MeChanICs

- Marie Curie linking Industry to CERN-

Mid-term Review 27.9.2012

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University of Helsinki, Finland
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Jukka Väinölä

MeChanICs

• **FP7/People/IAPP** (Industry-Academia Partnerships and Pathways) project **MeChanICs**, “Marie Curie linking Industry to CERN”

• start September 1st 2010, end 30th of August 2014

• budget: ~ 1 M€

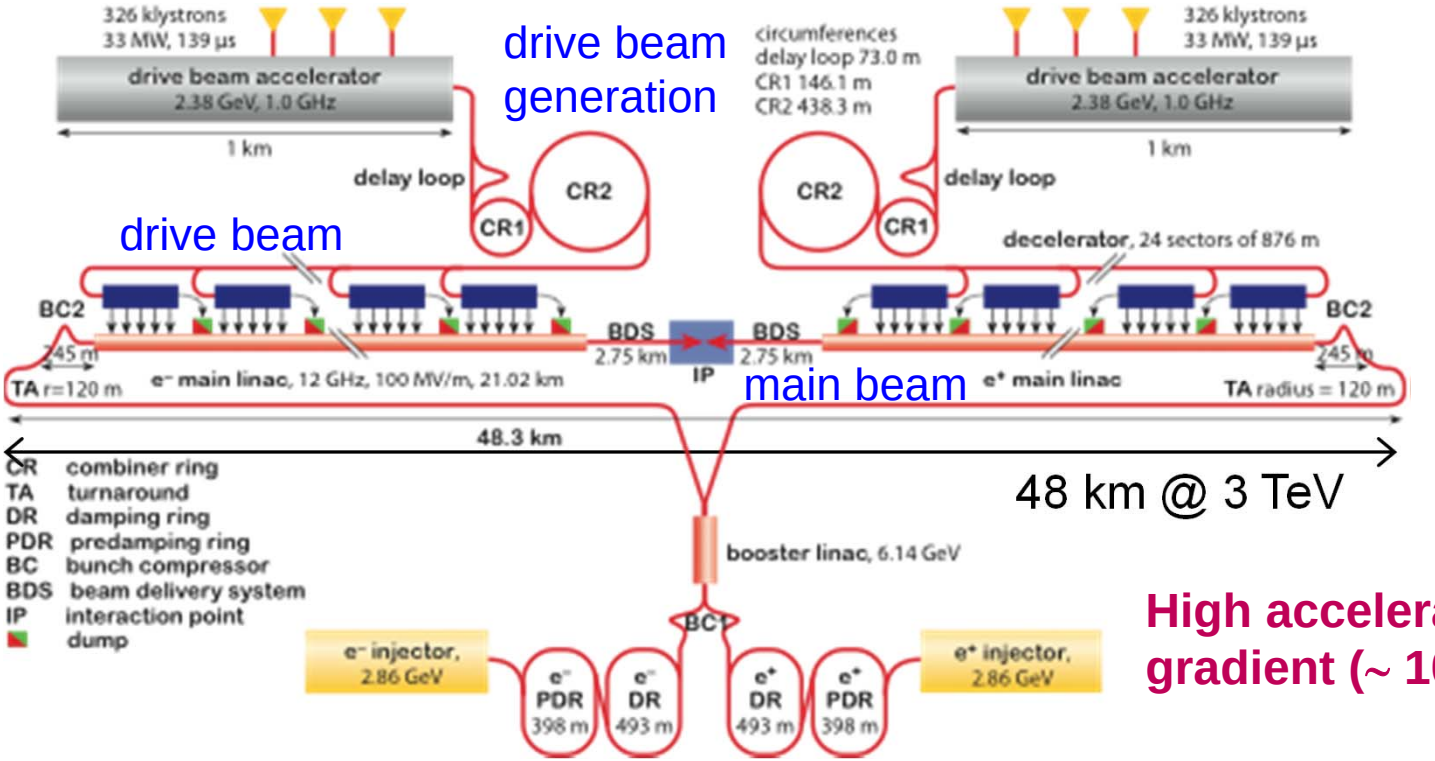
• to enhance knowledge exchange between Partners in high precision manufacturing by two-way intersectoral **secondments** and dissemination workshops

Compact Linear Collider study

- post-LHC physics: high precision measurements at an e^+e^- linear collider
- CLIC study = a feasibility study of development of realistic technology

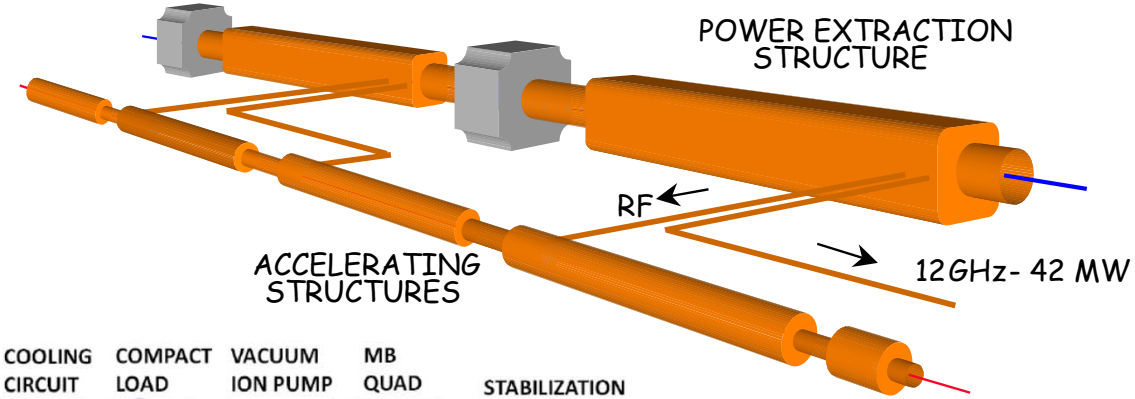
at affordable cost for e^+e^- collisions upto 3 TeV

- conceptual design report 2012 $\Rightarrow$ development phase 2012-16 $\Rightarrow$ decision 2016-17

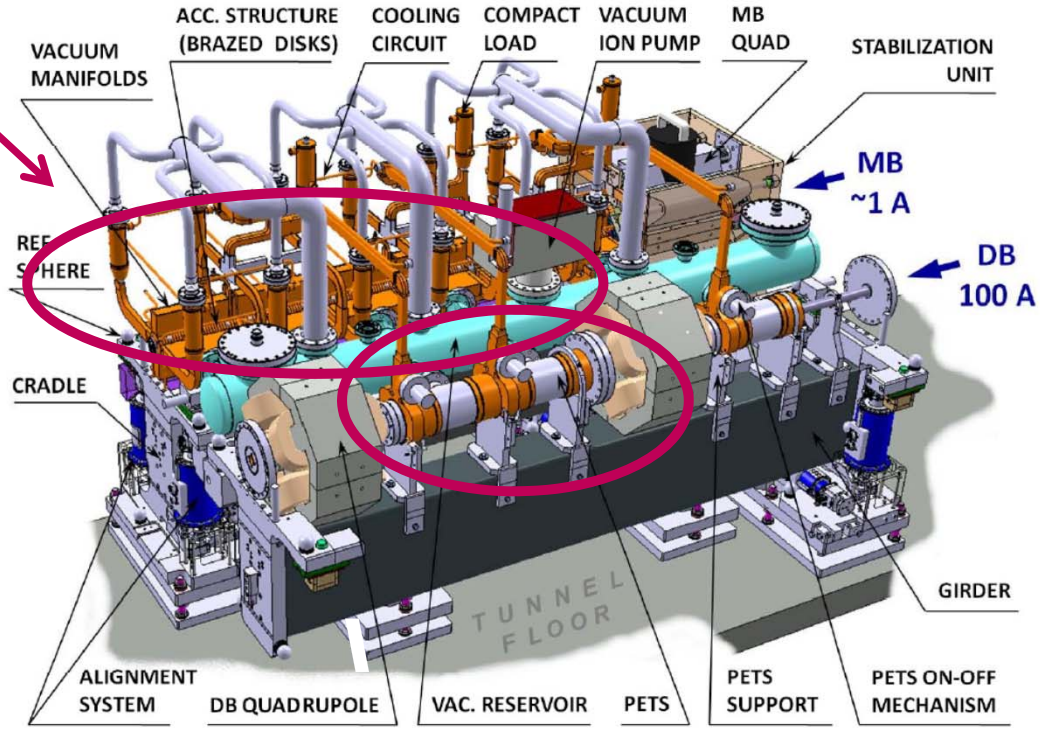


High accelerating gradient (~ 100 MV/m)

CLIC two-beam concept & module



Accelerating structures



Power extracting and transfering structures (PETS)

Fig. 2.46: Two Beam module.

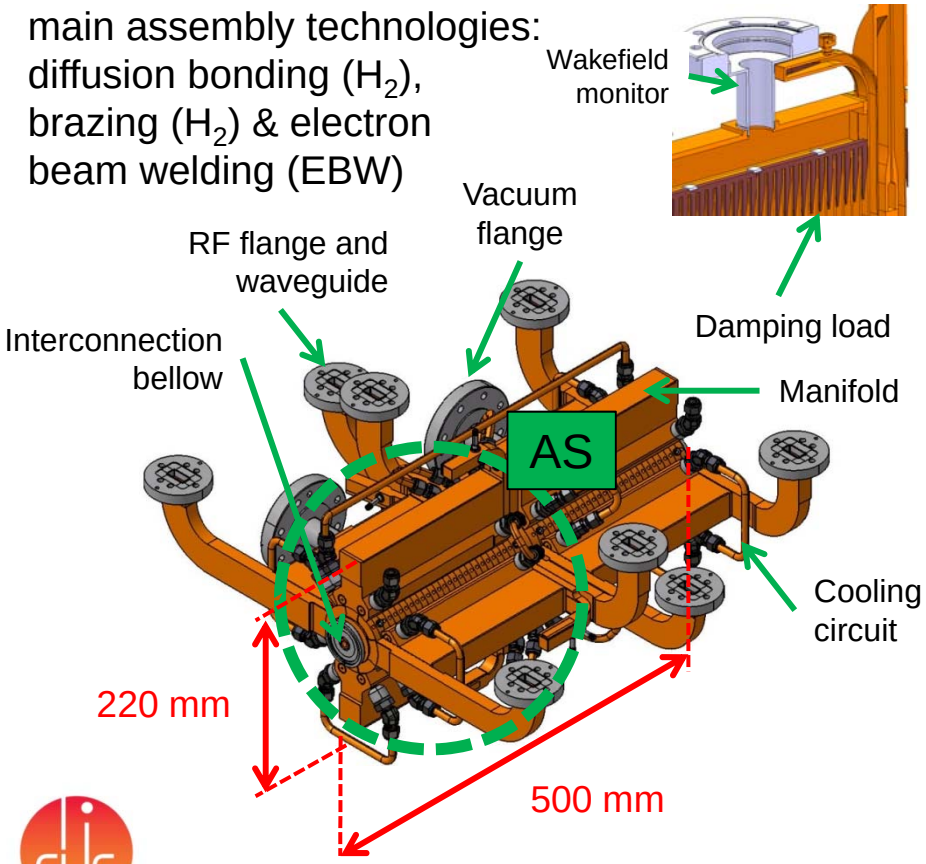
CLIC RF structures

ACCELERATING STRUCTURES (AS)

REQUIREMENTS

- COAXILITY ERROR: < 10 µm
- ALIGNMENT ERROR BTWN MANIFOLDS & DISKS STACK: ±10 µm

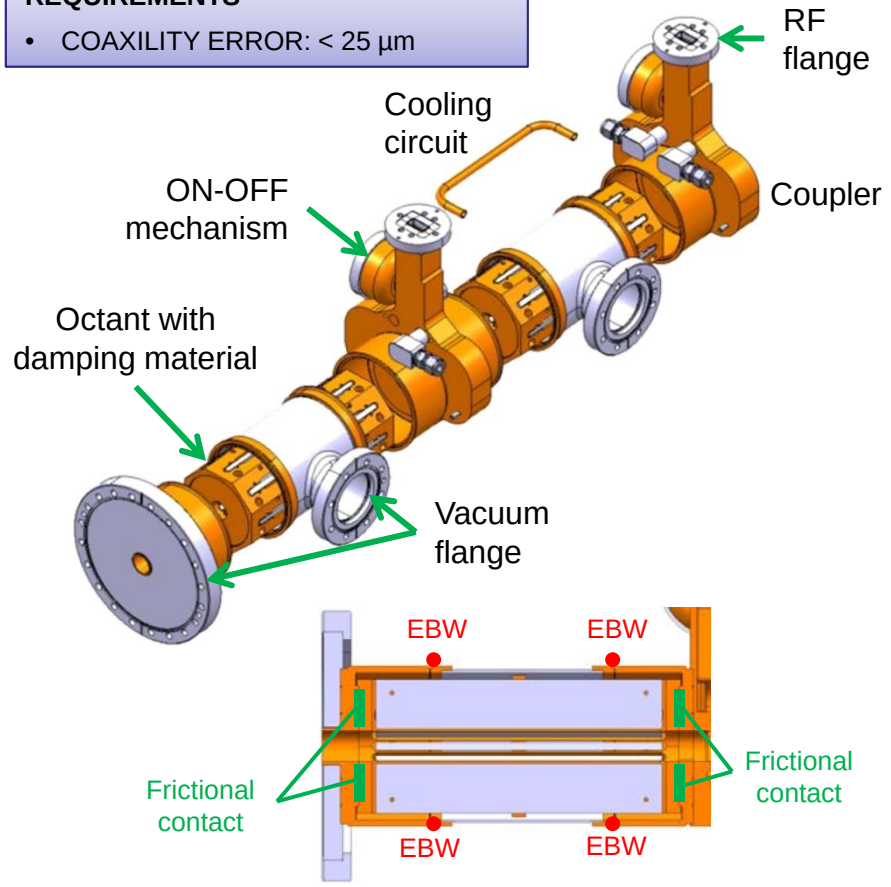
main assembly technologies: diffusion bonding (H_2), brazing (H_2) & electron beam welding (EBW)



POWER EXTRACTION AND TRANSFER STRUCTURES (PETS)

REQUIREMENTS

- COAXILITY ERROR: < 25 µm



CLIC RF structures: machining

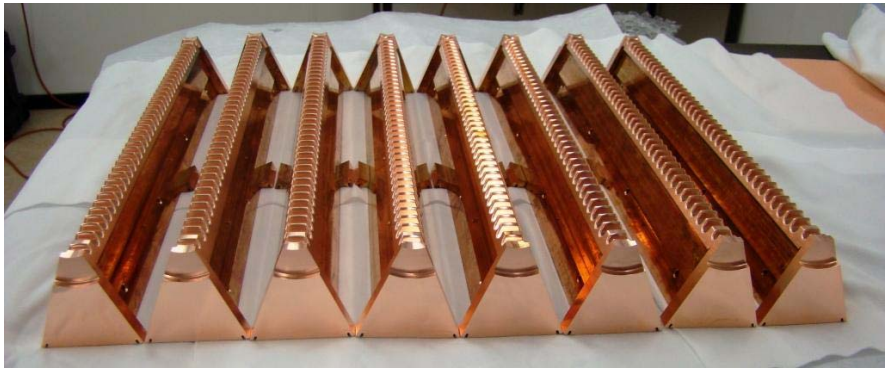
AS disks

- *Cu OFE UNS C10100*
- *Shape accuracy ± 2.5 µm (iris)*
- *Flatness accuracy ± 10 µm*
- *Roughness Ra 0.025 µm (iris)*
- *Ø 80 mm*
- *30 disks diffusion bonded*
- *Length 250 mm*

Diamond turning & milling

PETS quadrants

- *Cu OFE UNS C10100*
- *Shape accuracy ± 7.5 µm*
- *Roughness Ra 0.1 µm*
- *8 octants diffusion bonded*
- *Length 300-1000 mm*



Milling

CLIC RF structures: manufacturing & assembly

AS example:
TD26_CC_SiC

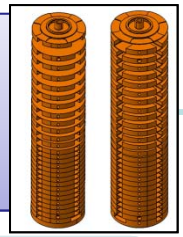
(1) MACHINING

(2) QUALITY CONTROL
1. Inlet inspection
2. Dimensional control
3. SEM
4. Preliminary RF tests

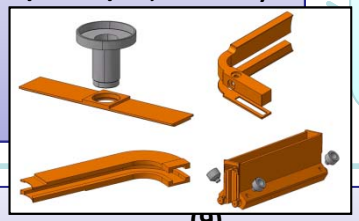
(3) CLEANING
1. Etching with SLAC solution
2. Degreasing + deoxidation + passivation

courtesy of F. Rossi

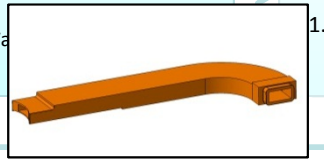
(4) H_2 DIFFUSION BONDING (1040 °C)
1. Disks stack (x2)



(5) H_2 BRAZING (Au/Cu 25/75, 1040 °C)
1.
2.
3.
4.

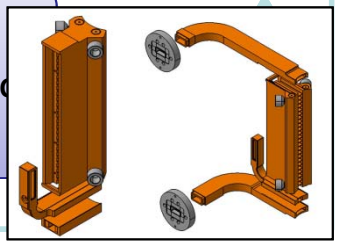


(6) MACHINING
1. Wa

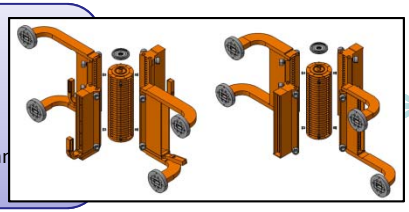


(7) CLEANING
1. Degreasing + deoxidation + passivation

(8) H_2 BRAZING (Au/Cu 25/75, 1040 °C
1. Vacuum manifolds (x6)

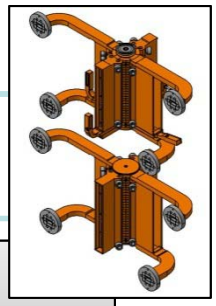


(9) H_2 BRAZING (Au/Cu 35/65, 1020 °C)
1. 4 vacuum manifolds + 1 disks stack + 1 interconn flange + 8 steel inserts + tuning studs (x2)

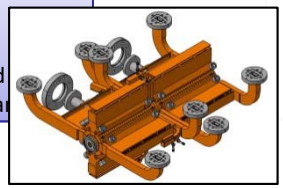


(10) QUALITY CONTROL
1. Vacuum test
2. Cooling circuit test

(11) H_2 BRAZING (Au/Cu 50/50, 980 °C)
1. 2 accelerating structures



(12) EBW
1. Covers and vacuum fla



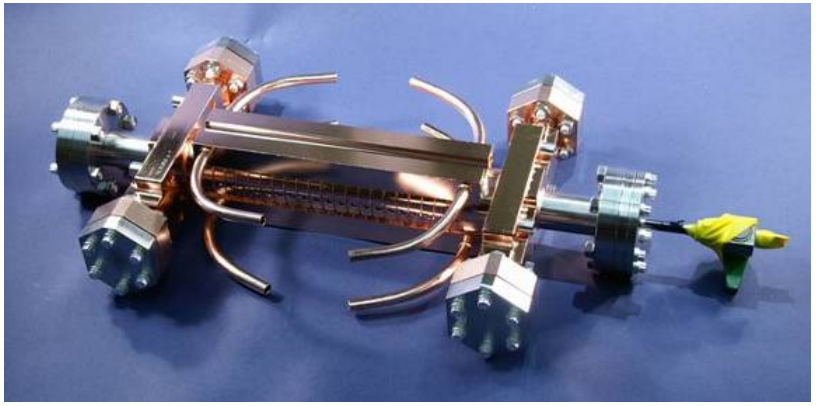
(13) QUALITY CONTROL
1. Vacuum test

(14) RF CHECK AND TUNING

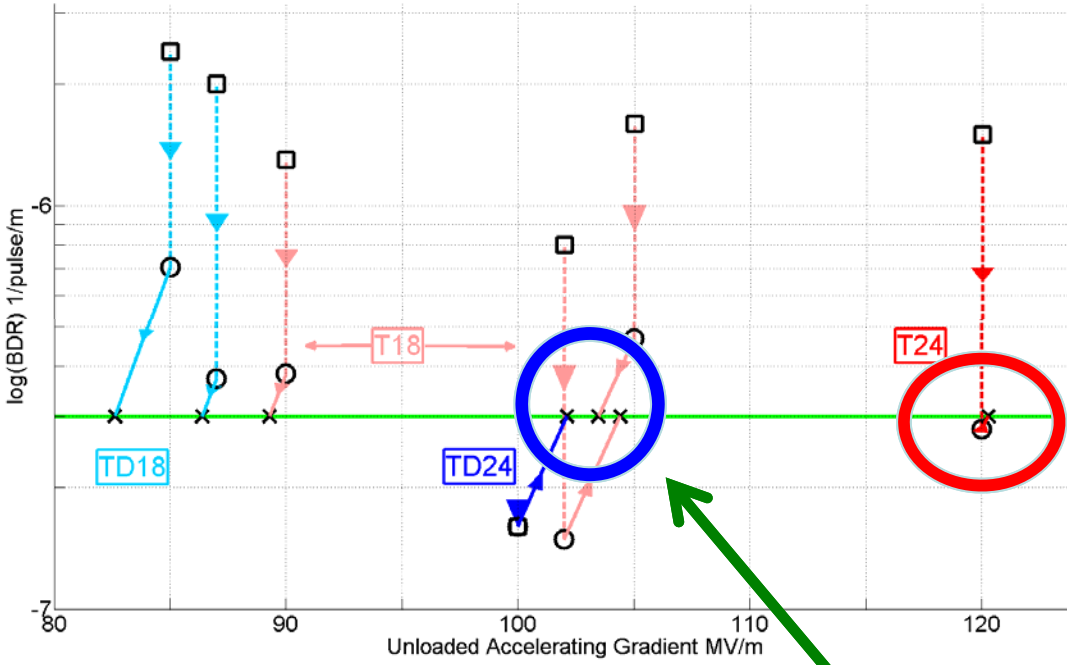
(15) VACUUM BAKING (650 °C, 10 days)

(16) CONDITIONING

Achieved gradient in acc. struc.



- Require acc. gradient > 100 MV/m & < 1% probability of even a single break down in any structure / pulse
  - $p \leq 3 \times 10^{-7} m^{-1} pulse^{-1}$



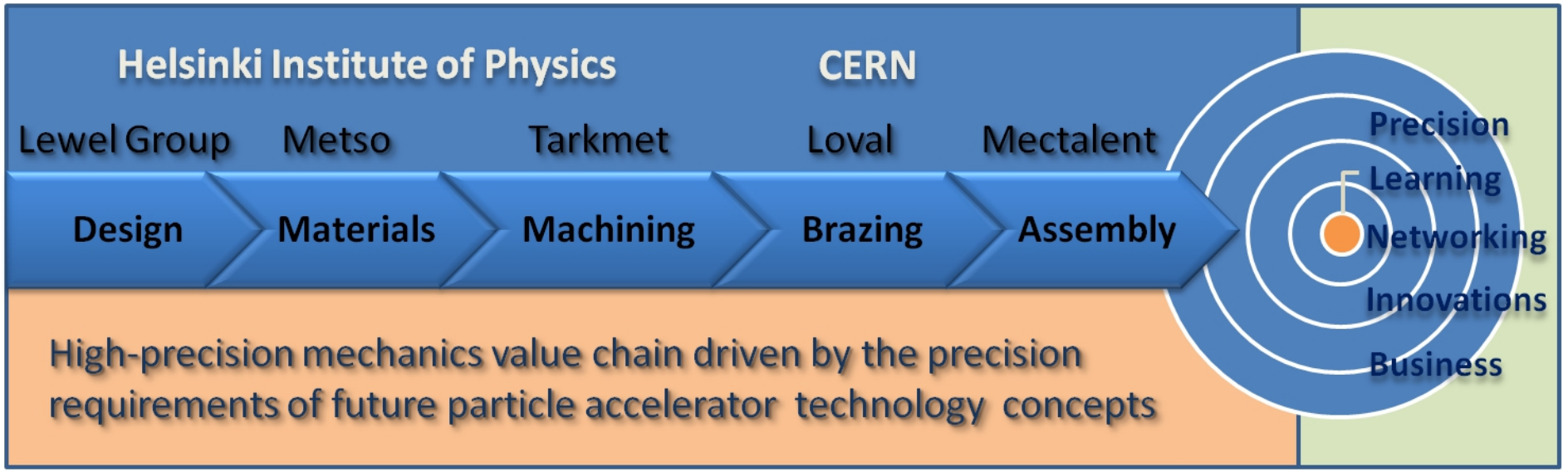
	Simple early design to start	More efficient fully optimised structure
No damping waveguides	T18	T24
Damping waveguides	TD18	TD24 = CLIC goal

Unloaded 103 MV/m
Expected with beam loading 86 -103 MV/m

MeChanICs

Objective: enable & enhance long term industry participation in **CLIC**, Compact LInear Collider, **RF structure R&D**

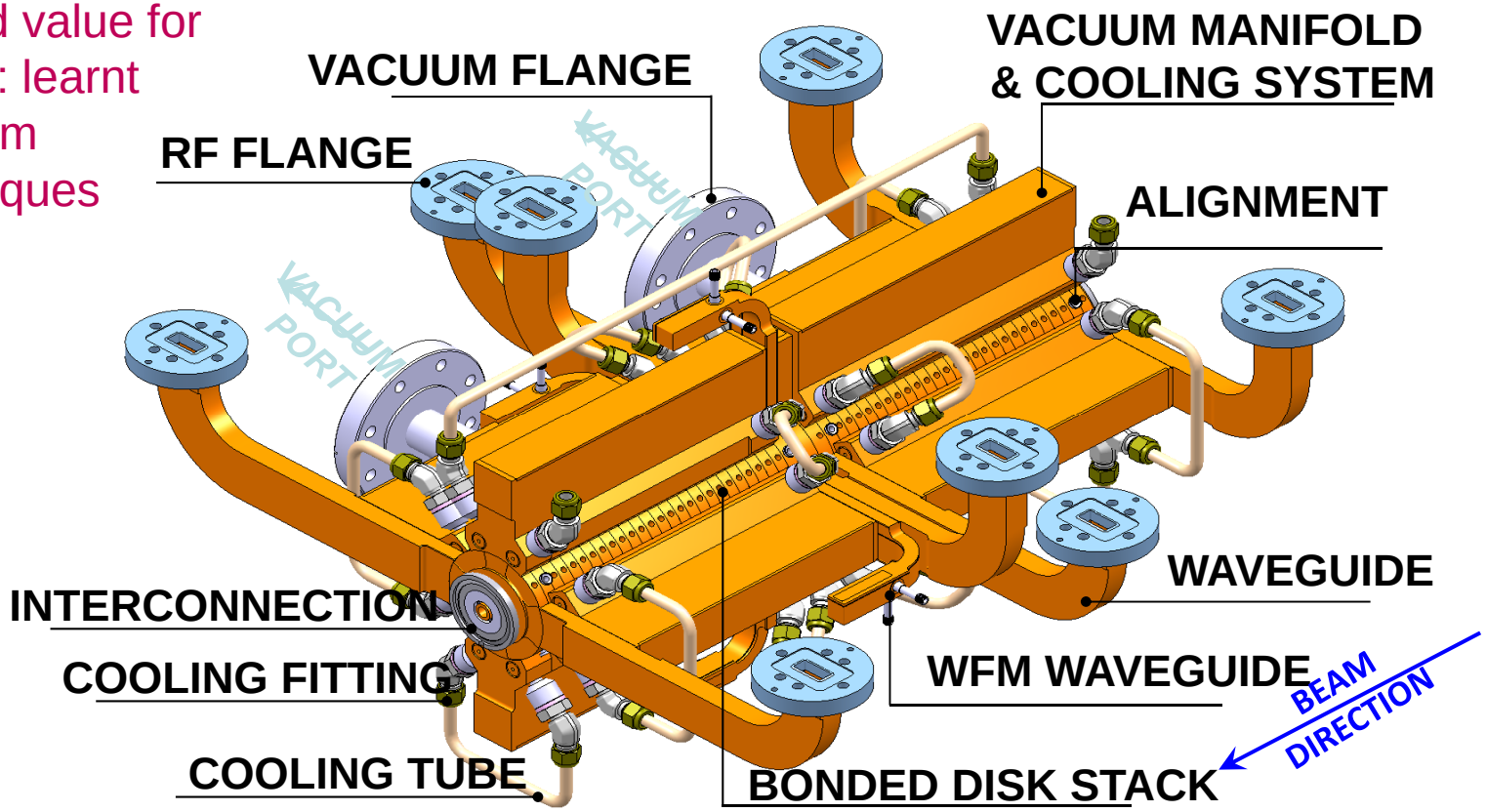
Participation in each step of RF structure manufacturing
- 5 Work Packages



WP 1 MeChanICs Design, Lewel Group

- participation of CLIC accelerating structures design (containing all necessary systems)
- 3 TeV CLIC will have 143 000 such structures

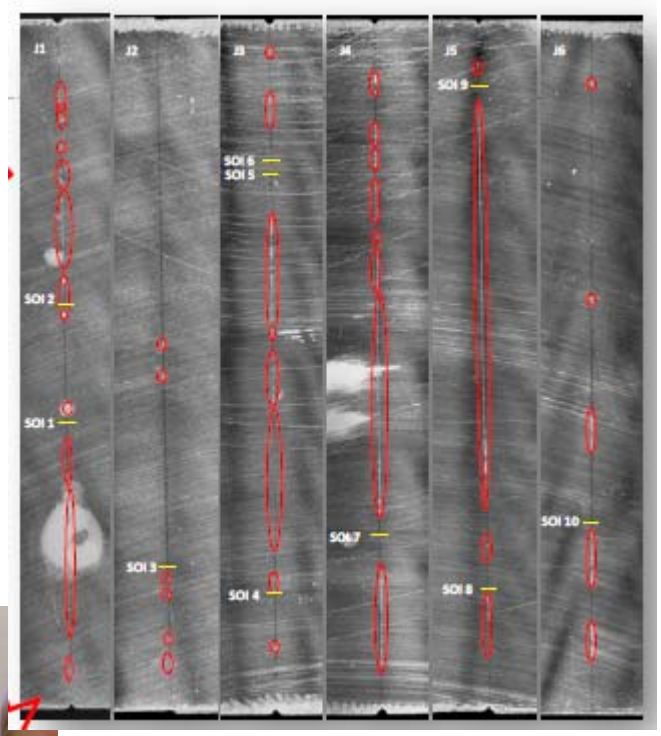
Added value for Lewel: learnt vacuum techniques



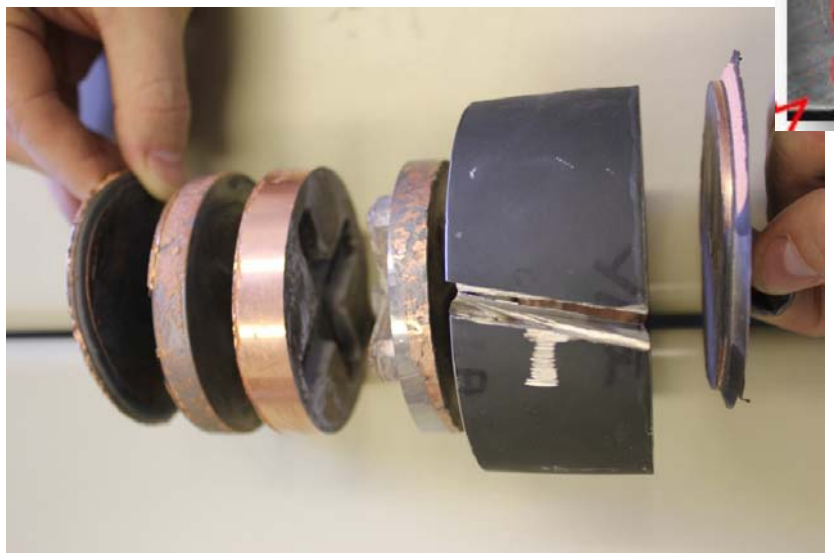
WP 2 MeChanICs material, Metso

Material research:

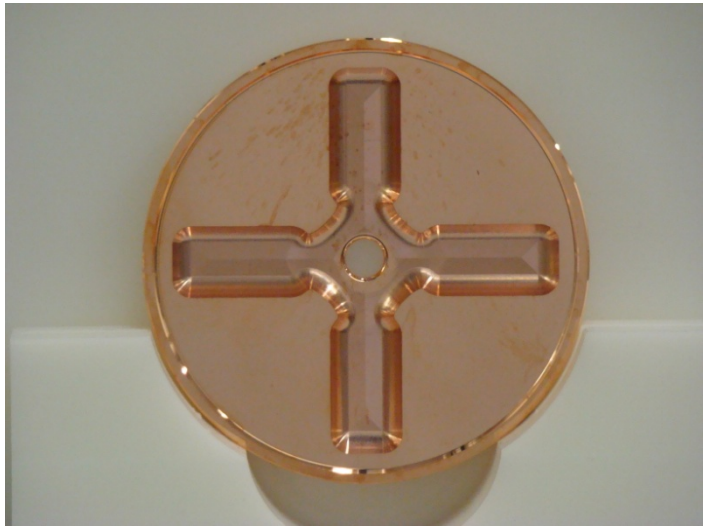
- HIP-diffusion bonding of copper disks
- The effect of heat treatment to diamond turned copper surface
- The effect of HIP-treatment to physical properties of solid copper
- HIP compaction of copper powder
- Brazing of copper with electrodeproted coating



Added value for Metso: learned more about Cu



WP 3 MeChanICs machining, Tarkmet

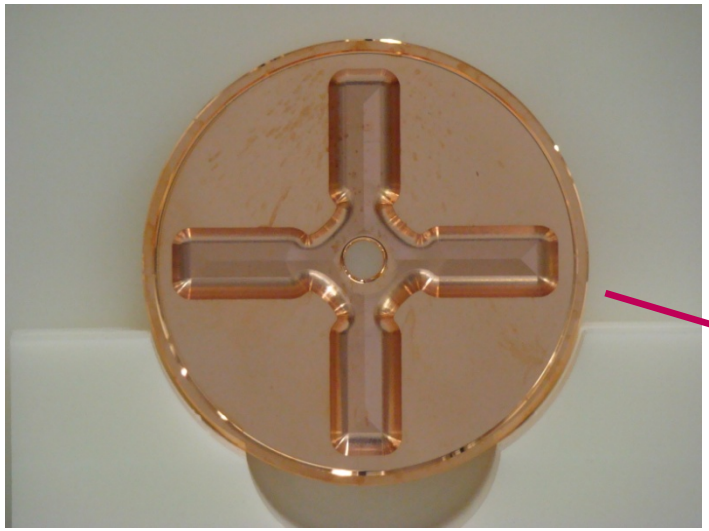


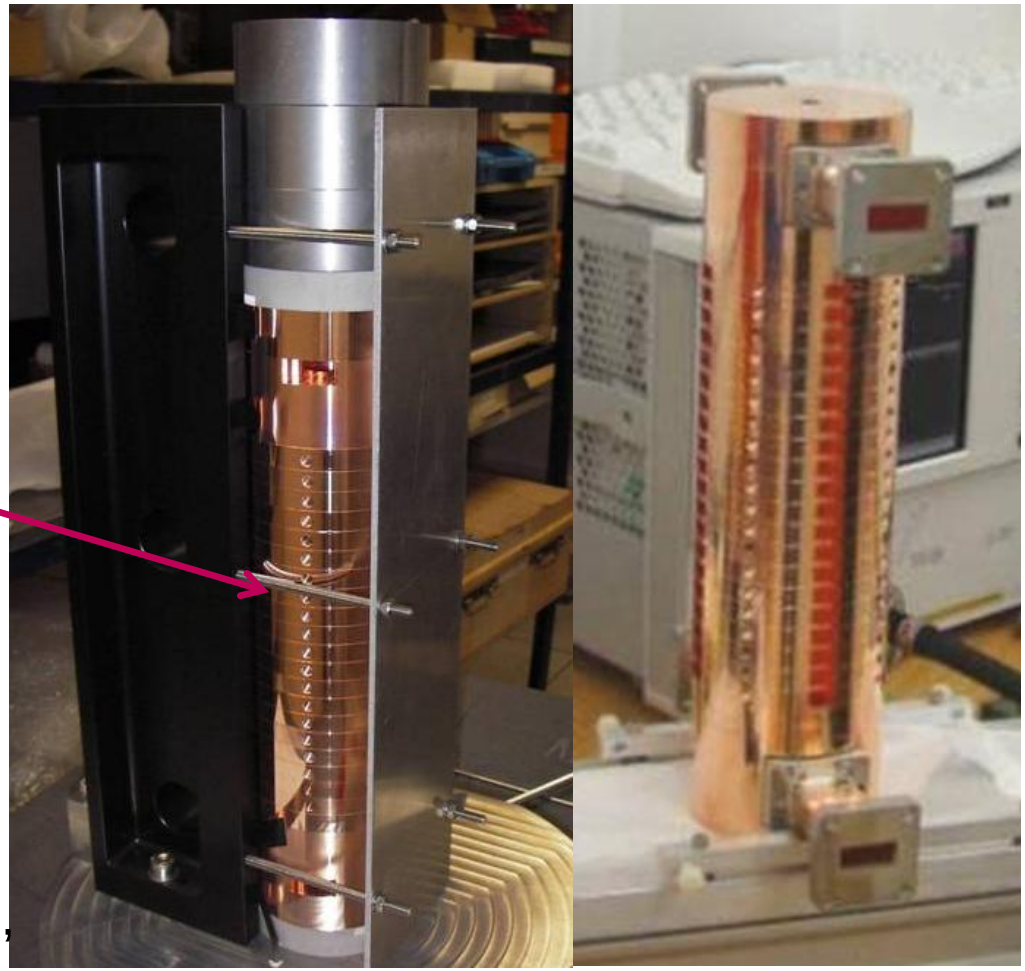
Topics of the work:
Precision machining
Laser welding
Metrology

26 high-precision machined disks (OFE Cu, shape accuracy ± 2.5 μm, surface roughness ± 0.025 μm, ∅ 45 to 88 mm) in each accelerator structure

WP 4 MeChanICs brazing, Loval

Bonding of the disk stack in partial H_2 pressure

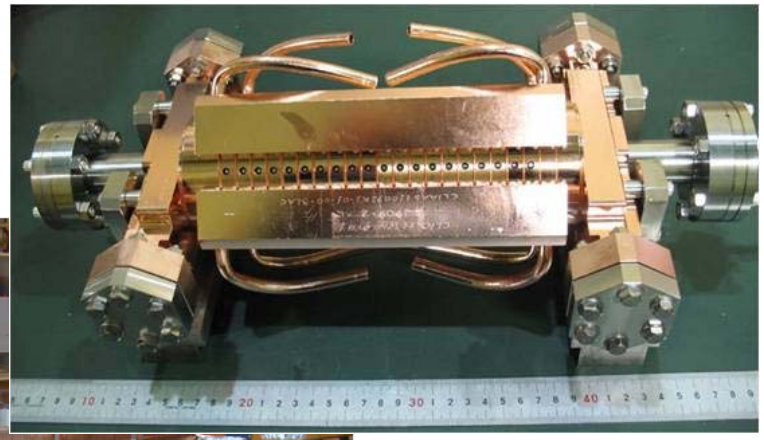




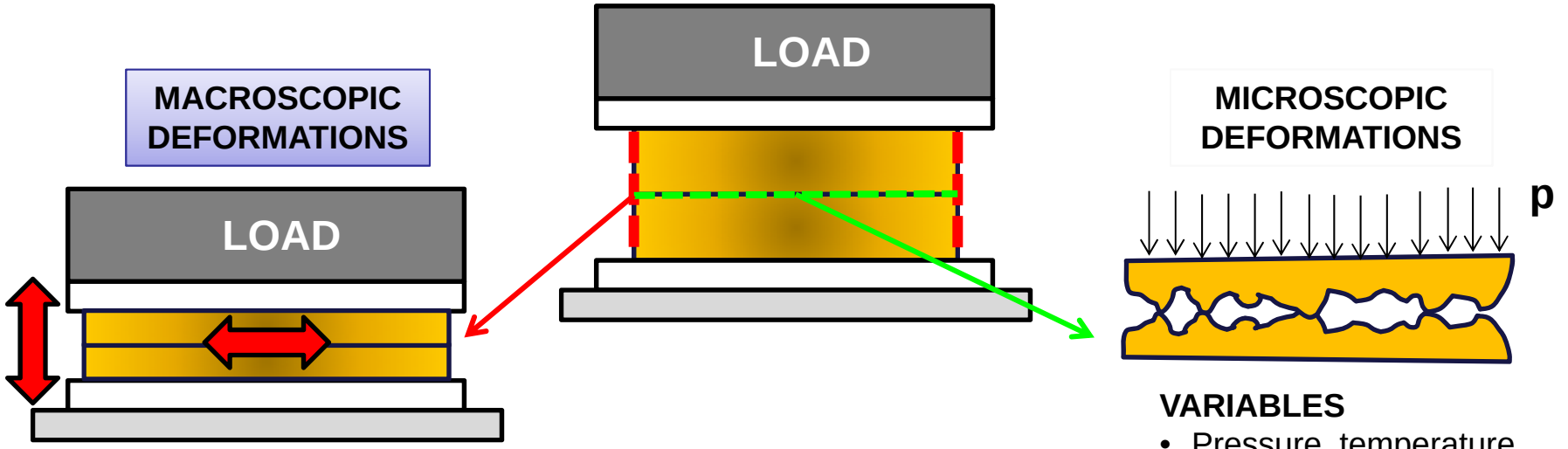
26 high-precision machined disks (OFE Cu, shape accuracy ± 2.5 μm, surface roughness ± 0.025 μm, ∅ 45 to 88 mm) bonded together

WP 5 MeChanICs assembly, Mectalent

- prototypes of CLIC accelerating structures
- assembly, tooling, test module, environment, thermomechanical behaviour, metrology, validation



Deformation during diffusion bonding



VARIABLES
- Load, time, temperature

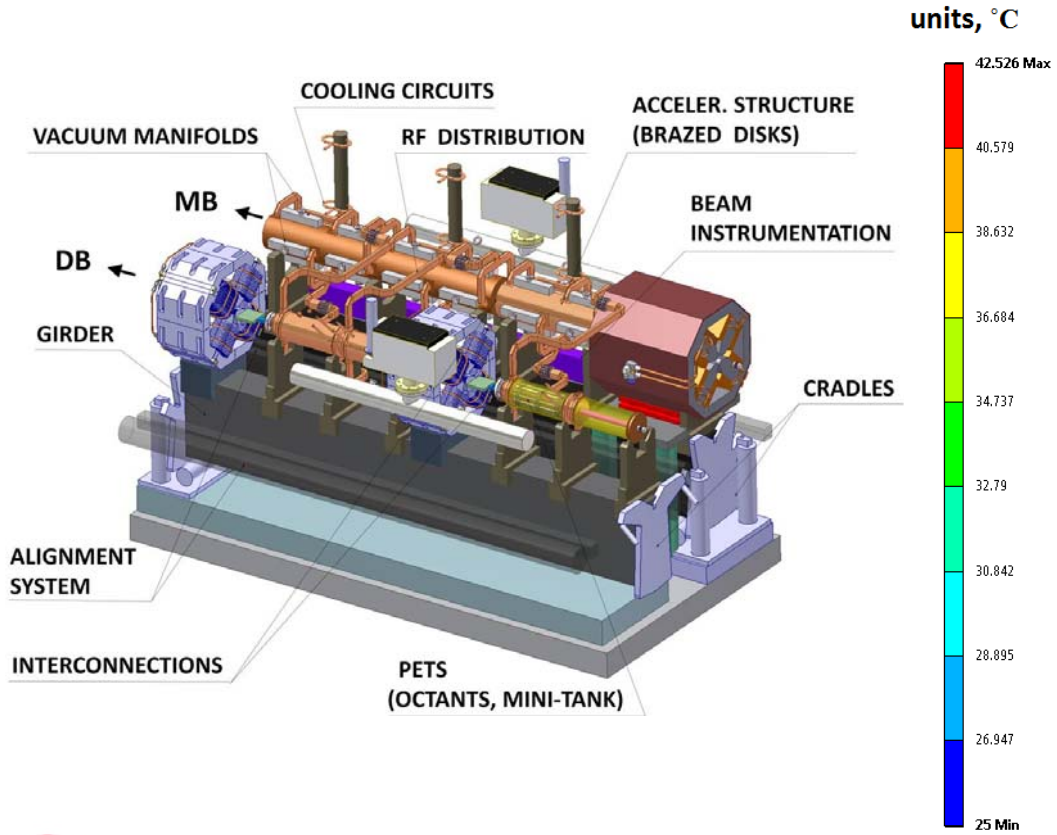
VARIABLES
- Pressure, temperature, time geometry (roughness & flatness), cleaning

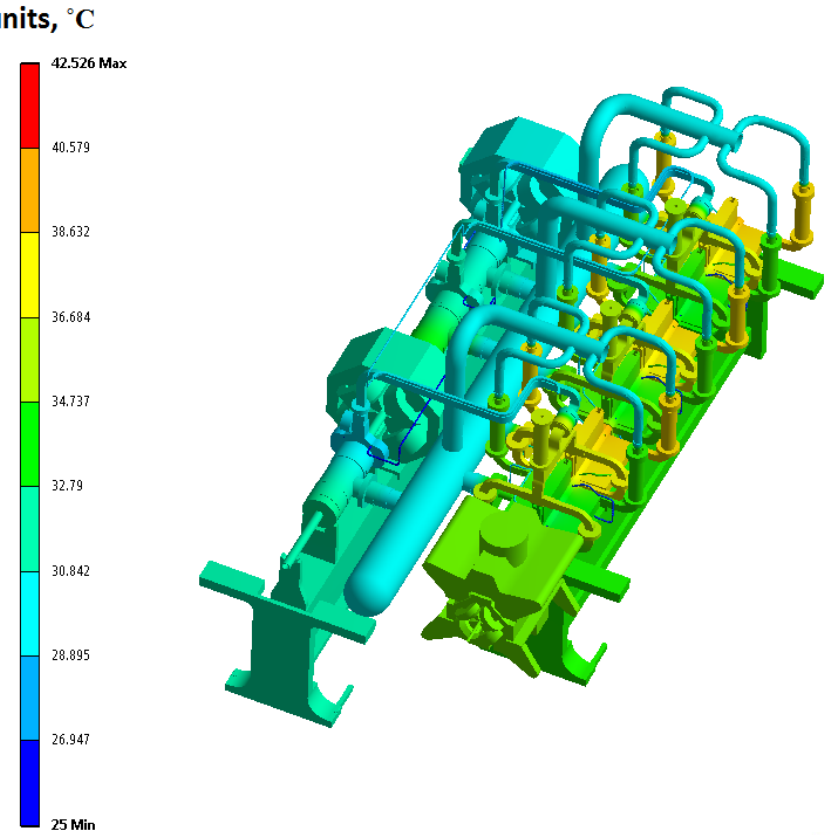
- experimental tests indicate visco-plastic behaviour, creep ($T/T_{melt} = 0.96$)
- on flat geometries experimental tests, analytic calculations & transient finite element with creep included seems to agree
- next: transient simulation of more complex geometries ⇒ AS disk stack
- *future: characterisation of creep behaviour of Cu near melting point*

(PhD student of National graduate school concurrent mechanical engineering)

CLIC module thermo-mechanical modeling

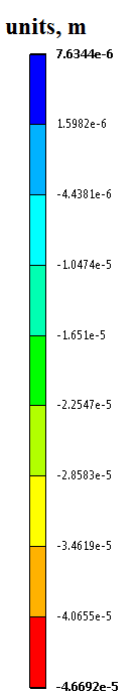
- ANSYS modeling of complete CLIC module ⇒ feedback on engineering design & check fundamental behaviour of the RF structures during operation
- test module program starting (→ end of 2012) to verify design



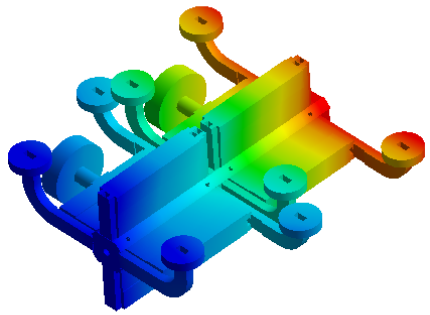


FP7 IA EuCARD activity with assistance from MeChanICs

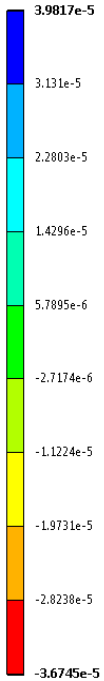
Deformation results: RF for AS

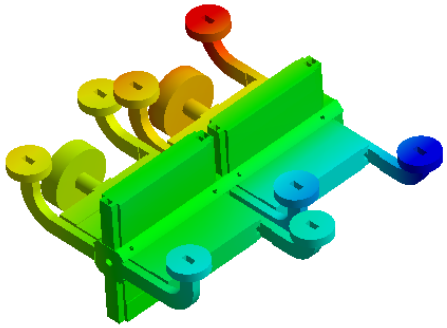


CLIC module type 1

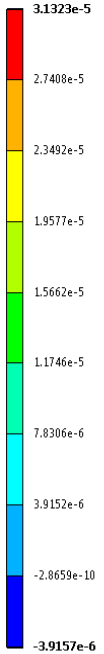


x-direction

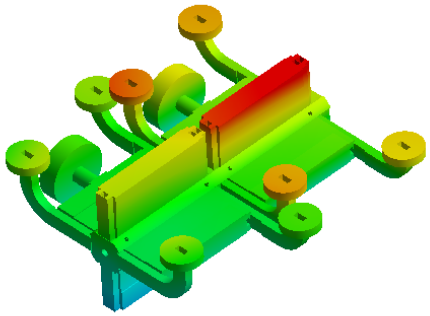




y-direction

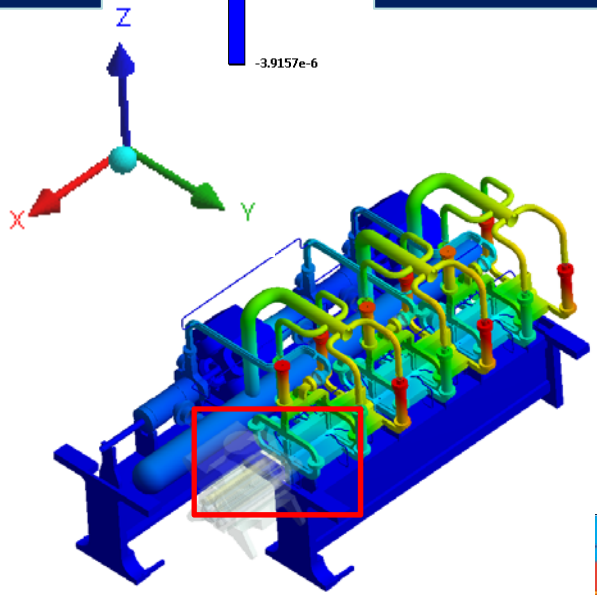


Environment at 30°C

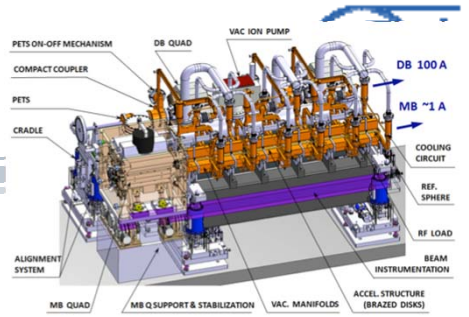


z-direction

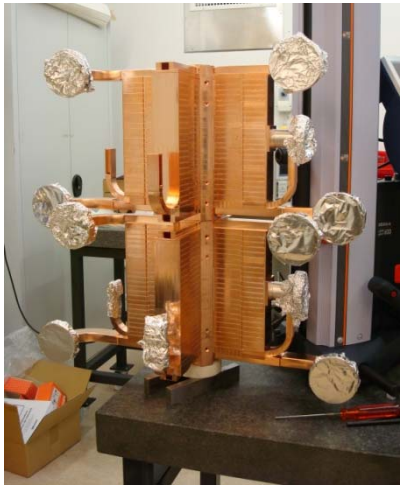
Item	x	y	z
Max. def. AS (RF unloaded)	45 µm	1.6 µm	15 µm
Max. def. AS (RF loaded)	40 µm	1.4 µm	12 µm

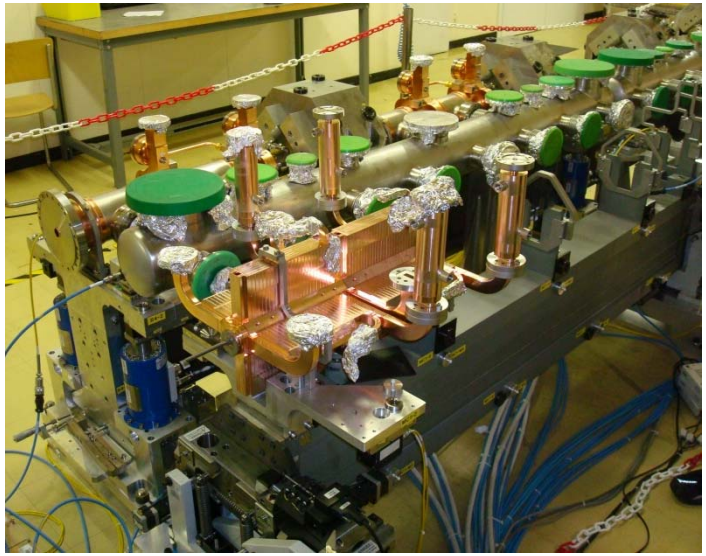


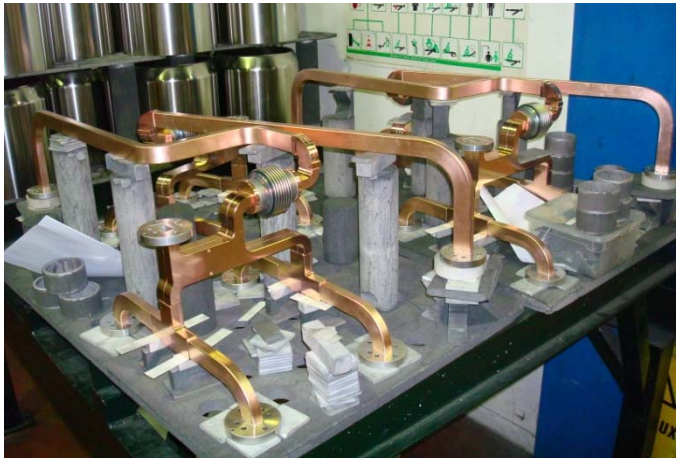
Prototype two-beam modules

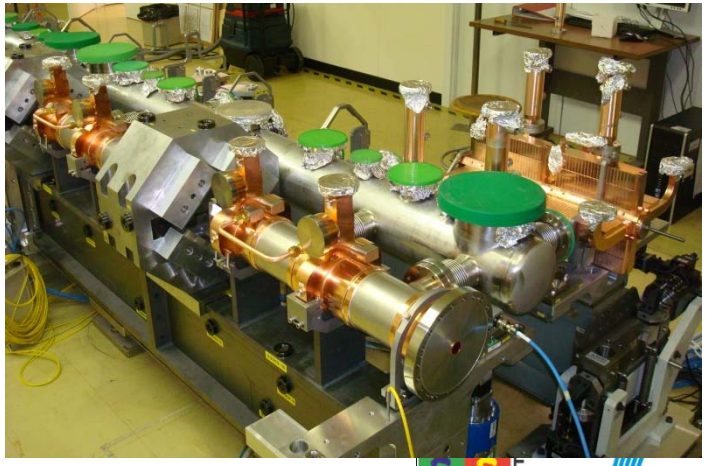


- 4 accelerating structures as one stack: 2-m long
- 2 PETS units completed
- RF and vacuum networks completed

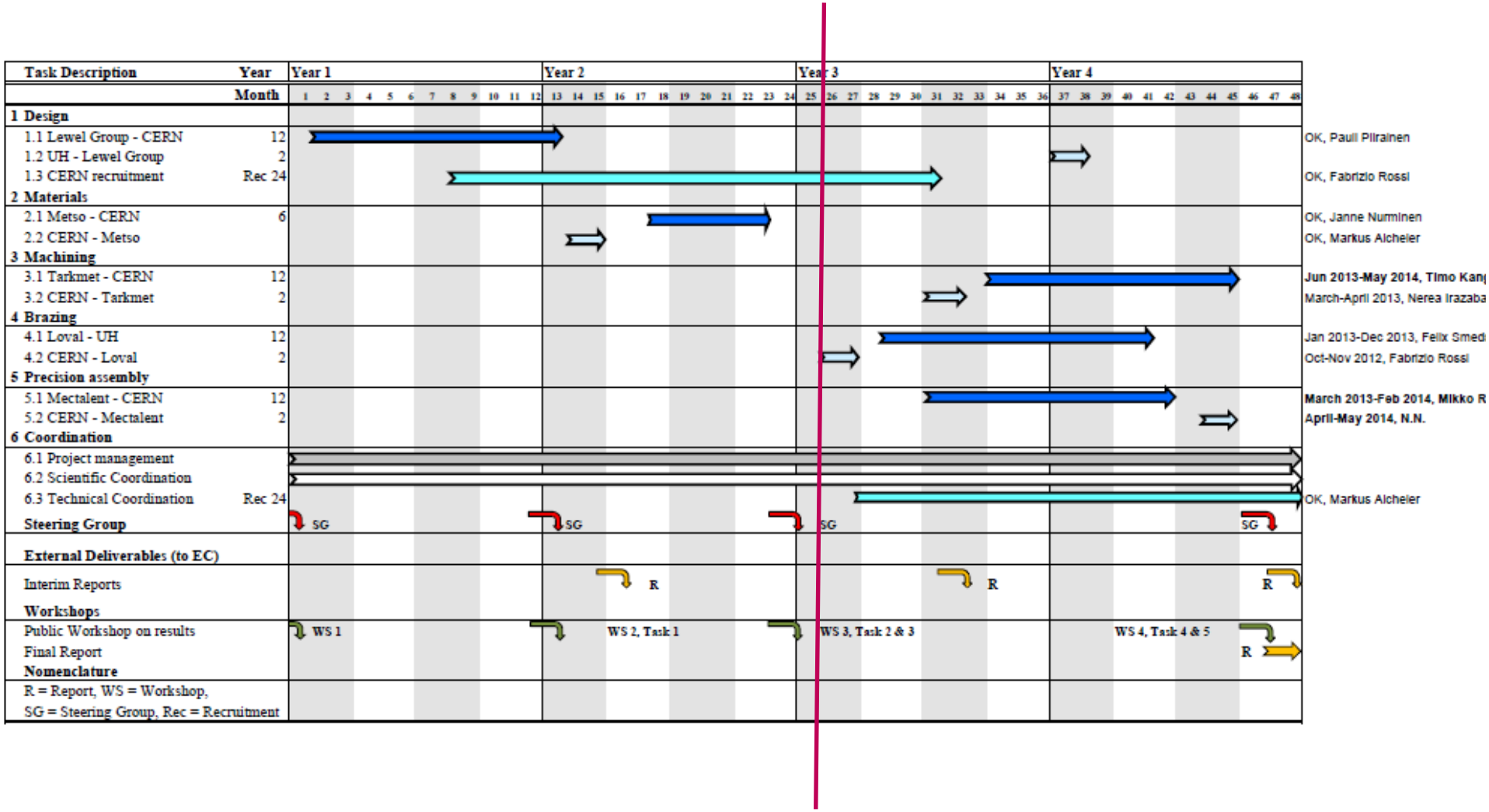








Secondments and recruitments
Modifications Tarkmet, Mectalent



mid-term review

Administration

Management team:
K.Österberg, coordinator,
G.Riddone, scientific coordinator
T. Niinikoski (upto 31.8.2012)/M.Aicheler (from 1.12.2012) technical coordinator
R.Nousiainen (upto 31.12.2010)/J.Väinölä (from 1.9.2011), administrative manager

Meetings
1. Workshops: Kick-off 6.9.2010, disk production 22.3.2011, open workshop and project meeting 6.9.2011
2. Steering commitee annually
3. Work package meetings
- Monthly
- Telecommunication
- Partner progress reporting, administration and planning
4. Mutual partner meetings and communication

Administration

Distribution of funding

First year reporting

Exchange of partner: Veslatec → Tarkmet

Mid term reporting

Overall progress report, submitted to EU end of August

Financial reporting:

- Reporting instructions has been sent to partners on June, 2012
- Reporting exercise done in June -> everyone has access to EU participant portal
- Mid term financial reporting
    - Within a month from Mid-term review (27.10.2012)
    - Reporting period from the beginning until end of September 2012

Dissemination

Open workshop and project meeting 6.9.2011 at CERN

Web pages www.hip.fi/mechanics

MeChaniCs in media:
K.Österberg in Finnish national radio 15th of Nov. 2011
Precision instruments and collision course: International Innovation Journal, 2/2011

‘TAVAKS’

(~”To Habit”)

Customer oriented development of ultrahigh precision manufacturing in Finnish industry

TArkuusValmistuksen Asiakaslähtöinen valmiuksien Kehittäminen Suomalaisessa teollisuudessa

Project introduction 27.9.2012

University of Helsinki, Helsinki Istitute of Physics, HIP
Technical Research Centre of Finland VTT
North Carelia University of Applied Science, NKUAS

TAVAKS; Objectives

The aim of the project is to increase the knowhow and capability of manufacturing **ultra-high precision components** and assemblies in Finnish industry.

Productions steps from raw material to finalized components and assemblies are considered as well as the requirements and interaction between different steps in the production chain.

6 work packages:

WP 1 Material research

WP 2 Ultra-high precision machining&Pre-machining

WP 3 Diffusion bonding and laser welding

WP 4 State of the Art and Market analysis

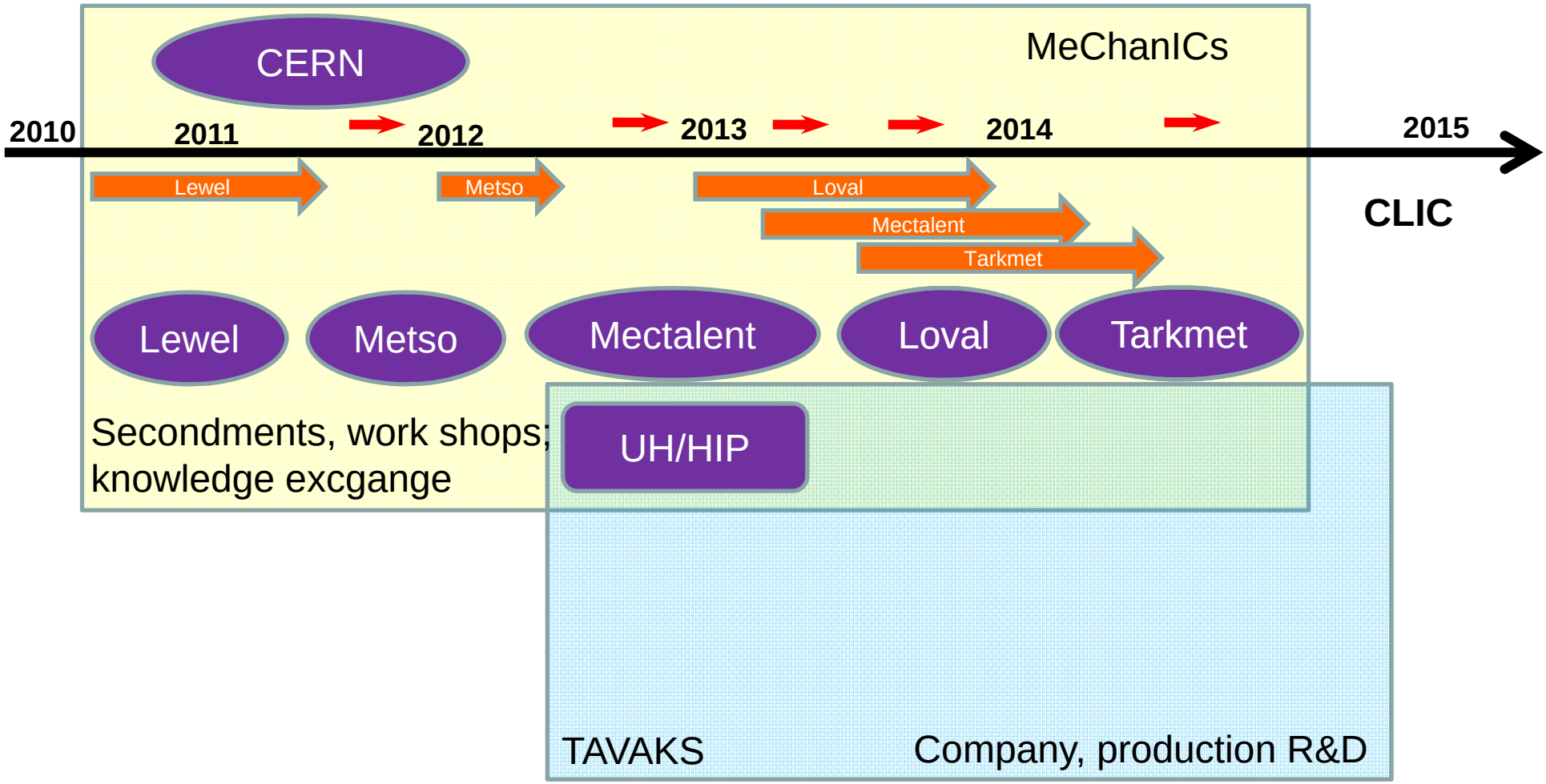
WP 5 International cooperation

WP 6 Coordination

Development work is based on **CLIC components and assemblies**.

One goal is to establish capability to produce CLIC disks and test components and support CLIC development work.

MeChanICs → TAVAKS



TAVAKS; Partners and funding

FUNDING DECISION TODAY!

Research Organisations

Helsinki Istitute of Physics UH/HIP

Technical Research Centre of Finland VTT

North Carelian University of Applied Science NKUAS

Industrial partners

Loval Oy, bonding (MeChanICs)

Tarkmet Oy, laser welding (MeChanICs)

Protoshop Oy, machining

Comatec Oy, FE-modeling

Luvata Oy, material delivery for project needs

Metlab Oy, metallurgical analysis

Centre for Metrology and Accreditation MIKES

Funding has been applied from TEKES separately for the individual projects. (TEKES=Finnish Funding Agency for Technology and Innovation).

Project is planned to last 2 years, from 2012 to 2014.

Thanks