Project X WG2 Summary

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Project X Research Program Scientist
Collaboration meeting
April 10-12, 2012

U.S. DEPARTMENT OF ENERGY

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Focus Working Group #2 Goals for this Meeting…

- Understand and begin to capture the requirements for atomic fountain edm experiments driven with an ISOL source.
- Continue to capture and understand the requirements of an ultra-cold neutron source for neutron-edm and neutron-antineutron oscillation experiments.
- Begin the capture the elements of a Materials & Technology test-stand roadmap. What is the role of Project-X in this roadmap?

Power Staging for the Research Program

Project X Campaign

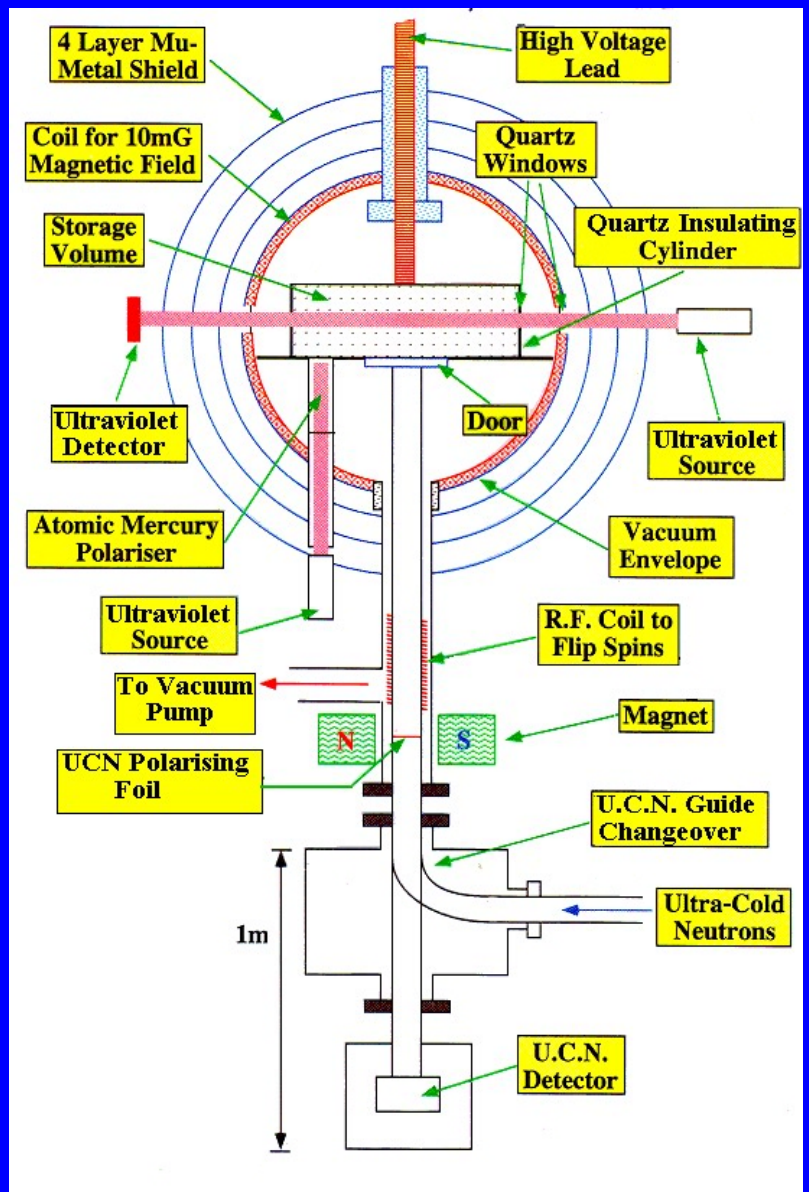
2017 2021

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:	585-735 kW	1660-2240 kW	4230 kW	5490 kW	11300kW

* 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.

The ILL n-EDM Experiment



$$\delta d = \frac{\hbar\sqrt{2}}{4} \cdot \frac{1}{E} \cdot \frac{1}{\sqrt{N\tau T}}$$

- Ramsey separated-field method
- N = 13,000; n~1/cm^3
- Storage time: τ = 130 s
- E = 4.5 kV/cm
- ^{199}Hg co-magnetometer
- Statistics-limited

From D. Budker

Tuesday April 10th WG2 focus on nEDM and atomic EDMs.
nEDM Findings:

- Difficult experiments, a diverse program world-wide pursuing different techniques all of which benefit from a higher UCN density/cm^3
- Different techniques require different duty factors. PSI cyclotron approach based on 1% df chopped beam, turns 1 MW -> 10 kW.
- Opportunities exist to mentor junior colleagues and grow the community in ultra-cold neutron R&D.
- ISOL: Atomic EDMs do clearly benefit from CW beam.

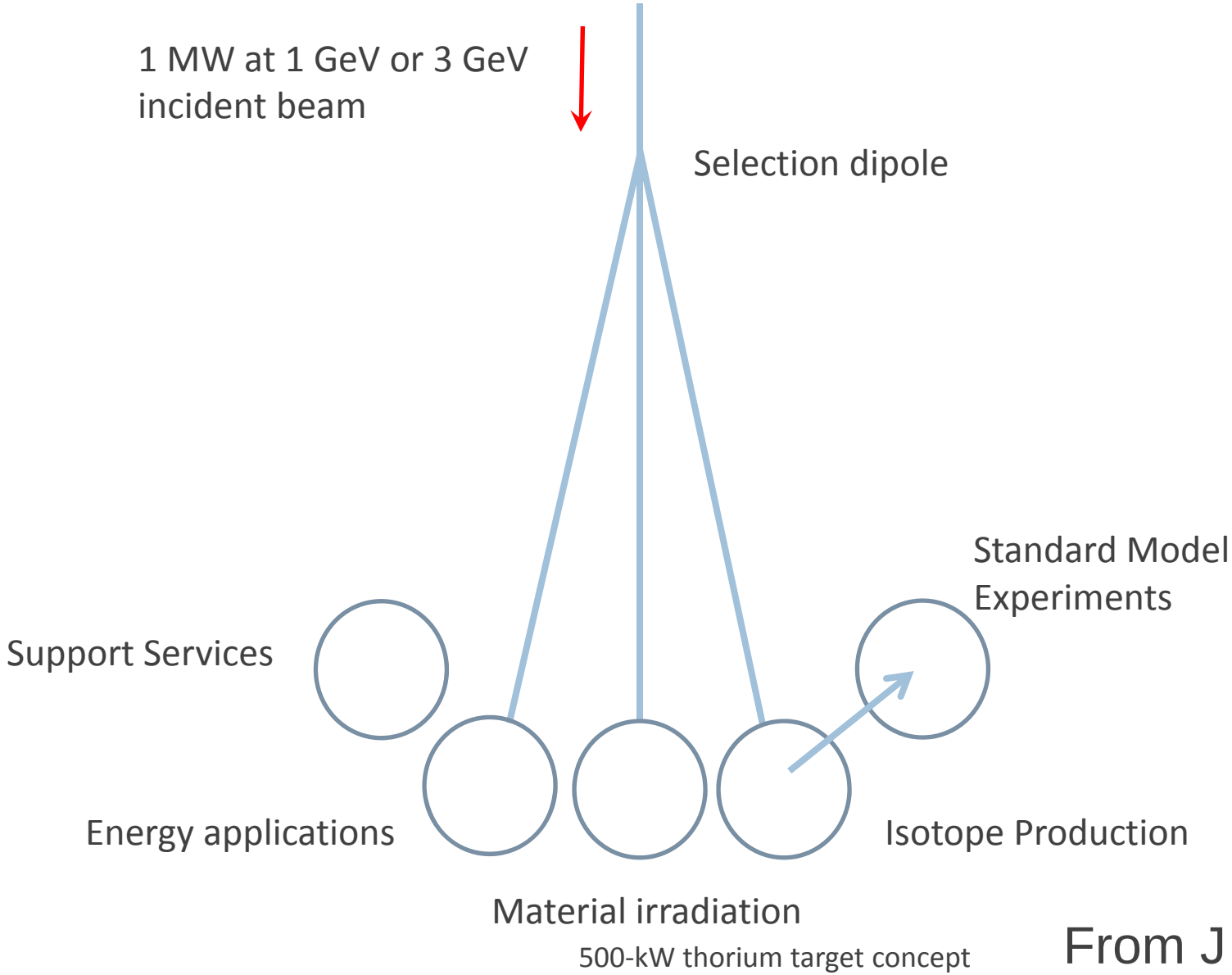
Tuesday April 10th WG2 focus on nEDM and atomic EDMs.
nEDM Action items:

- UCN source design: Work with the UCN community in June at the PXPS to develop source concepts optimized for nEDM.
- Duty Factor: As part of the UCN source design effort, determine the optimum duty factor and beam power requirements.

Tuesday April 10th WG2 focus on nEDM and atomic EDMs.
Atomic EDM Findings:

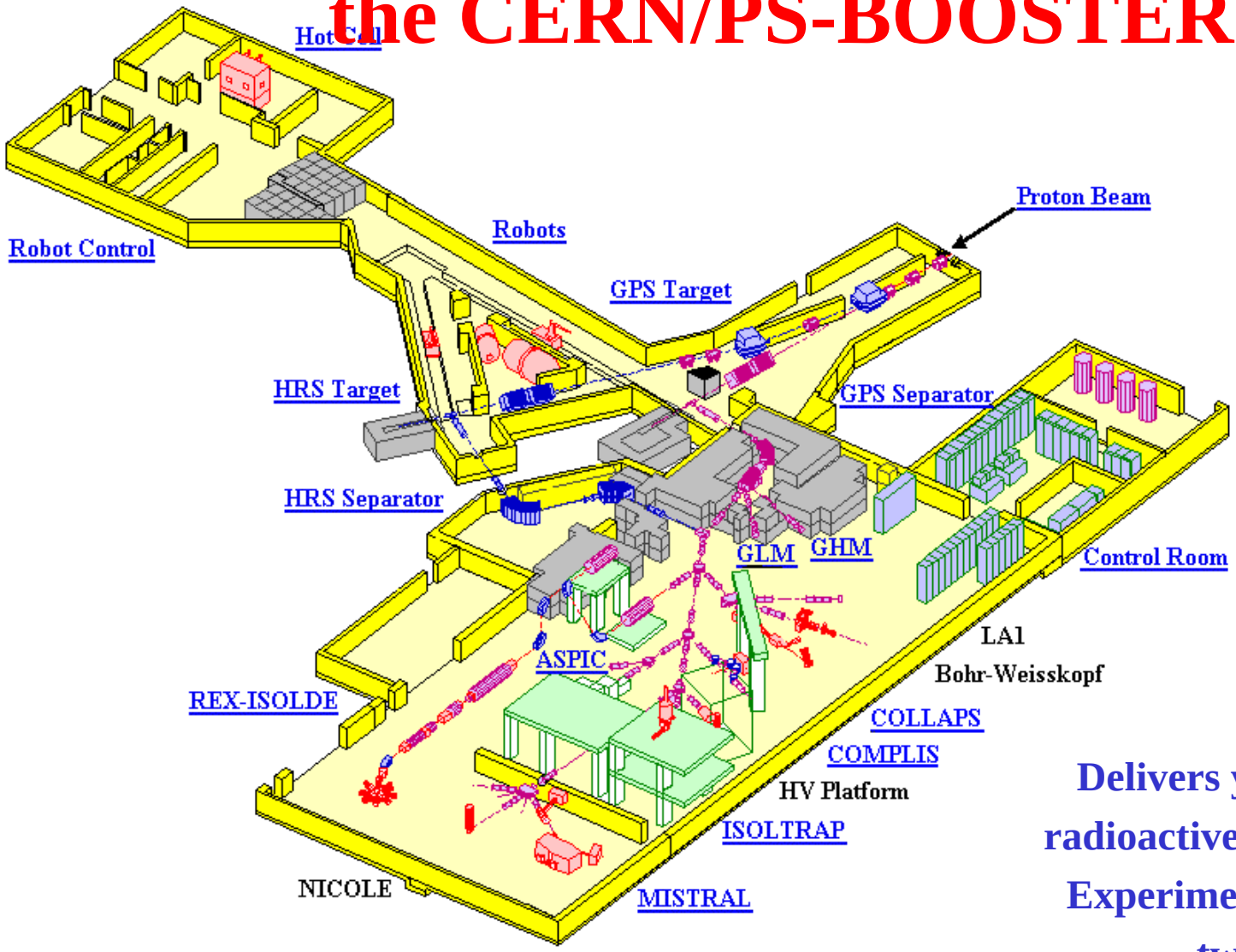
- A suite of EDM studies in different systems are much more powerful than the “sum”.
- The Atomic EDM ISOL research clearly benefits from CW beam.
- Conceptual designs exist for Atomic EDM research stations.
- PXIE presents an opportunity for an EDM target irradiation facility and a Stage-0 research program with fission fragments.

Functional Layout of the Joint Facility at Project X



From J Nolen

The Isotope Separator On-Line ISOLDE at the CERN/PS-BOOSTER



Proton beam:

1 -1.4 GeV

3E13 per pulse

2.4 μs pulse length

Rep. Rate 0.5 Hz

Max. current 4 μA

5.6 kW beam power

Delivers yearly 3200 h of radioactive ion-beam to 30 Experiments by means of two target stations

500-kW thorium target concept

From J Nolen

Tuesday April 10th WG2 focus on nEDM and atomic EDMs.

Atomic EDM Action items:

- Work with the theory community to analyzed a communicate the power of multiple-EDMs to constrain new physics.
- Using the RIA/FRIB planning and available documentation as a basis, develop a pre-conceptual design and cost-estimate for the fundamental physics ISOL station.
-
- Understand the research and irradiation opportunities afforded with PIXE.

Wednesday April 11th WG2 focus on Testing environments and energy applications.

Testing environment findings:

- Strong case exists for a “target science” approach to next-generation target designs based on developing the fundamental material science with test stations.
- Test stations exist (e.g. BLIP) and advanced (CD1 level) proposals for next generation test stations exist (MTS) driven by spallation sources.
- A reactor and CW spallation target environment can be well modeled with a pulsed proton source greater than 100-1000Hz. Point in this range is application dependent.

Wednesday April 11th WG2 focus on Testing environments and energy applications.

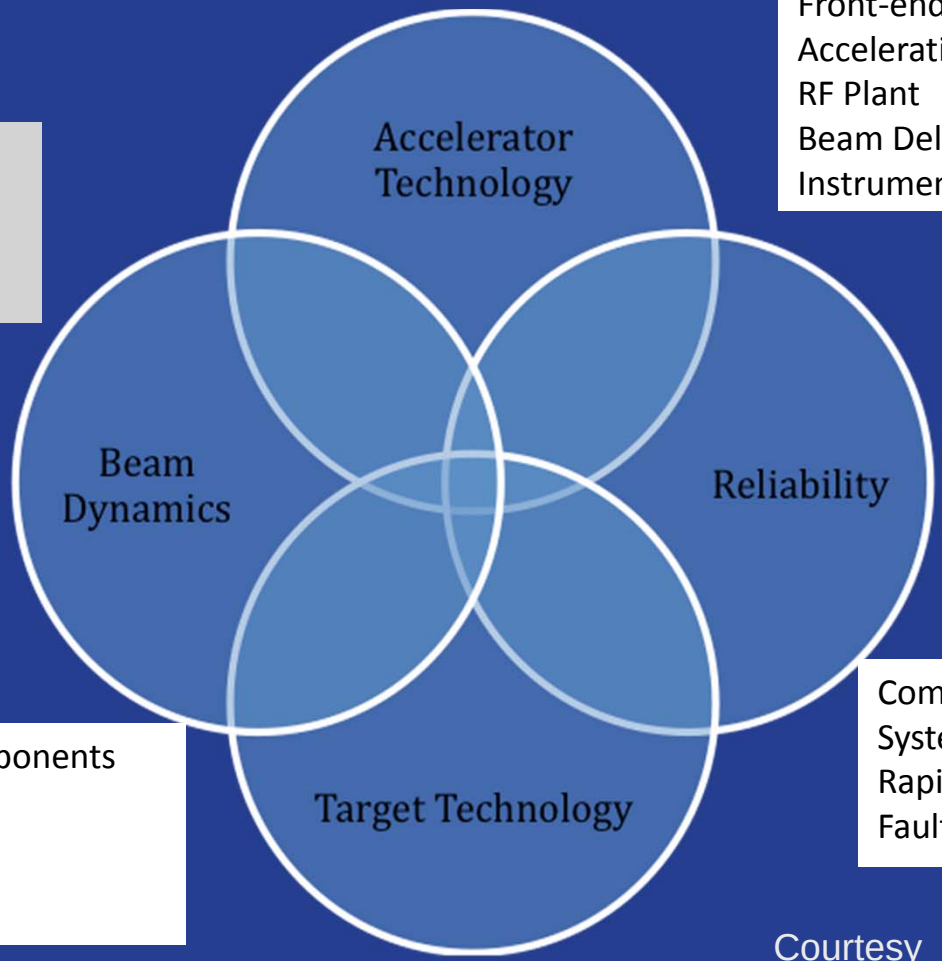
Testing environment action items:

- Continue to develop testing environment requirements for the Project X particle physics research program and communicate these to the testing community.
- Understand and develop a Project X test facility in the context of the well developed Materials Test Stand MTS initiative at LANL.

Key technologies to ADS:
Many of the most challenging technical issues are inter-related…

Front-end
Acceleration Section
RF Plant
Beam Delivery System
Instrumentation and Controls

Beam Quality
Beam Loss Mechanisms
Fault Tolerant Design
Beam-Target Interface



Component-level Reliability
System-level Reliability
Rapid-fault recovery
Fault tolerance

Liquid-metal target components
Chemistry Control
Remote Handling
Windowless Design

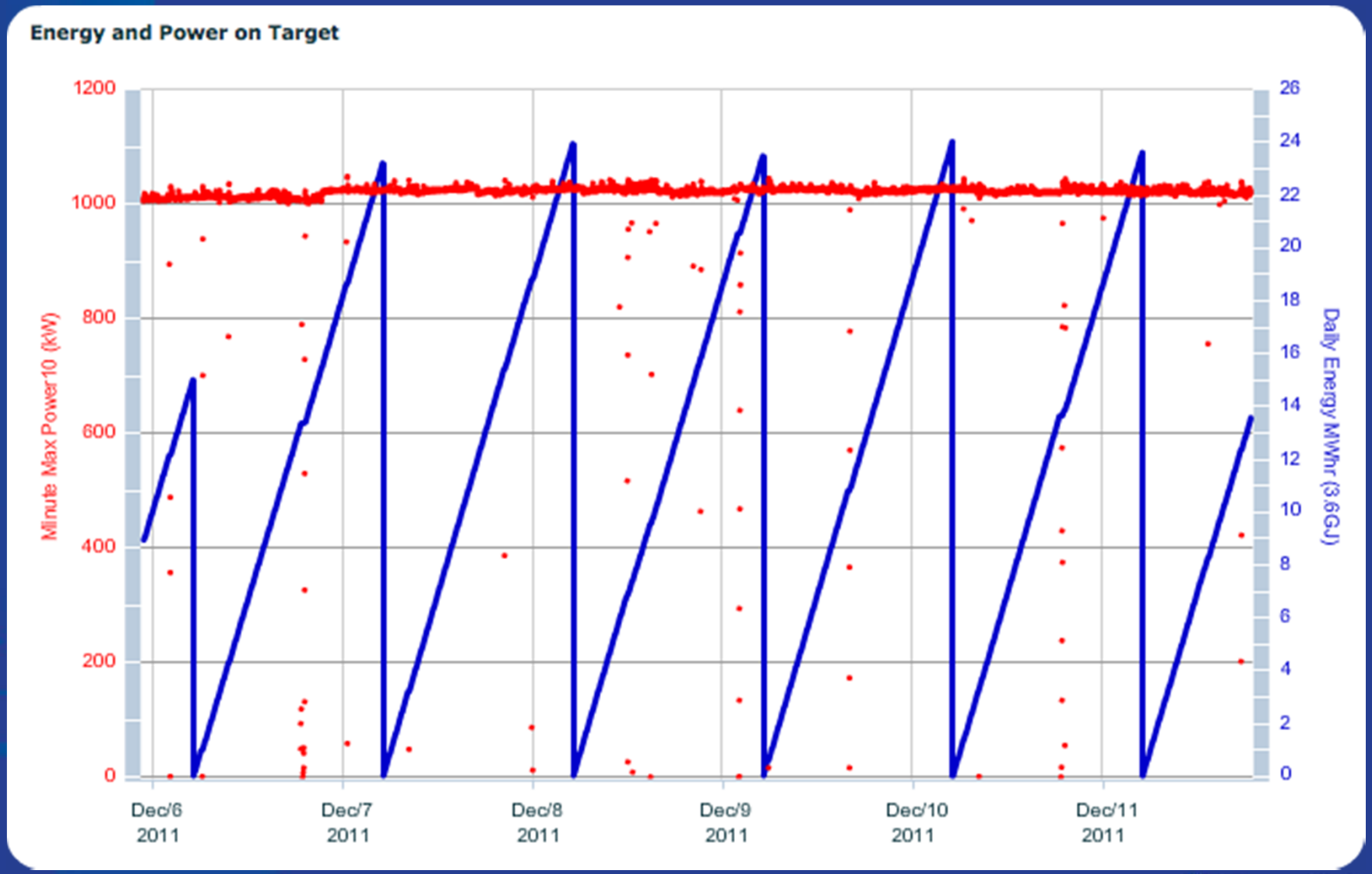
Courtesy Stuart Henderson, FNAL

Wednesday April 11th WG2 focus on Testing environments and energy applications.

Energy Applications Findings:

- The "Accelerator and Target Technology for Accelerator Driven Transmutation and Energy Production" white paper makes a strong case that SCRF accelerator technology is mature enough to consider development of "demonstrator" ADS designs.
- The time scale for a call for this development is not clear.
- Project X does offers an opportunity for a "demonstrator for the demonstrator"--- in particular demonstration of linac reliability and exquisite control of beams.

Performance of SNS, a MW-class Proton Linear Accelerator



E. Pitcher, S. Henderson

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Energy Application action items:

- Work to emphasize that “linac reliability and exquisite control of beams” is core to the Project X science program.
- In developing Project X machine performance metrics be conscious of the metrics described in the “Accelerator and Target Technology for Accelerator Driven Transmutation and Energy Production” white paper.

Associated Action Items

- ✓ Work to validate estimates of Booster and Main Injector performance in Stage-1
- ✓ Work closely with the ongoing LBNE staging activity
- Explore irradiation and “ISOL-lite” research program opportunities with PXIE.