# Project X WG2 Summary

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

U.S. DEPARTMENT OF ENERGY

Fermilab

# Focus Working Group #2 Goals for this Meeting…

- Understand and begin to capture the requirements for atomic fountain edm experiments driven with a thorium spallation source.
- Continue to capture and understand the requirements of sources for ultra-cold neutrons 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

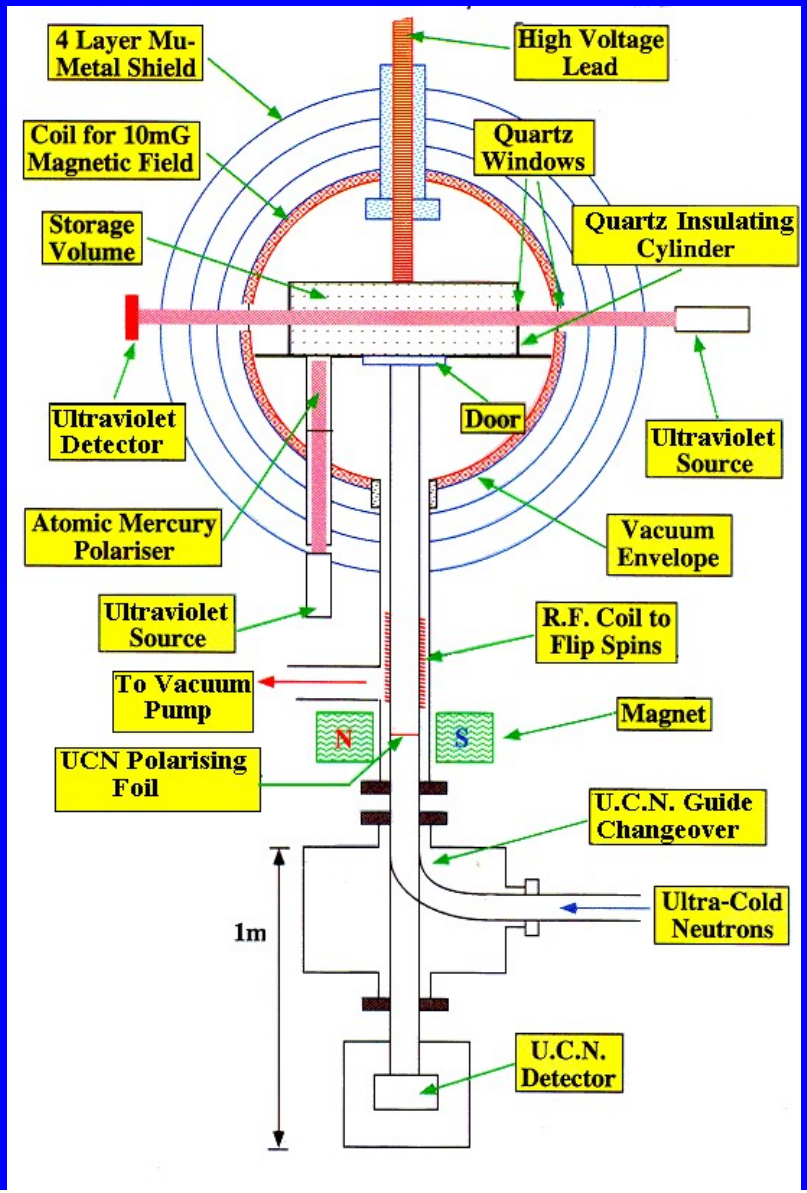
2017 2021

| 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: $\tau$ = 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.
- High-Z atomic EDMs do clearly benefit from CW beam.

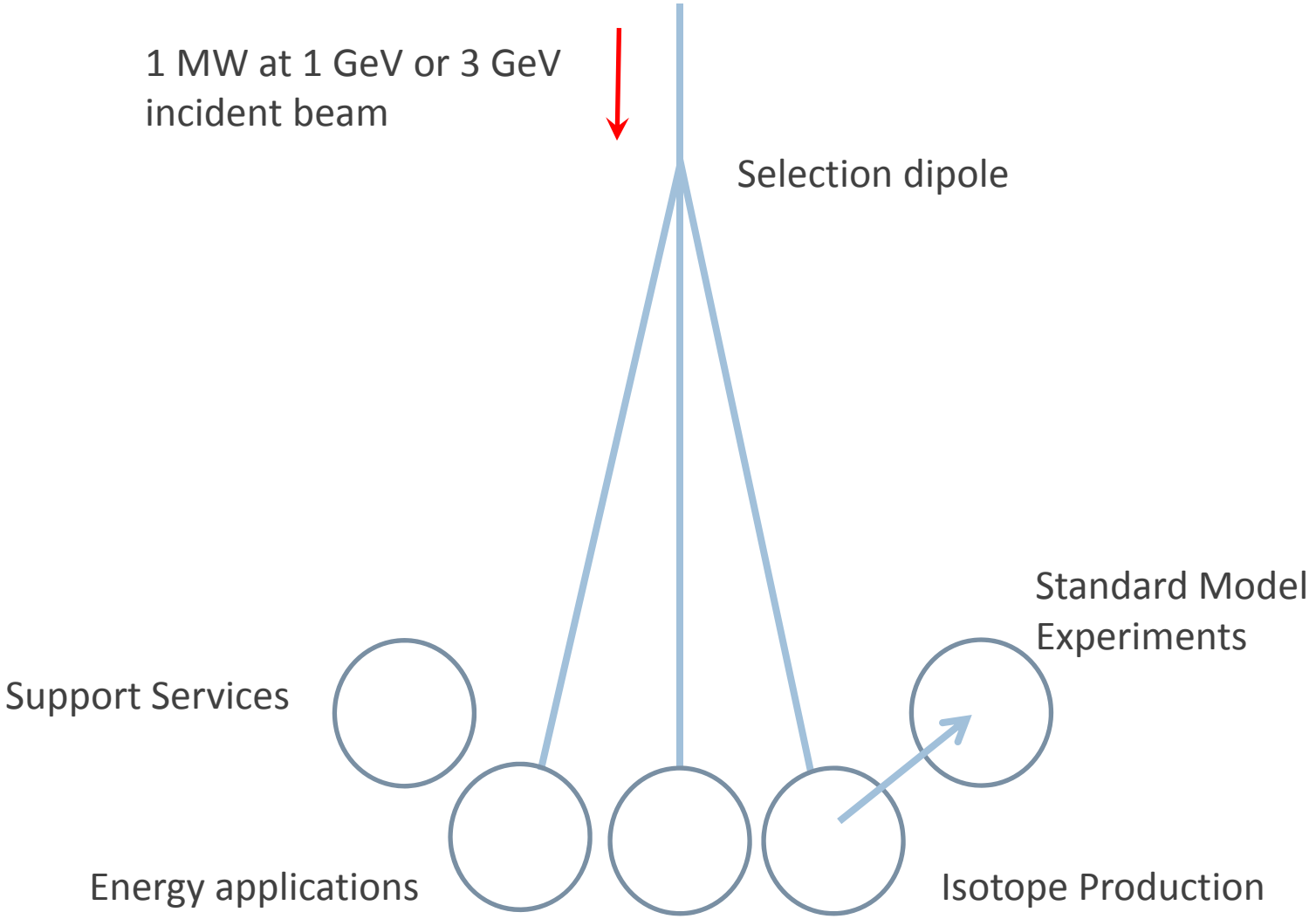
# Tuesday April 10th WG2 focus on nEDM and atomic EDMs.
## nEDM Action items:

- 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, moderator and beam power requirements.

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

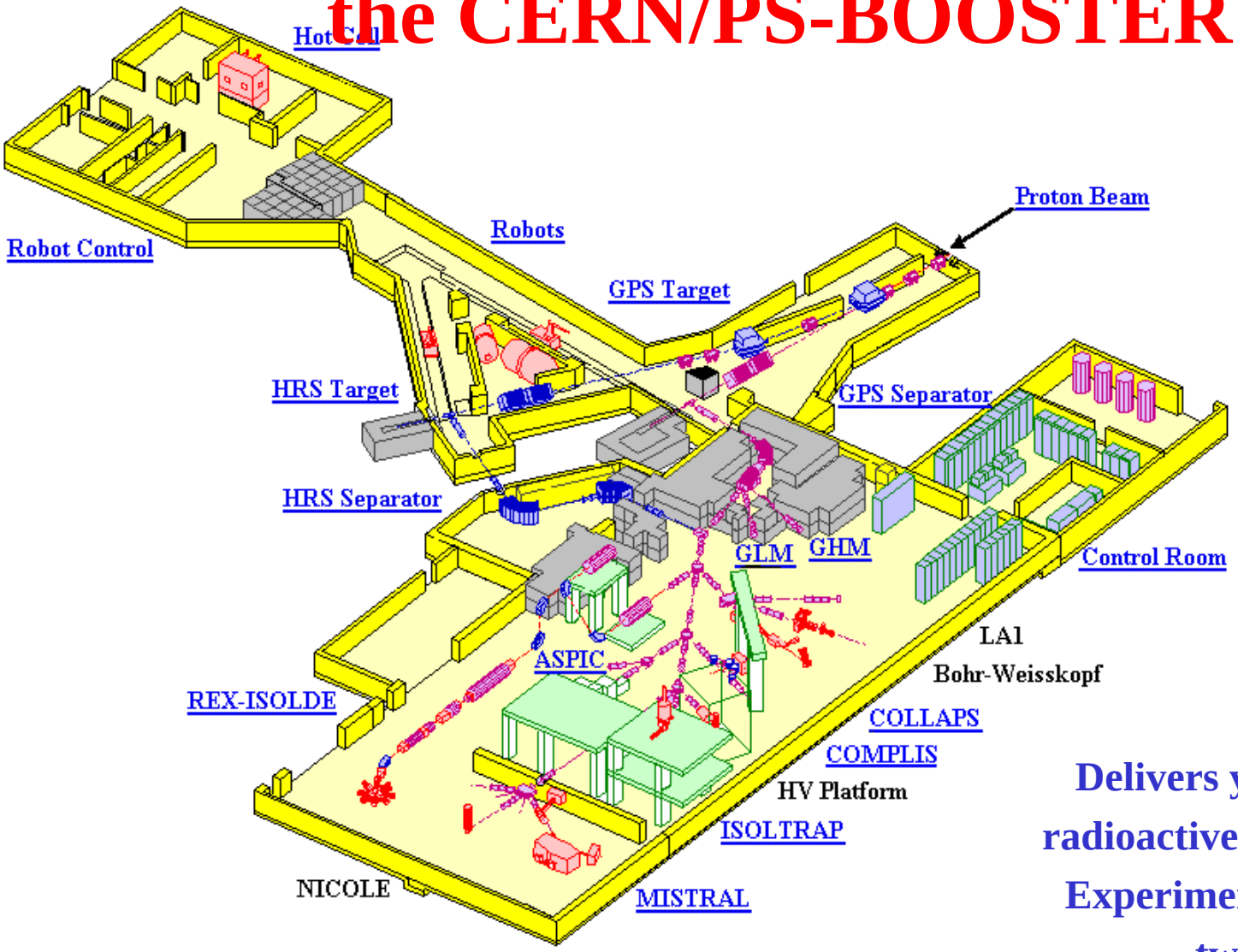
- A suite of EDM studies in different systems are much more powerful than the “sum”.
- High-Z Atomic EDM research clearly benefits from CW beam.
- Conceptual designs exist for Atomic EDM research stations.
- PXIE presents an opportunity for an EDM target irradiation facility and a Stage-0 research program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

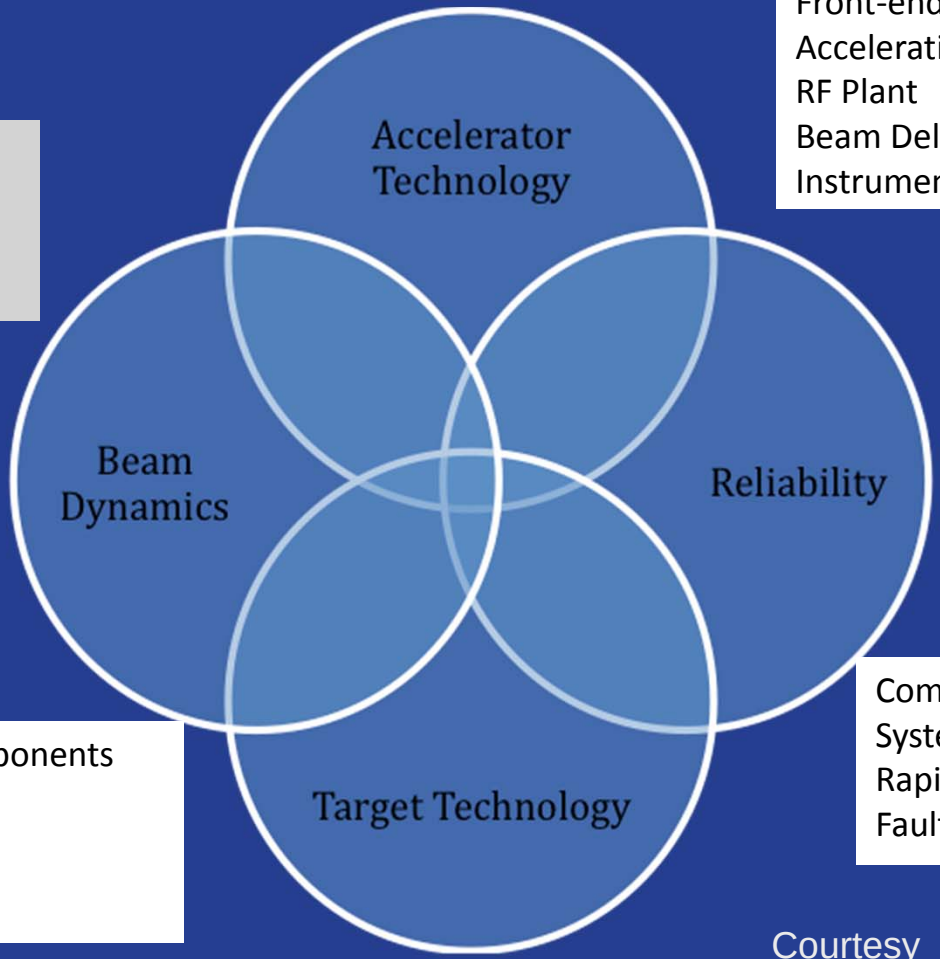
## Testing environment action items:

- 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

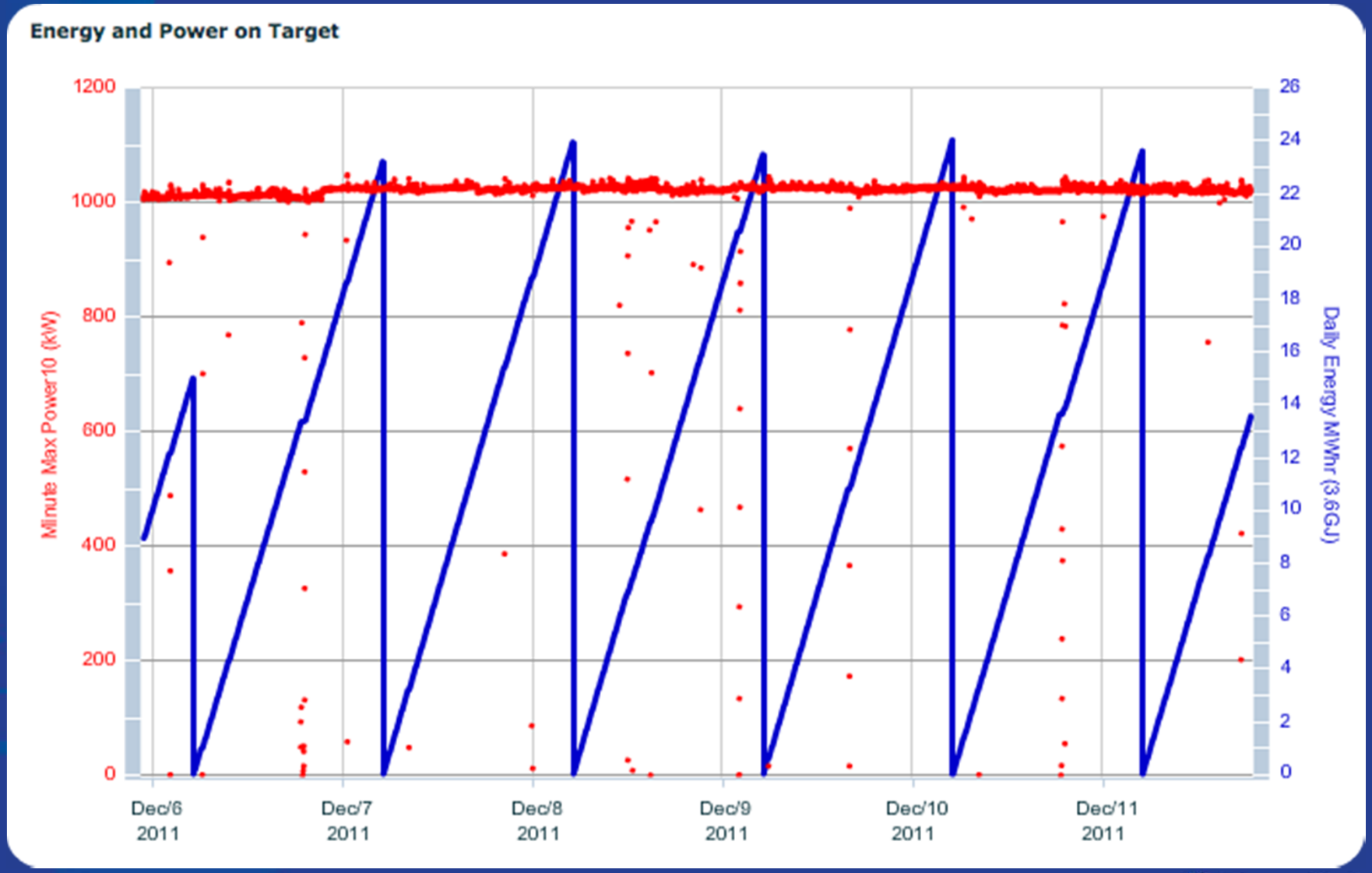
Courtesy Stuart Henderson, FNAL

# 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 isotope research program opportunities with PXIE.