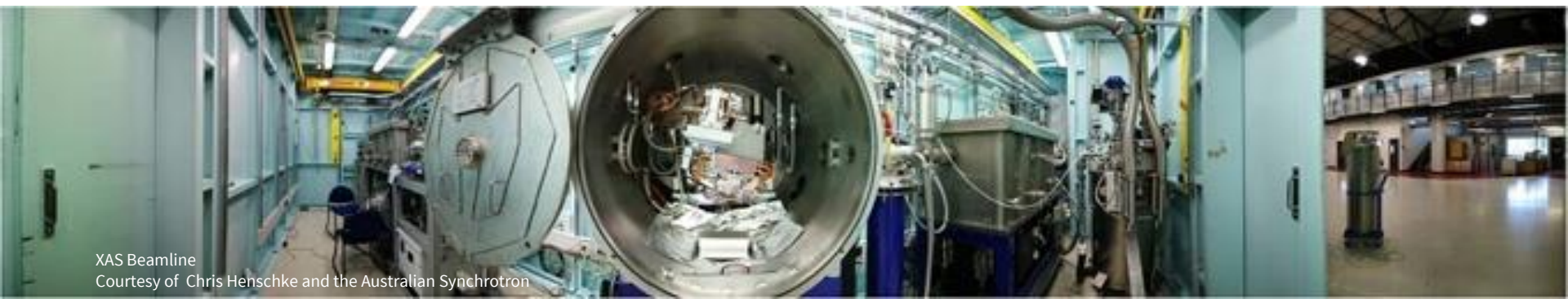


AXILON AG

Accelerator and X-Ray Instrumentation

for Laboratories, National Facilities and Industry

Timm Waterstradt
APPEC Technology Forum 2017



valuable partner

for the science and industrial community
on accelerator and x-ray instrumentation

Product Range:

- Beamlines and Beamline Components for FELs and Synchrotrons
- X-Ray Microscopy and Special Experimental Stations
- Insertion Devices
- Neutron Instrumentation
- Metrology Tools for Laboratory Applications (e.g. EUV Lithography)
- Engineering support/services

Background of the AXILON team:

1993/1994 ACCEL Instruments starts as a Management Buy-Out from SIEMENS Interatom with approx. 35 employees – focus: Accelerator technology



1998 **Start of the Synchrotron Instrumentation activities** in addition to Accelerator and Magnet Technology within ACCEL Instruments

2007 ACCEL grew as a leader in these special markets to approx. 270 employees ~ € 70 revenue with the business units superconducting magnets, accelerator technologies, synchrotron instrumentation – and: Proton Therapy synchrotron instrumentation: ~15 employees and ~5M€ revenue)

2007 Varian Medical Systems, Inc., purchases 100% of ACCEL Instruments to extract the Proton Therapy business



2009 Bruker Inc. buys the research instruments businesses from Varian/ACCEL
→ Bruker ASC continues the synchrotron instrumentation business

2010 Bruker ASC buys the assets of AIXUV GmbH (EUV source/metrology)



2014 Business has grown to ~30 employees and 8-10M€ revenue

2015 **Leading managers and experts of the business left Bruker and started privately owned AXILON AG**



- » Synchrotron instrumentation
- » Accelerator technology
- » Ultra-precision mechanics in vacuum
- » Mechanical engineering, CAD, FEA
- » System engineering and integration
- » Thermo mechanical engineering
- » X-ray optics
- » Ultra-high vacuum technology
- » Cryo-engineering
- » Magnetic systems and in particular Insertion Devices
- » Control systems

- » International project and contract management
- » World-wide Installation and commissioning

Serving our international customers with solutions in instrumentation and engineering services based on our competencies and well-established expertise

Office and Assembly Site in Cologne



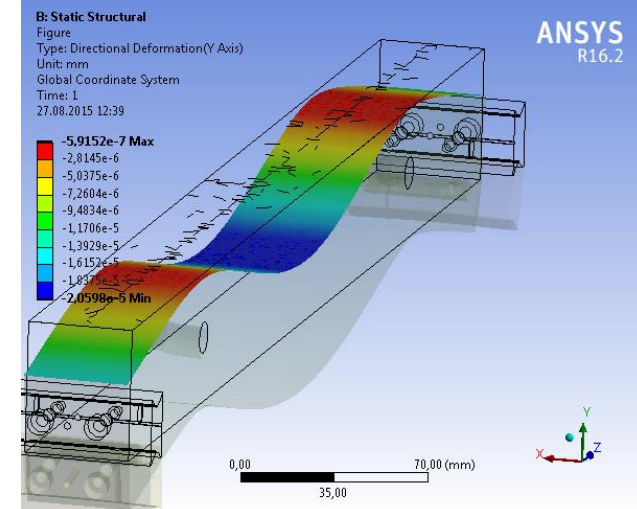
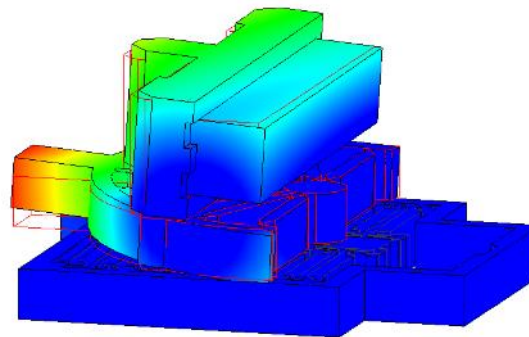
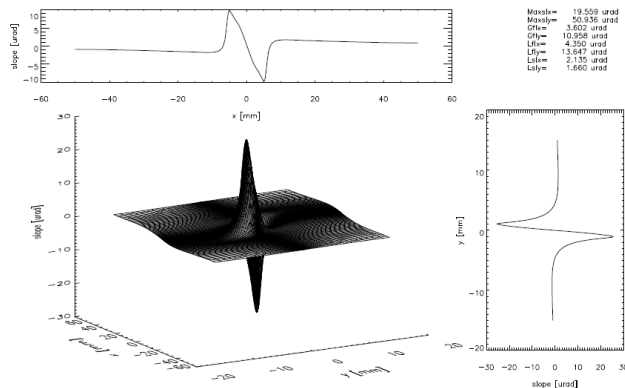
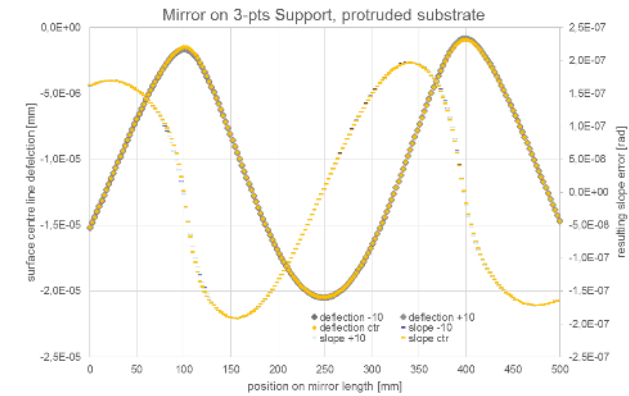
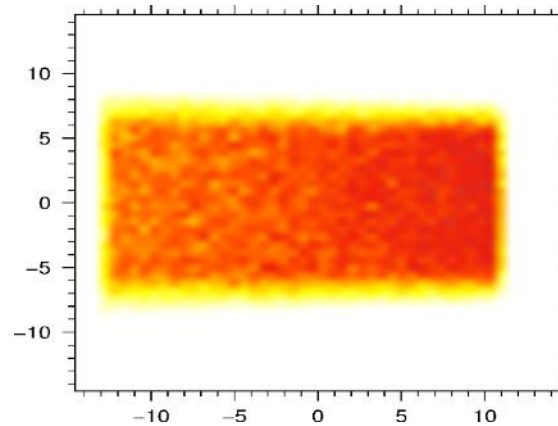
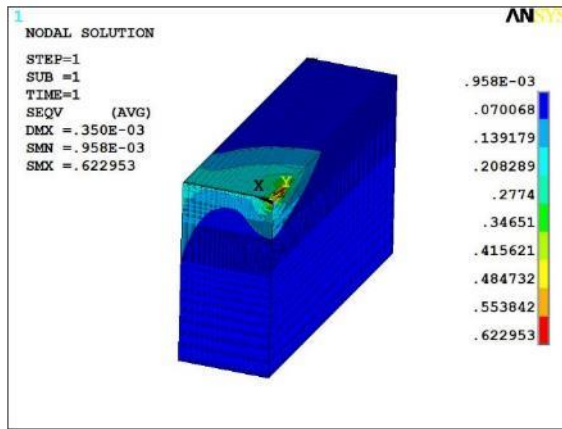
- Technology Park in Cologne (Germany)
- Office space: approx. 300 m²
- Assembly area approx. 250 m²
 - Required infrastructure in place
 - First projects finished (systems assembled, tested, delivered and accepted)



- AXILON team, currently 13 employees
 - 5 physicists
 - 4 project engineers
 - 2 design engineers
 - 1 technician
 - 1 commercial administration
 - Plan to increase to ~16 within one year
 - External support
 - 2 design engineers (almost working 100% for AXILON)
 - 3 additional technicians for support and electrical wiring
 - Company for support in programming control system (plc, motion controls)
 - Well established network of experienced sub-suppliers for all manufacturing steps
 - Co-operations and supply for specific tasks
 - Mechanical metrology, e.g. Zeiss, Moeller-Wedel,
 - Metrology on x-ray optics: BESSY, XFEL, DLS
- **Total available resources are meanwhile > 50% of the old team at Bruker ASC**

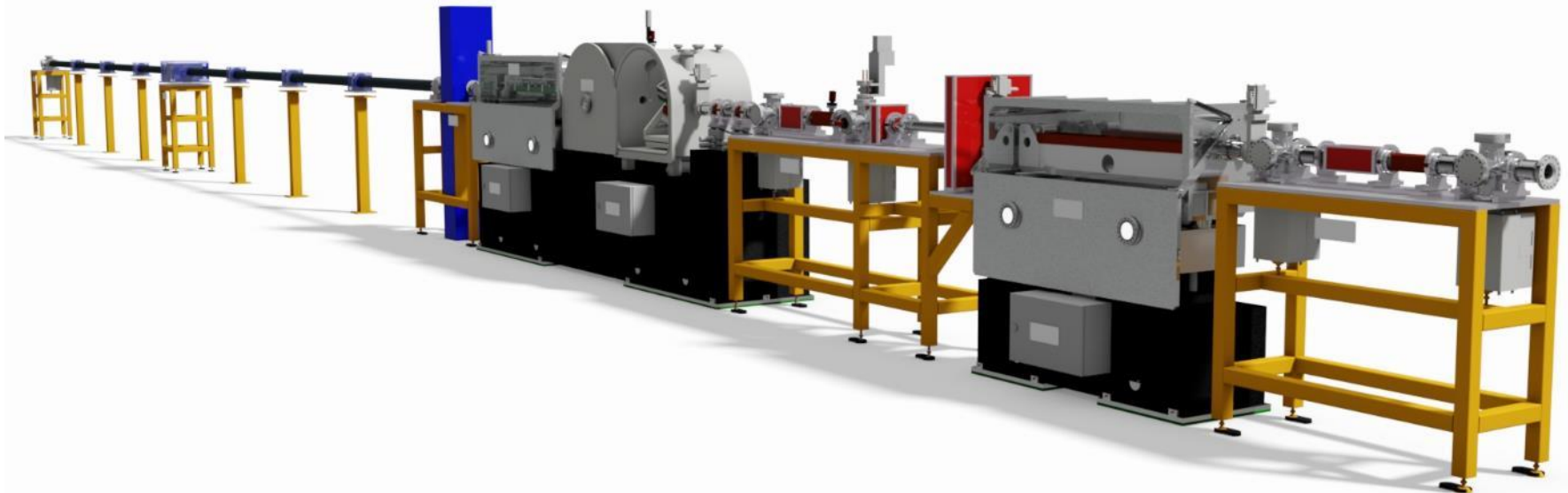
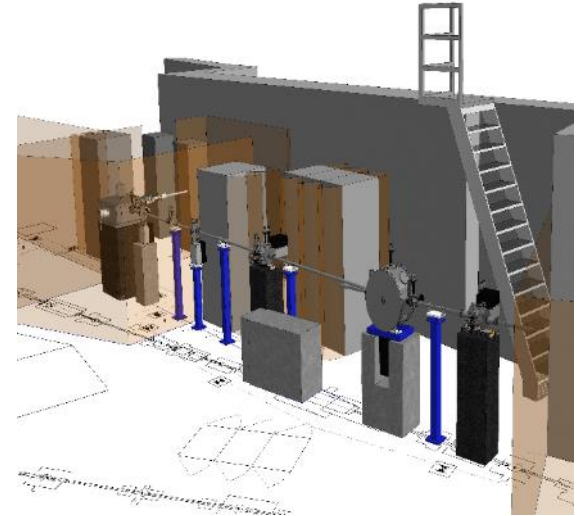


Modelling



Possible scope:

- Layout, ray-tracing and conceptual design
- FEA on thermal, thermo-mechanical and vibrational issues
- Detailed design
- Realization, assembly and detailed testing
- Installation, commissioning and service worldwide



Components, e.g. Monochromators

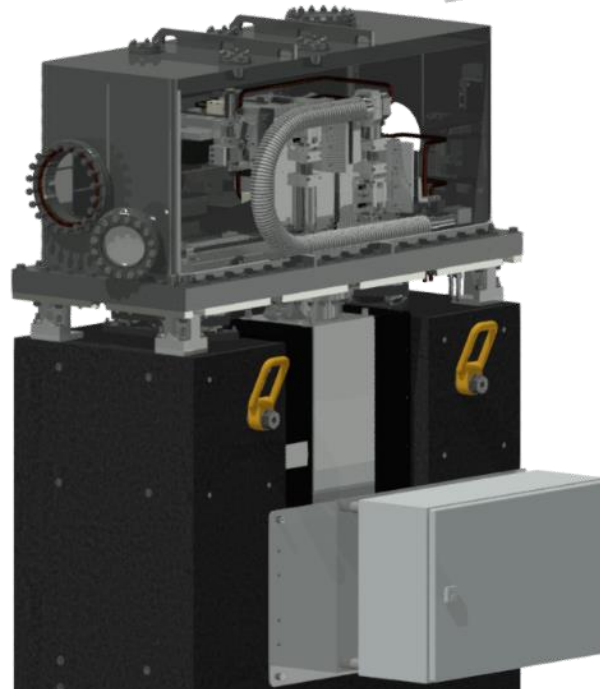
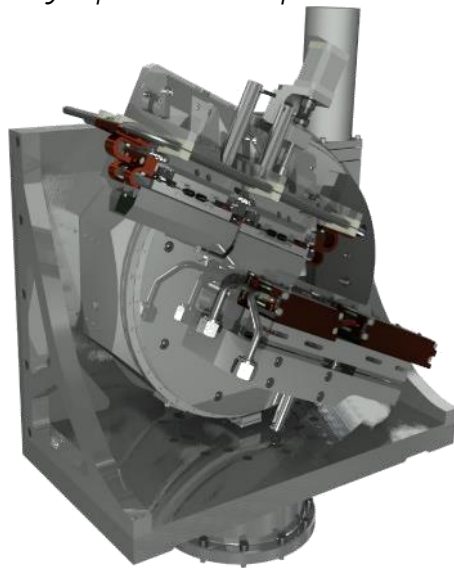


All kinds of different monochromators:

- crystal or multilayer
- water- or cryo-cooled
- single- or multi-bounce
- vertical or horizontal deflecting

Optimized design for:

- highest beam stability
- power load
- *or any specific requirement...*

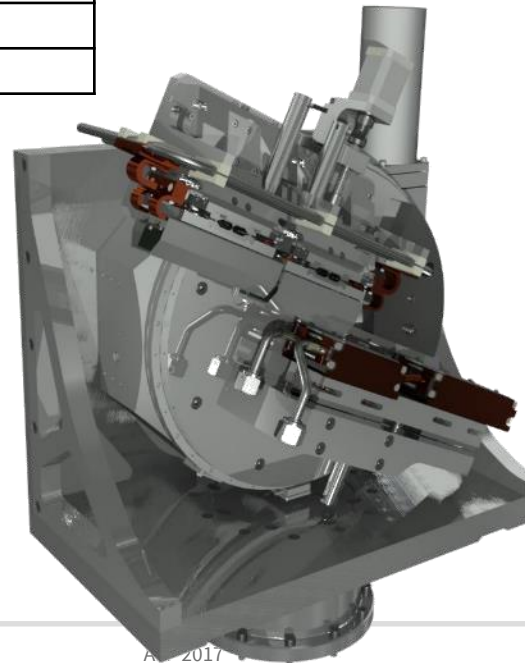
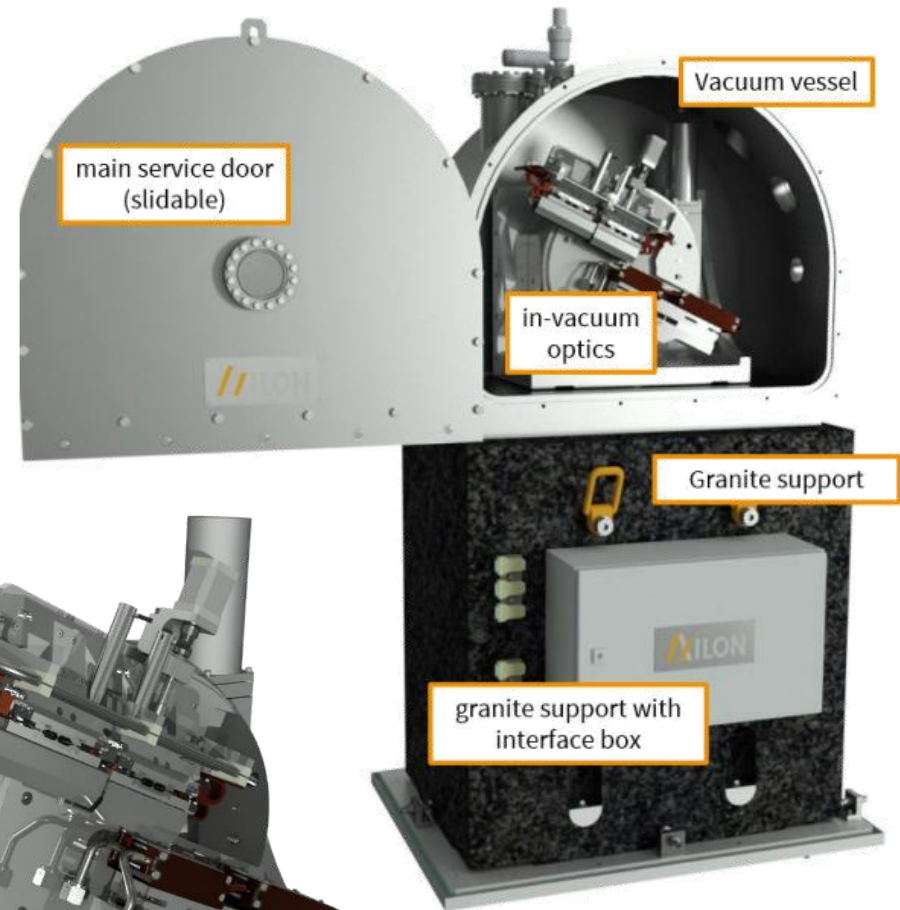
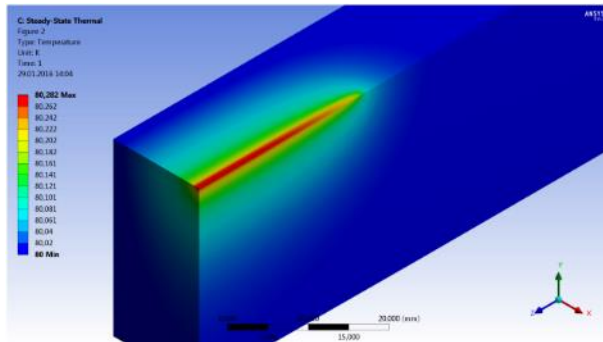


Double Crystal Monochromator for ALS



Liquid Nitrogen cooled monochromator for ALS (Berkeley, CA (USA)):

parameter	value
energy range for Si111 crystal pair	5 – 19 keV for Si111 crystal
position	18.53 m from source
beam size	2 x 2 mm ²
incident beam height	1,400 mm
beam offset	25 mm upwards
maximum power on 1st optics	17 W
maximum power density	4.4 W / mm ²
cooling method	indirect LN2 cooling

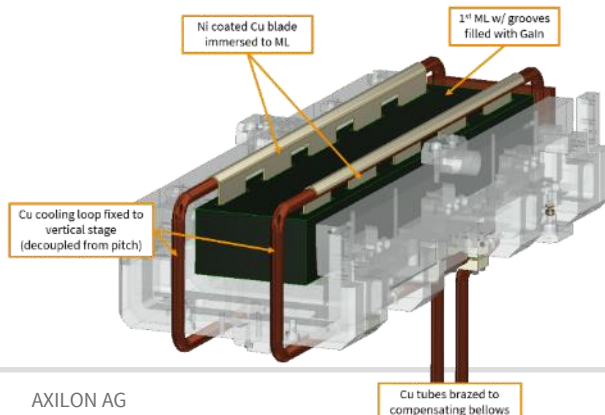


Multilayer Monochromator for DLS



Double-multilayer monochromator for Diamond Light Source

parameter	value
energy range	8 – 18 keV
Multilayer	Mo/B ₄ C
position	20.0 m from source
beam size	40 x 7.5 mm ²
incident beam height	1,400 mm
beam offset	18 mm upward
absorbed power at 1 st ML	235 W (no filter)
absorbed power at 2 nd ML	< 10 W
power density	0.32kW/mrad ² (no filter)
cooling method	water cooling
crystal cooling	Gallinstan; indirect, with grooves



ChillAX – Cryo Cooler



Most optimized and user friendliest liquid nitrogen (LN₂) chiller for cryogenically cooled optics

- superior stability in pressure and temperature
- wide range of cooling power up to 3kW
- fully automated controls
- flexibility, incl. different filling modes
- Typically used to cool high heat load x-ray optics (monochromators, mirrors) – or others ...

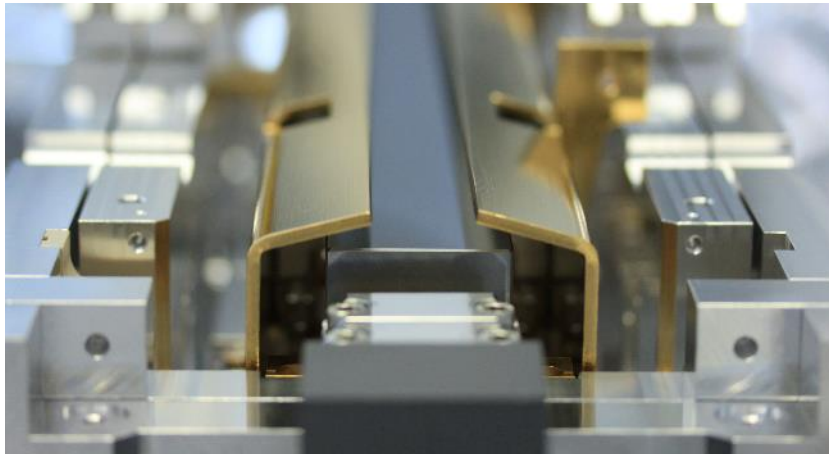


parameter	value
Cooling power	0 to 3,000 Watts
Flow rate	0 to 20 l/min
Cooling loop pressure	1 to 10 bar
Pressure stability	< 1 mbar (rms)
Cooling loop temperature	77 to 100 K



Special double mirror system for the MID instrument at XFEL.EU:

- Two Si mirrors facing each other allowing for different operational modes of the beamline
- Mirror substrates will be cryo cooled to 125K
- Full system mounted and tested in clean room class ISO5 to fulfill XFEL.EU's particle cleanliness requirements
- High slope error and surface roughness requirements – verified in fully mounted state → particular design challenges for substrate support and cooling interface !



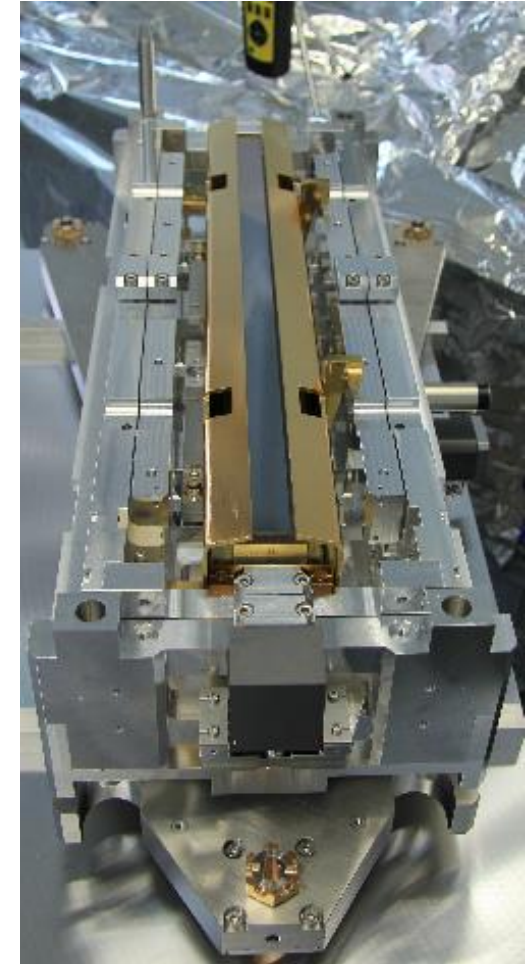
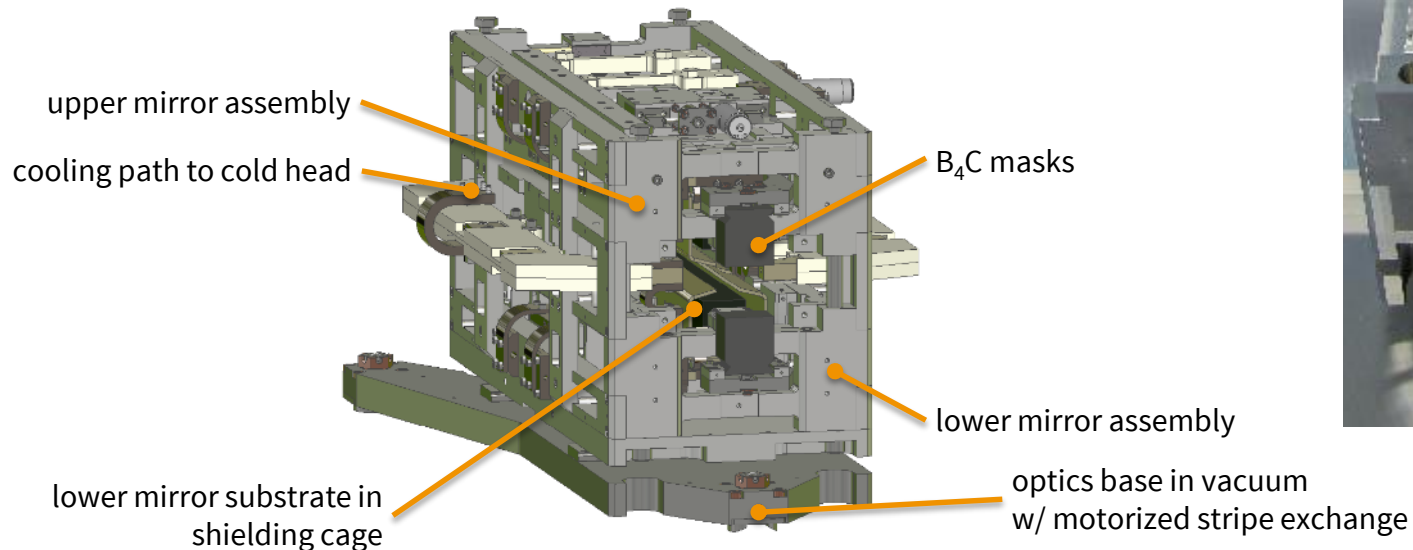
Thermal design

- Substrates allow for being cooled to 125K
- Intensive consideration of thermal aspects, i.e.:
Thermal radiation, shielding, conductance, emissivity, ...

→ has been implemented to the compact design

Balancing target temperature, thermal load and resistivity with cooling power of designated pulsed tube cryo cooler !

- Cold tests under way this summer @ XFEL.EU



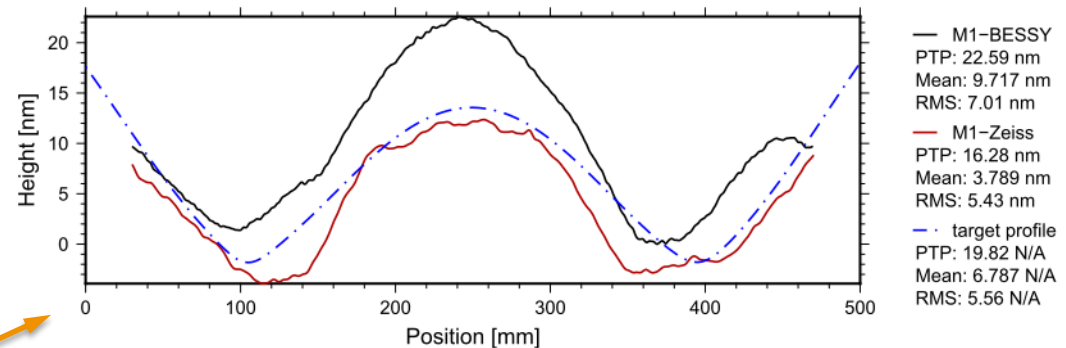
Optical performance

- Gravitational sag to be compensated by applying the inverse profile by IBF figuring
- Special substrate support strategy at Bessel points in neutral axis eliminates any substrate deformation from stick/slip at support points
- Mirror optical performance after pre-figuring and mounted in final configuration verified in NOM-measurements at BESSY (F. Siewert)

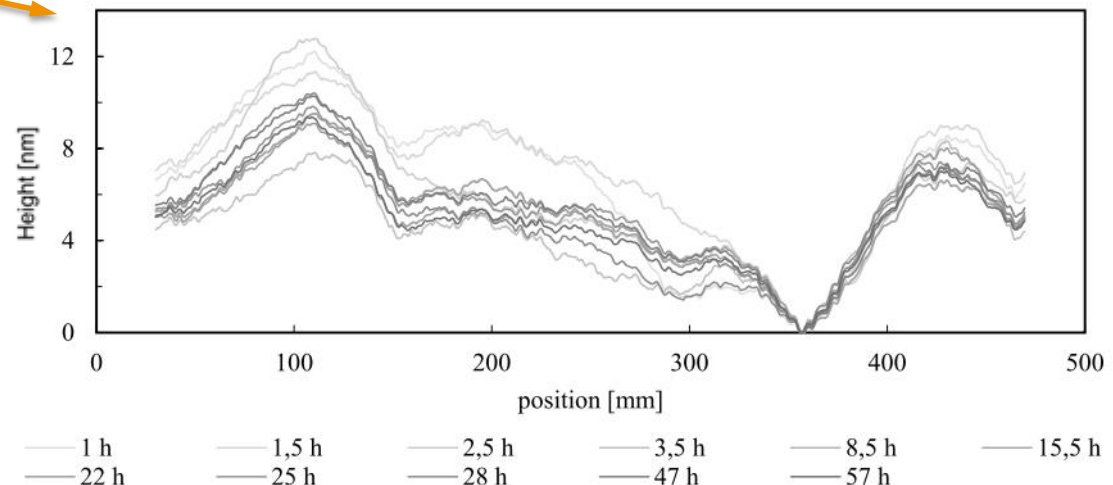
spec		results measured	
		free	mounted
slope error (RMS)	$<0.2\mu\text{rad}$	$0.18\mu\text{rad}$	$0.12\mu\text{rad}$
height error	n/a	7nm RMS 22.6nm PV	6nm RMS 10.2nm PV



Pre-figured mirror profile to compensate gravity sag:



Drift investigation with the fully assembled mirror:



Mirror Systems for LCLS at SLAC

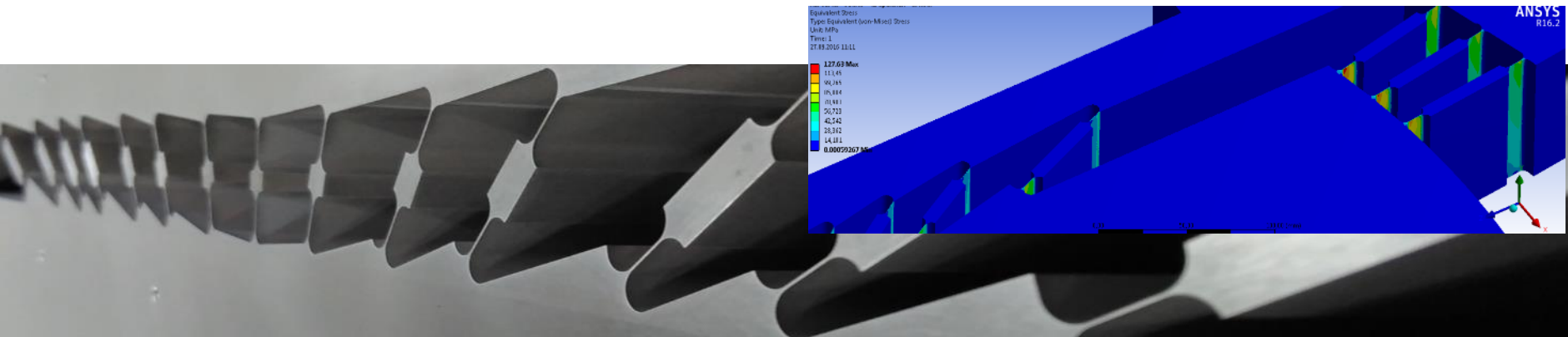


Six (6) horizontal offset mirror systems for LCLS:

- Highest precision and pointing stability demands
- Critical UHV cleanliness requirements
- Al wire sealed chambers
- Integration of SLAC bending mechanism
- All ex-vacuum adjustments stages:
tight specifications on coupling/parasitic motions
- Entire project realized and installed within tight time schedule (10 months)

Pitch adjustment stage:

Has to carry full chamber and in vacuum-mechanics, realized by specially designed cart wheel structure leading to highest pointing stability ! Validation via ANSYS FEA and measurements ...



Mirror Systems for LCLS at SLAC

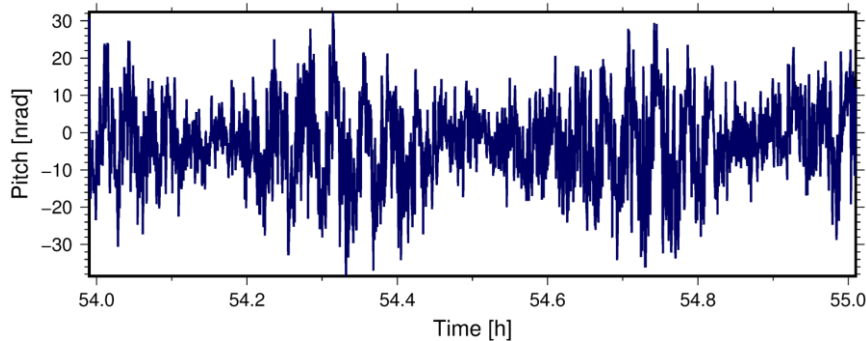


Qualification during Factory Acceptance Tests:

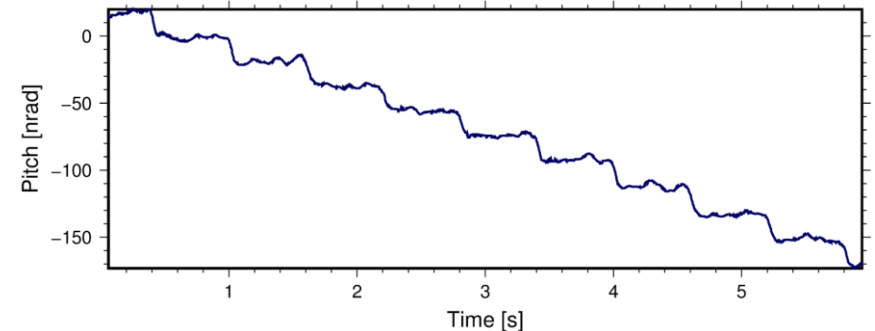
Table 1: Stability Requirement

Required Pointing Stability	
Value (nanoradian RMS)	Timescale
25 ✓	1 ms - 1 hours
100 ✓	1 - 12 hours

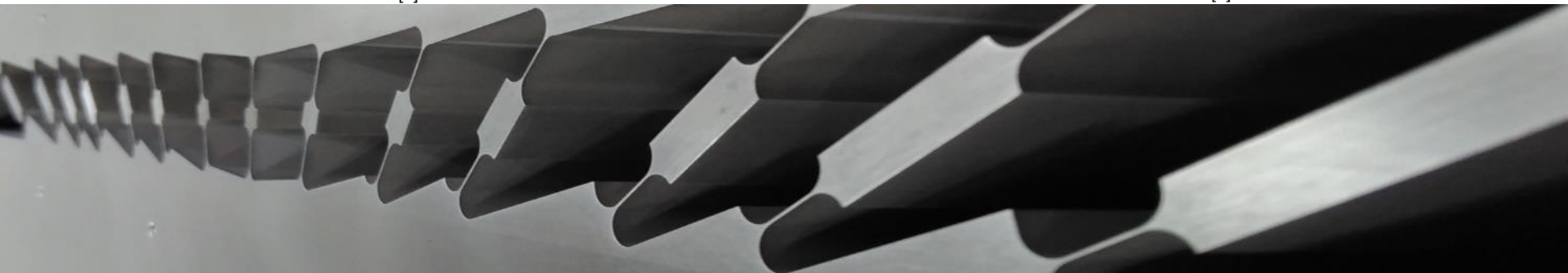
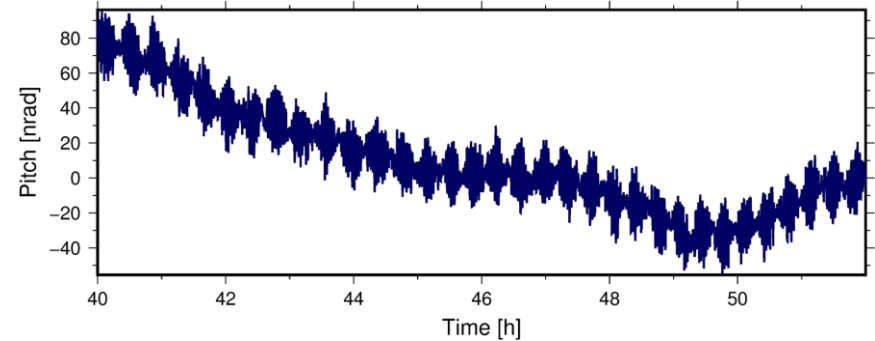
Drift: < 25 nrad over 1 hour (measured at AXILON)



Resolution: Pitch of the entire chamber & mirror: < 20 nrad



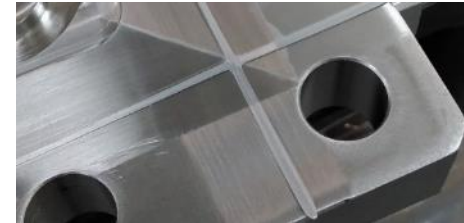
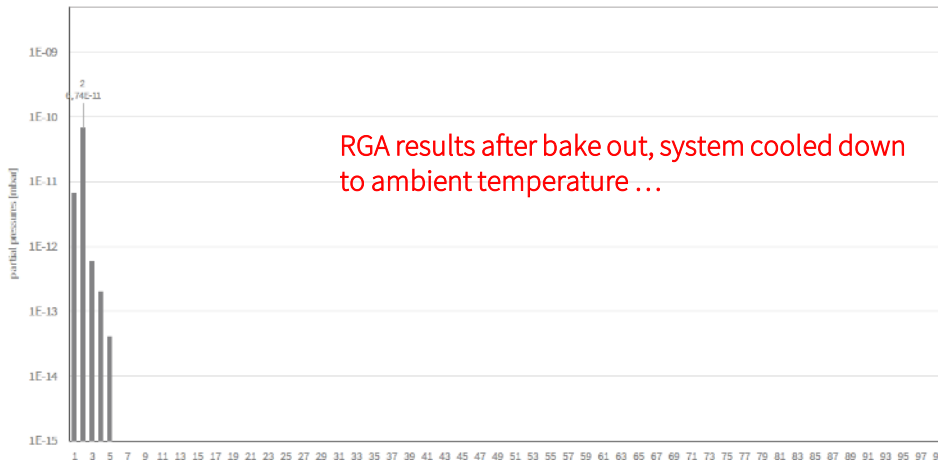
Drift: < 40 nrad over 12 hours (measured at AXILON)



Mirror Systems for LCLS at SLAC

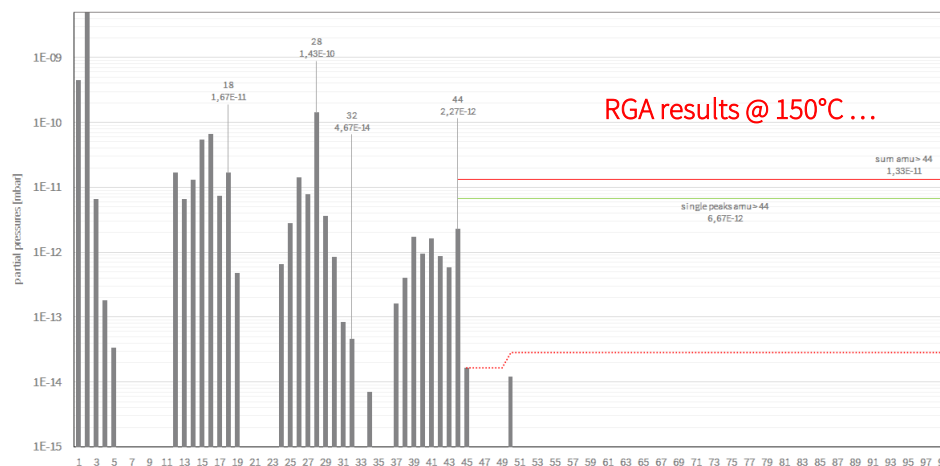


Final vacuum tests of Al wire sealed chambers:



SLAC demands RGA to be taken @ 150°C:

SLAC CRITERIA		RESULTS	
Sum of all masses amu above 44:	<1,3E-11mbar	ok	2,85E-14 mbar
Any single mass peak above amu 44:	<6,7E-12mbar	ok	1,65E-14 mbar



Extensive experience of the AXILON staff forms the strong basis to remain a valuable supplier and partner for instrumentation hardware, but also for engineering support.

- Beamline components, e.g. monochromators, mirror systems
- Cryo Cooler ChillAX
- Customer specific experimental stations, e.g. microscopes
- Other specific components or engineering tasks, where we could support with our competencies and experience

GIVING MONEY TO
LABS RATHER THAN
COMPANIES ?



In our understanding:

To guarantee the project success, it is of utmost importance to establish a very good cooperation and working relationship !

We are very interested to support new fields
and applications with our competencies and experience.



Thank you for your attention



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