CeC Open Issues

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Routine Losses and likely beam Faults

- Memo Nov. 12, 2015 on Lateral Shields
- Assumes 5 micro-amps for routine losses
- 175 hours of full power beam to final water cooled beam dump
- 8500 Watts at 25 MeV
- Conclude the lower power numbers at 1 Watt are not “relevant” (1200 hours)

Dose rates

Table 1: Summary of dose rates for 8500 Watts of CeCPoP beam

	Routine dose rate mrad/hr, mrem/hr	Fault dose rate mrads/hr, mrem/hr	Fault dose mrads, mrem
Transport-sidewall	0.023, 0.0005	1.6, 0.034	0.3, 0.007
Transport-roof	9, 0.7	634, 45	130, 9
Transport-truck door	0.034, nc[12]	2.3, nc	.5, nc
Beam dump-roof	11,500, 13	11,500, 13	na
Beam dump-berm	0.09, .0005	0.09, .0005	na

- mrad is photon dose
- mrem is neutron dose
- Electron dose about 10% of photon dose
- Main issue for the roof is the water cooled beam dump
- Expect the photon dose to be conservative
- Duration of faults is assumed to be 12 minutes

Skyshine Dose

Table 2: Summary of Skyshine Dose at the site boundary.

Source	Gamma (mrad/yr)	Neutron (mrem/yr)	comments
Dump	8	0.014	May require additional shielding-see text
Transport	0.007	nc[12]	

- 5 mrem/yr is maximum per facility to site boundary
- The dump numbers are expected to be conservative
  - Does not have air attenuation (0.1)
  - Dose rate high (.5-.1)
- Options
  - Add shielding
  - Conduct radiation surveys at low power then decide

Water Cooled Beam Dump

- Memo (preliminary)
- Issues are:
  - Material heating
  - Ozone production
  - Air Activation
  - Soil Activation
  - Water Activation
  - Gas creation in the water (H,0,….
  - Residual Activity
- Design for 8500 Watts at 22 MeV

Copper Dump

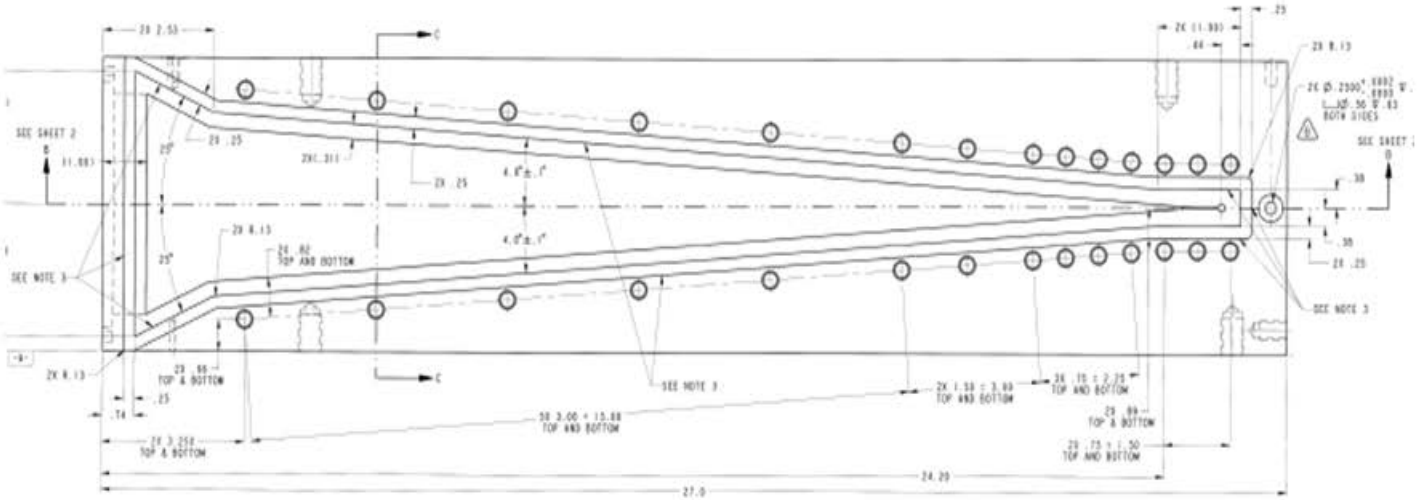


Figure 2: Side view of the beam dump. The overall elnght is 27 inches and 6 inches on a side. A long narrow slit with a round hole is located at the apex of the 4 degree slop to help relieve stress concenetration.

- 4 degree slop to spread thermal load
- Beam size has a sigma of 6 mm in x and y
- Stress must be at acceptable levels
- Early attempt found Cu to be better than Al

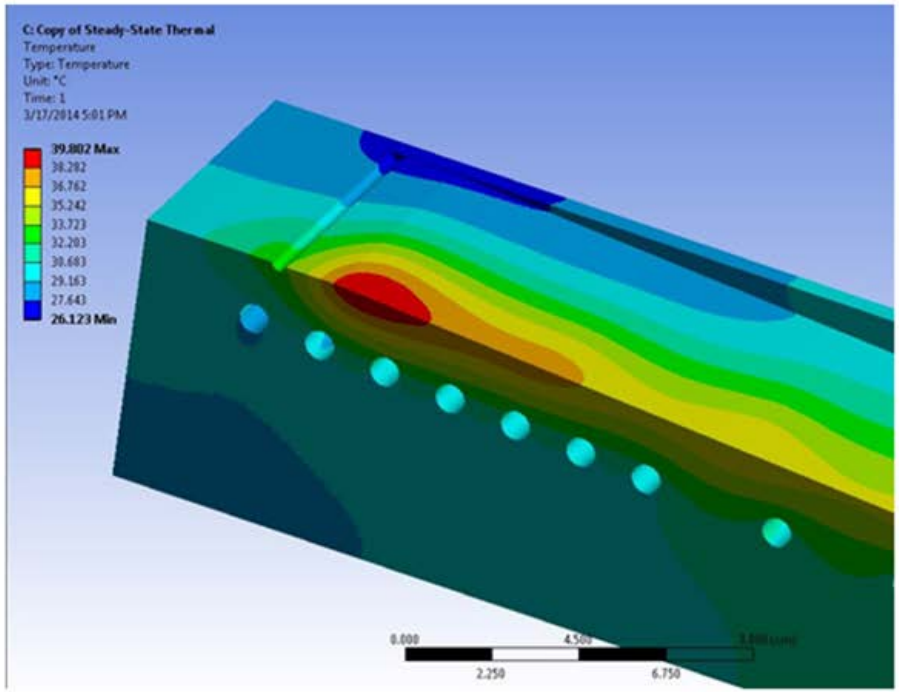
Photo of Fabricated Dump

Figure 3: Temperature profile for a beam spot of 6 mm (sigma) centered on the beam dump. Only a small temperature increase to 40 C occurs at the beam peak.

Figure 4: Photograph of the beam dump at the end of the test beam line. The ceramic insulator allows the dump to function as a Faraday cup. There are electrical isolations on the legs holding the dump. Beam was never delivered to the beam dump in this location.

Electrically isolated→ act as a Faraday Cup

Temperature Profiles



Maximum Temperature – 40C

Figure 3: Temperature profile for a beam spot of 6 mm (sigma) centered on the beam dump. Only a small temperature increase to 40 C occurs at the beam peak.

Residual Activity

Copper Saturation Activity for 8.5kW of 25 MeV Electrons

Radio-nuclide	½ life	Threshold MeV	Saturation Activity (GBq)	Saturation dose rate at 1 foot Rads/hr
Cu-61	3.32hr	19.73	8.5	15
Cu-62	9.76 min.	10.84	318	460
Cu-64	12.8 hr	9.91	155.	170

- Assumes several days of full power operation to saturate Cu-64
- Self shielding has not been calculated
- For 1 Watt low power →76 mrads/hr at a foot
- Al dump is being planned
- Change in March to April

Al Beam Dump

- Al-26 m half-life 6.37s→ 190 rads/hr at 1 foot
- Na-24 half-life 15 hr→ 80 mrads/hr at 1 foot
- Alloy Al 6061
  - .3% Cu → 300 times lower than Cu
  - 0.6% Si → need to look up cross-sections for these three elements
  - 1.0% Mg →
  - 0.2% Cr →
- Expect that the dose rates will be a fraction of Cu about 2%, but need to check. If true after an hour the Al would be at 3.4 R/hr at a foot.
- Plan is to use the copper dump for LEReC in the long term.

Plan for dump and shield

- Finish preliminary numbers
- Design a shield for the Al dump to reduce dose to a few 10's of mrem/hr
- Ensure that roof issues are resolved.
- Must also look at activity created in shield but expect this will be small. The desire would be to use Steel since it is cheap, easy to machine, etc.
- Assume 1% of energy absorbed by water would produce 0.09 liters of Hydrogen per hour

Air Activation

Air activity from high Power beam dump at 8500W of 25 MeV

nuclide	Saturation concentration[14] pCi/cm^3	10CFR835 Inhalation DAC (pCi/cm^3)	10CFR835 Immersion DAC (pCi/cm^3)	Half-life Min.
^{11}C	0.026	100	6	20.34
^{13}N	740.	n.a.	6	9.96
^{15}O	32.	n.a.	6	2.05
^{39}Cl	2	2	6	55.5

Other Dump Issues (Cu)

- Ozone
  - 3.4 *10**-7 or 3.4 TLV which is based on 8 hours
  - At 0.63 of TLV after two hours
  - No mixing used in analysis
- Soil Activation
  - None, The O and Si thresholds are too high
- Water activity
  - 0.06 Ci of O-15
  - Sphere→ 43 mrem/hr
  - Distributed over about 300 feet of 4 inch diameter pipe and smaller pipes in IR.
- Hydrogen, etc not calculated yet
- Redo calculations with Al dump but expect roughly same numbers

Misc

- Redo penetrations for 2 MeV to final dump
- Calculate penetrations for 25 MeV
- 3 chipmunks being added inside IR for measurements
- At least one chipmunk placed at Alcove 1B to warn of radiation from CeC.
- Outside chipmunk being moved to north cableway