Master thesis subjects proposed in the Geodetic Metrology group at CERN, for the first semester of 2026.

Master thesis topic 1

6 months in 2026

MASTER THESIS TOPIC 1

> ### Evaluation and integration of ATS800 Laser Tracker for the measurement of CERN accelerator components

Introduction

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Join the Geodetic Metrology group at CERN, where you will take part in the metrology and alignment of the wide variety of components that are used in particle accelerators and detectors. You will be using, developing or testing state-of-the art surveying tools and software to achieve the sub-millimeter accuracy necessary to achieve our goals. Take part!

Diversity has been an integral part of CERN's mission since its foundation and is an established value of the Organization.

Master subject topic and objectives :

The [Geodetic Metrology Group](#) within the Beams Department (BE-GM) provides metrology and alignment for components installed in the accelerators, their beam transfer lines and physics experiments throughout the CERN complex.

The ASG (Accelerator Survey & Geodetic Measurements) section within the GM group is responsible for the metrology and alignment of components along CERN's 60 km of particle accelerators. These elements are measured and aligned within a radial and vertical tolerance of ±0.2 mm, ensuring the smooth and efficient transportation of the particles. To achieve this precision challenge, the section uses various measurement techniques according to the specific constraints of the survey activity. Among these, laser trackers are commonly used to achieve precise measurements by following a reflector. However, these methods require manual positioning of reflectors on the components, which is a repetitive and time-consuming task. This issue is even more significant in radioactive environments, where minimizing human intervention is essential

To address these limitations, the ASG section has recently acquired an ATS800 laser tracker, capable of non-contact measurements by scanning features, edges, and surfaces with very high accuracy. ATS800 integrates also an AI-powered Feature Detect that allows automatic feature recognition. These capabilities offer a promising alternative to AT4xx measurements, as they enable the automation of our measurement process. Integrating this new instrument into our processes is a challenge for the ASG section and will require adapting our existing data acquisition and processing workflows.

As part of the BE-GM-ASG team and reporting to your supervisor, you will have several key objectives:

- Evaluate ATS800 performance with various measurement parameters (distance, inclination angle, surface type).
- Compare different types of targets and identify those that are suitable for large-scale and permanent deployment on accelerator components.
- Identify and collect necessary inputs and automate their generation.
- Define and automate the measurement workflow using the manufacturer's software (Spatial Analyzer).
- Integrate ATS800 measurements into our database and computational process using measurement planes and Python scripts in Spatial Analyzer.
- Evaluate the usage of non-verticalized laser trackers on the field.
- Perform a comparison between the least-square adjustment results based on ATS800 measurements and those obtained using AT4xx.
- Develop a workflow to automate the analysis of mechanical component deformations using point clouds acquired with the ATS800, processed in CloudCompare or Spatial Analyzer.

All the results of the study will help the section in planning the activities for Long Shutdown 3, which is scheduled to begin in July 2026 and will last for four years.

Qualifications:

Eligibility criteria:

- You are in your 5th year of master's degree.
- You are a full-time student and will maintain your full-time registration throughout the internship at CERN.
- You have good working proficiency in English and/or French.

Skills and/or knowledge:

- A strong desire to learn and grow professionally.
- A rigorous scientific approach to problem-solving.
- Theoretical and practical experience using least square-based algorithm.
- Proficiency in a programming language such as Python.
- Strong attention to detail and a curious mindset.

ADDITIONAL INFORMATION

What we offer:
- An internship contract for a duration of 1 to 6 months.
- A monthly allowance of 1,587 Swiss Francs
- One of CERN's key missions is education. Our experts are dedicated to sharing their knowledge with committed and passionate students.

How to Apply:

You will need the following documents to complete your application:

- A CV in English or French (in a PDF format)

Apply for the short-term internship 2026 HERE and inform be.gm.secretariat@cern.ch and jean-francois.segers@cern.ch of your application).

Further info and contacts:

- In case of questions, please contact:
    - Supervisor : Jean-Francois Segers : jean-francois.segers@cern.ch
    - ASG Section Leader : Jean-Frederic Fuchs : jean-frederic.fuchs@cern.ch
- Some information about the group: HERE.
- Some further information about our activities: Video_surveyor at CERN, Video_Alignment systems
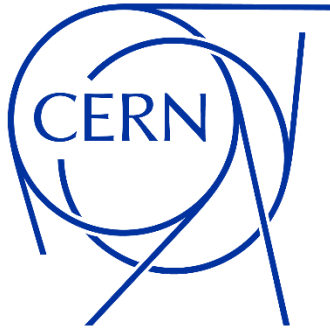
Master thesis topic 2

6 months in 2026

MASTER THESIS TOPIC 2

Evaluation and deployment of the HP robotic tracing solution within CERN beamline operations

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Introduction

At CERN, the European Organization for Nuclear Research, physicists and engineers are probing the fundamental structure of the universe. Using the world's largest and most complex scientific instruments, they study the basic constituents of matter - fundamental particles that are made to collide together at close to the speed of light. The process gives physicists clues about how particles interact and provides insights into the fundamental laws of nature. Find out more on http://home.cern.

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Master subject topic and objectives :

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As a part of the High-Luminosity Large Hadron Collider project (HL-LHC), a few hundred meters of the LHC accelerator will be replaced and new supporting infrastructure will need to be traced on the floor. The ASG section is introducing the HP SitePrint robotic solution to enhance the tracing process and address the increasing number of requests, including those for equipment outside the beamline. A tracing workflow has already been defined, and the next step is to evaluate its performance and integrate it into the team's operations, ensuring seamless data preparation, Survey Database integration, robotic tracing, and verification of results.

As part of the BE-GM-ASG team and reporting to your supervisor, you will have several key objectives:

- Perform extensive testing of the different accuracy modes and configurations of the HP SitePrint robot,
- Define and document, step by step, the operational process to be applied during LS3 within the scope of the HL-LHC project,
- Define quality controls for each step to ensure proper execution and guarantee the final deliverable,
- Compare various types of targets to be used with the robot to determine the most suitable option when used with Leica TS60,
- Define and validate the optimal method for collecting input data for the robot based on .dxf drawings,
- Ensure proper integration of HL-LHC input data from the Integration team into the Survey Database,
- Incorporate HP SitePrint measurements into the Survey Database,
- Review the HL-LHC tracing sequence to guarantee smooth and reliable interventions within the LS3 planning,

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Qualifications:

Eligibility criteria:

- You are in your 5th year of master's degree.
- You are a full-time student and will maintain your full-time registration throughout the internship at CERN.
- You have good working proficiency in English and/or French.

Skills and/or knowledge:

- A strong desire to learn and grow professionally.
- A rigorous scientific approach to problem-solving.
- Theoretical and practical experience using least square-based algorithm.
- Proficiency in a programming language such as Python.
- Knowledge and ability to use CAD software.
- Strong attention to detail and a curious mindset.

ADDITIONAL INFORMATION

What we offer:
- An internship contract for a duration of 1 to 6 months.
- A monthly allowance of 1,587 Swiss Francs
- One of CERN's key missions is education. Our experts are dedicated to sharing their knowledge with committed and passionate students.

How to Apply:

You will need the following documents to complete your application:

- A CV in English or French (in a PDF format)
- Apply for the short-term internship 2026 HERE and inform be.gm.secretariat@cern.ch and Kacper.widuch@cern.ch of your application).

Further info and contacts:

- In case of questions, please contact:
  - Supervisor: Kacper Widuch kacper.widuch@cern.ch
  - ASG Section Leader: Jean-Frederic Fuchs : jean-frederic.fuchs@cern.ch
- Some information about the group: HERE.
- Some further information about our activities: Video surveyor at CERN, Video Alignment systems
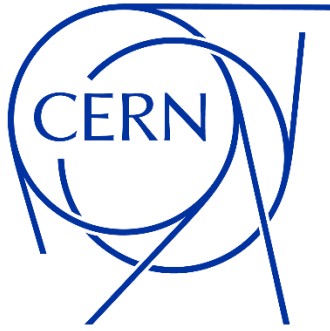
Master thesis topic 3

February - July 2026

MASTER THESIS TOPIC 3

Design Optimization of Measurement Configurations for Geodetic and Metrological Systems

Introduction

At CERN, the European Organization for Nuclear Research, physicists and engineers are probing the fundamental structure of the universe. Using the world's largest and most complex scientific instruments, they study the basic constituents of matter - fundamental particles that are made to collide together at close to the speed of light. The process gives physicists clues about how particles interact and provides insights into the fundamental laws of nature. Find out more on http://home.cern.ch

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Master subject topic and objectives:

The GM group at CERN develops and applies advanced adjustment methods for the estimation of positions, orientations, and other parameters in accelerator and experiment environments. A central question in such applications is how to choose measurement configurations (sensor locations, observation points, or target setups) to improve the information quality of the resulting parameter estimates.

This subject combines parameter estimation theory and practical geodesy/metrology. It focuses on the optimization of design variables in measurement systems. Instead of manually testing many candidate configurations, the project investigates how statistical design criteria can be used to compare different setups. The guiding principle is that, in least squares estimation, the covariance of the estimated parameters depends only on the Jacobian of the observation model at the nominal solution. This makes it possible to evaluate the information content of each design directly from the Jacobians, without running a full nonlinear adjustment for each candidate.

The project will build on LGC (Logiciel Général de Compensation), CERN's geodetic adjustment software, which provides a general framework for least squares estimation, covariance analysis, and simulation. Its Python interface allows automated evaluation of model functions and Jacobians across varying design configurations and serves as a realistic environment for testing design strategies.

You will have several objectives, building on the support of your supervisor and the expertise available in the GM group:

- Familiarize yourself with the LGC adjustment software and its Python interface.
- Learn how to evaluate model functions and their Jacobians for varying design configurations.
- Formalize and document the mathematical framework for evaluating design quality directly from the Jacobians.
- Investigate design criteria such as D-optimality (determinant of the normal matrix) and compare them with alternative scalar measures derived from the covariance matrix.
- Apply the methodology to selected case studies (e.g. orientation estimation of accelerator components or sensor calibration setups).
- Assess the potential of automated design optimization strategies for practical use in the GM group.

Qualifications:

Eligibility criteria:

- You are in your 5th year of master's degree.
- You are a full-time student and will maintain your full-time registration throughout the internship at CERN.
- You have good working proficiency in English and/or French.

Skills and/or knowledge:

- Strong motivation and background in least-squares-based estimation
- Curiosity for applying mathematical optimization approaches in applied environments

- Good knowledge of object-oriented programming mainly in Python; familiarity with C++ is an asset
- Rigorous and methodical scientific approach to problem solving

ADDITIONAL INFORMATION

What we offer:
- An internship contract for a duration of 1 to 6 months.
- A monthly allowance of 1,587 Swiss Francs.
- One of CERN's key missions is education. Our experts are dedicated to sharing their knowledge with committed and passionate students.
- Discovering the group's survey tasks and participating in some field activities is a key component of the internship.
- As an active member of the development team, you will receive continuous support from IT experts to follow best practices in the industry, including issue tracking, task management, code reviews, and test implementation.

How to Apply:

You will need the following documents to complete your application:

- A CV in English or French (in a PDF format)

Apply for the short-term internship 2026 HERE and inform be.gm.secretariat@cern.ch and Juergen.Gutekunst@cern.ch of your application.

Further info and contacts:

- In case of questions, please contact:
  - Jürgen Gutekunst Juergen.Gutekunst@cern.ch (Supervisor)
  - Dirk Mergelkuhl Dirk.Mergelkuhl@cern.ch (Section Leader)
- Some information about the group: HERE.
- Some further information about our activities: Video surveyor at CERN, Video Alignment systems
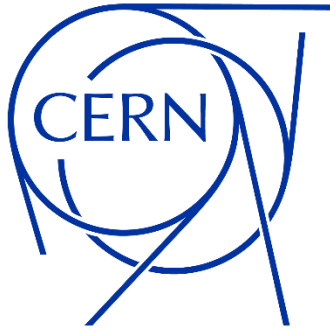
Master thesis topic 4

February - July 2026

MASTER THESIS TOPIC 4

REFRACTION CORRECTION OF HIGH PRECISION MEASUREMENTS BASED ON A METEOROLOGICAL MODEL AND A RAY TRACING APPROACH AT CERN

Introduction

At CERN, the European Organization for Nuclear Research, physicists and engineers are probing the fundamental structure of the universe. Using the world's largest and most complex scientific instruments, they study the basic constituents of matter - fundamental particles that are made to collide together at close to the speed of light. The process gives physicists clues about how particles interact and provides insights into the fundamental laws of nature. Find out more on http://home.cern.

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Master subject topic and objectives:

Laser trackers are a key tool used for high-precision measurements of accelerators and experiments in the Geodetic Metrology (GM) group at CERN. This technique is used in the Survey and Alignment team, which is responsible for surveying, the large-scale metrology, and alignment for CERN's accelerators and experiments. Typical use cases include alignment works in tunnels and experimental caverns. Environmental conditions are the main limiting factor to get to the highest accuracy.

We continuously strive to optimize and enhance the measurement process. In this context, the correction of vertical and eventually horizontal angle measurements for refraction caused by the temperature gradient should be implemented. The subject is related to the preparational work for the measurements demanded by the FCC-project with strict alignment tolerances.

Under the guidance of your supervisor and as a member of the Future-Projects (FP) section, you will concentrate on the steps necessary to enhance the results of laser tracker measurements. You will explore various data sources to enhance measurement accuracy and evaluate the potential improvements.

You will have several objectives:

- Learn and comprehend the typical measurement environments at CERN and getting hands-on tools for data acquisition and data processing.
- Definition of a workflow for the correction of angular measurements for refraction influences based on meteorological data using ray tracing method.
- Application of the workflow on a real case example that is the laser tracker network measurement of the cavern for the ATLAS experiments. This includes the optimisation of parameters to create a static respectively dynamic meteorological model using different data sources.
- Assessment of the results using CERN's open-source adjustment software LGC (Logiciel Générale de Compensation).

Qualifications:

Eligibility criteria:

- You are in your 5th year of master's degree.
- You are a full-time student and will maintain your full-time registration throughout the internship at CERN.
- You have good working proficiency in English and/or French.

Skills and/or knowledge:

- Proficiency in programming languages such as Python and/or Matlab.
- Demonstrated curiosity and attention to detail.
- Familiarity with least-squares methods.
- Interest in high-precision measurements.

ADDITIONAL INFORMATION

What we offer:
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How to Apply:

You will need the following documents to complete your application:

- A CV and covering letter in English or French (in a PDF format)

Apply on the short-term internship 2026 HERE and inform be.gm.secretariat@cern.ch and Dirk.Mergelkuhl@cern.ch of your application.

Further info and contacts:

- In case of questions, please contact:
  - Dirk Mergelkuhl Dirk.Mergelkuhl@cern.ch (Supervisor and Section Leader)
- Some information about the group: HERE.

- Some further information about our activities: Video_surveyor at CERN, Video_Alignment systems
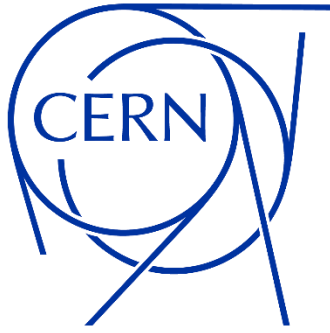
Master thesis topic 5

6 months in 2026

MASTER THESIS TOPIC 5

DETECTION, DECODING AND MEASUREMENT OF PHOTOGRAMMETRIC TARGETS USING AI TECHNOLOGIES AND EVALUATION TO CLASSICAL TECHNIQUES

Introduction

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Master subject topic and objectives:

The FP (Future Projects) section within the GM (Geodetic Metrology) group is responsible for the preparation of an alignment concept and strategy for the Future Circular Collider (FCC). Its components have extremely tight alignment tolerances, ensuring the smooth and efficient transportation of the particles.

The GM-group uses various measurement techniques, including photogrammetry, as a non-contact measurement technique and its advantageous capacity for automation of measurements. CERN works continuously to advance measurement techniques, and one possibility of improvements is the use of AI technologies within the photogrammetric workflow.

You will have several objectives:

- Implementing AI algorithm for the detection and precise measurement of photogrammetric targets in digital photos.
- Implementing AI based algorithm for the decoding of binary circular codes of 12-bit, 14-bit or 20-bit.
- Implementing AI algorithm for the detection and precise measurement of stretched wires in digital photos.
- Evaluation of the reliability of detection algorithms for targets and wires as well as decoding.
- Evaluation of the accuracy of the precise measurement of the circular targets and stretched wires in the photos compared to conventional algorithms.

Qualifications:

Eligibility criteria:

- You are in your 5th year of master's degree.
- You are a full-time student and will maintain your full-time registration throughout the internship at CERN.
- You have good working proficiency in English and/or French.

Skills and/or knowledge:

- Proficiency in a programming language such as Python and/or Matlab.
- Knowledge of image processing and machine learning algorithms.
- A rigorous scientific approach to problem-solving.
- Demonstrated curiosity and attention to detail.
- Familiarity with least-squares methods.

ADDITIONAL INFORMATION

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Apply for the short-term internship 2026 HERE and inform be.gm.secretariat@cern.ch and Bingru.Yang@cern.ch of your application.

Further info and contacts:

- In case of questions, please contact:
  - Bingru Yang: Bingru.Yang@cern.ch (Supervisor)
  - Dirk Mergelkuhl: Dirk.Mergelkuhl@cern.ch (Section Leader)
- Some information about the group: HERE.
- Some further information about our activities: Video surveyor at CERN, Video Alignment systems