

WGD Summary

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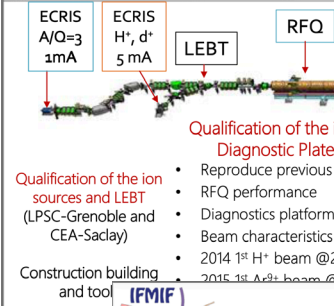
Some numbers to start

- 17 talks
 - 12 invited
 - 5 contributed
- Topics:
 - 7 Facility Commissioning/Status
 - 4 Facility Upgrade plans
 - 6 Operational aspects/Optimization for operations

Commissioning Talks

The SARAF MEBT

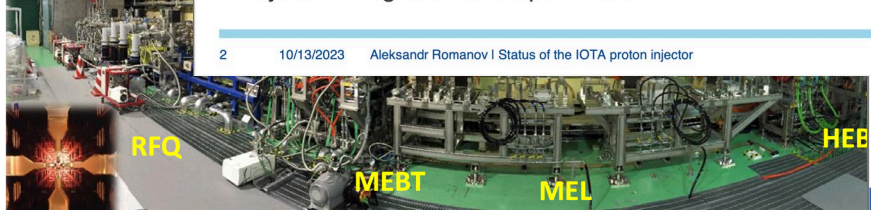
Beam Commissioning



2009-20

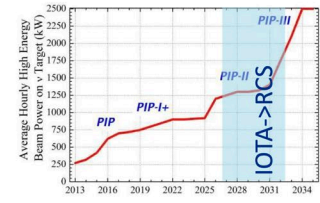
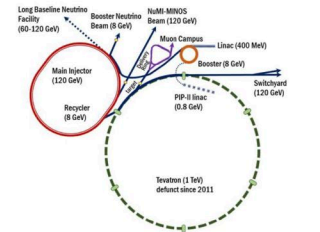


Injector

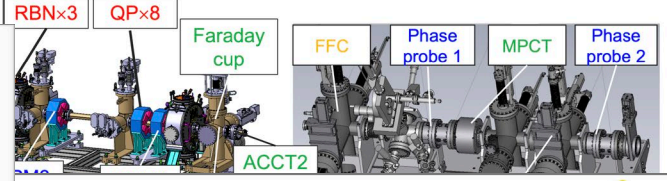


Motivation for IOTA

- Of particular interest to us:**
- Mitigation of beam losses at high-intensity:
 - Booster, Recycler and MI are intensity-limited by losses (~1 W/m).
 - Mitigation of instabilities in high-brightness beams:
 - Fast instabilities which can not be suppressed by external dampers, e.g. an "electron cloud" instability (observed in the Recycler)
 - Beam cooling
 - Future colliders
 - Quantum limits/properties of beams
 - System integration and optimization



2 10/13/2023 Aleksandr Romanov | Status of the IOTA proton injector

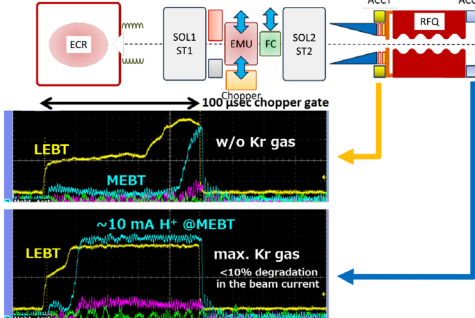


Background of CAFE² facility

2021 5-10mA, 100-200kW, CW

	ions	P, Alpha
Frequency		162.5 MHz
Current		10 mA
E _{out}		20MeV/u
Temp.		4.5 K

The beam commissioning of China Accelerator for research on superheavy elements, Zhijun Wang 5

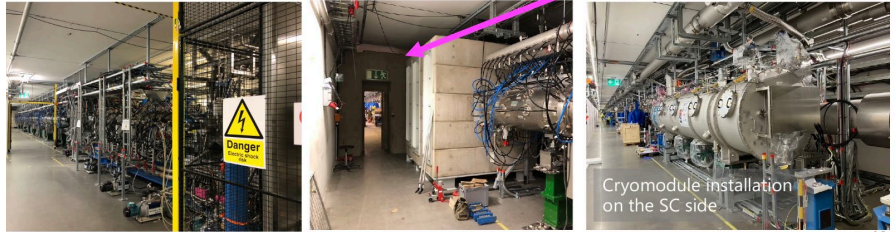


- ### Stage-1 (Jul. 2021 – Dec. 2021)
- ✓ The Pilot beam (10mA H⁺ and 20mA D⁺) were tested.
 - ✓ Chopper pulsing has been confirmed.
 - ✓ Alignment of full beam transport was checked in beam-based method.
 - ✓ Newly installed components were checked.
 - Validation of diagnostics → Stage-2 and -3 in high current and DC.
 - ✓ Measured beam size could be reproduced by the simulation.
 - ✓ Evaluation of space charge compensation degree.

Interesting topics observed from this stage

- Transient of chopper and space charge compensation.

1. K. Masuda, the Proc. of LINAC2022 (2022).



Commissioning Talks

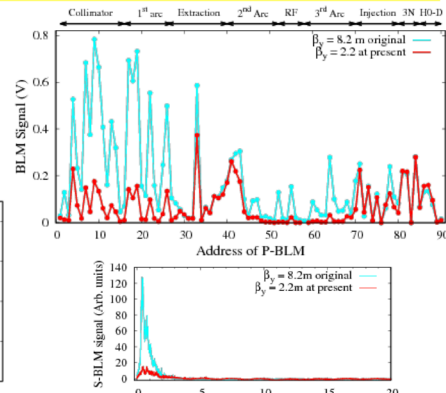
- Many facilities under commissioning or just out of it.
- Characterizing the machine at this early stage is important.
 - Knowledge of the dynamics + Diagnostics
 - How close/good is the machine model with respect to reality?
 - Longitudinal tuning is key (Linacs/low energy machines)
- Unforeseen events:
 - Scattering on beam dump
 - Phase oscillations for different beam currents

Established Facilities

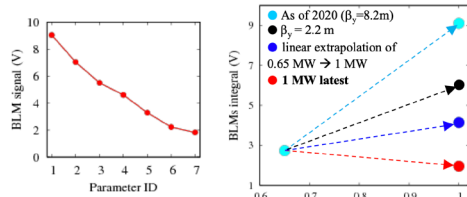
History of the RCS beam power to the MLF

Beam loss mitigation as compared to previous 1 MW operation

ID	Parameters	BLMs integral (V)
1	Original: Tune (6.46, 6.32), $\beta_y = 8.2\text{m}$	9.04
2	Tune: (6.45, 6.36) LP by $\Delta p/p$ offset of inj. beam	7.05
3	$\beta_y = 2.2\text{m}$; Foil Vert. 20mm \rightarrow 14mm	5.5
4	SB x0.8 for $3v_y = 19$ partial correction	4.6
5	LP optimization (LI Dp/p + RF freq. offset)	3.28
6	TP modification	2.22
7	Tune optimization	1.82



ation
: ~ 1MW
ty.)
RF trips
↓ 25 Hz.
reduced.
il 2024.



- The residual beam loss is <
 - ▶ The SC effect has sufficient
 - A laser stripping can thus g
- Pranab Saha

SNS power

The SNS is the highest SRF linac
Success at 1.7M
Capable

SNS does not open up leverage potential for scientific applications additional scatter

SNS science and opportunities beyond neutron science

At 1.7 MW the SNS linear accelerator is the **highest power proton accelerator in the world**. The facility will be capable of **2.8 MW** after the execution of the Proton Power Upgrade (PPU)

Discussed at the 2021 Neutron Advisory Board and included in NSCD 10-year strategic plan

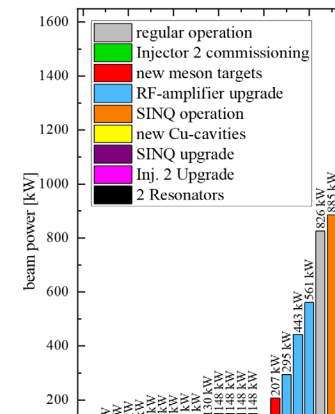
Opportunity: Advancing the construction of the STS beamline can make the extra power available for use before the STS is completed



A multi-MW **high-power linear accelerator** is the **optimal driver** for applications such as:

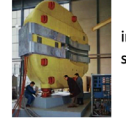
- **Isotope production** (accelerator driven production, ISOL)
- **Irradiation facility** (SEE – Single Event Effects, High-Power Target Testing Facilities)
- **Intense muon source** (mSR – muon spin resonance, muon beams)
- **Fundamental physics** (neutrinos, neutrons, accelerator R&D for muon collider)
- **Material testing for nuclear fusion** (with extracted SNS beam or target mount)
- **Accelerator driven systems** (transmutation nuclear fuel, energy production)

History of the Beam Power Designed for 60 kW



10 Year Upgrade Plan

- **Electronics and Control System**
 - Replacement of CAMAC-based system
 - New Firmware and Control system integration
 - interlock integration and level adaption
- **RF – Renewal and/or Upgrade**
 - new Flattop
 - Renewal / Upgrade of RF-amplifiers (SSD)
- **Magnet Renewal and Spares**
 - many coils over 50 years old
 - Bending magnets critical stock
- **Diagnostics**
 - Fast Wire Scanners (beam current 3 mA)
 - BPMs in 590 MeV beamline



started -2026

Injector 2 -2025
prestudies -2030
strategic decision

inventory
stock keeping

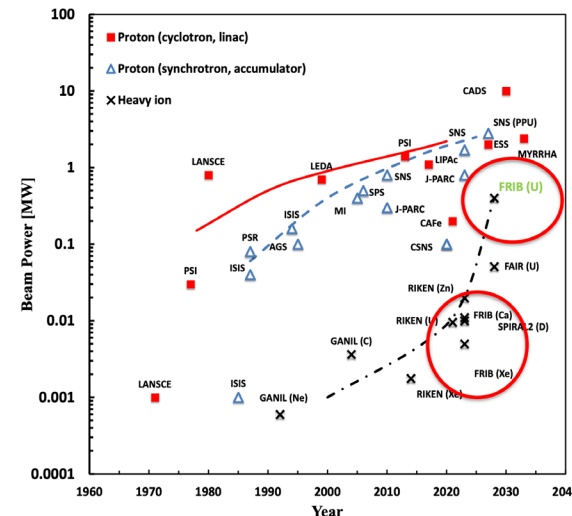
started -2026
strategic
started -2030

ing

g -2026

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Evolution of Proton and Heavy Ion Beam Power



Compared to proton-based facilities, lower-energy, heavy-ion based facilities face challenges, including high dissipation-power density and high radiation damage

- FRIB started user operations at 1 kW
- Progressively increasing the average beam current
- Currently operating at 10 kW
- Beam power ramp-up goal: 400 kW in 2028

Established Facilities

- There is a lot of drive to push machines beyond their original design power:
 - Upgrades and pushing the envelope: SNS, FRIB, JPARC and PSI
- Reduction of losses is the main concern and a lot of work done towards this goal:
 - Better understanding of transverse dynamics (instabilities and resonances)
 - Space charge and chromaticity tunes shifts
 - Optimization of working points and tuning (symmetry of the lattices and tunes)
 - Better understanding of your model vs real machine
- For user machines Reliability is also key
 - Combination of machine knowledge and experience
 - Fine balance between conservative goals and pushing the machine performance

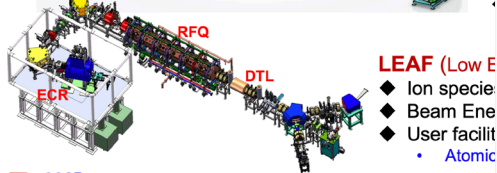
Operations



Heavy ion accelerators

HIRFL (Heavy Ion Research Facility in Lanzhou)

- ◆ Ion species: H~U
- ◆ Beam Energy: several MeV/u ~ 1 GeV/u
- ◆ User facility for: Nuclear physics, ion beam applications...



LEAF (Low Energy Antiproton Facility)

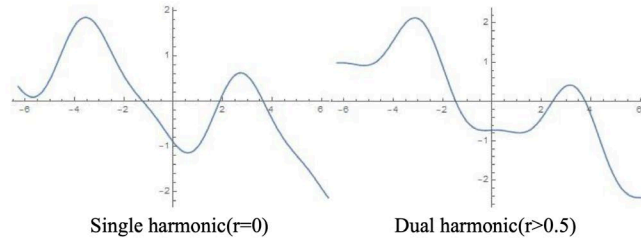
- ◆ Ion species: H~U
- ◆ Beam Energy: several MeV/u ~ 1 GeV/u
- ◆ User facilities: Atomic

- FB 2023

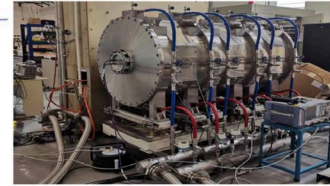
A Journey in Loss Summary

-
- Closed Orbit control critical in recovering post LS
 - Control re-established
 - Aim to leverage regular magnet surveys to predict closed orbit
 - New method of tune control being implemented and tested
 - Chopped beam measurement provides much utility in lattice
 - Lattice measurements improving lattice models
 - Beam loss critical to operations
 - Existing diagnostics provide robust machine protection
 - Utilising data for more systematic and detailed loss control
 - General trend: Reduction in beam intensity
 - Long-Term: Continue to support measurement-based machine setup
 - Develop understanding of our RCS by developing more based on regular measurements

The Dual Harmonic RF System



Reduce the longitudinal peak current intensity, and thus reduce the beam loss caused by space charge effect.



140kW has achieved

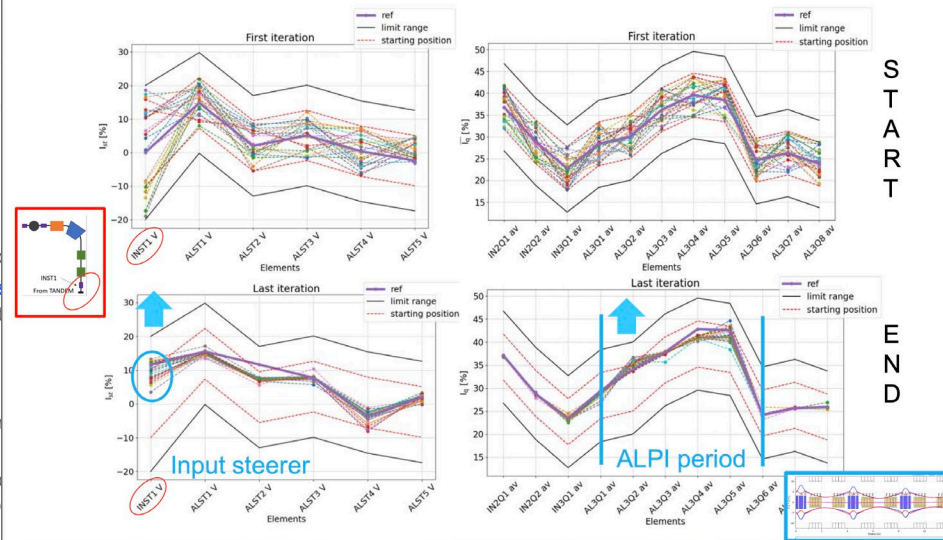


17 (Two MA)

25 swarm components, 1.5 h of time

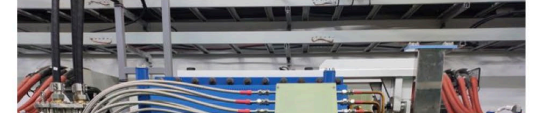
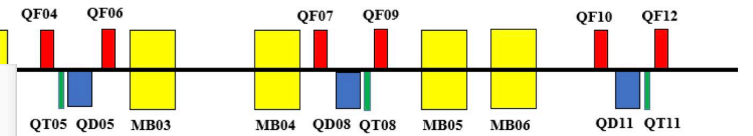
Results

FB 2023



START

END

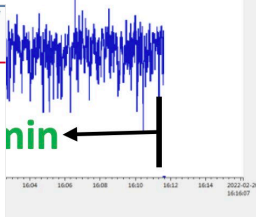


Operating mode @125 kW

98.1% @ with QT



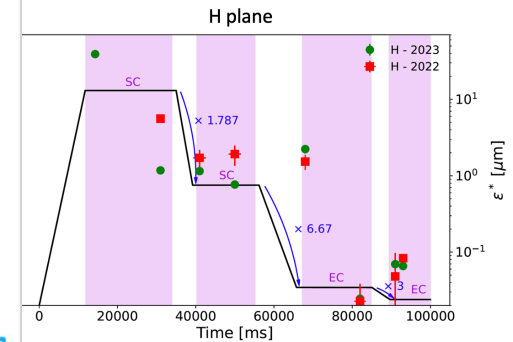
96.4% @ no QT



Performance of the CERN Antiproton Decelerator

Timing the cycle

decelerations plateaus → Performance assessment

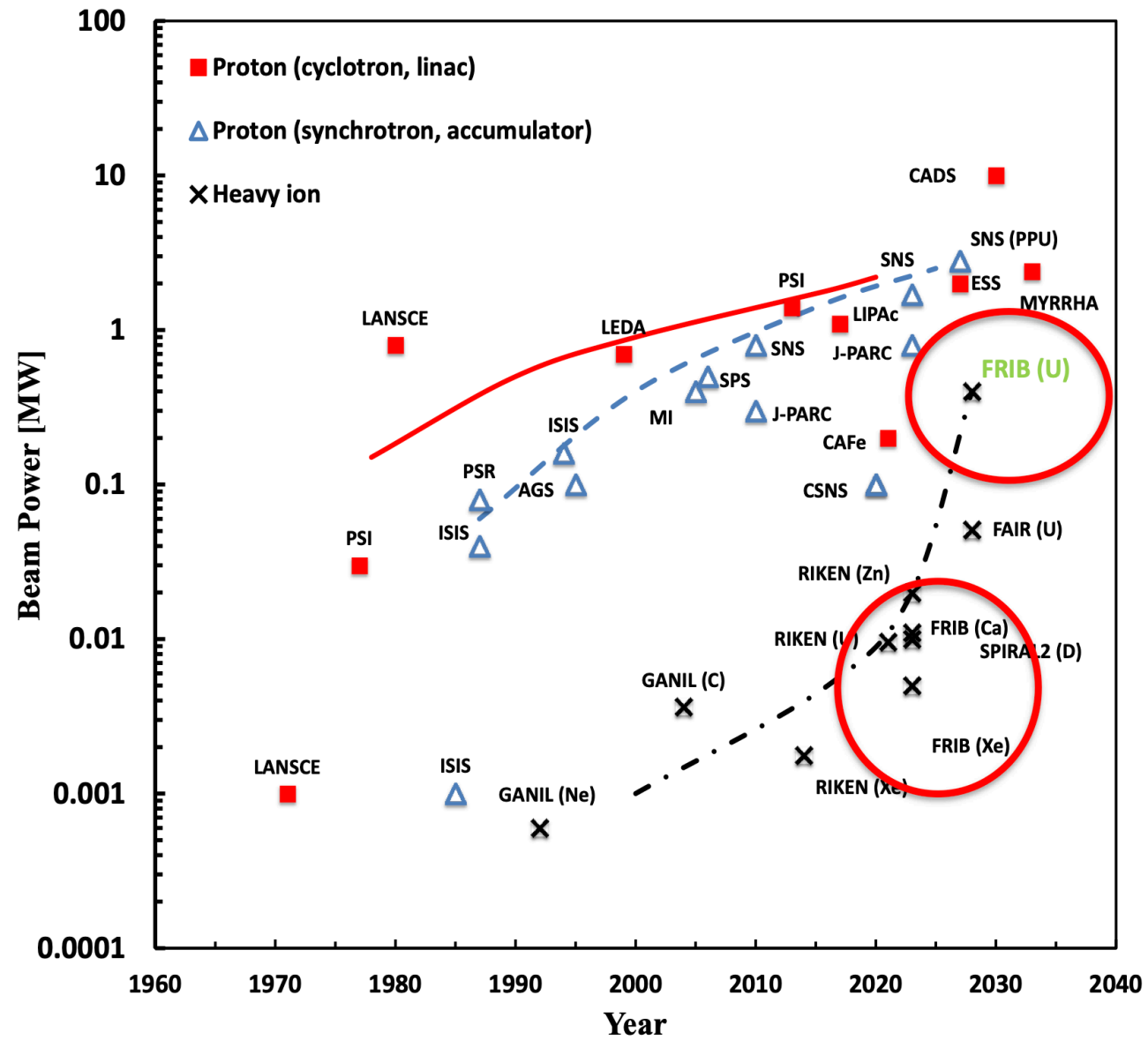


Workshop

8

Operations

- Reliability again is the word.
- Ensure you have the relevant data available (comparison with past performance, evolution on the machine and equipment, etc).
- Ensure you have the right diagnostics to the job, that is key to performance improvement and operations.
- Right people to do the job (training and knowledge transfer is important).



Thank you!