Project X at the Snowmass Intensity Frontier All Hands Meeting April 25th-27th @ ANL

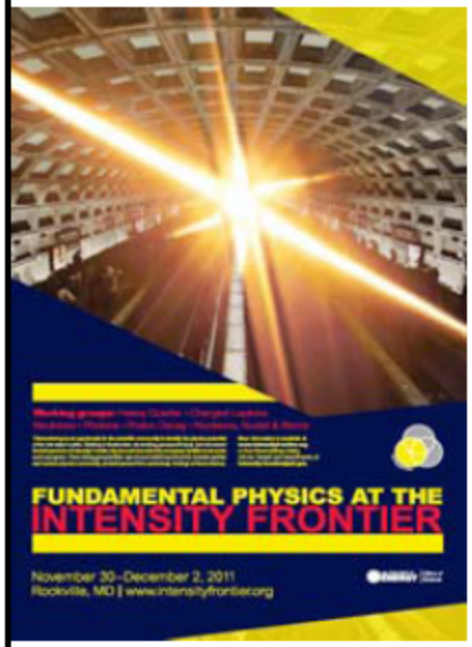
Link to All-Hands meeting:
(https://indico.fnal.gov/conferenceDisplay.py?ovw=True&confId=6248)

U.S. DEPARTMENT OF ENERGY

Fermilab

Intensity Frontier Workshop

SLAC



Fundamental Physics at the Intensity Frontier **: Rockville, MD Nov 30-Dec 2, 2011**

Jointly Sponsored by DOE office of HEP and Nuclear Physics

~500 participants

3 days of vibrant talks and discussion

Charge:

Document the science opportunities at the Intensity Frontier

Identify experiments and facilities needed for components of program

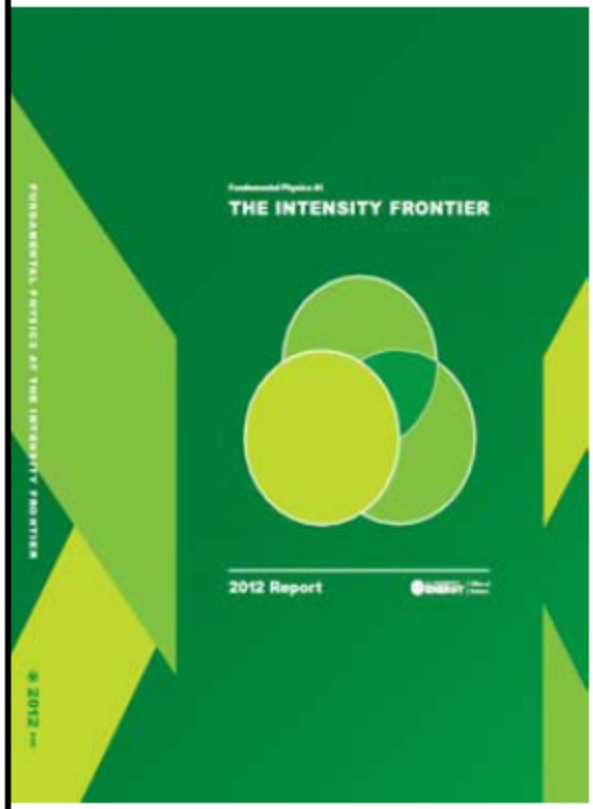
JoAnne Hewett, March 2013

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

Fermilab

Workshop Report

SLAC



arXiv:1205.2671

Everyone who contributed is an author

- ~ 440 authors
- ~ 220 pages

Contents:

- Exec Summary
- Chapter for each working group
- Technical Summary

JoAnne Hewett, March 2013

Intensity Frontier Plan for "Snowmass"

SLAC

- Follow same working group structure
- Incorporate recent results/plans in neutrino sector
- Continue to develop science case for next 2 decades
- Educate community on Intensity Frontier discovery potential so that community can communicate science to others
- Engage the full HEP community
- Further explore connections with other frontiers

Develop crisp message that captures the essence of Intensity Frontier science

JoAnne Hewett, March 2013

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

CSS13 Working Groups

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Quark Flavor Physics: Joel Butler, Zoltan Ligeti, Jack Ritchie	K, D & B Meson decays/properties
Charged Lepton Processes Brendan Casey, Yuval Grossman, David Hitlin	Precision measurements with muons, taus
Neutrinos Andre deGouvea, Kevin Pitts, Kate Scholberg, Sam Zeller	All experiments for properties of neutrinos. Accelerator & non-accel.
Baryon Number Violation Kaladi Babu, Ed Kearns	Proton decay, Neutron Oscillation
New Light, Weakly Coupled Particles Rouven Essig, John Jaros, William Wester	"Dark" photons, paraphotons, axions, WISPs
Nucleons, Nuclei & Atoms Krishna Kumar, Z.-T. Lu, Michael Ramsey-Musolf	Properties of nucleons, nuclei or atoms (EDM), as related to HEP

JoAnne Hewett, March 2013

All Hands Intensity Frontier Meeting

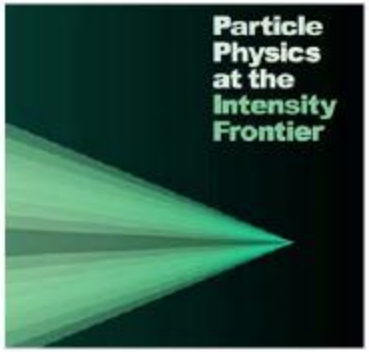
Intensity Frontier Workshop

25-27 April 2013 *Argonne National Laboratory*
US/Central timezone

- **Overview**
- Intensity Frontier Page
- Agenda
- Step 1: Register
  - Registration Form
- Step 2: Payment
- List of registrants
- Accommodations
- Where to Eat
- Transportation
- GreenLab Shuttle
- Child Care Options

Support

Registration is now open!



Please Register!!

As part of the ongoing 2013 Community Summer Study ("Snowmass") the Intensity Frontier working group will host an all-hands workshop on April 25-27, 2013 at Argonne National Laboratory. This workshop will directly follow a writers meeting of the Project X Physics Study which will be held at Fermilab on April 24, 2013.

Charge for the April 2013 Intensity Frontier Workshop

Develop a coherent and interconnected view of the Intensity Frontier that will be presented at Snowmass. Describe future facilities and experiments at the Intensity Frontier and their capabilities. Document the contributions of the Intensity Frontier towards addressing the major questions in particle physics and explain how and why it is complementary to the other frontiers, which together constitute experimental particle physics. Leave the workshop with a clear understanding of what the approach will be at Snowmass 2013.

JoAnne Hewett, March 2013

Project X in the process…

- Dec 2011: DOE IFW workshop, PX research themes generically discussed, no explicit discussion of PX in any summaries.
- May 2013: Intensity Frontier All Hands meeting, PX research themes and goals comprehensively discussed, explicit discussion of PX in every summary (IF1-IF6).

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

30 White Papers submitted that need accelerators as neutrino drivers

Super beams:

- Opportunities for Precision Tests of Three-Neutrino Mixing and Beyond with LBNE
- Precision Studies of Nucleon Structure and Medium Modifications with Neutrino Beams
- Hyper-Kamiokande Physics Opportunities
- Getting the Most Out of the On-Axis NuMI Beam
- Performance of a Low-Luminosity Low Energy Neutrino Factory
- Liquid Argon Near Detector for the BNB – Neutrino Intensity Frontier White Paper
- LAr1: Addressing the short-baseline anomalies
- Opportunities for Precision Neutrino Physics and Constraining Oscillation Systematics with an LBNE Near Detector
- NUMI Running with the LANL LDRD Liquid Argon TPC
- MiniBooNE+: A new investigation of oscillations with improved sensitivity in an enhanced MiniBooNE experiment
- Extending the NOvA Physics Program
- The MiniBooNE-II Proposal: A 5-sigma Test of MiniBooNE's Neutrino Mode Excess
- MINOS+: Using the NuMI Beam as a Precision Tool for Neutrino Physics
- A Second Detector at an Off-axis Location to Enhance the Mass Hierarchy Discovery Potential in LBNE
- Nonstandard Interaction in tau-neutrino nucleon scattering
- SciNOvA: A Measurement of Neutrino-Nucleus Scattering in a Narrow-Band Beam.
- CHerenkov detectors In mine PitS (CHIPS)A White Paper
- Proposal for a neutrino Super Beam using the ESS 5 MW, 2.5 GeV linac as proton driver
- Precision Neutrino Oscillation Measurements using Simultaneous High-Power, Low-Energy Project-X Beams

Decay-at-Rest (DAR) sources:

Whitepaper on Cyclotrons as Drivers for Precision Neutrino Experiments

Whitepaper on the DAEδALUS Experiment

Whitepaper on the IsoDAR experiment

Measuring Neutrino Cross Sections on Argon for Supernova Neutrino Detection

OscSNS: A Precision Neutrino Oscillation Experiment at the SNS

Searches for CENNS at the Spallation Neutron Source

Opportunities for Neutrino Measurements at the Spallation Neutron Source

Measuring CENNS in the Low Energy Neutrino Source at Fermilab

Muon storage rings and Neutrino Factories:

The Neutrino Factory

Nu-STORM: Neutrinos from STORed Muons

Cross section measurements at nu-STORM

Snowmass neutrino working group meeting SLAC, March 6th-7th 2013

30 White Papers submitted that need accelerators as neutrino drivers

Super beams:

- Concepts based on the 700kW 120 GeV Fermilab NuMI beam
- Concepts based on the 15kW+ 8 GeV Fermilab Booster Neutrino Beam
- Concepts based on the 700kW 120GeV Fermilab LBNE beam
- Concept based on the megawatt+ 30 GeV JPARC T2X beam.
- Concepts based on the 2300kW 60-120GeV Fermilab LBNE beam.
- Concept based on multi-Megawatt ESS beams.
- Concept based on dual multi-Megawatt Project-X beams illuminating LBNE.

Decay-at-Rest (DAR) sources:

- Concepts based on the 1000kW SNS Hg spallation target.
- Concept based on cyclotrons driving a nuclear beta decay target.
- Concept based on high power cyclotrons driving DAR sources.

Muon storage rings and Neutrino Factories:

- NuSTORM
- Low energy Neutrino Factory
- Neutrino Factory.

Snowmass neutrino working group meeting SLAC, March 6th-7th 2013

Project X presenters at All-Hands Meeting

- **Muons probes:**
  C. Cheng, B. Echenard, D. Glenzinski, R. Ray,
- **Kaon probes:**
  D. Jaffe
- **EDM probes:**
  Z. T. Lu
- **n-nbar probes:**
  T. Gabriel, Y. Kamyshkov, A. Young.
- **Hidden Sector probes:**
  A. Hatzikoutells, R. Van de Water

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

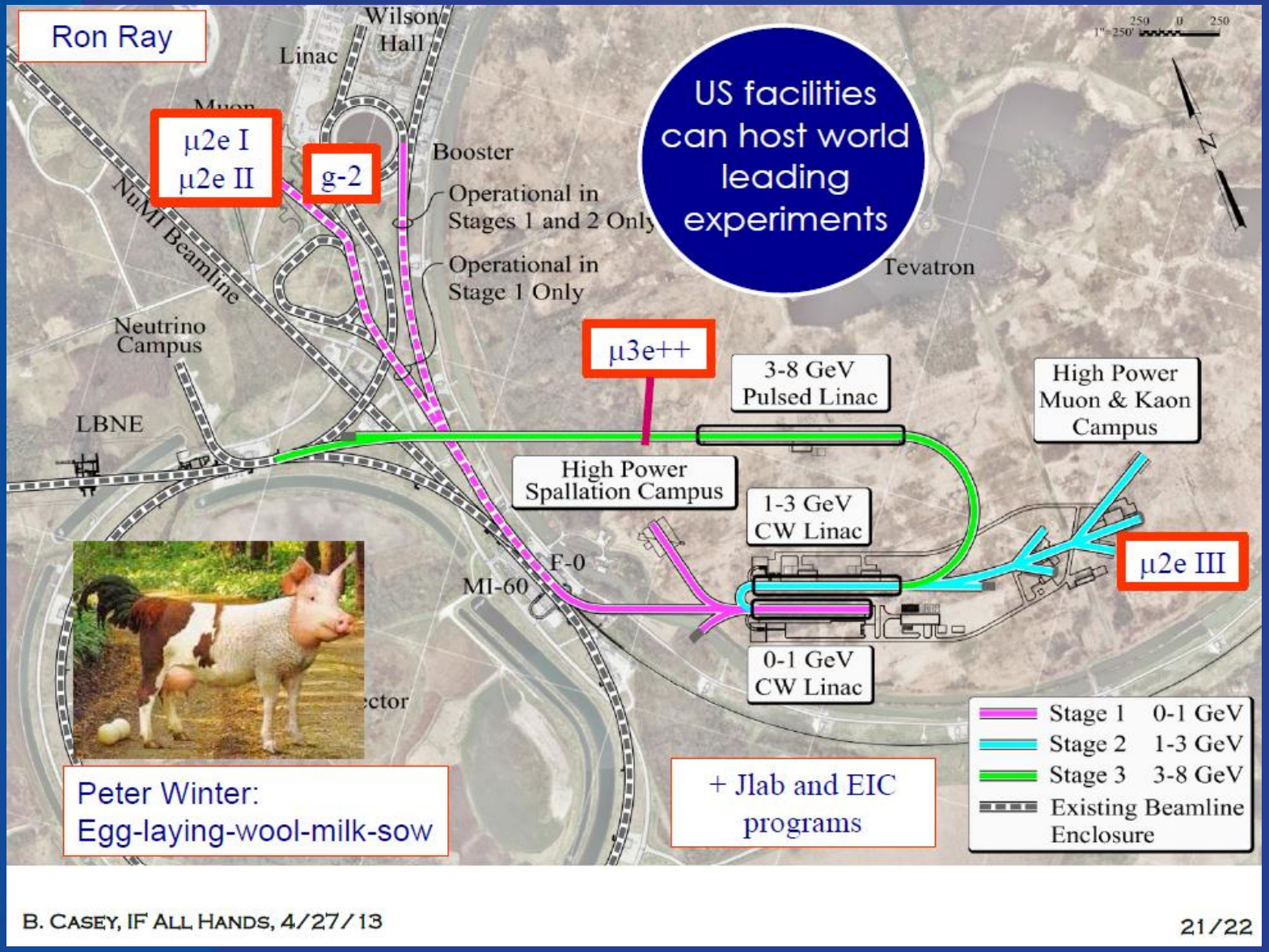
Summary

- Project X is an ideal platform for the next generation of kaon and muon experiments
  - Beam power and flexible beam parameters enable a broad program that addresses the unique requirements of each measurement.
  - Deliver substantial beam power simultaneously to multiple programs
  - Each stage of Project X is affordable and produces world class science
  - Staging of Project X matches well with the steps that can be made on the experimental side.
- When we build it, the world will come
  - At least the part of the world that is interested in neutrino, kaon and muon physics.

Summary

- A Mu2e-II at ~x10 better sensitivity relative to currently planned experiment
  - Interesting regardless of Mu2e outcome
  - Looks feasible at Project X
- Feasible because Project X offers important advantages:
  - High duty factor : re-use much of currently planned Mu2e
  - High power at low E_{beam} : get needed #muons without pbars
  - Narrow pulses, high intrinsic extinction: mitigate RPC bgd
- Plenty of work to do - if you're interested, please let us know.
  - Simulation tools exist… you can get started quickly!
  - douglasg@fnal.gov

Brendan Casey (Convener) Summary



R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

Quark Flavor Summary

Message for Snowmass

- Flavor physics probes far above the TeV scale.
  - A necessary complement to LHC if new physics is found there.
  - Probes above the reach of LHC and other foreseeable machines.
- Existing facilities at Fermilab can support unparalleled rare K decay experiments (ORKA, and potentially others).
  - A cost effective way to mount quark-flavor experiments in **this** decade with significant potential to uncover new physics.
  - This opportunity is not open-ended (the world won't wait).
- Project X can open a new regime of sensitivity for rare K decay experiments in the next decade.
  - An order of magnitude beyond other kaon sources in the world.
- B-physics and charm physics will be led by non-U.S. programs for the foreseeable future.
  - These programs will do great physics! The U.S. should be actively involved in these experiments (Belle II and LHCb).

April 27, 2013 Argonne IF Workshop 30

J. Ritchie

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

Baryon Number Violation Summary (Kearns)

- We need new ideas on how to take nucleon decay search to the next scale (beyond 1e35). Deep ice?
- A free neutron antineutron is an appealing method to pursue BNV, perhaps in the absence of proton decay.
- Observation of neutron antineutron oscillation would signal new physics at the 100 TeV scale and may fit in with new physics at higher scales.
- There is a specific proposal being evaluated for operation with Project X (NNBARX). The reach in free lifetime can be as high as 50x better than the current result.

LBNE

- Consensus has emerged that the “Baseline” concept in any staged scenario starts with a detector underground.
- Underground construction adds a premium to the cost/detector-mass, underscoring the importance of Project X in the neutrino physics FOM of (detector-mass x beam-power).

R. Tschirhart, Snowmass IF All Hands meeting summary, May 3rd, 2013

Issues and next steps for research program:

- Research Program document: Final draft posted May 31st, ready for Users Meeting.
- Staging dialog: Staging is an *opportunity*, not a requirement. Project X advances every research program element at every stage.
- Must up our game on targetry and beam delivery systems in FY14.

The Project-X Research Program

- ***Neutrino experiments***

A high-power proton source with proton energies between 1 and 120 GeV would produce intense neutrino sources and beams illuminating near detectors on the Fermilab site and massive detectors at distant underground laboratories.

- ***Kaon, muon, nuclei & nucleon precision experiments***

These could include world leading experiments searching for lepton flavor violation in muons, atomic, muon, nuclear and nucleon electron dipole moments (edms), precision measurement of neutron properties (e.g. n,nbar oscillations) 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.

- ***Material Science and Nuclear Energy Applications***

Accelerator, spallation, target and transmutation technology demonstrations which could investigate and develop accelerator technologies important to the design of future nuclear waste transmutation systems and future thorium fuel-cycle power systems. Possible applications of muon Spin Resonance techniques (muSR). as a sensitive probes of the magnetic structure of materials .

Detailed discussion on Project X website

Example Research Program, definitive space of accelerator parameters on PXPS Indico site

Project X Campaign

Program:	Onset of NOvA operations in 2013	Stage-1: 1 GeV CW Linac driving Booster & Muon, n/edm programs	Stage-2: Upgrade to 3 GeV CW Linac	Stage-3: Project X RDR	Stage-4: Beyond RDR: 8 GeV power upgrade to 4MW
MI neutrinos	470-700 kW**	515-1200 kW**	1200 kW	2450 kW	2450-4000 kW
8 GeV Neutrinos	15 kW +0-50kW**	0-42 kW* + 0-90 kW**	0-84 kW*	0-172 kW*	3000 kW
8 GeV Muon program e.g, (g-2), Mu2e-1	20 kW	0-20 kW*	0-20 kW*	0-172 kW*	1000 kW
1-3 GeV Muon program, e.g. Mu2e-2	-----	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	1870 kW	1870 kW
Nuclear edm ISOL program	none	0-900 kW	0-900 kW	0-1000 kW	0-1000 kW
Ultra-cold neutron program	none	0-900 kW	0-900 kW	0-1000 kW	0-1000 kW
Nuclear technology applications	none	0-900 kW	0-900 kW	0-1000 kW	0-1000 kW
# Programs:	4	8	8	8	8
Total max power:	735 kW	2222 kW	4284 kW	6492 kW	11870kW

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

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