
Future interests in high gradients at FERMI@Elettra FEL
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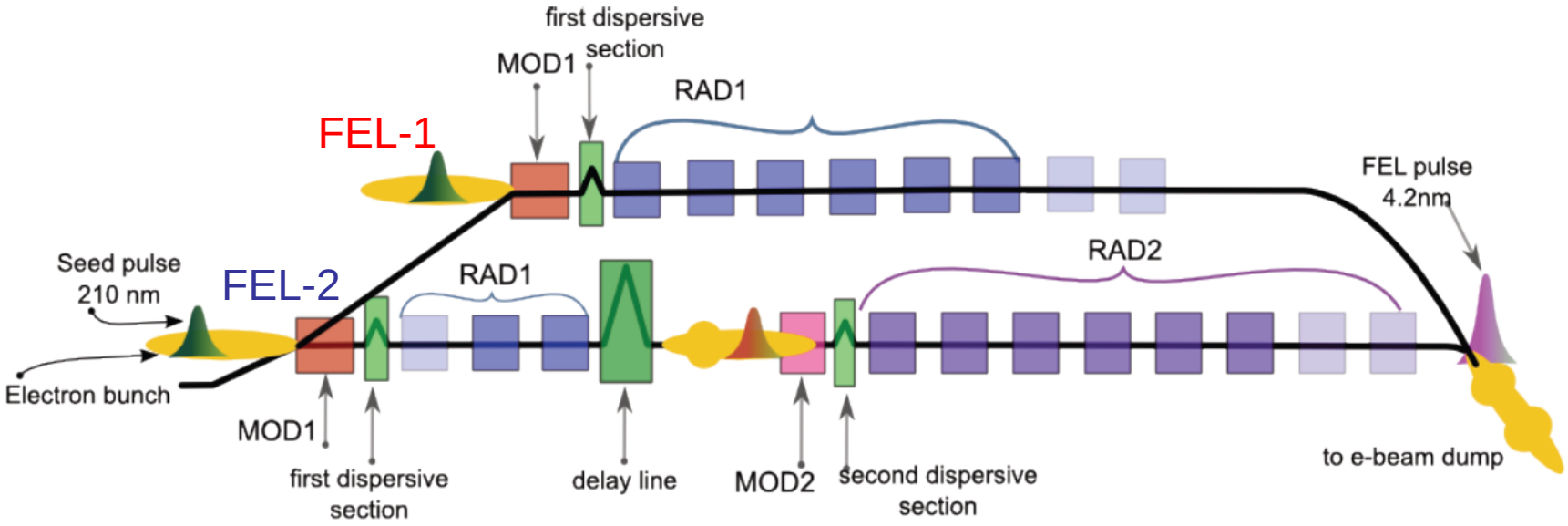
Outline

- *The FERMI@Elettra FEL project*
- *Present machine layout*
- *Weaknesses and possible upgradings*
- *C/X band test station*
- *Outlook and conclusions*

FERMI@ELETTRA FEL

FERMI@Elettra is a seeded Free Electron Laser facility presently in operation next to the third-generation Synchrotron Radiation facility Elettra. It has been developed to provide fully coherent ultrashort (10-100 femtosecond) pulses with a peak brightness ten billion times higher than that made available by third-generation light sources.

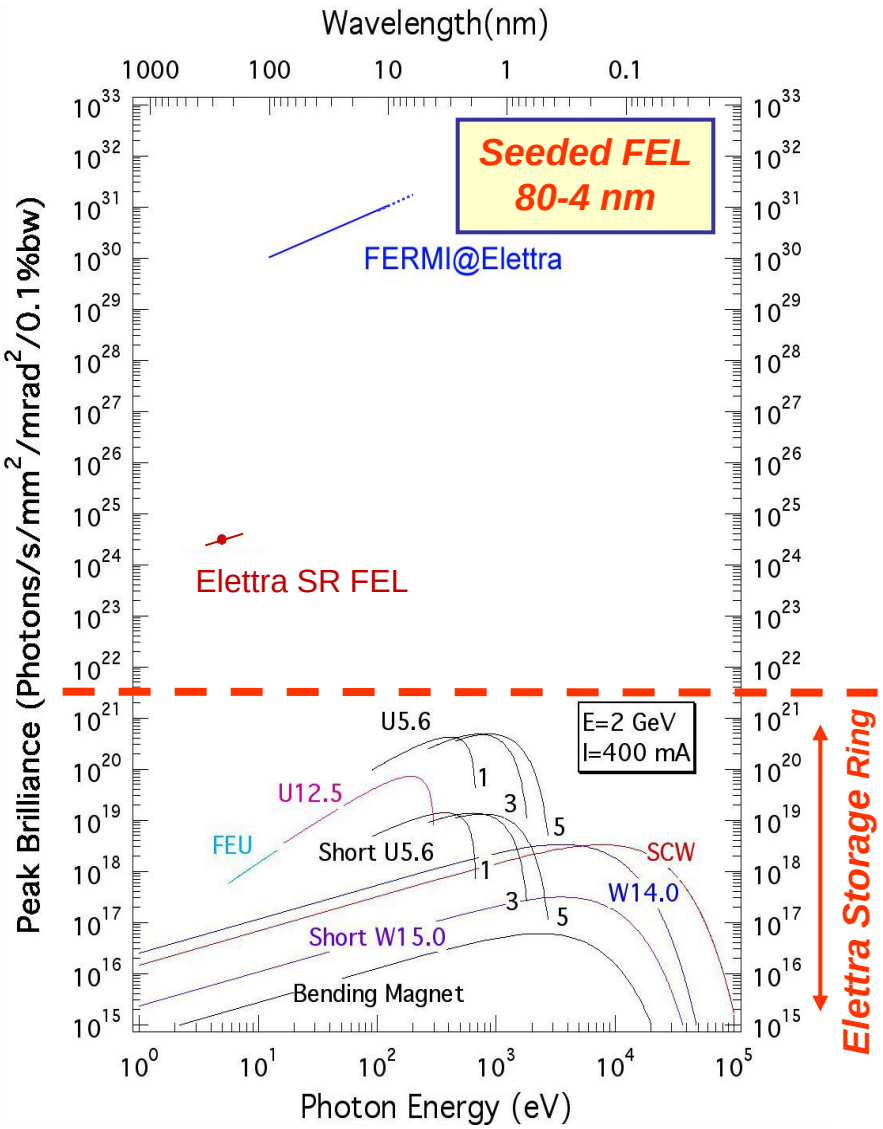
FEL-1 is based on a single stage High Gain Harmonic Generation (HGHG) scheme, using a UV seeding Laser and covers the spectral range 80-20 nm.



FEL-2 is based on a two stages High Gain Harmonic Generation (HGHG) scheme, with the "fresh bunch technique", to reach the wavelength range 20-4 nm.

FERMI@Elettra performance

FEL parameters	FEL 1	FEL 2
Output wavelength (nm, fundamental)	80-20	20-4
e-beam parameters	**FEL 1**	**FEL 2**
Energy (GeV)	1.2	1.5
Nominal charge (nC)	0.8	
Peak current (A)	850	
Bunch length, full width (fs)	700	
Slice normalized emittance (μmrad)	0.8 - 1.2	
Projected normal. emittance (μmrad)	≤ 2.0	
Uncorrelated energy spread, rms (keV)	≤ 250 keV	
Repetition rate (Hz)	10 - 50	
Pulse to pulse energy stability rms (%)	0.1	
Timing jitter, rms (fs)	≤ 150	
Undulator parameters	**FEL 1**	**FEL 2**
Period length (mm)	55	35
Minimum gap (mm)	10	
K param. @20 nm, 1.2 GeV	1.7	
K param. @10 nm, 1.2 GeV	1.0	
K param. @4 nm, 1.5 GeV		1.0

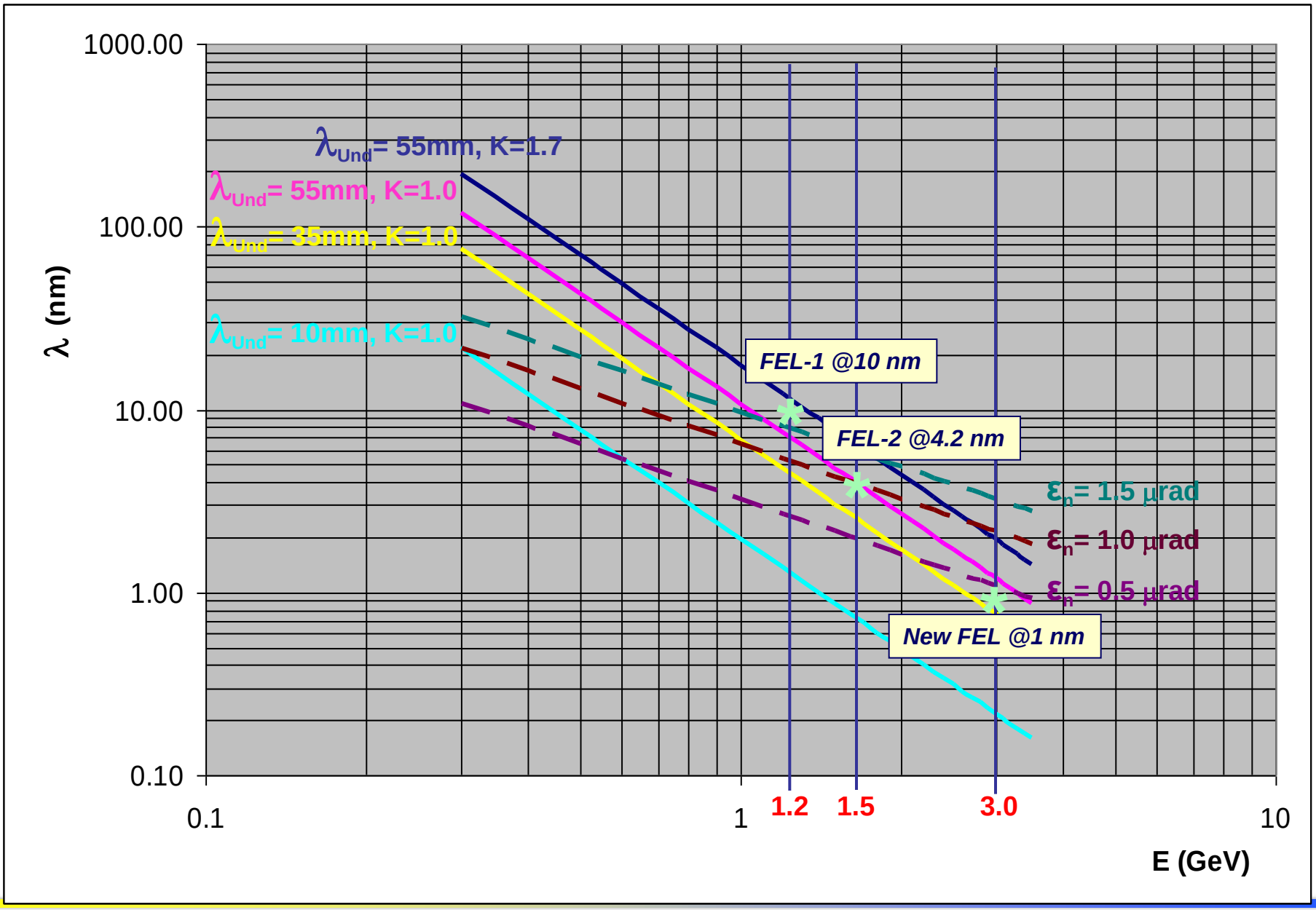


Future possibilities and developments

1. *Increase the linac repetition rate to increase the average photon flux.*
   - *FERMI is based on a NC linac, originally designed to work at 10 Hz and a 50 Hz extension is already foreseen for this year. A further increase, i.e. up to maximum 100 Hz, has to be carefully evaluated (maybe the related costs do not balance benefits…..)*

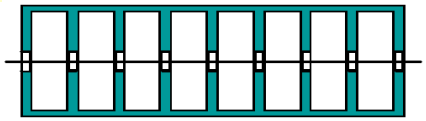
2. *Extend the FEL wavelenght range to 1 nm or lower*
   - *This could be pursued increasing the electron beam energy adding new linac sections at the end of the present machine.*

FEL scaling laws

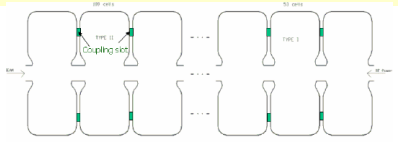


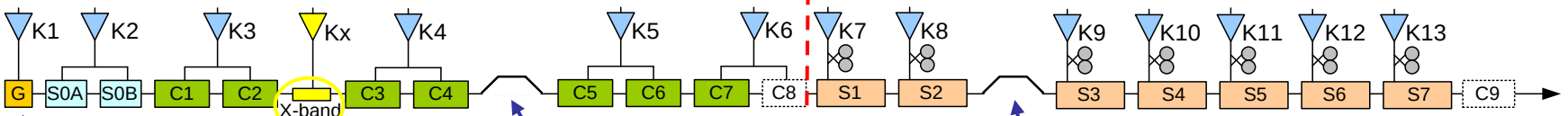
Linac layout

Slac type accel. structures



Nose-cone BTW accel. structures





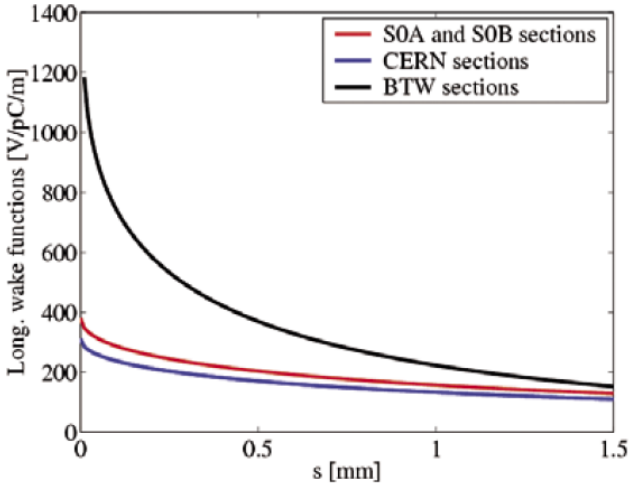
RF photoinj.

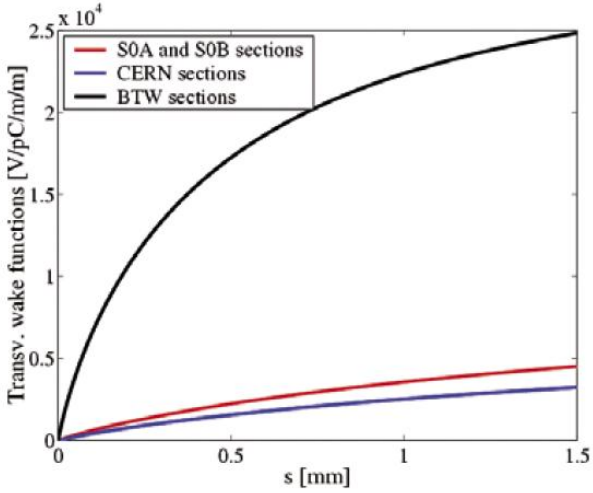
X-band linearizer

1st Magnet. Chicane E~300 MeV R_{56}=0.03 m C.F.=3.5

2nd Magnet. Chicane E~750 MeV R_{56}=0.02 m C.F.=3.0

E=1.5 GeV

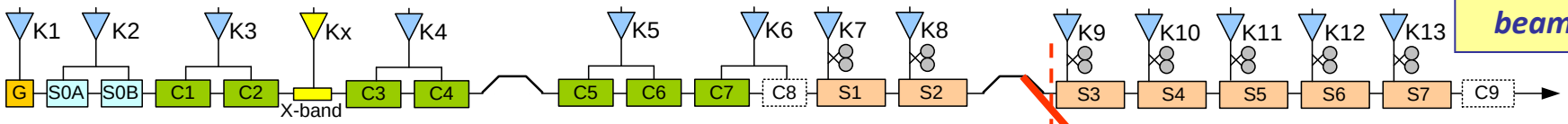




Linac layout and energy ugrading

Present machine layout

- E_{beam} up to 1.5 GeV
- FEL-1 at 80-20 nm and FEL-2 at 20-4 nm
- Seeded schemes
- Long e-beam pulse (up to 700 fs), with "fresh bunch technique"



FEL-1 & FEL-2 beamlines

Beam input energy
≥ 750 MeV

New FEL
beamline $\lambda < 1$ nm

Energy upgrade

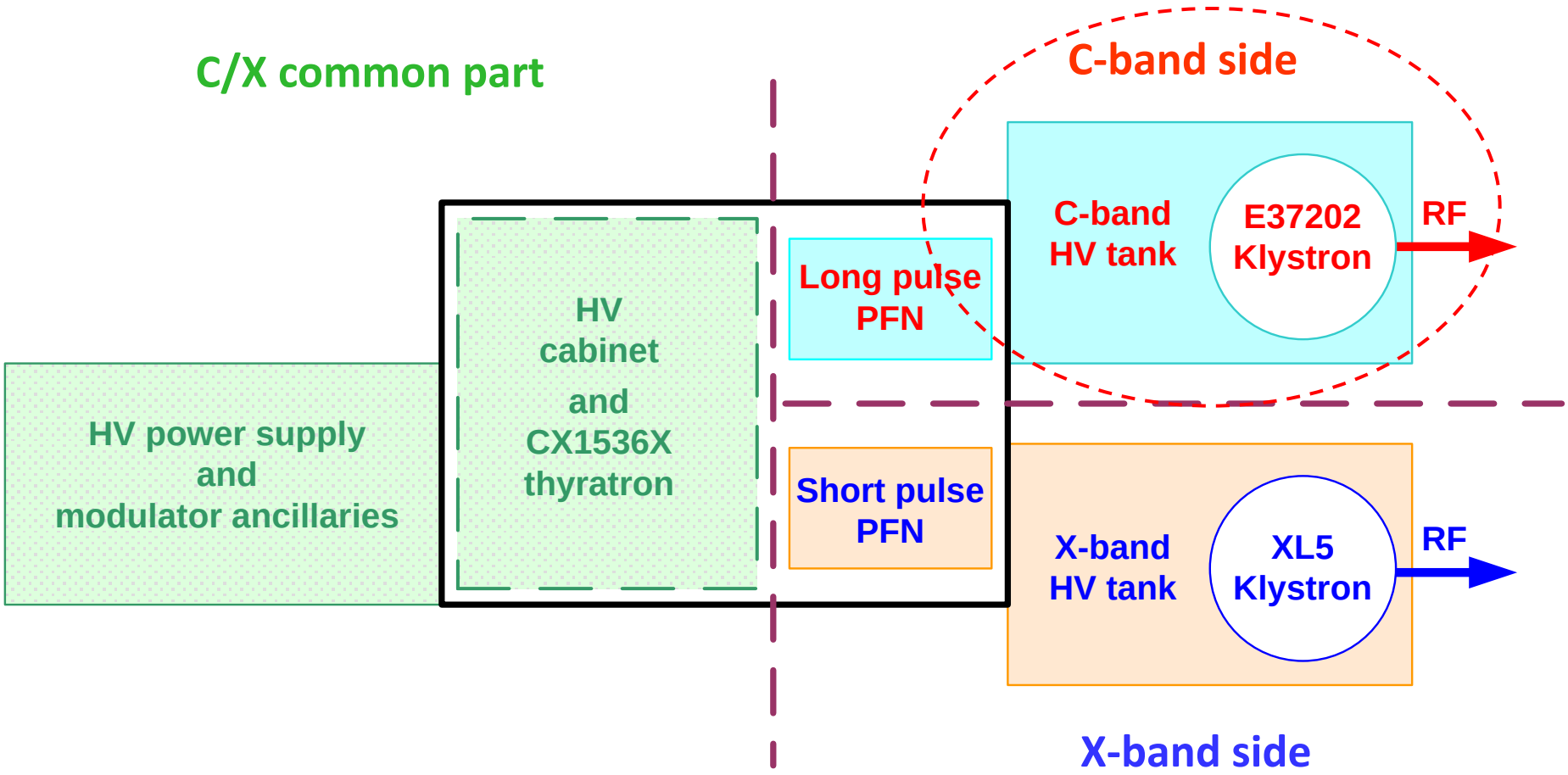
Space available for acceleration	40 m
Accelerating gradient @12 GHz	60 MV/m
X-band linac energy gain	2.4 GeV
Injection energy	.75 GeV
Linac output energy	3.15 GeV

~50 m available

40 m (80%)
available for acceleration

For short bunch (< 100 fs)
and low charge (< 100pC)
operation

New C/X band test station layout



Outlook and conclusions

- An important upgrading of the FERMI@Elettra FEL could be the extension of its waveleght range down to 1 nm or lower.
- This would require an increase of the electron beam energy up to 3.0 GeV.
- Due to the limited space available in the machine tunnel, the use of very high gradient structures is required.
- The X-band technology, working at 60 MV/m, meets this requirement.
- To explore more accurately this possibility, the assembly of a C/X band testing station is now being considered.