QUACO Project Status

PCP and R&D for accelerator technology

Marcello Losasso - CERN IP/KT

On behalf of QUACO Collaboration

8th HL-LHC Collaboration Meeting – 18.10.2018

This project has received funding from the European Union's Horizon 2020 PCP programme under Grant Agreement no. 689359

QUAdrupole COrrector Project Summary

QUACO is about how to engage industries into projects:

- Technically difficult
- Financially risky
- With low market impact
- In a EU market environment dominated by few big players

I will present an overview of the QUACO project, the funding scheme, timeline, organization, implementation, status.

QUAdrupole **CO**rrector **Project Summary**

The project run in collaborative effort among **CERN, CEA, CIEMAT, NBCJ**

Coordinated by CERN around the technical scope of **Q4 quadrupole**

QUACO is a Pre-Commercial-Procurement: **phased approach** to procure **R&D**.

→ **Lead Tendering Authority Model:** CERN is the Lead procurer in QUACO project, coordinating and leading the *joint procurement* in the name and on behalf of the partner organizations

Phased means that the implementation of the project is split in 3 phases:

solution design, detailed design, First-of-a-kind manufacturing

Project Coordinator: M. Losasso (CERN); Deputy: I.Bejar-Alonso
Tech Teams leaders: D.Simon, A.Foussat, F.Toral

Co-funded by EC under H2020

The group of procurers have committed >1.9 M€ of procurement funds to specify and prepare the development of innovative superconductive magnets and to follow-up the procurement and manufacture

Co-funded via H2020 under **Grant Agreement 689359**

Total Procurement >6.5M€

Project Summary

Project 689359 (Quaco) - SIGNED (IN FORCE)

Responsible Unit:	RTD/B/04
Call:	H2020-INFRASUPP-2014-2015 submitted for H2(
Topic:	INFRASUPP-2-2015 - Innovative procurement pi
Type of Action:	COFUND-PCP
Duration:	48

Important Dates:

Entry into force of the Grant:	18/02/2016
Project Start Date:	01/03/2016
Project End Date:	29/02/2020

Amendment Information:

Number:	IP2
Reference:	AMD-689359-2
Type:	IP (Information Procedure)

Budget Information:

Proposal overall costs :	6,647,891.25 €
Maximum grant amount after evaluatio :	4,653,526.51 €
Total costs (including non-EU funded)	6,647,891.25 €
Total Costs:	6,647,891.25 €
Maximum Grant Amount:	4,653,523.88 € 70.00 %

Officers:

Project Officer: Patricia POSTIGO MCLAUGHLIN (RTD/B/04)

Some background

PCP EU call was envisaged back in 2015 to implement R&D activities for design and development of some of the Q4.

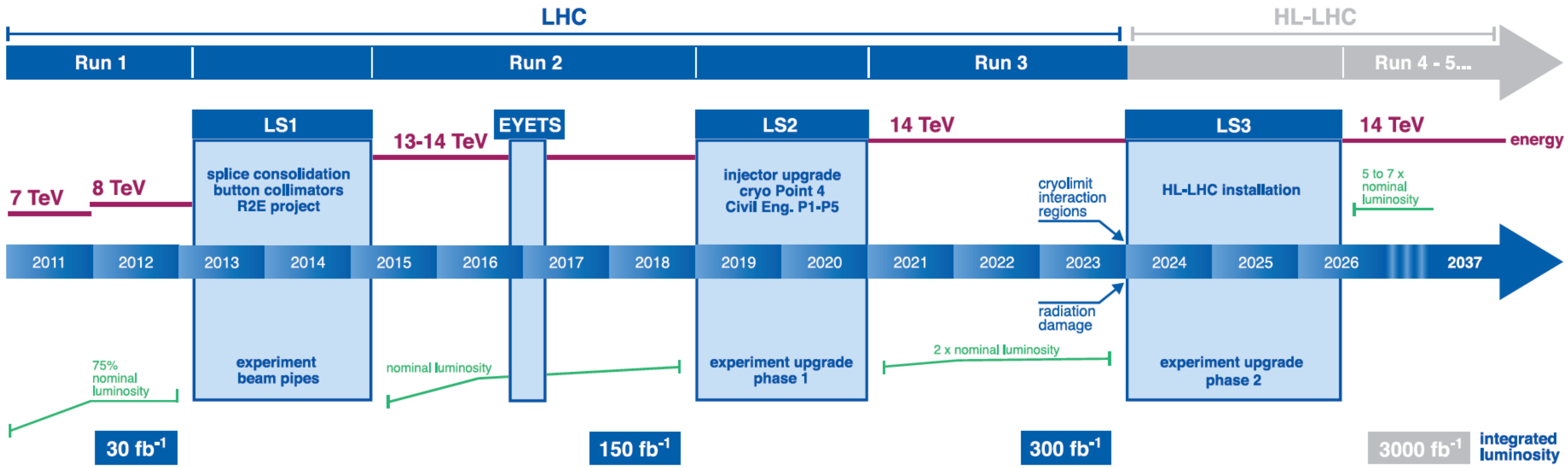
PCP procurement requires a minimum of 3 independent participants from 3 different Member States (MS) or Associated countries.

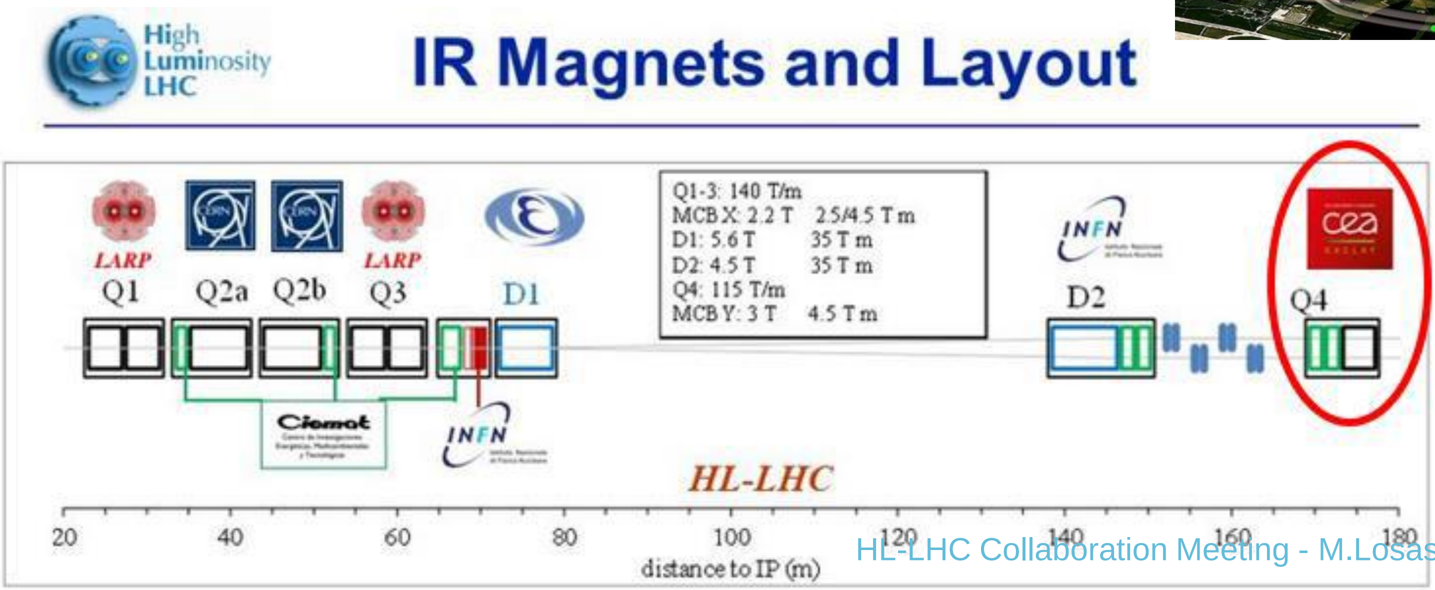
PCP is supposed to competitively steer the development of solutions towards concrete public sector needs → ***PCP is only for R&D***

Necessary to build a consortia of procurers, define scope and participants, negotiating the share. Worth mentioning the modification or derogation of the **CERN Financial Regulation** in order for CERN to participate in a PCP EC call

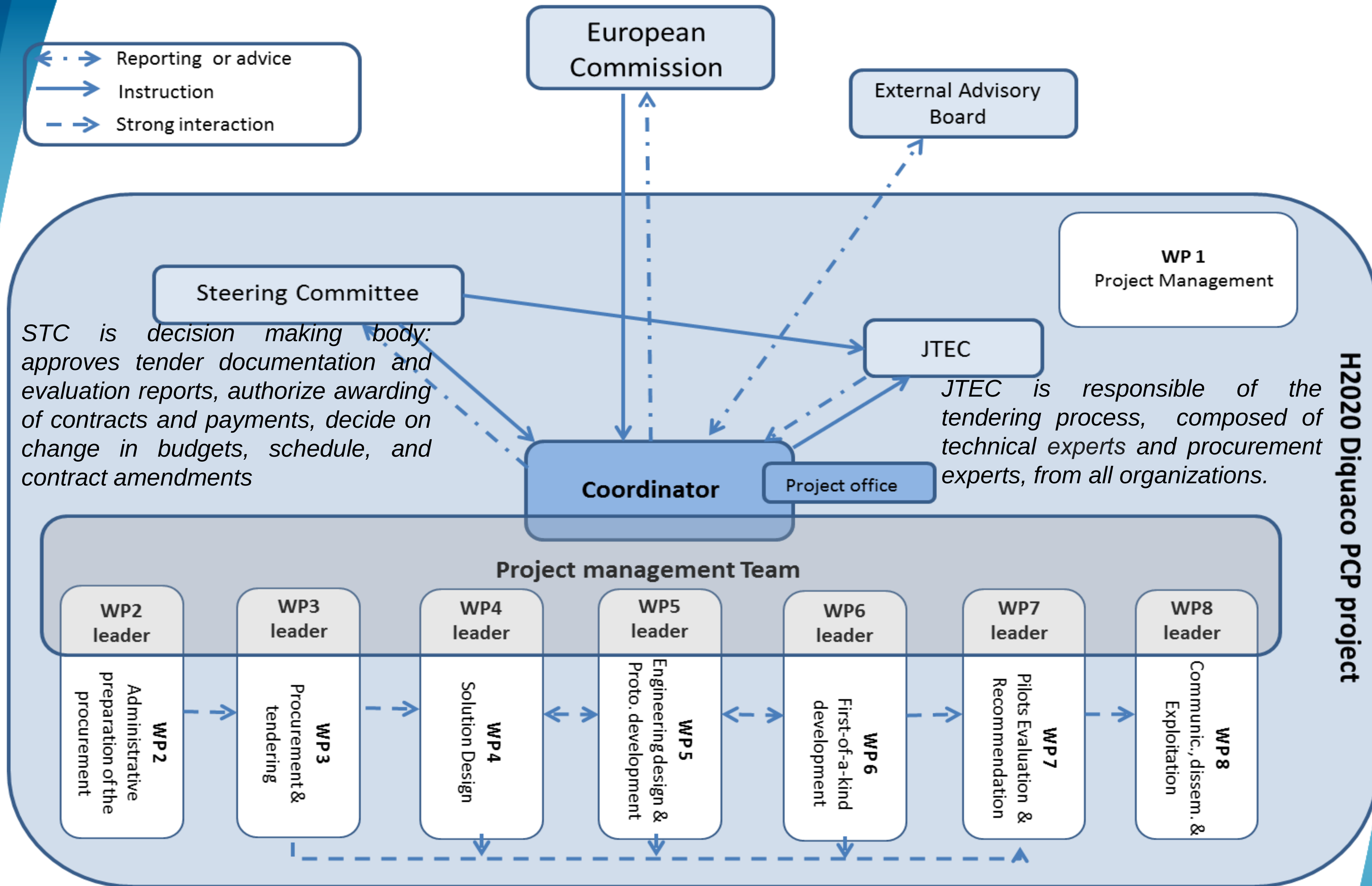
→ in PCP tenders awarded based on best value for money (not just lowest price) and market price. Derogation by the Finance Committee obtained in Nov 2015.

LHC / HL-LHC Plan





3.8 m quadrupole
90 mm aperture
440 T/m integrated gradient



PMT, chaired by PC, provides day-to-day management of the project, technical support and documentation. Organizes activities of the technical teams for the contracts follows-up

Project timeline

Grant Agreement → Signed by CERN, 14 January 2016

Start of the project (Consortium Agreement) → 15 February 2016

Start implementation of Phase I → Nov 4, 2016

Start of phase II → July 2017, lasting 13 months

Expected start of phase III → November 2018, lasting 21 months, pending STC award decision on Nov. 5th

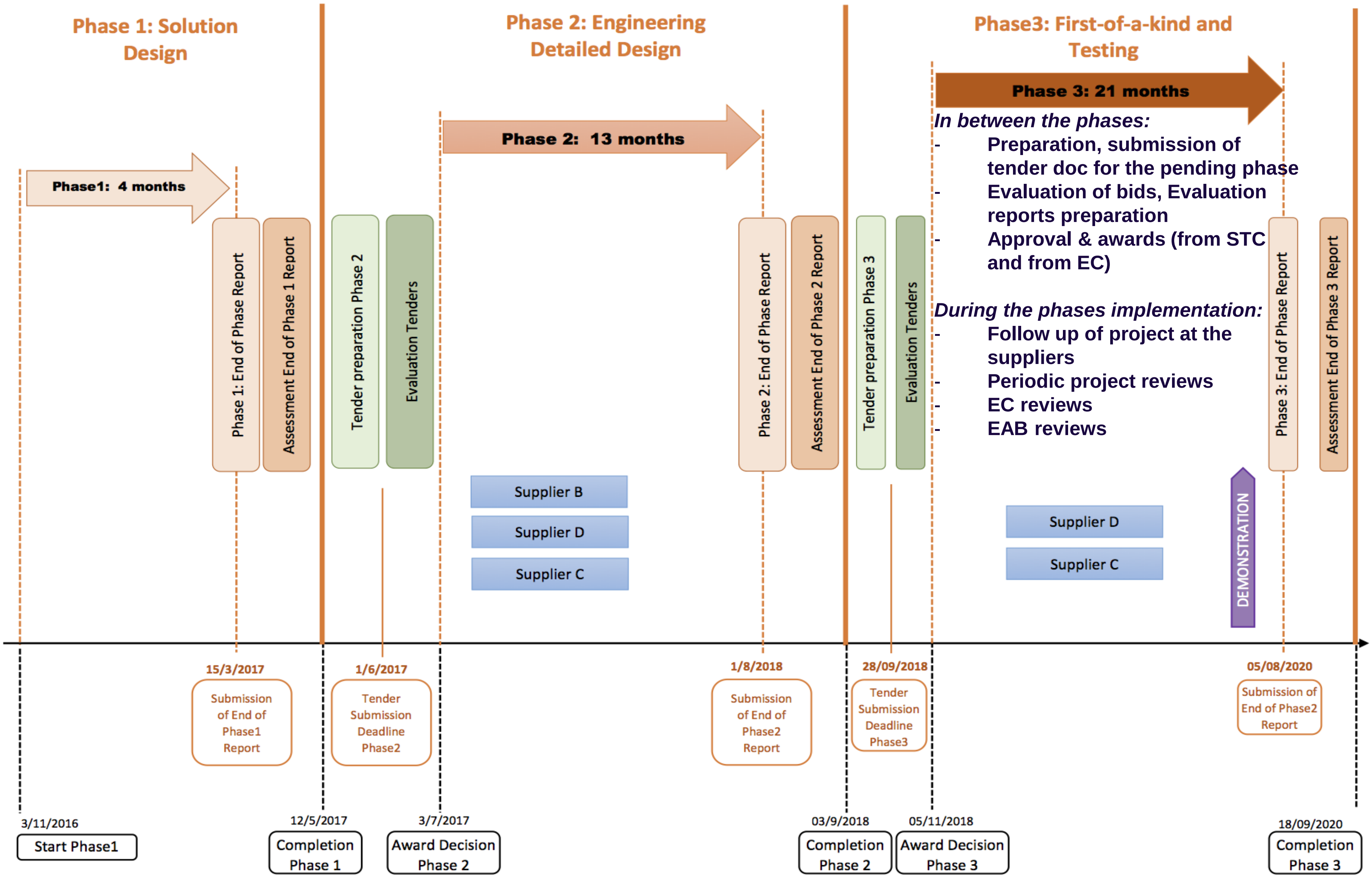
In between the phases:

- **Preparation and submission of tender doc for the pending phase**
- **Evaluation of bids, Evaluation Reports preparation**
- **Approval and awards (from STC and from EC)**

During the phases implementation:

- **Follow up of the project at the suppliers**
- **Periodic project Term reviews**
- **EC reviews**
- **EAB reviews**

PCP: Competitive development in 3 Phases



Tech scope

The technical scope is defined in terms of functional specification. A full list of deliverables and milestones for each of the 3 phases is stated. Mandatory requirements are spelled as General, Geometric, Magnetic, Mechanical, Quench.

i.e. magnetic:

Requirement	Description
R3.1	The magnet must produce an integrated gradient of 440 T at 1.9 K.
R3.2	The operating gradient at 1.9 K must be 120 T/m.
R.3.3	The reference radius Rref is 30 mm
R.3.4	The magnetic length must be 3.67 m at 1.9 K
R.3.5	The operating margin along the load line must be at least 20 % which means $\frac{I_{op}}{I_{ss}} \leq 80\%$
R.3.6	The two apertures must be powered independently.
R.3.7	The magnet must operate in regimes where the current imbalance between the two apertures can be up to 50%.
R.3.8	Field quality targets must be preserved in unbalanced regimes

Target	Description
T1.1	All the harmonics at Rref should be below one unit at high field on integrated multipole components

European Organization for Nuclear Research
Organisation européenne pour la recherche nucléaire

EDMS No.: 1612412 Group Code: TE/MSC
Document Ref.: LHC-MQYY-CI-0001 IT-4191/TE/HL-LHC

The HL-LHC Project

Invitation to Tender

Functional specification for the supply of R&D services for the development of the HL-LHC MQYY magnet prototype (Q4)

Abstract

This functional specification concerns the supply of R&D services for the three phases of the QuaCo project whose ultimate goal is to manufacture a the first-of-kind quadrupole magnet (MQYY) with two 90 mm aperture and a magnetic length of 3.67 m operating at 1.9 K as defined in this specification. The QUAdrupoleCOrrector (QUACO) project has received funding from the European Union's Horizon 2020 COFUND (PCP) programme under Grant Agreement no. 689359.

Suppliers Contracts and phases

phase 1: 4 Framework Contracts and 4 Contracts implemented

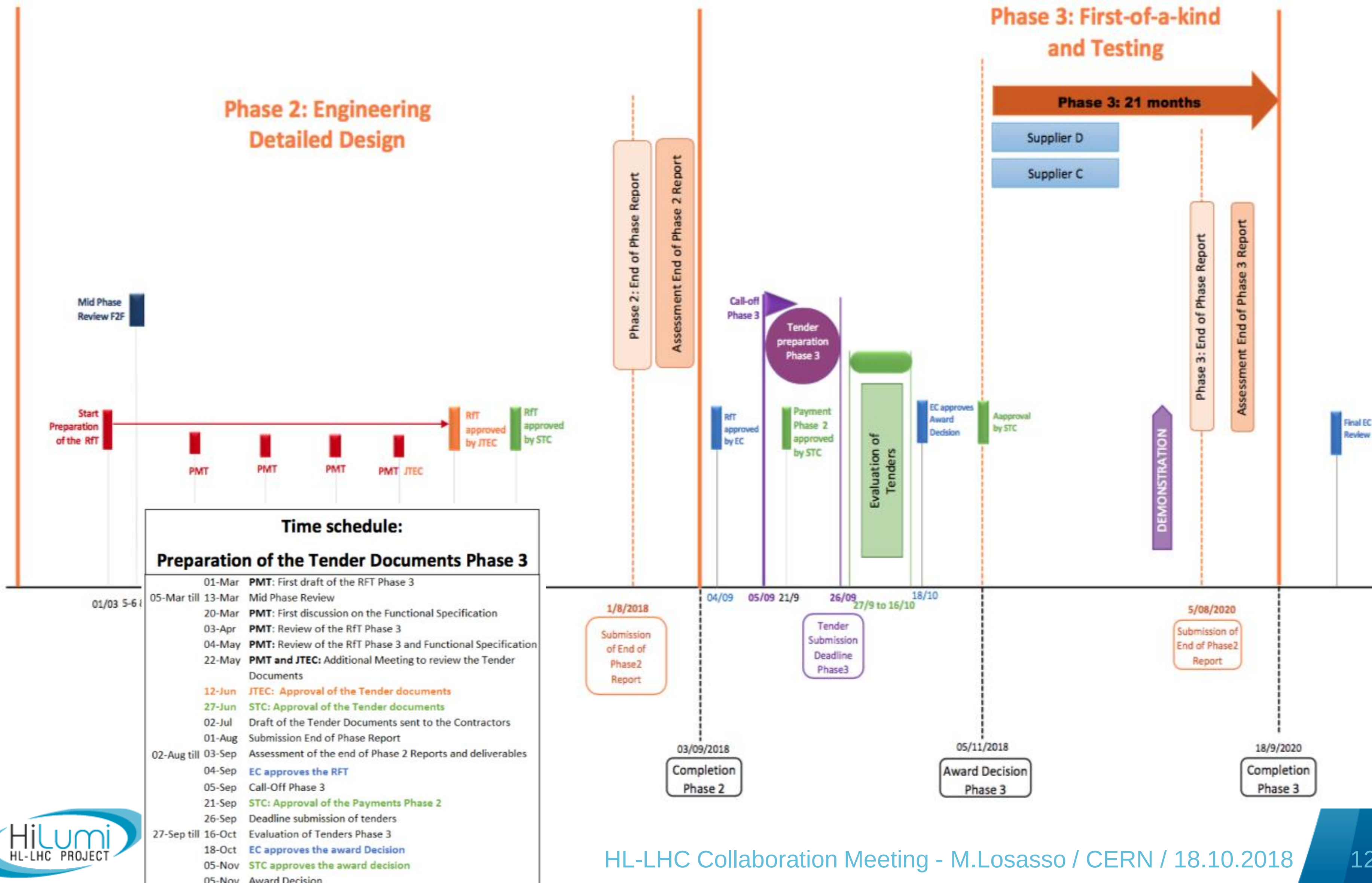
ELYTT Energy,
ANTEC & Fundacion TECNALIA Research & Innovation
SIGMAPHI
TESLA Engineering LTD

phase 2: 3 Contracts implemented
ANTEC & Fundacion TECNALIA Research & Innovation
ELYTT Energy
SIGMAPHI

phase 3: 2 Contracts to start soon
in final approval process, pending STC and EC decision by Nov 5th.

Tech status

<u>Due to the on-going process of evaluation and award, I cannot be detailed on aspects related to company's activities. What follows is not exhaustive</u>



Time schedule:

Preparation of the Tender Documents Phase 3

	01-Mar	**PMT**: First draft of the RFT Phase 3
05-Mar till	13-Mar	Mid Phase Review
	20-Mar	**PMT**: First discussion on the Functional Specification
	03-Apr	**PMT**: Review of the RfT Phase 3
	04-May	**PMT:** Review of the RfT Phase 3 and Functional Specification
	22-May	**PMT and JTEC:** Additional Meeting to review the Tender Documents
	12-Jun	JTEC: Approval of the Tender documents
	27-Jun	STC: Approval of the Tender documents
	02-Jul	Draft of the Tender Documents sent to the Contractors
	01-Aug	Submission End of Phase Report
02-Aug till	03-Sep	Assessment of the end of Phase 2 Reports and deliverables
	04-Sep	EC approves the RFT
	05-Sep	Call-Off Phase 3
	21-Sep	STC: Approval of the Payments Phase 2
	26-Sep	Deadline submission of tenders
27-Sep till	16-Oct	Evaluation of Tenders Phase 3
	18-Oct	EC approves the award Decision
	05-Nov	STC approves the award decision
	05-Nov	Award Decision

Tech status

Work very well progressing in all companies according to the technical scope defined in terms of functional specification.

Examples of innovation solutions investigated as spin-off from QUACO:

- Shrink-fit solution for magnet collaring. Azimuthal prestress of the coil is obtained with an oversize spacer and with the thermal shrinkage of Al collars. First time this method used for a 2-1 quadrupole manufacturing.

- Bladder & Keys for magnet assembly: an outer Al shell contains the forces during operation and provides additional compressive stress to the magnet after cooling down. First time B&K is used for a quadrupole manufacturing. Automated winding machine.

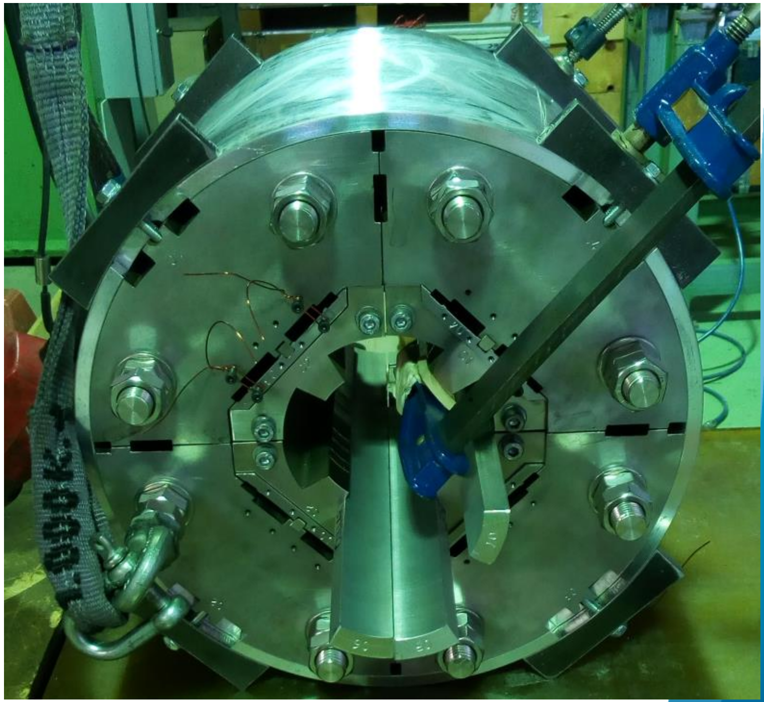
- Modular tools: Modular tooling concepts, which can easily be adapted to different size of similar magnets: a relevant cost reduction strategy for manufacturing and time to market.

Phase II Implementation: Antec-Tecnalia

ANTEC has investigated an automatic winding machine and the Bladder & Keys solution, in alternative to the collaring so far used to pre-stress the multipole magnets. First attempt to manufacturing a B&K accelerator quadrupole.

In B&K solution an outer Al shell contains the magnet forces during its operation and provides additional compressive stress to the magnet after cooling down.

mock-ups to measure mechanical parameters, validate calculations and
train with the B&K assembly process

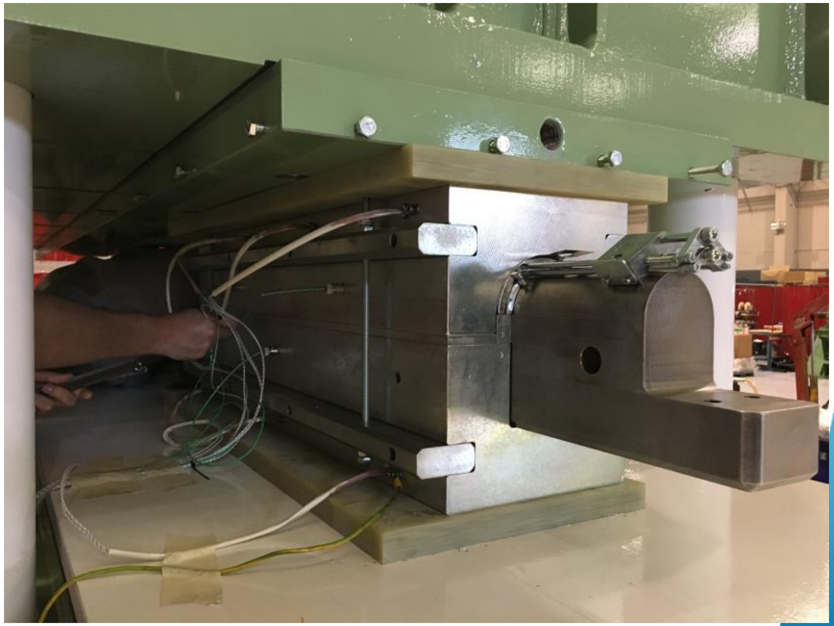


Phase II Implementation: ANTEC-Tecnalia

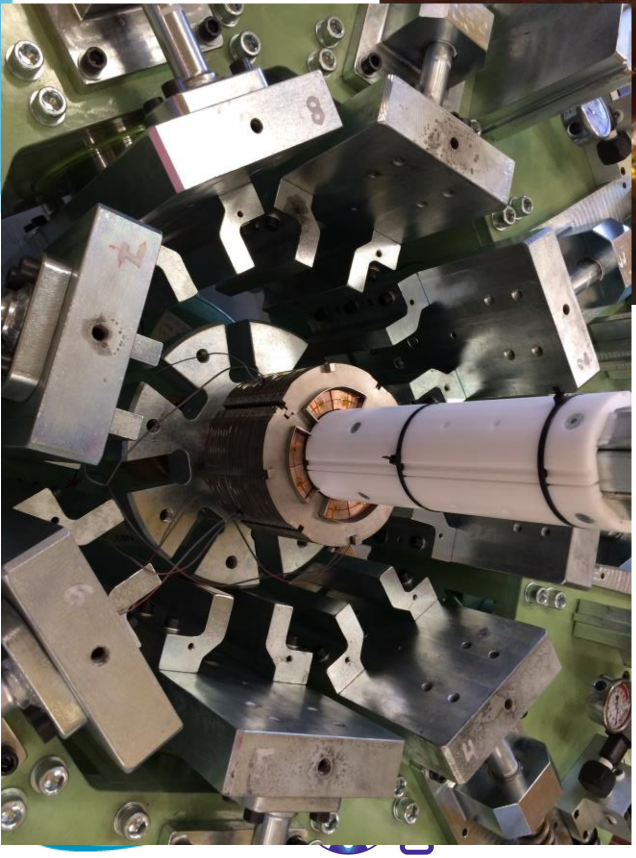
Phase II Implementation: Elytt

Short model (1 m long coil) winding test performed to optimize end-spacers.

Mock-up used to:
- validate components (i.e. insulation of Cu wedges, B-stage coating of end spacers and interlayer insulation)
- commission tooling (i.e. winding mandrel, winding posts and spools)
- verify design of the layer jump
- Optimize shape of end-spacers with real behavior of the conductor.
- Training operators in the winding of cosθ magnets
- validate the mechanical models regard to the azimuthal coil stress



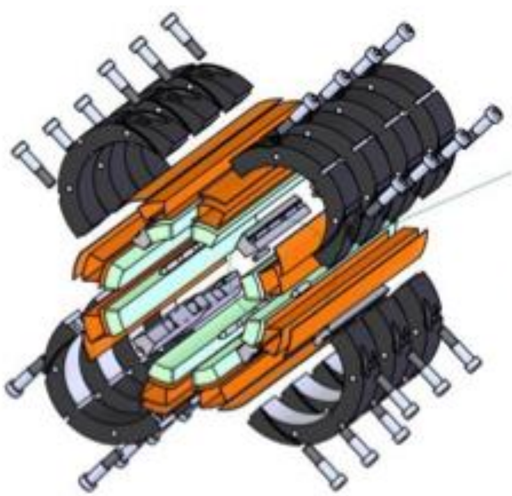
Phase II Implementation: Elytt

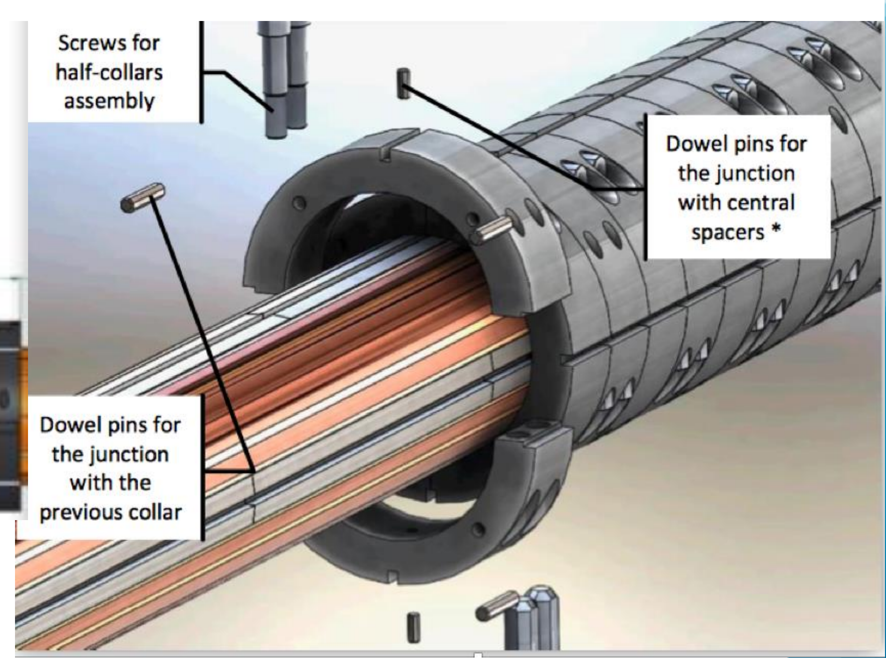


Phase II Implementation: Sigmaphi

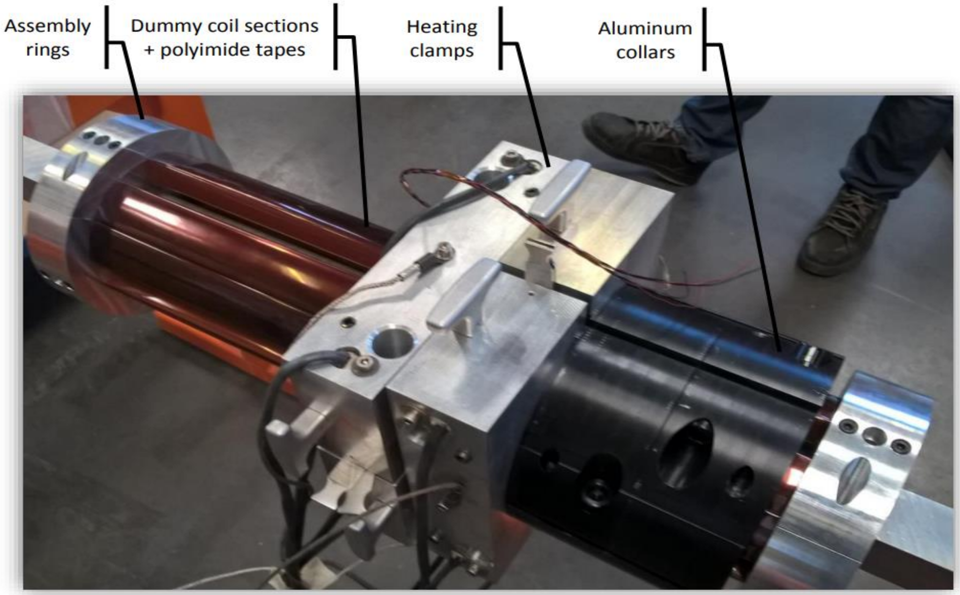
Sigmaphi has proposed an innovative concept for the collaring of MQYY magnets:
It relies on an azimuthal prestress of the coil with an oversize spacer.
This hybrid collaring melts the advantages of several existing collaring processes often used for cosΘ dipole and quadrupole sc magnets.

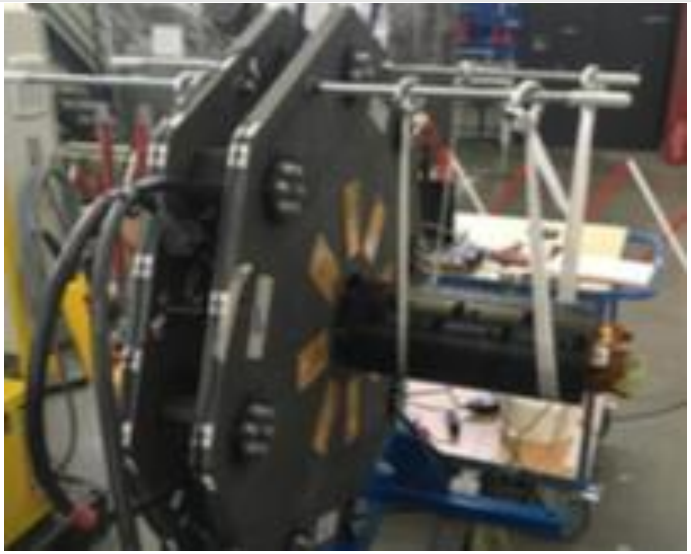
The mock-up program proposed by Sigmaphi is to prove the feasibility of the collaring with Al rings and to qualify winding, curing and collaring processes





Phase II Implementation SigmaPhi:



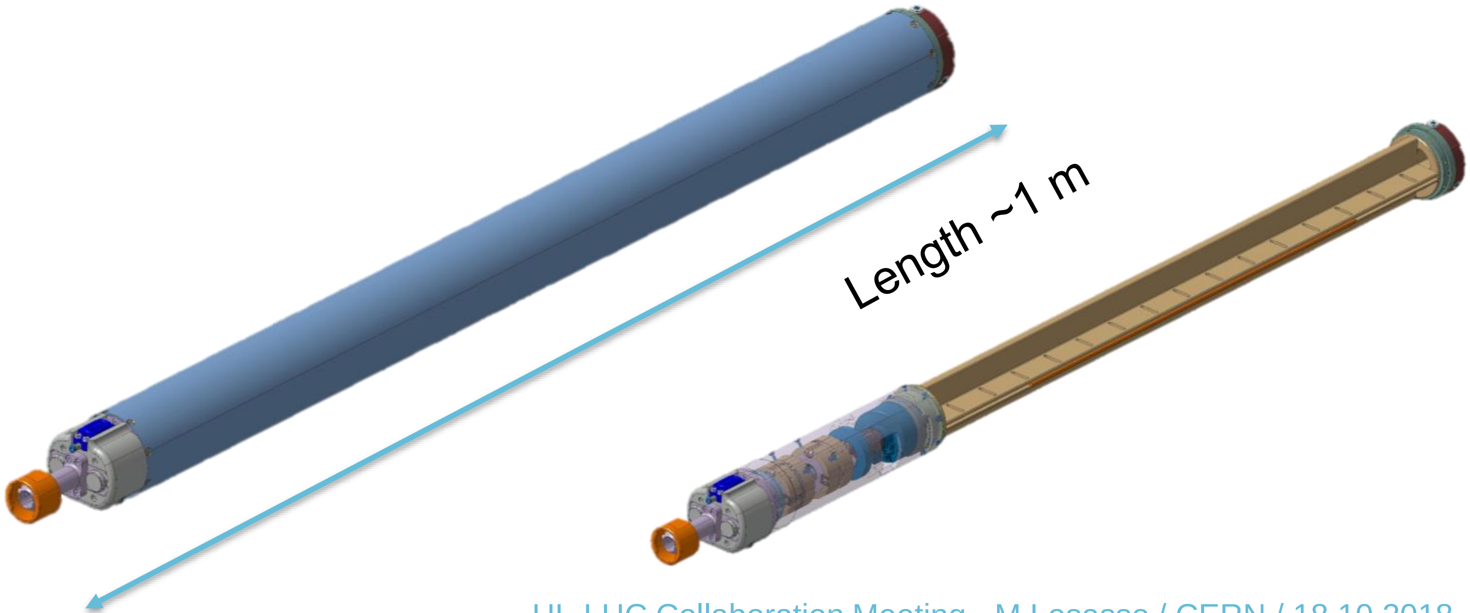


Magnetic measurement

Magnetic measures at warm shall be performed by EN/MM group (L.Fiscarelli)

Plan of magnetic measurements foresees a single equipment set of measurements for the 2 companies in phase II.

Depending on the type of magnets to measure, and on the schedule of the 2 suppliers it will be prepared a plan of activities (time duration, and schedule) that optimizes the measurements on coils.



QUACO: Business Case

Engage small/medium industries to work on edge technologies, even if no large market volumes are expected

Reduce financial risk for companies by gradually committing into the scope

Reduce technical risk for companies by splitting the scope in phases and operating technology transfer by the laboratories

Direct benefit (buyers groups)

- Pool resources to implement the project necessary for HL- LHC
- Shorten the time to R&D completion and reduce the cost
- Budget is capped → no risk of overspending
- Competition in a fixed time frame is constructive

Indirect benefit (companies and society)

- Acquire know-how potentially transferable to other markets than HEP
- Increase industrial capabilities by deploying tools usable for similar manufacturing
- Enlarge the market and incentivize innovation and novelties

Why a PCP

- No off-the-shelf technology is ready to meet the challenge represented by HL-LHC needs. The investigated advanced solutions are still at an immature level of development.

- A “conventional” tender instrument cannot address the purpose of the R&D challenge. Indeed, the effort is not matched by a potential large volume of products to attract large companies. Technological risk is too high for small companies, and the market basis is very small.

- PCP instrument can serve the purpose of enlarging the market basis (by reducing financial barrier for SMEs), to attract SMEs (by sharing the technological risk of committing into difficult R&D), to mitigate risk of over or under specifications, by engaging industries at the early stage).

- **Very innovative solutions investigated so far in QUACO: these would hardly have been possible to be developed outside of PCP scheme.**

Conclusion

The phase I and II of the project concluded successfully

4 companies (3 SME) engaged so far. 3 of those have produced extended analysis, engineering designs and mock-ups to demonstrate viability for a final manufacturing of the Q4.

Companies engaged into innovative, and in same cases, unprecedented technologies routes for this type of magnets

<u>The studied solutions are all very interesting for accelerator technology</u>

But…only 2 companies will access the last part of the project because PCP does not allow to proceed with 3 companies to the end

it is suggested to develop further all the lines of R&D progressed so far

No budget overrun. Deliverables are specified for each of the phases with mandatory requirements for payments to be done.
Time has been extended just as allowed by the HL-LHC project.

Acknowledgments

I need to thank our industrial partners **ANTEC, Elytt, SigmaPhi, Tesla** for willing to engage with the project QUACO.

A big thank to all the QUACO team for their fantastic commitment, and especially to:

CERN: I.Bejar Alonso ATS/DOC, **A.Foussat** TE/MSC, (Outi Heloma ATS/DO), J. Rodrigruez Alonso ATS/DO, C.Veys IPT/PI,

CEA: **D.Simon**, J.-M.Rifflet, E.Rochepault,

CIEMAT: **F.Toral**, T.Martinez de Alvaro,

NCBJ: P.Krawczyk, R.Nietubyc

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HL-LHC PROJECT

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Thank you !

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