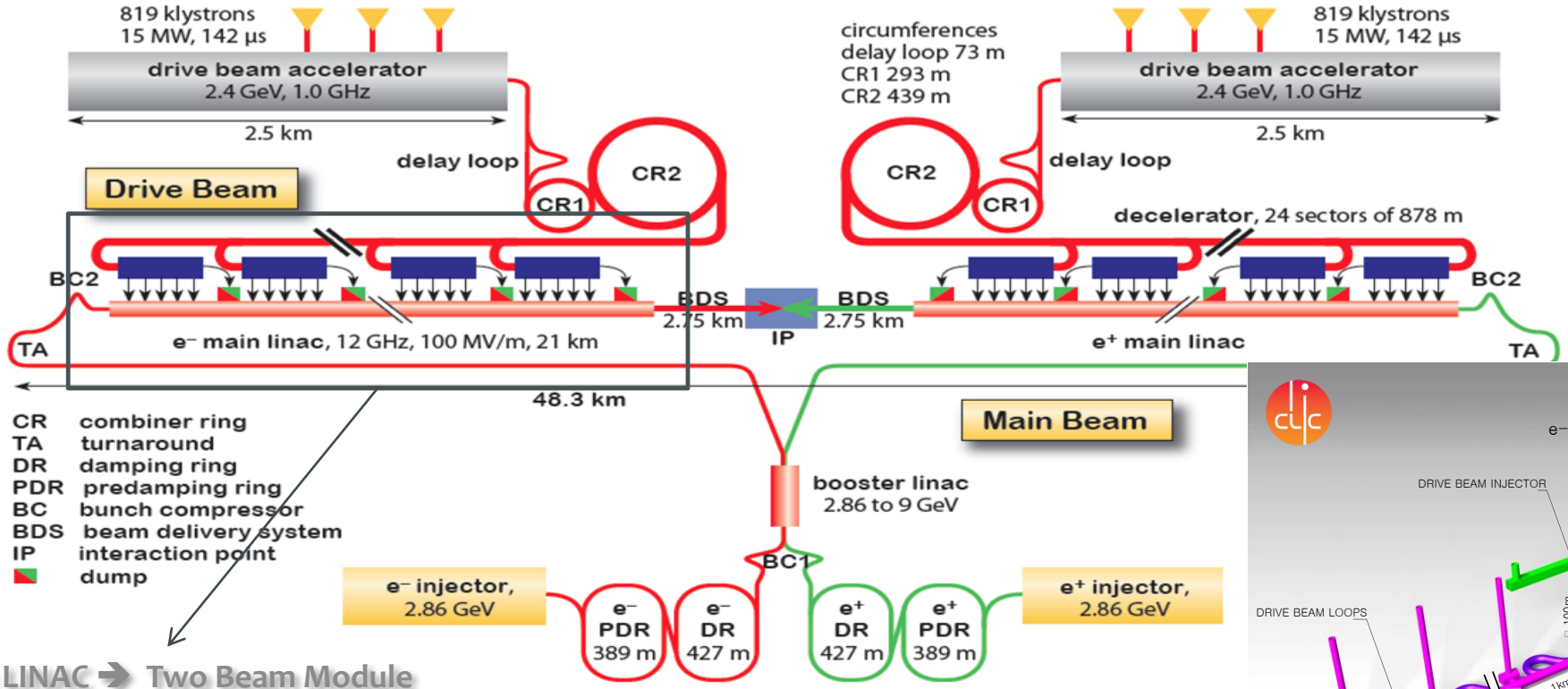
INDUSTRIAL TECHNOLOGIES FOR RF SYSTEMS IN CLIC

N. CATALAN LASHERAS.

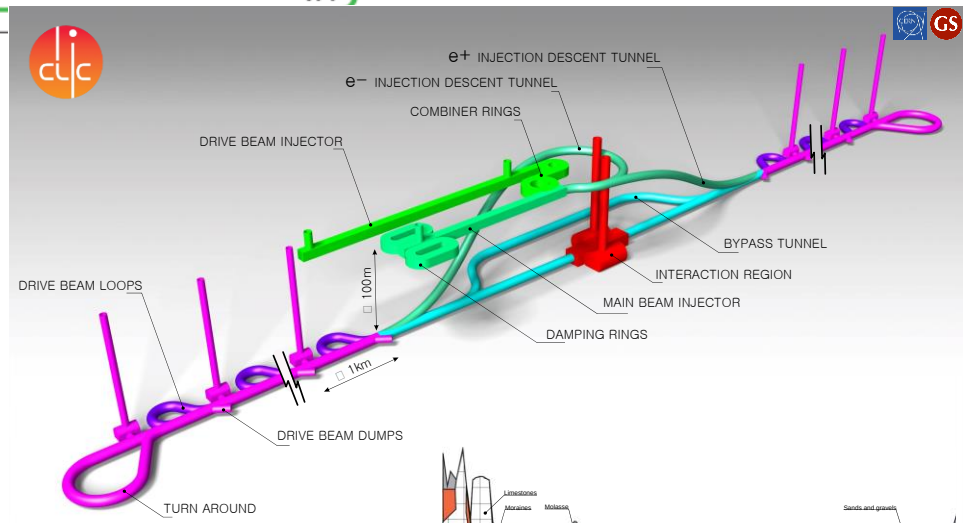
LCWS STRASBOURG 23-27 OCTOBER 2017

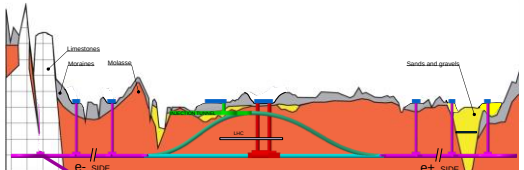
BRIEF INTRODUCTION TO CLIC

CLIC LAYOUT



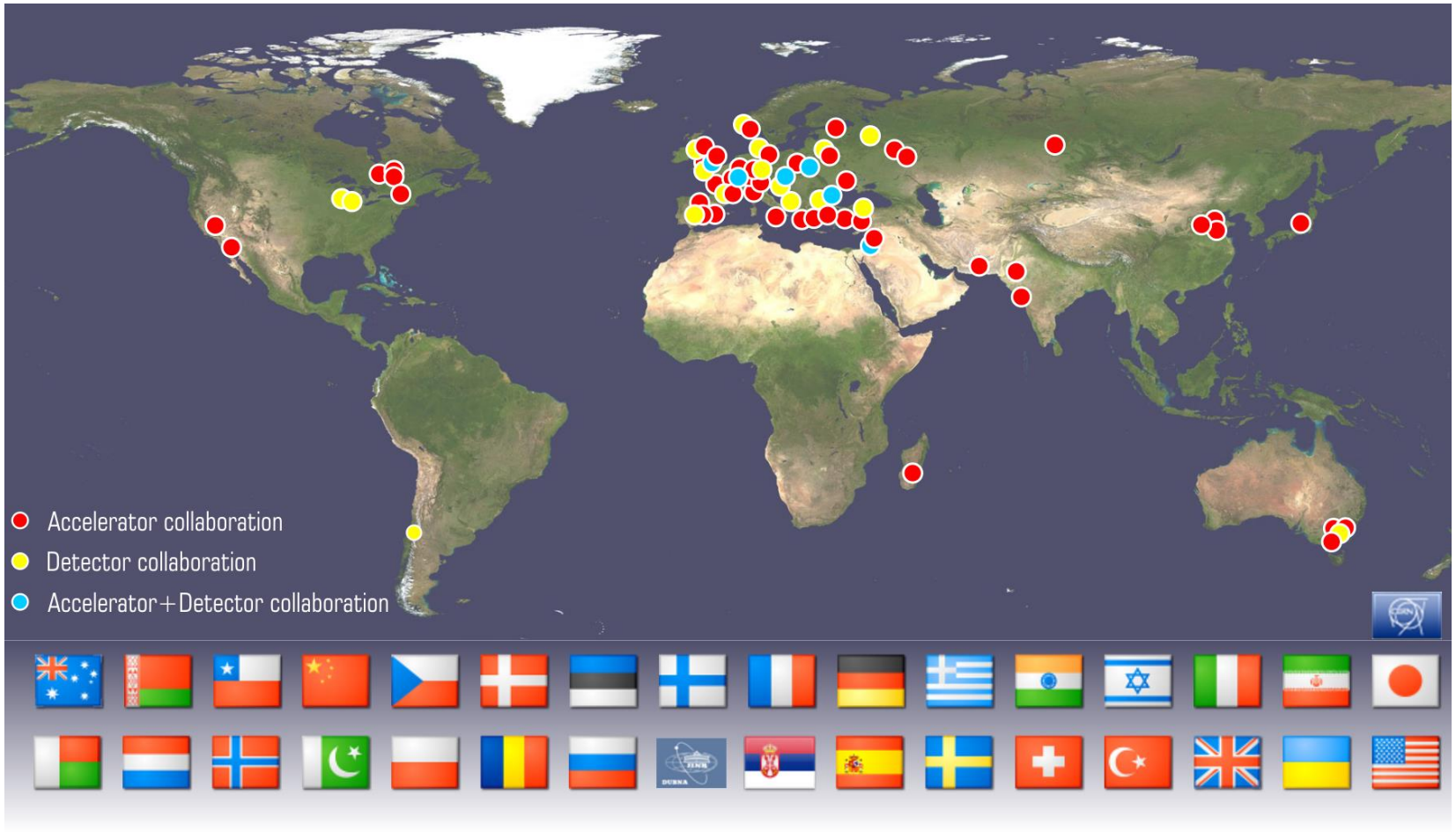
Main LINAC ➔ Two Beam Module



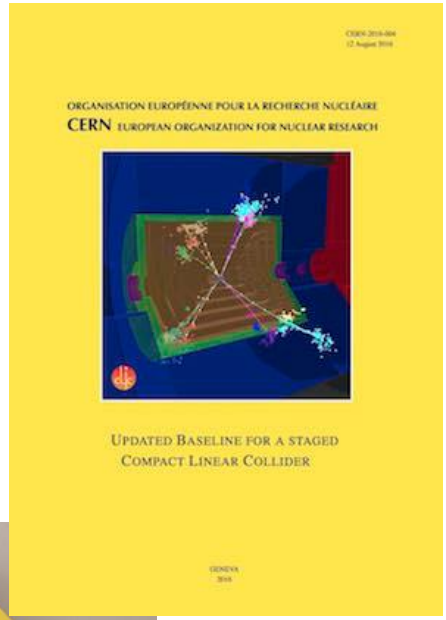


CLIC SCHEMATIC

COLLABORATION



58 institutes from 28 countries



CLIC TIMELINE

2013-18
Development phase

- Develop a Project Plan for a staged implementation in agreement with LHC findings; further technical developments with industry, performance studies for accelerator parts and systems, as well as for detectors

2018-19 Decisions

- On the basis of LHC data and Project Plans (for CLIC and other potential projects as FCC), take decisions about next project(s) at the Energy Frontier.

+5 years preparation
Phase

- Finalise implementation parameters, Drive Beam Facility and other system verifications, site authorisation and preparation for industrial procurement. Prepare detailed Technical Proposals for the detector-systems.

2024-25
Construction Start

- Ready for full construction and main tunnel excavation.

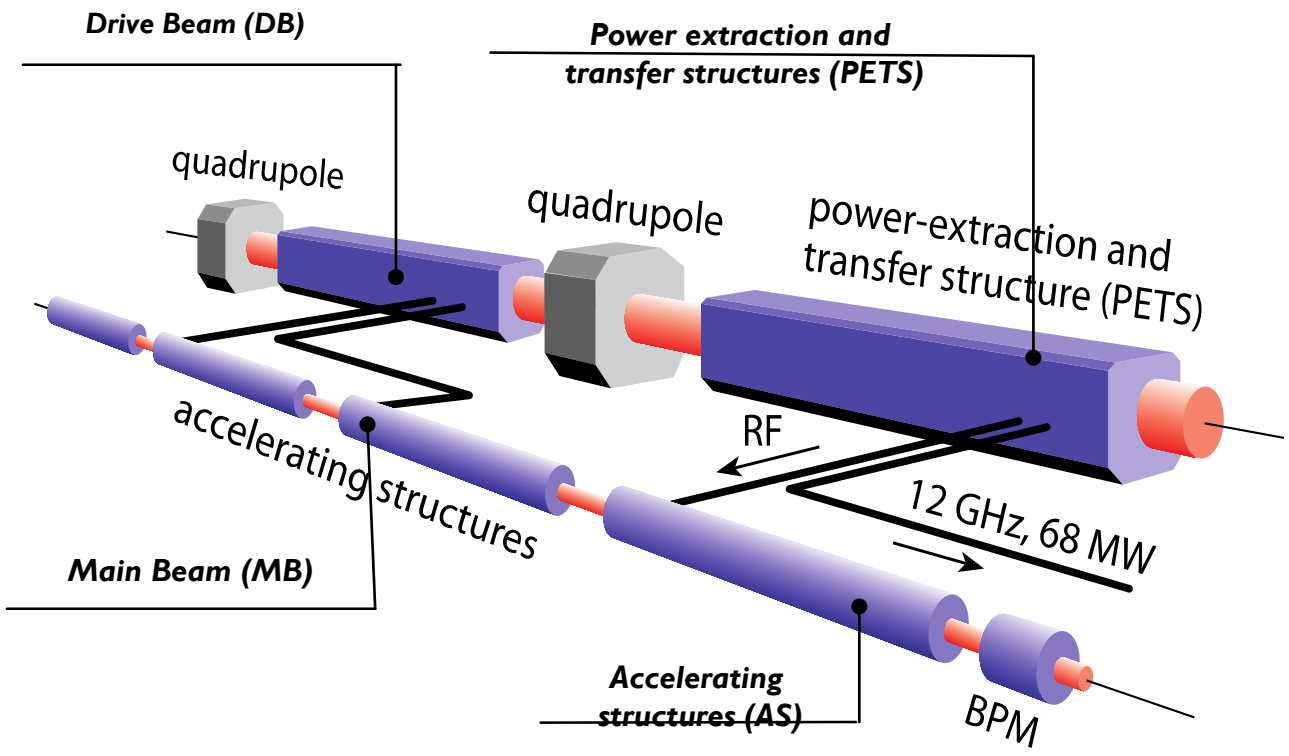
Construction phase

- Stage 1 construction of CLIC, in parallel with detector construction.Preparation for implementation of further stages.

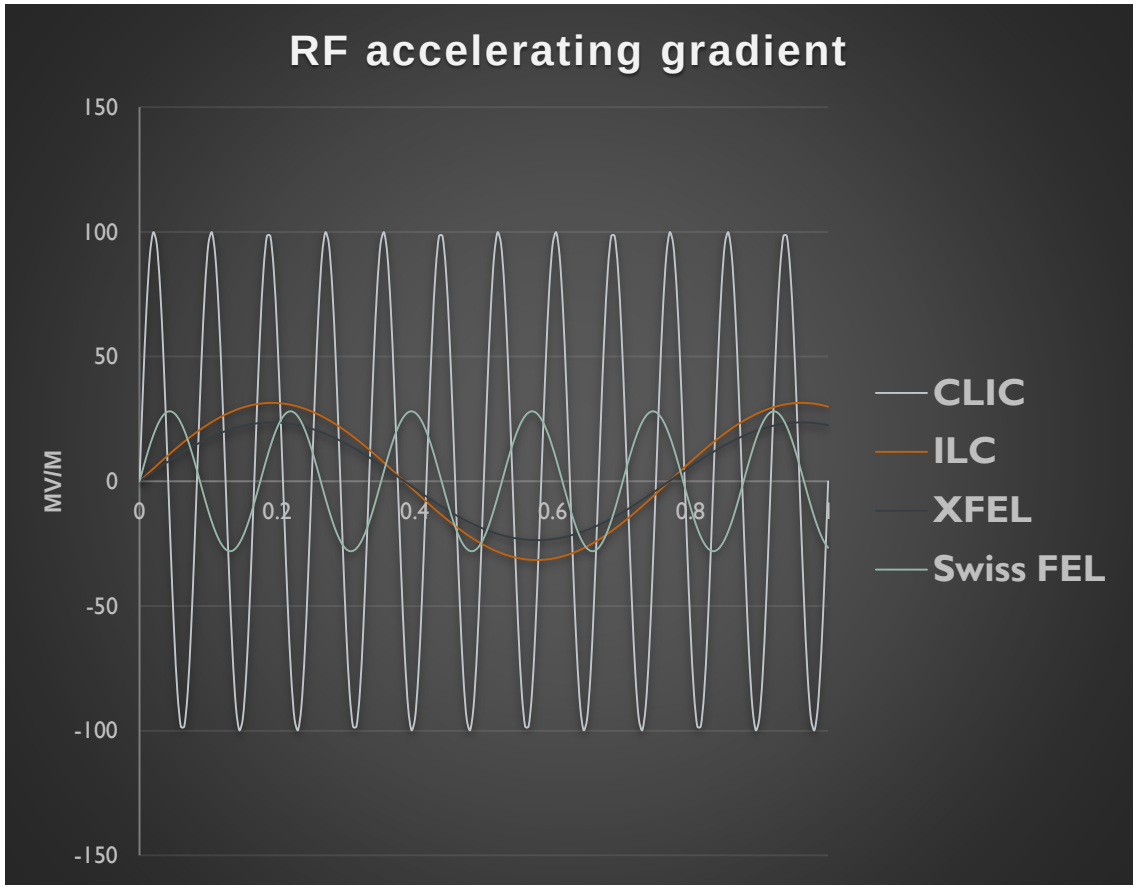
Commissioning

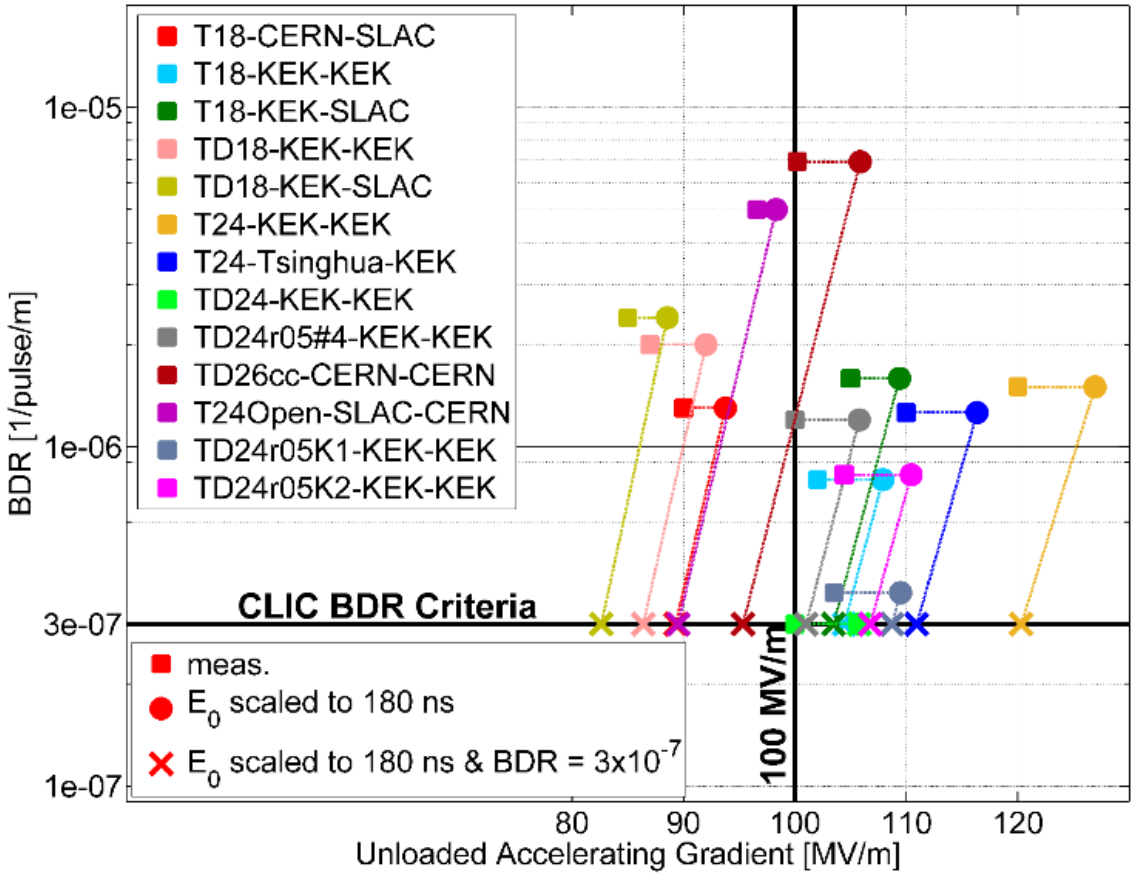
- Becoming ready for data-taking as the LHC programme reaches completion.

TWO-BEAM PRINCIPLE

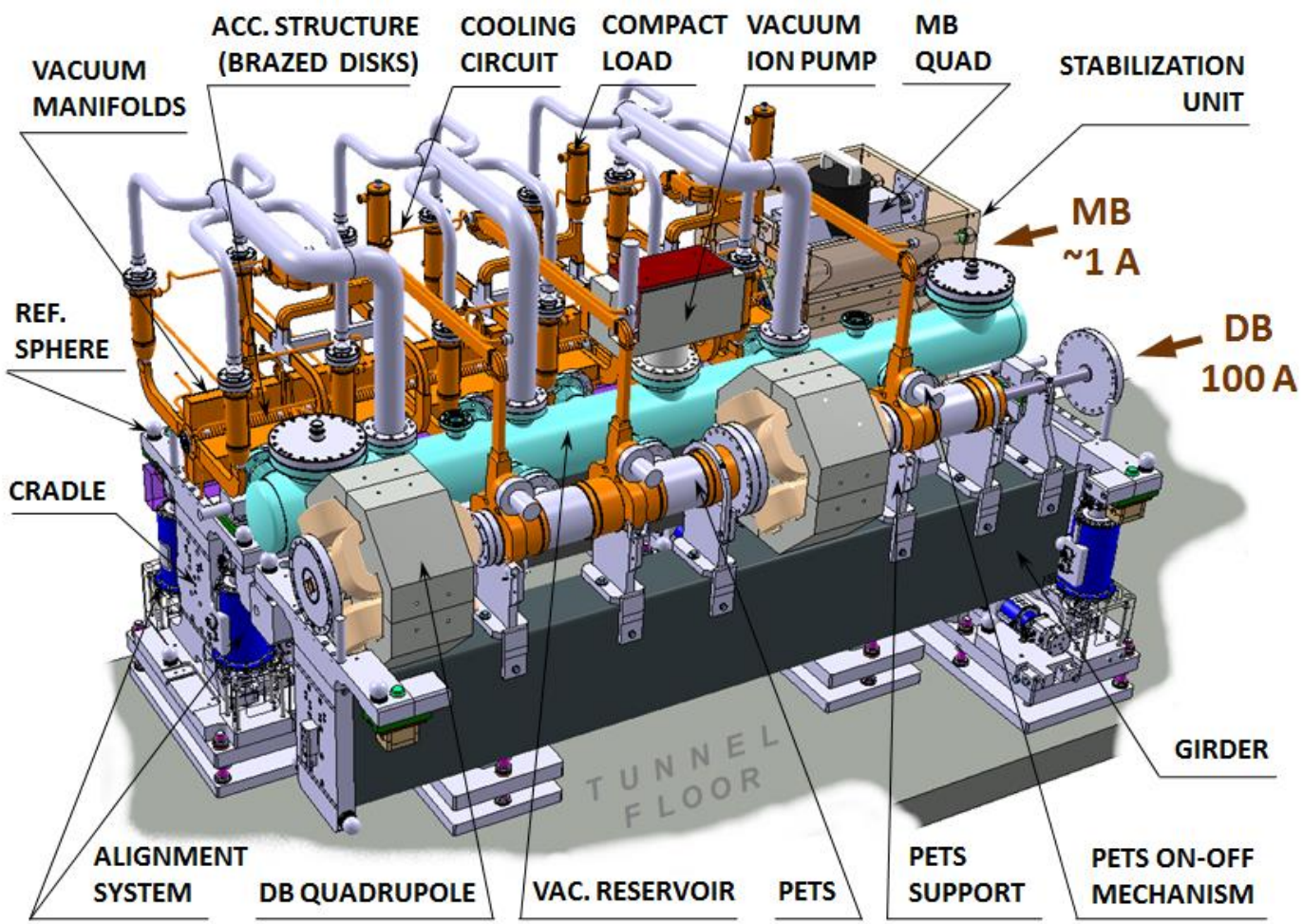


COMPACT ACCELERATION





CLIC MODULE

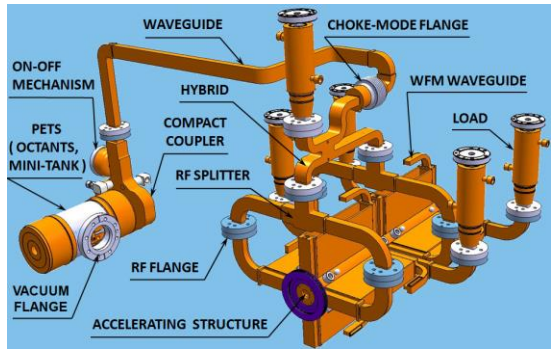


Main parameters of CLIC module		
Module length	2010	mm
PETS length	308	mm
PETS aperture	23	Mm
PETS gradient	6.5	MV/m
PETS power	136	MW
AS length	230	mm
AS aperture	5	Mm
AS gradient	100	MV/m
AS power	64	MW
Vacuum level	10^{-9}	mbar

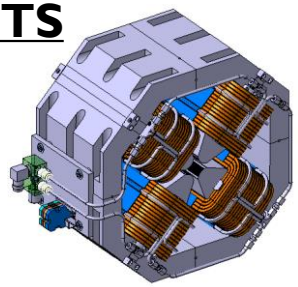
OTHER MODULE SYSTEMS

Number of elements in CLIC	3 TeV	380 GeV
Module	10638	…
PETS	35690	9973
Accelerating Structures	71380	19547
Loads	71380	19547
Quadrupoles	2818	574
Dipoles	21276	…
Beam position monitors	14184	…
Girders	10346	…
Cam movers	14090	…

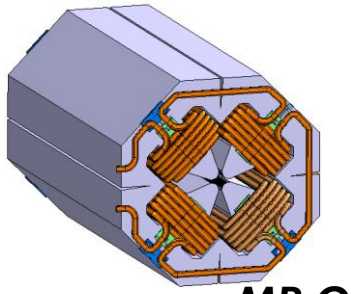
RF SYSTEM



MAGNETS

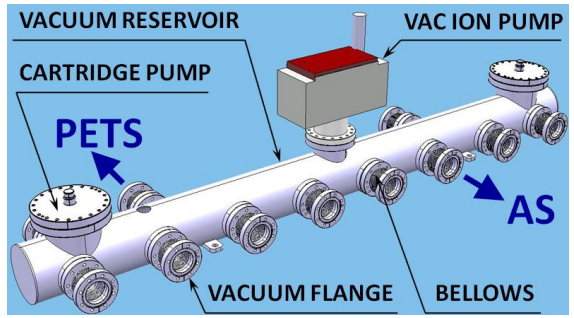


DB QUAD

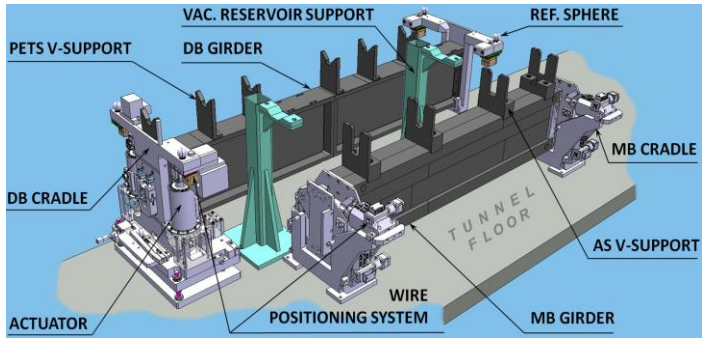


MB QUAD

VACUUM SYSTEM



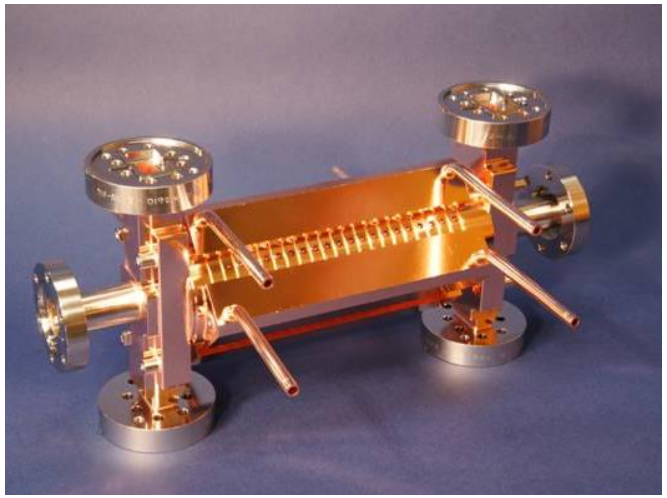
ALIGNEMENT, STABILISATION AND SUPPORT SYSTEM

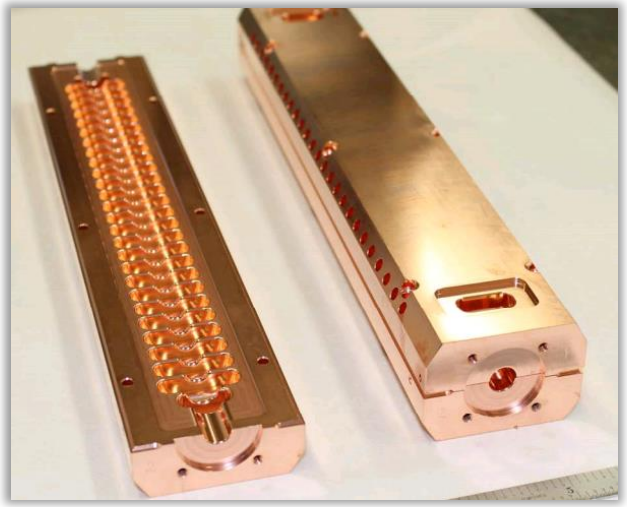


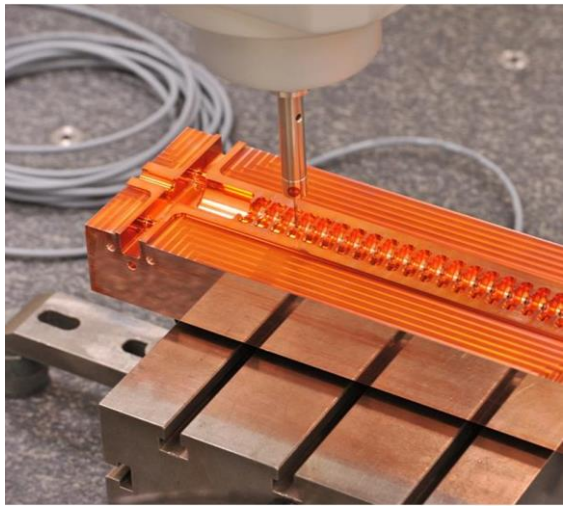
CLIC TECHNOLOGIES IN INDUSTRY

X-BAND COPPER STRUCTURES

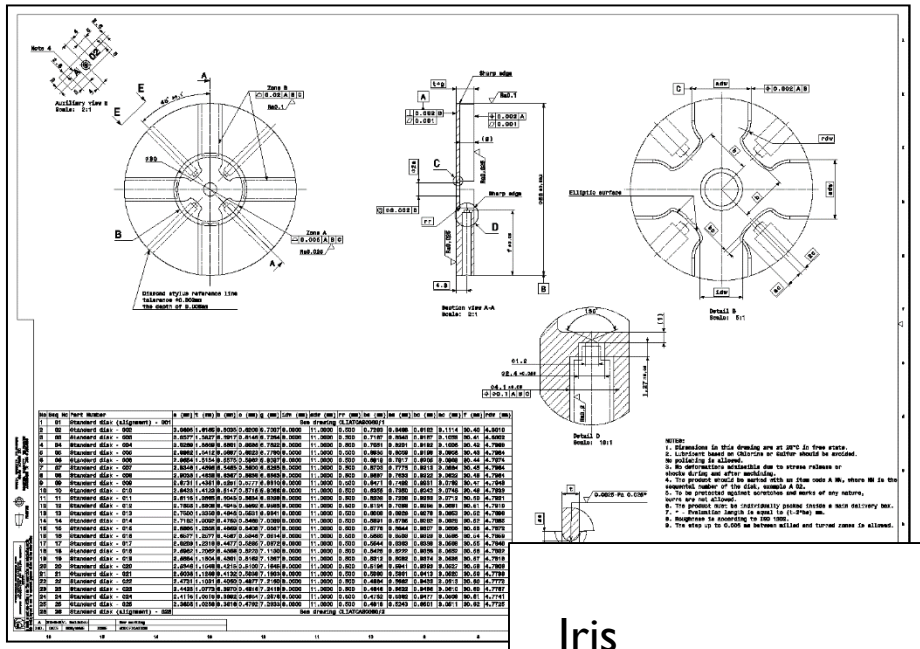
- Diamond-tool ultraprecision machining
- Turning and milling
- Very strict qualification based on visual inspection and CMM metrology
- VDL (NL), LT-Ultra (DE), Yvon Boyer (FR), DMP (ES), Morikawa (JP), KERN (DE)







ULTRA PRESICION MACHINING



Cell shape accuracy:

zone A - 0.005 mm

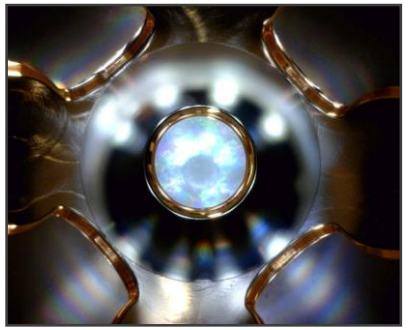
zone B - 0.02 mm

Flatness - 0.001 mm

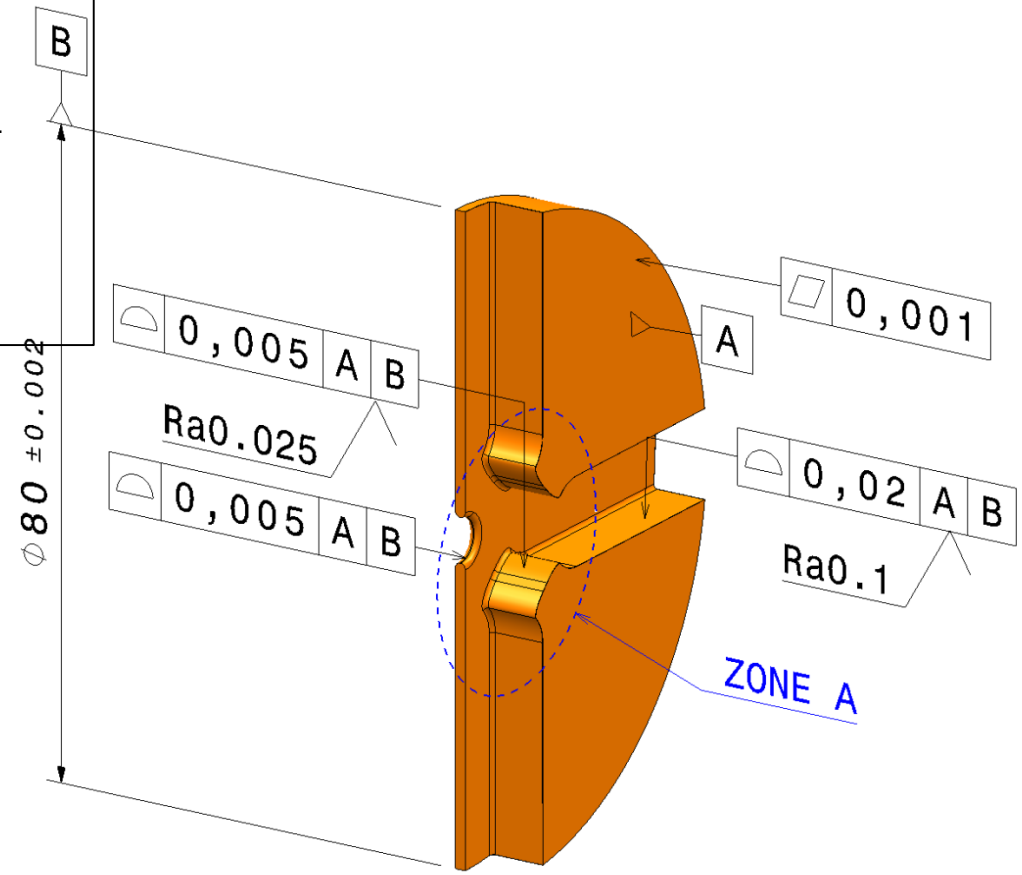
Surface roughness:

zone A Ra 0.025 μm

zone B Ra 0.1 μm

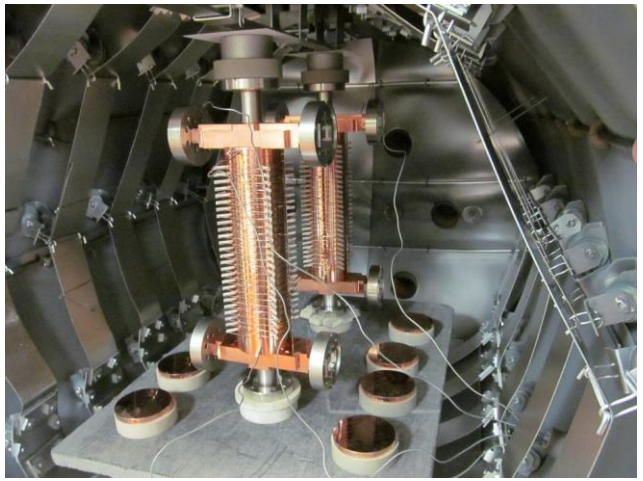


Iris

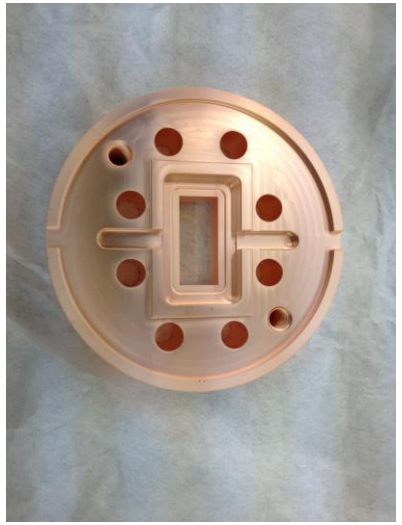


BONDING AND BRAZING

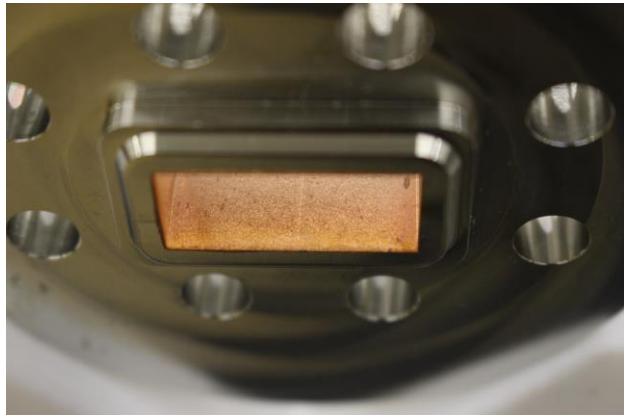
- Bonding and brazing with H2 atmosphere
- Qualification of the oven involving pollution tests with SEM
- Bodycote (FR), Reuter (DE), TMD (UK), MHI (JP)
- Potential extension to vacuum brazing following structure manufacture from PSI
- Electron-beam-welding of hard copper under investigation



SURFACE TREATMENT



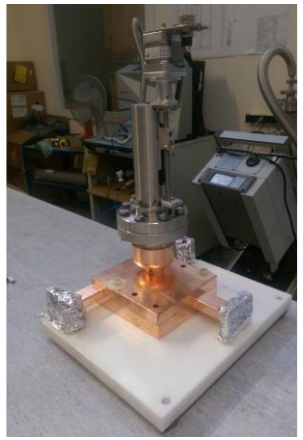
- Copper coating on stainless steel.
- Need to respect dimensioning
- Technology transfer from CERN
- Thermocompact (FR), BACMI (FR), Multivalent (NL)

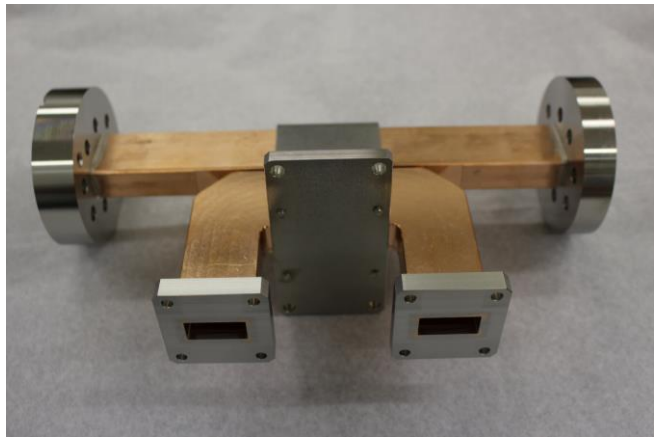


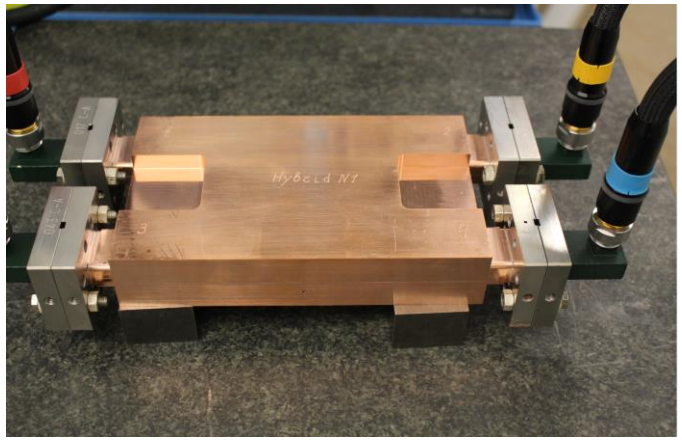
- Vacuum baking at 10-8 for 1-2 days
- Big furnace
- Bodycote (FR), COMEB (IT), MHI (JP)

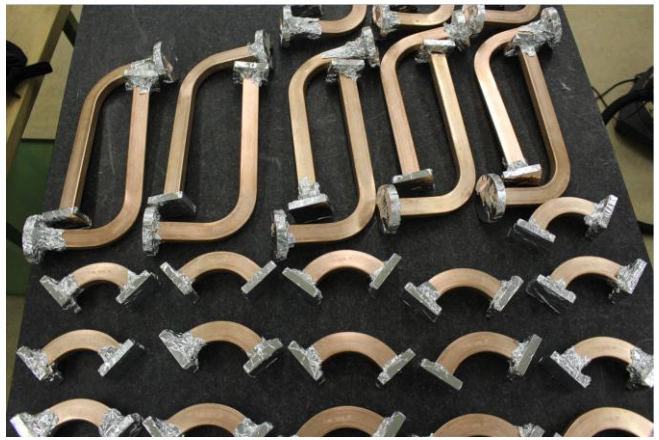
COMPONENTS

- Traditional machining of copper and stainless steel parts
- Brazing of copper to SS, copper to copper and copper to SiC
- Copper sintering
- Relative small series tested to 60 MW peak power
- CINEL (IT), VDL (NL), BACMI (FR), CECOM(IT) Reuter (DE), Nihon (JP), COMEB (IT), Viztrotech (KR)





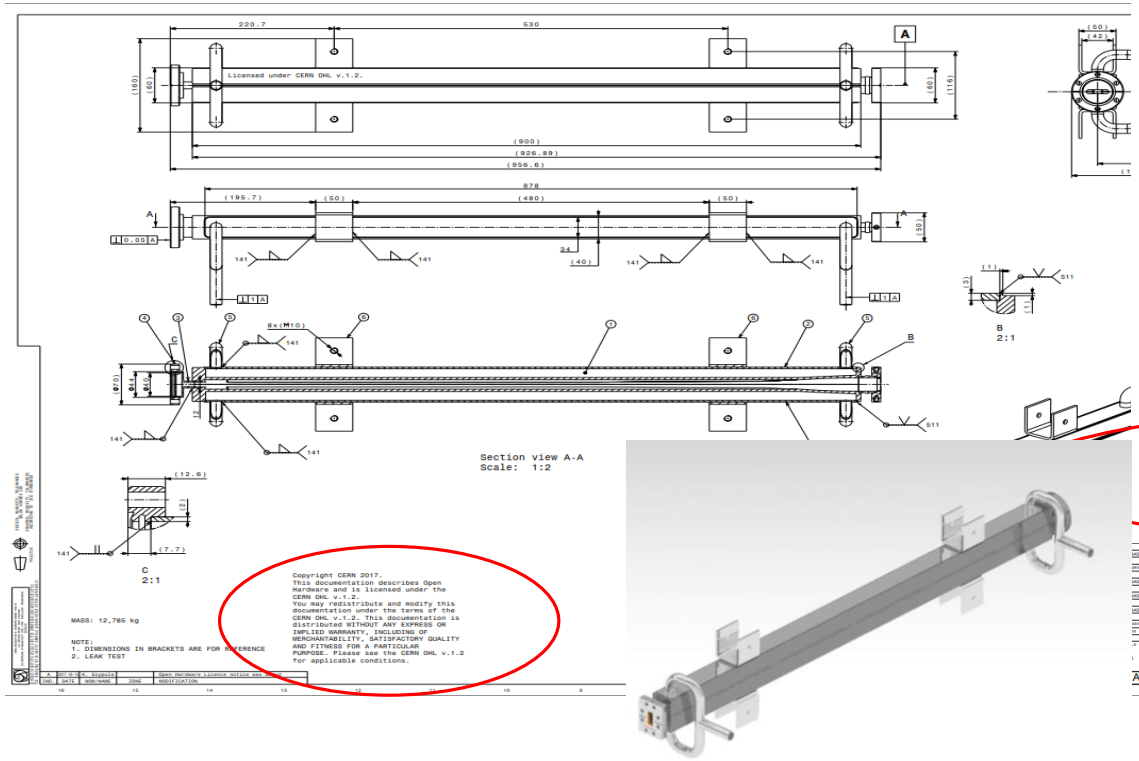


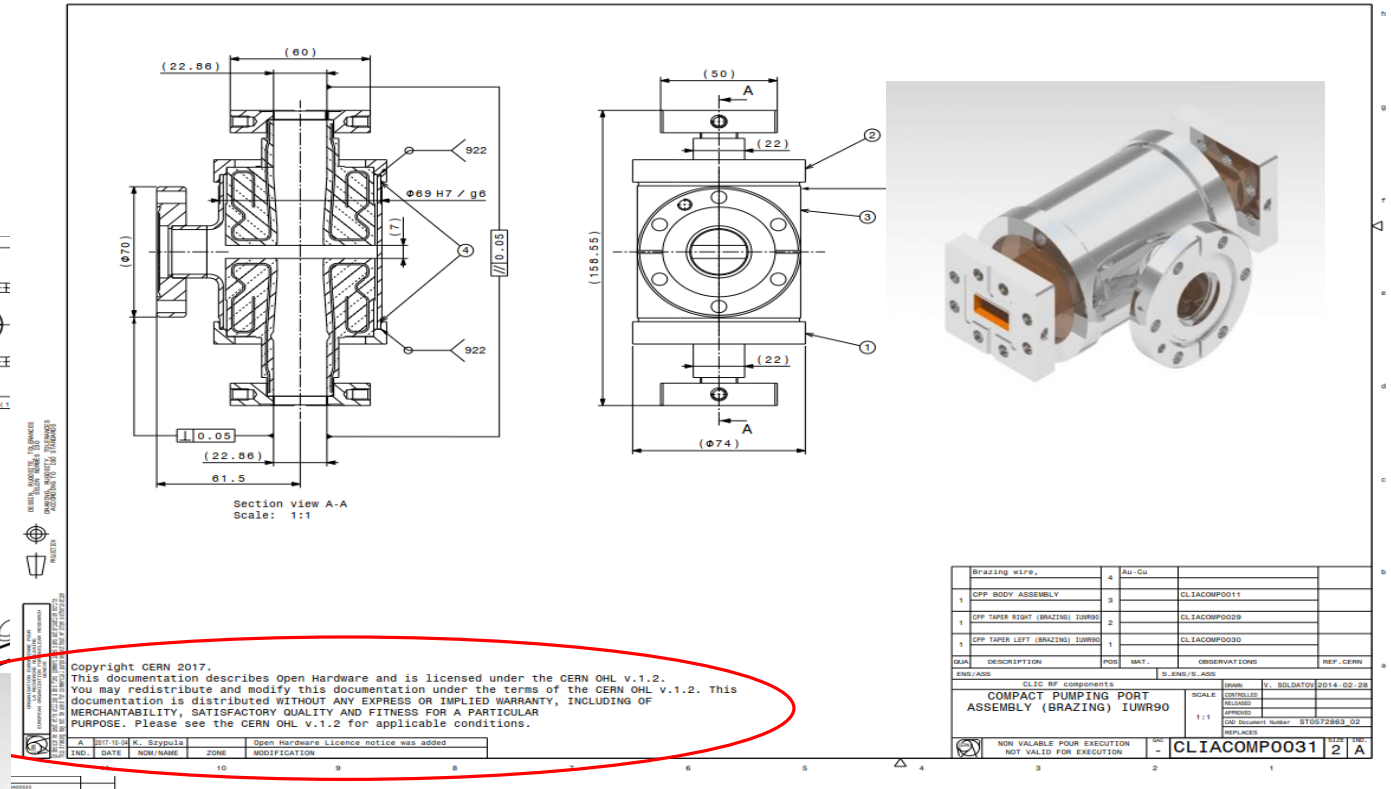


OPEN HARDWARE

OPEN HARDWARE REPOSITORY

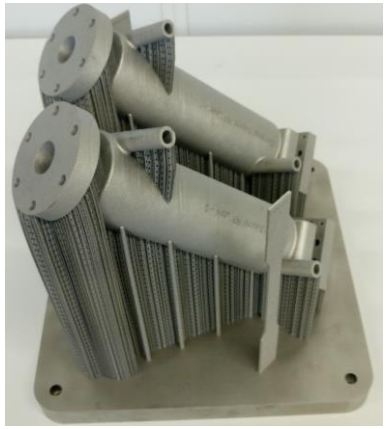
- https://www.ohwr.org/

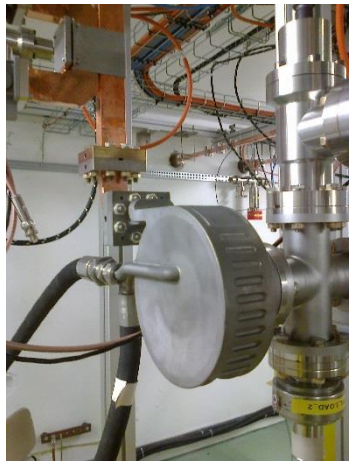




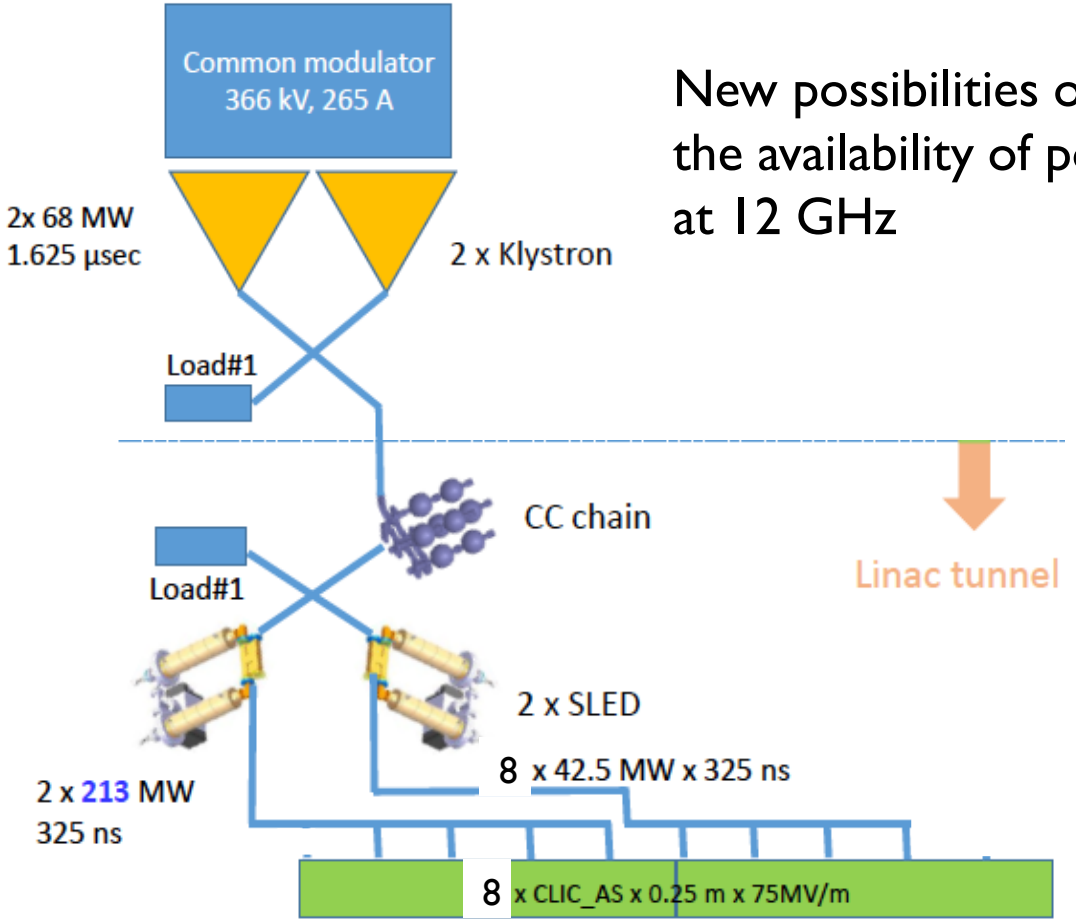
ADDITIVE MANUFACTURING

- 3D printing in Titanium for lossy parts like loads or low power components
- Parallel development at CERN and in industry
- SWISSto12 (CH), 3T RPD (UK), Concept Laser (DE), INITIAL (FR), Protoshop (DE)
- Currently under test for high power operation

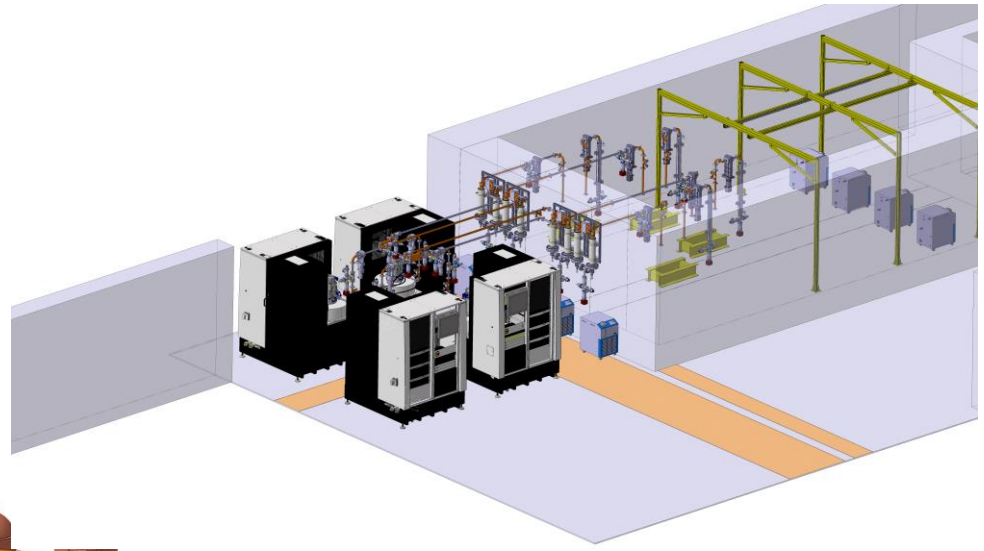


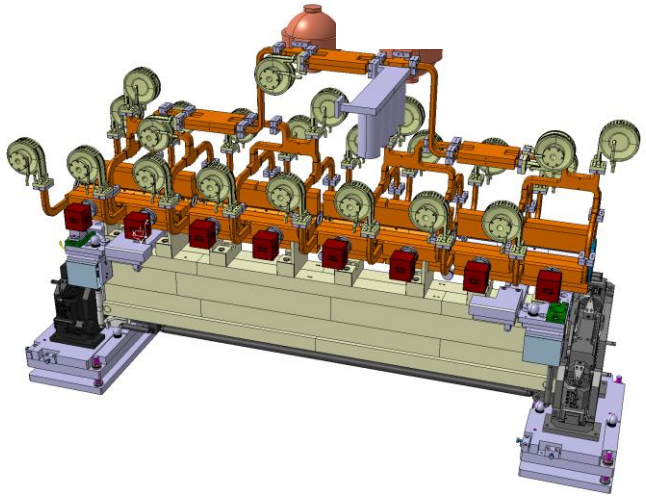


KYSTRON-BASED CLIC AND X-BAND TEST FACILITY.



New possibilities open thanks to the availability of power sources at 12 GHz





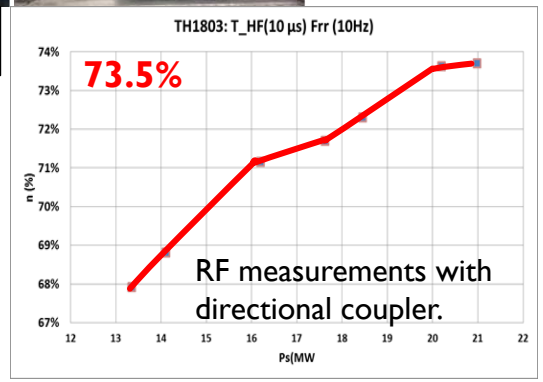
PULSED KLYSTRONS

CPI (US)VKX-8311A @ 11.9942 GHz
50 MW peak power, 1.5 μs pulse length
50 Hz rep. rate

Based on SLAC XL5 klystron
developed by SLAC from SLS XL4

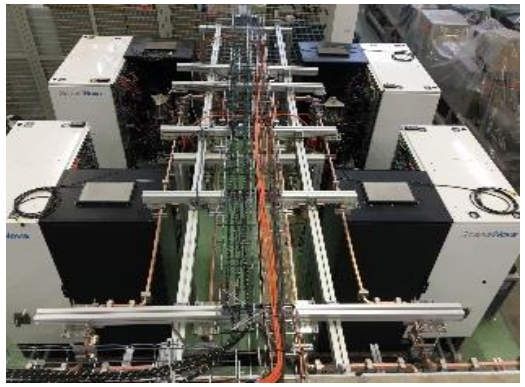
TOSHIBA (JP) E37113 @ 11.9942 GHz
6 MW peak power, 5 μs pulse length
400 Hz rep. rate
Developed by Toshiba on CERN contract

THALES (FR) MBKTH1803 @ 1.0 GHz
21 MW peak power, 10 μs pulse length
10 Hz rep. rate
Developed by THALES on CERN contract



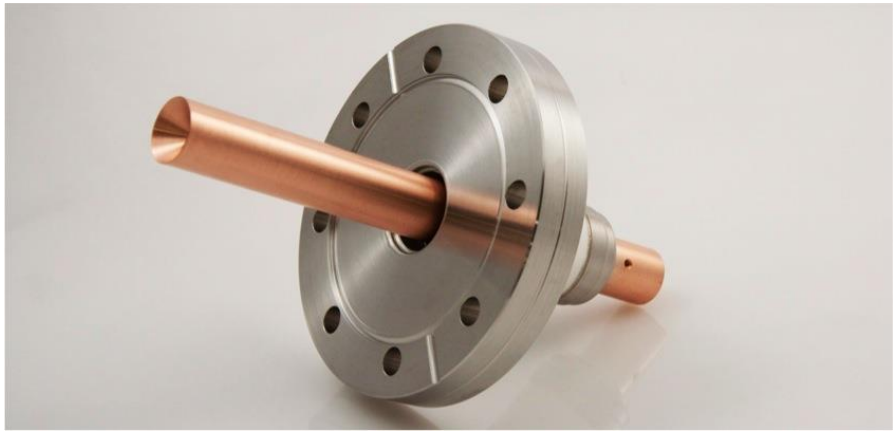
MODULATORS

- High Voltage Pulsed modulators.
- Maximum pulse voltage ripple 0.25%
- Pulse to pulse stability 0.1%
- Scandinova (SE) modified K1 and K2 modulators for Xboxes
- ETH-Zurich development in collaboration with CERN for drive beam.
- Pulse transformer buit by Pikatron (CH)



RF DRIVERS, DIAGNOSTICS AND LLRF

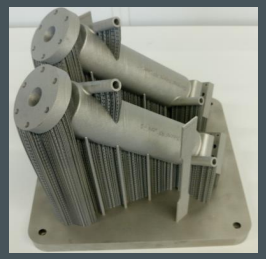
New Solid State Amplifier 400 W AM61-12S-60-56-PR SN001 by Microwave Amps (UK)
Two new units at 1 kW!



Radiabeam (US) faraday cups

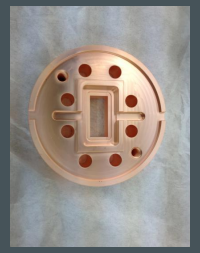
Killerbee high stability RF cables from Megaphase (US)

Bodycote (FR)
Reuter (DE)
TMD (UK)

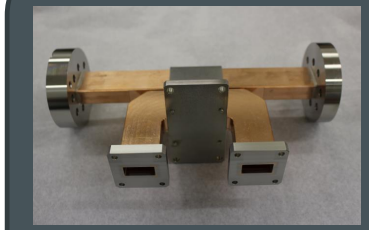


SWISSto12 (CH)
3T RPD (UK)
Concept Laser (DE)
INITIAL (FR)
Protoshop (DE)

VDL (NL)
LT-Ultra (DE)
Yvon Boyer (FR)
DMP (ES)
Morikawa (JP)
KERN (DE))



Thermocompact (FR)
BACMI (FR)
Multivalent (NL)



CINEL (IT)
VDL (NL)
BACMI (FR)
CECOM(IT)
Reuter (DE)
Nihon (JP)
COMEB (IT)
Viztrotech (KR)

Thales (FR)
CPI(US)
Toshiba (JP)

Scandinova (SE)
Jema (ES)
Picatron (CH)

Compact Linear Collider

EXISTING AND PLANNED XBAND INFRASTRUCTURE IN COLLABORATION WITH CERN

CERN	XBox-1 test stand	50 MW
	Xbox-2 test stand	50 MW
	XBox-3 test stand	4x6 MW
Trieste	Linearizer for Fermi	50 MW
PSI	Linearizer for SwissFEL	50 MW
	Deflector for SwissFEL	50 MW
DESY	Deflector for FLASHforward	6 MW
	Deflector for FLASH2	6 MW
	Deflector for Sinbad	tbd
Tsinghua	Deflector for Compton source	50 MW
	Linearizer for Compton source	6 MW
SINAP	Linearizer for soft X-ray FEL	6 MW
	Deflectors for soft X-ray FEL	3x50 MW

Australia	Test stand	2x6 MW
Eindhoven	Compact Compton source, 100 MeV	6 MW
Valencia	S-band test stand	2x10 MW
KEK	NEXTEF test stand	2x50 MW
SLAC	Design of high-efficiency X-band klystron	60 MW
Daresbury	Linearizer	6 MW
	Deflector	tbd
	Accelerator	tbd
Frascati	XFEL,plasma accelerator, 1 GeV	4(8)x50 MW
	Test stand	50 MW
Groningen	1.4 GEV XFEL Accelerator, 1.4 GeV	tbd

CONCLUSIONS

- Fruitful collaboration between CLIC and the industry
  - Encouraging the industry to reach new challenges on their own proprietary technology (Modulators, Klystrons, additive manufacturing, etc)
  - Transferring the knowledge acquired in research through prototypes and small series (Accelerating structures and components)
  - Licensing (open hardware) certified components for own manufacturing
- Not only by CERN but all the members of CLIC collaboration
- Not only in Europe but world-wide
- Not only CLIC but many other laboratories and universities