# Summary Report of PESP-2002 Workshop

*(A satellite workshop of SPIN2002 Symposium)*

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***MIT-Bates Linear Accelerator Center***
***Middleton, MA 01949, USA***

**SPIN2002 Symposium**

**BNL, Long Island, NY September 9-14 , 2002**

# OUTLINE

- Introduction to PESP-2002 Workshop
- Polarized electron sources for accelerators
- Polarized sources for non-accelerator applications
- Summary

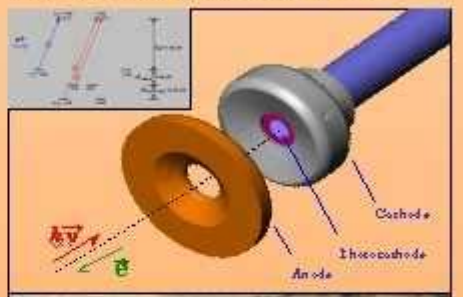
# PESP-2002

## Polarized Electron Sources and Polarimeters, Satellite Workshop of SPIN-2002

**TOPICS:**

- *Physics of Polarized Electron Photocathodes*
- *Polarized Electron Sources*
- *Low Energy Polarimeters*
- *Application of polarized electron sources*
- *Polarized Sources and Parity-Violating experiments*

**September 4-6, 2002**
MIT-Bates Linear Accelerator Center

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- *International and Local Organizing Committees of the Spin Physics Symposium*
- *MIT-Bates Linear Accelerator Center*

**For More Information:**

**http://mitbates.mit.edu/pesp2002**

**pesp2002@batespop.mit.edu**

PESP-2002 Workshop, September 4-6, 2002 MIT-Bates
Linear Accelerator Center

# Workshop Program

•A mix of high energy and low energy application and physics of PES and photoemission. An excellent mix of participants from these areas. Fruitful exchange between accelerator based PES and low energy surface physics researchers and engineers.

**Total of 8 sessions in 3 days**

**Session 1:** NEA and surface physics:/ Chair: C. Prescott

**Session 2:** Photocathode-Spin Physics / Chair: T. Maruyama

**Session 3:** Electron beam Polarimeters / Chair: K. Aulenbacker

**Session 4:** Polarized Electron Sources /Chair: E. Tsentalovich

**Session 5:** Development of PES and Lasers /Chair : J. Clendenin

**Session 6:** Applied spin physics and technology / Chair: Y. Mamaev

**Session 7:** Polarized Sources and parity-violation experiments /Chair: M. Farkhondeh

**Session 8:** Developments of Laser systems for polarized source/ Chair: T. Zwart

# Brief report of selected issues:

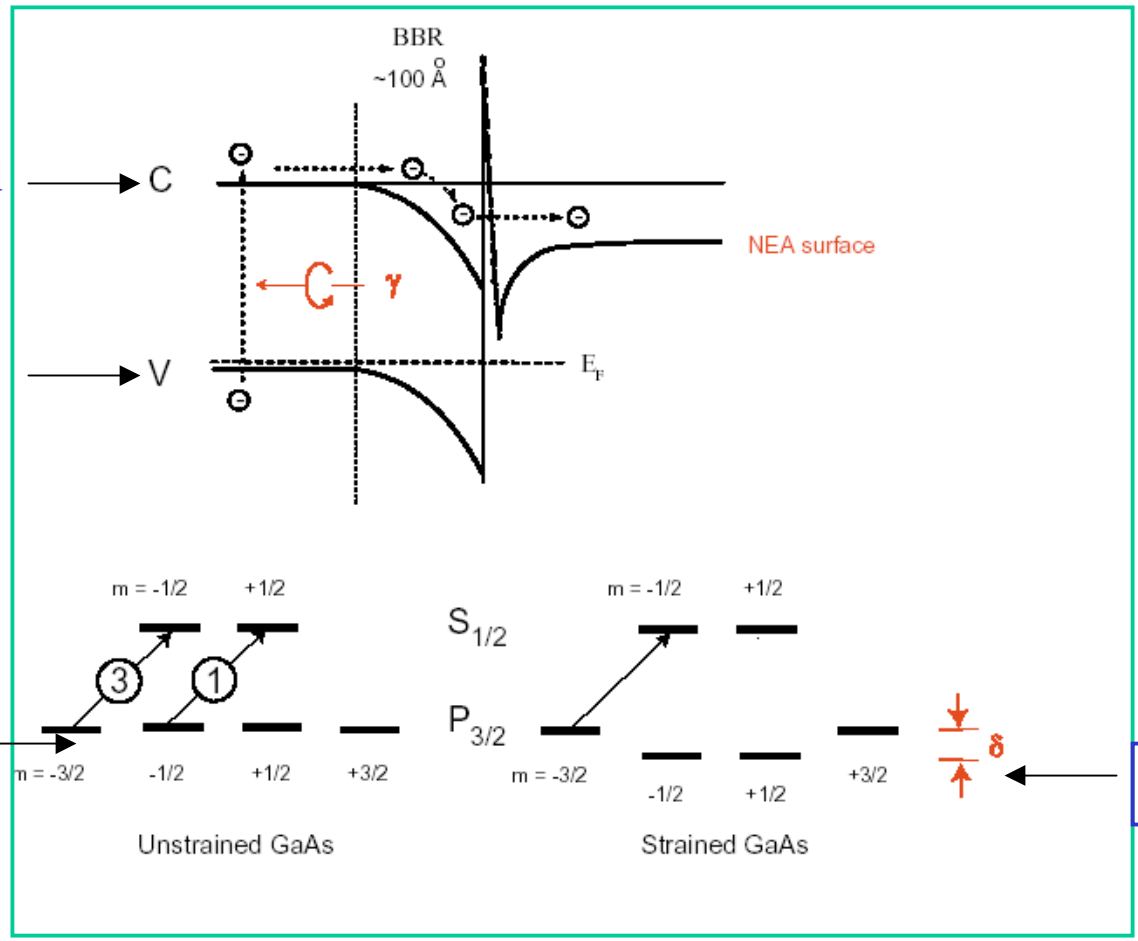
- **Basics of photoemission**
- **Surface charge limit effect and remedies**
- **PES at Accelerator Centers (SLAC, JLAB, MIT-Bates, Maniz and Bon)**
- **Electron polarimetry: few examples**
- **New lasers for Accelerator based PES**
- **Surface magnetization studies with spin polarized currents**

# Basics of Photoemission

- **Two fundamental principles:**
- Conservation of Angular Momentum
  - **excitation of the electrons in the valance band to the conduction band with circularly polarized photons**
- Negative Electron Affinity (NEA):

  **achieving NEA by lowering the work function to allow the conduction band electrons to escape**

# Polarized Photoemission




**Conduction band**

**Valance band**

**degenerate states**

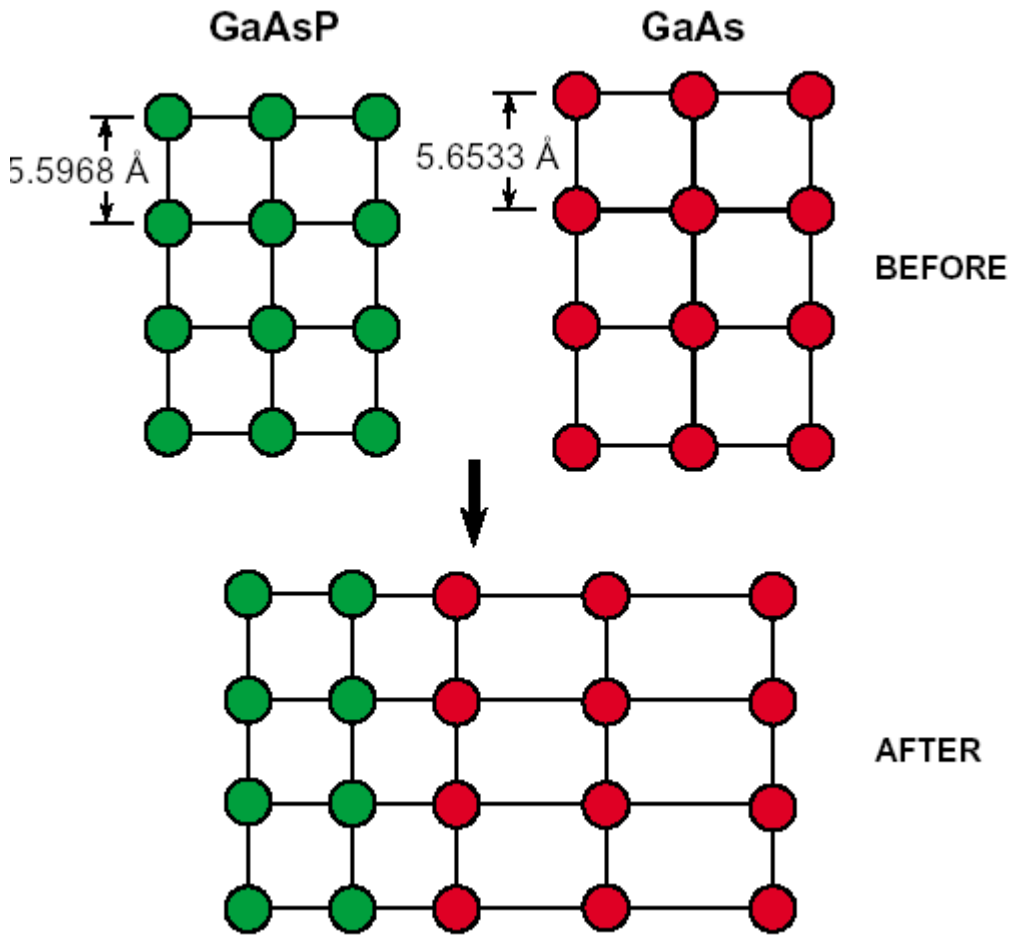
**Split states**

**Max Pol: 50%**

**(40%)**

**Max Pol: 100%**

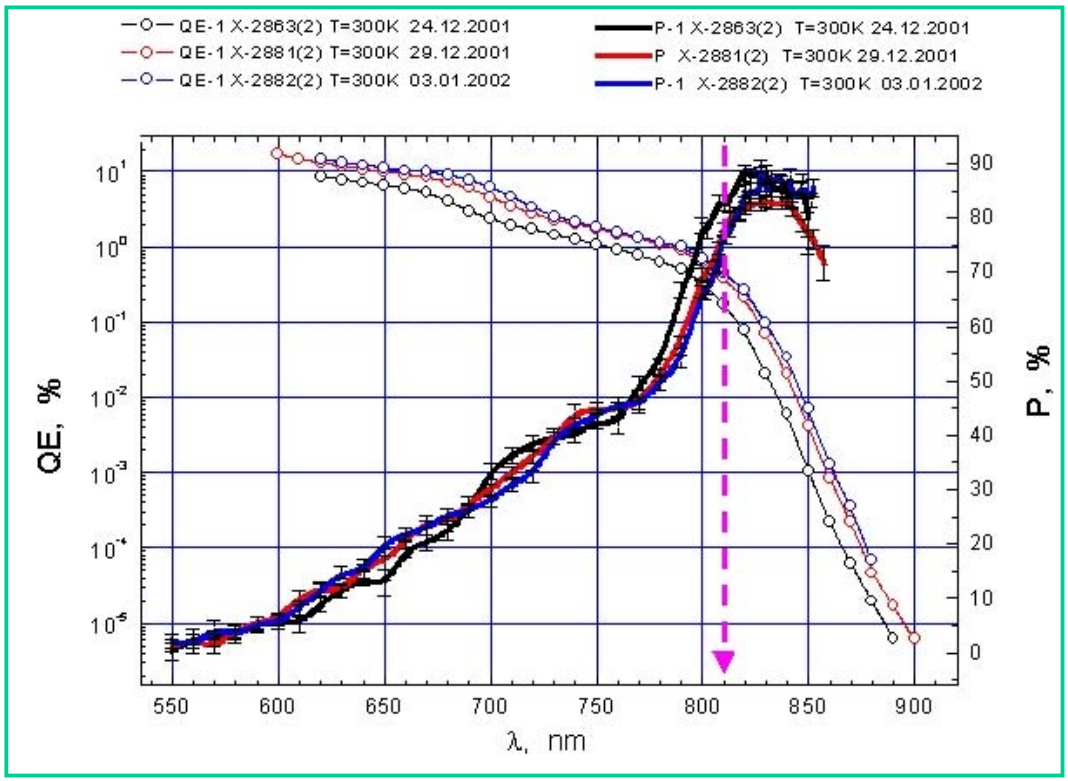
**(85%)**




Courtesy T. Maruyama, SLAC

2002 EIC workshop

# Strained GaAsP




**New SL sample from St. Petersburg,**

**sample x=2863 (St. Petersburg's data)**

**Can grow for specific wavelength**

## Quantum Efficiency (QE) :

**is very low in high P photocathode due to very thin active layer.**

**QE < 0.1 %**

## Polarization:

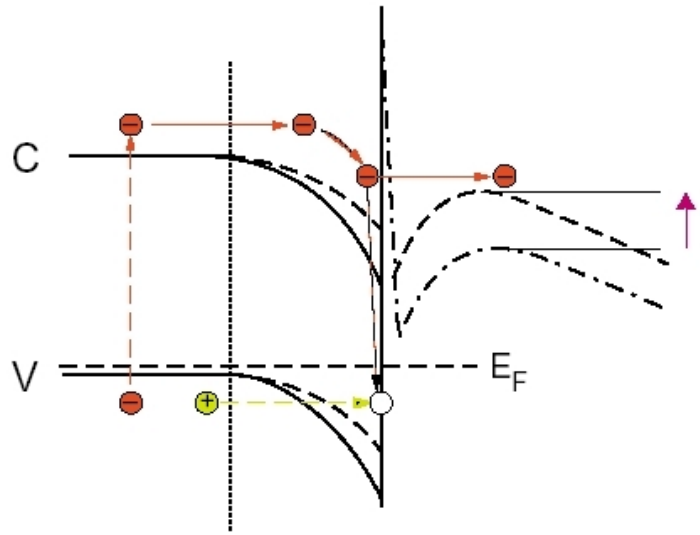
**Max. at a specific wavelength**

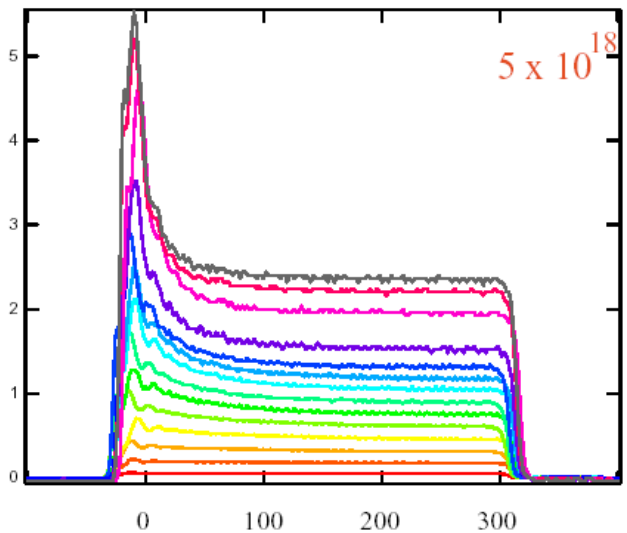
# Surface Charge limit

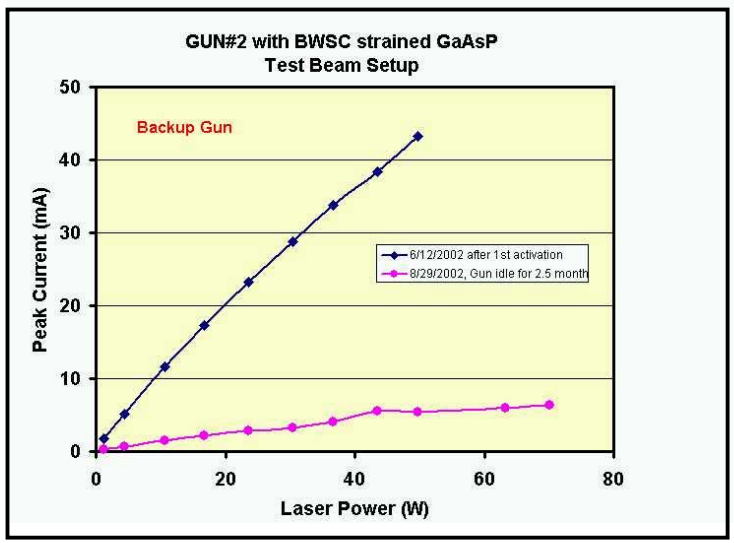
- **Charge Output is not proportional to light intensity**

- **Methods to overcome or reduce the effect:**

  - **superlattice layer (Nagoya, St. Petersburg)**
  - **highly doped thin layer on top (SLAC-SVT)**



# PES at Accelerator Centers

**High polarization beams are produced at all accelerator centers that have physics program with polarized electron beams. This is despite the fact that these accelerators are different in duty cycles, pulse length and average current by orders of magnitudes.**

**SLAC: pulsed beam, low average current, high peak current**

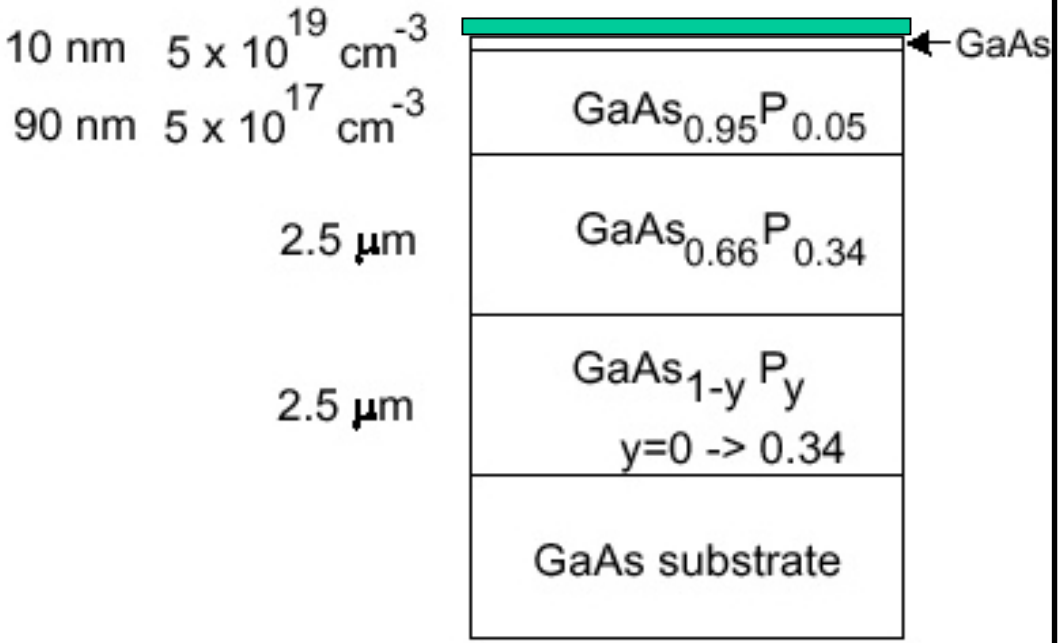
**Bates: pulsed linac, low and high average currents, moderate peak current, high average cw stored beam**

**Jlab: CW linac, high average current, low "micro peak"**

**Mainz: microtrun (CW beam), high average current, low "micro peak"**

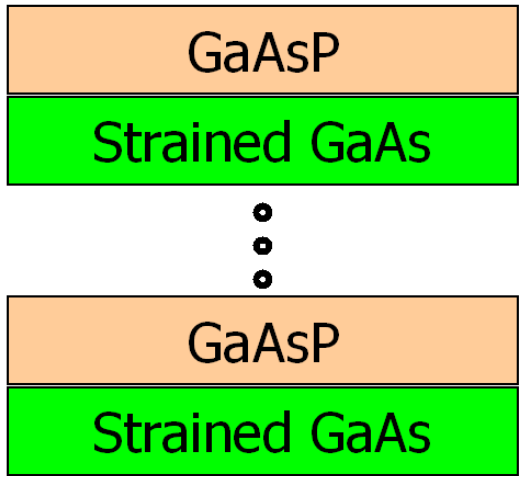
**Bon: pulsed linac, stretcher ring, low average current, high injected peak**

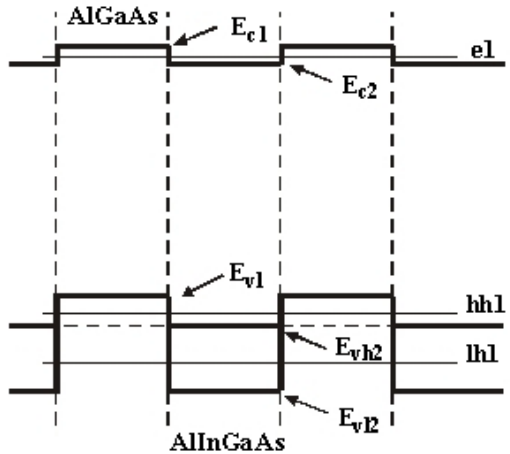
## Highly doped thin layer on top




**In use at SLAC and at Bates**

## Strained Superlattice

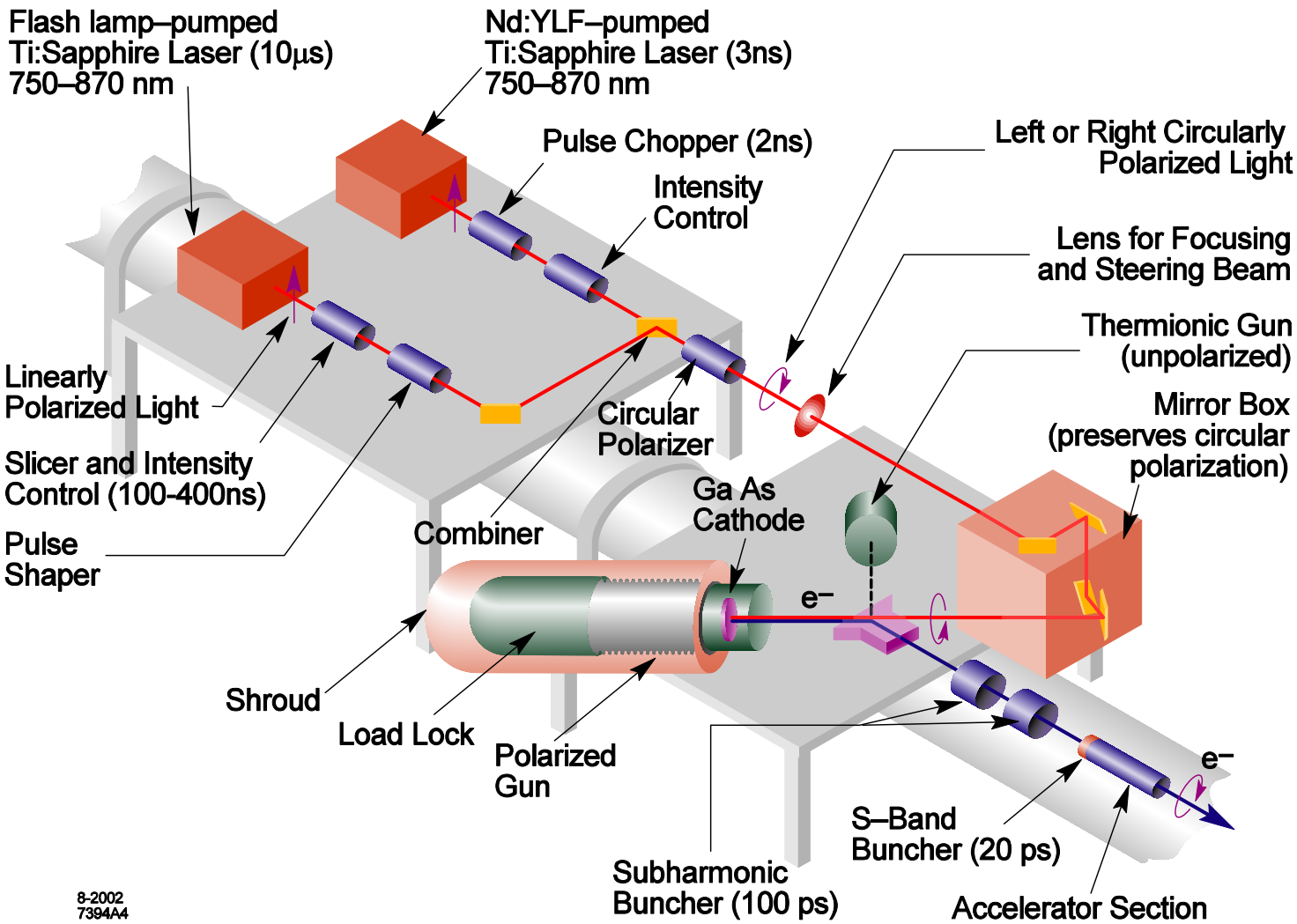



**In use at Mainz and Nagoya**

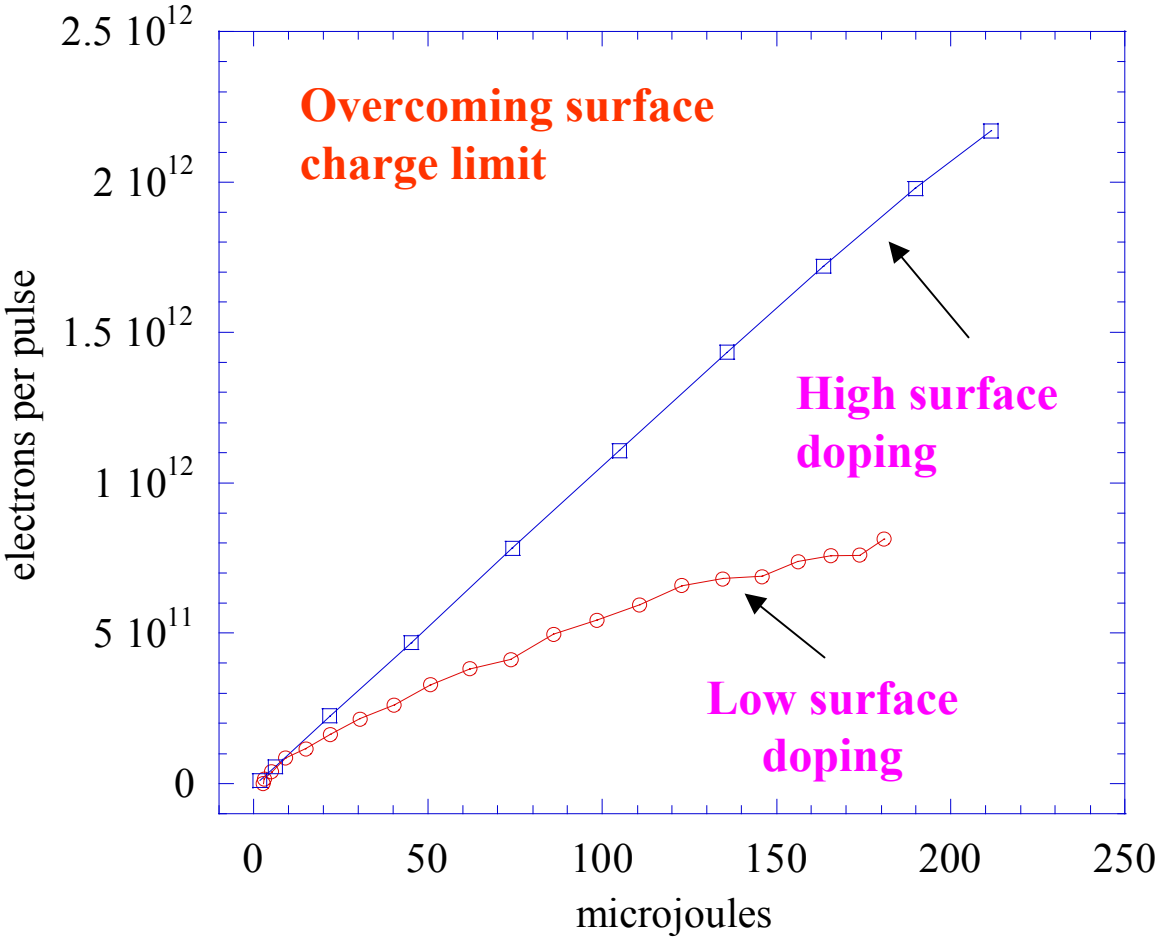
J. Clendenin

# SLAC Polarized Source



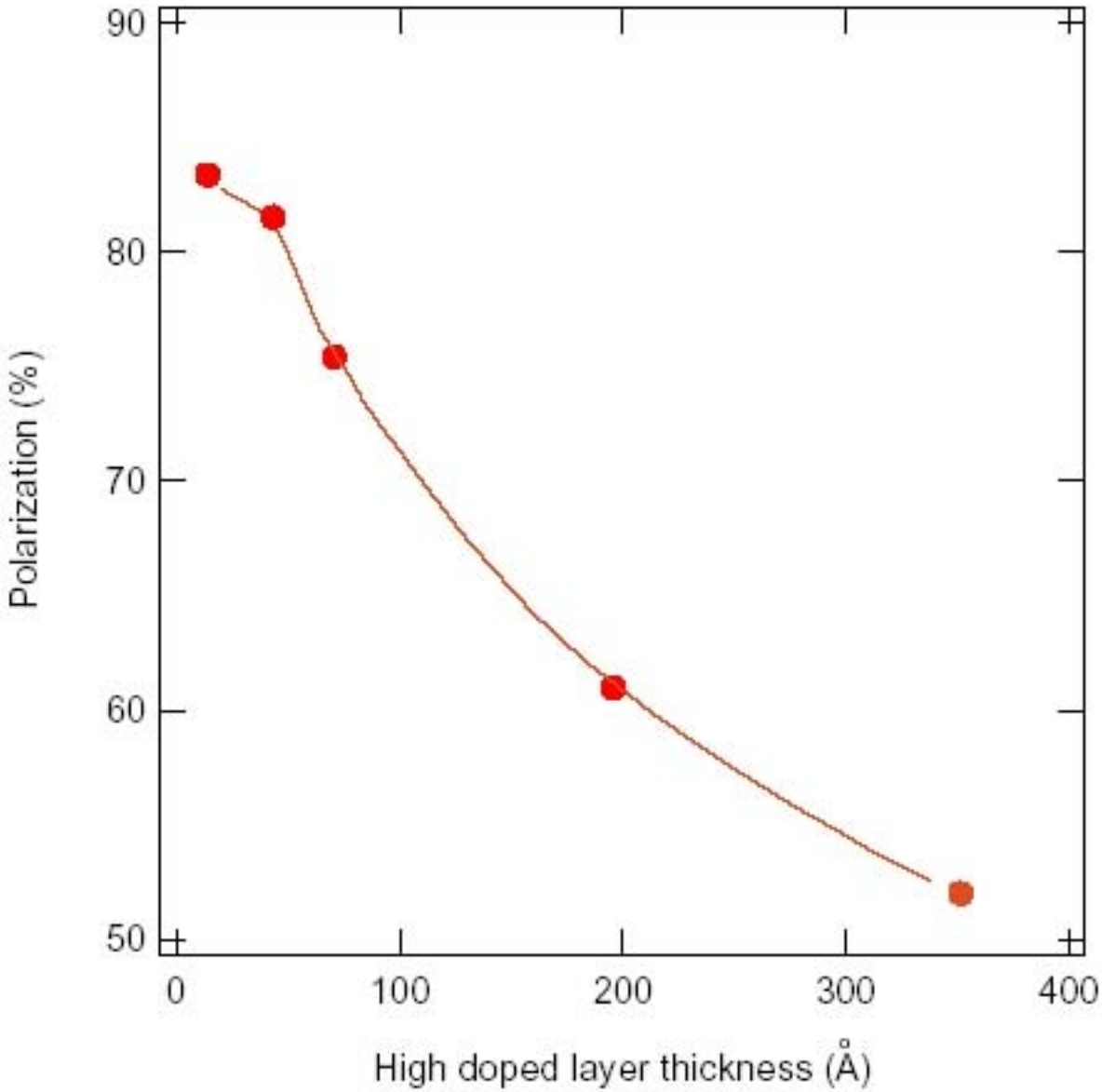
# SLAC, J. Clendenin, et al.

- **Now delivering high quality highly polarized beam to the E158 parity experiment.**

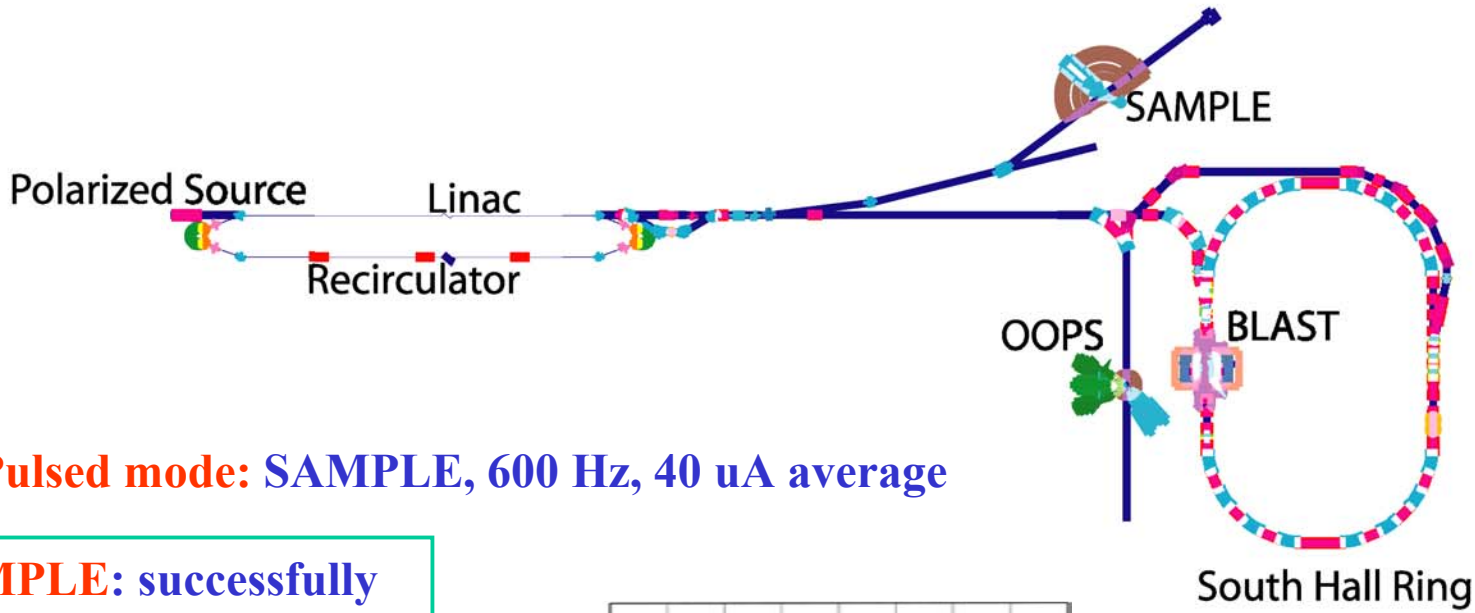



**Top curve: 100-ns** long train using the E-158 high-surface-doped ($5\times10^{19}/cm^3$) strained GaAs cathode plotted versus laser intensity. Lower curve: **350-ns** train using a standard SLC strained GaAs with $5\times10^{18}/cm^3$ uniform doping.

# Polarization vs High Doped Layer Thickness

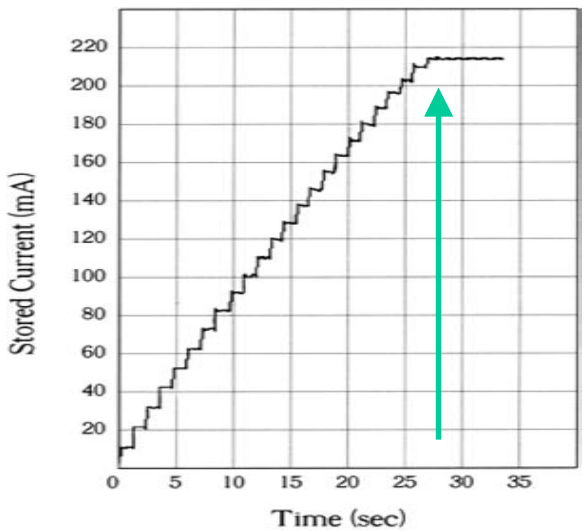


# The MIT-Bates Linear Accelerator




- **Pulsed mode: SAMPLE, 600 Hz, 40 uA average**

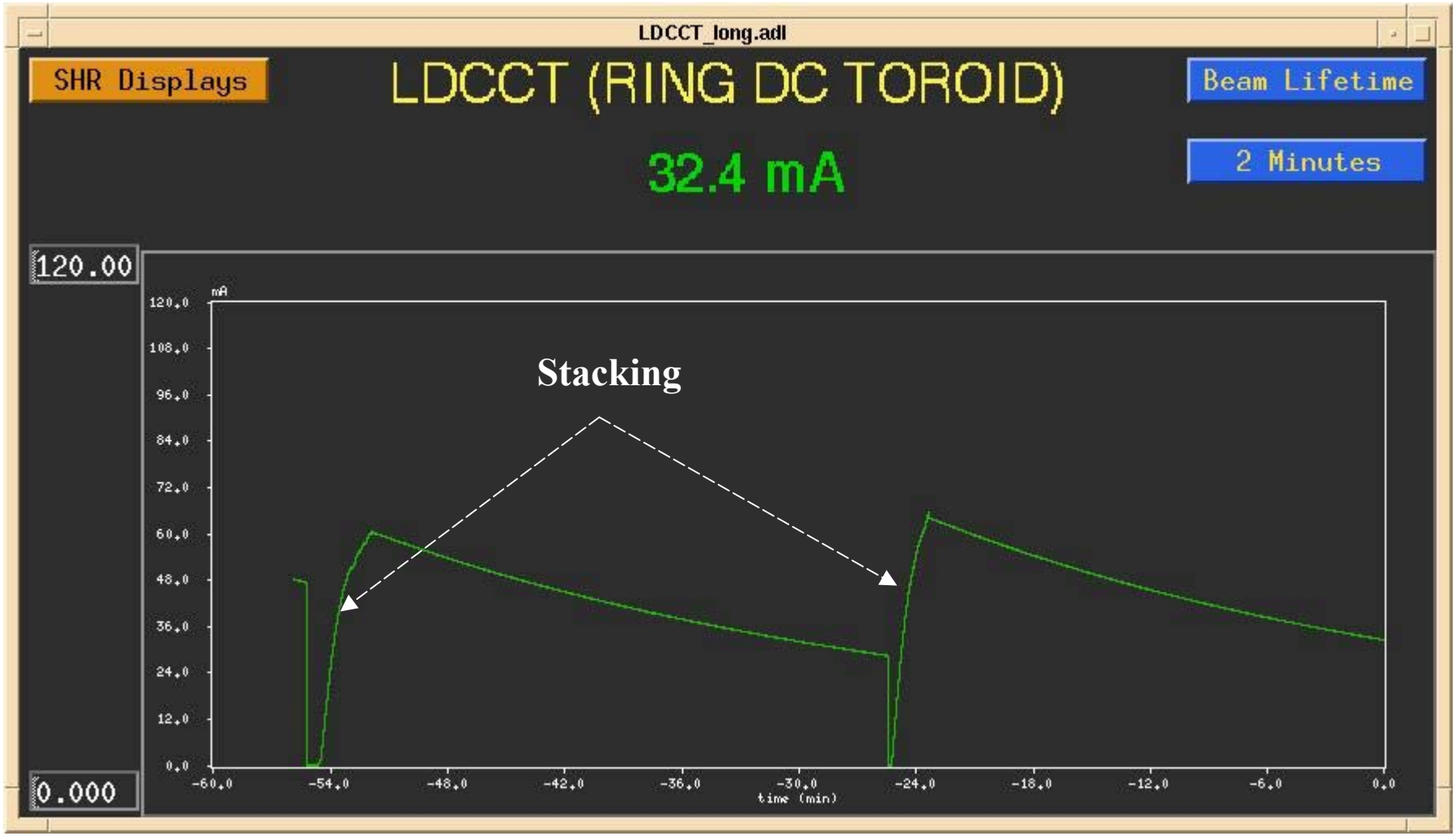
**SAMPLE: successfully completed 3 runs in 98, 99 and 2002 by delivering a total of ~450 coulombs of polarized beam**




- **Storage mode: 1-10 Hz and stacking to ~100 mA high polarization beam for BLAST since April 2002**

# South Hall Ring: Storage mode

# 100-200 mA high polarization

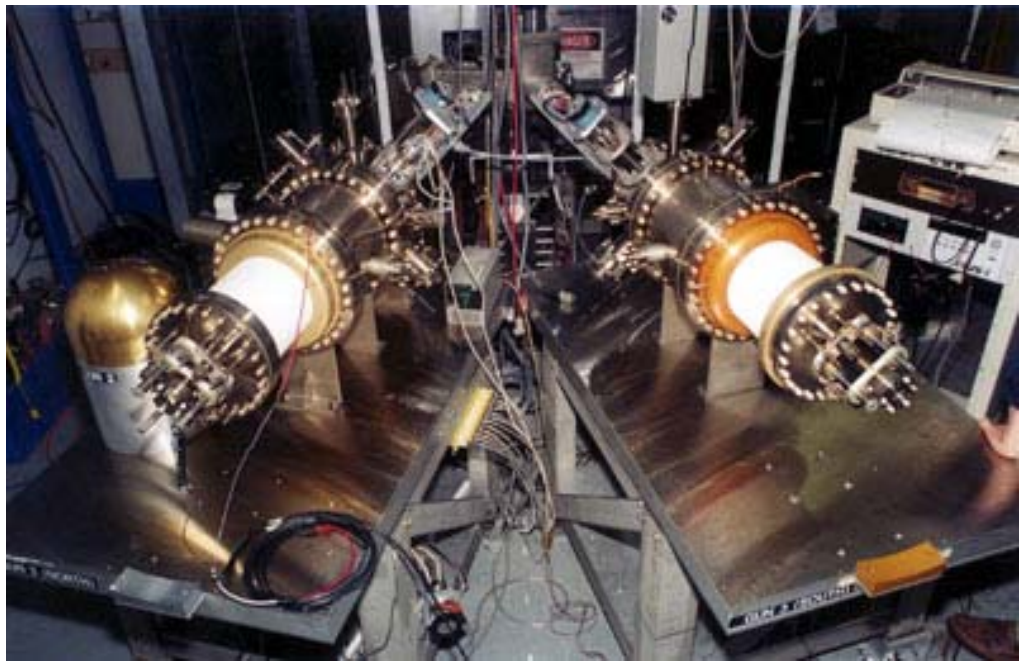


# J-Lab Polarized photoinjector

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%).

# Where are we now? (J-Lab PES)

J. Grames

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
- The Tiger laser 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 ?

# PES continued ….

- **MAMI at Mainz:**

  **Polarized program with high polarization beam in progress, intrinsically very stable machine (microtron!).**

## ELSA at Bonn:

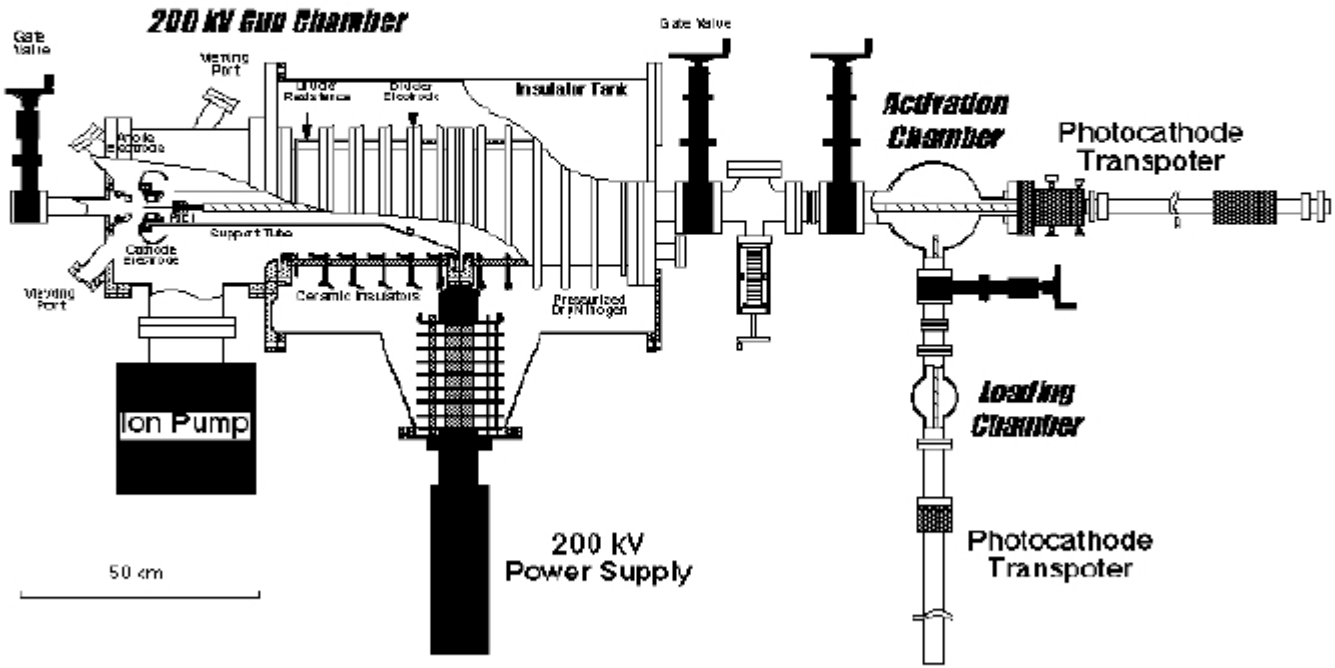
Pulse stretcher ring for extracted beam, low average current, high polarization beam in use

## Nagoya and KEK:

Major R&D in PES and photocathodes, 200 KEV gun for KEK

Nagoya Univ.

# 200 keV Polarized Electron Source
# NPES-3



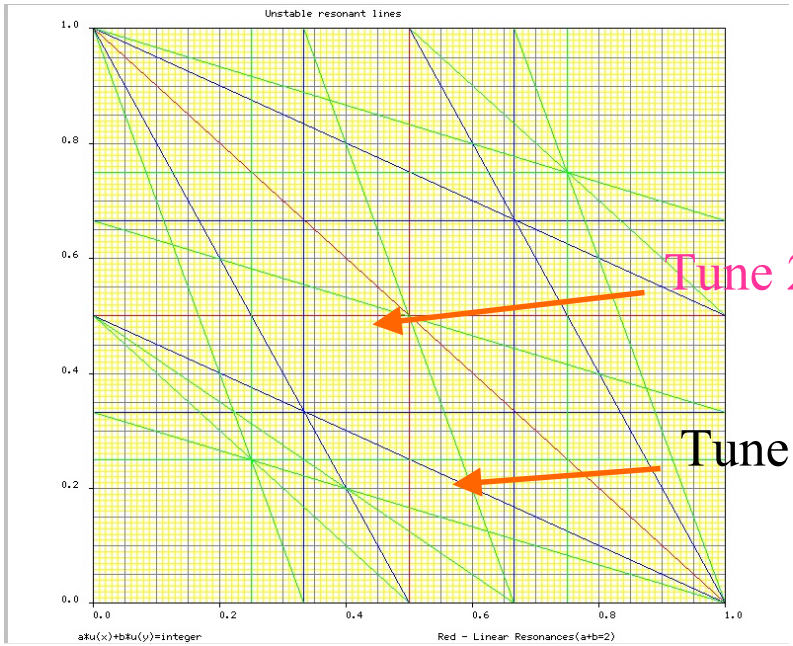

Field gradient at the photocathode is limited to 3MV/m with SUS electrode

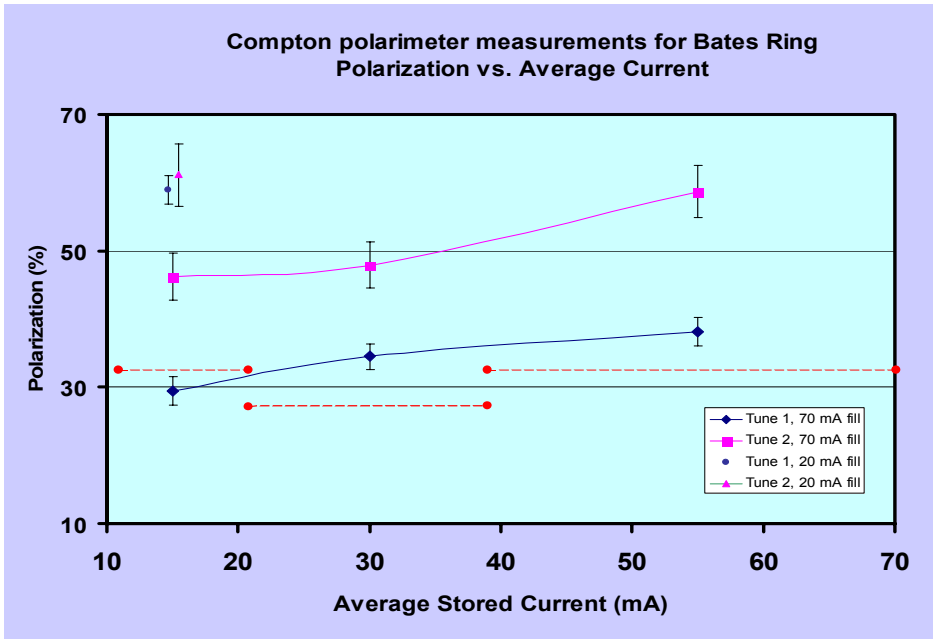
We want to achieve higher Voltage & Field gradient !

# Electron Polarimeters

- Electron polarimetry using noble gas targets
  *T. Gay U. Nebraska*
- The MIT-Bates Compton Polarimeter
  *B. Franklin MIT-Bates*
- Spin filters as very high-performance spin polarimeters
  *N. Rougemaille Polytechnique*
- Transmission Polarimetry for electron beams
  *T. Zwart MIT-Bates*
- A high efficiency electron polarimeter based on exchange scattering from a magnetic target
  L. Duò Polit. Di Milano

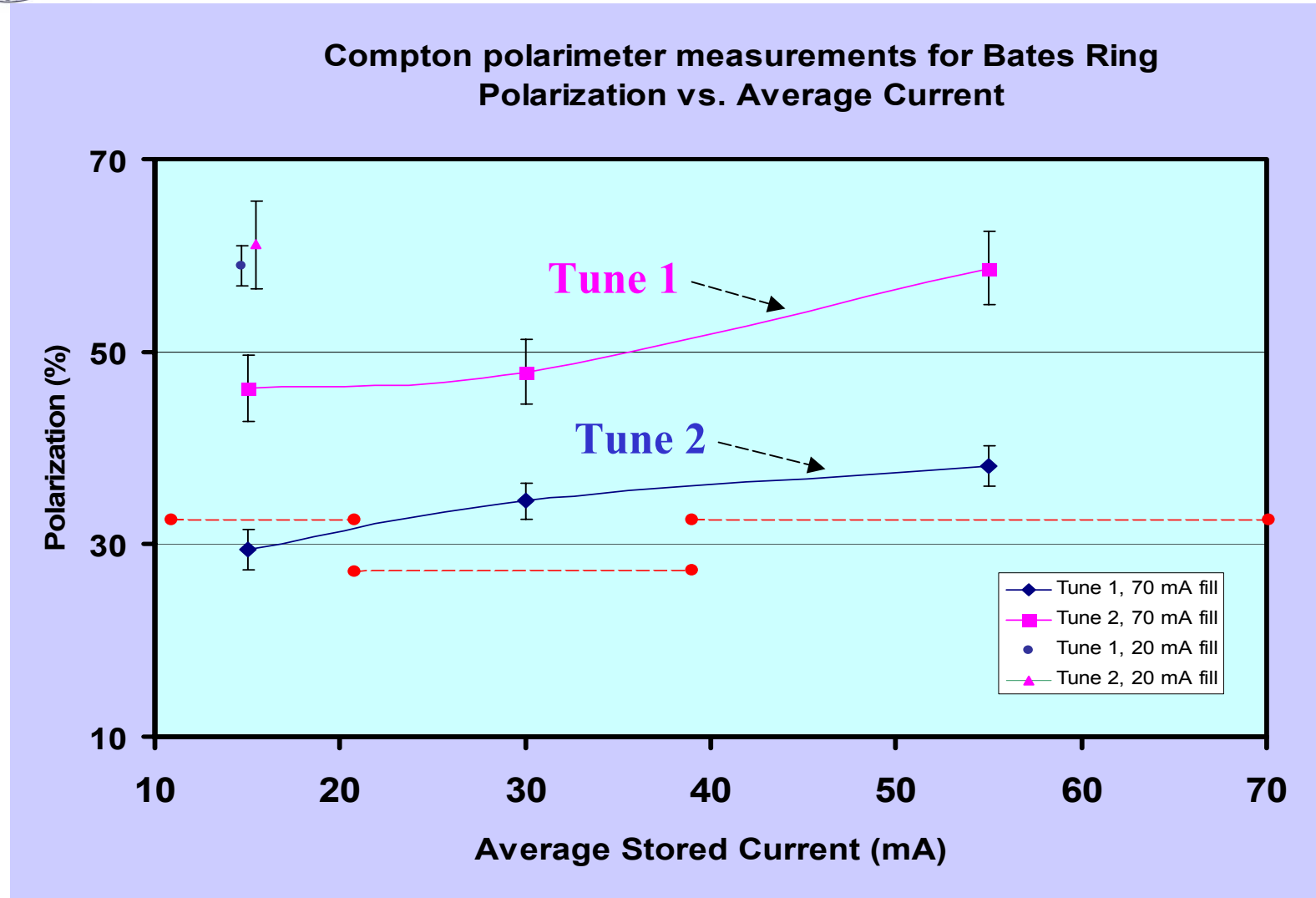
# Tune Dependence of SHR Polarization




- Depolarization at Tune #1 (Spin resonances)
- Much less depolarization at Tune #2
- with tune spreading out more at large current
- An interesting effect for the Ring-Ring electron-Ion Collider **(EIC)**

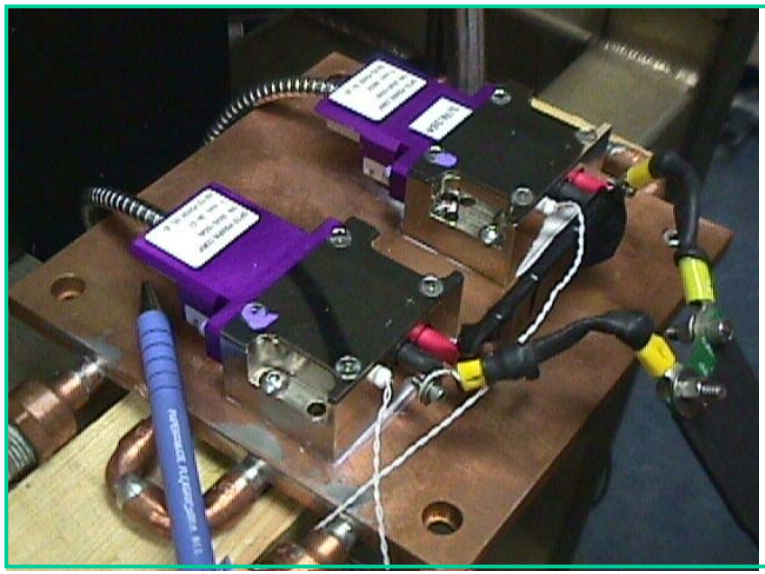
# Tune Dependence of SHR Polarization

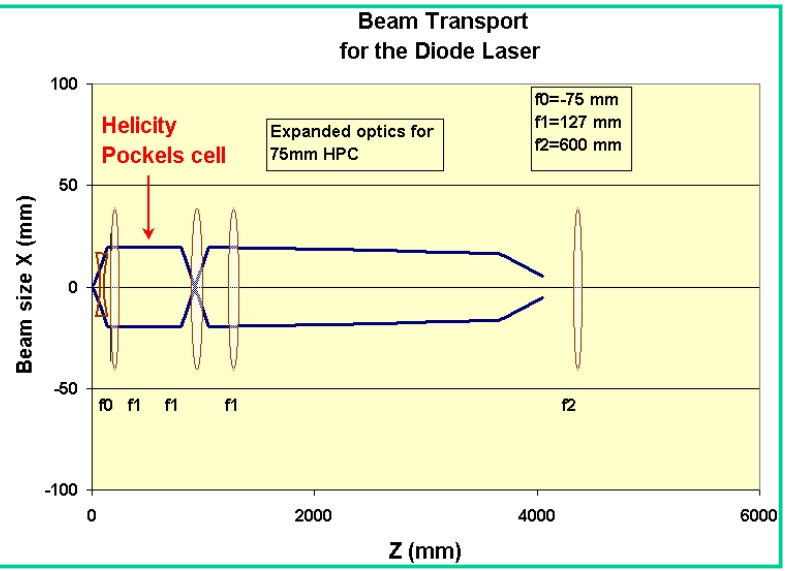



**New data from SHR: B. Franklin**

# NEW Lasers for PES

# High Power diode laser for Bates polarizes source



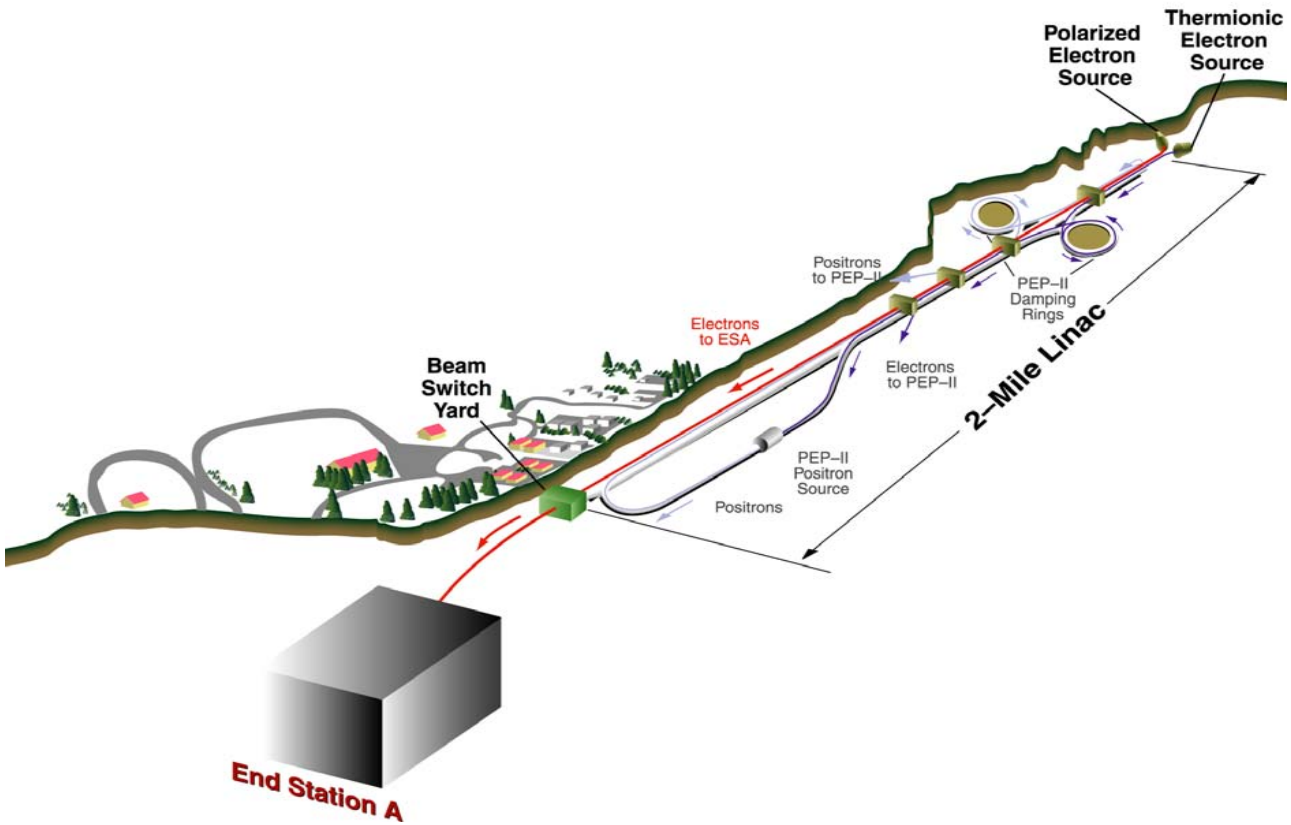



## Fiber-coupled diode array lasers

- **wavelength:** 808± 3 nm (fixed) (need matching wafers)
- **emittance:** ~200 mm.mr → (short working distance)
- **power:** unpolarized: ~ 150 W pulsed 60 W CW
- **stability:** Excellent: >10 better than Ti:sapphire W/ feedback
- **Cost:** Relatively inexpensive

# *Ultra-stable flashlamp-pumped laser*

*A.Brachmann, J.Clendenin, T.Galetto, T.Maruyama, J.Sodja, J.Turner, M.Woods*



# Dynamic laser configuration

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

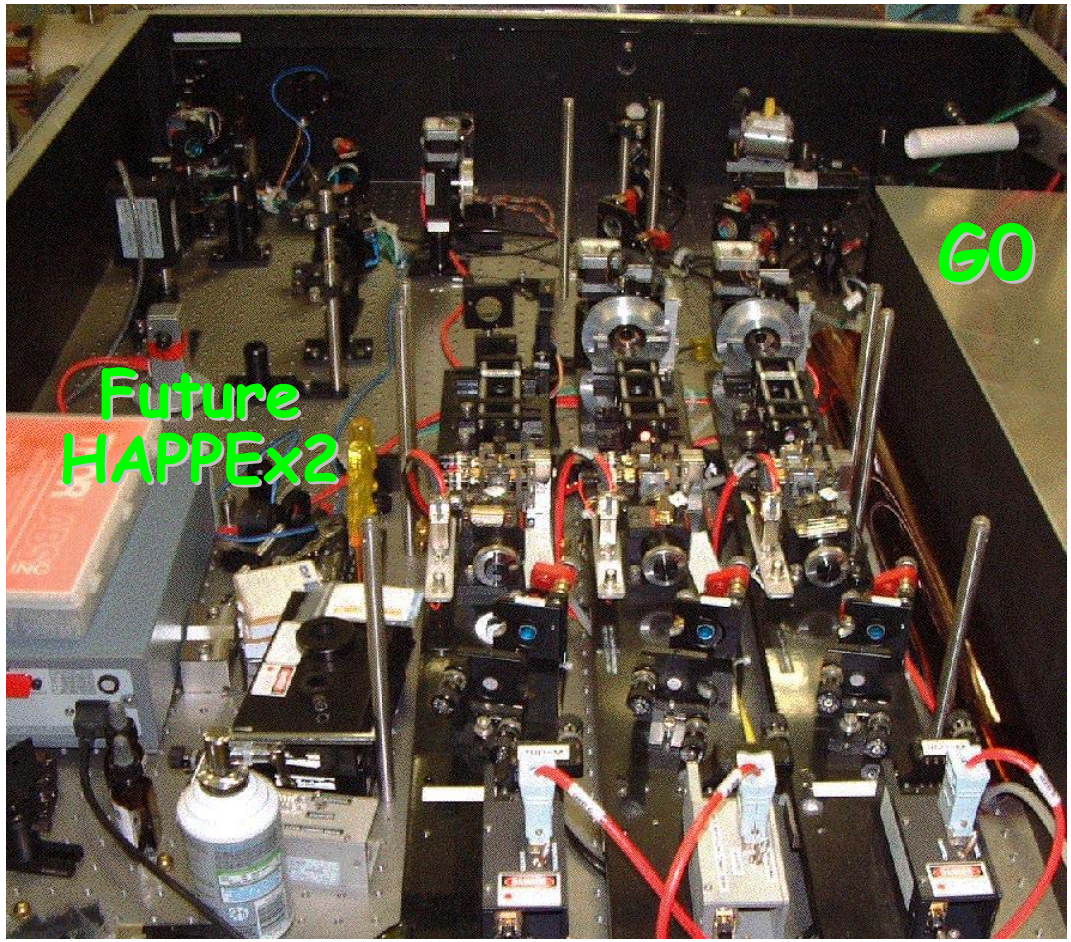
3 end-stations makes for a dynamic physics program which requires that the laser table be configurable for beam qualities:

Intensity (power)

Polarization (wavelength)

RF (1497, 499, 31.1875)

Parity (Independent)



# 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...

**J-Lab new laser for G0 experiment**

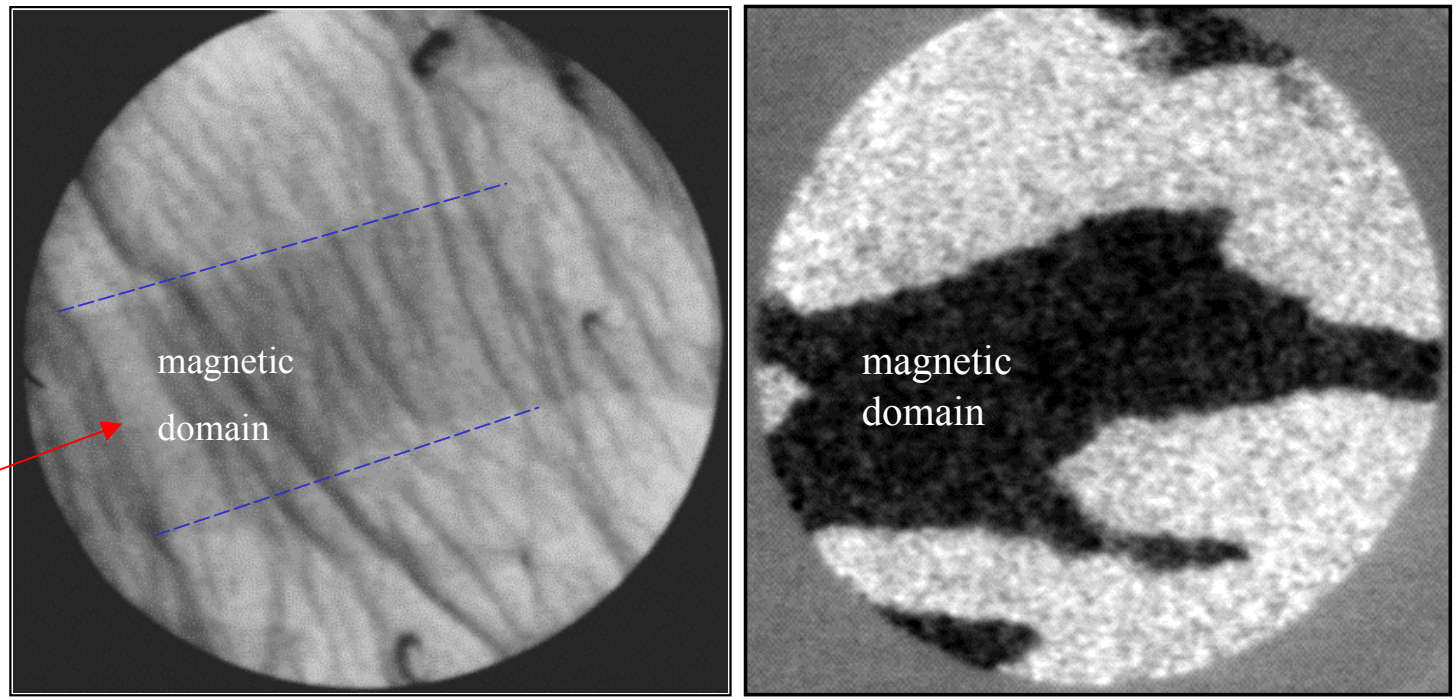
A. Schmid

LBL

# LEEM & SPLEEM
# Topography & Magnetic Contrast

Co/Au(111):
Single spin image

'difference image'




**Unpolarized beam**

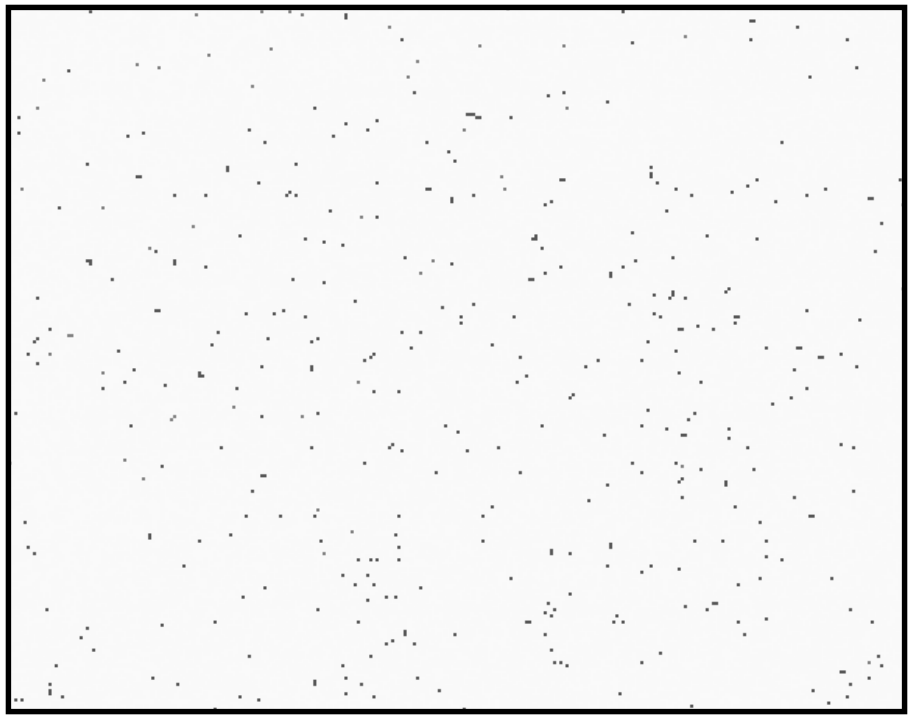
**Polarized beam**

$$A_{ex} = \frac{I^{up} - I^{down}}{I^{up} + I^{down}}$$

**Can benefit from high polarization beams**

A. Schmid LBL: PESP2002 workshop

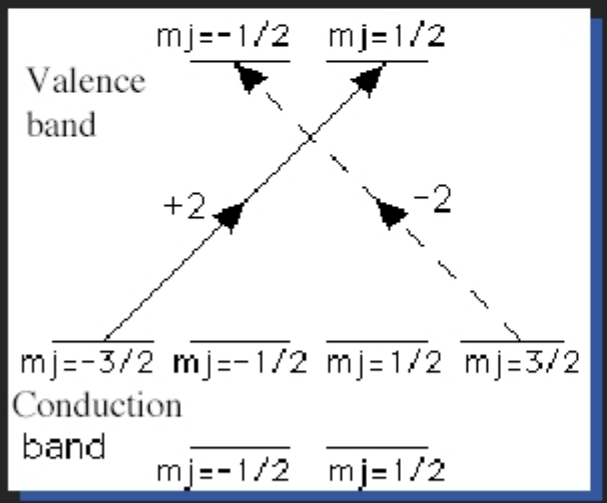
## Fe-Cu Growth Stripe Domains



Magnetization domains as the layers grow

Nagoya Univ.

# PES by Two Photon Excitation




- *Principle of Two Photon Excitation*
- *Photo-Luminescence Spectra* (Wavelength of 1.5μm, Pulse width of 120 fs)
- *Preliminary measurement by Mott polarimeter*
  (Wavelength of 1.5μm, Pulse width of 20 ns)

*Collaboration of Nagoya Univ. and Univ. of Osaka prefecture*

# Summary

•The PES-2002 workshop, a satellite workshop of Spin-2002 Symposium was a productive meeting for exchange of ideas and technical notes between photoemission scientists and engineers, and the researchers in the magnetization and surface physics using polarized electron sources

• Over the past few years, significant progress has been made in producing high polarization electron beams of exceptional qualities at all major accelerator centers with polarized electron program.

•This meeting provided opportunities for the low energy and surface physics scientists to the prospects of high polarization photoemission.

All talks will be on the web page within 2 weeks:

http://mitbates.mit.edu/PESP2002

**End of Talk**

**REST are extra for answering questions**