Proposal of a photo-injector for CTF3

1. **Previous results**
2. **CTF3 photo-injector specifications**
3. **Realization inside European Union program FP6**
4. **Remaining Laser and Photocathode work**
5. **Common developments RILIS-CTF3**
6. **Conclusion**

Previous result : Feasibility of the CTF3 Laser

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A simple design of amplifier capable of high power and based on Nd:YLF has been constructed and tested. Its performance provided good verification for the analytical predictions for gain and efficiency, and the optical quality of the amplifier at high average power was assessed. The most promising aspect of this amplifier has been the measured output pulse stability. At 0.7%rms over 1 hour this already competes favourably with the best previous measurements on lasers and we know this can be improved using a more stable diode-laser power supply and improved coolant temperature stabiliser. Additional stabilisation is also achievable using a closed cycle feedback control system.

I.N. Ross, M. Csatári, S. Hutchins, **A HIGH PERFORMANCE DIODE-PUMPED Nd:YLF AMPLIFIER - CTF3 Note 048 – July 2002**

BUT

To be taken into account the photo-injector MUST also demonstrate the feasibility for CLIC

From CTF3 Review 2/10/2001

- On paper for the laser and with the today technology

  ⇒ This has been done : see CLIC Note 462

- As close as possible of the CLIC working point for the photocathode

  ⇒ This has been done : see CTF3 Note 020

⇓

The photo-injector should be an option for CTF3 and CLIC

⇓

see CLIC Note 487

Previous result : Feasibility of the photo-cathode

- Cs_2Te photocathode produced by co-evaporation on an RF conditioned copper plug cleaned by argon ion bombardment
- Demonstrated for all CTF3 parameters excepted the number of bunches (not possible to test)
- Minimal quantum efficiency : 3 %
- Minimal lifetime : 1 week
- If the RF gun pressure is less than 2×10^{-10} mbar with the full RF power

Previous result : Feasibility of the RF gun

No special issue to build the CTF3 RF gun

But

Special attention must be paid to the vacuum

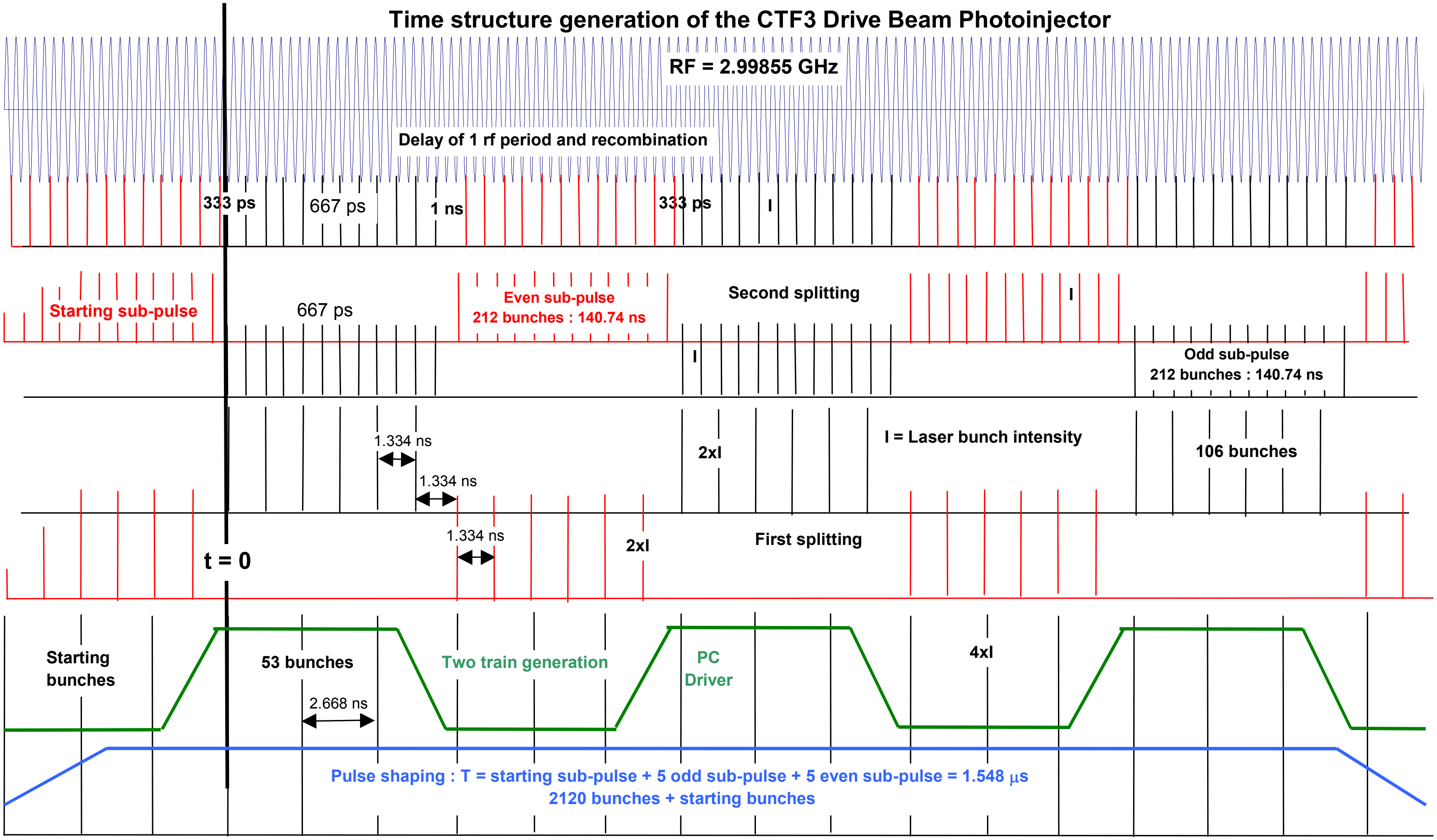
CTF3 photo-injector specifications

			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 (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
RF gun	RF frequency		2.99855			GHz
	RF power	≤	30			MW
	Beam energy	≥	5			MeV
	Beam current		3.51			A
	Vaccum pressure @ nominal charge	≤	2×10^{-10}			mbar
Photo-cathode	**Cs2Te : QE**	3	**3**	**3**	**3**	**%**
	Wavelength		262	262	262	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			%
	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		**0.03675**	**0.03675**	**0.03675**	
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			

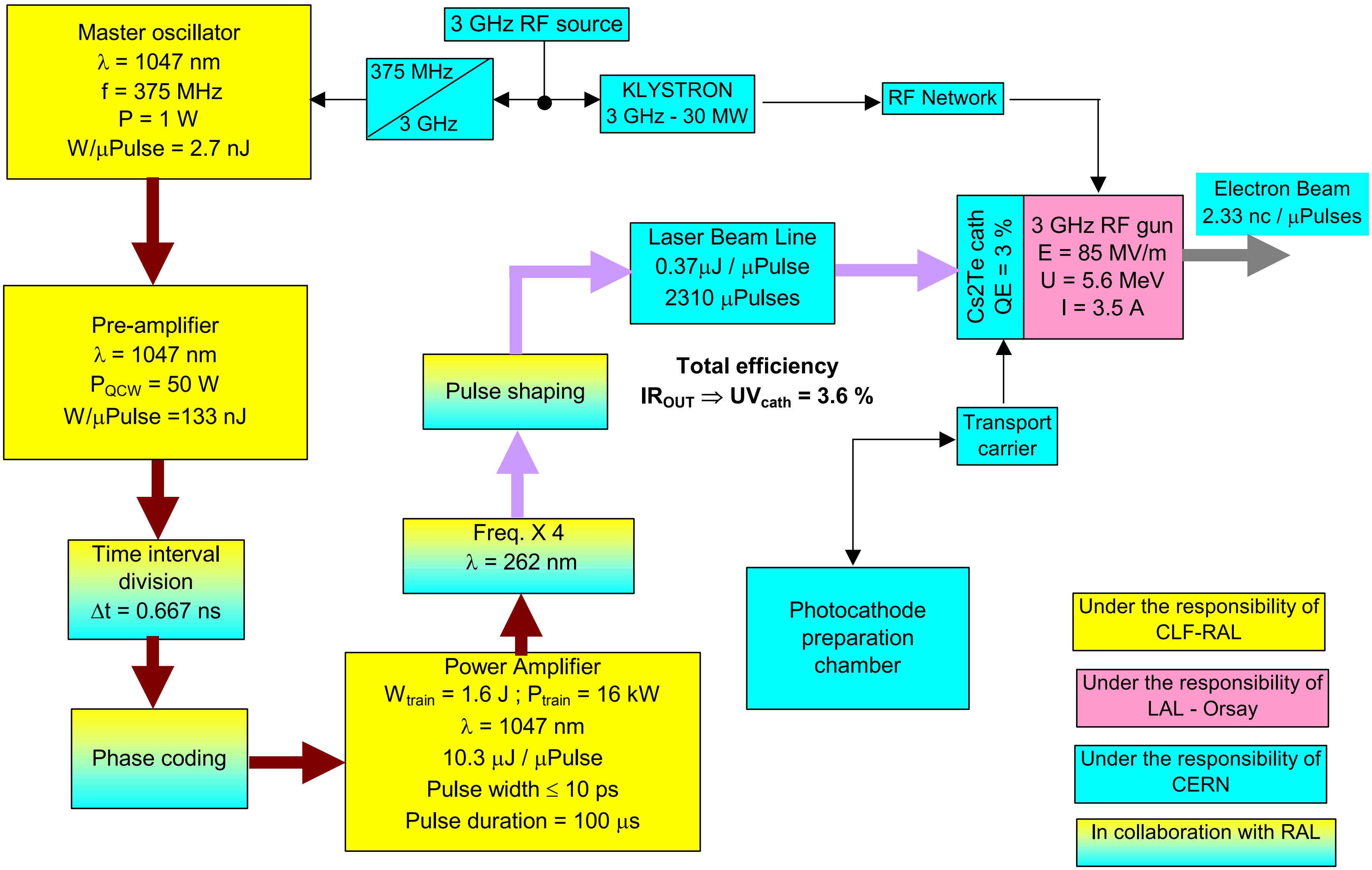
(1) **With starting bunches**

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

Train production



CTF3 photo-injector synoptic



E.U. FP6 - JRA3 in the CARE proposal

Title: Charge production with Photo-injectors

Acronym: PHIN   Coordinator: A. Ghigo (INFN-LNF)

Main Objectives: Perform Research and Development on charge-production by interaction of laser pulse with material within RF field and improve or extend the existing infrastructures in order to fulfill the objectives. Coordinate the efforts done at various Institutes on the photo-injectors.

Total Expected Budget	Requested EU Funding
3 M€ (FC) + 2.5 M€ (AC) Total = 5.5 M€	**4.0 M€**

One objective is to develop built and install the CTF3 photo-injector in a time scale of 2.5 years and for a requested budget of 1240 k€

Web site : http://esgard.lal.in2p3.fr/

Participating Laboratories and Institutes:

Institute	Acronym	Country	Coordinator	PHIN Scientific Contact	Associated to
CCLRC Rutheford Appletone Lab. (22)	CCRLC-RAL	UK	P. Norton	I.N. Ross	
CERN Geneva (19)	CERN	CH	H. Haseroth	G. Suberlucq	
CNRS-IN2P3 Orsay (3)	CNRS-Orsay	F	T. Garvey	G. Bienvenu	CNRS
CNRS Lab. Optique Appl. Palaiseau (3)	CNRS-LOA	F	T. Garvey	V. Malka	CNRS
ForschungsZentrum ELBE (10)	FZR-ELBE	D	J. Teichert	J. Teichert	
INFN-Lab. Nazionali di Frascati (11)	INFN-LNF	I	S. Guiducci	A. Ghigo	INFN
INFN- Milan (11)	INFN-MI	I	S. Guiducci	I. Boscolo	INFN
Twente University- Enschede (13)	TEU	NL	A. den Ouden	J. Verschuur	

JRA 3 organization

- Coordinator : A. Ghigo (INFN-LNF)
  - Deputy : L. Rinolfi (CERN)

Work Package	Full name	Short name	Coordinator	Laboratory
WP1	Management and Communication	M&C	A. Ghigo	INFN-LNF
WP2	Charge Production	CP	J. Teichert	FRZ-ELBE
WP3	Lasers	LAS	I. Ross	CCRLC-RAL
WP4	RF Guns and Beam Dynamics	GUN	G. Bienvenu	CNRS-LAL

CTF3 photo-injector Milestones

No	Date	Tasks or sub-tasks to be completed by milestone date	Task number
1	30/06/2004	Report on photcathode studies	2.1
		Report on laser oscillator design	3.1.1
2	01/12/2004	Report on 3 GHz RF gun design	4.2.1
		Laser oscillator test results	3.1.1
3	31/03/2005	Report on laser amplifier design	3.1.2
		Report on UV conversion crystal comparison	3.1.4
5	30/09/2005	Amplifier test results	3.1.3
		3 GHz RF gun test result and delivery to CERN	4.2.3
7	31/03/2006	Laser system test results and delivery at CERN	3.1.5
9	01/12/2006	Report on 3 GHz RF gun commissioning at CERN	4.2.3
		Report on new photocathode materials tests	2.1

Resources

- **Requested E.U. funding by work package and over JRA duration for the CTF3 photo-injector (k€)**

WP1 : M&C	WP2 : CP	WP3 : LAS	WP4 : GUN	TOTAL
15	55	970	200	1240

2004	2005	2006	2007	Total
518	518	208	6	1240

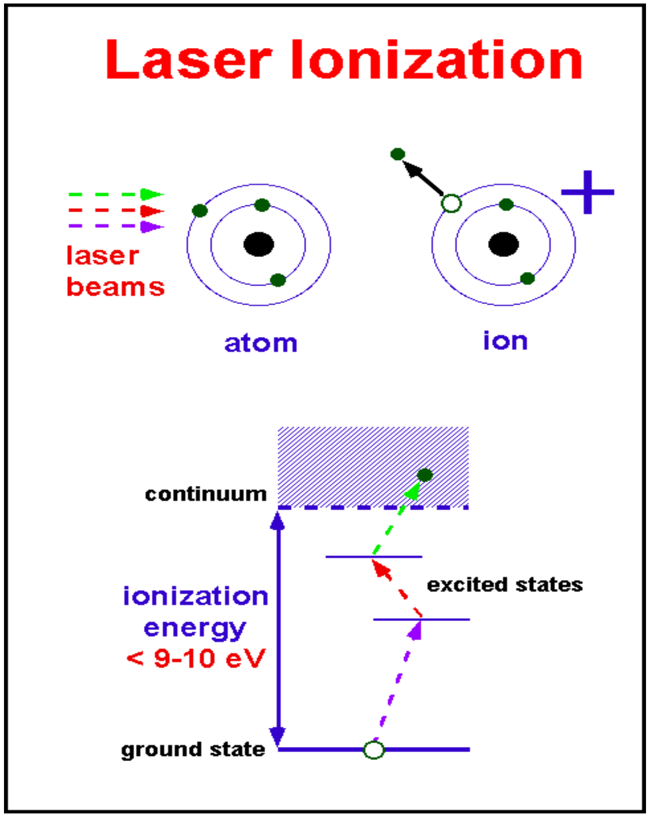
- **During the same period the CERN contribution to the Photo-injector (included commissioning) will be : 1370 k€**
  - Material : 170 k€
  - Personnel : 1200 k€
  - **Civil engineering is not included**

E.U. decision in October 2003

Remaining Laser and Photocathode work

- Acquisition of knowledge in Diode Pumped Solid State Laser (DPSSL)
- Pockel's cell study and train manipulation
- Harmonic conversion efficiency study
- Laser monitoring
- Feedback control, amplitude regulation
- Automatic control of the laser beam position
- Maintenance of preparation chambers both for probe and drive beam

RILIS : principle and general set-up

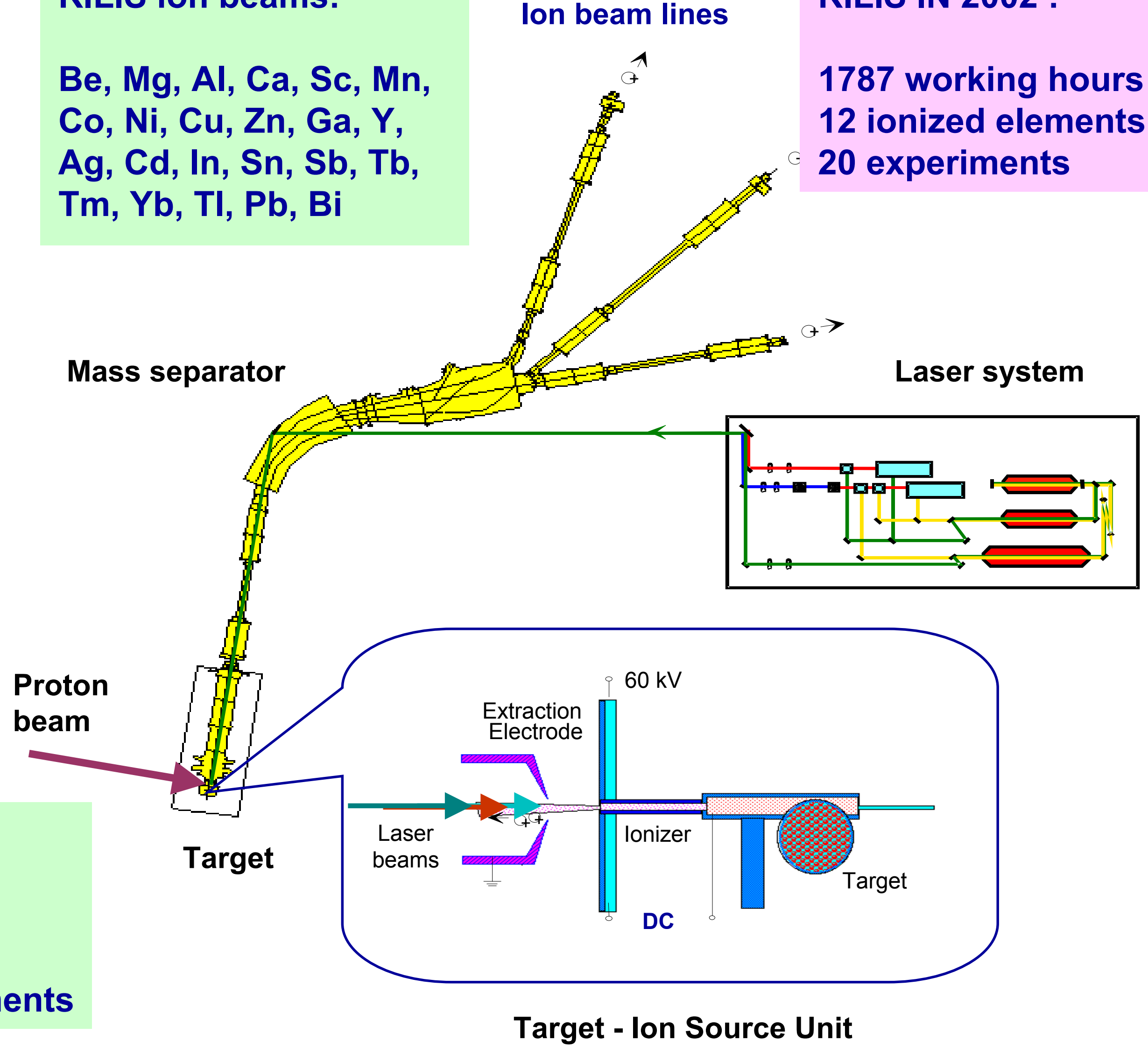


RILIS ion beams:

Be, Mg, Al, Ca, Sc, Mn, Co, Ni, Cu, Zn, Ga, Y, Ag, Cd, In, Sn, Sb, Tb, Tm, Yb, Tl, Pb, Bi

RILIS IN 2002 :

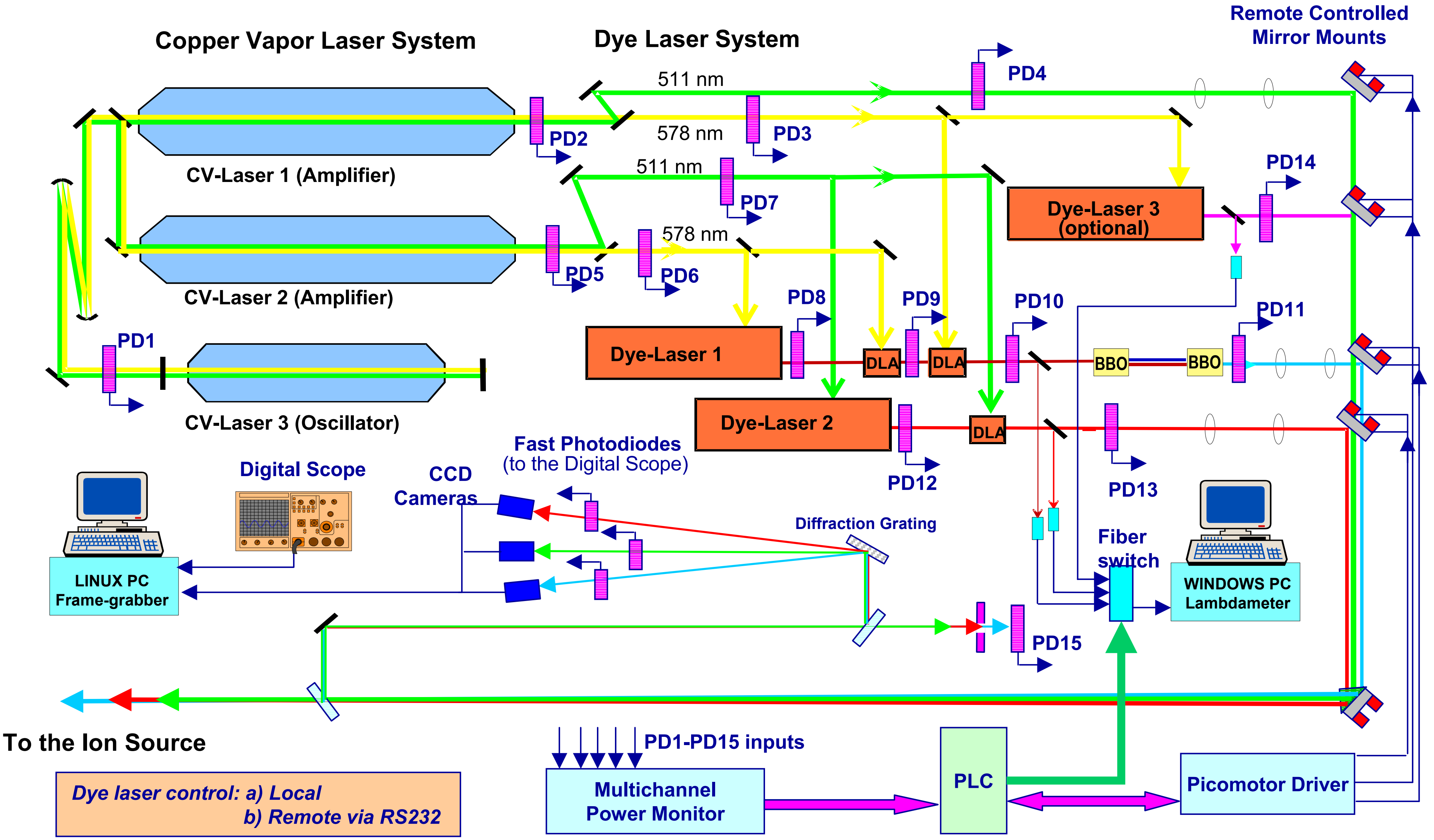
1787 working hours
12 ionized elements
20 experiments



Main features of RILIS:

- **Isobar and isomer selectivity**
- **Ionization efficiency: 2 - 27 %**
- **Feasibility for 80% of chemical elements**

RILIS : Automatic Laser Beam Position Control project



Common developments RILIS-CTF3

- **Acquisition of knowledge DPSSL – some material exist**
- **Laser monitoring – material exist – in progress for RILIS**
- **Automatic control of the laser beam position – material exist - in progress for RILIS**
- **Harmonic conversion efficiency study – material exist**

Conclusion

- **The CTF3 photo-injector is feasible**
- **A suitable parameter list is proposed**
- **Realization in collaboration with CNRS-LAL and CCLRC-RAL**
- **Inside well define resources and schedule**
- **Could be in the CARE E.U. framework**
- **Possible synergy with RILIS for the CERN part**