Second School on Dark Matter and Neutrino Detection

Laboratory and hands-on activities

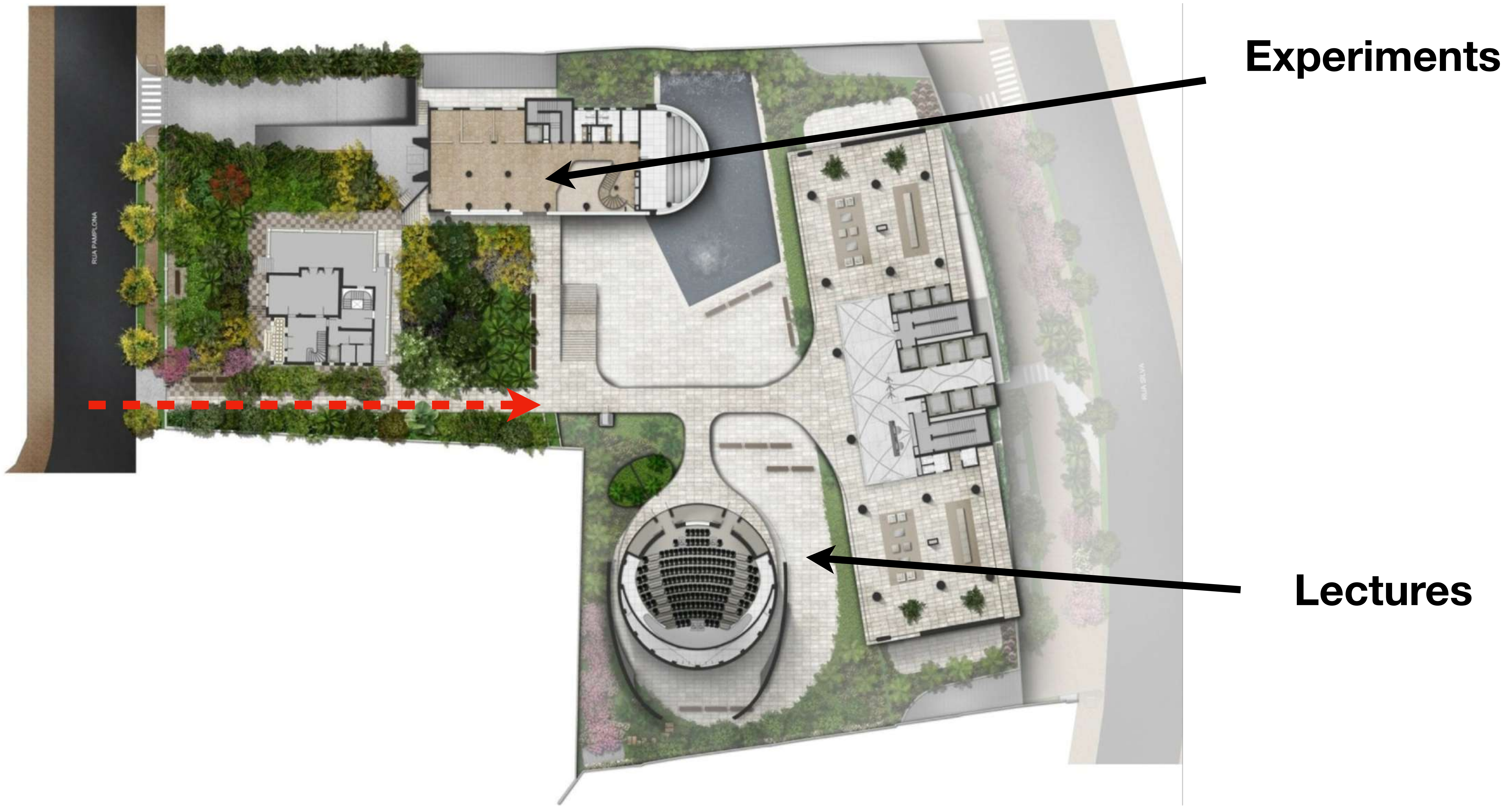
School on DM & Nu 2024

Laboratory and hands-on activities

- How it works?
  - We have a set of 9 options that each individual will rank in order of preference, i.e., the first is the one you are the more interested in
  - With this information we will organize the groups and we will let you know before next Monday lunch time which experiments were assigned to you
  - Each full-school participant will do a total of 5 experiments (one each day).

• Where?

- Principia Institute:
  - Experiment #1: Sensitivity and exclusion limits for DM & Nu experiments (1° floor - auditorium)
  - Experiment #2: LAr experiment design using Monte Carlo simulations (2° floor)
  - Experiment #3: Particle detection with a CMOS camera (1° floor)
  - Experiment #4: Muon veto systems based on plastic scintillators (1° floor - room 2)
  - Experiment #5: Particle detection using a silicon pixel detector (1° floor - room 3)

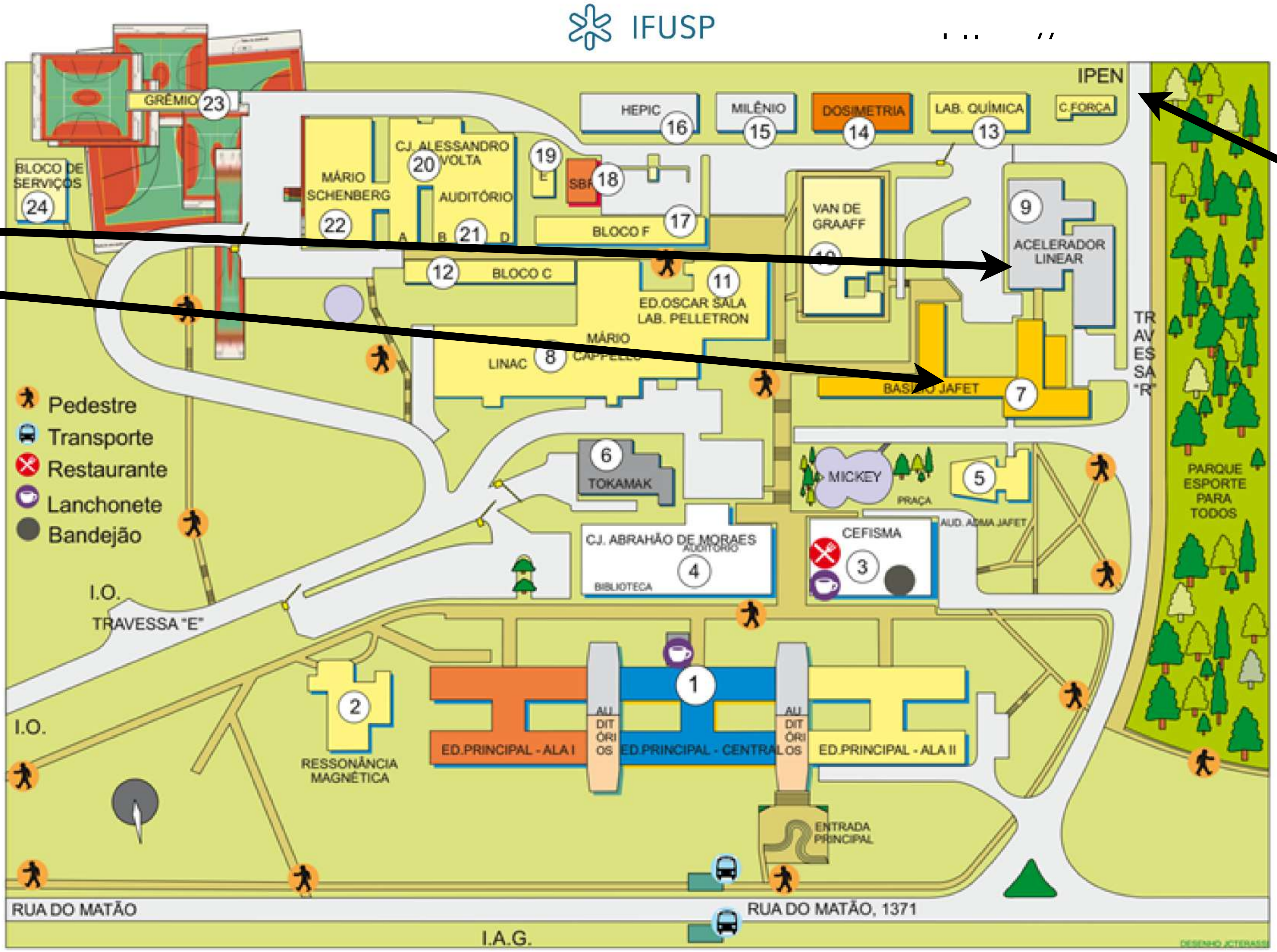


• Where?

• Universidade de São Paulo (USP):

- Experiment #6: Characterisation of Silicon PhotoMultipliers for astroparticle physics applications
- Experiment #7: Pulse-shape discrimination for gamma-neutron separation
- Experiment #8: Compton edge-based energy resolution measurements with a coincidence setup
- Experiment #9: Gamma Spectrometry using Semiconductor Detectors

Lab activities #6, #7 and #8 will be performed here:
=> Acelerador Linear
=> Edifício Basílio Jafet



Lab activity #9 will be performed here:
IPEN

We will organize the groups to go by UBER

Sensitivity and exclusion limits for DM & ν experiments

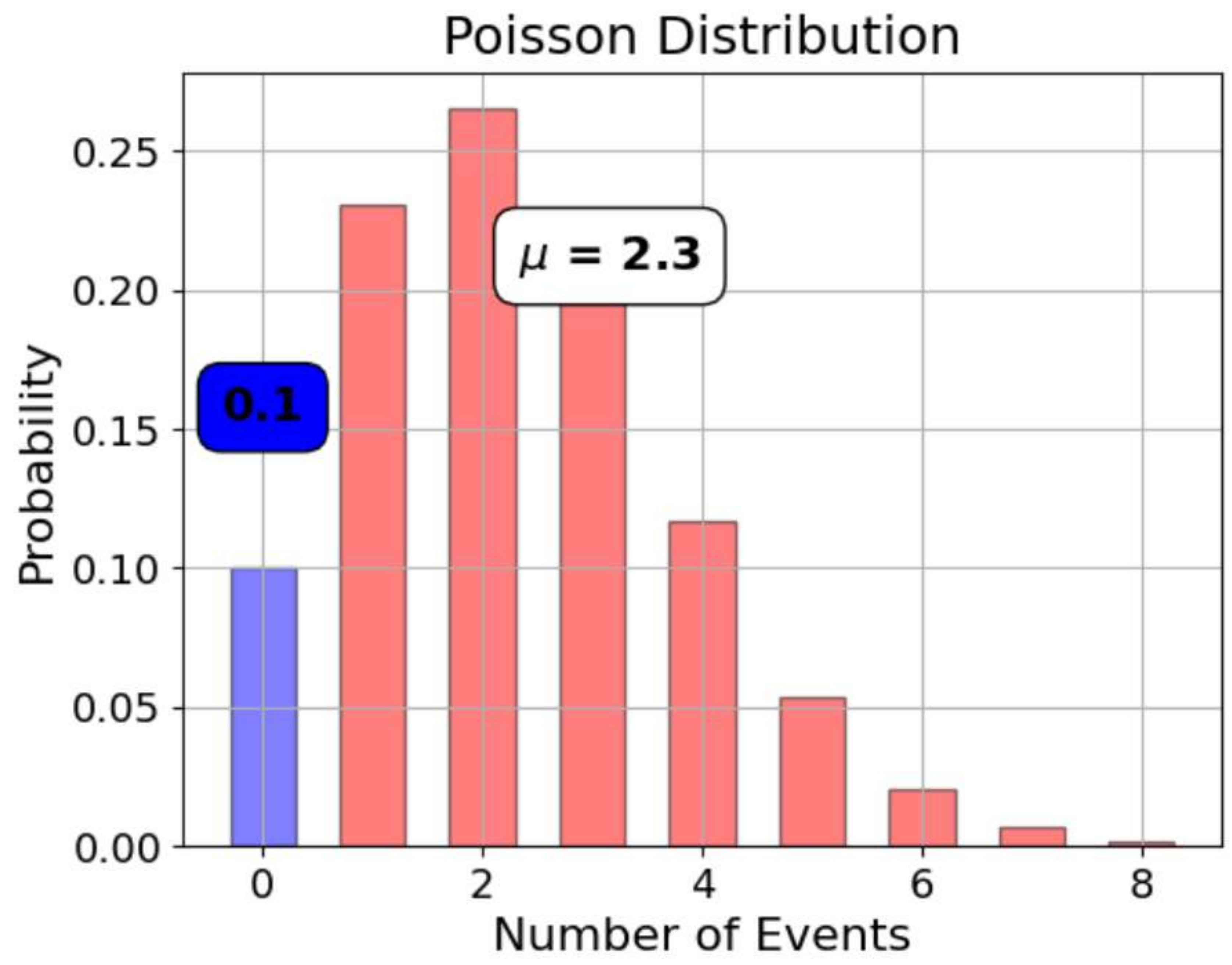
Dario Rodrigues (UBA, Argentina)

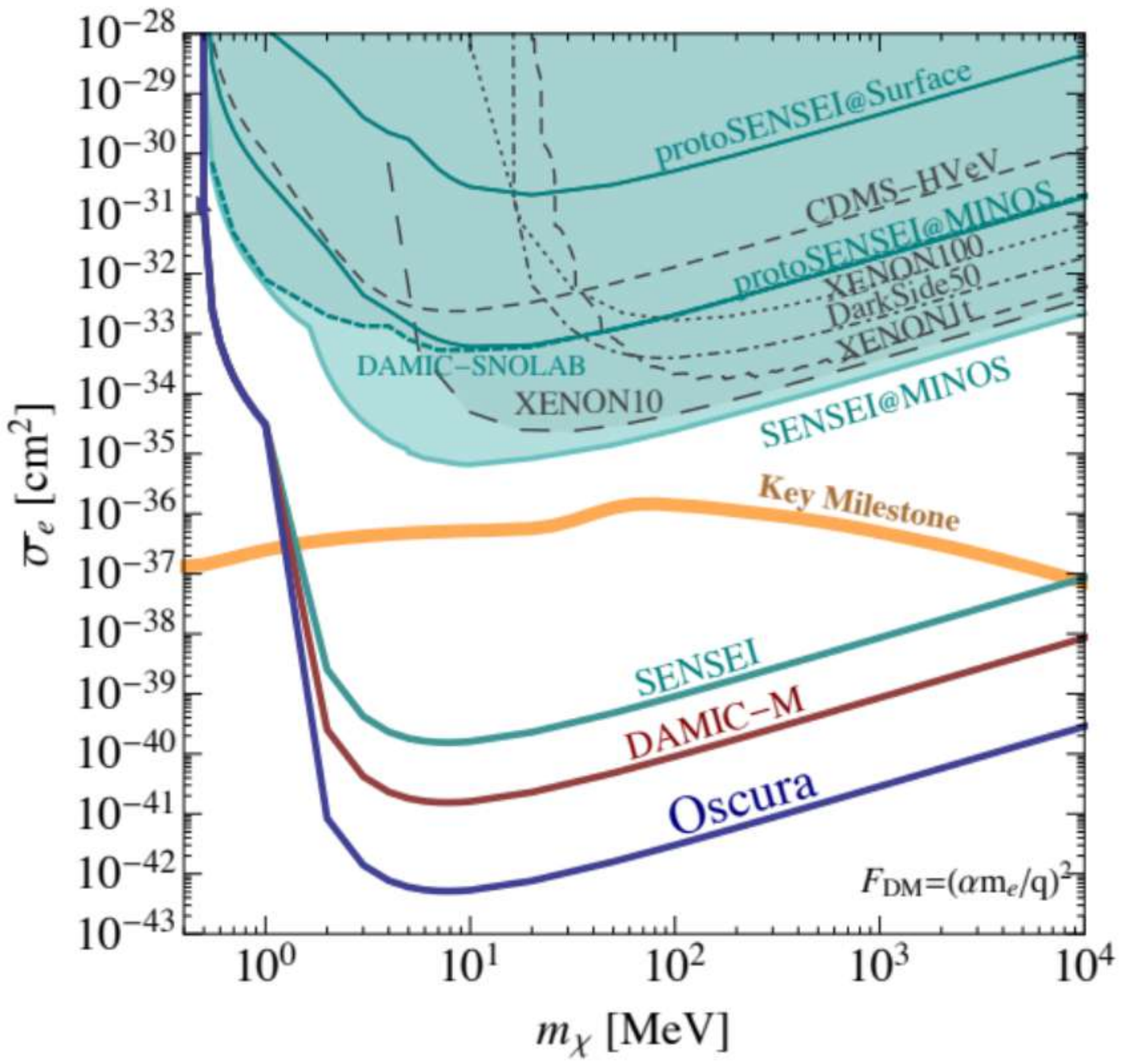
if (you can explain why the plot on the right illustrates the fundamental statistics used to rule out new physics when no events are observed**):**

print(“you have a strong background to take this course**”)**

else:

print(“you need this course!**”)**





This course aims to familiarize you with robust frequentist concepts and methodologies commonly used in particle physics

Join this course to learn how to understand and create plots like the one on the left, establish robust exclusion limits in Dark Matter and neutrino experiments, and write code to compute these results!

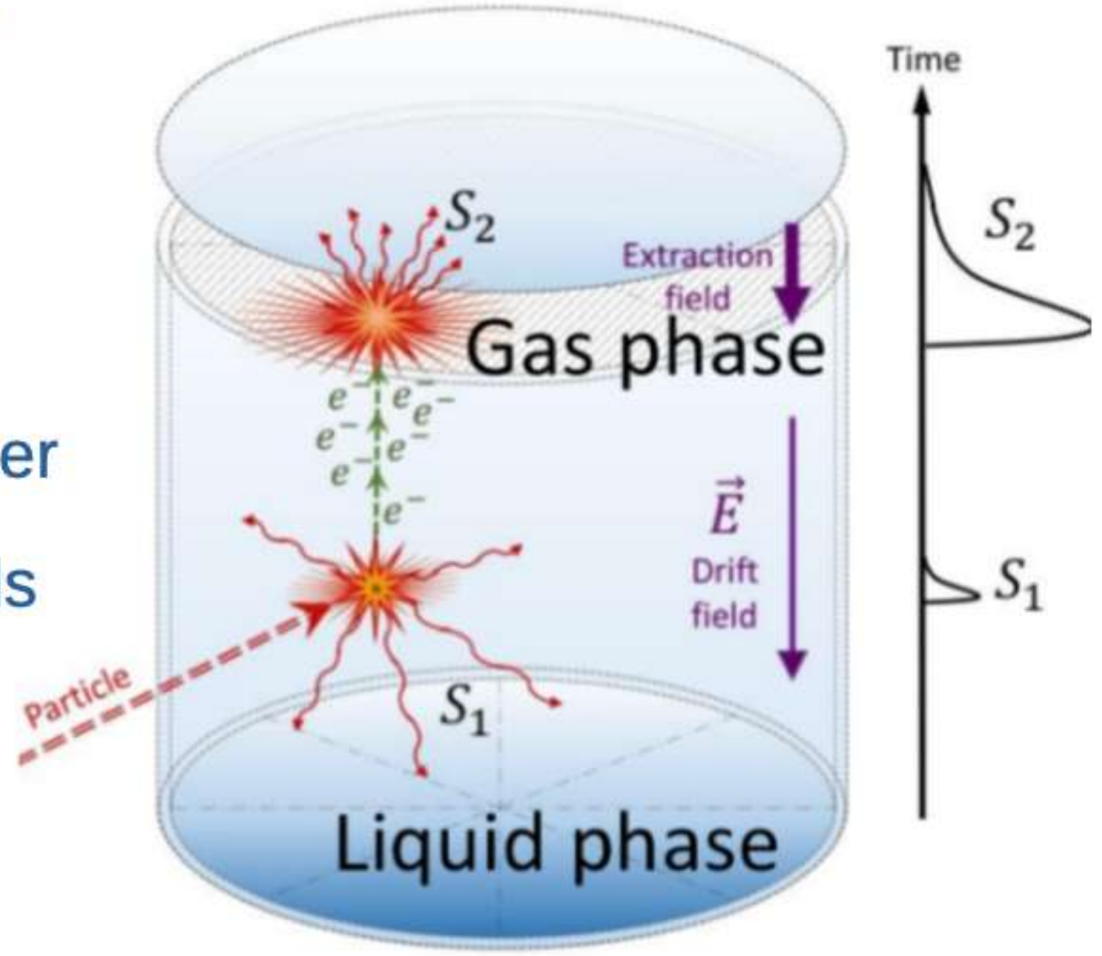
No strong background in statistics or coding is required!

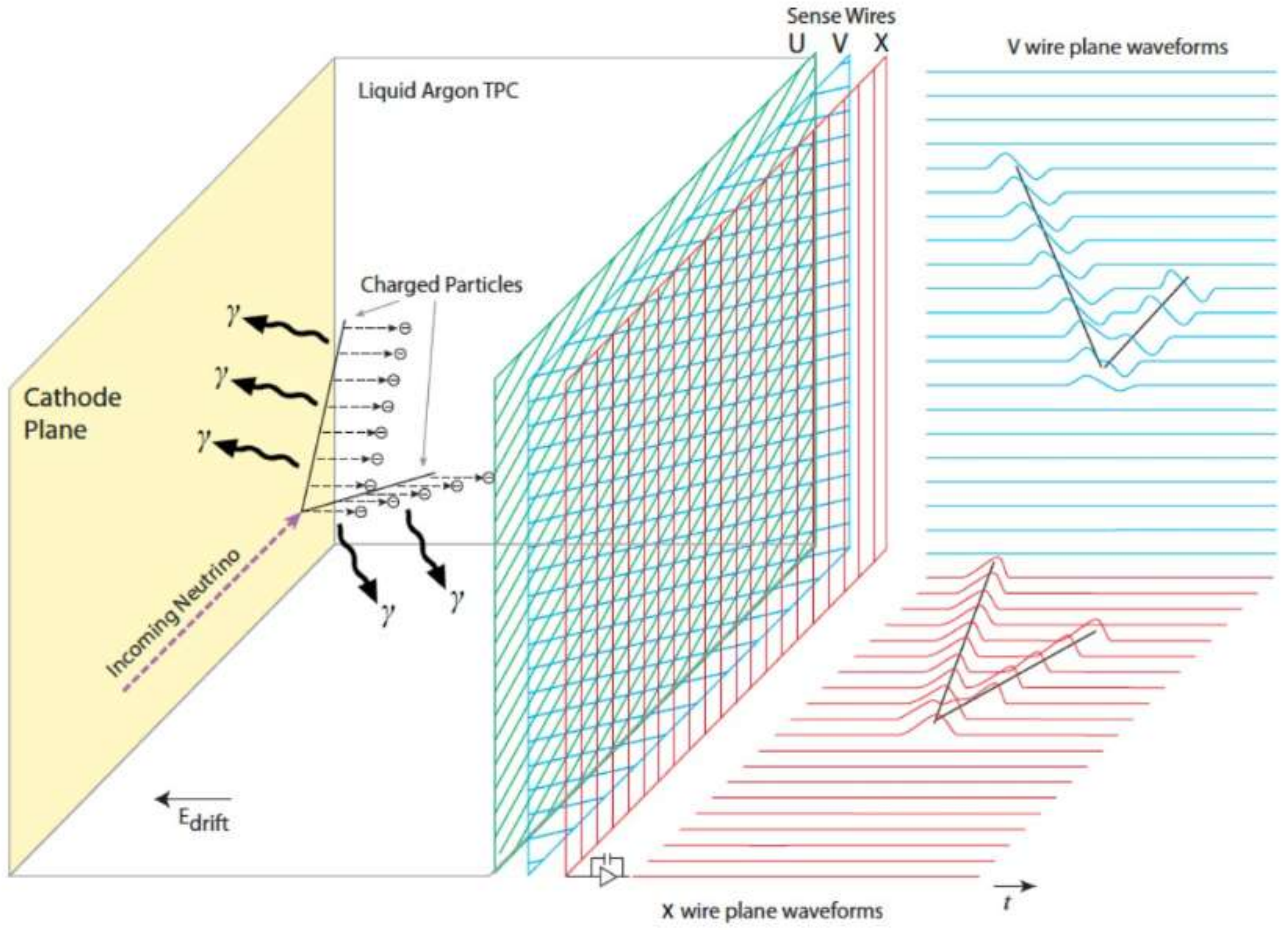
Experiment #2

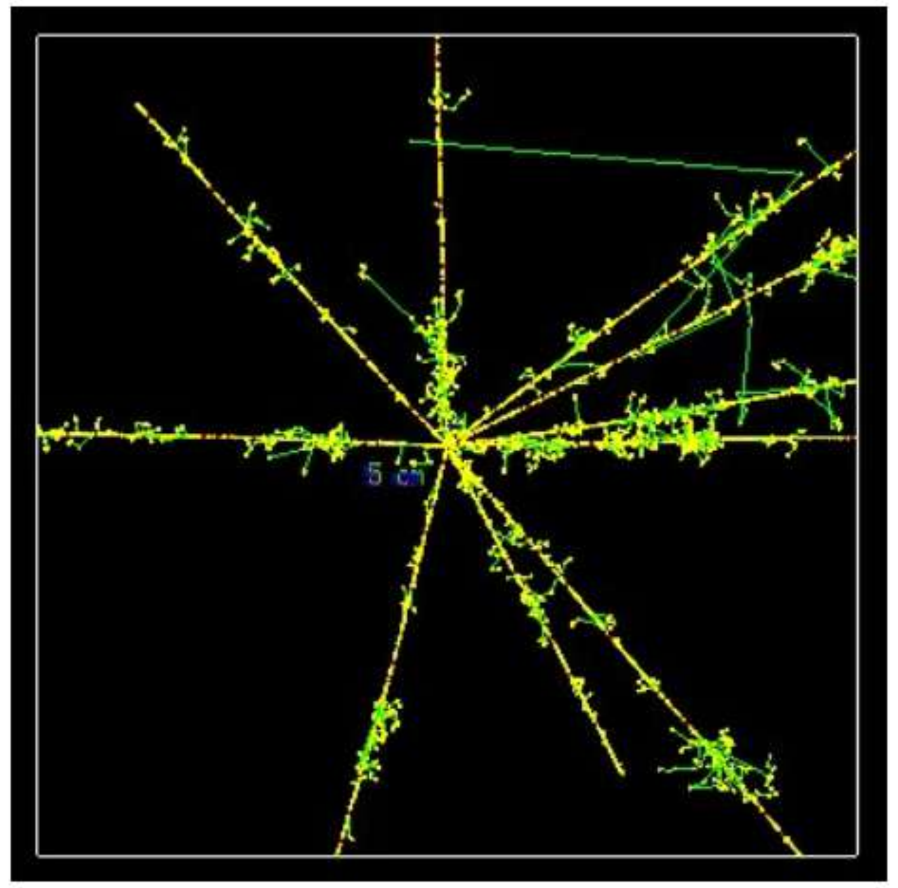
LAr experiment design using Monte Carlo simulations

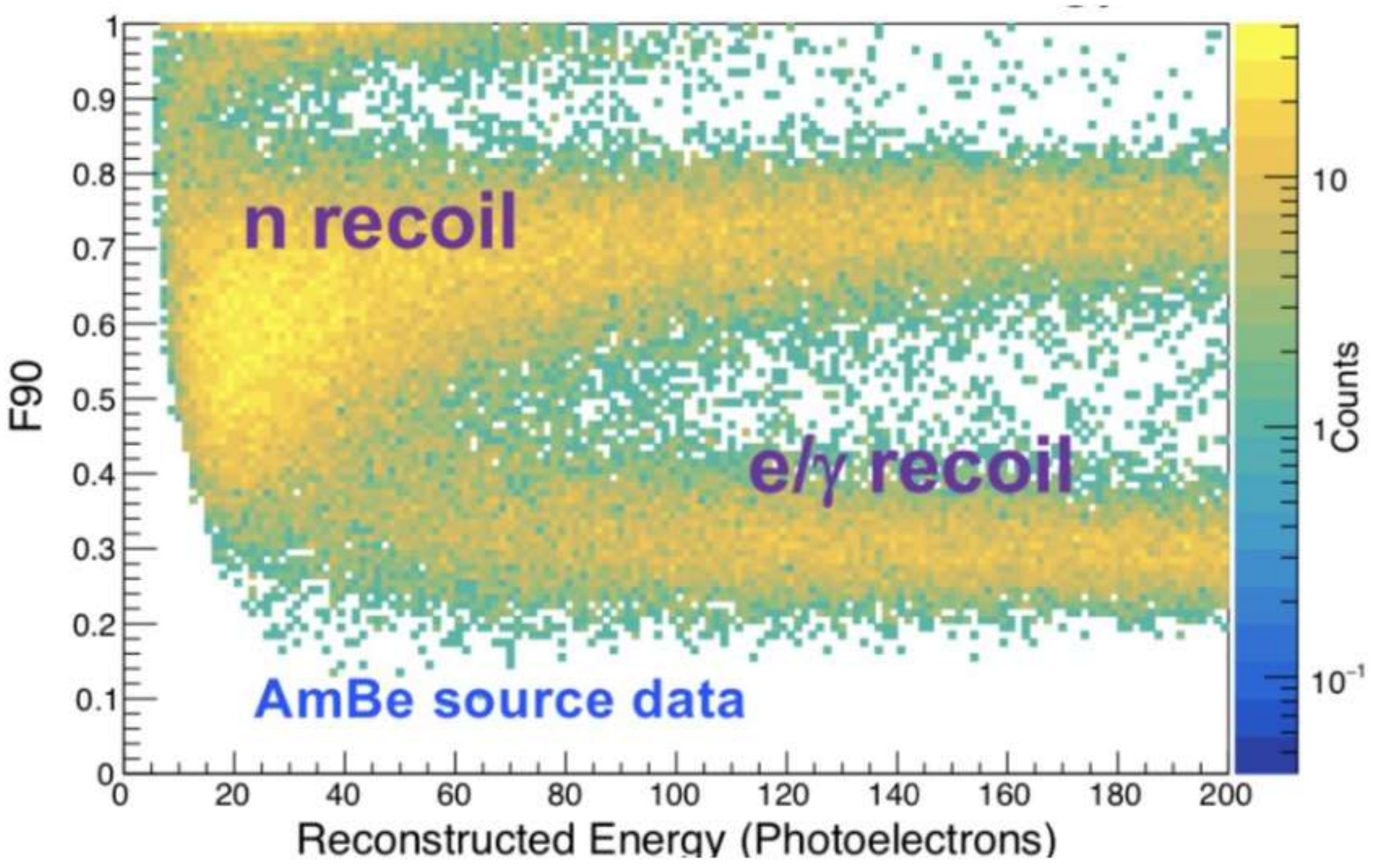
Franciole Marinho (ITA, Brazil) & Laura Paulucci (UFABC, Brazil)

- **Noble liquids** often used as active media for **neutrino detection** and **dark matter searches**
- Great physical and optical properties:
  - High mass density → very good stopping power
  - High scintillation light and electric charge yields (~10^4/MeV)
  - Transparency to scintillation light
  - High electron mobility/long drift times
- Reasonable avaiability and cost effective
- MC simulations as tools to explore detector characteristics with focus on LAr
  - Basic elements: Description of geometry, materials and particles interactions
  - Particle's propagation in the simulated media and UV light sensors
  - Analysis design and results based on physical interpretation









Experiment #3

Particle detection with a CMOS camera

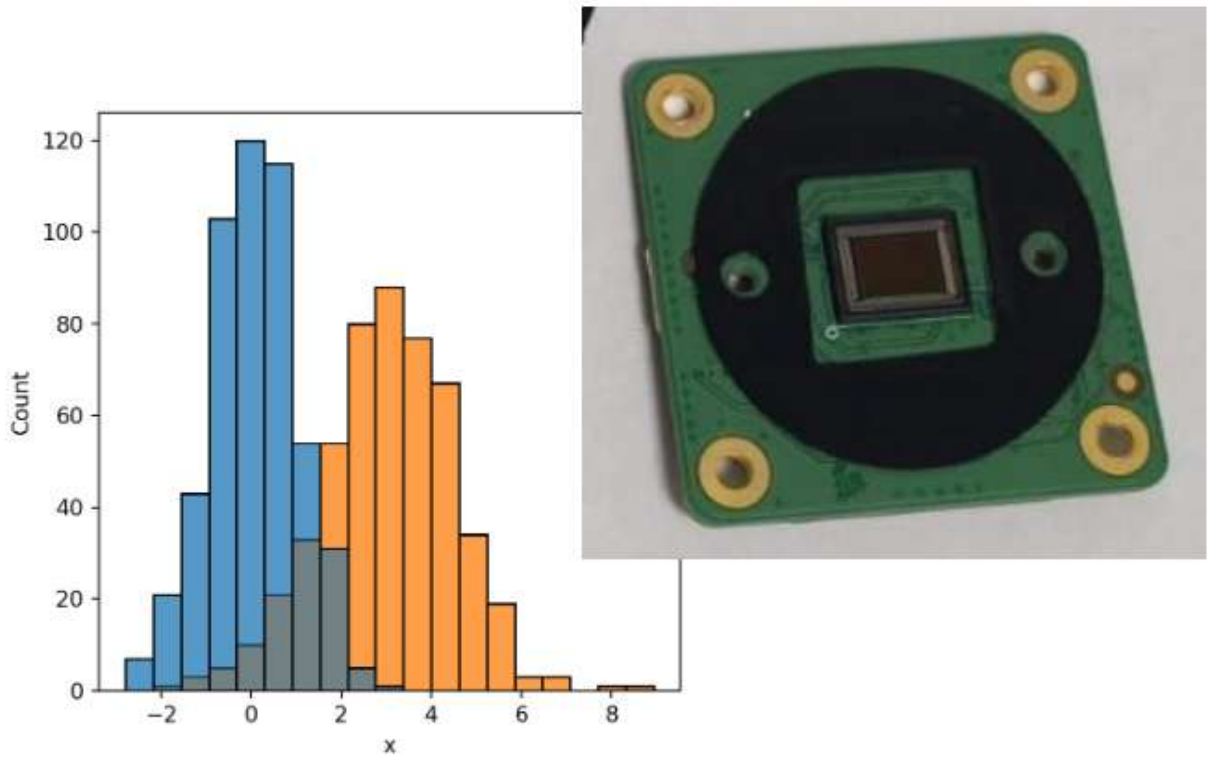
Ana Botti (Fermilab, USA)

Part 1: build and run a setup to calibrate a pixeled silicon detector

You will use this:

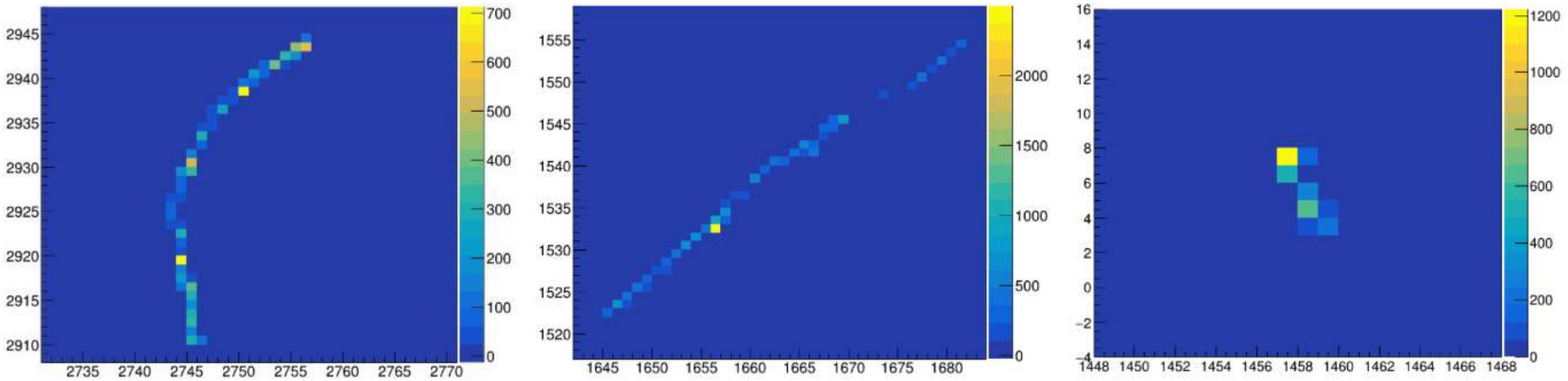
with this:

To calibrate this:

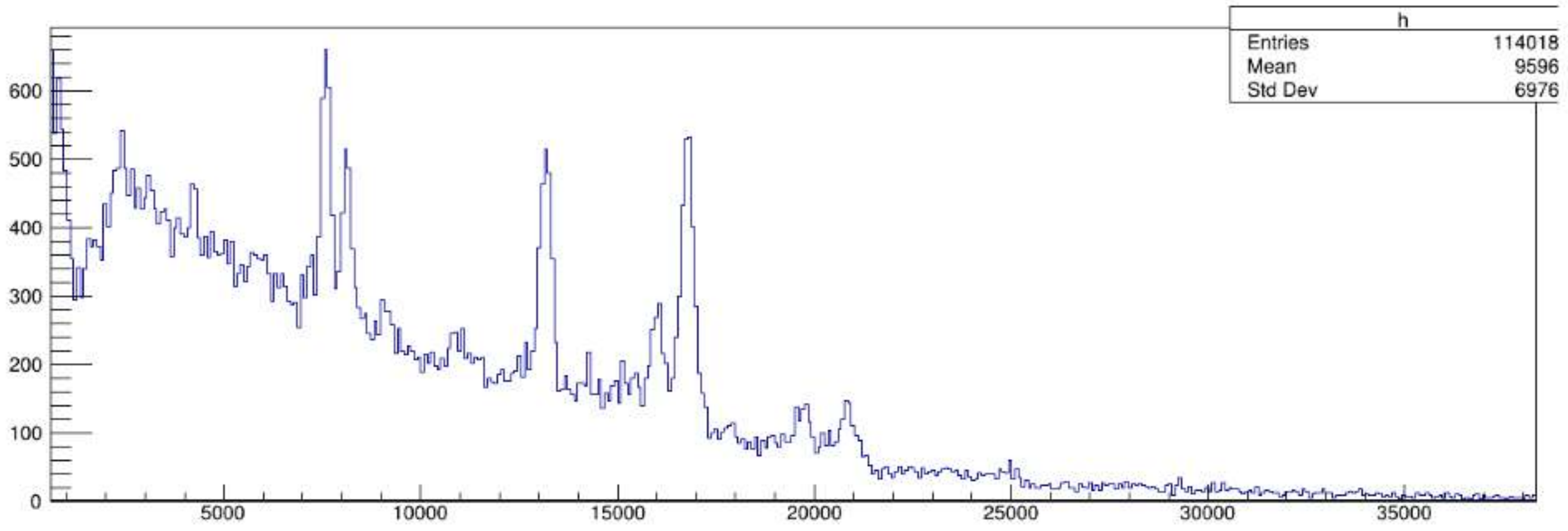


Part 2: use the camera to search for muons and analyze x-ray data

Select operation parameters to take data and define selection cuts to search particle types



Reconstruct and interpret an energy spectrum



Experiment #4

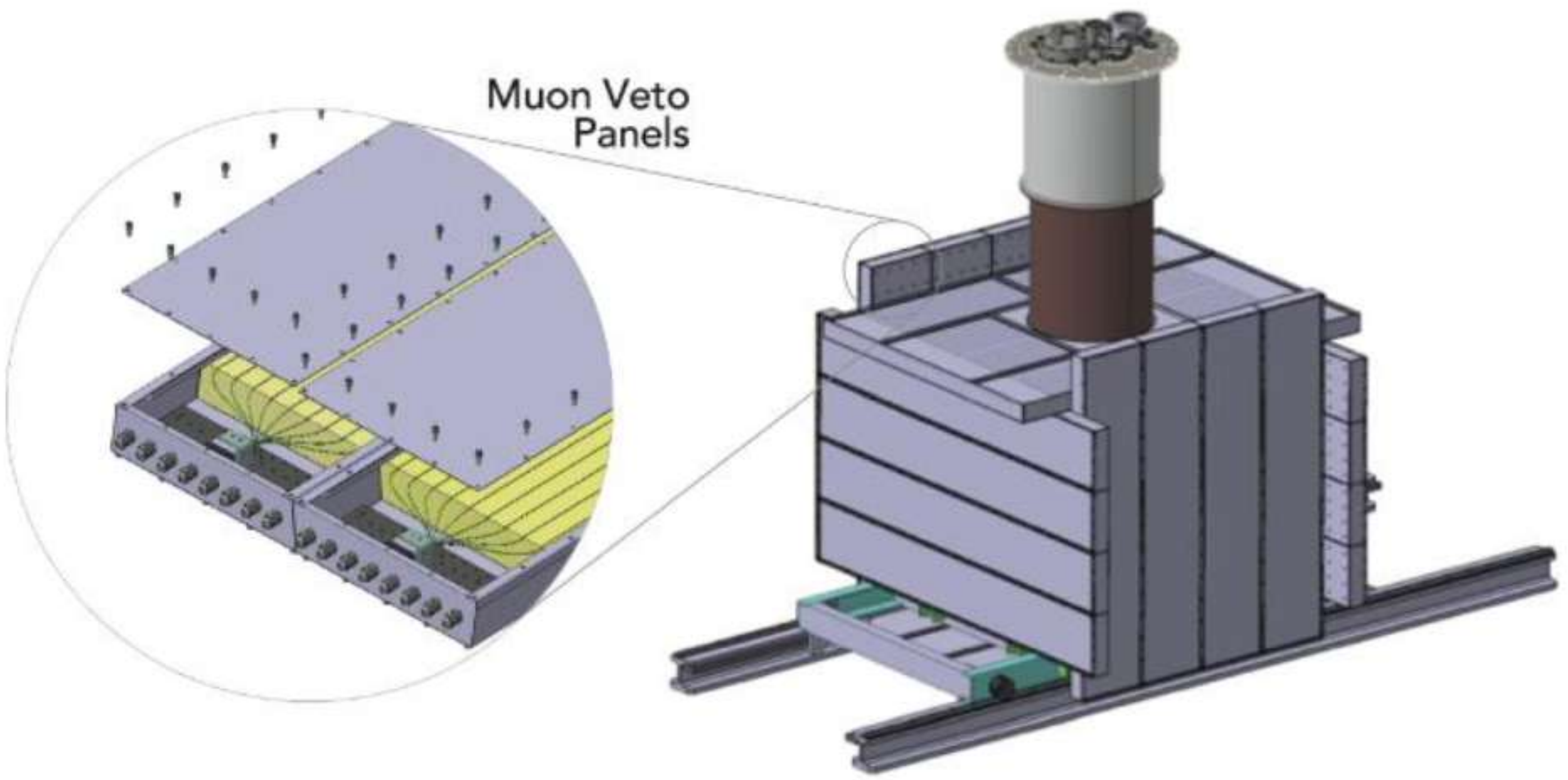
Muon veto systems based on plastic scintillators

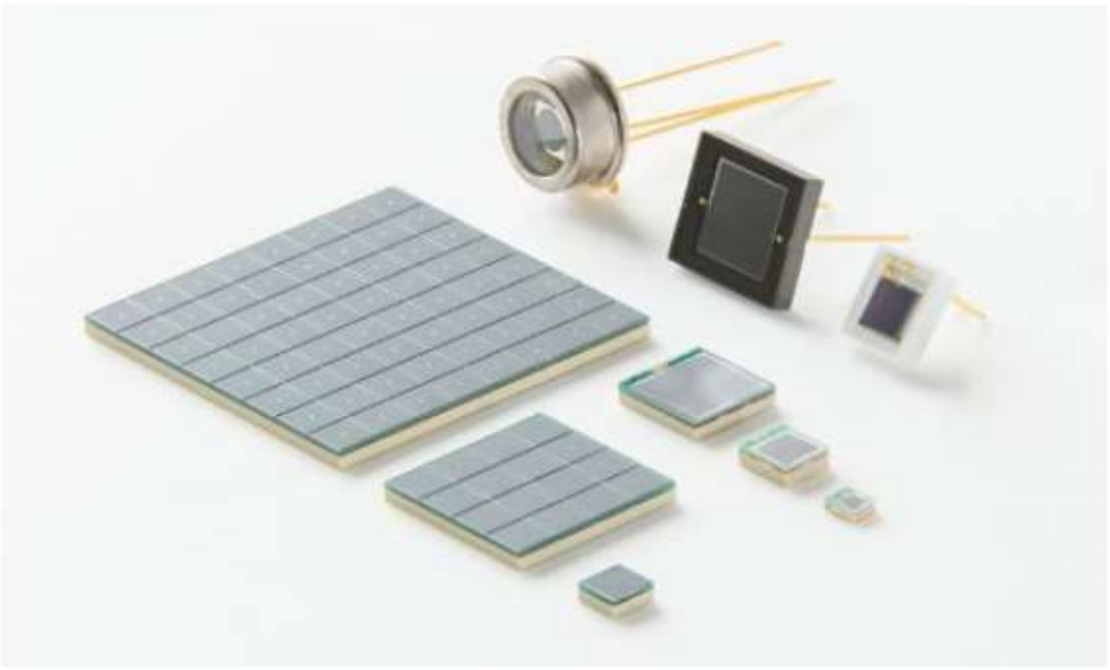
Matias Rolf Hampel

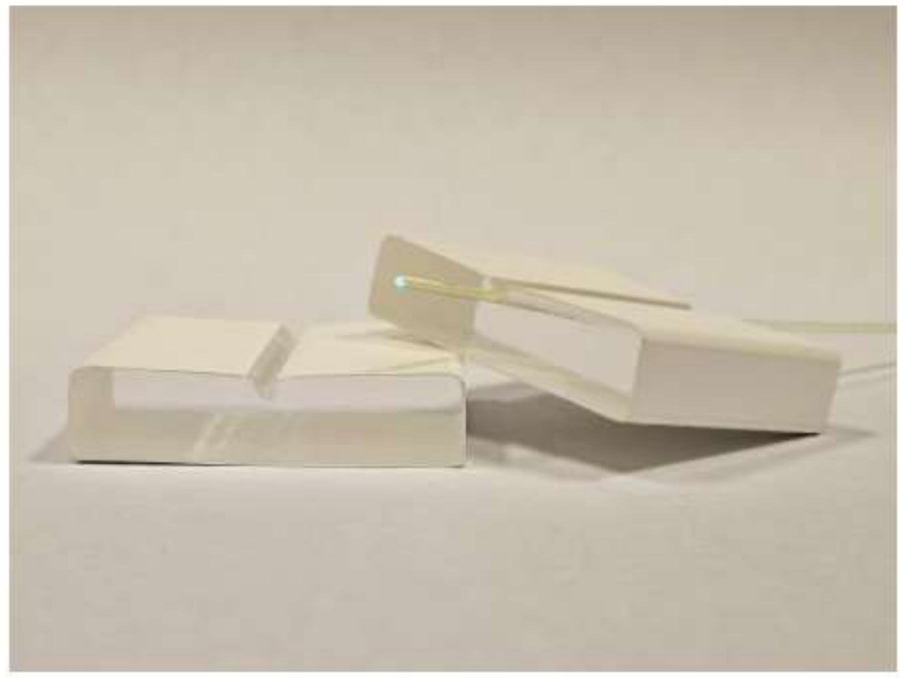
Learn how to build and use an active shield to tag any muon-induced activity in particle detection experiments.

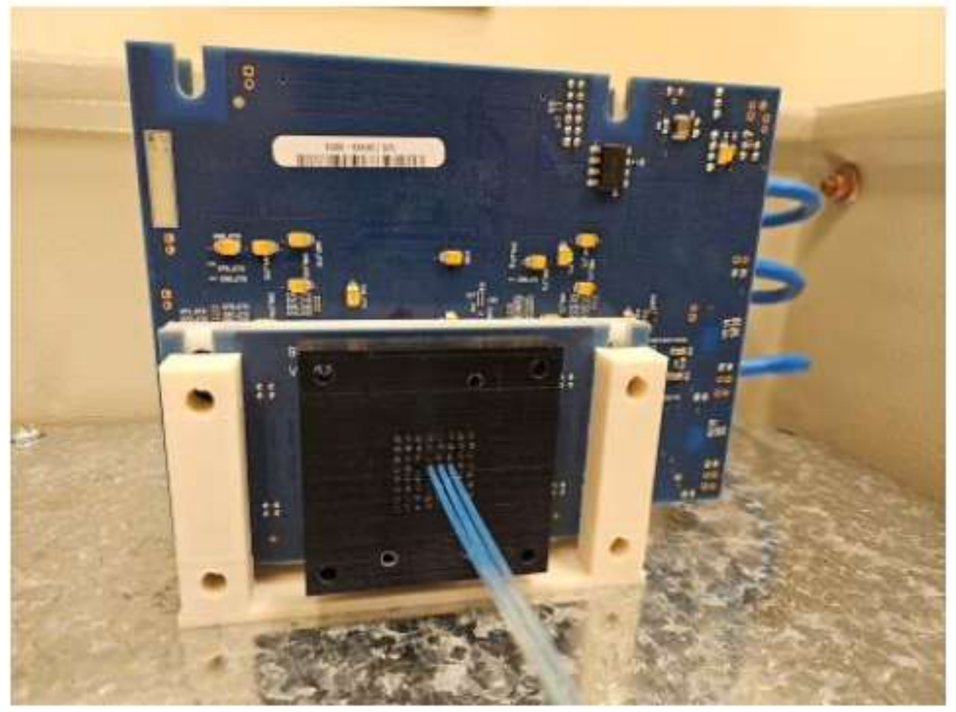
The laboratory will cover:

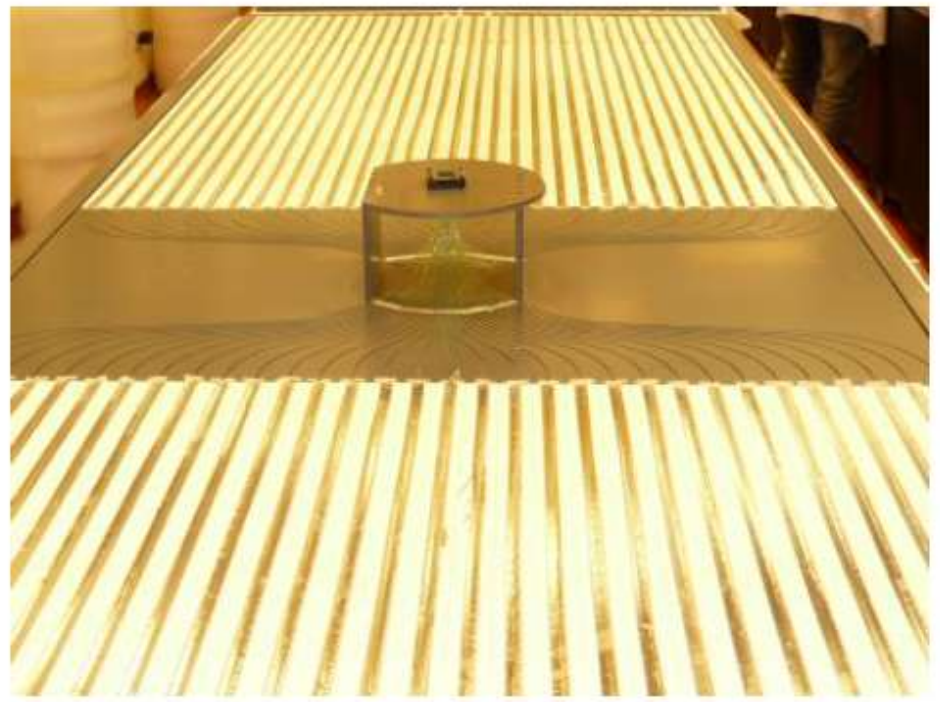
- Fundamental aspects of SiPMs as light detectors
- Techniques for muon detection using plastic scintillators
- Acquiring and analysing data from a muon detector











Experiment #5

Particle detection using a silicon pixel detector

Vinicius Franco Lima (UFRJ, Brazil)

School on DM & Nu 2024

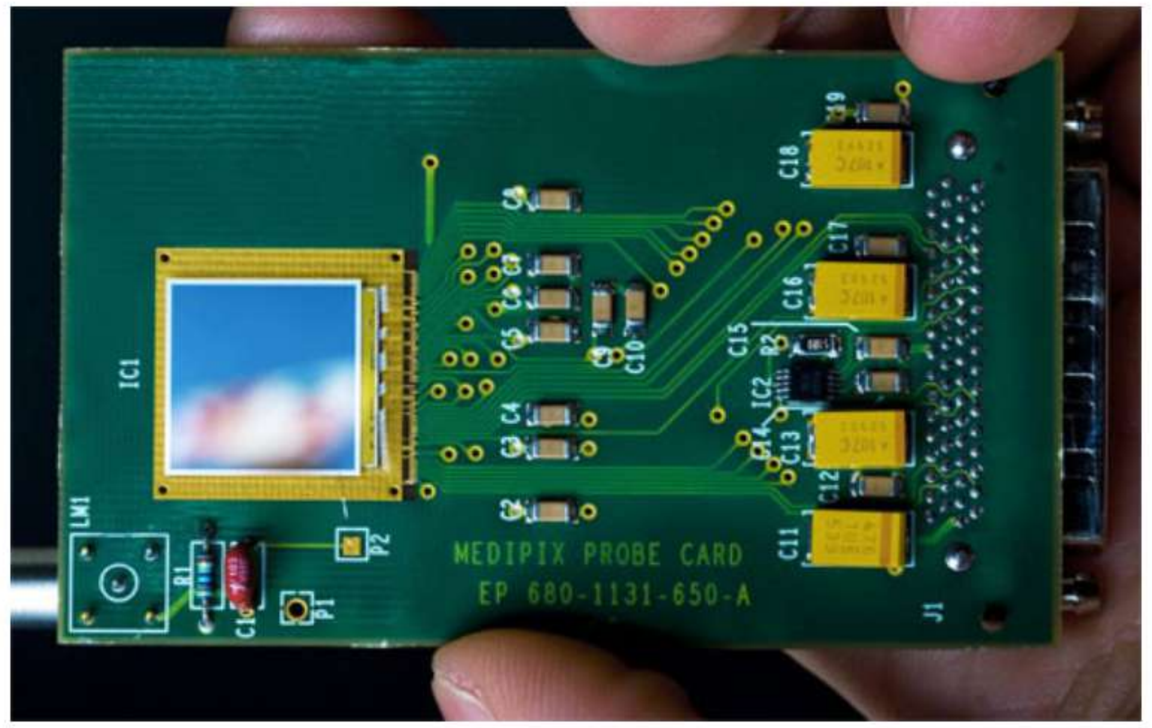
X-ray spectra measurements with Timepix.

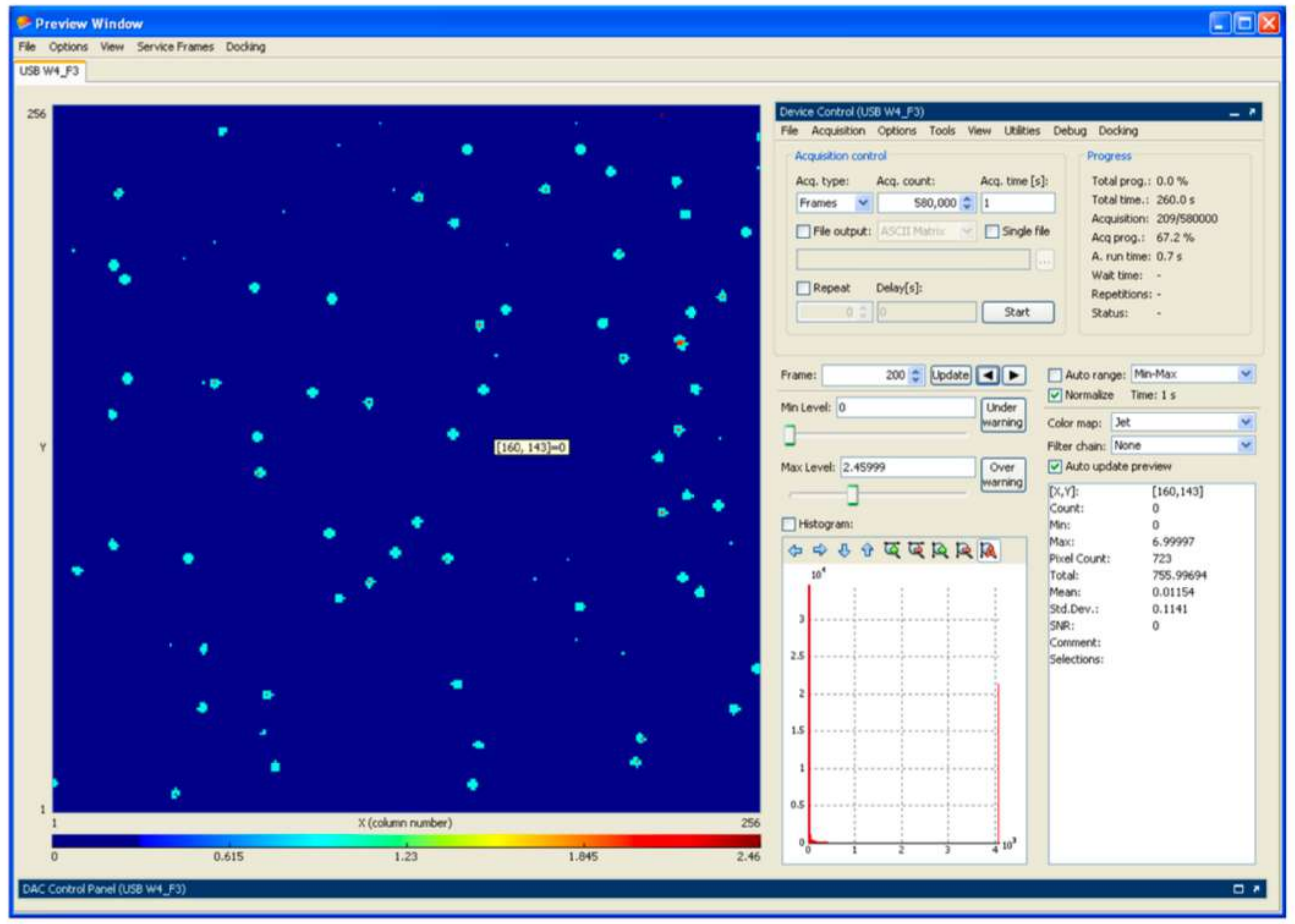
Hybrid pixel detectors used throughout high energy physics

In this lab we will learn how to operate a Timepix readout ASIC coupled to a silicon sensor.

We will then use several different radioactive sources to look at the different energy depositions in our sensor.

Finally students will be able to analyse data coming out of the detector.





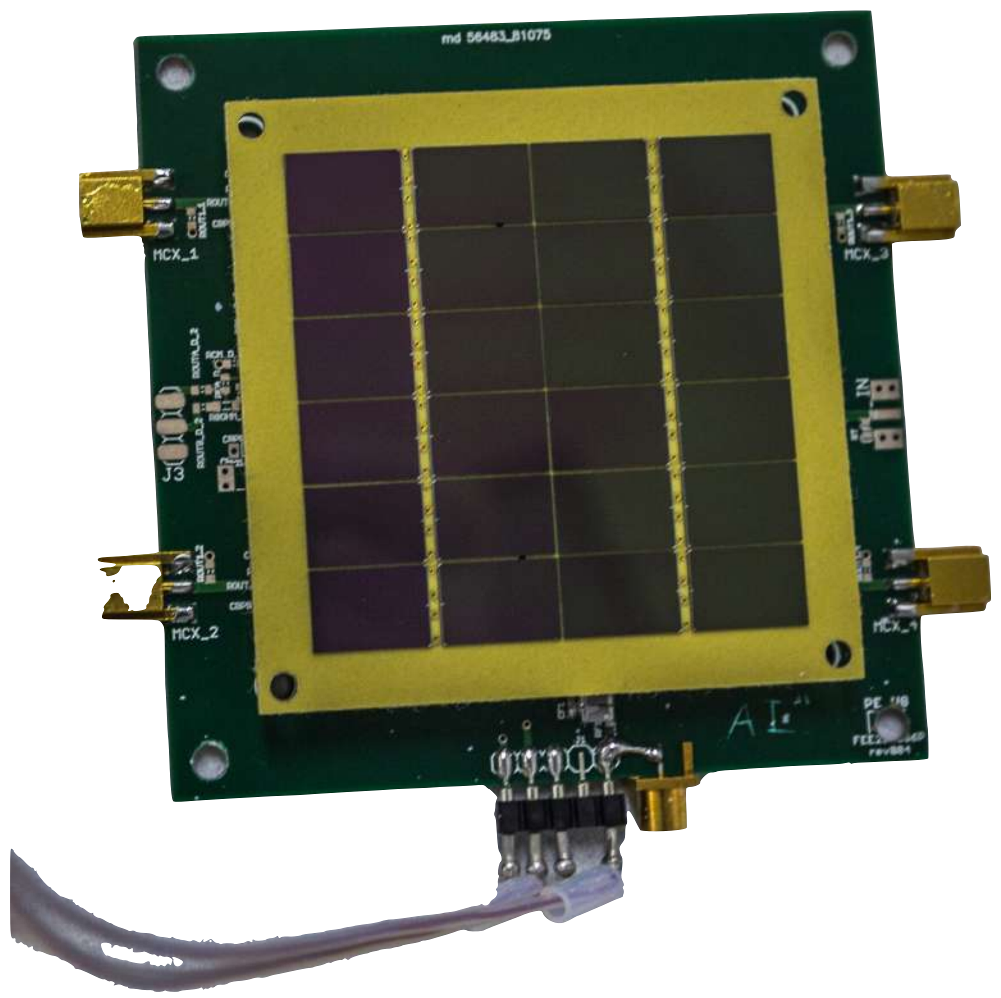
vinicius.franco.lima@cern.ch

Experiment #6

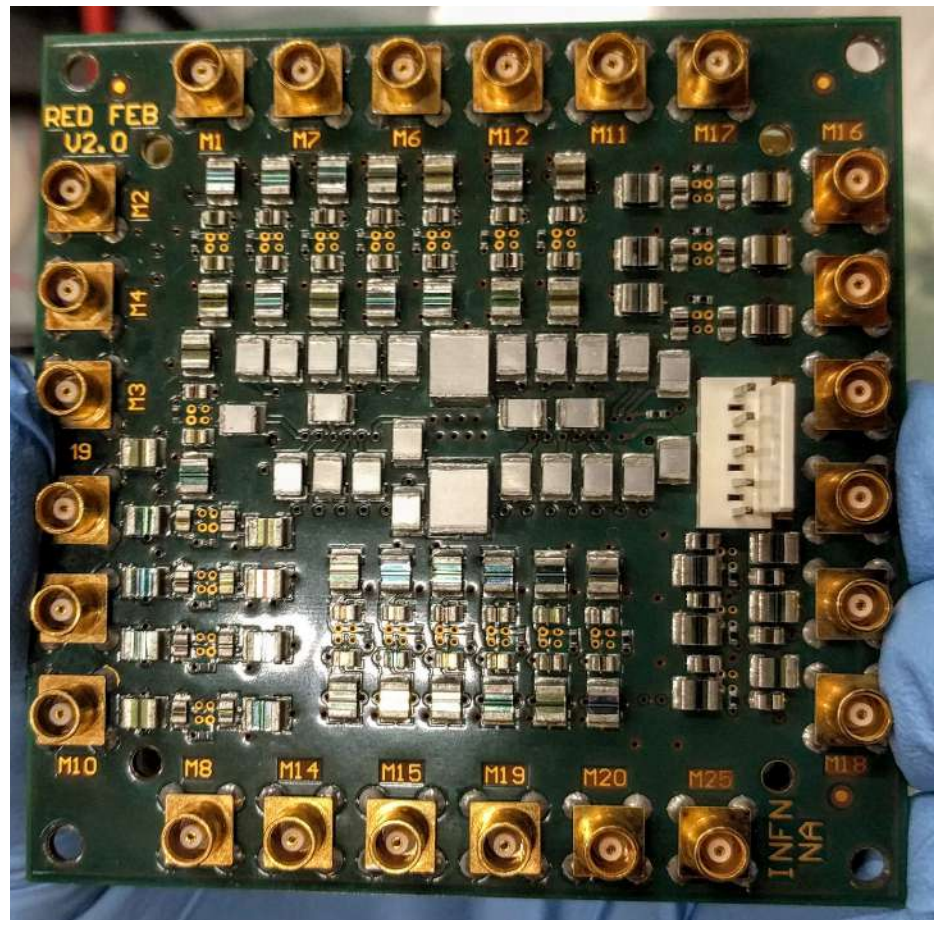
Characterisation of Silicon PhotoMultipliers for astroparticle physics applications

Simone Sanfilippo (INFN, Italy)

Students will be familiar with the standard procedure, used in many applications of neutrino and dark matter search, on the characterisation of Silicon PhotoMultipliers (SiPMs). In particular they will learn how to extract breakdown voltage and how to look at the single-electron spectrum from the acquired data.



- **Proposed activities:**
  - **Basic measurements:**
    - Enjoying the first SiPM spectrum and measuring the Dark Count Rate from a scope;
    - *Can you see the light?* Illuminating SiPM: triggering and integrating;
  - **Advanced measurements (if not out-of-time):**
    - Characterisation of a SiPM cell using an ultra-fast pulsed LED and estimation of the main features of the detector at fixed bias voltage;
    - Dependence of the SiPM properties on the Bias Voltage: study the dependence of the main SiPM figures of merit on the bias voltage. Measurement of the breakdown voltage and identification of the optimal woking point.

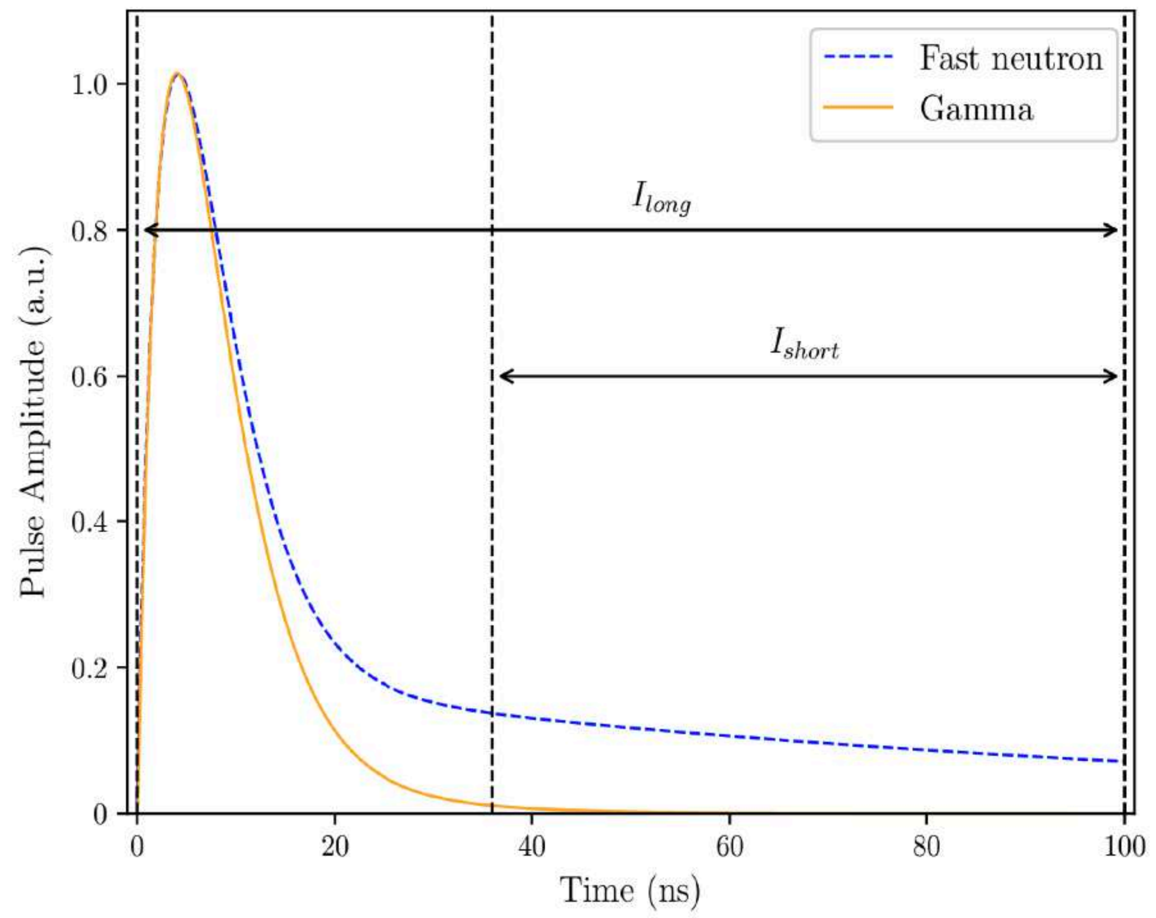


Experiment #7

Pulse-shape discrimination for gamma-neutron separation

Edivaldo Moura Santos (USP, Brazil) & Nikolas Kemmerich (USP, Brazil)

M.J. Cieślak et al 2019 JINST 14 P07017

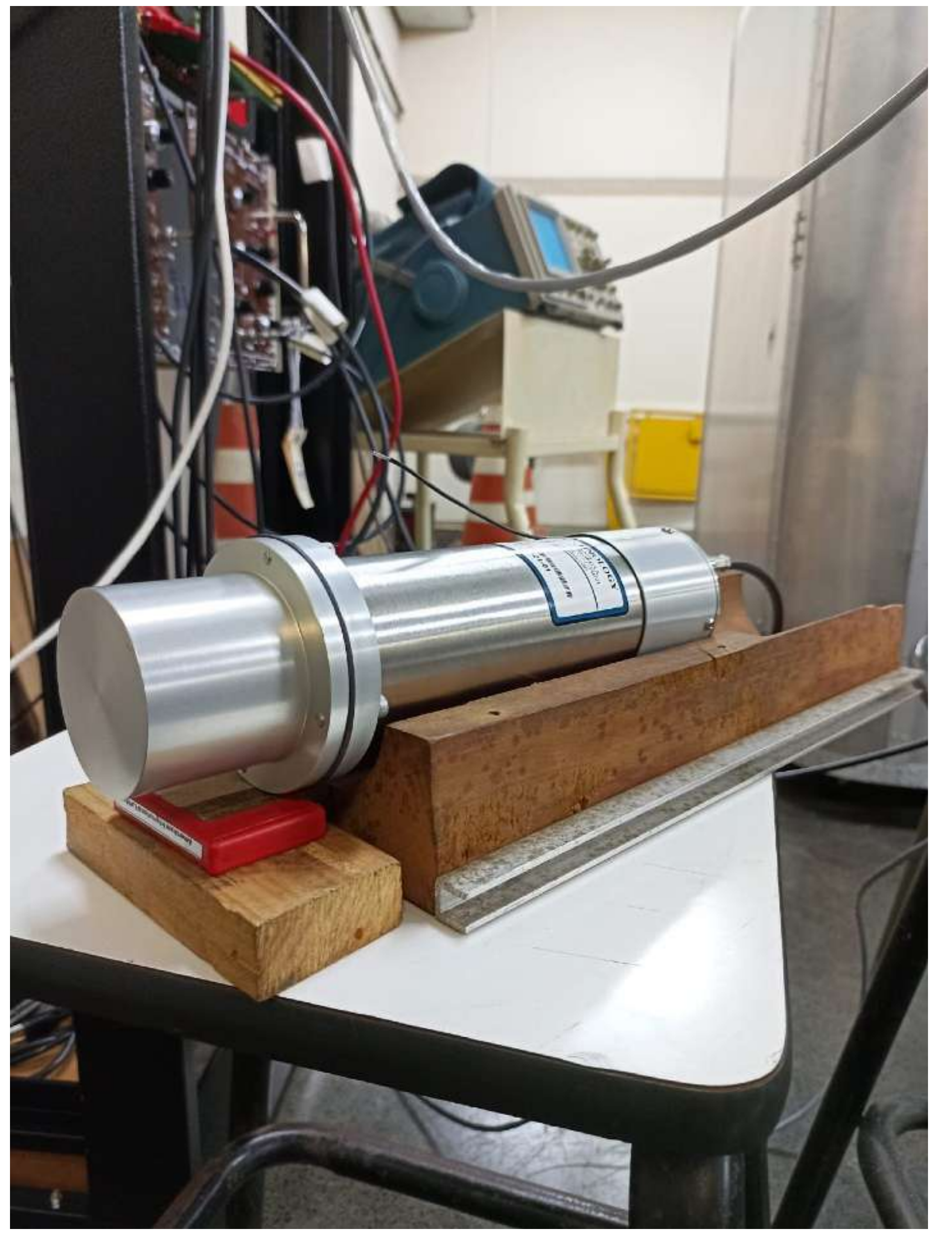


Goals:

- Study the time response of a scintillator detector to a gamma source
- Learn the Pulse Shape Discrimination (PSD) technique
- Use PSD to separate photon from neutron populations

Apparatus:

- A gamma-ray source
- Plastic scintillator with associated photomultiplier tube and bias
- Fast digitizer
- Data acquisition computer, custom-made software and ROOT



Location: IFUSP Instituto de Física da USP

Experiment #8

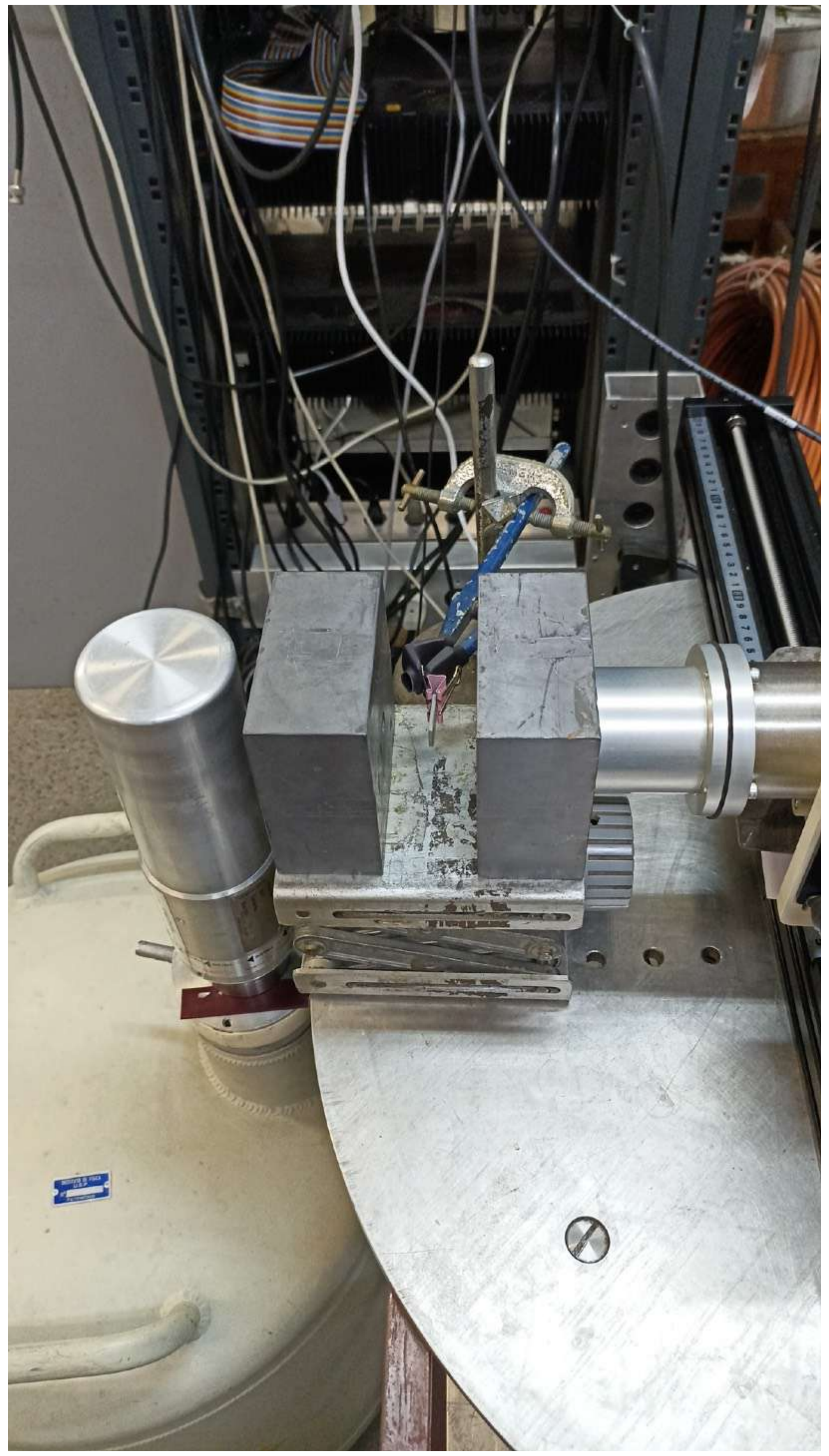
Compton edge-based energy resolution measurements with a coincidence setup

Edivaldo Moura Santos (USP, Brazil) & Nikolas Kemmerich (USP, Brazil)

School on Dark Matter & Neutrino 2024

Goals:

- Measure the energy resolution of a scintillator detector
- Learn how a high resolution germanium detector works
- Learn how to work with time coincidences
- See a real application of Compton and photoelectric effects



Apparatus:

- A gamma-ray source
- Plastic scintillator with associated photomultiplier tube and bias
- High purity germanium detector and its cryogenic setup
- Nuclear electronics: pre-amplifier, amplifier, fast digitizer
- Data acquisition computer, custom-made software and ROOT

Location: IFUSP Instituto de Física da USP

Experiment #9

Gamma Spectrometry using Semiconductor Detectors

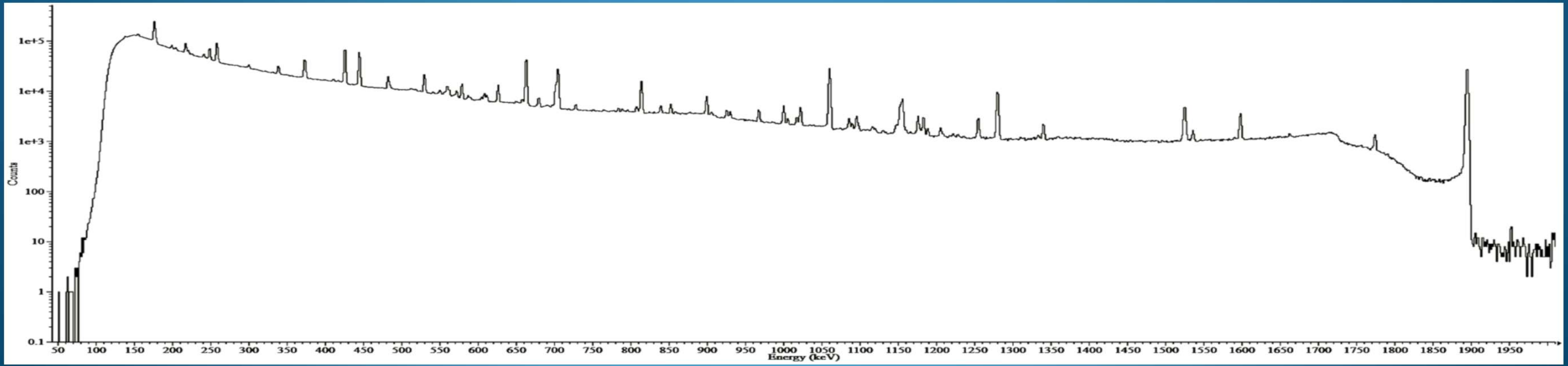
Guilherme S. Zahn (IPEN-CNEN/SP, Brazil), Paulo Sérgio C. da Silva (IPEN-CNEN/SP, Brazil)
& Frederico A. Genezini (IPEN-CNEN/SP, Brazil)

School on DM & Nu 2024

Objectives

- Know and understand a modern HPGe detector;
- Perform 100% hands-on measurements;
- Perform energy and efficiency calibrations;
- Understand the limitations and possible spectral issues;
- Analyze a real-life environmental sample and identify the main radionuclides
- Observe and analyze the ubiquitous gamma-ray background.

ipen
reator de pesquisa



• Google forms to make your experiment priority selection

Experimental Activities Preference Form

Please fill this form indicating your preferences for the experimental activities in the Second School on Dark Matter and Neutrino Detection. Information on the experiments can be found here: https://www.ictp-saifr.org/ssdmnd2024/. Please use the scale of 1 to 9, being 1 the one you want to attend the most.

carla.bonifazi@gmail.com Switch account

Not shared

* Indicates required question

Full name (as in official document) *

Your answer

ID number (RG or CPF for Brazilians, passport number otherwise) *

Your answer

Do you have a laptop you can take with you to perform experimental activities? *

- Yes
- No

https://forms.gle/fchcSk5TzqD76n337

Please mark your preference for the experiments: *

Exp #1: Sensitivity and exclusion limits for DM & Nu experiments
Exp #2: LAr experiment design using Monte Carlo simulations
Exp #3: Particle detection with a CMOS camera
Expt #4: Muon veto systems based on plastic scintillators
Exp #5: Particle detection using a silicon pixel detector
Exp #6: Characterisation of Silicon PhotoMultipliers for astroparticle physics applications
Exp #7: Pulse-shape discrimination for gamma-neutron separation
Exp #8: Compton edge-based energy resolution measurements with a coincidence setup
Exp #9: Gamma Spectrometry using Semiconductor Detectors

	1	2	3	5	6	7	8	9
Exp #1								
Exp #2								
Exp #3								
Exp #4								
Exp #5								
Exp #6								
Exp #7								
Exp #8								
Exp #9								

- Google forms to make your experiment priority selection

Experimental Activities Preference Form

Please fill this form indicating your preferences for the experimental activities in the Second School on Dark Matter and Neutrino Detection. Information on the experiments can be found here: https://www.ictp-saifr.org/ssdmnd2024/. Please use the scale of 1 to 9, being 1 the one you want to attend the most.

carla.bonifazi@gmail.com Switch account

Not shared

Please mark your preference for the experiments: *

Exp #1: Sensitivity and exclusion limits for DM & Nu experiments
Exp #2: LAr experiment design using Monte Carlo simulations
Exp #3: Particle detection with a CMOS camera
Expt #4: Muon veto systems based on plastic scintillators
Exp #5: Particle detection using a silicon pixel detector
Exp #6: Characterisation of Silicon PhotoMultipliers for astroparticle physics applications

Deadline: Friday 12th @ 6pm

Your answer

Do you have a laptop you can take with you to perform experimental activities? *

- Yes
- No

https://forms.gle/fchcSk5TzqD76n337

Exp #3
Exp #4
Exp #5
Exp #6
Exp #7
Exp #8
Exp #9

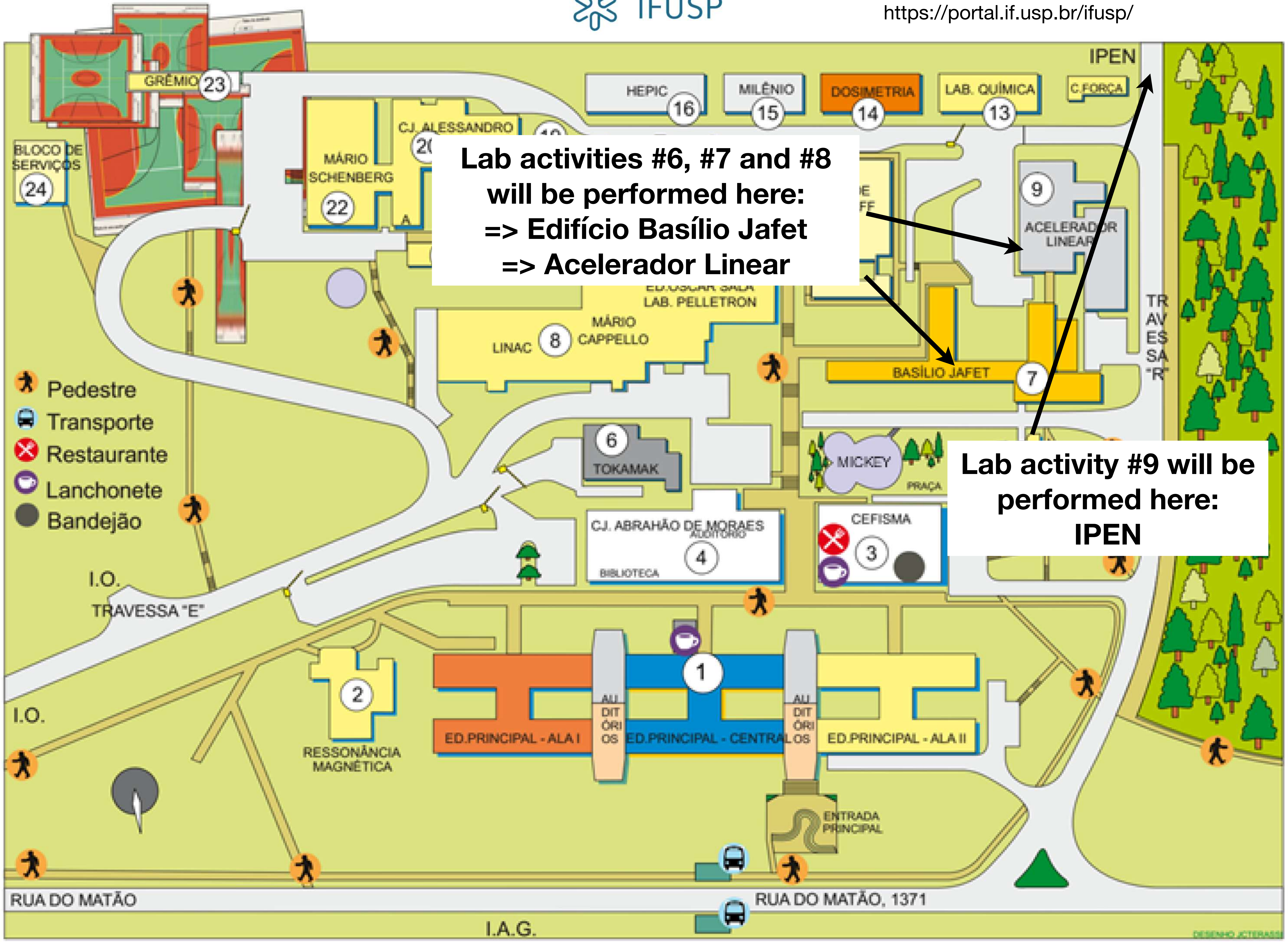
Backup slides

https://sites.usp.br/agorasouifusp/mapas/

CIDADE UNIVERSITÁRIA

IFUSP https://portal.if.usp.br/ifusp/

IFUSP https://portal.if.usp.br/ifusp/



Lab activities #6, #7 and #8 will be performed here:
=> Edifício Basílio Jafet
=> Acelerador Linear

Lab activity #9 will be performed here:
IPEN