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SwissFEL – Aramis Undulator U15

MEDSI, Barcelona, 1Xth September 2016

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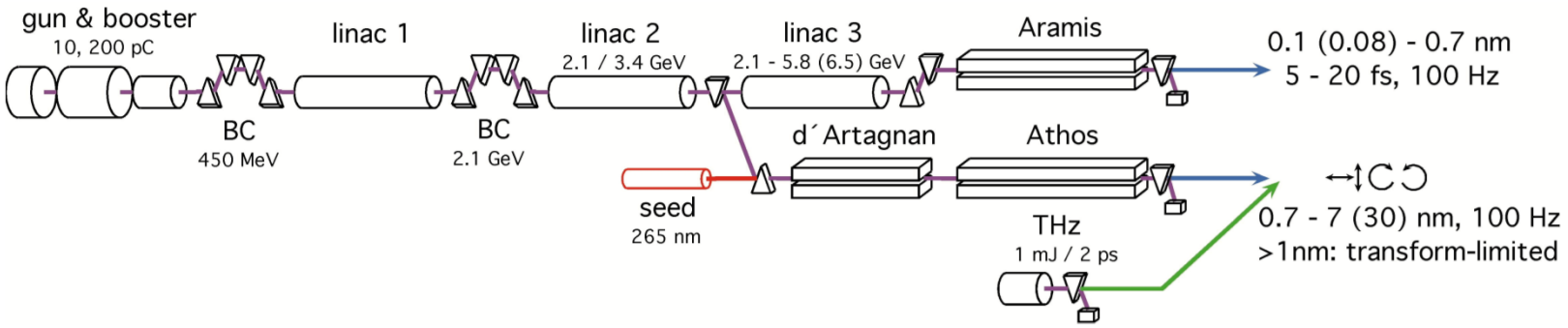
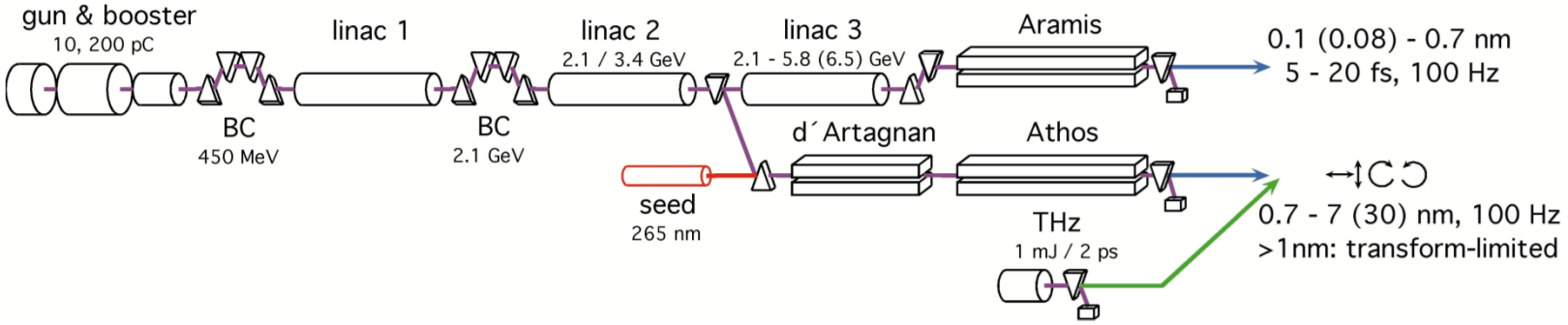
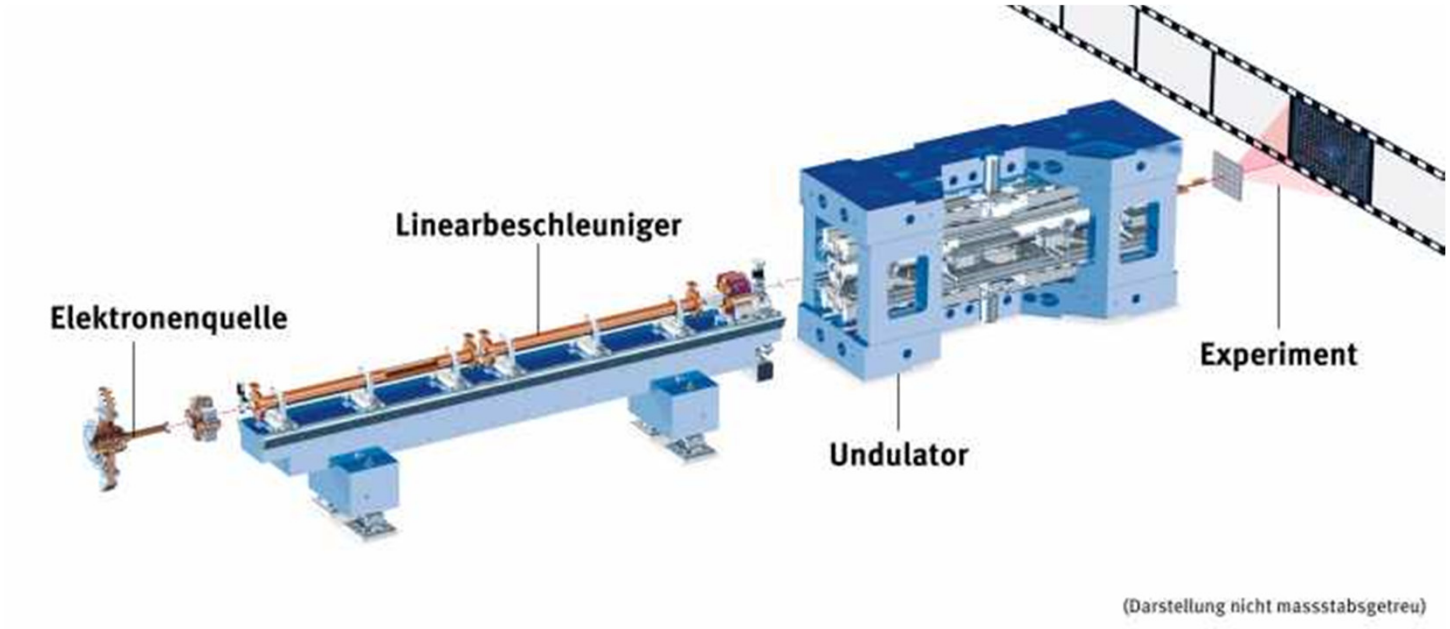
SwissFEL – project overview



SwissFEL – project overview





SwissFEL – project overview

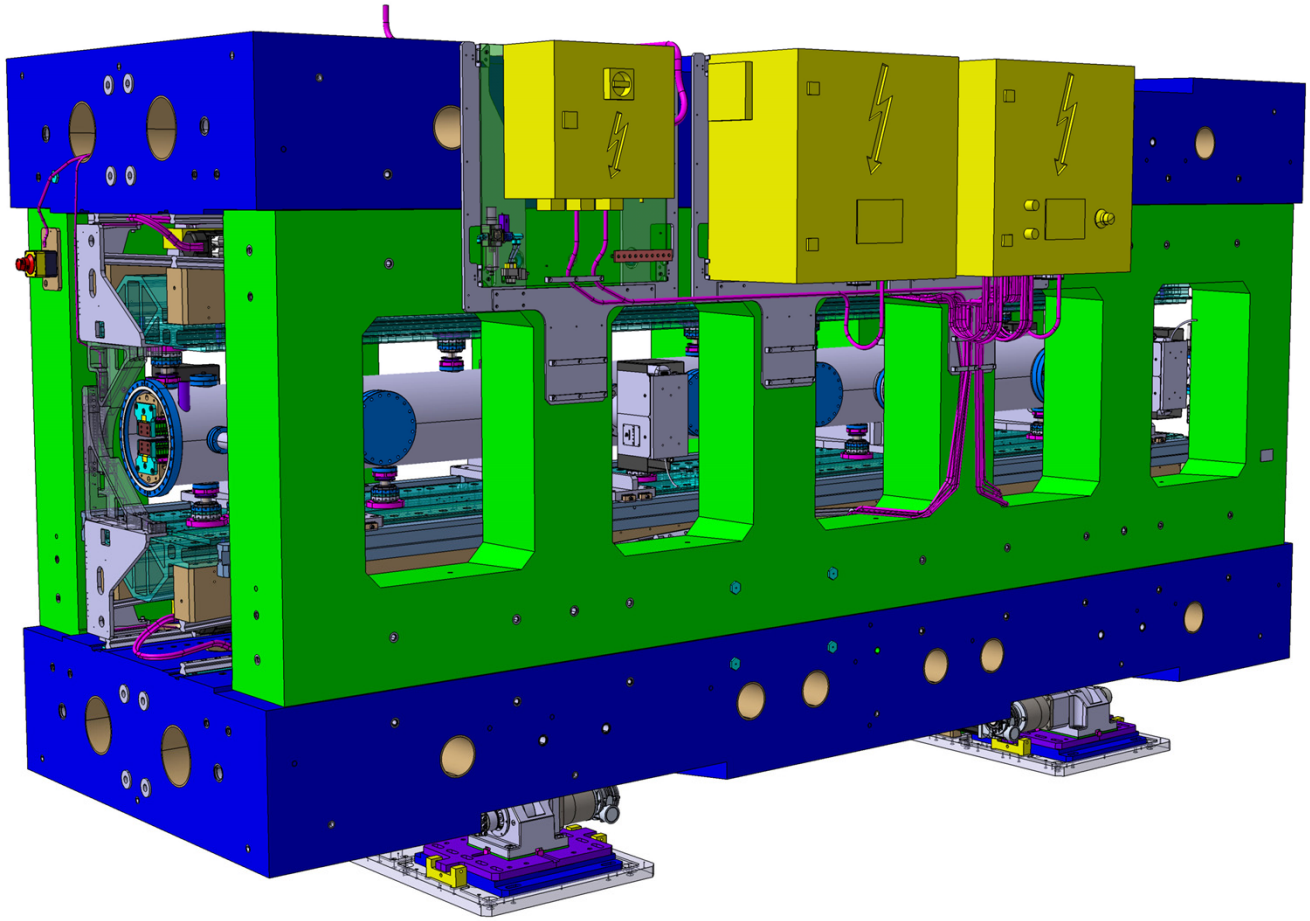
Summary:

- Building length: 750m
- Construction: April 2013 – April 2015
- Start maschine installation: January 2015
- First FEL-light: April 2017
- Hard x-ray beamline «Aramis» with 0.1 – 0.7nm, 5 – 20fs, 100Hz, 5.8GeV

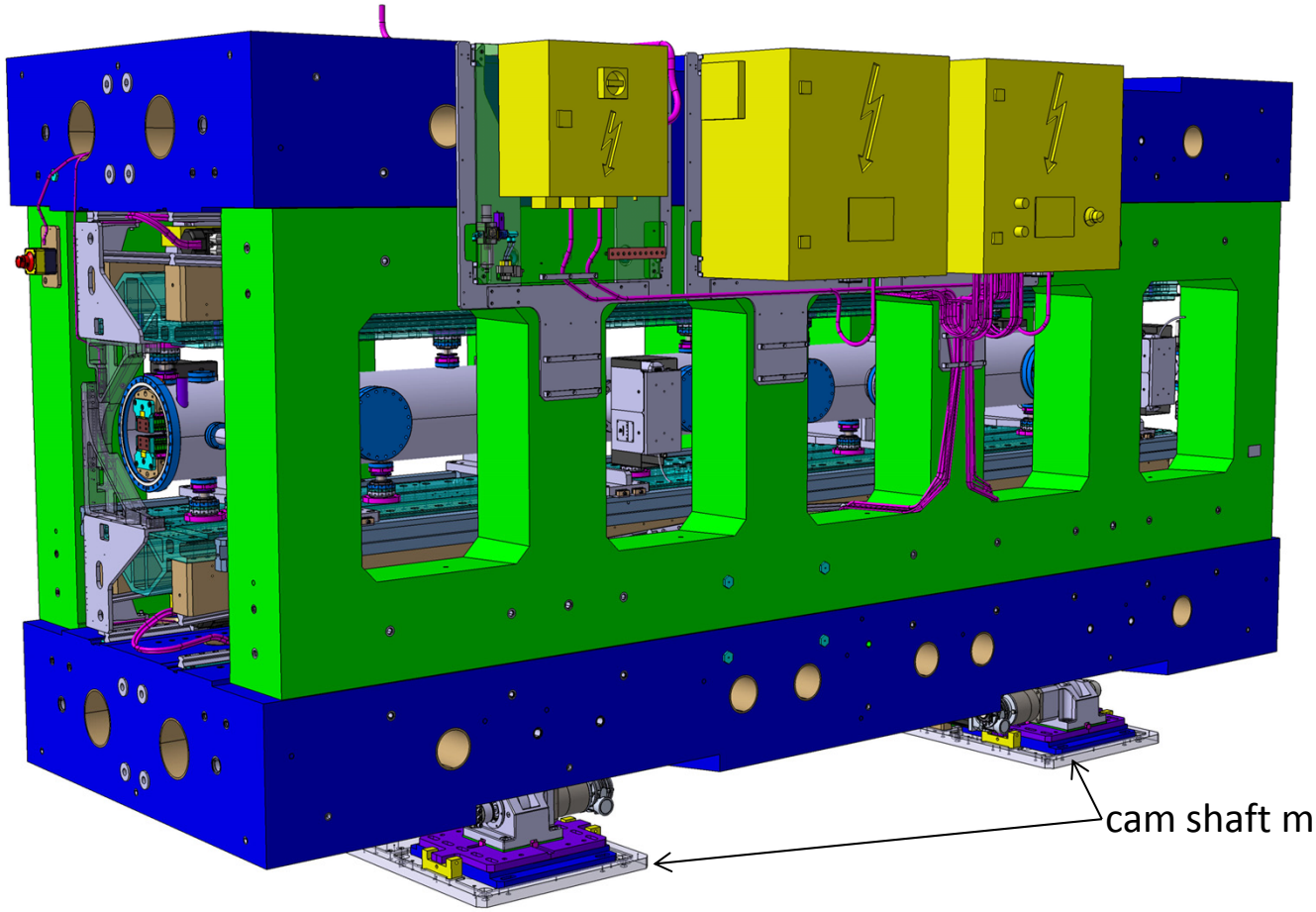
Links:

- https://www.youtube.com/watch?v=WxRSHTNPLbc (movie)
- https://www.psi.ch/media/film-swissfel (movie)
- https://www.psi.ch/swissfel/swissfel (official swissfel homepage)
- https://www.psi.ch/info/MediaBoard/Swiss_FEL_d.pdf

Aramis Undulator U15 – main parts



Aramis Undulator U15 – main parts



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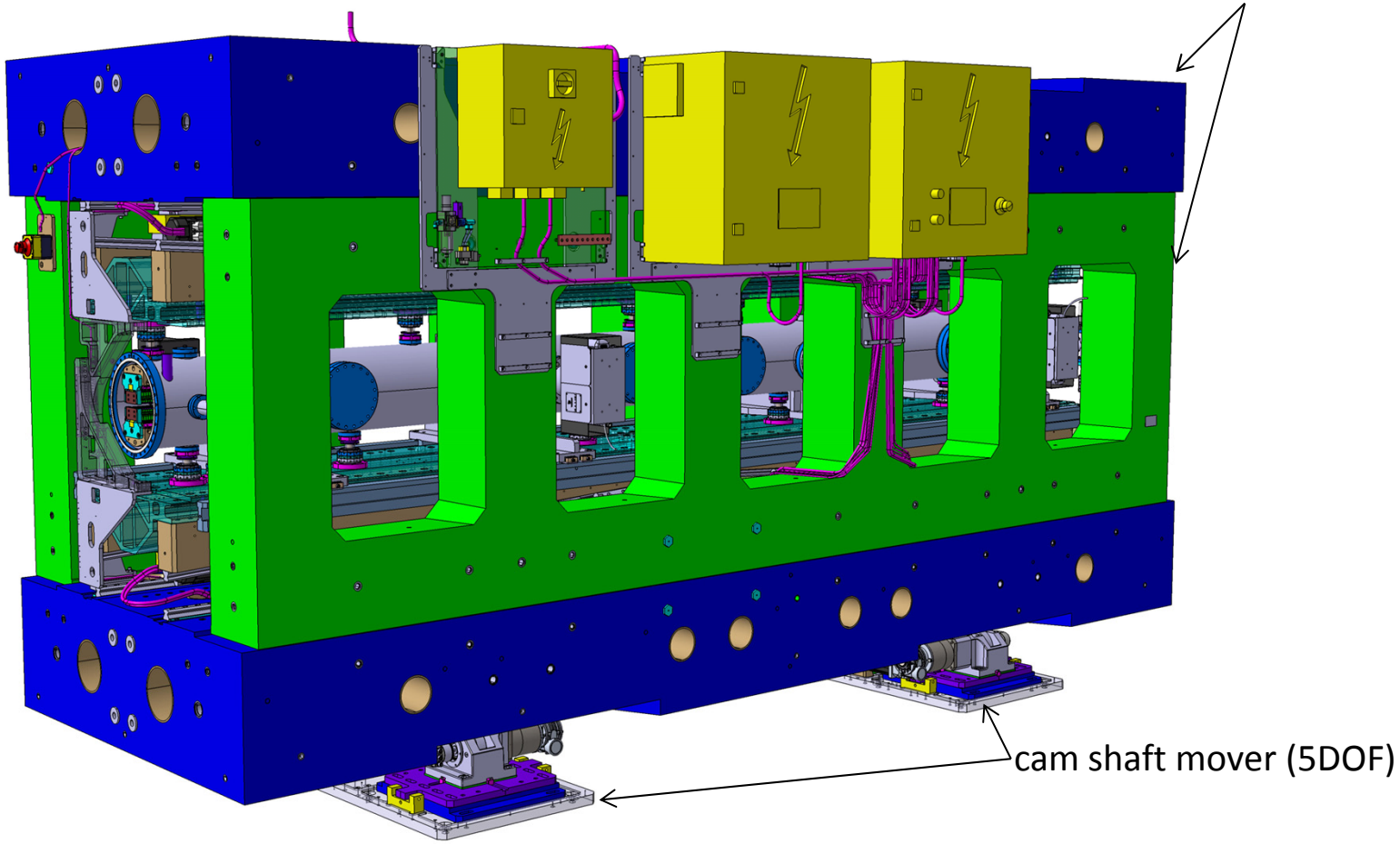

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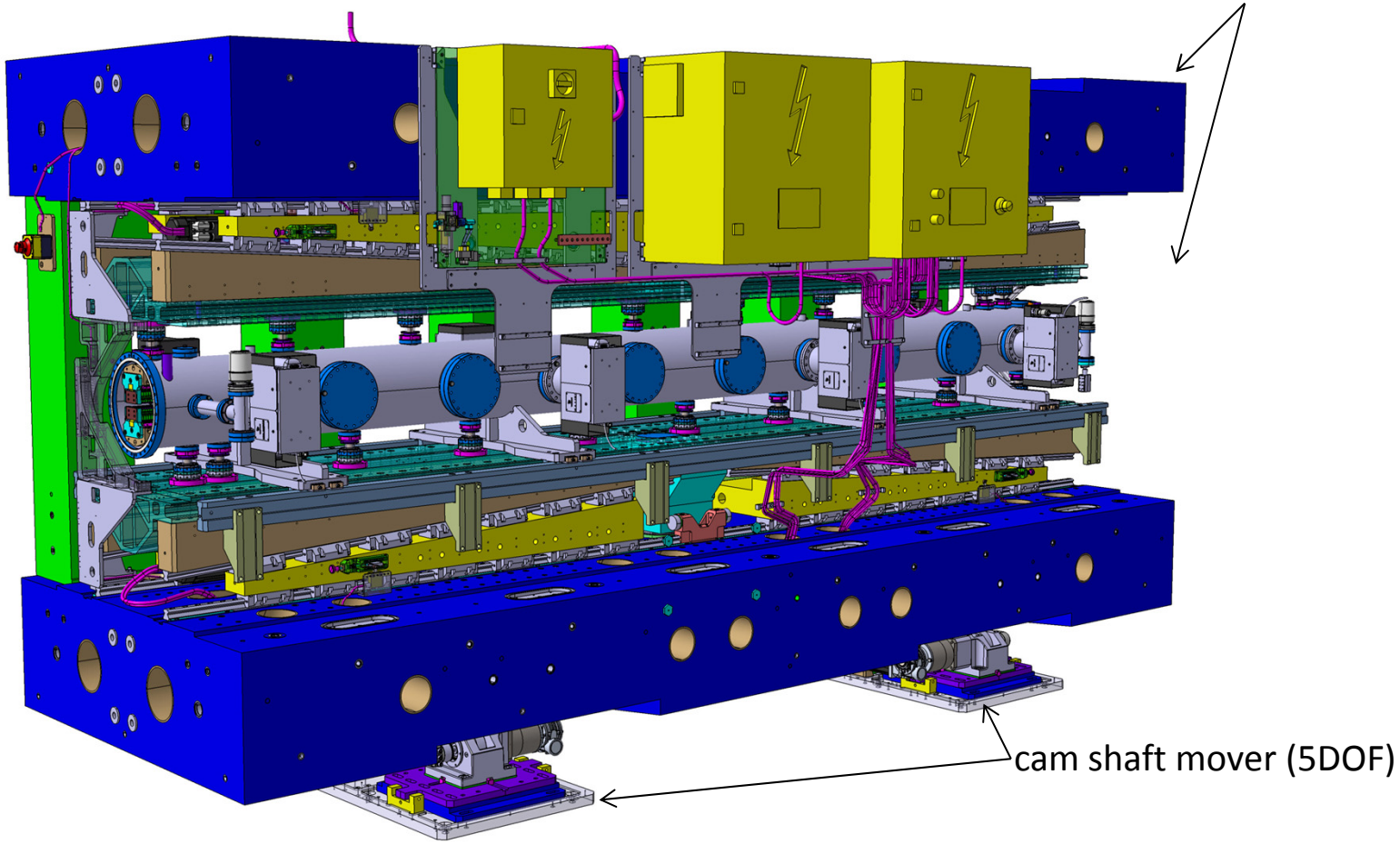

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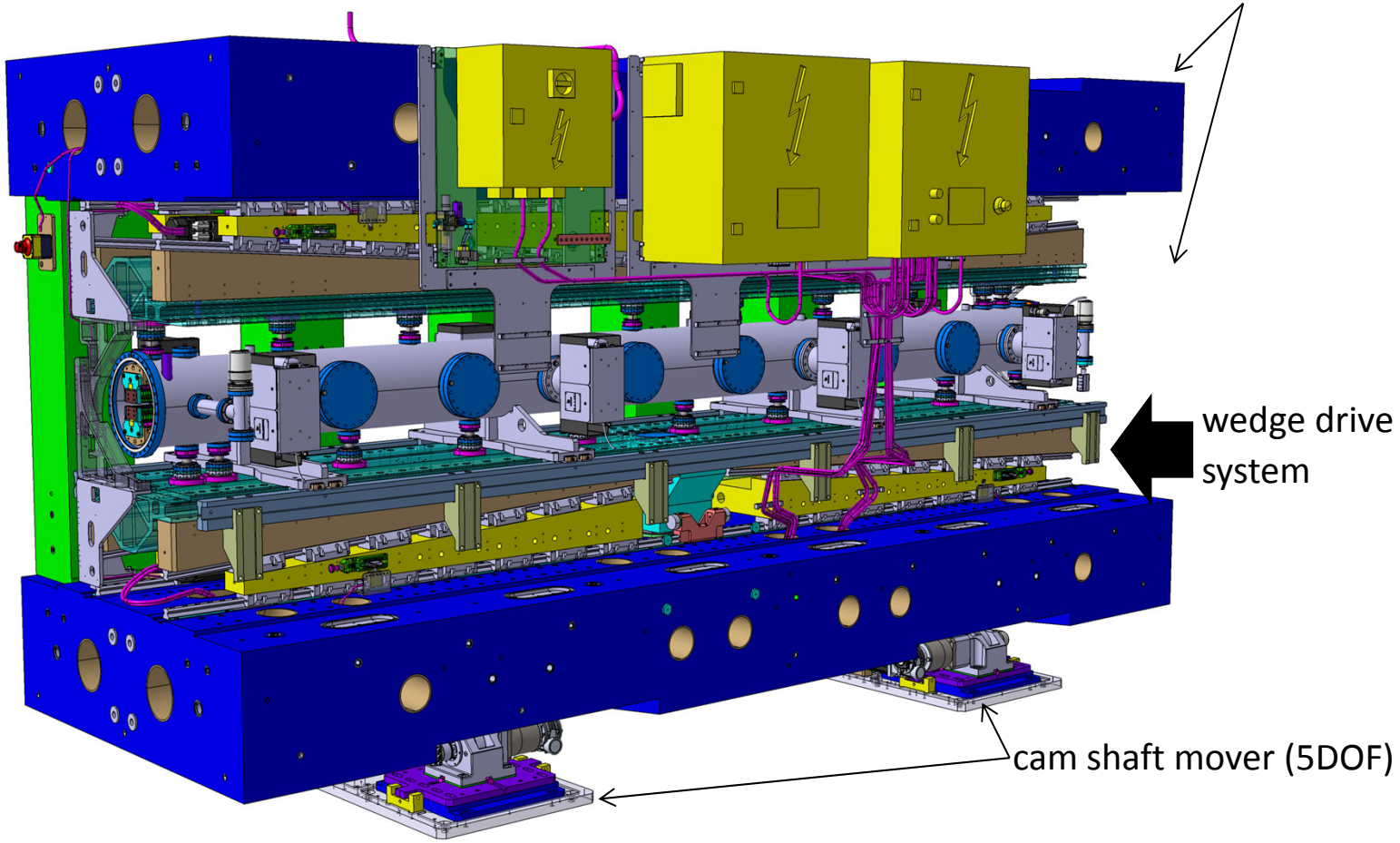

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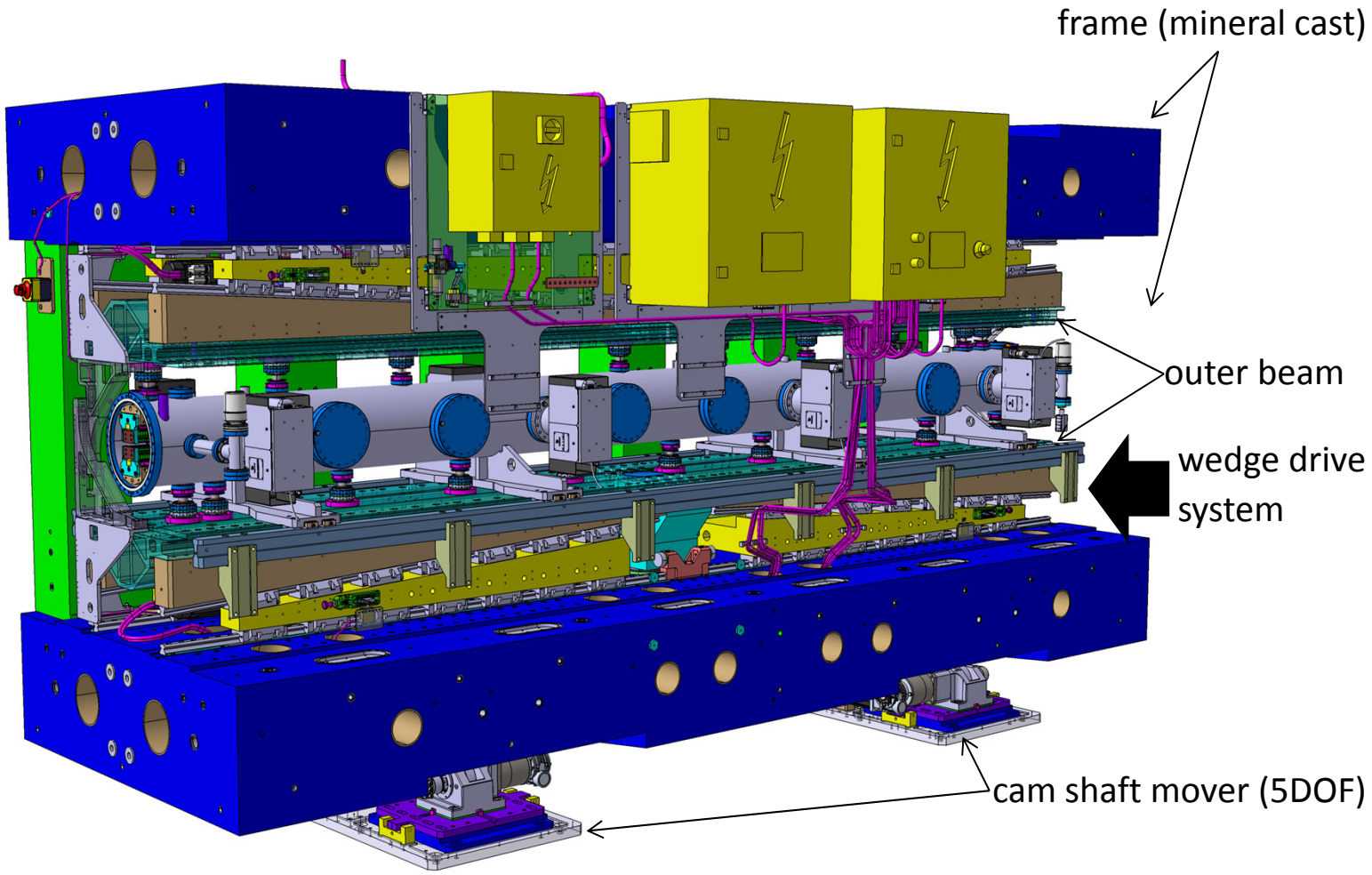
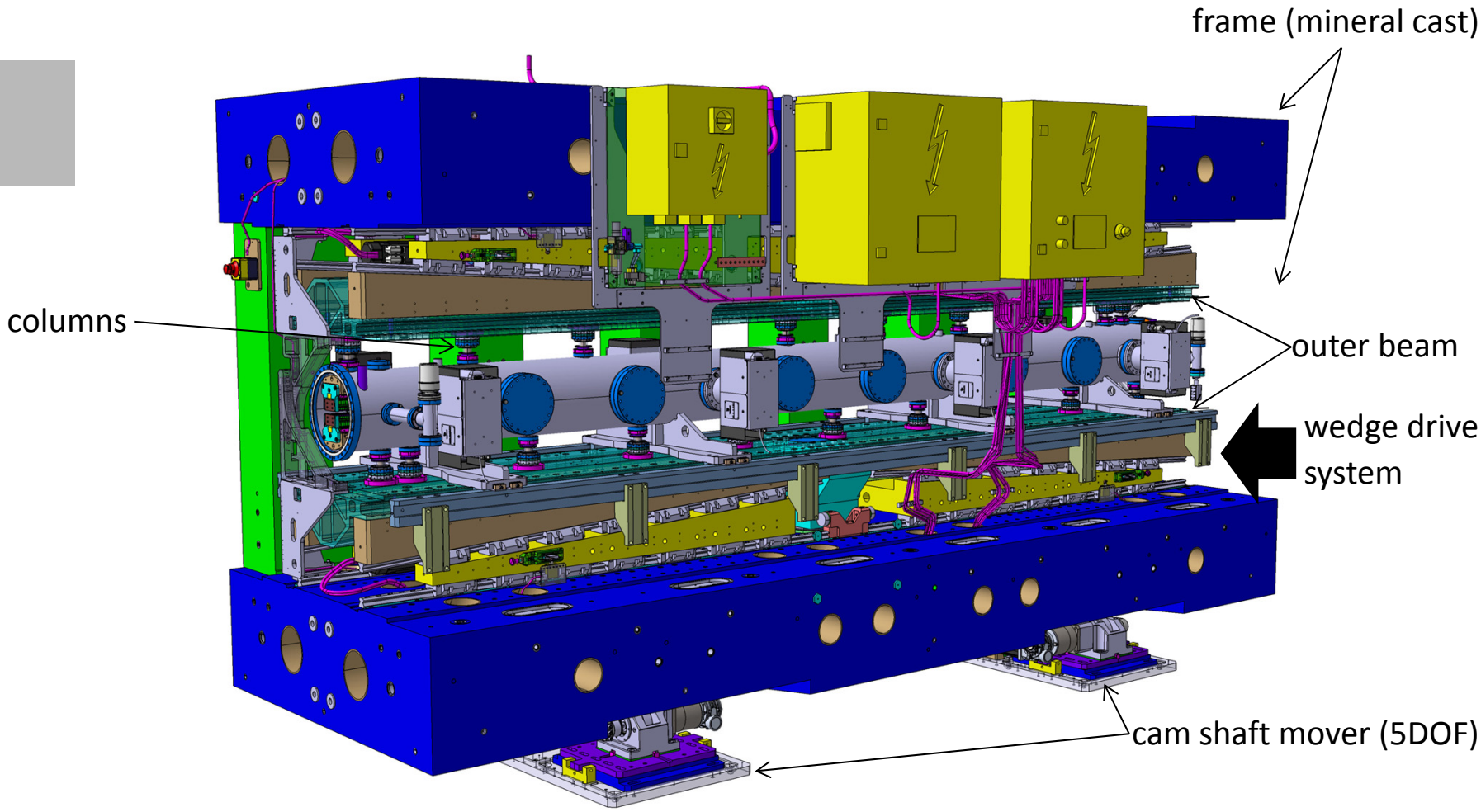


Aramis Undulator U15 – main parts



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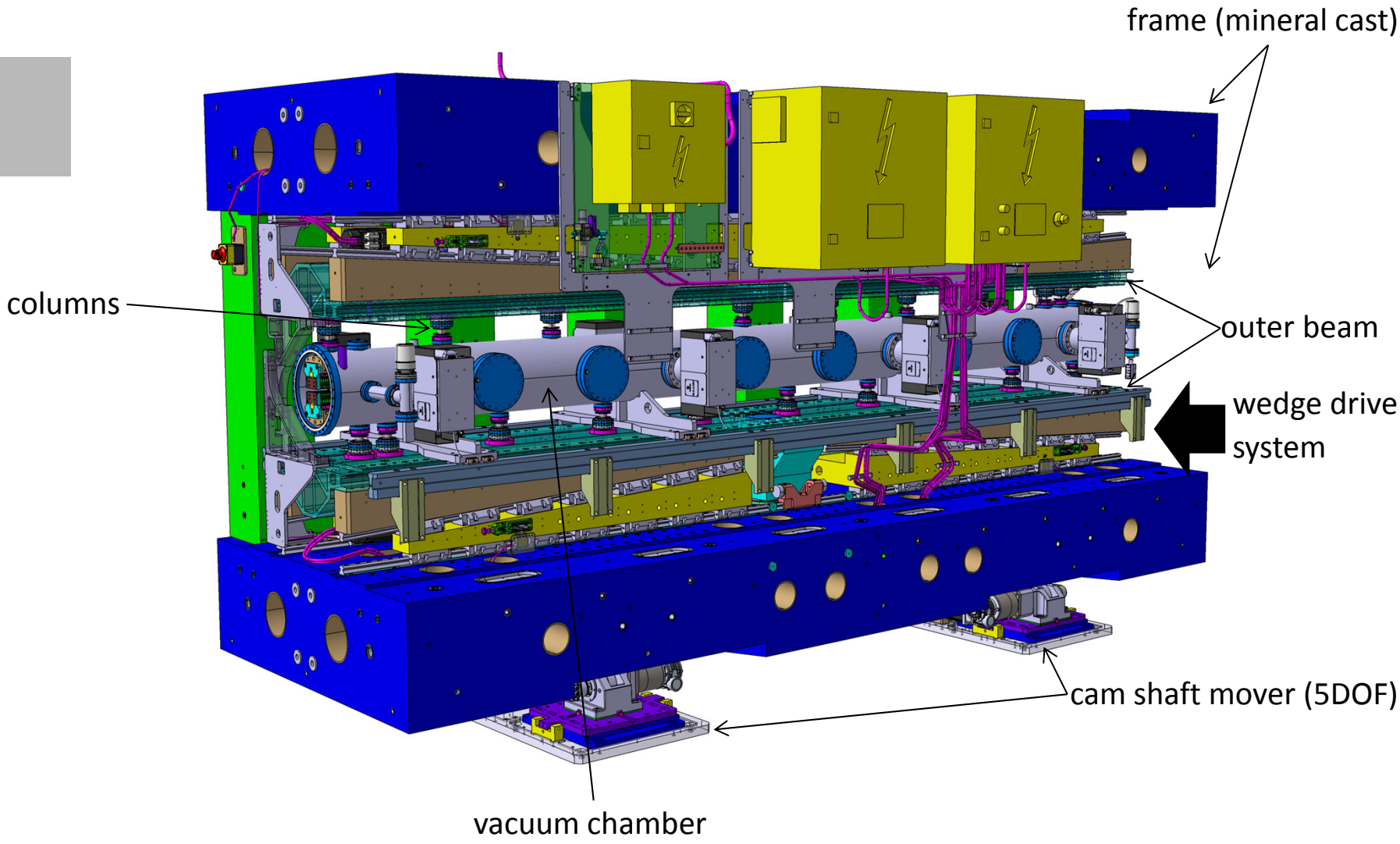
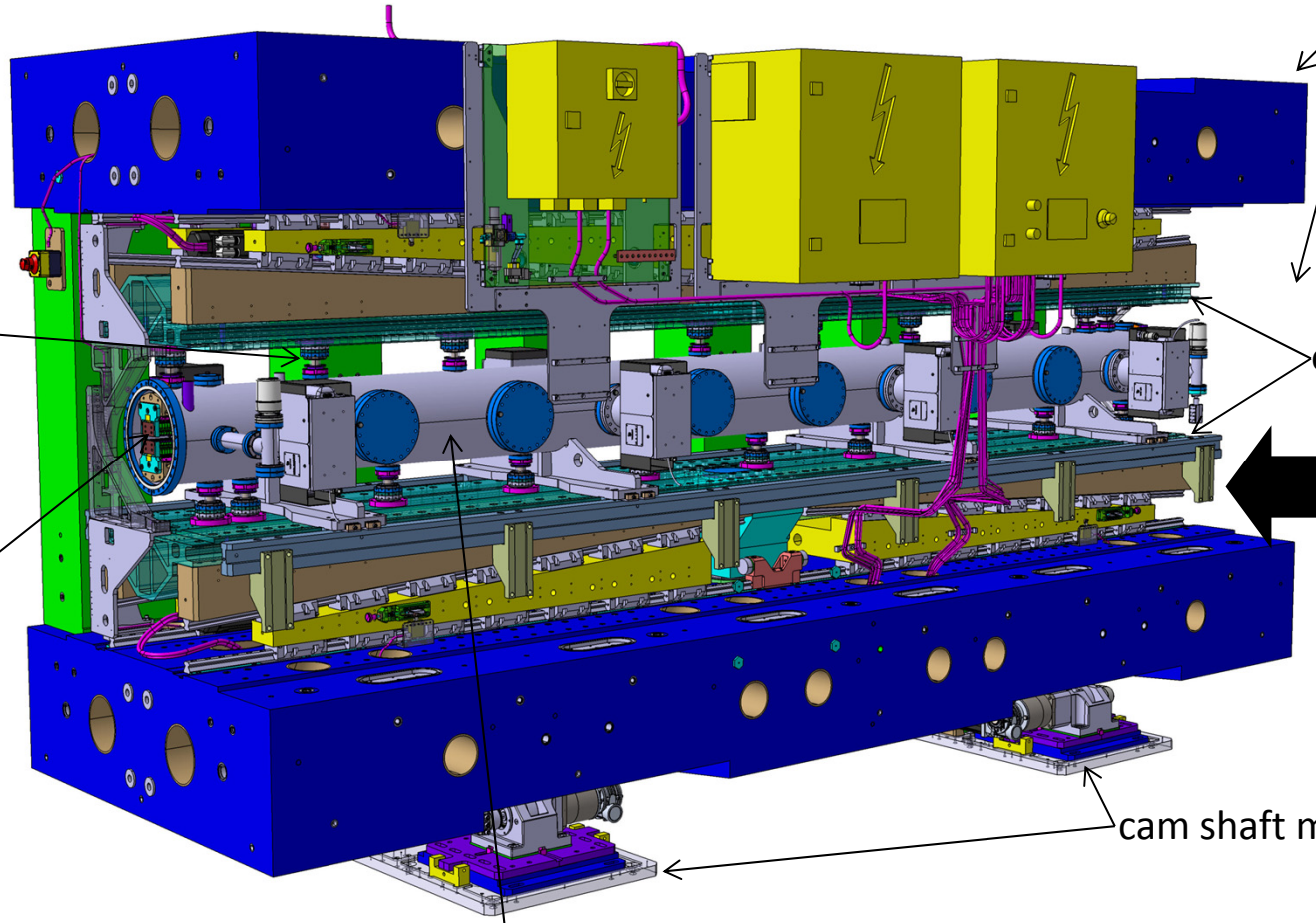
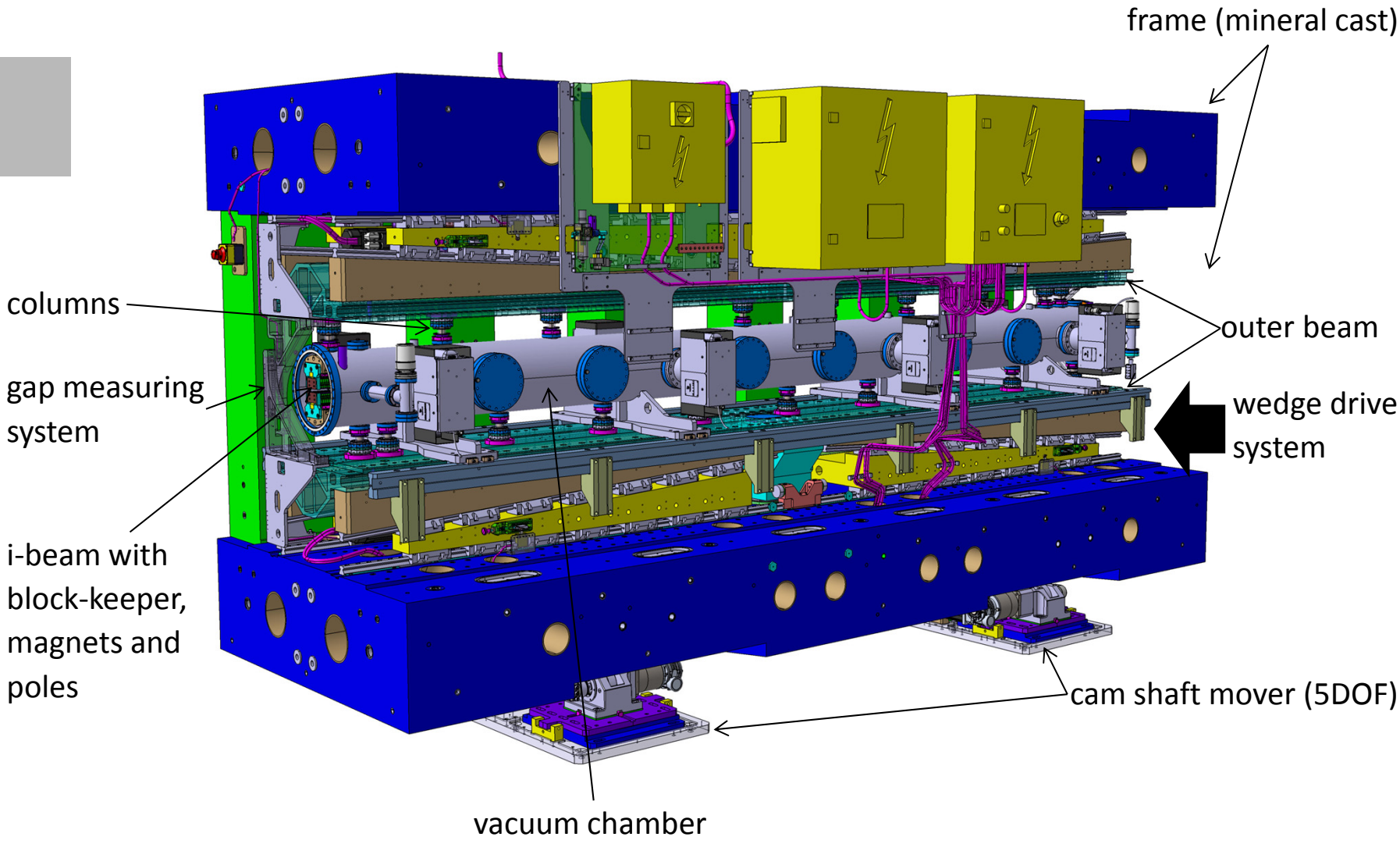


Aramis Undulator U15 – main parts



Aramis Undulator U15 – main parts



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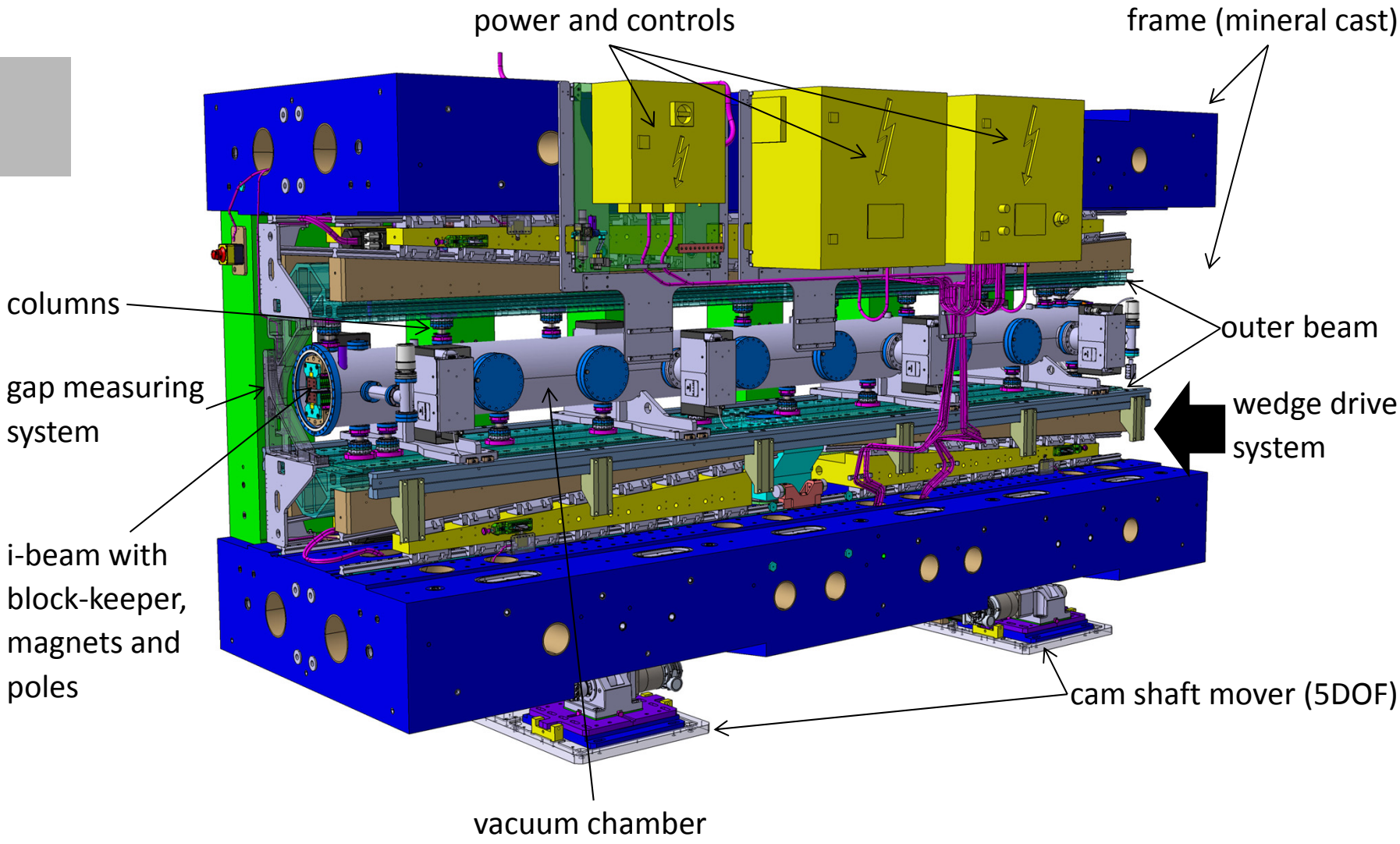
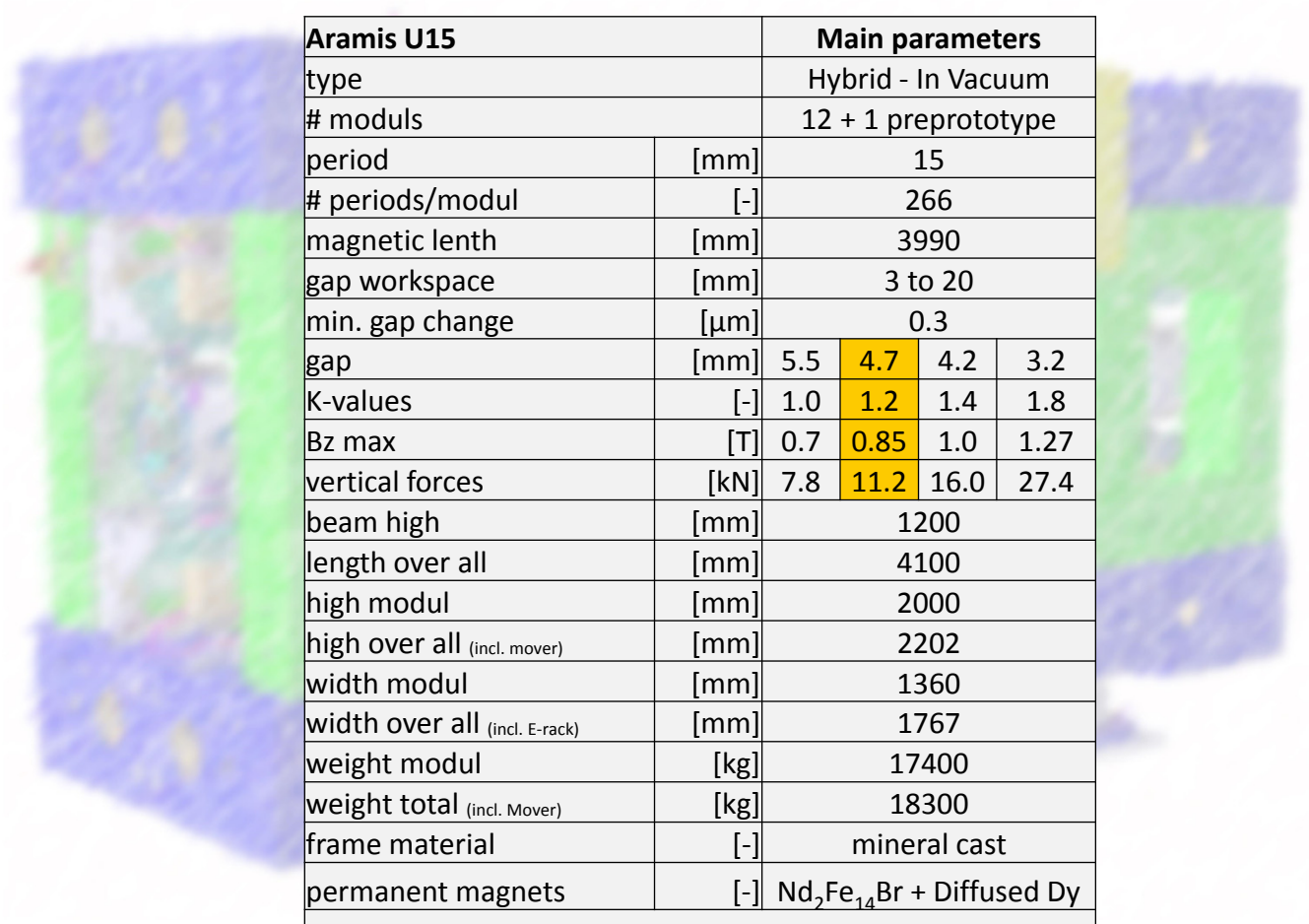


Aramis Undulator U15 – overview



Aramis U15		**Main parameters**			
type		Hybrid - In Vacuum			
# moduls		12 + 1 preprototype			
period	[mm]	15			
# periods/modul	[-]	266			
magnetic lenth	[mm]	3990			
gap workspace	[mm]	3 to 20			
min. gap change	[µm]	0.3			
gap	[mm]	5.5	4.7	4.2	3.2
K-values	[-]	1.0	1.2	1.4	1.8
Bz max	[T]	0.7	0.85	1.0	1.27
vertical forces	[kN]	7.8	11.2	16.0	27.4
beam high	[mm]	1200			
length over all	[mm]	4100			
high modul	[mm]	2000			
high over all (incl. mover)	[mm]	2202			
width modul	[mm]	1360			
width over all (incl. E-rack)	[mm]	1767			
weight modul	[kg]	17400			
weight total (incl. Mover)	[kg]	18300			
frame material	[-]	mineral cast			
permanent magnets	[-]	$Nd_2Fe_{14}Br$ + Diffused Dy			
good field region ($\Delta B/B<10^{-4}$) at gap 4.7mm is 2.0 x 0.06 mm					
nominal working parameters					

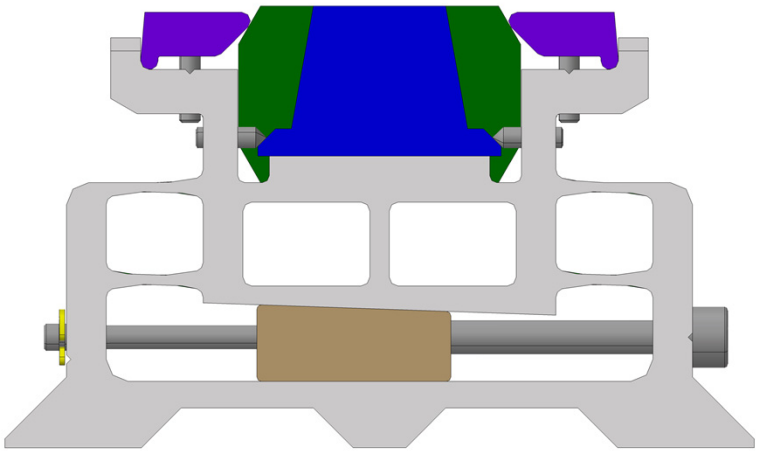
Aramis Undulator U15 – changes

After the design, manufacturing and measuring the pre-protoype we had to change and add several things:

- design and thicknes of magnets/poles considering existing block-keeper design
- design of columns in respect to the geometric space
- monitoring system of wedge drive
- motor cooling
- temperature stabilised assembling area
- FEM modul based column adjustment

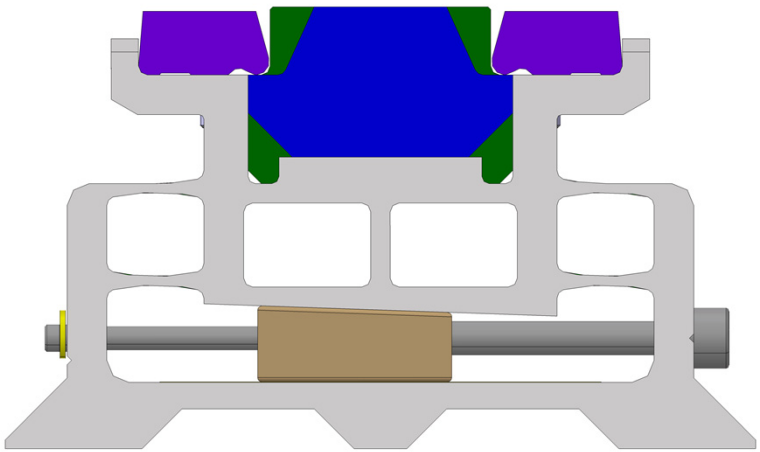
Aramis Undulator U15 – changes

Pre-Prototype



magnet thickness: 4.1mm
pole thickness: 3.3mm
accuracy: 0.3µm
clamp for magnet

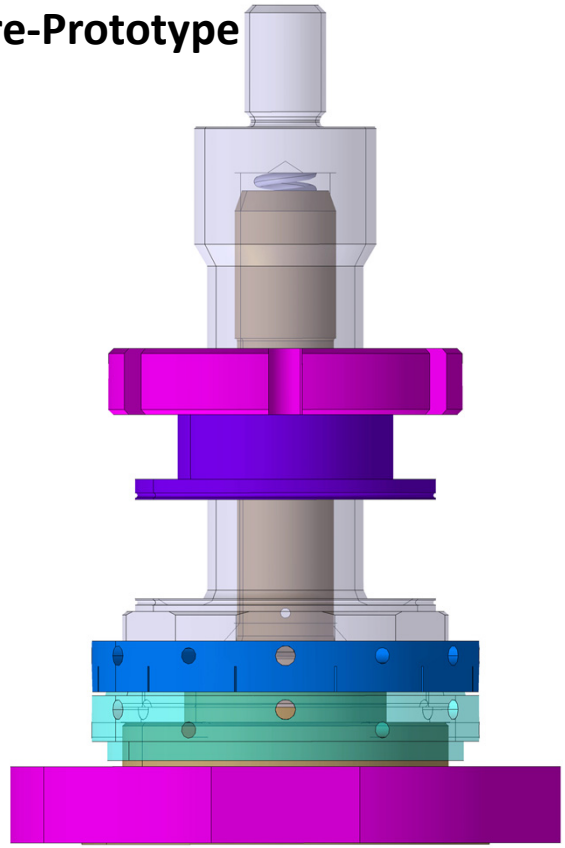
Series



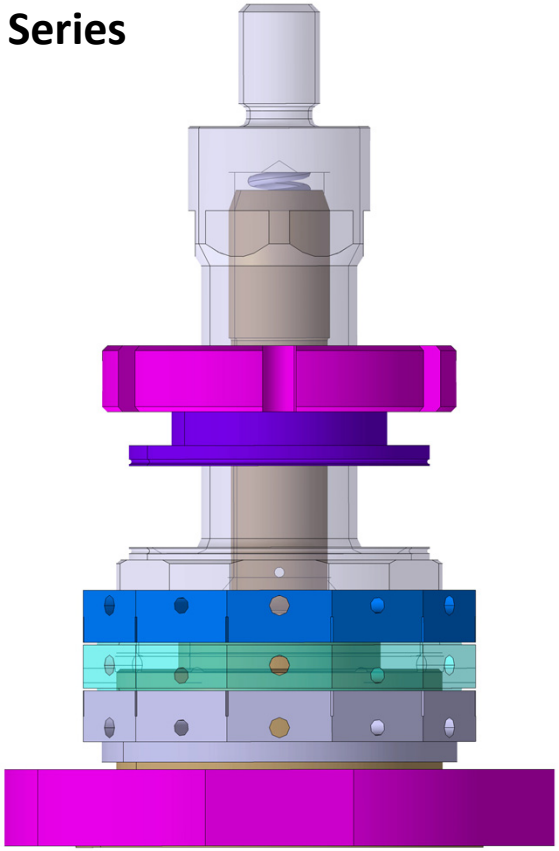
magnet thickness: 5.0mm
pole thickness: 2.4mm
accuracy: 0.3µm
clamp for magnet and pole

Aramis Undulator U15 – changes

Pre-Prototype



Series



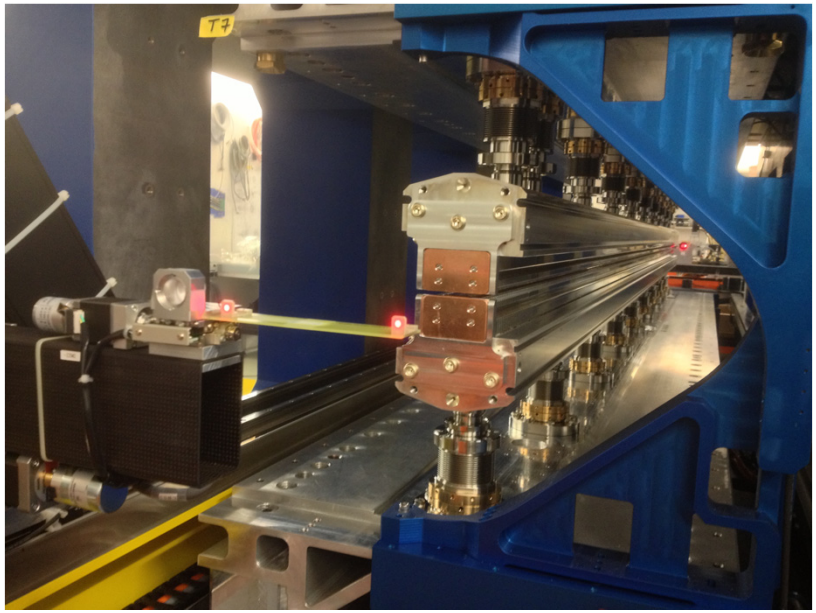
2nd lock nut to stabilize the fix position

adjustable range: ± 0.5mm

accuracy: 1µm

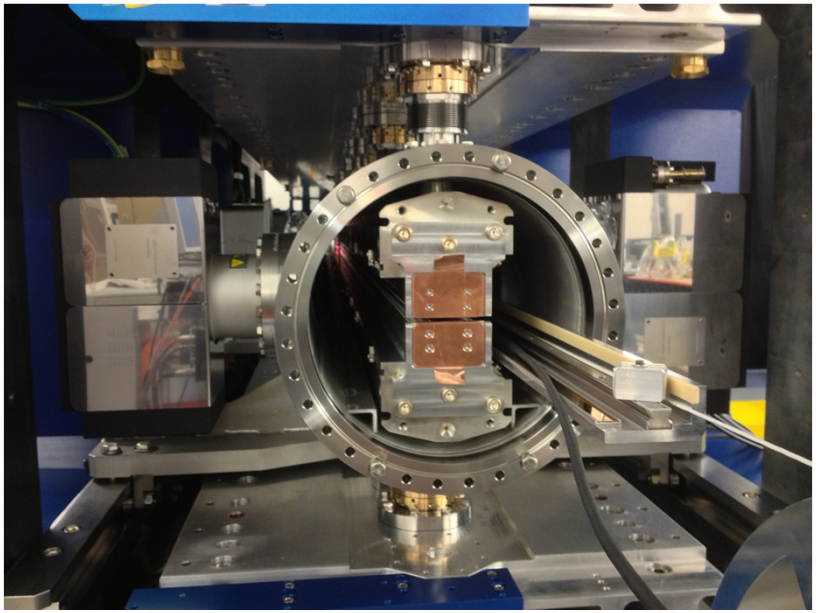
Aramis Undulator U15 – measurement benches

1st without tank: trajectory and phase



Hall probe, linear motor
laser based axes stabilization

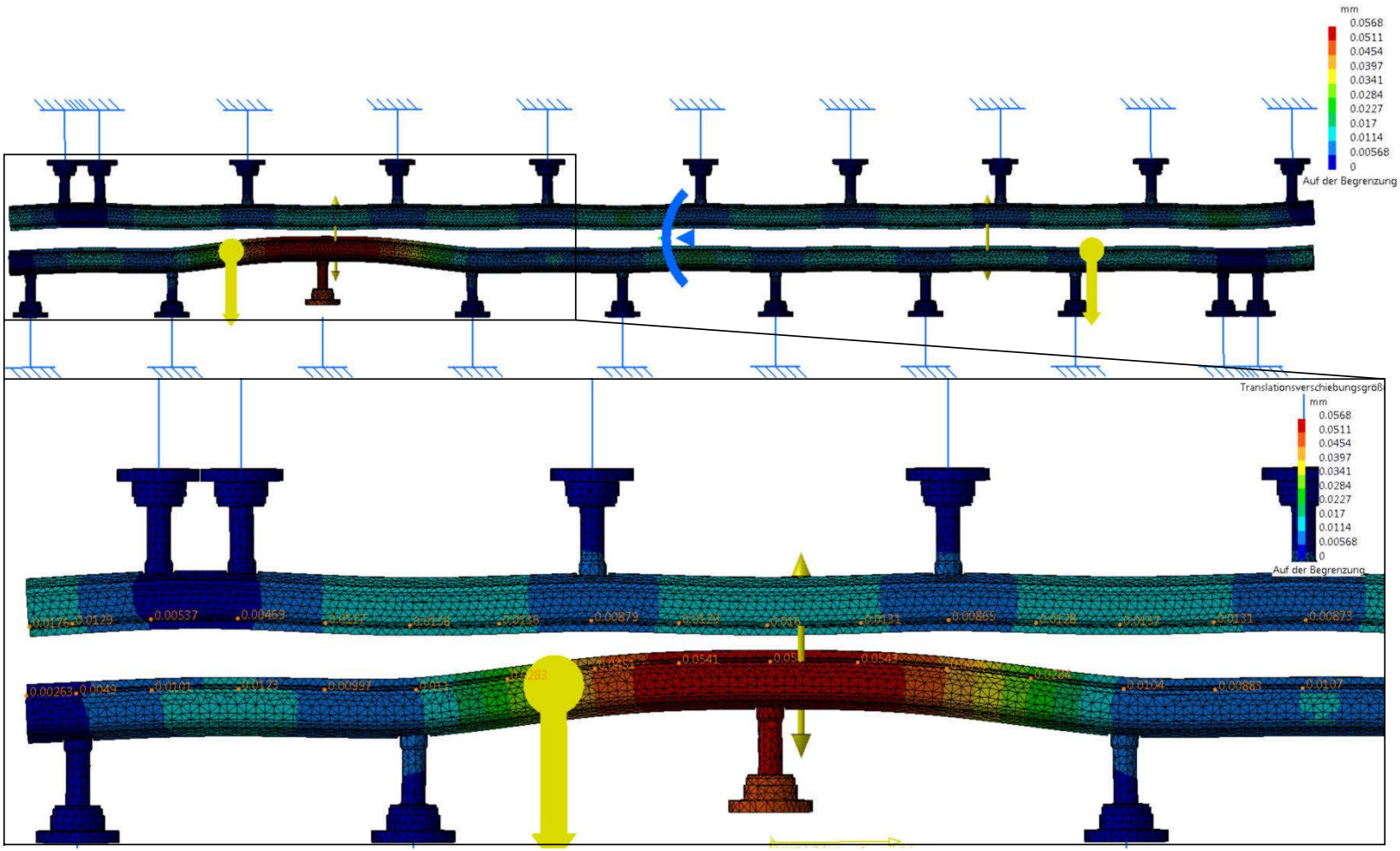
2nd inside tank: phase and calibration field vs gap



Hall probe, piezo stepper
laser based axes stabilization

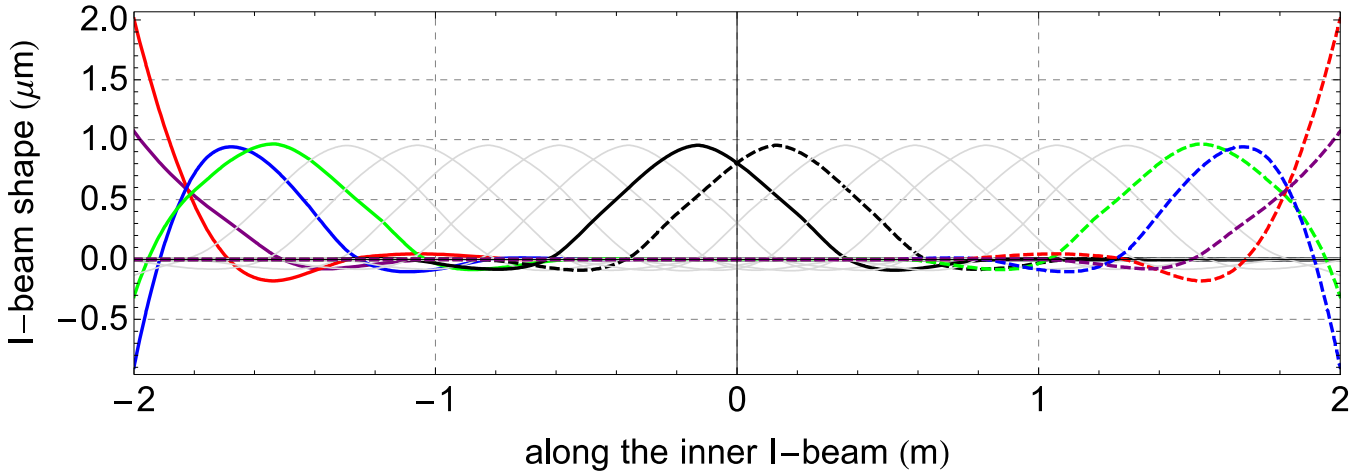
Aramis Undulator U15 – control algorithm

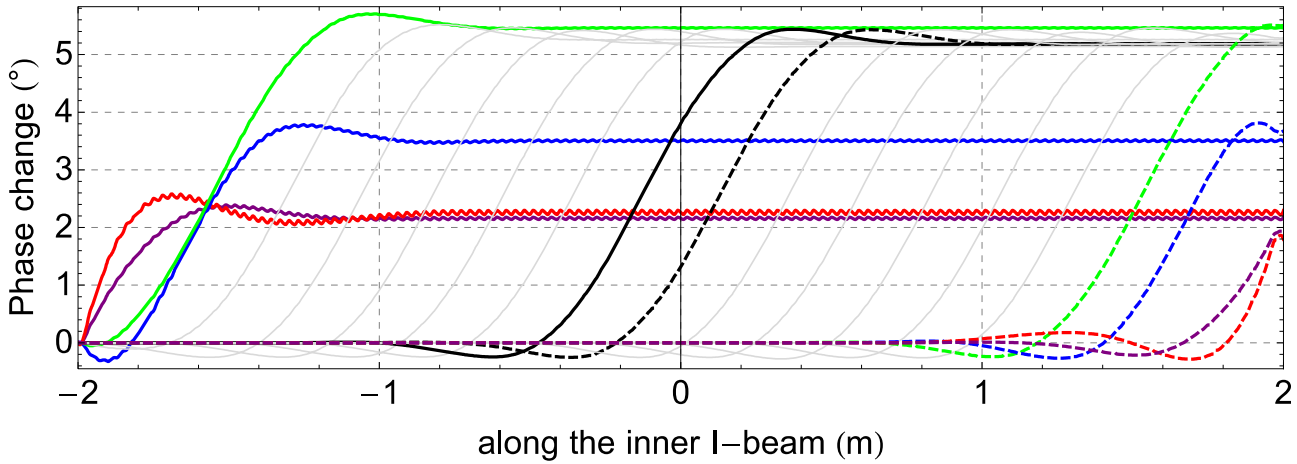
FEM calculations for every column with the influence to the i-beam



Aramis Undulator U15 – control algorithm

the results of FEM calculations were included in the control algorithm



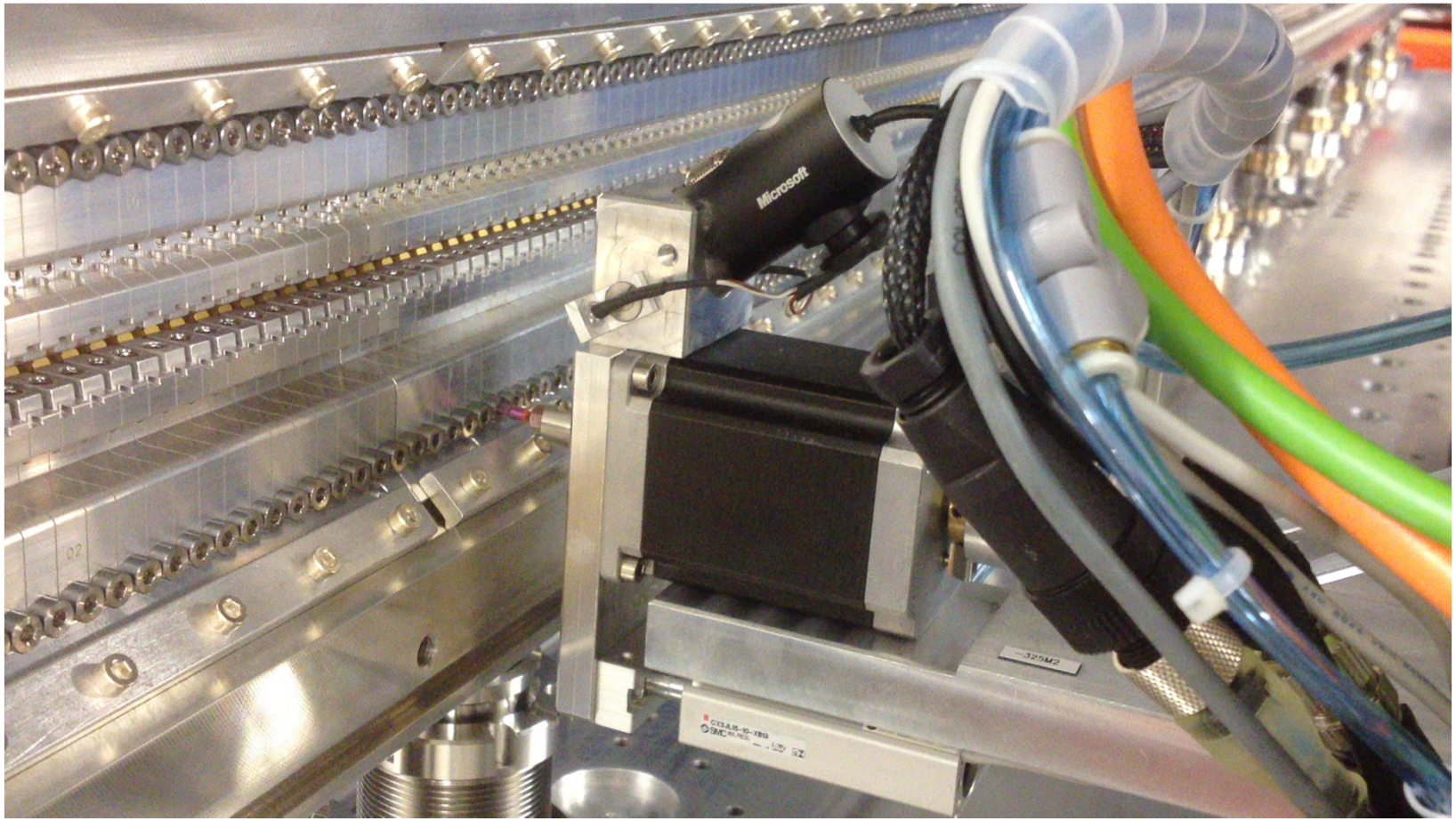


Aramis Undulator U15 – column adjustment

Model based column adjustment means 1 optimization run in 1hour

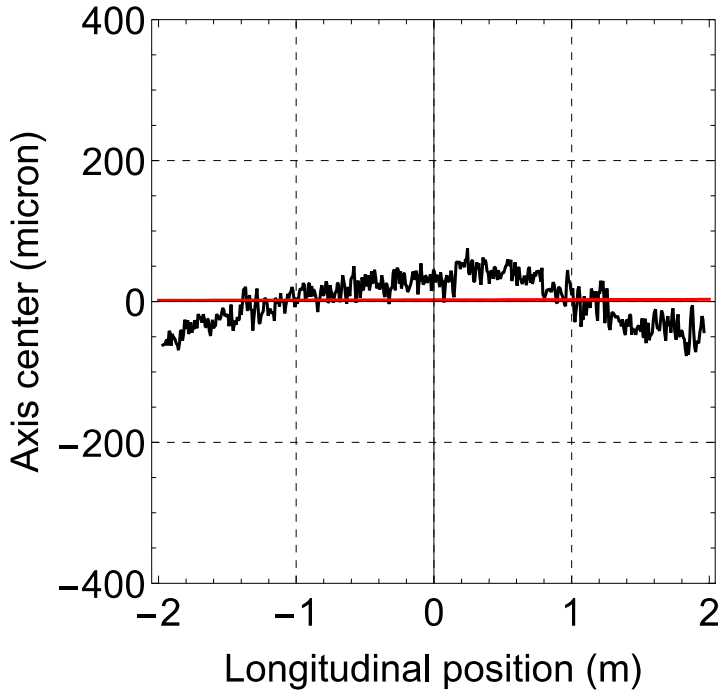
Aramis Undulator U15 –pole height adjustment

Automated pole height adjustment means 1 optimization run in 1 to 2hours

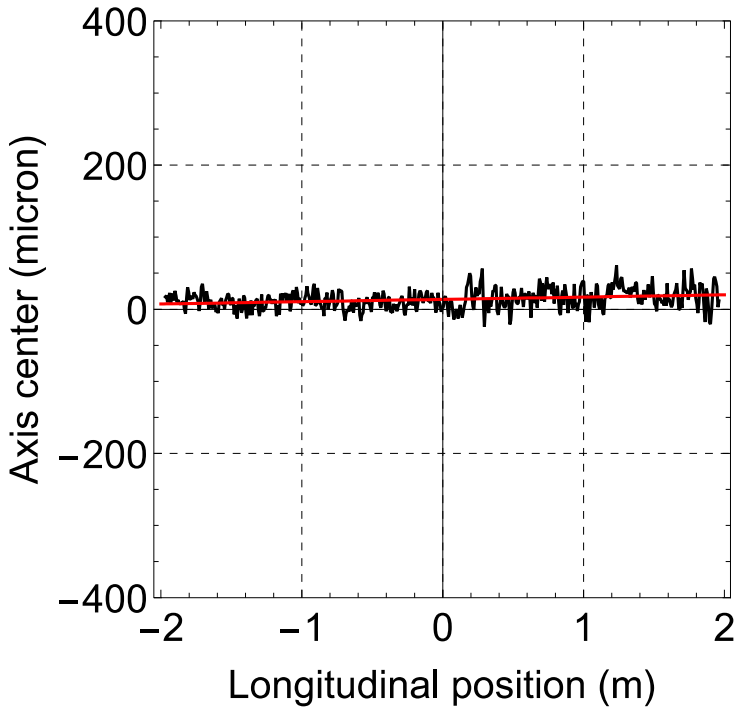


Aramis Undulator U15 – optimization

measuring the magnet field

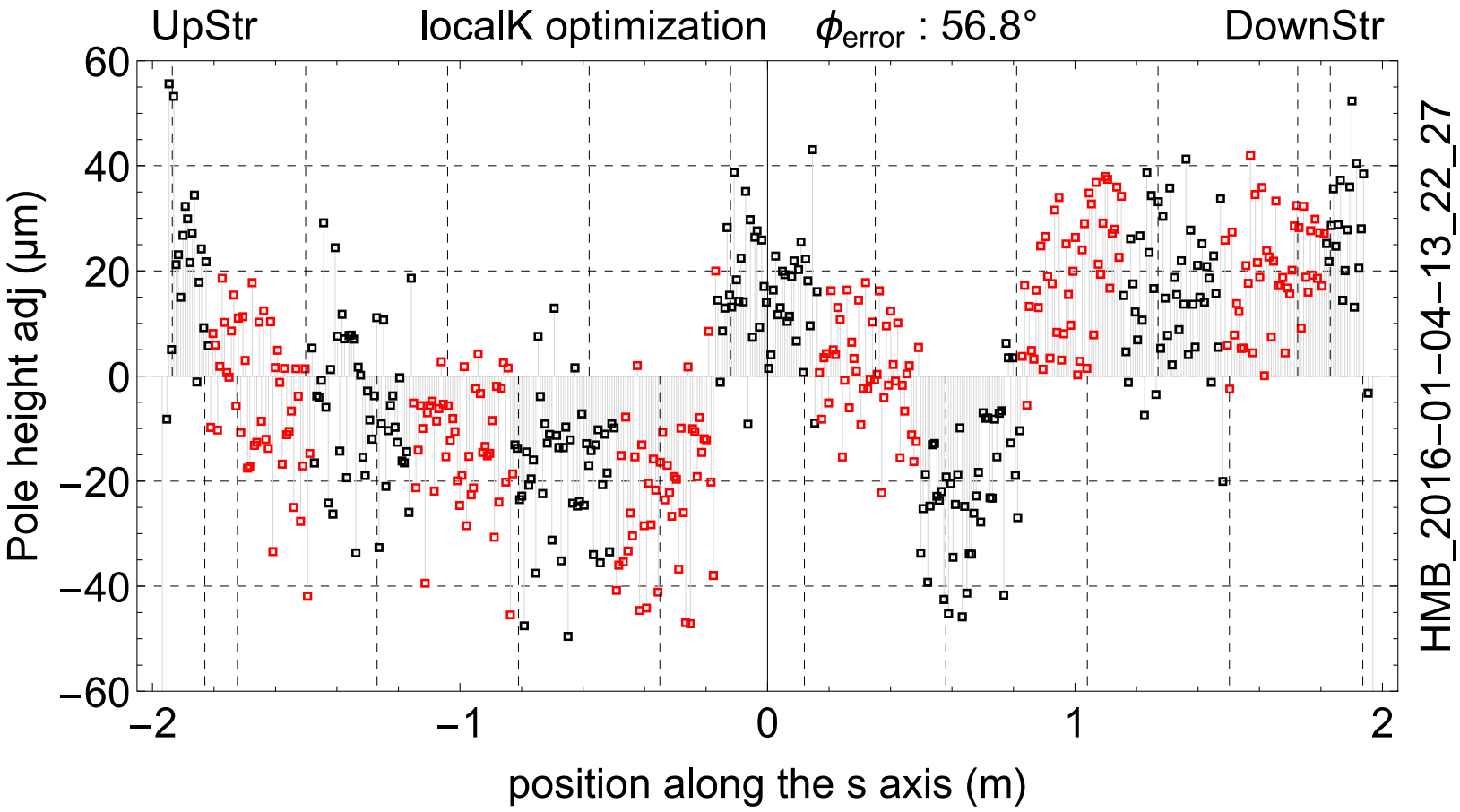


1st straighten axis with columns



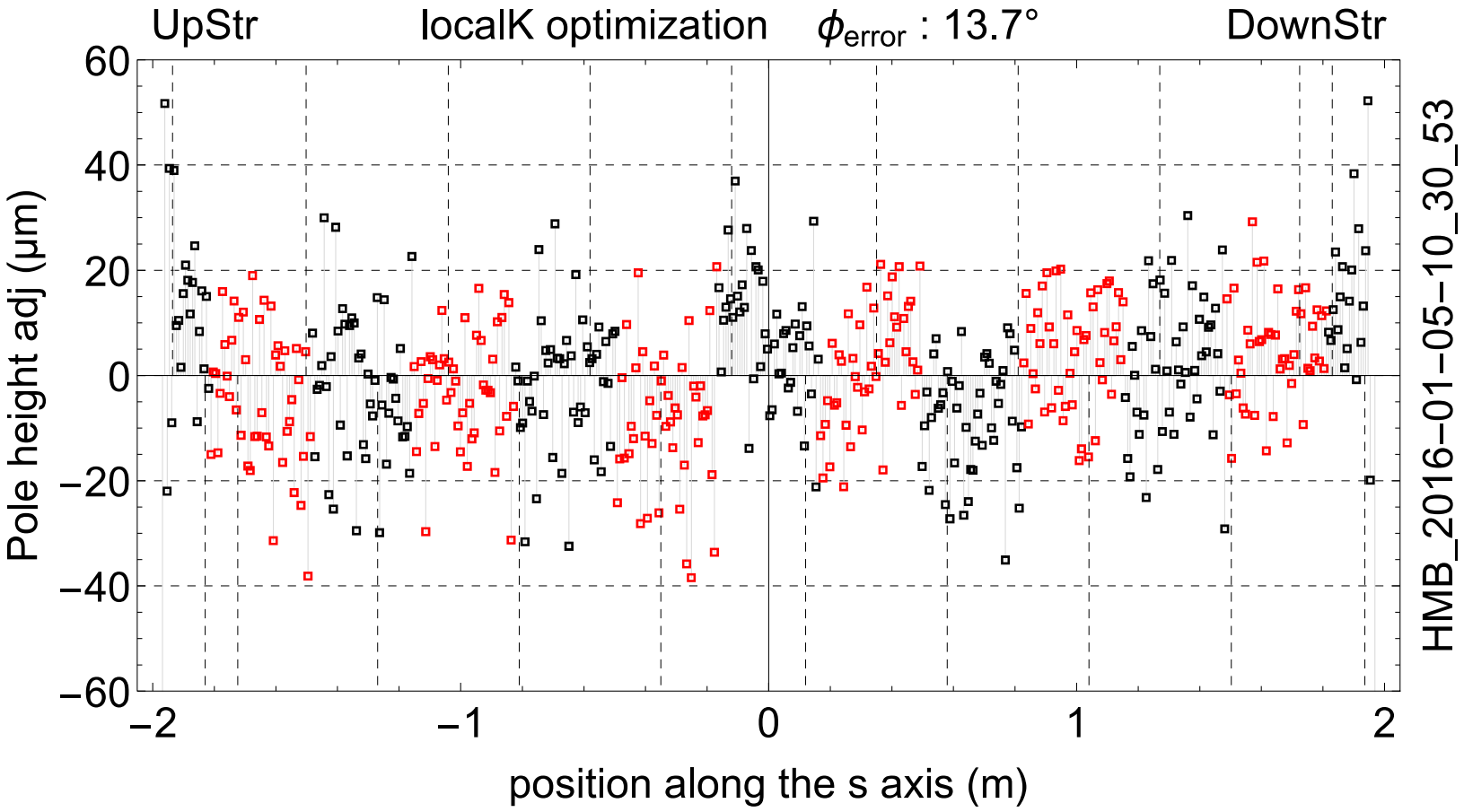
Aramis Undulator U15 – optimization

2nd correcting long rang distortions with columns



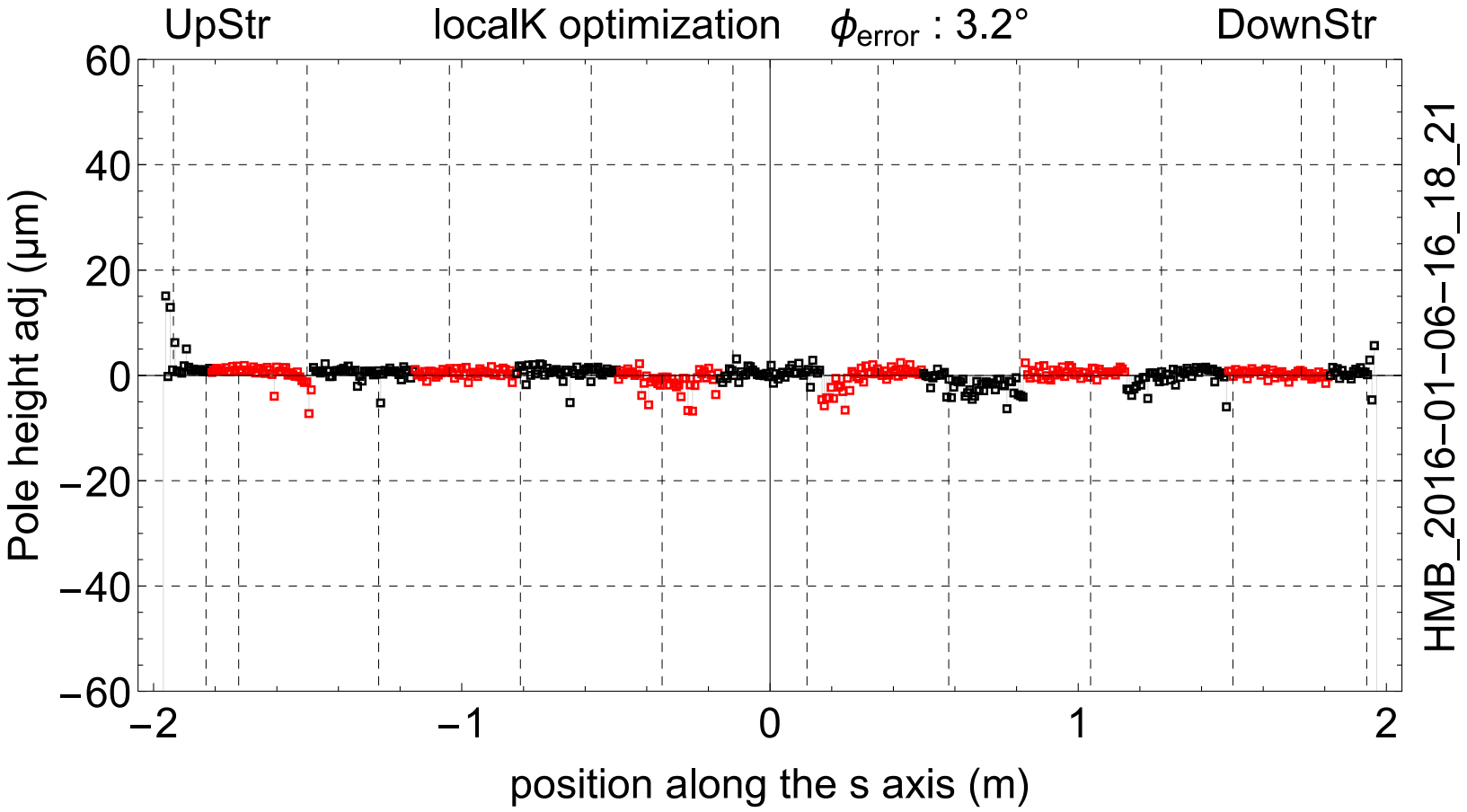
Aramis Undulator U15 – optimization

3rd now start with automated pole height adjustment



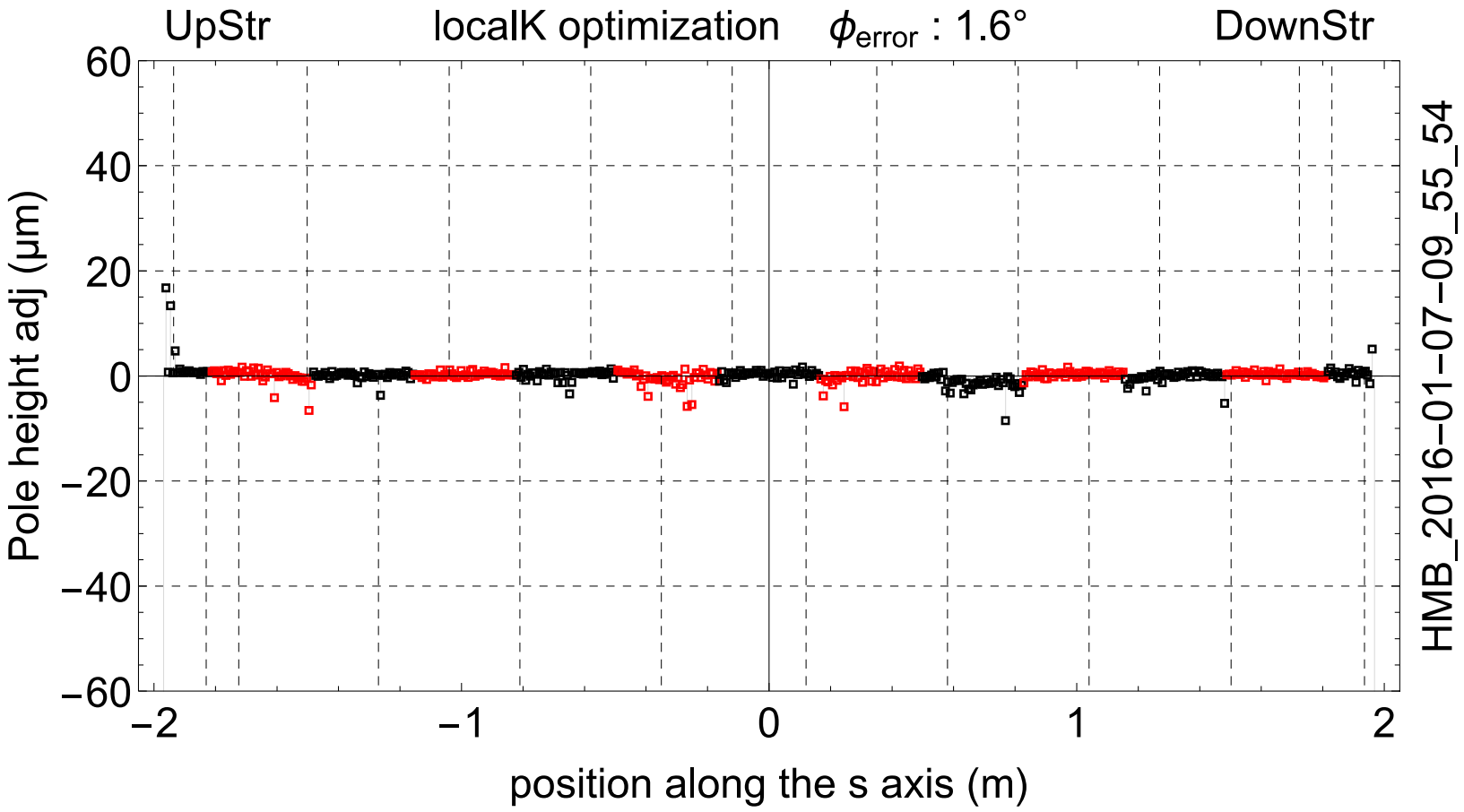
Aramis Undulator U15 – optimization

after 1st Yuri run (1064 individual keepers)



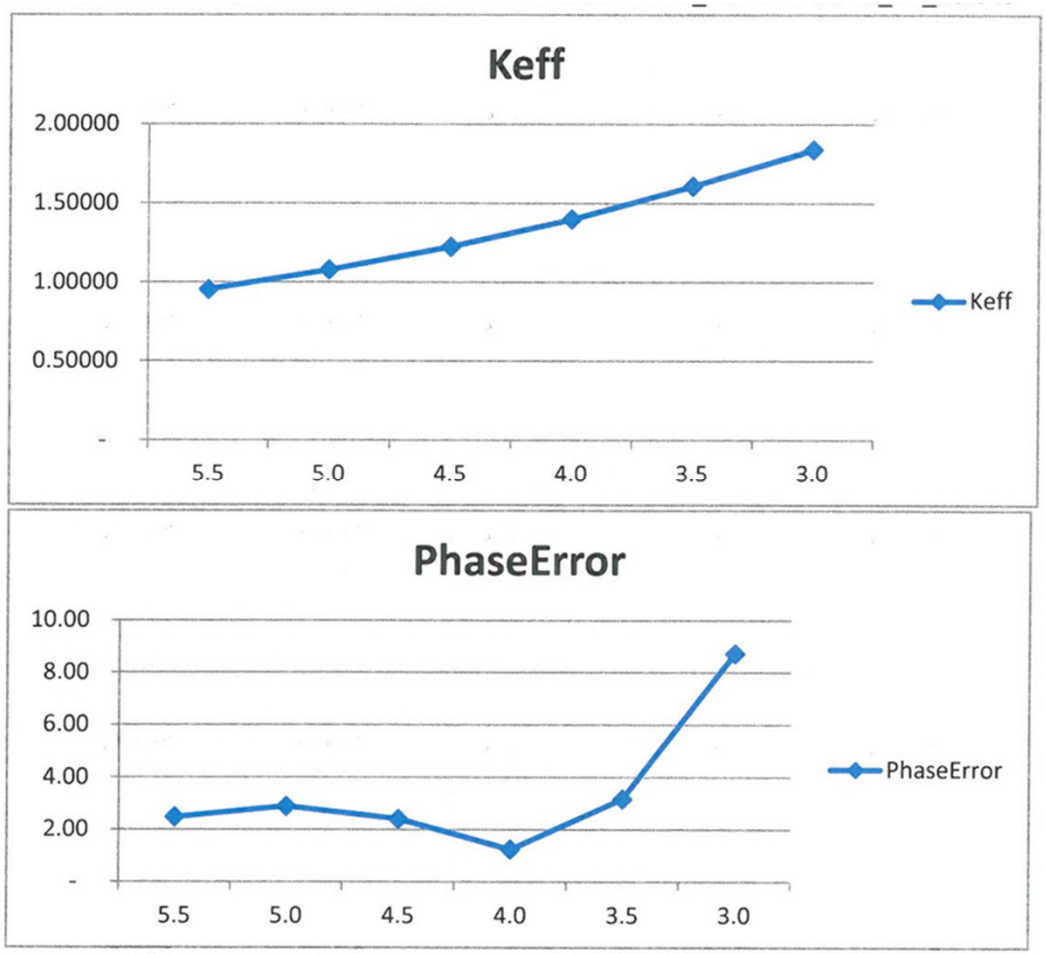
Aramis Undulator U15 – optimization

after 3rd Yuri run



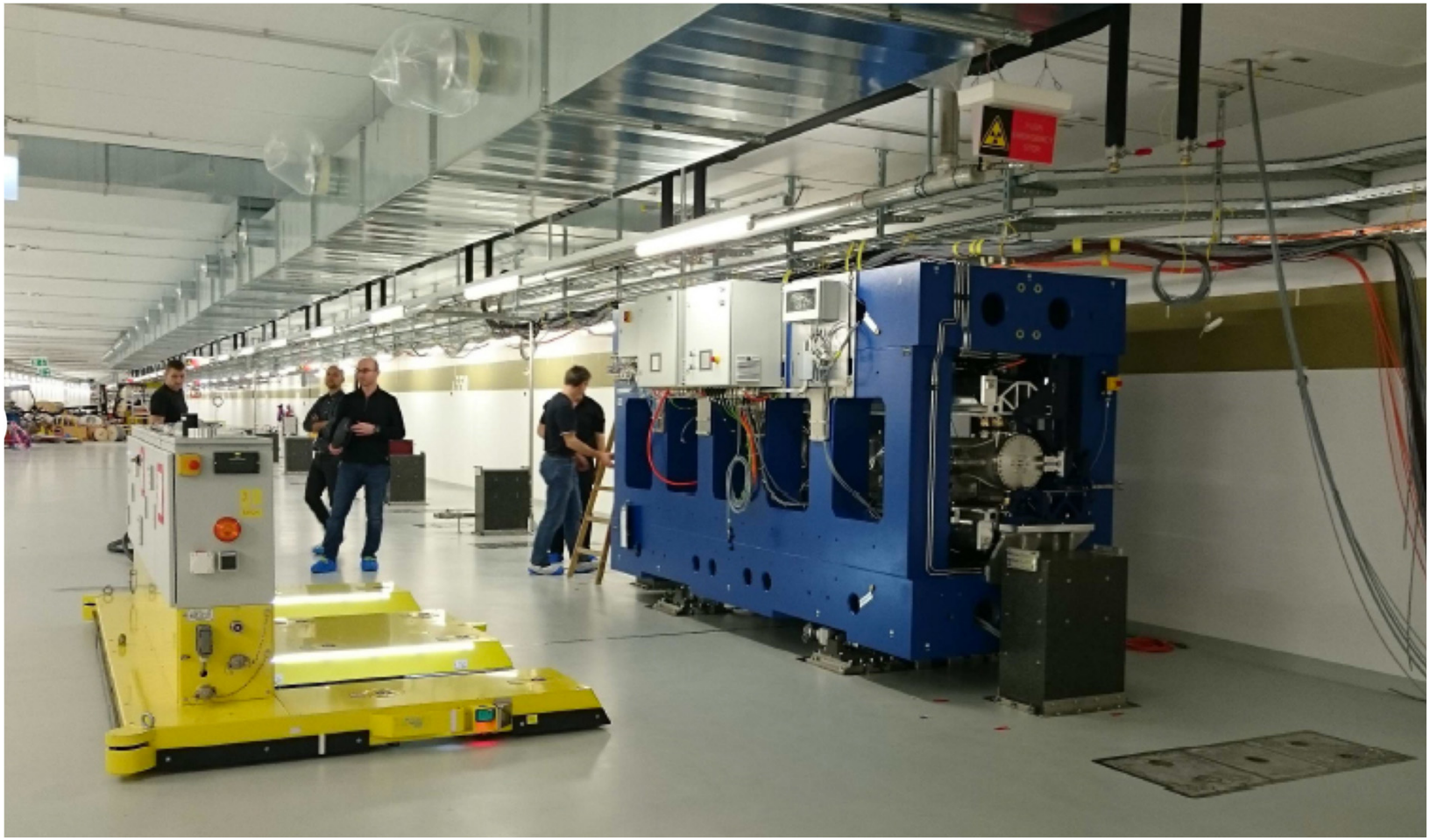
Aramis Undulator U15 – optimization

Total optimization in only 3 days, instead of 1 or 2 months



Aramis Undulator U15 – installation

1st U15 installed in January 2016



Aramis Undulator U15 – installation

August 2016, 9 U15 installed

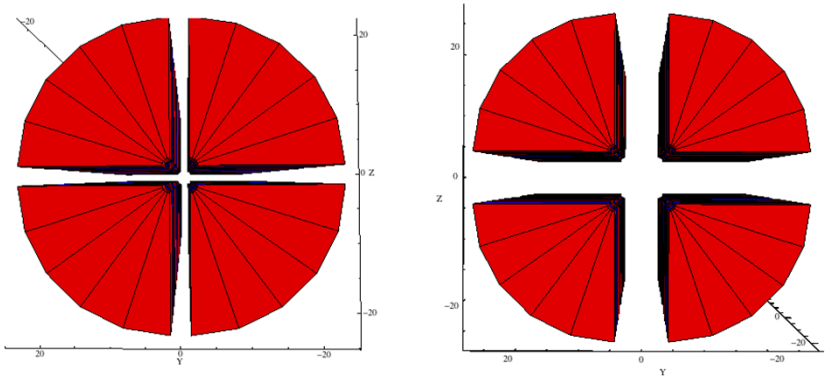
Wir schaffen Wissen – heute für morgen

Aramis U15

- … design from October 2008 – April 2014
- … pre-prototyp from November 2010 – October 2013
- … series from July 2013 – September 2015
- … optimisation in the ID-laboratory from September 2015 – September 2016
- … installation in the tunnel starts in January 2016

UE38 Design (End of Concept Phase)

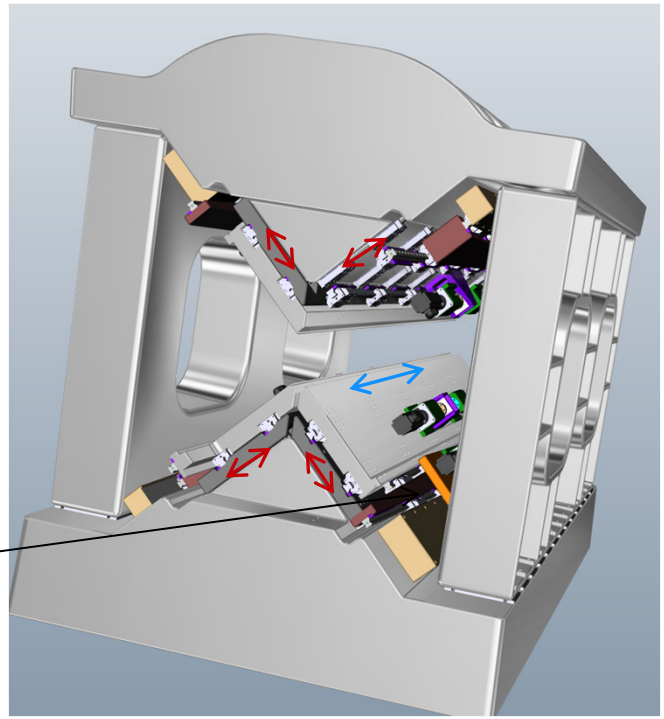
APPLE – X configuration

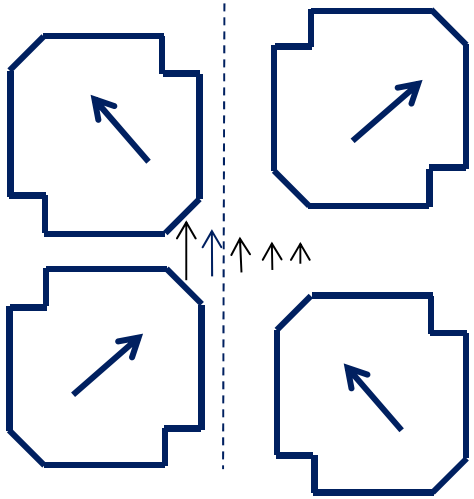


Frame in Cast Iron (Length 2m)

Movements (Gap and Shift) Ortho-gonal

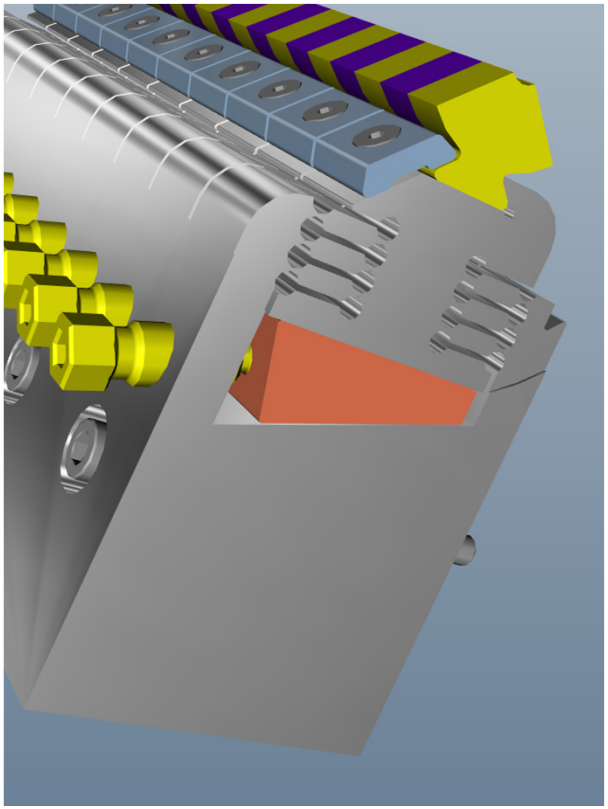
Gap with wedge drive





highest flexibility : gradients for ultra high bandwith mode

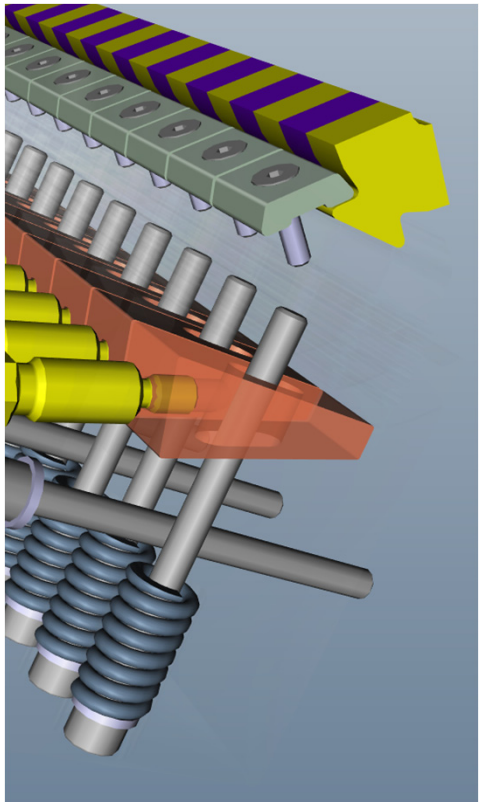
UE38 Design : Keeper



Optimized flexor

Differential Screw for adjustment with robot

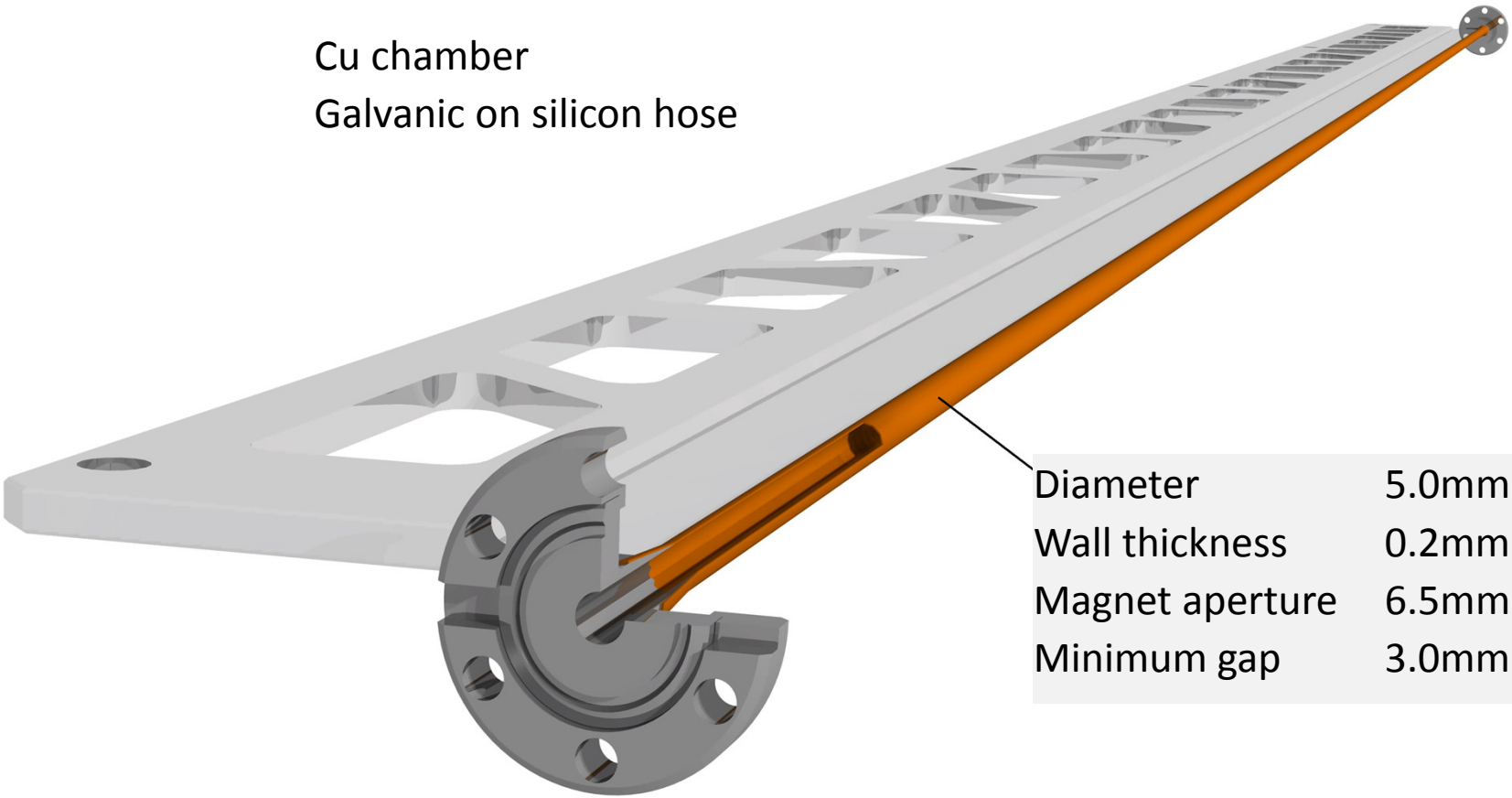
Spring preload for flexor



UE38 Design : Vacuum Chamber

Cu chamber

Galvanic on silicon hose



Diameter	5.0mm
Wall thickness	0.2mm
Magnet aperture	6.5mm
Minimum gap	3.0mm

Wir schaffen Wissen – heute für morgen

My thanks go to

- Andreas Keller
- Marcel Locher
- Haimo Jöhri
- Marc Brügger
- Dr. Thomas Schmidt
- Dr. Marco Calvi

and the whole ID-Team