The PHIN Photoinjector for the CTF3 drive beam

R. LOSITO - ATB/LPE

for the “PHIN Team”

Acknowledgements

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PHIN

- PHIN – Charge Production with **PH**oto**IN**jectors is a Joint Research Activity in CARE.
- It concerns several projects:
  - CTF3 Photoinjector

OUTLINE

- Photoinjector specs and design
- Photocathodes (CERN)
- RF Gun (LAL)

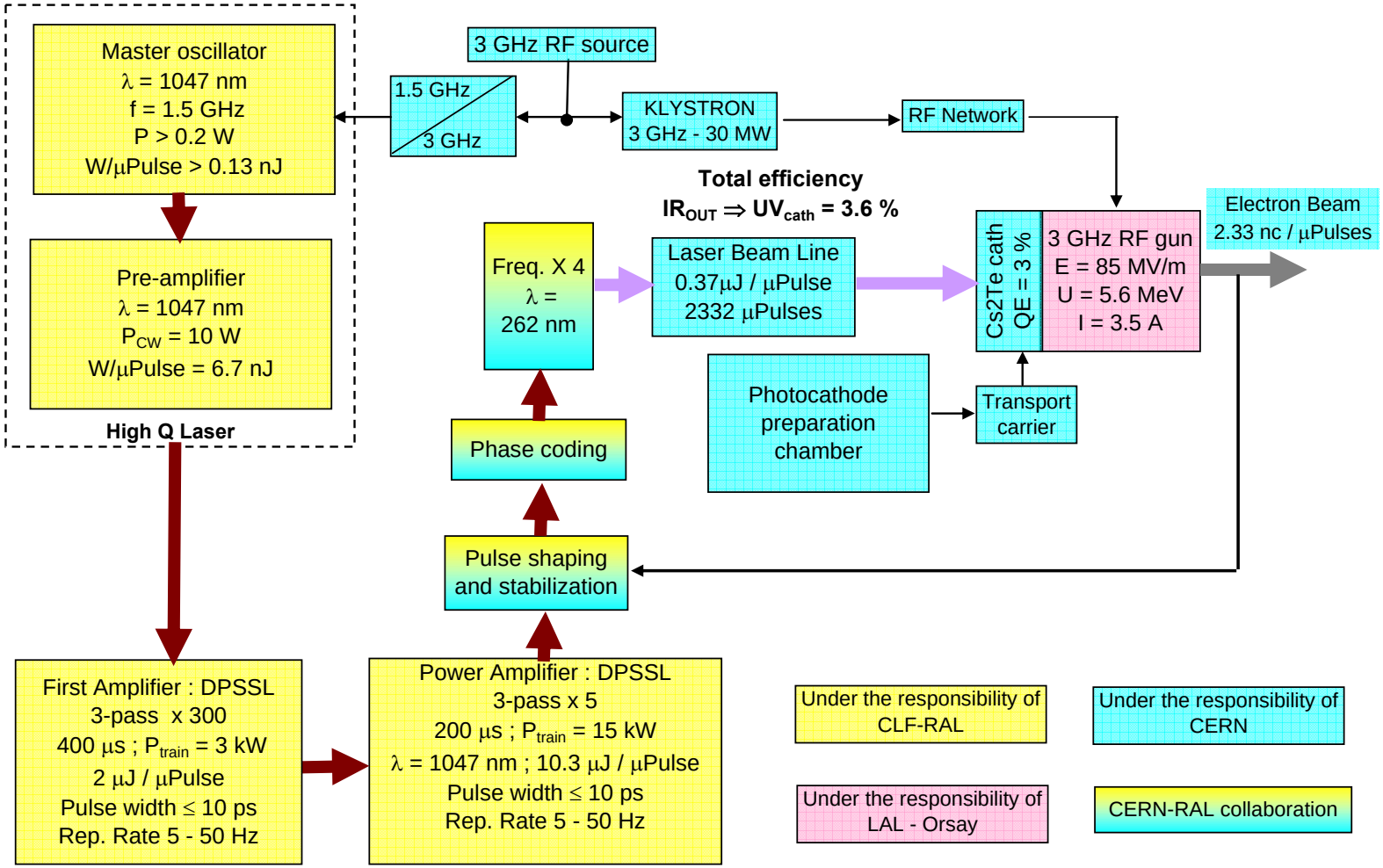
PHIN overview

			NOMINAL	OPTIONAL		Unit
e- beam	Pulse train duration (1)		1.548			μs
	Pulse train charge (1)		5434			nC
	Average current in the pulse train		3.51			A
	Number of bunches in the sub-pulse		212	106	53	
	Odd/even sub-pulse width (FWHH)		140.735			ns
	Number of bunches in the pulse train (1-2)		**2332**	1166	583	
	Charge / bunch		2.33	3	5	nC
	Distance between bunches		**0.667**	1.334	2.668	ns
	Bunch width (FWHH)		10	10	10	ps
	ε_T normalized	≤	25			π.mm.mrad
	Δp/p	≤	2			% rms
	charge stability	≤	0.25			% rms
	Repetition rate		**1 - 50**			**Hz**
	Mean current @ 50 Hz		271.68			mA
RF gun	RF frequency		2.99855			GHz
	RF power	≤	30			MW
	Beam energy	≥	5			MeV
	Beam current		3.51			A
	Vaccum pressure @ nominal charge	≤	**$2x10^{-10}$**			**mbar**
Photo-cathode	**Cs2Te : QE**	**≥**	**3**	**3**	**3**	**%**
	Wavelength	<	270	270	270	nm
	Lifetime	**≥**	40			working hours
Laser beam conv. and transport	UV energy / bunch @ the cathode		0.368	0.473	0.789	μJ
	Beam radius - min @ the cathode		1	1.4	2	mm
	Beam radius - max @ the cathode		2	2.8	4	mm
	Energy stability @ the cathode (rms)	≤	0.25			% rms
	Pointing stability	±	0.5			mm
	Odd/even sub-pulse width (FWHH)		140.74			ns
	Odd-even sub-pulse rise/fall time (10%-90%)		2 - 30			ns - ajustable
	IR-UV conversion efficiency		0.15			
	Safe margin		0.5			
	Laser beam transport transm.		0.7			
	Pulse shaping and coding transm.		0.7			
	UV cath. energy / Output IR energy		**0.037**	**0.037**	**0.037**	
Output Laser	Output IR energy / bunch	≥	10	13	21	μJ
	Bunch width (FWHH)	≤	10	10	10	ps
	Wavelength		1047			nm
	Repetition rate		1 - 50			Hz
	Timing jitter	≤	1			ps rms

(1) With starting bunches

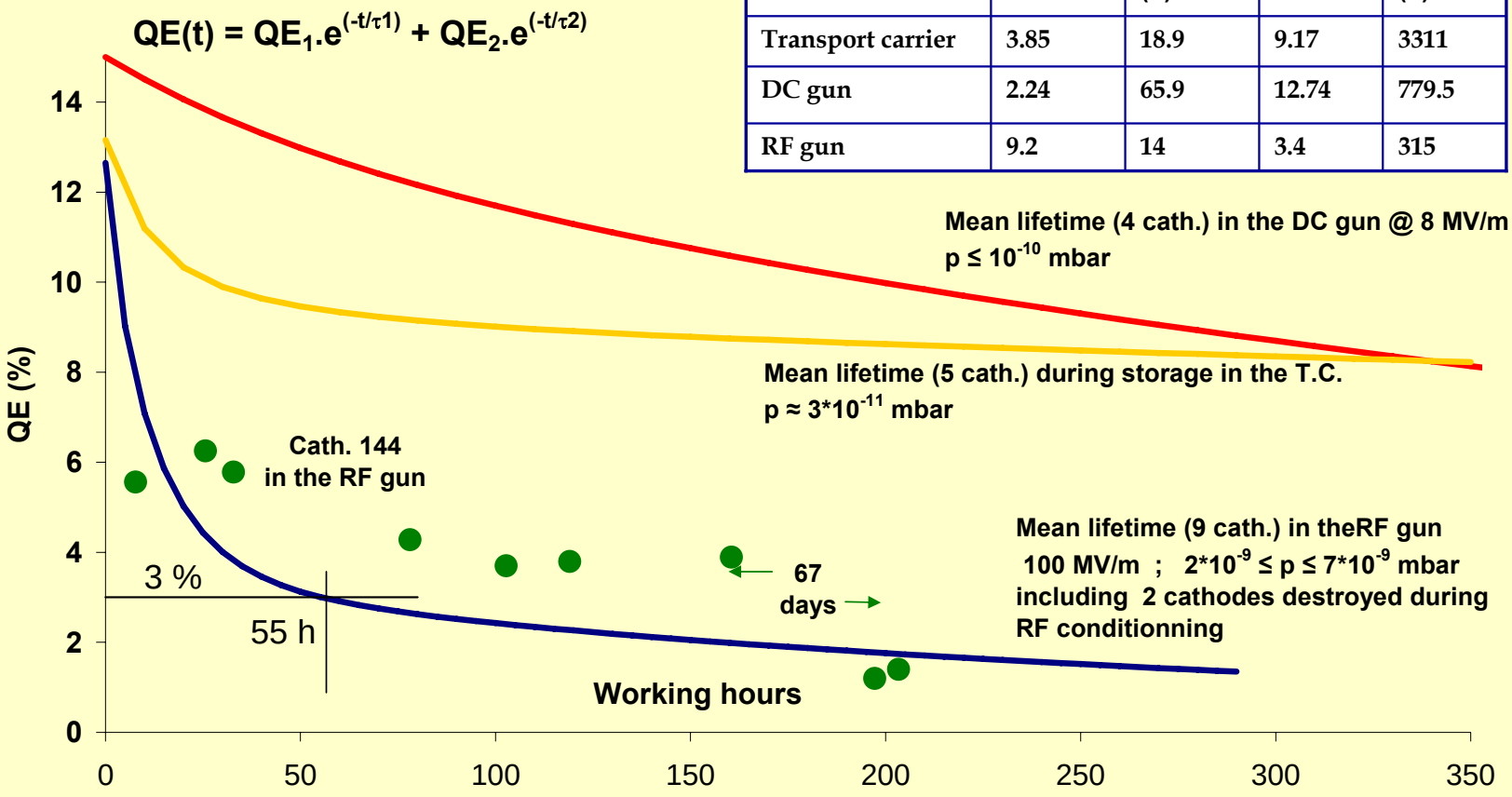
(2) The photo-injector must be able to produce only one electron pulse

PHIN overview



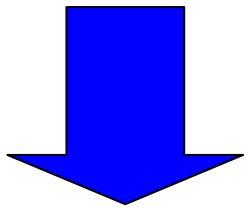
Photocathodes

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

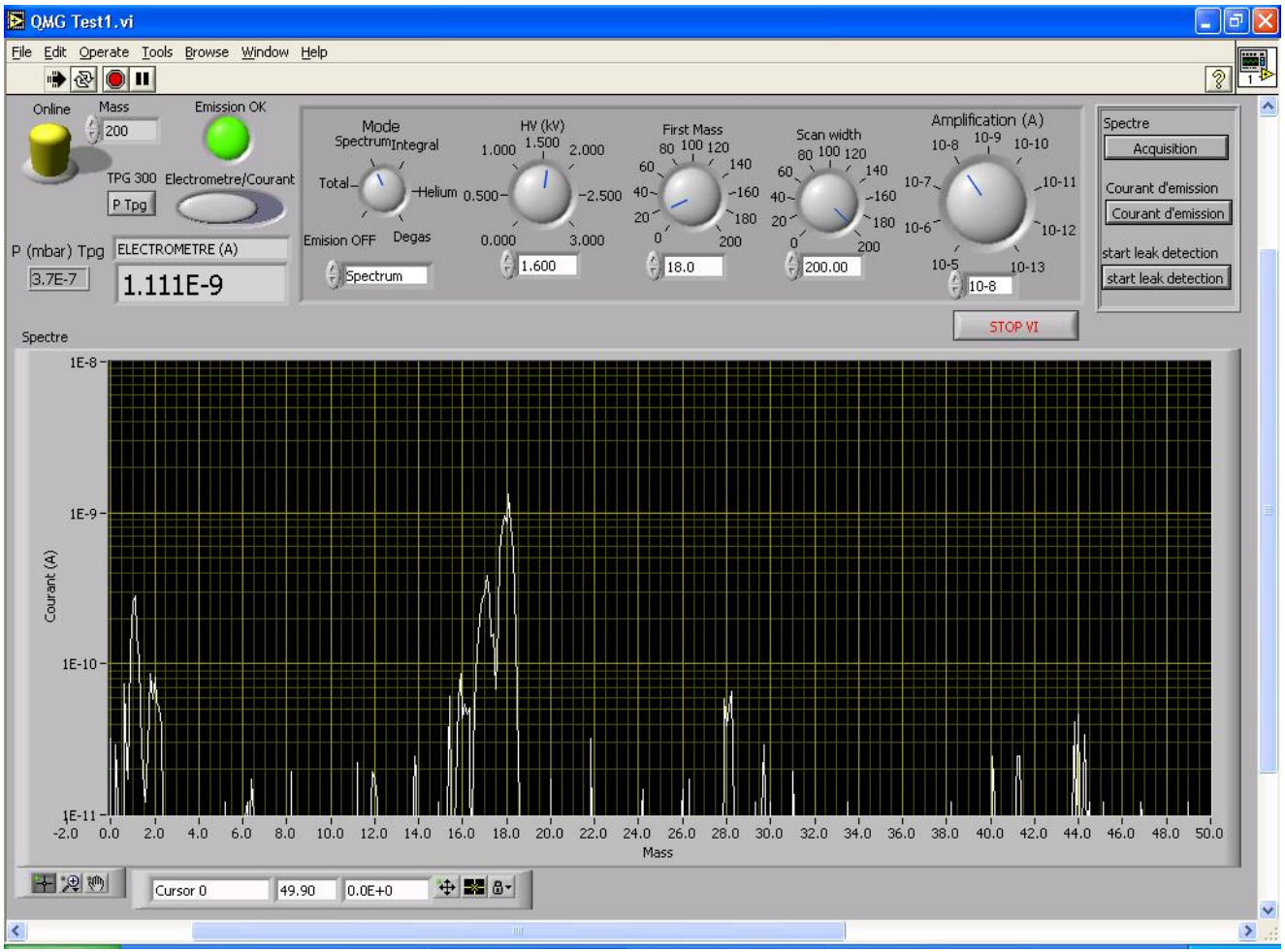
- R&D on photocathodes:
  - Cs_2Te cathodes produced at CERN show a large spread in quantum efficiency (min 3%, max 22%)



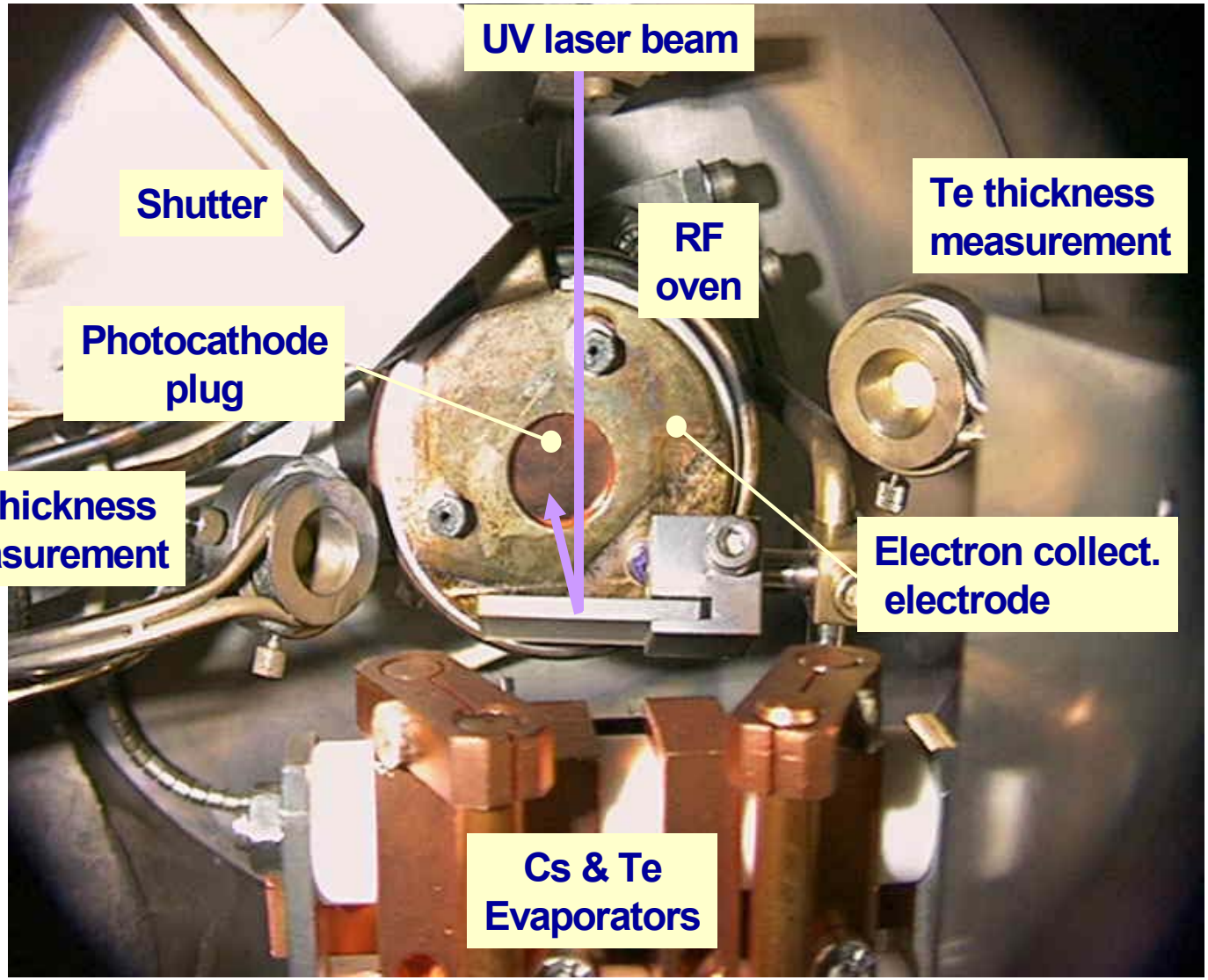
  - A better control of the process is necessary

Photocathodes

- Residual gas analysis by mass spectrum analyzer



Photocathodes



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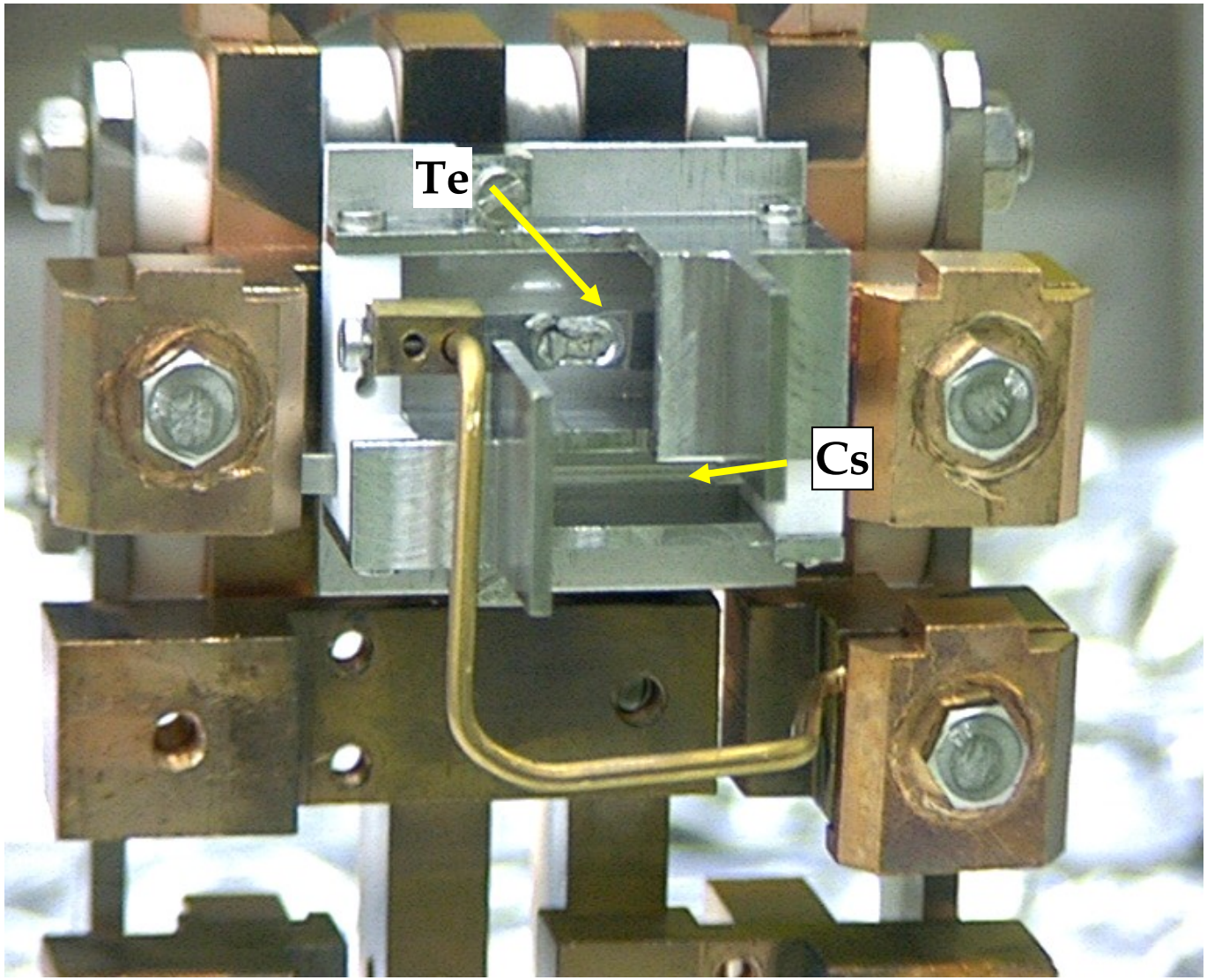

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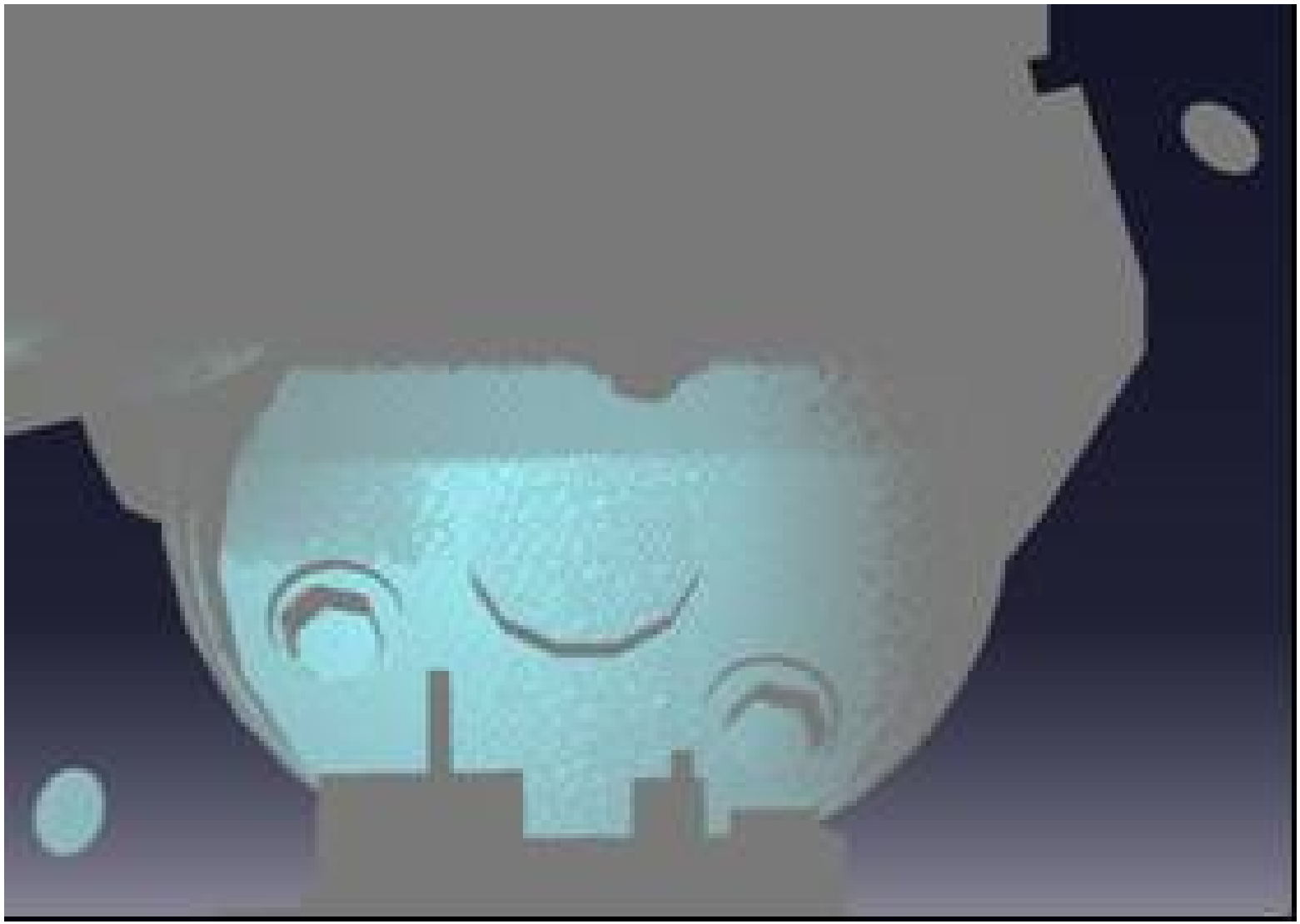
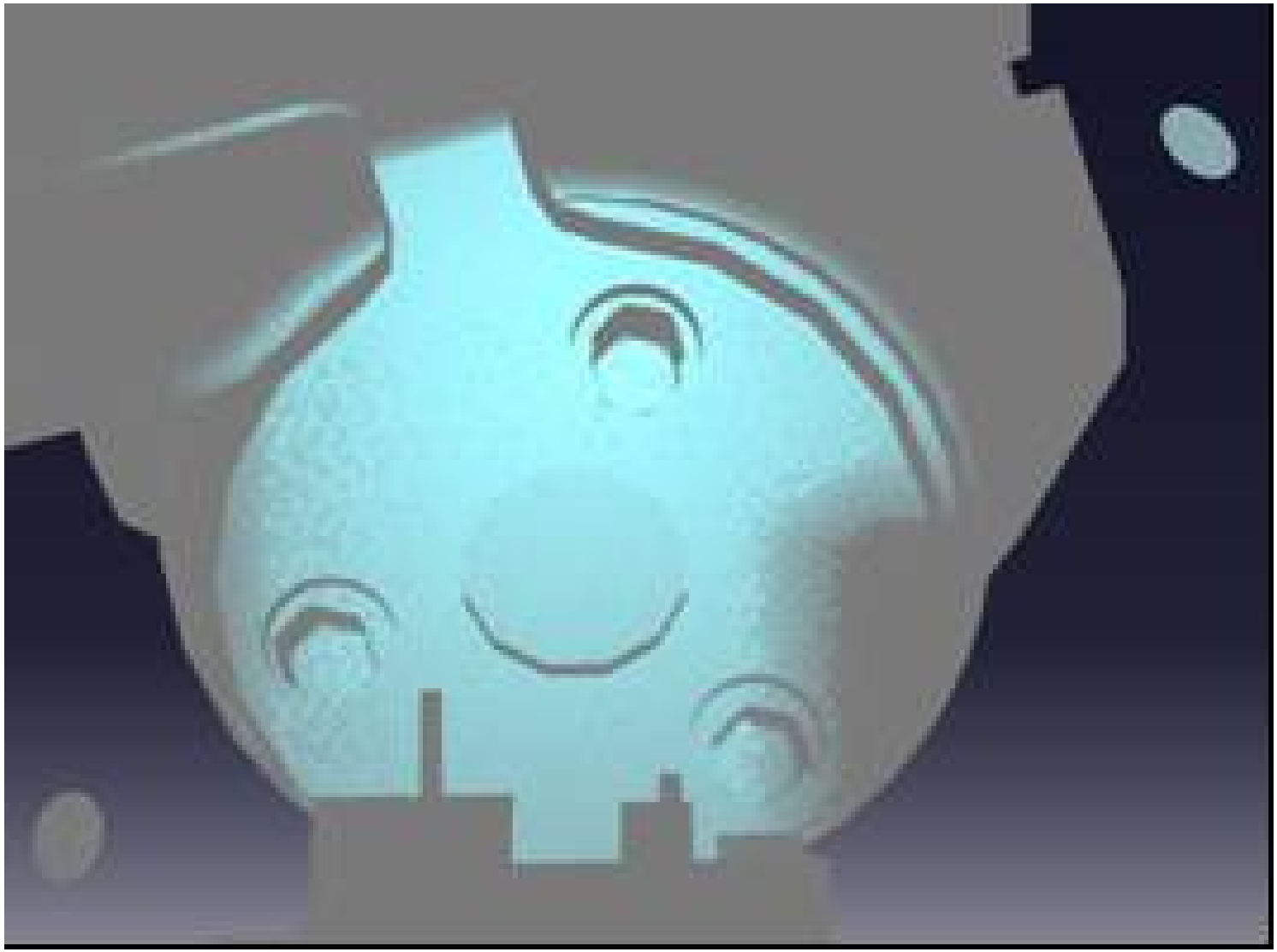


Photocathodes



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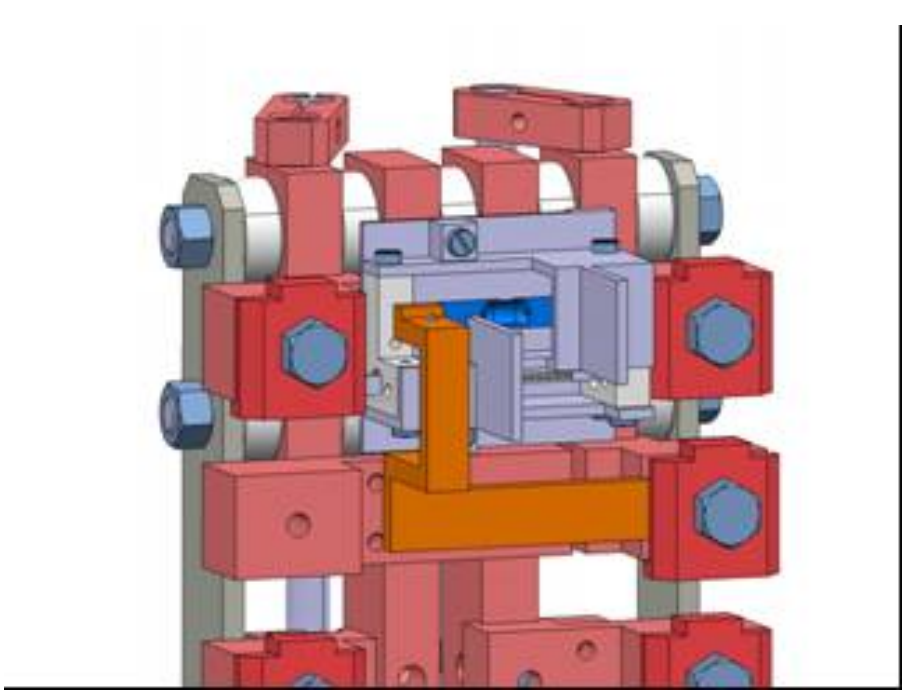
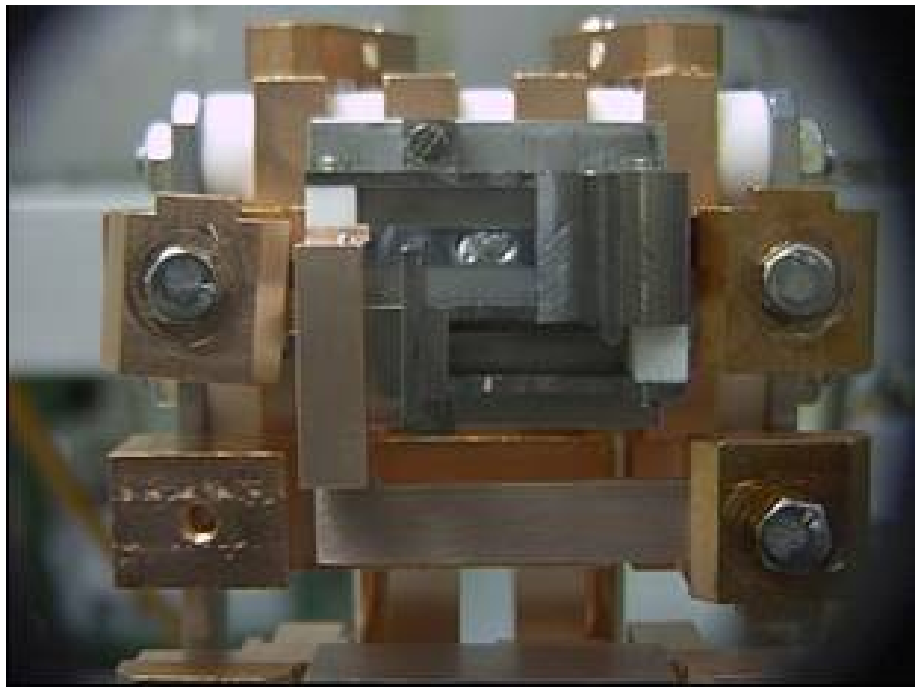
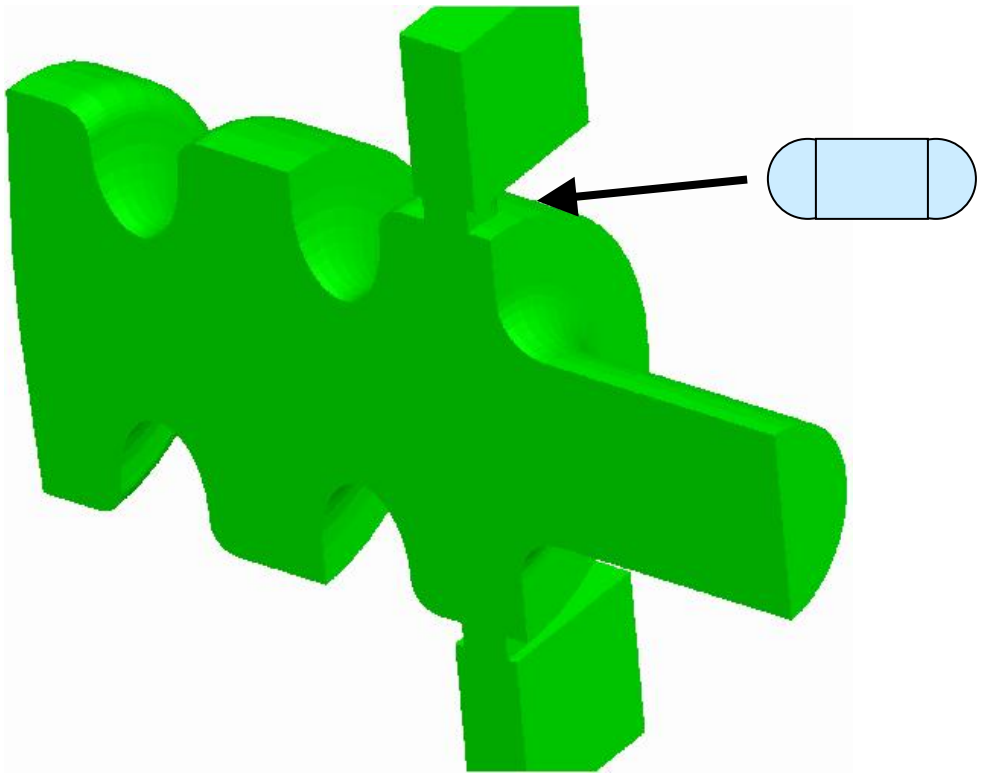




RF Gun

- 3D Simulations with HFSS

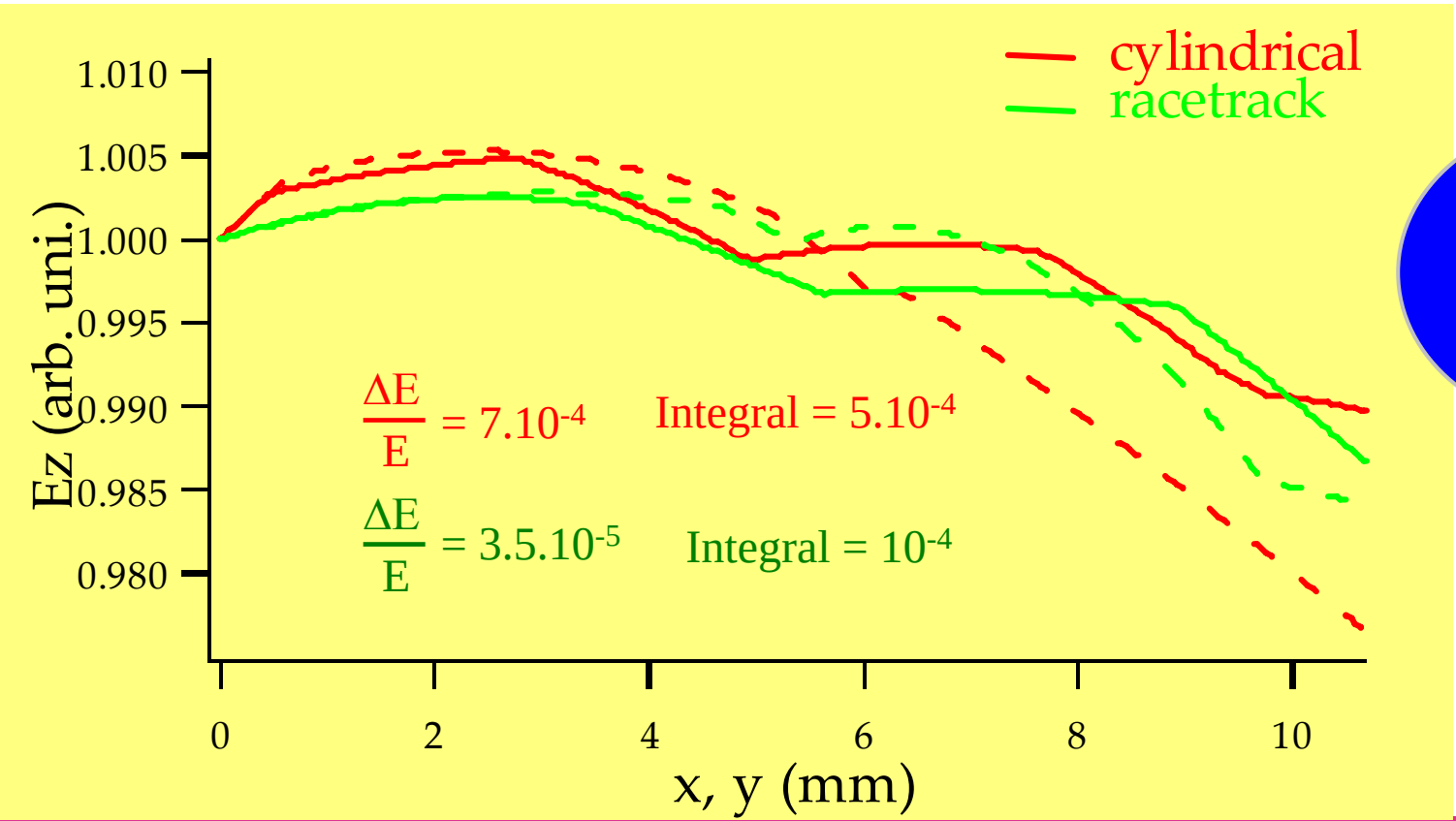


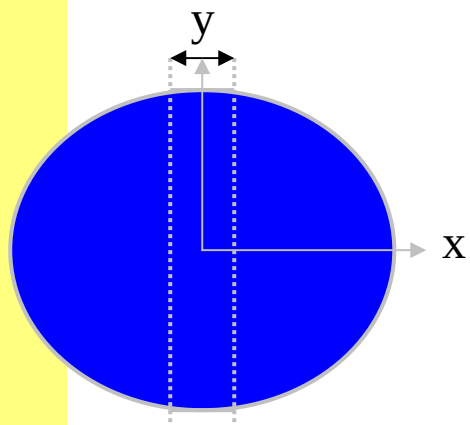
- Elliptical iris
- Two symmetric couplers to reduce transverse kick
- Overcoupled (β=2.9)

RF Gun

- Another trick to symmetrise the fields: Racetrack shape for cell iris (Haimson)

Straight part = 0.6 mm





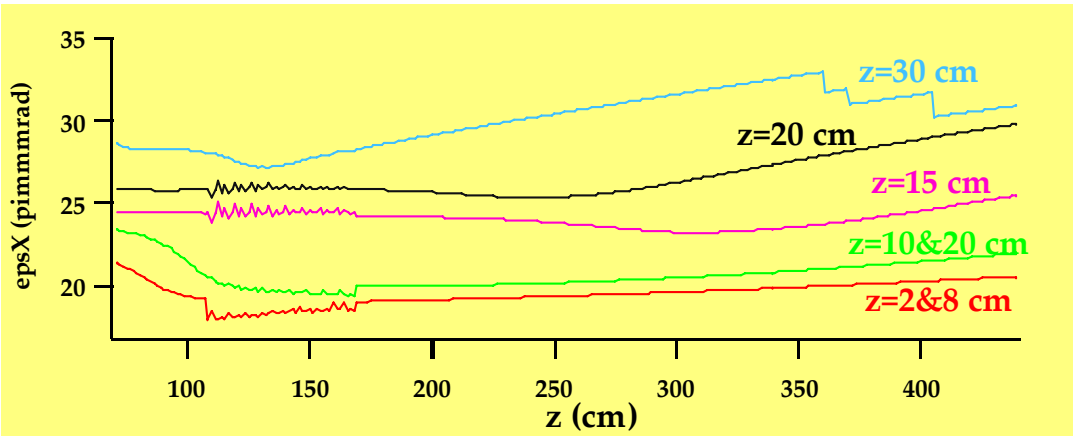
RF Gun

Electric field from 2D design → PARMELA →

I = 3.51 A

E (MeV)	5.45
ε_x (πmmmrad)	19.6
σ_x (mm)	3.2
σ_z (mm)	1.07
σ_γ / γ (%)	0.36

Compensation of space charge forces



- Best Result (Red curve):
  - 3 coils close to the cathode , 0.25T max
  - RF coupler on last cell after the coil

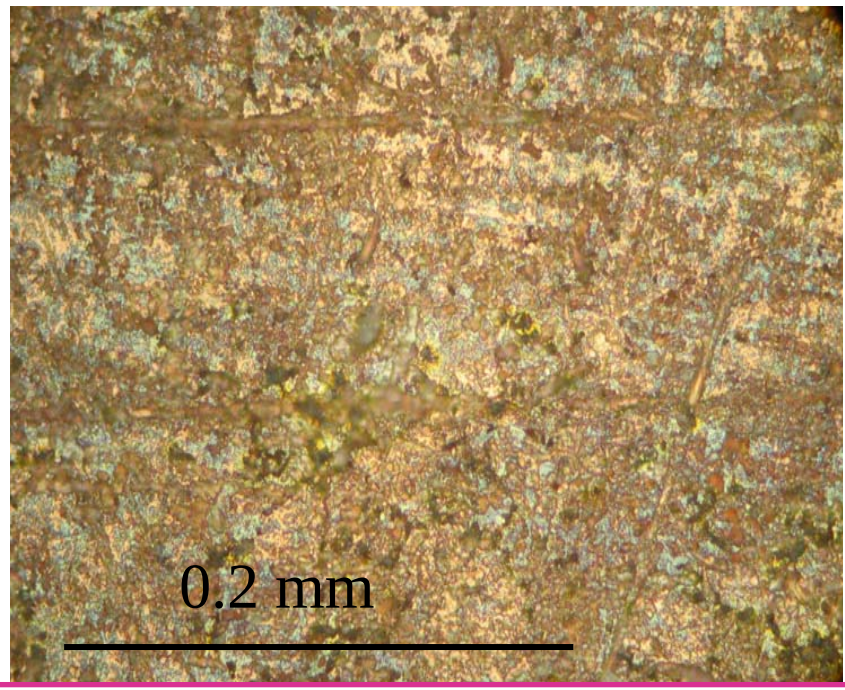
RF Gun

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

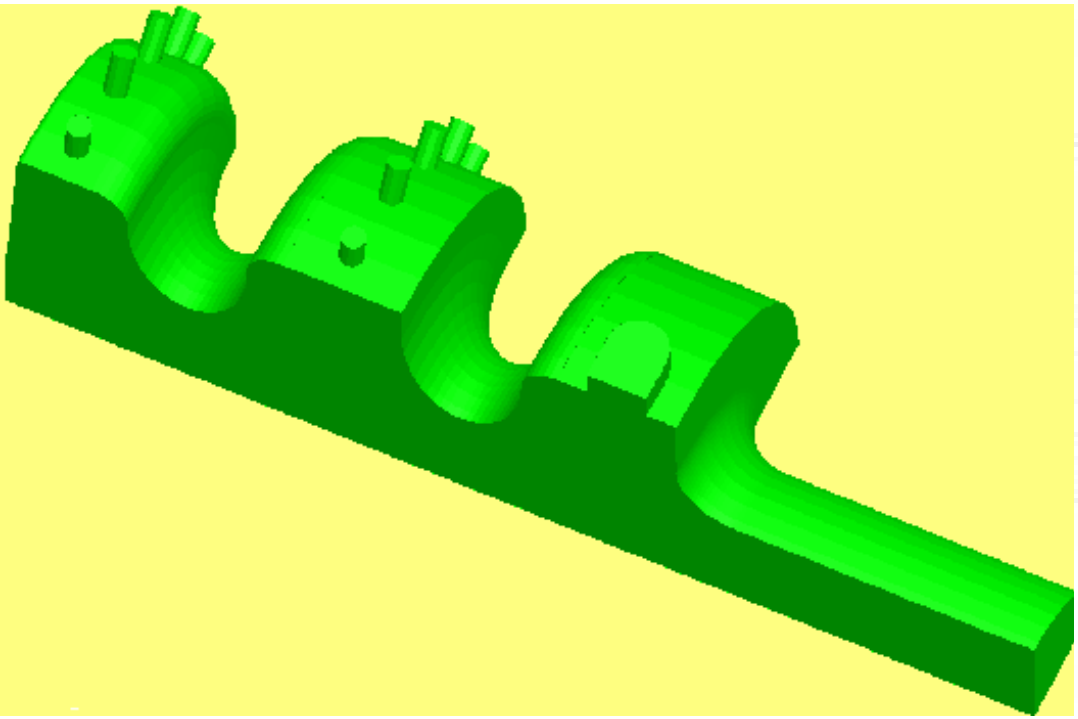
- Thanks to the high T bake-out

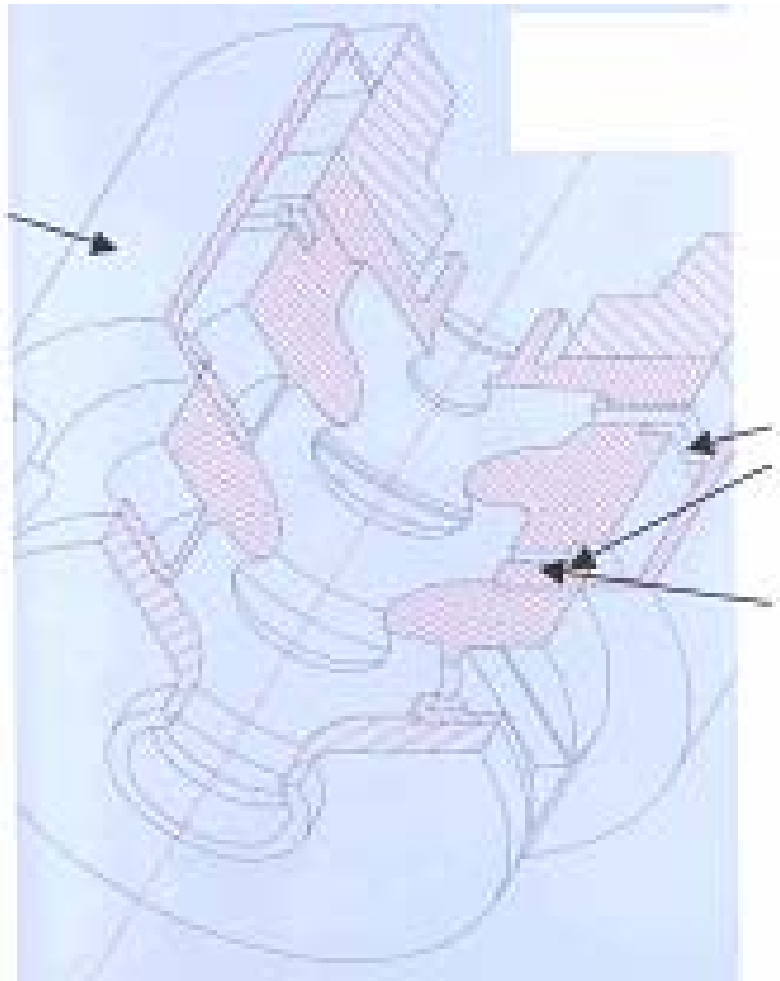
The residual pressure from copper outgassing should be reduced by at least one order of magnitude (down to 10^{-10} mbar)



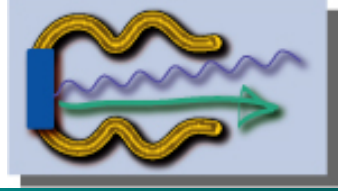
RF Gun

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





RF Gun: schedule



- July 2006: delivery of machined cells
- August 2006: low level measurements, fine tuning of cells
- September/October 2006: Brazing
- November/December 2006: installation of bake out system, final low level measurements.
- January 2007: installation in CTF2

- (ps: solenoids are already at LAL)