ODIN:

Progress update for the preliminary design

DENIM 2015

Stewart Pullen
Lead Instrument Engineer - ODIN

www.europeanspallationsource.se
September 9th, 2015

Overview

- Introduction to the ODIN instrument
- Partners – how will they get involved
- Project lifecycle and phases
- What have we done so far
- What do we still need to do for TG2

ODIN Origin
Optical and Diffraction Imaging with Neutrons

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Proposers

M. Strobl, ESS, Sweden, and University of Copenhagen, Denmark.

L. Udby, University of Copenhagen, Denmark.

H. Carlsen, University of Copenhagen, Denmark.

Scientific Partners

M. Schulz, Philipp Schmakat, B. Schillinger (TUM, DE)

E. Lehmann, M. Morgano, B. Betz, C. Gruenzweig (PSI, CH)

J. Plomp (TUD, NL)

L. Udby, H. Carlsen (KU, DK)

Proposal at:
https://europeanspallationsource.se/sites/default/files/odin_imaging_instrument_construction_proposal.pdf

Scientific case

Scientific Fields

- In energy research
- Magnetism and hard matter research
- Engineering materials
- Geology, earth and agricultural sciences
- Soft matter and biology
- Archaeology, Palaeontology, and Cultural heritage
- Alternative Energy and Environment
- Routine Non-Destructive Evaluation of Material Reliability

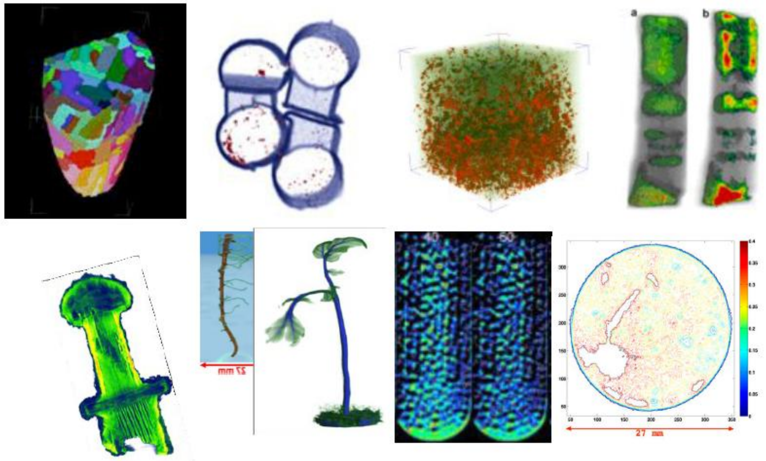
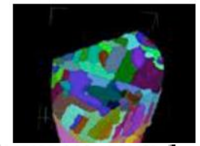
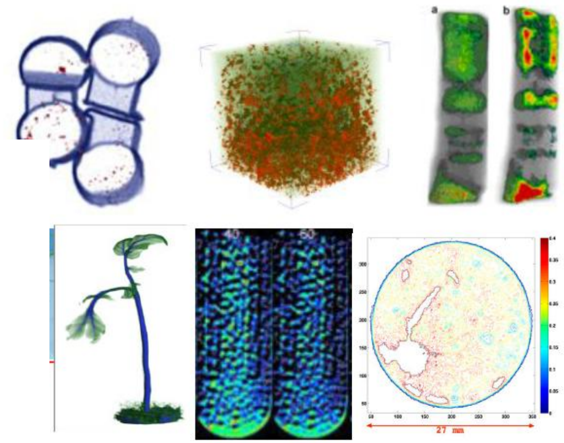


Fig. 1 scientific applications (from left to right) top: first visualization of magnetic domains (HZB), porosity distribution in casted Al specimen (HZB), crystalline phase distribution in martensitic steel sample (HZB), 3D Curie temperature map in NiPd crystal (HZB, TUM), sword artifact (HZB), plant root (PSI) and tomato seedling (HZB) from water uptake studies, hydrogen storage investigations (NIST), water distribution in soil around plant roots (PSI);

Scientific case





ɔm left to right) top: first visualization of magnetic domains (HZB), l specimen (HZB), crystalline phase distribution in martensitic steel ture map in NiPd crystal (HZB, TUM), sword artifact (HZB), plant root) from water uptake studies, hydrogen storage investigations (NIST), plant roots (PSI);

Scientific Fields

method/ application	wavelength band	wavelength resolution	max. FOV	max spatial resolution
Bragg edge/ strain mapping	1Å-5.5Å	0.3%	100x100mm2	<0.2mm
Bragg edge texture	1Å-5.5Å	1%	100x100mm2	<0.01mm
Bragg edge/ microstructure	2Å-6Å	10%	100x100mm2	<0.01mm
polarized neutrons/ magnetic phenomena	1Å-10(20)Å	1%	100x100mm2	<0.05mm
Dark-field contrast/ 2D SANS mapping	2Å-10(20)Å	10%	100x100mm2	<0.05mm
convetional imaging/ macroscop. structure	monochrom/cold thermal/bi-spec	10%/-/-/-	250x250 mm2	<0.001mm

Table 1 Instrumental requirements for the realization and efficient application of different modalities needed with respect to the defined science case and in order to take full advantage of the source characteristics for neutron imaging (note: parameters for FOV and spatial resolution are currently considered maximum requirements, which are currently not necessarily used or considered in combination).

ODIN Requirements

High-level scientific requirements for the instrument (13.6.4)

1. Shall be capable of a direct spatial resolution down to 10µm (3D).

2. Shall allow for time resolutions below 100ms in kinetic measurements.

3. Shall allow time resolutions of the order of 1 microsecond in stroboscopic mode.

4. Shall allow the measurement of sample areas of up to 25X25cm at once.

5. Shall allow the detection of contrast equivalent to 20 ppm H2 in steel.

6. Shall allow investigating macroscopic structural features of samples with attenuation thicknesses equivalent to xx cm steel.

7. Shall be able to detect lattice distortions of the order of 10 µε.

8. Should be able to detect and quantify structural features down to 10nm from dark-field scatter contrast imaging with direct spatial resolution of at least in the range of 1 mm.

9. Shall be able to characterise magnetic fields and structures with accuracy better than 1mT and field integrals up to xx mTm.

10. Should be able to provide complementary x-ray contrast with comparable spatial resolution (10µm) relatable to the neutron data with according accuracy.

11. Should be capable of visualising crystalline phases and grains with a 3D resolution of at least 100µm.

12. The System's design shall provide the space and flexibility necessary to host and drive future developments in the Neutron Imaging field.

ODIN Modalities

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Modalities configurations include:

I. “White beam” imaging with spectral choice

II. Grating interferometer in LToFR

III. SEMSANS imaging in LToFR (Spin-echo modulation small angle neutron scattering)

IV. Polarized and polarimetric neutron imaging set-up in MToFR

V. Bragg-edge and diffraction geometry set-up in MToFR and HToFR

VI. Perpendicular X-ray imaging set-up

What is ODIN:

Multi purpose imaging instrument

50m Source to pinhole

Sample located up to 14m from the pinhole

Straight beam line (direct view of the source)

Chopper cascade consisting of 9 axis (pulse 1 PPSc)

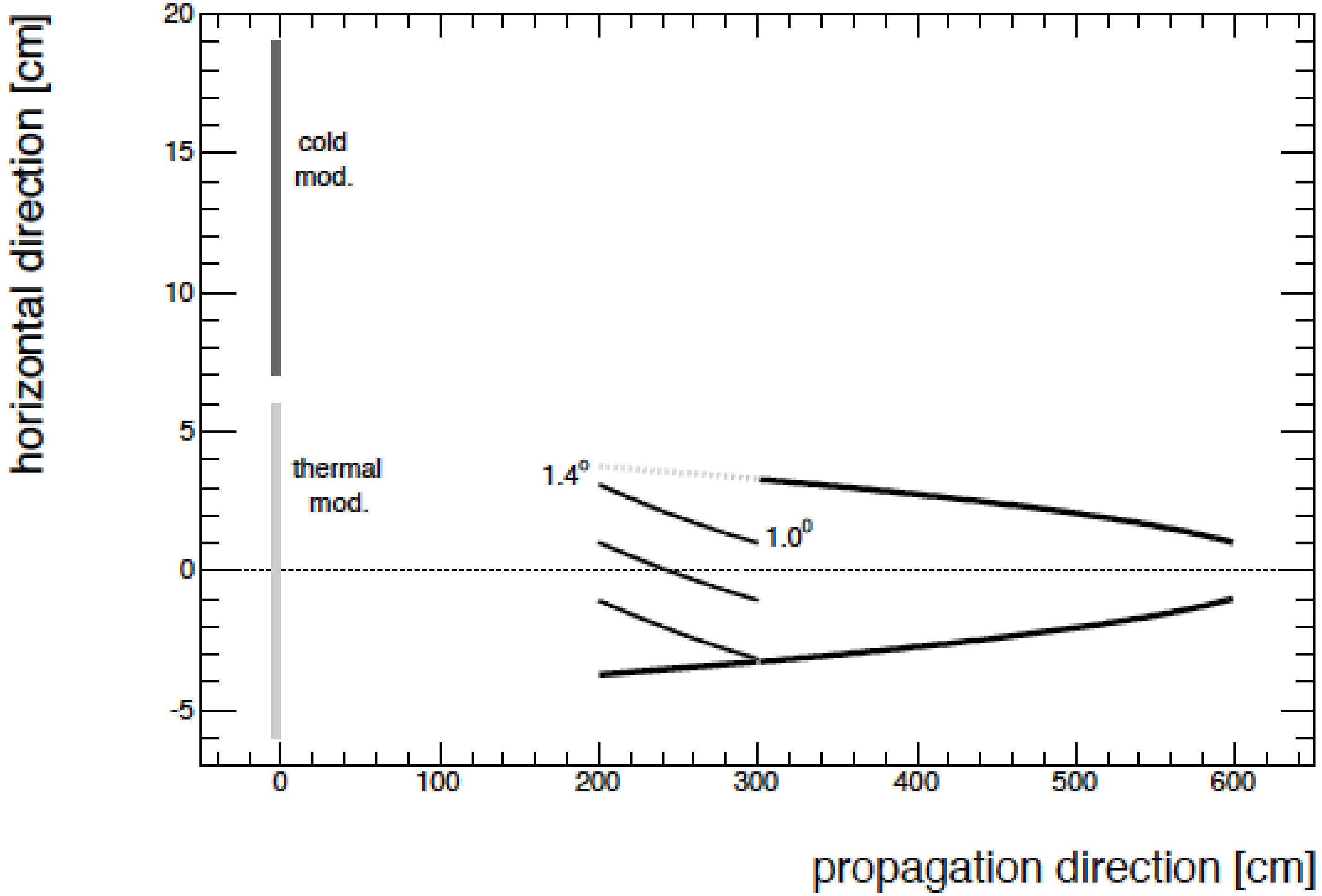
Range of operational modes:

- "White beam" imaging with spectral choice
- Grating interferometer in LToFR
- SEMSANS imaging in LToFR
- Polarized and polarimetric neutron imaging set-up in MToFR
- Bragg-edge and diffraction geometry set-up in MToFR and HToFR
- Perpendicular X-ray imaging set-up

Technical overview of ODIN

- 50m from source to pinhole, 15m from pinhole to beam stop.
- Current preference is for a straight beamline (curved is an option).
- Extraction will be bi-spectral, with focusing guides along the beamline.
- Chopper cascade consisting of 9 chopper axis.(2 of which are 1.8m diameter and 14Hz).
- Prompt Pulse Suppression chopper will likely be needed.
- Total number of motion axis will be >77

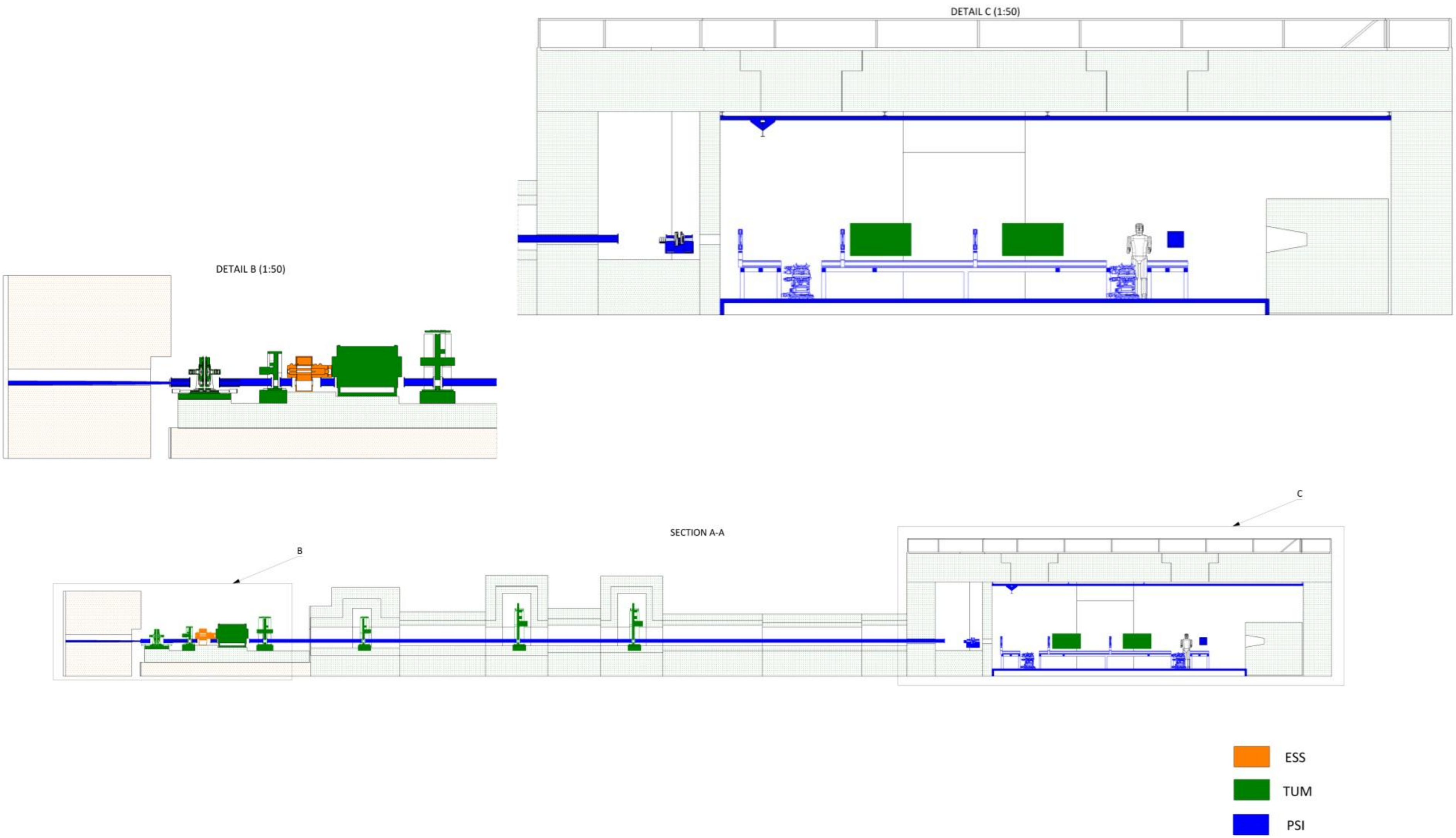
Bi-spectral extraction concept



ODIN’s Partners

- ODIN will be delivered using significant in-kind resources
- Technische Universität Munchen (TUM) – Project Lead Institute ≈58%
- Paul Scherrer Institute (PSI) ≈34%
- ESS ≈8% (pluse some items not included in the project cost ≈€1.8M)
- Other partners are likely to get involved later in the project
- An Instrument Consortium will be formed by the partners institutions

Partner contributions



Instrument Project Lifecycle

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ESS Instrument Project Stages

Proposal and Planning

Instrument Proposal

Deliverables
- A science case covering scientific relevance, impact and usage
- A conceptual design with credible estimates of its performance.
- A preliminary costing.

Phase-0
Preparation for Preliminary Design

Deliverables
- Conceptual design updates
- Prototyping, Definition of facility requirements and interfaces
- Clarification of the institutional responsibilities and the resources necessary.

Phase-1
Preliminary Design

Deliverables
- Technical requirements.
- Narrow list of technical choices to meet requirements
- PBS and In-kind deliverables plan.
- WBS and Project plans for phases 2-5.
- Staging plan.
- Seek support from ESS team to deliver.
- Assignment of cost category.
- Budget estimate to within 25%

Design and Construction

Phase-2
Detailed Design

Deliverables
- Define technical choices and design components.
- Begin procurement of long lead items
- Finalise design and facility interfaces.
- Refine project plans including construction & installation
- Refined WBS with assignment of WPs
- Refined budget to within 10%.

Phase-3
Procurement, Construction & Installation

Deliverables
- Procure and/or manufacture technical components.
- Construct physical infrastructure on site.
- Assemble and install technical components

Commissioning and Operation

Phase-4
Cold Commissioning

Deliverables
- Integrate technical components
- Component testing
- Integration testing without neutrons.

Phase-5
Hot Commissioning

Deliverables
- Validate instrument components with neutrons
- Finalise integration testing.
- Test Experiments
- Instrument Consortium Demonstration Experiments.

Phase-6
User Operations

Deliverables
- Perform User experiments

Tollgate 1
STAP review
SAC recommendation
STC Decision to enter NSS project baseline

Tollgate 2
STAP advice on choices
ICB Review of plans, budget and scope. ICB to concur for moving to next phase.

Tollgate 3
STAP/TAP advice on layout and technology.
ICB Engineering Review of design. ICB to concur for moving to next phase

Tollgate 4
Safety Systems Review. ESS decision for moving into cold commissioning.

Tollgate 5
Review Commissioning Plan and operational Readiness. ESS decision for moving into hot commissioning

Tollgate 6
Review Instrument Readiness for user operations. ESS decision to include instrument into science programme.

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TG2 Documentation (Baseline Documents)

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Requirements Document	Concept of Operations	Product Breakdown Structure	Process & Instrumentation Diagram	Interface Control Documents
• the scientific and technical requirements that describe the needed performance parameters of the instrument	• Describes the expected operation of the instrument during the ESS operations phase. • The basic steps of the experiments are explained	• A functional decomposition of the instrument into components	• Schematic layout of the instrument showing all of the connections	• Describes the interfaces between all of the systems within the instrument and to the "outside" world

Instrument Work Package Specification	Work Unit Documents	Technical Group design documents	Staging Plan	Draft Hot Commissioning Plan
• Provides a single document that describes what is going to be built, how much it will cost, and how long it will take.	• For each technology area/functional decomposition, an estimate of the cost to design, procure, fabricate, install, and commission these components	• Technical description of the components	• How to extend the capabilities of the instrument beyond what can be provided for in the construction budget	• Describes the initial experiments needed to verify the instrument performance

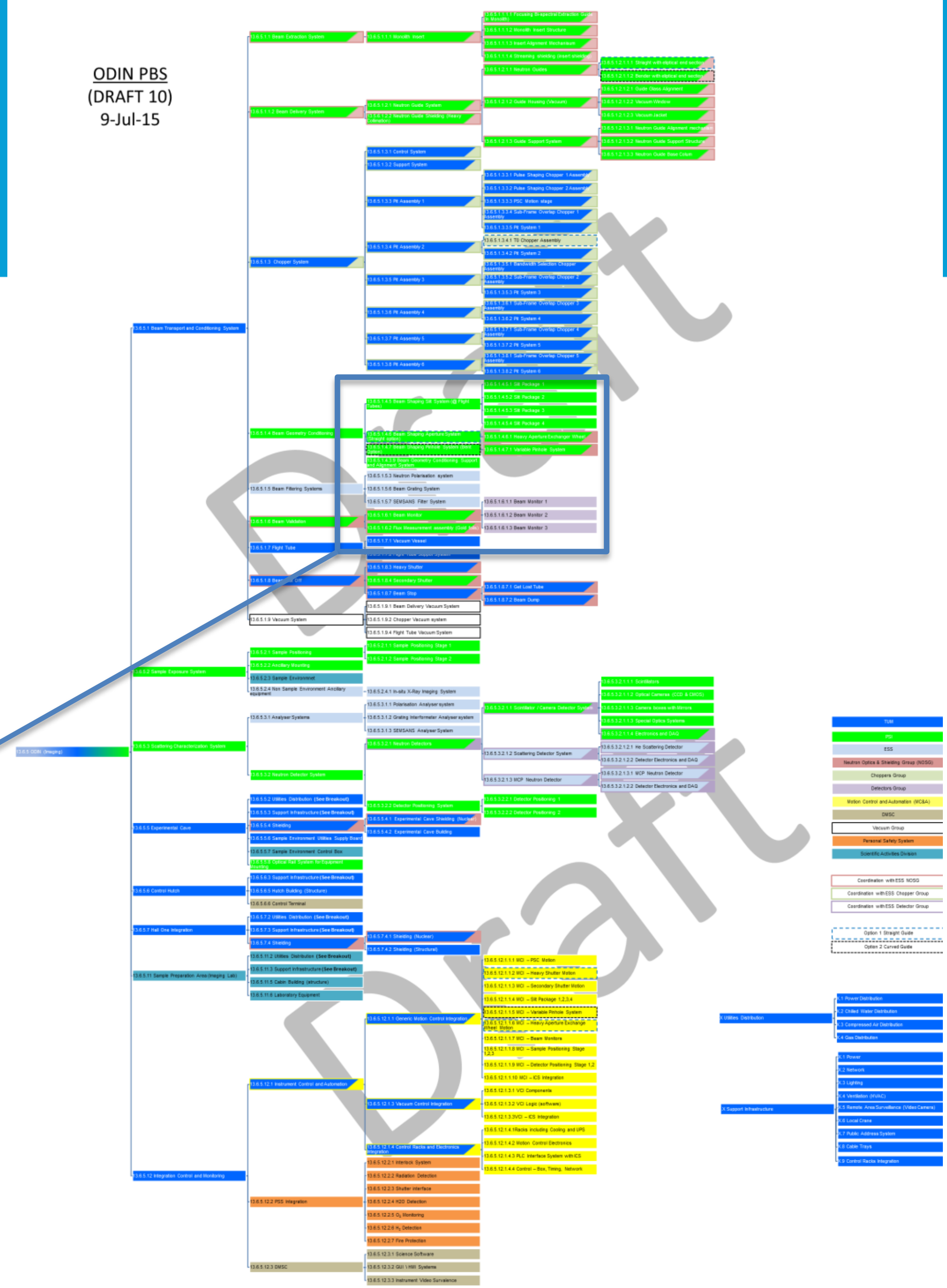
Schedule

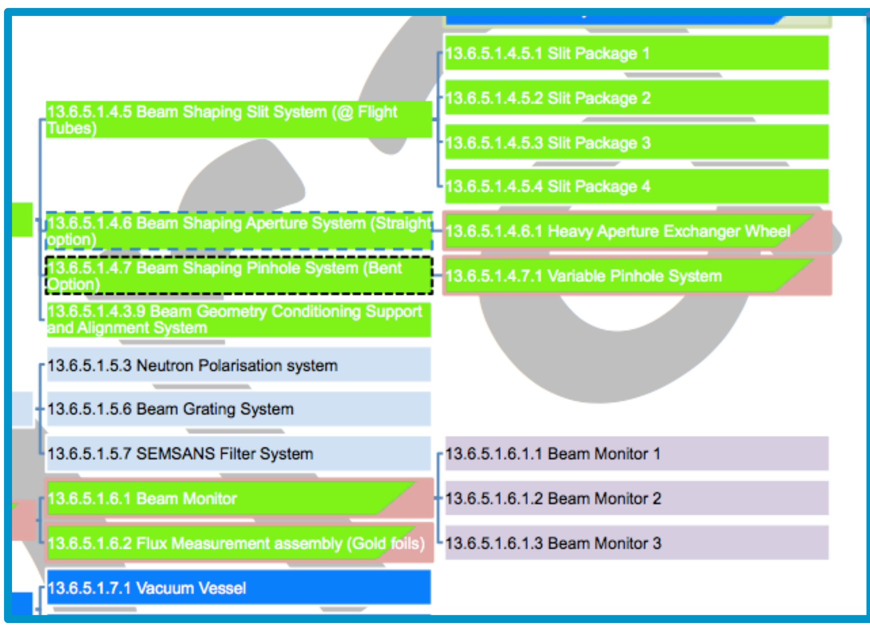
Budget

3D CAD model of instrument envelope

Product Break-down Structure (PBS)

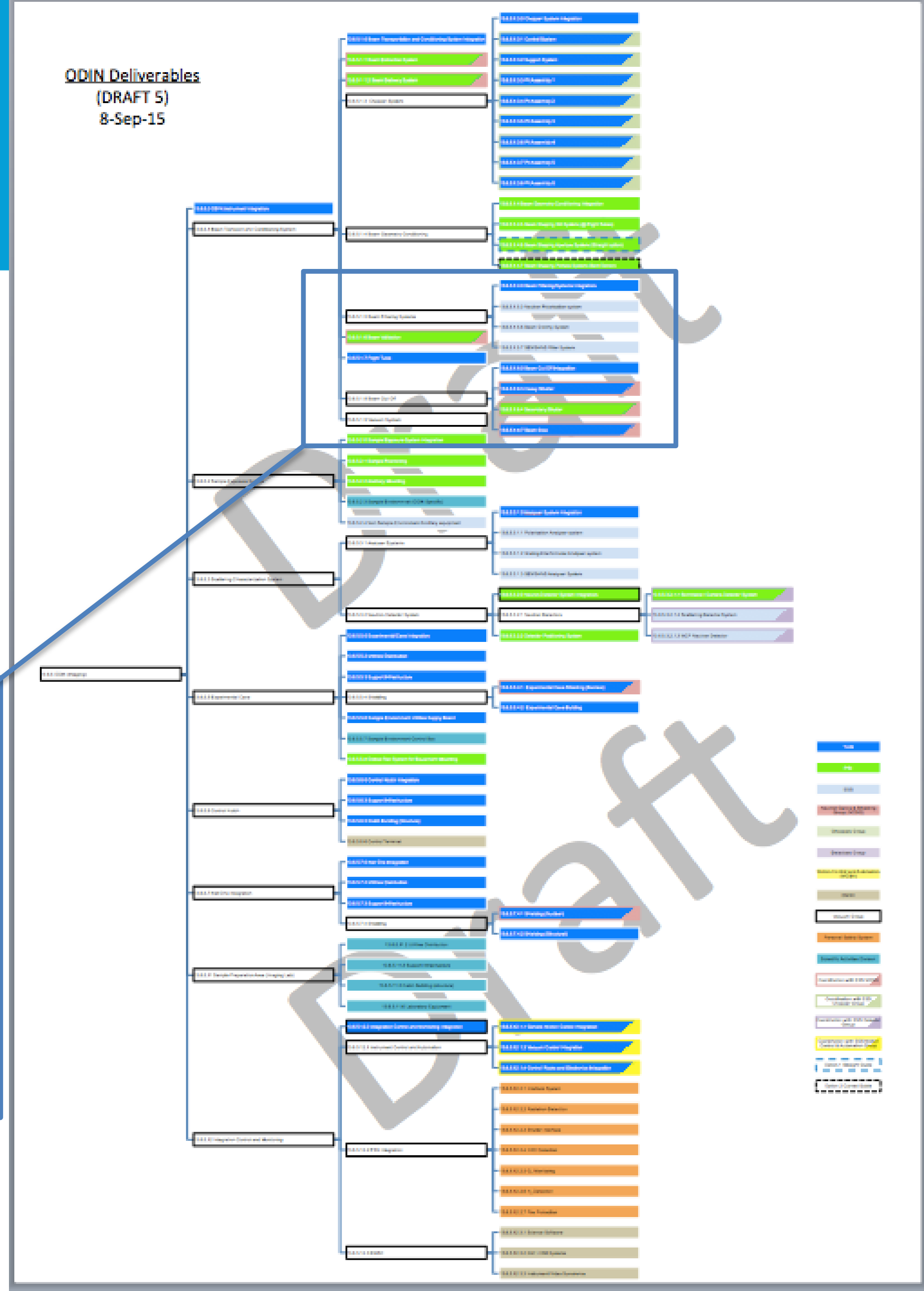
- The PBS aims to identify major component deliverables

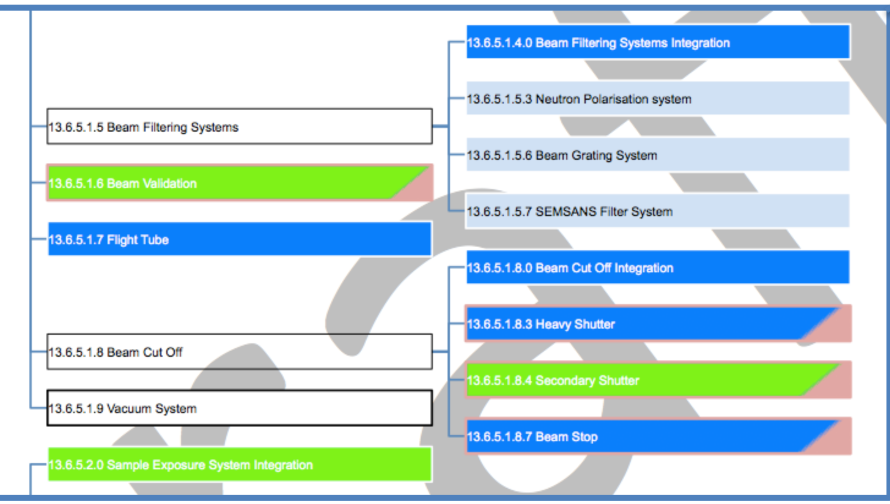




From PBS to Deliverables …

From the PBS we can establish levels that can be considered a deliverable.





… to Work Units

Deliverable Group	PBS Number	Deliverable Description	Delivering Institute
Within the ODIN Instrument Project Budget			
Integration and Management	13.6.5.0	ODIN Instrument Integration	
	13.6.5.1.0	Beam Transportation and Conditioning System Integration	
	13.6.5.1.3.0	Chopper System Integration	
	13.6.5.1.4	Beam Geometry Conditioning Integration	
	13.6.5.1.5.0	Beam Filtering Systems Integration	
	13.6.5.1.8.0	Beam Cut Off Integration	
	13.6.5.2.0	Sample Exposure System Integration	
	13.6.5.3.1.0	Analyser System Integration	
	13.6.5.3.2.0	Neutron Detector System Integration	
	13.6.5.5.0	Experimental Cave Integration	
	13.6.5.6.0	Control Hutch Integration	
	13.6.5.7.0	Hall One Integration	
	13.6.5.12.0	Integration Control and Monitoring Integration	
Neutron Transport System	13.6.5.1.1	Beam Extraction System	
	13.6.5.1.2	Beam Delivery System	
	13.6.5.1.4.6	Beam Shaping Aperture System (Straight Option)	
	13.6.5.1.4.7	Beam Shaping Pinhole System (Bent Option)	
	13.6.5.1.6	Beam Validation (Flux and Monitors)	
	13.6.5.1.7	Flight Tube	
	13.6.5.1.8.4	Secondary Shutter(s)	
Heavy Shutter	13.6.5.1.8.3	Heavy Shutter	
PPSc System	13.6.5.1.3.4.1	T0 Chopper Assembly	
Chopper System	13.6.5.1.3.1	Control System	
	13.6.5.1.3.2	Support System	
	13.6.5.1.3.3	Pit Assembly 1	
	13.6.5.1.3.4	Pit Assembly 2	
	13.6.5.1.3.5	Pit Assembly 3	
	13.6.5.1.3.6	Pit Assembly 4	
	13.6.5.1.3.7	Pit Assembly 5	
	13.6.5.1.3.8	Pit Assembly 6	
Cave, Cave Interior & Hutch	13.6.5.1.4.5	Beam Shaping Slit System (@ Flight Tubes)	
	13.6.5.2.1	Sample Positioning	
	13.6.5.2.2	Ancillary Mounting	
	13.6.5.3.2.2	Detector Positioning System	
	13.6.5.5.4.2	Experimental Cave Building	
	13.6.5.5.8	Optical Rail System for Equipment Mounting	
	13.6.5.6.5	Hutch Building (Structure)	
Add-on development	13.6.5.1.5.3	**Neutron Polarizationon system**	
	13.6.5.1.5.6	Beam Grating System	
	13.6.5.1.5.7	SEMSANS Filter System	
	13.6.5.2.3	Sample Environment (ODIN Specific)	
	13.6.5.2.4	Non Sample Environment Ancillary equipment	
	13.6.5.3.1.1	Polarisation Analyser system	
	13.6.5.3.1.2	Grating Interferometer Analyser system	
	13.6.5.3.1.3	SEMSANS Analyser System	
	13.6.5.5.7	Sample Environment Control Box	
Conventional white beam detectors	13.6.5.3.2.1.1	Scintillator / Camera Detector Systems	
ToF detectors	13.6.5.3.2.1.2	Scattering Detector System	
	13.6.5.3.2.1.3	MCP Neutron Detector	
Shielding	13.6.5.1.8.7	Beam Stop	
	13.6.5.5.4.1	Experimental Cave Shielding (Nuclear)	
	13.6.5.7.4.1	Shielding (Nuclear)	
	13.6.5.7.4.2	Shielding (Structural)	
Support Media	13.6.5.5.2	Utilities Distribution	
	13.6.5.5.3	Support Infrastructure	
	13.6.5.5.6	Sample Environment Utilities Supply Board	
	13.6.5.6.3	Support Infrastructure	
	13.6.5.7.2	Utilities Distribution	
	13.6.5.7.3	Support Infrastructure	
Outside the ODIN Instrument Project Budget			
Personnel Protection System & Access control	13.6.5.12.2.1	Interlock System	
	13.6.5.12.2.2	Radiation Detection	
	13.6.5.12.2.3	Shutter Interface	
	13.6.5.12.2.4	H_2O Detection	
	13.6.5.12.2.5	O_2 Monitoring	
	13.6.5.12.2.6	H_2 Detection	
	13.6.5.12.2.7	Fire Protection	
Vacuum System	13.6.5.1.9	Vacuum System	
	13.6.5.12.1.3	Vacuum Control Integration	
Motion controls	13.6.5.12.1.1	Generic Motion Control Integration	
	13.6.5.12.1.4	Control Racks and Electrical Integration	
Data DMSC	13.6.5.5.6.6	Control Terminal	
	13.6.5.12.3.1	Science Software	
	13.6.5.12.3.2	GUI \ HMI Systems	
	13.6.5.12.3.3	Instrument Video Surveillance	
Imaging Lab	13.6.5.11.2	Utilities Distribution	
	13.6.5.11.3	Support Infrastructure	
	13.6.5.11.5	Cabin Building (Structure)	
	13.6.5.11.6	Laboratory Equipment	

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Schedule and Budget Documentation

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Schedule:

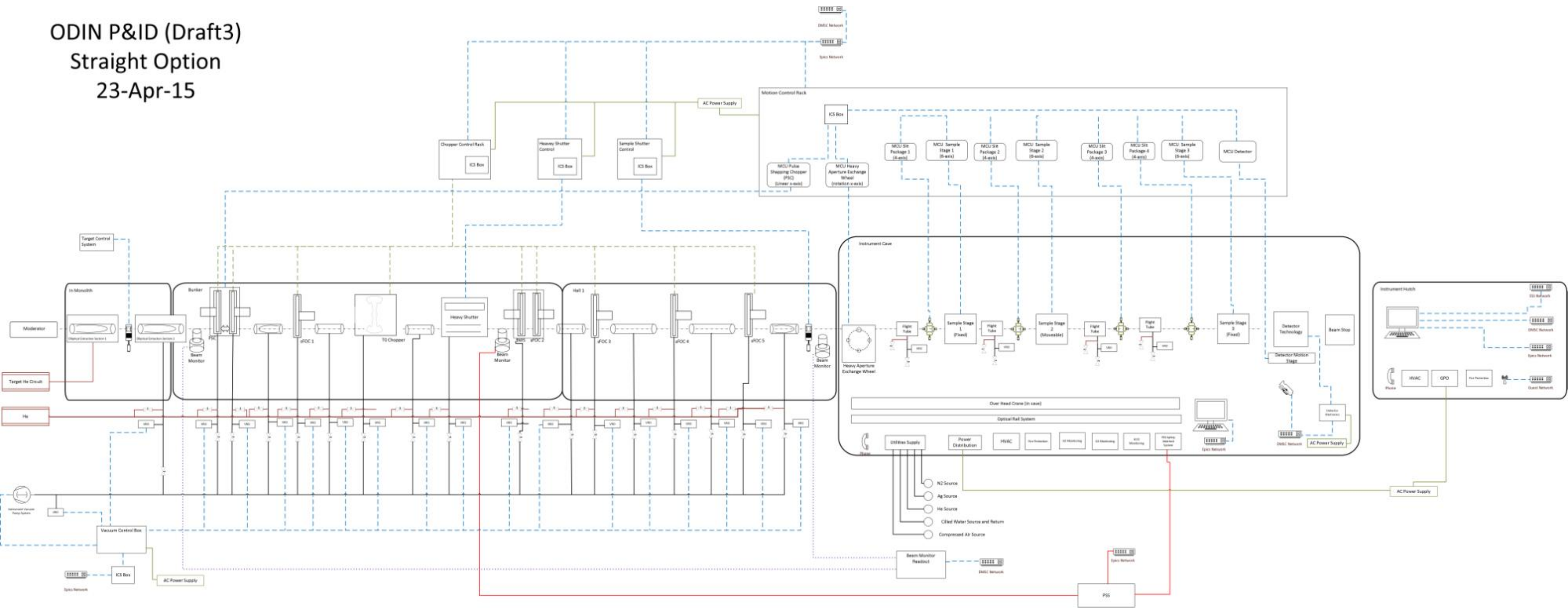
- We have begun a project schedule for Phase 2 and beyond.
- We have the activities, predessors and external milestones to form the project network.
- We just need good estimations of duration to form the project schedule.

Budget:

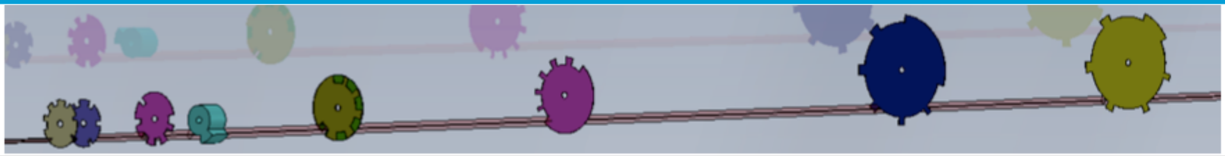
- A budget was created with the proposal, it is intended that this budget be refined with more accurate costs for the technical solutions that are proposed.
- These refined numbers will come typicaly as we get the numbers for the schedule.

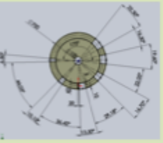
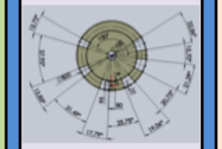
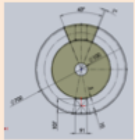
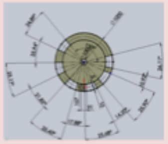
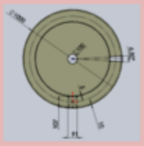
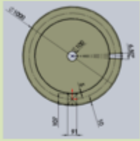
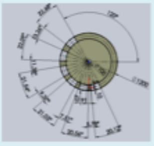
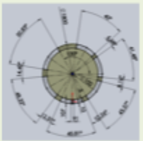
Process and Instrumentation Diagram (P&ID)

ODIN P&ID (Draft3)
Straight Option
23-Apr-15



Chopper Cascade



Assy1	Assy2	Assy3	Assy4	Assy5	Assy6		Assy7	Assy8	Assy9
Axis1 PSC1	Axis2 PSC2	Axis3 sFOC1	Axis4 PPSc	Axis5 sFOC2	Axis6 BWC1	Axis7 BWC2	Axis8 sFOC3	Axis9 sFOC4	Axis10 sFOC5
									
6500-6690	6810-7000	8500	9000	12480	12500	?	17700	25900	32000
700	700	800	700	1000	1000	1000	1200	1800	1800
56	56	42	42	28	28	28	14	14	14
6	6	6	1	6	1	1	6	6	6

Diameters range from 700mm to 1800mm

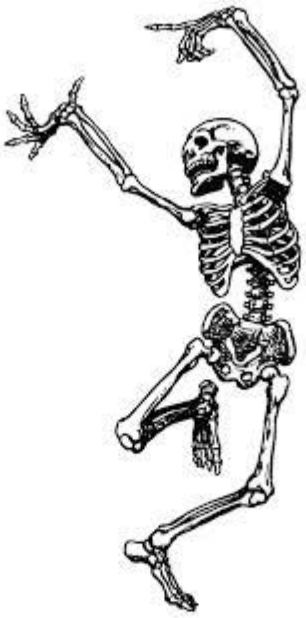
Frequency ranges from 14 – 56Hz

PPSc will require development

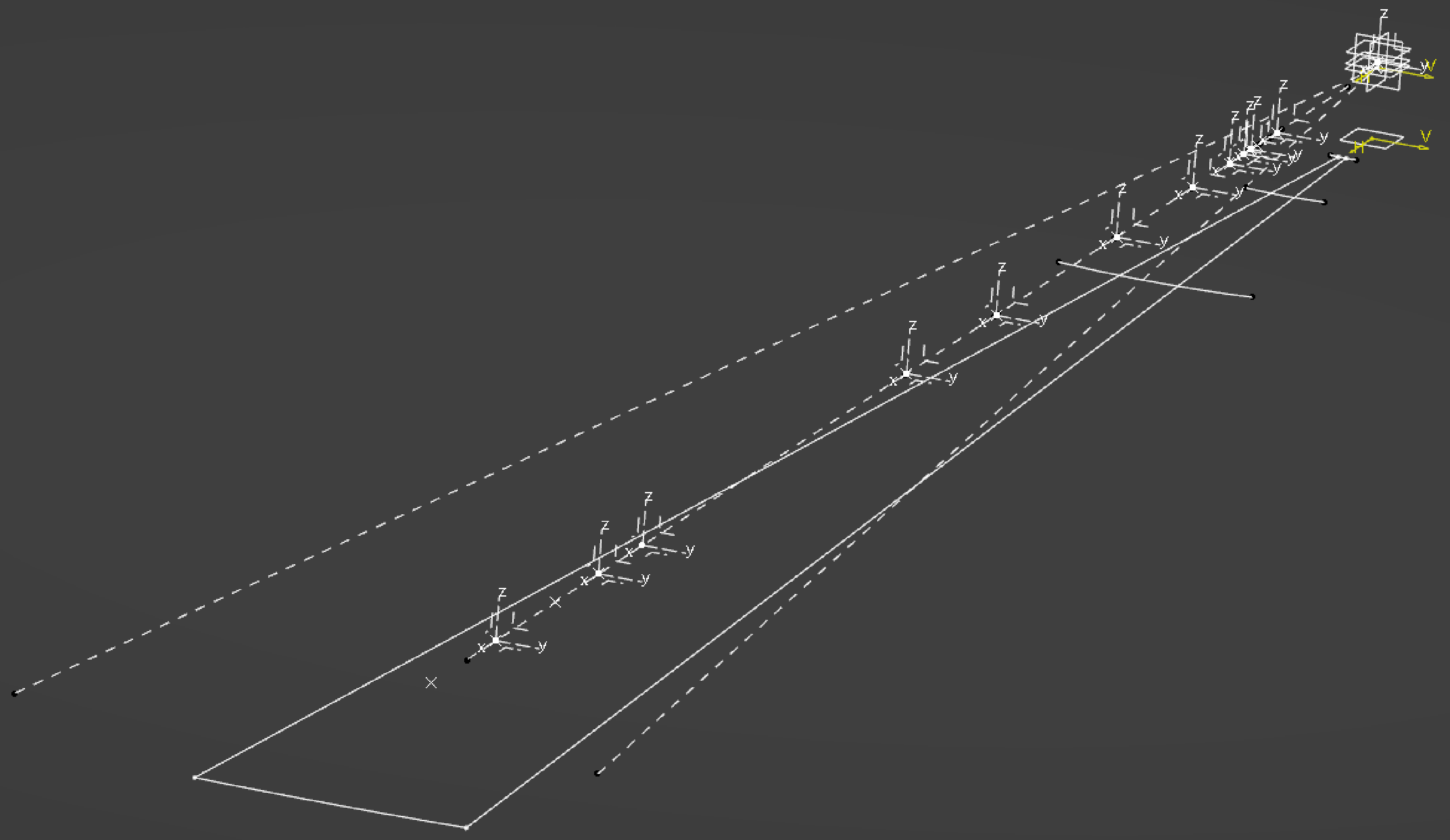
Large diameter rotors will also require development

CAD : Instrument Skeleton and Envelope

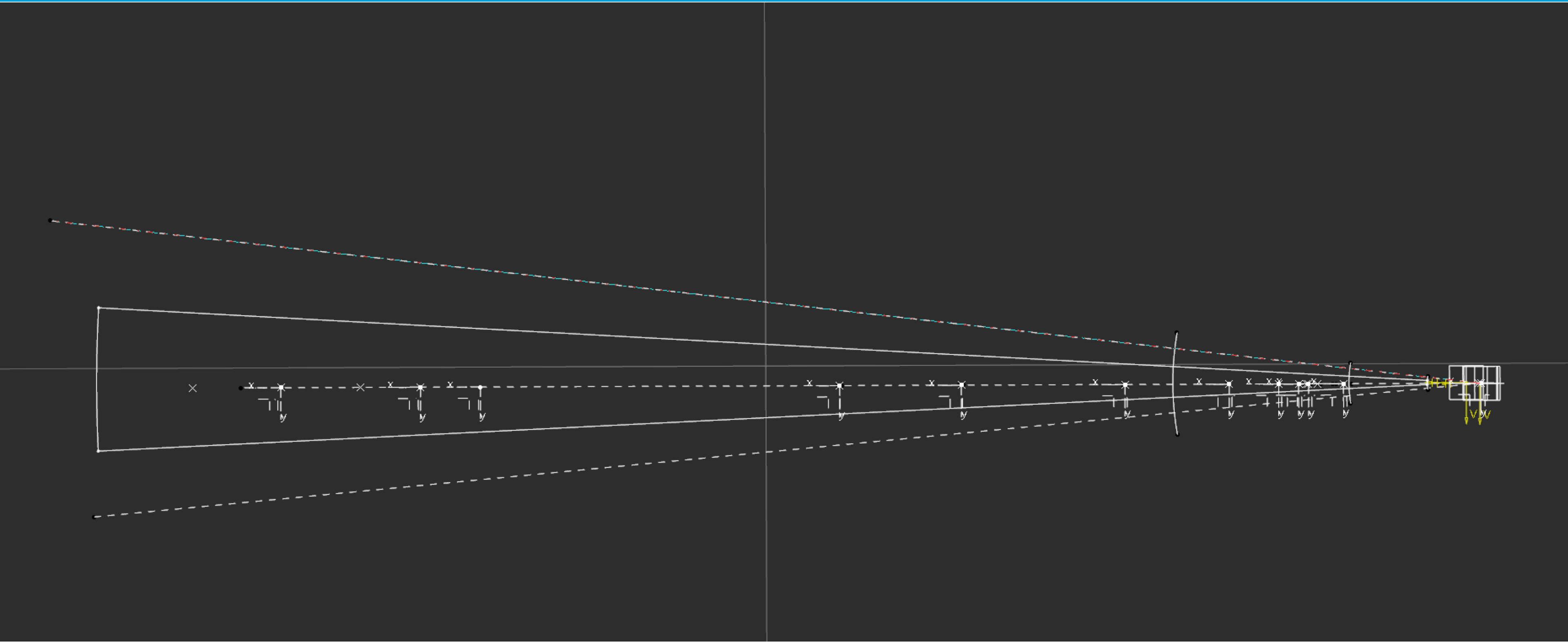
- The Instrument Skeleton is a basic geometric representation of the instruments key features.
- This will reflect the parameters used in the McStas model and shielding calculation so that all models reflect the same key instrument features.
- This should be performed by an agreement in the parameters used in all.
- The skeleton will allow for easy integration into the wider facility CAD (the ESS Plant Layout (EPL)).



Isometric view of the ODIN Skeleton



Top view of the ODIN Skeleton



ODIN CAD Model

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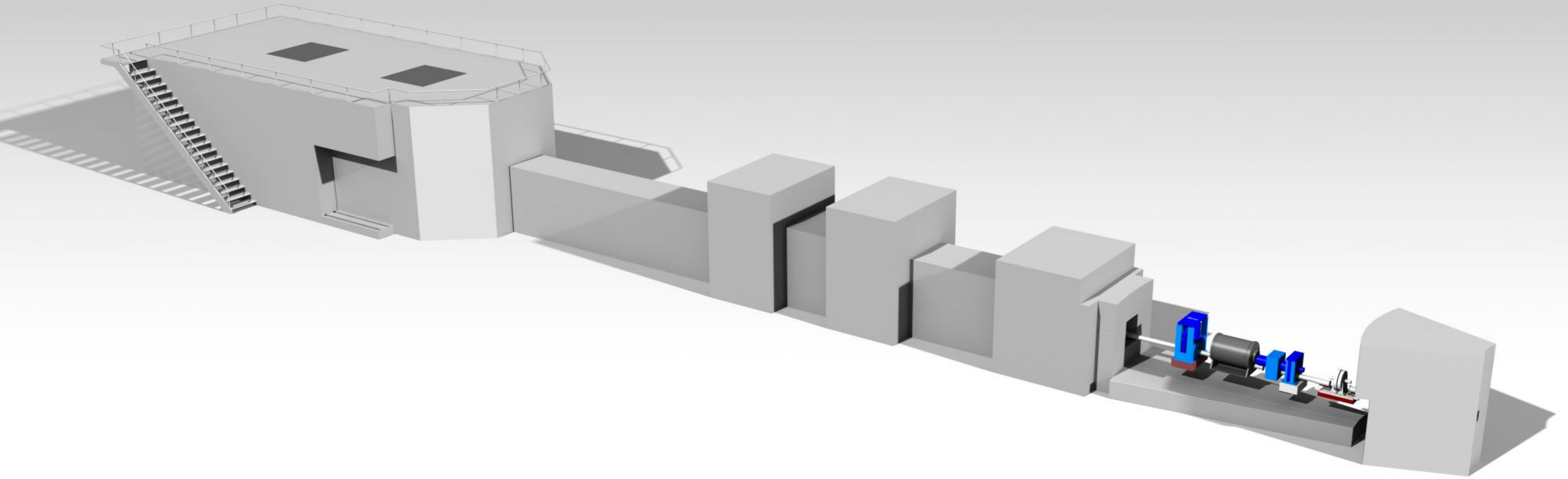
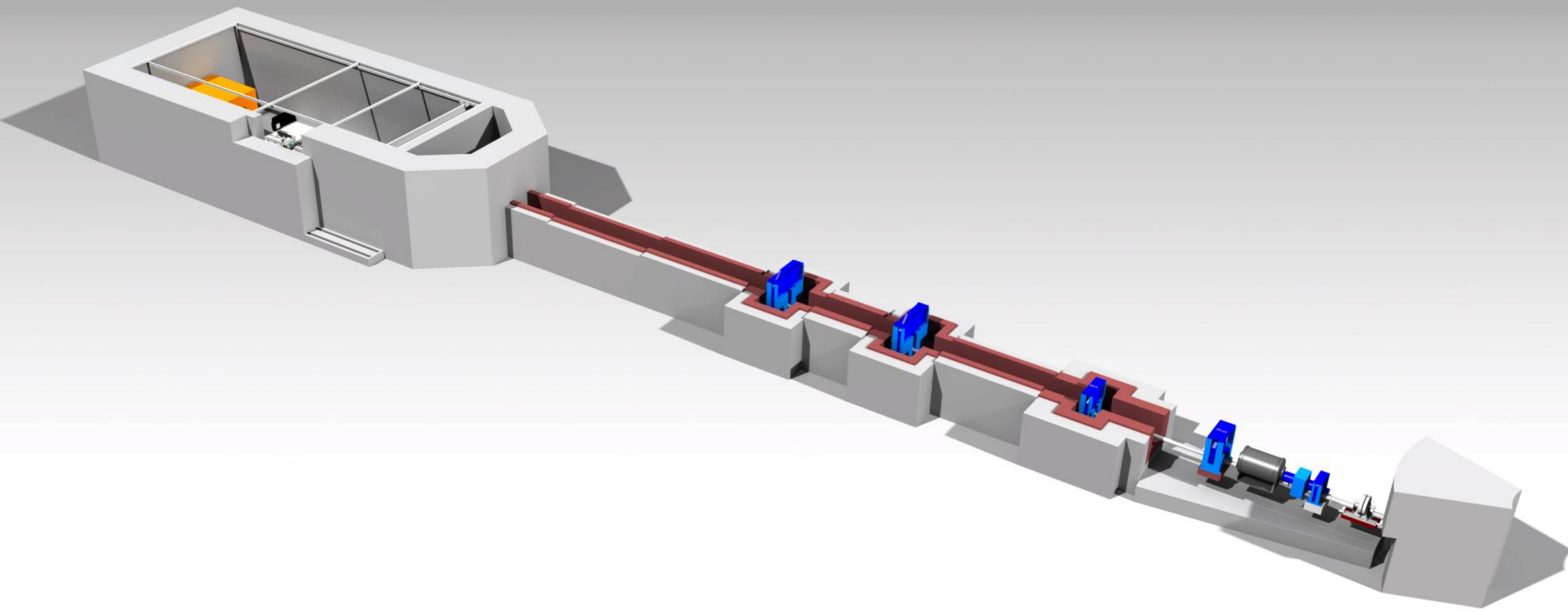
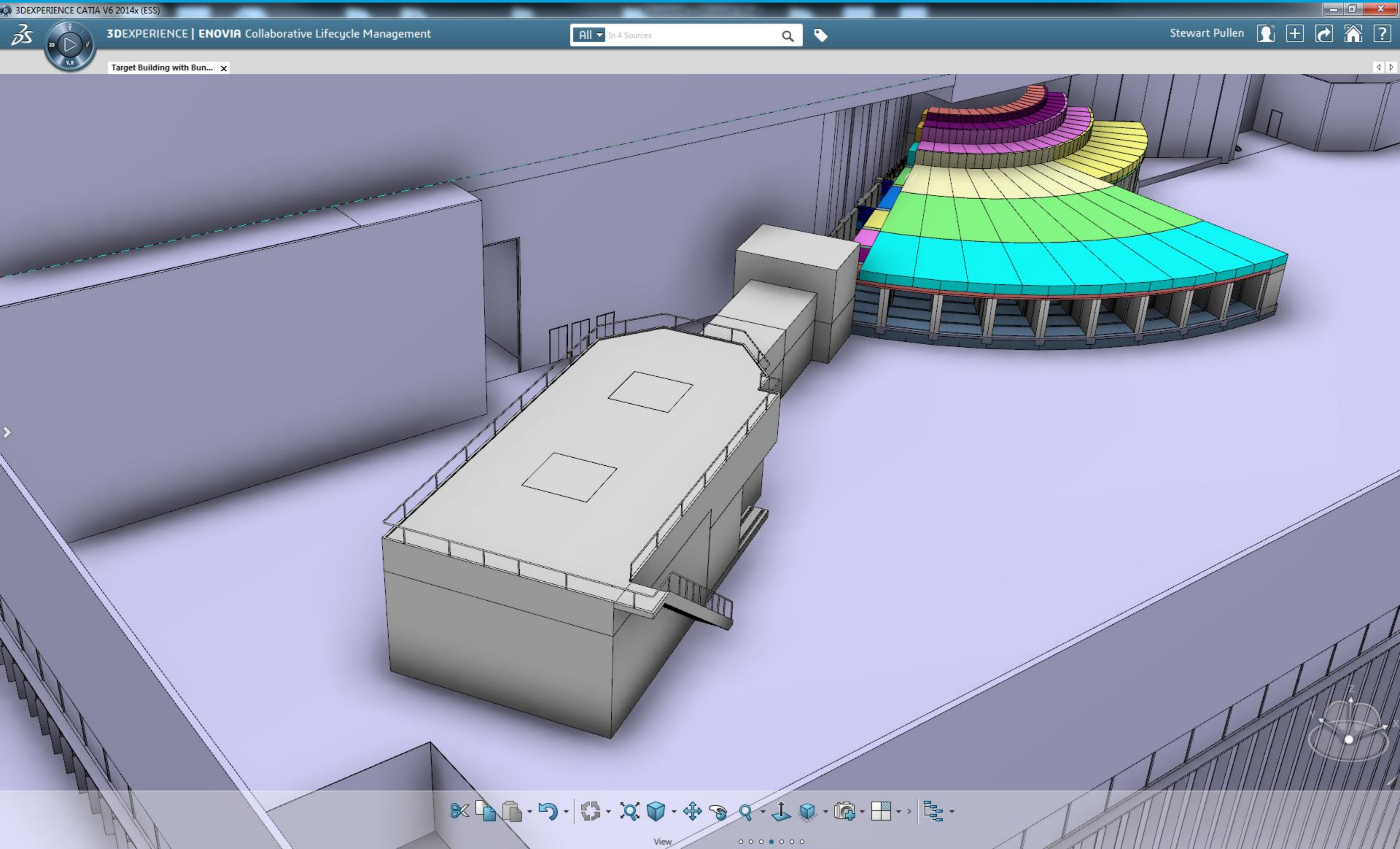


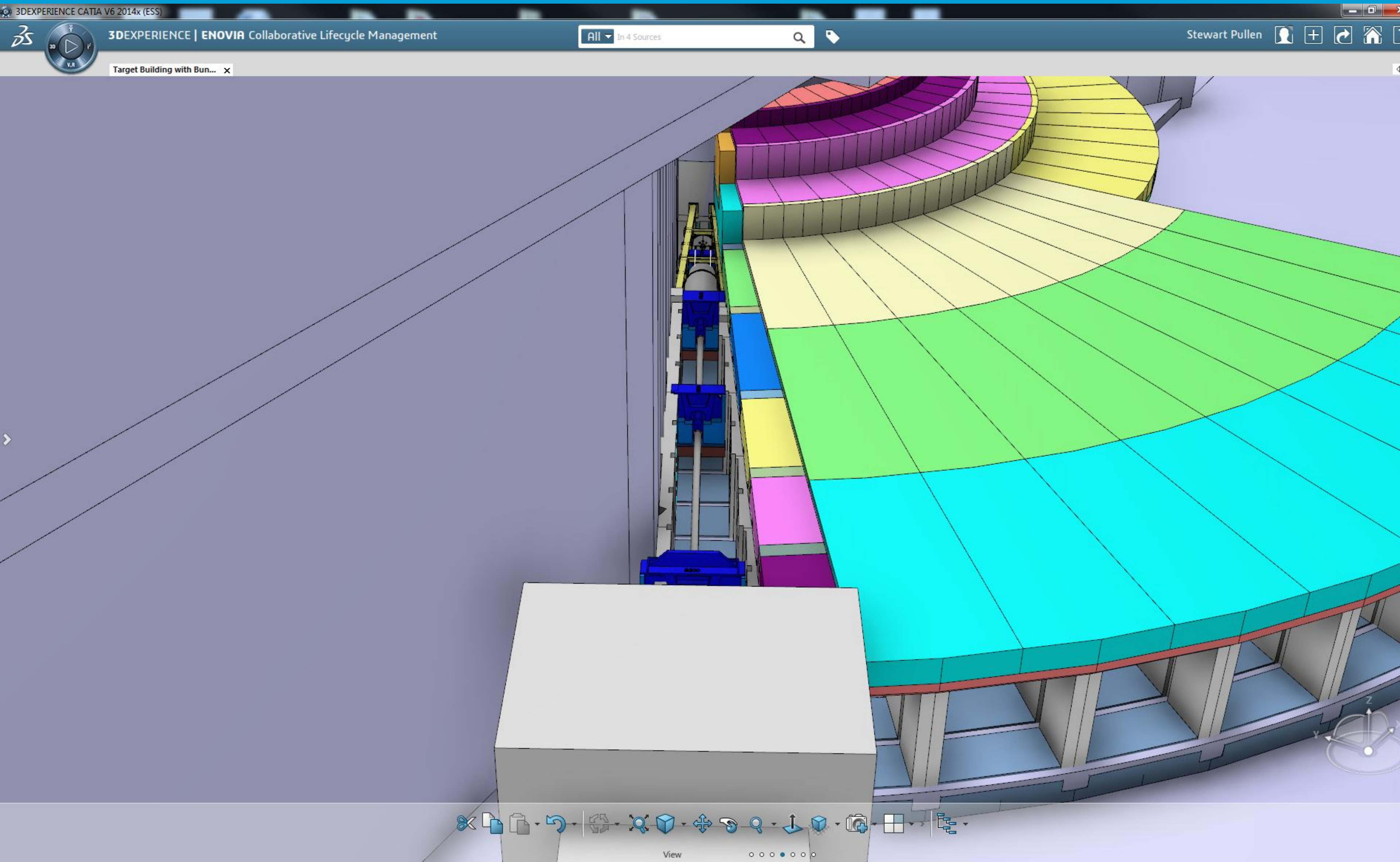
ODIN CAD Model cont.



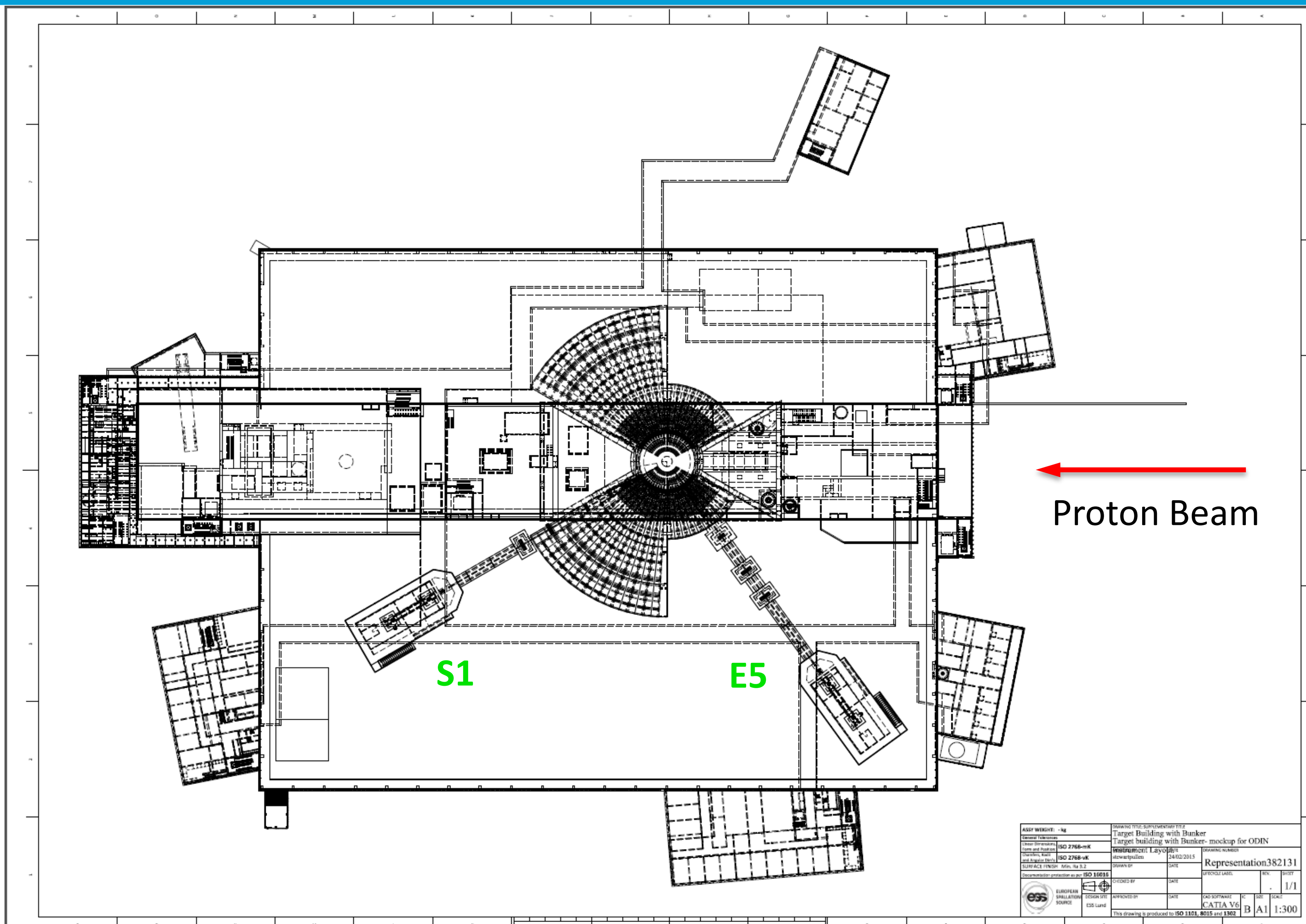
Preliminary EPL integration test

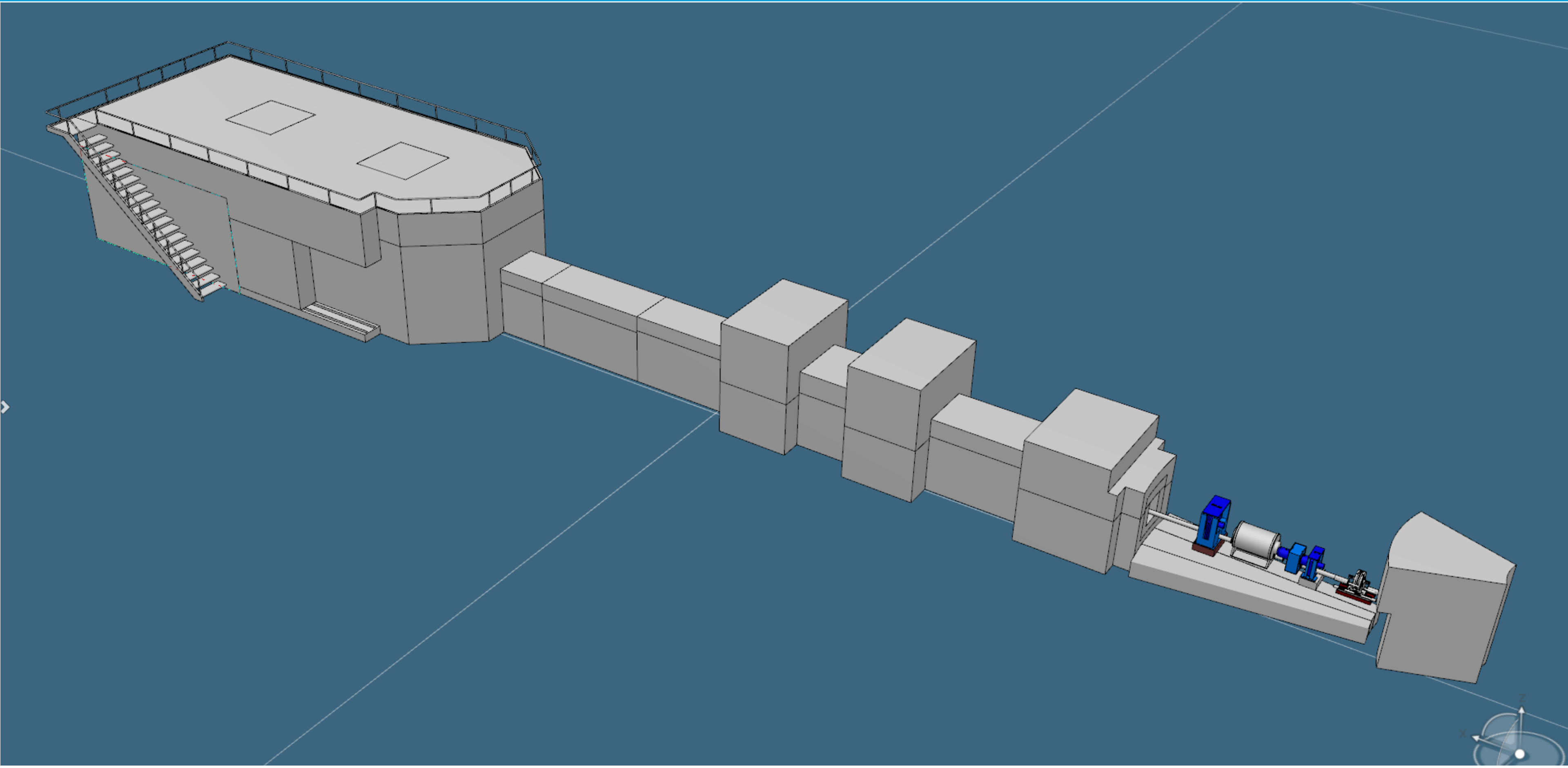


Preliminary EPL integration test

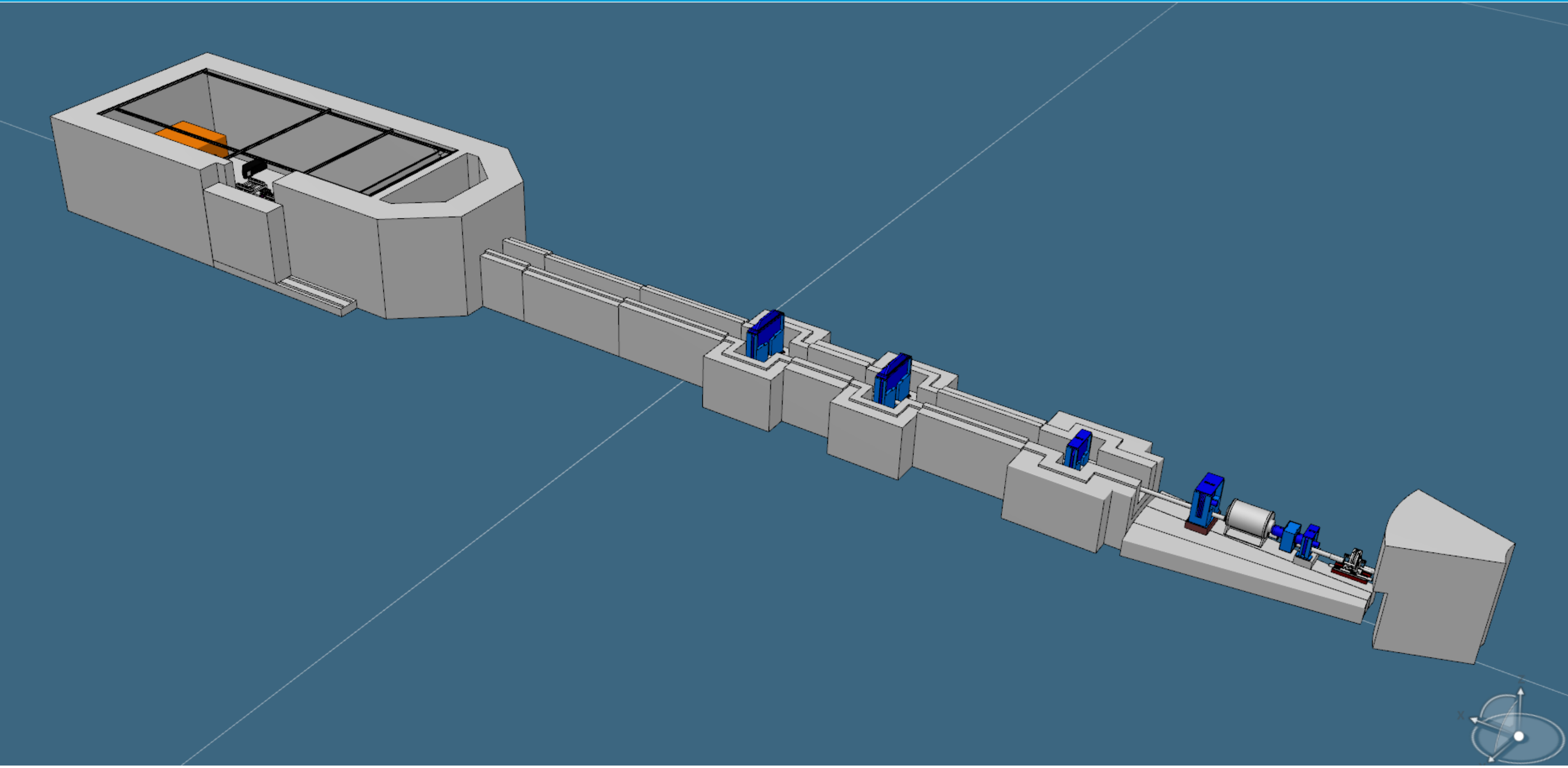


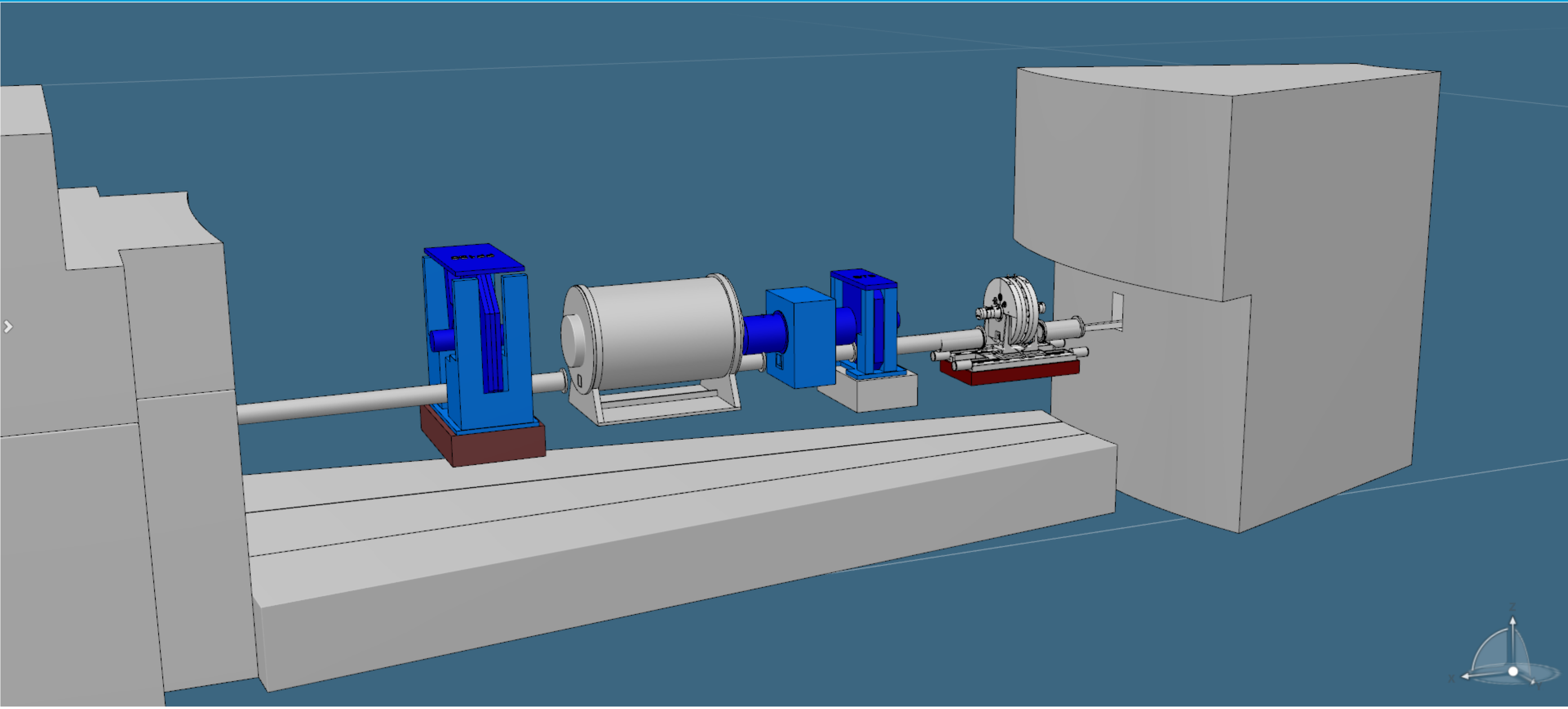
Current CAD progress on ODIN

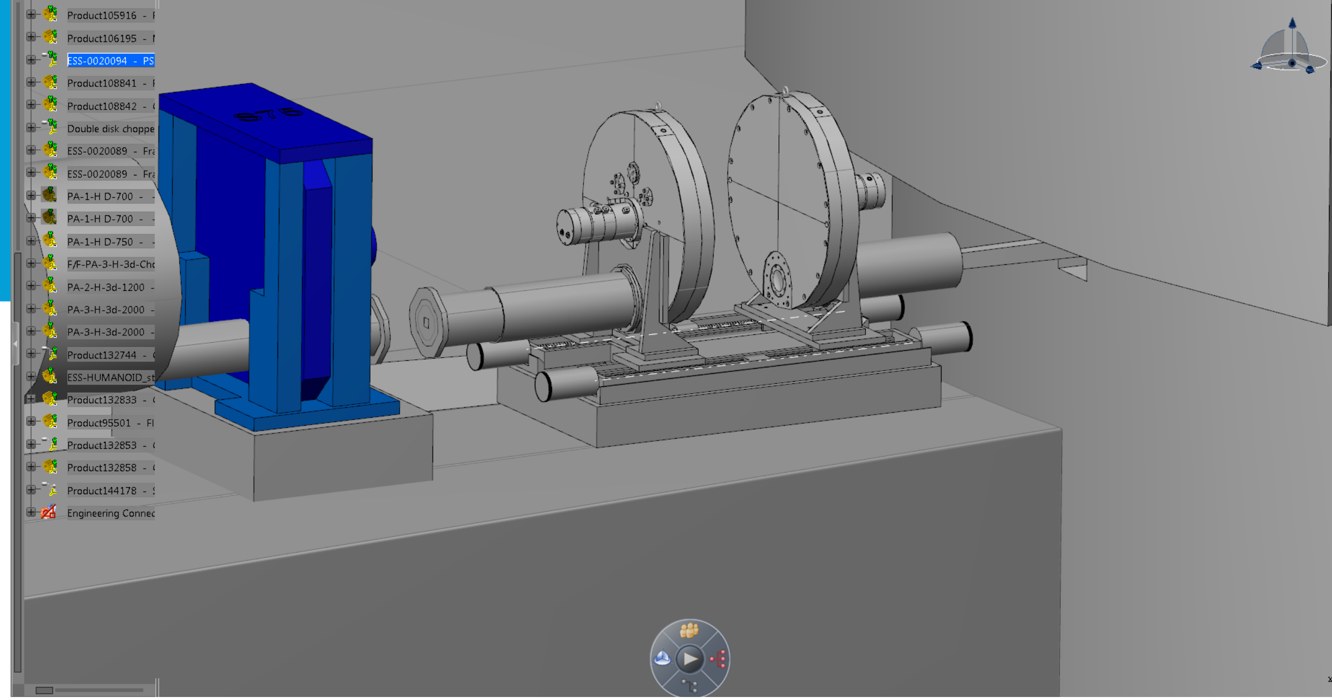




Draft layout drawings



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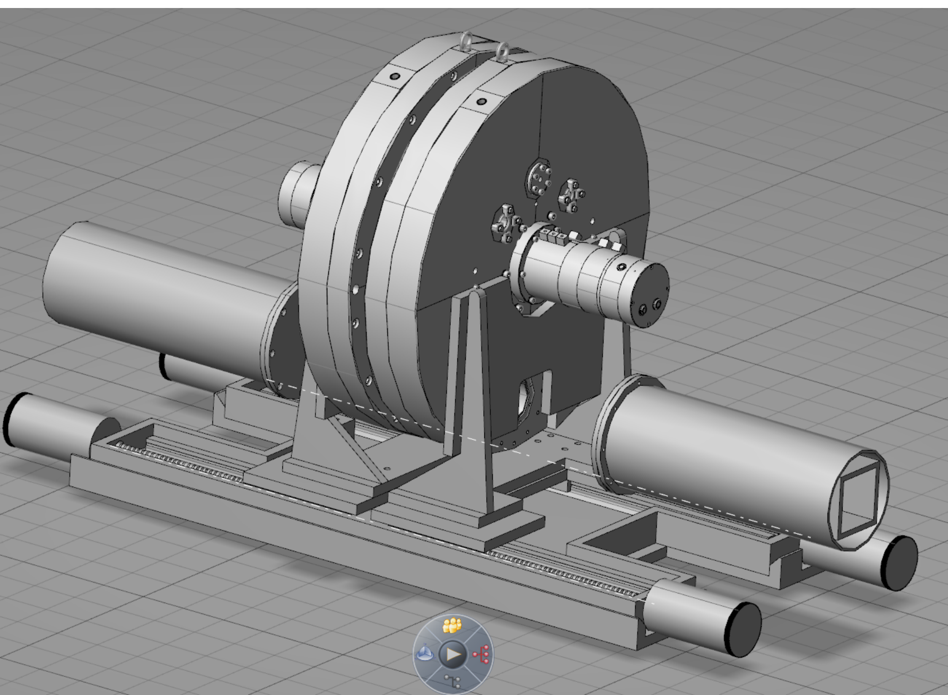
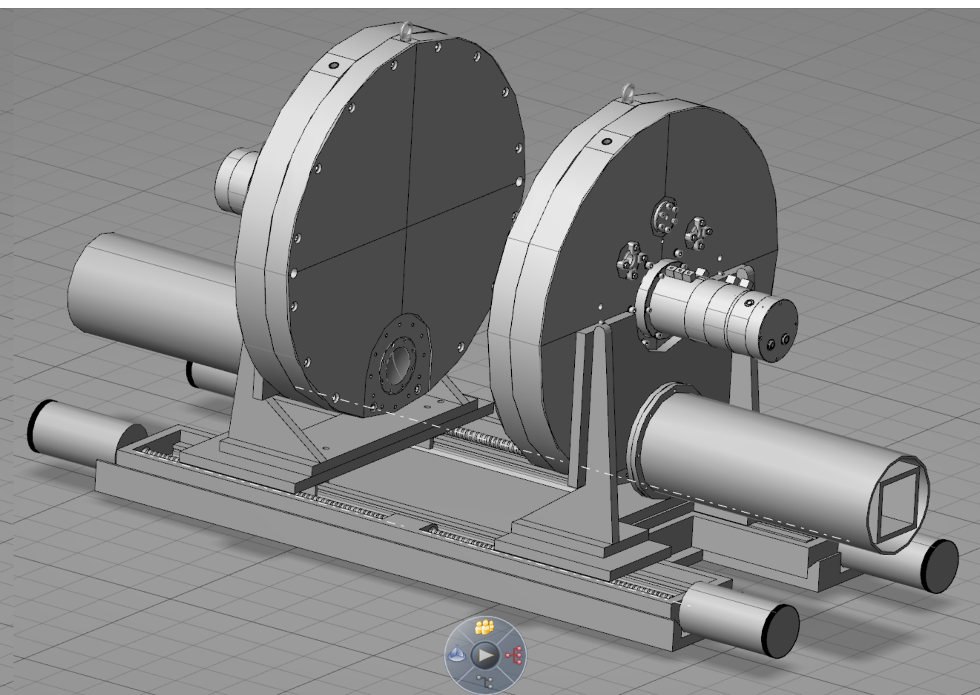
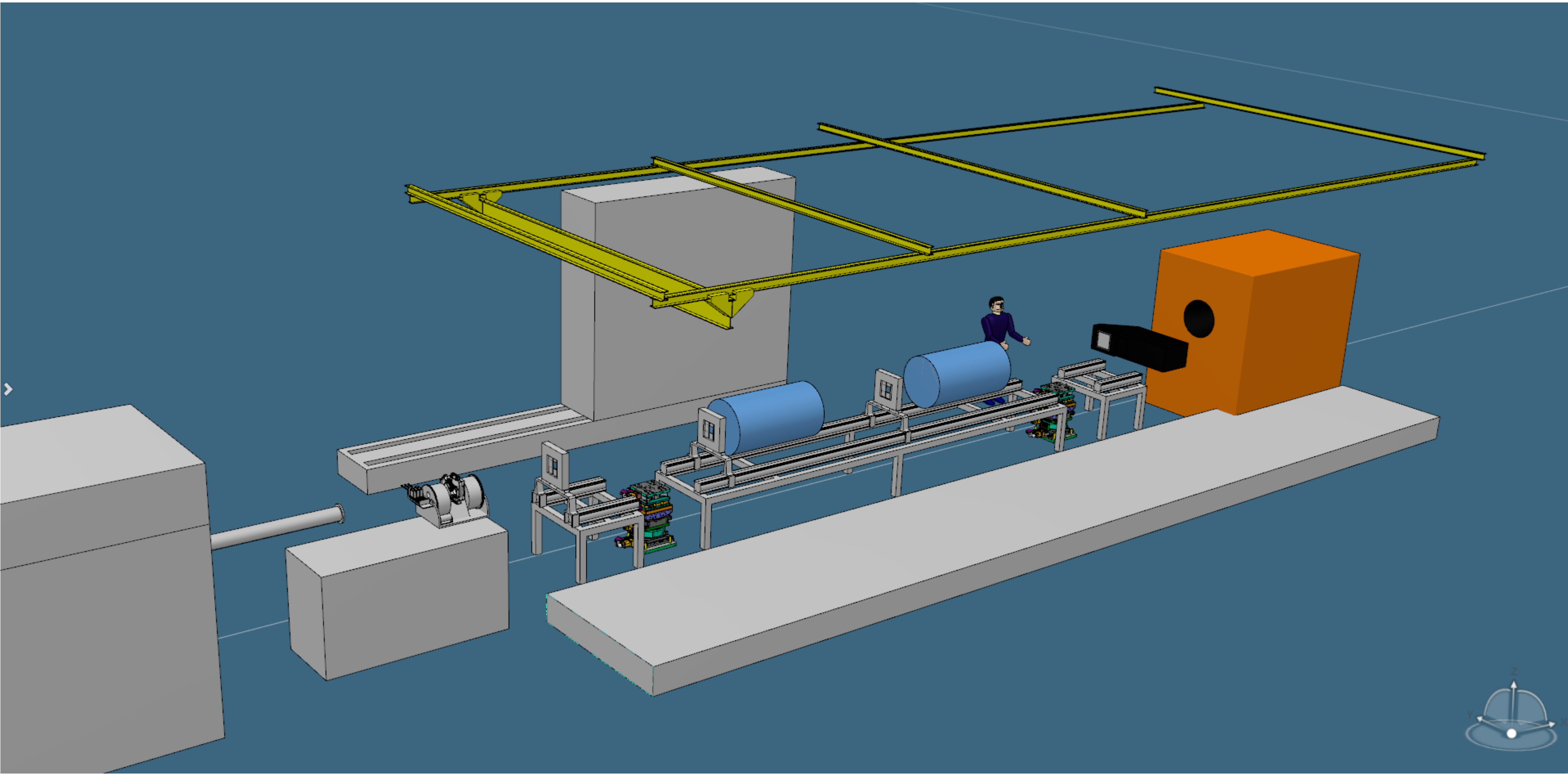
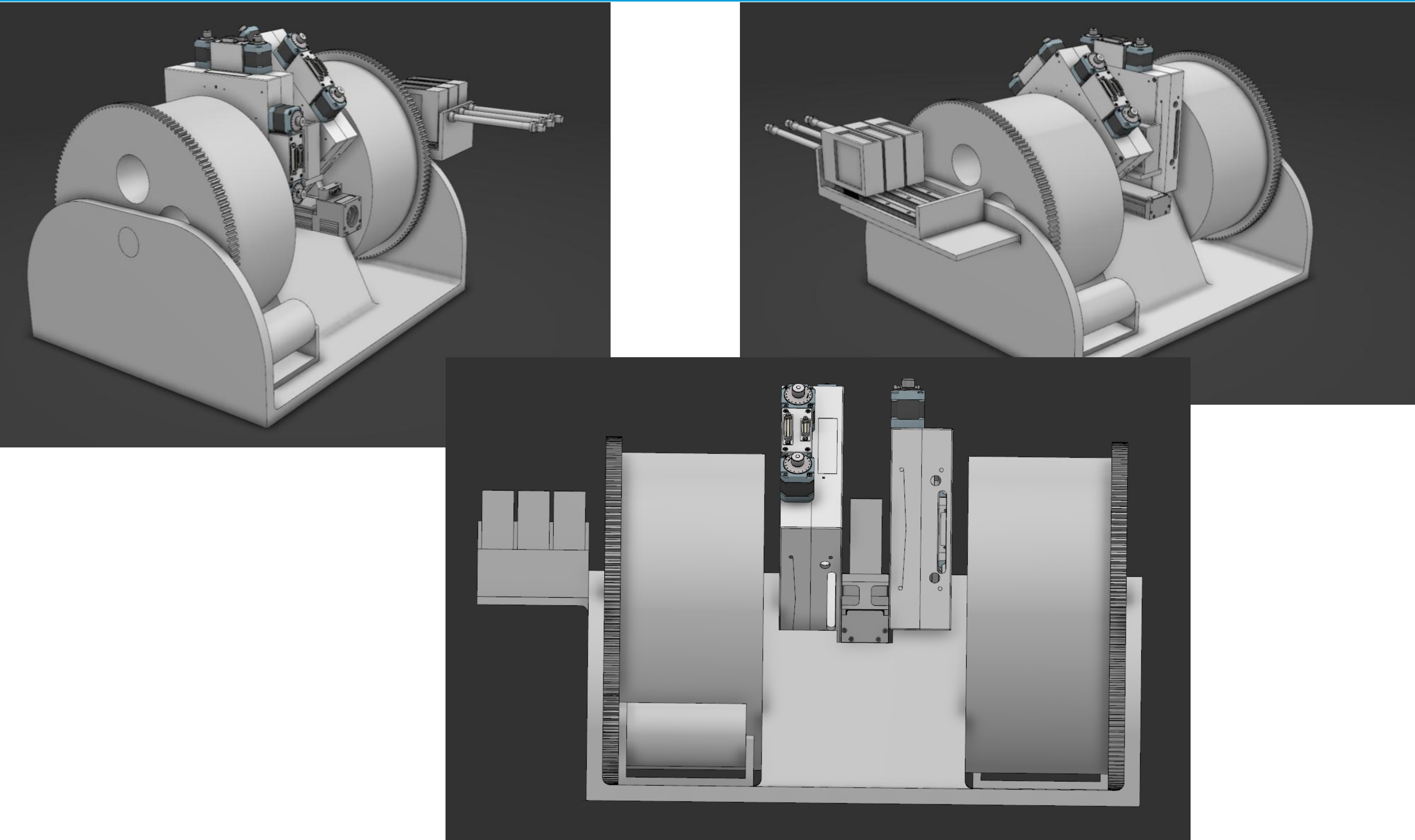




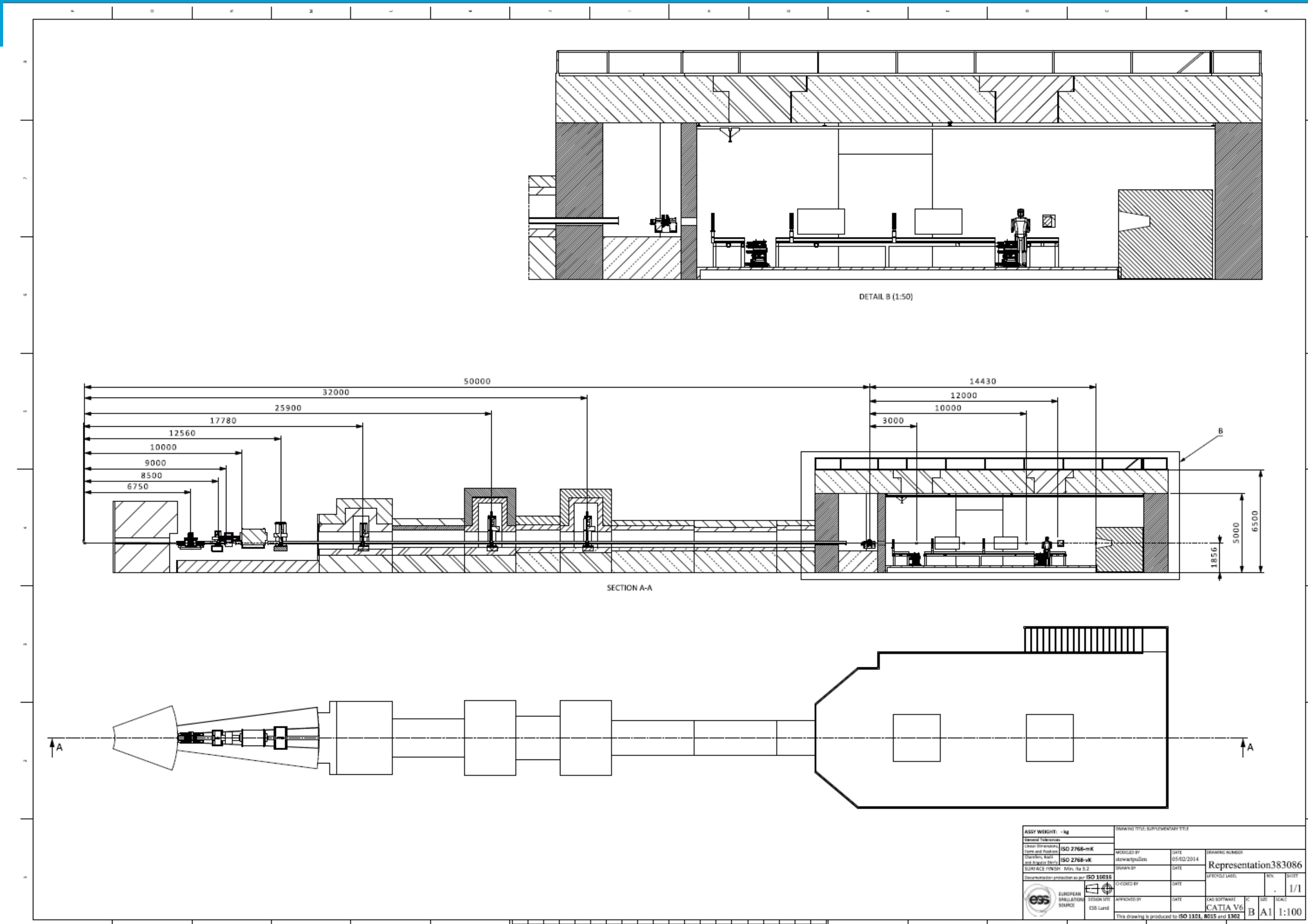
Concept for End Station Design (Cave layout)



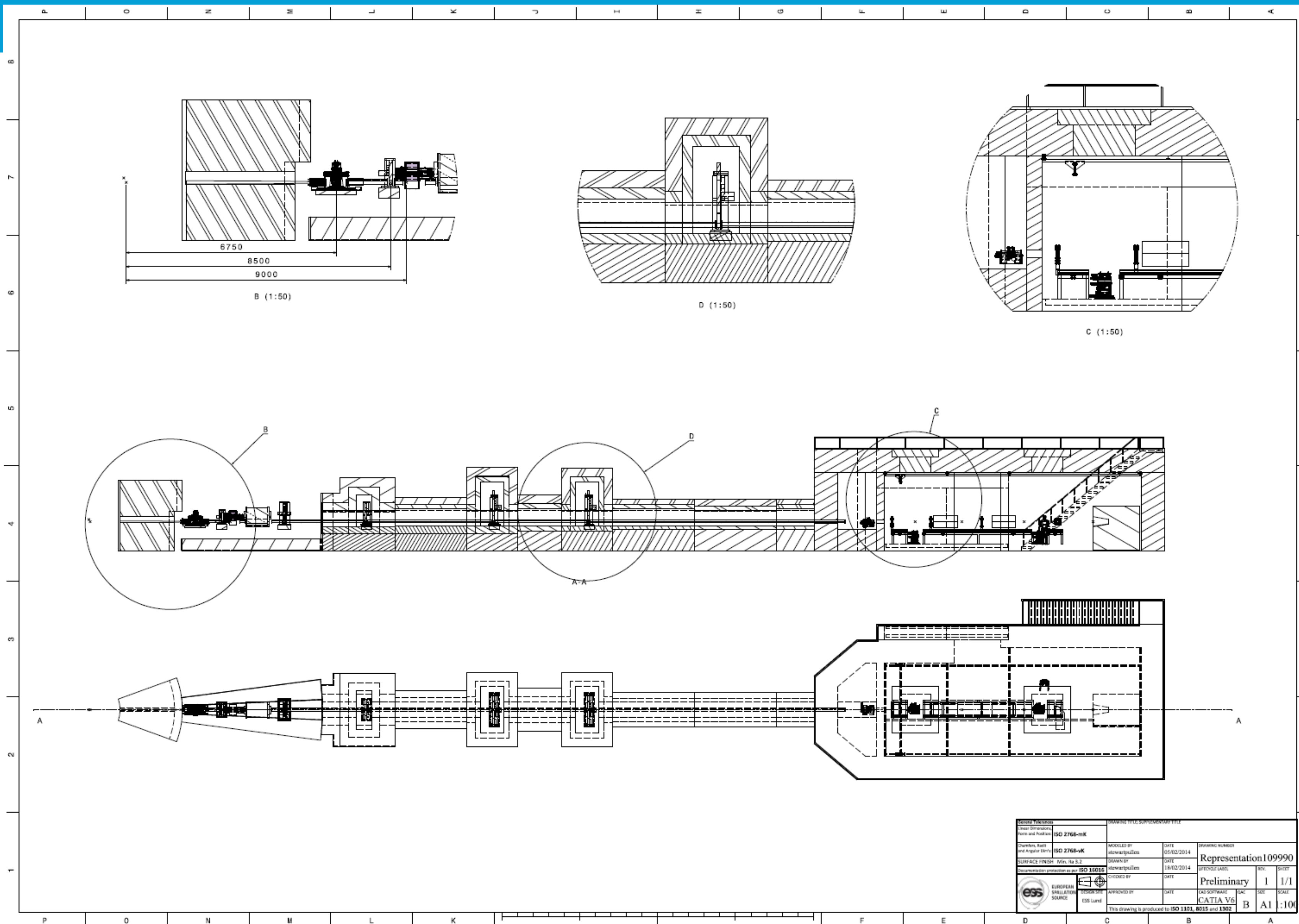
Concept for Pinhole Collimator



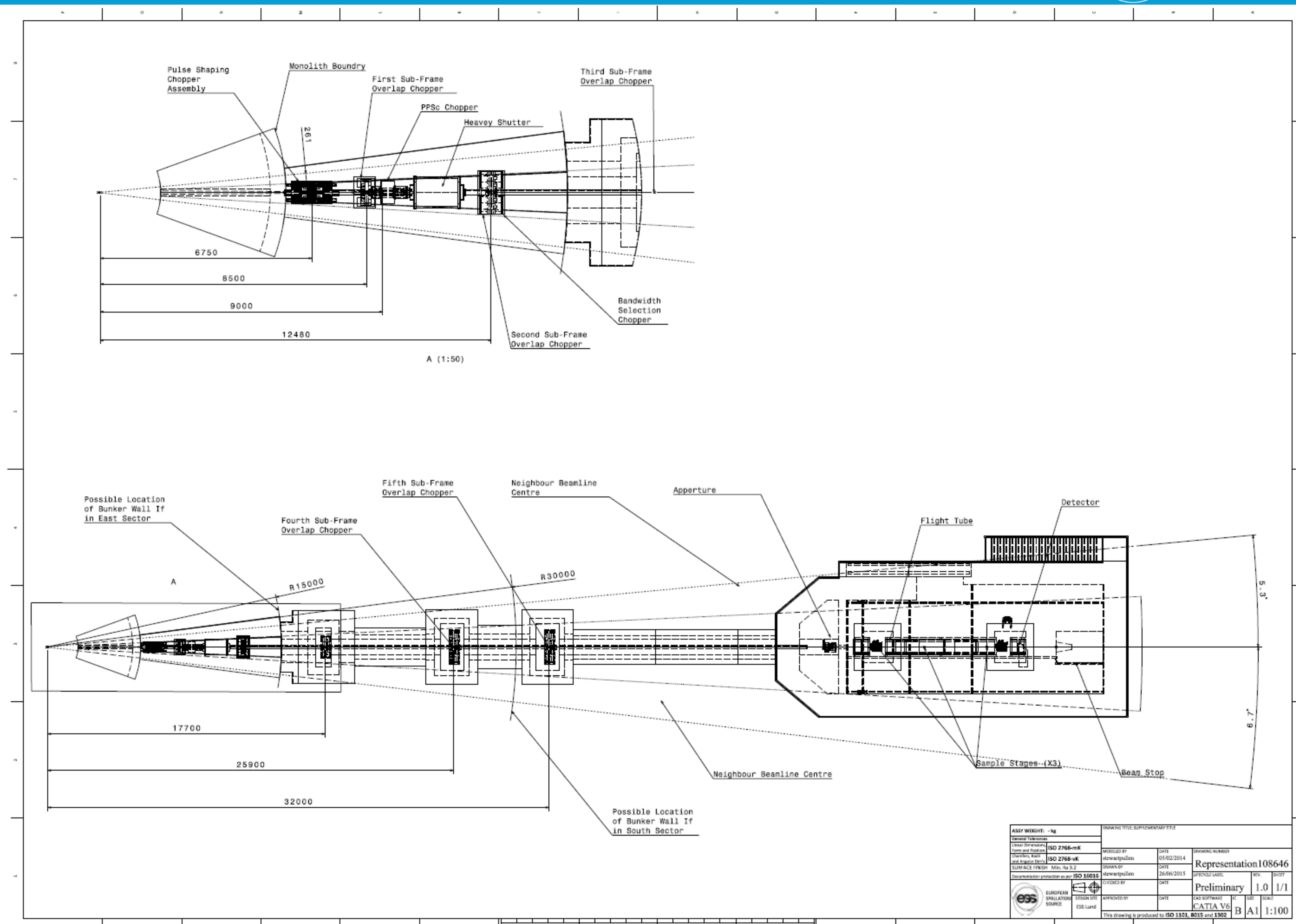
Draft layout drawings



Draft layout drawings



EUROPEAN SPALLATION SOURCE



Contributions* to Phase 1 (so far…)

ESS

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TUM

Burkhard Schillinger

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PSI

Eberhard Lehmann

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* Includes anyone I forgot to name here!

Thank You

Questions???