

HL-LHC Geodesy and Computing

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Outline

- Geodesy
 - Available Geodetic Infrastructure
 - Role in HL-LHC Project
- Computing
 - Software for Civil Engineering
- Project Activities
 - Past, Current and Future

Geodetic Infrastructure –Reference Systems

- CCS
 - Position and orientation of existing tunnels and infrastructure
- CGRF
 - Link to CCS and other Local Systems at CERN
 - Link to global geocentric reference frames (ITRF / WGS / ...)
- Ellipsoid and Geoid
 - LHC => GRS80 + CG1985 machine
 - Orthographic Projection CERN XYHg (LHC)

Geodetic Infrastructure –Reference Systems

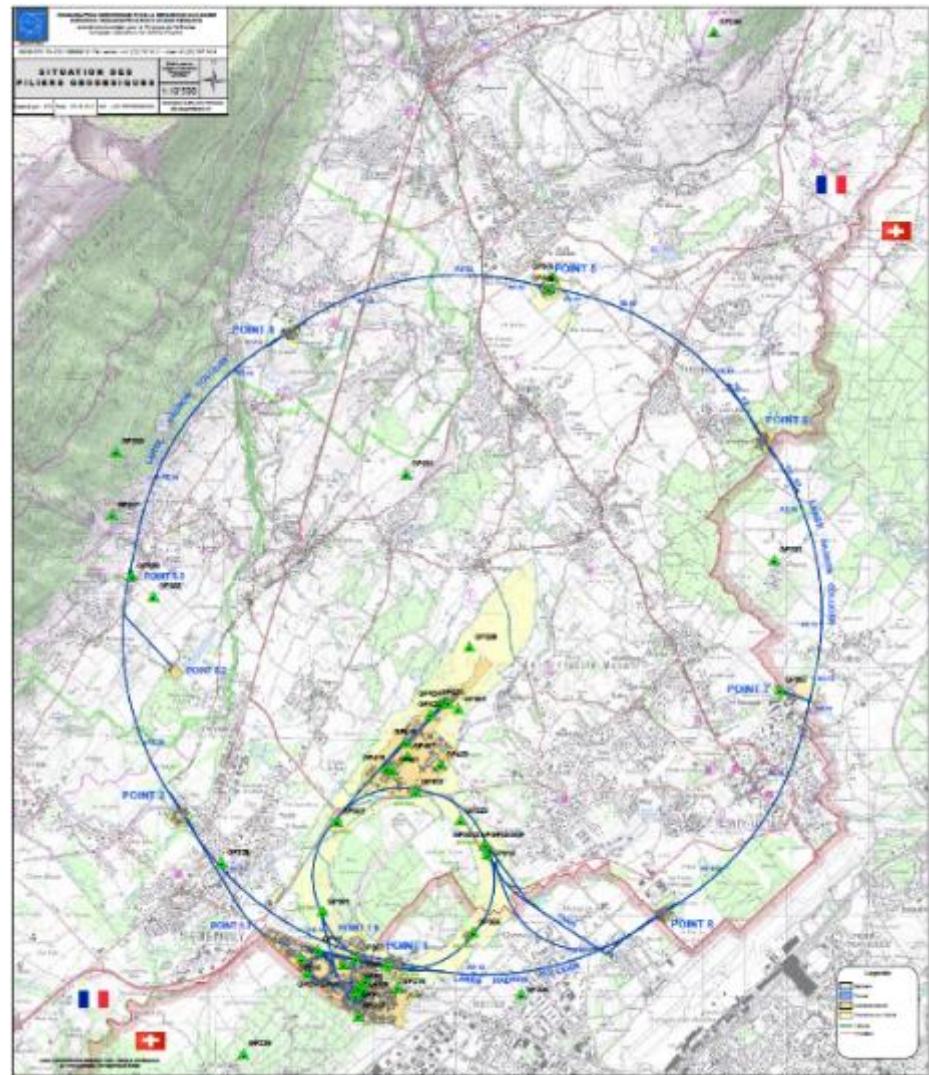
- Local Astronomical Systems
 - Atlas1102 at IP1 and CMS1503 at IP5
 - Civil Engineering and Integration teams
 - Project Design Work

Geodetic Infrastructure -Network and Control Baselines

- Permanent GNSS Reference Station on building 865
 - Integrated into French RGP : id = CERN
- Geodetic Surface Reference Network
 - ~40 Geodetic Pillars; Coordinates known
- External EDM Calibration Line
 - 13 pillars, 1.5 km; Distances known
- Gyro Theodolite Control Baselines
 - GP404 + GP228 used for LEP
 - GP231 + GP215/223/226/228/233
GP226 + GP215/229/231/353
 - Used for LINAC4; Azimuths known

Geodetic Surface Reference Network

~ 40 pillars across the CERN Site

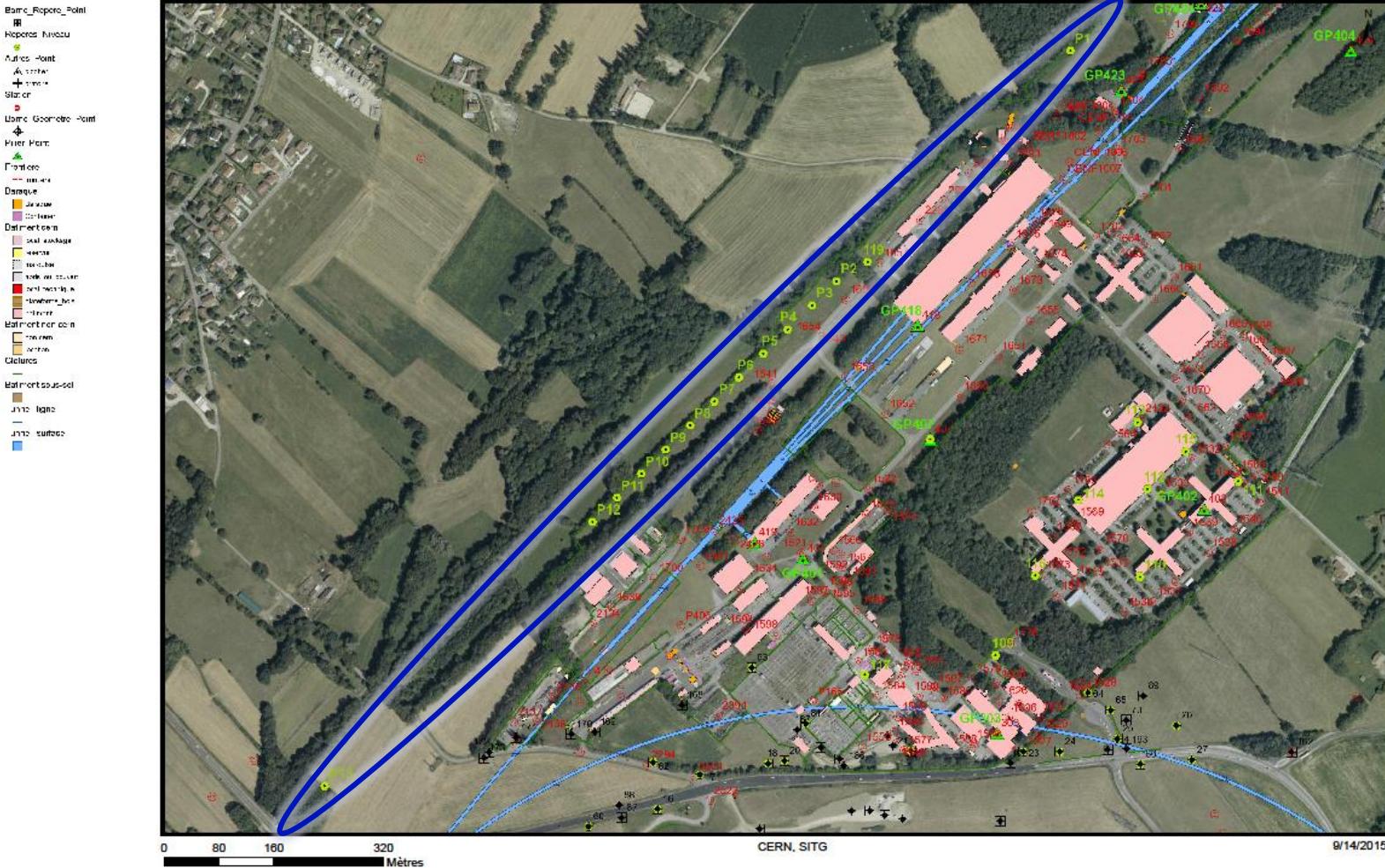


EDM Calibration BaseLine



CERN Geographic
Information System

Geodetic Calibration Line



Pillar Reference Point

CERN standard reference socket



Geodetic Infrastructure – Current References

- Jones, M.A., “Brief Description of the Principal CERN Reference Systems”
- Gervaise et al., “Système Tridimensionnel de Coordonnées Utilisé au CERN”
- Jones, M.A., “Geodetic Definition (Datum Parameters) of the CERN Coordinate System”
- Jones, M.A., “Geodetic and Astronomical Reference & Coordinate Systems”
- SURVEY Database → Pillars
(Zone = Surface; Classe = GP → Network,
Classe = PBASE → Calibration Line)

Role -Liaison for Geodesy

- Provide information and guidance
 - CERN geodetic reference systems and the transformations between them
 - Geodetic infrastructure
- Provide Documentation & presentations
- Contacts
 - CERN project team, civil engineering, integration
 - Construction Consultants and Contractors

Computing -Software Applications

- CERN_ZH
 - Application to transform points between the CCS and the CERN Orthographic Projection $(X_P, Y_P, Z_P) \leftrightarrow (X_P, Y_P, H_P)$
- CERN_dH
 - Application to determine the coordinates of a new point on the same plumbline (vertical) as another given point. The altitude of the new point is provided as a parameter.
- CSGeo
 - For SU use only (Preferably!)

Project Activities –Design / Plans

- Positioning of new shafts and tunnels
 - Point 5
 - Control of CMS1503 primary underground and surface point coordinates (where possible)
 - Determination of CCS coordinates
 - Point 1
 - Control of Atlas1102 primary underground and surface point coordinates (where possible)
 - Determination of CCS coordinates
- Review of Tender Design Documents
 - Control of coordinates in initial draft plans

Project Activities -Documentation

- Review and consolidate reference systems documentation
 - Merge / Update / Replace ?
 - Before end of 2017

Project Activities -Liaison

- Discussions with Civil Engineering and Integration 
- Preliminary presentation of CERN reference systems to civil engineering consultants 
- Provided documentation and software for the civil engineering consultants 

Project Activities –Surface Network

- GNSS Campaign Price Enquiry for the precise measurement of 15 pillars
- Pillars simultaneously stationed for 48 h, repeated twice.
- Optional control with high precision EDM (e.g. Mekometer)
 - Possible baselines to be confirmed
- Deadline 28/06 !
- 8-10 new adapters being produced for the antennas



Project Activities –EDM Calibration Line

- Re-determination of the Calibration Line Distances
 - Before Septembre 2017 (or earlier!)
 - Mekometer (x2)
 - Control instruments, software and computer hardware
 - Calibrate
 - Establish measurement procedure
 - Calibration Bench apps with Mekometer?
 - Calibration Line Measurement and Processing
 - Establish measurement procedure
 - Produce Report for Project Consultants
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Project Activities –Gyro Control Baseline

- Repair and upgrade gyro-theodolite
 - Replace theodolite with TDA 5005
 - Replace gyro batteries
- Measurement campaign of gyro control baselines
 - Learn to use instrument
 - Determine measurement procedure
 - Analyse and document results
- Deadline before Tunnel to Surface measurements (see next slide)



TODO!

Project Activities –Gyro Control Baseline

- Tunnel to Surface Transfer campaign *TODO!*
 - Establish azimuths to apply for control baseline
 - Independently for Point1 and Point5
 - Determine measurement procedure
 - LSS measurements both side of IP (YETS)
 - Gyro control baseline measurement
 - Independent analysis and report for each Point
 - Not to be confused if instrument constant is different!
 - Deadline February 2018

Project Activities -Software

- CSGeo
 - Restricted version for CERN civil engineering team



Project Activities -PCAS

Position Control and Alignment System (PCAS)

- Geodesy: develop new observation models
 - Tilts, HLS, WPS, DOMS, FSI
- LGC
 - Integrate sensors and measurements
 - Add L1 Norm / robust estimation algorithm
- SURVEY Database
 - Manage sensors and measurements
 - Manage fiducialisation and assembly data

TODO!

TODO!

TODO!

Project Activities -PCAS

- PCAS
 - Develop modules for sensors and measurements
 - Develop system control software and user interface
 - Prototype system for 2020

TODO!

Conclusions

- Lots of activities foreseen before the end of the YETS
- Can't reasonably expect to do measurements above ground in November and December
- Prototype PCAS needs to be done when our resources are most limited (LS2)
- Will have to decide what is realistically possible in the time available



Thank you for your attention