CLIC Module - Considerations on a roadmap for 2016 - 2019

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Outline

- Motivation and Strategy for a next generation module.
- Possible coordination with CLIC-related studies
- Areas for possible developments.
- Ideas for an industrialization study.
- Roadmap for the next three years.

Next generation module

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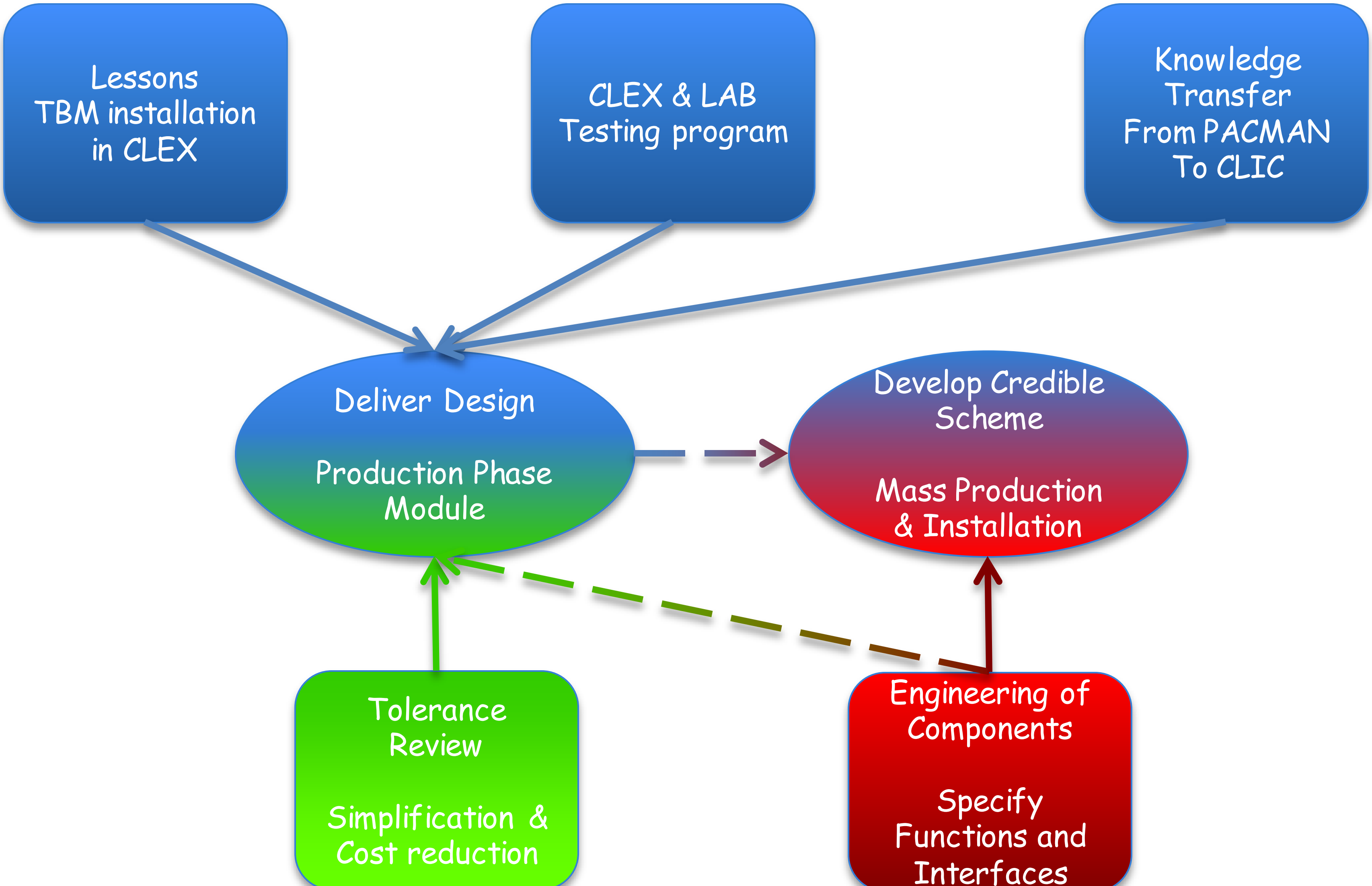
Production phase module

A "Production phase module" is the first step towards a pre-series prototype.

It must provide the information required to approach industry and obtain an outline and pricing for the production process.

Strategy for a production phase module program



A Credible Production and Installation Scheme

Credible: reasonable to trust, within the bounds of possibility

Merriam – Webster dictionary

Possibility must be checked and demonstrated within the limits of technology and of consolidated processes.

Possibility must be proven to be at reach with available resources and within reasonable time boundaries.

Synergies with CLIC-related Activities

PACMAN

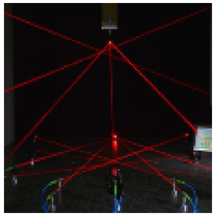
From H. Mainaud Durand's presentation at CLIC project meeting

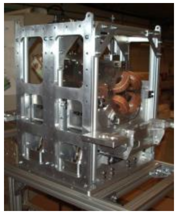
Particle **A**ccelerator **C**omponents' **M**etrology and **A**lignment to the **N**anometre scale

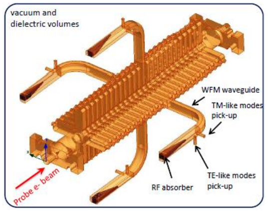
Combine references & methods of measurements in the same place to gain time and accuracy;

Prove their feasibility on a final bench;

Extrapolate the developed tools & methods to other projects → **CLIC**





XbFEL

Interest in the FEL community to exploit the potential of X-band accelerators to reduce the Linac length, the cost of buildings and to increase the beam repetition rate.

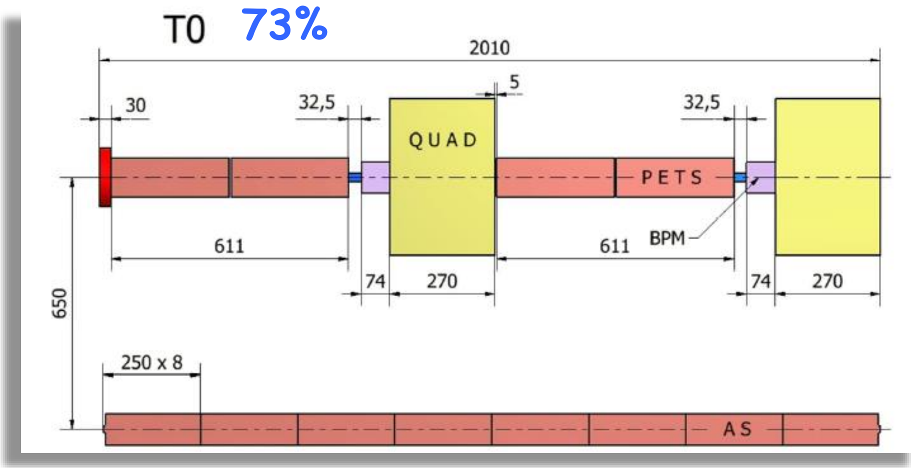
Interest of **CLIC** to have access to studies and funding driven by the FEL requirements to explore the klystron option and aspects related to machine availability.

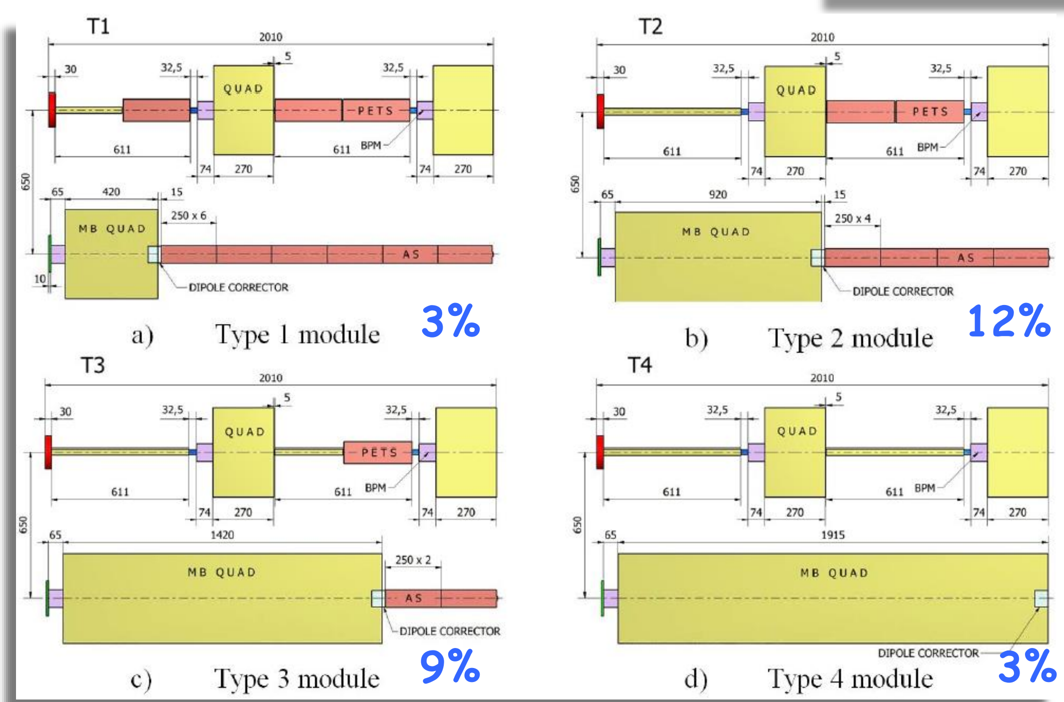
TBM Present Layout

Five Module configurations:

21452 modules over 48 machine sectors @ 3 TeV.

T0 = 15660





T1 = 643

T2 = 2575

T3 = 1931

T4 = 643

From G. Riddone @ LCWS2012

AREAS OF POSSIBLE DEVELOPMENT

Summary of Specified Tolerances

- Pre-alignment **tolerances MB**: 10 µm, 14µm rms for RF structures, 17µm rms for quads, BPMs 10 µm.
- Pre-alignment **tolerances DB**: Quads 20 µm, PETS 100 µm/1 mrad. BPMs 20 µm ?
- Is 10 µm acceptable as for girder coupling tolerance ?
- 5 µm difficult to be achieved for the localization of the articulation point.
- The WFM center must be aligned within 3.5 µm on the SAS axis. How to check this alignment requirement ?

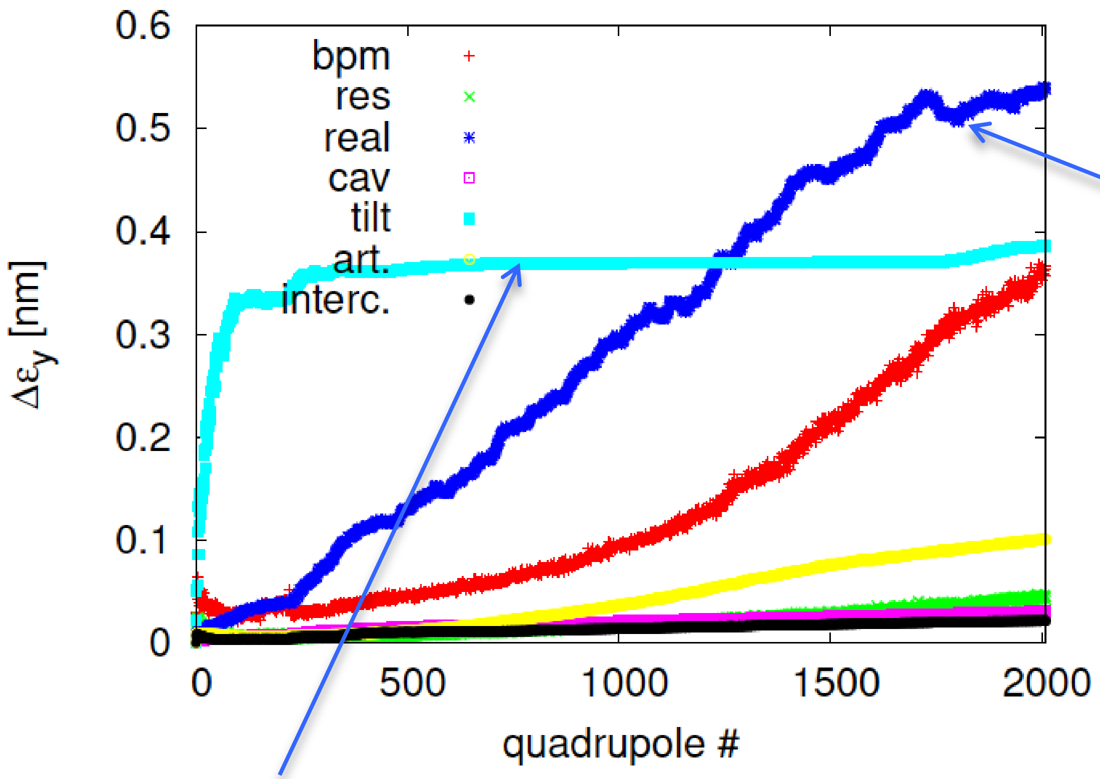
From S. Doebert's presentation at 29th April TBM WG meeting

imperfection	with respect to	symbol	value	emitt. growth
BPM offset	wire reference	σ_{BPM}	14 μm	0.367 nm
BPM resolution		σ_{res}	0.1 μm	0.04 nm
accelerating structure offset	girder axis	σ_4	10 μm	0.03 nm
accelerating structure tilt	girder axis	σ_t	200 μradian	0.38 nm
articulation point offset	wire reference	σ_5	12 μm	0.1 nm
girder end point	articulation point	σ_6	5 μm	0.02 nm
wake monitor	structure centre	σ_7	5 μm	0.54 nm
quadrupole roll	longitudinal axis	σ_r	100 μradian	$\approx$ 0.12 nm

From D. Schulte's lecture at LC School 2013

AREAS OF POSSIBLE DEVELOPMENT

Sensitivity to Alignment Errors – Main Beam



The cumulated realignment error imposes a tighter tolerance of 3.5 μm to the WFM positioning with respect to the SAS axis.

Structure tilt contribution to the vertical emittance degradation shows a behavior partly due to uncorrelated beam energy spread, to be investigated.

From D. Schulte's lecture at LC School 2013

DB Girder Considerations

AREAS OF POSSIBLE DEVELOPMENT

4.4.5.2 *Correctors*

The beam steering in the decelerator can be performed by using dipole correctors, quadrupole movers or by moving the girders themselves. The following four scenarios can be envisaged:

Preferred solutions !

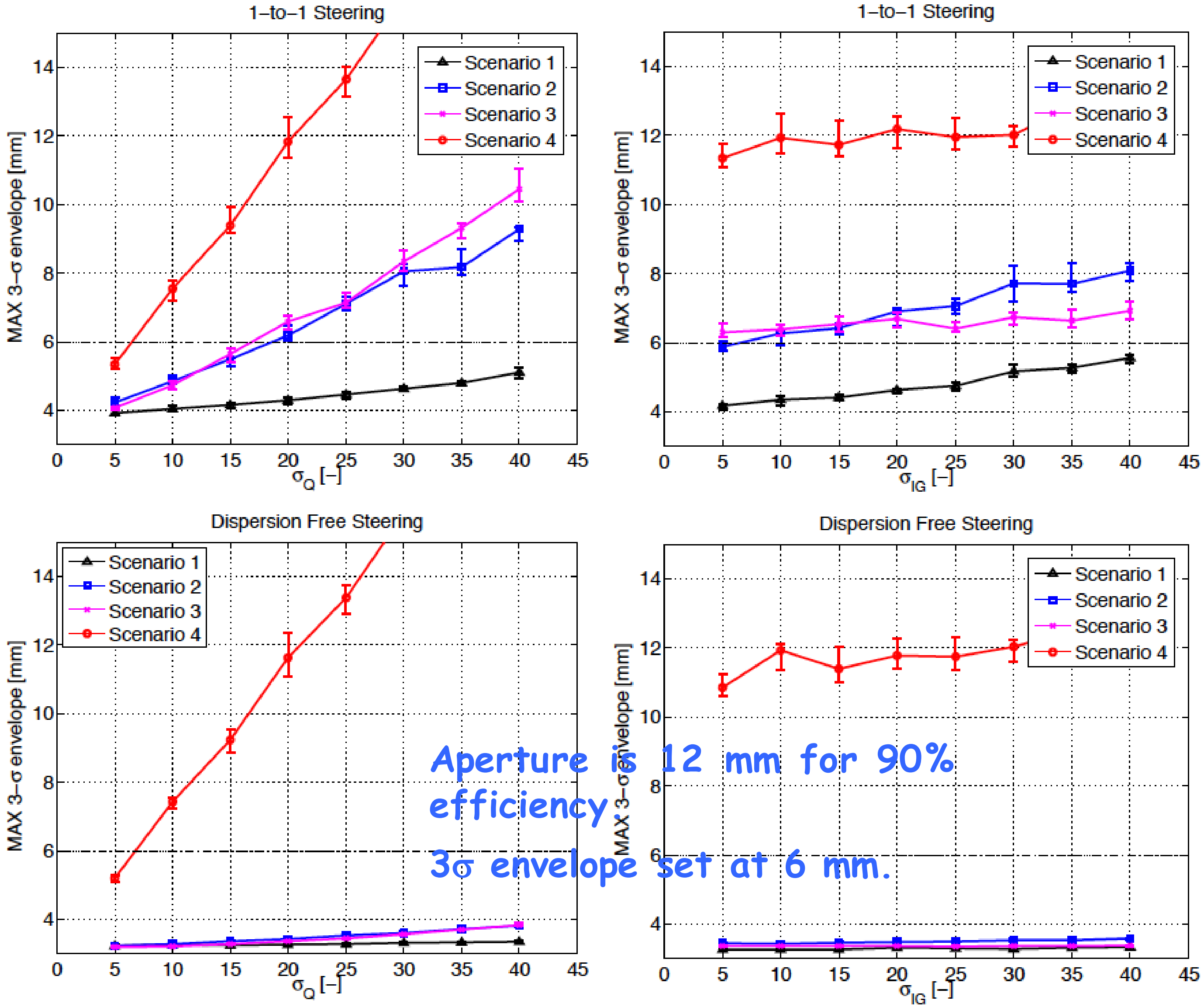
1. Each quadrupole is provided with a horizontal and vertical dipole corrector. Assuming that the quadrupole misalignment is kept within 50 μm r.m.s., the maximum integrated field required is $\pm$2 mT m (bipolar). The dipole correctors should ideally be integrated in the quadrupoles to ensure efficient correction for all drive beam energies.
2. Each quadrupole is installed on a vertical and horizontal mover. The corresponding maximum transverse offset required is $\pm$200 μm. The use of quadrupole movers for correction is particularly interesting if permanent magnets are to be used for the decelerator quadrupoles, as it is planned to include moving parts. For either correctors or movers, robust performance is ensured if at least 2/3 of the quadrupoles are equipped with a steering device.

   Since each girder will be positioned on horizontal and vertical movers for the active pre-alignment system, we can consider two additional scenarios :

3. Each quadrupole is provided with only a horizontal or vertical dipole corrector (or, equivalently, with a horizontal or vertical mover). In this case, with only half the number of movers/correctors, we can almost completely recover the full steering performance of the line.
4. Finally, we can use the girder movers only, with no correctors/movers. In this configuration, unlike the previous cases, the steering performance will be partially reduced. However, simulations show [29] that it stays within specification if the alignment tolerance of the quadrupole magnetic center is 20 μm or smaller. This scenario is presently the one considered for the module design (see §5.6).

From G. Sterbini's presentation in 2012

Girder Considerations – Drive Beam



Scenario 1:
2m – no snake

Scenario 2:
2m – snake

Scenario 3:
4m – no snake

Scenario 4:
4m – snake

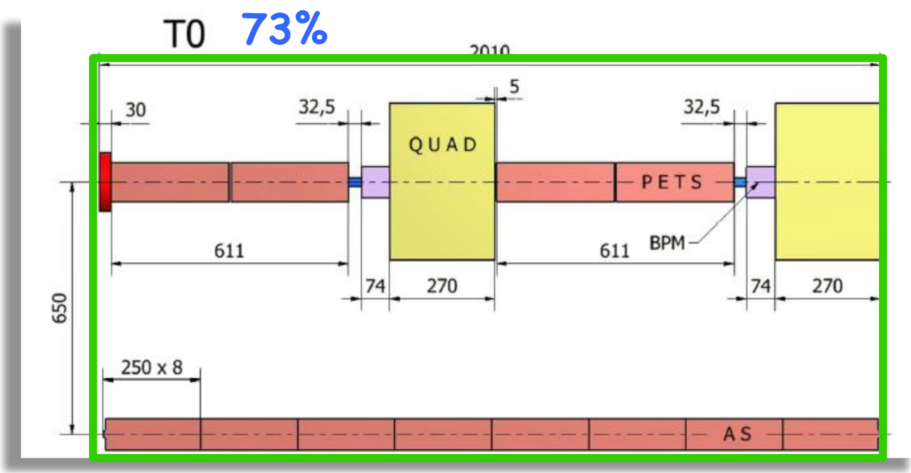
Provided that 20 μm of pre-alignment are achieved with quad magnetic centres

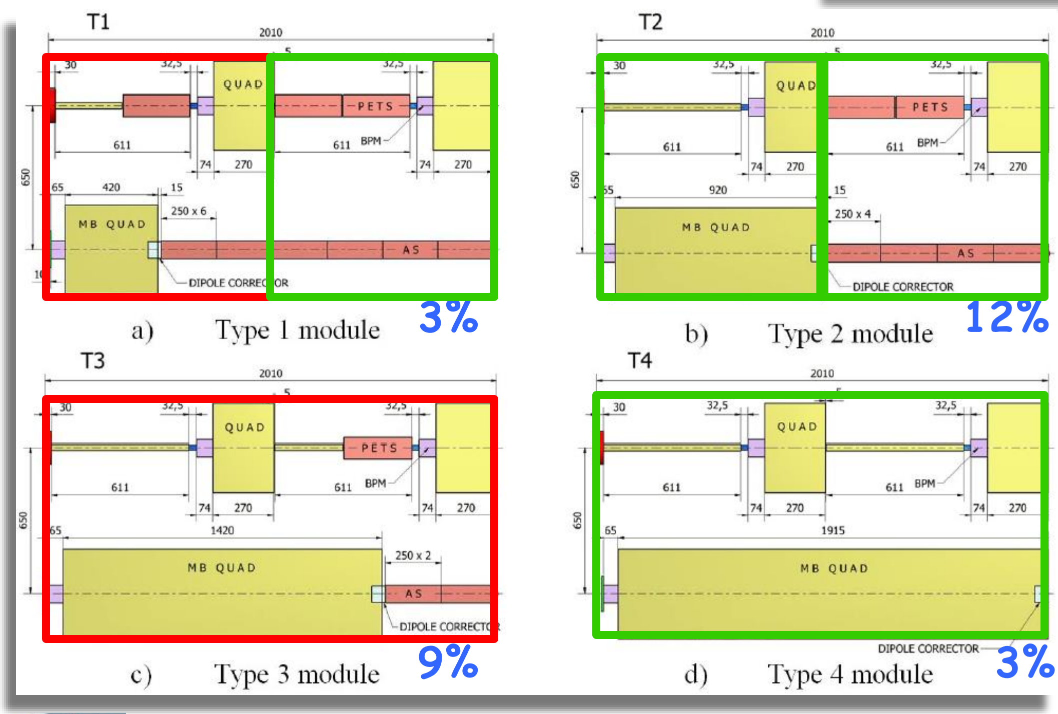
From G. Sterbini's presentation in 2012

Girder Considerations

Can the different MB and DB tolerances let us imagine a different scenario where AS and PETS sit on single / connected girders ?

Limit the assembly and cabling procedures in the tunnel to a minimum.





Achieve independent and simpler control of AS and Quad position of the MB.

The integration of beam instrumentation sections may introduce changes.

In case, overall integration should be explored.

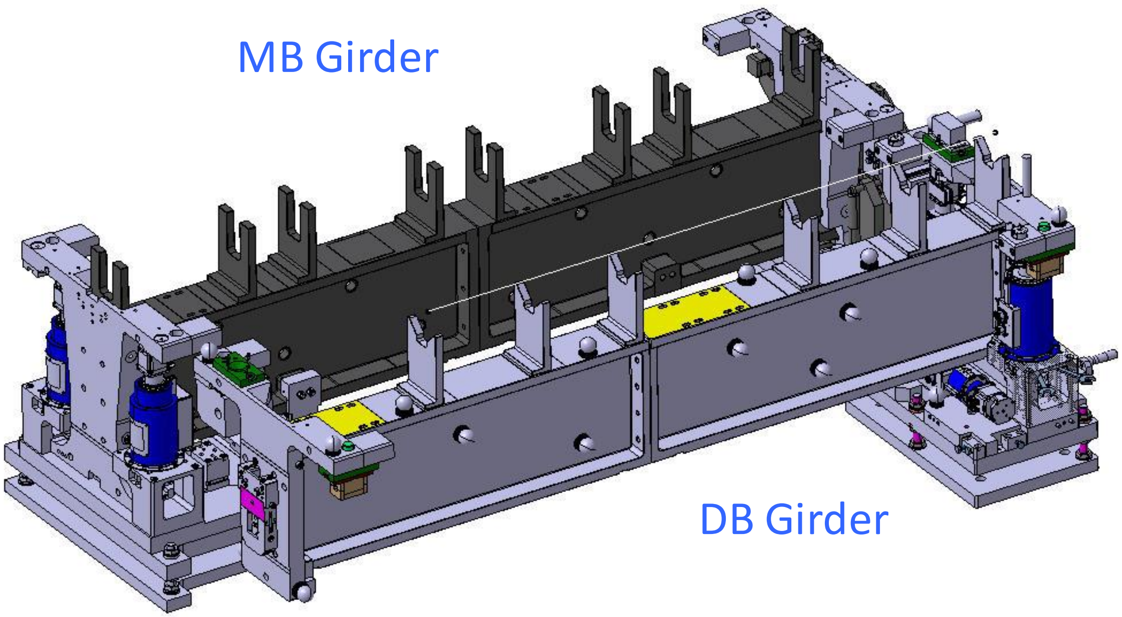
AREAS OF POSSIBLE DEVELOPMENT

Girder Material

Girder Specification:

Maximum Girder static deformation 10 μm

Maximum sustainable dead weight 400 Kg/m



From CLIC – Note – 857 2010

Girder Material

Girder Specification:

Maximum Girder static deformation 10 μm

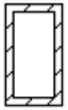
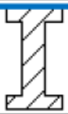
Maximum sustainable dead weight 400 Kg/m

Material	Static Deformation loaded with RF components (μm)
Aluminium -6061- AHC	43.39
Austenitic Stainless Steel	36.49
Silicon Carbide (SiC)	3.38
Structural Steel	36.29
Stainless Steel 440°C	35.32
Titanium	46.86
Beryllium	82.64
Carbon Fibers	66.68
Epument 140/5	15.08
Epoxy Aramid Fiber	69.96

Elasticity Modulus:

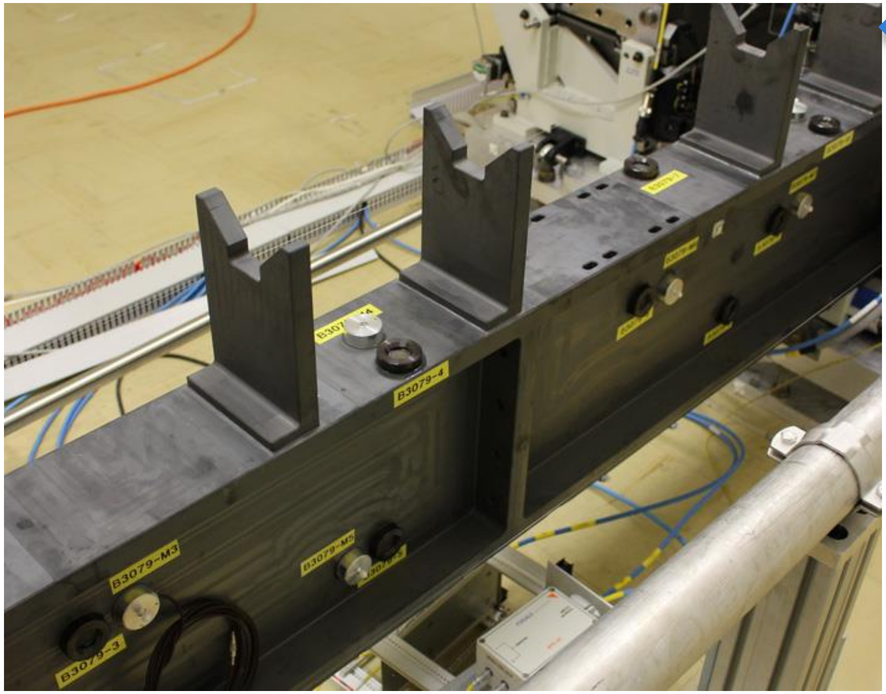
$E_{Epument}$ = 40 – 45 GPa

E_{SiC} = 170 – 210 GPa

Configuration		Deformation (μm)
SiC		3.38
SiC		Girder Baseline Configuration 1.14
SiC		3.52
SiC		1.95

From CLIC – Note – 857 2010

Girder Material – Cost Impact

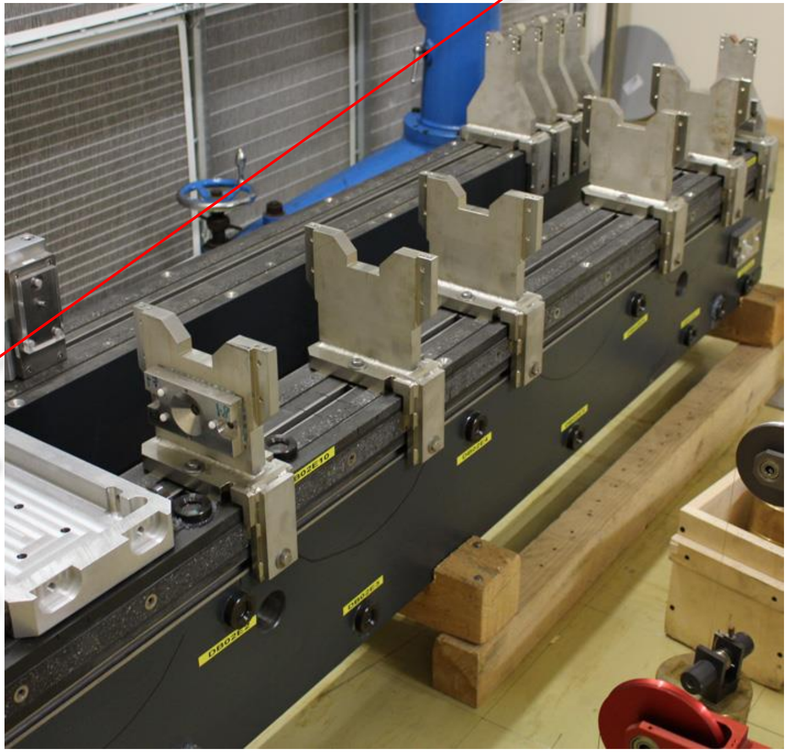


SiC GIRDERS

Boostec Industries[a] & Micro-Control[b]:

a) two prototypes @ 195 kCHF, additional with V-shaped supports 107 kCHF/piece.

b) two prototypes @ 210 kCHF.



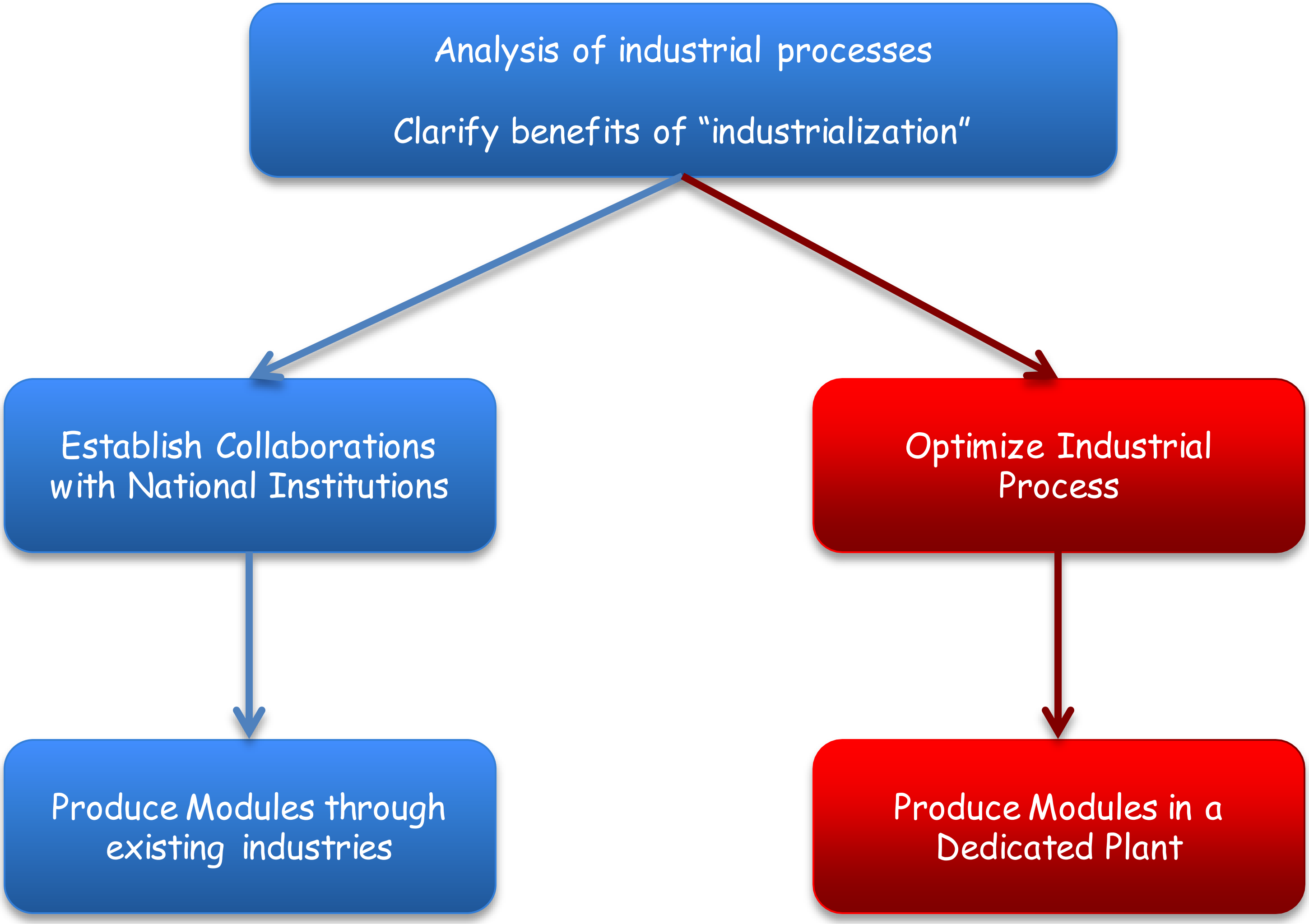
Epument 145/B Girders

EPUCRET:

two prototypes + mold @ 34 kCHF, additional 5 kCHF/piece.

AREAS OF POSSIBLE DEVELOPMENT

Two options


Analysis of industrial processes
Clarify benefits of "industrialization"
Establish Collaborations with National Institutions
Optimize Industrial Process
Produce Modules through existing industries
Produce Modules in a Dedicated Plant

The LHC Experience

Dipole prototypes have been developed at CERN

First long dipole developed in collaboration with Ansaldo and INFN

Importance of aligning:

1- the scientific interest of the research team;

2- the political / strategic interest of the institution;

3- the availability of sufficient resources.

L. Rossi

Procurement of key components managed by CERN

→ Critical logistics

Companies were responsible for the assembly, **but not for the performance.**

A bonus was recognized for good performance.

Acceptance and testing strategy is crucial !

A Different Approach

The assembly of CLIC modules requires: a solid quality assurance scheme, logistic capabilities, capacity to properly handle costly components, automated procedures when possible, mechanical and electrical integration, extensive cabling.

The production could envisage 5000 modules/year over four years with two years of preparation phase.

… which recalls a similarity with some sports car production …

A Different Approach

Fraunhofer IPK

Fraunhofer-Gesellschaft
Institute for
Production Systems and Design Technology (IPK)

Production Technology Center

Innovations for Industry

Mission and Goals

- Fundamental research and education as well as applied research and development
- Optimization of industrial processes – from the product idea through to product development, design and manufacture
- Fast transfer of R&D results into practical applications
- Cost-effective and environmentally friendly solutions for SME

D. Oberschmidt - CLIC Workshop 2015

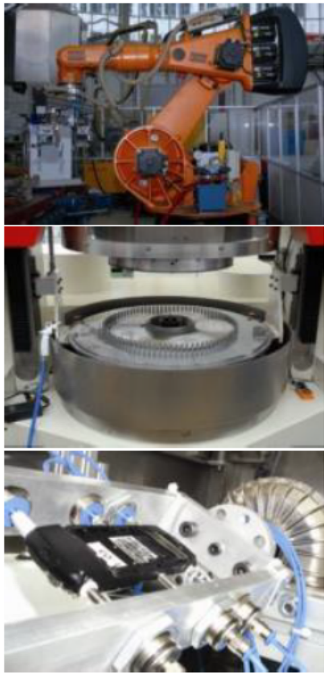
A Different Approach

Fraunhofer IPK

Markets and Customers

Our innovative technologies strengthen your competitive position

- Mechanical and plant engineering
- Tool and mould making
- Vehicle construction
- Electrical engineering
- Software applications
- Health care
- Public institutions



Fraunhofer IPK
INSTITUTE PRODUCTION SYSTEMS AND DESIGN TECHNOLOGY

IWF
INSTITUTE FOR MACHINE TOOLS AND FACTORY MANAGEMENT TECHNISCHE UNIVERSITÄT BERLIN

D. Oberschmidt - CLIC Workshop 2015

Summary of Milestones

Review the Design of the CLIC Module, integrate lessons learned, produce a design, on paper, for a next generation module, compatible with production.

Prepare a technical specification document for the CLIC module, specifying functions and interfaces, including results from possible development areas.

Define a Quality Assurance Policy, detailing acceptance and test procedures and specifying responsibilities.

Perform a preliminary Risk Analysis, for the production and installation phases.

Provide an analysis of the industrial processes involved or envisaged, clarifying the benefits of industrialization.

Clarify in a document the terms of the participation of national laboratories and industry to the module industrialization effort.

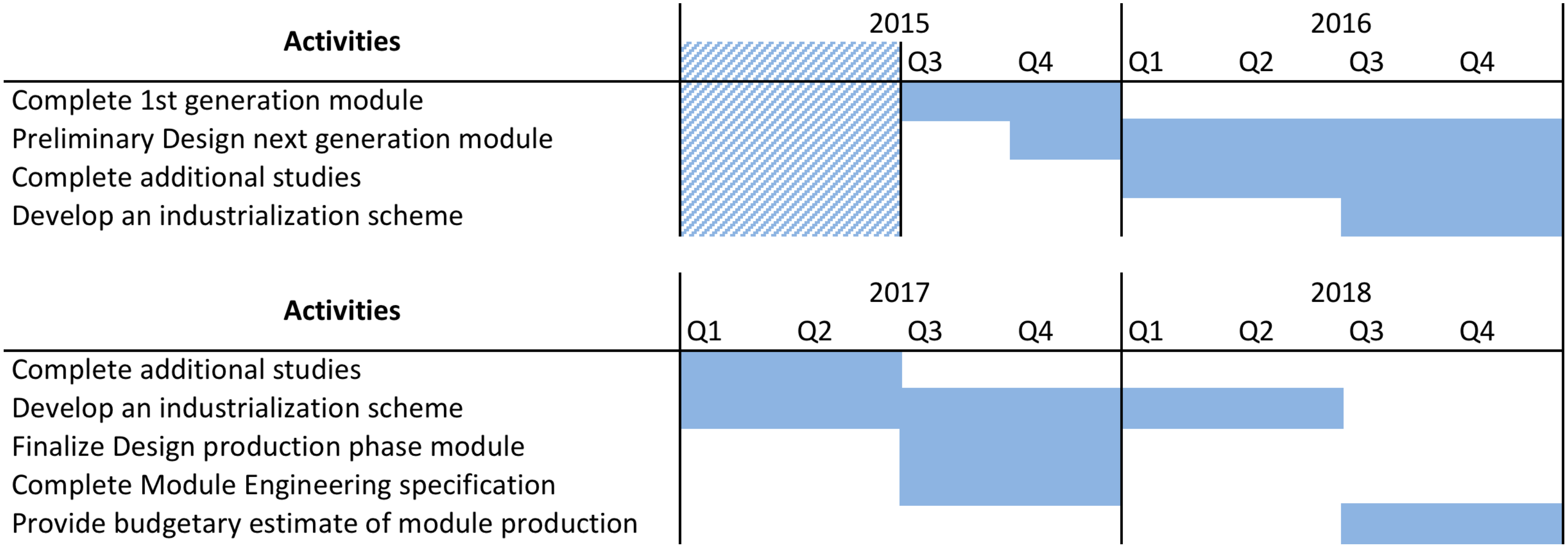
Build a network of national laboratories and institutions that are interested in supporting the module industrialization through national industries. Investigate on EU tools that could be made available.

Investigate the dedicated production plant option.

Spare Slides

Proposed Roadmap & Resources

2016 – 2019 ROADMAP



Limited material budget, for specific development and tests, to be decided following the outcome of this review.

2.5 FTE Engineering effort over 3 years for the whole program + external collaborators.