Electroforming and ICP-MS

LONGSECTION OF THE HOMESTAKE MINE

AARM

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PNNL

Pacific Northwest
NATIONAL LABORATORY

Electroforming Facility

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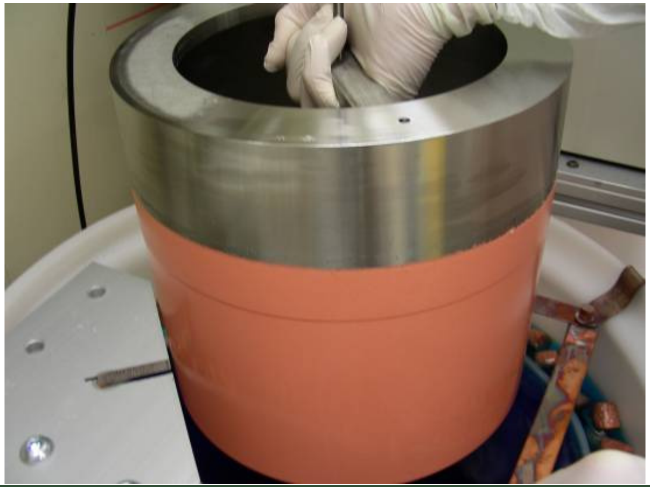
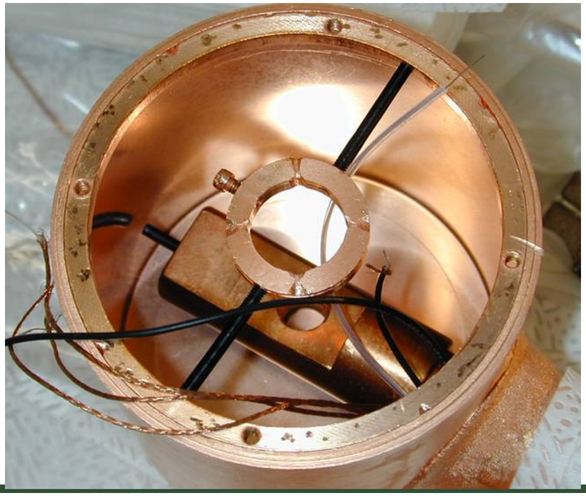
- Ultra High Purity Copper is needed for a wide variety of experiments including those for the next generation of neutrino physics, dark matter, and material sciences
  - **Submicro Bq/kg is now possible**
- Must be electroformed underground to minimize cosmogenic in-growth of impurities
- Other materials may also require electroforming. The number of experiments needing the material and the material compatibility must be evaluated to determine appropriate facility requirements





Electroforming Facilities-PNNL

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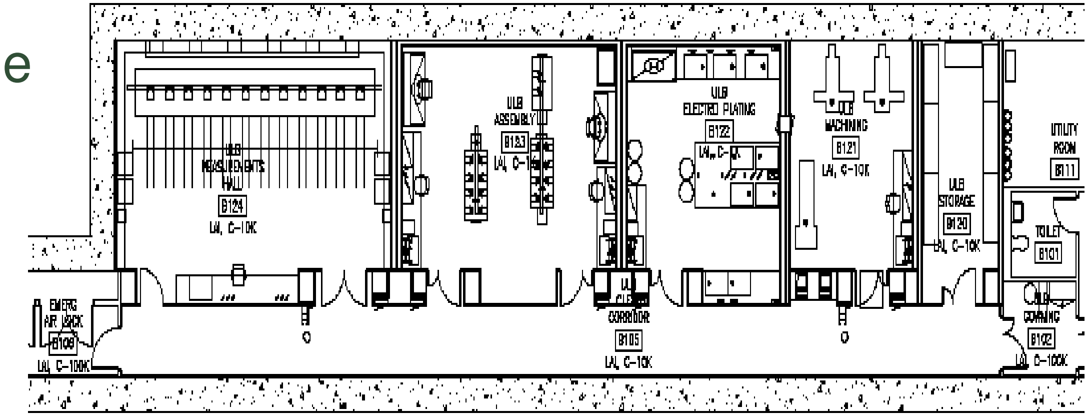
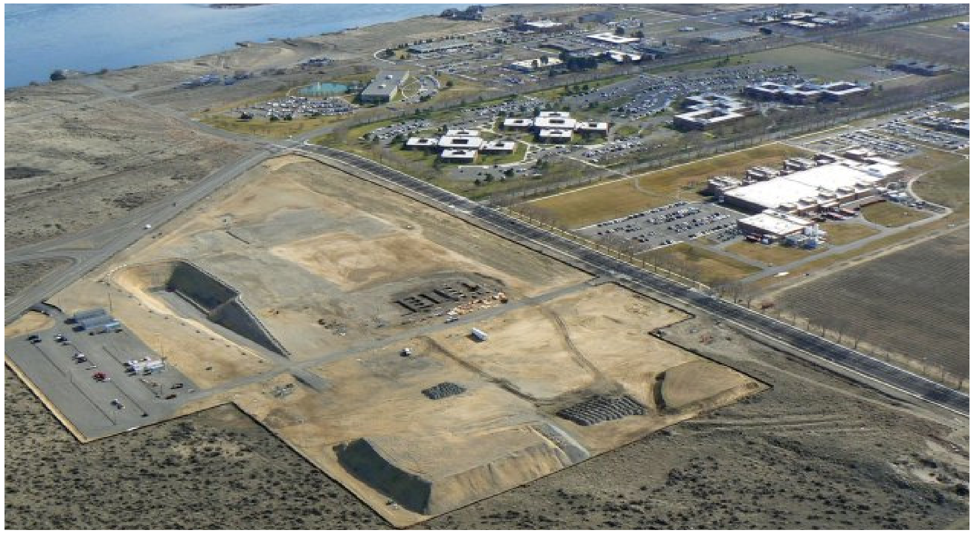
- Highest purity copper in the world to be produced
- Facilities will be extensive consisting of the main electroforming area, the cleaning/treatment area, and the storage area
- Cleanroom class 1000 for electroforming, class 100 for cleaning area
- Large quantities of acid sulfate electrolyte anticipated
- Extensively instrumented for process monitoring



Draw from recent design experience of similar
Pacific Northwest National Lab space



Electroforming Facilities-Initial SUL

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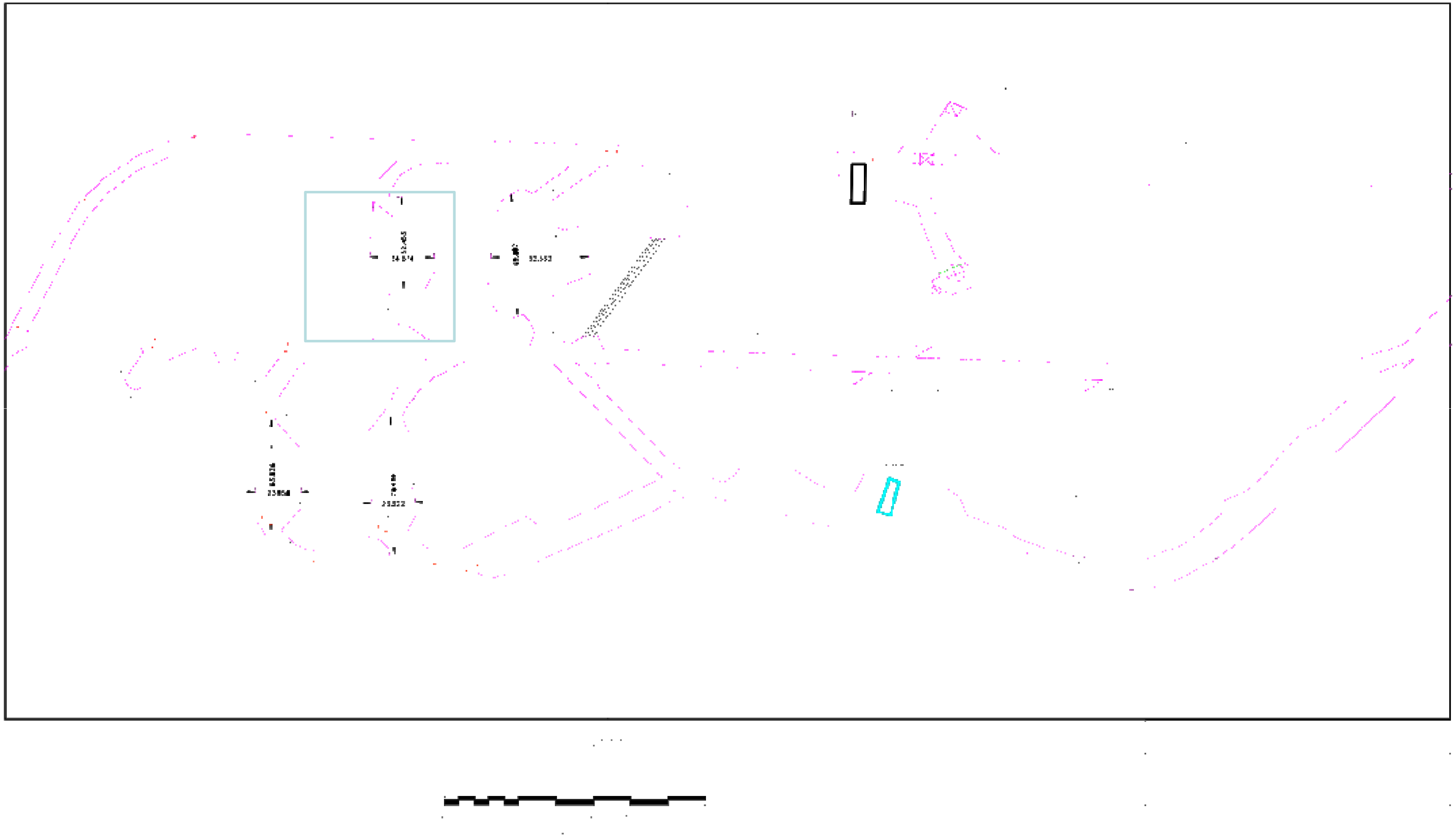

Electroforming Facilities-Initial SUL

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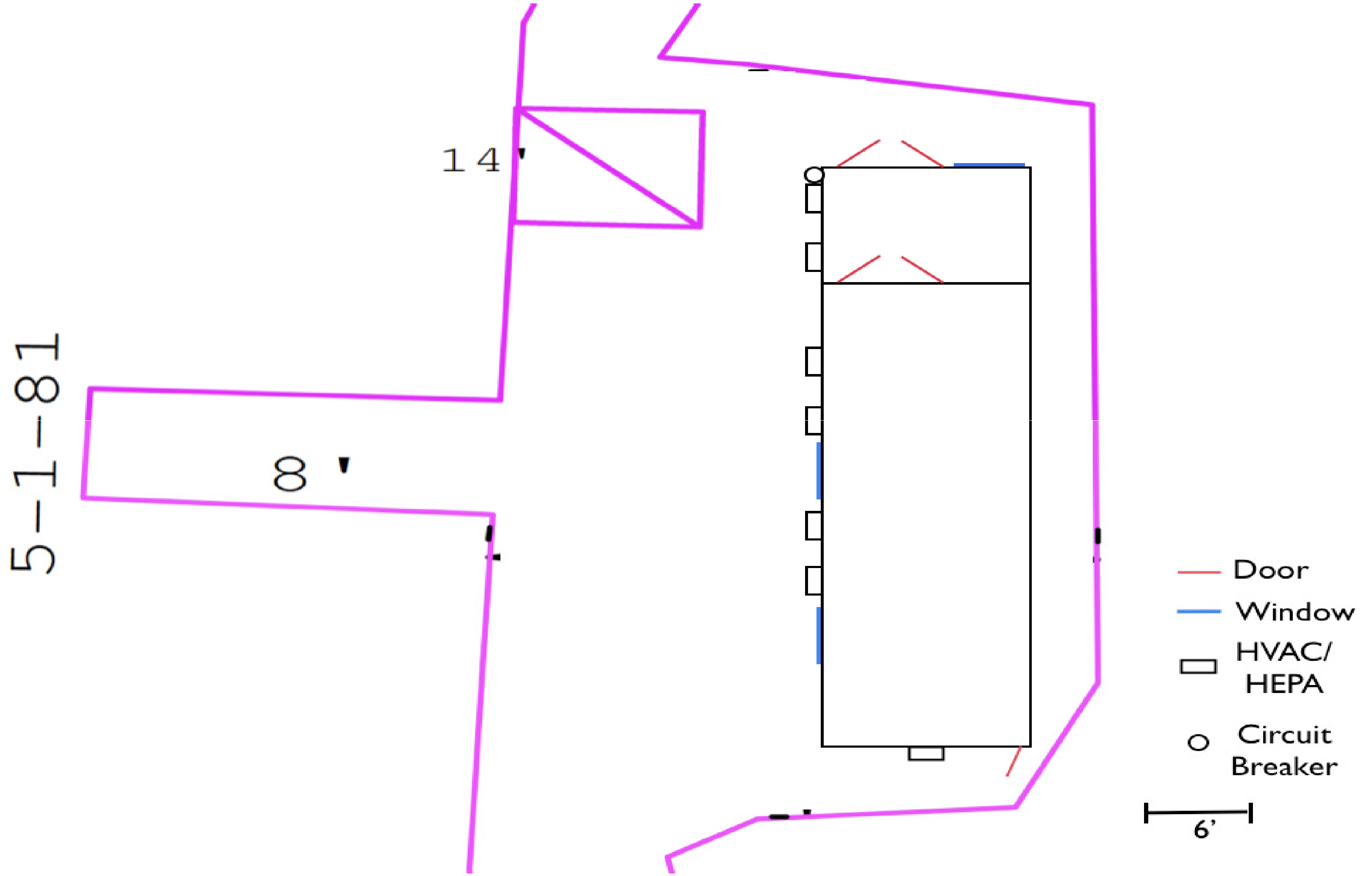
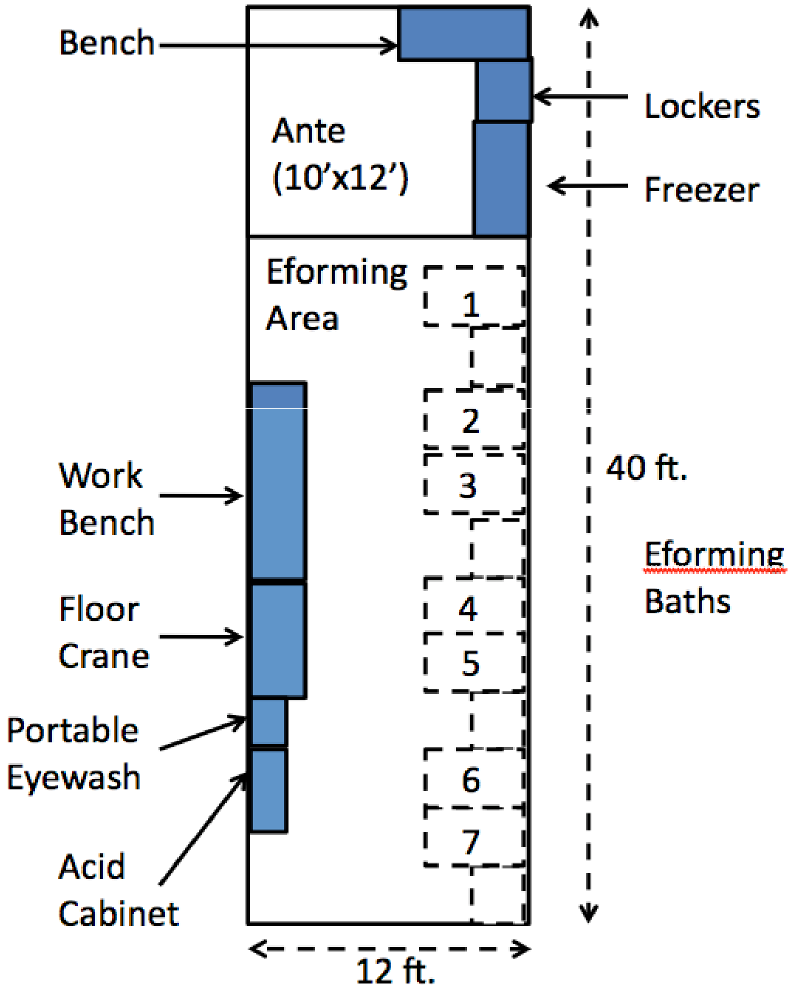


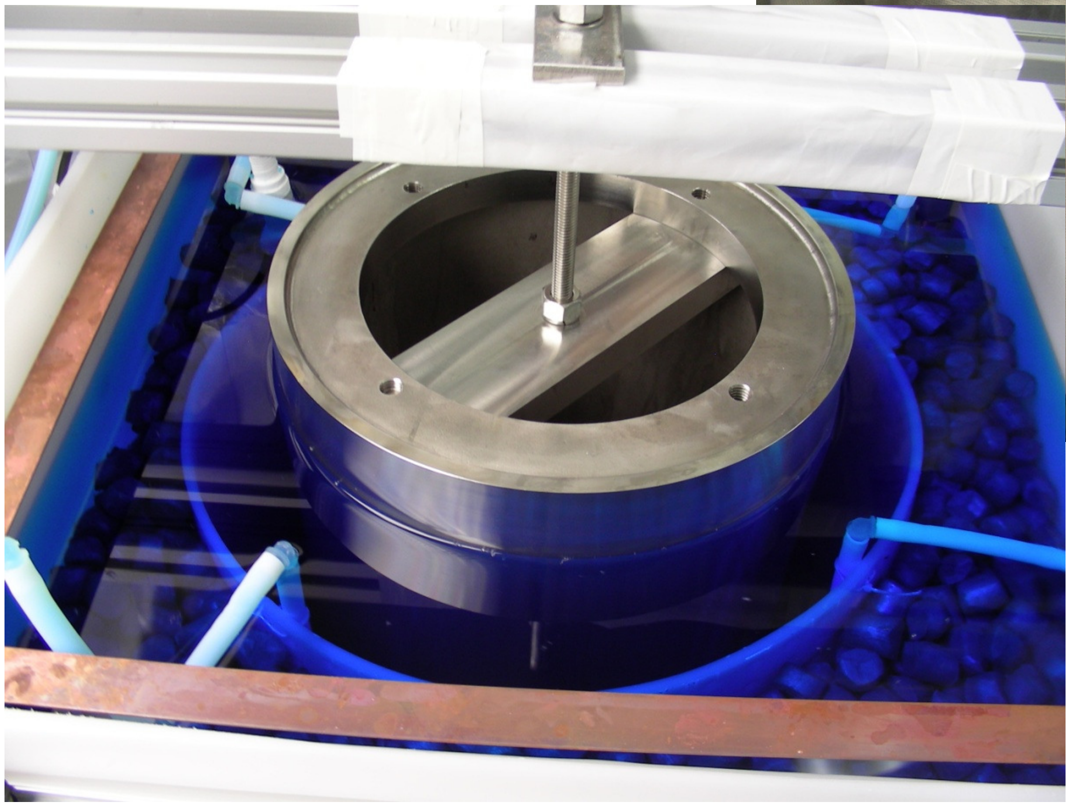
Electroforming Facilities-Initial SUL



Seven electroforming baths to be installed

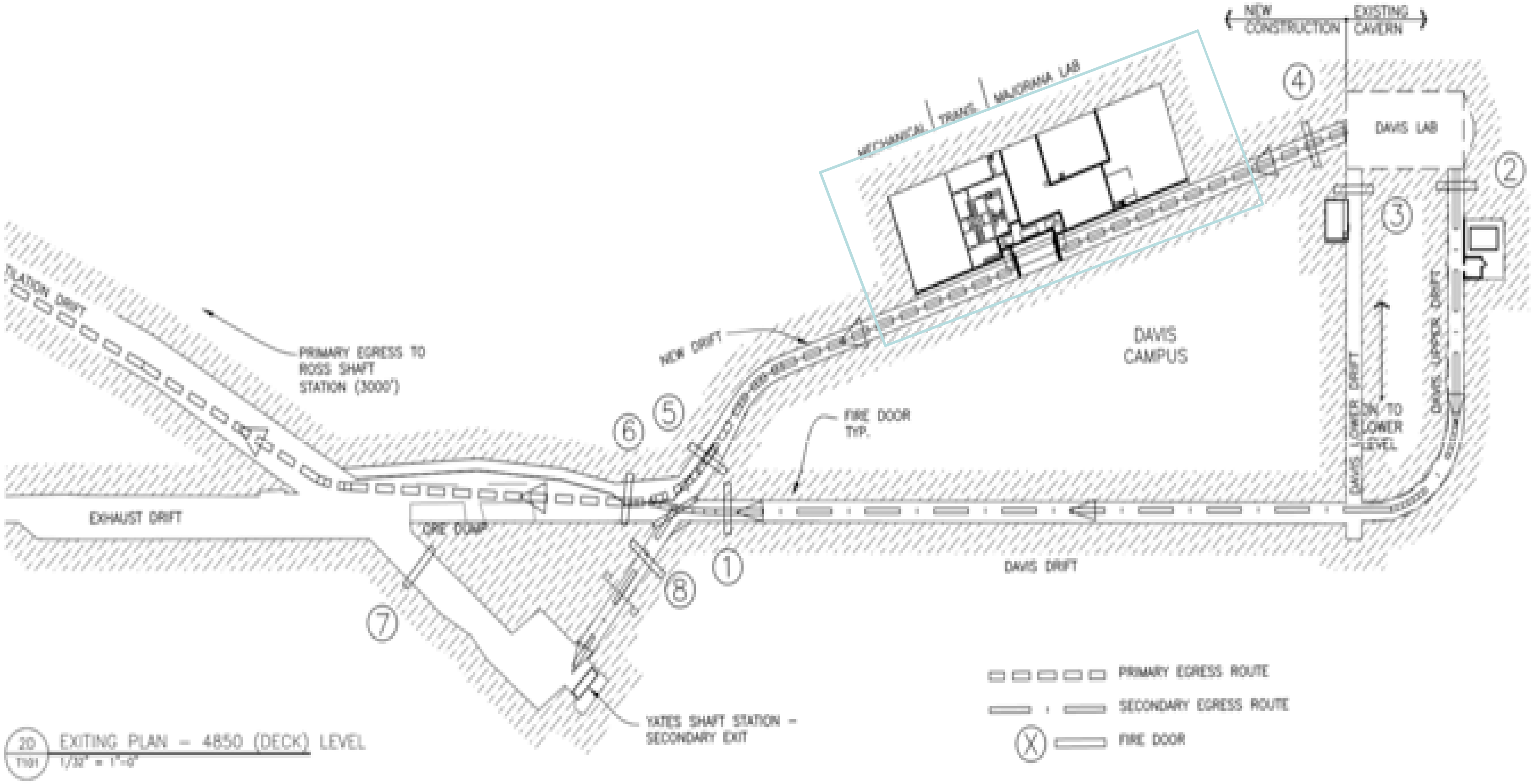
MAJORANA Electroforming Bath

Prototype MAJORANA electroforming bath, power supply, and mandrel are currently running at PNNL

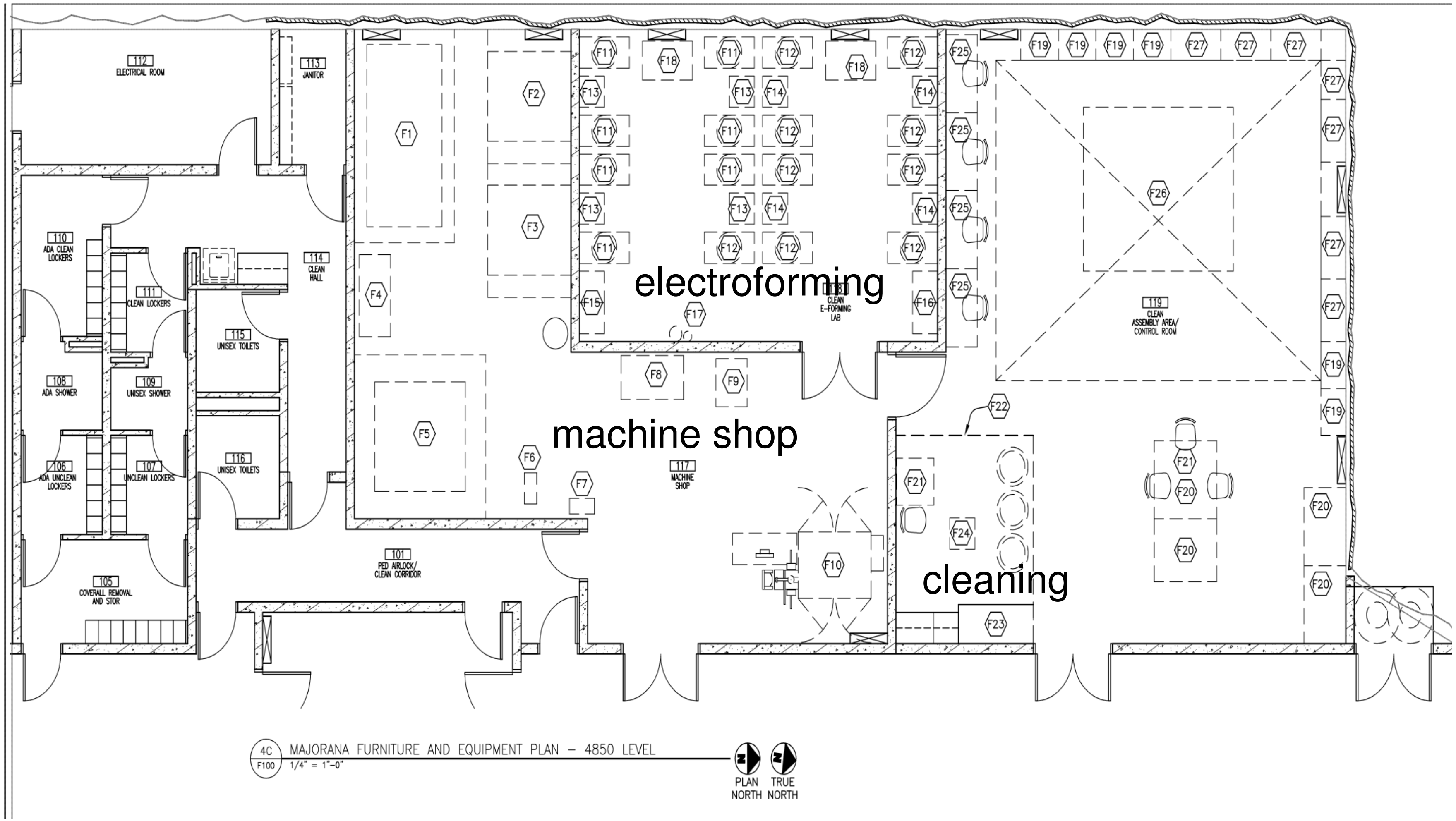


Each bath can produce ~100kg/yr on mandrel shown above (13” diameter x 23” height)

Electroforming Facilities-Davis Campus



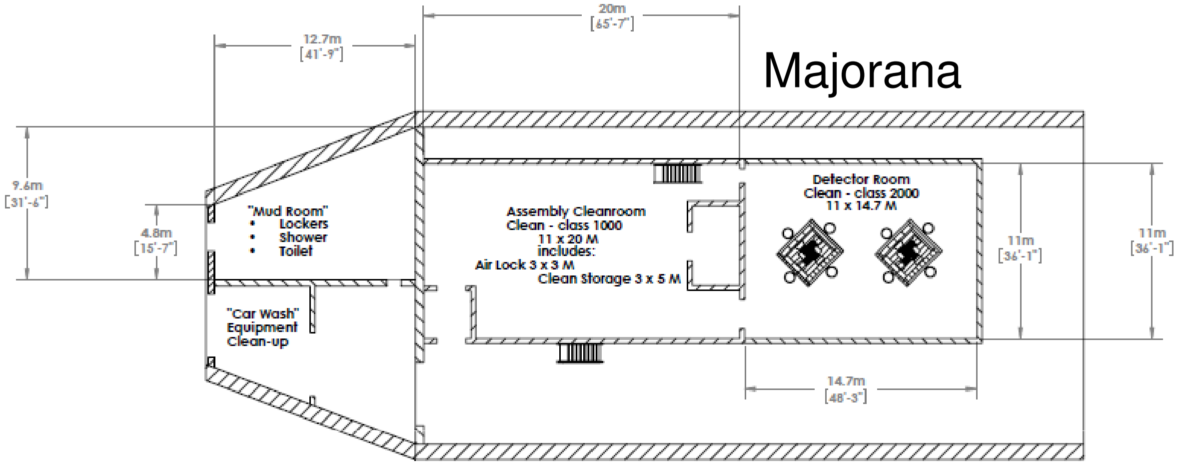
Electroforming Facilities-Davis Campus



Up to 16 electroforming baths, machine shop, class 100 cleaning area

Electroforming Facilities-1T support

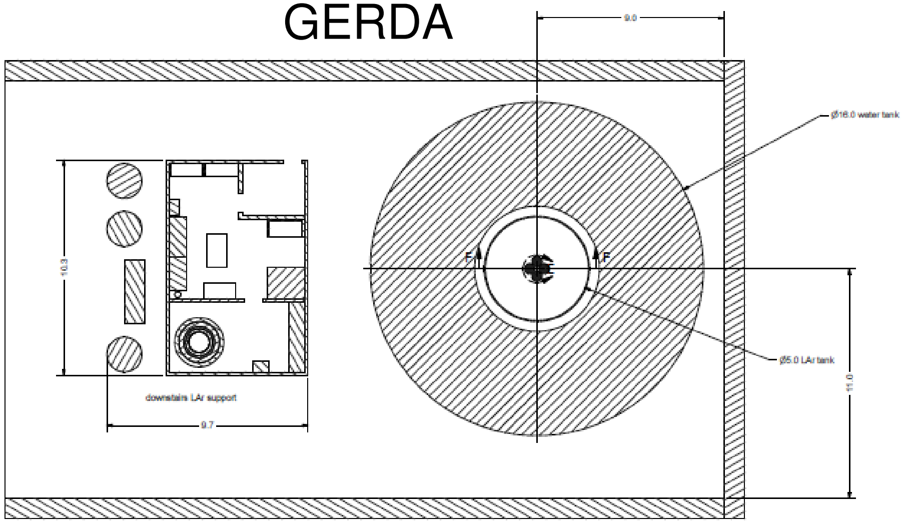
Majorana



Several experiments require significant amounts of electroformed copper including either of the germanium double beta decay experiments

1 tonne Majorana will need ~80 baths over 4-5 years

GERDA



Electroforming Summary

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- Bath cost ~$50k each
- Capacity ~100 kg/bath/year
- Significant capacity becoming available over next few years
  - PNNL shallow underground, 4 large 8 small baths, summer 2010
  - Majorana SUL temporary, 7 large, summer 2010 through summer 2012
  - Majorana Davis Campus, 16 large, late 2010-early 2011 through summer 2012
  - 1T Majorana, around 80 baths starting 2015

Mass Spectrometry

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- MS tools to consider
  - Inductively Coupled Plasma/Optical Emission Spectroscopy (ICP/OES)
  - Inductively Coupled Plasma/Mass Spectroscopy (ICP/MS)
  - Laser Ablation-ICP/MS
  - Secondary Ion Mass Spectrometry (SIMS)
  - Glow Discharge or Thermal Ionization Mass Spectroscopy (GD/MS or TIMS)

Mass Spectrometry

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- ICP-MS most versatile and sensitive
  - ~0.6 µBq ^{232}Th/kg Cu DL (0.15 x 10^{-12} pgTh/gCu)
- Requires chemistry/wet lab facilities to support the sample preparation/dissolution
- Cost ~$200-250k
- Needed underground? If not, then why on-site? (can be easily sent off-site)

Other Techniques to Consider

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- Other Analytical tools likely to be needed underground
  - Optical Microscopy
  - Scanning Electron Microscopy (SEM) with various electron excitation spectroscopies and electron backscatter
- Physical Properties Testing
  - Hardness and tensile strength
  - Grain size and orientation evaluation (from SEM and EBSD)
- Lesser need?
  - Transmission Electron Microscopy (TEM)
  - Scanning Tunneling Microscopy/Atomic Force Microscopy (STM or AFM)