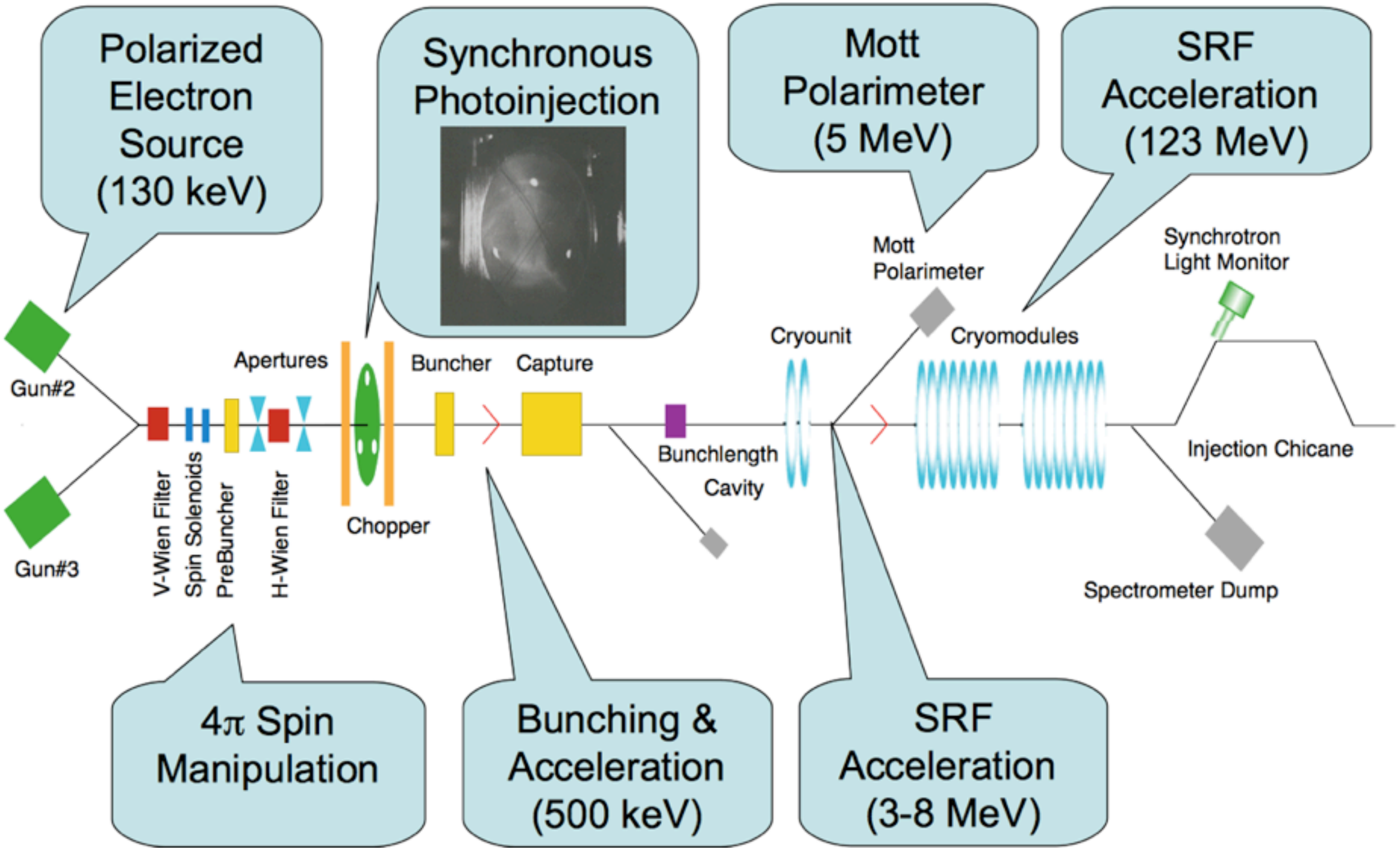
Twisted Electrons at JLab

Dipangkar Dutta
Mississippi State University

Outline

- Overview of Injector at JLab
- What has already been tried
- What we want to test
- Open questions and summary

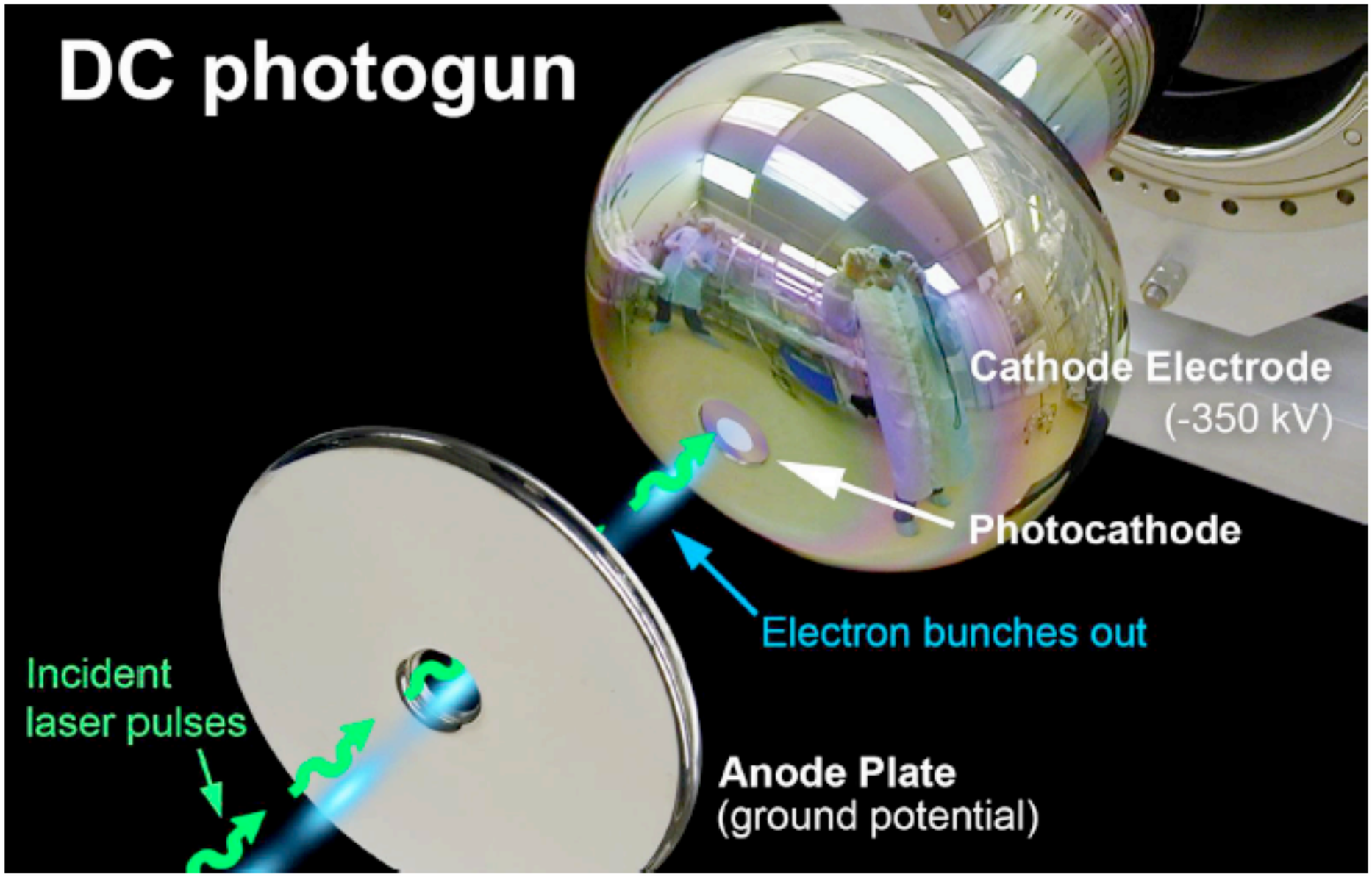
The JLab Injector



From R. Suleiman, J. Grames

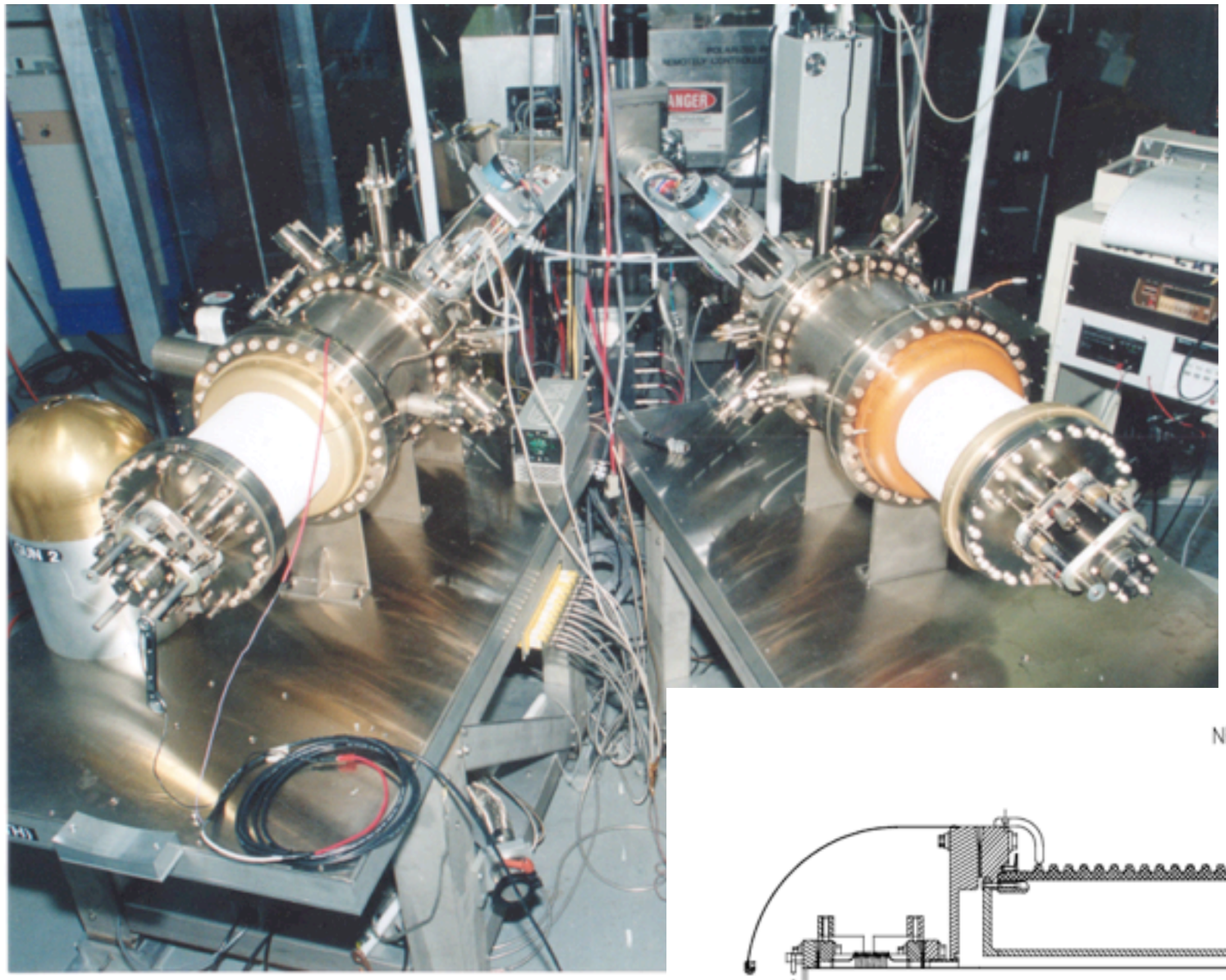
The Polarized Source

In a DC photogun, electron bunches are generated when the GaAs photocathode is illuminated with pulses from a drive laser

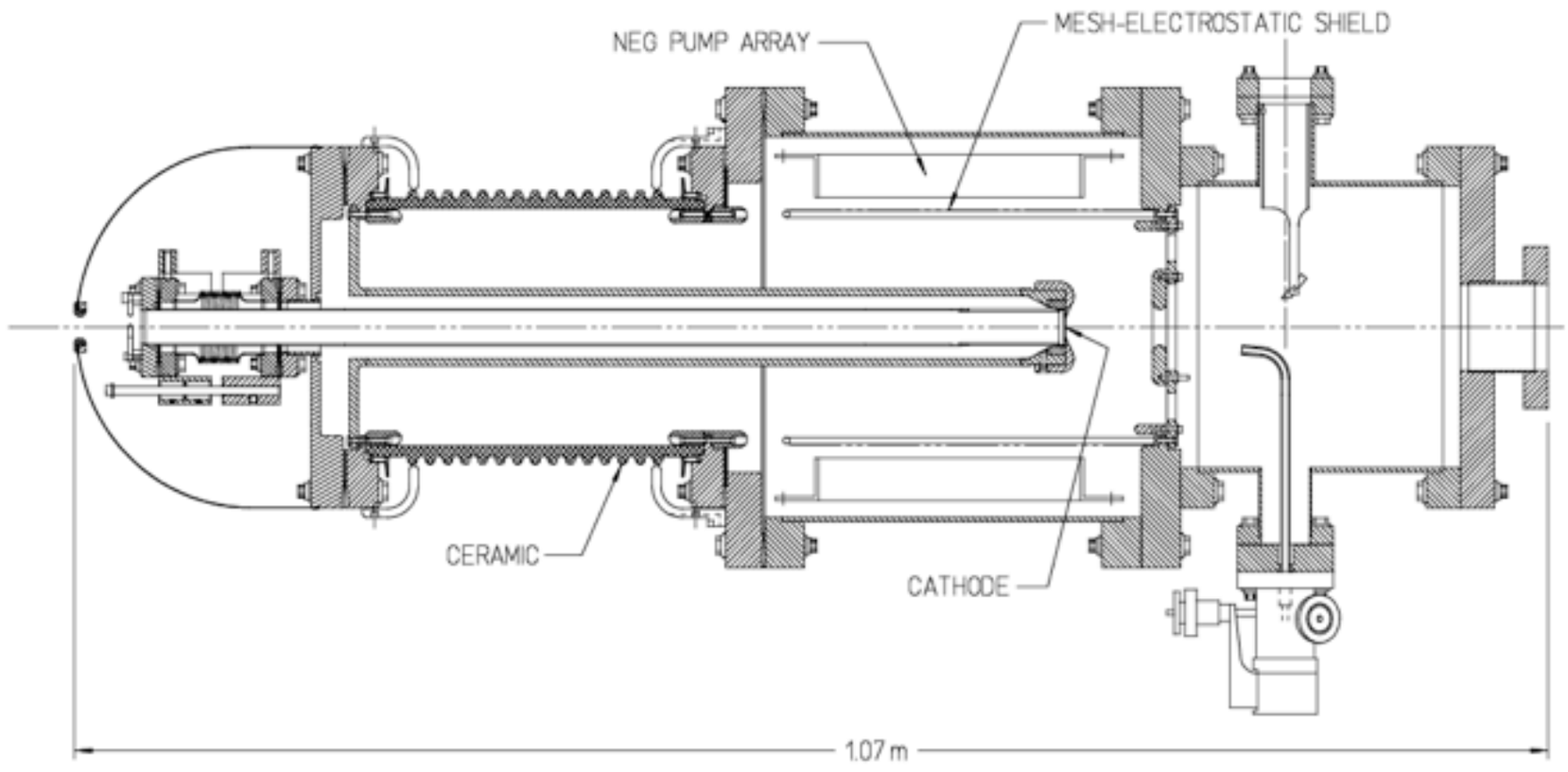


From C. Hernandez-Garcia

The Polarized Source



13 mm photocathode,
but only use center portion,
5 mm dia.
Beam current ~ 200uA,
laser 0.5mm dia.,
lifetime: ~ 100C, 1x10^5 C/cm^2



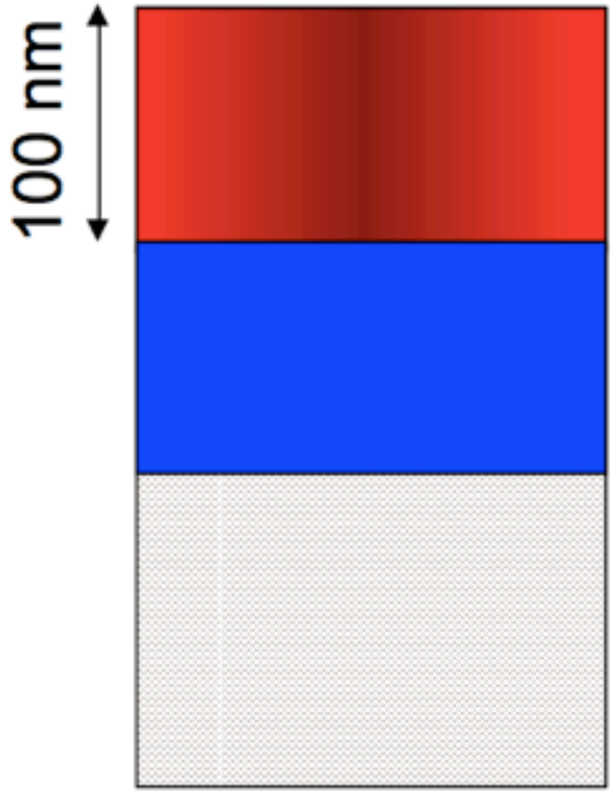
From M. Poelker

Photocathode Material

Bulk GaAs

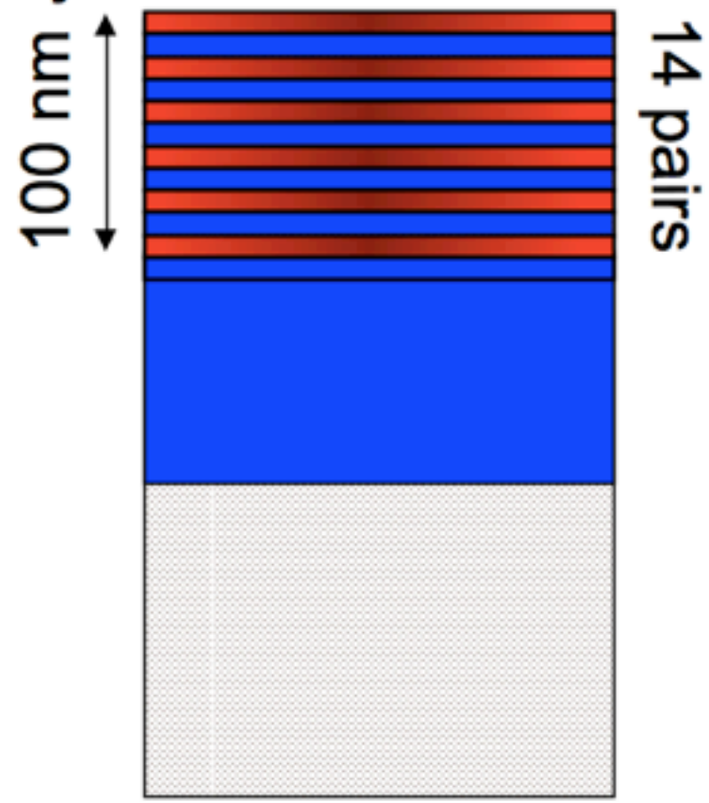
High QE ~ 10%
Pol ~ 35%

Strained GaAs:
GaAs on GaAsP



"conventional" material
QE ~ 0.15%
Pol ~ 75%
@ 850 nm

Superlattice GaAs:
Layers of GaAs on GaAsP



No strain relaxation
QE ~ 0.8%
Pol ~ 85%
@ 780 nm

$\Delta E \sim 10^{-5}$

From M. Poelker

What's been tested?

PHYSICAL REVIEW B **87**, 035204 (2013)

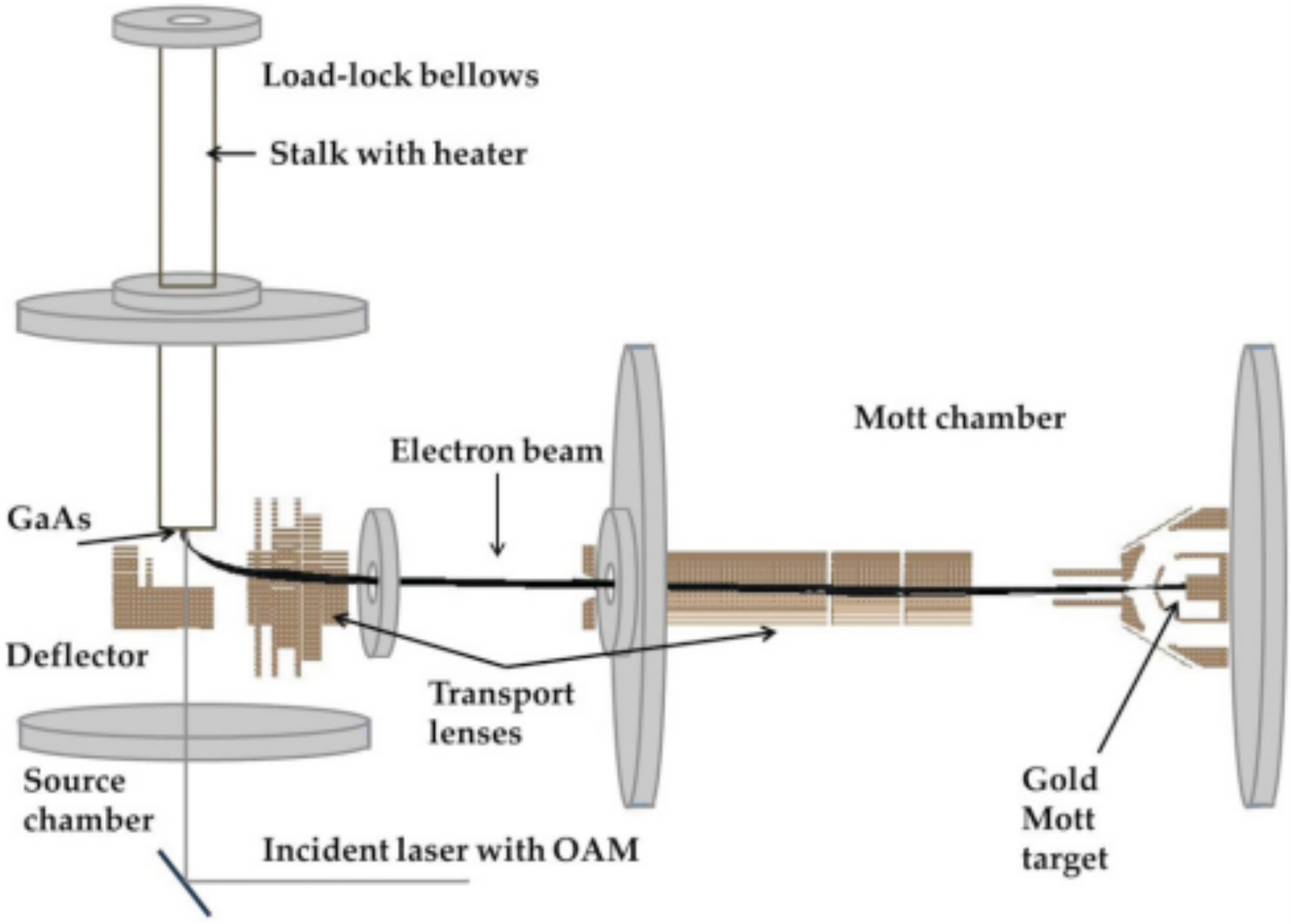
Search for spin-polarized photoemission from GaAs using light with orbital angular momentum

N. B. Clayburn,[1] J. L. McCarter,[2] J. M. Dreiling,[1] M. Poelker,[3] D. M. Ryan,[1] and T. J. Gay[1]
[1]*Jorgensen Hall, University of Nebraska, Lincoln, Nebraska 68588-0299, USA*
[2]*Department of Physics, University of Virginia, Charlottesville, Virginia 22904-4714, USA*
[3]*Thomas Jefferson National Accelerator Facility, 12000 Jefferson Avenue, Newport News, Virginia 23606, USA*
(Received 14 August 2012; revised manuscript received 29 November 2012; published 22 January 2013)

Laser light with photon energy near the band gap of GaAs and in Laguerre-Gaussian modes with different amounts of orbital angular momentum was used to produce photoemission from unstrained GaAs. The degree of electron spin polarization was measured using a micro-Mott polarimeter and found to be consistent with zero with an upper limit of ~3% for light with up to $\pm 5\hbar$ of orbital angular momentum. In contrast, the degree of spin polarization of 32.3 $\pm$ 1.4% using circularly polarized laser light at the as the same wavelength, which is typical for bulk GaAs photocathodes.

DOI: 10.1103/PhysRevB.87.035204 PACS number(s): 42.50.Tx, 34.80.Nz, 79.60.Bm, 07.77.Ka

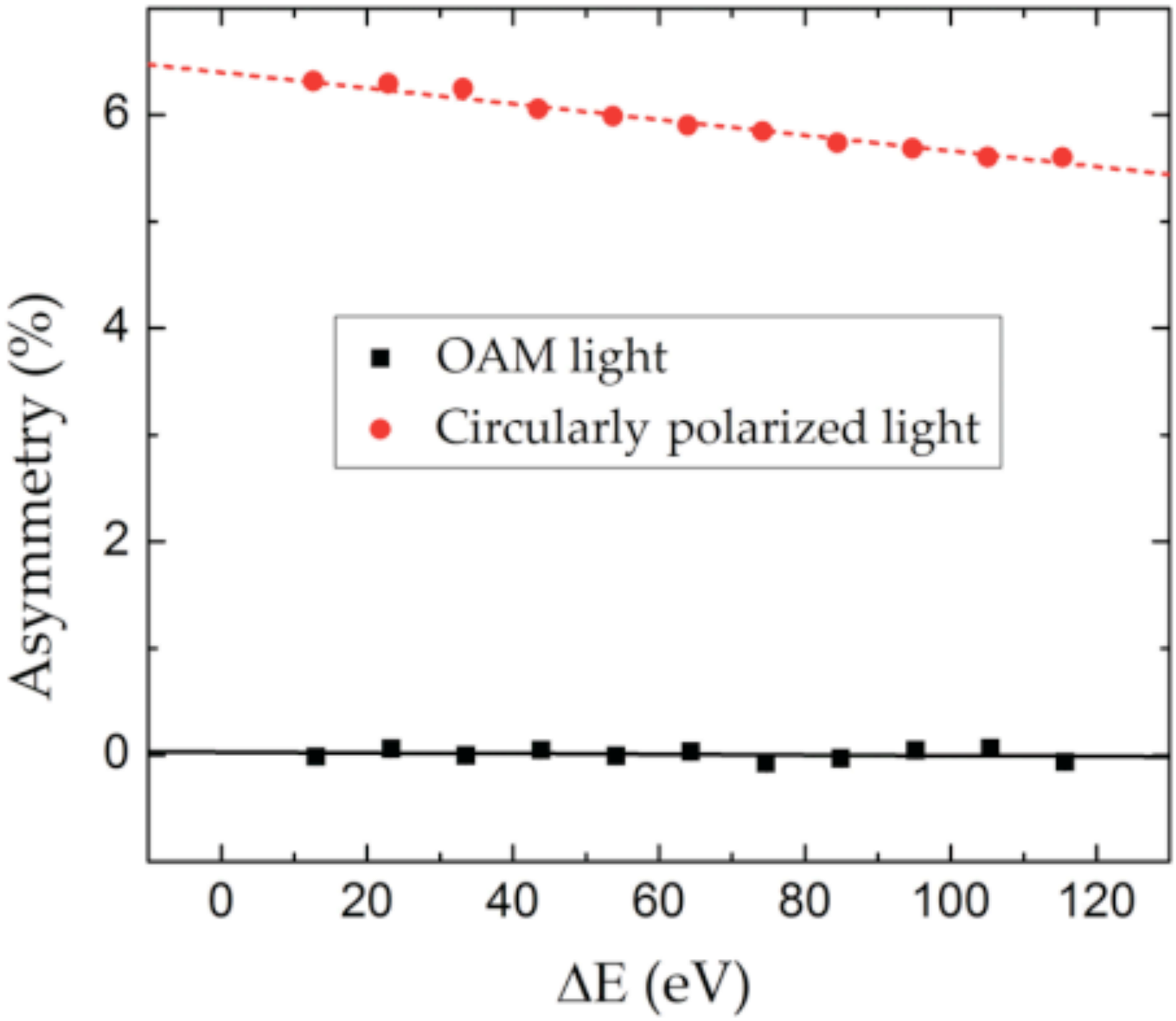
Electron polarization using twisted photons



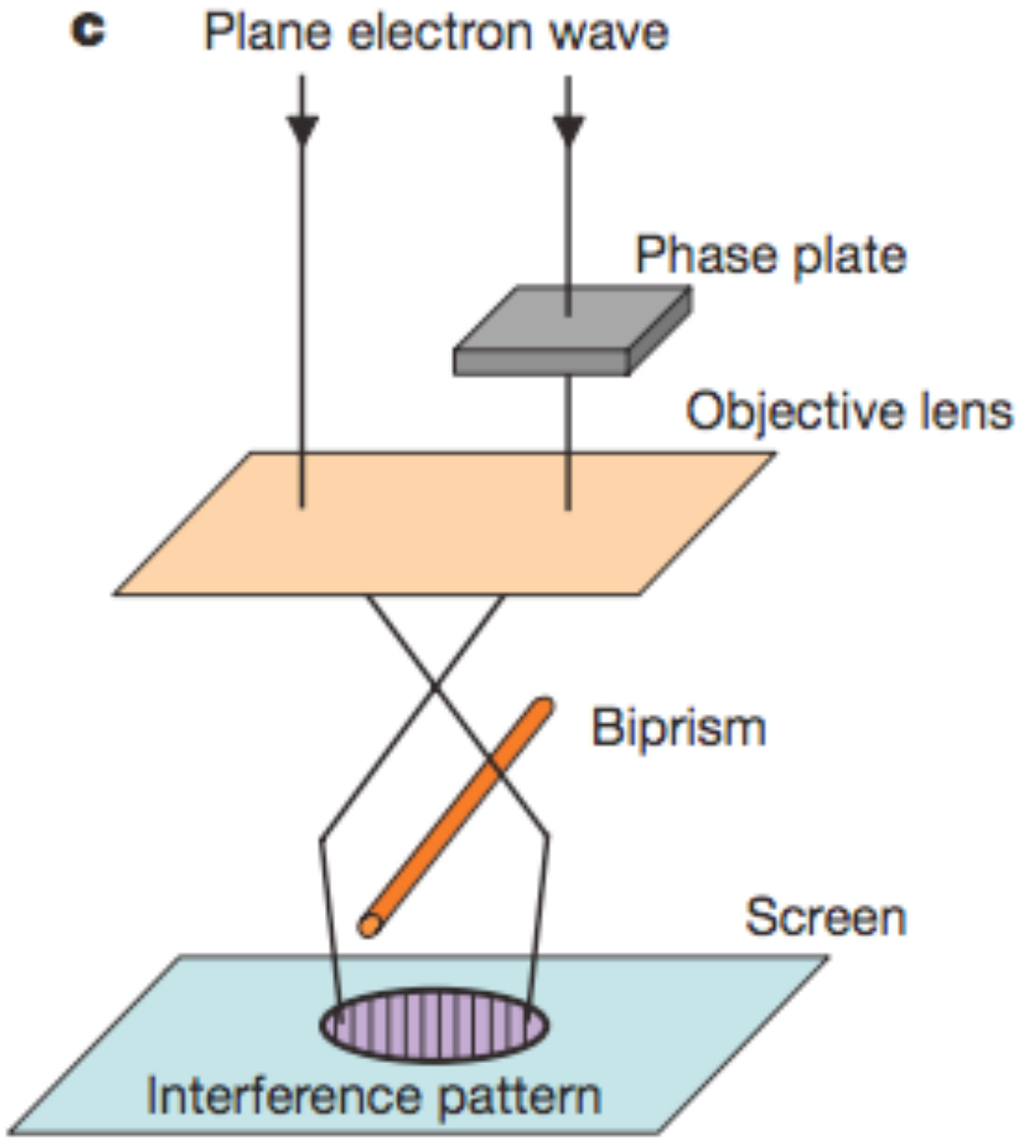
Incident Laser beam:

1. Circularly polarized (photons with SAM)
2. Linearly polarized + fork grating (photons with OAM)

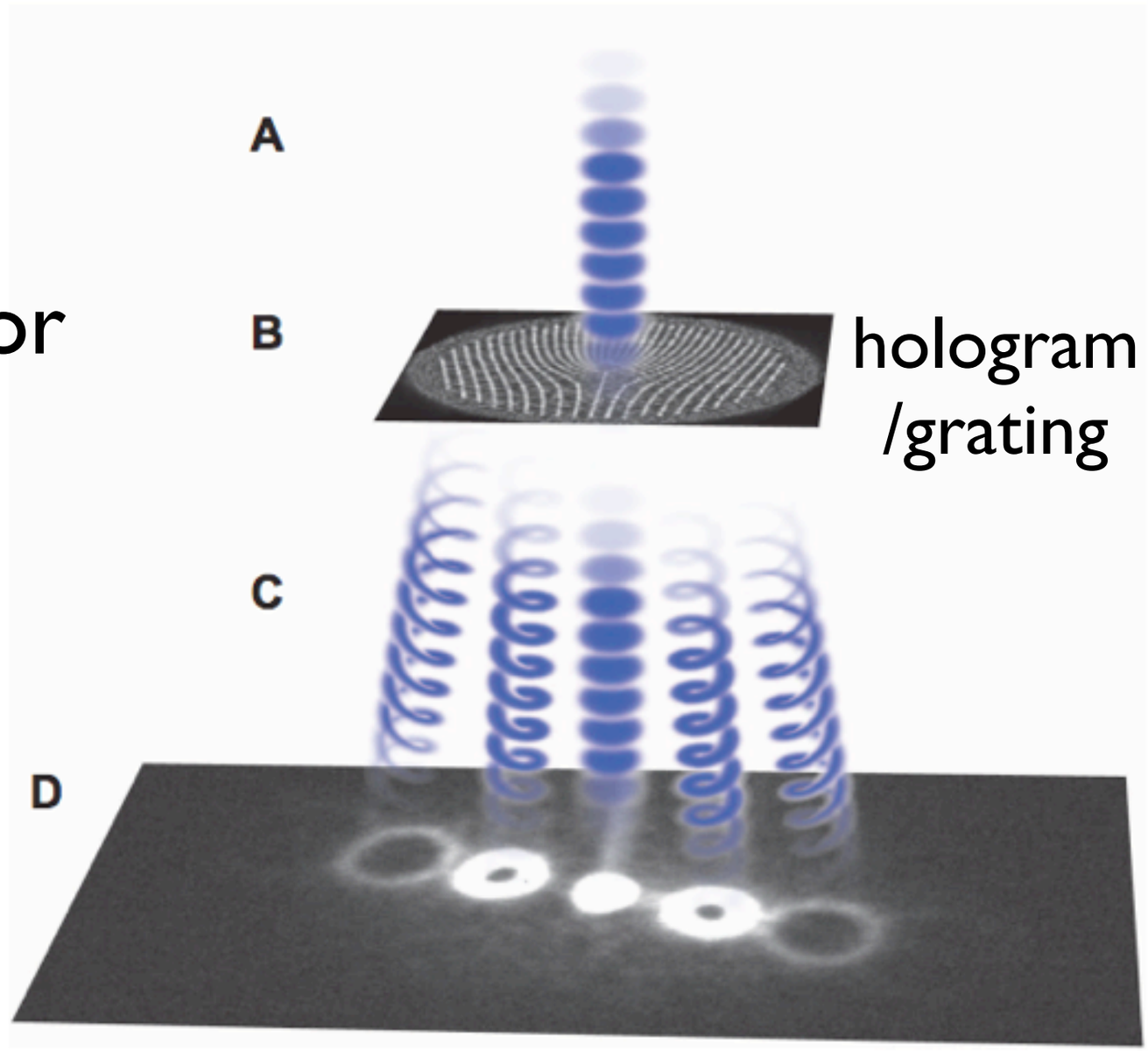
Electron polarization using twisted photons



How are twisted electrons produced?

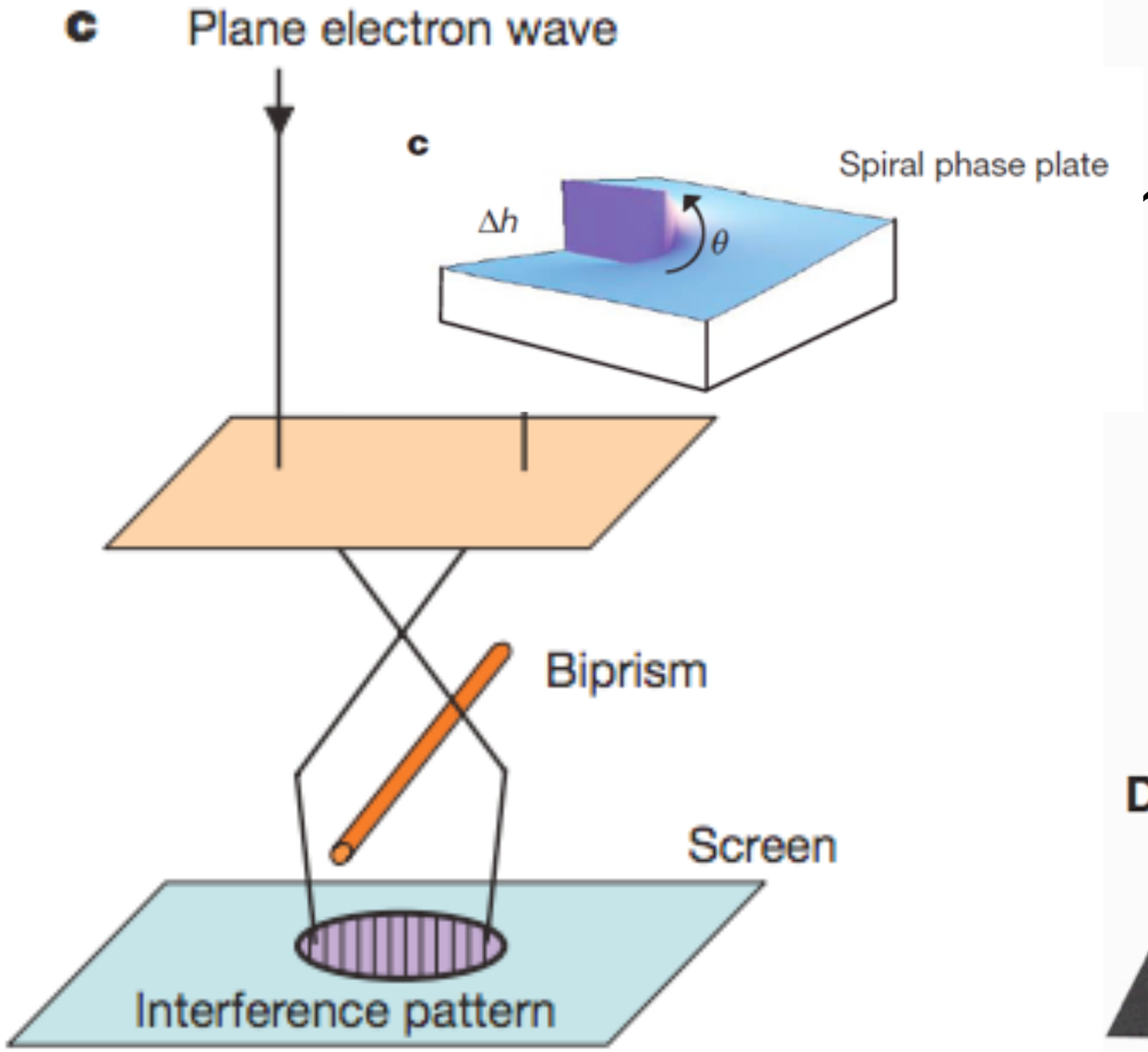


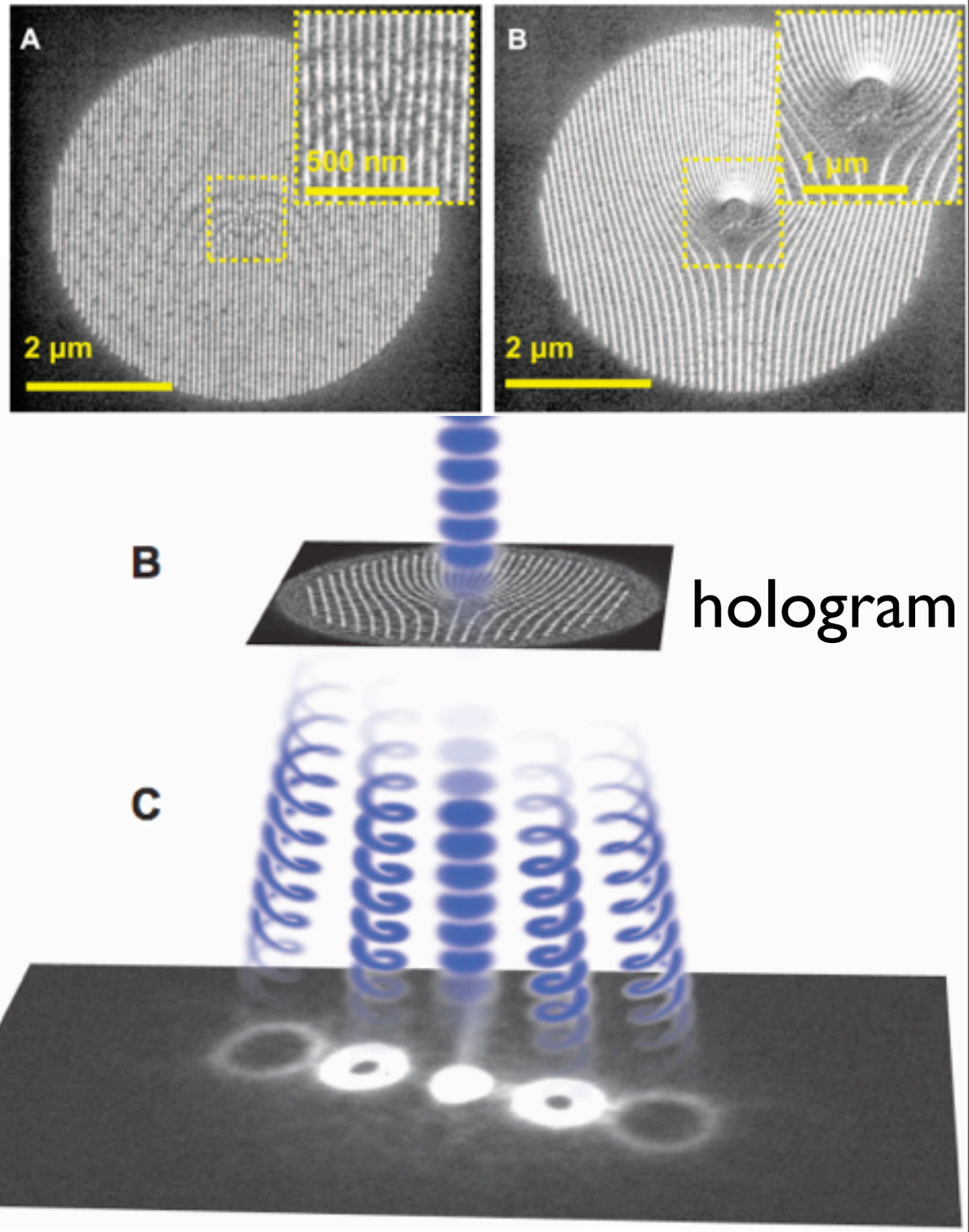
or



hologram /grating

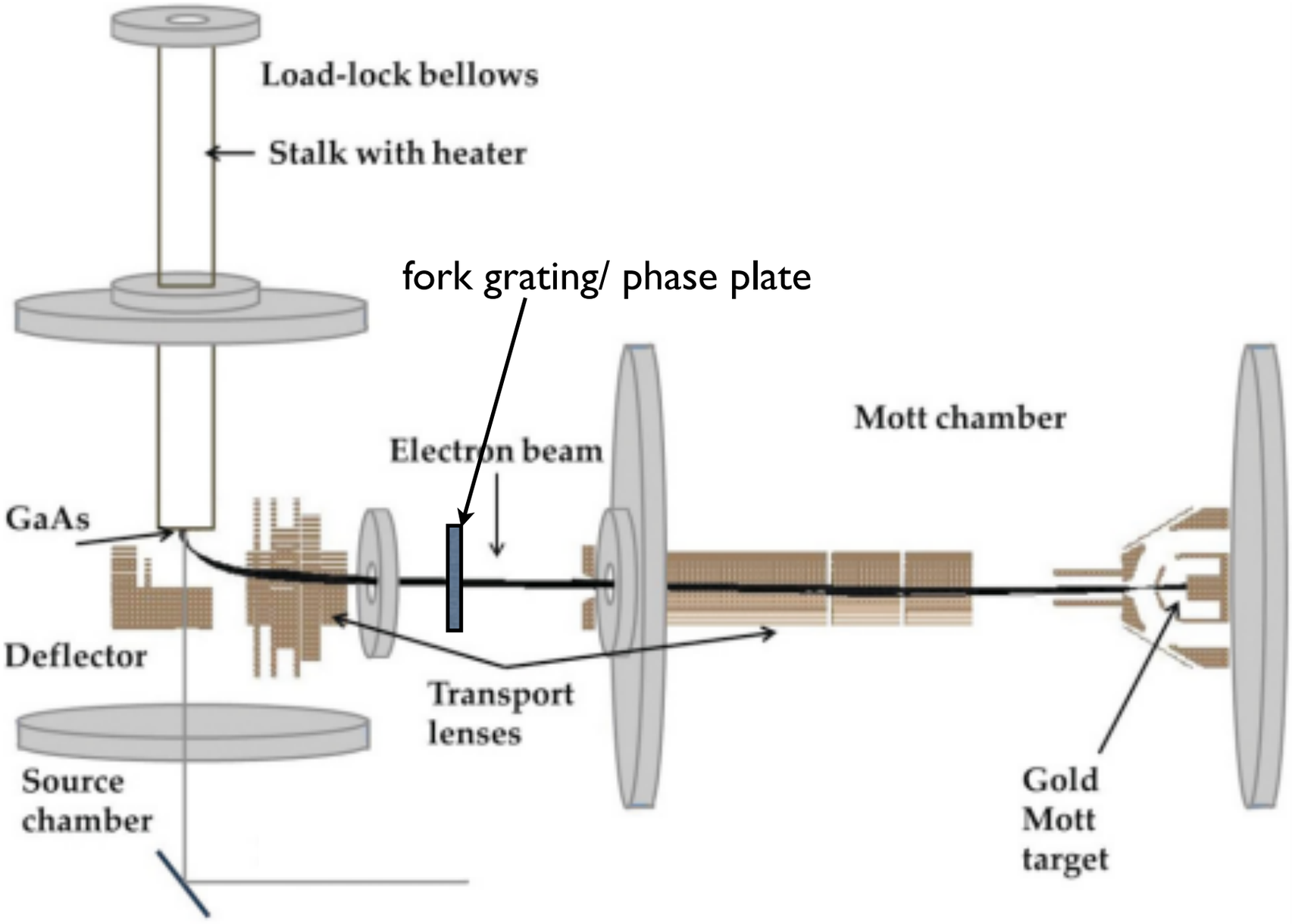
How are twisted electrons produced?





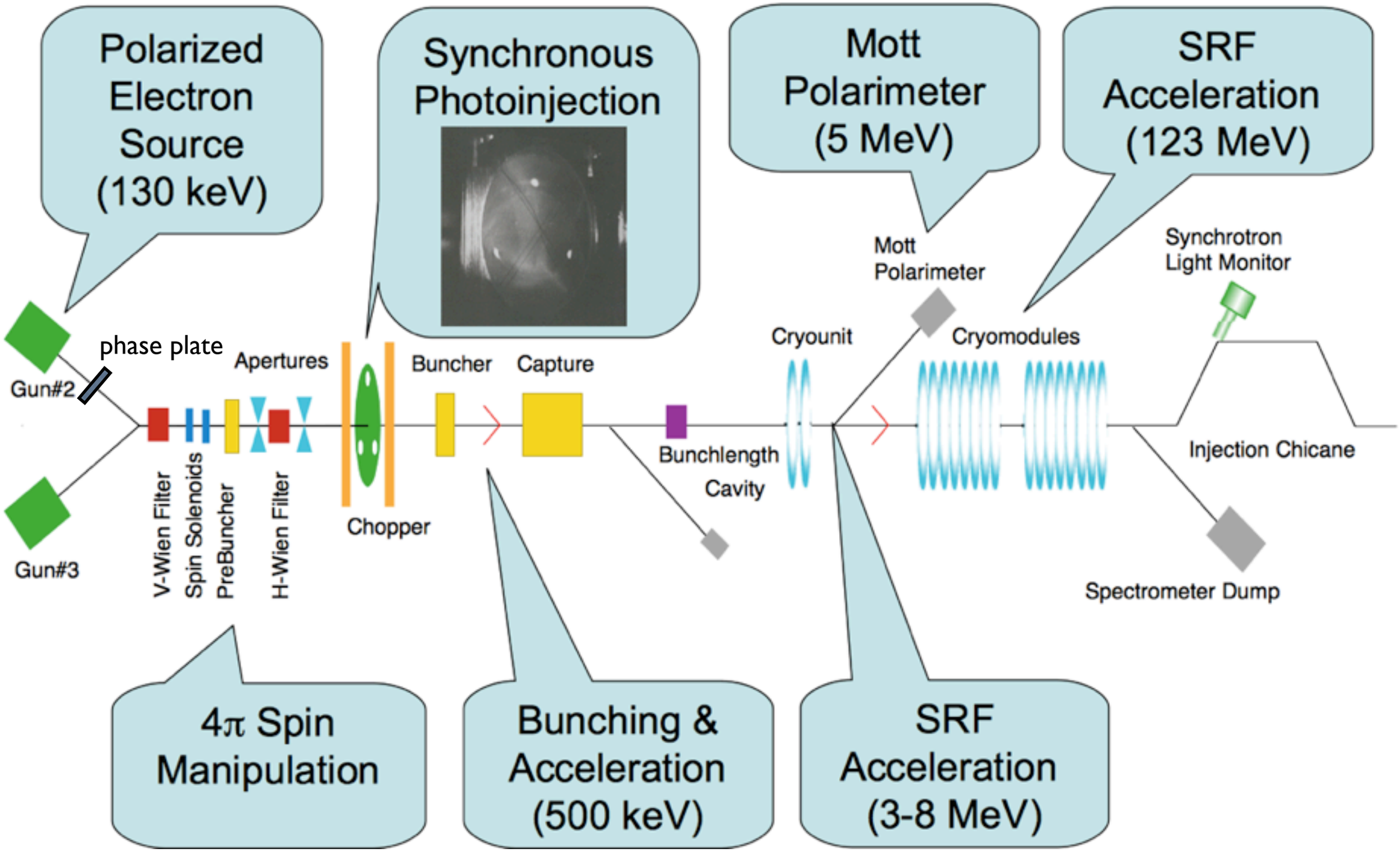
hologram

Plans for JLab



Incident Laser beam: circularly/linearly polarized

Plans for JLab



From R. Suleiman, J. Grames

Open Questions

- Will the electrons retain twisted-ness after acceleration to few MeV and 100s of MeV and GeV energies?

- What scattering observables can be used to monitor twisted-ness?

- Can correlations between spin polarization and twisted-ness provide useful observables?

- What values of $P_\perp/P_z$ is needed for these observables?

Ultimate Goal

- Study the proton structure for example quark OAM using new twisted-ness degree of freedom.