PRE-CONCEPTUAL DESIGN OF A CW POSITRON SOURCE FOR JLAB (2013-LDRD-02)

JOE GRAMES

LDRD PROPOSAL REVIEW - JULY 17, 2013

- ✓ PROJECT OVERVIEW
- ✓ THE TEAM
- ✓ LDRD EVALUATION CRITERIA
- ✓ REVIEWER QUESTION
- ✓ BUDGET

PHYSICS MOTIVATION

(bullets refer to letters of endorsement)

- 12 GEV CEBAF - The merits of positrons, polarized and/or unpolarized, for the Nuclear Physics program at JLab is comparable to the benefits of polarized with respect to unpolarized electrons.
  - *Dr. Volker Burkert, Principal Staff Scientist and Head of Hall B, JLAB*

- NEXT GEN FACILITIES - Unpolarized and polarized positrons in the next generation of accelerators (MEIC, ILC, LHeC) have been identified as either necessary or complementary tools for the completion of their Physics program.
  - *Dr. Yuhong Zhang, Senior Staff Scientist, MEIC Accelerator Design Study, JLAB*
  - *Dr. Alessandro Variola, Accelerator Department Director, LAL Orsay*

- NEW DIRECTIONS - There exists a long standing and never satisfied interest of the Material Science Community in an intense low energy (0.05-1.00 MeV/c) positron beam, as a characterization tool of material structure.
  - *Dr. Kelvin Lynn, Director for the Center for Materials Research, Washington State University, Boeing Chair for Advanced Materials*

PHYSICS INTEREST	POSITRON INTENSITY
Two Photon Exchange	10 – 50 nA
Positron Proton Elastic Scattering	20 – 40 pA
GPD's and DVCS with Positrons	8 – 40 nA
Inclusive Structure Functions	100 – 250 nA
U-Boson Dark Matter Search	20 nA
MEIC with Positrons	1 – 10 μA
Slow Positron Facility	10 – 100 pA

POSITRON SOURCE CANDIDATES

❑ WHAT CHARACTERIZES A POSITRON SOURCE CANDIDATE ?

✓ We believe a conventional design is best suited for Jefferson Lab

Suitable Electron Drive Beam → High Power Beam Absorber → Optimized Integrated Collection → Facility Integrated Acceleration → Well Defined User Beam Specifications

❑ EXAMPLES OF A "SUITABLE ELECTRON DRIVE BEAM"

✓ CEBAF INJ (100 MeV) ✓ FEL (100MeV) ✓ CEBAF (12 GeV)

HIGH POWER BEAM ABSORBERS

❑ HIGH POWER ABSORBERS ARE CHALLENGING

- ✓ Highly localized beam power (10-100 kW) to be dissipated
- ✓ Radiation management is a priority, specifically to cost and operability

❑ ABSORBER TECHNOLOGY BALANCES MANY IMPORTANT PARAMETERS

- ✓ Heat - energy absorption and heat dissipation in target
- ✓ Radiation - prompt radiation and material activation around target
- ✓ Accelerator Integration - collection beam line after target

❑ NEW DIRECTIONS

- ✓ A novel or original implementation of a positron source is likely
  - Study applicability of recently issued JLAB patents
  - Introduce “split two target” design
    - ➢ first (optimize bremsstrahlung) – high radiation
    - ➢ second (optimize positron production/collection) – low radiation footprint

MOGA SOURCE OPTIMIZATION

❑ DIVERSE SET OF PARENT PARAMETERS

- ✓ Electron Drive Beam (energy, intensity, radiation, polarization)
- ✓ Single- & Double- Targets (bremsstrahlung and e+/e- converters)
- ✓ Electron Beam Power (radiation, activation, thermal management)
- ✓ Positron Collection (adiabatic matching, acceleration, optics)
- ✓ Positron Beam (emittance, damping, transport, acceleration)
- ✓ Positron Polarization (PEPPo concept, self-polarization)
- ✓ Value (cost, size, scale)

❑ IMPLEMENT MULTI-OBJECT GENETIC ALGORITHM (MOGA)

- ✓ Principles of biological evolution to optimize multi-dimensioned non-linear problems
- ✓ Application to modern sophisticated problems
  - Operating highest brightness high current photoinjector (Cornell)
  - Design of optimized luminosity for ILC
  - Optimized design and operating costs of an SRF linac
- ✓ JLAB expertise

TECHNICAL REVIEW & PRE-CONCEPTUAL DESIGN REPORT

❑ DOWN SELECTION (CLOSED LOOP PROCESS)

- ✓ Technical Review
  - Internal and External reviewers
  - Review materials provided well in advance
  - One day agenda split between presentations and reviewer assessment
- ✓ Committee Charge
  - Assess and recommend scenario(s) for detailed study
  - Reduce to 1 or at most 2 concepts

❑ SHIFT EFFORT FROM CANDIDATES TO PRE-CONCEPUTAL DESIGN

- ✓ Limited to design and analysis of most critical components
  - Absorber
  - Collection
  - Optimization
- ✓ Explore prototype engineering plan
  - Critical path R&D
  - Positron source systems (targets, magnets, SRF, vacuum, shielding)
  - Facility integration
  - Risk assessment

THE TEAM

User Physics

Eric Voutier
Visiting Nuclear Physicist
LPSC, Grenoble

(5-10%)

High Power Absorbers

Pavel Degtiarenko
Radiation Physicist (SS)
ESH&Q

(5-10%)

Source Optimization

Joe Grames
Injector Physicist (SSIII)
ACC/CIS

(5-10%)

Scientific Lead

New
Post-Doctoral
Research Associate

(100%)

Engineering Analysis

Mechanical Engineer (ME II)
ENG

(7-15%)

"The **ultimate deliverable** of this proposal is a technically well-developed **Pre-Conceptual Design Report** based upon physics-motivated User input, with alignment and feasibility to the existing CEBAF and FEL facilities, and including an optimization and technical review of candidate design schemes."

LDRD EVALUATION CRITERIA

- POTENTIAL IMPACT ON JLAB
  - ✓ High
  - ✓ Grows and strengthens core expertise in (polarized) particle sources for CEBAF NP
  - ✓ Potential for center of growth in low energy or material science and collaboration

- LIKELIHOOD TO ACHIEVE GOALS
  - ✓ Strong
  - ✓ Builds upon JPOS'09, University Collaborators, 2 PhD's, JLab patents, ILC support, PEPPo

- PROSPECTS FOR ATTRACTING FUTURE FUNDING
  - ✓ New funding for future NP program
  - ✓ HEP funding to support high energy e+ colliders
  - ✓ US interests in materials sciences to compete with European leadership

- STRATEGIC VALUE OF YOUR PROJECT TO JLAB
  - ✓ Entirely new aspect to CEBAF NP program
  - ✓ Support MEIC at JLab with positrons

- LEVEL OF INNOVATION IN SCIENCE AND/OR TECHNOLOGY
  - ✓ First ever CW positron source
  - ✓ New technology to produce polarized positrons at low energy
  - ✓ Evolution of high power beam absorbers

REVIEWER QUESTION

Analyze the pro and cons of stretching the funding over 3 years.

- PROS
  - ✓ 3 year is preferable (submitted 2 year proposal to be most compact)
  - ✓ Improved task flow (more serial, less parallel)
  - ✓ Better synchronization with post-doctoral scientist search and funding term
- CONS
  - ✓ Deliverable delayed by one 1 year

BUDGET

				PI Name	Pavel Degtiarenko and Joe Grames			PI Name	Pavel Degtiarenko and Joe Grames		
				2 YEAR (SUBMITTED)				3 YEAR (QUESTION)			
	Indirect Rates			Proposal Title:	Accelerator Preconceptual CW Positron Source			Proposal Title:	Accelerator Preconceptual CW Positron Source		
CATEGORY	Yr 1	Yr 2	Yr 3	LDRD REQUEST YEAR 1 ($)	LDRD REQUEST YEAR 2($)	LDRD REQUEST YEAR 3 ($)	TOTAL ($)	LDRD REQUEST YEAR 1 ($)	LDRD REQUEST YEAR 2($)	LDRD REQUEST YEAR 3 ($)	TOTAL ($)
Direct Costs											
Labor - Fringe				75,418	77,680		153,098	35,670	82,200	40,452	158,322
Labor - Non-Fringe				0	0		0	0	0		0
Fringe	48.25%	48.25%	48.25%	36,389	37,481		73,870	17,211	39,662	19,518	76,391
Stats	8.90%	8.90%	8.90%	6,712	6,914		13,626	3,175	7,316	3,600	14,091
Total for Personnel				**118,519**	**122,075**		**240,594**	**56,056**	**129,178**	**63,570**	**248,804**
Travel <$50K							0				0
Consultants / Subcontractors <$50K				16,864	12,264		29,128	16,864	15,264	4,000	36,128
Materials and Supplies <$50K							0				0
Equipment <$50K							0				0
Other Direct Costs <$50K							0				0
Direct Costs >$50K							0				0
Total Direct Costs				**135,383**	**134,339**		**269,722**	**72,920**	**144,442**	**67,570**	**284,932**
Indirect Costs											
G&A	50.00%	50.00%	50.00%	67,691	67,170		134,861	36,460	72,221	33,785	142,466
Total Indirect Costs				**67,691**	**67,170**		**134,861**	**36,460**	**72,221**	**33,785**	**142,466**
TOTAL LDRD REQUEST				**203,074**	**201,509**		**404,583**	**109,380**	**216,663**	**101,355**	**427,398**
TOTAL BUDGET							**404,583**				**427,398**