CERN Lab activities related to PHIN

1. **DC and RF gun results with cesium telluride photocathode :**
   a) Cathode produced by the standard evaporation process
   b) Cathode produced by co-evaporation
2. **CTF3 photocathode requirements**
3. **Photocathode studies: CERN proposal**
4. **The CTF3 photo-injector: CERN part**
5. **Installation**
6. **Schedule**

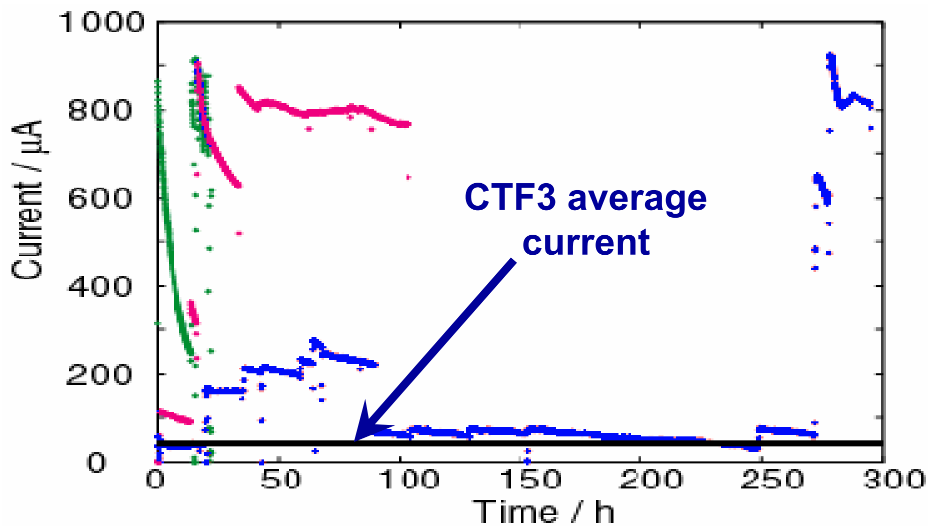
Standard evaporation process : Cs_2Te typical results

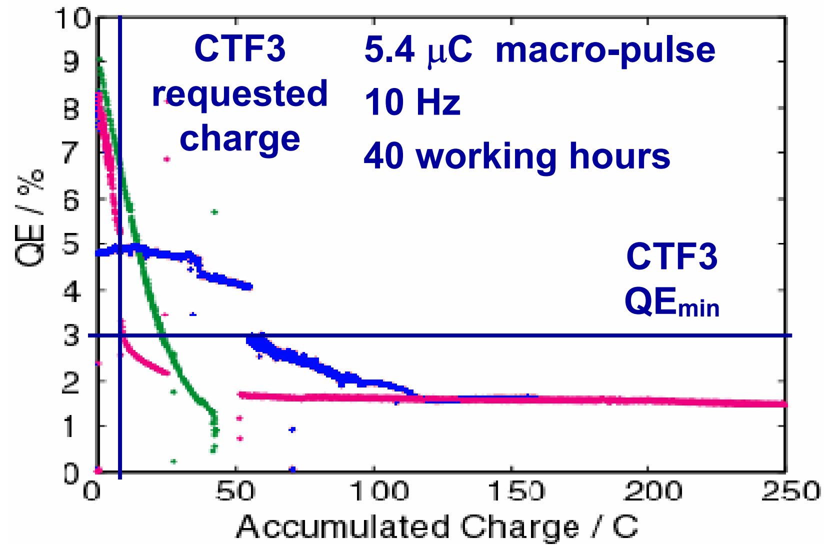
Standard evaporation process means : evaporation of an alkaline layer over a tellurium layer on different substratum

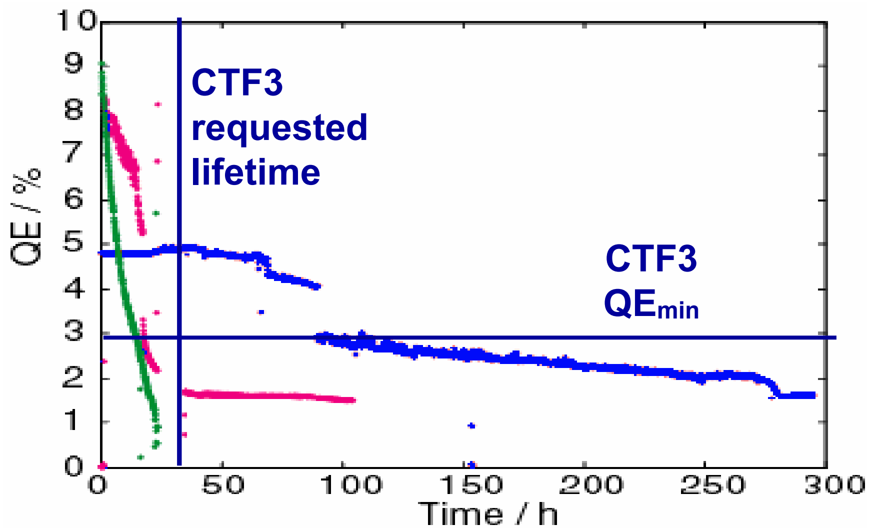
Typical results with Cs_2Te	DC gun (35 cath.)	RF gun (49 cath.)
Nom. electric field	8 MV/m	100 MV/m
Peak current	20 A	Few kA
Pulse width (FWHM)	6 ns	10 ps
Higher mean current	1 mA	8 μA
Best substratum	Au	Cu – Au (?)
Starting QE	4 % ≤ QE ≤ 22 %	2 % ≤ QE ≤ 8 %
Typical lifetime with QE > 1.5 %	Few months (extrapolated)	Few weeks
Working vacuum pressure	10^{-10} mbar	1 – 5 x10^{-9} mbar
Storage vacuum pressure	few 10^{-11} mbar	10^{-10} mbar

Standard evaporation process : High charge test (mC)

Cs_2Te photo-cathodes tested in the DC gun @ 9 MV/m
Up to 300mW UV on the cathode ; 100 ns pulse length, 10 A, 1kHz Rep.Rate







J_{max} = 21 mA/cm^2

F_{max} = 6 W/cm^2 @ 266 nm

Up to QE_{min} = 3 % Cs_2Te photo-cathodes fulfill CTF3 specifications

Recap of photocathode studies

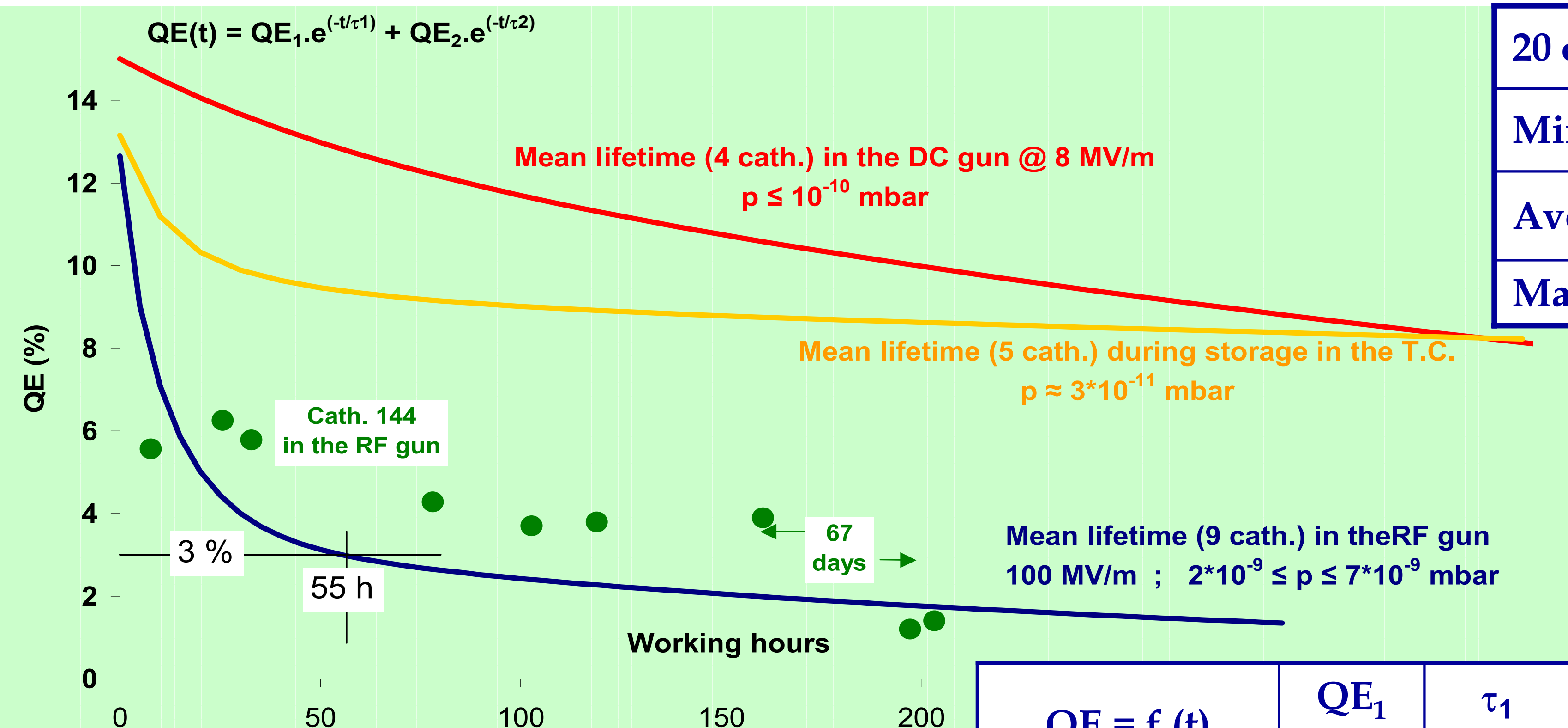
Since 1991 we tested many sorts of photocathodes :

1. **Metallic photocathodes : Al, Au, Cu, Mg, Mo, Sm, Y**
   - QE < 10^{-3} even with special treatment (etching, laser conditioning)
   - QE too low for high charge production : very high powerful laser and/or plasma production at the photocathode. Not suitable for our application
2. **Alkali-antimonide photocathodes : Cs_3Sb, K_2CsSb, K_3Sb**
   - Need ultra high vacuum
   - Good QE at visible light but lifetime too short (few hours) not suitable for our application
3. **Alkali-telluride photocathodes : Cs_2Te, Rb_2Te, RbCsTe, Li_2Te**
   - Need UHV
   - RbCsTe and Rb_2Te : possible rejuvenation after air exposure by heating or etching
   - **Cs_2Te : standard photocathode for our applications** : few % during weeks at high charge and high electric field (up to 120 MV/m)
4. **Other photocathodes : CsI, CsI+Ge, Cs_3As, GaAsO, PLZT, TiO_2**
   - CsI+Ge had been used from 1994 to 2000 in the Probe Beam RF gun because it is air transportable
   - We had no success with the GaAs activation for e-pol. production : preparation chamber not adapted to this application

Photocathodes were deposited on different substrates (Al, Au, Cu, Mg, Mo, Stainless Steel) chemically cleaned and/or cleaned by argon ion bombardment :

Cu with chemical and etching cleaning with RF conditioning seems to be the best for high electric field.

Co-evaporation process



20 cath.	QE(%)
Min	8.2
Average	14.9
Max	22.5

QE = f (t)	QE_1 %	τ_1 (h)	QE_2 %	τ_2 (h)
Transport carrier	3.85	18.9	9.17	3311
DC gun	2.24	65.9	12.74	779.5
RF gun	9.2	14	3.4	315

Evaporation at room temperature

	Tellurium	Cesium	
Thickness	1.3 - 11	3.9 - 49	nm
Evap. rate	0.1 – 0.5	0.5 - 2	nm/mn

Photocathode Requirements for the CTF3 - DB

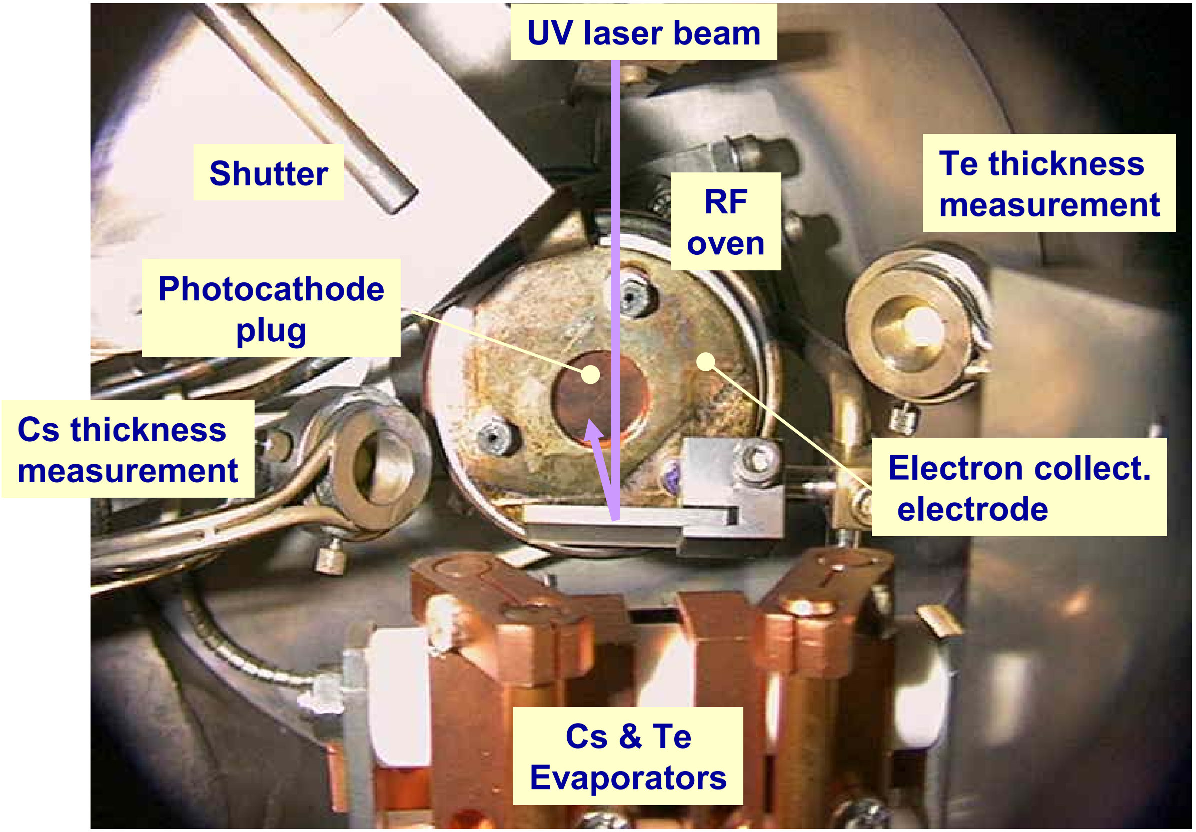
- Photocathodes with a QE ≥ 3 % during at least 40 working hours
- A photocathode production to guarantee a continuous run of at least 6 months

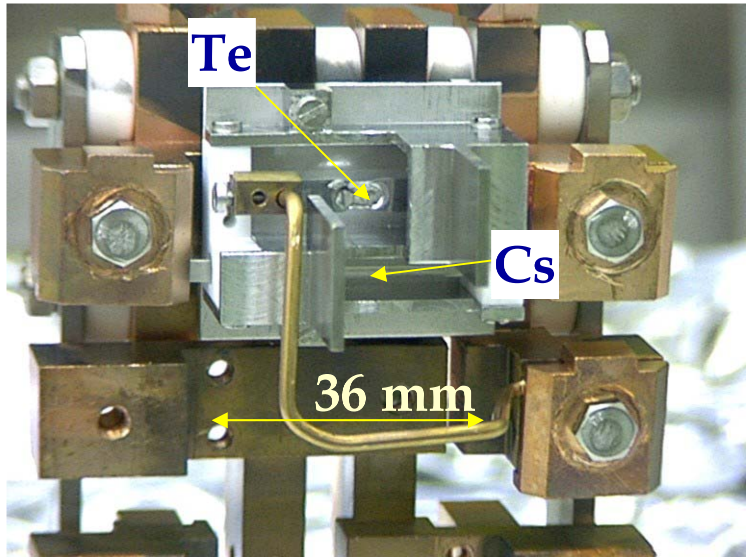
For that we have to do :

- A complete maintenance of the preparation chamber and of the transport carrier (for CTF2 and CTF3 thermoionic gun area installation)
- Adapt the RF gun transfer chamber (MPC) to the new gun and to the new sites (we assume the same photocathode plug)
- Re-use and/or develop an automatic RF conditioning process
- Pursue photocathode studies mainly to increase the lifetime, the reproducibility, and to fulfil the CLIC requirements
- Design and built new transport carrier and/or MPC for installation in the CTF3 linac area (not scheduled)

Photocathode studies – CERN proposal

- Reproducibility of alkali-telluride photocathodes produced by co-evaporation
- Study of alkali-antimonide photocathodes produced by co-evaporation
- Comparison between telluride and antimonide cathodes for the CTF3 specifications

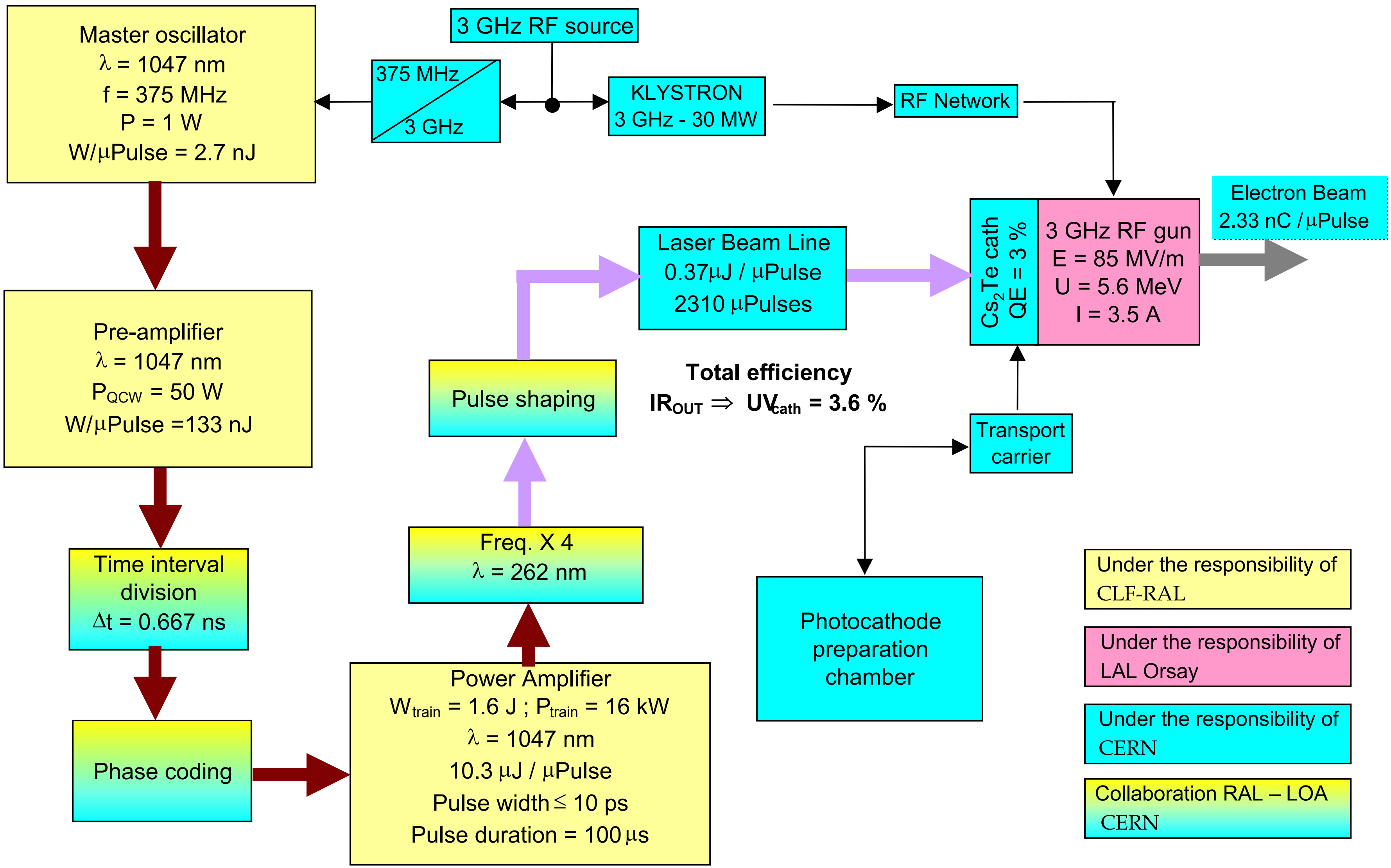




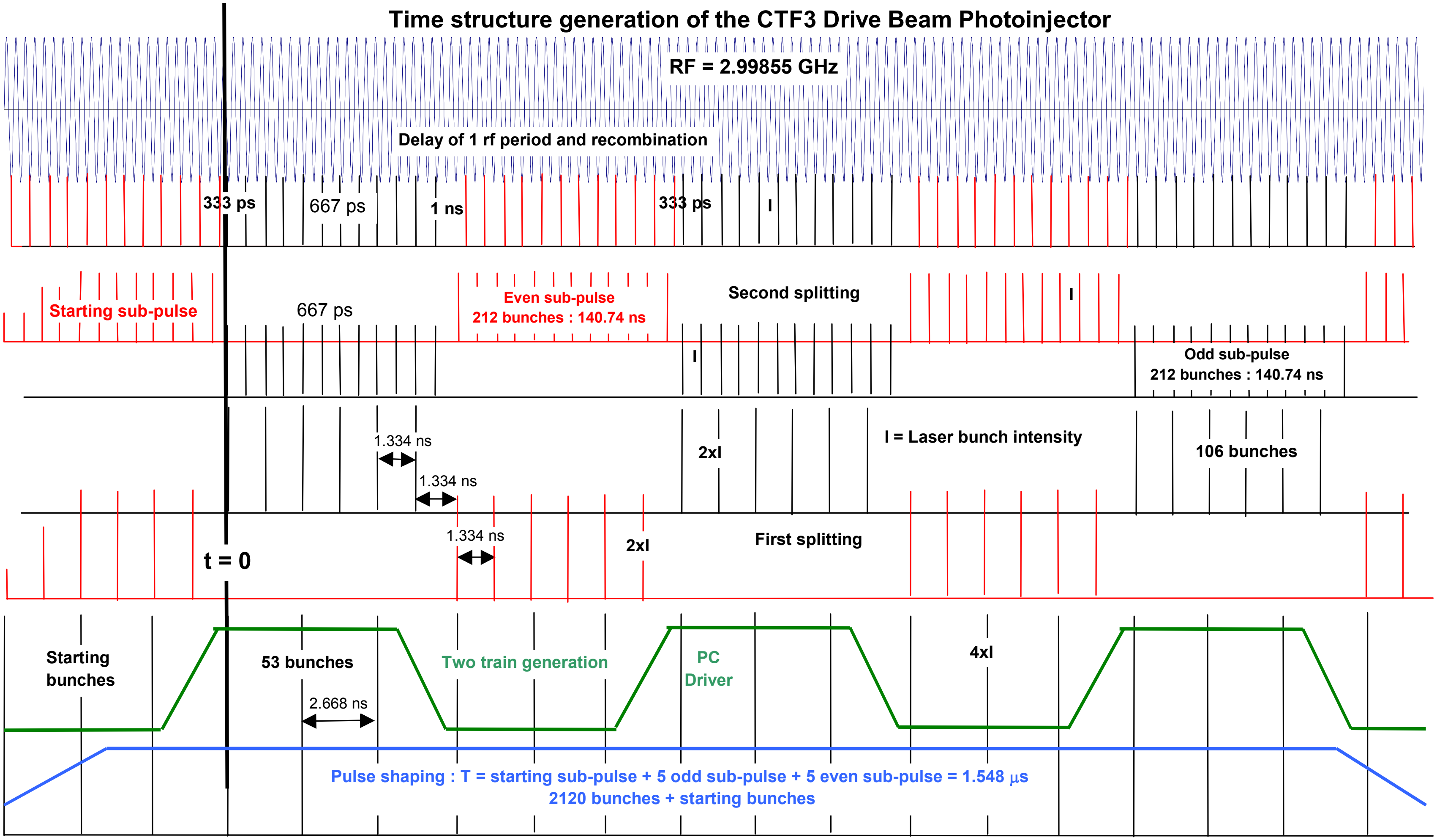
Preparation chamber developments

- Stoïchiometric ratio measurement
- Evaporation rate control
- Evaporator design for co-evaporation

The CTF3 photo-injector



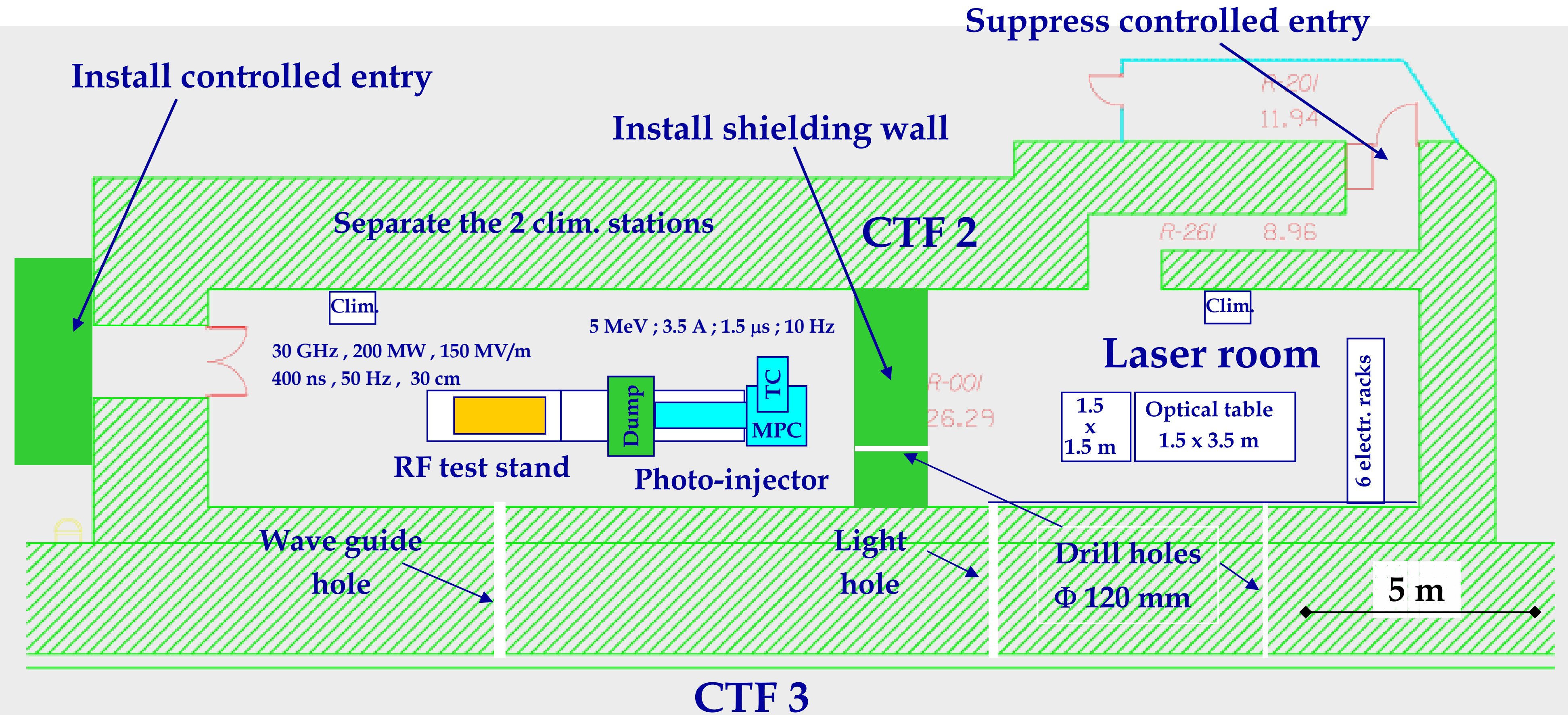
Pulse Train production



CTF3 photo-injector: CERN participation

- Laser :
  - Pulse train generation
  - Pockel's cell study
  - Harmonic conversion efficiency study
  - Laser monitoring
  - Feedback control, amplitude regulation
  - Automatic control of the laser beam position
- Timing
- Photocathodes
  - Maintenance of preparation chamber, TC and MPC
- RF power
- Installation and commissioning

Installation : Photo-Injector in the CTF2



Installation : Photo-Injector in the CTF3

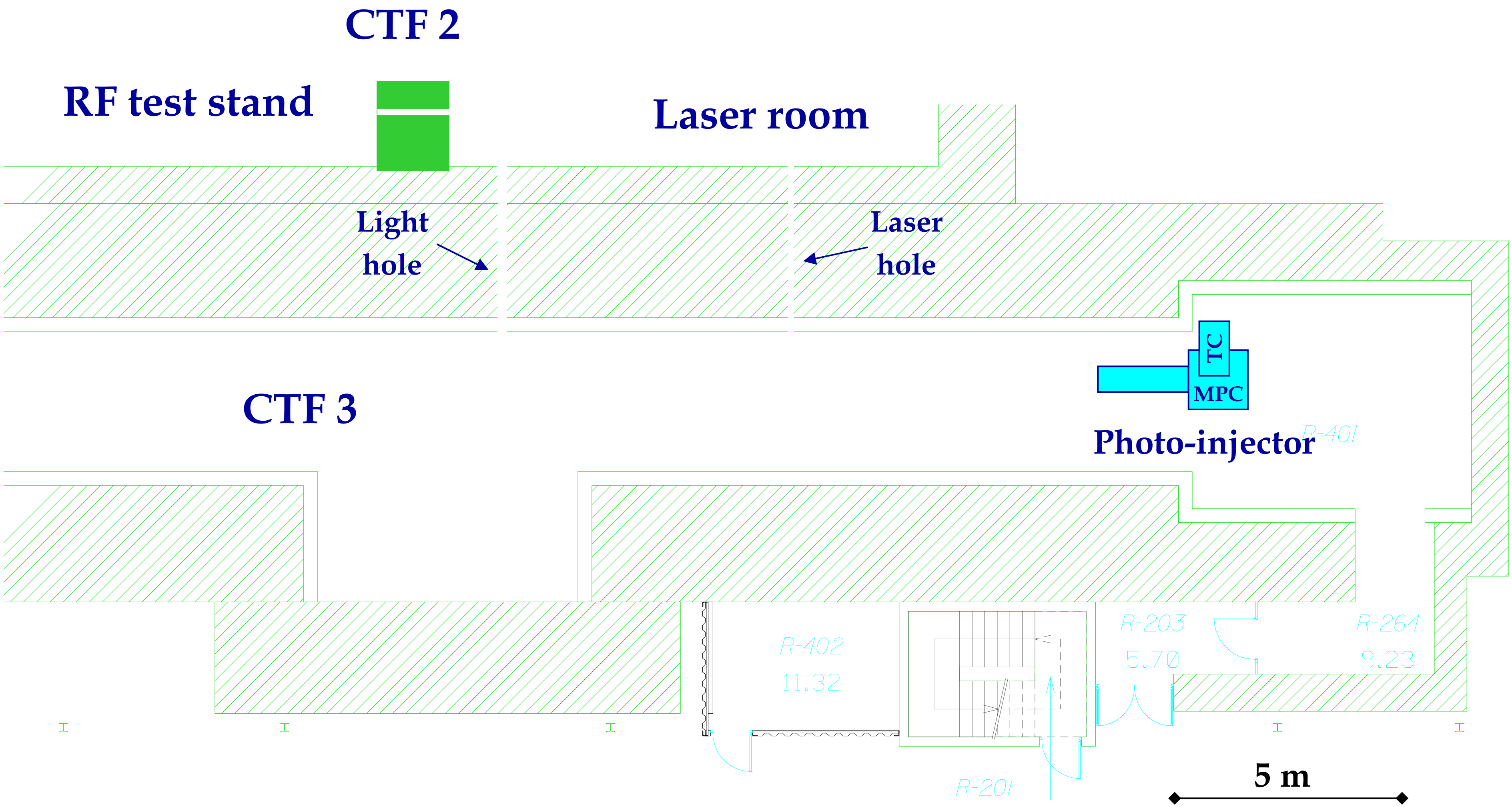
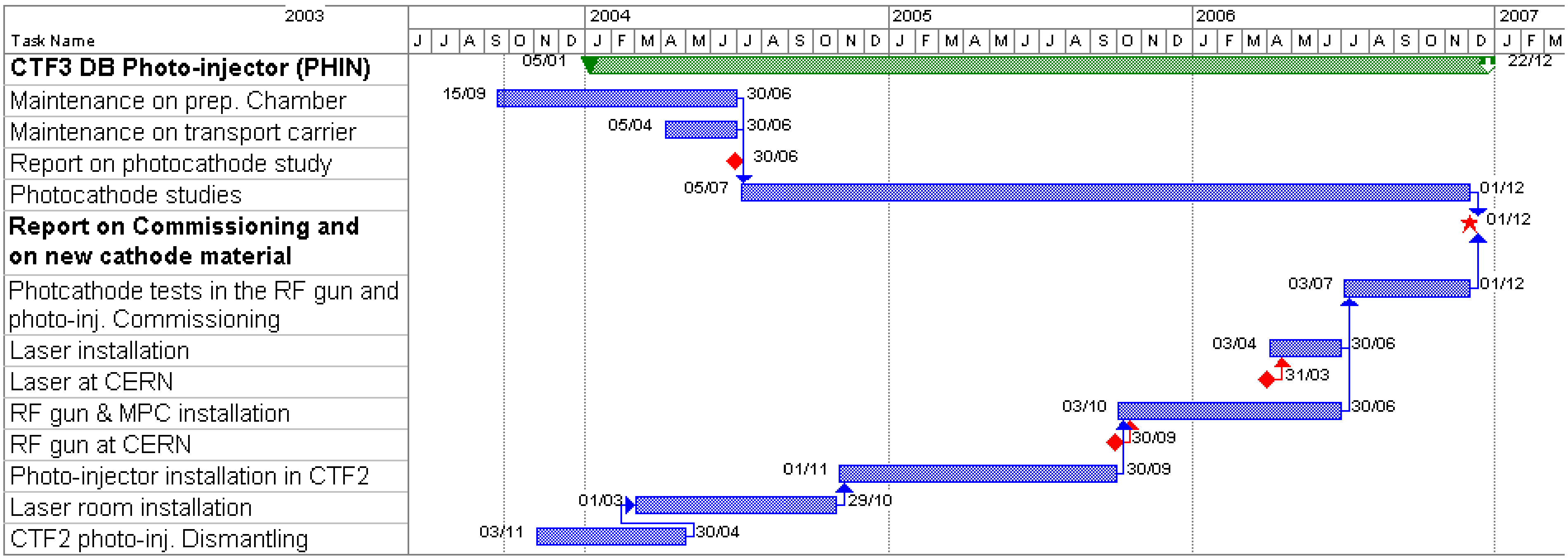


Photo-injector as the CTF3 source

Schedule

Realization of the photo-injector option in two steps :

- **Operational photo-injector in the CTF2 in the end of 2006**



- **Operational photo-injector in the CTF3 in the middle of 2007**
  - Installation during the shut-down 2006-2007
  - Commissioning spring 2007