Status of the Jefferson Lab Polarized Beam Physics Program and Preparations for Upcoming Parity Experiments

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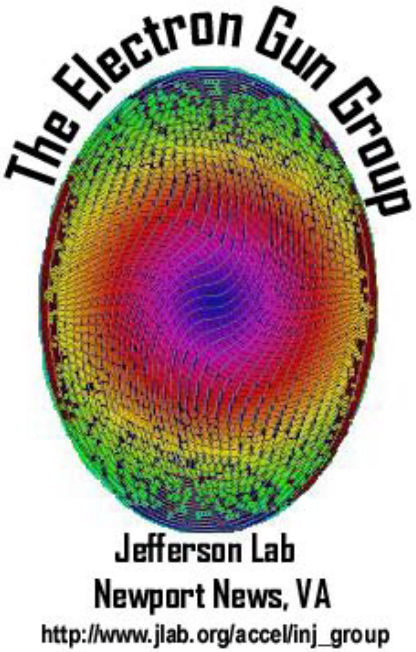


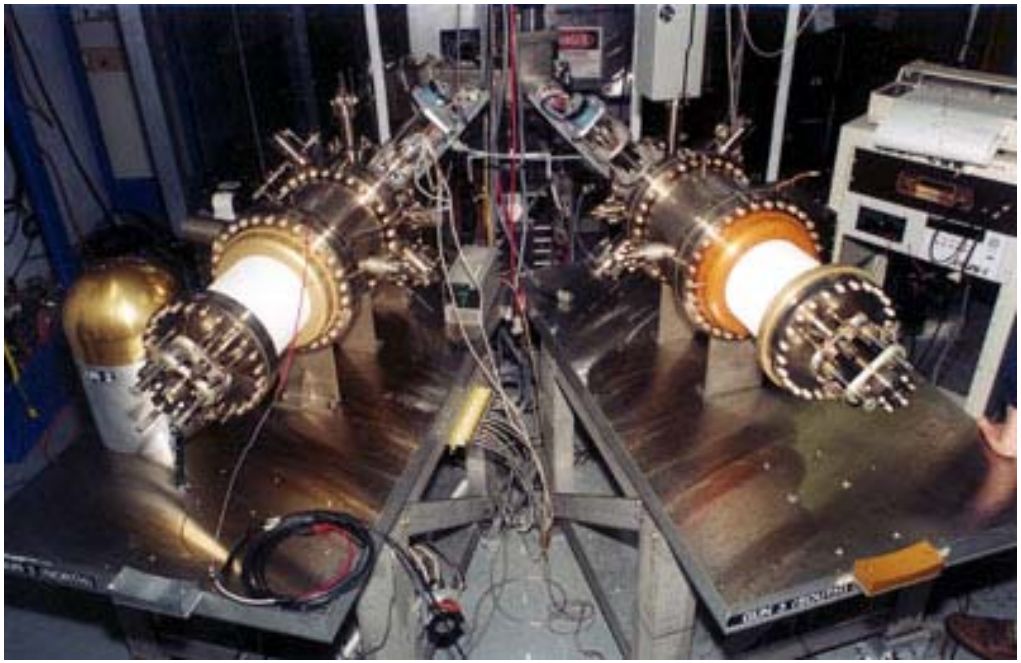
PESP 2002 Workshop
MIT-Bates
September 4-6 , 2002

Polarized photoinjector

2 identical horizontal guns installed in 1998

Gun 2

Oct 2000
to
Jan 2001



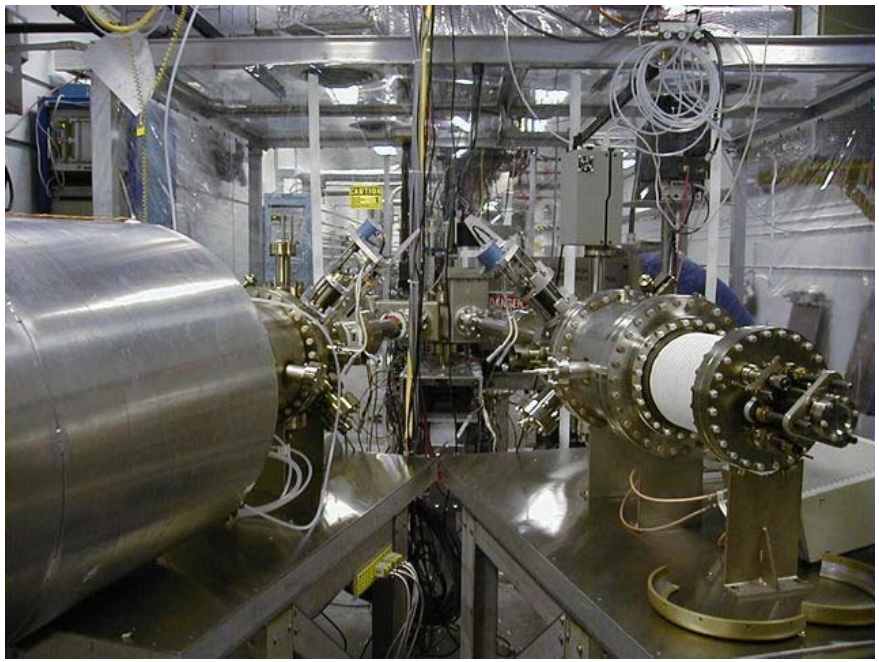
Gun 3

Feb 2001
to
Mar 2002

Gun service required once per year.
Both guns provide high polarization (>70%).

Source perspective

A 100 keV beam from either gun is deflected 15° by a magnet to a common pre-accelerator beamline.



Two laser tables straddle the beamline and provide a direct optical path to the cathode.

Laser options

Diode (a choice between high current or high polarization)

- easy, low maintenance, reliable
- low noise ~ 0.1% @ 30 Hz
- low power < 100 mW
- wavelength fixed
- DC light => leakage
- Original vendor SDL quit selling amps

Ti:Sa (can achieve both high current AND high polarization)

- high power ~ 300 mW
- wavelength adjustable
- higher maintenance
- homebuilt laser noise at 30 Hz can be high (~ 1%)

QE & Polarization

Quantum Efficiency

High polarization => 0.2 % at 840 nm yields 1 μA/mW

Low polarization => 1.0 % at 770 nm yields 6 μA/mW

Polarization

Laser polarization >99.5% and is flipped at 30 Hz helicity rate

Electron polarization is 70 to 80 % by Mott, Moller, & Compton

Lifetime (1/e)

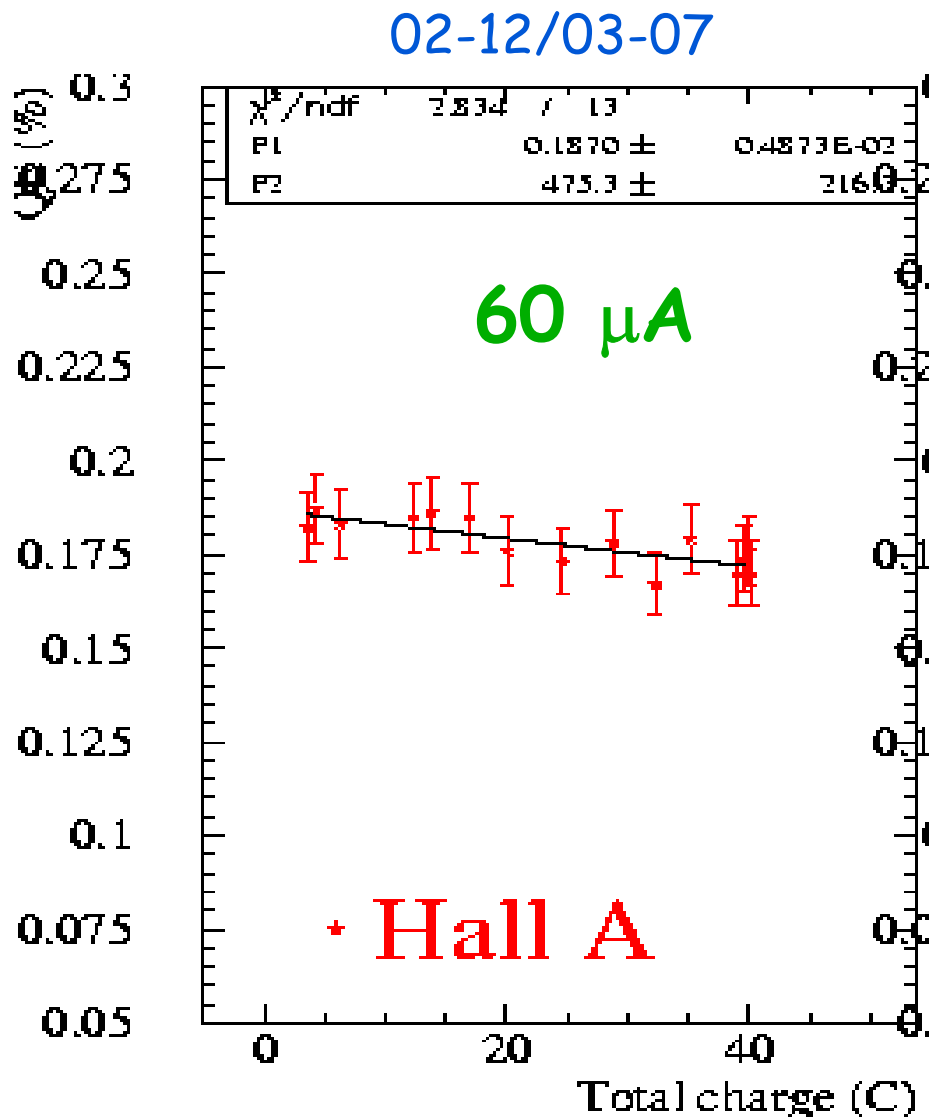
Low current : lifetime ~ 600 C

beam to 3 halls for 3 months
with single activation

High current : lifetime ~ 300 C

uninterrupted beam for 3 weeks

One year with only 3 activations!



Satisfying 3 Users

	Sep	Nov	Feb	Mar	June
A	E97-110 diode 840 nm	E94-107 diode 840 nm	Winter Shutdown	HAPPEx2 499 MHz TiSa tunable	
B	g7 diode 770 nm	e1 diode 840 nm		e1 diode 840 nm	g8 diode 770 nm
C	G0 31 MHz TiSa tunable			E00-002 diode 770 nm	E01-002 diode 770 nm

← A and C : independent parity knobs →

Dynamic laser configuration

Re-re-re-re-configuration. . .

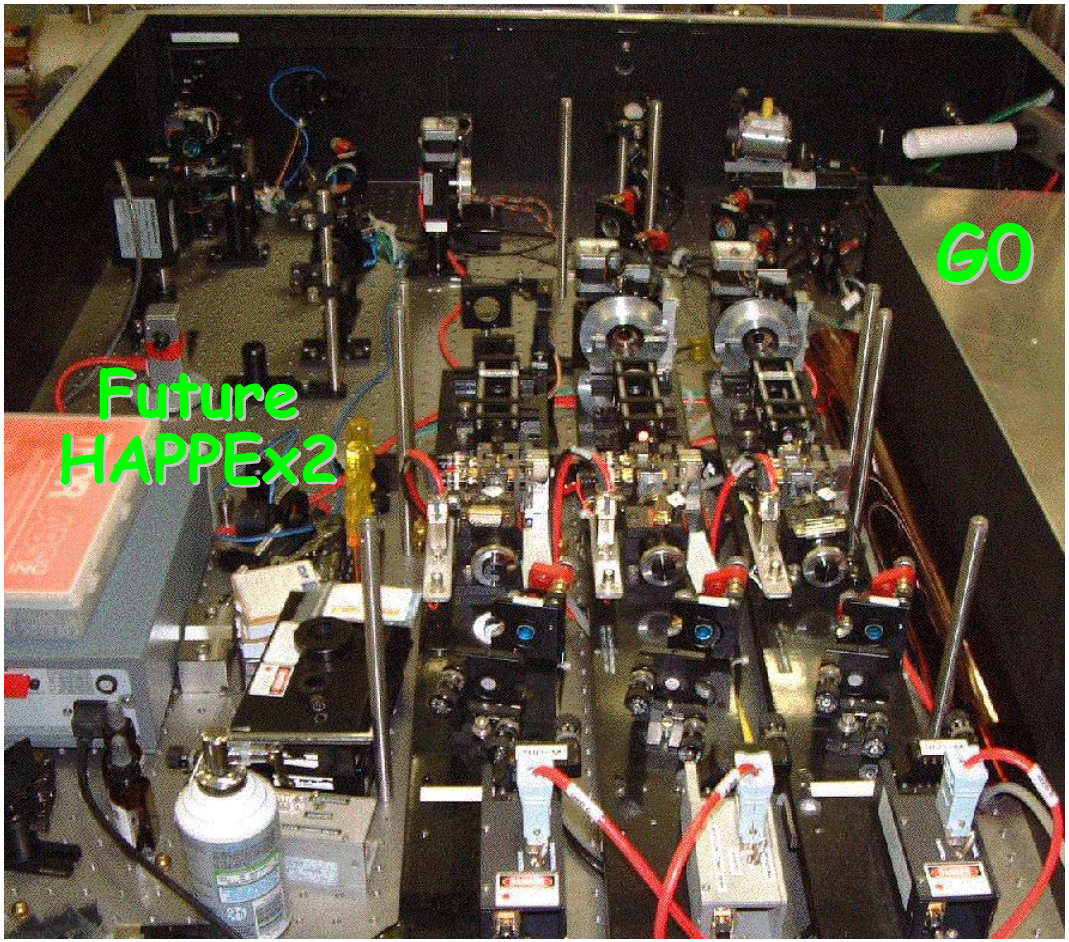
3 end-stations makes for a dynamic physics program which requires that the laser table be configurable for beam qualities:

Intensity (power)

Polarization (wavelength)

RF (1497, 499, 31.1875)

Parity (Independent)



Parity controls

3 hall operation forces laser configuration constraints.

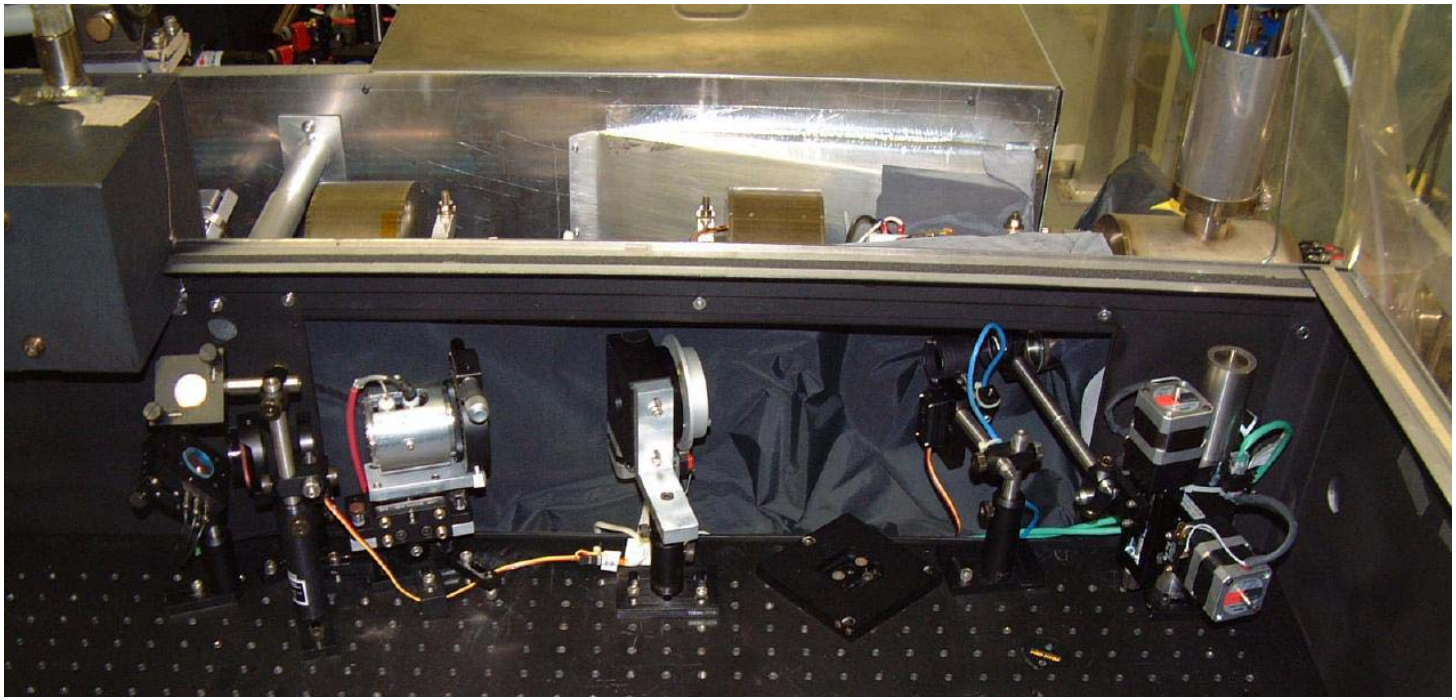
Must provide parity quality beam for G0 and HAPPEx2.

Independent intensity and position control for each end station.

Hall B continues using a diode-current modulated intensity feedback.

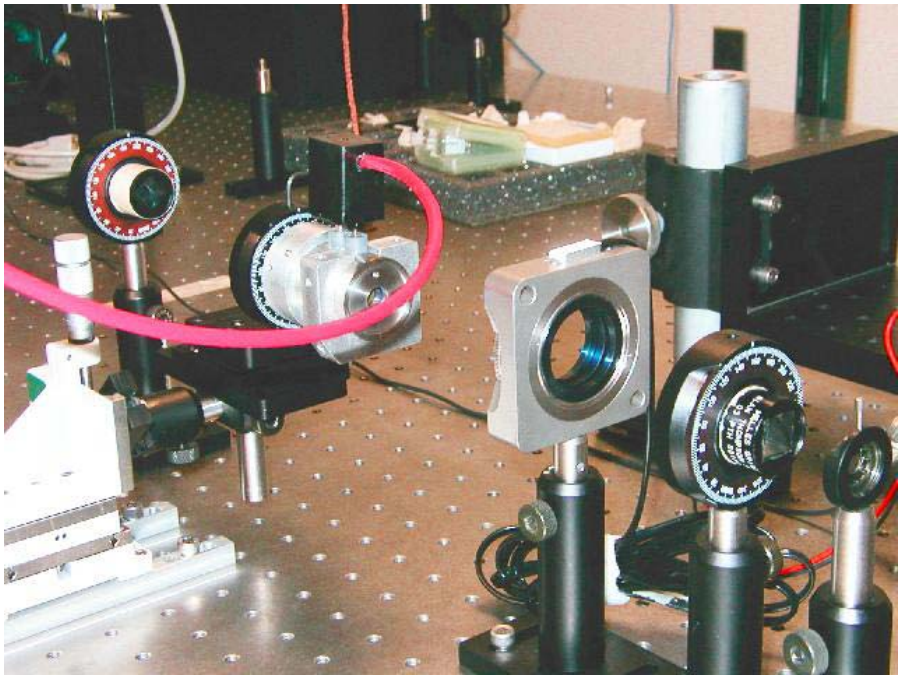
Asymmetry Lock Server provides Users access to the parity controls.

Parity devices common to all lasers

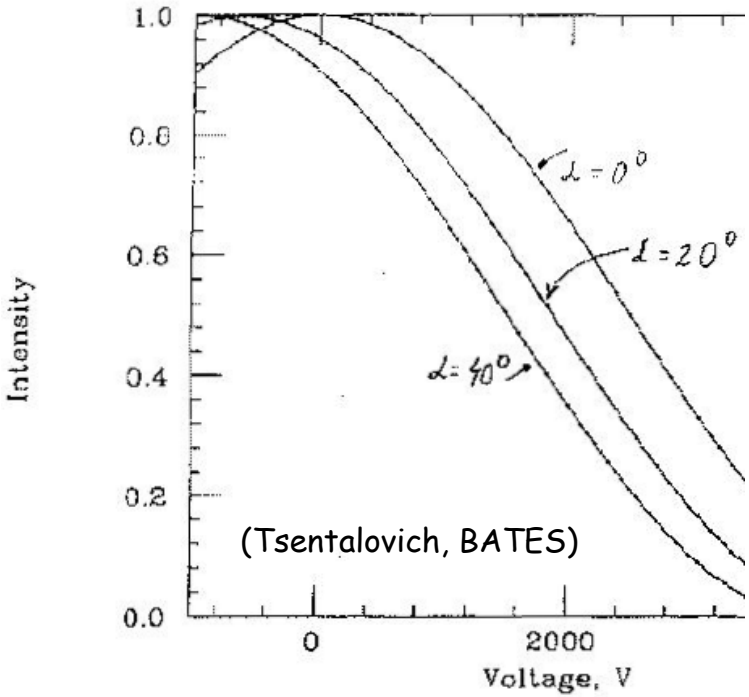


- PZT X/Y kinematic mount
- Insertable $\lambda/2$ waveplate for systematic helicity reversal
- 20 mm $\lambda/4$ Pockels cell for CP and PITA
- Rotatable $\lambda/2$ waveplate

Independent intensity control



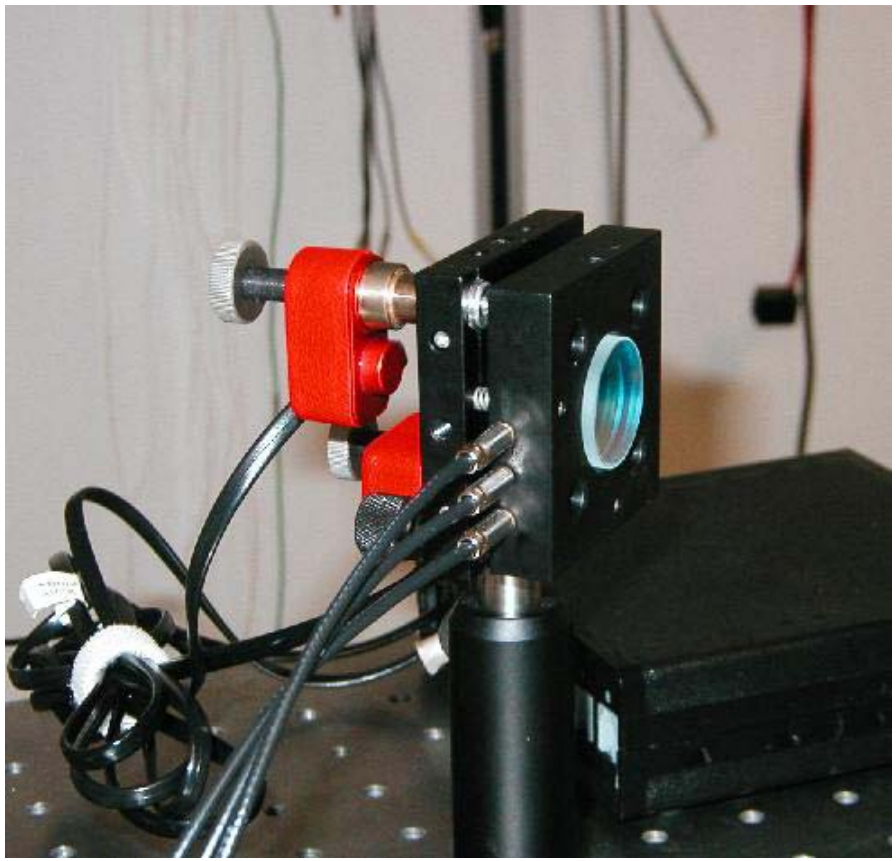
- Follows laser directly
- Stable slope ~300 ppm/V
- Low cell voltage
- Low insertion loss
- Compact footprint



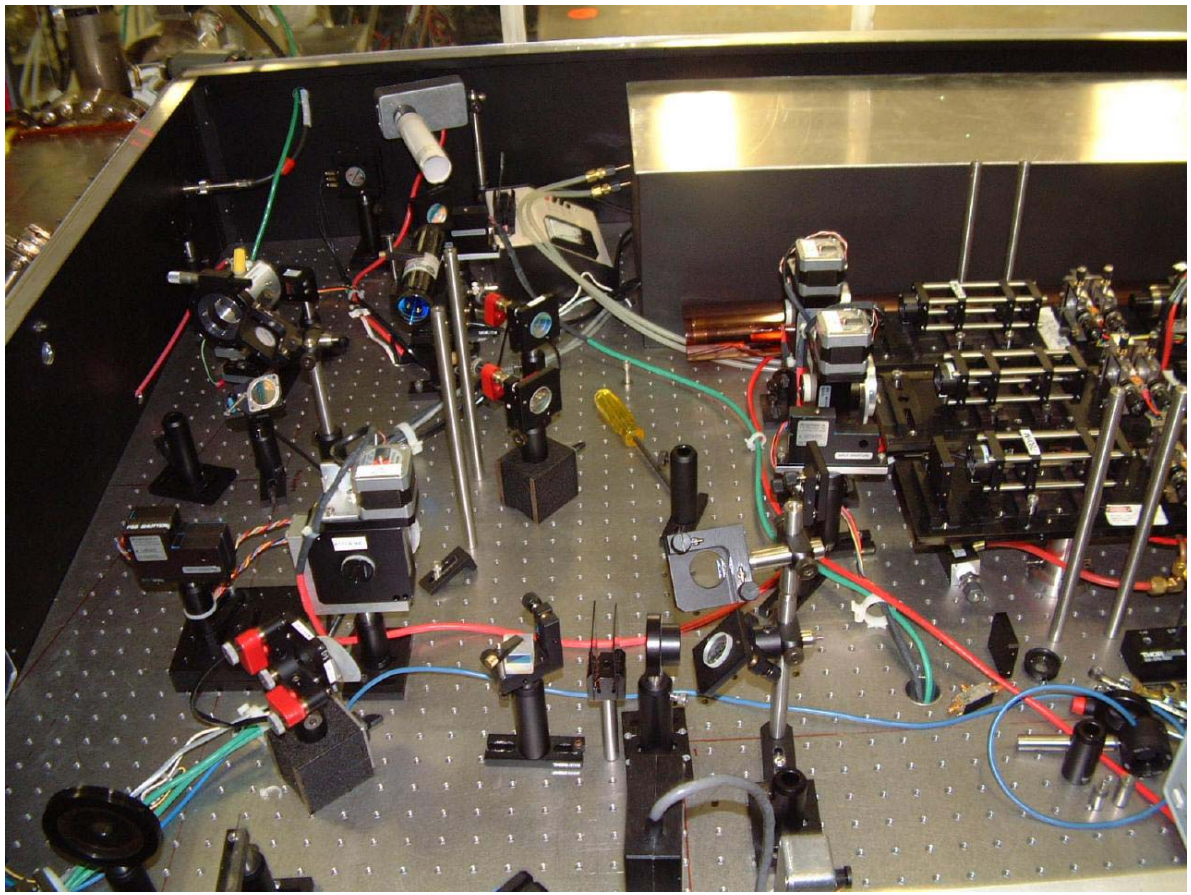
Independent position control

To achieve independent position control we retrofit a pico-motor mount with a kinematic mount that contains piezoelectric stacks for laser deflection.

This choice doubles the moment arm to the cathode and also increases the distance to the Pockels cell (from 10 to 100 cm).

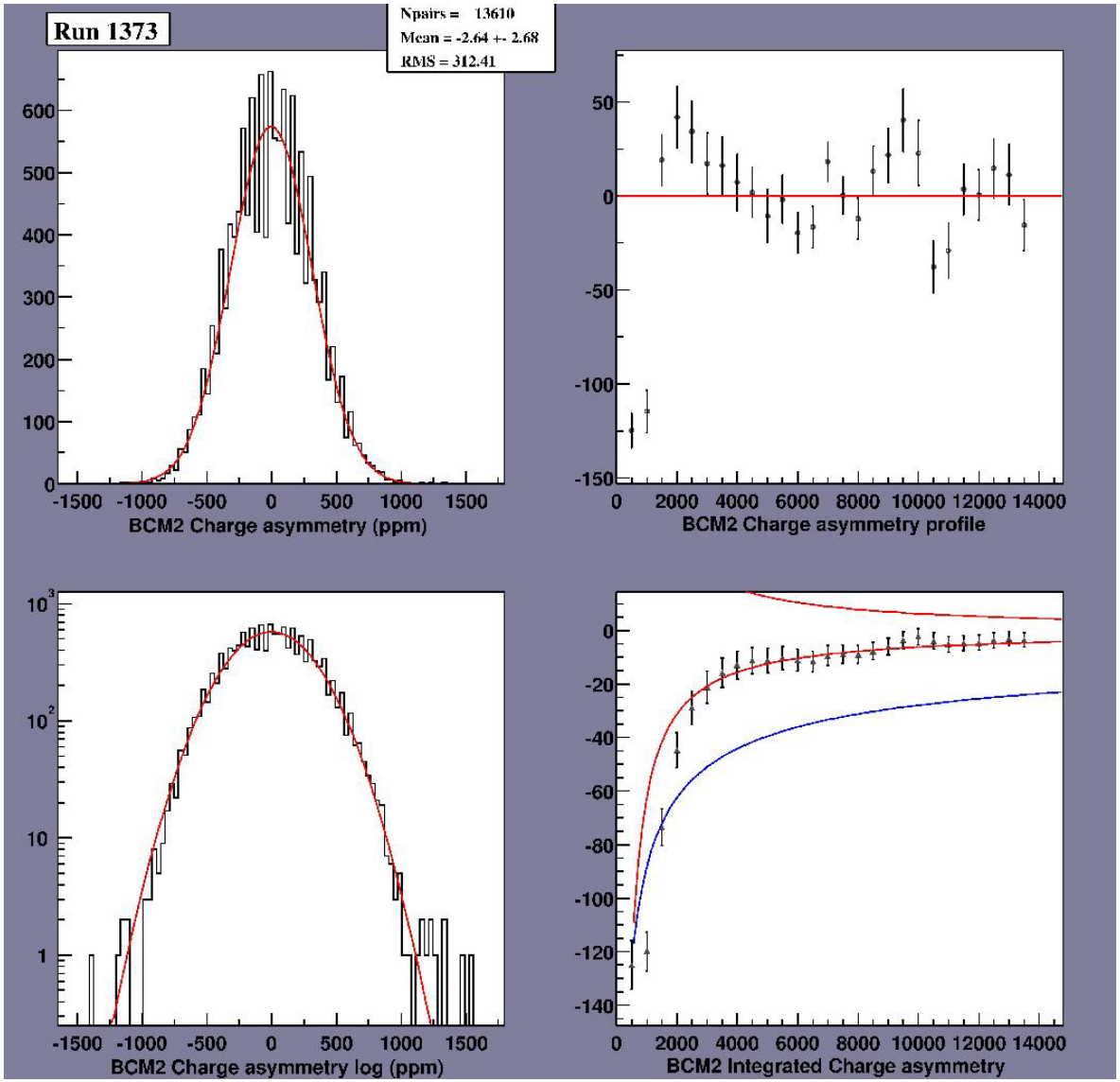


Independent parity devices



The independent devices are installed upstream of the location where the 3 lasers are combined.

IA beam test (Hall A)



Issues regarding position feedback

HC motion at injector apertures produce charge asymmetry.

- Original emittance filter resulted in Q_{asym}~ 300-400 ppm/volt.
- Enlarged (2x) aperture set reduced to this to < 40 ppm/volt.

HC motion on the cathode QE surface produces charge asymmetry.

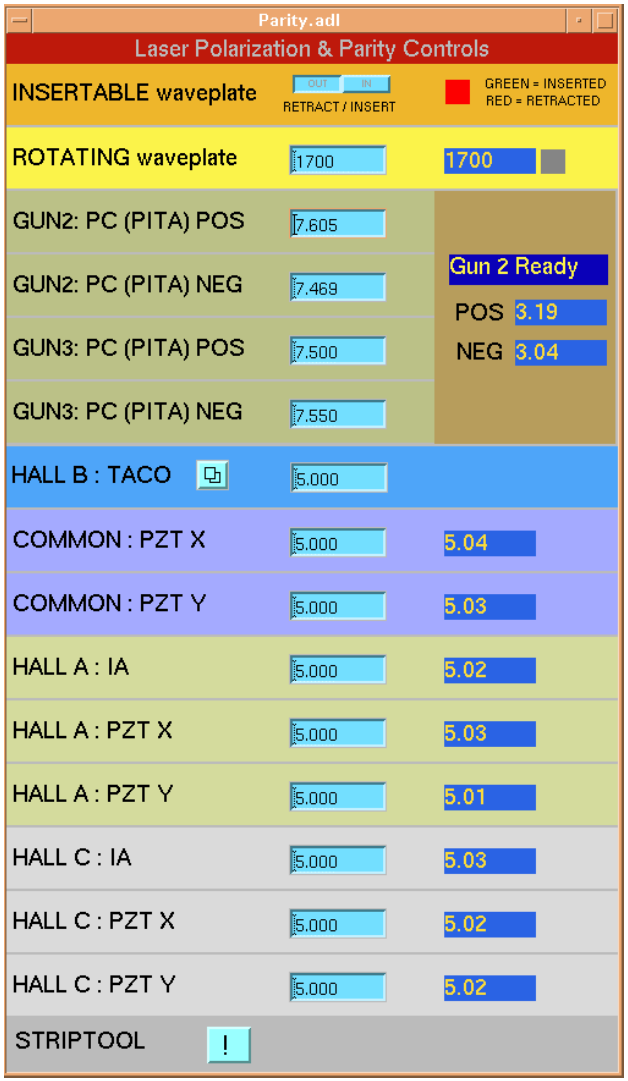
- Contribution from QE surface vs. apertures to be measured.

PZT kinematic mount is not perfect.

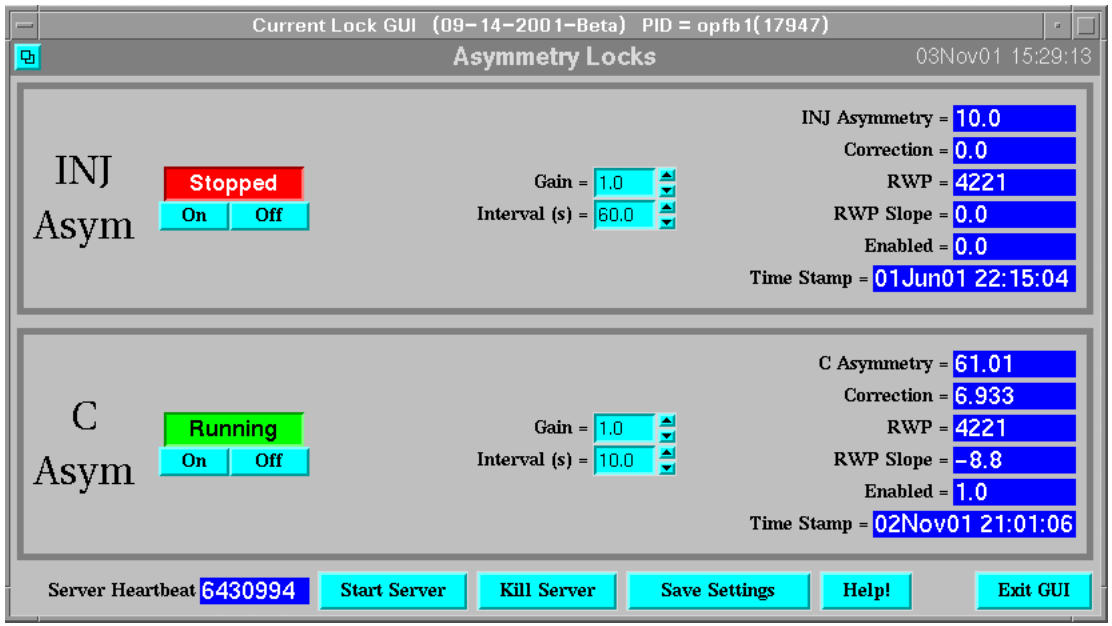
- Cross-talk < 0.1% at the coupled stack.
- Ringing at each stack ~0.5% for 5 msec.

HAPPEx2 is considering the possibility of employing HC magnets.

Asymmetry Lock Server



ALS provides User access to the parity controls via the EPICS control system.



Injector parity DAQ's

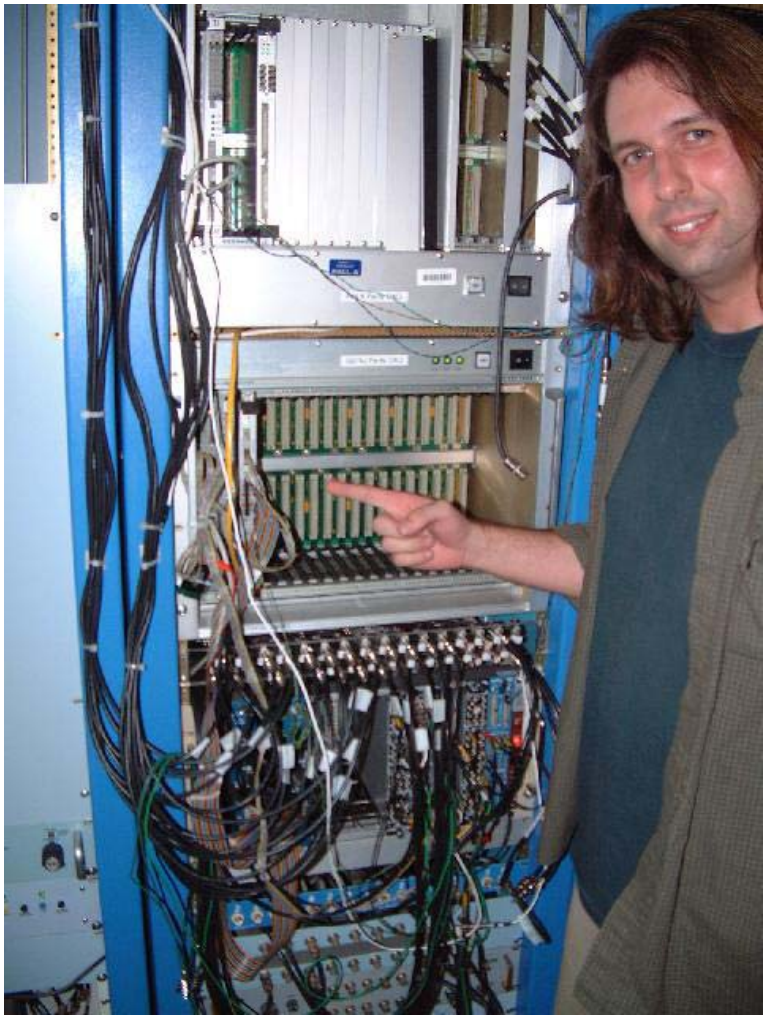
Monitoring HC beam quality at the injector provides the User additional information and confidence.

BPM's

#	Energy	Quality
1	100 keV	Prior to any apertures
3	100 keV	Between Wien & A1
1	100 keV	Between A1 & A2
1	100 keV	After chopper
3	5 MeV	After all apertures

BCM

#	Energy	Quality
1	5 MeV	After all apertures



Injector beam monitoring

Injector diagnostics see all 3 beams.

All HC feedback is applied from the end-stations.

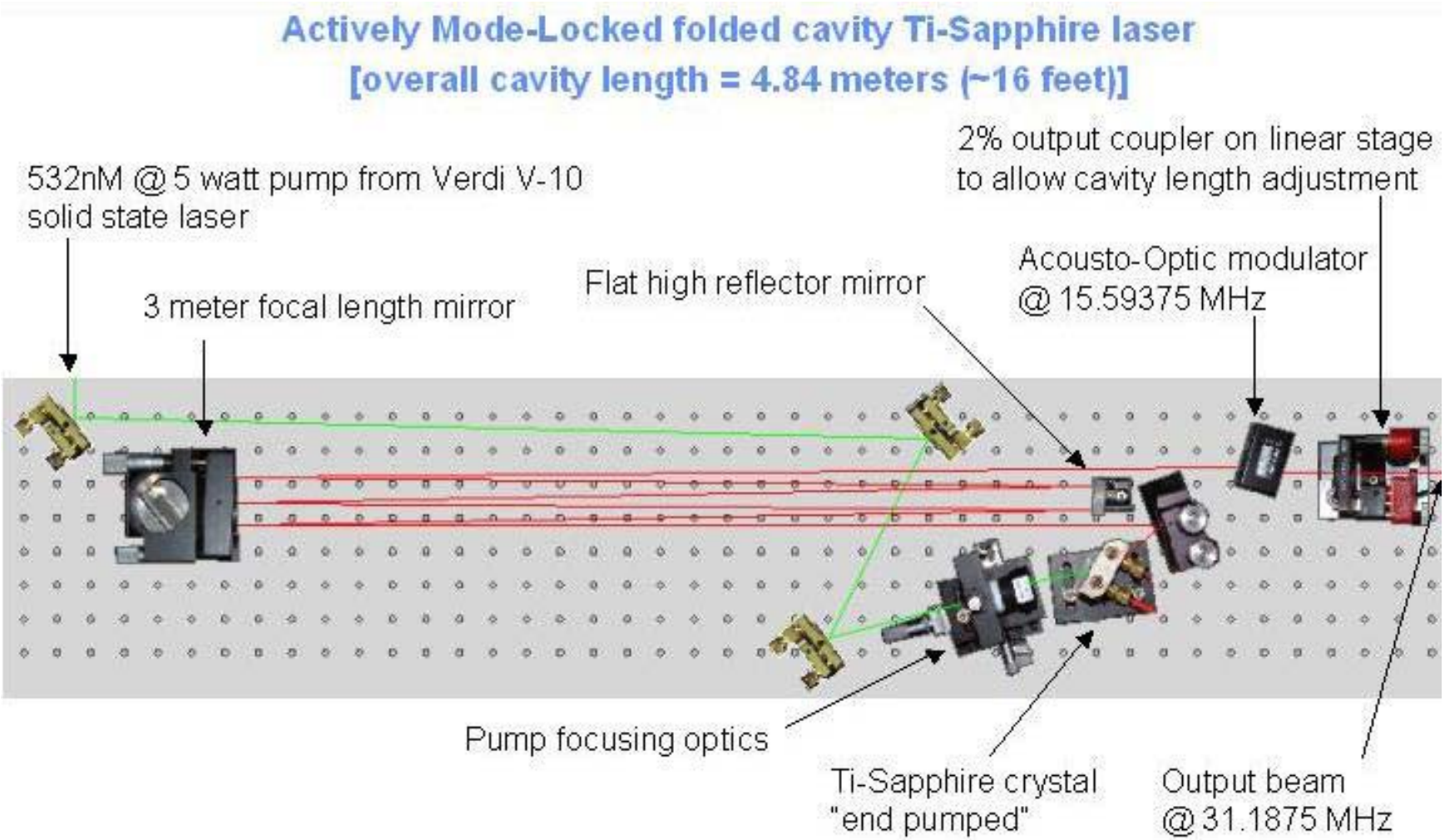
Parity Users want to keep it this way.

Some Users want us to null the HC asymmetries.

A drawing board idea for independent capability:

- Requires separate beam intensity modulation on each beam
- RF VME boards with DSP to use lock-in technique
- Project has Operations support
- Initial tests using the injector BCM before 2003

Homebuilt G0 Ti:Sa laser



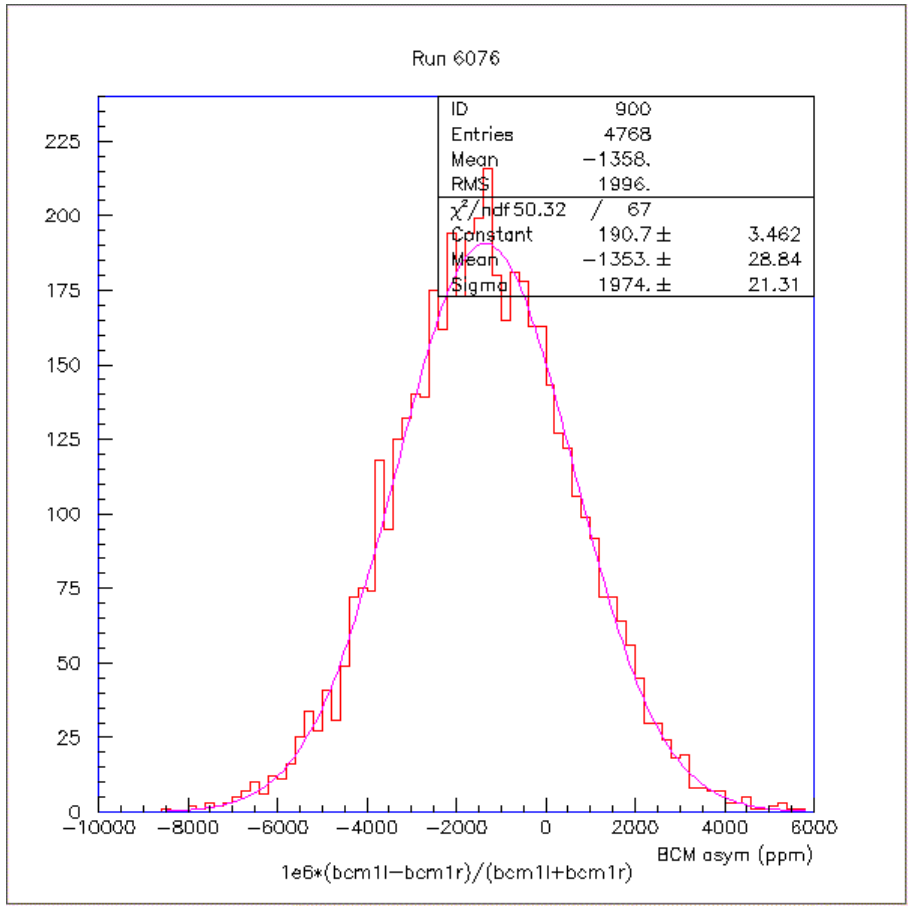
Ti:Sa performance

Power > 300 mW @ 825 nm

Laser pulse ~180 ps FWHM

I = 10μA @ 5 MeV BCM

30 Hz noise < 0.2%

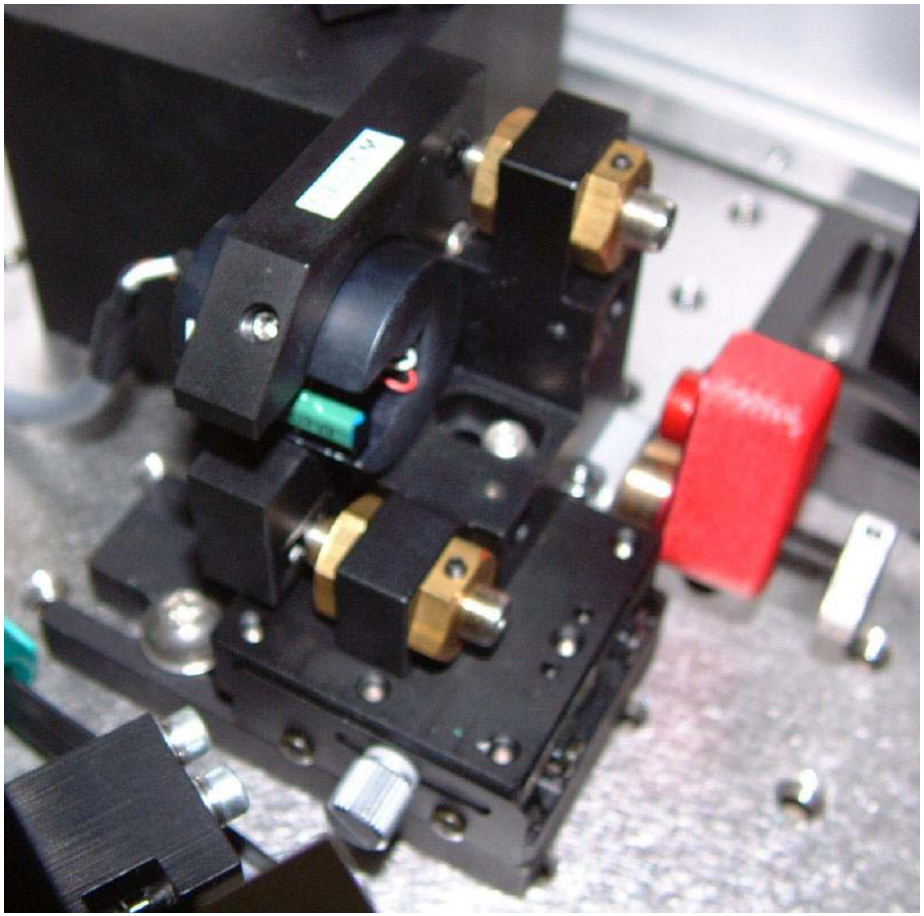


Time-Bandwidth Tiger Laser

A commercial Ti:Sa laser was purchased for the G0 experiment. The laser and designer arrived in August. The system, shipped from Switzerland, was uncrated, turned on and began pulsing…

Time-Bandwidth Laser

Passive mode-locking is achieved using SESAM technology and a PLL to the reference 31.1875 MHz RF source.



Time-Bandwidth Laser Performance

Measured > 300 mW at 840 nm; tunable from 770-860 nm.

Measured pulse width ~ 70 ps fwhm.

Etalons for 15 ps, 33 ps, 50 ps, and 70 ps received.

Phase noise measured < 700 fs.

Laser has met spec.
Training and testing in progress.

Where are we now?

We are in the midst of reaching many important G0 milestones. We are making progress both on the laser front, beam transport front, and parity front.

G0 requires 40μA at 31 MHz in November.

- We have been testing the homebuilt Ti:Sa
- This week the Tiger is installed and testing continues

HAPPEx2 requires 80μA at 499 MHz in January.

- Test and improve 499 MHz homebuilt laser
- Purchase another Time-Bandwidth laser ?

Where might we go from here?

Simplify our drive laser system:
Reduce the 3 different lasers to a single low maintenance laser capable of satisfying the User (100μA & P ~ 80%).

How ?
A turn-key DC, high power (5 Watt) diode array. It is available (and cheap!) at 810 nm, matched to Spire or Mamaev high-P cathodes.

The challenge!!!
To provide Users a 100μA beam means we then need to be able to routinely deliver 600μA with good life-time and parity quality. The Qweak parity experiment will want 200μA in 2006 !