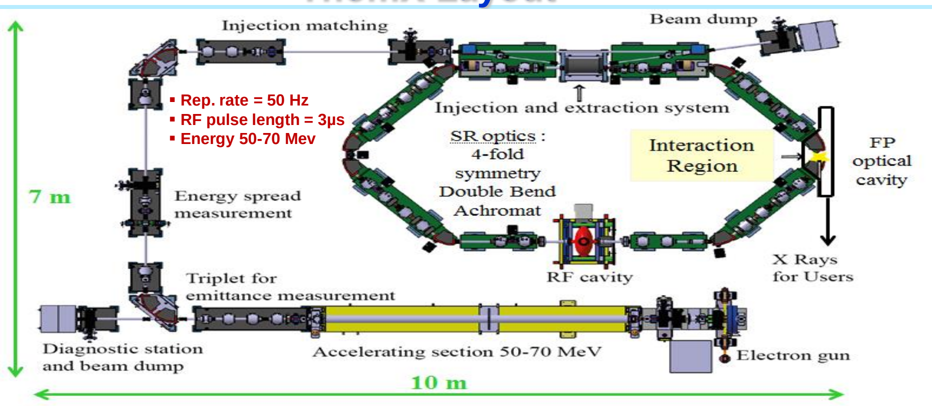
THE RF SYSTEM OF THOMX

M. El Khaldi, R. Marie, H. Monard , F. Wicek
LAL, Orsay, France
M. Diop, R. Lopes, A. Loulergue, M. Louvet, P. Marchand, F. Ribeiro, R. Sreedharan
SYNCHROTRON SOLEIL, Gif- sur -Yvette, France

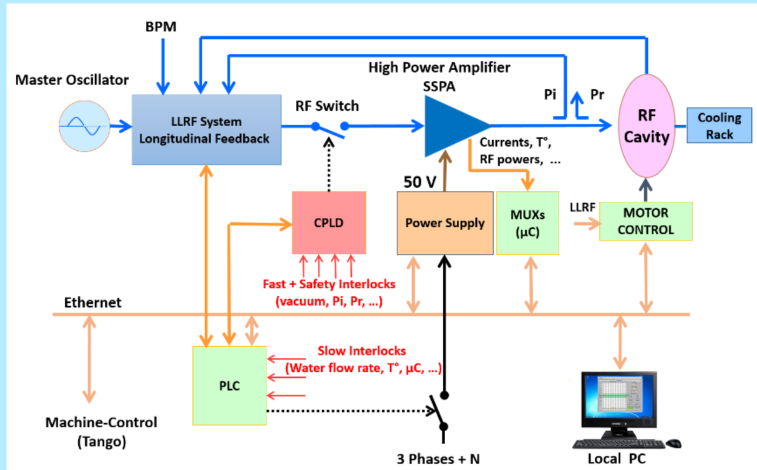
LINAC 16 — 28th LINEAR ACCELERATOR CONFERENCE — East Lansing, MI USA 25-30 September

ThomX Layout



Injection of a single e^- bunch (1nC; 16.7 mA), which collides at each turn with laser pulses at the IP, inside the FP optical resonator → Hard X rays (45-90 keV), average flux (10^{11}-10^{13} ph/s) from Compton Back Scattering.

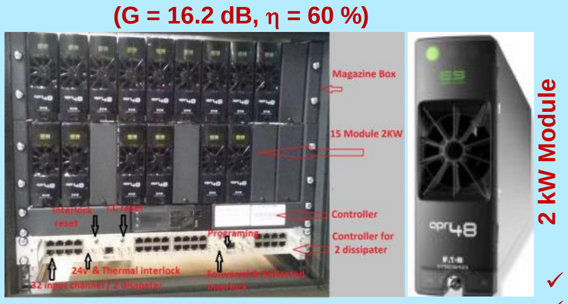
RF Control System for ThomX Storage Ring



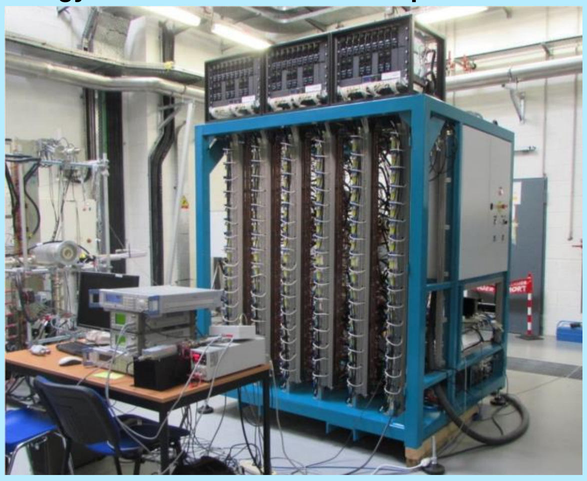
500 MHz Solid State Power Amplifier (SSPA)

SSPA using 6th generation LDMOS (BLF578) technology : based on 560 W CW amplifier modules → 96 amplifier modules are mounted on 6 dissipaters

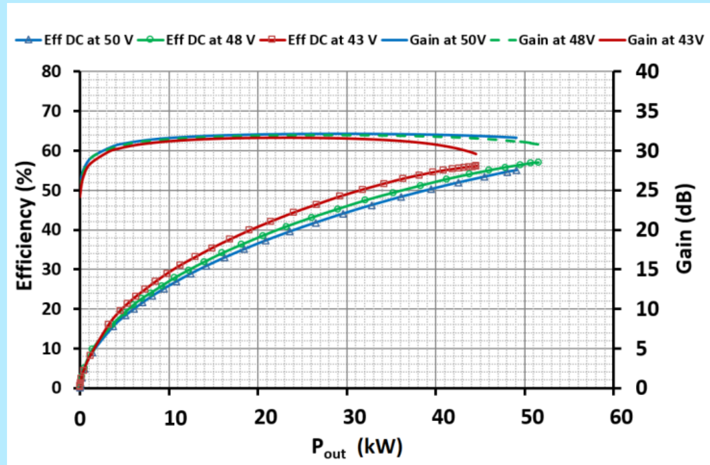
560 W CW- 500 MHz amplifier module
(G = 16.2 dB, η = 60 %)



Eaton APR48-Energy Saver 220 V AC / 50 V DC power converters (High efficiency: 96%)

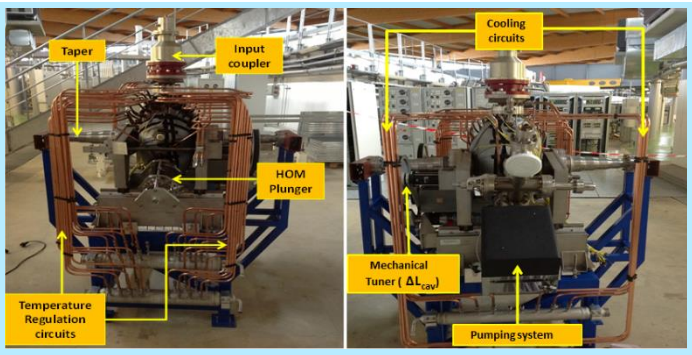


- ✓ February 2015: SSPA assembling
- ✓ March 2015: First tests on dummy load up to 52kW CW
- ✓ April 2015: All measurements achieved (pulse & CW, with full reflection and VSWR of 2.5:1)



For P_{out} = 51.5 kW (DC voltage =48 V) @ 1 dB gain compression point
→ Eff (DC)= 57% Eff (AC) = 54.7%

500 MHz RF Cavity



Single cell copper cavity of the ELETTRA type, with 2 tapers made of 316L stainless steel

Required voltage, V_{RF} = 500 kV → $P_{RF} \approx$ 50 kW

HOM fequency tuning → Prevent resonant excitation by the beam

- Cavity temperature control : 30 to 70°C (stability of ± 0,05°C)
- Movable HOM frequency shifter plunger (HOMFS)
- Axial deformation : ΔL_{cav} → Δf_o (~ 155 kHz/mm fundamental mode)

Thomx heat exchanger (cooling rack), similar to that was designed by the ESRF

Two of the ESRF cavity cooling racks.

❖ HOM impedance and instability thresholds

ΔU_{rad} ~ 0 → $\tau_{damping}$ (~ 1 s) >> $\tau_{storage}$ (~ 20 ms)

To preserve the beam quality → Instability growth time , τ_i > 20 ms

→ Impedance thresholds : ~ 5 kΩ/m for dipole and 0.5 kΩ.GHz for monopole modes

→ In both, longitudinal & transverse cases, damping of Z_{HOM} by few 10^3 is required !!

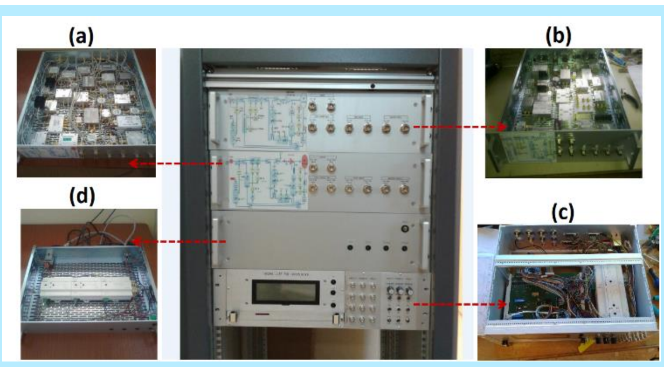
❖ Cures to HOM impedances

- « HOM de-Qing » → limited to a few 10^2 over a wide frequency range
- « HOM frequency tuning » more efficient for a small machine like ThomX :
  - Beam spectral line spacing, δf = 16.7 MHz >> BW_{HOM} ~ a few 10 KHz
  - HOM effective impedance, seen by the beam : $R_{eff} \approx R_s/(2Q_o.\delta f/f_{HOM})^2 << R_s$

Although the modes which propagate into the tapers are less critical than the trapped modes, their impedances are still above the specified thresholds

→ Longitudinal & Transverse Feedbacks are required to bring additional damping

Low Level RF & Feedback Systems



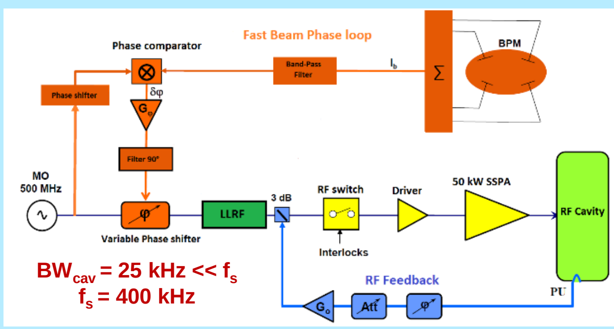
LLRF feedback and control systems; (a) LLRF (amplitude, phase & tuning loops) and LFB; (b): LLRF (IQ modulation/demodulation technique, tuning loop) and LFB; (c) PID controller and safety interlocks; (d) DC power supply.

LLRF → Compensation of slow perturbations >> τ_f^{cav} = 40 μs

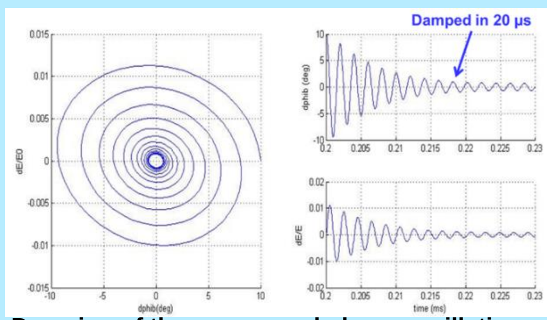
Comp.

- V_{cav} (A, φ) cst <=> δT, δp, Power supply ripple @ k. 50 Hz ± 0.1 % in A , ± 0.1° in φ & BW ~ few kHz (τ_{rep} ~ 1 ms)
- Mechanical tuning: BW ~ 1 Hz (τ_{rep} ~ 1 s)

TFB Rack based on FPGA processing,



BW_{cav} = 25 kHz << f_s
f_s = 400 kHz



Damping of the energy and phase oscillations with the LFB ($\Delta\phi_{inj}$=10°, G_o=50, G_ϕ=5, δ=150ns)

Fast perturbations @ fs → δEi , δΦi errors at inj., HOM…

LFB = Fast Beam Phase Loop + RF FB → $\tau_{damping}$ (~ 20 μs)

RF FB → BW_{eff} = BW_{cav} x (1 + G_o) > f_s → Modulate V_{cav} at f > f_s
($d_{ampli-cav}$ ~ 10 m → δ = 150 ns → G_o ~ 50 → BW_{eff} > 1 MHz >> f_s)

Phase loop (BW > f_s)
- Phase comparison between V_{MO} & I_b (BPM)
- The error signal, dφ (+ 90°) controls a PS

Conclusion

The THOMX RF system is being completed; its integration and commissioning in ThomX is scheduled for 2017. At first, the RF cavity will be RF conditioned up to full power with its final SSPA in the casemate "shielded room" of the new IGLEX research platform located on the Orsay university campus. Then the complete RF system will be implemented and commissioned in the ThomX storage ring.