



REX / HIE ISOLDE update and plans for 2021

90th ISCC meeting 1 Feb 2021, CERN

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Outline

- Overall planning
- Shutdown '20/'21 schedule: Status of REX/HIE activities
- 2020 beam commissioning and plans for 2021
- Conclusions and final remarks

Overall planning for REX/HIE ISOLDE:



- Lat year, 2020:
 Despite the COVID-19 impact, which introduced a delay of ~10 wks, crucial hardware tests and recommissioning were maintained: The HIE ISOLDE cooldown, Cryo Module recommissioning (CM4 was repaired during LS2) and a successful beam commissioning of the full REX/HIE ISOLDE facility using stable beam from REX and GPS (FE10) was carried out. Foreseen extensive machine studies could not be scheduled – however, numerous studies were achieved anyway.

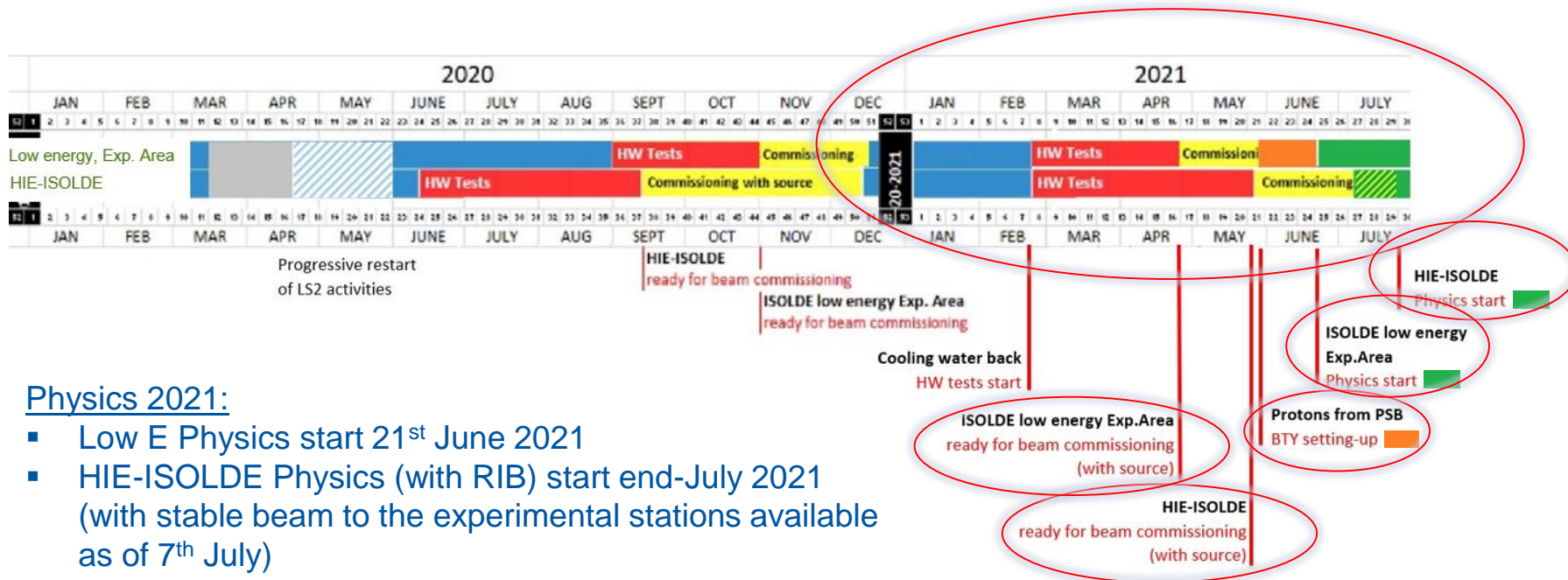


Overall planning for REX/HIE ISOLDE:



Restart this year, 2021:

- On the Low Energy side, the 2021 planning is mainly driven by the readiness of FE11 and the availability of the protons from PSB
- On the HIE ISOLDE side, the planning is mainly driven by the maintenance of CV (cooling towers) and Cryogenics (restart of the cryo plant, the cooldown of the SC Linac and associated recommissioning of the Cryo Modules)



Physics 2021:

- Low E Physics start 21st June 2021
- HIE-ISOLDE Physics (with RIB) start end-July 2021 (with stable beam to the experimental stations available as of 7th July)

Overall planning for REX/HIE ISOLDE:



2021 Physics time:

- The nr of weeks of REX/HIE Physics with RIB is driven by the Injector Accelerator Schedule -> the protons from PSB

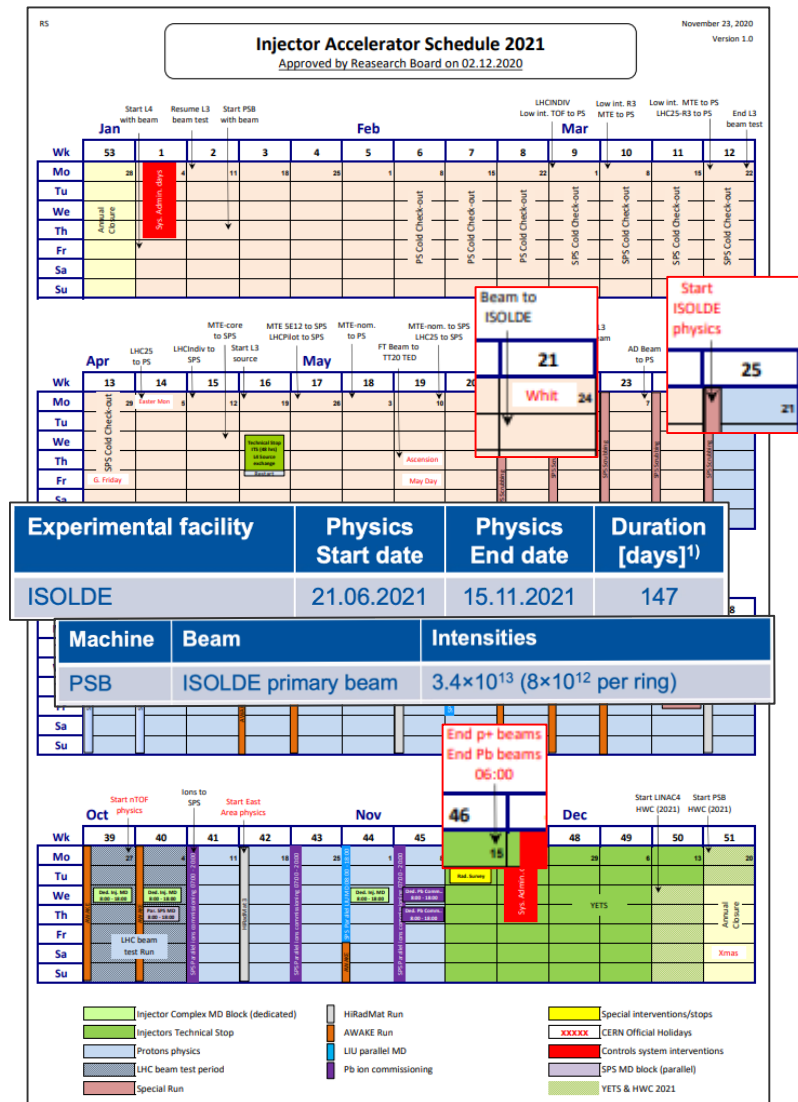
2021 Protons from PSB:

- Protons to ISOLDE as of the 25th May
- End of protons to ISOLDE on the 15th Nov (early Injector Complex stop in preparations of a short YETS '21-'22 and early start of LHC)

Taken in account the setting up of the BTY (proton) line to ISOLDE, FE and Target tests as well as on the REX/HIE side the cooldown and recommissioning of the SC linac:

ISOLDE Physics:

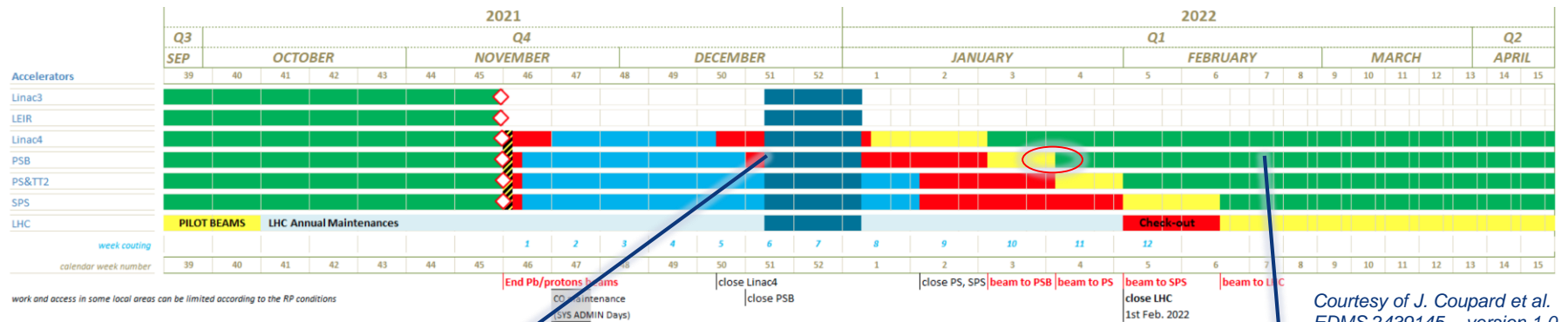
- Low Energy Physics 21st June – 15th Nov (+ long lived & stable until mid-Dec)
- REX/HIE Physics end-July – 15th Nov (stable as of 7th July + long lived & stable until mid-Dec)



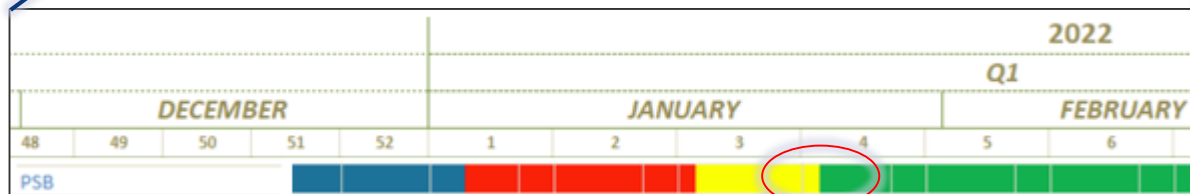
Overall planning for REX/HIE ISOLDE:

Presently Planned Short YETS '21-'22

(R. Steerenberg BE-OP, IEFC – 29 Jan 2021)



- 5 weeks for commissioning (hardware tests + cold check-out + beam commissioning) in the injectors (PSB, PS, SPS) before beam ready for PS to the LHC.
- The start of hardware re-commissioning in Linac 4 and PSB start before the annual closure.



- Protons from PSB available towards the end of Jan 2022 -> possible early start of 2022 ISOLDE Physics
- Requirements for an early start of 2022 REX/HIE ISOLDE physics: No stop of the cooling water plant and continuation of the Cryo plant for the SC HIE Linac over the '21-'22 annual closure

Outline

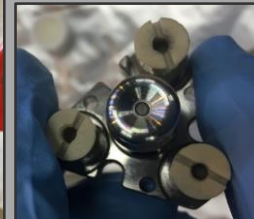
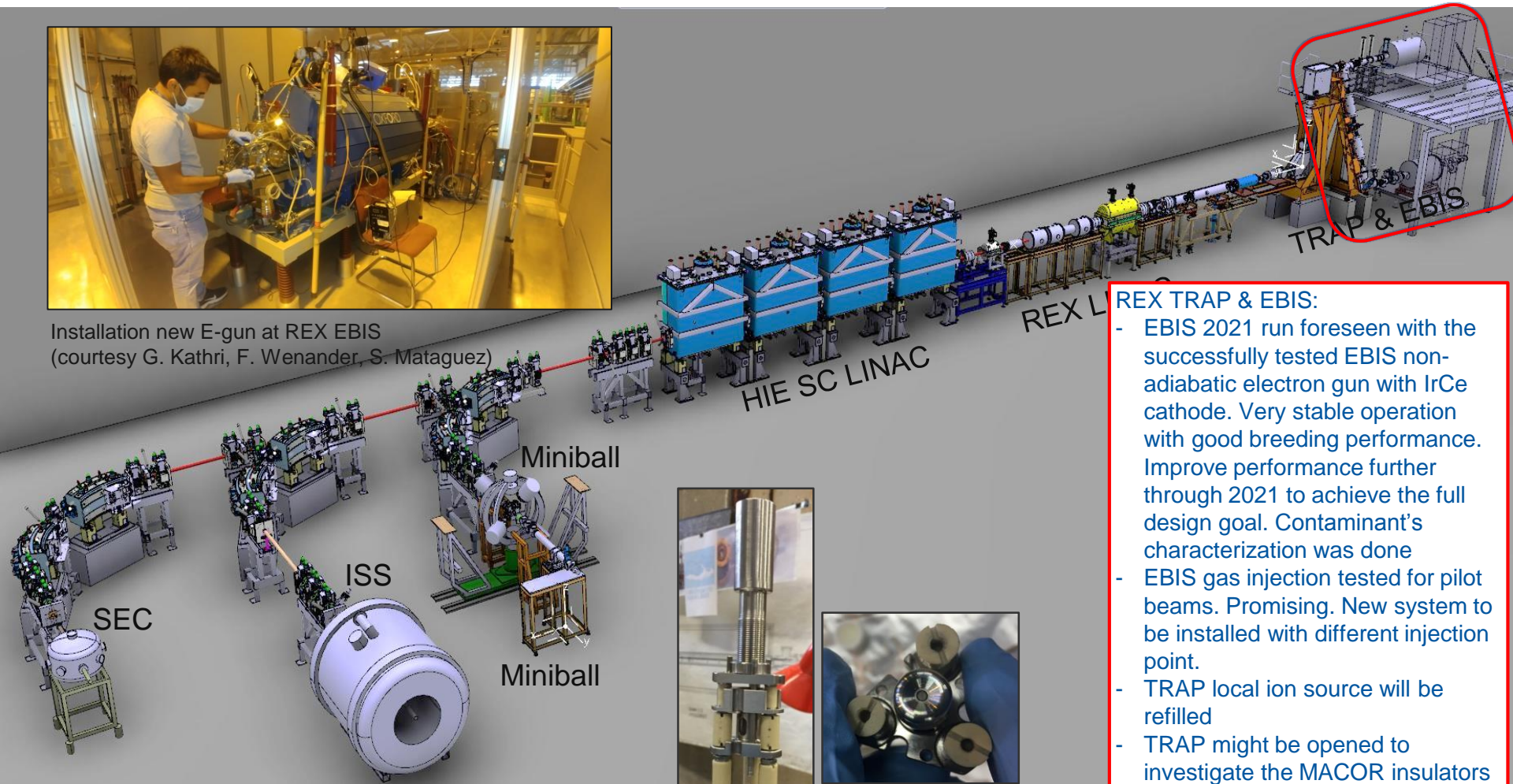
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Shutdown '20/'21 schedule: Status of REX/HIE activities:

All REX / HIE ISOLDE activities are on track



Installation new E-gun at REX EBIS
(courtesy G. Kathri, F. Wenander, S. Mataguez)



Installation new E-gun at REX EBIS
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REX TRAP & EBIS:

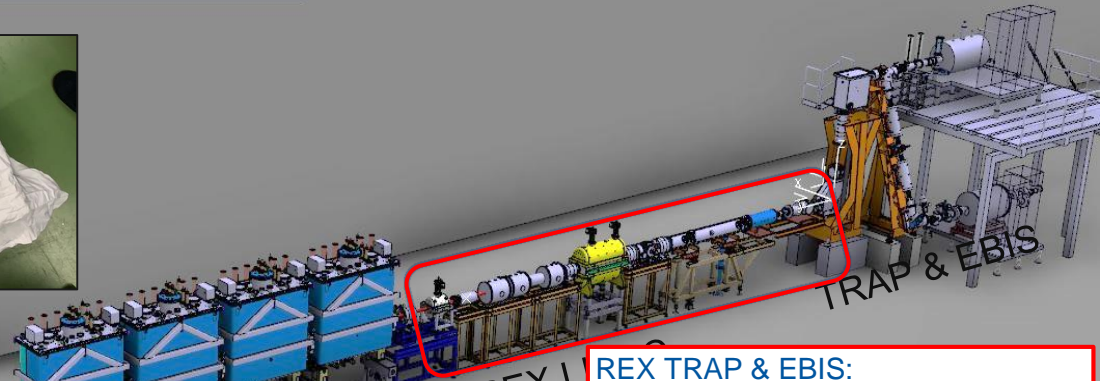
- EBIS 2021 run foreseen with the successfully tested EBIS non-adiabatic electron gun with IrCe cathode. Very stable operation with good breeding performance. Improve performance further through 2021 to achieve the full design goal. Contaminant's characterization was done
- EBIS gas injection tested for pilot beams. Promising. New system to be installed with different injection point.
- TRAP local ion source will be refilled
- TRAP might be opened to investigate the MACOR insulators between the trapping electrodes that might be causing the instabilities seen in 2020
- EBIS expected to be available by the end of Feb, TRAP at a later stage

Shutdown '20/'21 schedule: Status of REX/HIE activities:

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REX Linac 9Gap anodic capacitor repair
(courtesy C. Gagliardi)

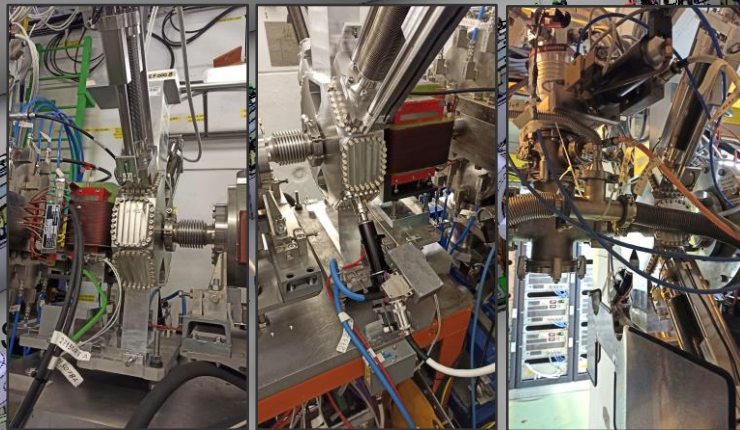


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REX NC LINAC:

- REX RF minimal 2021 maintenance, multiple new and refurbished components installed and tested in 2020.
- 9GAP amplifier anodic capacitor breakdown due to dielectric perforation resolved. Mechanical modifications carried out as well as new Kapton metallized dielectric installed improving reliability
- Buncher amplifier exchange for solid state end of '21
- IHS cooling water system tested and working well
- 9GAP cooling water system being modified
- 3 additional HIE ISOLDE type Diagnostic Boxes fully tested and commissioned
- REX vacuum maintenance all done in 2020



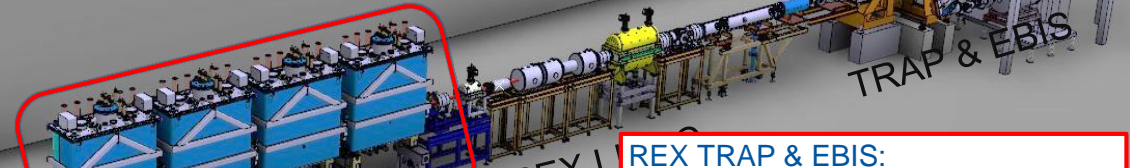
New Steerers and fully equipped Dboxes in the REX Linac
(courtesy W. Andreazza & BI team, J. Bauche & MSC team, S. Mataguez)

Shutdown '20/'21 schedule: Status of REX/HIE activities:

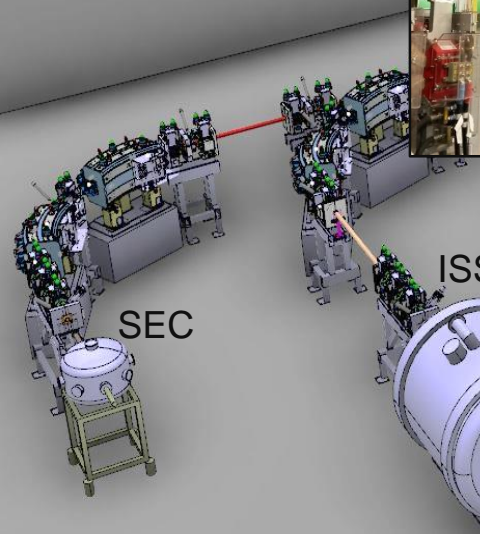
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CM4 during installation in Jan '20



TRAP & EBIS



SEC

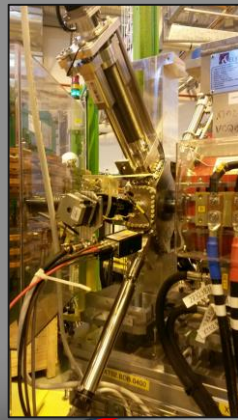
- HIE SC LINAC:**
- All CMs including the repaired CM4 (RF coupler cavity 3) were successfully recommissioned in '20
 - Optimization of the overall alignment of CMs and Linac elements will be carried out
 - CMs under static vacuum.
 - First year without CM transport, modifications or repair: On idle.
 - Cooldown as of 18 March

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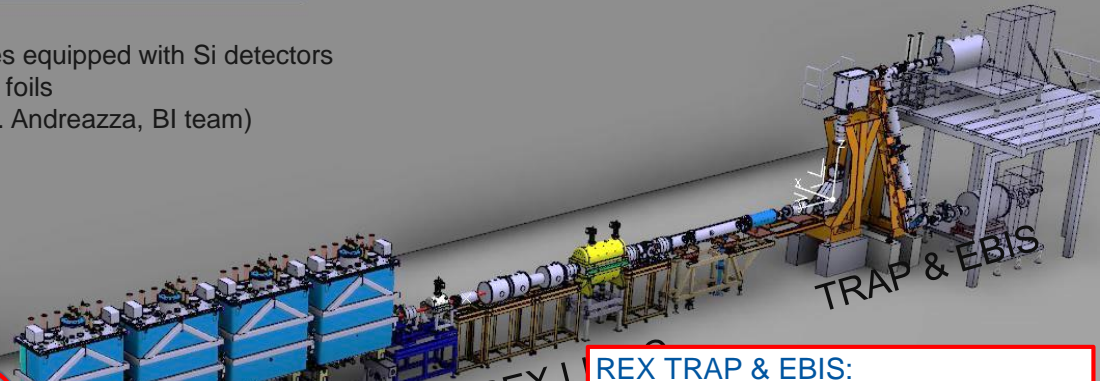
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Shutdown '20/'21 schedule: Status of REX/HIE activities:

All REX / HIE ISOLDE activities are on track



HEBT Dboxes equipped with Si detectors and stripping foils
(courtesy: W. Andreatza, BI team)



TRAP & EBIS

HEBT:

- Dboxes in all three lines equipped with Si detectors
 - All three lines foreseen to have stripping foils as well as two positions in the straight section (redundancy)
 - Optimization of the overall alignment of the HEBT elements will be carried out
- Experiments:
- WIZARD overhead crane renewed and heightened
 - ISS uninterrupted power being connected (chiller and compressor)
 - No MINIBALL this 2021 run..

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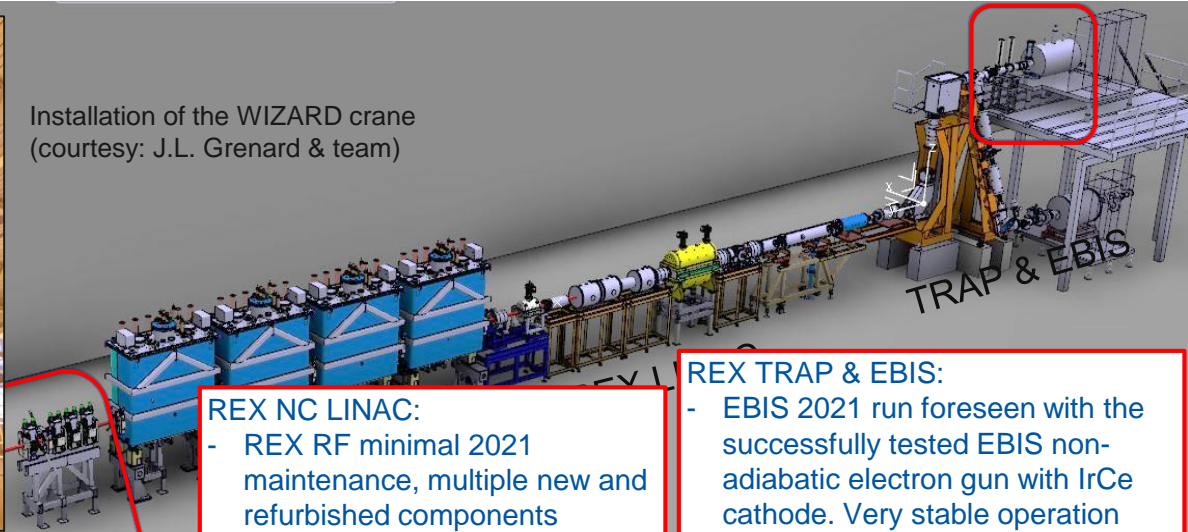
Miniball

Shutdown '20/'21 schedule: Status of REX/HIE activities:

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Installation of the WIZARD crane
(courtesy: J.L. Grenard & team)



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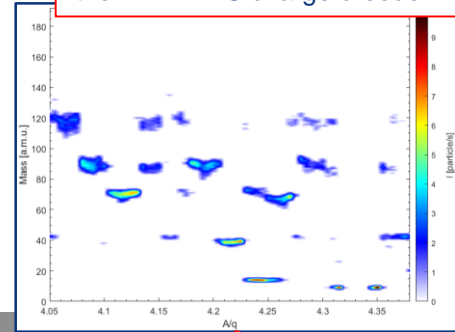
Highlights of the 2020 Beam Commissioning and Machine Studies :

(Courtesy: J.A. Rodriguez BE-OP-ISO)

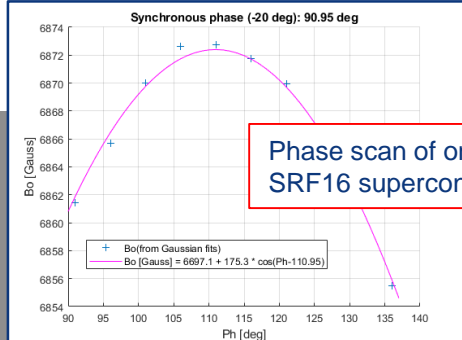
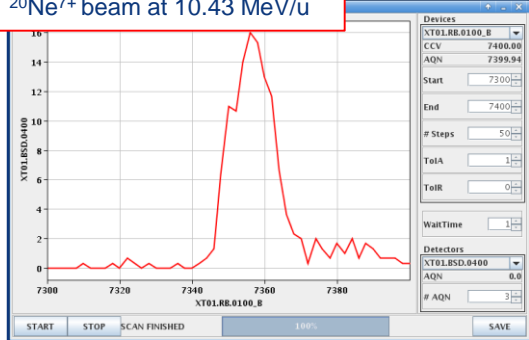


- Multiple beams accelerated to energies as high as 10.43 MeV/u
- Transverse and longitudinal phase space characterization for sub-femtoamp beams
- Characterization of the residual gas contamination from the REX-EBIS charge breeder
- New phasing procedure developed and validated
- Beam-based electric field calibration for the superconducting cavities

Residual gas mass spectrum of the REX-EBIS charge breeder



Energy measurement for a $^{20}\text{Ne}^{7+}$ beam at 10.43 MeV/u

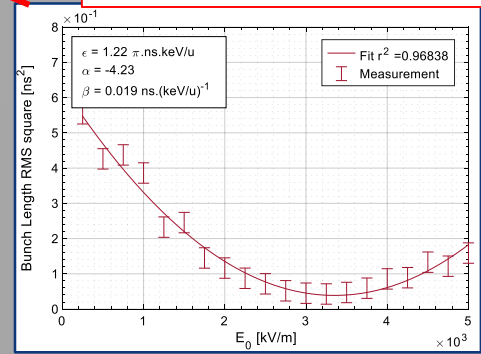


Phase scan of one of the SRF16 superconducting cavity

REX NC linac

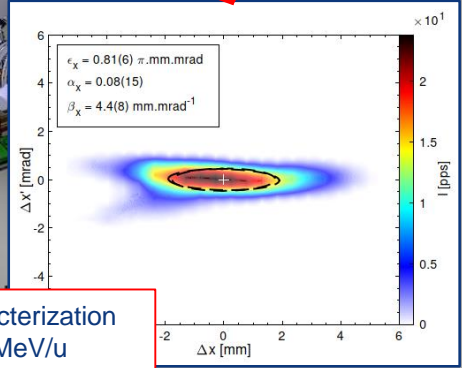
HIE SC linac

Longitudinal phase space characterization of a ^{20}Ne beam at 6.54 MeV/u measuring the bunch length for different gradients in an SRF cavity



SEC

Transverse phase space characterization of a $\sim 1 \text{ fA}$ $^{39}\text{K}^{10+}$ beam at 3.82 MeV/u



2021 REX/HIE-ISOLDE Beam Commissioning and Machine Studies (end-April – mid-July):



(Courtesy: J.A. Rodriguez BE-OP-ISO)

Commissioning of new software:

- Slow extraction application for EBIS (wk. 17)
- A/q scan application (wk. 18)
- Silicon detectors (oscilloscope, energy histogram, ToF) (wk. 19)
- Semiautomatic phasing application (wk. 21-22)
- Beam optimizer (using stable to the experiments) (wk. 28)

Commissioning of new hardware:

- External gas injection system at EBIS (wk. 16)
- Stripping foils in the HEBT lines (wk. 26)

Beam commissioning of existing hardware:

- Beam instrumentation (wk. 20, 23)
- REX and SRF cavities (wk. 21-22)
- Power converters and magnetic elements (wk. 19-20)
- REX-EBIS contaminants characterization (wk. 19)

Preparation of machine set-ups and documentation :

- $^{20}\text{Ne}^{7+}$ - A/q = 2.857 (wk. 20-22)
- $^{40}\text{Ar}^{9+}$ - A/q = 4.444 (wk. 24)
- $^{40}\text{Ar}^{10+}$ - A/q = 4.0 (wk. 25)
- $^{14}\text{N}^{7+}$ - A/q = 2.0 (wk. 26)

2021 REX/HIE-ISOLDE Commissioning and Machine Studies

Week 16-19 (April 19th – May 11th):

- Commissioning of the new slow-extraction application
- Commissioning of the new A/q scan application
- REX-EBIS contaminants characterization
- Commissioning of external gas injection system
- Commissioning of the new Silicon detector applications

Week 19-20 (May 12th – May 21th):

- Beam ($^{20}\text{Ne}^{7+}$ at 0.3 MeV/u) to the end of XT01
- Beam commissioning of diagnostic boxes and control software
- Beam energy measurement
- RFQ calibration
- Stability of the SRF cavities (evenings and nights). Determination of maximum operating gradients

Week 21 (May 23rd – May 28th):

- Commissioning of the new automatic phasing application
- Phasing of REX cavities ($^{20}\text{Ne}^{7+}$ at 2.85 MeV/u)
- Documentation for each intermediate energy set-up
- Stability of the SRF cavities (evenings and nights). Determination of maximum operating gradients

Week 22 (May 31st – June 4th):

- Commissioning of the new automatic phasing application
- Phasing of the SRF cavities ($^{20}\text{Ne}^{7+}$)
- Documentation for each intermediate energy set-up
- Stability of the SRF cavities (evenings and nights). Determination of maximum operating gradients

Week 23 (June 7th – June 11th):

- Beam ($^{20}\text{Ne}^{7+}$ at 0.3 MeV/u) to the end of XT02 and XT03
- Beam commissioning of diagnostic boxes and control software
- Beam energy measurements using silicon detectors in XT02 and XT03
- Beam from the GPS target to the end of the HEBT lines fully accelerated
- Stability of the SRF cavities (evenings and nights). Determination of maximum operating gradients

Week 24 (June 14th – June 18th):

- Phasing of REX cavities ($^{40}\text{Ar}^{9+}$ at 2.85 MeV/u) using external gas injection
- Phasing of SRF cavities
- Documentation for each intermediate energy set-up to the end of XT01, XT02 and XT03

Week 25 (June 21st – June 25th):

- Phasing of REX cavities ($^{40}\text{Ar}^{10+}$ at 2.85 MeV/u)
- Phasing of SRF cavities ($^{40}\text{Ar}^{10+}$)
- Documentation for each intermediate energy set-up to the end of XT01, XT02 and XT03

Week 26 (June 28th – July 2nd):

- Stability of the machine at very low A/q
- Phasing of REX cavities ($^{14}\text{N}^{7+}$ at 2.85 MeV/u)

- Phasing of SRF
- Commissioning
- Documentation

Week 27 (July 5th – July 12th):

- Preparation and delivery of the beam to the ISS

Week 28 – Start of Physics (from July 12th until start of Physics):

- Commissioning of the beam optimizer (injection into ISS)
- Development and testing of train extraction from the REX-EBIS charge breeder
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- Beam-based energy gain calibration for each of the superconducting cavities (particularly the ones in CM3)
- Determination of the correction factors to the RF-based calibration of the field
- Development and commissioning of a procedure to stretch/contract the bunch length at the experimental stations using one or more superconducting cavities as buncher/debuncher
- Development of the slit-based methods to reduce the transverse and longitudinal emittance of the beam minimizing the beam losses
- Validation of optics model for the superconducting cavities

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Conclusions and final remarks:



- Despite the severe impact of COVID-19 all crucial hardware tests as well as recommissioning of the REX/HIE ISOLDE facility were successfully carried out during 2020. The HIE ISOLDE Cryo Modules' cooldown and recommissioning (repaired CM4) went according to the revised plan. Beam Commissioning and numerous Machine Studies were realized using stable beam from REX and GPS (FE10). Many issues have been resolved and the machine is believed to be in a good state for a smooth 2021 start-up.
- All REX/HIE shutdown activities are on schedule with hardware tests starting as of 8th Feb
- A detailed Beam Commissioning and Machine Studies plan is in place (end-April – mid-July)
- REX/HIE RIB Physics foreseen from the end-July to the 15th Nov
(with stable beam as of 7th July + after 15th Nov: long lived & stable beam until mid-Dec)
- Request for the '21-'22 shutdown (YETS):
Keep the Cryo plant running over the CERN annual closure - no Cryo winter stop- to profit fully from the protons returning early in January 2022 for LHC.
Warming up and cooling down the HIE SC Linac would mean no HIE Physics before July 2022 whereas keeping the CMs cold could mean HIE Physics as of day one when protons are back.
Gain: 1) 4-5 months extra HIE ISOLDE physics and 2) not having to allocate the necessary Cryo and RF resources for the recommissioning phase.
Constraints: 1) Obligated yearly stop of the cooling water plants for legionella and maintenance, 2) costs of Cryo operations over the winter stop (sail on LHC support?) and perhaps 3) the maintenance interval of the Cryo Compressor station gearbox (~ 10khrs).

Keeping the Cryo plant running over the '20-'21 shutdown period was not granted by the CERN RB this year but as stated by Frederick Bordry (former Director of Accelerators and Technology Sector) in his reply: 'We could discuss the possibility for the 2021-2022 CERN closure, knowing that the LHC will be maintained with LHe'.

