



Konrad Jende

Praktische Teilchenphysik im Klassenzimmer

outline

1. Experimente
2. Datenanalysen
3. Materialien
4. Unterstützung

outline

1. Experimente
2. Datenanalysen
3. Materialien
4. Unterstützung

1. Experimente



6:43 PM

Latitude: 43.07515° Longitude: -89.40767°
 Altitude: 238.00m Bearing: 293°

Device Id: 00000000-7f71-62fb-f647-baf70033c587
 Status: Scanning
 Battery: 90% (32.0°C / 89.6°F) discharging (99.99.99)

Samples	Candidates	Events
2292781	310	142
Count	Count	Count
1.6 sec	---	---
Rate	Rate	Rate

Orientation: -3° / -5° / 293°
 Magnetic Field (μT): 29 / 7 / -51

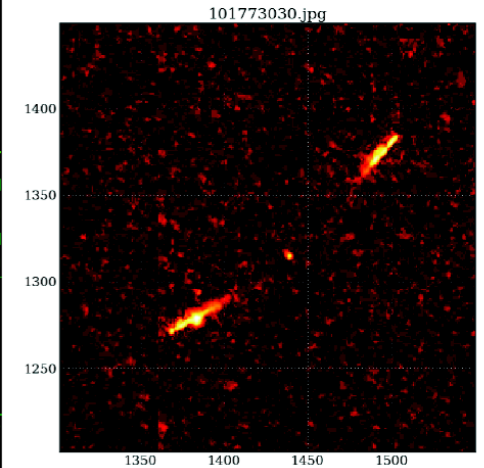


Figure 1. Left: screen shot of the DECO app. Right: Example event recorded by the DECO app. This particular event has an interesting and so far unexplained topology. The axes are in units of pixels. A high school student in the UW Madison internship program found this event in the database.



Tracker

File Edit Video Track Coordinate System View Help

Now available: version 4.87 memory in use: 53MB of 789MB

calibration stick A length: 100.0 angle from x-axis: 118.4°

Plot view of track data will appear here.

Table view of track data will appear here.



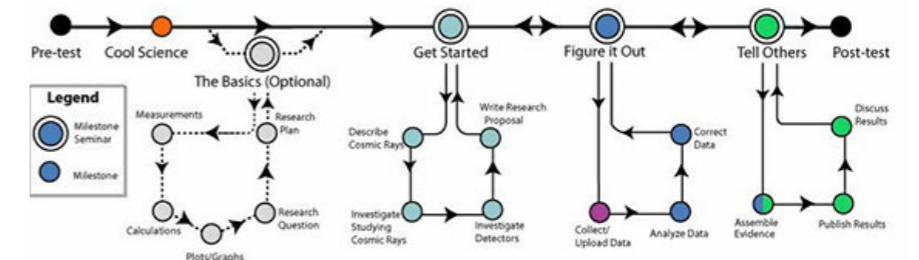
Cosmic Ray e-Lab

Project Map Library Data Posters Site Map Assessment

Text Version Cool Science About Us

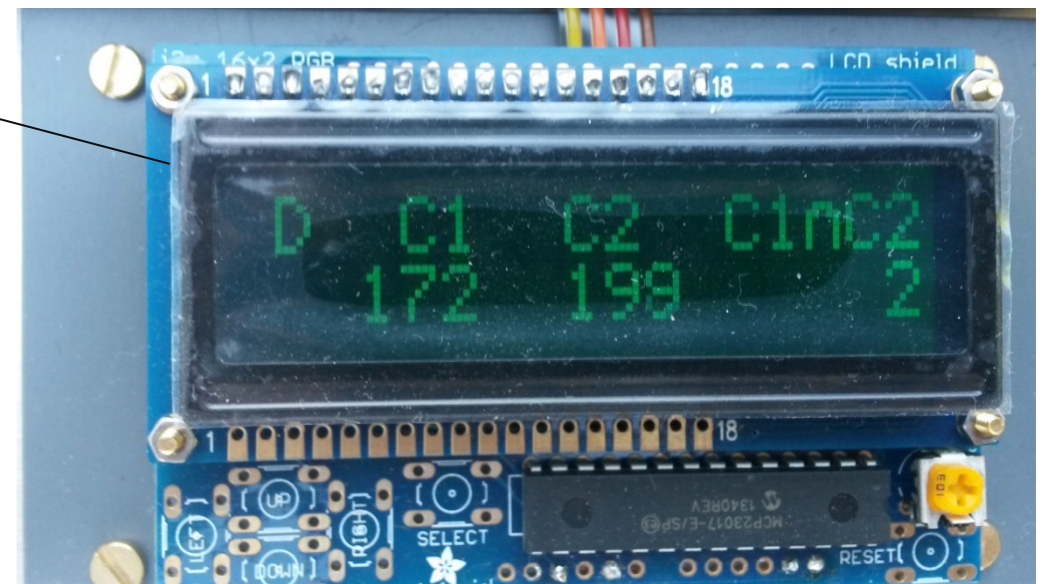
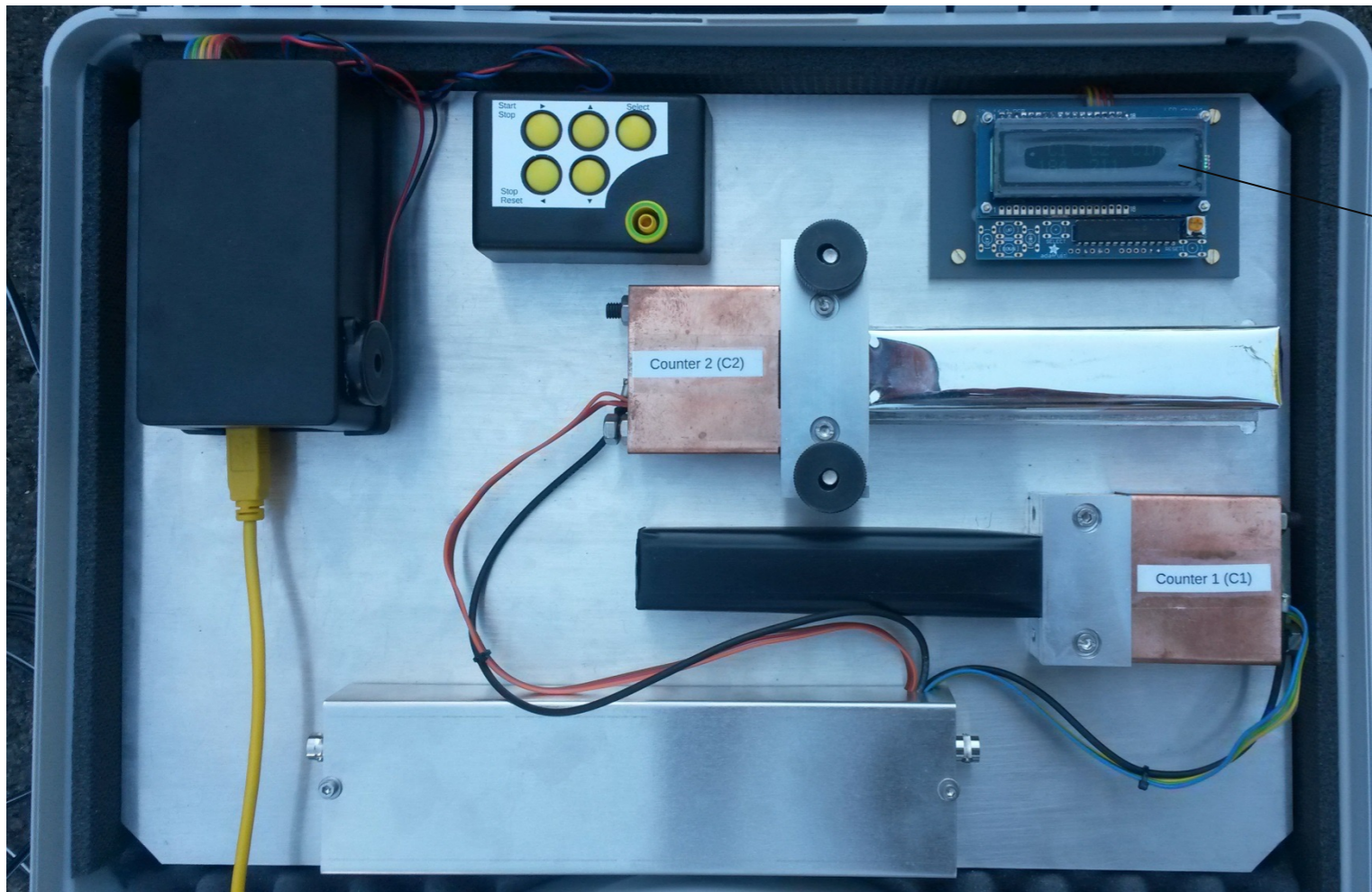
Home: Join a national collaboration of high school students to study cosmic rays.

Project Map: To navigate the Cosmic Ray e-Lab, follow the path; complete the milestones. Hover over each hot spot to preview; click to open. Along the main line are milestone seminars, opportunities to check how your work is going. Project milestones are on the four branch lines.

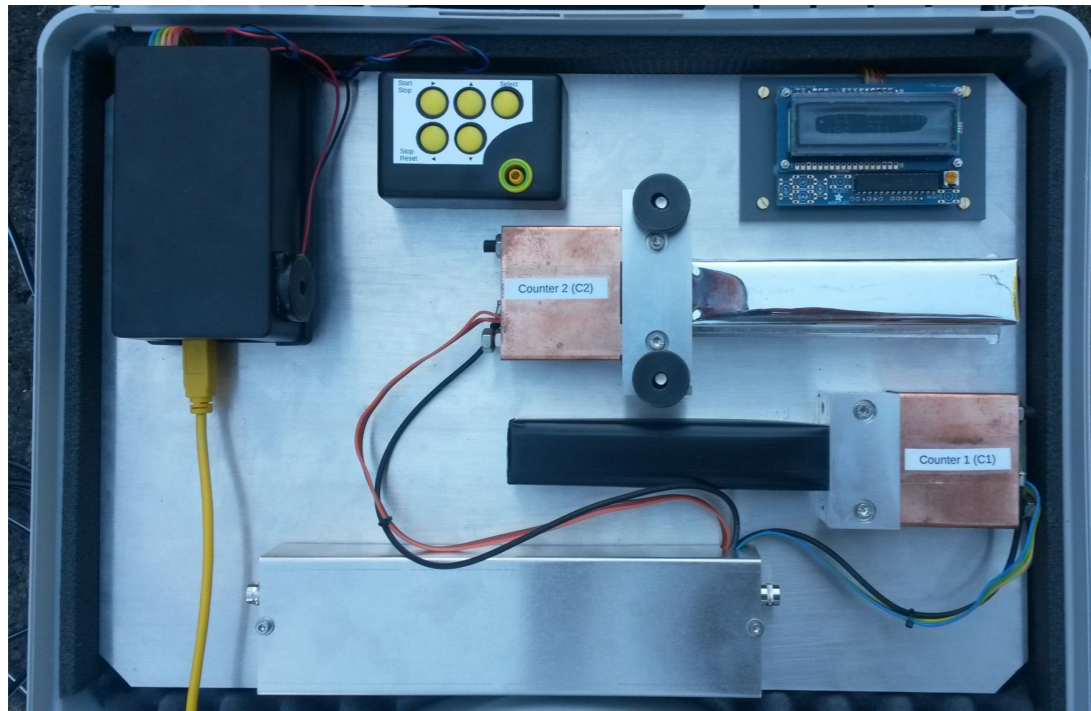


1. Experimente

COSMIX - *Arnaud* (2014)

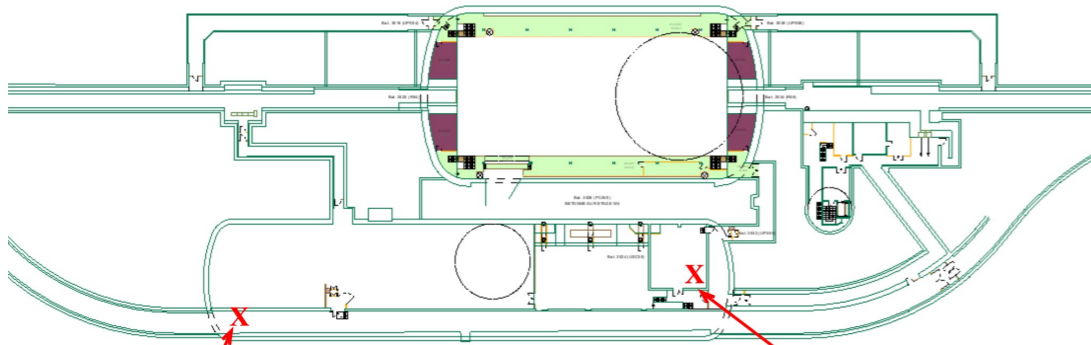


1. Experimente



Mögliche Experimente:

- Messung der Teilchenrate in verschiedenen Höhen, an verschiedenen Orten.
- Visualisierung der auslesbaren Signale.
- Koinzidenzmessung.
- Anwendung statistischer Methoden.



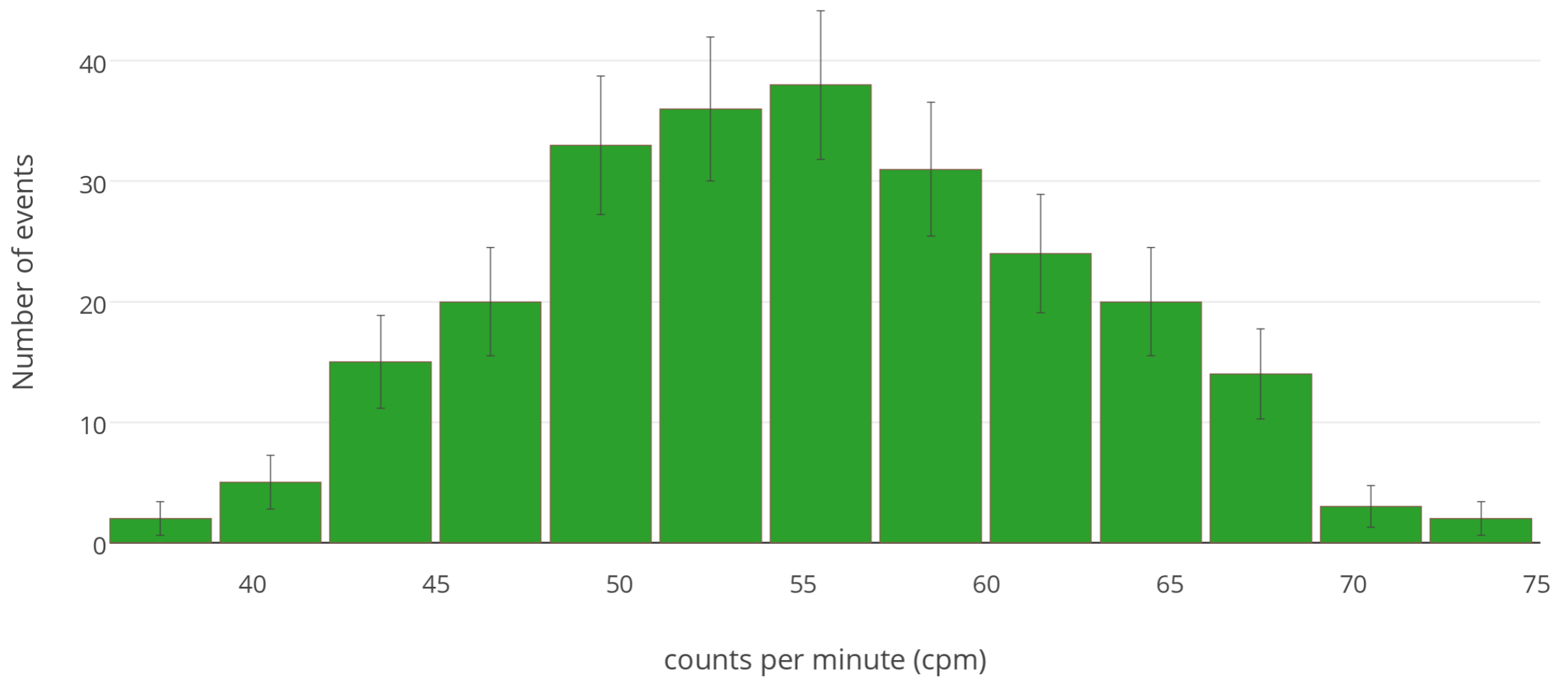
On the top of the bypass tunnel

In the underground control room



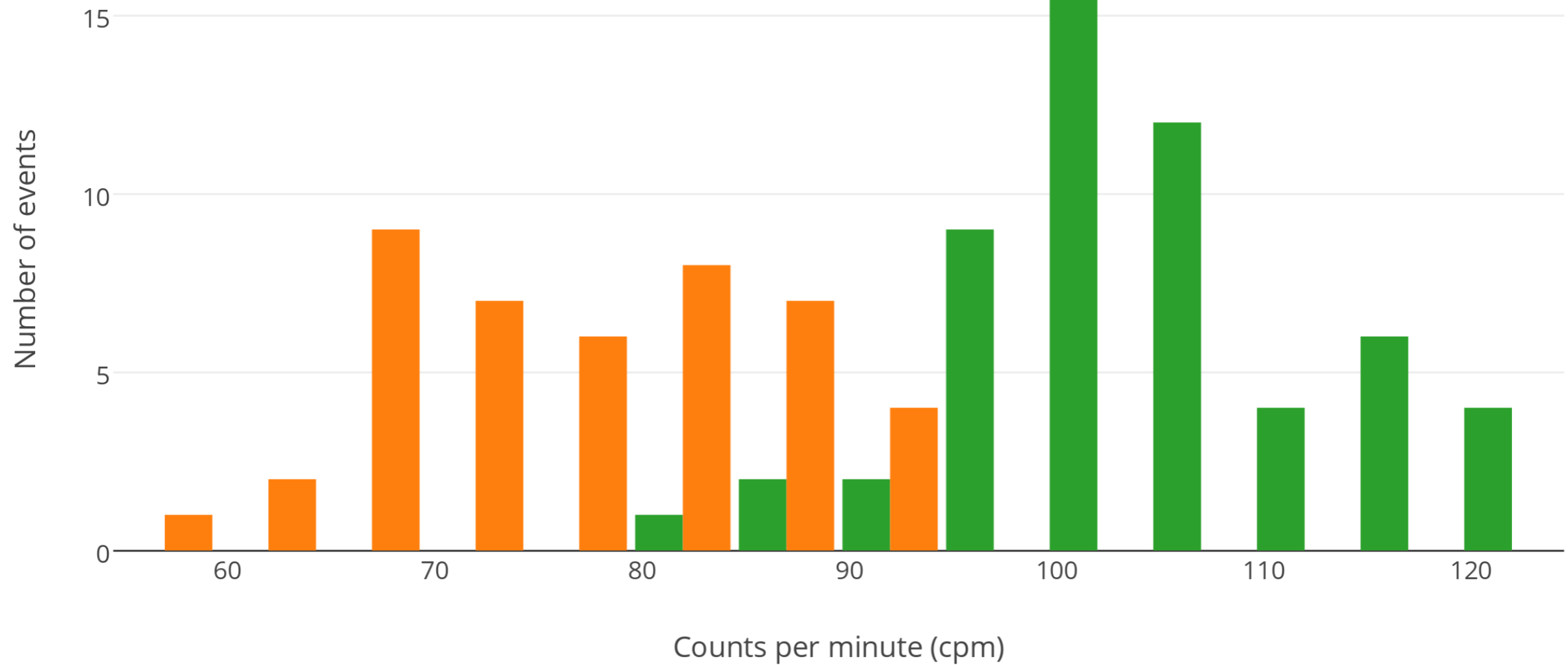
1. Experimente

Number of events vs cpm



1. Experimente

Number of muon events collected with the COSMIX detector vs counts per minute at 440m and 1326m



■ COSMIX: 2015-7-19 16:29:00 - 17:23:59 (GMT) 1326m Col de la Faucille Edourd
■ COSMIX: 2015-7-19 18:38:00 - 19:21:59 (GMT) 440m CERN parking Edourd

1. Experimente

CosMO - Cosmic Muon Observer - *Franke et al. (2013)*

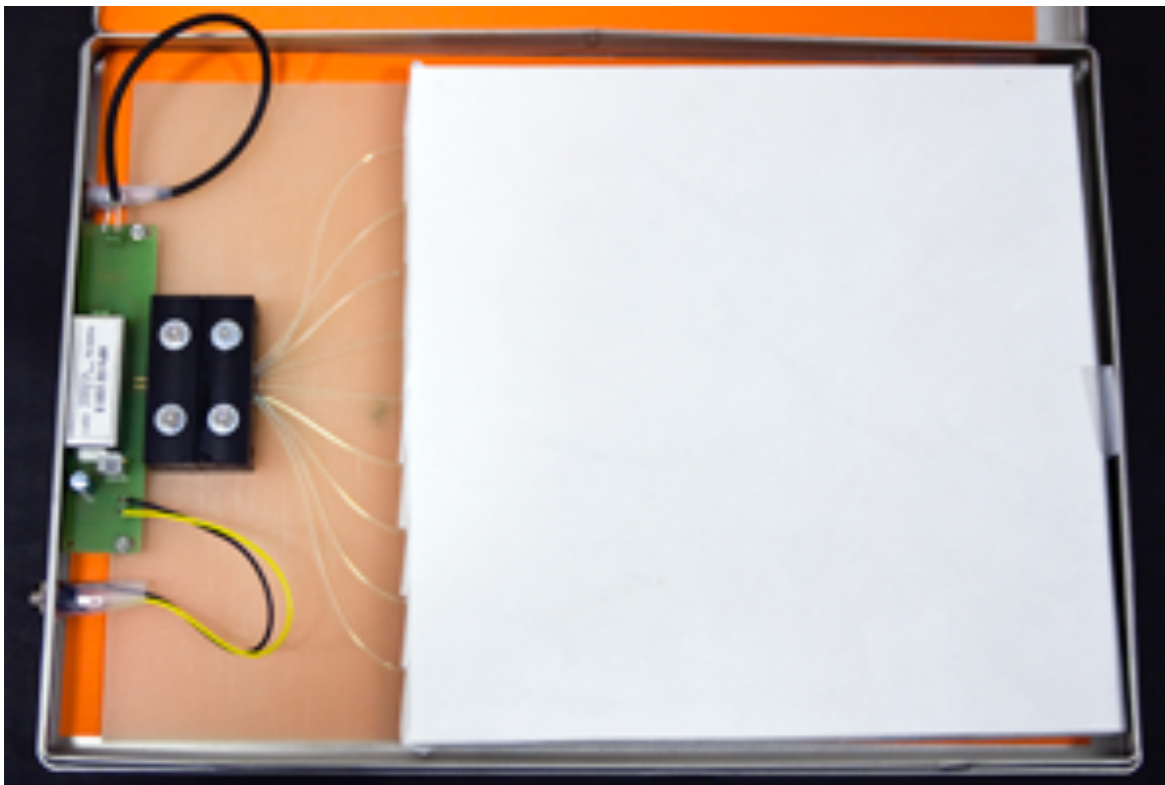


1. Experimente

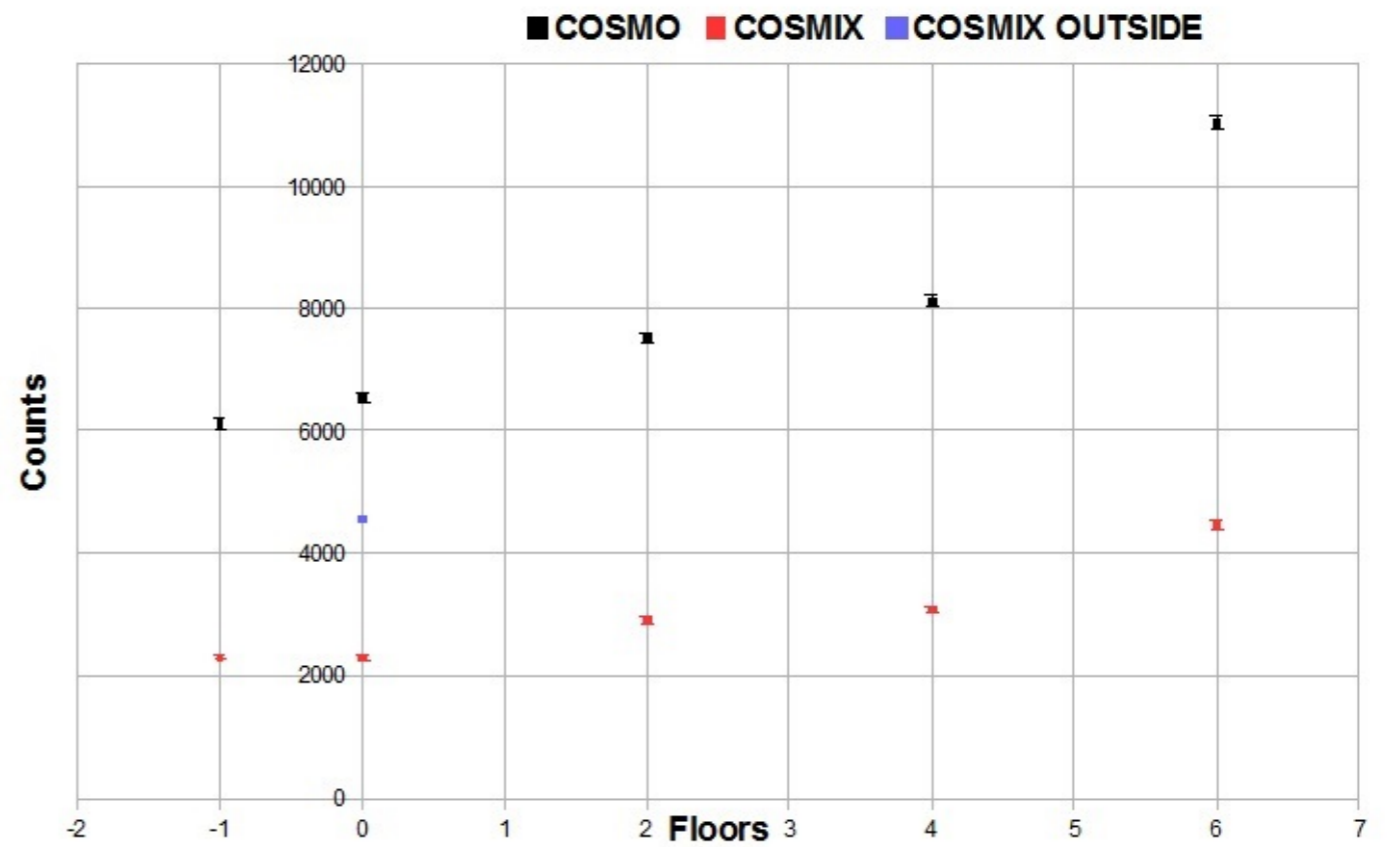


Mögliche Experimente:

- Messung der Teilchenrate bei verschiedenen Abständen der Detektoren und bei verschiedenen Winkeln.
- Messung von Teilchenschauern, wobei der horizontale Abstand der Detektoren variiert werden sollte.
- Messung der Geschwindigkeit mit der sich ein Myon bewegt.
- Messung der mittleren Lebensdauer des Myons.



1. Experimente



CosMO
2 scintillators in coincidence
20 cm x 20 cm x 1.8 cm

COSMIX
2 scintillators without coincidence
16 cm x 3 cm x 2 cm

1. Experimente

Geigerzähler



1. Experimente

Mögliche Experimente:

- Messung der Teilchenrate in unterschiedlichen Höhen (bspw. im Flugzeug)

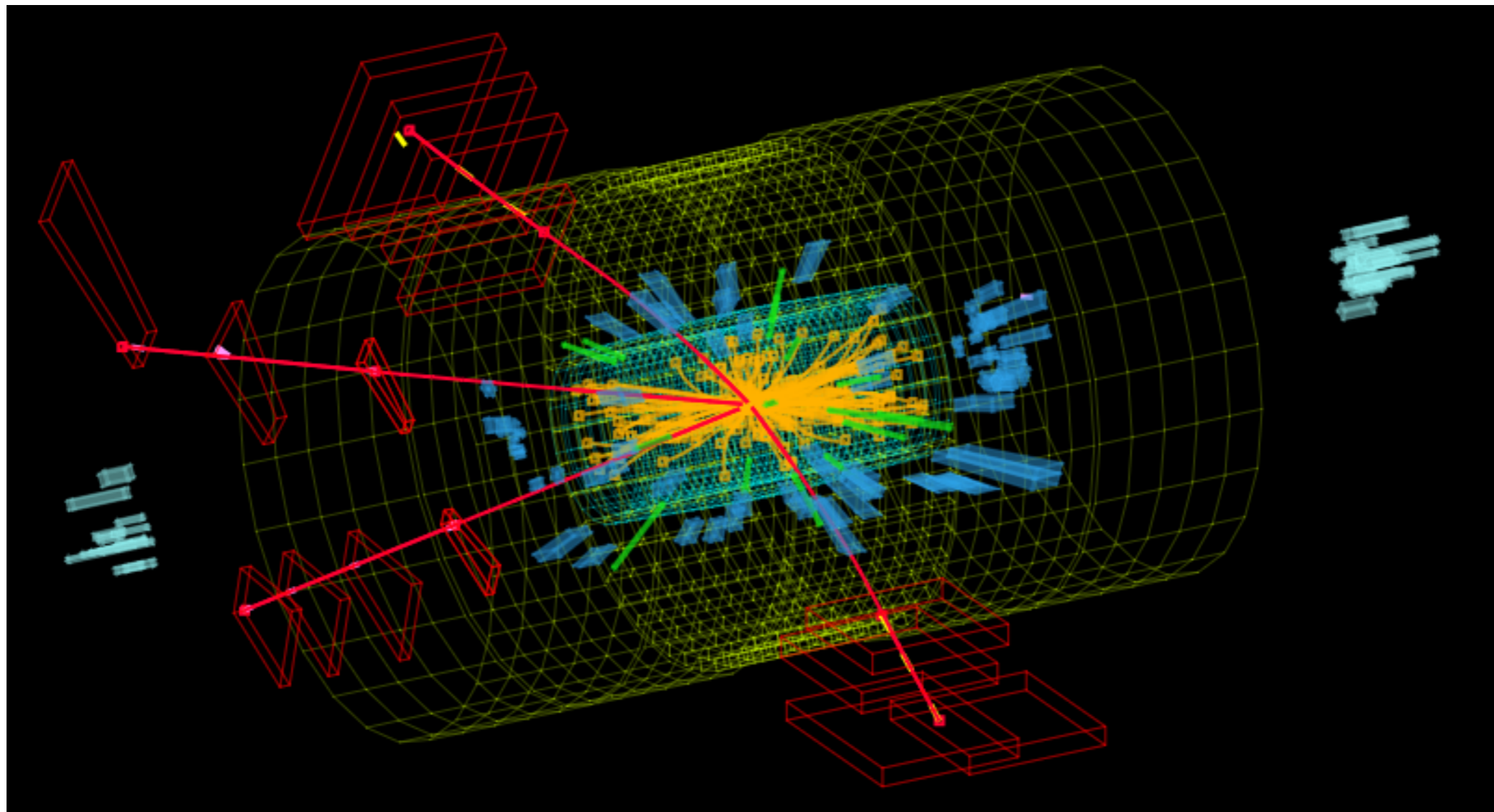


outline

1. Experimente
2. Datenanalysen
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2. Datenanalysen

Open Data Portal: <http://opendata.cern.ch/education>



2. Datenanalysen

Open Data Portal

Education

Datasets



The CMS (Compact Muon Solenoid) experiment is one of two large general-purpose detectors built on the Large Hadron Collider (LHC). Its goal is to investigate a wide range of physics such as the characteristics of the

Explore CMS >



ALICE (A Large Ion Collider Experiment) is a heavy-ion detector designed to study the physics of strongly interacting matter at extreme energy densities, where a phase of matter called quark-gluon plasma forms.

Explore ALICE >



The ATLAS (A Toroidal LHC ApparatuS) experiment is a general purpose detector exploring topics like the properties of the Higgs-like particle, extra dimensions of space, unification of fundamental forces, and

Explore ATLAS >

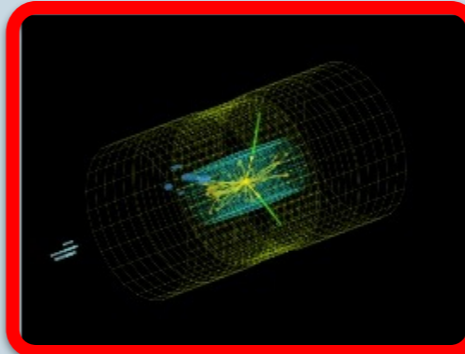


The LHCb (Large Hadron Collider beauty) experiment aims to record the decay of particles containing b and anti-b quarks, known as B mesons. The detector is designed to gather information about the identity,

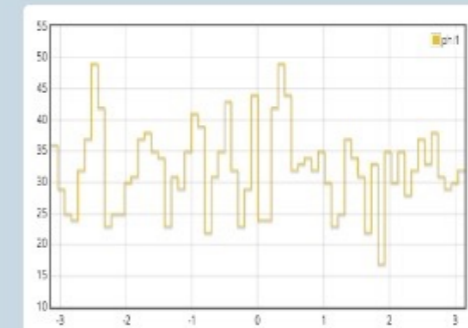
Explore LHCb >

For education purposes, the complex primary data need to be processed into a format (examples below) that is good for simple applications. Get in touch if you wish to build your own applications similar to those shown here

Event display



Visualise events >



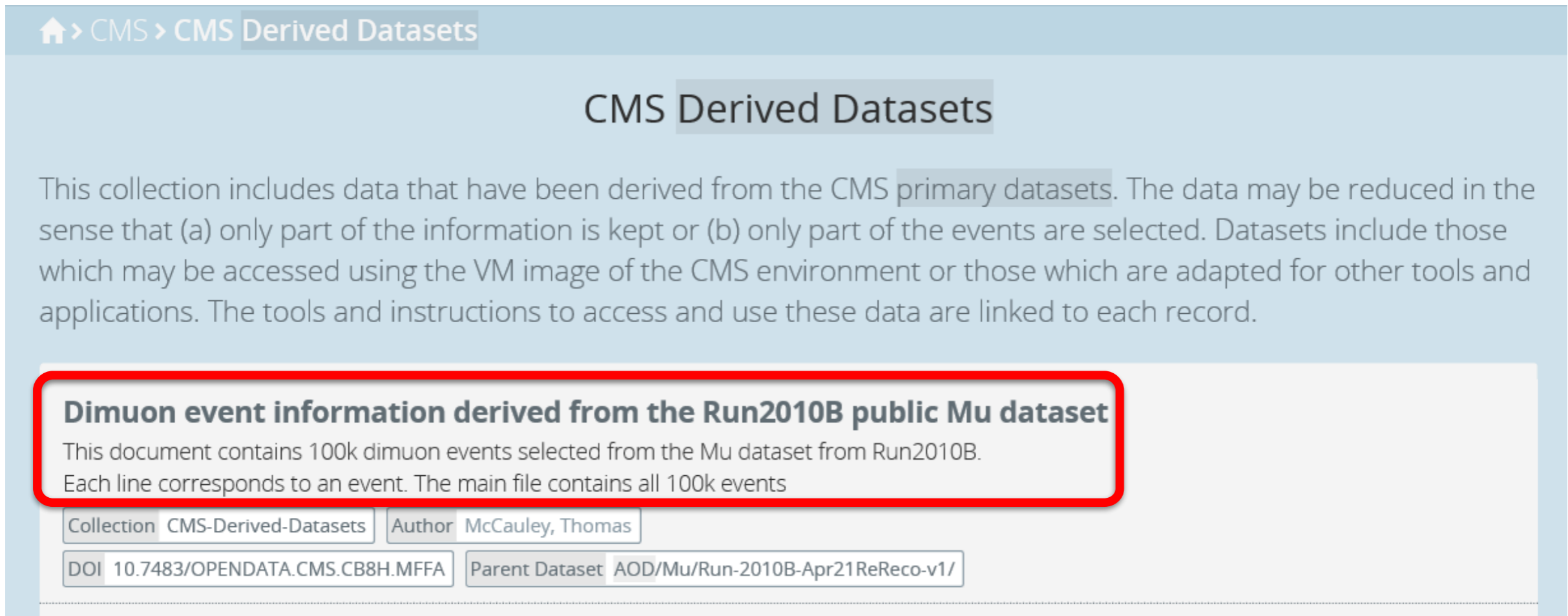
Visualise histograms >



Learning Resources >

2. Datenanalysen

Open Data Portal: <http://opendata.cern.ch/collection/CMS-Derived-Datasets>



Home > CMS > CMS Derived Datasets

CMS Derived Datasets

This collection includes data that have been derived from the CMS primary datasets. The data may be reduced in the sense that (a) only part of the information is kept or (b) only part of the events are selected. Datasets include those which may be accessed using the VM image of the CMS environment or those which are adapted for other tools and applications. The tools and instructions to access and use these data are linked to each record.

Dimuon event information derived from the Run2010B public Mu dataset

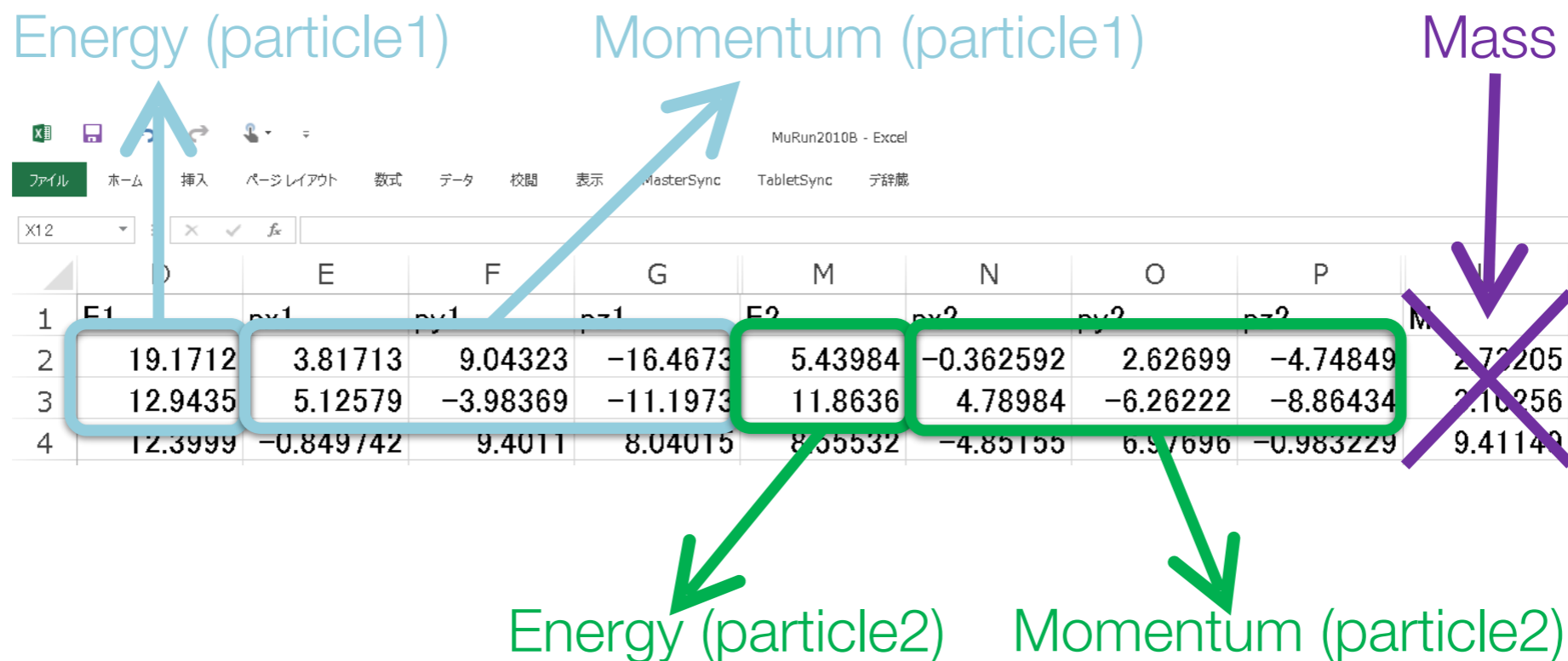
This document contains 100k dimuon events selected from the Mu dataset from Run2010B. Each line corresponds to an event. The main file contains all 100k events

Collection CMS-Derived-Datasets Author McCauley, Thomas

DOI 10.7483/OPENDATA.CMS.CB8H.MFFA Parent Dataset AOD/Mu/Run-2010B-Apr21ReReco-v1/

2. Datenanalysen

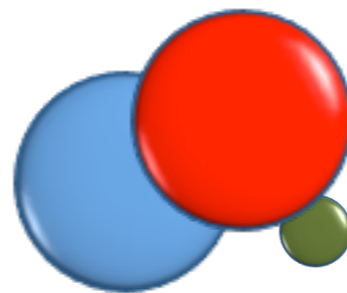
Open Data Portal: <http://opendata.cern.ch/collection/CMS-Derived-Datasets>



2. Datenanalysen

Open Data Portal: <http://opendata.cern.ch/collection/CMS-Derived-Datasets>

$$E_0, m_0, p_{0,x}, p_{0,y}, p_{0,z}$$



$$E_0^2 = m_0^2 c^4 + \mathbf{p}_0^2 c^2$$

$$m_0 = (E_0^2/c^4 - \mathbf{p}_0^2/c^2)^{1/2}$$

$$E_1, m_1, p_{1,x}, p_{1,y}, p_{1,z}$$
$$E_1^2 = m_1^2 c^4 + \mathbf{p}_1^2 c^2$$

$$E_2, m_2, p_{2,x}, p_{2,y}, p_{2,z}$$
$$E_2^2 = m_2^2 c^4 + \mathbf{p}_2^2 c^2$$

$$m_0 = ((E_1 + E_2)^2/c^4 - (\mathbf{p}_1 + \mathbf{p}_2)^2/c^2)^{1/2}$$

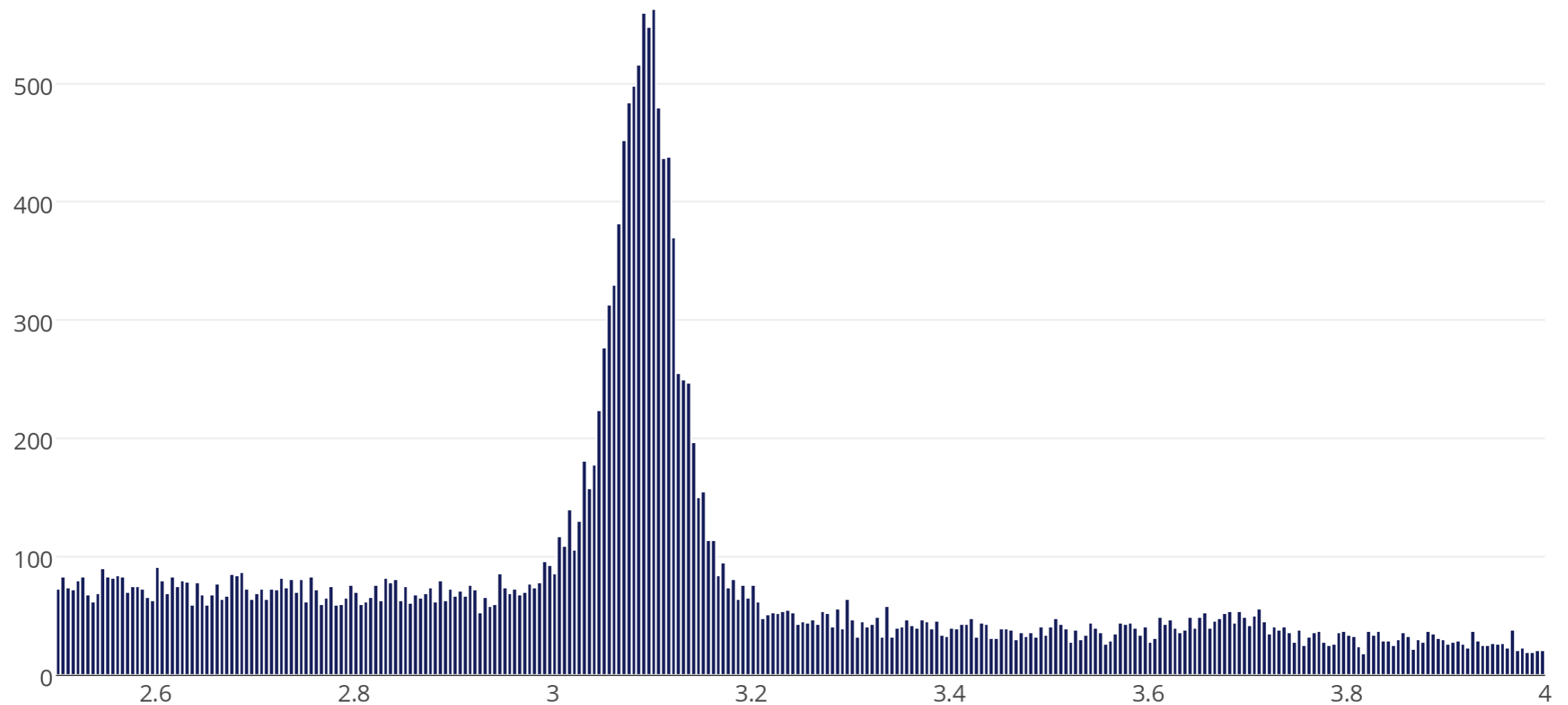
Energie und Impuls messen

$$m_0 = (((m_1^2 c^4 + \mathbf{p}_1^2 c^2)^{1/2} + E_2)^2/c^4 - (\mathbf{p}_1 + \mathbf{p}_2)^2/c^2)^{1/2}$$

Impuls messen, Teilchen identifizieren

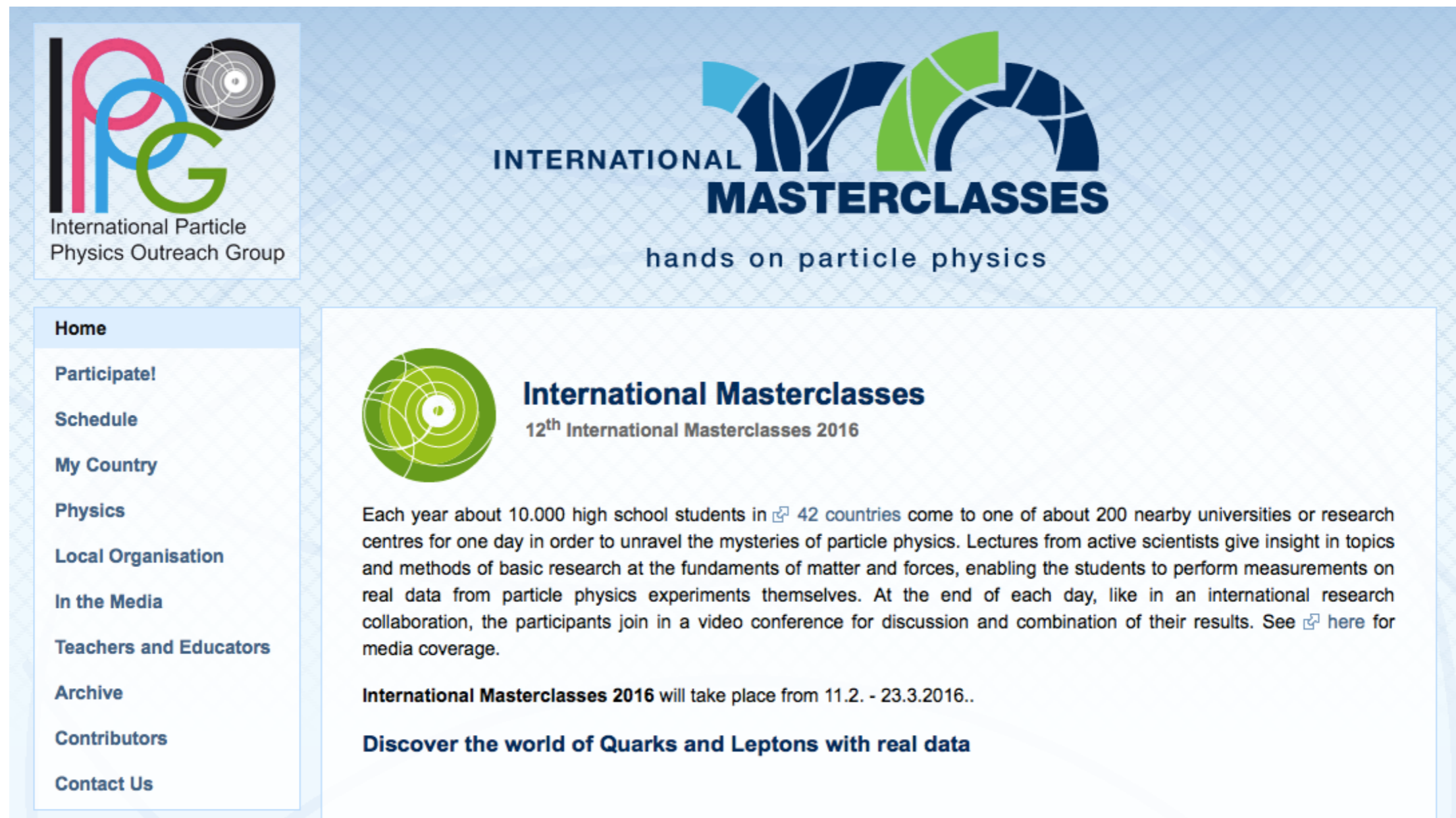
2. Datenanalysen

Open Data Portal: <http://opendata.cern.ch/collection/CMS-Derived-Datasets>



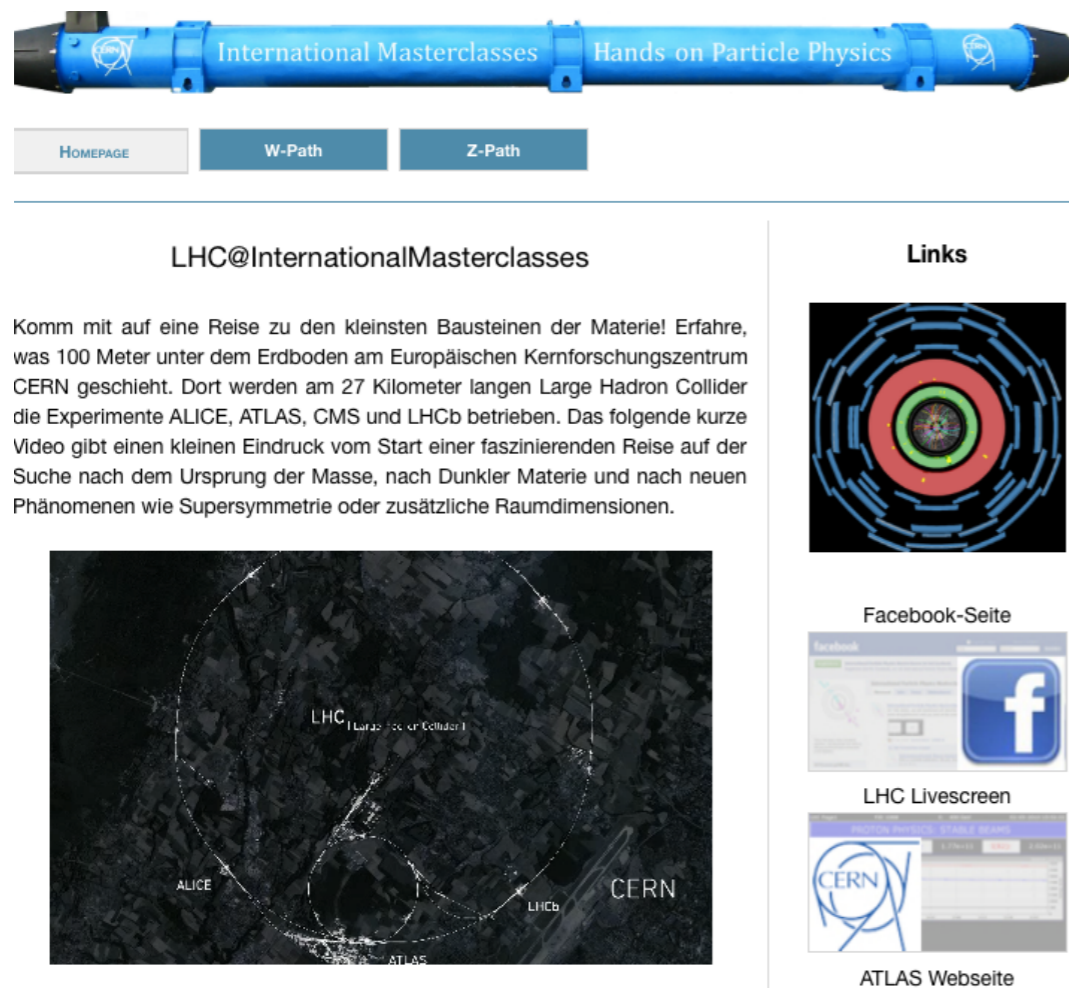
2. Datenanalysen

International Masterclasses: <http://physicsmasterclasses.org>



The image shows a screenshot of the International Masterclasses website. The page has a light blue background with a subtle grid pattern. In the top left corner, there is a logo for the International Particle Physics Outreach Group (IPPOG) featuring stylized letters 'IPPOG' in pink, blue, and green, and a particle detector cross-section. Below it, the text reads 'International Particle Physics Outreach Group'. In the top right, the main logo for 'INTERNATIONAL MASTERCLASSES' is displayed, with 'INTERNATIONAL' in a smaller font above 'MASTERCLASSES' in a large, bold, dark blue font. Below this, the tagline 'hands on particle physics' is written in a smaller, lowercase font. On the left side, there is a vertical navigation menu with the following items: 'Home', 'Participate!', 'Schedule', 'My Country', 'Physics', 'Local Organisation', 'In the Media', 'Teachers and Educators', 'Archive', 'Contributors', and 'Contact Us'. The main content area on the right features a green circular logo with a particle detector cross-section. To its right, the text reads 'International Masterclasses' in a bold font, followed by '12th International Masterclasses 2016' in a smaller font. Below this, a paragraph of text describes the event: 'Each year about 10.000 high school students in 42 countries come to one of about 200 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundamentals of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in an international research collaboration, the participants join in a video conference for discussion and combination of their results. See here for media coverage.' Below the paragraph, it states 'International Masterclasses 2016 will take place from 11.2. - 23.3.2016..' and 'Discover the world of Quarks and Leptons with real data'.

2. Datenanalysen



LHC@InternationalMasterclasses

Komm mit auf eine Reise zu den kleinsten Bausteinen der Materie! Erfahre, was 100 Meter unter dem Erdboden am Europäischen Kernforschungszentrum CERN geschieht. Dort werden am 27 Kilometer langen Large Hadron Collider die Experimente ALICE, ATLAS, CMS und LHCb betrieben. Das folgende kurze Video gibt einen kleinen Eindruck vom Start einer faszinierenden Reise auf der Suche nach dem Ursprung der Masse, nach Dunkler Materie und nach neuen Phänomenen wie Supersymmetrie oder zusätzliche Raumdimensionen.

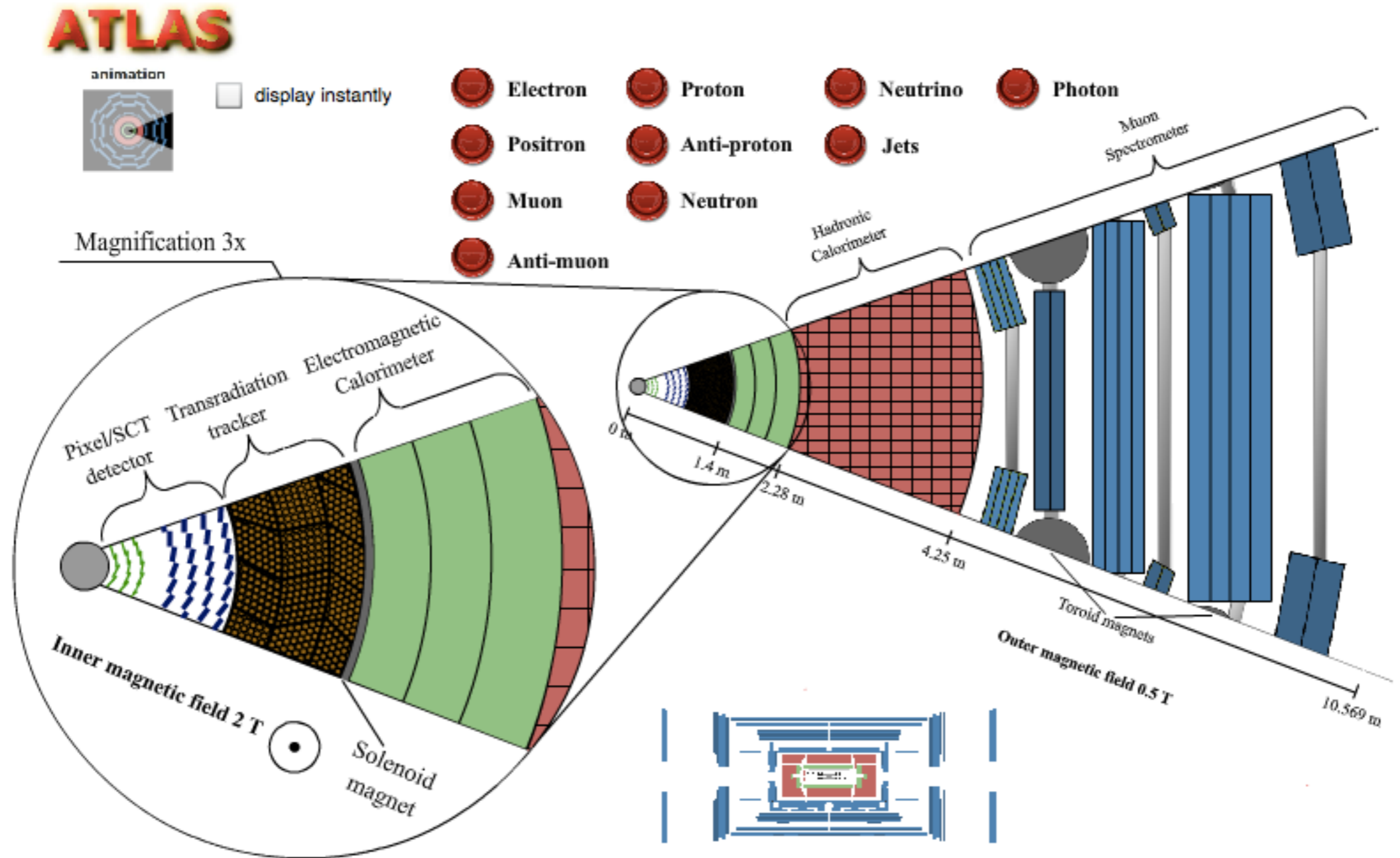
Links

- Facebook-Seite
- LHC Livescreen
- ATLAS Webseite

Mögliche Datenanalysen:

- ATLAS: Suche nach W- und Z-Teilchen, Suche nach dem Higgs
- CMS: WZH
- ALICE: Suche nach strangehaltigen Teilchen
- LHCb: Bestimmung der Lebensdauer kurzlebiger Teilchen

2. Datenanalysen



outline

1. Experimente
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3. Materialien

The screenshot shows the CERN 60 Multimedia page. At the top left is the CERN logo with the text "YEARS/ANS CERN". To the right are language options "EN" and "FR". Below these are navigation links for "NEWS", "EVENTS", "MULTIMEDIA" (with a dropdown arrow), and "MENU" (with a hamburger icon). The main banner features a folder icon and the heading "Multimedia" with the text: "Discover all the photos and videos of the CERN60 celebrations and download your posters, wallpaper and much more!". Below the banner, a breadcrumb trail reads "CERN 60 > Multimedia > CERN exhibitions content". On the left is a sidebar titled "CERN60 RESOURCES" with a sub-section "CERN EXHIBITION CONTENTS" containing a list of links: Overview, Physics, LHC Accelerators, Experiments, Computing, Knowledge Transfer, and History. The main content area is titled "CERN exhibitions content" and contains two cards. The "Overview" card shows a satellite map of the CERN site with labels for CMS, LHC (Large Hadron Collider), ALICE, ATLAS, and LHC2, and a "VIEW CONTENT >" button. The "Physics" card displays a diagram of particle physics with labels for Quarks (u, d, s, c, b, t), Leptons (e, μ , τ), Higgs boson, and various W and Z bosons, and a "VIEW CONTENT >" button.

3. Materialien

The screenshot shows the website for the International Particle Physics Outreach Group. At the top left is the logo, and at the top right are links for 'Login / Sign-up / FAQs' and a search bar. The main navigation menu includes 'HOME', 'ABOUT', 'MEMBERS', 'RESOURCES', and 'MASTERCLASSES'. The current page is 'Resources', with a breadcrumb 'HOME > RESOURCES'. A left sidebar lists various activity types such as 'Activities', 'Programs & Events', and 'Media'. The main content area features a 'Learning Topics' section with a green circular icon and a list of topics: Physics, Technology, International Collaboration, and Broader Impacts. Below this are two tabs, 'LATEST' and 'FEATURED', with a grid of resource cards. The cards include titles like 'Das Higgs Teilchen - eine Suche nach den Grenzen der Physik', 'Higgs-Teilchen entdeckt?', 'Symmetrien, Higgs-Teilchen und der Ursprung der Masse', and 'Neues vom Higgs - Suche nach dem Higgs-Boson am LHC'. On the right side, there is a 'Search by' filter section with dropdown menus for Learning Topic, Audience, Item Type, Availability, Duration, and Language, along with a 'Key Words' input field and a 'GO' button. Below the search filters is a 'Resources in your language' section with links for English, French, German, Italian, Portuguese, and Spanish, and a 'more' link. At the bottom right, there is a 'Filter by audience' section showing '6 to 9 years'.

International Particle Physics Outreach Group

HOME | ABOUT | MEMBERS | RESOURCES | MASTERCLASSES

HOME > RESOURCES

Resources

Activities

- Cart Demonstration
- Classroom Activity
- Facilitated Activity
- Presentation
- Game
- Display

Programs & Events

- Science Fair / Science Festival
- Science Camp
- Science Shows & Performances
- Symposium / Conference
- Classroom Outreach Program
- Multi-Media Contest

Media

- Audio / Podcast
- Film / Video
- Animation - real event
- Animation - simulated event
- Images
 - Photos
 - Illustrations
 - Event Displays (static)
 - Plots
- Computer game
- Non-game Interactives / Virtual Tours
- Website

Learning Topics

- ▶ Physics
- ▶ Technology
- ▶ International Collaboration
- ▶ Broader Impacts

LATEST FEATURED

Das Higgs Teilchen – eine Suche nach den Grenzen der Physik

Peter Schleper
Universität Hamburg
17.4.2012
Akademie der Wissenschaften In-Exzellenz

Higgs-Teilchen entdeckt?

Prof. Karl Jakobs
Physikalisches Institut
Universität Freiburg

Symmetrien, Higgs-Teilchen und der Ursprung der Masse

2013 NOBEL PRIZE IN PHYSICS
François Englert
Peter W. Higgs

A. Strassner

Neues vom Higgs – Suche nach dem Higgs-Boson am LHC

Günter Quast
Kolloquium Wuppertal
23.1.2012

Search by

Learning Topic
- Any -

Audience
- Any -

Item Type
- Any -

Availability
- Any -

Duration
- Any -

Language
- Any -

Key Words

GO

Resources in your language

English French German
Italian Portuguese Spanish

[more](#)

Filter by audience

6 to 9 years

3. Materialien



High School Teachers at CERN



WWW.CERN.CH [TEACHING MATERIALS](#) [HST PROGRAMMES](#)
[VISITING CERN](#) [LINKS & BOOKS](#) **HOME**

The main goal of this site is to document the work done by the participants of the programme and to collect material useful for classroom activities and public education in physics, which is then available for everyone.

NEWS

Applications for HST2014 are now being accepted

FOR MORE INFORMATION PLEASE FOLLOW THE LINK BELOW

HST TEACHING MATERIALS

- [Accelerators](#)
- [Bubble chambers](#)
- [Build a Cloud Chamber](#)
- [Feynman diagrams](#)
- [Detectors](#)
- [Experiments](#)
- [About CERN and HEP](#)
- [General Physics](#)
- [Syllabus review](#)



The First Z Particle 30th April 1983 (CERN Photo)

VISITING CERN

- [Microcosm](#)
- [CERN websites](#)

PHYSICS LINKS

- [General Physics](#)
- [Particle Physics](#)
- [Research Organizations](#)
- [Books and Journals](#)
- [CERN's Educational Page](#)

HST PROGRAMMES

1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014

[SITEMAP](#)

[WORKING AREA](#)

3. Materialien

indico

Home Create event ▾ Room booking Help ▾

Home » Outreach » Educational Outreach » Teacher Programmes

Teacher Programmes

There are 10 events in the *future*. [Show them.](#)

October 2015

- 25 Oct - 30 Oct [German Teachers Programme](#)
- 25 Oct - 30 Oct [Swedish Teachers Programme 10/2015](#)
- 18 Oct - 23 Oct [French Teachers Programme 2015](#)
- 11 Oct - 16 Oct [German Teachers Programme](#)
- 10 Oct - 17 Oct [Georgian Teachers Programme 2015](#)
- 04 Oct - 10 Oct [Bulgarian Engineering Teachers Programme](#)
- 04 Oct - 09 Oct [Italian Teacher Programme 2015](#)

September 2015

- 27 Sep - 03 Oct [SESAME Teacher Programme](#)
- 21 Sep - 24 Sep [Danish Teacher Programme](#)

3. Materialien

The screenshot shows the ATLAS Experiment website. At the top, there is a navigation bar with links for Home, Info, Multimedia, Blogs, Links, Visit ATLAS, Contact, Collaboration Site, Store, Press, and Student/Teachers. Below this is a news banner for "Live Science: First Glimpse of Higg_". The main content area is divided into several sections: "ATLAS Briefings" with two plots showing energy distributions; "ATLAS News" featuring a photo of a physicist and a "LHC shut down" announcement; "ATLAS Science & Art" with a section on "ATLAS and the Higgs"; "About ATLAS" with a section on "Mapping the Secrets of the Universe"; and "Higgs Multimedia Material" with a video player for "The ATLAS Story". A sidebar on the right displays "ATLAS RUN STATUS TOTAL LUMINOSITIES" with values for Proton-Proton, Proton-Lead, and Lead-Lead collisions.

The screenshot shows the CMS Experiment website. The top navigation bar includes "Compact Muon Solenoid experiment at CERN's LHC" and a search box. Below the navigation bar are tabs for "PUBLIC WEBSITE" and "COLLABORATION WEBSITE". The main content area features a large banner for the "Observation of a New Particle with a Mass of 125 GeV" dated 4 July 2012, accompanied by a visualization of a particle collision. To the right of the banner is a section titled "Introducing CMS" with a list of links: Engler and Higgs get the Nobel, Observation of a New Particle with a Mass of 125 GeV, Physics Results, CMS Detector, and About CMS. Below the banner are sections for "General News" (CHIPP Prize 2014 to Marco Peruzzi) and "Physics News" (Recent results in the search for supersymmetry). A sidebar on the right contains a "CMS Live" section with links to CMS Live, CMS Links, and Multimedia, as well as "Physics Results" and "Photographs" sections.

3. Materialien



NETZWERK
TEILCHENWELT QUARKS, ELEKTRONEN & CO.



DAS PROJEKT | AKTUELLES | MITMACHEN | ANGEBOTE | STANDORTE | MATERIAL | FORUM

Sie sind hier: Material > Materialien für Lehrkräfte

Materialien für Lehrkräfte

Auf dieser Seite finden Sie Materialien vom Netzwerk Teilchenwelt, die zur Einführung in die Teilchenphysik verwendet werden können. Sie eignen sich insbesondere zur Vor- und Nachbereitung von Masterclasses, können aber auch unabhängig davon eingesetzt werden.

▶ Teilchenphysik - Forschung und Anwendungen

Diese Materialien enthalten Informationen und Anregungen rund um aktuelle Forschungsthemen, Methoden und Anwendungen der Teilchenphysik.

▶ Das Standardmodell der Teilchenphysik und die vier Wechselwirkungen

Diese Materialien enthalten Fragen und Antworten rund um Elementarteilchen sowie die vier grundlegenden Wechselwirkungen und ermöglichen eine systematische Einführung in das Thema.

▶ Der ATLAS-Detektor

ATLAS ist einer von vier Detektoren für den Nachweise von Elementarteilchen am LHC. Dieses Material bietet auf der Grundlage des Animationsfilms „ATLAS Episode II – Die Teilchen schlagen zurück“ einen Überblick über die Technik und die Funktionsprinzipien des Detektors.



Lehrkräfte bei CERN-Workshop

Downloads zum Thema

- ▶ Tipps zur Vorbereitung einer Masterclass
- ▶ Materialsammlung - Kontextmaterialien für Lehrkräfte (109 MB)
- ▶ Materialsammlung - Kontextmaterialien für Lehrkräfte (komprimiert) (5,6 MB)

Artikel zum Thema

- ▶ Informationen für (angehende) Lehrkräfte
- ▶ Materialien für Vermittler
- ▶ Linksammlung zur Teilchenphysik (nach Kategorien sortiert)
- ▶ Linksammlung zur Teilchenphysik (nach Themen sortiert)

Nachrichten zum Thema

- ▶ 06.09.2013 Netzwerk Teilchenwelt und Joachim Herz Stiftung erstellen Unterrichtsmaterial zu Higgs und Co.

Impressum Materialien


outline

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4. Unterstützung



Sie sind nicht angemeldet.  Anmelden  Registrieren



 [Forum Startseite](#)  [Galerie](#)


Netzwerk Teilchenwelt - Forum



Lieber Besucher, herzlich willkommen bei: Netzwerk Teilchenwelt - Forum. Falls dies Ihr erster Besuch auf dieser Seite ist, lesen Sie sich bitte die [Hilfe](#) durch. Dort wird Ihnen die Bedienung dieser Seite näher erläutert. Darüber hinaus sollten Sie sich registrieren, um alle Funktionen dieser Seite nutzen zu können. Benutzen Sie das [Registrierungsformular](#), um sich zu registrieren oder [informieren Sie sich ausführlich](#) über den Registrierungsprozess. Falls Sie sich bereits zu einem früheren Zeitpunkt registriert haben, können Sie sich [hier anmelden](#).

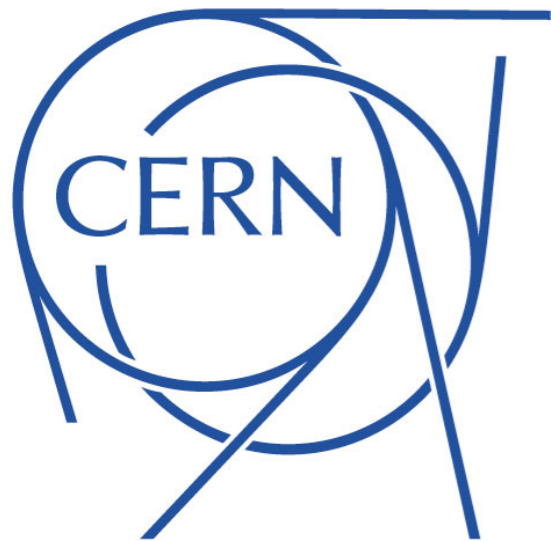
 [Interner Bereich](#)

 [Projekt: Unterrichtsmaterial Teilchenphysik](#)

 [Teilchenphysik](#)
Fragen und Antworten

 Atomhüllen und Quantenphysik	 Von Reeseid5g2 (16.09.2015, 18:32)	22 Themen 115 Beiträge
 Kernphysik, Subnuklearphysik und Standardmodell	 Beitrag der Masse der virtuellen Quarks zur Hadronenmasse Von Narr (11.09.2015, 04:42)	17 Themen 106 Beiträge
 Kosmische Strahlung und Astroteilchenphysik	 Gravitationswellen Von Legomann (21.05.2015, 22:33)	8 Themen 50 Beiträge
 Praxis Teilchenforschung CERN, DESY, u.v.m	 Brillanz von XFEL Von Kurt (29.03.2015, 23:56)	19 Themen 76 Beiträge
 Teilchenphysik FAQ Fragen zur Teilchenphysik, die immer wieder auftauchen!	 De Broglie Wellenlänge-experimentelle Grenzen Von MichaelKobel (24.06.2015, 22:25)	12 Themen 96 Beiträge

4. Unterstützung



e-mail us!

Vielen Dank!

References

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