

INŻYNIER W CERN: Metrologia i Automatyka

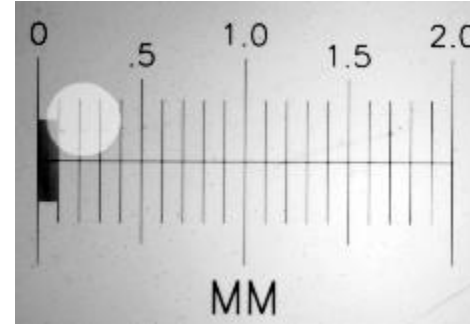
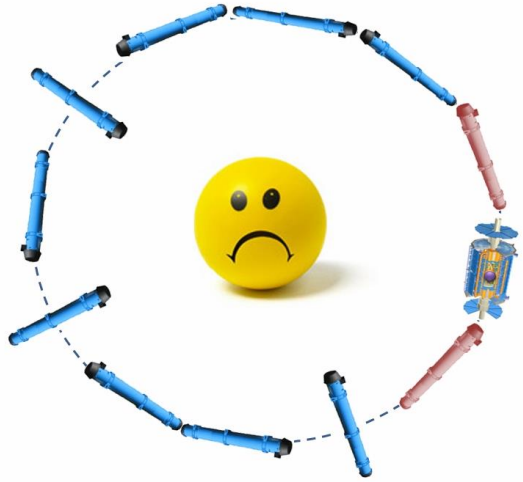
Mateusz Sosin
CERN High Precision Alignment Team



Content

- Introduction to accelerator alignment and metrology
- Our Team
 - Survey & Alignment
 - Acquisition, Processing & Controls
 - Mechatronics & Robotics
 - Measurement electronics , Tests & Analysis
- Polish engineers in SMM
- Summary

Accelerator alignment and metrology



$$1 \text{ micrometer} = \frac{1}{1\,000} \text{ millimeter}$$
$$= \frac{1}{1\,000\,000} \text{ meter}$$

- 1 hair = 100 micrometres
- 1 grain of flour = 10 micrometres

Precise alignment of accelerator components is crucial for proper operation of accelerator

- Typical accelerator components need to be aligned with precision 100...500 micrometres
- Special ones need to be aligned with a precision of few micrometres, remotely, in real time

But not only alignment → environment and mechanical measurements

CERN Surveyors

- A surveyor ?



Objects = land, building, roads, ...



- **At CERN**

- Objects = components of accelerators (magnets, detectors, accelerating structures ...)
- Huge quantities of objects to be measured and maintained
- Measurements often in harsh accelerator conditions (cryogenics, radiation)

S

urvey

M

echatronics

M

eamurements



ASG
Accelerators Surveying & Geodesy
D. Missiaen

ESA
Experiments Surveying & Alignment
J-C. Gayde

HPA
High Precision Alignment Technologies
H. Mainaud-Durand

APC
Acquisition, Processing & Control software
A. Masi

MRO
Mechatronics, Robotics & Operation
M. Di Castro

RME
Radiation Tolerant & Measurement Electronics
S. Danzeca

MTA
Measurements Tests & Analysis
A. Rijllart

Survey:

- Accelerators Metrology
- Experiments Metrology
- High Precision Alignment Technologies

Mechatronics:

- Mechatronics & Robotics
- Acquisition & Control Software
- Survey mechatronics

Measurements:

- Radiation effects on the electronics
- Measurement electronics development
- Measurements Tests & Analysis using LabVIEW and NI
- Position & Mechanical measurements in radiation (i.e. temperature, pressure, acceleration, vibrations, strain gauges, thermal camera, pyrometers, etc.)
- Measurement theory is an expertise common to the entire group

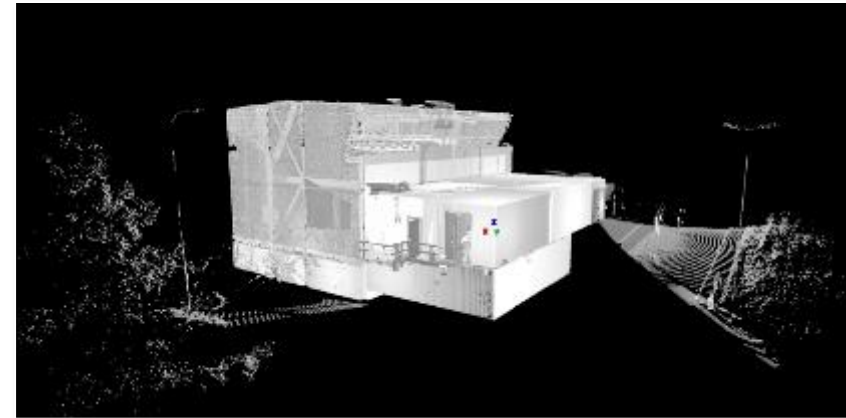


Accelerators Survey & Geodesy



Quality controls, contributions to assembly works, or fiducialisation of accelerators' components

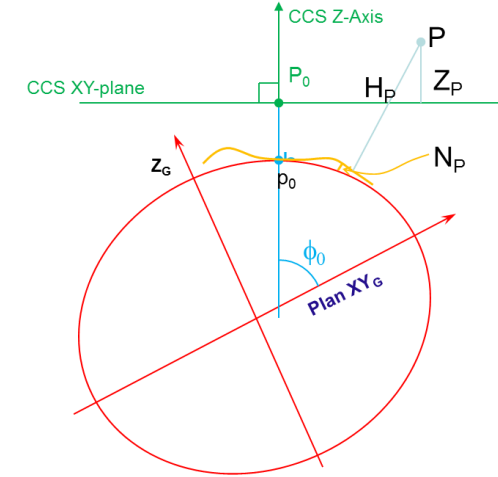
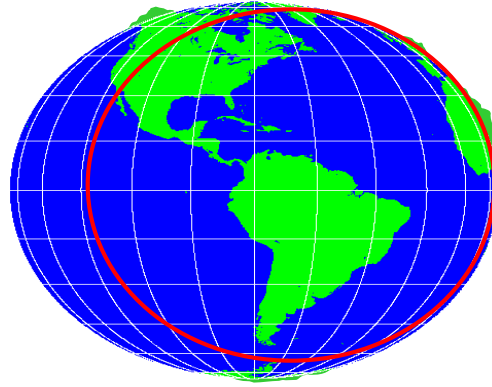
133 lines, 60 km of beam,
40000 components



3D high accuracy scans and as-built measurements

The metrology, alignment and smoothing of the components of accelerators and transfer lines as well as ...

Accelerators Survey & Geodesy



- The geodetic reference systems used for the CERN,
- The relationships between these and local reference systems geodetic mathematical models
- The maintenance and evolution of the related geodetic reference networks
- Definition of beam lines

the geodesy for all positioning related activities across the whole CERN site, current projects and studies

Experiments Survey & Alignment



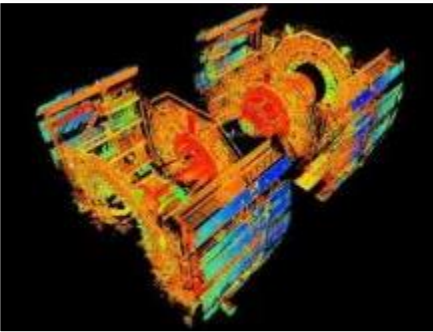
Detector metrology



Assembly geometrical follow-up



Alignment on the beam lines



As-built measurements



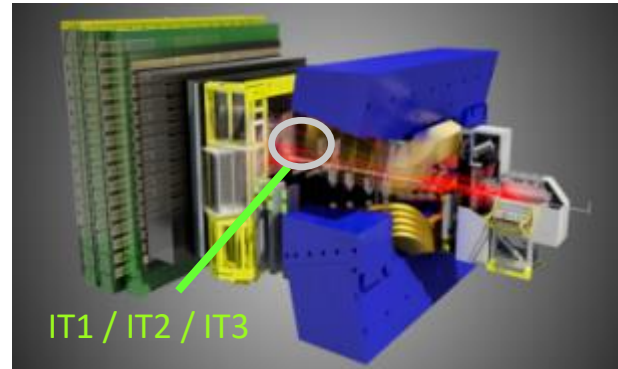
Geometrical infrastructure for detector installation



Survey for all the Experiments at CERN as well as ...

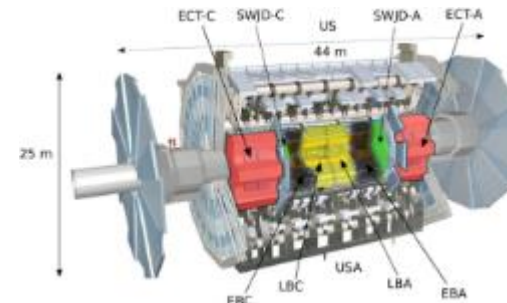
Experiments Survey & Alignment

LHCb Inner Tracker Monitoring system

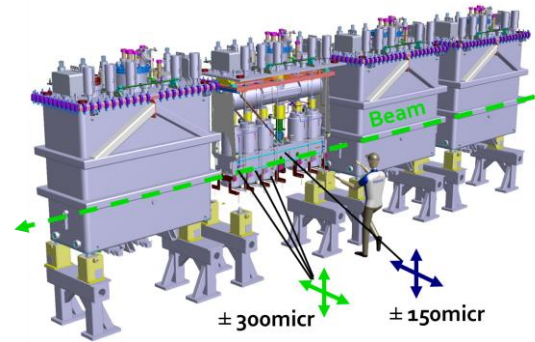


- Monitoring of the IT chambers
- Precision 0.1 mm for relative movements

ADEPO (Atlas DETector POsitioning)



- 6 Detectors to be re-positioned at closure
- *In total ~2500 t of detector are moved*
- Relative repositioning at 0.3 mm (1 sigma)
- Movement follow-up at 0.1 mm



HIE-ISOLDE Alignment - MATHILDE

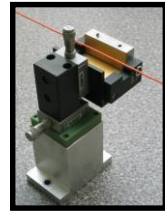
- Alignment and monitoring on full LINAC of Cavities and Solenoids
- Precision : 300 μm for Cavities / 150 μm for Solenoids
- Constraints: High vacuum 10⁻⁸ bar / Temperature 4K (cryo) / Integration / Large number of targets

The R&D for the experiments alignment and monitoring systems

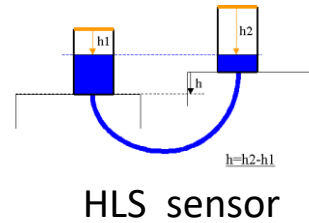
High Precision Alignment technologies



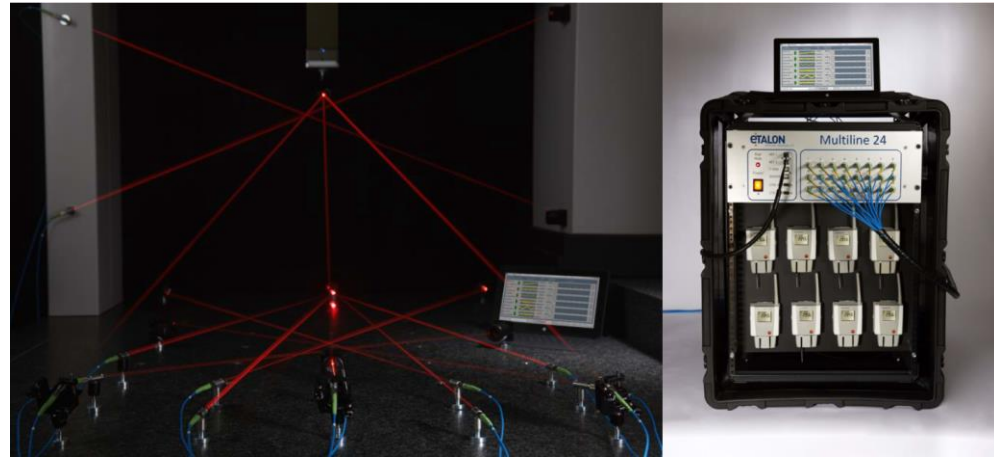
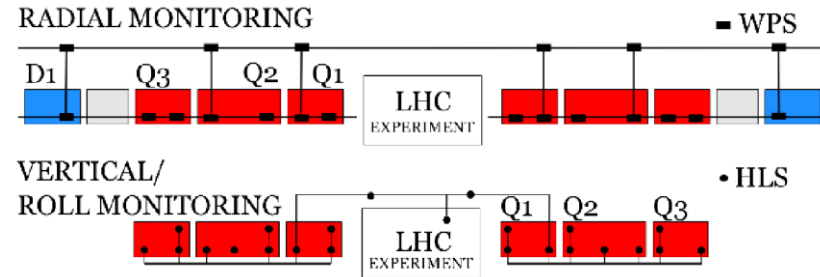
LHC low beta quadrupoles



WPS sensor



HLS sensor



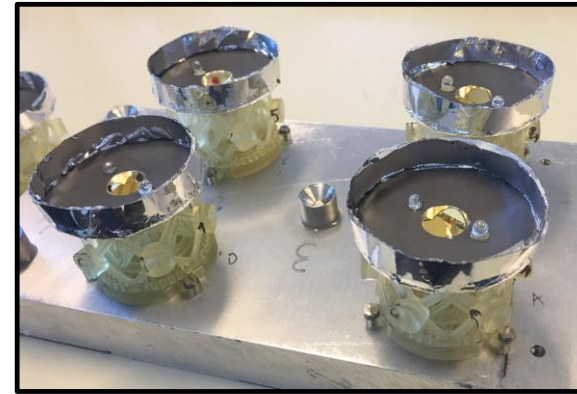
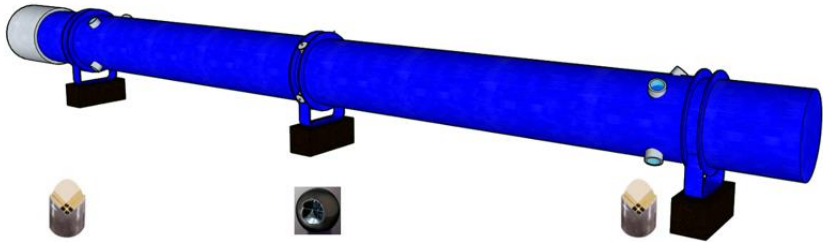
Design, implementation, operation and data analysis of 3D alignment solutions for specific components in the accelerators and experiments, within a micrometric accuracy in a harsh environment

High Precision Alignment technologies

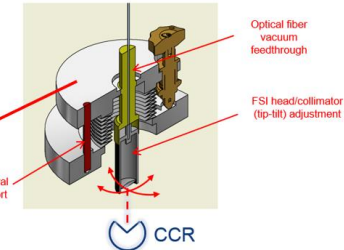
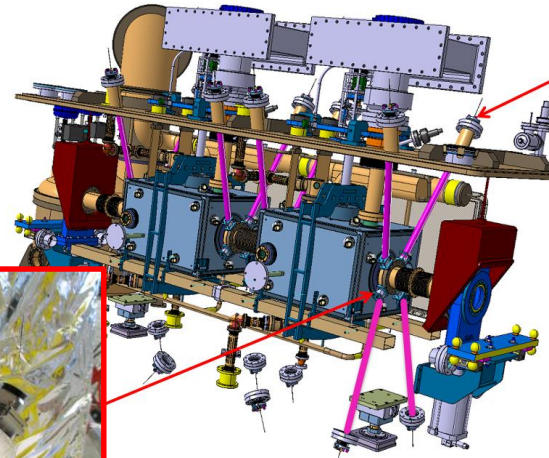
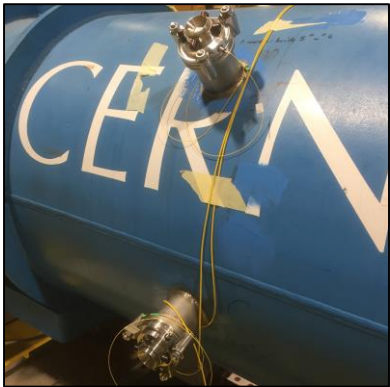
4 FSI mount + collimator
+ Viewport
+ 4 Newport reflector

4 Feedthrough
+ 4 CCR PLX (1.5")

4 FSI mount + collimator
+ Viewport
+ 4 Newport reflector



Internal monitoring of cold mass and crab cavities inside their cryostat through Frequency Scanning Interferometry

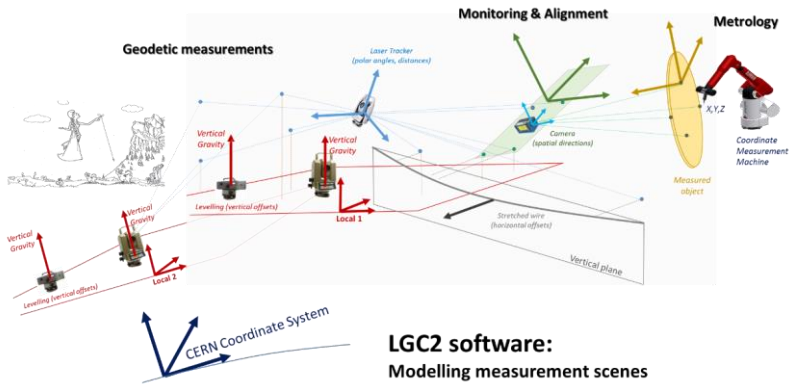
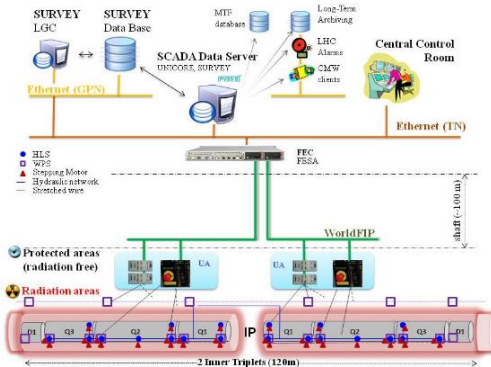


Research and Development to improve alignment techniques and methods

Acquisition, Processing & Control software

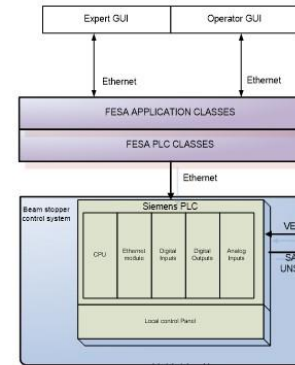
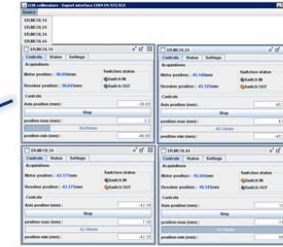


Survey Database and GEODE



LGC2 software:
Modelling measurement scenes
by frame hierarchies...

Development Expert User Interfaces and application programs for the moveable devices operation in Java



FESA Classes (C++ RT) development for monitoring & Control of Beam Intercepting Devices

interfacing to PLC through SILECS



BIDs

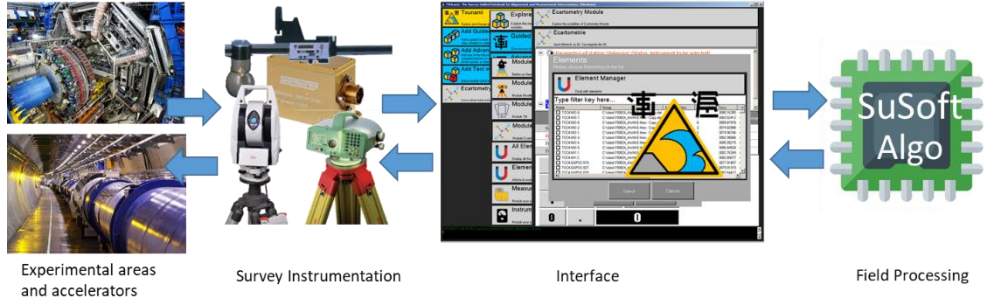


LHC collimators

Design, development and maintenance of the software for the survey and for the acquisition & control of mechatronic systems

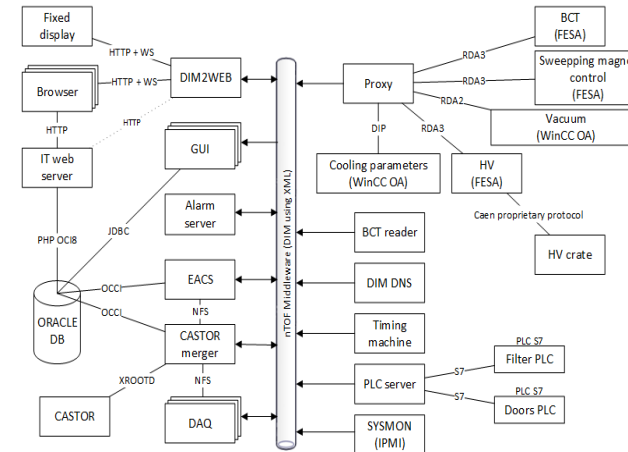
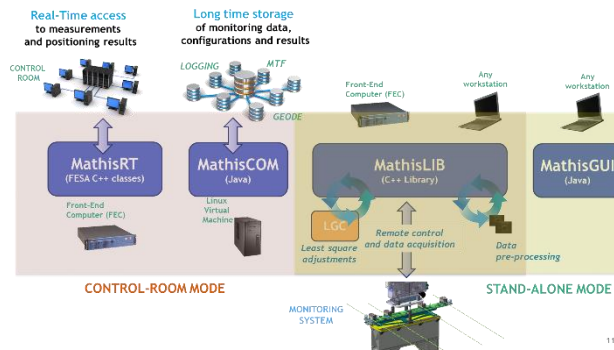
Acquisition, Processing & Control software

TSUNAMI (*The Survey Unified Notebook for Alignment and Measurement Interventions*)



Web monitoring

MATHIS (*Monitoring and Alignment Tracking*)



- Technical support to the informatics infrastructure of the group
- Development of software tools for surveyors

Mechatronics, Robotics & Operation



North Area BIDs consolidation



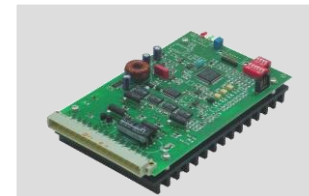
Control system PLC based



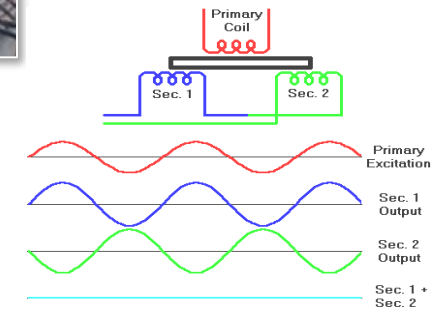
LHC Collimators



Motor



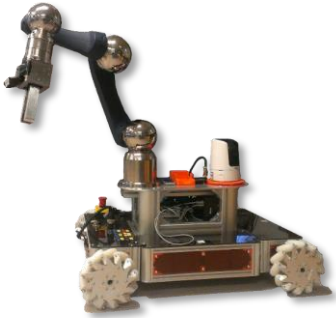
Driver



Position sensors

Design, installation, operation and maintenance of the mechatronics systems including the development and support of industrial automation solutions based on PLCs and sensors R&D

Mechatronics, Robotics & Operation



CERNBot



Teodor



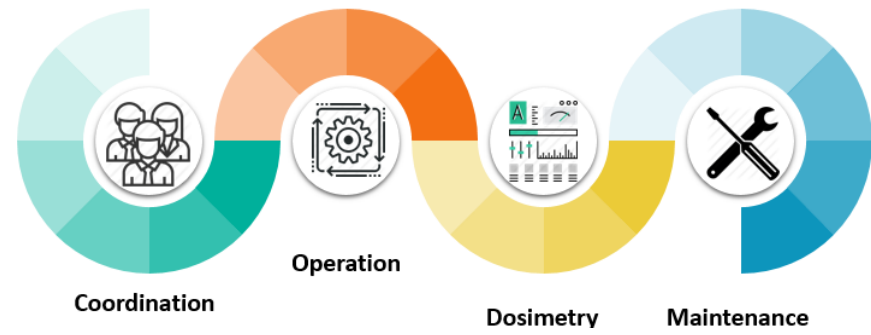
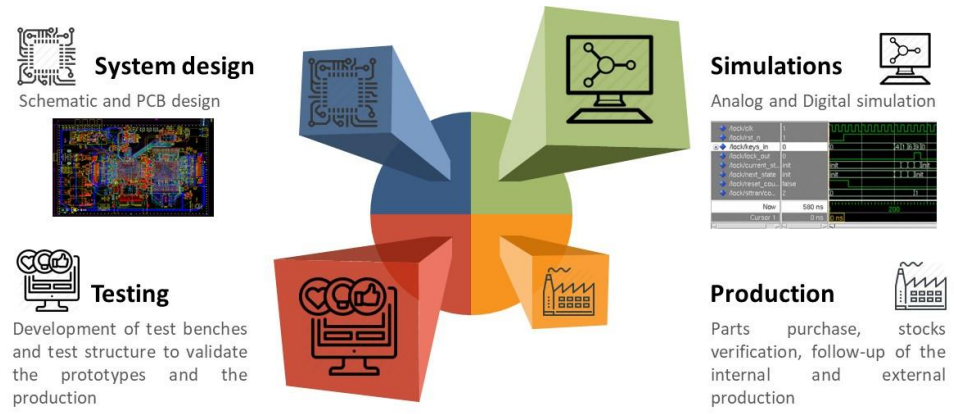
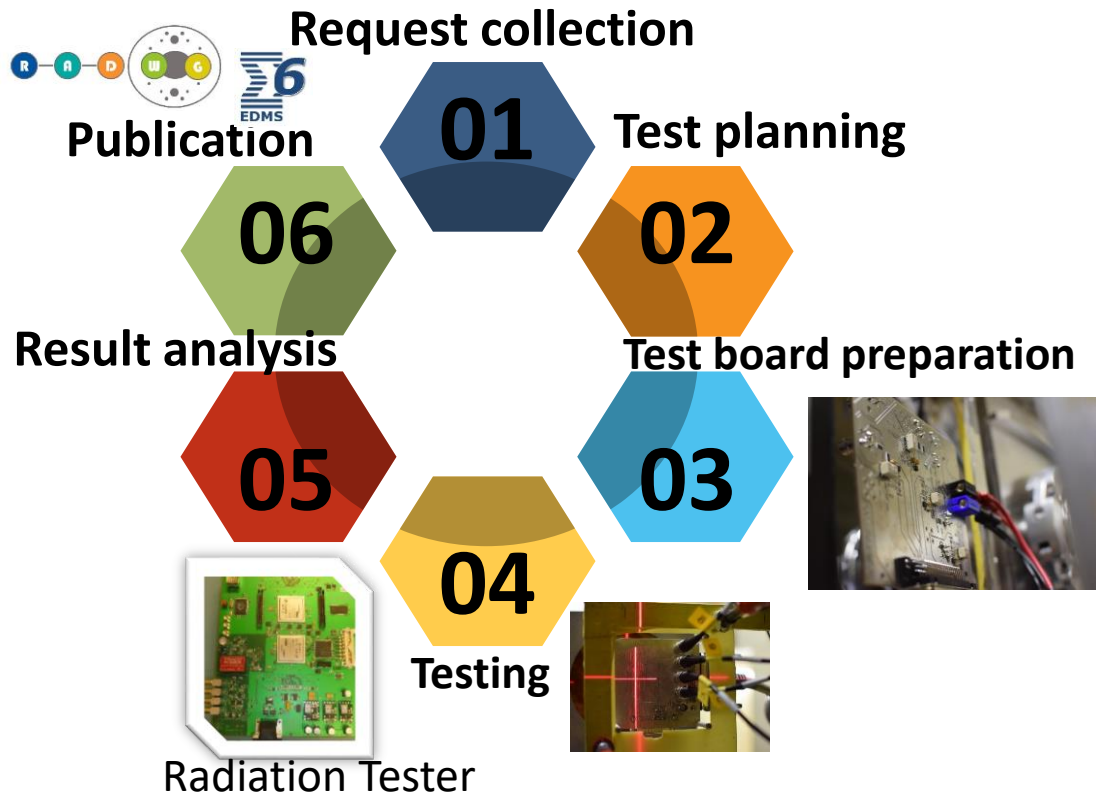
TIM



Telemax

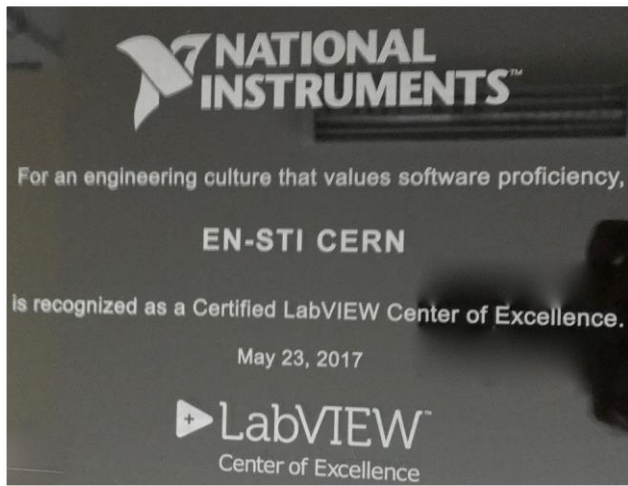
- Robotic support and remote interventions in the entire CERN accelerator complex
- Development of novel robotic solutions for remote robotic inspection and tele-manipulation in hazardous environments

Radiation tolerant and Measurement Electronics



- Radiation tests of electronic components and devices
- Design of radiation tolerant accelerator electronics
- Coordination and the operation of irradiation facilities

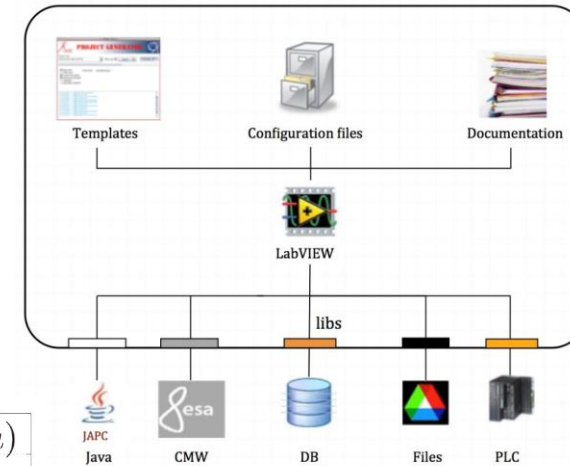
Measurement Tests & Analysis Section



LabVIEW support



RADE framework



Training

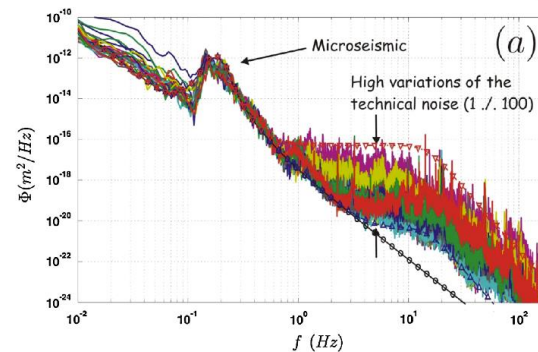


Support

LabVIEW software packages



Seismic DAQ at CERN



Solutions for measurement & test systems and data analysis applications for accelerator components, based on LabVIEW and National Instruments equipment



Our Team

SMM

GL: A.Masi
DGL: H. Mainaud-Durand
Administration: L. E. Catherall (TEMC)

ASG

Accelerators Survey &
Geodesy
D. Missiaen

Machines

- J-F. Fuchs
- P. Bestmann
- P. Dewitte
- T. Dobers
- J. Labarthe-Vacquier
- M. Tortrat
- P. Valentin
- C. Vendevre
- V. Vlachakis
- J. Mees

Geodesy

- M. Jones
- N. Ibarrola Subiza

Contracts

- 2 permanent + 13 during LS and YETS

ESA

Experiments
Survey & Alignment
J-C. Gayde

Experiments

- A. Behrens
- A. Beynel
- C. Cumer
- D. Mergelkuhl
- P. Sainvitu
- K. Nikolitsas

Ext. Collab. Support (During stops)

ATLAS/JINR:
N. Azaryan
V. Batusov
M. Lyablin
A. Pluzhnikov

CMS:
N. Beni

+ Additionnal FTE during programmed stops

HPA

High Precision Alignment
Technologies
H. Mainaud-Durand

MTI

- A. Herty
New Survey Eng.
- A. Marin
- M. Rousseau
- M. Sosin
- T. Dijoud
- M. Duquenne
- J. Jaros
- J. Kemppinen
- K. Kucel
- V. Rude
- A. Zemanek
- K. Jurkiewicz

Industrial support

Field Support unit (2)

APC

Acquisition, Processing &
Control software
A. Masi

Industrial informatics

- M. Donze`
New Software Engineer
- A. Chelba
- A. Giraud
- R. Esposito (VISC)

Computing Software

- F. Klumb
- A-V. Naegely
- M. Barbier
- Q. Dorleat
- C. Logren
- A. Bensahla Talet
- I. Iliev

MRO

Mechanics, Robotics &
Operation
M. Di Castro

Mechanics

- M. Butcher
- L. Grec
- K. Adam Szczurek
- K. Klys (TECH)
- P. Serrano Galvez (DOCT)
- J. Sola Merino (TRNE)
- S. Gargiulo (TECH)

Electromech. Projects

- T. Feniet

Test benches support & Fast prototyping

Robotics

- L. Faisandel
- L. R. Buonocore
- G. Lilli
- P. Ptasznik
- M. Baiguera Tambutti
- A. Mosca
- J. Camarero Vera
- L. Attard
- A. Ivanovs
- C. Veiga Almagro (FTEC)
- G. Lunghi (DOCT)
- D. Blanco Mulero (TECH)
- S. Solis Paiva (TRNE)
- M. Zheng (TRNE)
- A. Strano (TRNE)
- M. Enthoven (TRNE)

Industrial support

- Jerome Lendaro
- Field Support unit EN14 (15)

RME

Radiation Tolerant &
Measurement Electronics
S. Danzeca

Radiation tests

- S. Chalaye
- M. Sanchez
- T. Borel (COAS)
- M. Brucoli (DOCT)
- C. Cangialosi
- R. Castellotti (TECH)
- J. Cesari Bohigas (COAS)
- R. Ferraro (DOCT)
- G. Tsiligiannis
- G. Gnemmi (TRNE)

Electronics

- P. Peronnard
- G. Foucard (TEMC)
- C. Mcallister
- G. Piscopo (TRNE)

MTA

Measurements Test &
Analysis
A. Rijllart

MTA

- C. Charrondiere
- E. Rasoaseheno Dit Michel
- H. Reymond
- O. Oyvind Andreassen
New MTA Engineer
- J. Blanco Alonso
- K. Develle
- C. Dionisio Barreto
- M. Fernandez Garcia
- F. Gomez De La Cruz
- P. Koziol
- M. Miskowicz
- C. Quesada Jimenez (TECH)
- R. Rossel
- J. Soczynski
- S. Sudak
- J. Tagg (ENTC)
- T. Vadon (TRNE)

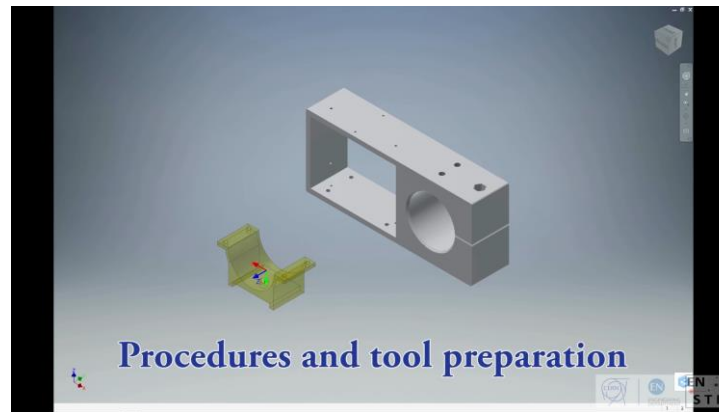
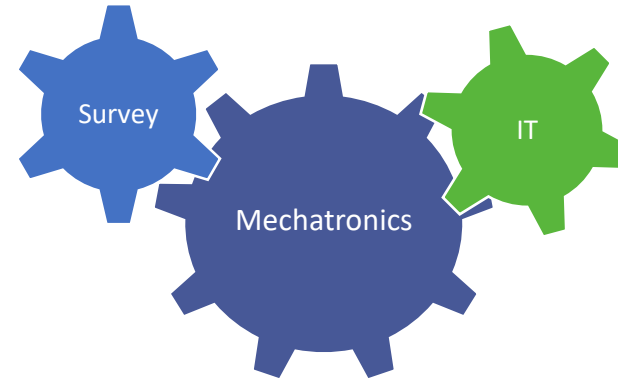
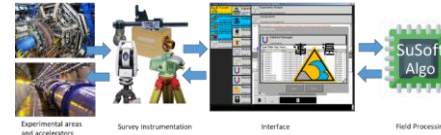
Staff
Fellow
PJAs/COAs
Tech. / admin / doc/Trn
Ent. / Temp
° New
From Ext. Collab

Our Team

- 14 Polish specialists works in SMM group
- Most of them started to work in CERN grace to collaboration with AGH UST
- Only in my (High Precision Alignment) section there is 6 Polish engineers per 15 team members

Modern metrology and automation of accelerators requires synergy of different teams with various specialisations

- Surveyors
- Mechanical & Material engineers
- Control engineers
- Electronics Engineers
- IT specialists
- Mathematicians



Thanks to all of you for your attention