Overview of CEBAF Electron Injector

Joe Grames
(and many others whose slides I’ve stolen)

PEPPO Collaboration Meeting
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- Injector overview for “Newbies” and Users alike
- Polarized Electron Source: a critical piece of this puzzle
- The “5 MeV Region” => A good place to stage PEPPo?
- Some “Bells & Whistles” that we might find useful
Polarized Electron 65 MeV Injector

2 SRF (600 MeV) linacs & recirculations arcs

3 Experiments
Polarized Electron Injector

- **Polarized Electron Source (130keV)**
- **Synchronous Photoinjection**
- **SRF Acceleration (<65 MeV)**
  - 5 MeV Dump
  - Synchrotron Light Monitor
  - Injection Chicane
  - 45 MeV Dump/Spectrometer

**Electron Spin Rotators**

**Bunching & Acceleration 500keV**

**SRF Acceleration (<10 MeV)**

**Injection Chicane**
Photoemission from GaAs

Bare GaAs surface; Large work function. No electrons

Alkalai (Cs) reduces work function. Some electrons.

Cesium + Oxidant (O or NF3) “Negative Electron Affinity”. Many electrons

“Activate” GaAs photocathodes by applying about one mono-layer of cesium and oxygen to surface, which must be very clean……
Layers of GaAs on GaAsP

No strain relaxation
QE = 1%, 6uA/mW
Pol > 80% @ 780 nm
High-P GaAs Photogun

DC High Voltage (130kV)

Circular Polarized Laser IN

Spin Polarized Electrons OUT
DC HV Inverted Photogun (2009)....

Load-locked dc high voltage GaAs photogun with an inverted-geometry ceramic insulator


Thomas Jefferson National Accelerator Facility, Newport News, Virginia 23606, USA
(Received 24 November 2009; published 26 January 2010)

A new dc high voltage spin-polarized photoelectron gun has been constructed that employs a compact inverted-geometry ceramic insulator. Photogun performance at 100 kV bias voltage is summarized.
Fiber-Based Drive Laser

Gain-switched seed

ErYb-doped fiber amplifier

Frequency-doubler
Synchronous Photoinjection

- Chopper
- FC#1
- Buncher
- Capture
- Bunchlength Cavity
- Cryounit
- Cryomodules
- 5 MeV Dump
- Injection Chicane
- 45 MeV Dump/Spectrometer
- 500 keV Dump

- Gun#2
- Gun#3
- V-Wien Filter
- Prebuncher
- PC,up
- H-Wien Filter
- Apertures

- 1497 MHz
- 60 degrees
The “5 MeV” Injector

Beam Parameter | Values
--- | ---
Energy | <10 MeV
Average Current | <200 μA
Repetition Rate | 499MHz (or sub)
Energy Spread | <20 keV
Bunch Length | < 1 ps
Norm. Emittance | ~1 micron
Beam Size (typ.) | ~0.50 mm
5 MeV region has good diagnostics...

- Beam position monitors
- Spectrometer (momentum & energy spread)
- Faraday Cup
- SRF (<10 MeV)
- Beam current cavity
- Mott electron polarimeter (precision <2%, Px & Py)
...and you can't beat the floor space!
A “bell” – 4π spin control

R(y) - Horizontal Wien Filter

R(z) - Two Solenoids

R(x) - Vertical Wien Filter
A “whistle” - Beat Frequency Modulator (BFM)

\[ f_{\text{beat}} = |f_{\text{laser}} - 499 \, \text{MHz}| \]

Laser = 467MHz

Beam = 31MHz

\[ f_{\text{laser}} \text{ (not 499 MHz), but } I_{\text{ave}} = 200 \, \mu\text{A} \]
So, test $e^-$ to $e^+$ production at "5 MeV"?

Yield $\sim 0.01$
Collection $\sim 10$

Not encouraging:
100$\mu$A $\Rightarrow$ $\sim 1$ nA

But, many $e^-$ is encouraging:
10mA $\Rightarrow$ $\sim 100$nA
(good for CEBAF)

Small Energy Footprint
Small Radiation Footprint

And higher energy even more tantalizing…
Summary

- CEBAF polarized electron injector is an ideal place to test the PEPPo concept in the <10MeV energy range.

- Advances in polarized electron sources make the idea of using the PEPPo concept to produce polarized positrons *not* unthinkable. 😊

- Jonathan has to “show off” his experiment concept, and then I’ll discuss how we might implement this at CEBAF.