From Particle Physics to Medical Applications: Life after CERN

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WHY THIS TALK?

- Describe my personal journey

- Honest experience about the transition from "academia to industry", for a high energy physicist, especially if one wants to stay in this area

- How to make the difficult decision, staying and trying harder to get a permanent position or leave before it's "too late"

ABOUT ME (1)

- ***BSc in Physics, University of Patras, Greece in 2006***
    Diploma Thesis: Three-dimensional image processing and virtual endoscopy

- ***MSc in High Energy Physics, University of Cyprus, 2008***
    Master Thesis: Estimation of the masses of supersymmetric particles

- ***First time I visited CERN, 2007 as a summer student***

- ***Ph.D. in Experimental Particle Physics, RWTH Aachen, Germany in 2013***
    PhD Thesis: Measurement of the Z/γ^*+b-jet cross section in pp collisions with the CMS Detector at 7 TeV

ABOUT ME (2)

Work Experience

- **2008-2013:** *Research Scientist | RWTH Aachen, Germany*

- **2013-2015:** *Post-doctoral Scientist | VUB, Belgium*

- **2018-2021:** *CERN Fellow Physicist | Radiation Protection Group, Switzerland*

- **2021-2022:** *CERN Project Associate - Institut de radiophysique (IRA), CHUV, Lausanne*

- **2022-present:** *Regulatory affairs specialist - Forimtech SA, Geneva*

- **2022-present:** *Medical Applications Physicist - Groupe 3R, Réseau Radiologique Romand SA, Sion*

Part I: Analyses at CERN

Estimation of the masses of supersymmetric particles at LHC

The general form of the three step sequential two-body decay is the following:

$$D \rightarrow Cc \rightarrow Bbc \rightarrow Aabc \qquad (4.2)$$

where D, C, B and A are massive satisfying $m_D > m_C > m_B > m_A$ and a, b, c are taken to be massless.

Measurement of the associated Z boson and b-jet production in proton-proton collisions at √ s = 7 TeV with the CMS Detector
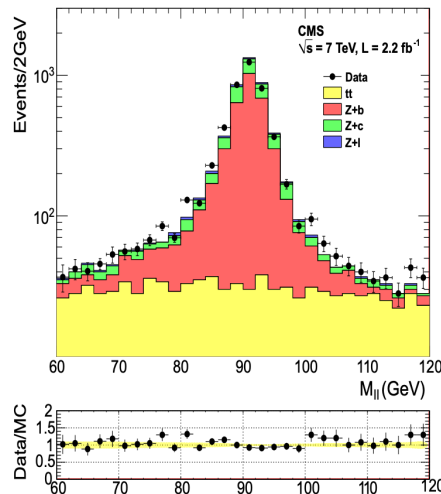

Figure 4.13: The invariant mass of the lepton pairs after the dilepton+b-jet selection. The distribution is consistent with the published results in [10].

Search for Displaced Supersymmetry in Dilepton Final States

A search for new physics producing final-state leptons whose trajectories are displaced from the interaction region. This search uses a data sample obtained from pp collisions at √s = 8 TeV, with an integrated luminosity of 19.7 fb−1, recorded by the CMS detector at the LHC

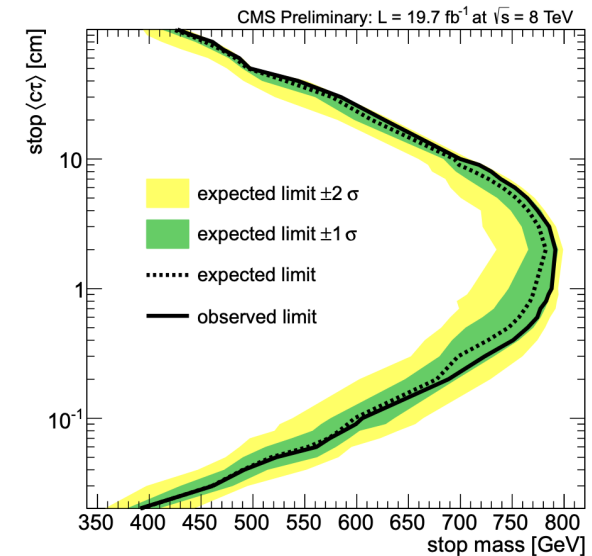Figure 4: Expected and observed 95% CL exclusion contours for stop pair production in the plane of stop $\langle c\tau \rangle$ and mass. The region to the left of the contours is excluded by this search.

Part II: Medical Applications

Radiation Protection Group, Special Projects

GEMPix and Large Area GEMPix

- Research activities in the area of medical physics

- Development of a new generation of large area GEMPix detector that would contribute to the quality assurance procedures that are currently used in cancer hadron therapy

- Successfully submitted an ATTRACT funding proposal

- First involvement with external companies, collaboration with industry, stakeholders and centres outside CERN

- Hands-on lab work and data analysis for the evaluation of the performance in clinical settings, test beams (Italy, Germany, Switzerland)
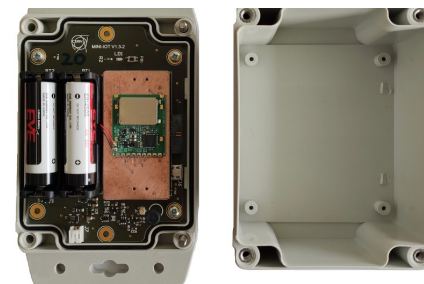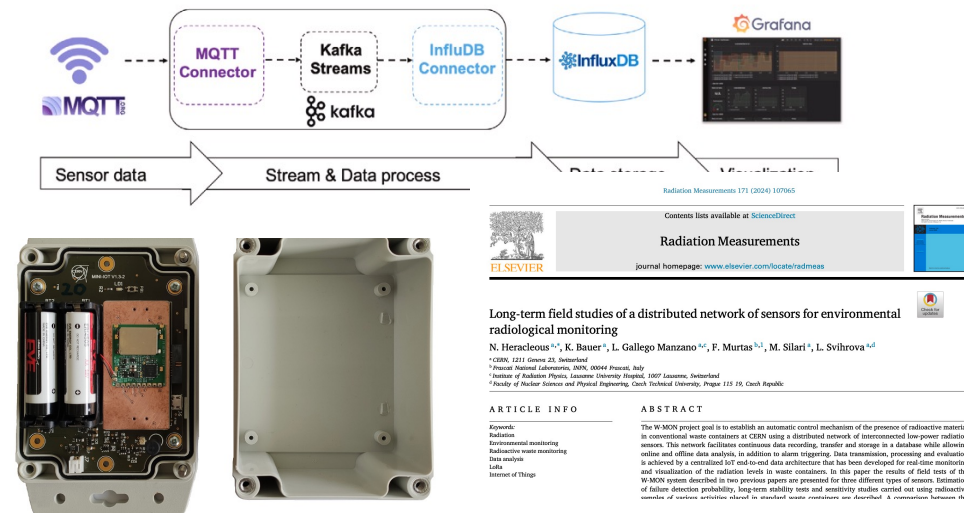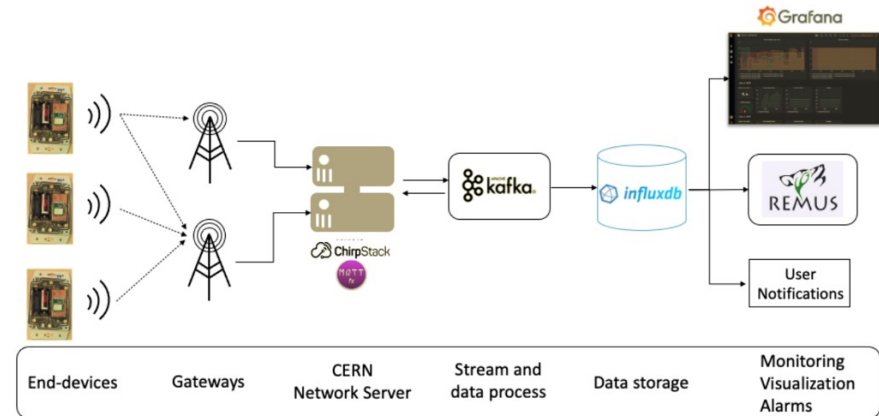
Part II: Environmental Monitoring

Radiation Protection Group, Special Projects and PJAS, CHUV, Lausanne
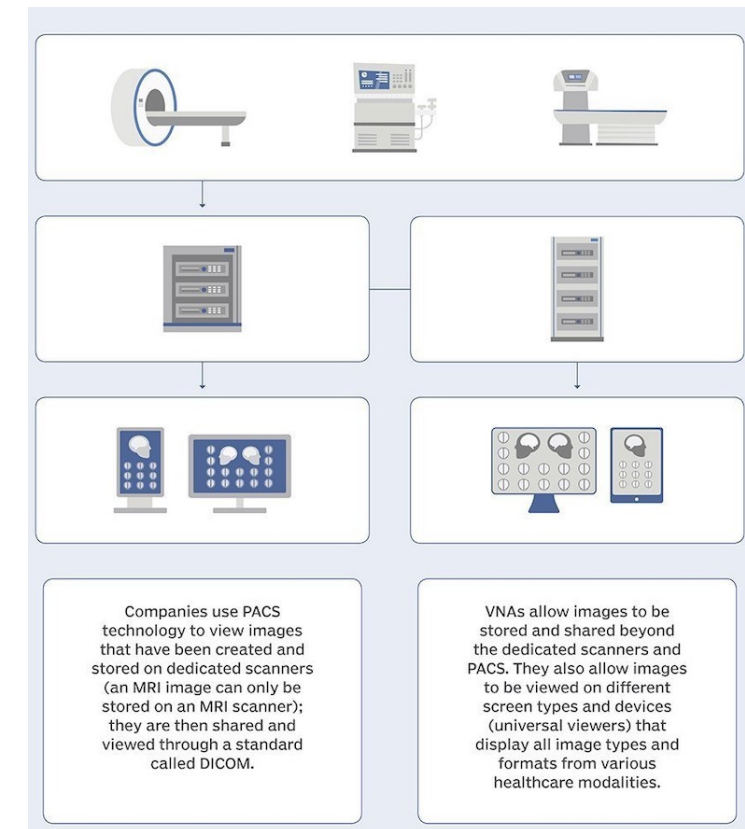
W-Mon

- Development of a wireless network of interconnected radiation sensors to be installed in the waste containers at CERN for radiation and environmental protection.

- Chance to expand my knowledge new things (Python, Pandas, NumPy, SciPy, Matplotlib, SQL, InfluxDB, MongoDB and Grafana, IoT applications, LoRa networks, Arduino, ESP32 programming)

A B S T R A C T

The W-MON project goal is to establish an automatic control mechanism of the presence of radioactive materials in conventional waste containers at CERN using a distributed network of interconnected low-power radiation sensors. This network facilitates continuous data recording, transfer and storage in a database while allowing online and offline data analysis, in addition to alarm triggering. Data transmission, processing and evaluation is achieved by a centralized IoT end-to-end data architecture that has been developed for real-time monitoring and visualization of the radiation levels in waste containers. In this paper the results of field tests of the W-MON system described in two previous papers are presented for three different types of sensors. Estimation of failure detection probability, long-term stability tests and sensitivity studies carried out using radioactive samples of various activities placed in standard waste containers are described. A comparison between the

MY CURRENT ROLE

- R&D department - Groupe3R Réseau Radiologique Romand SA

- Independent radiological network with 18 diagnostic centres in the French-speaking part of Switzerland

- Research activities in the area of medical applications and AI implementation in the diagnostic centers

- Healthcare professionals must navigate multiple systems and interfaces (PACS (Picture archiving and communication system), RIS (radiology information system), AI report). Need help from data scientists, medical physicists, engineers etc

Companies use PACS technology to view images that have been created and stored on dedicated scanners (an MRI image can only be stored on an MRI scanner); they are then shared and viewed through a standard called DICOM.

VNAs allow images to be stored and shared beyond the dedicated scanners and PACS. They also allow images to be viewed on different screen types and devices (universal viewers) that display all image types and formats from various healthcare modalities.

A DAY IN MY CURRENT ROLE

CT CONTRAST AGENT PERSONALIZATION

- Collaborate with **GE Healthcare**
- Data manipulation & statistical analysis
- Develop ML algorithms (train, test, cross-validation)
- Clinical validation using data and monitor data with special tools

MRI BREAST CANCER DIAGNOSIS

- Aid in ML algorithms for cancer diagnosis using Transpara™ screening software
- Extract, clean, analyze & anonymize patient data
- Primary contact point between 3R and **Screenpoint**
- Clinical validation and b-version evaluation

MRI KNEE ASSISTANT

- Implement KEROS, a Knee MRI dedicated AI software (**Incepto**)
- Conduct clinical validation & investigate metrics (exam reading time, diagnosis quality, reporting, population analytics)
- Primary point of contact with the data science team

INTELLIGENT PROTOCOLLING

- Extract & merge patient data from various sources (SAP, Xplore Analyse -SQL, Dose tracking systems)
- NLP model for faster and easier protocol decision making for exams
- Bi-weekly contact with **GE Healthcare** team for data labelling and evaluation

PERSONALIZED CONTRAST INJECTION

AIM: develop an ML model for the estimation of the patient fat-free mass (FFM) to personalize intravenous (i.v.) contrast volume injection in CT while ensuring liver enhancement and image quality

Collaboration with GE Healthcare, presentation in SPIE medical imaging 2024, RSNA 2023, publications

D. Clinical application & Validation
- Platform in php calculates volume based on the model used by technical staff before exam
- Clinical validation performed by enhancement measurement from the CT images (using a ROI) and estimating image quality
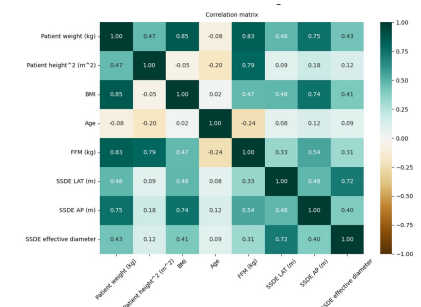
A. Data collection and pre-processing

- Data collection (CT patient data 2012-2024) with SAP BusinessObjects BI, SQL requests, Dose Tracking system for additional information

- Data cleaning and merging with Python (pandas)

C. k-fold cross validation
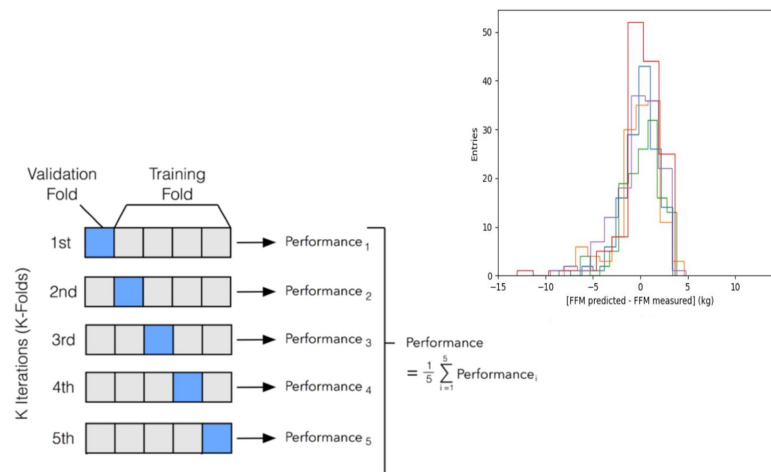
B. ML multiple regression model development

- Selection of variables via analysis of correlation

- Randomly divided into training and test sets according to the 80/20 rule
- Check the model using MAE, RMSE, R2 etc

Model	Description	Population used for model development	R^2
$FFM = P1 \cdot WT + P2 \cdot HT^2 + P3 \cdot Age + P4 \cdot Sex$	P1 = 0.268 P2 = 10.412 P3 = −0.057 P4 = 2.210 Sex = 1 (male) or 0 (female)	N = 275 (male) + 414 (female) Height range: 1.44–1.95 m Weight range: 38–170 kg Age range: 18–93 years	0.915 ± 0.019

SUMMARY

- Shared my personal perspective

- Difficult decision, staying and trying harder to get a permanent position or leave before it's ''too late''

- Various factors, like residing in France or working across different cantons in Switzerland, add complexity

- If you decide you want to change, be ready to get plenty of rejections

- Networking is key to discover interesting positions

- Learn new tools and more importantly familiarize with the latest terminology used in the field of ML and AI today