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.
The ELYSE project

LASER - femtosecond  ACCELERATOR - picosecond
Accelerator Specifications

- Energy 4 – 9 MeV
- Bunch charge ≥ 1 nC *
- pulse duration ≤ 5 ps (FWHM) I\text{peak} \sim 200 \text{ A} – 2 \text{ 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

RGA: Residual Gaz Analysis
WCM: Wall Current Monitor
ELM: Entrance Laser Mirror
ExLM: Exit Laser Mirror
HA: Horizontal Slit
VA: Vertical Slit
FAC: Faraday Cup
SC: Screen
KOV: cerenKOV radiator
CPC: Cathode Preparation Chamber
VC: Virtual Cathode
VGB: Vacuum Gauge Booster
**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)

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

PARMELA simulations
Choice of Photocathode

Want – (i) long life-time (~ 50 hours)
(ii) high quantum efficiency

\[ Q \sim E_L \cdot \eta \]

For \( E_L \sim 10 \, \mu \text{J} \) and \( Q = 10 \, \text{nC} \) need \( \geq 1\% \)

- need \( \text{Cs}_2\text{Te} \) 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)
Image of laser beam on an optically _Equivalent Plane_ to that of the photocathode plane.
H.F. of ELYSE accelerator

- **POWER SUPPLY**
- **MODULATOR**
- **KLYSTRON**
- **ISOLATOR**
- **SPLITTER**
- **ATTENUATOR**
- **PHASE SHIFTER**
- **GUN**
- **BOOSTER**

**Labels:**
- P = Power
- E = Entrance
- I = Incident
- K = Klystron
- G = Gun
- S = Section
- ML = Measure Loop

**Symbols:**
- fenêtre Vide-SF6
- pumping tee
- vacuum pump
- coupler
View of the ELYSE Accelerator
First photo-electron beam from the ELYSE Accelerator

Δ: 3.38 V
Ω: 3.40 V

18 Mar 2002
11:52:49
Image of beam on screen at Experimental Area 1

Dark current

Dark current + Photo current
Dispersed beam width at the analysing slit
(slit width = 10 mm)

Width at half height \( \approx 55 \text{ mm} \)

\( \Delta E/E \) @ half height = 12%

\( \Delta x \sim [\rho(1-\cos\theta) + 2L\tan(\theta/2)]\Delta E/E \sim 62 \text{ mm} \)
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$_2$Te 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)