EUROPEAN
SPALLATION
SOURCE

Status of the ESS Project

PRESENTED BY NATALIA MILAS

2021-07-12

Outline

- Status of the Project
- Normal Conducting Linac:
  - Ion Source and LEBT Commissioning (2018-2019)
  - RFQ Conditioning (2021)
  - MEBT and DTL Schedule
- Infrastructure and support systems
- Superconducting Linac
- ESS Linac upgrade (ESSnuSB)

Status of the Project

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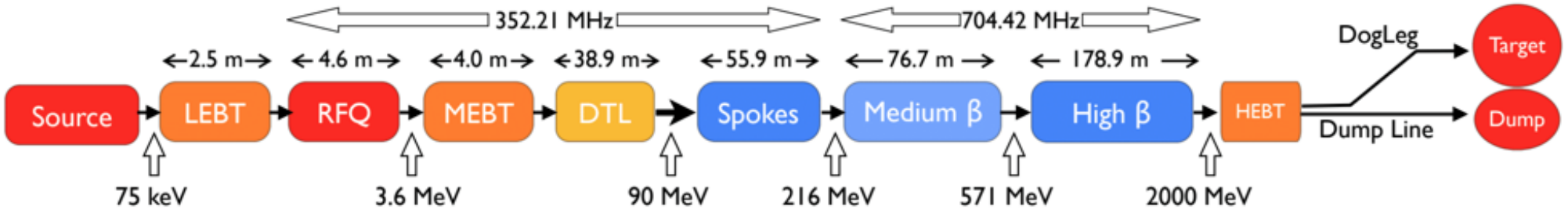
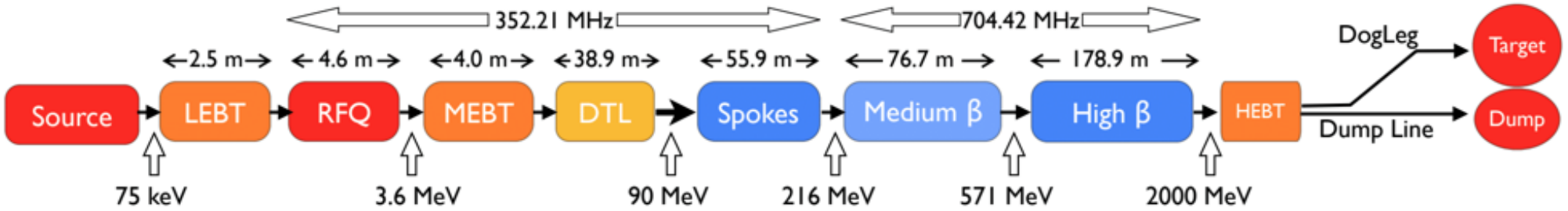


	Length	No. Magnet	#Cav x $\beta_{g/(Opt)}$	No. Sections	Power (kW)	IK partner
LEBT (from Plasma)	2.7	2 Solenoids	—	1	—	INFN-LNS
RFQ	4.5	—	1	1	1600	CEA Saclay
MEBT	4.0	11 Quads	3	1	15	ESS-Bilbao
DTL	38.9		5	5	2200	INFN-LNL
LEDP + Spoke	55.9	26 Quads	26 x (0.50)	13	330	IPNO
Medium Beta	76.7	18 Quads	36 x 0.67	9	870	LASA / CEA
High Beta I (~1.3 GeV)	93.7	22 Quads	44 x 0.86	11	1100	STFC / CEA
High Beta II	85.2	20 Quads	40 x 0.86	10	1100	STFC / CEA
Contingency + HEDP	132.3	32 Quads	—	15	—	Elettra
DogLeg	64.4	12 Quads + 2	—	1	—	Elettra
A2T	44.7	6 Quads + 8 Raster	—	1		Aarhus Uni
	603.0					

Status of the Project

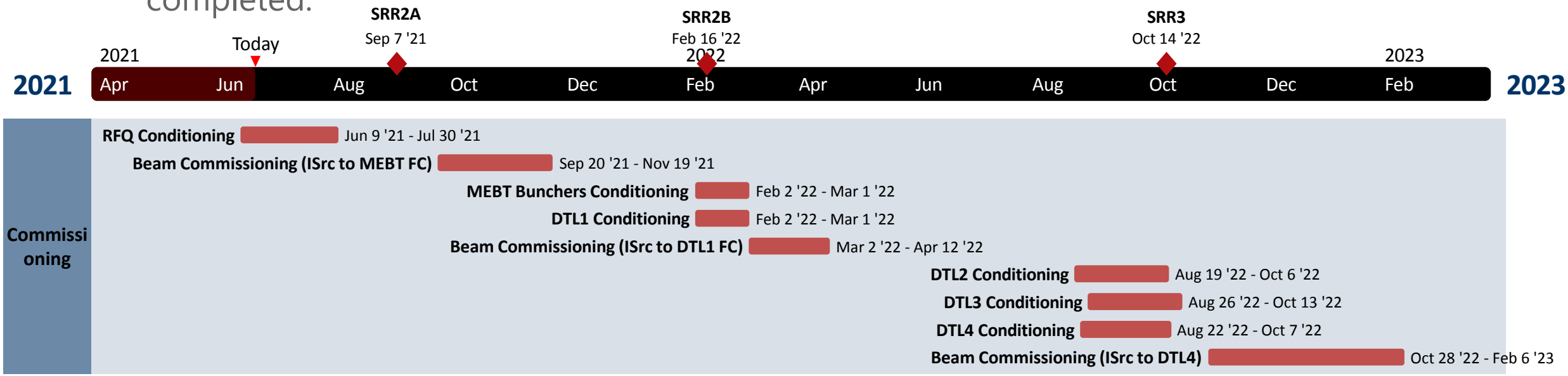


Parameter	Baseline	Design	Unit
Average Power	2	5	MW
Final Energy	0.8	2.0	GeV
Peak Current	62.5	62.5	mA
Pulse Length	2.86	2.86	ms
Repetition Rate	14	14	Hz
Duty Cycle	4%	4%	-

Status of the Project

NCL and beyond

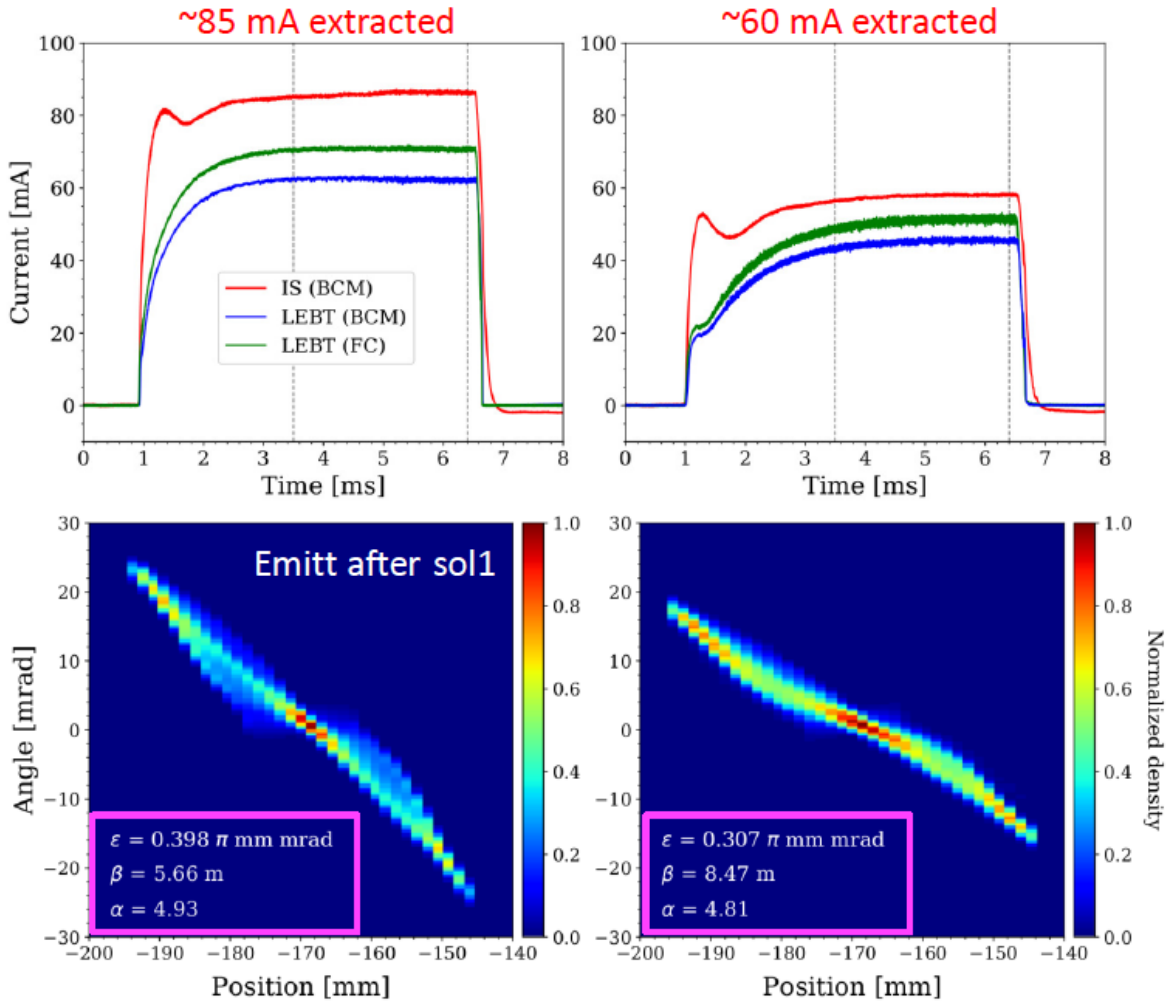
- NCL installation in ongoing at the moment. Next steps is the DTLs installations.
- Cryo distribution line for MB and HB is done. Spokes underway.
- TS2 and Freya as measuring the Elliptical cavities cavities and Spokes
- Cryo plant, LWU and PRL all installed and tested. RF distribution line is also completed.



Normal Conducting Linac

Ion Source and LEBT Commissioning (2018-2019)

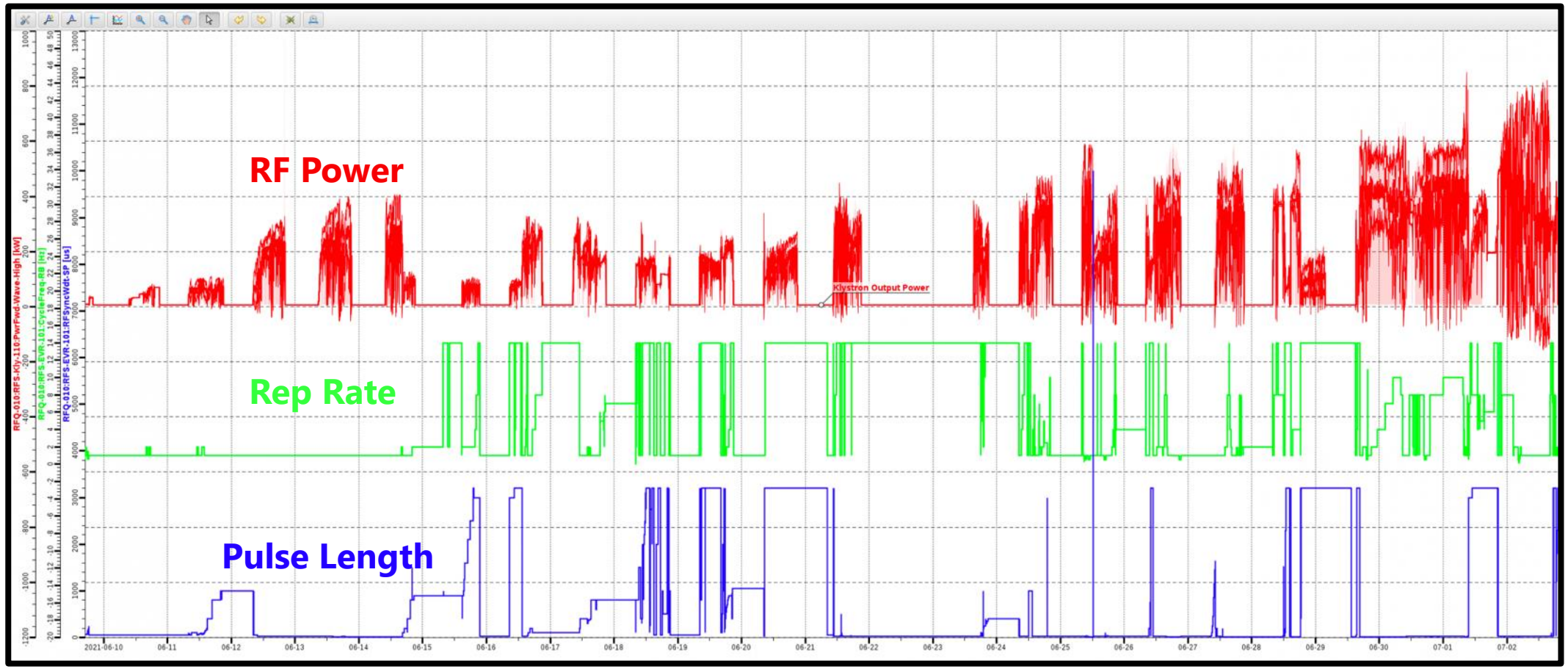
- Source and LEBT were commissioning between 2018 and 2019
- Source proved to be very flexible.
- We suspect the beam is coming out with a larger divergence than expected from simulations (still to be verified)
- Emittance is a bit higher than the design as well.
- Still some equipment left to be tested a commissioning at this next round (2021): iris and new chopper.



Normal Conducting Linac

RFQ Conditioning 2021

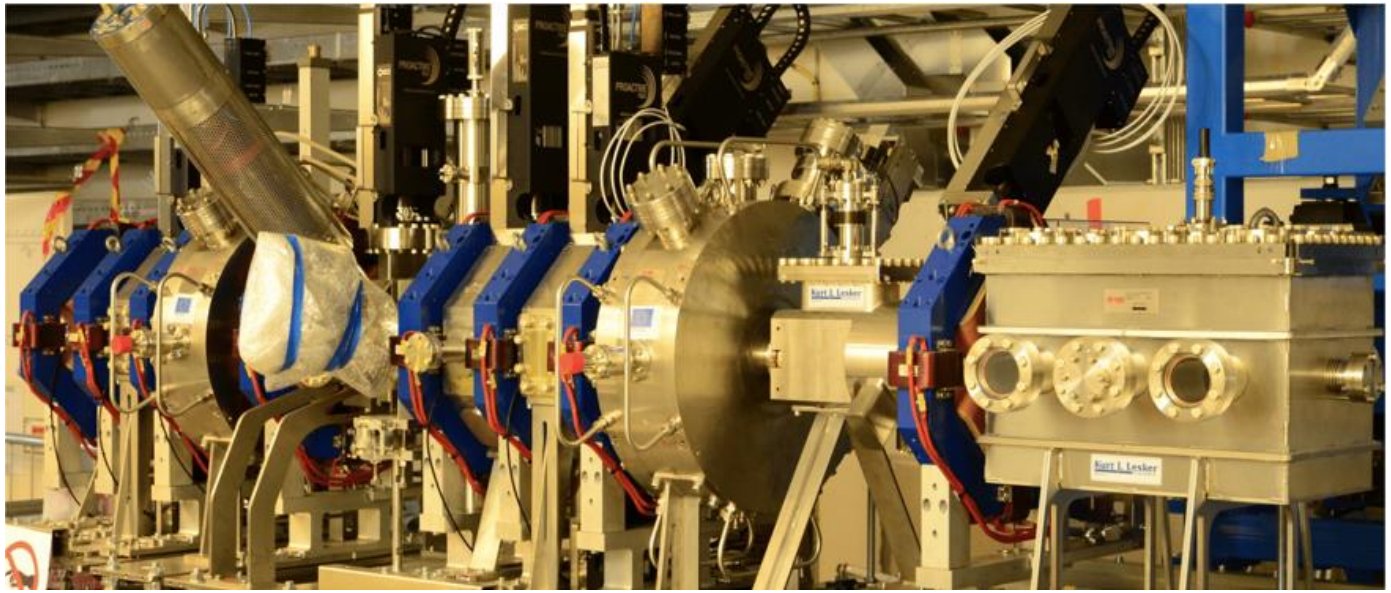
Reached 680kW peak power at 14Hz, 3.2ms, and 800kW at 1 Hz, 25 us.

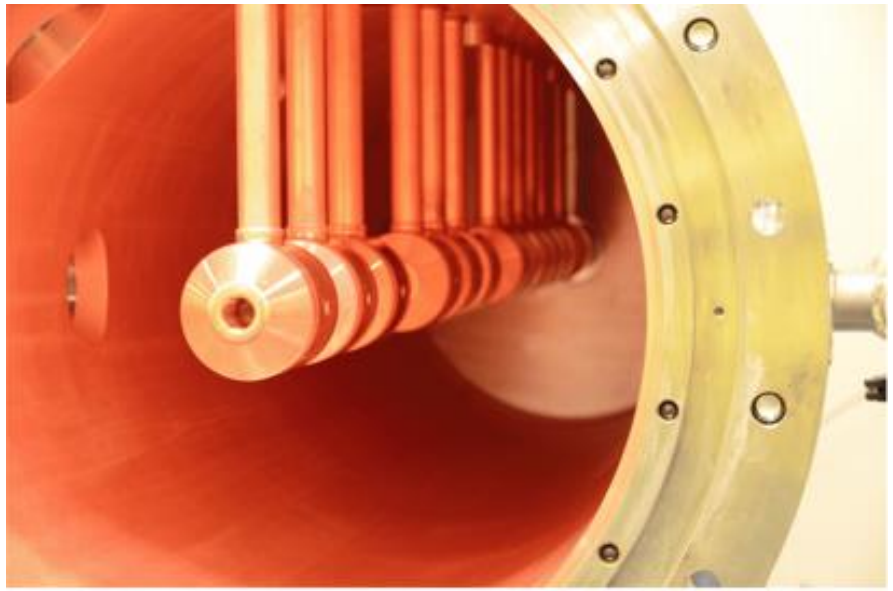


Normal Conducting Linac

MEBT and DTL plans

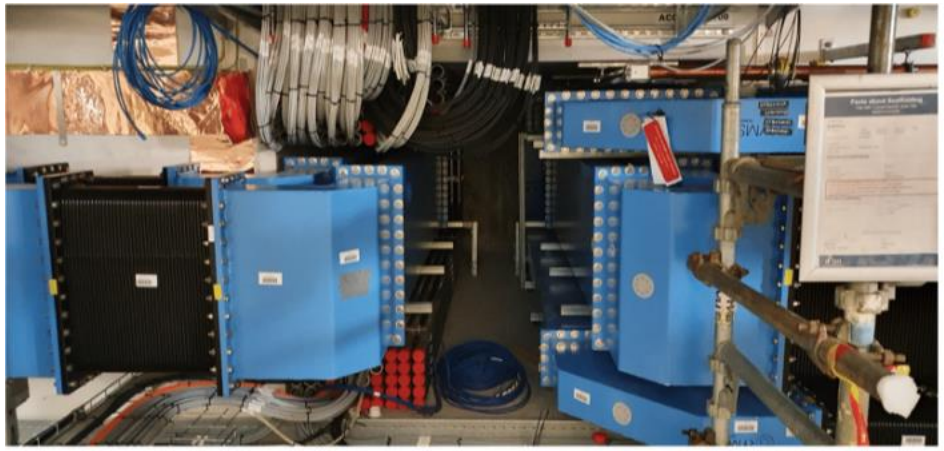
- Next commissioning round will include just the RFQ and partially the MEBT.
- DTL tanks installation will start this year (2021).
- MEBT is installed. RF power for the buncher cavities is the one piece still missing.





Infra and Support

RF Distribution Line



NCL RFDS, Tunnel

NCL RFDS, Gallery

SCL RFDS, Tunnel

SCL RFDS, Gallery

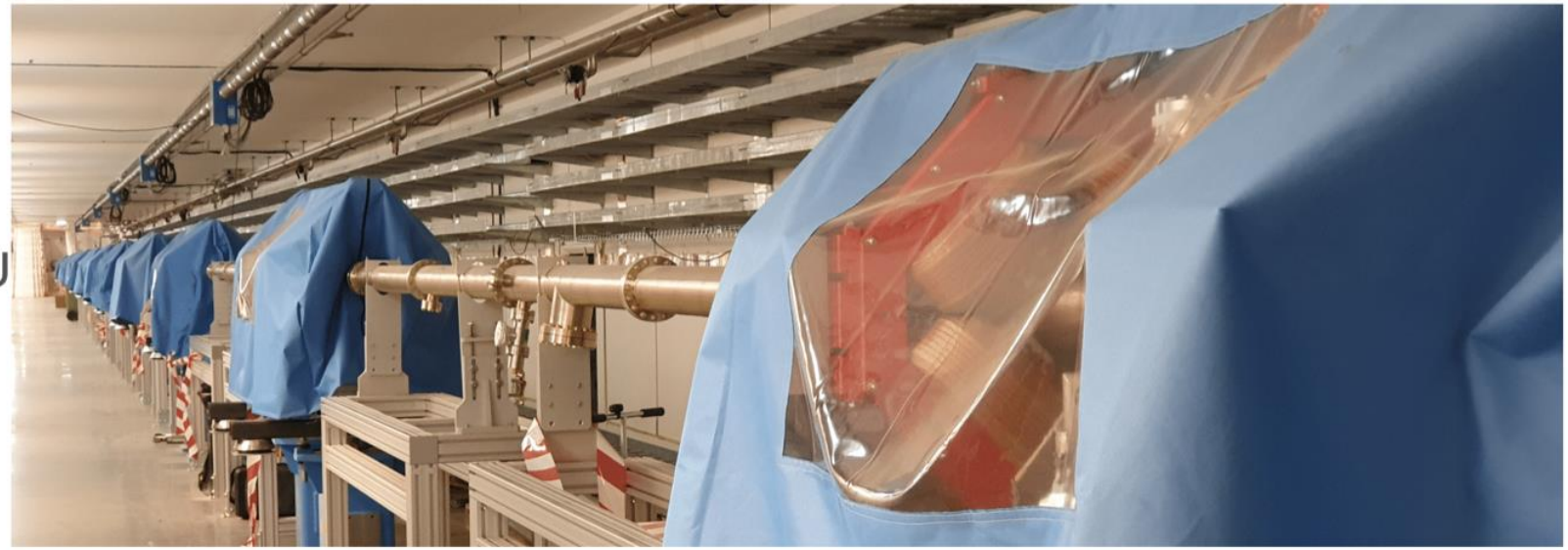
Infra and Support

Cryo Distribution System, Phase Reference Lina and Linac Warm Units

CDS

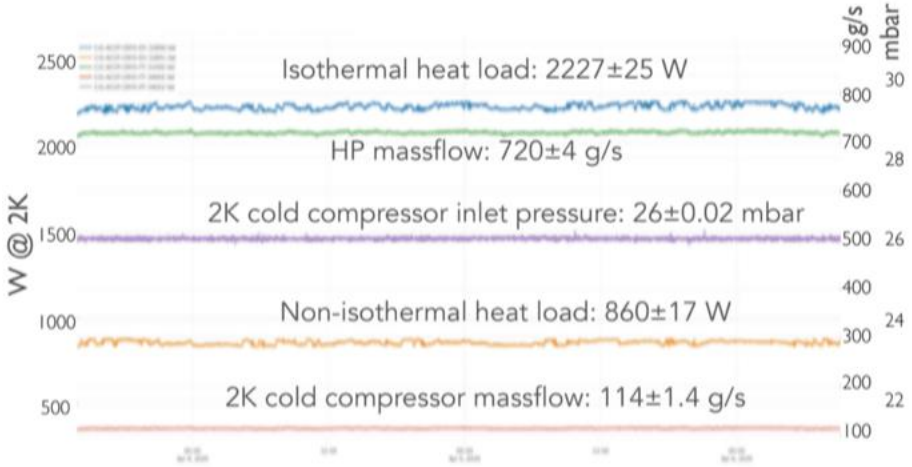
PRL

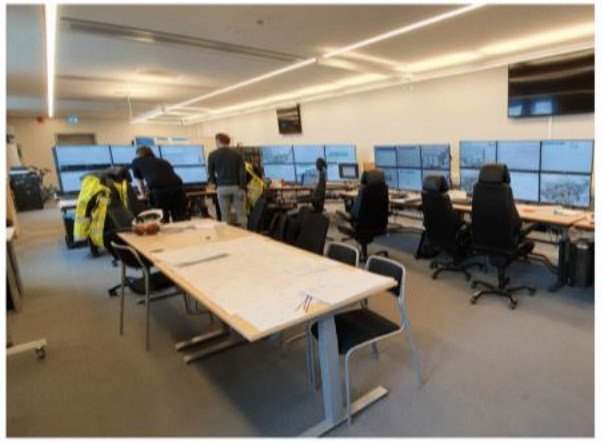
LWU



Infra and Support

Cryo Plant



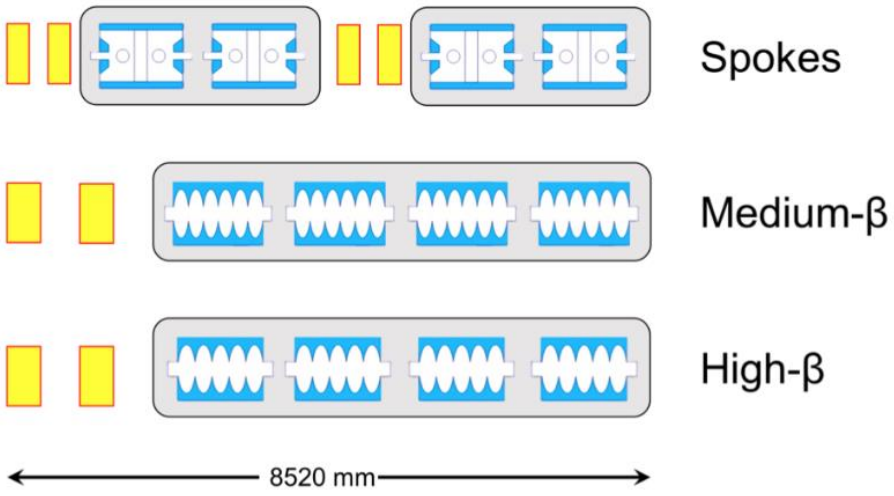


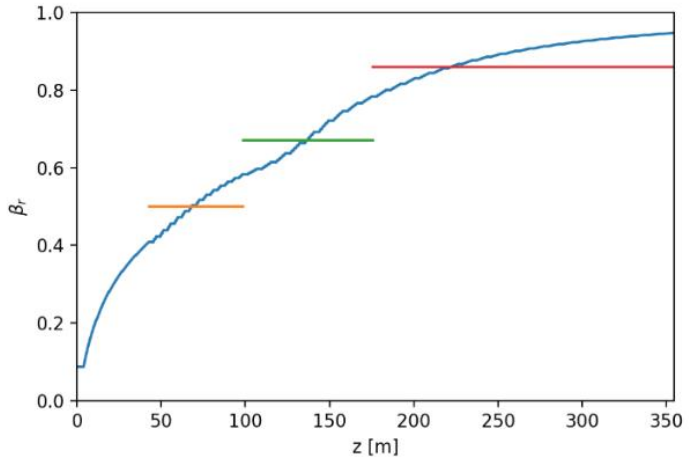
Courtesy: Philipp Arnold

Super Conducting Linac

Spokes, Medium and High Beta Cavities

- Cavity parameters:
  - Spokes: 2 cavities per cryostat, 13 cryostats in total, max. gradient 9MV/m. Built by IPNO Orsay
  - Medium Beta Ellipticals: 6-cells cavities, 4 per cryostat and 9 cryostats in total. Max gradient is 16 MV/m. Built by CEA.
  - High Beta Ellipticals: 5-cells cavities, 4 per cryostat and 21 cryostats in total. Max gradient is 20 MV/m. Built by CEA.





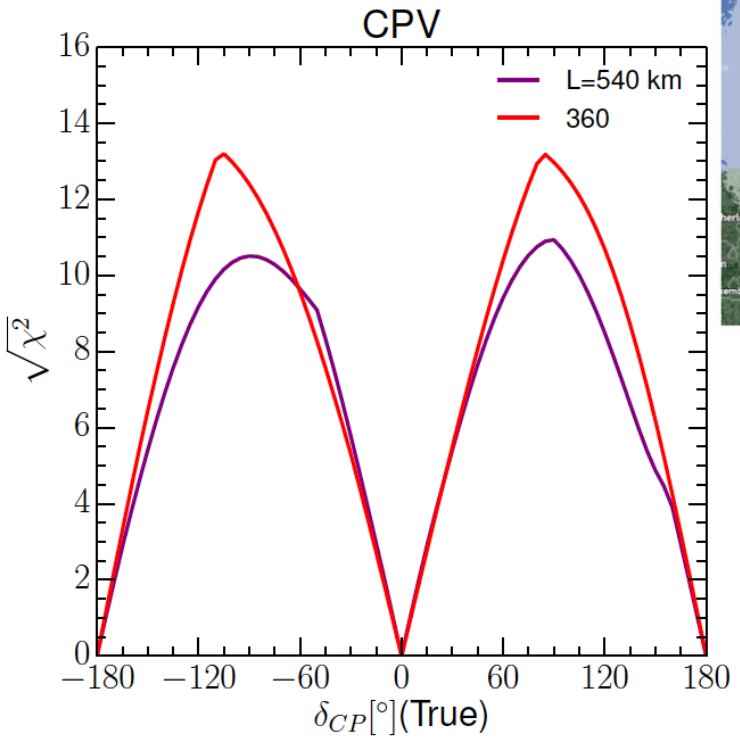
Super Conducting Linac

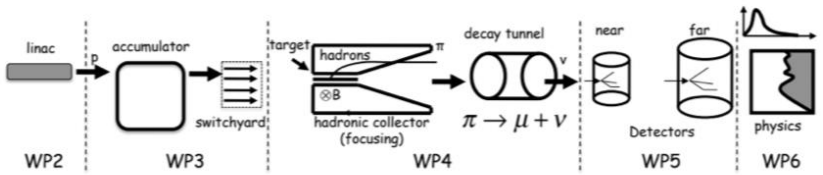
Test Stands

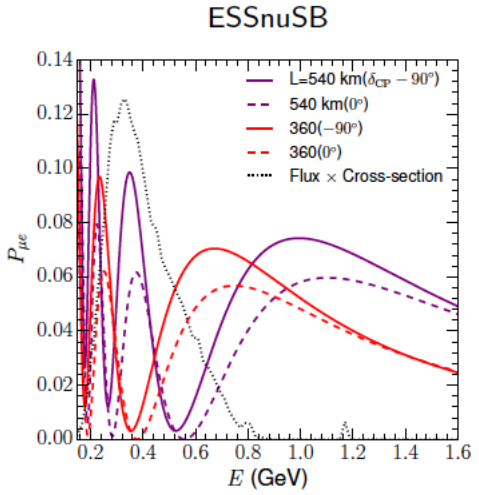
- Spokes cryomodules are to be tested in Uppsala at Freia Lab (right)
- Elliptical (medium and high beta) cryomodules are being tested at ESS (below)

ESS Upgrade: ESSnuSB

Neutrino facility for observation of CP violation







ESSNuSB: Unique to probe second oscillation maximum

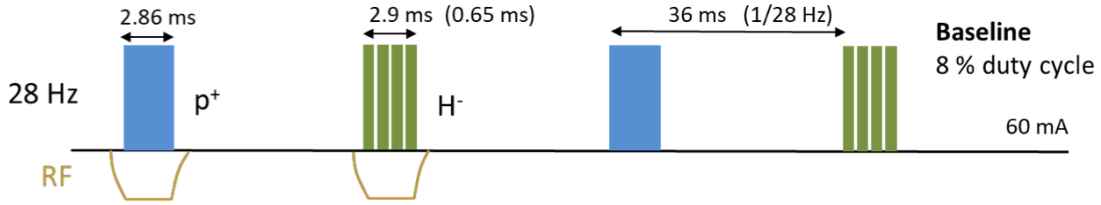
Courtesy: M. Eshraqi and M. Ghosh

ESS Upgrade: ESSnuSB

H⁻ Source and Stripping issues

Table 1: Beam parameters for ESS linac in standard mode and for the upgrade

Parameter	ESS	*Upgrade*	Upgrade
Ion	p	*p + H⁻*	p + H⁻
Average beam power	5 MW	*10 MW*	10 MW
Kinetic energy	2 GeV	*2 GeV*	2.5 GeV
Macro pulse current	62.5 mA	*62.5 mA*	30-60 mA
Macro pulse length	2.86 ms	*>2.9 ms*	>2.9 ms
Subpulse length	N/A	*~0.72 ms*	~0.72 ms
Pulse repetition rate	14 Hz	*28 Hz*	28 Hz
Beam Duty cycle	4%	*8 %*	8 %
Linac length	352.5 m	*352.5 m*	352.5 + ca 70 m



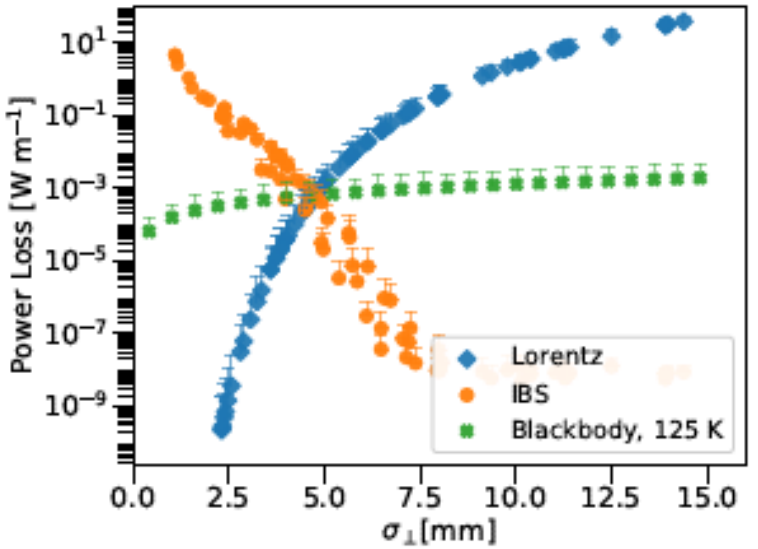


FIG. 8. Dependence of blackbody, IBSt and Lorentz stripping (quadrupoles only) on average transverse beam size $\sigma_\perp$ for a 2.5 GeV beam traversing a FODO lattice (6 m × 20 cells) of one quadrupole pair and one bunching gap per cell. Beam parameters are determined by setting phase advance and solving for optimum inputs. A range of 1–90° phase advance runs gives the resulting range of beam sizes. Blackbody stripping is simulated separately, assuming a constant $\sigma_\perp$ for each point.

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https://arxiv.org/abs/2103.16195

Courtesy: B.T. Folsom, M. Eshraqi and N. Blaskovic Kraljevic

Thank you!

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