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Analyses in Support of SNS Waste Classification

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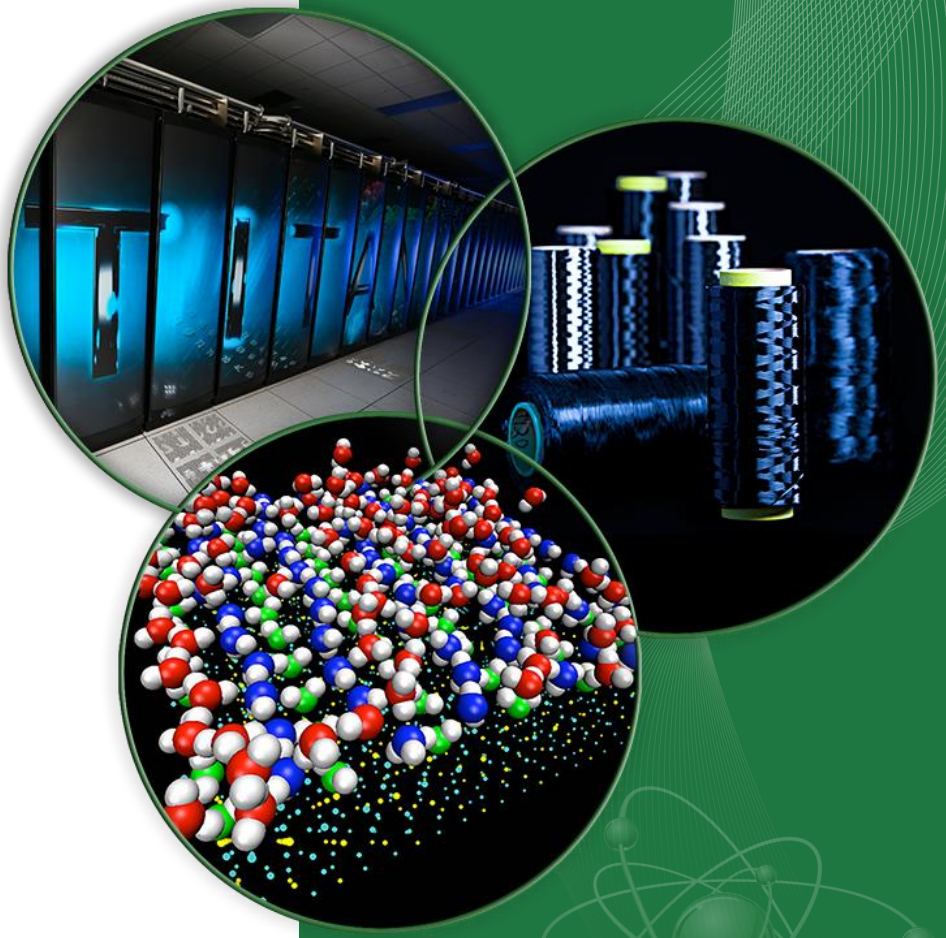

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Outline

- Introduction
- Methods and codes
- Target system
- Accelerator system
- Conclusions

Introduction

According to SNS operations plan some components are replaced:

- They have reached their end-of-life
- There where design improvements
- Components scheduled for removal

Components must be safely removed, placed in a container for storage, and transported away from the site

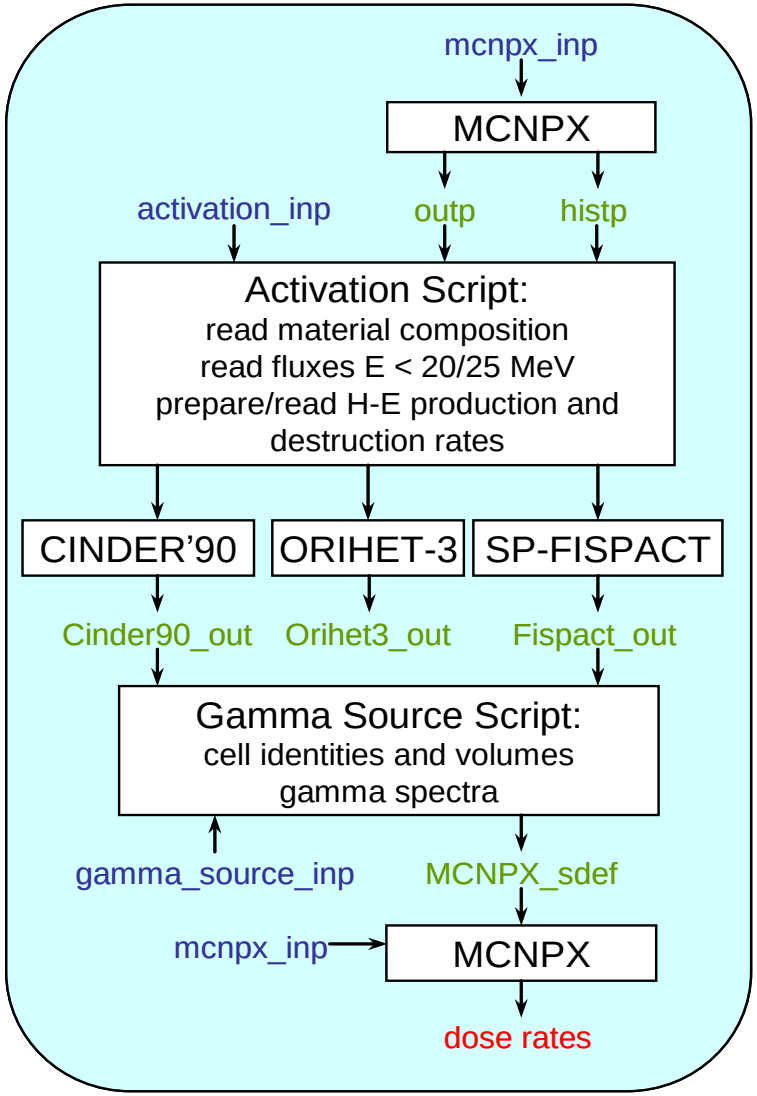
Neutronics analyses are performed for:

- Prediction of isotope composition for spend structures in order to do waste characterization analyses
- Choice of proper storage or transport box/package
- Development of shielding for transport and storage box/package

Codes and Methods

- The latest 3D as-built target station model and accelerator components models are used
- For accelerator facility only adjacent section to the component portion of accelerator is modeled.
- Effective dose rates are obtained by folding flues with flux to dose conversion coefficients, which are taken from standardized for SNS neutron and gamma flux-to-dose conversion coefficient libraries
- For waste classification purposes a report containing isotope inventory, dose rate and transport package description is generated

Code and Methods
Residual dose rates analyses



① reaction rates are calculated using MCNPX

② the reaction rates are fed into Activation Script that provides the interface between MCNPX and the transmutation codes CINDER'90, ORIHET3 and SP-FISPACT; then gamma decay spectra and isotope inventory are obtained

③ photon spectra are extracted

- converted to dose rates manually for simple geometry
- formatted into source descriptions in to MCNPX for decay gamma transport calculations

Target system facility

Components scheduled for replacement:

- Target vessel
- Proton beam window (PBW)
- Core vessel insert (CVI) plugs
- Inner reflector plug (IRP)

Components replaced:

- To avoid material damage for target vessel and PBM - allowable peak damage of steel and Inconel structures is 10dpa
- When beam line optical components are ready to be installed CVI plugs are extracted
- Planned reach end of life – IRP, 25,000MWh

Target system facility

Report for waste management contains:

- ✓ History of irradiation
- ✓ Radionuclide inventory
- ✓ Gamma dose contour plots
- ✓ Predicted dose rates to the distance 3000 ft from the component, for target vessel and PBW;
- ✓ Distances from the side and the bottom of the spent target in the liner for which the dose rates falls below 100 mrem/hr and 5 mrem/hr for target vessel and PBW
- ✓ Dose rates on the surface of components and dose rates at the locations required by department of transportation for the package for CVI plug and inner reflector plug

Target facility – target vessel

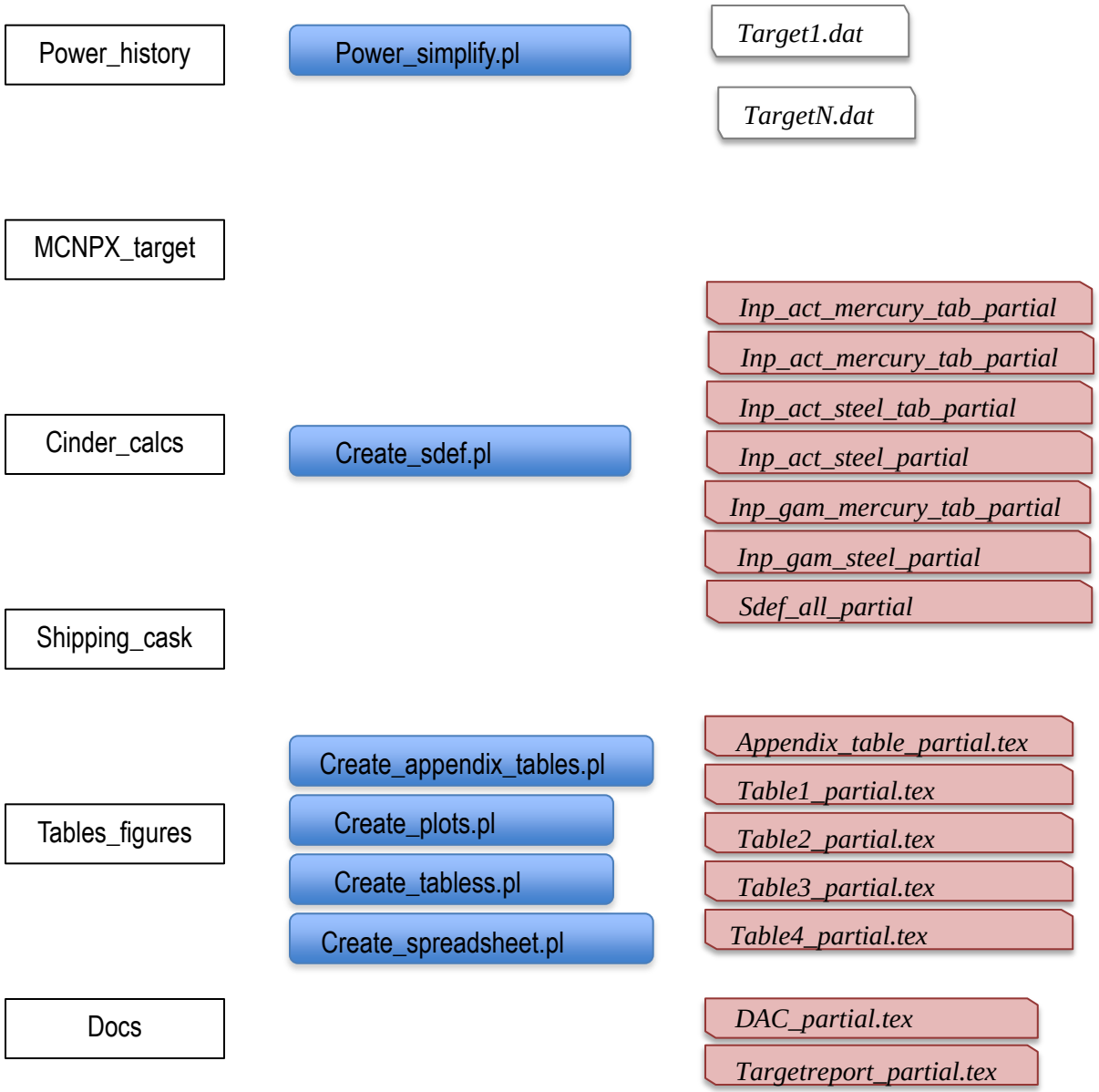
The target vessel radionuclide inventory included:

- The target vessel,
- 200 g of activated mercury dispersed in the target
- 10% of the mercury radionuclide inventory deposited on the mercury exposed steel piping and target structure of the mercury loop (target is 4.16% of the whole loop).

Perl script TARGET_DISPOSAL

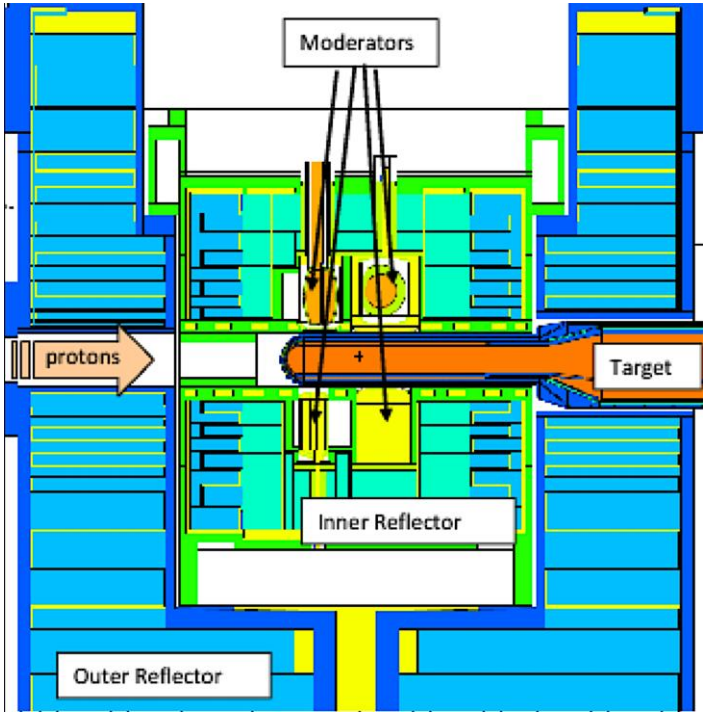
- Takes reaction rates from MCNPX analyses
- Performs activation analyses
- Residual transport calculations
- Creates a report

Target facility – target vessel

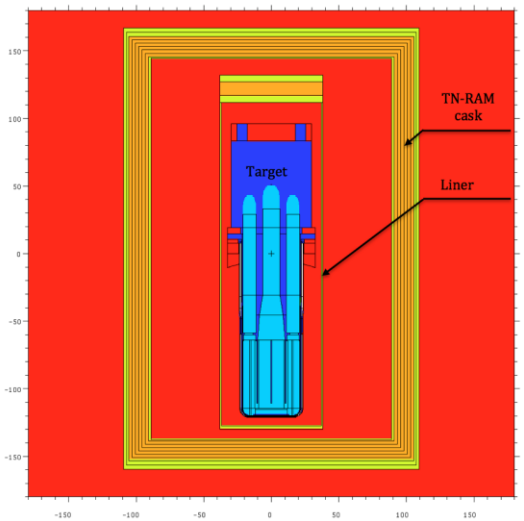


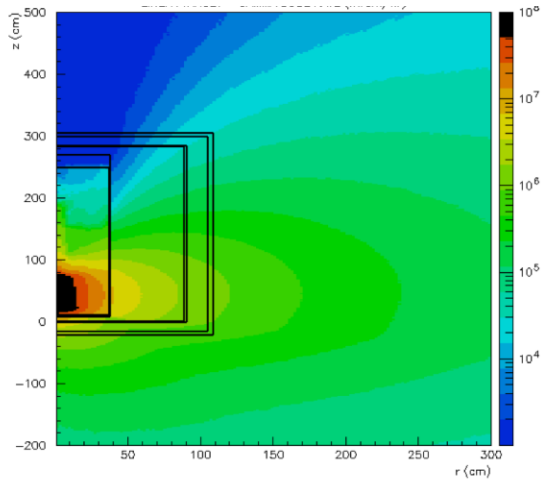
Target facility – target vessel

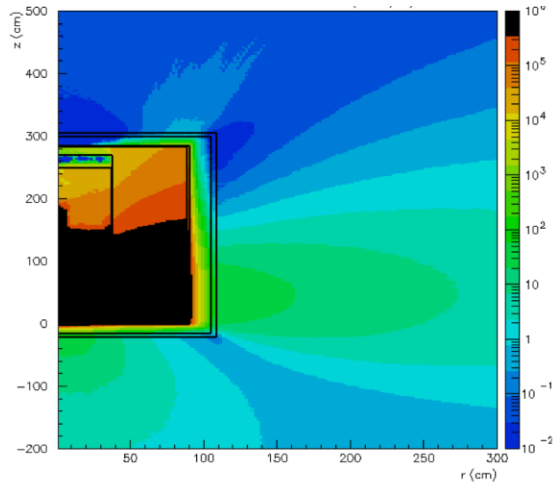
- After dismounting target vessel goes in to handling liner
- Stored on site to cool down
- TN-RAM cask is used for off site transport (on the base of bounding case irradiation of the target vessel for 2500 hours at 2MW proton beam power)



Target facility – target vessel





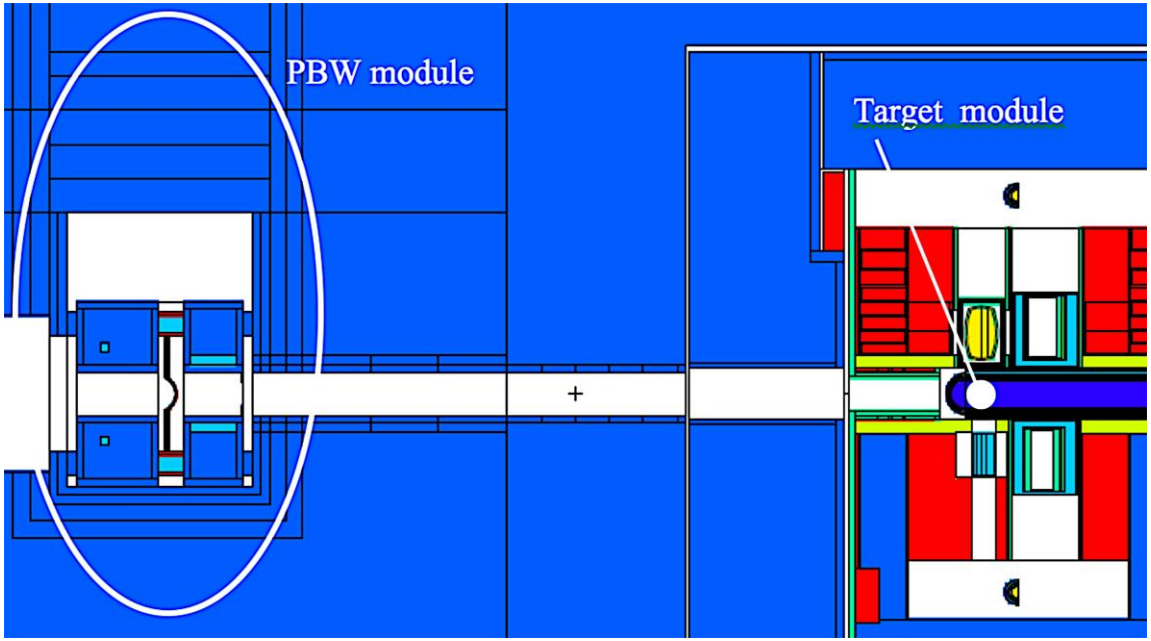


Target #9 after 135 days decay, service time of 0.75 years and accumulated about 4200 MWh proton beam energy at 1 GeV

Target facility - PBW

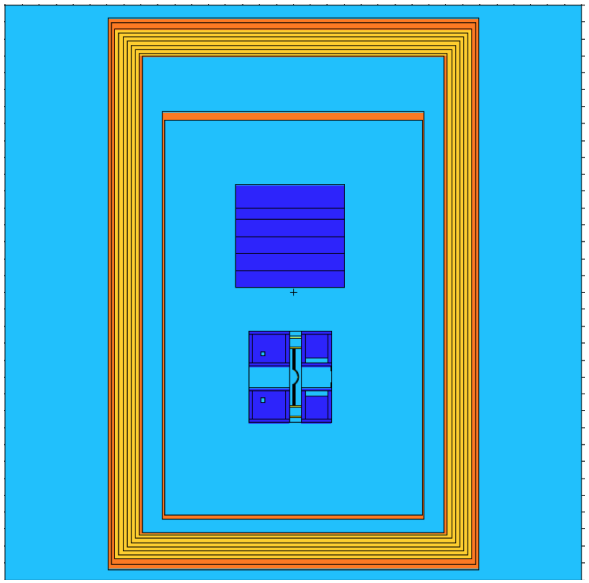
The SNS PBW module is mounted in the target monolith, approximately 2.3 meters upstream from the target :

- **Establishes the boundary between accelerator and target environment**

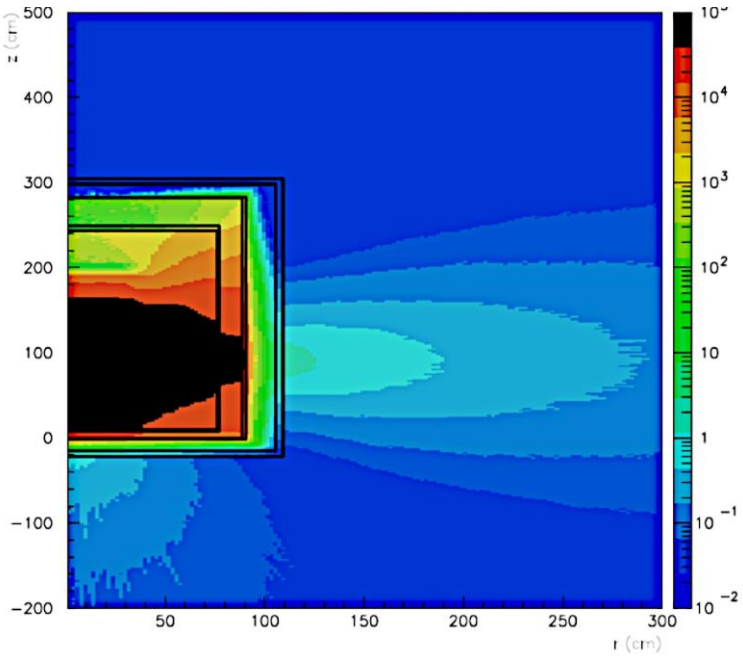


Target facility - PBW

After completing radiation transport and activation analyses, the PBW module is extracted from the target monolith model and placed into a steel liner and TN-RAM cask model

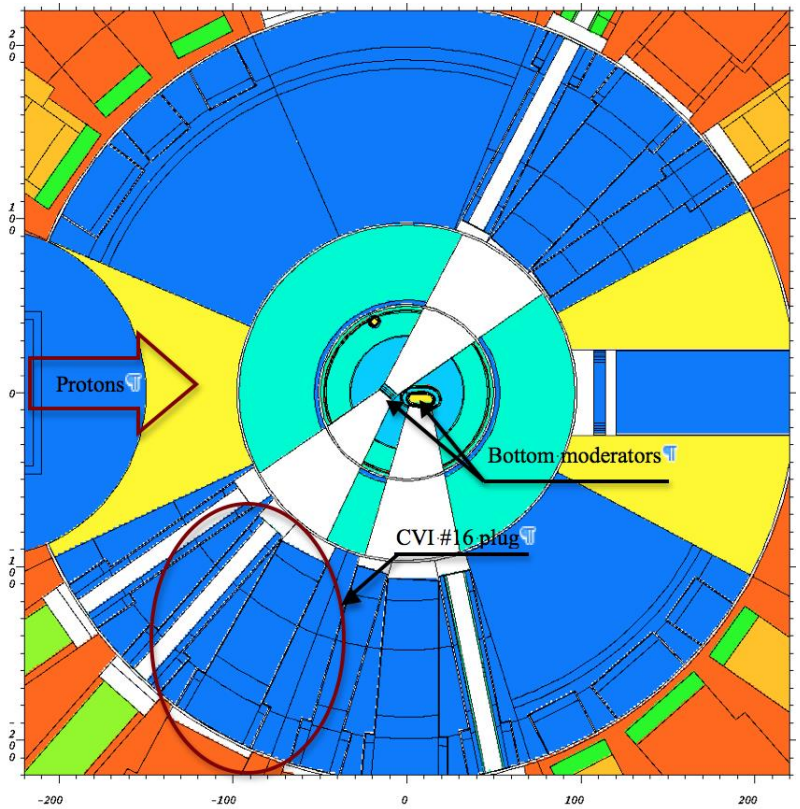


PBW #3 after 286 days decay



Target facility- CVI

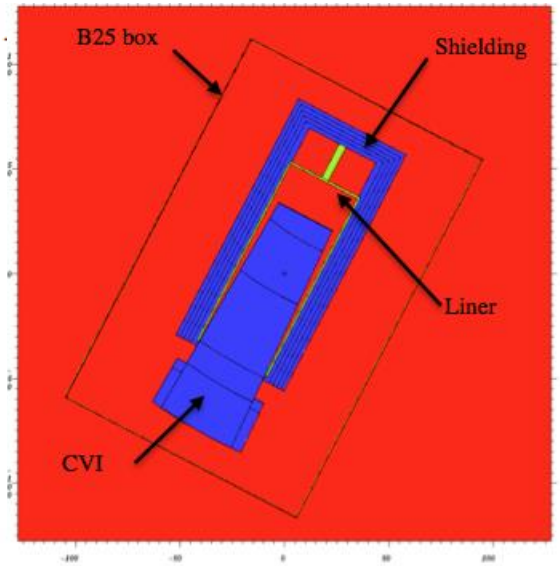
- Initially 4 beam lines received plugs
- Located at 1m from moderators
- CVI #16 plug module was analyzed



Target facility- CVI

- Choice for the package made on calculated dose rates, transport box B25
- Additional shielding was requested - 11 cm of steel shielding around the nose sides and 10 cm of steel behind the nose area
- CVI plus goes into tooling liner and then to the transport box

Location	Required by DOT dose rate, mrem/h	Calculated dose rate, mrem/h
On the package surface	1000	400/15/240
Contact on the truck side	200	75
At 2m from the truck side	10	10
Underneath truck	200	160
Top of the truck	200	20



Accelerator facility

Components replaced

- ✓ They have reached their end-of-life
- ✓ There where design improvements
- ✓ Components scheduled for removal

Components replaced or being prepared:

- Ring injection dump (RID)
- HEBT momentum beam stop;
- RTBT harp;

Temporary storage casks designed with criteria:

- 5 mrem/h at 30cm distance from the container surface ;

Accelerator facility RID

Beam stop core and window assemble will be replace, when they reach end of its life

4 containers were requested

- Beam stop core with attached shielding on the top,
- Beam window with attached shielding on the top
- Shielding block above the beam stop
- Shielding block above the beam window

Accelerator facility - RID

Beam stop core anticipates the highest losses in the accelerator facility, 5% (100kW)

Components replaced:

- HEBT momentum beam stop;
- RTBT harp;
- Ring injection dump (RID)

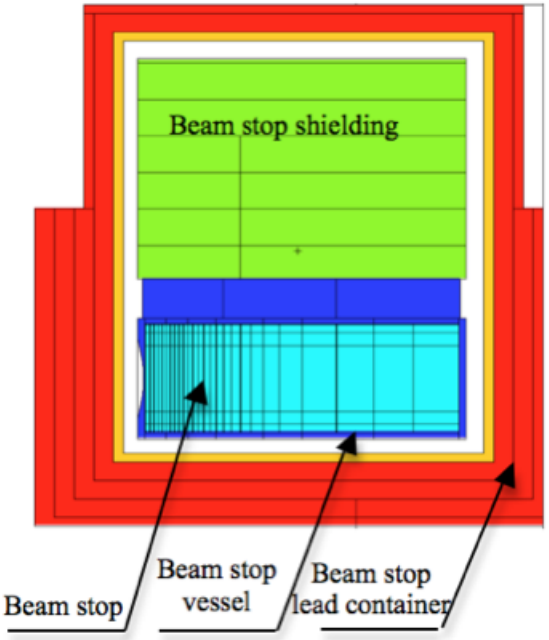
Space constraint - the roof hatch opening, limits material choice

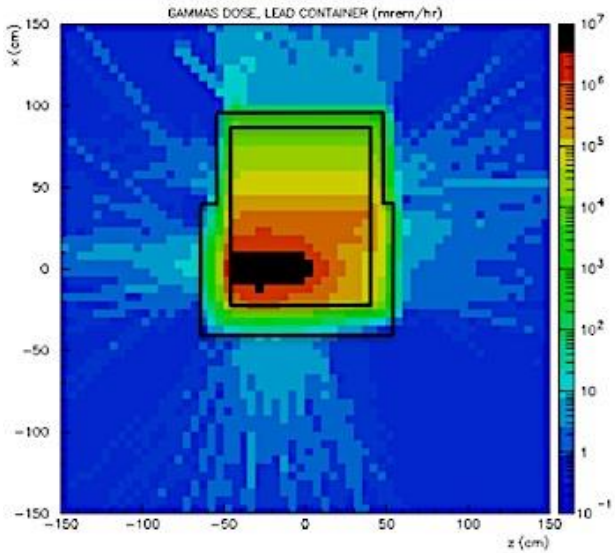
Accelerator facility - RID

Beam stop core anticipates the highest losses in the accelerator facility, 5% (100kW)

2 containers configuration were suggested:

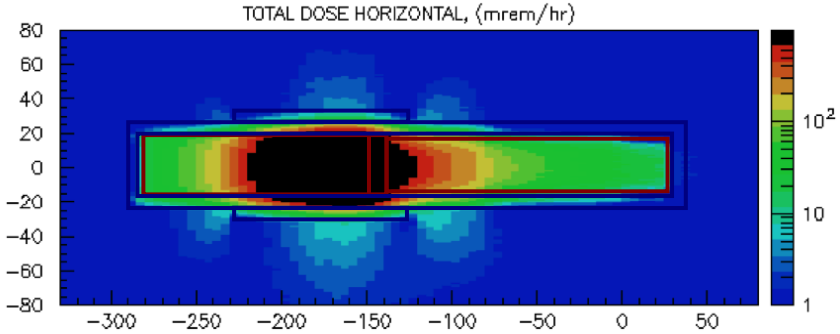
- **Lead container packed in steel**
- **Steel container fortified with lead**





Accelerator facility – HEBT momentum Dump

- Old HEBT momentum dump was replaced with newer design dump
- Container dimensions for HEBT momentum dump were calculated on the basis that the beam dump was cooling down for one year and then placed into container
- Source terms for the analyses was 850 MeV proton beam at 1 kW
- Cylindrical steel container with changing profile was designed



Conclusions

Transport and activation analyses are performed to support SNS spent components removal, storage and transport out of the facility.

- **On the base of calculated radionuclide inventory the spent component is classified and appropriate container for transport and storage is suggested.**
- **If needed, additional shielding is designed.**
- **For target vessel analyses script was created.**