Remarks From RadCon

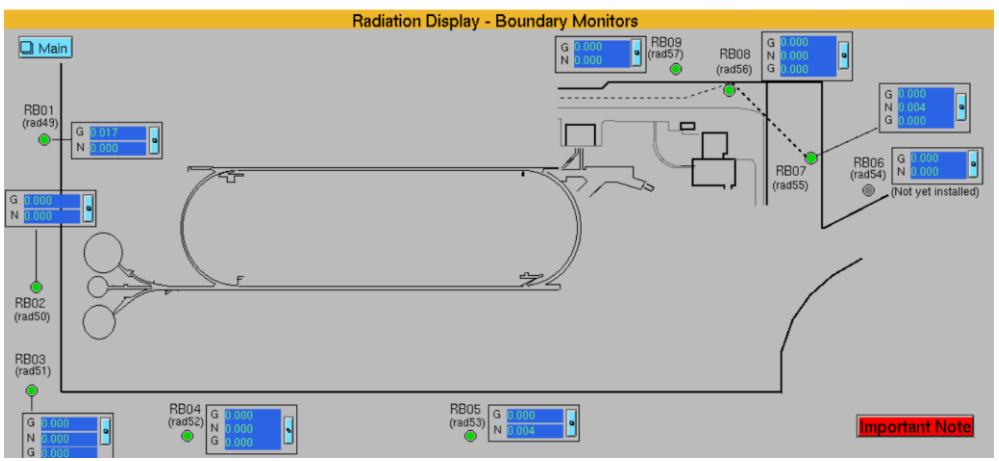
Mikhail Kostin

Wednesday, December 9, 2020

Dose to Public

- The collaboration is expected to prepare Radiological Safety Analysis Document (RSAD) before allowed to run
- Part of RSAD is estimation of public exposure to radiation
- Annual limit 100 mrem from all the sources
- Most significant contribution at JLAB is direct prompt radiation and skyshine
- JLAB ALARA for annual prompt dose is 10 mrem
- Typically calculated with a full scale model for high current experiments
- Measured at the site boundaries by Radiation Boundary Monitoring System

Boundary Monitoring Online at CEBAF



Jefferson Lab

Dose to Public

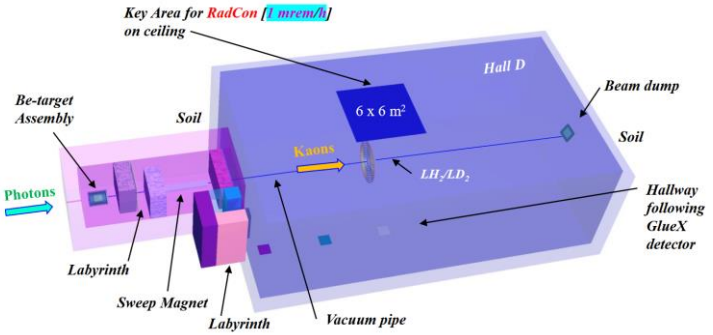
- First order estimation is found in "Conceptual Design of Beryllium Target for the KLF Project"
- Considered limit was 1 mrem/h in some area above target.
  This is based on Hall A calculation – boundary dose rate is OK if the dose rate above Hall A is several mrem/h.
- Hall D is farther away from the boundary which helps. But virtually no shielding above
- Additional sources that must be considered
  - CPS
  - Direct streaming from Be target assembly
  - Beam dumps are already well shielded

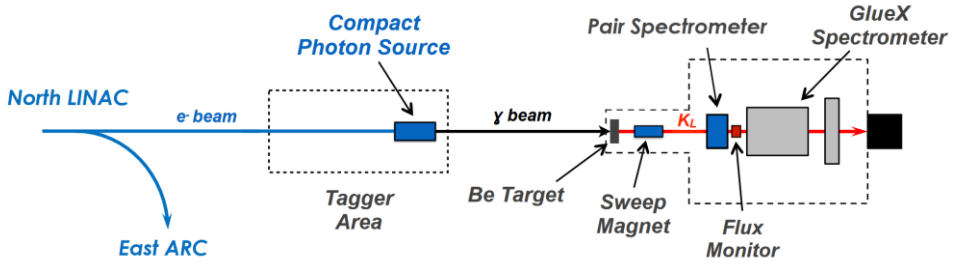
Conceptual Design of Beryllium Target for the KLF Project

Igor Strakovsky,[1,*] Moskov Amaryan,[2] Mikhail Bashkanov,[3] William J. Briscoe,[1] Eugene Chudakov,[4] Pavel Degtyarenko,[4] Sean Dobbs,[5] Alexander Laptev,[6] Ilya Larin,[7] Alexander Somov,[4] and Timothy Whitlatch[4]

[1] *Institute for Nuclear Studies, Department of Physics, The George Washington University, Washington, DC 20052, USA*
[2] *Old Dominion University, Norfolk, VA 23529, USA*
[3] *University of York, Heslington, York YO10 5DD, UK*
[4] *Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA*
[5] *Florida State University, Tallahassee, FL 32306, USA*
[6] *Los Alamos National Laboratory, Los Alamos, NM 87545, USA*
[7] *University of Massachusetts, Amherst, MA 01003, USA*

(Dated: February 12, 2020)



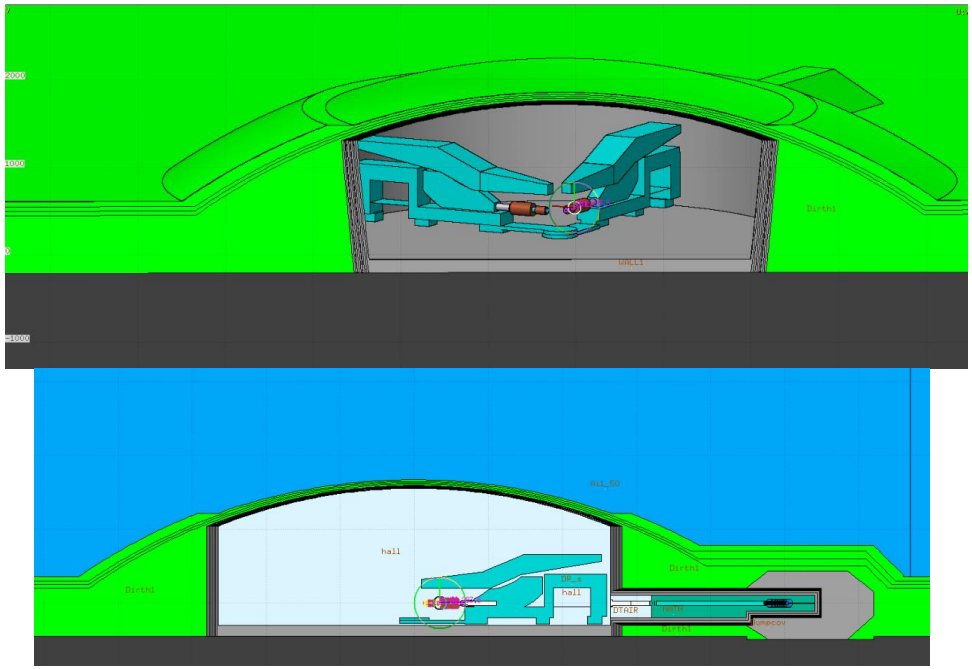


Jefferson Lab

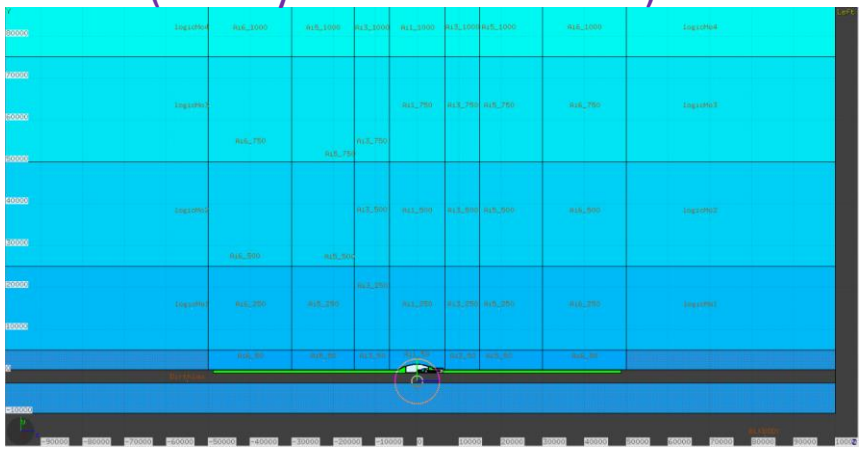
Dose to Public

- Examples of full-scale models

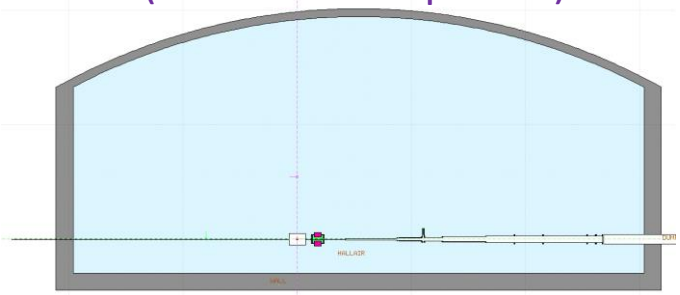
Hall A Base Model



Hall A and Surrounding Air
(for Skyshine Calculations)



Hall C Base Model
(Under Development)



- Radiation transport model for Hall D tagger area does not exist (to my knowledge)

Jefferson Lab

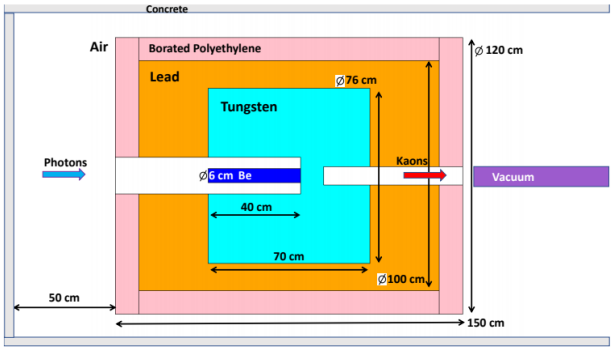
Other Radiological Effects to Consider

- Most of the following was not addressed so far (to my knowledge)
- More or less complete list, but some of items may not be necessary for KLF
  - Residual activation of components (hands-on maintenance)
  - Activation of cooling water (production of 3-H, 7-Be, 11-C, 13-N and 15-O)
    - Dose rate from closed-loop system
    - Plating of 7-Be
    - Potential leaks (3-He, 7-Be)
  - Activation of soil and ground water (3-H and 22-Na)
    - Most likely not a problem – ground water runs fast, no build up
    - But, it is a good idea to at least understand the scale of activation
  - Air activation – most likely not an issue
    - Workers – access control to beam enclosures
    - Public – dose must be small and difficult/impossible to measure
  - Energy deposition
    - Input to engineering design

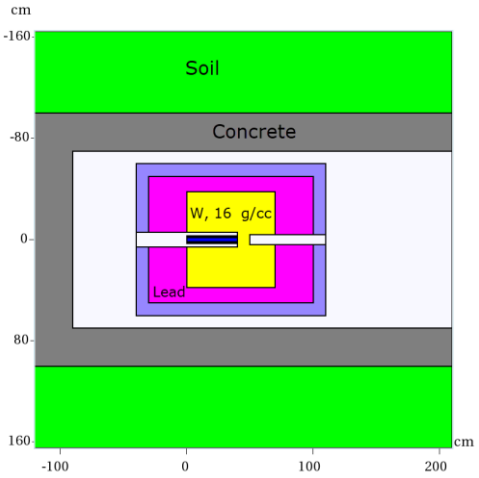
Be Target Assembly (Preliminary Results)

- Calculation for energy deposition, prompt dose and residual activation of one of Be target assemblies
  - Cylindrical symmetry
  - Added cooling water channels in Be
  - Approximate calculations – currently no access to MCNP data libraries for low energy neutrons (export controlled)

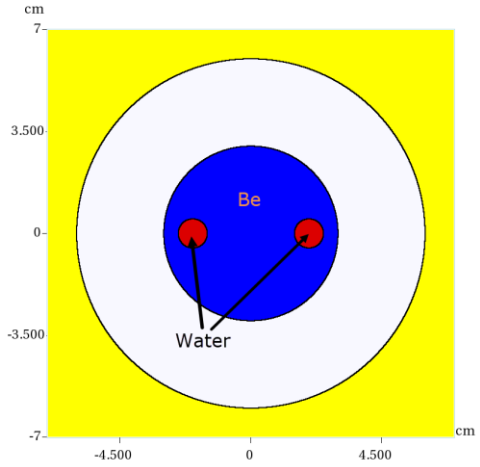
"Old" Model



Model Used Here



Target Cross-Section

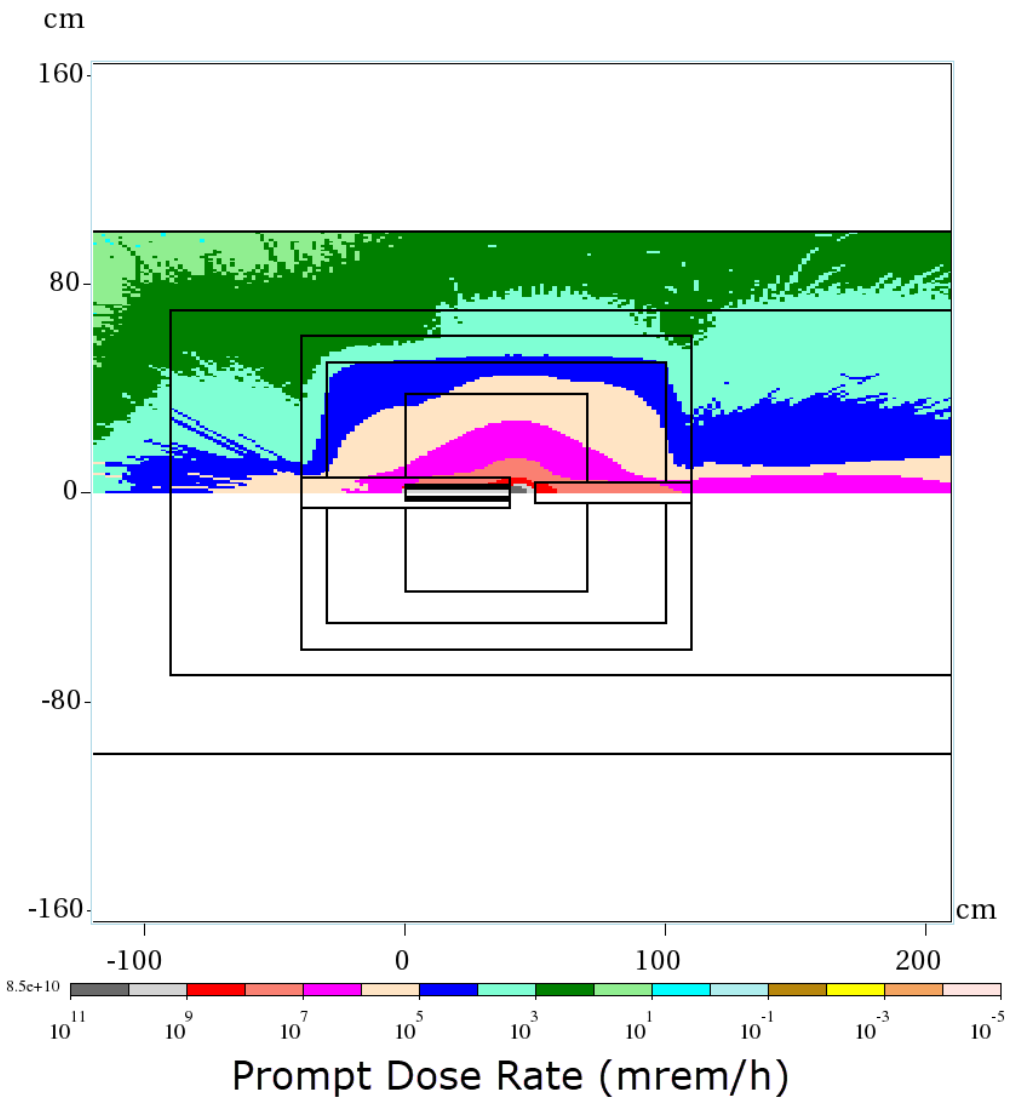


- Photon source
  - 10% Cu (0.14 cm) radiator instead of full CPS
  - 67 m upstream
  - 2 cm diameter on Be face
  - Originated from 12 GeV electron beam, 60 kW

Jefferson Lab

Be Target Assembly (Preliminary Results)

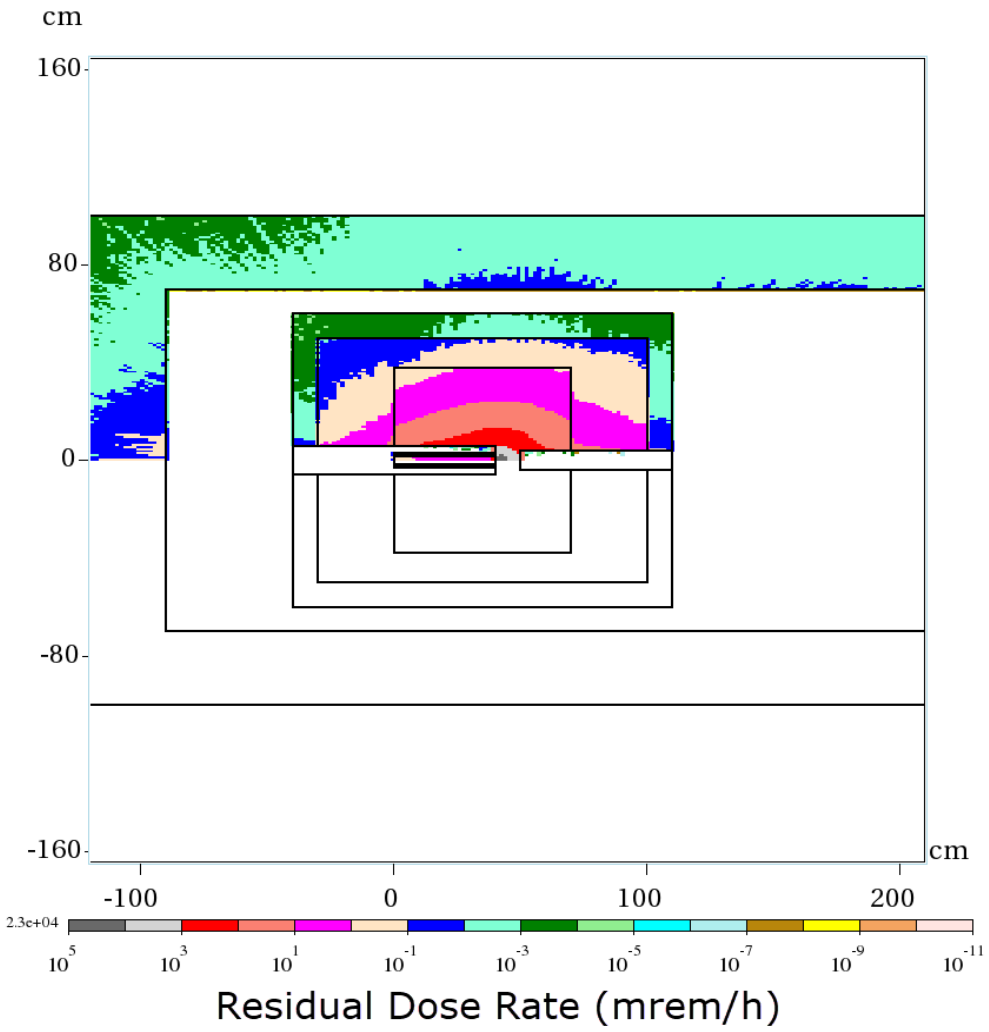
- Prompt Dose above
  - Higher than 1,000 mrem/h at ceiling
  - Approximately 3 m or so of shielding above alcove
  - Rule of thumb: 1 m of concrete or soil provide a factor of ~10 in dose reduction
- Expect >1 mrem/h above ground
- Too high to be comfortable – will need more accurate model



Jefferson Lab

Be Target Assembly (Preliminary Results)

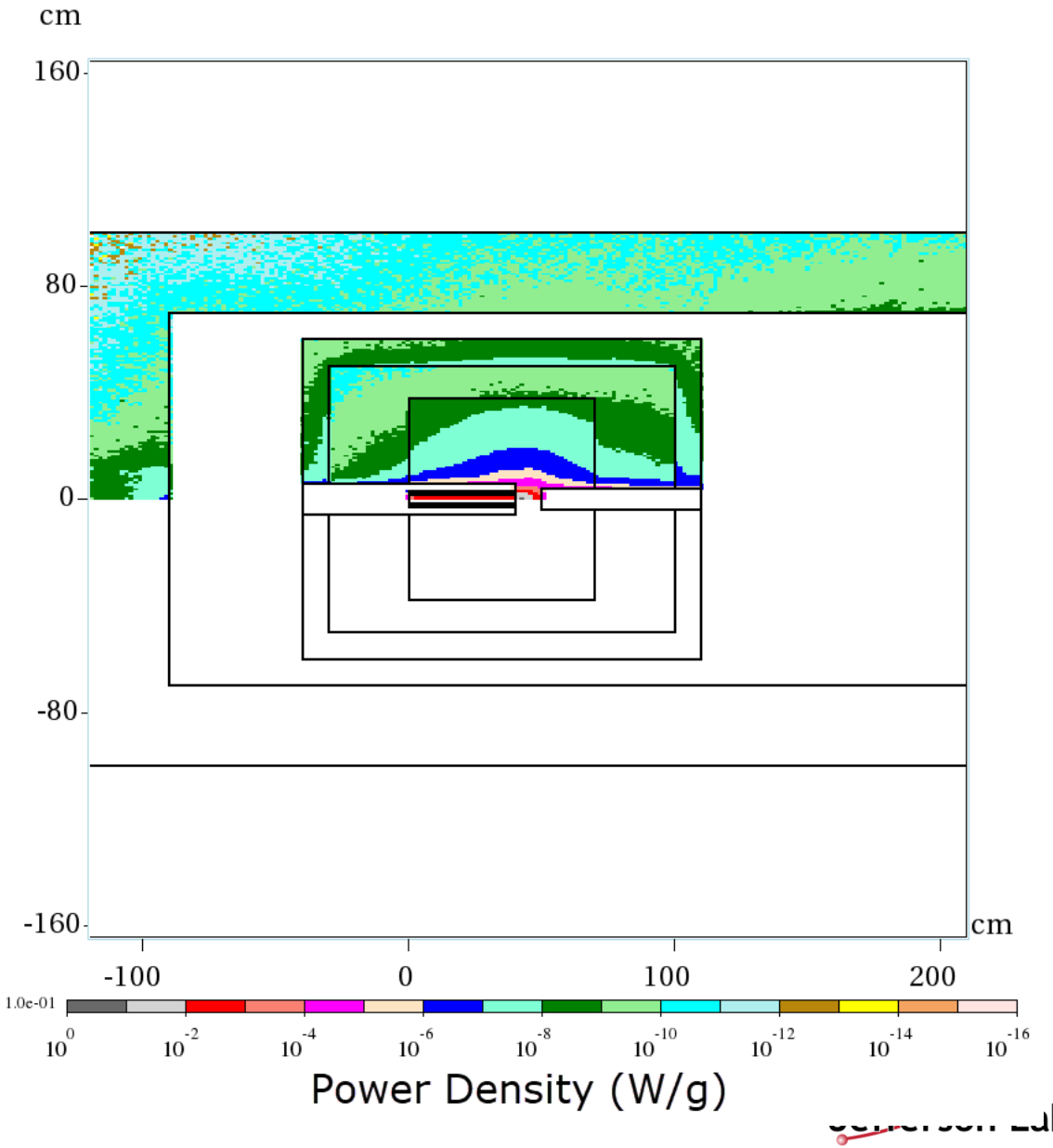
- Residual activation
- Dose on contact, 1 year of irradiation, 1 day of cooling
- Up to 0.1-1 mrem/h on lead surface
- Borated polyethylene is probably too thin (10 cm), may not be able to effectively shield components inside
- Residual dose is manageable



Jefferson Lab

Be Target Assembly (Preliminary Results)

- Deposited power density
  (need to check normalization)



Other Thoughts

- The KLF collaboration could save a lot of effort if the CPS collaboration could come up with a single device design good for all halls
  - 60 kW for Hall D is “only” a factor of 2 higher
- Utilizing 10% Cu radiator and the rest of the tagger beam line to deposit the beam could be a cheaper solution, but a significant effort to evaluate this option
- For tungsten-based shielding, machinable tungsten alloys may still be available (Hevimet – 7%-8% Ni, 2%-3% Cu, 95% of pure tungsten density).
  As opposed to pressurized tungsten powder blocks.

Questions?

- What was covered
  - What should be addressed for RSAD and design
  - Some estimates for Be target assembly
    - Prompt dose – need better model
    - Residual activation - manageable
    - Deposited power density
- Did not cover the activation of cooling water, but results exists