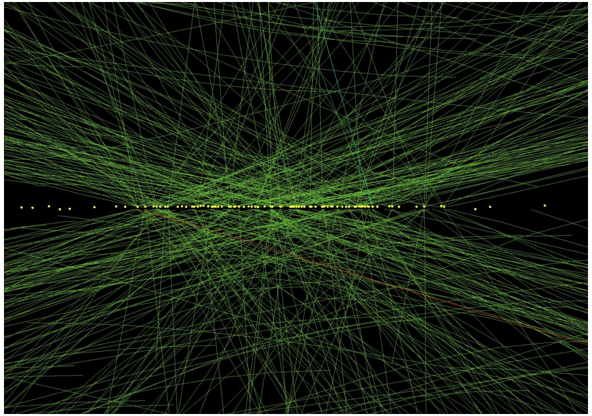
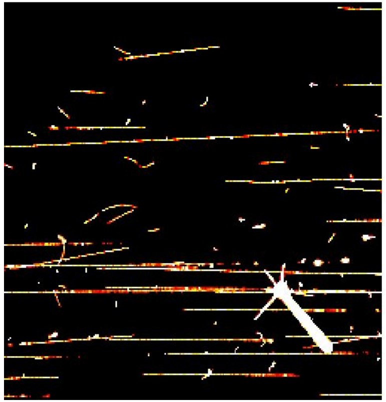
  

Částice částice částice

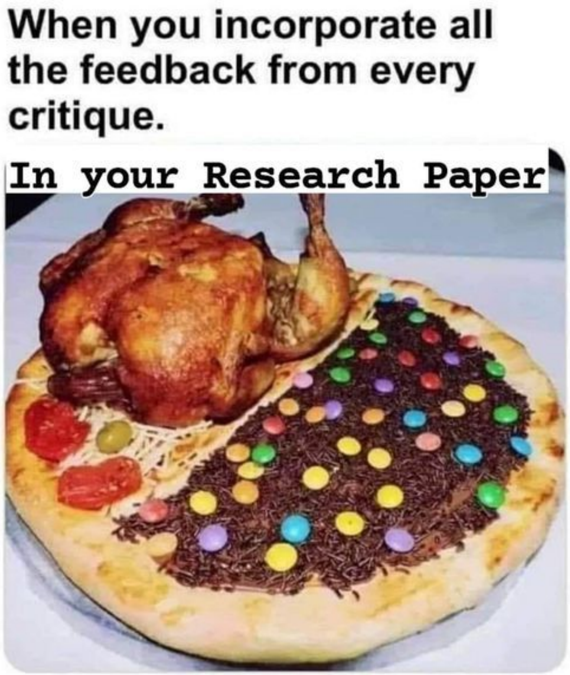
částice částice částice částice

Mgr. Jiří Kvita, Ph.D.
Společná laboratoř optiky UP
Letní Škola Badatele 2024

PALACKÝ UNIVERSITY OLOMOUC

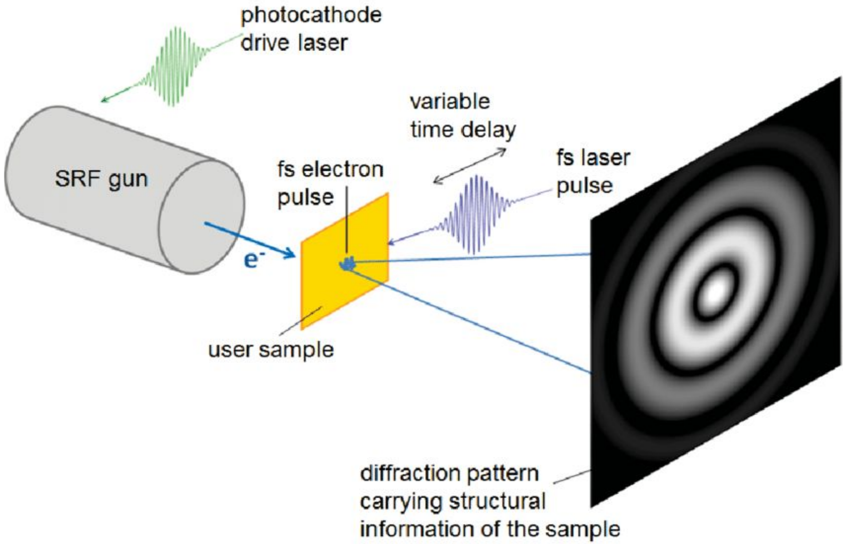
Co jsem slíbil…

V přednášce se podíváme na objevy prvních částic a antičástic, podivných částic a neutrin, a jak můžeme určit, která částice okolo nás právě "letí", čím se liší a čím jsou zajímavé. Také si připomeneme výročí 50 let od objevu jedné z nich, která znamenala listopadovou revoluci v částicové fyzice. A nakonec se podíváme kritickým okem na částicové experimenty ze seriálu Problém tří těles:)

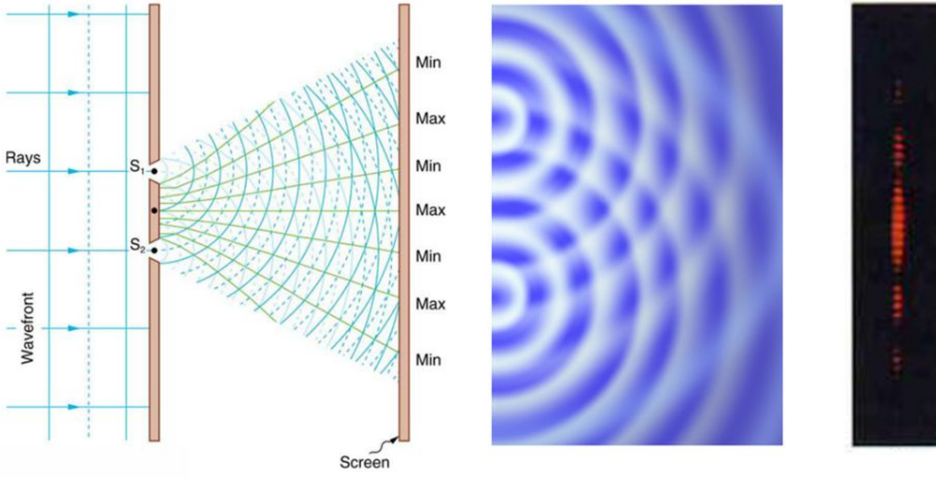


Částice nebo vlna?

Elektrony

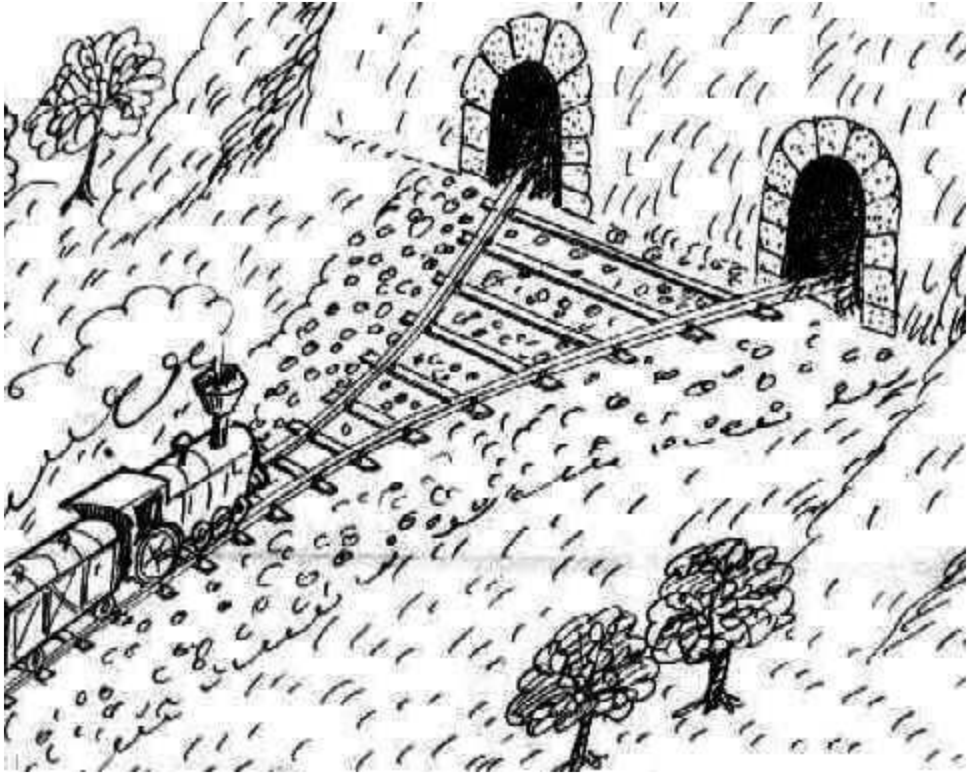


Světlo



https://www.researchgate.net/figure/The-setup-of-an-ultrafast-electron-diffraction-experiment-41_fig5_333639953
https://courses.lumenlearning.com/suny-physics/chapter/27-3-youngs-double-slit-experiment/

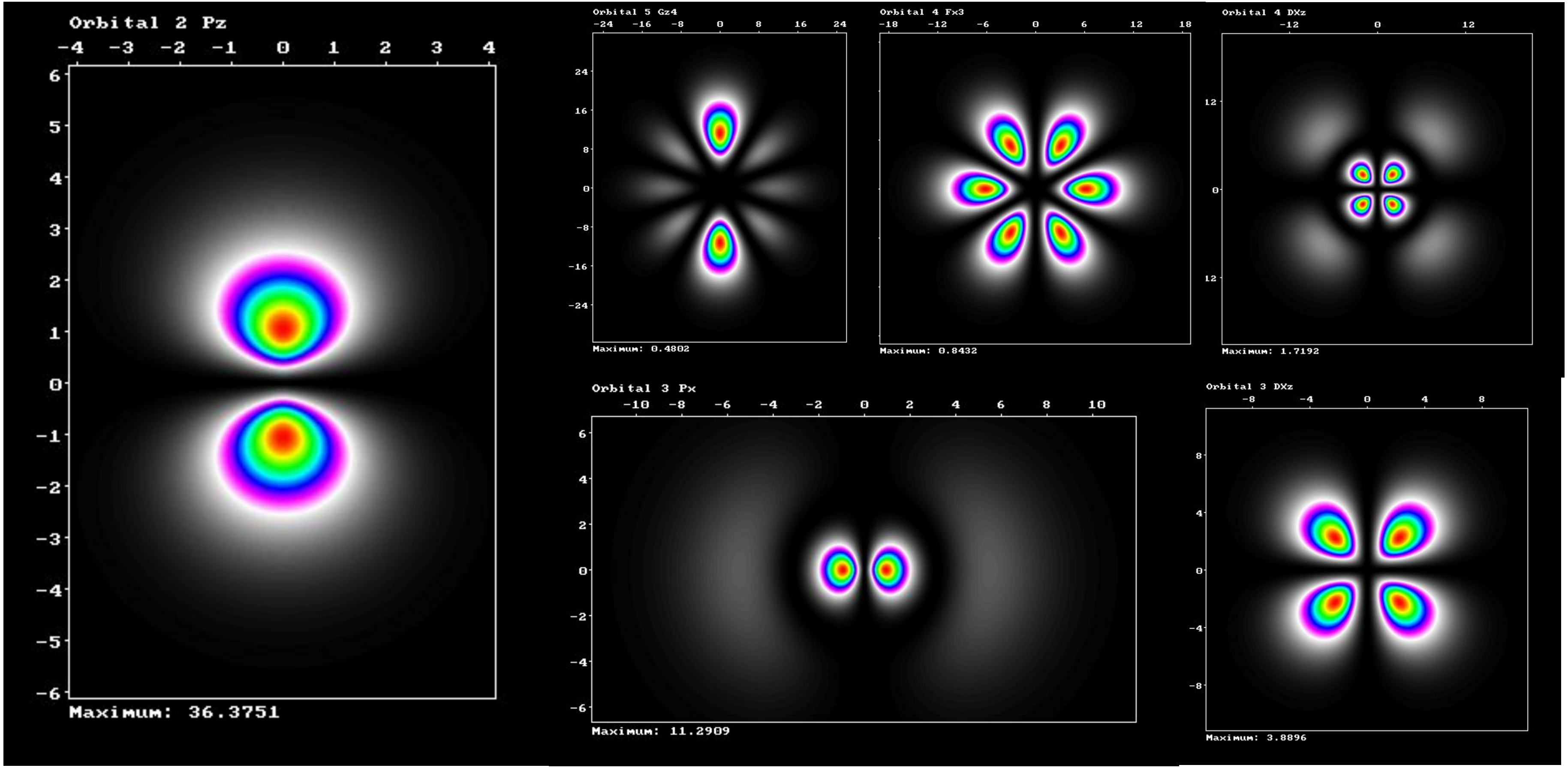
Částice nebo vlna?



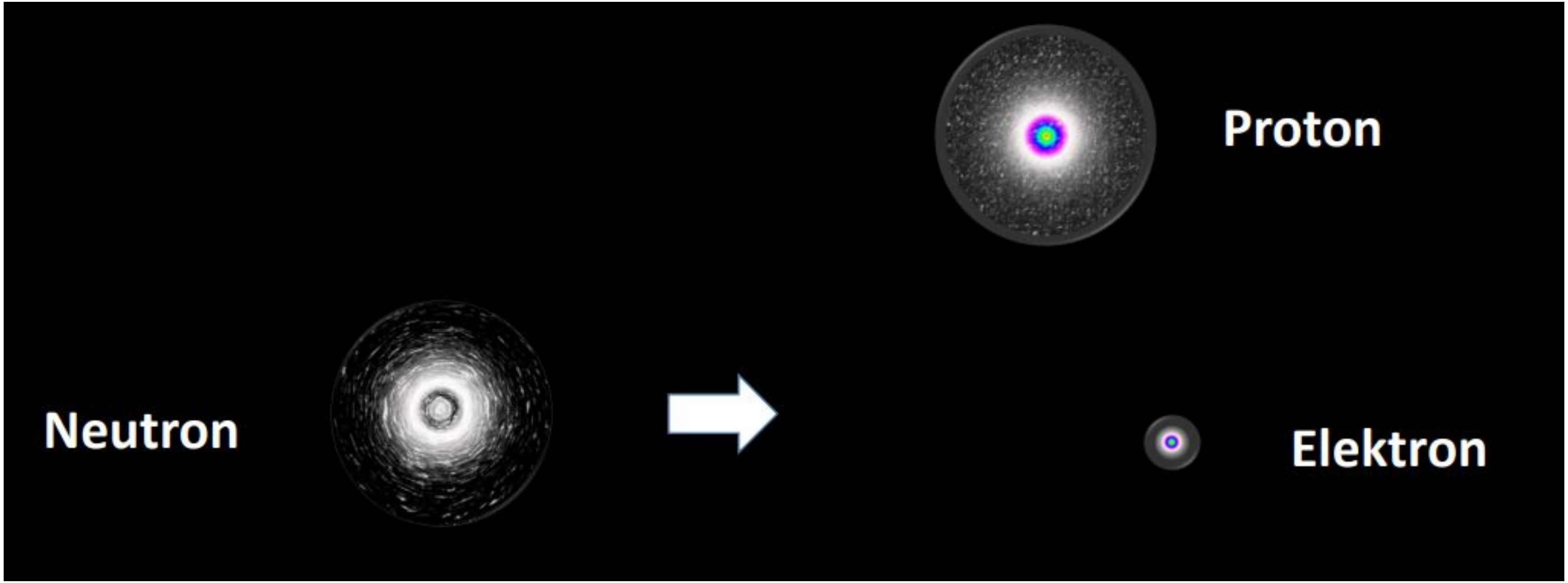
Jaké znáte částice?

Jaké znáte antičástice?

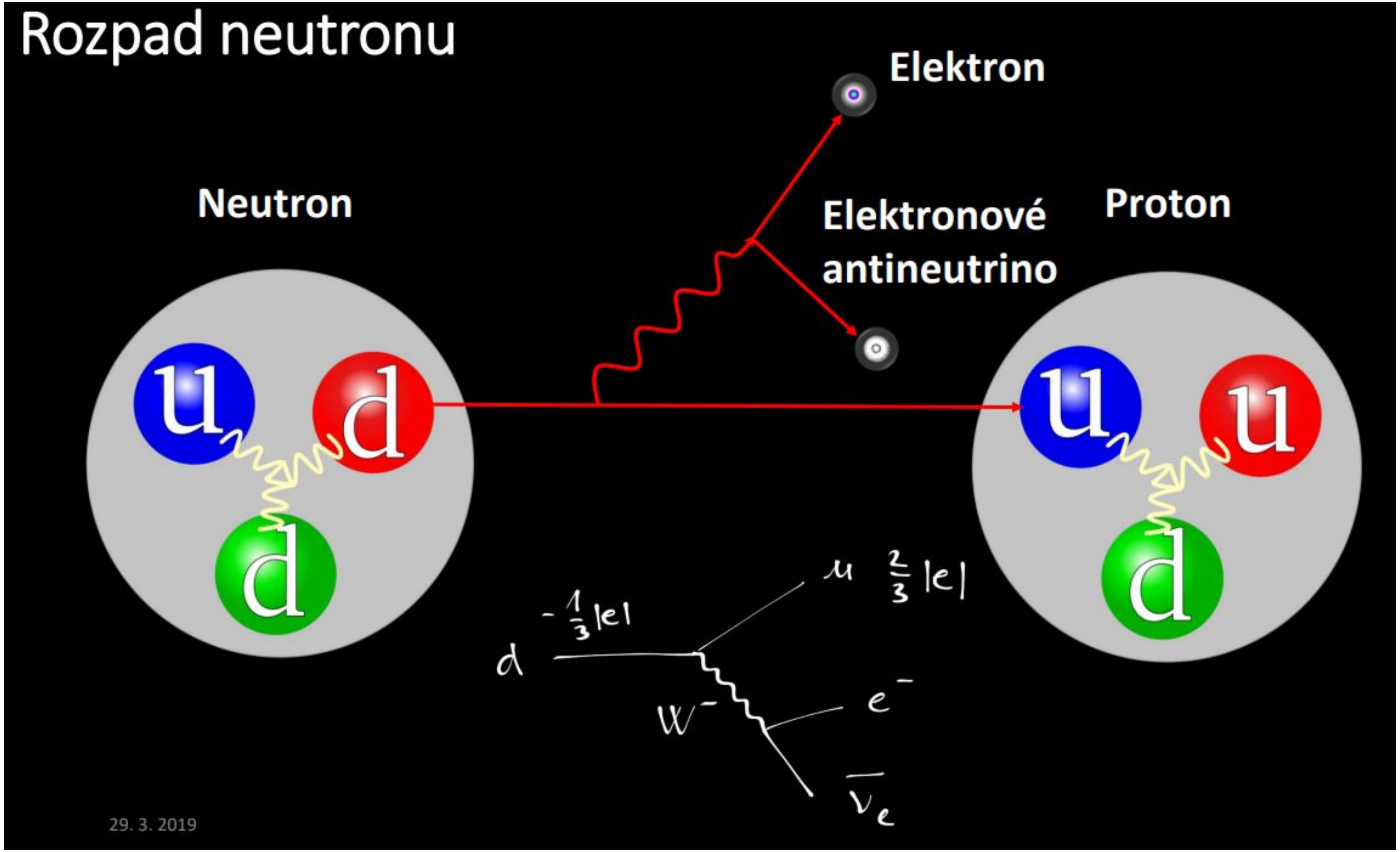
Atom – stojaté vlny elektronu okolo jádra



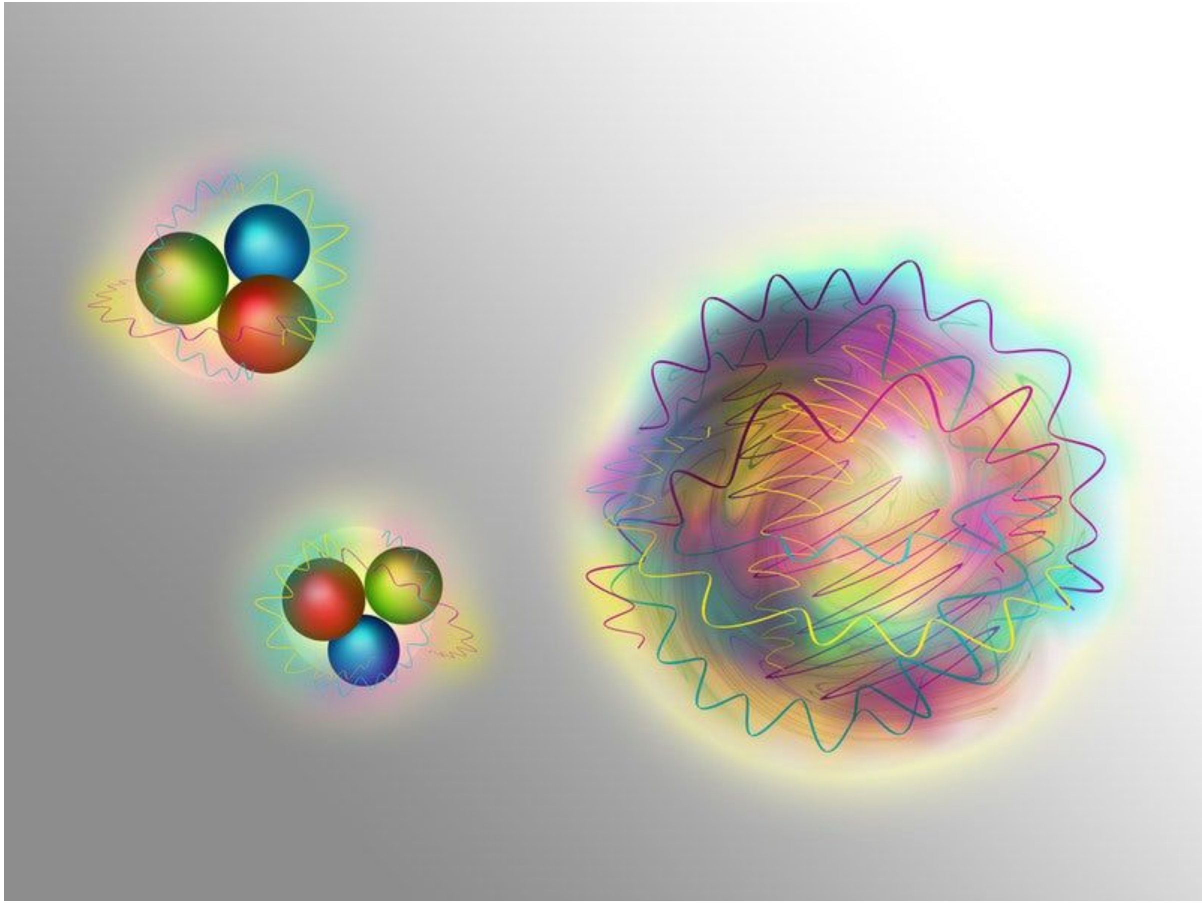
Rozpad neutronu



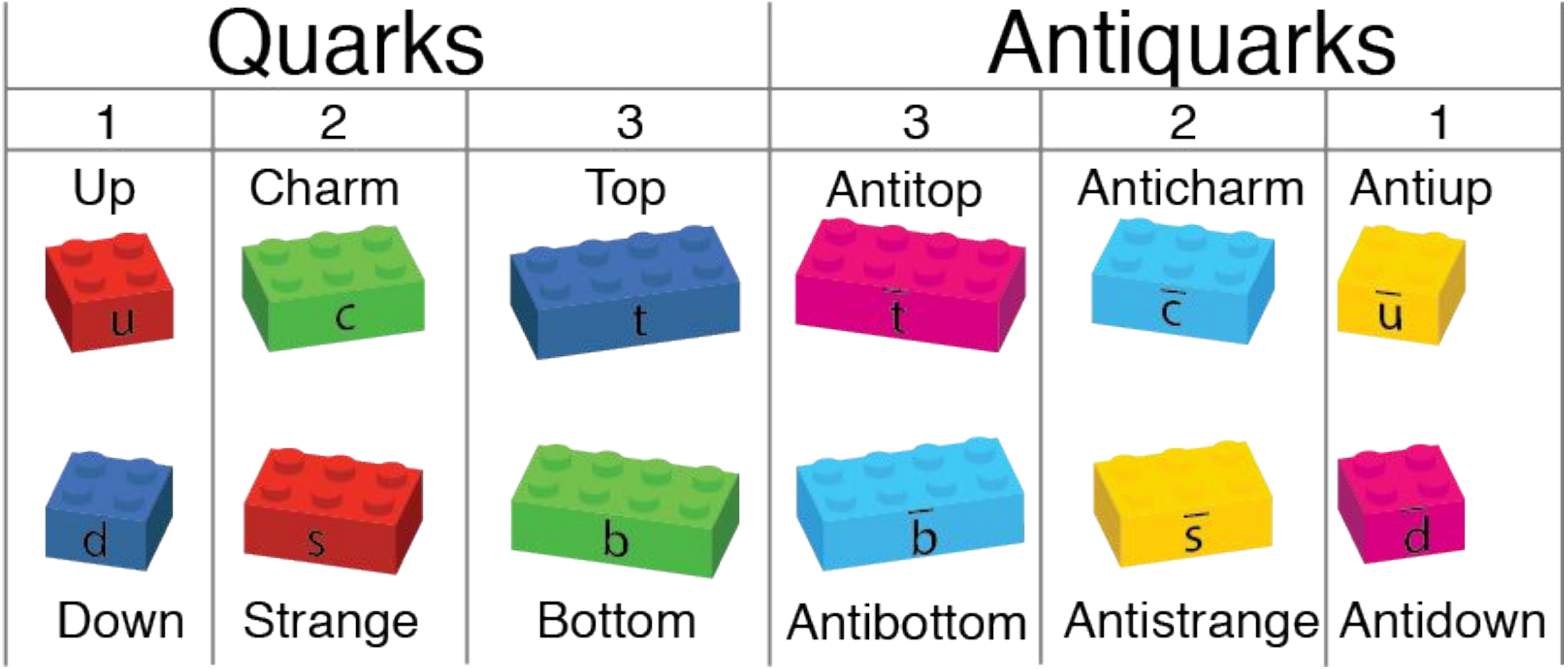
Rozpad neutronu



Proton

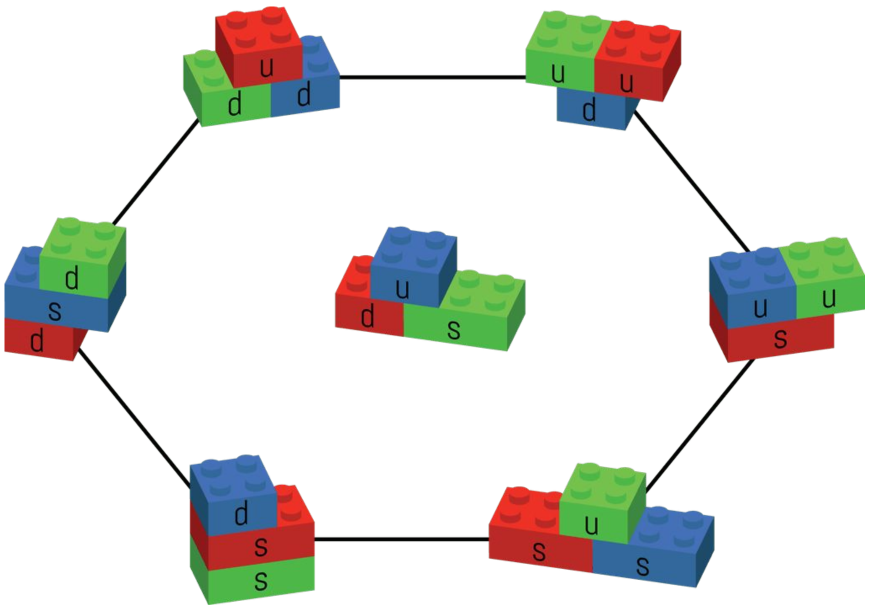


Kvarky a antikvarky

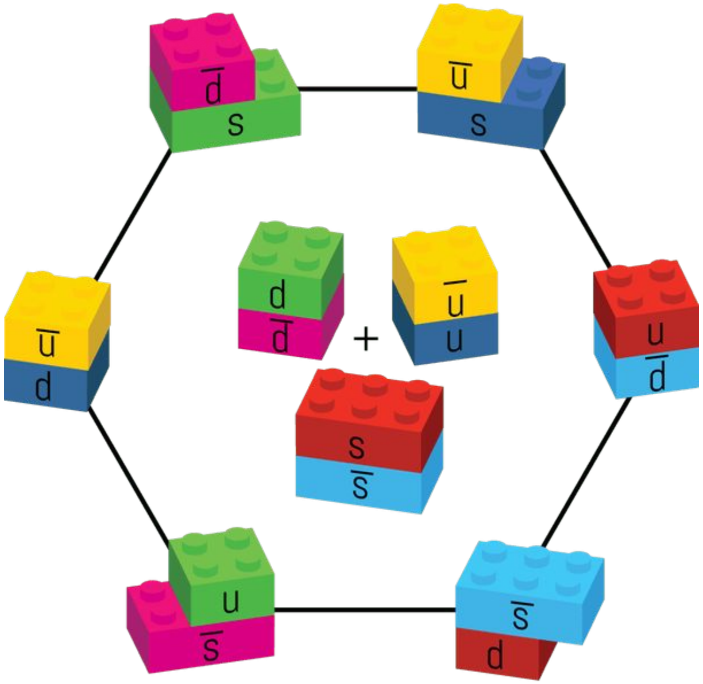


Hadrony, skládání kvarků u, d, s

Baryony = qqq

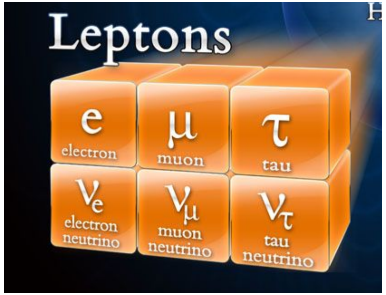


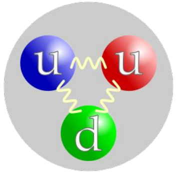
Mesony = q + anti-q

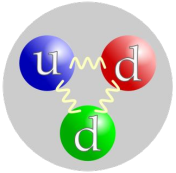


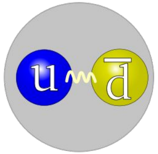
“Stabilní” částice: pozorovatelné v detektoru

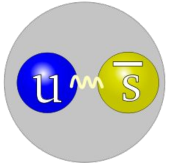
- Fotony, m=0
- Elektrony e^-, mc^2 = 0.511 MeV
  - Pozitrony e^+
- Protony p^+ , 938.3 MeV
- Neutrony n^0 , 939.6 MeV
- Neutrina – málo interagující
- Miony $\mu^\pm$ – doba života 2μs, cτ = 600m. mc^2 = 105.6 MeV
  - 200x těžší než elektrony, pronikavější, kosmické záření.
- Piony, 140 MeV
  - $\pi^\pm$ – doba života 26ns, cτ = 7.8m
  - π^0 – rychle se rozpadá
- Kaony
  - K^+, K^-: , cτ = 3.7m
  - K^0, anti-K^0



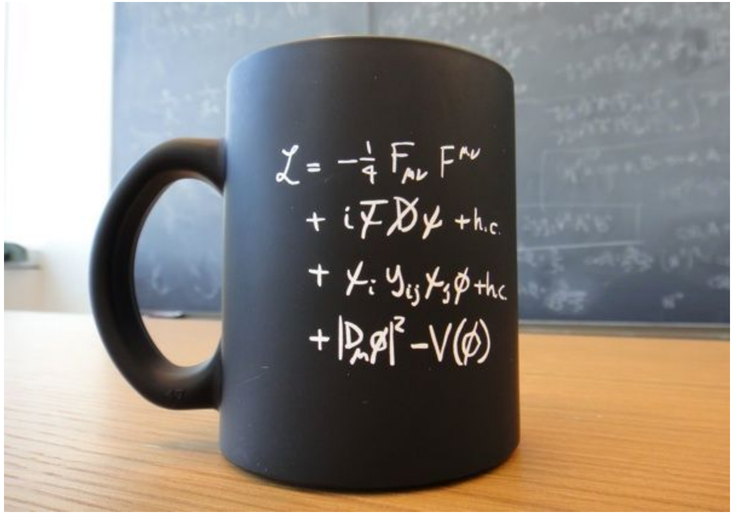


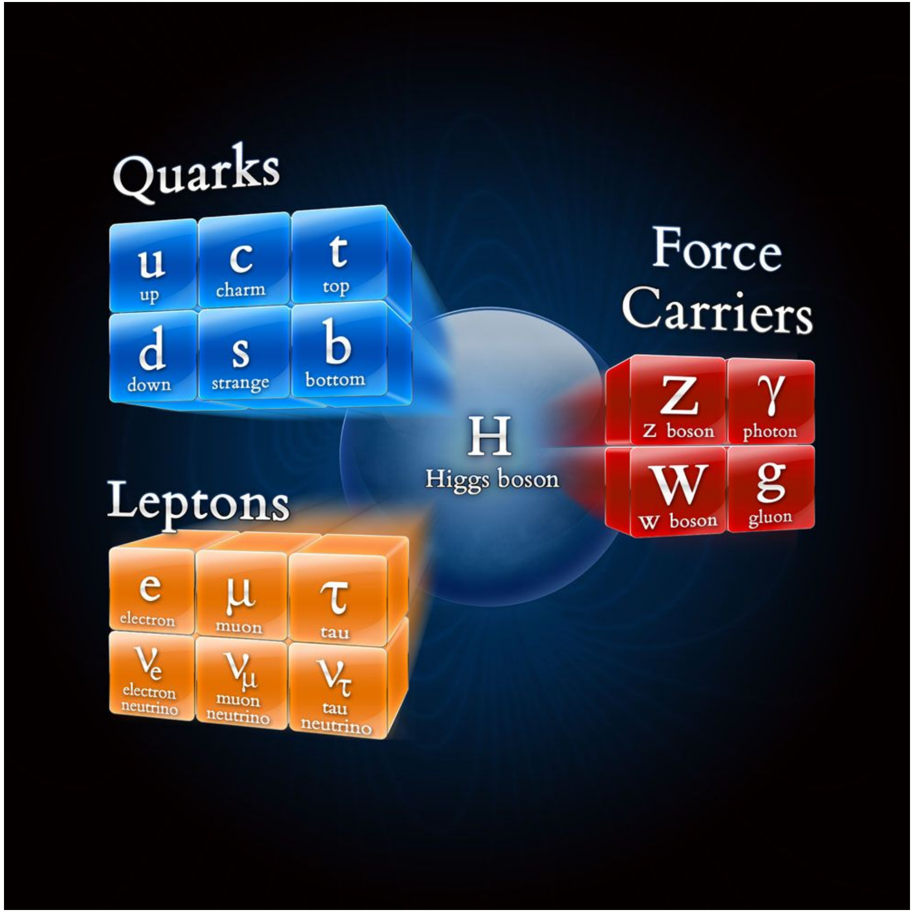




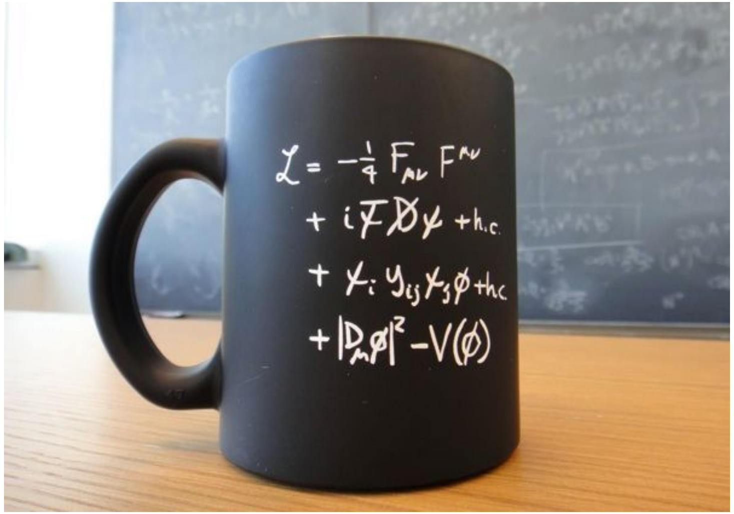


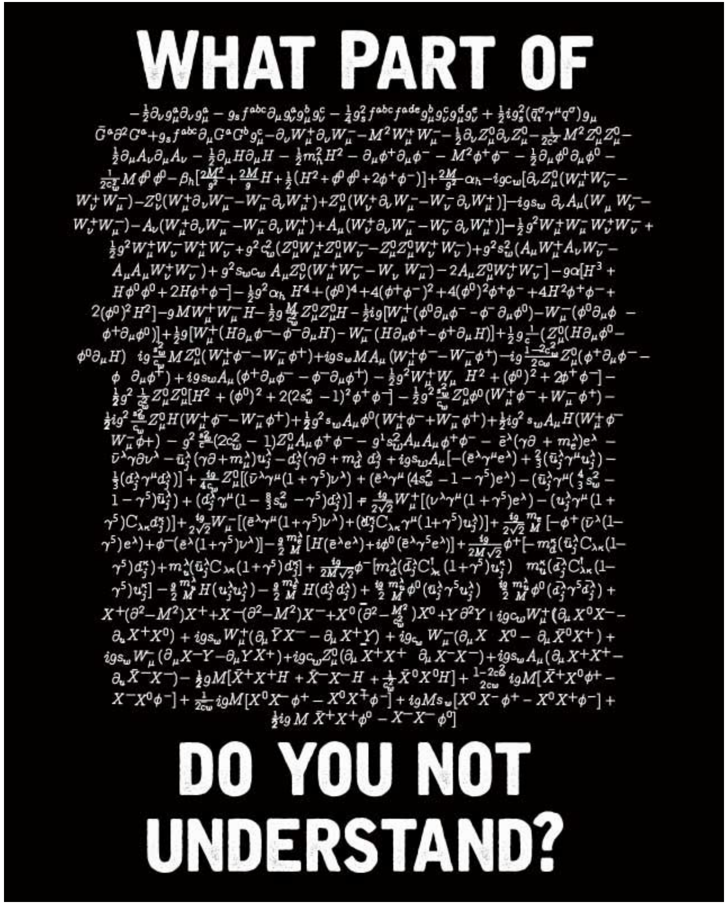
Quarks, Leptons, Gauge Bosons and the BEH boson



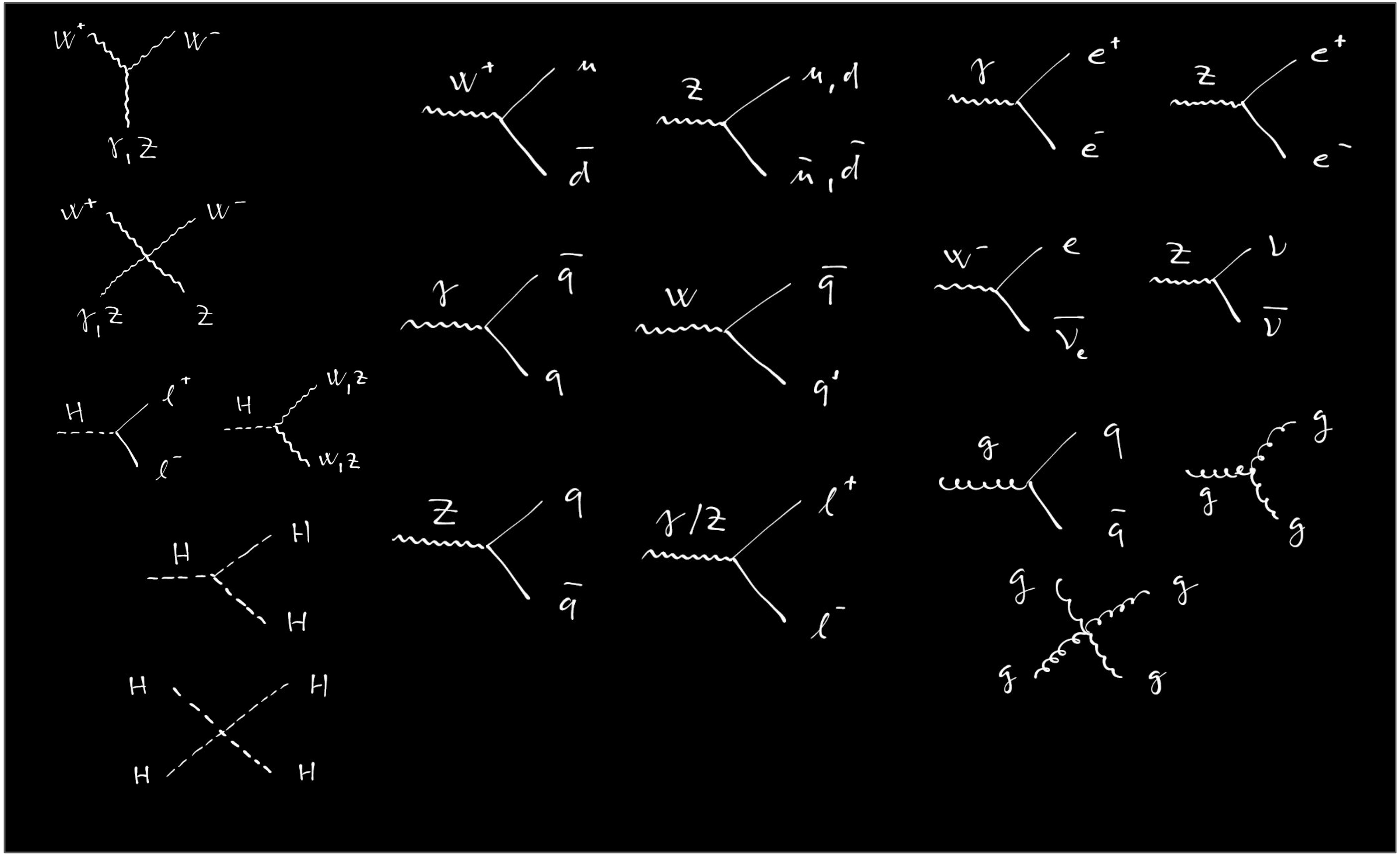


Quarks, Leptons, Gauge Bosons and the BEH boson





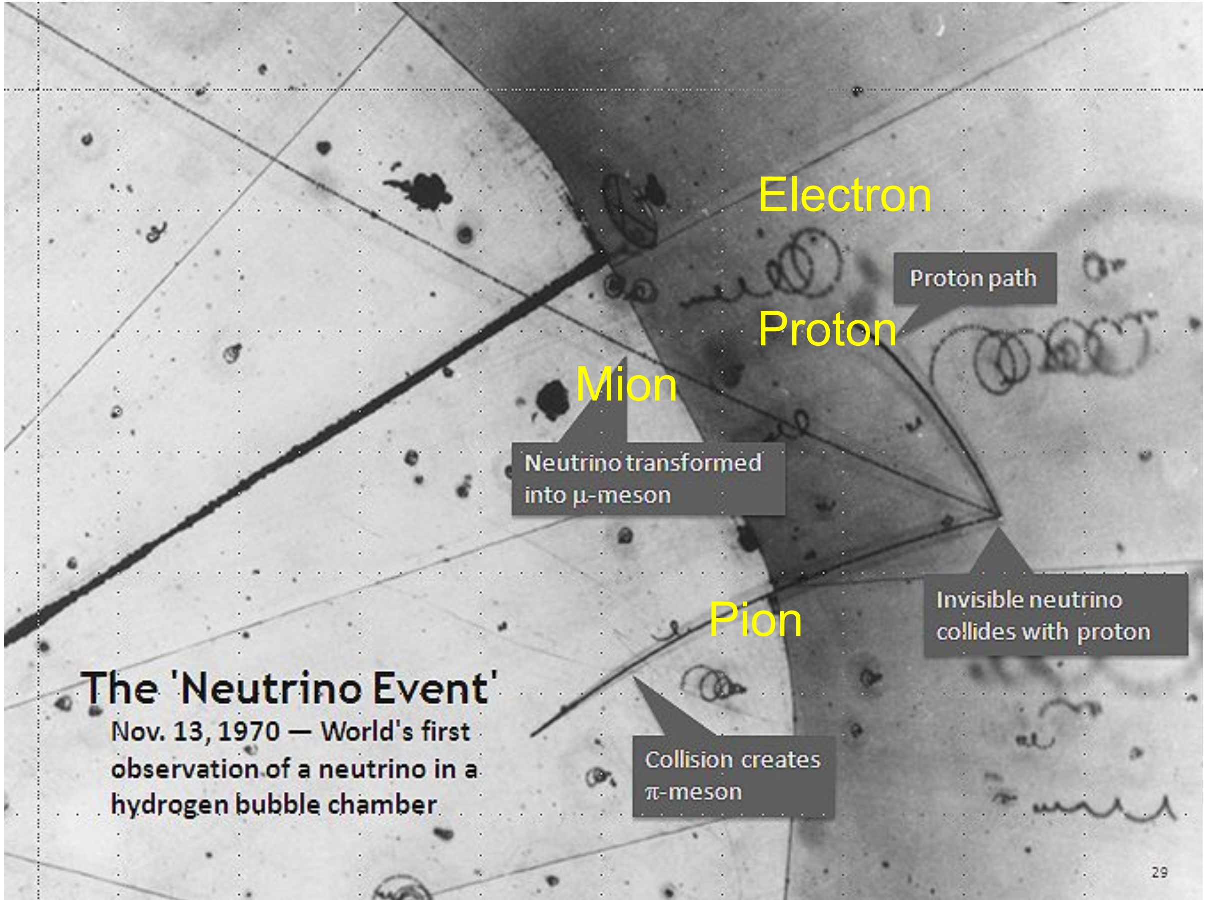
Quarks, Leptons, Gauge Bosons and the BEH boson



Jaké vidíme částice? :: Mlžná komora

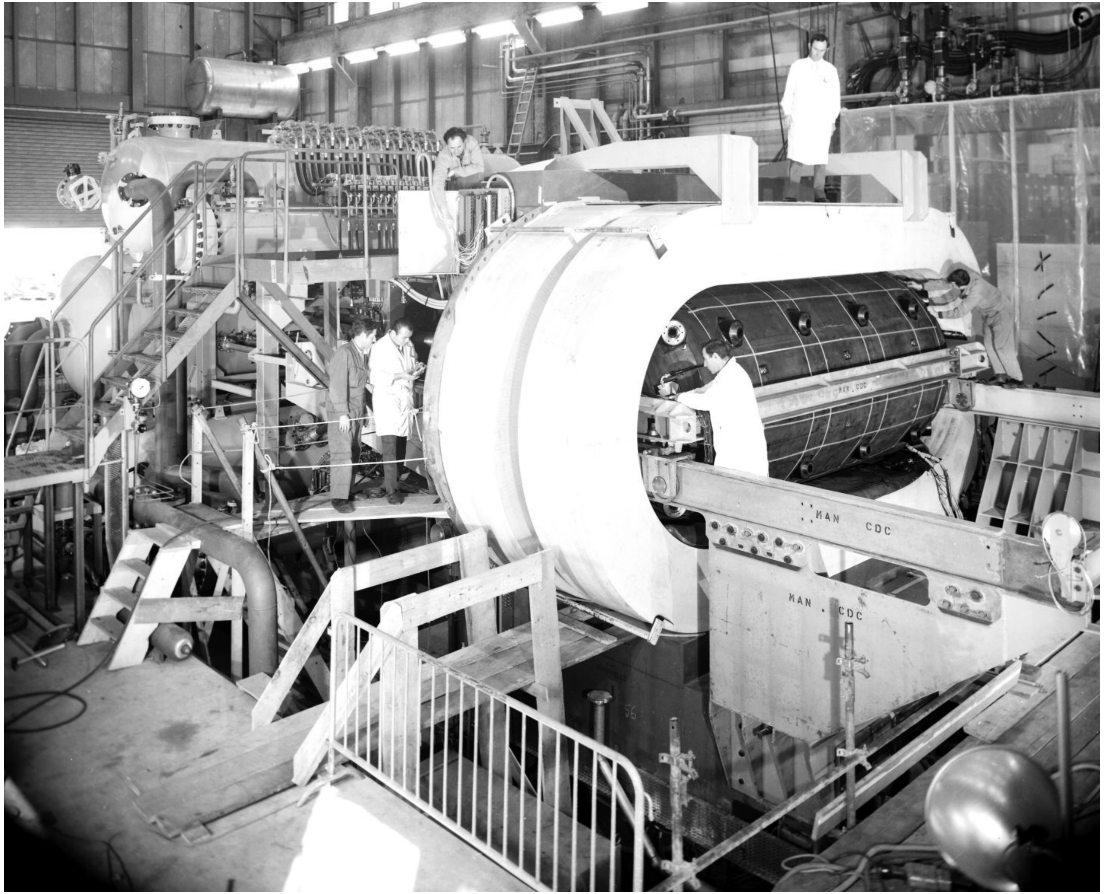
Jaké vidíme částice? :: Bublinová komora

https://en.wikipedia.org/wiki/Neutrino

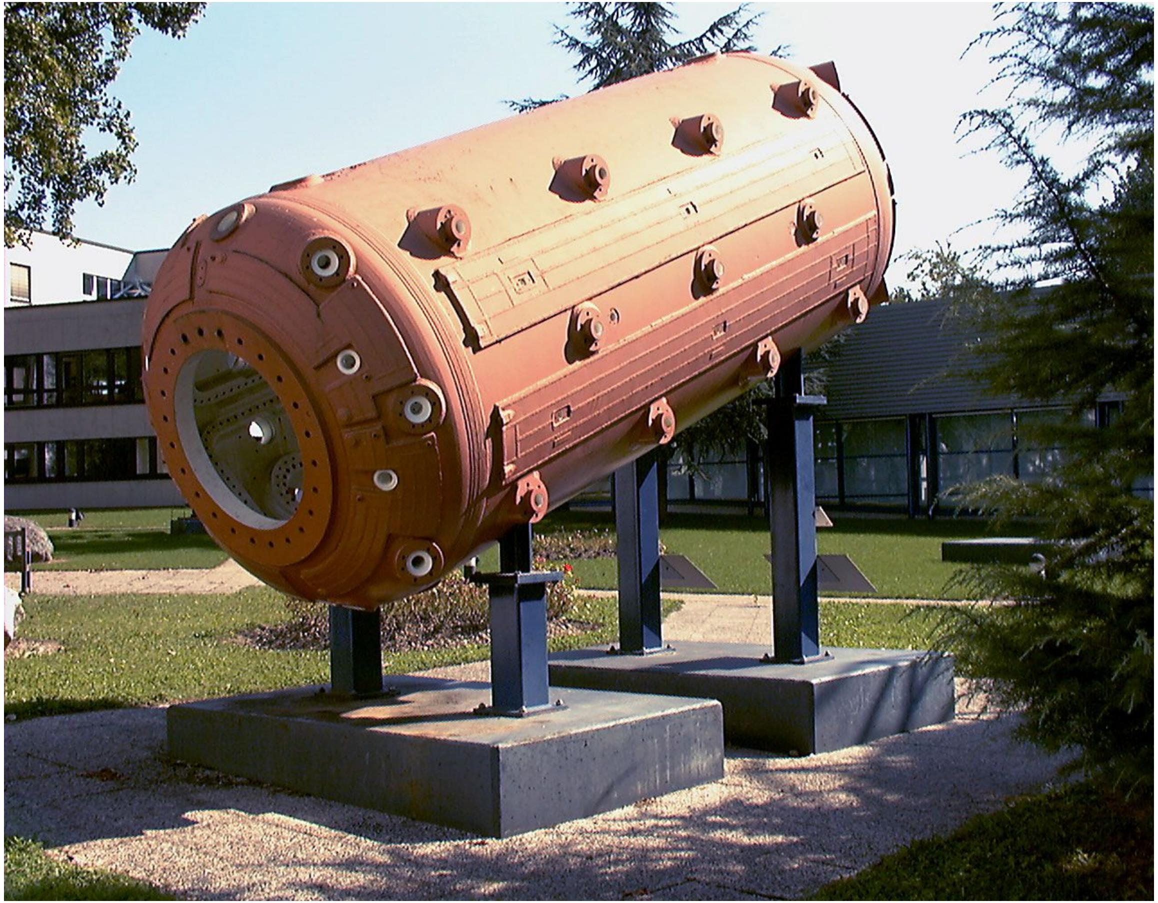


Bublinová komora Gargamelle

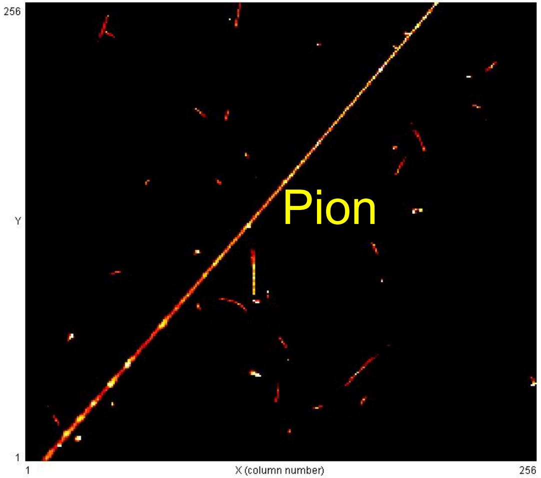
https://cds.cern.ch/record/39648

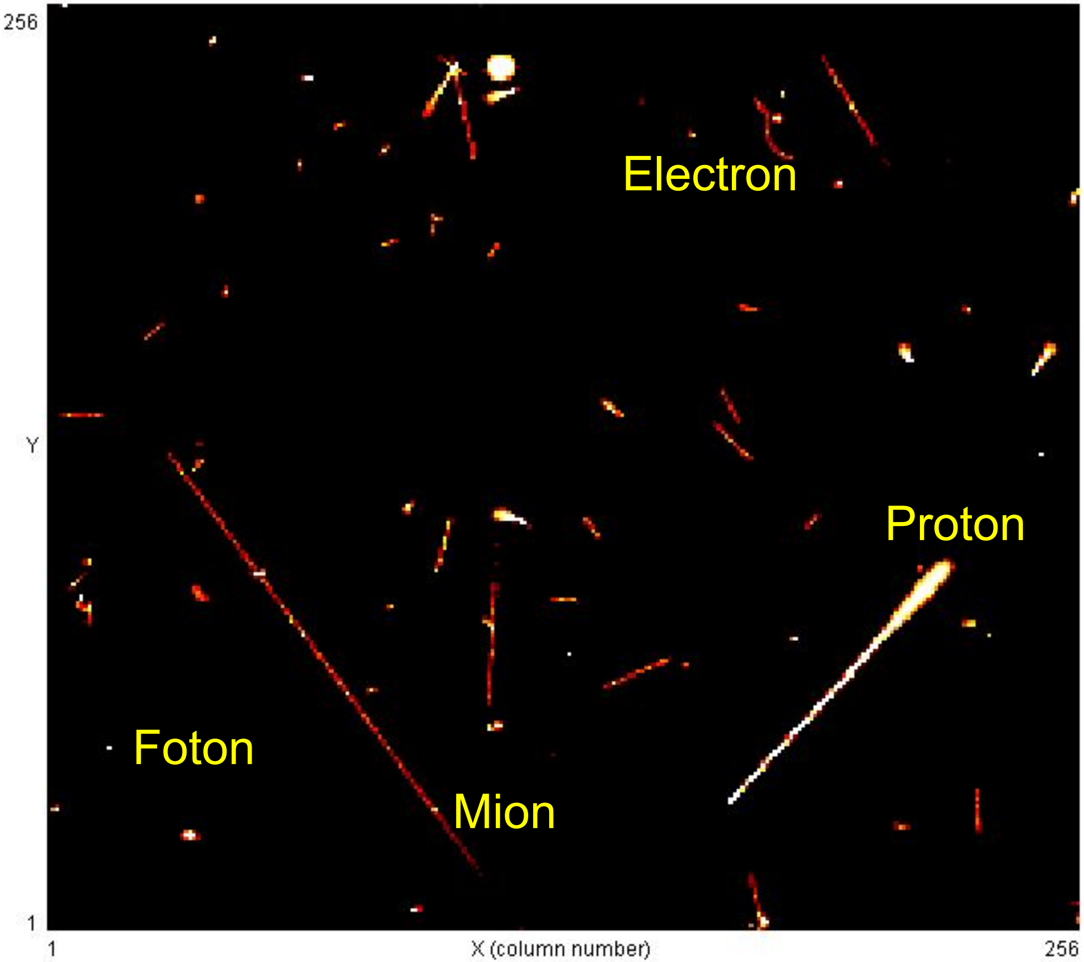


Bublinová komora Gargamelle

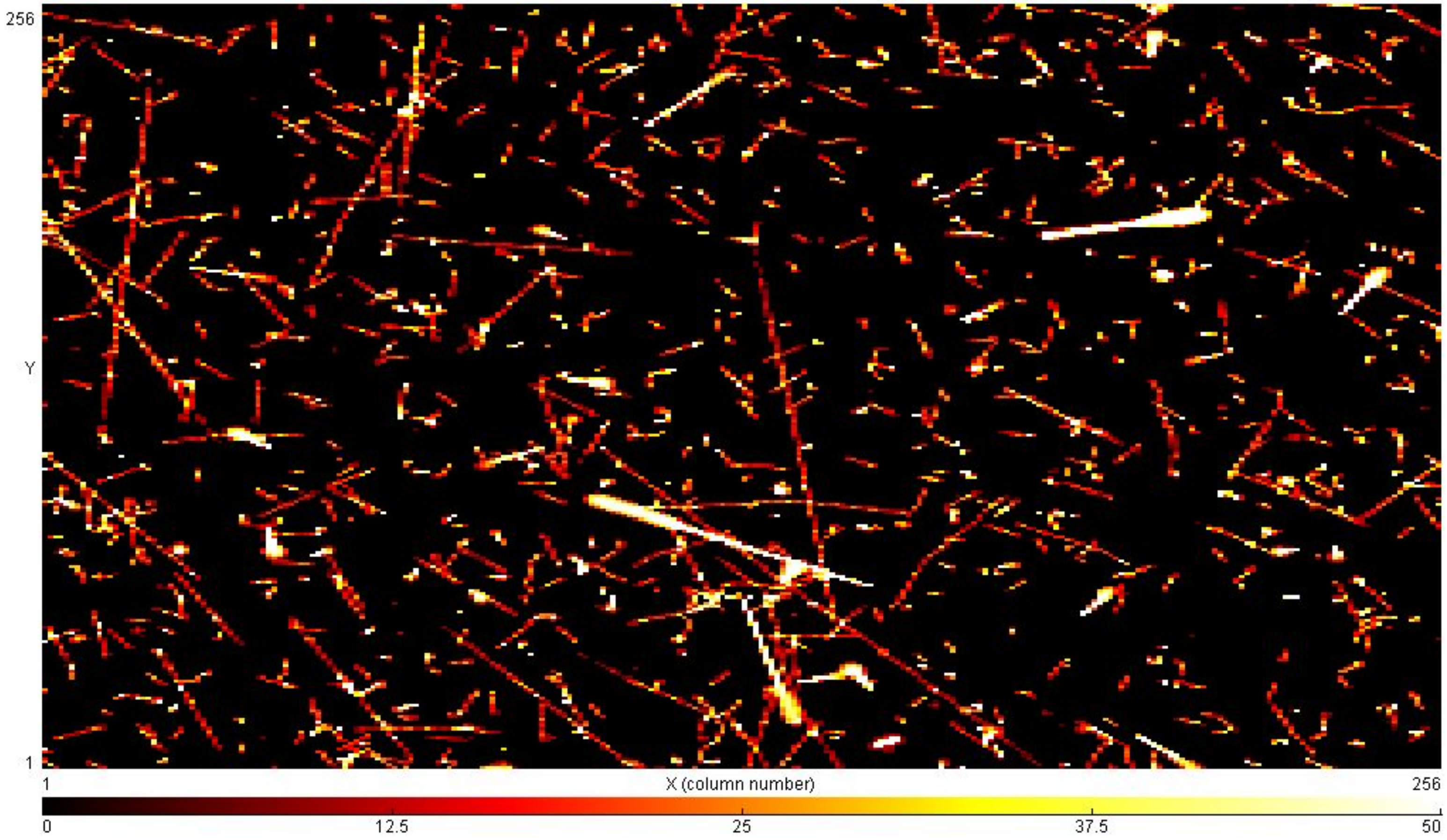


Částicová kamera

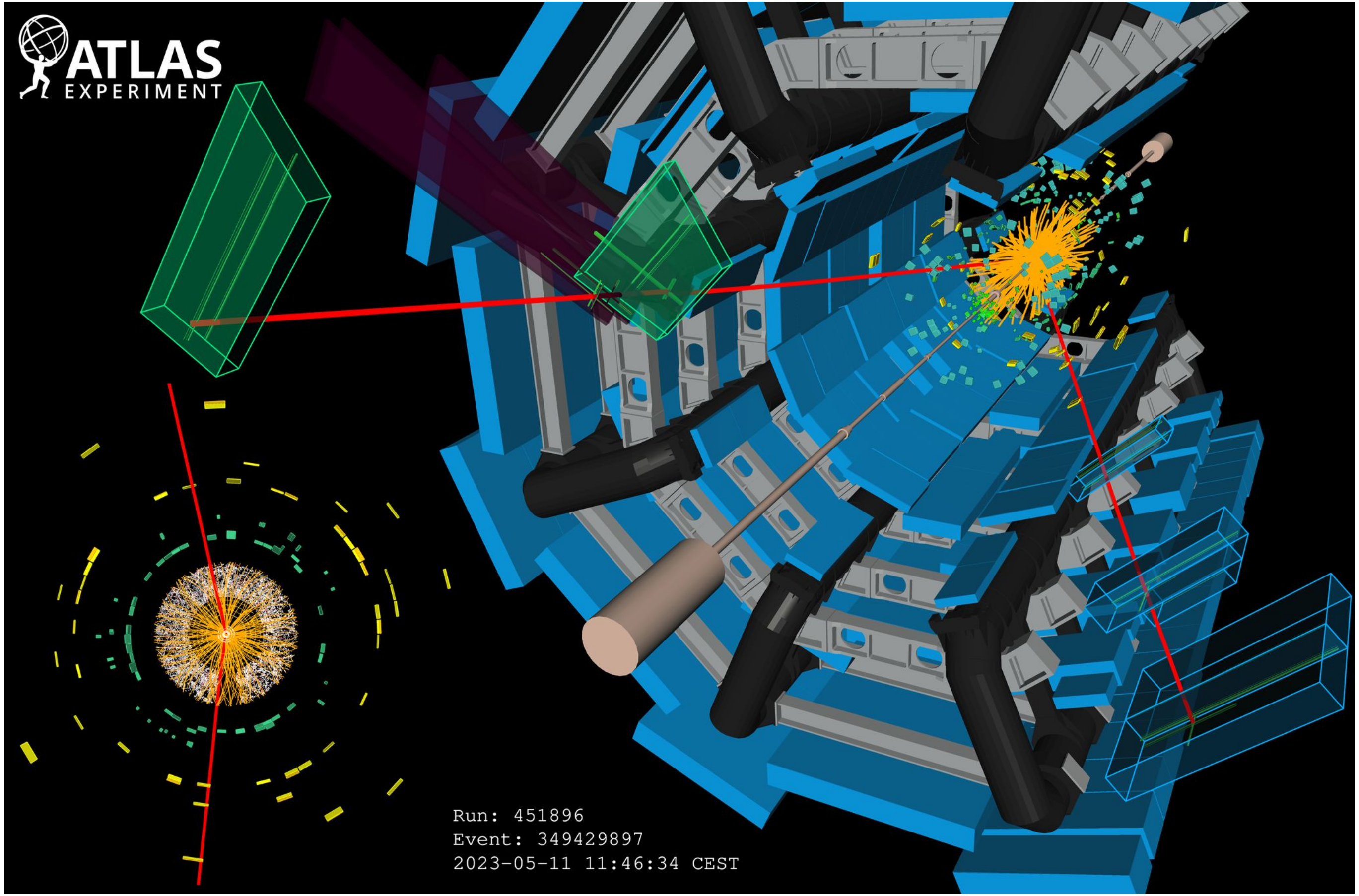




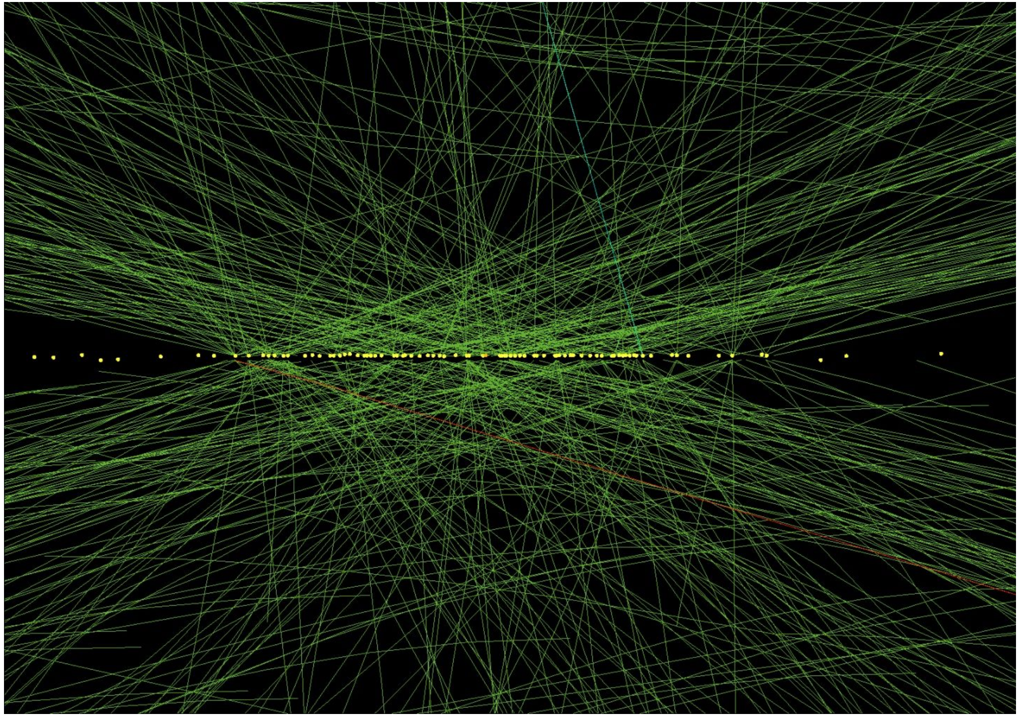
Částicová kamera :: Částice v letadle:)

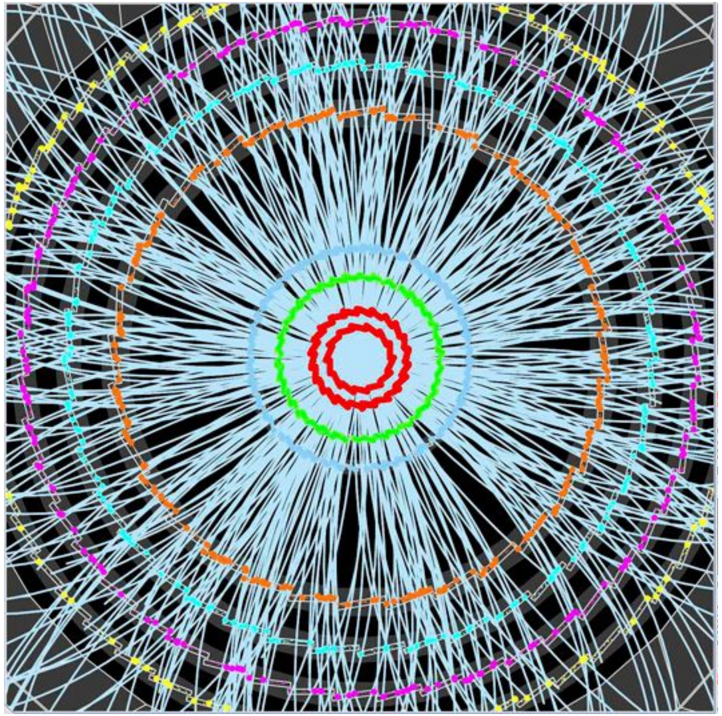


ATLAS Event Display



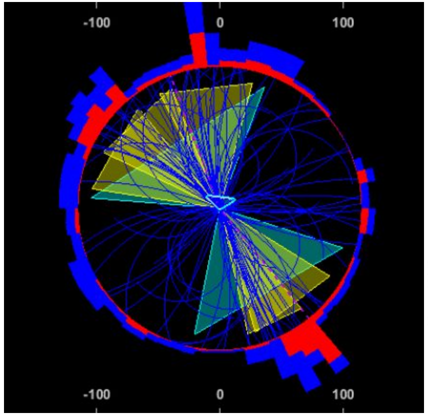
Many collisions at the same time!

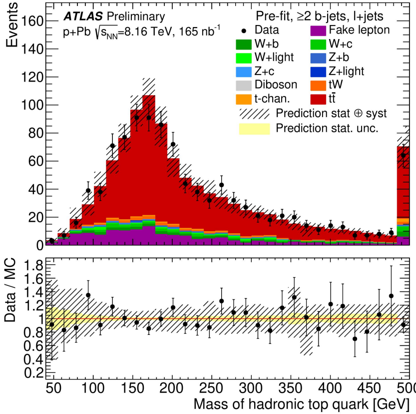




Data data data data data data data data data data data…

```cpp

    cout << "*** Number of events in nominal and Alternative trees: " <<  nentr

    // number of bytes read from TTrees
    Long64_t nbytes = 0;
    Long64_t nb_nominal = 0;
    Long64_t nb_nominalAlt = 0;
    Long64_t nb_ptcl = 0;
    Long64_t nb_truth = 0;
    m_ToRunOver = nentriesNominal;
    if (m_isMCsignal && m_runOverAllLevels) {
        // we need to go through all generated parton events
        // and find matching events in the detector nominal and particle trees
        m_ToRunOver = nentriesTruth;
    }
    if (m_isMCsignal && m_runOverPtclOnly) {
        m_ToRunOver = nentriesParticle;
    }
    // HACK!
    m_ToRunOver = 200000;

    this -> InitLoop();

    // +-----------+
    // |   LOOP!   |
    // +-----------+

    if (m_isData) {
        cout << "Will run over " << m_ToRunOver << " entries." << endl;
    } else {
        cout << "Will run over " << m_ToRunOver << " entries while sumWeights i
        m_h_sumWeights -> SetBinContent(1, m_sumWeights);
        m_h_sumWeightsSq -> SetBinContent(1, m_sumWeightsSq);
    }



    for (Long64_t jentry = 0; jentry < m_ToRunOver; jentry++) {
        if (jentry % verbose == 0) {
            cout << "Processing " << jentry << "/" << m_ToRunOver << endl;
        }
        nb_nominal = 0;
```






```python
        try:
            m = ms[particle]
        except:
            print('Failed getting particle mass and correct the beta!')
        if debug: print(f'  m={m:1.1f} A={A:1.1f} I={I:1.1f} Krel={Krel:1.3f} C={C:1.4f} Conv={Conv:1.4f}')
        if m > 0.:
            dXScinti = dXScale*gScintiThicknes
            dXMylar = dXScale*gMylarThicknes
            # evaluate the fitted lossed in TS0
            dE = -999.
            if 'TS1' in region:
              # beam window AND the TS0 passage:
              # assume losses will be similar, after all
              # let's avoid fitting I in plastics and Mylar as I has a high unc. anyway
              dE = (dXScinti + dXMylar) * Conv * getBaseMeanLossesFitVal(beta, A, I, C, debug)
              #dE = dXScinti * Conv * getBaseMeanLossesFitVal(beta, A, I, C, debug)
            else:
              # just the beam window;-)
              dE = dXMylar * Conv * getBaseMeanLossesFitVal(beta, A, I, C, debug)
              pass

            if dE > 0 and beta > 0. and beta < 1.:
                gamma0 = 1./sqrt(1. - pow(beta,2))
                E0 = m*gamma0
                p0 = sqrt(E0*E0 - m*m)
                gamma1 = (E0 - dE) / m
                fitFracEloss = dE / E0

                useHigherCorrs = False
                # ADD ALSO BEAM WINDOW FOR BOTH TS0 AND TS1!
                fullName = 'e'
                if particle == 'p':
                    fullName = 'Proton'
                if particle == 'D':
```

Princip objevu nových částic: invariantní hmota

$$E = mc^2$$

$$E = \sqrt{p^2c^2 + m^2c^4}$$

$$E^2 = p^2c^2 + m^2c^4$$

v jednotkách $c = 1$

$$m^2 = E^2 - p^2$$

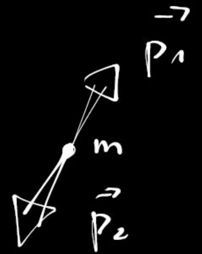
$$m^2 = \left(\sum_i E_i\right)^2 - \left(\sum \vec{p}_i\right)^2$$

$$E_i^2 = p_{ix}^2 + p_{iy}^2 + p_{iz}^2$$

$$E = \gamma mc^2$$

$$\gamma \equiv \frac{1}{\sqrt{1-\beta^2}} \qquad \beta \equiv \frac{v}{c}$$

$$E = \sqrt{p^2c^2 + m^2c^4}$$



$$E = E_1 + E_2$$

$$\vec{p} = \vec{p}_1 + \vec{p}_2$$

$$\vec{p}^{\,2} \equiv \vec{p}\cdot\vec{p} = \vec{p}_1^{\,2} + 2\vec{p}_1\cdot\vec{p}_2 + \vec{p}_2^{\,2}$$

$$m_1 \simeq m_2 \simeq 0 \Rightarrow$$

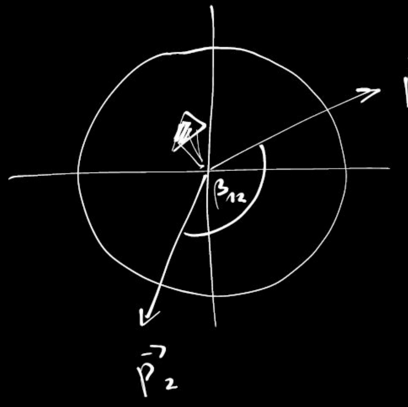
$$\doteq E_1^2 + 2\vec{p}_1\cdot\vec{p}_2 + E_2^2$$

$$= E_1^2 + E_2^2 + 2E_1E_2\cos\beta_{12}$$

$$m^2 = (E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2$$

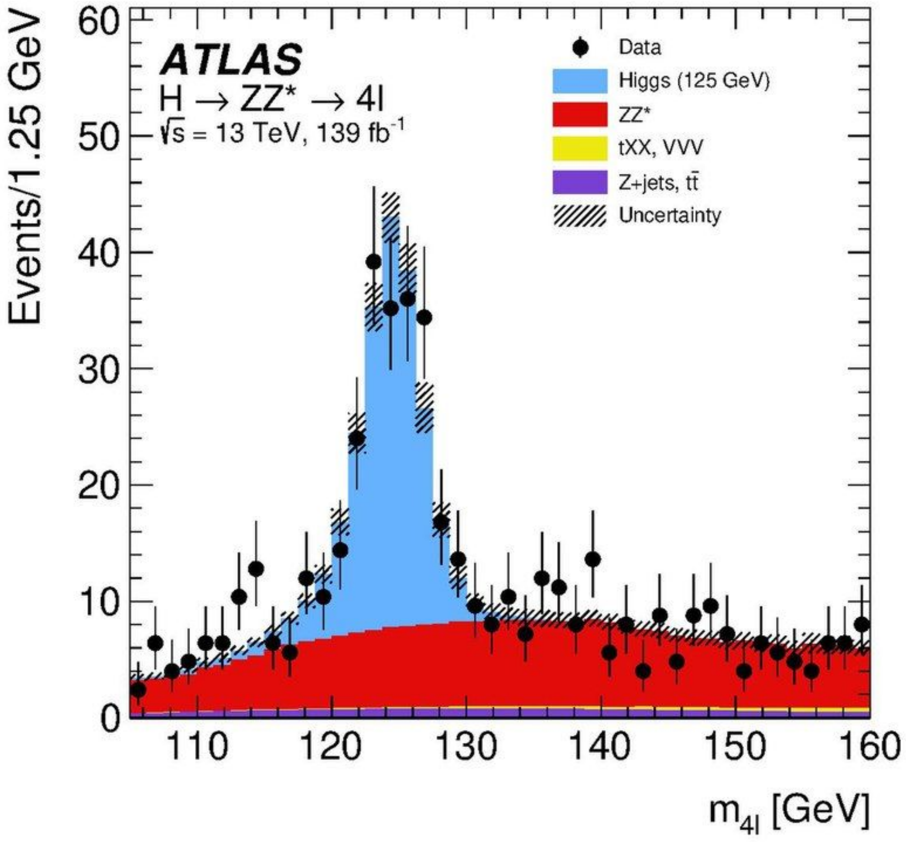
$$= \cancel{E_1^2} + 2E_1E_2 + \cancel{E_2^2}$$

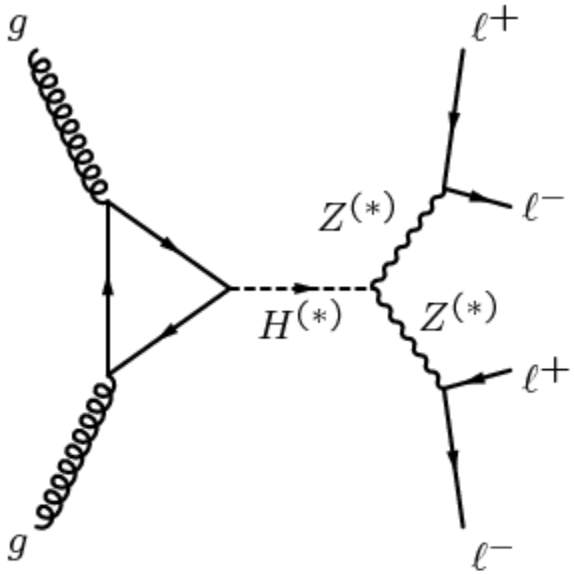
$$- \cancel{E_1^2} - \cancel{E_2^2} - 2E_1E_2\cos\beta_{12}$$



$$m^2 \simeq 2E_1E_2(1 - \cos\beta_{12})$$

Takhle “vidíme” nestabilní částice – peak!

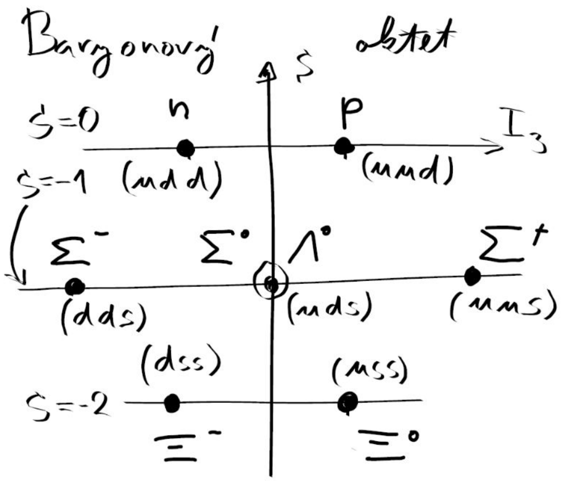


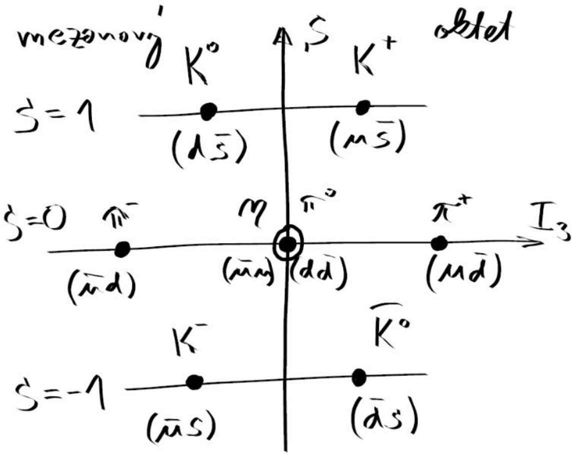


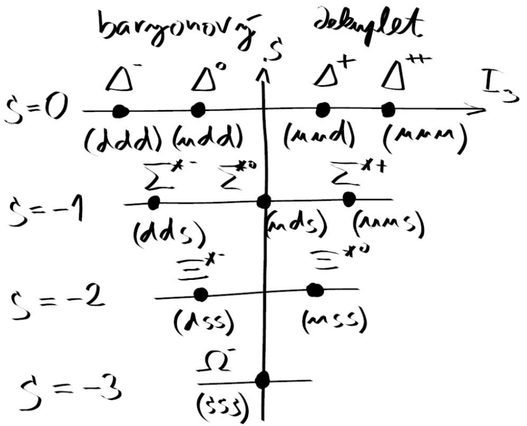
Listopadová revoluce …ve fyzice částic 1974

Listopad 1974

- Tehdy známé kvarky, tj. stavební kameny hmoty: u, d, s
- Podivné částice: obsahují s-kvark (strange)
- Rodily se v párech, rozpadaly se "pomalu" a různě, bylo jich mnoho, ale podařilo se je systematizovat







Listopad 1974

- Existovaly teoretické důvodu pro další, 4. kvark.
- Přesto byl jeho objev překvapivý, dobrodružný, spektakulární!
- Objeven současně ve dvou zcela odlišných experimentech!

Objev 4. kvarku a částice J/Psi :: Listopad 1974

- Skupina na urychlovači protonů Brookhaven National Laboratory.
- Urychlovač Alternating Gradient Synchrotron, AGS, 30 GeV protony.
- Srážky protonů s beryliovým terčem.
- Studium produkce párů elektron-pozitron.

VOLUME 33, NUMBER 23 PHYSICAL REVIEW LETTERS 2 DECEMBER 1974

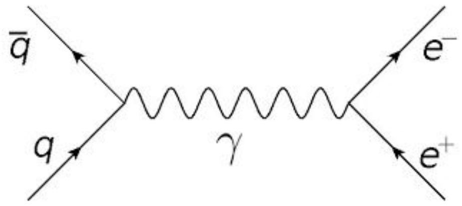
Experimental Observation of a Heavy Particle J†

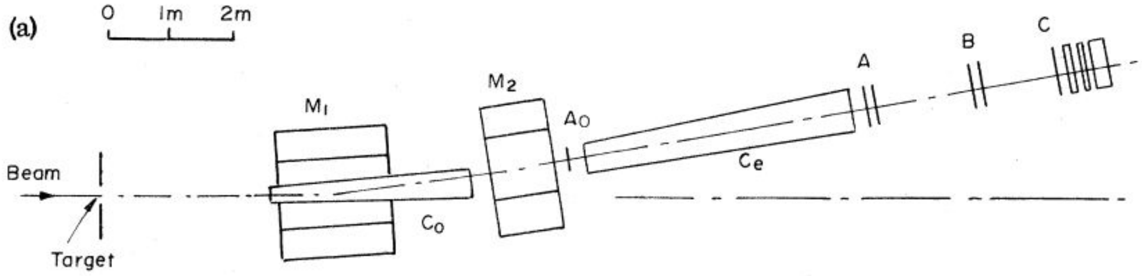
J. J. Aubert, U. Becker, P. J. Biggs, J. Burger, M. Chen, G. Everhart, P. Goldhagen, J. Leong, T. McCorriston, T. G. Rhoades, M. Rohde, Samuel C. C. Ting, and Sau Lan Wu
Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

and

Y. Y. Lee
Brookhaven National Laboratory, Upton, New York 11973
(Received 12 November 1974)

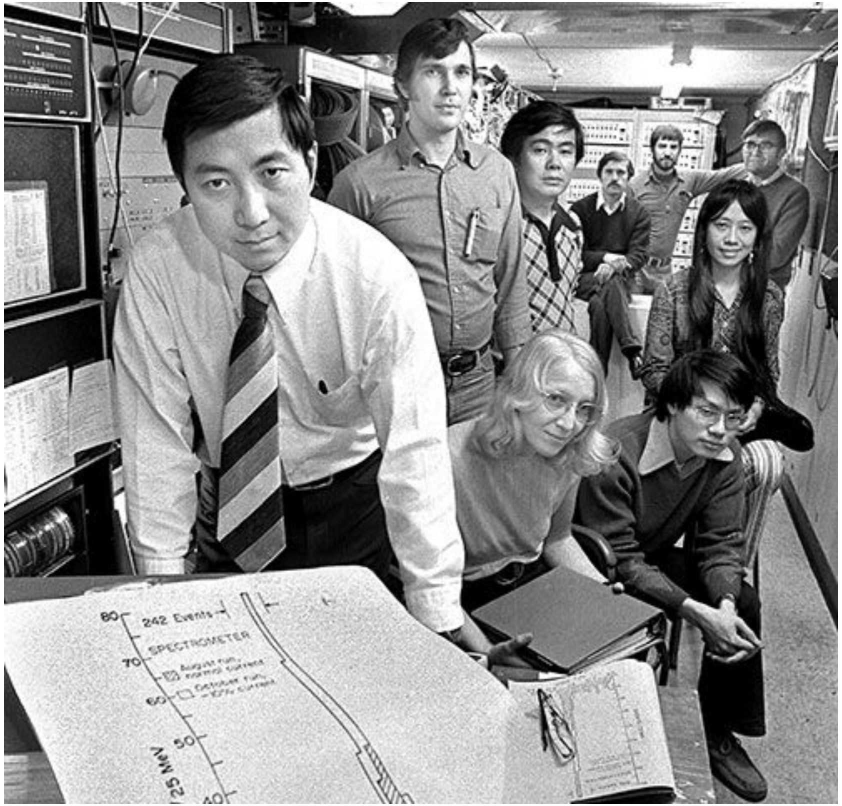
We report the observation of a heavy particle J, with mass $m = 3.1$ GeV and width approximately zero. The observation was made from the reaction $p + \mathrm{Be} \rightarrow e^+ + e^- + x$ by measuring the e^+e^- mass spectrum with a precise pair spectrometer at the Brookhaven National Laboratory's 30-GeV alternating-gradient synchrotron.

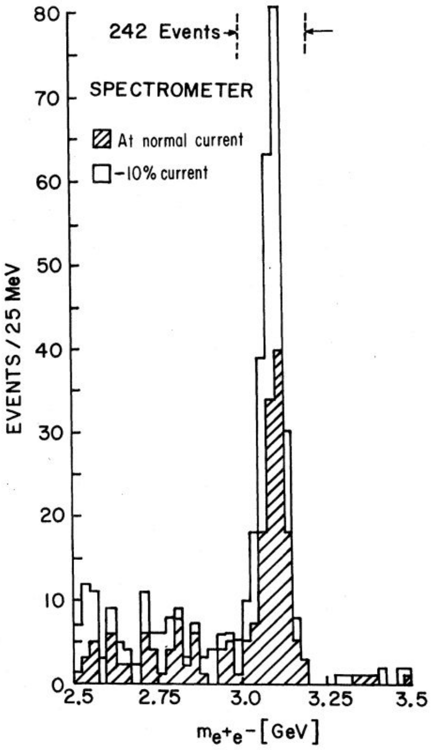




Objev 4. kvarku a částice J/Psi :: Listopad 1974

- Překvapivý peak v invariantní hmotě!

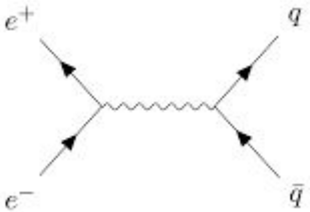


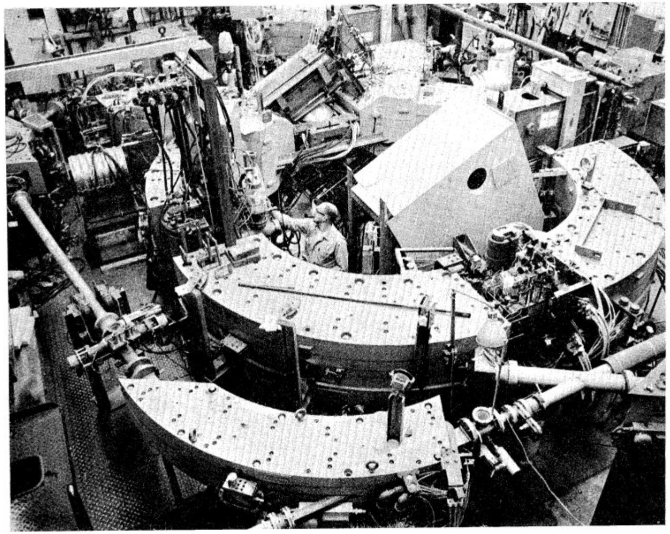


https://www.bnl.gov/bnlweb/history/nobel/1976.php

Objev 4. kvarku a částice J/Psi :: Listopad 1974

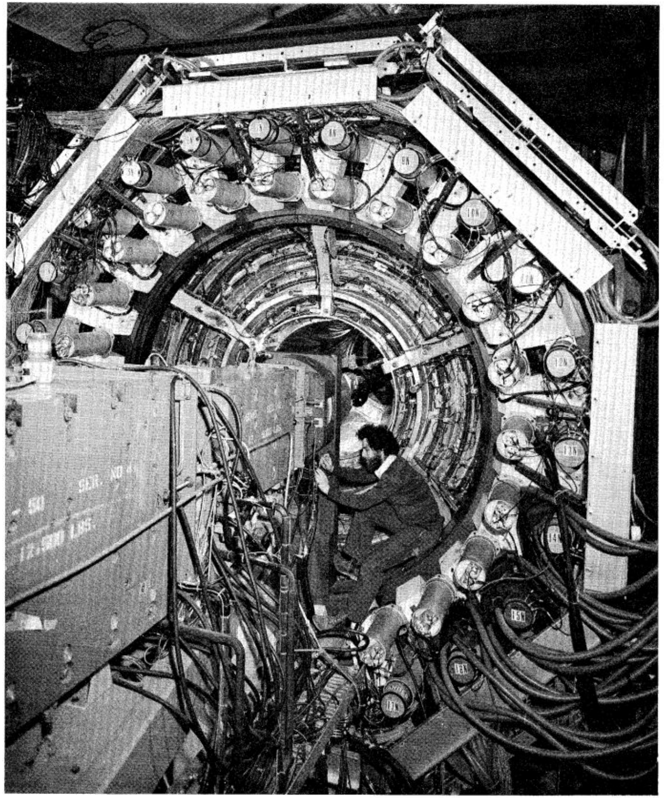
- Skupina v laboratoři SLAC, Stanford.
- Urychlovač elektronů a pozitronů SPEARS
- Detektor Mark I





This photo shows the figure-8-shaped 500 MeV electron-electron storage rings that were built as a collaborative Stanford-Princeton project at the High Energy Physics Lab at Stanford. The orientation of this double-ring machine in the photo is about like this: ∞ . The odd-shaped magnet in the foreground is a part of the beam-injection system. This was the first colliding-beam machine to carry out a successful program of physics experiments, its first results being obtained in 1965. Burt Richter was one of four principal collaborators in the construction and research use of these rings. *(Stanford News & Publications photo.)*

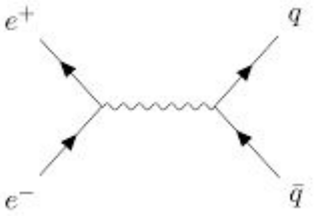
SLAC Beam Line, November 1976 S-7

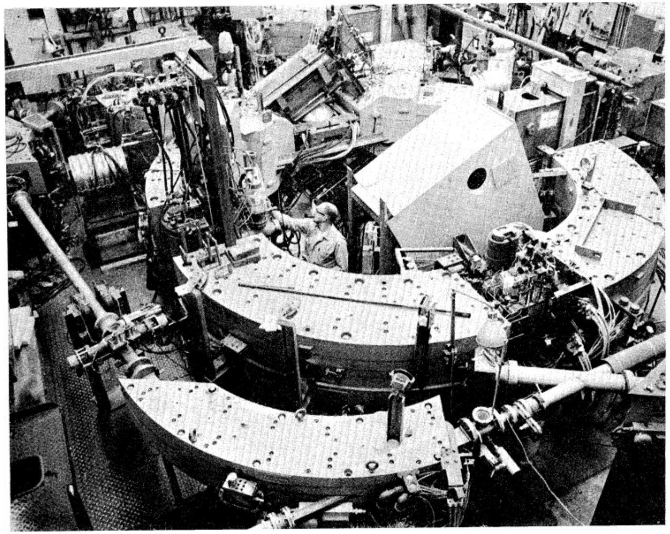


This photograph gives a better sense of the size and complexity of the SPEAR Mark I magnetic detector than the previous words. Former LBL experimentalist Carl Friedberg is shown working on the device with its end caps removed. The Mark I is connected to the outside world by water

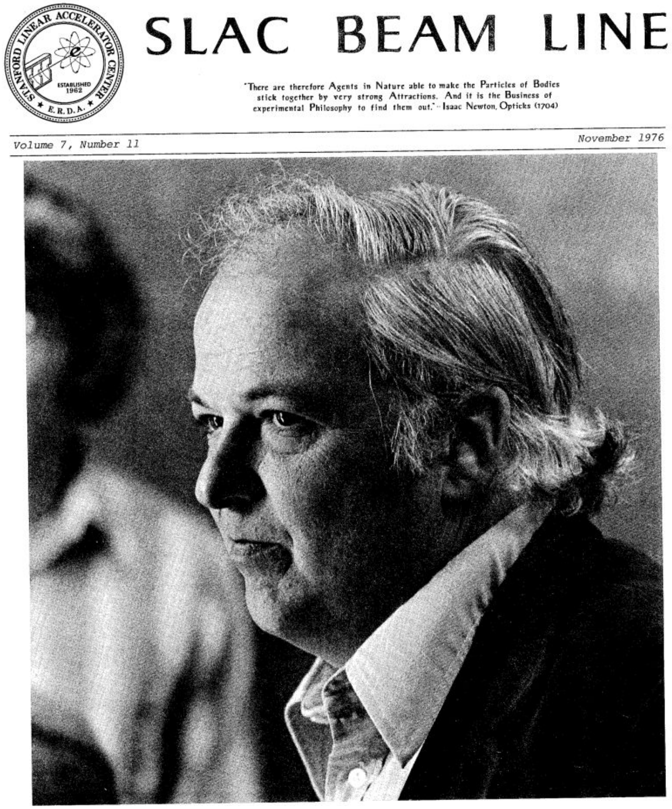
Objev 4. kvarku a částice J/Psi :: Listopad 1974

- Skupina v laboratoři SLAC, Stanford.
- Urychlovač elektronů a pozitronů SPEARS
- Detektor Mark I
- Burton Richter



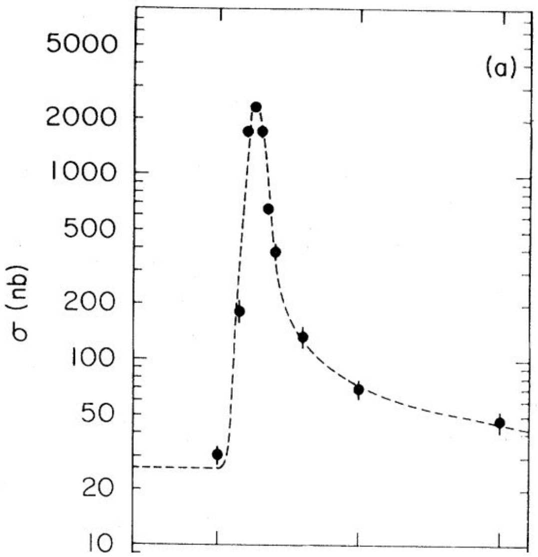


This photo shows the figure-8-shaped 500 MeV electron-electron storage rings that were built as a collaborative Stanford-Princeton project at the High Energy Physics Lab at Stanford. The orientation of this double-ring machine in the photo is about like this: ⊘ . The odd-shaped magnet in the foreground is a part of the beam-injection system. This was the first colliding-beam machine to carry out a successful program of physics experiments, its first results being obtained in 1965. Burt Richter was one of four principal collaborators in the construction and research use of these rings. *(Stanford News & Publications photo.)*



Objev 4. kvarku a částice J/Psi :: Listopad 1974

- Překvapivé navýšení počtu pozorovaných částic v úzké oblasti energií urychlovače!



Discovery of a Narrow Resonance in e^+e^- Annihilation*

J.-E. Augustin,† A. M. Boyarski, M. Breidenbach, F. Bulos, J. T. Dakin, G. J. Feldman, G. E. Fischer, D. Fryberger, G. Hanson, B. Jean-Marie,† R. R. Larsen, V. Lüth, H. L. Lynch, D. Lyon, C. C. Morehouse, J. M. Paterson, M. L. Perl, B. Richter, P. Rapidis, R. F. Schwitters, W. M. Tanenbaum, and F. Vannucci‡

Stanford Linear Accelerator Center, Stanford University, Stanford, California 94305

and

G. S. Abrams, D. Briggs, W. Chinowsky, C. E. Friedberg, G. Goldhaber, R. J. Hollebeek, J. A. Kadyk, B. Lulu, F. Pierre,§ G. H. Trilling, J. S. Whitaker, J. Wiss, and J. E. Zipse

Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720

(Received 13 November 1974)

We have observed a very sharp peak in the cross section for $e^+e^- \rightarrow$ hadrons, e^+e^-, and possibly $\mu^+\mu^-$ at a center-of-mass energy of 3.105 ± 0.003 GeV. The upper limit to the full width at half-maximum is 1.3 MeV.

Objev 4. kvarku a částice J/Psi :: Meanwhile in Frascati, IT…

VOLUME 33, NUMBER 23 PHYSICAL REV

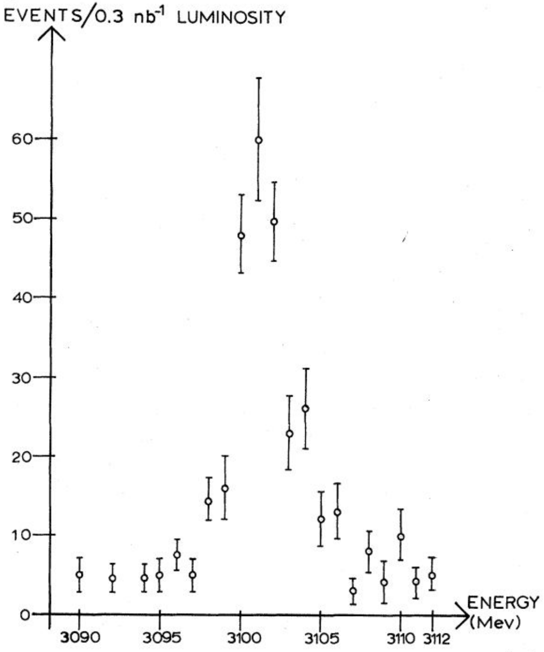


FIG. 1. Result from the Gamma-Gamma Group, total of 446 events. The number of events per 0.3 nb^{-1} luminosity is plotted versus the total c.m. energy of the machine.

Preliminary Result of Frascati (ADONE) on the Nature of a New 3.1-GeV Particle Produced in e^+e^- Annihilation*

C. Bacci, R. Balbini Celio, M. Berna-Rodini, G. Caton, R. Del Fabbro, M. Grilli, E. Iarocci, M. Locci, C. Mencuccini, G. P. Murtas, G. Penso, G. S. M. Spinetti, M. Spano, B. Stella, and V. Valente
The Gamma-Gamma Group, Laboratori Nazionali di Frascati, Frascati, Italy

and

B. Bartoli, D. Bisello, B. Esposito, F. Felicetti, P. Monacelli, M. Nigro, L. Paolufi, I. Peruzzi, G. Piano Mortemi, M. Piccolo, F. Ronga, F. Sebastiani, L. Trasatti, and F. Vanoli
The Magnet Experimental Group for ADONE, Laboratori Nazionali di Frascati, Frascati, Italy

and

G. Barbarino, G. Barbiellini, C. Bemporad, R. Biancastelli, F. Cevenini, M. Celvetti, F. Costantini, P. Lariccia, P. Parascandalo, E. Sassi, C. Spencer, L. Tortora, U. Troya, and S. Vitale
The Baryon-Antibaryon Group, Laboratori Nazionali di Frascati, Frascati, Italy
(Received 18 November 1974)

We report on the results at ADONE to study the properties of the newly found 3.1-BeV particle.

Objev 4. kvarku a částice J/Psi :: NP

The Nobel Prize
in Physics 1976

Summary

Laureates

Burton Richter

Samuel C.C. Ting

Press release

Award ceremony speech

Share this

The Nobel Prize in Physics 1976

Photo from the Nobel Foundation archive.

Burton Richter

Prize share: 1/2

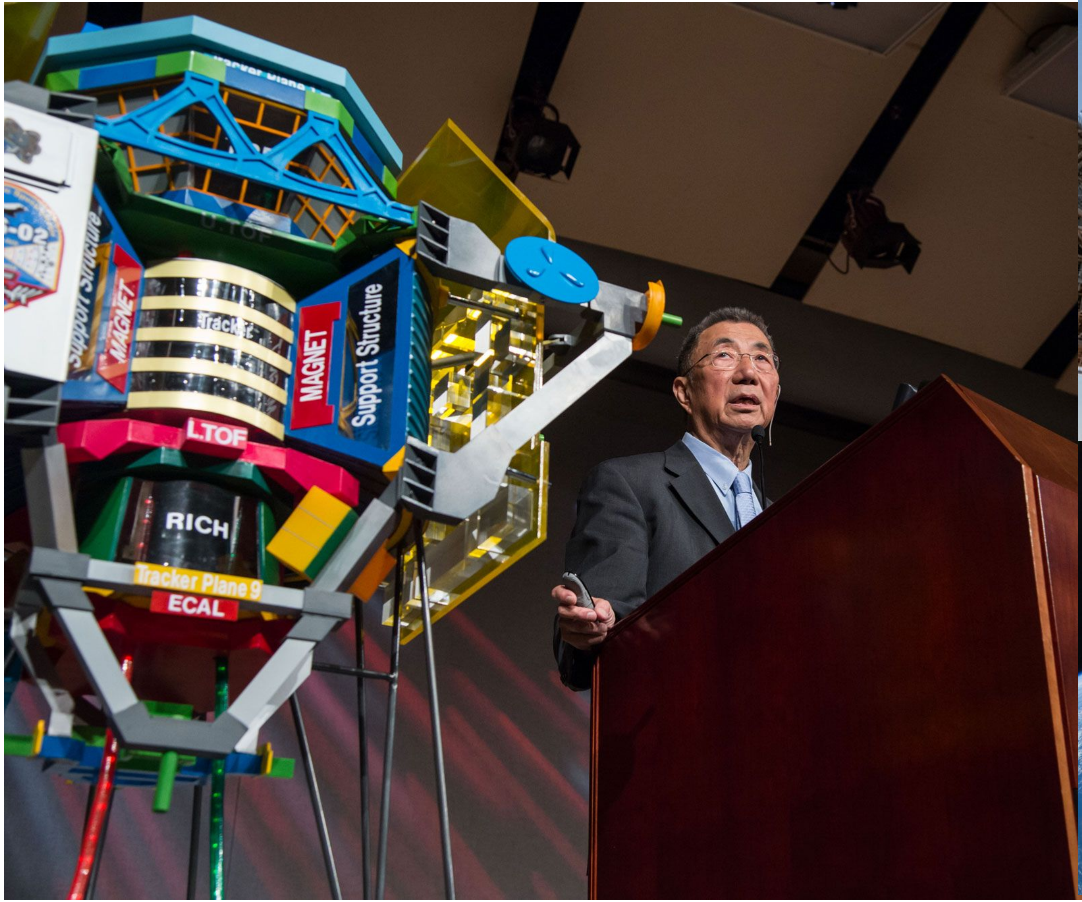
Photo from the Nobel Foundation archive.

Samuel Chao Chung Ting

Prize share: 1/2

The Nobel Prize in Physics 1976 was awarded jointly to Burton Richter and Samuel Chao Chung Ting "for their pioneering work in the discovery of a heavy elementary particle of a new kind"

Objev 4. kvarku a částice J/Psi :: Listopad 1974

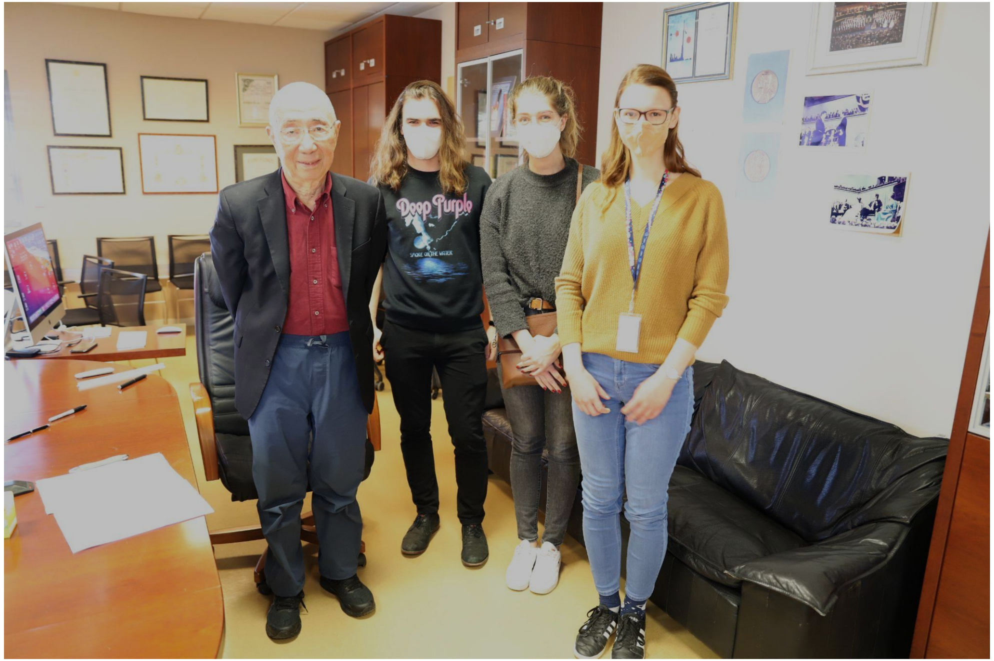


Objev 4. kvarku a částice J/Psi :: Listopad 1974

https://www6.slac.stanford.edu/news/2014-11-20-president-obama-bestows-national-medal-science-slac-director-emeritus-and-nobelist

Objev 4. kvarku a částice J/Psi :: Listopad 1974

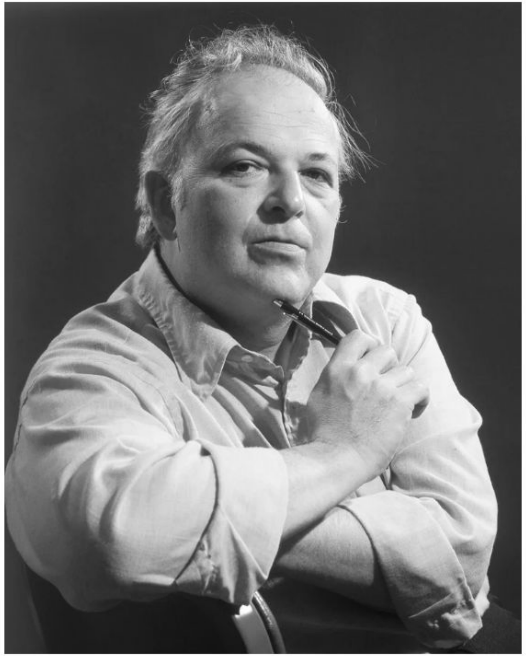
Meeting prof. Ting with our students, March 2022.



Burton Richter (1931–2018)

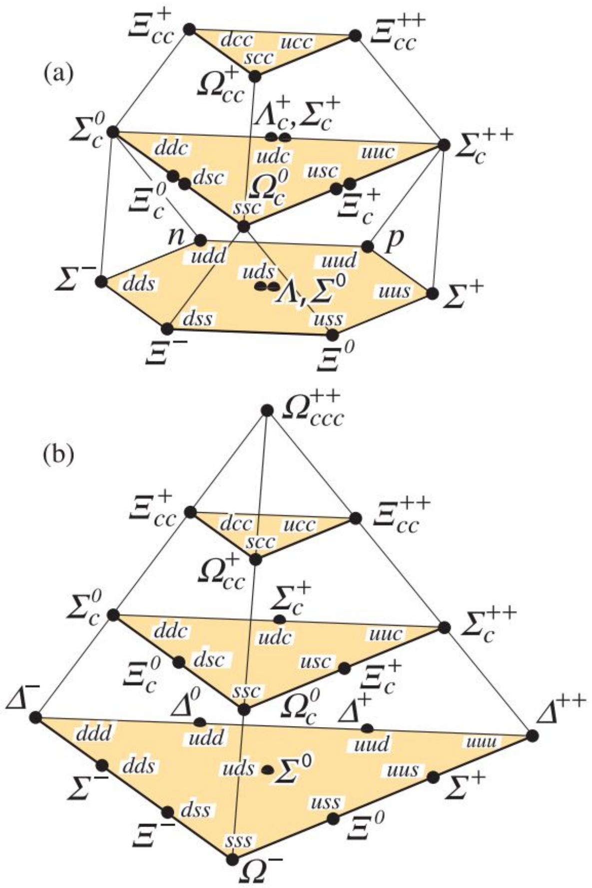
Physicist who helped to discover the first particle containing a charm quark.

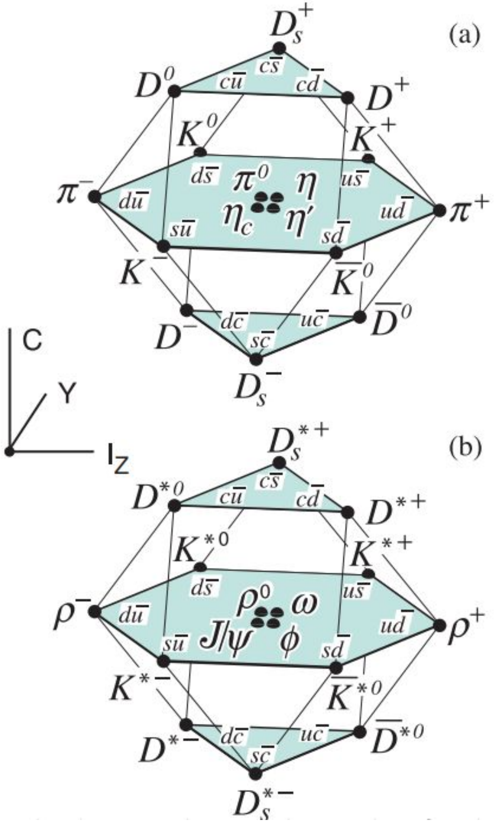
By Helen Quinn



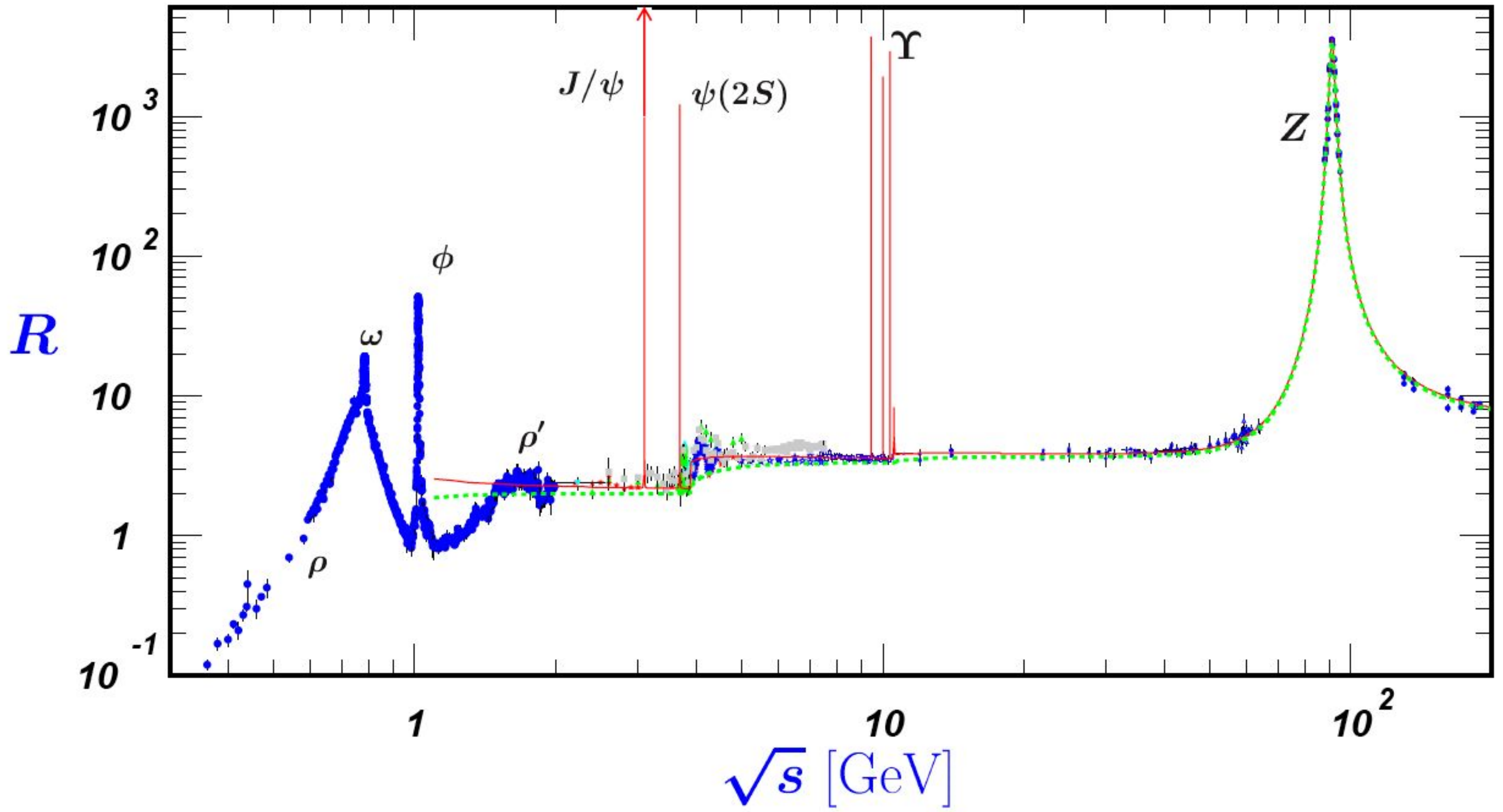
Credit: Eddie Adams/AP/REX/Shutterstock

Skládání kvarků u, d, s, c



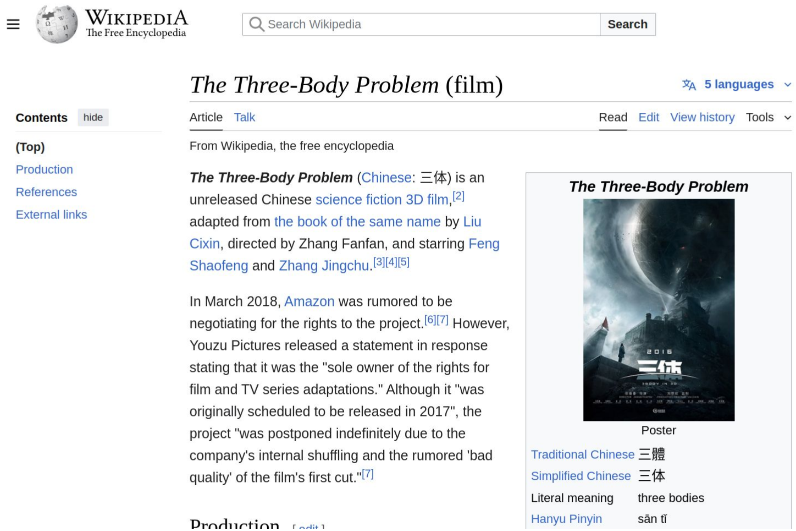


Krajina peaků a částic:)



The Three Body Problem :: Problém tří těles

Novel by Cixin Liu
Movie by China
Movie by Netflix


Wikipedia
The Free Encyclopedia

Search Wikipedia | Search

The Three-Body Problem (film)

5 languages

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(Top)
Production
References
External links

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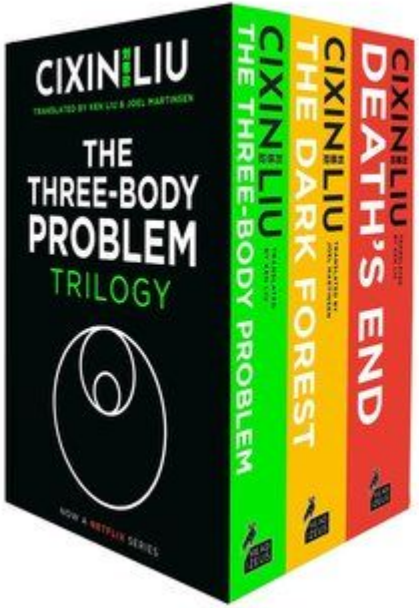
From Wikipedia, the free encyclopedia

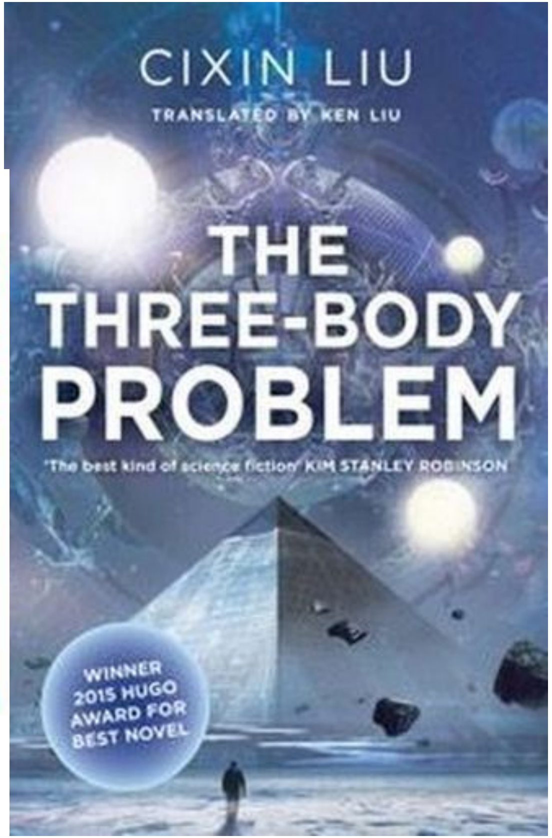
The Three-Body Problem (Chinese: 三体) is an unreleased Chinese science fiction 3D film,[2] adapted from the book of the same name by Liu Cixin, directed by Zhang Fanfan, and starring Feng Shaofeng and Zhang Jingchu.[3][4][5]

In March 2018, Amazon was rumored to be negotiating for the rights to the project.[6][7] However, Youzu Pictures released a statement in response stating that it was the "sole owner of the rights for film and TV series adaptations." Although it "was originally scheduled to be released in 2017", the project "was postponed indefinitely due to the company's internal shuffling and the rumored 'bad quality' of the film's first cut."[7]

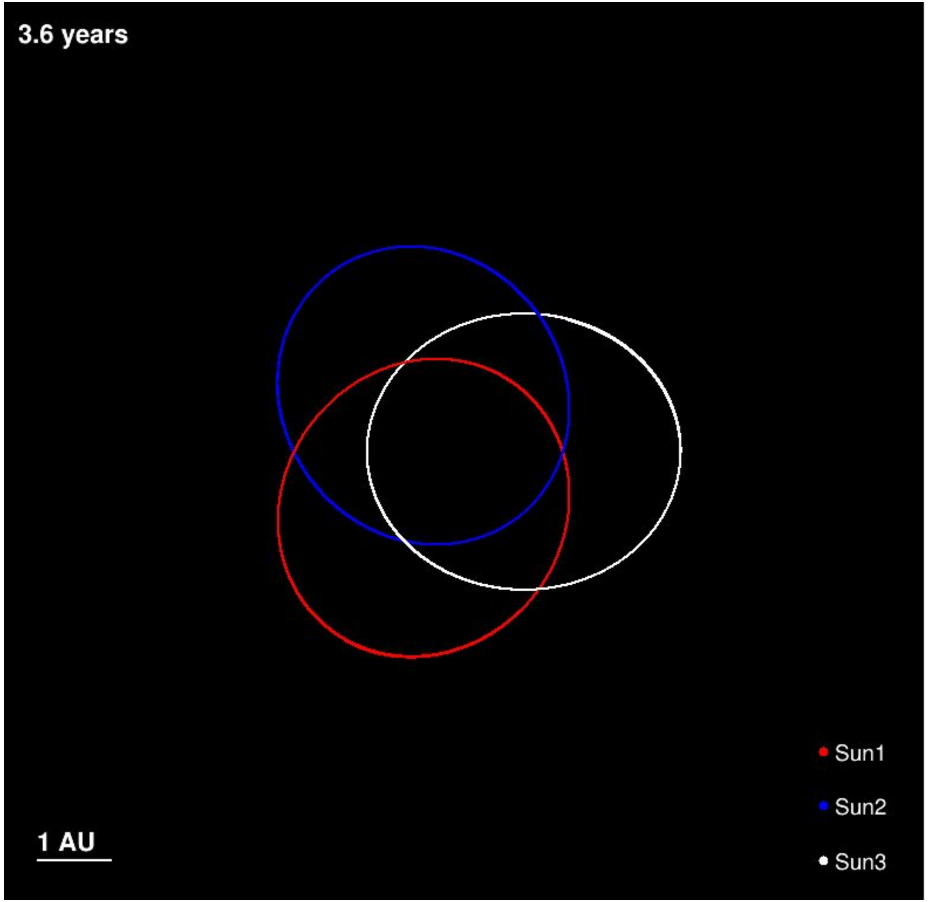
The Three-Body Problem	
Poster	
Traditional Chinese	三體
Simplified Chinese	三体
Literal meaning	three bodies
Hanyu Pinyin	sān tǐ

Production [edit]





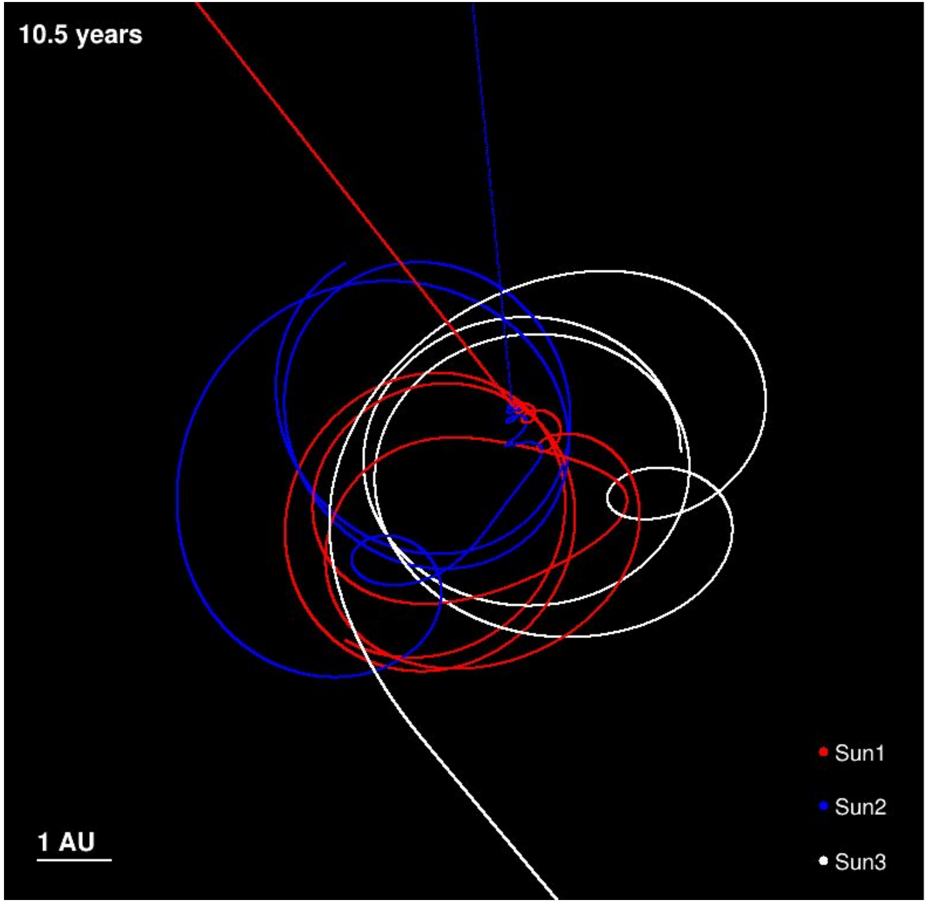
The Three Body Problem :: Problém tří těles



Same solar masses, quasi-sytability.

More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

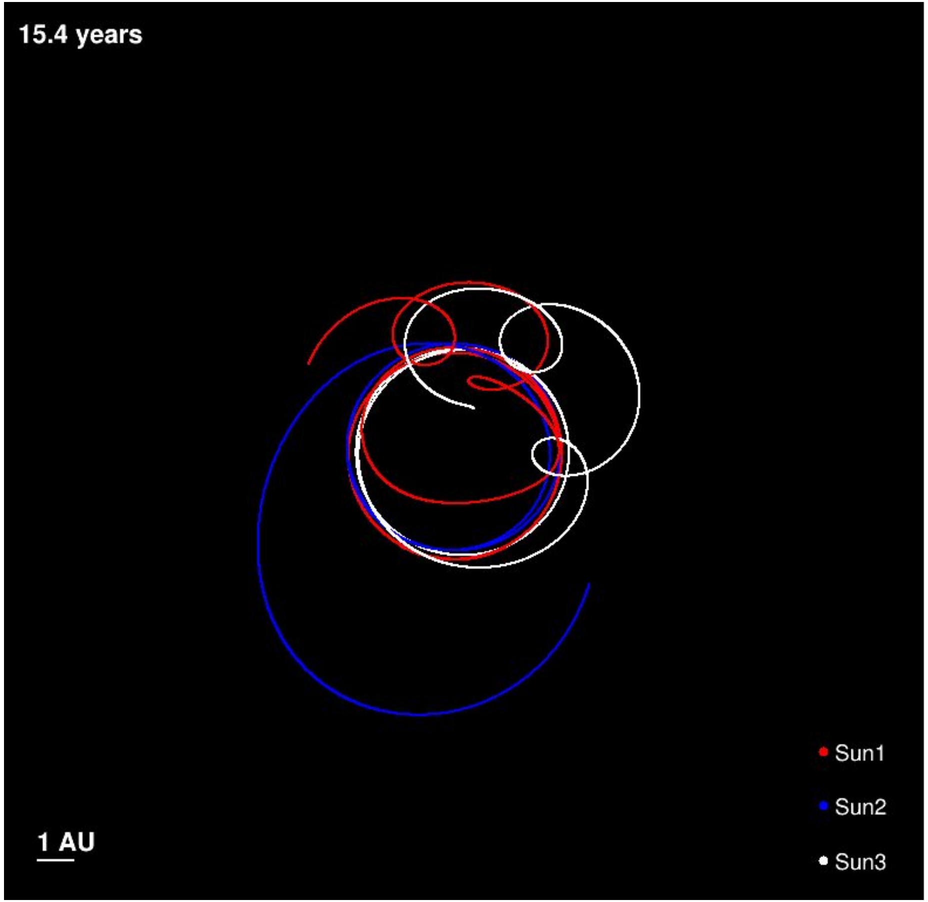
The Three Body Problem :: Problém tří těles



5% change in Solar masses

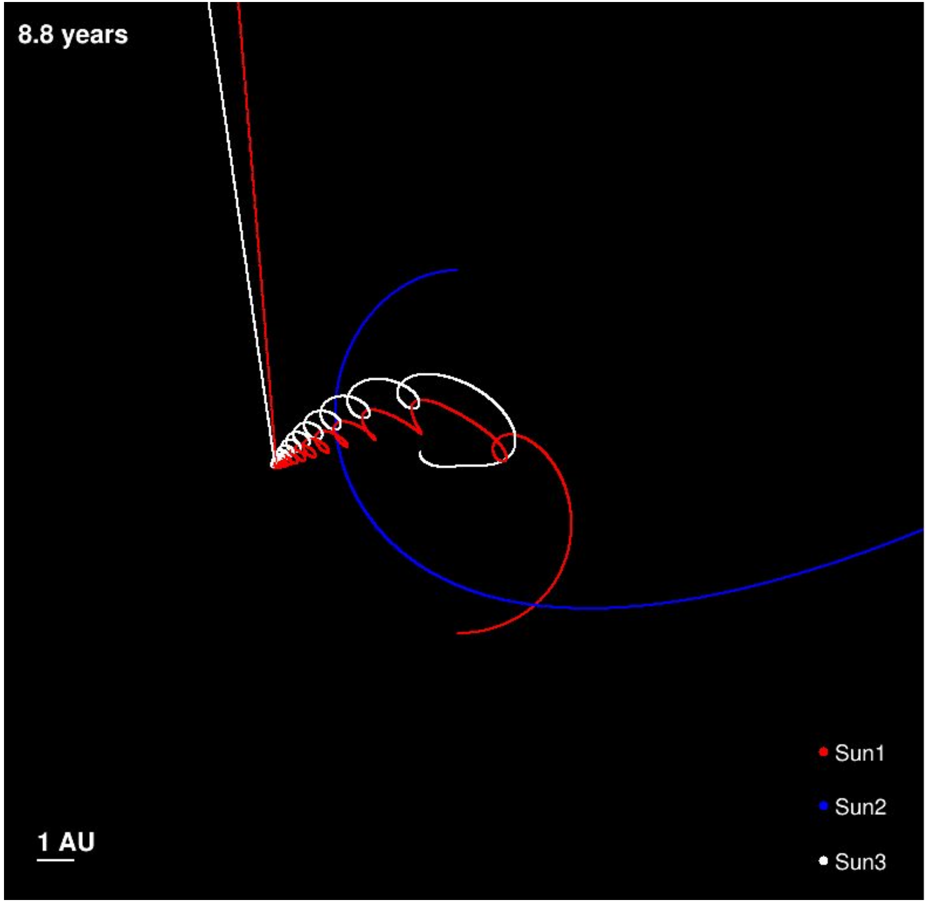
More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

The Three Body Problem :: Problém tří těles



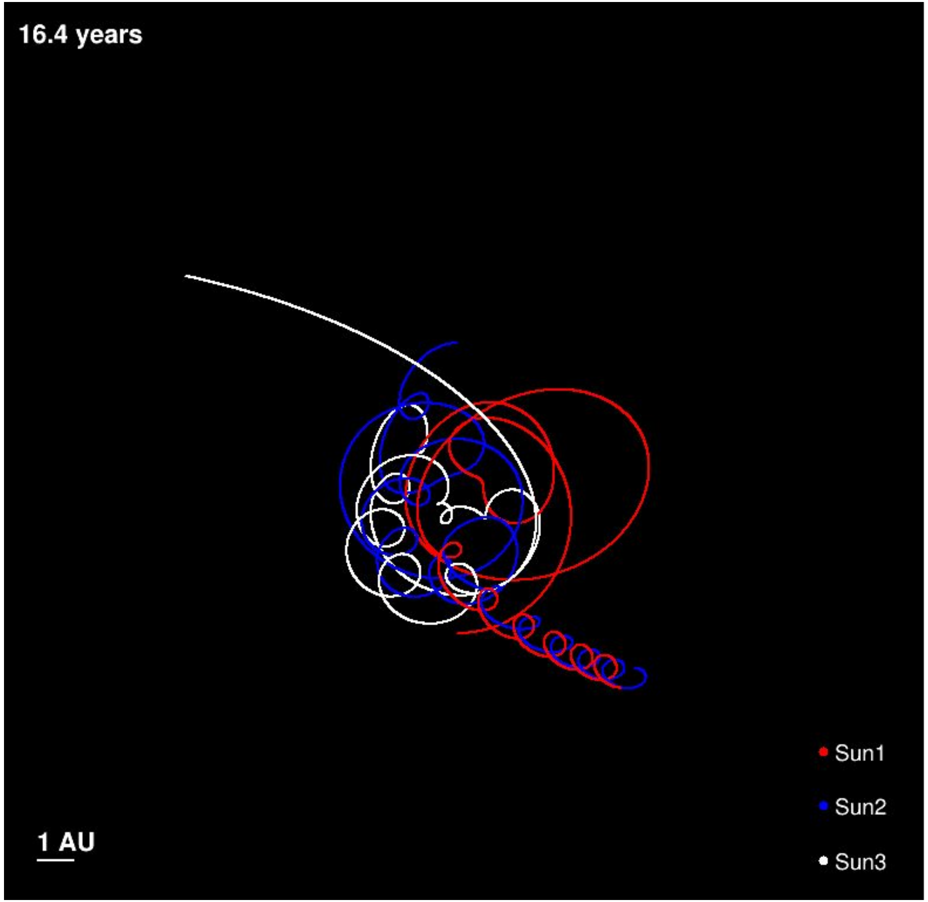
More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

The Three Body Problem :: Problém tří těles



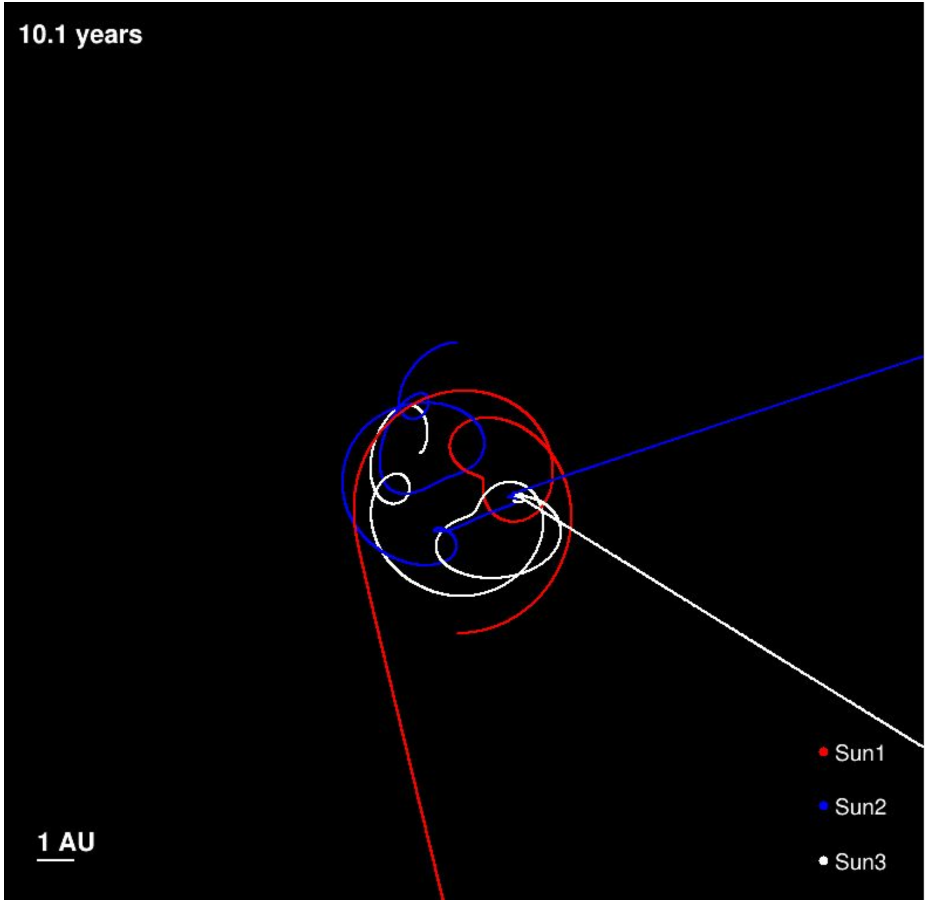
More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

The Three Body Problem :: Problém tří těles



More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

The Three Body Problem :: Problém tří těles



1% change in initial position of Sun2

More:
https://youtu.be/mm3I4m8YsnM?si=Ajz0tH_7xfPyW74o

The Three Body Problem :: “Oxford”

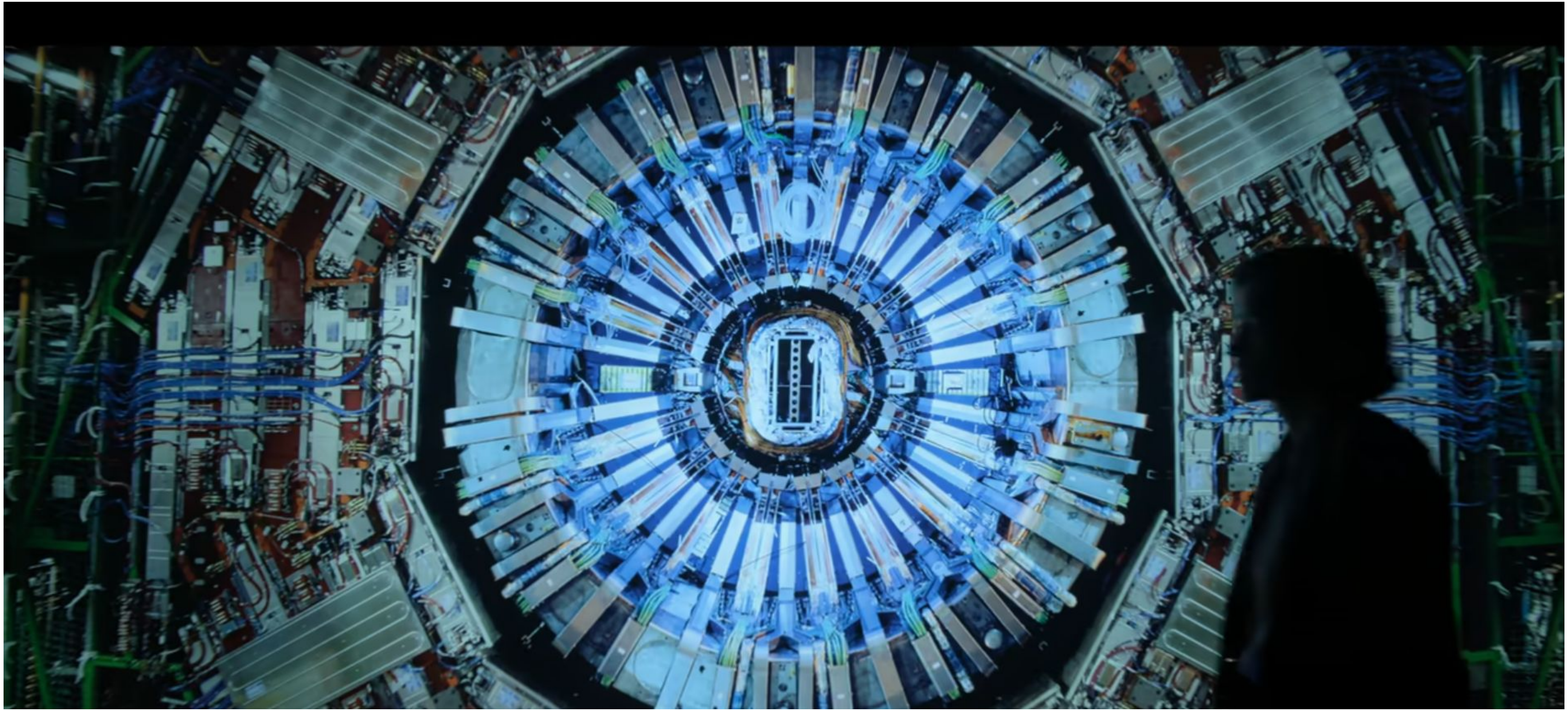
The Three Body Problem :: Brookhaven National Light Source, USA

The Three Body Problem :: “Oxford”

The Three Body Problem :: CERN’s Super Proton Synchrotron

https://cerncourier.com/a/the-sps-gets-ready-to-restart/

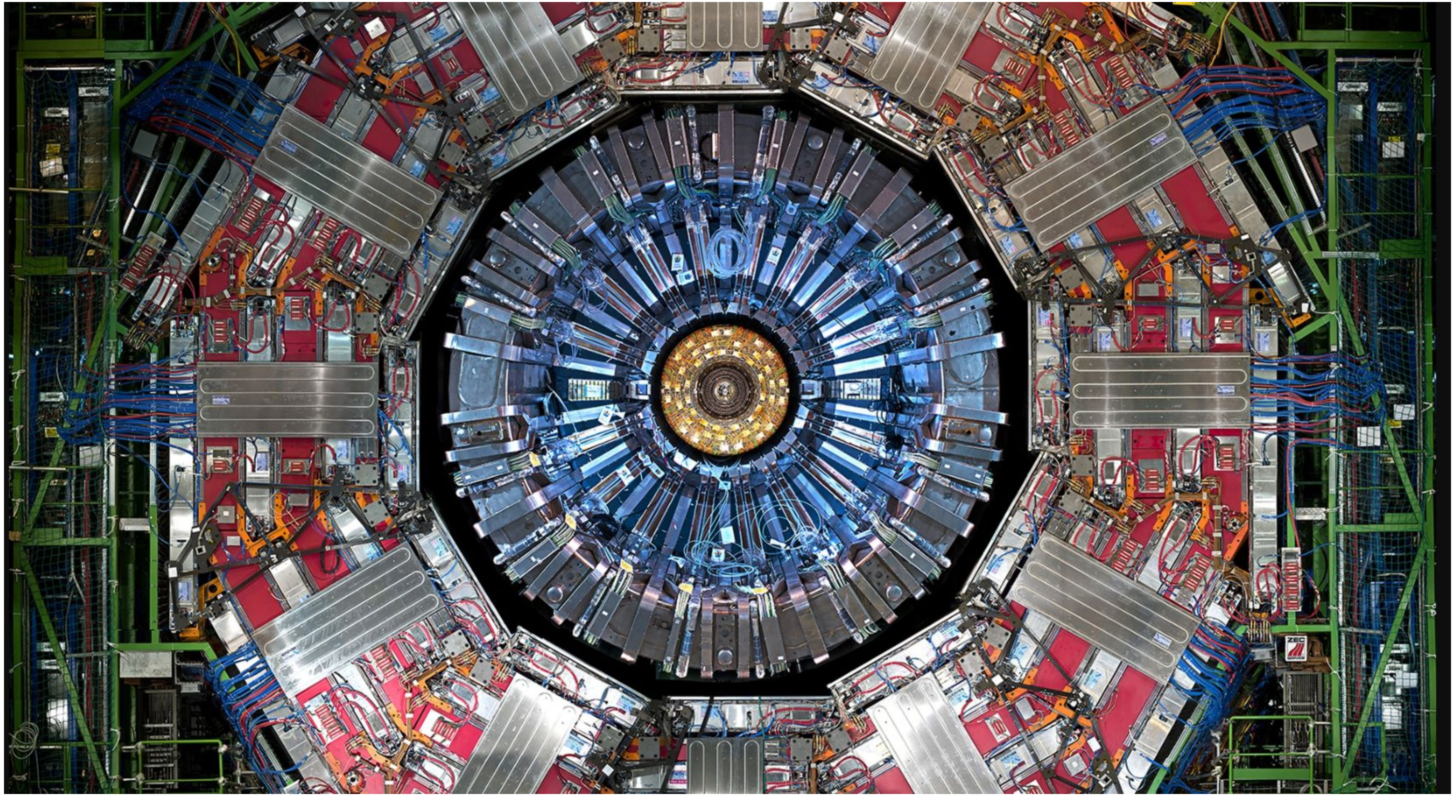
The Three Body Problem :: “Oxford”



The Three Body Problem :: CMS Experiment At CERN

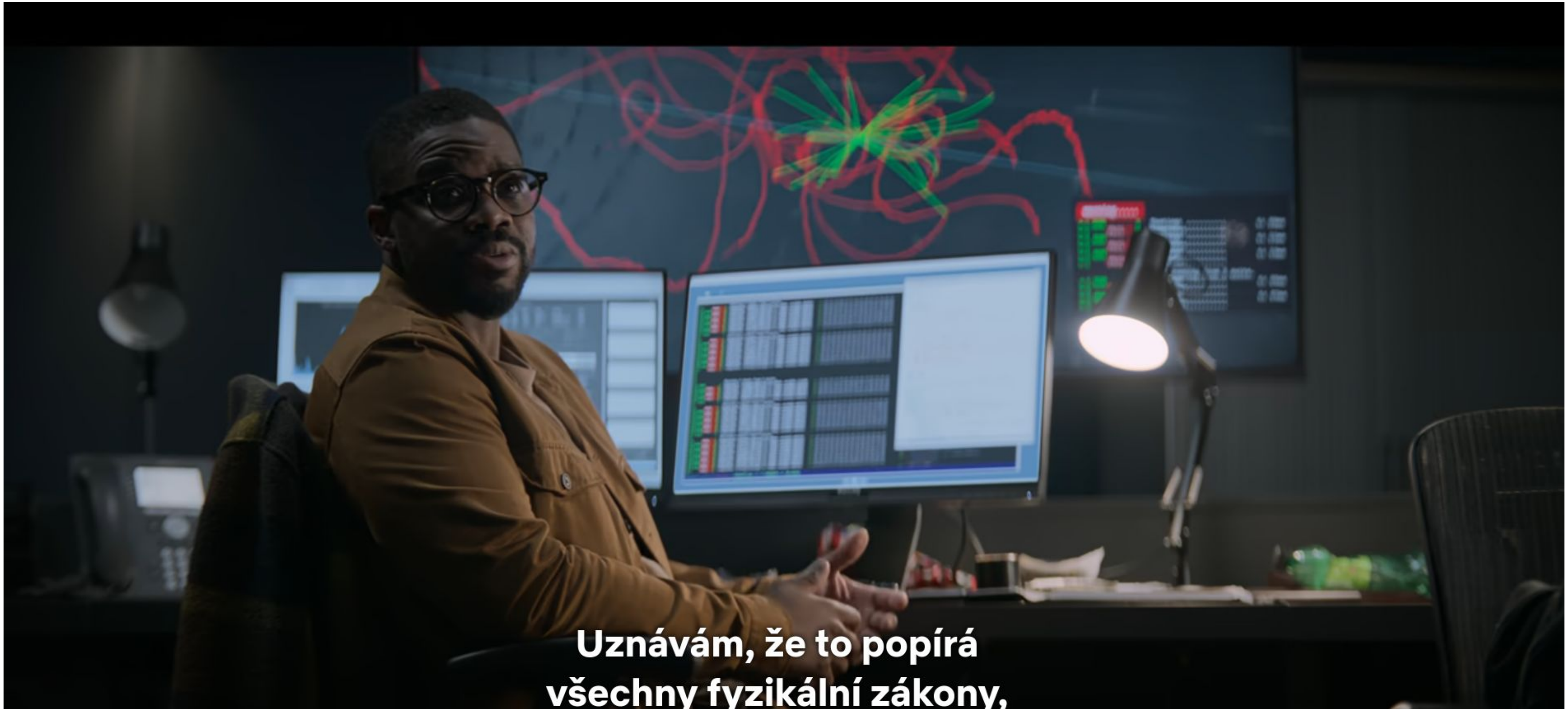
https://cms.cern/sites/default/files/2022-06/detector_stripe01-min_0_0.jpeg

https://cms.cern/detector



The Three Body Problem :: “Oxford”

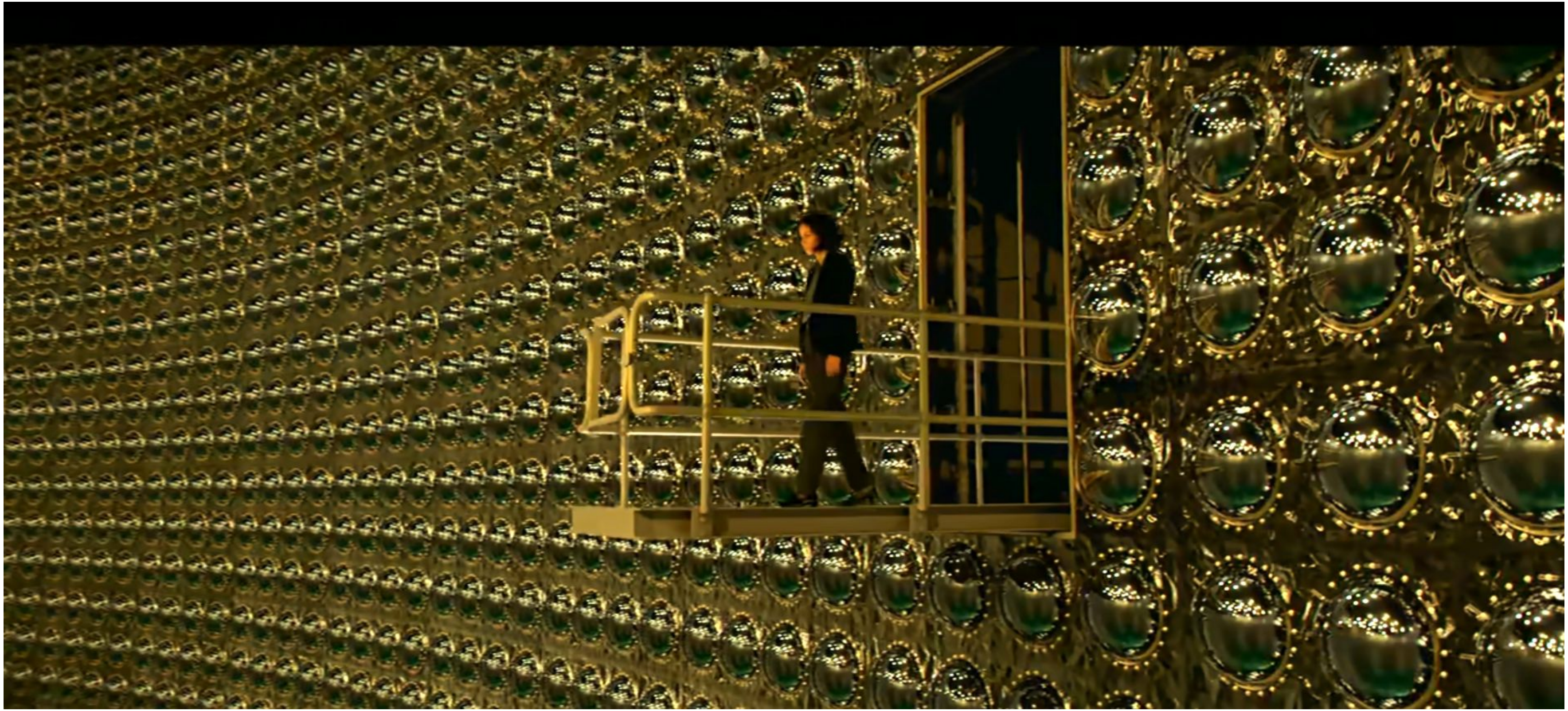
The Three Body Problem :: “Oxford”



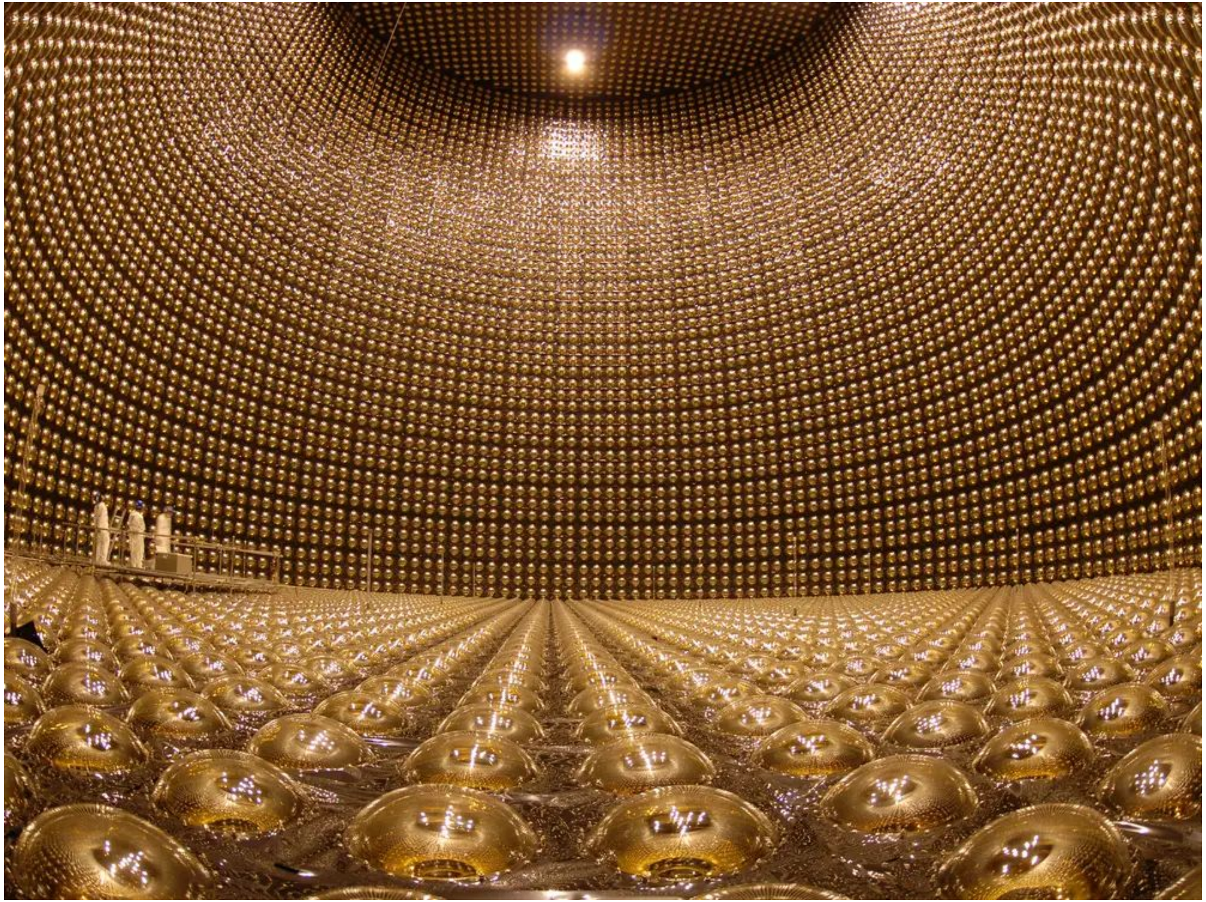
The Three Body Problem :: ATLAS Exp. Control Room

https://commons.wikimedia.org/wiki/File:ATLAS_experiment_control_room.jpg

The Three Body Problem :: “Oxford”



The Three Body Problem :: Super-Kamiokande Exp.



https://www.businessinsider.com/super-kamiokande-neutrino-detector-is-unbelievably-beautiful-2018-6

https://www-sk.icrr.u-tokyo.ac.jp/en/sk/

Experiment Kamiokande(-II) :: 3kt H_20

$$p^+ \rightarrow e^+ \pi^0$$

$$p^+ \rightarrow \mu^+ \pi^0$$

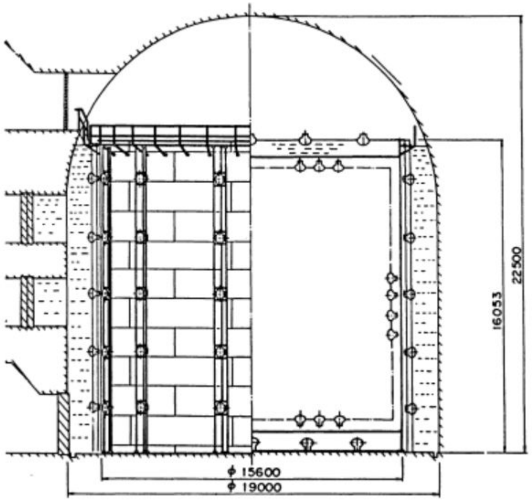
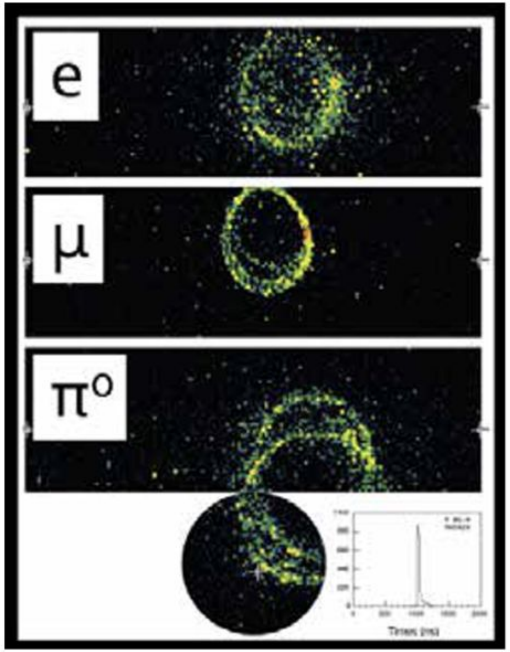


Figure 2: The detector of KAMIOKANDE -II. The dimensions are given in millimeters.



Neutrino identification

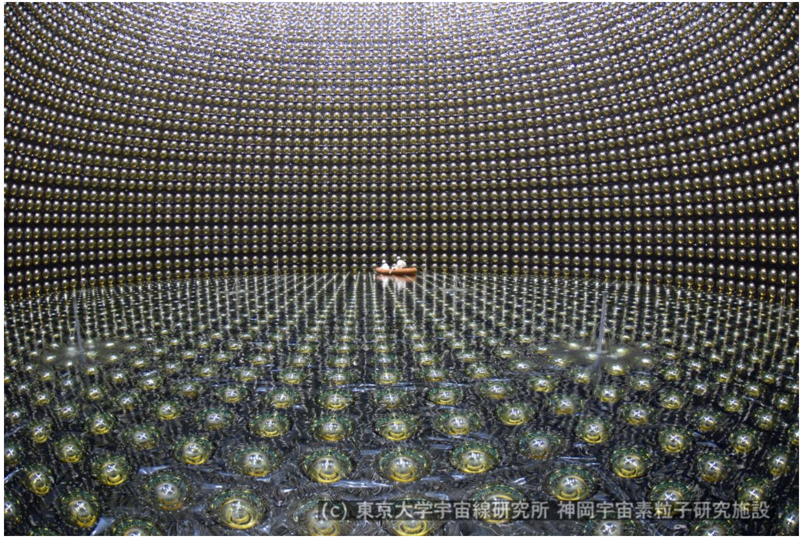
https://articles.adsabs.harvard.edu//full/1987ESOC...26..219K/0000220.000.html

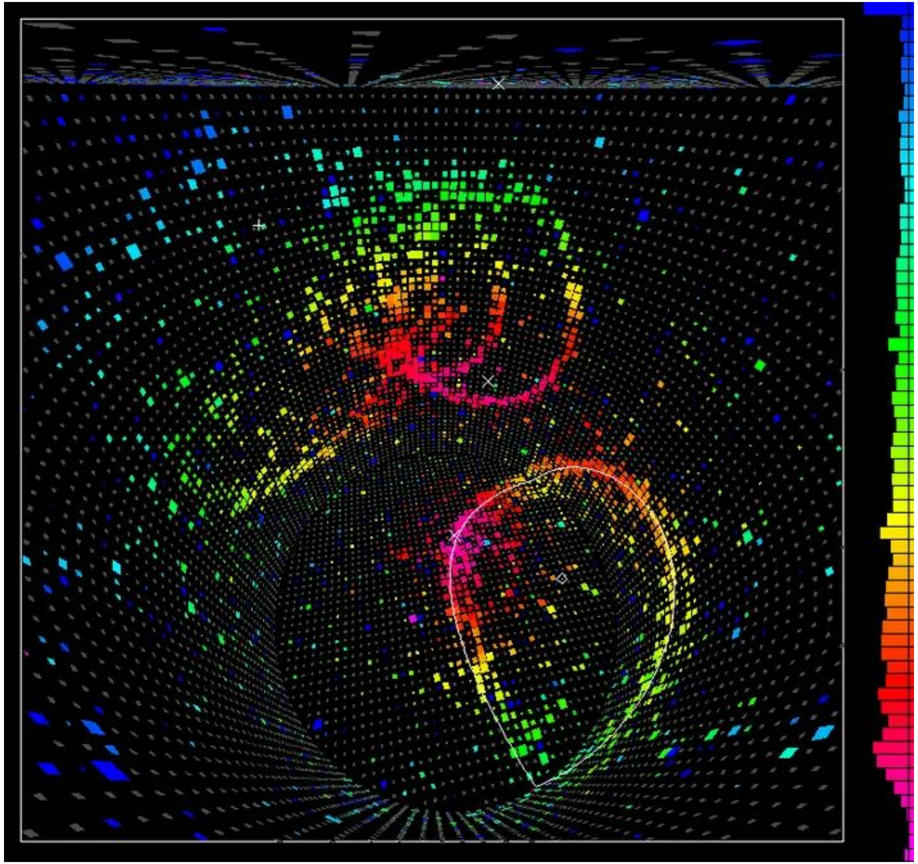
Super Kamiokande :: 50kt H_20
Kamioka Nucleon Decay Experiment

https://www-sk.icrr.u-tokyo.ac.jp/en/sk/about/history/

https://www-sk.icrr.u-tokyo.ac.jp/en/sk/experience/gallery/

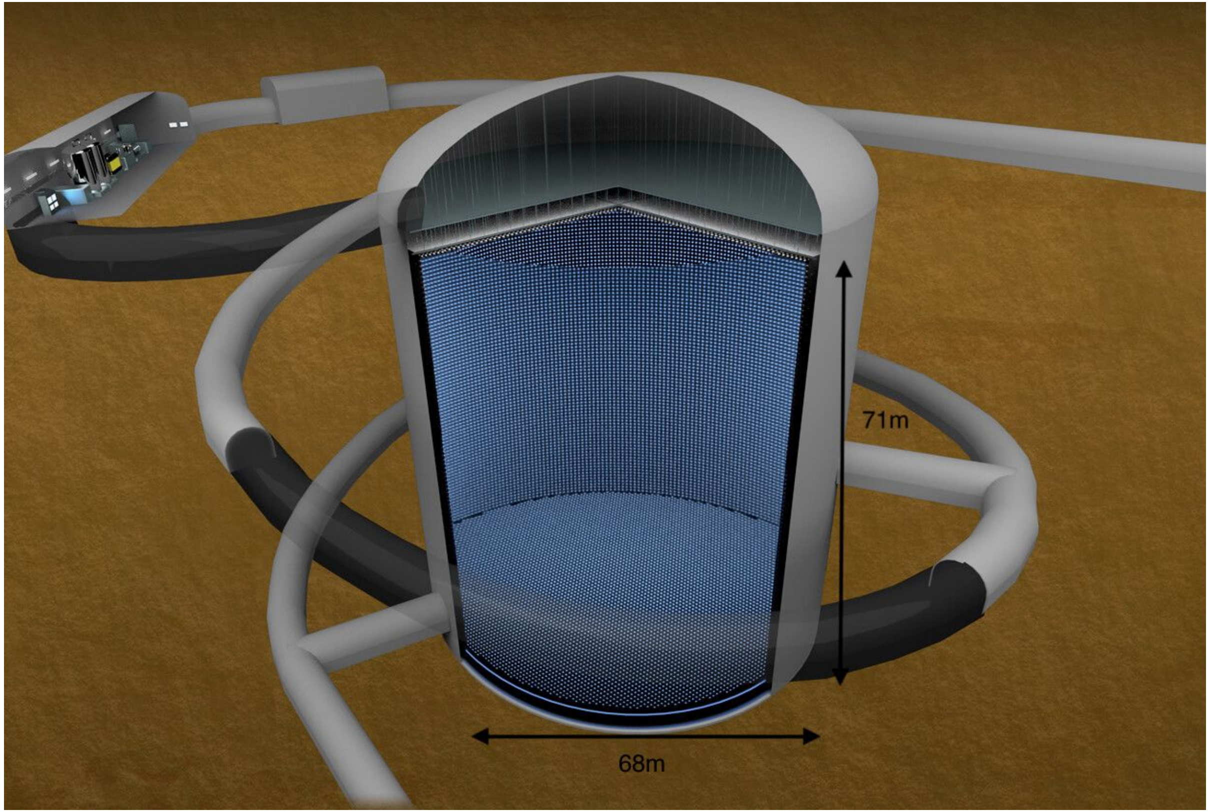
https://www.forbes.com/sites/startswithabang/2018/12/05/is-there-really-a-fourth-neutrino-out-there-in-the-universe/





Hyper Kamiokande :: 250kt H_20

https://www-sk.icrr.u-tokyo.ac.jp/en/hk/about/detector/
https://www-sk.icrr.u-tokyo.ac.jp/en/hk/

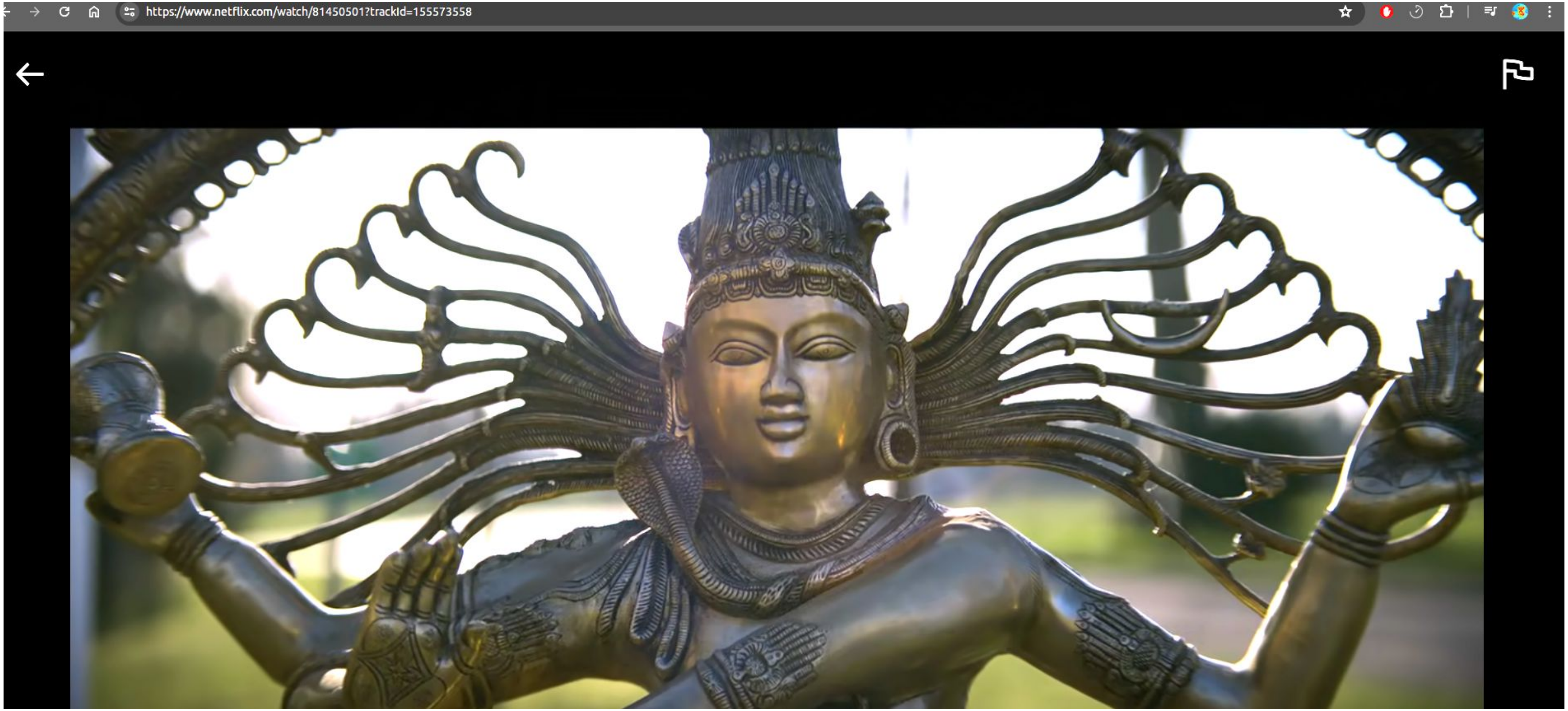


YT :: Hyper-Kamiokande
https://www.youtube.com/watch?v=JFOE3D2z7LM&t=12s&ab_channel=Hyper-Kamiokande

Hyper Kamiokande :: 250kt H_20 :: Dec. 2023

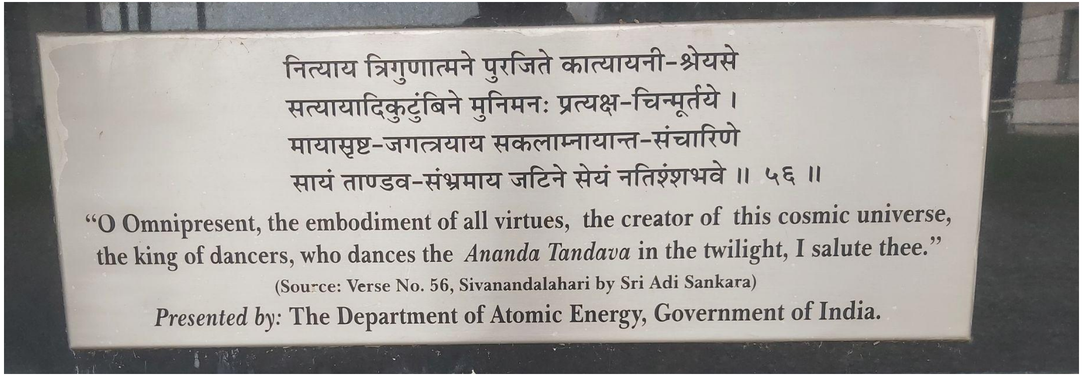
The Three Body Problem :: CERN

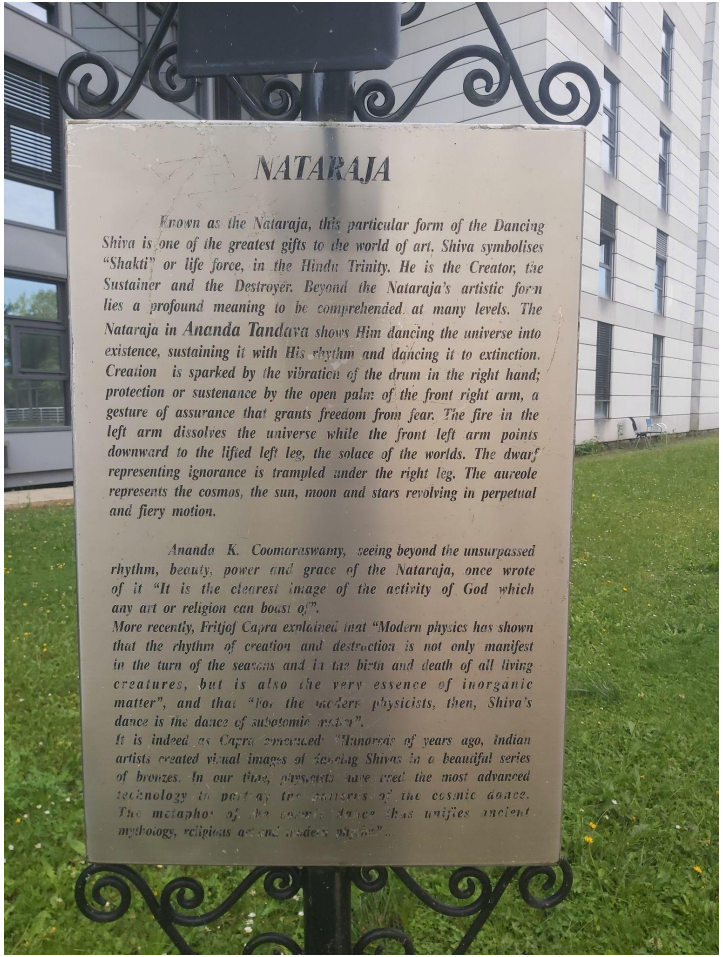
The Three Body Problem :: CERN



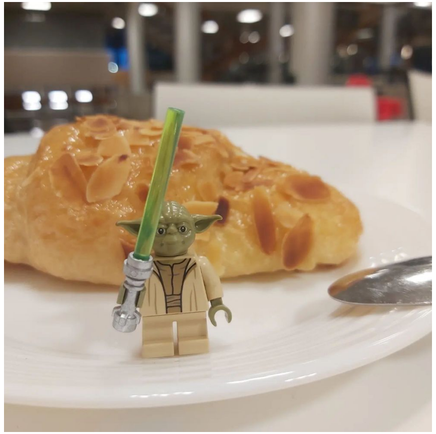
The Three Body Problem :: CERN – realita

The Three Body Problem :: CERN – realita



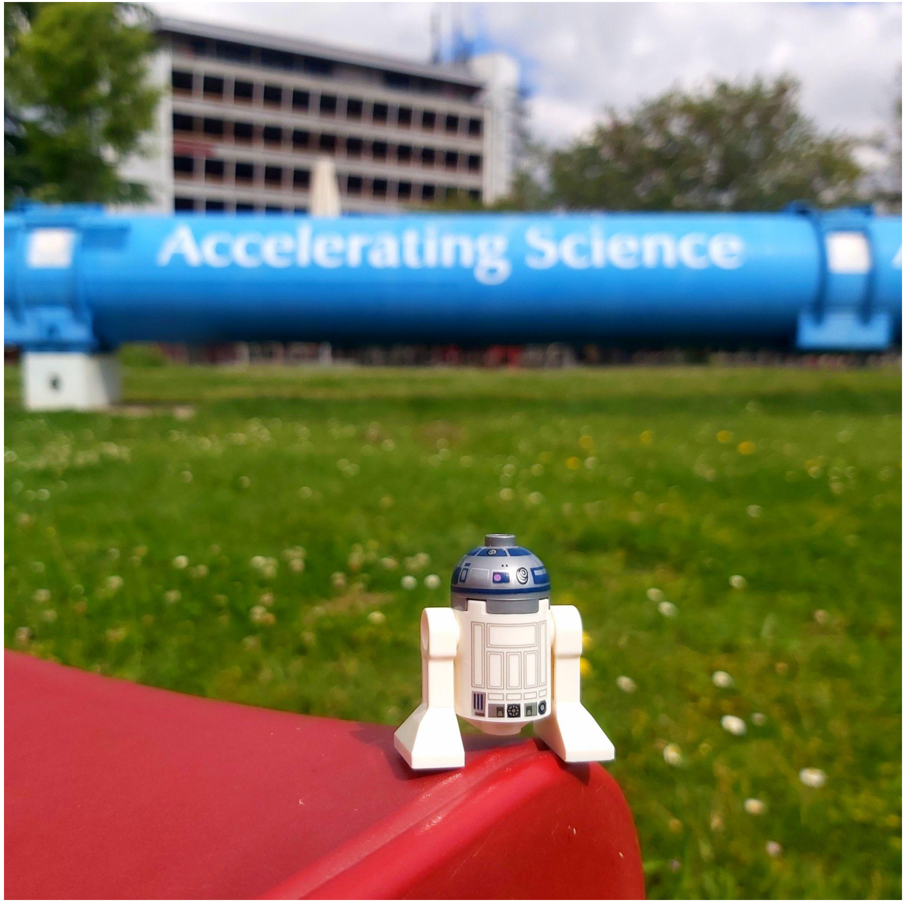


CERN



CERN

CERN




Accelerating science
Accélérateur de science
ATLAS
WHERE THE
WEB
WAS BORN
Route A. EINSTEIN
STOP
ANTIMATTER
FACTORY
ELENA
ANTIMATTER FACTORY MAP
COMPASS

Backup

SN1987A 24.2.1987 :: 170kly

SN1987A 24.2.1987 :: 170kly

SN1987A 24.2.1987 :: 170kly

https://en.wikipedia.org/wiki/SN_1987A

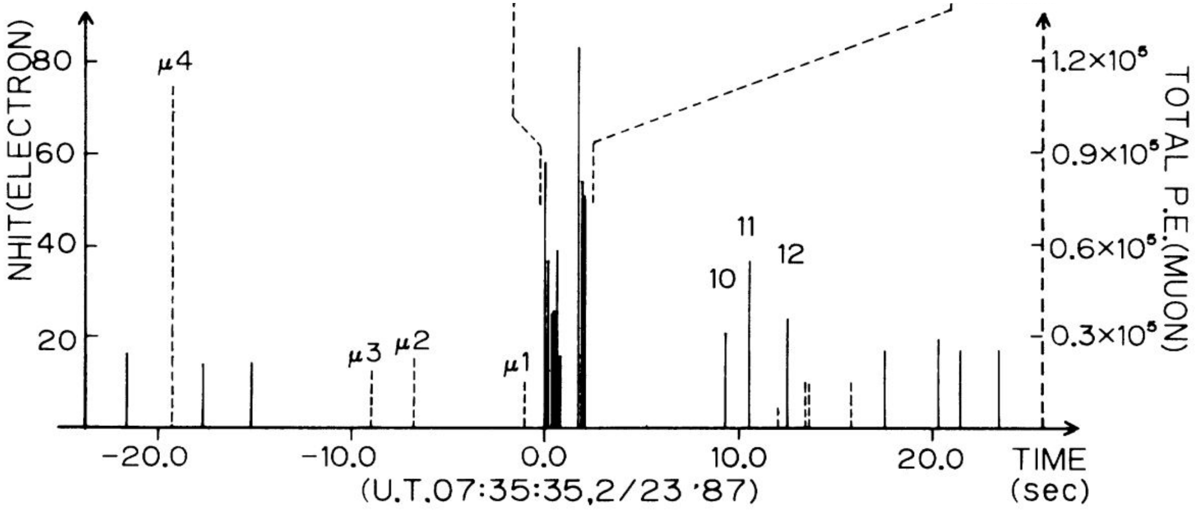
https://www-sk.icrr.u-tokyo.ac.jp/en/news/detail/324

Experiment Kamiokande(-II) :: 3kt H_20

VOLUME 58, NUMBER 14 PHYSICAL REVIEW LETTERS 6 APRIL 1987

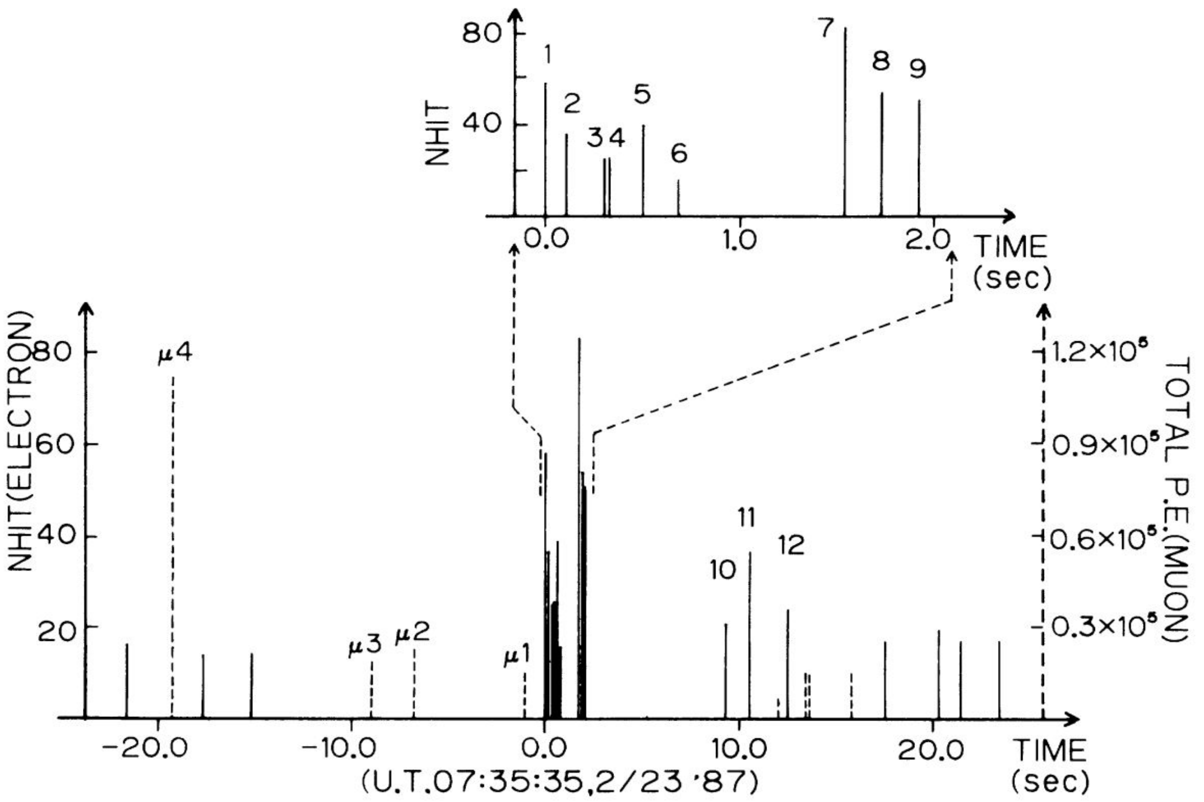
Observation of a Neutrino Burst from the Supernova SN1987A

K. Hirata,[a] T. Kajita,[a] M. Koshiba,[a,b] M. Nakahata,[b] Y. Oyama,[b]
N. Sato,[c] A. Suzuki,[b] M. Takita,[b] and Y. Totsuka[a,c]
University of Tokyo, Tokyo 113, Japan



Experiment Kamiokande(-II) :: 3kt H_20

- Počátky neutrinové astronomie! :-)



Experiment Kamiokande(-II) :: 3kt H_20

- Počátky neutrinové astronomie! :-)
- 1 Erg is a unit of energy equal to 10^{-7} Joules (100 nJ)

form volume distribution. Additional support is provided by the correlation in angle of the first two observed events with the direction to SN1987A. The event burst occurred roughly 18 h prior to the first optical sighting.[1] Correcting for energy-dependent detection efficiency, and assuming that nine of the twelve events are due to $\bar{\nu}_e p^+ \rightarrow e^+ n$, we obtain an integral flux of 1.0×10^{10} $\bar{\nu}_e$ cm^{-2} for the burst, where the $\bar{\nu}_e$ energy (the observed electron energy plus 1.3 MeV) is above 8.8 MeV. This, in turn, leads to the $\bar{\nu}_e$ output of SN1987A of 8×10^{52} ergs for an assumed average energy of 15 MeV.

This observation is the first direct observation in neutrino astronomy, and coincides remarkably well with the current model of supernova collapse and neutron-star formation.[6] In that model an aged, massive star, having exhausted its nuclear fuel, undergoes a supernova explosion. In supernovae of Type II almost all of the gravitational binding energy of the resultant neutron star, $\sim 3 \times 10^{53}$ ergs, is radiated within a few seconds in the form of 10^{58} neutrinos of all flavors with average energy in the vicinity of 10–15 MeV.

Experiment Kamiokande(-II) :: 3kt H_20

- Počátky neutrinové astronomie! :-)
- 1 Erg is a unit of energy equal to 10^{-7} Joules (100 nJ)

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This observation is the first direct observation in neutrino astronomy, and coincides remarkably well with the current model of supernova collapse and neutron-star formation.[6] In that model an aged, massive star, having exhausted its nuclear fuel, undergoes a supernova explosion. In supernovae of Type II almost all of the gravitational binding energy of the resultant neutron star, $\sim3\times10^{53}$ ergs, is radiated within a few seconds in the form of 10^{58} neutrinos of all flavors with average energy in the vicinity of 10–15 MeV.

Experiment Kamiokande(-II) :: 3kt H_20

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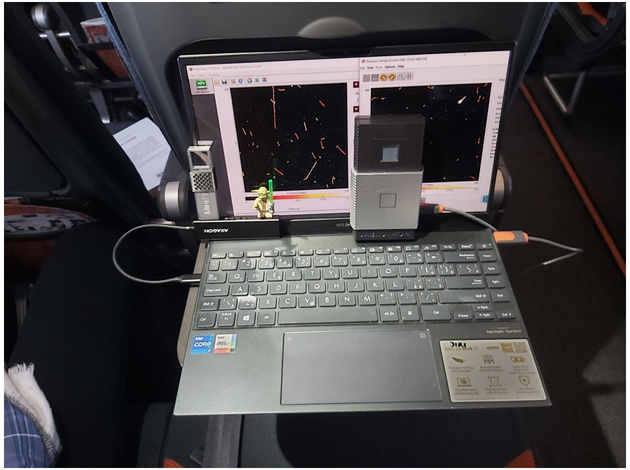
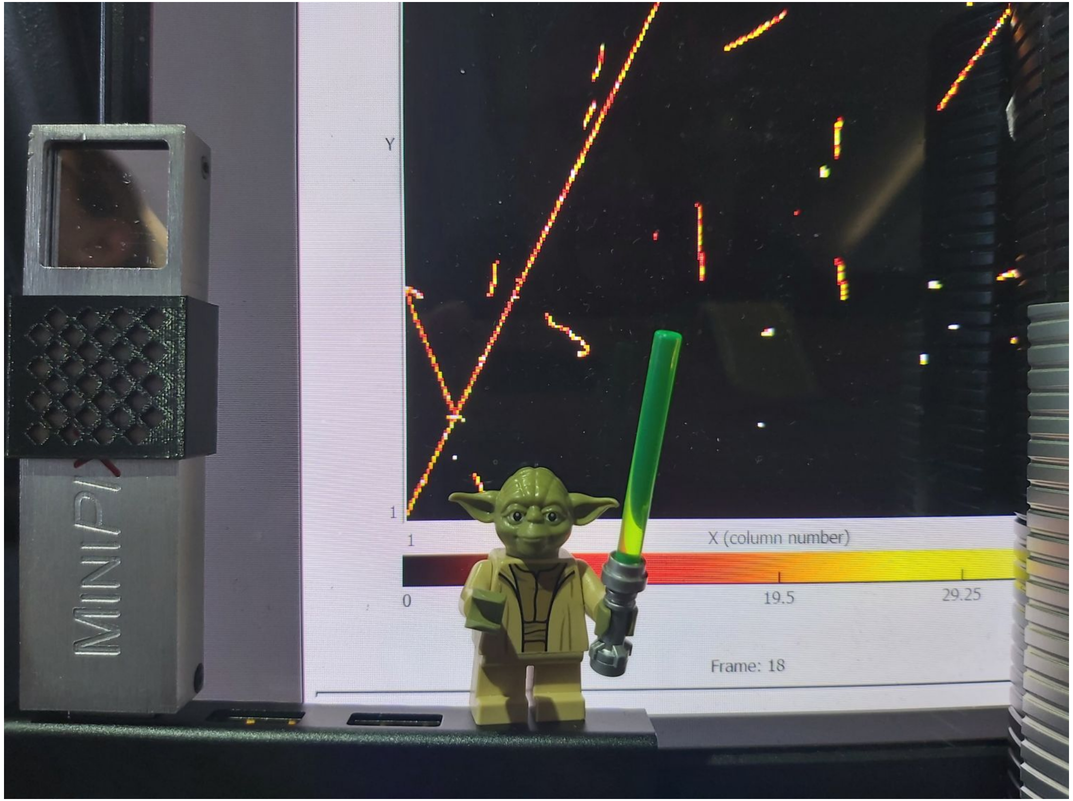
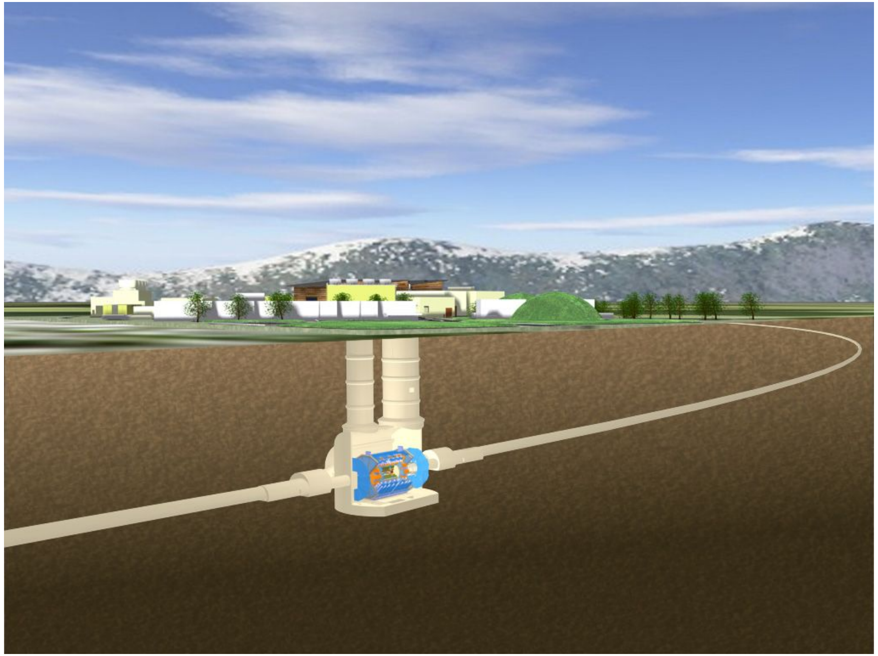
Flying to CERN – with particle cameras!





The ATLAS Experiment



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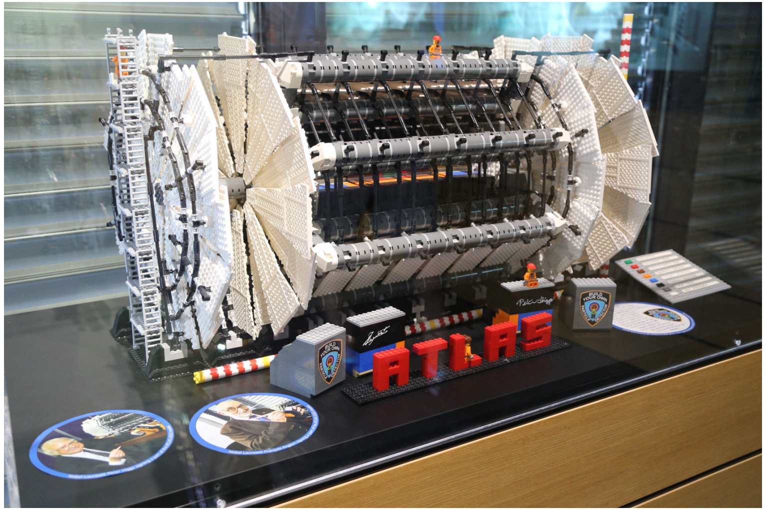

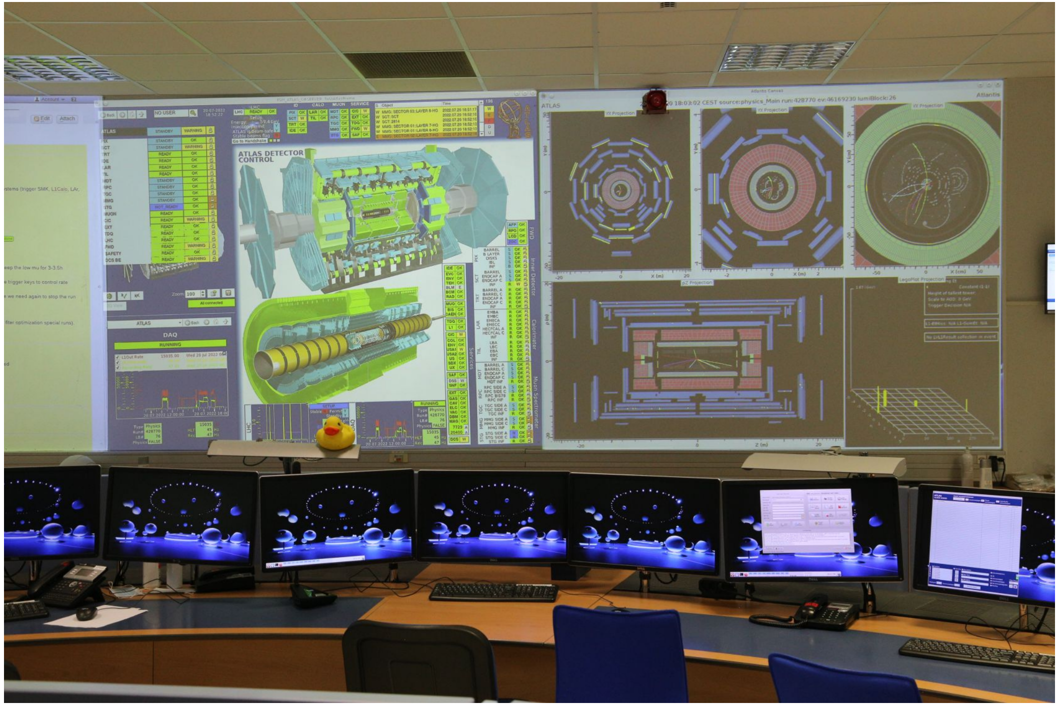

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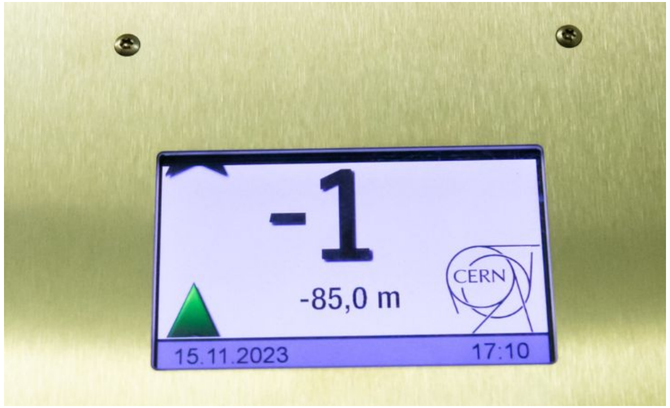

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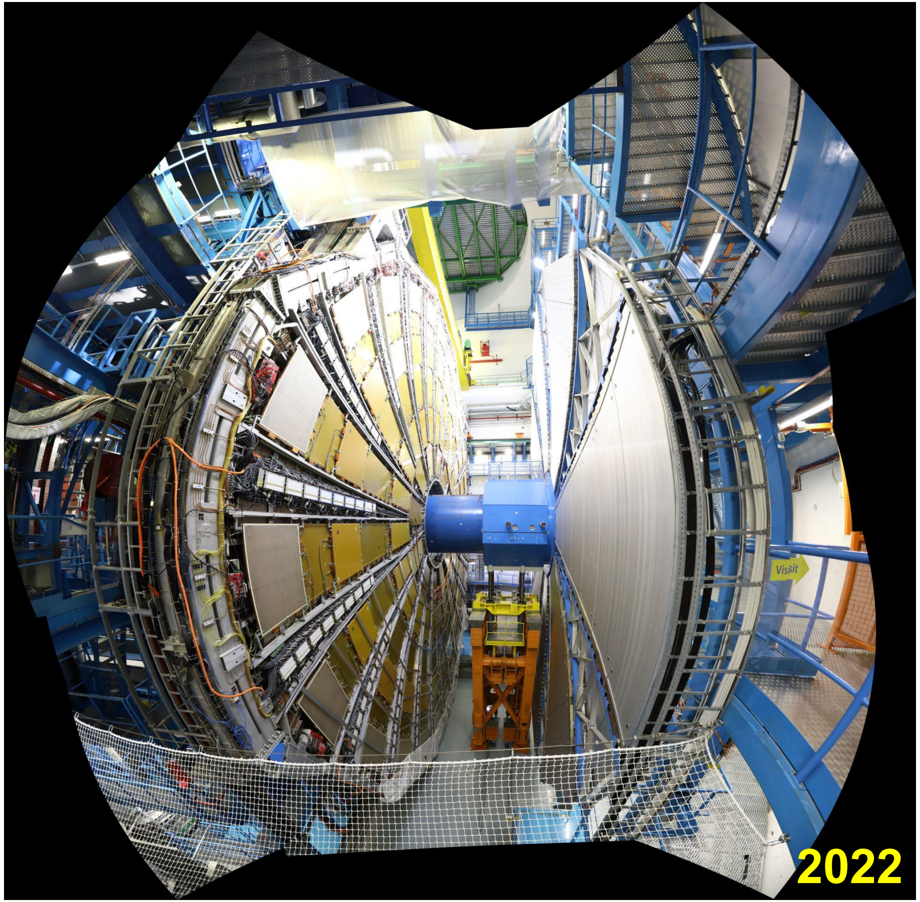

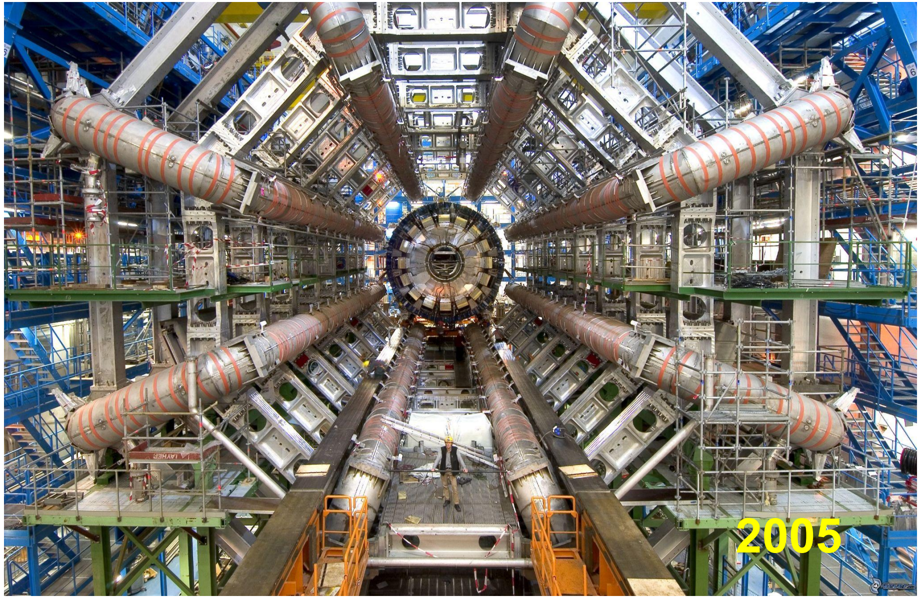

https://timeline.web.cern.ch/timeline-header/143

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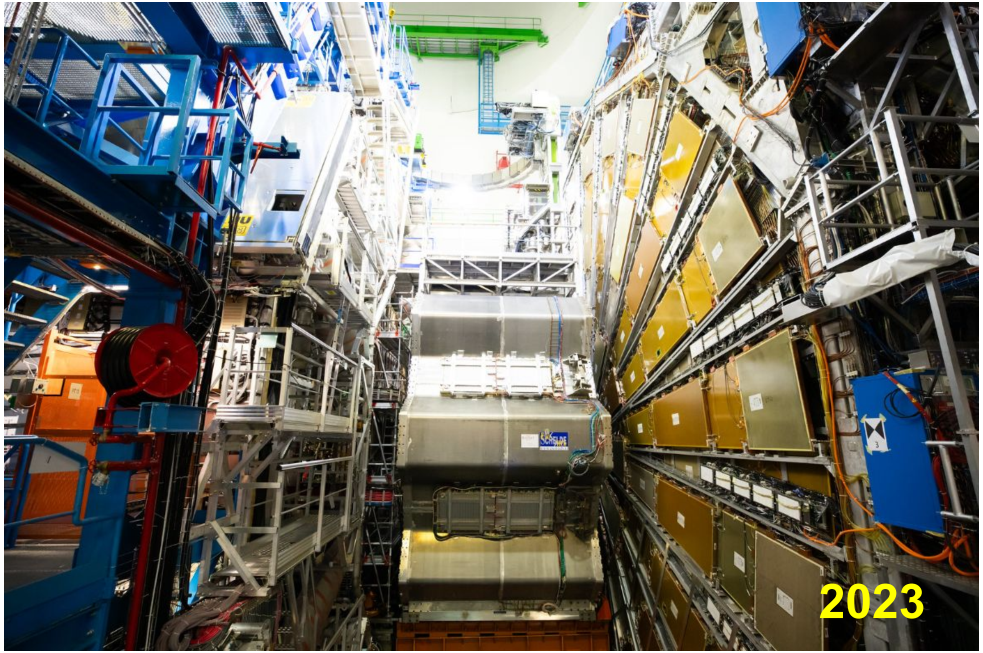

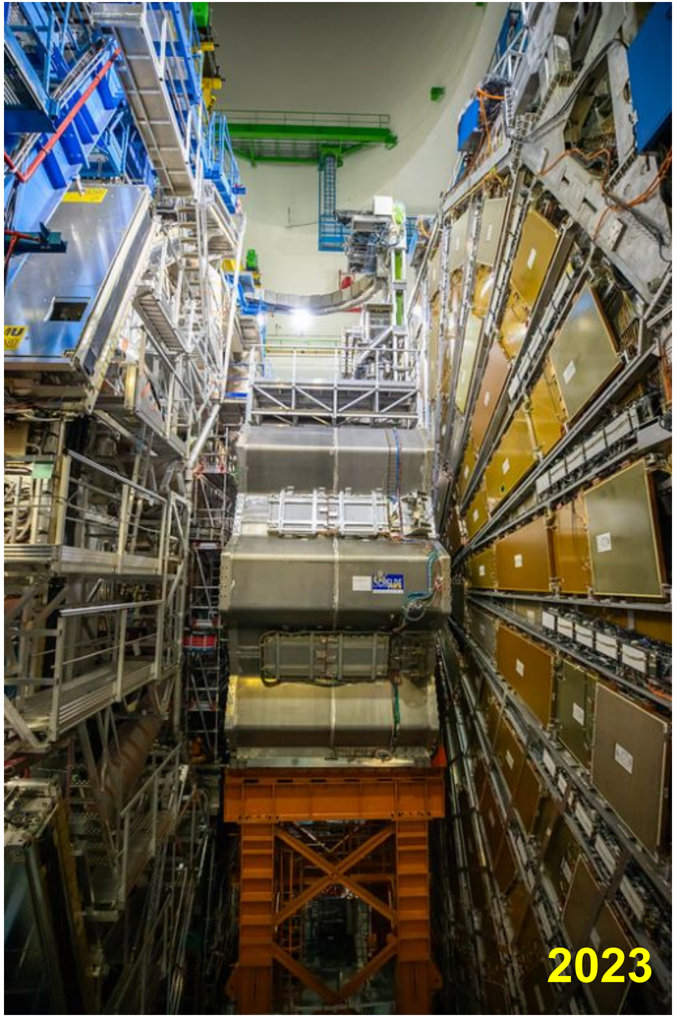

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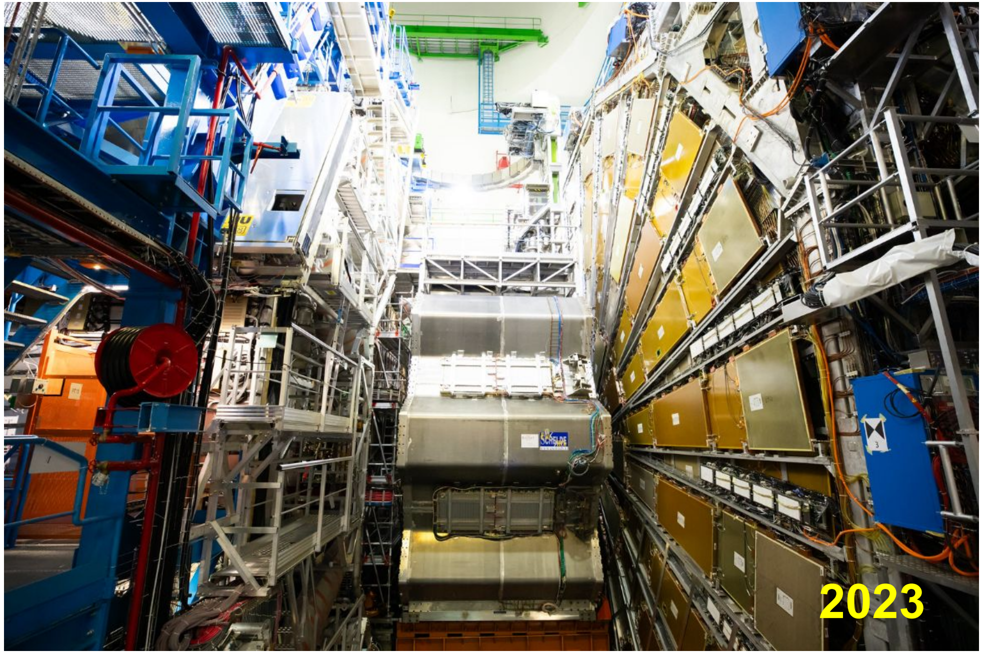


SWI swissinfo.ch   Swiss perspectives in 10 languages

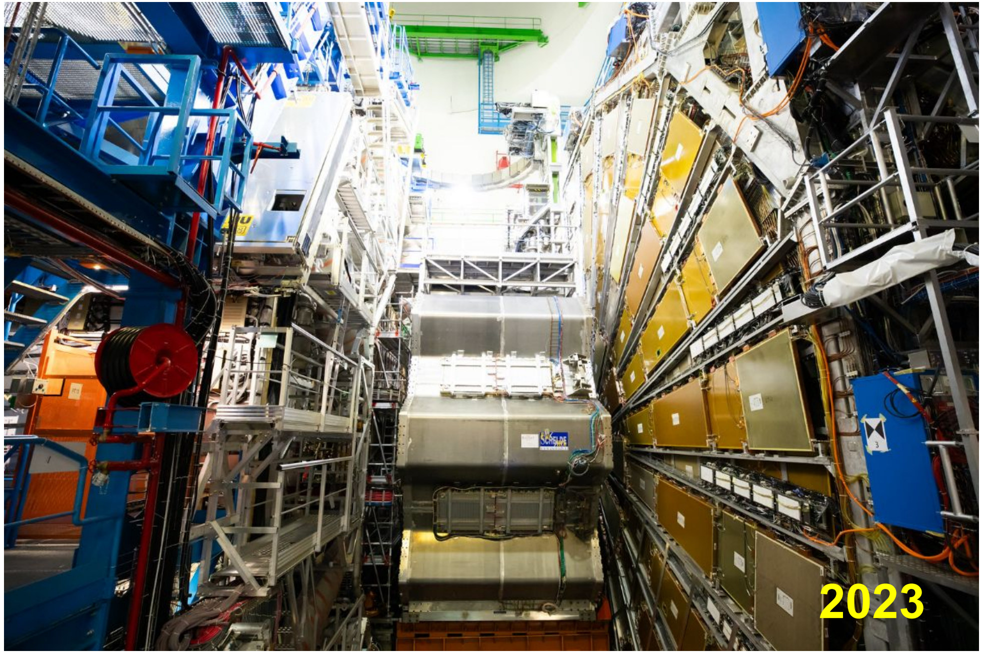
▲ French President Emmanuel Macron, left, with Fabiola Gianotti, Director General of CERN, and Swiss President Alain Berset in the ATLAS experiment on Thursday © Keystone / Martial Trezzini

read aloud

French President Emmanuel Macron spoke on Thursday of France's ambitions to remain in "first place" during a visit to the world's most powerful particle accelerator on the Franco-Swiss border, where a successor, even more powerful, is being studied.

November 17, 2023 - 10:33   2 minutes

The ATLAS Experiment



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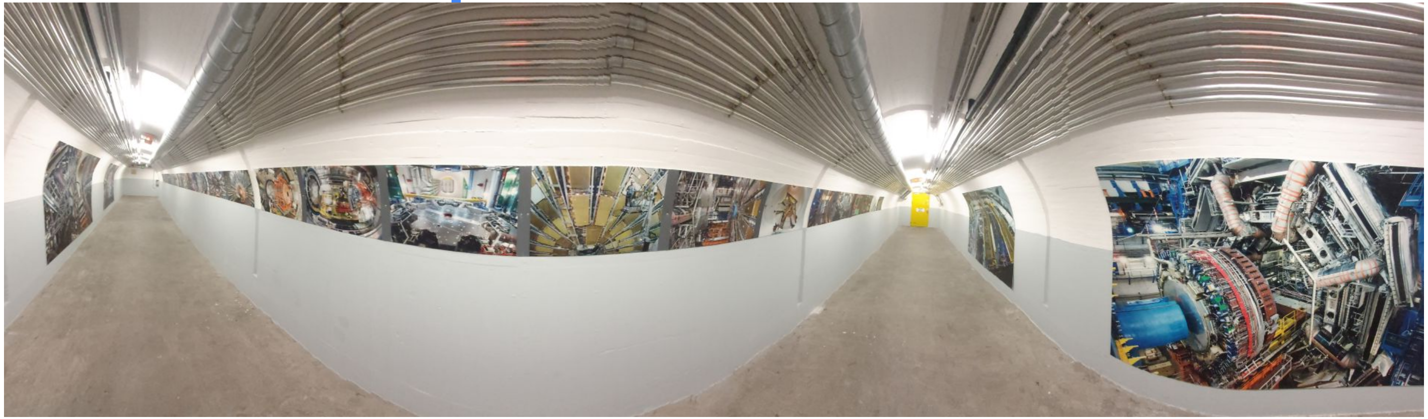

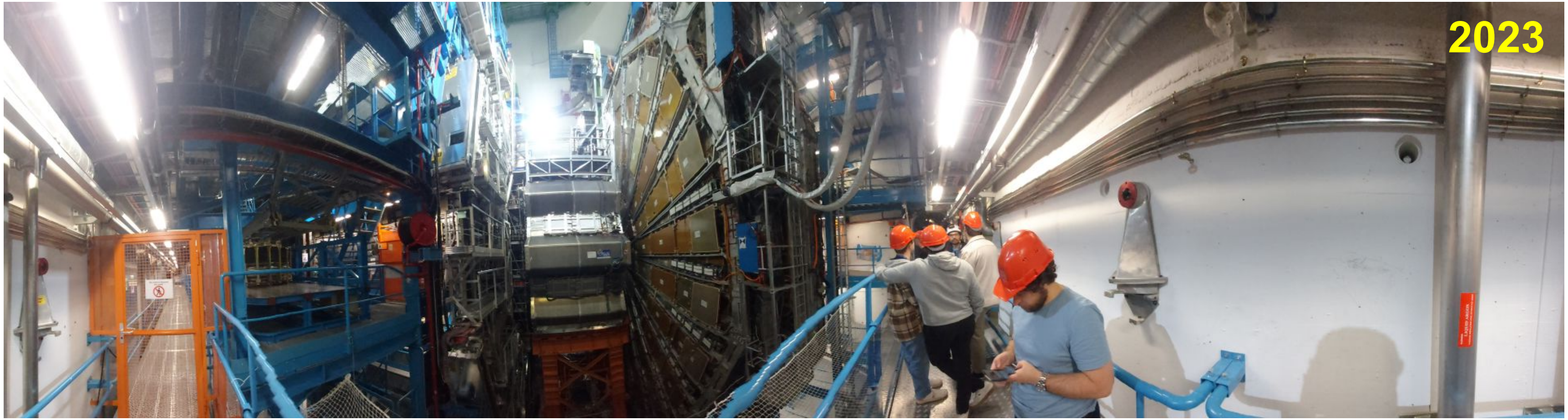

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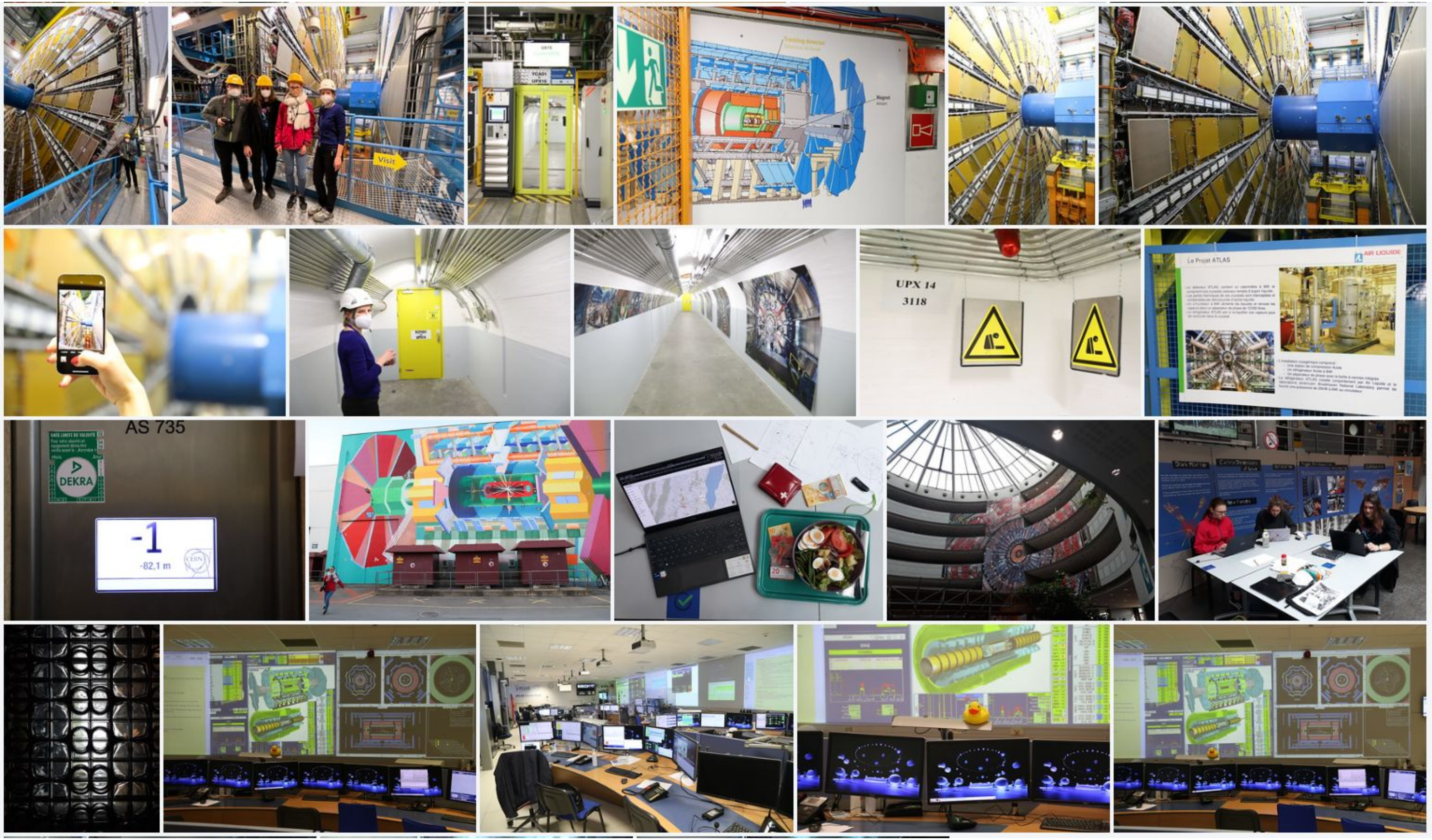

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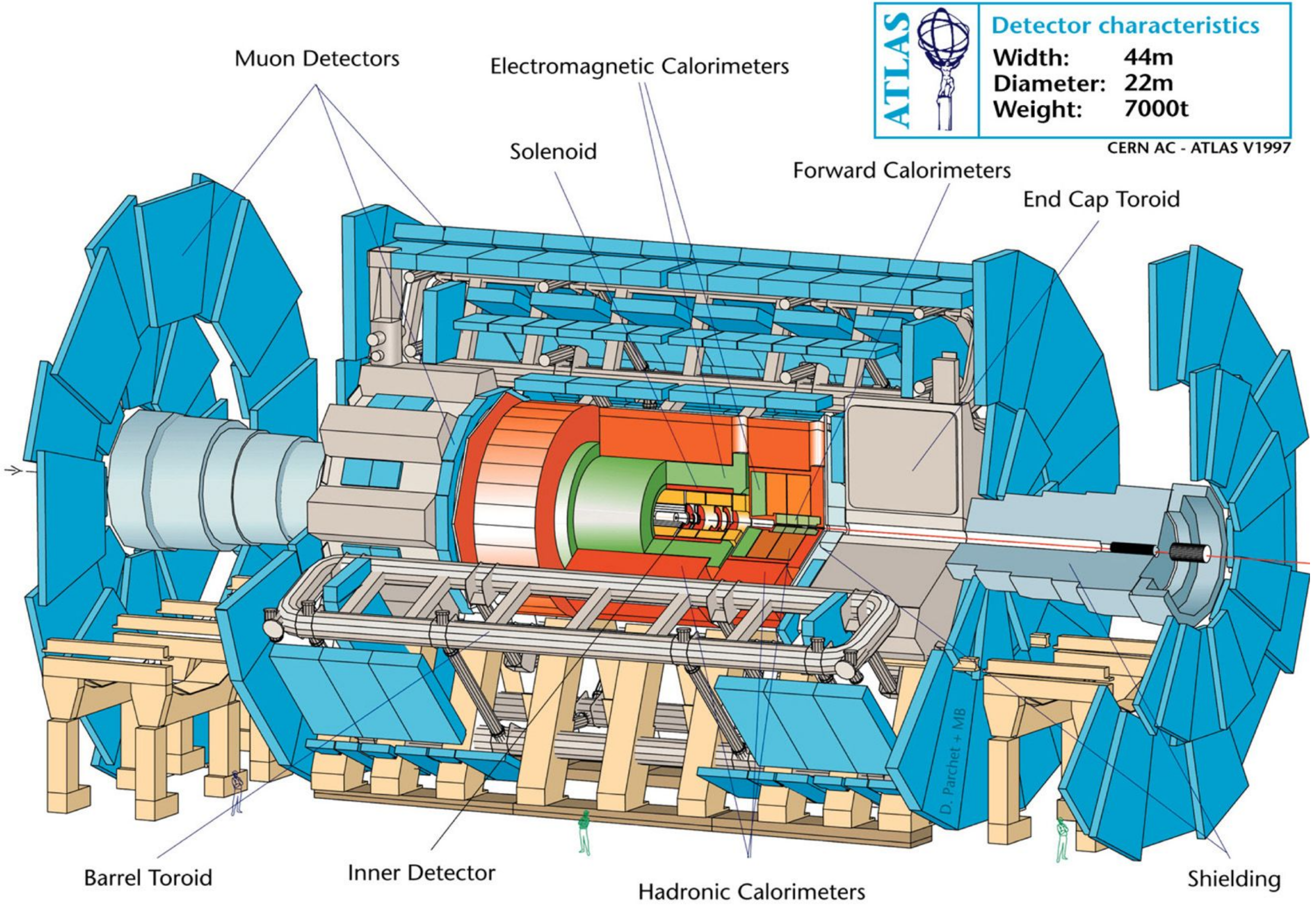

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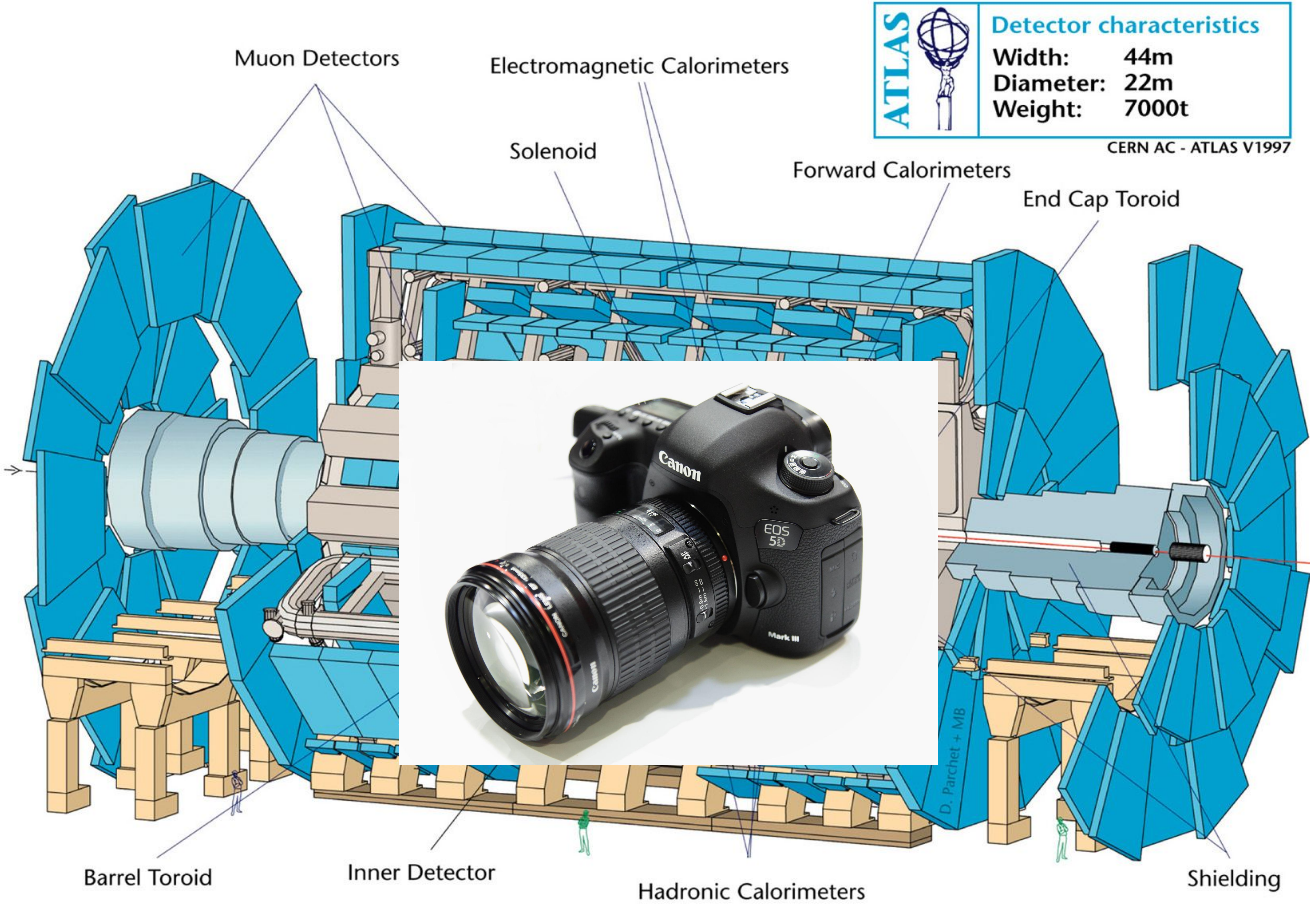

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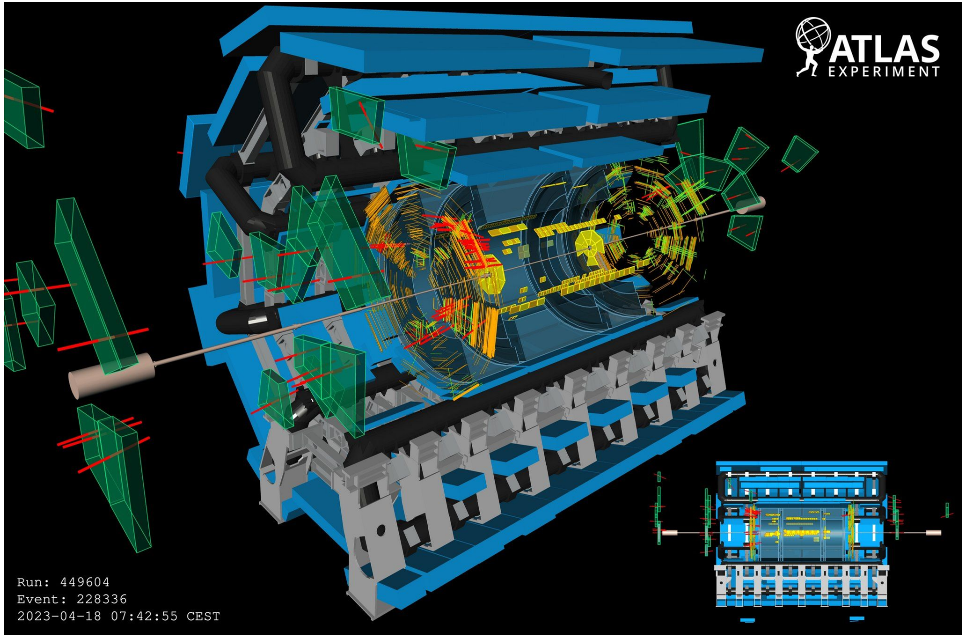
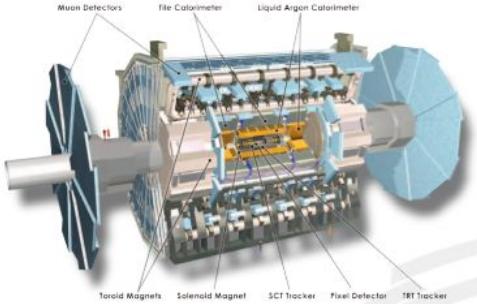


The ATLAS Detector

- Diameter 25 m -- Length : 46 m
- Barrel toroid length 26 m
- Overall weight 7 000 tonnes
- ~ 100 million electronic channels
- ~ 3 000 km of cables



Calorimeters

Measure the energies carried by the particles

Liquid Argon (LAr) Calorimeter
- Barrel 6.4 m long, 53 cm thick, 110 000 channels.
- Works with Liquid Argon at -183° C
- LAr endcap consists of the forward calorimeter, electromagnetic (EM) and hadronic endcaps.
- EM endcaps each have thickness 0.632 m and radius 2.077 m.
- Hadronic endcaps consist of two wheels of thickness 0.8 m and 1.0 m with radius 2.09 m.
- Forward calorimeter has three modules of radius 0.455 m and thickness 0.450 m each.

Tile Calorimeter (TileCal)
- Barrel made of 64 wedges, each 5.6 m long and 20 tonnes.
- Each Endcap has 64 wedges, each 2.6 m long.
- 500 000 plastic scintillator tiles.

Muon System

Identifies and measures the momenta of muons

Thin Gap Chambers
For triggering and 2nd coordinate measurement (non-bending direction) at ends of detector.
- 440 000 channels

Resistive Plate Chambers
For triggering and 2nd coordinate measurement in central region.
- 380 000 channels
- Electric Field 5 000 V/mm

Monitored Drift Tubes
Measure curves of tracks.
- 1 171 chambers with total 354 240 tubes (3 cm diameter, 0.85-6.5 m long).
- Tube resolution 80 µm

Cathode Strip Chambers
Measure precision coordinates at ends of detector.
- 70 000 channels
- Resolution 60 µm

The ATLAS Experiment – particle identification