

Beam Imaging at the Tuning Dump

Greyson Christoforo

University of Oslo

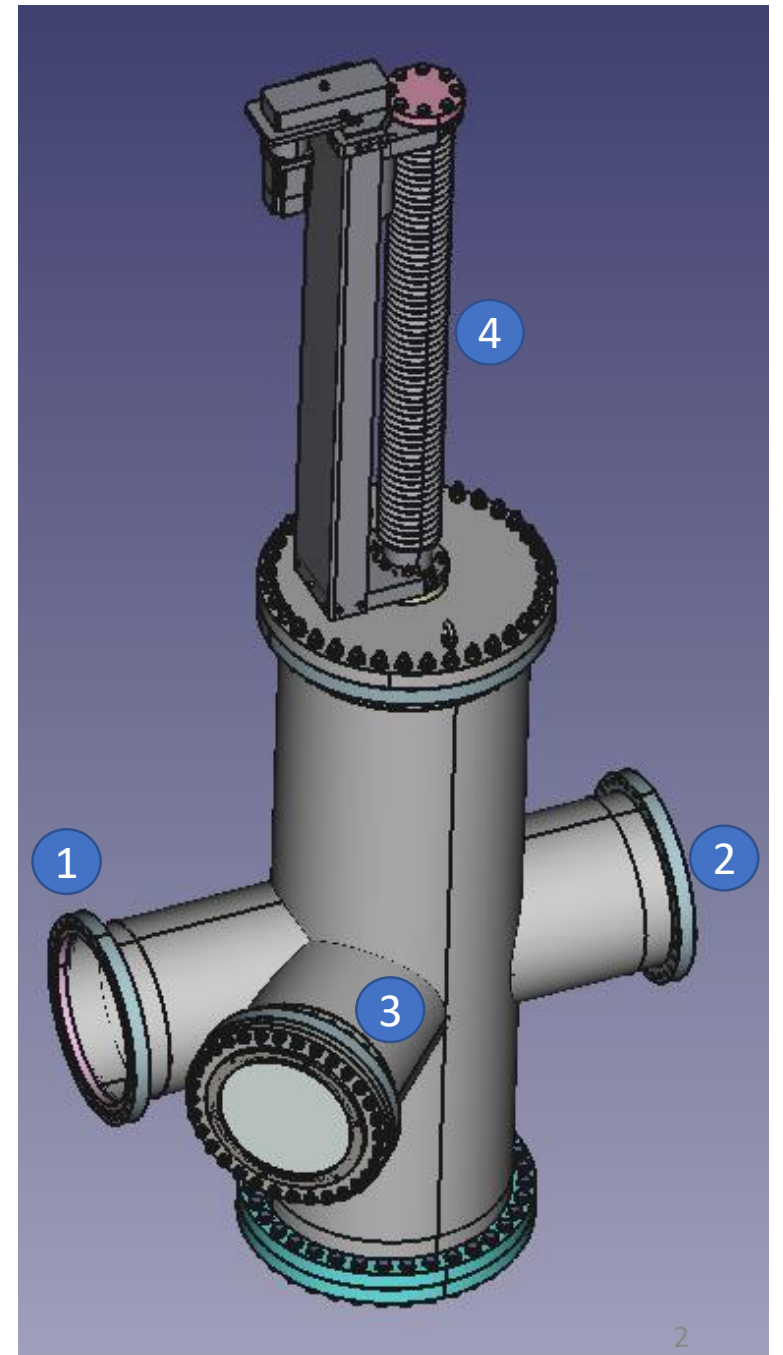
BI Forum, ESS Lund Sweden

21 November 2018

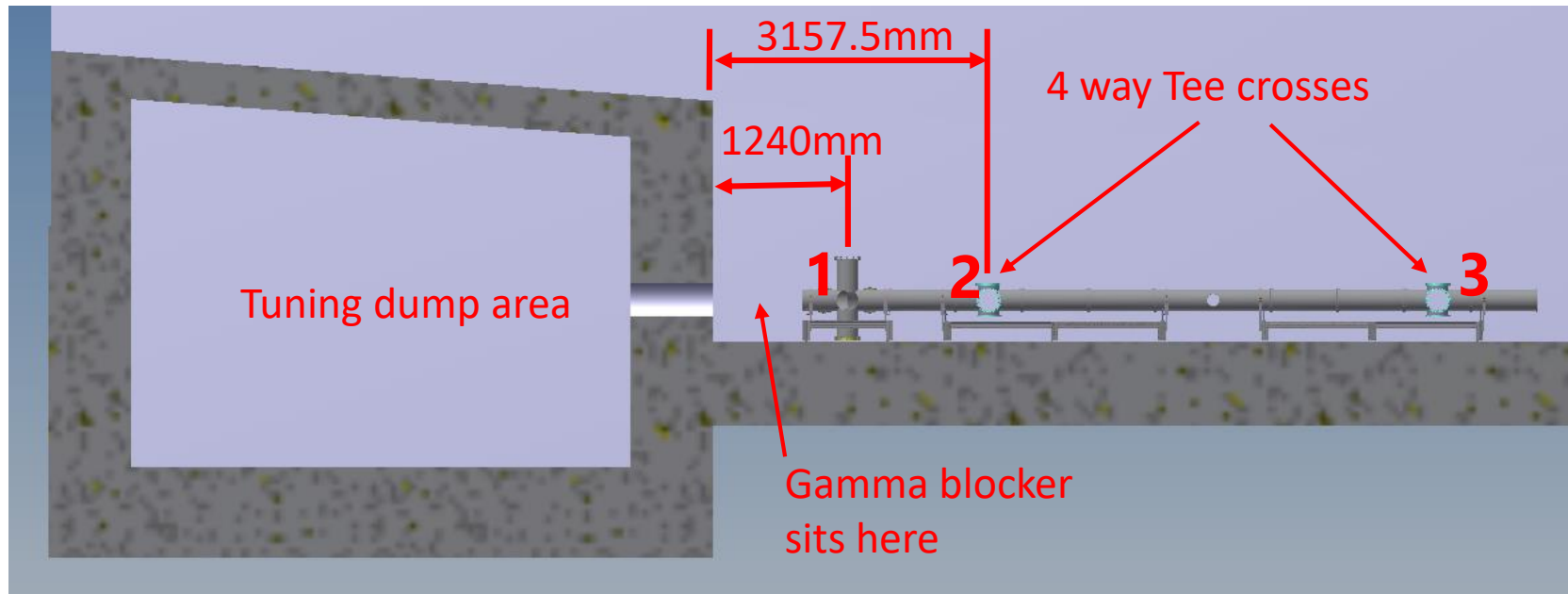
System Overview

- Purpose: Image the beam just before the tuning dump

- ① Beam input pipe
- ② Beam output pipe
- ③ View pipe
- ④ Linear actuator (moves scintillating screens)



System Overview: Where Will It Go?

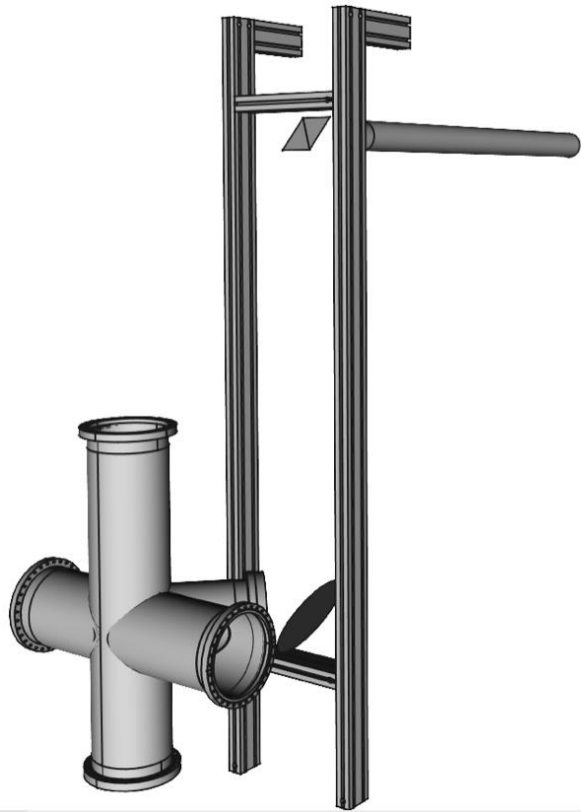


Quantity 2 (for now)—

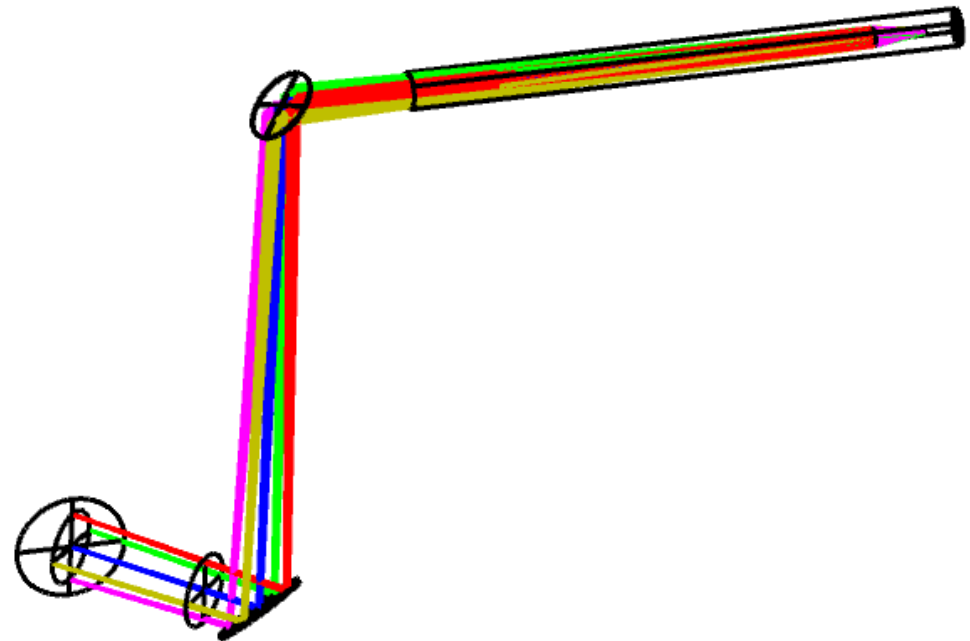
One just before the gamma blocker

One ~2m upstream of the first

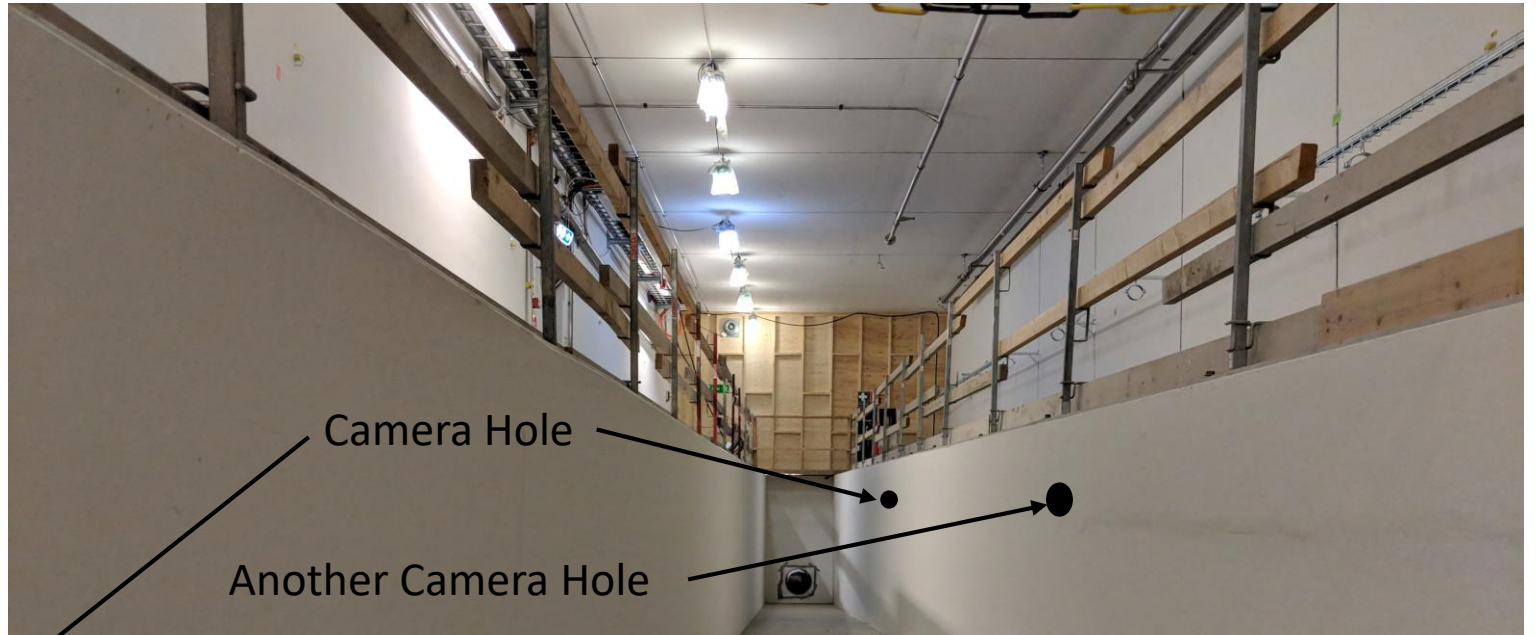
System Overview: Camera, Mirrors, Optics



mirrors and support structure



light path



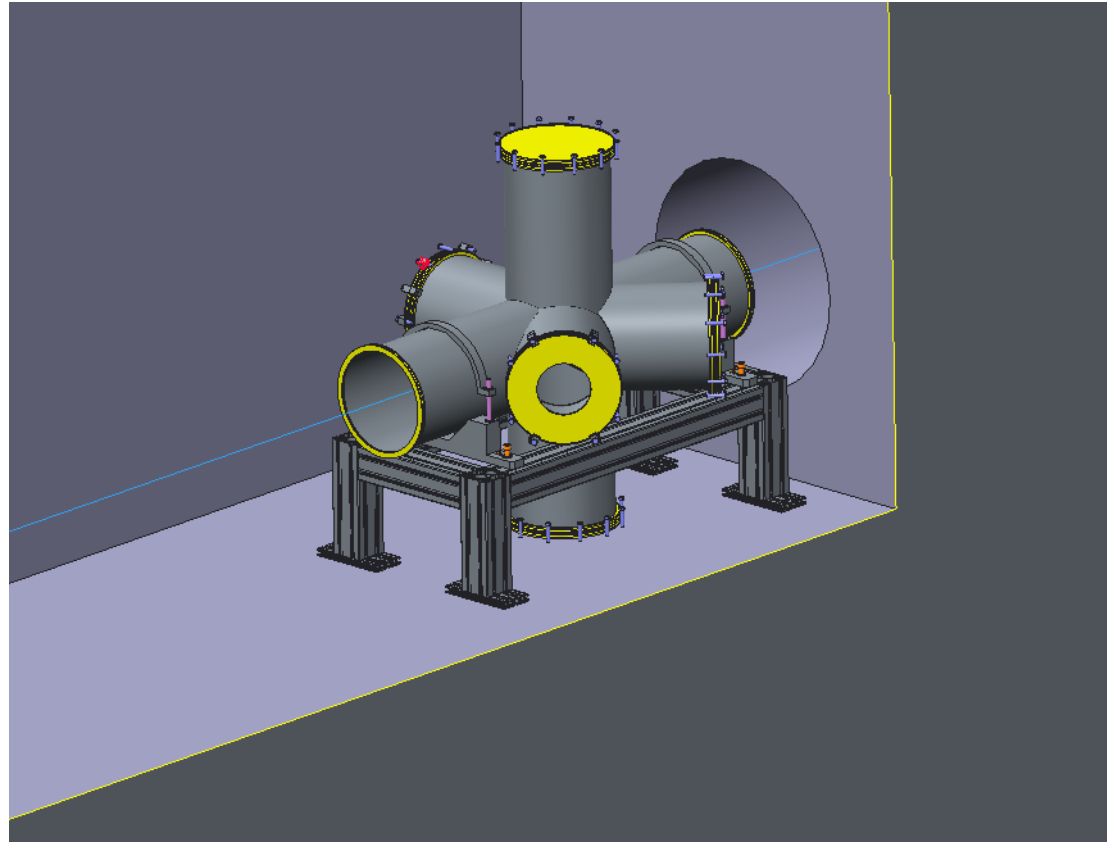
Camera Hole

Another Camera Hole

System Overview: Where
Will It Go?

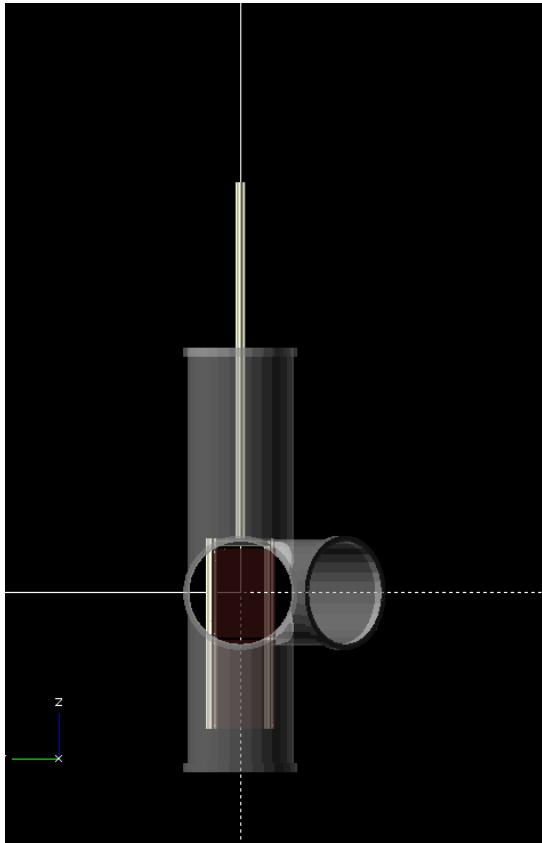
Recent Updates

- ✓ Dump chamber CDR passed two weeks ago
 - Design tweaked based on feedback here
 1. Move screen holder hardware away from beam
 2. Increase imaging area
 - Screens rotated to be normal to beam
 - Screens enlarged from 230x230mm to 230x320mm
 - Chamber enlarged accordingly
 - 250mm inner diameter vertical pipe → **350mm**

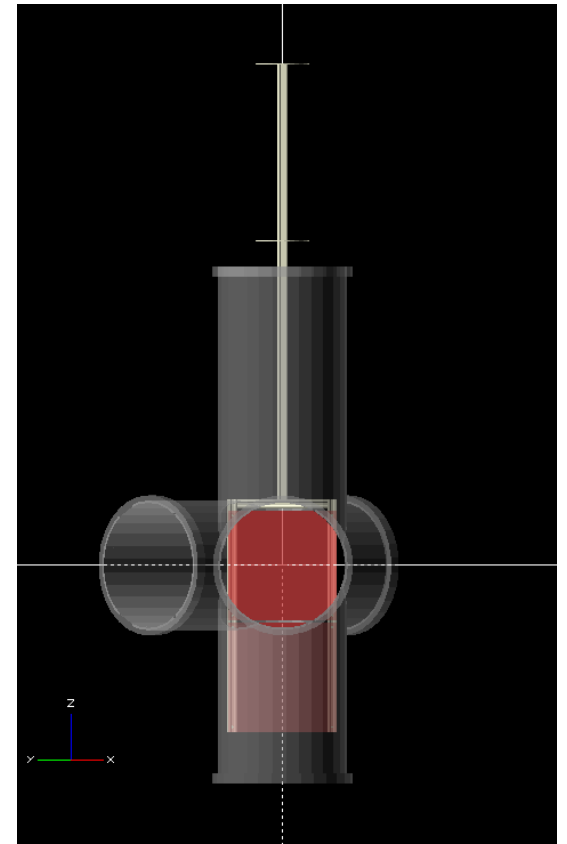
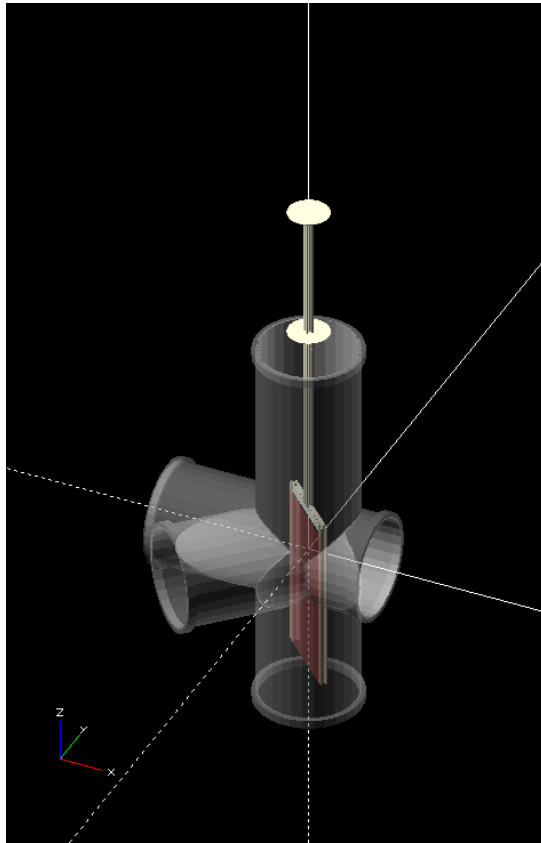


Early Design

Waaaay back in April 2018



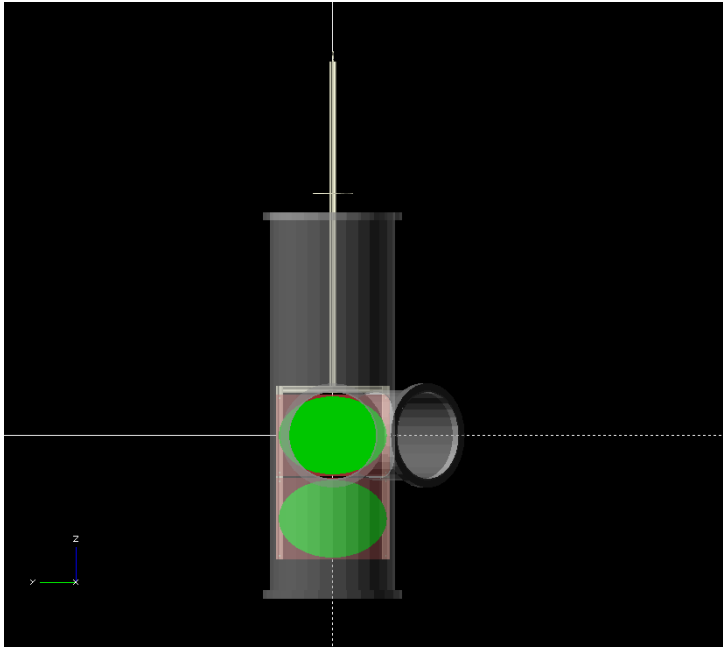
Beam view



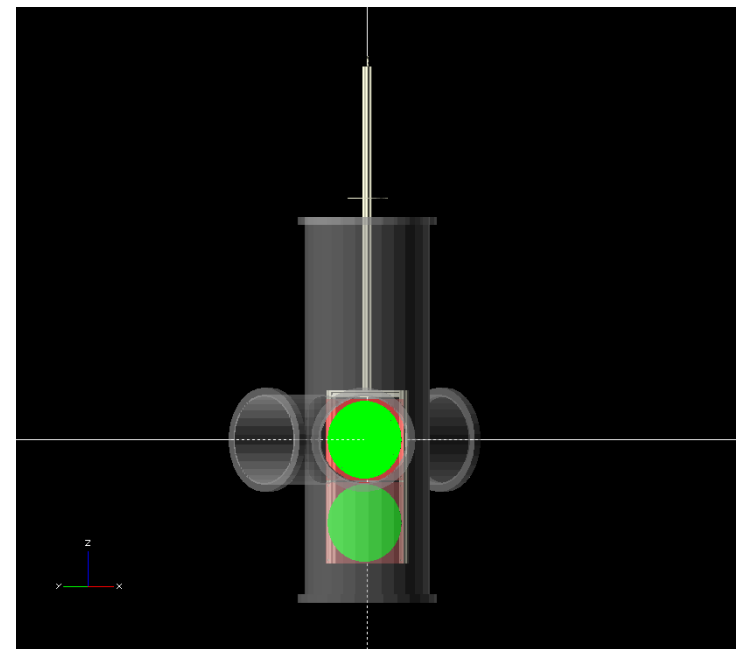
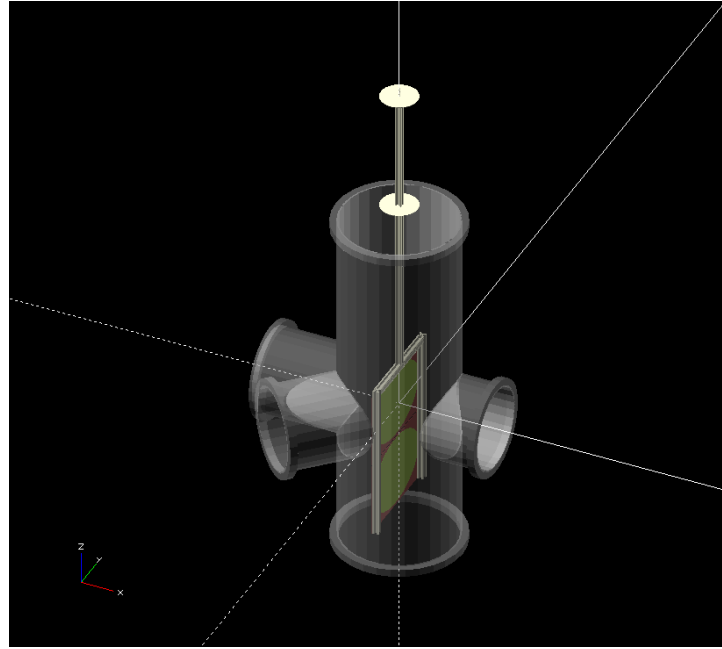
Camera view

Previous Design

Back in eaaaarly November 2018



Beam view

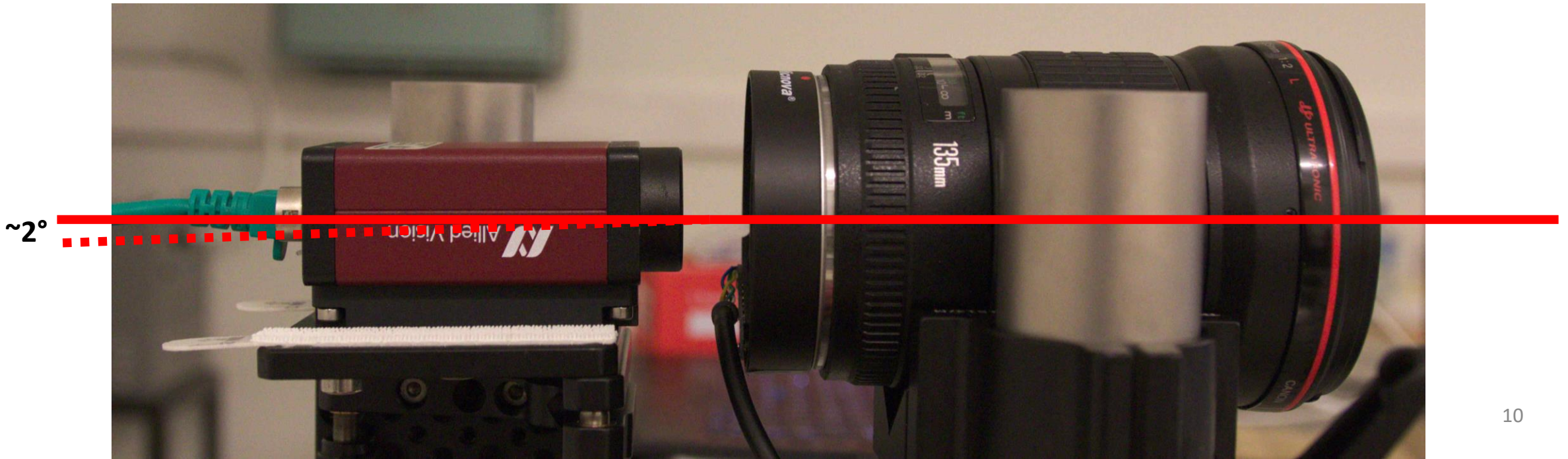


Camera view

New Design

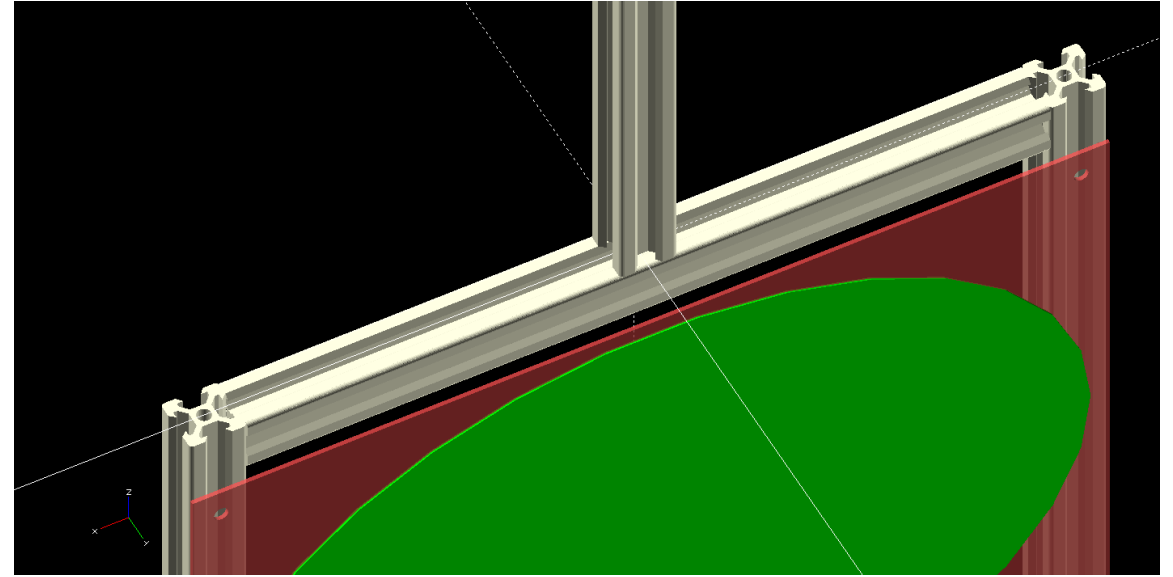
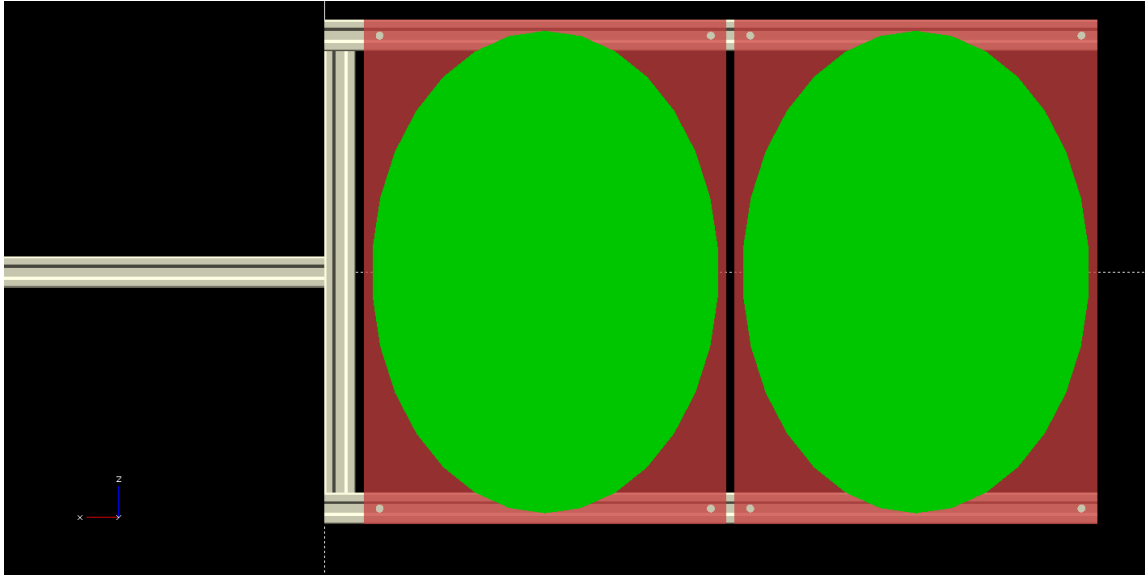
Depth of field tricks

- The scintillating screen is now angled (45 degrees) relative to the camera field of view
 - The camera's focal plane no longer corresponds to the screen surface
- We can tilt the camera sensor (~ 2 degrees) to compensate for this



Scintillating Screens

- Dimensions: 230x320mm
- Screen A
 - Same as what is used in LHC dump lines: “Chromox”
 - Purchased from Ceraquest (of France) at ~5k EUR each
- Screen B
 - Experimental sprayed coatings developed in partnership with University West, Trollhättan, Sweden

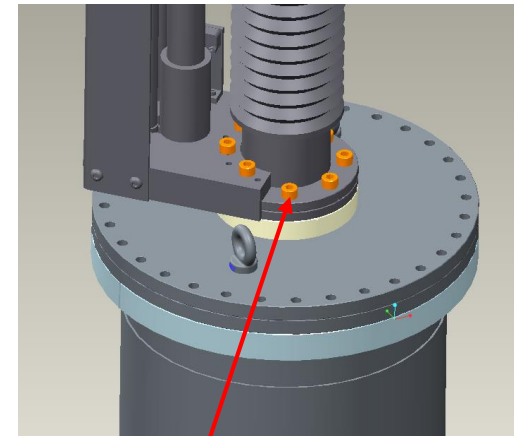
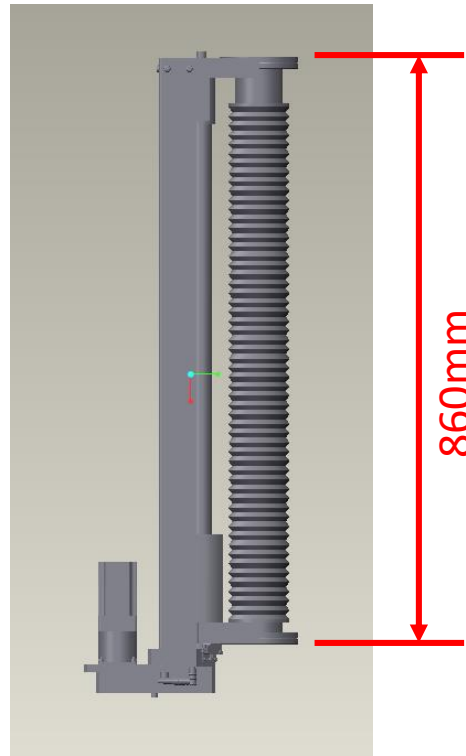
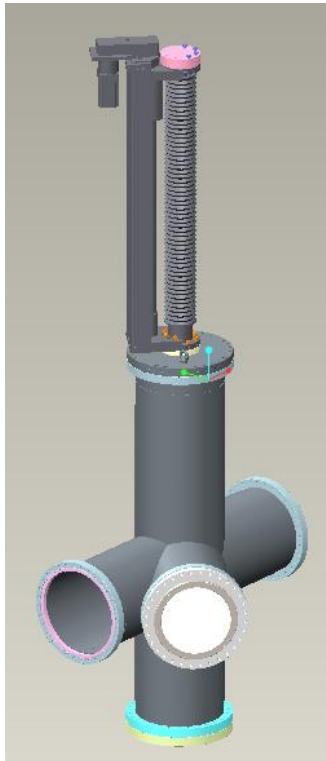


Screen Holder Design

Four pieces of 2x2cm Aluminum framing

Motion Control

- Screens moved by a stepper motor driven linear actuator



Bolted as shown
Top and bottom

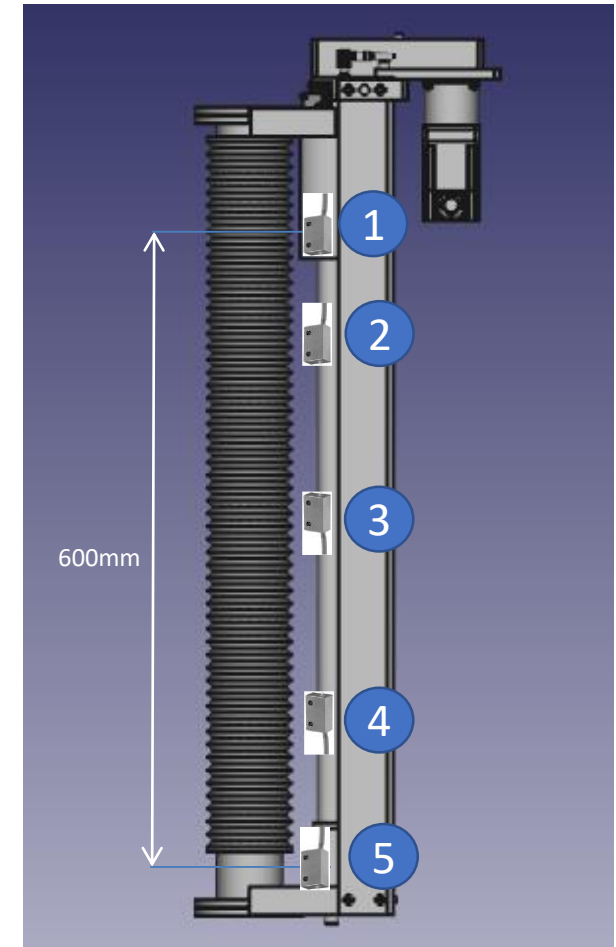
- Using standard EtherCAT motion control components (BECKHOFF), recommended by the ESS motion control group

Motion Control

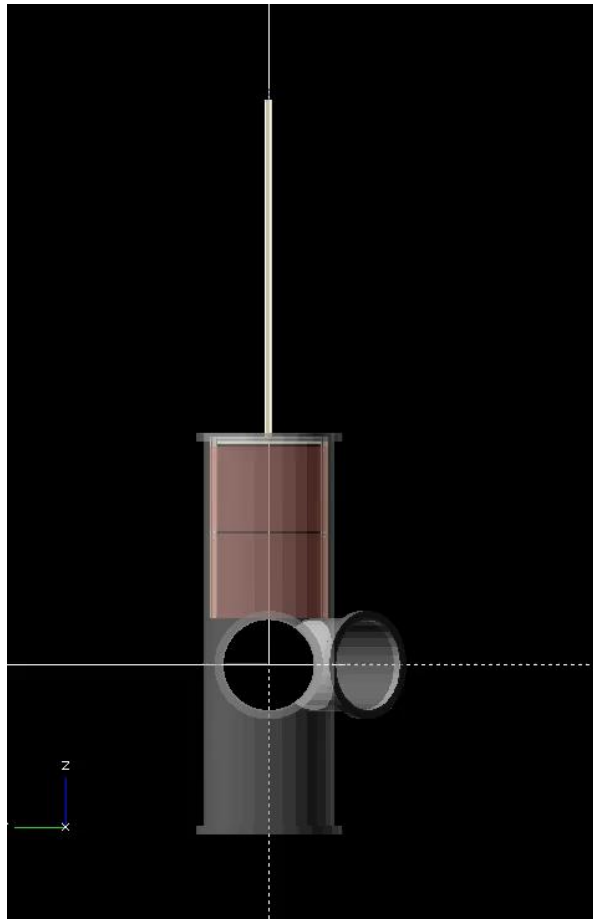
No position encoder

- Five limit/position switches
 - 1 Top limit switch
 - 2 Screens removed position switch
 - 3 Bottom screen installed position switch
 - 4 Top screen installed position switch
 - 5 Bottom limit switch

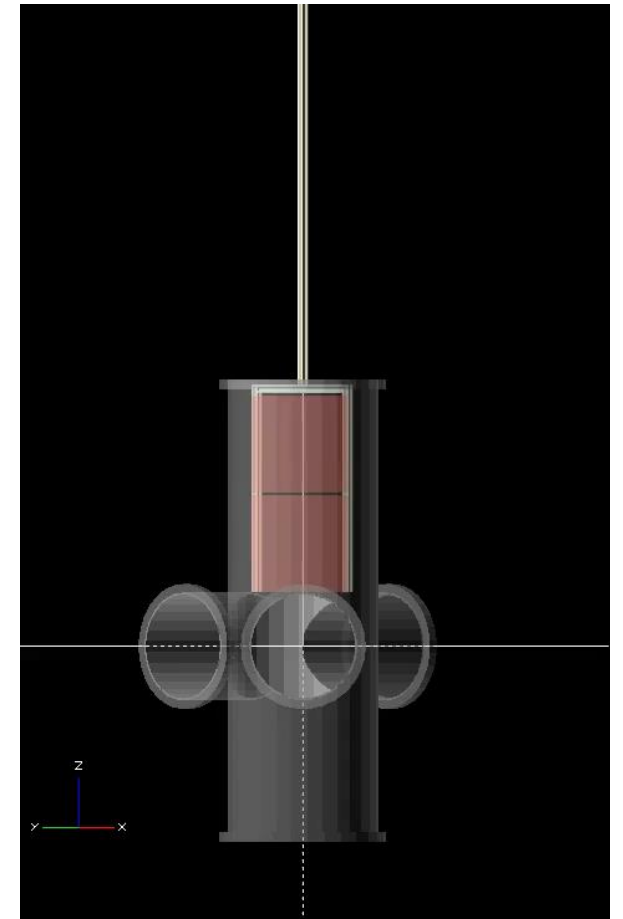
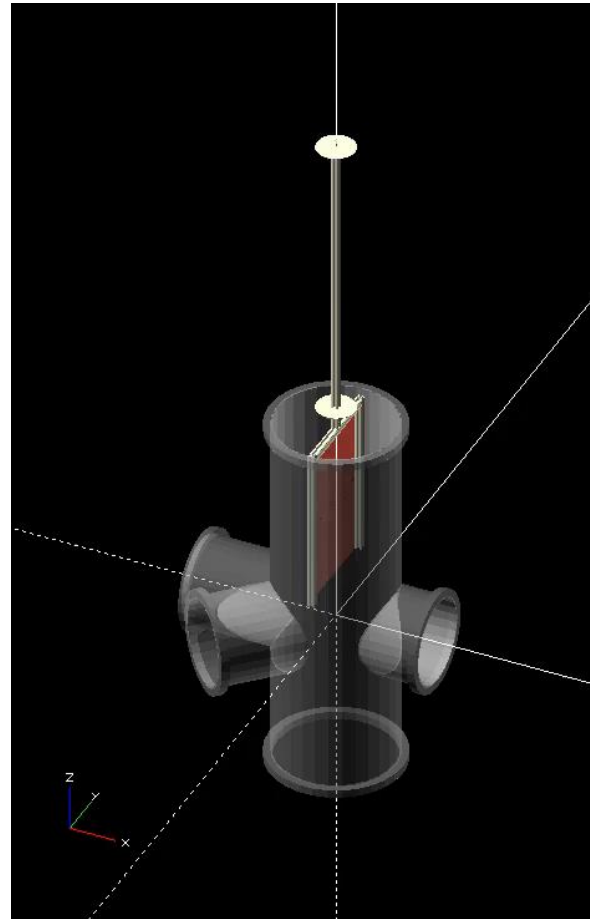
- Motion is slow (10s of seconds between positions)



Motion Control



Beam view



Camera view

Schedule

▲ ESS Tunning Dump	304 days	Fri 01/06/18	Wed 31/07/19
▲ Actuator Design	114 days	Fri 01/06/18	Wed 07/11/18
Flange Design	15 days	Fri 01/06/18	Thu 21/06/18
Actuator Mechanism Design	19 days	Fri 22/06/18	Thu 19/07/18
View port deisgn	9 days	Fri 10/08/18	Wed 22/08/18
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Prepare for CDR	4 days	Thu 01/11/18	Tue 06/11/18
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Procurement	117 days	Mon 19/11/18	Tue 30/04/19
Assembly and testing (1 vessel only)	43 days	Wed 01/05/19	Fri 28/06/19
Packing and Delivery (3 sets)	23 days	Mon 01/07/19	Wed 31/07/19

Questions?

Thanks for listening!

Danger: Backup Slides Below

ESS Tuning Dump Imaging System

Input to the Vacuum Vessel CDR

Prof. Erik Adli

Department of Physics, University of Oslo, Norway

Cockcroft Institute, November 6, 2018



Some overall requirements of Im. Sys.

- For the tuning dump, the overall limit is the 12kW.
- Full pulse are allowed a low frequency to stay below the 12kW limit overall (around 1 pulse/30 sec).
- If we send one full pulse we will be quite sure that the transversal optics is accurate so the beam size will be close to the nominal design.
- Although the nominal beam size is not larger than $1 \times 1 \text{ mm}^2$ at the dump, during beam tune up, the **dump line optics allows for very large beam sizes** at the dump and at the imaging systems.

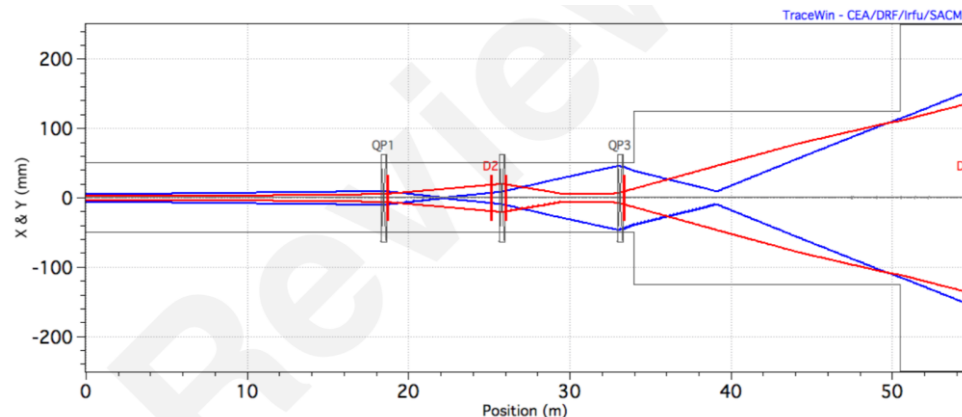
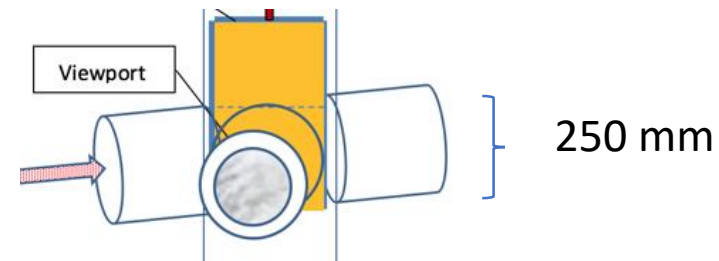


Figure 5: Envelope for a 3σ beam (rms). The quadrupoles were adjusted to maximize the beam size transported to the dump.

ESS-0191105

Beam Size Range on the Dump During Transverse Tuning



Imaging systems, including optical system and screen **designed to maximize FOV** in the beam plane, **while at the same providing a resolution of sub. 1 mm.**

Key challenges for system related to:

- large screens, long travel
- large FOV
- radiation environment

Two imaging systems

- Two imaging systems are required to measure both spot size and divergence.
- A third imaging system was discussed, but will not be installed due to cost.
- Each imaging system will be equipped with two screens. The two screens gives redundancy, or, the possibility to test different materials/coatings (test beam for target coatings).

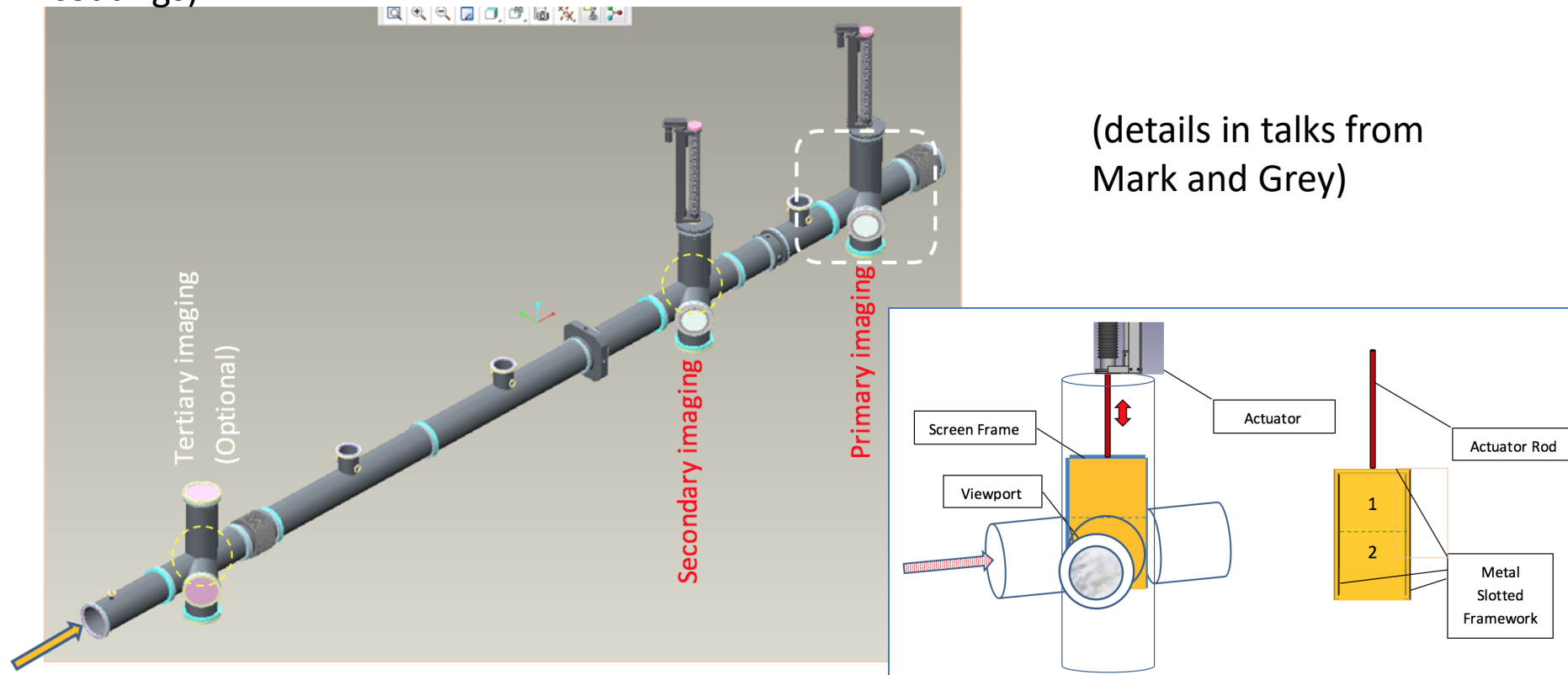
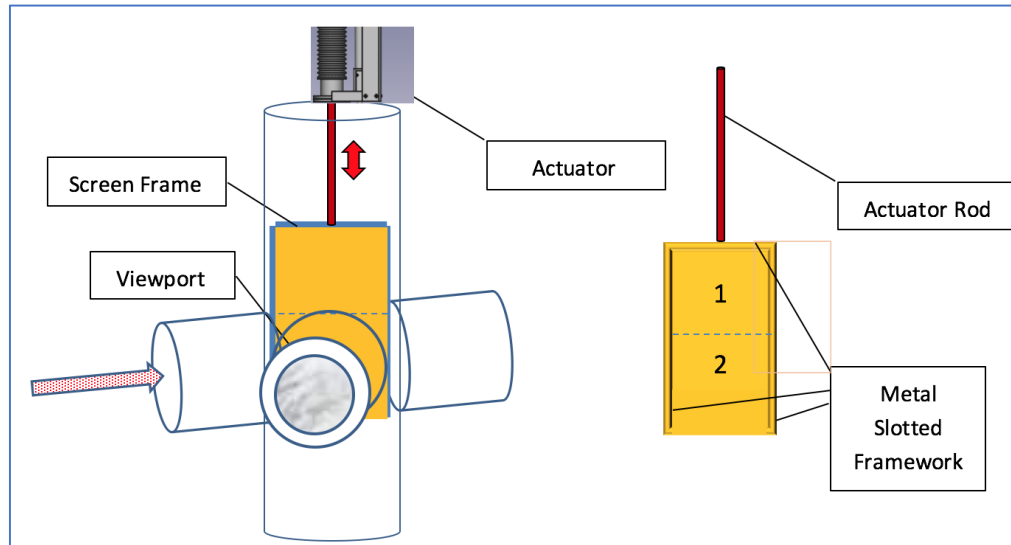


Figure 6 Planned locations for Primary and Secondary Imaging Vessels, and the optional Tertiary system. Beam direction is from lower left to upper right.

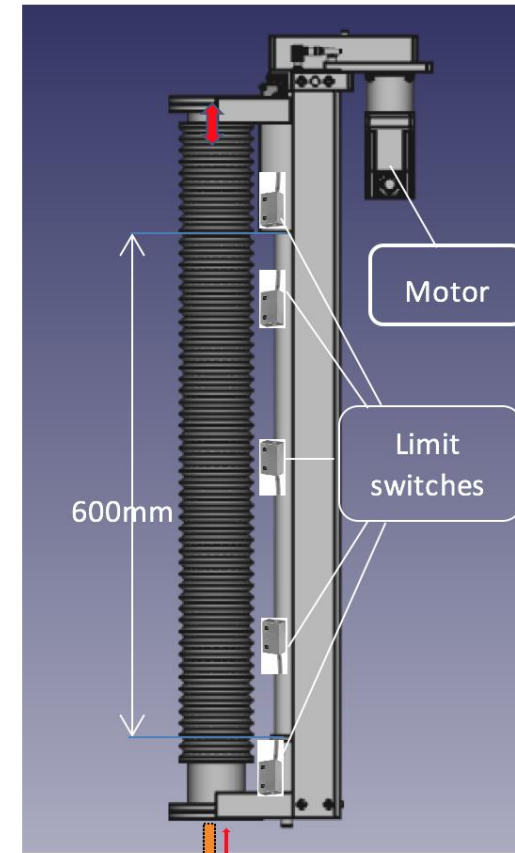
Interfaces imaging system and vacuum vessel

- The imaging systems themselves passed their [CDR in Oslo, 25-27 October 2017](#), with update to simplified system [ESS-0331227](#).
- Interfaces to vacuum vessel was not discussed at this time, but was discussed later at a meeting at Daresbury March 2018, and around the vacuum vessel PDR in August 2018.



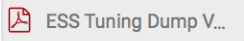
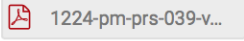
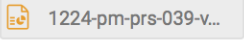
Gray zones and interfaces (know from the PDR and previously) seems to have been sorted out by now :

- The main mechanical interface imaging system and vacuum is the linear actuator. The actuator has been chosen in agreement with ESS, STFC and Oslo, and will be procured and integrated by STFC.
- The screen holders, screens, motor control will be provided by Oslo.



Vertical actuator, fully withdrawn

Agenda

09:00	→ 09:10	Meet and greet	🕒 10m
09:10	→ 09:20	Introduction, top level requirements for the imaging system Speaker: Erik Adli (University of Oslo (NO))	🕒 10m
09:20	→ 09:40	ESS schedule, top level requirements for the vacuum system, Speakers: Cyrille Thomas, Fabio Ravelli	🕒 20m
09:40	→ 10:00	Optical system: requirements, optical path, aperture, filtering Speaker: Havard Ervik Gjersdal (University of Oslo (NO))	🕒 20m
10:00	→ 10:20	Interface specifications: motion actuator, motor, limit switches Speaker: Mark Ibison 	🕒 20m
10:20	→ 10:45	Coffee break	🕒 25m
10:45	→ 11:30	Screen, screen holders, limit switch positions, motor control Speaker: Grey Christoforo	🕒 45m
11:30	→ 12:30	Vacuum vessel design, actuator integration, flanges, viewports Speaker: Danish Naeem  	🕒 1h
12:30	→ 13:15	Lunch break	🕒 45m
13:15	→ 14:15	Procurement, Work flow, test procedures, schedule Speakers: Danish Naeem, Erik Adli (University of Oslo (NO))	🕒 1h
14:15	→ 14:45	Tour of STFC assembly facilities	🕒 30m
14:45	→ 15:00	Close out; conclusions, recommendations Speakers: Cyrille Thomas, Fabio Ravelli	🕒 15m

Present all interfacing systems to the vacuum vessel

Present vacuum vessel design

Way forward

ESS Tuning Dump Vessel Actuator Design CDR

Danish Naeem

07th Nov 2018

Attendees:

- Danish Naeem (STFC Daresbury Lab)
- Mark Ibison (University of Liverpool)
- Erik Adli (Oslo)
- Greyson Christoforo (Oslo)
- Håvard Gjersdal (Oslo, Optional)
- Cyrille Thomas (ESS, Optional)
- Thomas Shea (ESS, Optional)
- Fabio Ravelli (ESS, Optional)

Scope:

- Procurement of Actuators with motors
 - Design and Procurement of mating flanges for vessel
 - Design and Procurement of mating flanges for Actuators
 - Procurement of Limit Switches
 - Procurement of view ports
 - Assembly and testing of above
 - Packing and Delivery to Oslo / ESS Sweden
-
- Design and Procurement of vessel for Tuning Dump is covered by ESS BTM WP12.

Quantities to Deliver:

Name	Qty / Vessel	No of Vessels	Reqd Qty	Spare Qty	Total Qty
Actuator Assembly	1	2	2	1	3
Stepper Motors	1	2	2	1	3
DN63CF Flanges	2	2	4	2	6
DN250CF Flange Top	1	2	2	1	3
M12 Eye bolts	2	2	4	2	6
DN250CF Blank Flange Top and Bottom	2	3	7	1	8
View Port	1	2	2	1	3
Limit Switches	5	3	15	15	30
M8 Nuts and bolts Set	112	3	336	34	370
Gaskets and Seals DN63	3	2	6	3	9
Gaskets and Seals DN250	3	3	9	3	12

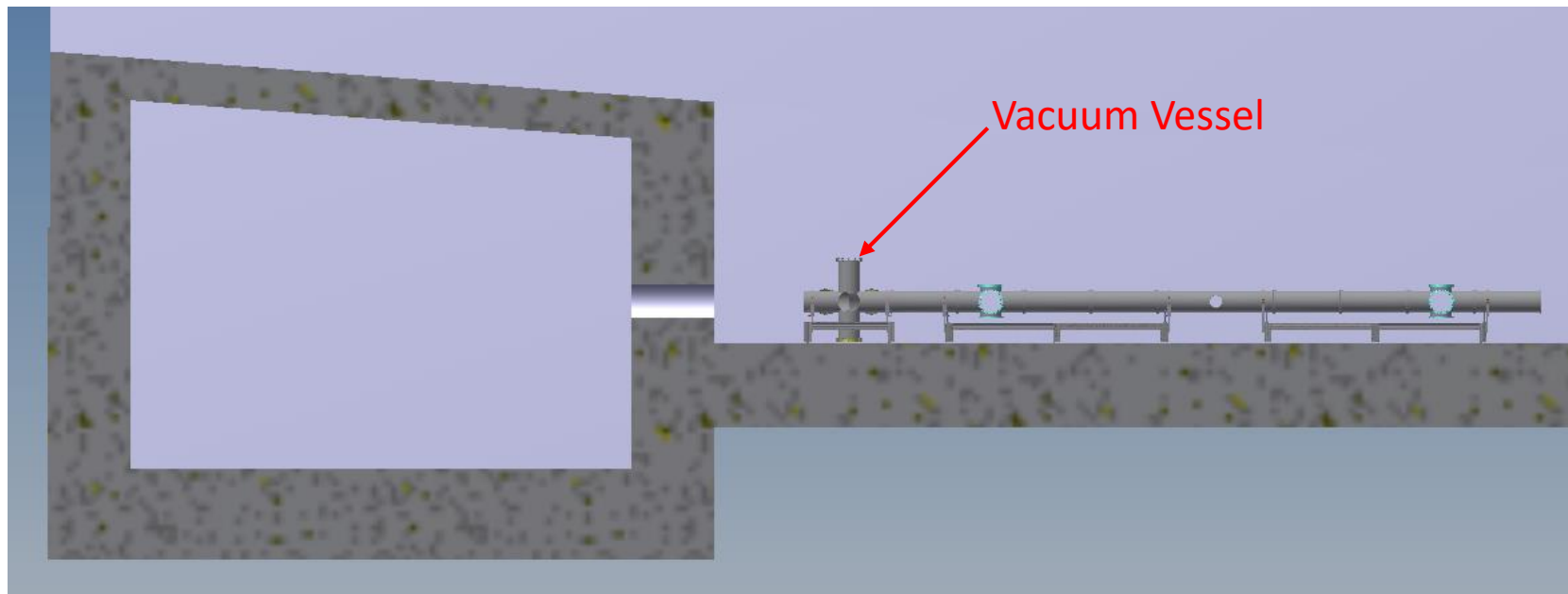
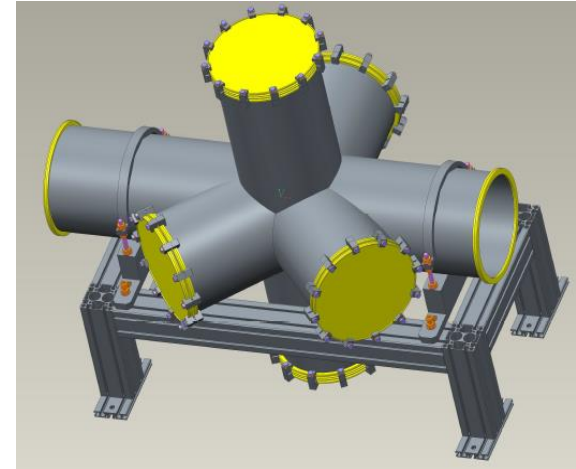
CDR Objective:

- To get approval for vessel manufacture.
- To get approval for procurement of Actuator and view port.
- To get approval for rest of the items.

Vessel Design

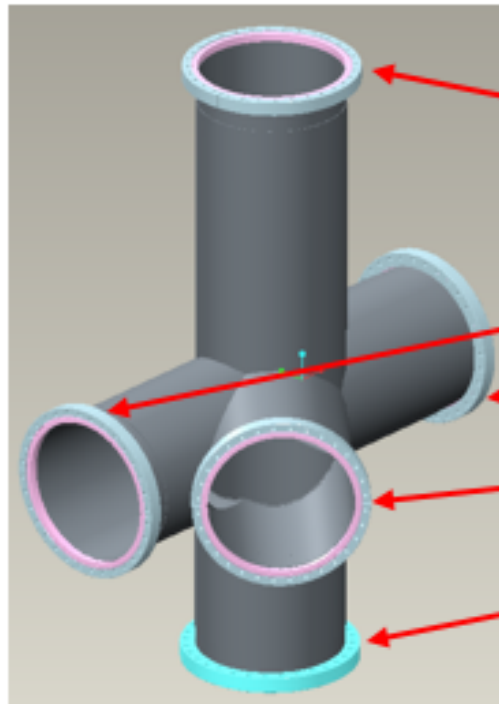
Original Design:

- Only 1 vessel
- Location: At the end of dump line before Gamma blocker



Final Design:

- Length significantly reduced
- Angular ports removed
- Rotatable flanges except Bottom flange.
- Location changed
- Qty increased
- Top & View port flange is 2 piece rotatable.



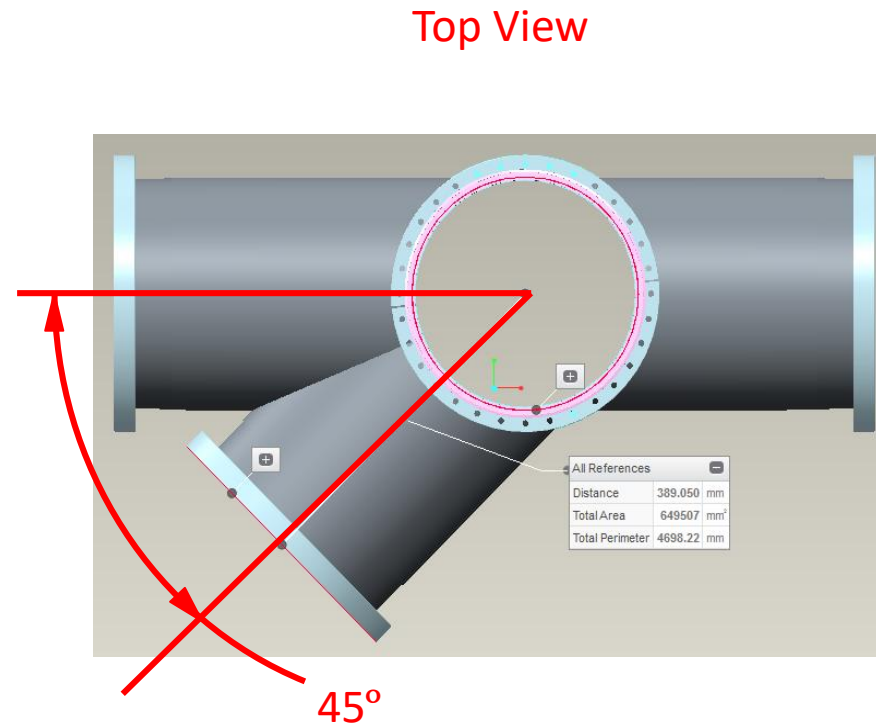
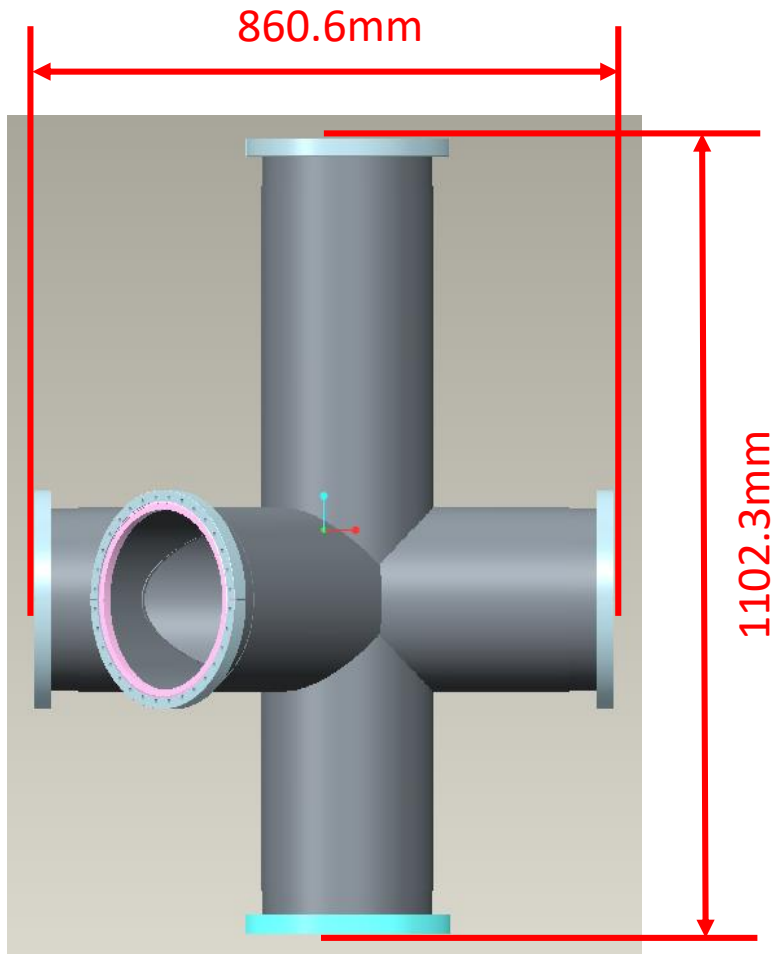
Summary - Vessel Flanges

Top (Actuator)	CF Bolted
Beamline (In)	CF Bolted
Beamline (Out)	CF Bolted
Viewport	CF Bolted
Bottom (Blank)	CF Bolted

All flanges DN-250

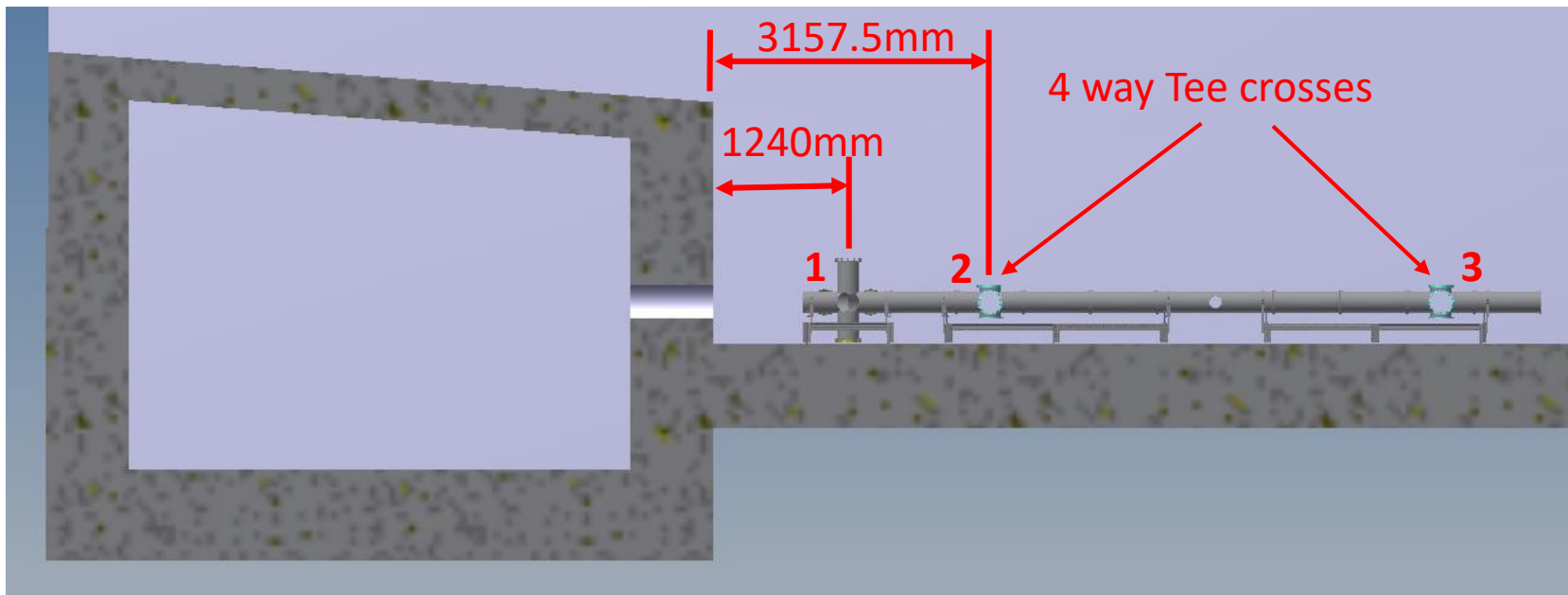
Dimensions (New Design):

- All ports are DN 250 size dia.

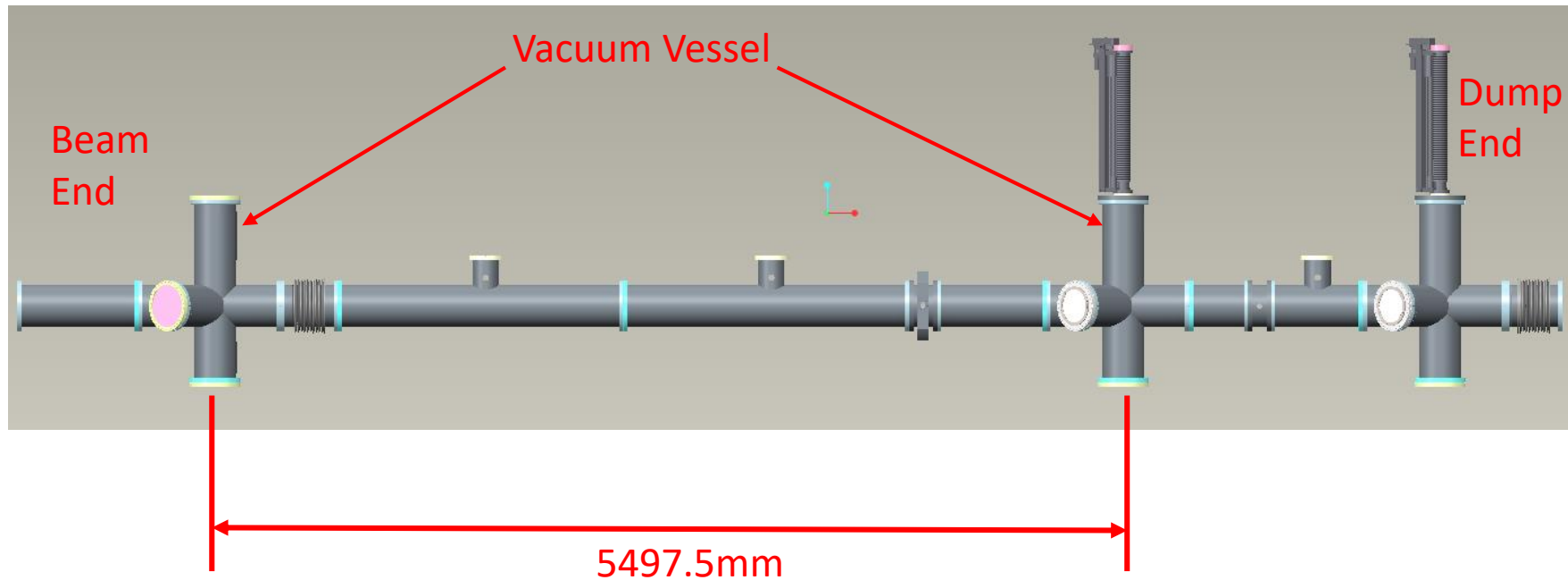


Location of New vessel:

The vessel quantity in dump line has been increased from 1 to 3. Where 2 vessels closure to the dump will be fully equipped with screen imaging system while 3rd vessel will work as beam pipe and future upgrade for ESS. The location for 2 new vessel has been chosen as to replace the 4-way tee crosses which exist earlier in the dump line. This will be done at 2 different locations in the dump line as shown below. This decision has been made by Oslo and Uni. Of Liverpool jointly but requires ESS approval.



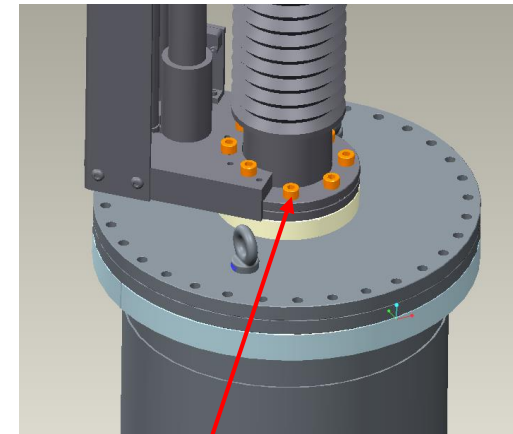
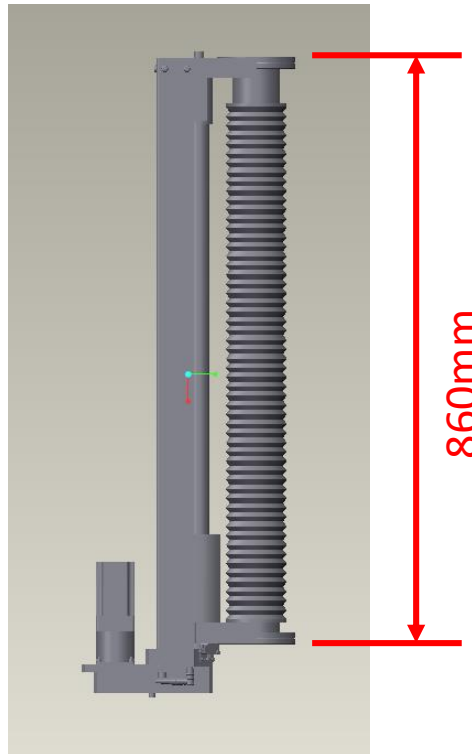
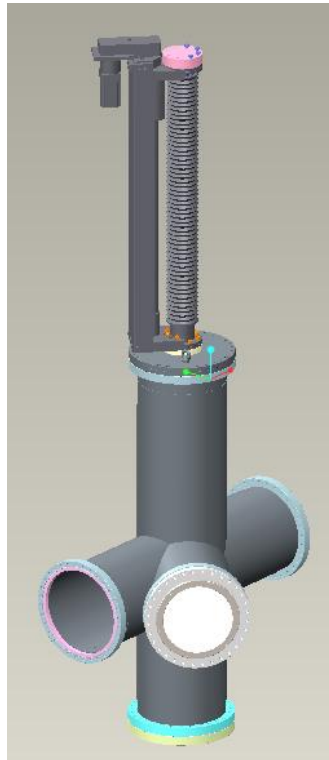
After replacement of Tee crosses with new vessel



The length of new vessel is same as the length of Tee crosses replaced here.
The vertical height of new vessel is determined based on travel and size required for screens.

Actuator Design

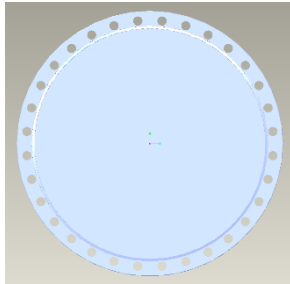
- Actuator design is provided by UHV motion.
- Travel is 600mm based on screen travel required.
- Phytron Stepper motor with limit and home switch included.
- Mounted on top of the vessel via transition flange.
- Size DN63



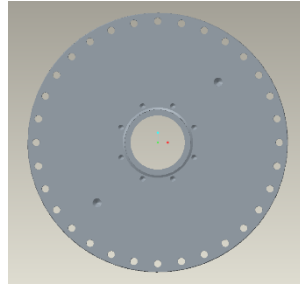
Bolted as shown
Top and bottom

Vessel Mounting Flanges

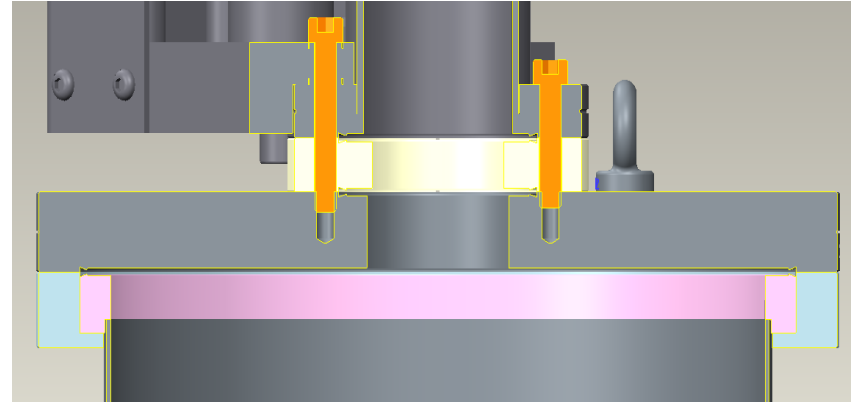
- The vessel vertical port will be equipped with 2 flanges. Both flanges will be DN250CF bolted with knife edge.
- The bottom flange will be a standard CF bolted blank flange.
- The top flange will be a standard CF bolted flange with modification i.e. a bore in centre to suit central rod passing through and a bolt pattern holes to suit DN63 flange bolt holes.
- Top flange will have knife edge on both faces to provide vacuum seal.
- Top flange will have blind threaded holes to provide lifting aid.
- Both flanges will mate with vessel welded rotatable flanges using bolts.



Bottom Blank
Flange



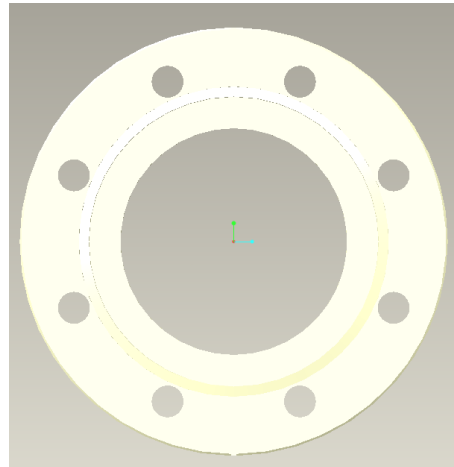
Top Bored Flange
With bolt holes



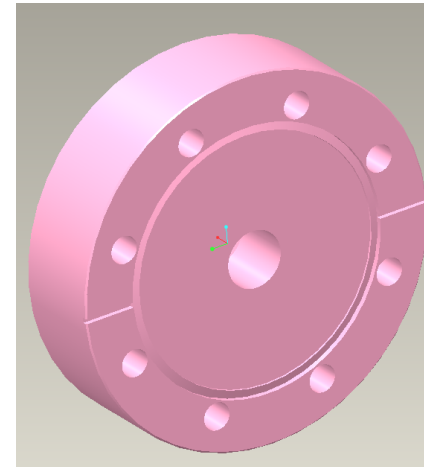
Top Flange connection with
vessel and DN63 Flange

Actuator Mounting Flanges

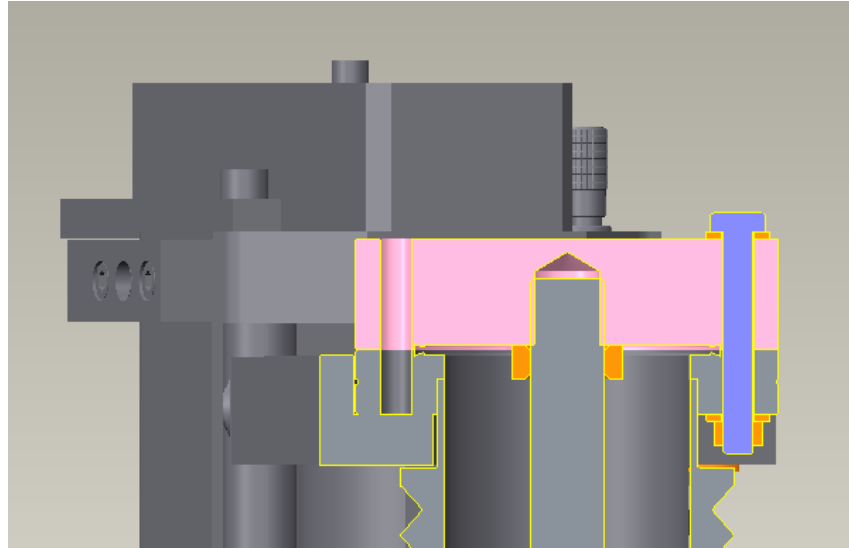
- The actuator will be equipped with 2 flanges at top and bottom. Both flanges will be DN63CF with knife edge.
- The bottom flange will sandwiched between actuator and vessel DN250CF flange.
- Bottom Flange will have knife edge on both faces to provide vacuum seal.
- The top flange will be a standard CF blank flange with modification i.e. a blind tapped hole in centre to suit central rod and a bolt pattern holes to suit DN63 flange bolt holes.
- Both flanges will be held in place using cap head screws.



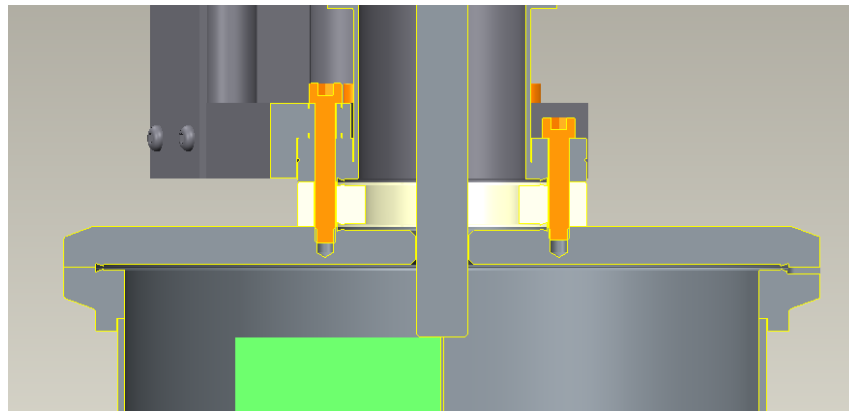
Bottom Flange



Top Bored Flange
With bolt holes



Top Flange connection with Actuator



Bottom Flange connection with vessel
Flange and Actuator

Limit Switches Design

- Location of Limit Switches (TBC)

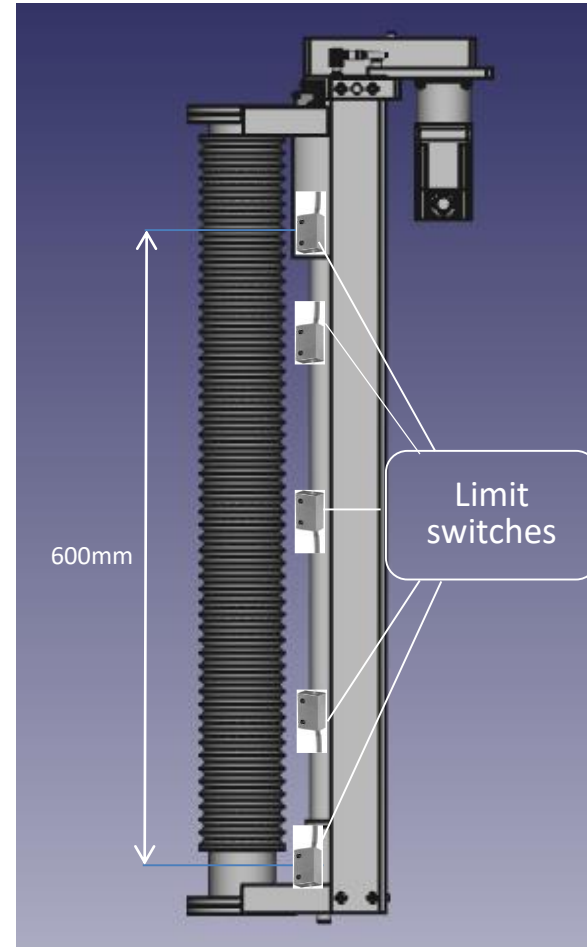
LT_pos : 860.00 [mm]

SA_pos : 850.00 [mm]

SB_pos : 607.55 [mm]

SC_pos : 372.55 [mm]

LB_pos : 352.55 [mm]



Testing

1. A detailed test procedure document will be written by STFC at the time due for testing.
2. Major tests are as follows
 - I. Visual and dimensional inspection of all incoming items i.e. purchased items
 - II. All items will go through vacuum cleaning process
 - III. Independent Actuator test before assembling onto the vessel to ensure its working. Oslo to conduct this.
 - IV. Electronics, motion controller, wiring tests to be conducted by Oslo.
 - V. Vacuum vessel cleaning, RGA scan, pumping and any other vacuum tests to be conducted by STFC. All these tests for vacuum vessel are covered in ESS BTM WP12.
 - VI. After assembly tests of actuator, screen positioning, location and working of limit switches to be done by both STFC and Oslo.

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Costs

1. A formal quotation has been issued to Oslo for the STFC works on this work package.
2. Quotation is under review with Oslo and will be signed shortly.
3. STFC will not proceed with any order until formal quotation has been signed and agreed.
4. All prices in quotation are based on current valid quotation from different supplier but final prices will be determined at the time of placement of order.
5. Quotation price of actuator has already gone up from supplier due to phytron motors and crouzet limit switches.
6. Any changes in prices will be reflected in final invoice to Oslo unless those changes are already covered.

Approvals

1. Do STFC have approval for vessel manufacture?
2. Do STFC have approval for Actuator order placement?
3. Do STFC have approval for View port order placement?

Please note that despite the client approvals, STFC will still have to go through internal approval process and acquiring 3 quotations for each item purchased.

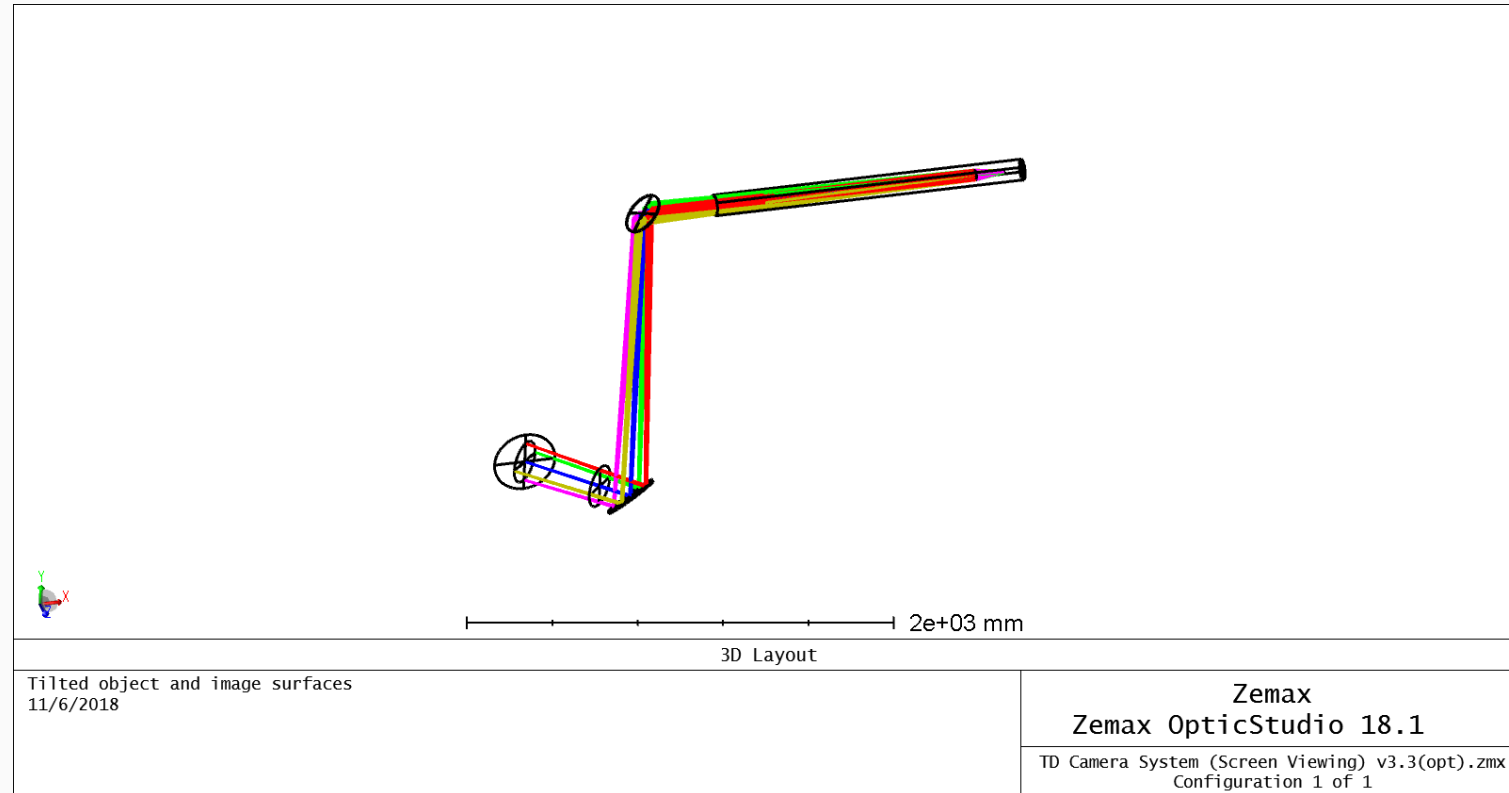
Tuning dump optical system

Håvard Gjersdal

2018-11-07

University of Oslo

Imaging system



- Goal: Image light from scintillating screen onto a camera.
- To minimize dose, camera placed 1.5m inside concrete wall.
- Optical path: through viewport, two flat mirrors and into hole in wall.

Requirements

- Should be able to measure very small test pulses, as well as full ESS pulse.
- Field of view: as large as possible
- Better than 1 mm resolution across field of view
- Camera and all other parts must be able to survive in environment without maintenance

- Mirrors
- Limiting apertures
- Camera, lens
- Filtering
- Illumination

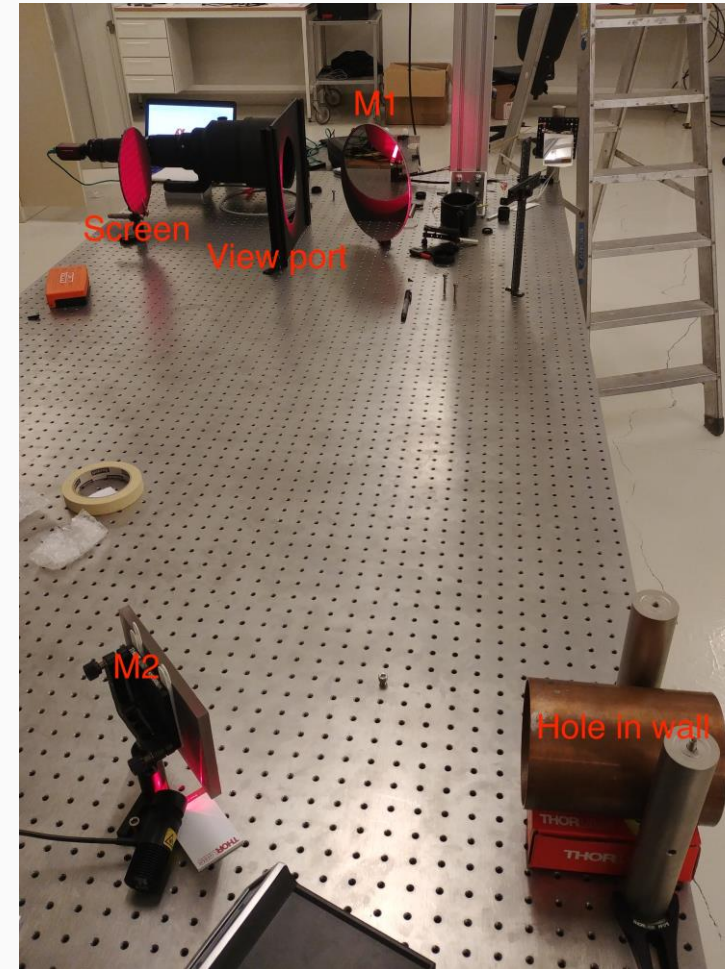
Mirrors

M1:

- Borosilicate
- 1λ over 25 mm
- 290mm diameter
- Centered on viewport

M2:

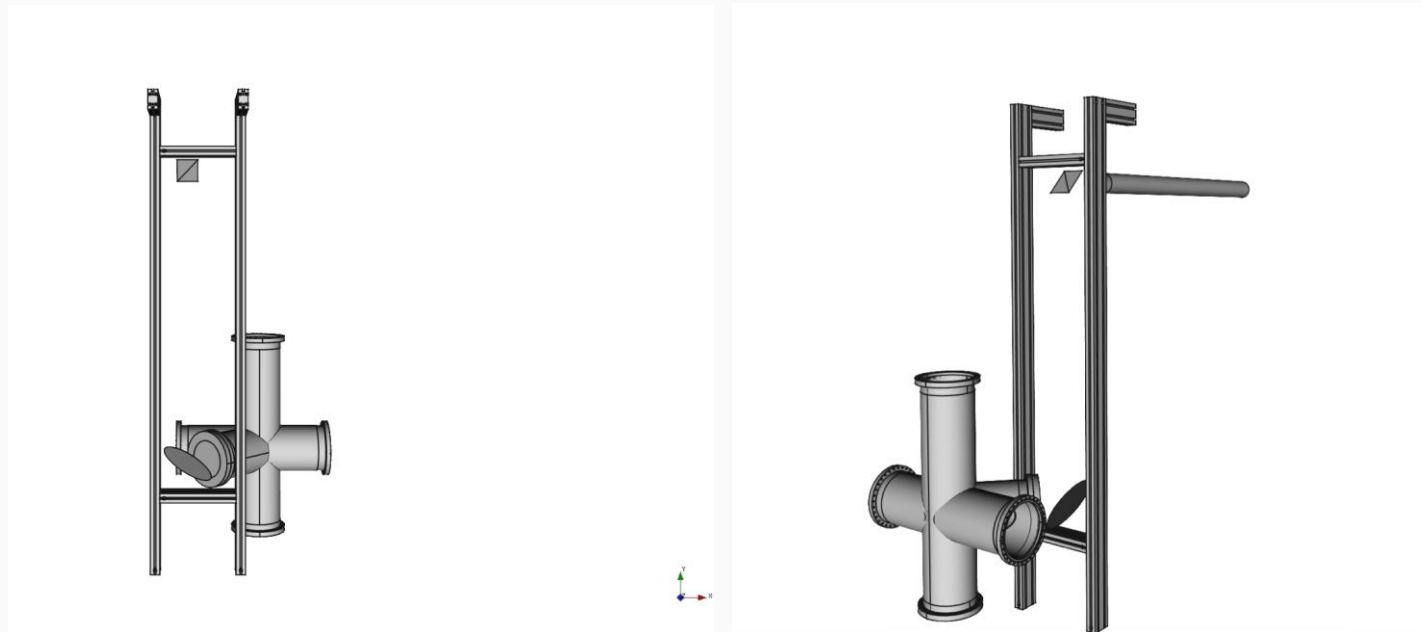
- Fused silica
- $\lambda/4$ over surface
- 110mm \times 150mm
- Centered hole in wall



Exact position of hole in wall is not known yet. Mirrors should remain centered on apertures, angles adjusted.

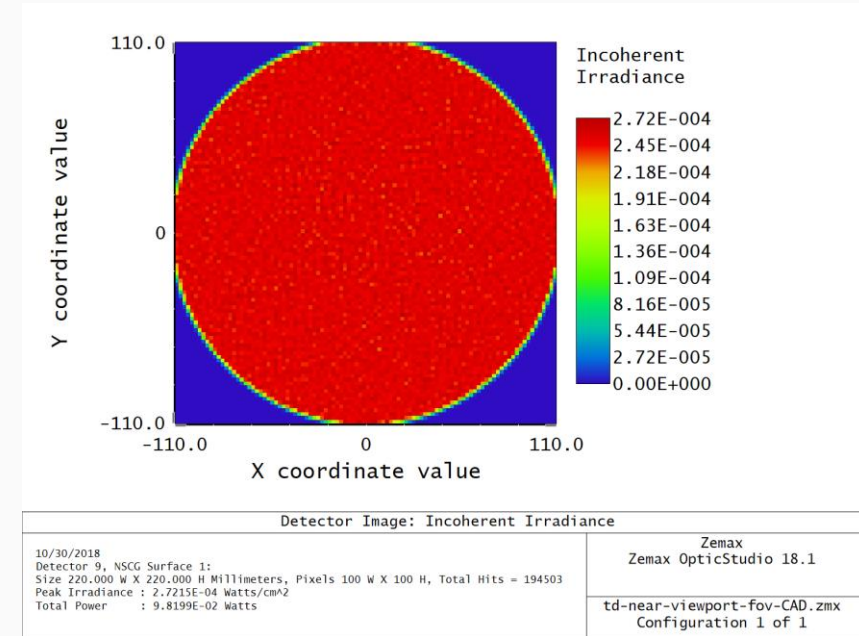
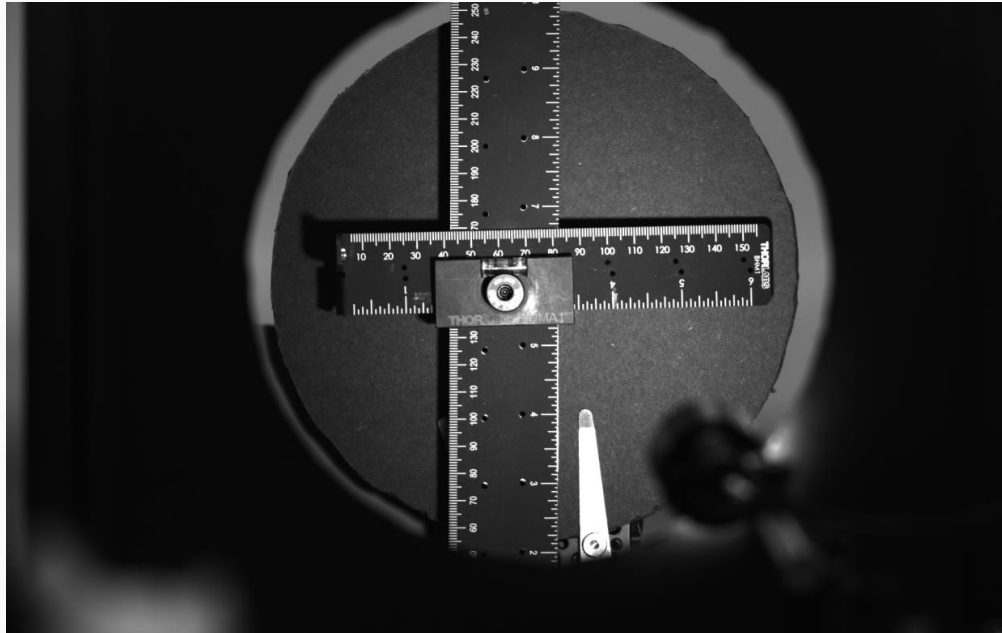
Mirror support

- Mirrors will be mounted to the Bendamount, allowing precise adjustment of three angles, one translation.
- Design of support for the mounted mirrors is not fixed. One option is a sturdy strut profile frame, bolted to the wall and the floor.



Limiting apertures

The viewport limits the field of view.

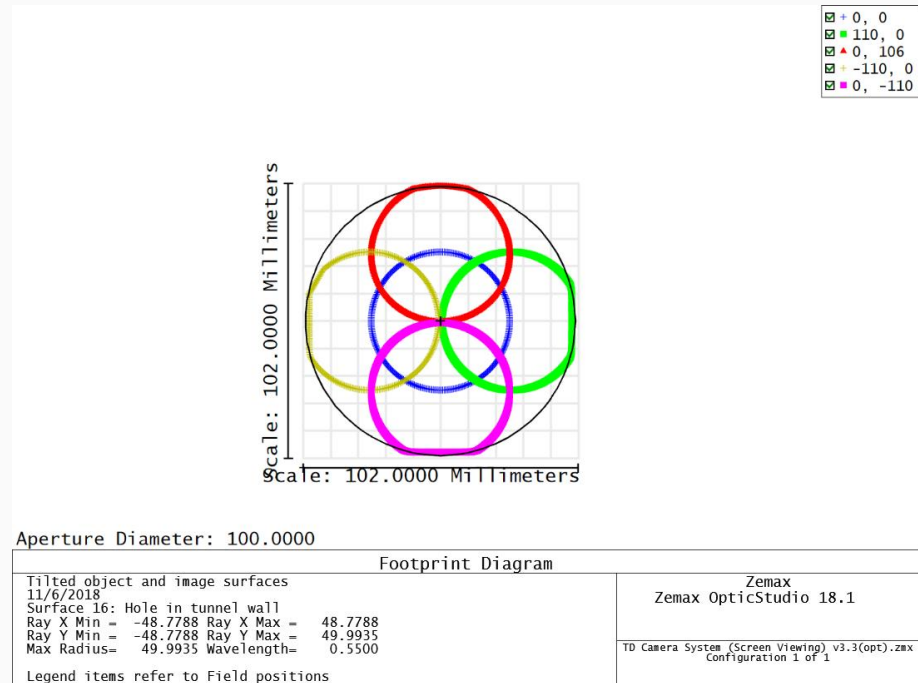


Field of view is very close to 220mm in screen coordinate system. Elliptical in beam orthogonal system, minor axis $220/\sqrt{2}$

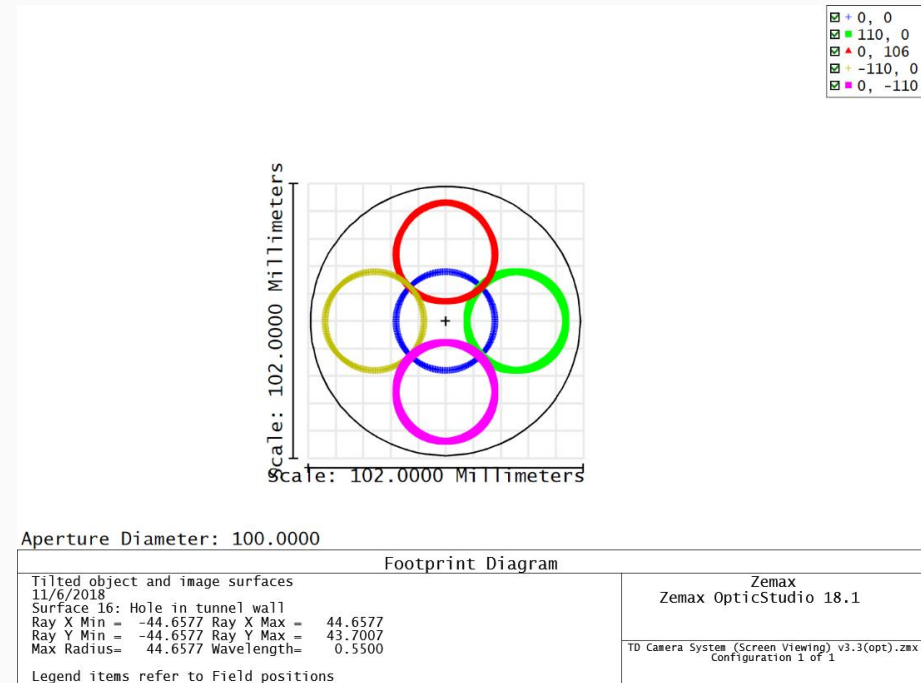
Limiting apertures

Hole in wall limits entrance pupil size.

Entrance pupil: 135mm/2



Entrance pupil: 135mm/2.8



This lets us use a 135mm lens operated at f/2.8 without vignetting. f/2 will brighten the center, but some darkening near the edges of the FoV.

Camera and lens



Canon 135mm f/2L

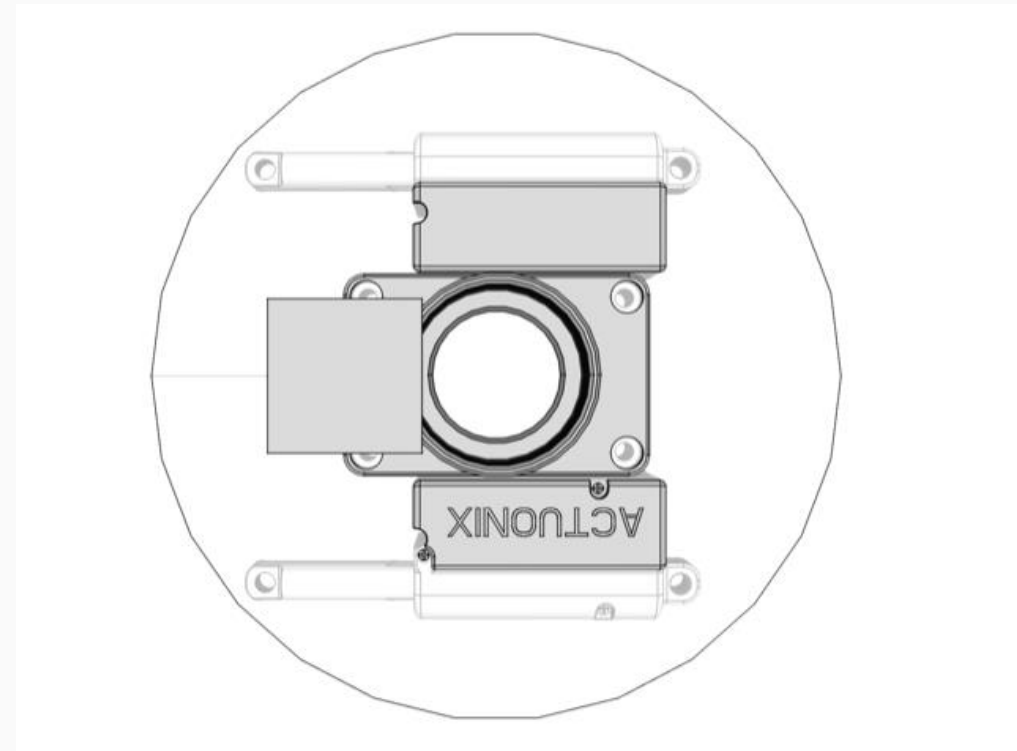
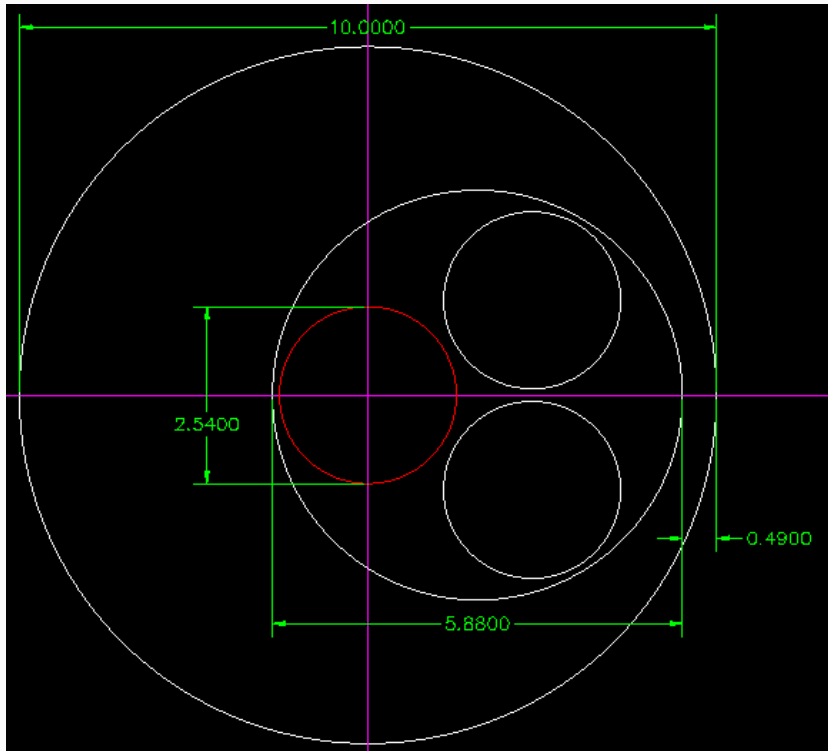
- Fast lens, large entrance pupil
- Lens has internal motors to adjust focus, aperture. Possible to remote control.
- Telephoto lens allows for large sensor, high sensitivity, high resolution.



- 1 inch sensor (11mm × 11mm), for example Manta G-419B
- GigE camera, power over ethernet
- Camera, lens, controllers will be mounted in a tube, aligned in a lab, inserted and fixed in the wall

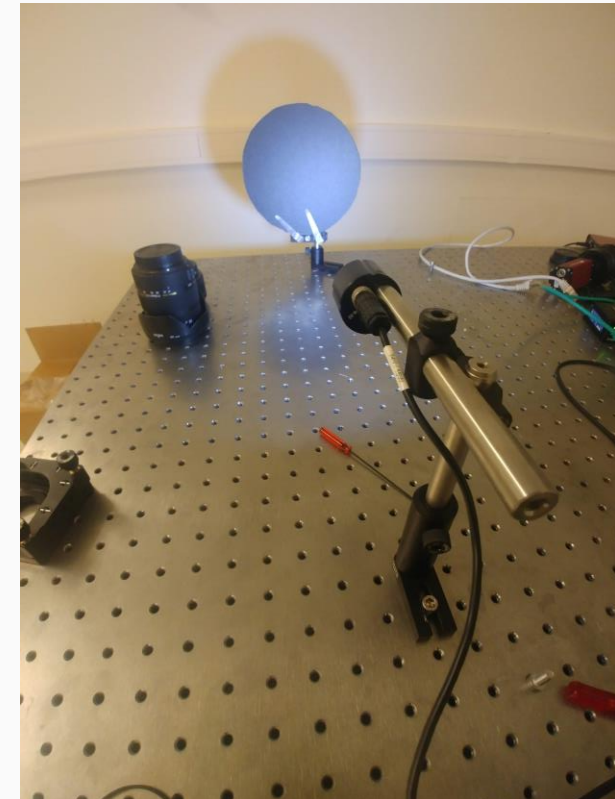
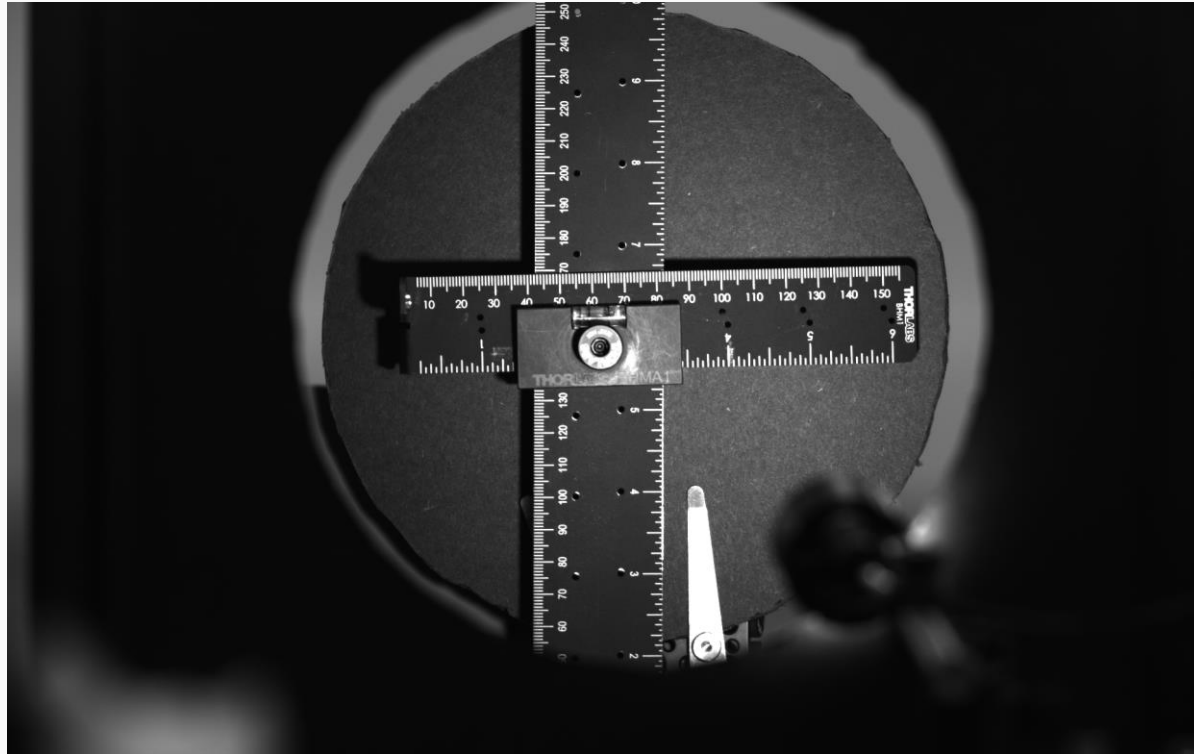
Filtering

- Large dynamic range: must be able to see first test pulses, as well as a full ESS pulse.
- Camera will saturate even at f/32, ND filters needed
- Options are small filters inside the hole in the wall, or large filters outside.



Illumination

- We need illumination for debugging
- Thorlabs LED lamp (LIUCWHA) mounted between M1 and the viewport
- 24V, supplied by EtherCAT module
- Lamp will obscure part of screen



A simple optical system.

- Performance tested in simulations and prototype
- Final mirrors ordered, mirror quality tested in prototype
- Work remaining on control of filters and lens, mechanical support of mirrors and camera.

ESS Tuning Dump Imaging Systems CDR Review for Vacuum Vessel

Specification: Motion Control System

Dr Mark Ibison
University of Liverpool

Attached to the University of Oslo team

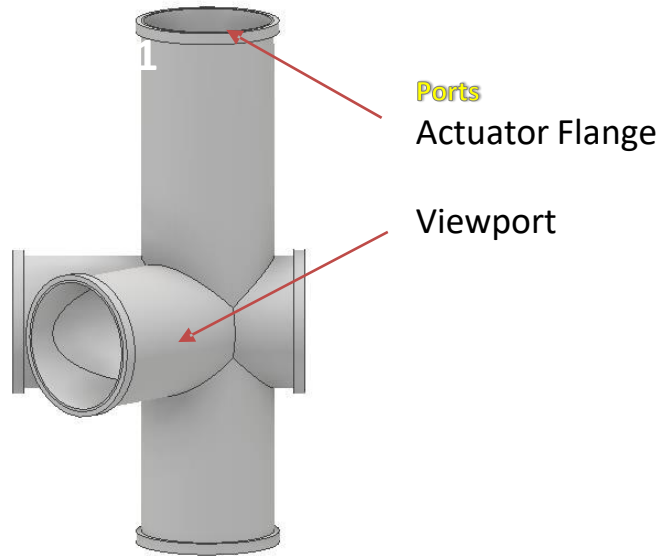
Outline of Presentation

- Requirements for Motion Control
- Selection of Actuator
- Actuator Details
- Motor Selection Criteria
- Motor Drive Details
- Limit Switch Functions
- Limit Switch Selection
- Conclusions

Requirements – Motion Control

- UHV Compatible
- Large Multiple Screens -> Long Travel
- Radiation Environment
- Access & Maintainability
- Machine Protection Interface
- ESS Standards (MCAG)

Selection of Actuator



Criteria

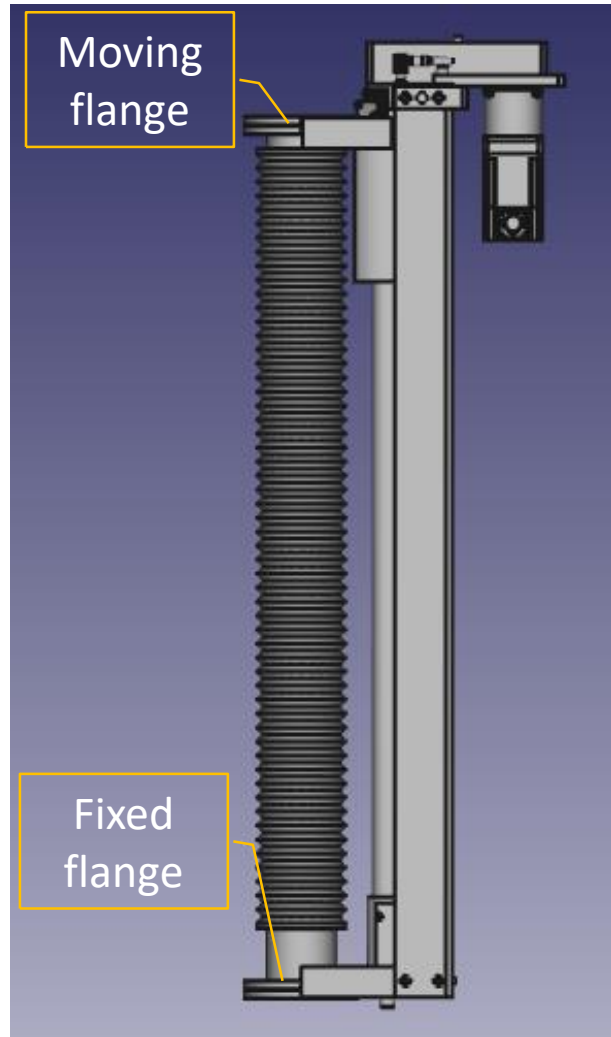
- Led by STFC Project experience
- Supplier options limited due to length of travel required
e.g. ***UHV Design, Vacgen (UK)***

Final Specification:

- Single actuator, vertical motion only
- Long Travel Linear Shift Mechanism
- Mechanical, driven by lead-screw
- Edge-welded bellows (replaceable)
- CF vacuum flange seals



Actuator Details



UHV Design *HLSML64-20895-002*

Long travel Linear Shift Mechanism mounted on CF63 (4 1/2" OD CF) flanges.

Fixed flange with metric clearance bolt-holes and travelling flange with metric tapped bolt holes.

600mm stroke. 65mm clear bore.

Demountable bellows assembly.

Lifetime of Bellows (expected)

10,000 operations

Maintenance (routine)

Greasing of screw

Total Mass (excl. motor)

26 kg

Motor Mass

1 kg

Motors - Selection Criteria

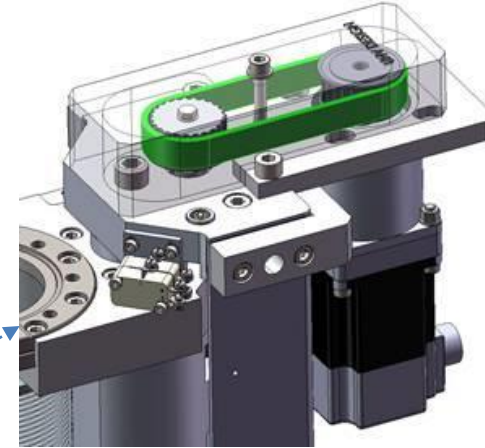
Feature	Property	Advantage
Motor type	Standard ESS 'harsh environments' stepper motor	includes high-radiation
	Torque > 2 Nm at lead-screw	
Gearbox ratios	for screen-change time ≤ 2 min	600 mm travel
	linear speed 5 mm/sec	extends lifetimes, avoids risk of lead-screws' lubrication breakdown
Transmission	Flexibility in motor mounting	Option to reduce overall length, if necessary



Type: **Phytron VSS 57.200.2.5**
Flange: *NEMA 23*

Motor Drive Details

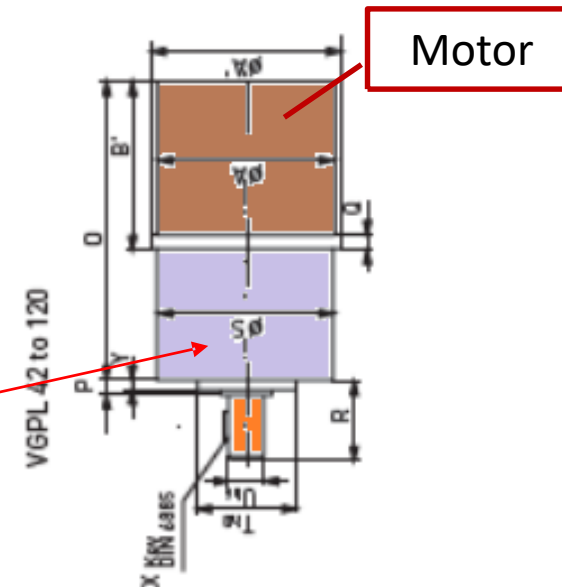
- Gearbox
 - Preference for ‘direct’ drive, **BUT ...**
 - Motor holding torque only 0.84 Nm
 - Other motor options require significant mounting modifications
 - *Retain gearbox*



- Transmission
 - Belt drive offered as standard, **BUT ...**
 - Implications for radiation hardness
 - *Alternative ‘in-line’ option accepted*
 - Height increase manageable ~ 70mm

Gearbox Type: Phytron VGPL52

Ratio: 16:1



Limit Switches - Requirements

- Feed back screen position for Motor Control
 - Indicate screen disposition to operator
- Protect screens and actuator from possible over-travel damage
- Must be highly reliable
- Precision to $\pm 1\text{mm}$ adequate, as screen alignment is not critical

Limit Switches - Functions

Mechanically-operated limit switches on actuator frames
— linked to motion control module (encoders not used)

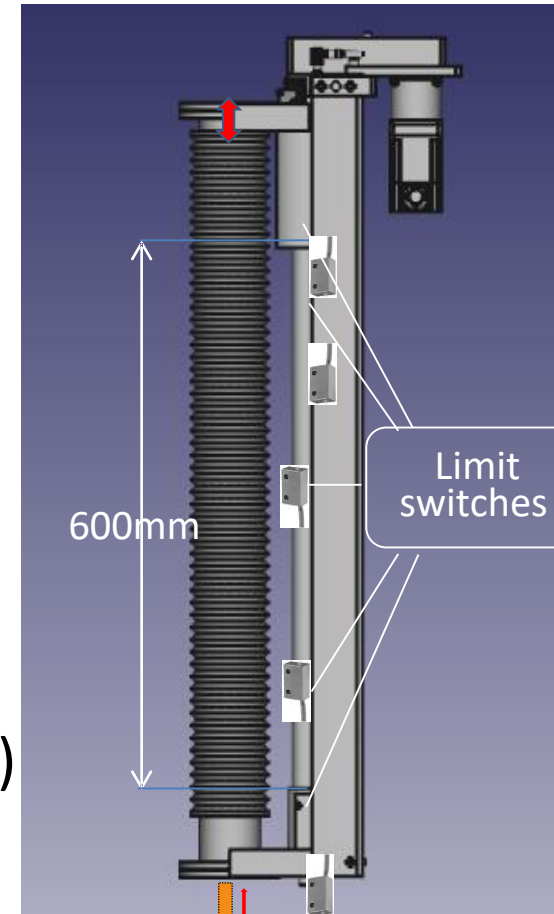
Position Indication

1. Upper End-of-travel (Top Limit)
2. Screens Out Position
3. Screen 2 Position (mid-way)
4. Screen 1 Position
5. Lower End-of-Travel (Bottom Limit)

Other Requirements

Optical sensing not approved

Radiation resistance mandated (ESS Standard)

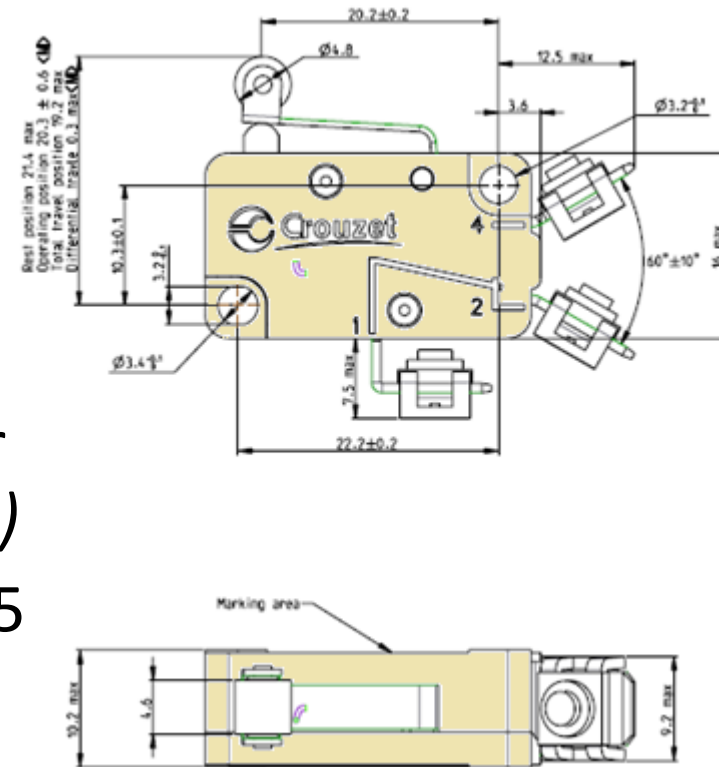


Limit Switch Selection

Switch Type

Le Crouzet **SF133210_B 83160154**

- Special, limited availability
- Contacts gold plated; body plastic
- Qualified for 'nuclear' use
- Dimensionally as Cat. No. 83160
- Compatible with actuator supplier suggested type *V3FN (unavailable)*
- Roller actuated; same type for all 5 positions



Conclusion

Next Steps

- Finalise Specification Document
 - Vessel, Actuators + Motors, Switches
- Discussions with Vessel Manufacturers
- Procurement action by STFC
 - Quotes (x 3) requested from suppliers
- Place orders for vessel, actuators and motors
 - Order limit switches for fitting by actuator supplier

Standards

Vacuum

ESS Vacuum Handbook Parts 1 and 2

- Materials, Flanges, ...

Motion Control (MCAG)

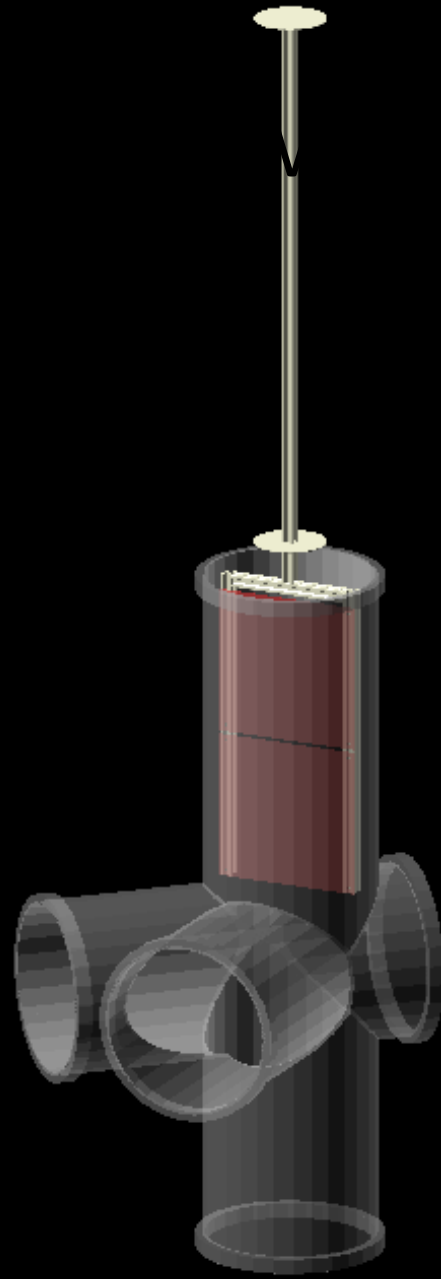
- ESS Motion Control Components Standard
- EtherCAT Motion Control System

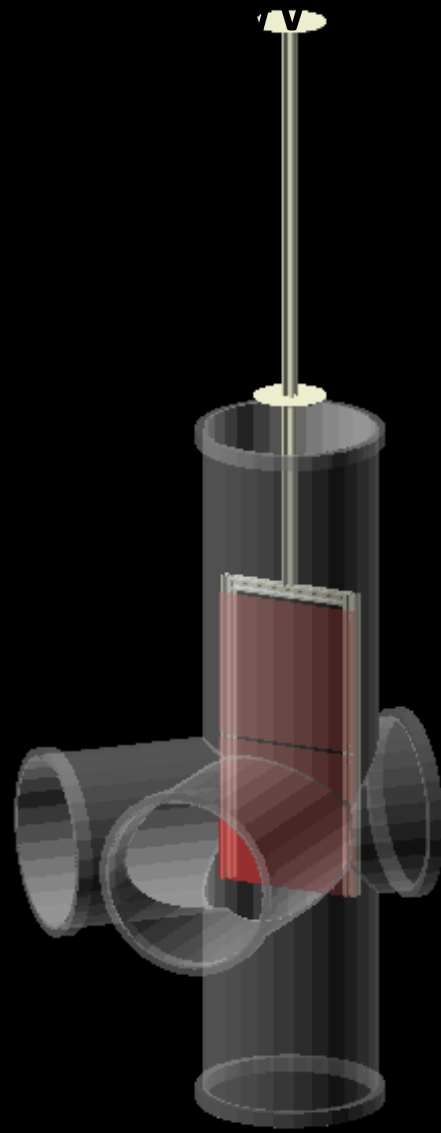
ESS Tuning Dump Imaging Systems Vessel CDR

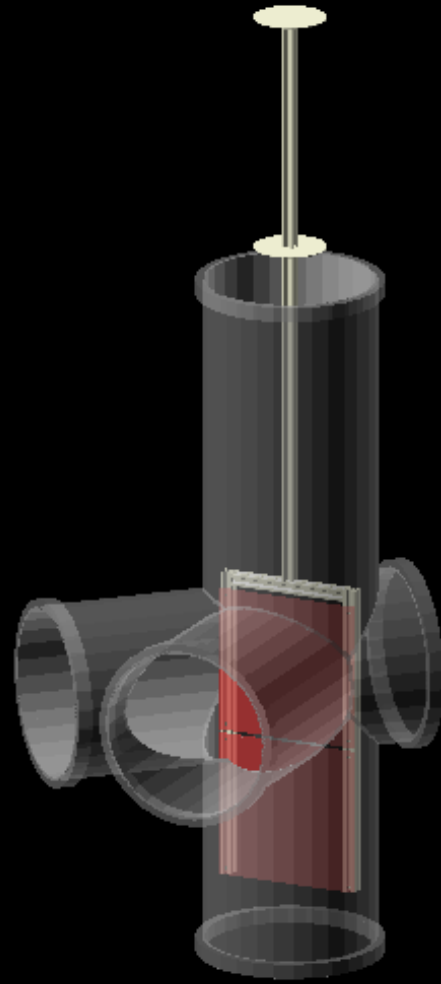
- Grey Christoforo
- Researcher, University of Oslo
- Nov 7, 2018
- at Daresbury Laboratory, UK

Outline

- 1) Imaging screen design
- 2) Screen holder design
- 3) Limit and position switch locations
- 4) Motion control electronics

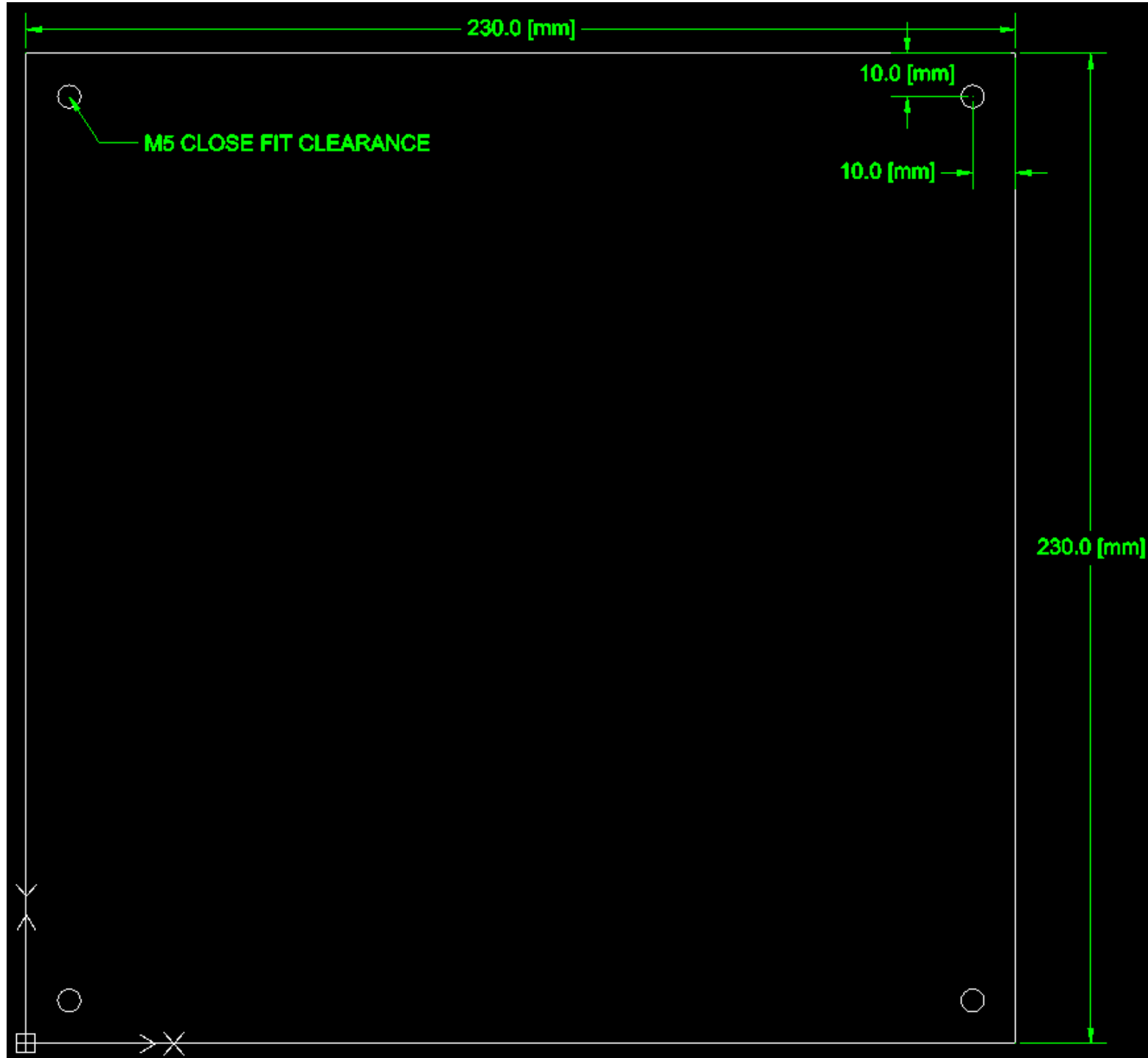






Imaging Screen Mechanical Design Rules

- Screens should be as large as possible
- Must be remountable/changeable in case they must be replaced



Screen details

- The chromux¹ screens are 230x230x1mm
- Has four holes for M5 screws to fit through in corners 1cm from edges
- Simple mounting hardware

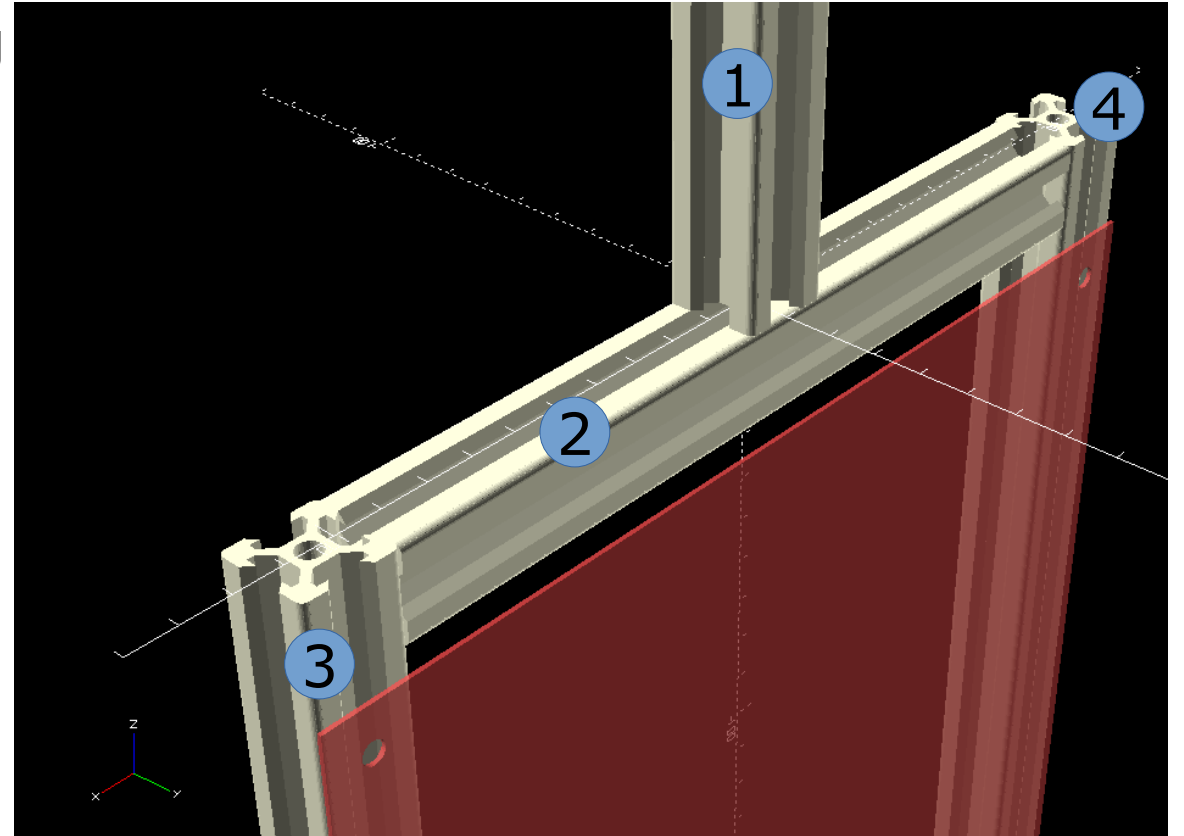


¹ see backup for chromux details

Screen Holder

Made of four pieces of Aluminum framing
.20x20mm cross-section
.Not anodized
.1405mm total height
.230mm total width
.M5 tapped hole for connection...

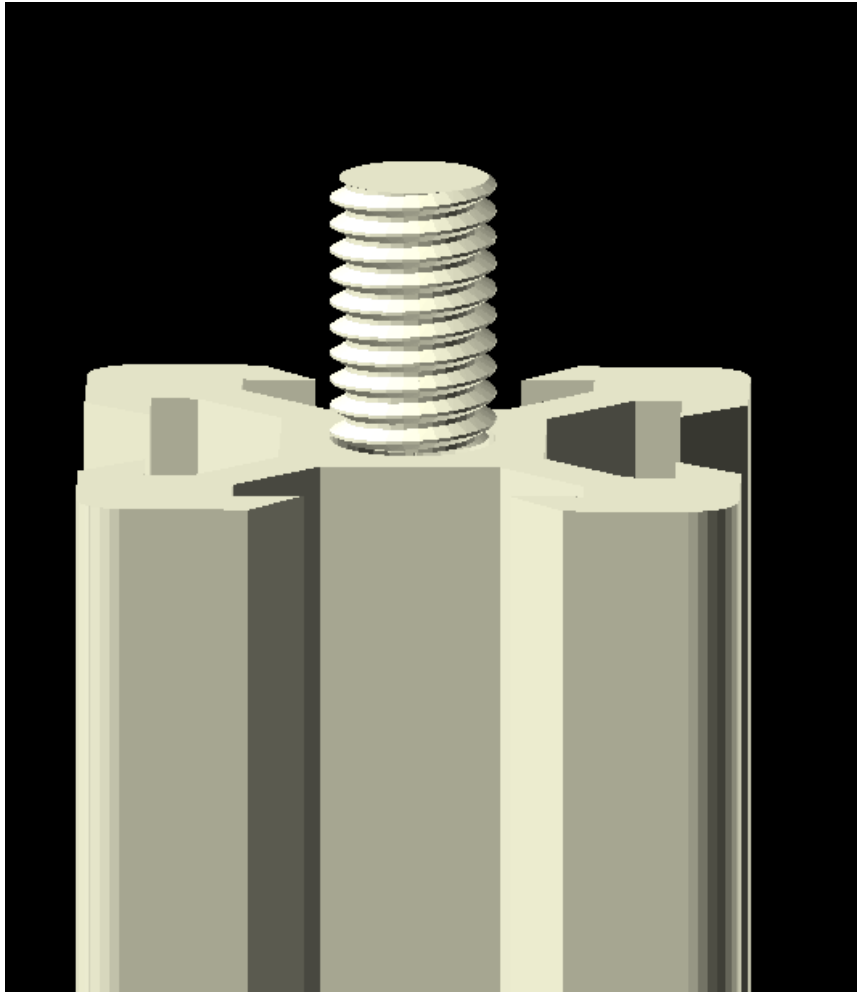
- ① Long Vertical Bar (915mm)
- ② Cross bar (190mm)
- ③ ④ Side bars (490mm)



Simple connection hardware:

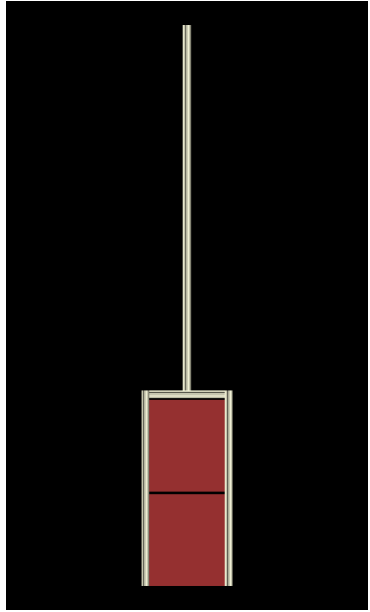


Screen Holder Connection to Moving Flange



Standard M5 0.8mm pitch
machine screw into moving flange plate

More Screen Holder Views

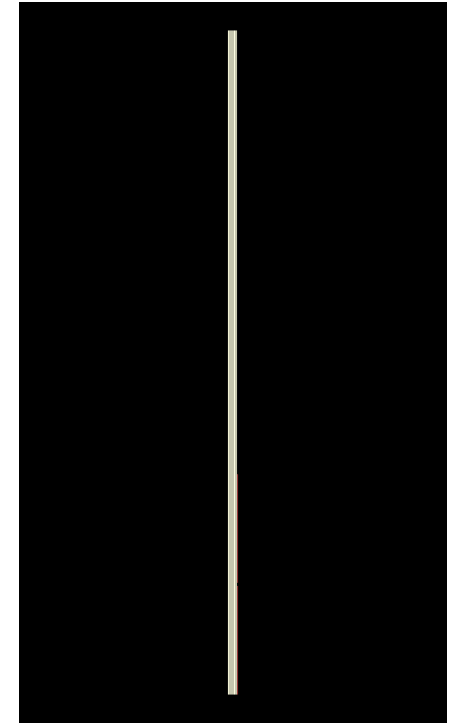
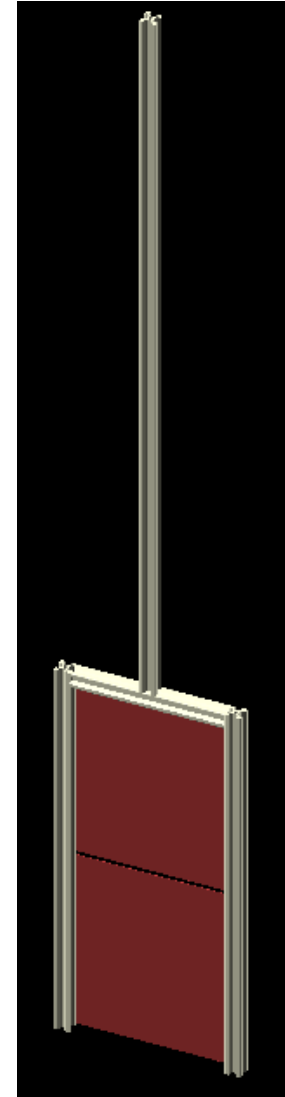


Back



Top

Back Isometric



Right Side

Screen Holder Design Rules

- Must not crash into or otherwise interfere with the chamber
- Must hold two screens centered on the beam & angled for the 45° viewport
- Must be made of vacuum compatible material
- Should have robust and easy/semi-easy screen mounting mechanism
- Must never interfere with the beam
- Must be possible to completely remove both screens from beam

Screen Positioner Location Feedback Switches

- Electromechanical switches installed by UHV Design on their actuator will tell the control system where the positioner is
- There will be five total switches

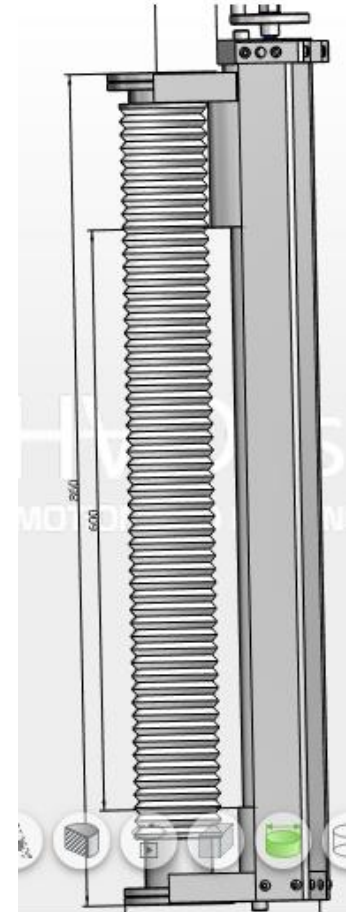
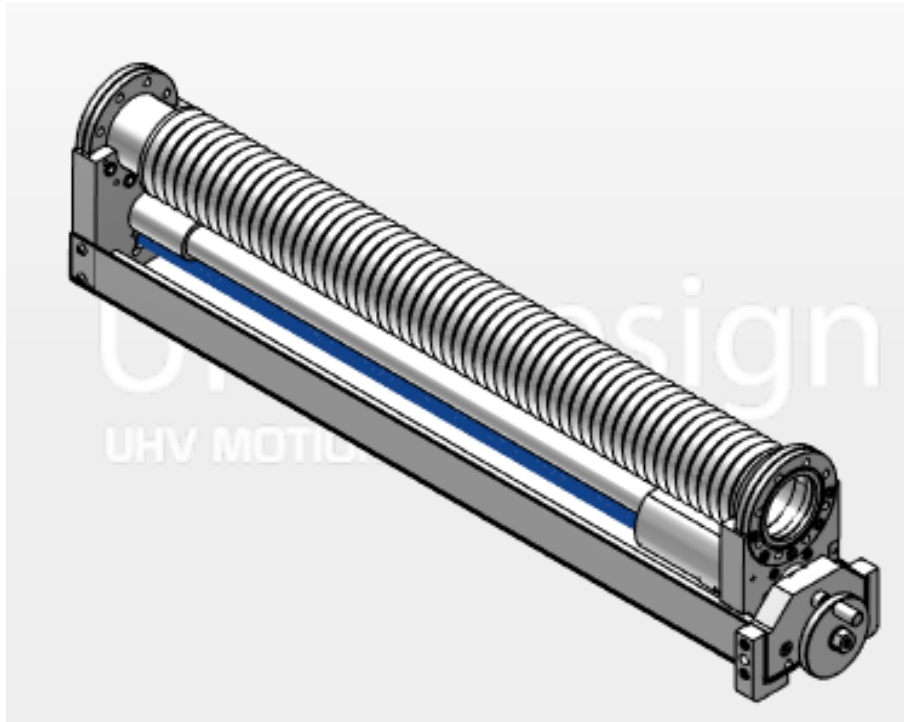
-Two limit switches (these should never be reached)

- 1) Screen extraction end of travel limit [LT]
- 2) Screen insertion end of travel limit [LB]

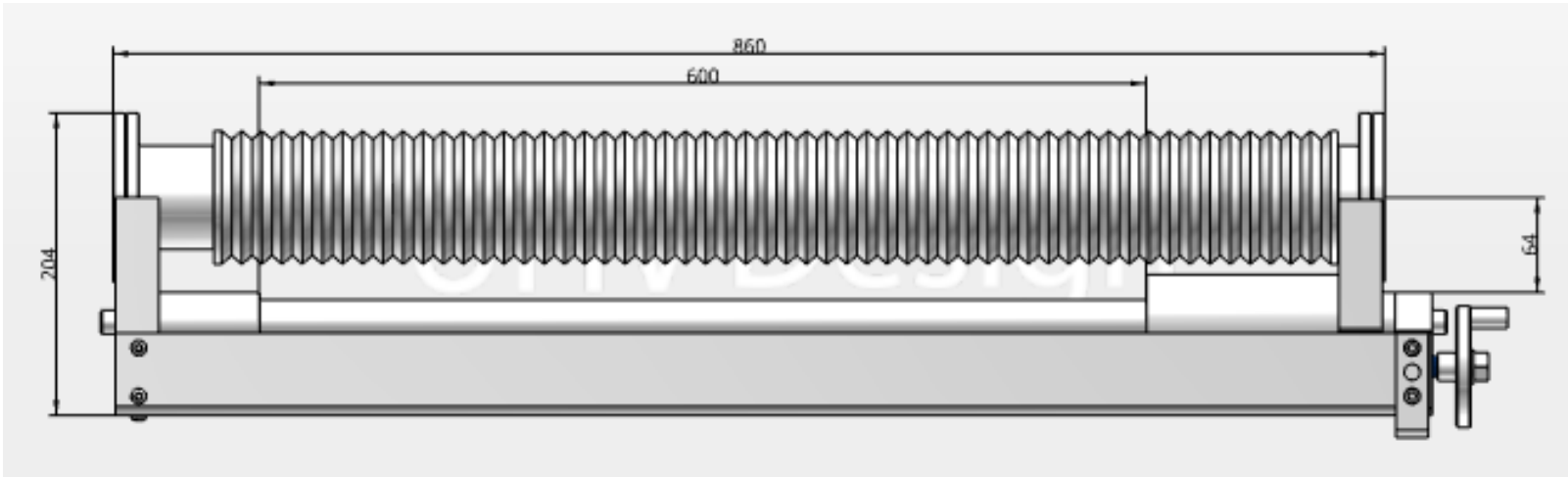
-Three position switches:

- 1) Screens fully withdrawn [SA]
- 2) Bottom screen centered on the beam [SB]
- 3) Top screen centered on the beam [SC]

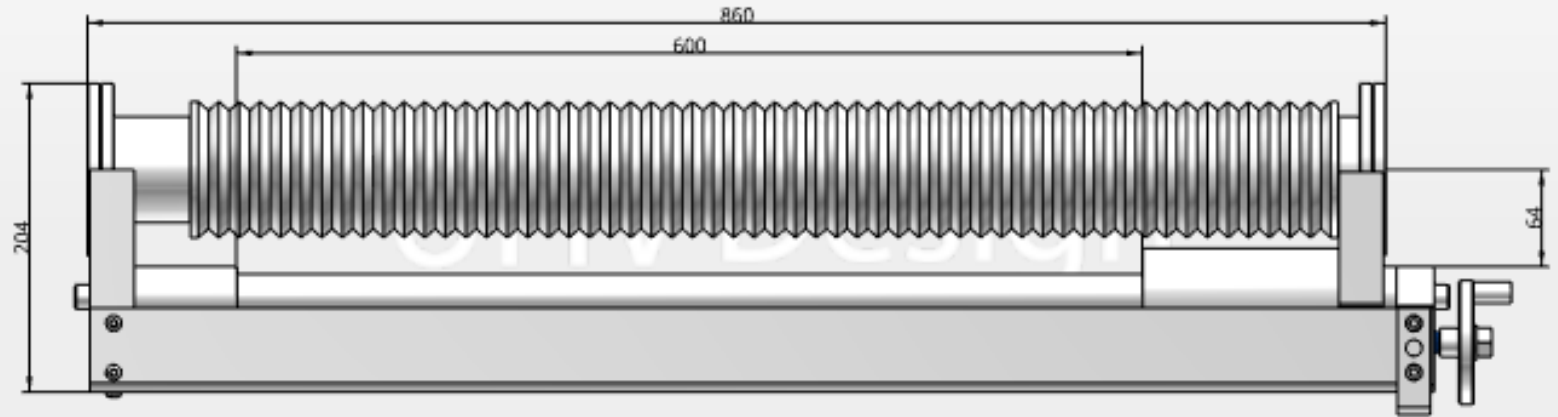
Linear Actuator



Actuator Travel Limits

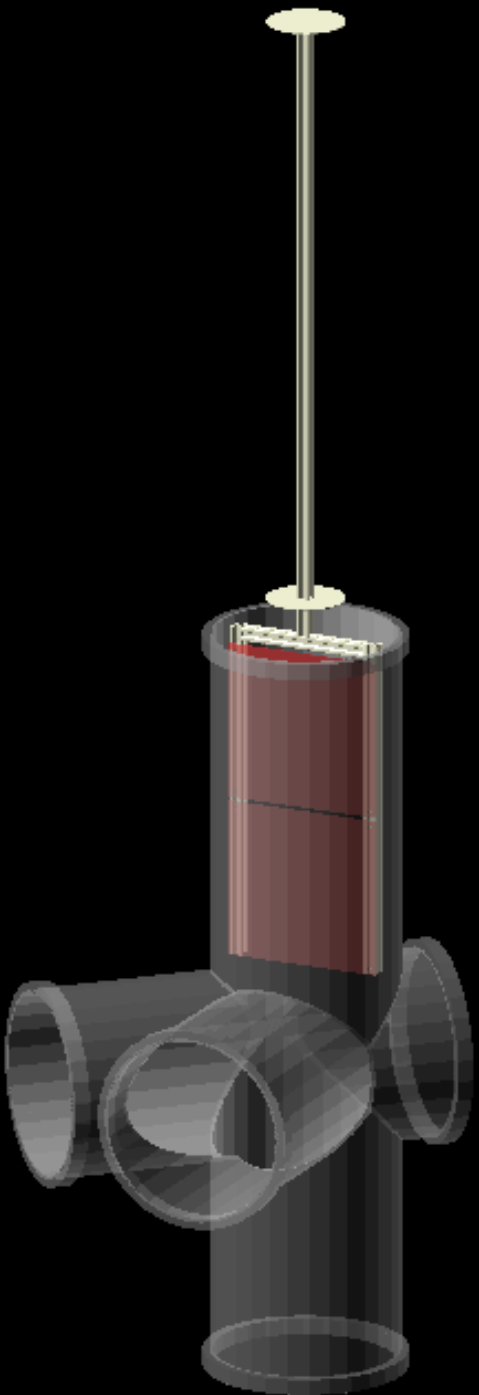


Switch

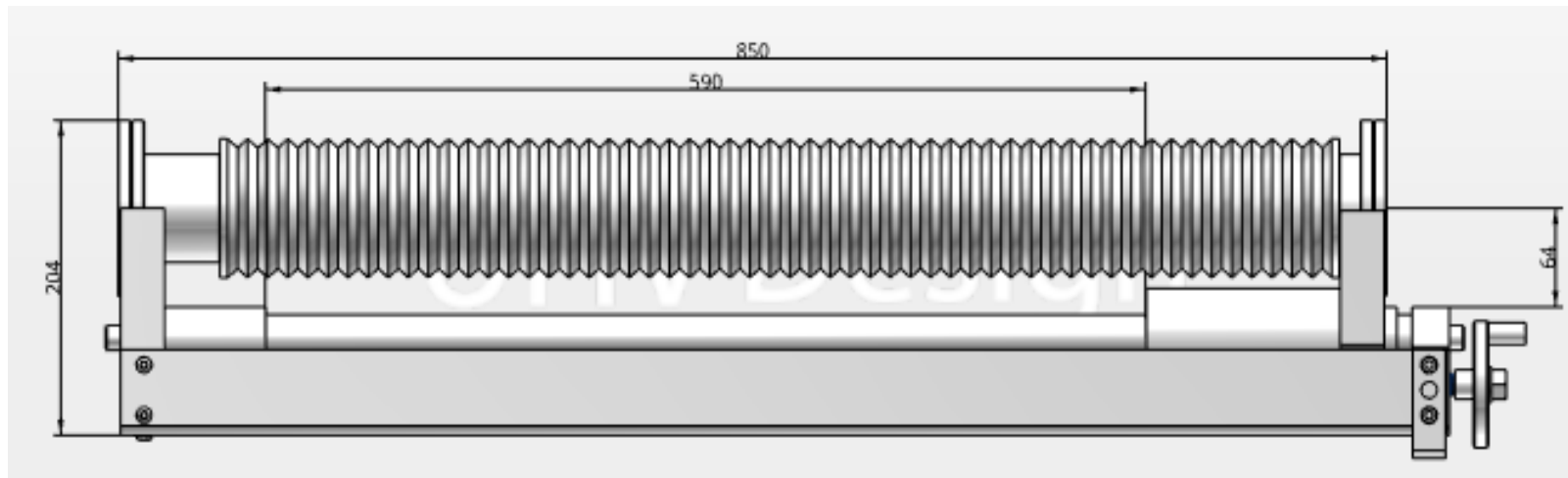
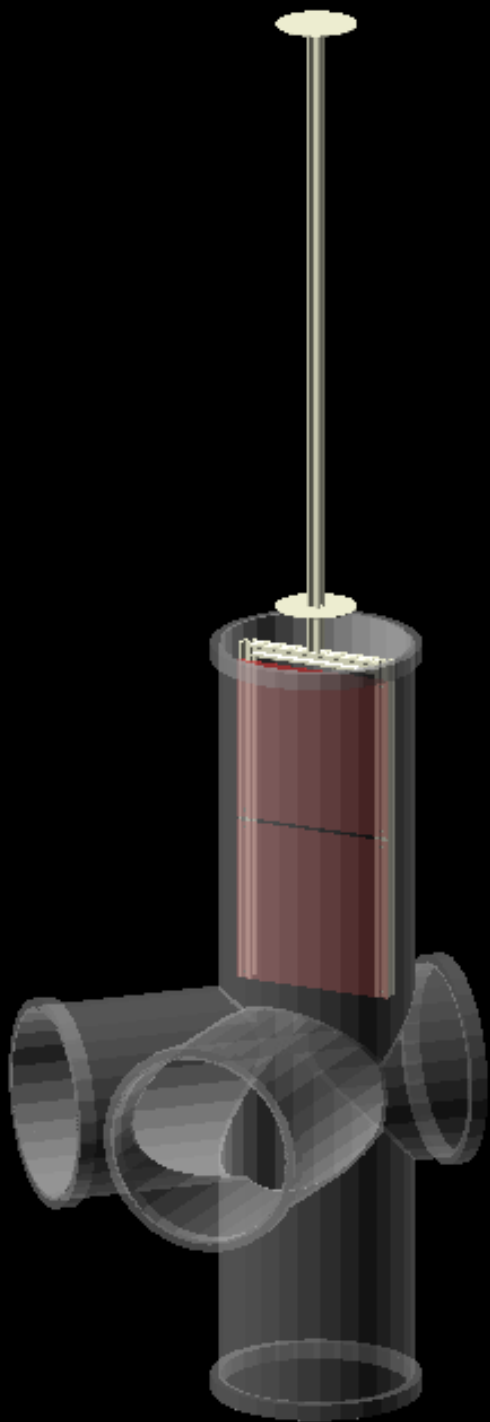


Location = 860mm

Prevents actuator from over extending
and the screen holder from crashing into the top of the chamber



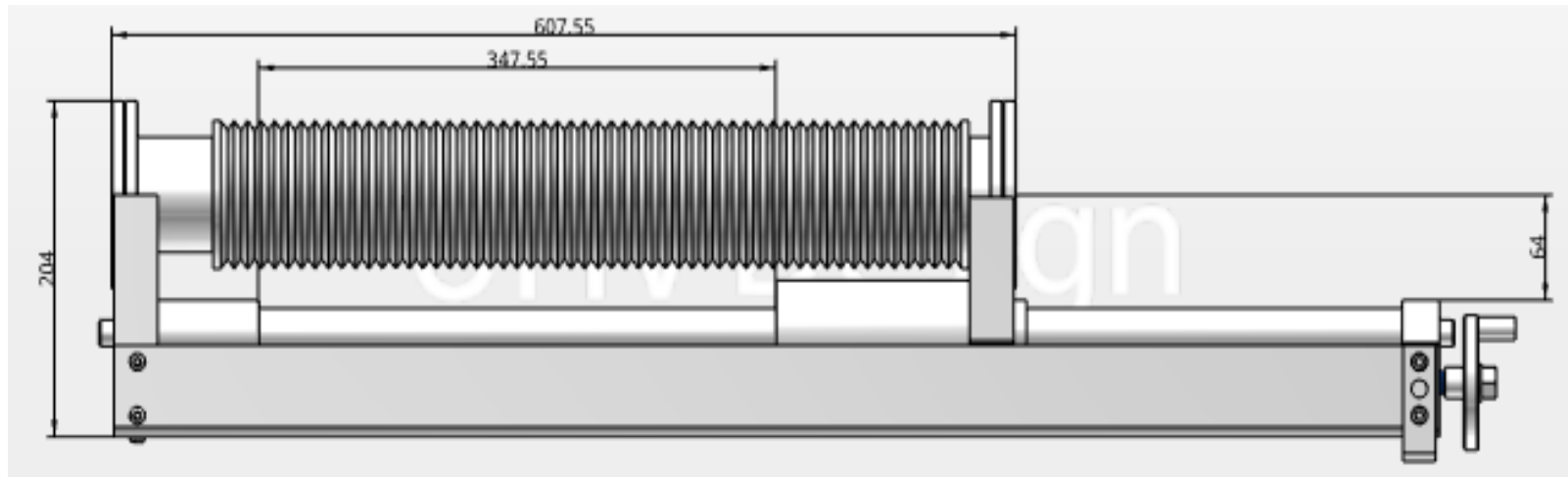
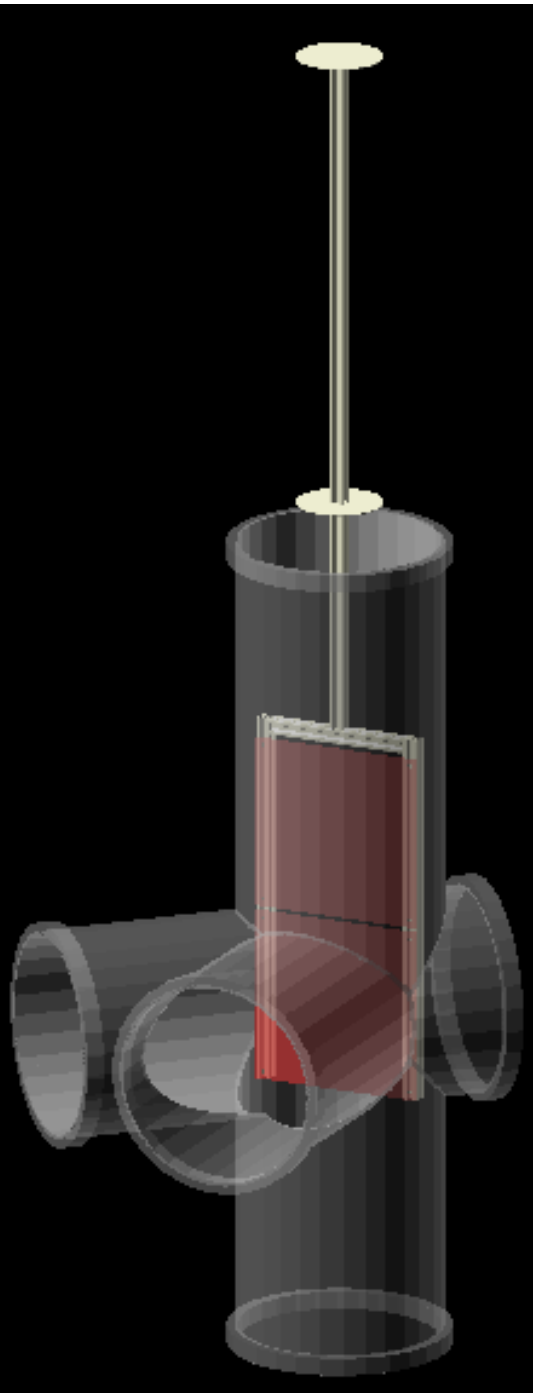
ion Switch



Location = 850mm

Both screens are removed from beam

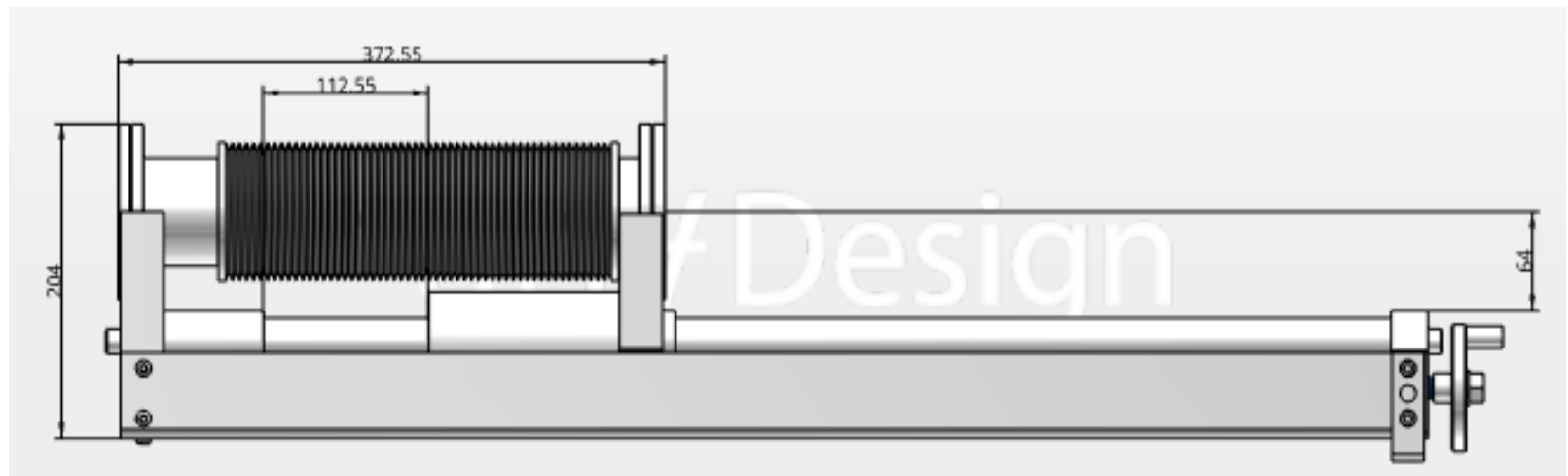
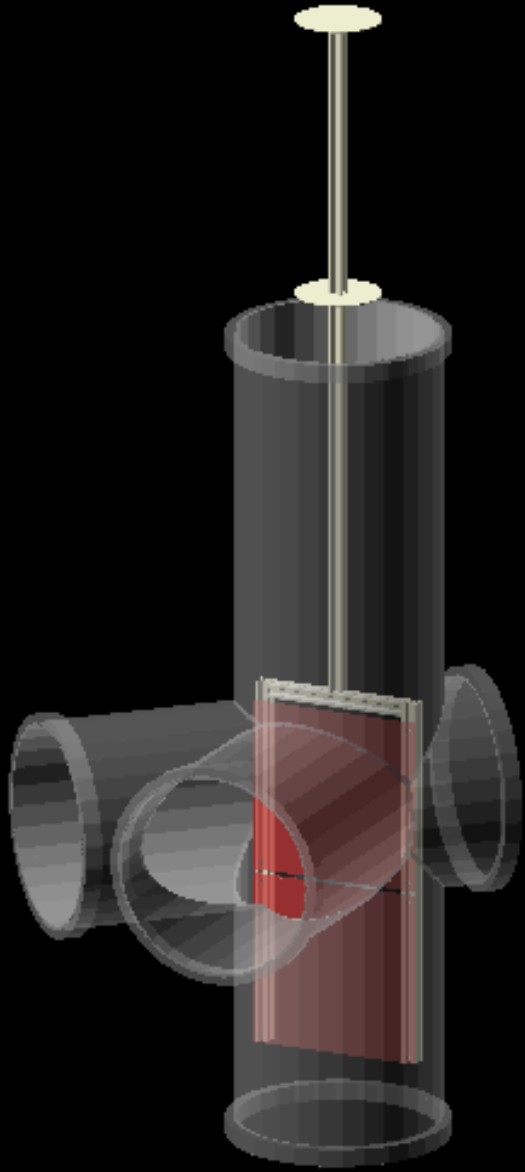
Position Switch



Location = 607.55mm

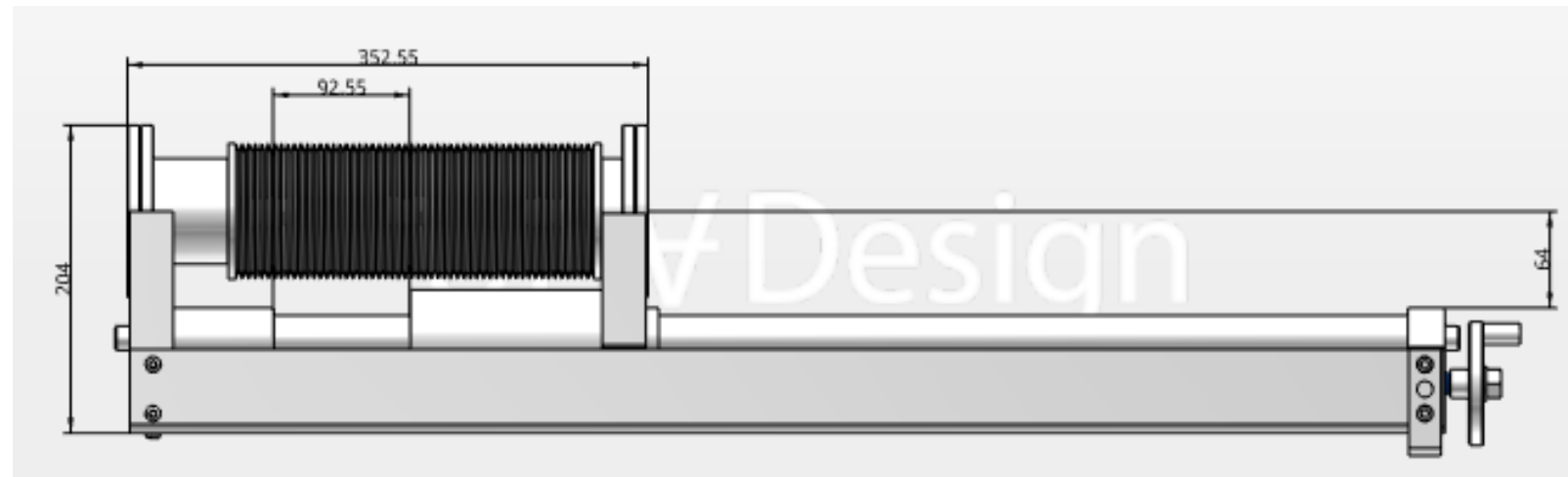
Bottom screen is centered in beam

on Switch



Location = 372.55mm
Top screen is centered in beam

Switch

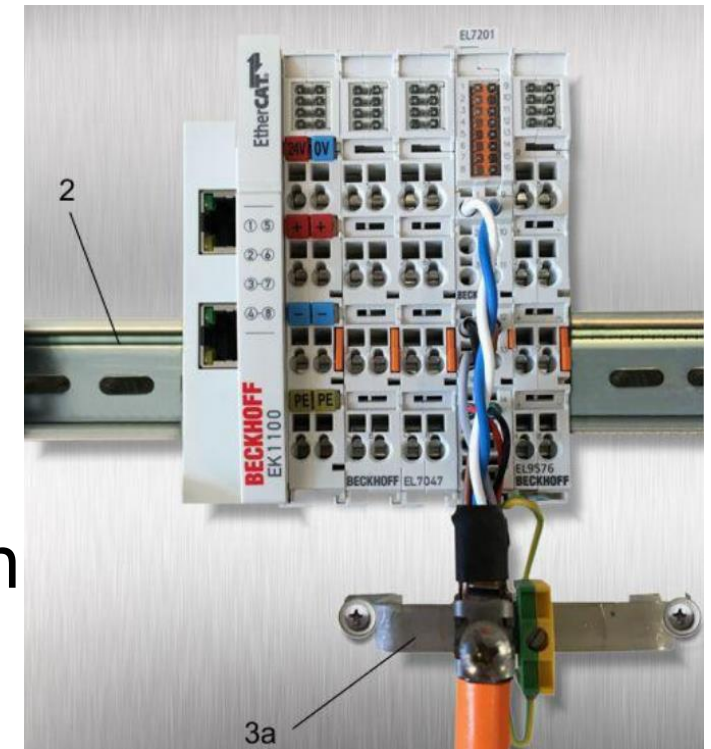


Location = 352.55mm
Prevents screen holder from being
inserted too far into the chamber

Screen Holder Animations

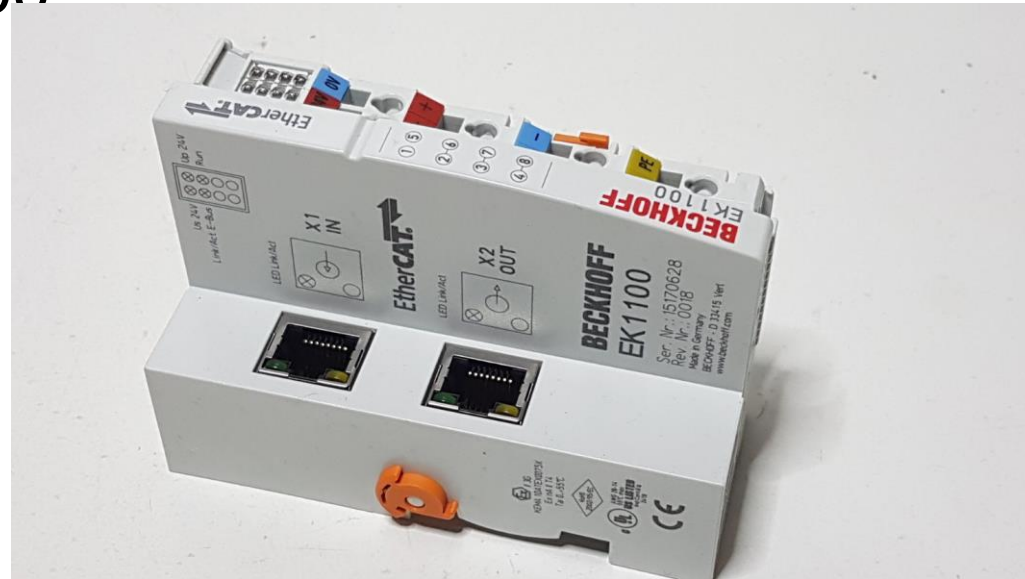
Motion Control Electronics

- Following standard EtherCAT recommendations from the ESS Motion Control and Automation Group
 - All from Beckhoff
- One EtherCAT coupler
 - One digital input terminal
 - One digital output terminal
 - One stepper motor driver terminal
- Power supplies
 - One 24V DC ~300W (for electronics, light)
 - One 50V DC ~200W (for stepper motor)



EtherCAT coupler

- Beckhoff EK1100



- Allows for computer ↔ EtherCAT communication

Digital Input Terminal

- Beckhoff EL1809



16-channel digital in

- Reads limit and position switches

Digital Output Terminal

- Beckhoff EL2819



16-channel digital output

- Powers sample illumination lights and actuator switches

Stepper Motor Driver Terminal

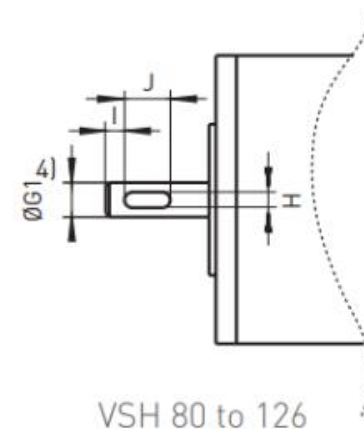
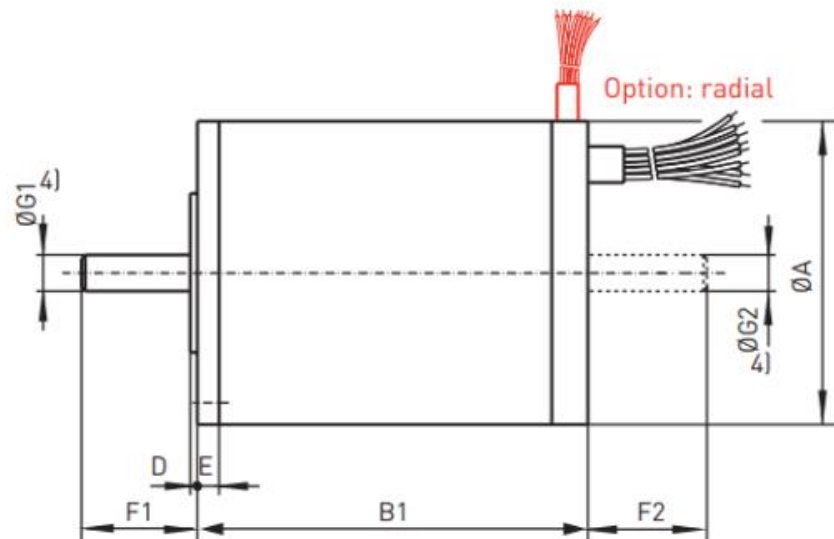
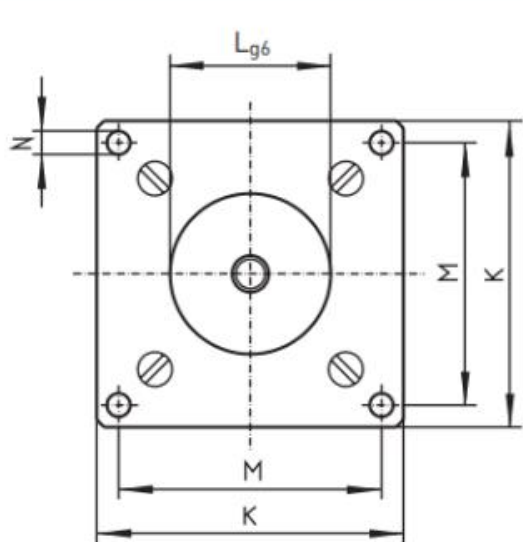
- Beckhoff EL7041-0052



Stepper motor terminal
encoder, 2 x 50 V DC, 5

- Drives the stepper motor through the screen holder

Stepper Motor VSS 19 to VSS 57, VSH 80 to VSH 126



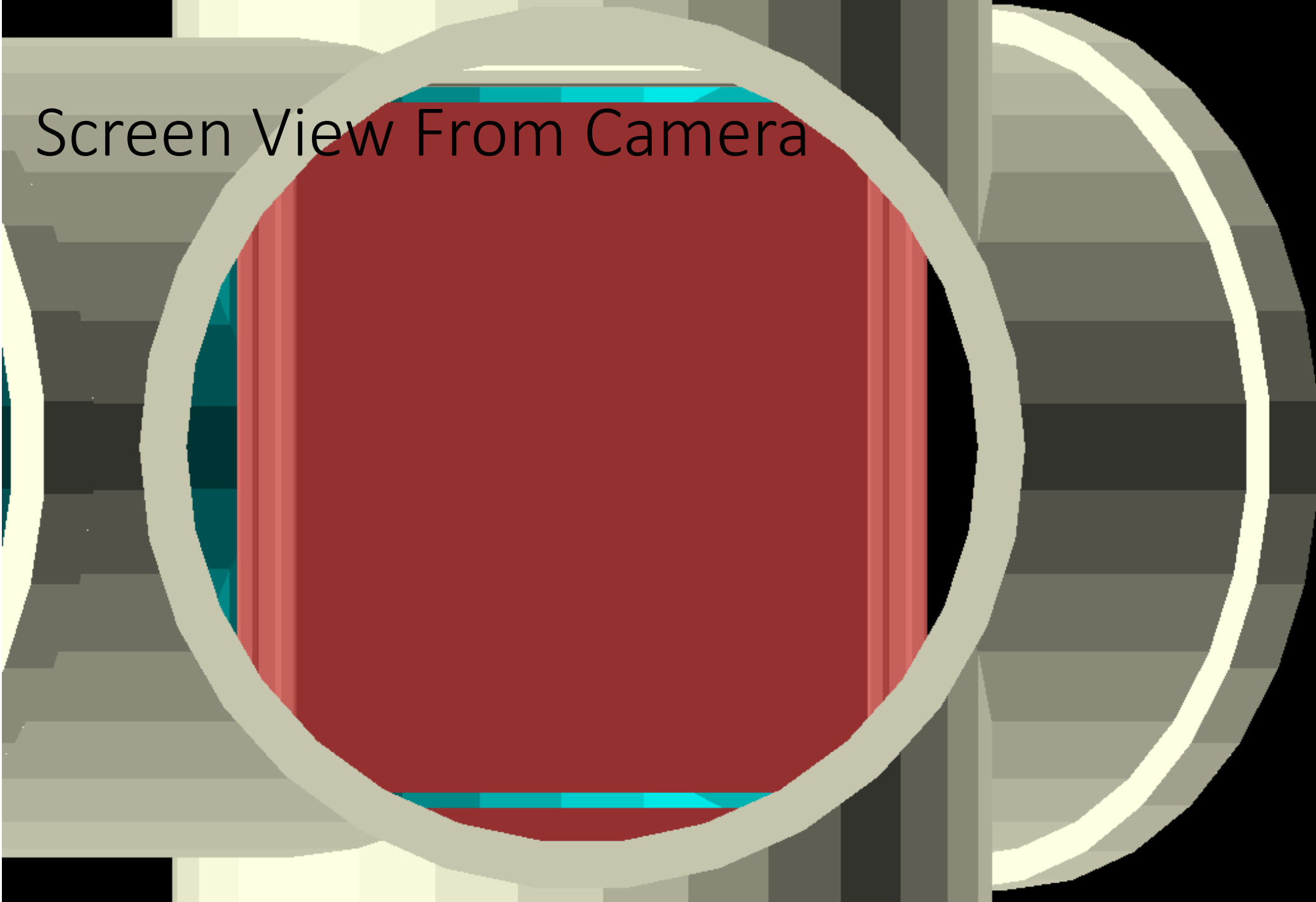
Key

	H	I	J
VSH 80	3	2.5	20
VSH 100	4	3	22
VSH 126	5	3.5	22

Dimensions / Electrical and Mechanical Characteristics

VSS/VSH Standard 200-steps 4 lead parallel ³⁾	Electrical Characteristics					Mechanical Characteristics						Dimensions in mm											
	Current/ Phase I _N	Resistance/ Phase	Inductivity/ Phase	max. operating voltage	AWG	Holding torque ²⁾	Detent torque	Rotor inertia	Loads		Mass	A	B1	D	E	F1	F2	G1 ⁴⁾	G2 ⁴⁾	K	L	M	N
									axial	radial													
57.200.1.2 57.200.2.5 ¹⁾	1.2 2.5	3.9 0.8	11.6 2.9	70	24 22	840	50	0.24	40	80	0.99	56.4	74.1	1.5	4.5	22	20.5	6.35	6.35	60	38.0 ⁴⁾	47.1	5.2

Screen View From Camera



Screen View From Beam

- Backup

Chromux screens

Several decades of research on ceramic phosphors at CERN [3] and at