BROOKHAVEN NATIONAL LABORATORY
PROPOSAL INFORMATION QUESTIONNAIRE
LABORATORY DIRECTED RESEARCH AND DEVELOPMENT PROGRAM

PRINCIPAL INVESTIGATOR	**Edouard P.Kistenev**	**PHONE**	**7502**
DEPARTMENT/DIVISION	**PH**	**DATE**	**4/2/09**
OTHER INVESTIGATORS	**C.Aidala, E.C. Aschenauer, A.Deshpande, Z.Li, A.Sukhanov**		
TITLE OF PROPOSAL	Development of a hybrid strip-pad (StriPad) single- and double-sided silicon sensors and associated readout for the high resolving power silicon-tungsten electromagnetic calorimetry for eRHIC.		
PROPOSAL TERM (month/year)	From **10/09**	Through **10/11**	

SUMMARY OF PROPOSAL

Description of Project:
Accurate measurement of photons will be crucial to exploring the gluon-dominated regime of nuclei with the EIC. Calorimetry will be the most important single tool for photon/π0 measurements and will drive the detector dimensions and cost. Recent progress in tracking and particle identification detectors resulted in continuous reduction of space occupied by central tracking.
The aim of this proposal will be to investigate a new silicon detector concept which could allow to enhance multi-photon resolving power in calorimeters so the calorimeters could be located close to the particle production point leading to substantial reduction in the total instrumented detector volume and cost.

Expected Results:
The project is expected to demonstrate the feasibility to build a W-Silicon electromagnetic calorimeter combining energy measurement with precision position and shower shape measurements along the shower depth while maintaining its radiation length and Moliere radius close to that of tungsten. Results will be essential to provide input to eRHIC detector design as mandated by the 2007 NSAC Long Range Plan.

PROPOSAL

Accurate measurement of photons will be crucial to exploring the gluon-dominated regime of nuclei with the EIC. In particular, Generalized Parton Distributions (GPD's), which provide detailed information on the space-time distributions of quarks and gluons within nucleons and nuclei, can be accessed via measurement of exclusive photon production from Deeply Virtual Compton Scattering (DVCS) (e+A -->e+A+gamma). In addition, various light mesons can be detected and triggered via their decay to photons, providing abundant probes to study the process of hadronization within an extended gluonic medium and addressing the question of the time scale on which the color of a struck quark is neutralized.
Calorimetry is the most important tool for photon/π0 measurements. Its performance drives the detector dimensions and consequently cost. Recent progress in tracking and particle identification detectors resulted in continuous reduction of space occupied by central tracking. Unfortunately the total instrumented detector volume is still set by the luck of a new concept which could allow to enhance multi-photon resolving power in calorimeters to match improvements to central tracking.

Recently such a concept based upon detailed shower measurements close to the photon conversion point was proposed by the PHENIX experiment for the PHENIX forward upgrade. Simulation have shown that while the concept works its performance is limited due to the rapid lateral shower grows in the large gaps occupied by position sensitive silicon sensors (Fig.1, white spaces are 4mm W plates, only Gap 1 has a pad structured readout. Gaps 2-5 also house two additional layers of strips oriented in X and Y directions). The PHENIX proposal already uses extremes of technology to reduce readout space for shower energy measurements down to ~2.5 mm. This proposal is aimed totally remove the 6.5 mm gap currently occupied by X/Y position measuring sensors by replacing already developed pad-structured sensors with new StriPad sensors.

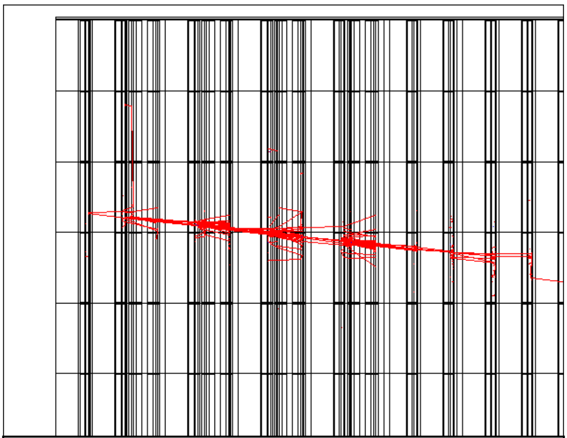

Fig. 1. 10GeV em shower development in the layers of the W-Si calorimeter. Effect of the large “:empty” gaps is an increased shower spread.

We propose to design, a prototype to study two kinds of novel silicon sensors for calorimetry, which will combine the energy measuring functionality (pad-structured readout) and precision position measurements (strip structured readout) on a single silicon device thus reducing the space requirements down to 2.5 mm combining the two kinds of measurements.

The first sensor option (Fig.2) will be designed and implemented following the idea proposed earlier at BNL instrumentation for single sided pixilated sensors with two-dimensional readout currently implemented in the outer two layers of the PHENIX central silicon tracker. Si stripixel detectors have been developed at BNL in 2004 [1], and implemented in the PHENIX SVTX Upgrade[2].

StriPad sensors based on this concept will be made on high resistivity (> 10 k-cm) n-type Si wafers, with 600 µm thickness. The detector will be made in $p^+/n/n^+$ configuration with the segmented side being the p+. The prototype detector shown in Fig. 2 will have at least 1.5x3 cm2 size. It will have 30 pixels, each one is divided into 3 sub-pixels: X-strip-pixel, Pad1-pixel, and Pad2-pixel. All Pad1-pixels will be connected via a second metal to a bonding pad marked as Pad1, and all Pad2-pixels will be connected via a second metal to a bonding pad marked as Pad2. Readout wise the sensor will be configured into 30 strips with a strip pitch of 0.5 mm and two pads.

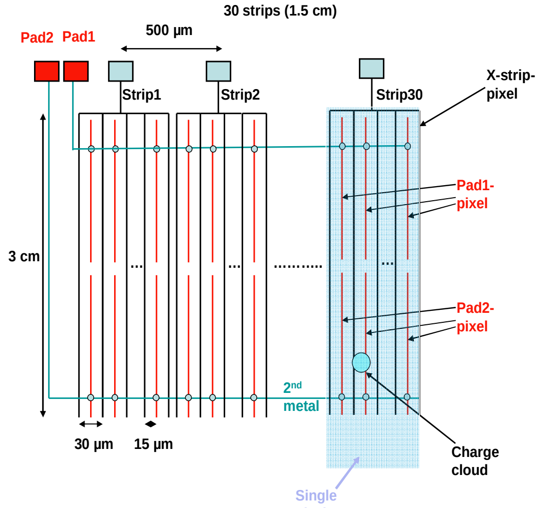

Fig. 2. Schematics of the proposed pixilated StriPad Si detector

An alternative to the single-sided StriPad detector is the standard double-sided Si detector with 500 µm pitch strips on the p^+ (junction) side, and big pads on the back n^+ (ohmic) side. This detector will however require double-sided processing technology, which will be much more complicated with more mask/lithography steps and less yield as compared to the single-sided process. The double-sided Si detectors are also radiation softer than single-sided ones due to the complicated surface arrangement in the back ohmic side. On the other hand this latter structure being technologically more challenging offers the advantage of reduced stray capacitances which may handicap the performance of the strip readout in the first option.

References

[1] Z. Li, “Novel Silicon Stripixel Detector: Concept, Simulation Design, and Fabrication”Nucl. Instrum. & Meth. Vol. 518, No. 3, (2004) 738-753

[2] J. Tojo, K. Aoki, H. En'yo Y. Fukao, Y. Goto, J.M. Heuser, Z. Li, H. Ohnishi, H. Okada, V. Radeka, V.L. Rykov, N. Saito, F. Sakuma, M. Sekimoto, K. Tanida, M. Togawa, and Y. Watanaabe; Development of a Novel Silicon Stripixel Detector for RHIC-PHENIX Detector Upgrade; BNL 73436-2004JA; IEEE Trans. Nucl. Sci. 51, No. 5, October (2004)2337-2340.

VITA (Principal Investigator)

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	1993	Doctor of Science degree from Institute for High Energy Physics in Protvino, Russia

Employment Record

Recent Publications

1. HUMAN SUBJECTS (Reference: DOE Order 443.1)

Are human subjects involved from BNL or a collaborating institution? Human Subjects is defined as "A living individual from whom an investigator obtains either (1) data about that individual through intervention or interaction with the individual, or (2) identifiable, private information about that individual". N

If **yes**, attach copy of the current Institutional Review Board Approval and Informed Consent Form from BNL and/or collaborating institution. Y/N __________

2. VERTEBRATE ANIMALS

Are live, vertebrate animals involved? Y/N N

If **yes**, attach copy of approval from BNL's Institutional Animal Care and Use Committee. Y/N __________

3. NEPA REVIEW

Are the activities proposed similar to those now carried out in the Department/Division which have been previously reviewed for potential environmental impacts and compliance with federal, state, local rules and regulations, and BNL's Environment, Safety, and Health Standards? (Therefore, if funded, proposed activities would require no additional environmental evaluation.) Y/N Y

If **no**, has a NEPA review been completed in accordance with the Subject Area National Environmental Policy Act (NEPA) and Cultural Resources Evaluation and the results documented? Y/N __________

(Note: If a NEPA review has not been completed, submit a copy of the work proposal to the BNL NEPA Coordinator for review. No work may commence until the review is completed and documented.)

4. ES&H CONSIDERATIONS

Does the proposal provide sufficient funding for appropriate decommissioning of the research space when the experiment is complete? Y/N Y

Is there an available waste disposal path for project wastes throughout the course of the experiment? Y/N Y

Is funding available to properly dispose of project wastes throughout the course of the experiment? Y/N Y

Are biohazards involved in the proposed work? If yes, attach a current copy of approval from the Institutional Biosafety Committee. Y/N N

Can the proposed work be carried out within the existing safety envelope of the facility (Facility Use Agreement, Nuclear Facility Authorization Agreement, Accelerator Safety Envelope, etc.) in which it will be performed? Y/N Y

If **no**, attach a statement indicating what has to be done and how modifications will be funded to prepare the facility to accept the work.

5. TYPE OF WORK Select Basic, Applied or Development Development

6. LINK TO LABORATORY STRATEGIC INITIATIVES

Identify below if the proposal is in support of RHIC, the Light Source, or any of the Strategic Initiatives that can be found listed at the LDRD web site, www.bnl.gov/ldrd.

Yes. Proposal is in direct support of: Evolution of RHIC to a QCD Lab

7. POTENTIAL FUTURE FUNDING

Identify below the Agencies and the specific program/office, which may be interested in supplying future funding. Give some indication of time frame.

Future funding for eRHIC/RHIC-II R&D by Division of Nuclear Physics of the Office of Science of the Department of Energy (DOE).

APPROVALS

Department /Division Administrator ______________________________
Print Name

Department Chair/Division Manager ______________________________
Print Name

Cognizant Associate Director ______________________________
Print Name

BUDGET REQUEST BY FISCAL YEAR

Department

Title

PI

(Note: Funding for more than 2 years is unlikely and cannot exceed 3 years)

COST ELEMENT	FISCAL YEAR _2010____	FISCAL YEAR _2011____	FISCAL YEAR _____	TOTAL COST
Labor* Post Doc @ 50% Fringe @31% Total Labor Organizational Burden @ ____ %	25k 7.75k	25k 7.75k		50k 15.5k
DISTRIBUTED TECHNICAL SERVICES				
Materials Supplies Travel Services Total MST Materials Burden @ ____%				
TECHNICAL COLLABORATORS/ CONSULTANTS				
Sub-contracts Contracts Burden @ ____%				
Electric Power Other (specify)				
Traditional G&A @ _____% Common Support G&A @_____%				
TOTAL PROJECT COST	100k	100k		200k
*Labor (give levels of effort with names, or if unknown indicate TBD) **Scientific & Professional** **Post Doc** **Other**				
Note: The Budget Office covers 20% of the Post Doc's salary/fringe.				
List all Materials Costing Over $5,000				