Summary of Graphite Sublimation Tests

J.R. Haines, C.C. Tsai

P.T. Spampinato

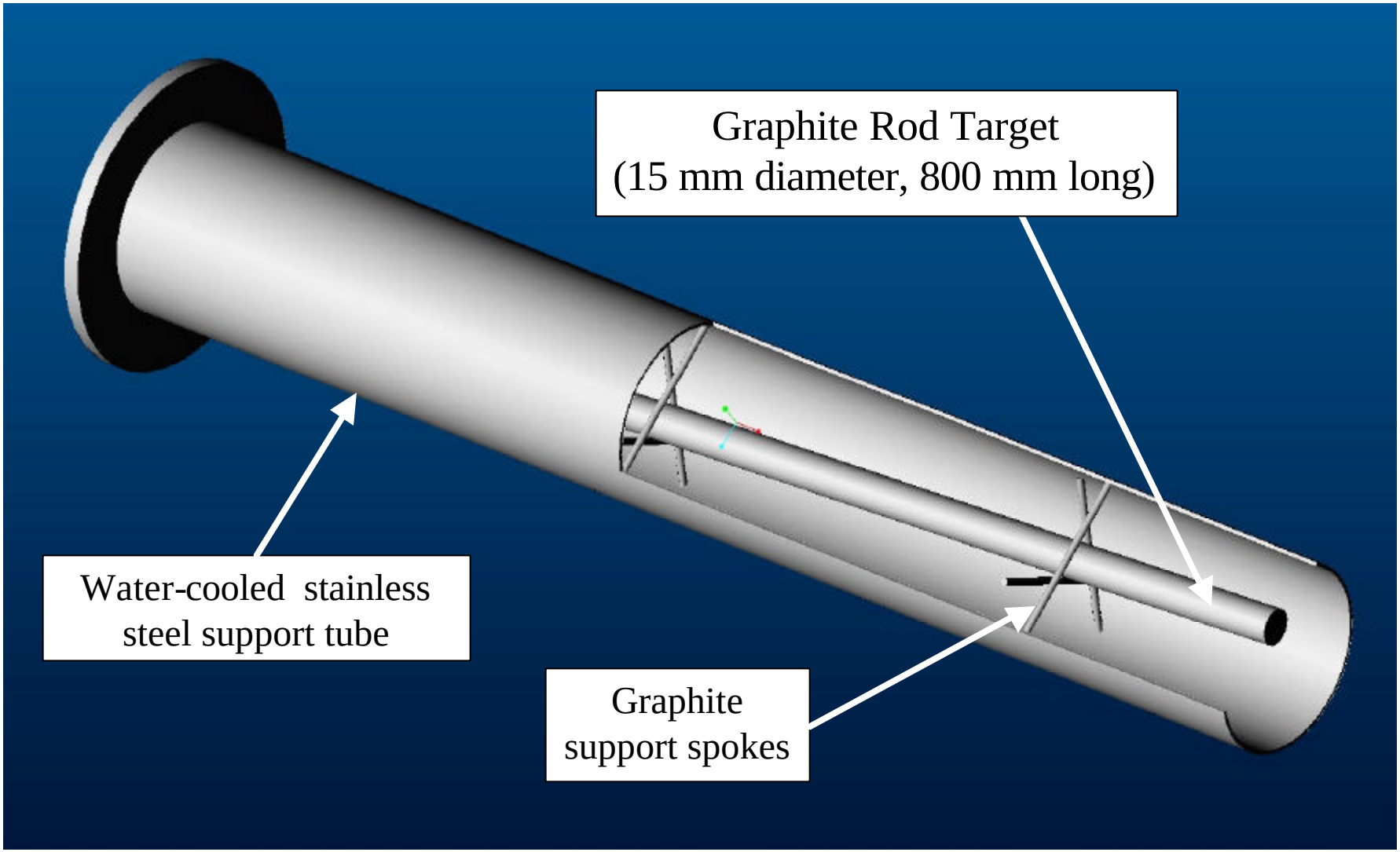
Neutrino Factory and Muon Collider 2002 Collaboration Meeting

Shelter Island, NY
May 9-15, 2002

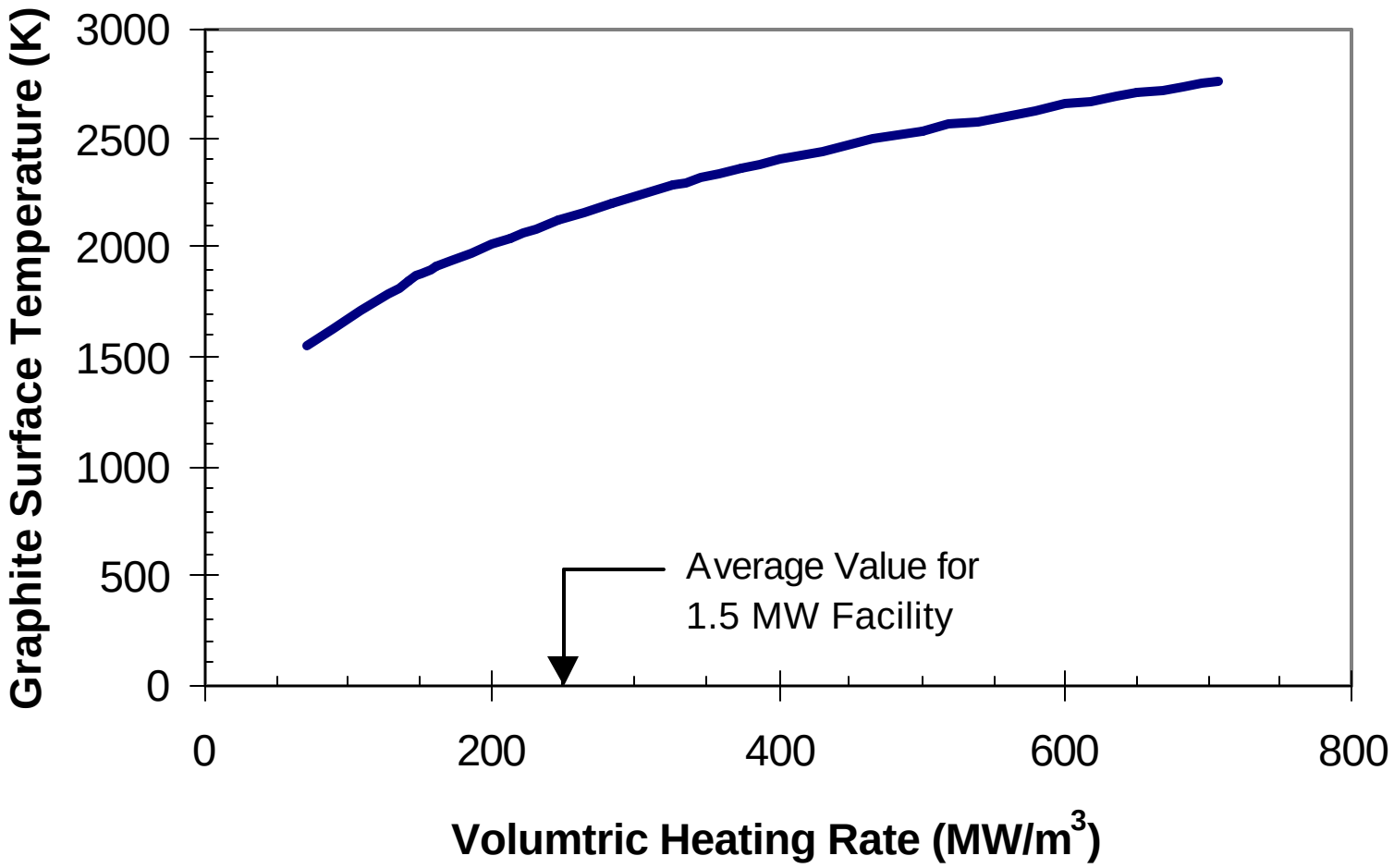
Motivation for Graphite Sublimation Tests

- A radiatively cooled graphite target was proposed as a candidate for a neutrino factory target – Feasibility Study 1
  - main advantage: solid, non-magnetic material in a magnetic field … but may be life-limited due to sublimation at elevated temperature
- Power level will be limited by sublimation lifetime if target environment is high vacuum
- The use of a helium environment to greatly reduce the net erosion rate of graphite was proposed
- Graphite sublimation tests have been conducted in an attempt to validate this design approach

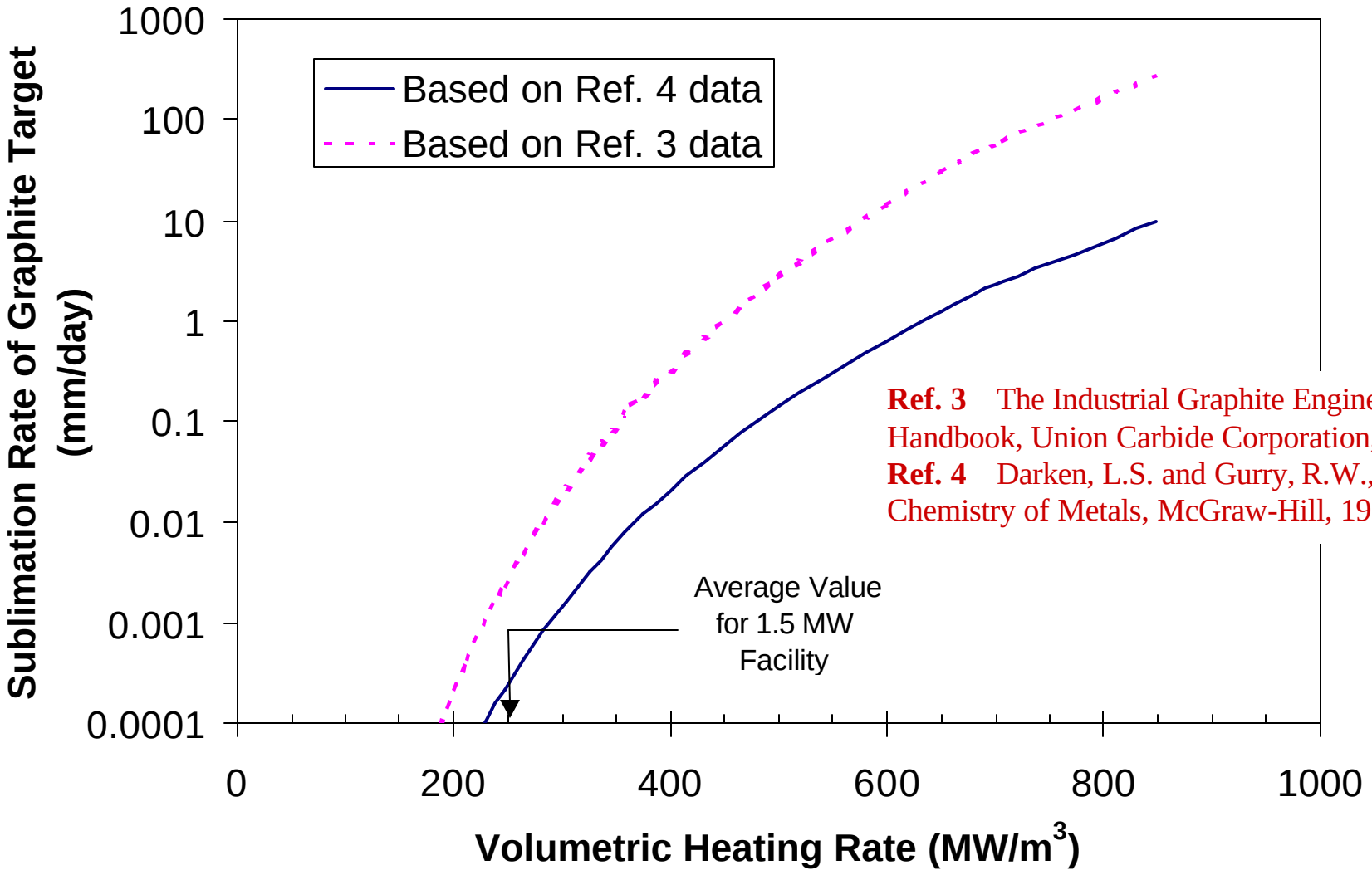
Passively Cooled Graphite Target Concept



Surface Temperatures Will Exceed 2000^{0}K for Radiatively Cooled Graphite Targets



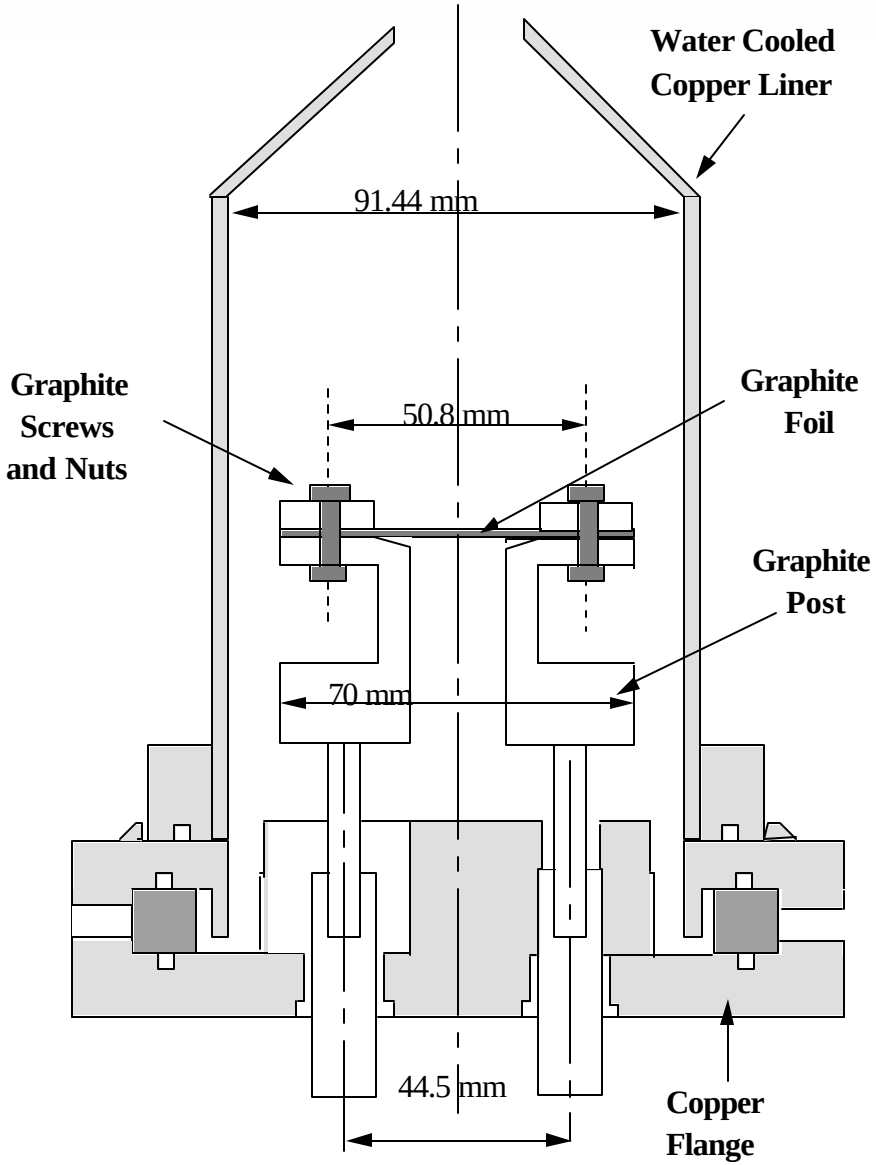
Graphite Erosion by Sublimation in a Vacuum is Significant for a 1.5 MW Facility



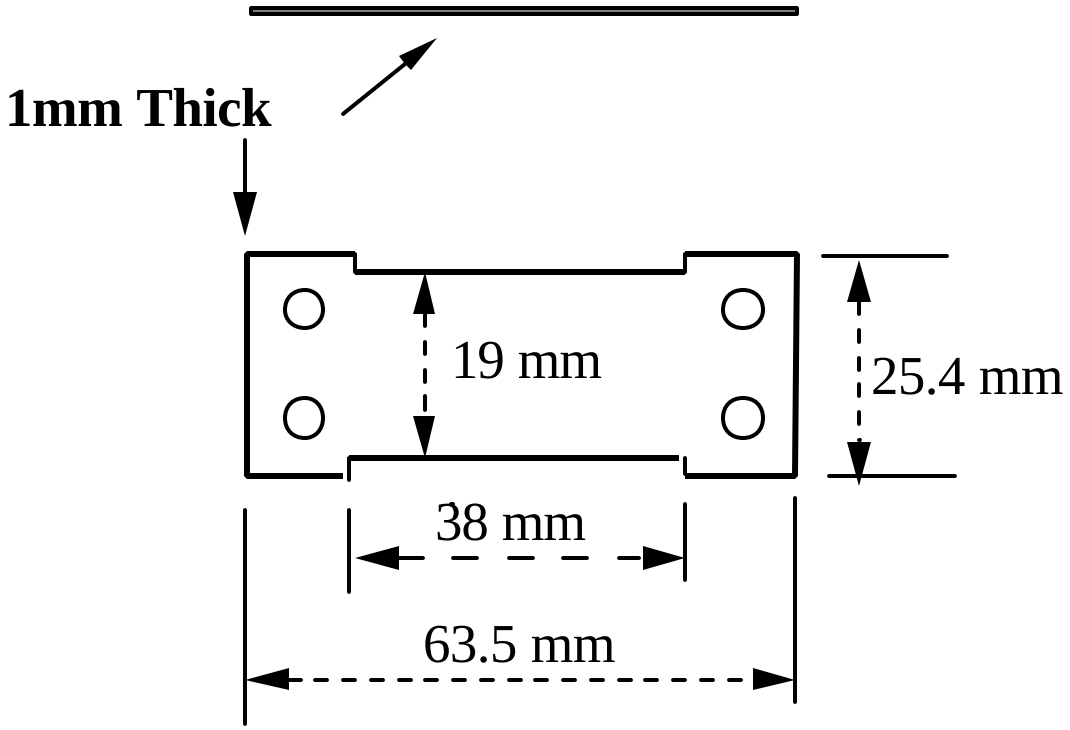
Ref. 3 The Industrial Graphite Engineering Handbook, Union Carbide Corporation, 1969.

Ref. 4 Darken, L.S. and Gurry, R.W., Physical Chemistry of Metals, McGraw-Hill, 1953

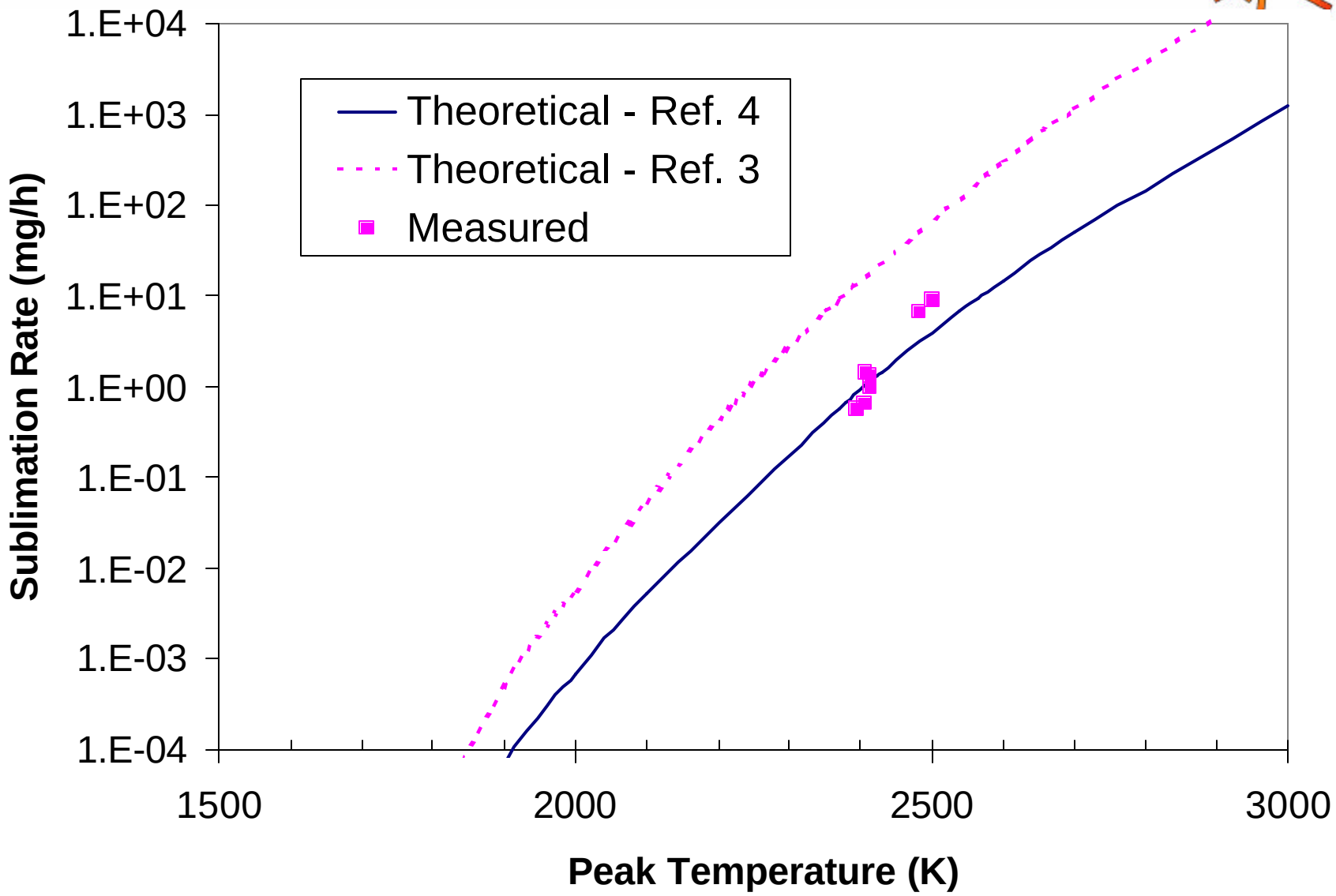
Graphite Sublimation Test Oven



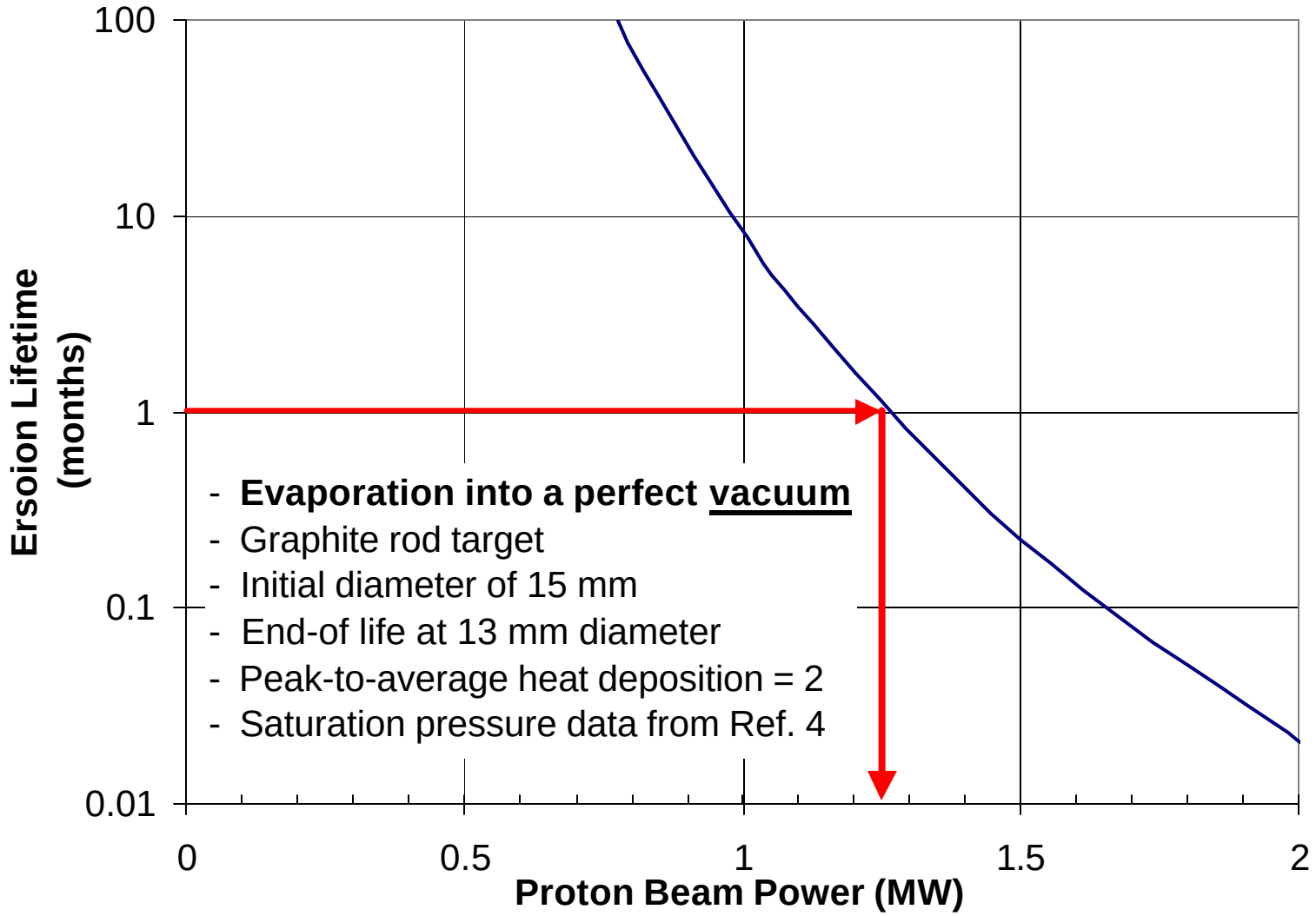
Design of Graphite Foils Used for Sublimation Tests



Measured Sublimation Rates Agree with Theoretical Results for Vacuum Conditions



Target Lifetime of One Month May Be Possible at Power Levels of 1.2 MW



Sublimation Tests with a He-Filled Chamber at 1 Atm Have Been Problematic

- Initial measurements had arcing damage, which was eliminated by redesigning the specimen holder
- Essentially the same weight-loss was measured for the helium-filled chamber and the evacuated chamber, at the same peak specimen temperature
  - this might be explained by the more uniform temperature distribution observed along the surface of the specimen for the He-filled case
    - ✍ significant sublimation occurs over a larger area with He due to convective heat transport along the graphite specimen
  - some of the area cannot be seen using pyrometer viewing thru the quartz window
  - revising the chamber window to view the entire specimen surface was beyond the scope of this activity

Summary

- Mass-loss measurements (mg/s-cm^2) validated the experimental apparatus under high vacuum conditions
- Sublimation data are consistent with saturation pressure data from a different source (Ref. 4) than that used for the initial target studies
- Using this lower (vacuum) sublimation rate and assuming that
  - ✍ the end-of-life for a 15 mm diameter target is defined to be 13 mm diameter (i.e. erosion of 1 mm)
  - ✍ the peak heating rate is twice the average value
  - then, a one month lifetime is achieved for a 1.2 MW neutrino factory facility with the target in a vacuum environment
- Tests for a helium-filled chamber were inconclusive, but a more uniform temperature distribution was observed indicating that erosion is more uniform
  - further tests with a larger viewing port and a more prototypical target/chamber geometry are required to better quantify the improvement with helium (currently there is no funding available for this effort)