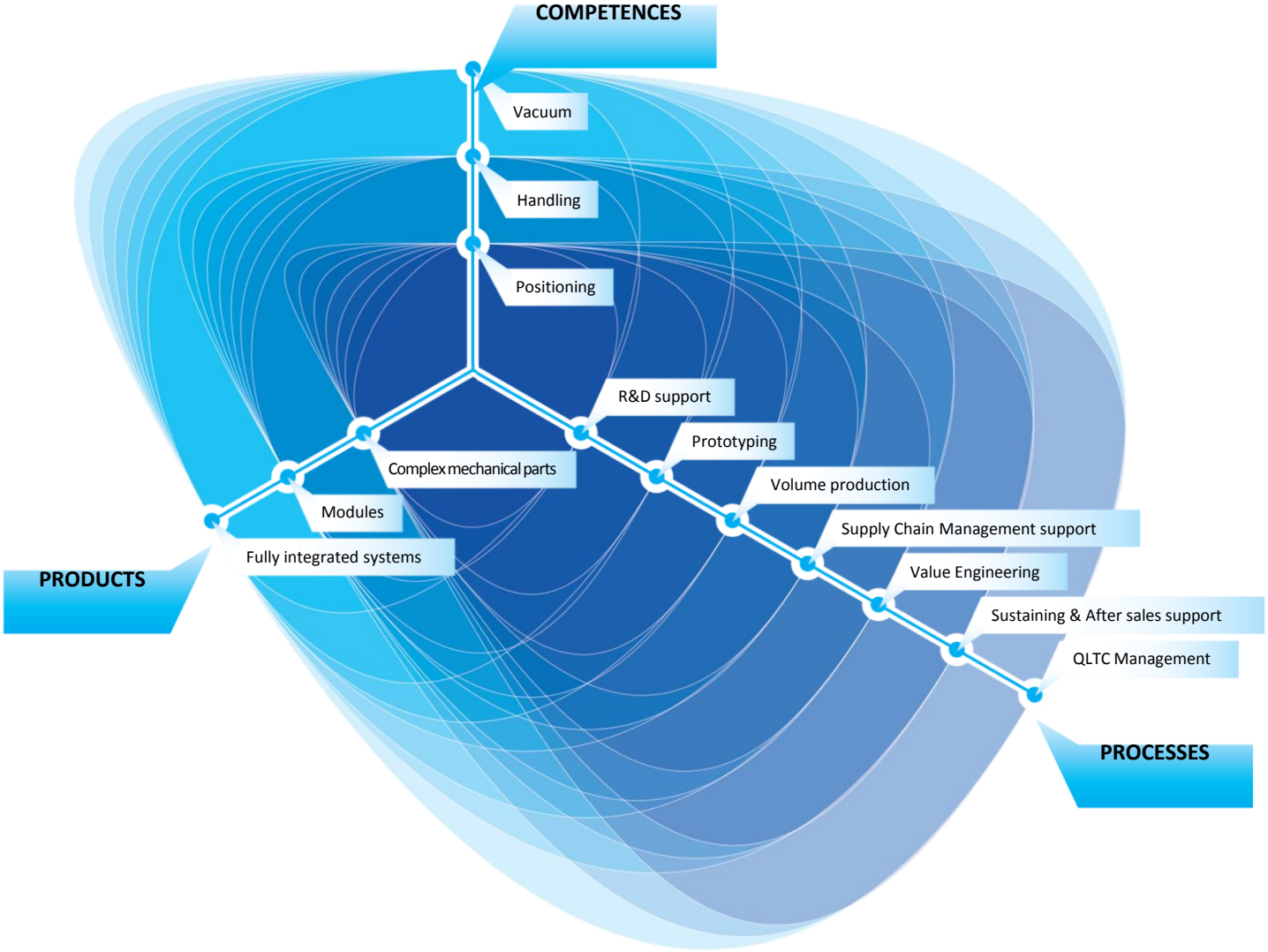
VDL ETG Science & Technology

Big Science Industry Day
Hans Priem, 15 October 2014

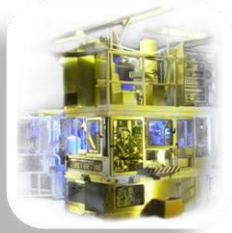
VDL Enabling Technologies Group

VDL ETG: our company DNA



VDL ETG Core Technology Markets

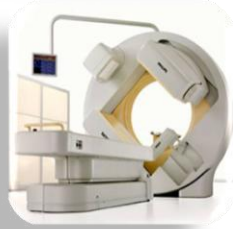
Semiconductor Capital Equipment



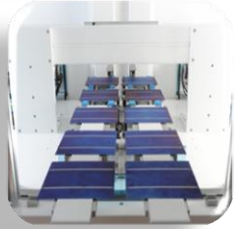
Turn Key Projects

Analytical Equipment

Led Manufacturing Equipment



Medical Equipment



Solar Production Equipment

Science & Technology

- ✓ *Is a technology driver for our main stream business*
- ✓ *Benefits from our expertise in manufacturing and assembly for series manufacturing*
- ✓ *Active focus of employing core technologies to :*
  - *Free Electron lasers and normal conducting accelerators*
  - *Optical modules for (astronomy) instruments.*

VDL ETG Competences – relevant to Science & Technology

- High Precision (HPT)
- Ultra High Precision (UPT)
- Metrology
- Welding/Vacuum Brazing
- Vacuum Technology
- Clean room assembly
- Industrialization & Redesign

VDL ETG Competences - Manufacturing

HPT Machining (High Precision Technology)

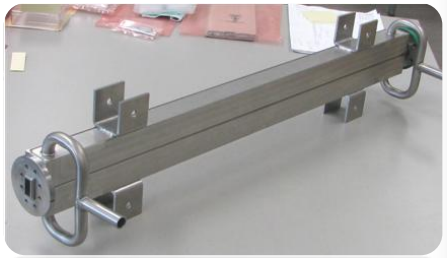
✓ Turning

- Form accuracies < 6 µm
- Surface finish better than 0.2 µm Ra
- 2/3 axis and freeform capabilities



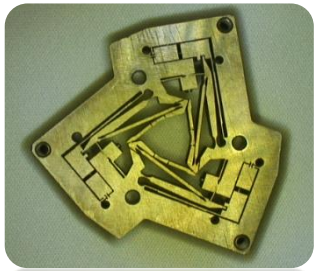
✓ Milling

- Form accuracies < 20 µm
- Surface finish better than 0.3 µm Ra
- Up to 5-axis capabilities
- Pallet machining of micron accuracy parts

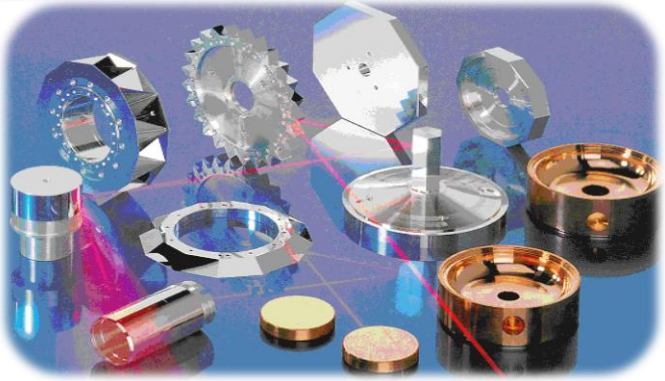
✓ EDM

- Wire-EDM (µm-accuracy and Ra 0.1)
- Sink EDM
- Micro EDM (holes as small as 20 µm)




VDL ETG Competences - Manufacturing

UPT Machining (Ultra Precision Technology)

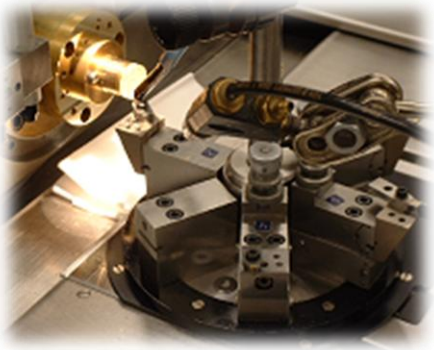


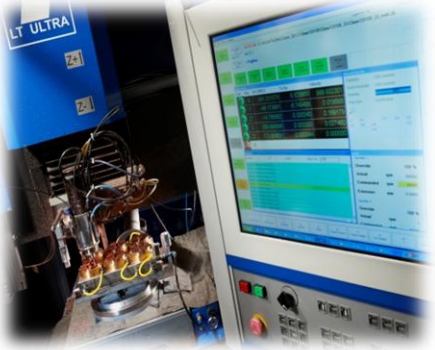
✓ Single Point Diamond Turning

- Form accuracies < 0.1 µm
- Surface finish better than 5 nm Ra
- 2/3 axis and freeform capabilities

✓ Milling

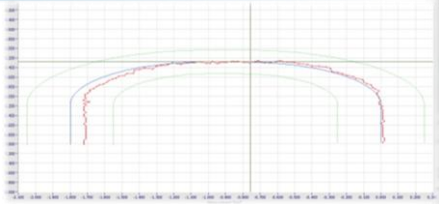
- Form accuracies < 1 µm
- Surface finish better than 25 nm Ra
- Up to 5-axis capabilities
- Pallet machining of (sub)micron accuracy parts

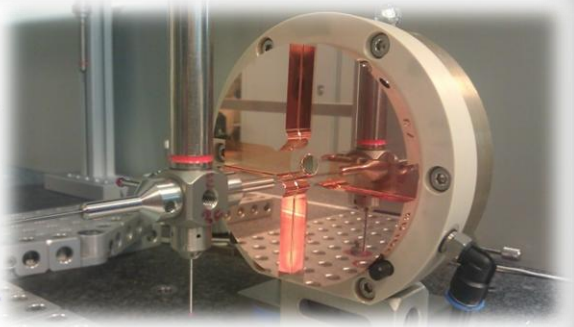




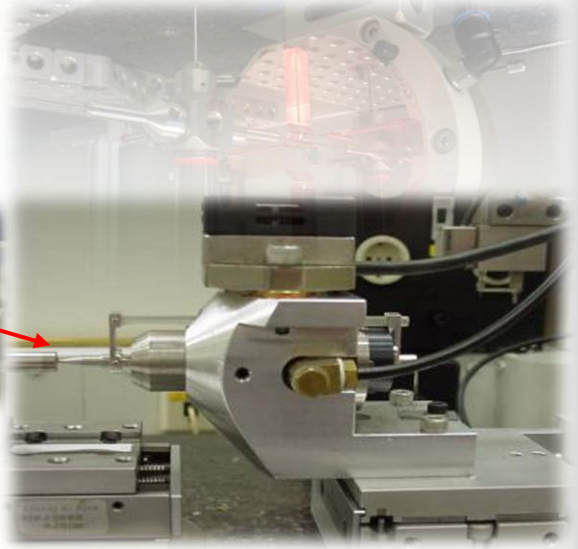
VDL ETG Competences - Metrology

Metrology

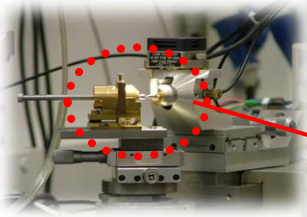




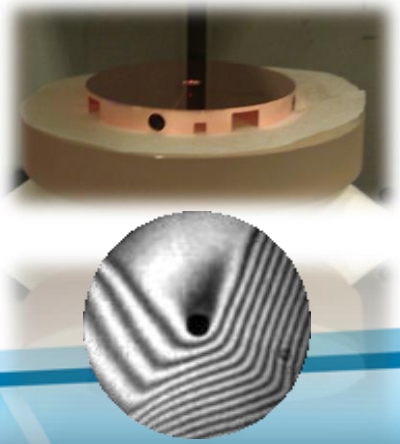
- ✓ 3D- metrology
  - 3D CMM ✕ 0.8 µm accuracy ✕ low measuring force
  - Multi sensor CMM ✕ camera / touch probe / laser

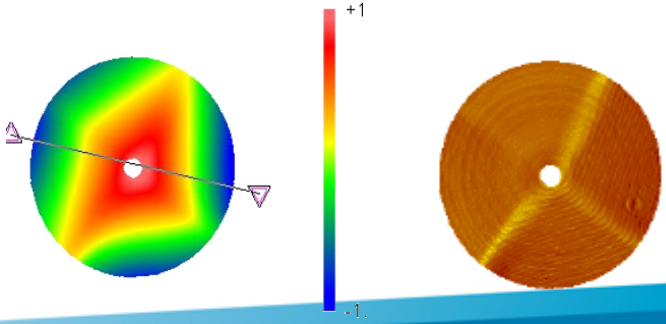


- ✓ Profilometry
  - Surface finish measurements
  - Form measurements (2D and 3D)



- ✓ Optical measurement techniques
  - Surface finish and step heights
  - Flatness (up to ø100) and form



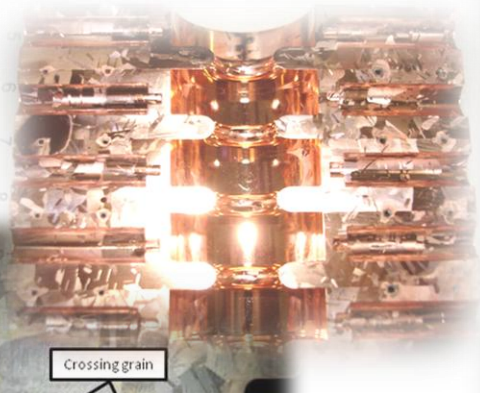


VDL ETG Competences – Joining Technology

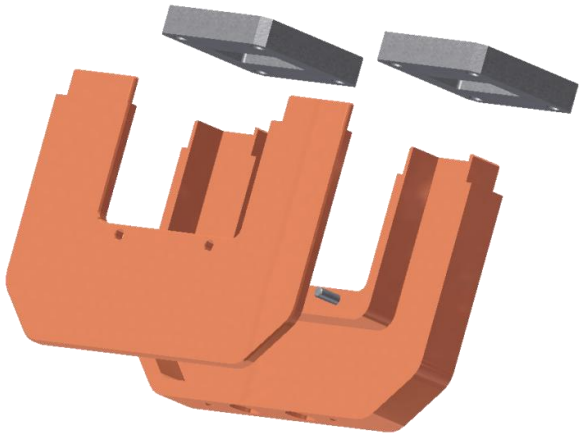
- ✓ Welding
  - TIG/MIG
  - Laser beam
  - E-beam
- ✓ Brazing
- ✓ Bonding

Bonding test

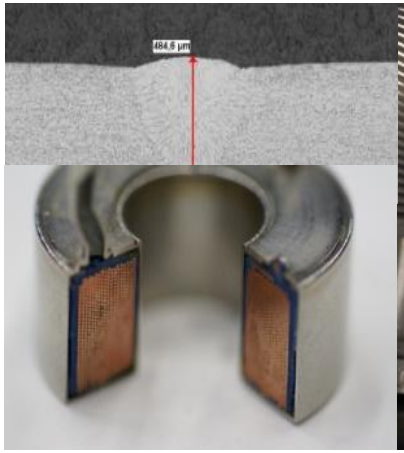
- ✓ *under Argon atmosphere*
- ✓ *Hydrogen bonding in very near future*



CERN EDMS Nr. 1182511 : *No discontinuities and presence of crossing grains in all the bonding planes means good bonding.*



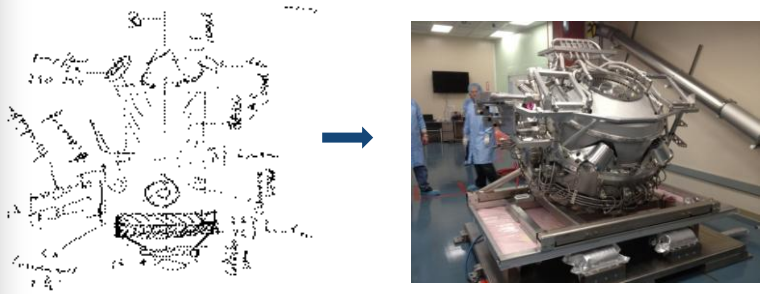
Brazing assembly
(SCP / AgCu / AuCu)



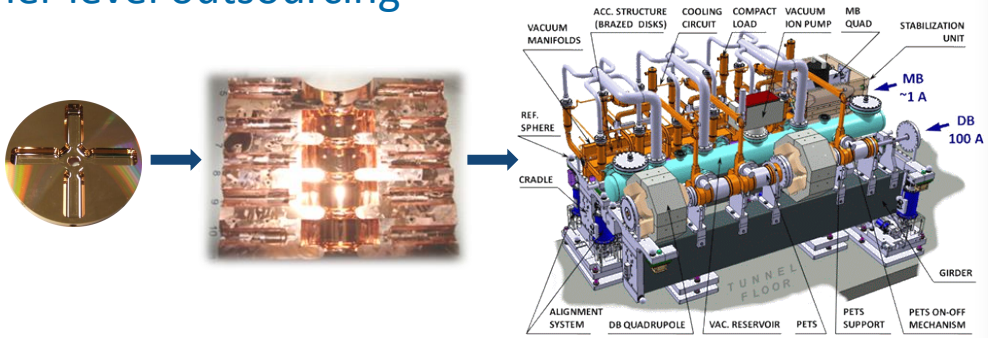
VDL ETG Competences – Industrialization & Redesign

✓ Time to market

- Co-development & rapid proto typing
- Increased complexity requires higher level outsourcing



EUV light source : from idea to product in 1 year



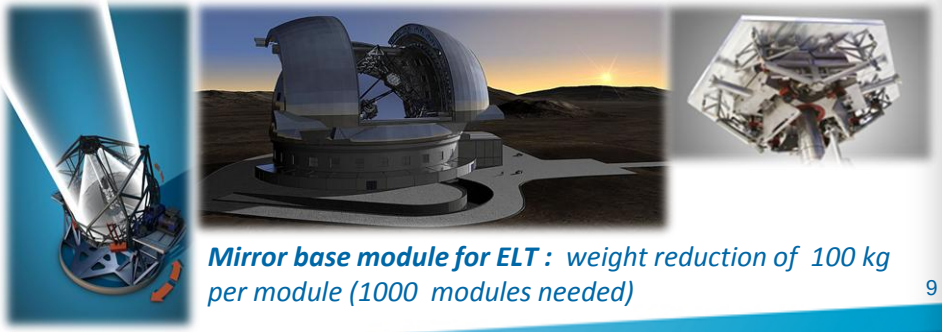
CLIC (future): from cell over bonding to (ultimately) complete module

✓ Industrialization

- Early customer involvement - cost control & risk reduction
- Co / Redesign for manufacturability

Second Harmonic Output Cavity for Yale University :
Cost optimization by reduction of

- ✓ *nr of parts (from 21 to 12)*
- ✓ *nr of brazing steps (from 3 to 2)*
- ✓ *Optimized RF tuning strategy*



Mirror base module for ELT : *weight reduction of 100 kg per module (1000 modules needed)*

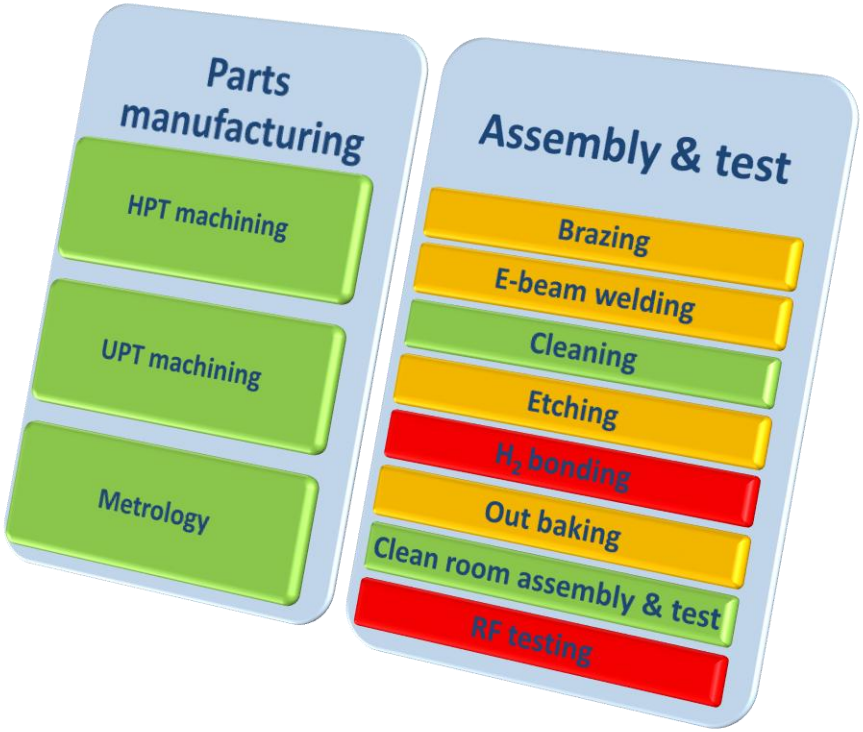
Plans for the future - Strengthening our capabilities

✓ Parts manufacturing

- Industrializing machining process
- Integrating quality control

✓ Assembly & test

- Strengthening our capabilities on
  - Brazing
  - E-beam welding
  - Etching
  - Out baking
- Building up experience on
  - H_2 bonding
  - RF testing

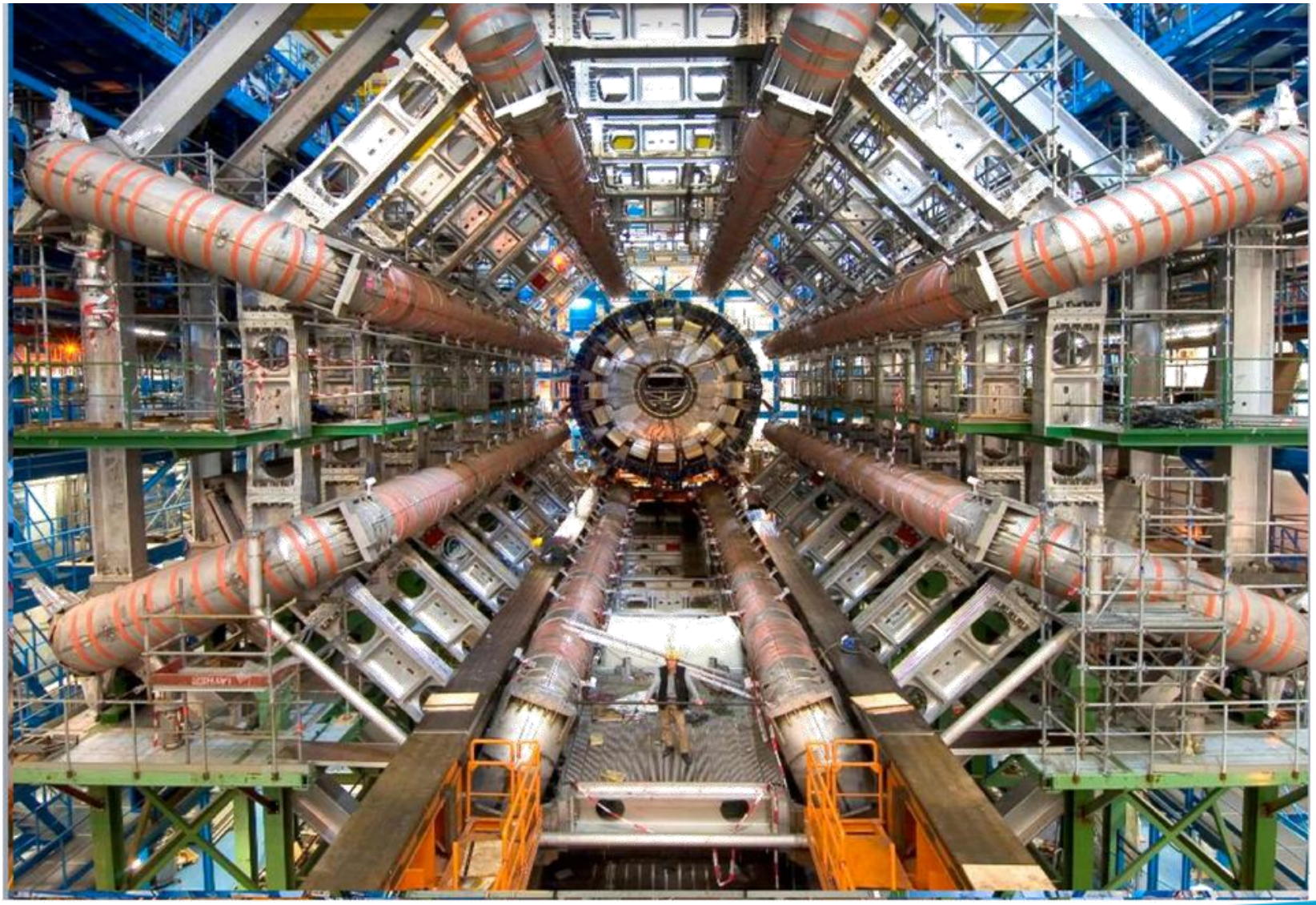


Capability reinforcement needs to be done with (international) partners in academia and industry.

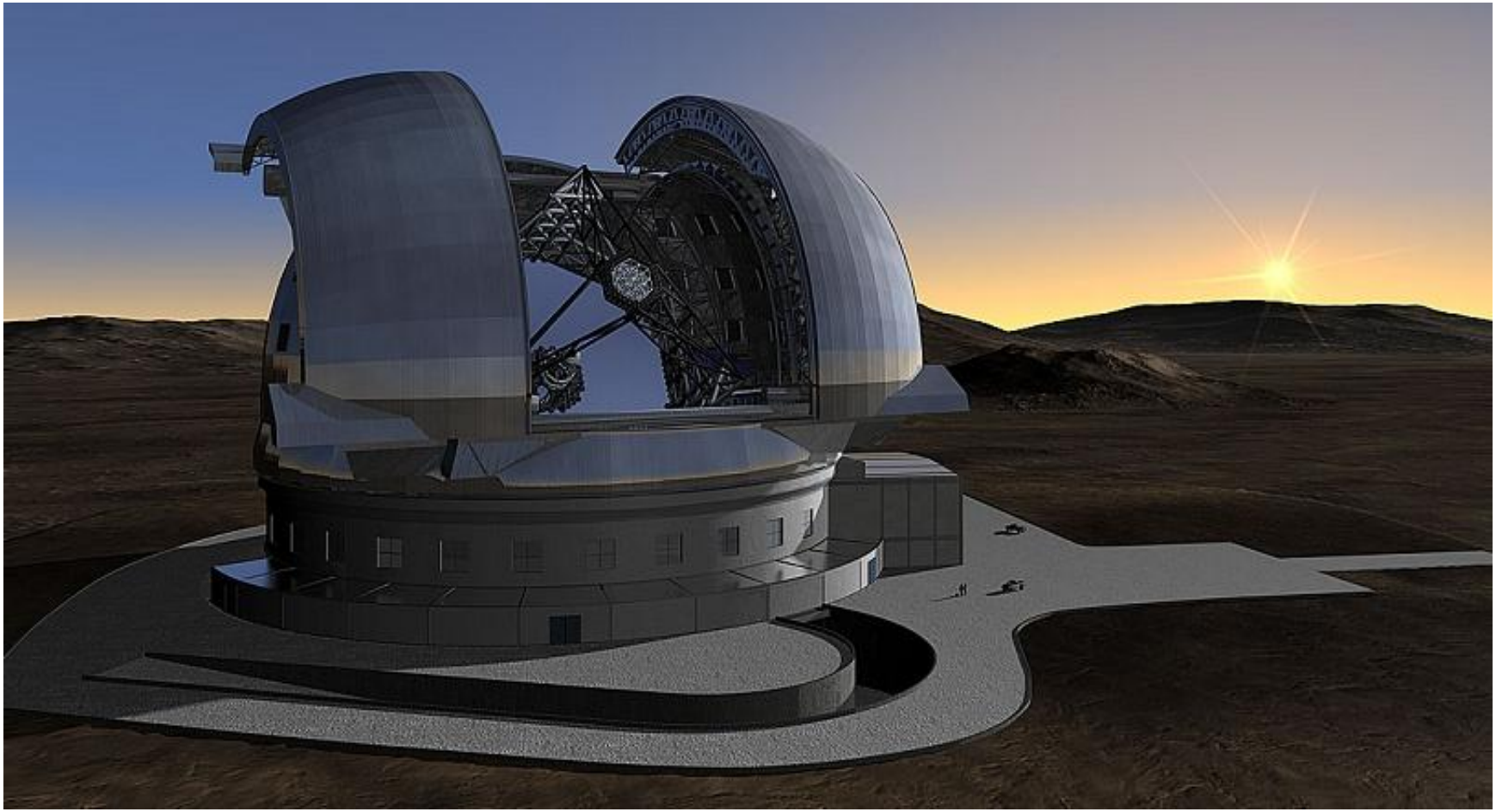
The Science & Technology Segment

- ✓ Free Electron lasers
- ✓ Normal Conducting Accelerators
- ✓ Optical Modules for instruments

The Science & Technology Segment – product examples

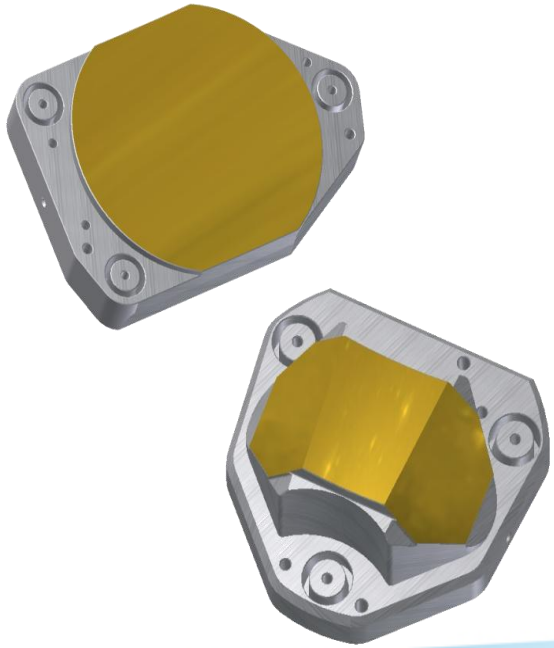


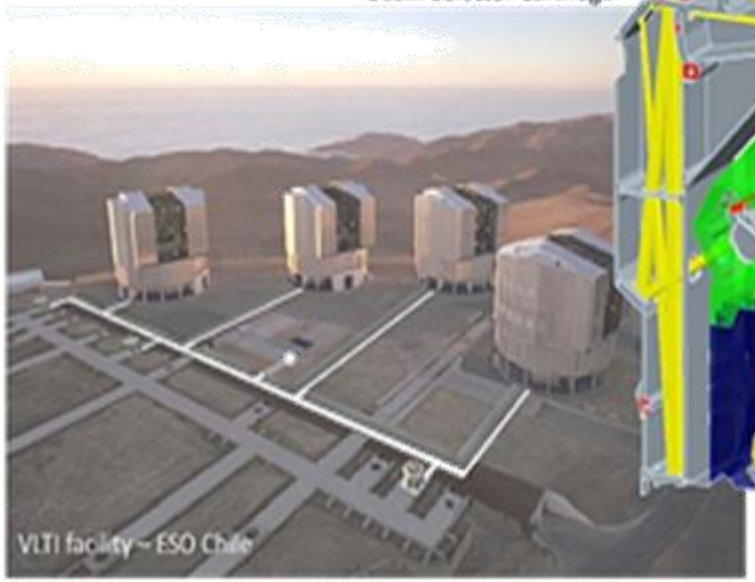
Astronomy



Matisse mirrors for VLT

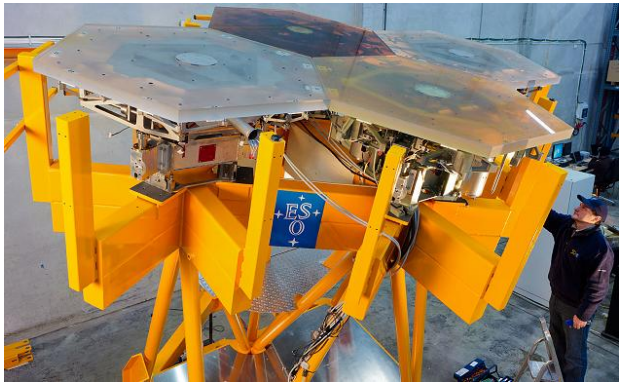
- ✓ Mid-IR spectro-interferometer combining the light of up to the four VLT telescopes (Atacama – Chili)
- ✓ Beam shaper box (3 types) as high accurate 5 axis milled part
- ✓ ø 100 mm freeform mirrors
  - Form accuracy < 100 nm
  - Surface finish < 10 nm
  - 5 sets of 2 mirrors manufactured

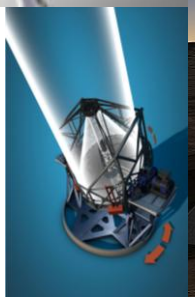


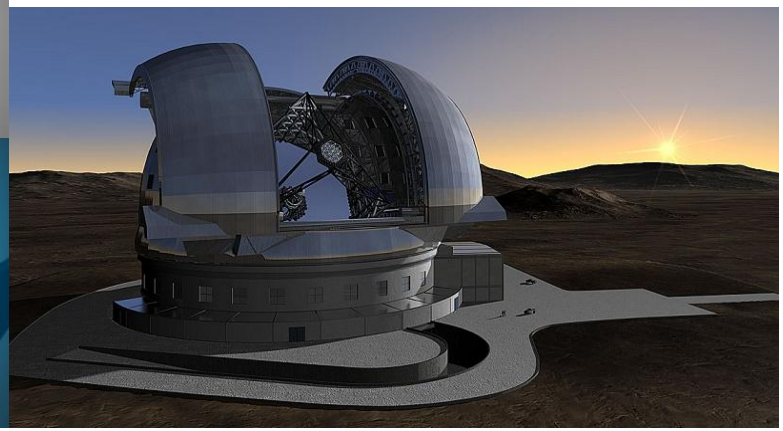


Mirror base module for ELT

- Co-operation between TNO and VDL for design optimization
- Nano positioning for adaptive optics
- Module Assembly
- Technical improvement support
- 39.3 m telescope for astro physical research







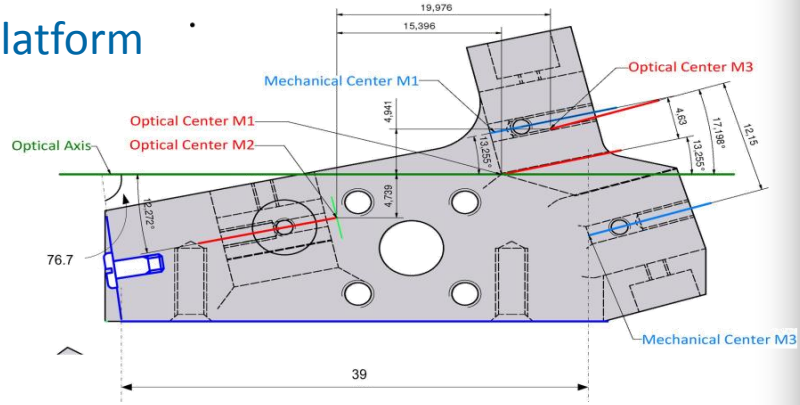
Breadboard for TMA nano satellite

Miniaturised satellites (CubeSats) as a cost effective platform

Telescope with complex aspherical mirrors

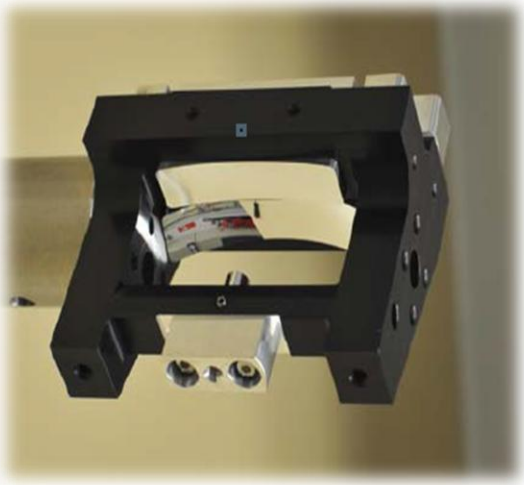
VDL's responsibility :

- ✓ Mechanical design
- ✓ Manufacturing
- ✓ Mechanical qualification
- ✓ Assembly



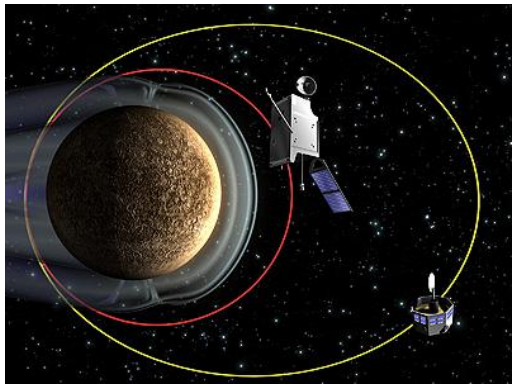
Results

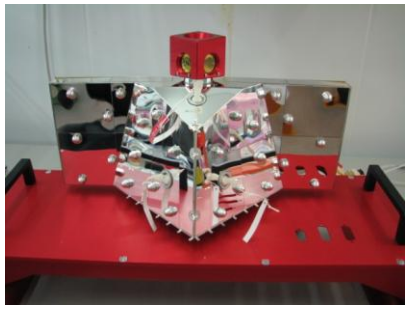
		Specified			Achieved		
		M1	M2	M3	M1	M2	M3
Form	RMS [nm]	25	15	25	18	6	17
	PV [nm]	125	65	125	95	36	84
Surface finish [nm]		5	5	5	3.1	3	4.7
Offset	X [µm]	21	22	20	0.7	0.1	0.1
	Y [µm]	31	22	16	1.0	2.3	2.3
	Z [µm]	34	16	27	0.8	1.1	1.1
Tilt	X [°]	0.028	0.200	0.025	0.004	0.006	0.004
	Y [°]	0.016	0.300	0.020	0.009	0.016	0.011
	Z [°]	0.068	0.500	0.090	0.001	0.022	0.001



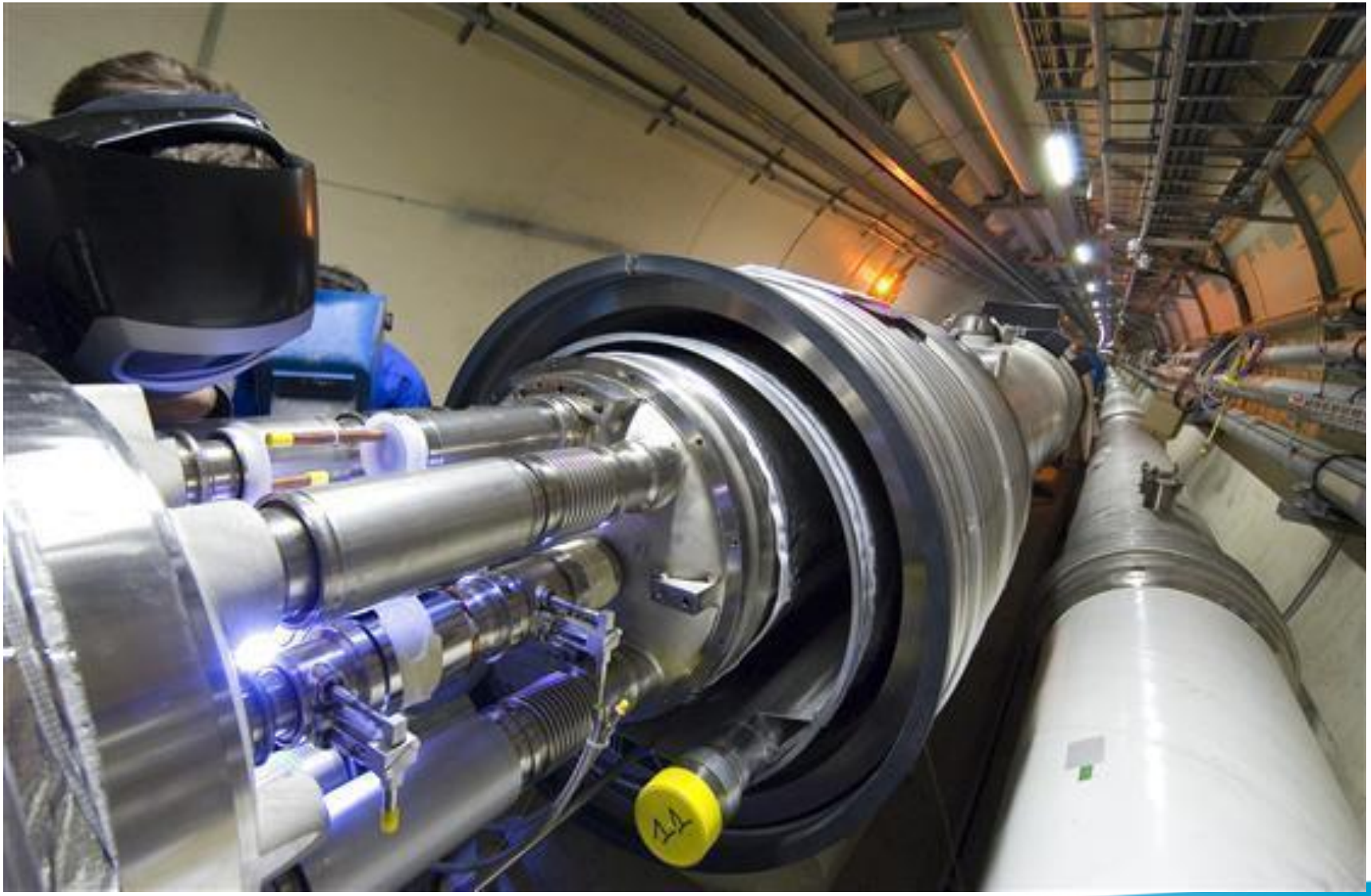
Sensor housing and Radiator for BepiColombo SIXS

- ✓ Space mission to Mercury planned for 2014
- ✓ Shielding for SIXS instrument
  (Solar Intensity X-ray & particle Spectrometer)
- ✓ Requires low surface finish in one side of 300 mm long V-grooves for radiator. Surface finish of Ra 6 nm achieved
- ✓ VDL's responsibility :
  - Defining manufacturing strategies
  - Realisation of Engineering qualification model
  - Realisation of Flight model and Flight spare model



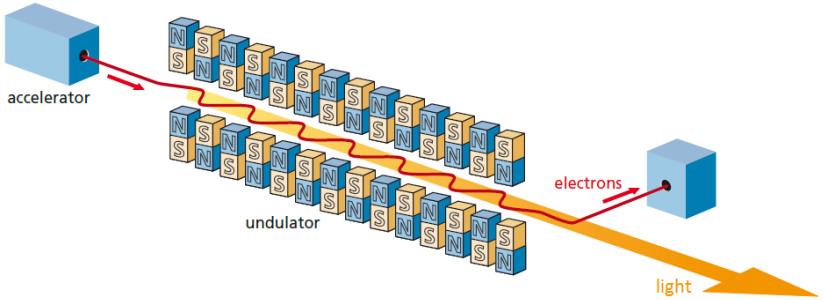


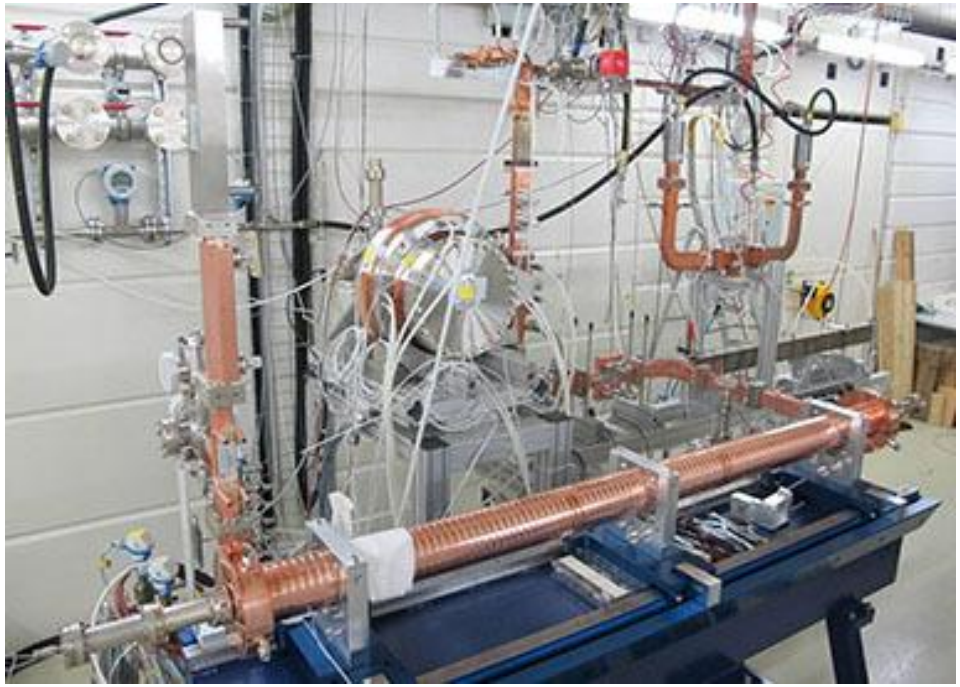
Particle accelerators



SwissFEL

- X-ray Free Electron Laser (FEL)
- Accelerator frequency: 6 GHz
- Total length: 700 m
- 0.1 – 7 nm radiation

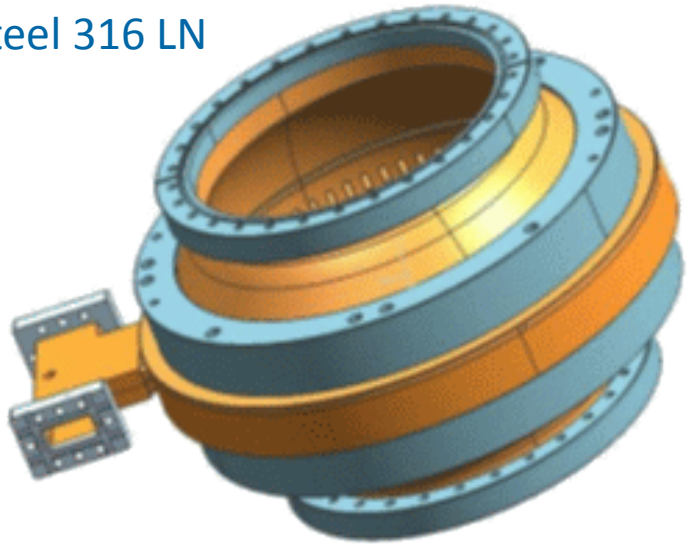


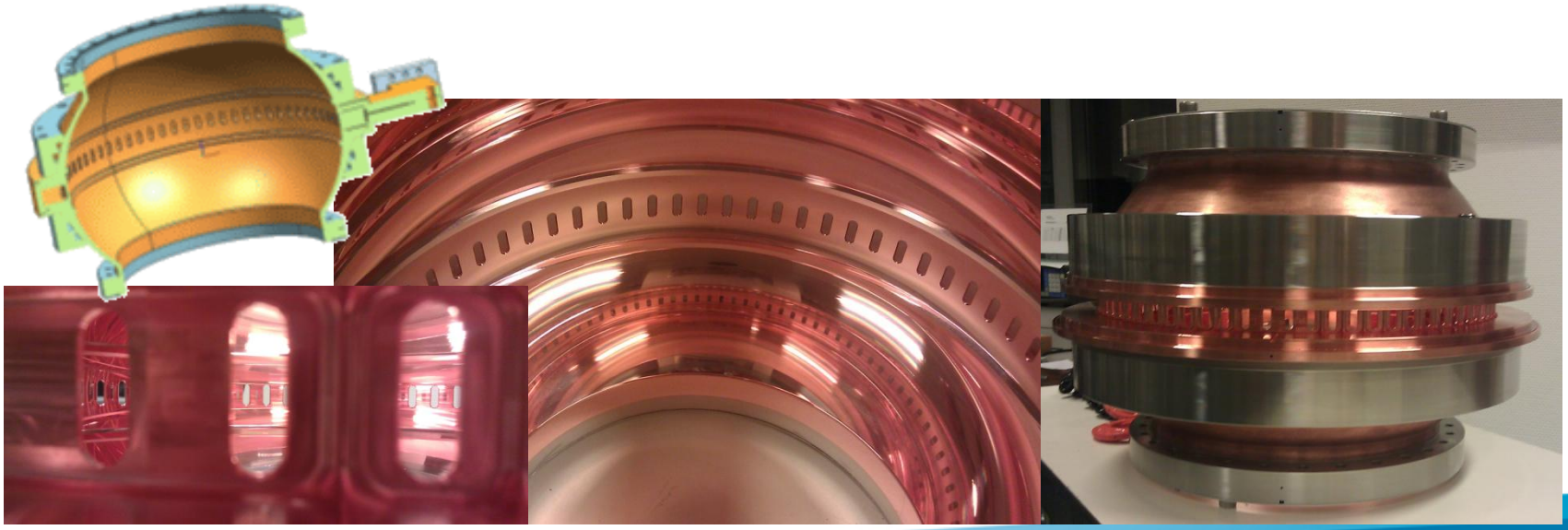


Source: PSI website

Pulse Compressor

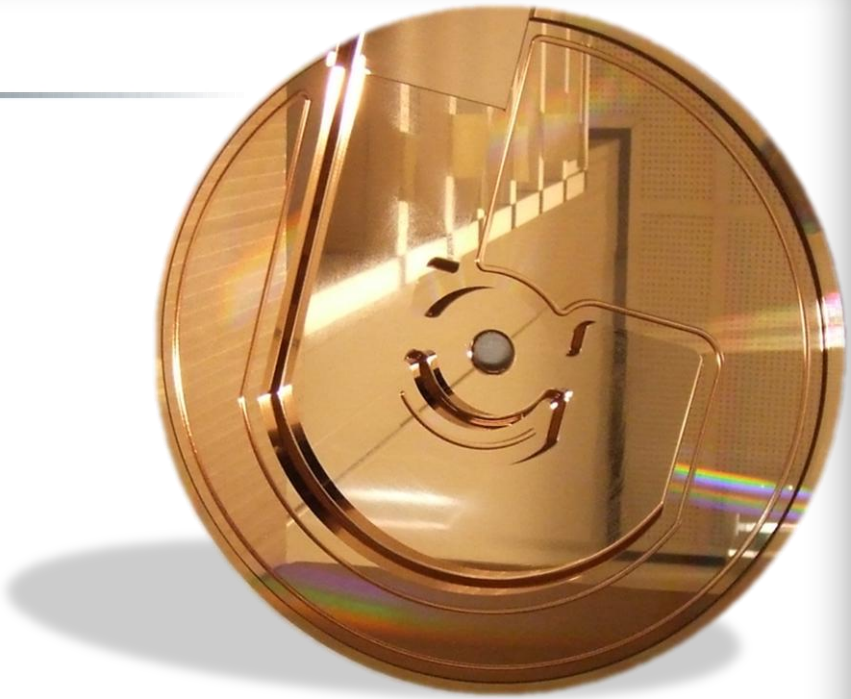
- Manufactured in OFE-Cu ø 500 mm & stainless steel 316 LN
- Product optimization for brazing
- Manufacturing engineering
- Leak testing < 2 x 10^{-10}, tuning support
- Inner surface roughness < 50 nm
- 320 MW Pulsed power tested @ PSI

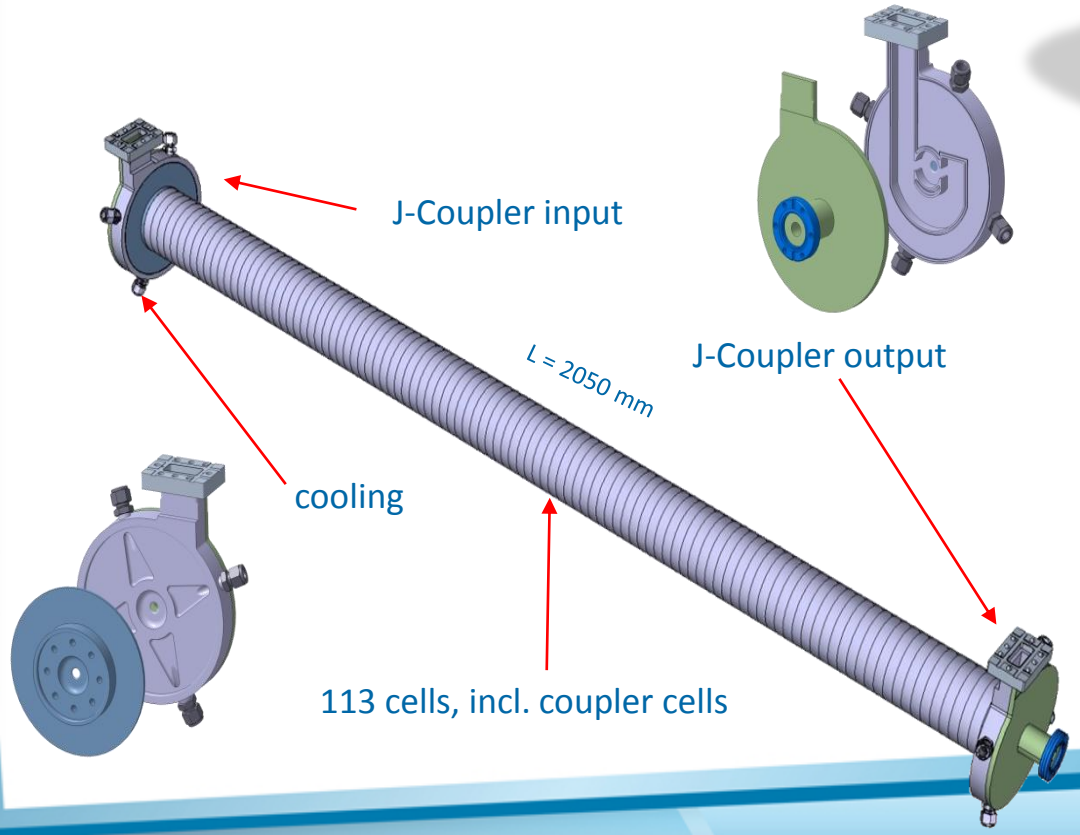


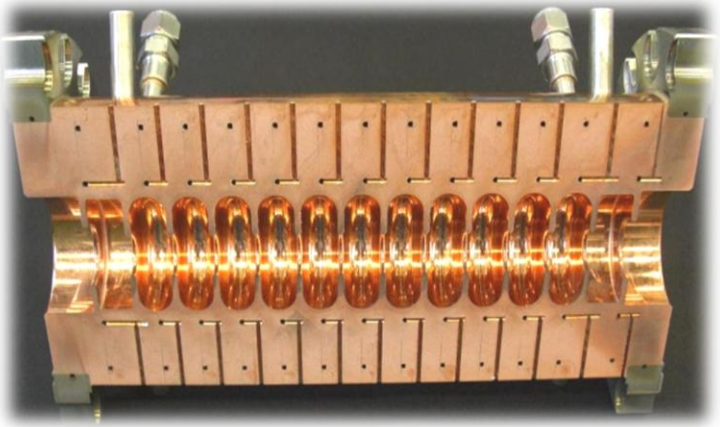


Couplers for SwissFEL

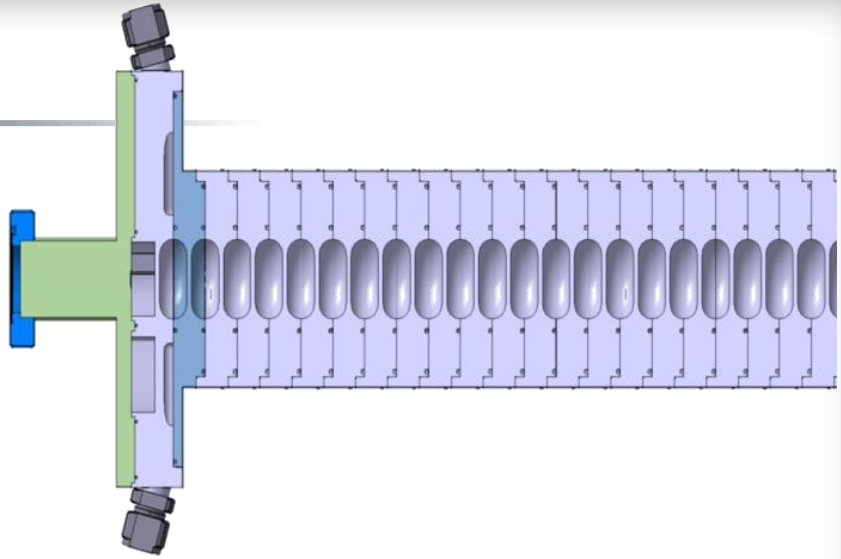
- ✓ ø 200 mm parts
  - 3 parts / coupler (input & output)
  - accuracy of 4 µm
- ✓ Several prototype sets manufactured
- ✓ Order for series manufacturing



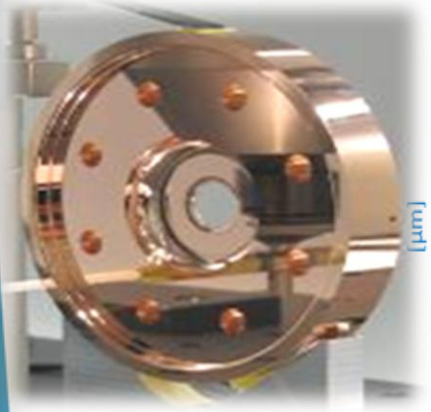


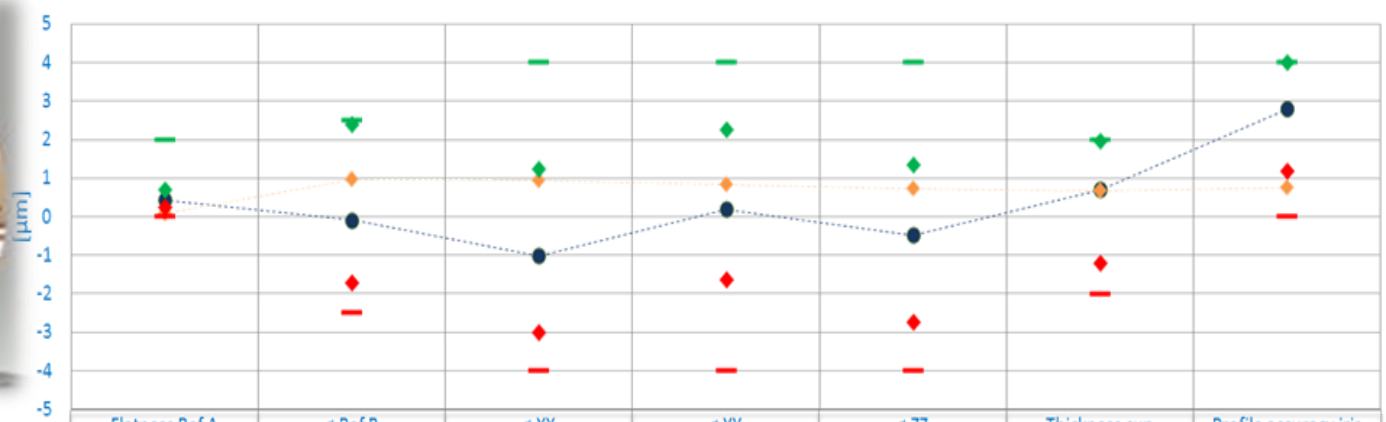


Cups for SwissFEL



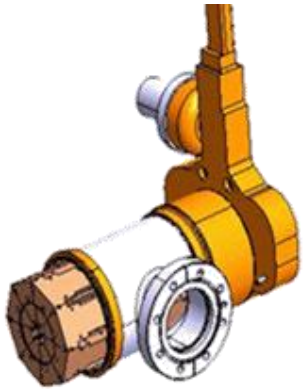
- ✓ Reference structure manufactured
- ✓ Series of 108 cups
- ✓ X-band accuracy for C-band structure
  - ⇨ ***No tuning needed***

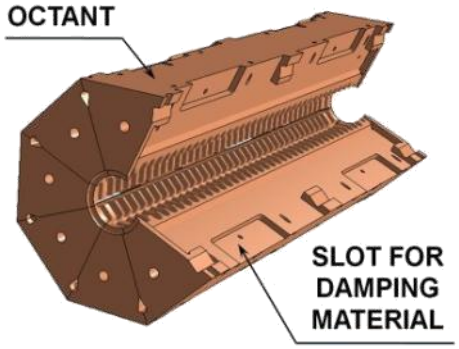




	Flatness Ref A	ø Ref B	ø XX	ø YY	ø ZZ	Thickness cup	Profile accuracy iris
Max tolerance	2.0	2.5	4.0	4.0	4.0	2.0	4.0
Min. tolerance	0.0	-2.5	-4.0	-4.0	-4.0	-2.0	0.0
Max. deviation	0.7	2.4	1.2	2.3	1.3	2.0	4.0
Min. deviation	0.3	-1.7	-3.0	-1.6	-2.7	-1.2	1.2
Range	0.5	4.1	4.2	3.9	4.1	3.2	2.8
Average	0.4	-0.1	-1.0	0.2	-0.5	0.7	2.8
Stdev	0.1	1.0	1.0	0.8	0.7	0.7	0.8

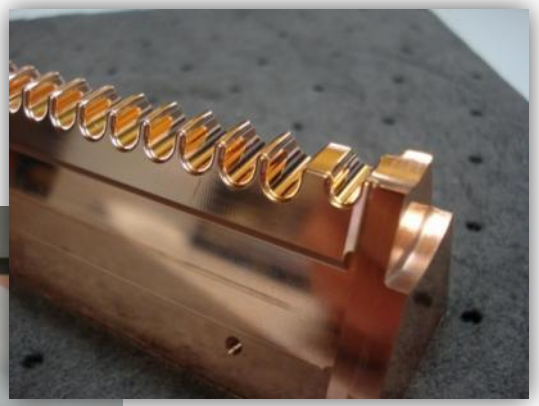
Power Extraction and Transfer Structure (PETS)





Results	Specified	Achieved
Form	15 µm	12 µm
Ra	100 nm	50 nm

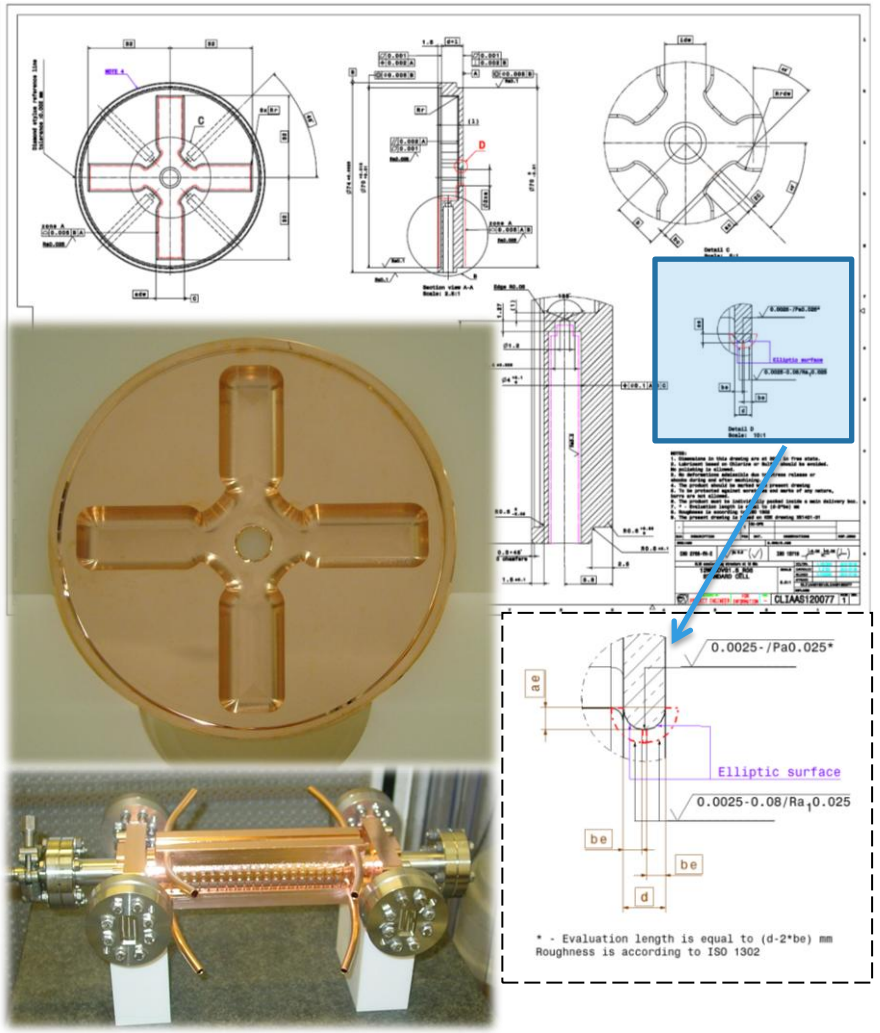
Length	50 cm
# Bars	8



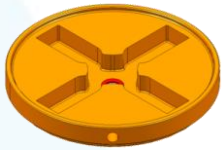
Best Practice : X-band structures for CLIC

- ✓ Manufacturing strategies
- ✓ Part handling and cleaning
- ✓ Part qualification
- ✓ Next step : sub-module assembly

Results	Specified	Achieved
Form	5 µm	2 µm
Ra Iris	25 nm	5 nm
Ra Cross	50 nm	25 nm

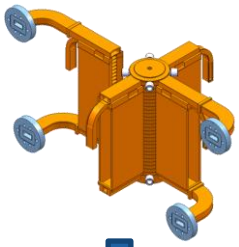


From CLIC Disc to 2 Beam Module for CLIC



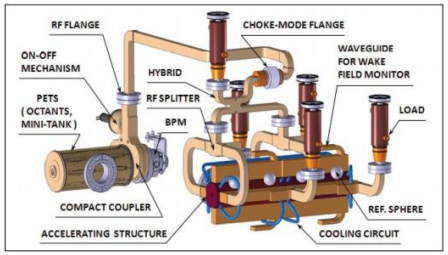
CLIC-disc

- O_2-free Copper
- Ultra Precision



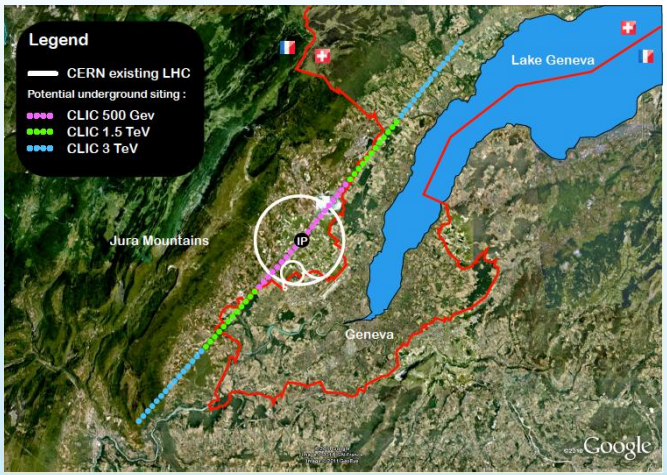
Accelerator Structure

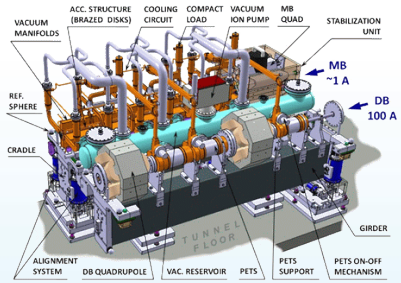
- H_2 - bonding
- Ultra Clean



RF-unit

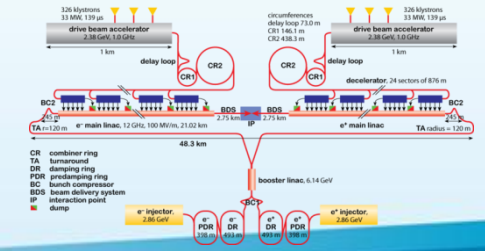
- E-beam welding
- Testing





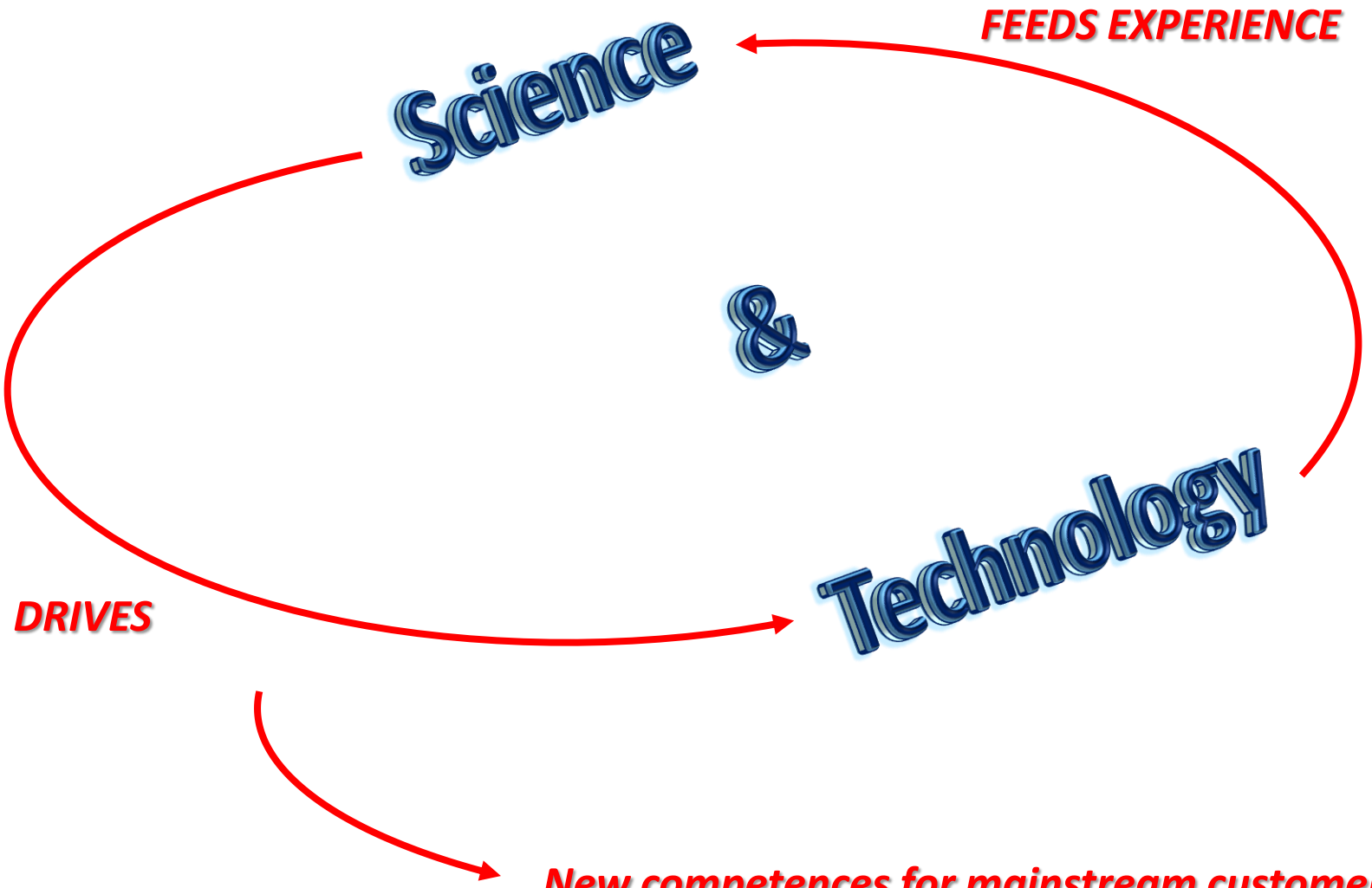
2Beam Module

- Tenderable TPD 2018
- Final Assy & Test



CLIC

Science drives to new competences



Plans for the future - Targeting new markets for X-band

- ✓ Using X-band normal conducting accelerators opens new perspective on market drivers
  - Increased field strengths / gradients
  - Ability to scale down
  - Cost of ownership
    - Reliability (using C&S-band frequencies and parts with X-band specifications)
    - Life Time (using C&S band frequencies and parts with X-band specifications)
    - Infrastructure (less energy & no cryogenic infrastructure required)
- ✓ Addressing the potential markets
  - Intensifying the relationship with our technology partners and capitalizing our common knowledge and (future) experiences in X-band
  - Identifying accelerator applications
  - Building up expertise teams on commercial applications for X-band