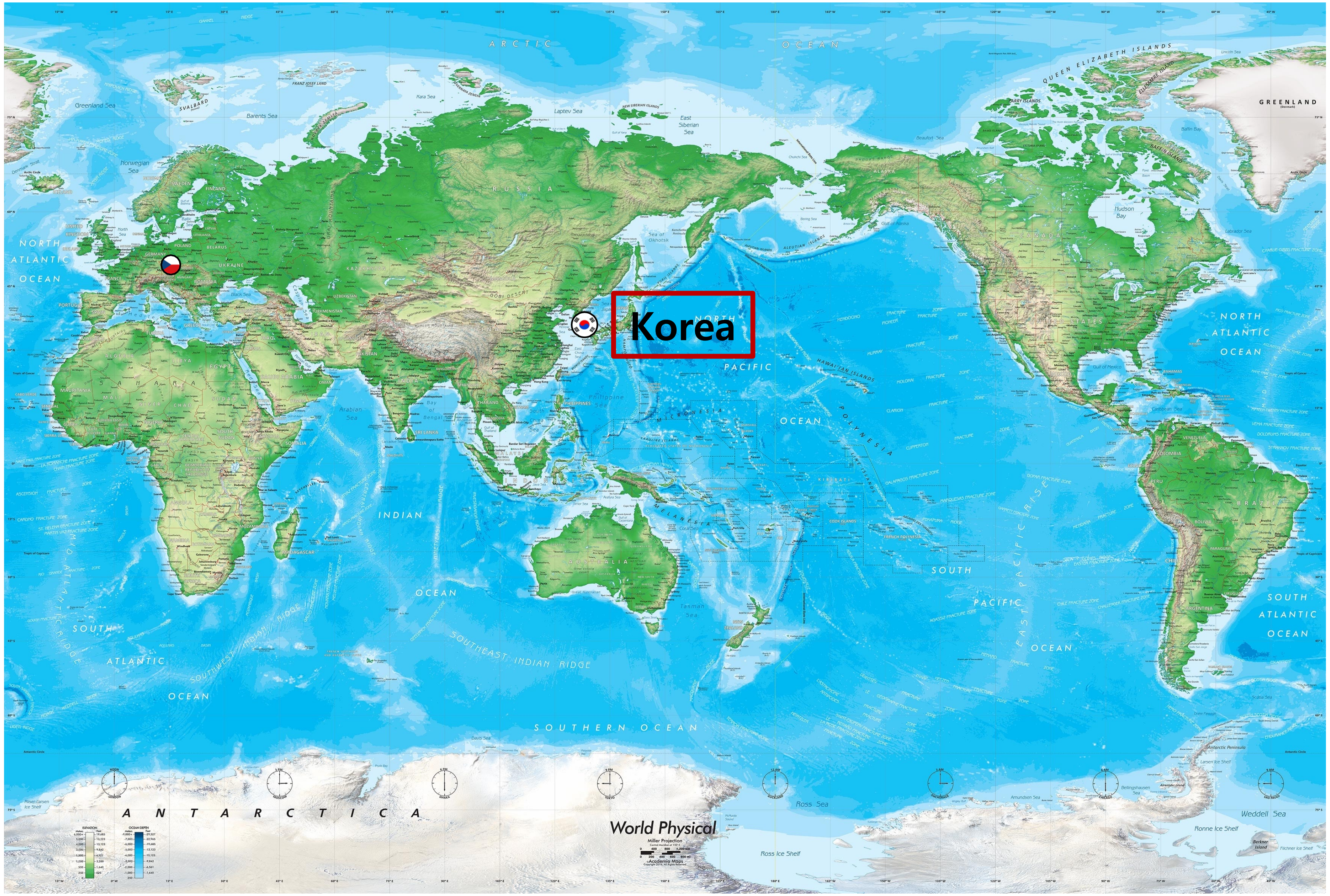
INTRODUCE MY SELF

BI SHIN from South Korea



INTRODUCE MY SELF

BI SHIN

Ph.D. Candidate, Chungnam National University(CNU) in South Korea

Education

- B.S. Astrophysics, CNU (2017)
- Master Theroretical Particle Physics, CNU (2019)

  Thesis: Phenomenological studies on the nature of dark matter using cosmic-ray measurements

  Advisor: Prof. Jong-Chul Park
- Ph.D. Theroretical Particle Physics, CNU (2019-present)

  Advisor: Prof. Jong-Chul Park

Research Interest

- Dark Matter Direct/Indirect Search
- High-energy cosmic-ray
- Machine learning

Phenomenology of Multi-Higgs Models

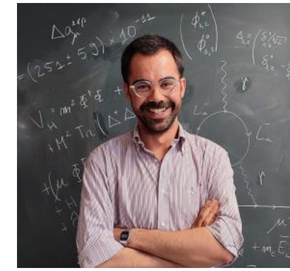
Bernardo Gonçalves

Supervisors: Filipe Joaquim[1] and Pedro Ferreira[2,3]

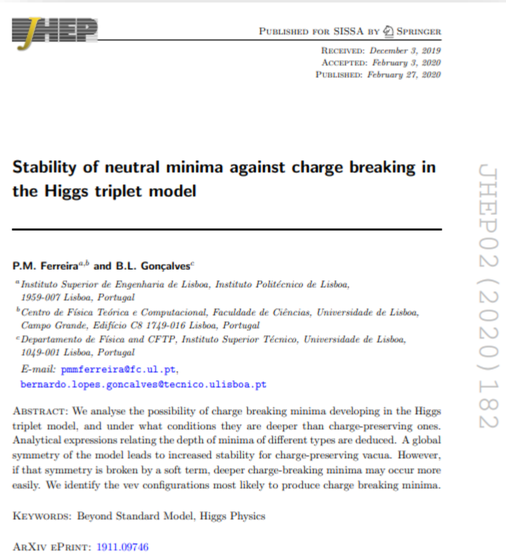
[1] Departamento de Física and CFTP, Instituto Superior Técnico, Universidade de Lisboa

[2] Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa

[3] Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa



3 published papers



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Accepted: February 3, 2020
Published: February 27, 2020

Stability of neutral minima against charge breaking in the Higgs triplet model

P.M. Ferreira[a,b] and B.L. Gonçalves[c]

[a] *Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, 1959-007 Lisboa, Portugal*

[b] *Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Edifício C8 1749-016 Lisboa, Portugal*

[c] *Departamento de Física and CFTP, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal*

E-mail: pmmferreira@fc.ul.pt, bernardo.lopes.goncalves@tecnico.ulisboa.pt

Abstract: We analyse the possibility of charge breaking minima developing in the Higgs triplet model, and under what conditions they are deeper than charge-preserving ones. Analytical expressions relating the depth of minima of different types are deduced. A global symmetry of the model leads to increased stability for charge-preserving vacua. However, if that symmetry is broken by a soft term, deeper charge-breaking minima may occur more easily. We identify the vev configurations most likely to produce charge breaking minima.

Keywords: Beyond Standard Model, Higgs Physics

ArXiv ePrint: 1911.09746

JHEP02(2020)182

PHYSICAL REVIEW D **104**, 053008 (2021)

$(g-2)_\mu$ in the 2HDM and slightly beyond: An updated view

P. M. Ferreira,[1,2] B. L. Gonçalves,[3,2] F. R. Joaquim,[3] and Marc Sher[4]

[1] *Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, 1959-007 Lisboa, Portugal*

[2] *Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Edifício C8, 1749-016 Lisboa, Portugal*

[3] *Departamento de Física and CFTP, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal*

[4] *High Energy Theory Group, William & Mary, Williamsburg, Virginia 23187, USA*

(Received 20 April 2021; accepted 16 August 2021; published 22 September 2021)

The recent measurement of the muon $g-2$ anomaly continues to defy a Standard Model explanation but can be accommodated within the framework of two-Higgs doublet models, although the pseudoscalar mass must be fairly light. If one further includes extra fermion content in the form of a generation of vectorlike leptons, the allowed parameter range that explains the anomaly is even further extended, and clashes with B-decay constraints may be avoided. We show how the muon magnetic moment anomaly can be fit within these models, under the assumption that the vectorlike leptons do not mix with the muon. We update previous analyses and include all theoretical and experimental constraints, including searches for extra scalars. It is shown that the inclusion of vectorlike fermions allows the lepton-specific and muon-specific models to perform much better in fitting the muon's $g-2$. However, these fits do require the Yukawa coupling between the Higgs and the vectorlike leptons to be large, causing potential problems with perturbativity and unitarity, and thus, models in which the vectorlike leptons mix with the muon may be preferred.

DOI: 10.1103/PhysRevD.104.053008

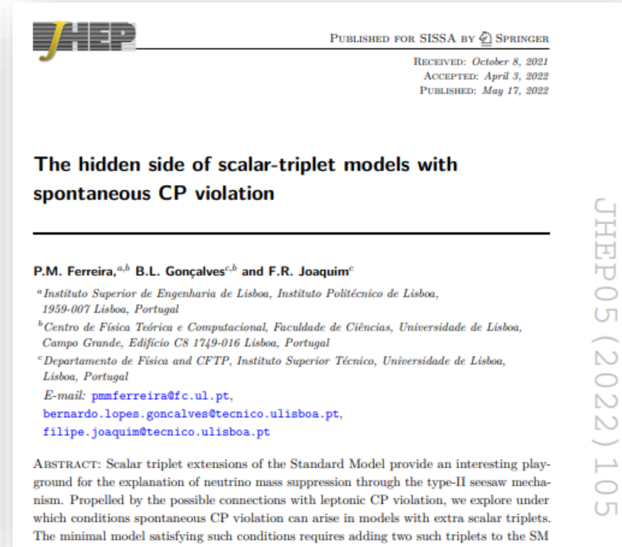
I. INTRODUCTION

Recently, the Muon g-2 Collaboration at Fermilab reported new results [1] from run 1 of their experiment measuring the anomalous magnetic moment of the muon a_μ. Prior to this announcement, the discrepancy between the experimental measurement $a_\mu^{\rm exp}$ [2] and the Standard Model (SM) theoretical prediction $a_\mu^{\rm SM}$ [3–6] was

$$\Delta a_\mu^{\rm exp} = a_\mu^{\rm exp} - a_\mu^{\rm SM} = (279 \pm 76) \times 10^{-11} \quad (3.7\sigma). \quad (1)$$

In this paper, we focus on 2HDMs (for a review, see Ref. [8]) and discuss the implications of the new result from the Muon g-2 Collaboration.

In the 2HDM, it is possible to ensure that tree-level flavor-changing neutral currents mediated by scalars do not exist by imposing a discrete Z_2 symmetry on the model. There are four such versions of the 2HDM, referred to as type-I, type-II, type-X (sometimes called lepton-specific), and type-Y (sometimes called flipped) models. In the type-II and type-X models, the coupling of the muon to the heavy Higgs



Published for SISSA by Springer

Received: October 8, 2021
Accepted: April 3, 2022
Published: May 17, 2022

The hidden side of scalar-triplet models with spontaneous CP violation

P.M. Ferreira,[a,b] B.L. Gonçalves[c,b] and F.R. Joaquim[c]

[a] *Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, 1959-007 Lisboa, Portugal*

[b] *Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Edifício C8 1749-016 Lisboa, Portugal*

[c] *Departamento de Física and CFTP, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal*

E-mail: pmmferreira@fc.ul.pt, bernardo.lopes.goncalves@tecnico.ulisboa.pt, filipe.joaquim@tecnico.ulisboa.pt

Abstract: Scalar triplet extensions of the Standard Model provide an interesting playground for the explanation of neutrino mass suppression through the type-II seesaw mechanism. Propelled by the possible connections with leptonic CP violation, we explore under which conditions spontaneous CP violation can arise in models with extra scalar triplets. The minimal model satisfying such conditions requires adding two such triplets to the SM field content. For this model, the scalar mass spectrum in both the CP-conserving and

JHEP05(2022)105

+ 1 conference proceedings + 5 talks + 6 posters

Phenomenology of Multi-Higgs Models

Multi-Higgs scenario	Higgs-triplet model (HTM)	Two-scalar-triplet model (2STM)	Two-Higgs-doublet models (2HDMs)
Motivation	Neutrino masses in type-II seesaw mechanism	Minimal triplet extension in which spontaneous CP violation occurs	2HDMs can fit the muon *g*-2 anomaly but in a restricted parameter spce
Problem	Are neutral minima stable against charge breaking?	Do we have decoupling in the scalar mass spectrum?	Can the addition of VLLs help 2HDMs to fit the muon *g*-2?

11th IDPASC School - Introduction

Pedro Gabriel (CFTC – ULisbon)

CFTC – University of Lisbon

Olomouc, 29th August 2022

Personal introduction

- Born in Lisbon
- In 2018 got a Bachelor’s degree (BSc) in Physics at the Faculty of Sciences of the University of Lisbon
- In 2021 got a Master’s degree (MSc) in Physics, specializing in Nuclear and Particle Physics, at the Faculty of Sciences of the University of Lisbon
- In 2022 will start (officially) a PhD program between the Center for Theoretical and Computational Physics of the University of Lisbon (CFTC-UL) and the Karlsruhe Institute of Technology (KIT)

Work

- **One-loop corrections to the Higgs boson invisible decay in the dark doublet phase of the N2HDM (MSc thesis) (JHEP 10 (2021), 044)**:
  - Calculate the radiative corrections to the possible Higgs boson decays to DM candidate particles and use the experimental measurements of the Higgs boson decay to invisible to constrain the model's parameter space at NLO.
- **Direct detection of pseudo-Nambu-Goldstone dark matter in a two Higgs doublet plus singlet extension of the SM (arXiv:2207.04973 – submitted for review to JHEP)**
  - Calculate the DM direct detection cross-section at NLO in a SM extension with 2 Higgs doublets and a complex Higgs singlet in which the DM particle is pseudo-Nambu-Goldstone boson.
- **Testing the WIMP paradigm to the limit (PhD)**
  - Radiative corrections to the physical processes that contribute to the three DM search modes: direct, indirect and collider within the SM complex singlet extension (CxSM).
  - Use Effective Field Theory (EFT) to try and relate the three search modes by identifying the minimal set of EFT operators for the CxSM

Sven Põder

- PhD student from Tallinn, Estonia
  - Tallinn University of Technology
  - Junior researcher at the National Institute of Chemical Physics and Biophysics
- Search for dark substructures in the Milky Way using machine learning techniques

TAL TECH

Background & Current Work

- Bachelor's and master's in applied physics from TalTech
  - Working with ESA's Gaia Mission data
- DM subhalo detection in galaxy simulation data using machine learning (FIRE-2, synthetic gaia surveys)
- Milky Way disk kinematics, DM-induced exoplanet heating

gaia

Contact

E-mail: sven.poder@kbfi.ee
LinkedIn: linkedin.com/in/sven-põder/

11th IDPASC School

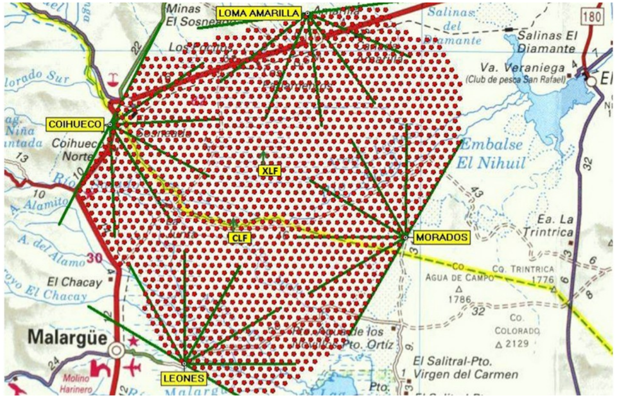
Supervisor: Dr. Raul Sarmento
Co-supervisors: Prof. Dr. Ruben Conceiçao
Prof. Dr. Nuno Castro

Enhanced Searches with the Pierre Auger Observatory in the Era of Multi-messenger Astrophysics

Alexandra Fernandes

Using the observatory to:

- detect high energy photons
- energies above 10^{16} eV



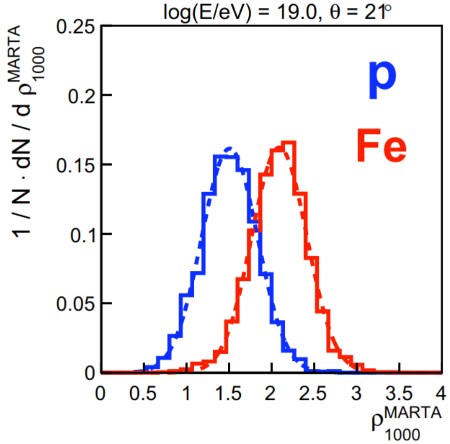
Map of the Pierre Auger Observatory
Source: Pierre Auger Collaboration. "The Pierre Auger cosmic ray observatory". (2015)

1 - Phenomenology Studies

Objectives:

Study the shower core → More information; Never before studied

Taking a look at the number of muons → Measuring the muonic component; New discriminant variable



→ Looking at the muon measurements near the shower core

ρ_{1000}^{MARTA} distributions for proton and iron primaries at zenith angle θ = 21°, E = 10^{19} eV

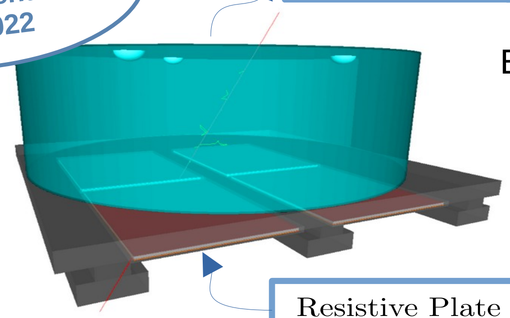
(Abreu, P., et al. The European Physical Journal C 78.4 (2018))

2 - MARTA

Upgrade to the Observatory

To be implemented in 2022

Water Cherenkov Tank



Resistive Plate Chambers (RPC's)

↓ directly measure the number of muons

Energy range:

10 to 300 PeV

3 - Discriminant Analysis

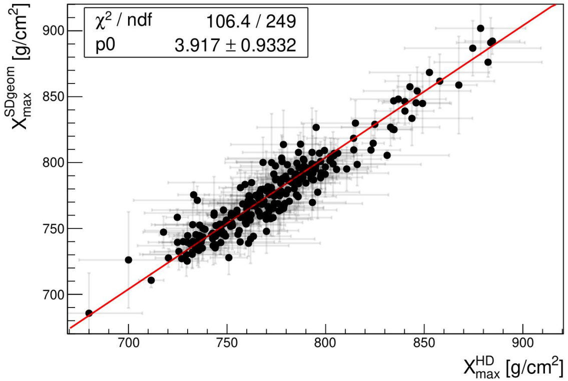
Using what was learned to:

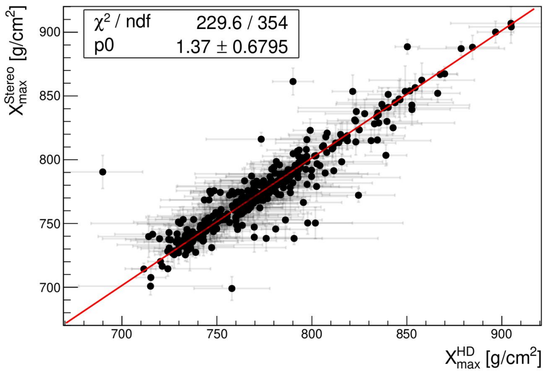
- Construct a discriminant analysis for MARTA using muon measurements

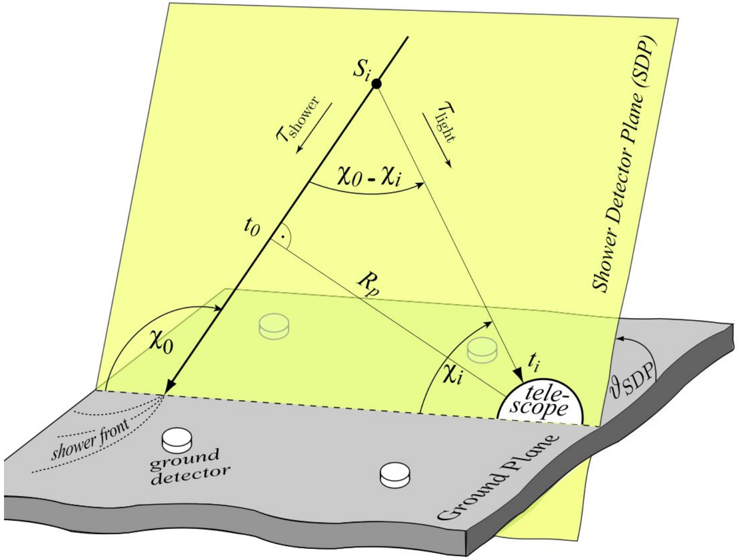
This work is supported by FCT under the grant PRT/BD/153345/2021

Longitudinal profiles of the highest energy cosmic-ray air showers measured at the Pierre Auger Observatory

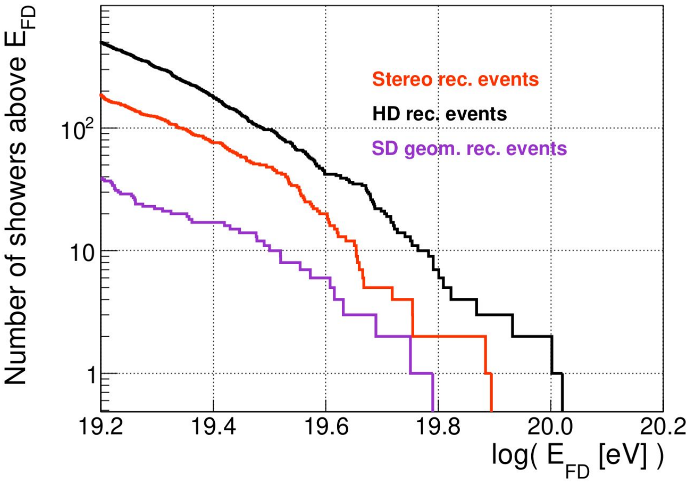
- reconstruction of showers detected by FD using three different methods: standard hybrid method, hybrid method using the SD geometry and stereo method
- comparison of biases in X_{max} and fluorescence energy between the three methods => methods are compatible
- the possibility to increase the number of studied showers at the highest energies

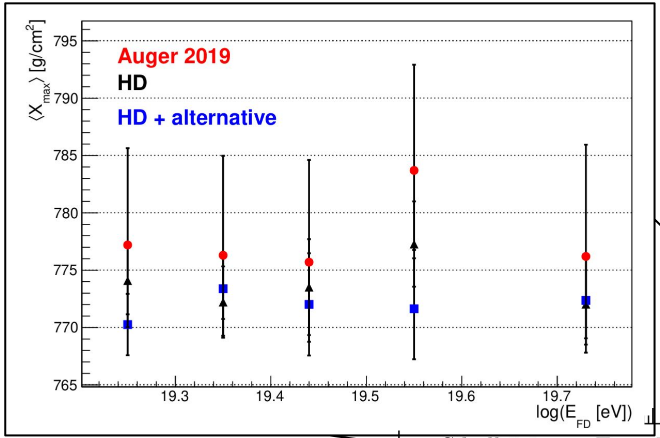


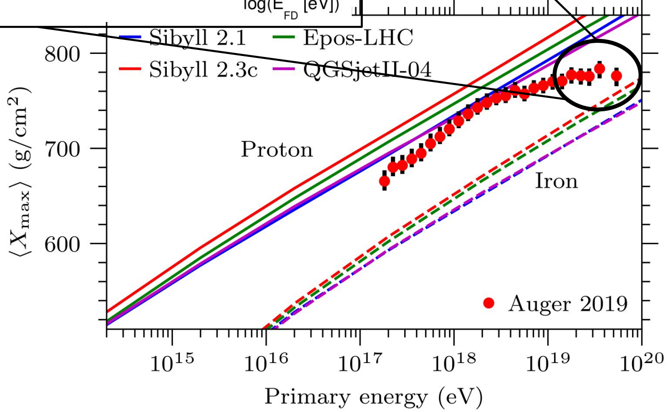




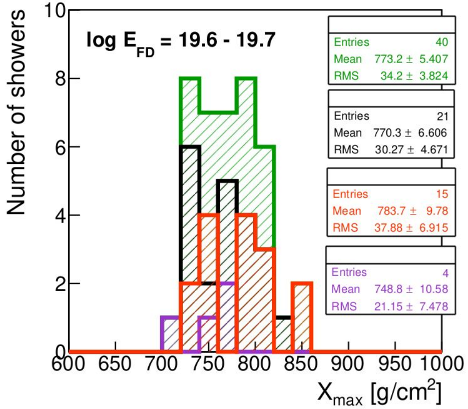
D. Kuempel, K. Kampert, M. Risse
Astropart. Phys., 30(4):167–174, Nov 2008

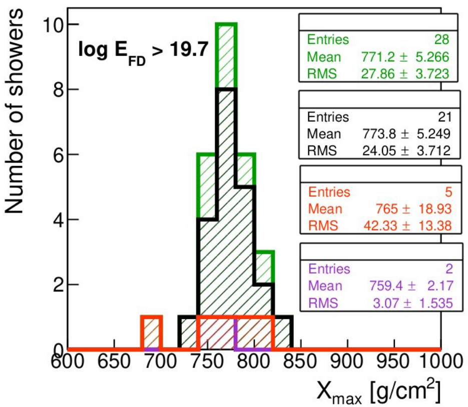






F. Riehn, R. Engel, A. Fedynitch, T. K. Gaisser, T. Stanev
Physical Review D, 102(6), Sep 2020





IDPASC school 2022

Despoina Farakou
farakoudespoina@gmail.com

National Technical University of Athens

Fyzikální ústav Akademie věd České republiky

FACULTY OF MATHEMATICS AND PHYSICS
Charles University

August 29, 2022

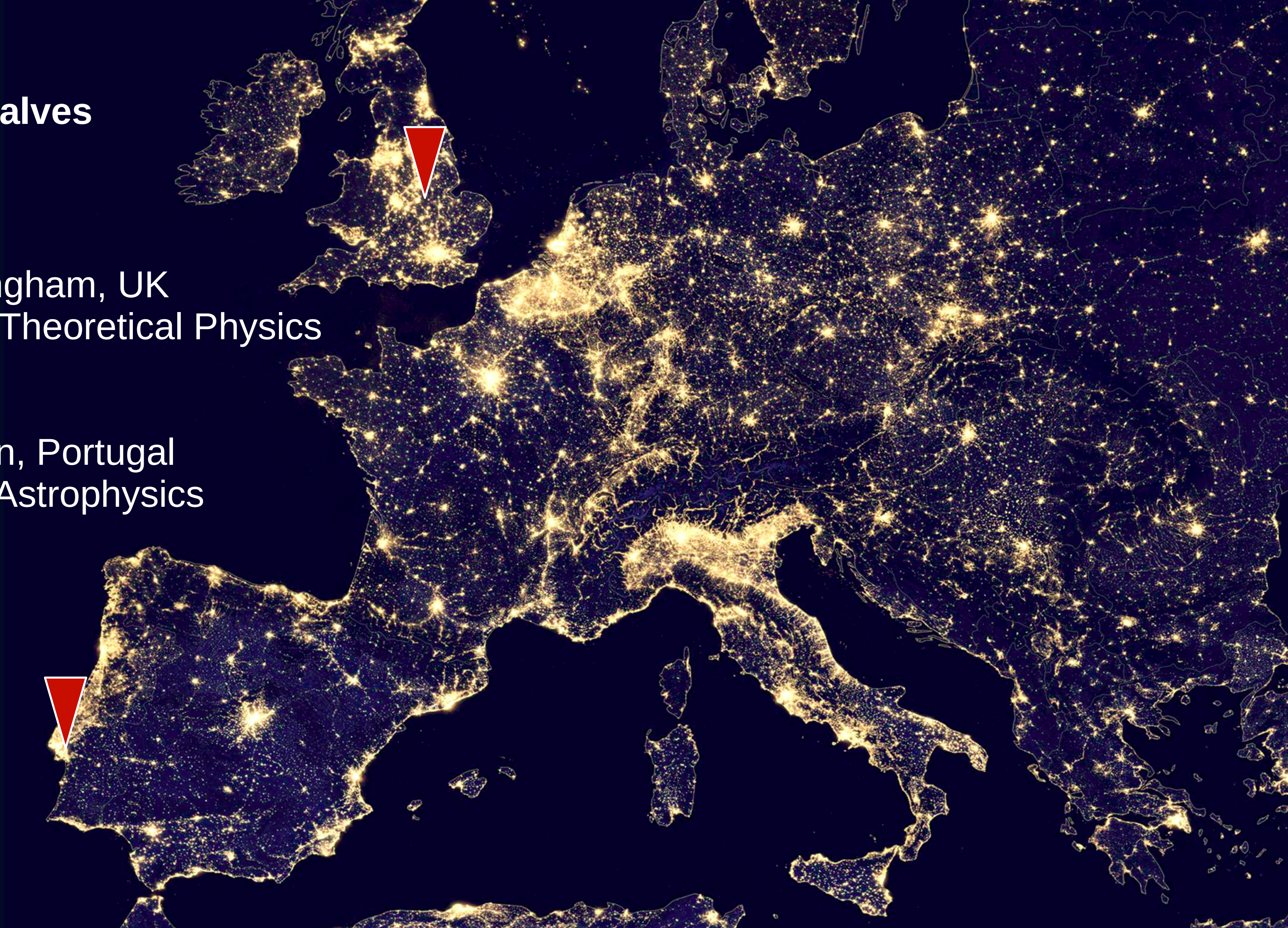
Research work

- Dark Matter Bound States
  - DM bound state formation and decay
  - Cosmological effects
- Running Vacuum in Sting Inspired Cosmologies and Matter-Antimatter Asymmetry in the Universe - Baryogenesis through Leptogenesis
  - CP Asymmetric Decay of Right Handed Neutrinos into fermions
  - Baryogenesis through Leptogenesis
- Cosmological effects of Dark Matter
  - Large Scale Structure
  - Relativistic Theory for Modified Newtonian Dynamics

Tiago Gonçalves

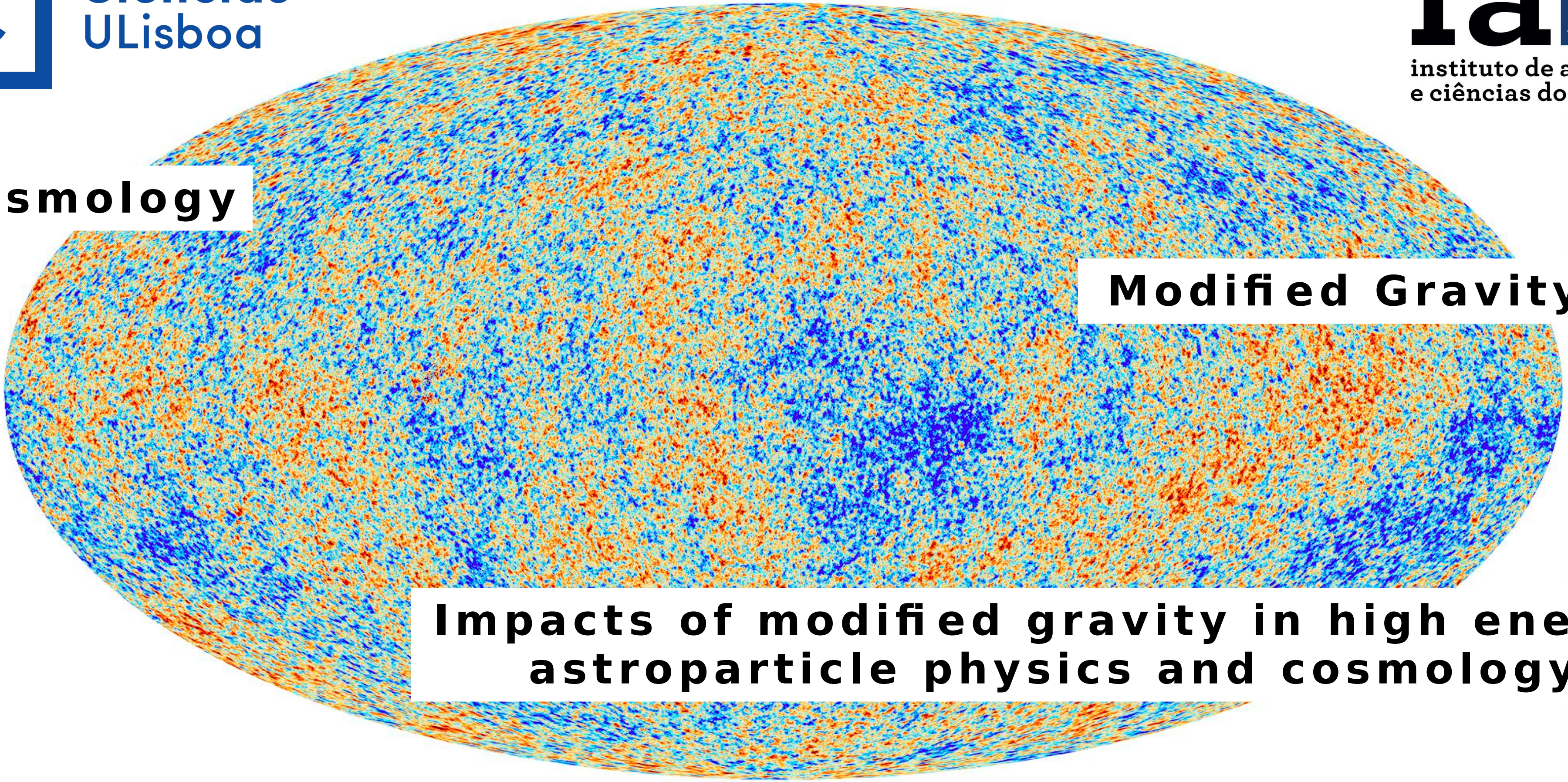
2013–2017
University of Nottingham, UK
MSci Physics with Theoretical Physics

2021–
University of Lisbon, Portugal
PhD Astronomy & Astrophysics



Ciências ULisboa

instituto de astrofísica e ciências do espaço



Cosmology

Modified Gravity

Impacts of modified gravity in high energy astroparticle physics and cosmology

Acknowlegments: UIDB/04434/2020 & UIDP/04434/2020, PTDC/FIS-OUT/29048/2017, PTDC/FIS-AST/0054/2021, PRT/BD/153354/2021.

Pedro Costa

IDPASC 2022 - Introduction

Previous Experience

- **Integrated Master's in Physics Engineering at Instituto Superior Técnico (IST), Portugal**
  - Summer internship at LIP
    - Expanded into Master's thesis

- **Master's Thesis** – defended on November 2021
  – "*Evaluation of the potential of a gamma-ray observatory to detect astrophysical neutrinos*"

- **Currently -** PhD student at IST and LIP
  - Thesis Title: "*Multi-messenger physics with the Pierre Auger Observatory and SWGO*"

IDPASC

SWGO The Southern Wide-field Gamma-ray Observatory

PIERRE AUGER OBSERVATORY

TÉCNICO LISBOA

FCT Fundação para a Ciência e a Tecnologia

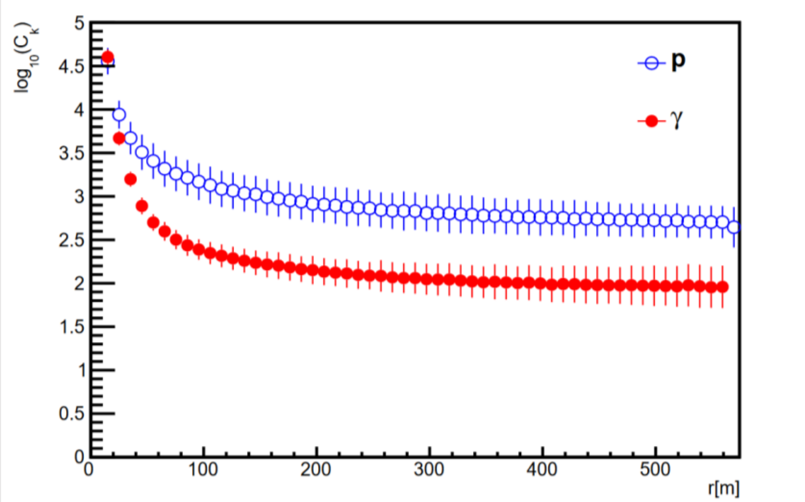
LIP LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS *partículas e tecnologia*

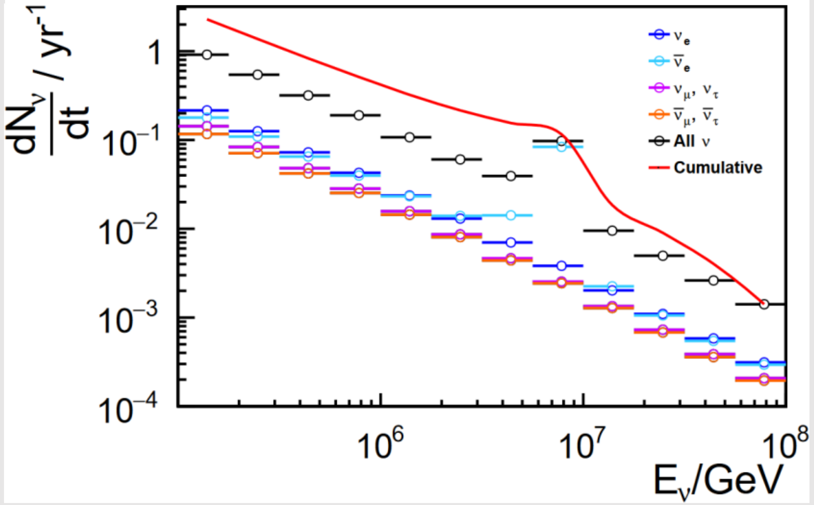
Pedro Costa

IDPASC 2022 - Introduction

Current Occupation (PhD)

- ***"Multi-messenger physics with the Pierre Auger Observatory and SWGO"***
  - <u>Objective</u>**:** Boost the capabilities of the **Pierre Auger Observatory** and **SWGO** in detecting multi-messenger phenomena.
  - <u>Particularly</u>**:** ability to detect extreme energy **photon** and **neutrino** events from astrophysical sources.
  - Achieved by combining novel detection techniques with new measured shower quantities.





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SWGO The Southern Wide-field Gamma-ray Observatory

PIERRE AUGER OBSERVATORY

TÉCNICO LISBOA

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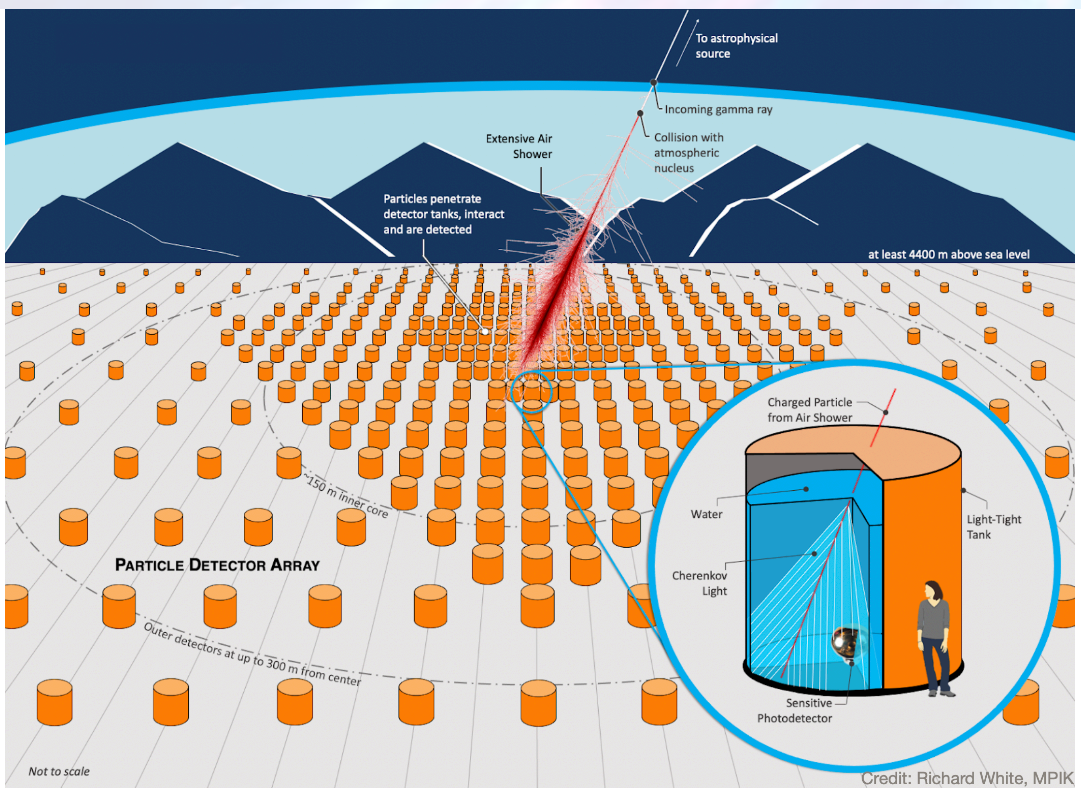
Lucio Gibilisco

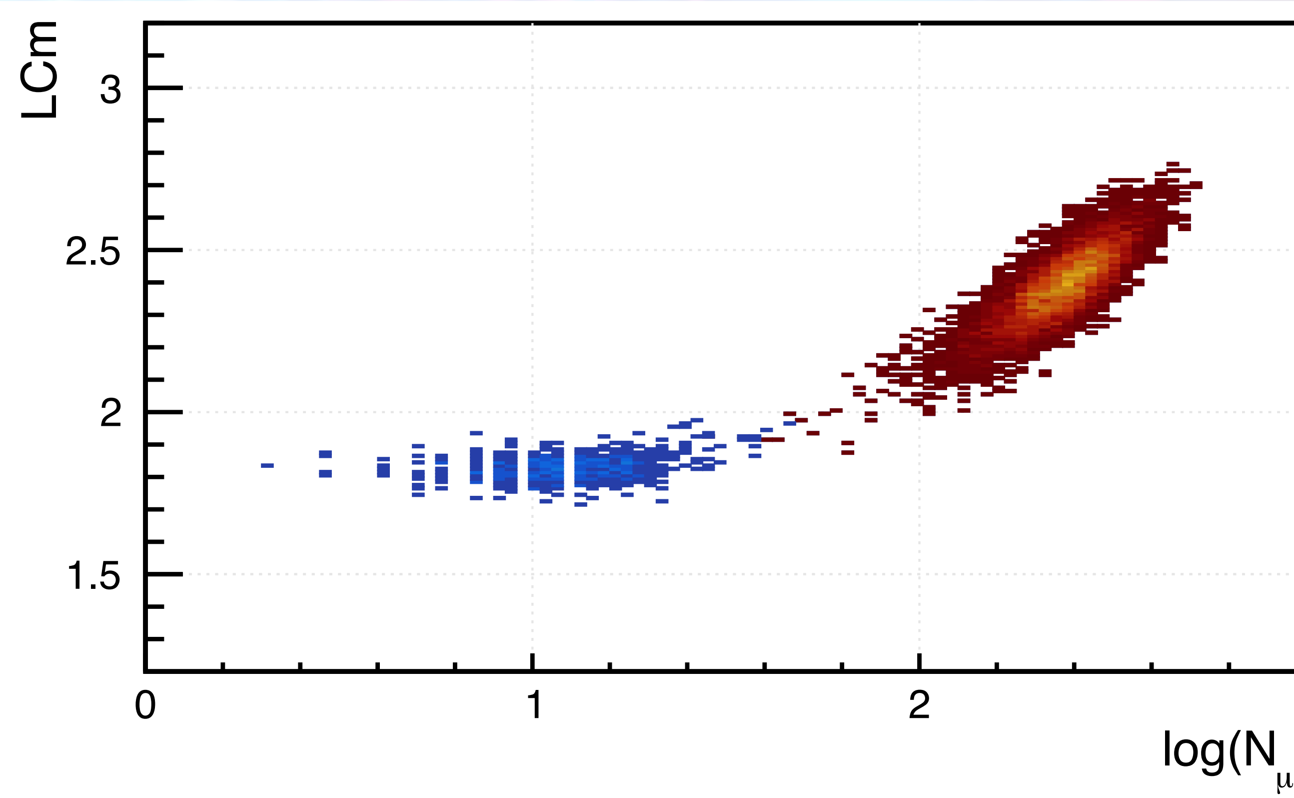
- June 2021 - Master Degree in Astrophysics at Università degli Studi di Torino.
- October 2021 - Start of student fellowship at Laboratório de Instrumentação e Física Experimental de Partículas (LIP), Lisbon.
- Currently - PhD student at Instituto Superior Técnico (IST) and LIP, Lisbon.
- Thesis title: *Reaching for PeVatrons with the Future Southern Wide-field Gamma-ray Observatory.*

SWGO
The Southern Wide-field Gamma-ray Observatory

- Gamma-ray observatory in R&D phase.
- Excellent gamma/hadron separation capability needed to reject overwhelming background.
- First part of my PhD: investigating gamma/hadron separation through the analysis of the shower footprints at the ground and quantification of their asymmetries.
- Future tasks: application of the method to real data, studies on cosmic ray mass composition and hadronic interaction features at PeV, SWGO sensitivity to PeVatrons, …

The Southern Wide-field Gamma-ray Observatory





LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS

TÉCNICO LISBOA

Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Kateřina Jarkovská

- PhD student at Charles University in Prague
- Research group: M. Malinský, V. Susič, K. Jarkovská

Quantum analysis of SO(10)

$$SU(3)_c \times SU(2)_L \times U(1)_Y \subset SO(10)$$

Matter fields

Type-I seesaw

$$16_F = L_L \oplus \overline{d}_L \oplus Q_L \oplus \overline{u}_L \oplus \overline{e}_L \oplus \boxed{N_L^c}$$

Gauge fields

$$45_G = G_\mu^b \oplus A_\mu^a \oplus B_\mu, Y_\mu \oplus (3,1,\tfrac{2}{3}) \oplus \boxed{(3,2,-\tfrac{5}{6})} \oplus \boxed{(3,2,\tfrac{1}{6})} \oplus (1,1,1) + h.c.$$

Mediate proton decay

Scalar fields

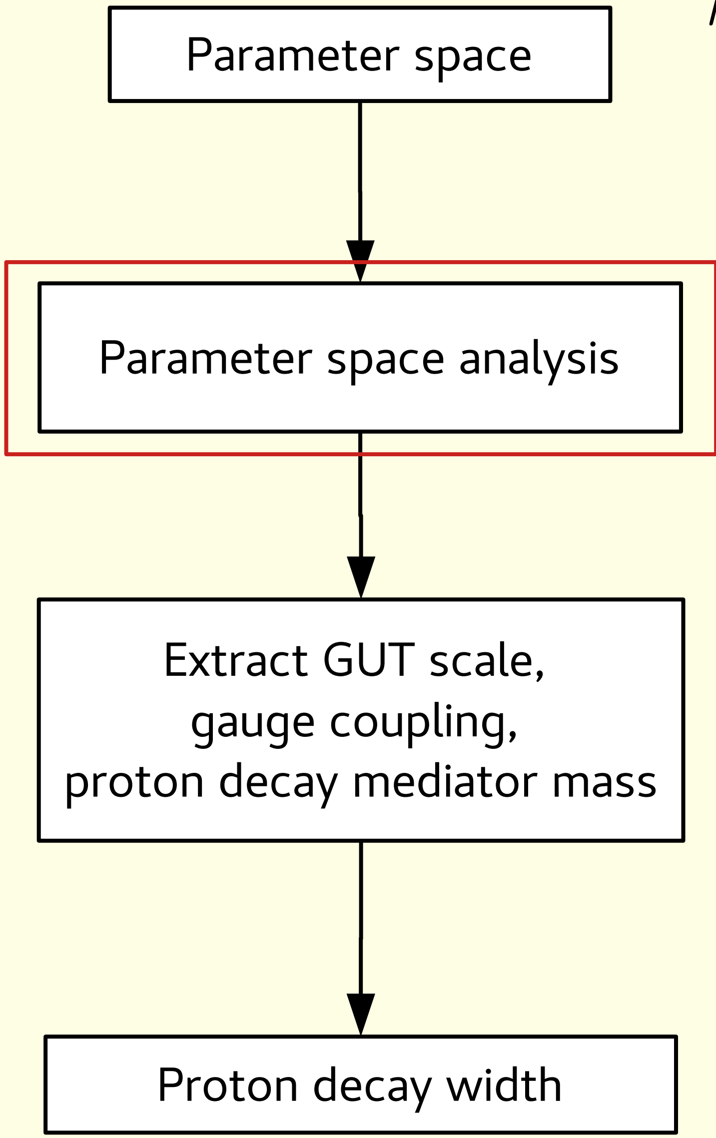
Type-II seesaw

$$45_S \oplus \boxed{126_S} \oplus 10_S$$

IDPASC Summer School, 29.08.2022

Proton decay in SO(10)

Proton lifetime prediction in the non-SUSY minimal renormalizable SO(10) is **robust with respect to the Planck-scale induced theoretical uncertainties**.



$$h_4, h_3, h_2, h_2', a_0, a_2, \lambda_0, \lambda_2, \lambda_4, \lambda_4', \eta_2, \kappa_0, \kappa_2, \kappa_0', \kappa_2', \zeta, \zeta', \rho_0, \rho_2, \rho_0', \rho_2', \psi_2, \psi_1, \psi_0, \alpha, \beta_4, \beta_4', \gamma_2, \phi, \phi', g$$

$$\omega_{BL}, \omega_R, \sigma, \xi, \xi', \tau'$$

1) Tachyonicity: complete calculation of full one-loop effective scalar mass corrections is required

2) Gauge unification: multi-stage spontaneous symmetry breaking, two loop beta functions

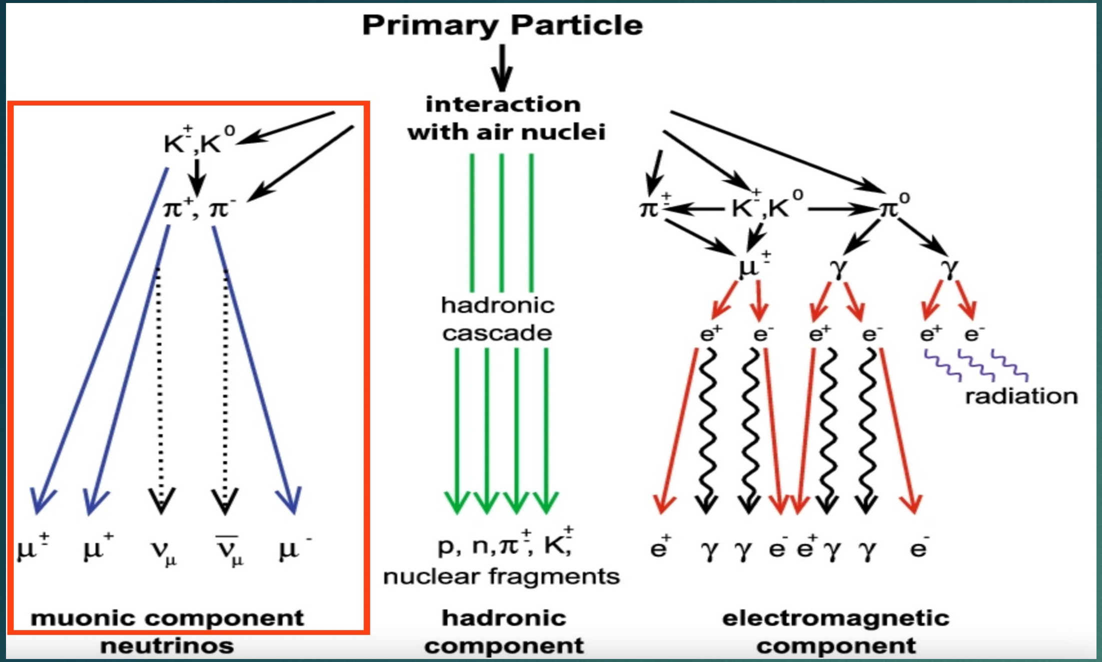
3) Perturbativity:
- **Global mass perturbativity** – the relative size of the one-loop mass corrections is restricted
- **Stability under RG running** - complete system of one-loop beta functions of all dimensionless couplings
- **Vacuum position stability** - only two viable distinct breaking chains

[K.Jarkovská, M.Malinský, T. Mede, V. Susič: Phys.Rev.D 105 (2022) 9, 095003]

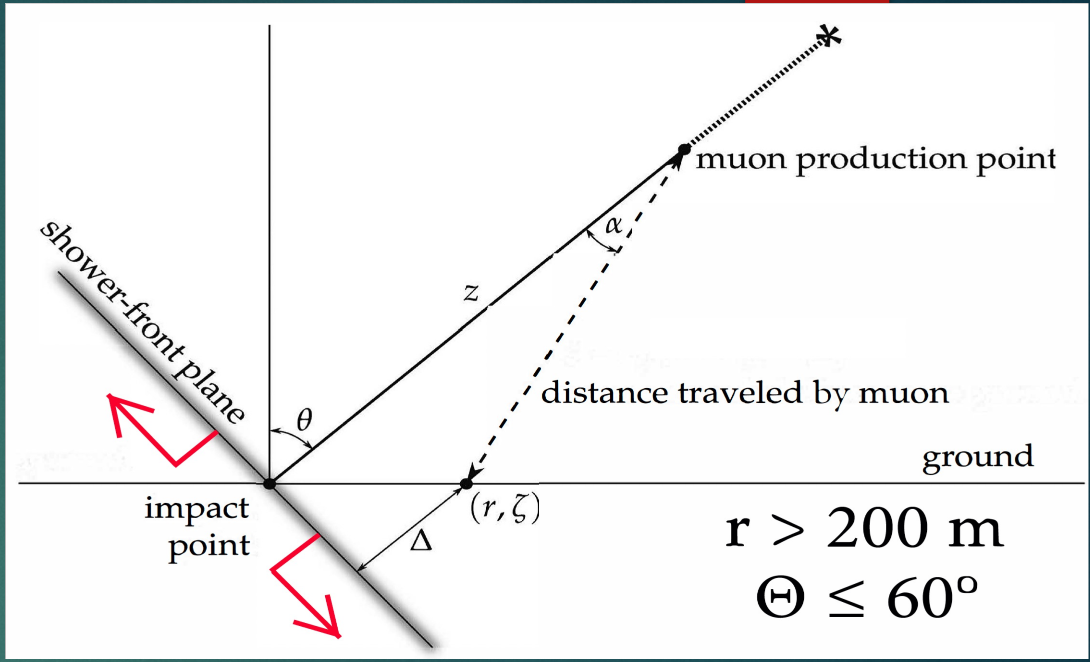
Something about me

- Masters student @ the CTU – Faculty of Nuclear Sciences and Physical Engineering
  - State exams in January ⇒ Ing. ⇒ … ⇒ start PhD.
- Bachelor/Diploma thesis @ the Institute of Physics of the CAS
  - Topic: Production Depth of Muons in Extensive Air Showers
    - Supervisor: Dr. Eva Maria Martins dos Santos
    - Co-supervisor: Dr. Alexey Yushkov
- Data analysis (pure MC as of yet), machine learning (DNNs)

Antonín Kravka



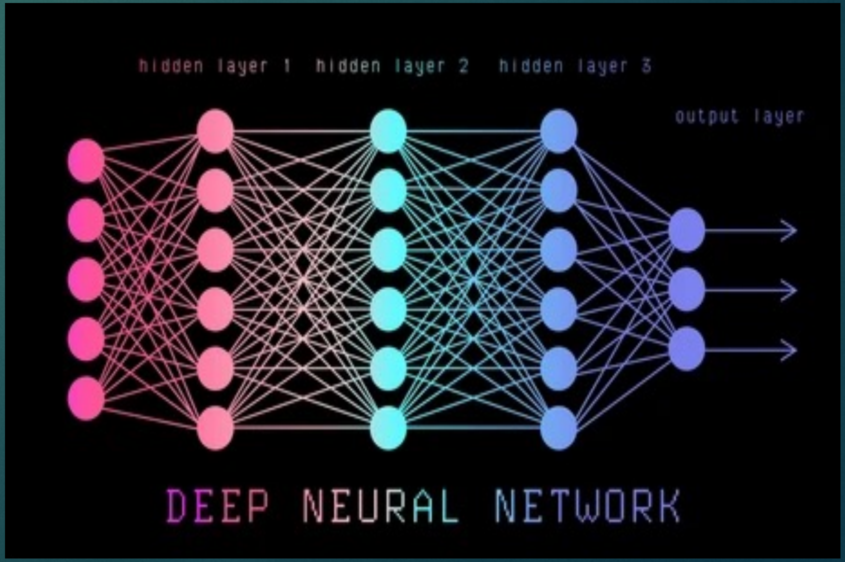
My aim is to:



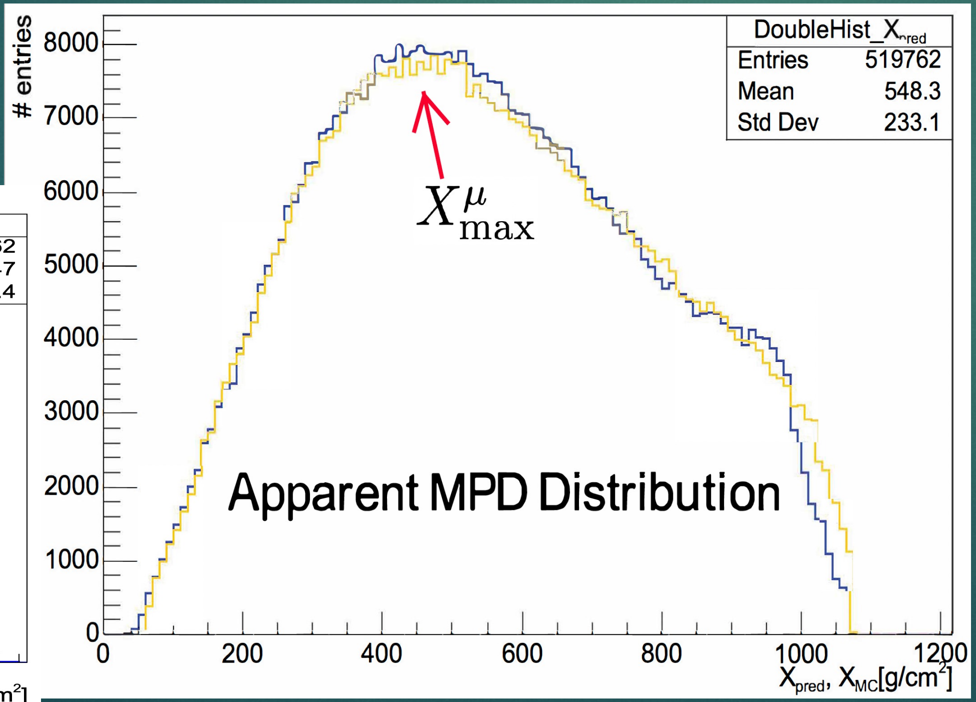
Reconstruct the MPD …

… close to the shower core …

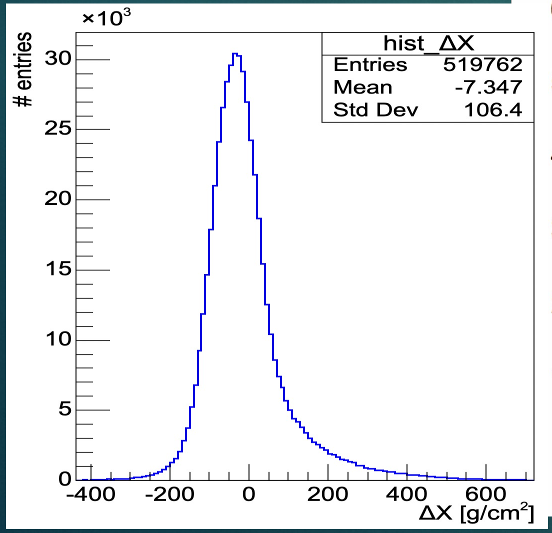
… for vertical showers …



… and obtain X^{μ}_{max} …

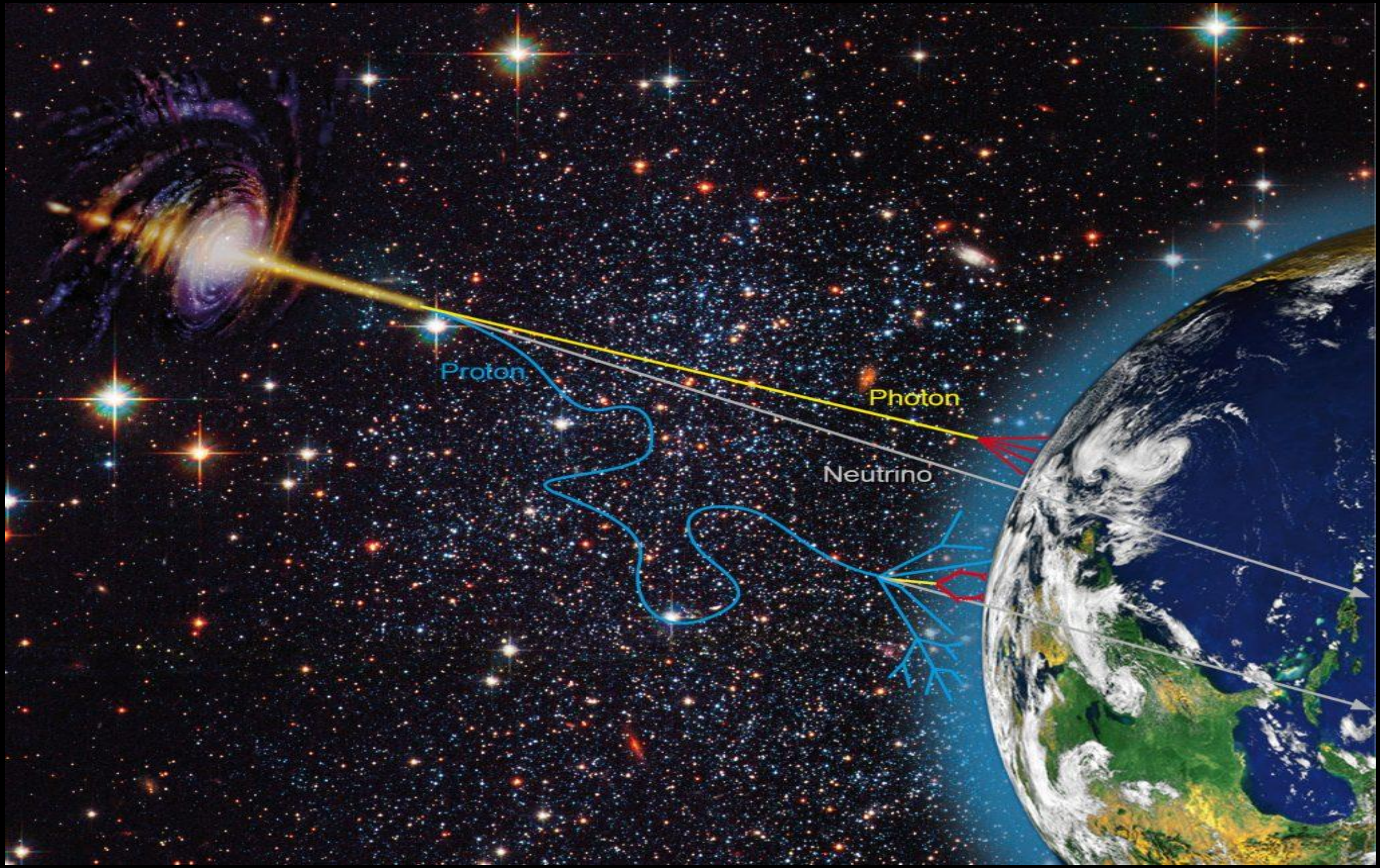


… as X^{μ}_{max} is also sensitive to mass composition of CR!



Multi-messenger studies
With Vera C. Rubin Observatory data

KUNAL BHARDWAJ



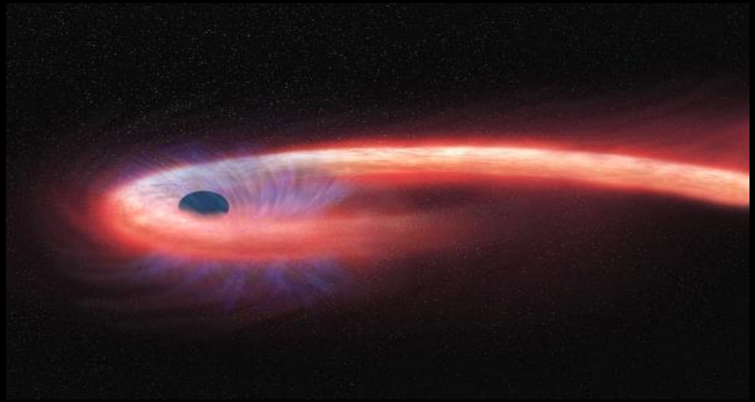
→ Aim: To optically identify potential sources of cosmic rays (e.g. TDEs, GRBs) with Rubin LSST and search for possible direction and time correlations with public data of different types of messengers :

→ Photons (multiwavelength) : Fermi-LAT, CTA

→ Neutrinos : IceCube

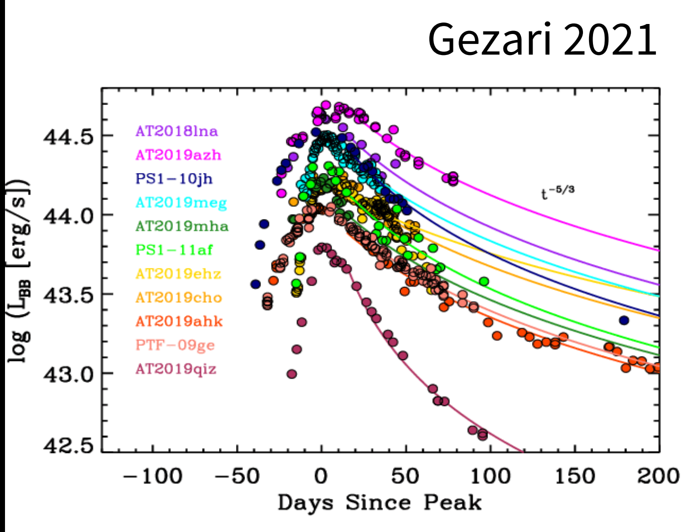
→ Cosmic rays : Pierre Auger, TA

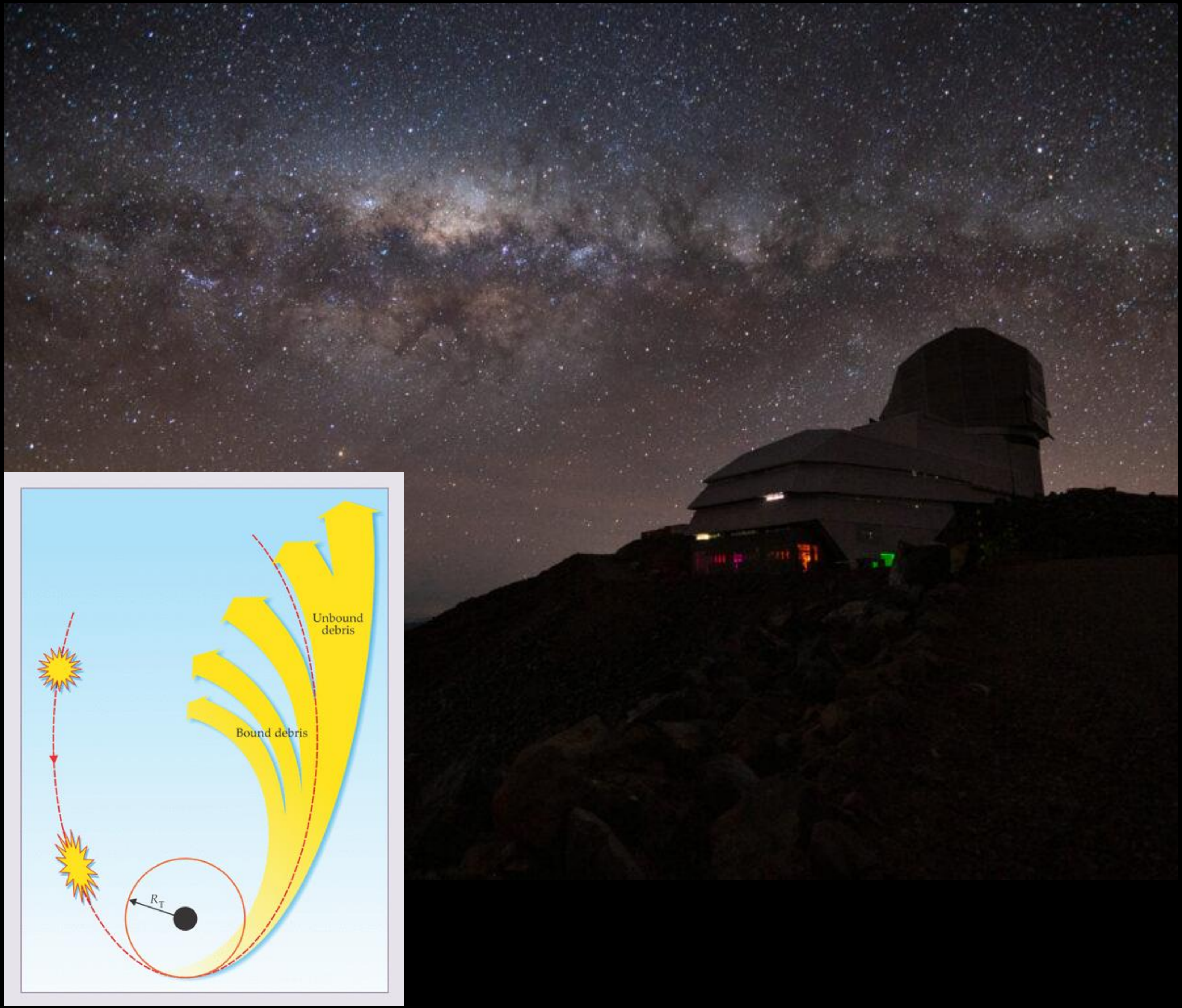
(figure from DESY website)



→ LSST will see many more nuclear transients e.g. AGN, SNe, TDE

→ In preparation, currently working on ZTF data; filter transients and classify TDEs





Laurits Tani

- Junior researcher @ National Institute of Chemical Physics and Biophysics.
- *Measurement of Higgs boson parameters in leptonic final states using machine learning methods.*
- Mostly focused on machine learning techniques
  - Hyperparameter optimization
  - Tau reconstruction using graph neural networks
- HH $\rightarrow$ multilepton analysis

Past & future

Bachelor's degree

TAL TECH

- Engineering physics
- Solar panels & its properties

Master's degree

ETH zürich

- Astroparticle physics
- FACT

PhD studies

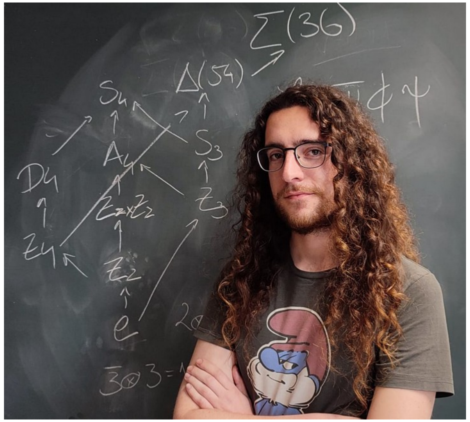
- Evolutionary algorithms for hyperparameter optimization in machine learning for application in high energy physics; Tani et al.
- Comparison of Bayesian and particle swarm algorithms for hyperparameter optimisation in machine learning applications in high energy physics; Tani et al.
- Search for Higgs boson pairs decaying to $WWWW$, $WW\tau\tau$, and $\tau\tau\tau\tau$ in proton-proton collisions at $\sqrt{s} = 13\,TeV$; CMS Collaboration

Future:

ACAT 2022 BARI

?

Name: Miguel Levy



Institution: Instituto Superior Técnico (Universidade Lisboa)

Centre: Centro de Física Teórica de Partículas (CFTP)

Supervisors: Ivo de Medeiros Varzielas & Gustavo Castelo Branco

Research Fields: BSM, Flavour Symmetries (Traditional & Modular), Fermion Masses and Mixings

Research Fields

Extraction of the muon signals recorded by the Surface Detector of the Pierre Auger Observatory using Neural Networks

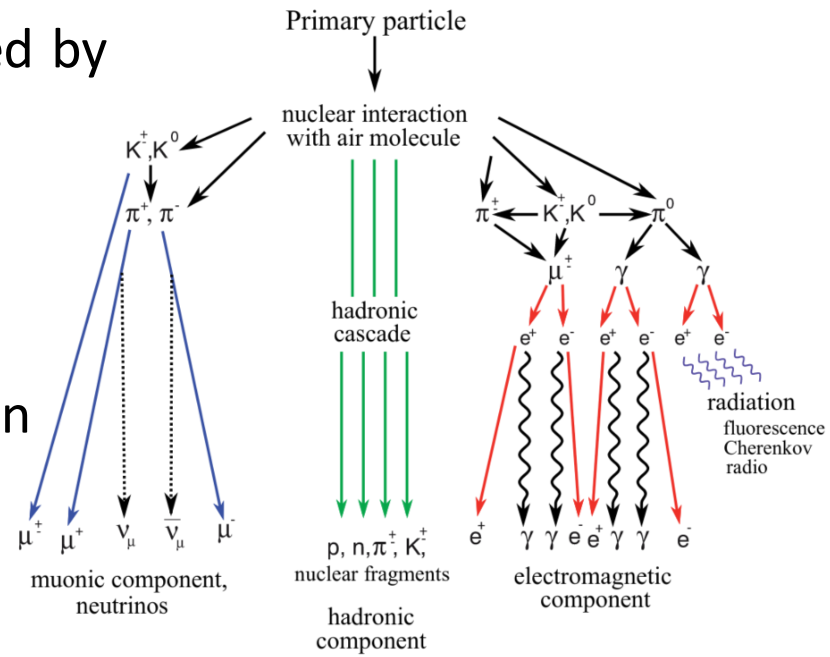
Margita Majerčáková

Supervisor: Dr. Alexey Yushkov

11th IDPASC School
29.8.2022

Motivation

- Primary cosmic ray generates a shower of particles which is detected by the surface detectors of the Pierre Auger Observatory

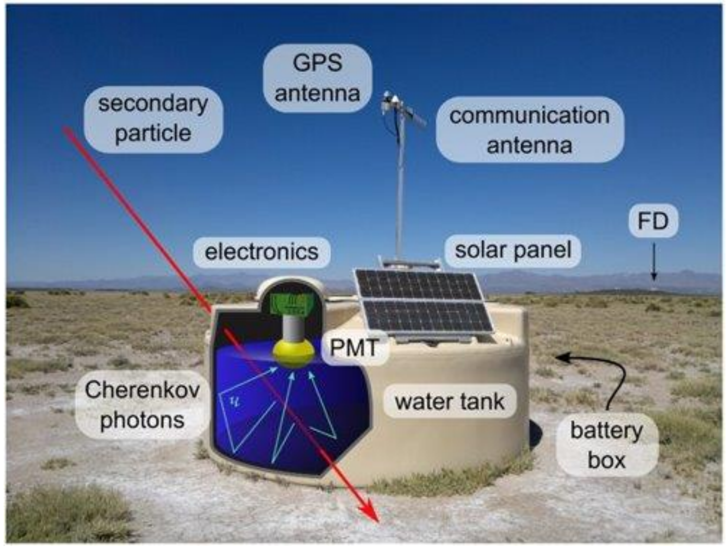


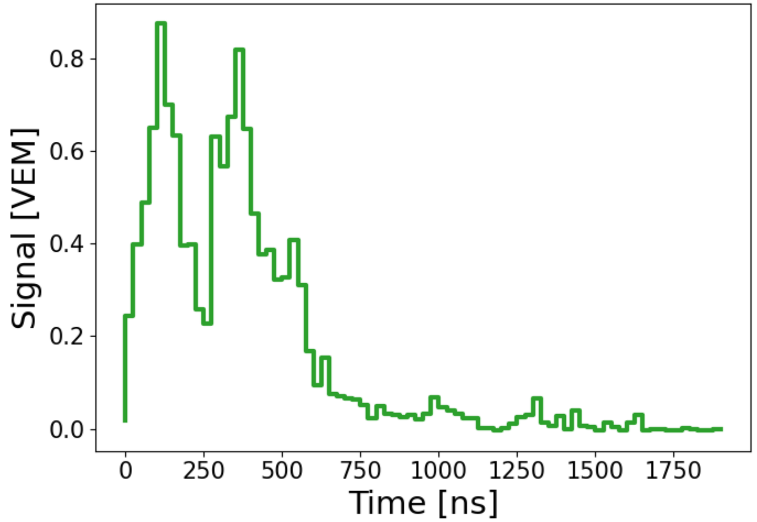
Why muons?

- Mass composition: more muons from heavier nuclei
- Hadronic interactions: modern models do not describe well the muon shower component

Why neural networks?

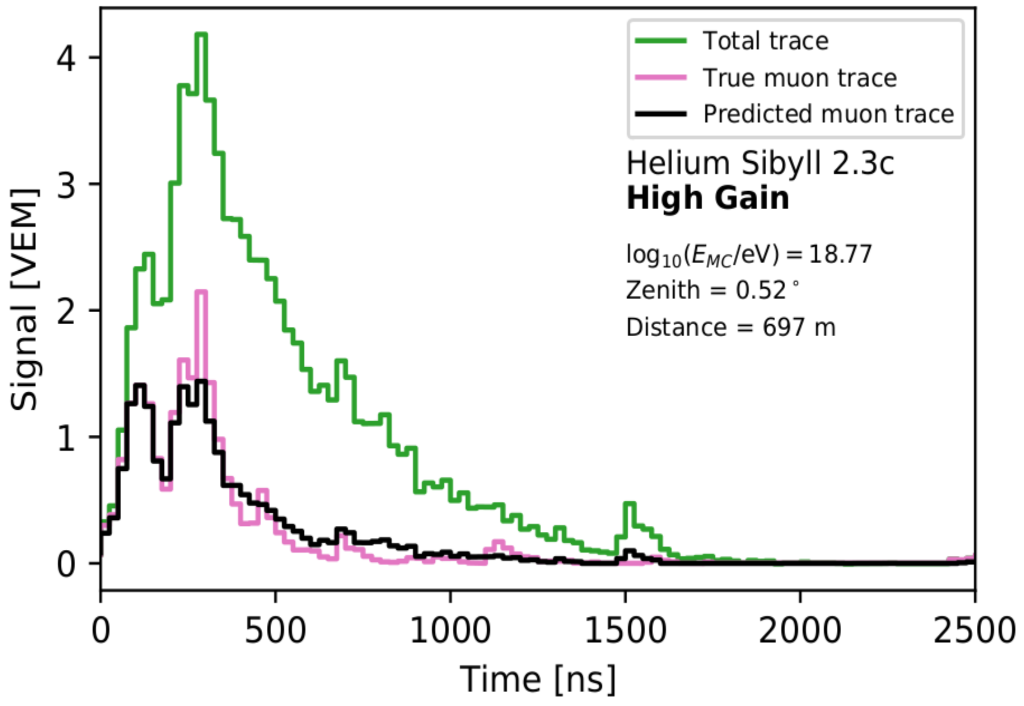
- The surface detector of the Observatory measures signal in time - trace

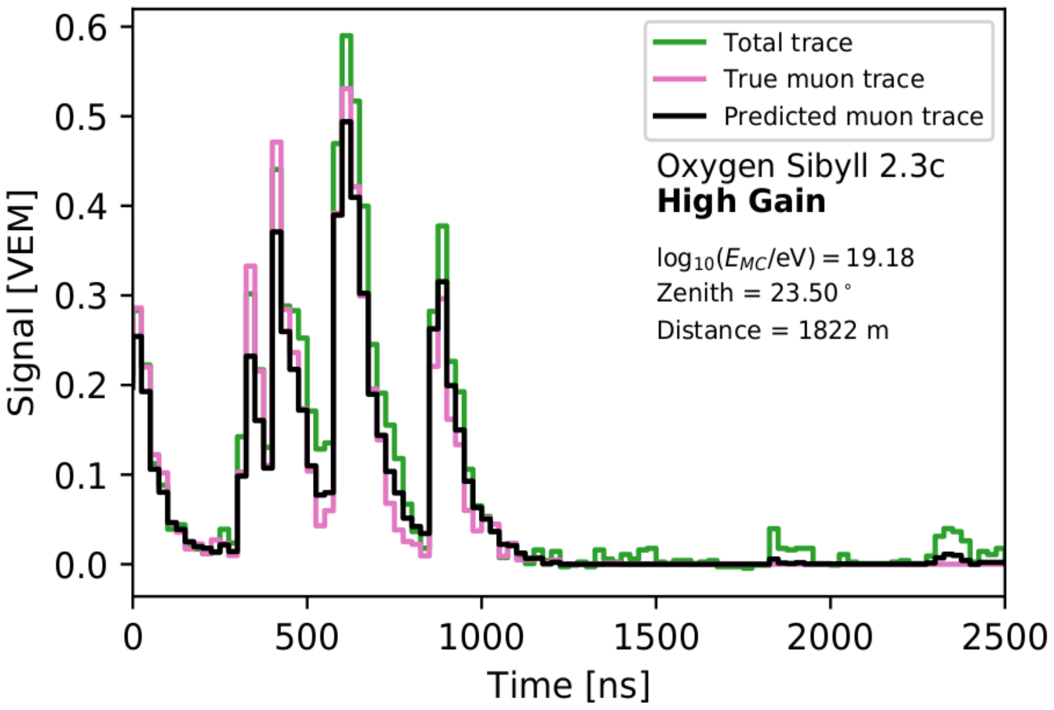




- SD trace – too difficult to disentangle EM and muons -> machine learning methods could find underlaying patterns

Examples of extracted muon traces





Plans for my PhD

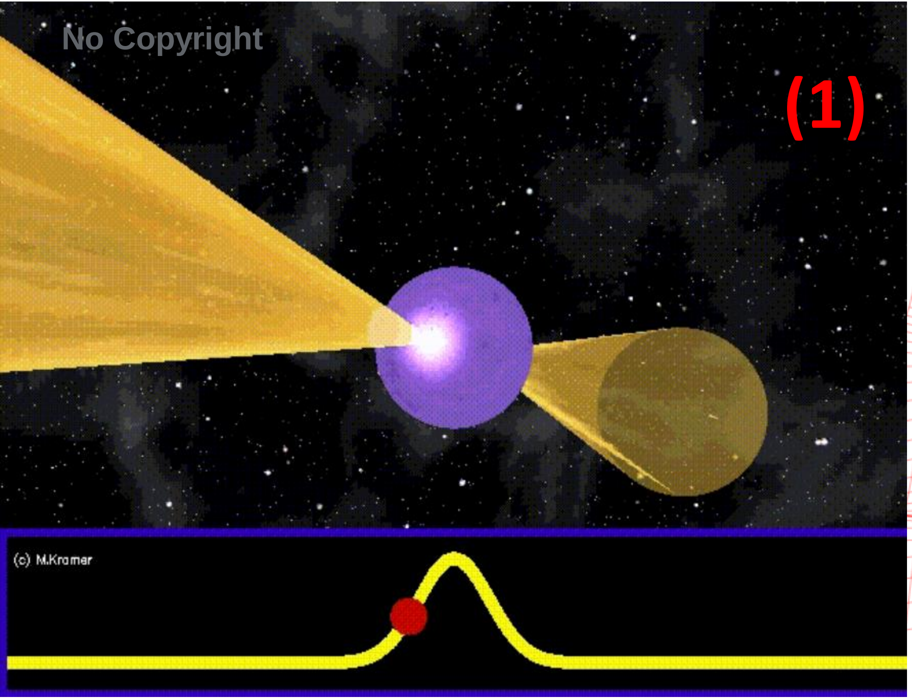
- Optimization of the network performances: architecture, input variables, application phase space
- Study of systematic uncertainties
- Application to the Auger and Auger upgrade (AugerPrime) data

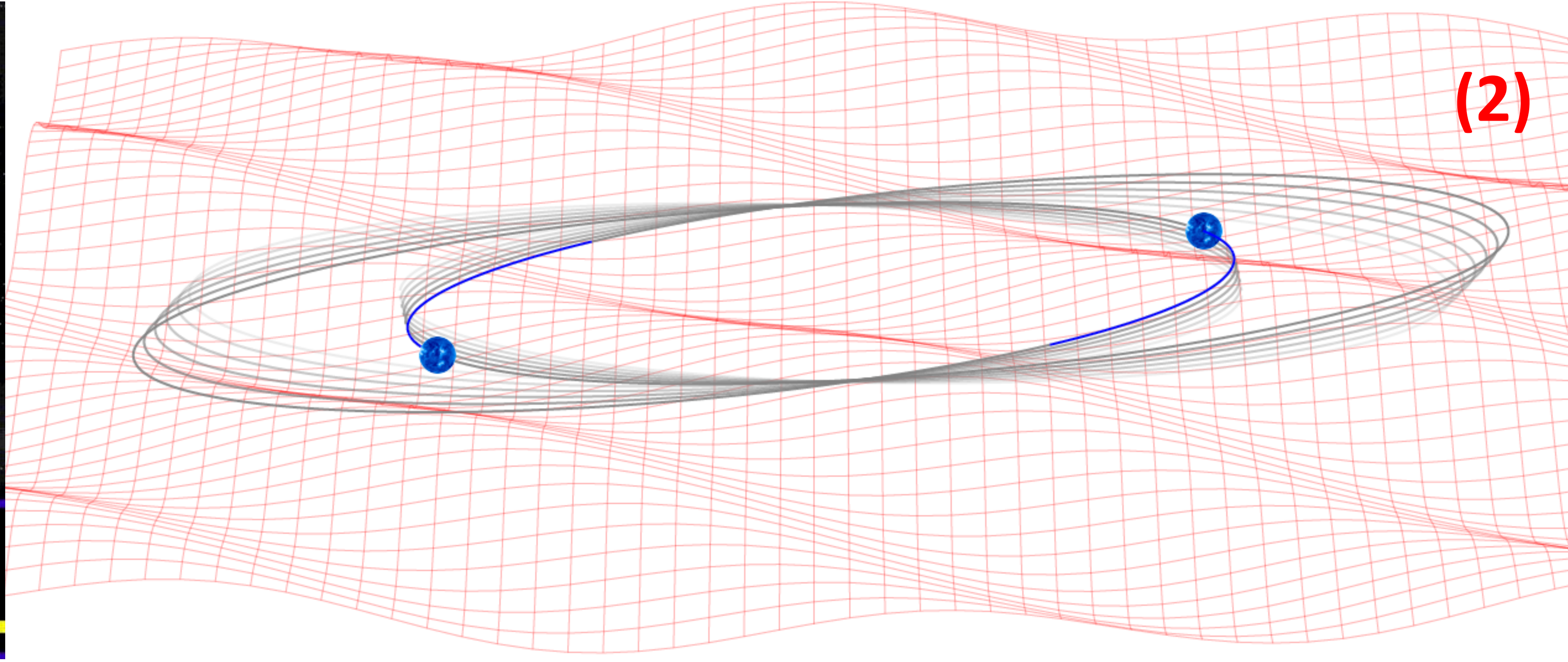
About me

Pavel Kůs
1st year PhD student
CEICO, FZU CAS & Charles University, Prague
pavel.kus@fzu.cz

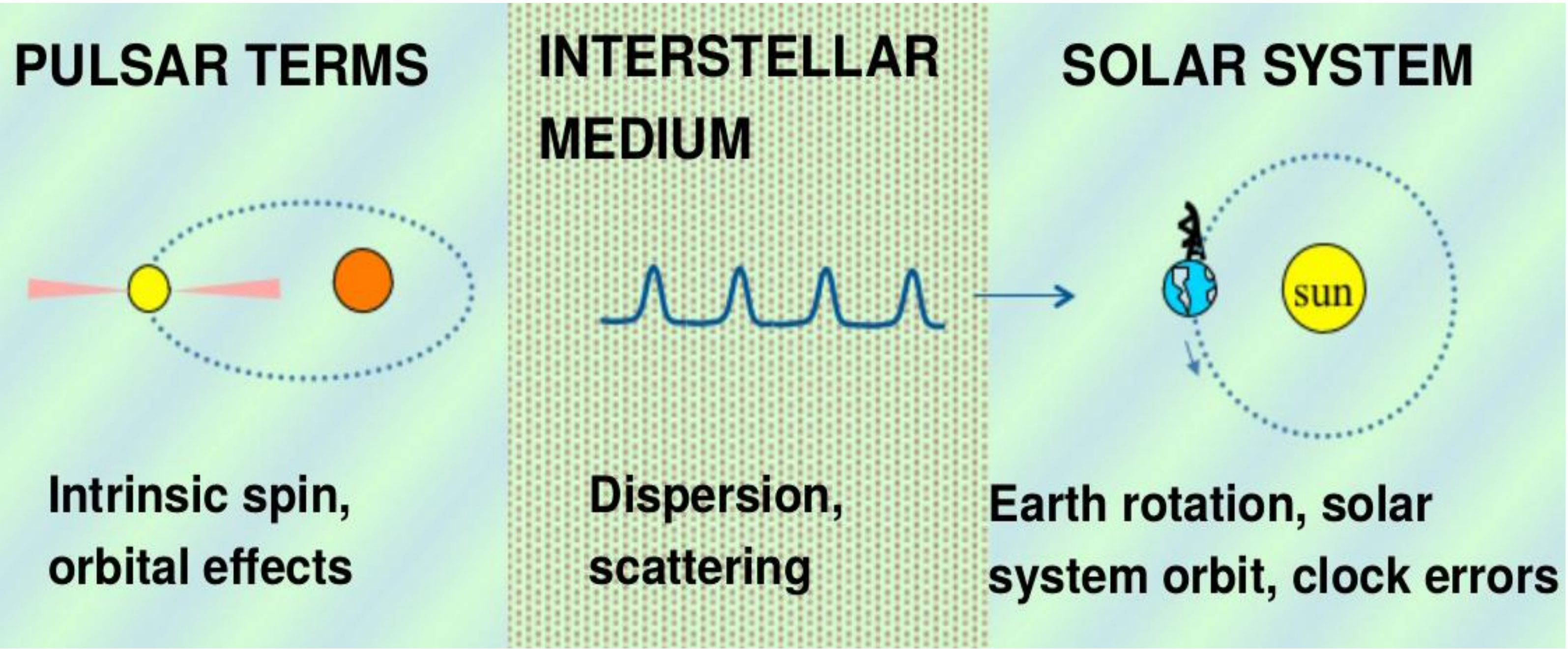
Main research topic

Using pulsar timing to constrain coupling constants of ultralight dark matter

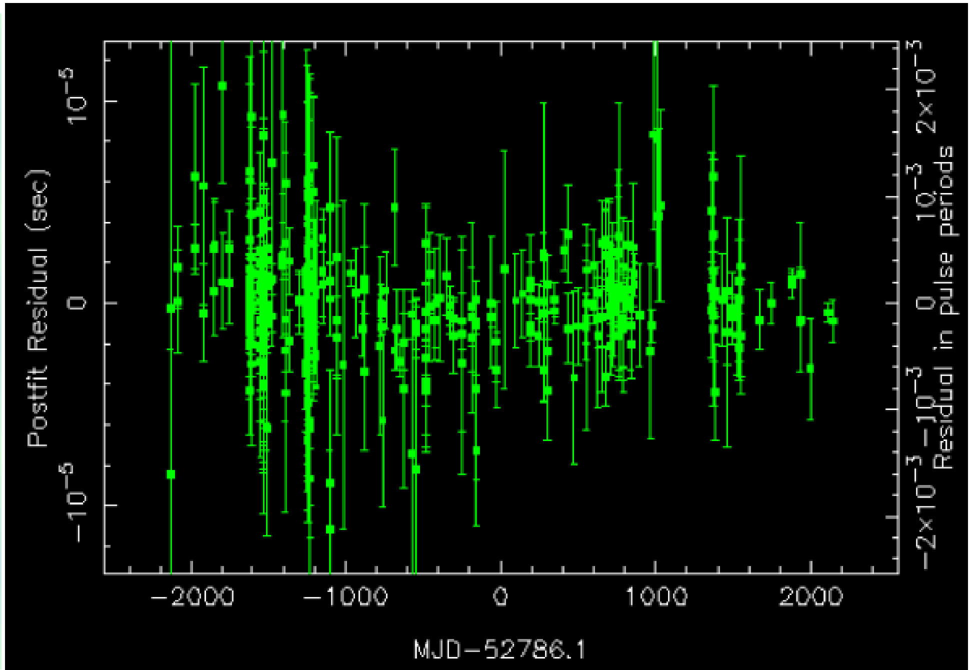

No Copyright
(1)
(c) M.Kramer


(2)

(3)


PULSAR TERMS
INTERSTELLAR MEDIUM
SOLAR SYSTEM
sun
Intrinsic spin, orbital effects
Dispersion, scattering
Earth rotation, solar system orbit, clock errors

(4)


Postfit Residual (sec)
Residual in pulse periods
MJD−52786.1
−2000
−1000
0
1000
2000

Rafael Boto

Integrated Master's in Engineering Physics (2015-2021)
IST, Lisboa, Portugal
Best dissertation in Particle Physics 2021 (20/20)

Current 1^{st} year of PhD in Physics (2021-)
"Constraining Multi-scalars models with colliders and Dark Matter"

Supervisors: Jorge C. Romão, João P. Silva

TÉCNICO LISBOA

CFTP
Centro de Física Teórica de Partículas

Work done

Interests in Beyond the Standard research with focus on multi-scalar models. Published work:

- Basis-independent treatment of CPV and (softly broken) $\mathbb{Z}_2$

  Basis-independent treatment of the Complex 2HDM, PRD101, 055023 [Boto, Fernandes, Haber, Romão, Silva, 2020]

- 2HDM Symmetry Map with basis invariants

  A fully basis invariant Symmetry Map of the 2HDM, JHEP 2021, 229 [Bento, Boto, Silva, Trautner, 2021]

- Phenomenology of a 3HDM with $\mathbb{Z}_3$ symmetry

  Current bounds on the Type-Z Z3 three Higgs doublet model PRD104, 095006 [Boto, Romão, Silva, 2021]

- Bounded from below conditions

  BFB conditions on a class of symmetry constrained 3HDM arxiv:2208.01068 [Boto, Romão, Silva, 2022]

  $\Rightarrow$ Under review for publication.

Starting work as an assistant teacher at IST.

IDPASC Summer School 2022

Shima Ujjani Shivashankara

- First year PhD student at University of Nova Gorica, Slovenia.
  - Work on cosmic particles
  - Collaborator-Pierre Auger Observatory (PAO)

Image: ESA website

Research Work

Analysis of identity of the cosmic particles from data captured by upgraded detector system at PAO

Institute of Physics of the Czech Academy of Sciences
Jordi Tuneu
tuneu@fzu.cz

Profile-Constrained Geometry Fit of Cerenkov light

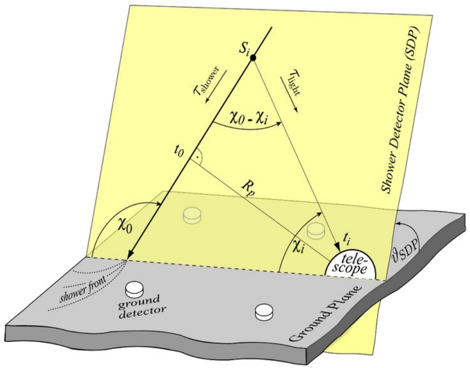
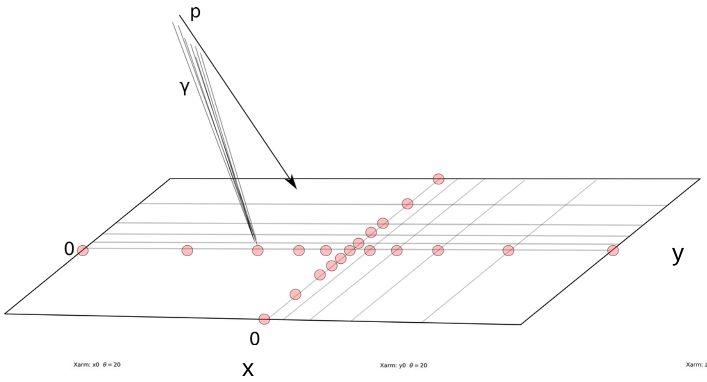
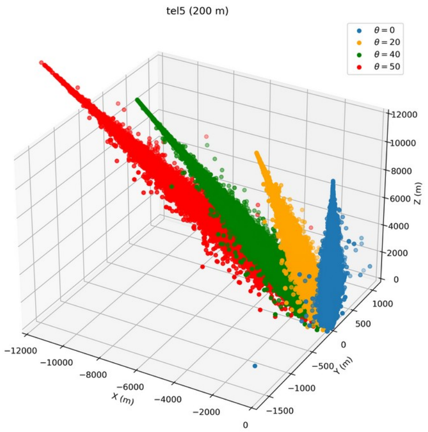
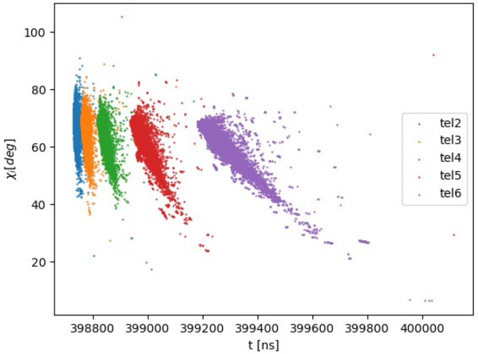
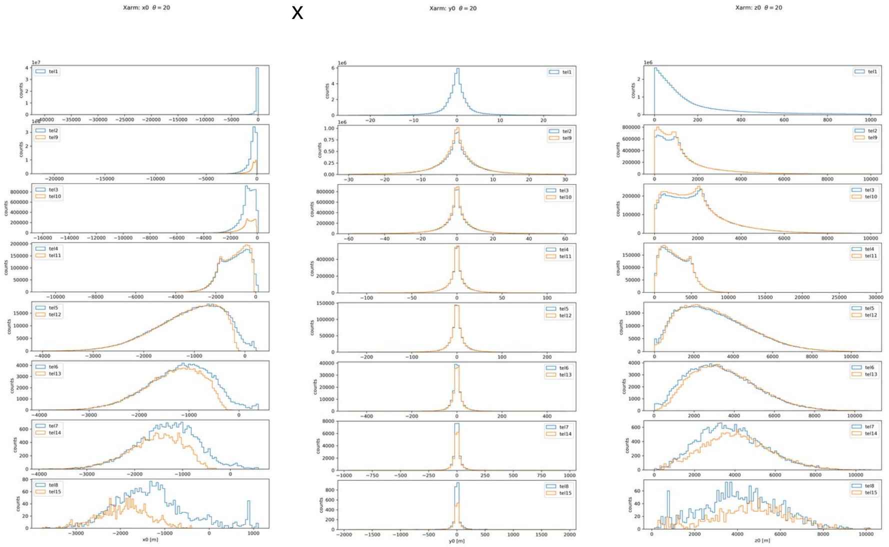


Image from ‘Geometry reconstruction of fluorescense detectors revisited’ D.Kuempel et al. 2008







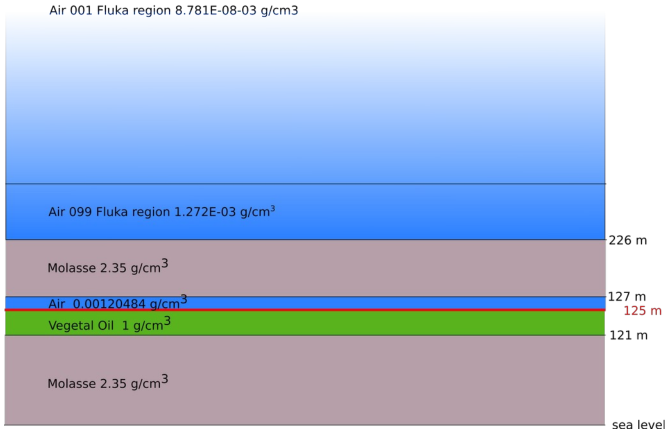


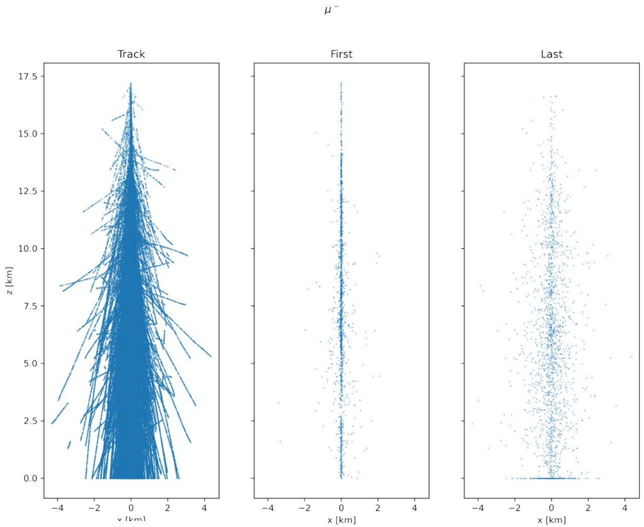
FZU Institute of Physics of the Czech Academy of Sciences

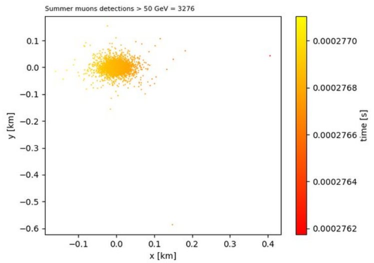
Jordi Tuneu
tuneu@fzu.cz

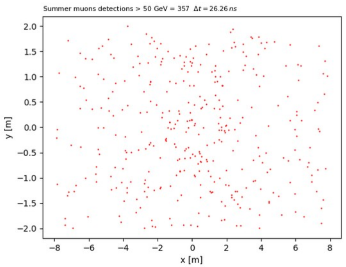
IDPASC

Propagation of muons underground with Fluka



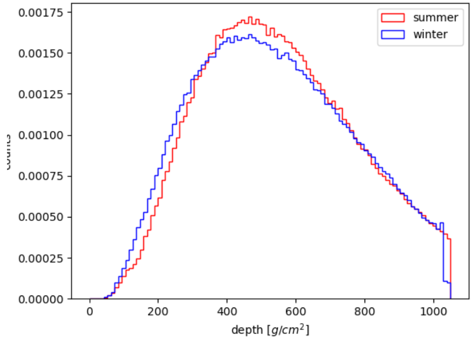


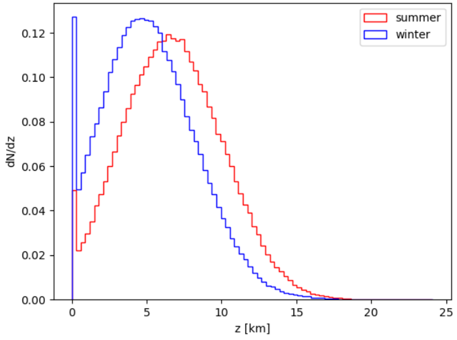


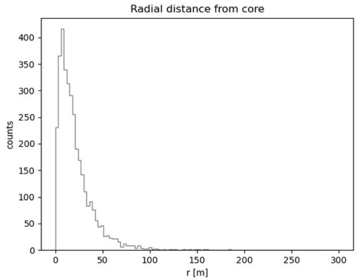


Primary proton 100 TeV

Primary proton 100 PeV

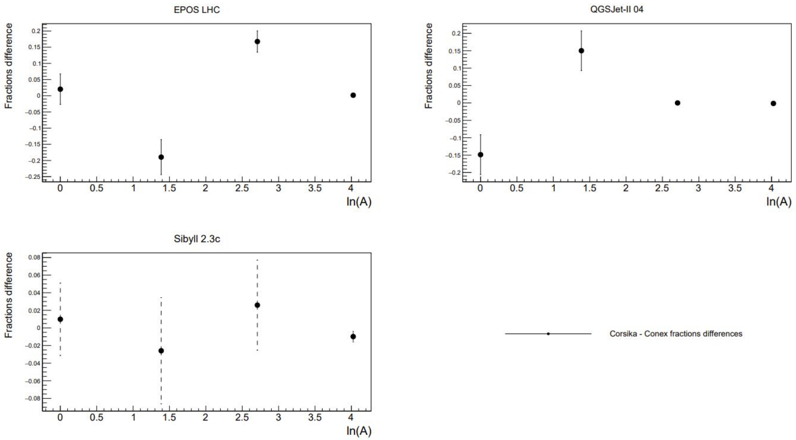


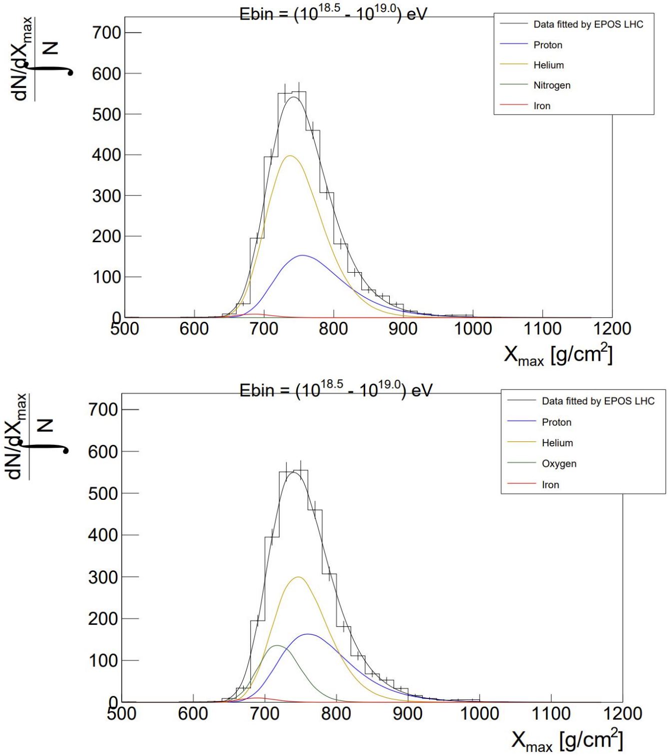




Bachelor's Thesis: Systematic uncertainty of mass composition of cosmic rays interpreted from measurements of depth of shower maximum using different Monte Carlo generators

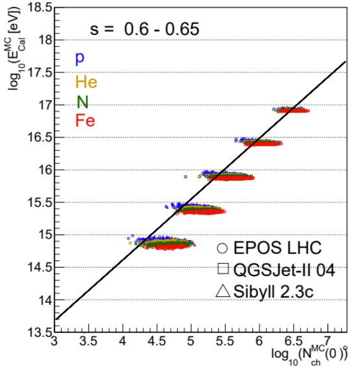
- International Pierre Auger Observatory in Argentina
- Parametrizing distributions of MC simulated EAS
- Fitting data from 01-01-04 – 31-12-18
- Establishing differences in primary fractions with respect to different MC simulation programs
- Uncovered a bug in CORSIKA 7.7100, least visible in model Sibyll 2.3c
- Won 1st place in international student conference in Physics in Bratislava

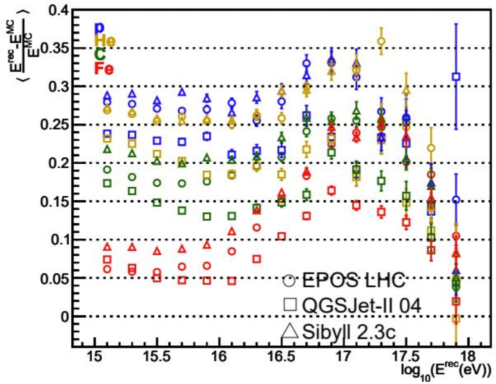


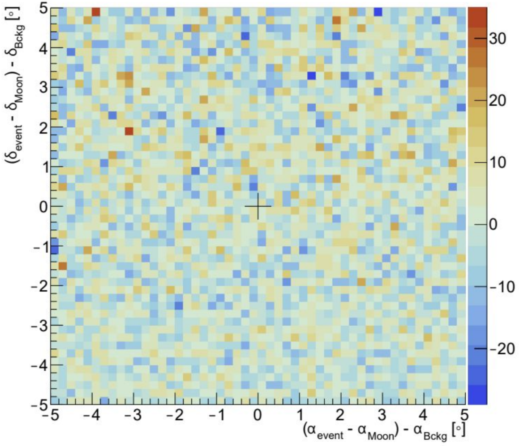


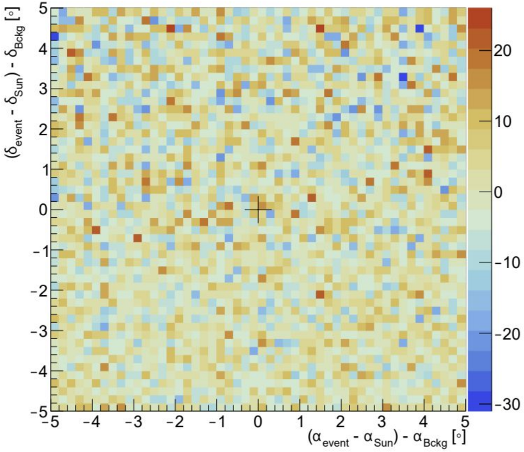
Research Topic: New Energy Calibration of Experiment KASCADE

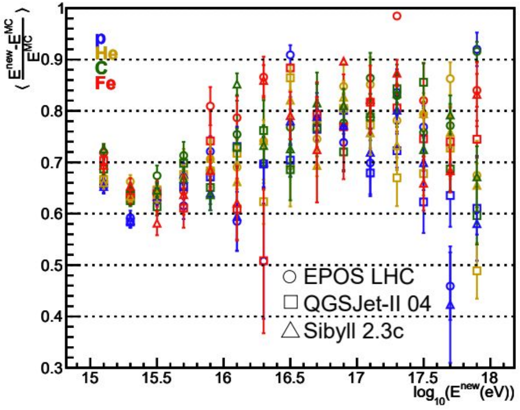
- Experiment KASCADE & KCDC
- Moon & Sun shadow from KASCADE data: so far invisible (data 08-05-98 – 20-12-03)
- New energy reconstruction formula: implementation of shower age and zenith angle (so far increases biases, correction of calorimetric energy in plan)











LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS
partículas e tecnologia

Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Universidade do Minho
Escola de Ciências

Using Machine Learning to Scan Beyond Standard Model Parameter Spaces

In collaboration with Miguel Crispim Romão, Nuno Filipe Castro, Mehraveh Nikjoo, Werner Porod

11th IDPASC School - August 2022

Based on ***Exploring Parameter Spaces with Artificial Intelligence and Machine Learning Black-Box Optimisation Algorithms***, arXiV preprint: **2206.09223**

Fernando Abreu de Souza
LIP - Minho
abreurocha@lip.pt

Beyond Standard Model Validation

Several questions are left **unanswered** by the **Standard Model** (SM)

→ Need to go **beyond** the SM (**BSM**)

→ **BSM validation**: use **experimental data** to constrain the **parameter space** of **BSM** models

Inefficiency: Large **parameters space** + a plethora of **experimental constraints**

How can we make this process more **efficient**?

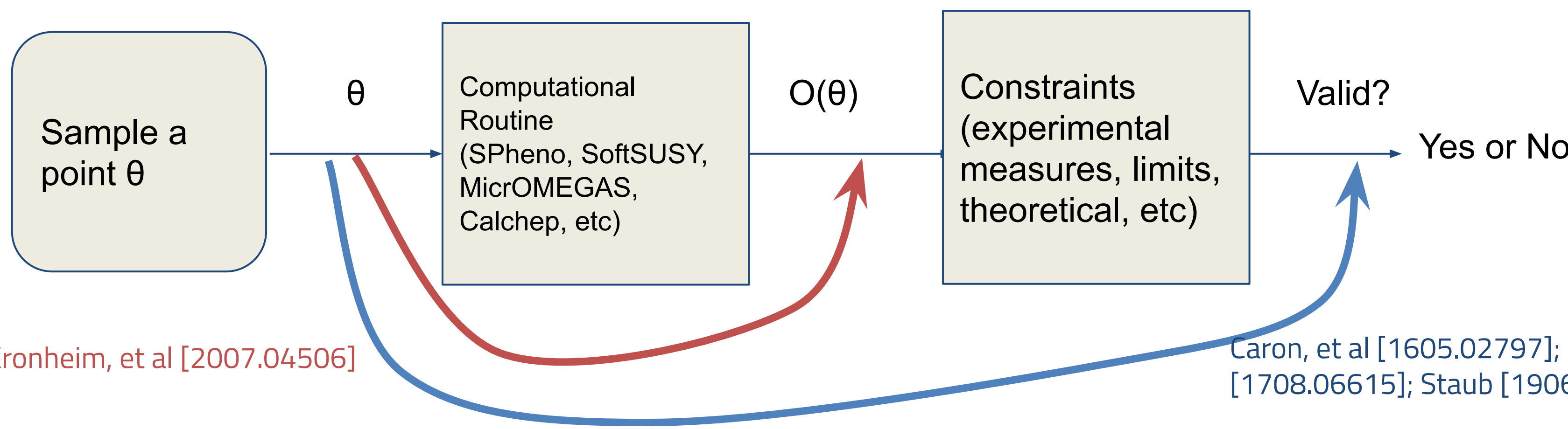
Observable computation: heaviest step

↳ can be **replaced** by:

- **predicting the observables (regression)**
- **predicting if a point is valid (classification)**

} **large amounts of training data** required

→ **Our approach:** **what if instead we change the sampling itself?**



Kronheim, et al [2007.04506]

Caron, et al [1605.02797]; Ren, et al [1708.06615]; Staub [1906.03277]

Black-Box Optimisation

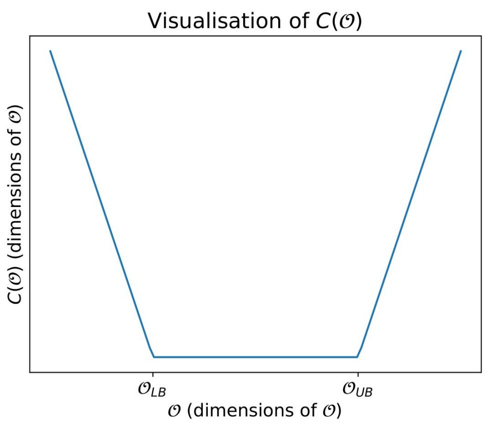
The **sampling** is done via **optimisation algorithms** which learns the parameter space from the **cost function C(O):**

$$C(\mathcal{O}) = max(0, -\mathcal{O} + \mathcal{O}_{LB}, \mathcal{O} - \mathcal{O}_{UB})$$

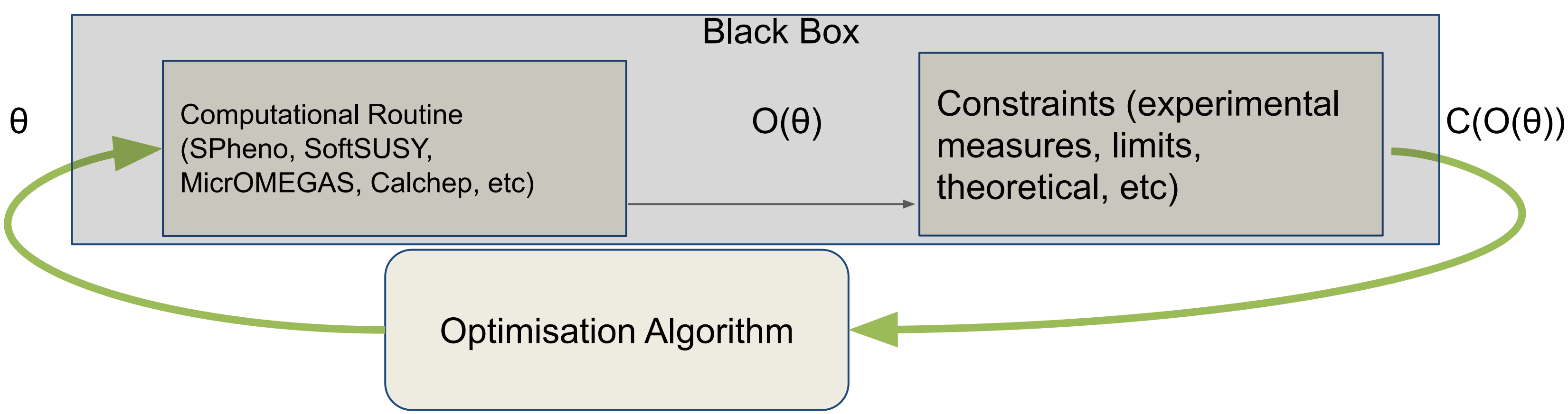
If **θ** is within bounds ⟹ *C = 0*

Optimisation Algorithms

Bayesian: **TPE**
Genetic: **NSGA-II**
Evolutionary (non-genetic): **CMA-ES**



- The **algorithms** only see a **black box** with input **θ** and output **C(θ)**.
- The algorithms suggests new **promising points θ** to be sampled minimising the **cost function**.
- **Prior data** is **not** required.



David Hlaváček

Background

2012 | 2016 **Faculty of Mechanical Engineering, CTU in Prague**
Ph.D. degree at the Dept. of Aerospace Engineering

FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

2013 | 2021 **Employed in industrial and engineering companies**
Analyses of structural mechanics, aerodynamics and thermodynamics

Howden
TechSoft

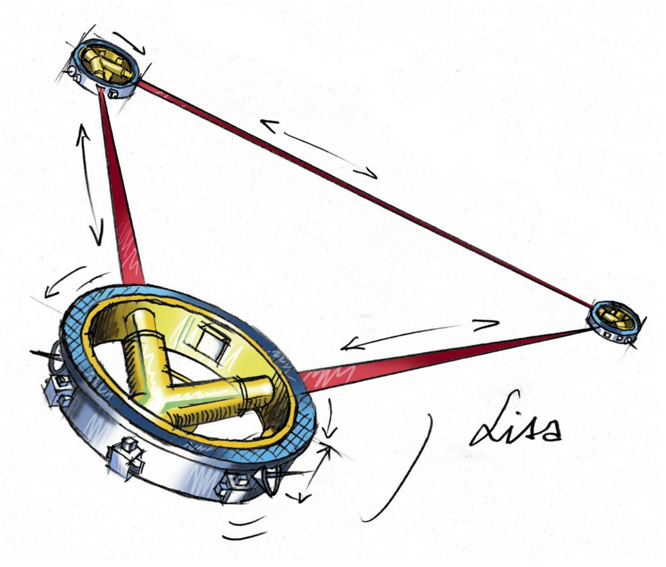
> 10 | 2021 **Institute of Physics, Czech Academy of Sciences**
Postdoc at the Dept. of Astroparticle Physics

FZU Institute of Physics of the Czech Academy of Sciences

Currently working on...

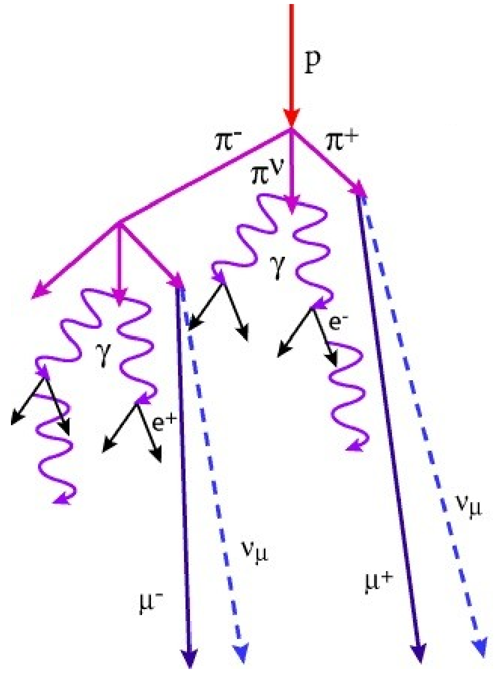
LISA Project

Developing an actuator for a space gravity wave detector



Pierre Auger Observatory

Ultrahigh energy cosmic ray anisotropy, cosmic ray propagation simulation



Science Communication

Taking part in various outreach events

FZU Institute of Physics of the Czech Academy of Sciences

11th IDPASC school, Olomouc

Alena Bakalová

Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering (FJFI) & FZU - Institute of Physics of the Czech Academy of Sciences

- Master‘s degree (2018) in experimental particle physics (FJFI)
- PhD student since 2018 (FJFI)

Scientific focus

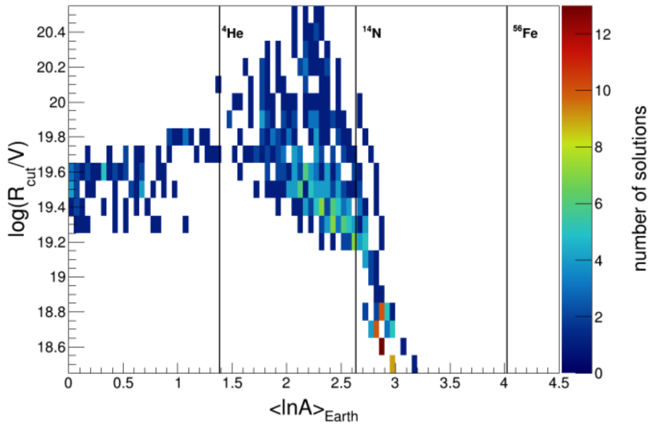
Ultra-high energy cosmic rays, high energy gamma rays

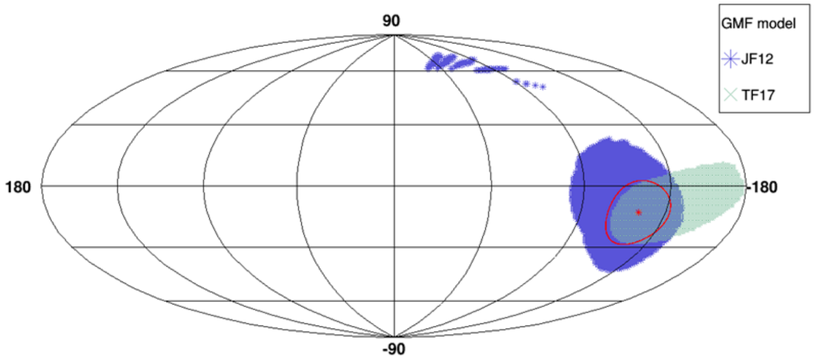
bakalova@fzu.cz

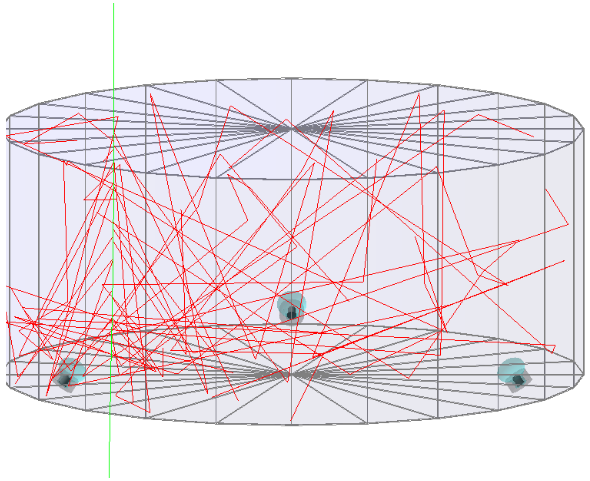
11th IDPASC school, Olomouc

Research Topics

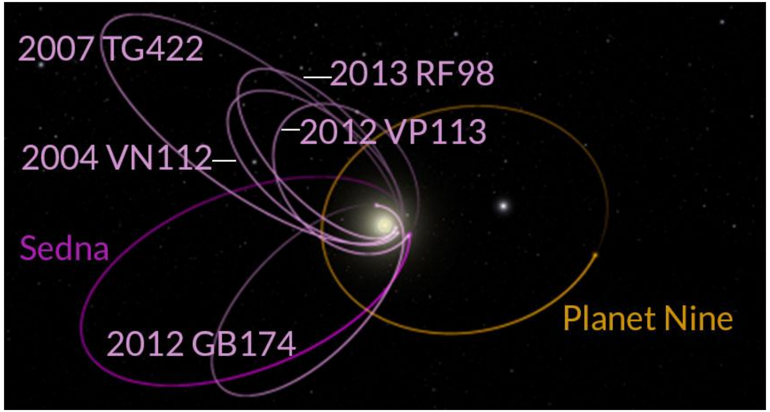
- Influence of the Galactic magnetic field on the arrival directions of ultra-high energy cosmic rays: *PoS(ICHEP2020)618*
- Properties of UHECR sources, possibility of explaining shape of the end of the energy spectrum by a single source: *PoS(ICRC2021)363*
- Simulating water Cherenkov detector response for the planned Southern Wide-field Gamma-ray Observatory







Name: Shefali Negi
Affiliation: Faculty of Mathematics and Physics, Charles University
Supervisor: Dr. Jan Ebr, Institute of Physics of the Czech Academy of Sciences

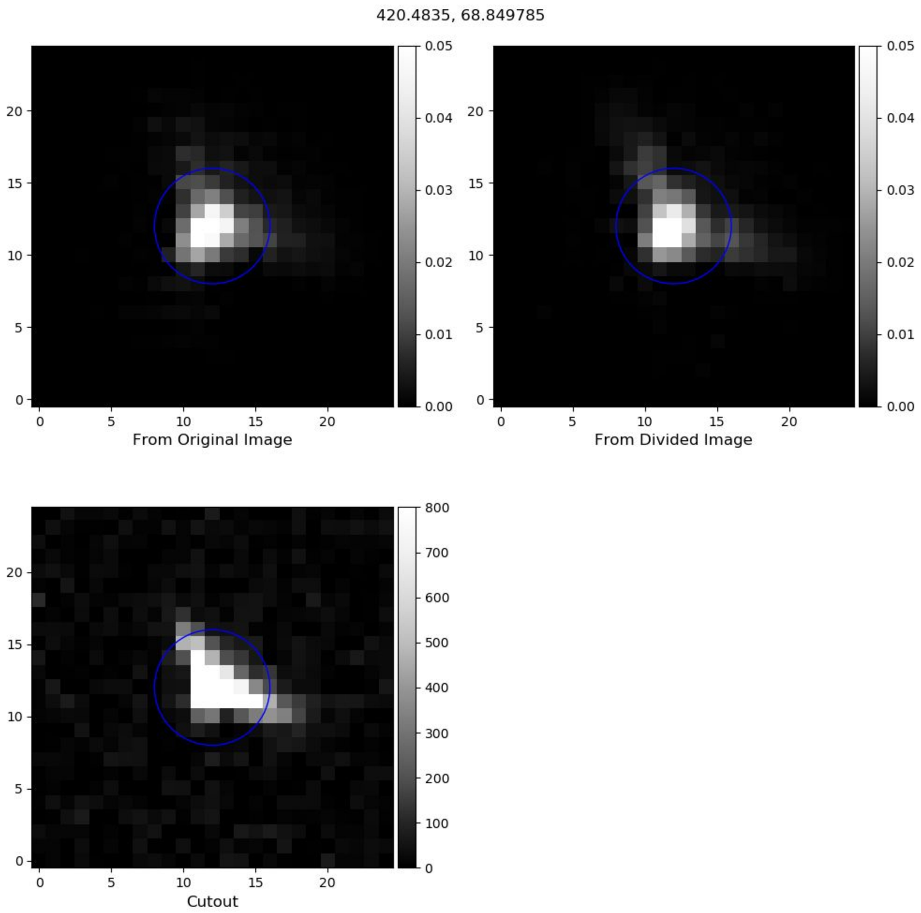


Present work

- **FRAMS (F/Photometric Robotic Atmospheric Monitor),** a small robotic astronomical telescope operated for the purposes of atmospheric monitoring (measure Vertical Aerosol Optical Depth) using stellar photometry.
- Operated at the Pierre Auger Observatory in Argentina for more than a decade and at Future Cherenkov Telescope Array (CTA) site (CTA-n at La Palma and CTA-s at Chile).

Previous work: DIFFERENCE IMAGING, to search for the variable/transient objects in astronomical images.
Planet nine as science motivation.

- Observed a strong correlation between zeropoint and fwhm(full width at half maximum).
- Aperture Photometry: To measure brightness of a star using a predefined aperture.
- Need to account for the lost flux of the deformed stars.
- aperture correction = sum of pixel value within the aperture / sum of pixel value within the stamp of 25x25



11th IDPASC School
Self presentation:

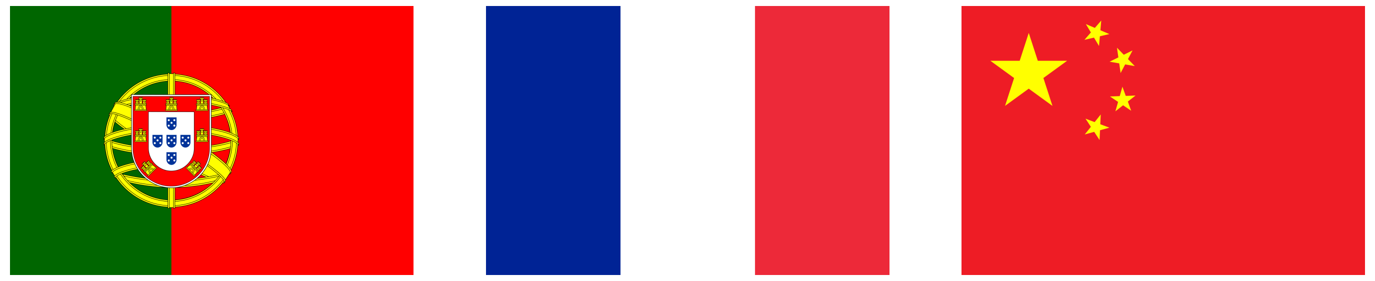
Mateus Hufnagel

- 3rd year of PhD in Electrical engineering in UFJF - Brazil
- Visitor at LPNHE - Sorbonne Paris in collaboration with the ATLAS experiment (2021-2022)
- Bachelor’s in control and automation and master’s in electrical engineering and electronics instrumentation

Research in calorimetry for HEP detectors

- Since the master's working in pile-up readout improvement for conditions of the HL-LHC, in the Tile Calorimeter
  - Energy estimation at cell level
  - Linear filter, Machine learning analysis
- In the PhD, the main research is based on how energy estimation algorithms at cell level impacts on physics objects detection, such as jets and clusters
- Studying the Cross-Talk effect in cluster timing in the Liquid Argon Calorimeter (LAr) and applications using ML to mitigate it.

- Developing of a tool to build a dataset of instrumentation data from the ATLAS calorimeters to apply ML algorithms
  - Energy estimation, cross-talk studies and timing
- We expect to to analyse the effects of energy and time estimation improvement in both low level (readout electronics) and physics (jets, electrons)



Artur Cordeiro Oudot Choi

Born in 1998 in Lisbon

Lived in Portugal for 18 years and went to university in Paris at Sorbonne Université.

- Physics Bachelor

- Master 1 in fundamental physics

- Master 2 in experimental particle physics

What I like to do :

IDPASC 2022 Olomouc

PhD (end of 1st year) in ATLAS

Working on accelerator experiments at :

Laboratoire de Physique Nucléaire et des Hautes Énergies (Paris)

PhD subject : Search for long lived axion like particles

- Building new variables from **calorimetric data to have more precise jet shapes** of possible ALPs decaying into 2 photons far from the collision point.

- Using Machine Learning tools to build a classifier and optimize **signal efficiency / background rejection**.

Qualification task (becoming ATLAS author) :

Characterization and validation of pixel detectors that will be used in the next Inner Tracker of Atlas for the High Luminosity Phase (2027)