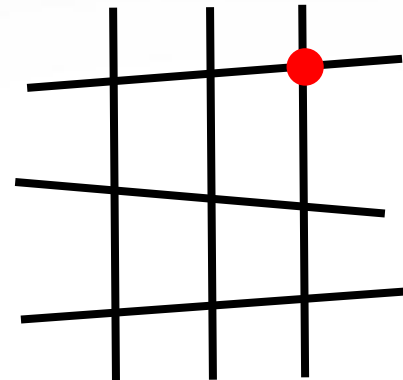


# VDL Enabling Technologies Group

## VDL ETG Precision Technology

Hans Priem

KEK 2012 HG Workshop  
20 April 2012



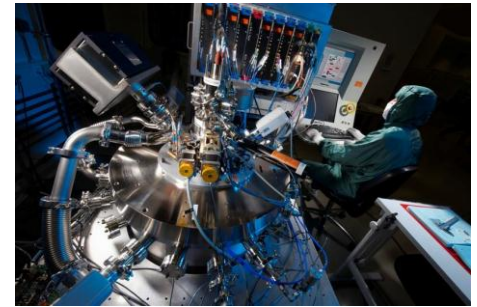
# Agenda

- Introduction of VDL ETG
- VDL ETG Core Technology Competences
- Accelerator Technology Trends
- Future Business Requirements
- Commitment to accelerator development

# Key Figures VDL ETG

*VDL Enabling Technologies Group*

- Subcontracting Business Unit of the VDL Group
- A Privately Owned Business
- > €500M Revenues (VDL total €1,7B )
- VDL ETG is a key supplier of complex modules to semiconductor and analytical equipment manufacturers WW
- Market Drivers
  - Reliability
  - Time to Market
  - Operational Excellence

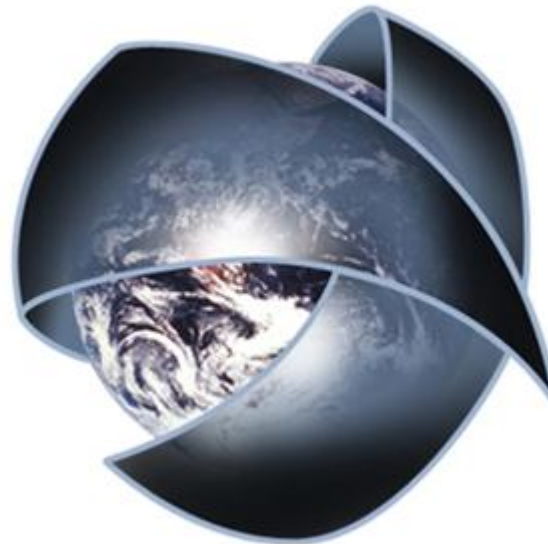


# VDL ETG Combines key strengths in one global operating company

## PROCESSES



Design  
Engineering  
Proto Typing  
Built to Print  
Sustaining



## COMPETENCIES

Positioning  
Handling  
Vacuum Technology  
Ultra / High Precision  
Metrology  
Time-to-Market  
Operational Excellence

## Products & Services

Manufacturing Engineering  
Parts Manufacturing  
Module Assembly  
System Integration



## Commitment to accelerator engineering & manufacturing

- Precision technology is a key building block in VDL ETGs company strategy – creating synergy is essential
  - Immediate tangible added value to the accelerator requirements based on our >30 year experience..and..because of this..
  - Spin-off to our main stream businesses in mid / long-term
- One integral process to handle high complexity, secure fast response, and deliver highest quality & reliability
- One dedicated team is responsible for entire process: from RFI to Delivery
  - From design to proto typing to series manufacturing

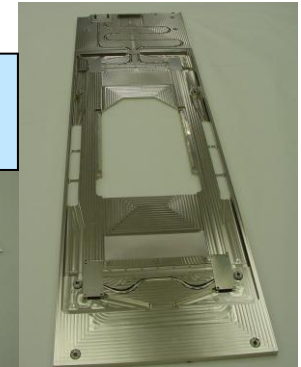
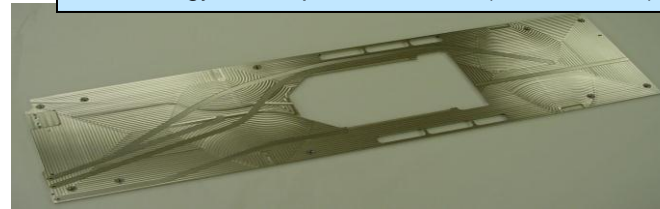
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- **VDL ETG Core Technology Competences**
- Accelerator Technology Trends
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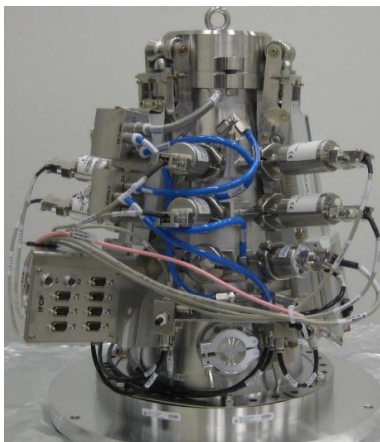
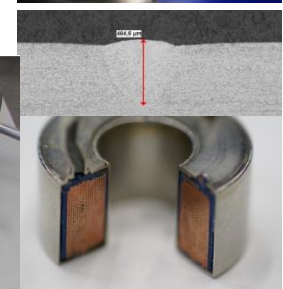
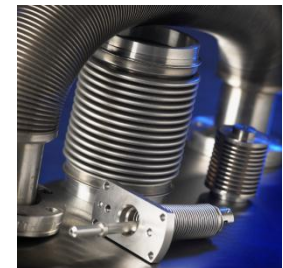
# VDL ETG Core Technology Competences

- High Precision (HPT)
- Ultra High Precision (UPT)
- Metrology
- Welding / Vacuum Brazing
- Vacuum Technology

Accuracy: 10  $\mu\text{m}$  flat over 900 mm length  
 Shape: Water-cooling and N-purging channels  
 Technology: 4 mm plate thickness (900x280 mm)



Guide ways for NANO-CMM  
 Accuracy: 0.2  $\mu\text{m}$  straightness over 300 mm



Parts manufacturing, cleaning, and assembly for EUV vacuum applications



Extensive experience in vacuum parts  
 Laser welding capabilities  
 Leak detection (HeNe : achieved  $10^{-9}$ )

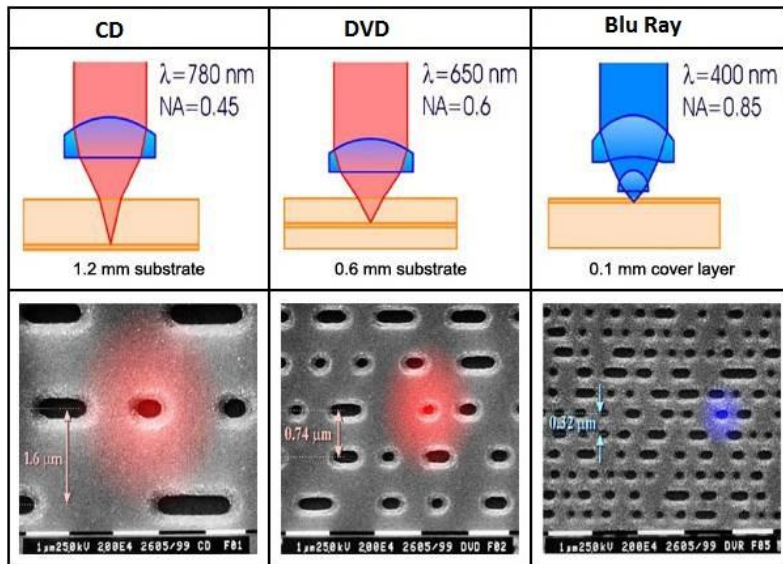


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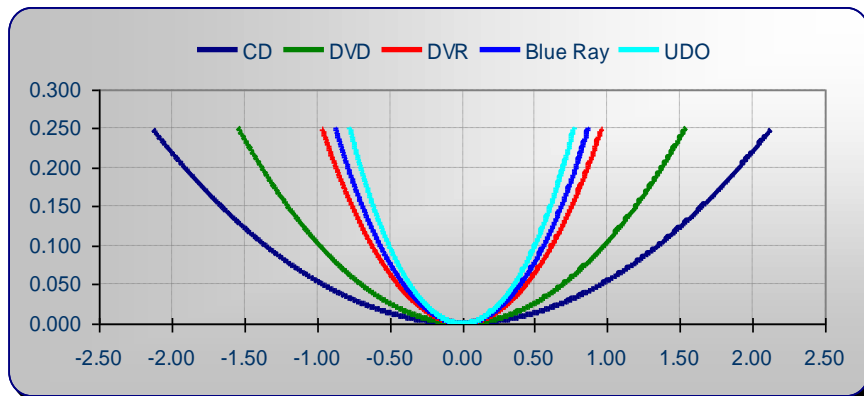
# Continuous challenge to achieve higher accuracy



Required accuracy's change :

- ✓ Form accuracy : 150 nm  $\Leftrightarrow$  50 nm
- ✓ Roughness Ra : 5 nm  $\Leftrightarrow$  2 nm

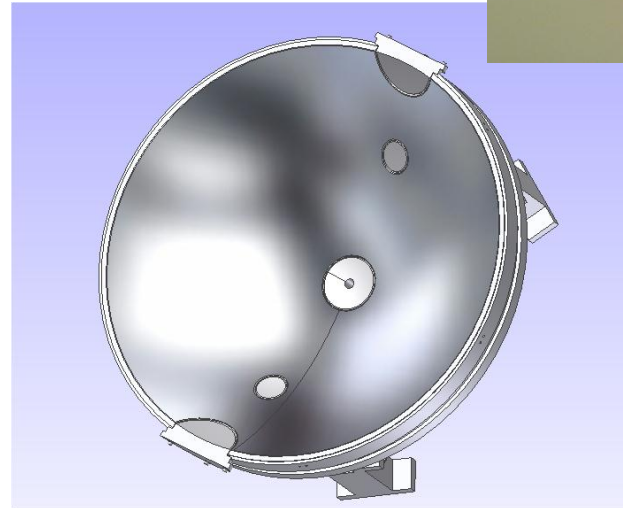
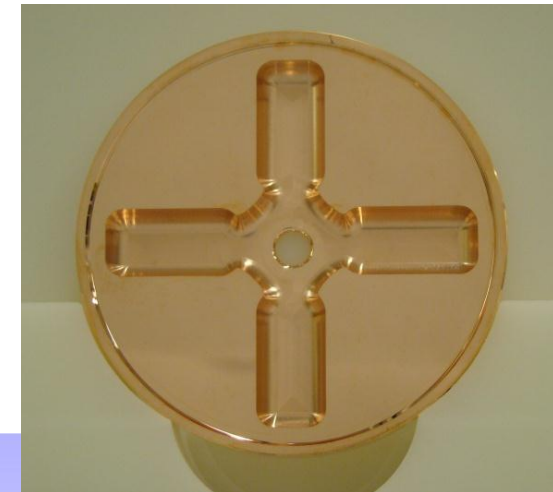
All with higher NA and steeper aspheres  
Increasing influence of tool setup errors



Constant push to improve manufacturing and metrology capabilities (means and equipment) to meet the demands

# Tight accuracy specifications for series manufacturing

- Mould for DVD optics :
  - 50 nm form accuracy on  $\varnothing$  2 mm
  - equals ratio of 1 / 40000
- CLIC disk
  - 2  $\mu$ m accuracy on  $\varnothing$  80 mm
  - equals ratio of 1 / 40000
- Collector for EUV light source
  - 5  $\mu$ m form accuracy on  $\varnothing$  400 mm
  - equals ratio of 1 / 80000

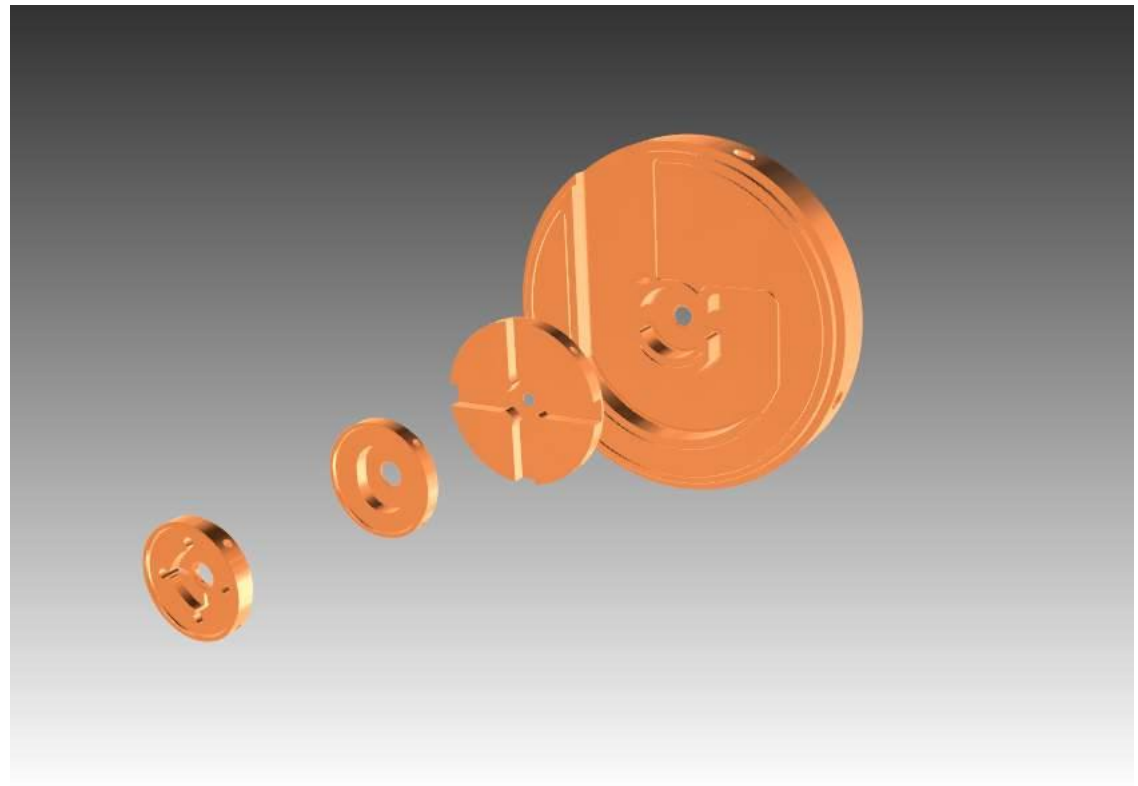


# Bigger structures, same tolerances

Diameter increases – accuracy specification remains the same

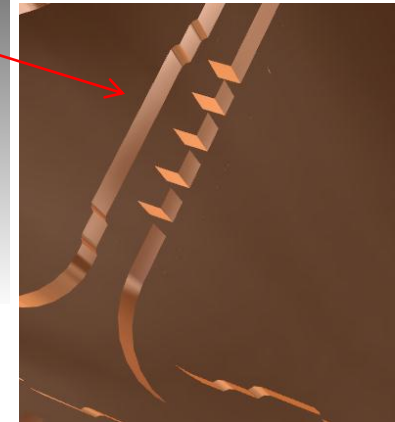
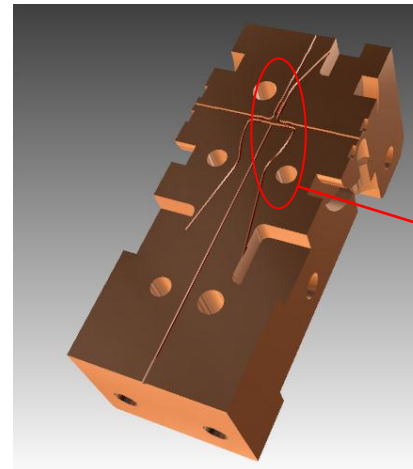
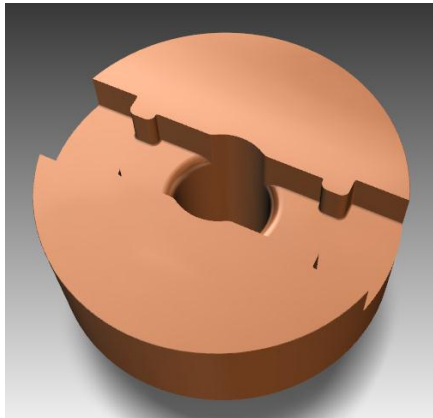
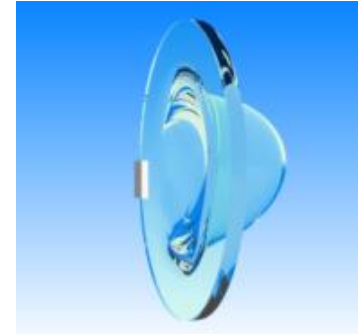
- 4  $\mu\text{m}$  profile accuracy
- 2  $\mu\text{m}$  on diameters
- 1  $\mu\text{m}$  flatness

- $\varnothing$  40 - DDS
- $\varnothing$  50 - Crab cavity
- $\varnothing$  80 - TD 24
- $\varnothing$  200 - Coupler



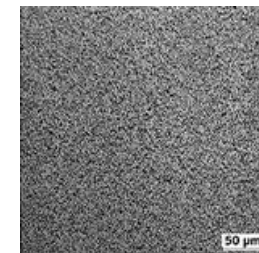
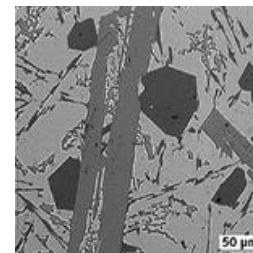
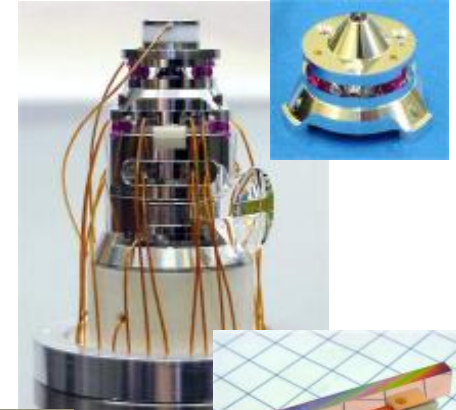
# Product specifications will demand special tooling

- Free form parts
  - Diamond tools with extreme clearance angles
- RF components for astronomy
  - Small tools ( $\varnothing 50\mu\text{m}$ ) with large depth of cut (4xd)
- Acceleration structures
  - Long tools with small radii required



# Difficult to machine materials and combinations

- Parts for electron optics
  - Combination of ceramics and copper
- Mirrors for satellites
  - High reflectivity required on aluminum
- Acceleration structures
  - Soft copper is difficult to machine
  - Sensitive to scratches and marks

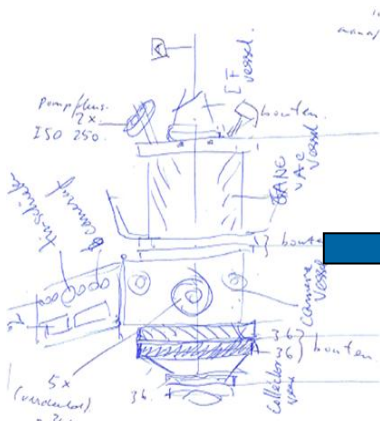


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# Time to Market

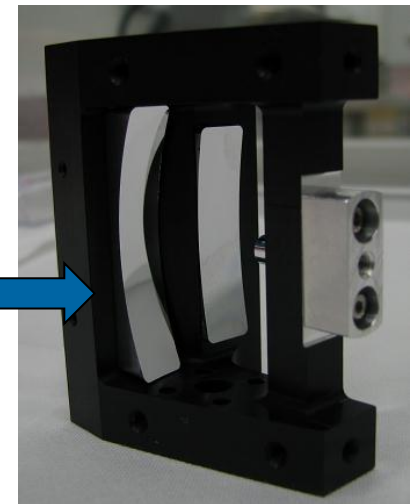
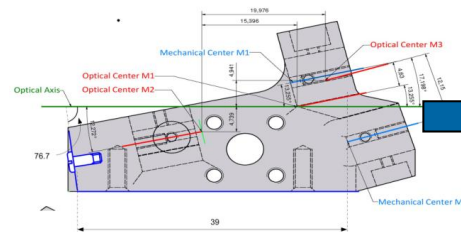
- Co-development & rapid proto typing to enable innovation to effectively reach its end-users
  - EUV source vacuum vessel (lithographic process semiconductor production)
  - ESA nano satellite - telescope with complex aspherical mirrors



24-01-2011

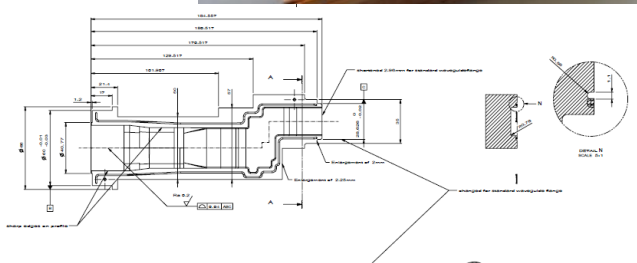
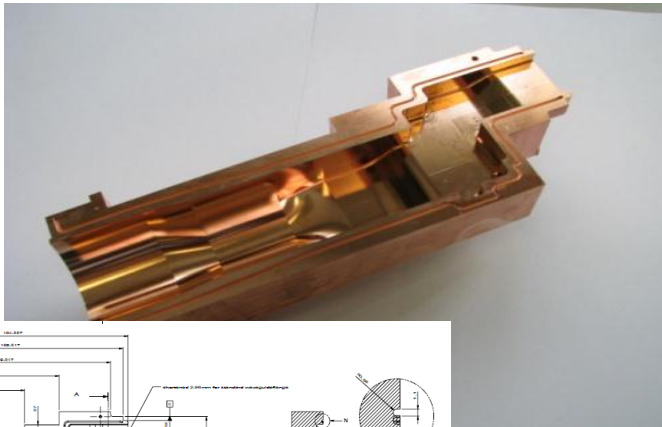


28-01-2012



# Industrialization

- Early customer involvement - cost control & risk reduction
  - A successful proto typing process results in a design verification
- Co / Redesign for manufacturability
  - Straight mode converter - from 16 to 2 parts
  - E-ELT frame and actuators redesigns – reduced weight 100kg
  - Pulse compressor – reduced cost





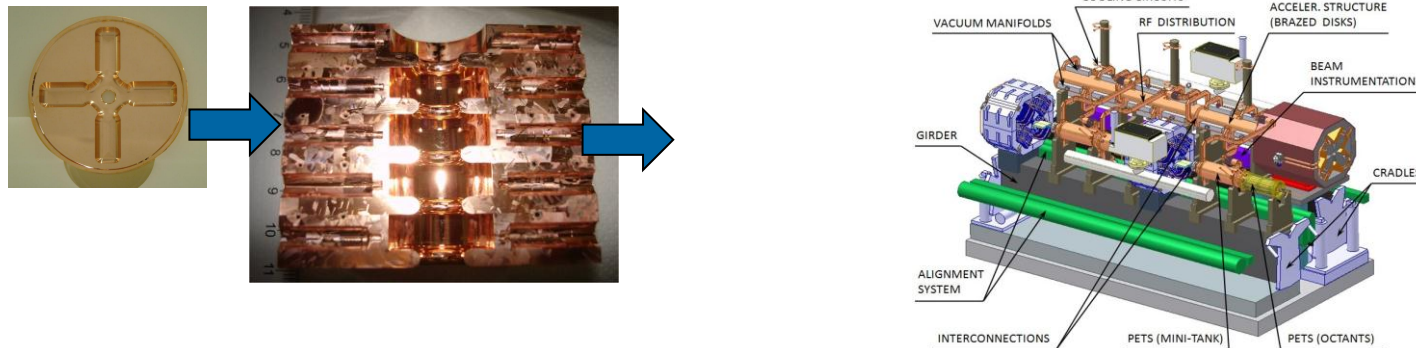
# Increased complexity requires higher level outsourcing

## Securing shortest cycle time to end-product

- EUV Vacuum Wafer Stage: from magnet table to complete qualified module



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



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# Industry Commitment Required

- Accelerator development is reaching maturity step by step
  - From conceptual designs and proto typing towards industrialization
- Manufacturing process experience & knowledge is essential
  - secure time to market, cost control / reduction, yield, and quality
- Capital investments are increasing significantly
  - High mutual commitment between industry and institutes is essential
  - Alignment is required now to meet time to market

	2010				2011				2012				2013				2014				2015				2016			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
CTF3 TBTS operation	inst.	1-2 structures, beam loading, breakdown kick			Diacer final deceleration 8 test (16 PETS, 50%)																							
CTF3 TBL operation	inst.	PETS			further tests, installation 4 modules				testing				pre-series production, industrialization															
Modules lab	initial tests, installation 2 modules				testing				testing 3 modules				testing 3 modules				> upgrades?											
Modules CTF3	design, hardware tests				installation				testing				RF testing, potential upgrades															
CTF3 phase feedback	design, hardware tests				installation				testing				RF testing, potential upgrades															
CTF3 TBL+	design & hardware construction				installation				commissioning				staged upgrade & testing															
CLIC DB injector & linac	design & hardware construction				installation				commissioning				staged upgrade & testing															
RF structures construction	precision metrology, fabr. procedures				up to 40 structures built, establish precision machining at CERN or elsewhere, 5 µm tolerances achieved				more than 200 structures built, final cost optimization, pre-series with industry																			
RF test infrastructure	CERN test stand (two slots)				continue testing with increased capabilities, CERN or elsewhere, up to 10 slots				testing, up to 200 accelerating structures plus PETS and RF components																			
Prototypes of critical components	technical choices, design				construction, hardware tests				finalization, performance & cost optimization, industrialization for large scale components																			

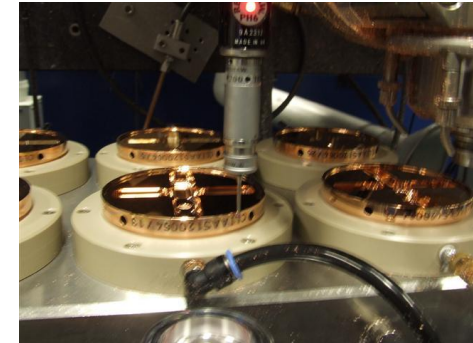
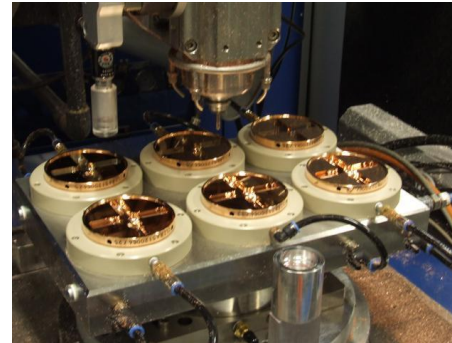
Example: CERN CLIC roadmap 09-2011



# VDL ETG Industry Commitment

- Investments in new skills

- H2 bonding
- Micro milling
- Pallet machining
- On machine metrology

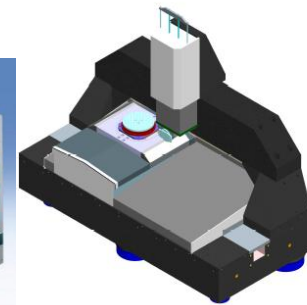


- Investments in people

- Cooperation programs with schools, universities, institutes
- Internal education
- Career paths

- Investments in infrastructure

- Equipment
- New Facility



• **Guidance is required to steer investments in the right direction**

# VDL ETG Industry Commitment

By combining technological competences and extensive experience in industrialization of complex modules, VDL ETG enables you to successfully steer accelerator technology towards maturity

Accelerators are essential to future applications

We will enable your ambitions