Particle Physics Outreach with Netzwerk Teilchenwelt in Bonn

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Particle Physics Seminar, Oct. 13, 2022

NETZWERK TEILCHENWELT

UNIVERSITÄT BONN

Motivation for outreach

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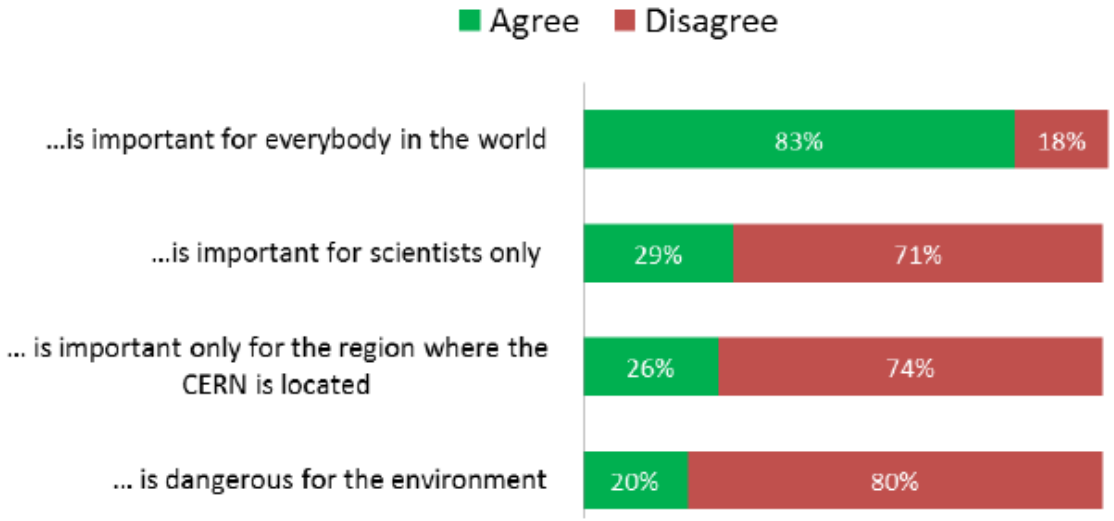
Recruitment of
future scientists

Motivation for outreach

- Secure funding for our projects (“1 coffee/year”)
- **A price worth paying** R. Heuer (2020) https://cerncourier.com/a/a-price-worth-paying/
- **Scientific Research at CERN as a Public Good: A Survey to French Citizens** M. Florio et al. (2018) http://cds.cern.ch/record/2635861

Figure 8. Scientific research at CERN ... (n=1,005)



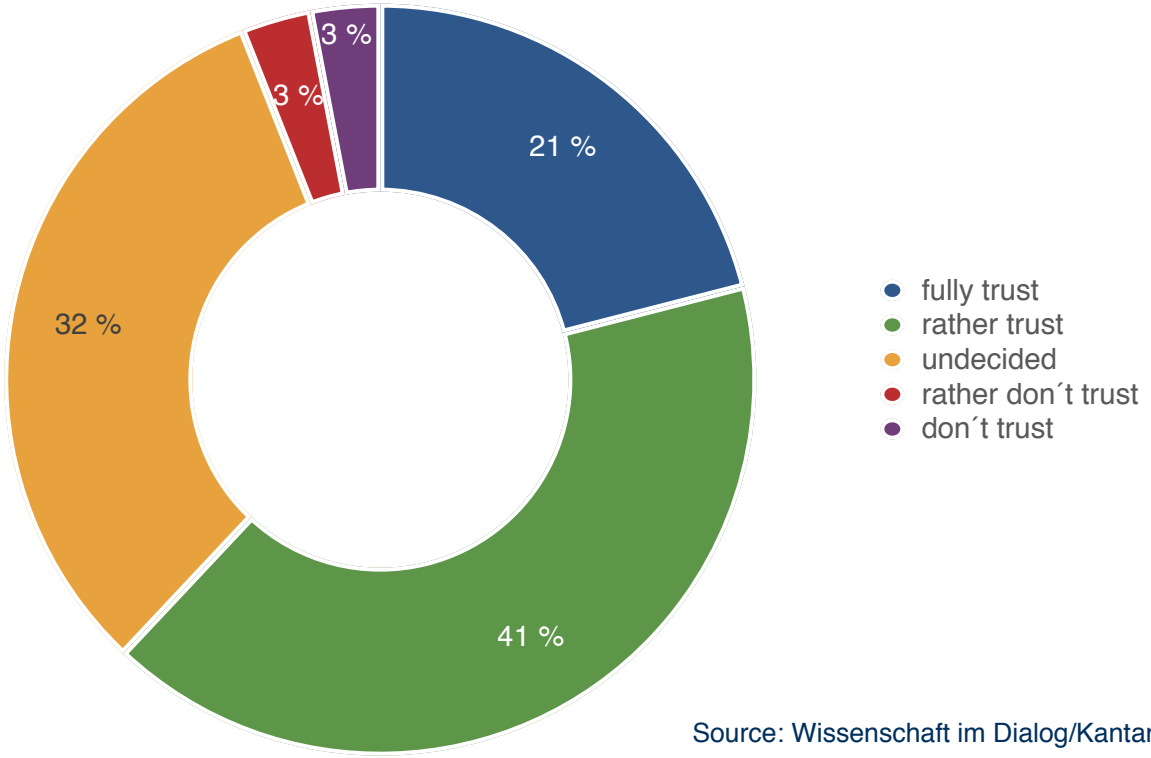
Recruitment of future scientists

Explanation & legitimation

Motivation for outreach

"How much do you trust science and research?"

Wissenschaftsbarometer 2021



Source: Wissenschaft im Dialog/Kantar

Recruitment of future scientists

Explanation & legitimation

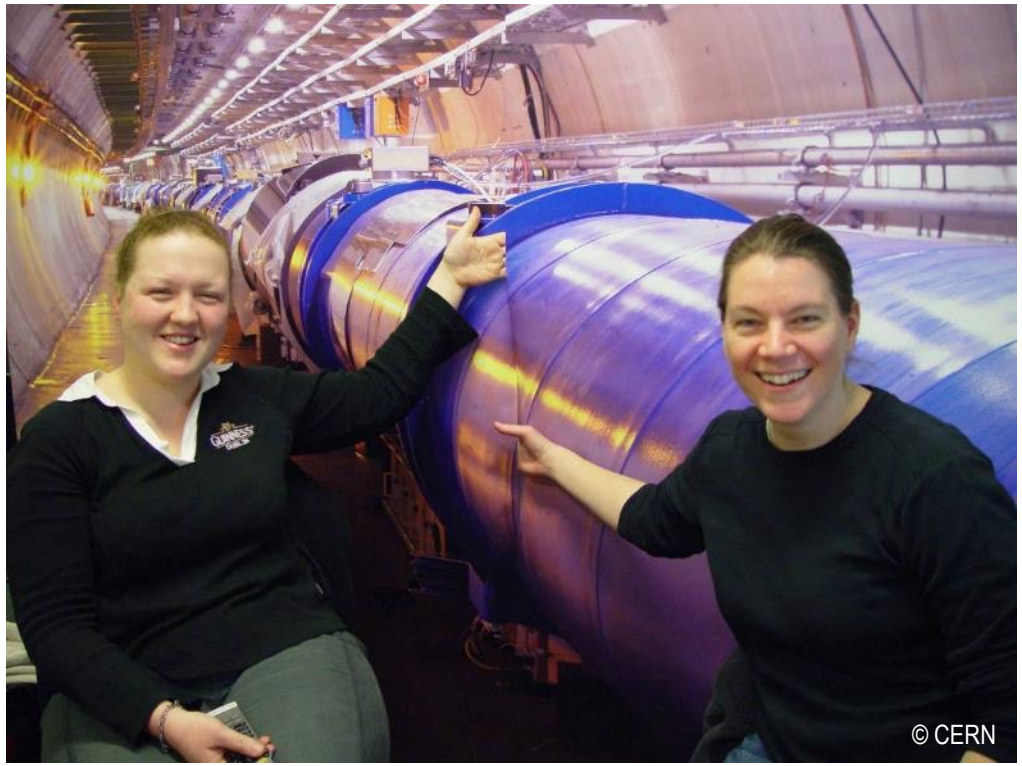
Create trust in science

Motivation for outreach

Quotes from Masterclasses moderators:

“The best thing is actually answering the questions and seeing how excited and how happy they are, waving at the camera. They're really excited to be talking to physicists based at CERN!”

“It is very satisfying, because we do many video conferences and rarely do people cheer on the other side if you say something. Here they do!”



Recruitment of future scientists	Explanation & legitimation	Create trust in science	Intrinsic motivation

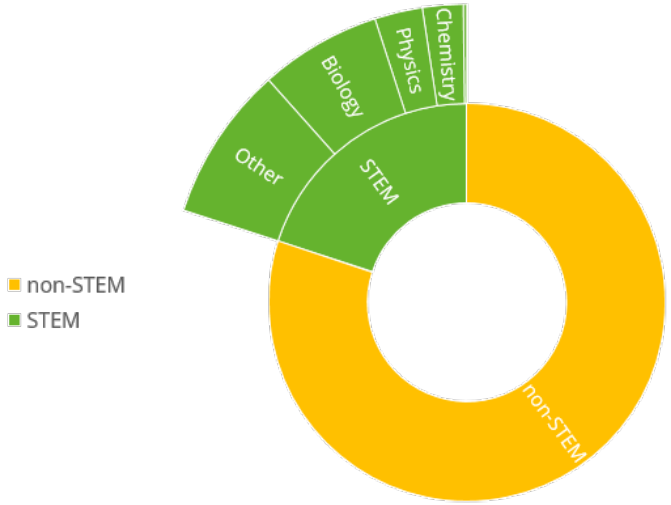
Motivation for outreach

- Performance of 15-year-olds declining since 2012
- (Only) 20 % of high school students choose STEM subjects on a higher level

performance of 15-year-olds declining since 2012

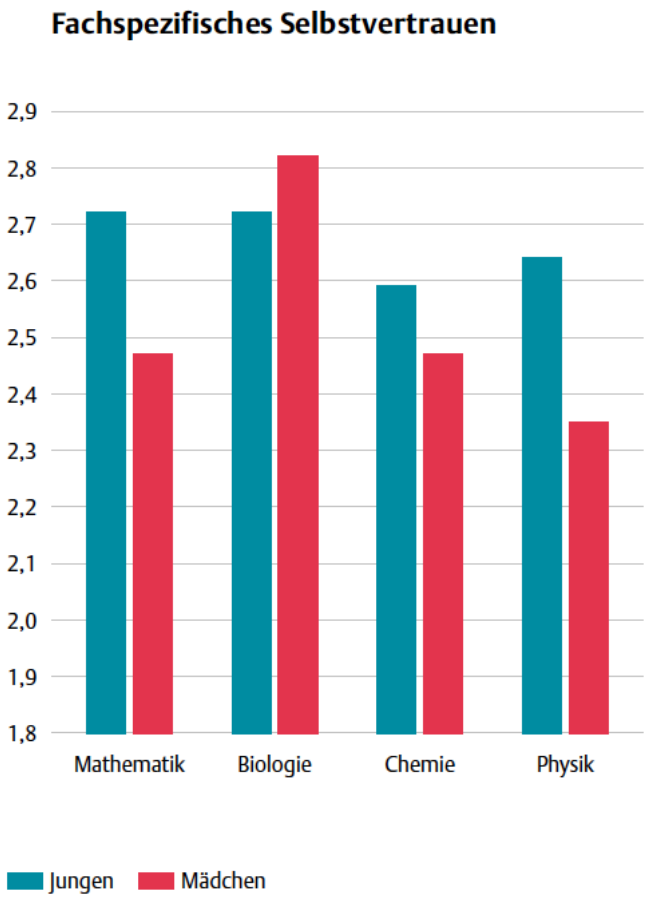
STEM young talent barometer 2020

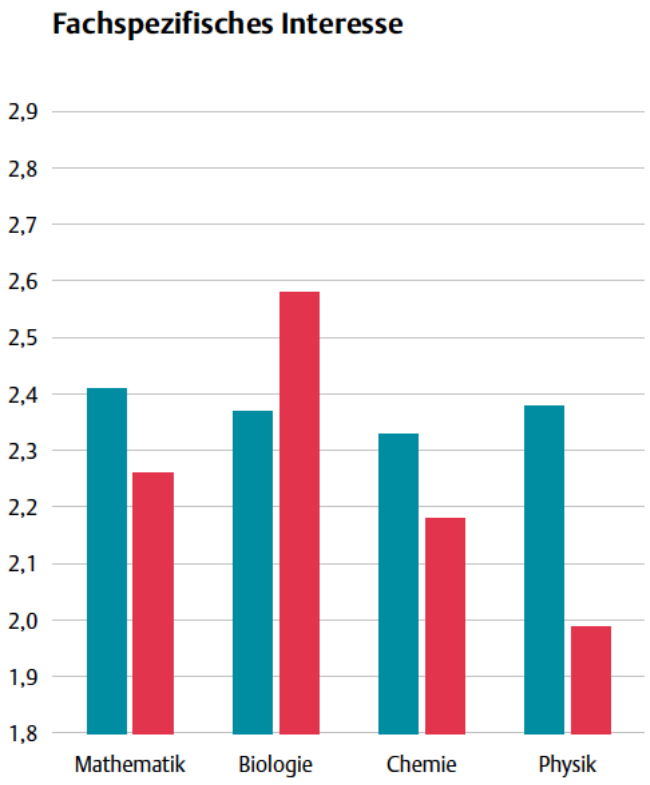
20 % of high school students choose STEM subjects on a higher level (advanced course or “Leistungskurs”)



Motivation for outreach

Interest and self-confidence in physics low (compared to other STEM subjects) especially for girls





STEM young talent barometer 2020

Low percentage of girls in physics & computer science courses:

- Biology: 60 %

- Physics: 26 %

- Computer Science: 15 %

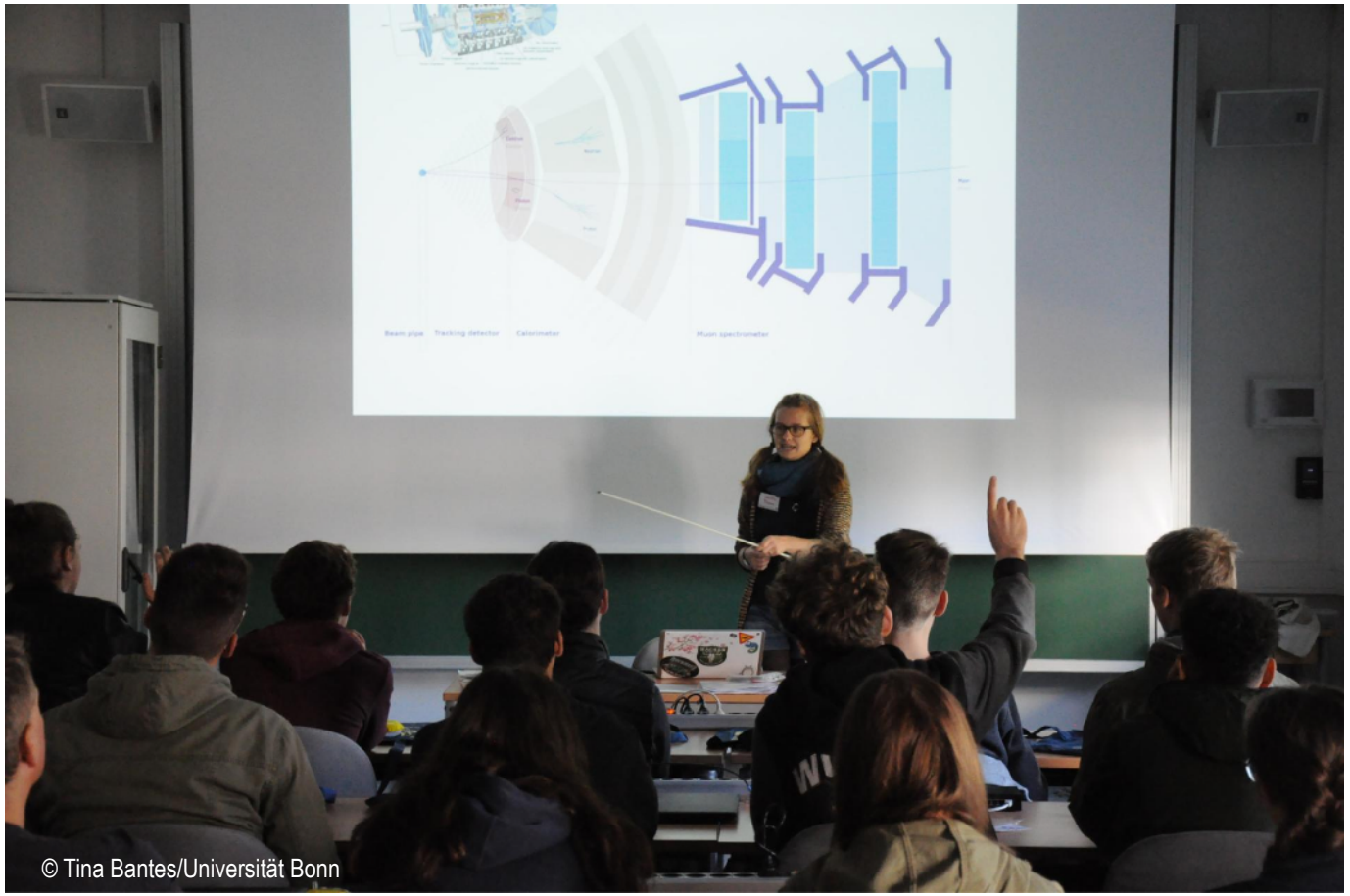
Motivation for outreach

How can you change that?

- Be a role model
- Talk about your research

What does it give to you?

- Experience interest in own research
- Acquire soft skills, for personal and professional development
- Increase general acceptance for fundamental research



Particle physics, a research area with a lot of potential

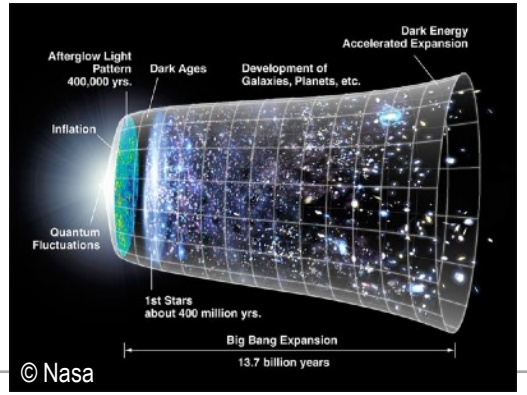
Strength and chances

- Strong media interest
- Many people interested in fundamental questions
- Unique research methods & experimental setups
- Connected to captivating terms, e.g. Big Bang, Antimatter

Challenges

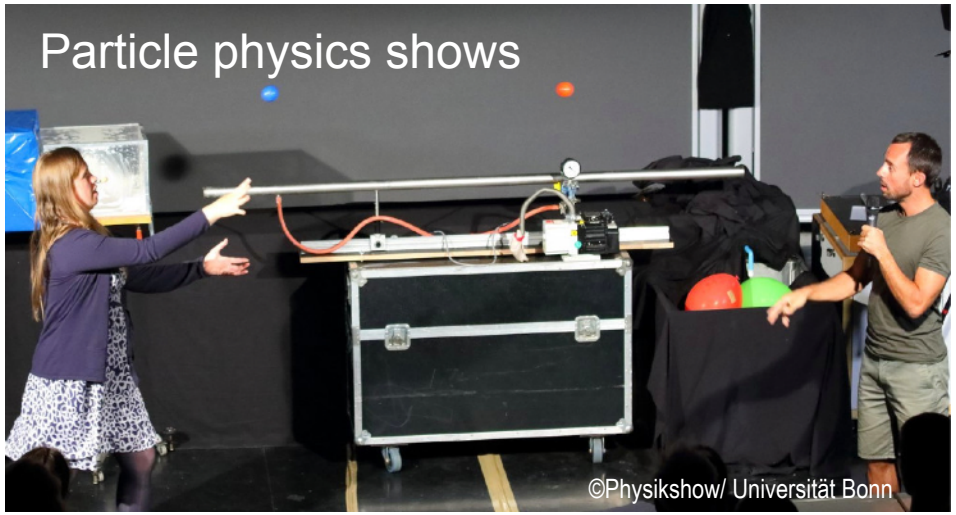
- Modern physics often not in school curricula
- Many new concepts & perceptions
- Large number of new terms
- Connection to everyday experience

© CERN

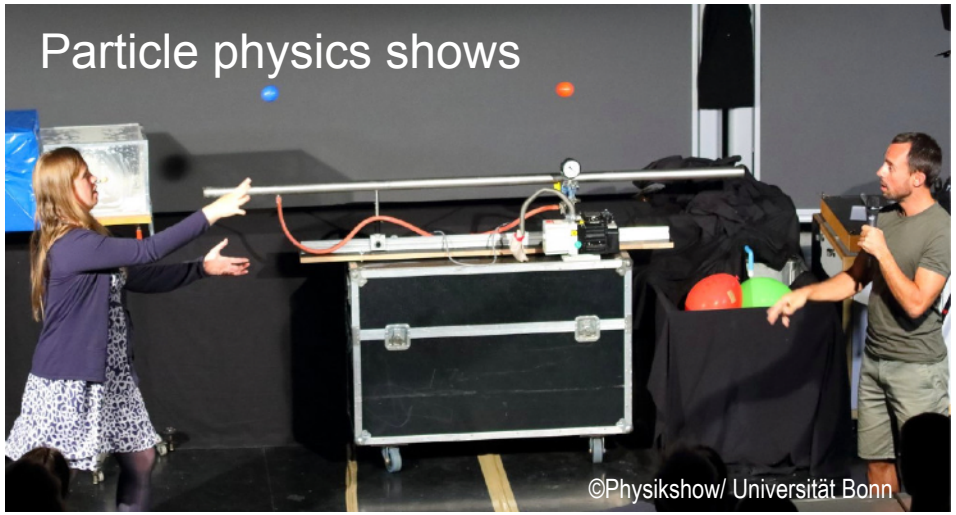


© Nasa

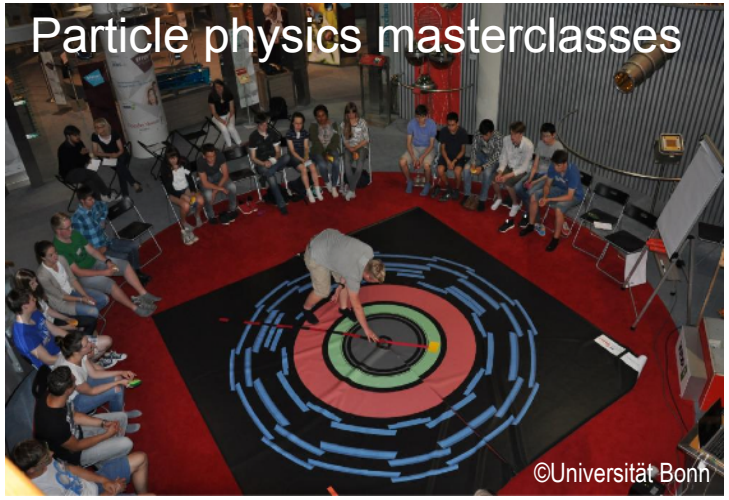
Outreach - How to?



Outreach - How to?



Today focus on



NETZWERK TEILCHENWELT

The Idea behind Masterclasses

Act as a "scientist for a day"

- Close to current research
- Own "hands-on" activities (listen = forget, see = remember, do = understand)

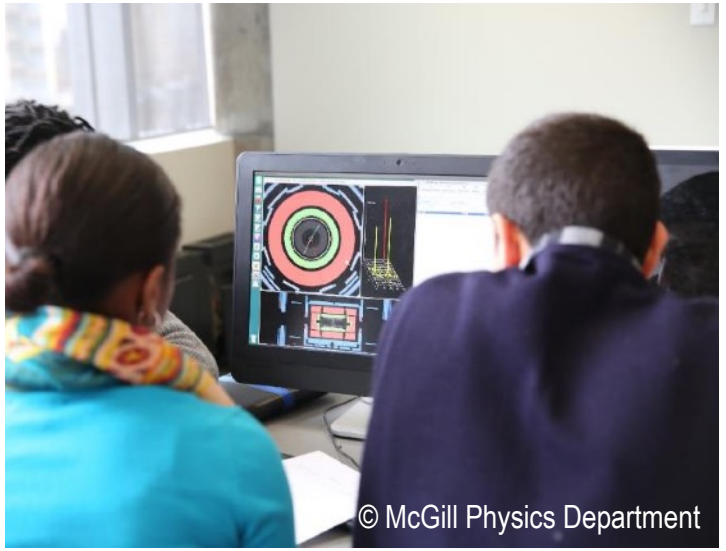
Get insight into the research process

- Use of relevant methods and tools
- Comparisons between experiment and theory

Authentic experiences

- Analysis of real scientific data
- Meeting and discussion with scientists

© Marzena Lapka


© McGill Physics Department

©Universität Bonn

Why “Masterclass”?

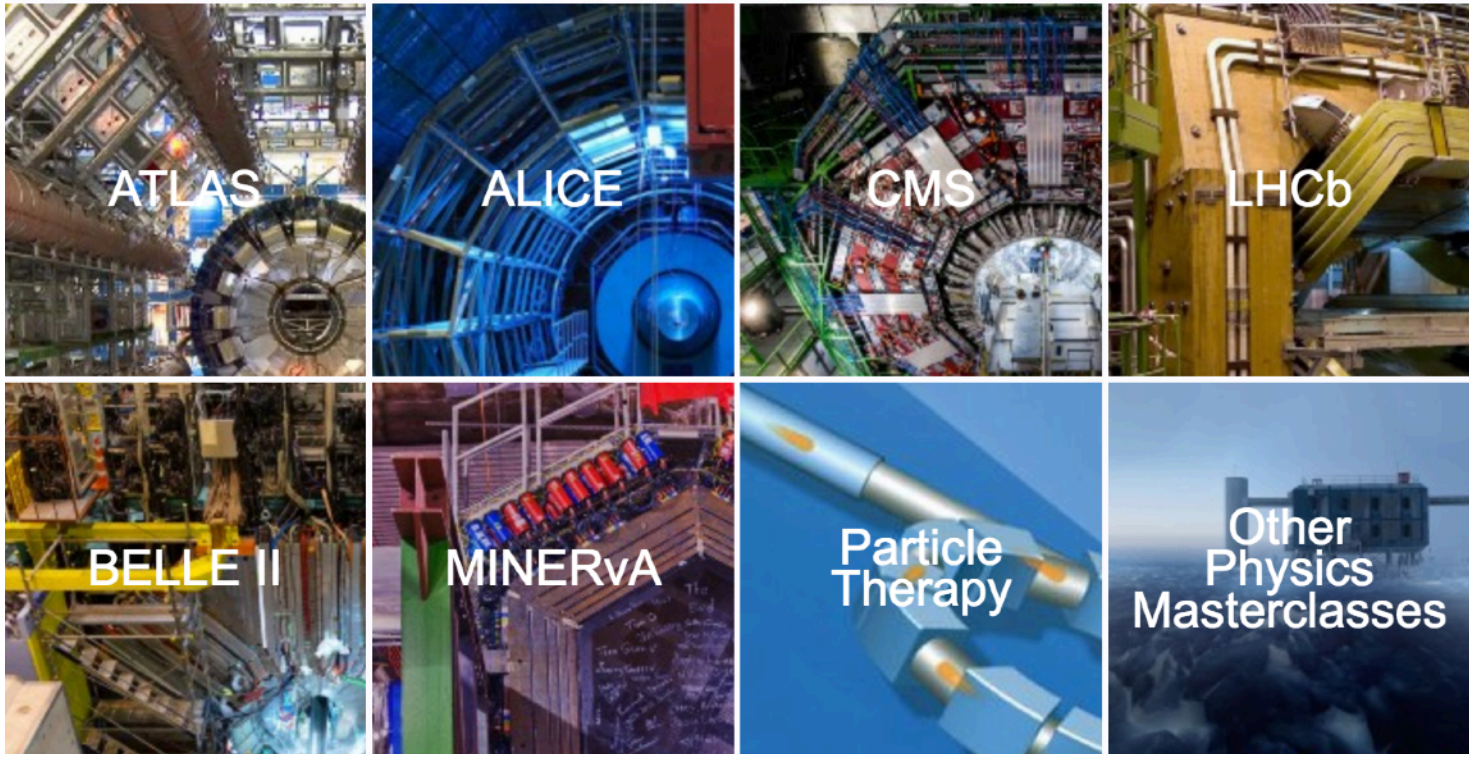
As in a Masterclass in the arts, students work with an expert

Expert = particle physicist

Violin = particle physics data analysis

A variety of Masterclasses - there's a lot to discover

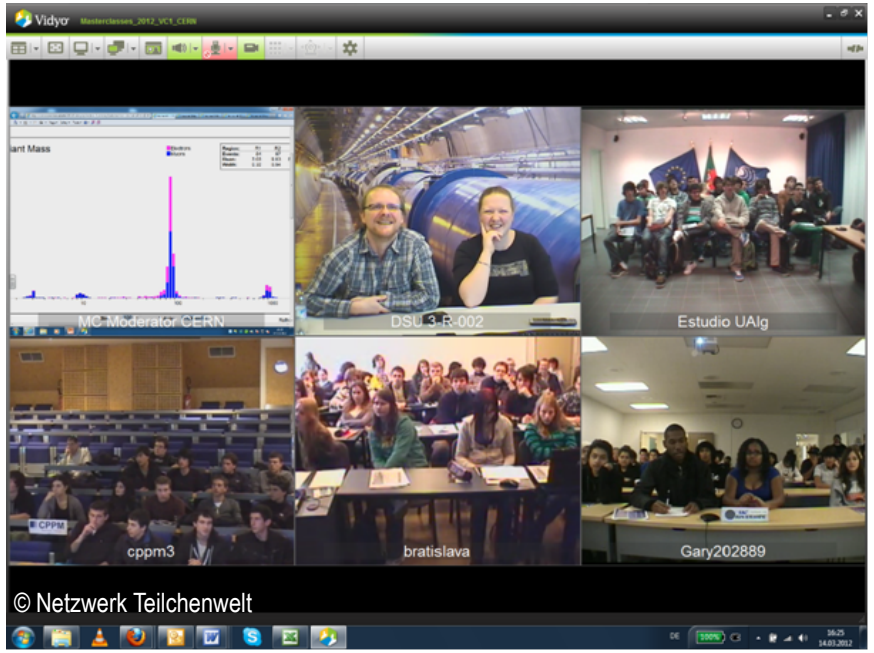
- ATLAS: W-Path, Z-path
- CMS
- ALICE
- LHCb
- Belle II: Measure quark colors, Reconstruct B-mesons
- Machine Learning with OPAL data
- Particle Therapie
- Astroparticle physics: Auger, IceCube



Contact us and join with your favourite MC!

Concept of International Masterclasses

- High school students (15 – 19) are „scientists for one day“
- Get invited to a research institute or university
- Introductory talks (standard model, detectors, accelerators)
- Measurement with data
- International video conference (3 – 5 inst. + moderators)



Sample Agenda

Local time	Activity
8:30 - 9:00	Registration & Welcome
9:00 - 10:00	Introduction to Particle Physics
10:30 - 11:30	Second talk or tour
12:00 - 13:00	Lunch
13:00 - 15:00	Data analysis
15:00 - 16:00	Local combination + Discussion
16:00 - 17:00	International video conference

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Video Conference

- 45-60 min
- 3-5 institutes, reflecting international collaboration
  - Same measurement, different data
- 2-3 Moderators (PhD students, Postdocs)
- Moderation centers: CERN, Fermilab, KEK, GSI, TRIUMF
- Agenda
  - Welcome
  - Combination and discussion of results
  - General Q & A
  - Quiz

You are welcome to join the community of moderators!

(see [list of CERN moderators for IMC 2022])

Worldwide program

- Organized by IPPOG (International Particle Physics Outreach Group)
- 60 countries involved
- 220 research labs
- 2019: 15.000 high school students
- Coordination: Ken Cecire (QuarkNet) / TU Dresden

IPPOG Goals

Sustainable Development of Particle Physics Outreach

- Discussion forums for scientists active in Education and Public Engagement
- Information exchange between individuals, institutions and laboratories
- Active working groups addressing specific challenges of global Outreach

Improving Outreach Standards Worldwide

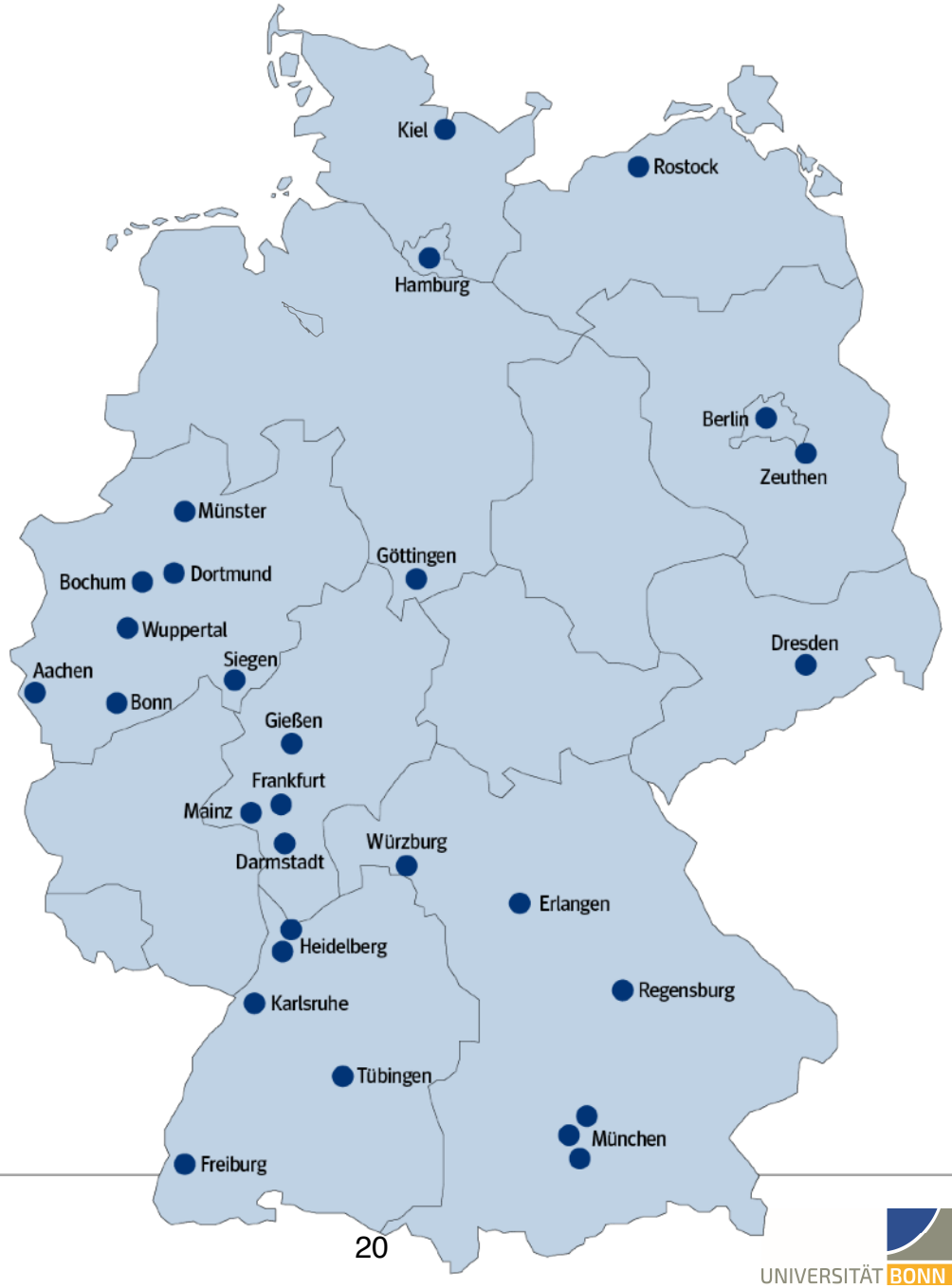
- Development of strategies based on current best practices and experience
- Long-Term links between scientists and education specialists
- Continual development & improvement of explanatory material

Extending Global Reach

- Expansion to countries and peoples underrepresented in particle physics
- Usage of new methods, activities and topics to reach broader audiences
- Active online communication platforms

Netzwerk Teilchenwelt

- Funded as integral part of research by the German Ministry of Education and Research
- KONTAKT[1] project funded since 2018, ErUM[2]=supporting program
- **30 sites** (universities/research labs + CERN)
- Joint outreach in particle, astroparticle and hadron (since 2018) physics
  - Bundle existing activities
  - Share structures and programs
  - → **High visibility and impact**



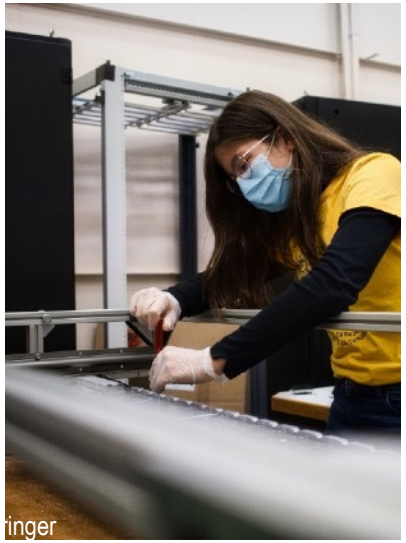
1) KONTAKT = **Ko**mmunikation, **N**achwuchsgewinnung und **T**eilhabe der **A**llgemeinheit an Erkenntnissen auf dem Gebiet der **K**leinsten **T**eilchen“
2) ERUM= Erforschung von Universum und Materie

Netzwerk Teilchenwelt

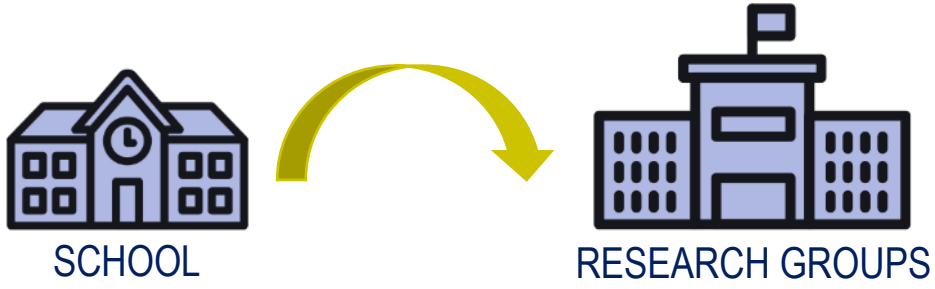
- Project team: TU Dresden / DESY / CERN

+ **3 hubs** in Bonn, Mainz & Münster
  - Raised funding for activities at Bonn hub of > 330000€

Core: Multi-step Program for High School Students



Fellow program



- 200 people, 50% female
- Mainly alumni of CERN workshops
  - →Often studying physics or shortly before that
  - →Close connection between highly motivated students and research groups

Central offers: Fellow physics schools (HEP, detectors),“Ask the expert“ sessions (online), national physics conference attendance, etc.

Local offers: internships, excursions, invitation to outreach events, colloquia, regulars´ table, etc.

Teachers as multipliers

- Development of material
  - Teaching material for schools, 4 volumes (>20k printed, >35k downloaded)
  - Portal Leifi Physik: Chapter on particle physics
  - Particle profile cards
  - GeoGebra Analysis of Bubble Chamber images
  - Context material

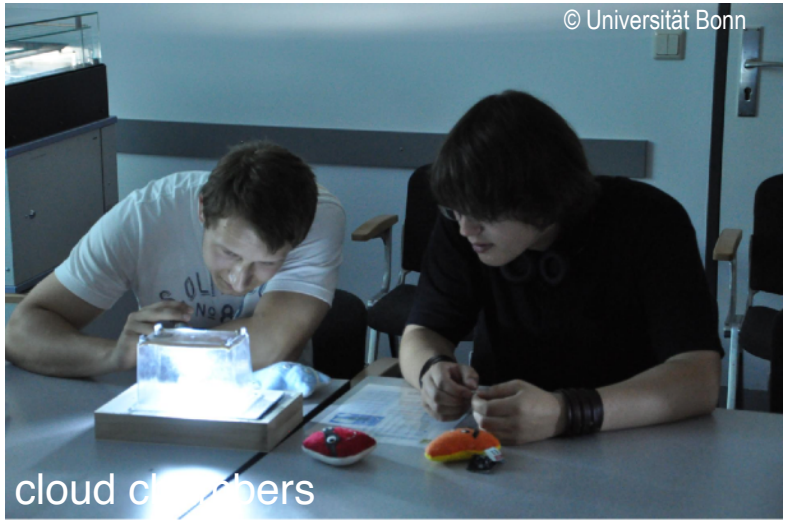
- Teacher training „Forschung trifft Schule“, funded by: Dr. Hans Riegel-Stiftung
  - 2-day training: Introduction to particle physics, 6 trainings p.a.
  - Summer School at CERN: 6 days, once per year

Student experiments on Astroparticle physics

- Experiments can be used in Masterclasses or workshops
- Teachers can borrow experiments for school

CosMO detector

Kamiokanne detector



cloud c[illegible]bers

Big Bang on the Road (Urknall Unterwegs)

- Interactive mobile exhibition modul on particle physics
  - Tunnel: time travel through the history of the universe
  - Columns: Interactions and particles, Research methods, spin-offs
  - Pavilion with games (Particle Twister, Particle Yenga)
- Target audience: general public, people with less affinity for science
- On the road since the end of July 2021

Science Communicators

- ~ 150 PhD and Master students
- Guide Masterclasses, supervise students´ research projects
- Influence students´ career-related aspirations and choices
- Reimbursement of expenses and travel cost
- Get training courses on communication, didactics, and presentation techniques

Netzwerk Teilchenwelt on social media

Webseite

Newsletter „Teilchenwelten“
3 x per year (Abo)

Facebook

Instagram

YouTube-Videos „Netzwerk Teilchenwelt mit Moritz“

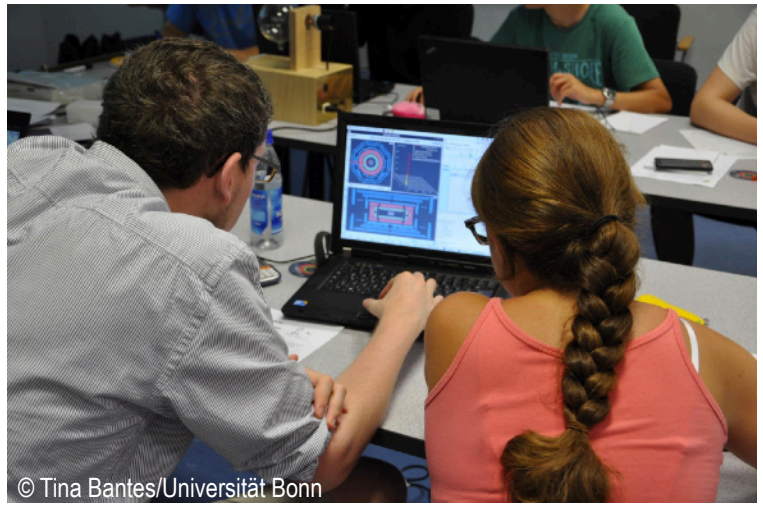
Netzwerk Teilchenwelt in Bonn - Who is involved?

- Head of Bonn hub: Barbara Valeriani-Kaminski
- Coordination hub activities: Maike Hansen
- Site contact: Barbara Valeriani-Kaminski & Nicole Felde

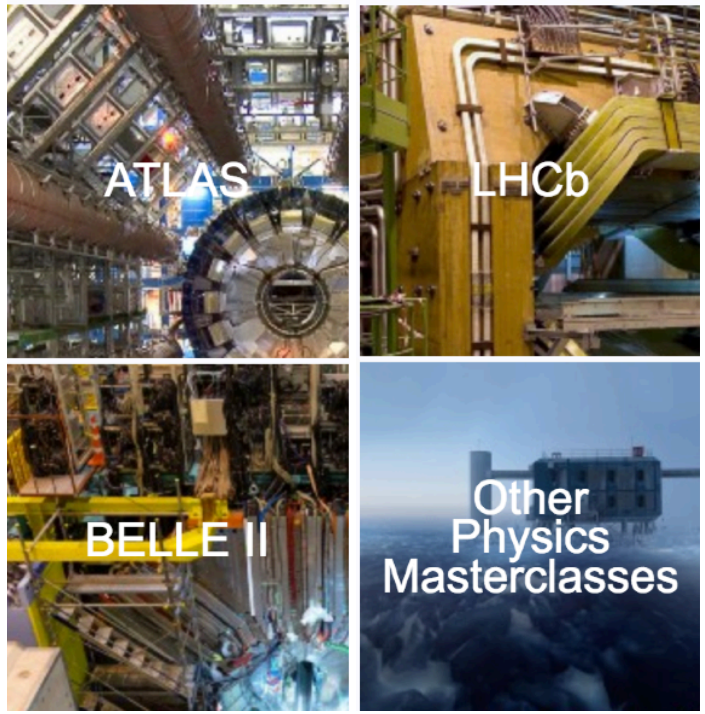
- Science communicators: 22 Master/PhD-students from ATLAS, BELLE II, LHCb, Lohengrin, ELSA, Detector development, BCTP & teachers

Activities at Netzwerk Teilchenwelt site Bonn

- International Masterclasses (ATLAS, Belle II, LHCb) at site
- Masterclasses in museums & schools in/around Bonn
- Student experiments related to astroparticle physics (e.g. cloud chamber workshops)
- Teacher Trainings on (astro-)particle physics (latest on 26./28.09.2022)
- Research projects for students
- Supervision of Bachelor-/Master theses in didactics related to particle physics outreach



A variety of Masterclasses offered in Bonn



Masterclasses

- **ATLAS W-Path**
- **Belle II**: Measure quark colors, Reconstruct B-mesons
- **LHCb**: Hadron Spectroscopy
- **Machine Learning** with OPAL data

In total 160 (international) Masterclasses since 2011 in Bonn

ATLAS W path

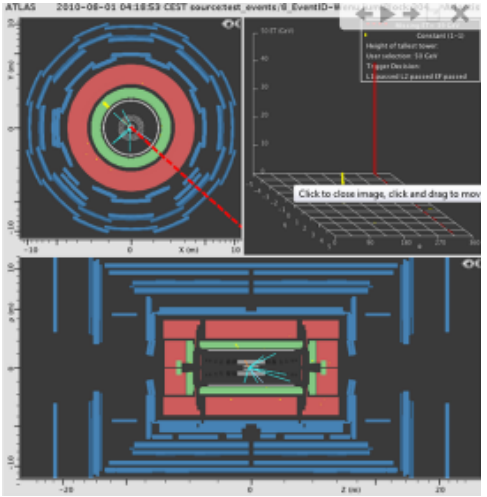
Students analyse event displays (50 collision events per pair of students)

2 tasks:

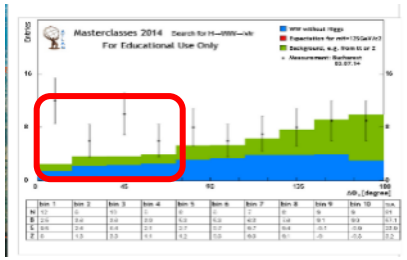
- Identify W bosons, determine type and electric charge of leptons
- Resulting W+/W- is used to reveal the inner structure of the proton (and compared to results from ATLAS)

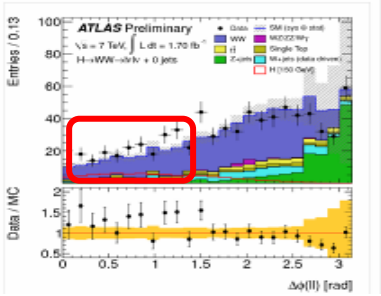
- Identify W pairs and measure azimuthal opening angle Δϕll
- Resulting histogram is used to provide insight into Higgs discovery process at CERN

https://atlas.physicsmasterclasses.org/en/wpath.htm



Total #	W → ... + ν				Background
532	e^+	e^-	μ^+	μ^-	
group A	9	4	10	1	24
group B	11	12	13	10	19
group C	5	3	1	1	19
group D	7	4	11	5	21
group E	11	10	3	2	31
group F	15	3	3	1	26
group G	6	4	3	5	27
group H	15	10	3	2	13
group I	5	3	3	4	5
group J	4	0	1	0	21
group K	5	1	5	3	18
group L	4	7	4	2	31



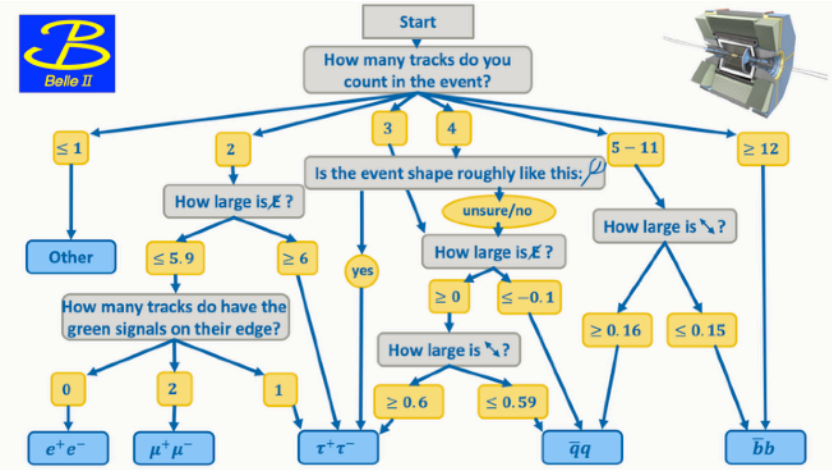


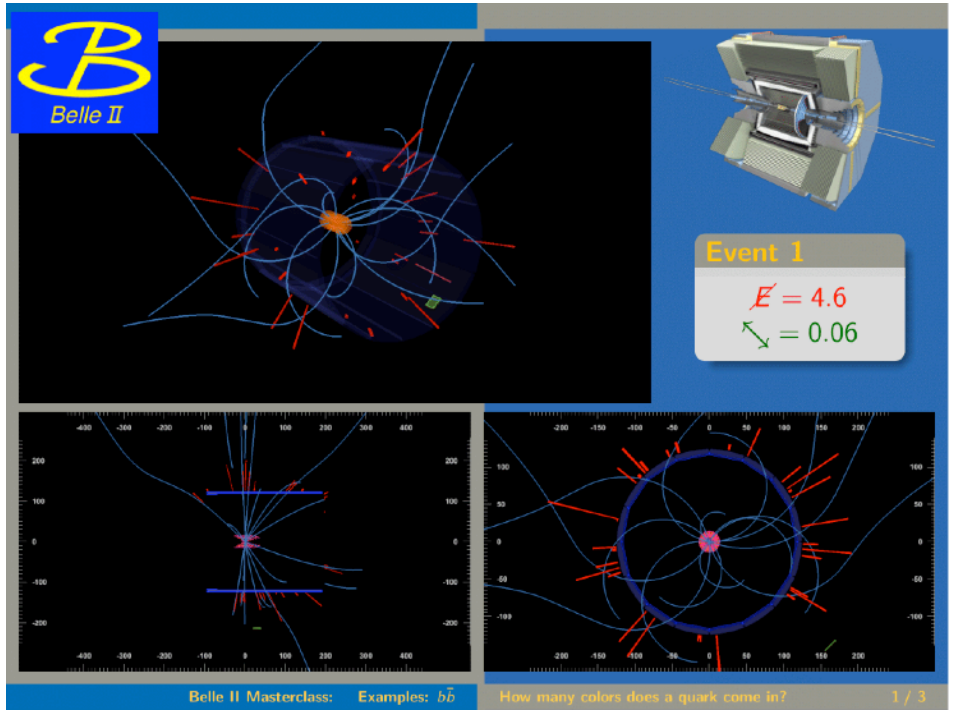
Belle II MC: Measure Quark Colors

Students analyse event displays (50 collision events per pair of students)

Task:

- Categorise Events by final state
- Measure R-Value i.e. in how many colours does the quark come in
- https://belle2.ijs.si/public/home/quark-colors/





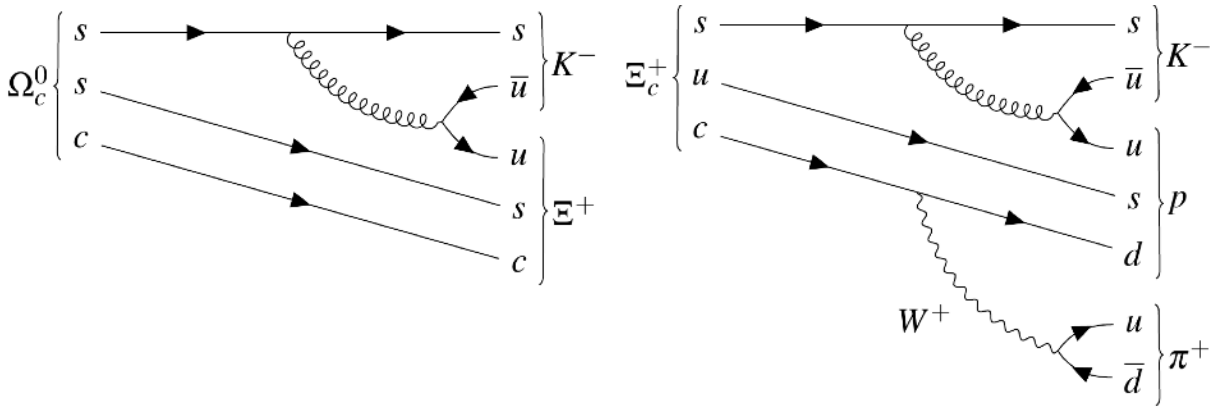
Data set A

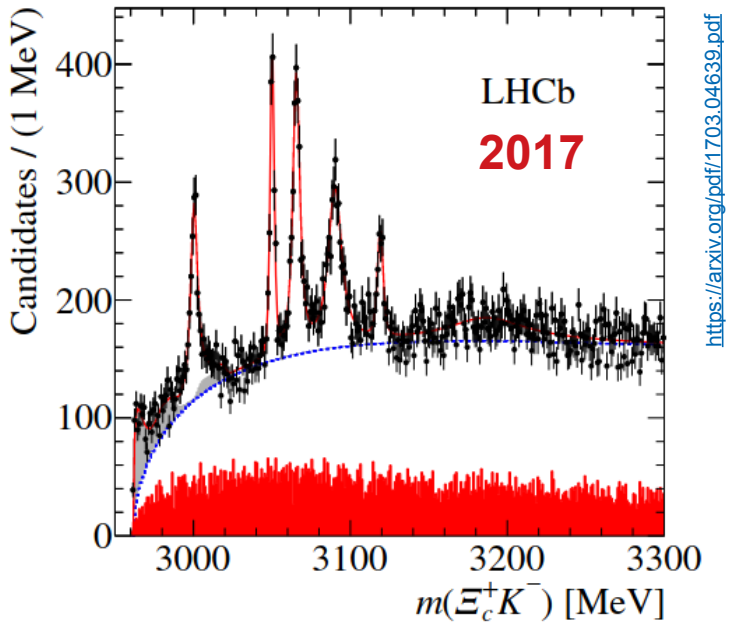
		Event type					
Event	Classified	ee pair	μμ pair	ττ pair	qq pair	bb pair	Other
1		☐	☐	☐	☐	☐	☐
2		☐	☐	☐	☐	☐	☐
3		☐	☐	☐	☐	☐	☐
4		☐	☐	☐	☐	☐	☐
5		☐	☐	☐	☐	☐	☐
6		☐	☐	☐	☐	☐	☐
7		☐	☐	☐	☐	☐	☐
8		☐	☐	☐	☐	☐	☐

Developed by research group of Prof. Dr. Bernlochner & Prof. Dr. Dingfelder

LHCb - Hadron Spectroscopy

Students analyse LHCb data and observe resonances in the decay

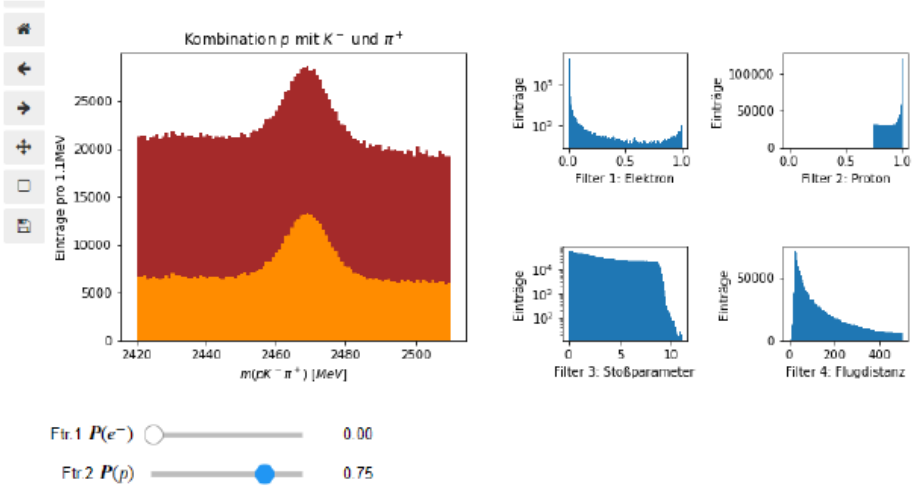




https://arxiv.org/pdf/1703.04639.pdf

Aim:

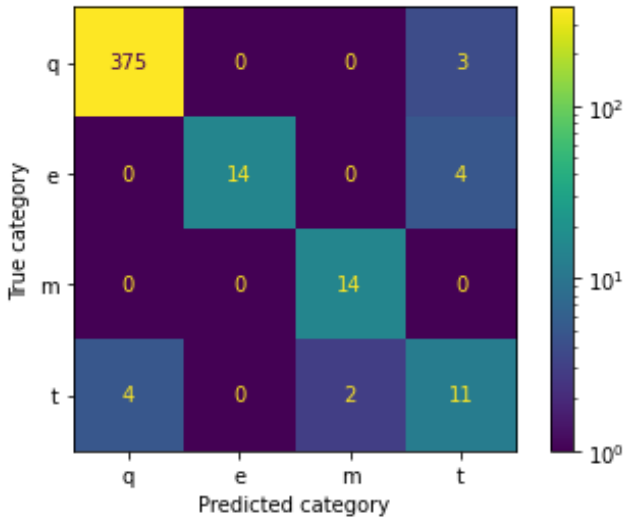
- Introduction into reconstruction of decay chains, visualisation of variables, cut selection and fit of models to a histogram
- Analysis based on interactive Jupiter Notebook using python



Developed by research group of Prof. Dr. Neubert

Machine Learning with OPAL data

- Classify Z decays using machine Learning methods
- Analysis based on interactive Jupiter Notebook using python
- Goal: Classify Z-decays most accurately and measure branching ratios



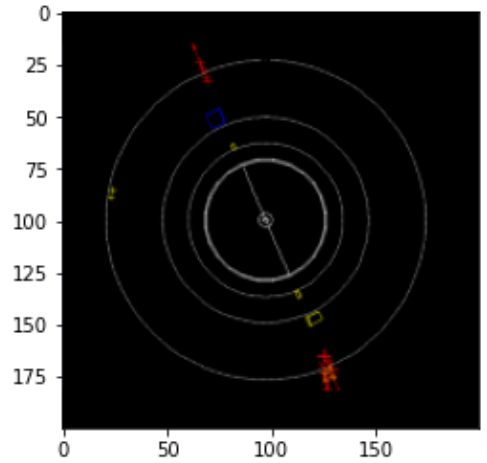

```
In [2]:  eventliste = load_events()

         609 events loaded
```

Mit `eventliste[x]` kann auf das `x-1` -ste Ereignis zugegriffen werden.

Die Methode `.show_image()` gibt das Ereignis grafisch aus.

```
In [3]:  eventliste[53].show_image(show_category=True)
```

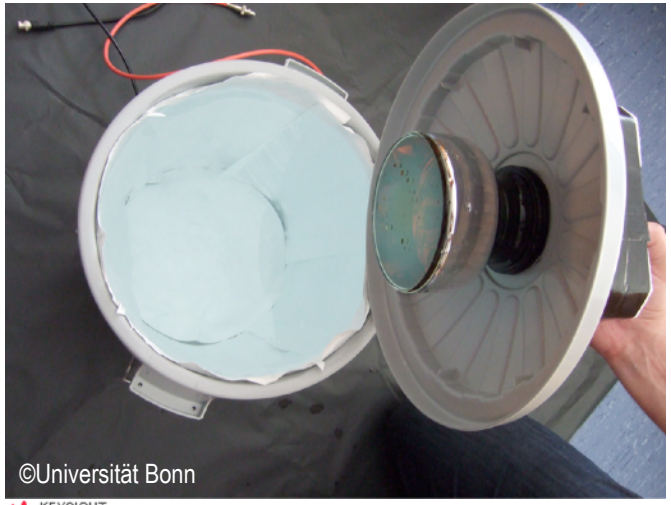


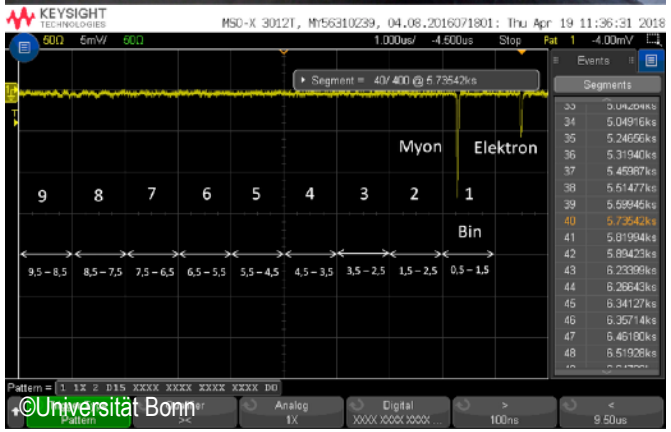

```
Name: z5293_15219.png     Category: m
```

	Roh		TV		TV verm		Train		Vali		Test		Vorh		Theory
#Evt:	609		182		2313		1850		463		427		427		
q:	529	86.86%	151	82.97%	453	19.58%	376	20.32%	77	16.63%	378	88.52%	379	88.76%	87.38%
e:	24	3.94%	6	3.30%	360	15.56%	268	14.49%	92	19.87%	18	4.22%	14	3.28%	4.20%
m:	27	4.43%	13	7.14%	780	33.72%	637	34.43%	143	30.89%	14	3.28%	16	3.75%	4.21%
t:	29	4.76%	12	6.59%	720	31.13%	569	30.76%	151	32.61%	17	3.98%	18	4.22%	4.21%

Theses in didactics related to particle Physics/Netzwerk Teilchenwelt

- Stefan Harst, *Entwicklung einer LHCb Masterclass zum Thema Hadronenspektroskopie*, **November 2021**
- Sebastian Lülsdorf, *Development of a didactic concept on the measurement of the R cross section ratio within the context of the Belle II - Masterclass*, **September 2021**
- Jannik Stammnitz *Weiterentwicklung der Belle II Masterclass* **November 2020**
- Malte Koch, Fertigstellung und erste Messungen mit der Schul-TPC, **Mai 2020**
- Kai Gerschlauer, Ein spielerischer Ansatz zur Vermittlung von Feynman-Diagrammen, **März 2020**
- Inga Woeste, Erprobung und Evaluierung des Vorbereitungskurses für die Teilchenphysik-Masterclass des Netzwerks Teilchenwelt, **September 2019**
- Johanna Rätz, Eine Suche nach neuer Physik basierend auf dem ATLAS-Experiment für die International Masterclass, **August 2019**
- Michael Geldermann, Entwicklung von Lehrmaterialien zur Messung der Lebensdauer des Myons mit einem Cherenkov-Detektor, **September 2018**
- Felix Scherfose, *Moglichkeiten zur Lebensdauermessung kosmischer Myonen mit der Kamiokanne fur den Einsatz im zdi-Schulerlabor Physikwerkstatt Rheinland*, **November 2015**
- Linda Kühlem, *Entwicklung von Begleitmaterialien für die Teilchenphysik-Masterclasses des „Netzwerk Teilchenwelt“*, **August 2015**



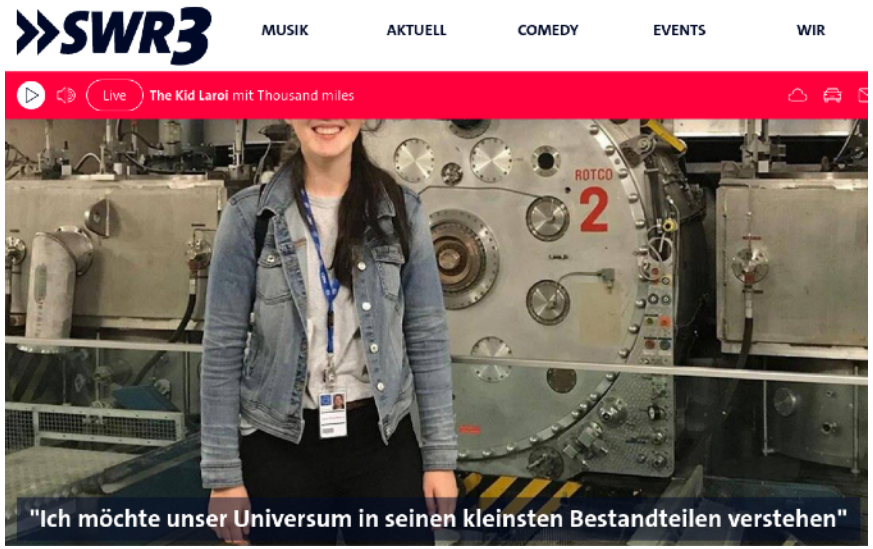


cosmic4school

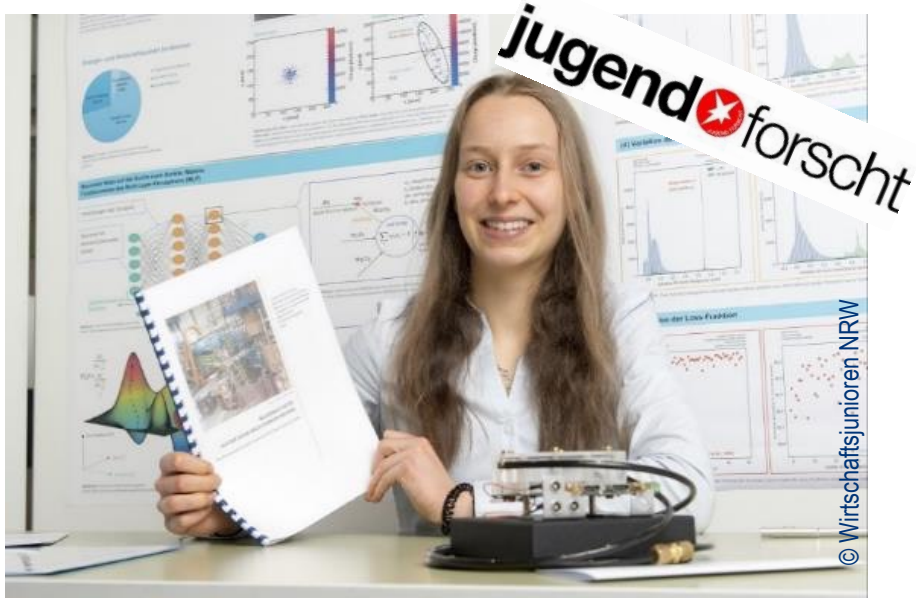
Average number of Students in step program in Bonn

Avg # students from Bonn/year	15 Masterclasses → ~300	4-6	1-2

Student research projects: examples from Bonn



- Lebensdauer von B-Mesonen (Justin Skorupa, 2013)
- Datenanalyse beim Hadronischen Kalorimeter (Lavinia Thimm, 2014)
- Untersuchung von Ereignissen mit zwei hadronischen Tau – Leptonen bei ATLAS (Naomi Davis, 2015)
- Search for Supersymmetry and Dark Matter (Sophie Li, 2017)
- Erste Datenklassifikation des InGrid Detektors am CAST Experiment mittels Deep Learning (Carolin Kohl, 2018)
- Studien zur Zeitauflösung des VMM3a ASICs (Daniel Kloppenburg, 2019)



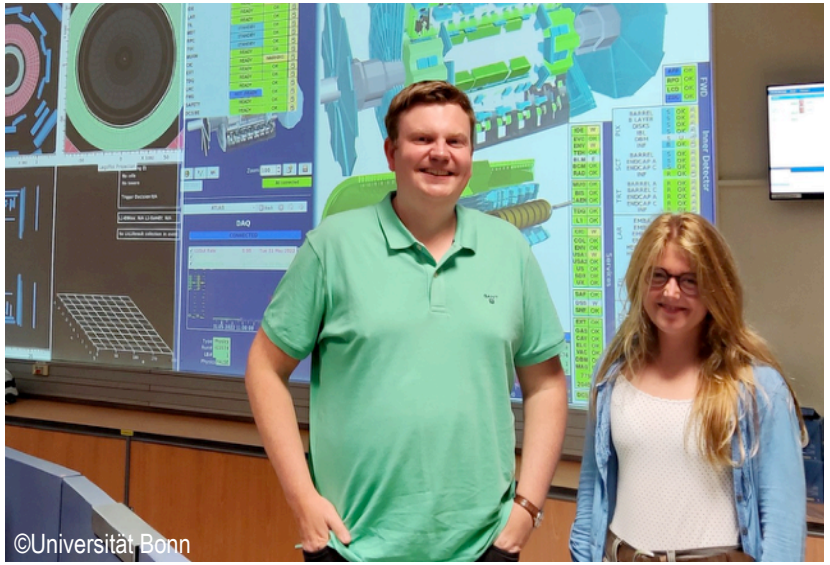
CERN Project Weeks (24 October 2022 - 5 November 2022): https://indico.cern.ch/event/1147898/

- Two students from Bonn, ATLAS Analysis supervised by Christian Grefe

Events for the general public

Workshop for kids

Workshops, talks & guided lab tours e.g.for 10 years Higgs discovery (July 4, 2022)



Evening Talk by Dr. Christian Grefe & Lena Herrmann

Guided Lab Tours in FTD

Goals of Netzwerk Teilchenwelt hub Bonn

1. Expand cooperation between the universities

2. Develope new formats of science communication

3. Educate & recruit new science communicators

1. Expand cooperation between the universities

Corporation with other Institutions

- Workshops and booth at MINT-EC[1] principal & teachers meeting (4.-5.11.2022, Koblenz) with Bochum & Karlsruhe
- MINT-EC Camp on particle physics: masterclass, lab tours & science video skills workshop for high school students with Guillaume Durey from CERN
- Organise regular meeting with local site contacts

Tandem Masterclasses

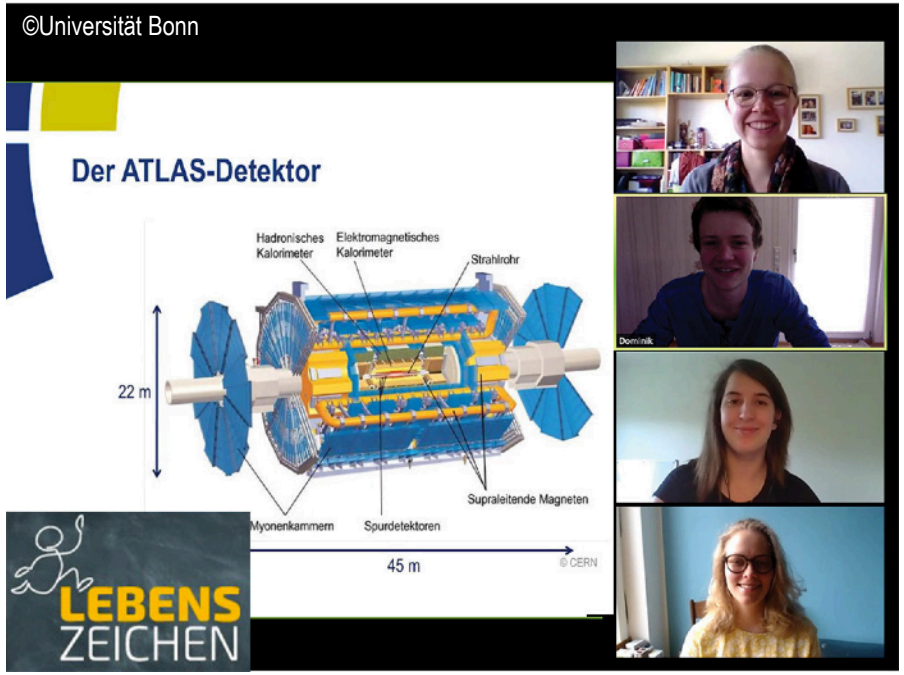
- Tandem masterclasses with communicators from different sites/universities
- E.g. Machine Learning Masterclass with OPAL (02.11.2022 & 12.01.2023)
  - Cooperation with PUNCH4NFDI & University of Münster
- Cooperation with other universities for Masterclasses@home

Activities for Fellows

- Workshop on Auger Open Data with Julian Rautenberg (University of Wuppertal)
- Excursions (e.g. DLR research center, FZ Jülich, Astropeiler Stockert)
- Guided Lab tours
- A Coffee with a scientist ("Teilchencafe")

1) German excellent cluster of schools with STEM focus

2. Develope new formats for science communication



Science Snacks – Kurzvorträge & Experimente prest. by Jacob Beautemps

Physikshow Uni Bonn
677 Abonnenten
Abonnieren
77
Teilen
Speichern

2513 Aufrufe vor 1 Jahr gestreamt
Im Rahmen der Woche der Teilchenwelt (https://www.wochederteilchenwelt.de/) lädt die Rheinische Friedrich-Wilhelms-Universität Bonn zu einer Online-Abendveranstaltung für die breite Öffentlichkeit ein.
...mehr

https://www.youtube.com/watch?v=javONfk7LLQ

- Masterclass@home (premiere 28.4.2020)
- Science Snacks: 5 min talks on modern (astro-)particle physics experiments
- **Workshop on science videos** for young students in corporation with Guillaume Durey from CERN

Science Video Skills Workshop

- 3-days workshop (29.6.-1.7.2022) for high school students
- Location: Deutsches Museum Bonn & PI (+guided ELSA tour)
- Cooperation with Guillaume Durey (CERN)

- Learn to produce short scientific videos for Youtube, TicToc etc.
- Film & present own hands-on experiment
- **Next date: 6.2.-10.2.2023** with focus on particle physics/ CERN experiments

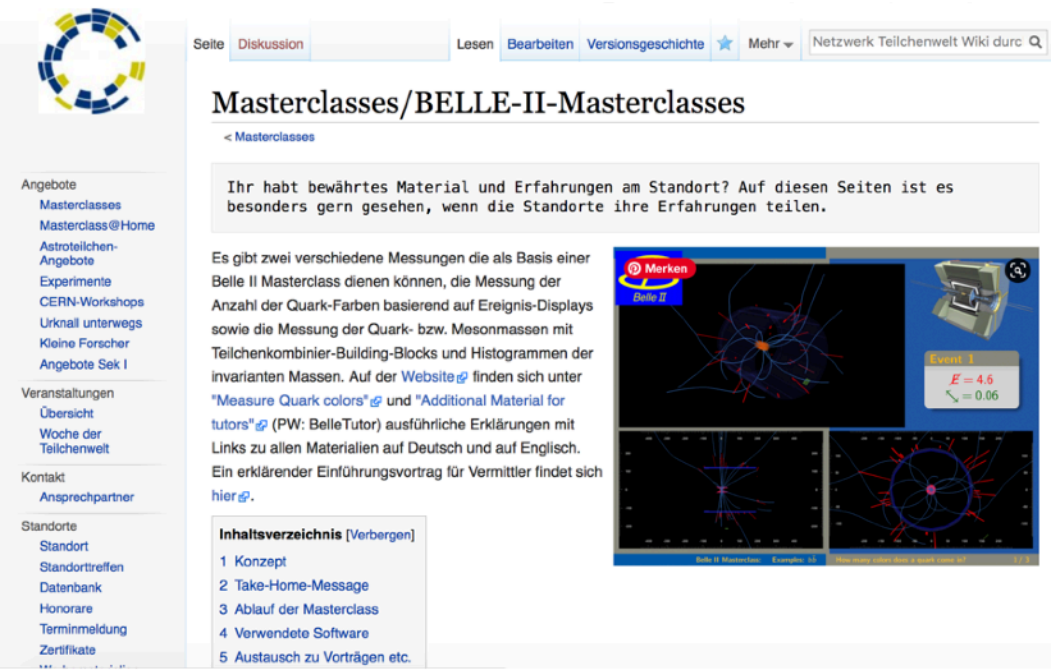
3. Educate & recruit new science communicators

Enrich potential group of science communicators

- Support other sites to recruit & educate new science communicators
- Offer on-boarding & science communication workshops
- Include students with no/little german linguistic proficiency
  - Translate materials, corporate with international schools

Expand & improve NTW Wiki-page

- Provide documentation of new (& existing) formats & materials
- Keep it:
  - a useful tool for science communicators
  - a platform for exchange of materials, talks, experiences among different sites
- Register here to benefit & contribute



Workshops for science communicators

The Basics 1x1 - On-boarding for new students

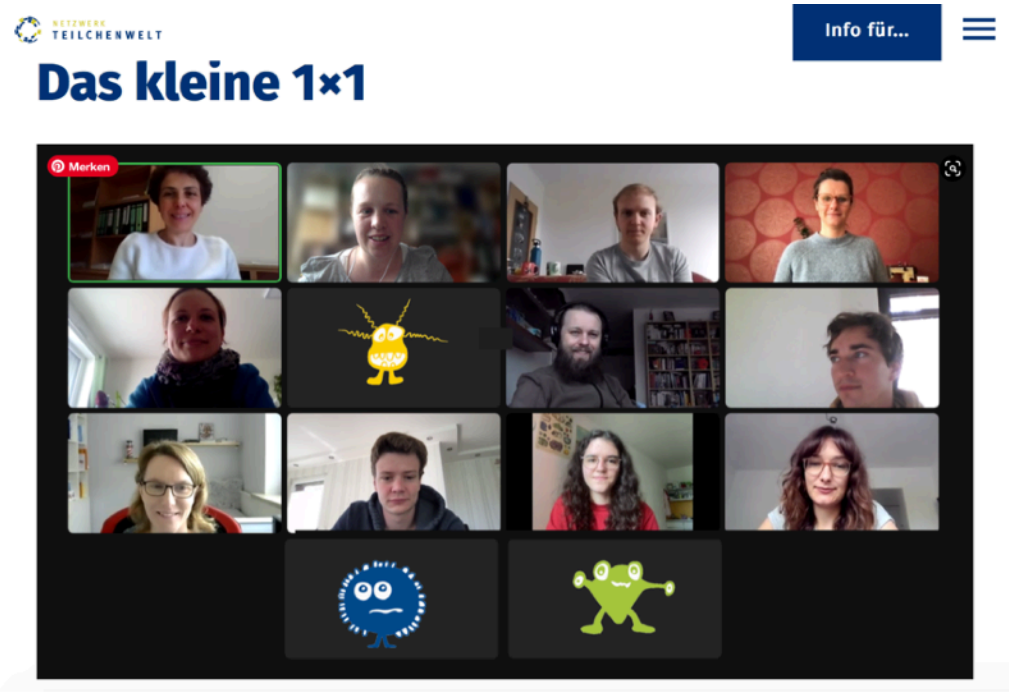
- Regular format every three month
- Next date: 25.11.2022 10:00 - 11:00 am
- https://indico.cern.ch/event/1200379/

Spotlight On - Introduction into one example Masterclass

- Regular format (always subsequent to on boarding event) with alternating topics
- 25.11.2022 11:00 - 12:00 CMS-Masterclass

Workshop on science communication & Masterclasses (in english):

- 19.-21. April 2023 Bad Honnef



Workshop on science communication & Masterclasses (in german):

- Facilitator's workshop, once per year, introduction in didactics, science communication & interactive methods for Masterclasses
- **Link** for this year's workshop
- 20. - 22. Februar 2023 Fulda

Why join the effort?

win-win

- Become a science communicator
- Perform Masterclasses or supervise research projects
  - Be a role model
  - Talk about your research
  - Acquire soft skills, for personal and professional development
  - Experience interest in own research
  - Practice supervision
  - You are paid with a fee of 100€ (for a 1-day event) + travelling costs

Summary

- Informing the **public** is our duty as scientists
- Inspiring the **next generation** is an important task
- **Masterclasses** are a proven and robust (COVID19!) tool for outreach and comes in many flavours
- **IPPOG** is a collaboration working on sustainable development of particle physics outreach and improving outreach standards worldwide
- The German network **Netzwerk Teilchenwelt** uses Masterclasses as the basic stage in a sustainable program to attract and promote young STEM talent
- Existing programs and structures create **multiple benefit**
  - win for **high school students**: experience modern research first-hand
  - win for **science communicators/PhD students**: train their communication skills, participate in a rewarding activity
  - win for **physicists**: get young talents for the research groups

You are enthusiastic about outreach?

- Join the effort!

Contact:

Dr. Barbara Valeriani-Kaminski

bonn@teilchenwelt.de

James Montgomery Flagg, Public domain, via Wikimedia Commons

Lets meet at our annual coffee meeting!

Get together of Netzwerk Teilchenwelt science communicators in Bonn

- October 25, 2022, 3 pm, conference room II
- Get to know us & other students
- Talk to experienced and new science communicators
- Have delicious coffee & cake

To conclude …

Kahoot!

….let’s do a Quiz :)

Mitmachen bei **www.kahoot.it**
oder mit der **Kahoot!-App**

Spiel-PIN:

319 279

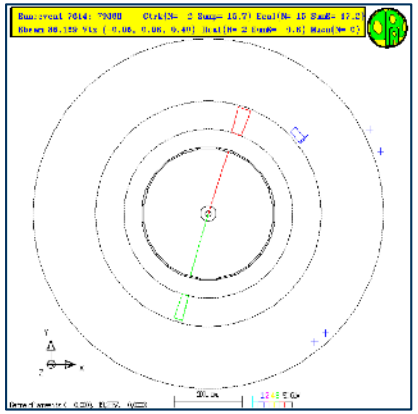
https://create.kahoot.it/details/c9ababe3-42a8-4c4e-bb59-7a2f8eee0027

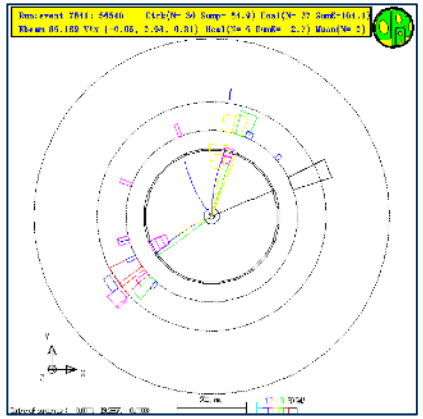
Thank you for your attention!
Questions?

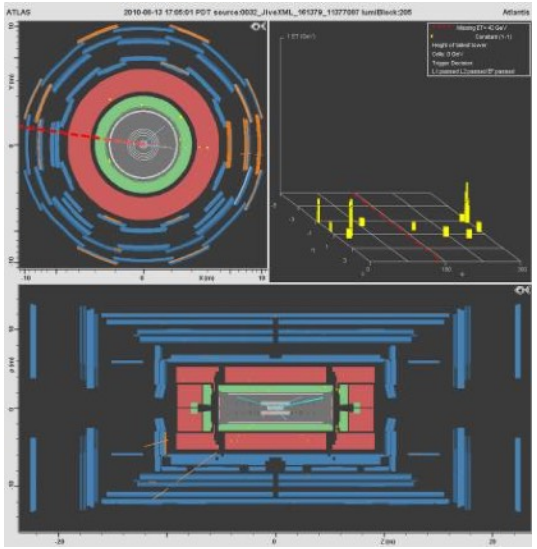
Backup Material

Brief History of Masterclasses

- 1996: Idea from R. Barlow et al.
- 1997: 1. Masterclass in UK with 7 institutes
- 1998: nationwide uptake
- 2005: Adopted by EPPOG/IPPOG for all Europe
- Use of LEP data
  - OPAL Identifying Particles
  - DELPHI Hands on CERN
- 2006: U.S. joined program (QuarkNet)
- 2011: LHC-based Masterclasses only
- 2014: all 4 LHC experiments







http://cerncourier.com/cws/article/cern/55890 (How it all begun)
http://cerncourier.com/cws/article/cern/57305 (MC in the LHC era)

Broad Physics Scope

Today:

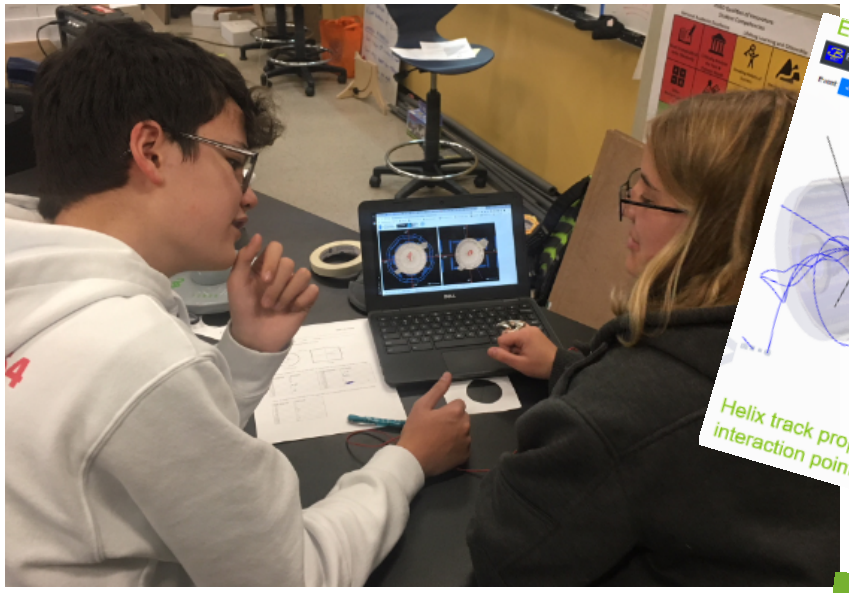
- LHC (since 2005)
- MINERvA (since 2019)
- Belle II (since 2020)
- Particle Therapy (since 2020)

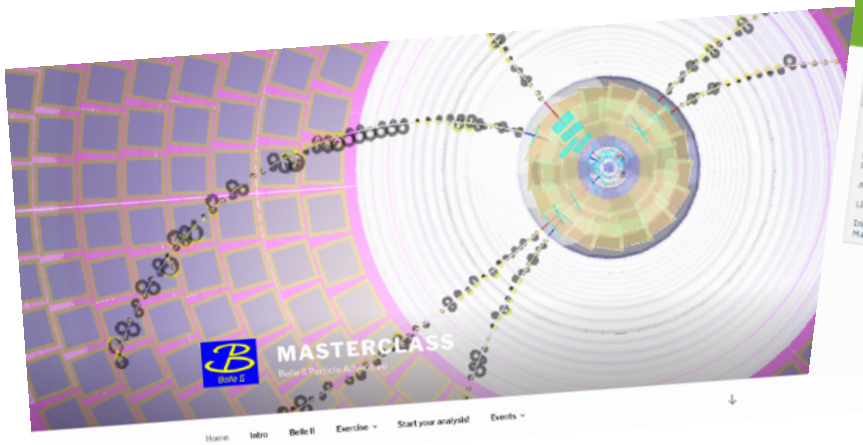
Under development:

- NOvA
- MicroBooNE

More Masterclasses:

- IceCube
- Pierre Auger
- DarkSide
- …





IPPOG

International Scientific Collaboration

- Active Researchers with Experience in Education & Public Engagement
- Experts in Communication & Education

Global Network

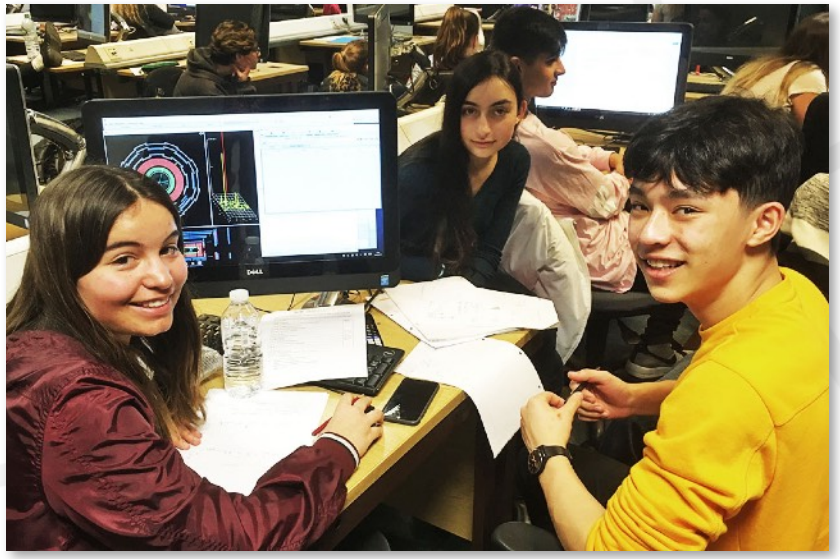
- 37 members: 30 countries, 6 experiments, 1 intl lab (CERN)
- 2 associate members: 2 national labs (DESY, GSI)

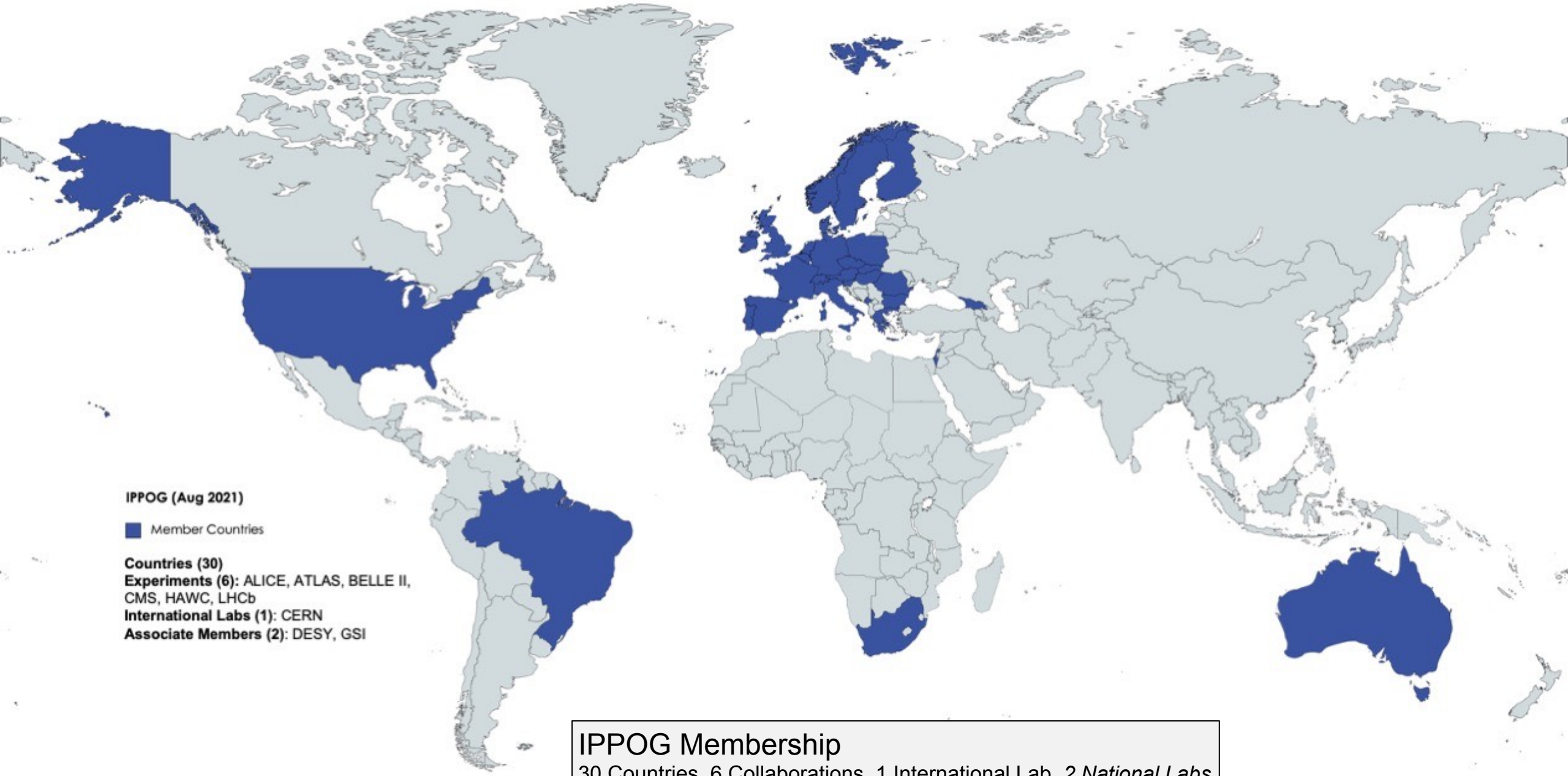
Organise Global Activities

- International Particle Physics Masterclasses
- World-Wide Data Day, Global Cosmics, etc.

Support Local Activities

- Sharing of expertise, best practices, material database
- Resources to support events, kick-start activities





IPPOG Membership

30 Countries, 6 Collaborations, 1 International Lab, *2 National Labs*

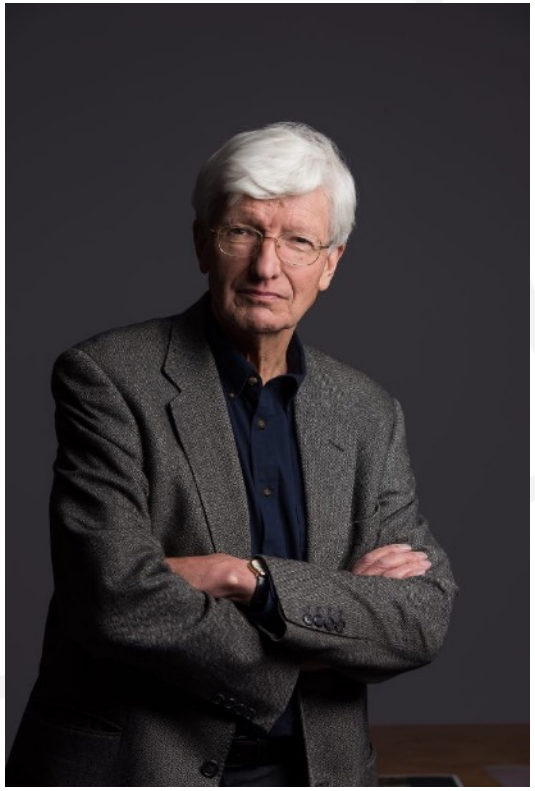
IPPOG Origins

1997 Birth of European Particle Physics Outreach Group (EPPOG)

formed under the joint auspices of ECFA and EPS-HEPP

> *"…the particle physics community has a moral obligation to inform the public on its activities. To do this well, experiences must be shared among countries in view of the need to optimize the use of resources."*

- Chris Llewellyn-Smith, CERN DG



2005 Launch of International Masterclasses

2011 Global Expansion to IPPOG

Israel, Australia, USA (now South Africa, Brazil,…)

2016 Formal Scientific Collaboration

Memorandum of Understanding

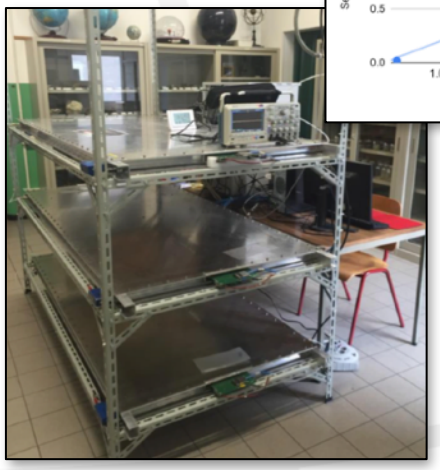
Activitites

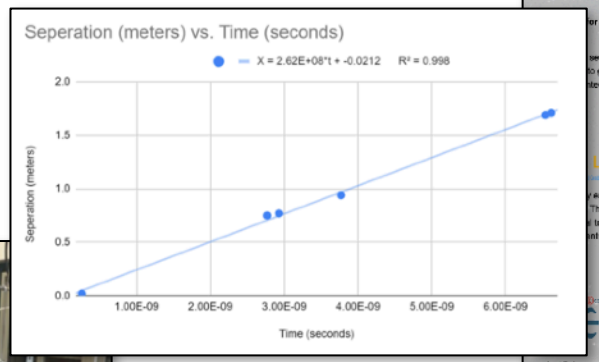
International Masterclasses

Global Cosmics

- High School Initiatives Exploring Cosmic Rays
  - International Muon Week
  - International Cosmic Day

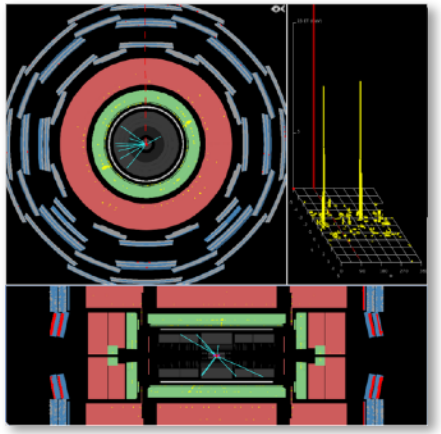
Resources Data Base





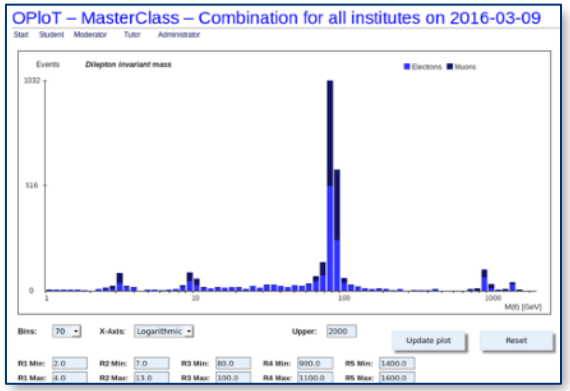
ATLAS Z path

- Students search for 2-lep, γγ, or 4-lep events
- Calculate invariant mass, upload results to a plotting tool
- Results are combined, invariant mass distributions are built



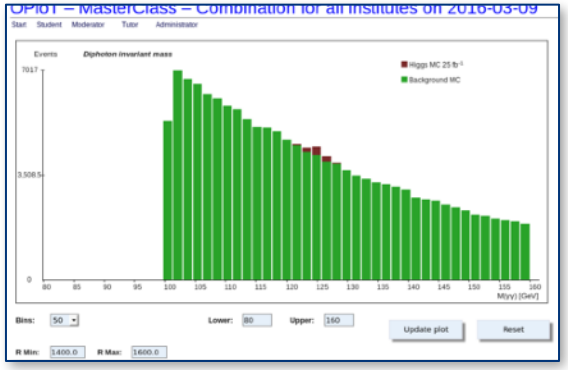
2-lep invariant mass distribution:

- Resonance peaks of known particles: Z^0, J/Ψ, Y
- Search for new particles: Z‘, graviton



4-lep, di-photon:

- Provide insight into the process of discovering the Higgs at CERN
- Explain concepts of statistics, modelling, signal significance

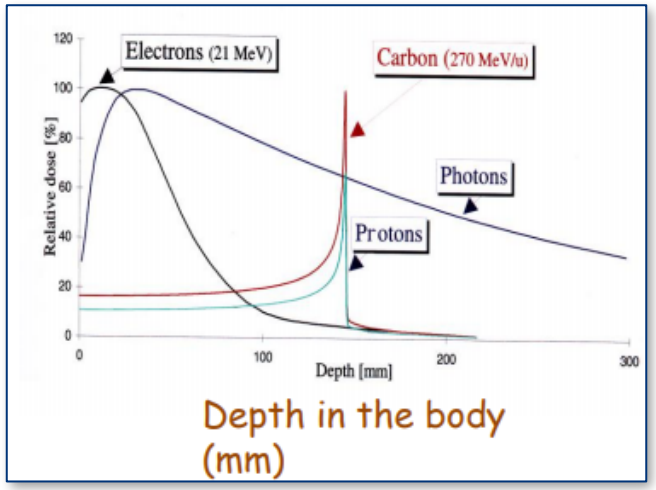


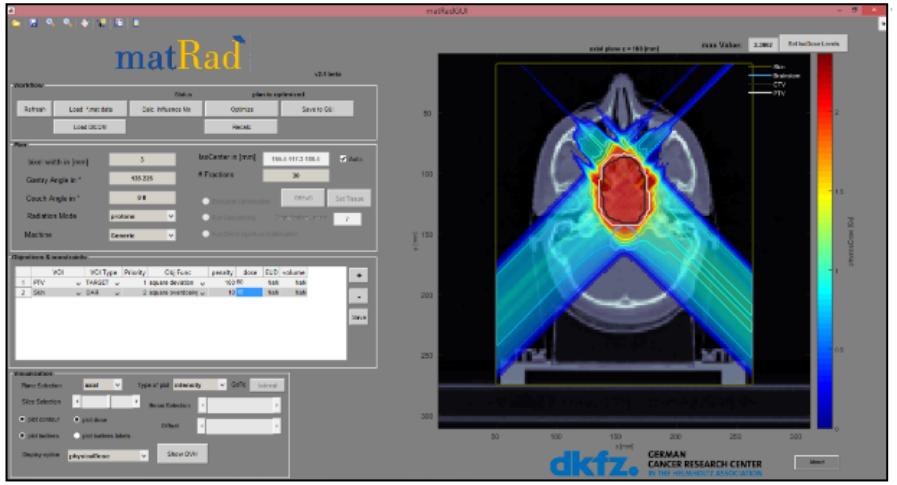
https://atlas.physicsmasterclasses.org/en/zpath.htm

Particle Therapy Masterclass

- Particle treatment planning
- highlights some of the benefits for society from the technology developed for particle physics research

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

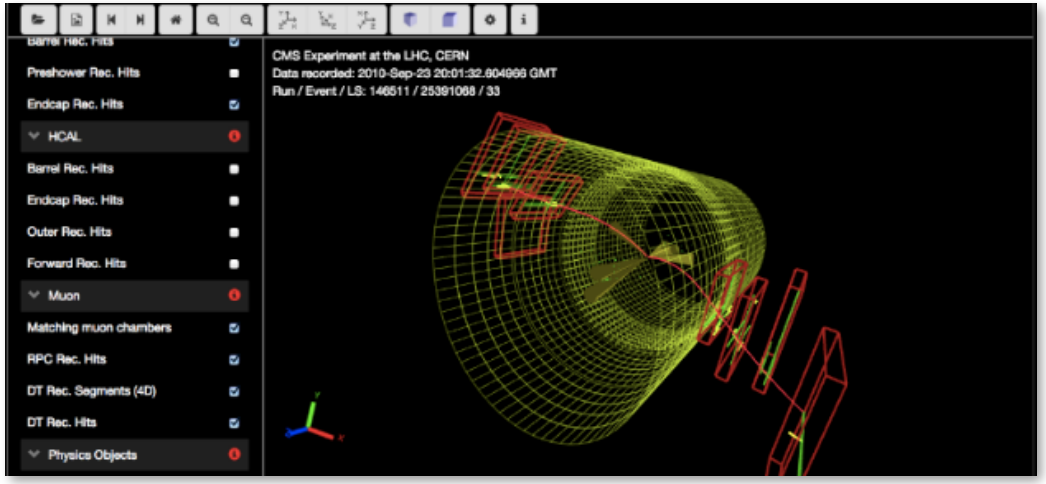


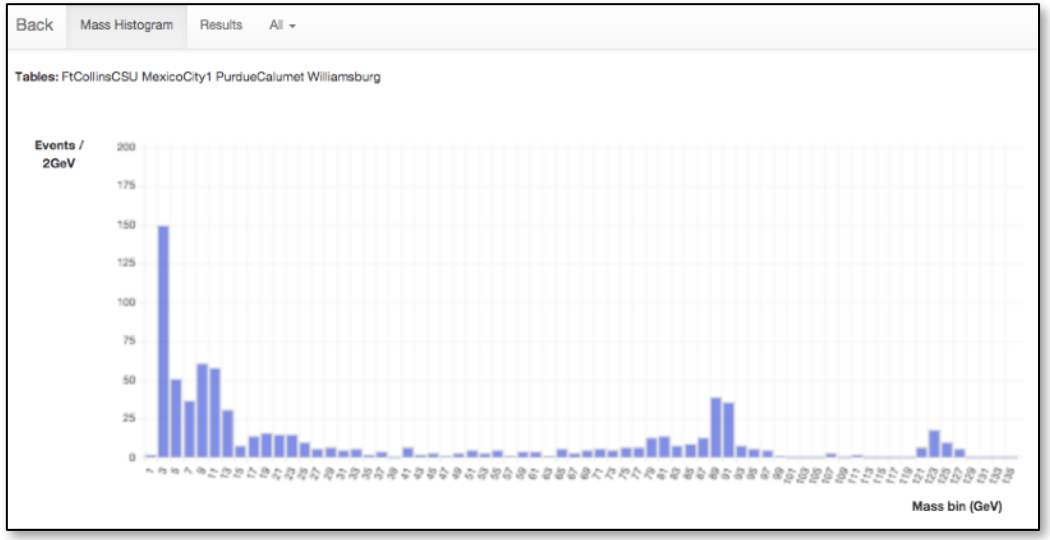


CMS WZH measurement

- WebGL 3D event display
- 1-, 2-, and 4-lepton events
- Students characterize W, Z, and Higgs candidates
- Create 2-l and 4-l mass plots of standard model particles, plus Higgs
- Ratios W+/W-, e/m

https://web.quarknet.org/mc/cms/imc2021/cms.html

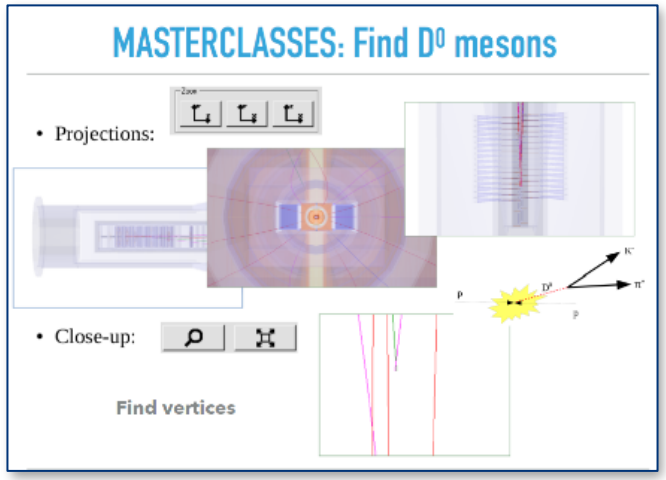


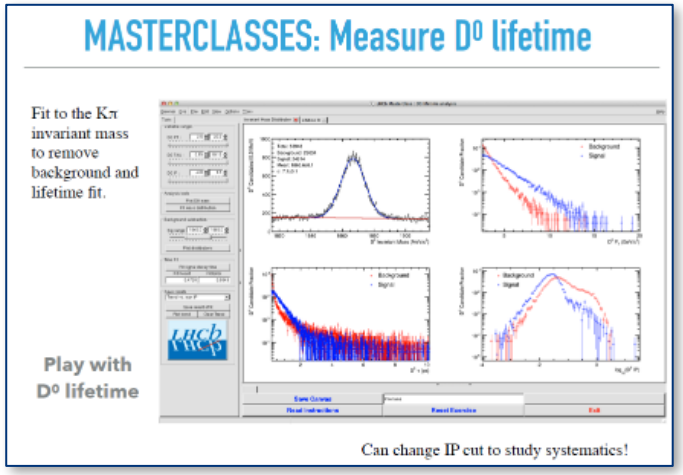


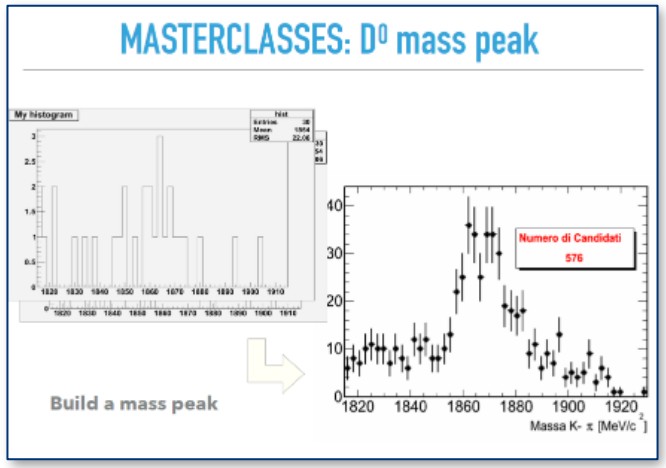
LHCb Masterclass

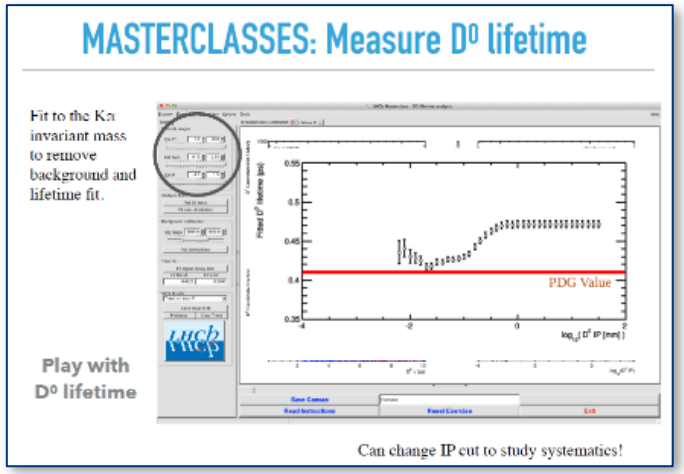
- Students search for the $D^0 \rightarrow K\pi$ decay using an event display
- Students perform a lifetime measurement at the 1 % level
- Live merging of histograms from all groups in the VC

https://lhcb-public.web.cern.ch/en/LHCb-outreach/masterclasses/en/





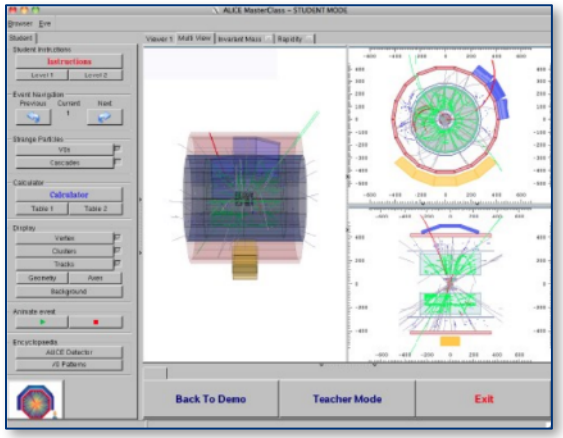


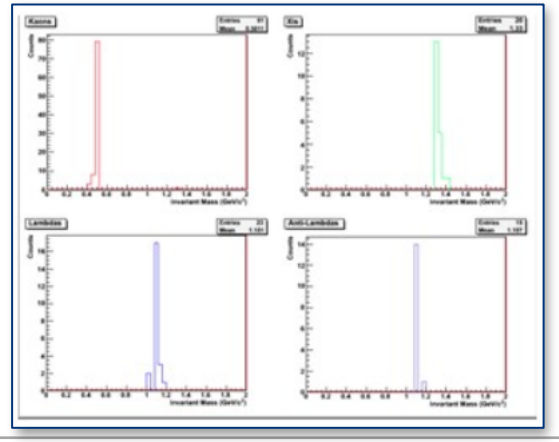


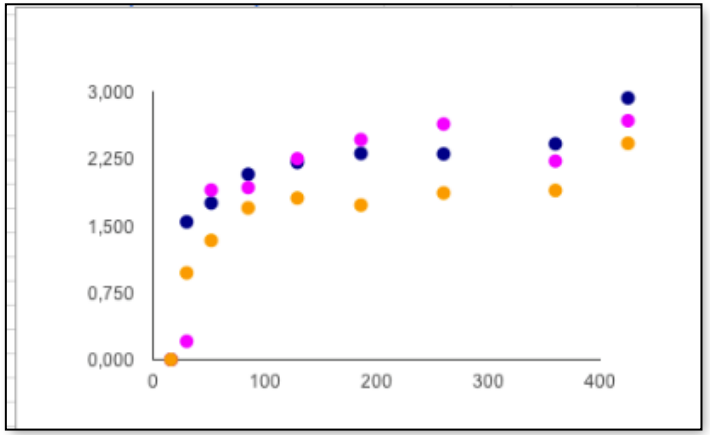
ALICE I: Looking for Strange Particles

- Visual identification of V0s from decay pattern, invariant mass calculation
- First part: visual analysis of ~ 15 events per group
- Second part: Calculation of numbers of Ks, Λ , anti Λ from invariant mass distributions (fit gaussian/ polynomial to peak/background; subtract background) for different centrality regions in lead-lead collisions
- Concepts conveyed: invariant mass; centrality of PbPb collisions; background
- Results: observe strangeness enhancement in PbPb collisions comparing with pp collisions

https://alice-masterclass.web.cern.ch/



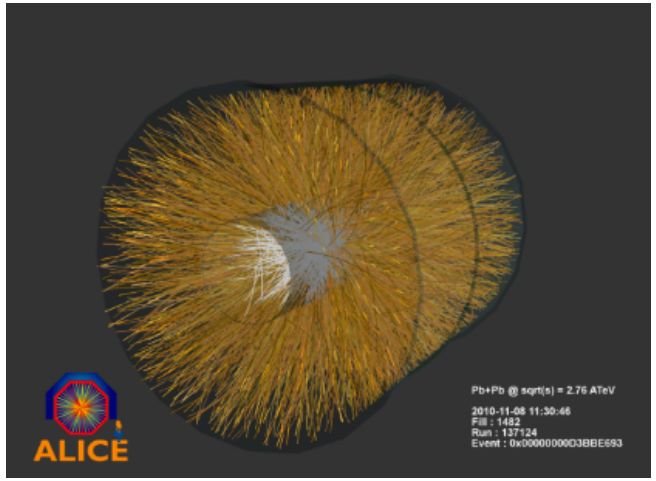


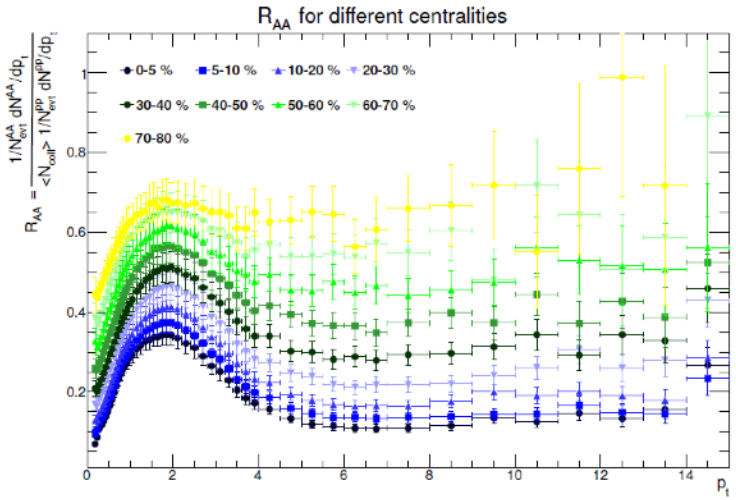


ALICE II: Nuclear Modification Factor

- event-display based visual analysis
- RAA simply via counting of tracks
- ROOT based large scale analysis
- RAA as a function of momentum in various Pb-Pb centrality classes
- students discover jet suppression!

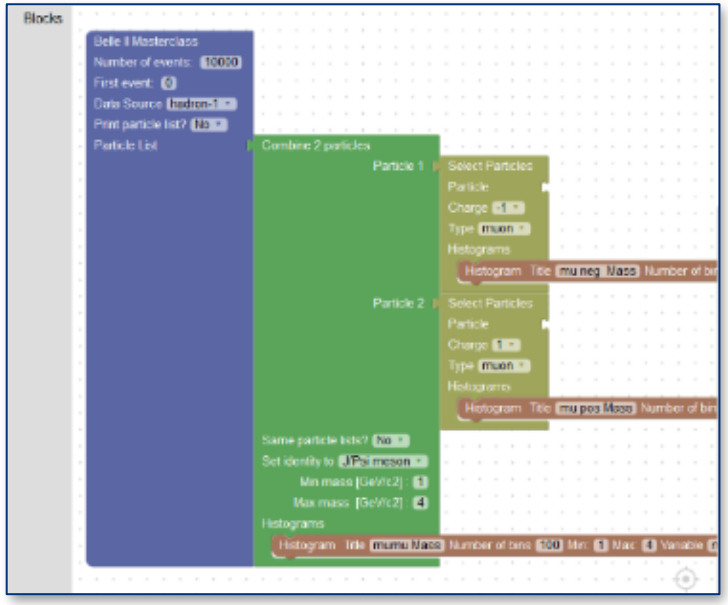
http://www-alice.gsi.de/masterclass/



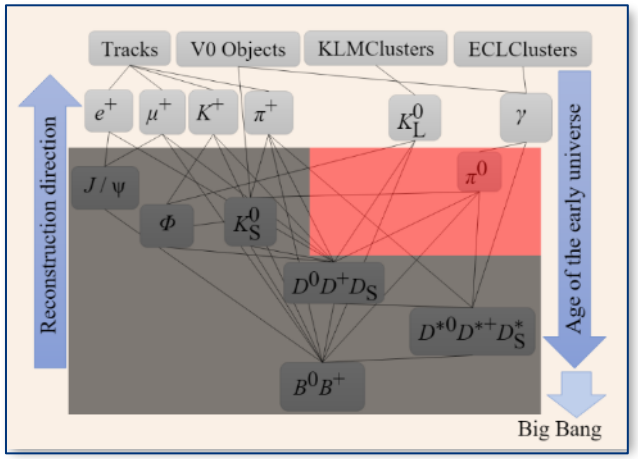


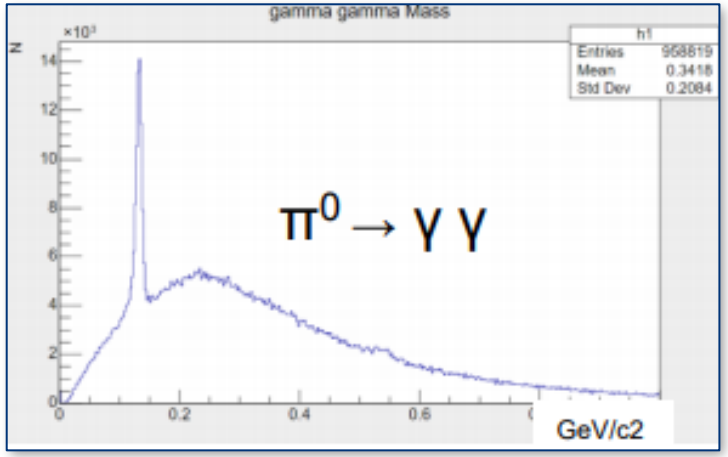
Belle II Masterclass

- Shows students how to code B-physics analysis
- Students describe decays, make simple cuts, “discover” particles
- Visual code editor Blockly
- Running from the web or download virtual machine
- Analysis of 6M clean reconstructed events
- Basic/advanced level (fit peaks, determine width)
- Videoconference with KEK



http://belle2.ijs.si/public

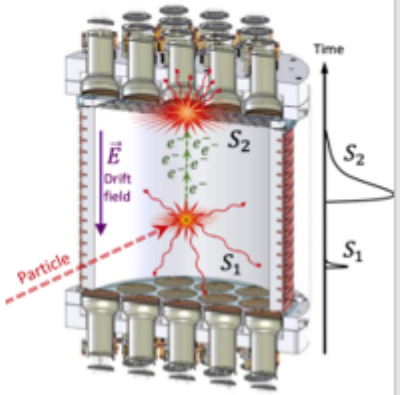
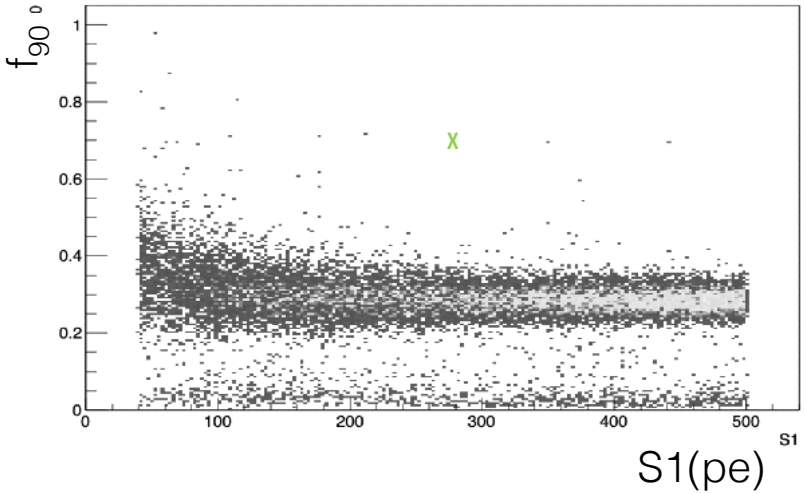




Darkside Masterclass

- By Francesca Carnesecchi, University and INFN of Bologna, Centro Fermi Roma, et al.
- Darkside experiment at Gran Sasso
- Dark Matter / WIMPs in a dual phase Ar TPC
- Talks on DM and Darkside experiment
- Data analysis via excel
- Reconstruction position part (few events): to exclude background signals
- Analysis of events (~20000) of background and few “good” WIMPs.
- Plot of f90 vs S1 and then apply some cuts: to select WIMPs signals

https://sites.google.com/unisa.it/darksidemasterclass/home-page

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