Discussion Materials for the PXPS Conveners Meeting

Thursday April 5th 2012

R. Tschirhart for the organizing committee:

S. Holmes, A. Kronfeld, S. Parke, E. Ramberg,
R. Tschirhart

Conveners for Experimental Concepts and Sensitivities

"Long Baseline Neutrinos" :

P. Huber (Virginia Tech) , K. Nishikawa (KEK, FNAL), [Steve Geer (FNAL)]

"Short Baseline Neutrinos":

A. de Gouvea (Northwestern University), G. Mills (LANL)

Muon Experiments:

R. Bernstein (Fermilab), [co-convener theorist, TBA]

Kaon Experiments:

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EDMs:

W. Haxton (Univ of California Berkeley), T. Chupp (Univ. of Michigan) , Zheng-Tian Lu (ANL)

n-nbar oscillations:

C. Quigg (FNAL), A. Young (North Carolina State University)

Enabling Technologies and Techniques Conveners

High rate Precision Photon Calorimetry:

D. Hitlin (Caltech), M. Diwan (BNL)

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R. Lipton (FNAL), J. Ritchie (University of Texas, Austin)

Time-of-Flight System Performance below 10 psec:

M. Albrow (FNAL), [co-convener TBA]

High Precision Measurement of Neutrino Interactions:

K. McFarland (Rochester), Jonghee Yoo (FNAL),), [co-convener TBA]

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M. Sanchez (Iowa State University), Y. Kamyshkov (University of Tennessee)

Lattice QCD:

Ruth Van de Water (BNL), Tom Blum (University of Connecticut)

The Project-X Research Program

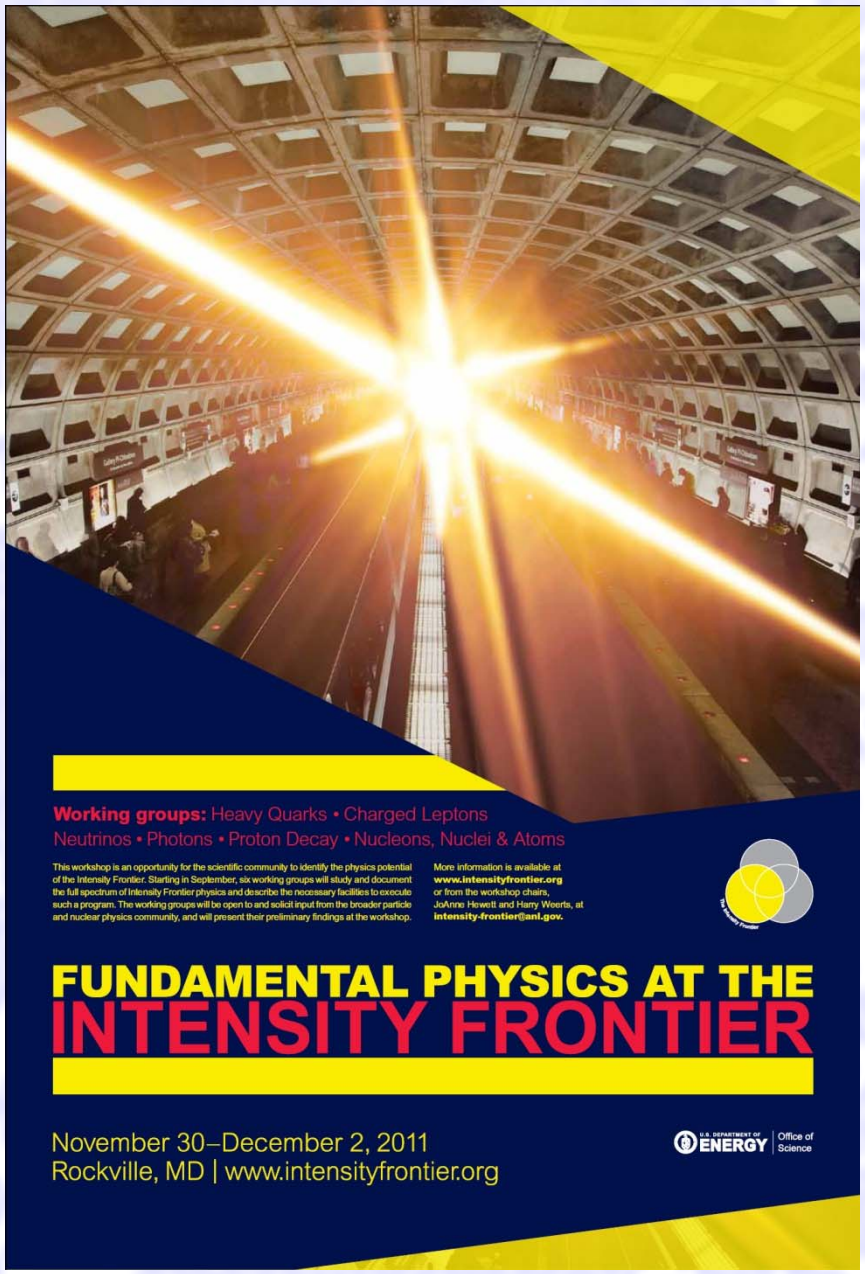
- ***Neutrino oscillation experiments***
- A high-power proton source with proton energies between 8 (3) and 120 GeV would produce intense neutrino beams directed toward near detectors on the Fermilab site and massive detectors at distant underground laboratories.

- ***Kaon, muon, nuclei & neutron precision experiments***
- These could include world leading experiments searching for muon-to-electron conversion, nuclear and neutron electron dipole moments (edms), precision measurement of neutron properties and world-leading precision measurements of ultra-rare kaon decays.

- ***Platform for evolution to a Neutrino Factory and Muon Collider***
- Neutrino Factory and Muon-Collider concepts depend critically on developing high intensity proton source technologies.

- ***Nuclear Energy Applications***
- Accelerator, spallation, target and transmutation technology demonstration which could investigate and develop accelerator technologies important to the design of future nuclear waste transmutation systems and future thorium fuel-cycle power systems.

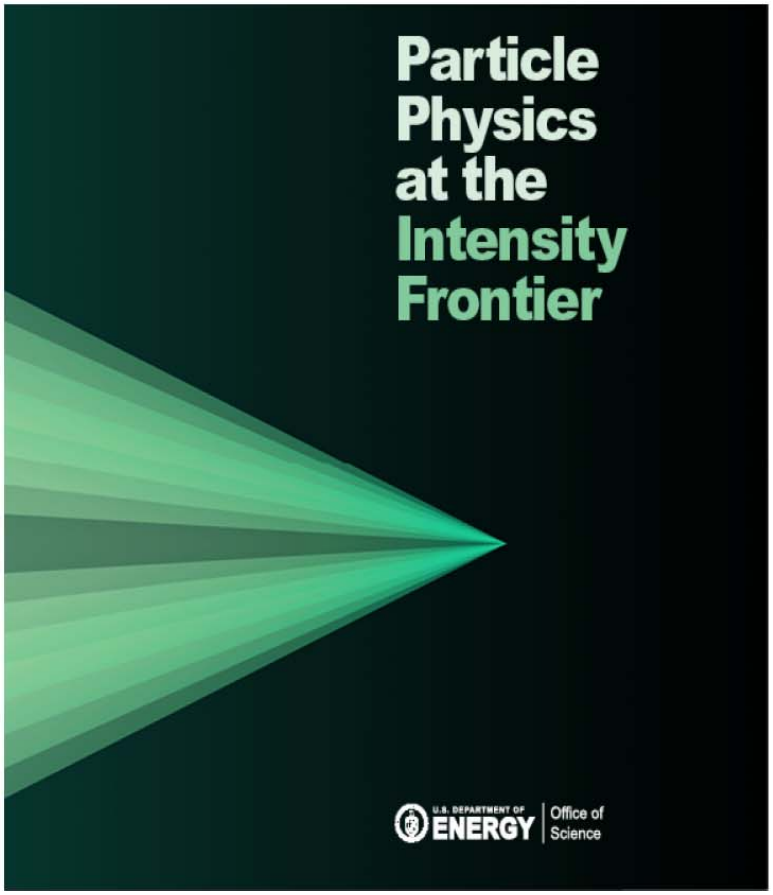
Detailed Discussion: Project X website



- 500+ Attendees
- Six very active working groups:
- Charged leptons
- Heavy Quarks
- Hidden Sector
- Neutrinos
- Nucleons/Nuclei/Atoms
- Proton Decay
- DOE OHEP listened…

(http://www.intensityfrontier.org/)

Vision for Program Development



Dr. Jim Siegrist, Associate Director
Office of High Energy Physics
Office of Science, U.S. Department of Energy

- Our domestic program is the world leader in 'Intensity Frontier' area, and we need to increase investments there, while keeping a balance with the other frontiers
- Community is engaged on further developing the science case on all 3 frontiers – we need a healthy portfolio of construction ideas supported by compelling science drivers at achievable budget levels
  - Will need more help from the community here; see also talks tomorrow
- Our program will deliver science now, in the near term, and in the long term on all 3 frontiers

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Presentation to the High Energy Physics Advisory Panel, March 12th 2012

HEP Priorities for the Next 12 Months

- Develop Mission Need statement for US participation in LHC detector upgrades
- Make critical decisions on Long Baseline Neutrino Experiment
- Issue solicitation for R&D leading to Next Generation Dark Matter Experiments and make selections
- Develop strategic plans for Intensity Frontier and Accelerator R&D programs

Community Assistance in Program Development

- **We need to continue to develop the science case and planned program on all 3 frontiers. We need more projects in the pipeline than we have budget to be certain the funding directed out of the program onto construction will not be lost.**
- **Plan for 'Snowmass' in summer 2013 to assess our program (neutrino and LHC results available for guidance)**
- **We need active participation of our community in the development of the science case, with lab leadership in the background. DOE and NSF agree on this approach.**
  - This is an inversion of the "traditional" HEP modus operandi
  - The HEP community needs to own the science case, and sell the science case
- **For the intensity frontier, DOE/NSF plan to work with DPF to continue the development of the science case started at the December workshop.**
  - FNAL will lead work on research infrastructure improvements to support that science case.
- **For the energy frontier, DPF could do the same, or the LHC users organization.**
  - Less time-critical than the intensity frontier, but discoveries at LHC could change this rapidly. Your thoughts are welcome.
- **For the cosmic frontier, HEP is less clear how to proceed.**
  - Solicitations for 2nd Generation Direct Dark Matter detection in place
  - Work is needed to further develop other parts of the program, especially in dark energy.

Intensity Frontier Issues

- **Science case development – see IF workshop talks yesterday**
  - **Continued community engagement a must**
  - Theorists need to engage in development of the program here
- **Generally, need more protons on target at FNAL to support the intensity frontier program.**
  - FNAL looking at options here
- **Program internationalization**
  - International contributions to our intensity frontier efforts will help stabilize our program

Project-X Accelerator
Functional Requirements*

CW Linac		
Particle Type	H^-	
Beam Kinetic Energy	1.0-3.0	GeV
Average Beam Current	1	mA
Linac pulse rate	CW	
Beam Power @ 3 GeV	3000	kW
Beam Power to 3 GeV program	2870	kW
RCS/Pulsed Linac		
Particle Type	protons/H^-	
Beam Kinetic Energy	8.0	GeV
Pulse rate	10	Hz
Pulse Width	0.002/4.3	msec
Cycles to MI	6	
Particles per cycle to Recycler	2.6×10^{13}	
Beam Power to 8 GeV program	190	kW
Main Injector/Recycler		
Beam Kinetic Energy (maximum)	120	GeV
Cycle time	1.3	sec
Particles per cycle	1.6×10^{14}	
Beam Power at 120 GeV	2200	kW

simultaneous

* http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=658

Power Staging for the Research Program

Project X

Project X Campaign

Program:	Stage-0: Proton Improvement Plan	Stage-1: 1 GeV CW Linac driving Booster & Muon, EDM programs	Stage-2: Upgrade to 3 GeV CW Linac (MI>70 GeV)	Stage-3: Project X RDR (MI>60GeV)	Stage-4: Beyond RDR: 8 GeV power upgrade to 4MW
MI neutrinos	470-700 kW**	515-1200 kW**	1200 kW	2300 kW	2300-4000 kW
8 GeV Neutrinos	15 kW + 0-50 kW**	0-40 kW* + 0-90 kW**	0-40 kW*	85 kW	3000 kW
8 GeV Muon program e.g, (g-2), Mu2e-1	20 kW	0-20 kW*	0-20 kW*	85 kW	1000 kW
1-3 GeV Muon program	-----	80 kW	1000 kW	1000 kW	1000 kW
Kaon Program	0-30 kW** (<30% df from MI)	0-75 kW** (<45% df from MI)	1100 kW	1100 kW	1100 kW
Nuclear edm ISOL program	none	0-900 kW	0-900 kW	0-900 kW	0-900 kW
Ultra-cold neutron program	none	0-900 kW	0-900 kW	0-900 kW	0-900 kW
Nuclear technology applications	none	0-900 kW	0-900 kW	0-900 kW	0-900 kW
# Programs:	4	8	8	8	8
Total* power (mean):	660 kW	1950 kW	4230 kW	5490 kW	11300kW

* Operating point in range depends on MI energy for neutrinos.

** Operating point in range is depends on MI injector slow-spill duty factor (df) for kaon program.

Project X Research Program Milestones…

- June 2012 Physics Study.
- Summer 2012 through Spring 2013:

Evolve existing white papers into comprehensive program.

- October 11th-13th 2012:

US particle physics town meeting at Fermilab preparing for "Snowmass", summer 2013.

- Snowmass, summer 2013:

Event to develop US strategies.

Project X Physics Study Deliverables

- **Conveners for Experimental Concepts and Sensitivities:**

Update white papers with a particular focus on quantitative physics sensitivities for each stage of Project X, and a road-map of studies up to Snowmass 2013.

- **Enabling Technologies and Techniques Conveners:**

Develop a roadmap of enabling technologies and as appropriate draft Field Work Proposals to the DOE OHEP for critical generic detector R&D.

Resources

- Intensity Frontier documentation and participants
- Project X physics workshops
- Project X white papers
- Detector R&D: Glen Crawford (DOE OHEP)
- Detector R&D at Fermilab : Erik Ramberg.

Resources for PXPS

- $25K from the FRA visiting scholars program to support travel for critical URA institution researchers.
- Some travel support for critical non-URA institution researchers.
- Indico site, conveners will all have pages and management access of these pages.
- The Short Baseline Neutrino Study Focus Group.
- Associated collaborations, LBNE staging study activity.
- Fermilab conference office. C. Sazama, S. Weber.
- Local Organizers.

Structure of Study

- Not a monolithic tiling of presentations over nine days. Not an attendance jamboree.

Suggestion of:

- 1 day of fully plenary: Thursday June 14th.
- 2 days of integrated parallel sessions between the enabling technology teams and the concept and sensitivities teams.
- Saturday June 16th PM BBQ, Sunday June 17th off.
- 3-4 days of focused working group activity with ala carte cross-term interaction with other groups.
- Dinner at Chez Leon (Thursday PM or Friday PM) followed by 1 day of closing plenaries.
- Embedded accelerator expert in each concept team.

Group Issues

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Group Issues

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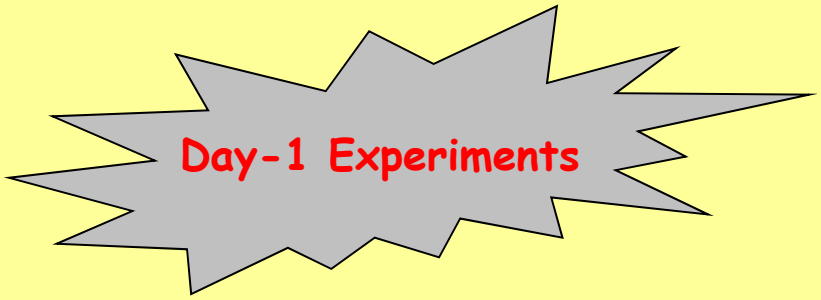
Common Issues

- Group conveners will meet separately and bi-laterally as necessary to develop agendas and assignments.
- Conveners are invited to give status reports at the four bi-weekly organizer meetings between now and June 14th.
- Final convener meeting will be June 4th-6th. Doodle pending.
- Indico site.
- Requests for travel support will be subject to convener recommendation.

Spare Slides

An Incomplete Menu of World Class Research Targets Enabled by Project-X

Neutrino Physics:



- **Mass Hierarchy**
- **CP violation**
- **Precision measurement of the θ_{23} (atmospheric mixing). Maximal??**
- Anomalous interactions, e.g. $\nu_\mu \rightarrow \nu_\tau$ probed with target emulsions (Madrid Neutrino NSI Workshop, Dec 2009)
- Search for sterile neutrinos, CP & CPT violating effects in next generation $\nu_e, \overline{\nu}_e \rightarrow X$ experiments….x3 beam power @ 120 GeV, **x10-x20 power @ 8 GeV**.
- Next generation precision cross section measurements.

An Incomplete Menu of World Class Research Targets Enabled by Project-X

Muon Physics:

Day-1 Experiment

- **Next generation muon-to-electron conversion experiment, new techniques for higher sensitivity and/or other nuclei.**
- Next generation $(g\text{-}2)_\mu$ if motivated by next round, theory, LHC. New techniques proposed to JPARC that are beam-power hungry…
- μ edm
- $\mu \rightarrow 3e$
- $\mu^+e^- \rightarrow \mu^-e^+$
- $\mu^- A \rightarrow \mu^+ A'$; $\mu^- A \rightarrow e^+ A'$; $\mu^- e^-(A) \rightarrow e^- e^-(A)$
- Systematic study of radiative muon capture on nuclei.

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Kaon Physics:

Possible Day-1 Experiments

- **$K^+ \to \pi^+ \nu\bar{\nu}$: >1000 events, Precision rate and form factor.**
- **$K_L \to \pi^0 \nu\bar{\nu}$: 1000 events, enabled by high flux & precision TOF.**
- $K^+ \to \pi^0 \mu^+ \nu$: Measurement of T-violating muon polarization.
- $K^+ \to (\pi,\mu)^+ \nu_x$: Search for anomalous heavy neutrinos.
- $K^0 \to \pi^0 e^+ e^-$: <10% measurement of CP violating amplitude.
- $K^0 \to \pi^0 \mu^+ \mu^-$: <10% measurement of CP violating amplitude.
- $K^0 \to X$: Precision study of a pure K^0 interferometer: Reaching out to the Plank scale ($\Delta m_K/m_K \sim 1/m_P$)
- $K^0, K^+ \to$ LFV: Next generation Lepton Flavor Violation experiments

...and more

An Incomplete Menu of World Class Research Targets Enabled by Project-X

Possible Day-1 Experiment

Nuclear Enabled Particle Physics:

- **Production of Ra, Rd, Fr isotopes for nuclear edm experiments that are uniquely sensitive to Quark-Chromo and electron EDM's. Production of Very-cold and Ultra-cold neutrons for EDM and n-nbar.**

Baryon Physics:

- $pp \rightarrow \bar{\Sigma}^{+} K^{0} p^{+}$; $\Sigma^{+} \rightarrow p^{+} \mu^{+} \mu^{-}$ (HyperCP anomaly, and other rare Σ^{+} decays)
- $pp \rightarrow K^{+} \Lambda^{0} p^{+}$; Λ^{0} ultra rare decays
- neutron – antineutron oscillations
- $\Lambda^{0} \leftrightarrow \bar{\Lambda}^{0}$ oscillations (Project-X operates below anti-baryon threshold)
- neutron EDMs