Science & Technology Facilities Council

Target Station Design for Neutrino Superbeams

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Contents

- Background – EUROnu Design Study
- Purpose of the Target Station
- Key Challenges
- Target Station for EUROnu Superbeam
- Relevance to CN2PY

Background

- A conceptual target station design was developed for the EUROnu superbeam design study;
  - 4MW conventional superbeam
  - 4 targets in parallel operating at 1MW each
  - 4.5GeV proton driver based on proposed HP-SPL
  - CERN to Fréjus (130km baseline)

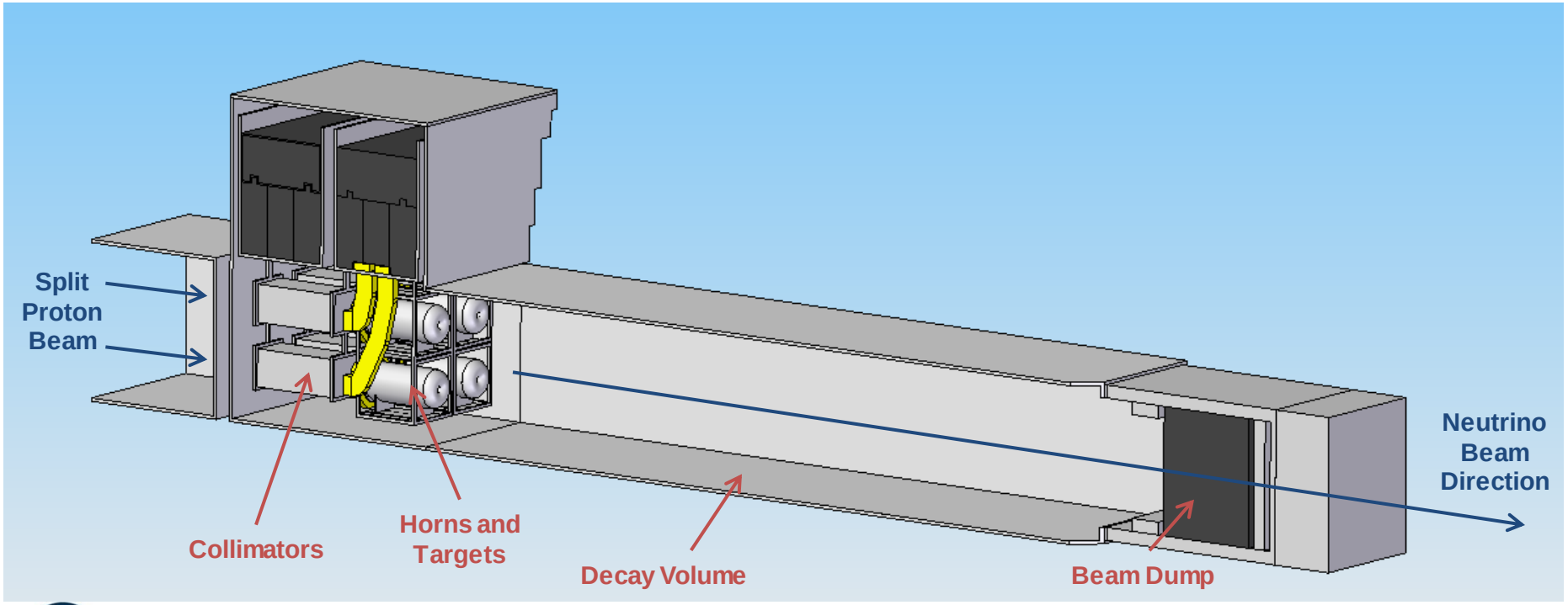
- Aim was to design a target station and remote handling system to cope with multi-megawatt operation

- The challenges faced are relevant to many current and proposed neutrino facilities

Purpose of the Target Station

- To contain the targets and magnetic horns
- To contain support infrastructure for these components (maintenance, cooling, etc.)
- Facilitate safe operation
- Allow for planned maintenance and replacement of components

- For EUROnu, the target station contains the section of beamline shown below;



Key Challenges

Common to all high-power beams:

- High radioactivity of components
- Limited horn and target lifetimes – multiple failures expected during facility lifetime
- Remote handling system
- Precise alignment of horns and targets required (±1mm)

- Minimise Downtime
- Minimise Cost

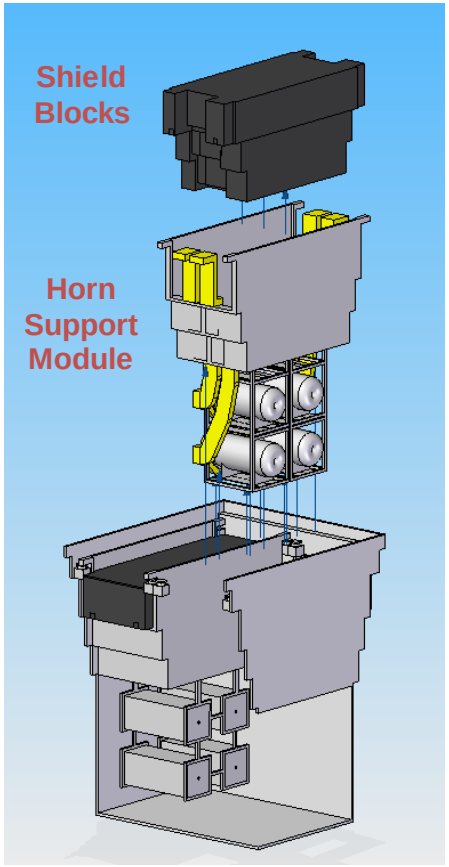
Euronu specific:

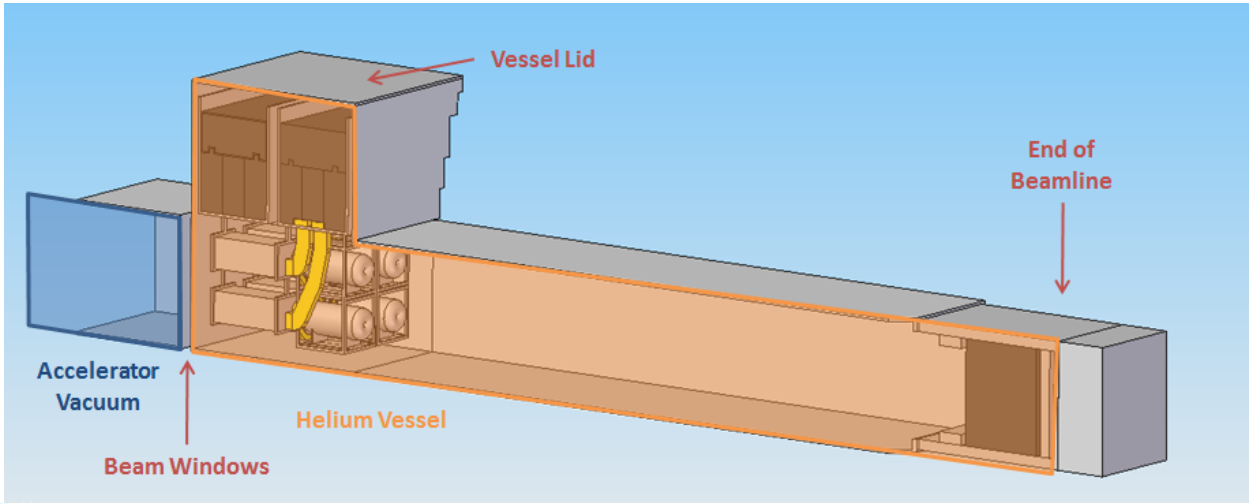
- High rep rate (50Hz/4) at high current (300kA)
- 4 horns mean increased complexity and increased target station volume

EUROnu Target Station Overview

- Solution inspired by T2K target station
  - Proven concept, designed for comparable beam power and activation

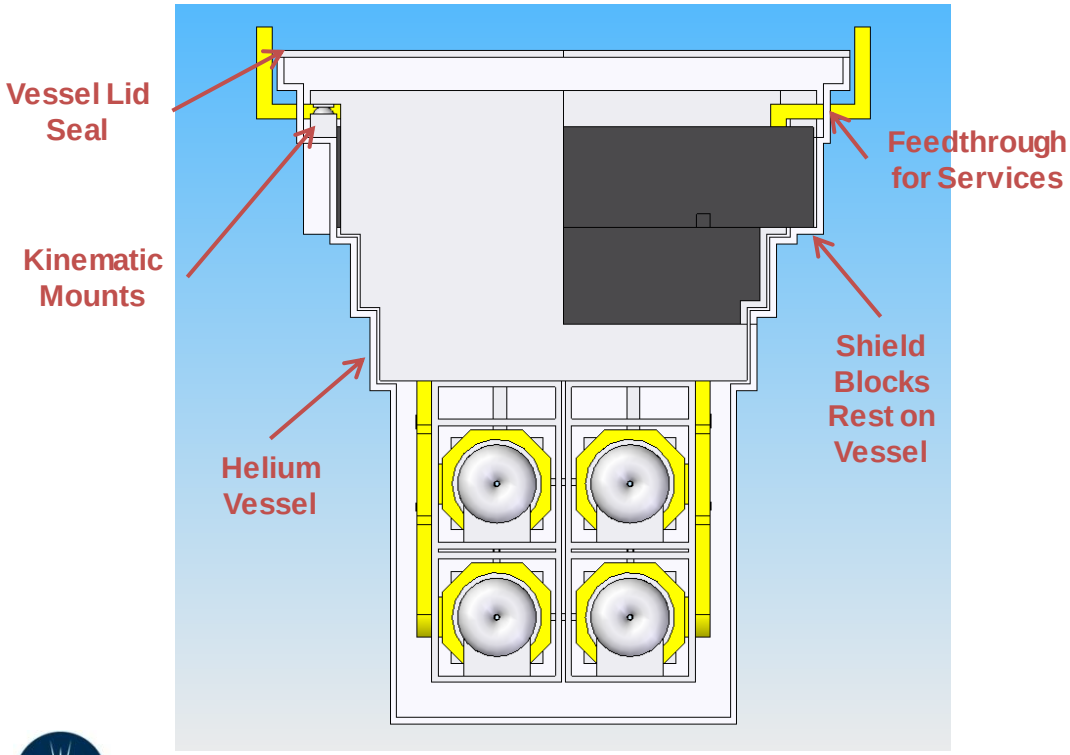
- Key Features
  - Components run in helium environment
  - Beam windows separate helium from accelerator vacuum
  - Gantry crane for remote handling
  - Support modules carry horns and targets
  - For access, must pump out helium and remove shielding

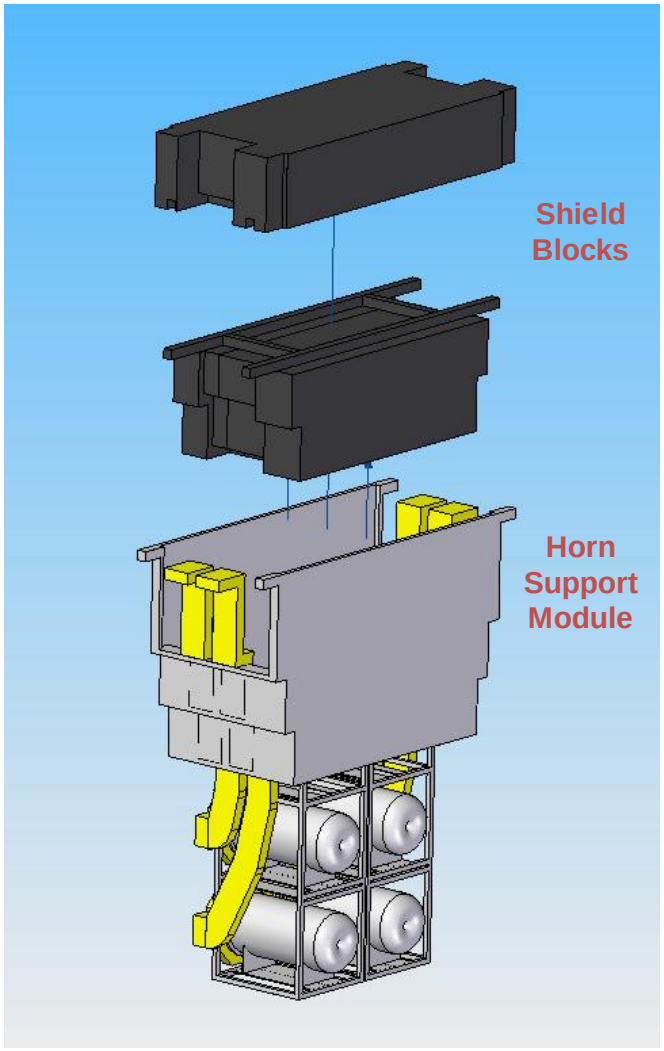




Horn Support

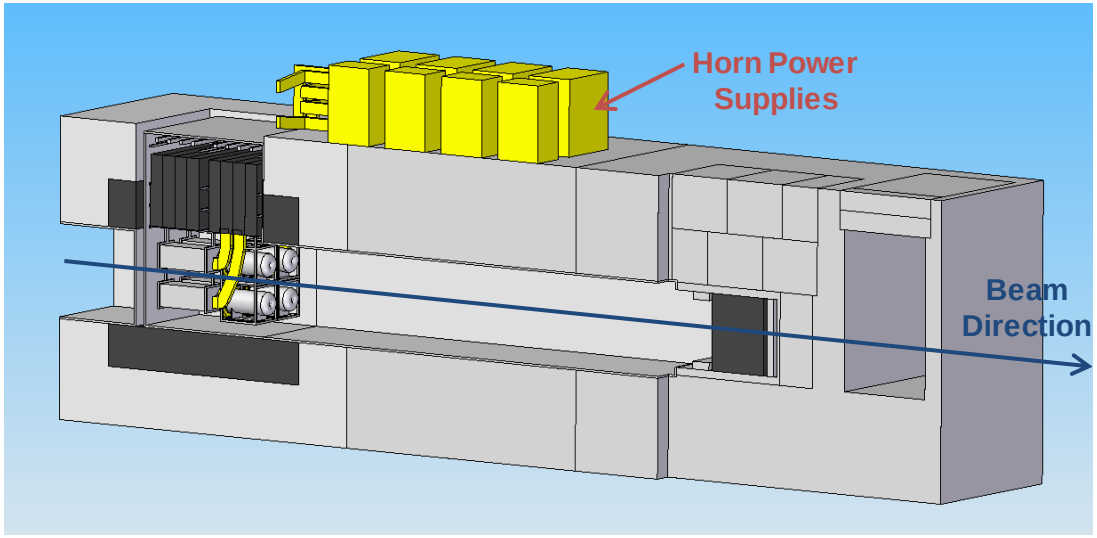
- Kinematic mounts ensure accurate alignment
- Must disconnect services inside vessel
- Shielding inside vessel protects kinematic mounts, service connections and lid seal
- Removable shield blocks fit inside module
- Labyrinth to prevent radiation shine

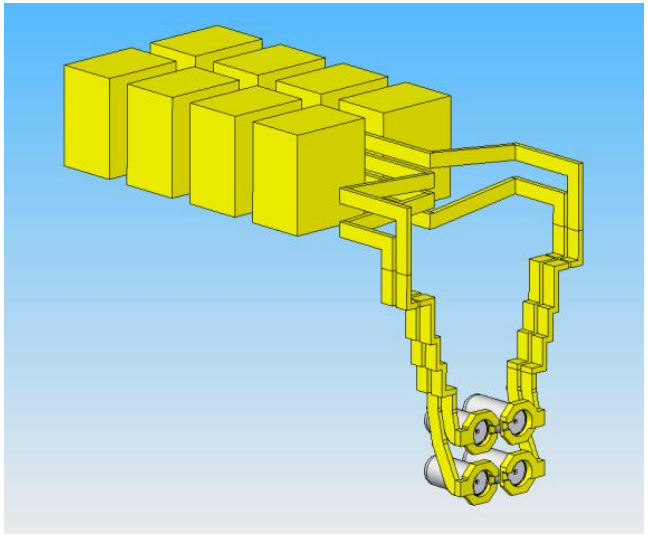




Power Supply

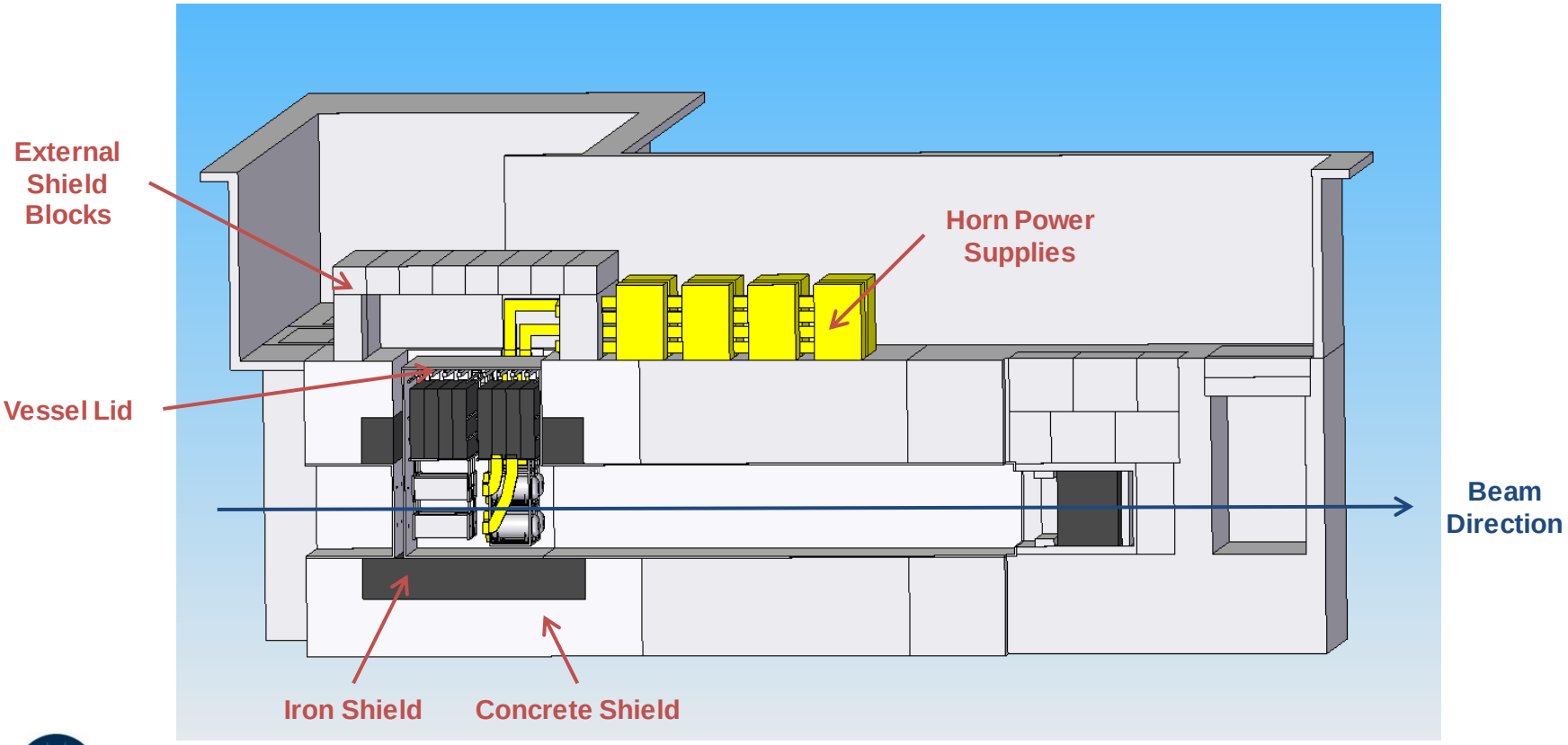
- Power fed to horns via striplines
- Stripline length must be minimised, without compromising shielding thickness
- Horn power supplies located on top of decay volume shielding
- Need equal stripline length to each horn





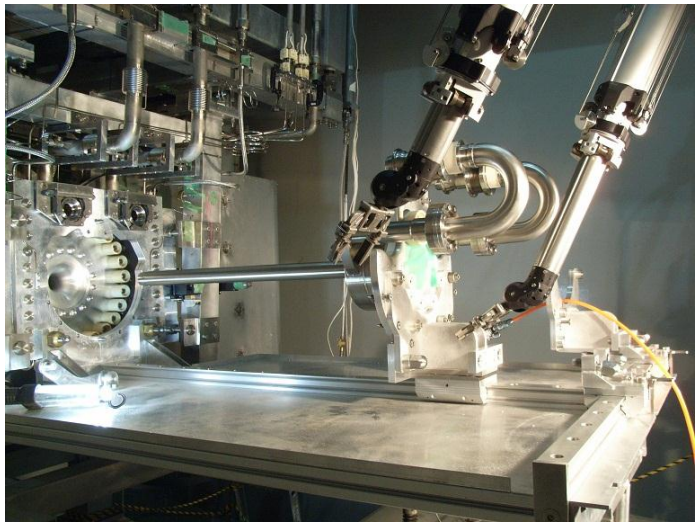
Shielding

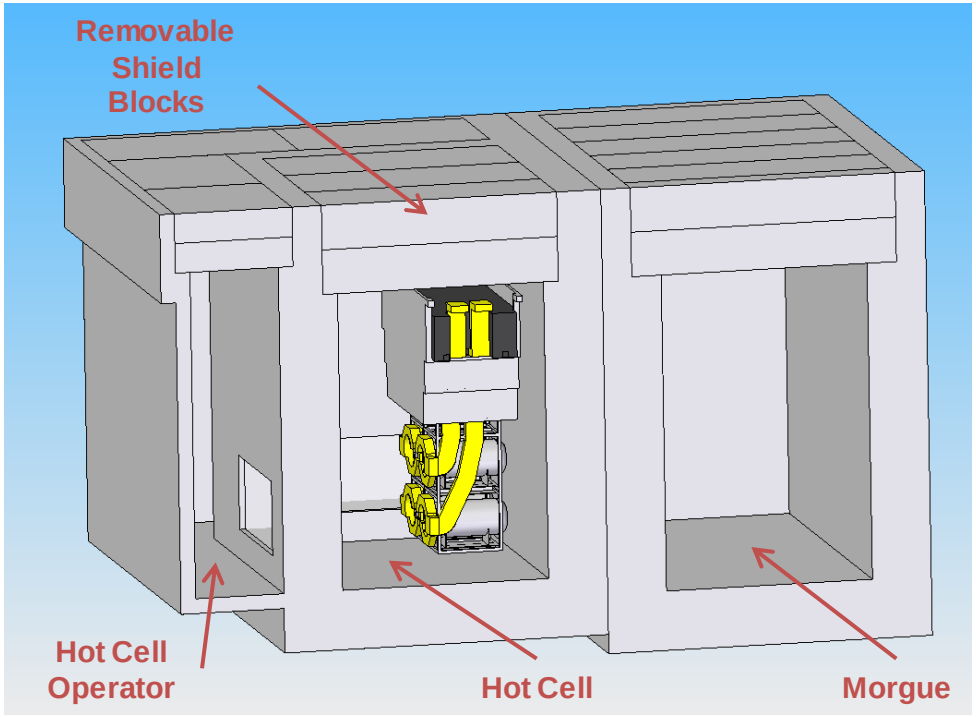
- Beamline shielded by concrete, target station also has an iron inner shield
- Movable shield blocks allow the horn assembly to be removed
- Vessel also has external shielding to reduce dose in main hall and power supplies
- Shielding will require careful design and sealing to minimise release of activated air into target hall



Repair and Disposal

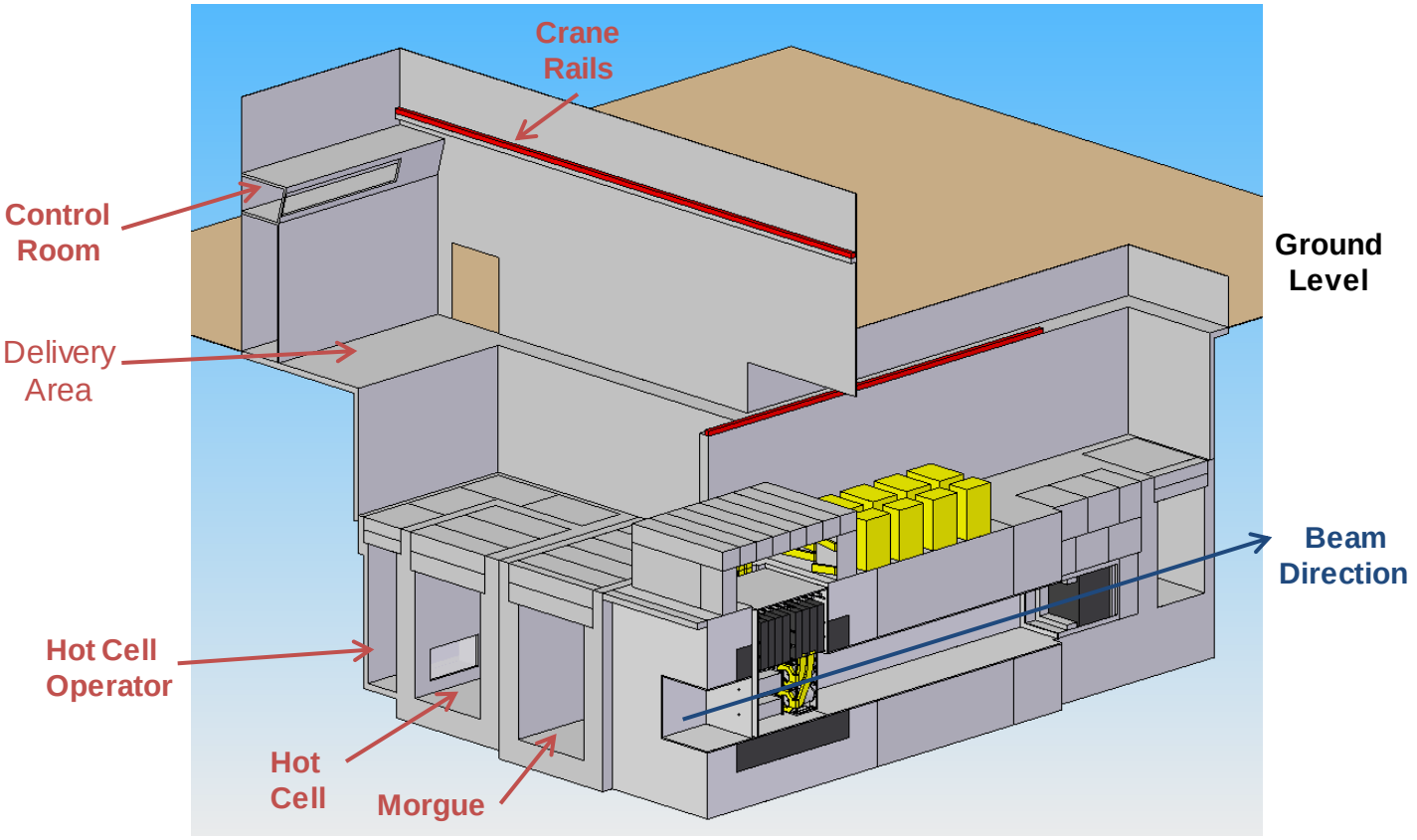
- Hot cell allows activated components to be repaired or dismantled
- Morgue stores broken components in steel casks until activity reduced for disposal
- Hot cell operator uses remote manipulators, with cameras and lead glass windows for visibility
- Replace targets within horns. Hope to replace individual horns from the support module?





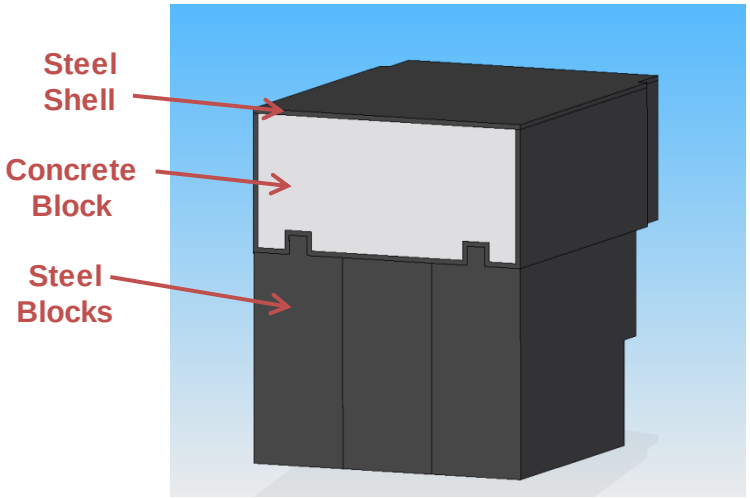
Remote Handling

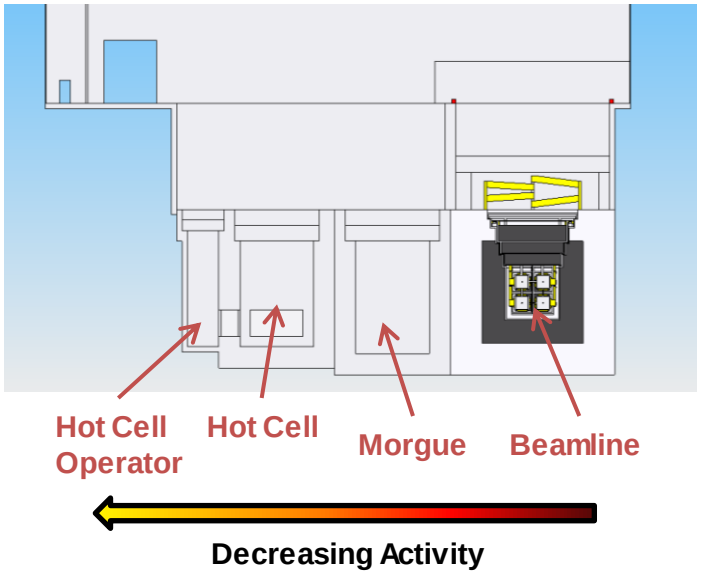
- Gantry crane covers helium vessel, morgue, hot cell and delivery area
- Second, smaller crane to move power supply units
- Pit to reduce radiation shine while moving horns
- Two assemblies of four horns will be used – one is running while the other is being repaired



Reducing Downtime

- Large helium volume to pump out – this is unavoidable
- Concrete shielding in the helium vessel will be encased in a steel shell to prevent tritium contamination of the helium vessel
- Main hall layout designed to minimise dose to hot cell operator. This is essential if one set of horns is to be repaired while the other is running





Additional Challenges Introduced by CN2PY

(Cern Neutrinos to Pyhasalmi, 2300km baseline)

- Target station deep underground
  - Will have to be excavated by tunnel boring, not cut and cover
  - More difficult to reach components for maintenance

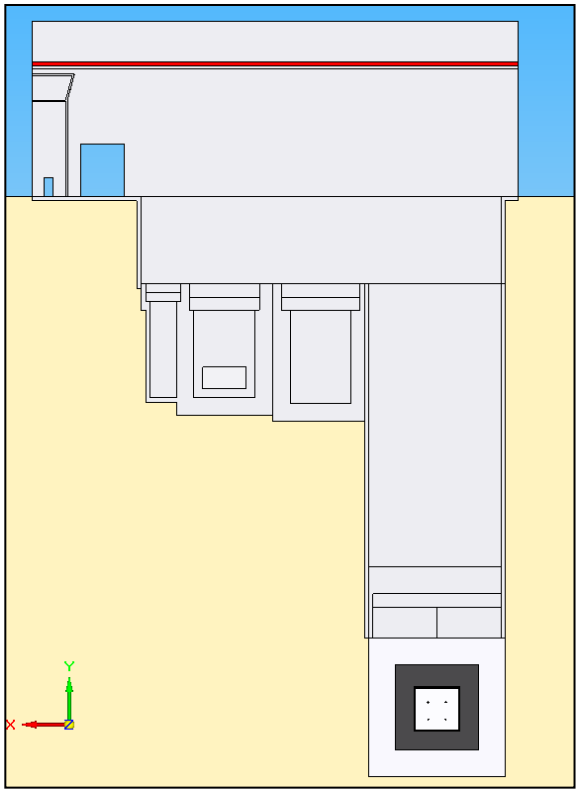
- Long decay volume
  - Will require more helium to fill and more time to pump out
  - Would be beneficial to fit a large beam window between targets and decay volume

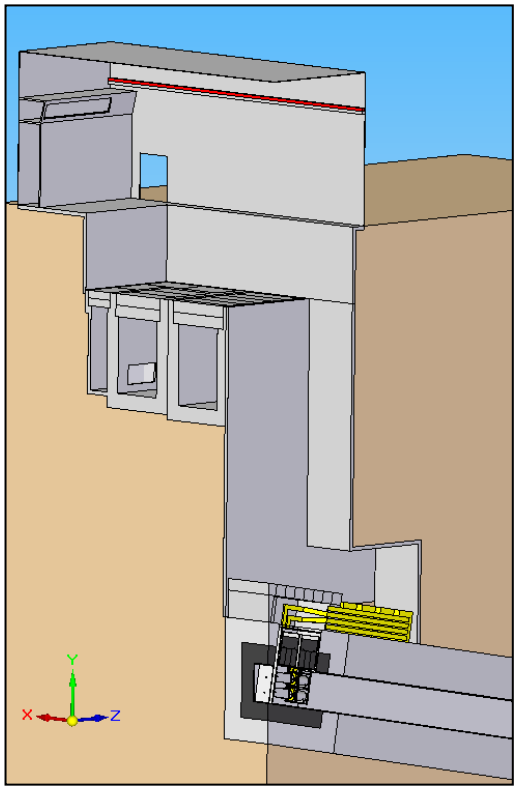
- Steep gradient of beamline
  - Beam dump will be about 240m below ground level

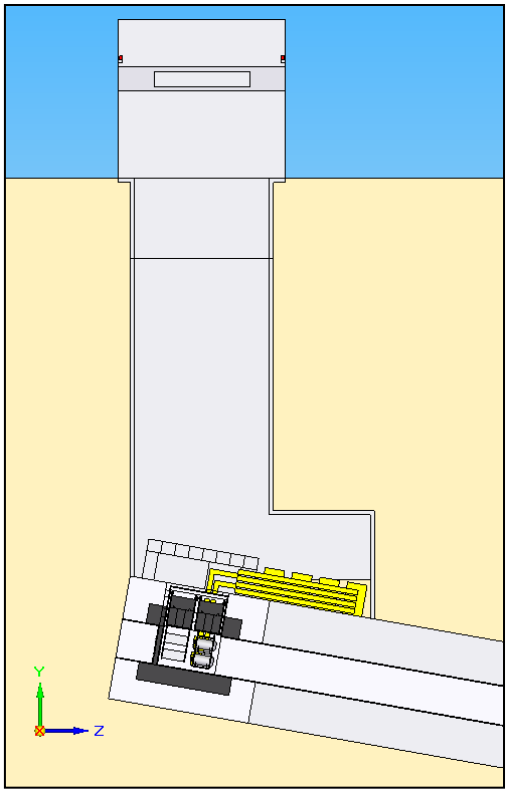
	EUROnu	CN2PY
Target Depth	20m	60m
Decay Volume Length	25m	≈500m
Beamline Angle	0.6°	10.4°

Preliminary Concept for CN2PY

- Keep as many buildings as possible at the surface to keep construction costs down
  - Must have a shaft to access the horns and targets
  - Power supplies (or transformers) must be underground, close to the beamline
  - The pump house may also be underground, depending on the acceptable pressure drop







Drawings not to scale: number and layout of horns will be different in practice, as will beamline dimensions

Summary

- Have presented a target station design concept for a 4MW superbeam, which builds on practical experience from current facilities
- Many of the challenges faced are common to all high power neutrino facilities
- This means many of the same design concepts will be applicable to other planned facilities
- Key challenges for future facilities include;
  - Minimising release of activated air
  - Minimising construction costs of deep target stations
  - Maximise up-time for the facility by minimising time to replace targets/horns