Science and Technology Facilities Council

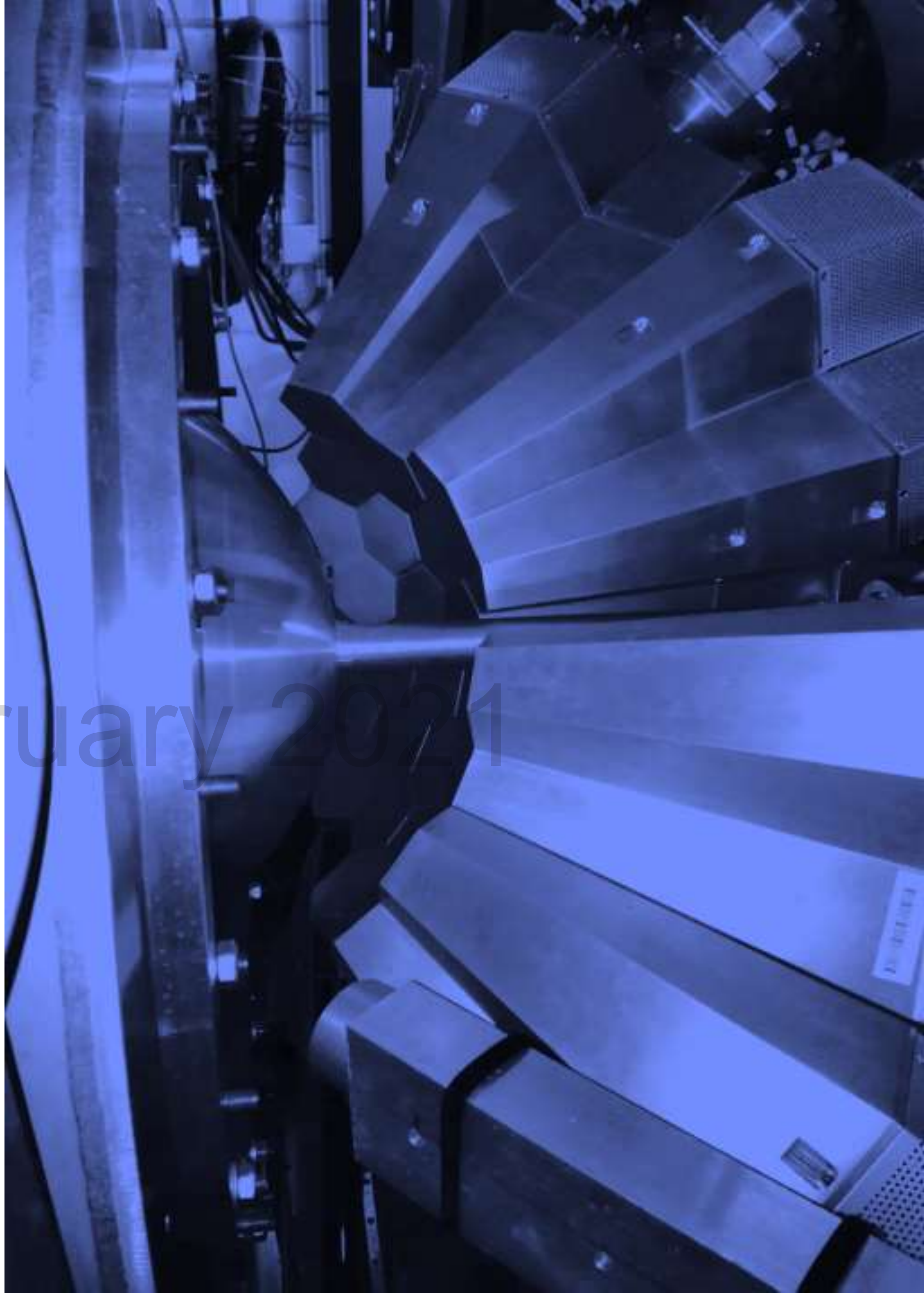
AGATA Week Mechanics

February 2021

Richard Smith
STFC Daresbury Laboratory

Introduction

- Who am I?
- What am I doing here?
- Why am I here?



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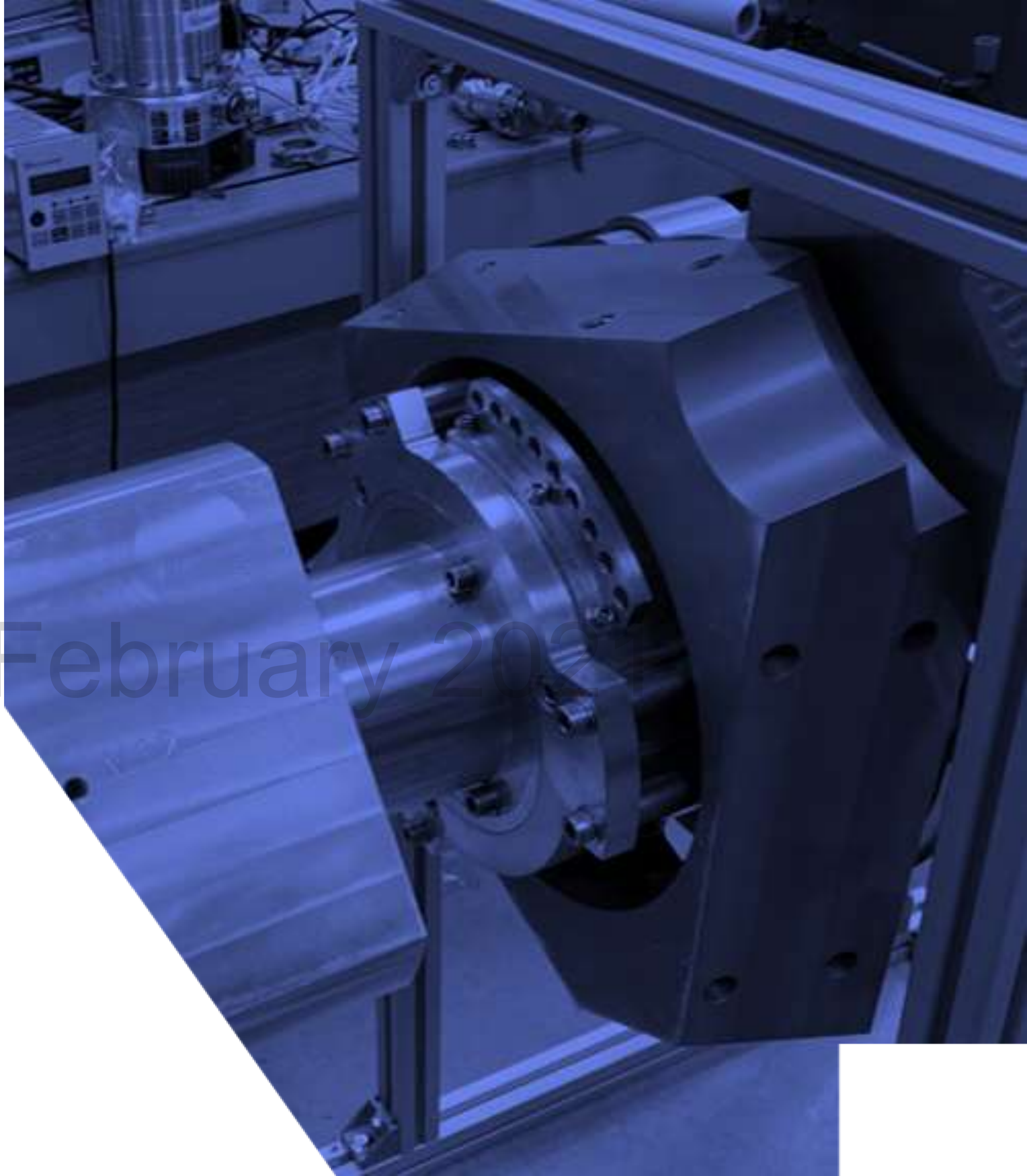
Ian
Alan
Bid farewell to Ian Burrows & Alan Grant,
we thank them both for their hard work & we wish them
a very happy retirement ☺

Ian and Alan’s farewell gift

Mechanics Update

AGATA Week February 202



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Mechanics update - Topics

- Support structure design for 2π array
- Conceptual design for 4π array
- Finite Element Analysis of the support structure & 2π array
- Support structure manufacture and assembly progress
- Associated mechanics:
  - ATC mounting rings (10 sets)
  - ATC Patch box mounting revision
  - ATC mounting leadscrew extension
  - Review lifting procedure for the ATC
  - ATC handling fixture
- Looking forward – What is next?

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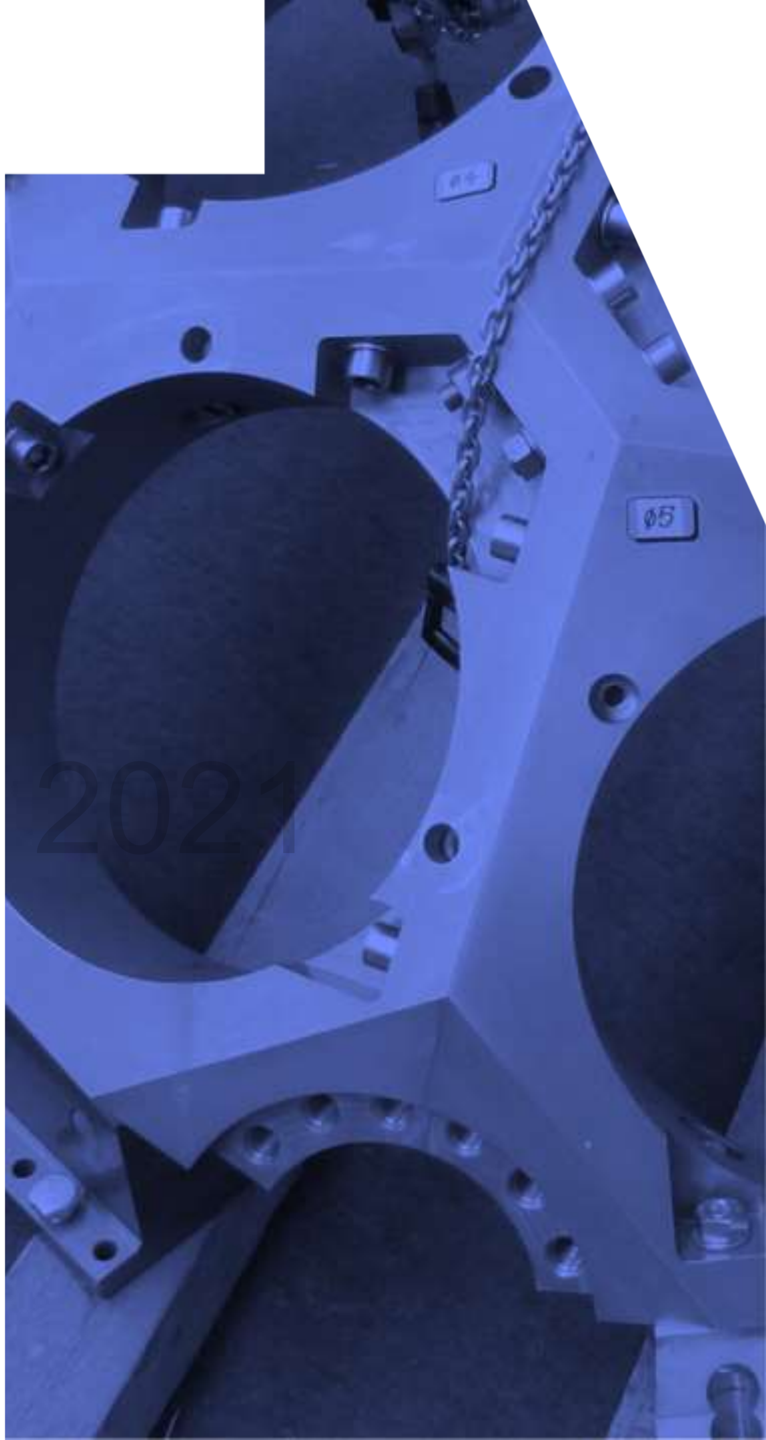
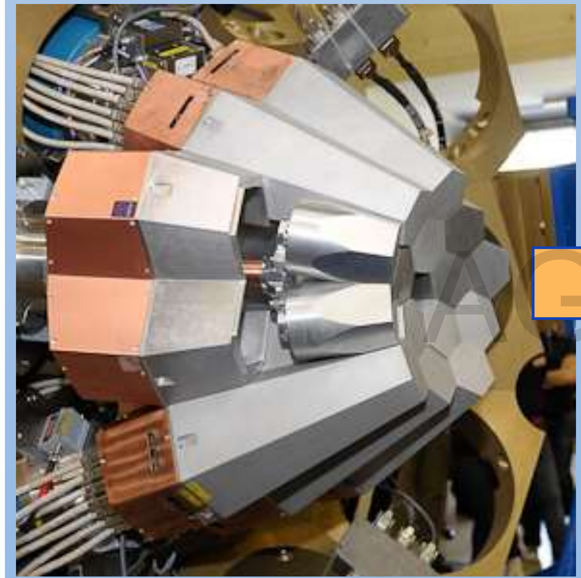


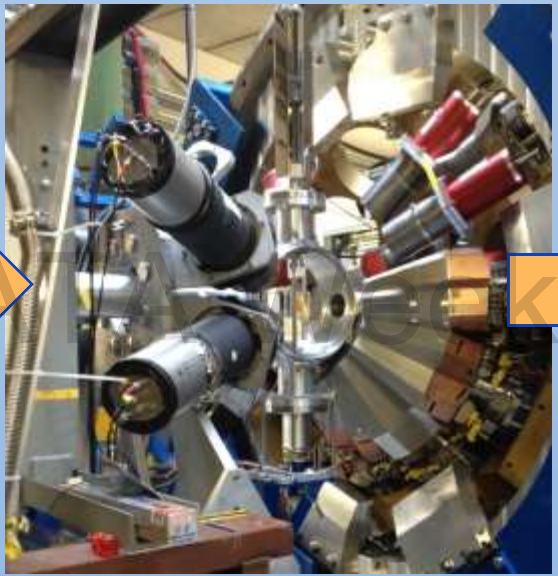
Support structure evolution

2010-2012
Legnaro, Italy
15 detectors



AGATA at LNL

2012-2014
GSI, Germany
25 detectors

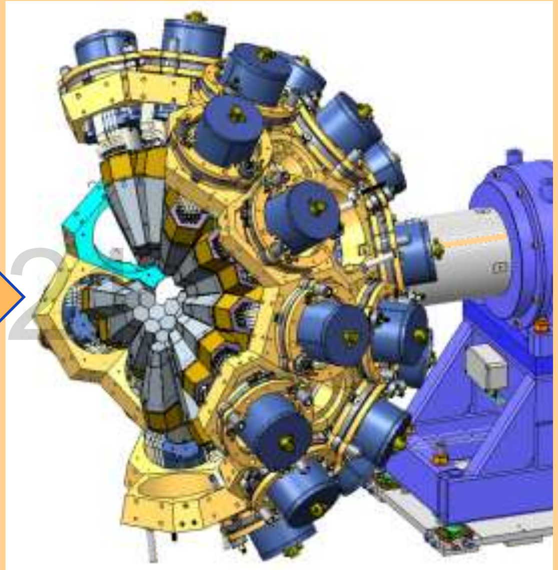


AGATA at GSI

2014-2021
GANIL, France
45 detectors

AGATA at GANIL

2021-2024
Legnaro, Italy
87 detectors



AGATA at LNL

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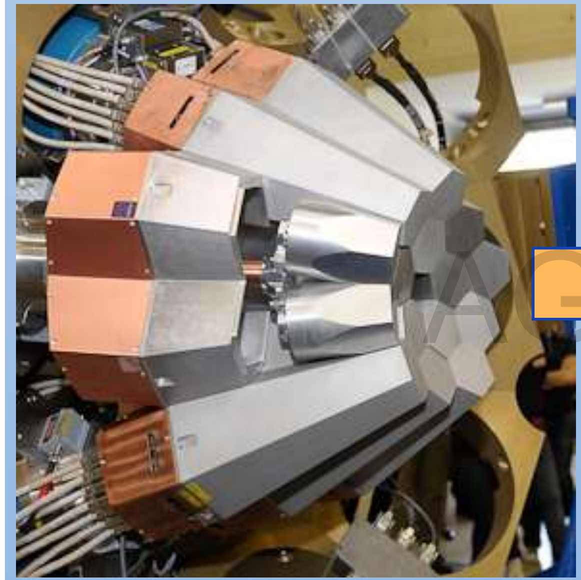

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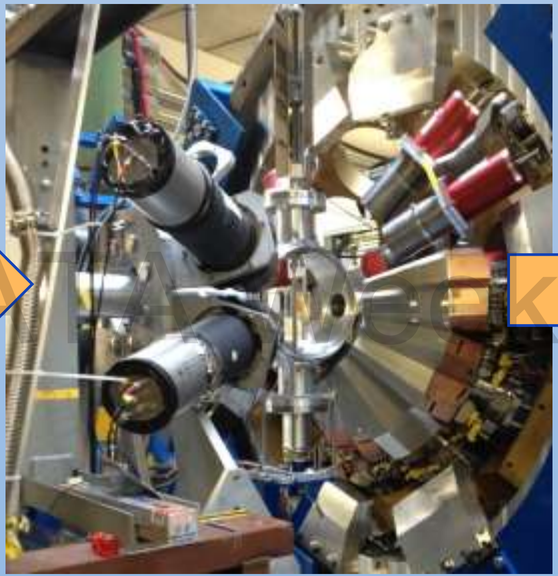

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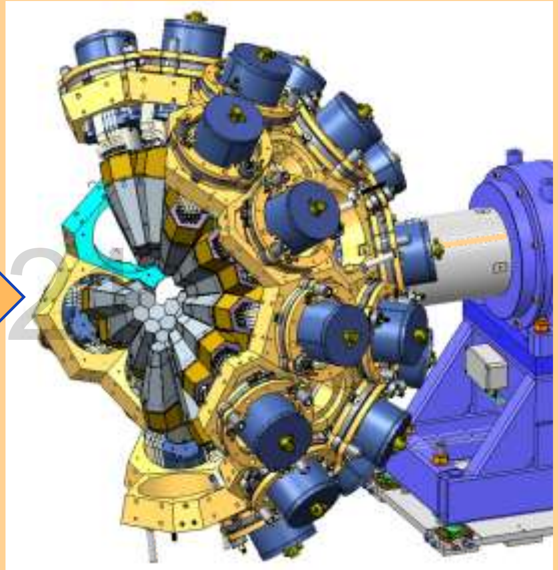

AGATA at LNL

Future facilities
180 detectors

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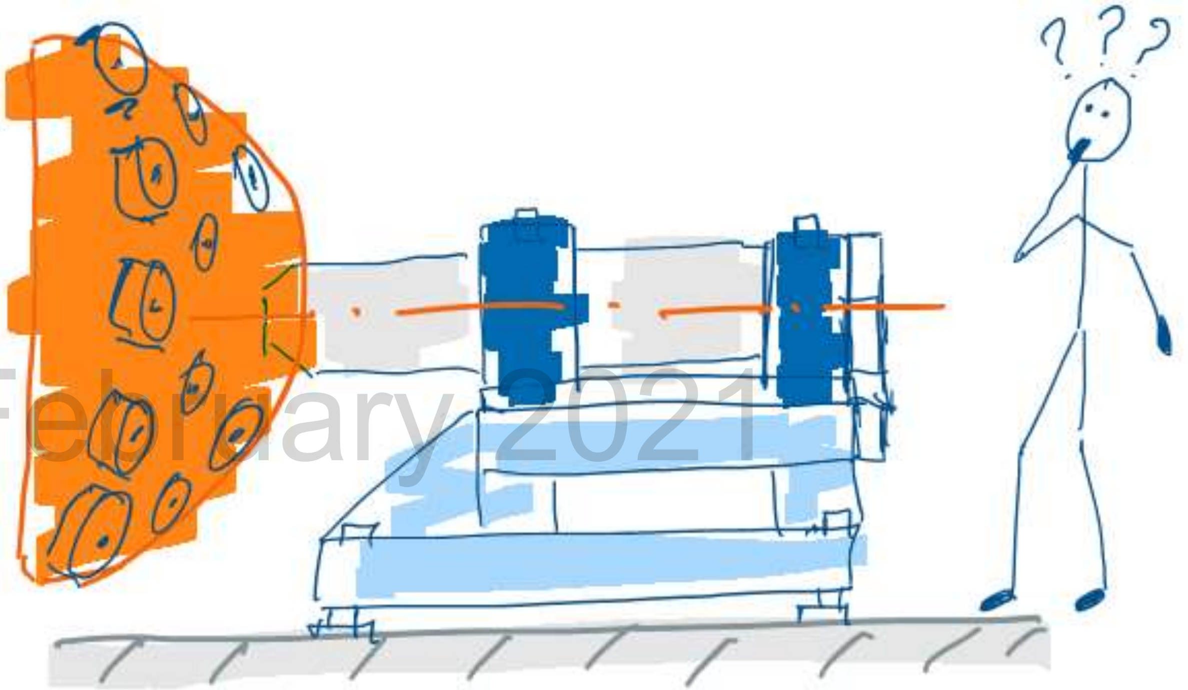
Support structure design

- Support 2π configuration (90 detectors)
- Design adaptable for future 4π array
- Assist mounting & unmounting the ATCs
- Stiff structure with high level of repeatability
- Adjustable frame to allow alignment
- Support LN_2 manifold ~250kg
- Interface with area at LNL & future sites



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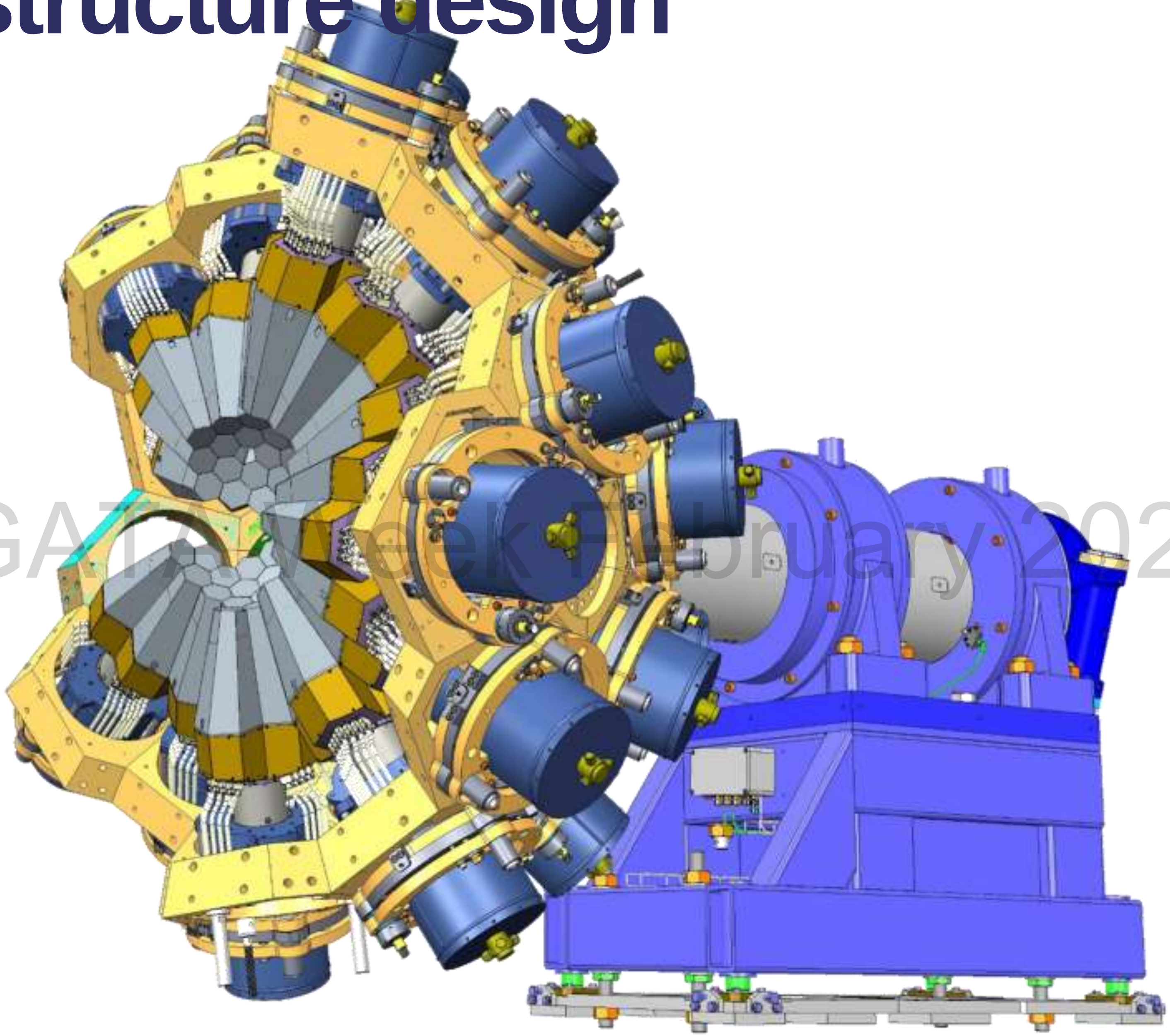
Support structure design



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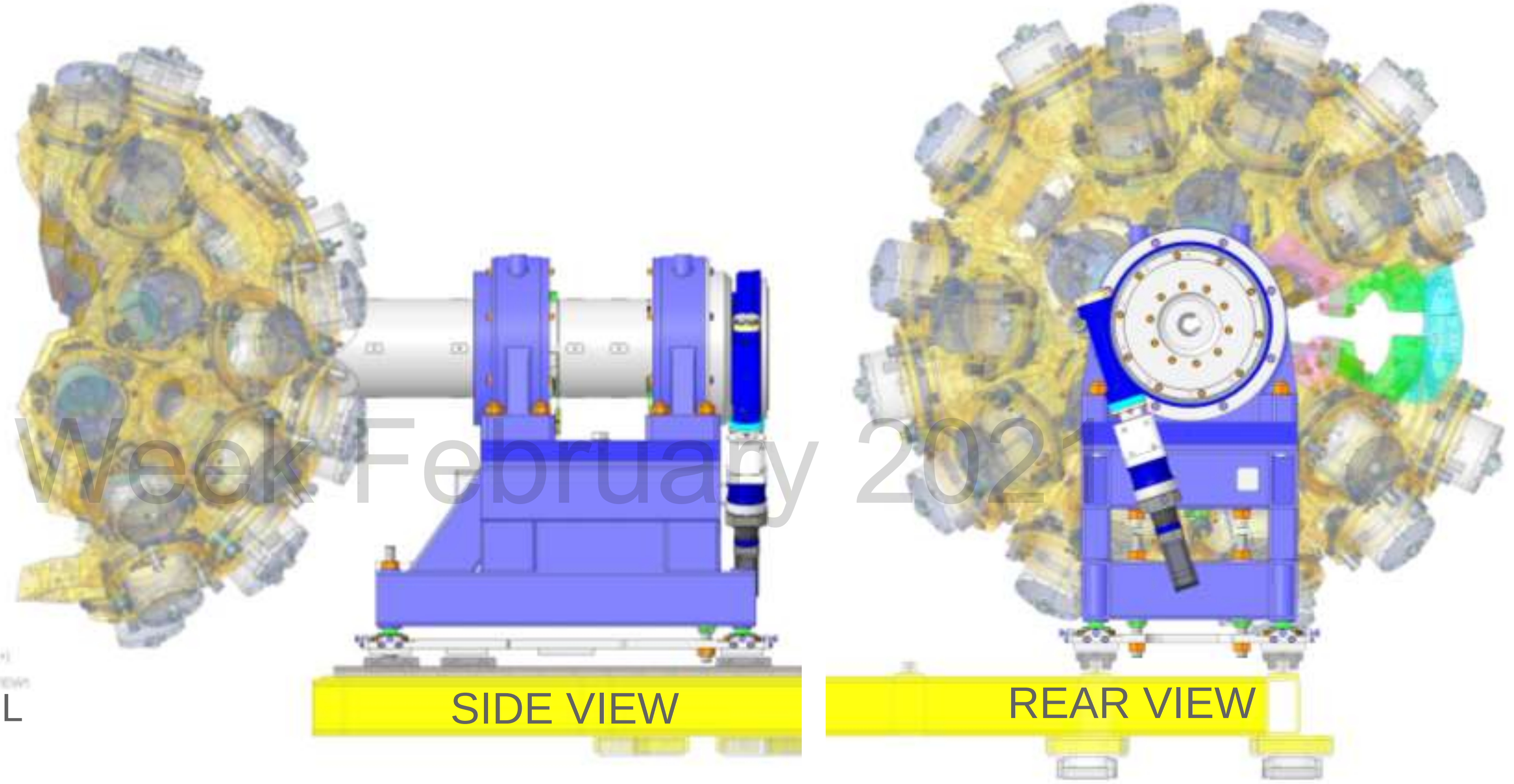
Support structure

- Cantilever design
- 360mm diameter hollow steel shaft
- Spherical roller bearings & housings
- Slewing drive
- Stepper motor driven
- Dual gearbox (combined ratio 80:1)
- Optical encoder feedback
- Mechanical limit switches
- Fabricated main frame
- Kinematic adjustment
- Interface with rail carriage system at LNL
- Multiple survey points



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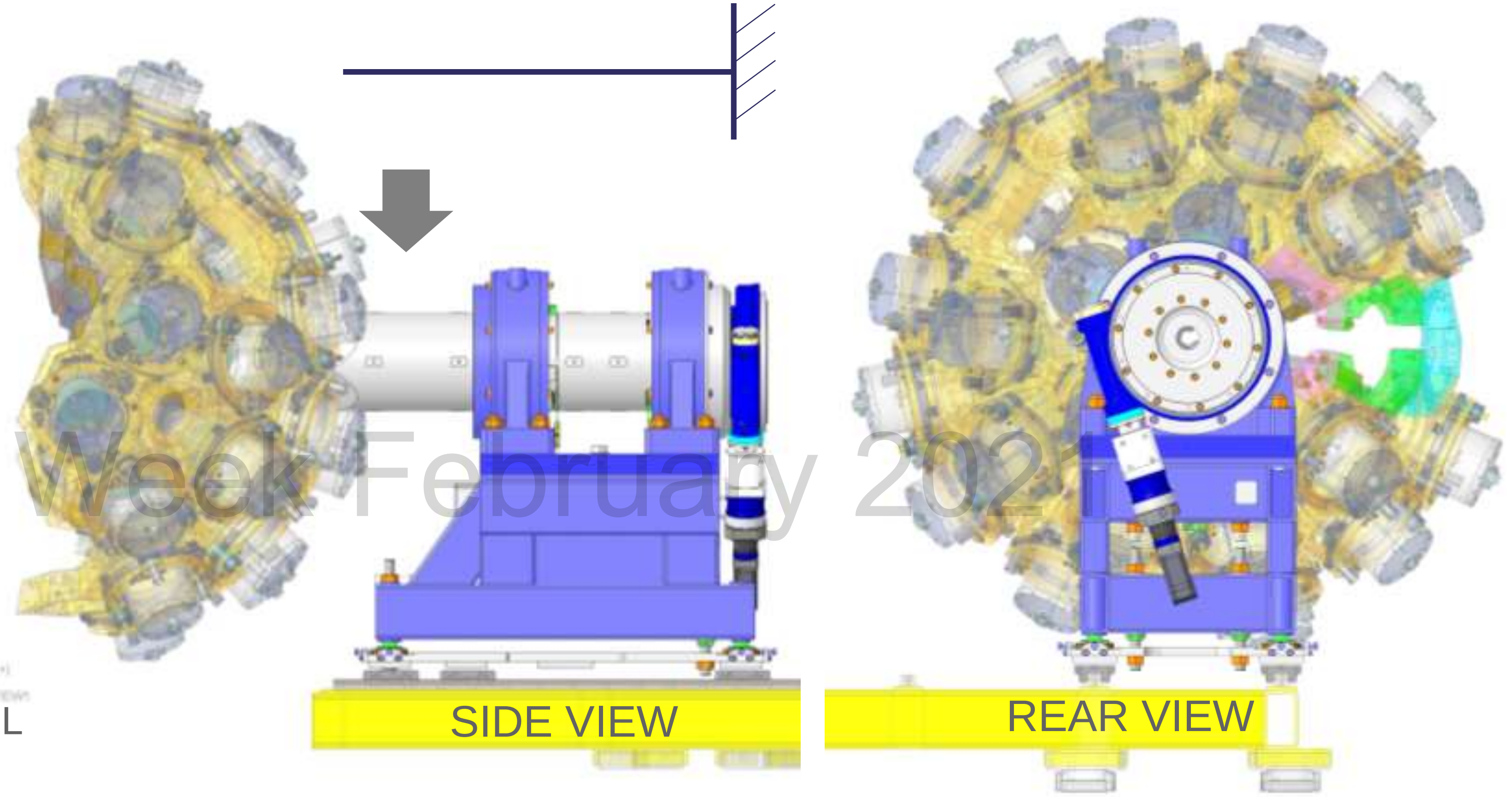

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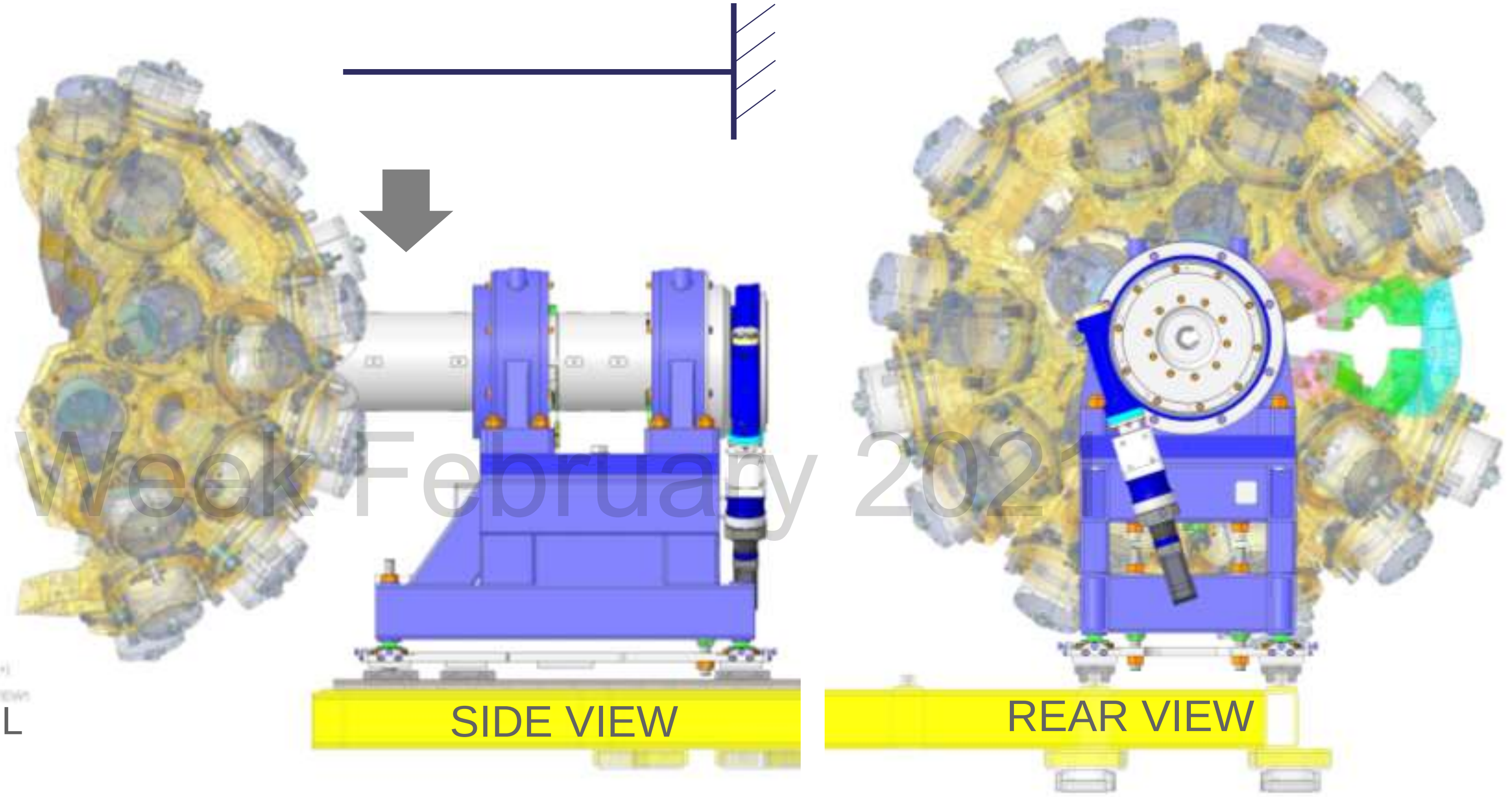

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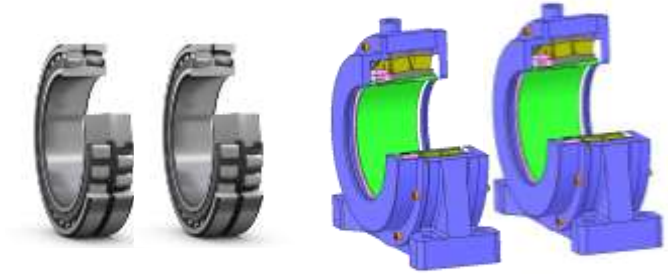

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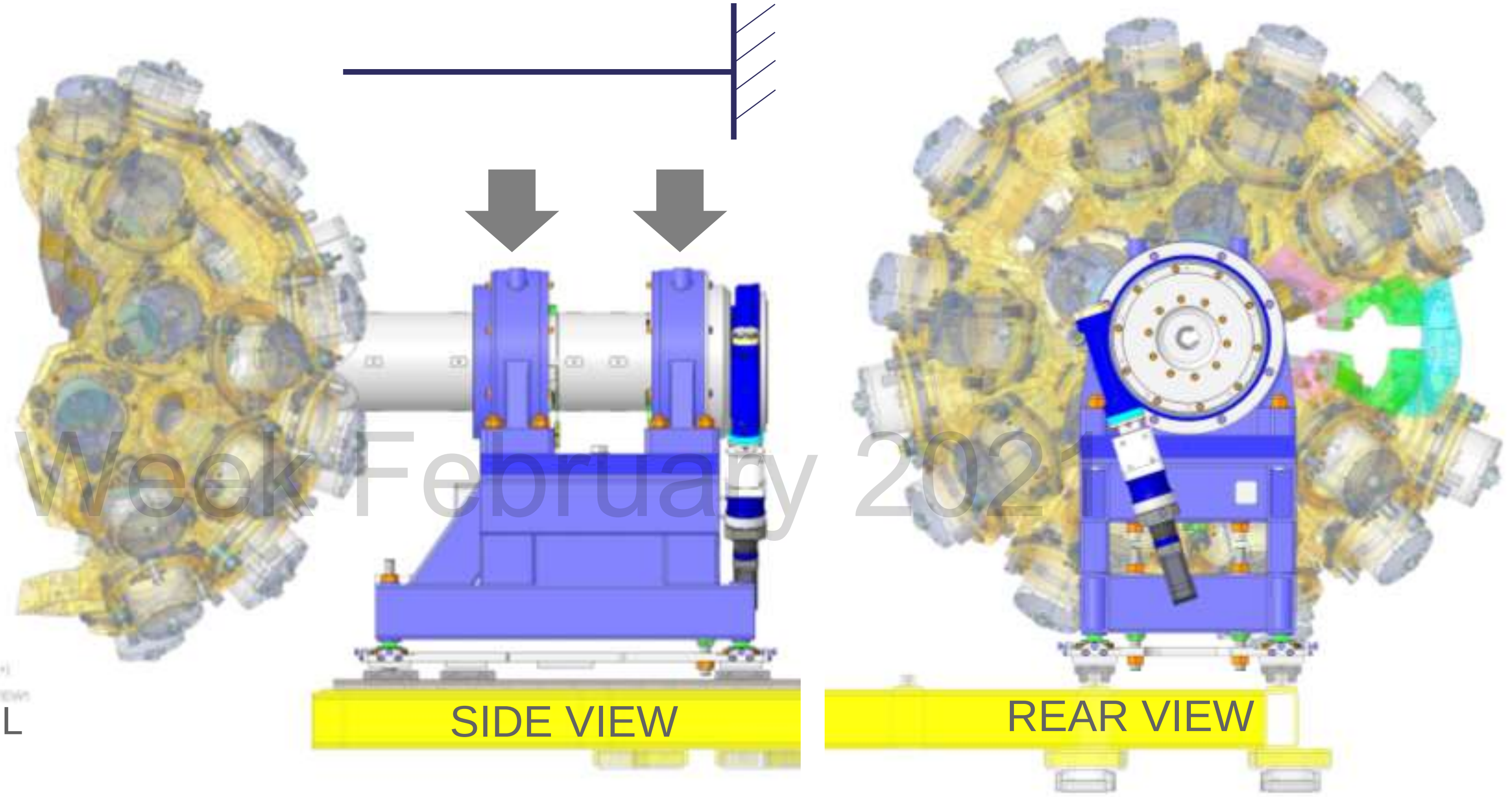

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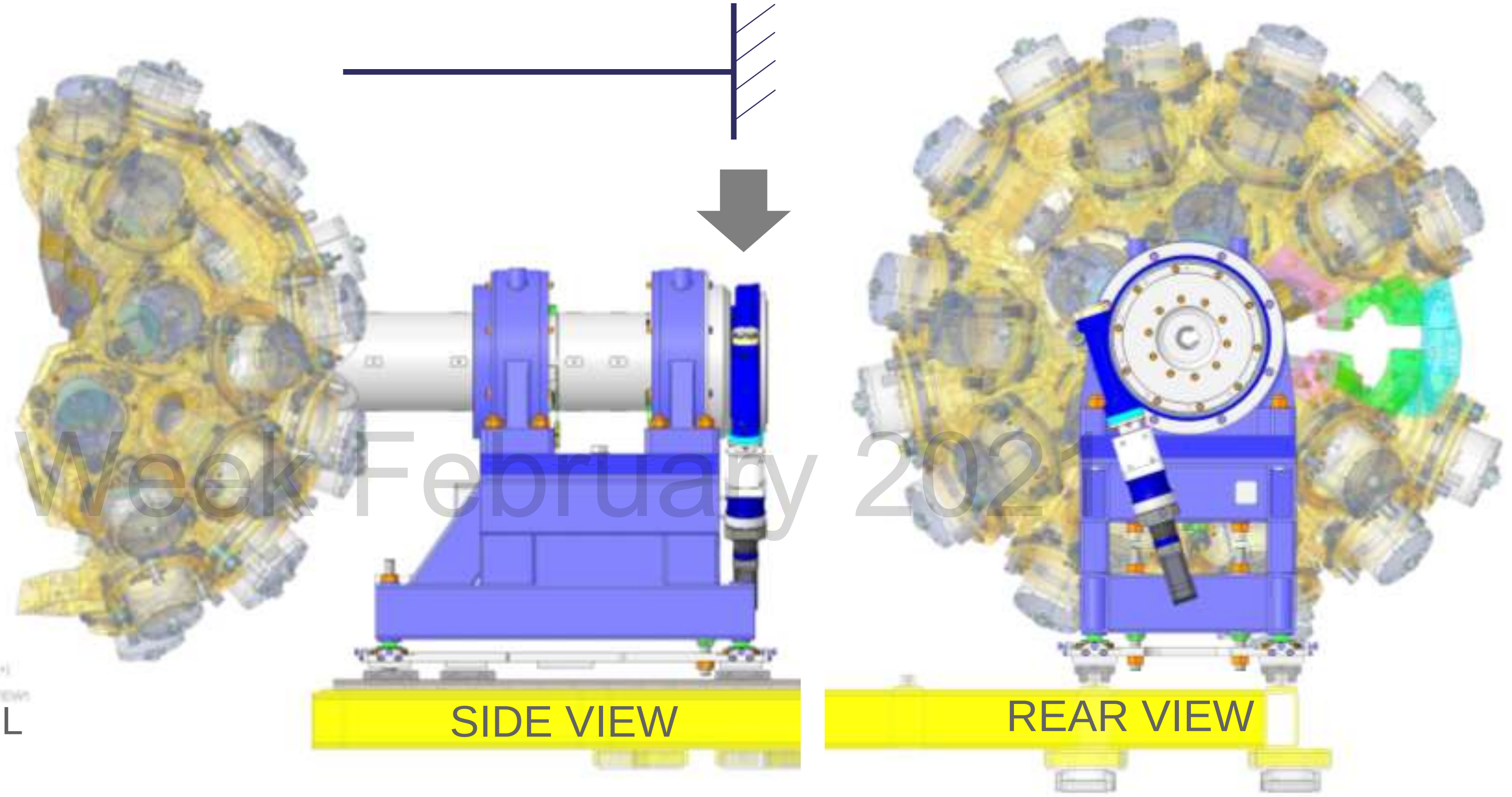

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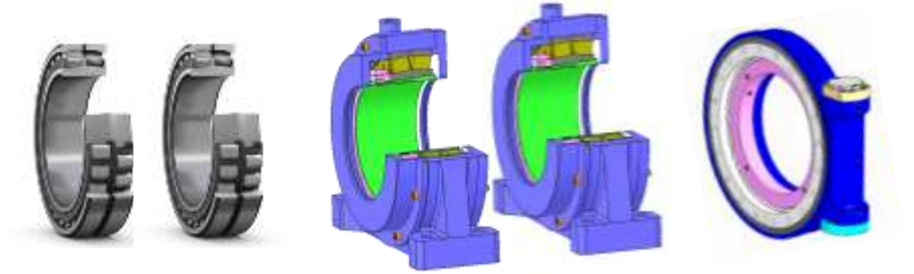

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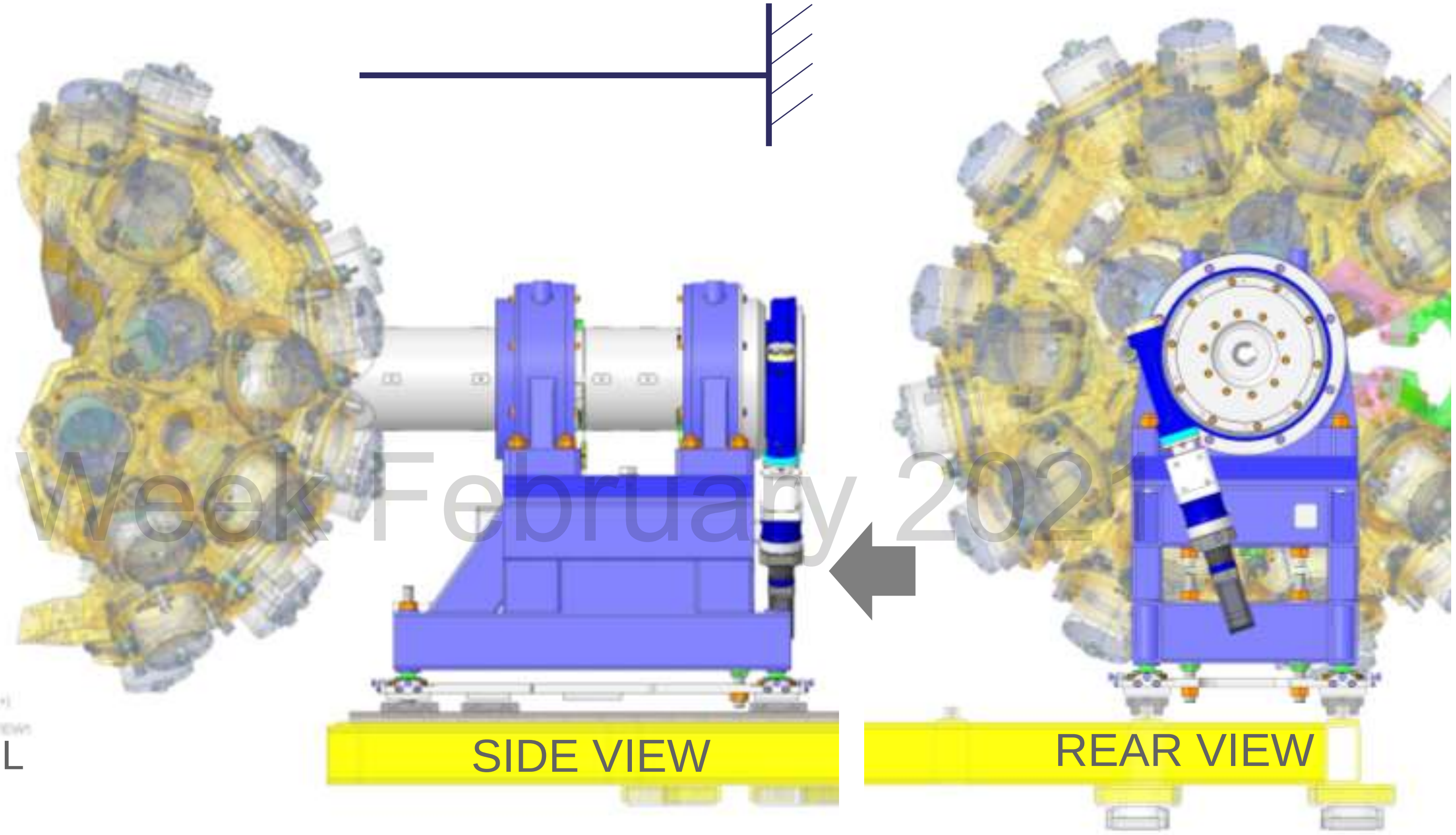

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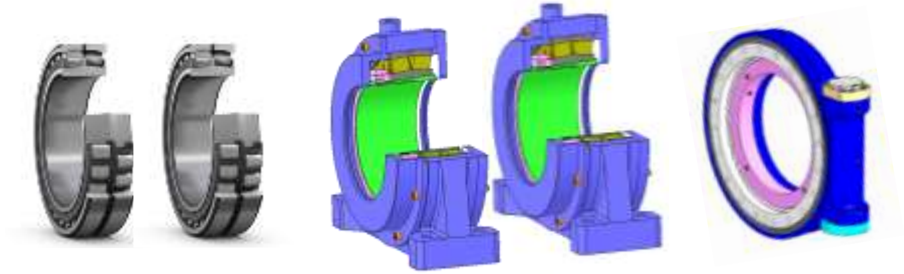

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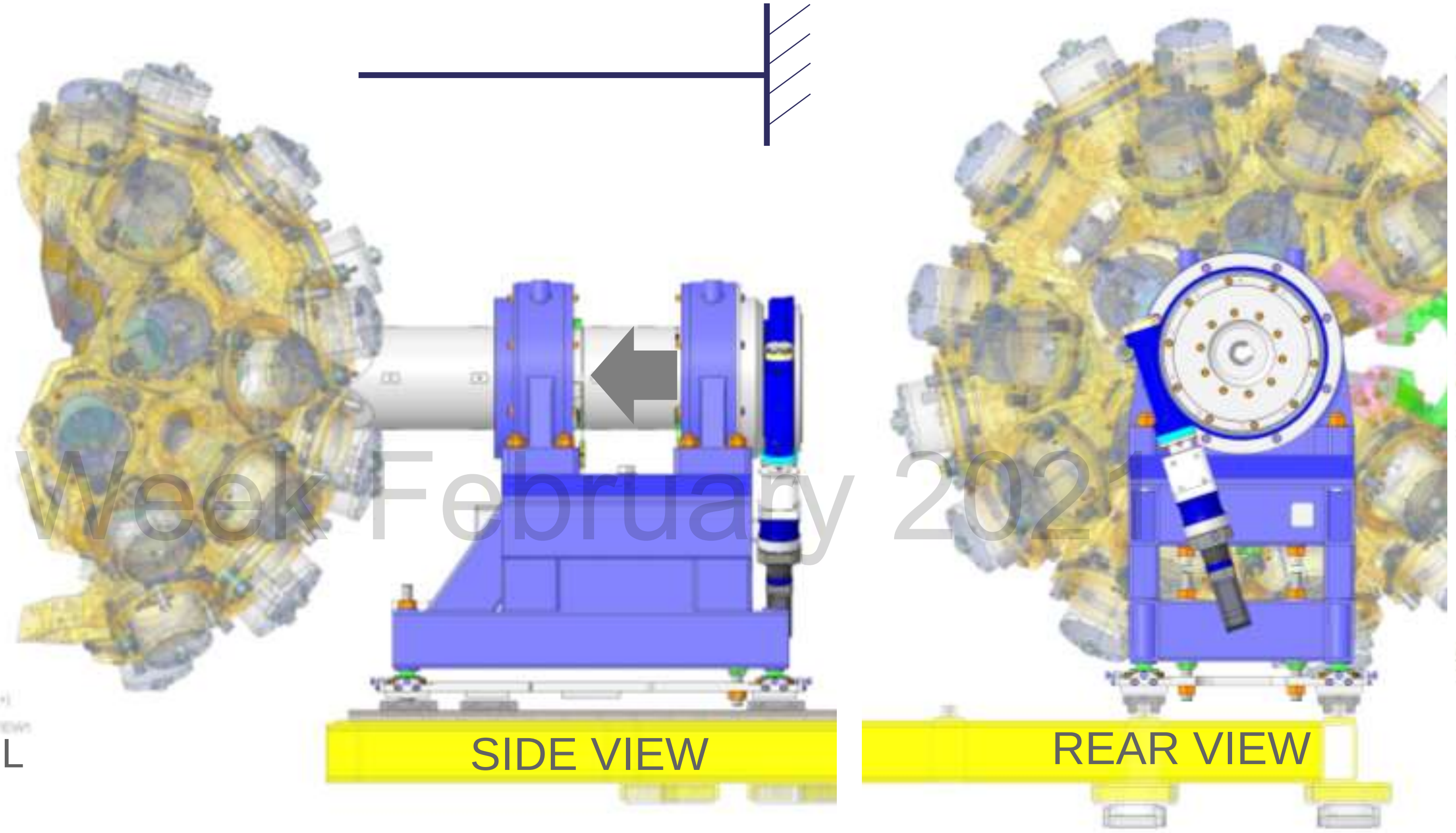

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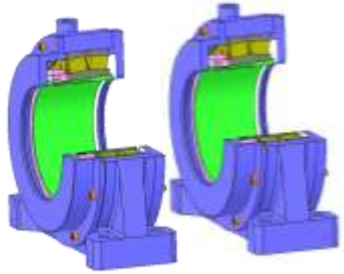

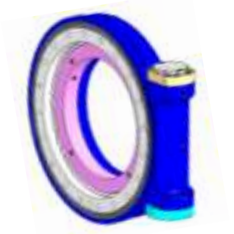

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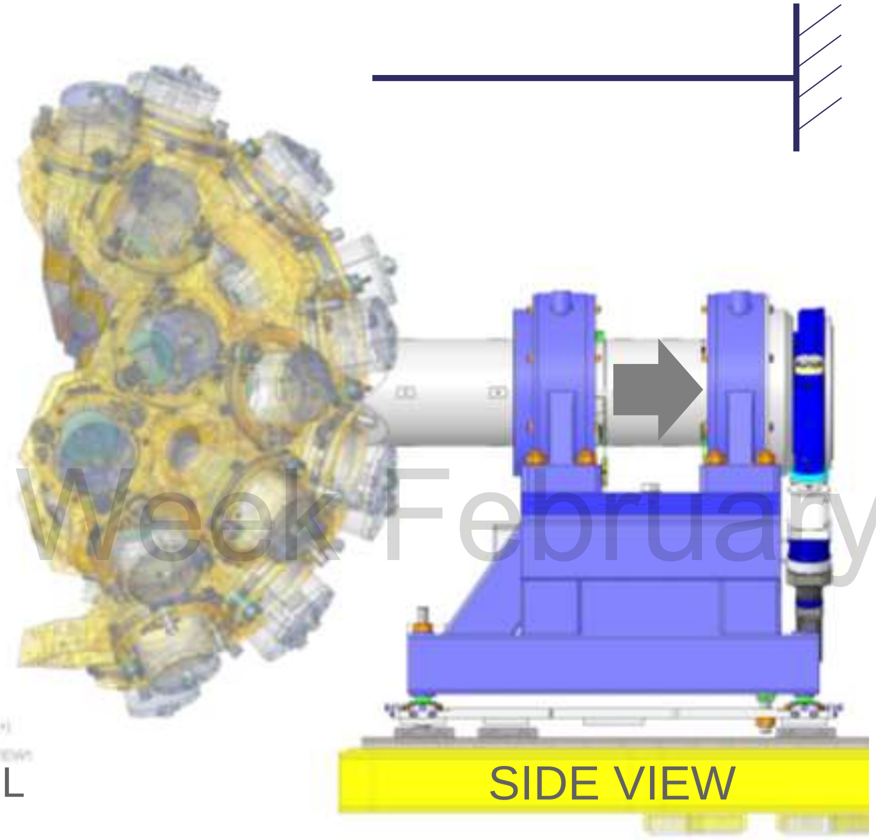

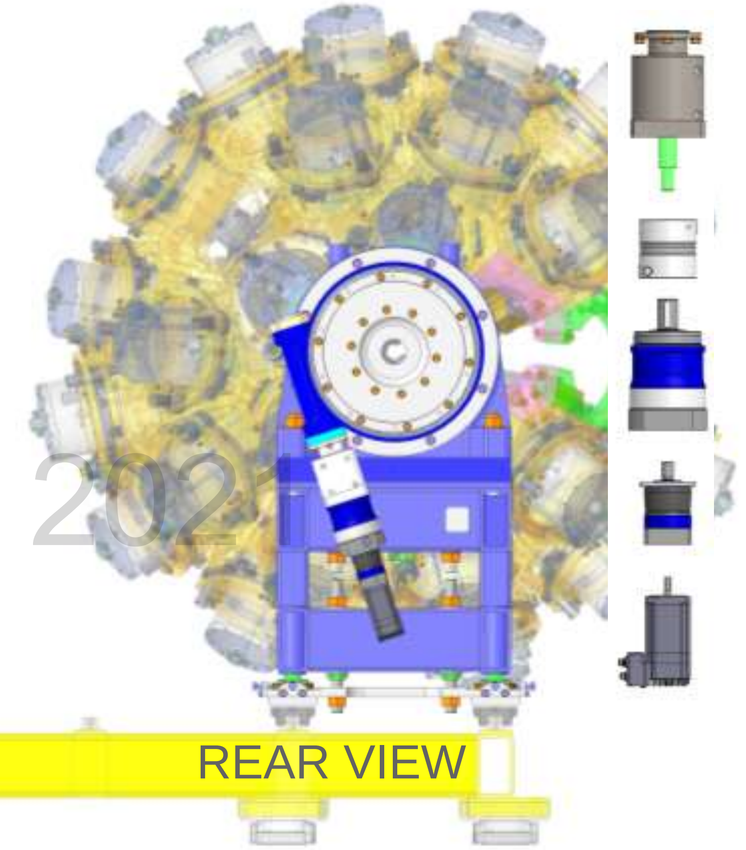

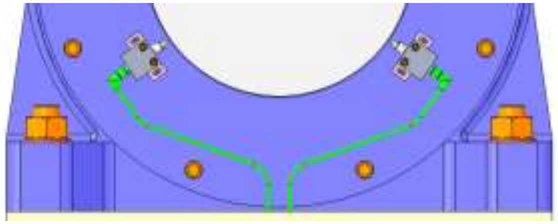

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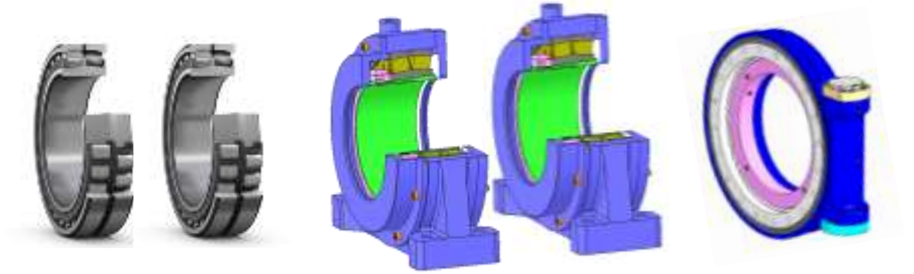

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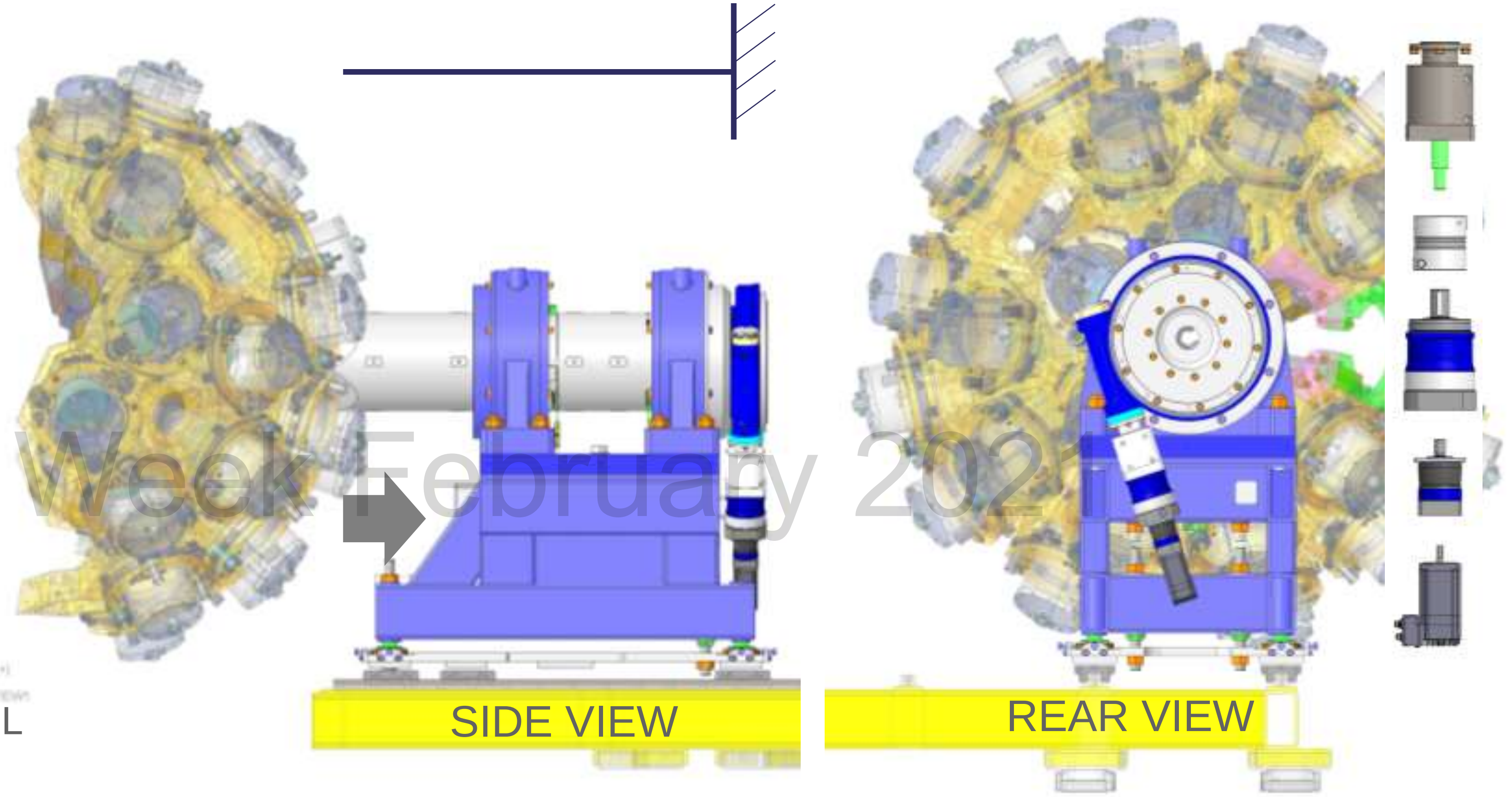

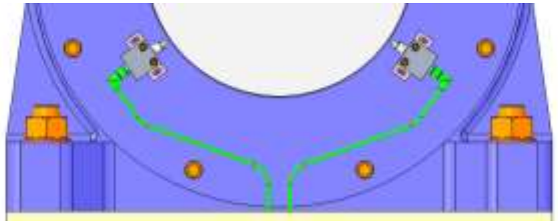

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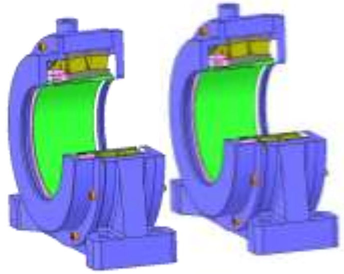

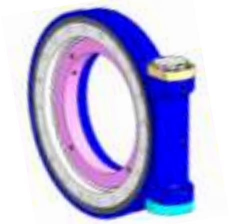

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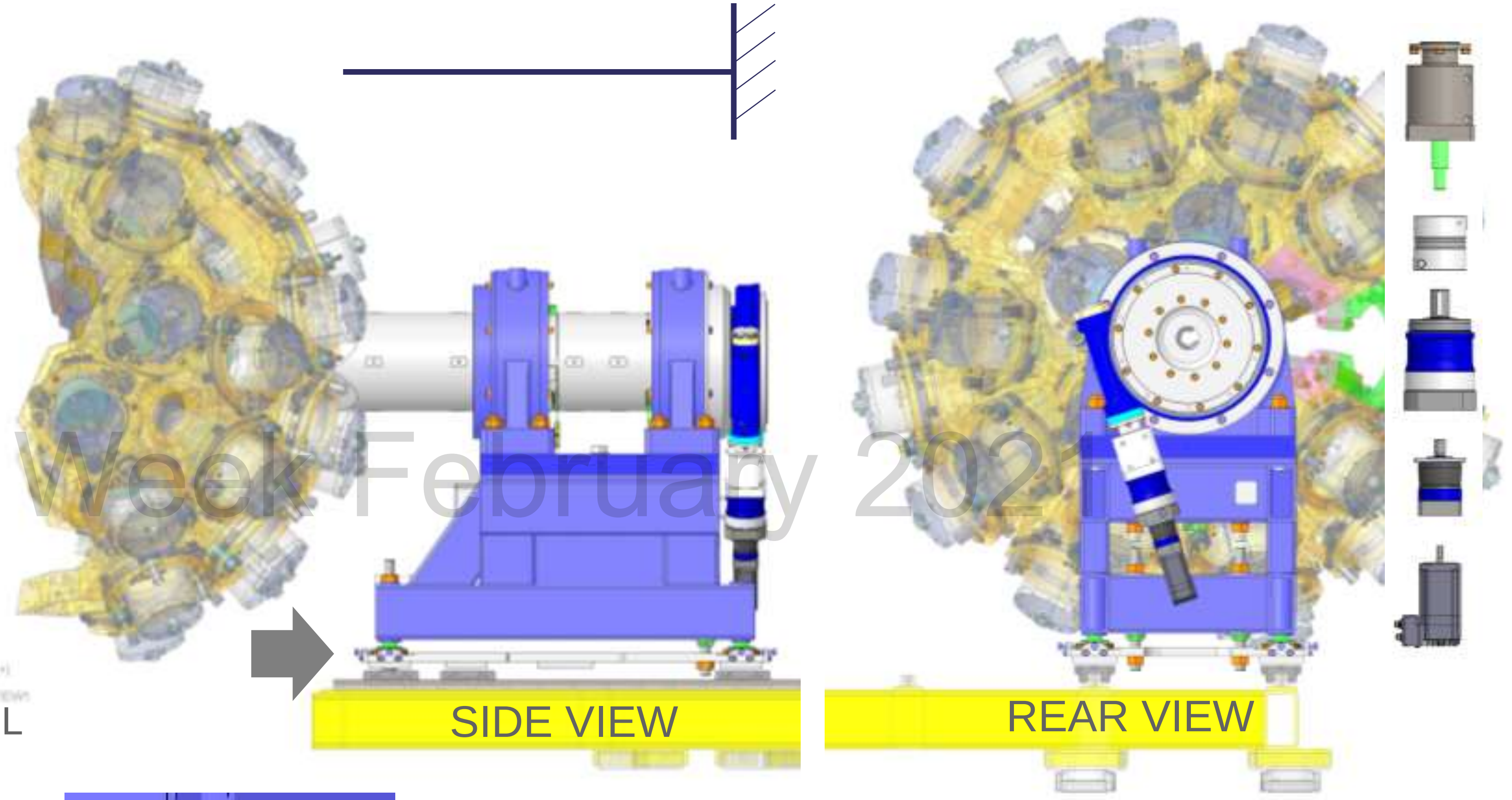

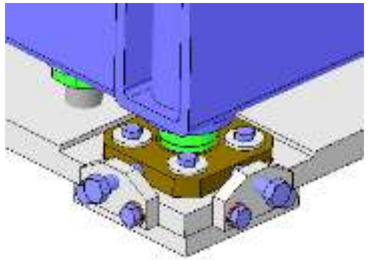

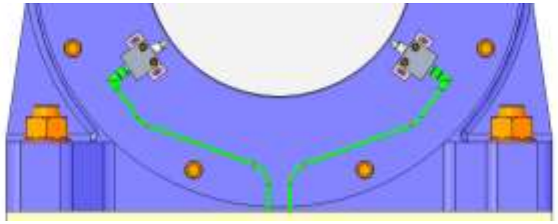

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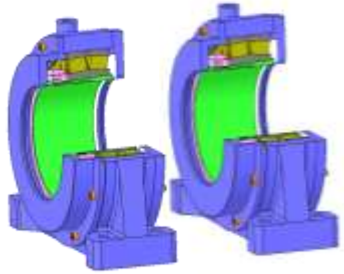

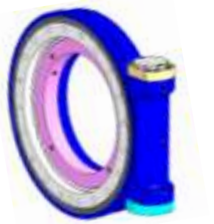

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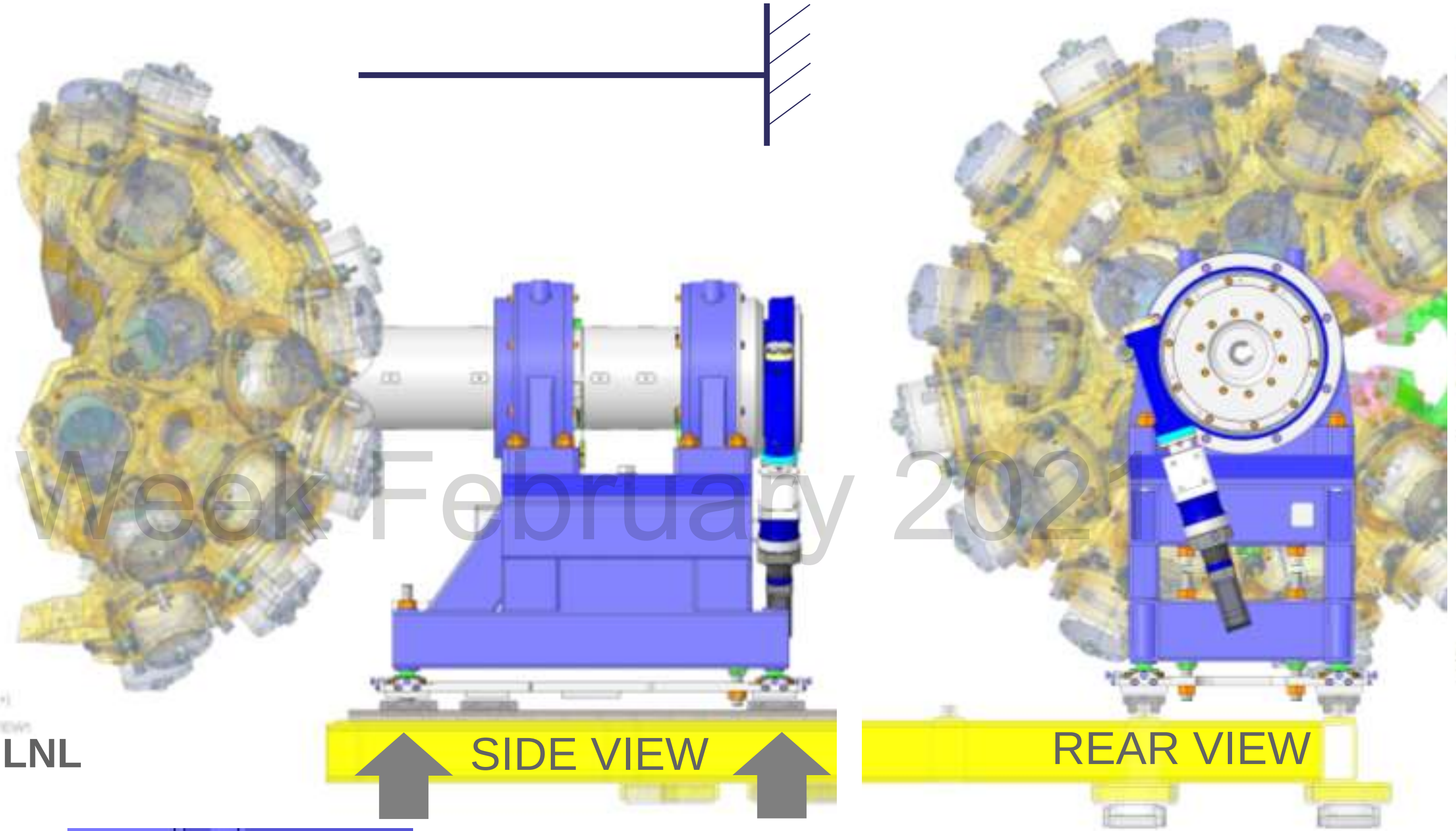

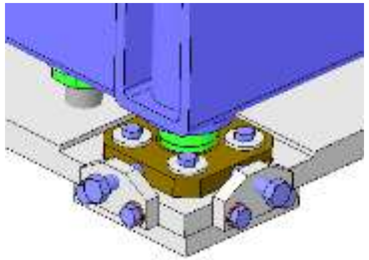

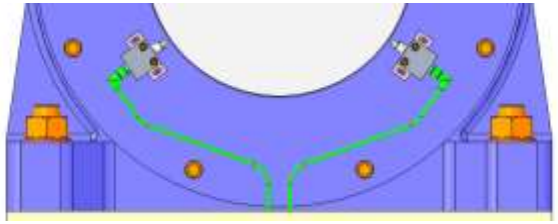

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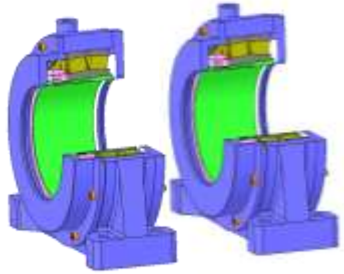
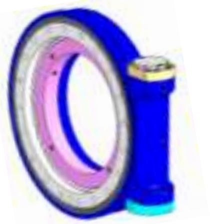
Support structure



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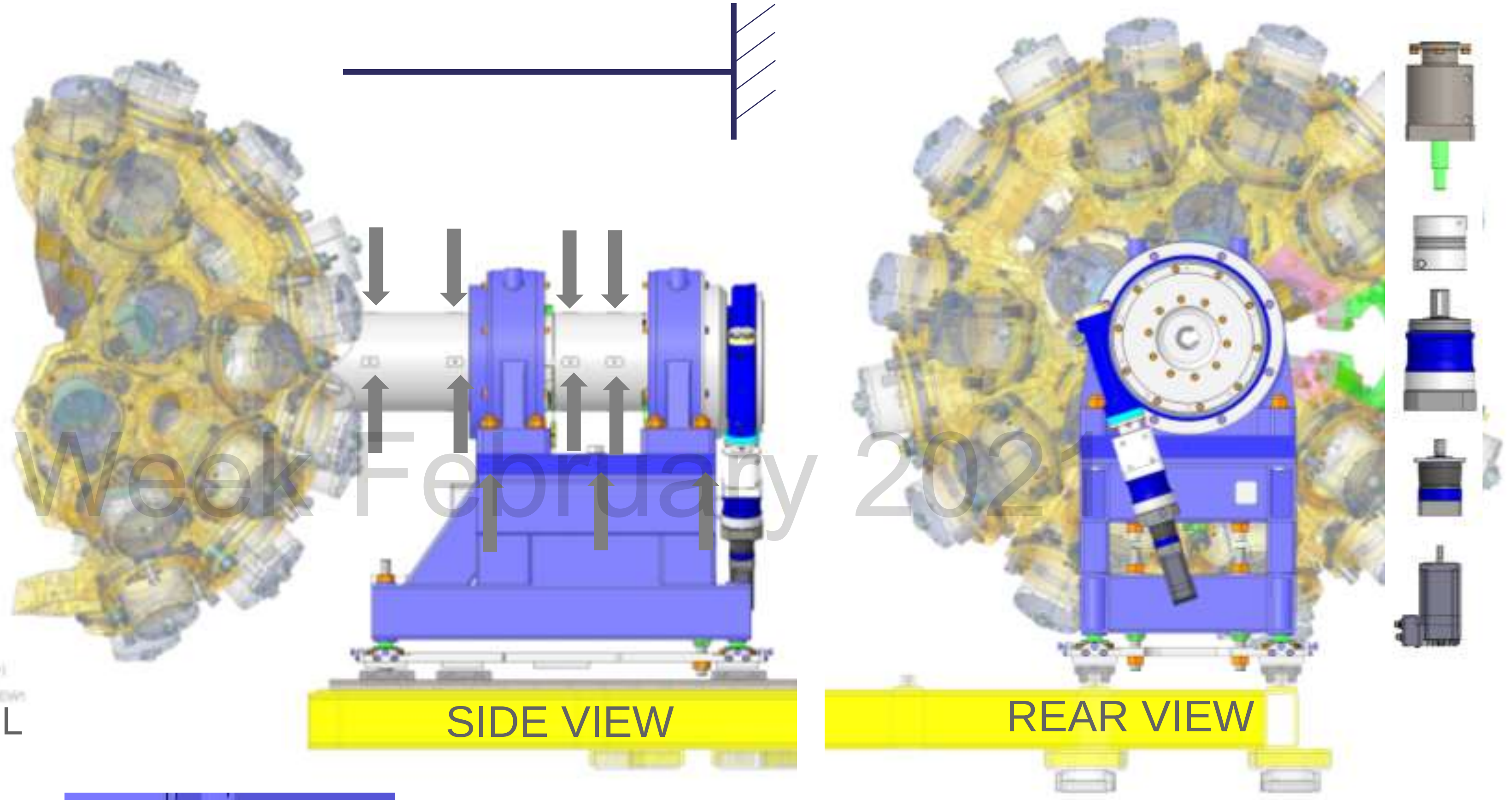

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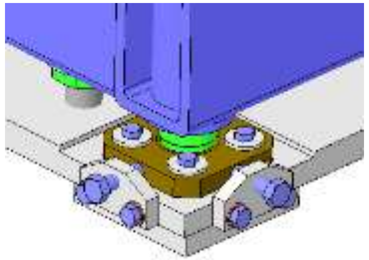
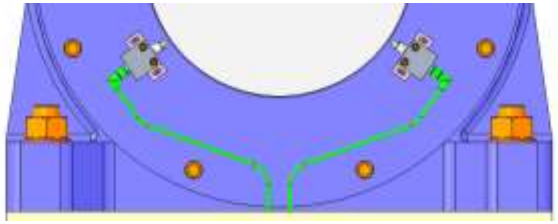
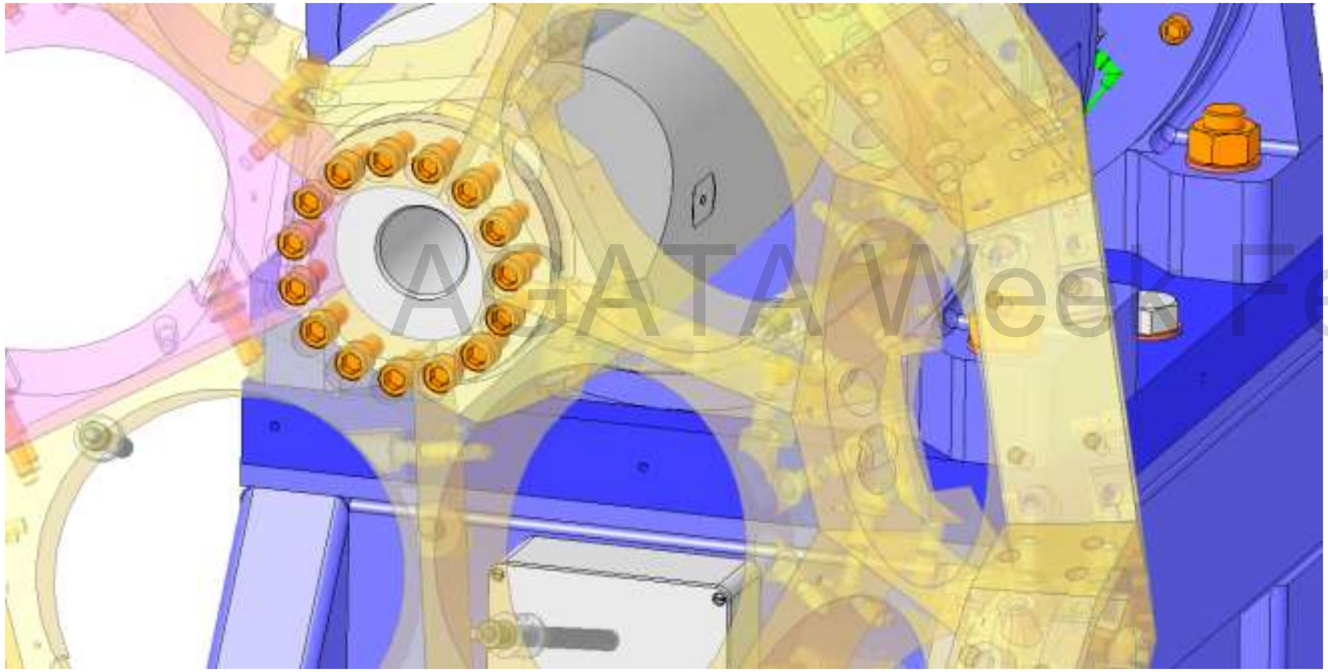
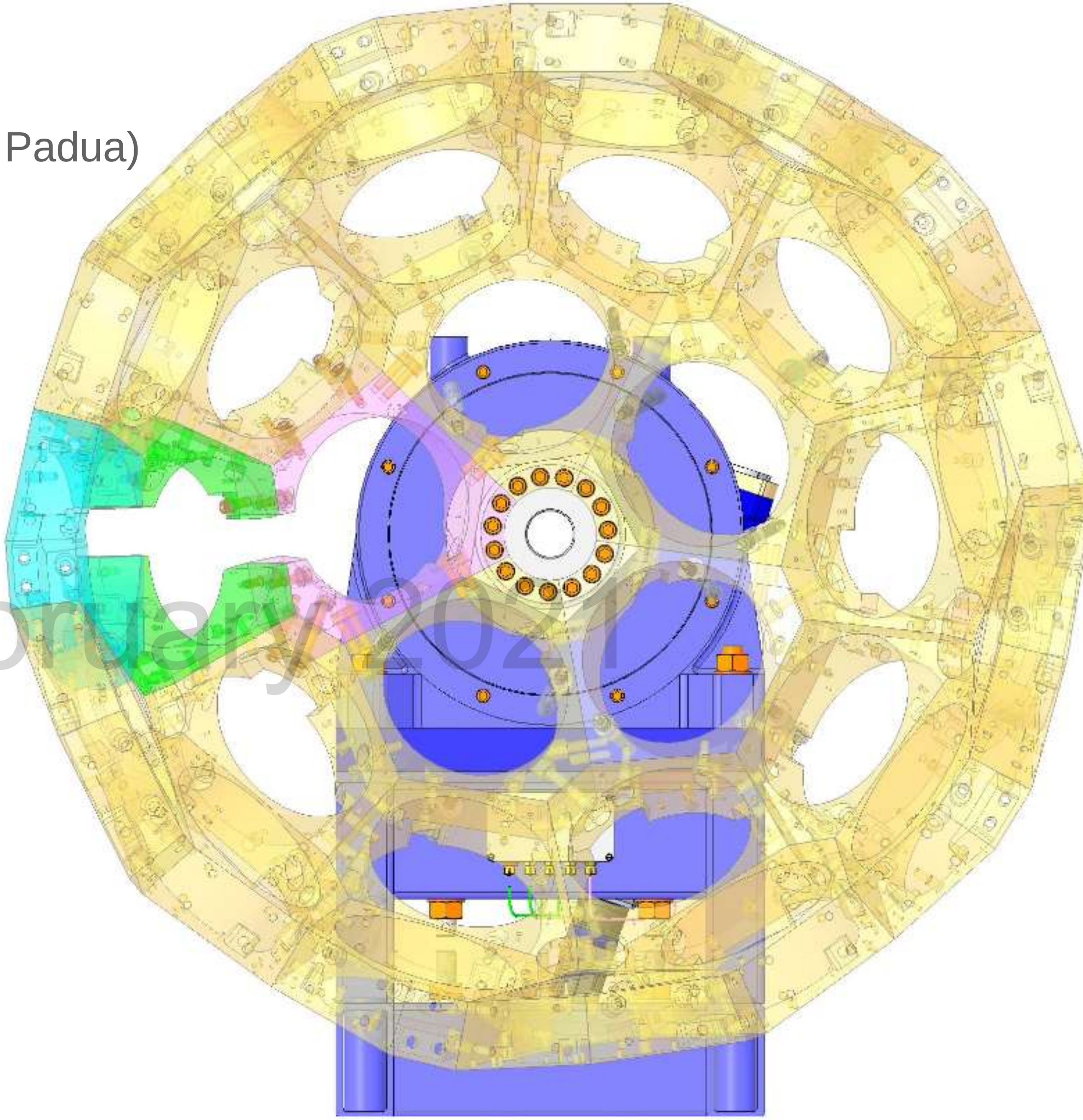




Support structure

- 5 revised flanges with through holes (currently being manufactured in Padua)
- Flanges secured to shaft with M20 fasteners





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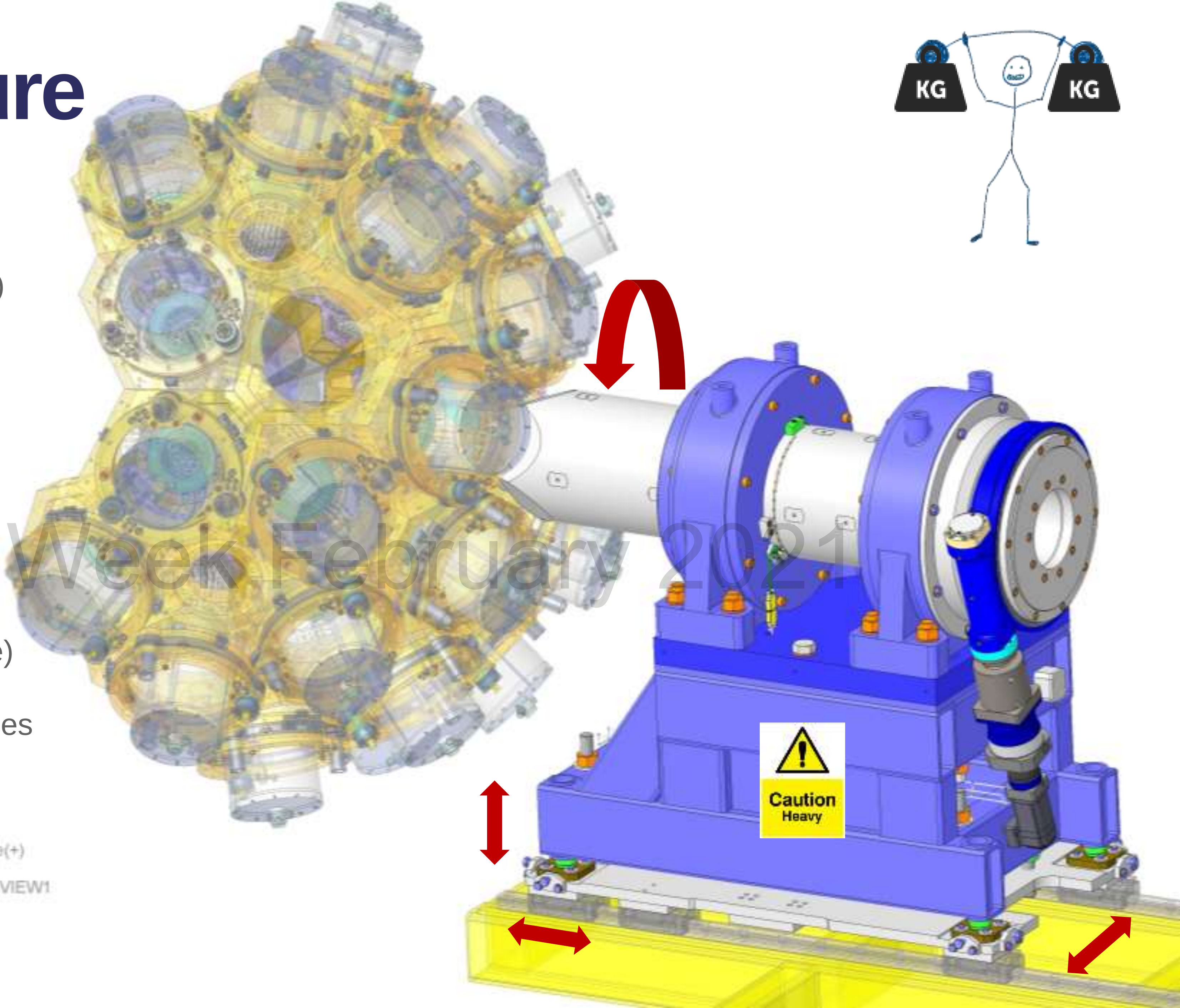
Support structure

- ±85 degrees rotation
- Supports 4000kg (ATCs & LN_2 manifold)
- Weighs ~3700kg (support alone)
- +/- 15mm lateral adjustment
- +/-25mm vertical adjustment
- Rotation controlled via PC or jog box
- 2 motion stop buttons (one on each side)
- Current speed ~3 minutes 0 to 85 degrees



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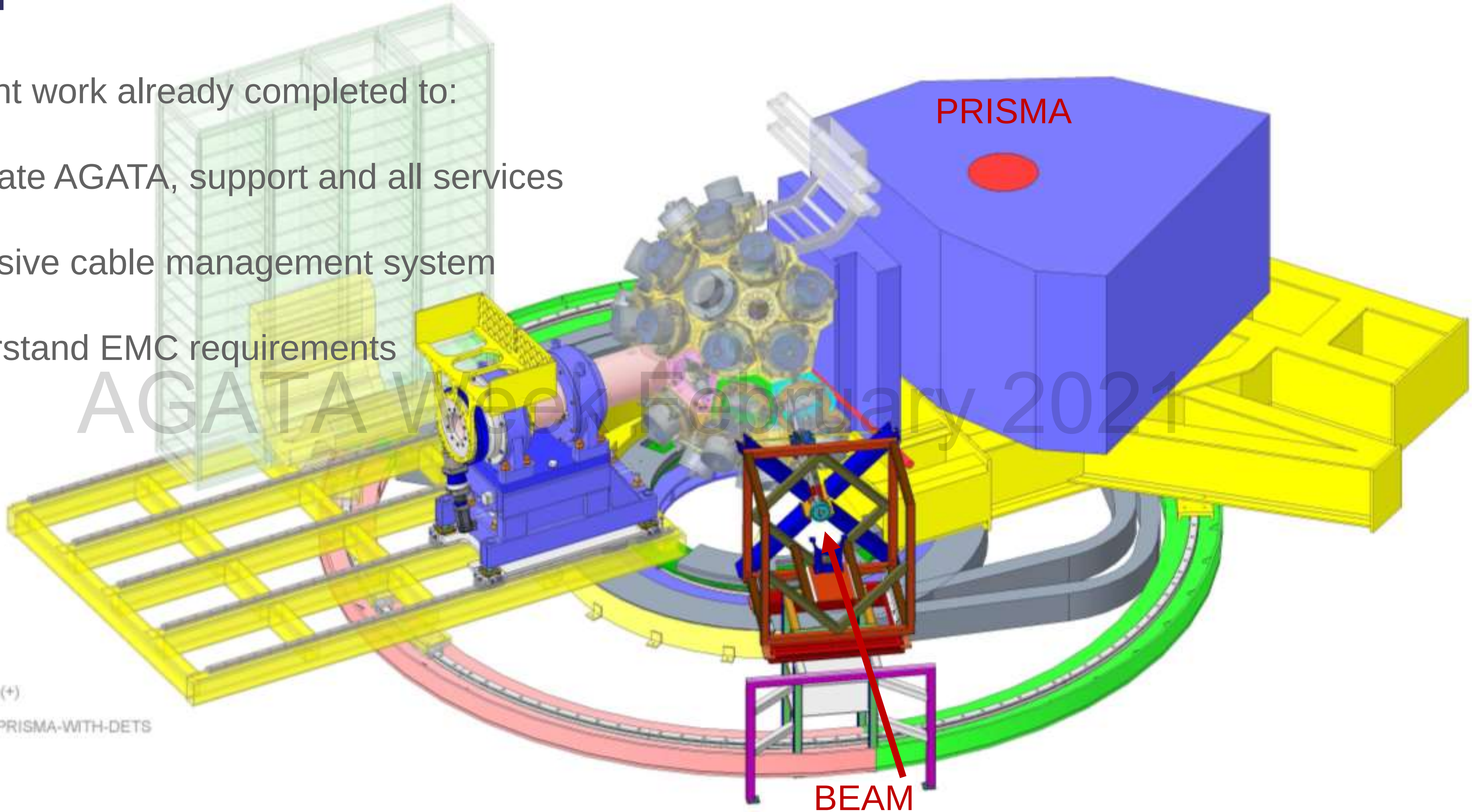
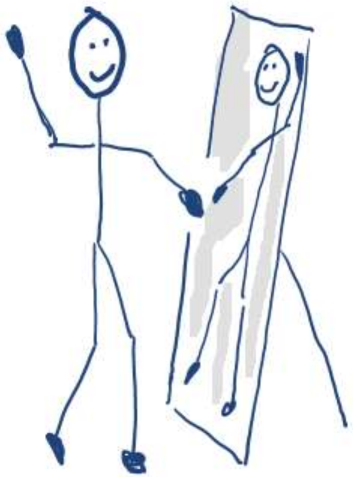
Support structure at LNL

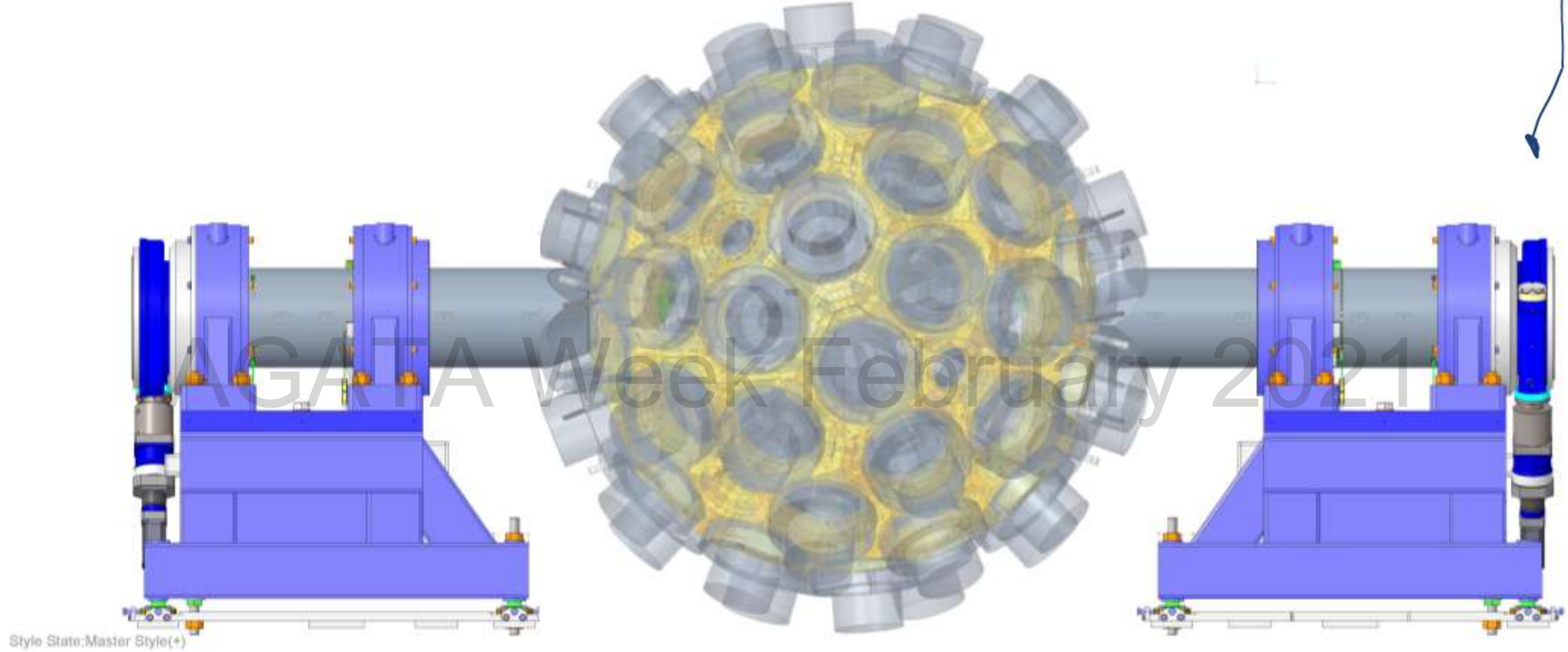
Significant work already completed to:

- Integrate AGATA, support and all services
- Extensive cable management system
- Understand EMC requirements



4π Support structure





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Design would be a mirror of current design

Finite Element Analysis

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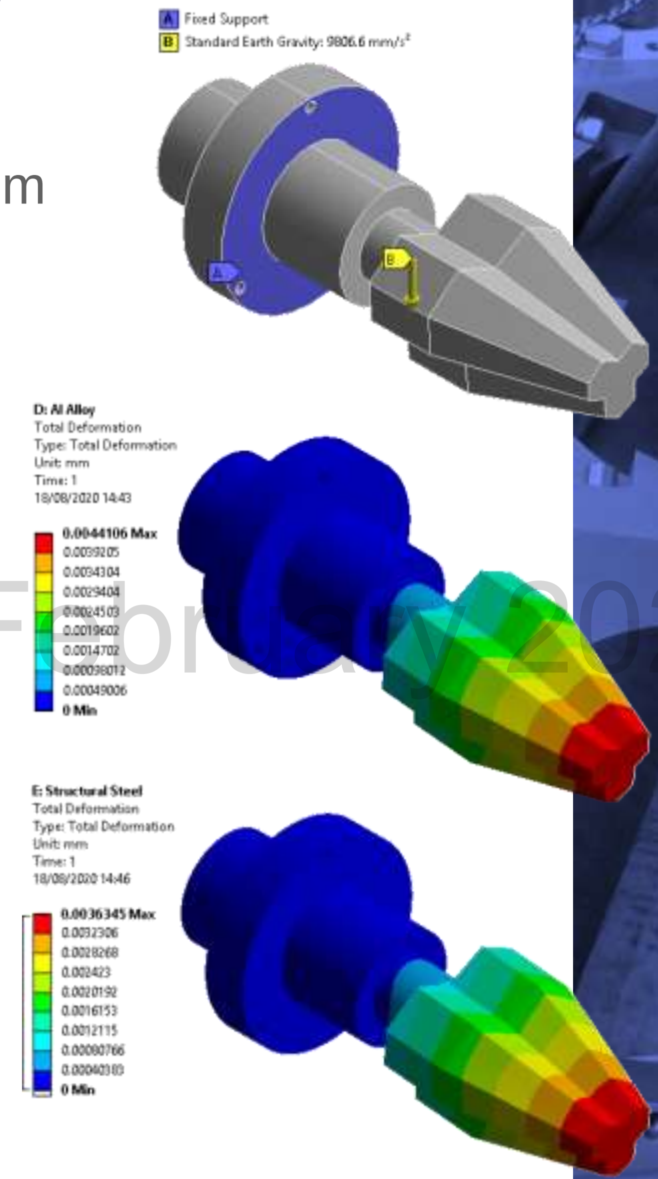
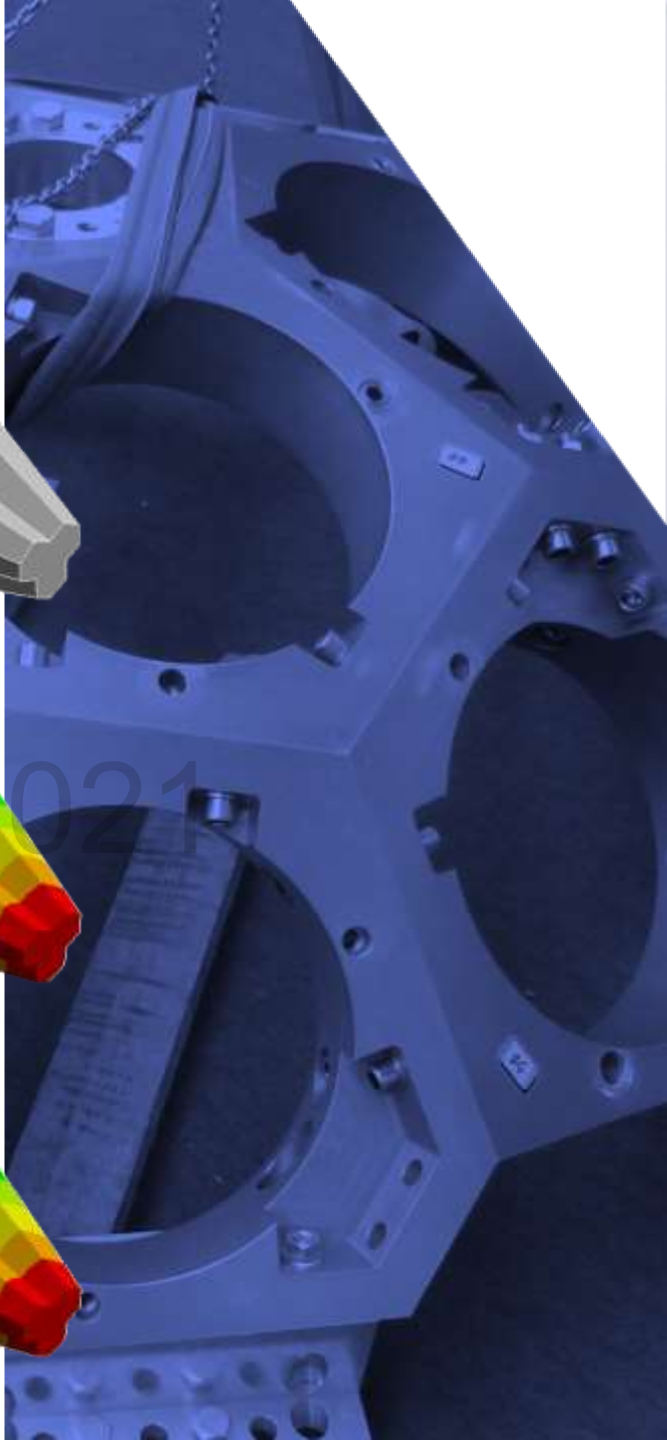
Finite Element Analysis

- Expected deflection range of complete system
- Directional deflection characteristics
- LN_2 manifold impact and orientation
- Relative deflection of triple cluster
- Flange cut-out for LNL campaign





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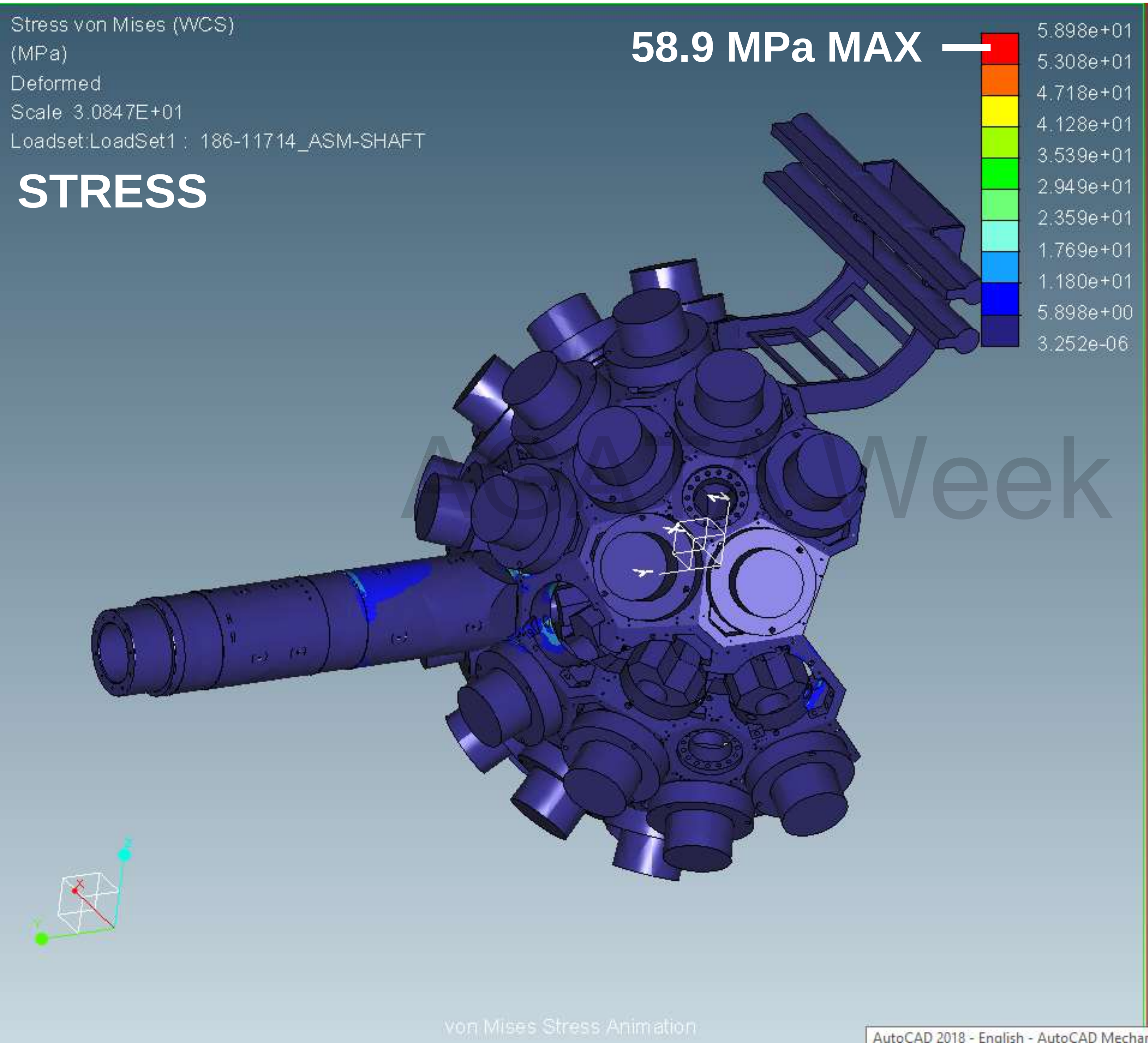
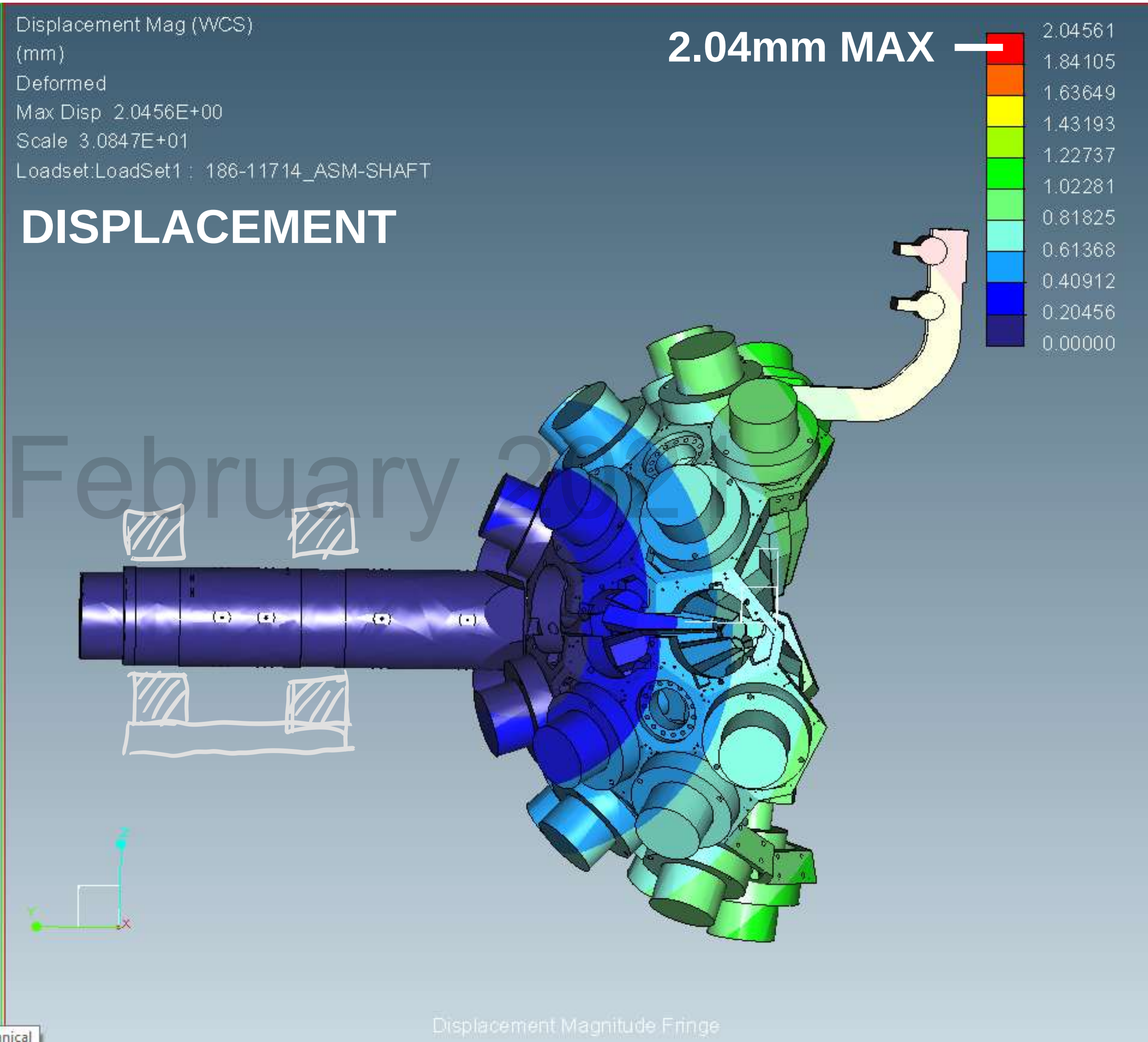
Finite Element Analysis





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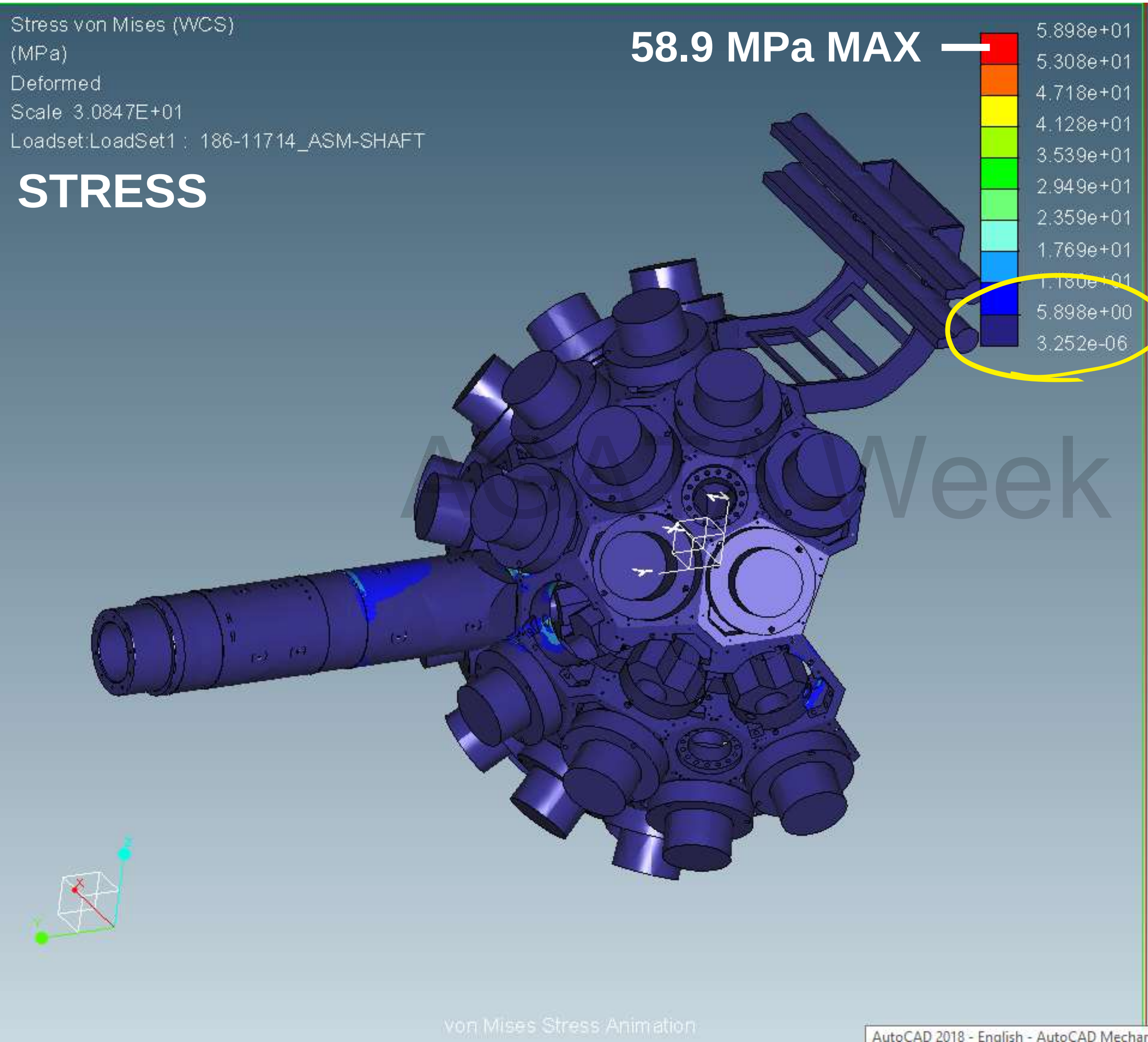
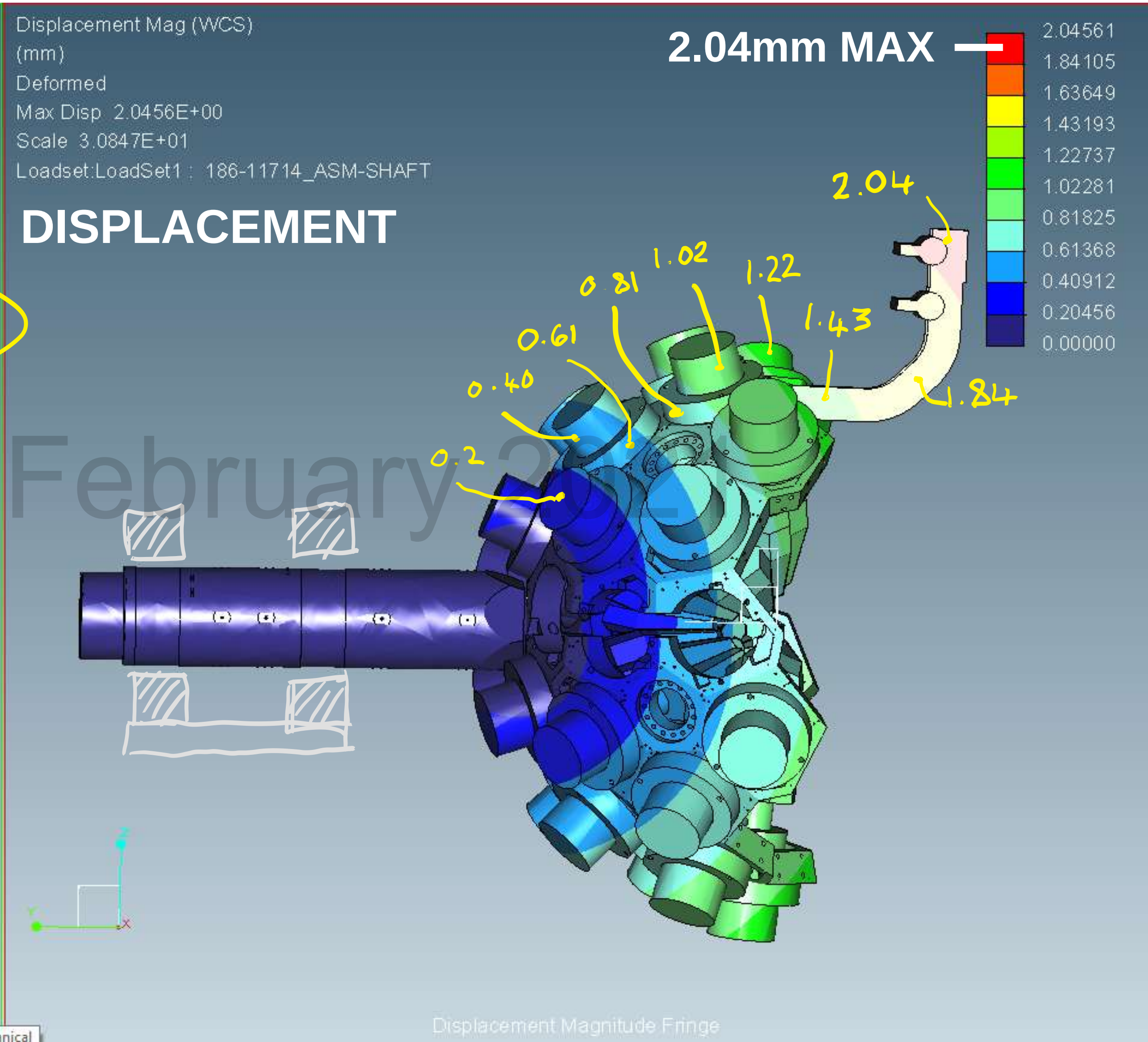
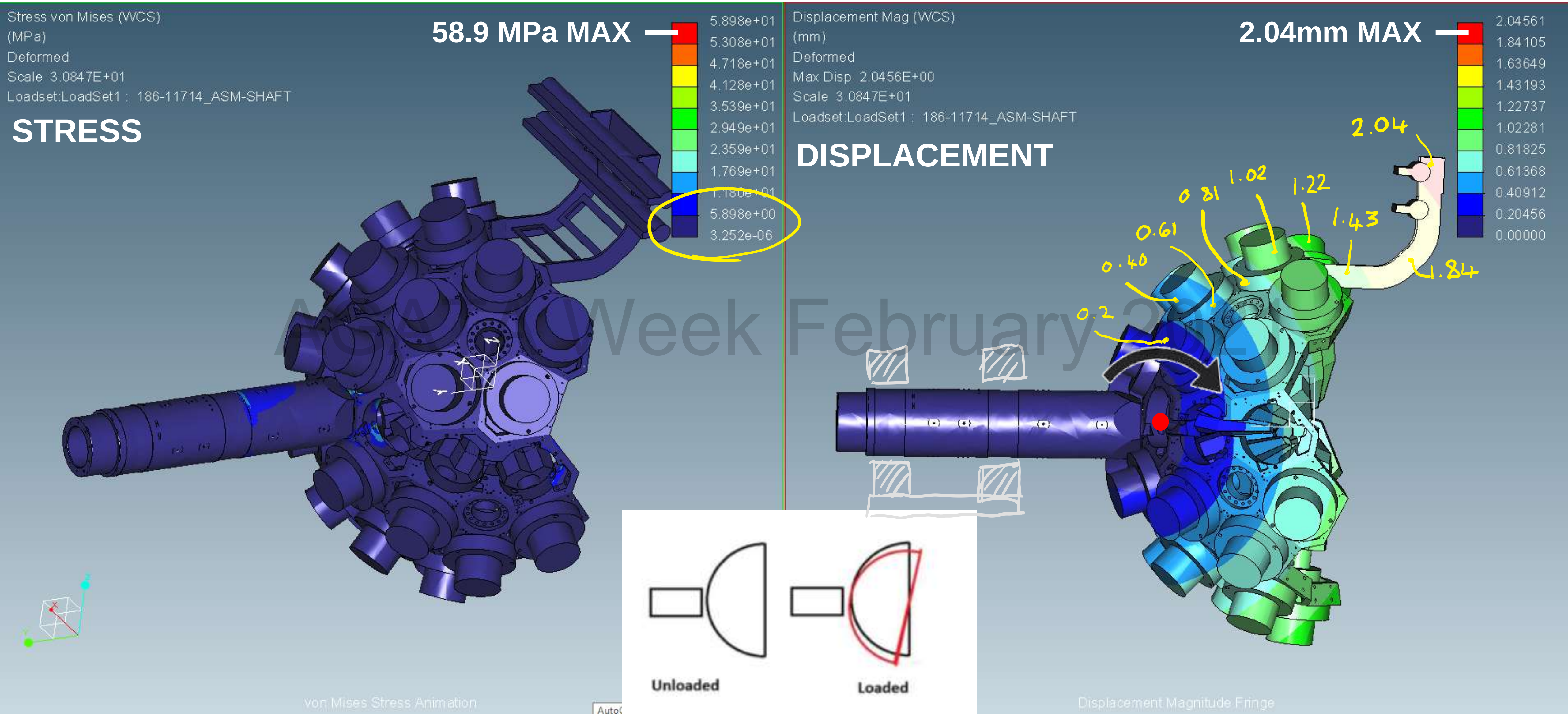




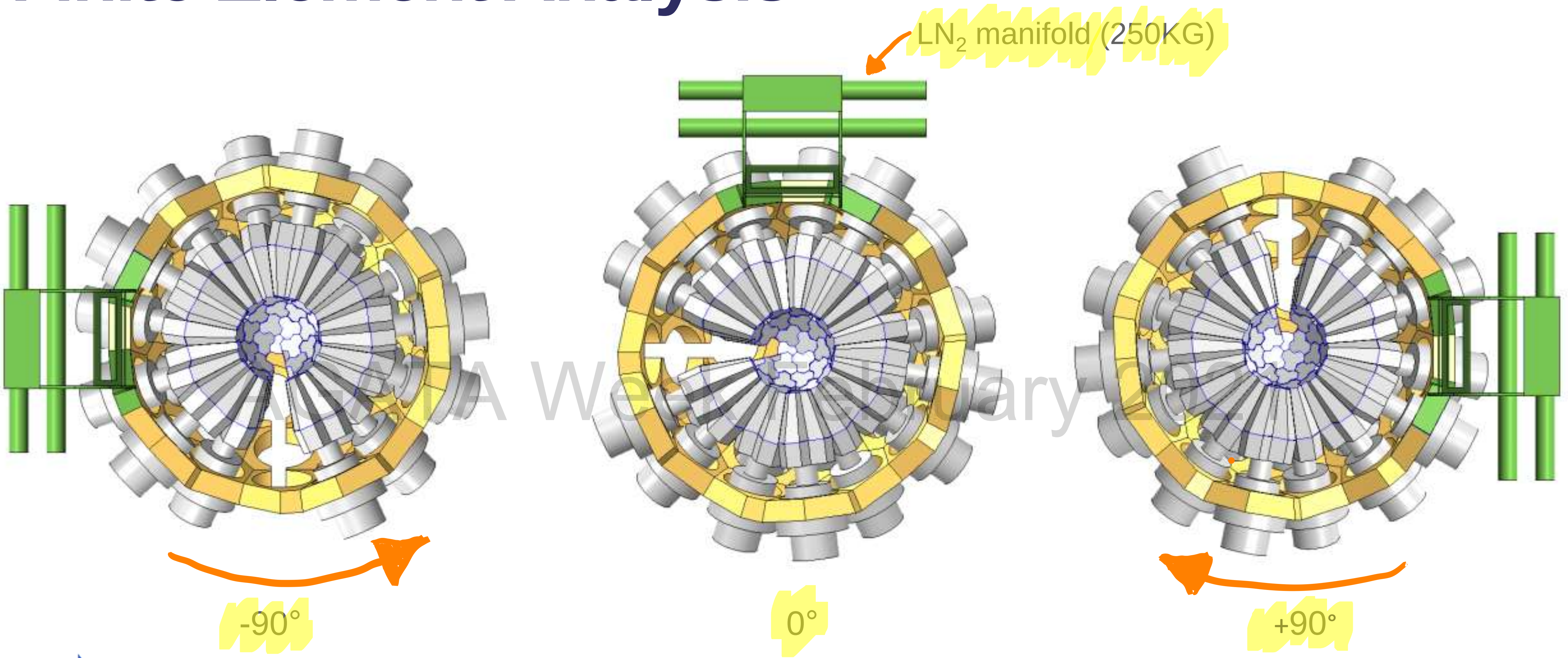
AutoCAD 2018 - English - AutoCAD Mechanical

FEA

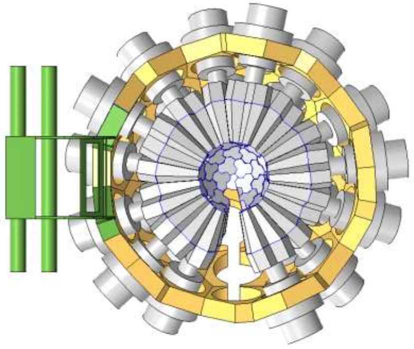
During installation/removal of the triple clusters, survey of the honeycomb should be performed at regular intervals to bring the ‘target point’ back into the desired position.

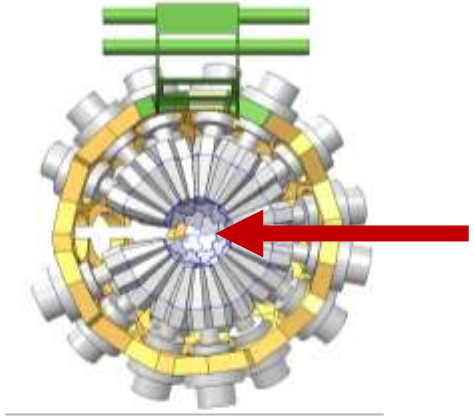


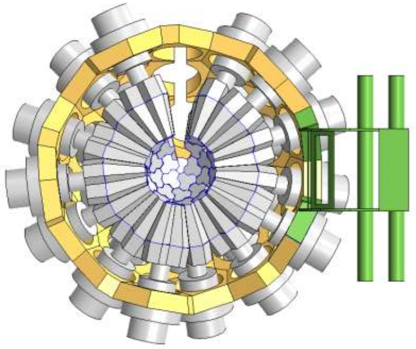
Finite Element Analysis

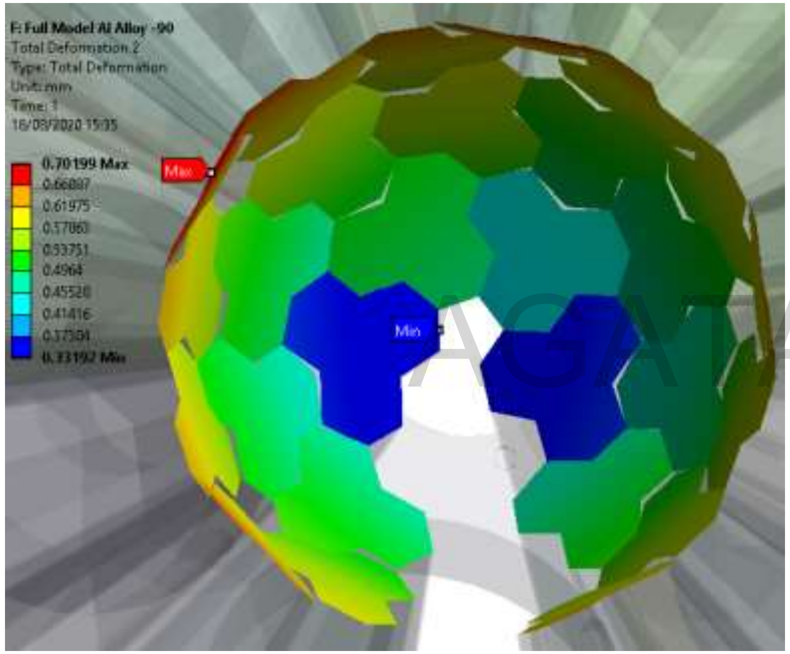


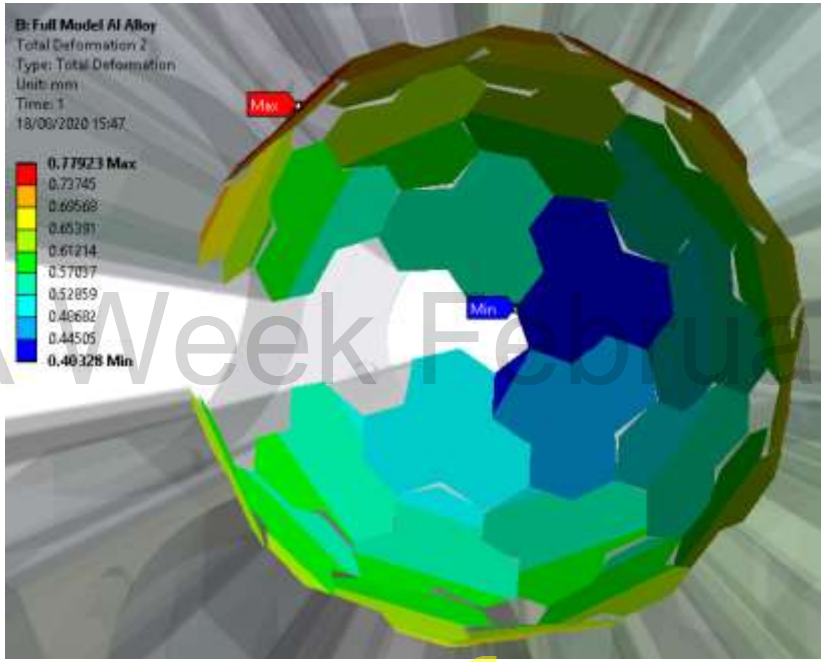
The worst case triple cluster deflection is found in the 0° position with the liquid nitrogen manifold above the array

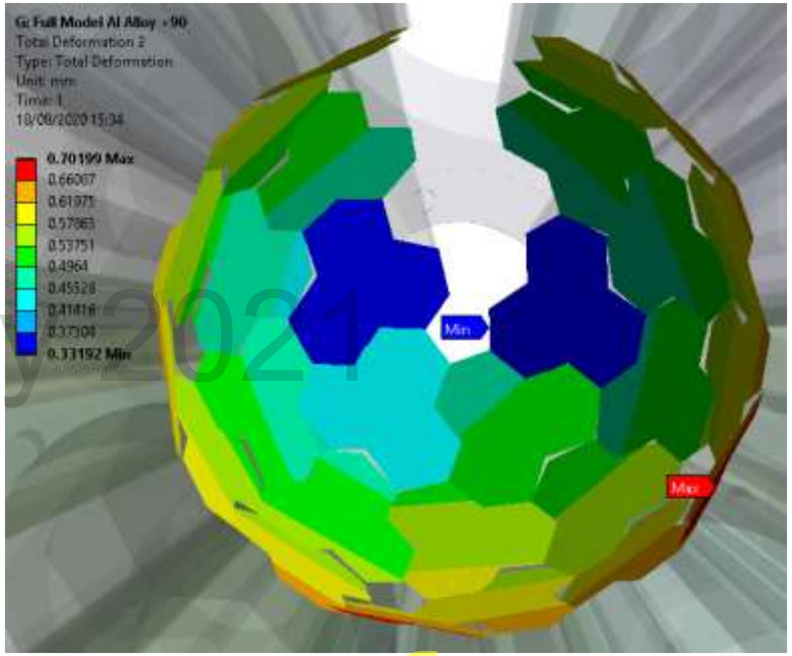












-90° 0° +90°

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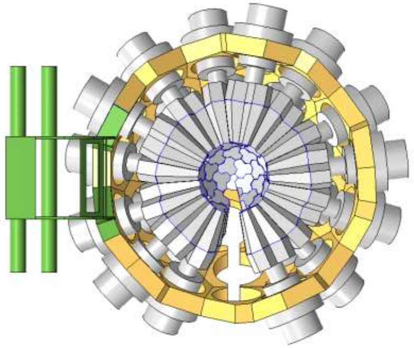
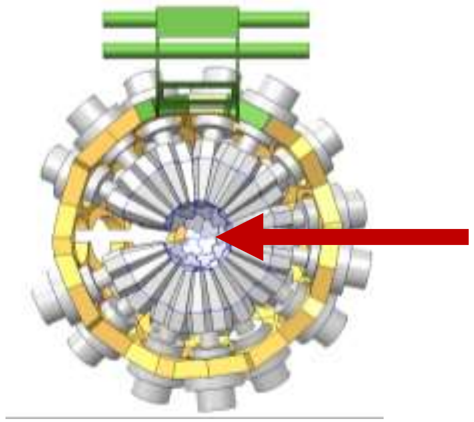
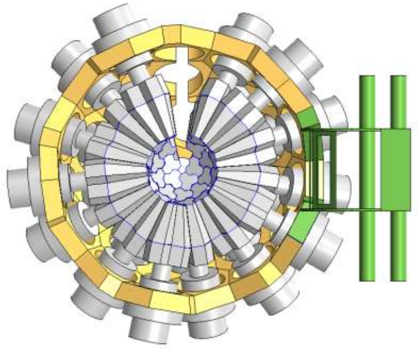
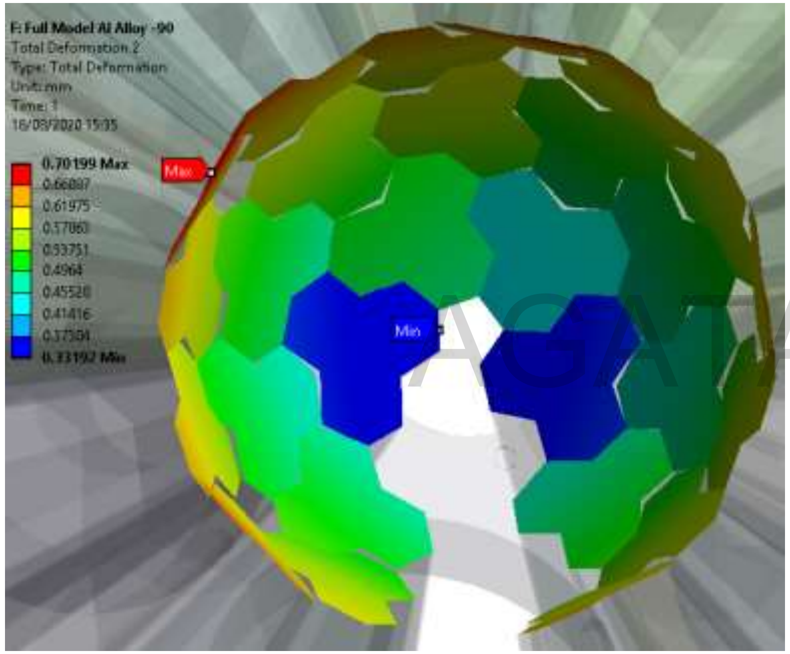
The triple cluster's deflections range from 0.33 - 0.78 mm, in the same direction

Nominal clearance between clusters ~1.0mm - 0.5mm

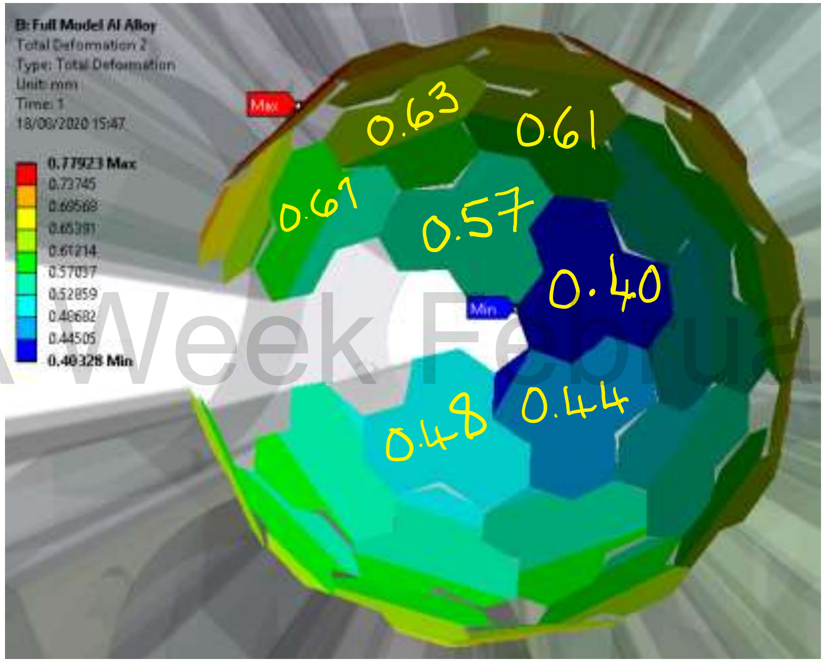




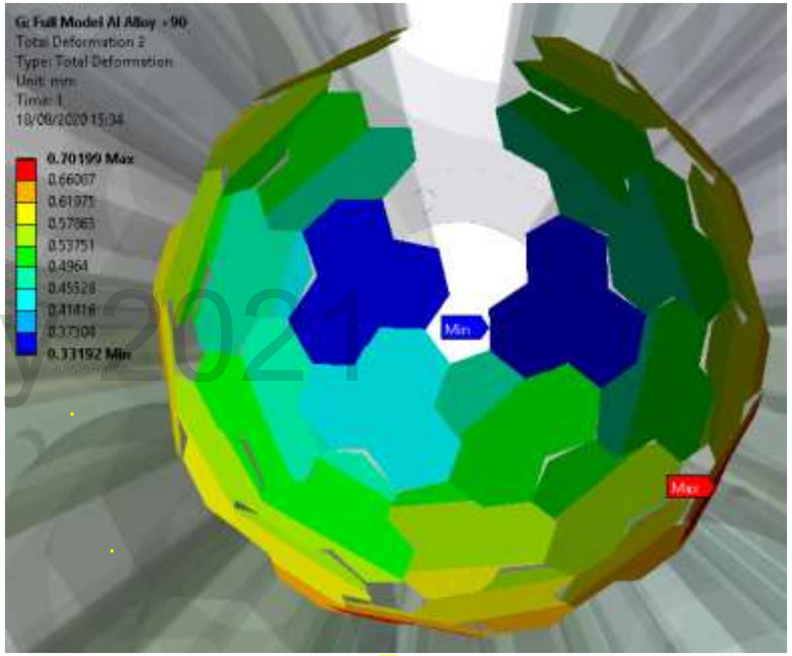




-90°



0°



+90°

Science and Technology Facilities Council

The triple cluster’s deflections range from 0.33 - 0.78 mm, in the same direction

The relative movement of neighbouring triple clusters is less than 0.2 mm

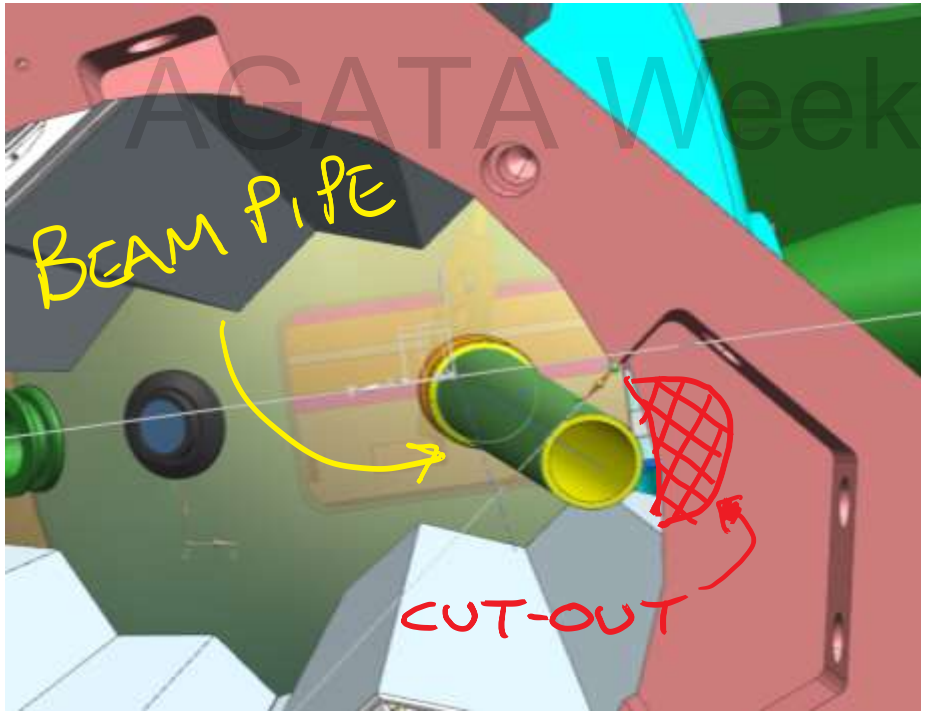
FEA – Main takeaways

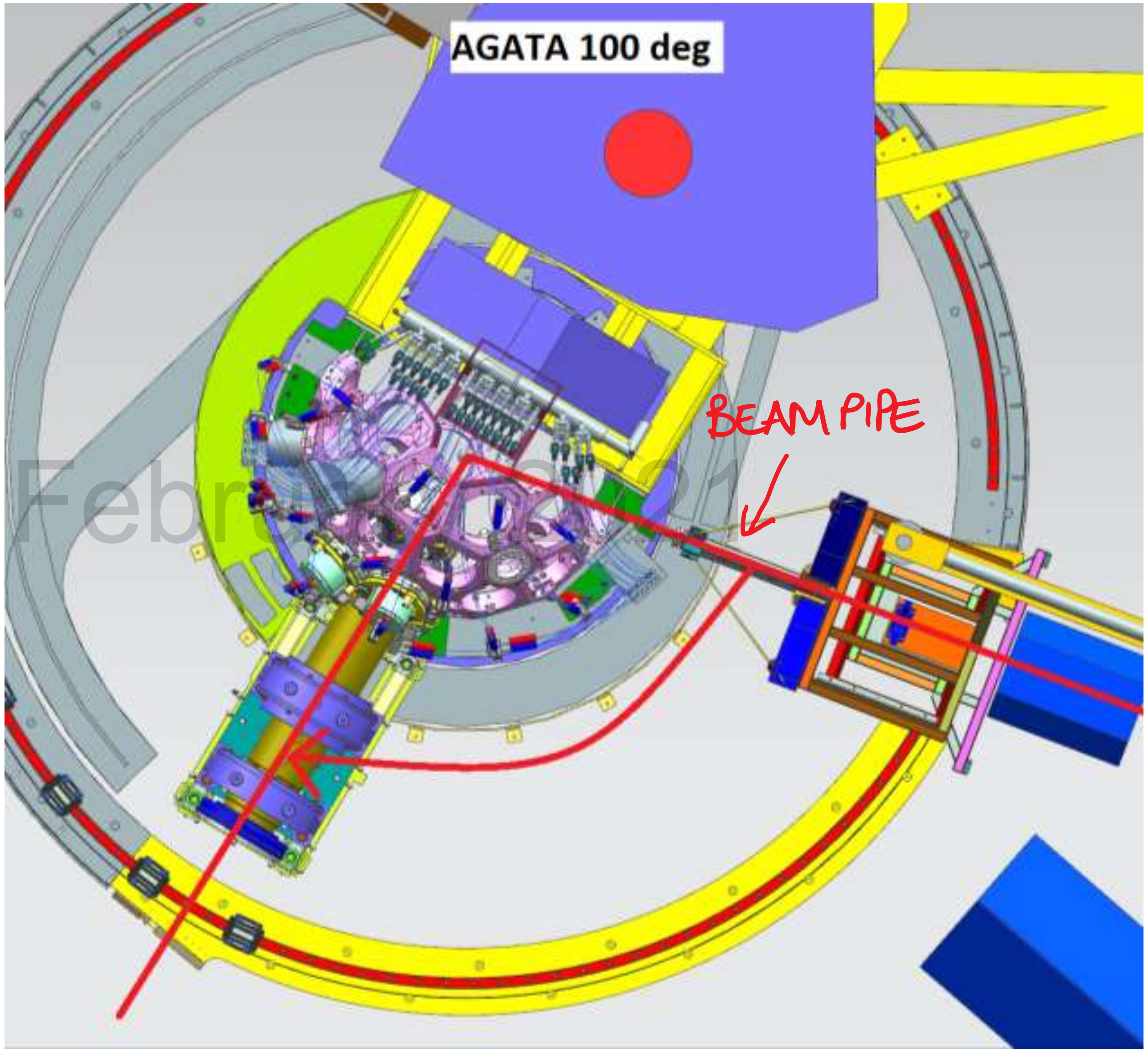
- Shaft deflection insignificant
- Main deflection due to the array pivoting at the interface between shaft and array
- Max triple cluster deflection 0.78mm
- **Relative movement of neighbouring triple clusters is less than 0.2 mm for all load cases**
- Minimal compression of the array, but it does deform slightly
- Manufacturing & alignment errors the biggest issue when it comes to potential clashes

It is recommended that when installing all the triple clusters for the first time, do not drive them in to their final position until all the clusters have been fitted and no further rotation of the array is required.

FEA - Flange #26 cut-out at LNL

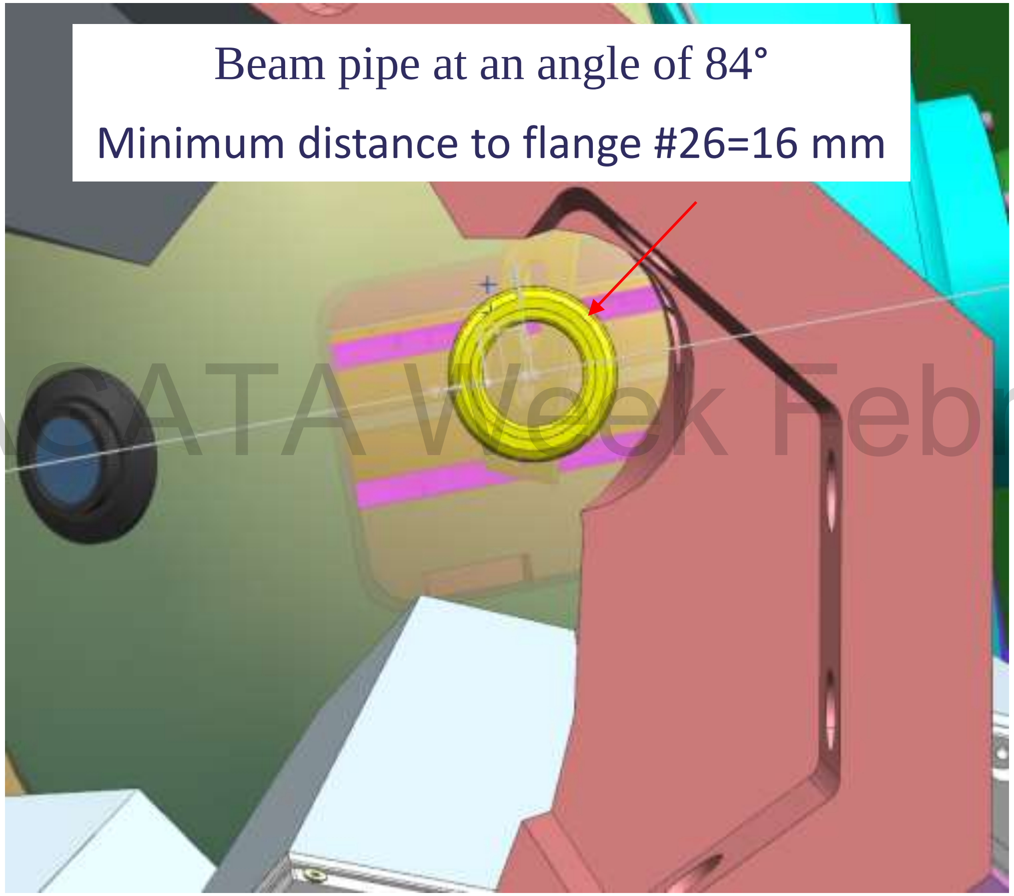
- Flange aperture restriction on beam pipe
- Limits beam range between 80° - 99°
- Proposal to add cut-out to outer flange

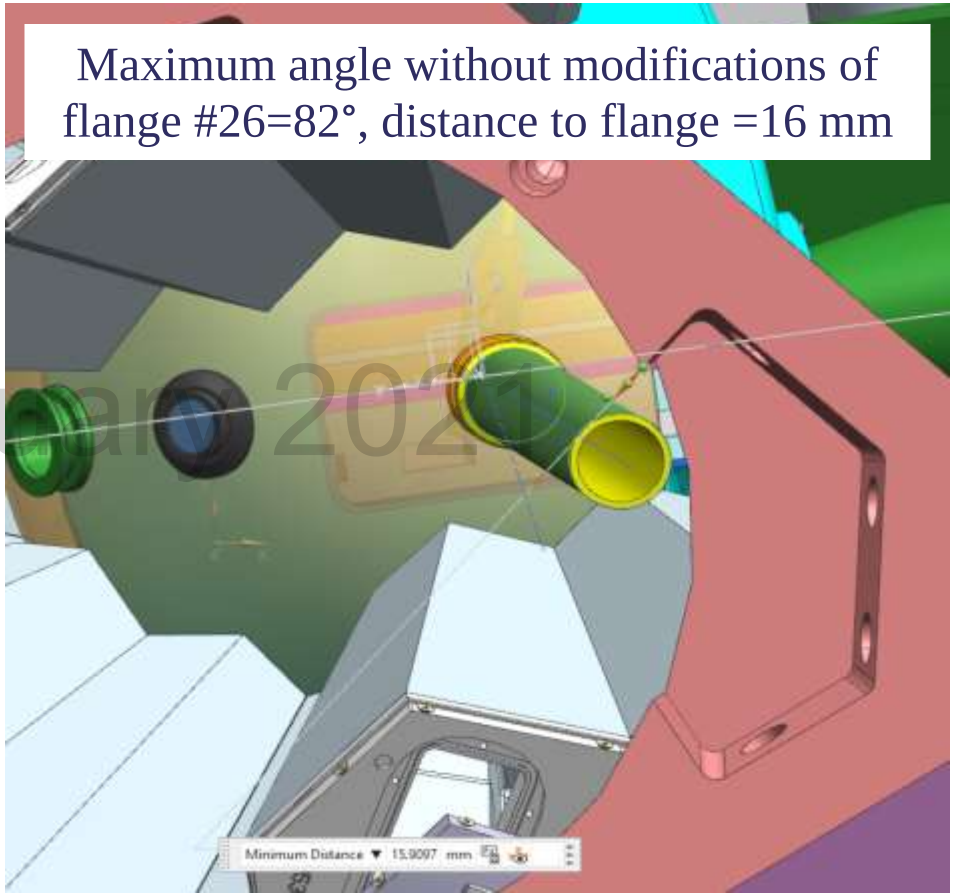




Flange #26 Cut-out

Details provided by Giovanna Benzoni and flange model from Fabio Tomasi





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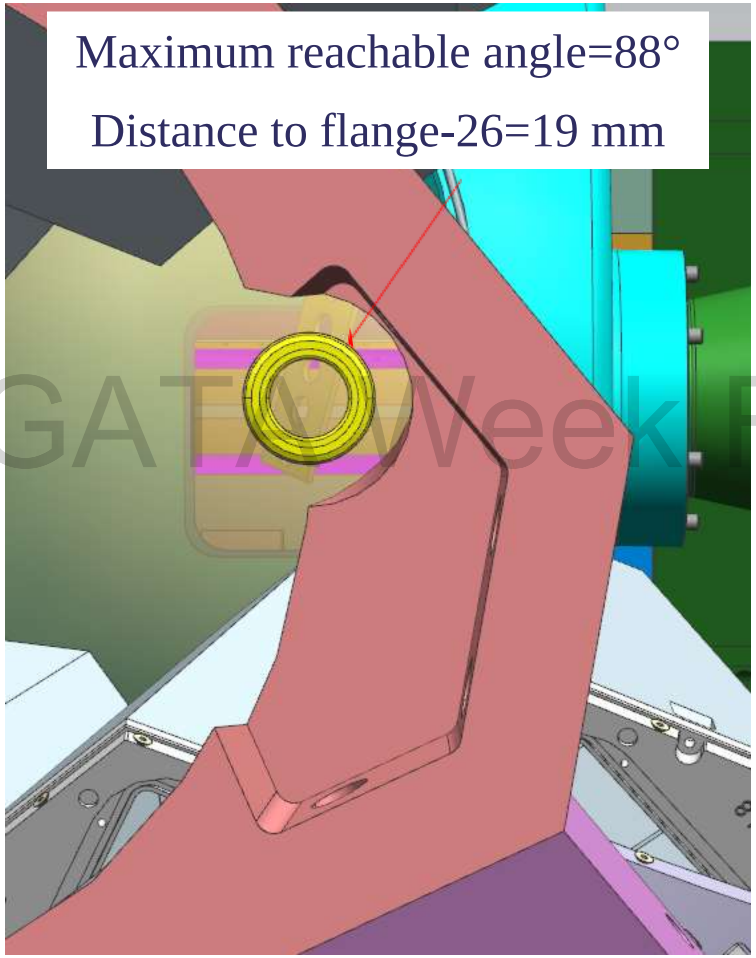
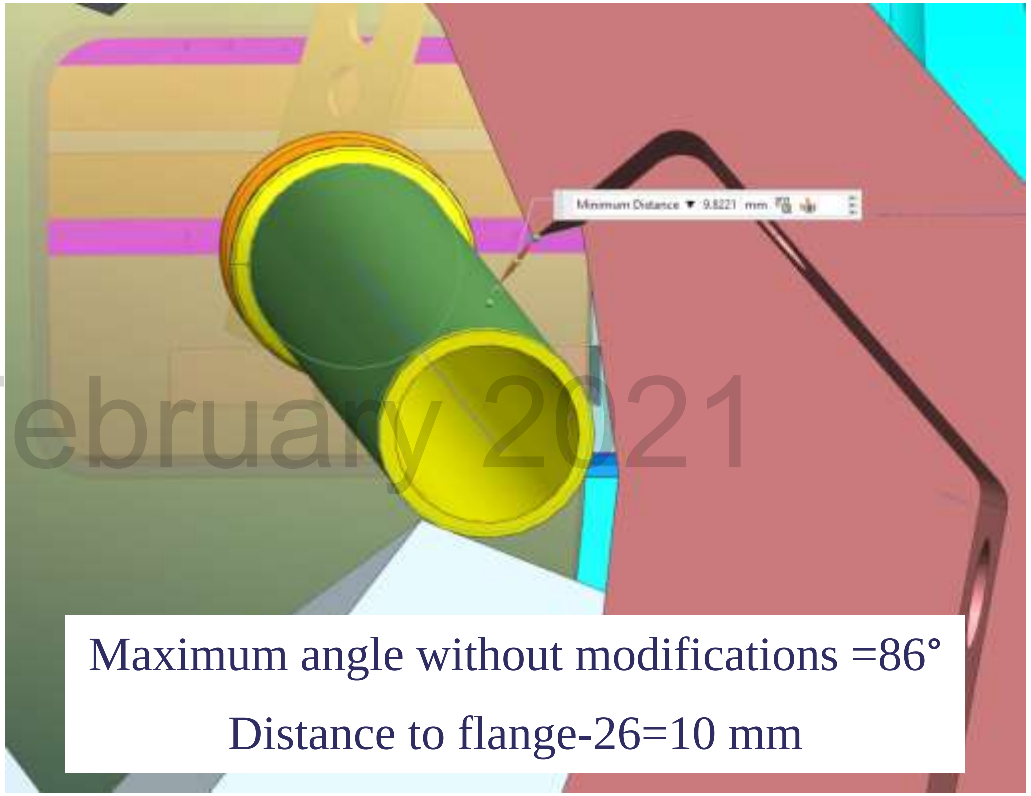
AGATA Nominal Position = 0 mm

Flange #26 Cut-out

Details provided by Giovanna Benzoni and flange model from Fabio Tomasi





Maximum. efficiency=+ 55 mm

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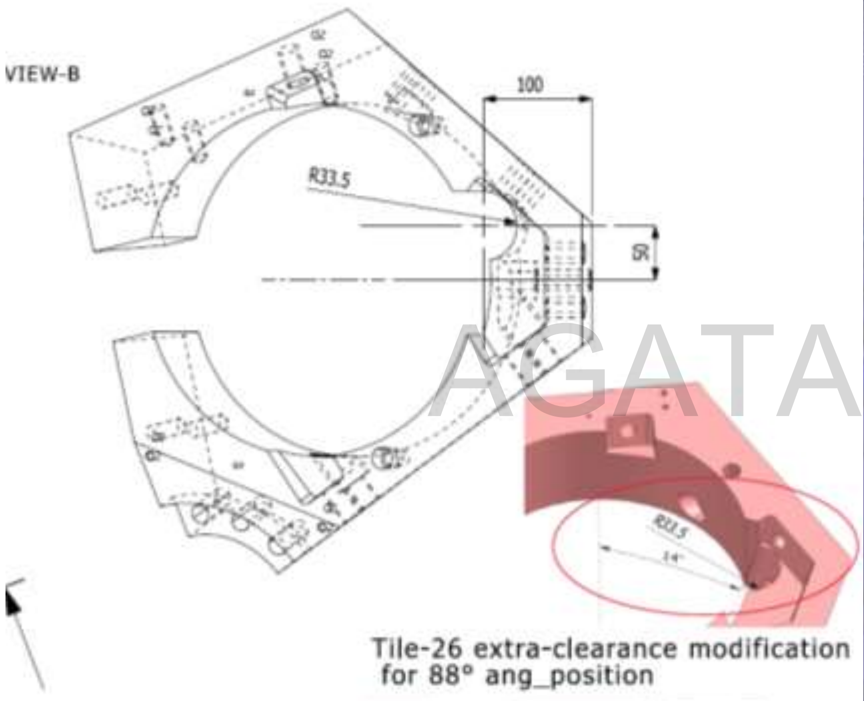
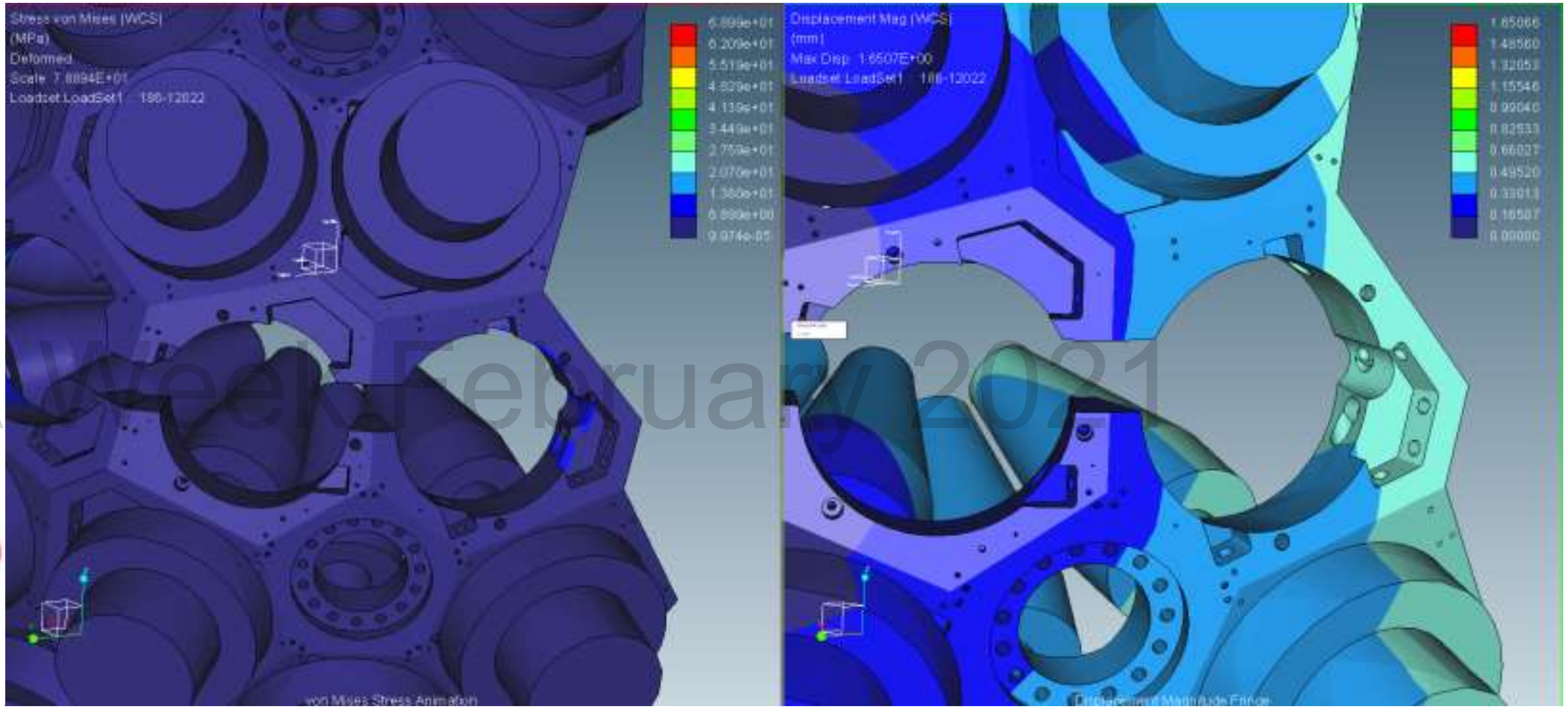
FEA - Flange #26 conclusion

Extra cut-out to flange #26 has minor effect on stress and negligible impact on deflection





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Support Structure Manufacture & Assembly Progress

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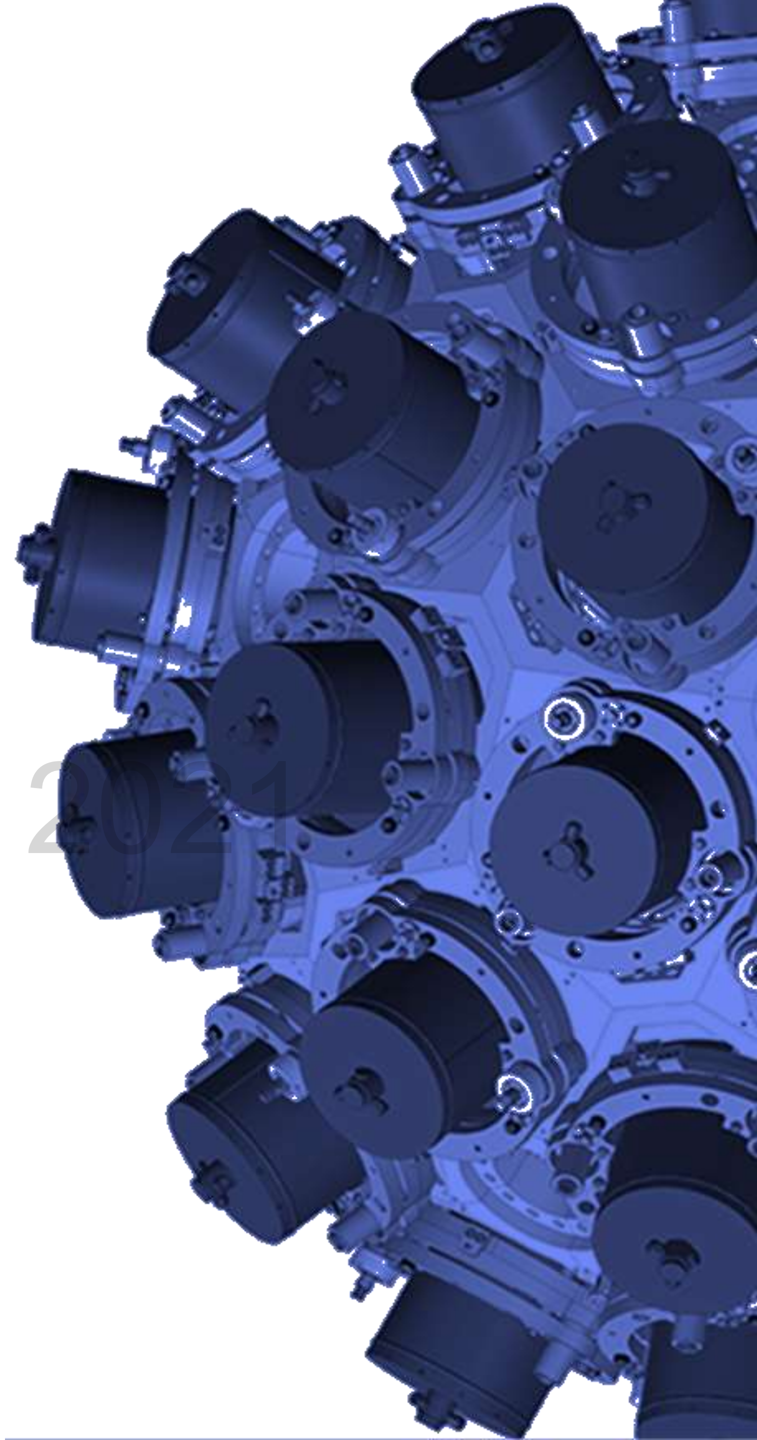

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November 2020

November 2020

November 2020

December 2020

December 2020

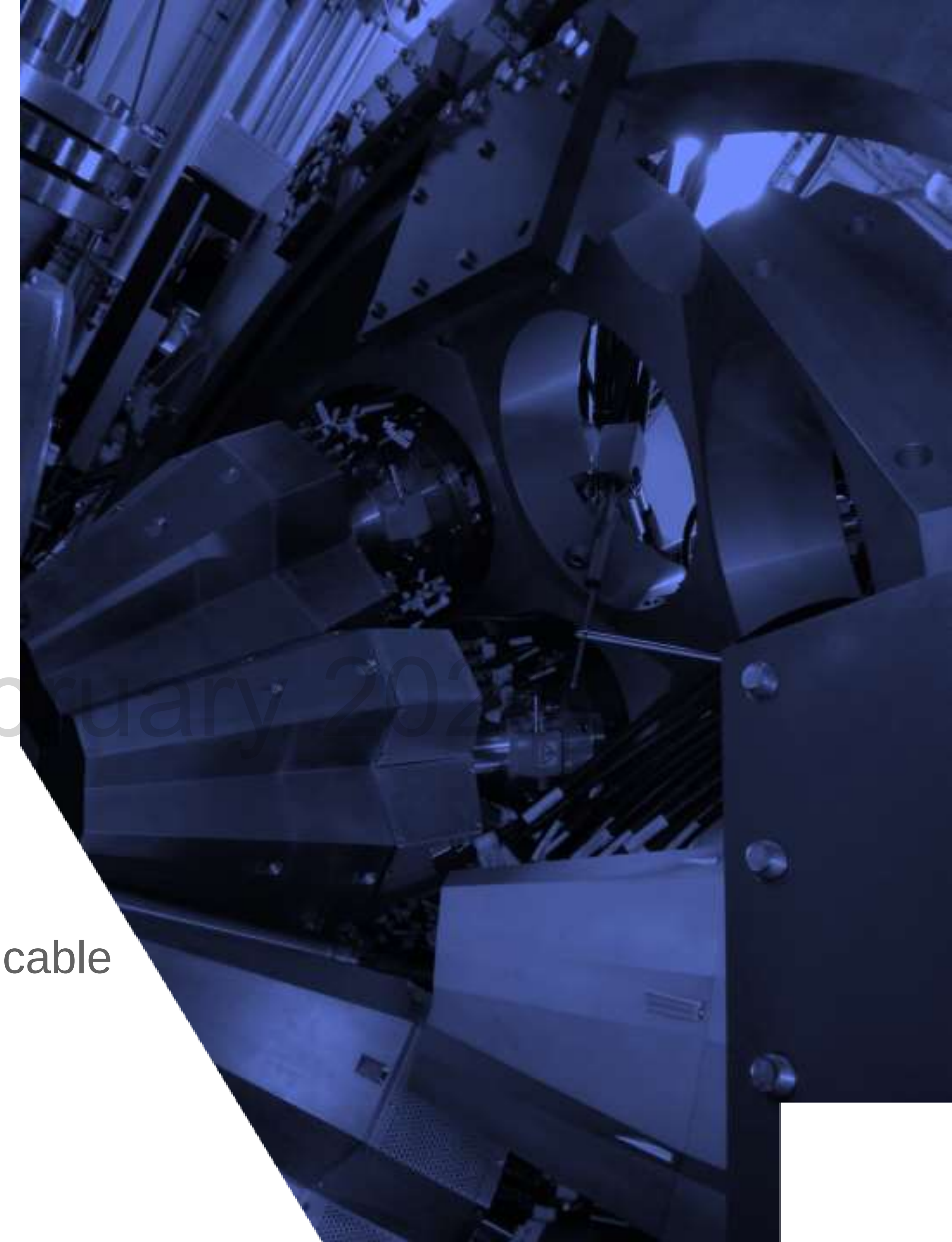

December 2020

January 2021

February 2021

Motion control system

- Absolute optical encoder (rotation control)
- Software limits
- Mechanical limit switches
- Mechanical stop
- 2 motion stop buttons on the support
- 1 extra motion stop to be mounted at Legnaro
- Remote jog box control +/- (with fast jog) on a 5m cable



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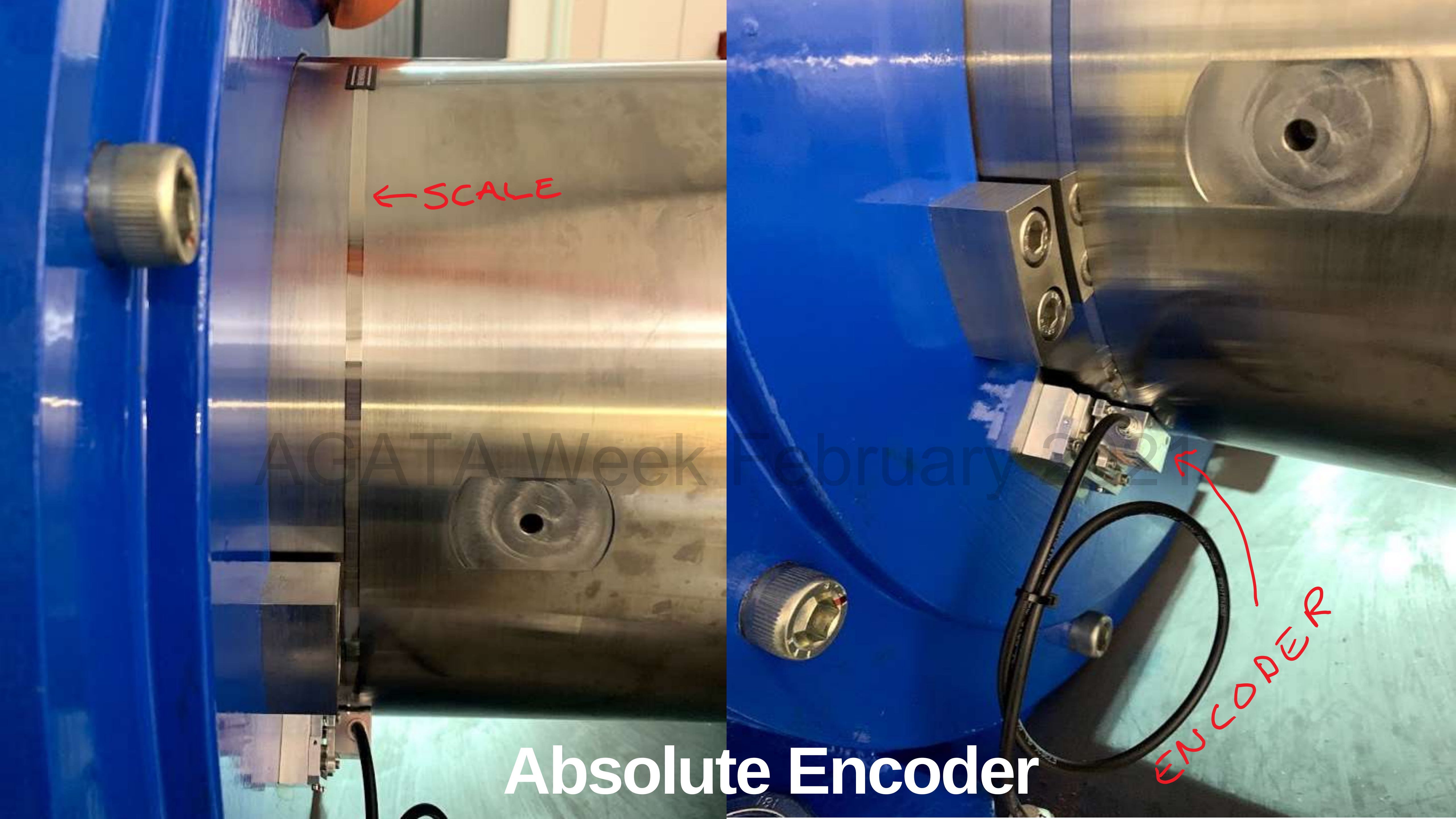
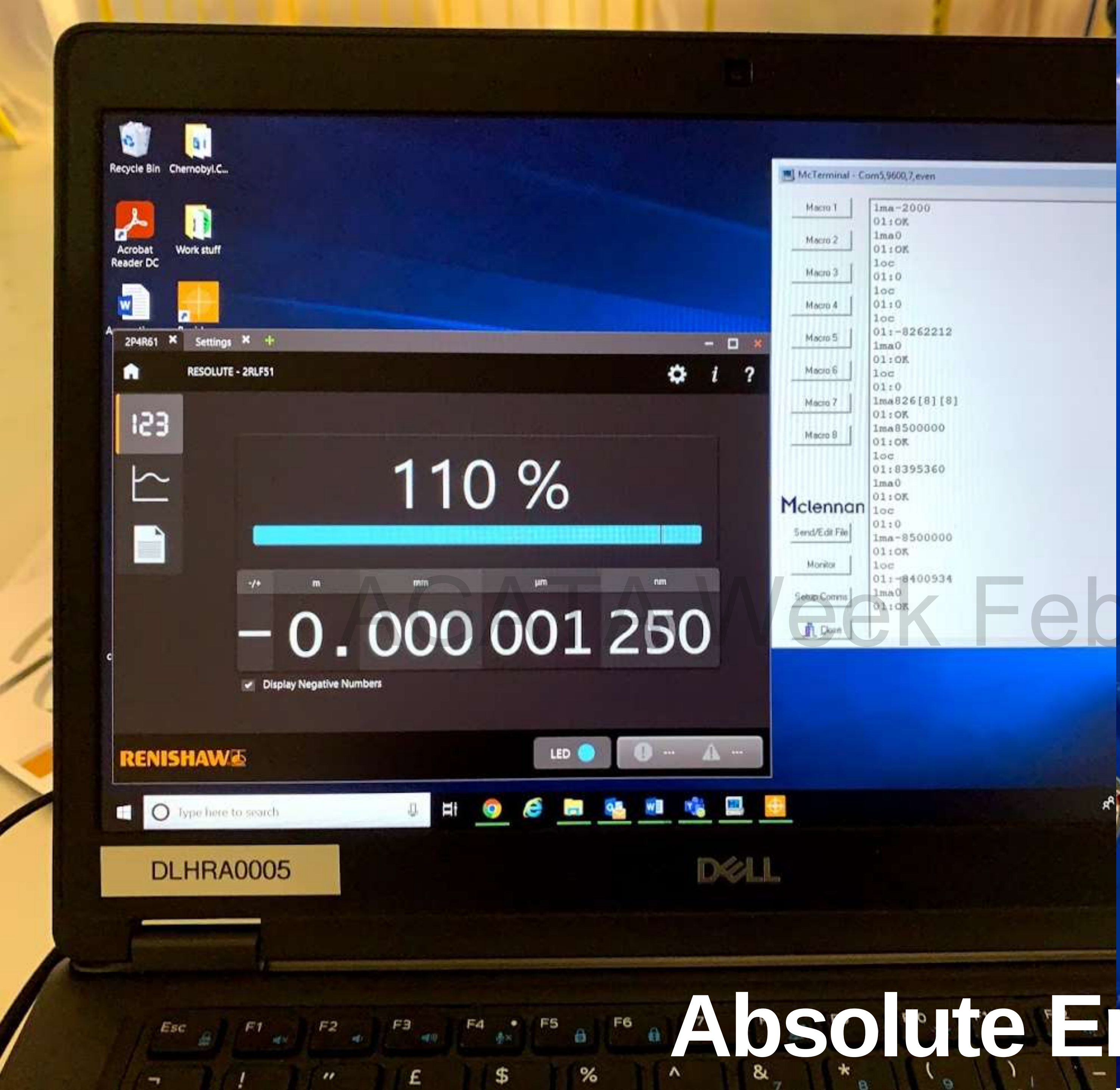
Absolute Encoder





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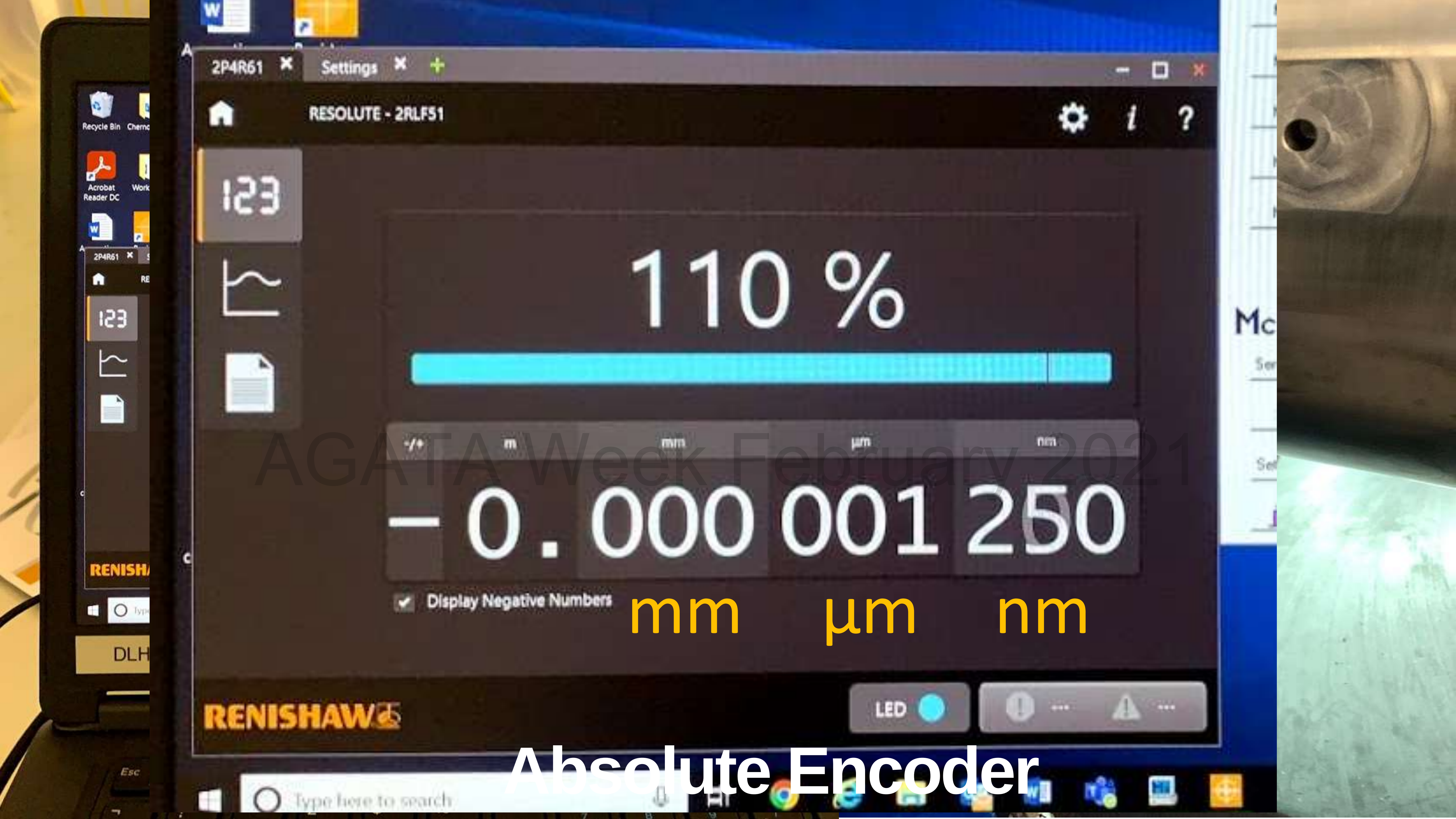
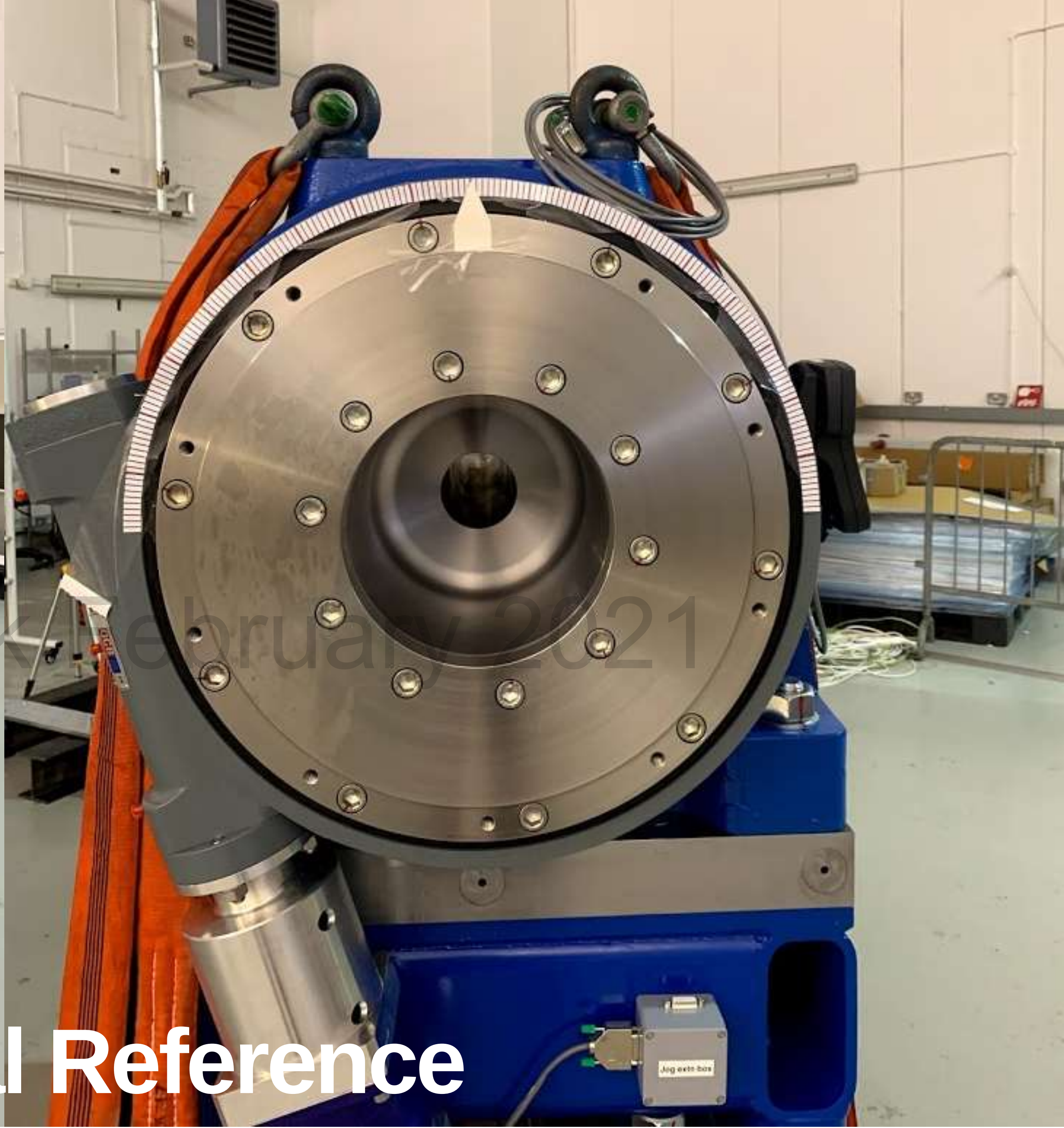
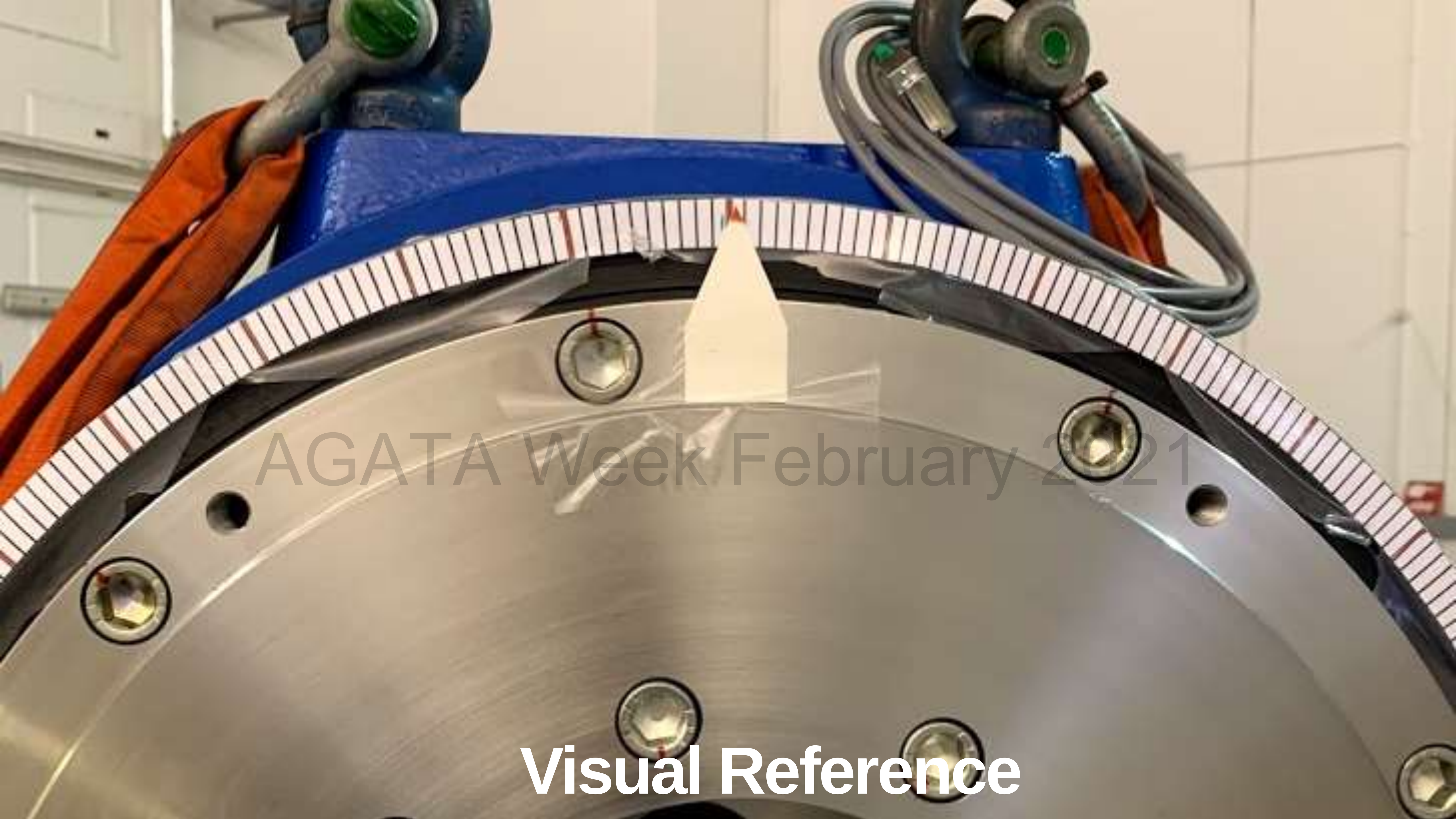
Absolute Encoder



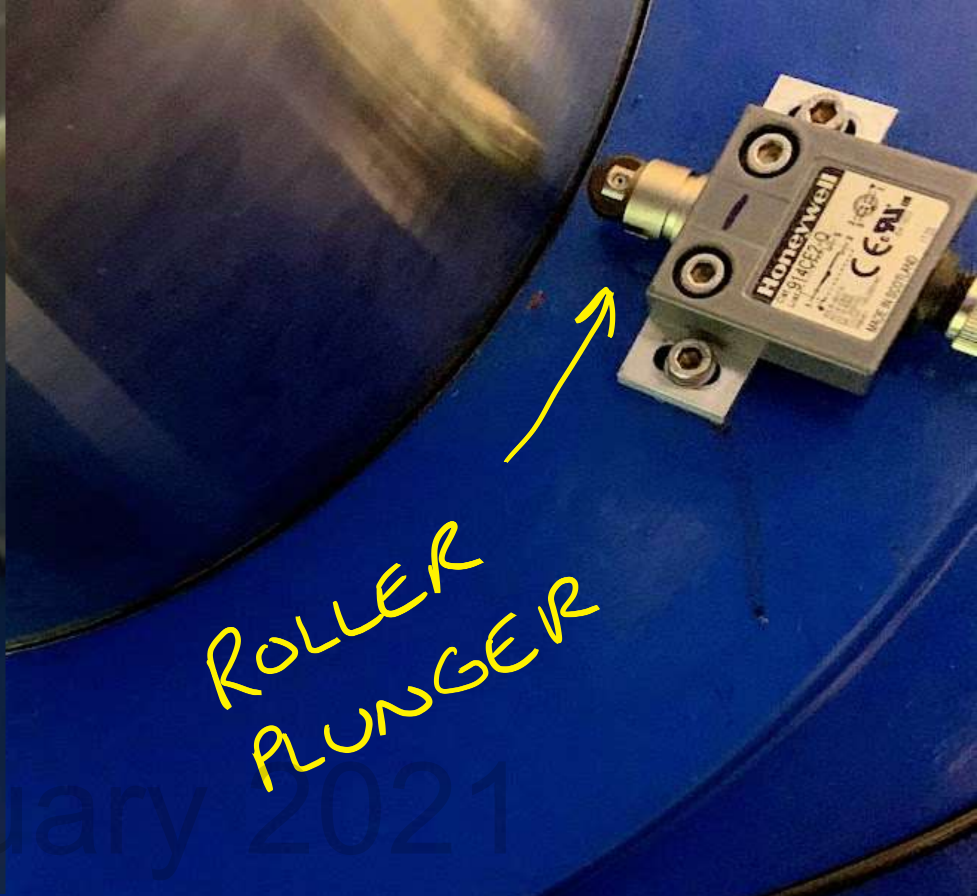
Absolute Encoder

Visual Reference




AGATA Week February 2021
Visual Reference

Mechanical limit switches



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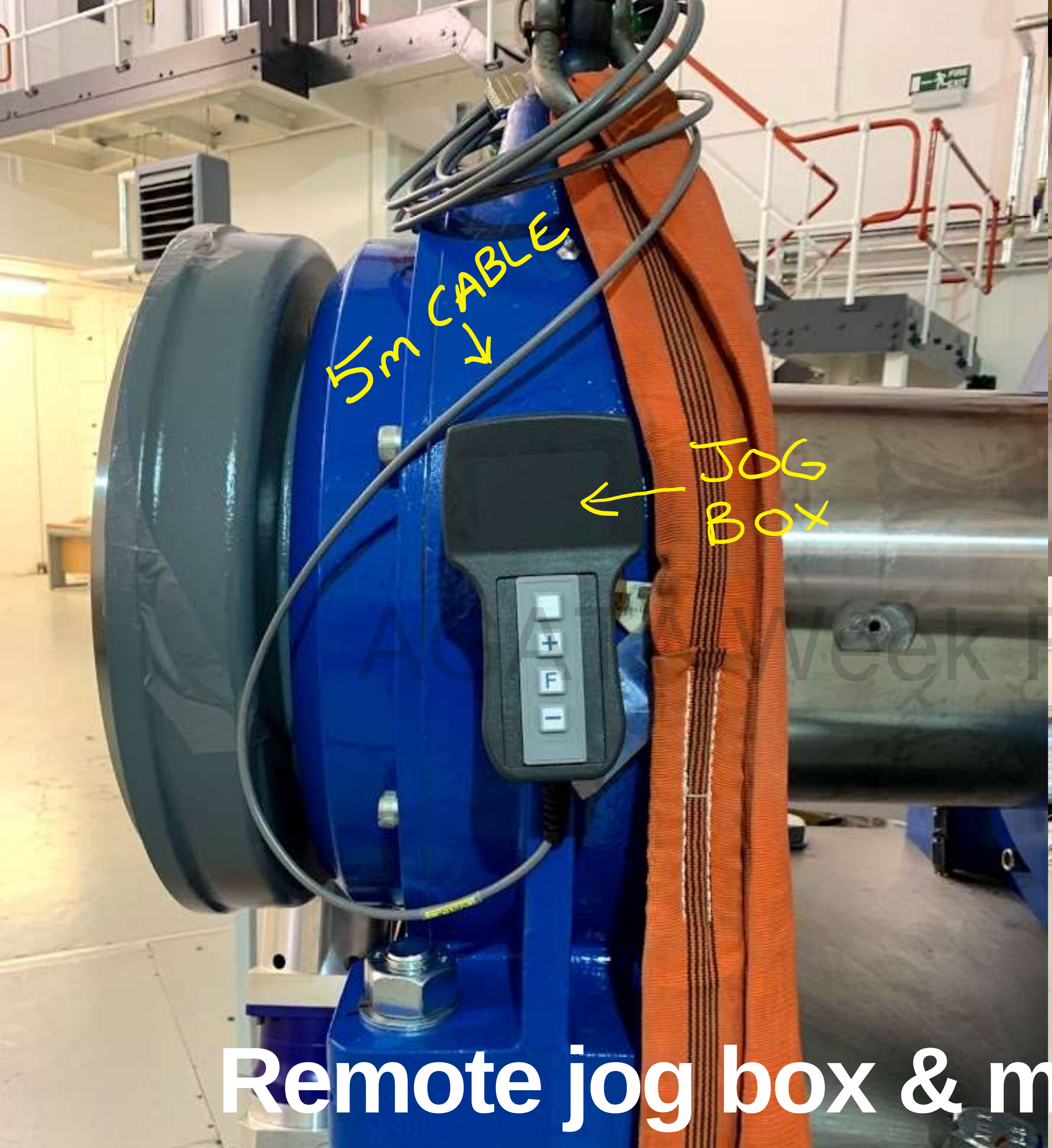
Mechanical limit switches



Remote jog box & motion stop buttons

What is next for the support?

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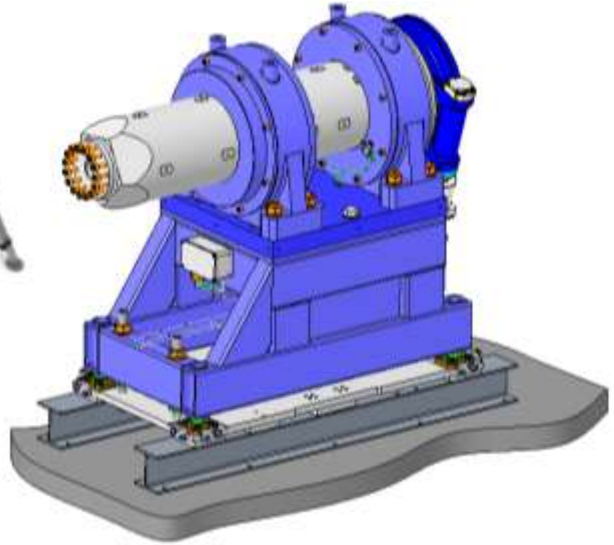
Facilities Council

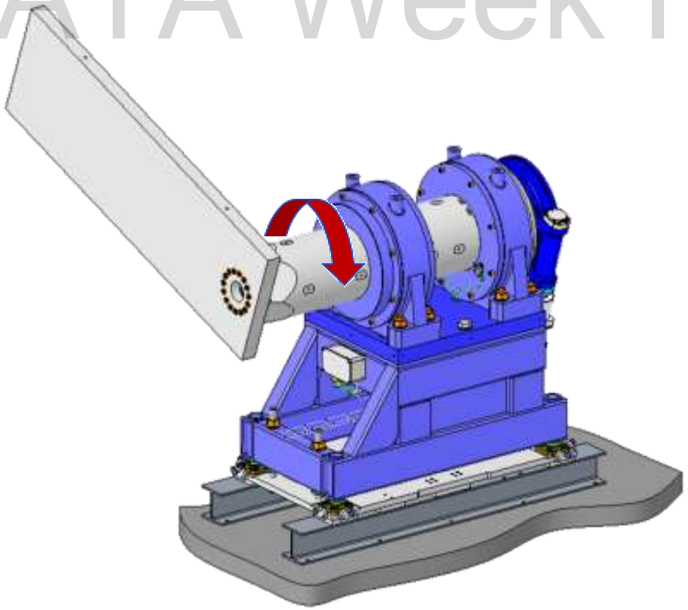
Mechanical tests

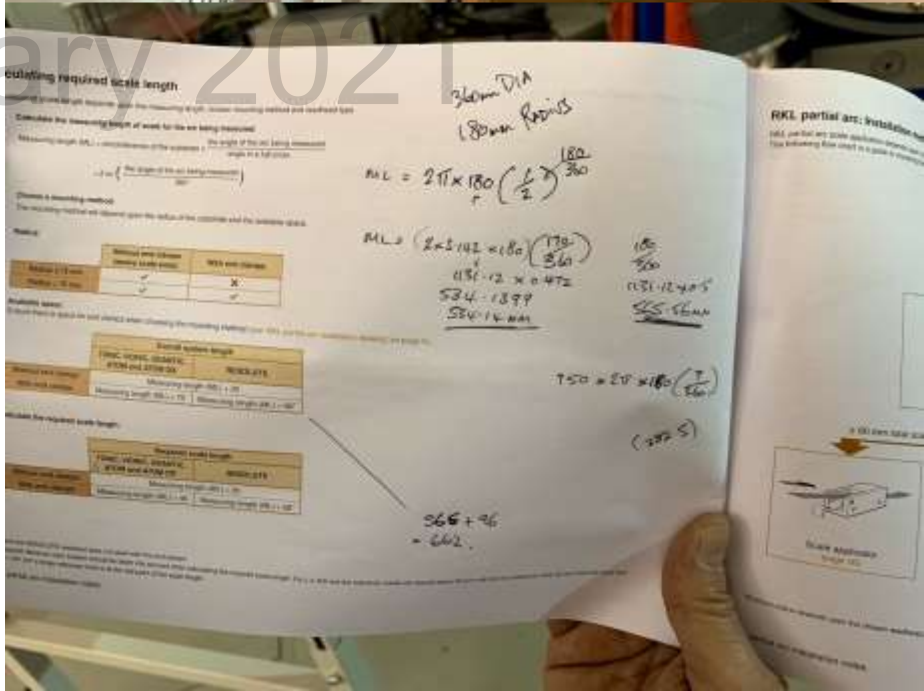
- Anchor support to floor
- Survey and align (obtain baseline figures)
- Rotate 750kg test weight (offset load of 5 ATCs + manifold)
- Evaluate mechanical performance
- Further load tests with increased load



Control system tests

- Repeatability tests with weight
- Tune (detune) the system (encoder sensitivity window)
- Set suitable acceleration profile
- Support complete – On target for end of March





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Associated Mechanics

AGATA Week February 202

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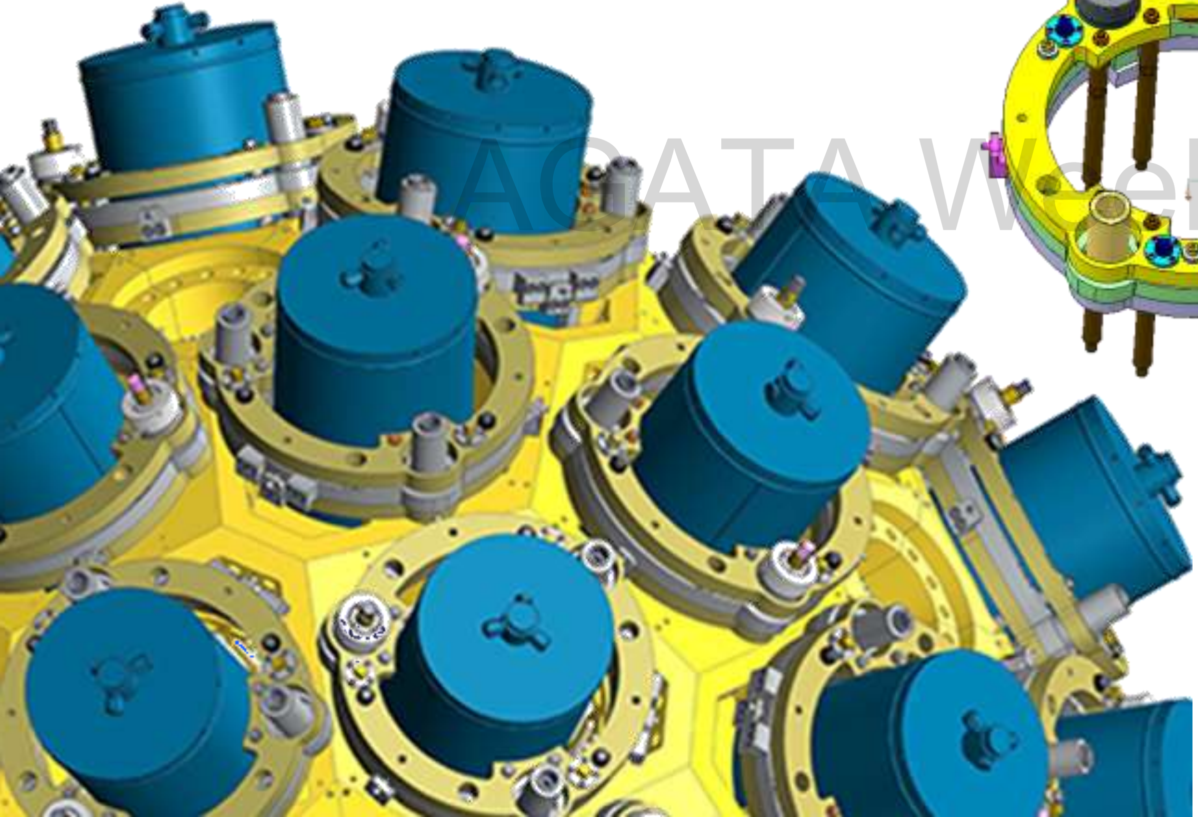
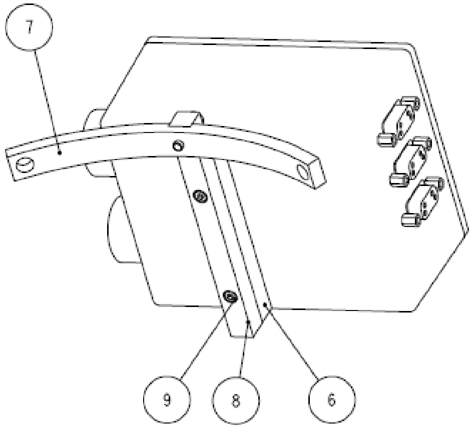
ATC mount rings

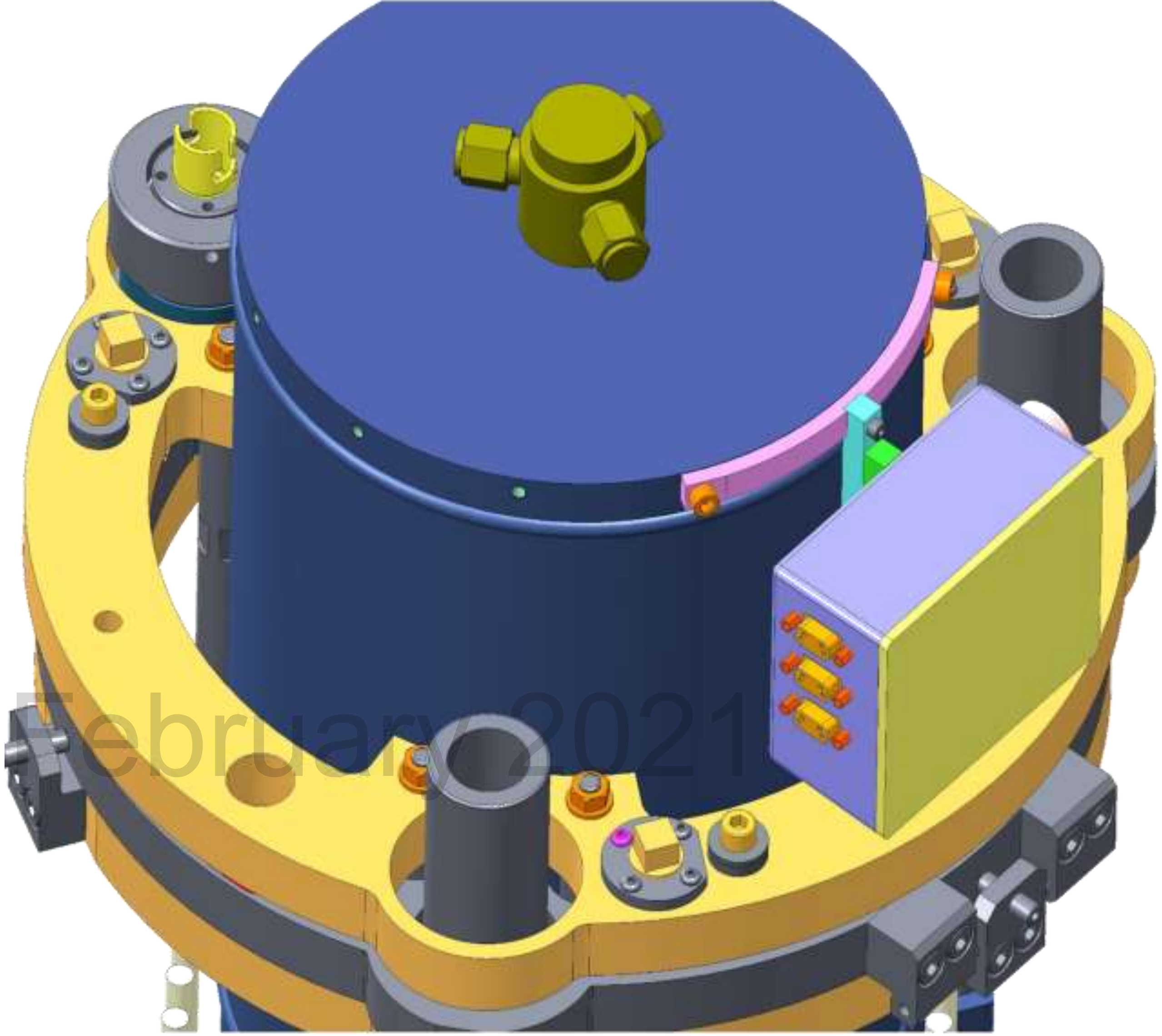
- 10 rings assembled at Daresbury
- Completed and ready to ship



Patch box

- Two piece construction
- Easier to access and remove
- Allows removal with ATC mounted
- Manufactured and ready to ship





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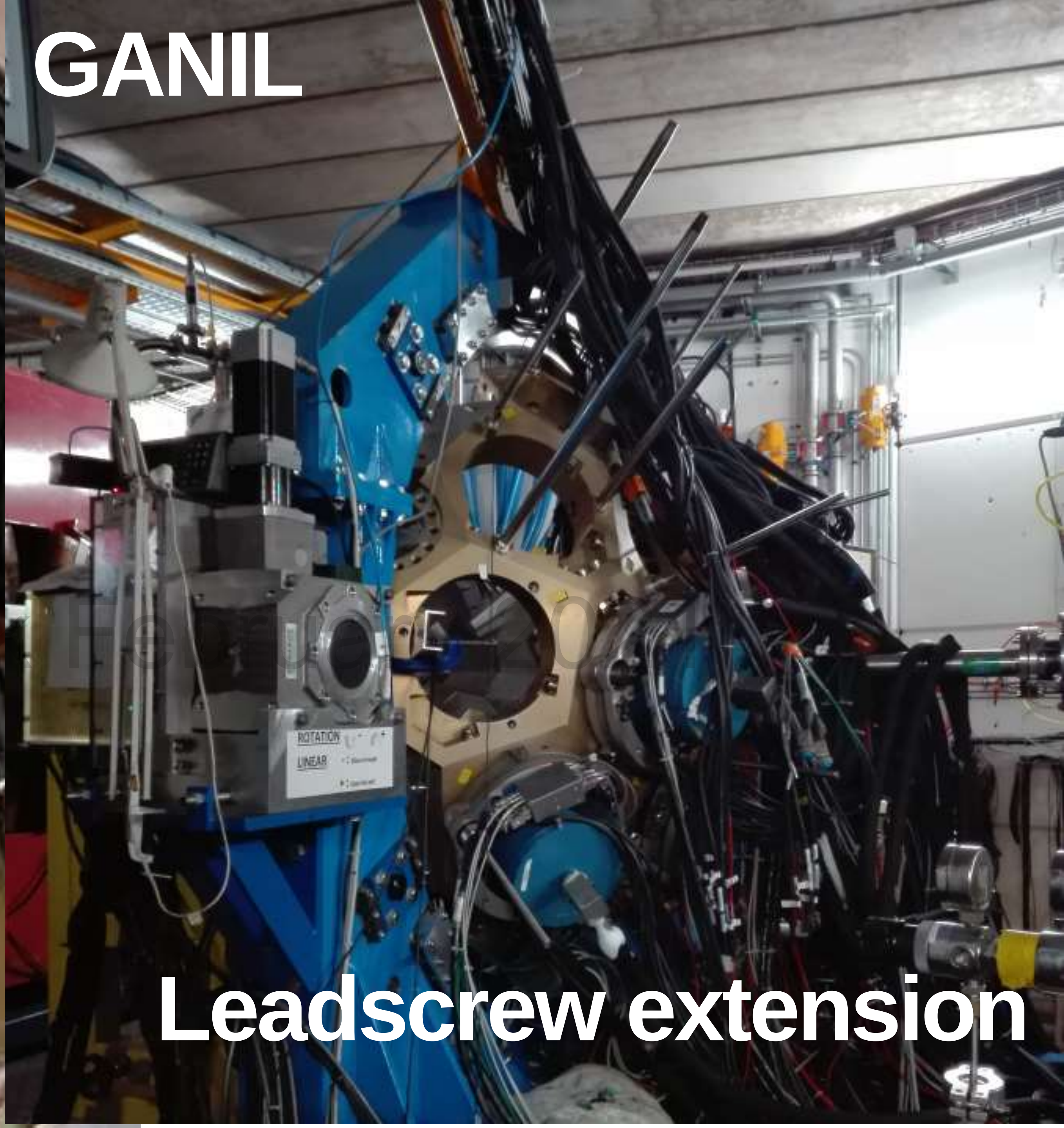
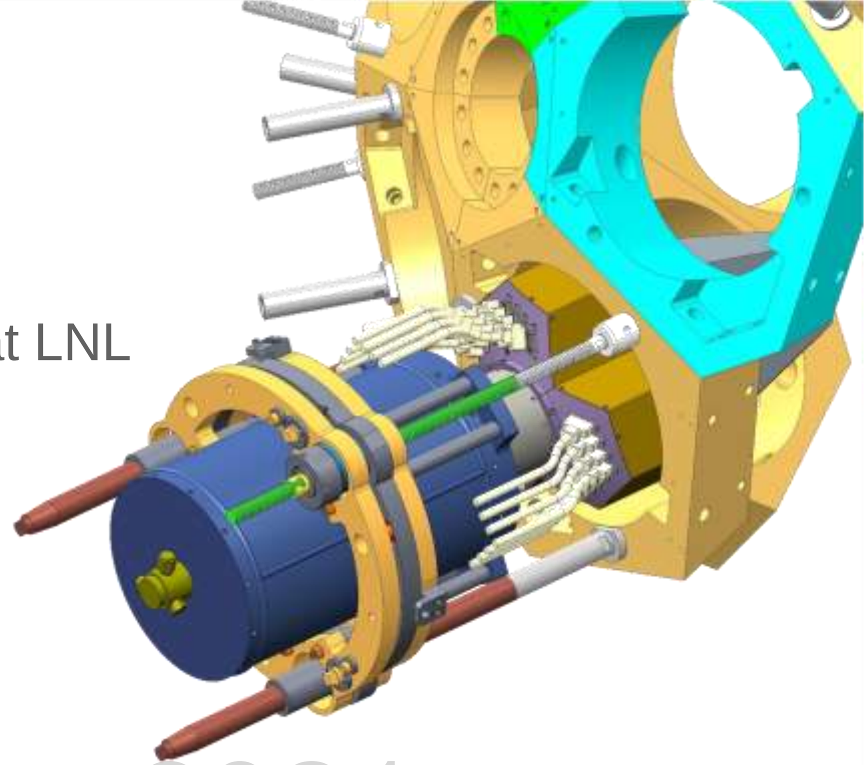
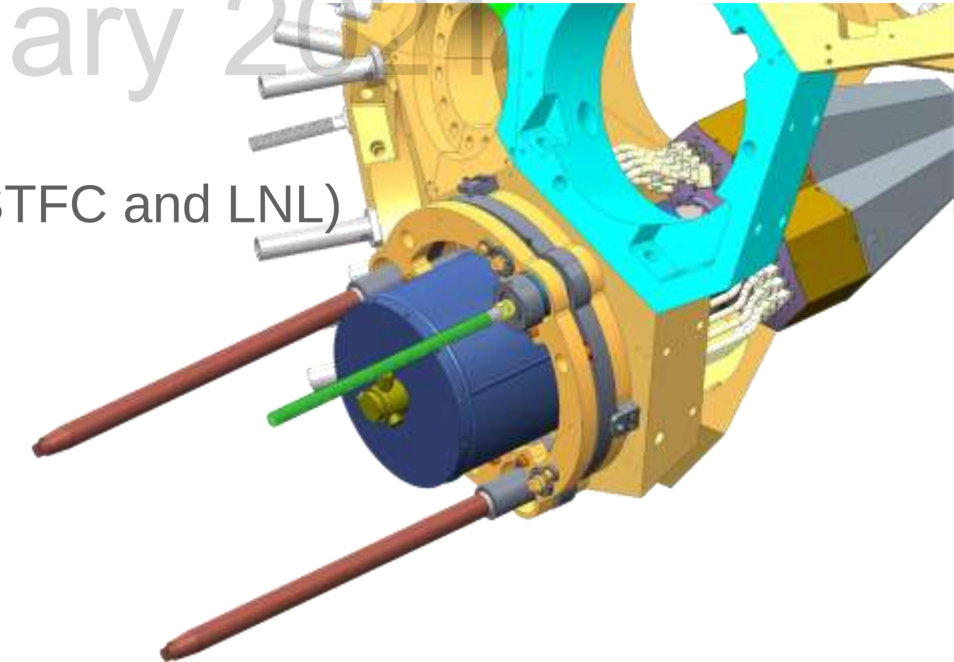

GANIL
ROTATION
LINEAR
Leadscrew extension

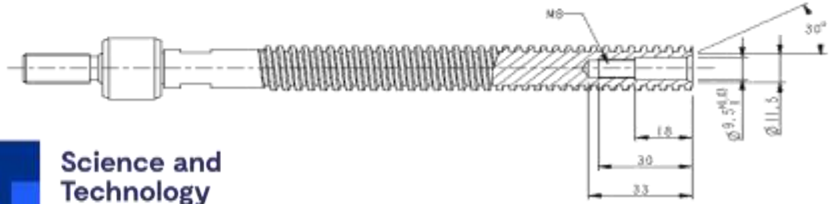

GANIL
ROTATION
LINEAR
Leadscrew extension

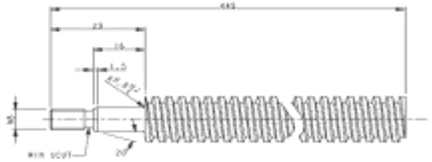
Leadscrew extension

- For clearance purposes the leadscrews have to be shorter at LNL
- Required to retract the triple cluster 400-500mm
- Two piece proposal
- Extension screw and additional ‘test’ nut
- Initial tests positive
- Modification would need to be done on all leadscrews (STFC and LNL)









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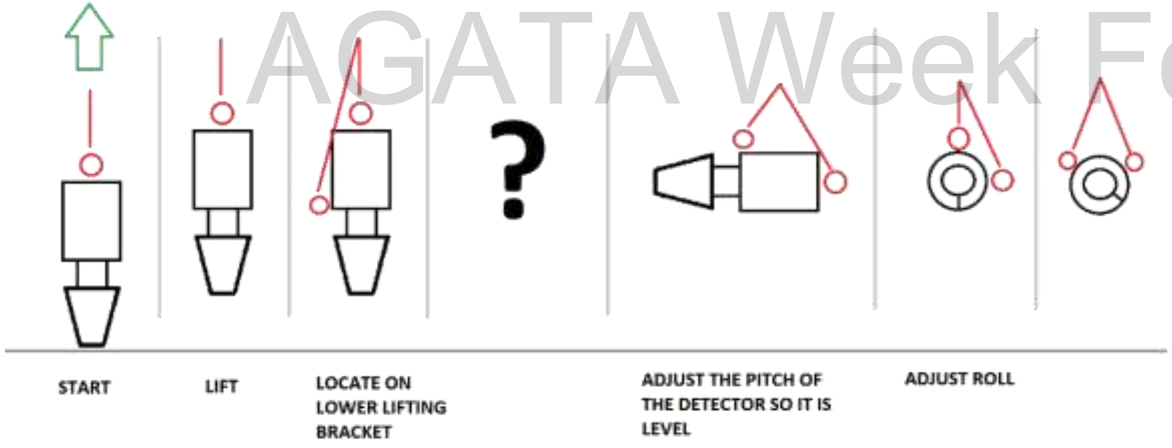
ATC handling & installation

ATC handling

- Working with lifting specialists to determine the optimal way to lift and rotate the ATC safely
- Tests restart once new lifting hardware delivered
- Installation with the dummy ATC and fixture at various angles to be included in tests



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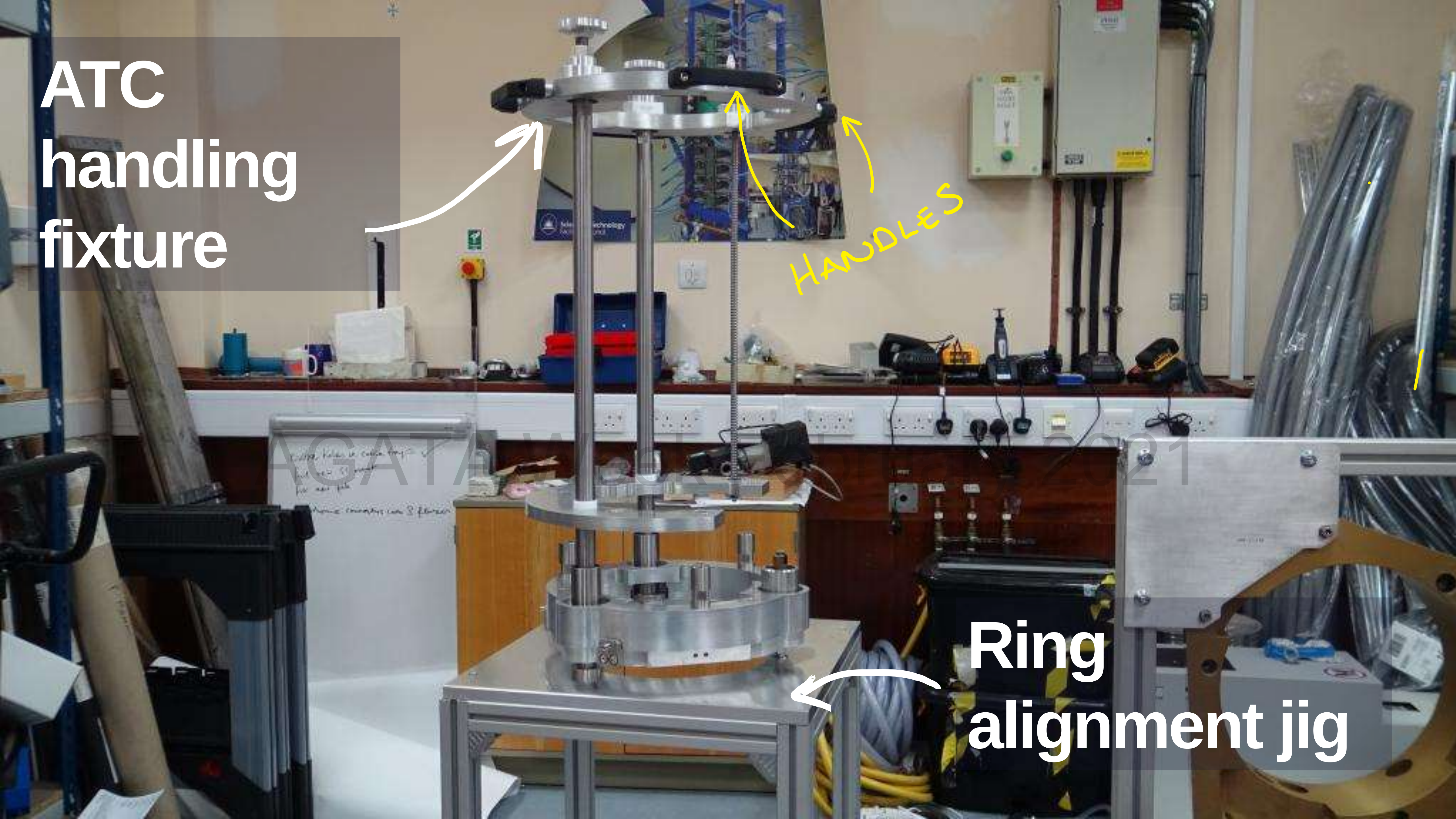
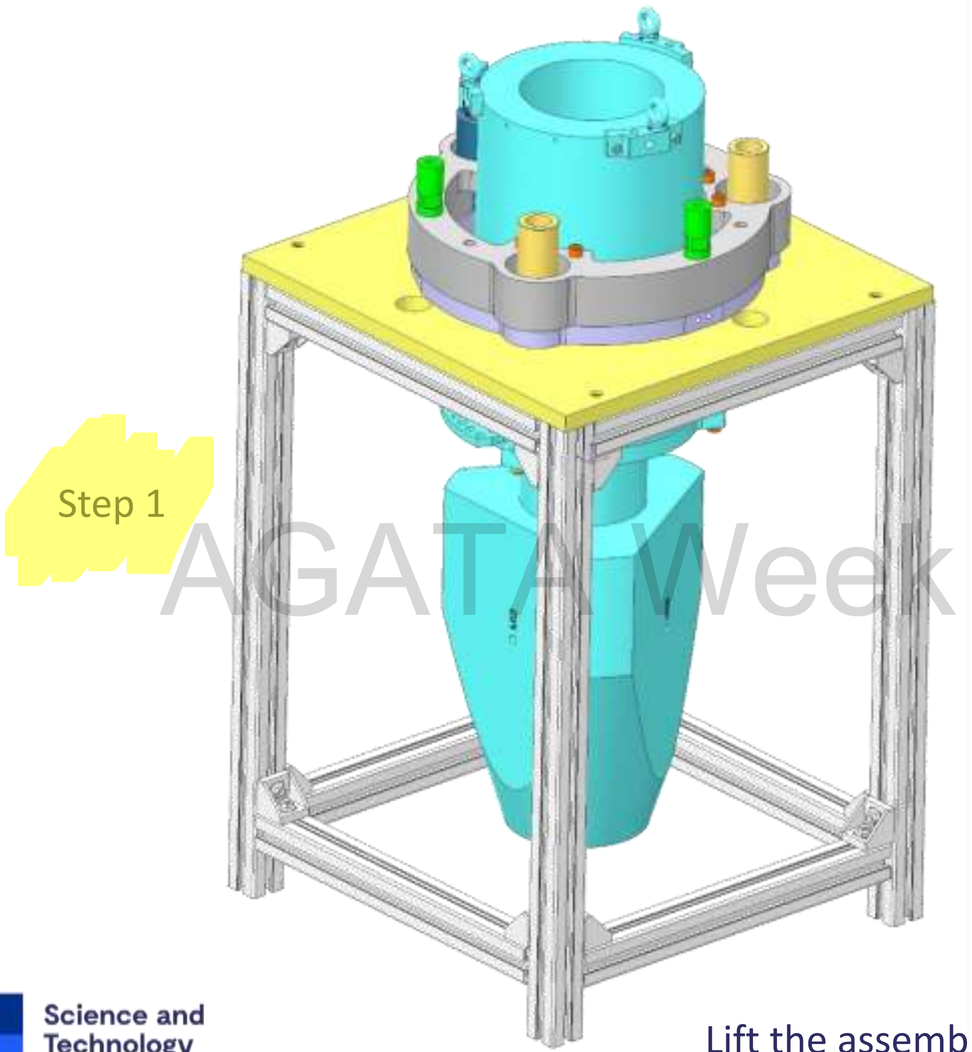
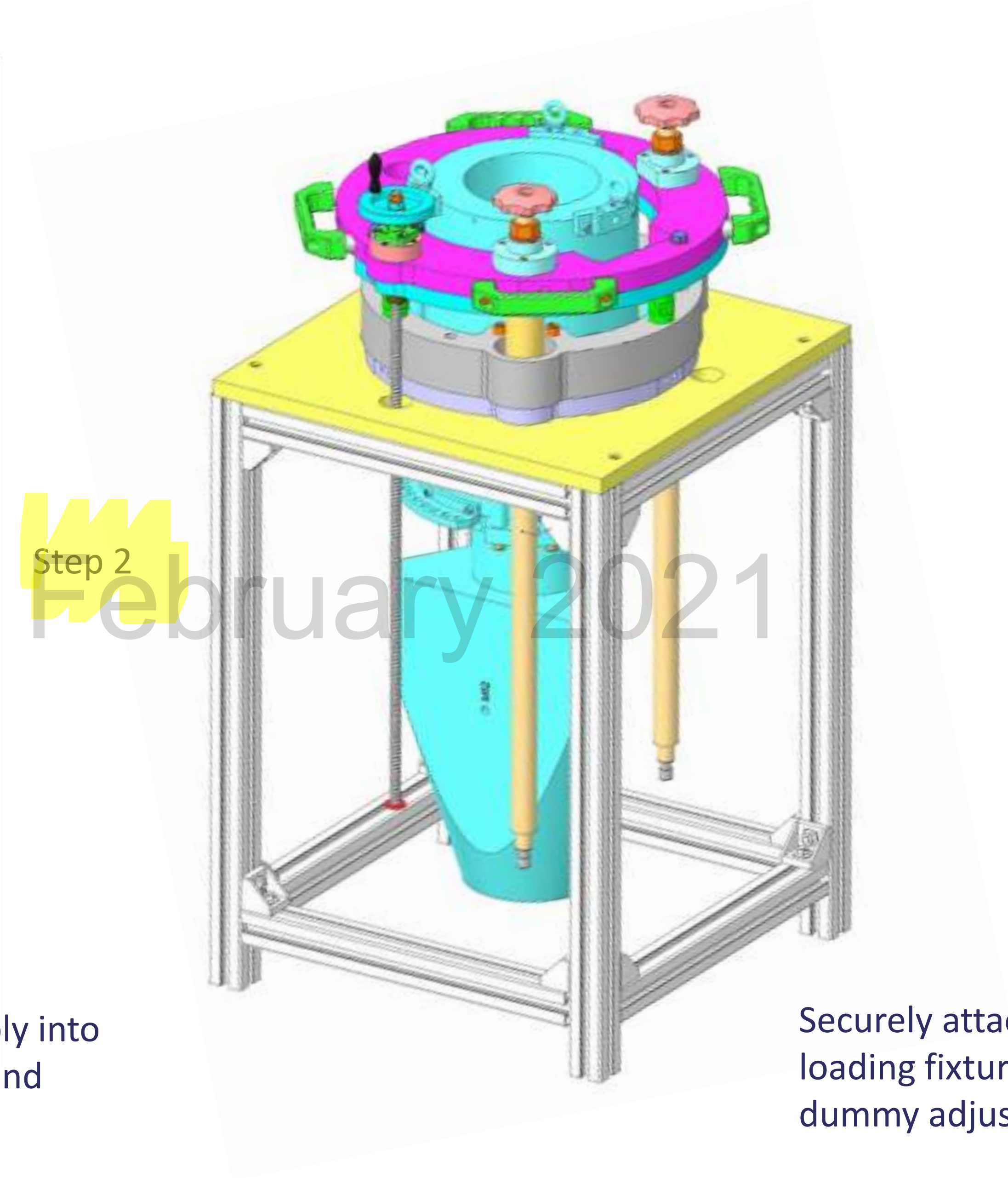

ATC handling fixture
HANDLES
Ring alignment jig

ATC handling fixture





Lift the assembly into the support stand

Securely attach the loading fixture to the dummy adjusting ring

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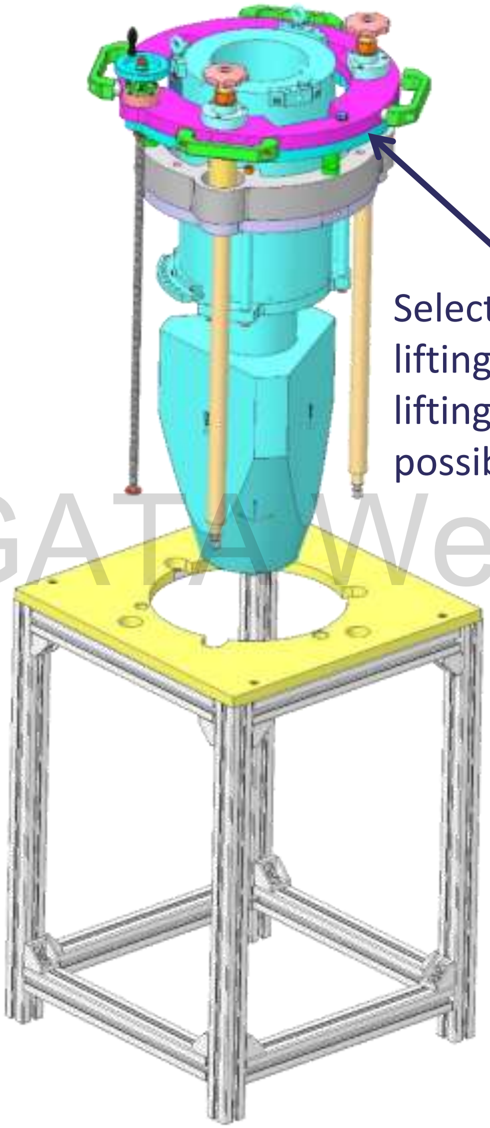
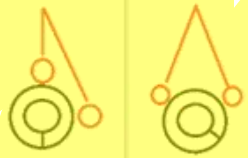
ATC handling fixture

Step 3

Lift the assembly from the tripod stand using a crane/hoist



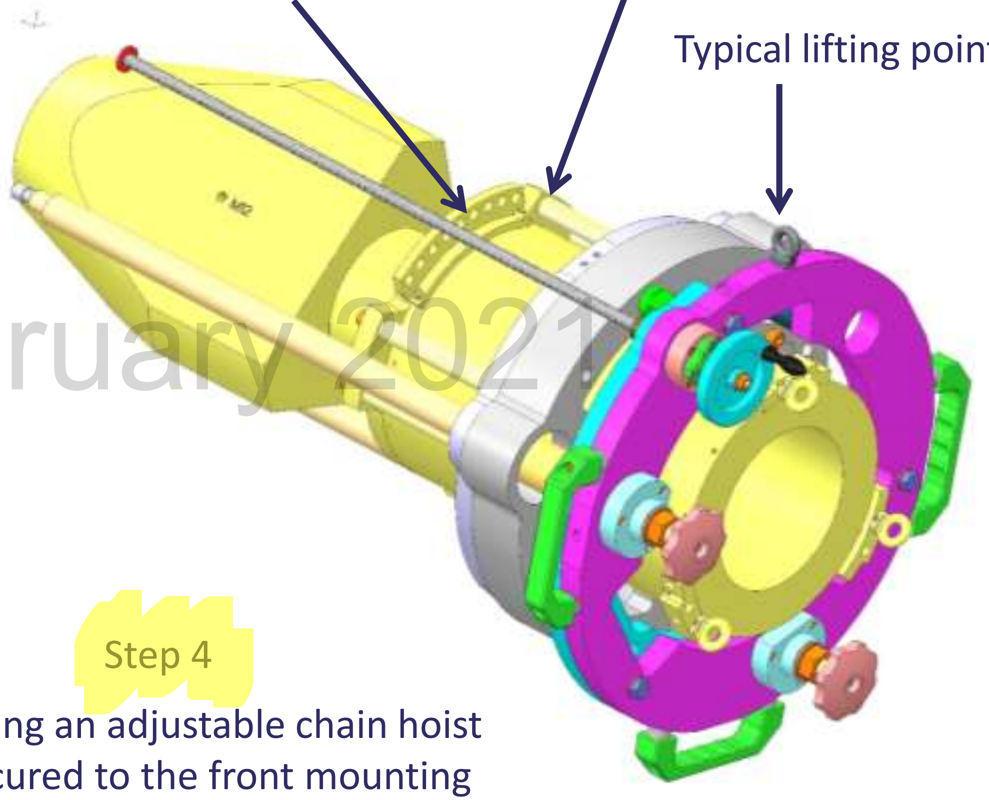
Select the appropriate lifting point and fit the lifting eye & sling (5 possible positions)



Second lifting bracket added to provide roll adjustment

Adjustable chain hook/shackle

Typical lifting point



Step 4

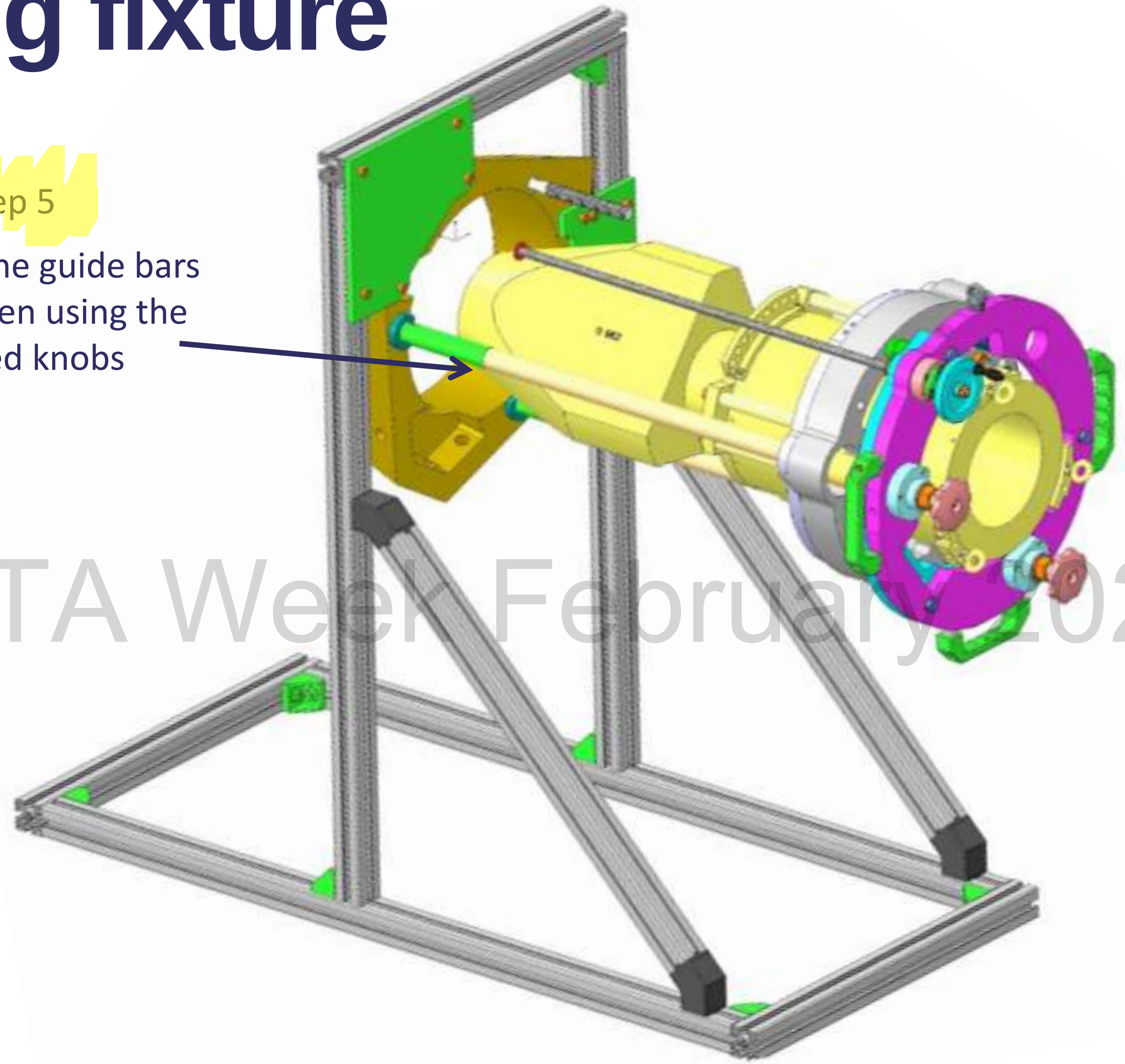
Using an adjustable chain hoist secured to the front mounting point, bring to the horizontal orientation

Science and Technology Facilities Council

ATC handling fixture

Step 5

Engage the guide bars and tighten using the sculptured knobs



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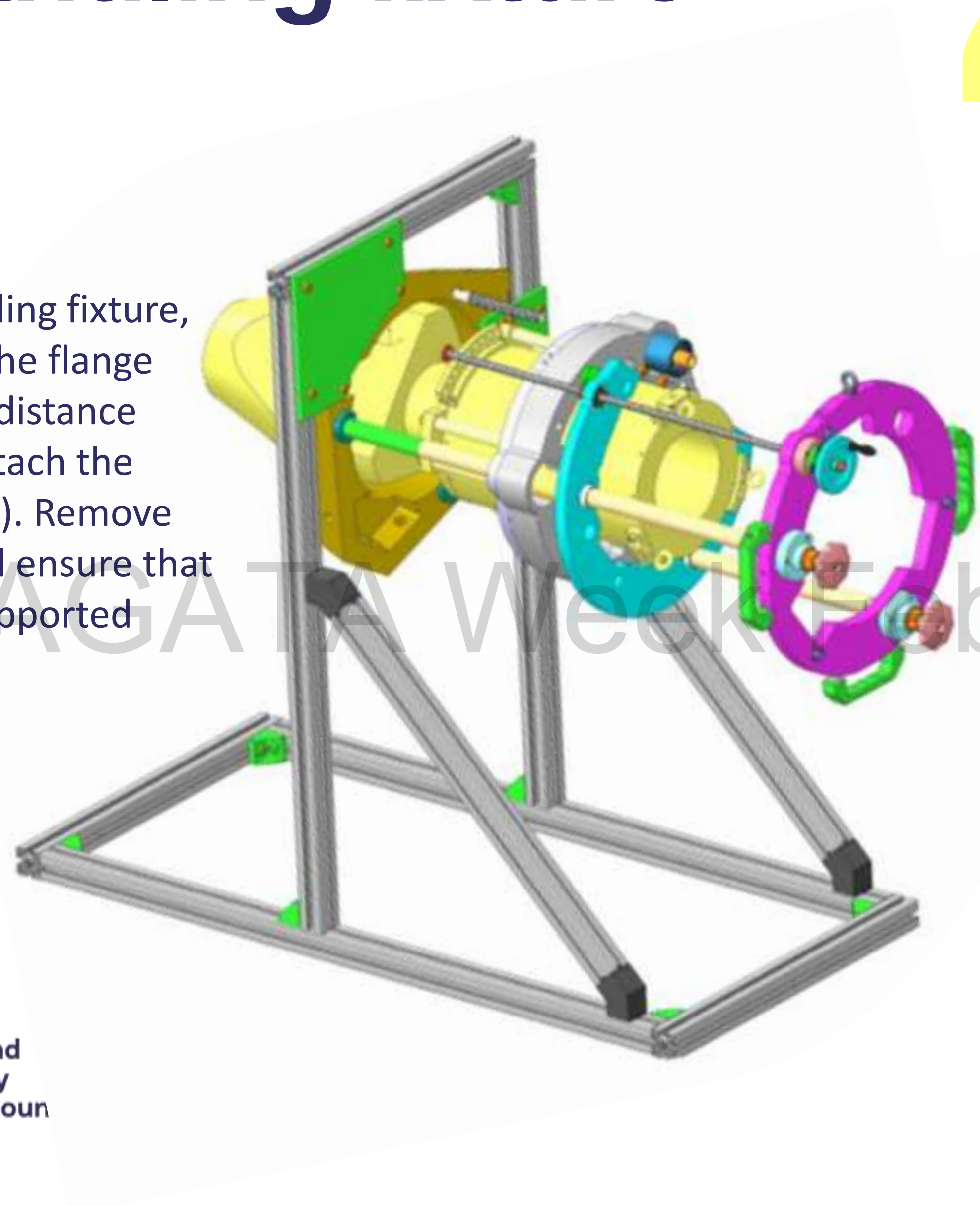
ATC handling fixture

Step 6

Still attached to the loading fixture, wind the detector into the flange using the hand wheel – distance ~350 mm in order to 'attach the digitiser cables' (real life). Remove the adjustable chain and ensure that the rear end remains supported

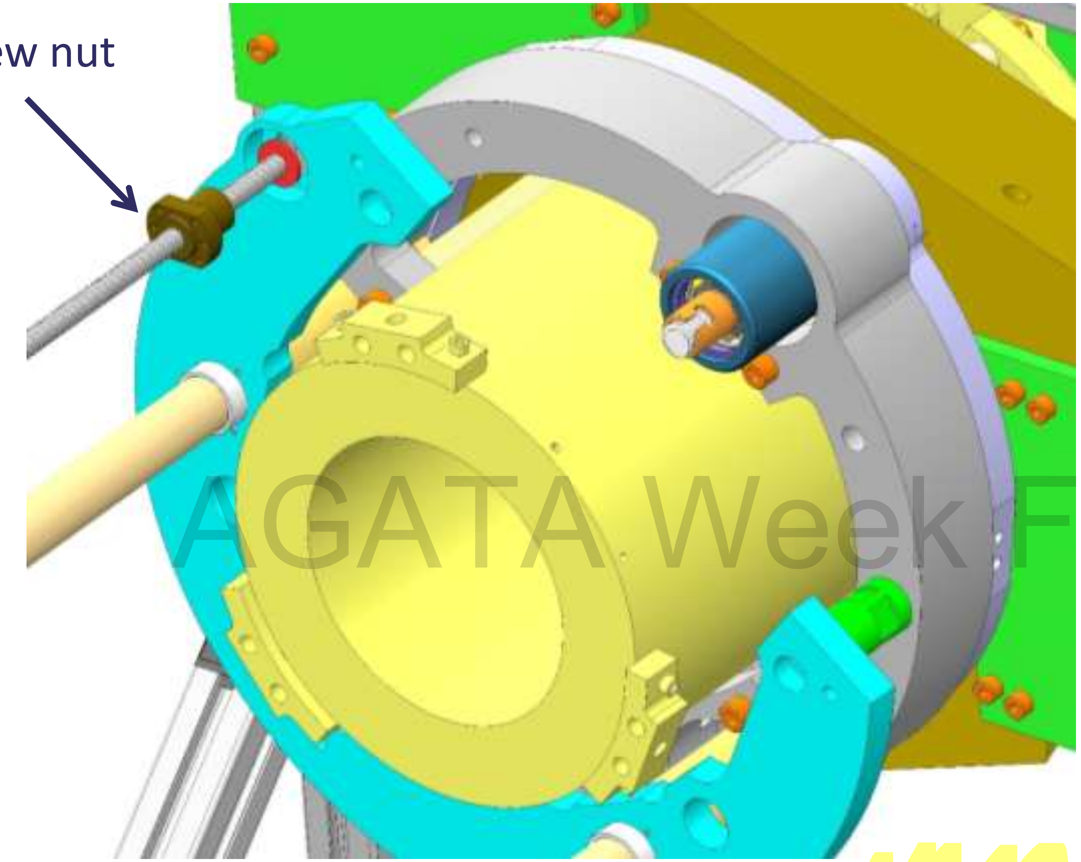


Step 7

Continue to wind the detector into the flange until the leadscrew nut engages with the end of the leadscrew then disconnect the ballscrew nut (see step 8)

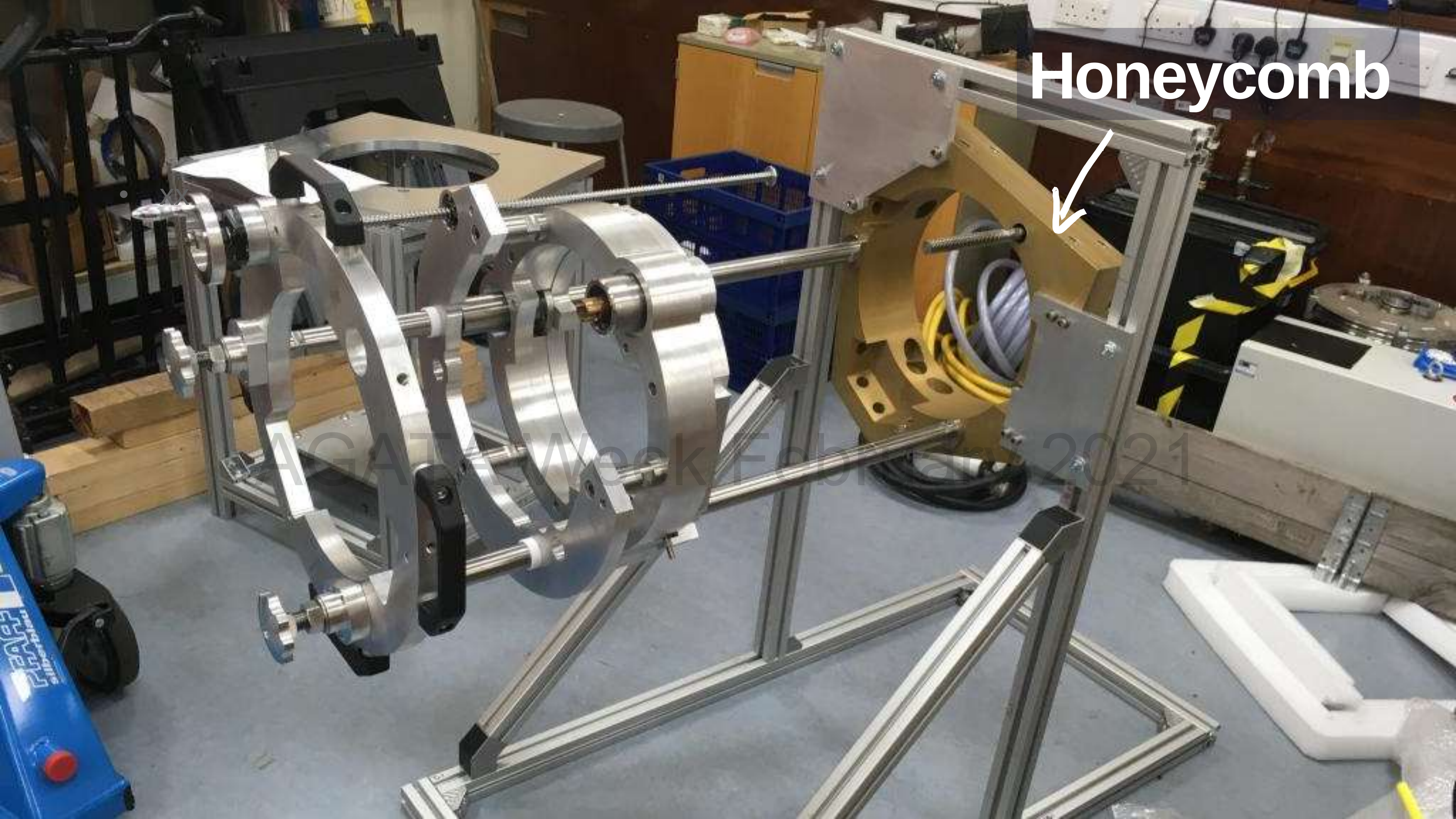
ATC handling fixture

Ballscrew nut



Step 8

Remove the loading fixture and continue to wind the detector into the flange. Removal is the reverse of this procedure


Honeycomb

Dummy detector

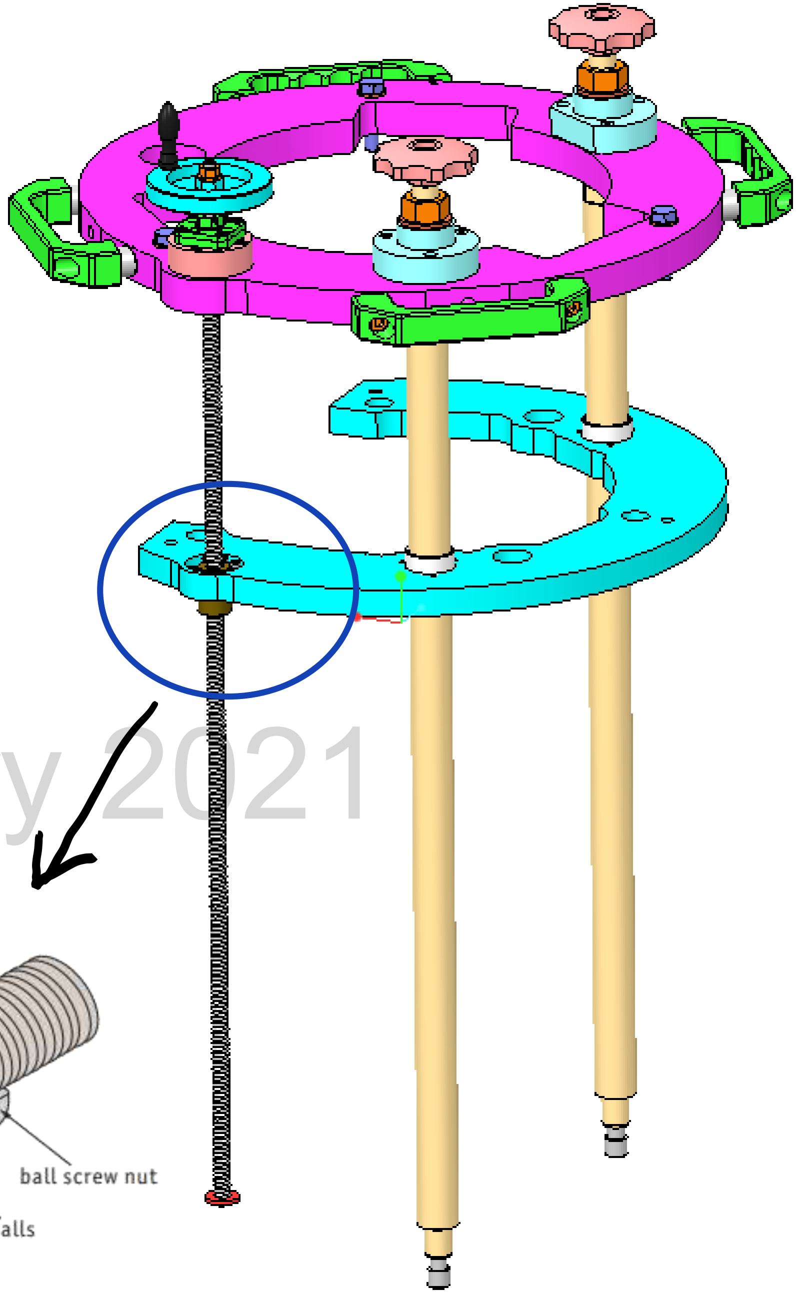

JBL
FACOM

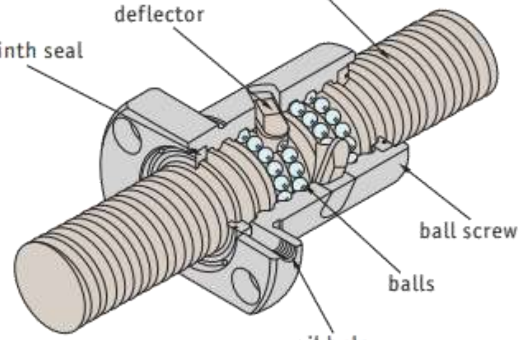

JBL


AGATA Week February 2021
47674

ATC handling fixture

- Insufficient friction in the system to prevent the fixture back-driving when operated at an angle
- Uses a low friction ballscrew to drive the detector
- Current design can only be used horizontally without risking damage to detector
- Design revised





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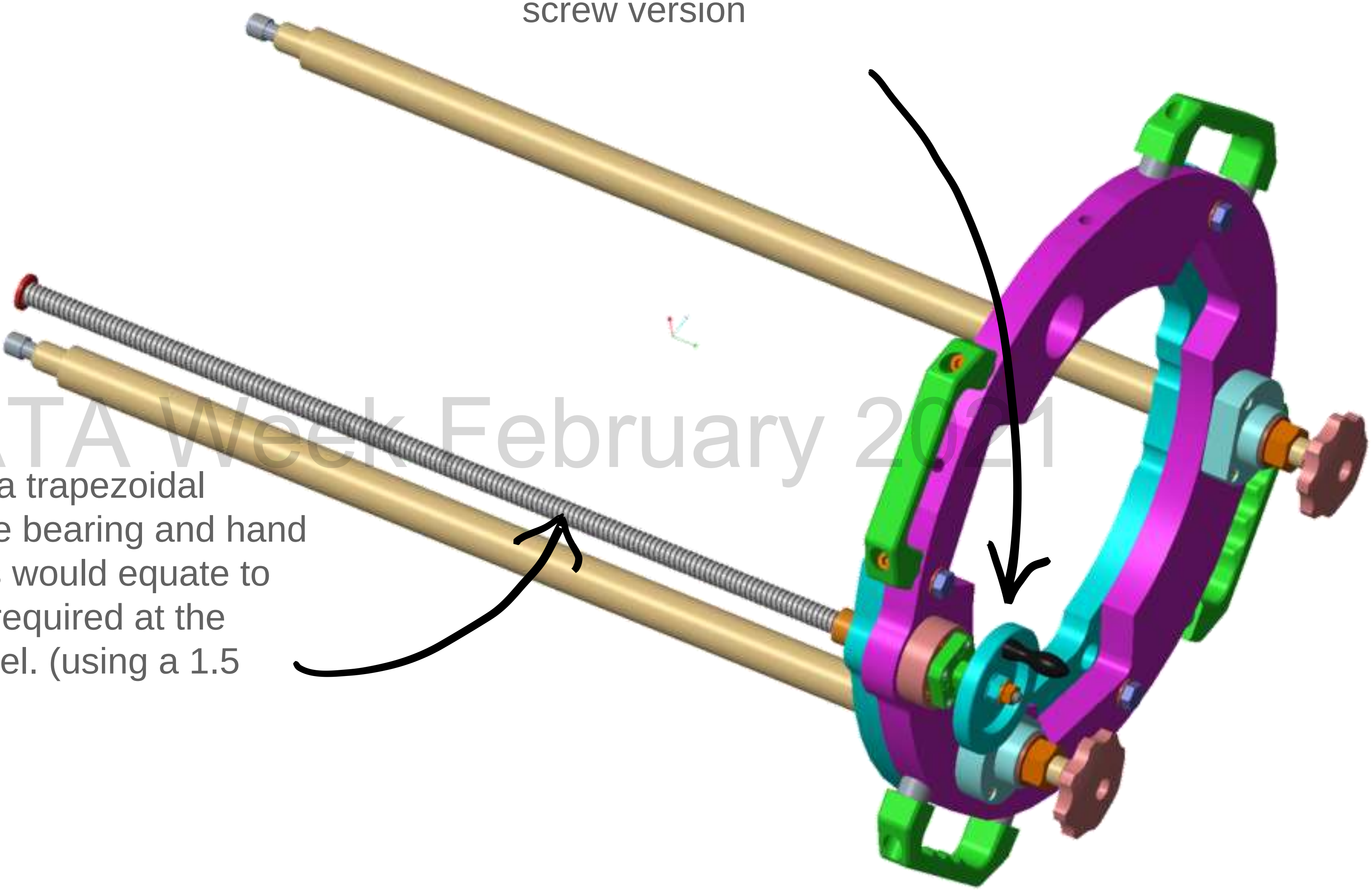
ATC handling fixture

The force at the black handle is estimated to be 3.5 Kg (with 1.5 times safety factor) for the original ball screw version



Replacing the ball screw with a trapezoidal screw and nut and keeping the bearing and hand wheel the same. However this would equate to approximately 13 Kg of force required at the black handle on the hand wheel. (using a 1.5 times safety factor).

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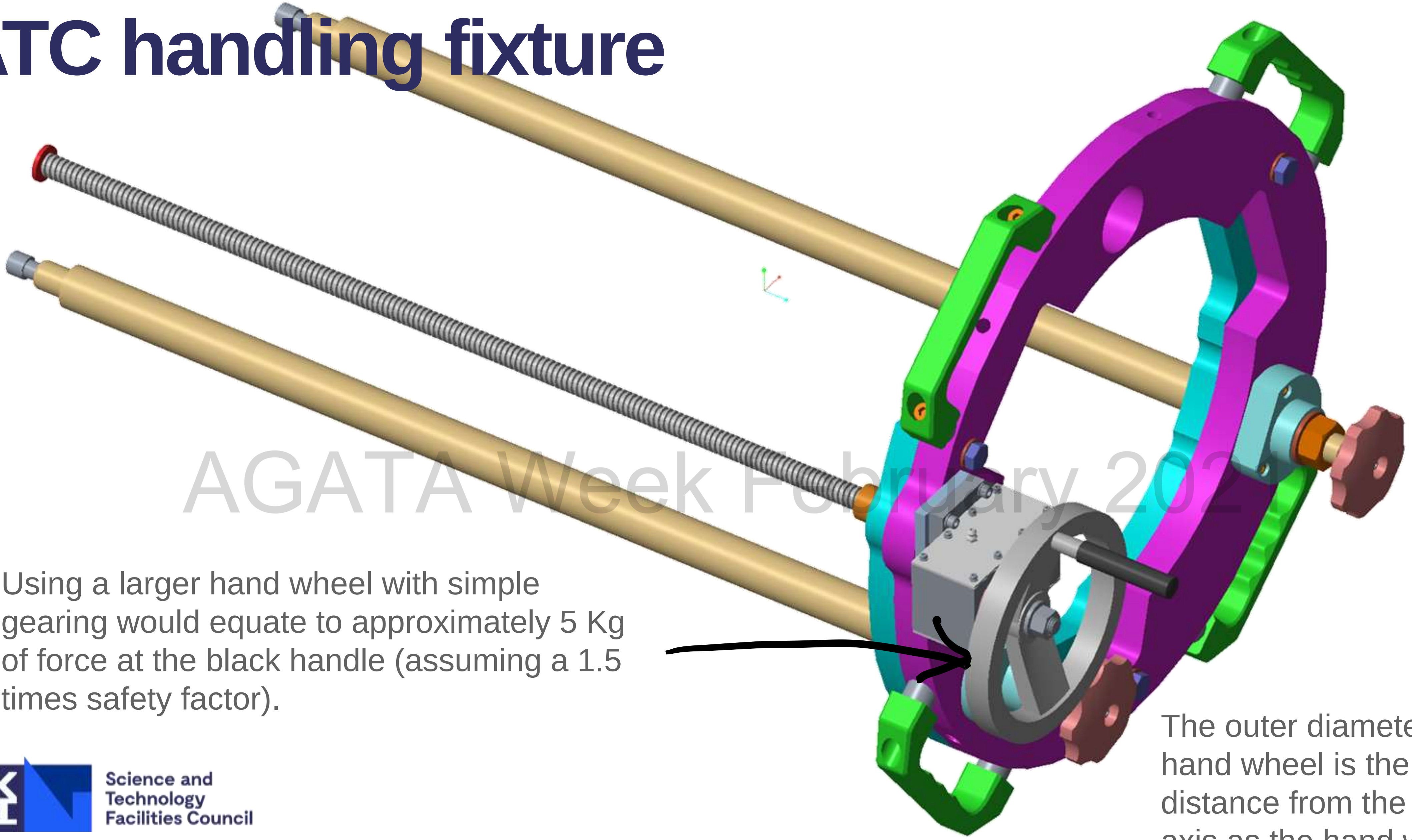
ATC handling fixture



Using a larger hand wheel with simple gearing would equate to approximately 5 Kg of force at the black handle (assuming a 1.5 times safety factor).

The outer diameter of this hand wheel is the same distance from the detector axis as the hand wheel for the original ball screw thread

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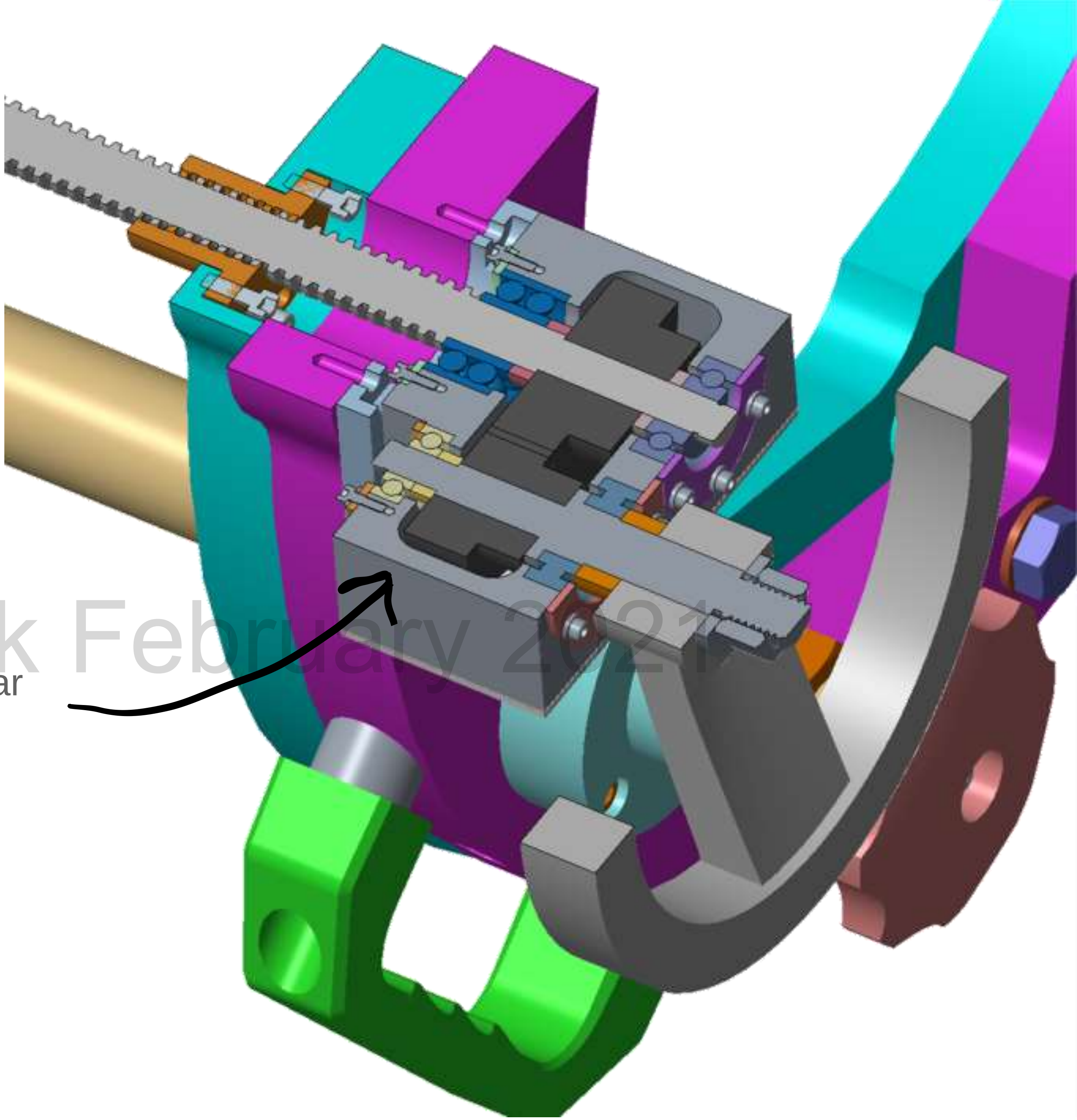
ATC handling fixture



Having a smaller driving gear and a larger driven gear gives a torque advantage. However the speed of the screw will be reduced.

Mechanics - Looking forward

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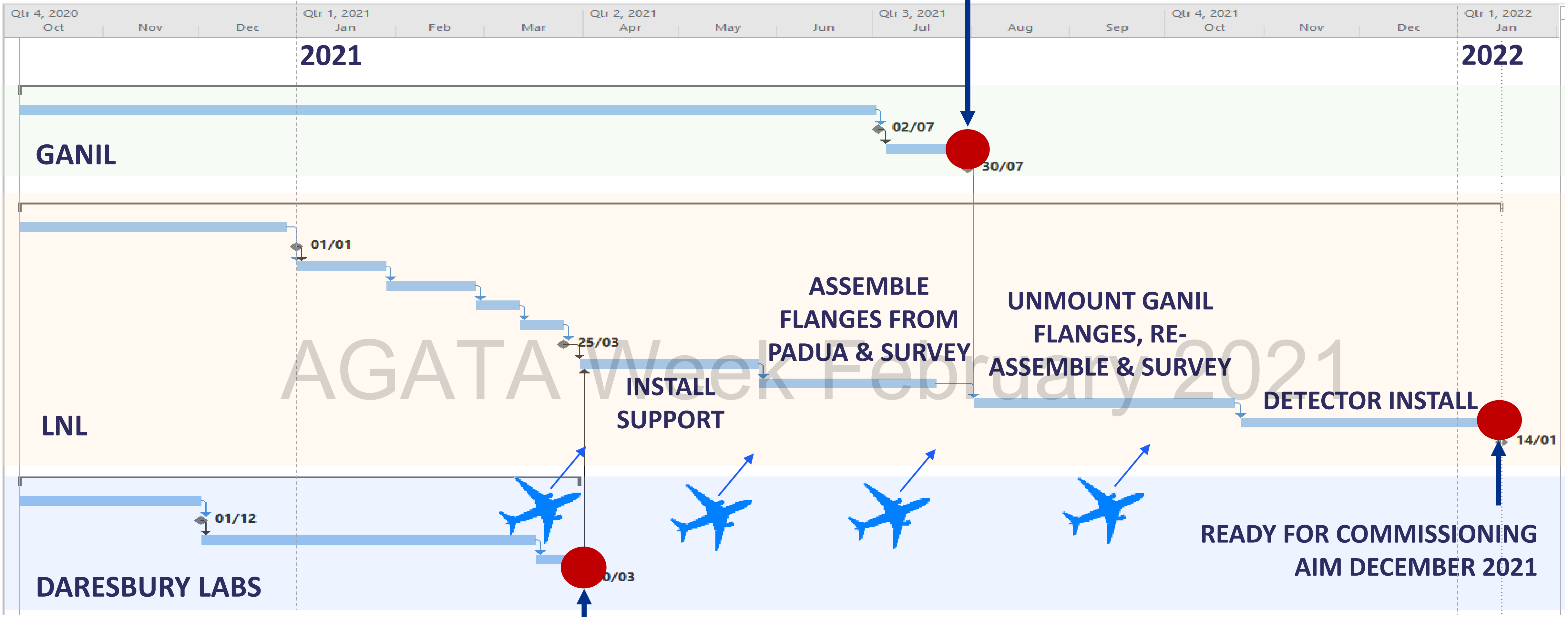
Timescales (Pre-COVID)

AGATA SHIPPED FROM GANIL
JULY



SUPPORT SHIPPED FROM DL
MARCH

Science and Technology Facilities Council

COVID impact

National lockdowns

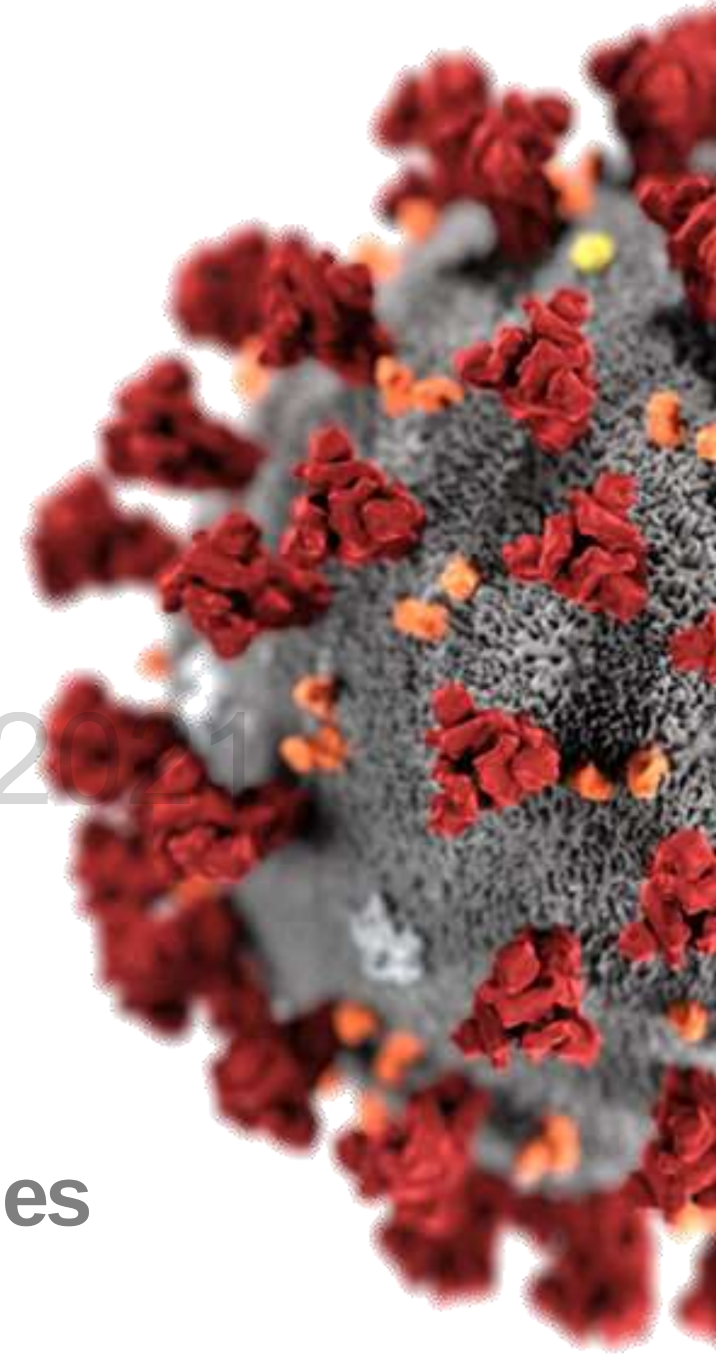
Workshops closed

Limited staff

Supply chain issues

Travel restrictions

Material shortages



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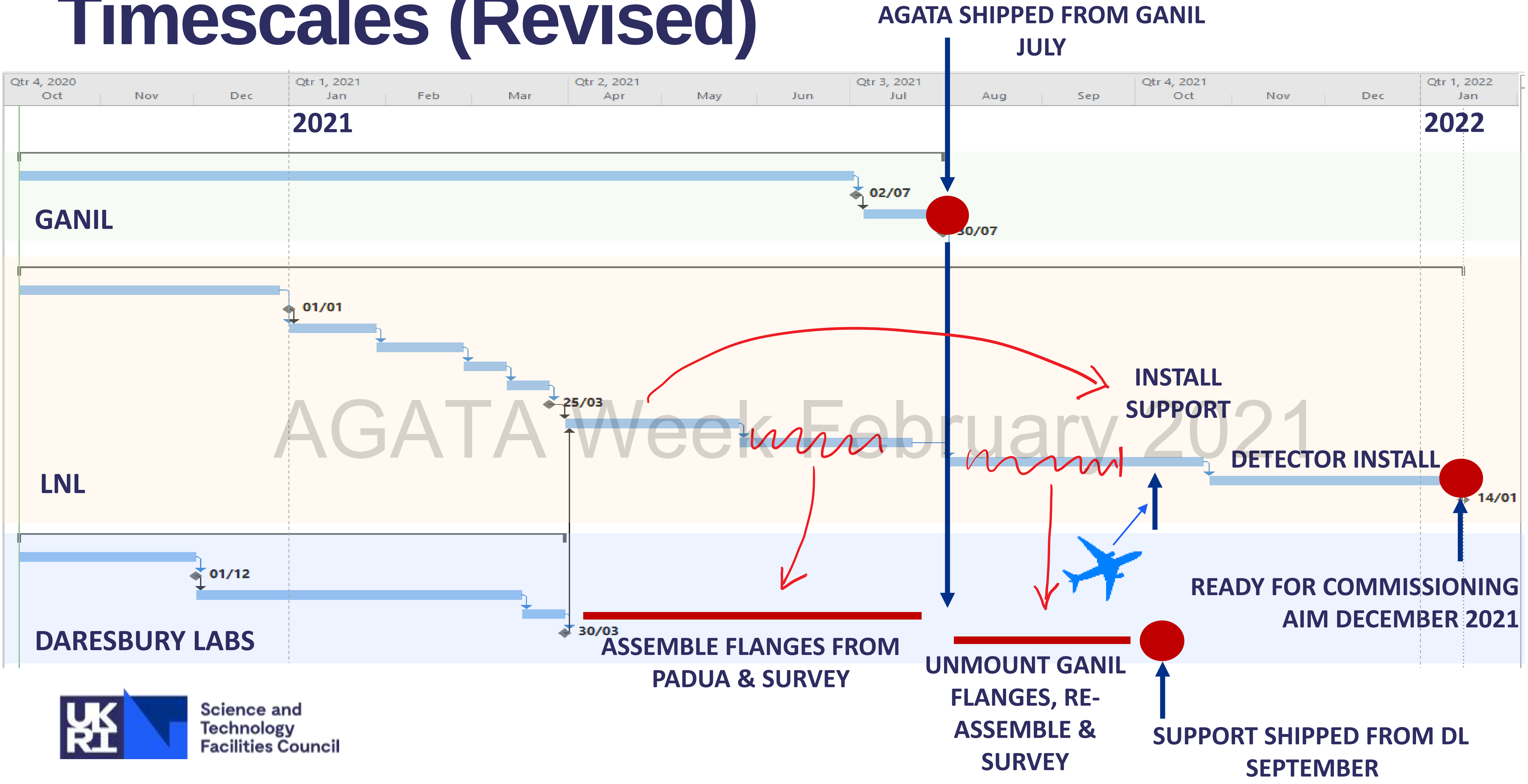
Timescales (Revised)



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Assembly & survey at DL

- Ship 20 new flanges from Padua to Daresbury (1st batch end March)
- Ship the 15 flanges from GANIL direct to Daresbury (est. July)
- Assemble 30 flanges on shaft at Daresbury & survey into position
- Unmount 30 flange array as a single piece & ship with support to LNL (September)
- This pushes the need for international travel to later in the year
- Overcomes current travel restriction issues & allows work to progress
- Reduce the number and duration of visits to LNL ☹

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Assembly & survey at DL

- Opportunity to check shaft & flange interface whilst still in the UK
- Corrective action can then be taken at Daresbury or by the supplier
- Allows Daresbury team to become familiar with assembly & survey
- Refine processes whilst Daresbury team have all their equipment available to hand
- Prevents the need for a second building for storing support at Legnaro

The current situation has provided us with a few opportunities to derive some positives ☺

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Summary

- Overall mechanics is progressing well
- Schedule is adapting to the changes and obstacles
- Busy year with a lot of developments
- Support structure is on target
- Tests on ATC lifting & handling process are ongoing
- Production of flanges at Padua progressing well
- Focused on shipping full array & support in September

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Thank you

AGATA Week Febru