CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

IN2P3 INSTITUT NATIONAL DE PHYSIQUE NUCLEAIRE ET DE PHYSIQUE DES PARTICULES

Université de Paris-Sud

ELYSE – An Intense Electron Linac for Pulsed Radiolysis Research

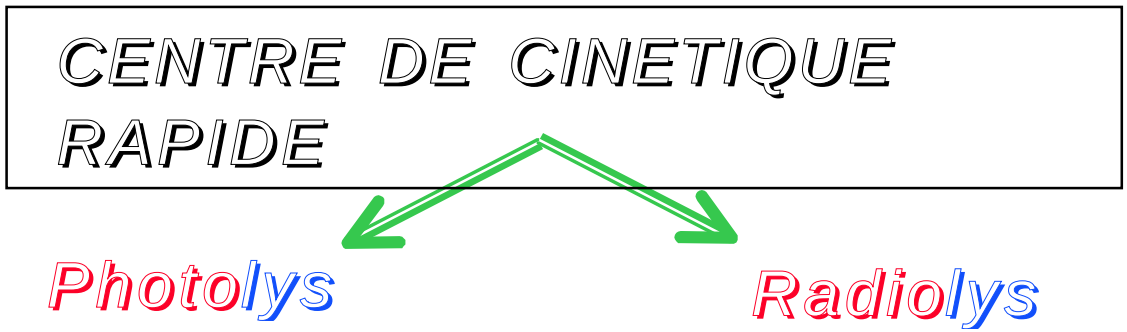
T. Garvey, M. Bernard, H. Borie, J.C. Bourdon, B. Jacquemard, B. Leblond, P. Lepercq, M. Omeich, M. Roch, J. Rodier, R. Roux
Laboratoire de l'Accélérateur Linéaire, Orsay.

F. Gobert, H. Monard,
Laboratoire de Chimie-Physique, Orsay.

Conseil Régional d'Ile de France

Essonne

The ELYSE project



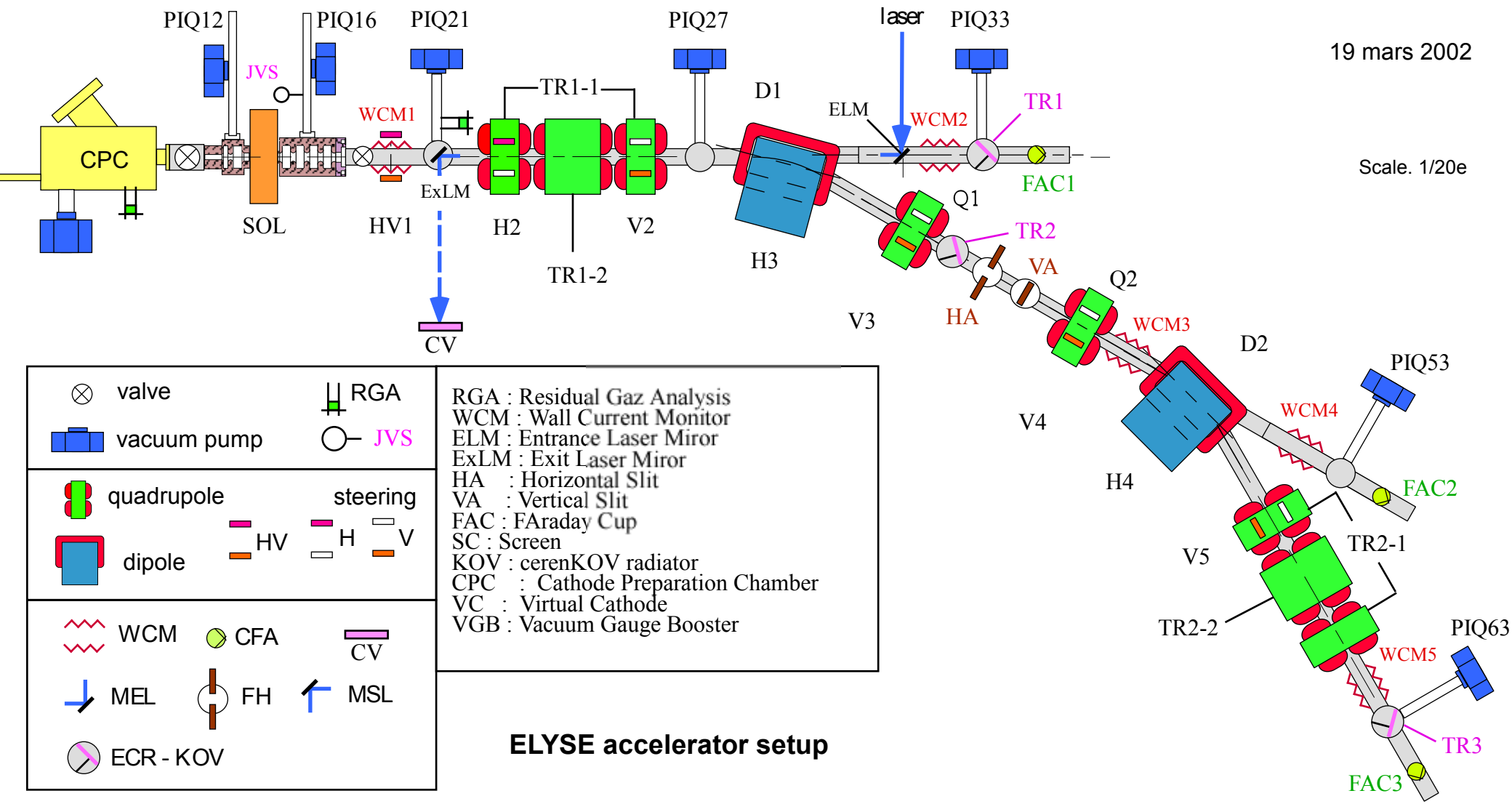
LASER - femtosecond ——— ACCELERATOR - picosecond

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Accelerator Specifications

Energy	4 – 9 MeV
Bunch charge	≥ 1 nC *
pulse duration	≤ 5 ps (FWHM) _ I_{peak} ~ 200 A – 2 kA
Energy spread	≤ 2.5% (RMS)
Normalised emittance	≤ 60 mm-mrad (RMS)
Beam size on target	2 – 20 mm diameter
Repetition frequency	10 – 100 Hz

- *10 nC would be desirable!*



ELYSE accelerator setup

Longitudinal Bunch Compression (H. Monard)

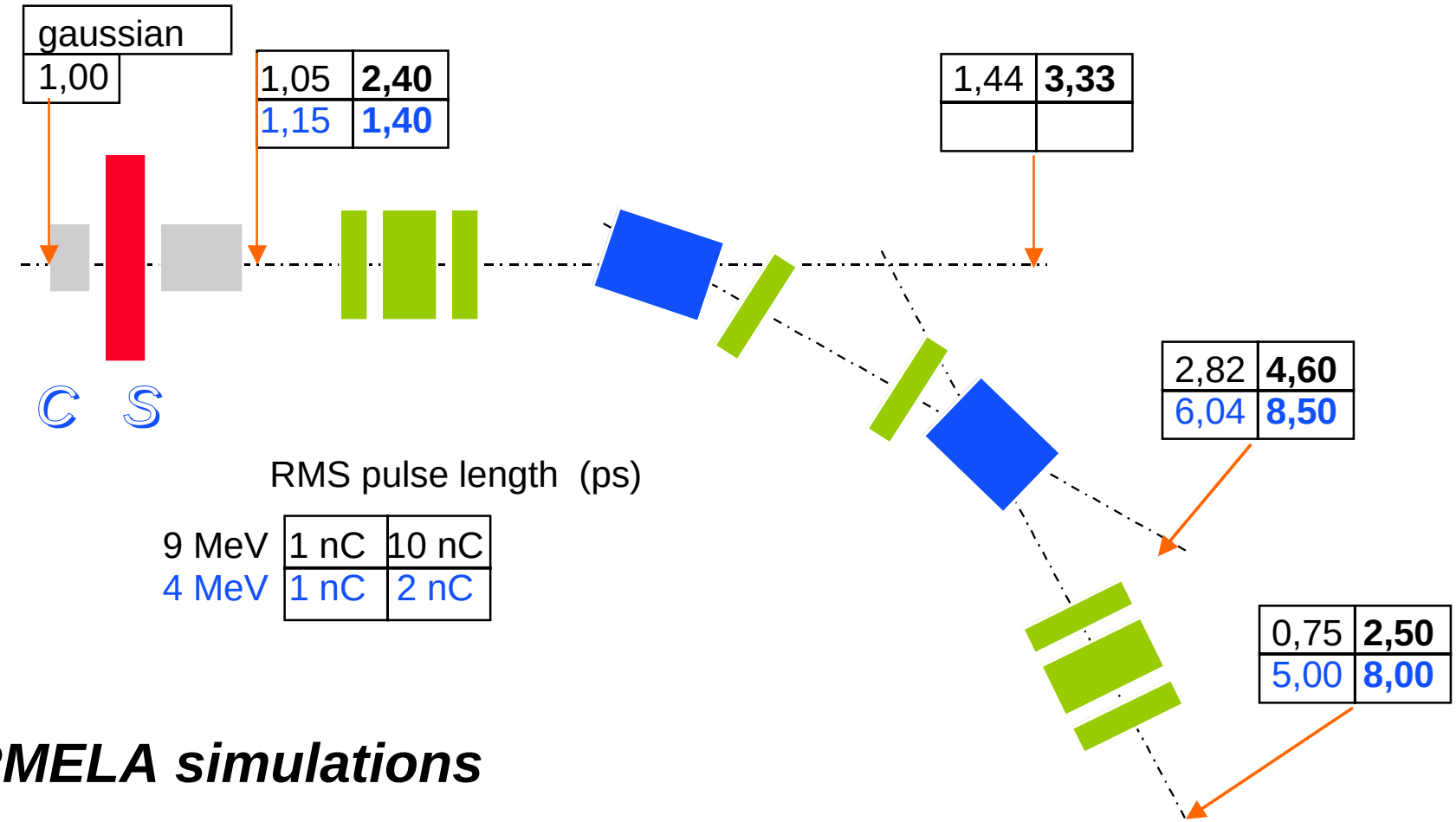
- Accelerate bunch off-crest of RF wave
  - generate correlated phase-energy spread
  - energy dependant path lengths in dipoles allow tail to catch up with head
  - longitudinal compression - $\Delta l = R_{56}\, \delta E/E$

M. Uesaka et. al., Nucl. Inst and Meth. A 406, pp 371-379 (1988)

Simulations show : **bunch compression can compensate for lengthening due to space charge effects.**

Tests foreseen using streak photography of Cerenkov radiation from the beam

Simulations – pulse duration



RMS pulse length (ps)

	1 nC	10 nC
9 MeV		
4 MeV	1 nC	2 nC

PARMELA simulations

Choice of Photocathode

Want – (i) long life-time (~ 50 hours)

(ii) high quantum efficiency

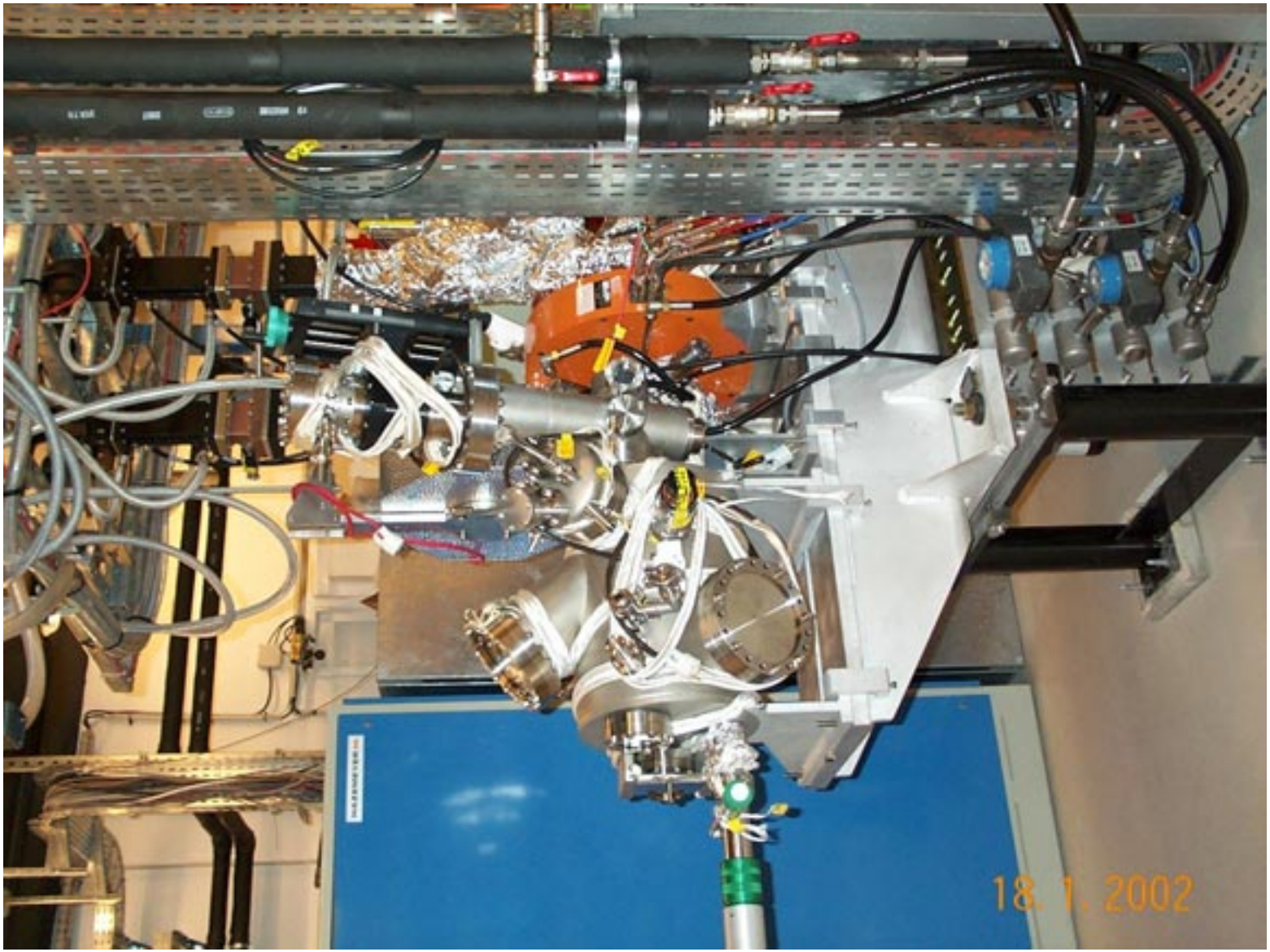
$$Q \sim E_L \,.\, \eta$$

For $E_L \sim 10\ \mu J$ and $Q = 10$ nC need $\geq 1\%$

- need Cs_2Te photo-cathode
  - high vacuum requirements
  - relatively easy fabrication

- Photo-cathode preparation chamber (cf. CTF, TTF)

(c.f. Brookhaven project – LEAF; large E_L and metallic cathode)


18. 1. 2002

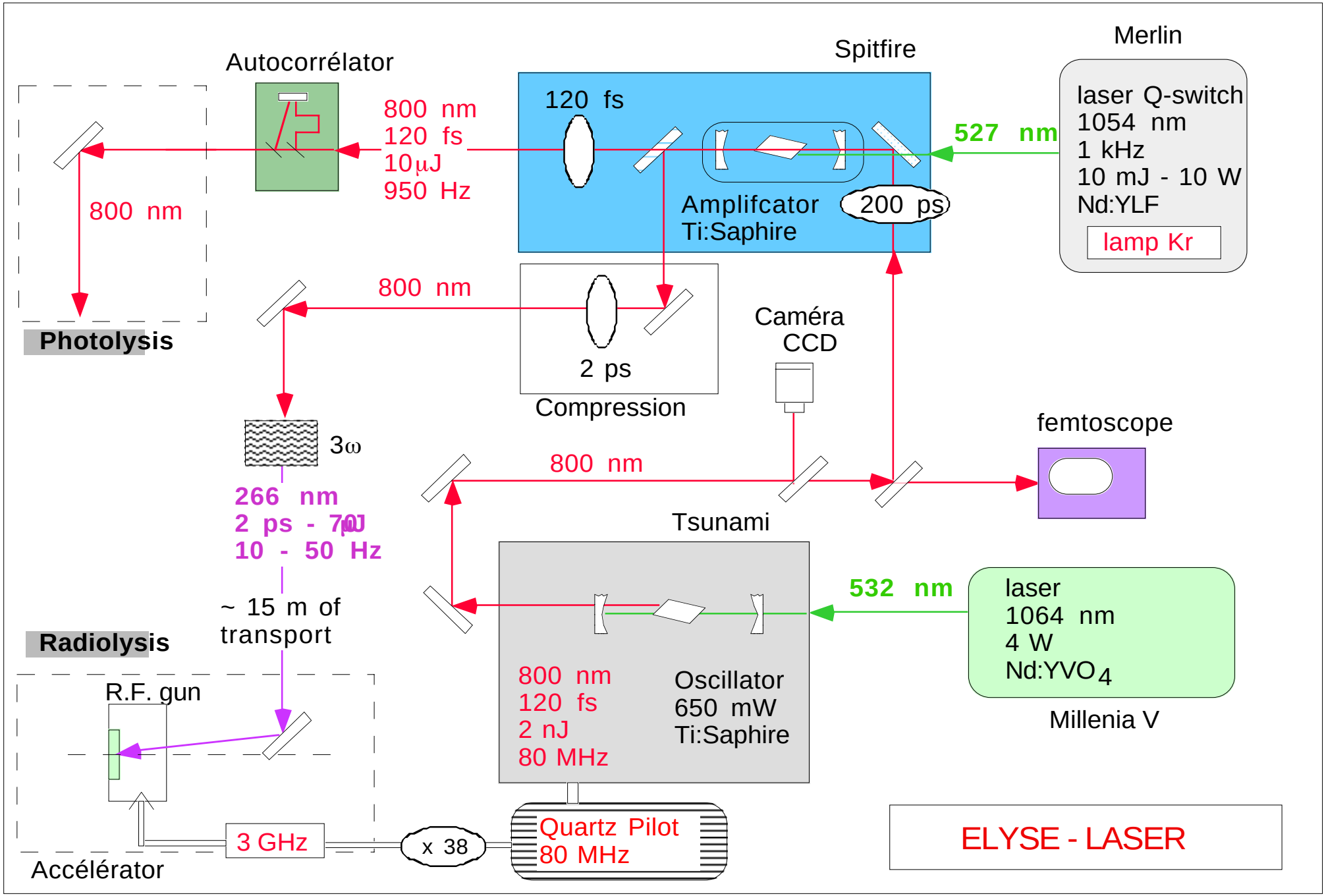
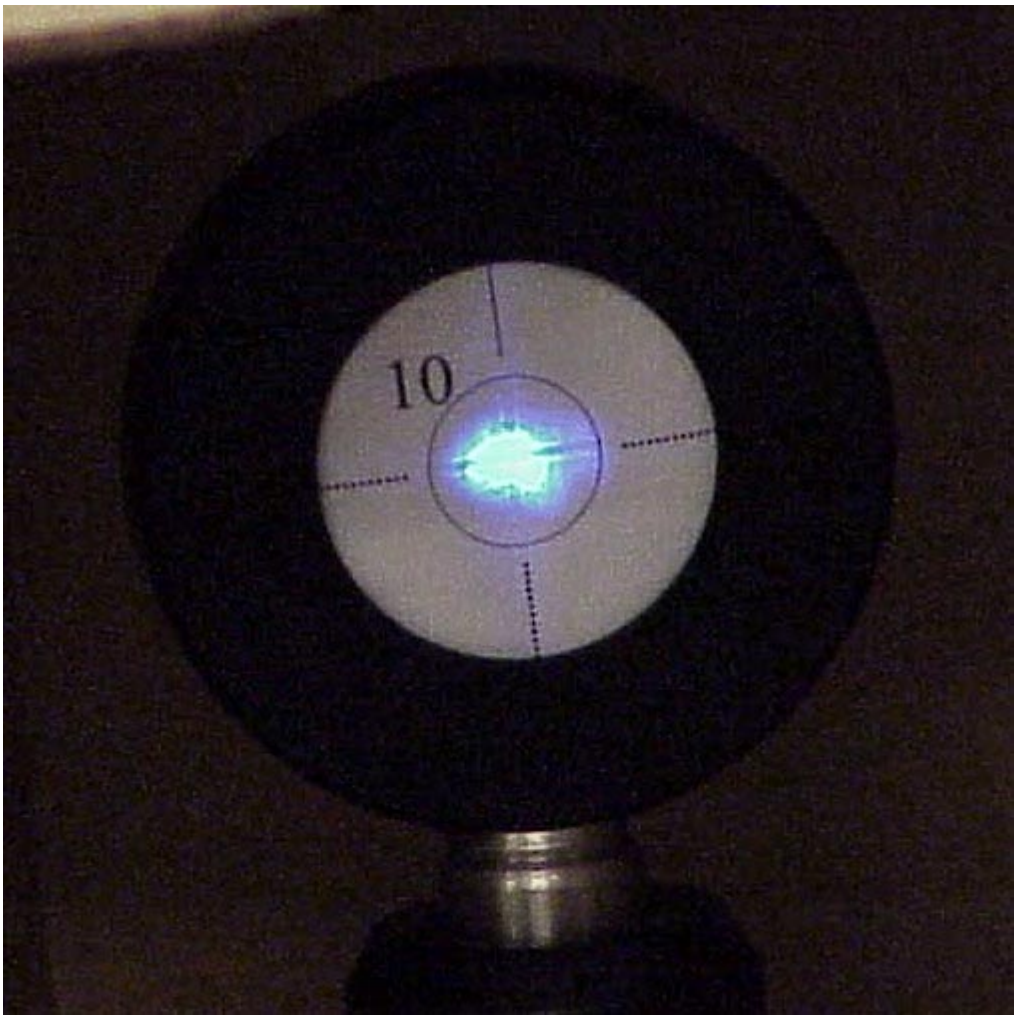
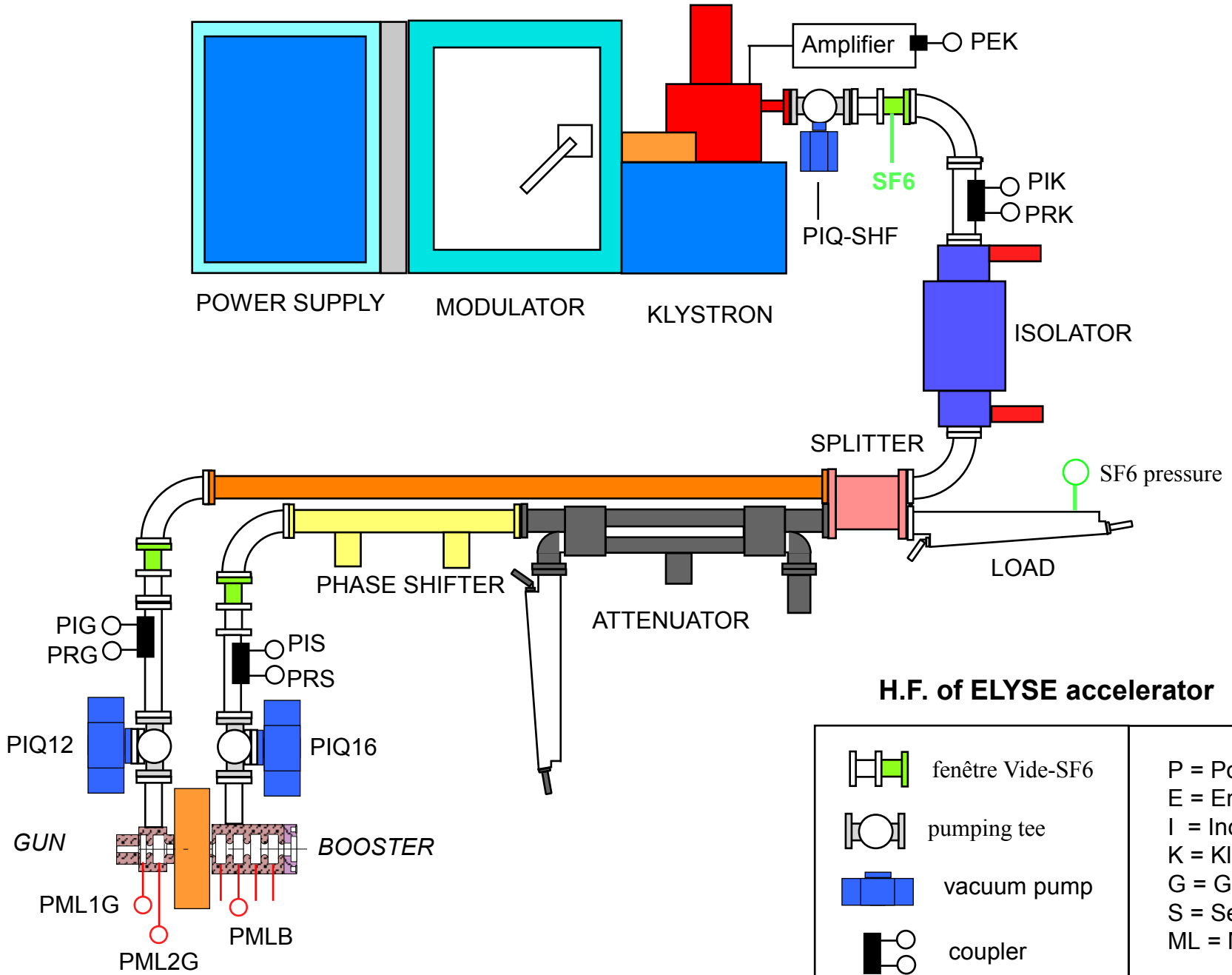

Autocorrélator
800 nm
120 fs
10 µJ
950 Hz
Spitfire
120 fs
Amplifcator
Ti:Saphire
200 ps
527 nm
Merlin
laser Q-switch
1054 nm
1 kHz
10 mJ - 10 W
Nd:YLF
lamp Kr
800 nm
Photolysis
800 nm
2 ps
Compression
Caméra
CCD
femtoscope
3ω
266 nm
2 ps - 7µJ
10 - 50 Hz
800 nm
Tsunami
~ 15 m of
transport
532 nm
laser
1064 nm
4 W
Nd:YVO4
Millenia V
Radiolysis
R.F. gun
800 nm
120 fs
2 nJ
80 MHz
Oscillator
650 mW
Ti:Saphire
3 GHz
x 38
Quartz Pilot
80 MHz
Accélérator
ELYSE - LASER

Image of laser beam on an optically *Equivalent Plane* to that of the photocathode plane.



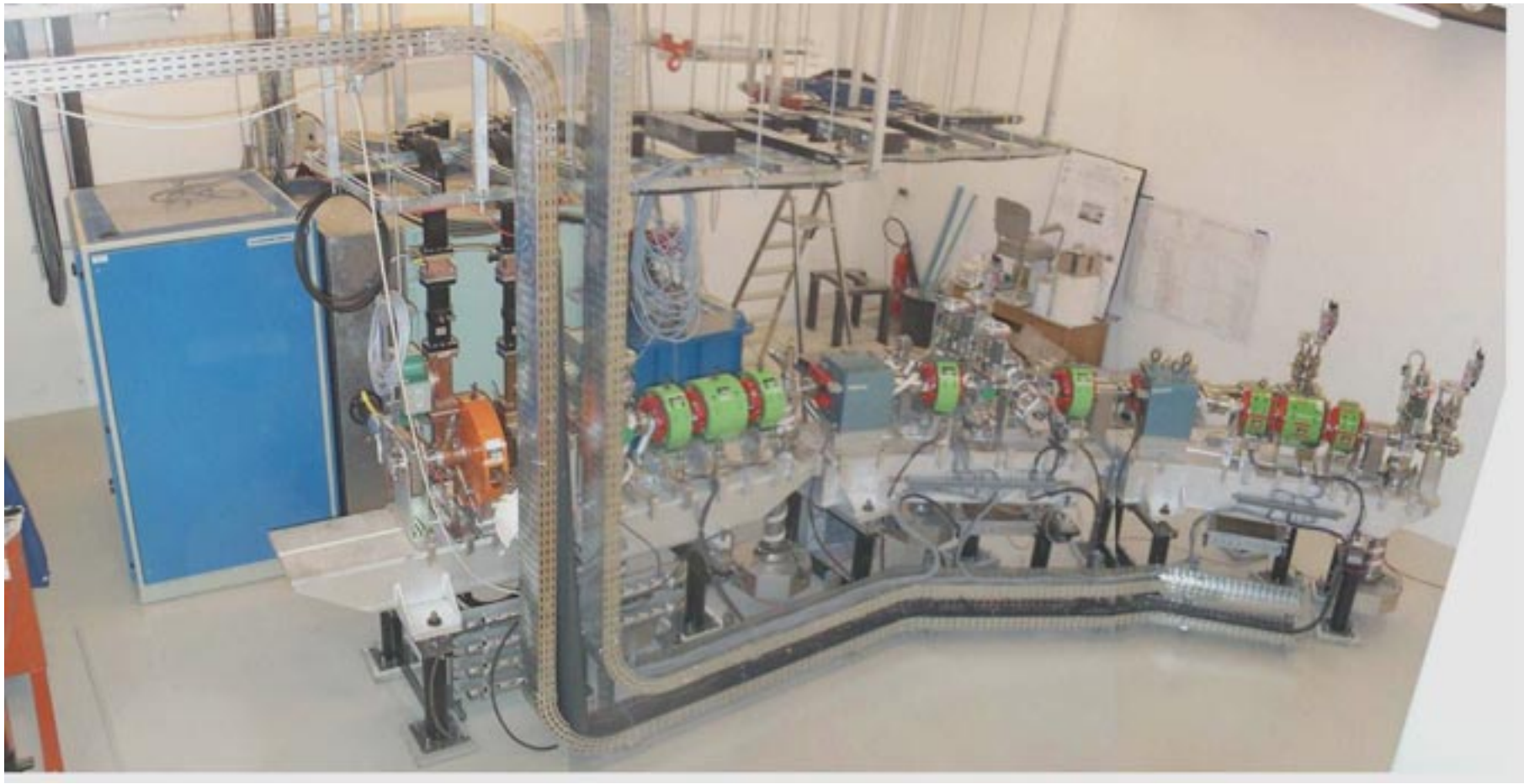
19 mars 2002



H.F. of ELYSE accelerator

fenêtre Vide-SF6	P = Power E = Entrance I = Incident K = Klystron G = Gun S = Section ML = Measure Loop
pumping tee	
vacuum pump	
coupler	

View of the ELYSE Accelerator



First photo-electron beam from the ELYSE Accelerator

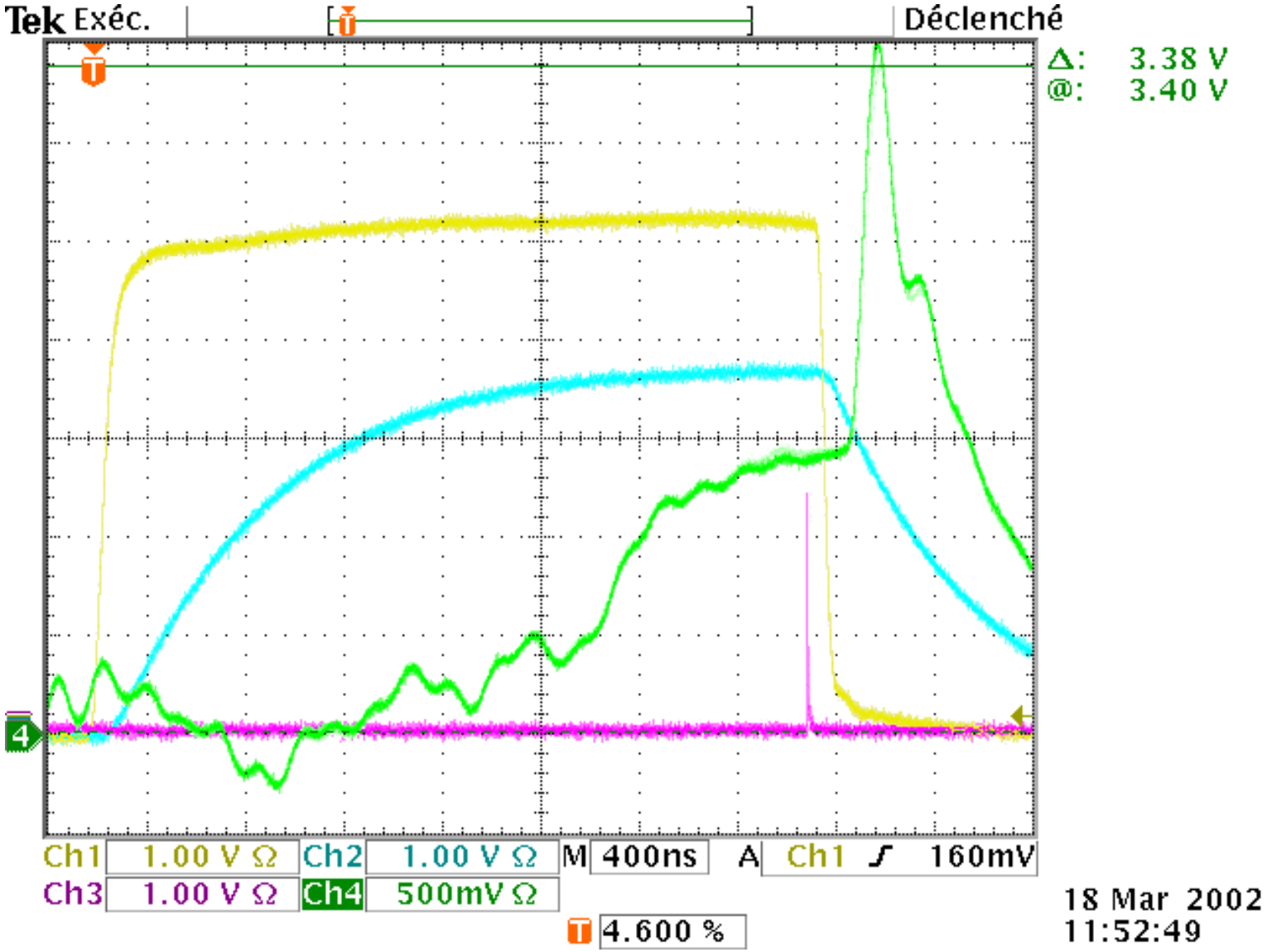
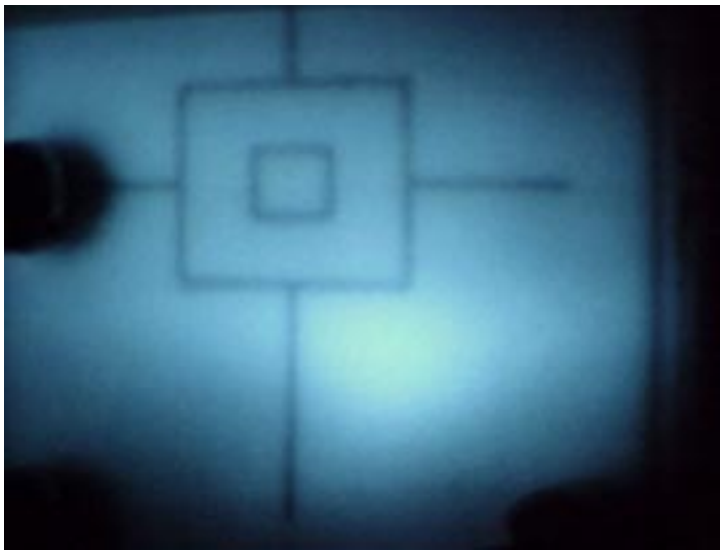
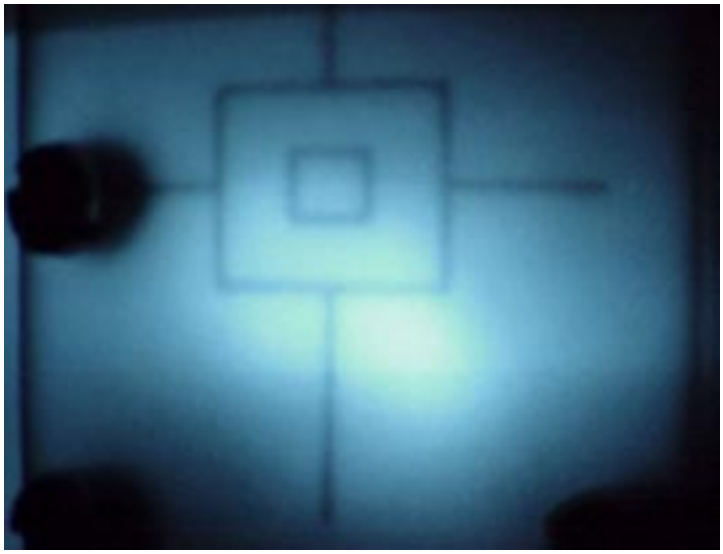


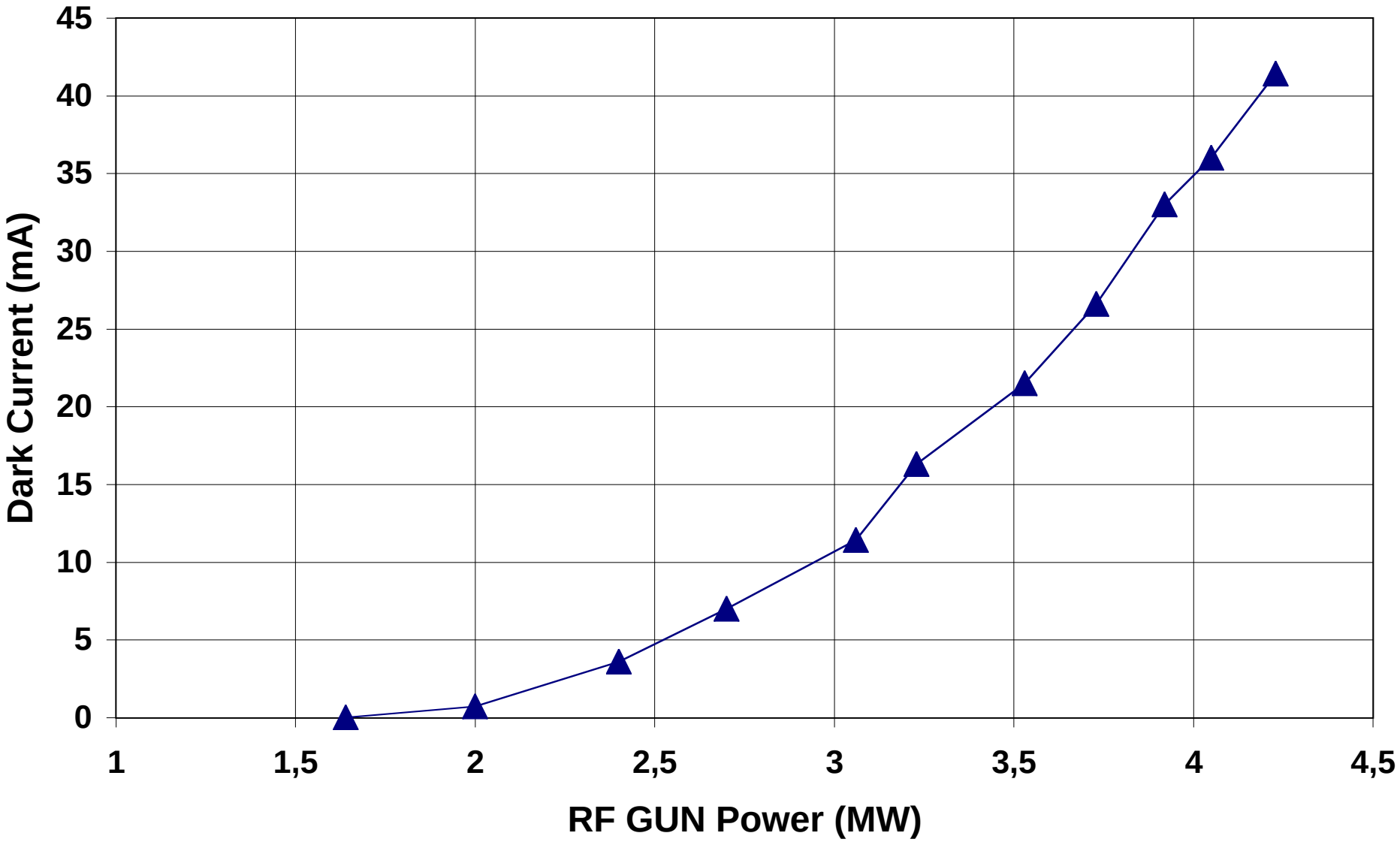
Image of beam on screen at Experimental Area 1



Dark current

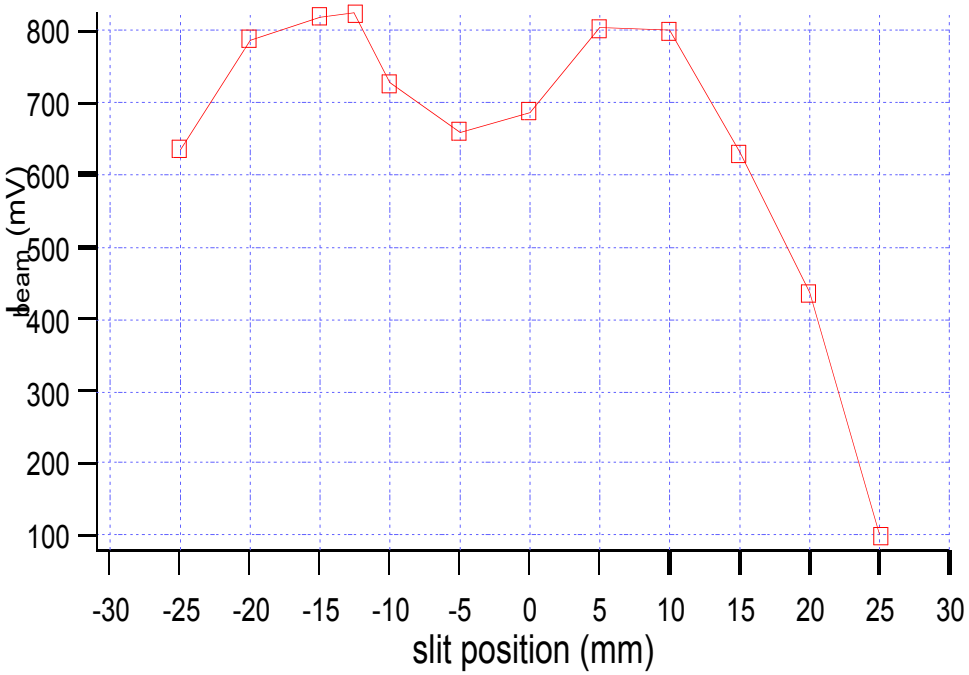


Dark current +
Photo current

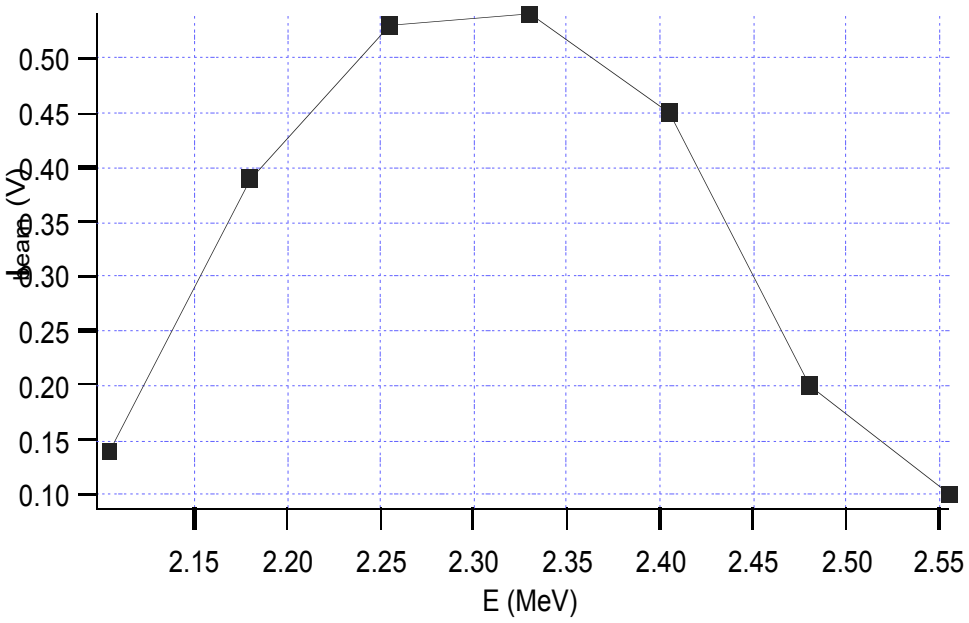

45
40
35
30
25
20
15
10
5
0
Dark Current (mA)
1
1,5
2
2,5
3
3,5
4
4,5
RF GUN Power (MW)

Dispersed beam width at the analysing slit

(slit width = 10 mm)



Width at half height ≈ 55 mm



ΔE/E @ half height = 12%

$$\Delta x \sim [\rho(1-\cos\theta) + 2\,L\tan(\theta/2)]\,\Delta E/E \sim 62 \text{ mm}$$

Cathode surface showing signs of damage

Conclusions

- ELYSE has produced its first photo-electron beam
  (albeit with a copper cathode).
- First tests with a Cs_2Te cathode will be performed soon.
- Excessive dark current levels need further studies.
- Considerable work remains to be done for machine optimisation
  - relative phases between laser and rf
  - optics settings.

Note: *Such guns exist today for the physical chemistry community thanks to investment in R&D programs for HEP (linear colliders), e.g. CTF.*

Acknowledgements

LURE Personnel

M. Corlier and J. Vétéran – magnet tests and measurements

M. Begard and P. Corona – magnet power supplies

J.C. Frank and M. Geeraert – radiation safety

P. Robert – cooling system

LAL technical support

G. Arnaud, F. Blot, J.N. Cayla, V. Chaumat, F. Cordillot, J. Lamouroux.

Thanks to – R. Bossart, J.C. Godot, K. Hubner, G. Suberluqc (CERN)