

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS

Central Coordination
Uta Bilow + Ken Cecire

IMC steering group meeting, CERN
28.11.2019



✓ SG members

Members of the SG are: Project Leader, coordinator(s), one person from each measurement, other consultants (max. 3).

- Representative from Belle II Masterclass
- Representative from Particle Therapy Masterclass

✓ New IPPOG and IMC webpage

- <https://test-ippog-d8.web.cern.ch/> and <https://test-ippog-d8.web.cern.ch/imc>
- Developers Giorgos and Charis from BLIND studio
- SG (Nicolas, Catia, Marzena, Steve, HP, Barbora, Sotirios Boutas)
- At the moment, there are some key issues that need to be addressed. These include the development method and the maintainability of the site.
- Nevertheless, Ken + Uta provided input

Logo + IMC

International MCs

tagline

← P.P. for a B

measurements tiles

menu

INFO
↓
TCHR
PHYS.
STUDEN
PET

Social media buttons

↑ FB
Tw ↓

Explanatory text

Image: student + event display

✓ Social media plans

- <https://twitter.com/physicsimc> @physicsIMC
- Need a new hashtag? #LHCIMC
- Twitter team as usual – more volunteers?
- Hire a person?

✓ Use of funds

- In 2018: 5 k€ allocated, 2.5 spent
- In 2019: 2 k€ allocated, 1 spent
 - Social media person? Pull up banner?...?

✓ Masterclass training session

- Idea from Kate Shaw: let IPPOGers and CERNois experience Masterclasses
- Today from 11-12:30 in room Charpak
- Training for: ALICE, ATLAS Z, CMS, Belle II, MINERvA

✓ Email from Pauline Gagnon

„my popular science book on CERN and particle physics is now available in five languages (German, English, French, Turkish and Chinese). [...] I hope you will see my book as the perfect complement after a Masterclass or other outreach activities, that students could take back home with them.“

<https://paulinegagnon3.wixsite.com/boson-in-winter>

✓ Upgrading World Wide Data Day

News from the following Masterclasses

- ALICE
- Belle II
- CMS
- Neutrino
- Darkside
- LHCb
- Particle Therapy



**Faculty
of Physics**

WARSAW UNIVERSITY OF TECHNOLOGY



**Faculty of Electronics
and Information
Technology**

WARSAW UNIVERSITY OF TECHNOLOGY



New version of ALICE MasterClasses

Łukasz Graczykowski, Piotr Nowakowski

IMC Steering Group Meeting
CERN, Geneva, Switzerland
November 27, 2019

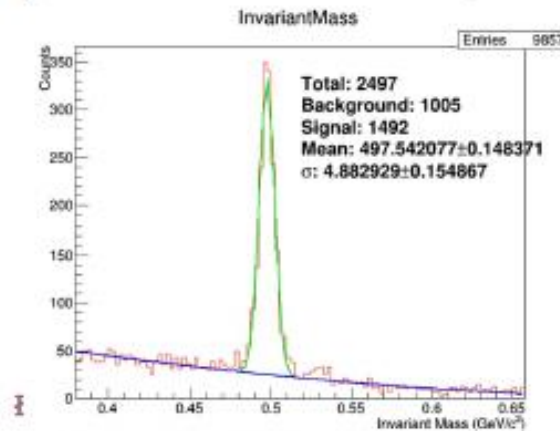
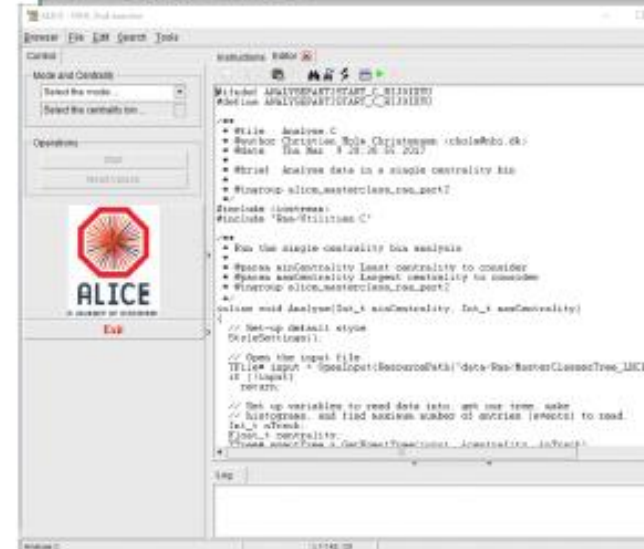
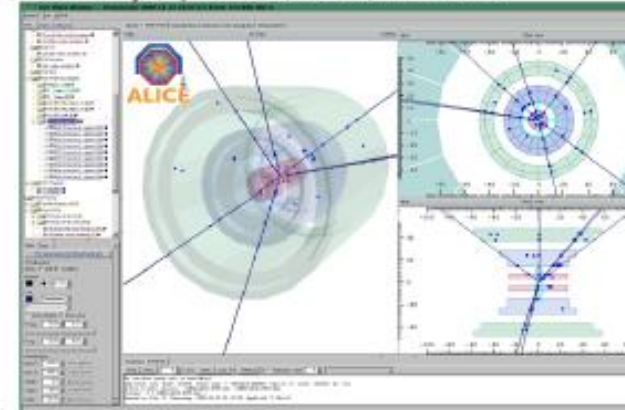


ALICE MasterClass

first pp event seen by ALICE
Eur. Phys. J. C65 (2010) 111-125

Based on ROOT (EVE):

- simplified event display, close to the one used in the control room
- visual analysis of small sample of events (~50)
- statistical analysis of larger samples (fitting, background parameterization)
- “writing code”



27 Nov. 2019, IMC-SG Meeting

ALICE MasterClass – measurements

Three measurements initially developed independently

- 1) decay patterns of strange particles
- 2) nuclear modification factor (R_{AA})
- 3) J/Ψ suppression (work in progress)



New developments

Initial work by Christian Christensen (Copenhagen) and later by CERN Summer Student (Jonas Toth) in 2018

Taken over by Piotr Nowakowski (WUT) afterwards

- **Macros** → standalone app
- **Common framework**
 - all exercises share core classes

- **Source code on CERN GitLab:**
<https://gitlab.cern.ch/pinowako/masterclass-continued>

- **CMake build system**

- **Available versions:**

- **Linux** (AppImage binary, clickable, **ROOT embedded!**)
- **Windows** (Visual Studio compiled, installer, clickable, **ROOT embedded!**) – first time provided!
- **Virtual Box** machine (pre-configured Ubuntu)



Piotr Nowakowski > masterclass-continued > Details

M

masterclass-continued

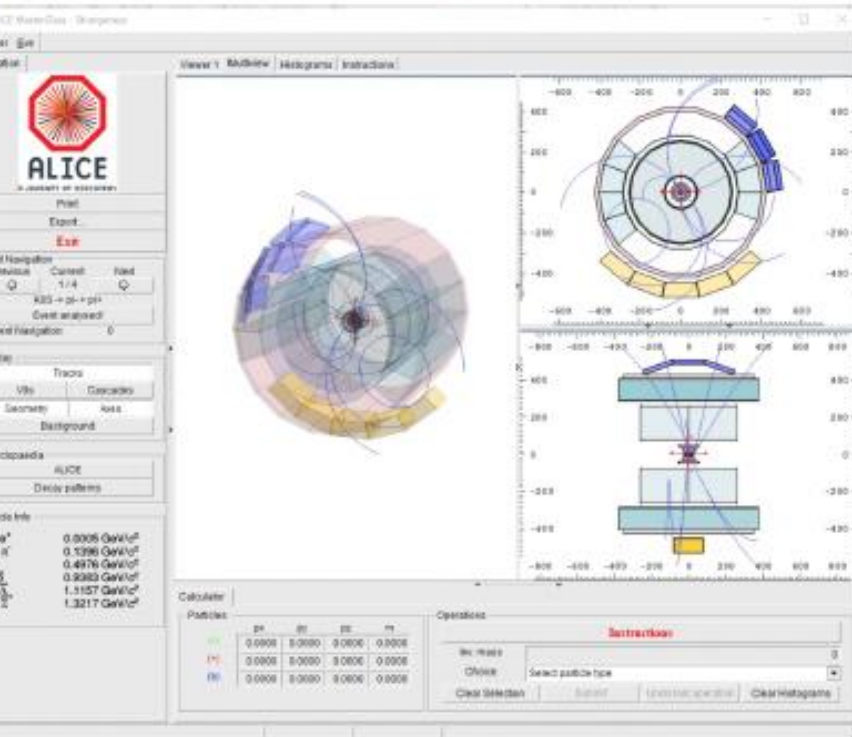
Project ID: 71281

GNU GPLv3 752 Commits 2 Branches 4 Tags 759.1 MB

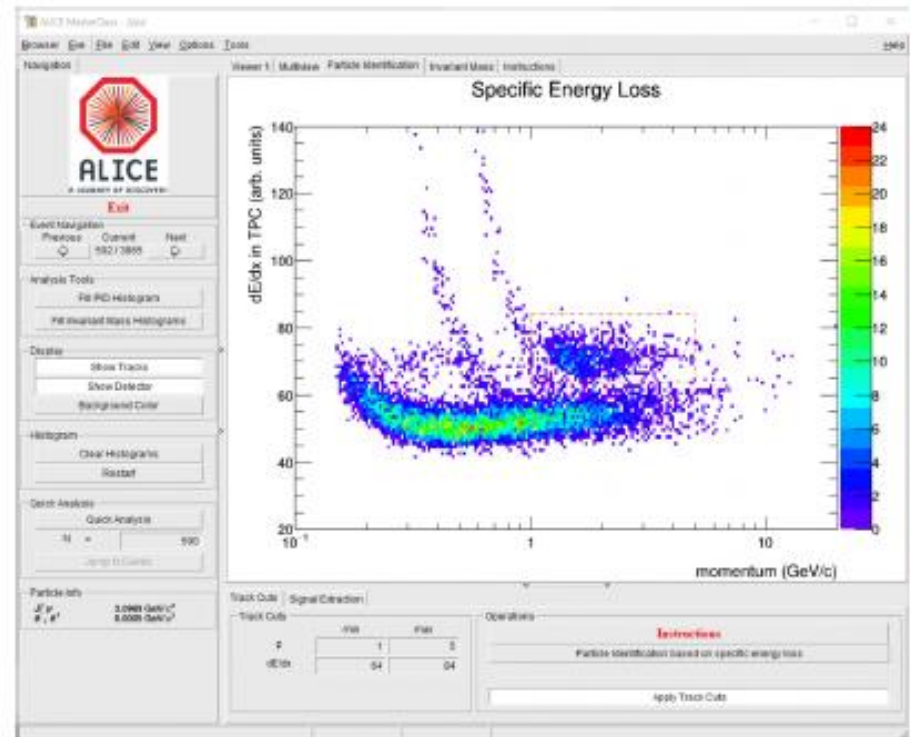
Continuation of the ROOT-based MasterClass refactor.

How does it look like?

Looking for strange particles
visual analysis



J/ Ψ suppression
electron PID



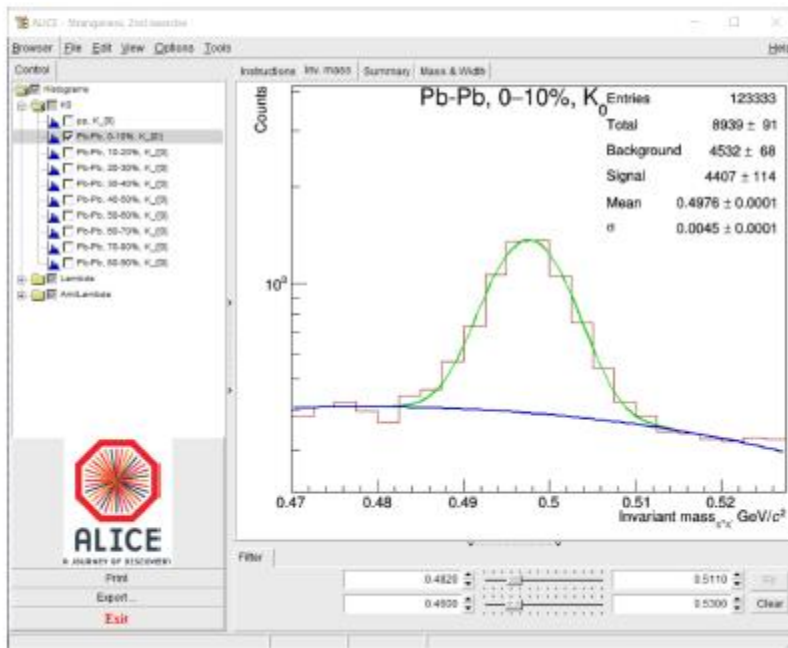


Windows 10

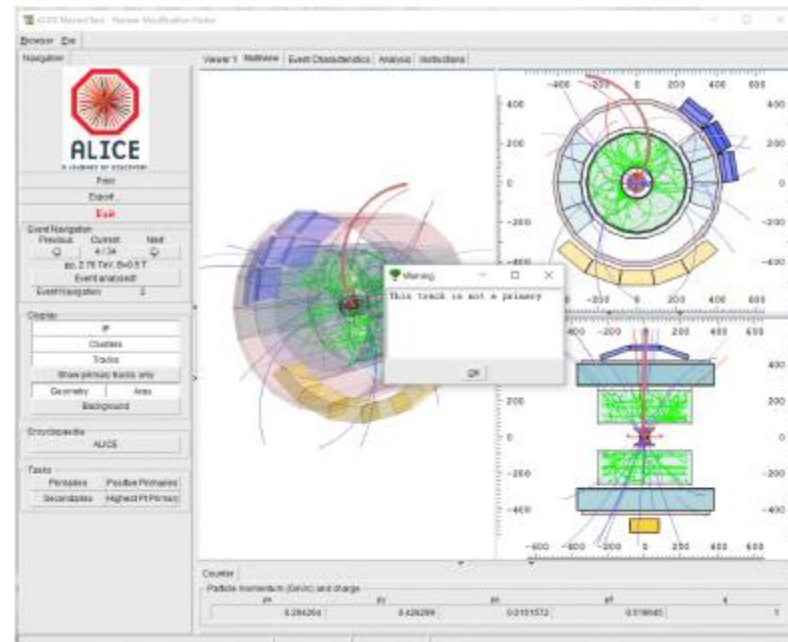
How does it look like?

Looking for strange particles
invariant mass fits

Nuclear modification factor (R_{AA})
selecting primary tracks



27 Nov. 2019, IMC-SG Meeting



Ł. Graczykowski, P. Nowakowski (WUT)

6/4

Belle II Masterclass status

Rok Pestotnik, Jožef Stefan Institute, Ljubljana, for the Belle II

Select Particles

Particles

Charge **-1**

Type **muon**

Histogram

Histogram

Title **mu neg Mass**

Number of bins **40**

Min: **0**

Max: **5**

Variable **mass**

Belle II Masterclass

Number of events: **10000**

First event: **0**

Data Source **hadron-1**

Print particle list? **No**

Particle List

Combine 2 particles

1. Particle

2. Particle

Same particle lists? **No**

New Particle **J/psi**

Min mass [GeV]: **1**

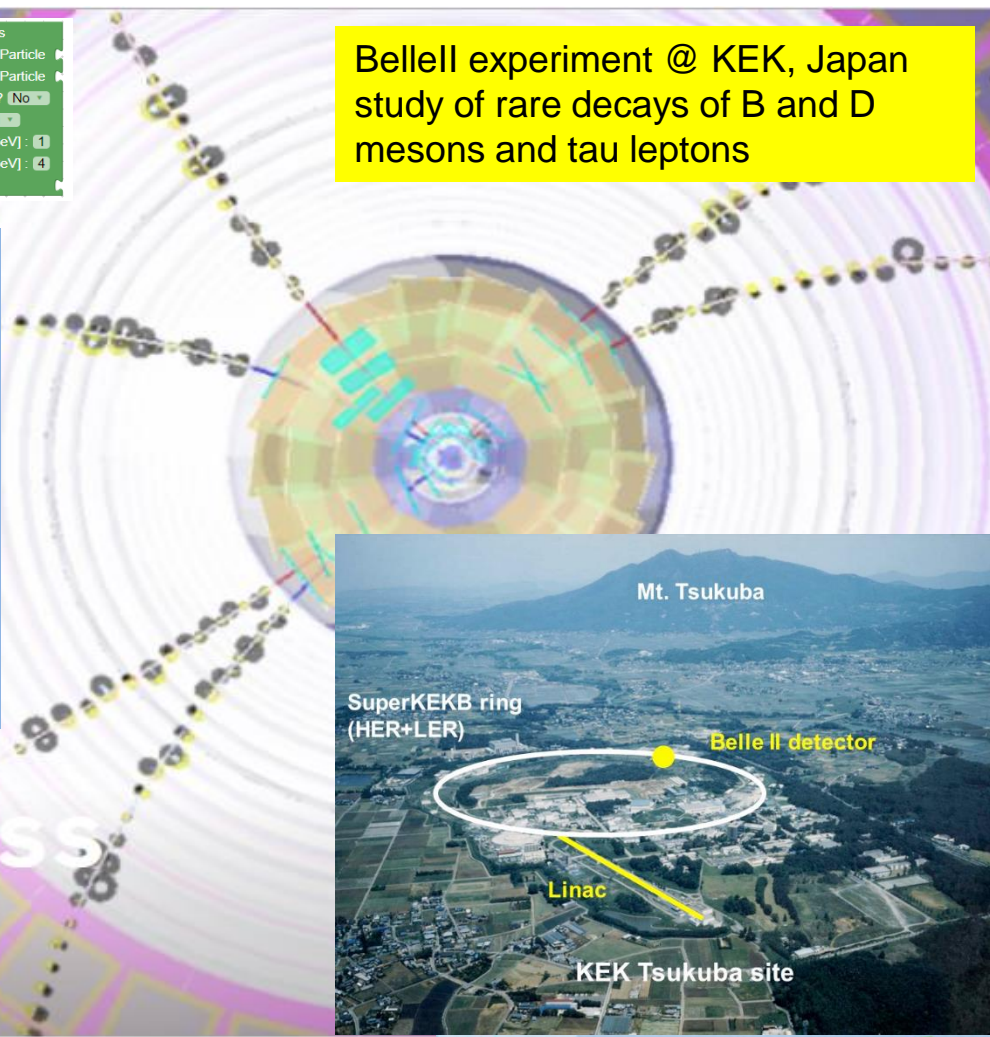
Max mass [GeV]: **4**

Histogram

BelleII experiment @ KEK, Japan study of rare decays of B and D mesons and tau leptons

Resources

- Exercises with data: <http://belle2.ijs.si/public>
- You Tube introductions:
- Start: https://youtu.be/q6M2_dnp3pl
 - Particle distribution: https://youtu.be/q6M2_dnp3pl
 - J/psi to mumu: <https://youtu.be/xUYmXoPfZOU>
 - J/psi to ee: <https://youtu.be/3TGsHJ8j8pE>
 - Fit: <https://youtu.be/wWbjWYHVLU>
 - B to J/psi K <http://youtube.com/watch?v=e-GERqzY3HM>
- Virtual Reality <http://www1.phys.vt.edu/~piilonen/VR/>



MASTERCLASS

Belle II Particle Adventure

Run Analysis Interrupt Save Diagram Load Diagram

Interactive web application

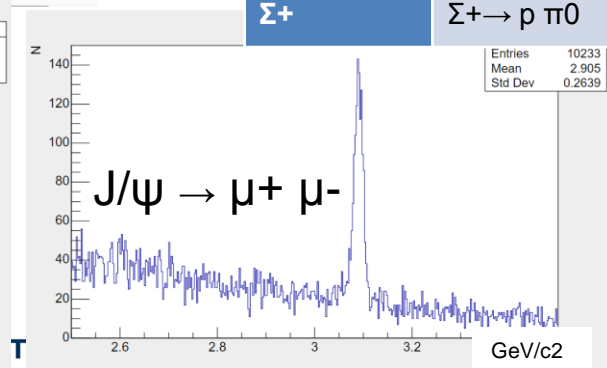
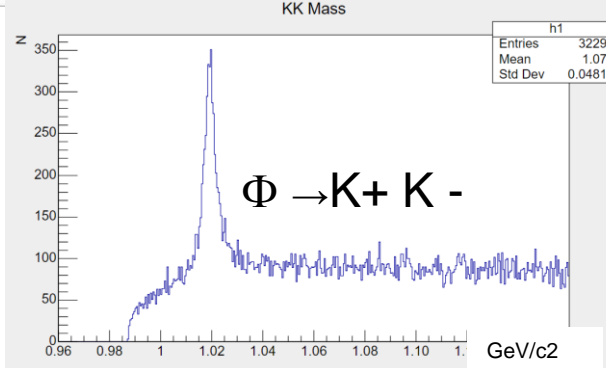
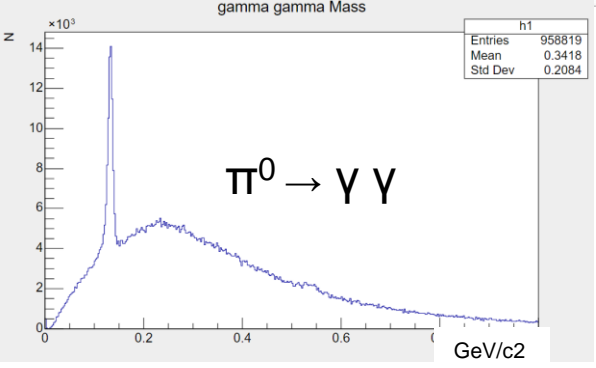
<http://belle2.ijs.si/masterclass>

Describe decays, make simple cuts, "discover" particles

Runs on a **web server** or in a **virtual appliance**

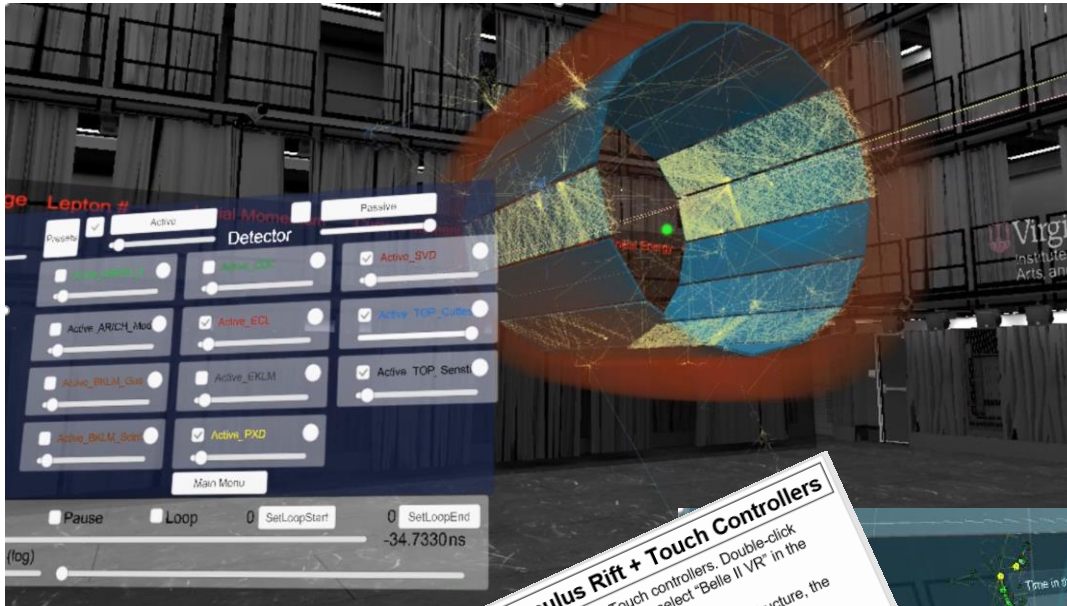


Particle	Process
π^0	$\pi^0 \rightarrow \gamma \gamma$
Ks	$K_s \rightarrow \pi^+ \pi^-$
ϕ	$\phi \rightarrow K^+ K^-$
J/ψ	$J/\psi \rightarrow e^+ e^-$
	$J/\psi \rightarrow \mu^+ \mu^-$
D ⁰	$D^0 \rightarrow K^+ \pi^-$
	$D^0 \rightarrow K^- \pi^+$
D ^{*+}	$D^{*+} \rightarrow D^0 \pi^+$
D ^{*-}	$D^{*-} \rightarrow D^0 \pi^-$
B ⁺	$B^+ \rightarrow J/\psi K^+$
B ⁻	$B^- \rightarrow J/\psi K^-$
Λ	$\Lambda \rightarrow p \pi^-$
Σ ⁺	$\Sigma^+ \rightarrow p \pi^0$



MASTERCLASSES

hands on particle physics 14

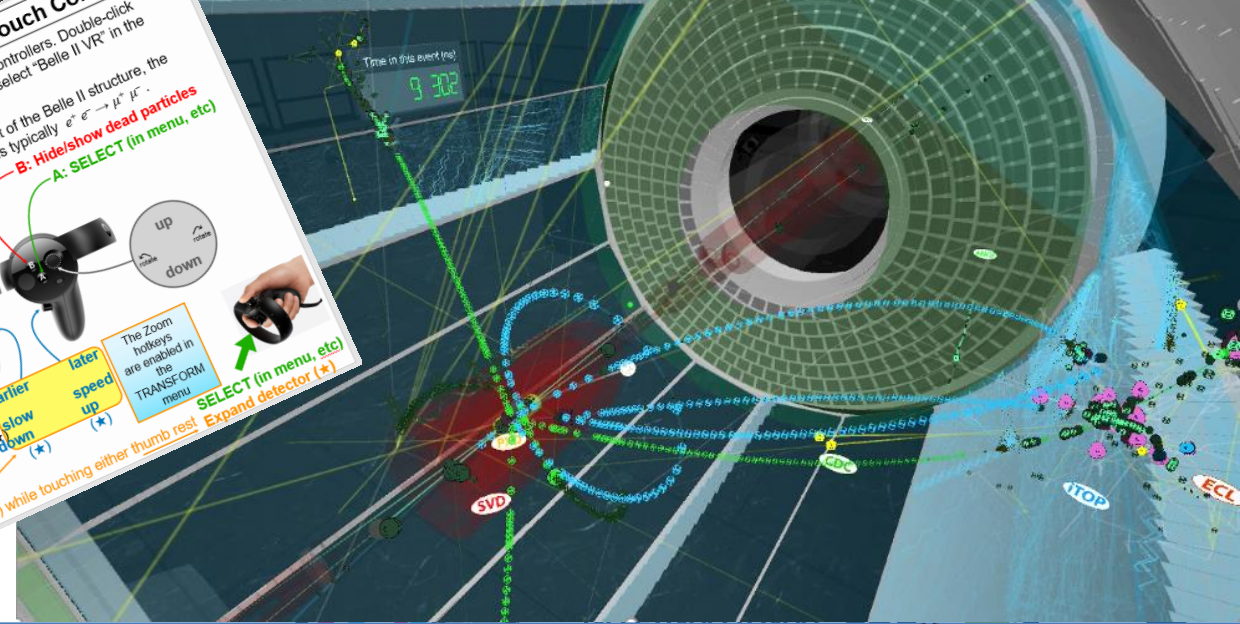


Belle II in Virtual Reality: Oculus Rift + Touch Controllers

- Put on the Oculus Rift headset and pick up the Touch controllers. Double-click the "Belle_II_VR_OculusRift" icon on the computer or select "Belle II VR" in the headset's menu. Wait for the VR world to appear.
- After the loading scene and an introductory fade-out of the Belle II structure, the animation will begin automatically. The first event is typically $e^- \rightarrow \mu^- \mu^+$.

Controller actions:

- X:** Pause / Resume
- Y:** Hide/show detector-hits
- B:** Hide/show dead particles
- A:** SELECT (in menu, etc)
- forward, right, left, backward
- up, down
- earlier, later, speed up, speed down
- Show/Hide Menu
- Previous Scene
- SELECT (in menu, etc) Shrink detector (*)
- SELECT (in menu, etc) Expand detector (*)
- The Zoom hotkeys are enabled in the TRANSFORM menu
- (*) while touching either thumb rest



Pilot Run held on March 22, 2019, video conference 16h-17h

- 6 participating sites from Europe: around 200 high school students

Ready to run IMC in 2020

Scheduled events:

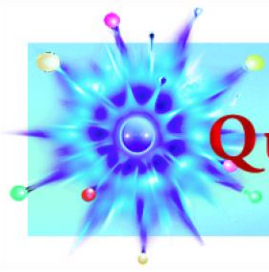
- ❖ Europe - March 4, 11, 18 with a video conference at 16:00 CET
- ❖ Asia – interest from several groups from China, India and Taiwan –
 - ❖ the date will be fixed in December

The events announced through IMC and Belle II collaboration channels

Planned activities:

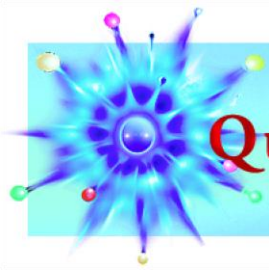
- Introductory materials for different languages
- Training session for the instructors:
 - CERN, IPPOG Hands on IMC
 - Belle II collaboration meeting @ KEK, Japan
 - February 3-5, 2020, date will be announce among the participants
 - Web video connection
- Technical meeting – end of February
- Events and follow up meeting after each event to improve and share the experiences
- Evaluation - Belle II collaboration meeting in June 2020





QuarkNet CMS and Neutrino Masterclasses

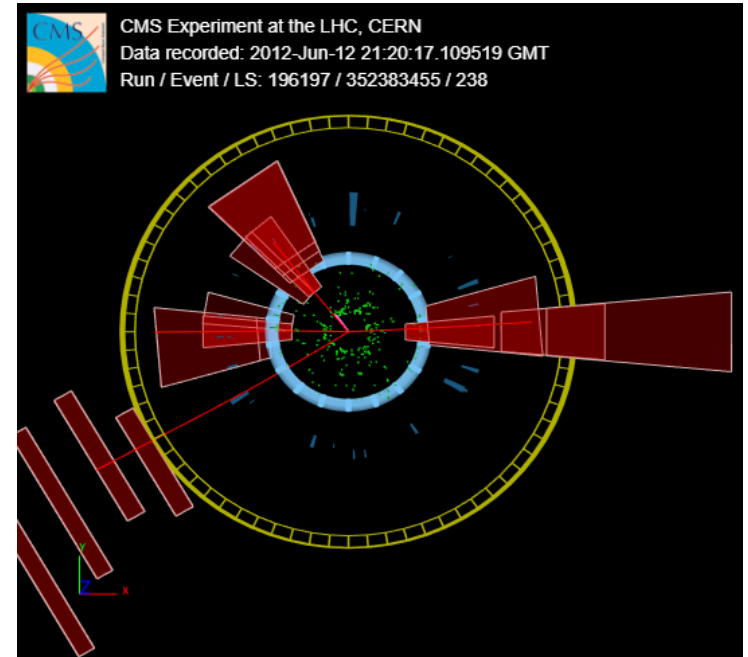
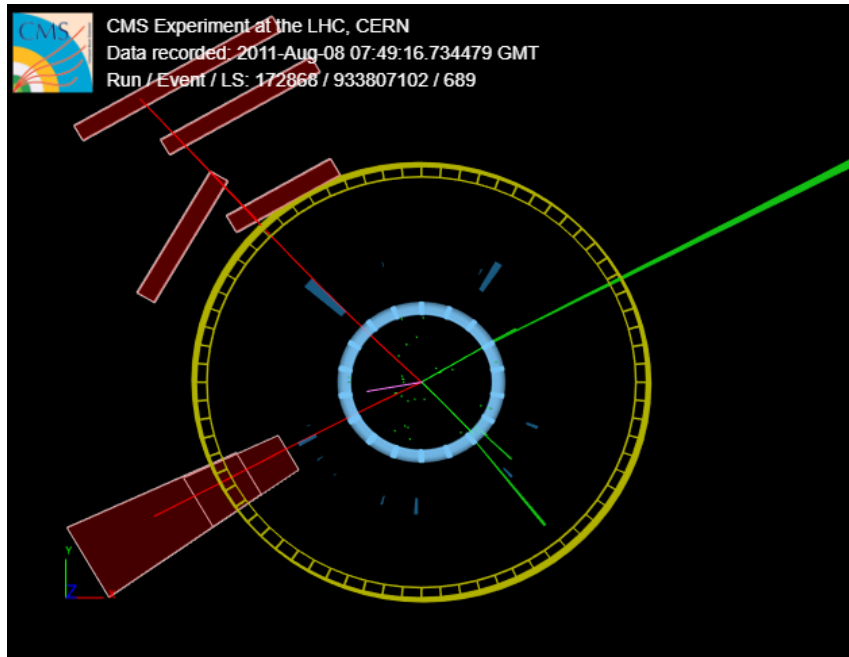


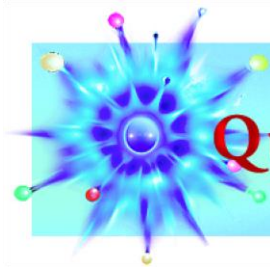


QuarkNet

1, 2, or 4 leptons in iSpy?

Which of these events is 1-, 2-, or 4-lepton? Which flavors of leptons? What else do you see?



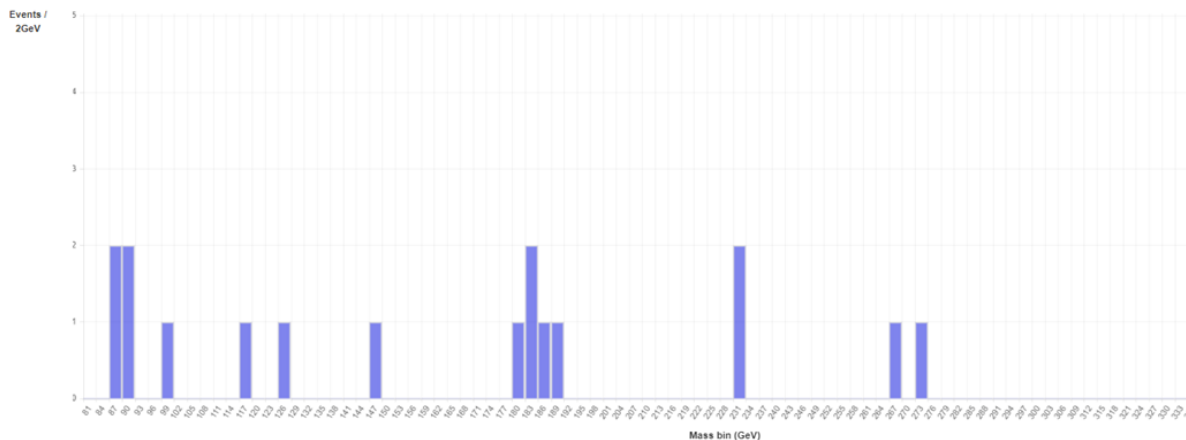
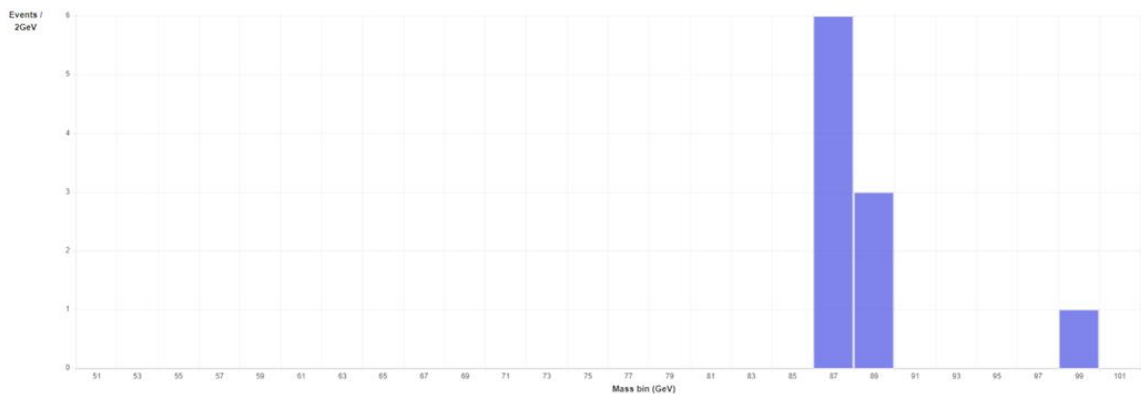


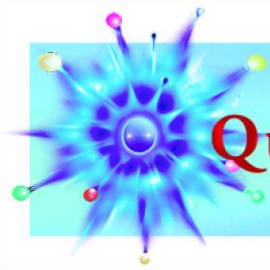
QuarkNet

2- and 4-lepton plots CIMA

CIMA makes mass histograms automatically:

Masterclass: CUA-FIU-WM-6Aug2019
location: FIU-Aug2019





QuarkNet

New website for MINERvA



MINERvA Neutrino Masterclass

from 19 March 2020 to 4 April 2020

 Search

US/Central time zone

Overview

Introduction

Measurement

Events

MINERvA Experiment at Fermilab

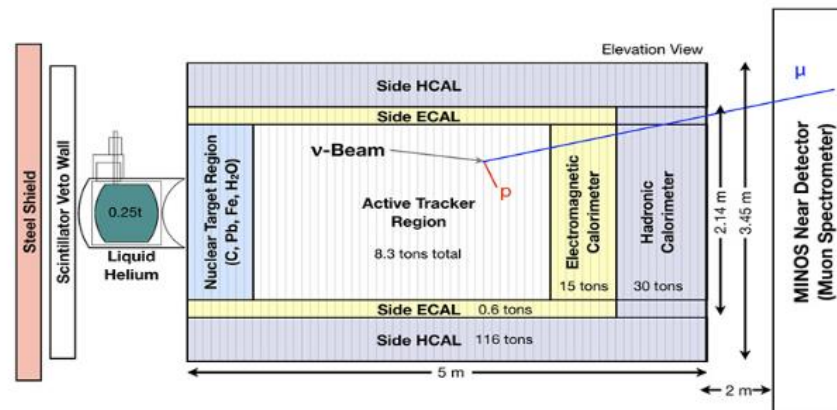
All Things Neutrino

Library

International Masterclasses

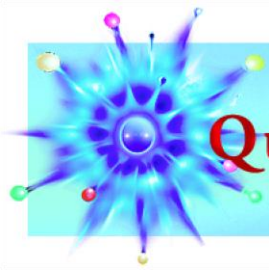
MINERvA is about neutrinos

Our universe is awash in neutrinos. As you read this, millions of them pass right through you. Fortunately, they have negligible mass and negligible interactions with other matter, so you're OK. Negligible...but...that tiny amount of mass is enough to create mysteries about the nature of neutrinos and those tiny, rare interactions enable us to build dedicated detectors like MINERvA to study neutrinos.

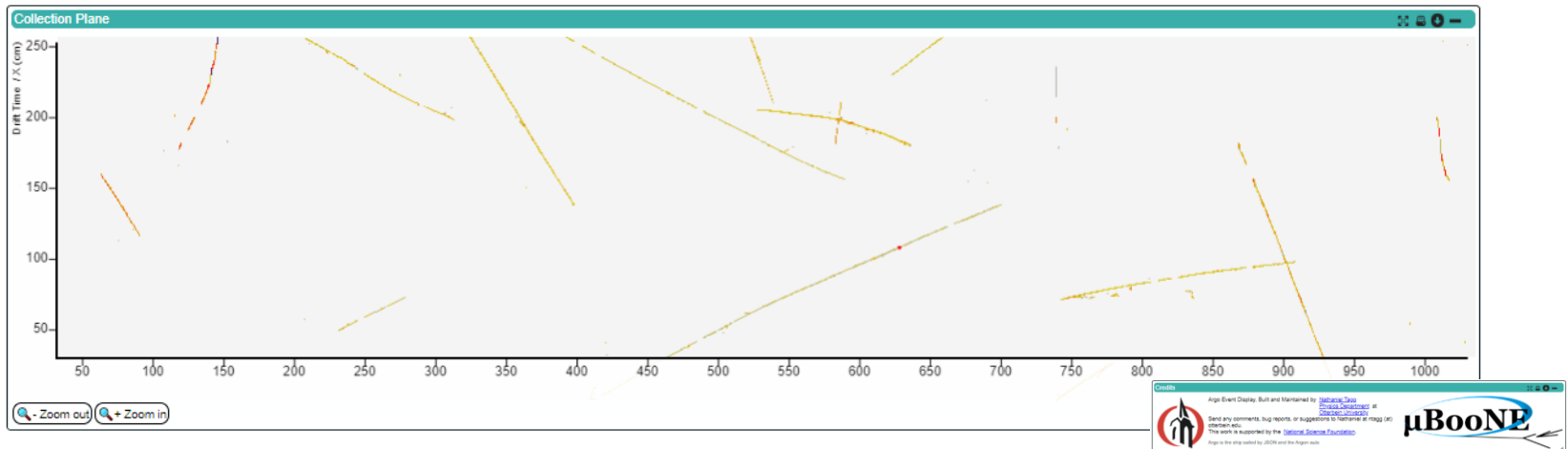
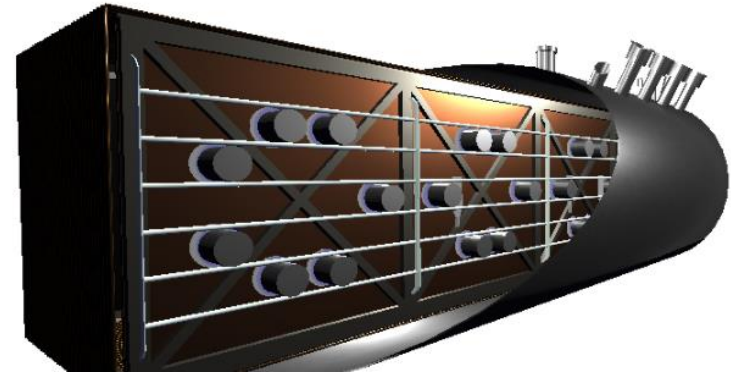


Schematic of the MINERvA detector.

<https://indico.fnal.gov/event/22340>



- Instrumentation masterclass
 - Argon purity
 - Electron drift velocity
- Test in IMC 2020
 - Fermilab VC
 - Small, select number of institutes



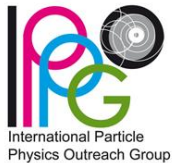
Darkside Masterclass

Francesca Carnesecchi, University and INFN of Bologna, Centro Fermi
Roma

Get a feeling of the physics case behind and of the Darkside experiment solution, making the students face also the (simplified) analysis steps that lead to the final results

- **Organized in classes also remotely connected between different countries**
- Lessons about the physics case and the experiment
- Data analysis via Excel
- Discussion of the results together with a small competition

Masterclass developed and realized by Centro Fermi



18th IPPOG meeting CERN
28-30 November 2019



MUSEO
STORICO DELLA FISICA
E
CENTRO
STUDI E RICERCHE

Darkside Masterclass

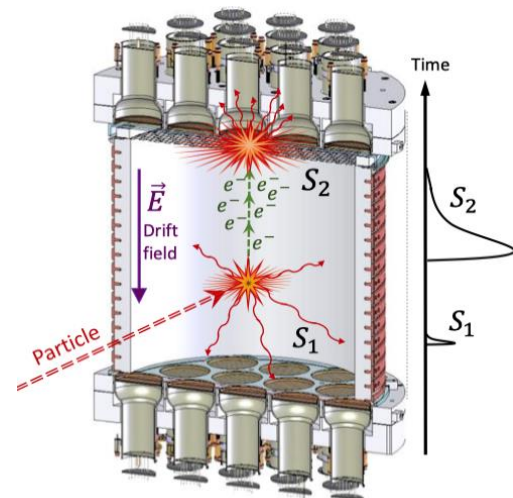
- **Lessons** about the physics case and Darkside experiment: **talks** + event displays

Physic: what is Dark Matter

- Gravitational effect not explained by visible matter
- One explanation: the existence of an as-yet-undiscovered elementary Weakly Interacting Massive Particle (**WIMP**)

Darkside experiment: how to detect WIMP

- WIMP-nucleus elastic collisions revealed by a detector capable of unambiguously identifying a small number of nuclear recoils
- **Dual phase (gas + liquid) Argon TPC** for direct detection of WIMPs

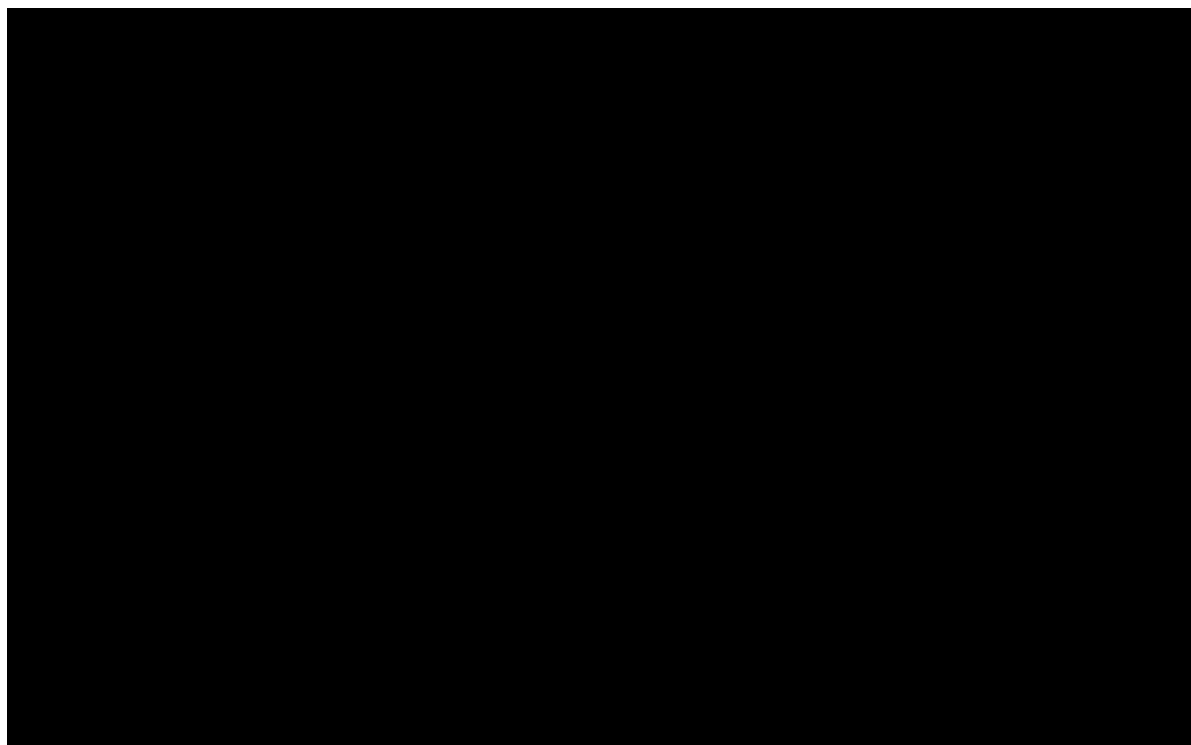


Darkside Masterclass

- **Lessons** about the physics case and Darkside experiment: talks + **event displays**

To let the students understand the working principle of the TPC and how to recognize a WIMP:

- **LAr-TPC – WIMP**, S1 and S2 signals
- NR/ER – S1 and charge in PMTs
- Veto
- Fiducial Volume

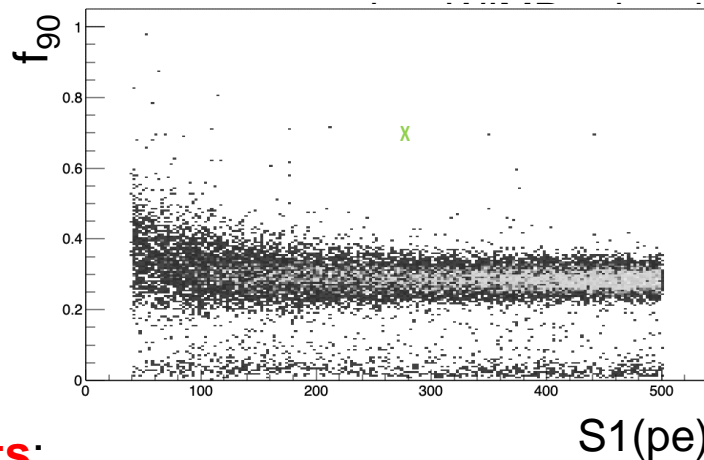


Darkside Masterclass

Data analysis via Excel, groups of 2-4 students working together on:

- Reconstruction position part (few events): to exclude background signals
- Analysis of events (~20000) of background and few “good” WIMPs. Plot of f_{90} vs S1 and then a

f_{90} = fraction of S1 light detected in the first 90 ns of a signal



Discussion of the results:

- Small competition on searching for the fake WIMPs signal (added on purpose)
- Report on the results, provided by students



Switching to a browser-based Masterclass for LHCb

- ◇ Initial software
 - ◇ implemented in C++
 - ◇ ROOT required
- ◇ Create a web version to avoid deployment issues and improve maintainability

LHCb Masterclass project

Measuring D^0 lifetime

PART 1 - D^0 identification

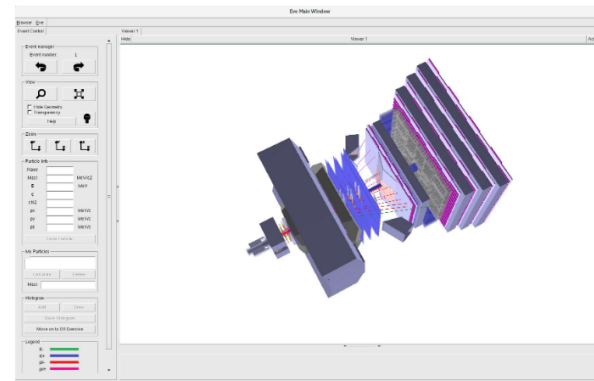
Locate displaced vertices belonging to D^0 particles for 30 events

PART 2 - D^0 lifetime fit

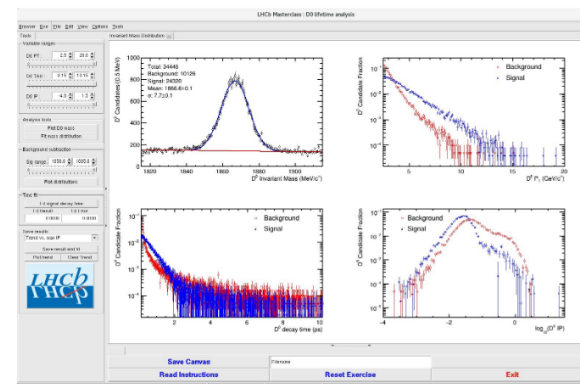
54 000 events

Fit data to measure signal properties and observe effect of IP cut on D^0 lifetime

Existing software



PART 1 - 3D scene



PART 2 - Data visualization

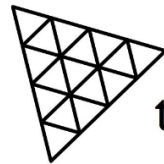
Technological choices



Angular 8

- Single Page Application (Client only)
- Typescript based
- Led by Google
- Open source

Javascript libraries



three.js

Create 3D scene
Uses WebGL



D3.js

Create dynamic and interactive
data visualizations

Event Display Exercise

The screenshot shows the LHCb Masterclass Event Display Exercise interface. The browser address bar shows "Non sécurisé — test-lhcb-masterclass.web.cern.ch/test-lhcb-masterclass/event...". The page title is "LHCb Masterclass" with "About" and "Language" links. The main content area is titled "Event Display Exercise" and contains several panels:

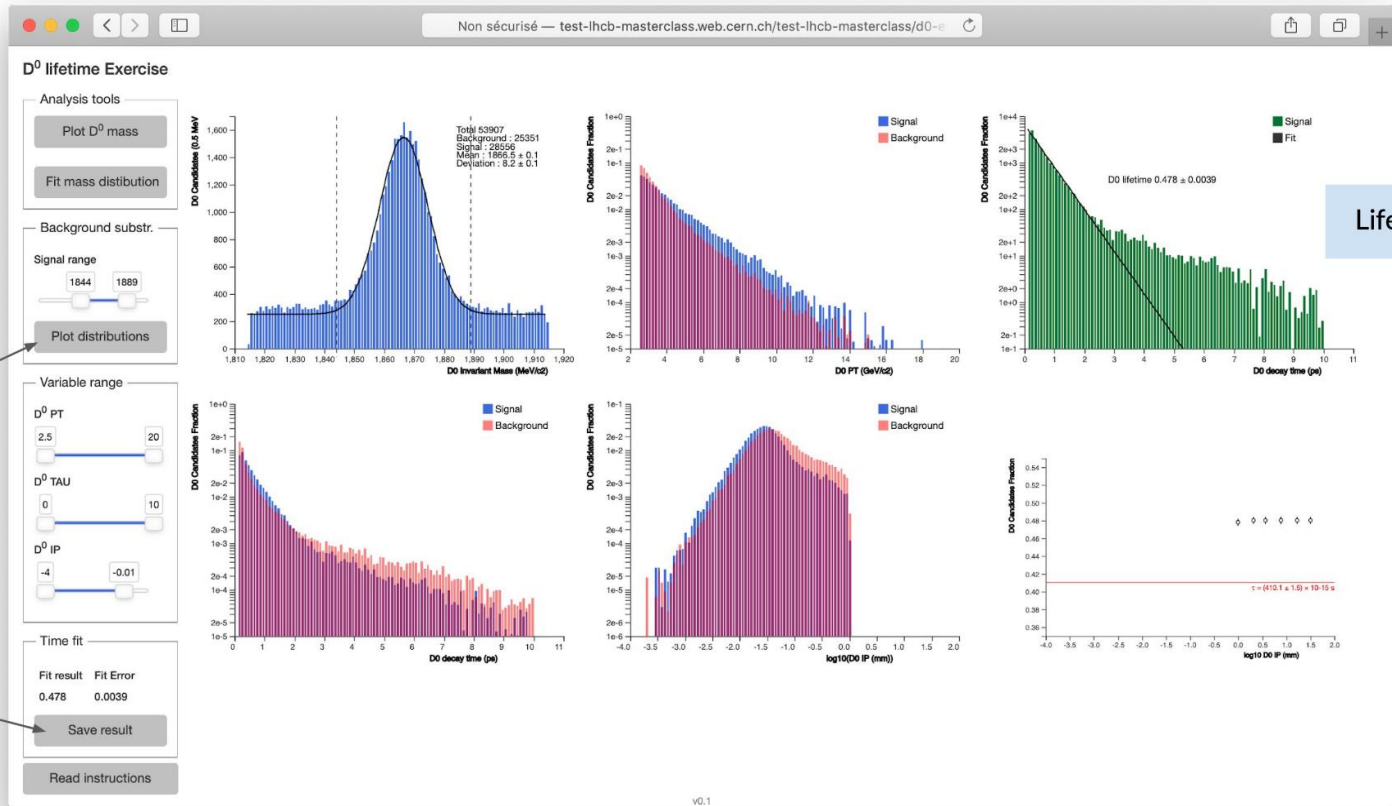
- Event handler:** "event_3_0.json", "previous", "next" buttons.
- View:** "Zoom" (checked), "Detector" (checked), "Help" (checked).
- View (dropdown):** "Auto rotate" (unchecked).
- Legend:** K⁻ (red), K⁺ (blue), pi⁺ (green), pi⁻ (purple), D⁰ (grey).
- Buttons:** "Read instructions", "Download JSON".

The central "Event display" shows a 3D visualization of a collision event with particle tracks and detector planes. Annotations point to various features:

- Close up on collision:** Points to the "Zoom" control.
- Projections:** Points to the "View" dropdown.
- Detector opacity:** Points to the "Detector" control.
- Information of selected particle:** Points to the "Particle information" panel, which displays:

E	MeV
chi2	
ipchi2	
mass	MeV/c ²
name	
ZFstM	
- Particles saved K⁺ and pi⁻:** Points to the "My particles" panel, which shows a list of particles and an "Add" button.
- Invariant mass:** Points to the "Mass" input field in the "My particles" panel.
- Histogram of masses saved:** Points to a histogram titled "D0 Candidates (0.5 MeV)" with the x-axis "D0 Invariant Mass (MeV/c²)" ranging from 1,810 to 1,920 and the y-axis "D0 Candidates (0.5 MeV)" ranging from 0.0 to 1.0.

D⁰ Lifetime Exercise



Step 4 : plot the variable distributions

Step 5 : save result of the fit to add it in the scatter plot

Try it for yourself

<https://test-lhcb-masterclass.web.cern.ch/test-lhcb-masterclass/>

Particle Therapy MasterClass



[Uni Sarajevo: web pages](https://indico.cern.ch/event/840212/) <https://indico.cern.ch/event/840212/>

Amila Avdic

Amra Ibrahimovic

Mirsad Tunja

Particle Therapy MasterClass



<https://indico.cern.ch/event/840212/>

Demo

A demo of the matRad software package showing the different steps for a treatment planning therapy using x-rays, protons or carbon ions can be found clicking on image.

Simplified matRad version for Masterclass

The screenshot shows the matRad software interface. On the left, there are several panels: 'Workflow' with buttons for 'Load / Load data', 'Calc. influence', 'Refresh', 'Save to DCM', 'Load DICOM', and 'Export'; 'Plan' with various input fields; 'Organisms & structures' with a table of structures; and 'Visualization' with options for 'View' and 'Type of plot'. The main window displays a 3D visualization of a patient's head with a tumor and a particle beam path. A play button icon is overlaid on the 3D view.

ID	VOI name	VOI type	priority	obj. / strand	parality	class	RTOG volume
1	PTV1	PTV	1	square deviation	100	100	100
2	PTV2	PTV	1	square deviation	100	100	100
3	PTV3	PTV	1	square deviation	100	100	100

Material in the web in several languages

- Presentations
- Posters
- Animations
- Instructions
- Workplan
- Demos

<https://videos.cern.ch/record/2690592>

Full matRad version for University Students

The screenshot shows the full matRad software interface. It is similar to the simplified version but includes more advanced features and options. The main window displays a 3D visualization of a patient's head with a tumor and a particle beam path.

- Home
 - Posters
 - Aim
 - Materials
 - Agenda
 - Instructions
 - Invitation
 - Survey
 - Articles
 - Photos
 - Contacts and Teams
 - Events
 - Sponsors
 - Contact
- pt.mc@cern.ch



PTMC Plans

- **Big interest: open more dates**
 - 5 March US time zone
 - 27, 30, 31 March and 6 April Europe time zone
- **Training sessions during summer at CERN including summer students**
- **Next training at CERN 10 Dec 16:00-18:00 (with video for MXC/LatinoAmerica to join also)**
- **Moderators: experts and matRad developers (GSI/HIT)**
- **CERN technical students/fellows will help with CERN PTMC and then go to home institutes to do it there also**
- **Participation of SEE region (science for peace)**
 - Sarajevo uni UNSA playing role of coordinator for SEE
- **mid-september: local at St Petersburg (at high-school level 15 years old)**
- **Full version: at uni level and part of Masters Programme**

Contact with CERN admin fellow (willing to help with PR items)



PTMC Conferences, Open Days

in web page PR material: articles, photos, description of events
 Invitation to CONF14, Norway: plenary and demos at Poster session
ENLIGHT. Caen. 2019

ACCELERATORS FOR HEALTH AND INTERNATIONAL MASTERCLASSES

Yiota Foka, for the PTMC Team, GSI, Germany



Particle Therapy MasterClass – an accelerator-driven application for health

ACCELERATORS AND PARTICLE THERAPY

During the past century, particle accelerators played an essential role on advancing scientific knowledge and on improving standards of living. Today, they are being increasingly used not only in research laboratories but also in hospitals and industry. As accelerator technology develops, the potential for new applications expands. Such developments are systematically supported by EU funded projects such as EuCARD2, ARIES, among others. In particular, the potential of accelerator-variant therapy and diagnostic techniques increased considerably over past decades, playing an increasingly important role in identifying and curing otherwise difficult to treat cancers.



MASTERCLASS CONCEPT

With the aim to highlight benefits from fundamental research for medical applications and cancer treatment, a new MasterClass on Particle Therapy was developed. It was proposed to enrich the program of the International Physics MasterClasses (IMC) an educational outreach activity and flagship project of the International Particle Physics Outreach Group (IPPOG). The program engages young people with fundamental research and its applications offering them the chance to become scientists for a day and get a hands-on experience on real data. At the end of the day they join a common video conference to discuss their results as international scientific collaborations do.



HANDS ON: TREATMENT PLANNING

The newly developed Particle Therapy MC is addressing high-school students who are invited at a university or research laboratory for a day to immerse in the world of science.



One of the main software for Treatment Planning



After introductory lectures on the role of physics in medical applications, a hands-on session allows them to experience actual radiation techniques employed for treatment of cancer tumors using x-rays, protons or carbon ions. In a realistic way, Participants get in touch with this heavily computer aided process via the open source treatment planning research toolkit **optiPlan**, developed by the DFPZ Heidelberg.

All material is free to be used for any academic purpose. Its potential can be exploited in many ways (i.e. locally at schools, teachers programs, training sessions, laboratories, open days, ...)

PILOT PARTICLE THERAPY IMC

A pilot full day IMC took place in April 2019 with the participation of GSI-FAR, DFPZ Heidelberg, and CERN, all having the same agenda:

- Lectures, accelerators, medical applications...
- Virtual experiments, IMT therapy facility;
- Hands-on: raytraced treatment planning;
- International Videoconference: results, Q&A

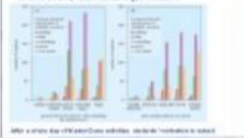


Videoconference with the 2 participating groups

EVALUATION

The goal of the IMC program is to allow school-children to experience methods and tools used in research. Evaluations have shown that they:

- enjoy the event,
- develop an appreciation and interest for fundamental science and its applications,
- get motivated to pursue scientific studies and to contribute to further developments,
- contribute to enhancing awareness of their immediate environment, such as family, friends, ...



OUTLOOK

The IMC project reaches out to about 15,000 school children around the world with about 225 institutes from 55 participating countries in 2019.

The Particle Therapy MasterClass was approved by the International Physics MasterClasses Steering group and will be integrated into the IMC 2020 schedule.

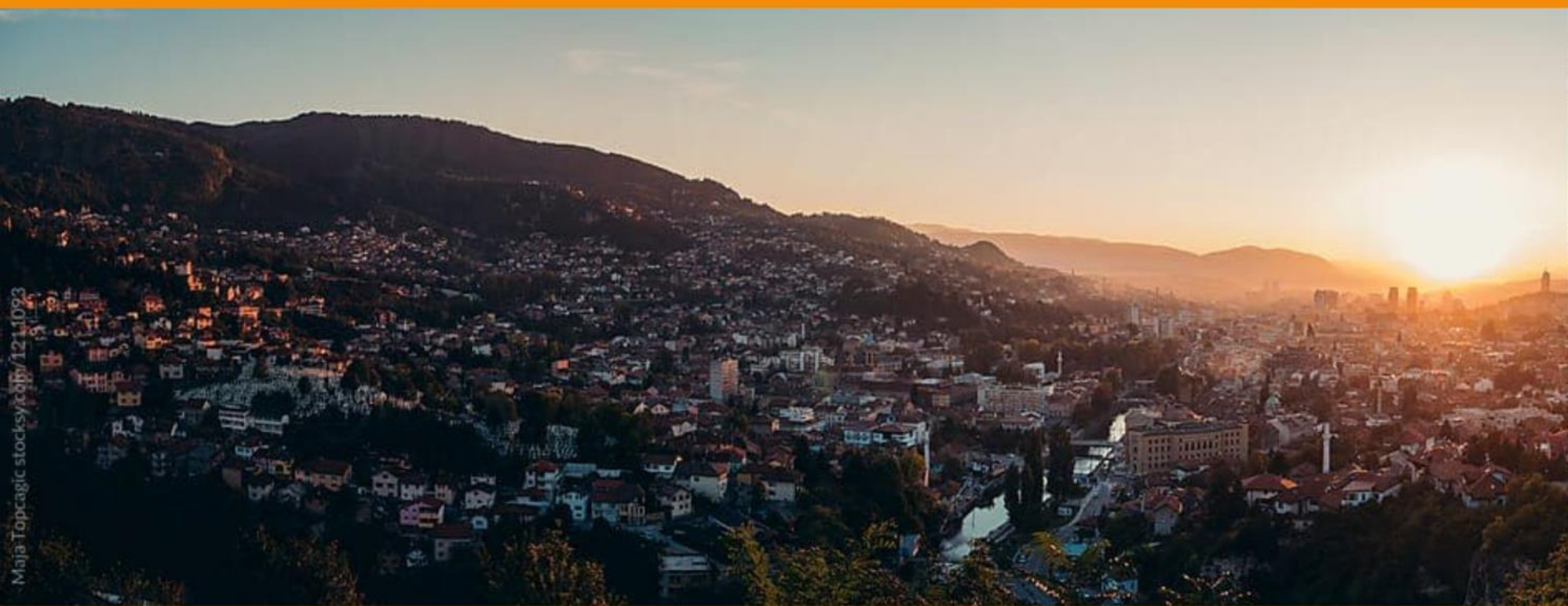


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Open Days: CERN and Montenegro 2019





Under development: SEEIST meets Industry (draft)

1-3 April 2020
Sarajevo City Hall
Europe/Sarajevo timezone

Fri 3 April 18:00 Public Event

Home

Organization

Workshop Poster

The workshop **SEEIST meets Industry** will take place 1-3 April 2020 in the **Sarajevo City Hall**, Bosnia and Herzegovina. It will be followed by an event for general public **SEEIST meets Sarajevo** in the evening of 3rd of April 2020, also in the **Sarajevo City Hall**.

Mon 30 March Particle Therapy MasterClass in Sarajevo UNSA
Tue 31 March Particle Therapy MasterClass in Tuzla, oncology

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