

INTERNATIONAL MASTERCLASSES HANDS ON PARTICLE PHYSICS



hands on particle physics

New developments for ALICE MasterClasses and the new Particle Therapy MasterClass

Łukasz Graczykowski, Piotr Nowakowski (WUT)

Yiota Foka (GSI)

on behalf of IPPOG and IMC Steering Group



November 7, 2019



INTERNATIONAL

MASTERCLASSES

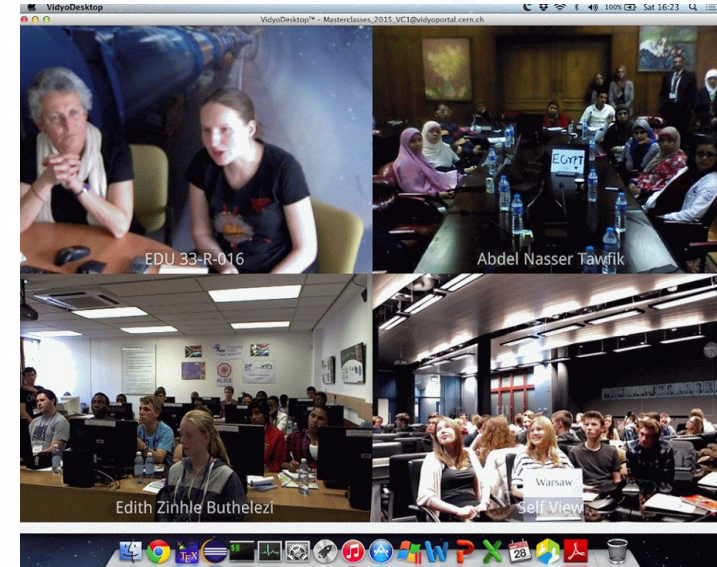
International MasterClasses

IMC aim: motivate the next generation of scientists!

- IMC brings **fundamental research** results and methods into the **classroom**
- New developments expanding the scope and reach

Theme: ions from fundamental research to therapy

- ALICE – framework and new measurement
 - new Particle Therapy Masterclass
- For details see:
 - on IPPOG by S. Goldfarb (T8, Nov. 5 11:00)
 - on IMC by F. Ould-Saad (T8, Nov. 4 15:00)

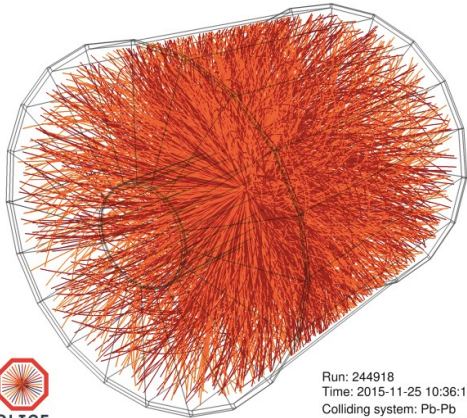


Radiation & ion beams

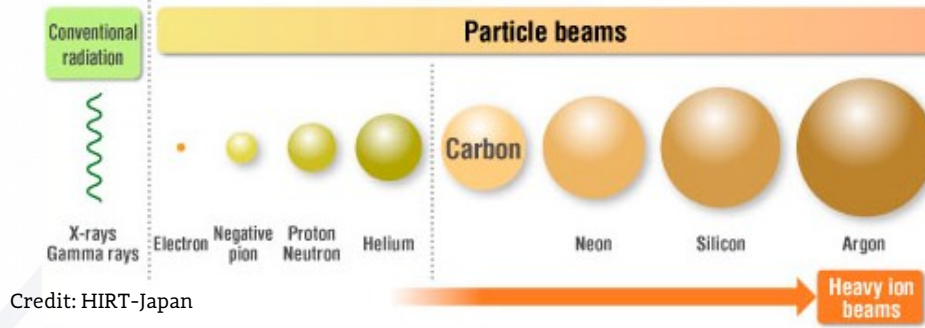
fundamental science
QGP studies



Credit: CERN



Run: 244918
Time: 2015-11-25 10:36:18
Colliding system: Pb-Pb
Collision energy: 5.02 TeV

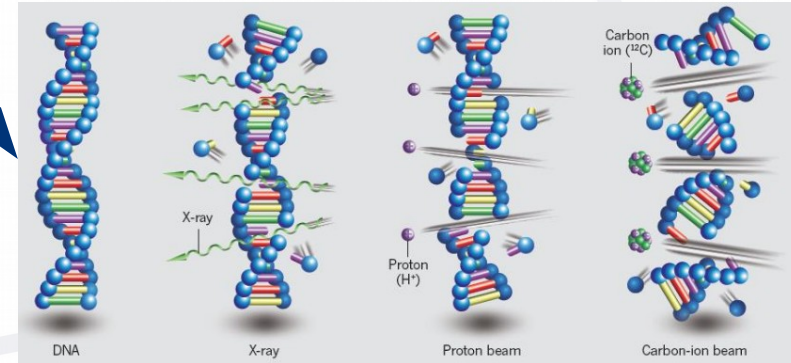


Credit: HIRT-Japan

applied science
medicine



Credit: HIT Heidelberg



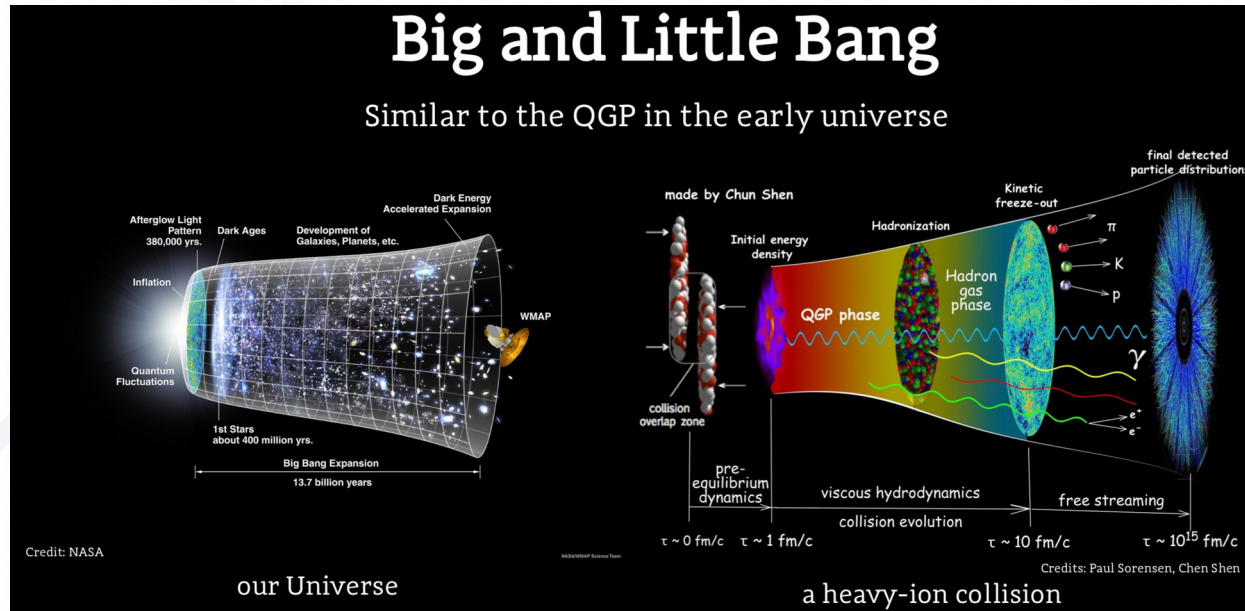
Credit: T. Nomiya, NIRS Japan



hands on particle physics

From heavy-ion physics to therapy

Probing the early Universe with heavy-ion collisions



Ion (carbon) therapy pioneered at **GSII**

Implemented at HIT in Heidelberg





ALICE



INTERNATIONAL

MASTERCLASSES

hands on particle physics

ALICE MasterClasses

ALICE MasterClass is a part of MatPhysChemWUT project which is partially funded by the European Union through the European Social Fund



**European
Funds**

Knowledge Education Development



**Republic
of Poland**

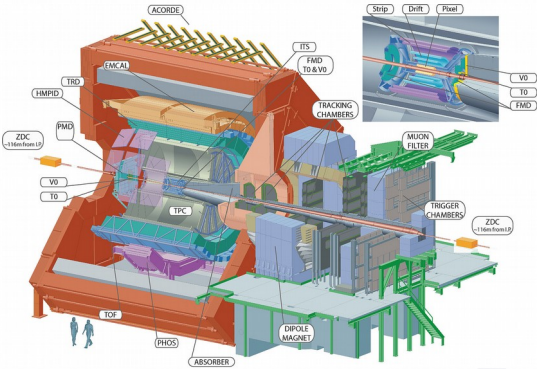
European Union
European Social Fund



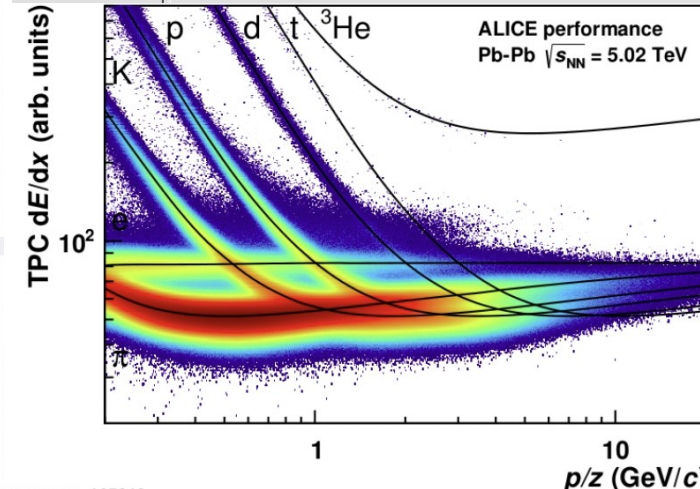
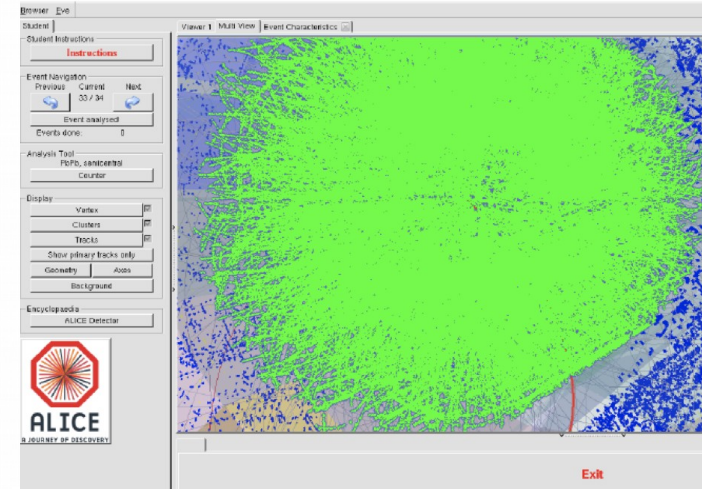
ALICE at LHC/CERN

Dedicated heavy-ion experiment

Study of multitude of observables
to explore matter under
extreme conditions



- Challenging tracking
- Almost all known PID techniques
- TPC: heart of ALICE for tracking and dE/dx
- ALICE MasterClass measurements:
 - 1) strange particles production
 - 2) R_{AA} – nuclear modification factor
 - 3) J/Ψ suppression (in progress)

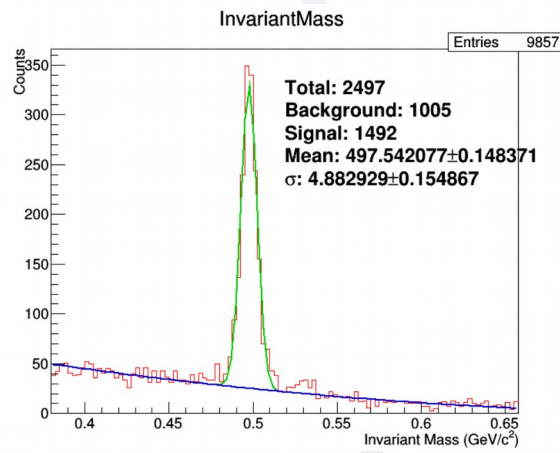
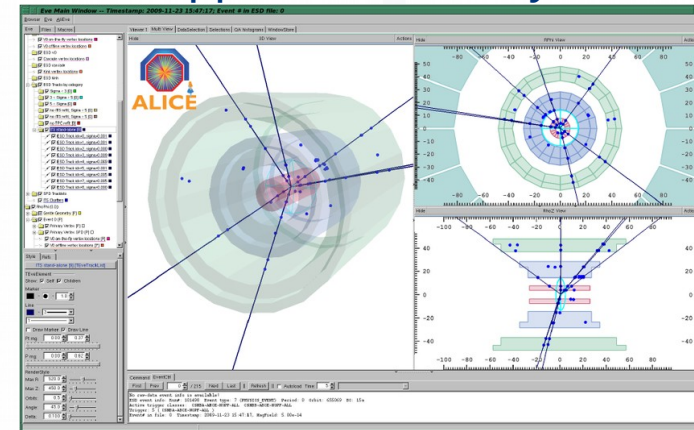


ALICE MasterClass

M. Tadel (T8, Nov. 5 16:30)
first pp event seen by ALICE

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”



The screenshot shows the ALICE RAA 2nd exercise code editor. The interface includes a menu bar, a toolbar, and a code editor. The code editor contains a C++ script for event analysis, including comments and code for setting up the analysis, opening the input file, and reading the data into histograms.

```
#ifndef ANALYSEPARTSTART_C_RIJ01XU
#define ANALYSEPARTSTART_C_RIJ01XU

/**
 * @file Analyse.C
 * @author Christian Holm Christensen (cholm@nbi.dk)
 * @date Thu Mar 9 20:30:55 2017
 * @brief Analyse data in a single centrality bin
 * @ingroup alice_masterclass_raa_part2
 *
 * @include ciostream
 * @include "Raa/Utilities.C"
 *
 * Run the single centrality bin analysis
 * @param minCentrality Least centrality to consider
 * @param maxCentrality Largest centrality to consider
 * @ingroup alice_masterclass_raa_part2
 */
inline void Analyse(Int_t minCentrality, Int_t maxCentrality)
{
  // Set-up default style
  StyleSettings();





  // Open the input file
  TFile input = OpenInput(ResourcePath("data/Raa/MasterClassesTree_LHC10h_Ru
  if (!input)
    return;

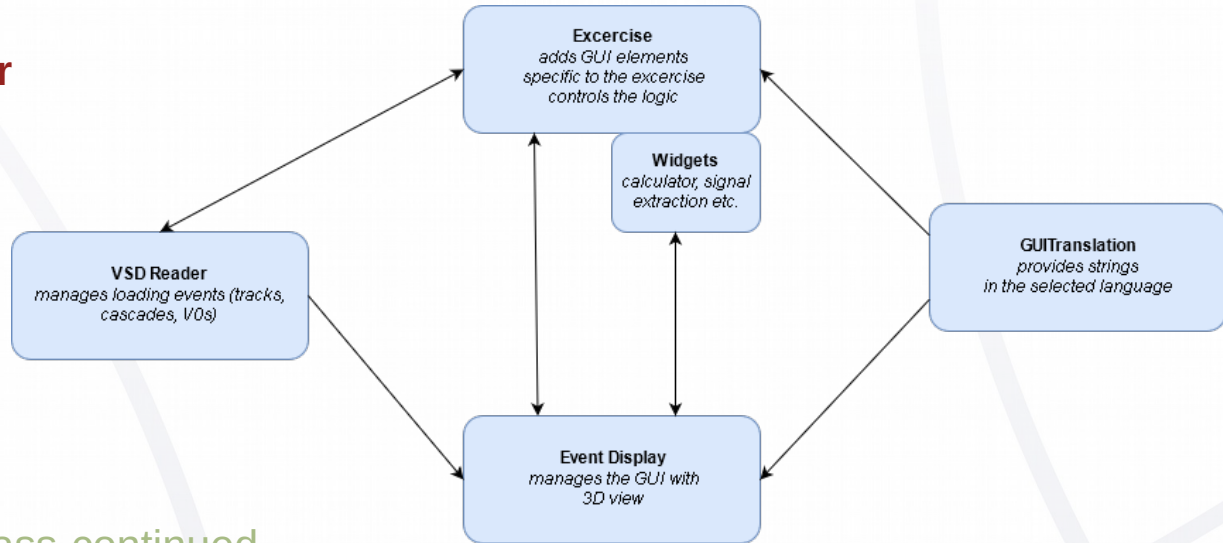
  // Set up variables to read data into, get our tree, make
  // histograms, and find maximum number of entries (events) to read.
  Int_t nTrack;
  Float_t centrality;
  TTree_suspectTree = GetEventTree(input, centrality, nTrack);
}
```




ALICE MasterClass – new developments






Initial work by GSI/CERN Summer Student
Taken over by WUT dedicated programmer

- Macros → standalone app
- Common framework
 - all three exercises share core classes
 - *in future*: possibility to use data from other experiments
- Source code on CERN GitLab:
<https://gitlab.cern.ch/pinowako/masterclass-continued>
- CMake build system    
- Available versions:
 - Linux (Applmage binary, clickable, **ROOT embedded!**)
 - **Windows** (Visual Studio compiled, installer, clickable, **ROOT embedded!**) – first time provided
 - VirtualBox 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 Files

Continuation of the ROOT-based MasterClass refactor.

• New webpage: <https://alice-masterclass.web.cern.ch>

Łukasz Graczykowski (WUT)

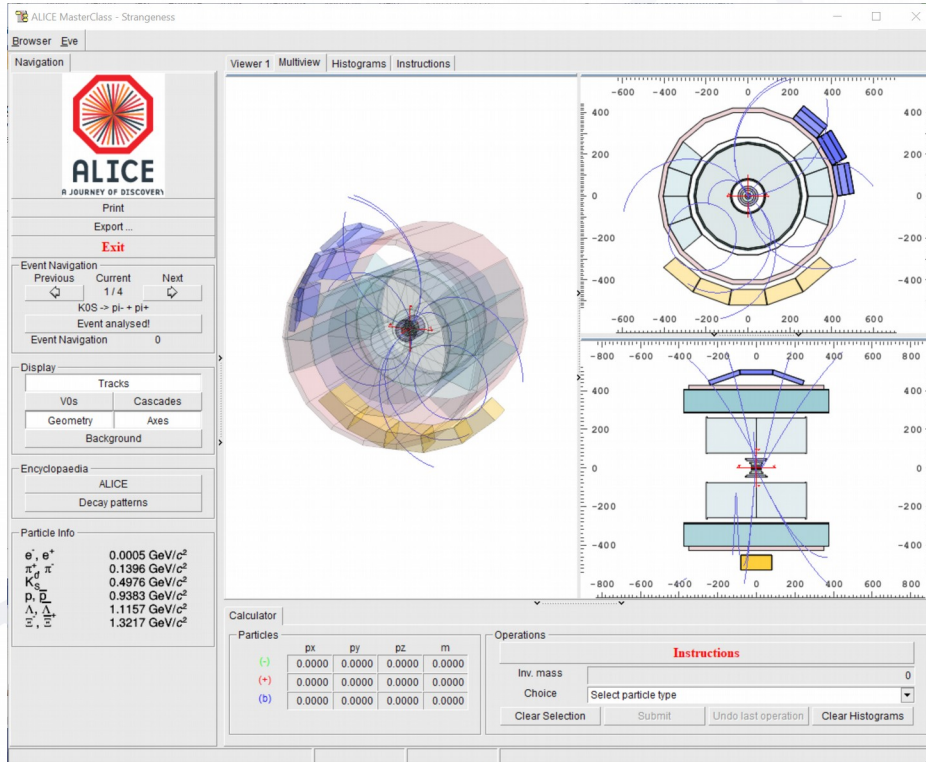


ALICE MasterClass – how does it look like?

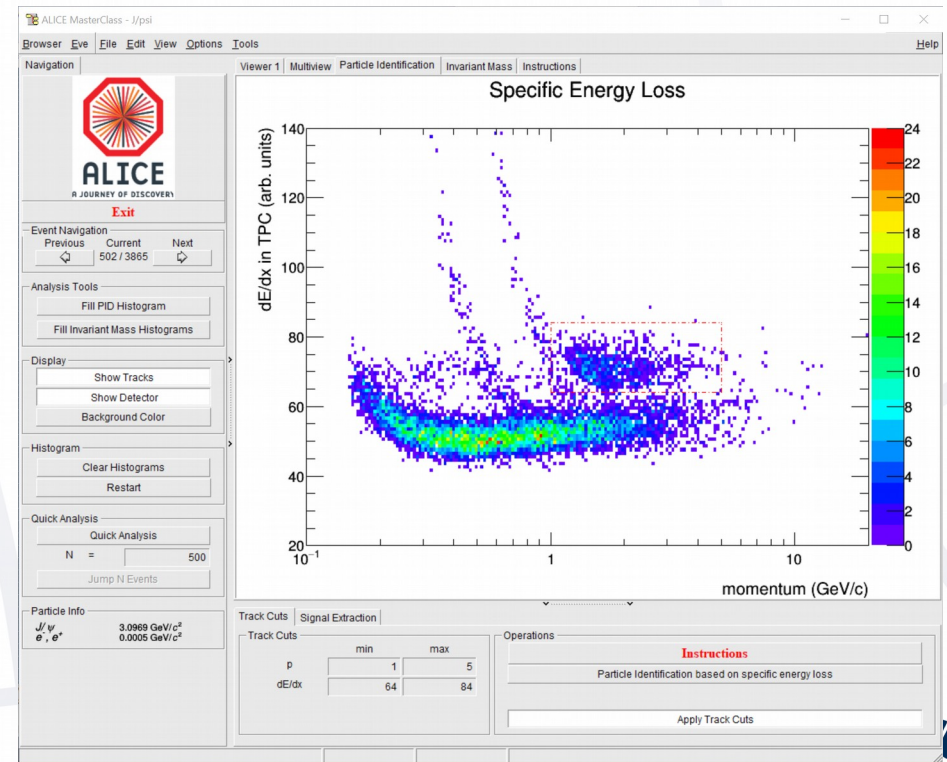


Windows 10

Looking for strange particles visual analysis

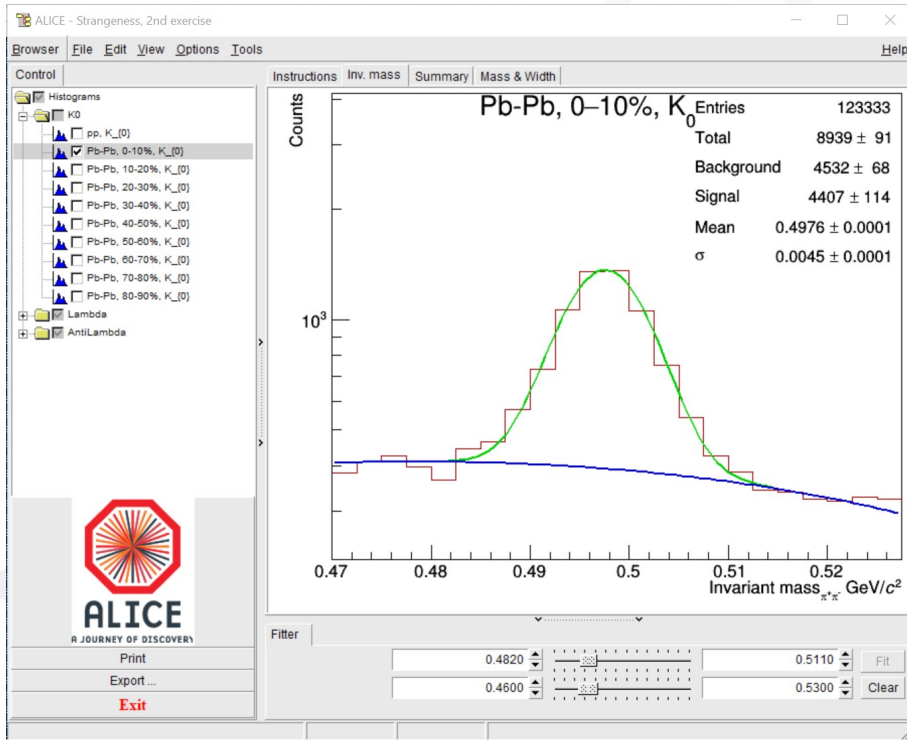


J/ψ suppression electron PID

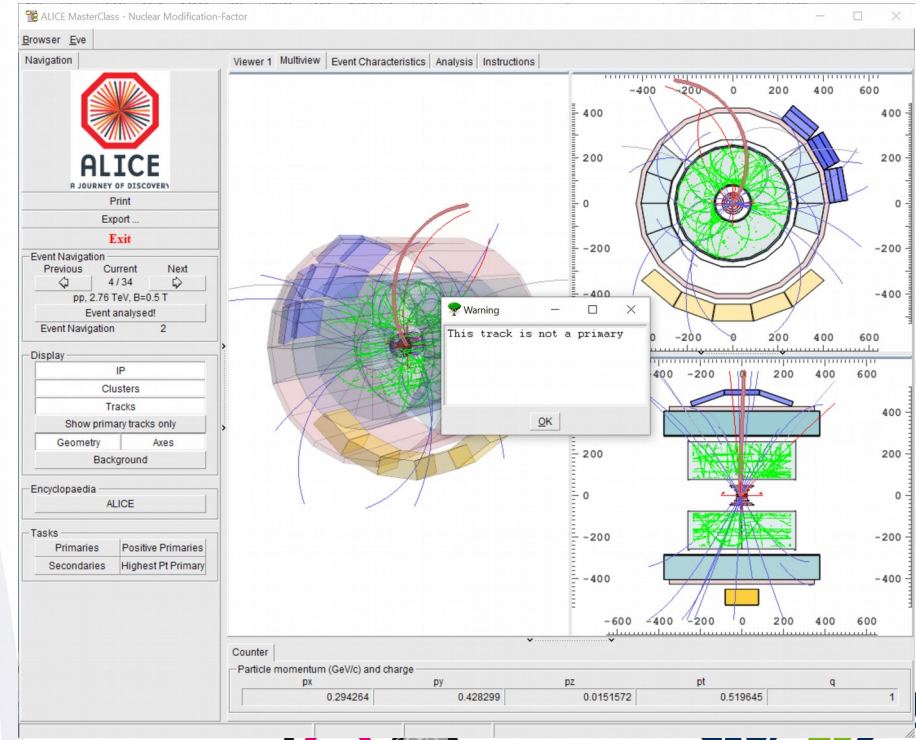


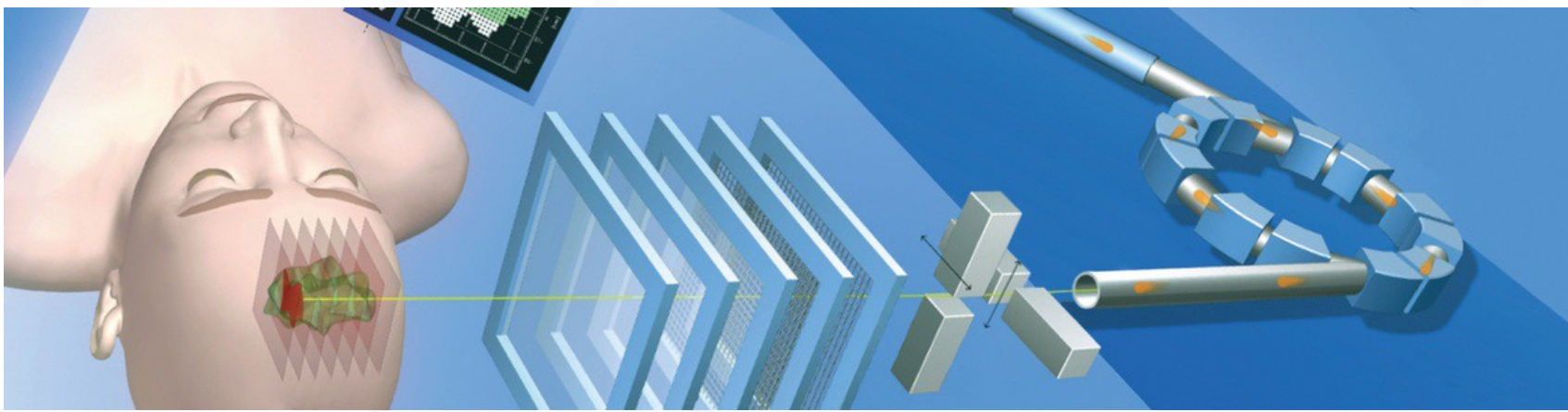
ALICE MasterClass – how does it look like?

Looking for strange particles
invariant mass fits



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





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

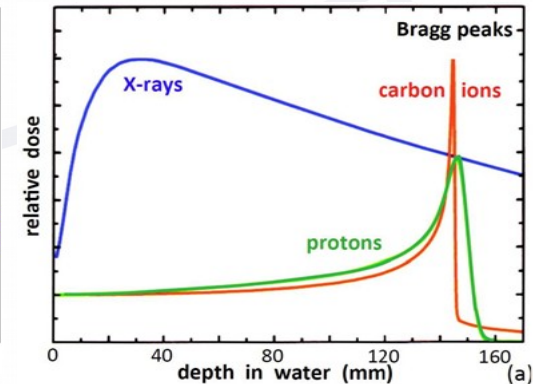
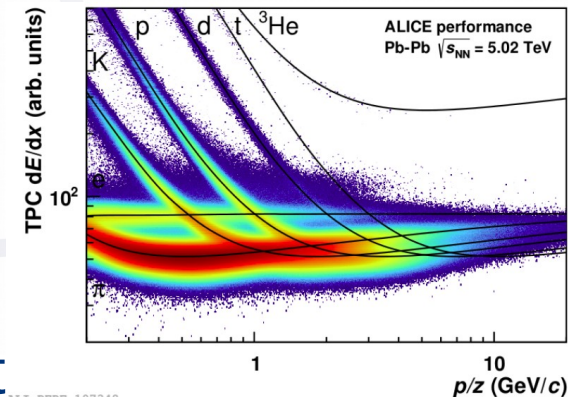
Particle Therapy MasterClass

Aim: benefits for society from fundamental research

- direct applications for health of instrumentation: **accelerators, detectors, software**

- Aim: enhance awareness on hadron therapy cancer treatment

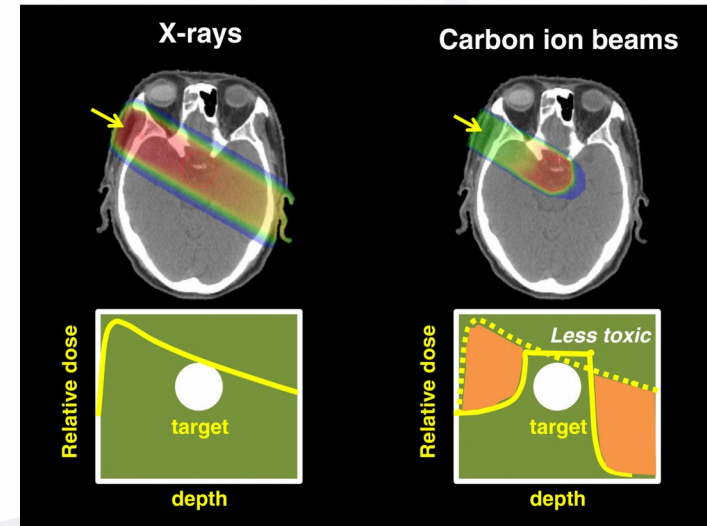
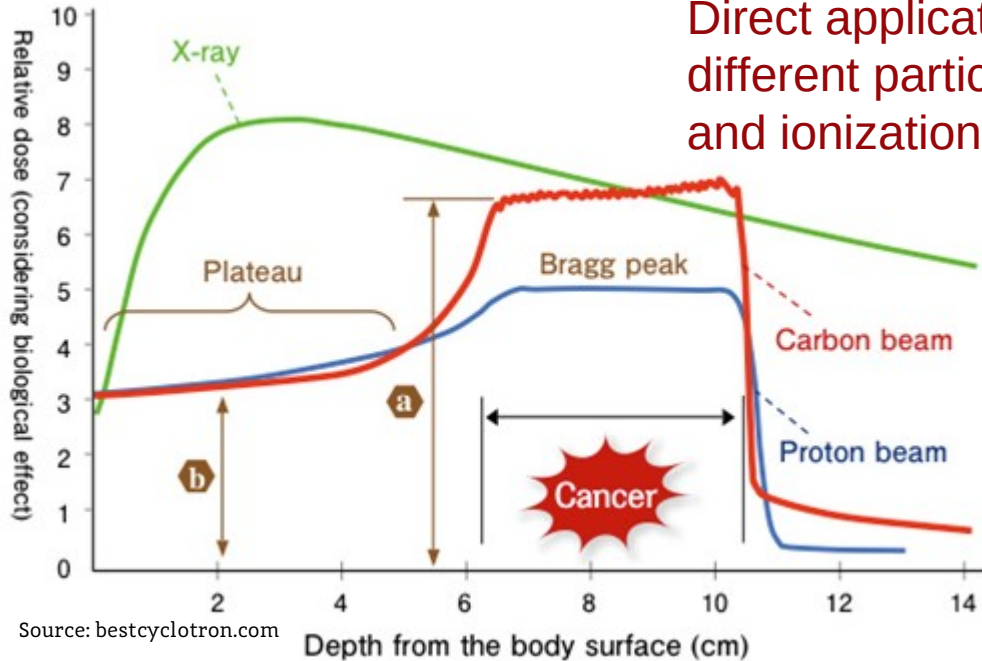
From Bethe-Bloch ionization for PID to Bragg peak for cancer therapy



Hadron therapy

- Hadron (proton, ion) therapy is precise and more effective way of treating cancer
- **Reduced dose for the surrounding tissue:**
 - preferred for children, pregnant women deep-seated and radio-resistant tumors

Direct applications of different particle properties and ionization loss in matter

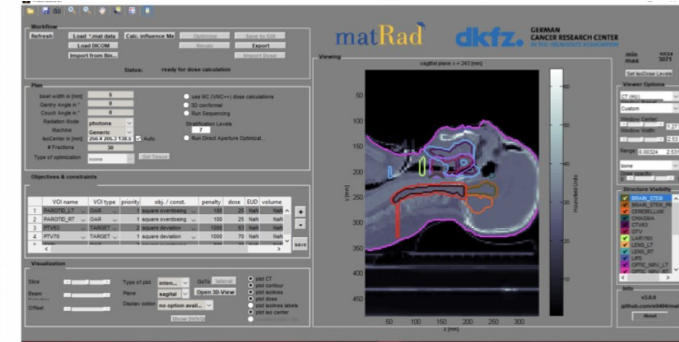


Source: EPMA J. 2013; 4(1): 9

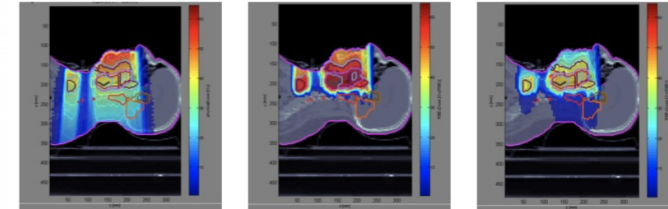
Particle Therapy MasterClass



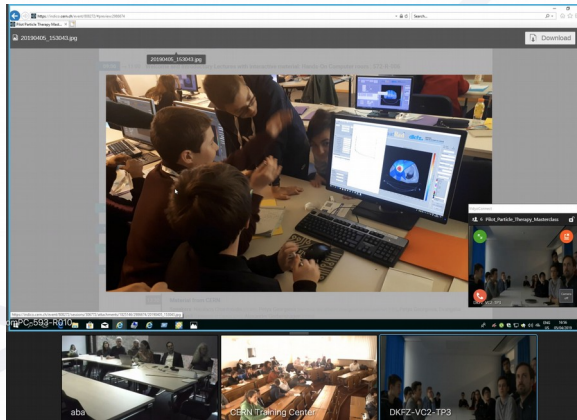
- Based on **matRad** <http://e0404.github.io/matRad/>
 - developed by DKFZ in Heidelberg
 - professional and **open-source** toolkit for dose calculation
 - photon, proton, carbon ion therapy



Demo⁴ of the matRad software kit for Treatment Planning .



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



- PTMC: **head and liver** data
- First test: locally at GSI Feb 2019
- Pilot: GSI, Heidelberg DKFZ, CERN Apr 2019
- IMC Steering Group Approval: GSI May 2019



PTMC conferences, CERN Open Days

- Support and PR material available on the webpage

ENLIGHT, Caen, 2019

ACCELERATORS FOR HEALTH AND INTERNATIONAL MASTERCLASSES

Viola Foka, for the PTMC Team, GSI, Germany

Particle Therapy MasterClass – an accelerator-driven application for health

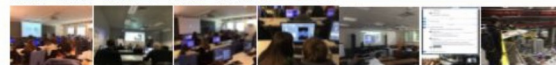
ACCELERATORS AND PARTICLE THERAPY

During the past century, particle accelerators played an essential role in advancing scientific knowledge and in 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 ECARE2, ARIES, among others. In particular, the potential of accelerator-related therapy and diagnostic techniques increased considerably over past decades, playing an increasingly important role in identifying and curing otherwise difficult to treat cancers.



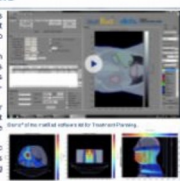
MASTERCLASS CONCEPT

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. After introductory lectures on the role of physics in medical applications, a hands-on session allows them to experience advanced radiation techniques employed for treatment of cancer tumors using x-rays, protons or carbon ions. In a realistic way, participants get in touch with the heavily computer-aided process via the open source treatment planning research toolkit **plato**, developed by the DKFZ (Heidelberg). All material is free to be used for any academic purpose. Its potential can be exploited in many ways (e.g. 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-FKIT, DKFZ, Heidelberg and CERN, all having the same agenda:

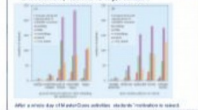
- Lectures: accelerators, medical applications.
- Visits: experiments, HIT therapy facility.
- Hands-on: treatment planning.
- International Videoconference: results, Q&A.



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 50 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.



After a month the IMC activities continue via videoconferences in real time.

1. Top speaker presentations (1h)
2. Hit therapy (1h)
3. Hit training (1h)
4. Hands-on (1h)
5. Videoconferences (1h)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 739977 for particle accelerator outreach.



Open Days

CERN

Montenegro

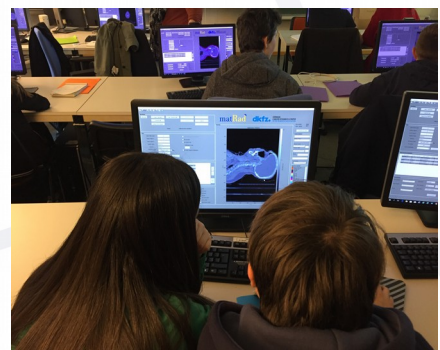


First tests

and pilot

GSI, CERN,

DKFZ

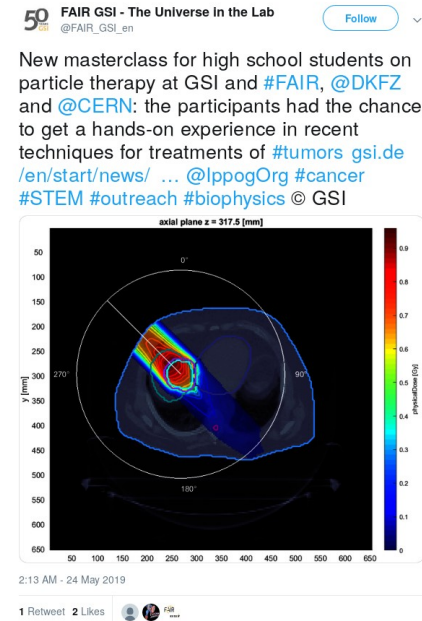


Particle Therapy Masterclass

- Presented and approved by IPPOG in 2019 for IMC 2020:
 - **to register:** <https://indico.cern.ch/event/840212/page/18008-2020-ptmc-dates>
- Advertised on webpages and Twitter (i.e. GSI)



The screenshot shows the GSI website homepage. At the top is the GSI logo and the text "GSI Helmholtzzentrum für Schwerionenforschung GmbH". Below this is a navigation bar with links for "ABOUT US", "RESEARCH/ACCELERATORS", "JOBS/CAREER", "PRESS", and "@WORK". A sidebar on the left lists categories like "Visitors & Pupils", "Job Applicants & Students", "Business & Industry", "Journalists", and "Staff & Scientists". The main content area features a large image of the accelerator tunnel with the heading "GSI Helmholtzzentrum für Schwerionenforschung" and a sub-heading "International group of experts presents final report on the FAIR project". Below this is another sub-heading "New Masterclass for pupils on particle therapy" with a small image of a person and a circular diagram.



The screenshot shows a Twitter post from the account "FAIR GSI - The Universe in the Lab" (@FAIR_GSI_en). The text of the tweet reads: "New masterclass for high school students on particle therapy at GSI and #FAIR, @DKFZ and @CERN: the participants had the chance to get a hands-on experience in recent techniques for treatments of #tumors gsi.de /en/start/news/ ... @lppogOrg #cancer #STEM #outreach #biophysics @ GSI". Below the text is a circular plot titled "axial plane z = 317.5 [mm]". The plot shows a cross-section of a target with a color-coded dose distribution. The x and y axes are labeled in millimeters, ranging from 50 to 650. A color scale on the right indicates dose values from 0 to 0.9. The plot includes angular markers at 0°, 90°, and 180°. Below the plot, the tweet's timestamp "2:13 AM - 24 May 2019" and engagement statistics "1 Retweet 2 Likes" are visible.



Outlook

- ALICE MasterClasses:
 - new framework ready to be tested by the collaboration
 - to be used for IMC 2020
 - *in future*:
 - possibility to extend to other experiments (geometry, data)
 - towards a web version (move to EVE-7?)
- Particle Therapy MasterClass:
 - approved by IPPOG in 2019 for IMC 2020
 - test and pilot sessions held in 2019
 - Institute registration for IMC 2020 open

<https://indico.cern.ch/event/840212/page/18008-2020-ptmc-dates>



Thank you!



Acknowledgements – ALICE MasterClass

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Yiota Foka,

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Pawel Dębski
Piotr Nowakowski
Maja Kabus

Also thanks to A. and M. Tadel and the ROOT team

ALICE MasterClass is a part of MatPhysChemWUT project which is partially funded by the European Union through the European Social Fund



**European
Funds**

Knowledge Education Development



**Republic
of Poland**

European Union
European Social Fund



ics

Acknowledgements – PTMC

matRad Developers

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GSI

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Ralf Averbeck, Malzacher, Peter
GSI IT :
Thorsten Kollegger, Behnert, Katharina
Osdoba, Sascha

Sponsors : Edmond Offermann



General Coordination:
Yiota Foka (GSI)

CERN (staff and users)

CERN: tutors
Loc Org: Nikolaos Charitonidis
Alexander Gerbershagen
Evangelia Dimovasili
Elena Benedetto

CERN/ARIES: Maurizio Vretenar, Valerie Brunner
CERN/ENLIGHT: Manjit Dosanjh Petya Georgieva
CERN/KT: Manuela Cirilli Anais Rassat Rita Ferreira
Giovanni Porcellana
CERN: Visits Service Erwan Harrouch Francois Butin
CERN: Training Centre: Eric Bonnefoy M-L LECOQ

Uni Sarajevo: web pages

Amila Avdic
Amra Ibrahimovic
Mirsad Tunja

