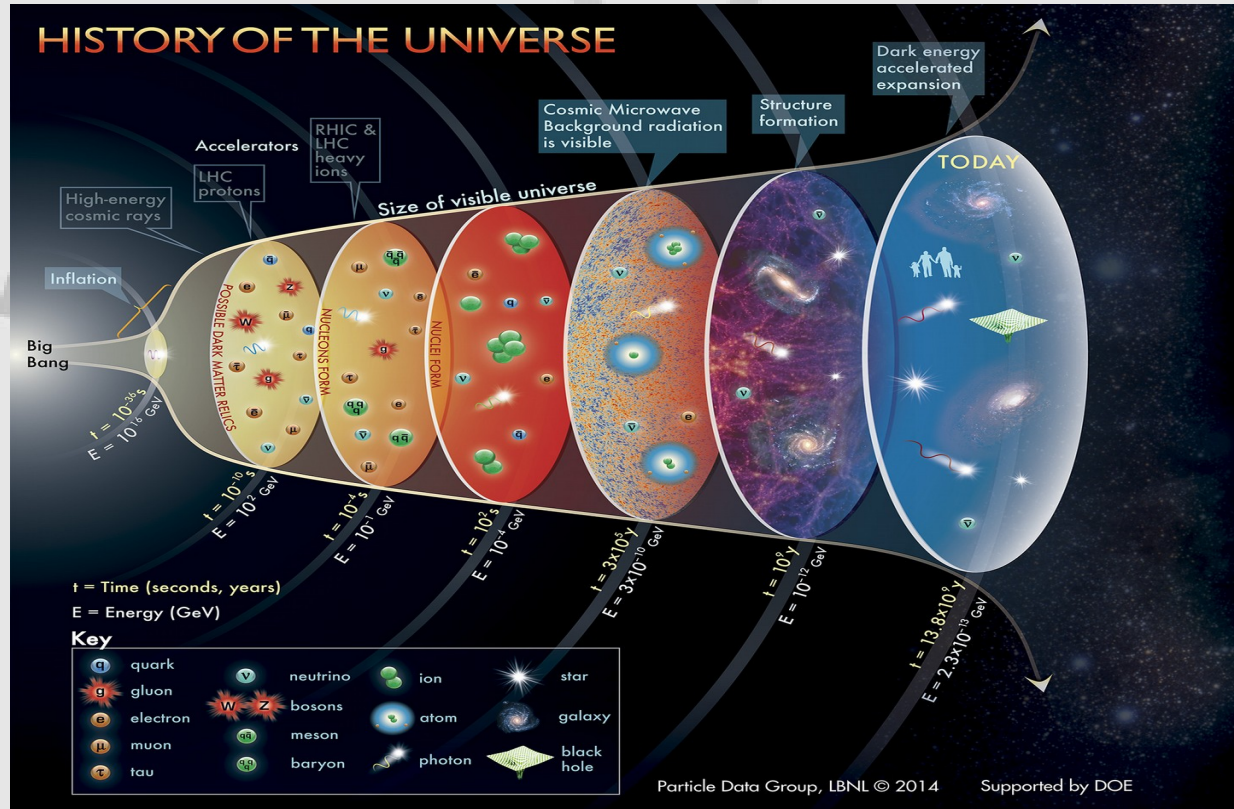




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Mörk Materia på labbet

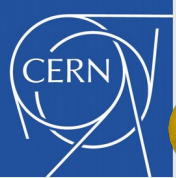
Richard Brenner - Uppsala universitet





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Hur beskrivs det allra minsta- Mikro-Kosmos?

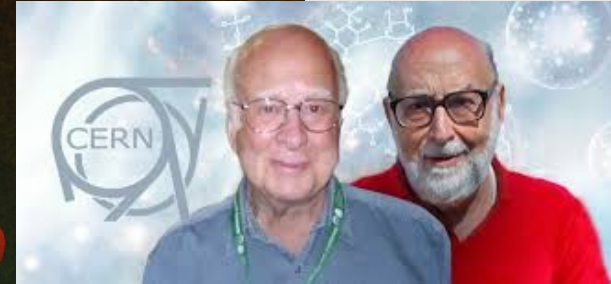


1979

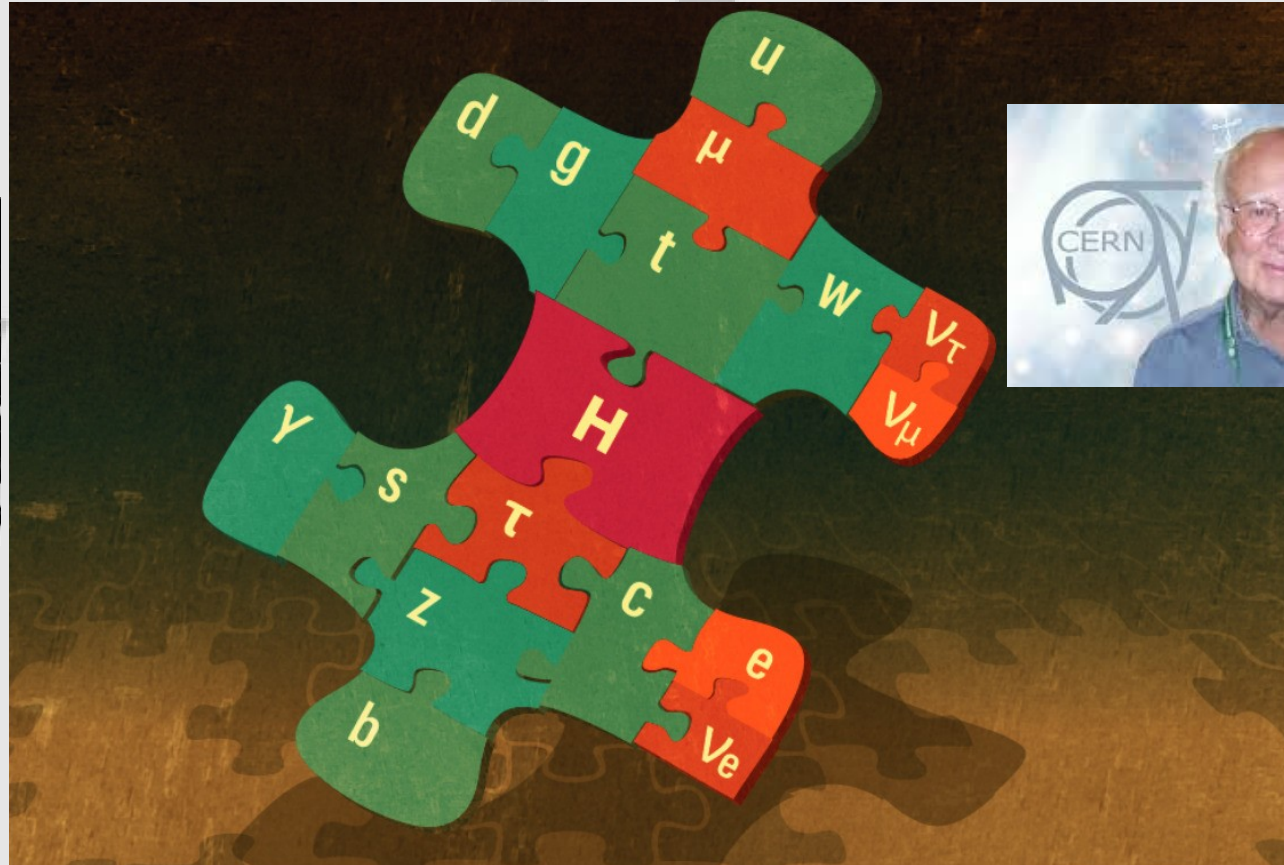


S.L. Glashow
A. Salam
S. Weinberger

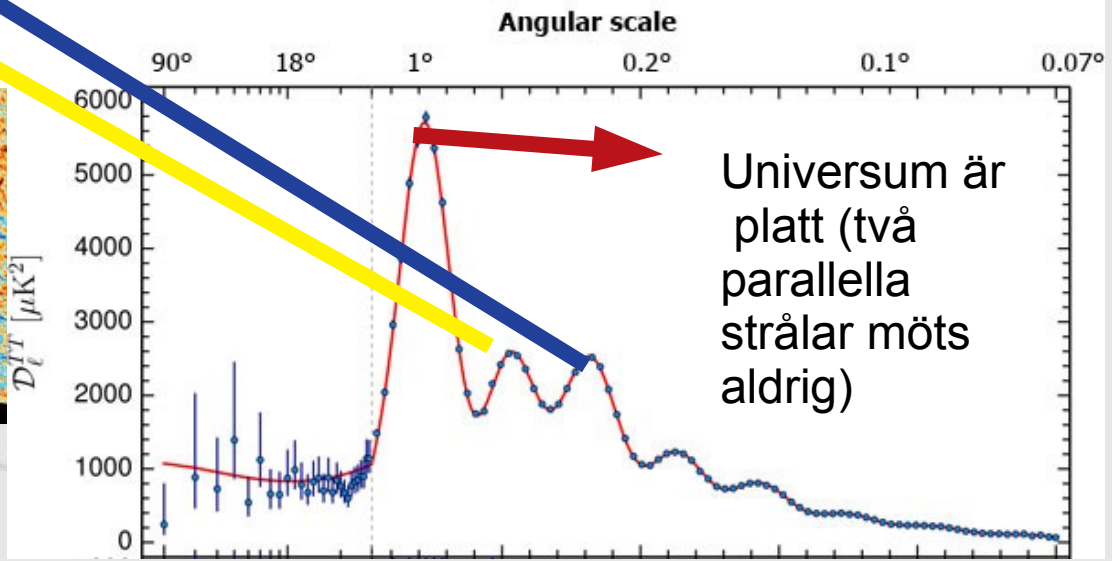
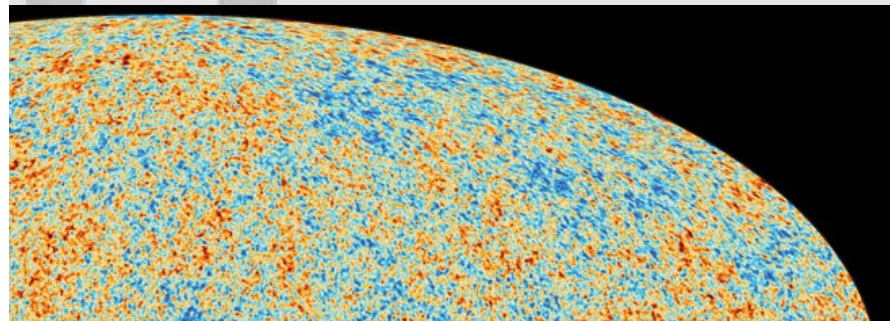
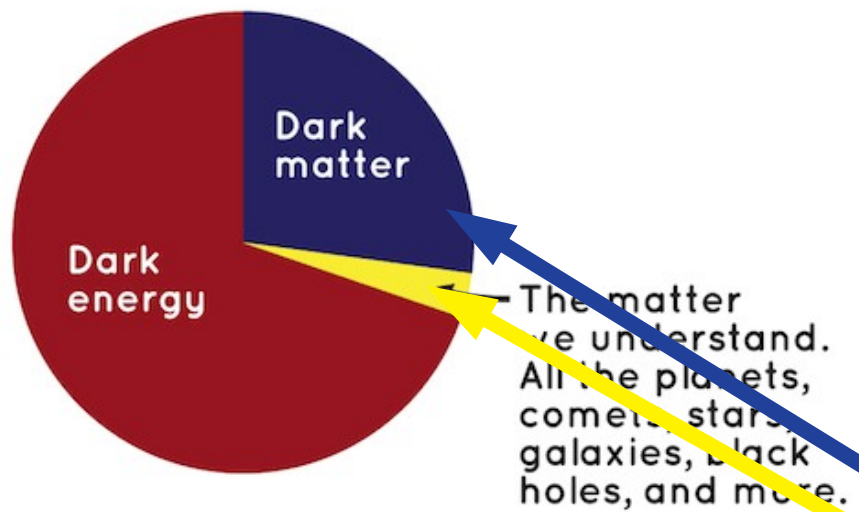
2013



P. Higgs
F. Englert



största i Kosmos?



2019



James Peebles



Världen häger ej ihop



$$\begin{aligned} \mathcal{L} = & -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} \\ & + i\bar{\psi}\not{D}\psi + \text{h.c.} \\ & + \chi_i y_{ij} \chi_j \phi + \text{h.c.} \\ & + |D_\mu \phi|^2 - V(\phi) \end{aligned}$$





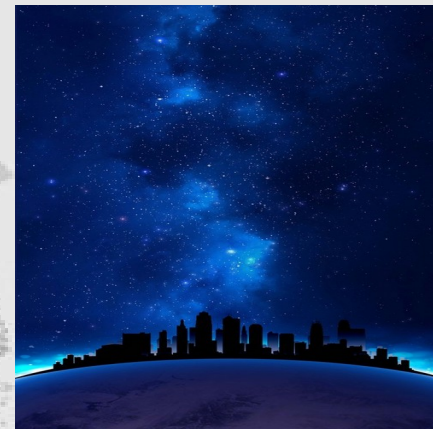
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Världen häger ej ihop



$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i\bar{\psi}\not{D}\psi + h.c. + \chi_i Y_{ij} \chi_j \phi + h.c. + |D_\mu \phi|^2 - V(\phi)$$



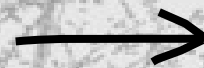
, och är ej stabil.....





Mörk Materia i laboratoriet? (Hemmagjord)

Kan vi skapa
Mörk Materia?



Kanske, med hjälp
av accelerators

Kan vi detektera
Mörk Materia?



Inte direkt, men indirekt
i experiment



Principen för att skapa materia



Total energi = Energi i vila + Energi från rörelse



materia



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CERN

Materia - inte vad som helst

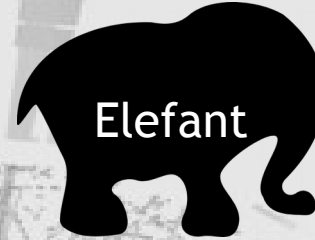
↑ Energi

Materia



Kanin

Lätt = lite energi

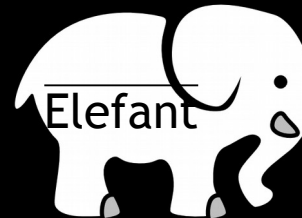


Elefant

Tung = mycket energi



Kanin



Elefant

Antimateria

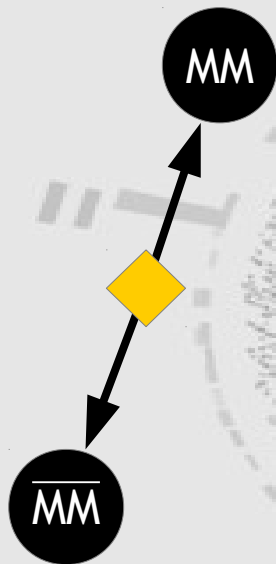


**Mörk Materia skapas på samma sätt
som Materia**

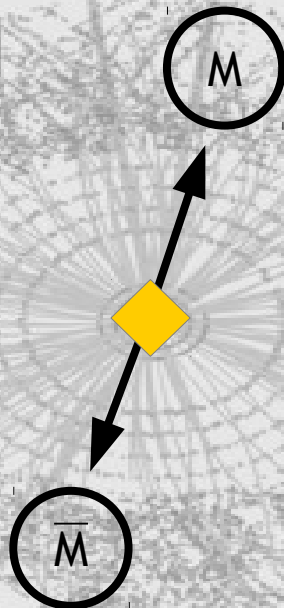
**I processen att omvandla energi till Materia
skapas lika mängder Materia som Antimateria**



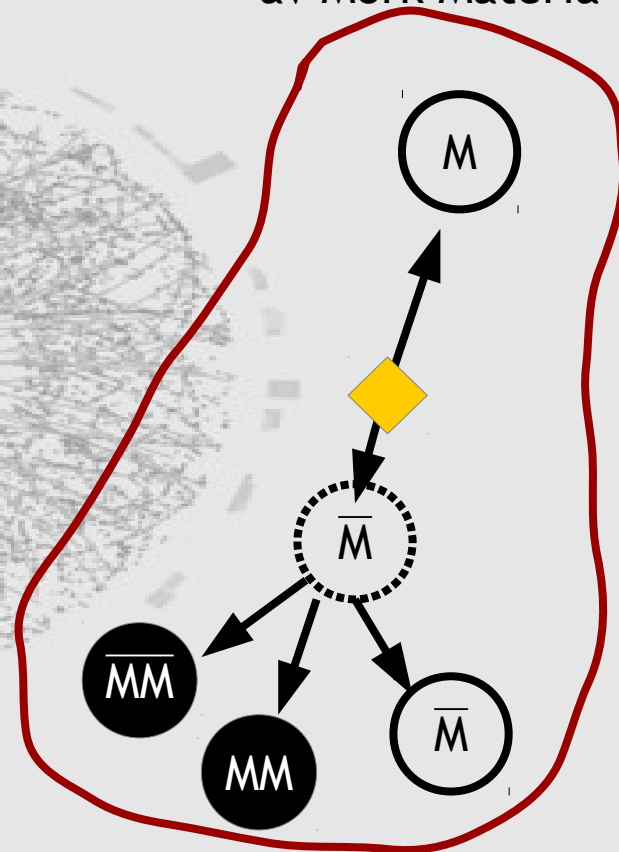
Produktion
av Mörk Materia



Produktion
av Materia



Produktion
av Materia med
indirekt produktion
av Mörk Materia



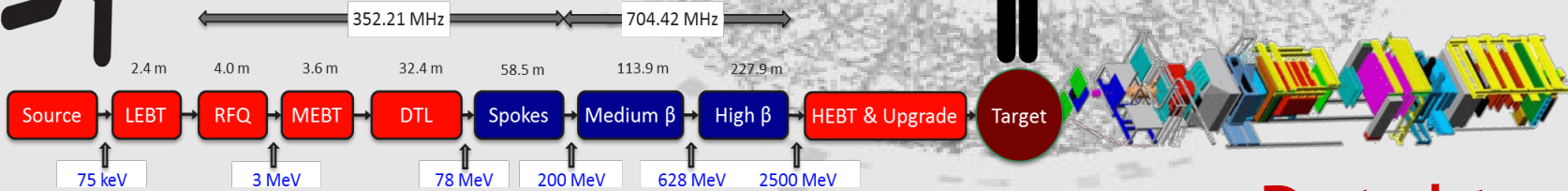
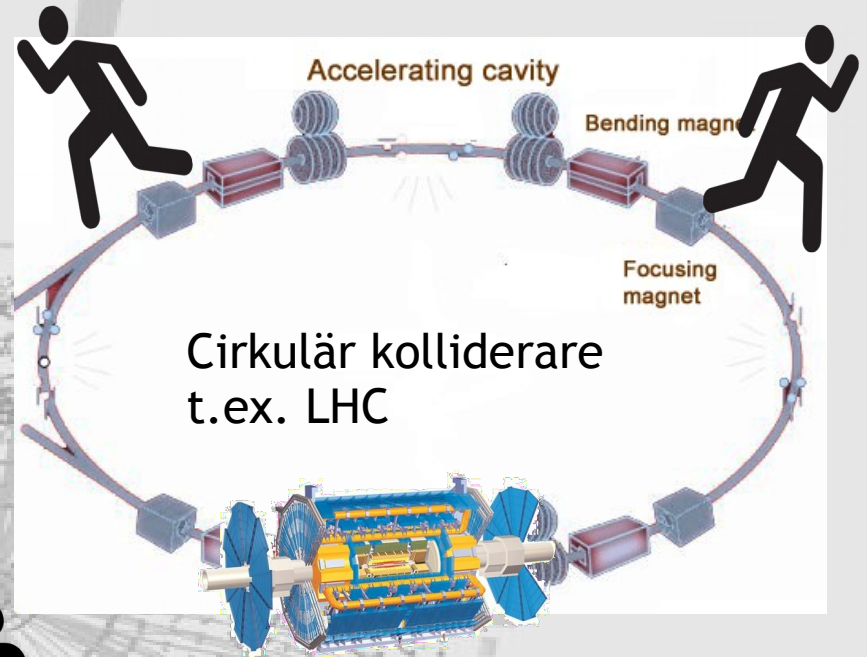


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Acceleratorer

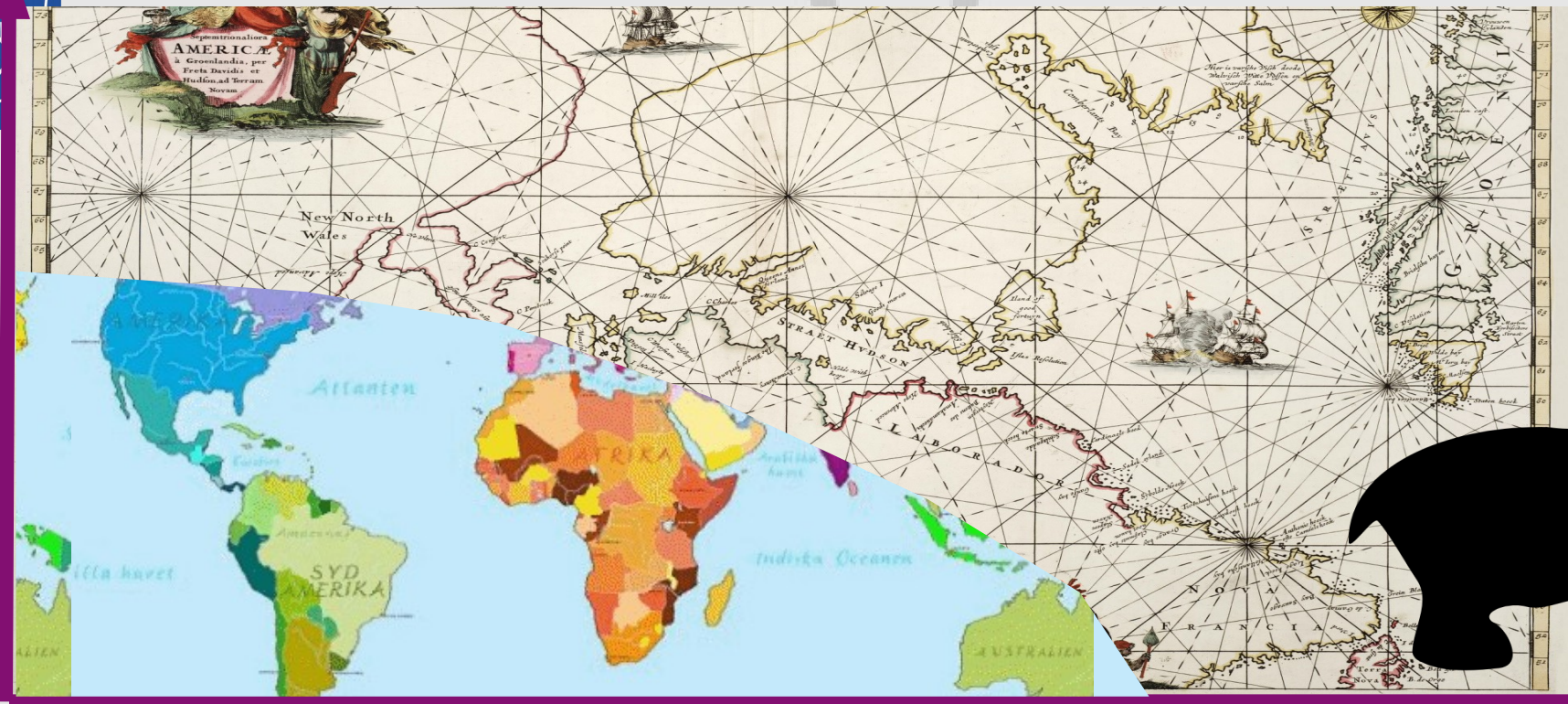
Linjäraccelerator t.ex. ESS
med strålmål ("fixed-target")



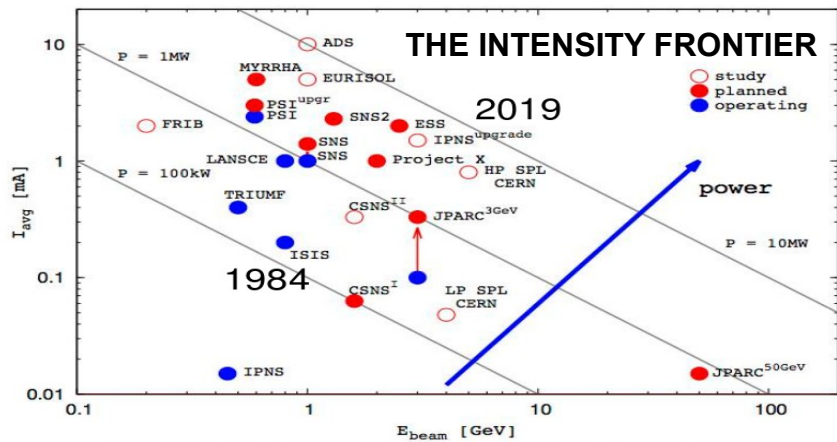
Detektorer

Utforskade territorier

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Intensitet

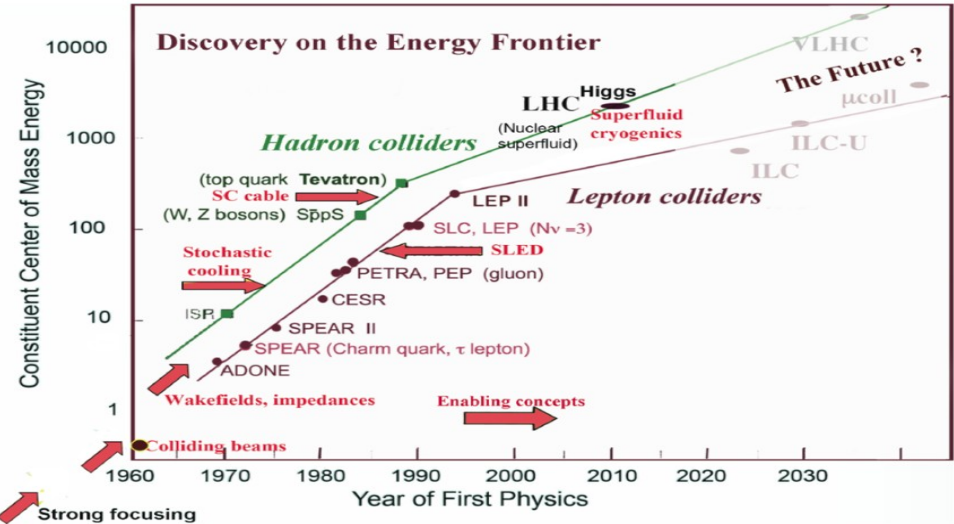
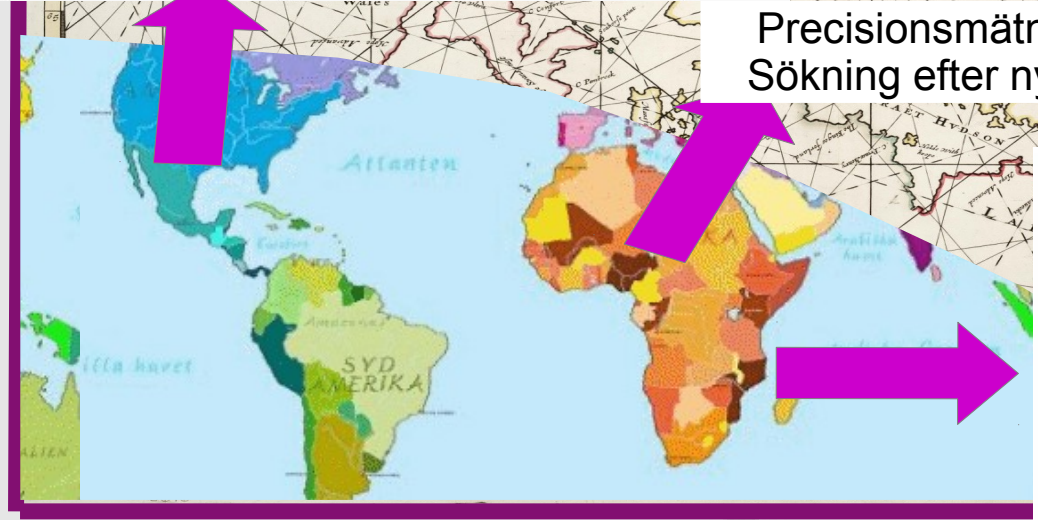


Energi



Courtesy of Mike Seidel (PSI) and Emmanuel Laface (ESS)

Precisionsmätningar
Sökning efter ny fysik

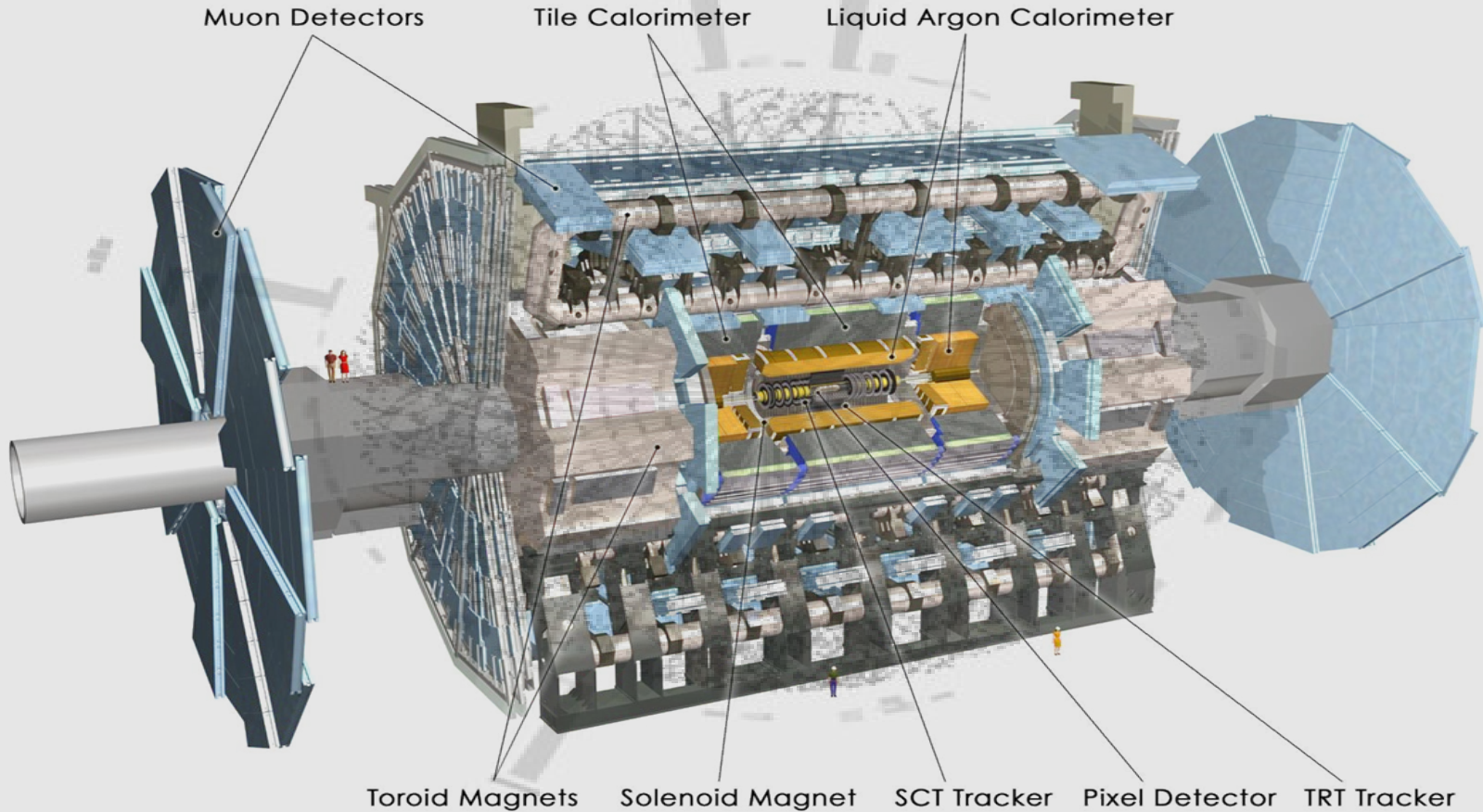




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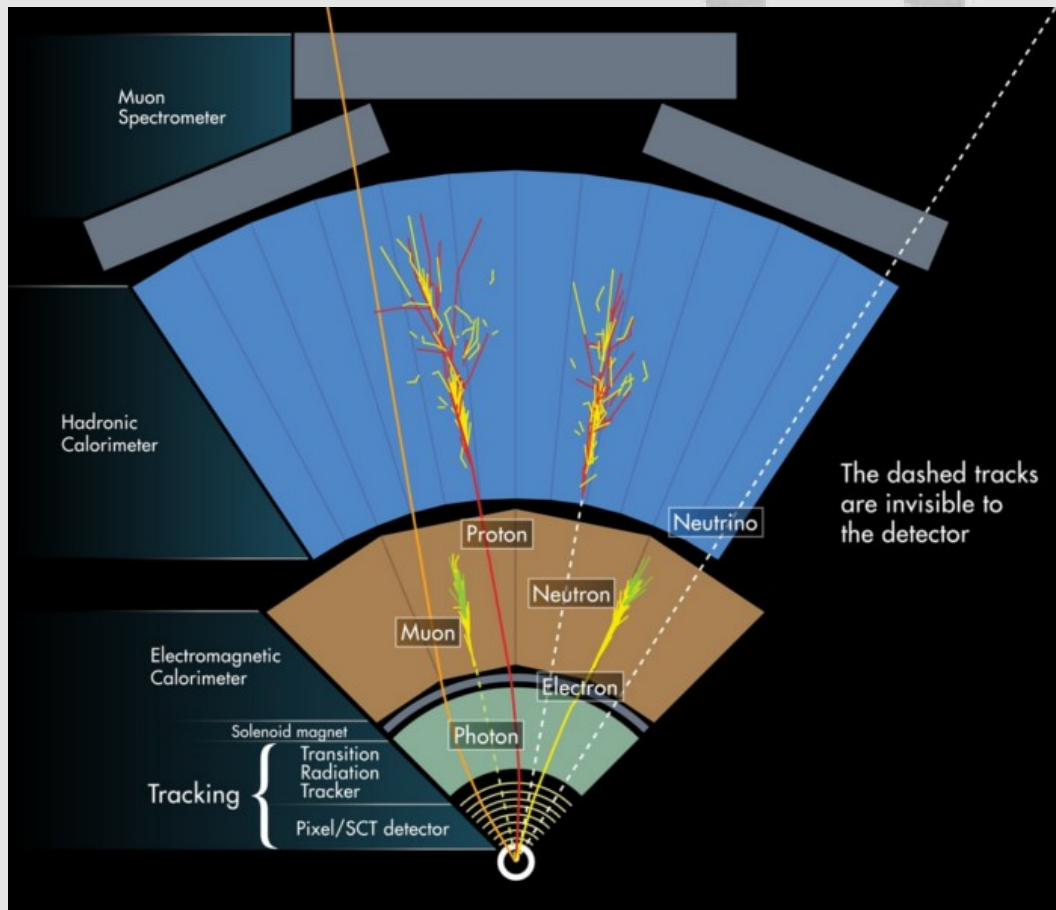


Mörk Materia vid kolliderare med ATLAS experimentet





Att (ej) detektera Mörk Materia



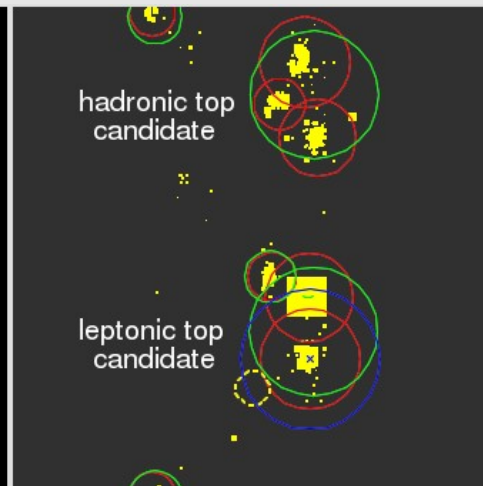
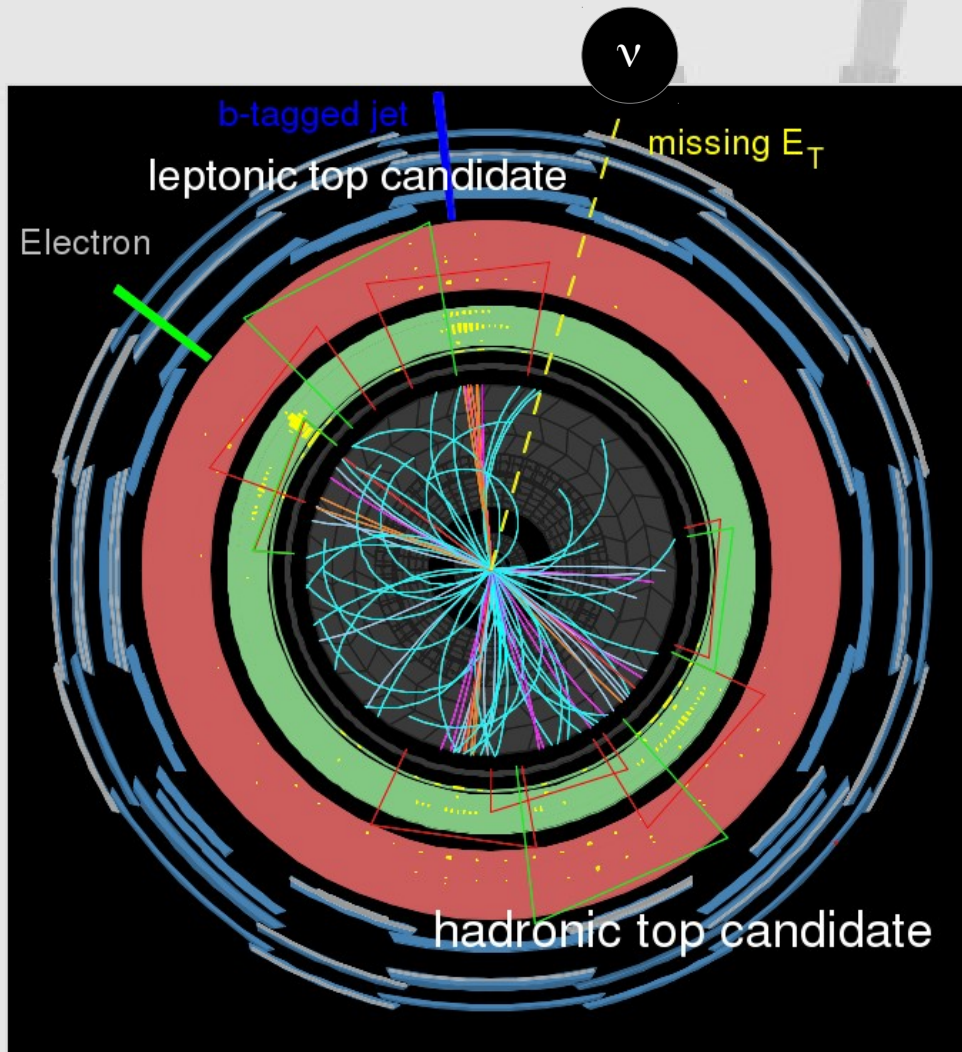
Neutriner
och
Mörk Materia
ger inga direkta spår
i våra experiment



Letar därför efter
energi som försvunnit
ur experimentet



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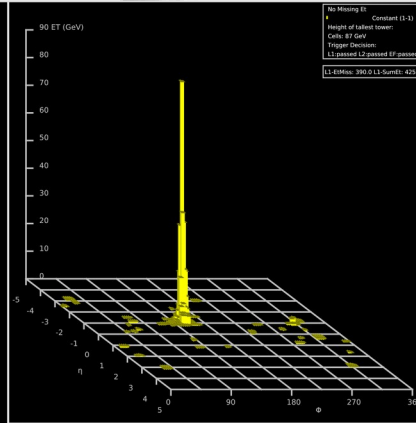
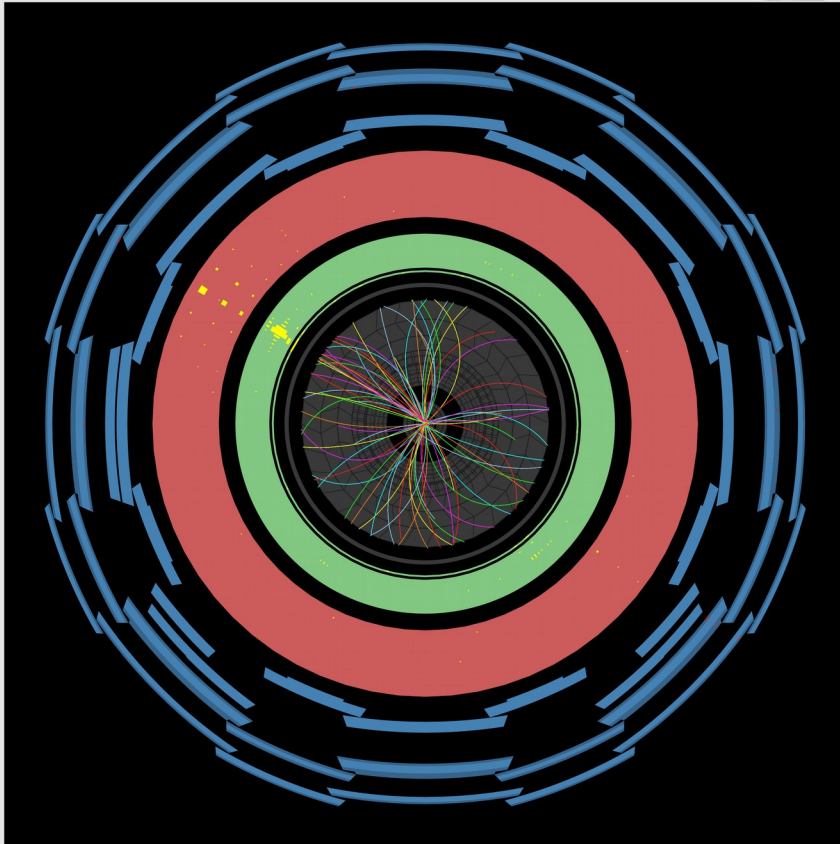
ATLAS
EXPERIMENT

Run Number: 166658, Event Number: 34533931

Date: 2010-10-11 23:57:42 CEST

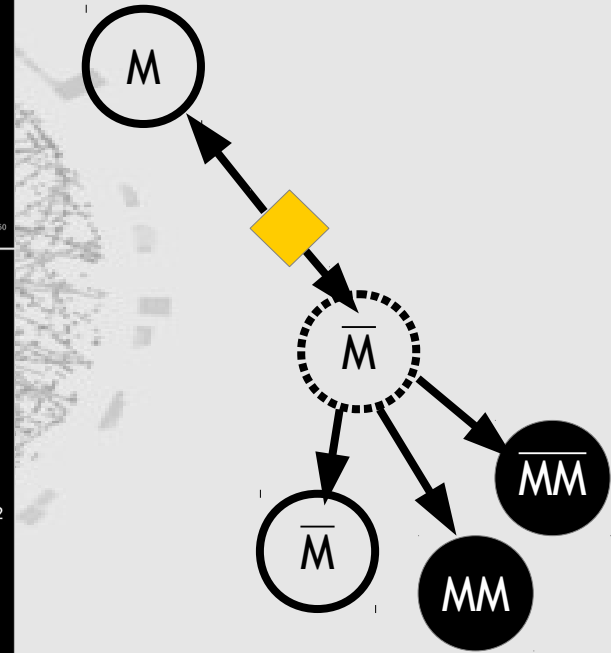


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ATLAS
EXPERIMENT

Run Number: 180309, Event Number: 36060682
Date: 2011-04-27 02:33:15 CEST

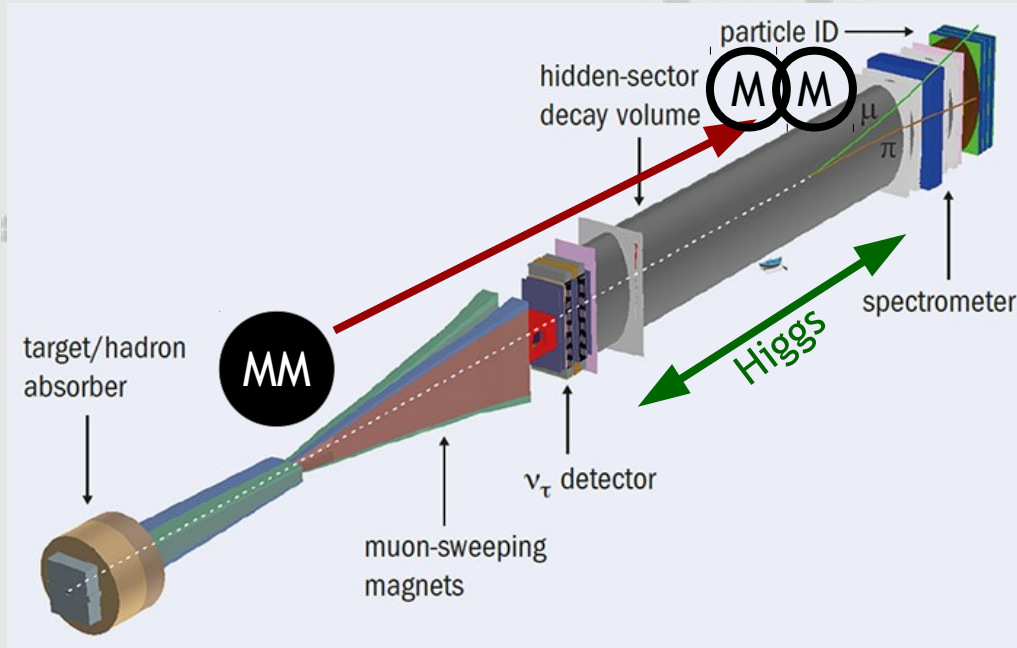




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Mörk materia vid experiment med strålmål med SHiP experimentet



När Mörk Materia partnern till den "vanliga" neutrino rör sig genom Higgs-fältet skapas Materia som ger spår i våra experiment



Kanske kommer vi att upptäcka att det mörka trots allt inte är så mörkt



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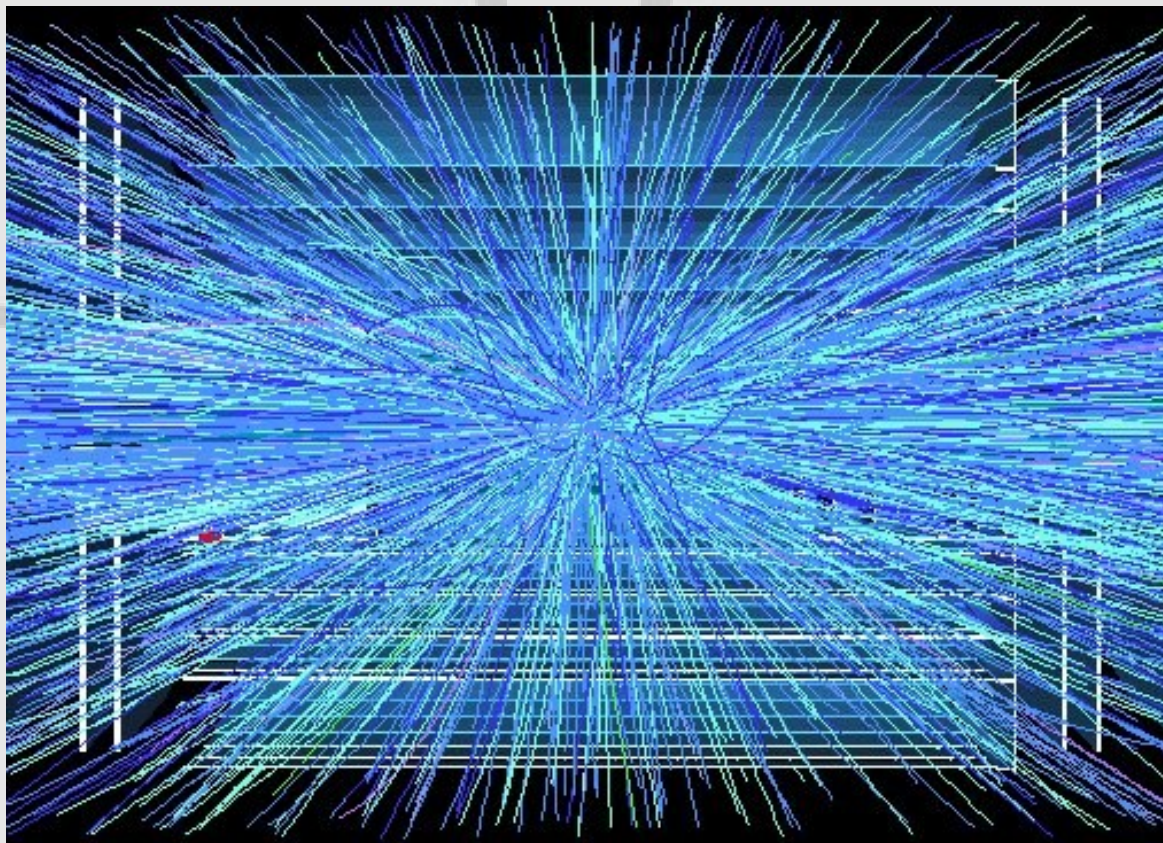


Del II: Vad gör jag?



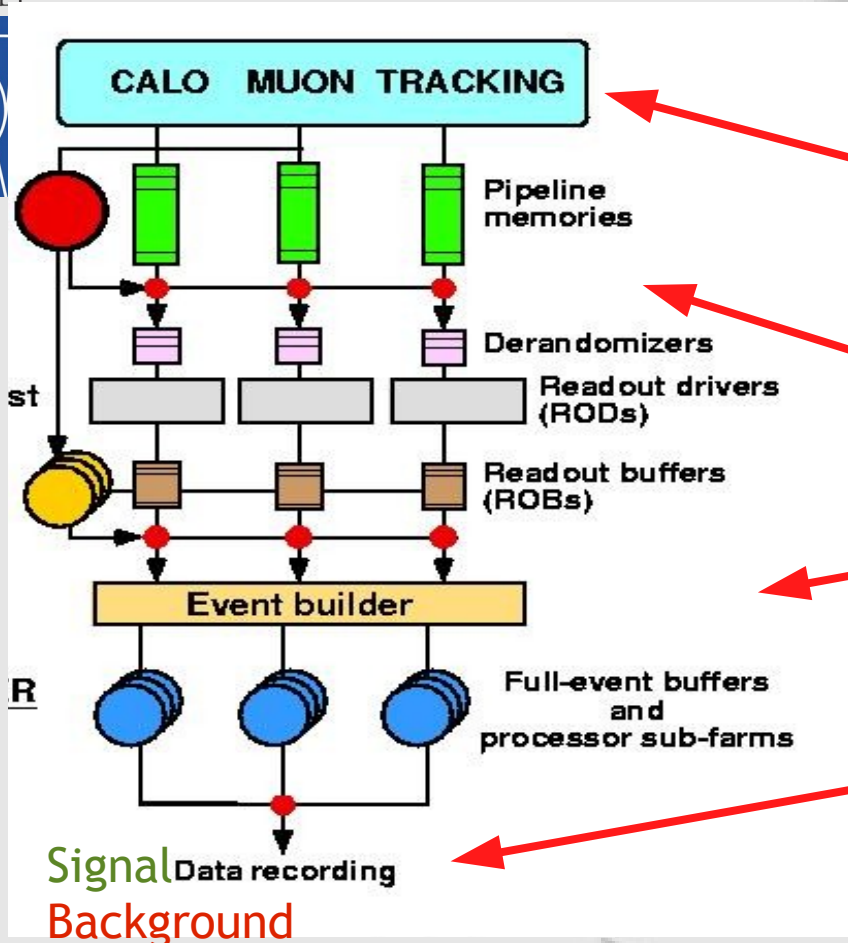
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Förbereder jakten.....





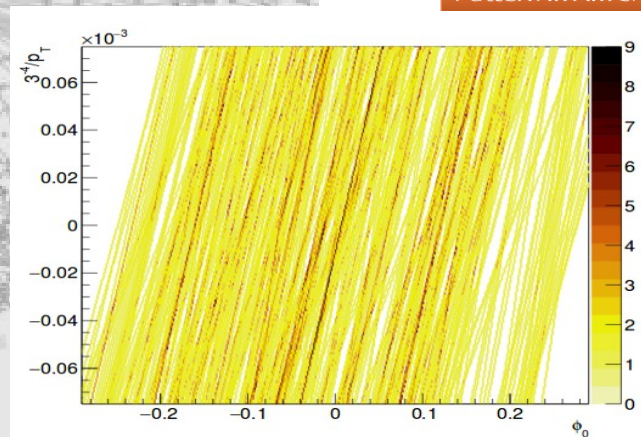
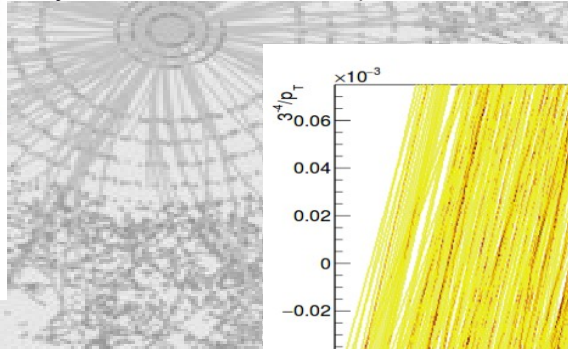
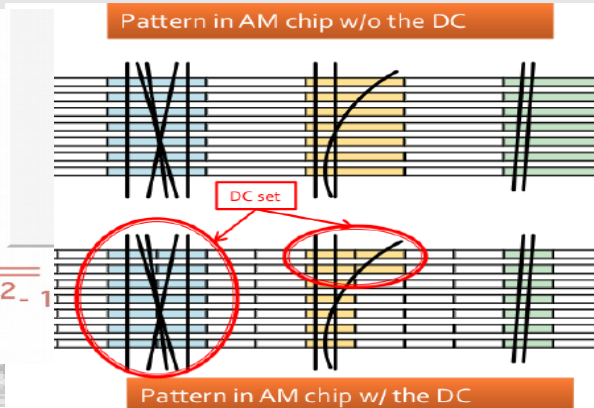
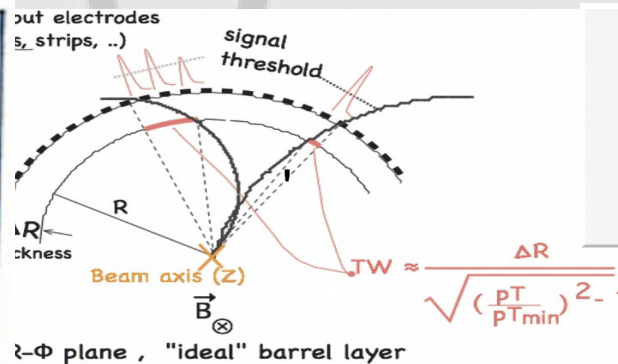
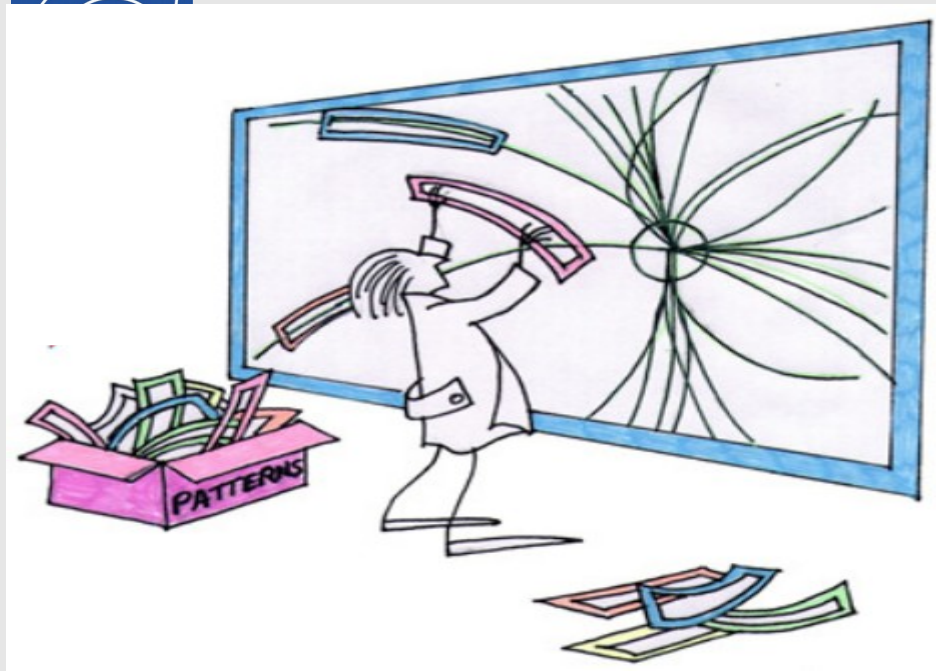
En stor data utmaning idag (imorgon)



- 40 miljoner händelser/s (när protonhopar kolliderar)
- ~800(8000) miljoner proton kollisioner/s (~500000(5M) CD'/s)
- 40 miljoner händelser sparas 3 (10) μ s, och reduceras med snabba elektroniska system till 100 000 händelser/s
- Algorithmer i mjukvara reducerar data till mellan 500 och 1000 händelser/s sparas på magnetband (~10-50 PB/år)
- Data distribueras and analyseras på GRID. WLCG med ~170 data center i 42 länder.



Utveckla AI för att hitta spår av mörk materia



Rekonstruktion av data inom $3 \mu s$



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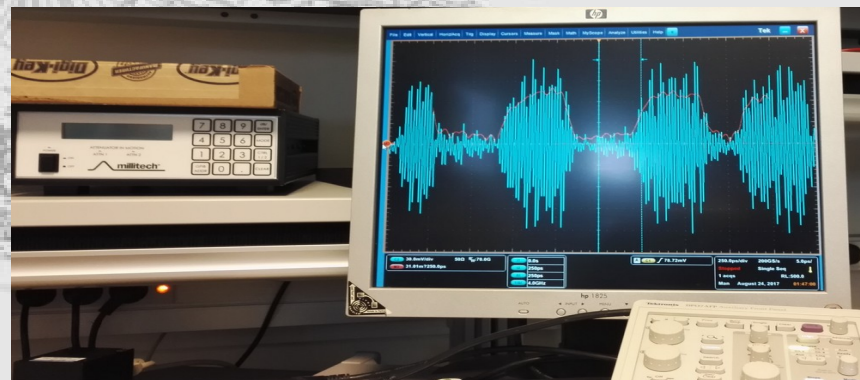
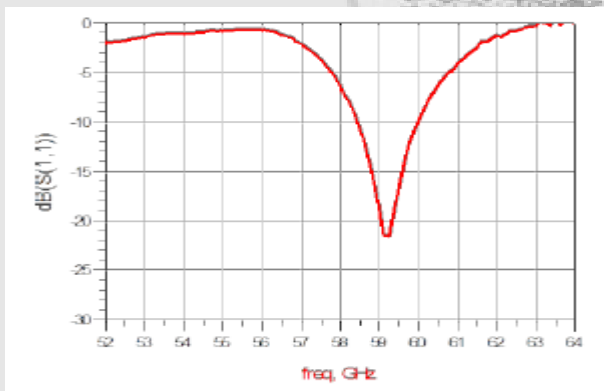
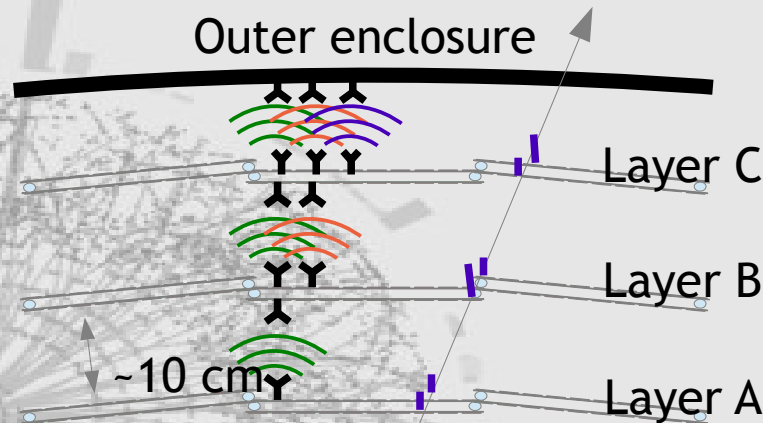
Utveckla teknologi för att läsa ut mer data

The future - Wireless data links?

Chip



Antenna





www.jolyon.co.uk

Hitta en nål i en höstack?



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A large, faint, grayscale image of a particle detector cross-section, likely the ATLAS detector at CERN. It shows a complex network of detector components arranged in a circular pattern. The word "NEJ" is overlaid in large red letters in the center of the detector image.

NEJ



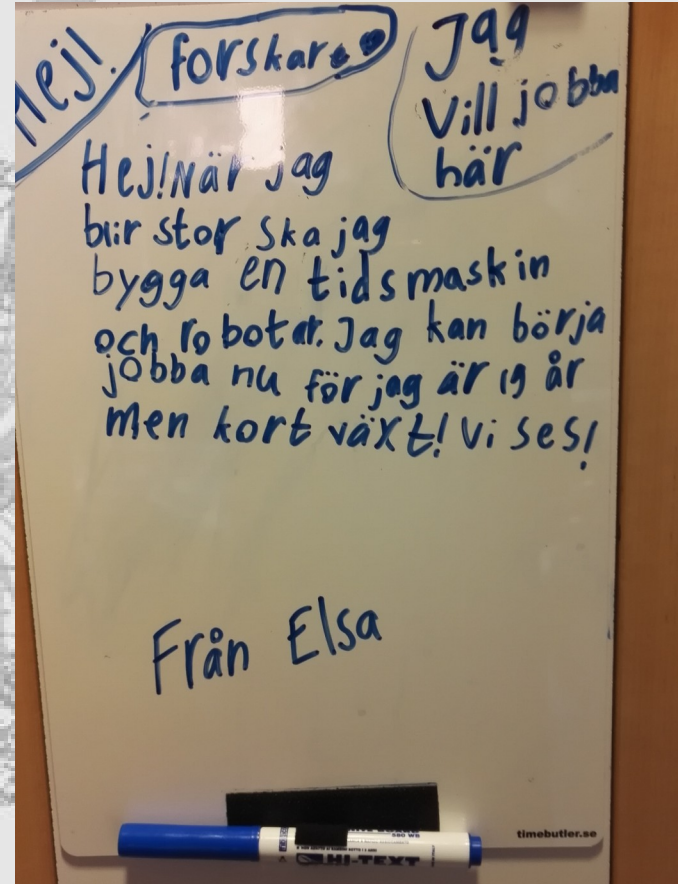
Hitta en nål bland en massa nålar!



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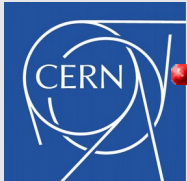


Extra material





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CERN-Conseil européen pour la Recherche nucléaire

- Founded 1952 (1954 ratified) by 12 countries: Belgium, Denmark, France, Germany(West), Greece, Italy, Netherlands, Norway, Sweden, Switzerland, Great Britain and Yugoslavia
- Name today: European Organization for Nuclear Research/Organisation européenne pour la Recherche nucléaire with two official languages (Eng/Fr). Today 22 member states (and 5 associative member states) + 40 more user countries
- ~2400 employee and ~10000 users (Uppsala University has ~6200 employee)
- Budget ~1.2 GCHF/year (~9GSEK, comparable with a large university in Sweden). Sweden pay 2.73% (~30MCHF)/year (2017)





The Large Hadron Collider



- The worlds largest and most powerful accelerator, started in 2008
- Creates currently the hottest temperature in Universe (~ 5 trillion $^{\circ}\text{C}$)
- 27km circumference with 1237 superconducting magnets (-271°C , colder than outer space)
- Consumes 120MW



	Injection	Collision
Proton energy [GeV]	450	7000
Number of particles per bunch	1.15E+011	
Number of bunches	2808	
Circulating beam current [A]	0.58	
Stored energy per beam [MJ]	23.3	362
RMS bunch length [cm]	11.24	7.55
RMS beam size [μm]	375.2	16.7



High energy-what??

The LHC ring will store a beam energy of 360 Megajoules.

$2\,808 \text{ bunches} \times 1.15 \cdot 10^{11} \text{ protons @ } 7 \text{ TeV each} =$

$2\,808 \times 1.15 \times 10^{11} \times 7 \times 10^{12} \times 1.602 \times 10^{-19} \text{ Joules} = 362 \text{ MJ per beam}$

This can be compared to:

Kinetic energy

- 1 small cruise ship of 10 000 tons moving at 30 km/hour
- 450 automobiles of 2 tons moving at 100 km/hour

Chemical energy

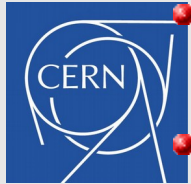
- 80 kg of TNT
- 70 kg of chocolate (counting the calories)

Thermal energy

- melt 500 kg of copper
- raise 1 cubic meter of water 85° C: "a tonne of tea"

Milk chocolate is 520 calories per 100 g , which gives 350 MJ = 69 kg of chocolate.

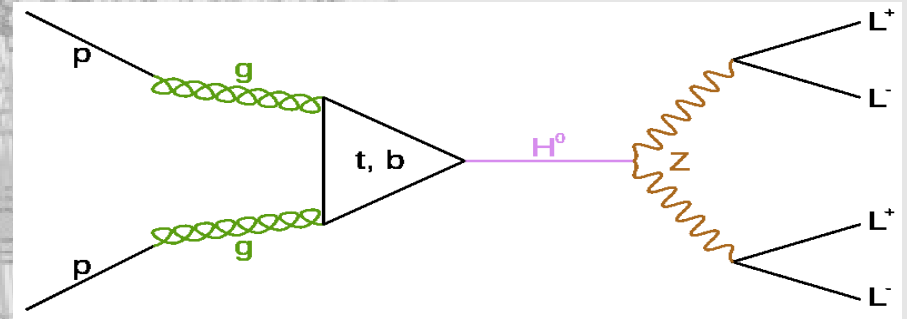
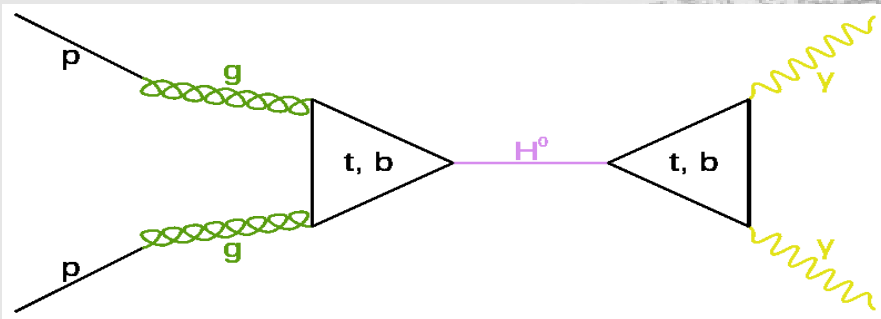
The energy in chocolate is released a bit more slowly than in TNT!



Higgs boson discovery

The two large experiments ATLAS and CMS at LHC announced on 4 July 2012 that both had independently made the same discover the Higgs boson.

The Higgs boson was discovered in two different decay channels.

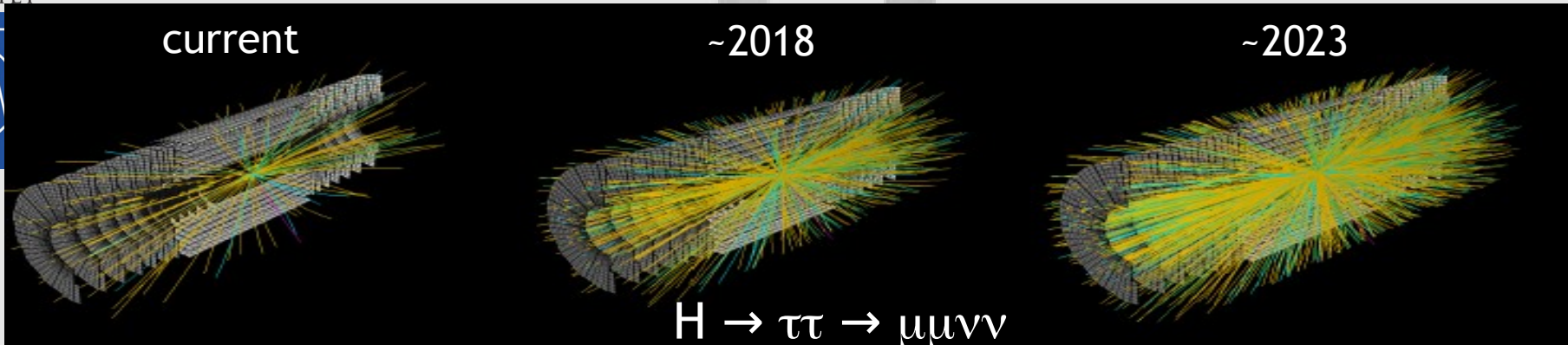


- More precise studies has confirmed that the discovered partcle is the Higgs boson.
- The Nobel prize in Physics was awarded François Englert and Peter Higgs for the theoretical discovery of the Higgs boson.





Future challenges → upgrade



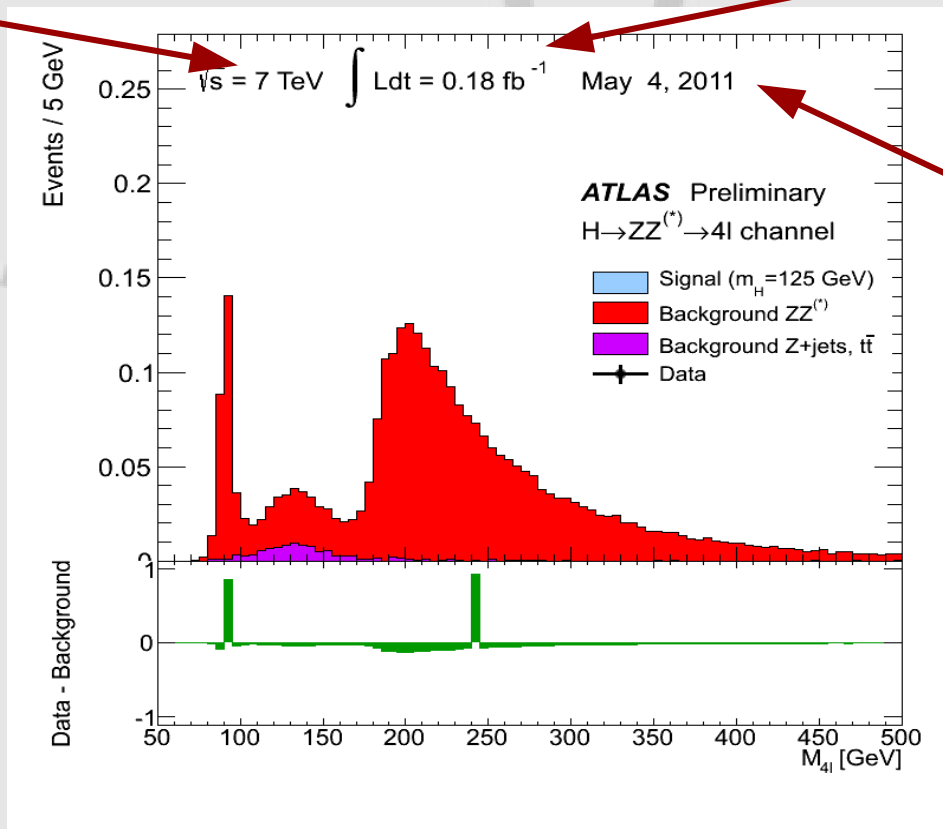
- To gain sensitivity for rare processes the intensity of the LHC beam will be increase $>10X$ → more data/event and much more difficult environment for the trigger to decide
- Currently 20 simultaneous collisions in every event. When LHC is running at full intensity (High Luminosity LHC) 200 simultaneous collisions will be recorded in every event. One of the collision may contain interesting physics....
- The radiation damage to the electronics will also increase by an order of magnitude. Some parts may get $> 10MGy$!



Higgs \rightarrow 4 leptons (electrons/muons)

Kollisionsenergi

Datamängd

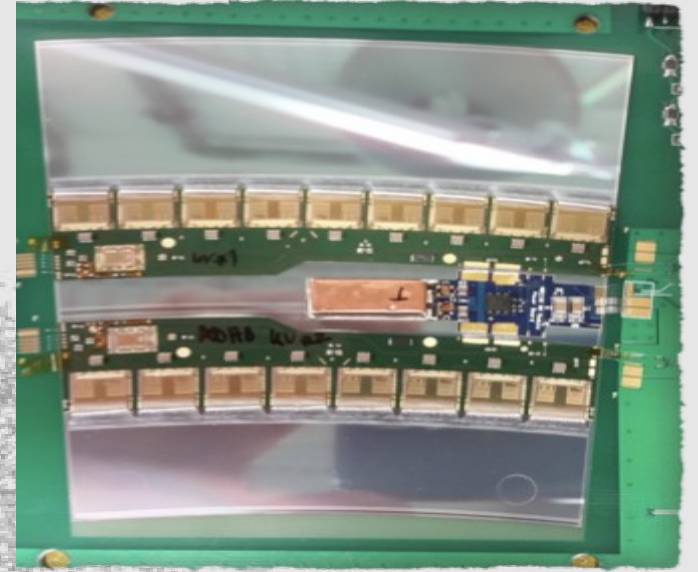
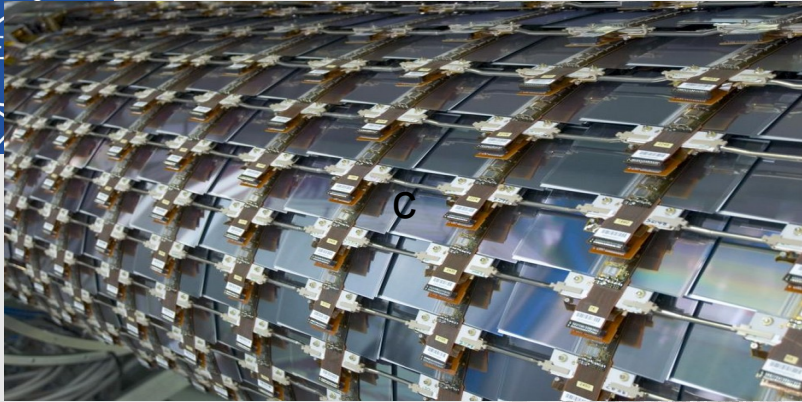


Datum



Large silicon tracker

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Industrialisation of assembly method to allow for large scale production in industry

