THE ESS LINAC AS THE DRIVER FOR ESSNUSB

Mamad Eshraqi for ESSnuSB

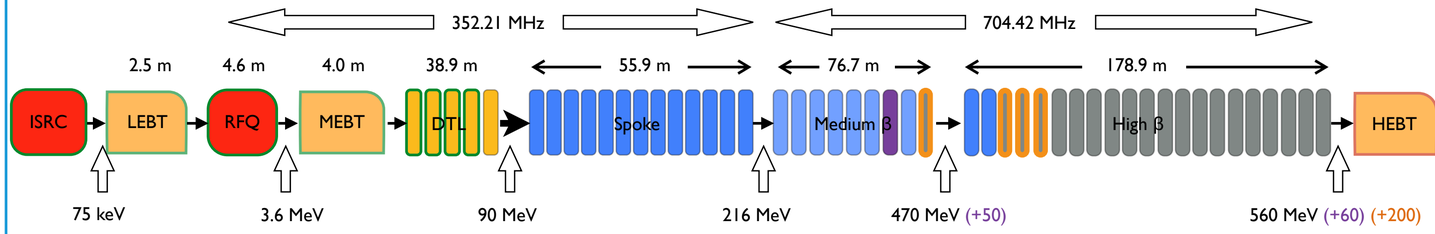
Beam physics section leader / Accelerator Division / ESS

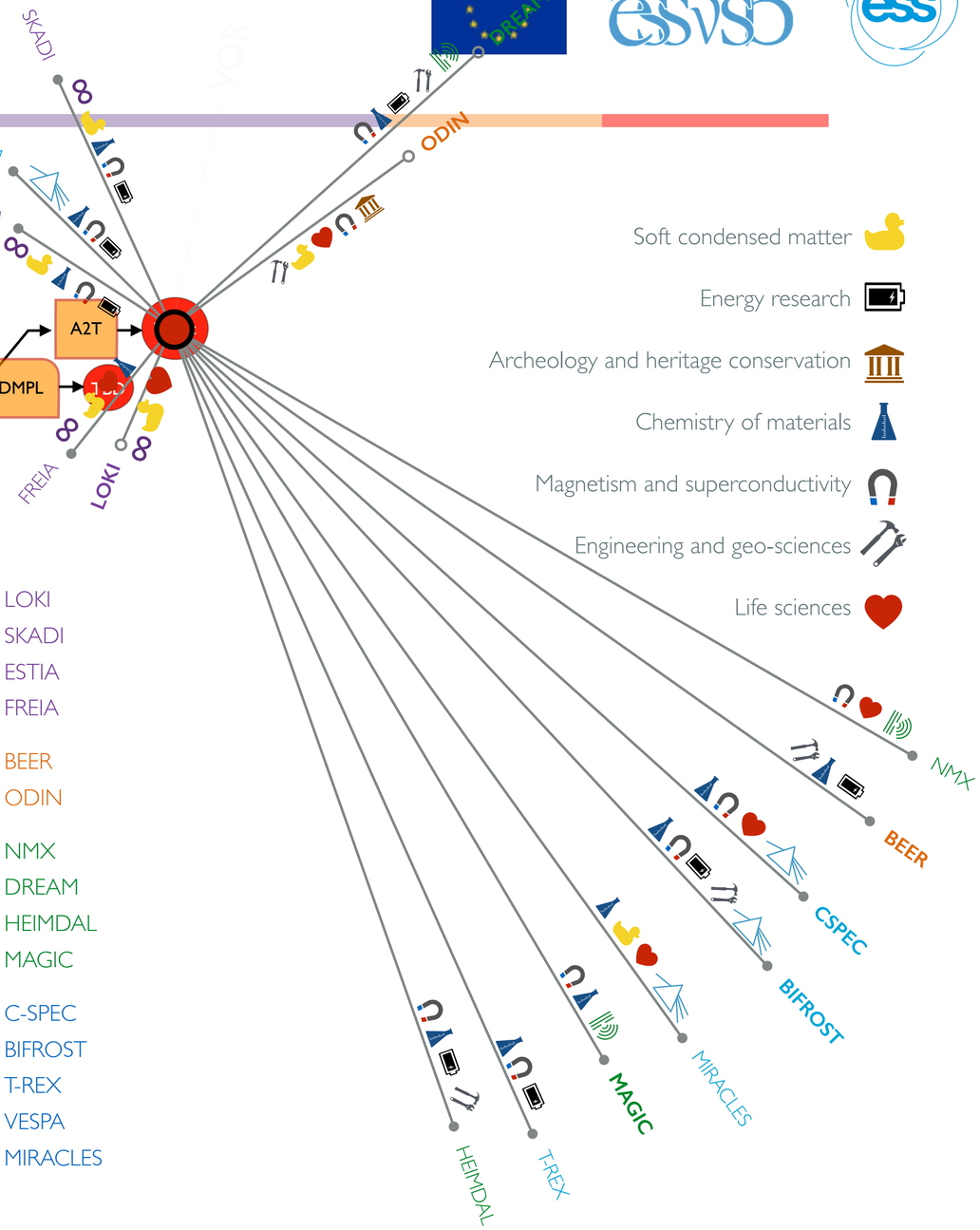
ESS

2022 Feb 22

ESS

Most of it in one slide





Linac

Energy	2.0 GeV
Current	62.5 mA
Repetition rate	14 Hz
Pulse length	2.86 ms
Losses	<1W/m
Ions	p

Flexible/Upgradable design

Minimize energy consumption

Controls

Control variables.	~1.6E6 PVs

MPS and PSS

EPICS7

µTCA.4

Rotating tungsten target

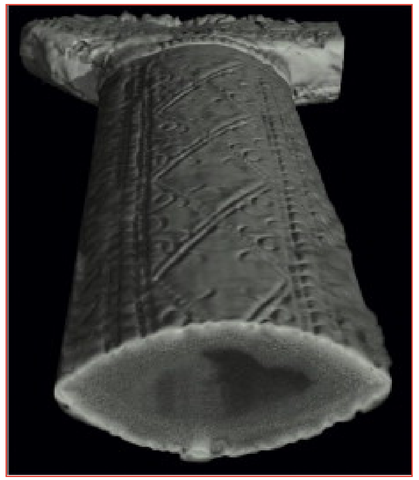
Target diameter	2.6 (0.45) m
Mass	11 (3) tons
	36 sectors
Rev. freq.	~0.4 Hz
Expected lifetime	5 years
Cooling	He gas
Beam ports	42
Peak flux	~30-100 x ILL
Cold moderator	Liquid H_2
	17 K
	30 mm
Thermal moderator	H_2O
	300 K
	30 mm

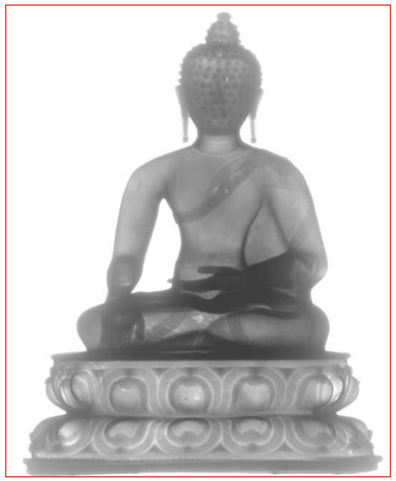
Instruments

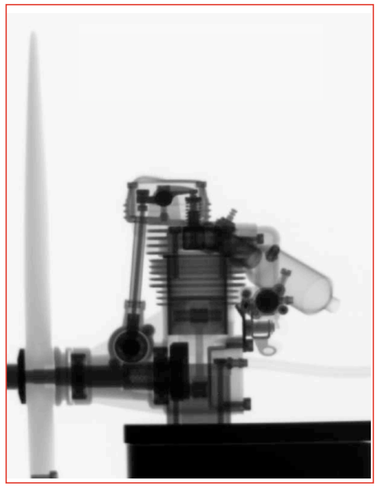
∞ Large Scale Structures	LOKI
	SKADI
	ESTIA
	FREIA
Engineering	BEER
	ODIN
Diffraction	NMX
	DREAM
	HEIMDAL
	MAGIC
Spectroscopy	C-SPEC
	BIFROST
	T-REX
	VESPA
	MIRACLES

Photons vs. Neutrons

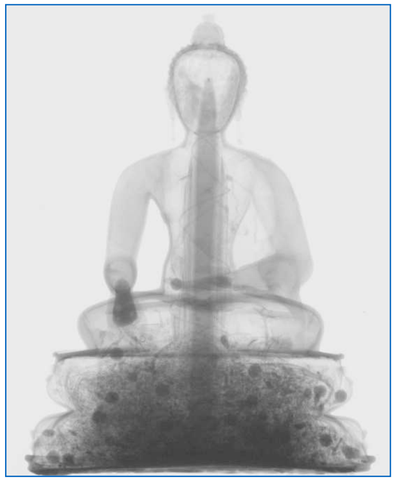
X-rays

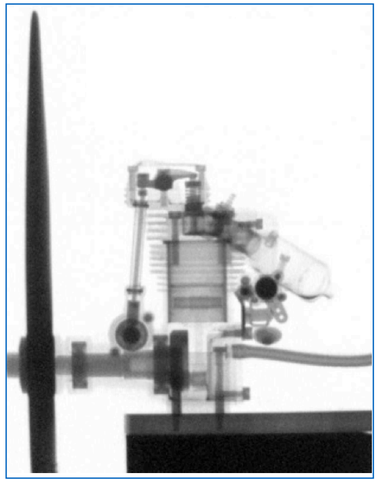






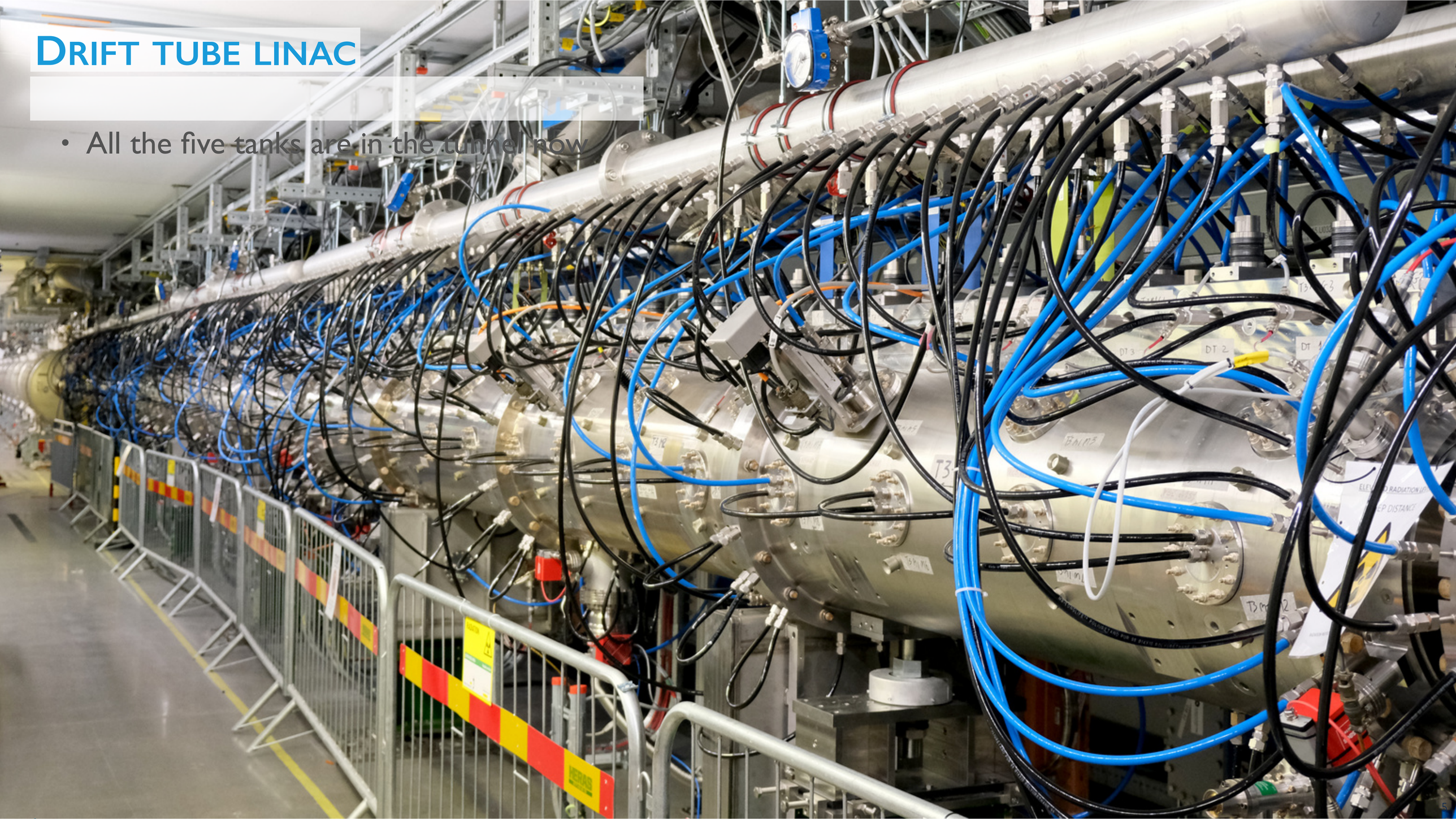
Neutrons





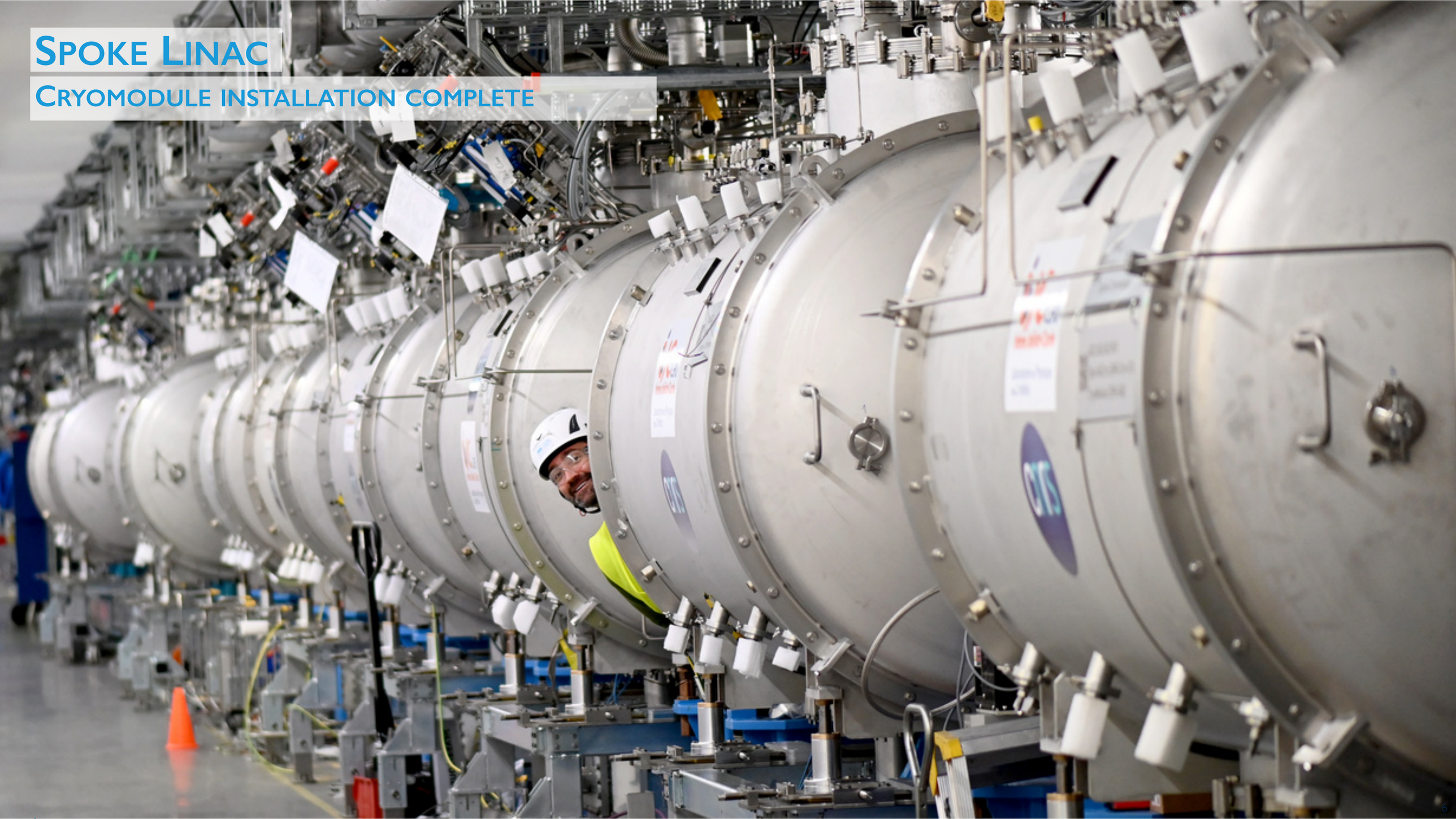
DRIFT TUBE LINAC

- All the five tanks are in the tunnel now



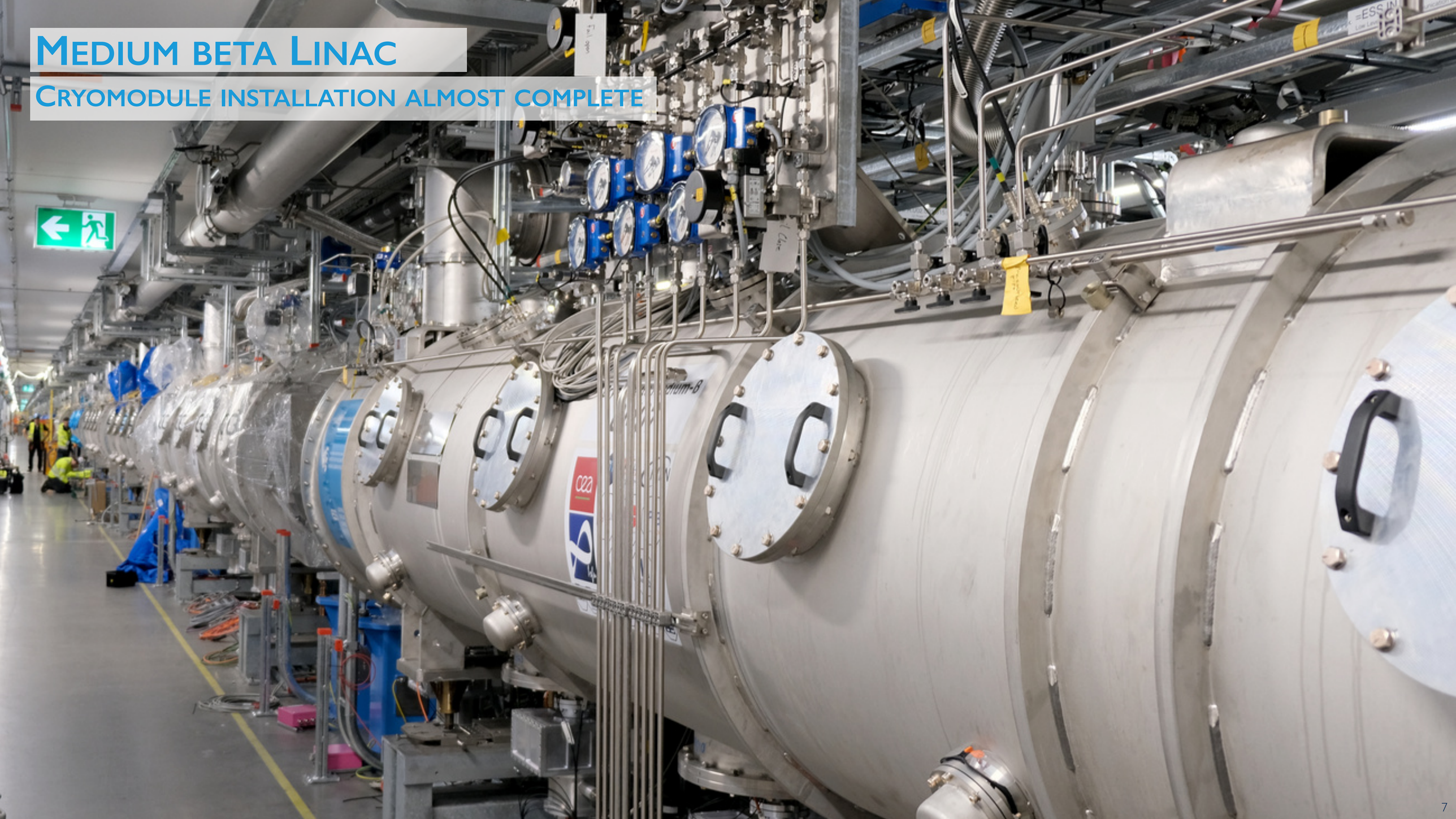
Spoke Linac

Cryomodule installation complete



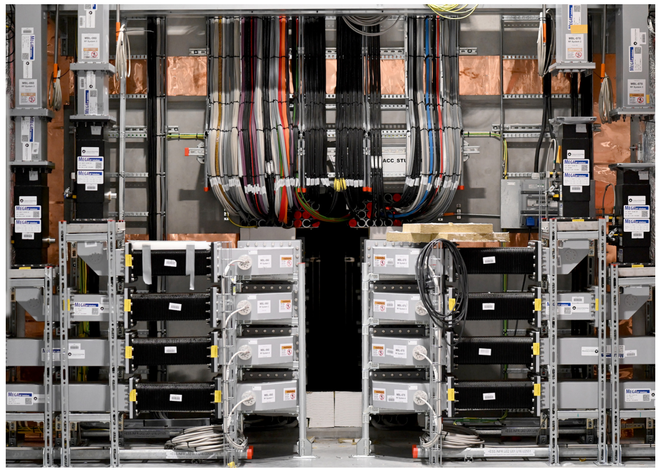
Medium beta Linac

Cryomodule installation almost complete



KLYSTRON GALLERY

- High voltage moderators, RF, RFDS and Controls



TARGET, INSTRUMENT HALL

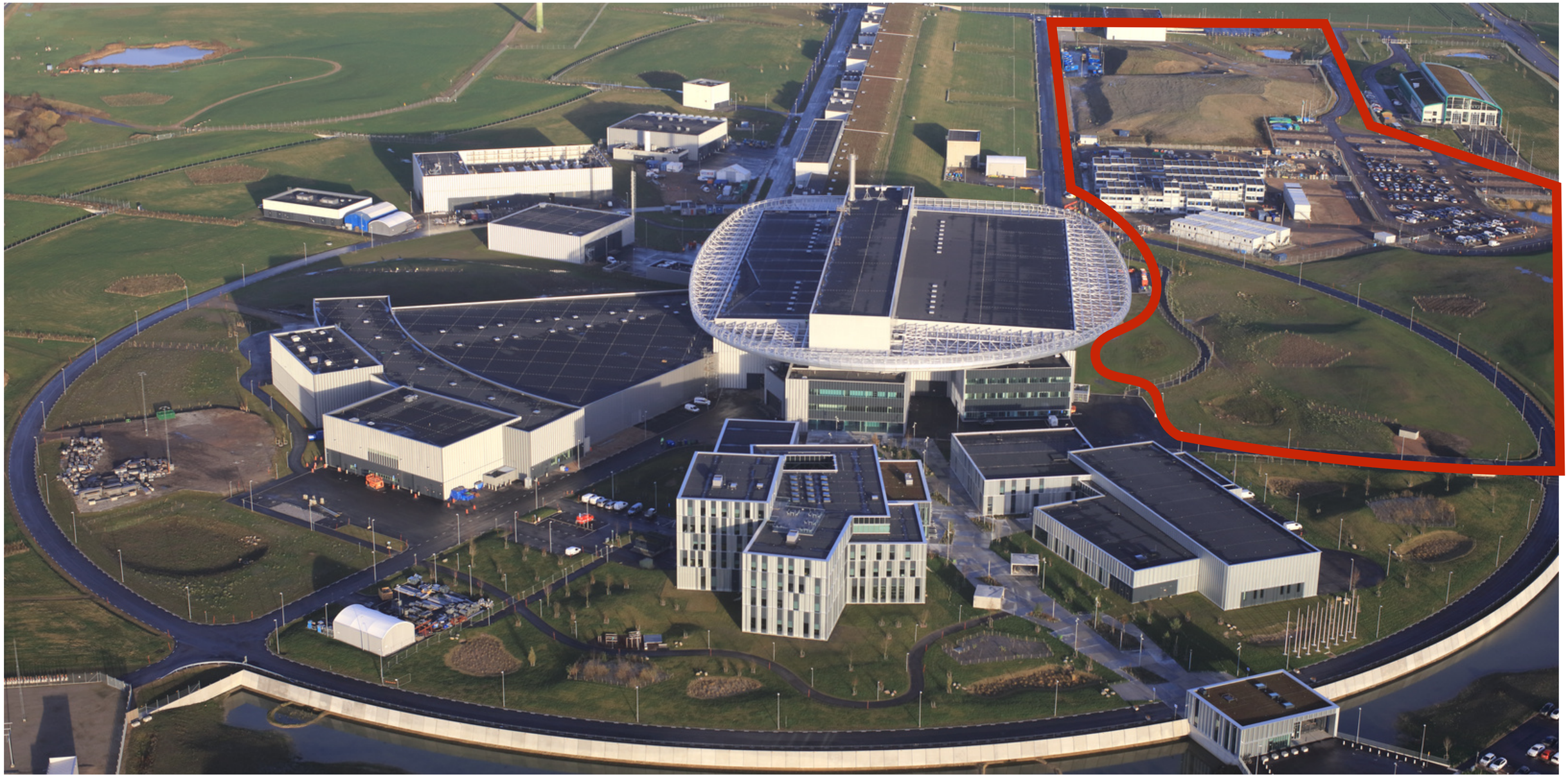
Ulrika Hammarlund (2020-2022)

SpaceX, Falcon 9

You don't use them 10 times a year

Image courtesy of SpaceX

ESS



Lund to Garpenberg via Zinkgruvan

ESSnuSB has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777419

Top Level Parameters

Design Drivers:

High average beam power	5 MW
High peak beam power	125 MW
High availability	>95 %

Key Linac parameters:

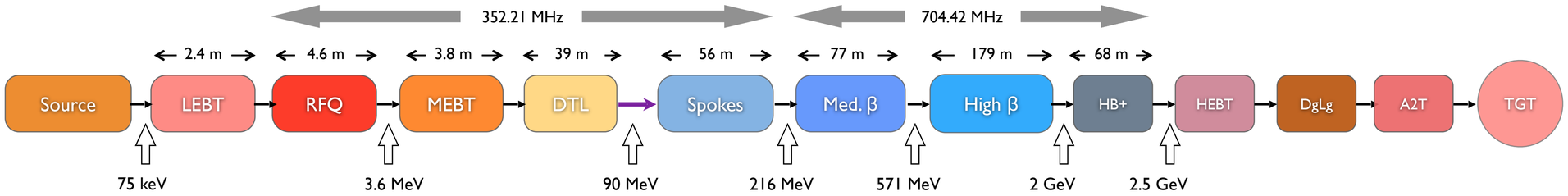
Energy	2.0 GeV
Current	62.5 mA
Repetition rate	14 Hz
Pulse length	2.86 ms
Losses	<1W/m
Ions	p

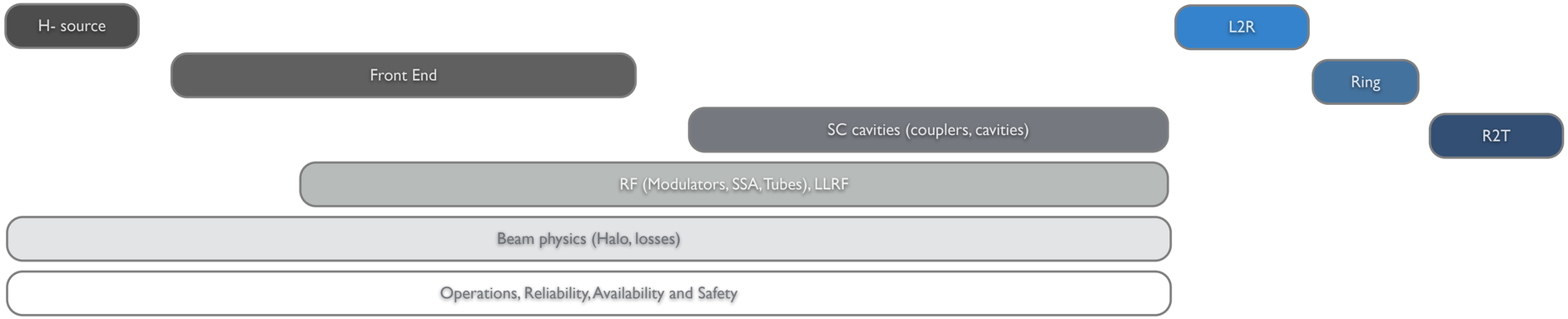
ESSnuSB beam:

Energy	2.5 GeV
Current	62 mA (50 mA)
Repetition rate	14 Hz (x 4)
Pulse length	<3.5 ms
Losses	<1W/m
Ions	H-

Flexible/Upgradable design

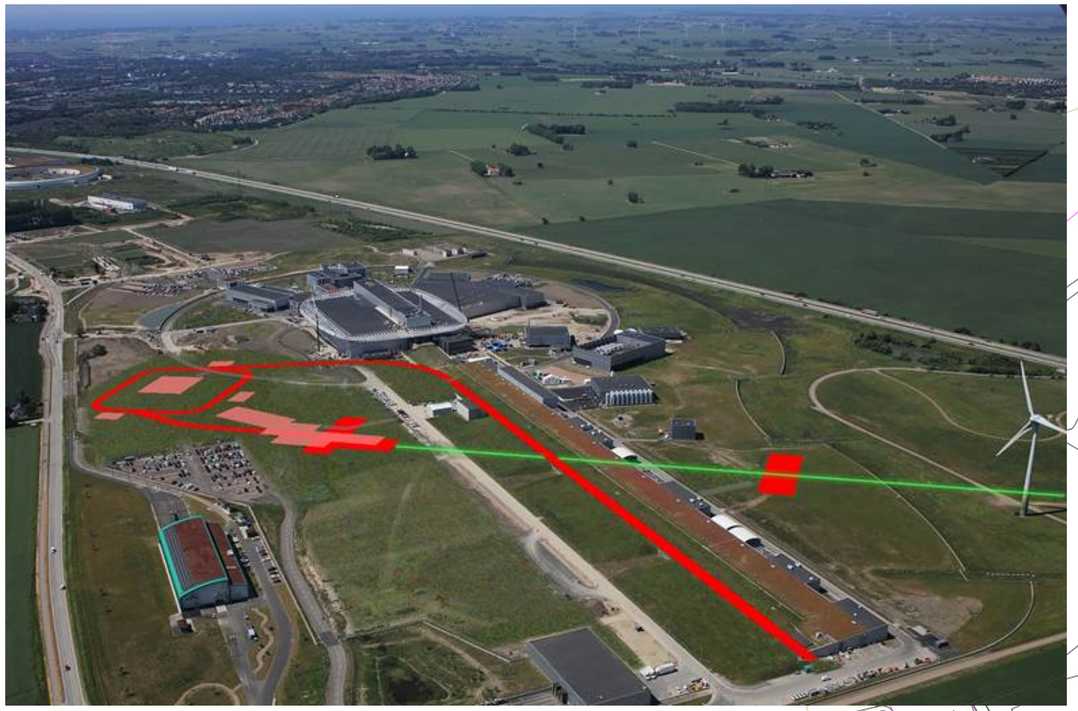
Minimize energy consumption





Frank Gerigk and Eric Montesinos, CERN-ADD-NOTE-2016-0050

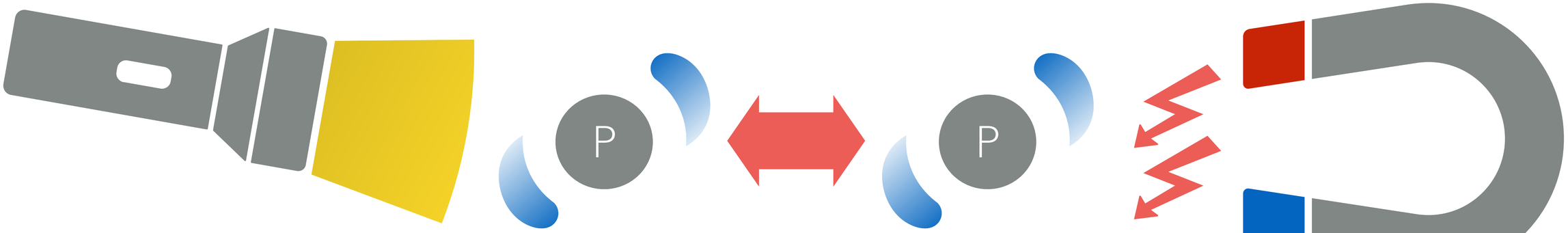
ESSnuSB Layout

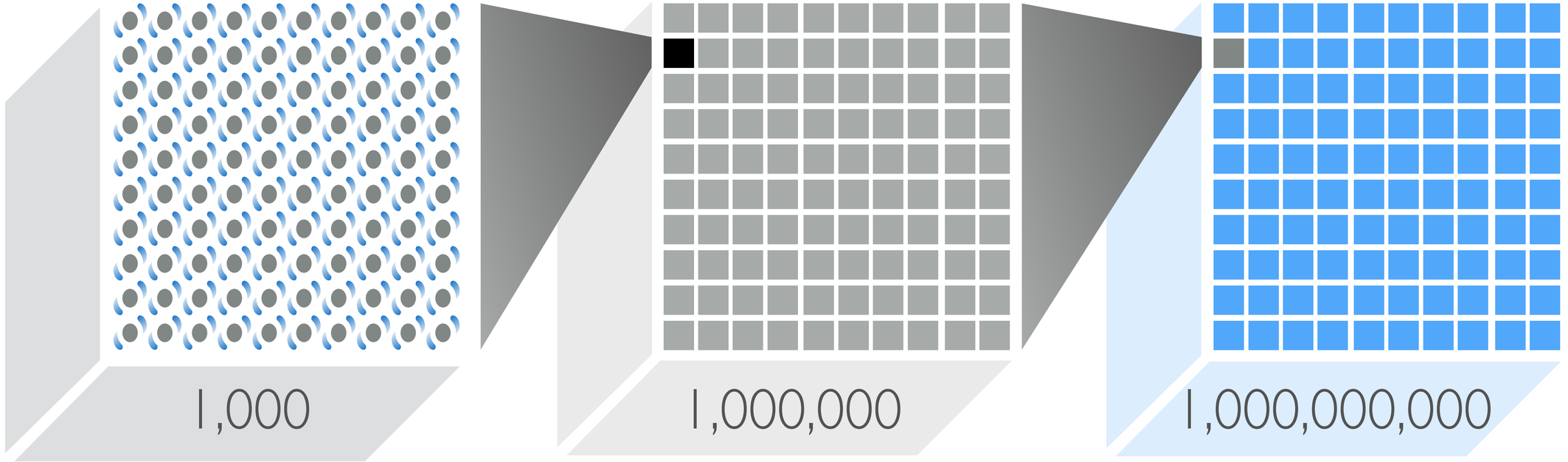


Rasmus Johansson and Nick Gazis

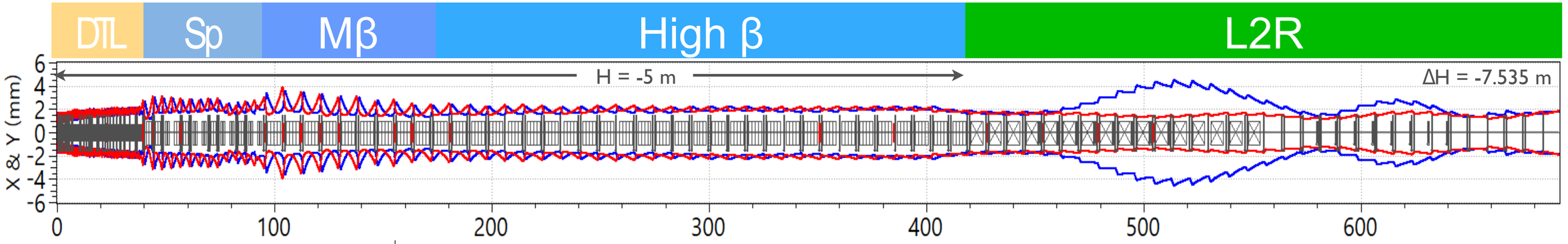
THE PHENOMENA BETWEEN PARTICLES

known

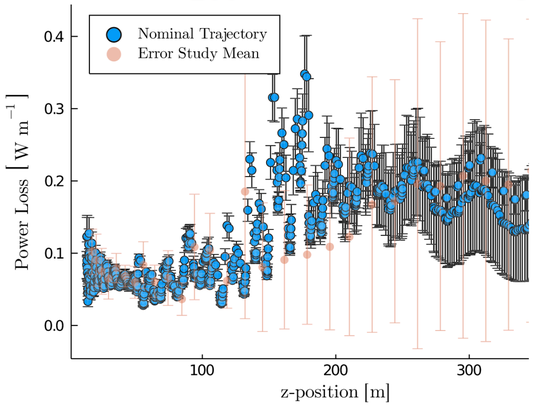


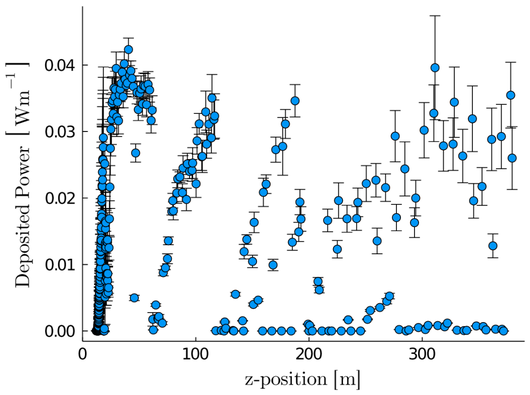


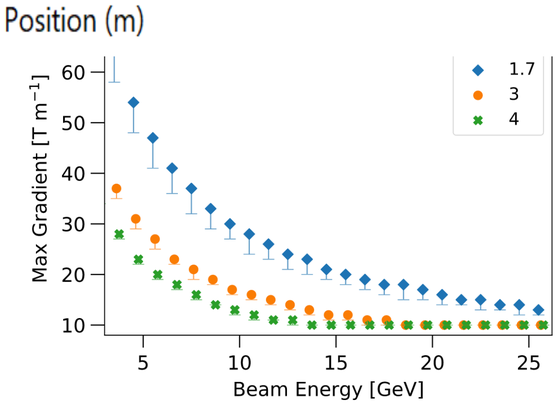
H- Transport and Losses

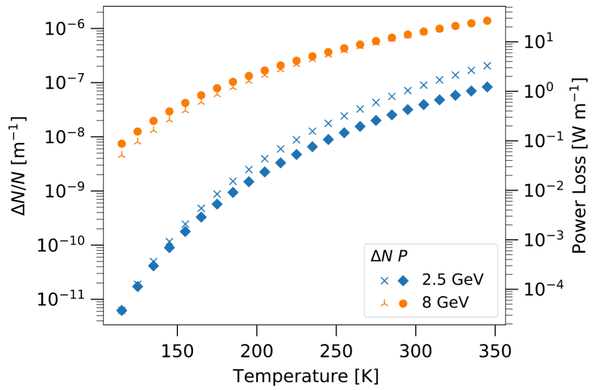


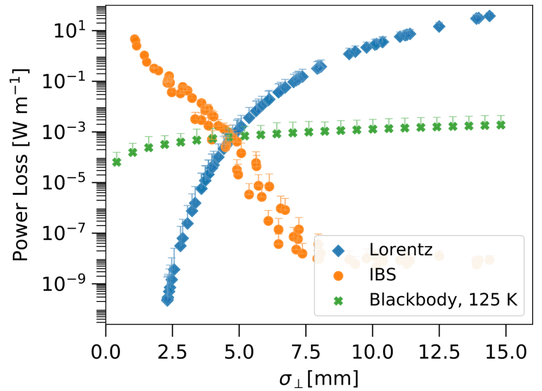
The electron is very loosely bound to the proton.

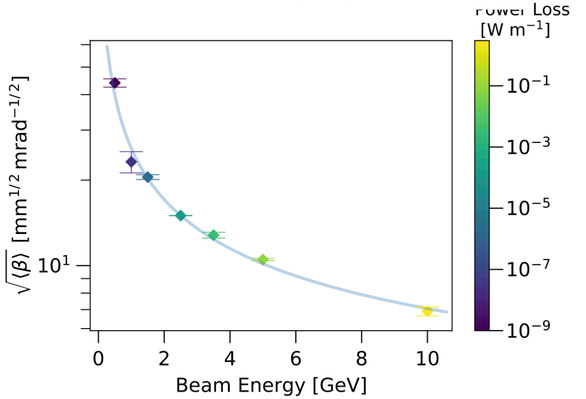






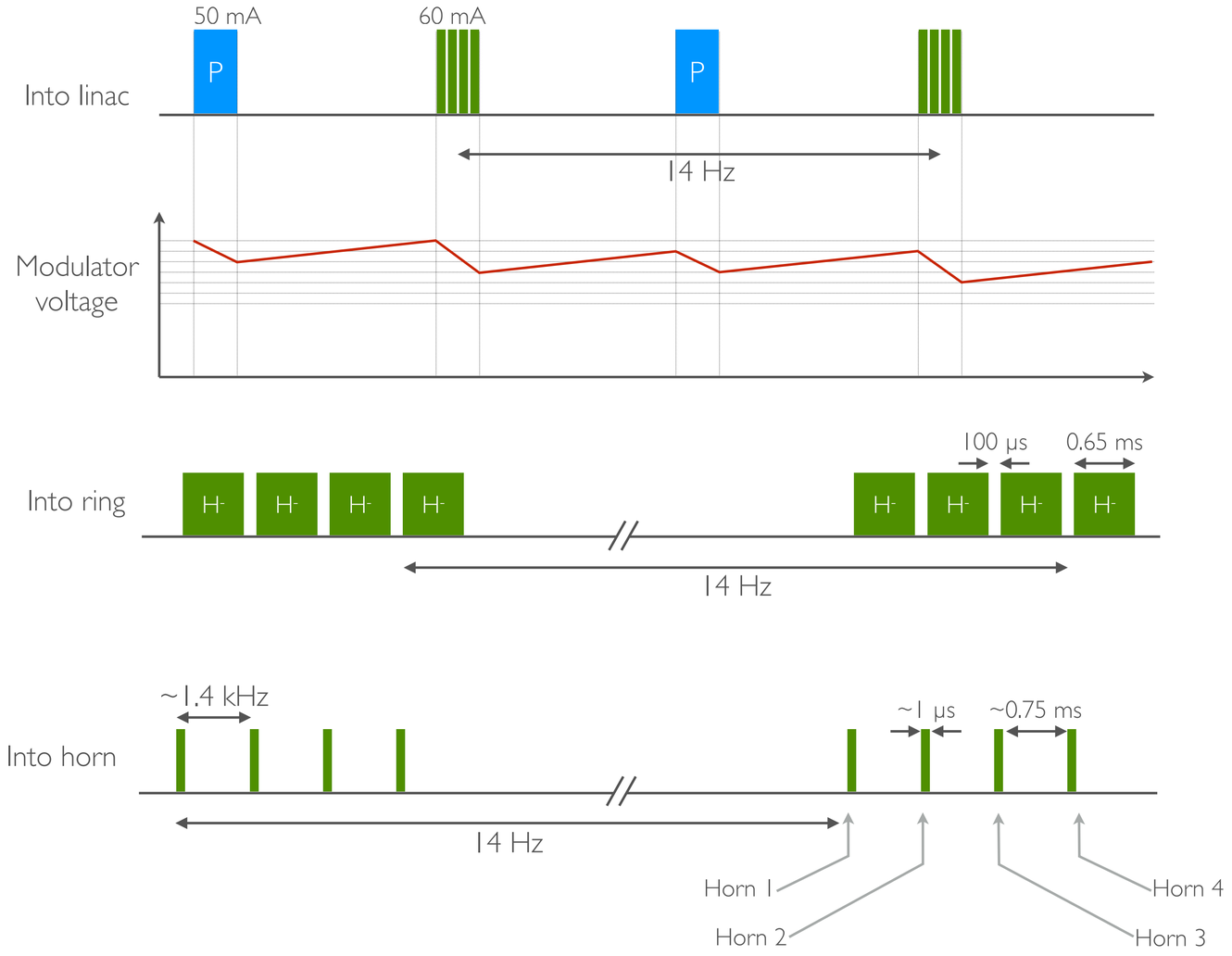




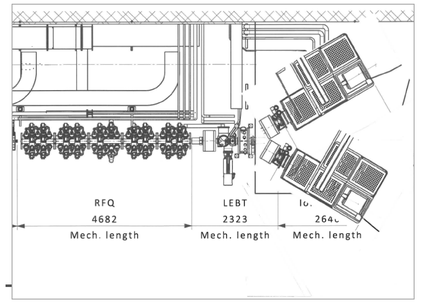


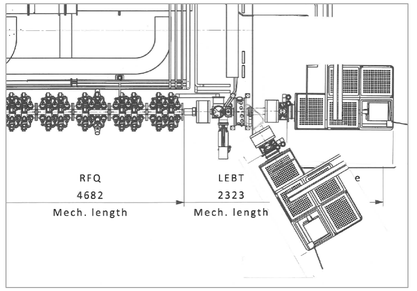
B. Folsom et al, PRAB 24, 074201 (2021)

Pulsing in the Linac, Ring and Target

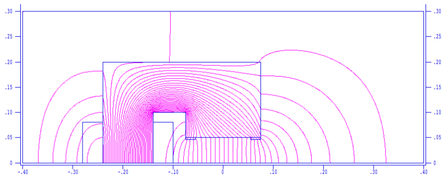


- Possibility of merging the two beams at 70 Hz





- Bending radius: 400 mm
  - pole gap: 100 mm
- A coil with 100 turns
  - Inductance: 17 mH
    - possible to switch at 70 Hz
- Power supply:
  - Current: 80 A
  - Voltage: 170 V

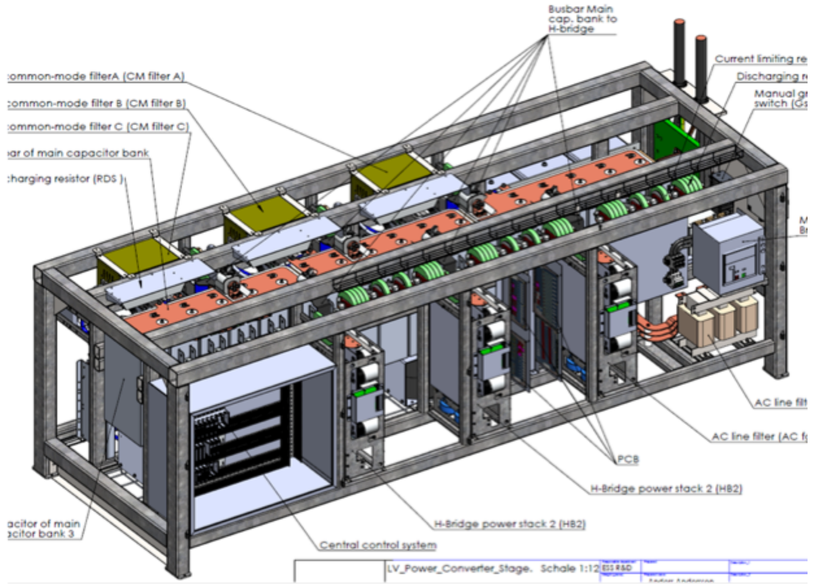


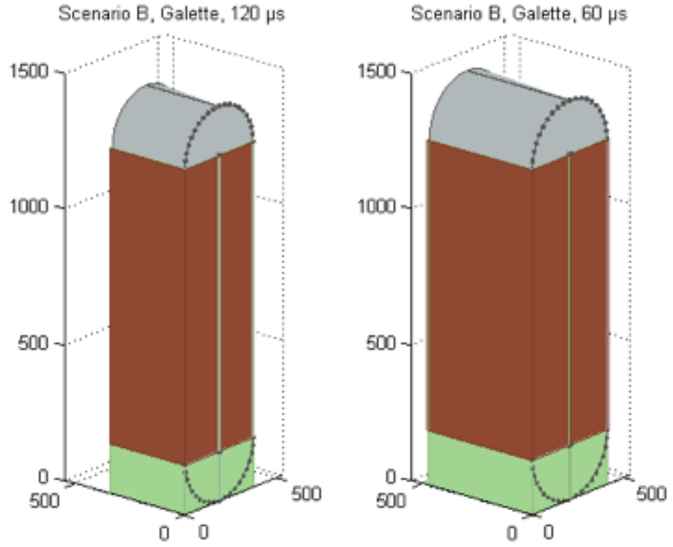
Håkan Danared, Björn Gålnander

MODULATOR

- Two different power upgrades for the modulators have been studied:
  - Using the SML modulators of ESS and upgrading the capacitor chargers
  - Using the SML modulators of ESS and adding pulse transformers for the H- beam

Scenario	Solution	Eta	Investment cost [M€]	Electricity cost per year [M€/y]	Increased system footprint [m²]	Total system height [m]	H^- pulse rise time [µs]
A	SML upgr.	0.82	13.4	14.6	0	3.1	< 120
B	SML upgr.	> 0.80	13.4	14.8	0	3.1	< 80
	SML + PT	> 0.80	26.3	14.8	< 2.5 x 1.5	2.4	60-120
C	SML upgr.	> 0.71	13.4	16.7	0	3.1	< 170
	SML + PT	> 0.72	26.6	16.5	< 2.5 x 1.5	2.4	50-120
Baseline	SML	0.82	N/A	7.30	N/A	2.6	N/A





Max Collins and Carlos Martins

SUMMARY

- **The ESS project** has seen good progress, with RFQ beam commissioning completed
- **ESSnuSB** received funding to study the feasibility of ESS linac upgrade from 5 MW to 10 MW to deliver 1E23 p.o.t/yr for neutrino oscillation studies
  - **Linac upgrade**
    - The ESS linac lattice is capable of accelerating and transporting the H- beam with minimal stripping losses, such that the total losses of p and H- remain within 1 W/m
    - H- loss phenomena have been studied, and the transfer line to ring designed to respect the loss limits
    - The ESS's stacked multi-layer modulator has the capability to be upgraded for the ESSnuSB

EUROPEAN SPALLATION SOURCE

Thank you!