PACMAN Project

PACMAN WORKSHOP

12-15 June 2016

Outline

- The technical objectives of the PACMAN project
- Introduction to the 10 PhD subjects
- Towards the PACMAN Final Test Bench

PACMAN project

PACMAN = a study on Particle Accelerator Components' Metrology and Alignment to the Nanometre scale
It is an Innovative Doctoral Program, hosted by CERN, providing training to 10 Early Stage Researchers.

Web site: **http://pacman.web.cern.ch/**

8 academic partners
8 industrial partners
Duration : 4 years
Start date: 1/09/2013

PACMAN NETWORK

CERN, CH
Cranfield University, UK
Delft University of Technology, NL
ETH Zürich, CH
IFIC, ES
LAPP, FR
SYMME, FR
University of Liberec, CZ
University of Sannio, IT
SYMME, FR
University of Pisa, IT
DMP, ES
ELTOS, IT
ETALON, DE
Hexagon Metrology, DE
METROLAB, CH
National Instruments, HU
SIGMAPHI, FR
TNO, NL

Scientific aspects

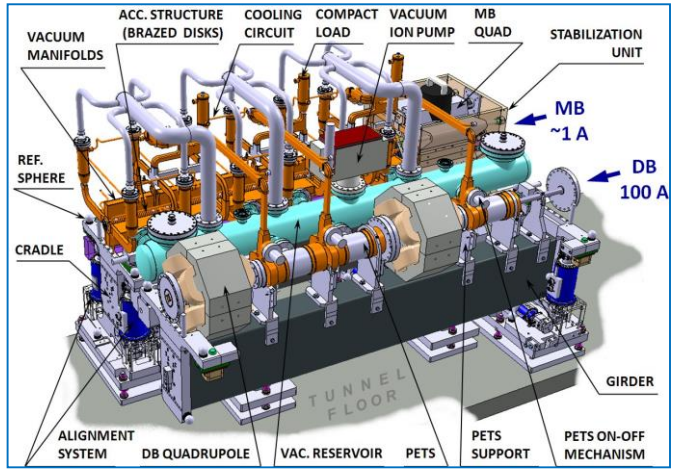
Why PACMAN?

Objective of the next generation of colliders: get the highest number of collisions

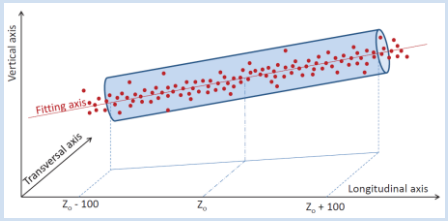
To achieve this: beams with a nanometric size

Such size of beam has a strong impact on the alignment requirements of the components of colliders:

- Micrometric pre-alignment
- Nanometric stabilization



Beam off



Mechanical pre-alignment — ~0.2 - 0.3 mm over 200 m

Active pre-alignment — 14 - 17 µm over 200 m

Beam on

Beam based Alignment & Beam based feedbacks

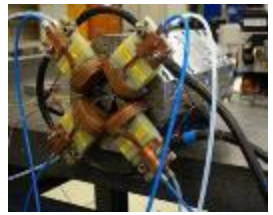
One to one steering	Dispersion Free Steering	Minimization of AS offsets
Make the beam pass through	Optimize the position of BPM & quads by varying the beam energy	Using wakefield monitors & girders actuators

→ **Minimization of the emittance growth**

Why PACMAN?

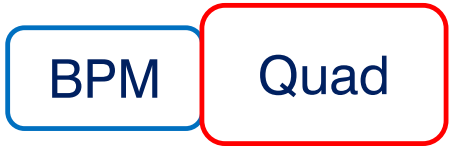
(2) State of the art

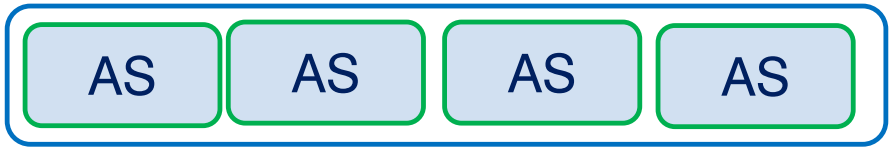
Components to be aligned:



Number of components	~ 4000	~ 4000	~ 140 000
Budget of error	14 μm	17 μm	17 μm
	BPM	Quad	AS

Strategy:



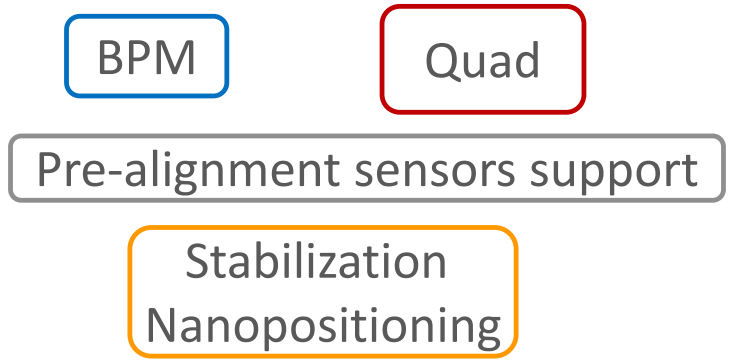


3 steps:

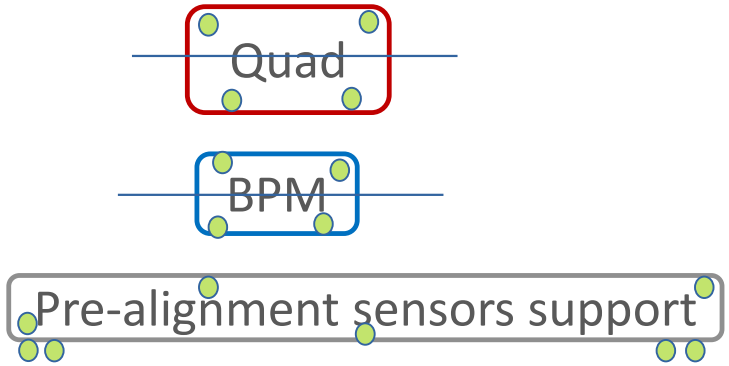
- Fiducialisation of the components and their support
- Initial alignment of the components on their support
- Transfer in tunnel and alignment in tunnel

Why PACMAN?

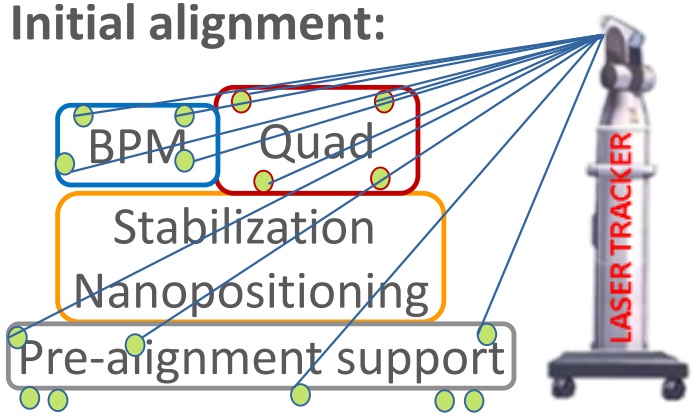
(3) Example: case of MB quad + BPM



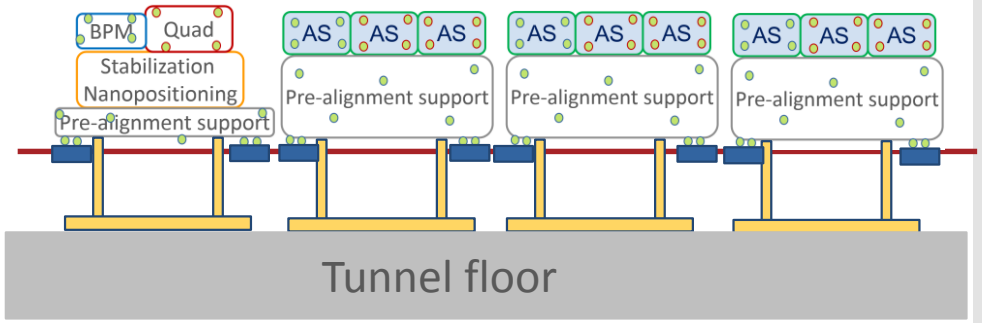
Fiducialisation:



Initial alignment:



Transfer in tunnel & alignment



- Strategy proposed for CDR in 2012. More than 20 000 assemblies!
- Accuracy achieved at that time: better than 15 µm over 140 m (mechanical reference axis) ➔ PACMAN project aims at improving that !

Objectives of PACMAN

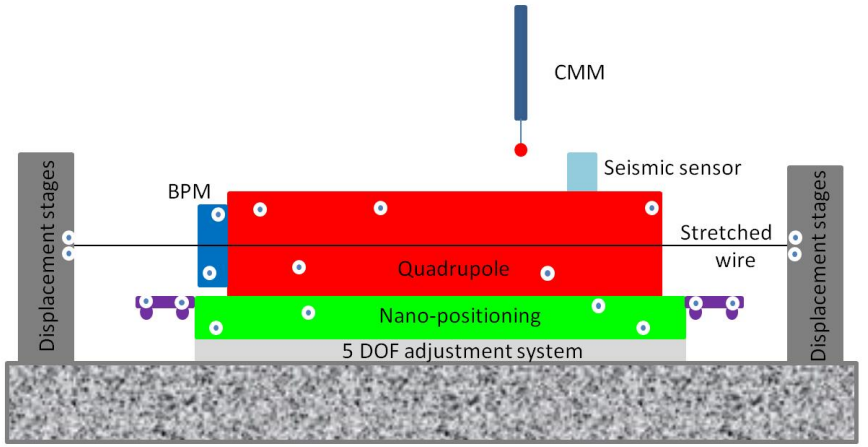
Combine references & methods of measurements in the same place to gain time and accuracy

Prove their feasibility on a final bench

Extrapolate the tools & methods developed to other projects

Some key issues:

- Upgrade of the magnetic measurements with a vibrating stretched wire (and alternative based on printed circuit boards rotating search coils)
- Determination of the electromagnetic center of BPM and AS using a stretched wire
- Development of absolute methods of measurements: new sensor for the measuring head of the 3D Coordinate Measuring Machine (CMM), Frequency Scanning Interferometry (FSI) and micro-triangulation measurements as an alternative
- Design of seismic sensors to study ground motion
- Upgrade of the nano-positioning system to check the resolution of BPM

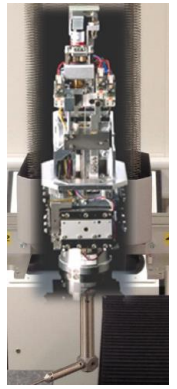


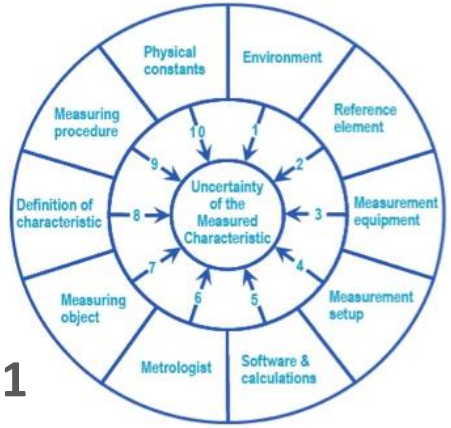
ESR 3.3

ESR 4.1

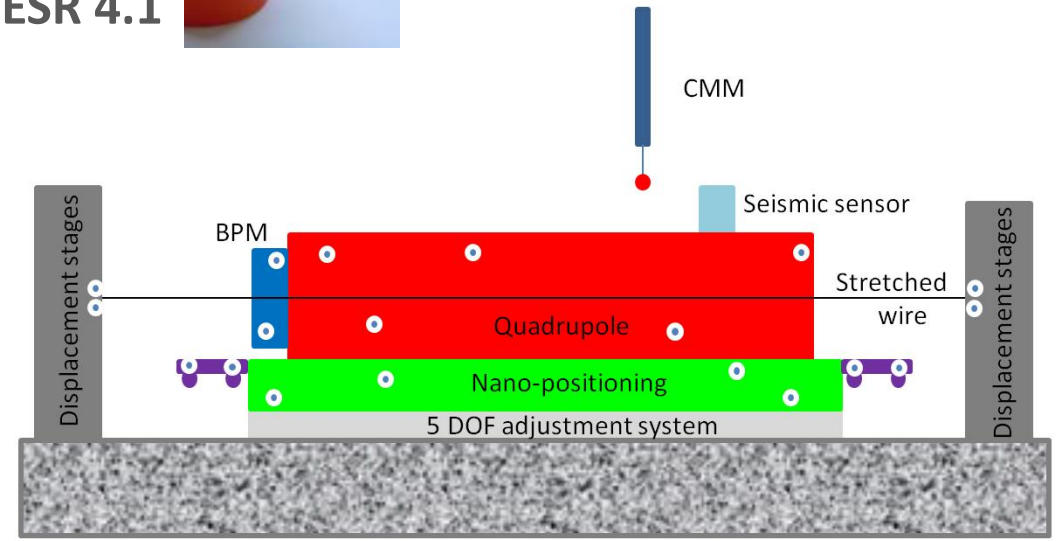
ESR 3.2

ESR 1.1





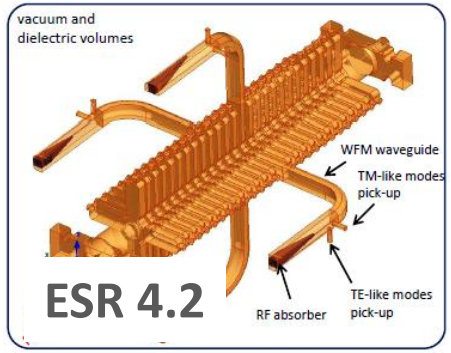
ESR 3.1



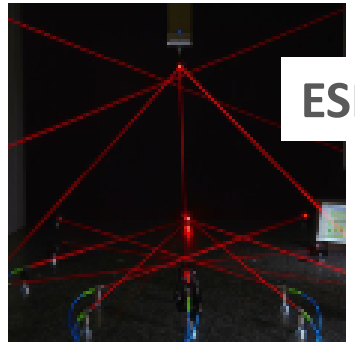
ESR 1.3

ESR 2.1

ESR 2.2



ESR 4.2



ESR 1.2

Management

Organization

Supervisory Board
CERN,
HEXAGON METROLOGY, ETALON, ELTOS, METROLAB, DMP, SIGMAPHI, NI
PISA univ., CRANFIELD, SANNIO univ., LAPP, ETHZ, IFIC, SYMME, Tech. Univ. of Liberec

Management team

WP0 Management
H. Mainaud Durand

WP5 Training
N. Catalan Lasheras

WP6 Diss & Outreach
M. Modena

Communication & admin. tasks
T. Portaluri

WP1 Metrology & Alignment
H. Mainaud Durand

WP2 Magnetic Measurements
S. Russenschuck

WP3 Precision mech. & nano-positioning
M. Modena

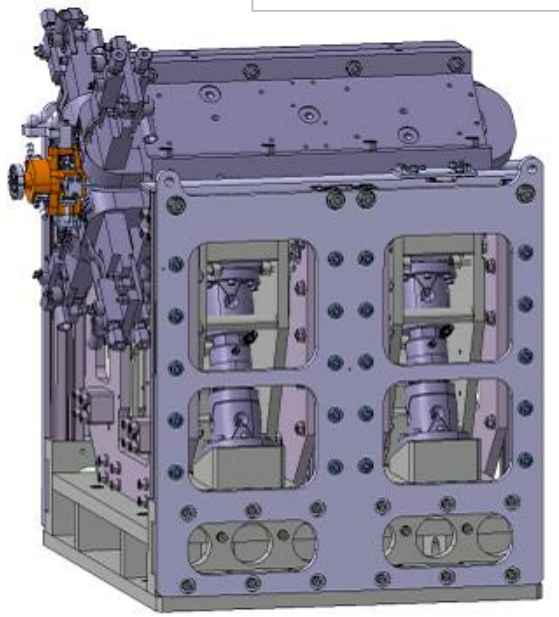
WP4 Microwave Technology
M. Wendt

Technical systems

Components to be aligned

MB quadrupole
Nominal field gradient: 200 T/m
Bore Ø: 100 mm
Length: 441 mm

RF-BPM
Operating @ 15 GHz

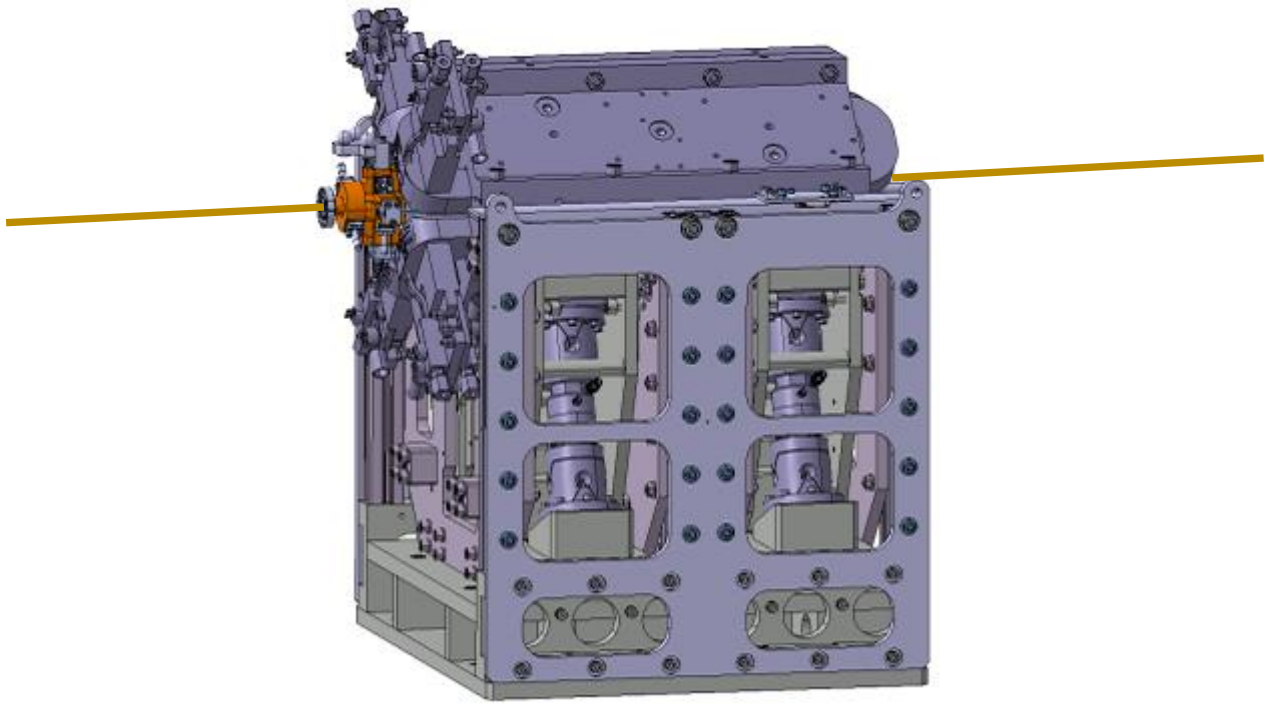


Nano-positioning
4 dofs (radial & vert. translations, pitch & yaw)
Piezo stack actuator:
- Stiffness: 480 N/µm
- Stroke: 15 µm
- Resolution: 0.15 nm

Flexural joints (high axial & rotational stiffness)

Technical systems

Reference wire

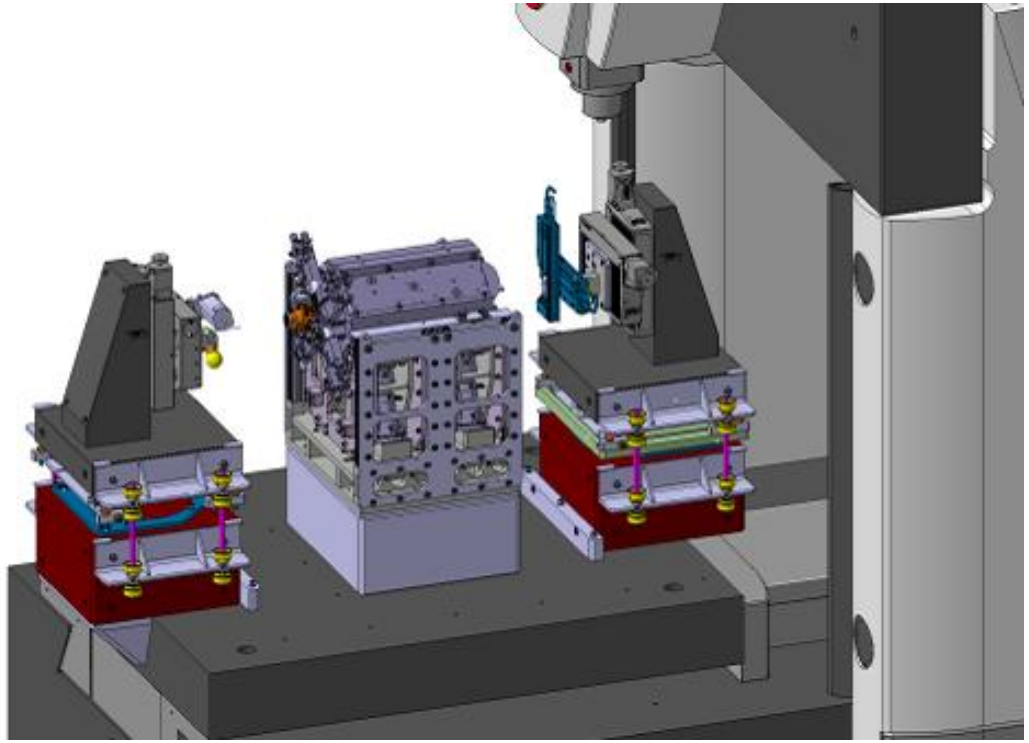


Reference wire
Copper/Beryllium (98%/2%)
Wire Ø : 100 µm

Technical systems

Wire displacement system

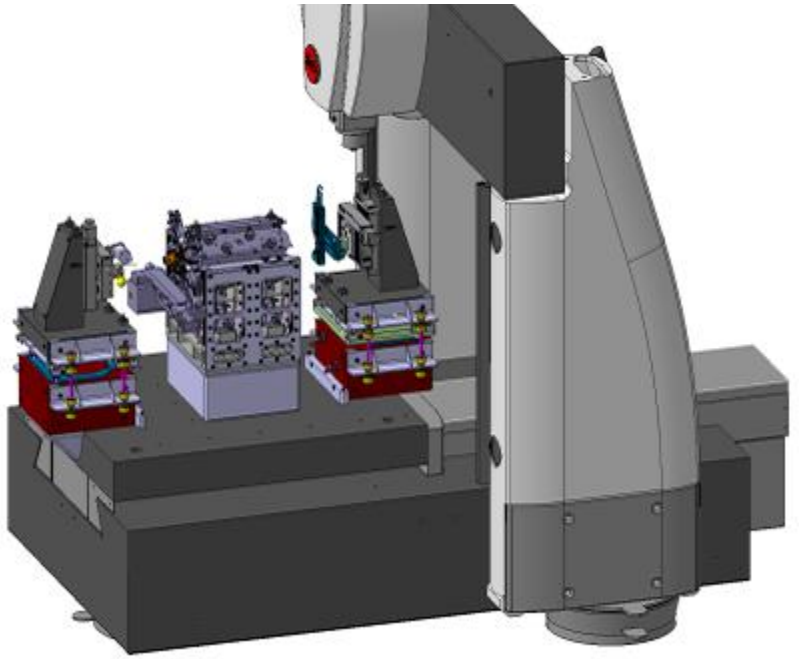
Linear displacement stages
Repeatability to position the wire < 0.1 µm
Absolute accuracy < 1 µm
Travel range : 50 mm



Sensor
Optical micrometres
Orthogonally mounted
Range: 6 mm
Repeatability: ± 0.3 µm
Accuracy: ± 0.5 µm

Technical systems

Fiducialisation

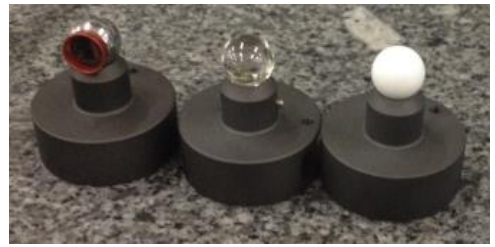


Fiducialisation

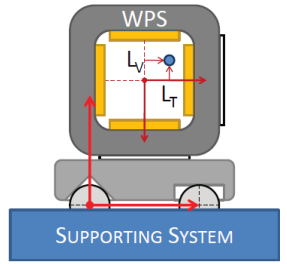
Determination of the reference axis (wire) w.r.t

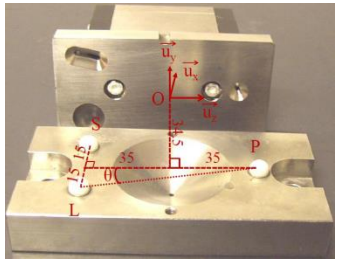
- External targets
- Sensor interface

Fiducials



Sensor interface



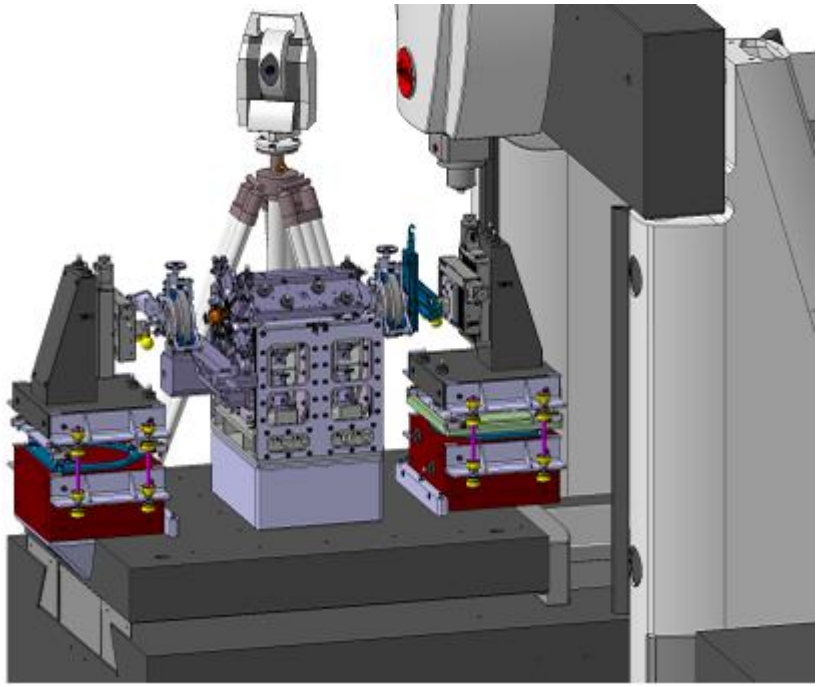


Technical systems

To locate the wire

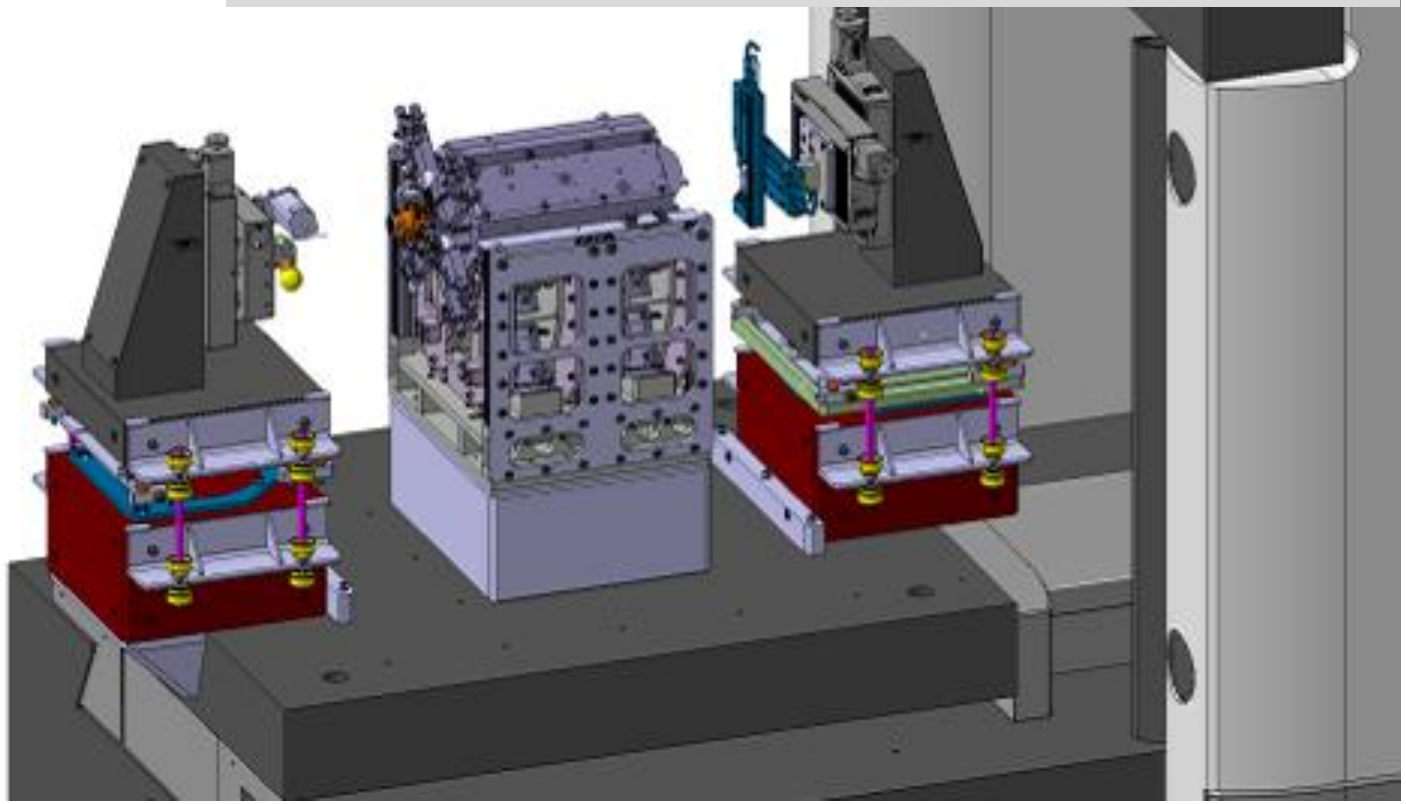
3 methods to determine the position of the wire w.r.t fiducials:

- CMM measurements
- Frequency Scanning Interferometry (FSI)
- Micro-triangulation



Next steps

- Assembly foreseen beginning of June in ISR8
- First measurements end of June in ISR8
- Measurements in the metrology lab last week of July



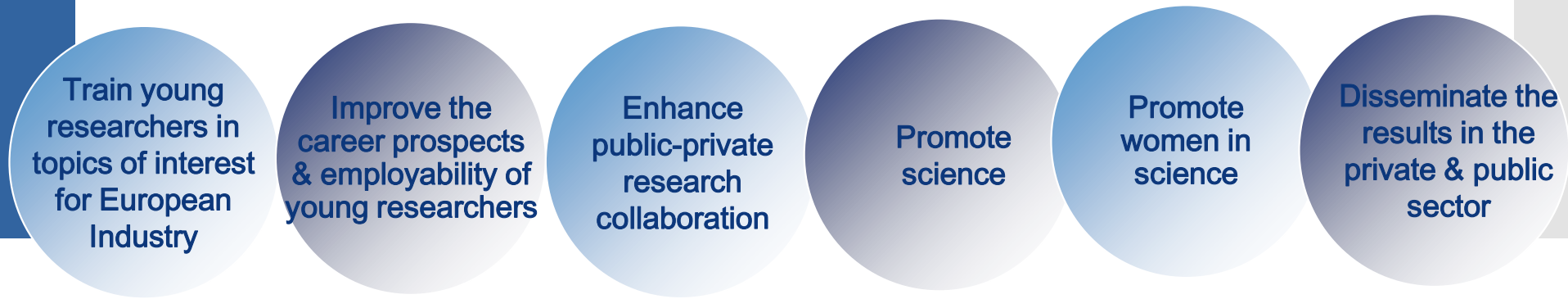
Summary

PACMAN:

- Ambitious project to improve the precision & accuracy of the pre-alignment of the CLIC components
- The solutions developed will be validated on individual test setups, before being integrated in the PACMAN final validation bench
- The tools & methods will be extrapolated to other projects

This is the technical dimension of the project, but there is another dimension:

➔ a high quality training program, with the aim to:



PACMAN is a team work :

The students:

- Claude Sanz
- Vasileios Vlachakis
- Solomon Kamugasa
- Domenico Caiazza
- Giordana Severino
- Iordan Doytchinov
- Peter Novotny
- David Tshilumba
- Silvia Zorzetti
- Natalia Galindo Munoz

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- Pasquale Arpaia
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- Bernard Caron
- Jo Spronck
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- Angeles Faus Golfe

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- Jean-Frédéric Fuchs
- Stefan Russenschuck
- Marco Buzio
- Michele Modena
- Andrea Gaddi
- Kurt Artoos
- Manfred Wendt
- Nuria Catalan Lasheras

The industrial partners:

- Jurgen Schneider, Norbert Steffens, Heinrich Schwenke, Marie-Julie Leray, Pascal Lequerre, Alicia Gomez, Teun van den Dool, Augusto Mandelli, Jacques Tinembart, Philip Keller, Miroslav Sulc

CERN support:

- Seamus Hegarty, Charlyne Rabe, Karen Ernst, Gregory Cavallo, Nicolas Friedli, David Mazur

Thank you very much!

PACMAN WORKSHOP

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