EUROPEAN SPALLATION SOURCE

Status of the Design Study of the power upgrade of the ESS linac from 5 MW to 10MW for ESSnuSB

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on behalf of
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Leader of the ESSnuSB linac power upgrade work-package

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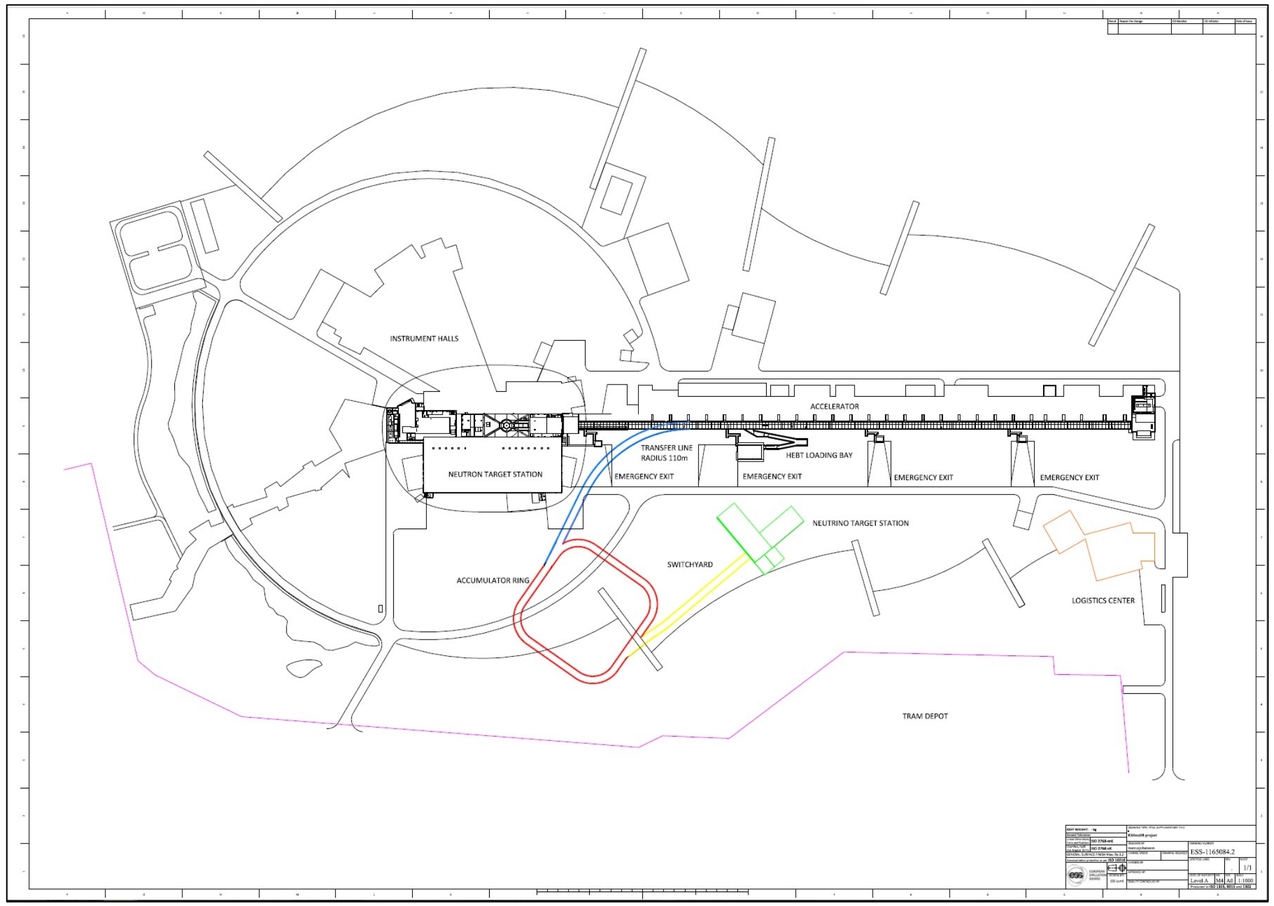
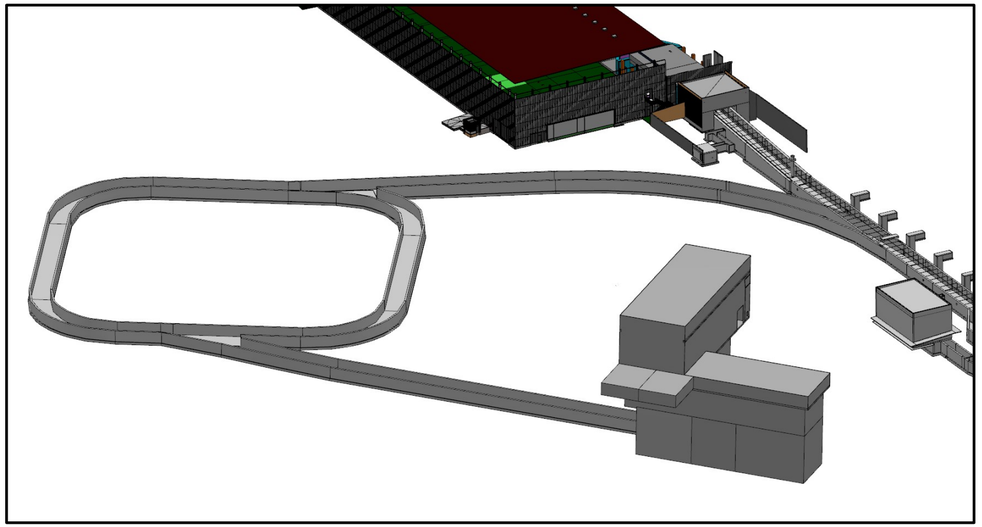
EUROPEAN SPALLATION SOURCE (ESS) SITE

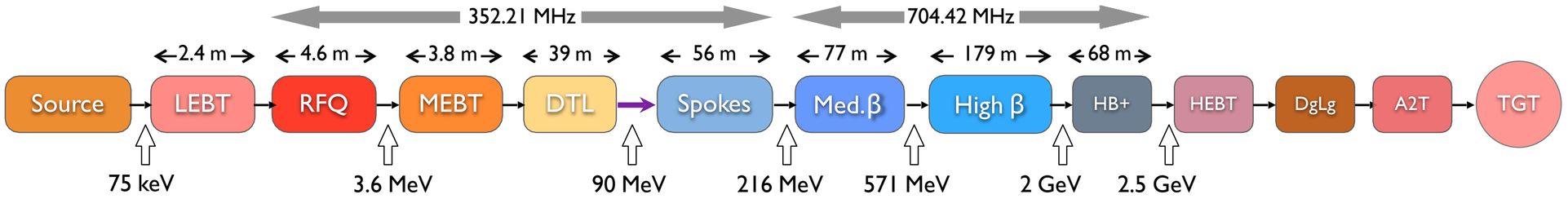
ESSnuSB Layout



- Transfer line straight end.
- Longer possible switchyard length.
- Target station position flexibility increased.



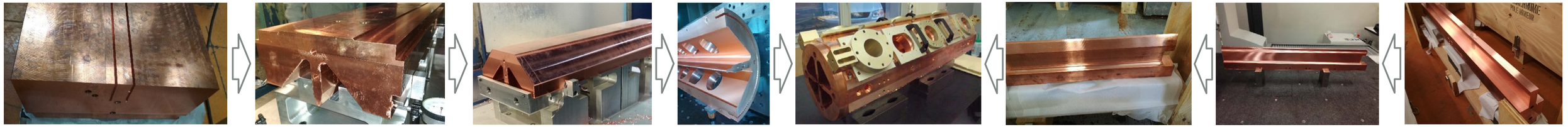
LINAC LAYOUT

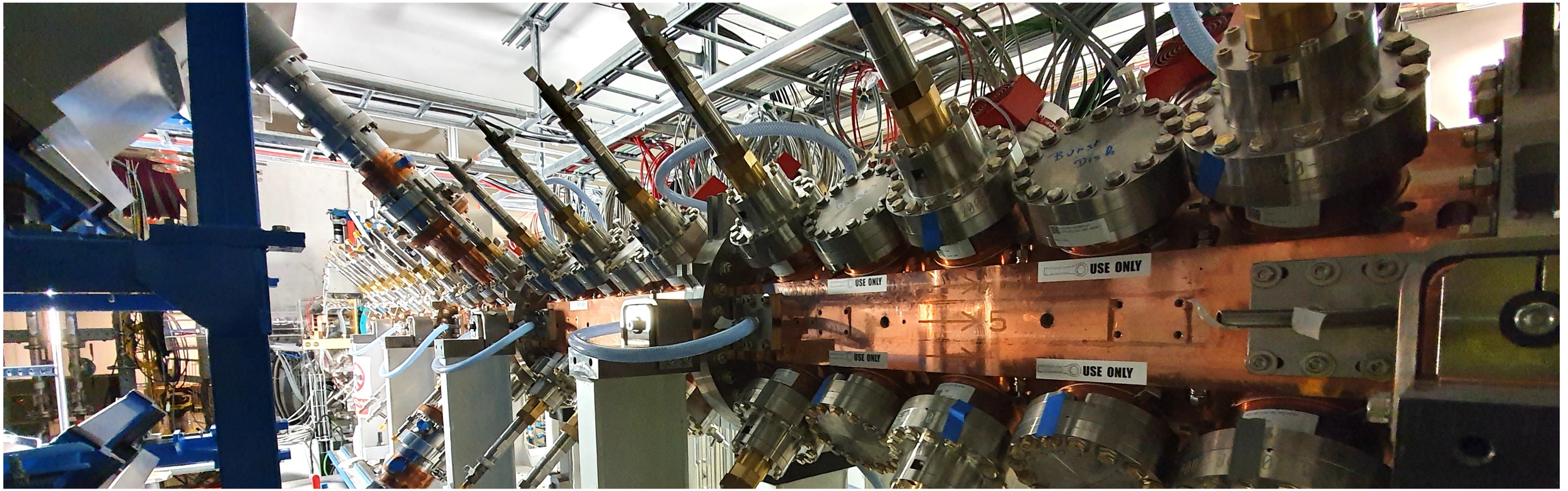


	Length (m)	W_out (MeV)	F (MHz)	β Geometric	No. Sections	T (K)
LEBT	2.38	0.075	—	—	1	~300
RFQ	4.6	3.62	352.21	—	1	~300
MEBT	3.83	3.62	352.21	—	1	~300
DTL	38.9	89.8	352.21	—	5	~300
LEDP + Spoke	55.9	216.3	352.21	0.50 (Opt)	13	~2
Medium Beta	76.7	571.5	704.42	0.67	9	~2
High Beta	178.9	2000	704.42	0.86	21	~2
HB+	68.2	2500	704.42	0.86	8	~2
HEBT	59.6	2500	—	—	7	~300
DogLeg	66.3	2500	—	—	6	~300
A2T	44.6	2500	—	—	1	~300

ESS UPDATES

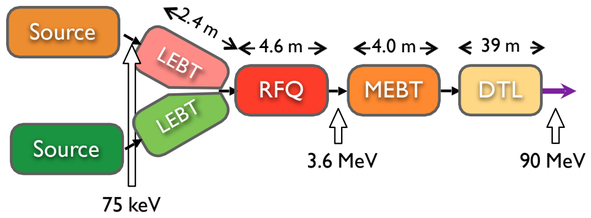
- Radio Frequency Quadrupole (RFQ) installed in the tunnel

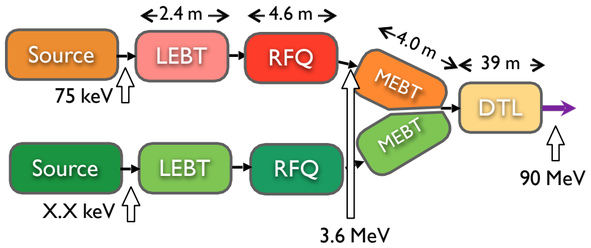


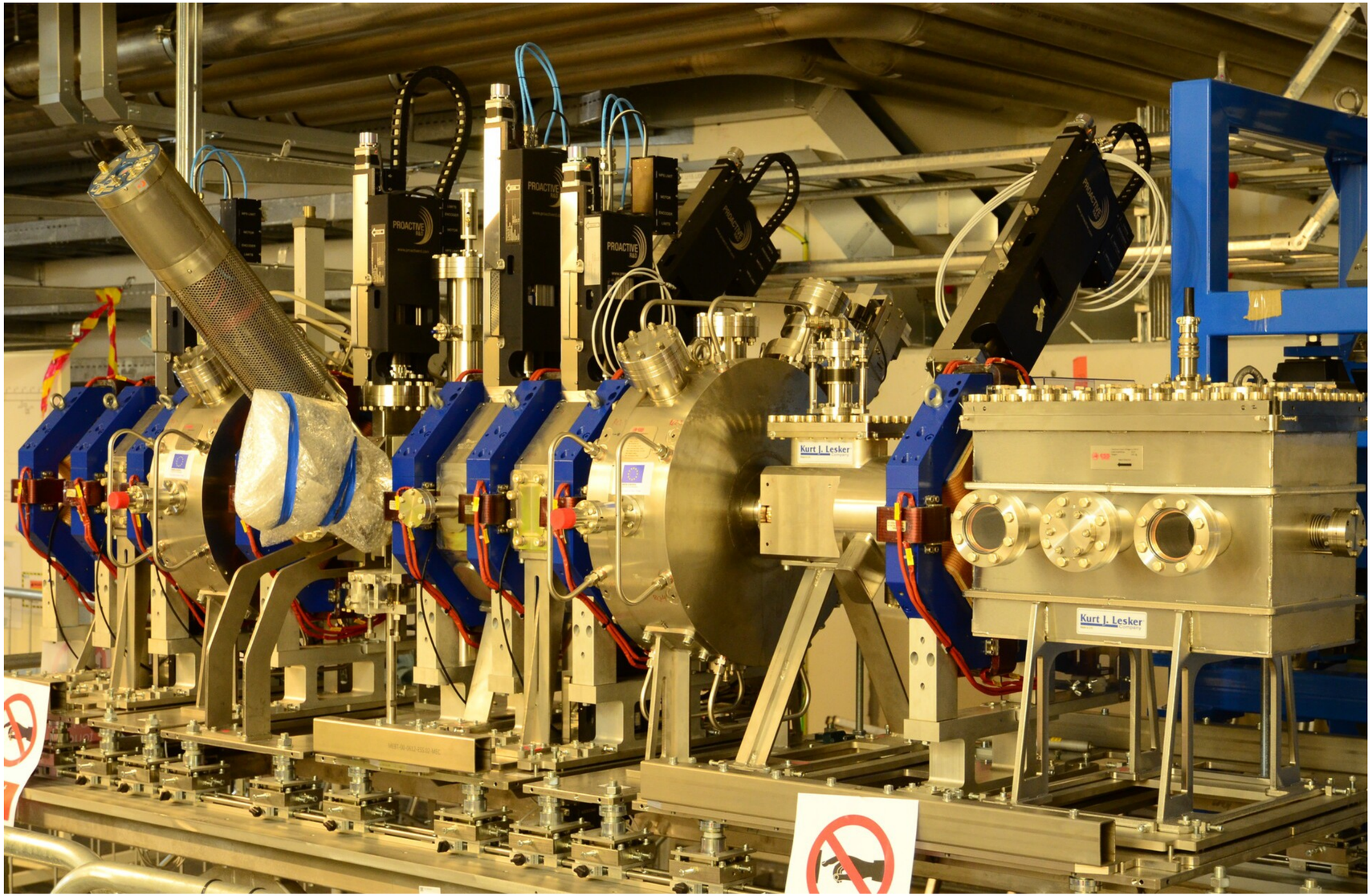


ESS UPDATES

- Medium Energy Beam Transport (MEBT)
  - Installed in the tunnel

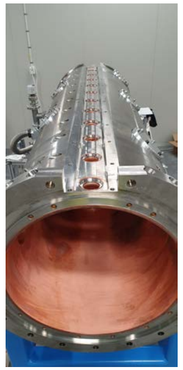


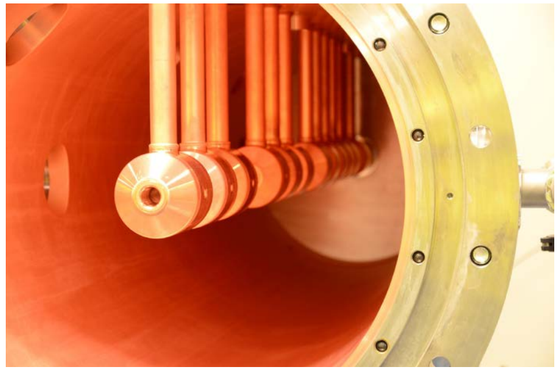




ESS UPDATES

- Drift Tube Linac (DTL),assembled on site

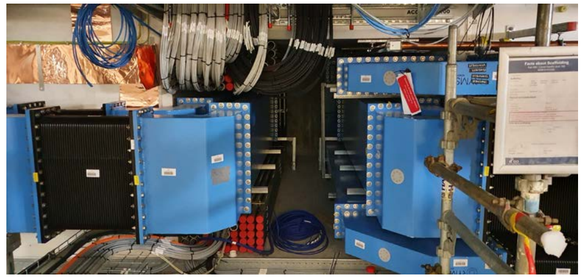




ESS UPDATES

NCL RFDS, Gallery

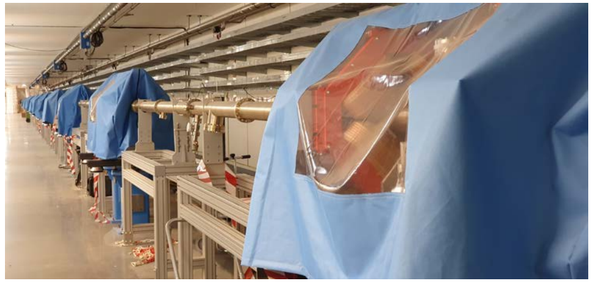
SCL RFDS, Gallery



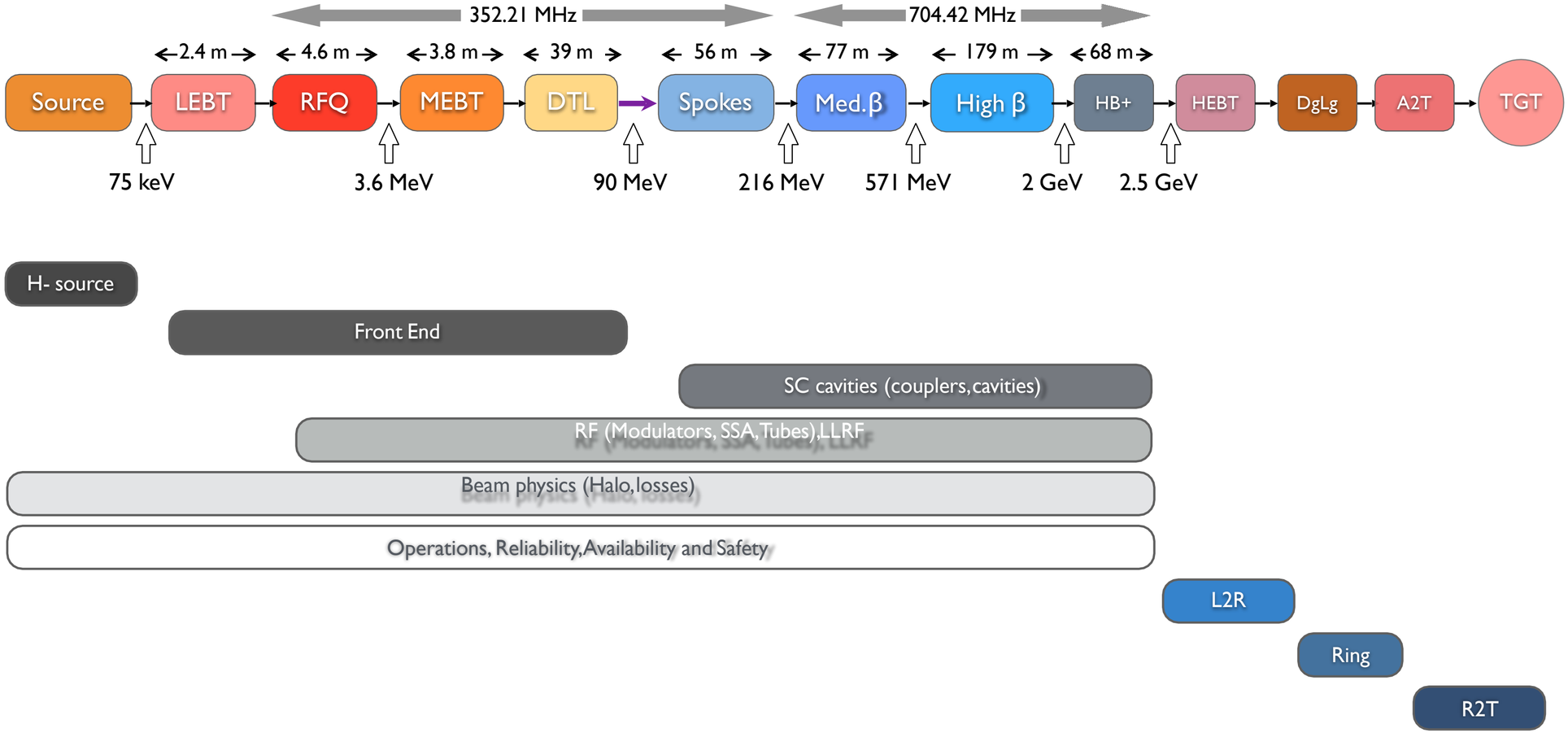
NCL RFDS, Tunnel

SCL RFDS, Tunnel

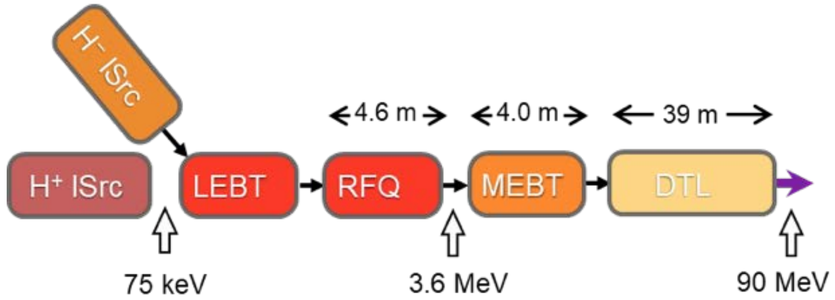
Radio Frequency Distribution system

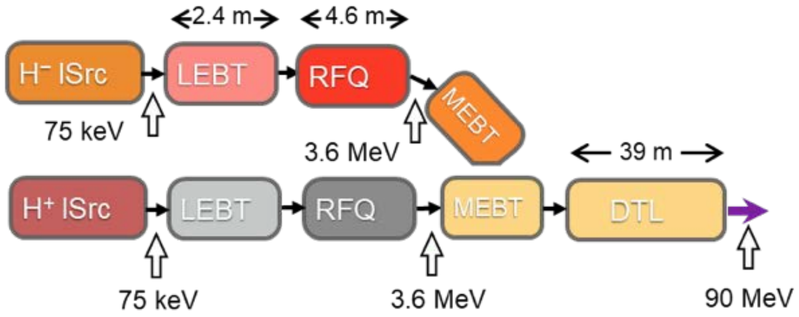


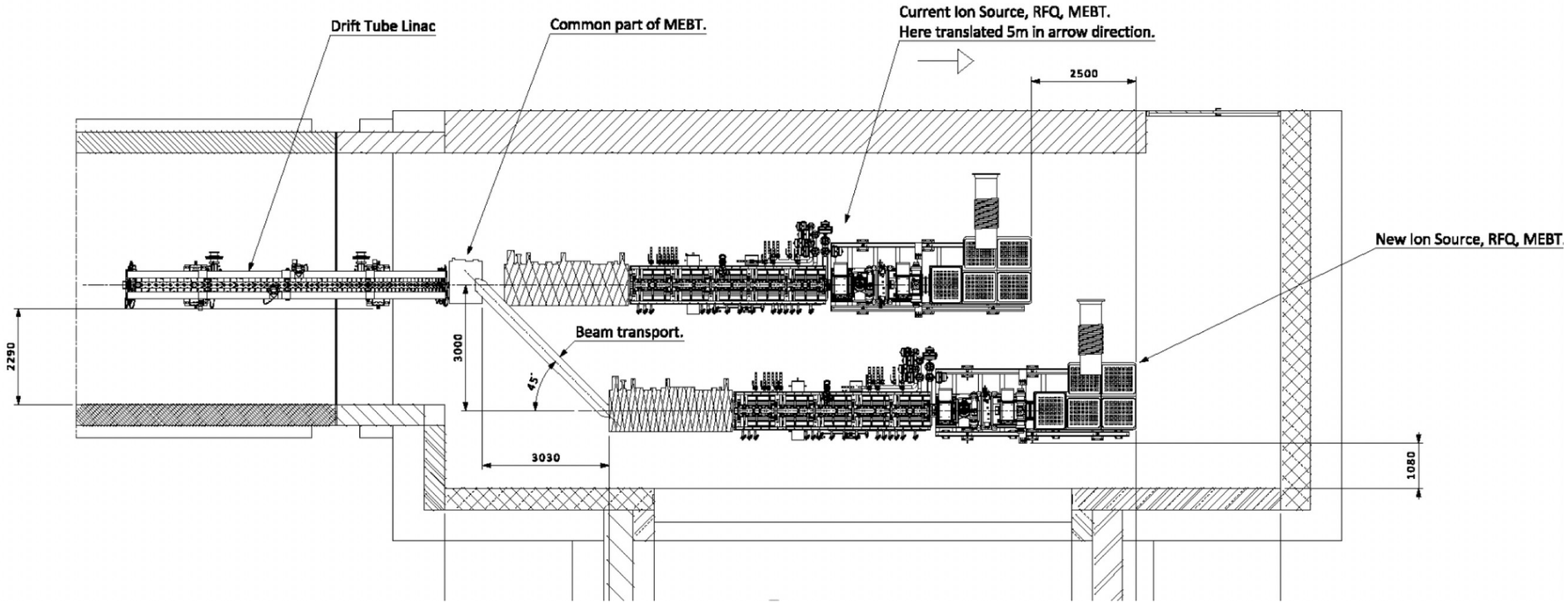
AREAS OF CHANGE



MEBT

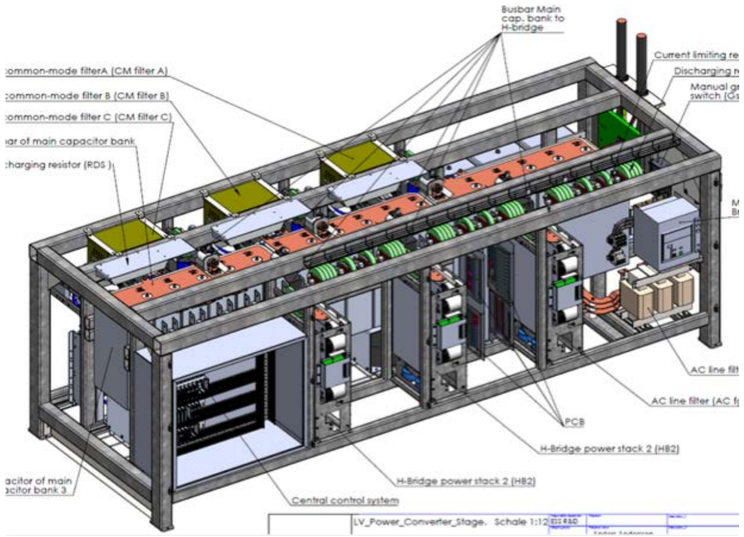

H⁻ ISrc
H⁺ ISrc
LEBT
RFQ
MEBT
DTL
4.6 m
4.0 m
39 m
75 keV
3.6 MeV
90 MeV

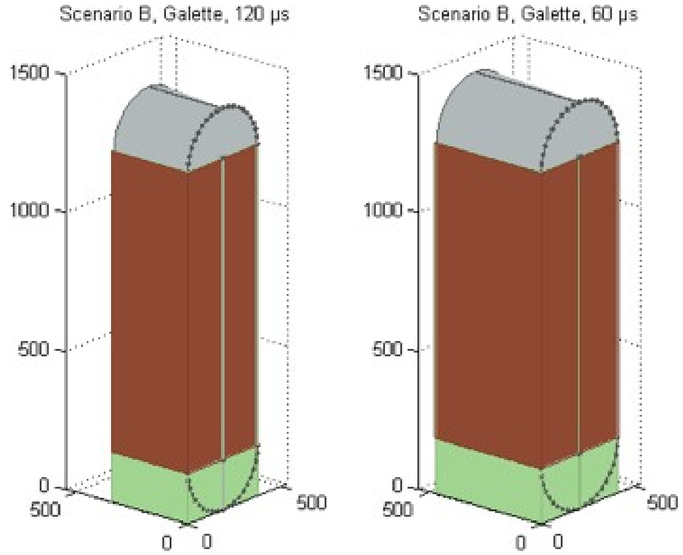

2.4 m
4.6 m
H⁻ ISrc
LEBT
RFQ
MEBT
75 keV
3.6 MeV
39 m
H⁺ ISrc
LEBT
RFQ
MEBT
DTL
75 keV
3.6 MeV
90 MeV


Drift Tube Linac
Common part of MEBT.
Current Ion Source, RFQ, MEBT.
Here translated 5m in arrow direction.
2500
New Ion Source, RFQ, MEBT.
Beam transport.
45°
2290
3000
3030
1080

MODULATOR

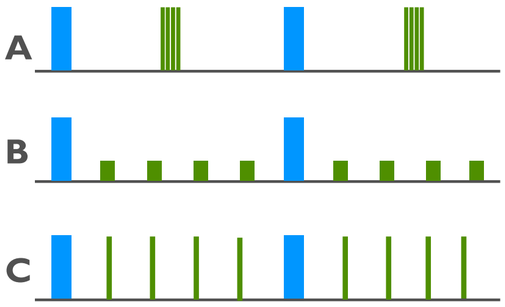
- Two different power upgrades for the modulators have been studied:
  - Using the SML modulators of ESS and upgrading the capacitor chargers
  - Using the SML modulators of ESS and adding pulse transformers for the H- beam





MODULATOR

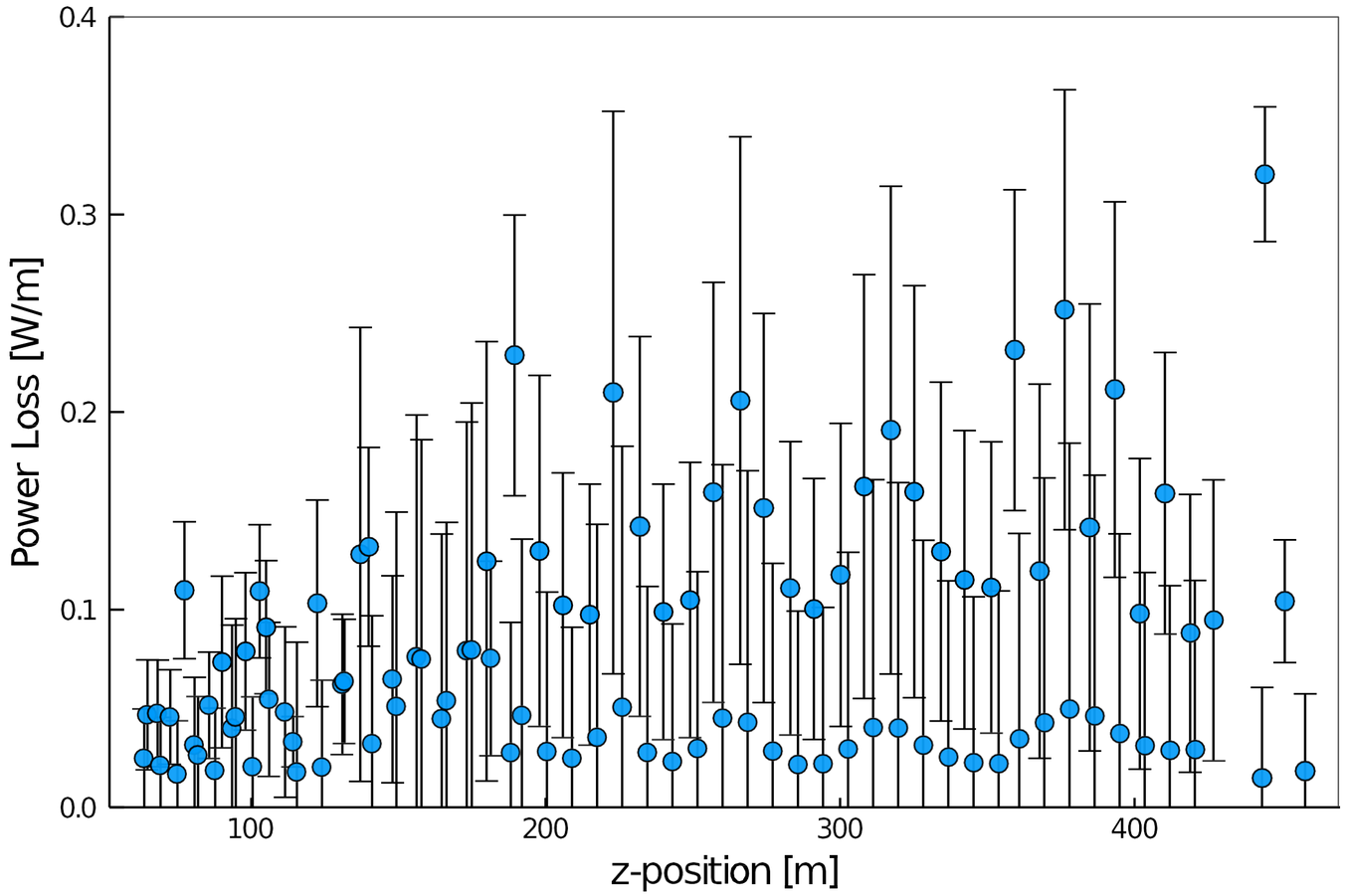
Scenario	Solution	Eta	Investment cost [M€]	Electricity cost per year [M€/y]	Increased system footprint [m²]	Total system height [m]	H⁻ pulse rise time [μs]
A	SML upgr.	0.82	13.4	14.6	0	3.1	< 120
B	SML upgr.	> 0.80	13.4	14.8	0	3.1	< 80
	SML + PT	> 0.80	26.3	14.8	< 2.5 x 1.5	2.4	60-120
C	SML upgr.	> 0.71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

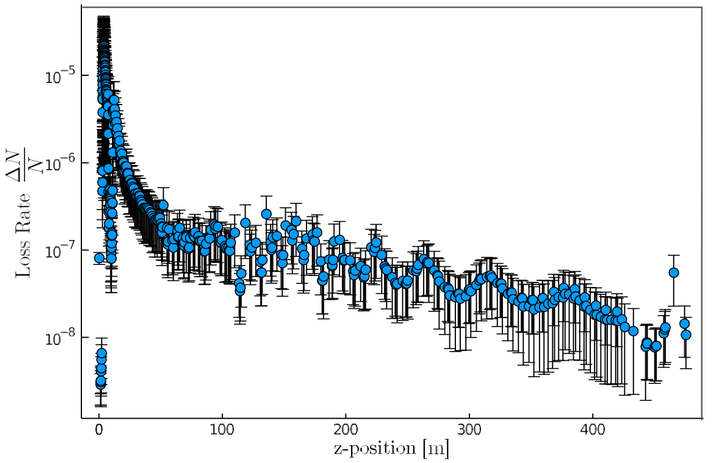


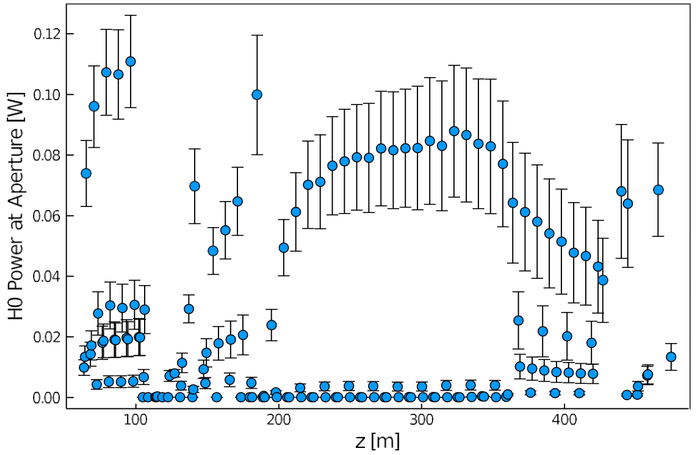
Max Collins and Carlos Martins

INTRA BEAM STRIPPING

$$\frac{1}{N}\frac{dN}{dS} = \frac{N\sigma_t\sqrt{\gamma^2\theta_x^2 + \gamma^2\theta_y^2 + \theta_z}}{8\pi^2\gamma^2\sigma_x\sigma_y\sigma_z} F\left(\gamma\theta_x, \gamma\theta_y, \theta_z\right)$$

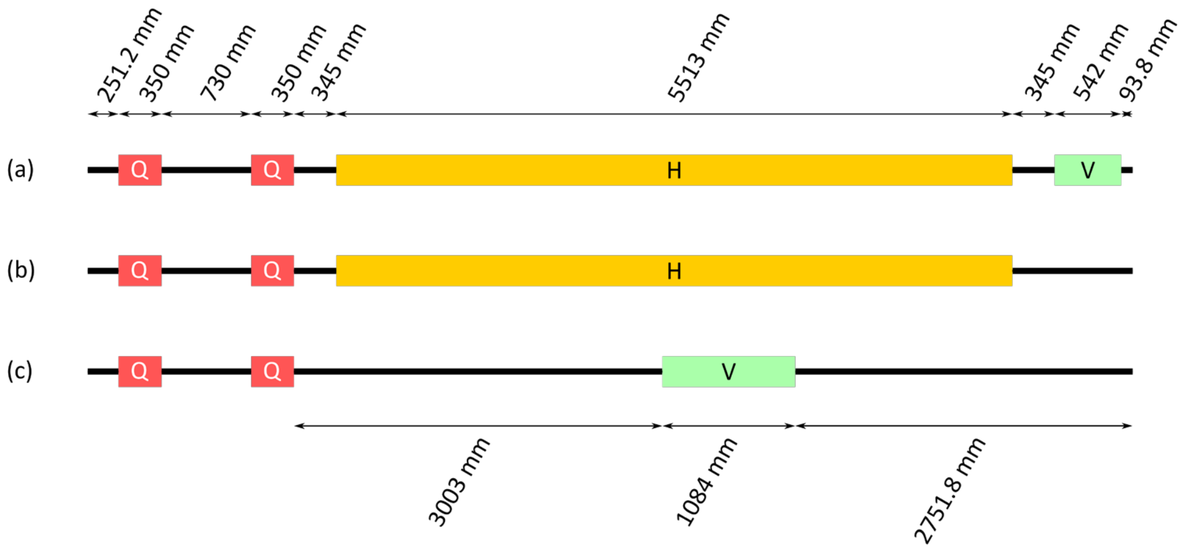


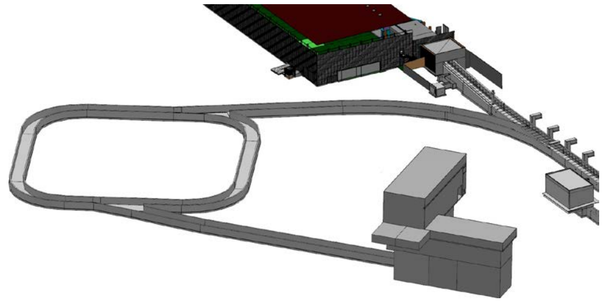




Ben Folsom

LINAC TO RING (L2R) TRANSFER LINE

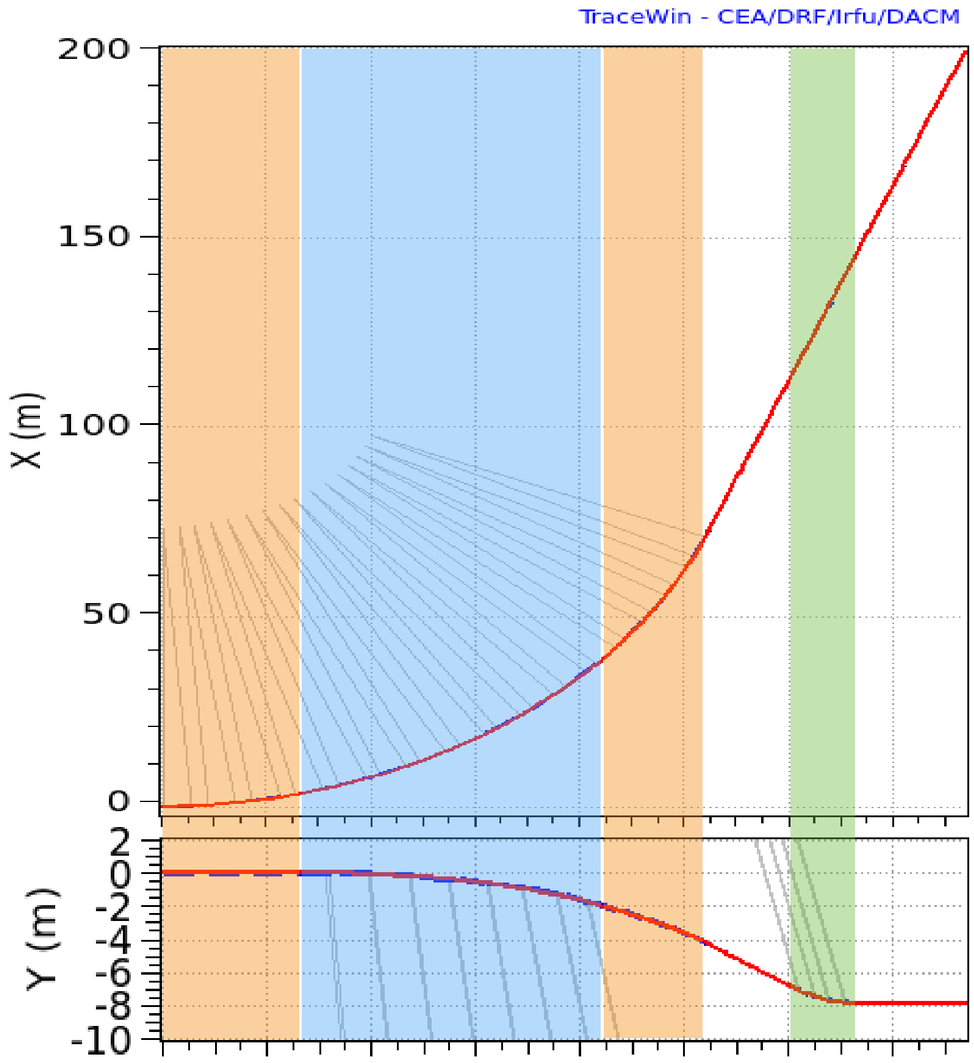


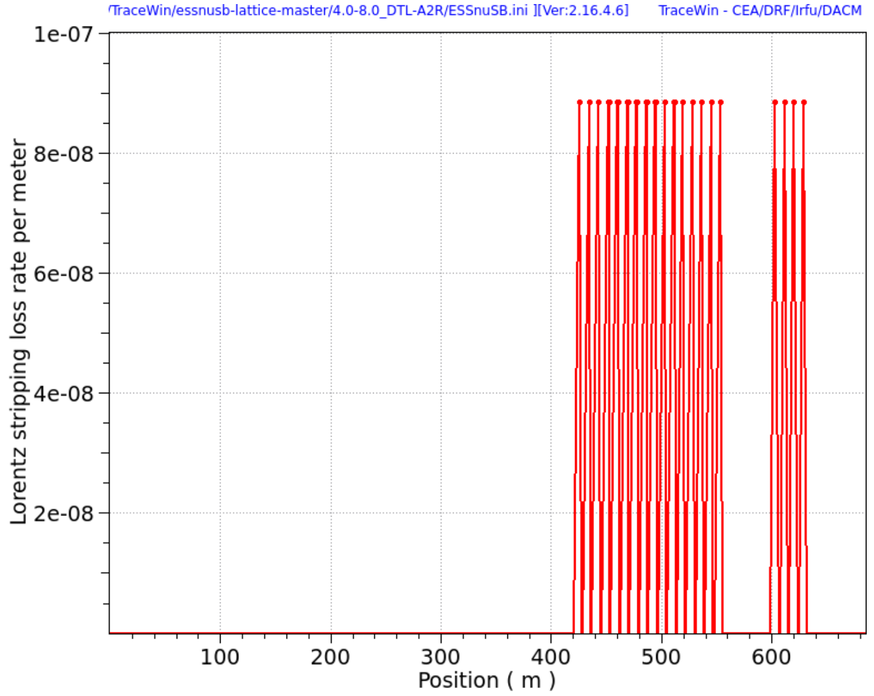


b a b c

AR depth (m)	Lattice cells																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
7.864																																
8.887																																
9.514																																

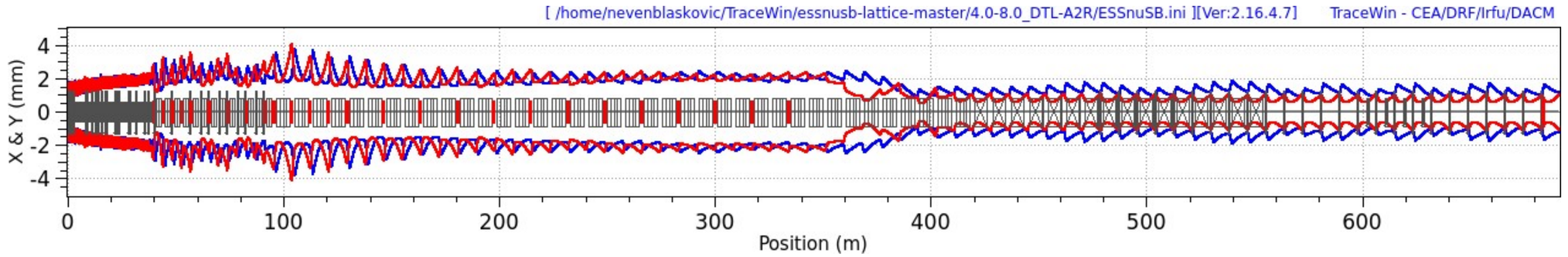
LORENTZ FORCE STRIPPING IN THE L2R

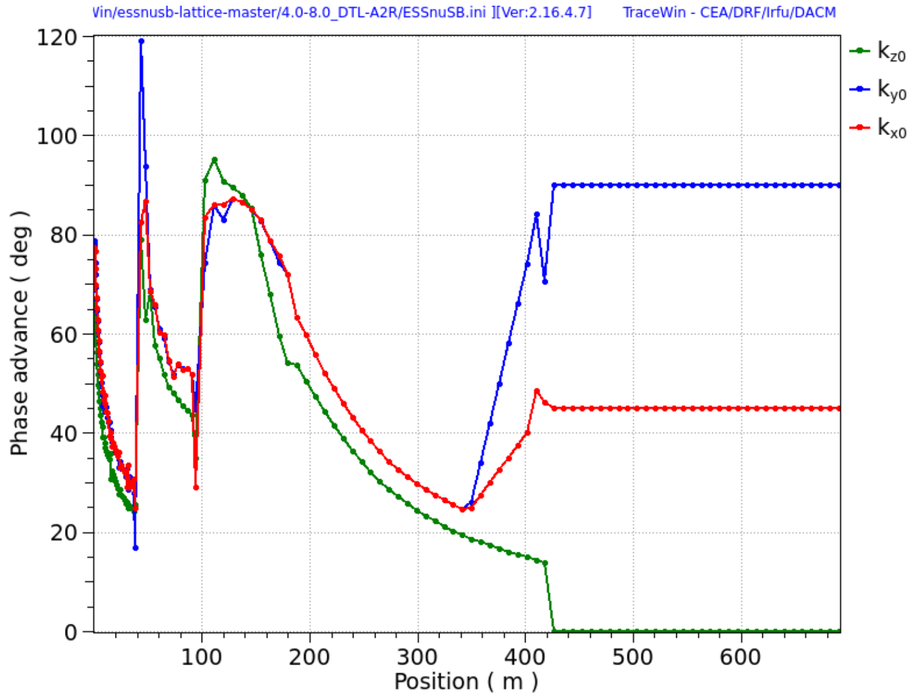


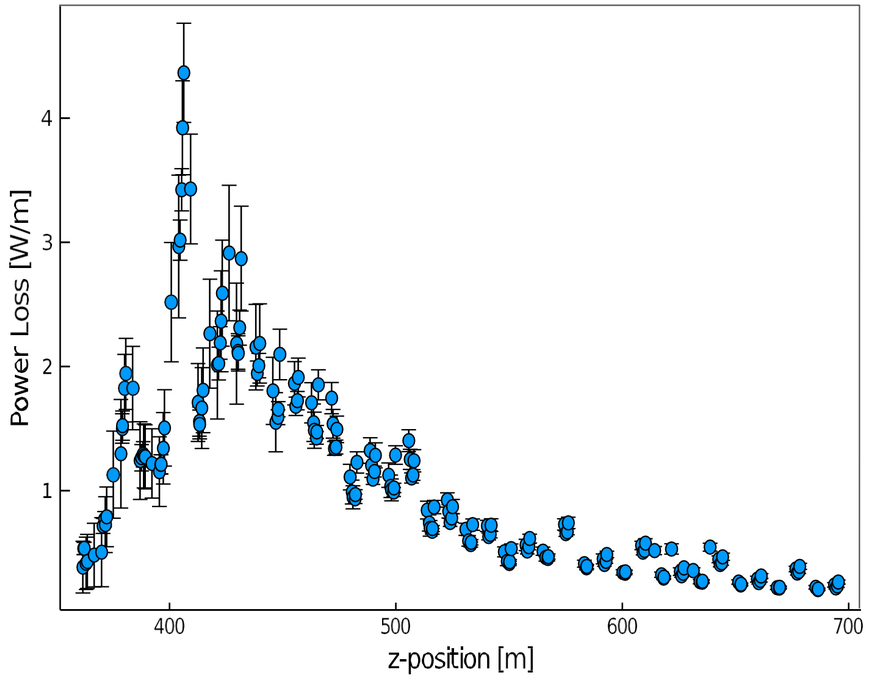


- Tunnel arc bending radius: 110 m
- Dipole bending radius: 73.5 m (corresponding to 0.15T @ 2.5 GeV)
- Accumulator ring depth: 7.864 m

INTRABEAM STRIPPING IN THE L2R







Neven Blaskovic, Ben Folsom

SUMMARY

- Feasibility studies so far have not found any show-stoppers on the possibility of using the ESS linac for ESSnuSB
  - Developments in H- ion sources demonstrate a trend which would fit the needs of ESSnuSB
  - Only a couple of structures in the NCL of ESS may need an upgrade
  - RF sources are consumables and could be replaced with adequate ones for ESS+ESSnuSB
    - Existing modulators could be upgraded
  - Losses, which are the main concern in H- beams, are controlled in the linac
    - L2R is being redesigned