Overview of a photo-injector

Photocathodes

Lasers

Guns

CTF3 Drive beam photo-injector

CLEX Probe beam photo-injector

Photocathode developments
The photo-injector is a source, it must fulfill the specifications and it must be available and reliable.

Typical expected behavior:

- Operation time: 2000 – 5000 h / year
- Availability > 95%
- MTBF > 1000 h ; MTTR < 4 h
- 1 long annual shutdown (2 – 3 months)
- 2 or 3 short shutdowns / year (1 week)
- Total lifetime: ~ 10 years
Photo-injector

- Master Oscillator Laser
- Frequency divider
- Klystron
- DC power supply or RF Network
- RF source
- Preparation chamber
- Transport carrier
- Photocath.
- RF/DC gun
- Laser beam line
- Electron beam
- Pulse selection & time structure generation
- Pre-amplifier Laser
- Power Amplifier Laser
- Pulse shaping
- Freq. Multip.
- Feedback stabilization
- Monitoring

G. Suberlucq

CLIC meeting 28/10/05
Photocathodes

Three main sorts:

- **Metallic photocathodes**
- **Activated Gallium-Arsenide photocathodes**
- **Alkali photocathodes**
  - Cesium-iodide
  - Alkali-antimonide
  - Alkali-telluride

Weak part of photo-injectors
Metallic Photocathodes

- Require UV light and high laser power
- Special surface treatment for reasonable QE
- Well adapted for high electric field $\geq 100$ MV/m
- Well adapted for “low” charge production, typically 1 to few nC per pulse and low mean current: few $\mu$A

With QE $\sim 10^{-3}$, Mg seems to be the best metallic photocathode
Activated Ga-As photocathodes
Mandatory for polarized electron photo-injectors

**Requirements**
- Strong cleaning by heating and/or with H⁻
- NEA activation with Cs+O₂ or Cs+NF₃
- Very good vacuum < 10⁻¹¹ mbar
- Low electric field < 5 MV/m
- NO breakdown
- Very low dark current

**Best performances**
- Polarization ~ 90 % ; QE ~ 0.5 % @ 780 nm
- Low output energy ~ 25 meV
- Shorter pulse length ~ 80 ps
- I_max ~ 8 A

**Main limitations**
- Surface Charge Limit (SCL)
- Lifetime
- Response time

Could be overcome with the two photon process
## Alkali photocathodes

<table>
<thead>
<tr>
<th>Photocathodes</th>
<th>$\lambda$ (nm)</th>
<th>QE (%)</th>
<th>Lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alkali iodide</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CsI</td>
<td>$&lt; 200$</td>
<td>20</td>
<td>years</td>
</tr>
<tr>
<td>CsI+Ge</td>
<td>$&lt; 270$</td>
<td>0.2</td>
<td>years</td>
</tr>
<tr>
<td>Air transportable,</td>
<td></td>
<td></td>
<td>Wavelength too short</td>
</tr>
<tr>
<td>Delicate conditioning process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alkali antimonide</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$K_2CsSb$</td>
<td>$&lt; 600$</td>
<td>10</td>
<td>Days-hours</td>
</tr>
<tr>
<td>$Na_2K(Cs)Sb$</td>
<td></td>
<td></td>
<td>Lifetime too short,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>UHV required</td>
</tr>
<tr>
<td><strong>Alkali telluride</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$Cs_2Te, RbCsTe$</td>
<td>$&lt; 270$</td>
<td>15</td>
<td>Months-weeks</td>
</tr>
<tr>
<td>Good lifetime and QE,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UHV and UV light</td>
<td></td>
<td></td>
<td>required</td>
</tr>
</tbody>
</table>

For the time being, Cs-Te photocathodes are the most used for high current and high charge production in operational photo-injectors.
Improvement of alkali cathode preparation: Co-evaporation process

Difficult thickness measurements and poor reproducibility

<table>
<thead>
<tr>
<th>20 cath.</th>
<th>QE(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>8.2</td>
</tr>
<tr>
<td>Average</td>
<td>14.9</td>
</tr>
<tr>
<td>Max</td>
<td>22.5</td>
</tr>
</tbody>
</table>
**Lifetime of Cs-Te photocath.**

- Dramatic improvement of QE and lifetime of photocathodes produced by the co-evaporation process

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

**CERN measurements**

\[ QE(t) = QE_1 \cdot e^{-t/\tau_1} + QE_2 \cdot e^{-t/\tau_2} \]

<table>
<thead>
<tr>
<th></th>
<th>QE1</th>
<th>( t_1 )</th>
<th>QE2</th>
<th>( t_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport carrier</td>
<td>3.85</td>
<td>18.9</td>
<td>9.17</td>
<td>3311</td>
</tr>
<tr>
<td>DC gun</td>
<td>2.24</td>
<td>65.9</td>
<td>12.74</td>
<td>779.5</td>
</tr>
<tr>
<td>RF gun</td>
<td>9.2</td>
<td>14</td>
<td>3.4</td>
<td>315</td>
</tr>
</tbody>
</table>

Mean lifetime (4 cath.) in the DC gun @ 8 MV/m, \( p \leq 10^{-10} \) mbar

Mean lifetime (5 cath.) during storage in the T.C., \( p \approx 3 \times 10^{-11} \) mbar

Mean lifetime (9 cath.) in the RF gun 100 MV/m, \( 2 \times 10^{-9} \leq p \leq 7 \times 10^{-9} \) mbar including 2 cathodes destroyed during RF conditioning

G. Suberlucq
Secondary Emission Enhanced photo-emitter

Proposal from I. Ben-Zvi et al. C-A/AP#149, April 2004, BNL

- The diamond window is transparent to photons and electrons
- Electrons are produced by a laser beam shooting an alkaline cathode
- Electrons are multiplied by secondary emission by the diamond window

Expected advantages
- Very high equivalent QE ~ 1000 %!
- Low laser power
- Low thermal emittance (NEA surface)
- No mutual contamination between the gun and the photocathode
- Possible high mean current
- No load-lock system

Cathode insert consist of:
- Alkali antimonide cathode
- A sealed diamond window (~10 μm thick)
- UHV in between
Lasers

Master Oscillator Power Amplifier setup to allow ps synchronization

**STRONG** progress in optical pumping and in lasing medium

- Laser diode pumped solid state (LDPSS) lasers
- Nd:Vanadate lasers are replacing Nd:YAG lasers
- Thanks to InGaAs laser diodes emitting in the 900–980 nm, Ytterbium ($\text{Yb}^{3+}$) is the most promising doping material.
- Many new crystals: apatite (S-FAP, CLYPA, SYS, ...), tungstate (KYW, KGW), sesquioxyde ($\text{Sc}_2\text{O}_3$, ...) $\text{Yb}^{3+}$ doped
- High power oscillator > 60 W
- Fiber laser (not yet actively mode-locked)
- High frequency mode-locked oscillator: 1.5 GHz commercially available
- Transversal and Longitudinal pulse shaping.

**SMALL** progress in frequency conversion

- 50–55 % IR to VIS ; 25–30 % VIS to UV
Pulses per train 1 - 200 adjustable
Pulse rate 357MHz or 714MHz
Pulse length 200psec to 700psec adjustable
Pulse temporal shape Square, or adjustable with 100psec bandwidth
Train temporal shape Adjustable: 30 nanosecond time constant
Wavelength range 750 to 870nm (with optics change)
Wavelength tuning range +/- 5nm remote tuning
Bandwidth <1 nanometer
Pulse energy 5 - 30 micro Joules to photocathode maximum.
Transverse profile TEM00
Intensity Stability 0.5% RMS
Position stability <1% spot radius RMS
Wavelength stability 0.1 nanometers
Bunch timing stability <10 picoseconds RMS
System MTBF >1000 Hours (Single laser)
System MTTR <4 Hours (Single laser)
System lifetime >50,000 Hours
CERN - CTF3 Laser proposal

1.5 GHz Nd:YLF Oscillator + preamplifier

10 W
6.7 nJ/pulse

3-pass Nd:YLF amplifier x300

diode pump 15 kW peak

400 μs, 5-50 Hz

~2332 pulses
370 nJ/pulse

Energy stability ≤ 0.25 % rms

3 pass Nd:YLF amplifier x5

diode pump 25 kW peak

200 μs, 5-50 Hz

~3 kW
2 μJ/pulse

Feedback stabilisation

or

Pockels cell

Beam conditioning

1.4 μs

Optical gate (Pockels cell)

4ω
2ω

~2332 bunches
2.33 nC/bunch

M. Divall - RAL

Design and construction supported by E.U. inside CARE - JRA - PHIN

G. Suberlucq

CLIC meeting 28/10/05
SPARC Laser proposal

Operating wavelength: 260-280 nm
Repetition rate: 10-100 Hz
Number of micropulse per pulse: 1
Pulse energy on cathode: 500µJ (Q.E.=10⁻⁵)
Pulse rise time (10-90%): < 1 ps
Pulse length: 2-10 ps FWHM
Temporal pulse shape: Uniform (10% ptp)
Transverse pulse shape: Uniform (10% ptp)
Energy jitter (in UV): 1 % rms
Laser-RF jitter: < 1ps rms
Spot diameter on cathode: Circular 1 mm
Spot diameter jitter: 1% rms
Pointing Stability: 1% diameter rms

SPARC Laser group
C. Vicario, A. Ghigo,
F. Tazzioli, I. Boscolo,
S. Cialdi

CLIC meeting 28/10/05
Temporal pulse shaping

Liquid crystal spatial light phase modulator in Fourier plane

D. Meshulach, D. Yelin, Y. Silberberge

Collinear Acousto-Optic modulator (AOM)

F. Verluise et al. Arbitrary dispersion control of ultrashort optical pulses with acoustic waves,

Study supported by E.U. inside CARE - JRA - PHIN
## Guns

<table>
<thead>
<tr>
<th>Unpolarized e^-</th>
<th>High intensity, high electric field</th>
<th>RF gun</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High mean current</td>
<td>SRF gun</td>
</tr>
<tr>
<td></td>
<td>Very good vacuum, low electric field</td>
<td>DC gun</td>
</tr>
<tr>
<td></td>
<td>Medium I, medium electric field</td>
<td>PWT Under dev.</td>
</tr>
<tr>
<td></td>
<td>Very high electric field (GV/m)</td>
<td>Pulsed DC gun Under dev.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Polarized e^-</th>
<th>Low electric field</th>
<th>DC gun</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medium I, medium electric field</td>
<td>PWT Under dev.</td>
</tr>
</tbody>
</table>
CTF2 drive beam RF gun

RF gun optimized for high charge and high stored energy to minimize transient beam loading. Successfully operated since 1996 until 2002.

- 100-110 MV/m operational field at the cathode
- 16 MW input power at 100 MV/m
- Beam energy 7 MeV at 100 MV/m
- Maximum produced charge: 750 nC in 48 pulses
- Pulse width 10 ps FWHM
- Maximum single pulse charge: 100 nC
- Used photocathodes: Cs$_2$Te, Rb$_2$Te, Mg, Cu, Al
RF gun desorption

- Gun desorption is a potentially serious problem for high charge production
- Special attention must be paid to the pumping speed
- Low desorption material must be used

---

CTF2 Drive beam
RF gun

- $f = 3$ GHz
- $E = 105$ MV/m
- $\Delta t = 333$ ps
- Rep. = 5 Hz

---

<table>
<thead>
<tr>
<th>Material</th>
<th>QE</th>
<th>$Q$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs$_2$Te No 117</td>
<td>2%</td>
<td>535 nC</td>
</tr>
<tr>
<td>Cs$_2$Te No 120</td>
<td>3.6%</td>
<td>520 nC</td>
</tr>
<tr>
<td>Cu No 4A04</td>
<td>1.6x10^{-5}</td>
<td>0.4 nC</td>
</tr>
<tr>
<td>Cs$_2$Te No 137</td>
<td>3%</td>
<td>460 nC</td>
</tr>
</tbody>
</table>
Superconducting RF gun (1)

T. Srinivasan-Rao et al. PAC 2003
Q. Zaho et al. PAC 2003

J. Teichert et al., SRF 2003, Lübeck

Radiation source ELBE

Superconducting RF gun under Development at BNL
½ cell Niobium cavity, 1.3 GHz
\( E_{\text{max}} = 45 \text{ MV/m} \)
Niobium cath. QE ~ 5.10^{-5} at 262 nm
with laser cleaning.

For high mean current, the requested laser power is too large:
\( P_L = 95 \text{ W} / \text{mA} \)

Superconducting RF gun at Rossendorf
½ cell Niobium cavity, 1.3 GHz
Tesla geometry
Normal-conducting \( \text{Cs}_2\text{Te} \) photocath.
at \( \text{LN}_2 \) temperature and thermally insulated. Illuminated with 1 W laser at 262 nm
Superconducting RF gun

1. 3 GHz, 10 kW
- optimized half cell & 3 TESLA
  - $E_{z,max} = 50$ MV/m (T cells)
  - $= 33$ MV/m (1/2 cell)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{av}$</td>
<td>1 mA</td>
</tr>
<tr>
<td>$E$</td>
<td>9.5 MeV</td>
</tr>
<tr>
<td>0.5 mm mrad</td>
<td>2.5 mm mrad</td>
</tr>
</tbody>
</table>

Project under study
- $3\frac{1}{2}$-cell niobium cavity
- Will be operated at 2 K
- $Cs_2Te$ cath. @ LN$_2$ temp. thermally insulated
- Expected QE ~ 5%

Study supported by E.U. inside CARE - JRA - PHIN
DC guns

Advantages

- Very good vacuum: $10^{-12}$ mbar range
- Very low dark current: ~2 pA/cm$^2$ @ 30 MV/m
- High mean current

Disadvantages

- Limited current density: $J = \text{perv.} \cdot U^{1.5} \sim 200$ A/cm$^2$
- Limited electric field: $E \leq 30$ MV/m
- Limited potential: $U \leq 500$ kV

For the present time mandatory for GaAs photocathode applications
Other guns

Plane Wave Transformer RF gun
Large vacuum conductance and moderate electric field

THE UCLA PEGASUS PWT S-band gun
60 cm total length Tank diam. : 12 cm
11 cells Disk diam. : 4.2 cm

E\(_{\text{peak}}\) : 60 MV/m
Energy : 12 - 18 MeV
Emittance\(_N\) : 4 mm.mrad (rms)
Charge : 1 nC ; Bunch length : 1 - 10 ps

G. Travish et al. PAC 2003

Pulsed DC + RF gun
Alpha-X project DC/RF photo-injector
Strathclyde university and Eindhoven University of Technology

U\(_{\text{DC}}\) = 2 MV ; 1 ns
E\(_{\text{peak-DC}}\) : 1 GV/m ; Gap : 2 mm
S-band RF gun : 100 MV/m
Output Energy : 10 MeV
Emittance\(_N\) : 1.\(\pi\).mm.mrad
Charge : 100 pC
Bunch length : 50 - 200 fs
Peak current : 1 kA

M.J. de Loos et al. EPAC 2002
http://phys.strath.ac.uk/alpha-x/index.html
**CTF3 Drive Beam photo-injector**

**G. Suberlucq**

- **Master oscillator**
  - $\lambda = 1047 \text{ nm}$
  - $f = 1.5 \text{ GHz}$
  - $P > 0.2 \text{ W}$
  - $W/\mu\text{Pulse} > 0.13 \text{ nJ}$

- **Phase coding + amplification**

- **Pre-amplifier**
  - $\lambda = 1047 \text{ nm}$
  - $P_{CW} = 10 \text{ W}$
  - $W/\mu\text{Pulse} = 6.7 \text{ nJ}$

- **First Amplifier**
  - DPSSL
  - 3-pass $\times 300$
  - 400 $\mu$s; $P_{\text{train}} = 3 \text{ kW}$
  - 2 $\mu$J/ $\mu$Pulse
  - Pulse width $\leq 10 \text{ ps}$
  - Rep. Rate 5 - 50 Hz

- **Power Amplifier**
  - DPSSL
  - 3-pass $\times 5$
  - 200 $\mu$s; $P_{\text{train}} = 15 \text{ kW}$
  - $\lambda = 1047 \text{ nm}; 10.3 \mu\text{J/}\mu\text{Pulse}$
  - Pulse width $\leq 10 \text{ ps}$
  - Rep. Rate 5 - 50 Hz

- **Laser Beam Line**
  - 0.37 $\mu$J/ $\mu$Pulse
  - 2332 $\mu$Pulses

- **Total efficiency**
  - $\text{IR}_{\text{OUT}} \Rightarrow \text{UV}_{\text{cath}} = 3.6 \%$

- **Electron Beam**
  - 2.33 nC/$\mu$Pulses

Design & construction supported by E.U. inside CARE - JRA - PHIN

Under the responsibility of
- CLF-RAL
- CERN
- LAL - Orsay

Under RAL responsibility with CERN collaboration

CLIC meeting 28/10/05
Laser layout

Will be presented in details during the next CTF3 collaboration meeting

M. Divall et al, (RAL-GB)
N. Champault
CTF3 RF gun design

Four new improvements:
- Elliptical iris ➔ reduces the surface electric field
- Race track coupler ➔ Gives better field symmetry
- NEG & Ion pumping ➔ Give better vacuum
- Solenoids around the gun ➔ Give lower emittances

RF frequency (GHZ) 2.99855
RF power (MW) 30
Acc. electric field (MV/m) 85
Beam energy (MeV) 5.6
Beam current (A) 3.5 - 5
Charge/bunch (nC) 2.33
Bunch length (ps) 10
Energy spread (%) < 2
Normalized emittance (π.mm.mrad) < 25
Number of pulses ~ 2332
Pulse train duration (µs) 1.548
Coupling factor (β) 2.9
Vacuum pressure (mbar) 2.10^{-10}
Repetition rate (Hz) 50

G. Bienvenu, R. Roux, et al, LAL-IN2P3 - Orsay

G. Suberlucq
RF gun layout

Will be presented in details during the next CTF3 collaboration meeting

G. Suberlucq
Photocathodes

Re-use of the former CTF2 equipment:

- Cs-Te photocathodes produced with an upgraded version of the present co-evaporation system
- Same Transport Carrier (TC)
- Same Manipulator of Photo Cathode (MPC) attached to the gun

Will be presented in details during the next CTF3 collaboration meeting
**CLEX Probe beam photo-injector**

- **“Light” version**
  - Reduced frequency in the burst: 1.5 GHz
  - Reduced charge per micro-pulse ≈ 0.2 nC
  - Re-use of the preparation chamber attached to the former CTF2 Probe beam RF gun. ➔ Not TC nor MPC
  - Substantial simplification and economy in the laser system.

- **RF Network**
  - 3 GHz RF source
  - KLYSTRON 3 GHz - 30 MW
  - RF Network
  - Total efficiency
    - \( I_{OUT} \Rightarrow \text{UV}_{\text{cath}} = 3.4\% \)
  - Laser Beam Line
    - Freq. X 4
    - \( \lambda = 262\,\text{nm} \)
    - 3 GHz RF gun
    - \( E \leq 100\,\text{MV/m} \)
    - \( U = ? \)
  - Cs2Te cath
    - QE \( \geq 0.3\% \)
    - 3 GHz RF gun
    - \( Q_{\text{\mu Pulses}} \geq 0.2\,\text{nC} \)
  - Photocathode preparation chamber
  - TEMporal window
  - Unused part of the drive beam laser output
    - \( \lambda = 1047\,\text{nm} \):
    - 10.3 \( \mu\text{J} / \mu\text{Pulse} \)
    - Pulse width \( \leq 10\,\text{ps} \)
    - Frequency: 1.5 GHz
    - 20 ns \( \leq \) burst duration \( \leq 70\,\text{ns} \)
    - Single pulse Rep. Rate 5 Hz
  - Under the CERN responsibility
  - The responsibility has to be defined inside a new collaboration

G. Suberlucq

CLIC meeting 28/10/05
Timing Drive - Probe beam

2100 bunches @ 666 ps
3.5 A - 1.4 μs - 150 MeV

Delay Loop : 42 m
Transfer line : 30 m
Combiner Ring : 84 m

DB RF gun

Laser-room
Linac : ~ 85 m

PB RF gun

Transfer line : 48 m

2100 bunches @ 66.6 ps
35 A - 140 ns - 150 MeV

First pulse of the Drive beam
Laser-room → DB gun 15 m 0.05 μs
Photo-injector → Delay Loop 85 m 0.2833 μs
Delay Loop 42 m 0.14 μs
TL Delay Loop → Comb. Ring 30 m 0.1 μs
Combiner Ring 84 m 0.28 μs
TL Comb. ring → Probe Beam 48 m 0.16 μs
Total with 1 DL and 4.5 C. Ring 598 m 1.9933 μs
Macro pulse length 0.14 μs
Filling time of PETS+Acc. 0.02 μs
TOTAL time 2.1533 μs

Probe Beam
Laser-room → PB gun 75 m 0.25 μs
PB macro-pulse length 0.021312 μs
TOTAL time 0.271312 μs
Conv. 1.5 GHz to 3 GHz 0.021312 μs
Probe beam preparation chamber

Drive-beam: Transfer chamber

Drive-beam: RF gun

Probe-beam: Preparation in situ

Probe-beam: RF gun
Photocathode developments

- Co-evaporation process
  Stochiometric ratio monitored with two different ways:
  - Separate thickness measurement with microbalances
  - Mass spectrometry

- Photocathode poisoning study: mass spectrometry

- Alkali-antimonide photocathodes

study supported by E.U. inside CARE - JRA - PHIN
Co-evaporation process

Evaporator prototypes allowing the monitoring of the evaporation rates

Every microbalance sees only a single product, while the cathode receives the 2 homogenously.

New tellurium oven, CEA-type

G. Suberlucq
**Co-evaporation process**

**Mass spectrometry**

Ion current of the metallic vapor $\propto$ evaporation rate

"Closed loop multi source evaporation rate control with a quadrupole mass spectrometer in an ultra high vacuum system", K. Wellerdieck et al.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Te (%)</th>
<th>Cs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>133</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>34.5</td>
<td></td>
</tr>
<tr>
<td>128</td>
<td>31.8</td>
<td></td>
</tr>
<tr>
<td>126</td>
<td>18.7</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Thickness calibration program is current

Mass spectrometer upgraded to be able to scan masses up to 200
Photocathode poisoning study

Calibration of species is achieved excepted for water vapor (soon)

Compatibility with TS/MME for XPS analysis is current (vacuum transportation).

Species analysis during electron production in DC and RF guns are foreseen.

Study of water contamination

Study of contamination by ion pump

Effect of the stoichiometric ratio on the surface passivation

Effect of the substratum on the contamination process

<table>
<thead>
<tr>
<th>Species</th>
<th>Cs-Te (L)</th>
<th>Cs-Te P (max) mbar</th>
<th>Cs-K-Sb (L)</th>
<th>Cs-K-Sb P (max) mbar</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂O</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>O₂</td>
<td>15</td>
<td>6x10⁻¹²</td>
<td>0.1</td>
<td>4x10⁻¹⁴</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>1x10⁻¹⁰</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>1100</td>
<td>4x10⁻¹⁰</td>
<td>1</td>
<td>4x10⁻¹³</td>
</tr>
</tbody>
</table>

L = Langmuir, 1 L = 1.33x10⁻⁶ mbar.s
P (max) = absolute partial pressure to get QE_{max}/e after 1000 hours

G. Suberlucq
Alkali-antimonide photocathodes

- \( \text{QE}_{\text{GREEN}} \approx \text{QE}_{\text{UV}}/8 \)
- \( \text{QE}_{\text{GREEN}} \geq 0.4\% \) to produce the requested DB charge with the same IR power.

Two tests are foreseen

- Co-evaporation process with a slight cesium deficit to improve the lifetime and the robustness at high electric field

- Cathode/gun separate vacuum like SEE proposal from BNL
  - Electron transparency of the window have to be checked
  - Compatibility with the RF and high electric field should be demonstrated

Informal collaboration with CEA-SP2A
Don’t forget

* **Ga-As photocathodes for polarized electron production**

Today performances not directly compatible with CLIC specifications.
A l’occasion de mon départ à la retraite, j’ai le plaisir de vous inviter à venir boire le verre de l’amitié

le lundi 31 octobre à 16h30
au “Glass Box” du restaurant n°1

Guy Suberlucq