The PHIN Photoinjector for CTF3

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Acknowledgements

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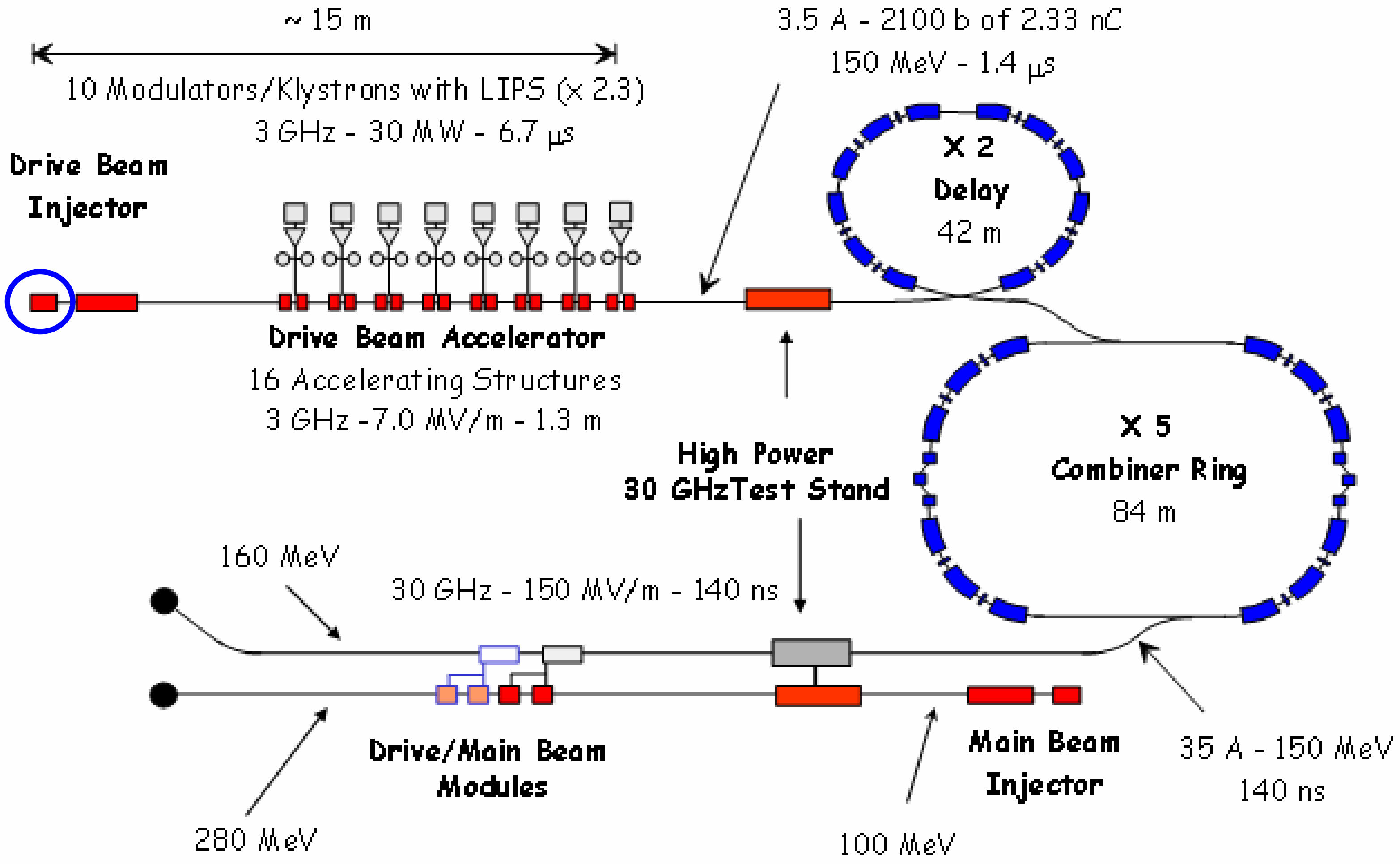
OUTLINE

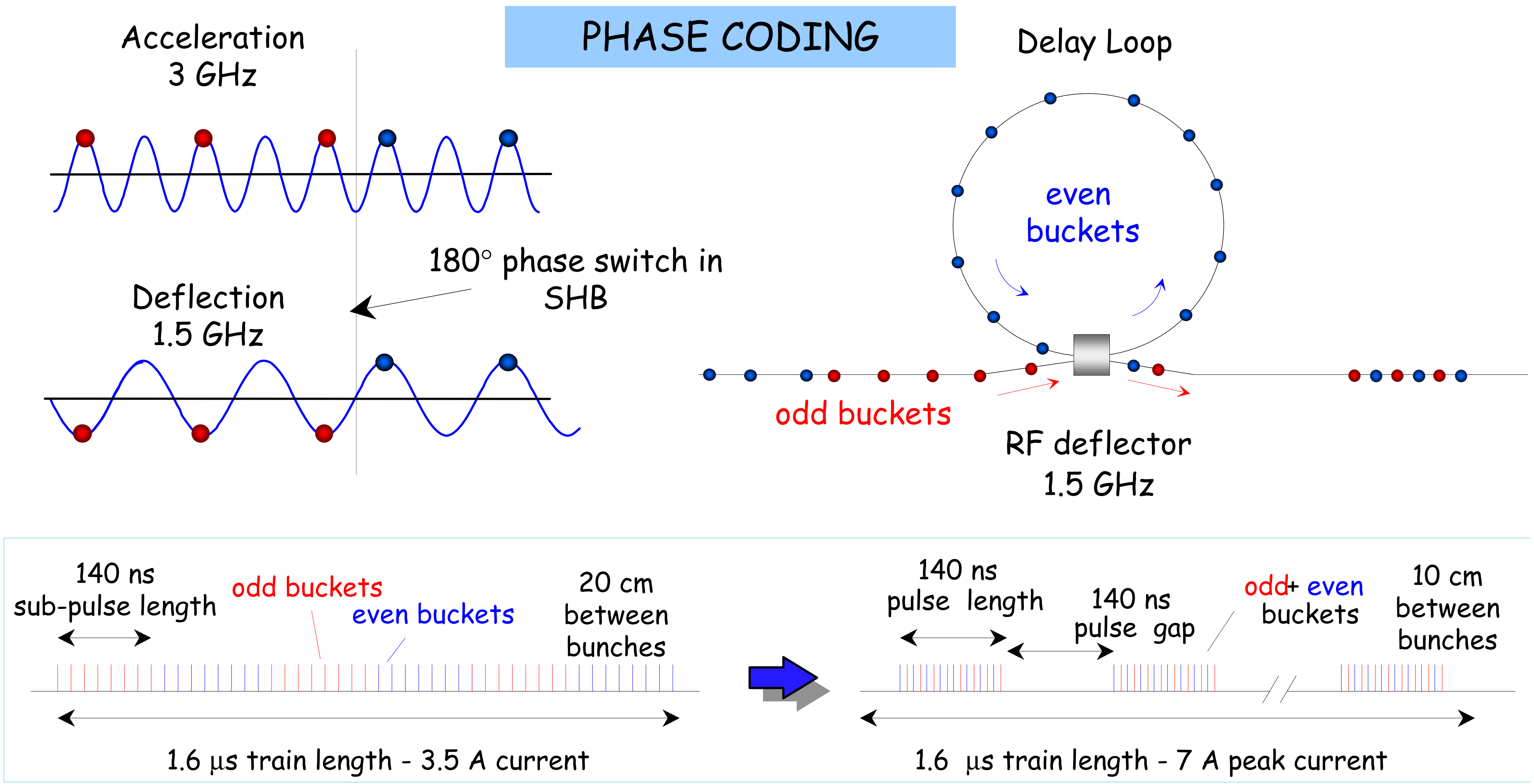
- CTF3 overview
- Photoinjector specs and design
- Laser (RAL)
- RF Gun (LAL)
- Photocathodes (CERN)
- Putting all together
- Conclusions

CTF3 overview

CTF3 - Test of Drive Beam Generation, Acceleration & RF Multiplication by a factor 10



CTF3 overview

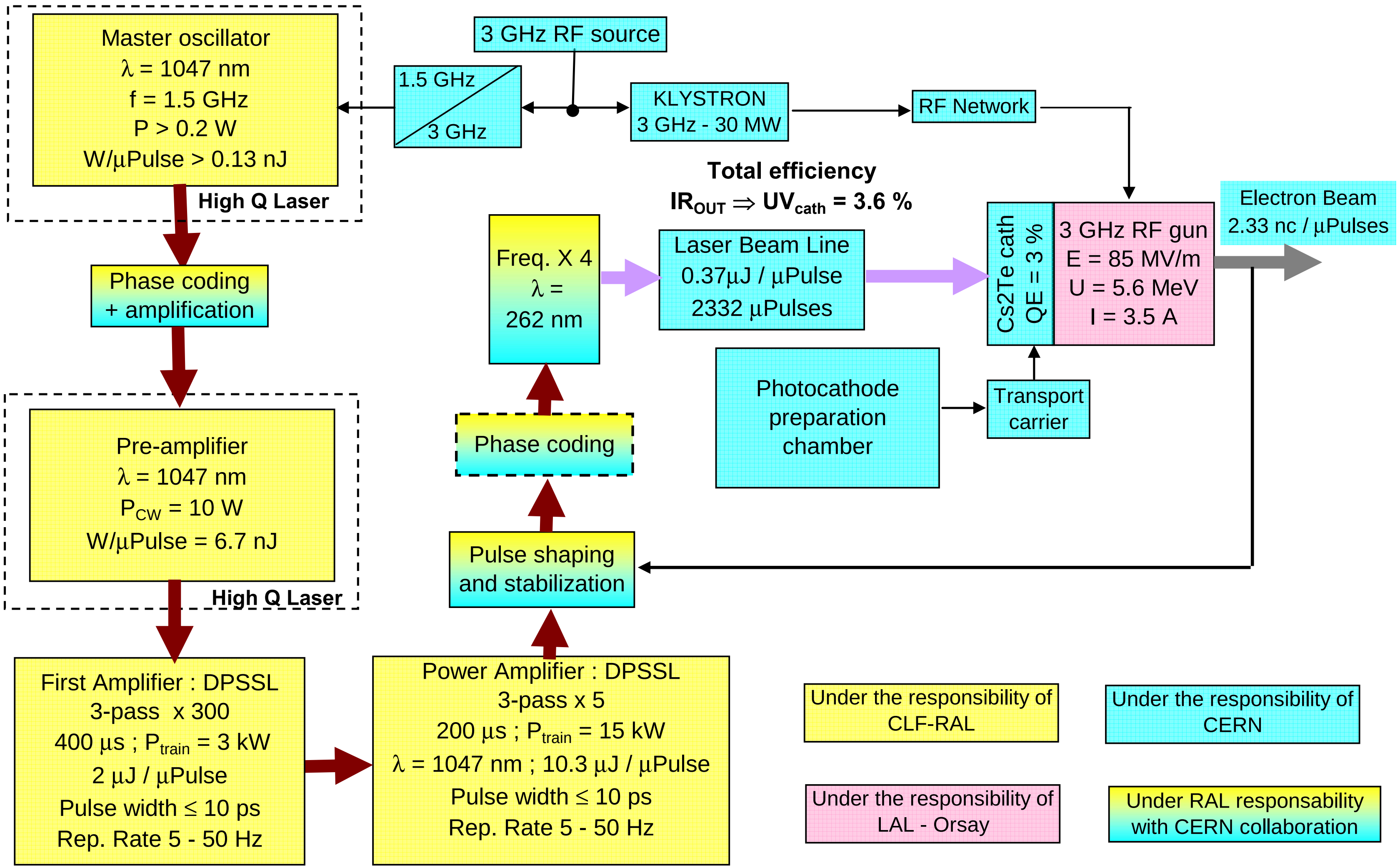


CTF3 overview

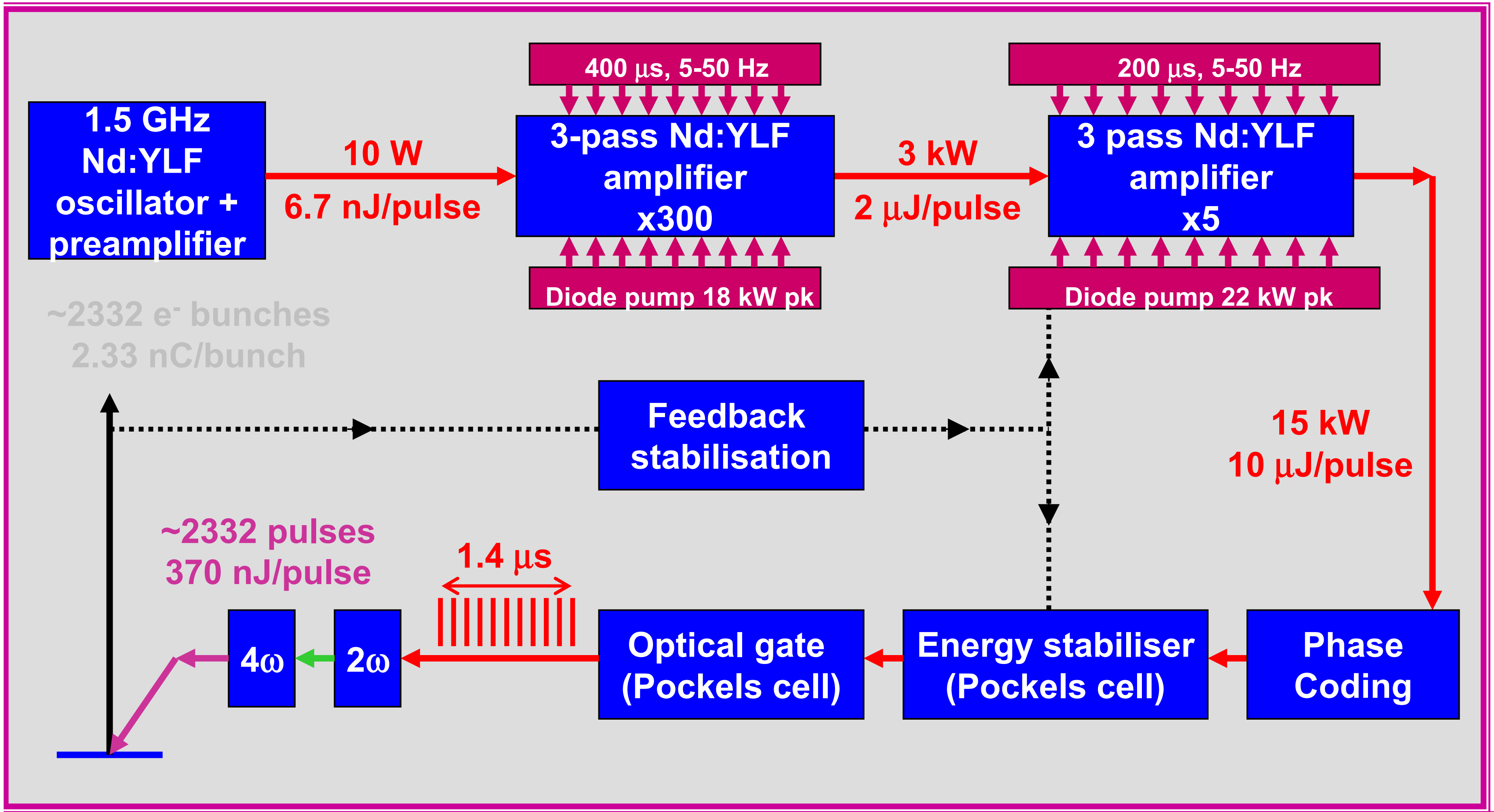
- Photoinjector Specifications:

  - Current in the train: 3.5 Amps
  - Charge in each pulse: 2.33 nC
  - Pulse frequency: 1.5 GHz
  - Rep rate: 1÷50 Hz (nominal: 5 Hz)

PHIN overview



LASER



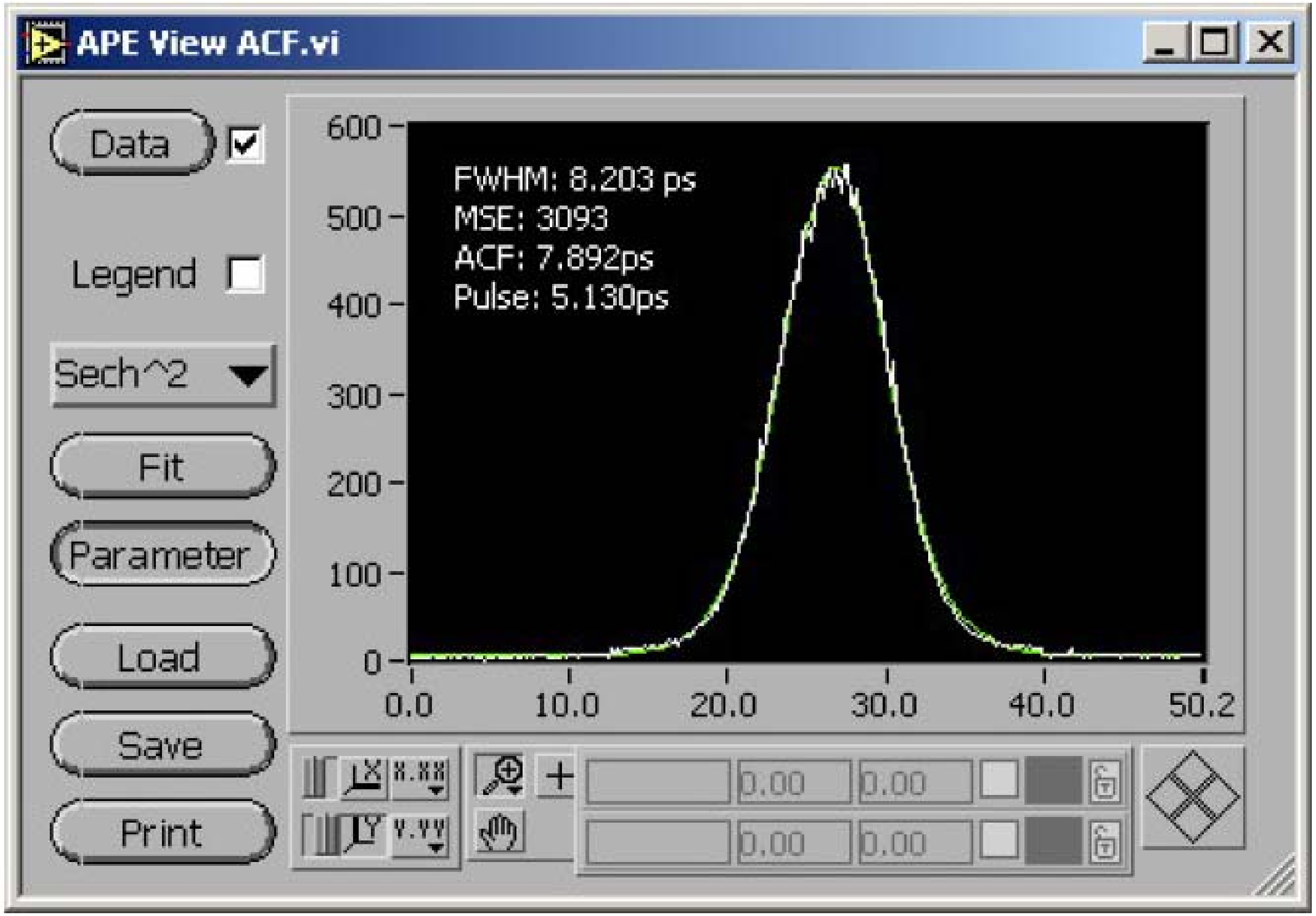
1.5 GHz Nd:YLF oscillator + preamplifier
10 W
6.7 nJ/pulse
400 µs, 5-50 Hz
3-pass Nd:YLF amplifier x300
Diode pump 18 kW pk
3 kW
2 µJ/pulse
200 µs, 5-50 Hz
3 pass Nd:YLF amplifier x5
Diode pump 22 kW pk
~2332 e- bunches
2.33 nC/bunch
Feedback stabilisation
15 kW
10 µJ/pulse
~2332 pulses
370 nJ/pulse
1.4 µs
4ω
2ω
Optical gate (Pockels cell)
Energy stabiliser (Pockels cell)
Phase Coding

LASER

- Oscillator :
  - Oscillator frequency increased from 250 MHz (CTF2) to 1.5 GHz thanks to availability of SESAM (**SE**miconductor **SA**turable **M**irror) technology for passive mode locking of the oscillator.
  - This technology allows well controlled pulse-to pulse jitter, and very good amplitude stability (<1%), on long term and from pulse to pulse.
  - Acceptance tests have shown full agreement with specifications.

LASER

- Pulse duration measured with APE autocorrelator



LASER

Optical and electronic phase stability measurements

Measured from error signal

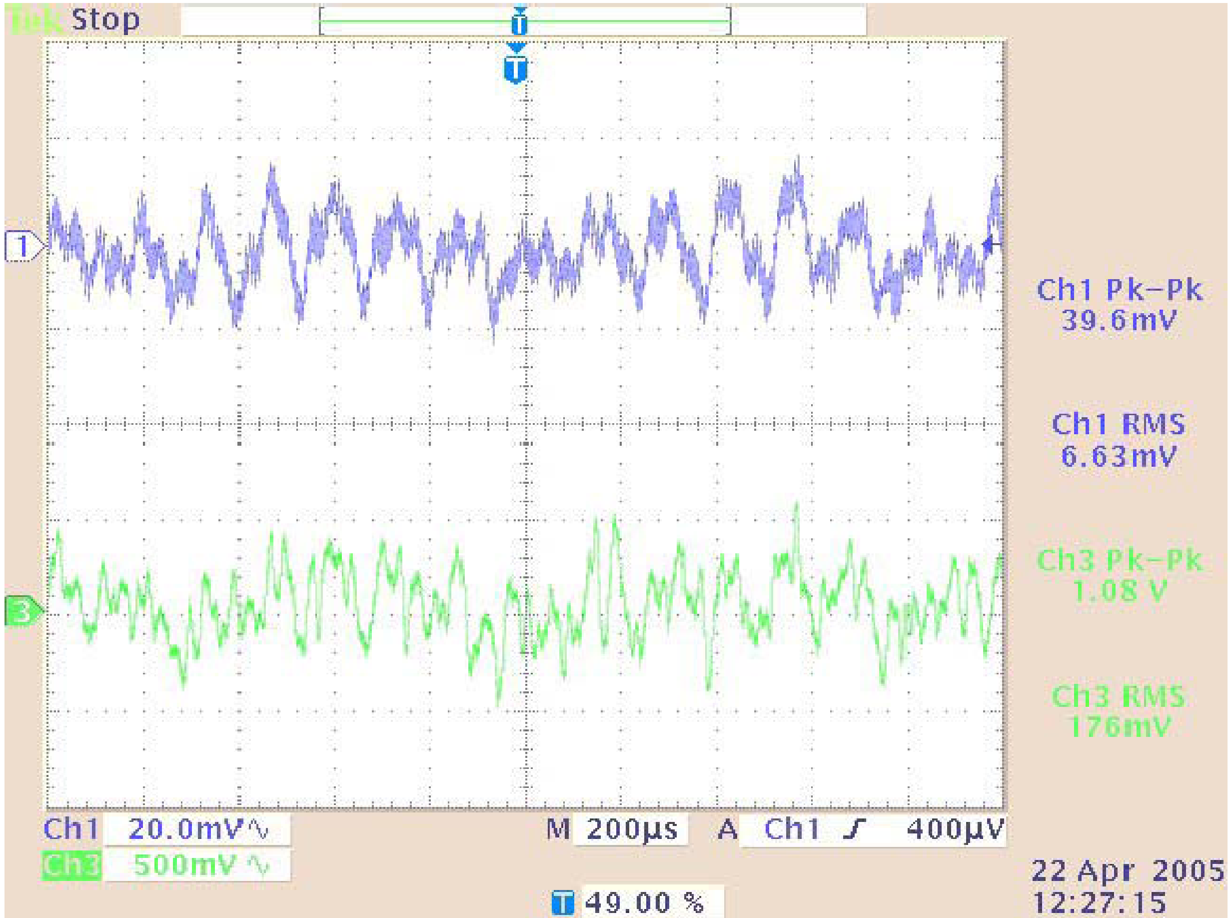
$$Jitter_{pk-pk} = 733\,fs$$

$$Jitter_{rms} = 122.8\,fs$$

Measured with Xcorrelation

$$Jitter_{pk-pk} = 771\,fs$$

$$Jitter_{rms} = 125.7\,fs$$



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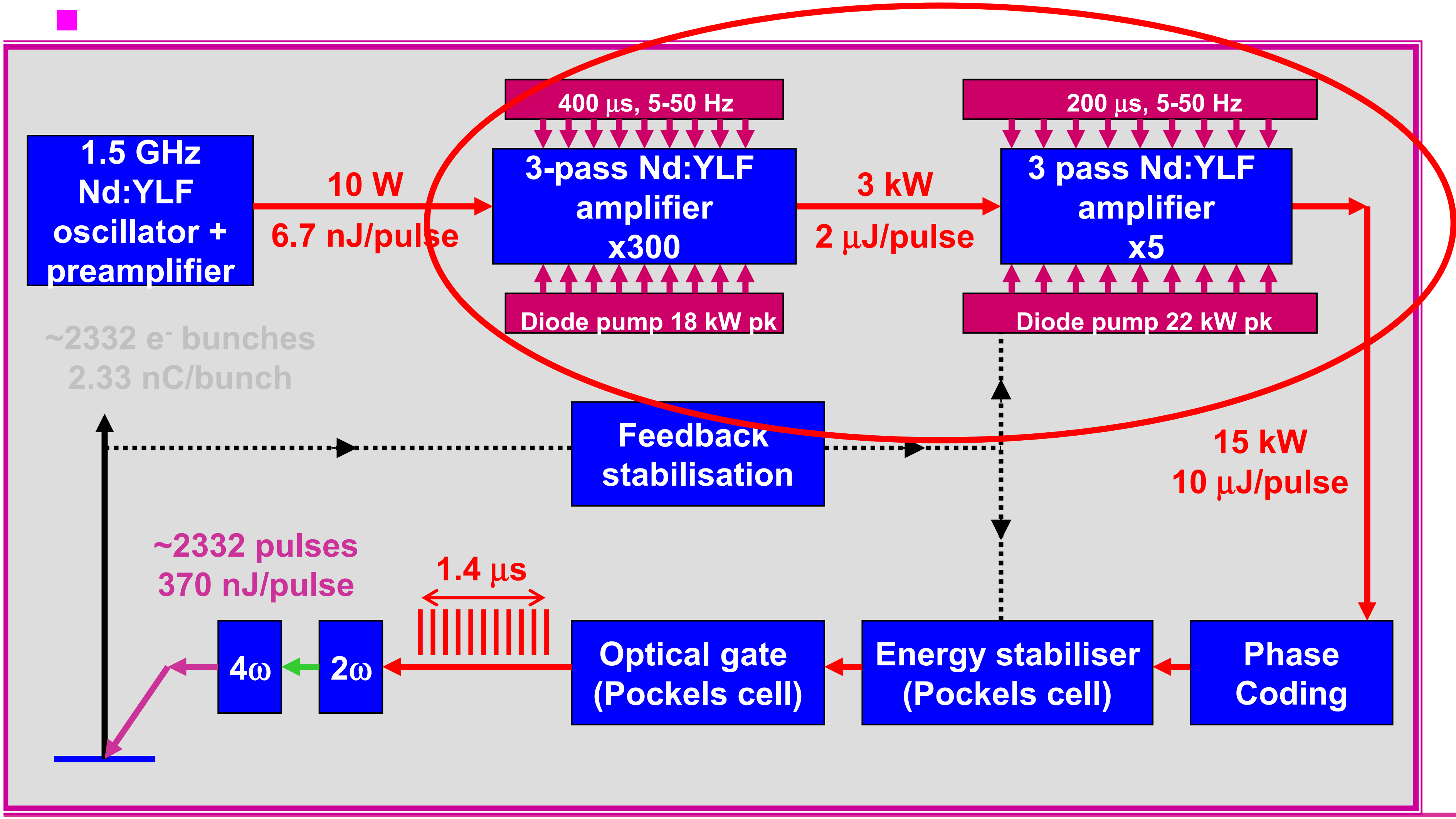

400 μs, 5-50 Hz
200 μs, 5-50 Hz
1.5 GHz Nd:YLF oscillator + preamplifier
10 W
6.7 nJ/pulse
3-pass Nd:YLF amplifier x300
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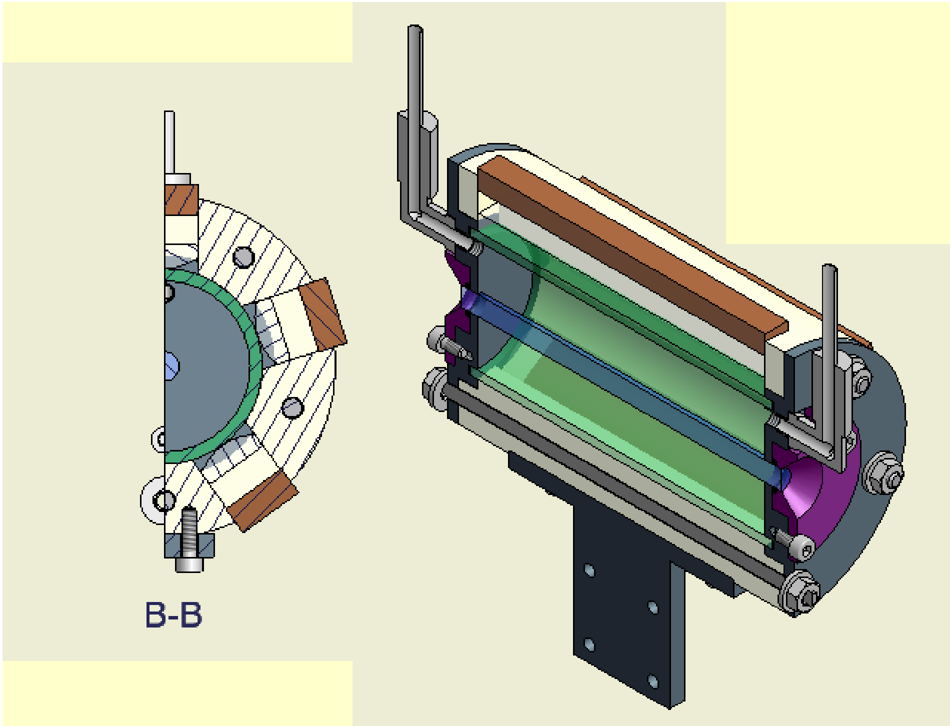
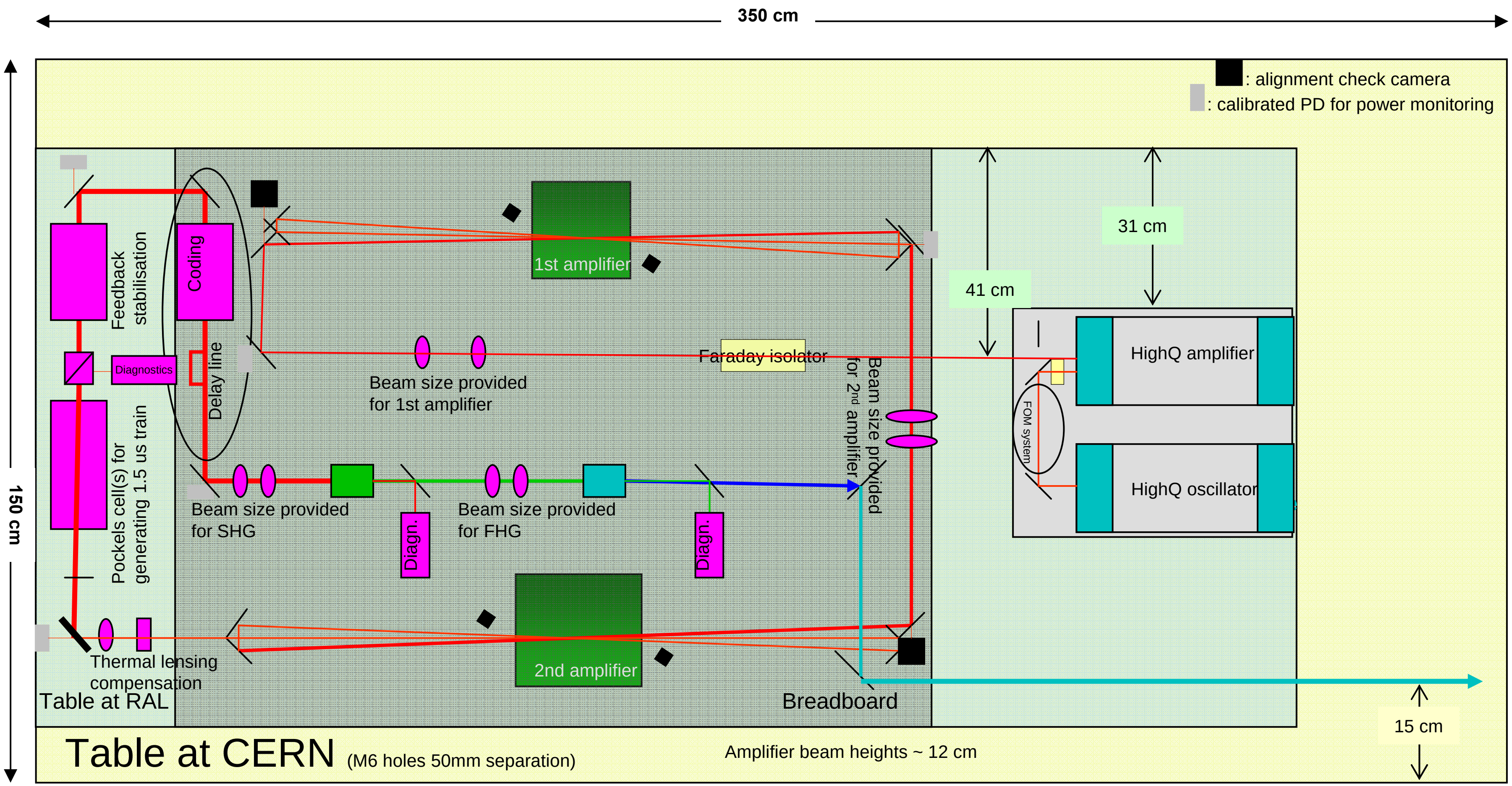
Optical gate (Pockels cell)
Energy stabiliser (Pockels cell)
Phase Coding

Mechanical Assembly for the amplifiers heads

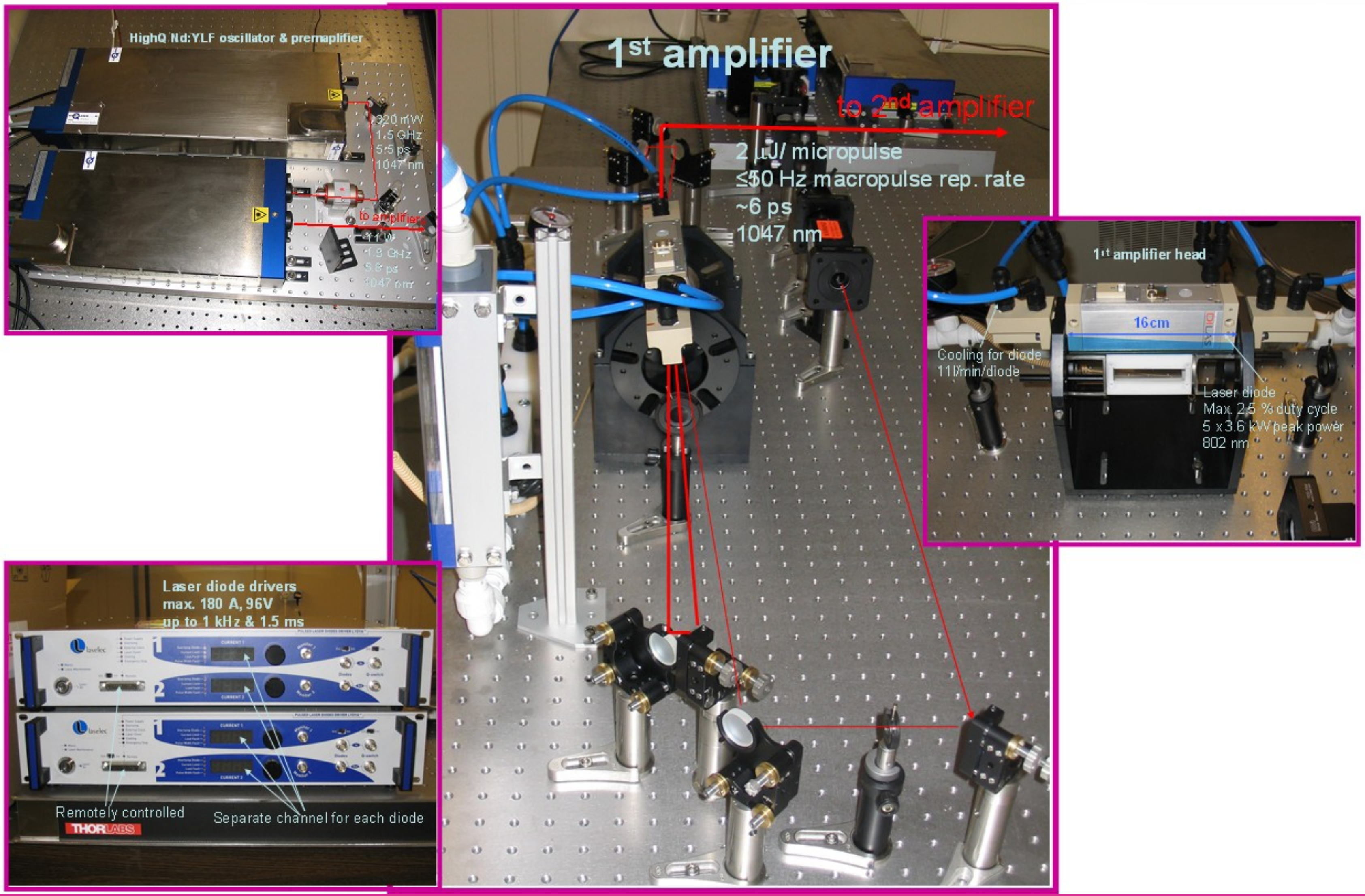
- Easy connections of water and Electrical plugs
- Accurate positioning of the focusing optics
- Easy assembly
- Possibility of rotating the rod in situ
- Similar design for the two amplifiers



- How it will look like



LASER

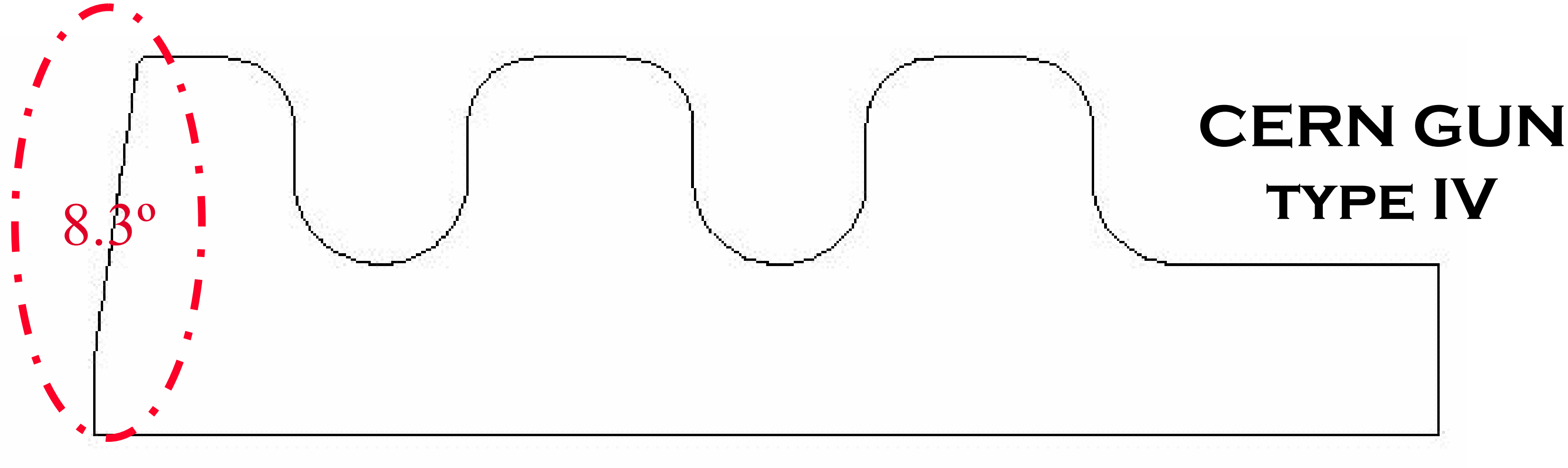

HighQ Nd:YLF oscillator & premaplifier
320 mW
1.5 GHz
5.5 ps
1047 nm
to amplifier
1.5 GHz
5.5 ps
1047 nm
1st amplifier
to 2nd amplifier
2 µJ/ micropulse
≤50 Hz macropulse rep. rate
~6 ps
1047 nm
1st amplifier head
16cm
Cooling for diode
11l/min/diode
Laser diode
Max. 2.5 % duty cycle
5 x 3.6 kW peak power
802 nm
Laser diode drivers
max. 180 A, 96V
up to 1 kHz & 1.5 ms
Remotely controlled
Separate channel for each diode
THORLABS

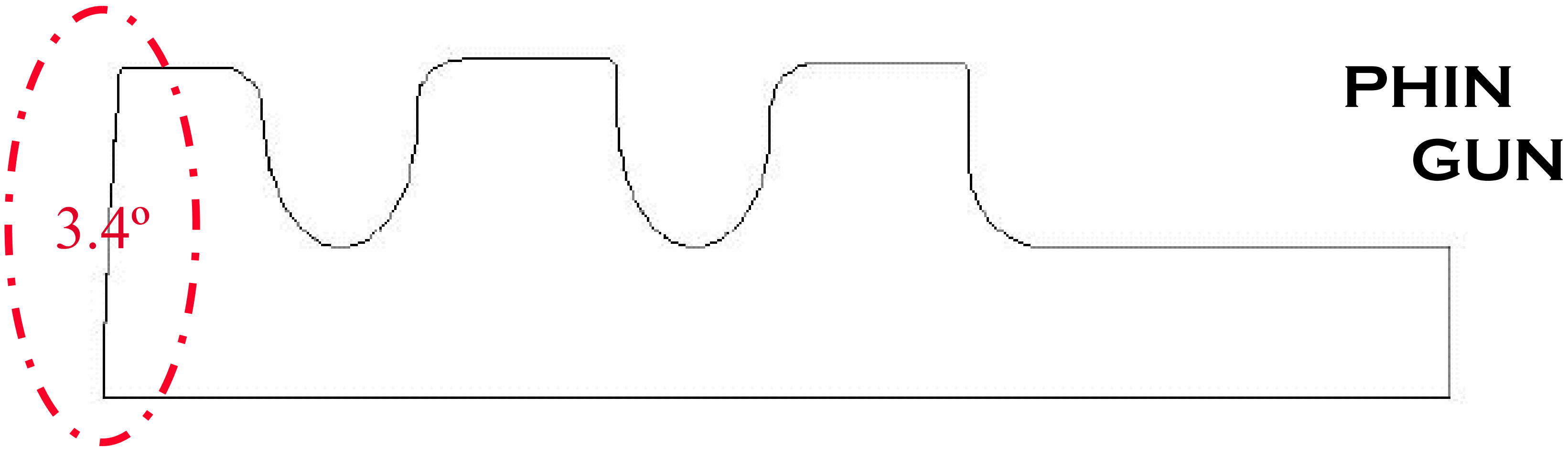
RF Gun

- Design inspired to CTF2 Gun type IV, but ended on a completely new gun.

- Optimization for higher charge, lower emittance, lowest possible vacuum level ($2 \cdot 10^{-10}$ mbar)

RF Gun



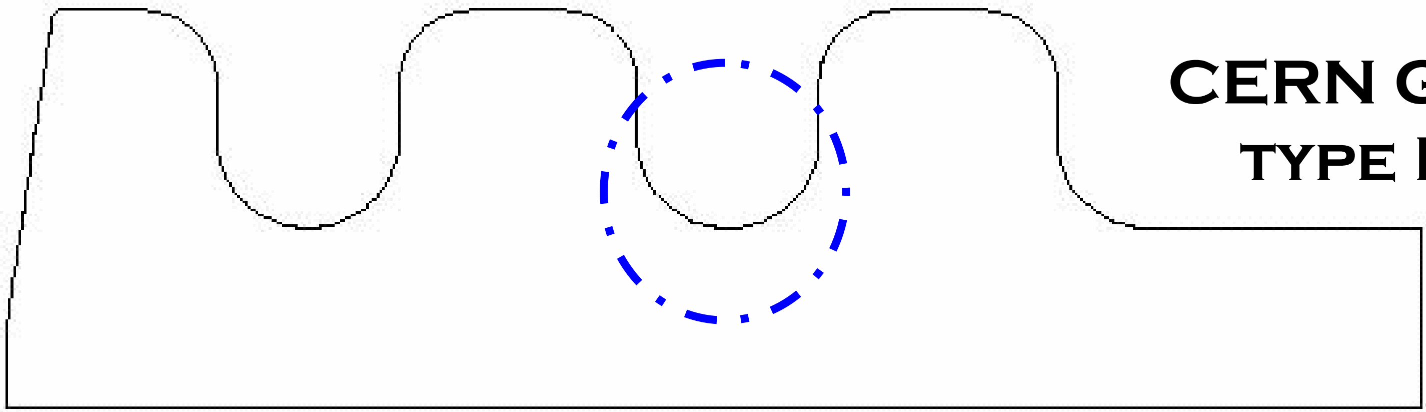


RF GUN

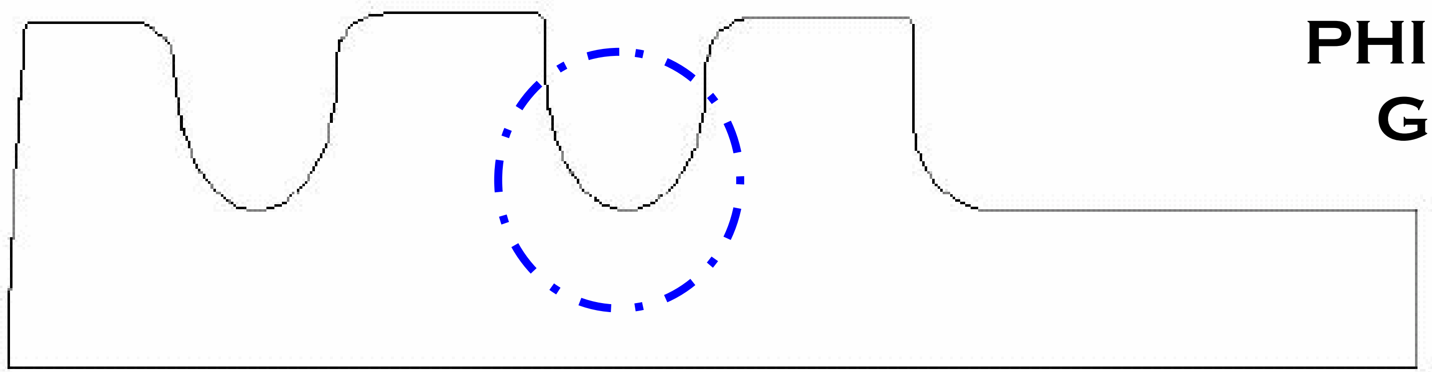
- Effect of cathode wall angle

	0°	3.4°	8.3°
σ_x (mm)	3.4	3.25	3.04
ε_T (π mm-mrad)	20.6	20.7	22.3
σ_z (mm)	1.11	1.15	1.2
$\frac{\Delta p}{p}$ (%)	0.6	0.75	2.6

RF Gun



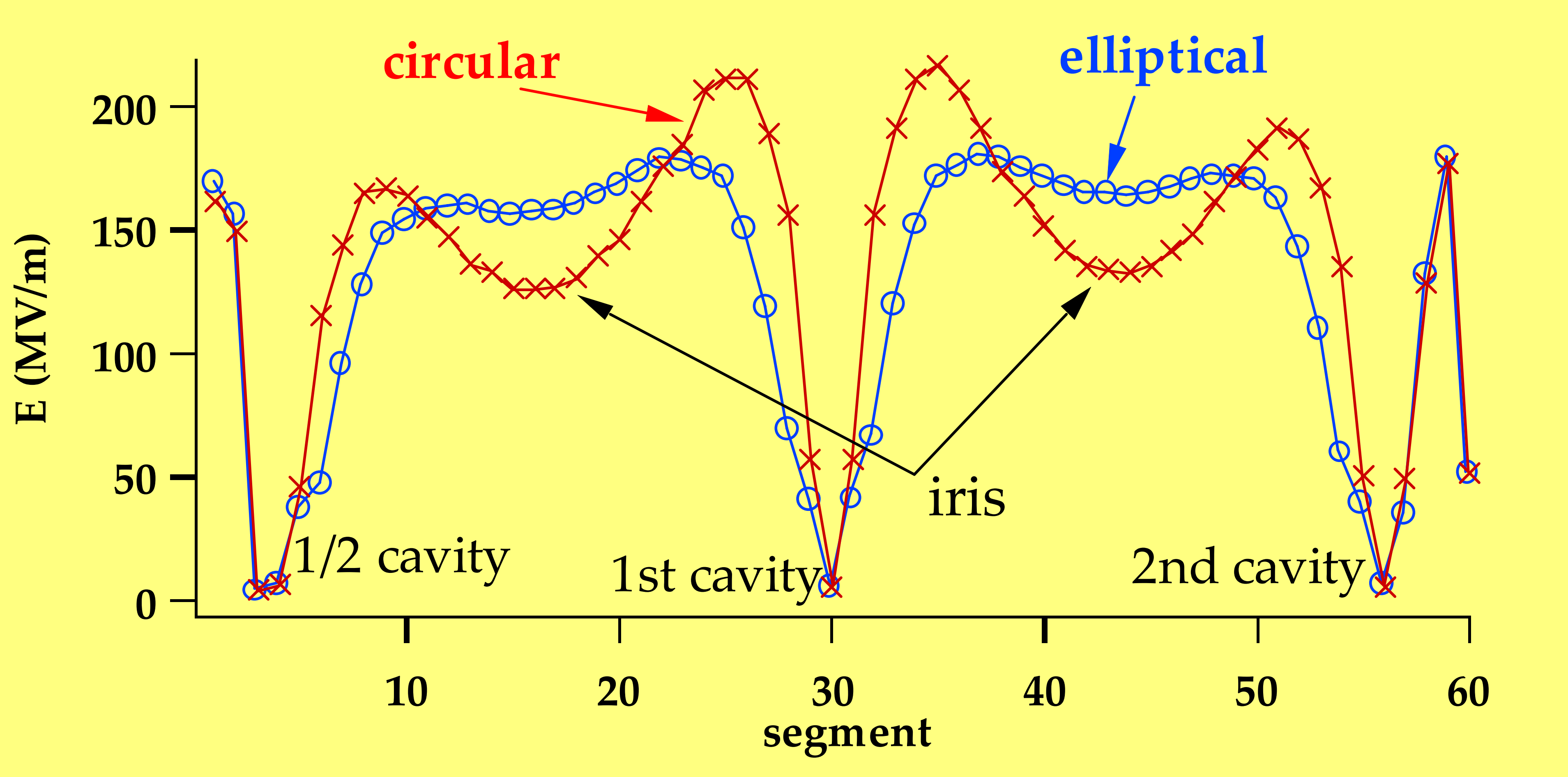
CERN GUN
TYPE IV



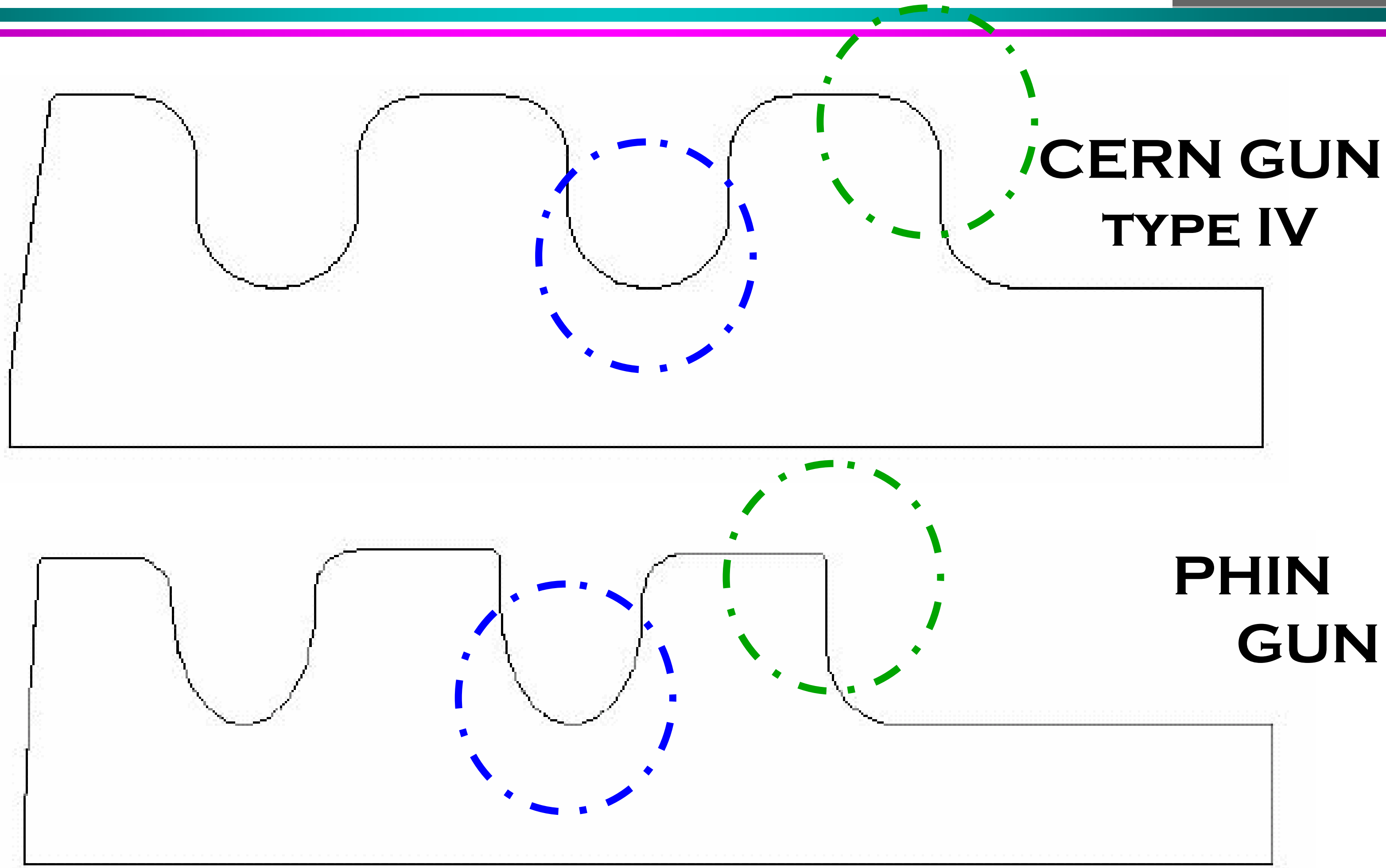
PHIN
GUN

RF GUN

- Effect of Iris Shape

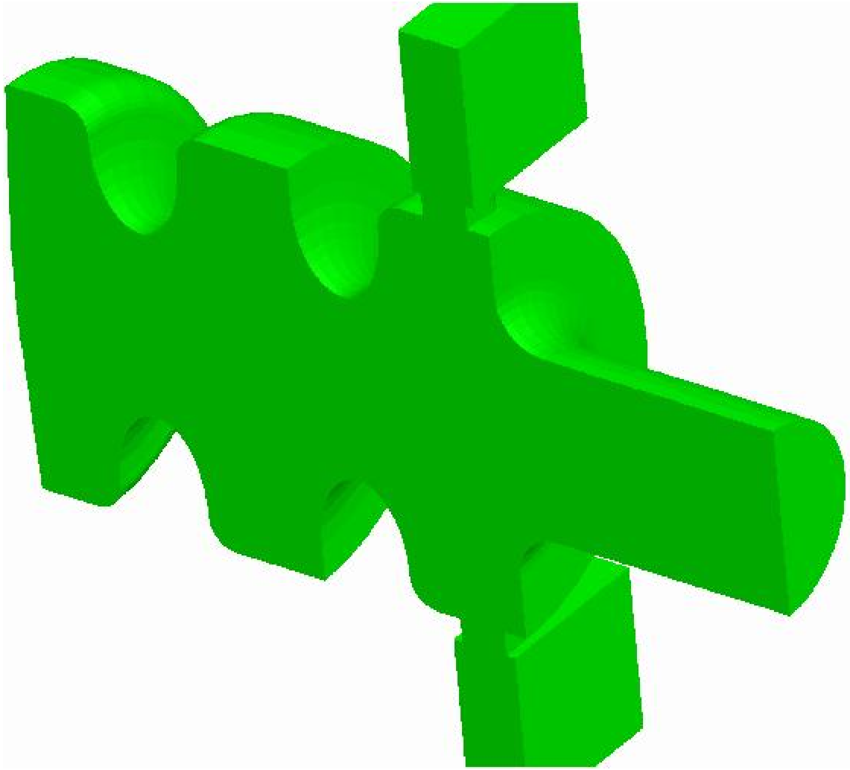


RF Gun



RF Gun

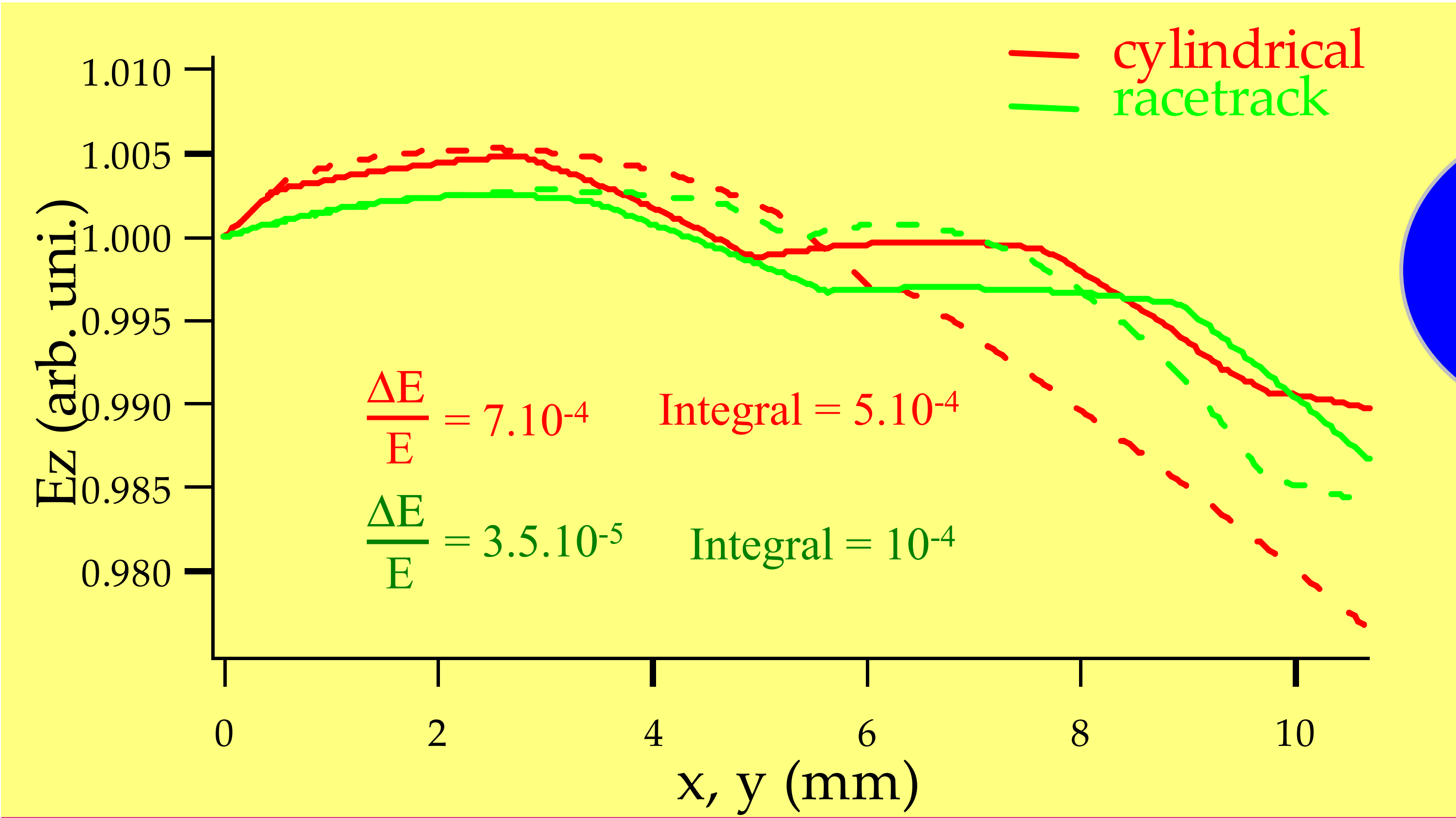
- Next step: 3D Simulations with HFSS



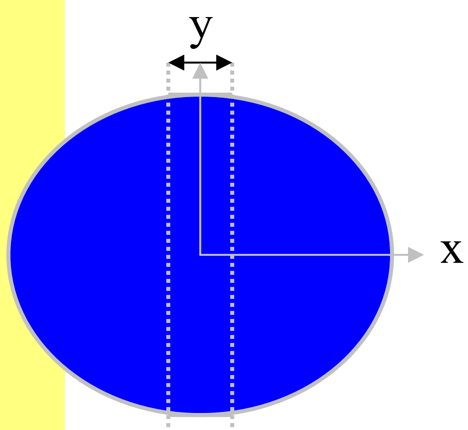
- Two symmetric couplers to reduce transverse kick
- Overcoupled (β=2.9) to match the beam.
- 30 MW are needed to compensate beam loading

RF Gun

- An idea to symmetrise the fields: Racetrack shape for cell iris (Haimson)

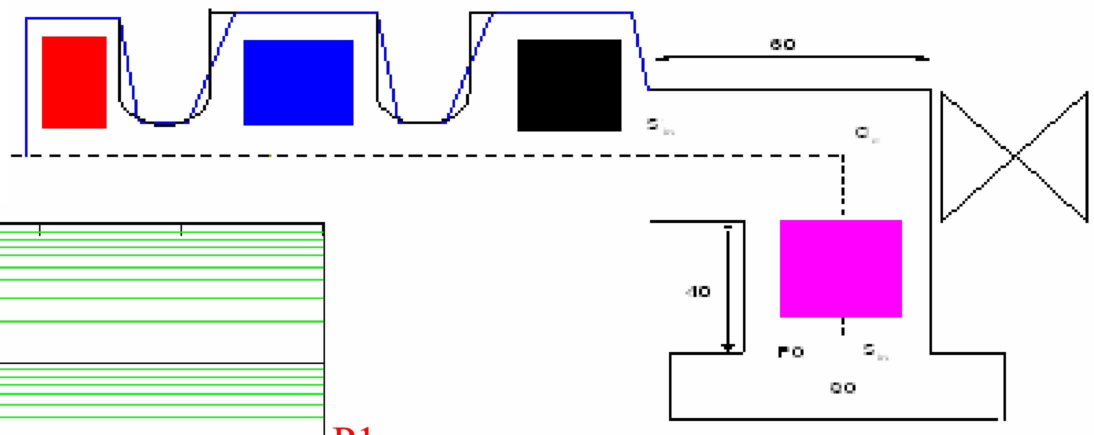


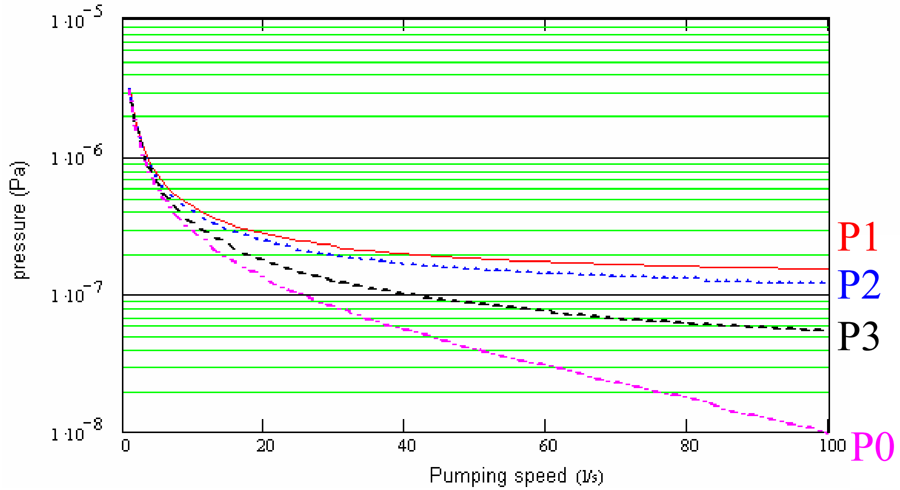
Straight part = 0.6 mm



RF Gun

Monte-Carlo based simulations of the residual pressure





- Useless above 40 l/s
- Weak help of a supplementary pumping

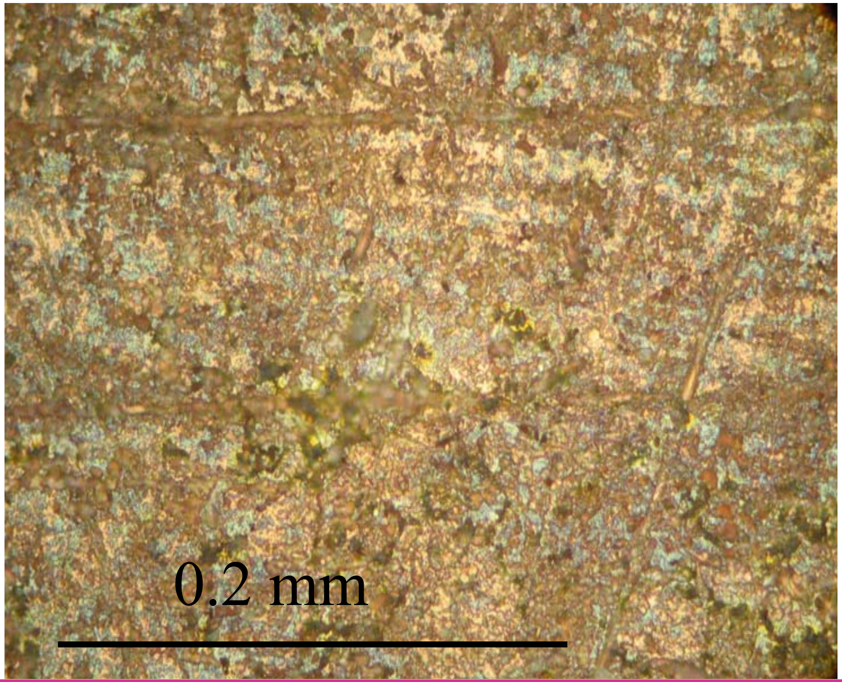
RF Gun

Improvement of static pressure:
minimize the out-gassing rate by High temperature bake

Copper in oven 3 days, t° = 550°C
Fast cooling with Ar jet 150°C
=>No grain size enhancement

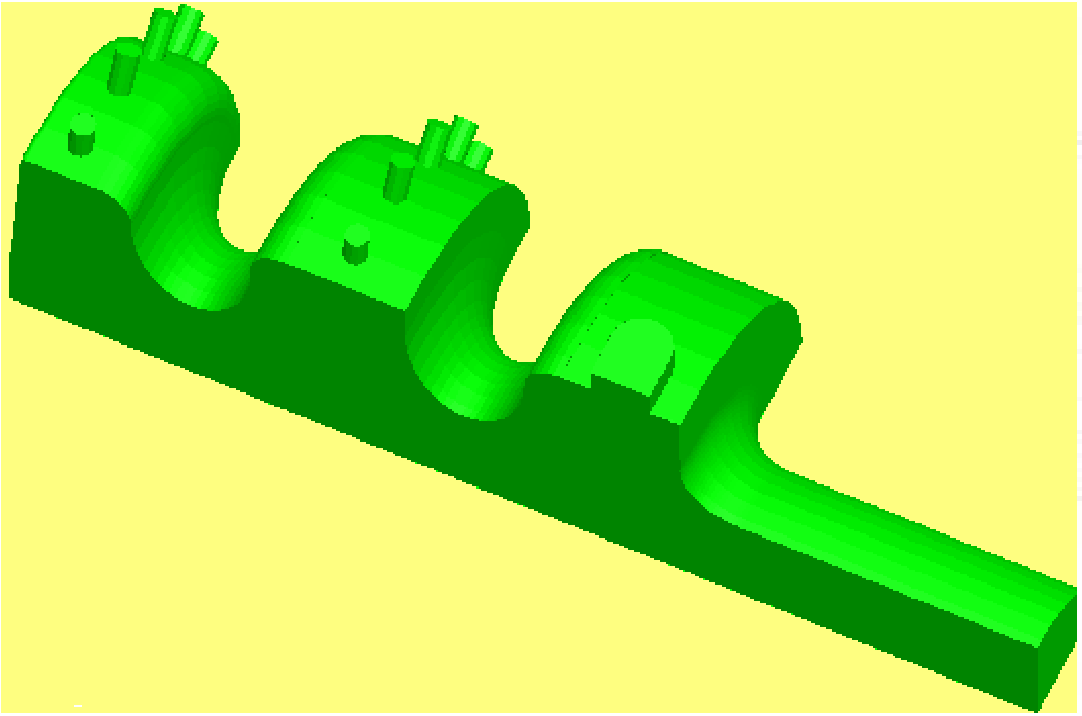
- Thanks to the high T bake-out

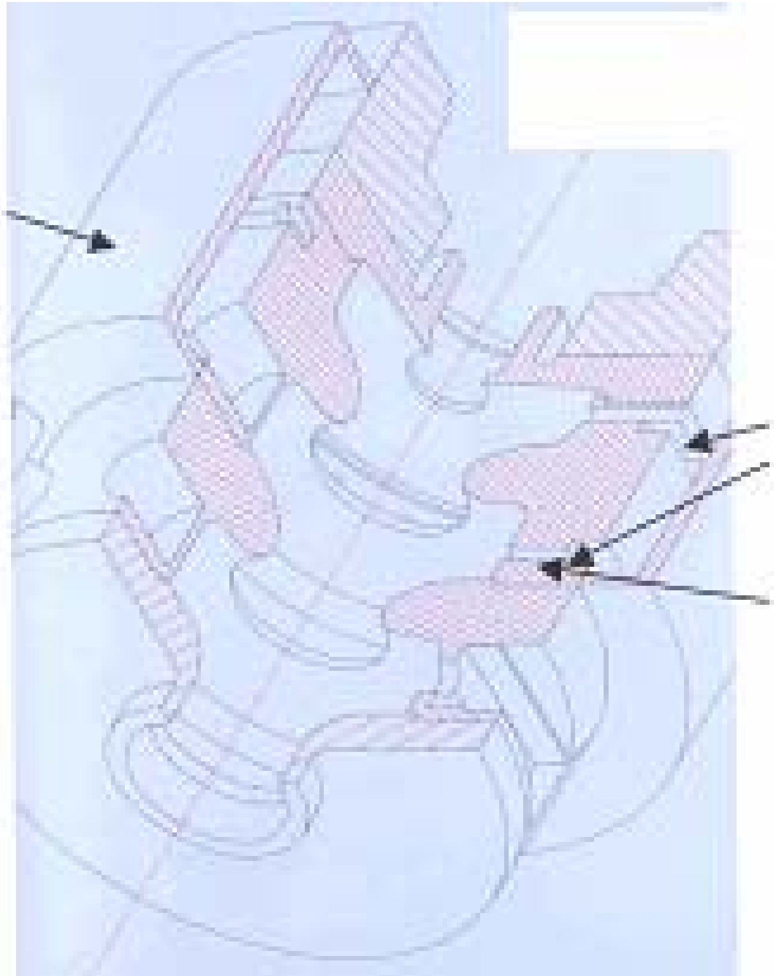
The residual pressure from copper outgassing should be reduced by at least one order of magnitude (down to 10^{-10} mbar)



RF Gun

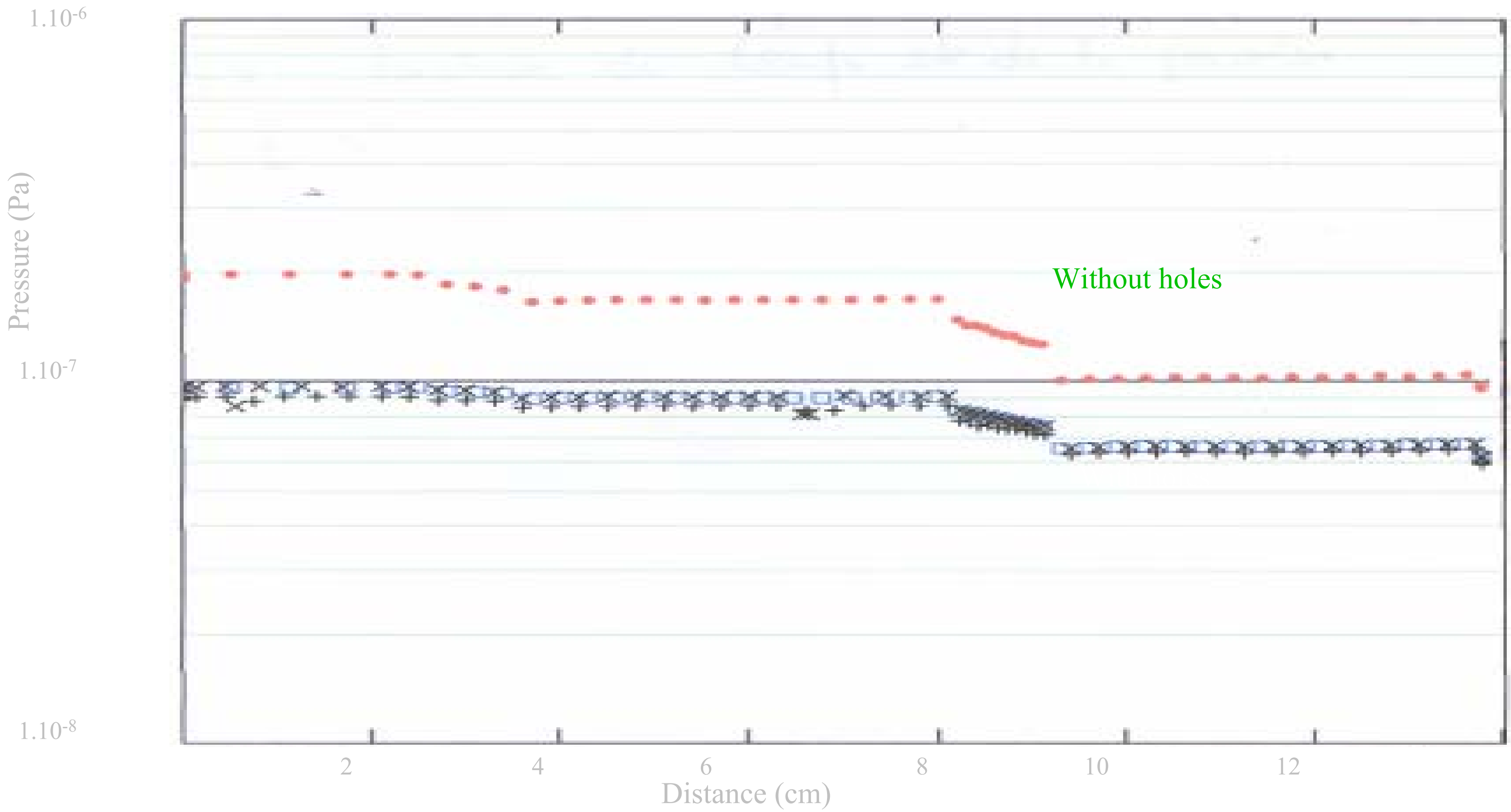
42 holes drilled in the gun walls (Φ=4mm)
Volume around the holes coated with NEG



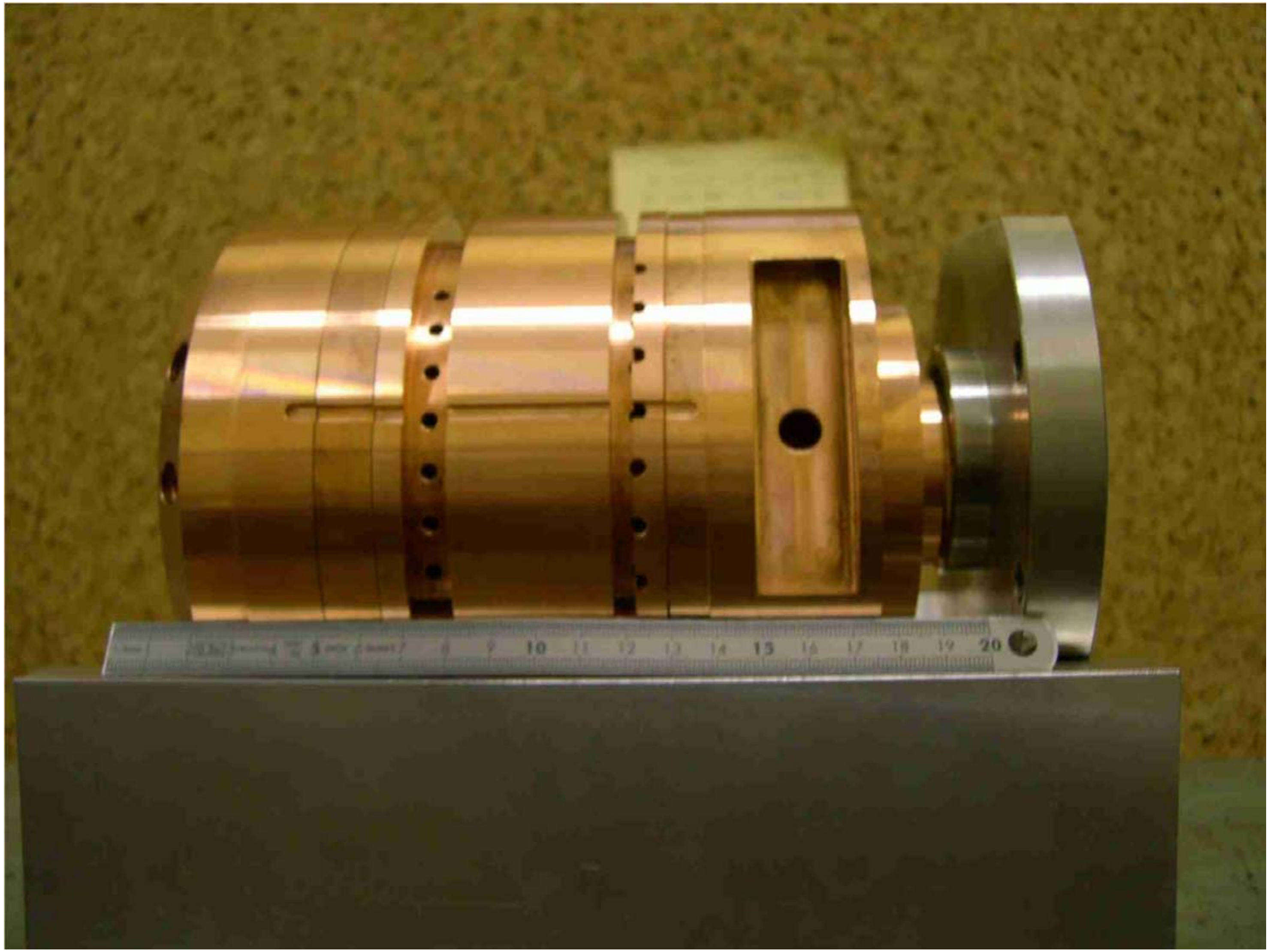


RF Gun

Improvement of static and dynamic pressure:
Drill holes in the cells and depose a NEG film in the volume outside

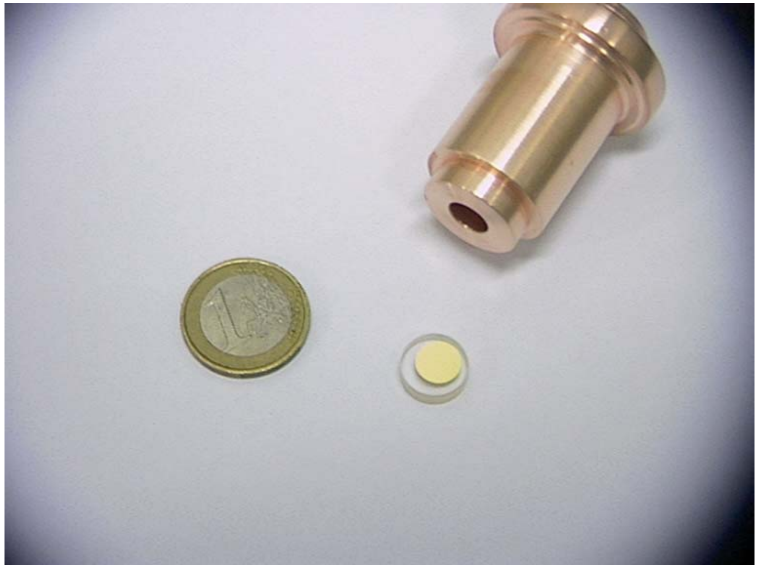


RF Gun

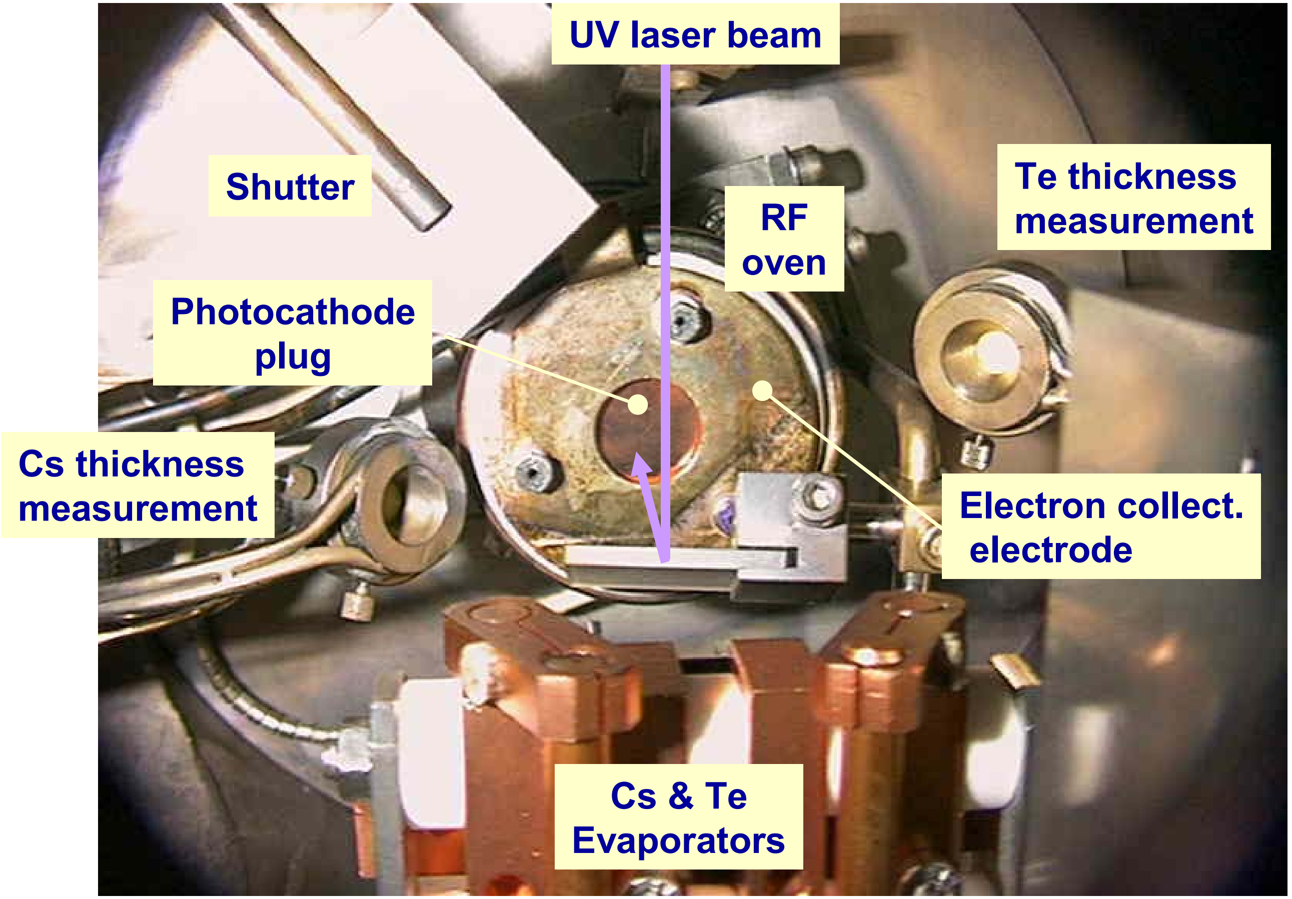


Photocathodes

- 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

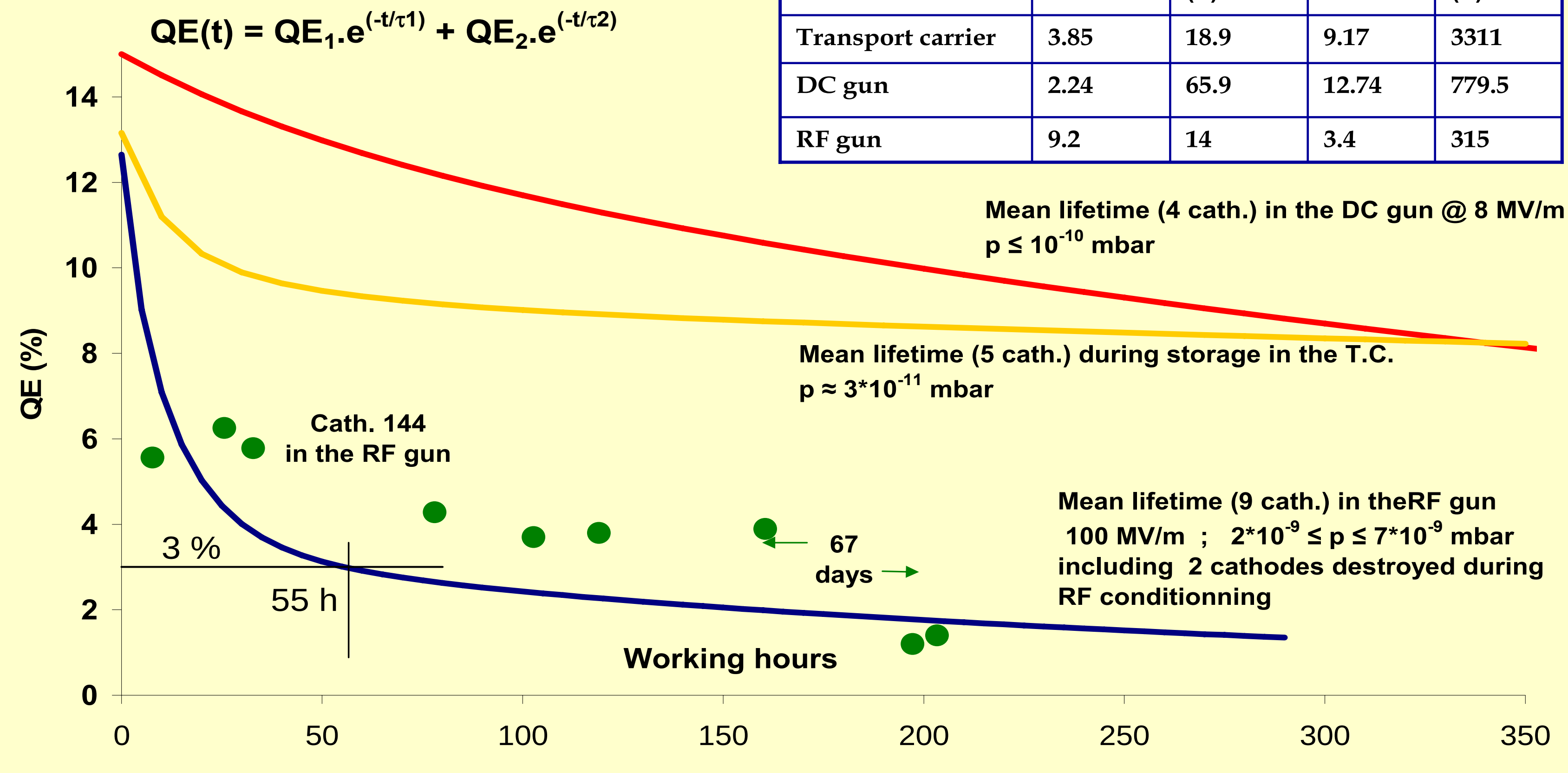
Photocathodes

- Improvement of Cs-Te cathode production (standard cathodes for CTF3)
- Co-evaporation : thickness calibration ➔ evaporation rate control ➔ stochïometric 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

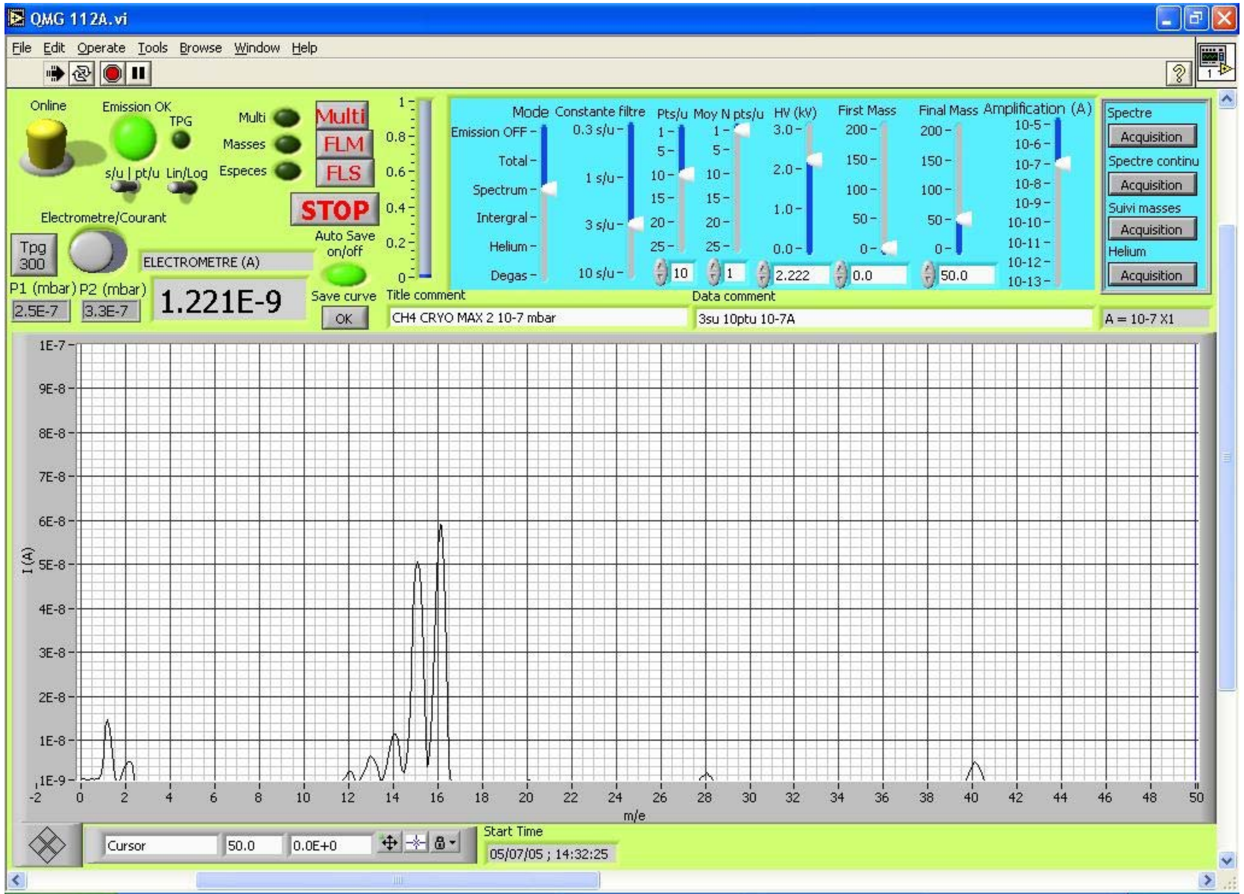
- But photocathodes produced by co-evaporation seem to be more sensitive to the vacuum quality

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

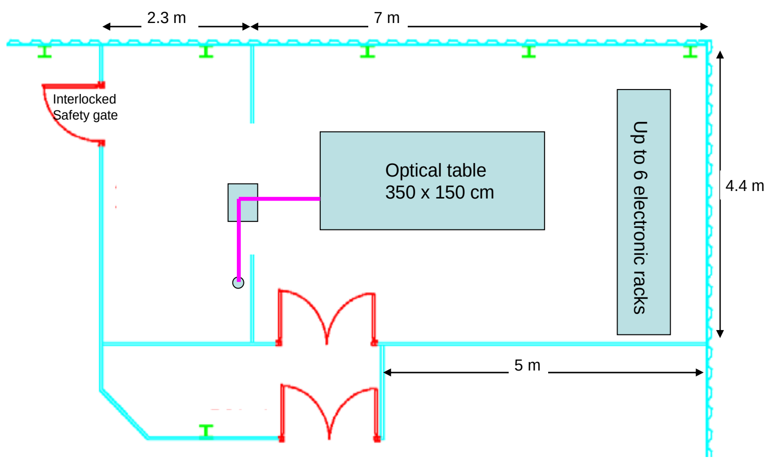


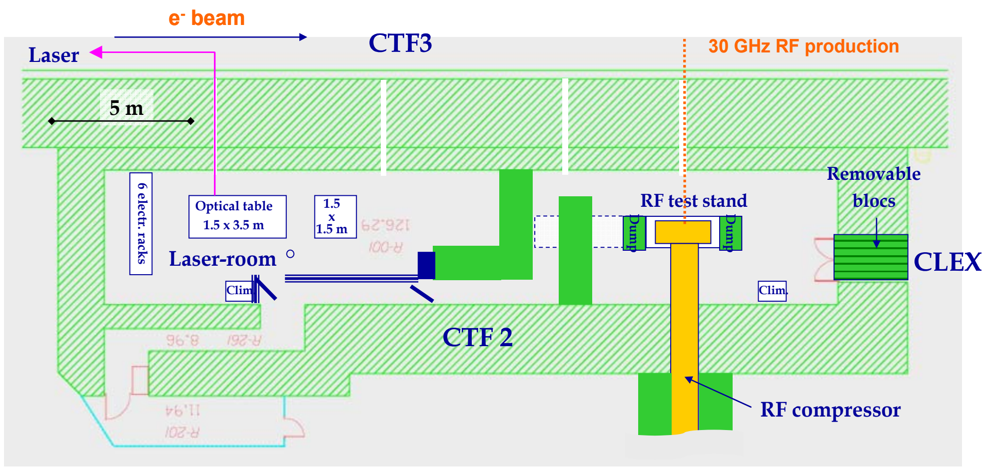
Photocathodes

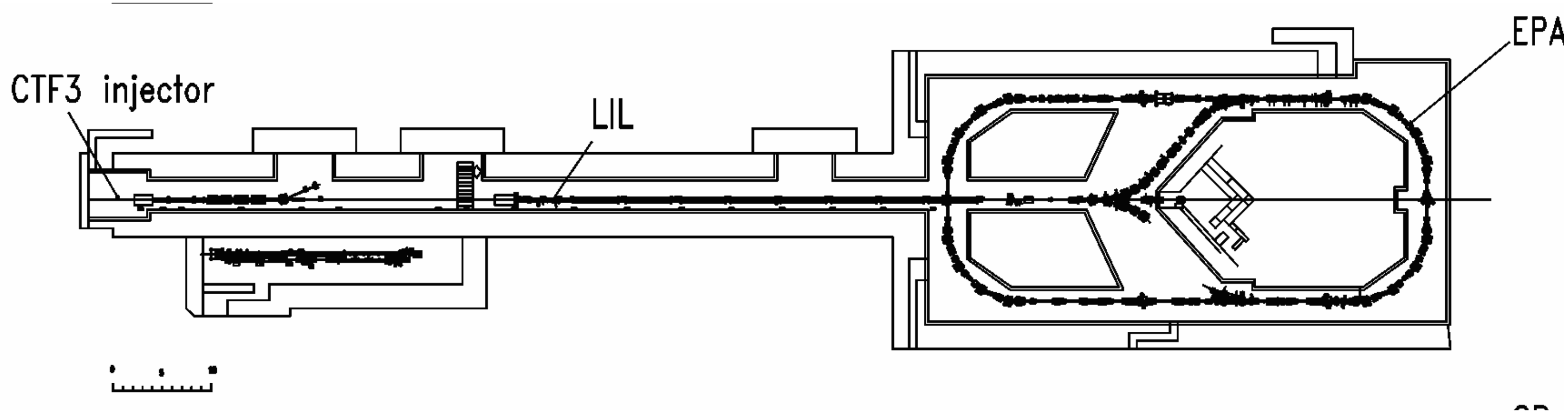
- Rest gas analysis by mass spectrum analyzer: spectrum of CH_4



Putting All Together







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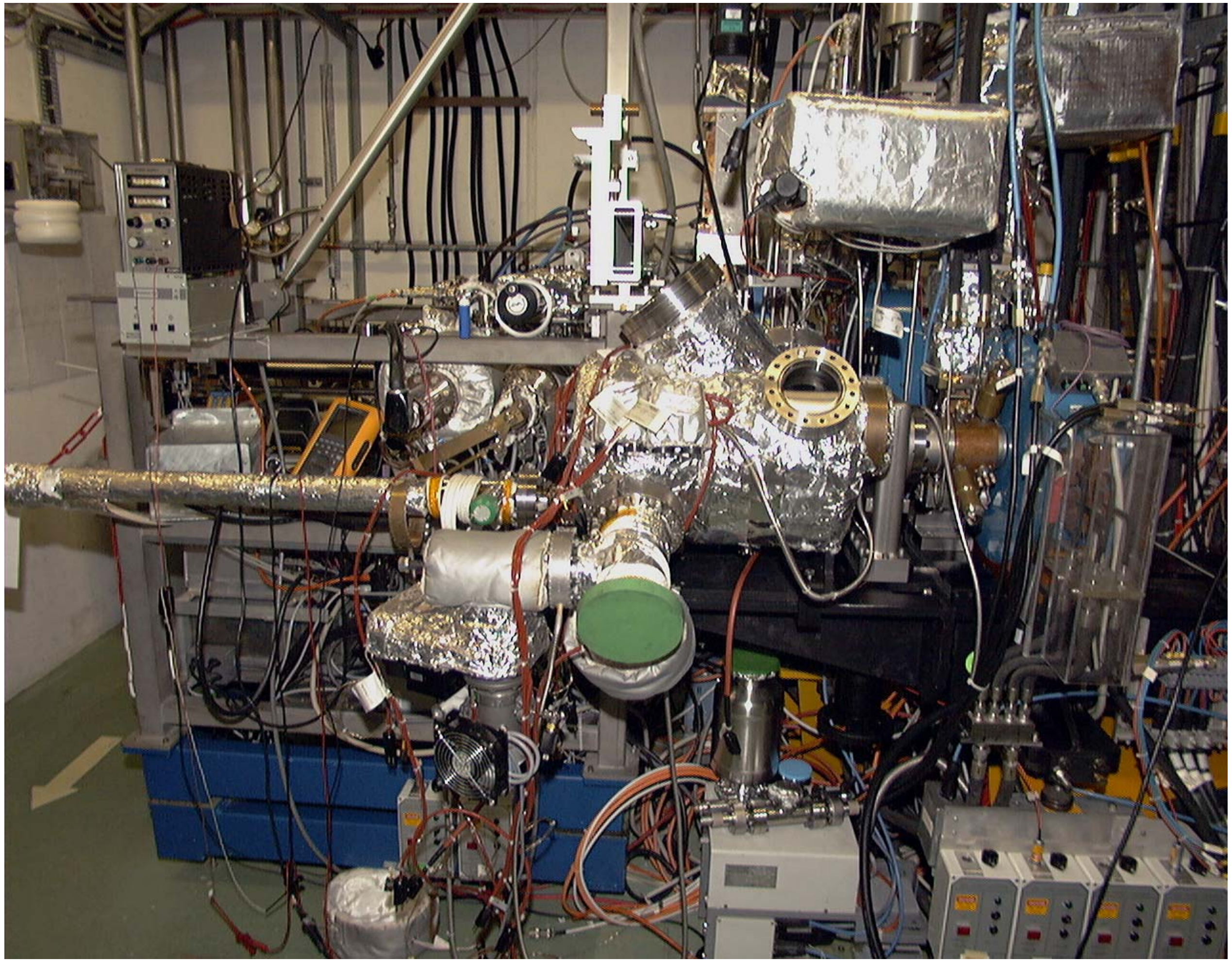

Conclusions

- Design Phase is concluded, both for the Gun and the Laser
- A solid solution for photocathodes already exists, we will try to improve the reproducibility
- Laser is expected at CERN by May 2006
- The RF Gun is expected by August 2006
- The first beam is for Care '06