The background of the slide features a composite image. On the left, there is a view of a galaxy with a bright, glowing jet of light extending from its center. On the right, there is a 3D simulation of a particle diverter, showing a central orange cylindrical component with several blue and yellow particle trajectories radiating outwards. A small 3D coordinate system with x, y, and z axes is visible in the bottom right corner of the simulation area.

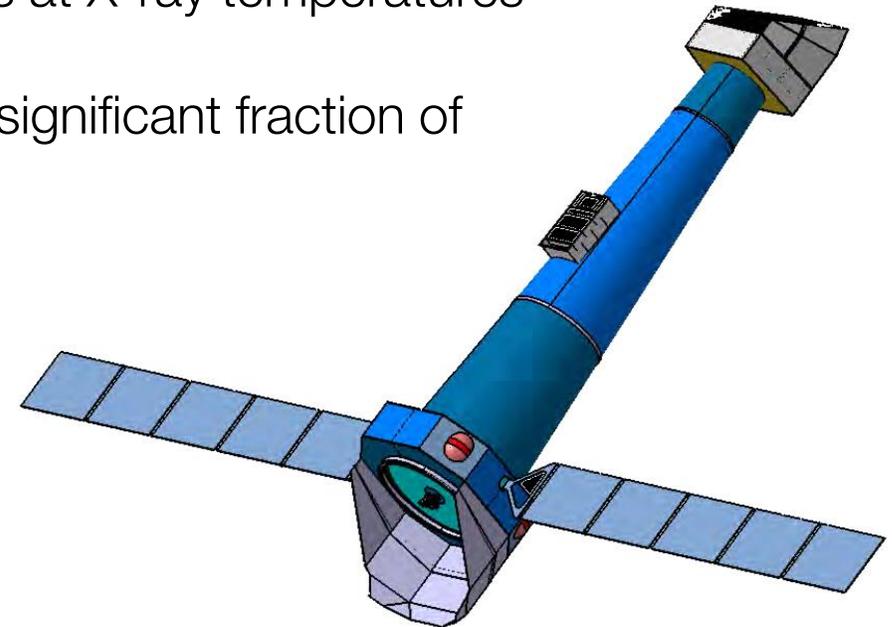
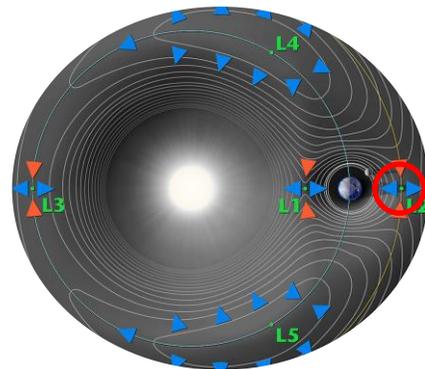
ATHENA Charged Particle Diverter

Copyright: ESA

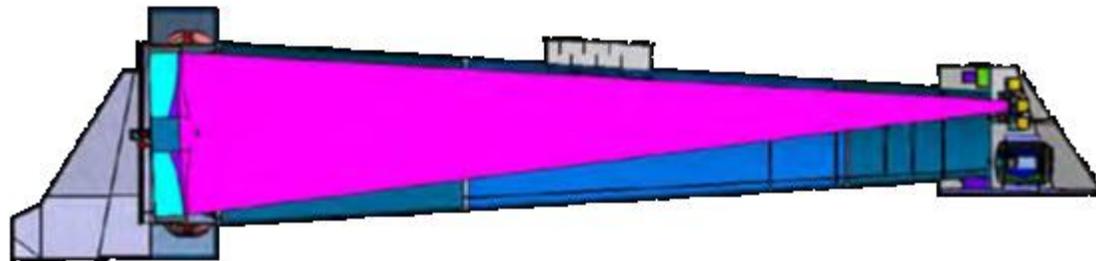
Jakub Zlámal (BUT), Richard Hynek (L.K.Engineering)

Copyright: BUT

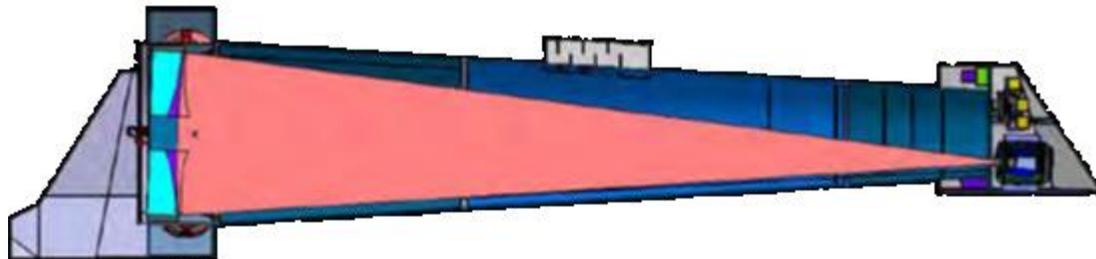
- Large X-ray observatory
- Second L-class mission in ESA “Cosmic Vision” program
- Addresses Science Theme “The Hot and Energetic Universe”:
 - How does ordinary matter assemble in large structures as seen today? Most ordinary matter in the universe is in the form of hot gas at X-ray temperatures
 - How do black holes grow and shape the universe? A significant fraction of the luminous energy in the universe is from accretion
- Periodic L2 “Halo orbit ”



- Protons impinging X-ray detectors cause decrease of signal to noise ratio – they should be deflected away
- Deflection of protons by magnetic field of permanent magnets – no power consumption
- Protons with energies up to 76 keV (WFI detector) and 66 keV (X-IFU detector)
- Magnets cannot shield X-ray photons focused by mirror
- Working temperature range ± 35 °C, survive range ± 50 °C



WFI detector
(Wide field imager)



X-IFU detector
(integral field – superconducting calorimeters) cooled to 50 mK

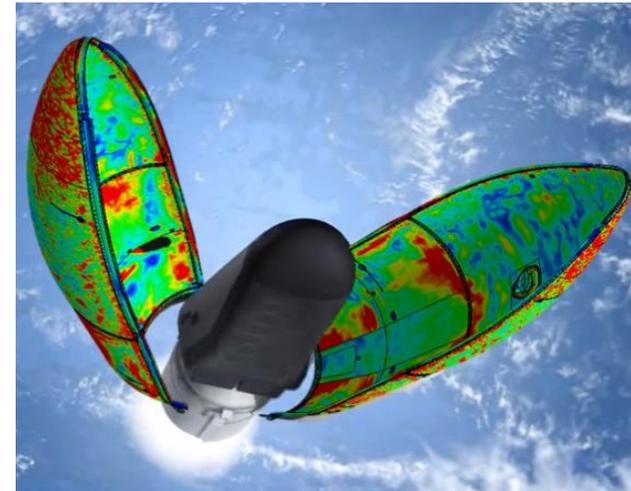
- Technology preparation of Charged Particle Divertor
- Cooperation of experienced science and industrial entities in Brno
 - Frentech Aerospace s.r.o. – prime contractor and manufacturer
 - Brno University of Technology – magnetic design of the divertor
 - L.K.Engineering s.r.o. – structural design of the divertor



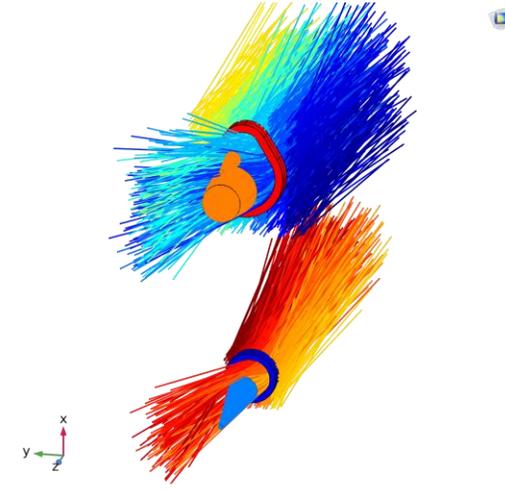
Copyright: Frentech Aerospace



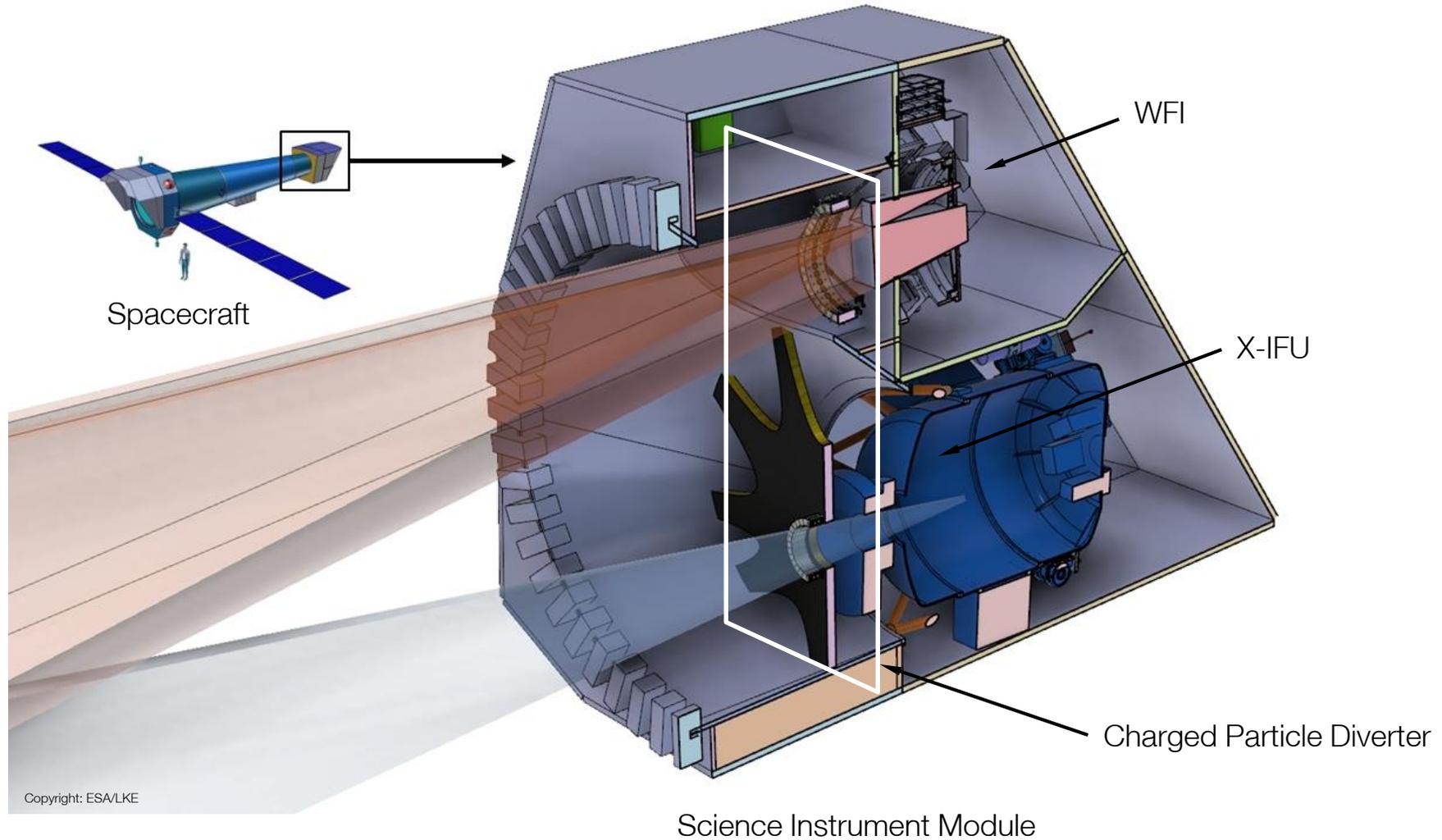
Copyright: Frentech Aerospace

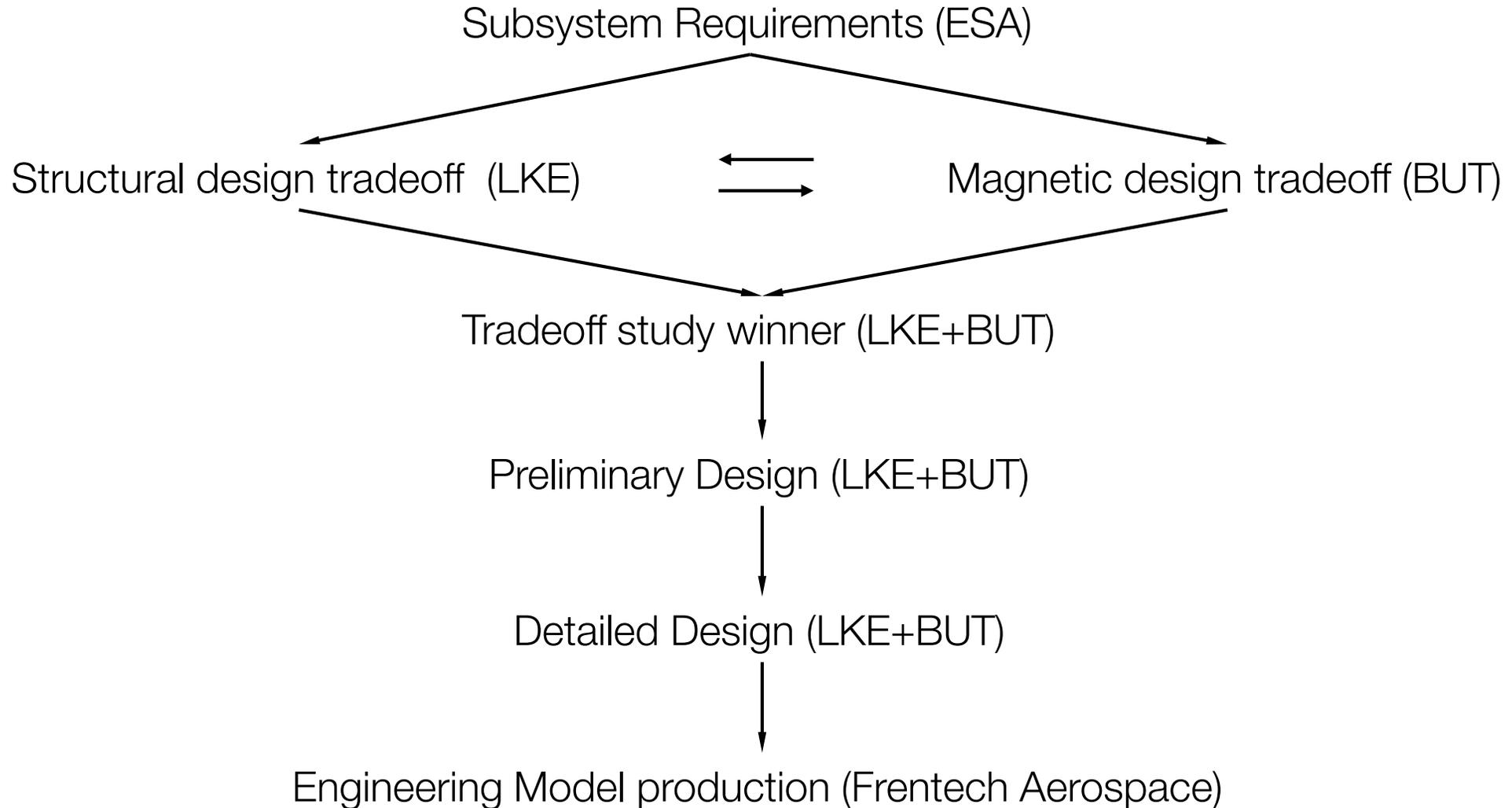


Copyright: ESA/LKE

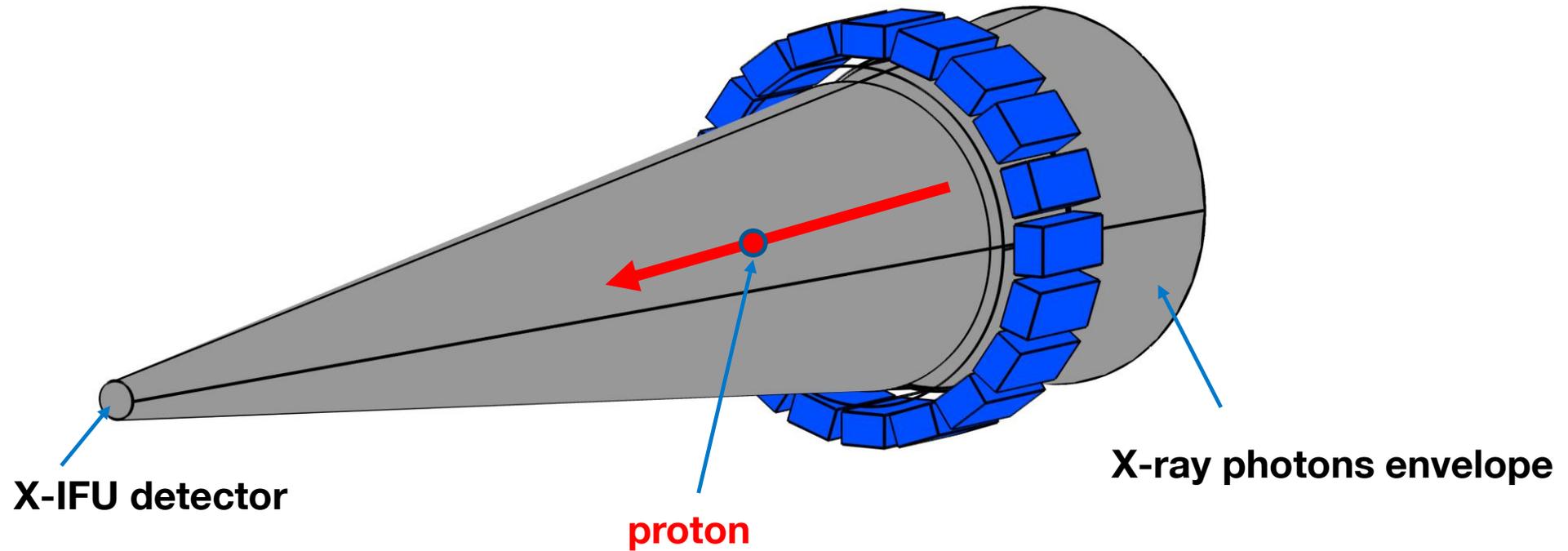


Copyright: BUT

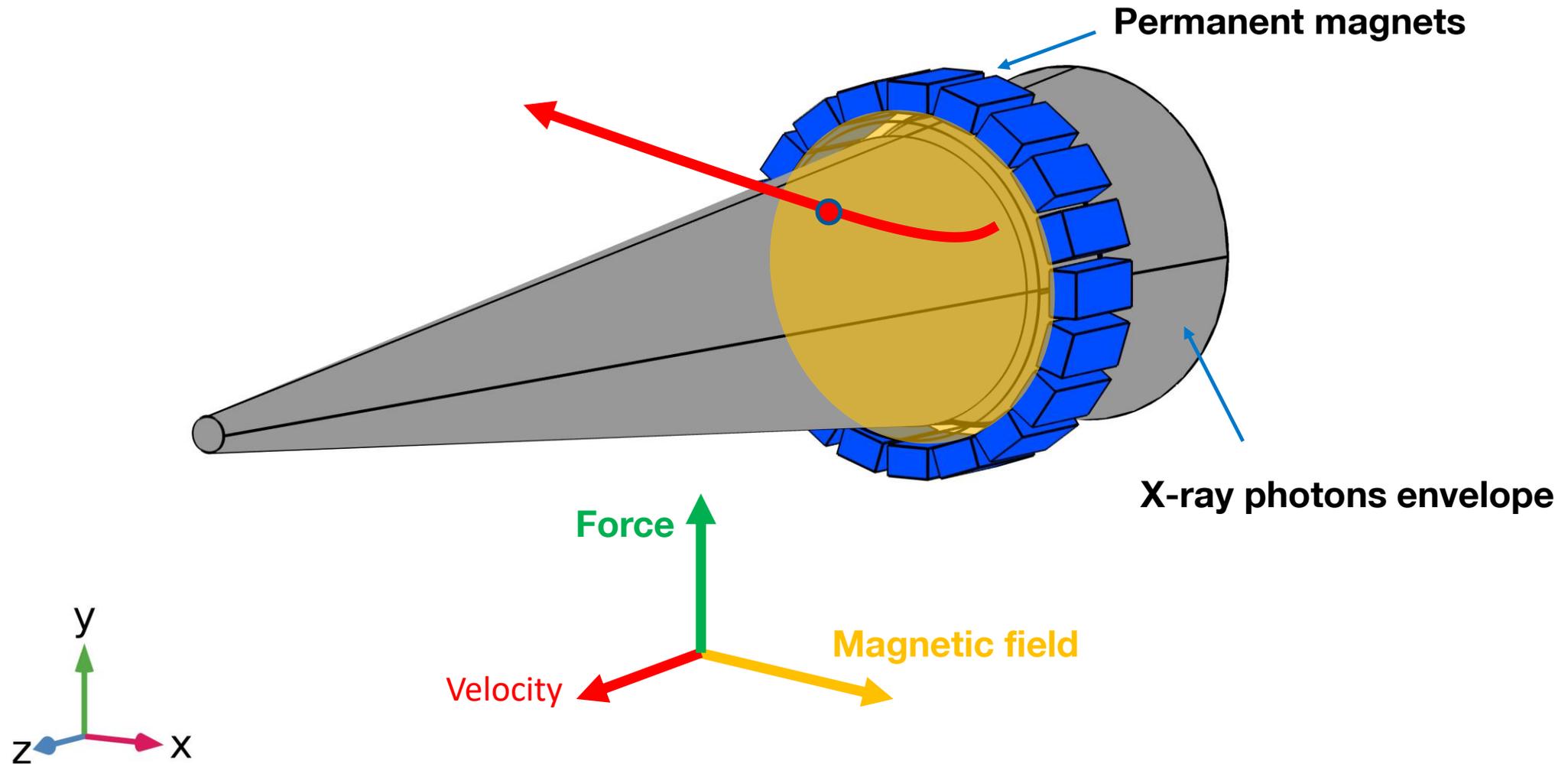




PRINCIPLE OF MAGNETIC DIVERTER

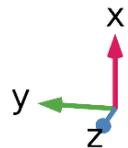


PRINCIPLE OF MAGNETIC DIVERTER



- WFI detectors
- WFI pear-shape Halbach Array

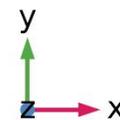
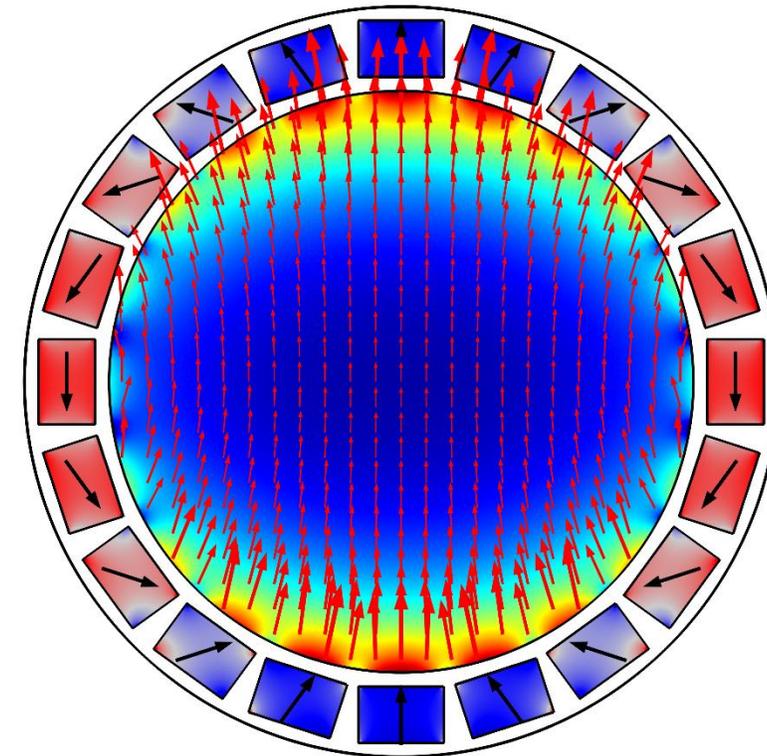
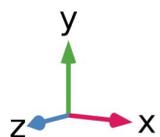
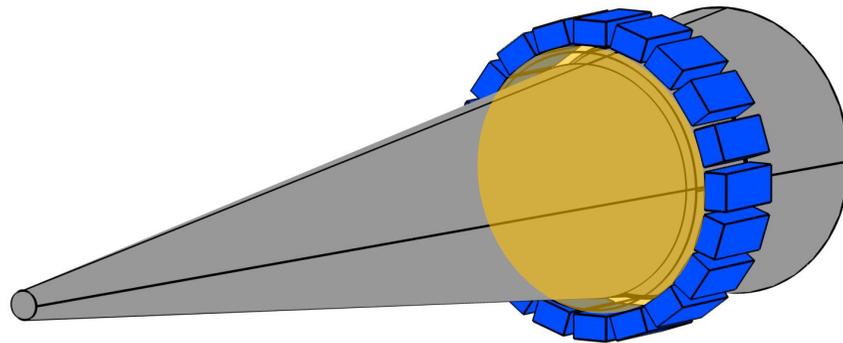
- X-IFU detector
- X-IFU Halbach Array



Circular Halbach Array

Uniform field

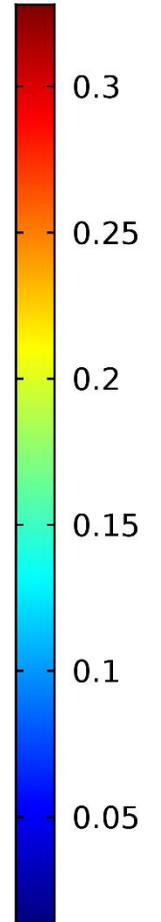
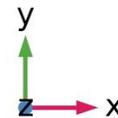
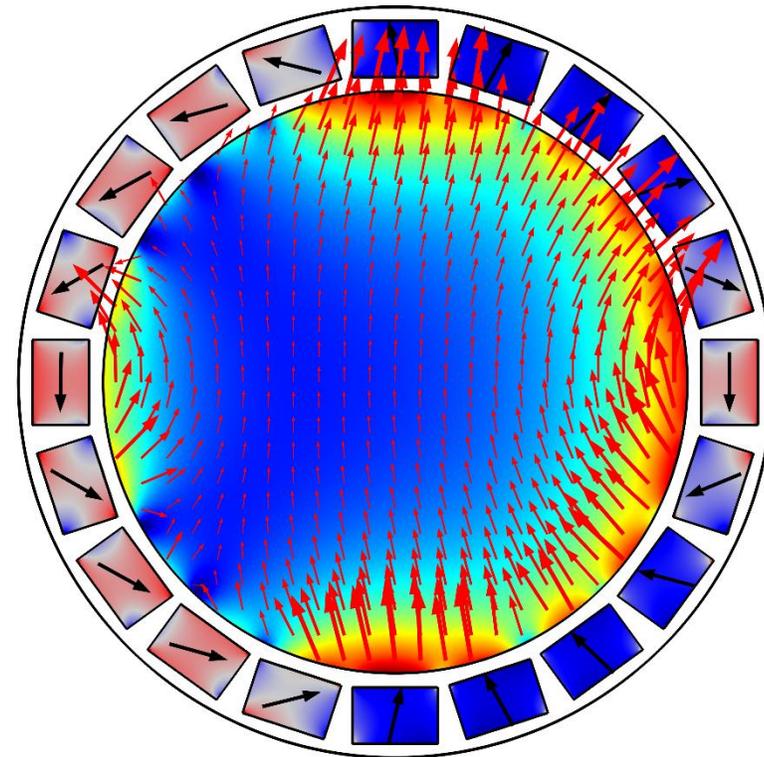
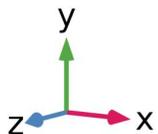
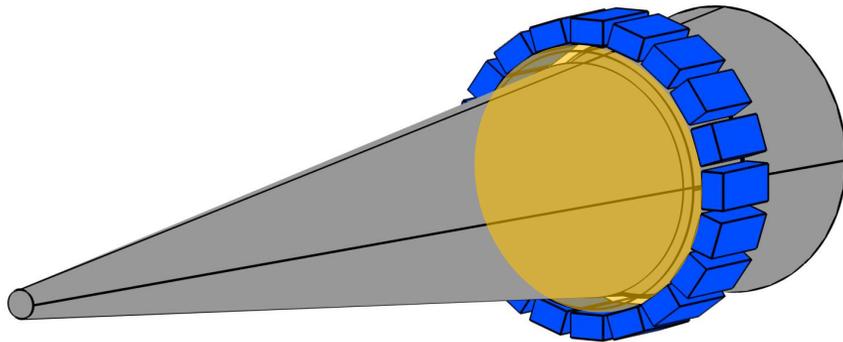
- Permanent magnets
- Strong magnetic field inside
- Small magnetic field outside



Circular Halbach Array

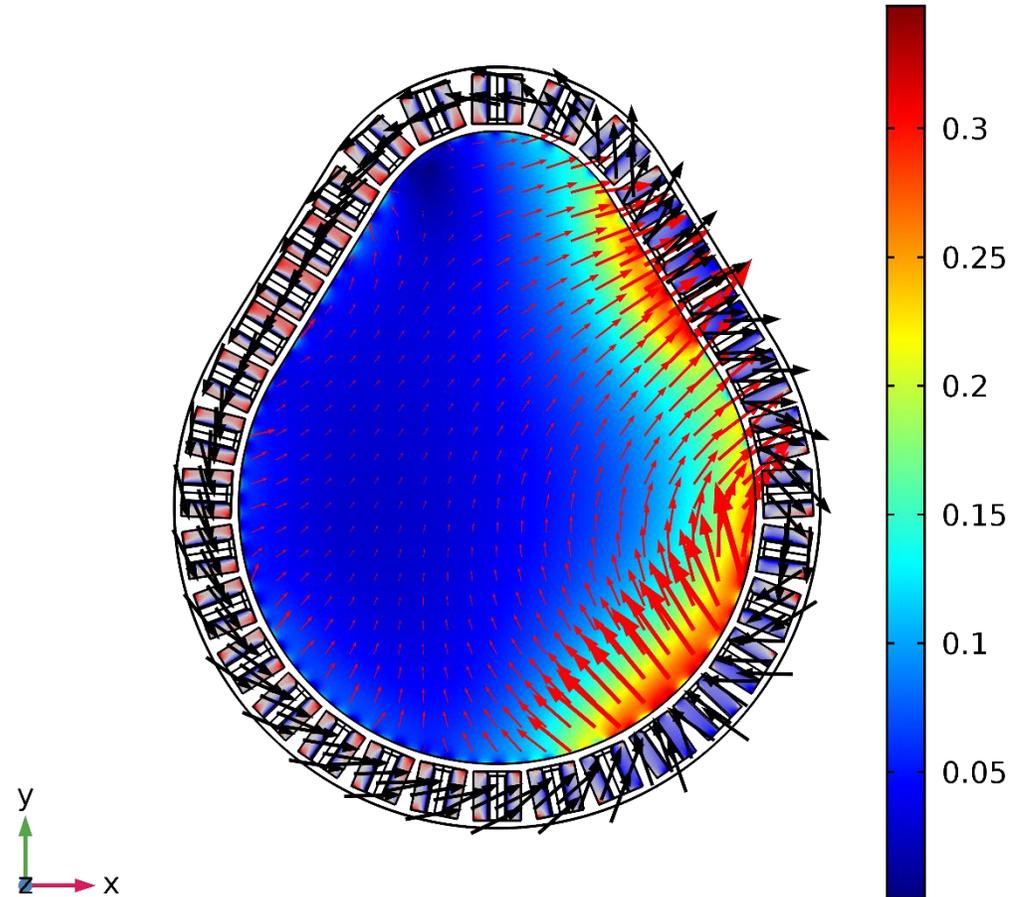
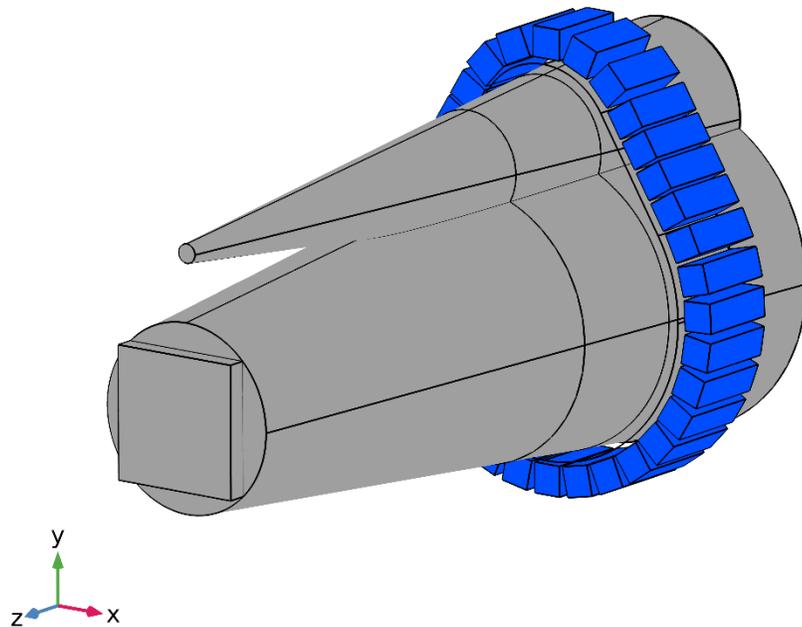
Nonuniform field – better performance

- Permanent magnets
- Strong magnetic field inside
- Small magnetic field outside
- Weight of magnets 6 kg



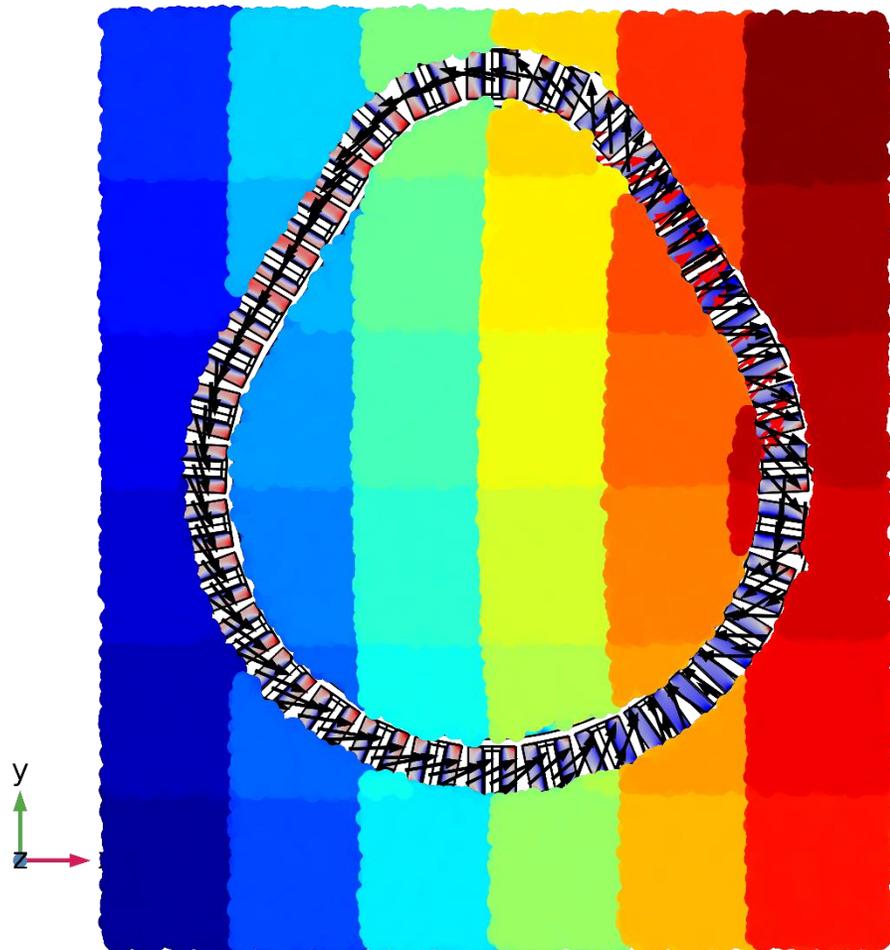
Pear-shape Halbach Array

- In front of WFI detector
- Inner diameter of 35 cm
- Weight of magnets 21 kg

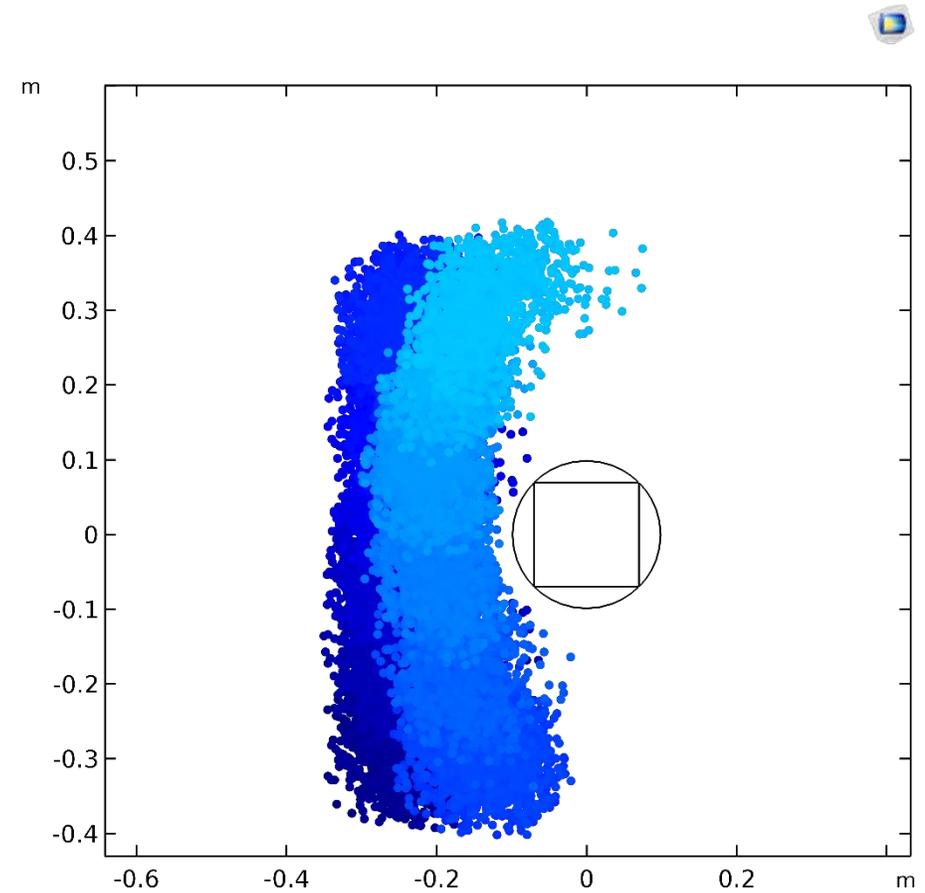


Pear-shape Halbach Array optimization

Entrance of Halbach Array

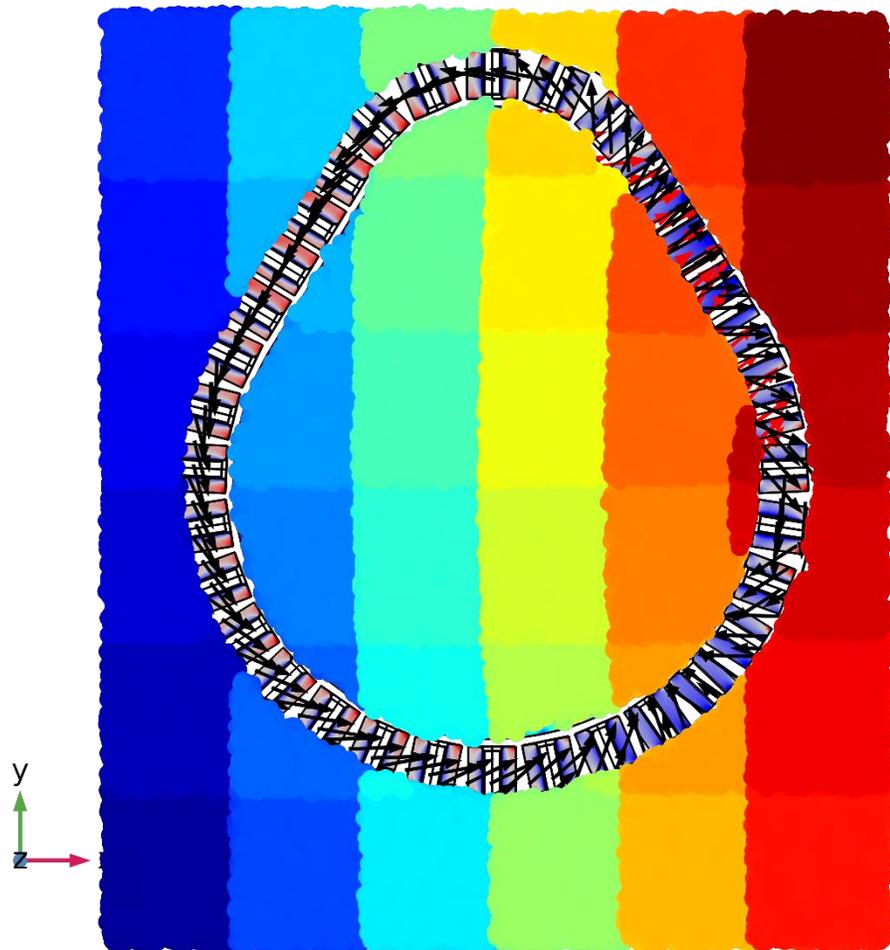


WFI detector plane

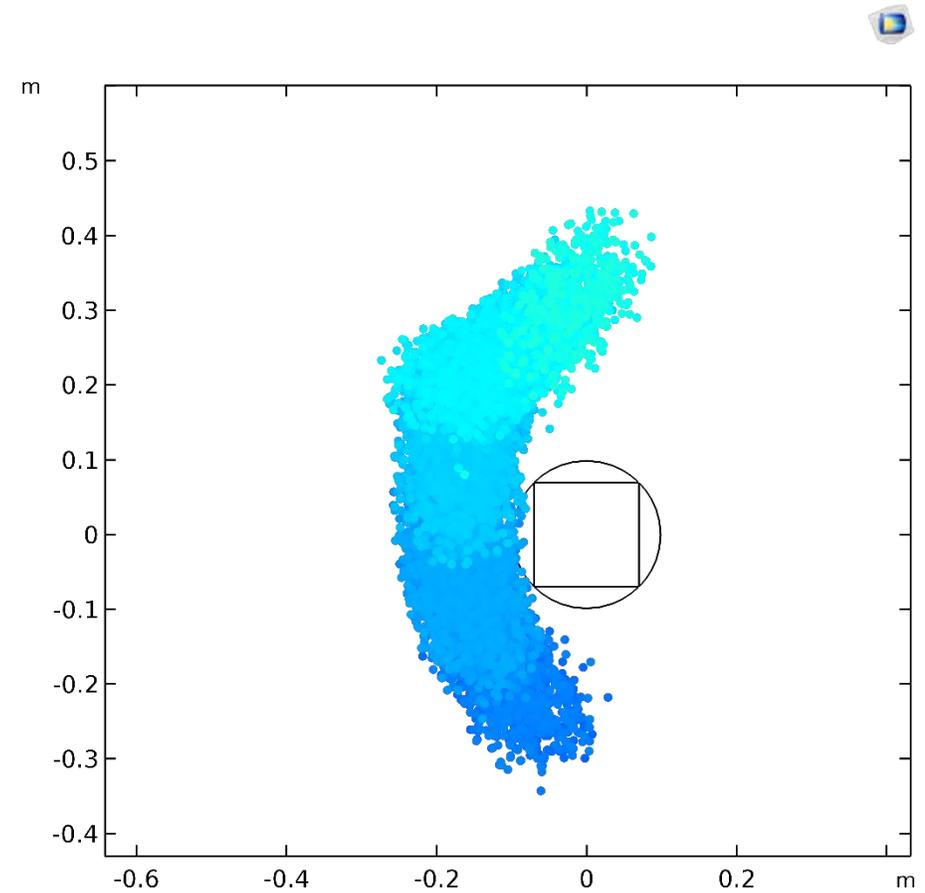


Pear-shape Halbach Array optimization

Entrance of Halbach Array

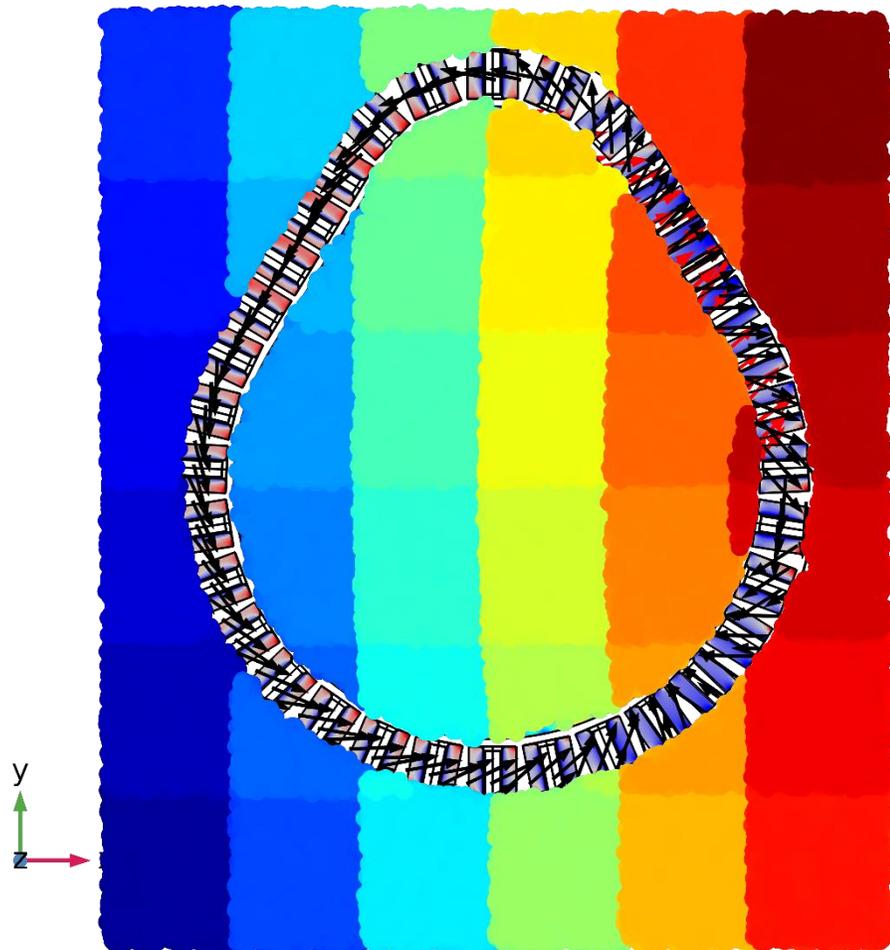


WFI detector plane

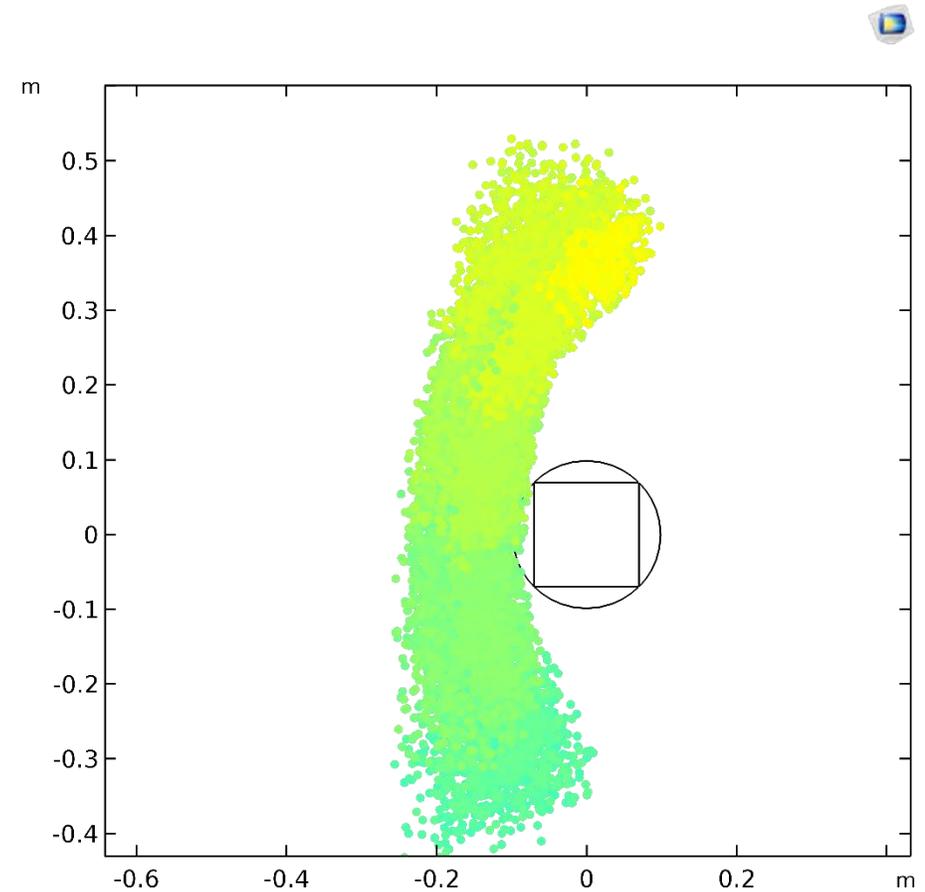


Pear-shape Halbach Array optimization

Entrance of Halbach Array

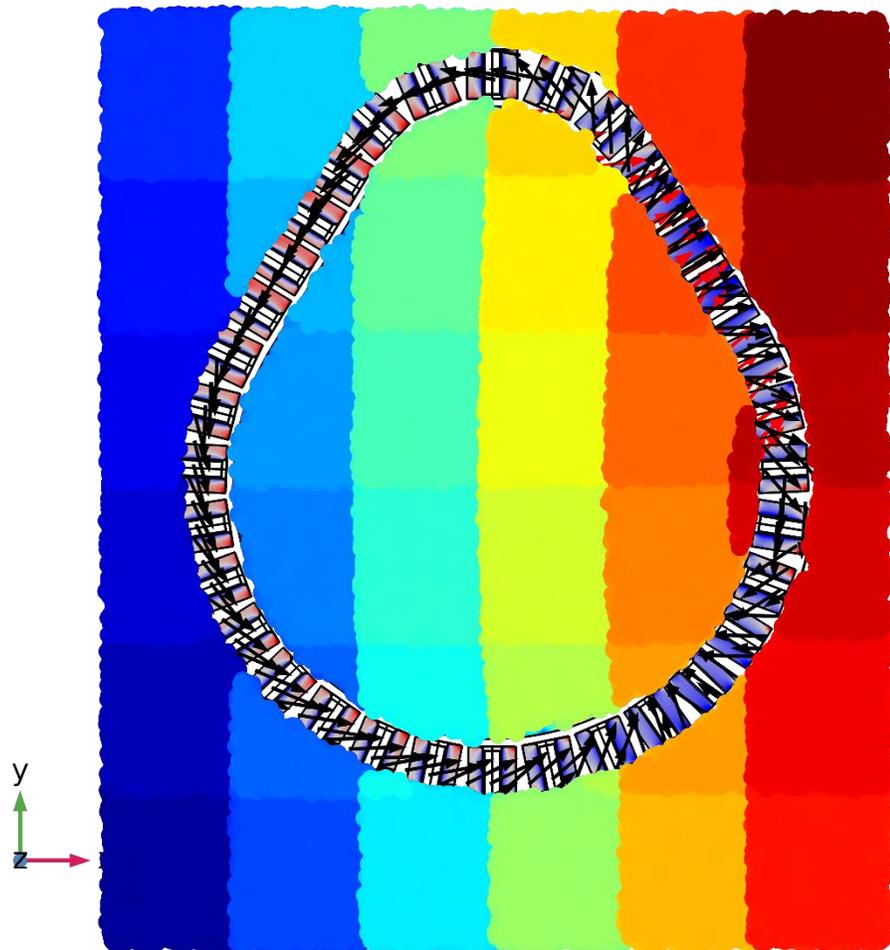


WFI detector plane

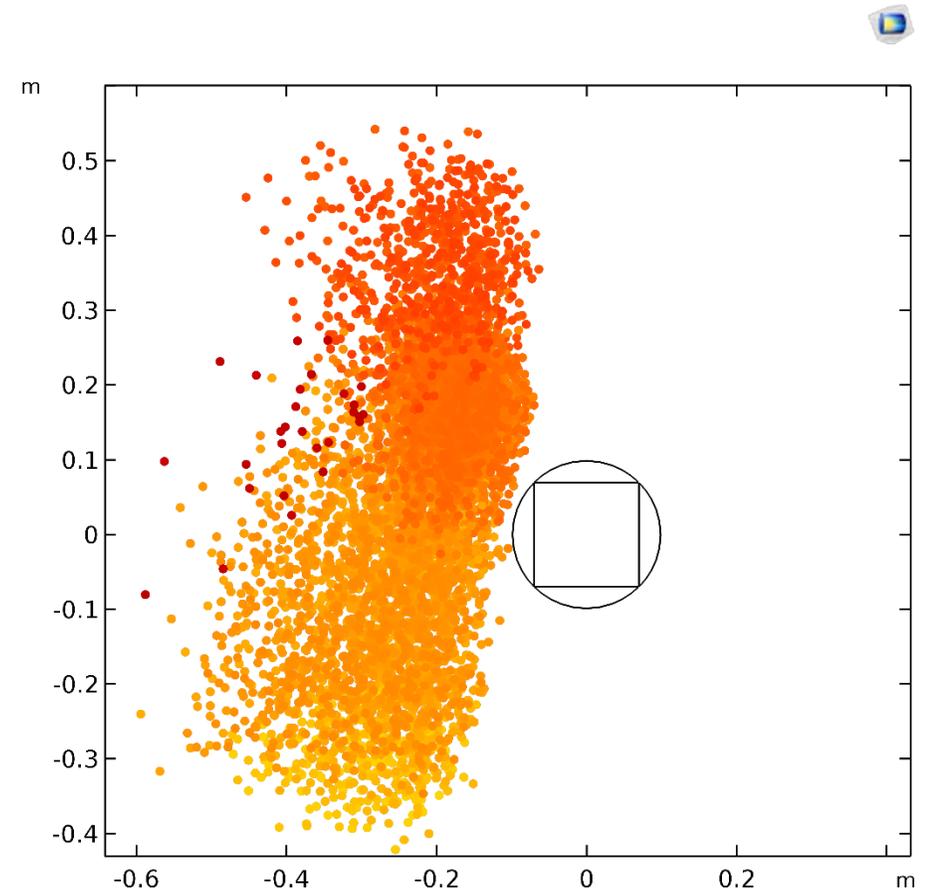


Pear-shape Halbach Array optimization

Entrance of Halbach Array

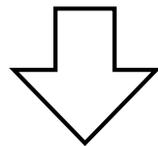


WFI detector plane

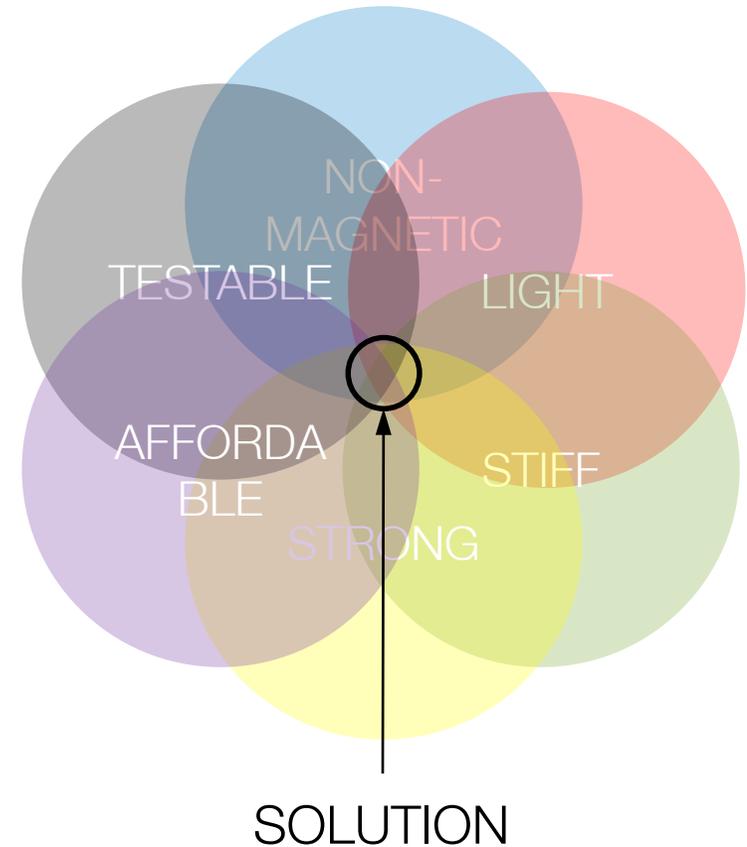


STRUCTURAL SOLUTION SHOULD:

- Be compliant to magnetic requirements
- Be as light as possible
- Be as stiff as possible
- Survive all loads with margin
- Be economically feasible
- Be feasible to test in Czech facilities



TRADEOFF STUDY

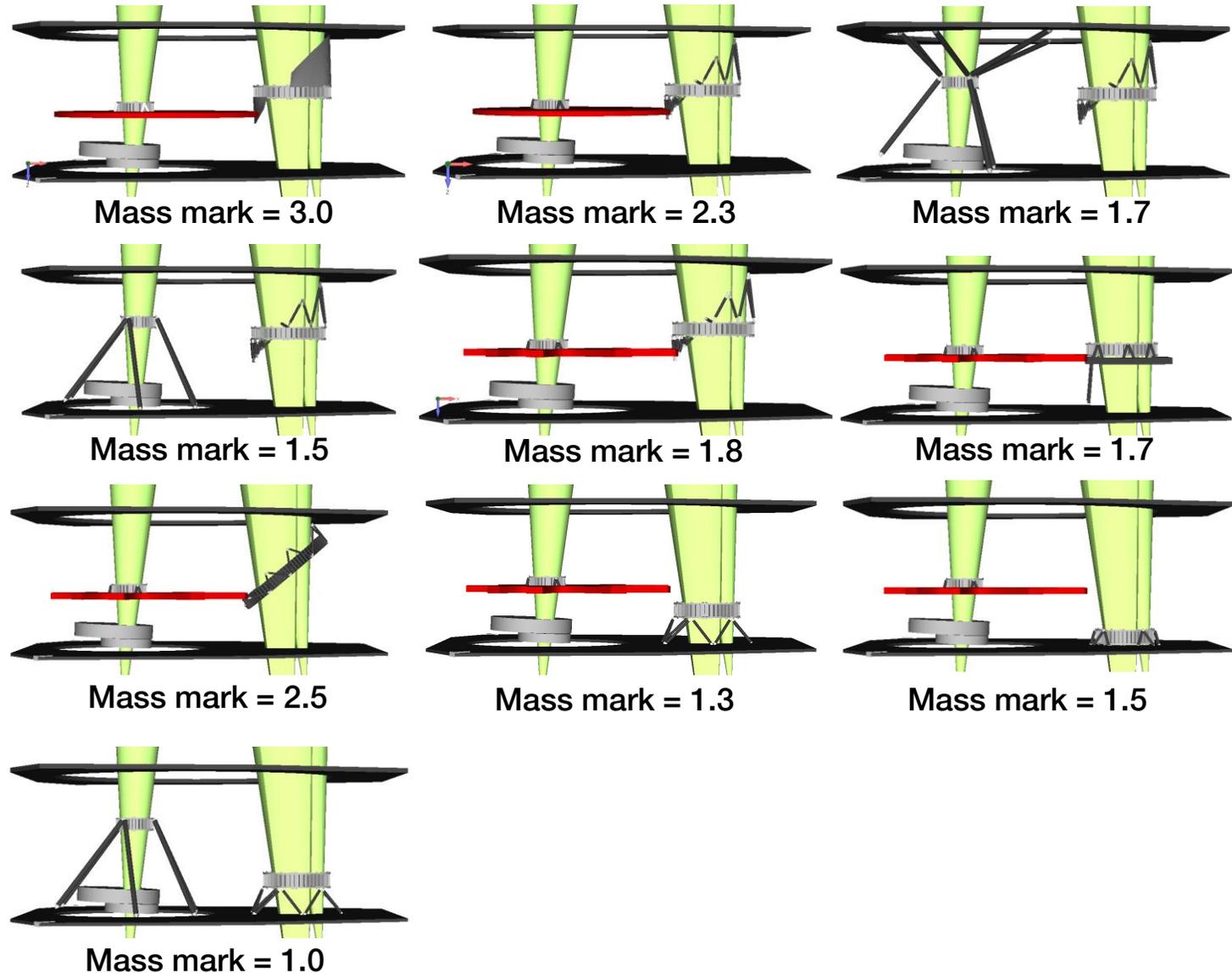




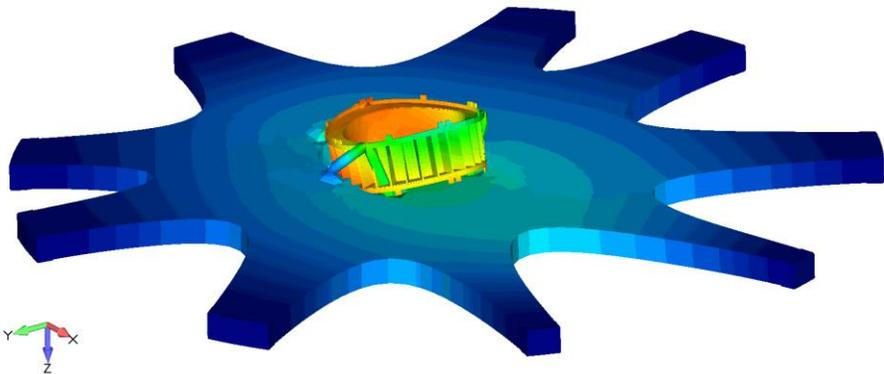
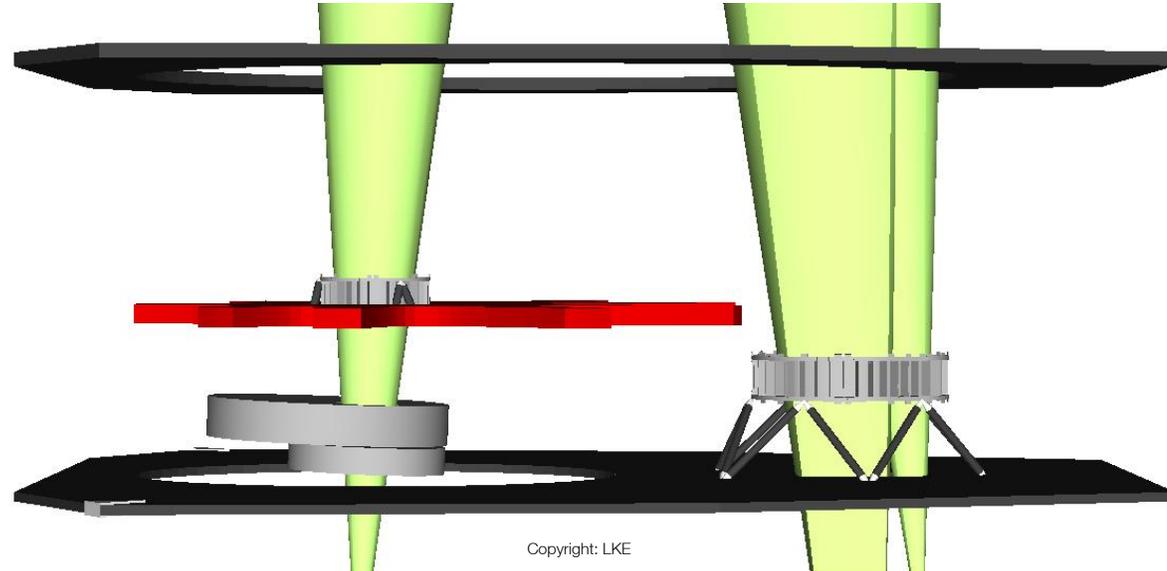
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10 semi-final configurations

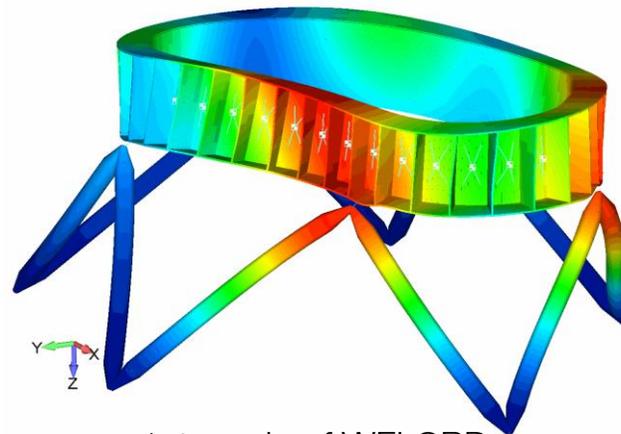
- Mass performance
- Modal performance
- Strength performance
- Test feasibility



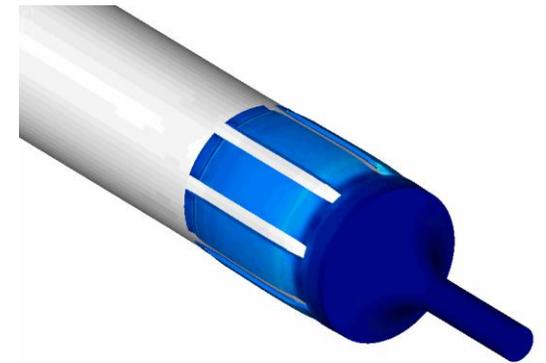
Trade-off winning configuration – Mass mark 1.3 | compliant eigenfrequency | feasible for test and production



1st mode of X-IFU CPD

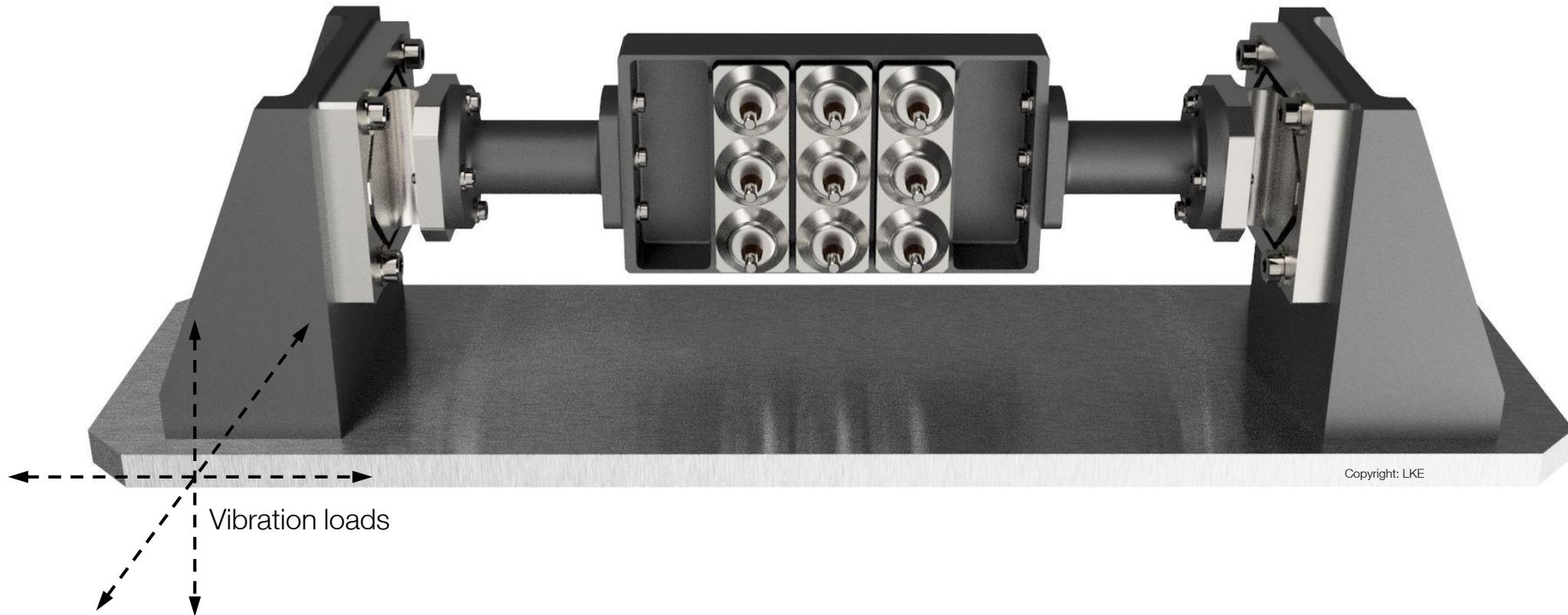


1st mode of WFI CPD



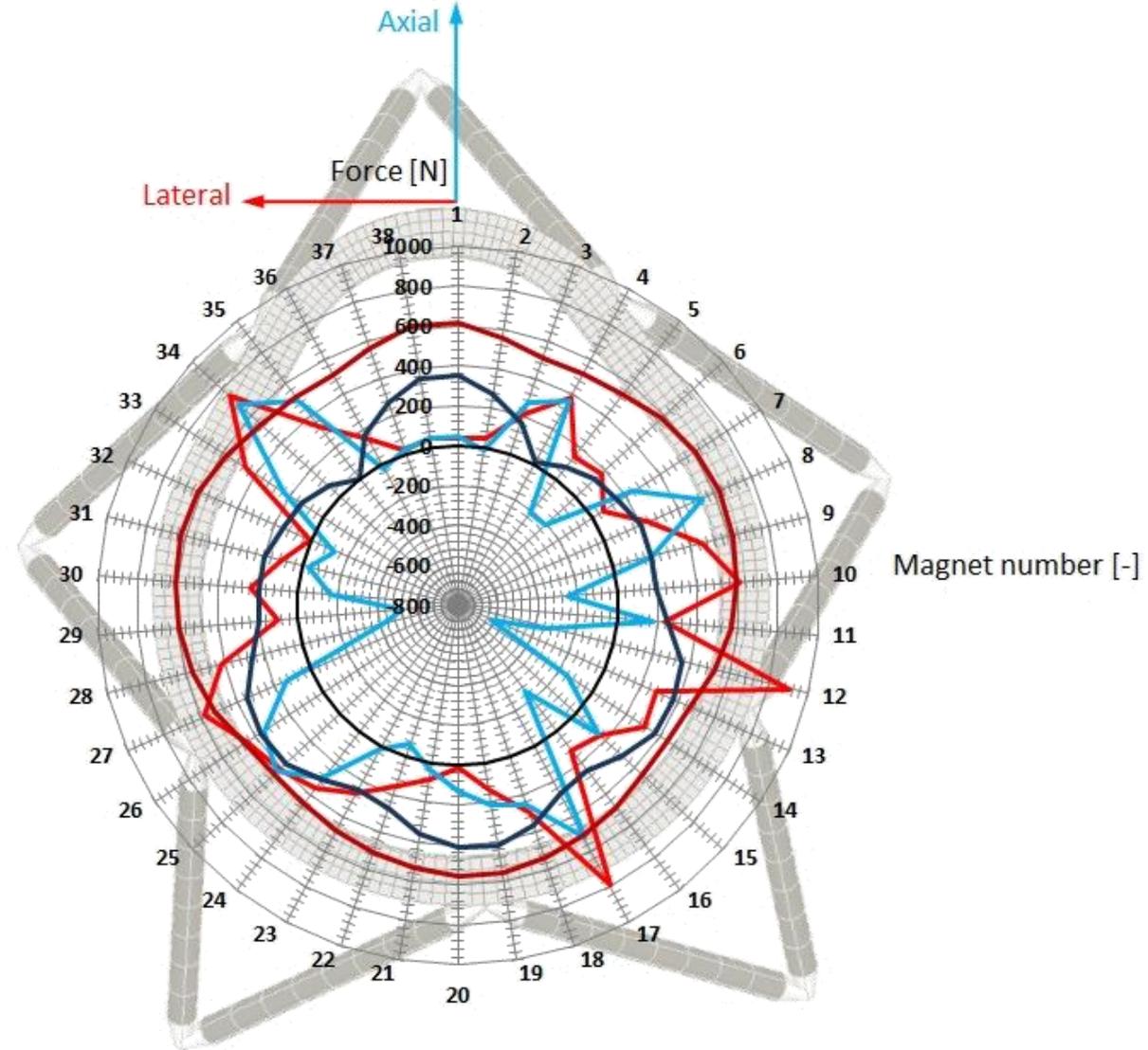
Thermoelastic deformation of strut fitting

BREAD BOARD MODEL

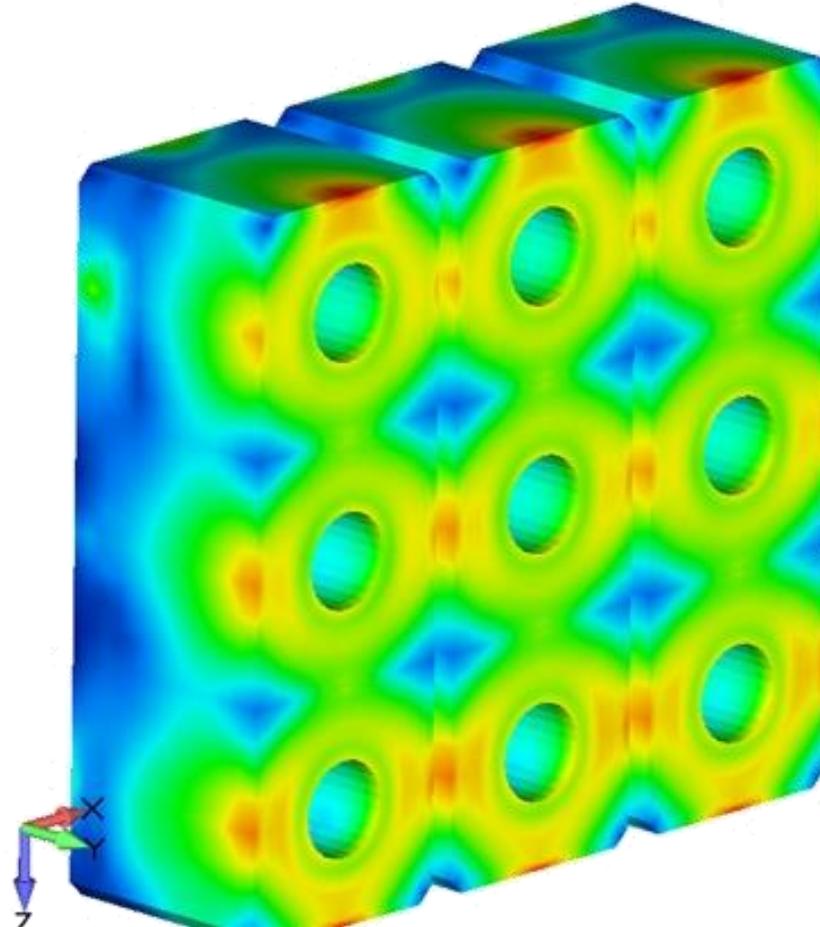


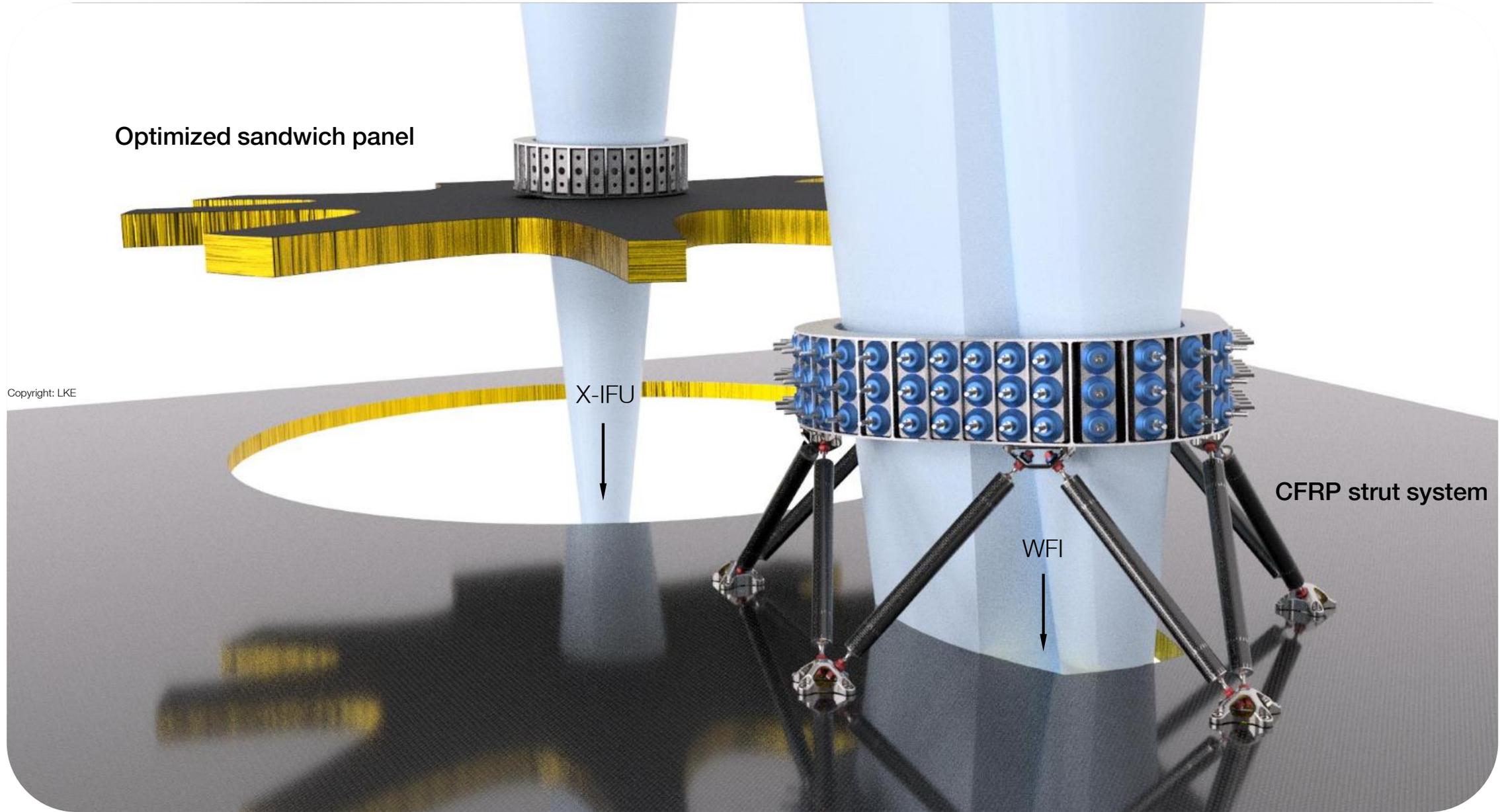
Copyright: LKE

BREAD BOARD MODEL



BREAD BOARD MODEL





Optimized sandwich panel

X-IFU

CFRP strut system

WFI

Copyright: LKE

- Preliminary magnetic & structural design
- Preliminary Design Review **january 2019**
- Critical Design Review **spring 2019**
- Engineering qual. model **summer 2019**



Qualification tests late 2019 ⇒ Roadmap to flight model

Thank you for your attention

Ask us