# The Photoinjectors for CTF3

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CTF3 Collaboration Meeting

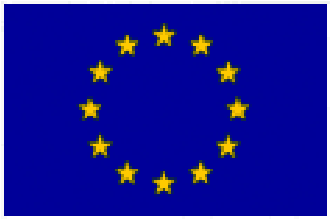
30/11/2005

# OUTLINE

- DRIVE Beam
- PROBE Beam
- Conclusions

# DRIVE Beam

- Photoinjector Funded jointly by :





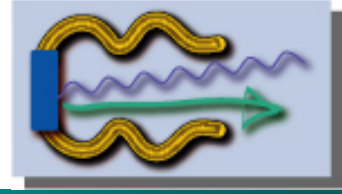
- We acknowledge the support of the European Community-Research Infrastructure Activity under the FP6 "Structuring the European Research Area" programme (CARE, contract number RII3-CT-2003-506395).



# DRIVE Beam

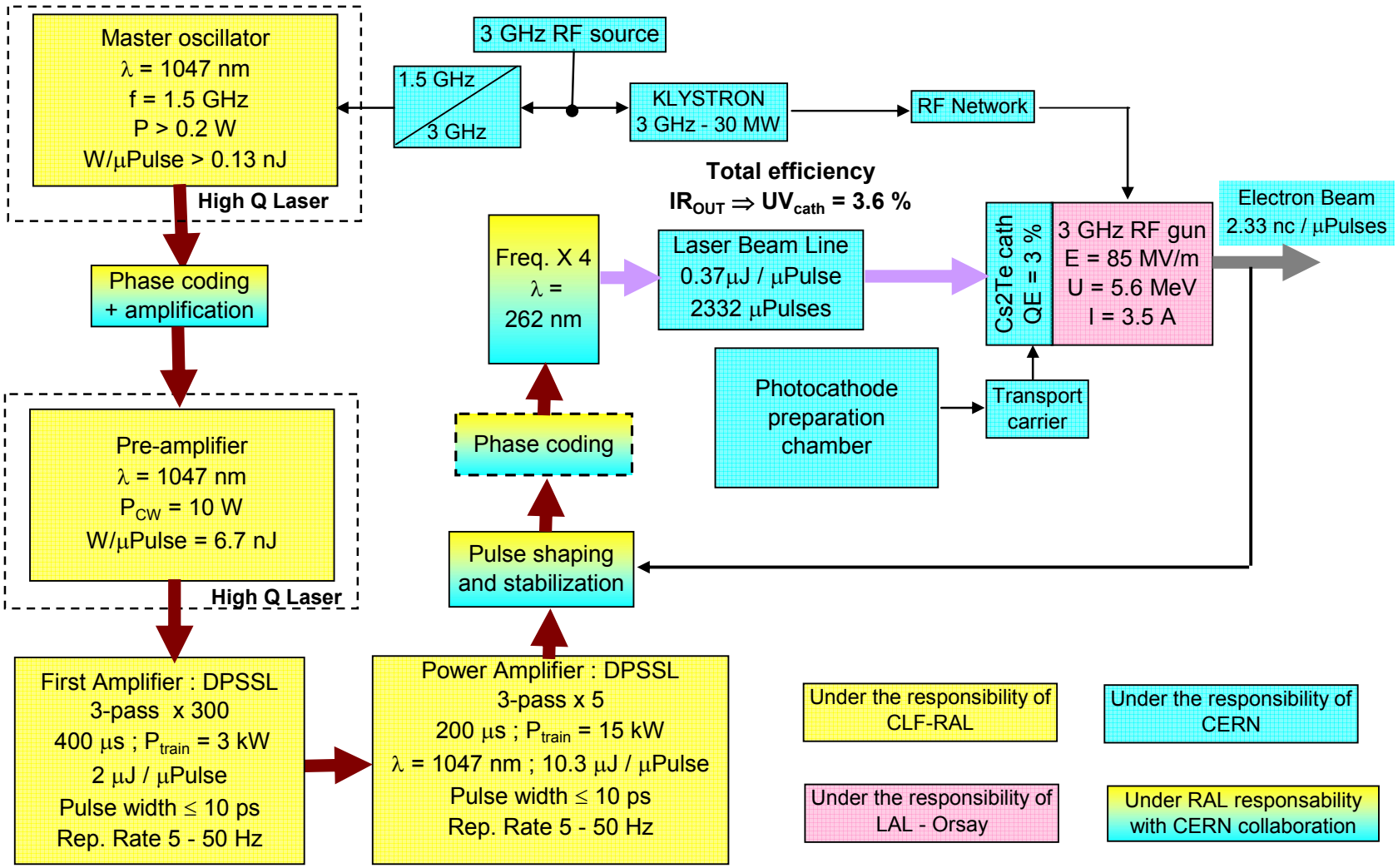
| | | |
|---|---|---|
| Pulse train duration | 1.548 | μs |
| Pulse train charge | 5434 | nC |
| Average current in the pulse train | 3.51 | A |
| Number of bunches in the sub-pulse | 212 | |
| Odd/even sub-pulse width (FWHH) | 140.735 | ns |
| Number of bunches in the pulse train | 2332 | |
| Charge / bunch | 2.33 | nC |
| Distance between bunches | 0.667 | ns |
| Bunch width (FWHH) | 10 | ps |
| $\varepsilon_T$ normalized (rms) | ≤25 | π.mm.mrad |
| Δp/p (rms) | ≤2 | % |
| charge stability | ≤0.25 | % |
| Repetition rate | 1 - 50 | Hz |
| Mean current @ 50 Hz | 271.68 | mA |

# DRIVE Beam

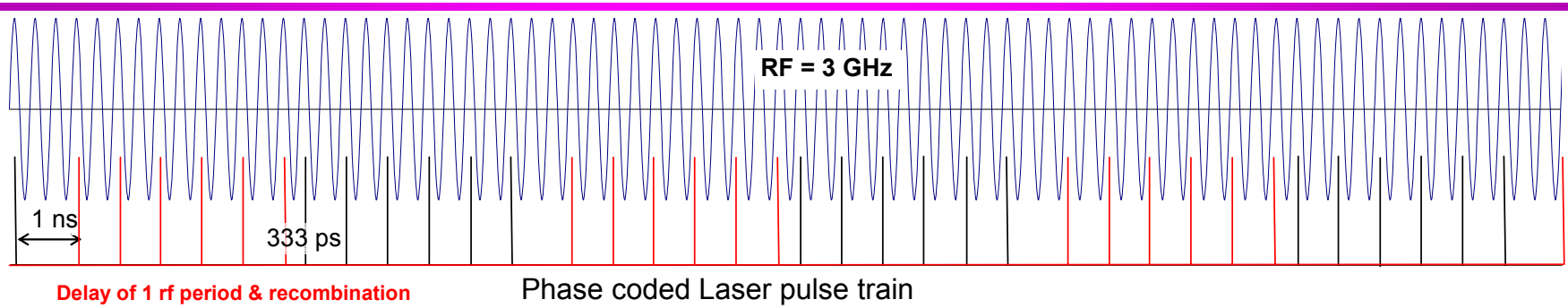


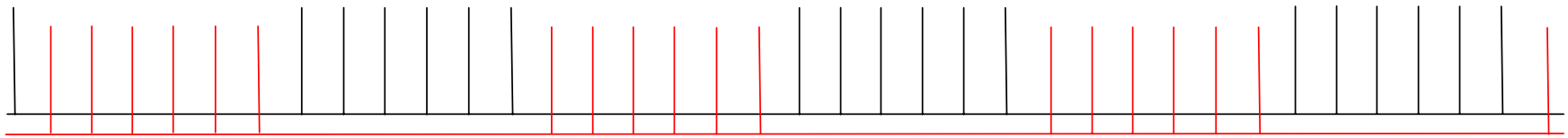
- OPTIONS:
  - Single bunch
  - 3 GHz, 5 Amps

# DRIVE Beam

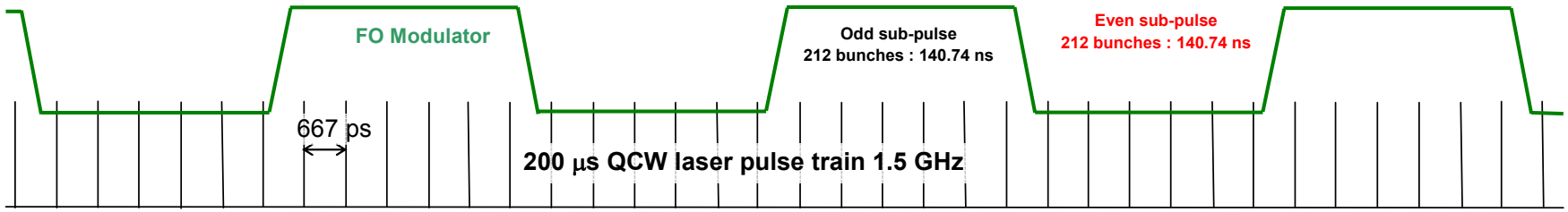

Master oscillator
λ = 1047 nm
f = 1.5 GHz
P > 0.2 W
W/μPulse > 0.13 nJ
High Q Laser
3 GHz RF source
1.5 GHz
3 GHz
KLYSTRON
3 GHz - 30 MW
RF Network
Total efficiency
IR_OUT ⇒ UV_cath = 3.6 %
Electron Beam
2.33 nc / μPulses
Phase coding
+ amplification
Freq. X 4
λ =
262 nm
Laser Beam Line
0.37μJ / μPulse
2332 μPulses
Cs2Te cath
QE = 3 %
3 GHz RF gun
E = 85 MV/m
U = 5.6 MeV
I = 3.5 A
Photocathode
preparation
chamber
Transport
carrier
Pre-amplifier
λ = 1047 nm
P_CW = 10 W
W/μPulse = 6.7 nJ
High Q Laser
Phase coding
Pulse shaping
and stabilization
First Amplifier : DPSSL
3-pass x 300
400 μs ; P_train = 3 kW
2 μJ / μPulse
Pulse width ≤ 10 ps
Rep. Rate 5 - 50 Hz
Power Amplifier : DPSSL
3-pass x 5
200 μs ; P_train = 15 kW
λ = 1047 nm ; 10.3 μJ / μPulse
Pulse width ≤ 10 ps
Rep. Rate 5 - 50 Hz
Under the responsibility of CLF-RAL
Under the responsibility of CERN
Under the responsibility of LAL - Orsay
Under RAL responsability with CERN collaboration

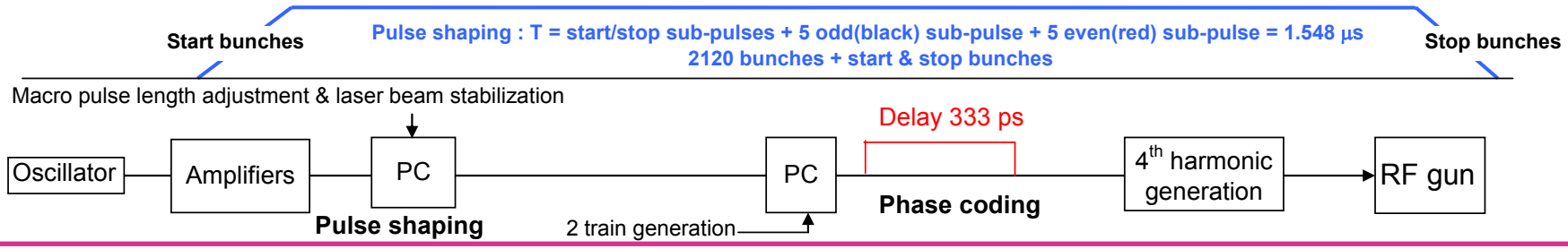
# DRIVE Beam



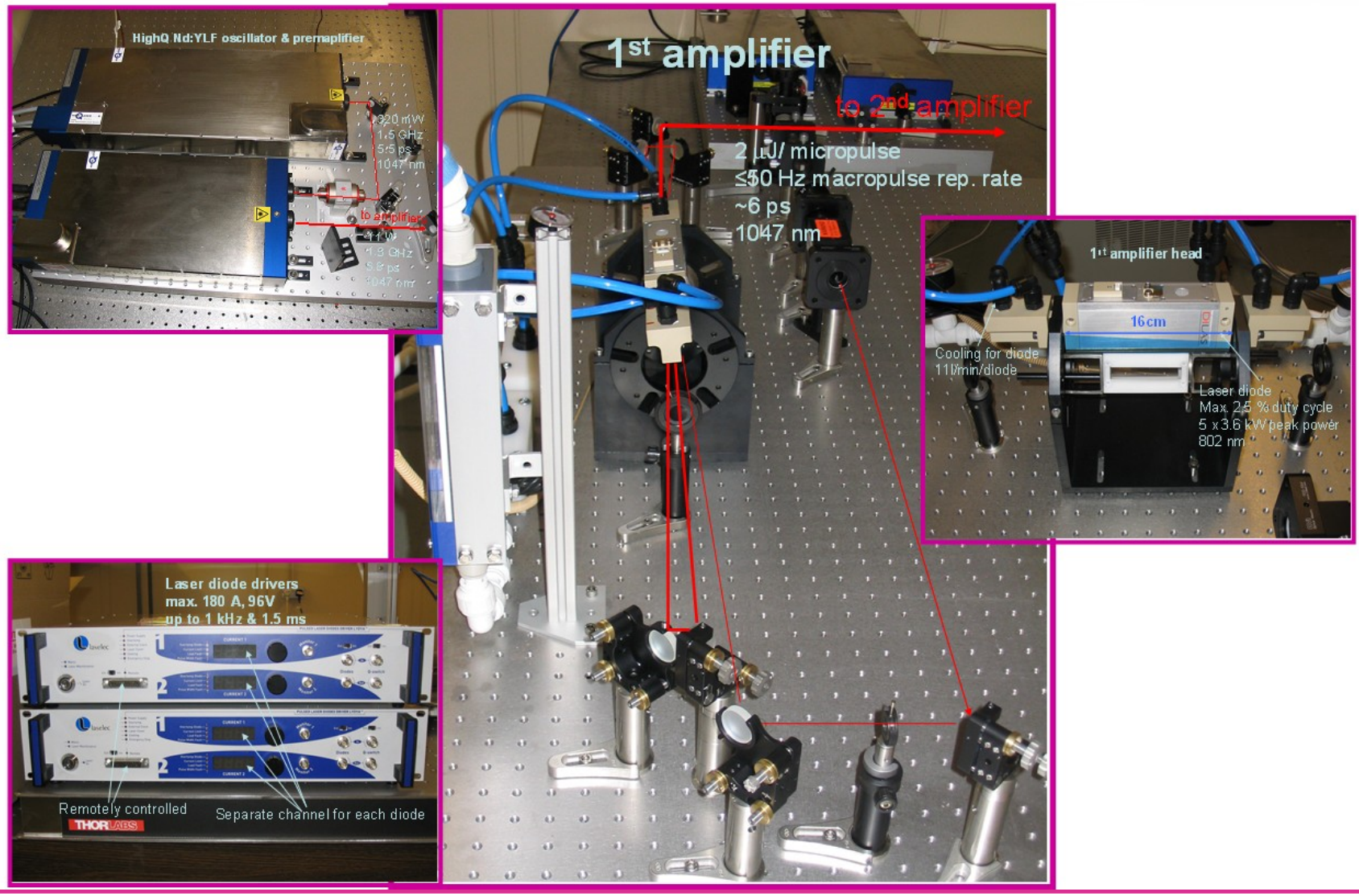



Two train generation

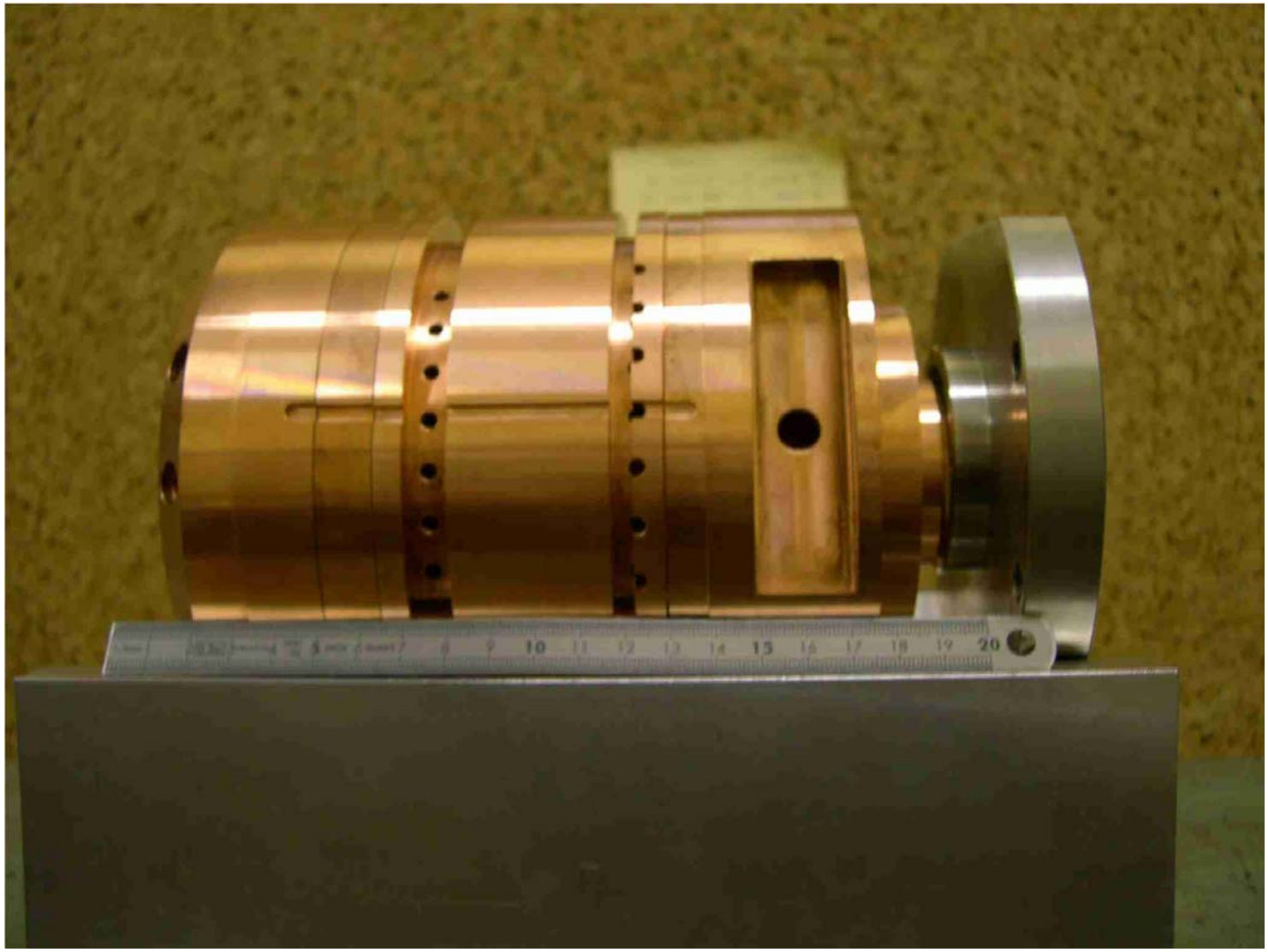


# LASER (see G. Hirst Talk)

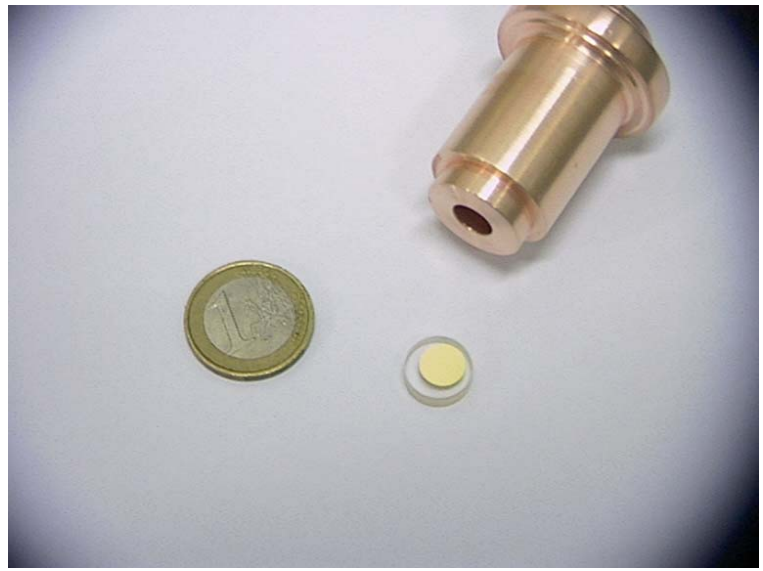


# RF Gun (see R. Roux's talk)

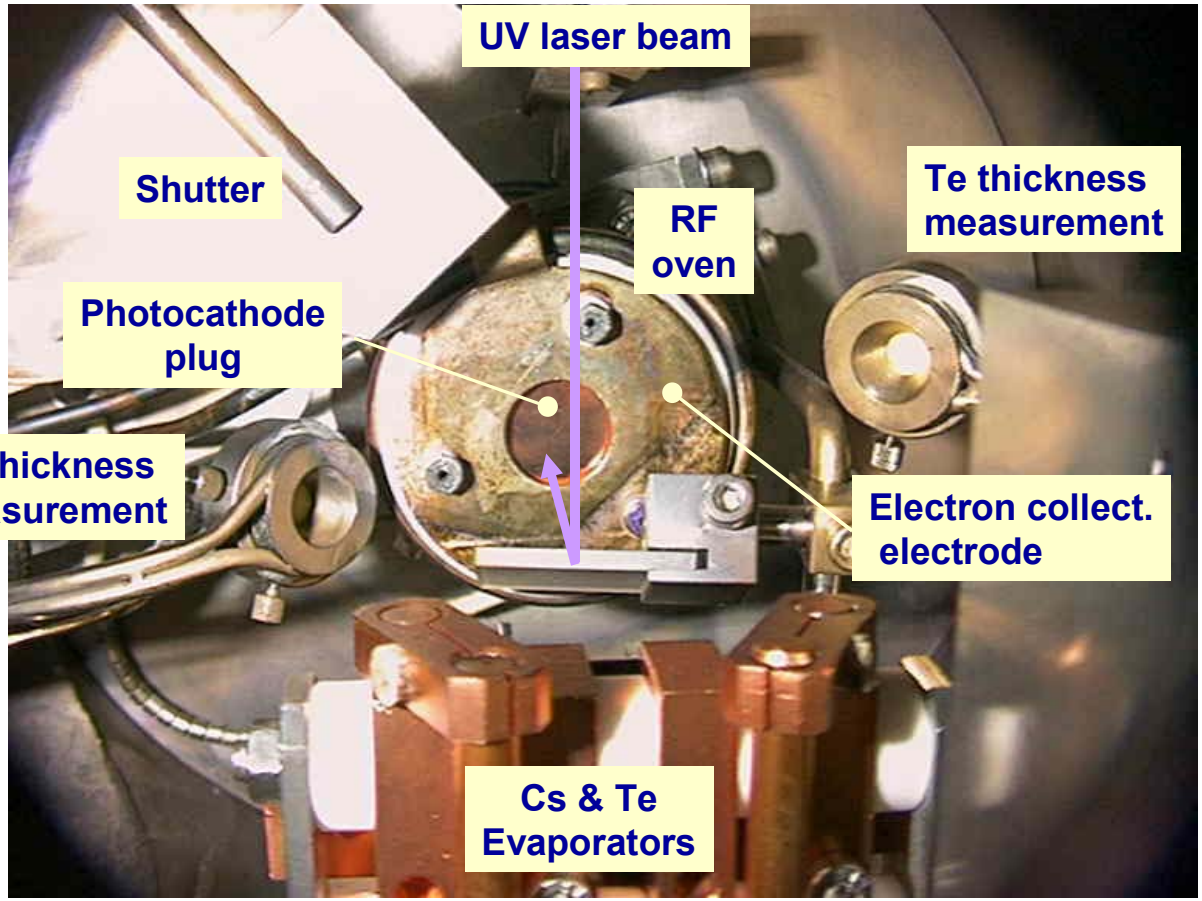


# Photocathodes

- CERN photocathode Lab was working without interruption since 15 years.
- The whole line (preparation chamber, DC Gun, transport carrier) has been inspected and repaired.
- We started again few days ago with the first calibration coatings.
- We will start very soon with production of $CsTe_2$ by co-evaporation



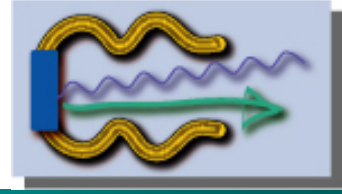
# Photocathodes




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

**Difficult thickness measurements and poor reproducibility**

# Photocathodes

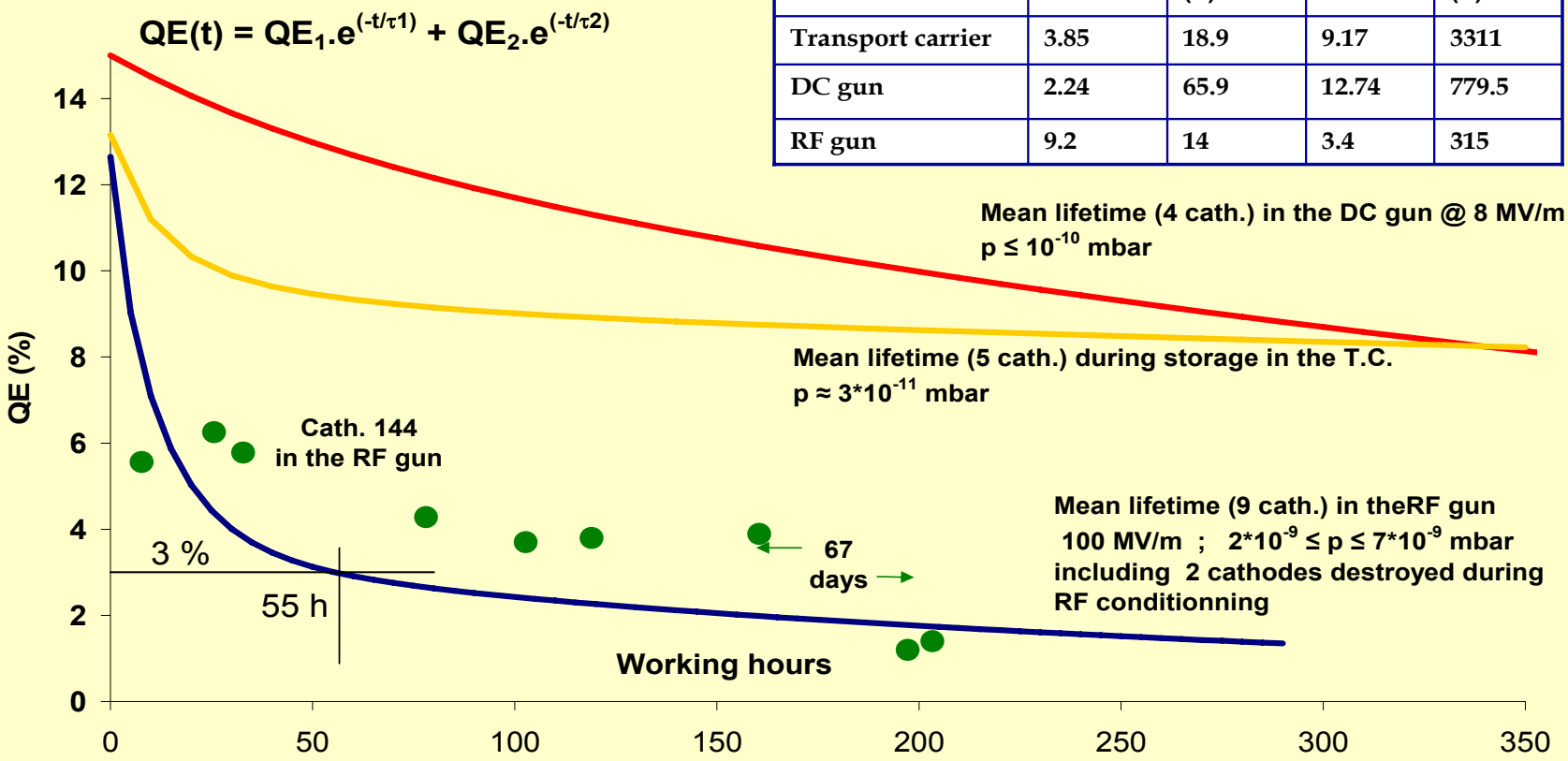


- Improvement of Cs-Te cathode production (standard cathodes for CTF3)
- Co-evaporation : thickness calibration ➔ evaporation rate control ➔ stoichïometric ratio control
  - New evaporators : CEA's oven
  - New control system: VME based
  - Improved vacuum pressure measurement and new rest gas analysis
  - New transfer arm for XPS analysis

# Photocathodes

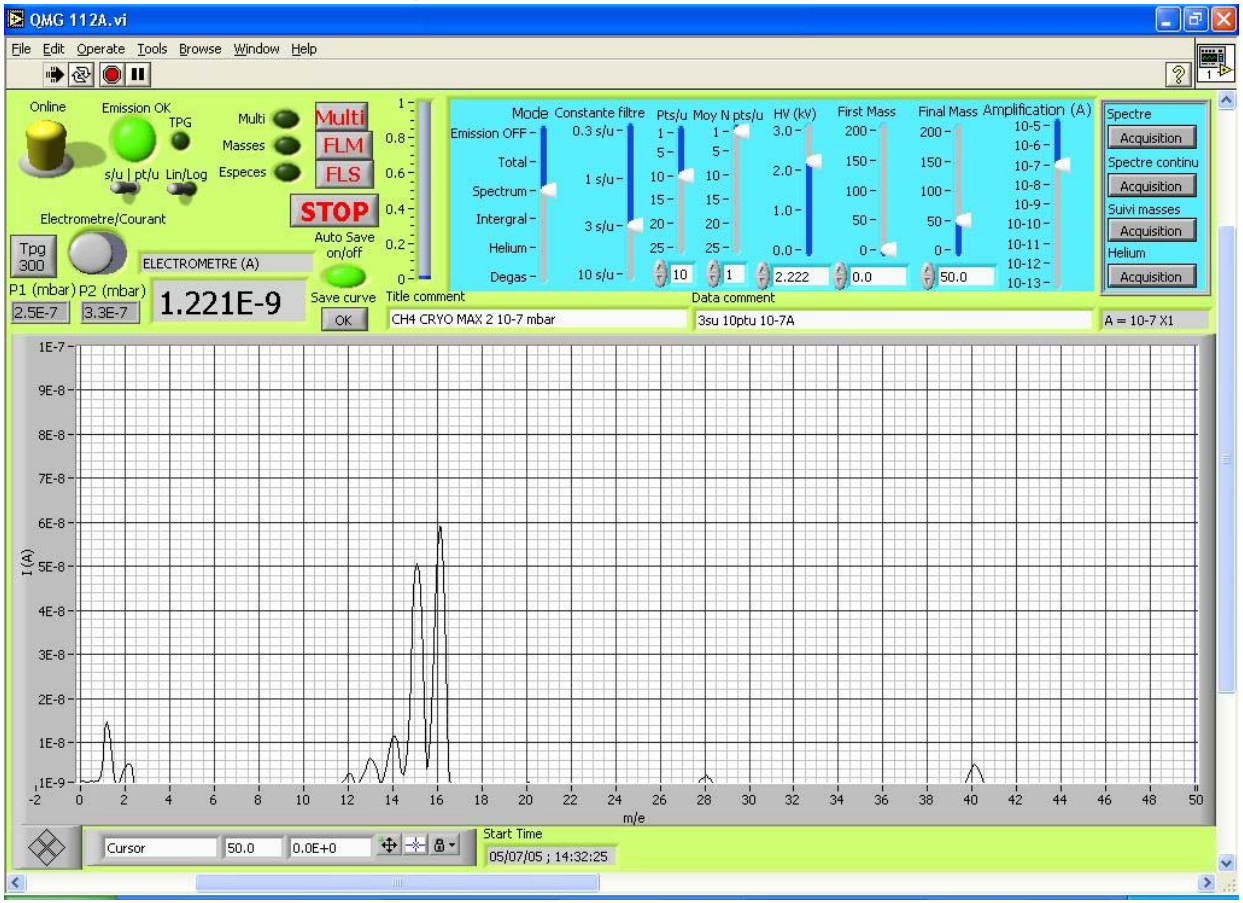
- But photocathodes produced by co-evaporation seem to be more sensitive to the vacuum quality

| QE = f (t) | QE1 % | τ1 (h) | QE2 % | τ2 (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 |

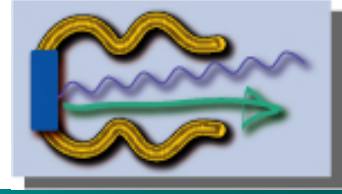


# Photocathodes

- Rest gas analysis by mass spectrum analyzer: spectrum of $CH_4$



# Photocathodes



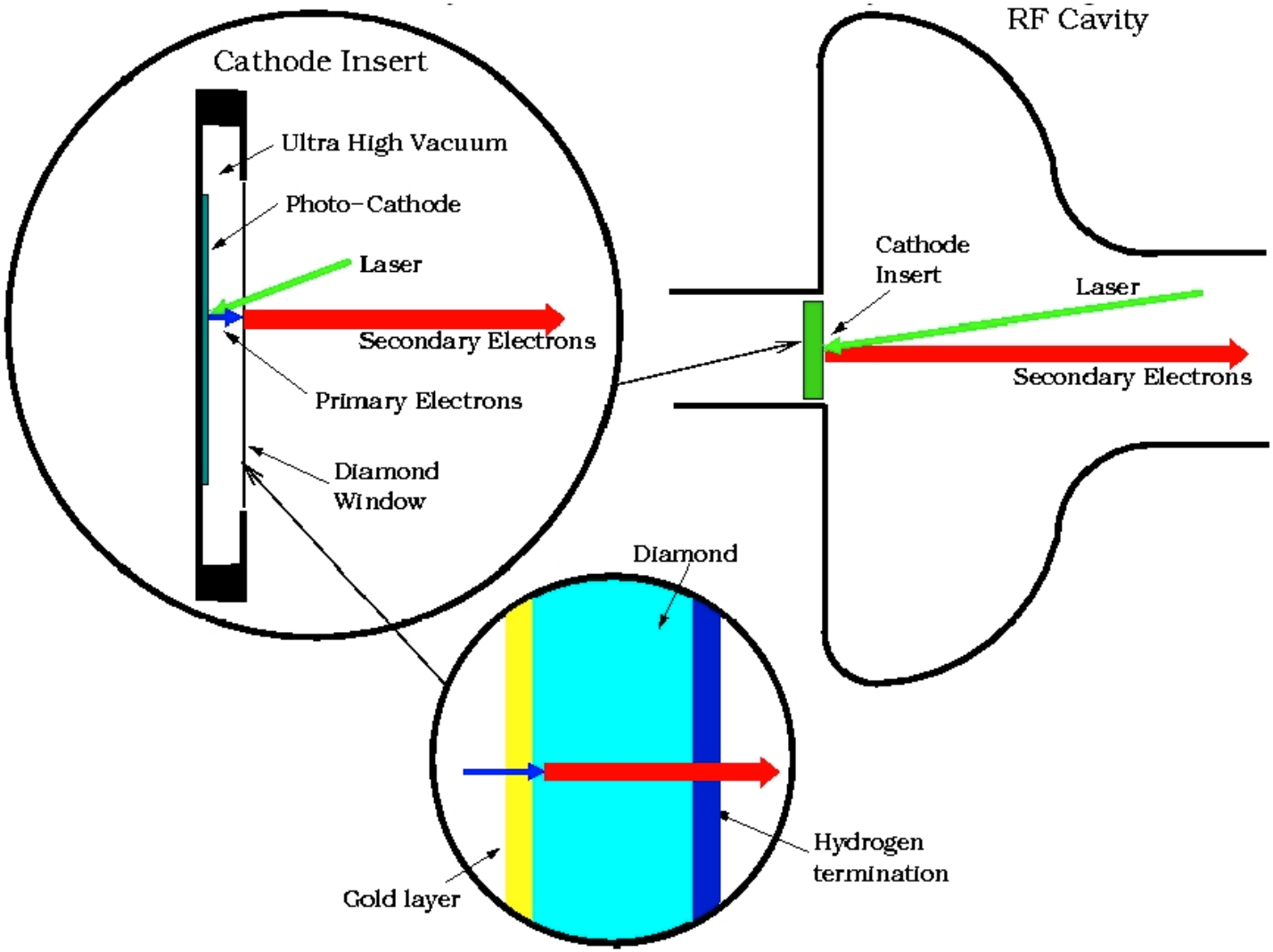
- R&D on photocathodes:
  - Our wish: Photocathodes working in the second harmonic of Nd doped crystals (green light)
    - Visible to UV conversion efficiency : ~ 20 – 25 %
    - Minimum QE @ UV ≥ 3 % during at at least 40 working hours
    - ➔ Minimum QE @ green light ≥ 0.6 % during at least 40 working hours
    - Alkali-antimonide photocathodes produced by co-evaporation in collaboration inside PHIN + CEA Bruyère-le-Châtel

# Photocathodes

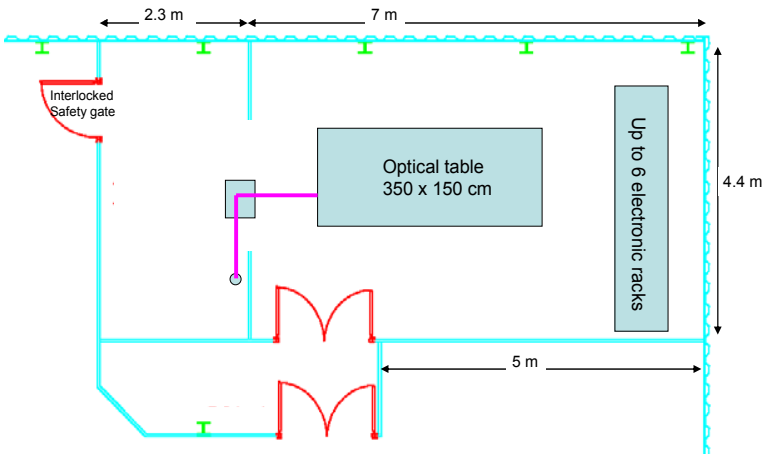
- R&D on photocathodes:

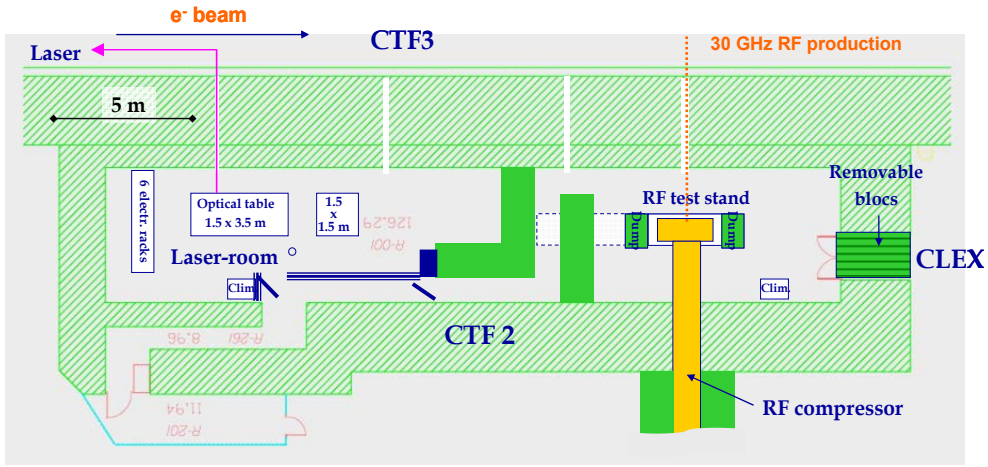
- Secondary Emission Enhanced photo-emitter (SEE) in collaboration with CEA Bruyère-le-Châtel :
  - Idea from Brookhaven
  - photocathode plug exchange under UHV
  - Vacuum separation by transparent window
  - Secondary emission enhancement

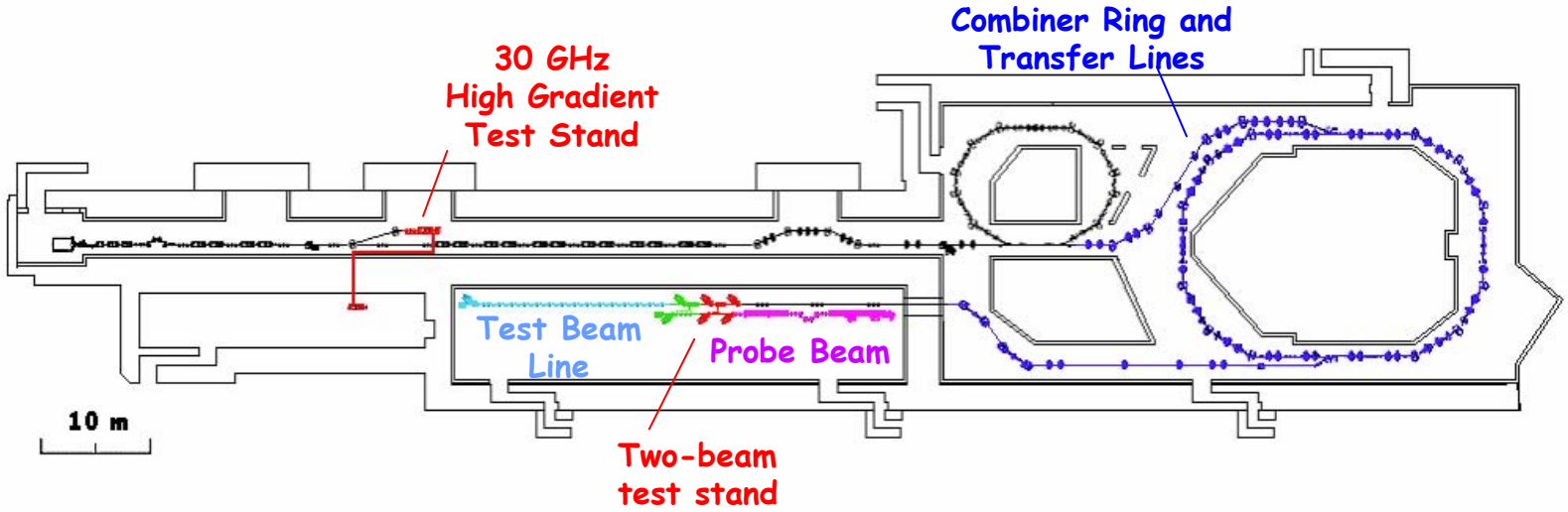
# Photocathodes



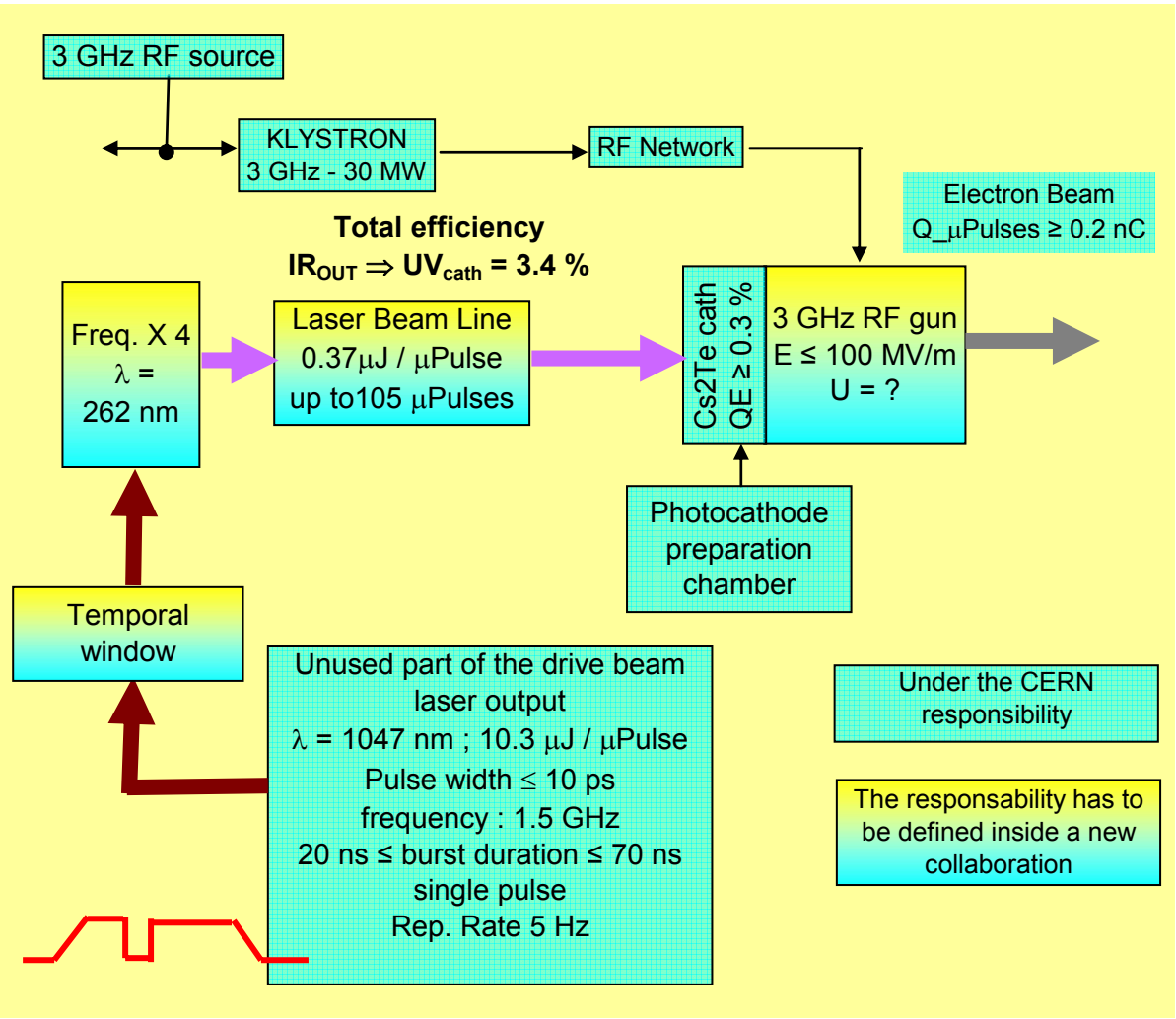
# Putting All Together



# CLEX Probe beam photo-injector



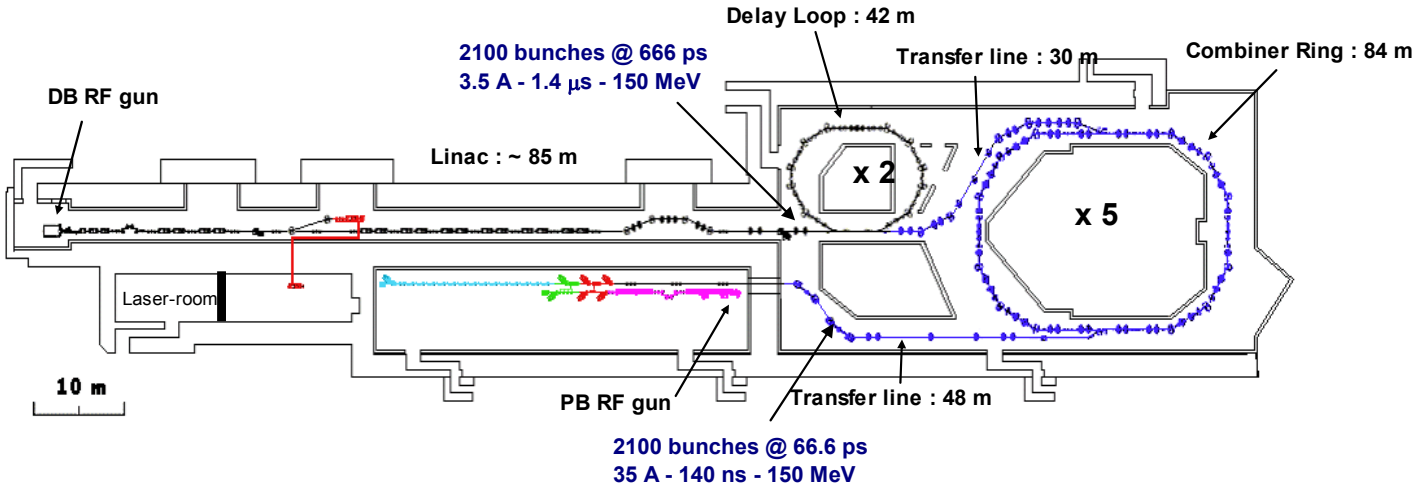

## "Light" version

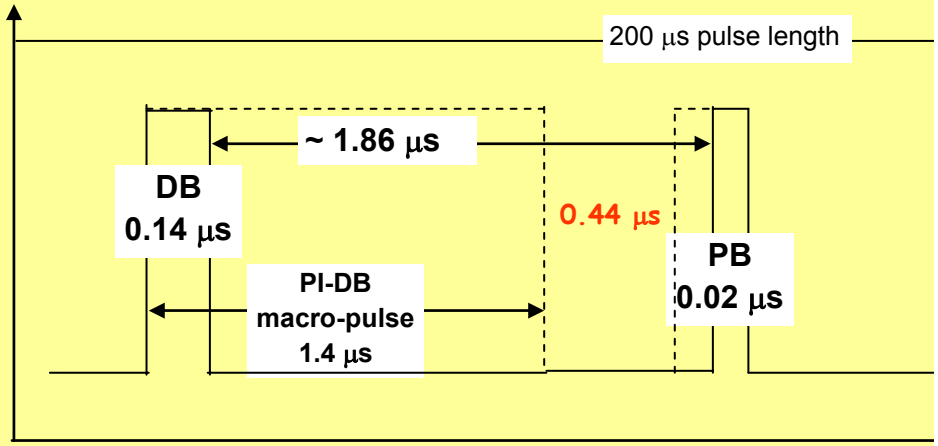
- Reduced frequency in the burst : 1.5 GHz
- Reduced charge per micro-pulse ~ 0.2 nC

⬇

- Re-use of the preparation chamber attached to the former CTF2 Probe beam RF gun. ➔ Not TC nor MPC
- Substantial simplification and economy in the laser system.

# Timing Drive - Probe beam

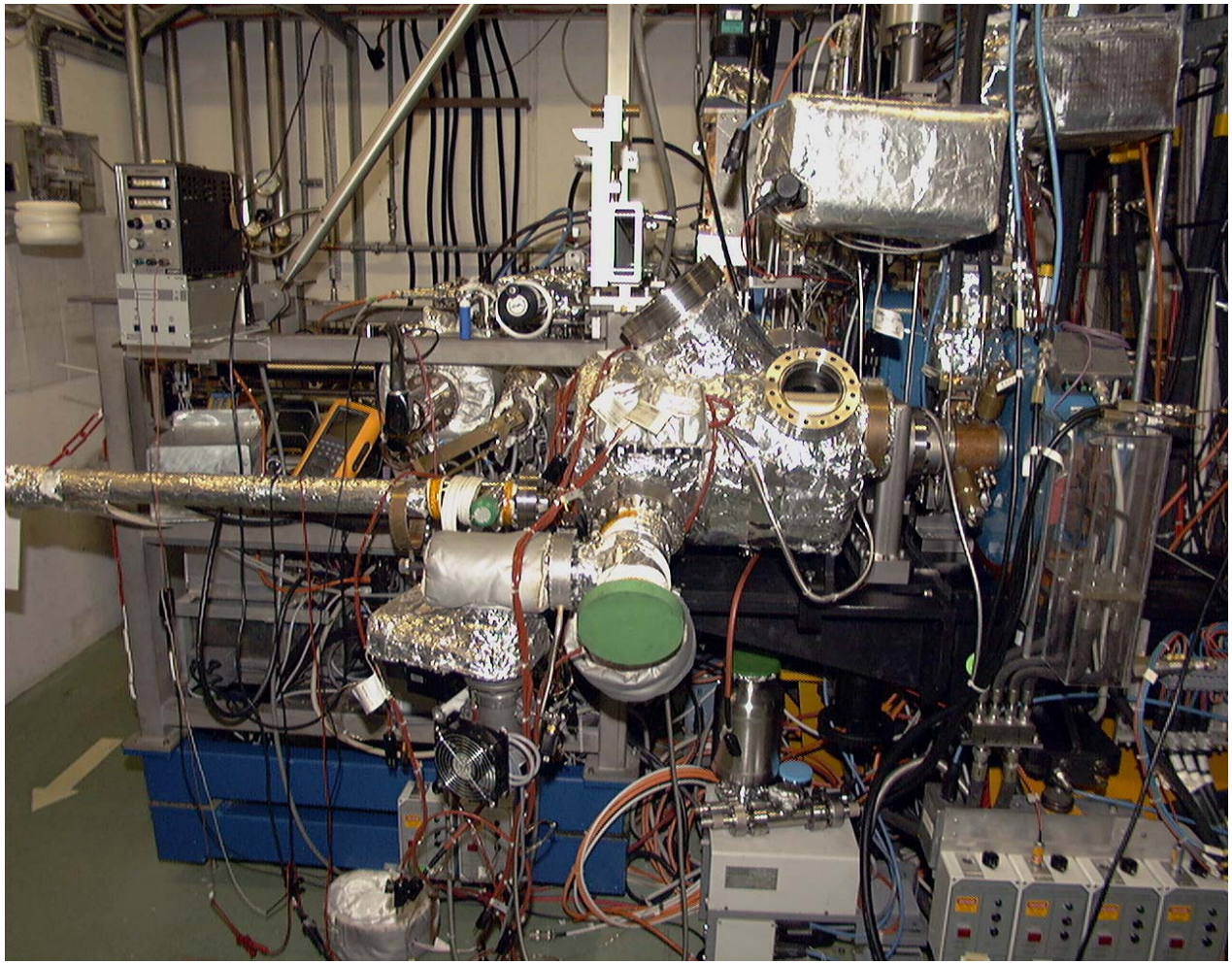



| First pulse of the Drive beam | | |
|---|---|---|
| Laser-room ➔ DB gun | 15 m | 0.05 μs |
| Photo-injector ➔ Delay Loop | 85 m | 0.2833 μs |
| Delay Loop | 42 m | 0.14 μs |
| TL Delay Loop ➔ Comb. Ring | 30 m | 0.1 μs |
| Combiner Ring | 84 m | 0.28 μs |
| TL Comb. ring ➔ Probe Beam | 48 m | 0.16 μs |
| Total with 1 DL and 4.5 C. Ring | 598 m | 1.9933 μs |
| Macro pulse length | | 0.14 μs |
| Filling time of PETS+Acc. | | 0.02 μs |
| TOTAL time | | 2.1533 μs |

| Probe Beam | | |
|---|---|---|
| Laser-room ➔ PB gun | 75 m | 0.25 μs |
| PB macro-pulse length | | 0.021312 μs |
| TOTAL time | | 0.271312 μs |
| Conv. 1.5 GHz to 3 GHz | | 0.021312 μs |

# Putting All Together



# CONCLUSIONS

- DRIVE Beam
  - Design Phase is concluded, both for the Gun and the Laser
  - A solution for photocathodes already exists, we will try to improve the reproducibility
  - The Laser is expected at CERN by May 2006
  - The RF Gun is expected by August 2006
- PROBE Beam
  - Specifications defined, re-use of drive beam Laser and CTF2 preparation Chamber
  - To be realised within CTF3 extended collaboration