ILC Polarized Electron Source R&D at SLAC

A. Brachmann, J. Clendenin, T. Maruyama, K. Ioakeimidi

Snowmass '05

Overview

- Source Parameters
- Drive Laser System
- Photocathode
- DC and RF Electron Gun Development Plans
- Bunching and Pre-acceleration, Polarization Control

Source Parameters

Parameter	Symbol	Value	Unit
Electrons per micro bunch	n_e	$4*10^{10}$[1]	Number
Number of micro bunches	N_e	2820	Number
Micro bunch repetition rate	$F_{\mu b}$	3	MHz
Macro bunch repetition rate	F_{mb}	5	Hz
Micro bunch charge at source	C	6.4	nC
Micro bunch length at source	Δt	2	ns
Peak current in µbunch at source	I_{avg}	3.2	A
Energy stability	S	< 5	% rms
Electron polarization	Pe	90	%
Photocathode Quantum Efficiency	QE	1	%
Drive laser wavelength	λ	780 (tunable)	nm
Micro pulse laser energy at cathode	E	2	µJ

[1] twice the charge required at the IP

Polarized Electron Source Drive Laser

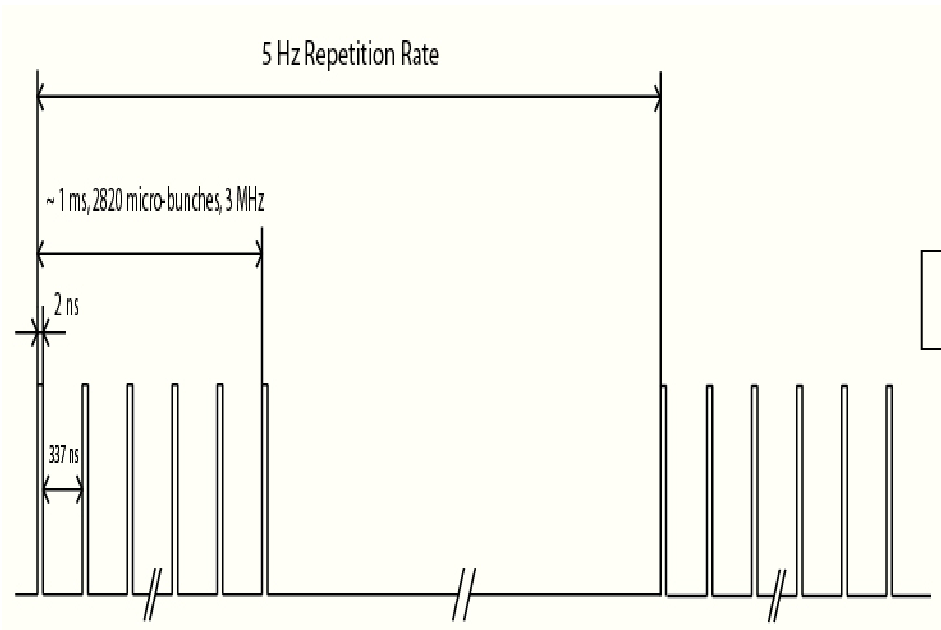
- Baseline: Laser system for DC Gun that generates pulse train and charge from photocathode with 0.5% QE
- Principles of technology similar to TTF Gun drive laser but different amplifier material and pulse length (for DC gun)
- Laser system is not commercially available:
  - In house development
  - SBIR/STTR
  - Academic collaboration
- Use of SLAC's upgraded 'Injector Test Facility' for laser development
- For polarized RF – Gun drive laser system:
  - Same principles as above
  - Picosecond micro - pulse a higher peak power for identical electron number

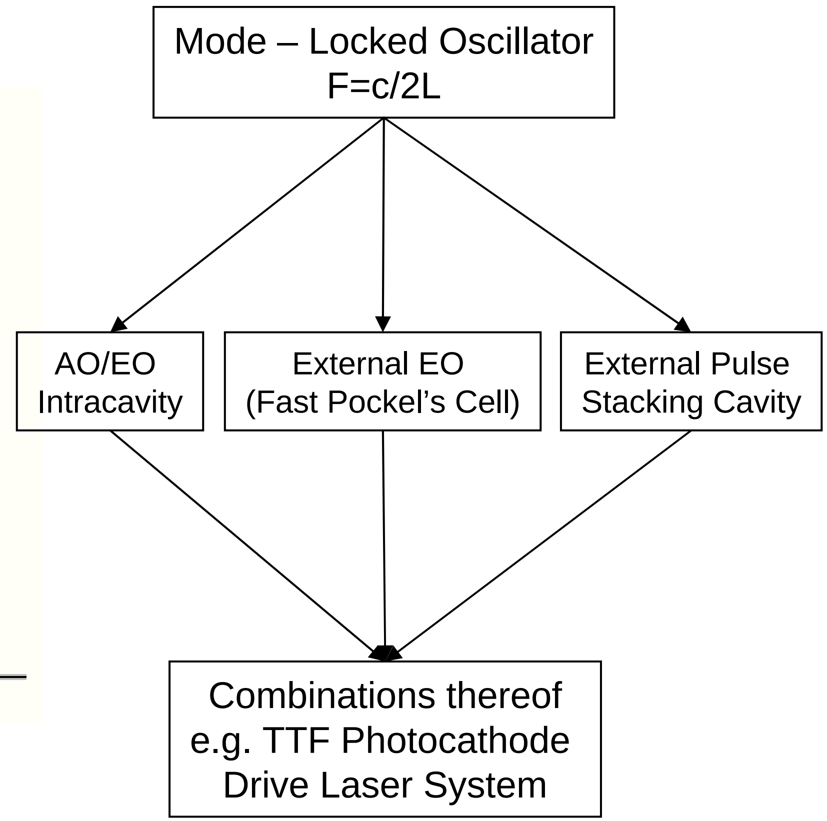
PES Drive Laser – Possible Scheme

Modelocked Oscillator Synchron. to ext. RF	Pulse Train generation (AO/EO)	Pre Amplifier	Temporal pulse stretching & Shaping	Power Amplifier	Helicity Control

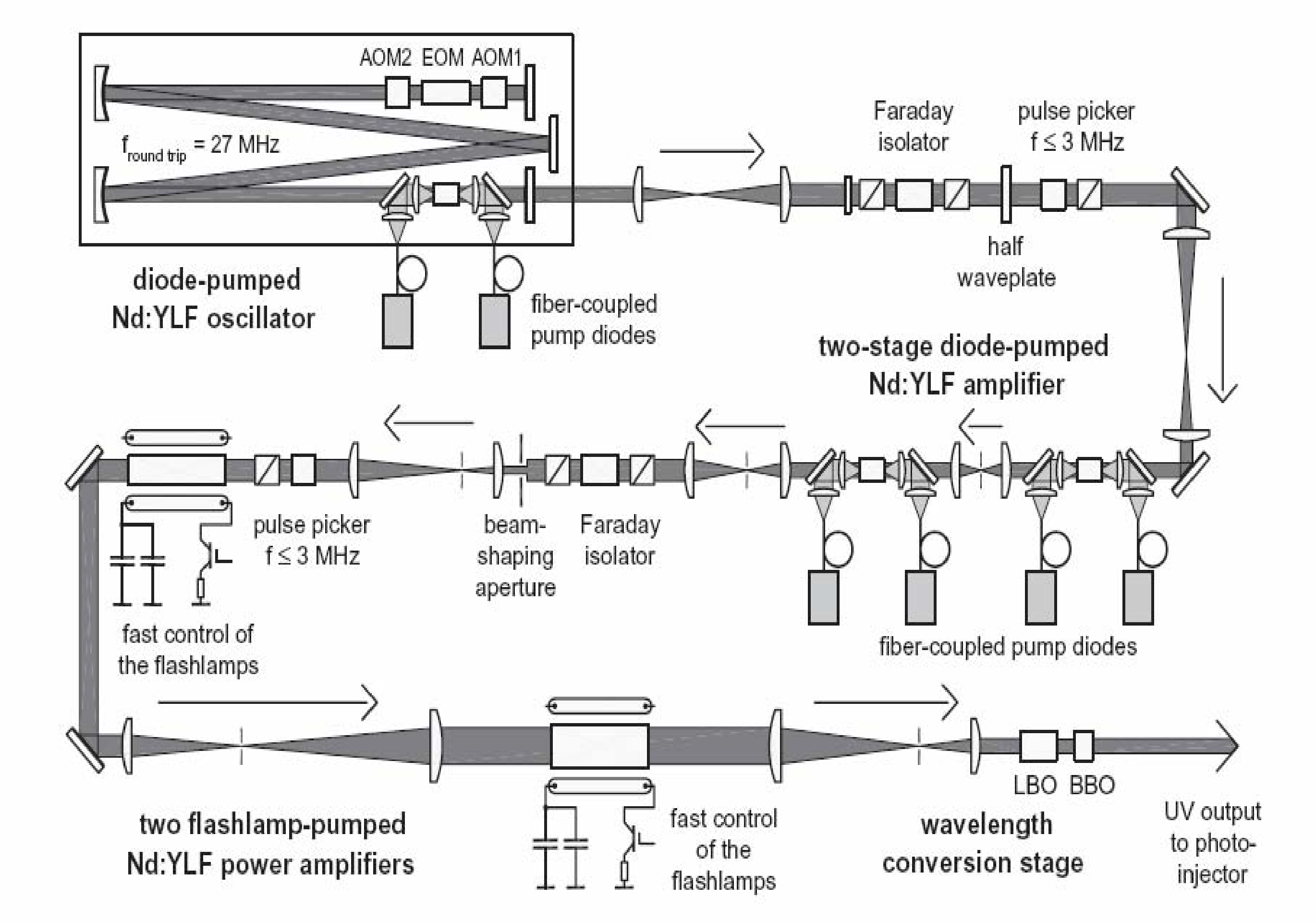
- Choice of laser material depends on cathode requirements:
  - Oscillator: Ti:Sapphire (must generate pulse train)
  - Amplifier: Ti:Sapphire
Cr:LiCAF
combination thereof
- Pulse train generation → next slide
- Temporal pulse stretching and shaping required to overcome space charge limit of DC – gun
- Issue: Response of photocathode to bandwidth and chirp?

3 MHz Pulse Train Generation





TTF drive laser system at DESY



I. Will, G. Koss and I. Templin, The upgraded photocathode laser of the TESLA Test Facility, NIM A *541/3, 11, 467-477*

Micro - Pulse Laser Energy Requirement

$$E = \frac{n_e \bullet h \bullet c}{QE \bullet \lambda \bullet e}$$

For $n_e = 4 * 10^{10}$ (twice n_e required at IP), QE = 0.005 at λ = 800 nm

→2 µJ at cathode

Assuming transport efficiency of 80 %, helicity control losses of 10 %, pulse shaping efficiency of 50 %, laser amplifier must produce ~ 5.5 µJ.

Source Drive Laser issues

(applicable to both Gun options)

Issue	Status	Comments
Mode-locked oscillator	√	Ti:Sapphire oscillator readily available
Locking to external frequency	√	e.g. SPPS laser
Pulse train generation	√ (?)	intra-cavity or external AO/EO techniques, limited commercial availability Vendor cooperation or in house development
Pulse train amplification	?	Must be demonstrated, R&D required
Temporal stretching of μ-pulse	√	Stretching factor ~ 1000 → Grating techniques
Helicity Control	√	E158 experiment
Details	?	μ - Pulse shape (Rise & Fall time, Flatness) Pulse Train Shape Amplitude stability Reliability

Polarized DC Electron Gun R&D

- SLC – Gun:

  - Demonstrate pulse train extraction from cathode
  - Continue Photocathode R&D
  - Charge limit of SLC gun is ~ 11 A (peak current) at 120 kV
  - (Current ILC design calls for e- energy at Gun of 120 – 500 keV)

- Improved HV Performance of DC – Gun

  - Reduction of space charge limitations (see Nagoya, Cornell, J-Lab)
  - Electrode materials (Ti, Mo) and design (see Nagoya)
  - Improved vacuum performance beyond 10^{-12} Torr to eliminated ion and electron back-bombardment of cathode

Polarized RF Electron Gun R&D

- Status:
  - Cryogenic cooling approach (see talk by Fliller)
  - PWT Gun (see talk by Yu)
  - Issue: e^- back-bombardment of cathode (field emission, vacuum)

- Future Polarized L-band RF – Gun Project at SLAC
  - Proof of principle
  - Challenges:
    - Vacuum conditions
    - Cathode bombardment by back accelerated electrons (vacuum, field emission, secondary e^-)
    - Cathode in magnetic and RF field (RF processing)?
    - Loadlock
  - Experimental program using the L-band RF in SLAC's Endstation 'B'

Status of Photocathode R&D

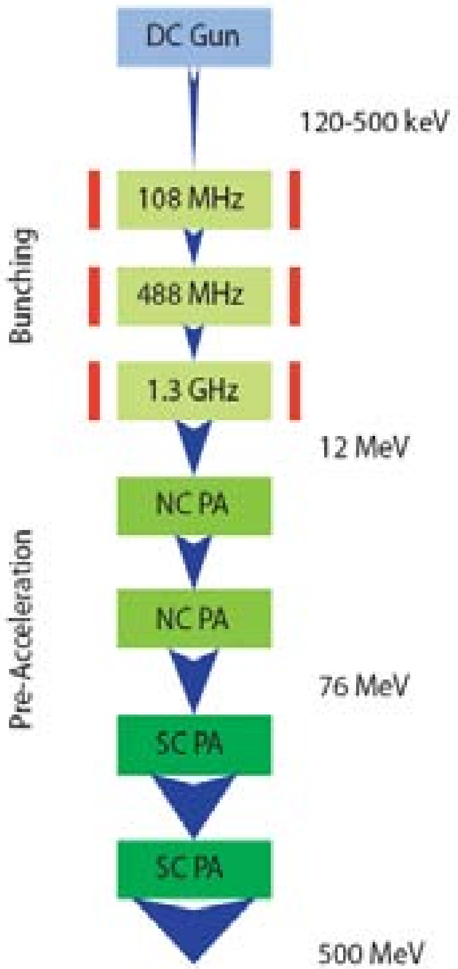
Strong R&D program at SLAC:

See talk by Naoto Yamamoto (Nagoya University)

Open issues

- Bunching and Pre-acceleration
- Polarization Control

→ Initial phase of simulations
→ Limited manpower and resources



Please join the

ILC Polarized Electron Source Study Group!

http://www-project.slac.stanford.edu/ilc/acceldev/injector/ILCPES/index.htm

Upcoming Workshop:

XI-th International Workshop on Polarized Sources and Targets,
Nov. 14-17, Tokyo/Japan
(Registration deadline: 08/31/05)
http://www.cns.s.u-tokyo.ac.jp/pst05/