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# Polarized Electron Sources for Linear Colliders

## October, 2010

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SLAC

# ILC Electron Beams

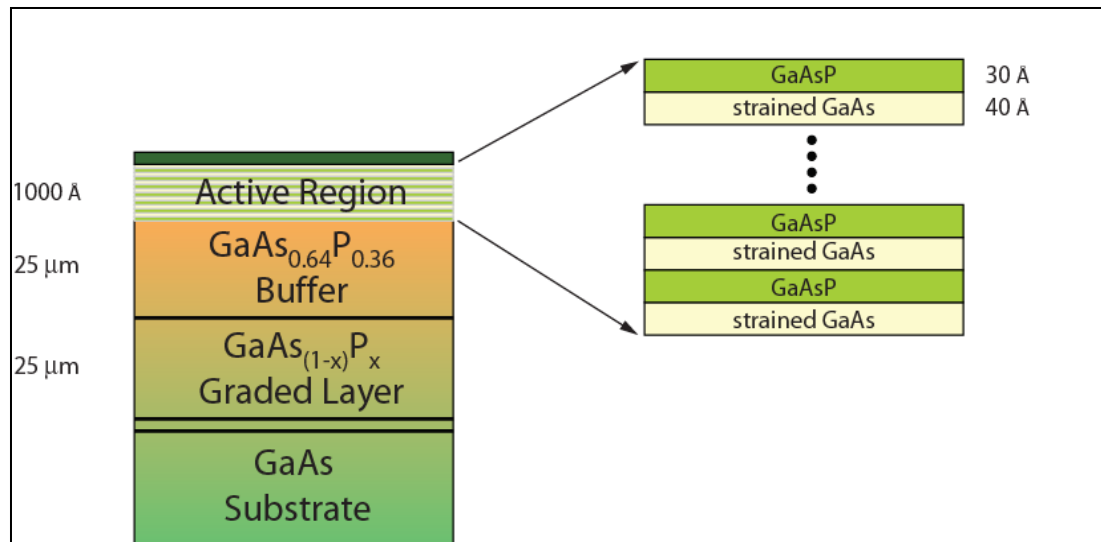
**TABLE 1).** Major parameters of the ILC and CLIC high-current high-polarization electron sources.

Parameters	ILC RDR	CLIC 3(0.5)TeV
Particles Per Microbunch	$3 \times 10^{10}$	$7 \times 10^9 (14 \times 10^9)$
Number Of Microbunch	2625	312
Width Of Microbunch	1 ns [ $\sim$ ps bunched]	100 ps [ $\sim$ ps bunched]
Time Between Microbunches	369 ns	500.2 ps [1 ns?]
Bunching Frequency	3 MHz	2 GHz [1 GHz?]
Width Of Macropulse	1 ms	156(177) ns
Macropulse Repetition Rate	5 Hz	50 Hz
Charge Per Macropulse	12600 nC	300 nC
Normalized Emittance, source	0.1 m-rad	0.0001 m-rad
Normalized Emittance, damped	$1 \times 10^{-5} / 4 \times 10^{-8}$ m-rad	$6 \times 10^{-7} / 2 \times 10^{-8}$ m-rad
Polarization, electrons	>80%	>80%

# Electron Beams, Cathode Status

Baseline design: strained layer superlattice GaAs/GaAsP

Polarization ~ 85 - 90 % ,QE 1% maximum, 0.3-0.5% routinely



High gradient p-doping increases QE and reduces surface charge limit:  
 $5 \times 10^{19} \text{ cm}^{-3} \rightarrow 5 \times 10^{17} \text{ cm}^{-3}$

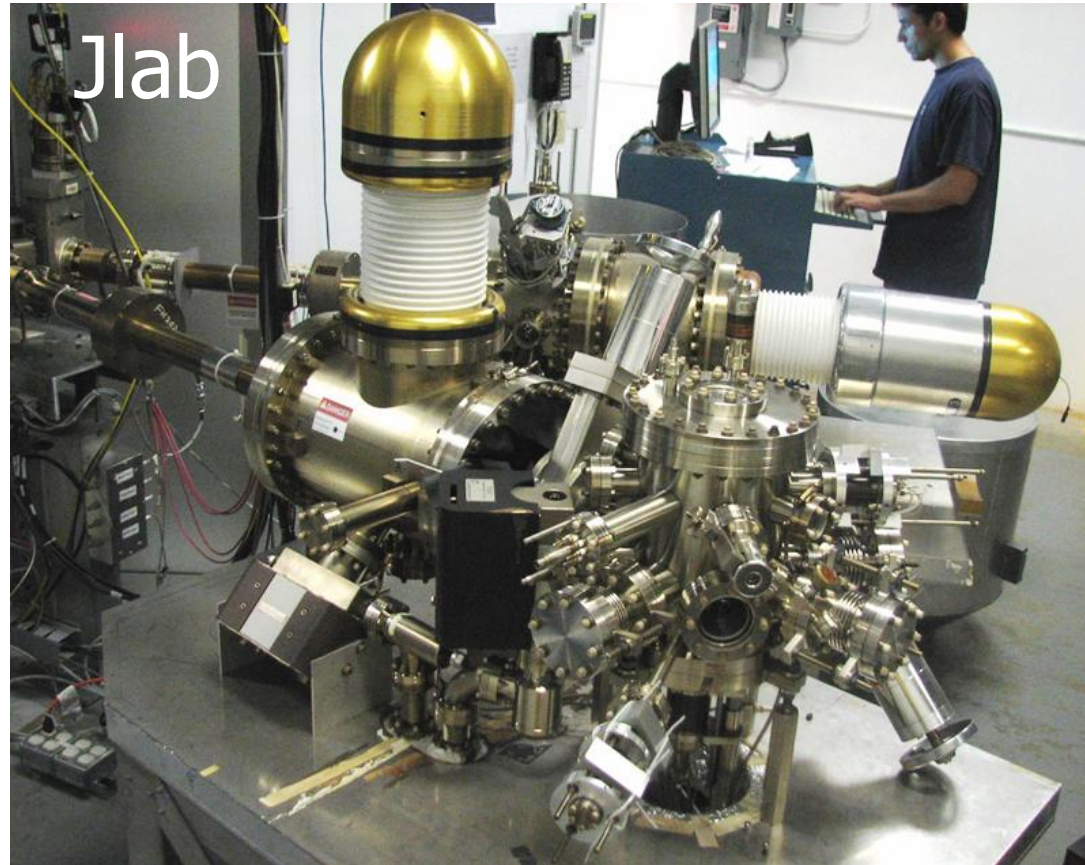
# SLAC Polarized Electron Gun, GTL

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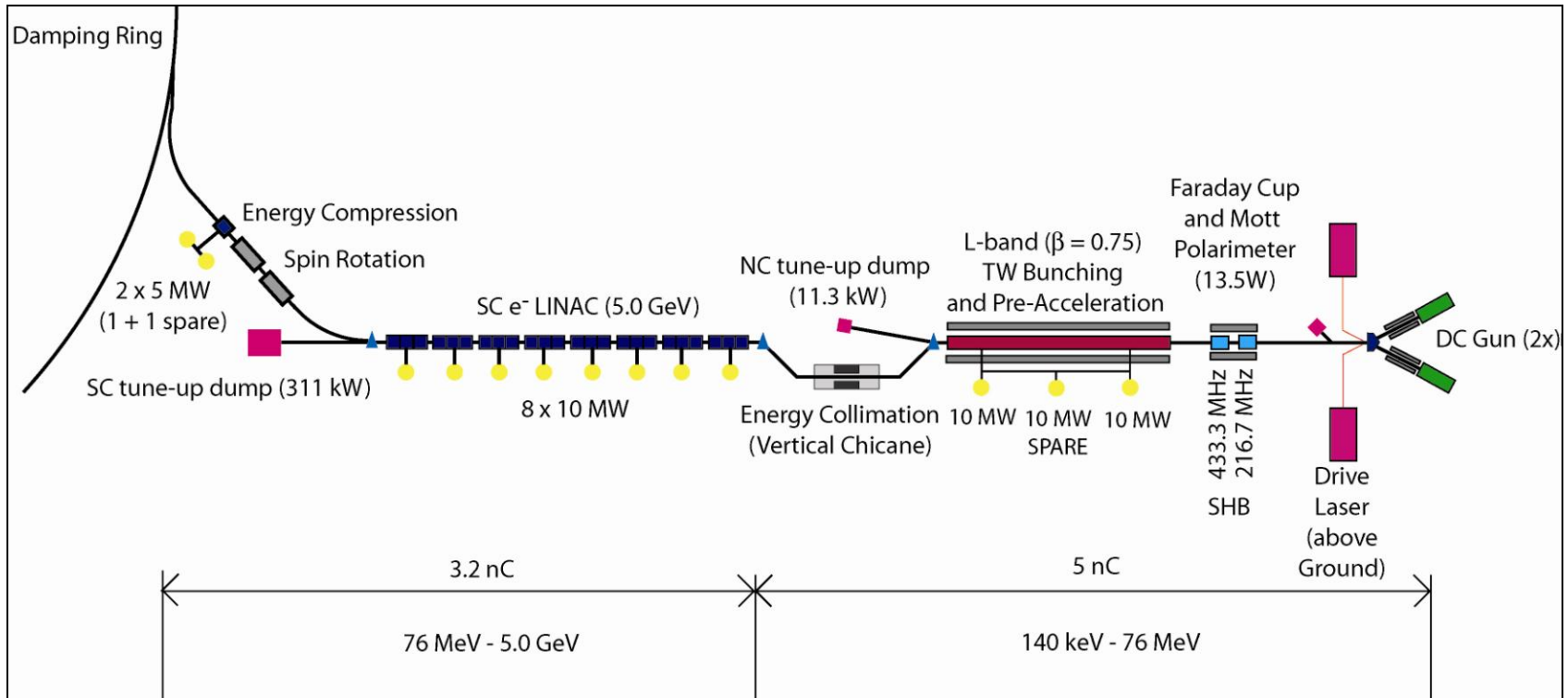
# Jefferson Lab Polarized Electron Gun



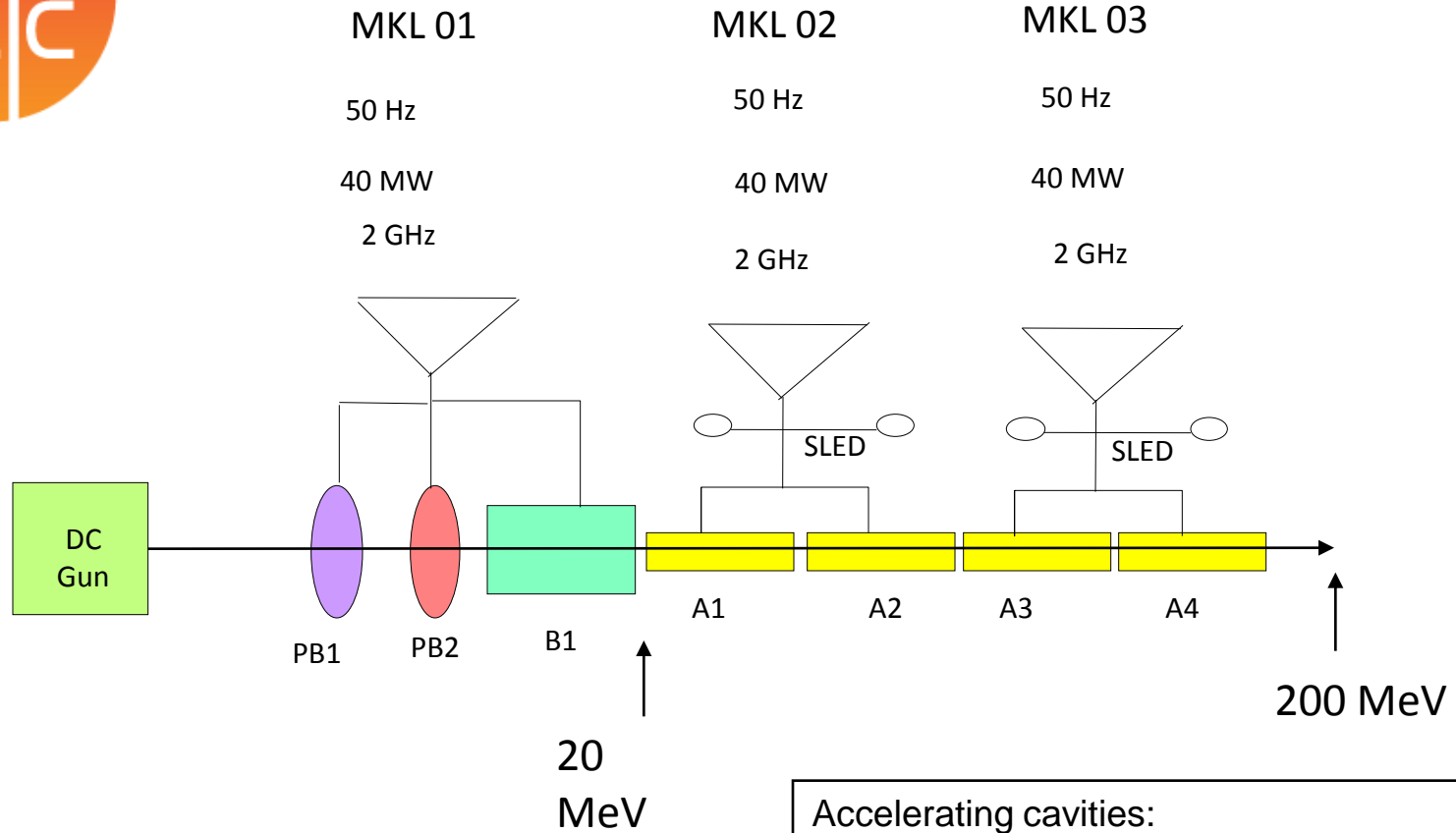


# The Baseline ILC Electron Source

Electron source provides polarized electron beam and consists of all systems from source laser to 5 GeV injection to damping rings.



# CLIC Pre-Injector e<sup>-</sup> Linac



## Accelerating cavities:

- Number of cavities:  $N = 4$
- Length:  $L = 3 \text{ m}$
- Aperture radius:  $r = 20 \text{ mm}$
- Energy Gain:  $\Delta E = 45 \text{ MeV}$
- Accelerat. gradient:  $E_z = 15 \text{ MV/m}$
- Frequency:  $f = 2 \text{ GHz}$





# ILC Electron Beams, Critical Issues

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3 MHz Laser System (in development)

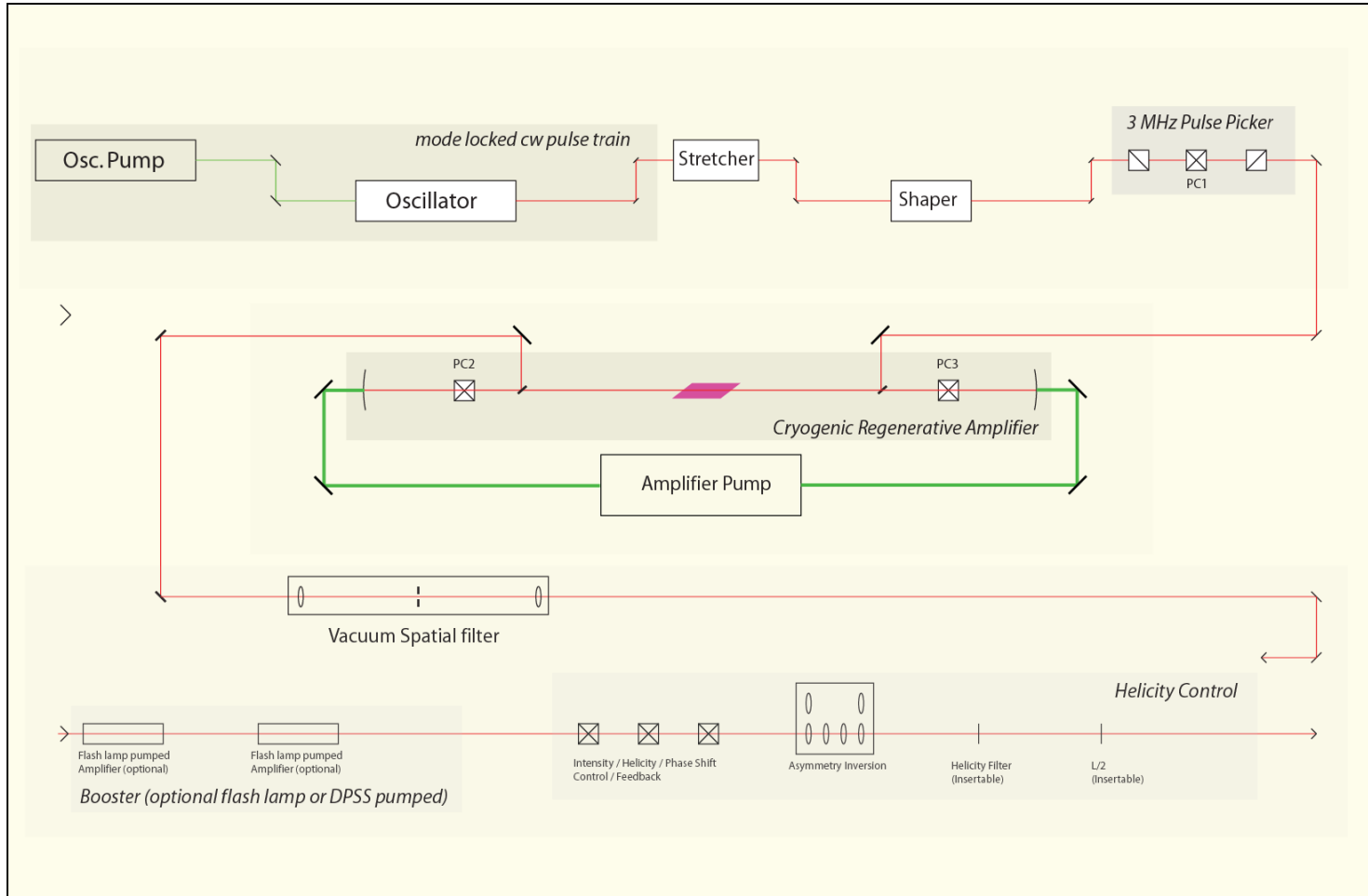
Cathode Demonstration (probably okay)

SLAC Laser and Jlab Gun





# ILC Electron Beams, Laser Development





- InvGun2 at 140kV
- InvGun3 Start
- Pump Laser Delivered

# ILC Polarized Electron Source Development

End ILC R&D phase



Order Coherent V-18 Pump laser(s)

By end of FY11:

- InvGun3 at 200kV
- Final Laser Demo
- ILC Beam Demo w/SLC Gun and Photocathodes

Beam Test Summer 2012

Install ILC Gun and Laser at CEBAF during year-long shutdown

Now:

- Inverted Gun Concept OK at 100kV
- Low Power Laser with ILC Time Structure
- SLC Gun OK at 120kV
- Acceptable Photocathodes

Ship SLAC/ILC Laser to JLab



V-18 Pump Lasers installed Aug 12<sup>th</sup> at SLAC



# ILC Electron Beams, Laser Development

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76 MHz fs mode locked cw oscillator

fs-to-ns pulse stretcher/shaper

3 MHz Pockels cell pulse selection

Pair of 18W cw green pump lasers (July, 2010)

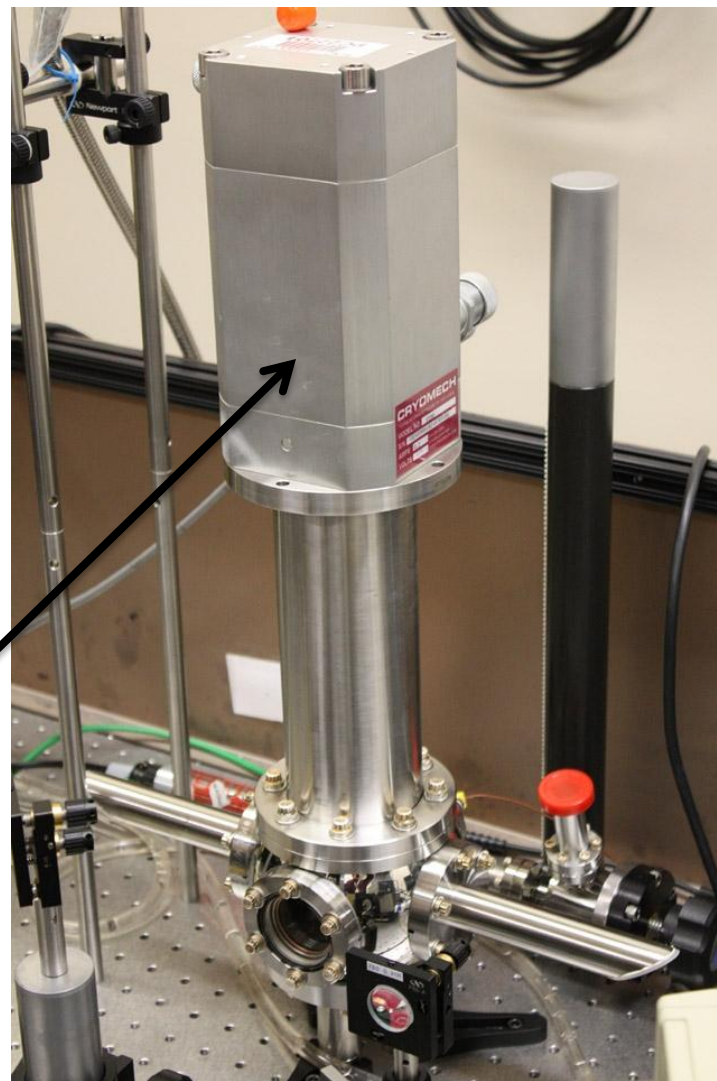
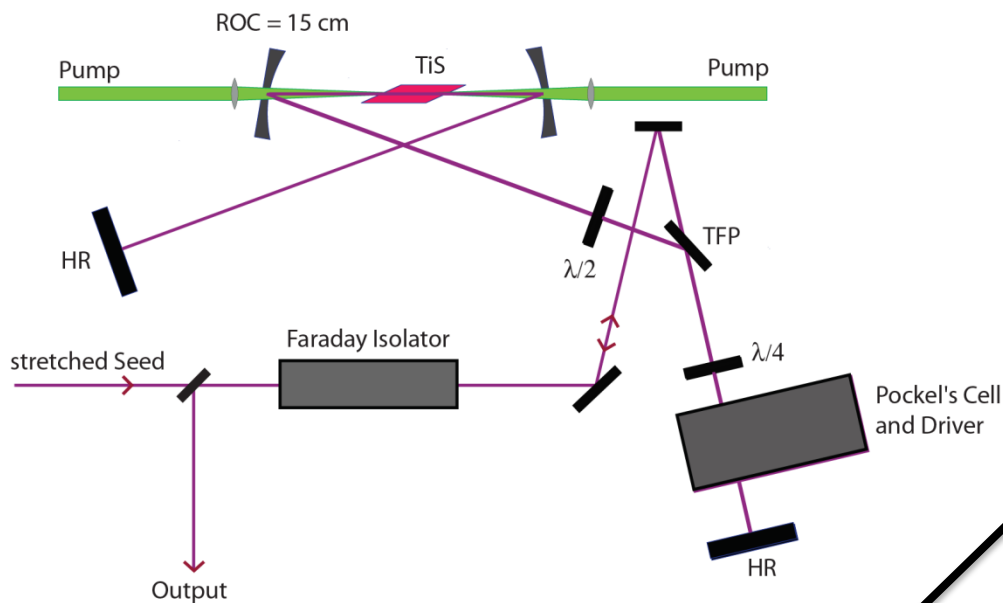
Cryocooled Ti:Al<sub>2</sub>O<sub>3</sub> gain cell

Regen amp in development (Spring, 2011)



# ILC Electron Beams, Laser Development

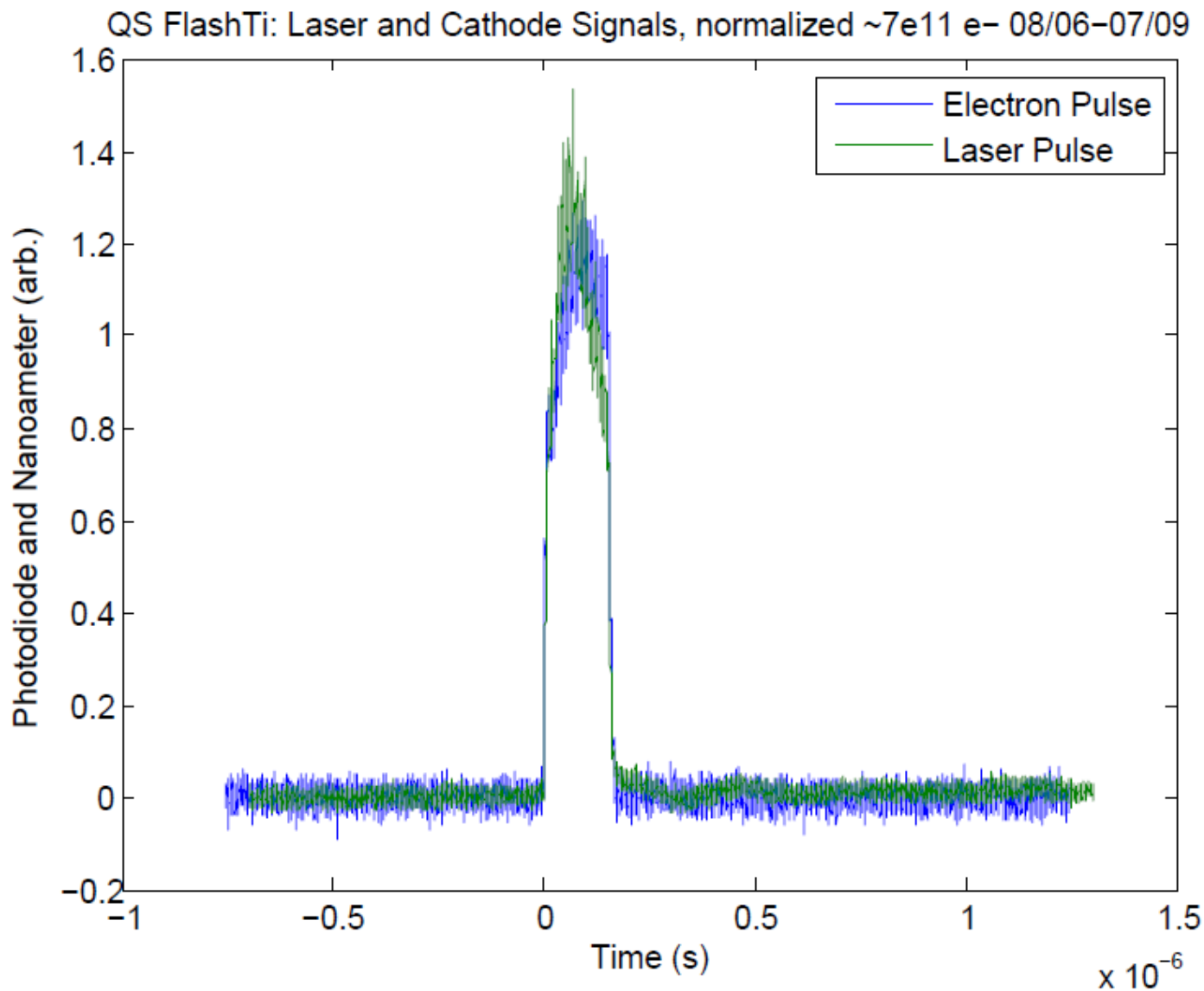
## 3 MHz Regen Amp



Cryocooled  $\text{Ti:Al}_2\text{O}_3$  gain cell

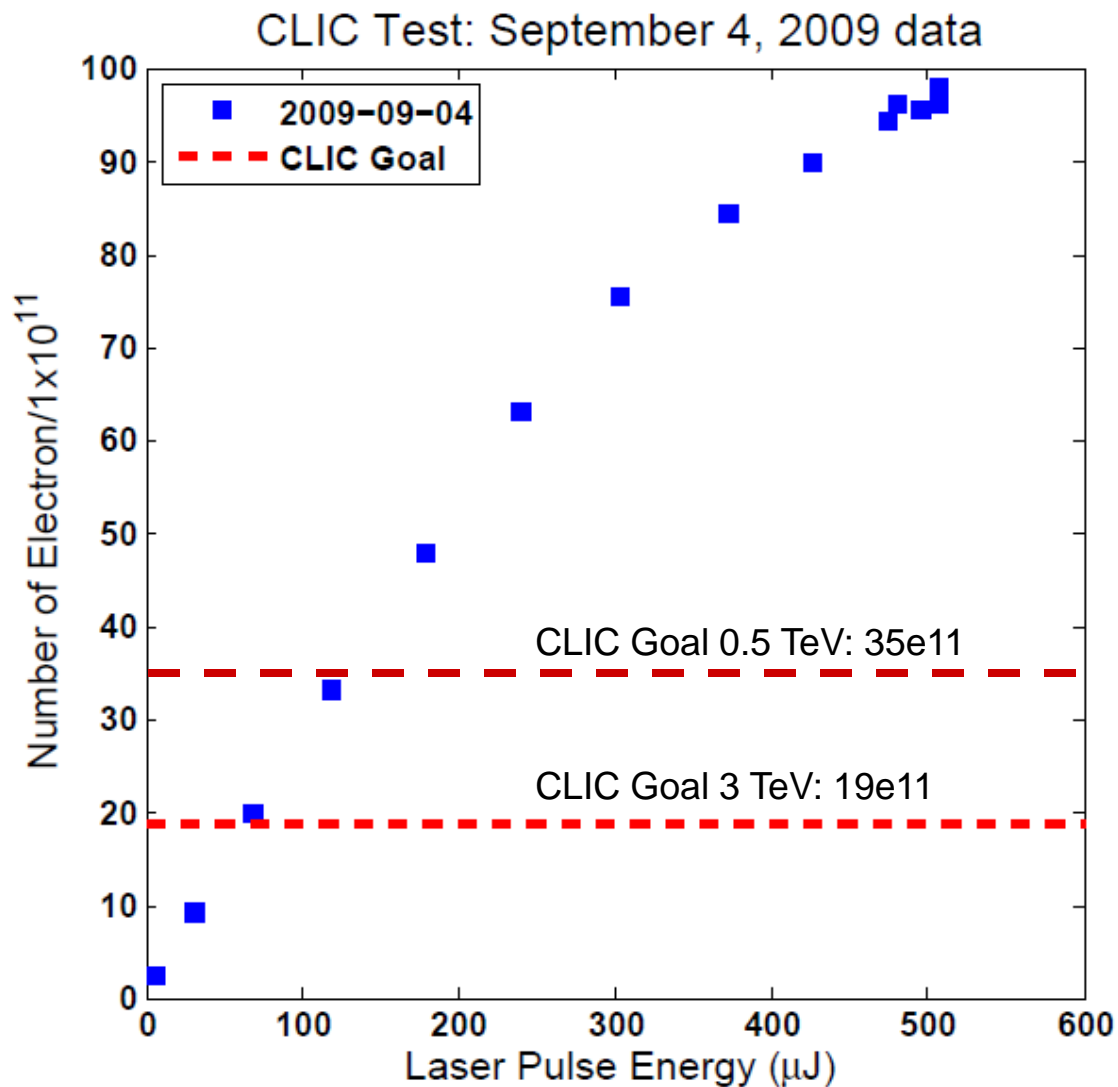


# CLIC Electron Beams, Demonstration 2009





# CLIC Electron Beams, Demonstration 2009



# CLIC Electron Beam: Bunching

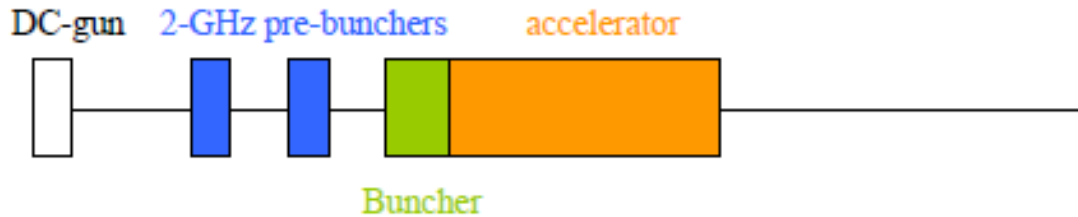


Figure 1: The schematic layout of bunching system for CLIC electron source.

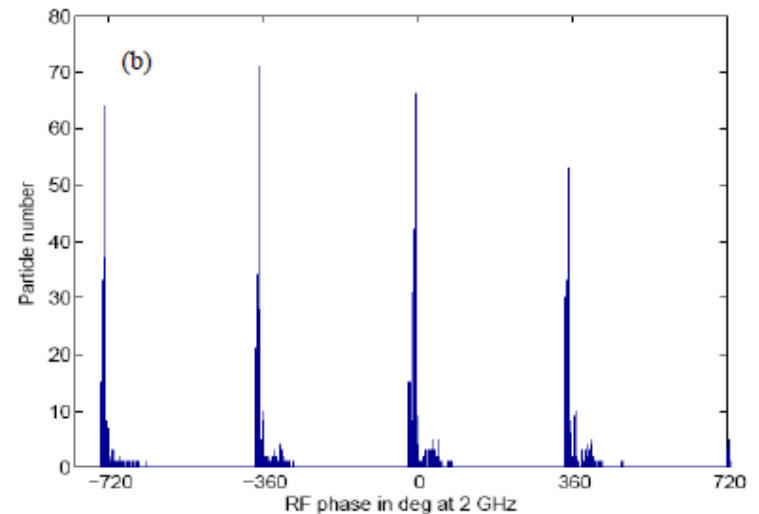
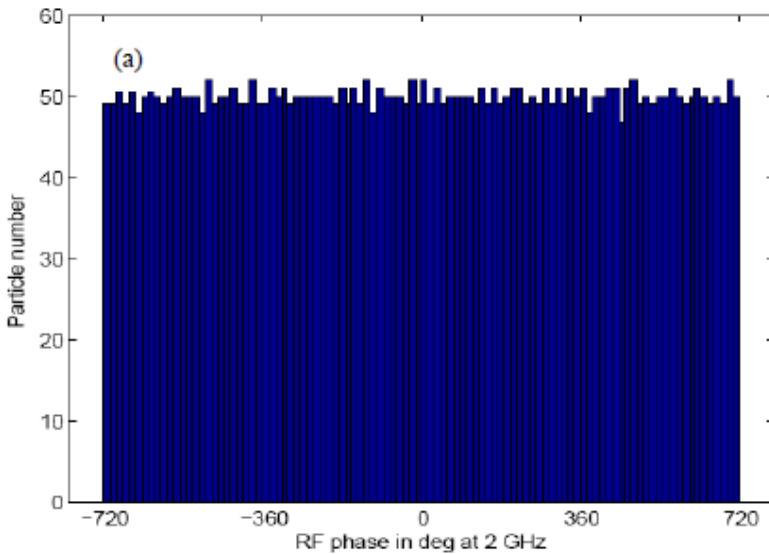
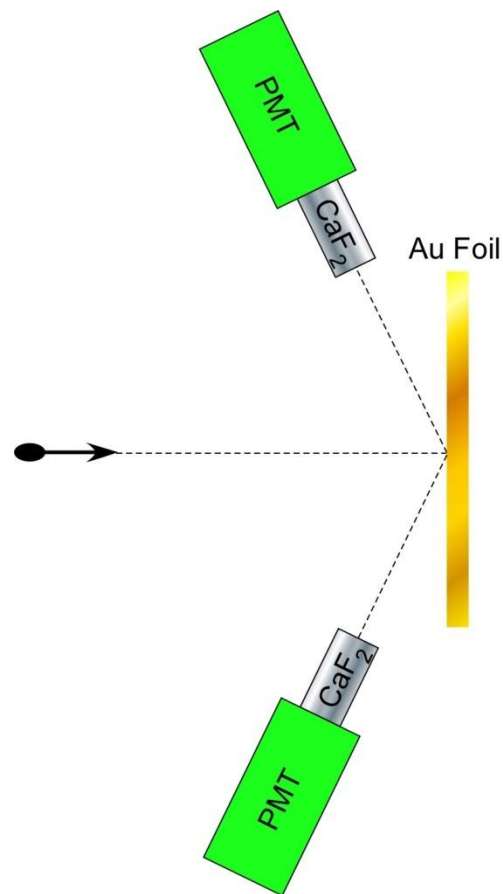


Figure 3: Initial pulse duration (a) on the cathode, and final bunched pulse structure (b) at 19 MeV



## Mott Polarimetry:

Scatter electrons off a gold foil and measure up-down asymmetry



# Electron Beams, Polarimetry

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Need to say something about polarization measurements

Polarization is ~85%. Measured at low Q. Are exploring how to make a hi Q measurement; difficulties with PMT/DAQ saturation and possibly space charge voltage loading. No previous evidence of polarization decrease with charge

ILC numbers are good from SLC running at 2 ns gun pulses and  $7e10$ /pulse

# LC Electron Beams, Issues

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Cathodes okay

Guns, largely okay

Need full Q, time resolved polarimetry

CLIC laser-gun-cathode demonstration 2009

ILC laser-gun-cathode demonstration 2012

CLIC bunched beam demonstration at 200 MeV ?

2 MHz laser development (? maybe not so important?)

High Voltage-yes but high gradient guns? Needs simulation

CLIC e- source emittance seems tight

Continuation of cathode r&d.....technology keep alive