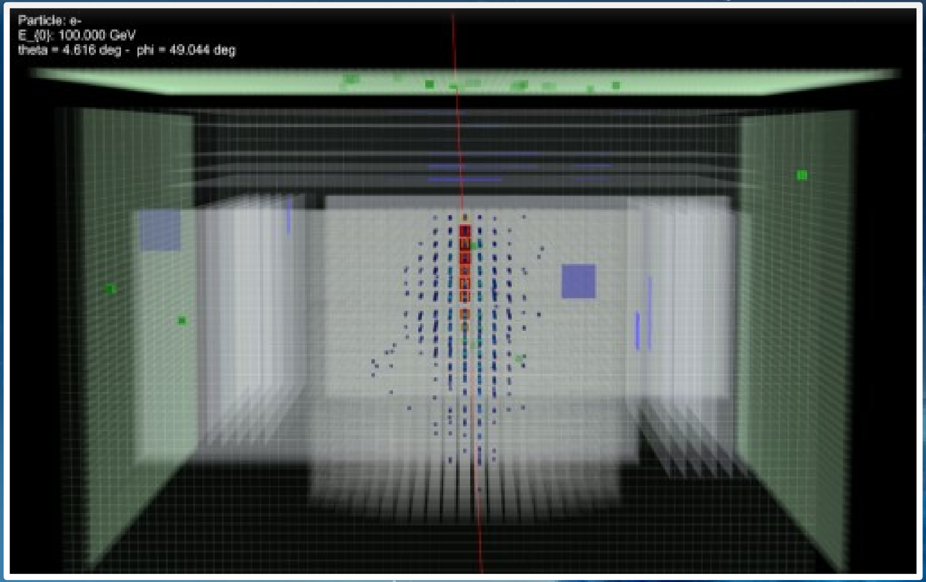
INFN International School on
Architectures, Tools and Methodologies for Developing Efficient Large Scale Scientific Computing Applications

ESC

The HERD space mission



GRAN SASSO SCIENCE INSTITUTE
SCHOOL OF ADVANCED STUDIES
Scuola Universitaria Superiore

Francesca Alemanno

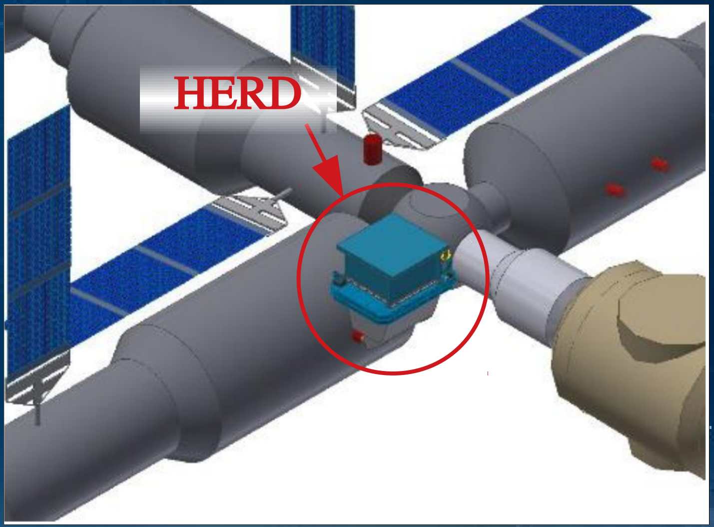
INFN LNGS
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

Bertinoro, 04-09/10/2021

The High Energy cosmic Radiation Detection facility

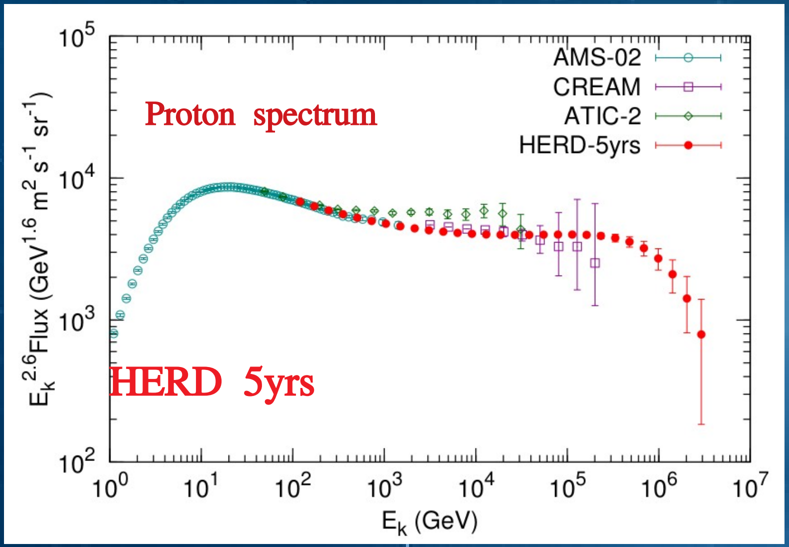
HERD is an international collaboration involving several institutes in Europe and China

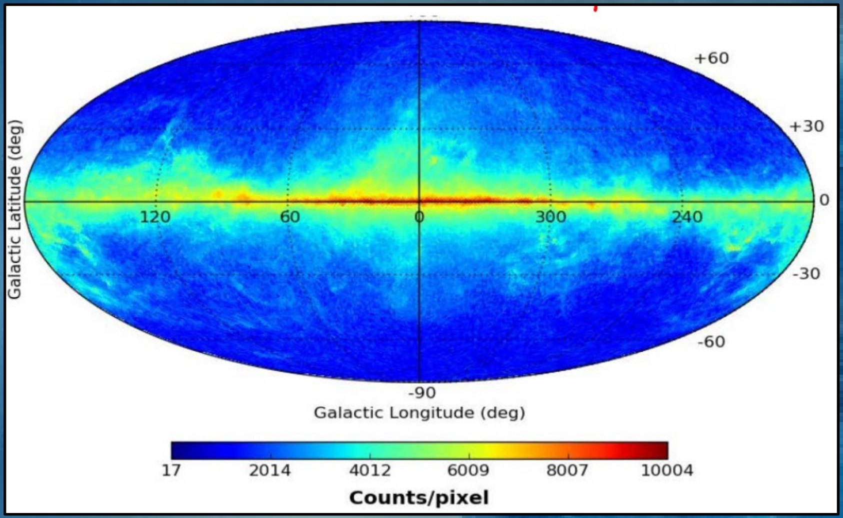
Planned to be installed on-board the China's Space Station (CSS)



HERD Scientific objectives

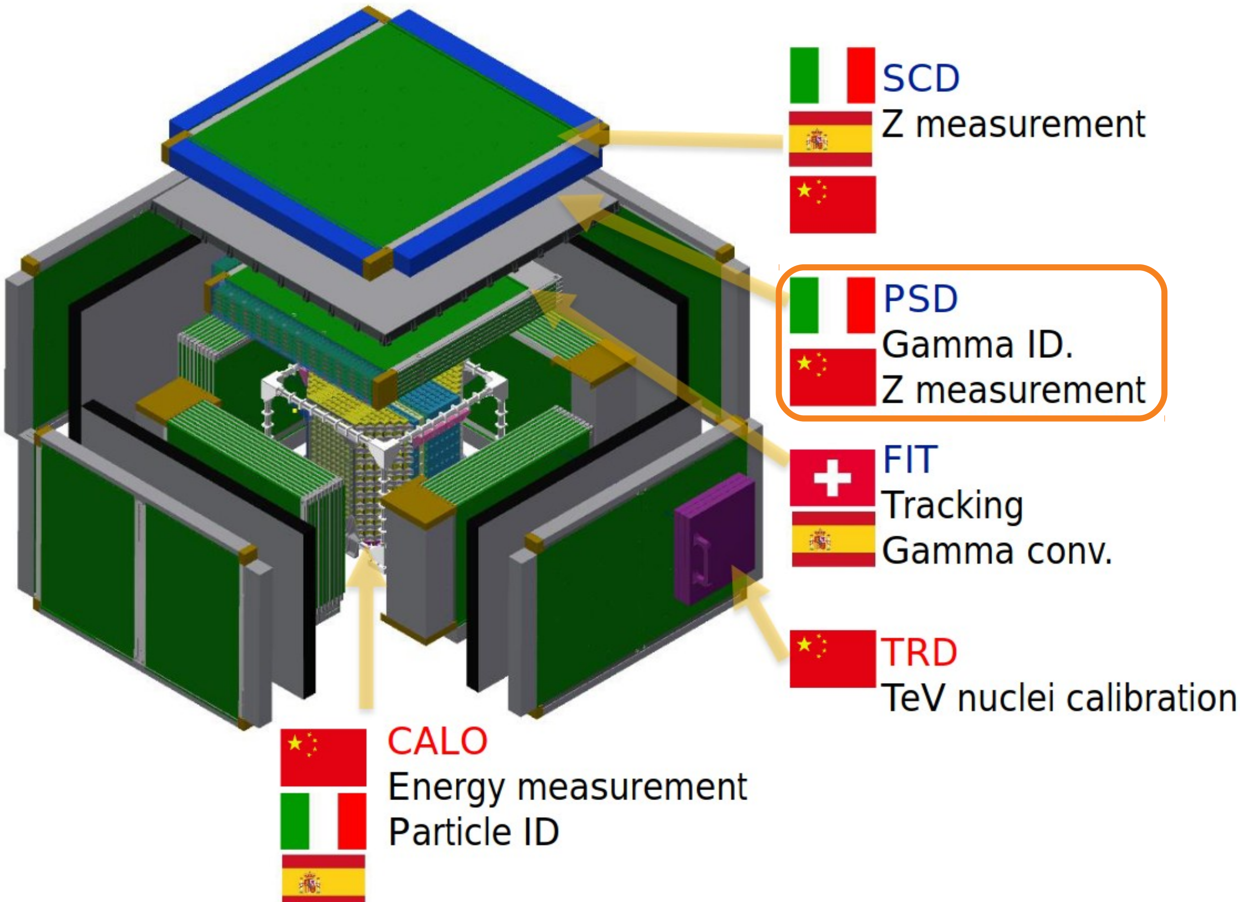
- Galactic Cosmic Rays studies
- Indirect Dark Matter searches
- High Energy Gamma Ray Astronomy

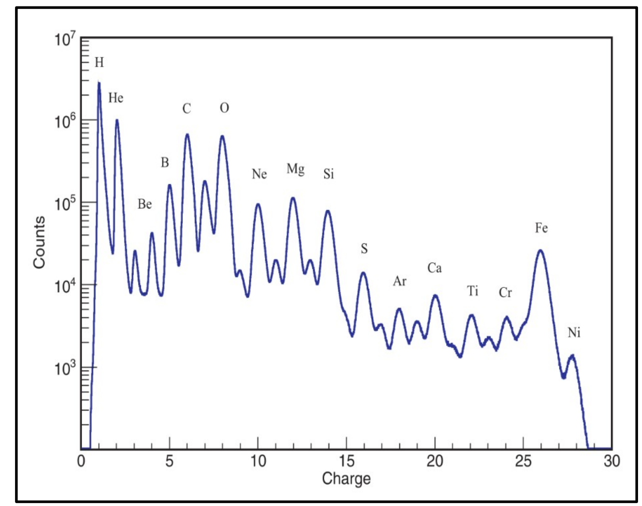




The HERD detector

Detecting particles from the top and from four lateral sides!

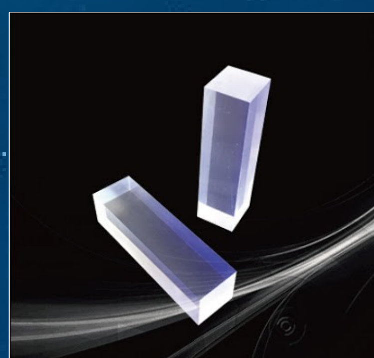




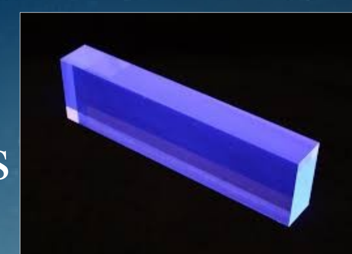
One possible PSD layout is composed by long scintillator bars coupled with Silicon Photo-Multipliers on both ends

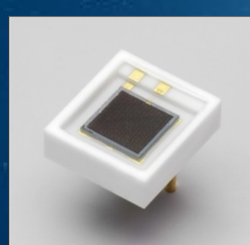
Hardware activities @ LNGS

Looking for the best PSD configuration…

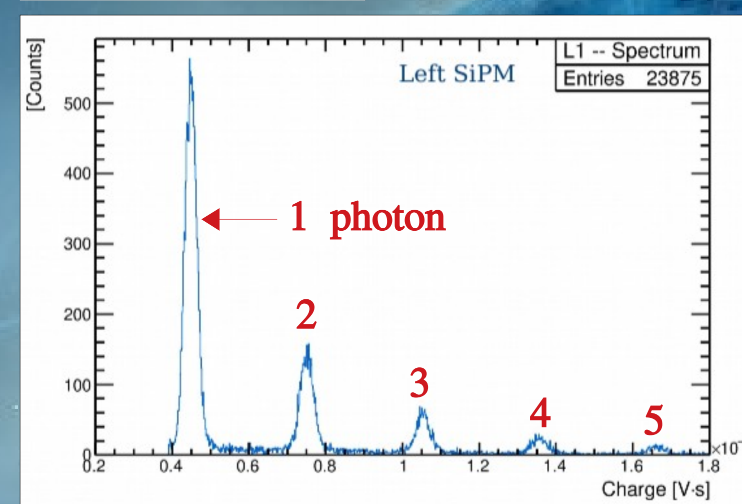


Test of various scintillating materials and geometries

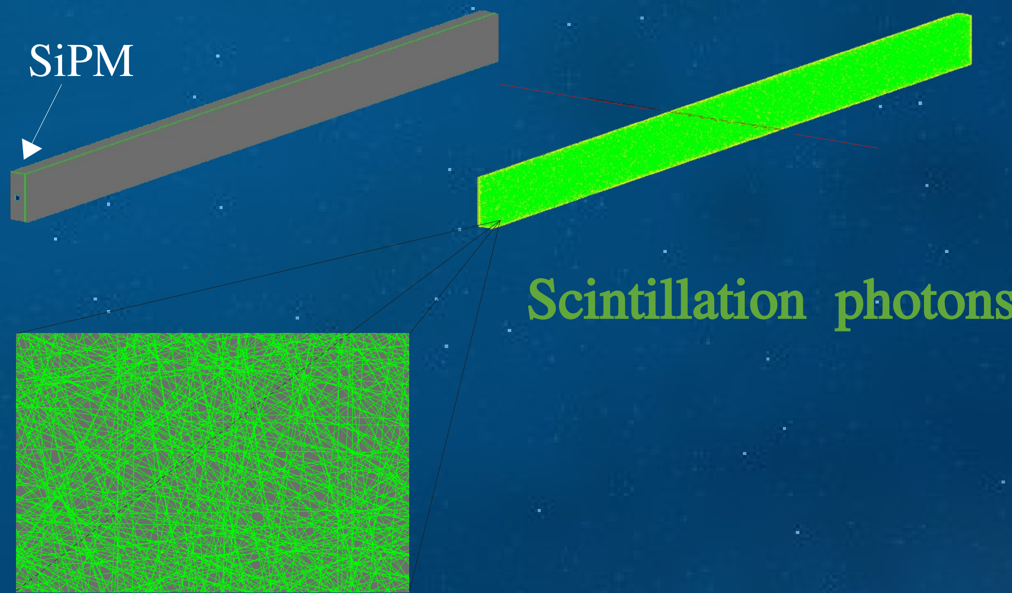




SiPM characterization



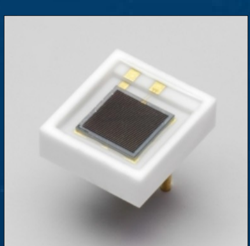
Software activities @ GSSI

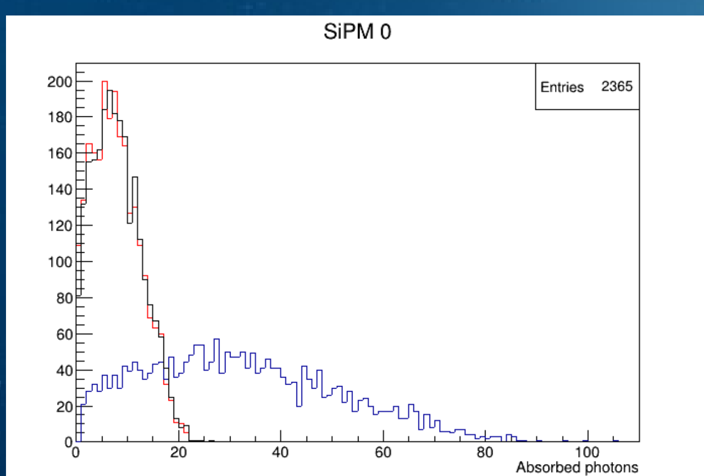


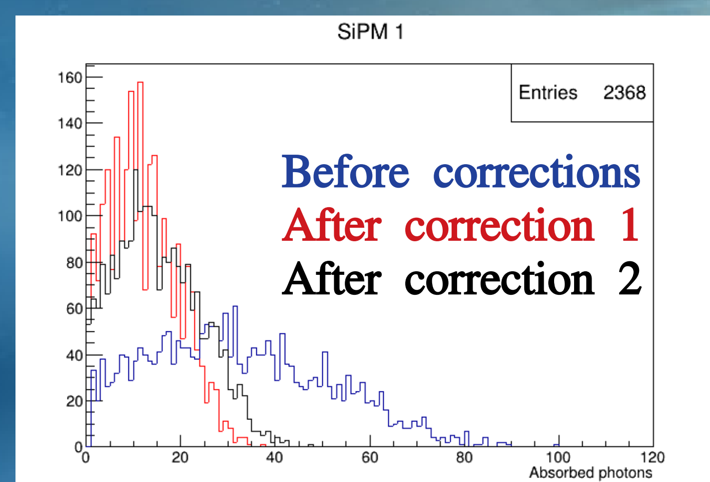
Evaluation of the best PSD configuration by varying:

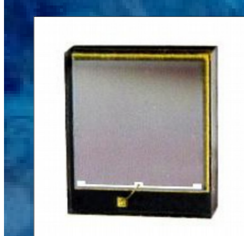
- Scintillator shape, size, material
- Wrapping thickness and material
- SiPMs size, position, type

Simulation of various SiPM characteristics



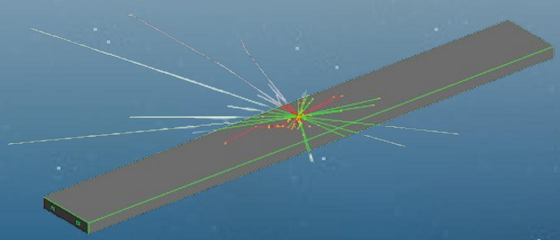




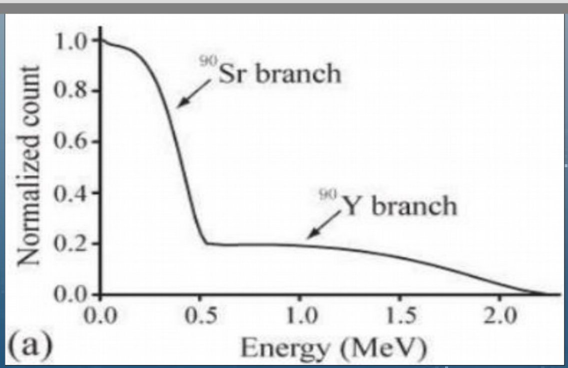


Software activities @ GSSI

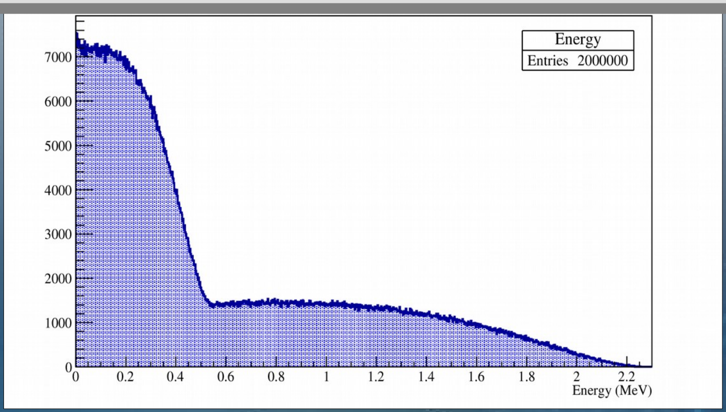
Simulation of Sr90 radioactive decay



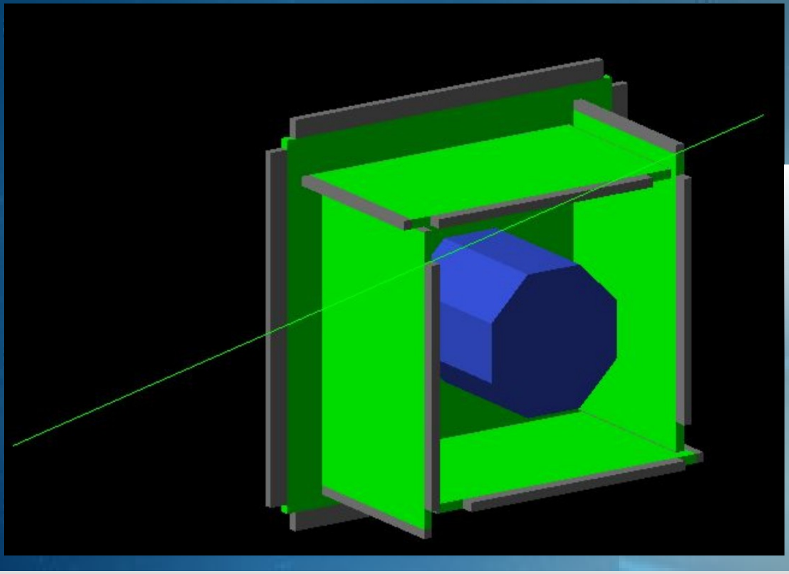
Theoretical spectrum



Simulated spectrum



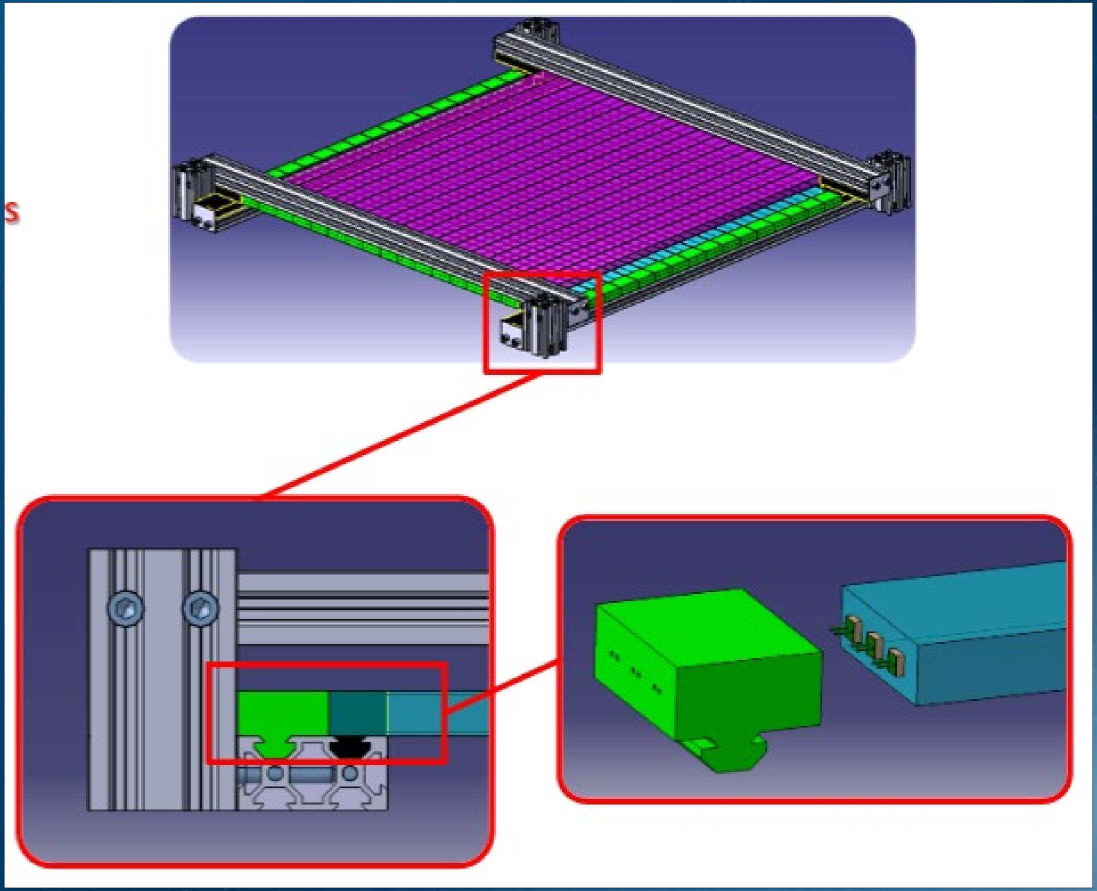
Simulations of the HERD detectors using CAD models



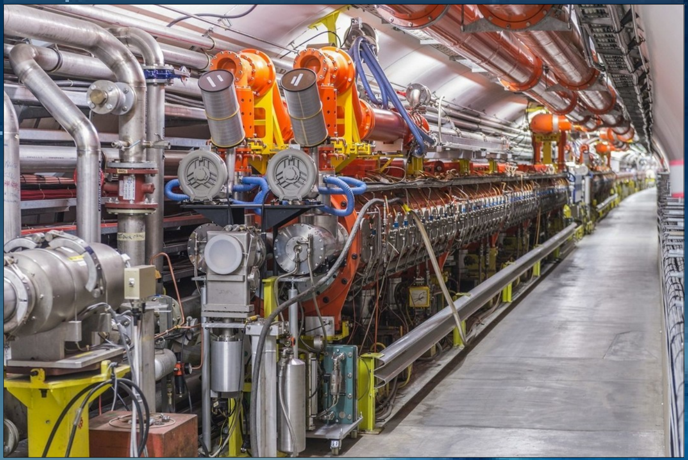
- Hermeticity studies
- Avoid particles mis-identification

Preparation for the beam test in October - November 2021

2 perpendicular layers of 14 bars each



To be tested at CERN SPS



Thanks for the attention!

UNIVERSITÀ DEGLI STUDI DI PADOVA

INFN PADOVA
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

ALICE

CERN

ECS21

The iMPACT proton Tomography Scanner

Filippo Baruffaldi

D. Chiappara, P. Giubilato, J. Wyss, D. Pantano

04 October 2021

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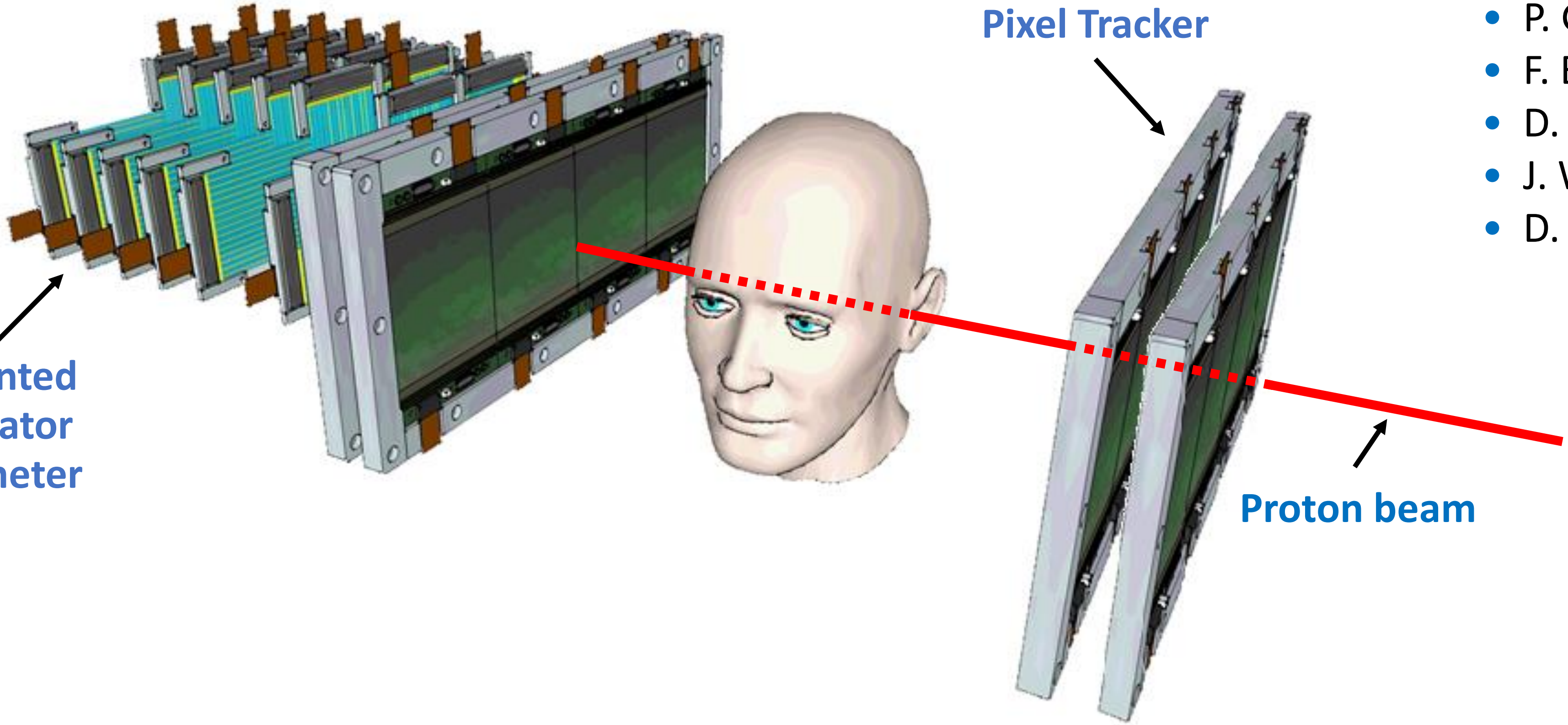


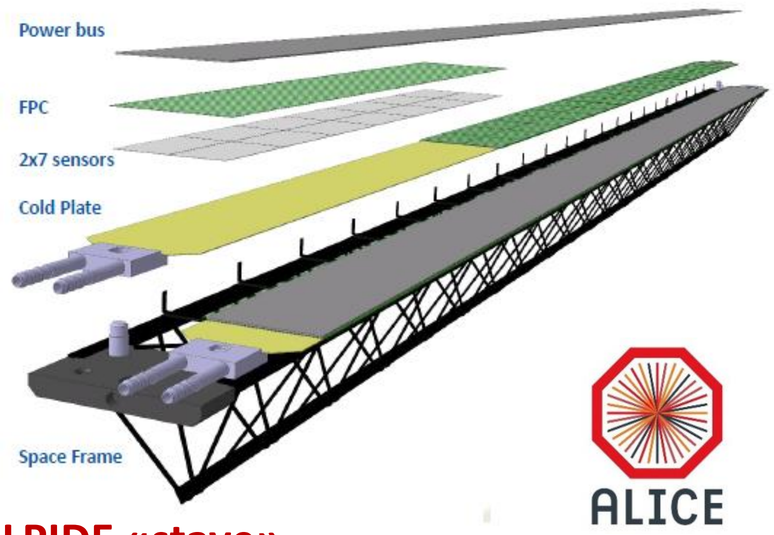
Group components:
- P. Giubilato (Professor)
- F. Baruffaldi (PhD student)
- D. Chiappara (PhD student)
- J. Wyss (Professor)
- D. Pantano (Technician)

- **iMPACT** (University of Padova, INFN and H2020 ERC) project aims at developing a high-resolution, high-speed (10^9 particles in < 10 s over 100cm^2) **proton tomography** scanner.
- Medical Application; 200-250 MeV protons.

Why pCT?

- The **Monolithic Pixel Silicon Sensor ALPIDE** ($30 \times 30\ \mu m^2$) pixels, developed for the **ALICE** detector upgrade) is the current solutions for prototyping the proton **tracking** system

- New design (INFN-ARCADIA) are being developed.

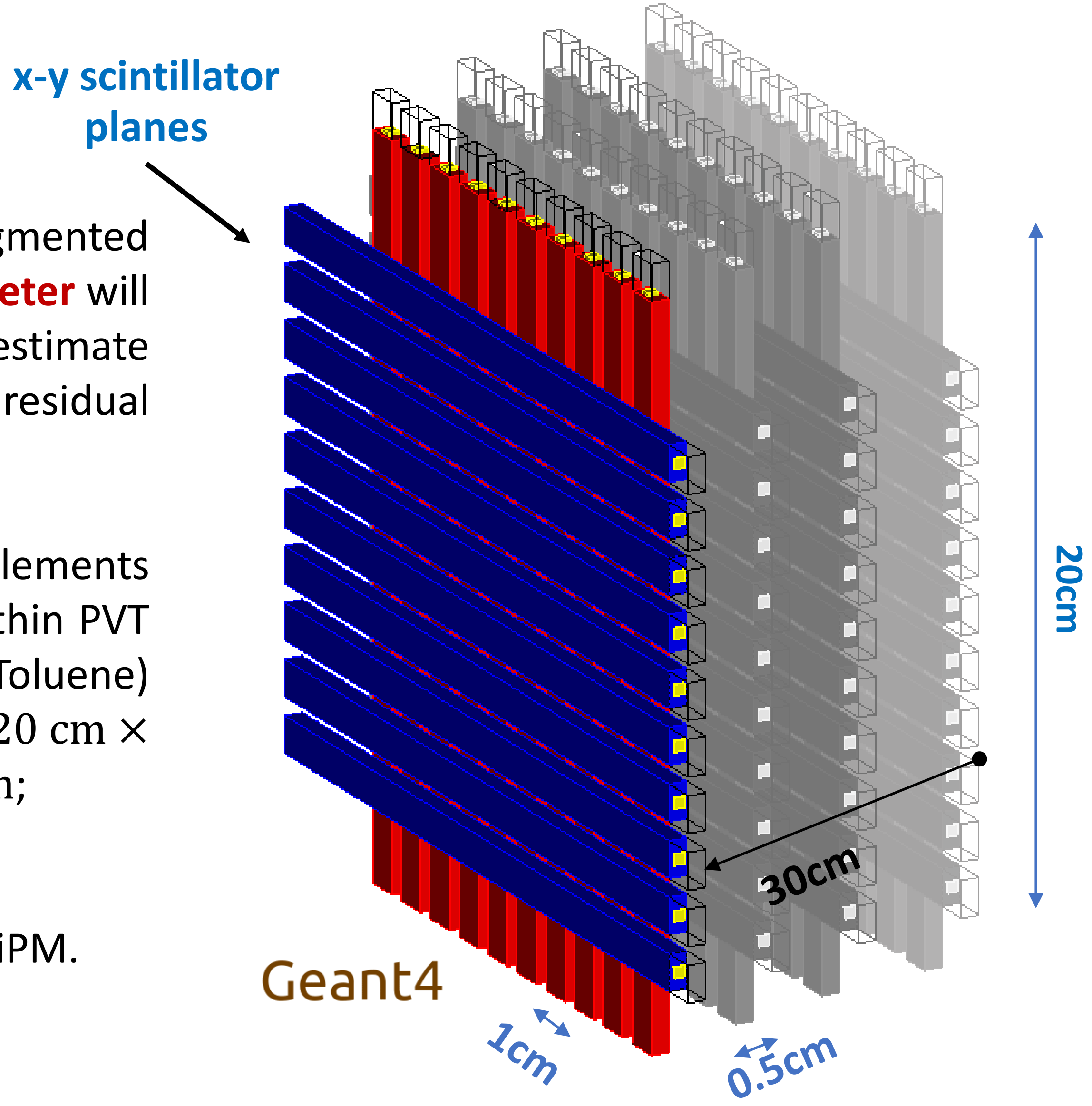


ALPIDE «stave»

- A highly segmented **range calorimeter** will be used to estimate the proton residual energy;

- Scintillating elements are long and thin PVT (Poly-Vinyl Toluene) ***fingers*** $20\ \text{cm} \times 1\ \text{cm} \times 0.5\ \text{cm}$;

- $3\text{mm} \times 3\text{mm}$ Hamamatsu SiPM.



The iMPACT calorimeter

Filippo Baruffaldi

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Istituto Nazionale di Fisica Nucleare
Sezione di Padova

- The **iMPACT** calorimeter is a **range calorimeter**, not an energy calorimeter:

- We want to obtain a 3D Map of the local Relative Stopping Power (to water):

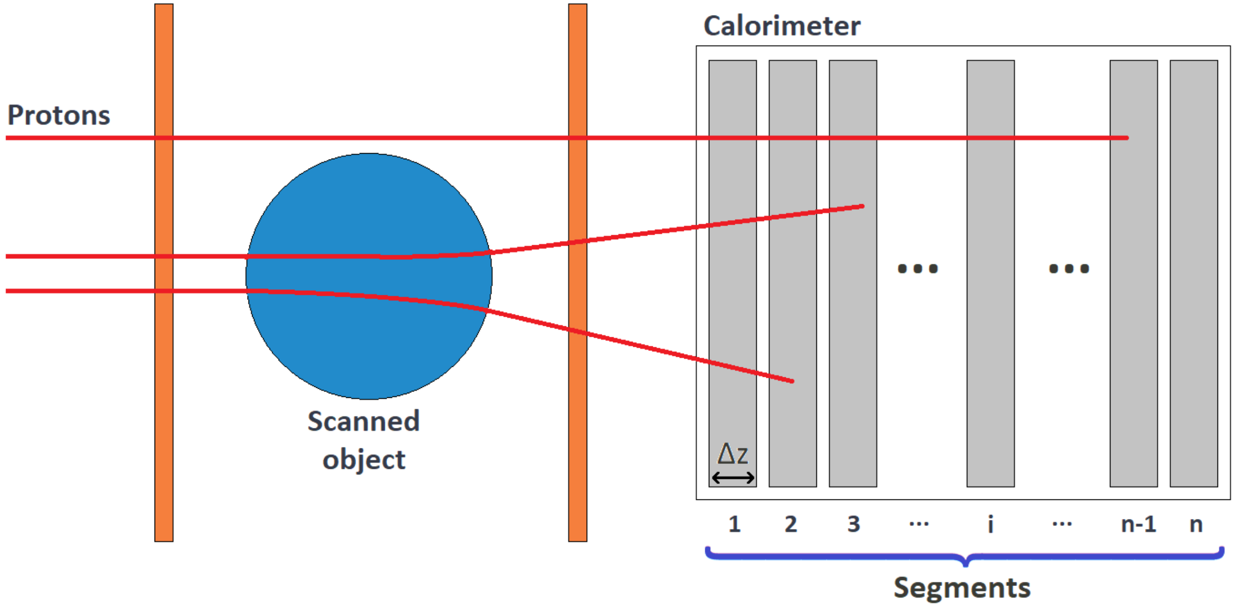
$$\mathrm{RSP} = \frac{S_p^{\text{material}}}{S_p^{\text{water}}}$$

- The charged particle Range is equal to:

$$R(E) = \int_0^E \left\langle \frac{dE'}{dx} \right\rangle^{-1} dE'$$

- Water Equivalent Path Length inside the object:

$$\mathrm{WEPL} = \int_L \mathrm{RSP}(l)dl$$



Total Range of protons in water (200 – 230 MeV)

$$\mathrm{WEPL} = R_{\text{tot}} - R$$

(Equivalent) Range inside the calorimeter

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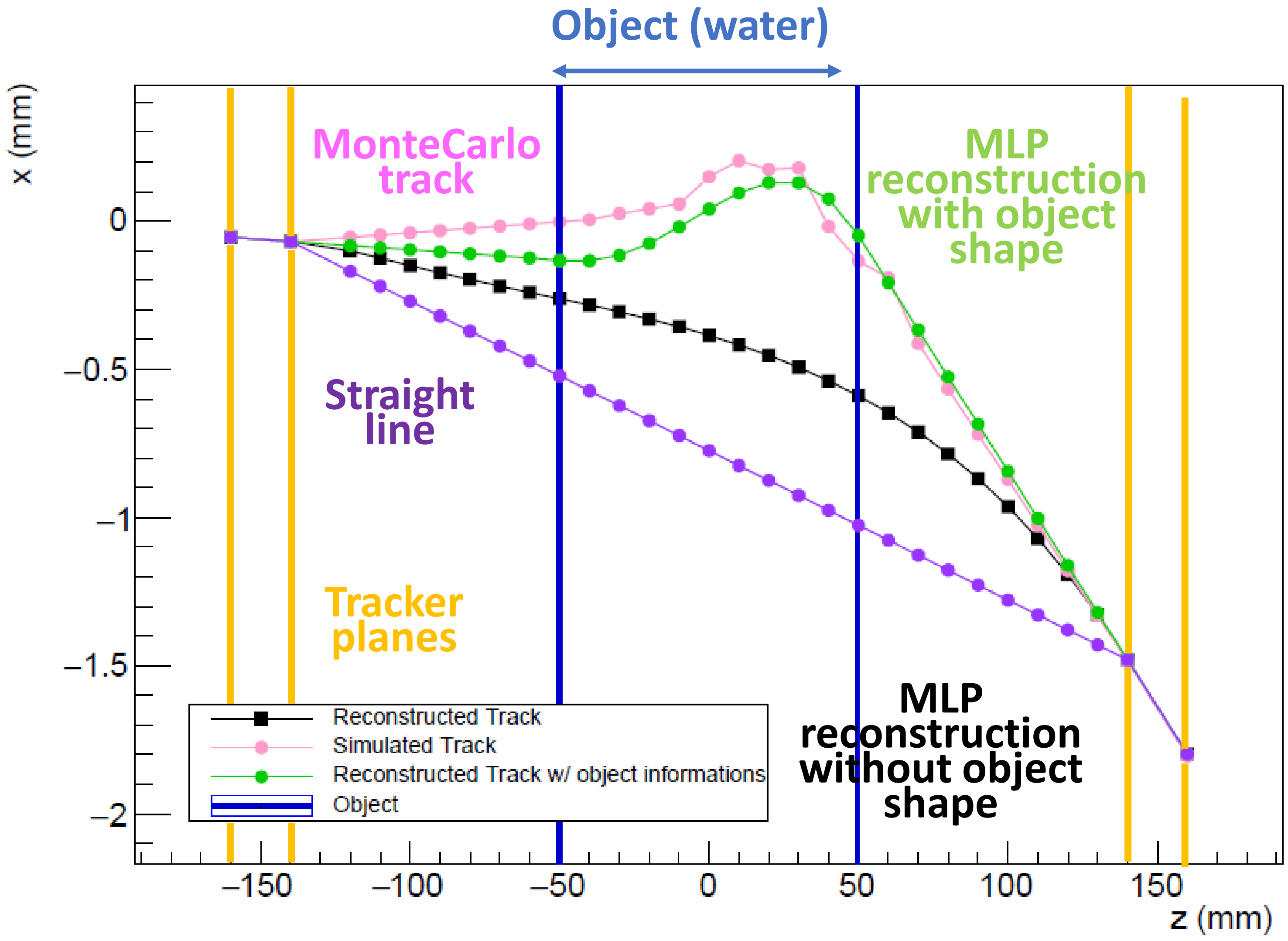

W/ object info <u>wins</u> $> 80\%$ of times over w/o object info

Tracking

- **Bayes Theorem**:

$$L(y_1|\text{exit data}) = L(\text{exit data}|y_1)L(y_1|\text{entry data})$$

- **Maximize likelihood:**

$$L(y_1 = y_{\text{MLP}}|\text{exit data}) = \max,$$

or

$$\nabla L(y_1|\text{exit data}) = \begin{pmatrix} \partial t_1 \\ \partial \theta_1 \end{pmatrix} L(y_1|\text{exit data})|_{y_1 = y_{\text{MLP}}} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

Schulte, R. W., et al. "A maximum likelihood proton path formalism for application in proton computed tomography." Medical physics 35.11 (2008): 4849-4856.

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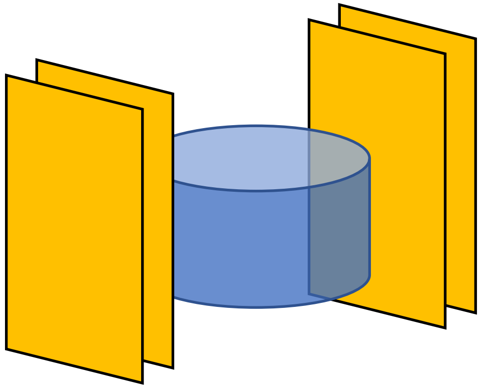
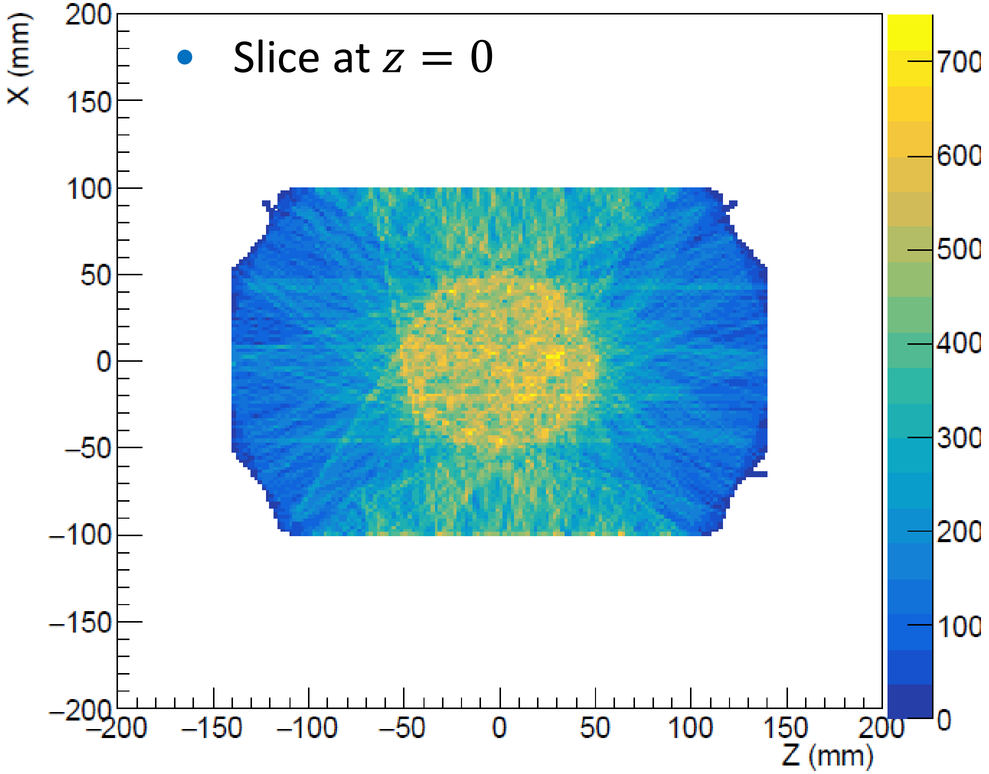
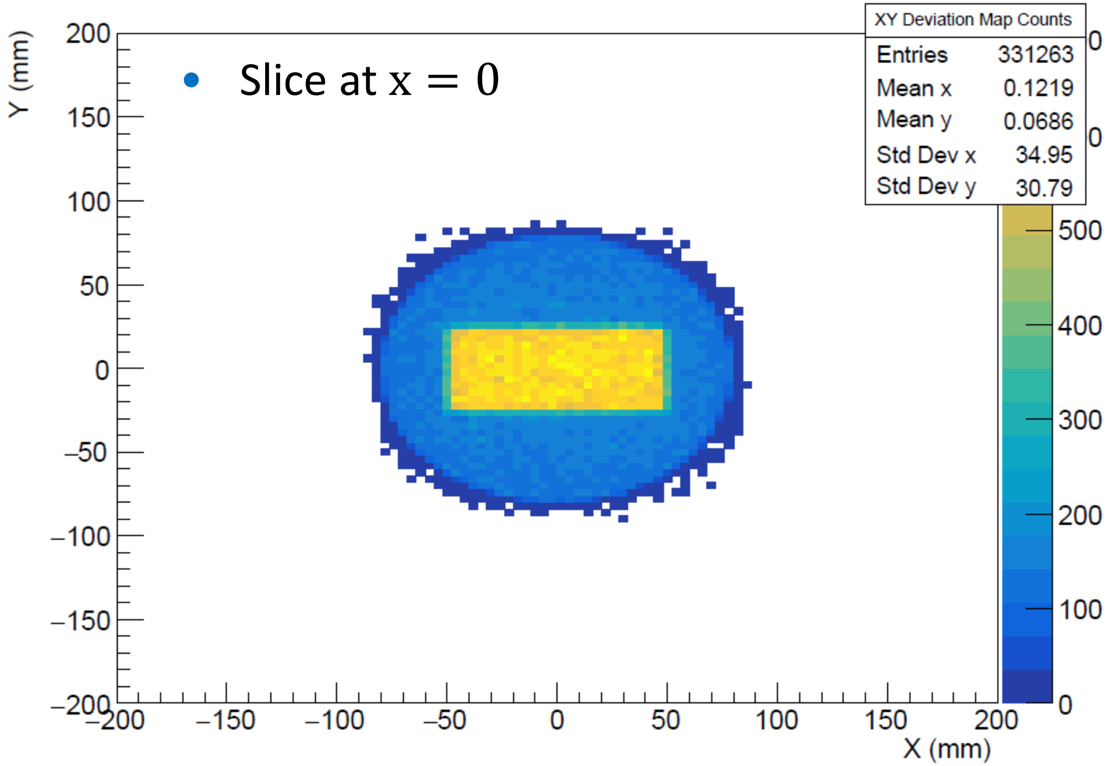
- Moliere theory of multiple scattering in AIR:

$$\sigma_\theta = \frac{1.41\mathrm{MeV}}{\beta pc} z \sqrt{\frac{d}{L_{\mathrm{rad}}}} \left[1 + \frac{1}{9}\log_{10}\left(\frac{d}{L_{\mathrm{rad}}}\right)\right]$$

- Integration of tails above $(1; 2; 3) \times \sigma_\theta$







- Only with angle informations (not ΔE).

Department of Physics and Astronomy, University of Padua
PhD School in Physics –XXXV Cycle

VALENTINA BIANCACCI

valentina.biancacci@pd.infn.it

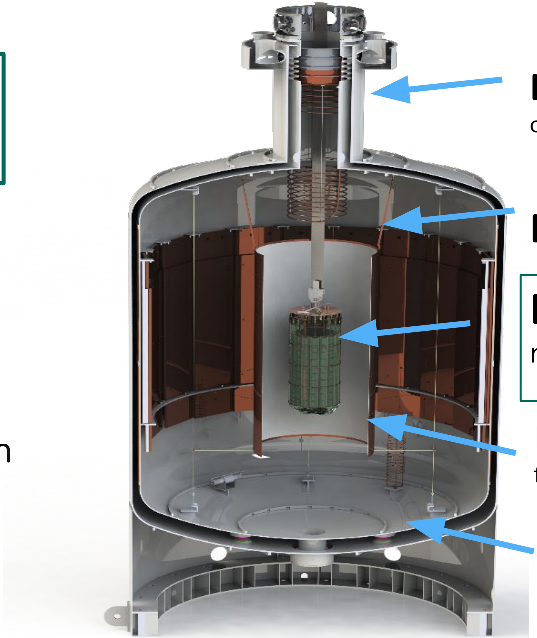
Gerda experiment - Legend experiment

GERmanium **D**etector **A**rray   **L**arge **E**nriched **G**ermanium **E**xperiment for **N**eutrinoless double-beta **D**ecay

searching for the neutrinoless double beta decay of ^{76}Ge

Gerda

- Installed at INFN Laboratori Nazionali del Gran Sasso (LNGS)
- Up to 41 enriched detectors deployed
- Two data taking periods with an upgrade in between.



Lock system: for the deployment of the Ge detectors

LAr cryostat: coolant shielding

Detectors array: string of naked enriched germanium detectors

LAr veto: shrounds with scintillating fibers for the detection of the light

Water tank: neutron moderator/absorber muon Cherenkov veto

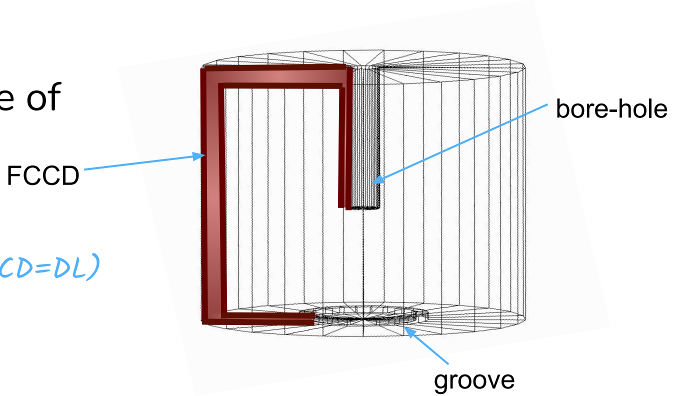
Legend-200

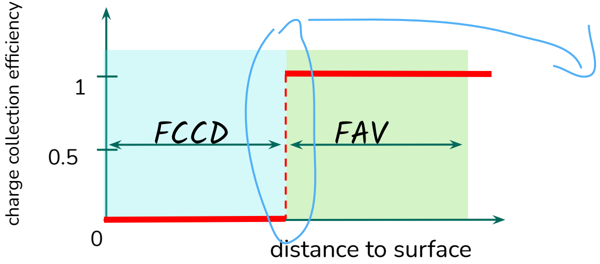
- Upgrade of the existing infrastructure of GERDA experiment
- ~200 kg of detector mass: 35 kg from GERDA + 30 kg from MJD + 140 kg which are new
- Reduction of the BI of a factor 5 w.r.t. GERDA Phase II goal

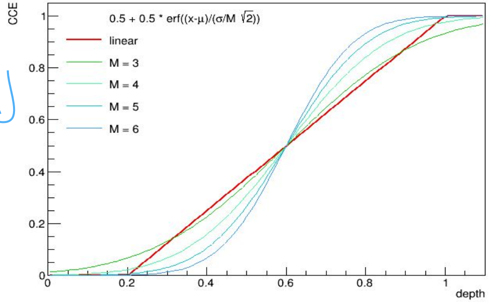
Active volume characterization

In addition to the fully active volume (FAV), around the surface of the detector there is the full charge collection depth (FCCD).
It consists of:

- dead layer (DL) = zero charge collection;
- ~~transition layer (TL) = partial charge collection.~~ ignored at first order (FCCD=DL)

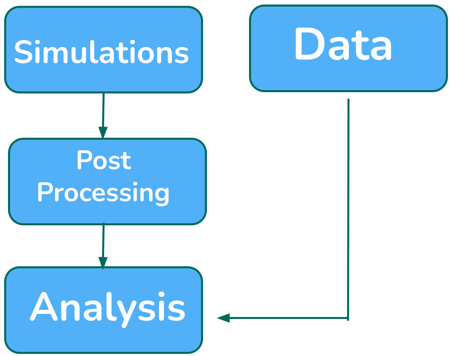






1. MC simulations are created through g4simple tool.
2. Starting from raw MC, generate subsequent spectra for different FCCD thicknesses.
3. Compare post-processed simulations and data by constructing a sensitive observable.

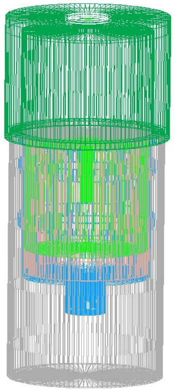
workflow

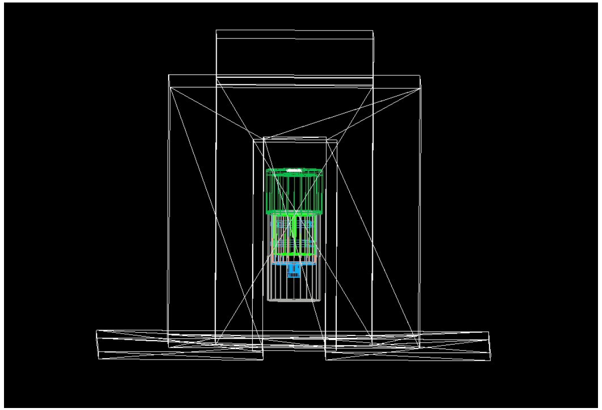


G4simple simulations and results

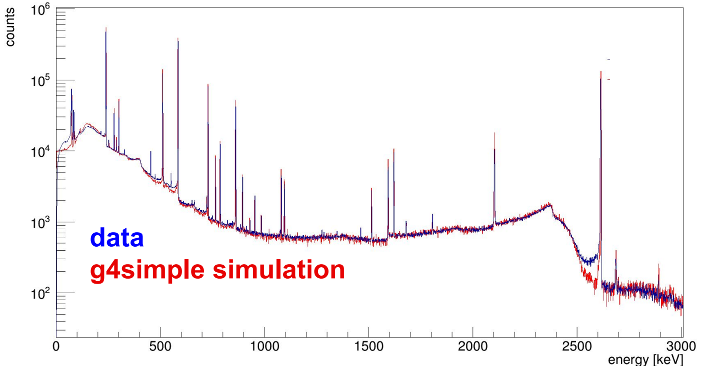
G4simple is a simple Geant4 simulation suite developed by the Legend collaboration.

- Lead **castle**
  - Aluminium alloy* **cryostat**
    - Enriched germanium **detector**
    - Aluminium alloy* **holder**
    - HD1000 **wrap**
  - Acrylic **source holder**
    - Acrylic/HD1000 **source**

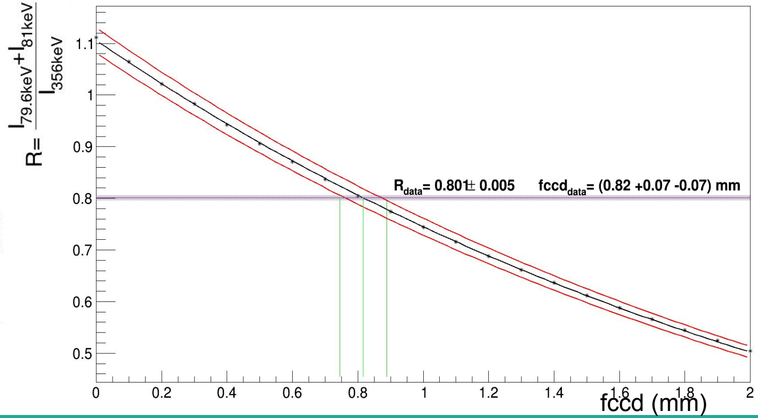




Comparison between data and post-processed MC simulations by a FCCD sensitive observable



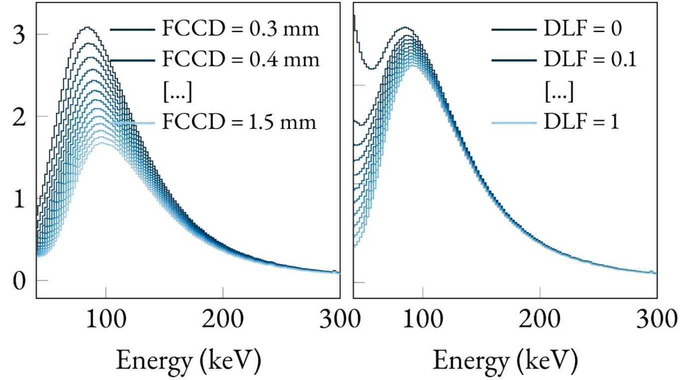
$$R = \frac{I_{79.6keV} + I_{81keV}}{I_{356keV}}$$



^{39}Ar - a tool for the FCCD determination

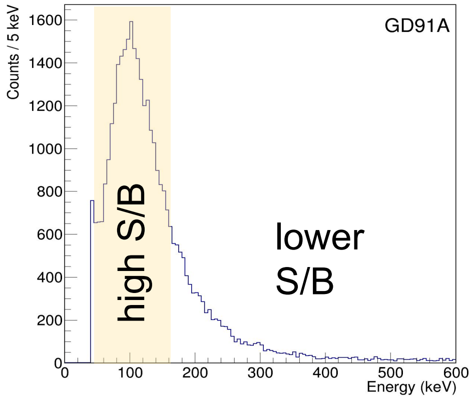
The shape of the ^{39}Ar spectrum mainly depends on the FCCD and DLF

- Analysis range: **[45, 160] keV**
- Define **test statistics t_S**: $t_S(F,D;a_{39}) = -2\log\frac{\mathcal{L}(F,D;\hat{\hat{a}}_{39})}{\mathcal{L}(\hat{F},\hat{D};\hat{a}_{39})}$



Study the test statistic to extract **best-fit FCCD/DLF** + **Confidence Intervals**

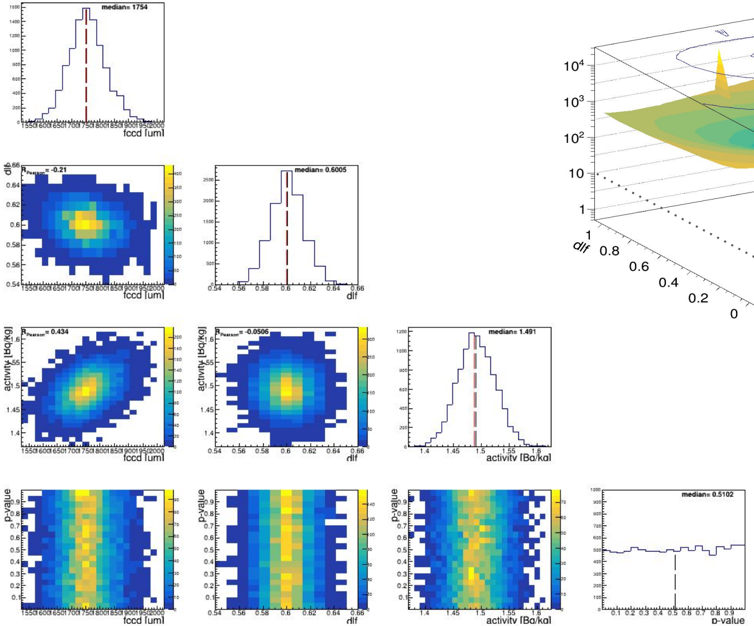
Classic **frequentist** construction
- Build MC expected **pdfs**, **2D discrete grid** varying FCCD x DLF
- Determine best-fit on data (Likelihood profile)

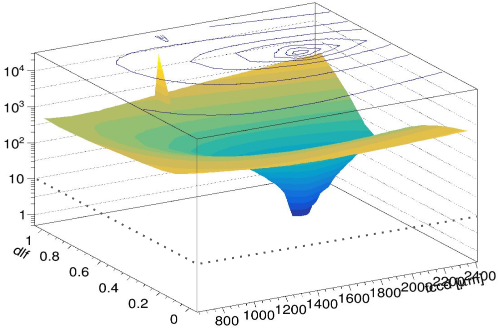


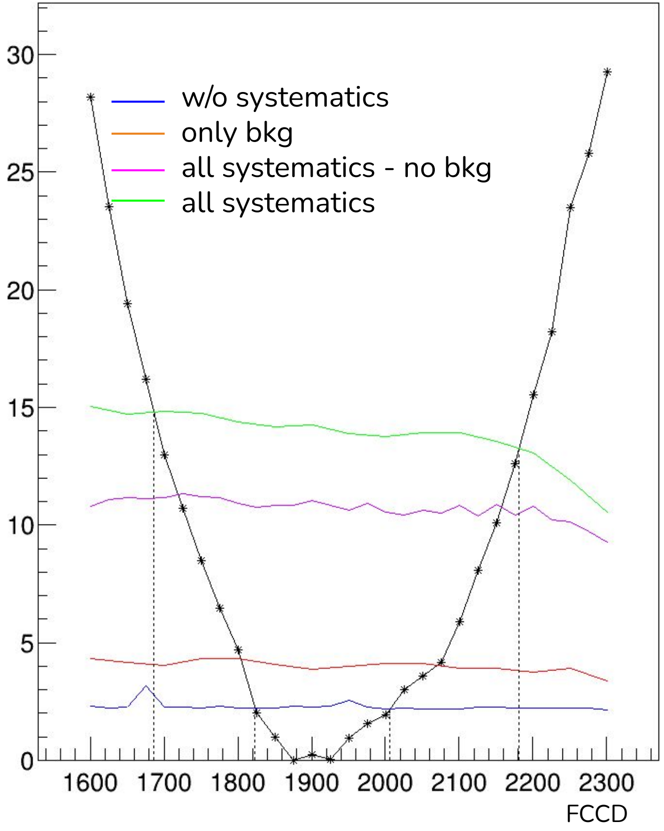
With ensemble of 10^4 **toy experiments**
- Ability to distort toys according to systematics
- Check shape of **t_S distribution**
- Check **distribution of best-fit** parameters
- Determine 68% intervals by computing t_S **critical threshold**

Preliminary checks and results

- Check on the distribution and correlation between parameters
- Profile likelihood obtained from the data
- Critical threshold (68% CL) of the t_s







Summary

This work is focusing on the characterization of germanium detectors using two different approaches:

1) Direct comparison between data taken in lab and post-processed MC simulations which simulate the lab apparatus.
2) Study the ^{39}Ar shape generating expected PDFs with different parameters values.

I'm dealing with large amount of data, many of them are stored in cluster.

efficient C++ programming

cluster computing

GPU usage for ML

Research activity and interests in scientific computing

Marco Bortolami – PhD student in Physics

ESC 2021 - Bertinoro

Università degli Studi di Ferrara

Istituto Nazionale di Fisica Nucleare

Billi Matteo
<u>Bortolami Marco</u>
Gruppuso Alessandro
Natoli Paolo
Pagano Luca

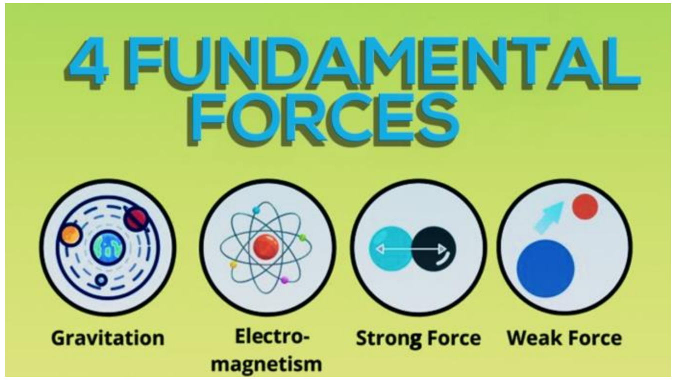
The Cosmic Birefringence effect

- Fundamental interactions: gravitation, electromagnetism, strong, weak
- Parity violating addition to standard electromagnetism: new Physics!

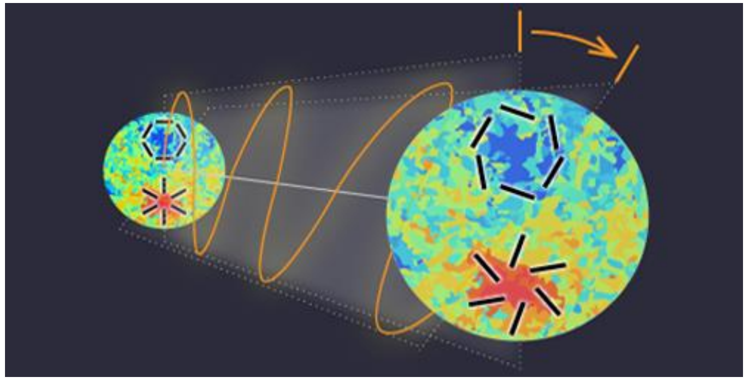
$$\mathcal{L} = -\frac{1}{4}F_{\nu\lambda}F^{\nu\lambda} - \frac{1}{2}p_\alpha A_\beta \tilde{F}^{\alpha\beta}$$

Carroll et al., Phys. Rev. D 41, 1231 (1990)

- Vacuum rotation of linear polarization plane by α (CB angle)
- Polarized light from distant sources: cosmic microwave background, the most ancient light emitted in the history of our Universe!



https://www.youtube.com/watch?v=TY-VWQRwssQ



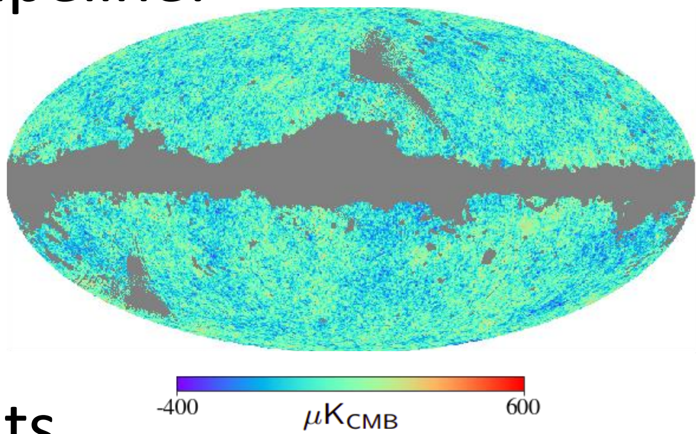
Credits: Y. Minami/KEK

Cosmic Birefringence with sky patches

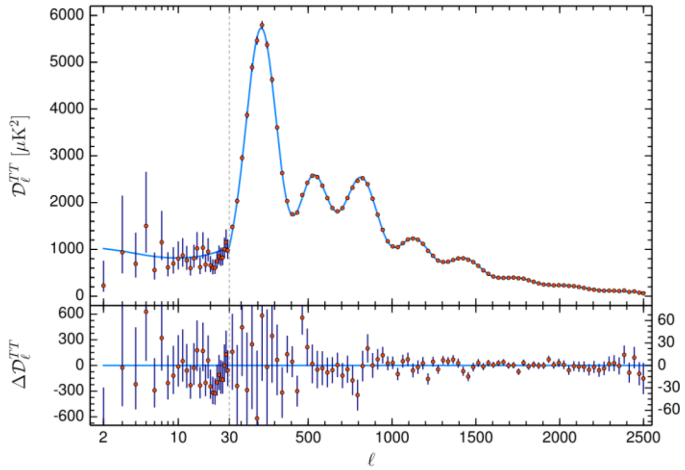
Idea: estimate CB <u>isotropic</u> angle in sky patches, then study its features

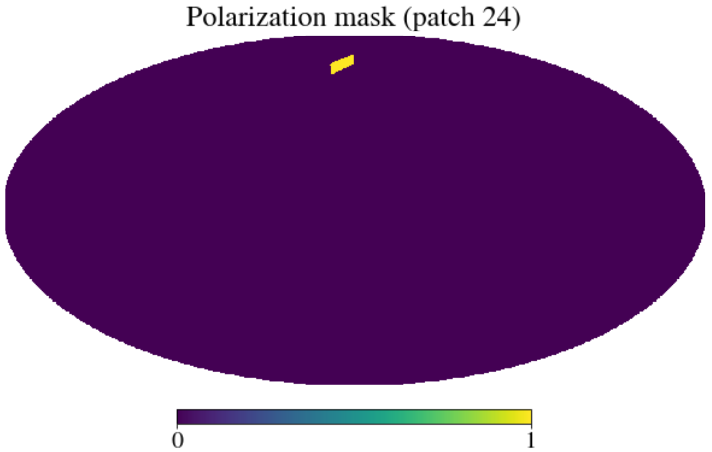
New parallel data analysis pipeline:

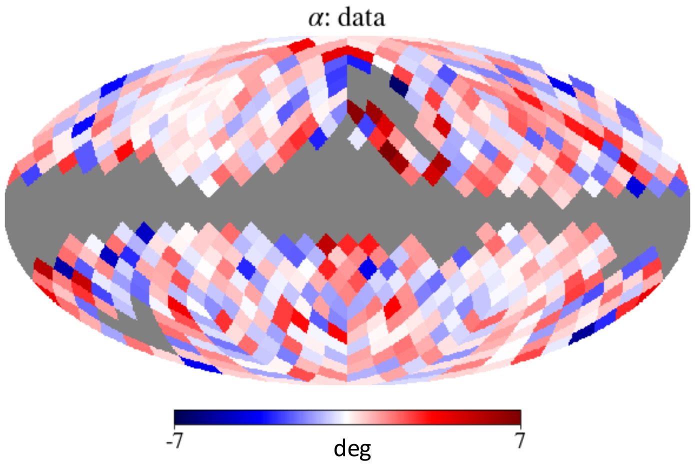
1. Patches selection
2. File decomposition
3. Spectra + cov.
4. CB angles
5. CB spectra and constraints

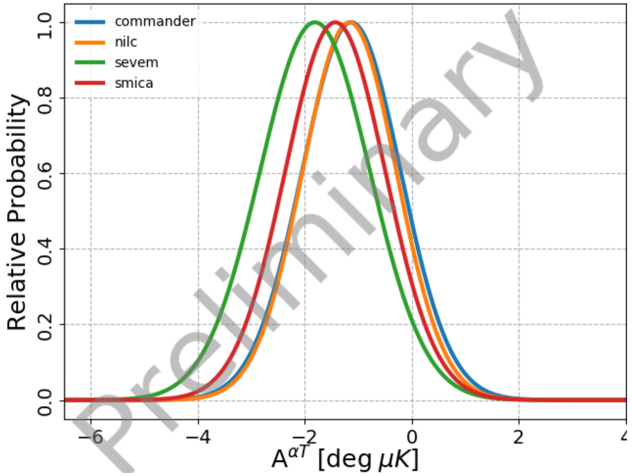


Planck Collaboration, Planck 2018 results. VI. Cosmological parameters



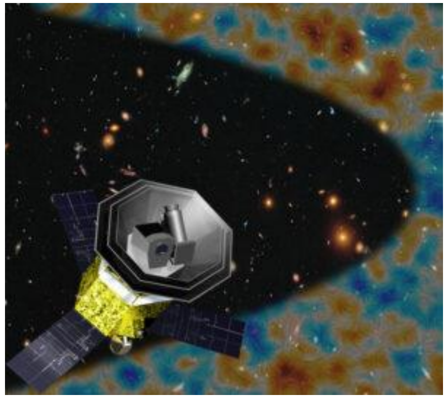






Overview of future work + interests

- Future work: implementation of simulation pipeline
  - Modelling of future CMB experiments' systematic effects
  - Propagation of the effects to the observed maps
  - Need of fast and accurate pipeline



https://www.oas.inaf.it/it/progetti/litebird-it/

- Interests:
  - Modelling of experiments
  - Efficient pipeline development for scientific applications
  - Parallel computing
  - Usage of HPC

Thank you!

12th School on Efficient Scientific Computing

TriDAS

Laura Cappelli[1], Tommaso Chiarusi[2], Francesco Giacomini[1], Carmelo Pellegrino[1]

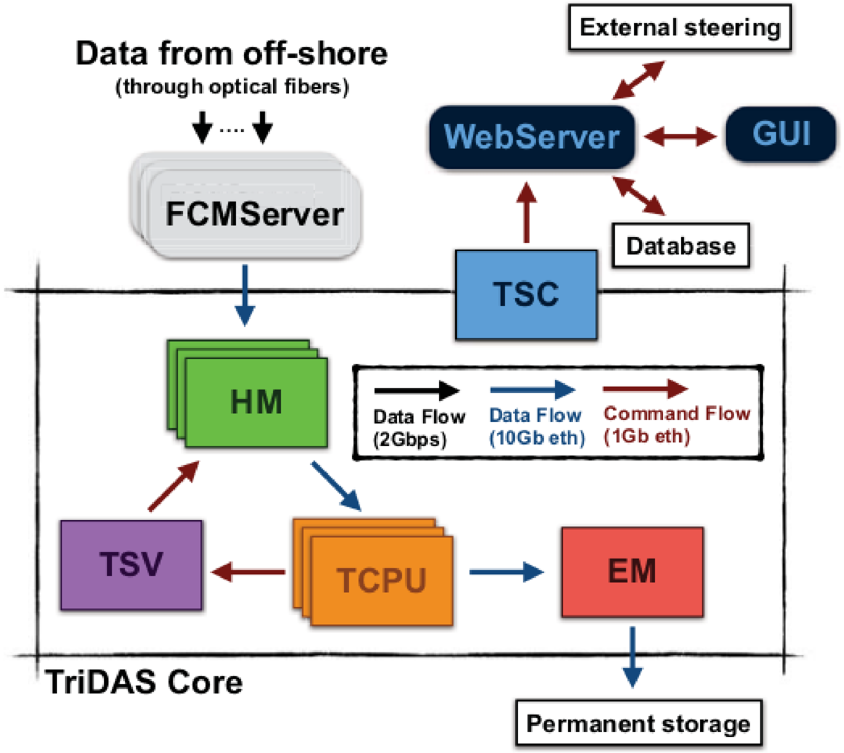
[1] INFN-CNAF, [2] INFN Bologna

Ce.U.B. Bertinoro, 4 – 9 October 2021

The born of TriDAS

- Designed for streaming read-out of Astro-particle Physics events (NEMO project)

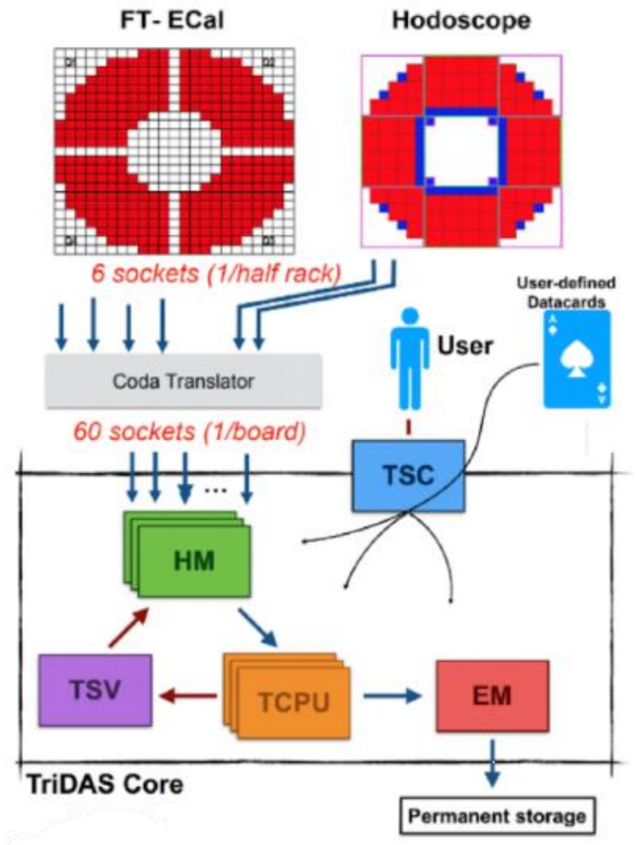
- TriDAS characteristics:
  - Multithreading software written in C++
  - scalable and modular
  - State machine driven process
  - flexible design
  - with a minimal effort is adaptable to a beam-based experiment



Reference
Chiarusi T. *et al, The Trigger and Data Acquisition System for the KM3NeT-Italy neutrino telescope*, Journal of Physics: Conference Series (2017)

TriDAS @ JLab

- TriDAS was used in a triggerless prototype system at the Jefferson Lab
  - A new read-out system is needed for the HI-LUMI upgrade
  - Collect data from the Hall-B detector
  - Integrated with CODA DAQ system and JANA2 framework
- In summer 2020 the prototype system was successfully tested on Forward Tagger sub-detector
  - The system is being used as the basis for developing a larger system for the entire CLAS12 experiment



Reference

Ameli F. *et al, Streaming Readout of the CLAS12 Forward Tagger Using TriDAS and Jana2*, EPJ Web of Conferences (2021)

TriDAS in 2021

- Main effort: developing a new TriDAS version
  - Update C++ version
  - General review of each component
  - Update and improve the software dependencies
    - ZeroMQ, Boost, CMake, Docker, …
  - Updating TriDAS for receiving data in a new format
  - Implementing a new monitoring system
  - Testing in Hall-B the new changes

- Goal: TriDAS – ERSAP integration
  - ERSAP, or *Environment for Realtime Streaming Acquisition and Processing*, is a micro-services architecture for data-stream acquisition and processing under developing at Jlab
  - Might be the entire new software for the CLAS12 experiment

QUESTIONS?

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@lauraCappelli8

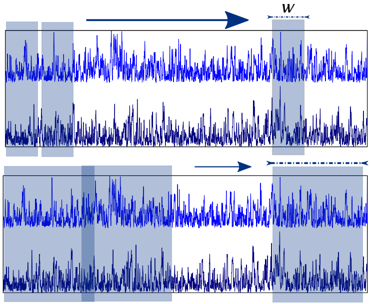
University of Trento
Department of Physics

Efficient Scientific Computing school
Bertinoro
October 4th-9th, 2021

NSE LAB
Nonlinear Systems & Electronics

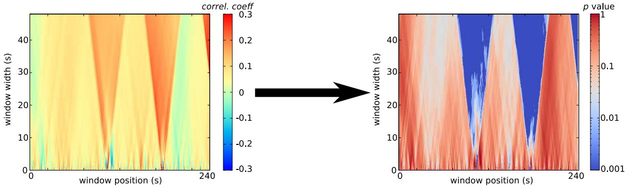
Michele Castelluzzo

TIME SERIES ANALYSIS AND ELECTRONICS



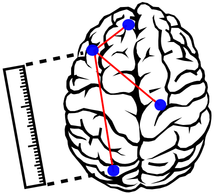
Finding links and estimating **connectivity strength** via moving windows of cross-correlation

Significance of correlations evaluated via **surrogates method**

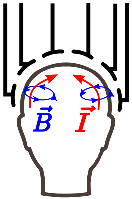


Brain connectivity[1]

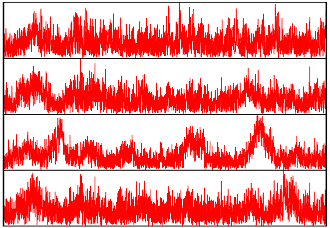
Analysing the relation between **connectivity strenght** and **geometric distance**



MEG recording

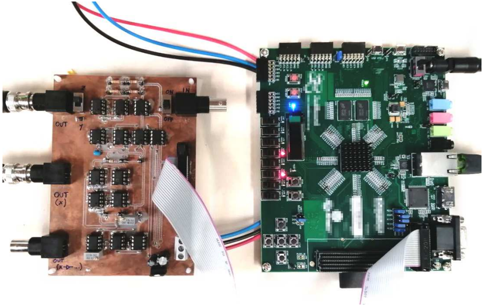


Source reconstruction



[1] M. Castelluzzo, A. Perinelli, D. Tabarelli, L. Ricci, in *Frontiers in Physiology*, 11, 611125 (2021)

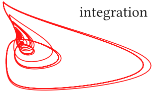
Electronic implementation of the **Minimal Universal Model** for chaos



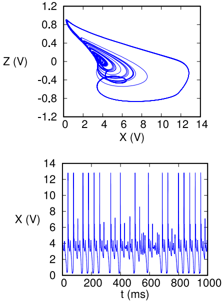
Theory

$$\frac{dx}{d\tau} = -\varepsilon_1\, x\left(1 + k_1 z^2 - p_0 y\right),$$
$$\frac{dy}{d\tau} = -y - xy + 1\,,$$
$$\frac{dz}{d\tau} = -\varepsilon_2\,(z - B_0 + B_1 x)\ .$$

Numerical integration

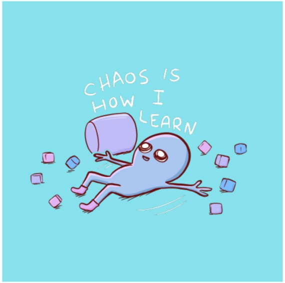


Experiment



[2] L. Ricci, A. Perinelli, M. Castelluzzo, S. Euzzor, R. Meucci, in *International Journal of Bifurcations and Chaos*, 31, 2150205 (2021)

My colleagues



- Leonardo Ricci (Lab head)
- Michele Castelluzzo (PhD student)

- Alessio Perinelli (Post-Doc, former PhD student at NSE)

ARCADIA project for innovative silicon trackers

Davide Chiappara - UNIPD - INFN-PD

4 October 2021

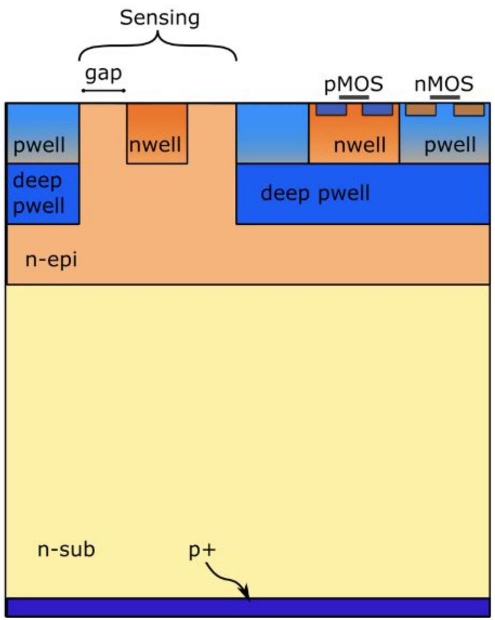
Istituto Nazionale di Fisica Nucleare
Sezione di Padova

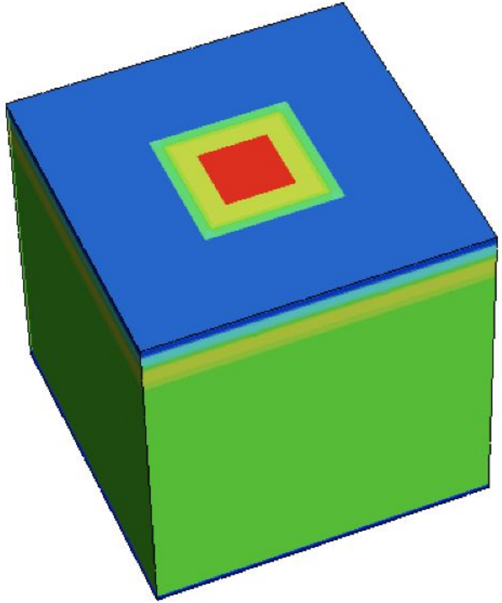
ARCADIA

F. Alfonsi, G. Ambrosi, A. Andreazza, E. Bianco, S. Beolè, M. Caccia, A. Candelori, D. Chiappara, T. Corradino, T. Croci, M. Da Rocha Rolo, G. F. Dalla Betta, A. De Angelis, G. Dellacasa, N. Demaria, L. De Cilladi, B. Di Ruzza, A. Di Salvo, D. Falchieri, M. Favaro, A. Gabrielli, L. Gaioni, S. Garbolino, G. Gebbia, R. Giampaolo, N. Giangiacomi

INFN

P. Giubilato, R. Iuppa, M. Mandurrino, M. Manghisoni, S. Mattiazzo, C. Neubüser, F. Nozzoli, J. Olave, L. Pancheri, D. Passeri, A. Paternò, M. Pezzoli, P. Placidi, L. Ratti, E. Ricci, S. B. Ricciarini, A. Rivetti, H. Roghieh, R. Santoro, A. Scorzoni, L. Servoli, F. Tosello, G. Traversi, C. Vacchi, R. Wheadon, J. Wyss, M. Zarghami, P. Zuccon



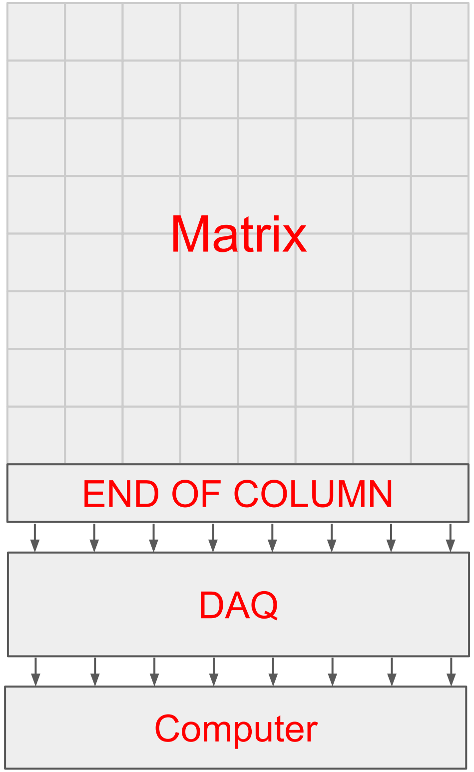


ARCADIA as MAPS

Signal is created and charge information is turned to voltage information

EOC asks for the readout of a single pixel and resets it

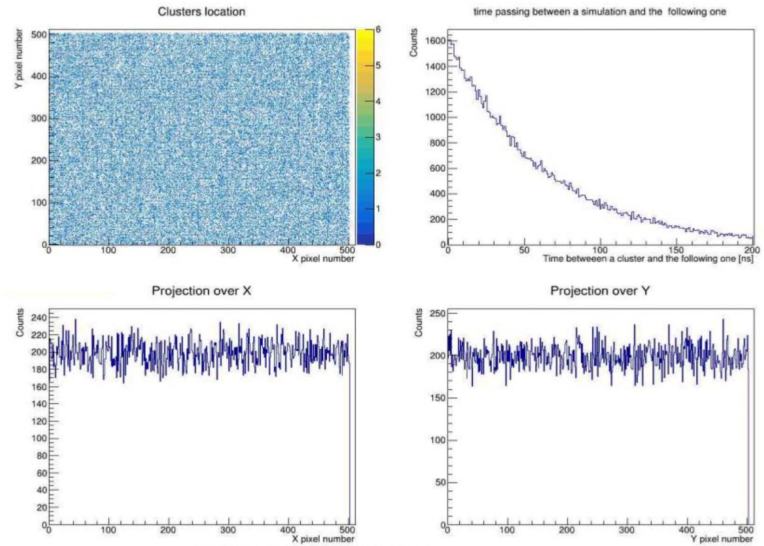
The rest of the chain amplify the signal and make it human readable



Name	ARCADIA Goal	ALICE - ALPIDE
Power consumption	10 mW/cm^2	40 mW/cm^2
Pixel pitch	25 um	28 um
Matrix area	12.8 mm x 12.8 mm (scalable up to 25 mm x 50 mm and beyond)	15 mm x 30 mm
Hit Rate	100 MHz/cm^2	6 MHz / cm^2
Timing resolution	O(1 us)	2 us

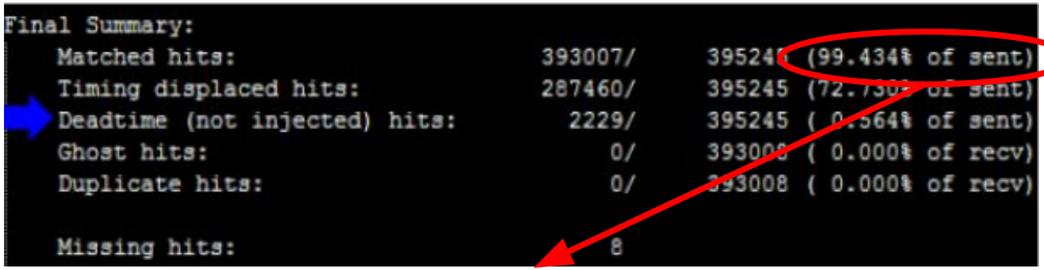
ARCADIA: data analysis

Hits injection from files → cluster position



Arcadia chip simulation and verification

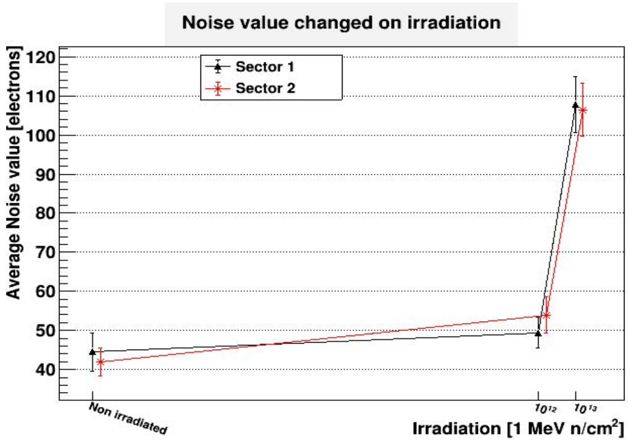
100 MHz / cm² uniform (Poissonian in time)



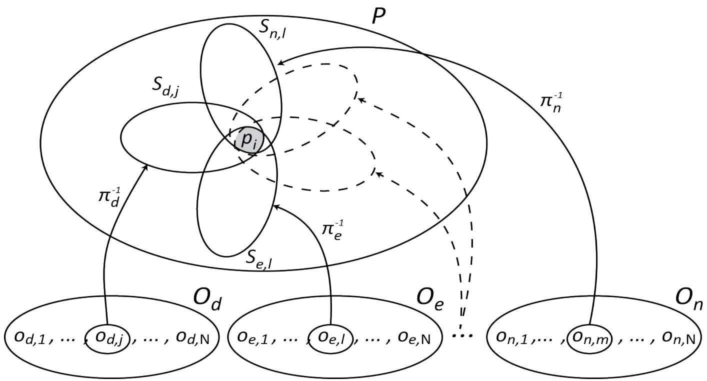
```
Final Summary:
    Matched hits:                      393007/     395245 (99.434% of sent)
    Timing displaced hits:             287460/     395245 (72.730% of sent)
    Deadtime (not injected) hits:        2229/     395245 ( 0.564% of sent)
    Ghost hits:                             0/     393008 ( 0.000% of recv)
    Duplicate hits:                         0/     393008 ( 0.000% of recv)

    Missing hits:                           8
```

Successful readout in > 99% cases

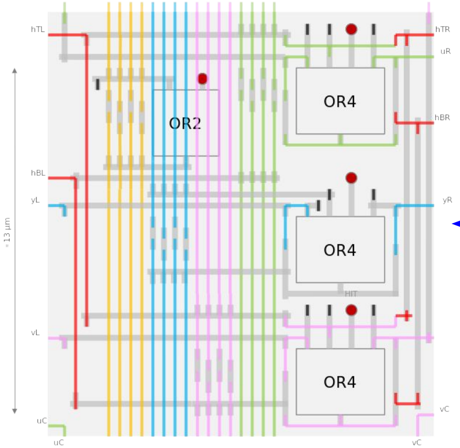


ARCADIA Hash: actual implementation

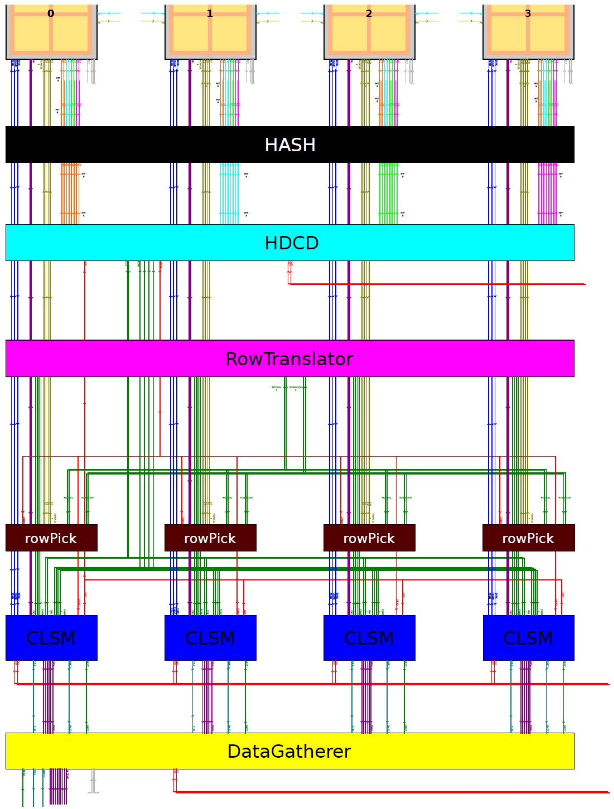


Mathematical modeling

System Verilog code



Physical space modeling



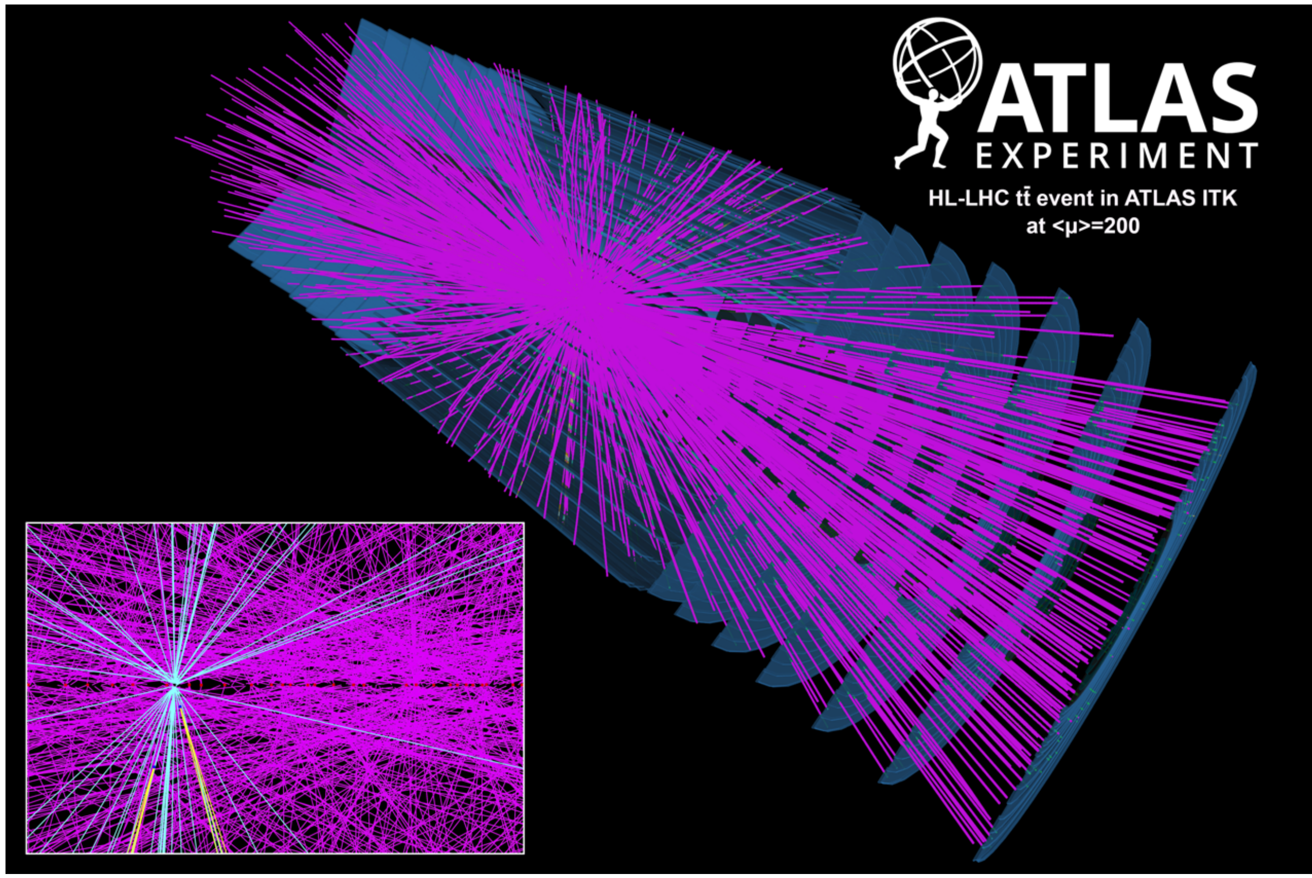
Using tracks for triggering: a computing challenge

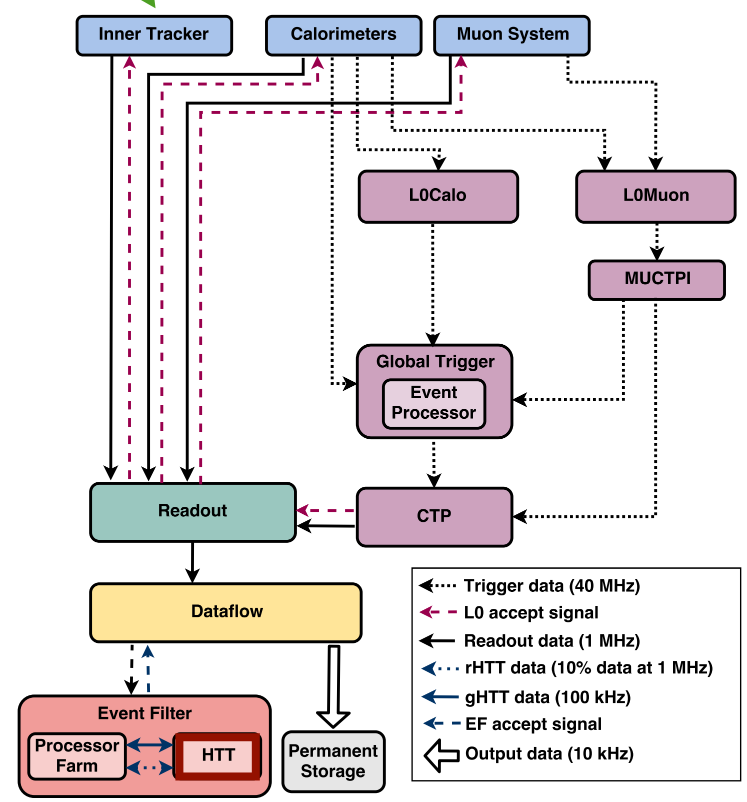
Louis D'Eramo[1]

[1]Northern Illinois University

ESC 2021 - 22/06/2020

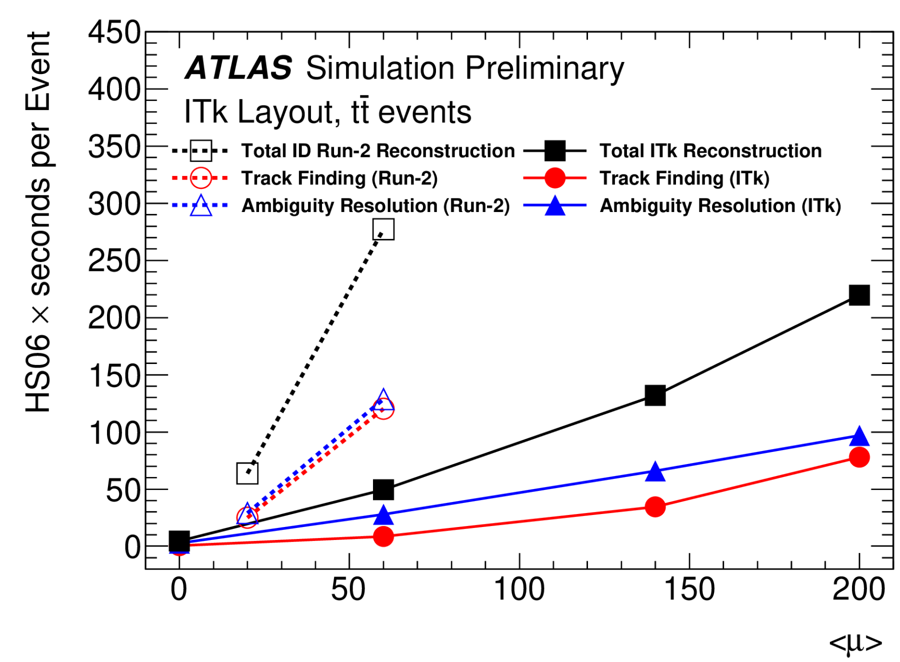
Why tracks matter for triggering





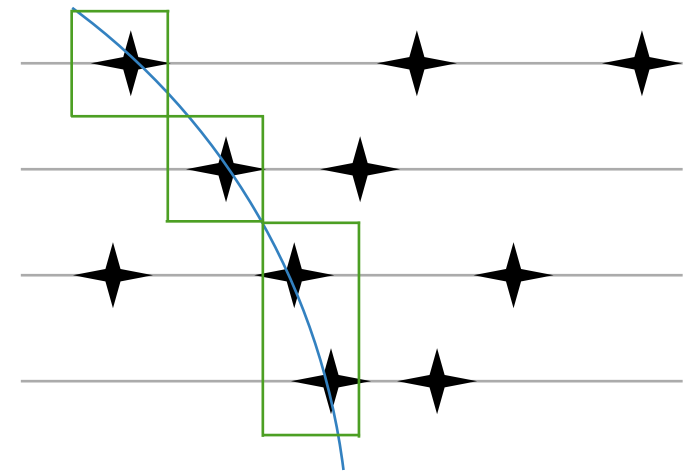
With increased number of interactions per bunch crossing, the High Luminosity phase of the LHC implies harsher conditions for the **trigger system**.

The **track reconstruction** could bring further discrimination but rely on **time** and **ressource intensive** algorithms.



Principle of track triggers

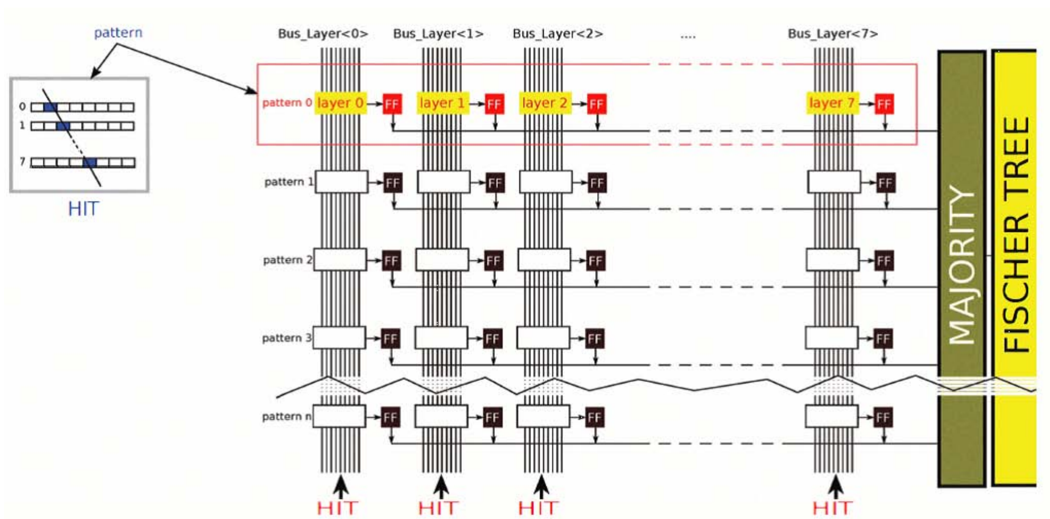
To speed up the process, the algorithm is broken into sub-tasks :



1 Hit association

Goal: find connected hits to form a track candidate

- ➤ Via pattern matching and associative memory
- ➤ Via Hough Transform and FPGA



particle	min p_T	Eff. (%)	# roads	# fits	# tracks $\chi^2 < 40$
muon	1 GeV	99.5	144	1115	55
muon	2 GeV	99.1	79	586	23
muon	4 GeV	99.2	48	313	16

2 Track fitting

Tracks estimated parameters can be computed on FPGA from the hit positions and sets of pre-computed constants :

$$p_i = \sum_{j=1}^{N} C_{ij}x_j + q_i$$

However, the constants can be highly non linear:

- Divide the detector in sub-regions where linear approximation is correct.

Similarly a first fit quality can be measured to make a first track rejection:

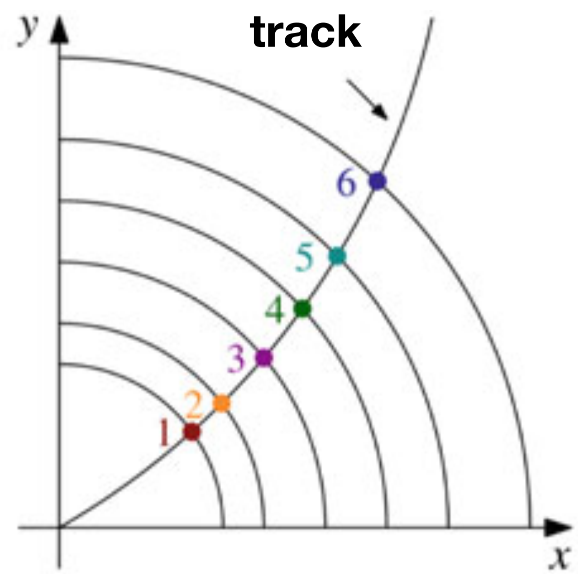
$$\chi^2 = \sum_{i=1}^{N-5}\left(\sum_{j=1}^{N} A_{ij}x_j + k_i\right)^2$$

Using Hough Transform for hit association

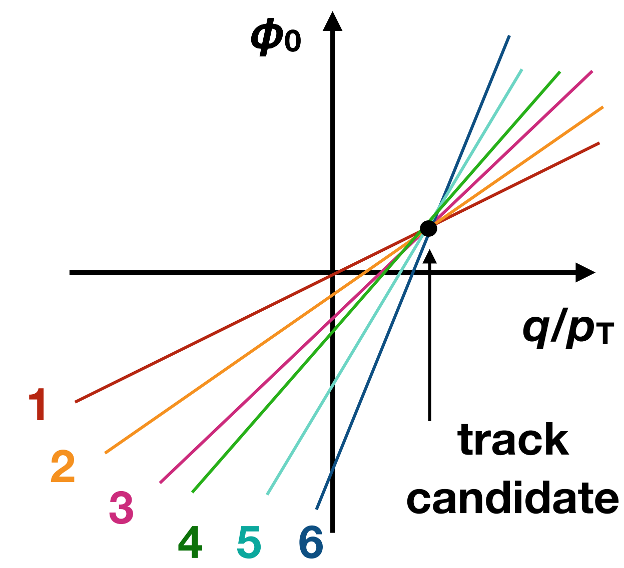
There is a unique relationship linking the radius r_h and ϕ_h angle of the measured hits and the track's transverse momentum p_T and ϕ_t coordinate:

$$\frac{qA}{\boxed{p_\mathrm{T}}} = \frac{\sin\left(\boxed{\phi_t} - \boxed{\phi_h}\right)}{\boxed{r_h}}.$$

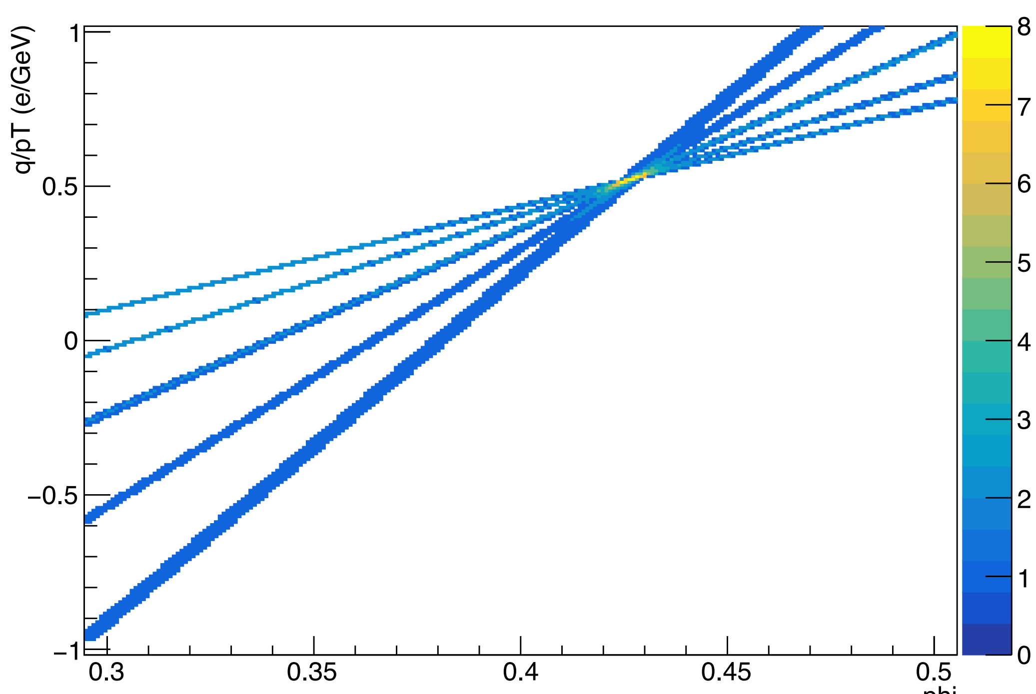
Therefore hits belonging to the same track must cross at the same point in the (ϕ_t, q/pt) space.

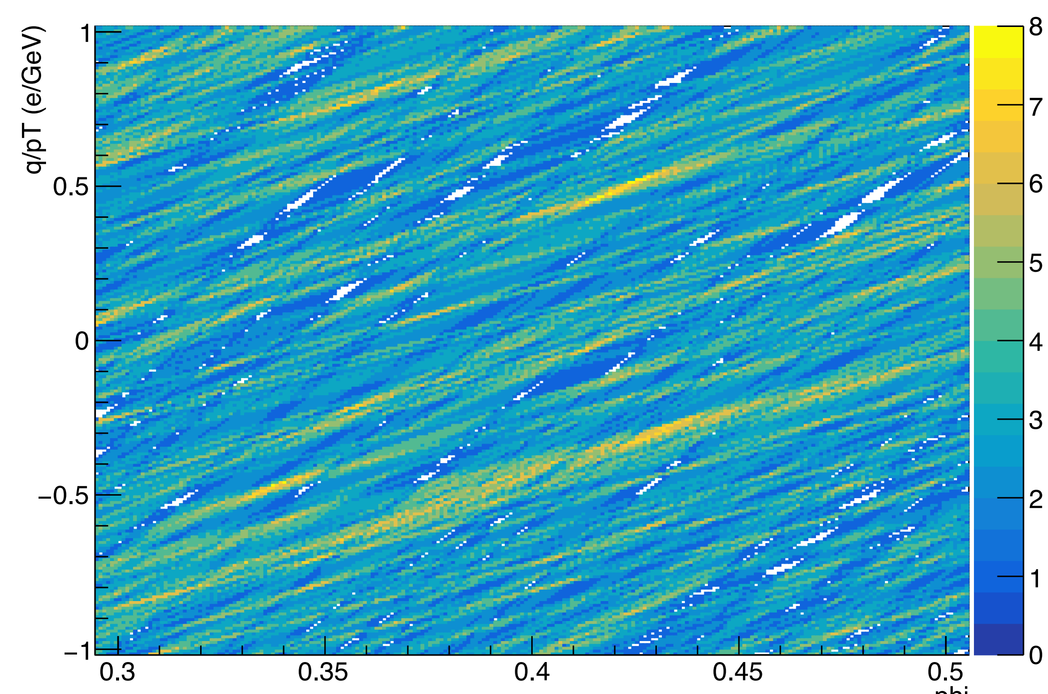


a



b





When adding pile-up

Challenges and future developments

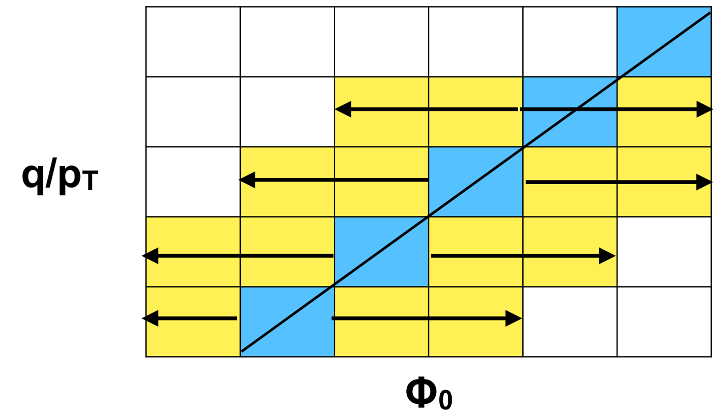
Rejecting the fake and pile-up tracks

Several methods imagined to remove duplicate tracks (hit sharing) and fake tracks:

- Performing a simple χ^2 cut to select good quality tracks;
- Using Machine Learning algorithms on FPGA to remove fake hit combination and apply overlap removal.

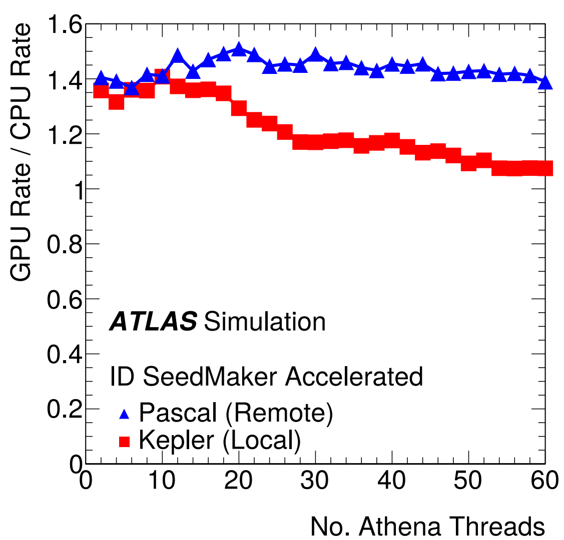
Binning of the Hough space

Due to the resolution effects of the measurements and the small shifts in the interaction point, the binning of the Hough space has to be fine tuned:



Other commercial solutions

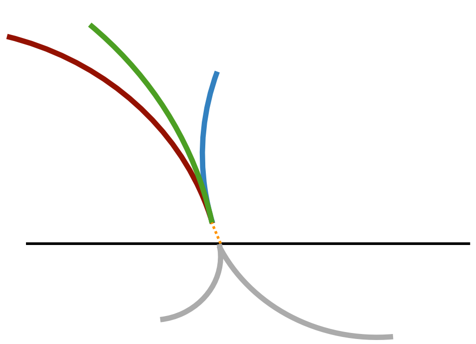
Important new developments to reduce the tracking time on CPU and/or using GPUs.



Effects of displaced tracks:

The Hough equations can be adapted to account for tracks originating for displaced vertex

Useful for SUSY signatures, b-tagging...

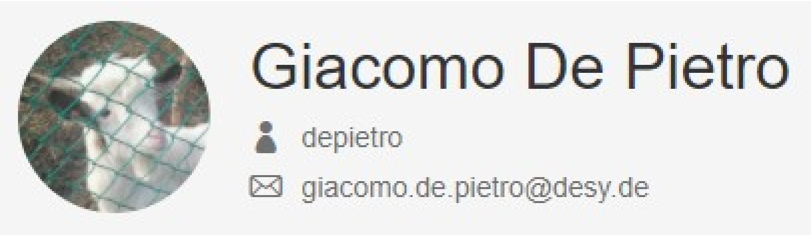


depietro@Lenovo:~$ whoami

I am a PostDoc at INFN Roma Tre since April 2020.

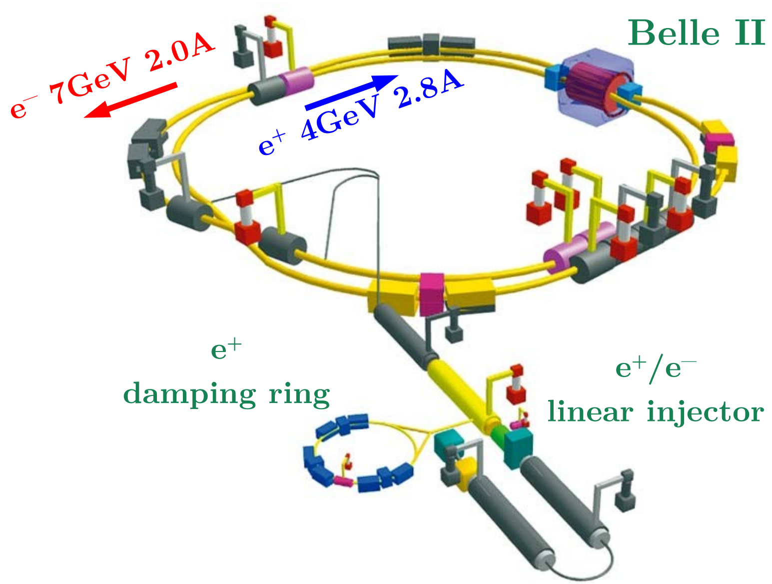
I work in High Energy Physics: I joined the Belle II collaboration in 2015 and now I am involved (not only) in:

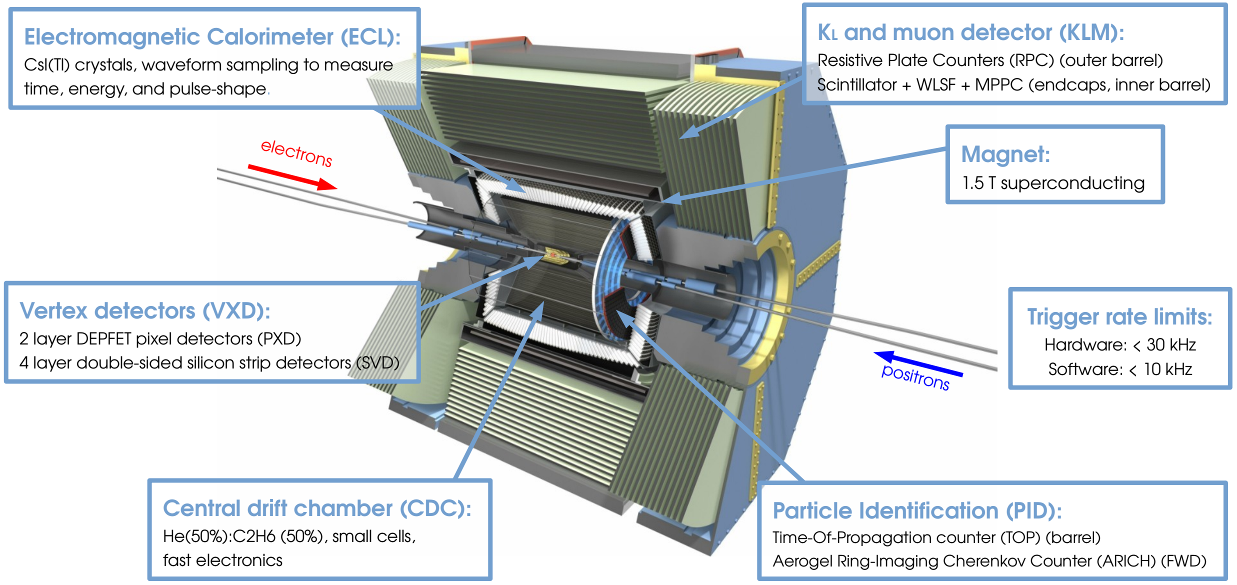
- dark sector physics;
- Klong and Muon subdetector;
- software development and management.



how Belle II sees me

What is Belle II





Core physics program:

- B physics
- tau physics
- quarkonia/spectroscopy
- dark sector physics

What I am doing: physics

I play with Belle II data looking for dark sector / dark matter signatures.

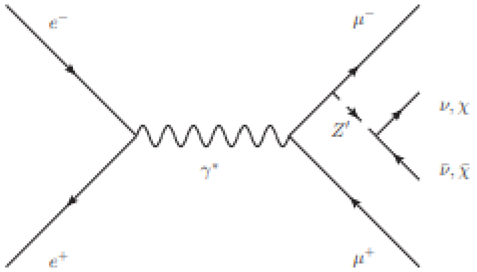
From the past (subject of my PhD thesis):

Featured in Physics | Editors' Suggestion | Open Access

Search for an Invisibly Decaying Z' Boson at Belle II in $e^+e^- \to \mu^+\mu^-(e^\pm\mu^\mp)$ Plus Missing Energy Final States

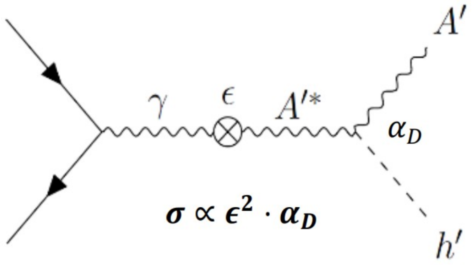
I. Adachi *et al.* (Belle II Collaboration)
Phys. Rev. Lett. **124**, 141801 – Published 6 April 2020

Physics See synopsis: Closing in on the Z' Boson

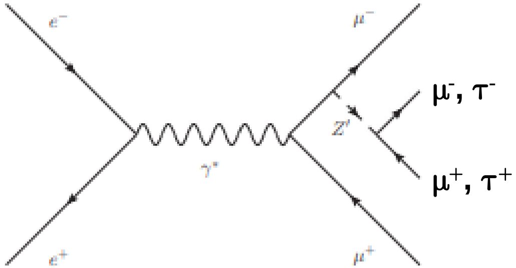


This may look easy…
Unless it's the first physics analysis done with a new detector!

From the present:



Dark Higgsstrahlung (with Dark Photon decaying into muons)



Visible decays of our friendly Z′ boson

What I am doing: software

Since roughly one year I am the software release manager of Belle II:

- I regularly tag minor/patch releases when necessary;
- I have to coordinate with (many) groups for making sure a release contains what's expected;
- I must ensure that performance and backward compatibility are preserved.

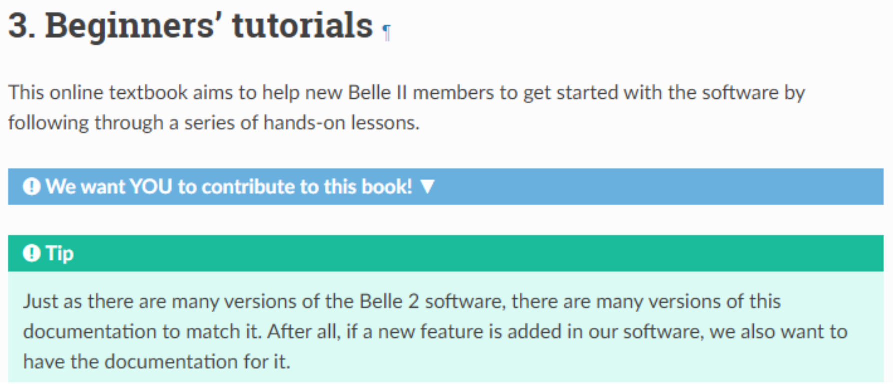
Since few months I am the deputy software coordinator of Belle II:

- together with the coordinator, I follow many (long-term) projects for improving our software;
- I am the administrator of our software-oriented collaborative tools:
  - git repositories on Stash; software pipelines on Bamboo; etc.

What I am doing: software

Some of the ongoing projects I am coordinating:

Better documentation


3. Beginners' tutorials

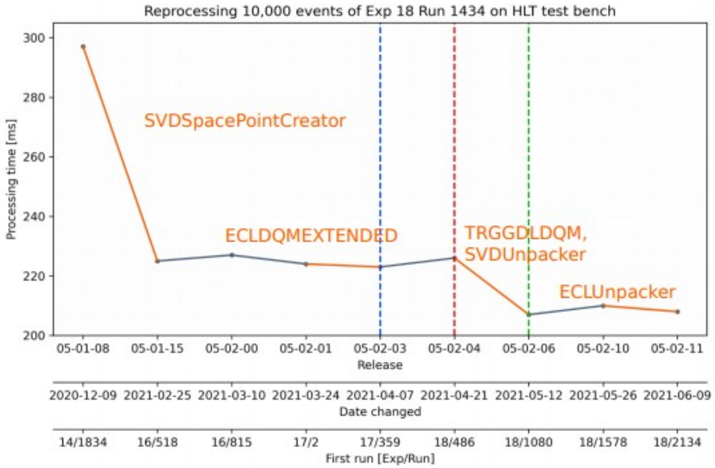
This online textbook aims to help new Belle II members to get started with the software by following through a series of hands-on lessons.

We want YOU to contribute to this book!

Tip

Just as there are many versions of the Belle 2 software, there are many versions of this documentation to match it. After all, if a new feature is added in our software, we also want to have the documentation for it.

Faster software (crucial for taking data at higher luminosity)



Open source (https://github.com/belle2/basf2)

Directional Dark Matter searches with CYGNO/INITIUM

G. Dho

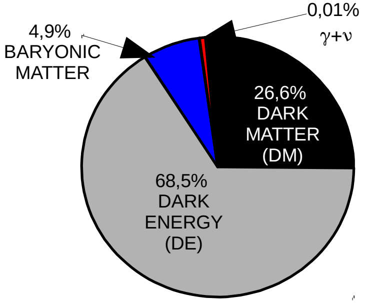
Gran Sasso Science Institute, L'Aquila, Italy

Part of this project has been funded by the European Union's Horizon 2020 research and innovation programme under the ERC Consolidator Grant Agreement No 818744

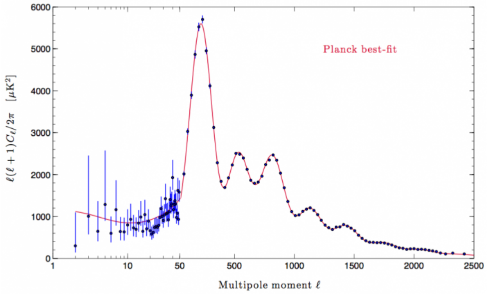
ESC 21 School

October 4–9 2021

CYGNO



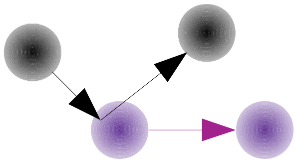
- Dark Matter is a well established paradigm of modern physics, even though it has not been positively detected yet.



- CYGNO is the project of a **directional** detector, whose main goal is the direct detection of Dark Matter

For the direct detection, it uses a material (He:CF_4 gas) as target and looks at its recoils

Dark Matter particle

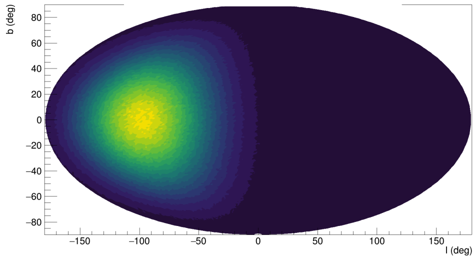


Detectable recoiling nucleus

The directionality information can provide:

Means of positive discovery

Better background discrimination



Fluorine recoil angular spectrum

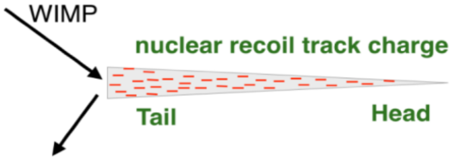
G. Dho

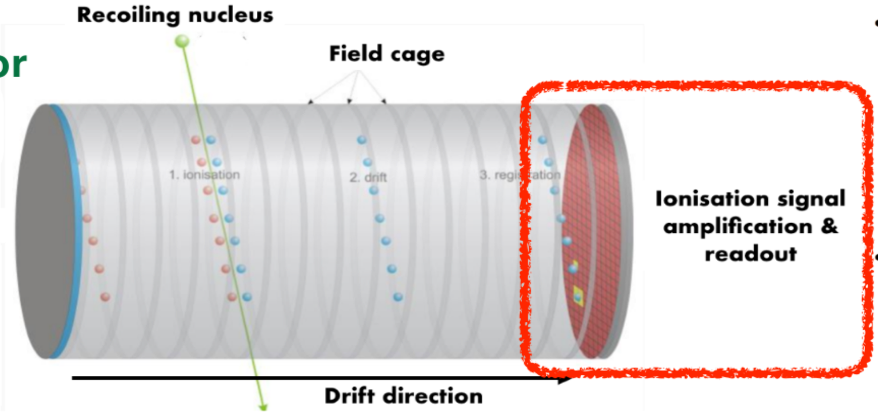
CYGNO

TPC

Inherently a 3D detector

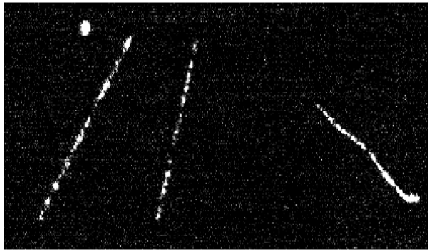
Sensitive to track sense & direction



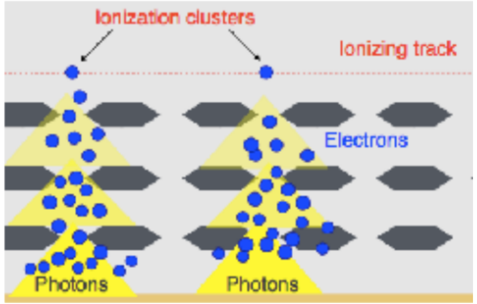


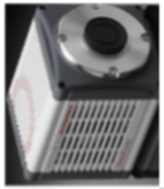
- Advantages:
  - Axial Directionality
  - **Head/tail**
  - Background rejection
  - Particle ID
  - 3D fiducialization
- Technologically challenging, but now achievable via multiple technologies

sCMOS camera

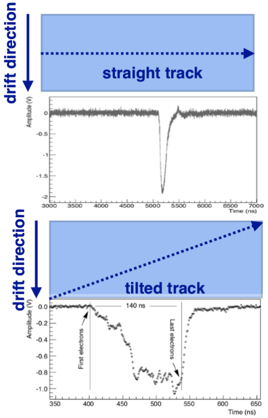


Energy
x-y coordinate

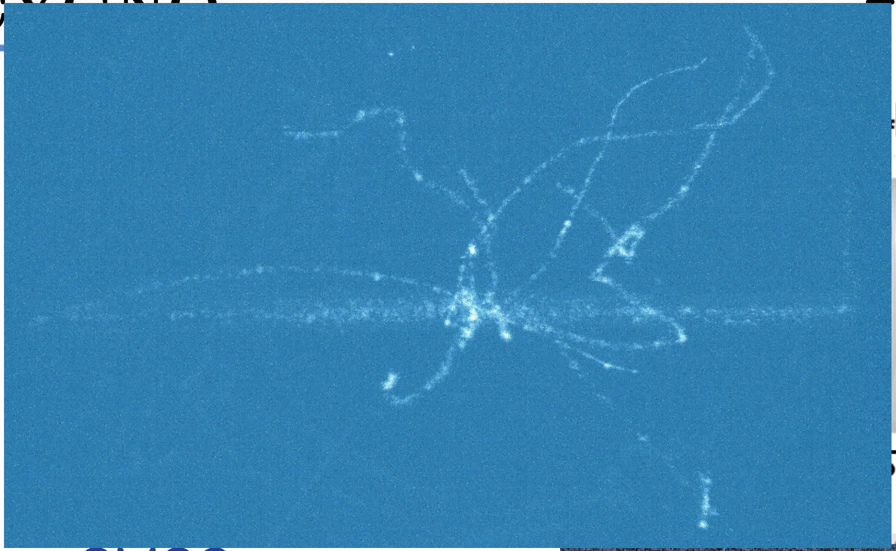


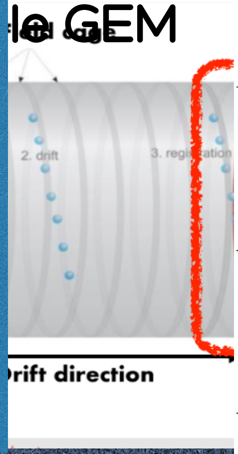


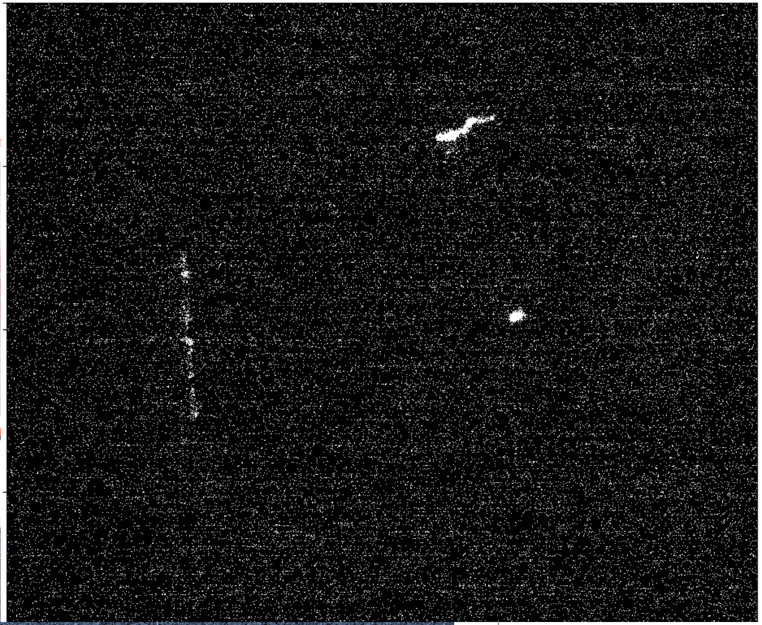
PMT



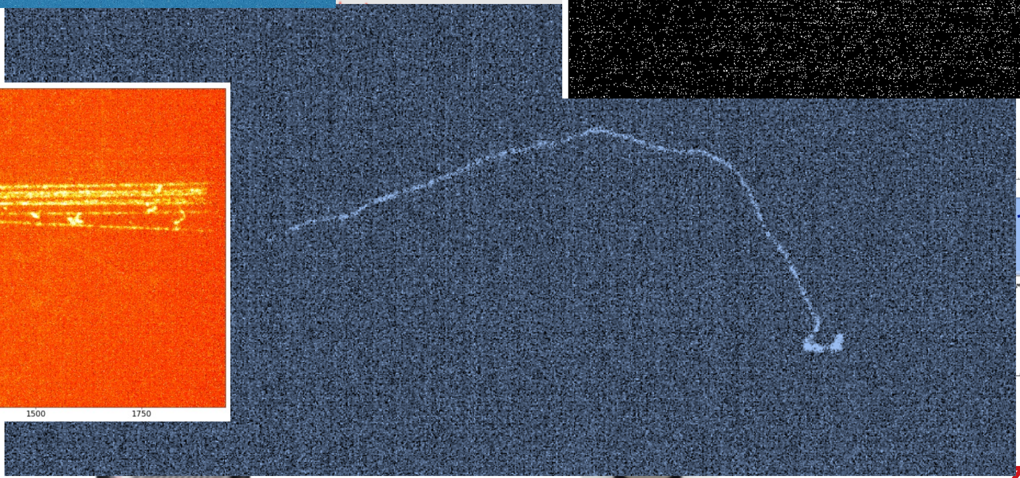
Energy
z coordinate

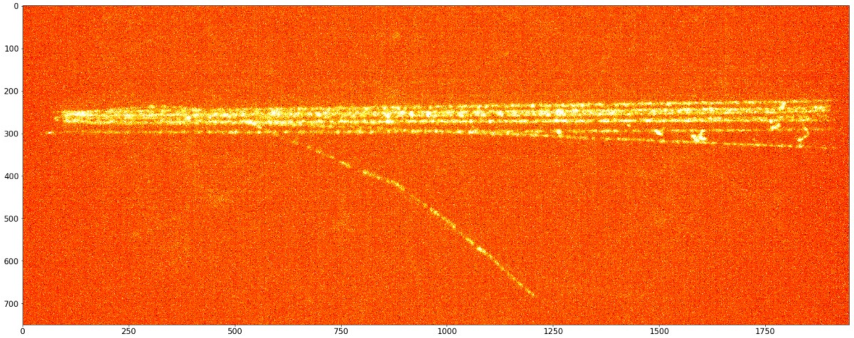


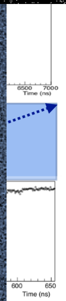




sCMOS camera





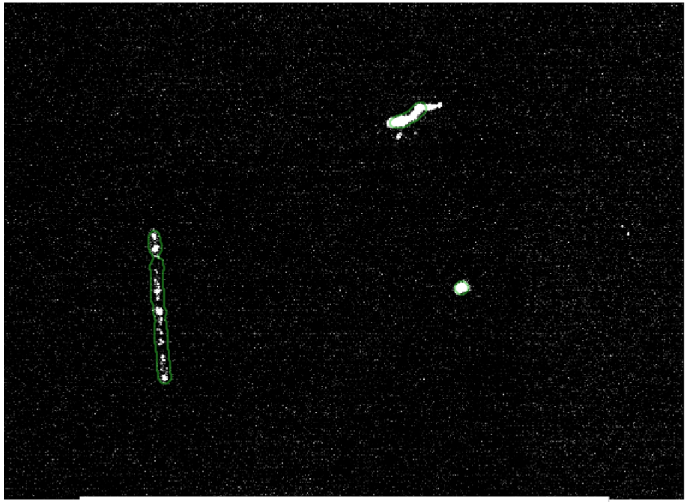


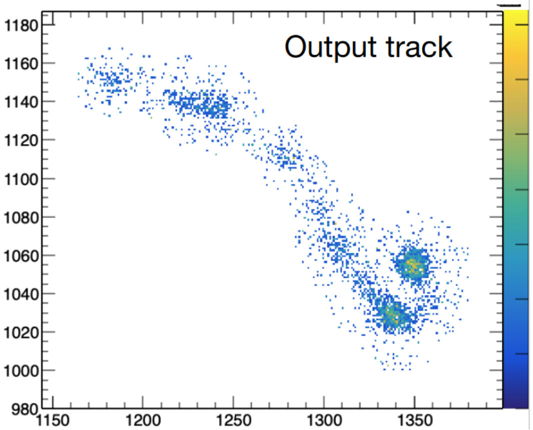
x-y coordinate

Energy
z coordinate

Image Analysis

- The data to analyse is made of pictures with tracks to be recognized and characterized:

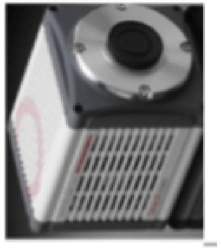




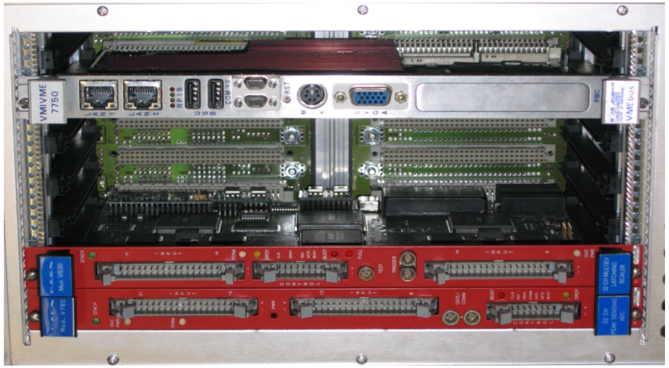
  - Not simple to define tracks limits as local ionzation density can vary a lot
  - Quantities as direction of the tracks need complex algorithms
  - 2304x2304 pixels images need optimization not to take long time to be analyzed

CYGNO DAQ

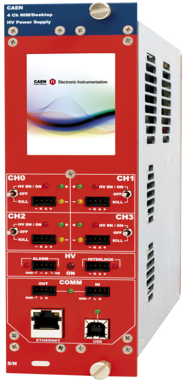
- C++ object oriented framework that needs to control



Camera
Time response O(100s) ms



Trigger logic and acquisition
Time response O(100s) ns



High voltage supply

- Some online data analysis is foreseen to be included and needs to be optimized to avoid dead time

- Possible switch to GPUs for online analysis

GPU and performance portability : a high energy physics use case

Sylvain Joube - PhD student

IJCLab CNRS :
David CHAMONT
Hadrien GRASLAND

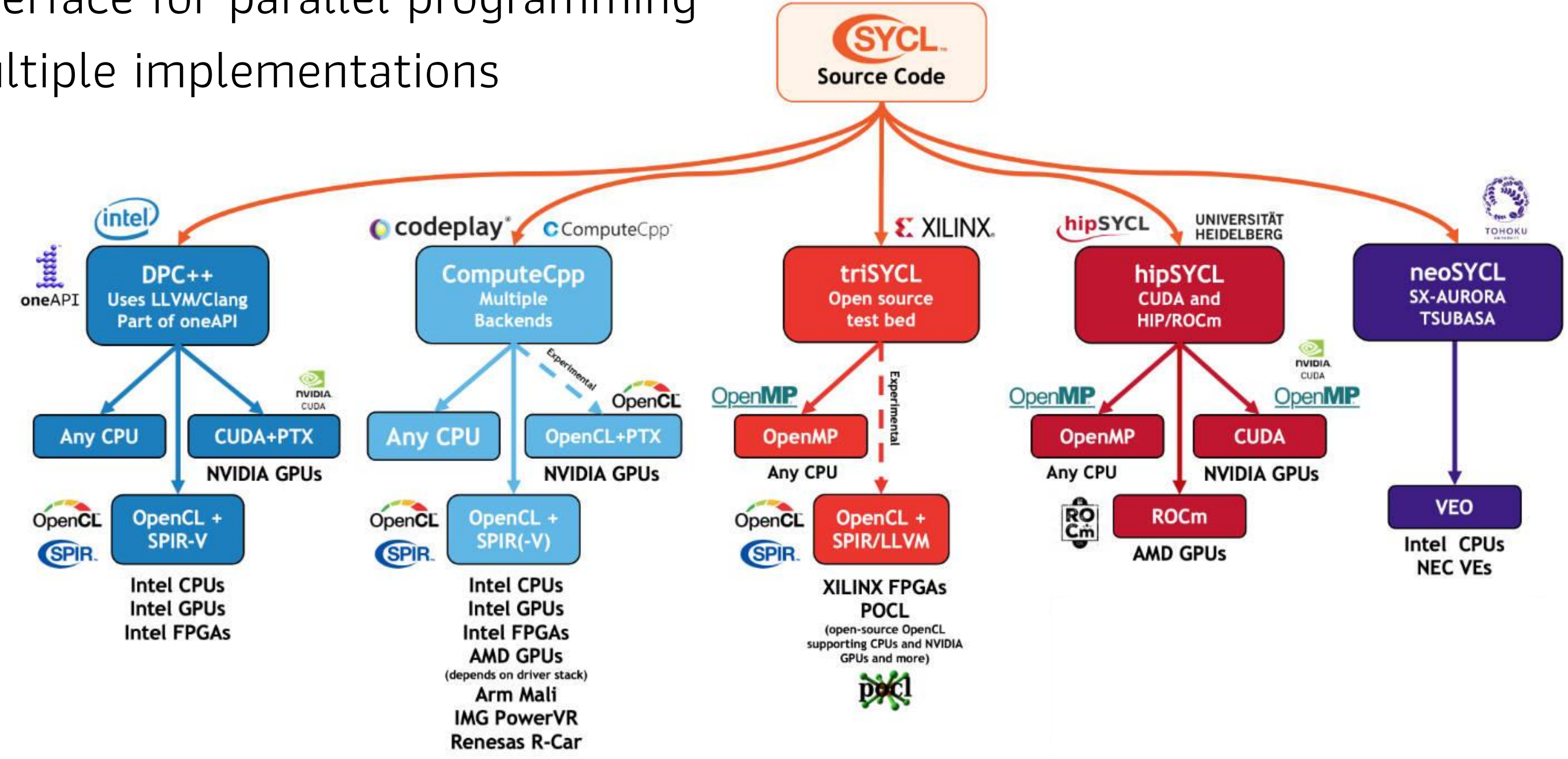
LISN Université Paris Saclay :
Joël FALCOU

ESC 2021, oct. 2021

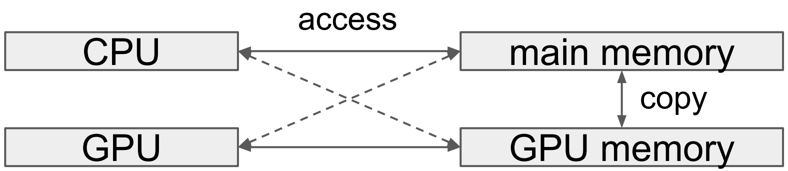
SYCL

Interface for parallel programming

Multiple implementations



SYCL memory models



Unified Shared Memory (USM)

- “USM device” : located on GPU, explicit transfer
- “USM host” : host-pinned, GPU-accessible
- “USM shared” : implementation decides data location

Buffers and accessors

- Dependency graph between tasks (kernels)

Current research activity

Parallel computing on GPU

SYCL performance portability across :

- Implementations
- Architectures

Current focus on SYCL memory managment

High energy physics use case [LHC[1], ATLAS[2] experiment]

Submitted abstract to ACAT'21[1]

[1]LHC : Large Hadron Collider, CERN, https://home.cern/science/accelerators/large-hadron-collider
[2]ATLAS experiment : on LHC, CERN, https://atlas.cern/
[3]ACAT'21 workshop : https://indico.cern.ch/event/855454/

Thank you !

Links

My (very WIP) github : https://github.com/SylvainJoube/SYCL_tests

hipSyCL : https://github.com/illuhad/hipSYCL

SYCL : https://www.khronos.org/sycl

Data Parallel C++ : https://software.intel.com/content/www/us/en/
develop/tools/oneapi/components/dpc-compiler.html