CATHODE SCINTILLATOR DETECTOR FOR ELECTRO-CHEMISTRY

Kenneth Conley, Principal Investigator,
Energetics Technology Center

Washington, DC
September 8, 2023

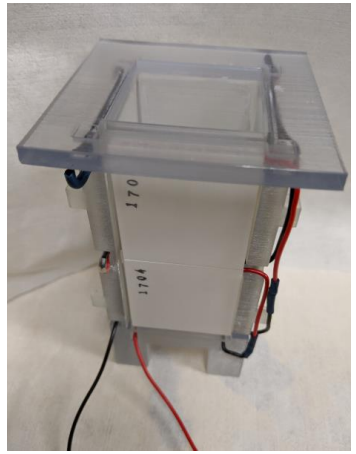
ARPA-E LENR: Energetics Technology Center

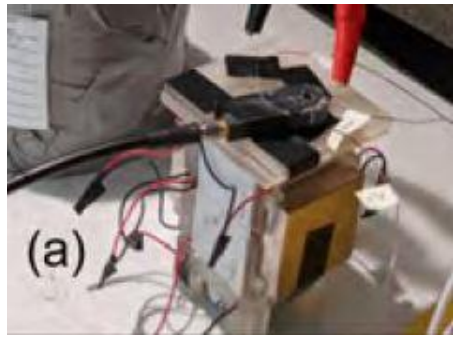
- **Project Title:**
  - CATHODE SCINTILLATOR DETECTOR FOR ELECTRO-CHEMISTRY

- **PI:**
  - Kenneth Conley
  - Energetics Technology Center
    - kconley@etcmd.com

- Project Outcomes:

- Direct correlation established between LENR co-deposition experimental conditions and nuclear product generation
- Peer-reviewed publication of results and theoretical analysis, with experimental detail to replicate results and extend theory





Operating Cell

KEY TAKEAWAY: Proving LENR Exhibits Nuclear Activity will promote accelerated R&D by broad scientific community, leading to high-impact, low-cost, zero-carbon power generation.

Hypothesis

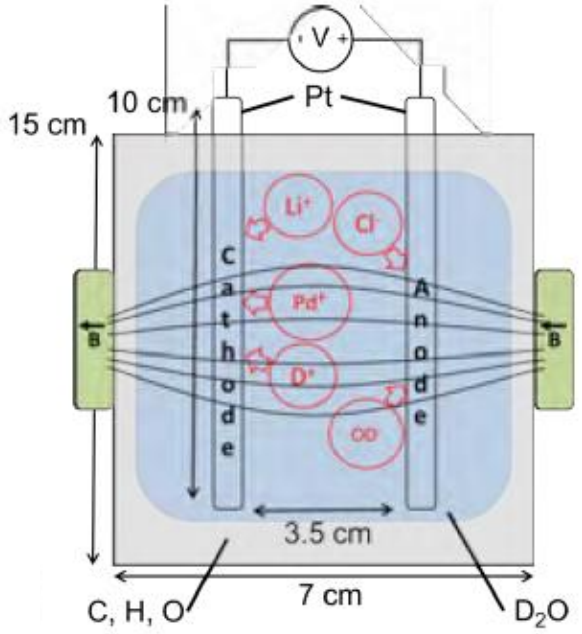
- Electrochemical co-deposition of a deuterated palladium metal compound, on a metal substrate, will result in a dendritic structure on the substrate, comprising an environment that can generate and sustain LENR reactions. These LENR reactions will result in MeV-energy particles and/or gamma rays that can be detected at 3σ significance in real-time by charged particle (alpha, beta, proton), neutron, and/or gamma detectors.

Primary Variables and Values		
Variable Type	Variable	Value
Independent	$PdCl_2$ Molarity	1.25 millimolar (mM)
Independent	Constant Current (steps)	0.1 – 1.1 amp
Dependent	He gas	0.1% resolution
Dependent	1-3 MeV Neutrons	1 – 25 min^{-1}
Dependent	1 – 10 MeV Charged Particles (α, ß, p)	10 – 250 min^{-1}
Dependent	1 – 25 MeV gamma rays	1 – 10 min^{-1}

Experimental Teams

- Experiments conducted by two teams:
  - NSWC Indian Head Team Led by Mr. Brian Shaffer
    - Very Similar to the DARPA HIVER experiments
    - Looking to work closely with Capability Teams to determine nuclear activity
    - Includes some DFT modeling efforts to support testing and explain phenomena
  - Naval Research Lab “COSINE” Effort Led by Dr. Scott Mathew
    - Unique Experimental Designs to allow for nuclear activity detection

Experimental Setup – NSWC Indian Head



Cell Cross-Section

Experimental Materials

Chemical or Other Component	Amount / Molar Concentration	Purity / Grade	Source	Notes
D_2O	125 mL	99.8 %	alfa.com	Heavy water is basis for electrolyte
LiCl	150 mM	99.995 %	alfa.com	Vast majority of solute is LiCl
$PdCl_2$	1.25 mM	99.999 %	alfa.com	Roughly 1/100 LiCl concentration
Pt Wire	~10 cm; 0.25 mm dia.	99.997 %	alfa.com	Electrode material is platinum wire
NdFeB Magnet	2,704 G (0.27 T)	BY0Y08	kjmagnetics.com	Static magnetic field (“B-Field”)

Initial Test Plan

1. Acquisition of Materials & Capability Team Consultations
    a. Modify test configuration designs as necessary to accommodate Capability Teams
    b. Acquire and assemble hardware
    c. Analyze and prepare ingredients / materials
    d. Conduct test readiness reviews
2. Cell Performance Check-out
    a. Calibration / Inert runs
    b. Run configurations anticipated to be productive
3. Coordinate with Capability Teams for Data and Sample Collections
    a. Capability Team collection and analysis
    b. Conduct subsequent data and sample collections as needed including analysis
4. Prepare reporting of ingredients, processes, equipment, data collection, sample collection, and analysis results

Modeling

- Fusion rate (“cross-section”) calculation
- D_2 vibrates due to parametric pumping
- Vibrations increase in magnitude until fusion occurs
  1. Density of electrons in neighborhood of D_2 molecule inside metal lattice computed via DFT; verified spherically symmetric near molecular vibrational turning points.
  2. Molecular Dynamics run using quantum forces from DFT.
  3. Gamow Factor calculated following NASA*
  4. Nuclear cross section (probability of reaction) value calculated using:
     - Assumed astrophysical constant
     - Calculated Gamow Factor
     - Includes e-screening effects

*Vladimir Pines et al., "Nuclear fusion reactions in deuterated metals," Phys Rev C, 2020.

Experimental Setup – Naval Research Lab

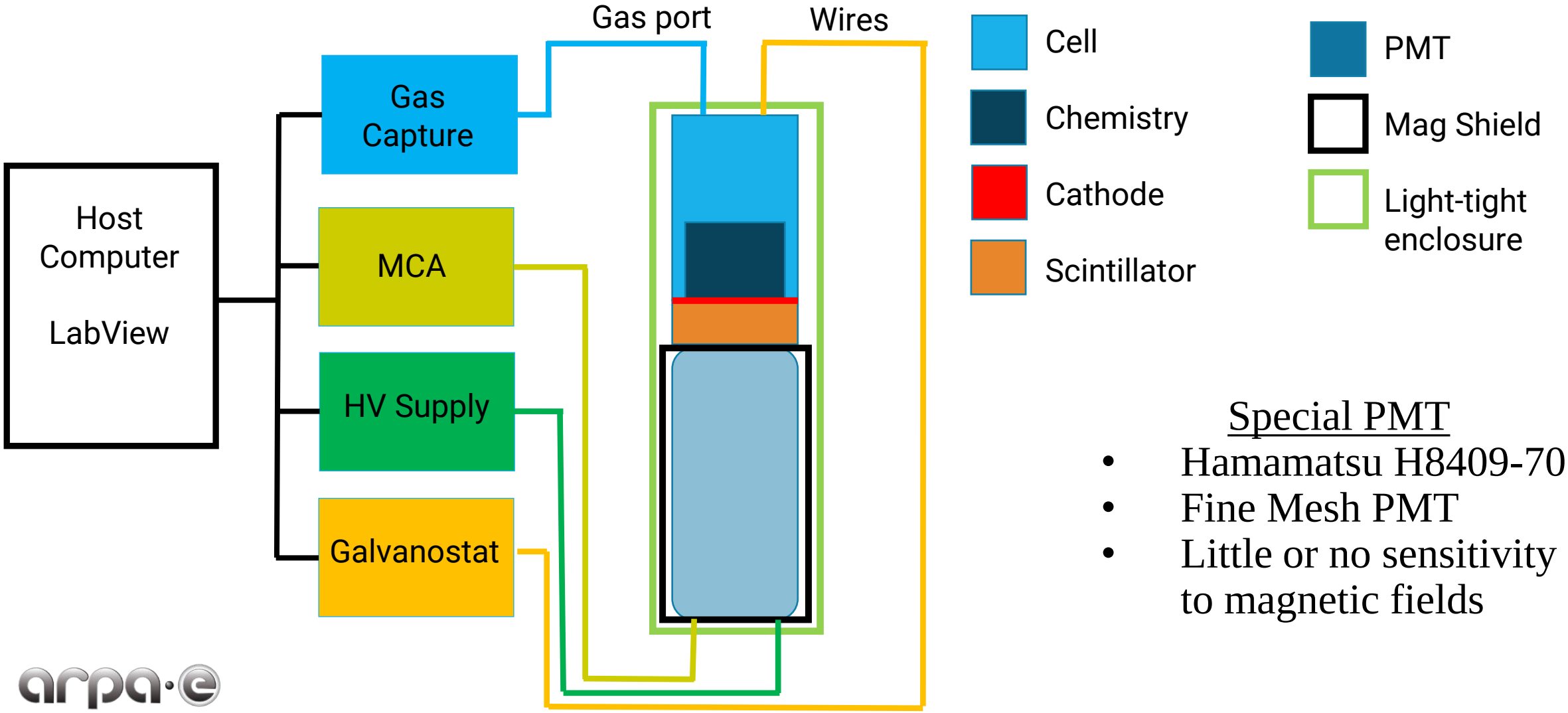
BLUF: Bottom Line Up Front

Cathode on scintillator

- The palladium deuteride at the cathode is the presumed source of nuclear activity.
- Put the source as close to the detector as possible.
- The detector is a plastic scintillator with thin film metallization.
- Two approaches:
  - Co-deposition: plate-up PdD on the base metal (primary).
  - Thin film deposition of Pd on the base metal (secondary).

Experimental Setup – Naval Research Lab

System A: No calorimetry



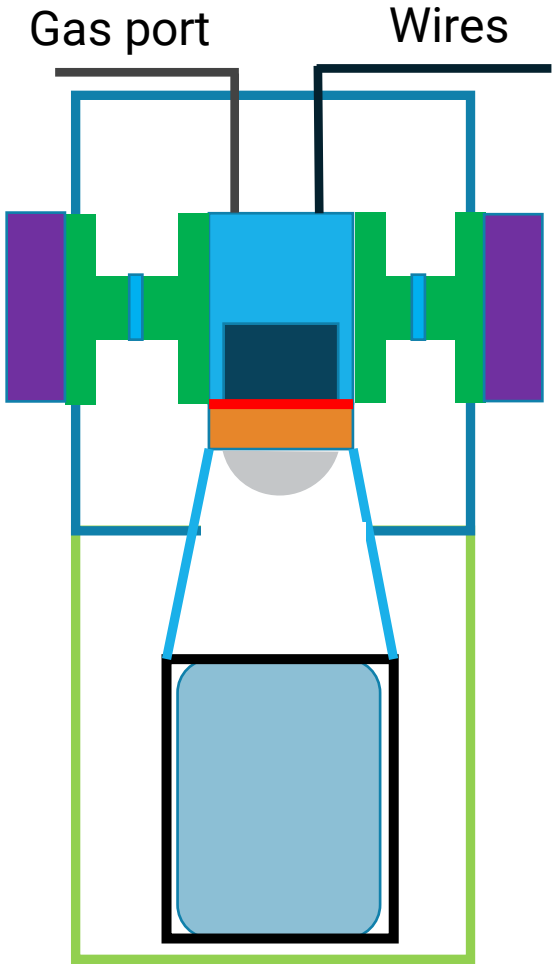
Special PMT

- Hamamatsu H8409-70
- Fine Mesh PMT
- Little or no sensitivity to magnetic fields

Experimental Setup – Naval Research Lab

System B: with calorimeter

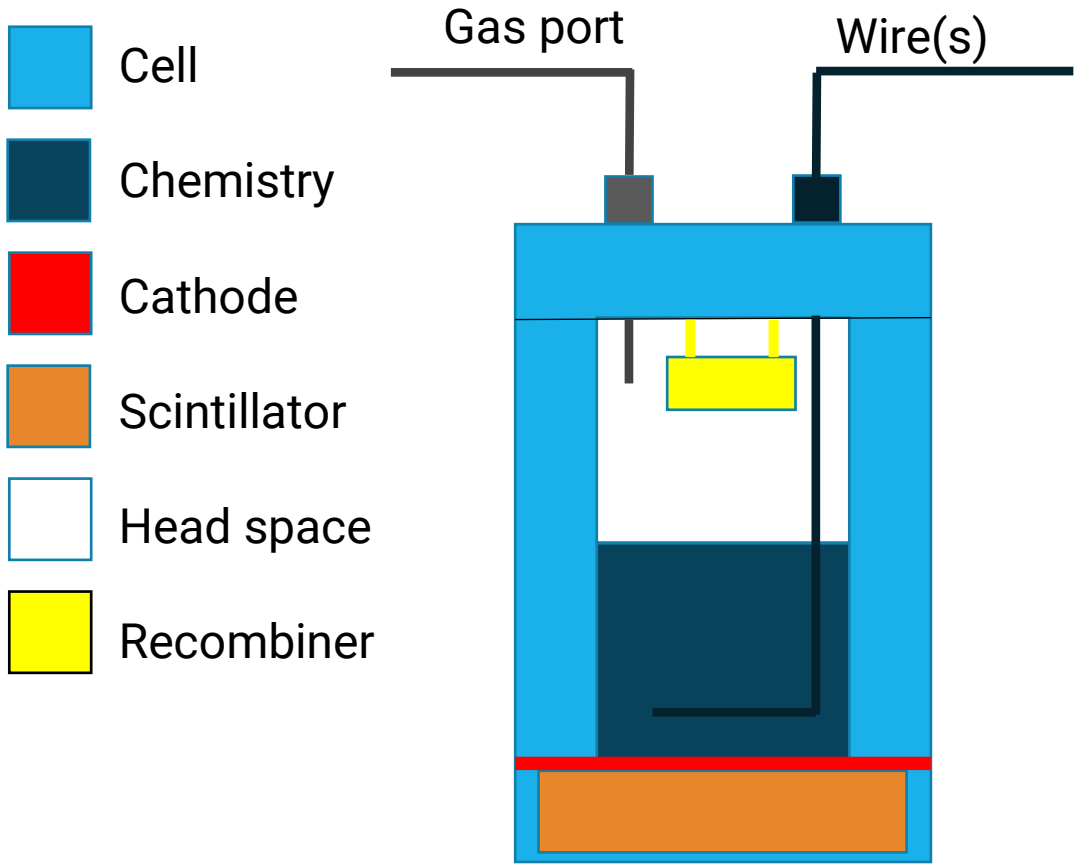
- Heat pipe
- Peltier
- Cold sink
- Styrofoam
- PMT
- Mag Shield
- Light-tight enclosure
- Cell
- Chemistry
- Cathode
- Scintillator

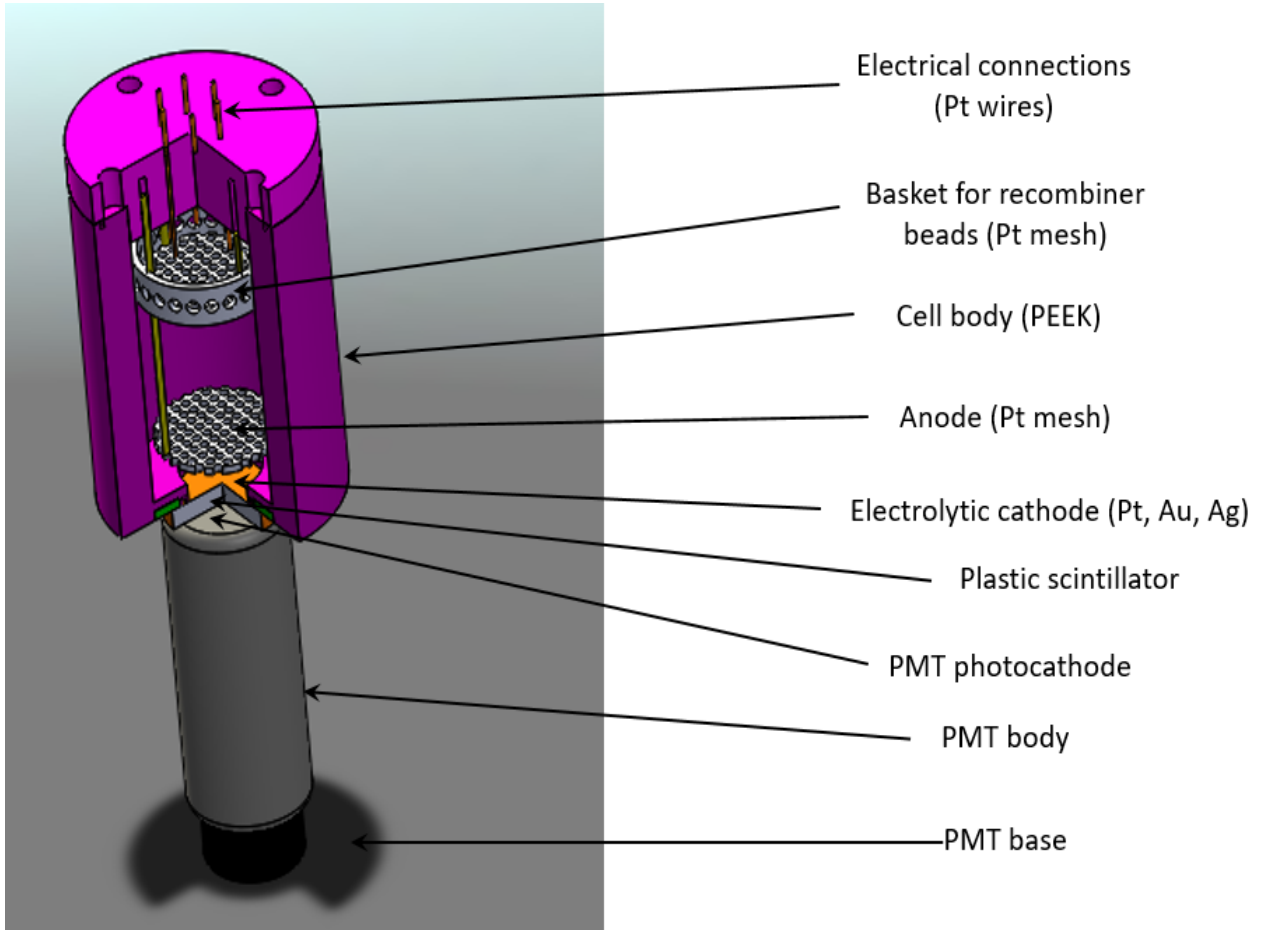


- All the same connections to instrumentation and host PC.
- Cell is thermally isolated from the PMT.
- High NA optics to couple light from scintillator into PMT.

Experimental Setup – Naval Research Lab

Same cell design for both systems





Data Acquisition

Measurement	Recording Method	Settings	Latency	Storage Media
Nuclear Particles	Multichannel Analyzer	Calibrated with check sources	Fast (At MCA in usec's Stored every 10-20 min.)	Host PC Back-up to shared drive
Heat	Peltier calorimeter	Calibrated with shunt resistor	Slow (response time minutes)	Host PC Back-up to shared drive
Gas sampling	Hermetically sealed in Al tube	"Pinch off" when appropriate	Really slow Ship to Rob Duncan?	?
Temperature and Pressure	Embedded sensors	Calibrated before experiments	Fast (response time seconds)	Host PC Back-up to shared drive
Neutrons	Igor's detectors?	Connected to PC?	Fast (Stored every 10-20 min.)	Host PC Back-up to shared drive
Background Radiation	Multiple GM tubes	?	Fast (Stored every 10-20 min.)	Host PC Back-up to shared drive

Initial Results

- Initial results anticipated 3-4 months after funding is received

Plans for Next Quarter

- Refine Tasks and Milestones
- Hosting Capability Team Meetings
- Ordering initial supplies
- Begin Design of new cells in consultation with Capability Teams