US Targets and Sources Roadmap Workshop

Spencer Gessner, **SLAC**

LCWS2023

May 18, 2023

SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

US Target and Sources Roadmap Workshop

- The Target and Sources Roadmap Workshop was a hybrid event hosted by Fermilab April 11-12.
- The goal of the workshop was to provide input to HEP GARD on R&D topics for the next decade and prepare input to P5.
- Target research is focused on needs for LBNF/DUNE and a subsequent Muon Collider.
- Sources R&D will attempt to address many applications, including Linear Colliders, EIC, FELs, and polarized positrons at CEBAF.

Target Working Group Summary

F. Pellemoine P5 Short Remark: https://indico.slac.stanford.edu/event/7992/contributions/6093/attachments/2702/7723/HPT%20RD%20-%20P5%20Town%20Hall%20-%20F-Pellemoine-%20open%20session.pdf

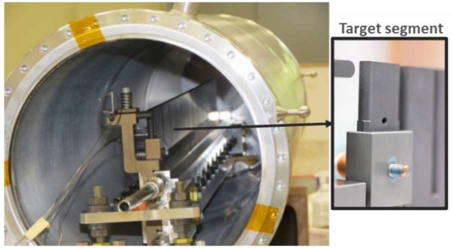
The High Power Targetry Working Group was chaired by Frederique Pellemoine from FNAL.

HPT produced a draft document and contributed a Short Remark to the P5 Townhall at SLAC.

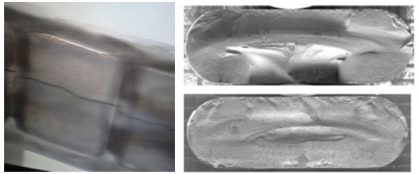
	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
Qualified material development/design										
Graphite *	LBNF - 1.2 MW									
Graphite *	LBNF - 2 MW+									
Ti-alloys *	LBNF-1.2 MW									
Ti-alloys *	LBNF - 2 MW+									
Novel material development										
High Entropy Alloys (HEAs)	LBNF - 2MW+ / multi MW targetry									
Nanofibers	multi MW target									
Refractory high-Z material			Rare Process multi MW target							
Composite material (SiC-coated graphite and SiC-SiC composites, 2D/3D carbon/carbon, Mo-C, etc...)	multi MW targetry									
Potential novel material to be considered in the future **										
Liquid metal					Rare Process multi MW target					
Fluidized flowing target material					Rare Process multi MW target					

*continuing study, started in the past- assume 10-year development

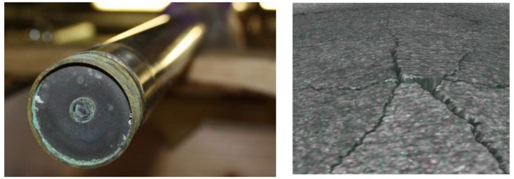
** only feasible with expending workforce



Graphite neutrino target (NOvA MET series)



MINOS NT-02 target failure: radiation-induced swelling (FNAL)



Beryllium window embrittlement (FNAL)

Sources Working Group Summary

The Sources Working Group was chaired by Yine Sun from ANL.

Luca Cultrera,[1] Spencer Gessner,[2] Joe Grames,[3] Siddharth Karkare,[4]

Pietro Musumeci,[5] Philippe Piot,[6,7] John Power,[7] Yine Sun[7]

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[6]Northern Illinois University, DeKalb, IL 60115
[7]Argonne National Lab., Lemont, IL 60439

Sources R&D Timeline

Year	Near-term (<5 years)	Mid-term (5~10 years)	Long-term (10~20 years)
e^- Cathode	Reliable high-P GaAs supply chain	Cryogenic temperatures and very high fields operation	
	Robust photocathodes in DC guns (20mA pol. and 100 mA unpol.)		
	Photocathodes with 1% QE and 30 meV MTEs	Photocathodes with 1% QE and 5 meV MTEs	
	Continue to explore new and promising photocathodes (robust surfaces, nano-structures, higher QE and polarization)		
e^- Gun	DC gun beam ~1-10 mA polarized	10^{-14} Torr vacuum for long GaAs lifetime	DC gun beam 10~20 mA polarized
	NCRF: cryo gun at 250 MV/m; x-band gun, CW and Low Frequency rf gun		
	Polarized GaAs in an SRF photogun	SCRF gun 50 MV/m	
e^- Injector	Control laser profile, limit nonlinear SC induced emittance growth: beer can (mid); elliptical (far)		
	NCRF, SRF accelerating cavities: fully RF symmetrized fields to eliminate emittance growth to 10% (near), 1%(mid), 0.1%(far)		
		Partition phase space: RFBT+EEX for damping ring free (mid), linear LPS (long)	
	High Charge Drive Bunch Trains: charge-balanced, equal energy bunches duration 5-25 nsec.		
e^+ polarized	SC undulators		Collider-class polarized e+ source
	Compton-based sources - high flux circularly polarized gamma-rays R&D		
	Bremmstrahlung polarized positron source development		
e^+ unpolarized	Targets for high intensity		
	Capture and acceleration sections		
	Compact sources for accelerator and ultrafast science (also polarized)		

Cathode R&D

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

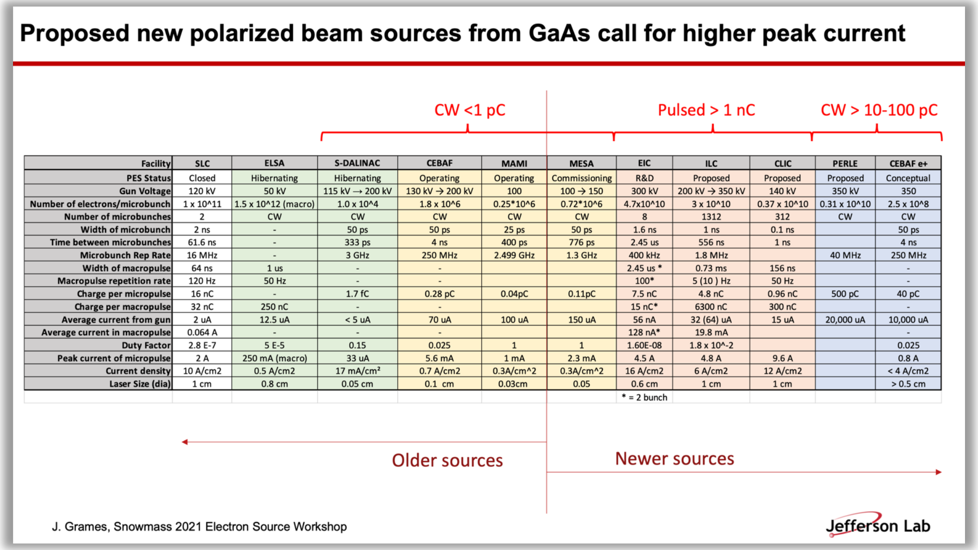
Polarized Photocathodes for Future Linear Colliders: *Status and Outlook*

Jared Maxson
Cornell Physics, CLASSE

LCWS: May 16 2023
SLAC

See talk by J. Maxson:
https://indico.slac.stanford.edu/event/7467/contributions/5569/

Gun R&D



Proposed new polarized beam sources from GaAs call for higher peak current

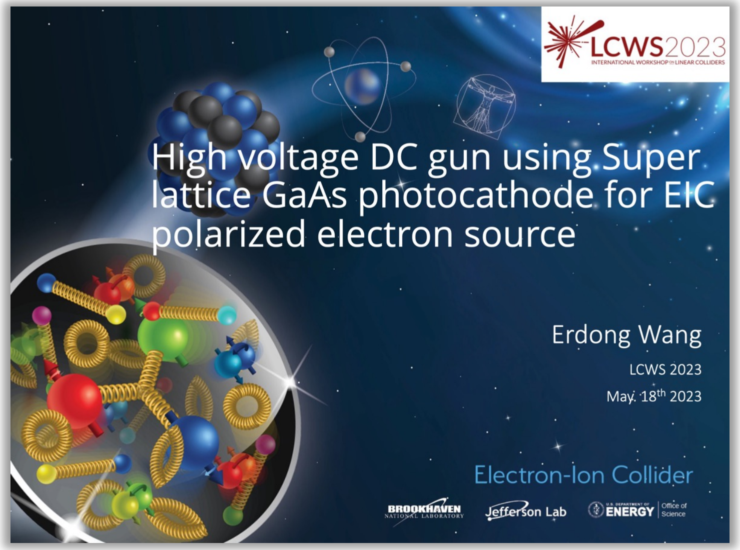
CW <1 pC | Pulsed > 1 nC | CW > 10-100 pC

Facility	SLC	ELSA	S-DALINAC	CEBAF	MAMI	MESA	EIC	ILC	CLIC	PERLE	CEBAF e+
PES Status	Closed	Hibernating	Hibernating	Operating	Operating	Commissioning	R&D	Proposed	Proposed	Proposed	Conceptual
Gun Voltage	120 kV	50 kV	115 kV → 200 kV	130 kV → 200 kV	100	100 → 150	300 kV	200 kV → 350 kV	140 kV	350 kV	350
Number of electrons/microbunch	1 x 10^11	1.5 x 10^12 (macro)	1.0 x 10^4	1.8 x 10^6	0.25*10^6	0.72*10^6	4.7x10^10	3 x 10^10	0.37 x 10^10	0.31 x 10^10	2.5 x 10^8
Number of microbunches	2	CW	CW	CW	CW	CW	8	1312	312	CW	CW
Width of microbunch	2 ns	-	50 ps	50 ps	25 ps	50 ps	1.6 ns	1 ns	0.1 ns		50 ps
Time between microbunches	61.6 ns	-	333 ps	4 ns	400 ps	776 ps	2.45 us	556 ns	1 ns		4 ns
Microbunch Rep Rate	16 MHz	-	3 GHz	250 MHz	2.499 GHz	1.3 GHz	400 kHz	1.8 MHz		40 MHz	250 MHz
Width of macropulse	64 ns	1 us	-	-			2.45 us *	0.73 ms	156 ns		-
Macropulse repetition rate	120 Hz	50 Hz	-	-			100*	5 (10) Hz	50 Hz		-
Charge per micropulse	16 nC	-	1.7 fC	0.28 pC	0.04pC	0.11pC	7.5 nC	4.8 nC	0.96 nC	500 pC	40 pC
Charge per macropulse	32 nC	250 nC	-	-			15 nC*	6300 nC	300 nC		-
Average current from gun	2 uA	12.5 uA	< 5 uA	70 uA	100 uA	150 uA	56 nA	32 (64) uA	15 uA	20,000 uA	10,000 uA
Average current in macropulse	0.064 A	-	-	-			128 nA*	19.8 mA			-
Duty Factor	2.8 E-7	5 E-5	0.15	0.025	1	1	1.60E-08	1.8 x 10^-2			0.025
Peak current of micropulse	2 A	250 mA (macro)	33 uA	5.6 mA	1 mA	2.3 mA	4.5 A	4.8 A	9.6 A		0.8 A
Current density	10 A/cm2	0.5 A/cm2	17 mA/cm²	0.7 A/cm2	0.3A/cm^2	0.3A/cm^2	16 A/cm2	6 A/cm2	12 A/cm2		< 4 A/cm2
Laser Size (dia)	1 cm	0.8 cm	0.05 cm	0.1 cm	0.03cm	0.05	0.6 cm	1 cm	1 cm		> 0.5 cm
							* = 2 bunch				

Older sources ← | → Newer sources

J. Grames, Snowmass 2021 Electron Source Workshop

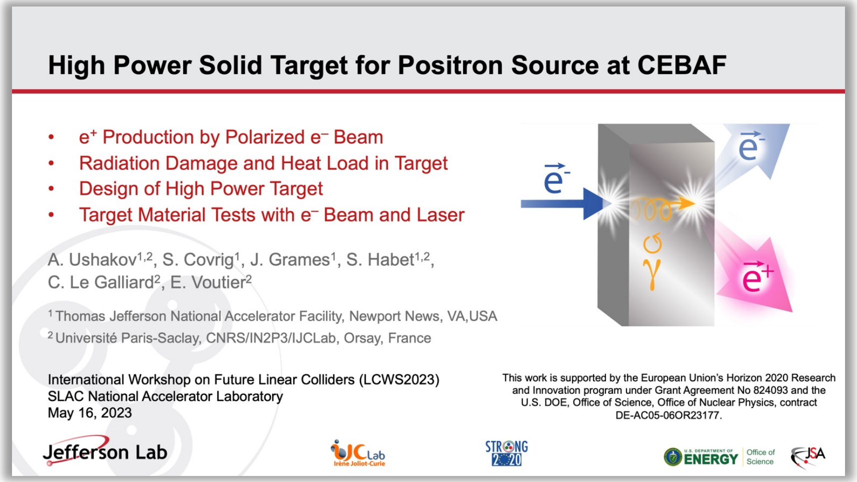
Jefferson Lab

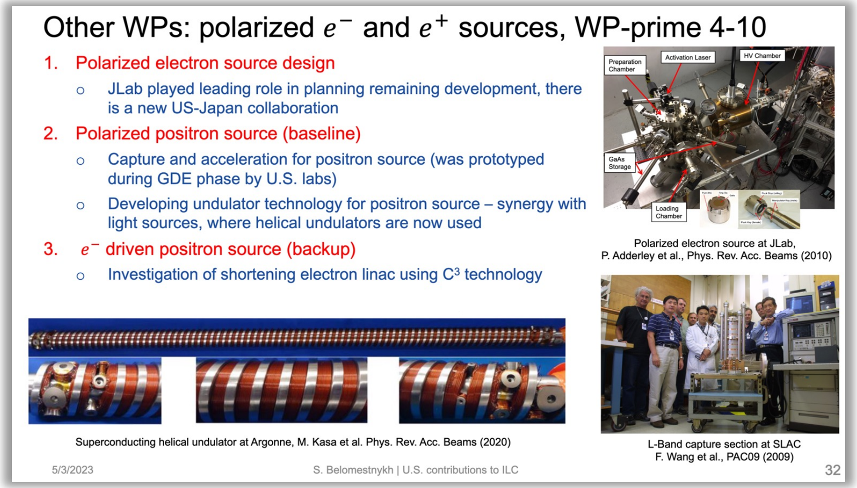


See talk by C. Hernandez-Garcia: https://indico.slac.stanford.edu/event/7467/contributions/5631/

See talk by E. Wang: https://indico.slac.stanford.edu/event/7467/contributions/6108/

Polarized Positron R&D





See talk by A. Ushakov: https://indico.slac.stanford.edu/event/7467/contributions/5582/

See talk by S. Belometskyh: P5 SLAC Townhall