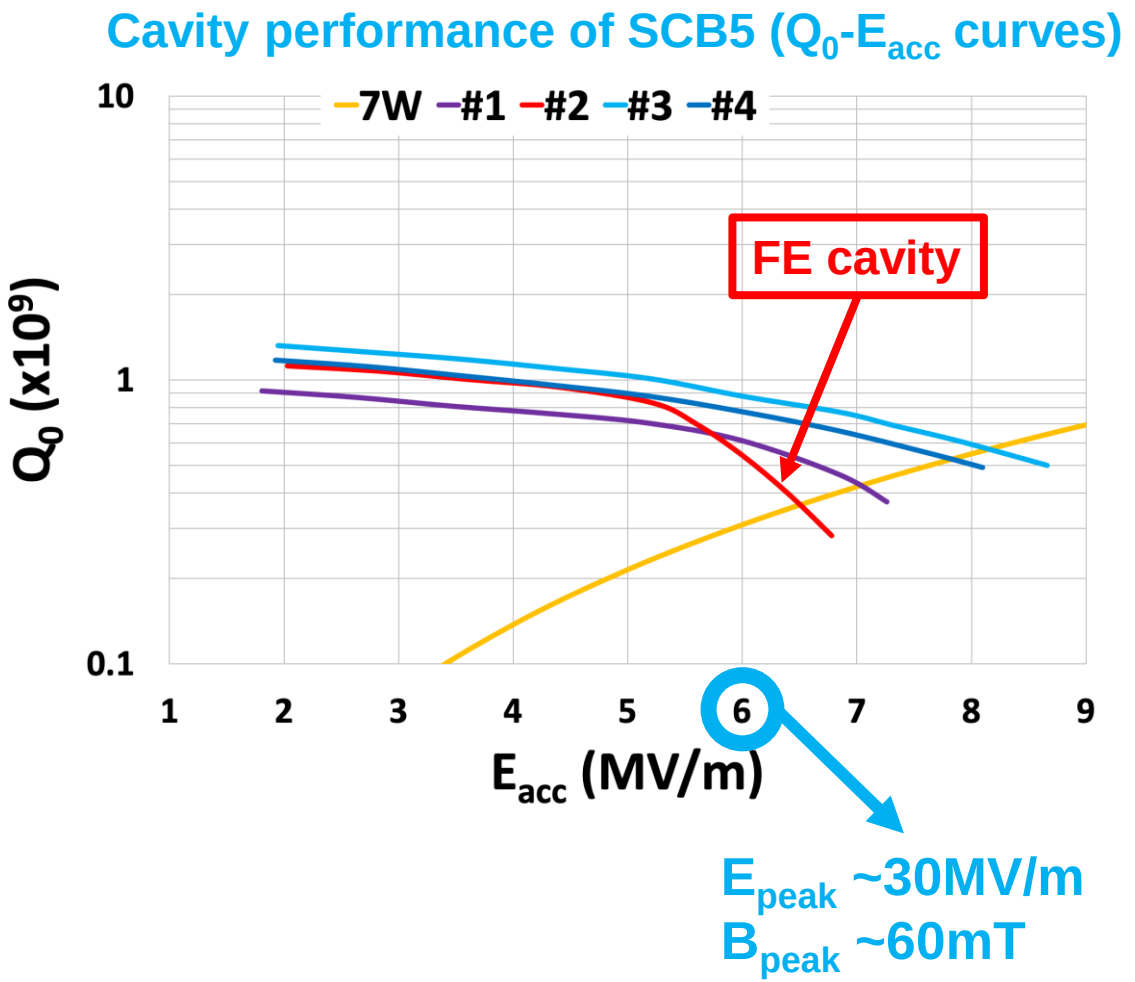
RF heating by contact resistance between cable IC and connector (~8W)



Tuner Plate

Cavity Challenge

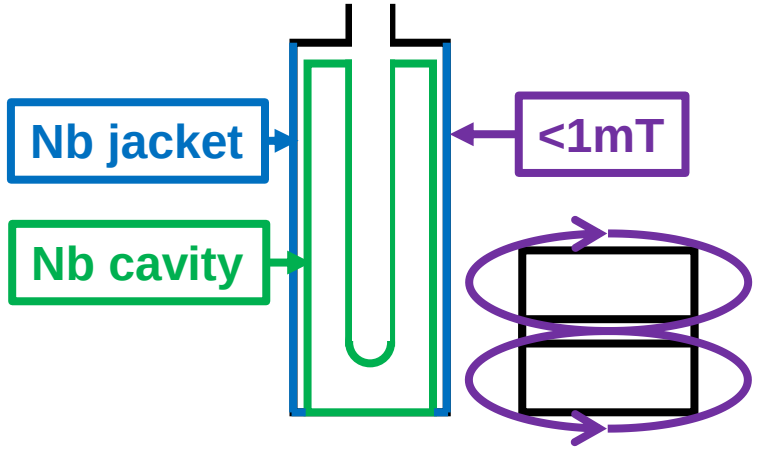
- Issue – field emission (FE)
  - Caused by particulates on RF surface with high e-field
  - Reduce cavity performance
  - Increase RF instability
  - Cause cavity trips and operation downtime
  - Severe cavity degradation (next slide)
- Mitigation solution
  - Optimize operating setpoints
    - Run FE cavities below FE onset
    - Push FE free cavities to compensate total voltage
  - Monitor cavity performance and apply RF conditioning as required

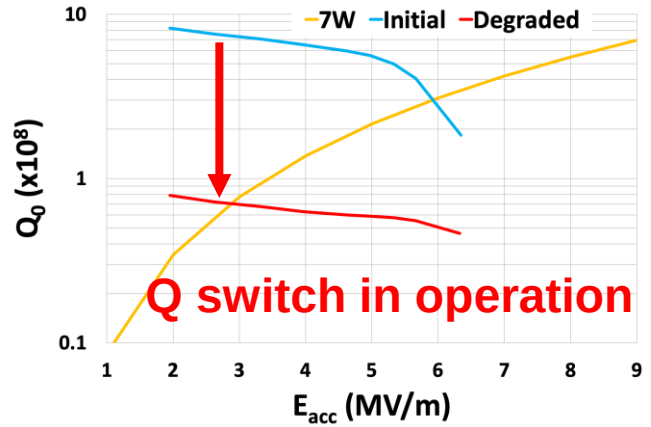


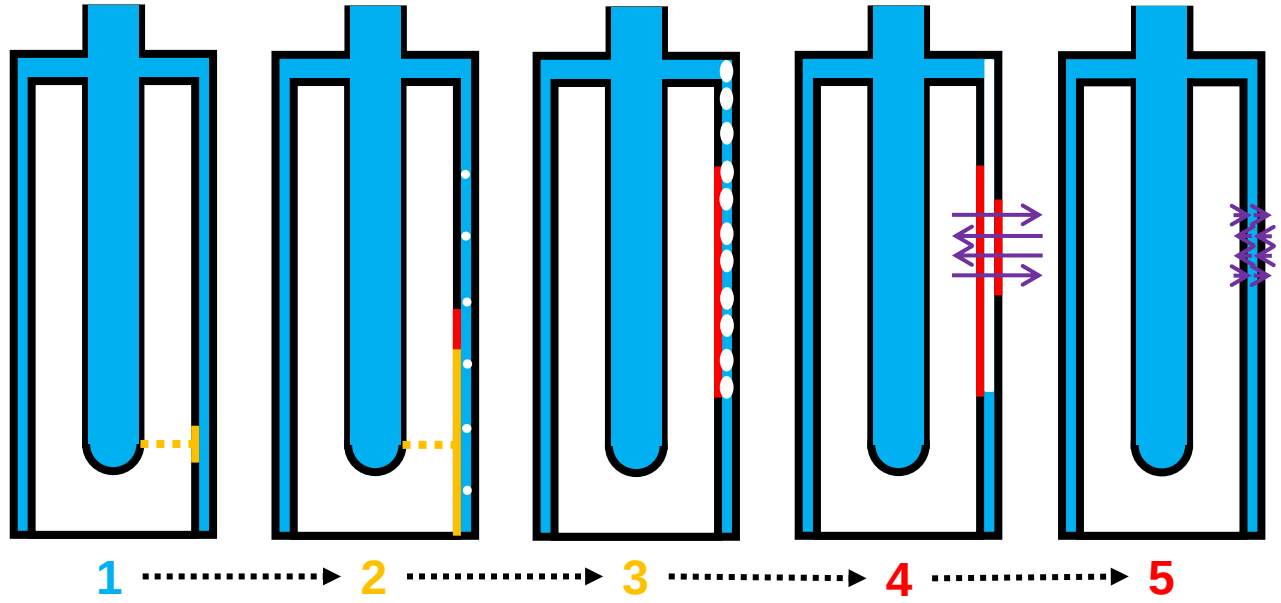
Discovery, accelerated

Cavity Challenge (2)

- Issue – magnetic poisoning from solenoid fringe field
  - A ‘hole’ opened in the Meissner shield and flux trapped in FE cavities cause severe Q degradations
- Recovery procedure
  - 15K cavity thermal cycle in zero magnetic background (~4hours)
- Avoidance solution
  - Run cavity below FE onset
  - Quench detection & interlock







Cavity Challenge (3)

- Issue – higher hydrogen content in SCC cavities
  - Show stronger Q-slope in the medium field regime and limited cavity operating gradient at 7W
  - Back trace to cavities manufacture
  - SCB tolerated up to 10 hours in 50-150K, while SCC degraded in Q after 1 hour soaking
- Solution – employ UHV furnace for hydrogen degassing
  - Potential ~30% improvement on SCC based on test date
  - Should also improve SCB performance

Average operating gradient in 2022

SCB 6.3MV/m v.s. SCC 5.4MV/m