Netzwerk Teilchenwelt

Experimente und Masterclasses

NETZWERK
TEILCHENWELT

Untersuchung kosmischer Teilchen

- CosMO-Detektor
- Kamiokanne
- Nebelkammer
- Cosmic@Web
- Pierre Auger Masterclass
- IceCube Masterclass

Astroteilchen-Angebote: Detektoren

- Detektoren für Jugendliche
  - Szintillations-Detektoren (CosMO)

Mehr Infos

  - Cherenkov-Detektoren (Kamiokannen)

- Ausleihbar an vielen Standorten
- Gut geeignet für Forschungswochen und Projektarbeiten
- Verschiedene Messungen (Winkel, Lebensdauer, Abschirmung)

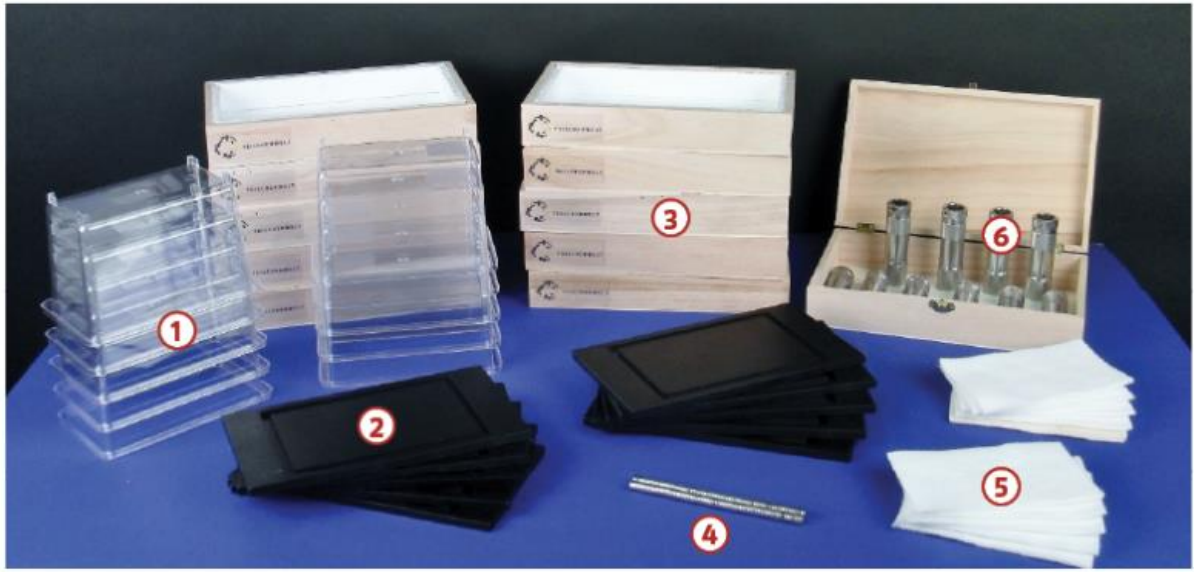
Mehr Infos

Astroteilchen-Angebote: Nebelkammern

- Jedes Set beinhaltet Material für den Bau von 10 Nebelkammern:

① 10 durchsichtige Plexiglasboxen
② 10 schwarz eloxierte Metallplatten mit Rille
③ 10 Holzkisten mit Styroporauskleidung
④ 100 Neodym-Magnete (8 mm x 3 mm)*
⑤ 10 Stück Filz*
⑥ 10 LED Taschenlampen (mit Batterien)*
* in Holzkiste

Eine Mappe mit:
- 10 laminierten Anleitungen
- Hinweisen und Kopiervorlagen

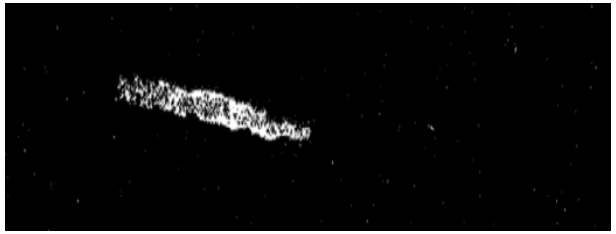


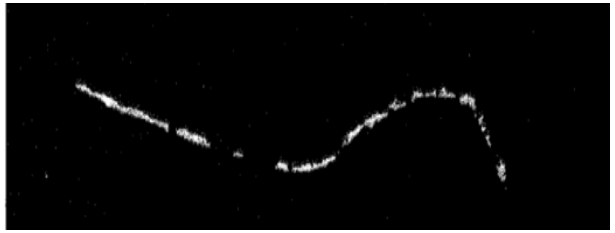
- Anleitung mit Kopiervorlagen, Hintergrundwissen, weiterführenden Links
- Nicht enthalten sind Verbrauchsmaterialien (Isopropanol, Trockeneis) und Schutzausrüstung (Schutzbrillen, Handschuhe)

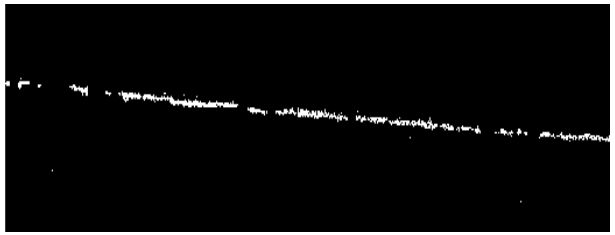
Astroteilchen-Angebote: Nebelkammern

Identifikation von Teilchenspuren

- Dicke, kurze Spuren
  - α-Teilchen (Helium-Kern)
  - aus Zerfall von Radon
- Dünne, krumme Spuren
  - niederenergetische Elektronen oder Positronen
  - aus β-Strahlung oder kosmischen Strahlung
- Dünne, lange, gerade Spuren
  - hochenergetische e+, e- oder Myonen aus kosmischen Strahlung







Astroteilchen-Angebote: Cosmic@Web

Abb.: Carolin Schwerdt

Cosmic@Web

Grundlagenwissen
Experimentbeschreibung

Bedienungsanleitung

Glossar Literaturhinweise

ausführliche Analysen

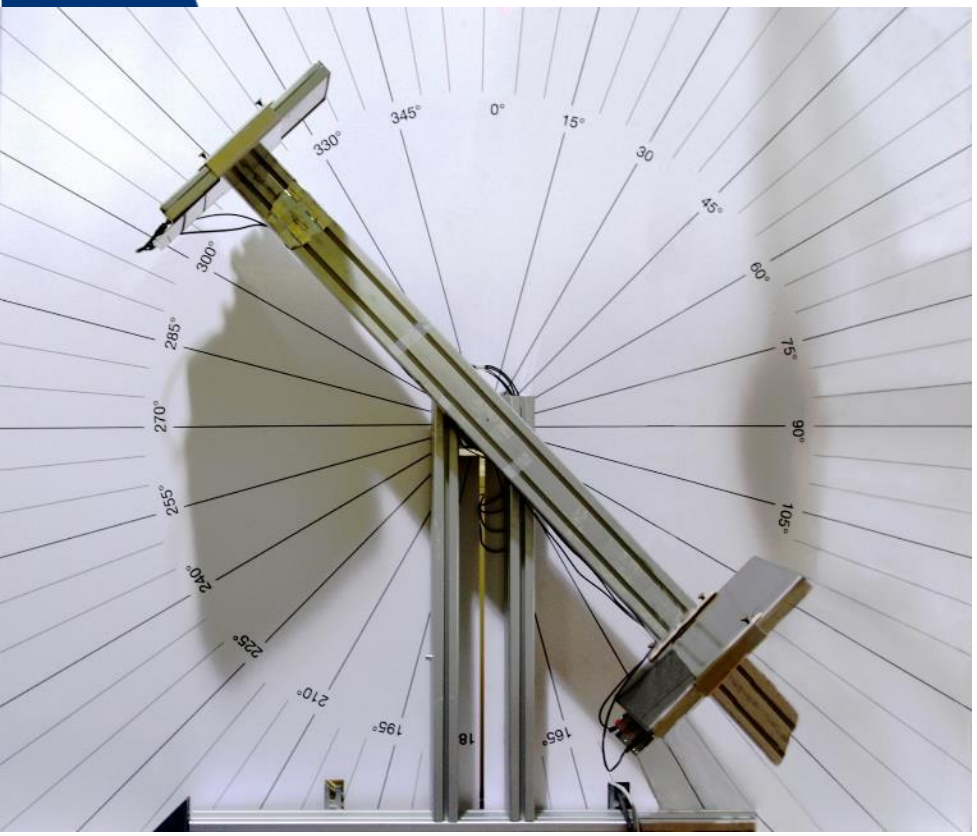
Datenfilter

Regelmäßig digitale Workshops für Jugendliche und Lehrkräfte (2h)

Astroteilchen-Angebote: Cosmic@Web

Experimentelle Daten zur Untersuchung von kosmischen Teilchen, u. a.:

- Lebensdauer von Myonen
- Abhängigkeiten der Myonenrate von unterschiedlichen Faktoren



CosMO-Mühle (Zeuthen)

Neumayer III Station (Antarktis)

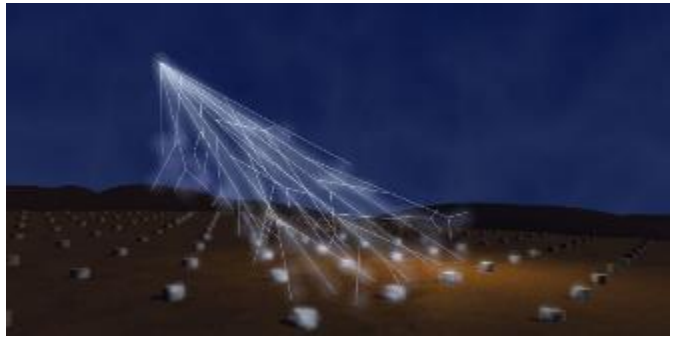
Forschungsschiff Polarstern

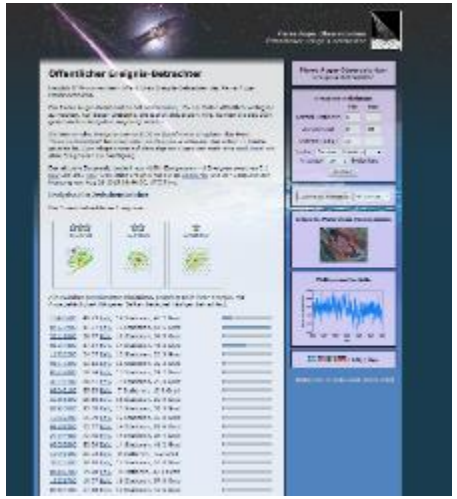
Astroteilchen: Auger Masterclass

Jugendliche…

- rekonstruieren einen Teilchenschauer
- leiten daraus physikalische Gesetzmäßigkeiten her
- können ihr Wissen in Physik, Mathematik und Informatik ausbauen:
  - Gewichteter Mittelwert
  - Arbeit mit einem Tabellenkalkulationsprogramm
  - Trigonometrie
  - Polar- bzw. Kugelkoordinaten
  - Koordinaten- und Vektorgleichung
  - Fitten, Fehlerrechnung, e-Funktion

@DESY in Zeuthen, Dresden, Erlangen, Karlsruhe, München (TU), Münster, Würzburg, Wuppertal

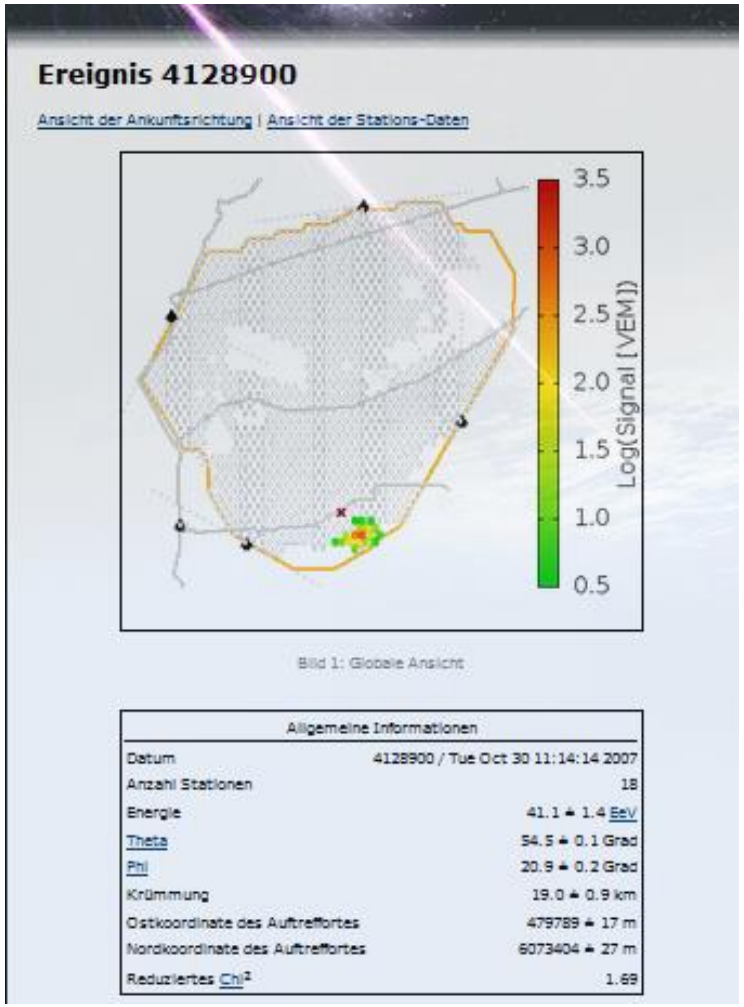


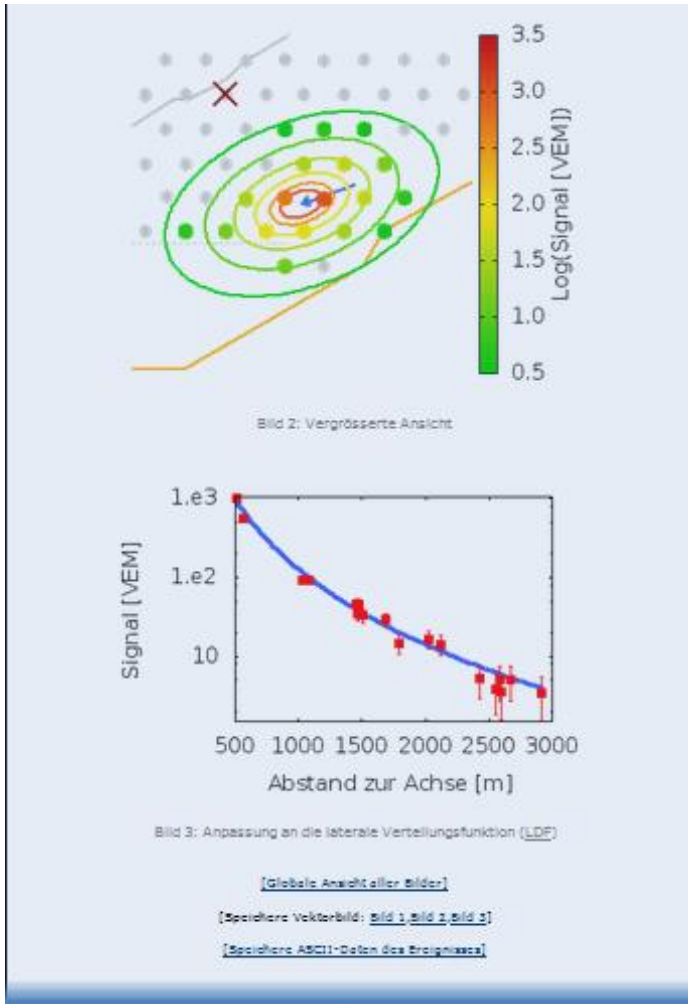


1 % der Daten öffentlich verfügbar

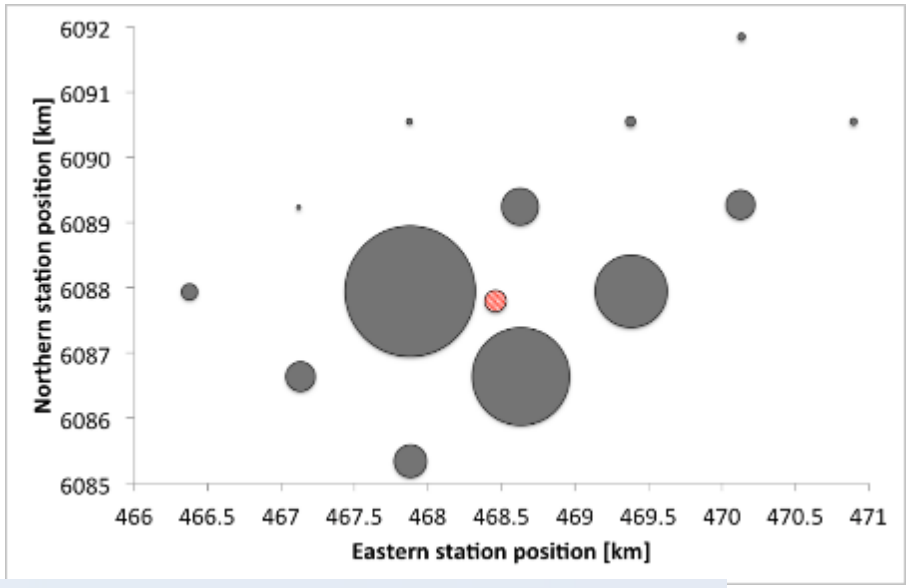
http://auger.uni-wuppertal.de/ED/

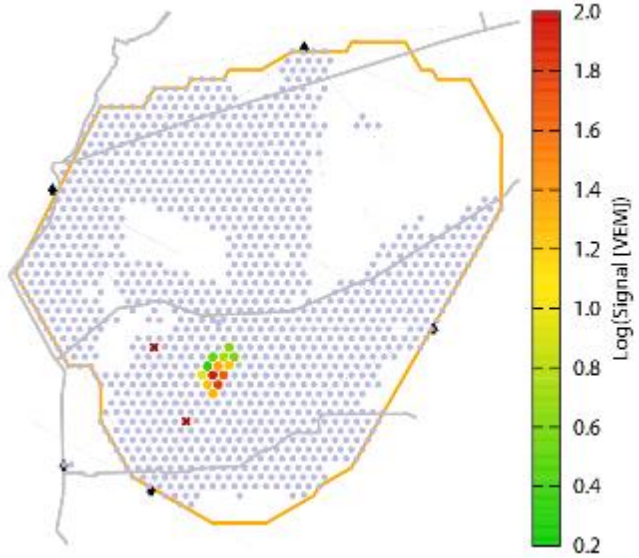
Betrachtung von einem Ereignis





Auftreffpunkt des Schauers

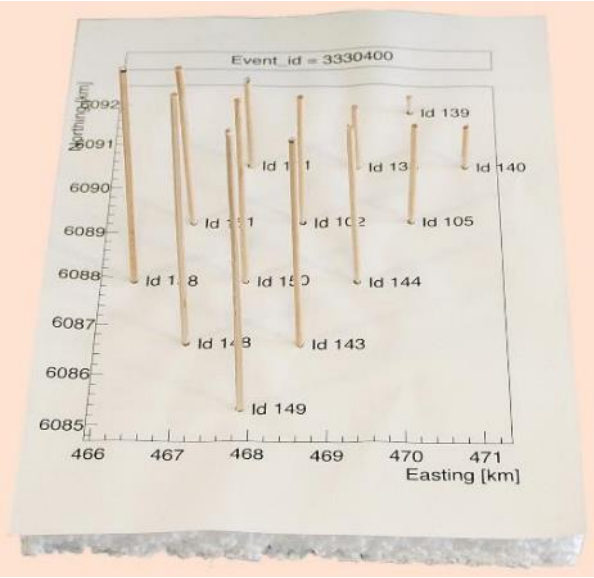




Allgemeine Informationen	
Datum	3330400 / Sun Apr 15 09:31:09 2007
Anzahl Stationen	13
Energie	9.7 ± 0.6 EeV
Theta	59.2 ± 0.1 Grad
Phi	62.2 ± 0.2 Grad
Krümmung	21.2 ± 2.0 km
Ostkoordinate des Auftreffortes	468352 ± 51 m
Nordkoordinate des Auftreffortes	6087466 ± 58 m
Reduziertes Chi^2	2.33

Bau eines Modells

→ Schauerfront



Neue Auger-Masterclass

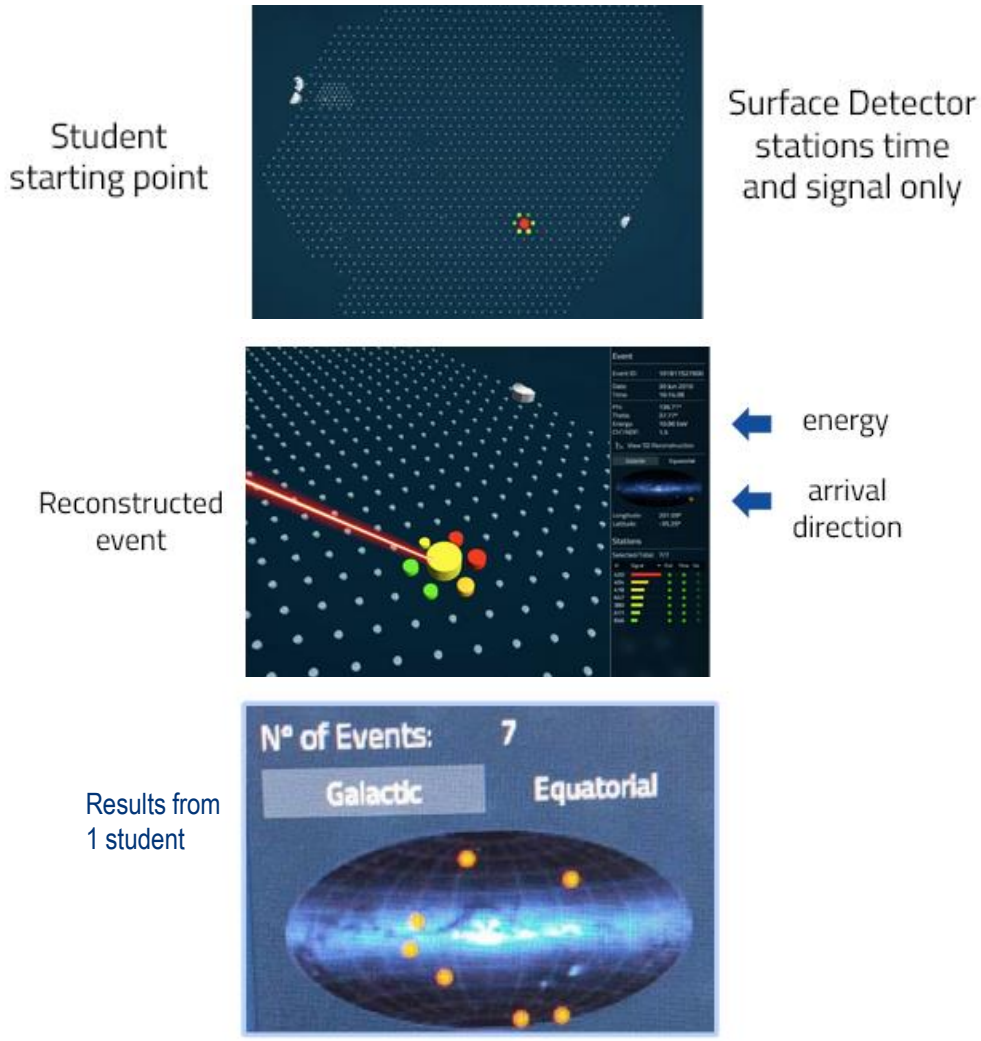
- Erstmalig bei den International Masterclasses 2023
- (noch) keine Standorte aus Deutschland

Concept of Auger Masterclass

Question: What is the origin of ultra-high energy cosmic rays?

Experimental procedure:

- reconstruct the arrival direction and energy of real Auger events + perform event selection
- a sky map with the reconstructed arrival directions of selected events is produced and discussed



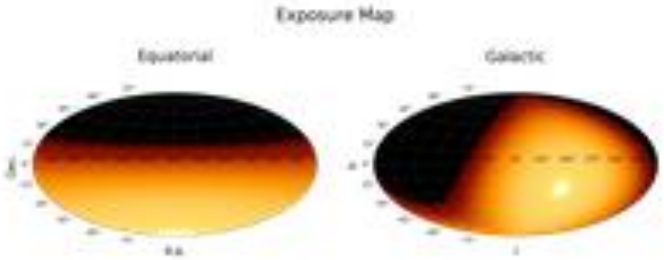
https://augermasterclasses.lip.pt/

Combination and discussion of results

Auger Masterclass
discussion of the results

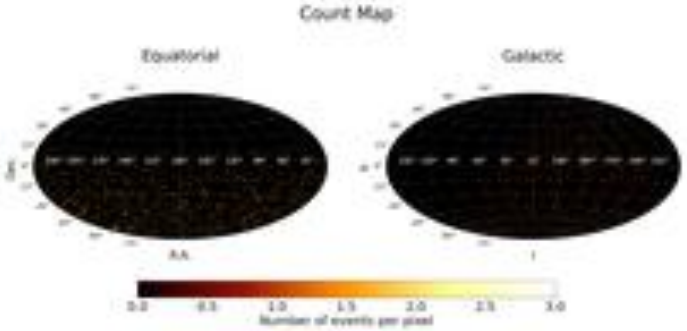
1) sky-map coordinates

2) observatory exposure to the sky

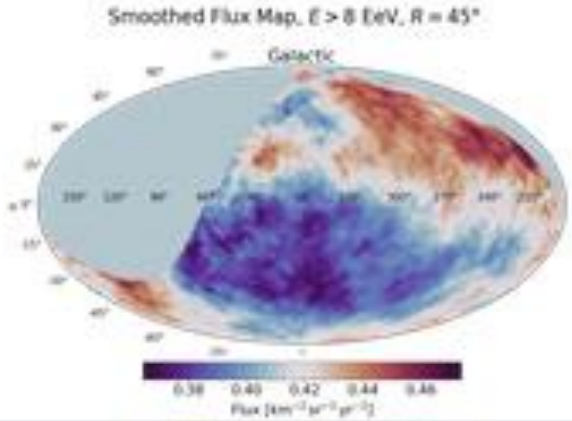


combining statistics of from all students

3) count maps of arrival directions

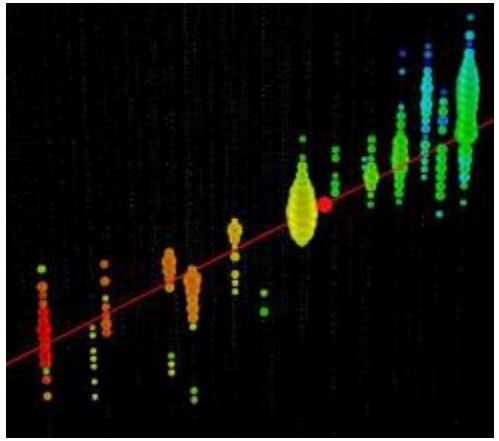


4) smoothed flux map

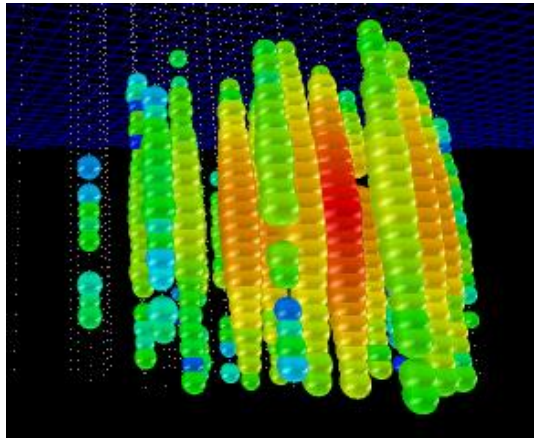


IceCube MasterClass
AN AUTHENTIC ASTROPHYSICS RESEARCH EXPERIENCE

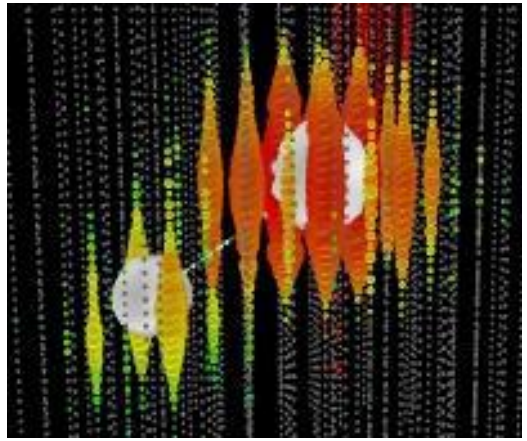
- https://masterclass.icecube.wisc.edu/de, mit Videokonferenz
- @Aachen, Erlangen, Mainz, Münster, DESY in Zeuthen (Tübingen und Dortmund sind interessiert)
- Aufgabe für Jugendliche: Neutrinos filtern und Signaturen unterscheiden



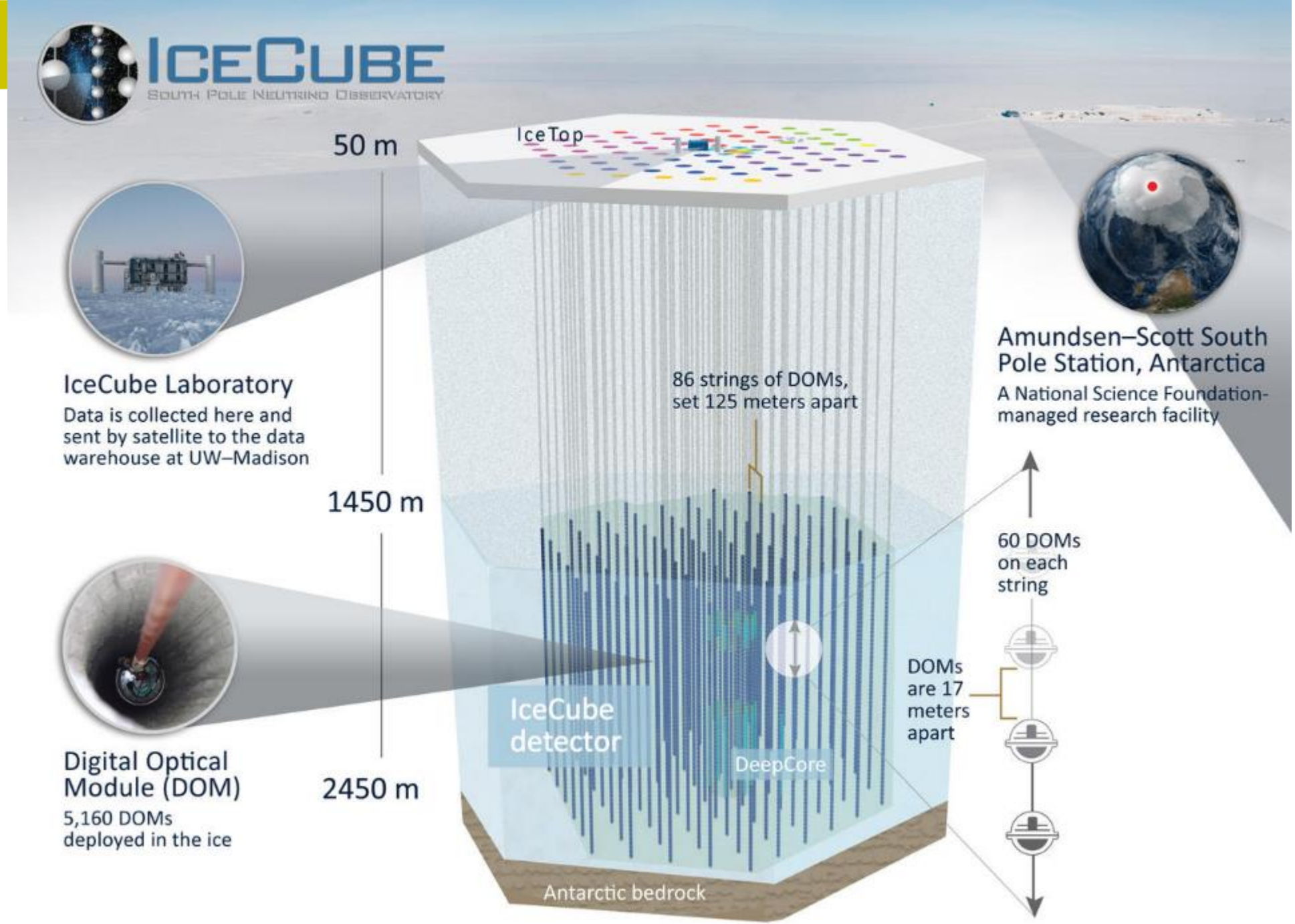
Myon Neutrino (data)



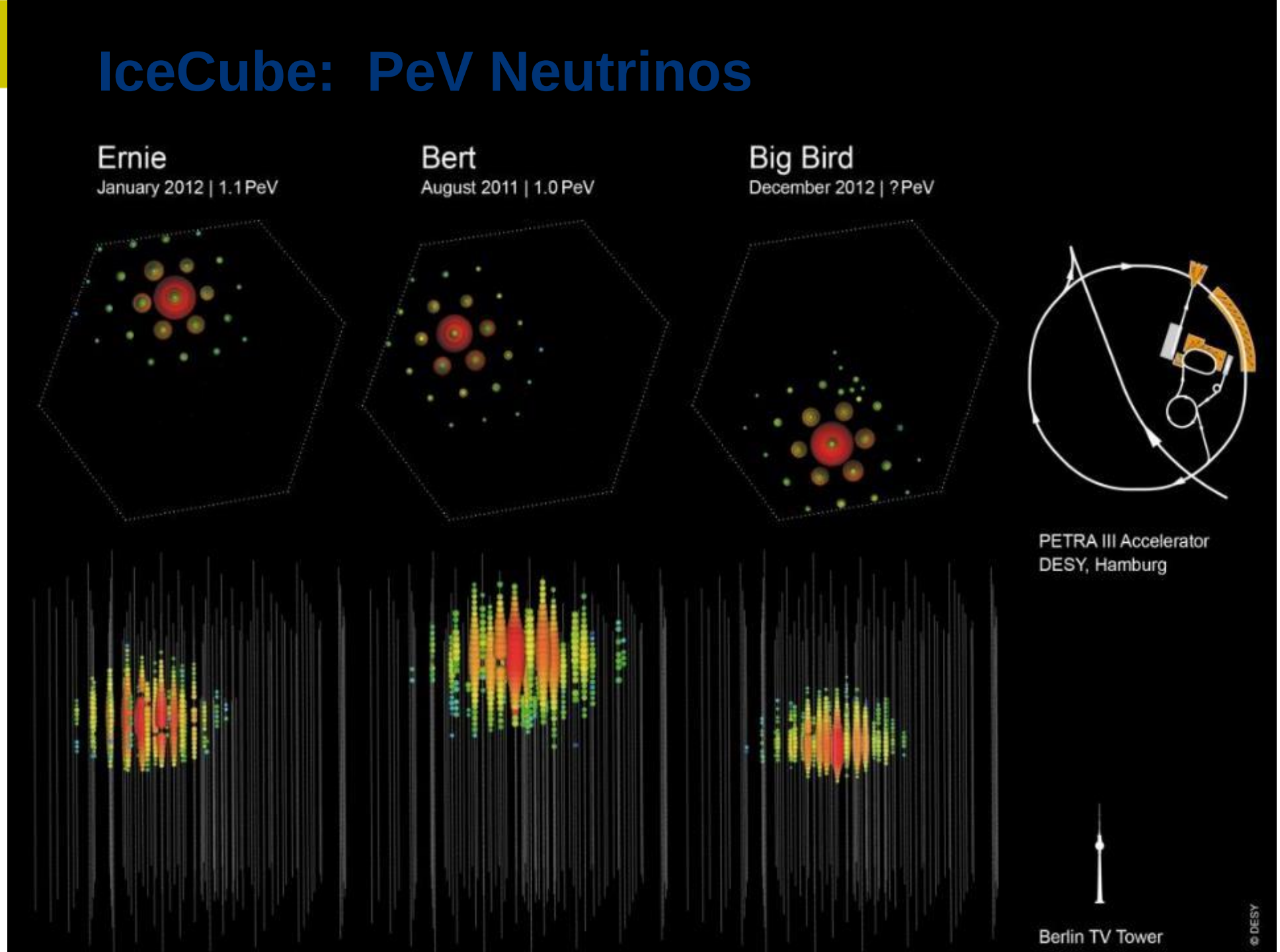
Elektronen Neutrino (data)



Tau Neutrino (simulation)


IceCube
South Pole Neutrino Observatory
50 m
IceTop
IceCube Laboratory
Data is collected here and sent by satellite to the data warehouse at UW–Madison
1450 m
86 strings of DOMs, set 125 meters apart
Amundsen–Scott South Pole Station, Antarctica
A National Science Foundation-managed research facility
60 DOMs on each string
DOMs are 17 meters apart
IceCube detector
DeepCore
Digital Optical Module (DOM)
5,160 DOMs deployed in the ice
2450 m
Antarctic bedrock

IceCube: PeV Neutrinos



Masterclasses zur Teilchen- und Kernphysik

- LHC Masterclasses
- ML in der Teilchenphysik
- Belle II Masterclasses
- Hadronentherapie-Masterclass
- Masterclass zur nuklearen Astrophysik

ATLAS W path

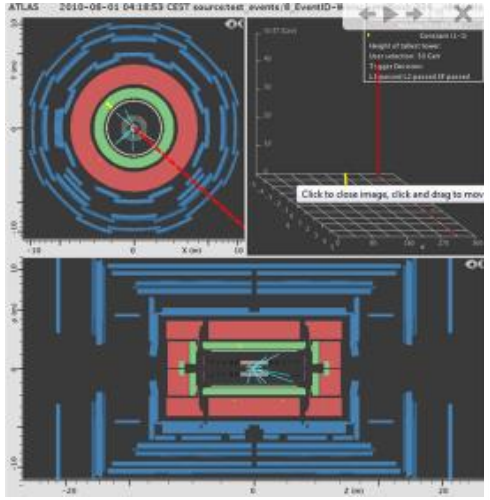
Students analyze event displays (50 collision events per pair of students)

2 tasks:

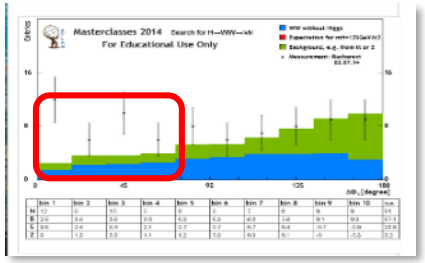
- Identify W bosons, determine type and electric charge of leptons
- Resulting W+/W- is used to reveal the inner structure of the proton (and compared to results from ATLAS)

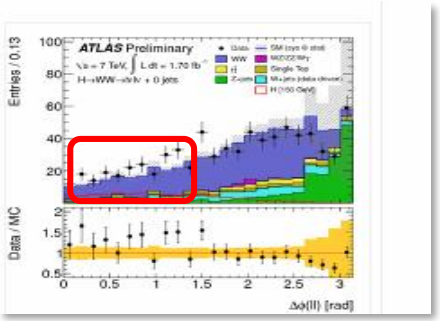
- Identify W pairs and measure azimuthal opening angle Δφll
- Resulting histogram is used to provide insight into Higgs discovery process at CERN

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



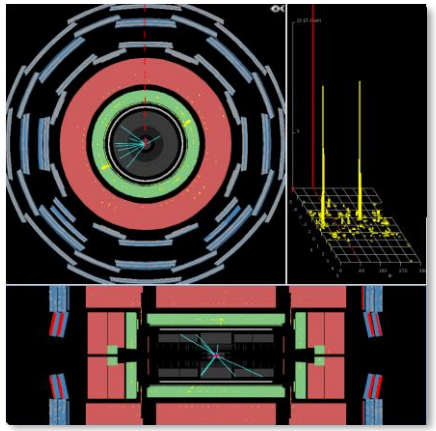
Total #	W → ... + ν				Background
532	e^+	e^-	μ^+	μ^-	
group A	9	4	10	1	24
group B	11	12	13	10	19
group C	5	3	1	1	19
group D	7	4	11	5	21
group E	11	10	3	2	31
group F	15	3	3	1	26
group G	6	4	3	5	27
group H	15	10	3	2	13
group I	5	3	3	4	5
group J	4	0	1	0	21
group K	5	1	5	3	18
group L	4	7	4	2	31





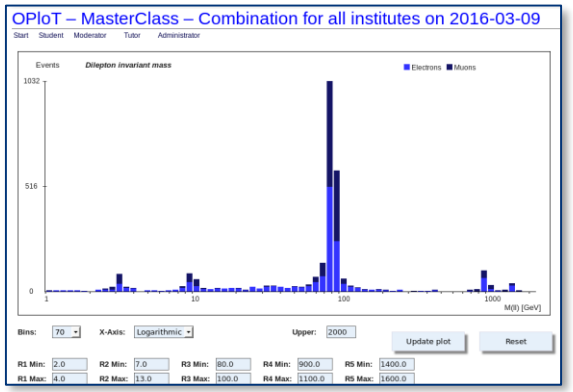
ATLAS Z path

- 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



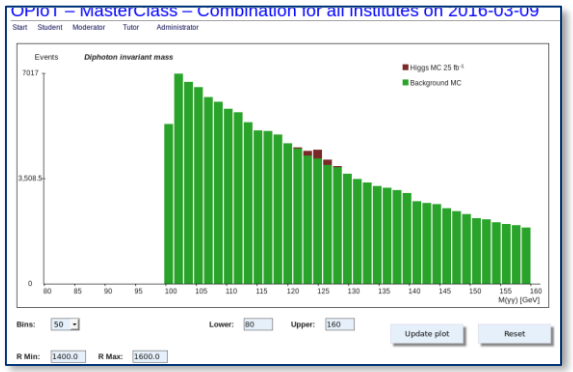
2-lep invariant mass distribution:

- Resonance peaks of known particles: Z^0, J/Ψ, Υ
- 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

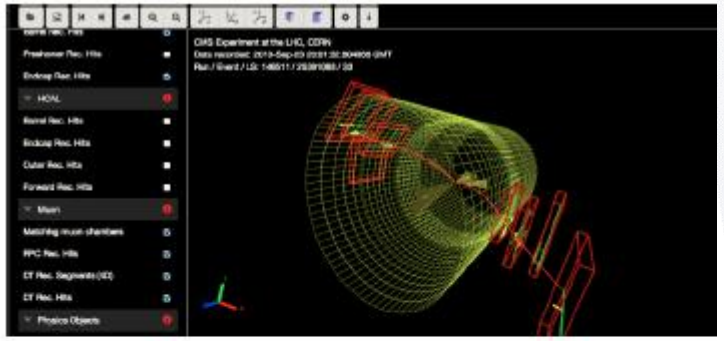


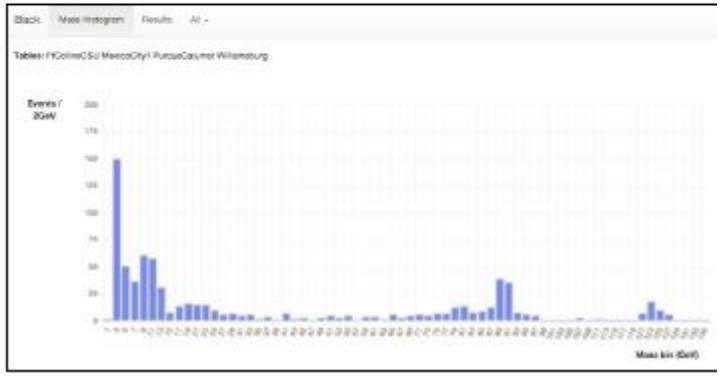
https://atlas.physicsmasterclasses.org/en/zpath.htm

CMS Measurement

- 3D event display (iSpy-webgl)
- Students identify W, Z, and Higgs candidates
- Create mass plot of standard model particles that decay into 2 or 4 leptons, incl. Higgs
- Ratios W+/W-, e/μ

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

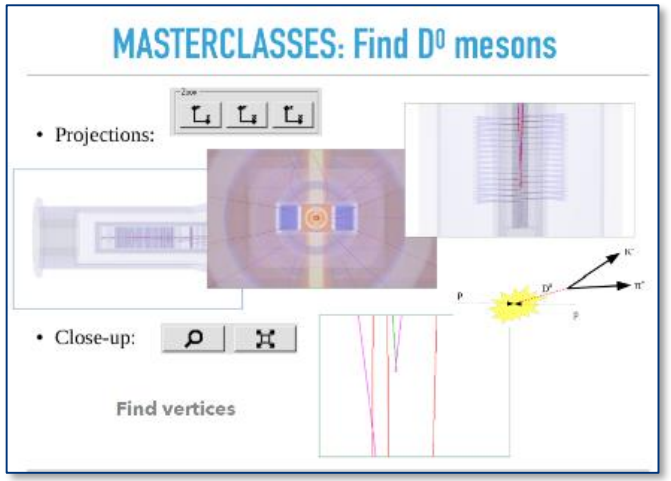


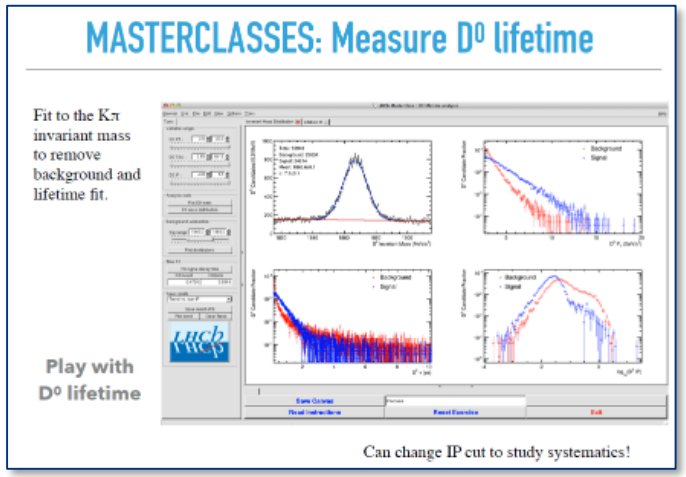


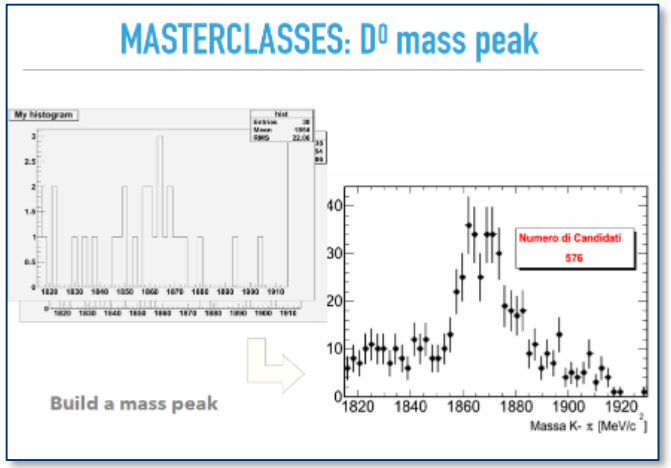
LHCb Masterclass

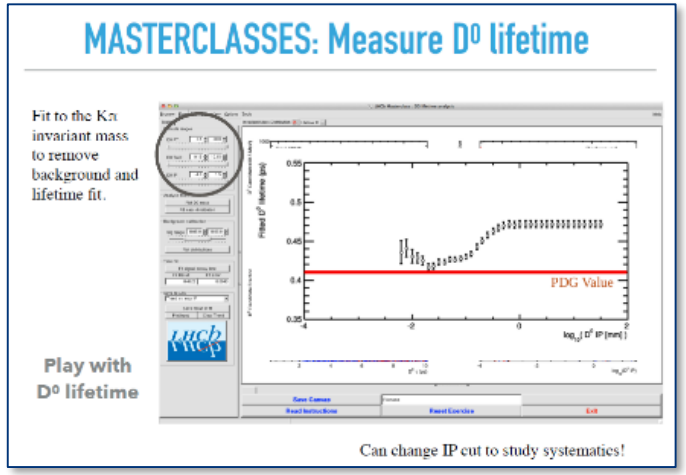
- Students search for the $D^0 \rightarrow K\pi$ decay using an event display
- Students perform a lifetime measurement at the 1 % level
- Live merging of histograms from all groups in the VC

https://lhcb-outreach.web.cern.ch/lhcbinternationalmasterclasses/d0-lifetime/





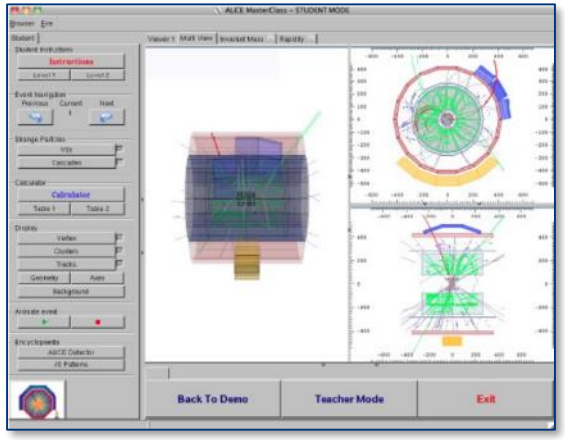


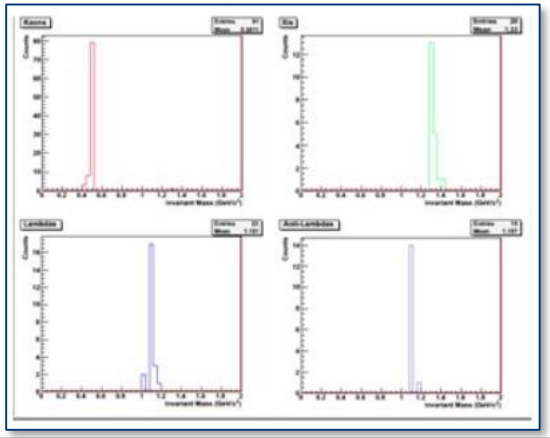


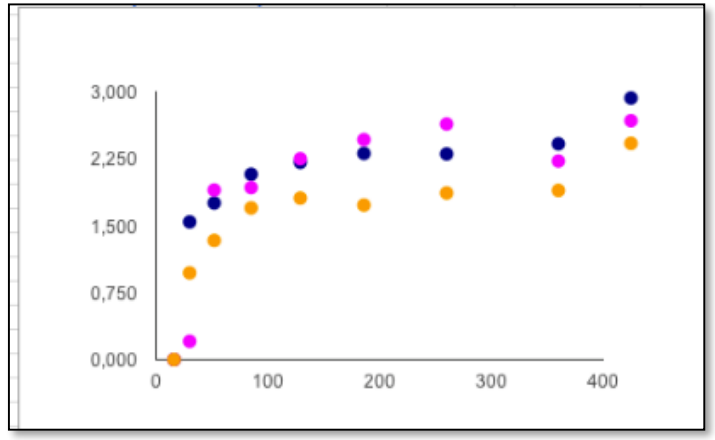
ALICE: Looking for Strange Particles

- 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/



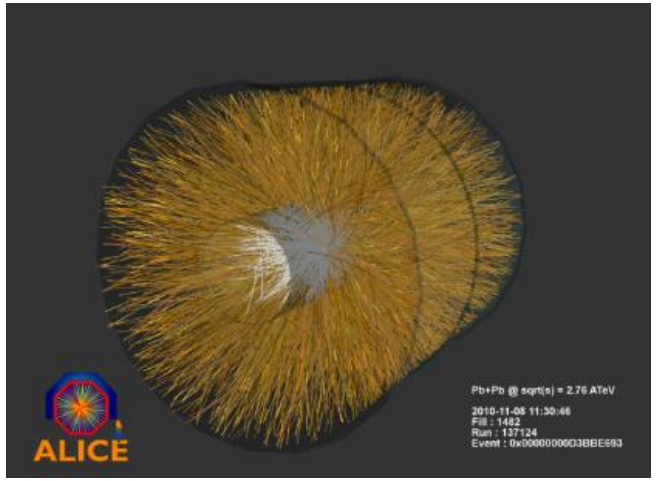


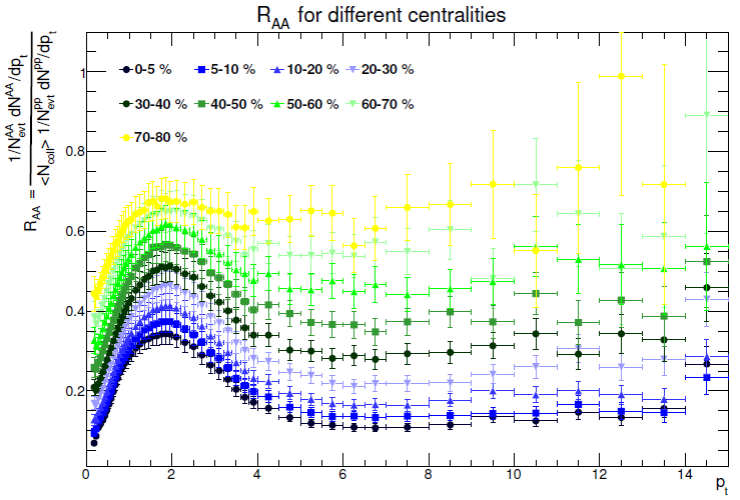


ALICE: Nuclear Modification Factor

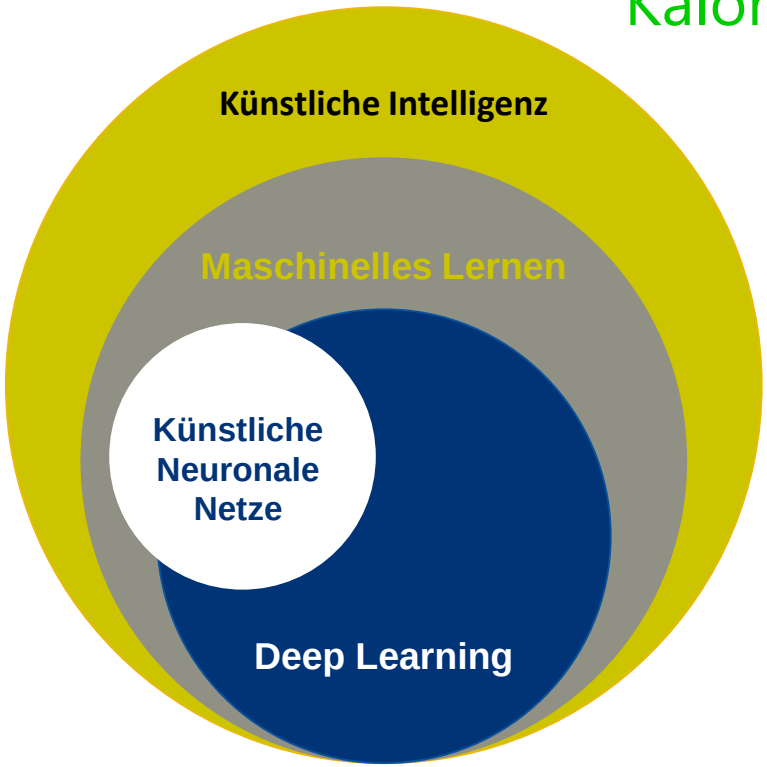
- event-display based visual analysis
- RAA simply via counting of tracks
- Python based large scale analysis
- RAA as a function of momentum in various Pb-Pb centrality classes
- students discover jet suppression!

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





ML in der Teilchenphysik

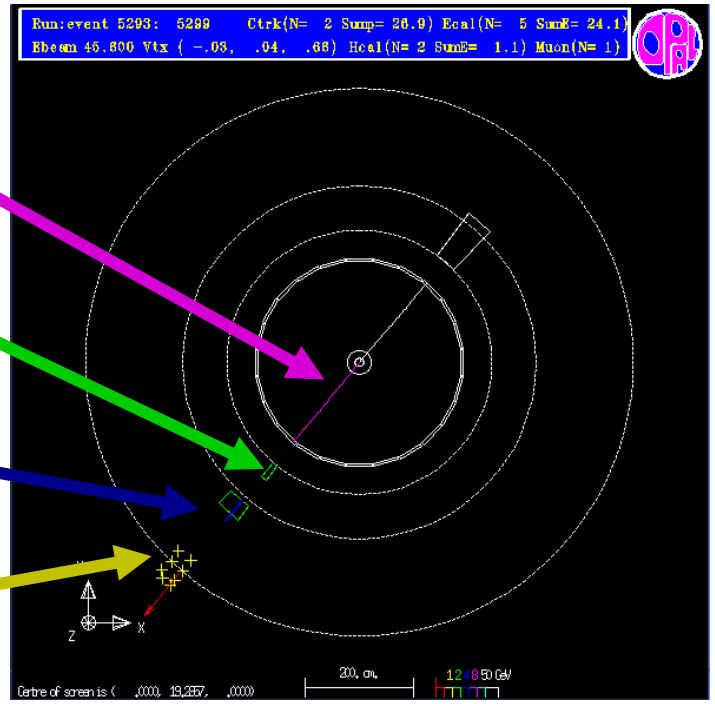


Spurkammer

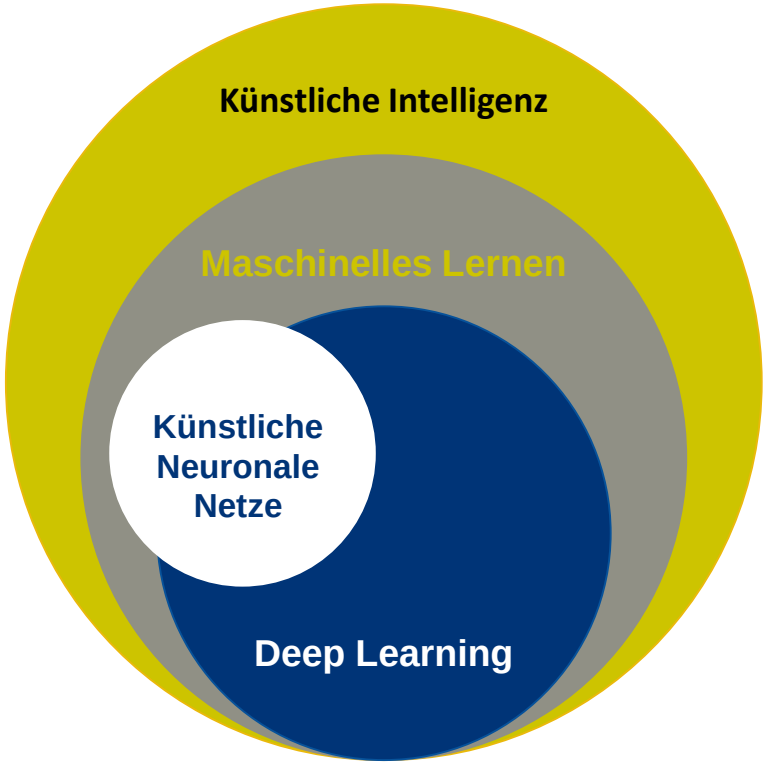
Elektromagnetisches Kalorimeter

Hadronisches Kalorimeter

Myon Kammer



ML in der Teilchenphysik

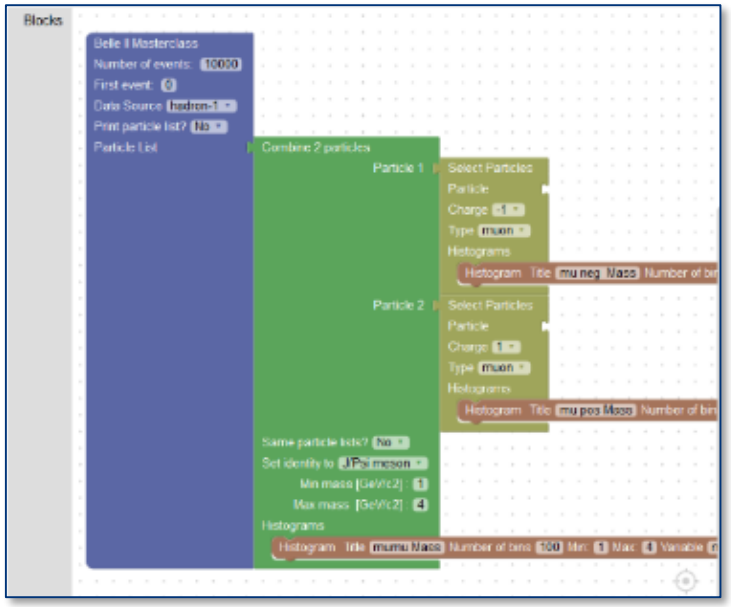


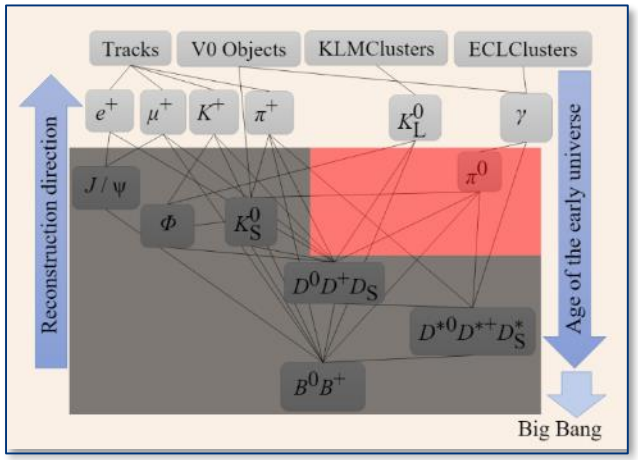
- Es werden die OPAL Eventdisplays mit einem ML Modell ausgewertet
- Programmierung des ML Modells
- Diskussion von ML als Methode in der modernen Physik

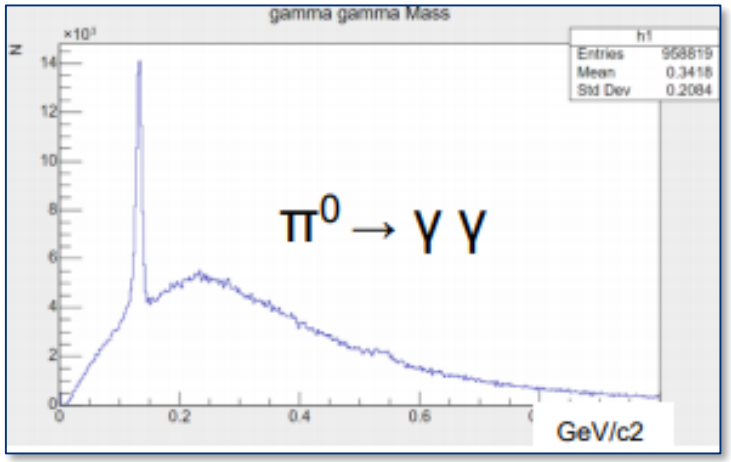
Belle II: Reconstruct B mesons

- 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

https://belle2.ijs.si/public/home/reconstruct-b-mesons/





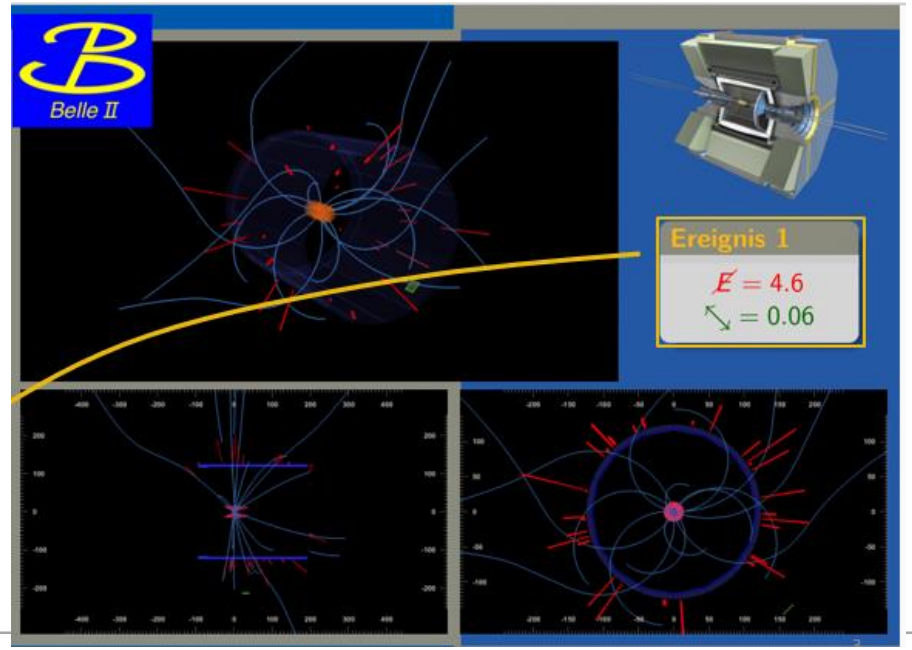


Belle II: Quark Colors

- Concept: Based on event displays, classify event as e^+e^-/ $\mu^+\mu^-$/ $\tau^+\tau^-$/ $\bar{q}q$/ $\bar{b}b$
- Derive R-value: $R = \frac{N(\bar{q}q)}{0.5\cdot[N(\mu^+\mu^-)+N(\tau^+\tau^-)]} = N_c \cdot \sum_{\text{Quarks}} q^2_{\bar{q}q} = N_c \cdot \frac{10}{9}$
- Deduce **number of quark colors**

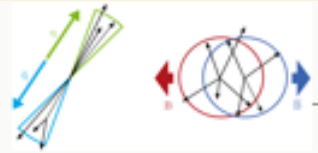
EXAMPLE EVENT DISPLAY

$e^+e^- \to \Upsilon(4S) \to \bar{b}b$

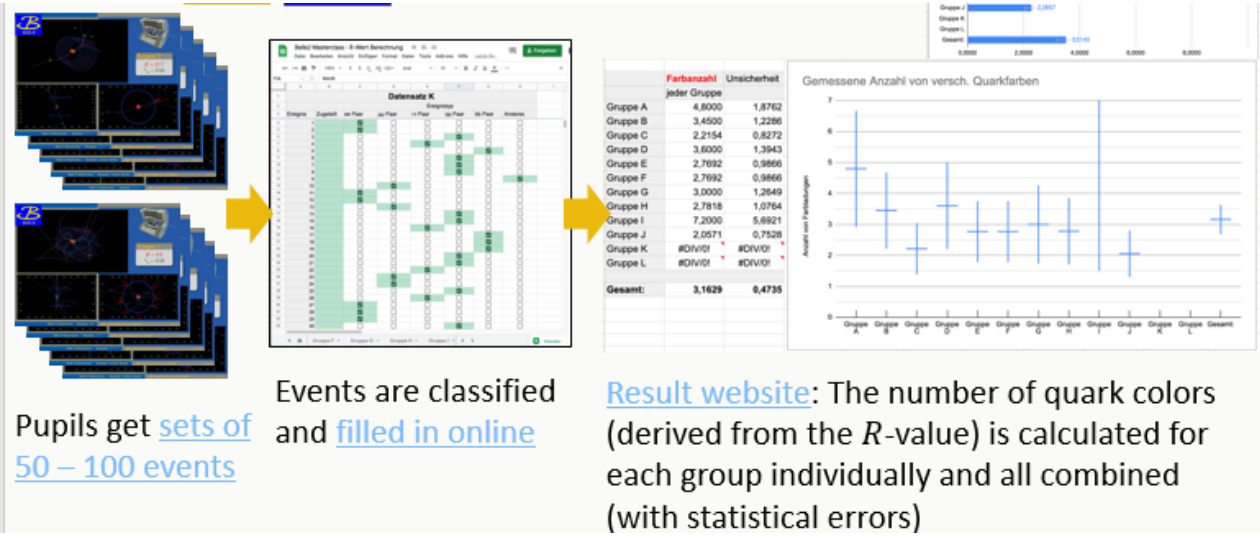


m^2_{miss} as "missing energy" or $\not{E}$

foxWolframR2 as "straightness" or ↘



Belle II: Quark Colors



MC data!

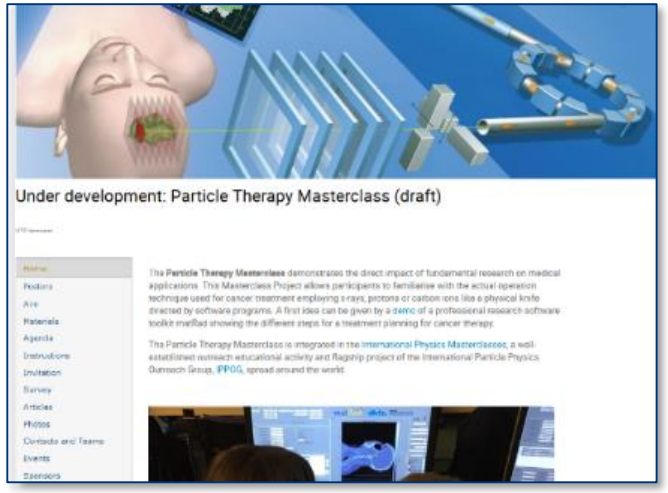
- In German and English, more languages will follow
- Developed by physicists and teacher students
- Accompanying material: videos, interactive worksheet, quizzes

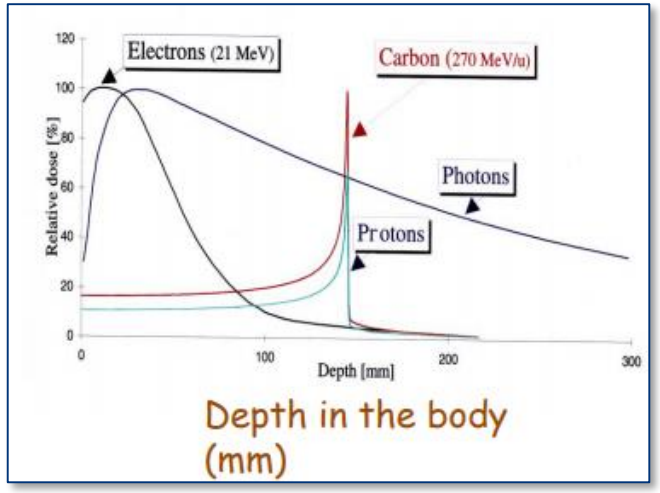
- https://belle2.ijs.si/public/home/quark-colors/

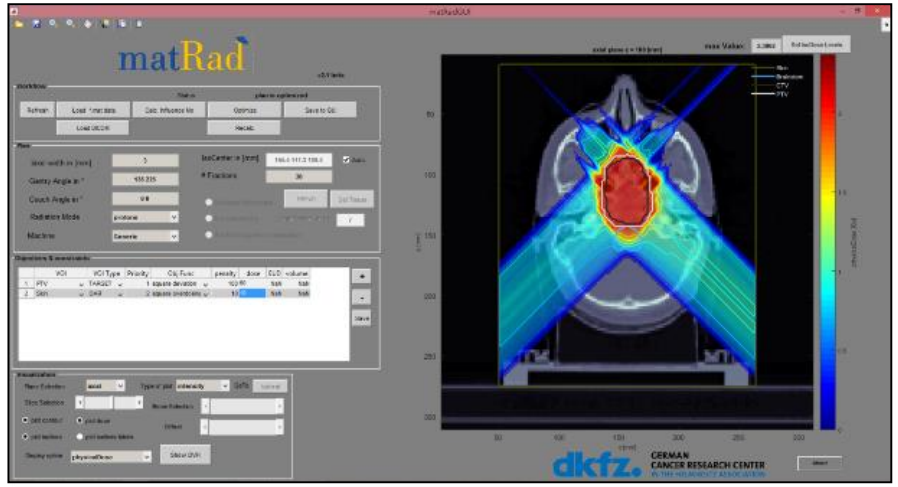
Particle Therapy Masterclass

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

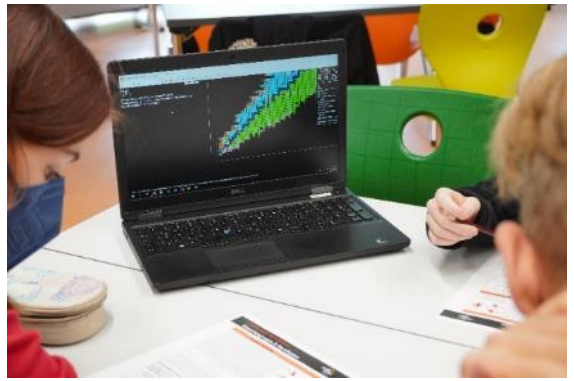
https://indico.cern.ch/event/840212/



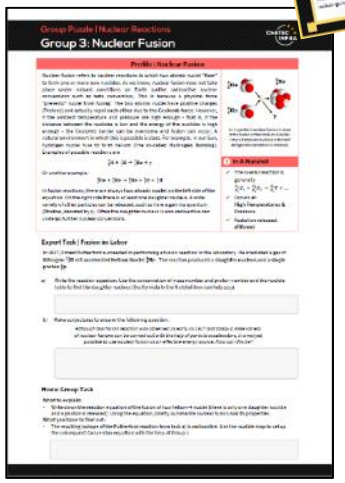




Neue Masterclass zur nuklearen Astrophysik



- Inhalte: Kernstruktur, Kernreaktionen, Elementhäufigkeiten, Nukleosynthese, Sternentwicklung usw.
- Vielfältige Aktivitäten:
  - Erstellung Hertzsprung-Russell-Diagramm mit Stern-Karten
  - Aufgabenblätter zu Kernreaktionen
  - Würfelspiel mit Nuklidkarte
- Analyse der $^{14}N(\alpha,\gamma)^{18}F$-Reaktion
  - Daten aus Gammaspektroskopie
  - Berechnung Wirkungsquerschnitt und Reaktionsrate
- Entwickelt von Hannes Nitsche (Doktorand TUD) im Rahmen von EU-Projekt
- Verfügbar auf deutsch und englisch
- http://mc.chetec-infra.eu/de/index.html



Spotlight on...

- Vorstellung einer Masterclasses, einmal pro Quartal
- Nächster Termin: 28.2., 11-12 Uhr: Masterclass Nukleare Astrophysik
- https://indico.cern.ch/event/1243818/
- Vorgelagert jeweils Onboarding für neue Vermittler:innen (10-11 Uhr), beide Veranstaltungen können unabhängig besucht werden
- Weitere Termine:
  - Mittwoch, 24. Mai
  - Donnerstag, 31. August
  - Freitag, 24. November

NETZWERK TEILCHENWELT

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mail@teilchenwelt.de

PROJEKTLEITUNG

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FÖRDERER

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Dr. Hans Riegel-Stiftung

Verbreitung LHC Masterclasses an den Standorten

Was?	Wer setzt die MC ein?	Entwickelt bei
ATLAS Z-Pfad	B, BO, DO, FR, GI, GÖ, HD, HH, M, SI, TÜ, W	Uni Oslo
ATLAS W-Pfad	BN, DD, ER, MZ, WÜ	TU Dresden
CMS	AC, HH, KA	QuarkNet
ALICE R_AA	MS, DA, F	R. Averbeck, GSI
ALICE strange particles	HD	D. Hatzifotiadou, CERN
ALICE J/Psi	DA	R. Averbeck, GSI
LHCb	DO, HD	F. Redi, CERN