ELECTRON LINAC UPGRADE FOR THOMX PROJECT

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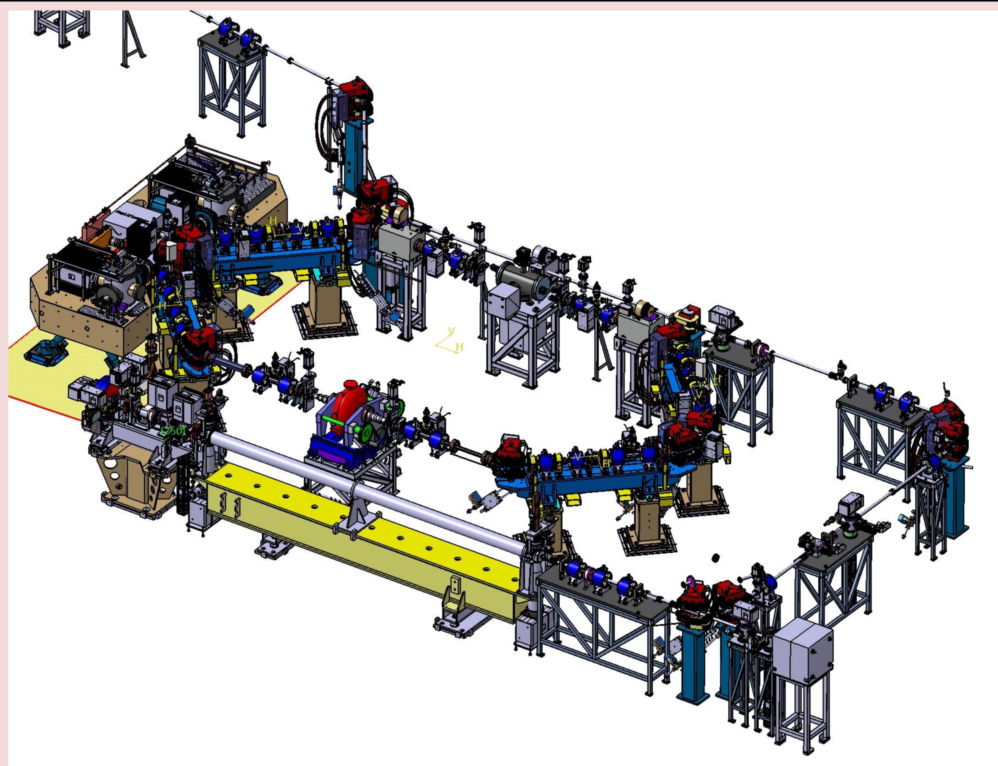
THOMX: A COMPACT HIGH FLUX X-RAYS SOURCE



- Compton back-scattering compact light source machine.
- Collisions between laser pulses and relativistic electron bunches in a optical cavity (Fabry-Perot resonator).
- Intense flux of monochromatic X-rays (10^{12} – 10^{13} ph/s, 45 - 90 keV energy) for a 50 / 70 MeV Linac.
- Low energy electron machine which allows the integration in hospitals or museums.
- THOMX accelerator is under construction in the Orsay university campus.

MOTIVATIONS

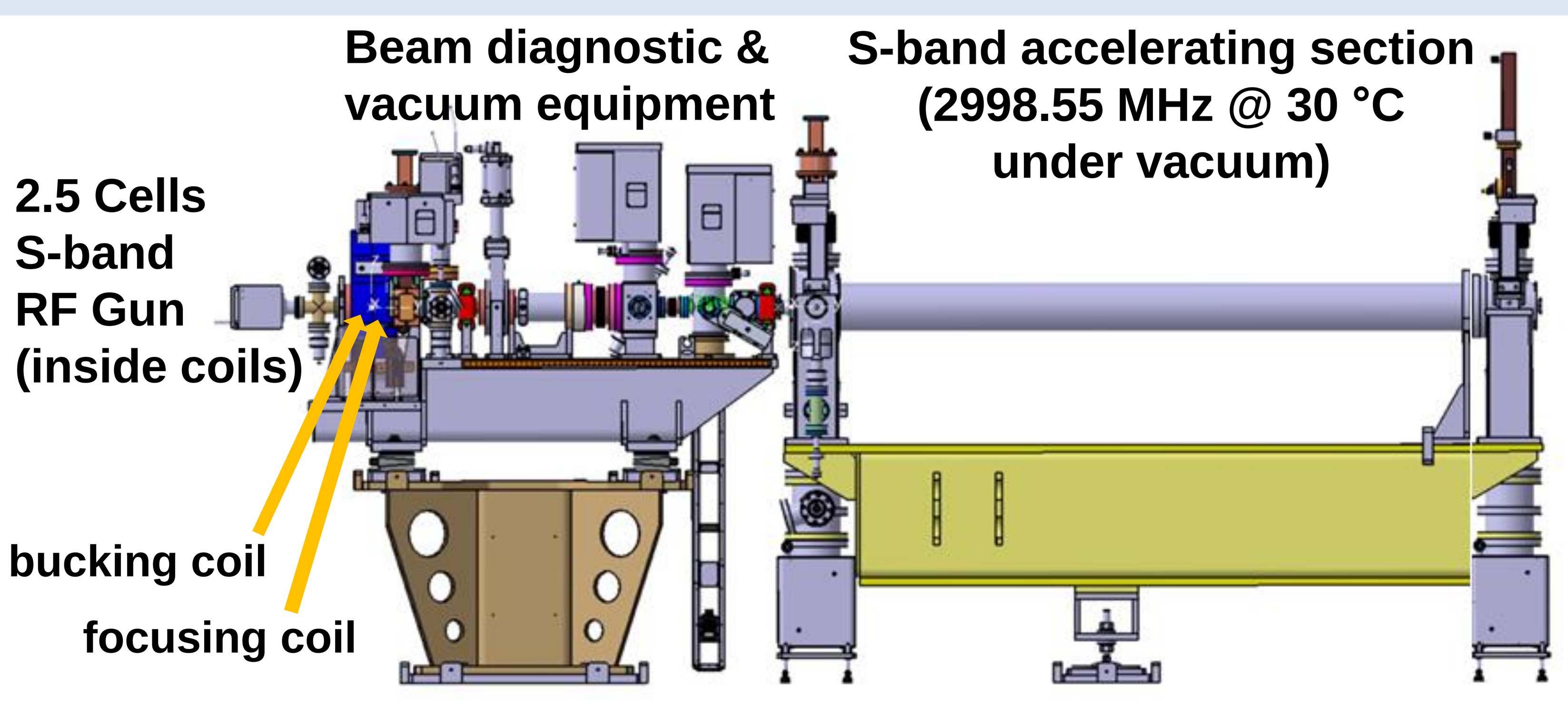
- To accomplish technical specifications at the interaction point, the LINAC has to be carefully designed, especially the photo-injector.

LINAC REQUIREMENTS

- Nominal Energy 50 MeV
- Bunch charge 1 nC
- rms norm. emittance < 5 π mm mrad
- rms energy spread < 0,3 %
- rms bunch length < 5 ps
- Average current 50 nA
- Repetition frequency 50 Hz

THE THOMX S-BAND LINAC SCHEME

- The RF Gun design ➡ almost the same as for the Probe Beam Photo-Injector (PBPI) at CLIC Test Facility 3.
- To avoid vacuum constraints with high efficiency ➡ metallic magnesium photocathode has been chosen.
- RF Gun properties: Q-factor = 15000, shunt Impedance = 50 MΩ/m, pulse = 5 MW, 3 μs, E_{peak} = 80 MV/m, energy gain = 5 MeV.



Commissioning phase:
LIL structure
Standard section

Length: 4.5 m (135 cells)
Travelling wave section (TW)
Quasi-constant gradient field
ΔΦ per cell: 2π/3-mode
$<E_{acc}>$ = 14 MV/m @ 12 MW,
Filling time ~ 1.35 μs
Final Energy: 50 MeV 45 MeV section + 5 MeV RF gun

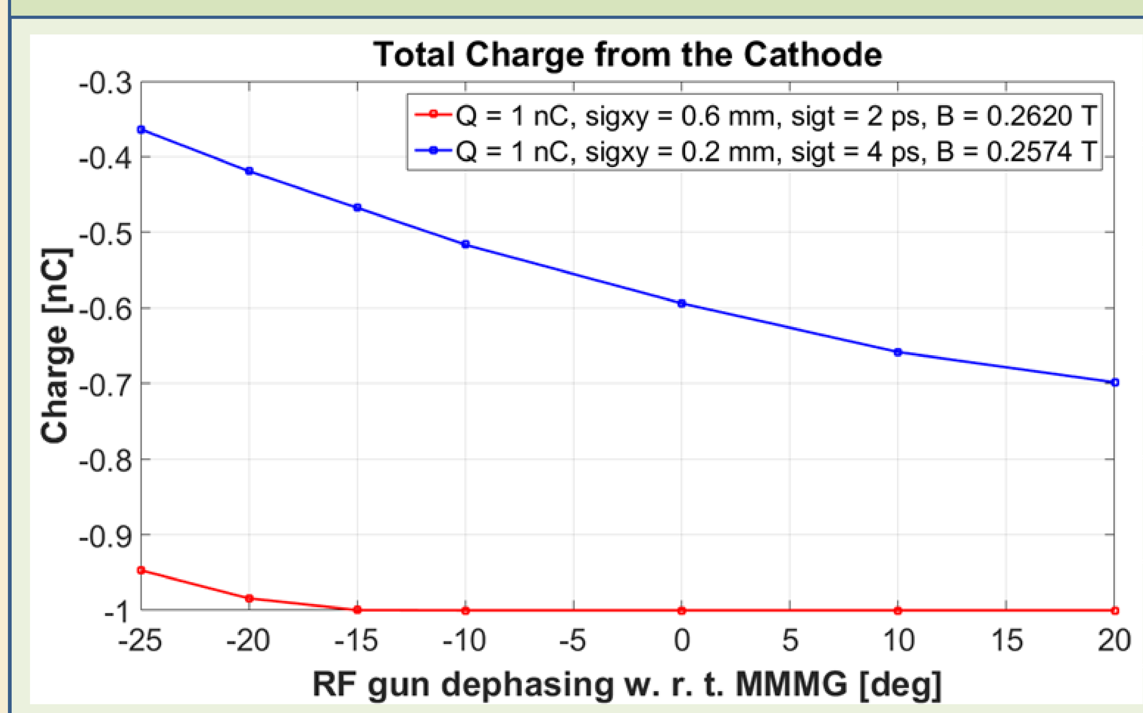
Upgrade ➡ under development

X-rays energy:
50 MeV ➡ γ ~ 45 keV
70 MeV ➡ γ ~ 90 keV

Upgrade phase:
PMB ALCEN - LAL
HG structure (HGAS)

Length: 3.2 m (96 cells)
Travelling wave section (TW)
Quasi-constant gradient field
ΔΦ per cell: 2π/3-mode
$<E_{acc}>$ = 20.5 MV/m @ 22 MW,
Filling time < 1 μs
Final Energy: 70 MeV 65 MeV section + 5 MeV RF gun

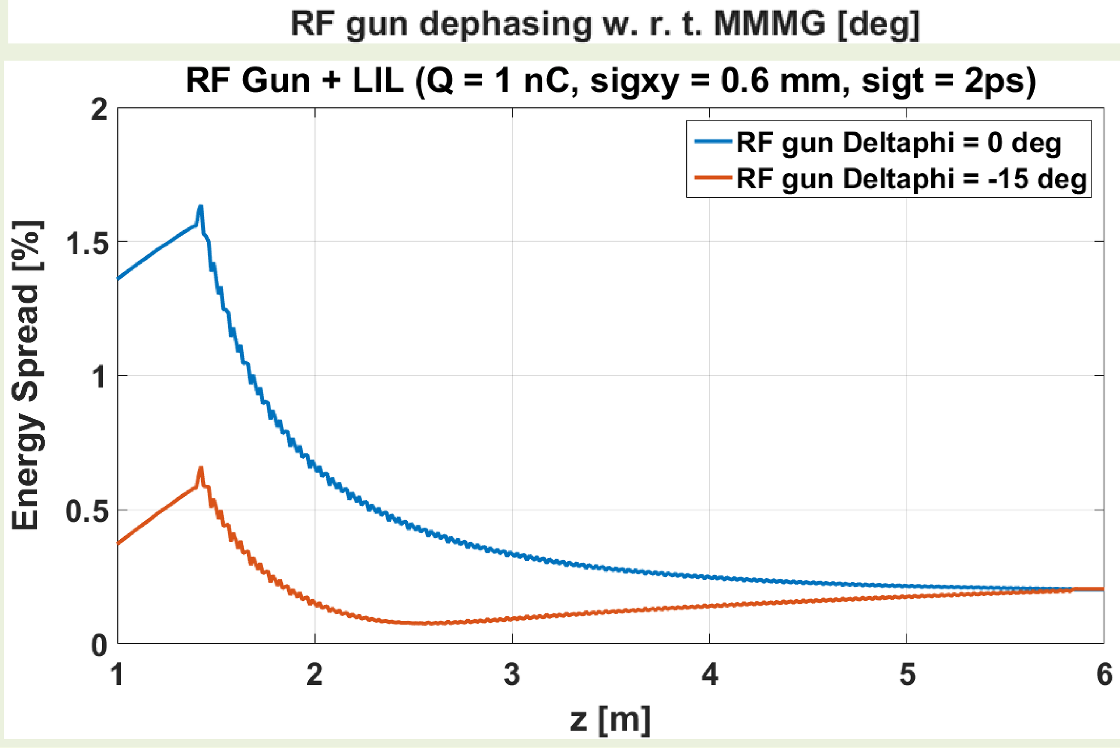
LINAC BEAM DYNAMICS



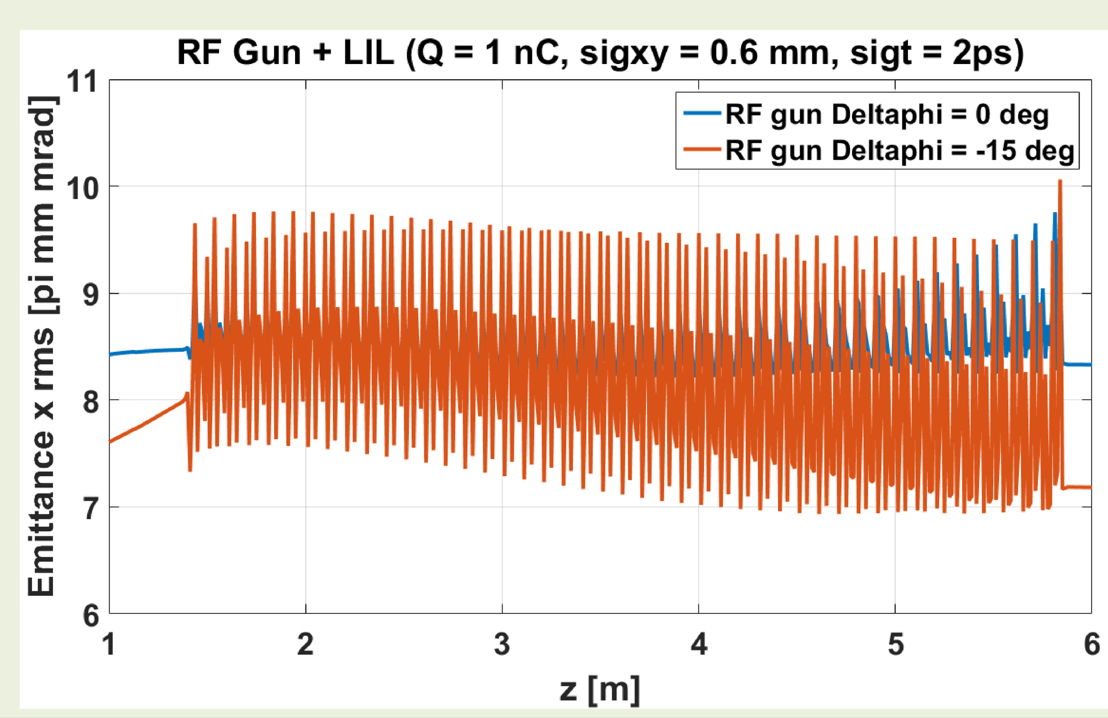
- $\Phi_{RF\ gun}$ = 0°, Φ_{LIL} = 0° Maximum Mean Momentum Gain (MMMG).
- $\sigma_{x,y}$ = 0.2 mm, σ_t = 4 ps, $B_{peak\ coils}$ = 0.2574T ➡ $\varepsilon_{n,x,y,tot}$ = 4 π mm mrad.
- High transverse density e^- emission ➡ strong image charge @ 1 nC.
- $\Phi_{RF\ gun}$ = 0°, $\sigma_{x,y}$ = 0.2 mm, σ_t = 4 ps loses more than 40% of total charge.
- $\varepsilon_{n,x,y,tot}$ & σ_z approximately constant, dephasing has not effect.
- ΔE/E vs $\Phi_{RF\ gun}$ significant variation, dephasing has strong impact.

Beam parameters at z = 1 m

	Dephasing [deg]			
Parameters	-15	-10	0	+10
$\varepsilon_{x,y}$ [π mm mrad]	7.6	8	8.4	8.5
ΔE/E [%]	0.37	0.6	1.3	2.2
σ_z [ps]	3.1	3	3.1	3.4



- ΔE/E = 0.2 % for both cases ($\Phi_{RF\ gun}$ = 0°, $\Phi_{RF\ gun}$ = -15°).
- $\varepsilon_{n,x,y,tot}$ > 8 π mm mrad, $\Phi_{RF\ gun}$ = 0°;
- $\varepsilon_{n,x,y,tot}$ ≈ 7 π mm mrad, $\Phi_{RF\ gun}$ = -15°.
- σ_z ≈ 3.4 ps, $\Phi_{RF\ gun}$ = 0°; σ_z ≈ 3.2 ps, $\Phi_{RF\ gun}$ = -15°.
- σ_x ≈ 3.5 mm in both cases ($\Phi_{RF\ gun}$ = 0°; $\Phi_{RF\ gun}$ = -15°).



CONCLUSIONS & PROSPECTS

- Preliminary beam dynamics investigation on the ThomX Linac ➡ ASTRA tracking code.
- Transverse laser spot $\sigma_{x,y}$ = 0.2 mm, pulse duration σ_t = 4 ps ➡ Nominal $\varepsilon_{n,x,y,tot}$ = 4 π mm mrad out of the RF gun; at the expense of ΔE/E & σ_z. (*)
- A first set of parameters: $\sigma_{x,y}$, σ_t, $E_{peak\ RF\ gun}$, $<E_{LIL}>$, $B_{peak\ coils}$ strengths and RF gun dephasing for energy spread minimization, has been proposed.
- The set $\sigma_{x,y}$ =0.6 mm, σ_t = 2 ps, $E_{peak\ RF\ gun}$ = 80 MV/m, $<E_{LIL}>$ = 14 MV/m, $B_{peak\ coils}$ = 0.2620 T, $\Phi_{RF\ gun}$ = -15°, Φ_{LIL}= 0° respect with $\Phi_{RF\ gun}$ = 0°, Φ_{LIL}= 0° Maximum Mean Momentum Gain (MMMG) allows to obtain ΔE/E = 0.2 % with $\varepsilon_{n,x,y,tot}$ = 7 π mm mrad, σ_z = 3 ps, σ_x = 3.5 mm.
- To improve ΔE/E with $\varepsilon_{n,x,y,tot}$, σ_z trade off ➡ better position of solenoids & accelerating cavity, several $H_{peak\ coils}$, strength, high gradient accelerating section electric field profile (PMB ALCEN – LAL section).

* L. Garolfi et al., "BEAM DYNAMICS SIMULATIONS OF THE THOMX LINAC", Proceedings of IPAC2016, Busan, Korea.