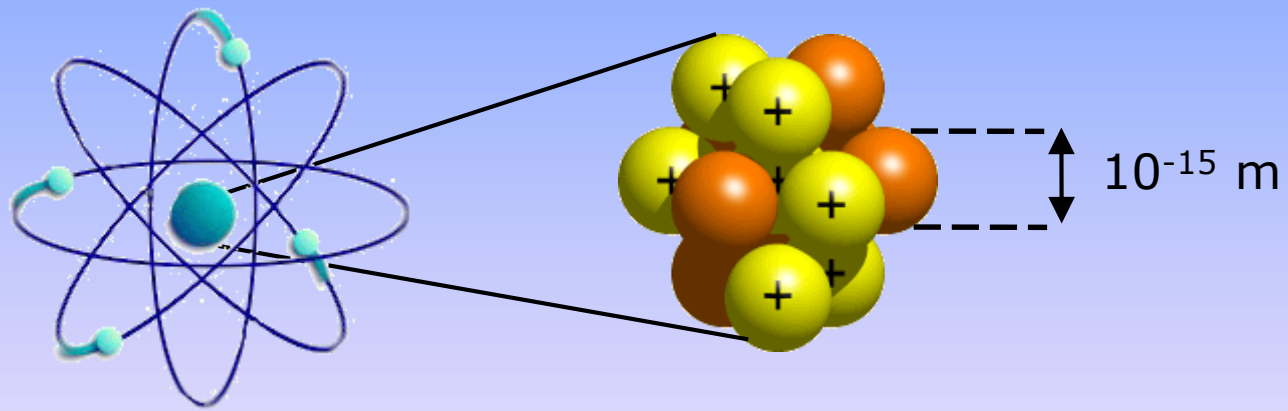
LHCb

LHCb

- Waarom deeltjesfysica?
- Waarom LHCb?
- Resultaten

Deeltjesfysica

Bestudeert de natuur op afstanden < 10^{-15} m

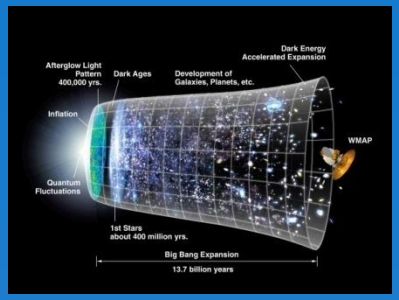


atoom kern

Quantum theorie beschrijft alle metingen tot 10^{-18} m

(Ter vergelijk: 10^{+18} m = 100 lichtjaar)

Machten van tien …



Heelal
10^{26} m

Melkweg
10^{21} m

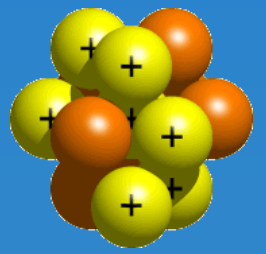
Zonnestelsel
10^{13} m

Aarde
10^{7} m

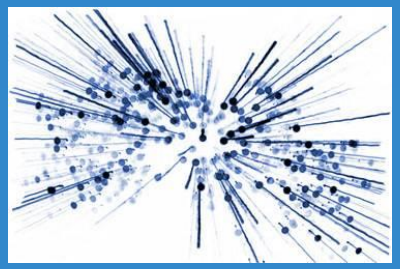
Spin
10^{-2} m

Atoom
10^{-10} m

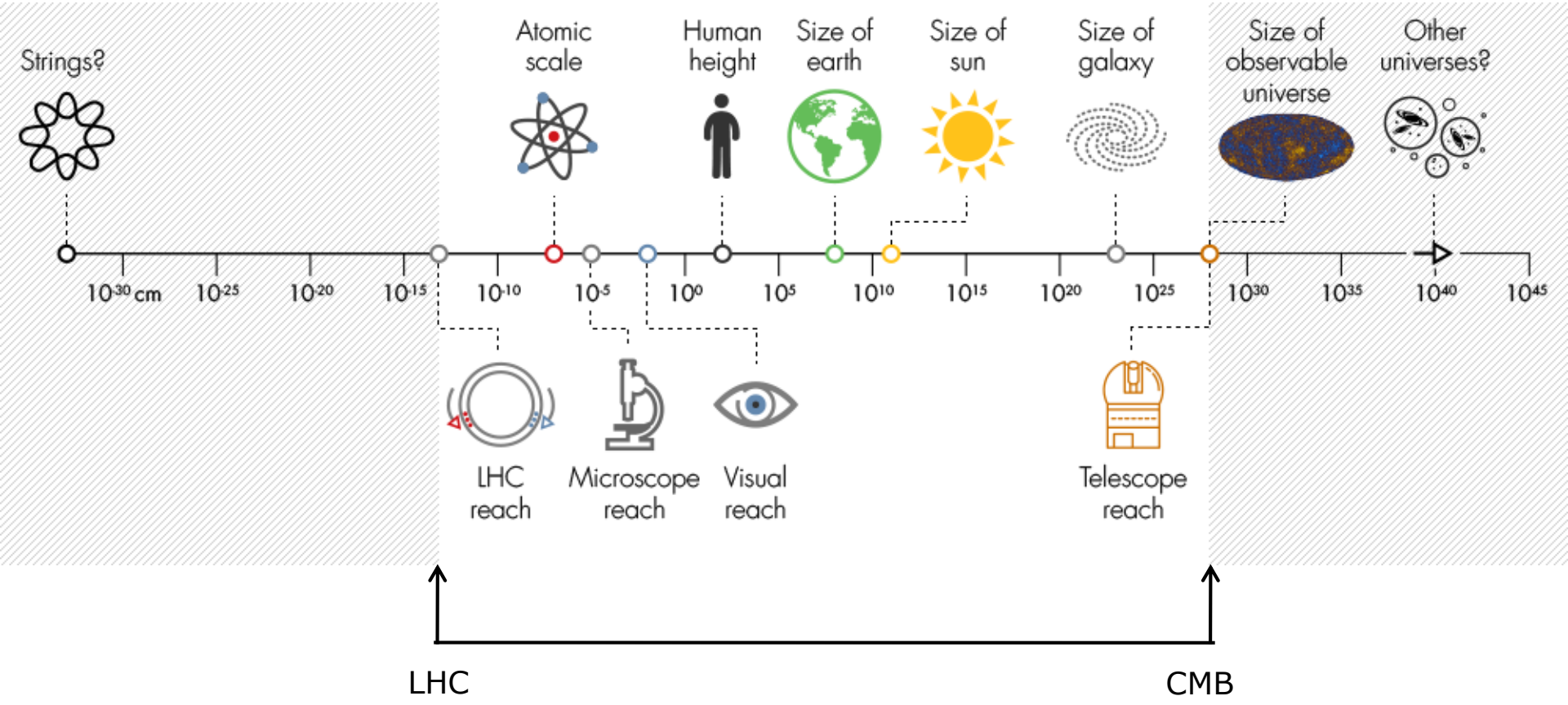
Kern
10^{-15} m

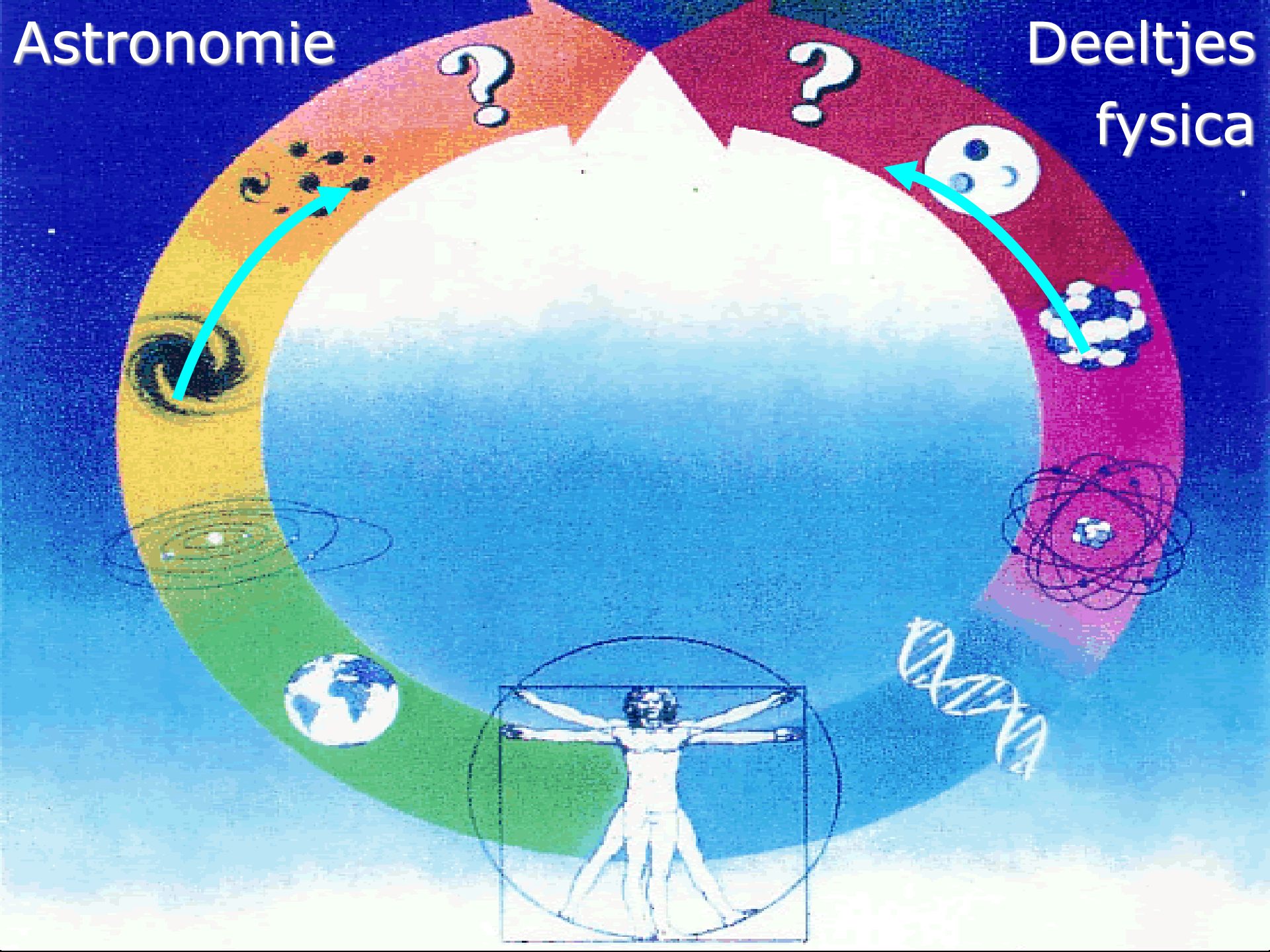


Botsingen
10^{-18} m



Schaal


Strings?
Atomic scale
Human height
Size of earth
Size of sun
Size of galaxy
Size of observable universe
Other universes?
10-30 cm
10-25
10-20
10-15
10-10
10-5
100
105
1010
1015
1020
1025
1030
1035
1040
1045
LHC reach
Microscope reach
Visual reach
Telescope reach
LHC
CMB


Astronomie
?
?
Deeltjes
fysica

De stand van zaken in 2019

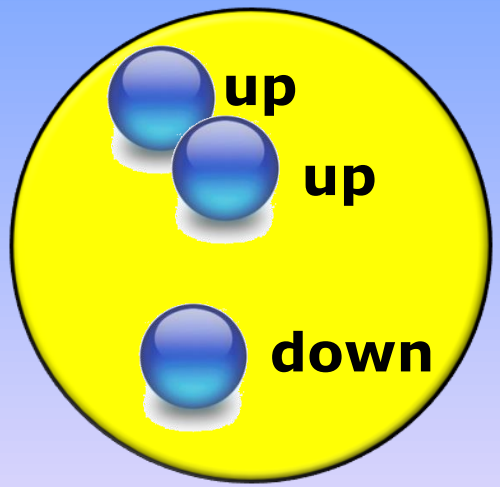
http:// pdg.lbl.gov

De elementaire deeltjes

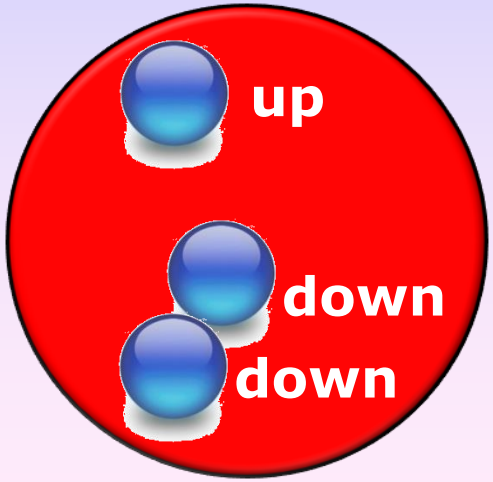
up

down

elektron

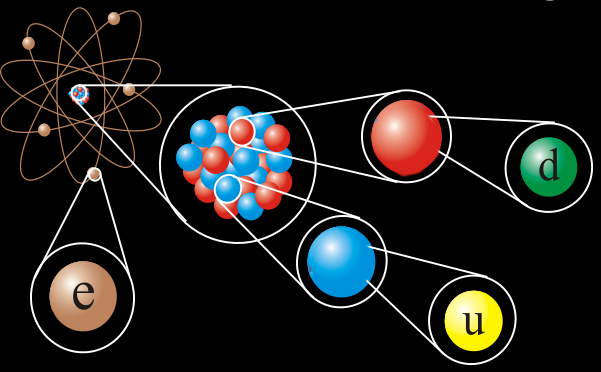


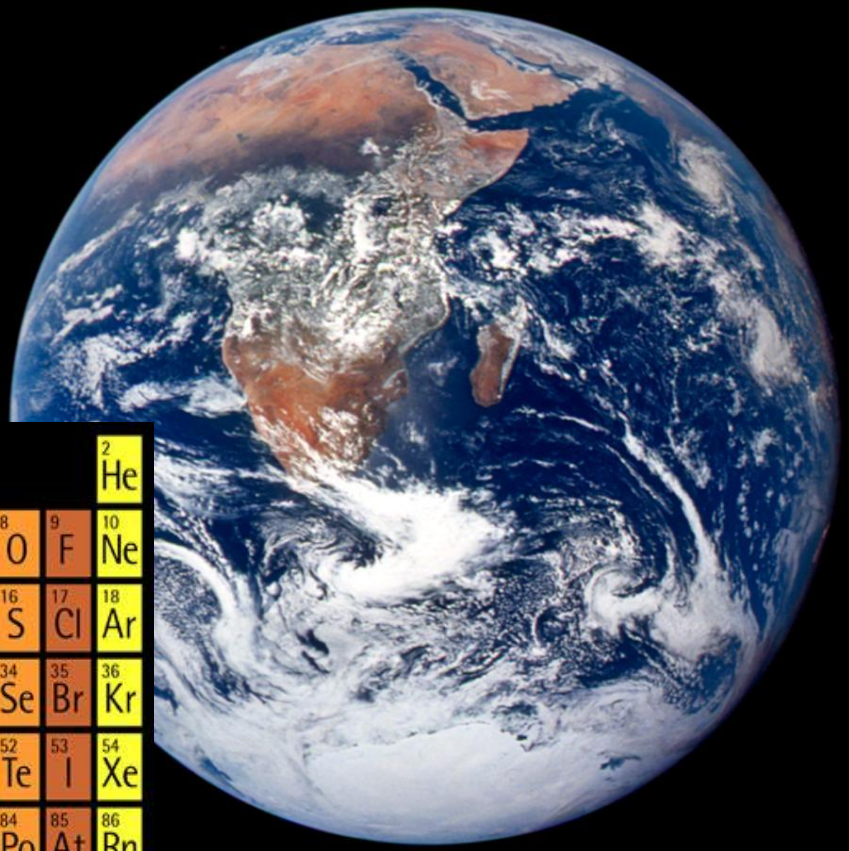
Proton



Neutron

Wat kan je maken van deze 3 bouwstenen?





periodiek systeem
van Mendeleev

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt									

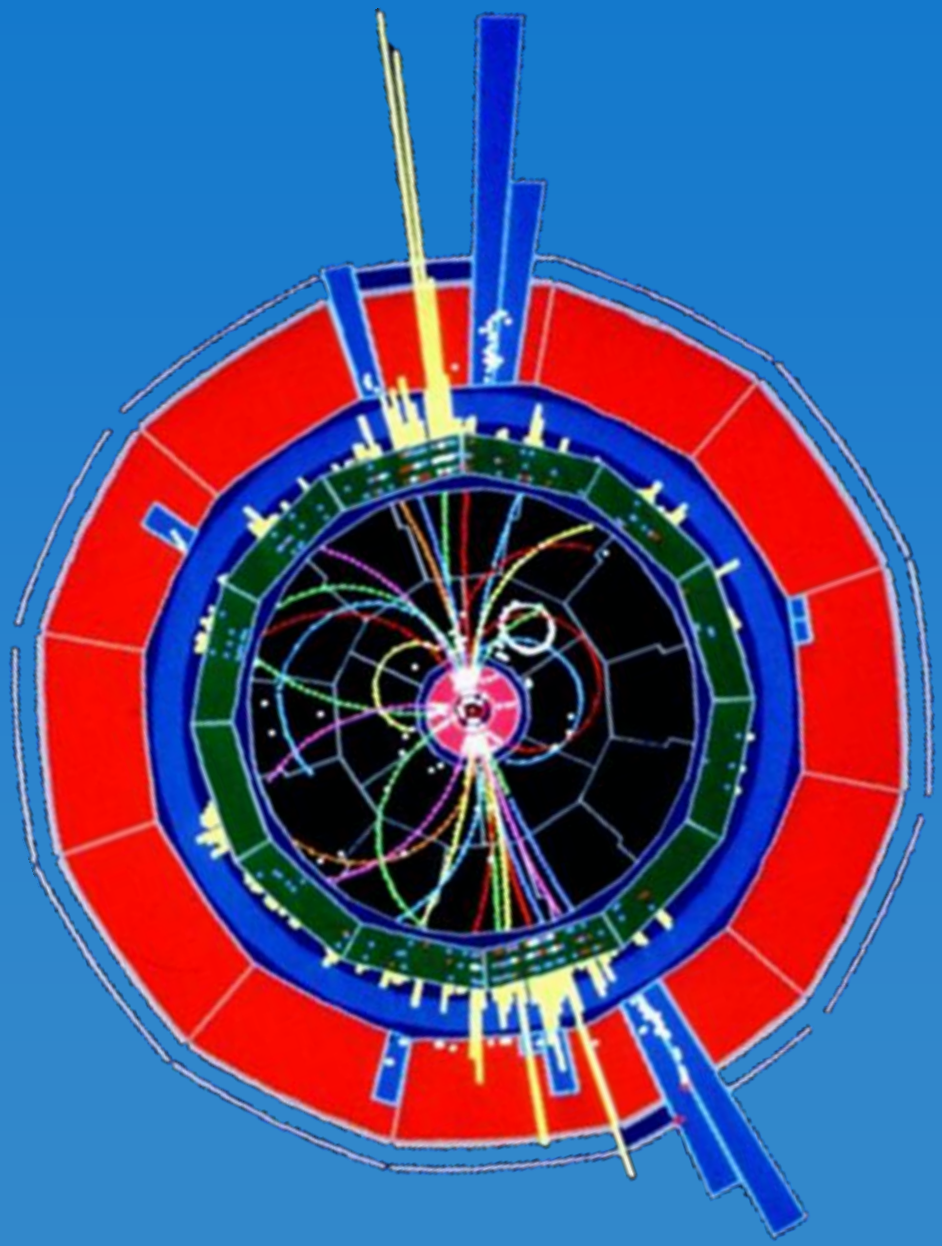
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

Alles!

De elementaire deeltjes

Niet één serie, maar drie!

	I	II	III
quarks	u	c (1976)	t (1995)
	d	s (1947)	b (1978)
leptons	e (1895)	μ (1936)	τ (1973)
	ν_e (1956)	ν_μ (1963)	ν_τ (2000)

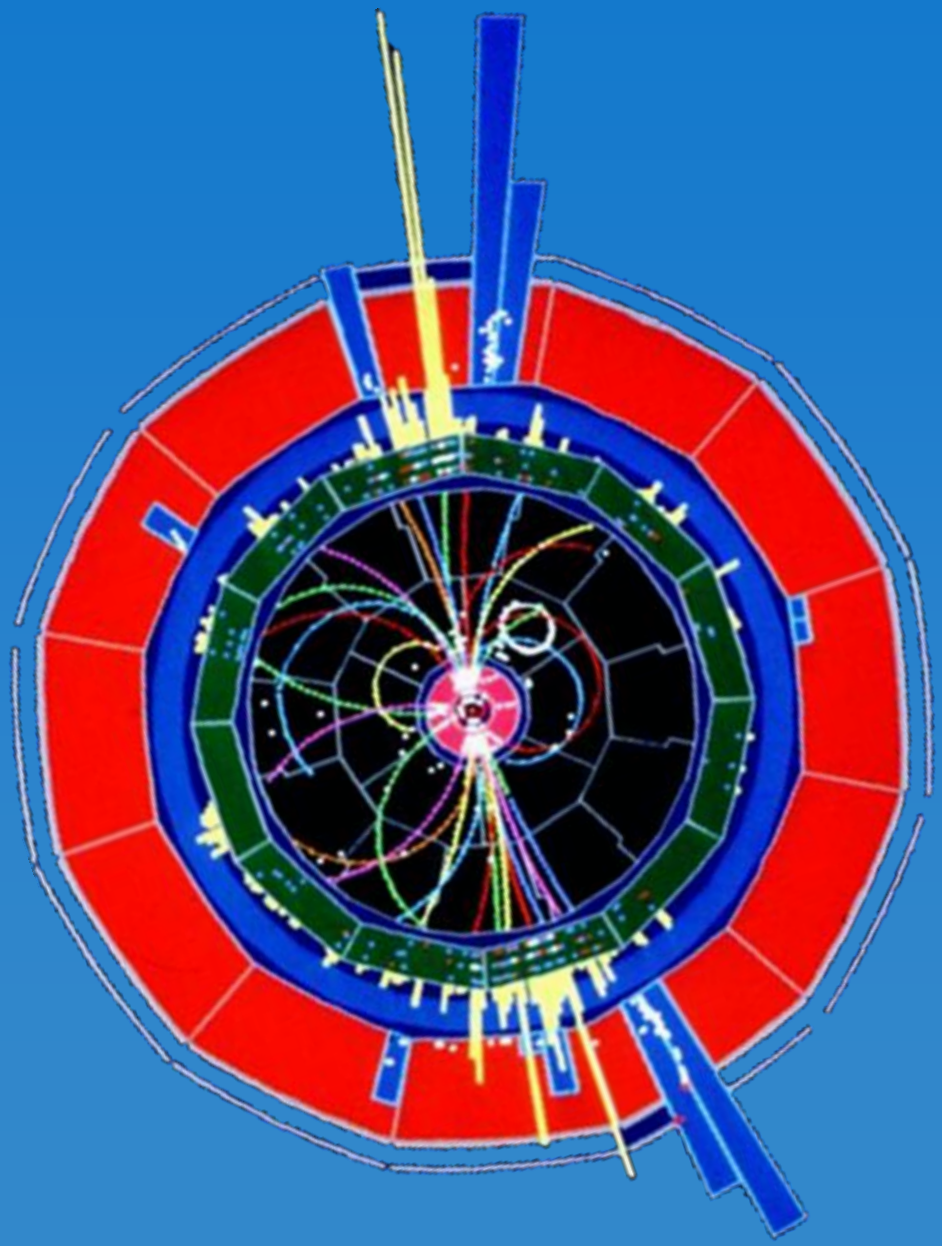


De elementaire deeltjes

Generatie:

	I	II	III	Lading
quarks	u	c (1976)	t (1995)	+2/3 e
	d	s (1947)	b (1978)	-1/3 e
leptons	e (1895)	μ (1936)	τ (1973)	-1 e
	ν_e (1956)	ν_μ (1963)	ν_τ (2000)	0 e

Materie

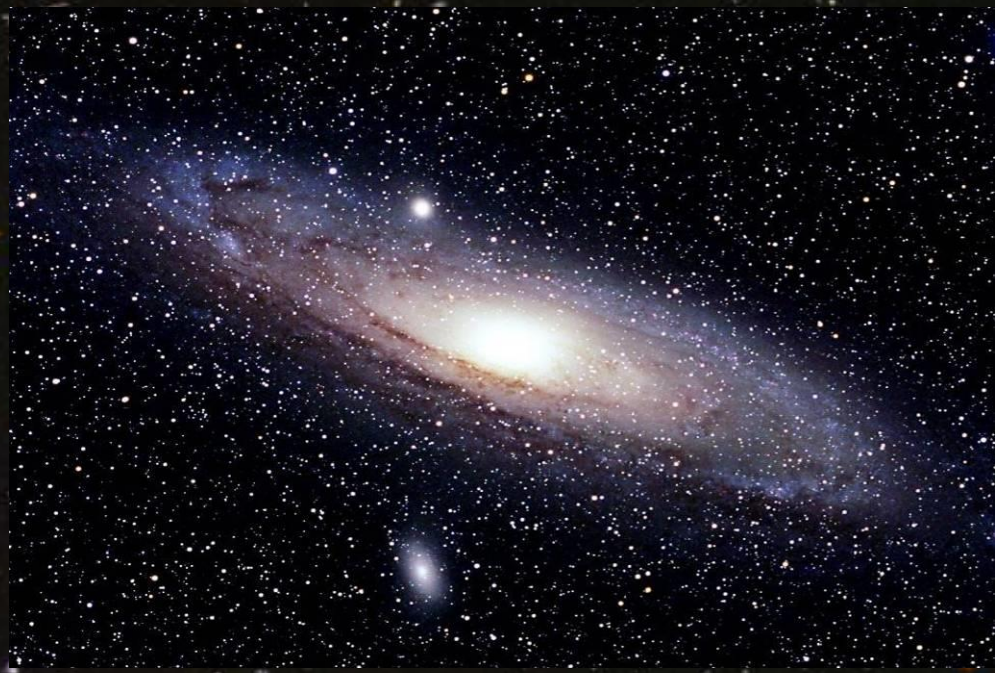


Is dit alles?

Generatie:

	I	II	III	Lading
quarks	u	c (1976)	t (1995)	+2/3 e
	d	s (1947)	b (1978)	-1/3 e
leptons	e (1895)	μ (1936)	τ (1973)	-1 e
	ν_e (1956)	ν_μ (1963)	ν_τ (2000)	0 e

Materie

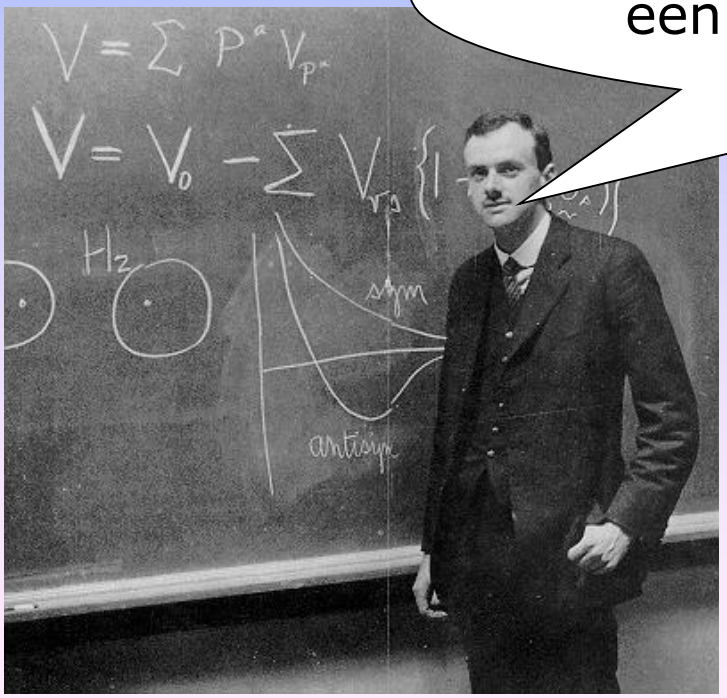


Anti-materie

Revoluties begin vorige eeuw:

- Relativiteitstheorie
- Quantum Mechanica

Paul Dirac (1928): relativistische quantum theorie!



Anti-materie deeltje:

- Zelfde massa
- Tegenovergestelde lading

De elementaire deeltjes

	I	II	III	Lading
quarks	u	c (1976)	t (1995)	+2/3 e
	d	s (1947)	b (1978)	-1/3 e
leptons	e (1895)	μ (1936)	τ (1973)	-1 e
	ν_e (1956)	ν_μ (1963)	ν_τ (2000)	0 e

Materie

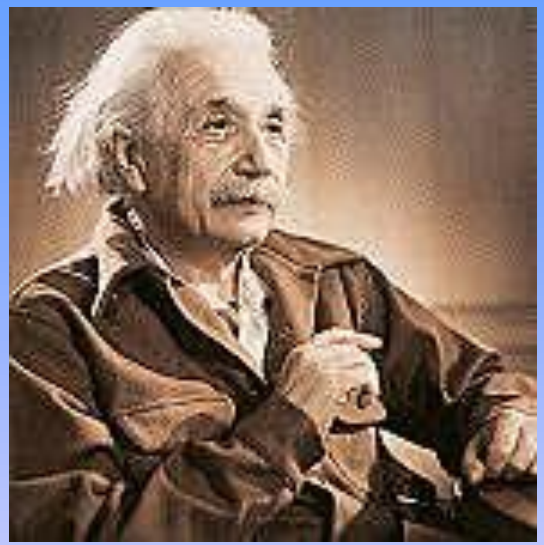
De elementaire deeltjes

	I	II	III	Lading	Lading	I	II	III
quarks	u	c (1976)	t (1995)	+2/3 e	-2/3 e	$\bar{u}$	$\bar{c}$	$\bar{t}$
	d	s (1947)	b (1978)	-1/3 e	+1/3 e	$\bar{d}$	$\bar{s}$	$\bar{b}$
leptons	e (1895)	μ (1936)	τ (1973)	-1 e	+1 e	$\bar{e}$	$\bar{\mu}$	$\bar{\tau}$
	ν_e (1956)	ν_μ (1963)	ν_τ (2000)	0 e	0 e	$\bar{\nu}_e$	$\bar{\nu}_\mu$	$\bar{\nu}_\tau$

Materie

Anti-materie

Hoe maak je anti-materie??

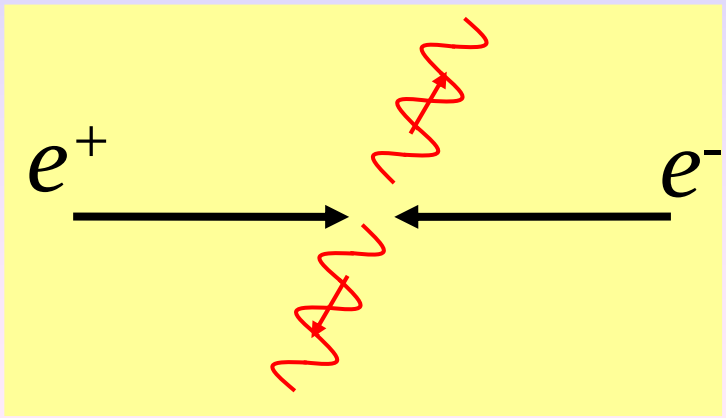


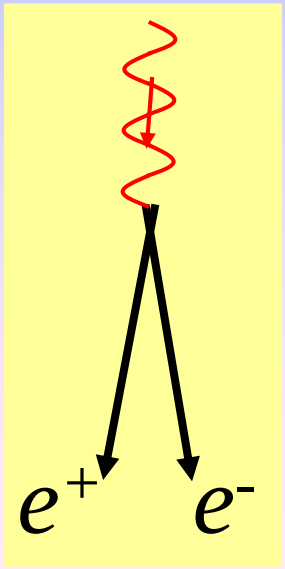
Albert Einstein:

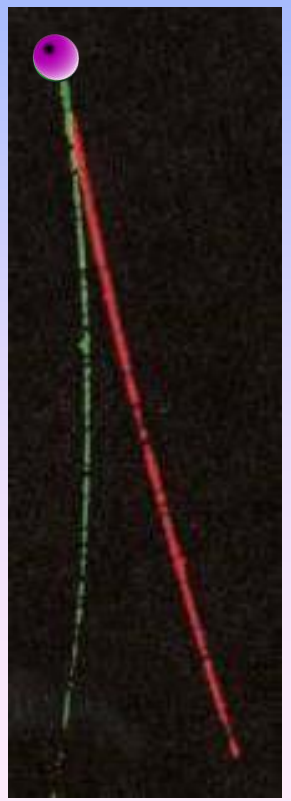
$E=mc^2$

materie + antimaterie = licht !

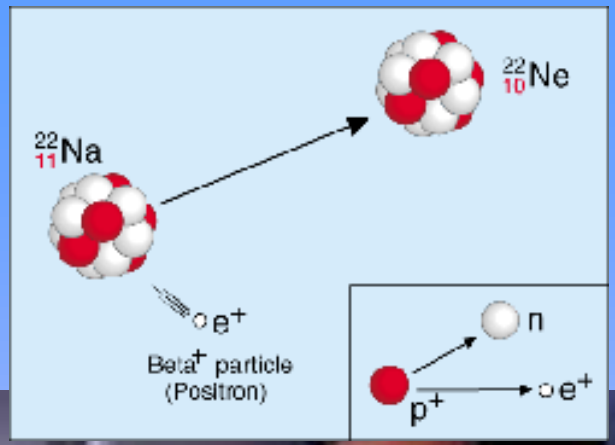
(en vice versa)

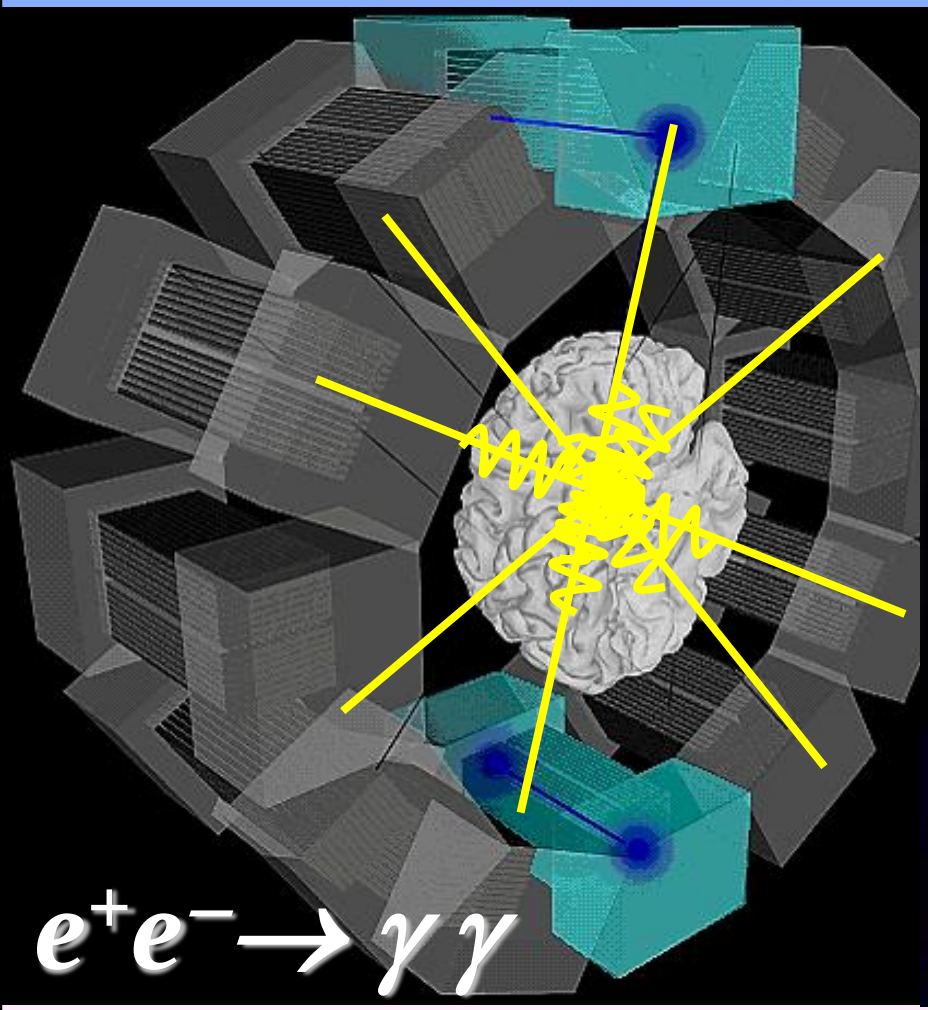






Anti-materie in ziekenhuizen: de PET-scan



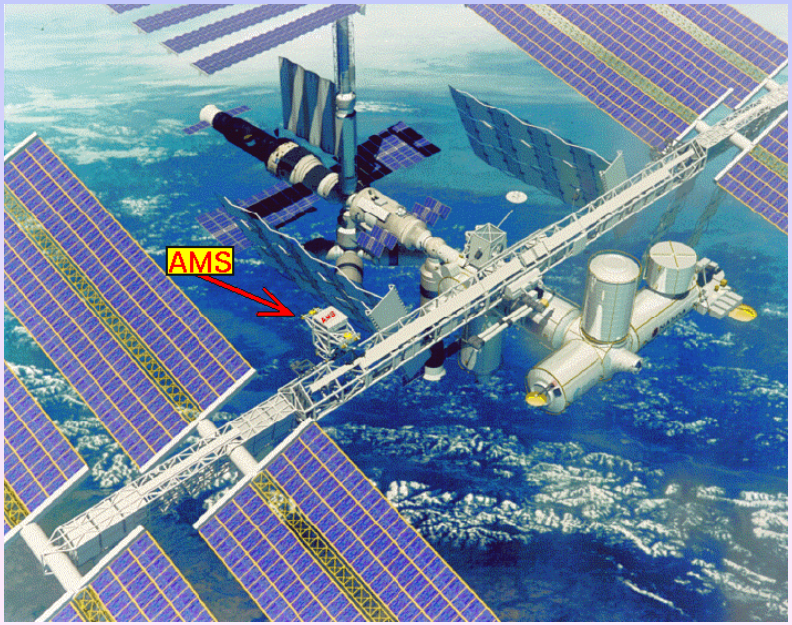


Wat snappen we nog niet:

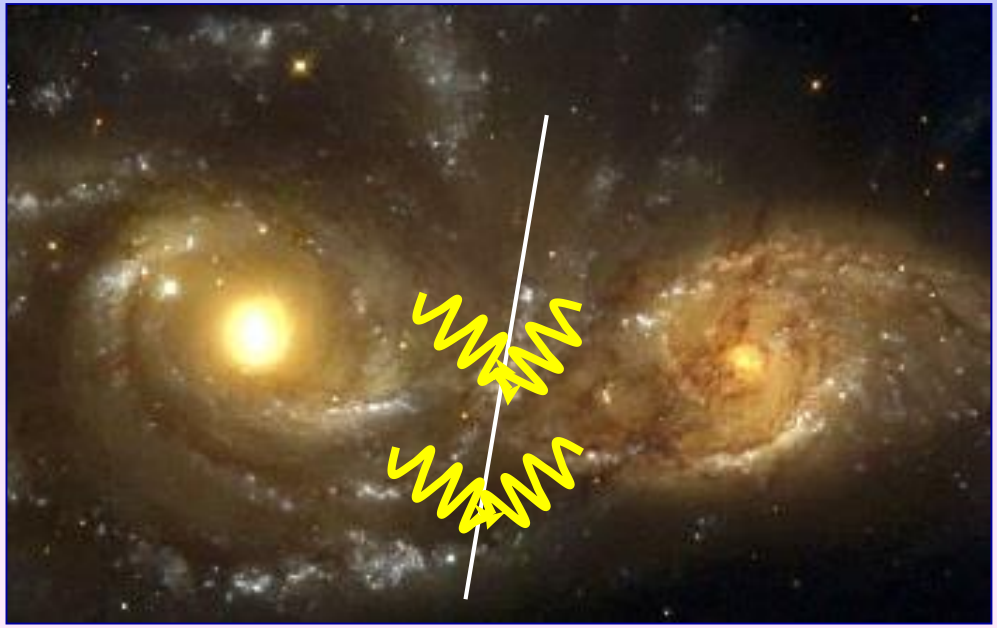
I. Wat snappen we nog niet? “*Anti-materie*”

Waar is de anti-materie gebleven?

Geen anti-materie met satellieten

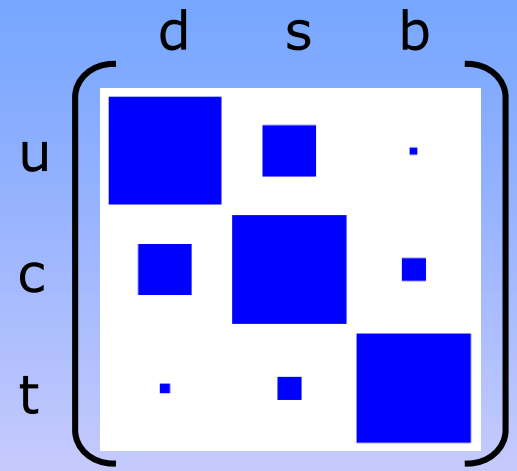


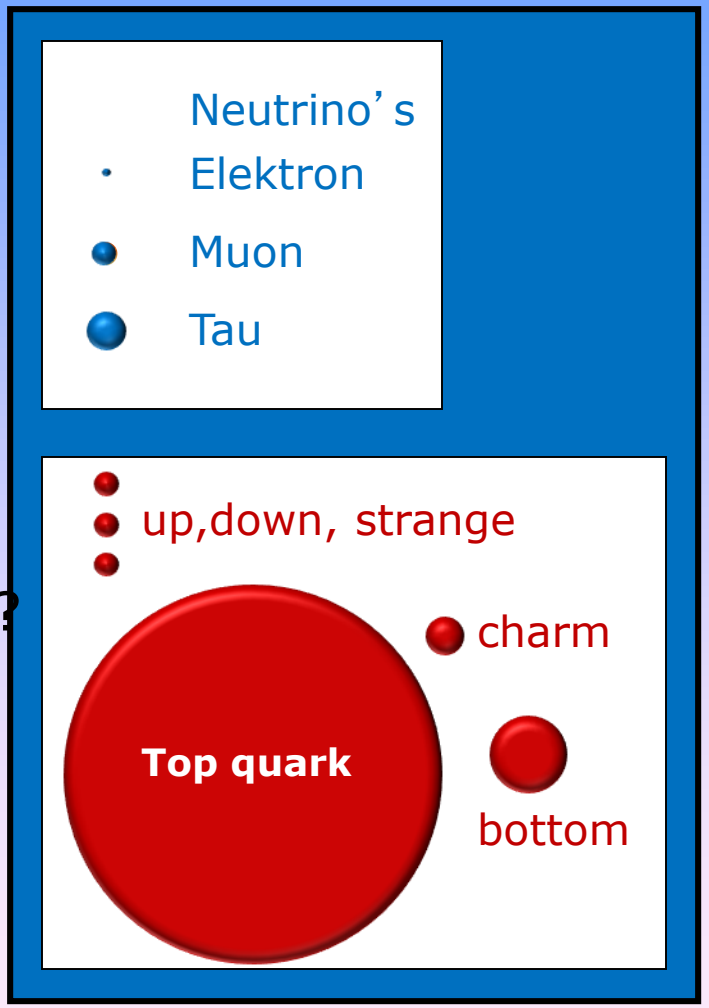
Geen anti-materie sterrenstelsels



II. Wat snappen we nog niet? “Patronen”

Quark koppelingen:



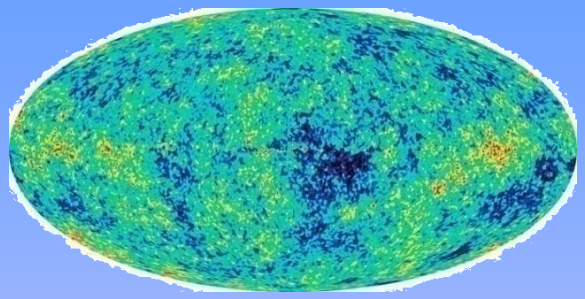


Waarom dit patroon in quark koppelingen?

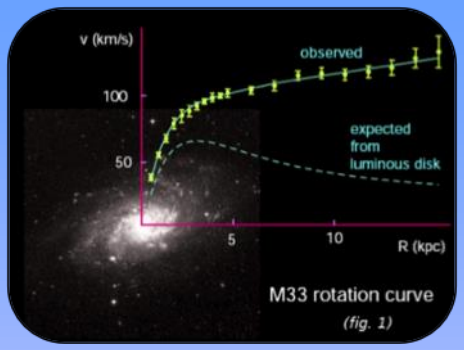
Waarom dit patroon in quark massa’s?

→ Is er een verband?

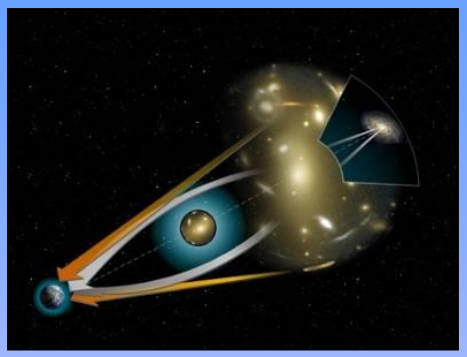
III. Wat snappen we nog niet? *"Donkere materie"*



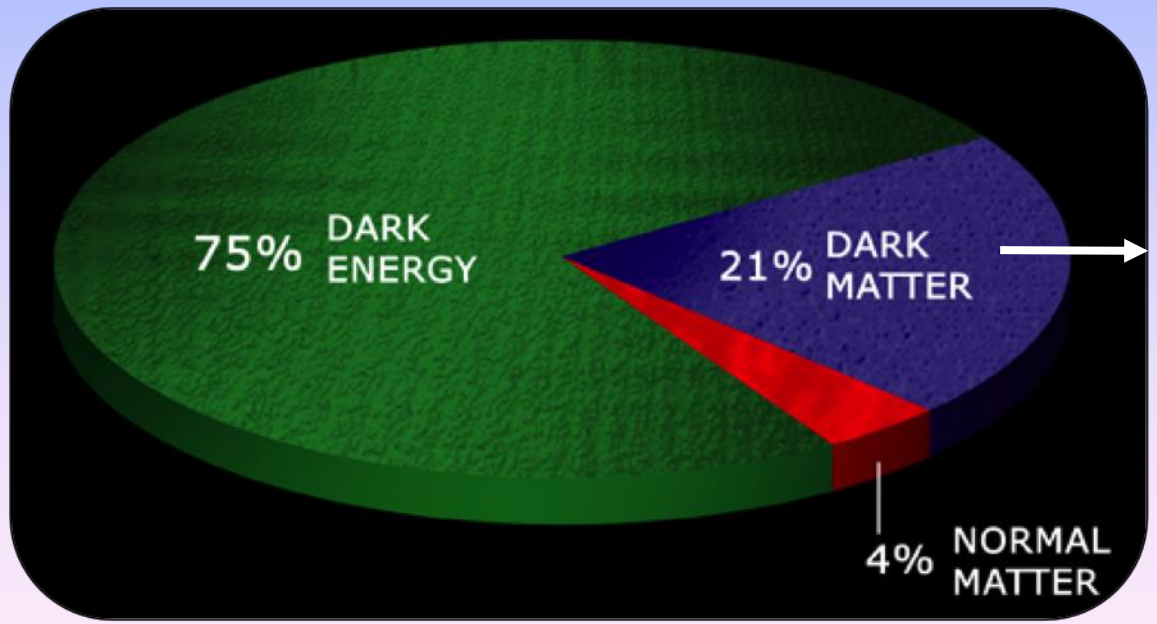
Temperatuurfluctuaties
structuur van het heelal



Rotatie-curves



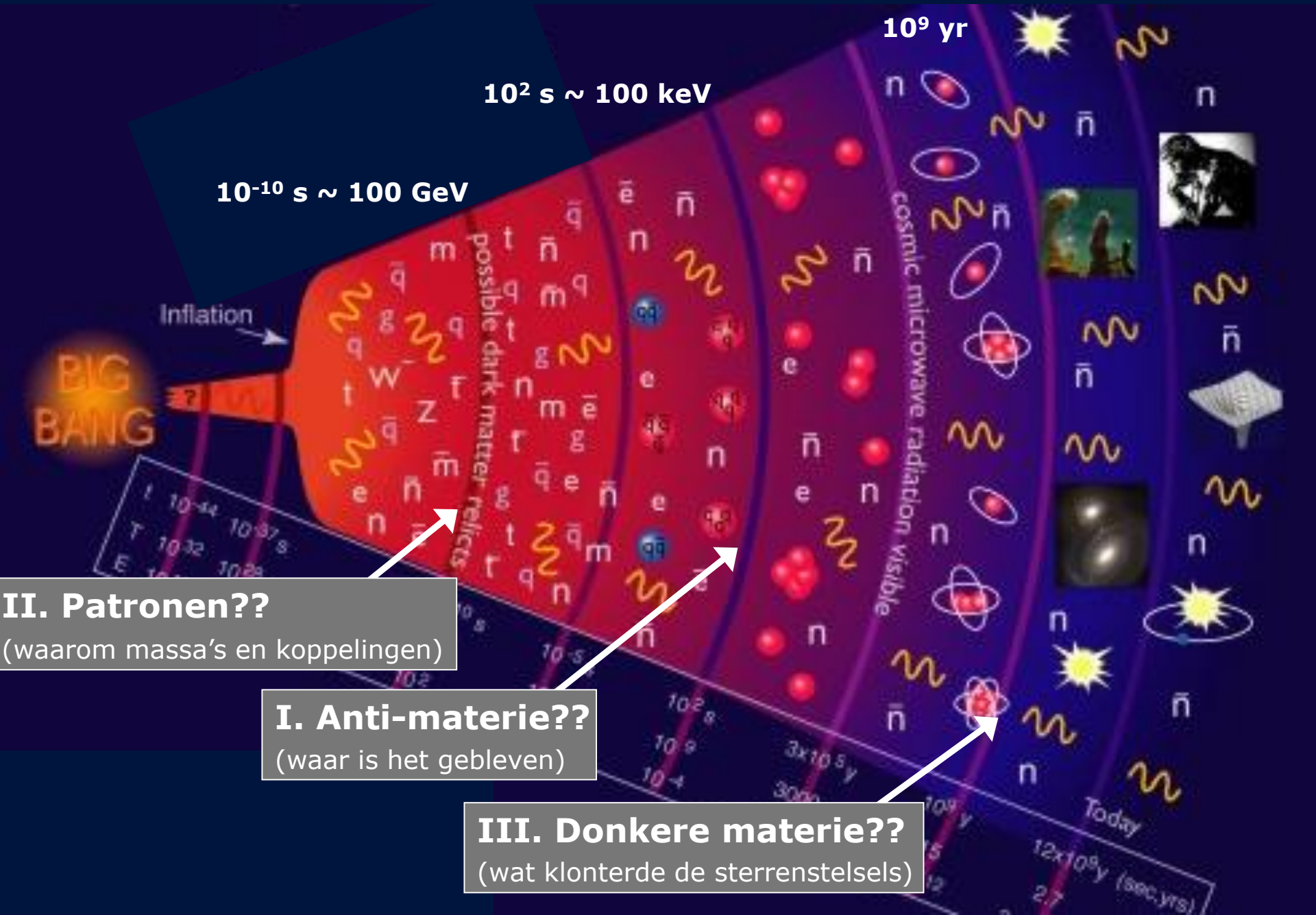
Gravitationele lens



Wat is de donkere materie ?

We hebben al die tijd maar 4% van het heelal bestudeerd!

Wat snappen we niet? Drie Grote Vragen

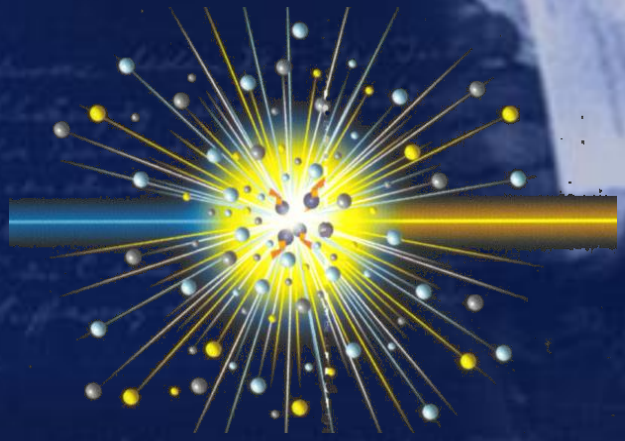



Astronomie
Deeltjes fysica
Fundamenteel
(nieuwsgierigheid gedreven)
onderzoek

Hoe ontdekken we nieuwe deeltjes?

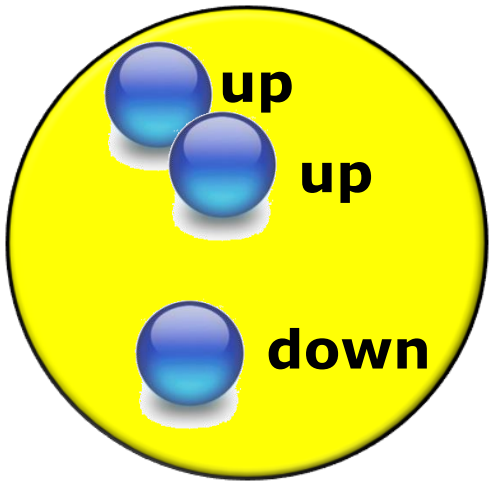
<u>Bij de LHC op Cern</u>:

1) Verander energie in materie!

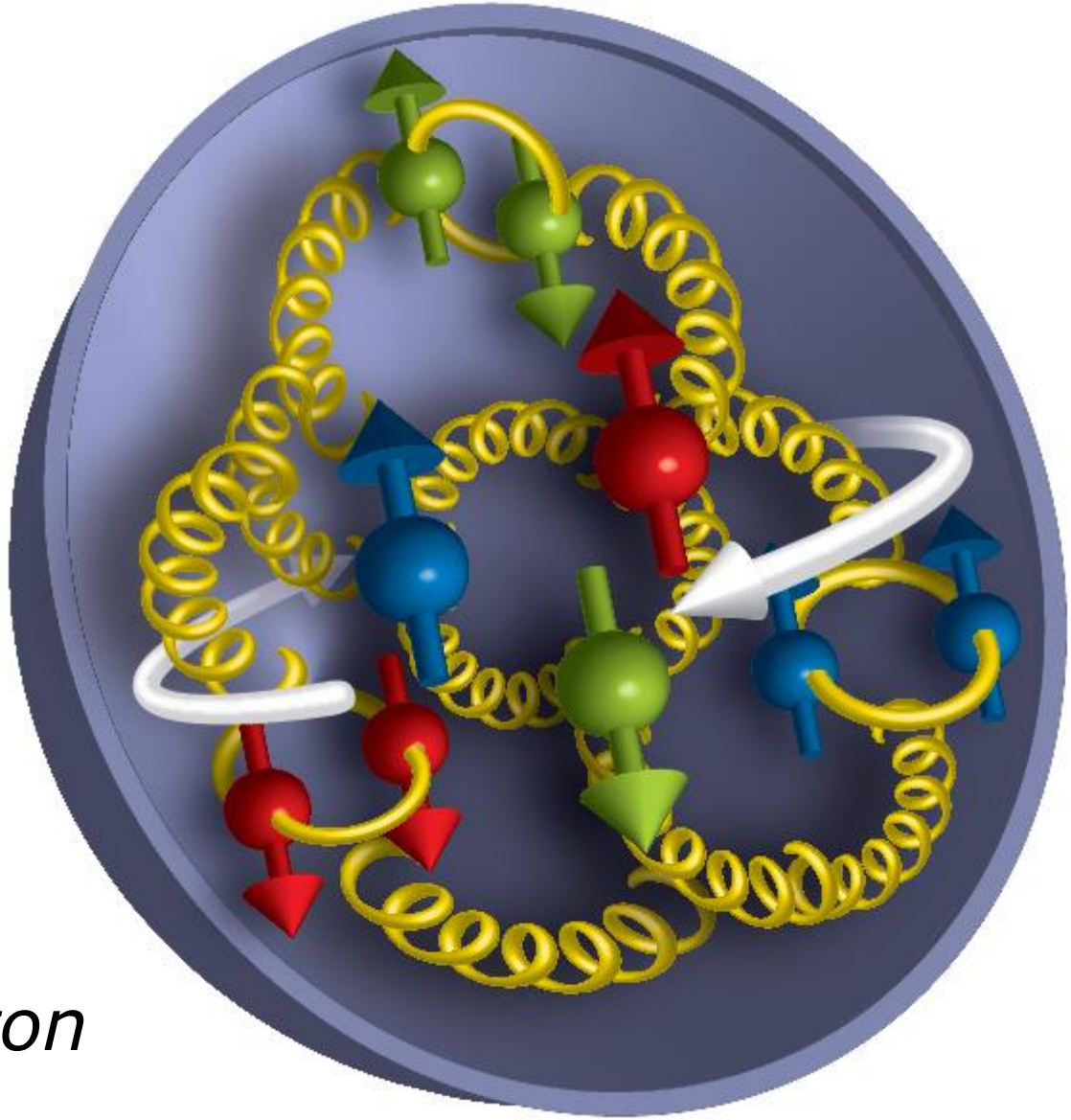


Klassiek botsen

Quantummechanisch botsen



Proton



Wat verwacht je ?

$$-\tfrac{1}{2}\partial_\nu g^a_\mu \partial_\nu g^a_\mu - g_s f^{abc}\partial_\mu g^a_\nu g^b_\mu g^c_\nu - \tfrac{1}{4}g_s^2 f^{abc}f^{ade}g^b_\mu g^c_\nu g^d_\mu g^e_\nu + \tfrac{1}{2}ig_s^2(\bar{q}^\sigma_i\gamma^\mu q^\sigma_j)g^a_\mu + \bar{G}^a\partial^2 G^a + g_s f^{abc}\partial_\mu \bar{G}^a G^b g^c_\mu - \partial_\nu W^+_\mu \partial_\nu W^-_\mu - M^2 W^+_\mu W^-_\mu - \tfrac{1}{2}\partial_\nu Z^0_\mu \partial_\nu Z^0_\mu - \tfrac{1}{2c_w^2}M^2 Z^0_\mu Z^0_\mu - \tfrac{1}{2}\partial_\mu A_\nu \partial_\mu A_\nu - \tfrac{1}{2}\partial_\mu H \partial_\mu H - \tfrac{1}{2}m_h^2 H^2 - \partial_\mu \phi^+ \partial_\mu \phi^- - M^2\phi^+\phi^- - \tfrac{1}{2}\partial_\mu\phi^0\partial_\mu\phi^0 - \tfrac{1}{2c_w^2}M\phi^0\phi^0 - \beta_h[\tfrac{2M^2}{g^2} + \tfrac{2M}{g}H + \tfrac{1}{2}(H^2+\phi^0\phi^0+2\phi^+\phi^-)] + \tfrac{2M^4}{g^2}\alpha_h - igc_w[\partial_\nu Z^0_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - Z^0_\nu(W^+_\mu\partial_\nu W^-_\mu - W^-_\mu\partial_\nu W^+_\mu) + Z^0_\mu(W^+_\nu\partial_\nu W^-_\mu - W^-_\nu\partial_\nu W^+_\mu)] - igs_w[\partial_\nu A_\mu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - A_\nu(W^+_\mu\partial_\nu W^-_\mu - W^-_\mu\partial_\nu W^+_\mu) + A_\mu(W^+_\nu\partial_\nu W^-_\mu - W^-_\nu\partial_\nu W^+_\mu)] - \tfrac{1}{2}g^2 W^+_\mu W^-_\mu W^+_\nu W^-_\nu + \tfrac{1}{2}g^2 W^+_\mu W^-_\nu W^+_\mu W^-_\nu + g^2 c_w^2(Z^0_\mu W^+_\mu Z^0_\nu W^-_\nu - Z^0_\mu Z^0_\mu W^+_\nu W^-_\nu) + g^2 s_w^2(A_\mu W^+_\mu A_\nu W^-_\nu - A_\mu A_\mu W^+_\nu W^-_\nu) + g^2 s_w c_w[A_\mu Z^0_\nu(W^+_\mu W^-_\nu - W^+_\nu W^-_\mu) - 2A_\mu Z^0_\mu W^+_\nu W^-_\nu] - g\alpha[H^3 + H\phi^0\phi^0 + 2H\phi^+\phi^-] - \tfrac{1}{8}g^2\alpha_h[H^4+(\phi^0)^4+4(\phi^+\phi^-)^2+4(\phi^0)^2\phi^+\phi^-+4H^2\phi^+\phi^-+2(\phi^0)^2H^2] - gMW^+_\mu W^-_\mu H - \tfrac{1}{2}g\tfrac{M}{c_w^2}Z^0_\mu Z^0_\mu H - \tfrac{1}{2}ig[W^+_\mu(\phi^0\partial_\mu\phi^- - \phi^-\partial_\mu\phi^0) - W^-_\mu(\phi^0\partial_\mu\phi^+ - \phi^+\partial_\mu\phi^0)] + \tfrac{1}{2}g[W^+_\mu(H\partial_\mu\phi^- - \phi^-\partial_\mu H) - W^-_\mu(H\partial_\mu\phi^+ - \phi^+\partial_\mu H)] + \tfrac{1}{2}g\tfrac{1}{c_w}(Z^0_\mu(H\partial_\mu\phi^0 - \phi^0\partial_\mu H) - ig\tfrac{s_w^2}{c_w}MZ^0_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) + igs_wMA_\mu(W^+_\mu\phi^- - W^-_\mu\phi^+) - ig\tfrac{1-2c_w^2}{2c_w}Z^0_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) + igs_wA_\mu(\phi^+\partial_\mu\phi^- - \phi^-\partial_\mu\phi^+) - \tfrac{1}{4}g^2W^+_\mu W^-_\mu[H^2+(\phi^0)^2+2\phi^+\phi^-] - \tfrac{1}{4}g^2\tfrac{1}{c_w^2}Z^0_\mu Z^0_\mu[H^2+(\phi^0)^2+2(2s_w^2-1)^2\phi^+\phi^-] - \tfrac{1}{2}g^2\tfrac{s_w^2}{c_w}Z^0_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) - \tfrac{1}{2}ig^2\tfrac{s_w^2}{c_w}Z^0_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) + \tfrac{1}{2}g^2s_wA_\mu\phi^0(W^+_\mu\phi^- + W^-_\mu\phi^+) + \tfrac{1}{2}ig^2s_wA_\mu H(W^+_\mu\phi^- - W^-_\mu\phi^+) - g^2\tfrac{s_w}{c_w}(2c_w^2-1)Z^0_\mu A_\mu\phi^+\phi^- - g^1s_w^2A_\mu A_\mu\phi^+\phi^- - \bar{e}^\lambda(\gamma\partial + m^\lambda_e)e^\lambda - \bar{\nu}^\lambda\gamma\partial\nu^\lambda - \bar{u}^\lambda_j(\gamma\partial + m^\lambda_u)u^\lambda_j - \bar{d}^\lambda_j(\gamma\partial + m^\lambda_d)d^\lambda_j + igs_wA_\mu[-(\bar{e}^\lambda\gamma^\mu e^\lambda) + \tfrac{2}{3}(\bar{u}^\lambda_j\gamma^\mu u^\lambda_j) - \tfrac{1}{3}(\bar{d}^\lambda_j\gamma^\mu d^\lambda_j)] + \tfrac{ig}{4c_w}Z^0_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{e}^\lambda\gamma^\mu(4s_w^2-1-\gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(\tfrac{4}{3}s_w^2 - 1-\gamma^5)u^\lambda_j) + (\bar{d}^\lambda_j\gamma^\mu(1-\tfrac{8}{3}s_w^2-\gamma^5)d^\lambda_j)] + \tfrac{ig}{2\sqrt{2}}W^+_\mu[(\bar{\nu}^\lambda\gamma^\mu(1+\gamma^5)e^\lambda) + (\bar{u}^\lambda_j\gamma^\mu(1+\gamma^5)C_{\lambda\kappa}d^\kappa_j)] + \tfrac{ig}{2\sqrt{2}}W^-_\mu[(\bar{e}^\lambda\gamma^\mu(1+\gamma^5)\nu^\lambda) + (\bar{d}^\kappa_jC^\dagger_{\lambda\kappa}\gamma^\mu(1+\gamma^5)u^\lambda_j)] + \tfrac{ig}{2\sqrt{2}}\tfrac{m^\lambda_\nu}{M}[-\phi^+(\bar{\nu}^\lambda(1-\gamma^5)e^\lambda) + \phi^-(\bar{e}^\lambda(1+\gamma^5)\nu^\lambda)] - \tfrac{g}{2}\tfrac{m^\lambda_e}{M}[H(\bar{e}^\lambda e^\lambda) + i\phi^0(\bar{e}^\lambda\gamma^5 e^\lambda)] + \tfrac{ig}{2M\sqrt{2}}\phi^+[-m^\kappa_d(\bar{u}^\lambda_jC_{\lambda\kappa}(1-\gamma^5)d^\kappa_j) + m^\lambda_u(\bar{u}^\lambda_jC_{\lambda\kappa}(1+\gamma^5)d^\kappa_j] + \tfrac{ig}{2M\sqrt{2}}\phi^-[m^\lambda_d(\bar{d}^\lambda_jC^\dagger_{\lambda\kappa}(1+\gamma^5)u^\kappa_j) - m^\kappa_u(\bar{d}^\lambda_jC^\dagger_{\lambda\kappa}(1-\gamma^5)u^\kappa_j] - \tfrac{g}{2}\tfrac{m^\lambda_u}{M}H(\bar{u}^\lambda_ju^\lambda_j) - \tfrac{g}{2}\tfrac{m^\lambda_d}{M}H(\bar{d}^\lambda_jd^\lambda_j) + \tfrac{ig}{2}\tfrac{m^\lambda_u}{M}\phi^0(\bar{u}^\lambda_j\gamma^5u^\lambda_j) - \tfrac{ig}{2}\tfrac{m^\lambda_d}{M}\phi^0(\bar{d}^\lambda_j\gamma^5d^\lambda_j) + \bar{X}^+(\partial^2-M^2)X^+ + \bar{X}^-(\partial^2-M^2)X^- + \bar{X}^0(\partial^2 - \tfrac{M^2}{c_w^2})X^0 + \bar{Y}\partial^2Y + igc_wW^+_\mu(\partial_\mu\bar{X}^0X^- - \partial_\mu\bar{X}^+X^0) + igs_wW^+_\mu(\partial_\mu\bar{Y}X^- - \partial_\mu\bar{X}^+Y) + igc_wW^-_\mu(\partial_\mu\bar{X}^-X^0 - \partial_\mu\bar{X}^0X^+) + igs_wW^-_\mu(\partial_\mu\bar{X}^-Y - \partial_\mu\bar{Y}X^+) + igc_wZ^0_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) + igs_wA_\mu(\partial_\mu\bar{X}^+X^+ - \partial_\mu\bar{X}^-X^-) - \tfrac{1}{2}gM[\bar{X}^+X^+H + \bar{X}^-X^-H + \tfrac{1}{c_w^2}\bar{X}^0X^0H] + \tfrac{1-2c_w^2}{2c_w}igM[\bar{X}^+X^0\phi^+ - \bar{X}^-X^0\phi^-] + \tfrac{1}{2c_w}igM[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + igMs_w[\bar{X}^0X^-\phi^+ - \bar{X}^0X^+\phi^-] + \tfrac{1}{2}igM[\bar{X}^+X^+\phi^0 - \bar{X}^-X^-\phi^0]$$

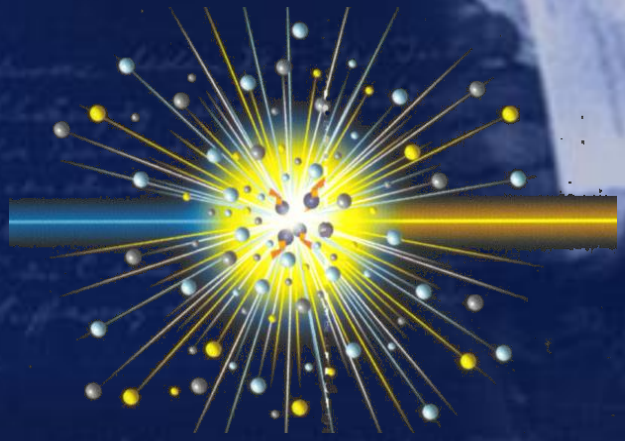
Al 40 jaar bestaan er precieze wiskundige voorspellingen!

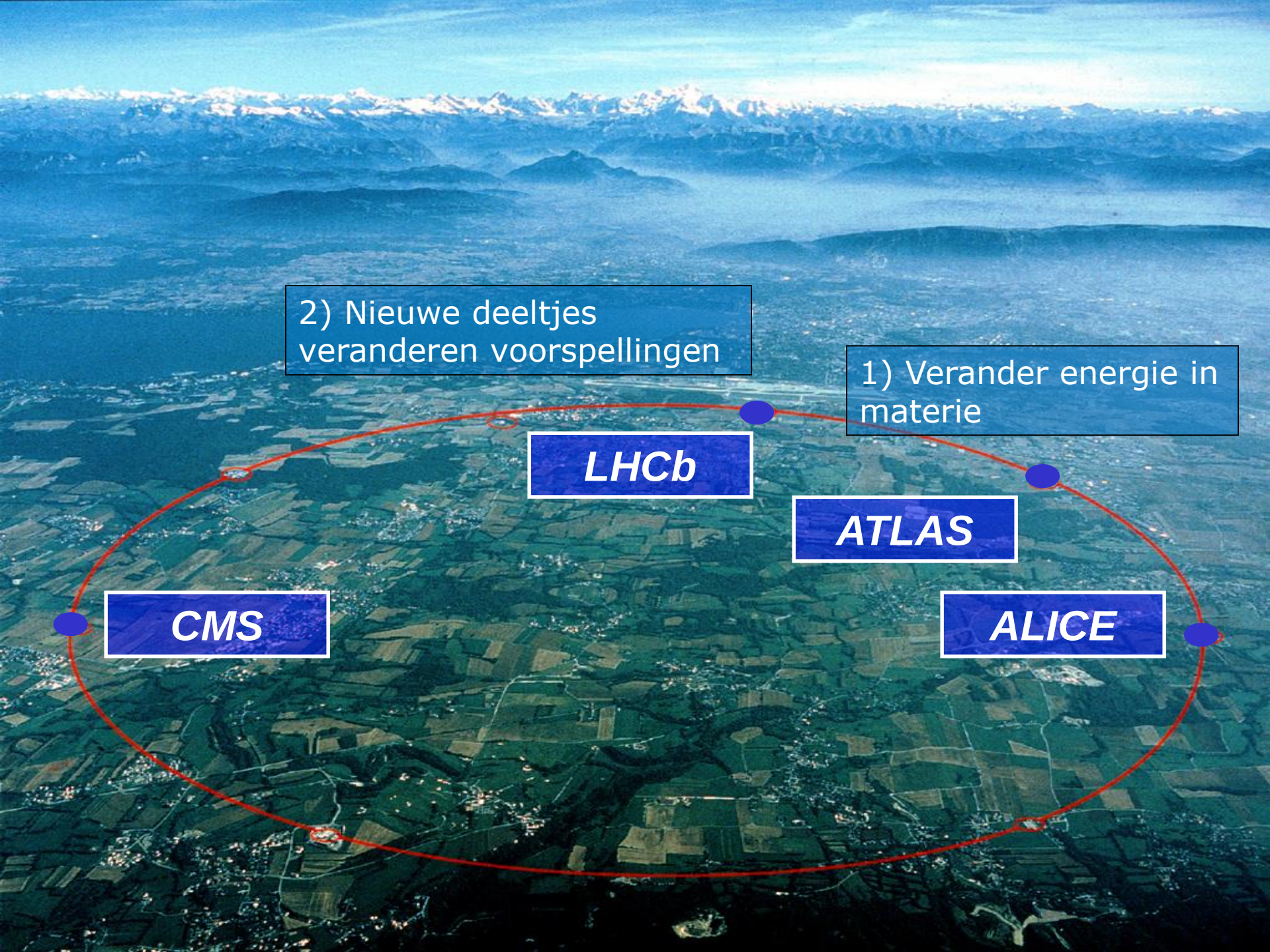
Hoe ontdekken we nieuwe deeltjes?

Bij de LHC op Cern:

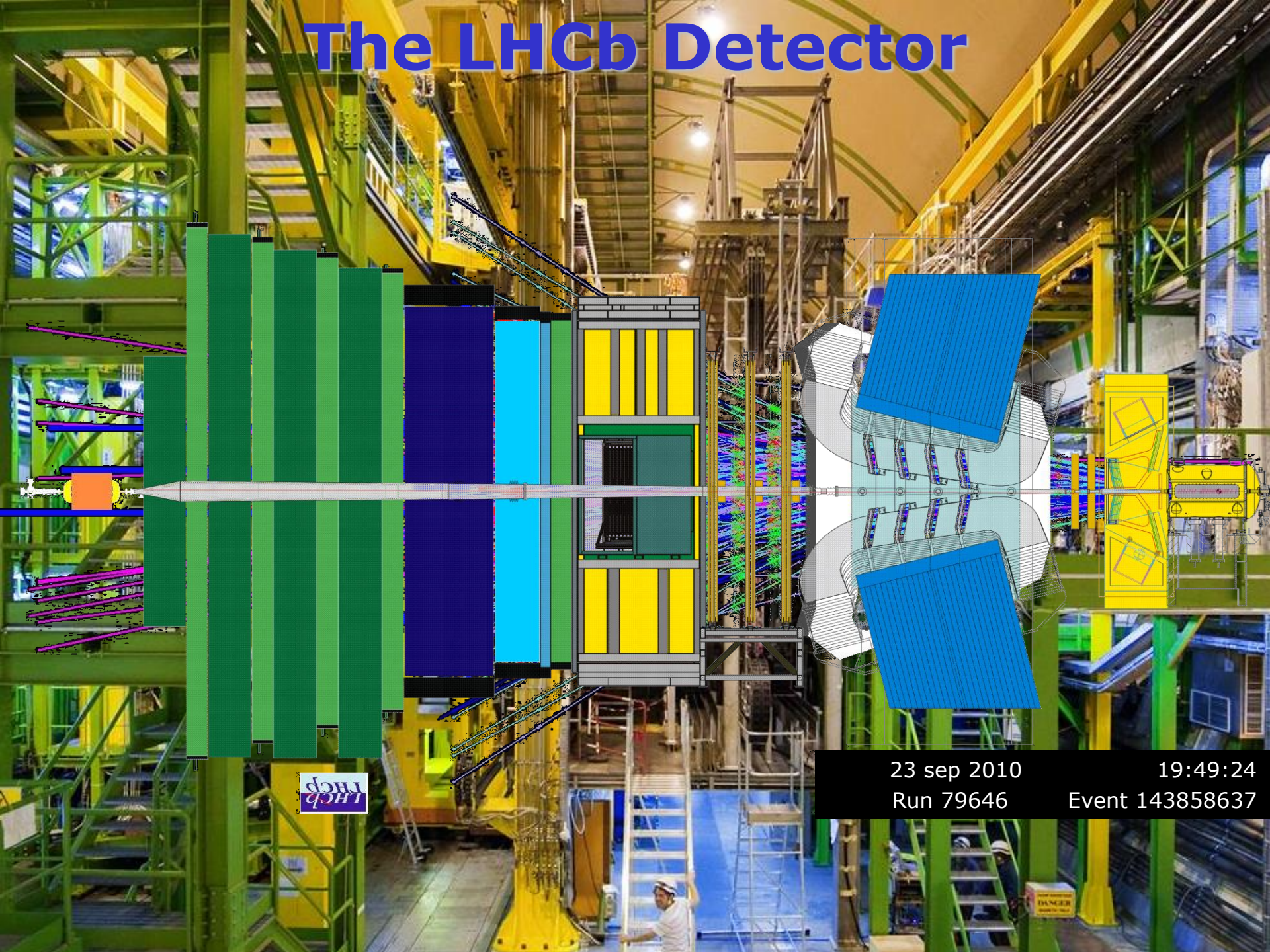
1) Verander energie in materie!

2) Nieuwe deeltjes veranderen voorspellingen

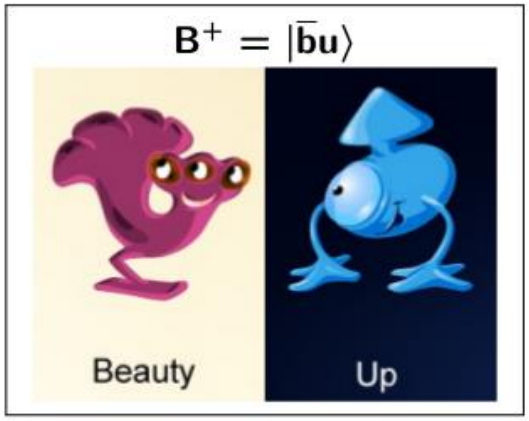


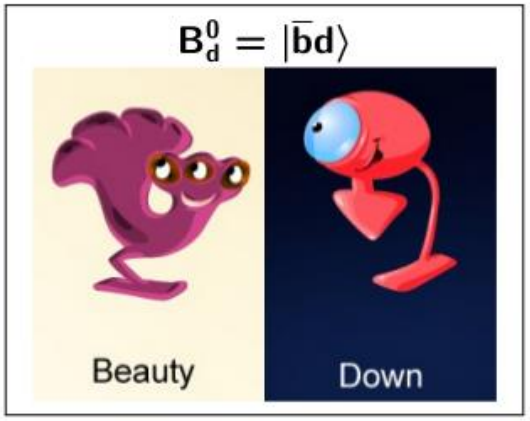

2) Nieuwe deeltjes veranderen voorspellingen
1) Verander energie in materie
LHCb
ATLAS
CMS
ALICE

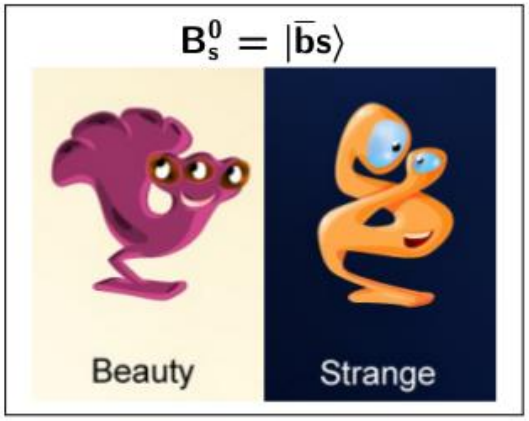
The LHCb Detector



B mesons … de b in LHCb







B meson = anti b-quark + lichter quark

Onstabiele deeltjes

Levensduur: 1.5 10^{-12} seconden

Meer dan 250 verschillende manieren om uit elkaar te vallen
→ Veel verschillende mogelijkheden om meetingen te doen

Hiermee kunnen we ons deeltjesfysica model testen

LHCb in getallen

120,000 B events per sec

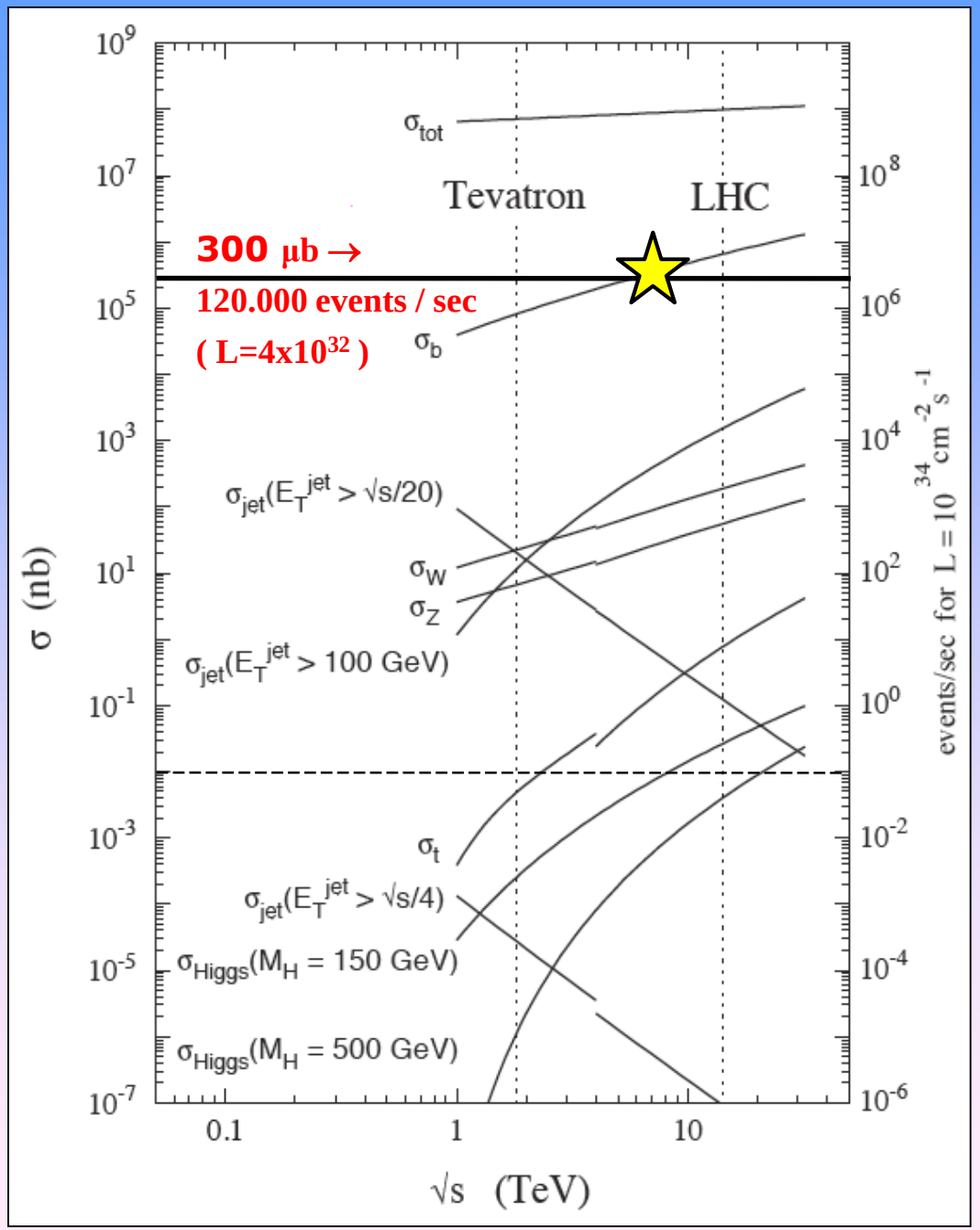
(ter vergelijk: in ATLAS : 1 Higgs in 100 sec)

10^{11} B events in 2011

(ter vergelijk: Babar heeft in totaal 10^9 B events)

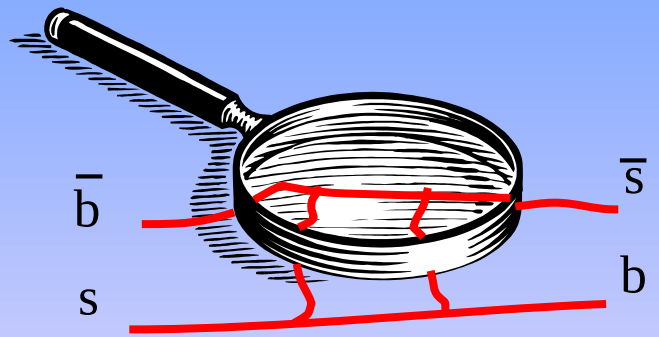
3 kHz naar tape

(ter vergelijk: ATLAS schrijft 200 Hz weg)

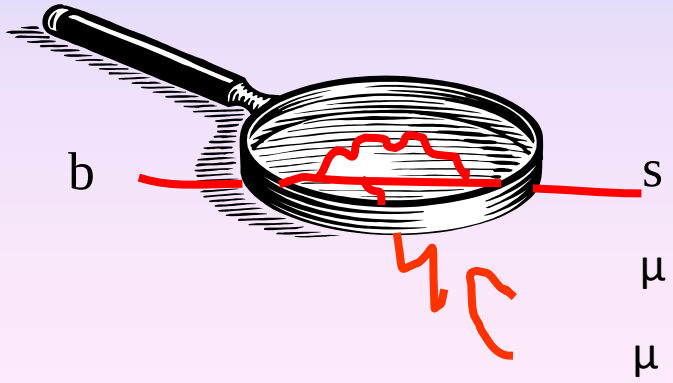


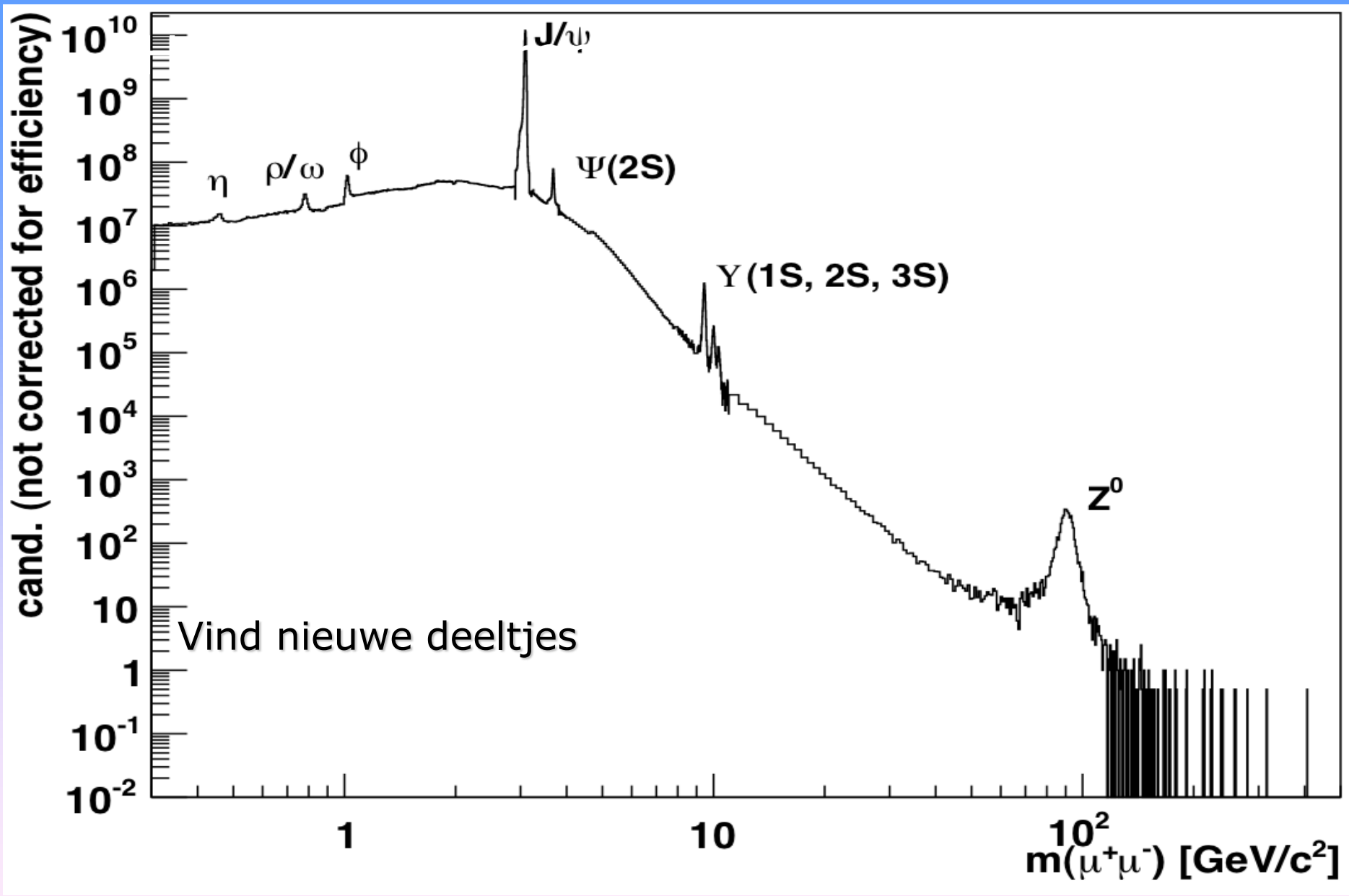
LHCb: bestuderen van *B* deeltje

1) Vind verschillen tussen materie en anti-materie

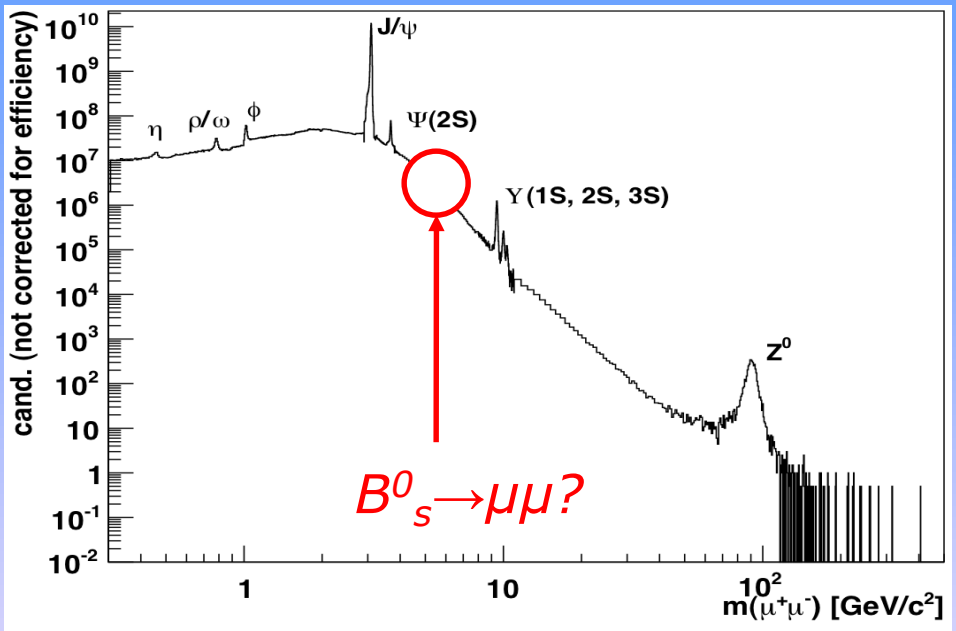


1) Vind nieuwe deeltjes



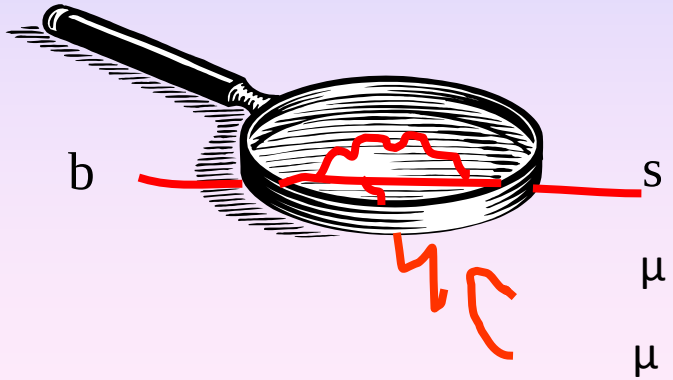

cand. (not corrected for efficiency)
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10
1
10^{-1}
10^{-2}
J/ψ
η
ρ/ω
φ
Ψ(2S)
Υ(1S, 2S, 3S)
Z^0
Vind nieuwe deeltjes
1
10
10^2
$m(\mu^+\mu^-)$ [GeV/c^2]

LHCb: bestuderen van *B* deeltje

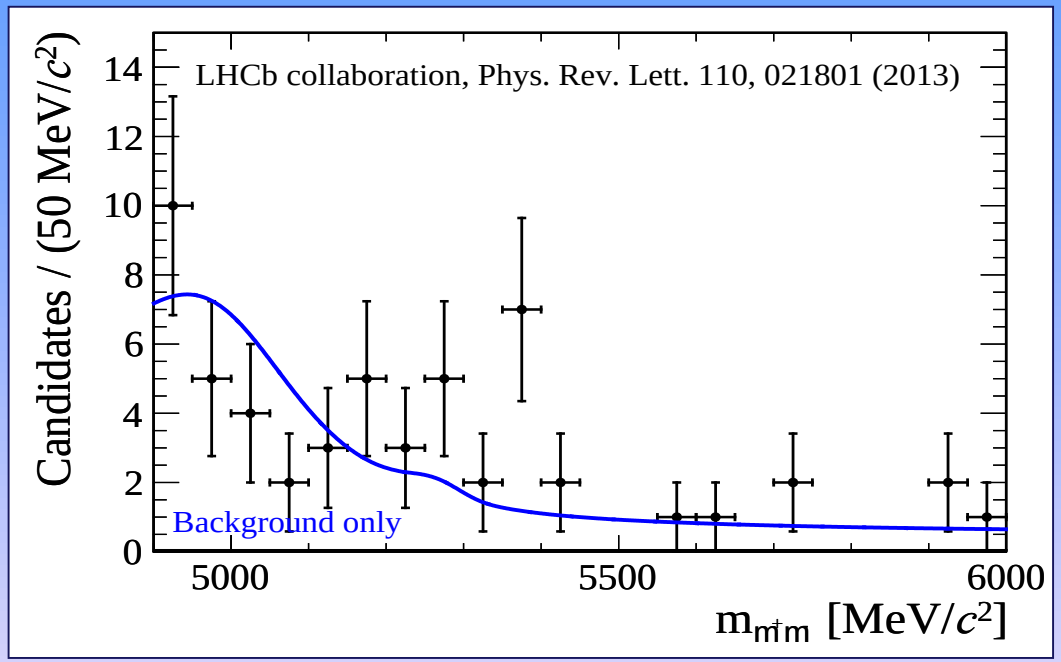


2) Vind nieuwe deeltjes

$B^0_s \rightarrow \mu\mu$

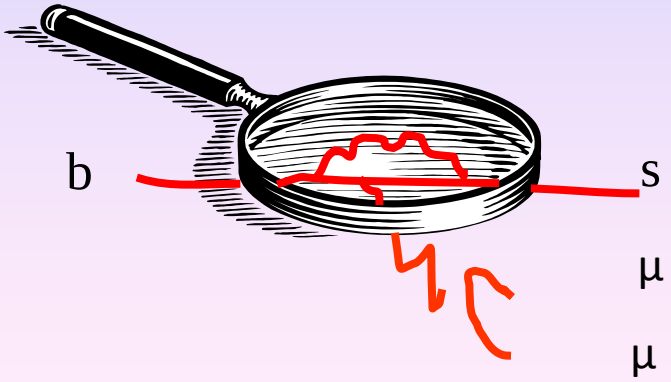


LHCb: bestuderen van *B* deeltje

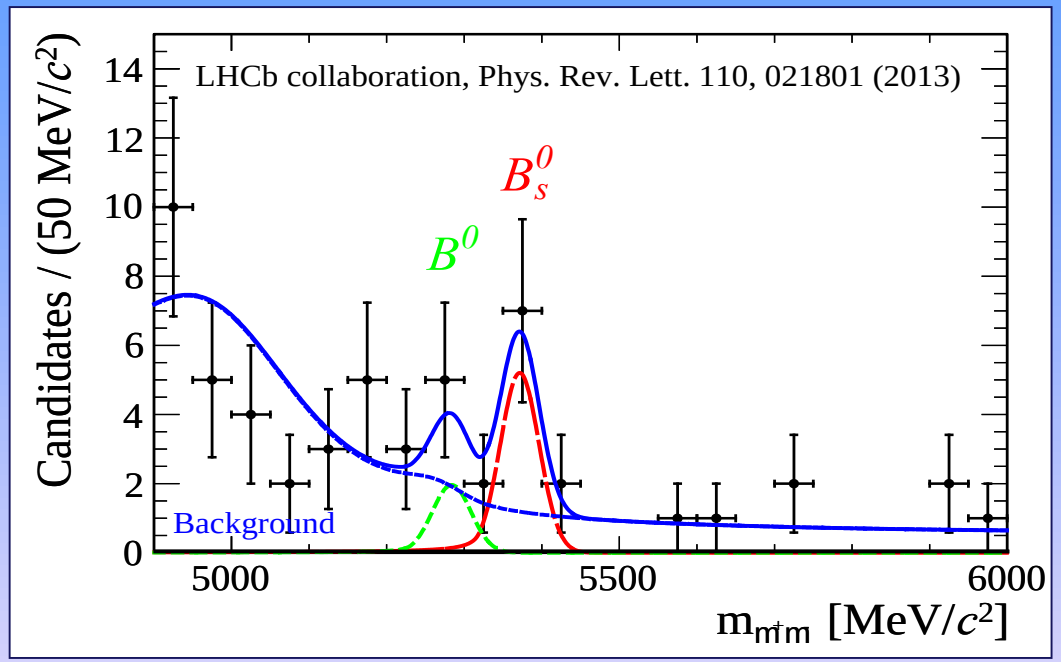


Slechts 3 op de miljard *B* deeltjes vervalt naar 2 muonen

Bestaan er nieuwe deeltjes?

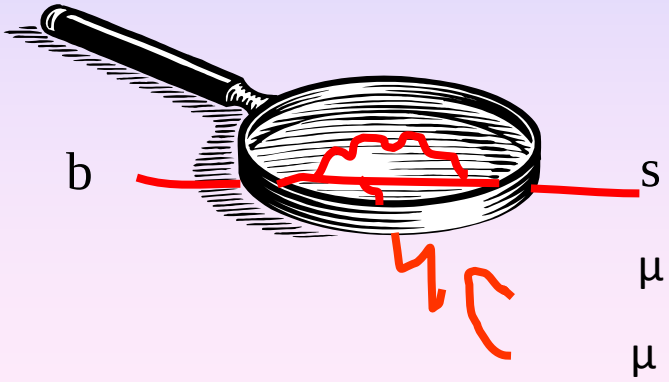


LHCb: bestuderen van *B* deeltje

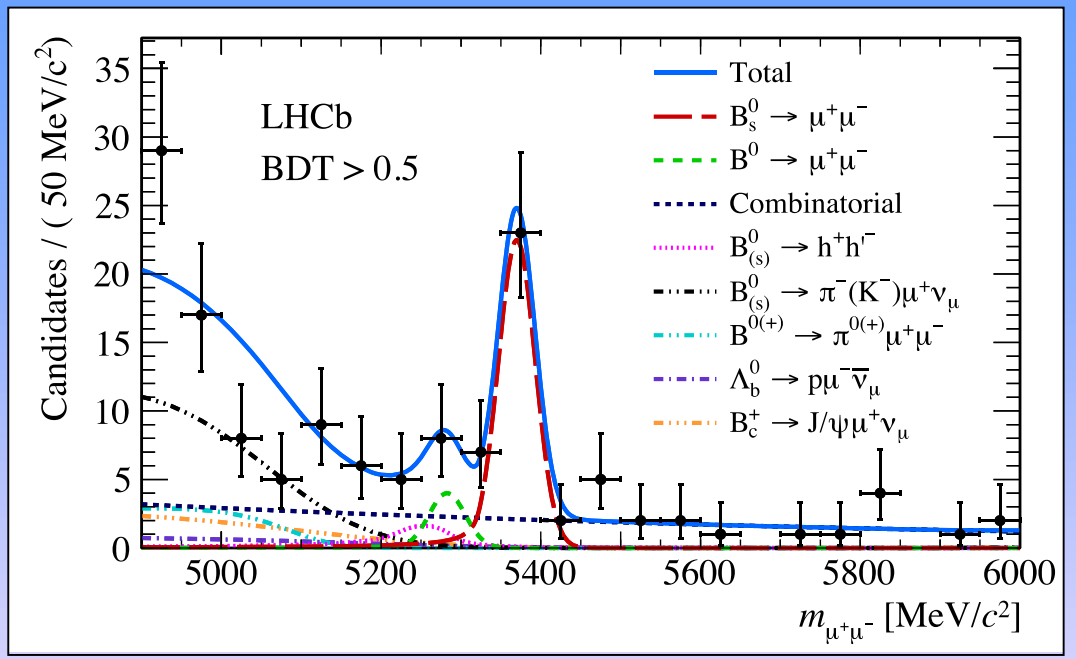


Slechts 3 op de miljard *B* deeltjes vervalt naar 2 muonen

Bestaan er nieuwe deeltjes?

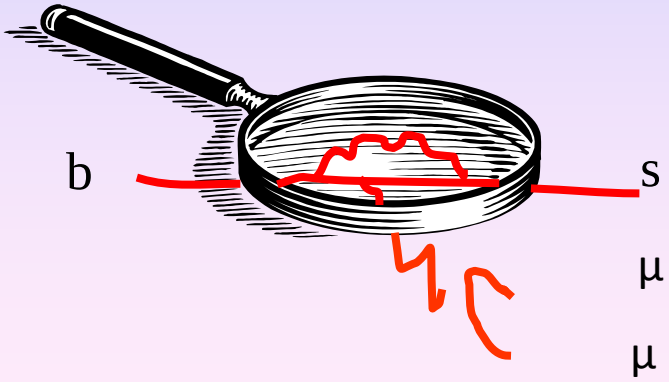


LHCb: bestuderen van *B* deeltje

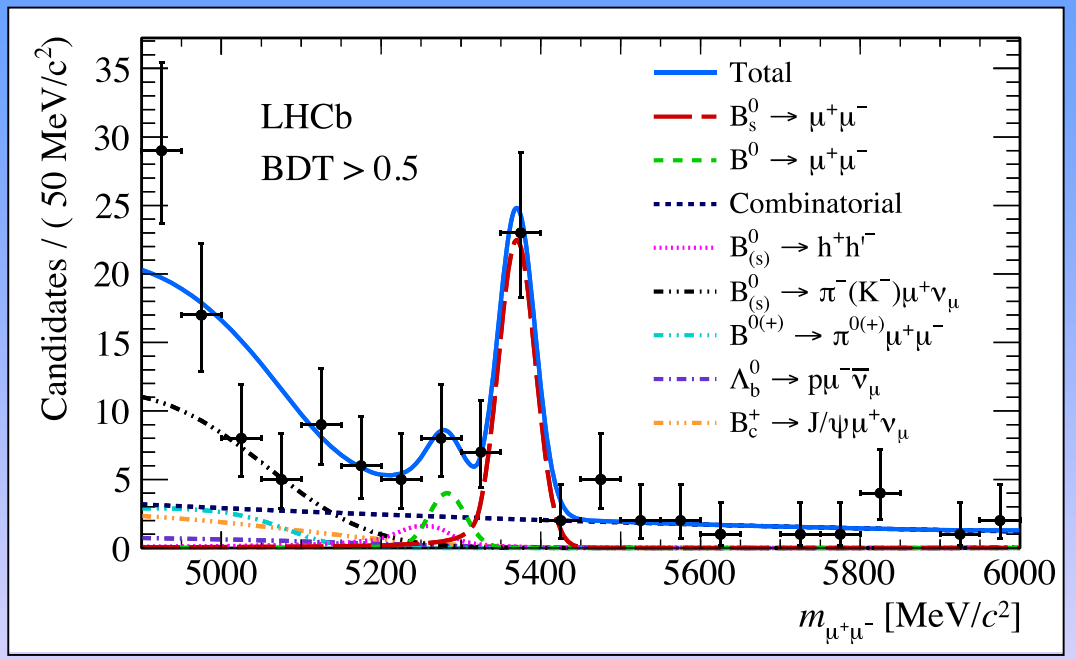


Slechts 3 op de miljard *B* deeltjes vervalt naar 2 muonen

Bestaan er nieuwe deeltjes?



LHCb: bestuderen van *B* deeltje

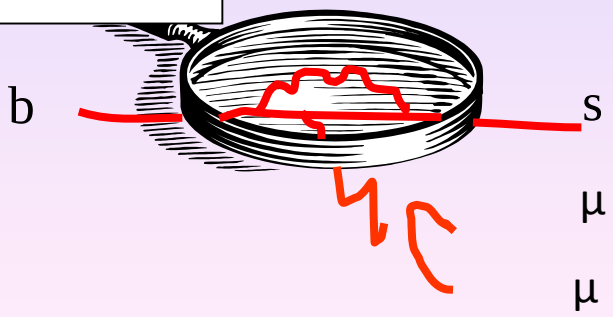


$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \left(3.0 \pm 0.6\,^{+0.3}_{-0.2}\right) \times 10^{-9}$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 3.4 \times 10^{-10}$$

Theory:

$B(B_s^0 \to \mu^+\mu^-) = (3.65 \pm 0.23) \times 10^{-9}$

$B(B^0 \to \mu^+\mu^-) = (1.06 \pm 0.09) \times 10^{-10}$

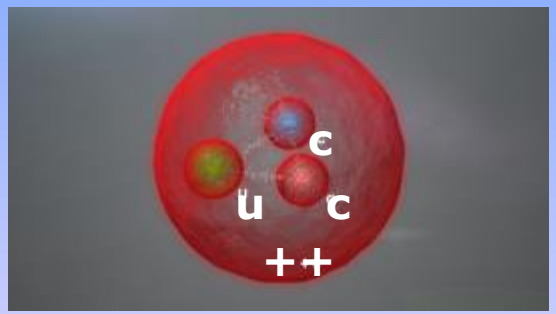


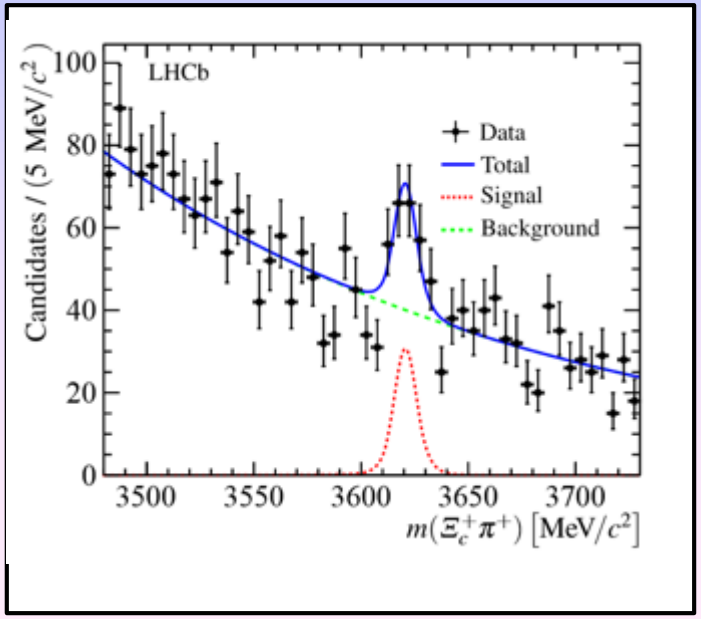
LHCb: highlights

1) Nieuwe ‘gewone’ hadronen
2) Nieuwe ‘exotische’ hadronen: Tetraquark en pentaquark
3) Ontdekking ‘CP schending’ B_s
4) Ontdekking ‘CP schending’ charm

LHCb: nieuwe ‘gewone’ hadronen

(ccu): Ξ_{cc}^{++}



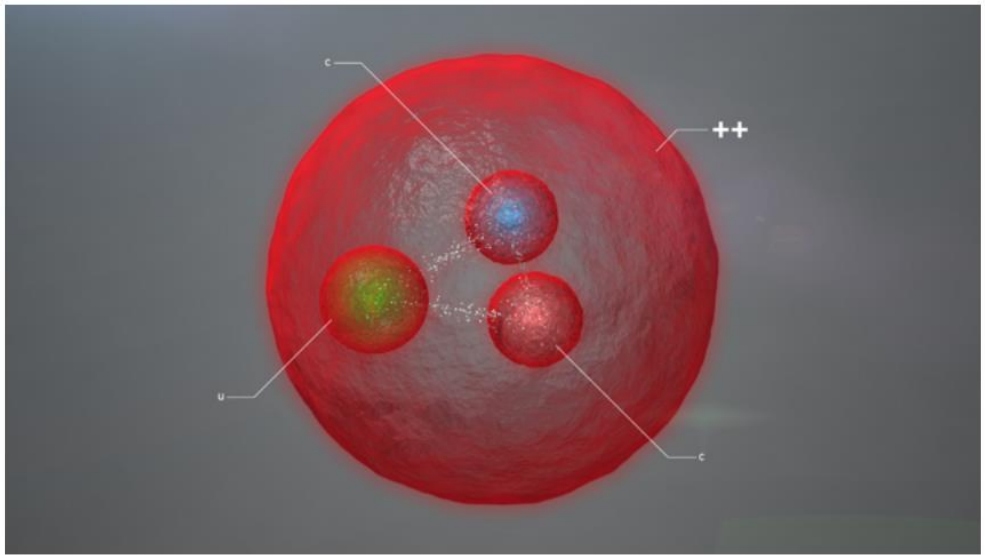


NewScientist
IDEEËN DIE DE WERELD VERANDEREN

Nieuw zwaar deeltje legt sterke kernkracht op de pijnbank

12 juli 2017

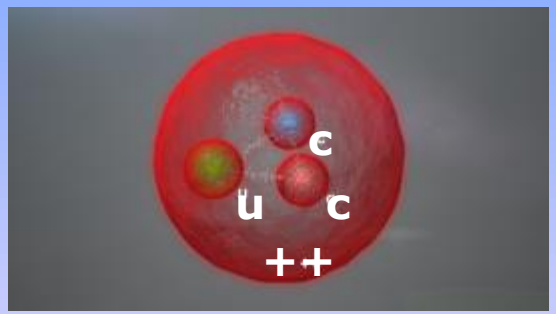
Jacob Aron en Leah Crane

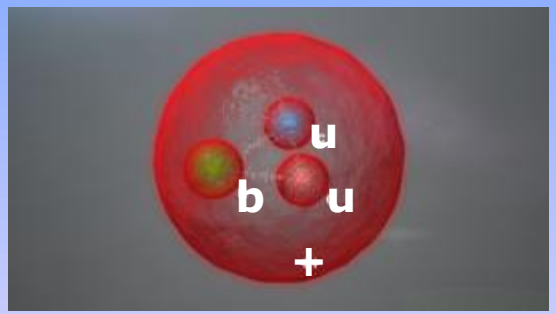


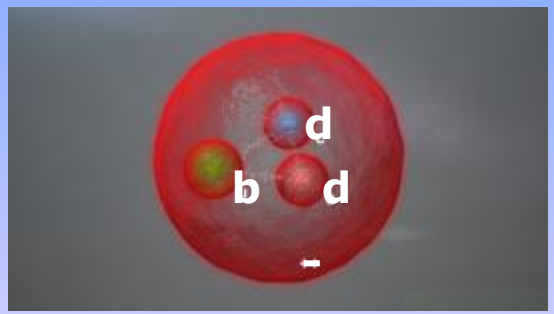
Het nieuwe deeltje bevat twee charm-quarks in het midden en een up-quark daaromheen. Beeld: Daniel Dominguez/CERN.

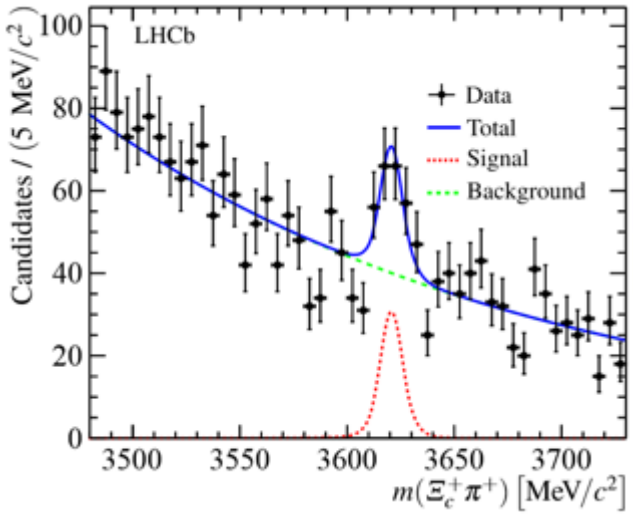
LHCb: nieuwe ‘gewone’ hadronen

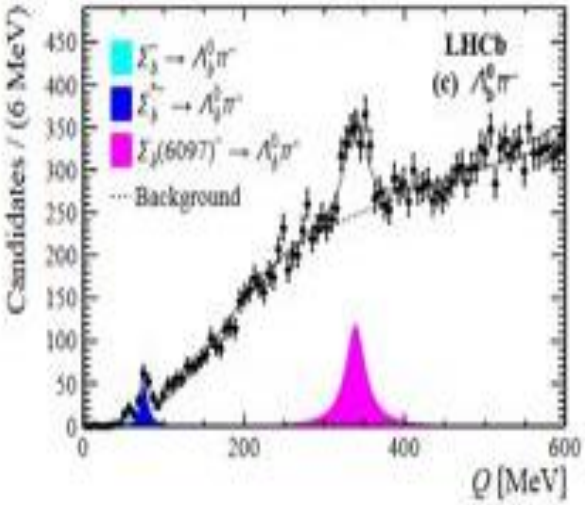
(ccu): Ξ_{cc}^{++} (buu): $\Sigma_b(6097)^+$ (bdd): $\Sigma_b(6097)^-$

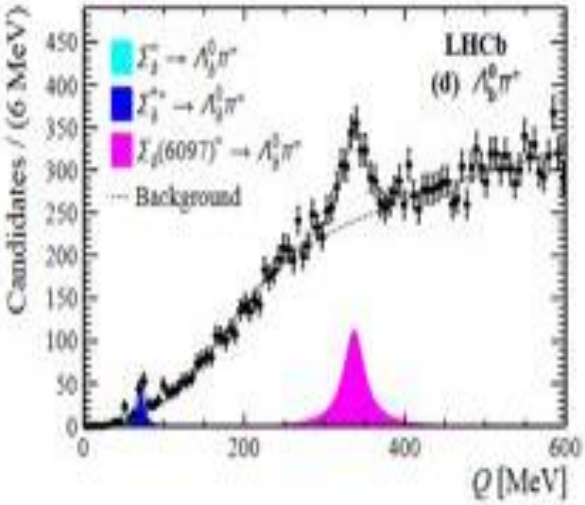






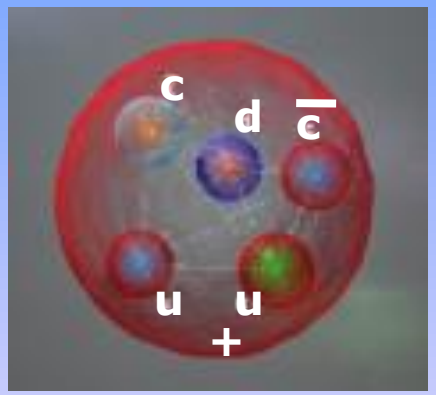




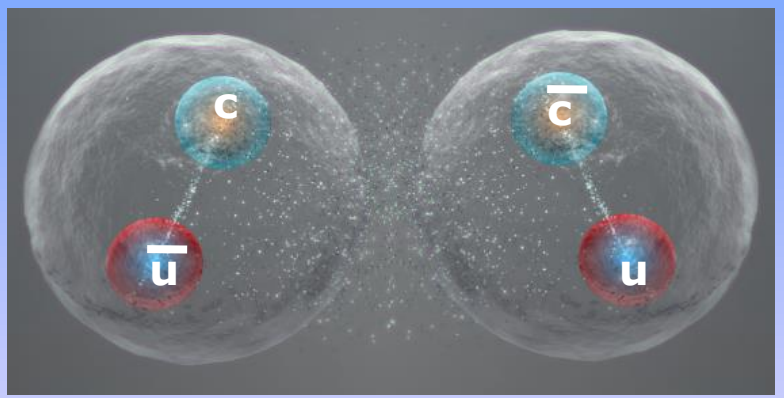


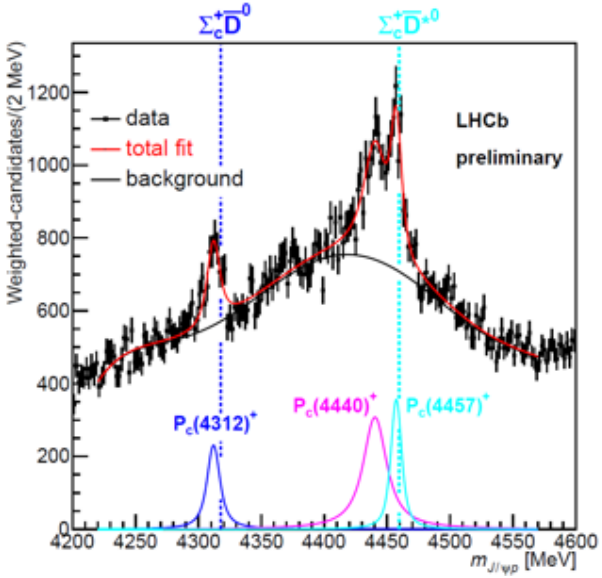
LHCb: nieuwe ‘exotische’ hadronen

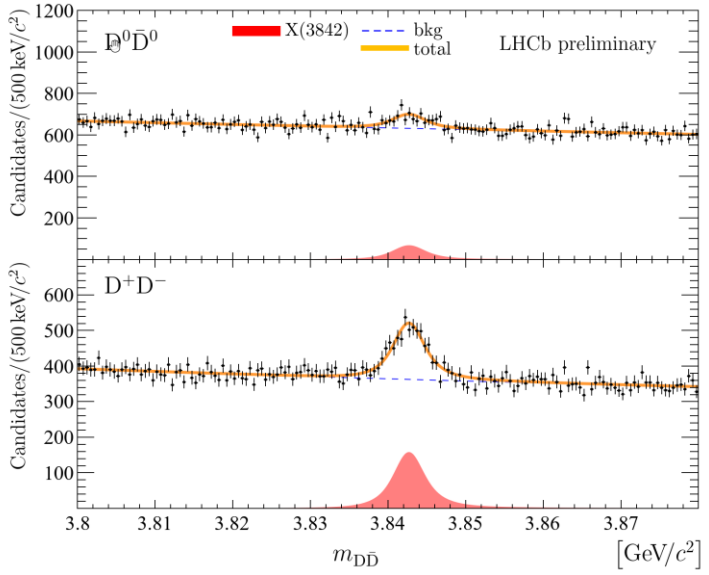
(c$\bar{c}$duu): **$P_c(4312)^+$**



(c$\bar{u}$ $\bar{c}$u): **X(3842)**

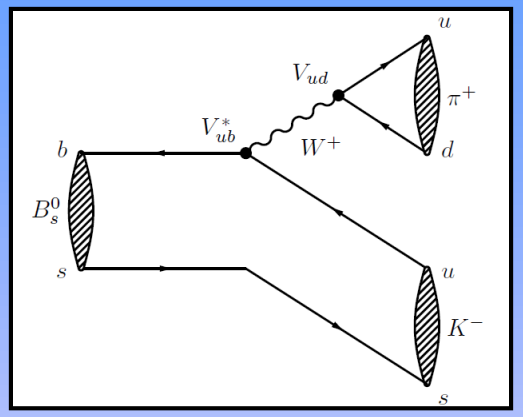


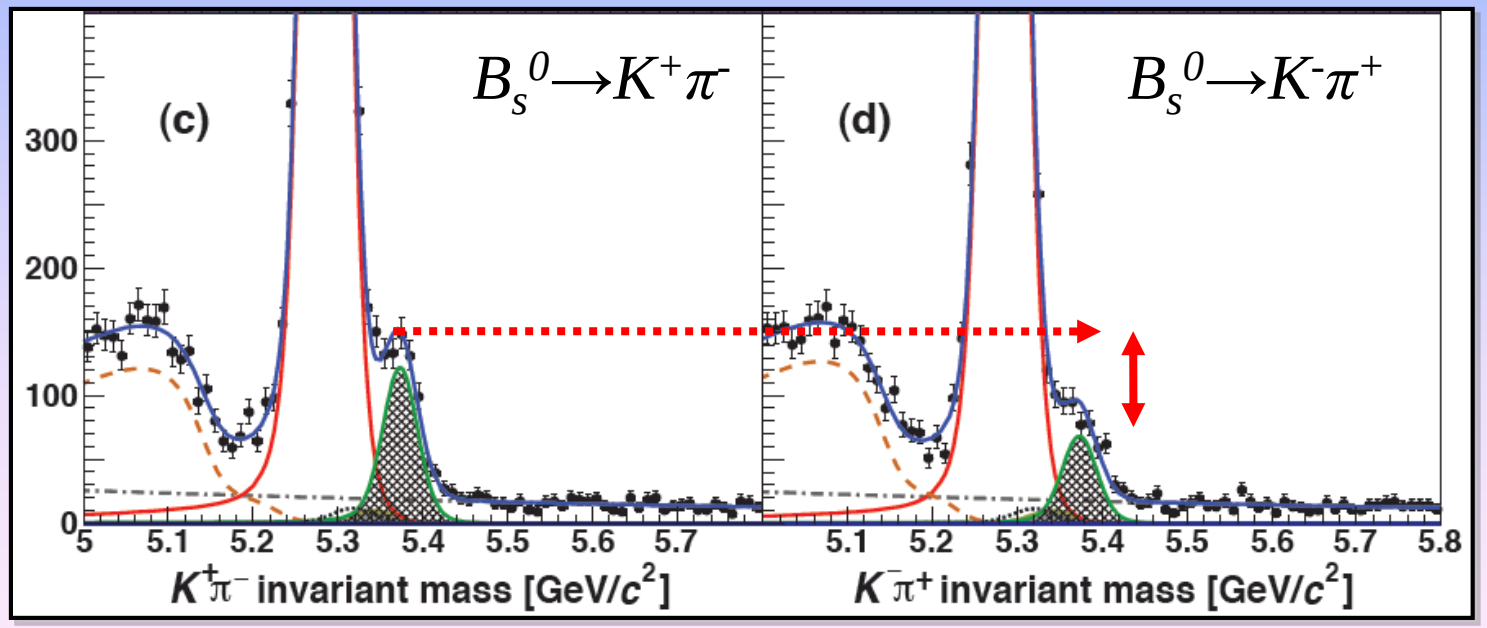




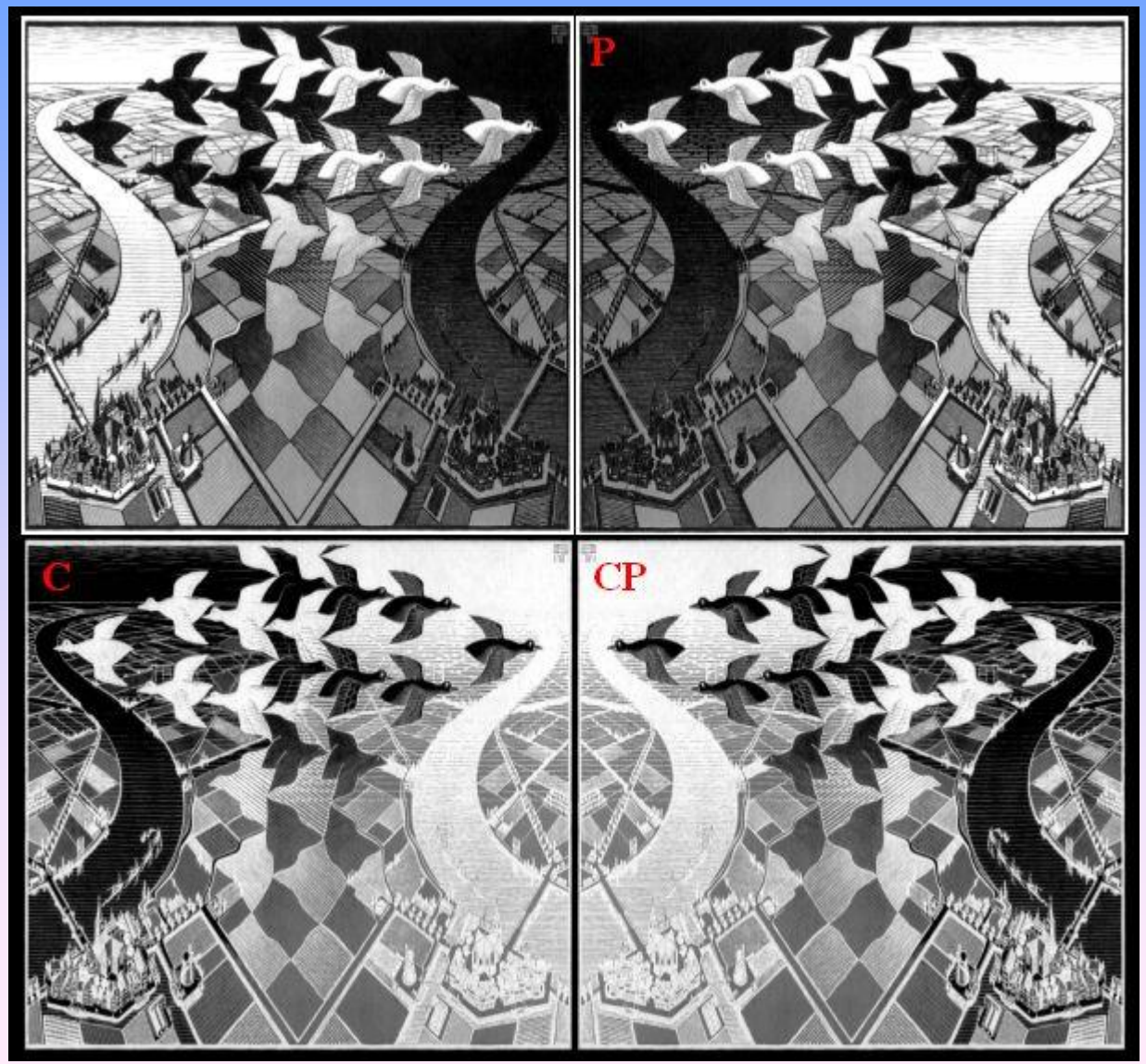
LHCb: antimaterie verschil in B_s^0

CP schending in B_s^0





CP Schending



LHCb: antimaterie verschil in charm

"CP schending"

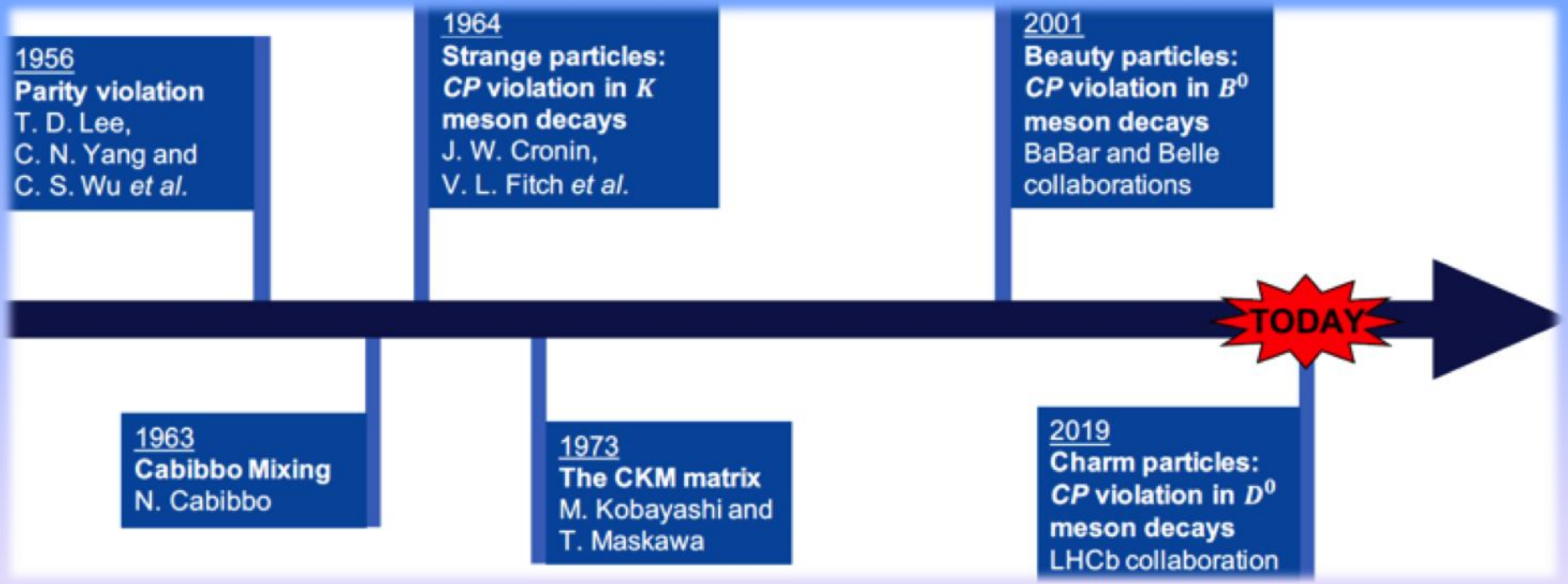
$D^0 \rightarrow K^+K^-$ same as

$\overline{D}^0 \rightarrow K^+K^-$??

at least it is different compared to $D^0 \rightarrow \pi^+\pi^-\ldots$:

$$\Delta A_{CP} = (-15.4 \pm 2.9) \times 10^{-4}$$

LHCb: antimaterie verschillen



(ds)	**1964**: CP schending met K^0	(Nobelprijs 1980)
(bd)	**2000**: CP schending met B^0	(Nobelprijs 1998)
(bs)	**2012**: CP schending met B^0_s	(LHCb)
(cu)	**2019**: CP schending met D^0	(LHCb)

LHCb: highlights

1) Nieuwe ‘gewone’ hadronen
2) Nieuwe ‘exotische’ hadronen: Tetraquark en pentaquark
3) Ontdekking ‘CP schending’ B_s
4) Ontdekking ‘CP schending’ charm

Hot topic:

5) Verschil electron, muon, tau??

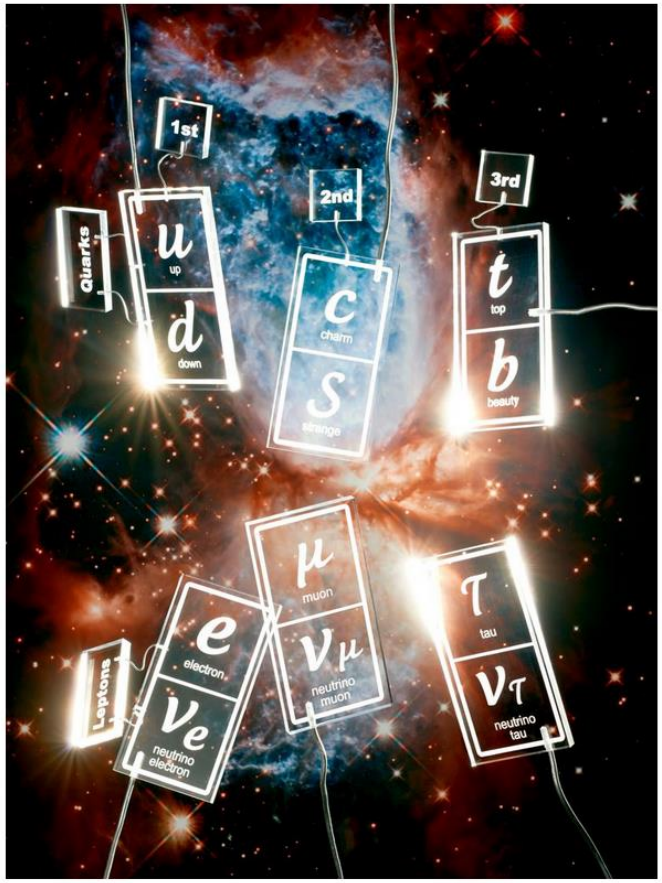
LHCb: hot topic

deVolkskrant

Moeder aller deeltjes: de zoektocht naar de leptoquark

Is het fundamenteelste deeltje in het universum altijd over het hoofd gezien? Komende week kan de wereld opgeschud worden, als natuurkundigen in Seoul hun resultaten bekendmaken. Leptoquark, onthoud dat woord.

Martijn van Calmthout 29 juni 2018, 11:25



Beeld Rein Janssen

NewScientist
IDEEËN DIE DE WERELD VERANDEREN

Cern vindt nieuwe hint voor scheurtjes in standaardmodel

19 april 2017

George van Hal

mogelijke hint dat er meer is dan alleen het
rdmodel. Beeld: Cern.

deVolkskrant

CERN is 'voorzichtig opgewonden' over subtiele verschillen in deeltjeswereld

Een gevoel van 'voorzichtige opwinding' heeft zich meester gemaakt van deeltjesfysici van CERN in Genève. Dinsdag maakte de LHCb-detector daar bekend subtiele verschillen te zien tussen bepaalde deeltjes. De gangbare deeltjestheorie neemt aan dat deeltjes in essentie identiek zijn.

Martijn van Calmthout 19 april 2017, 21:29

Wellicht is de deeltjeswereld niet zo democratisch als vooraf gedacht werd. Beeld epa

LHCb: hot topic

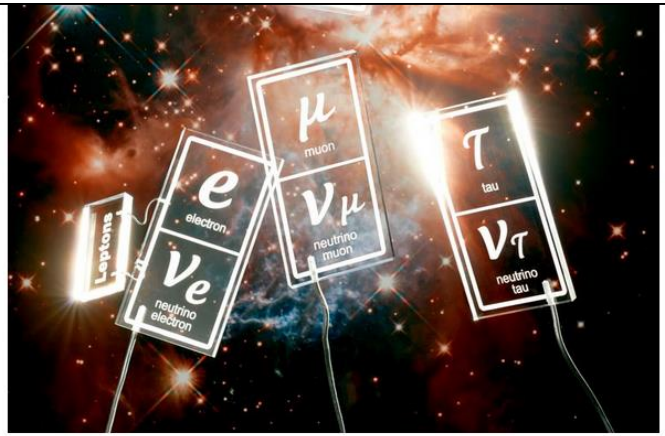
deVolkskrant

Moeder aller deeltjes: de zoektocht naar de leptoquark

Is het fundamenteelste deeltje in het universum altijd over het hoofd gezien? Komende week kan de wereld opgeschud worden, als natuurkundigen in Seoul hun resultaten bekendmaken. Leptoquark, onthoud dat woord.

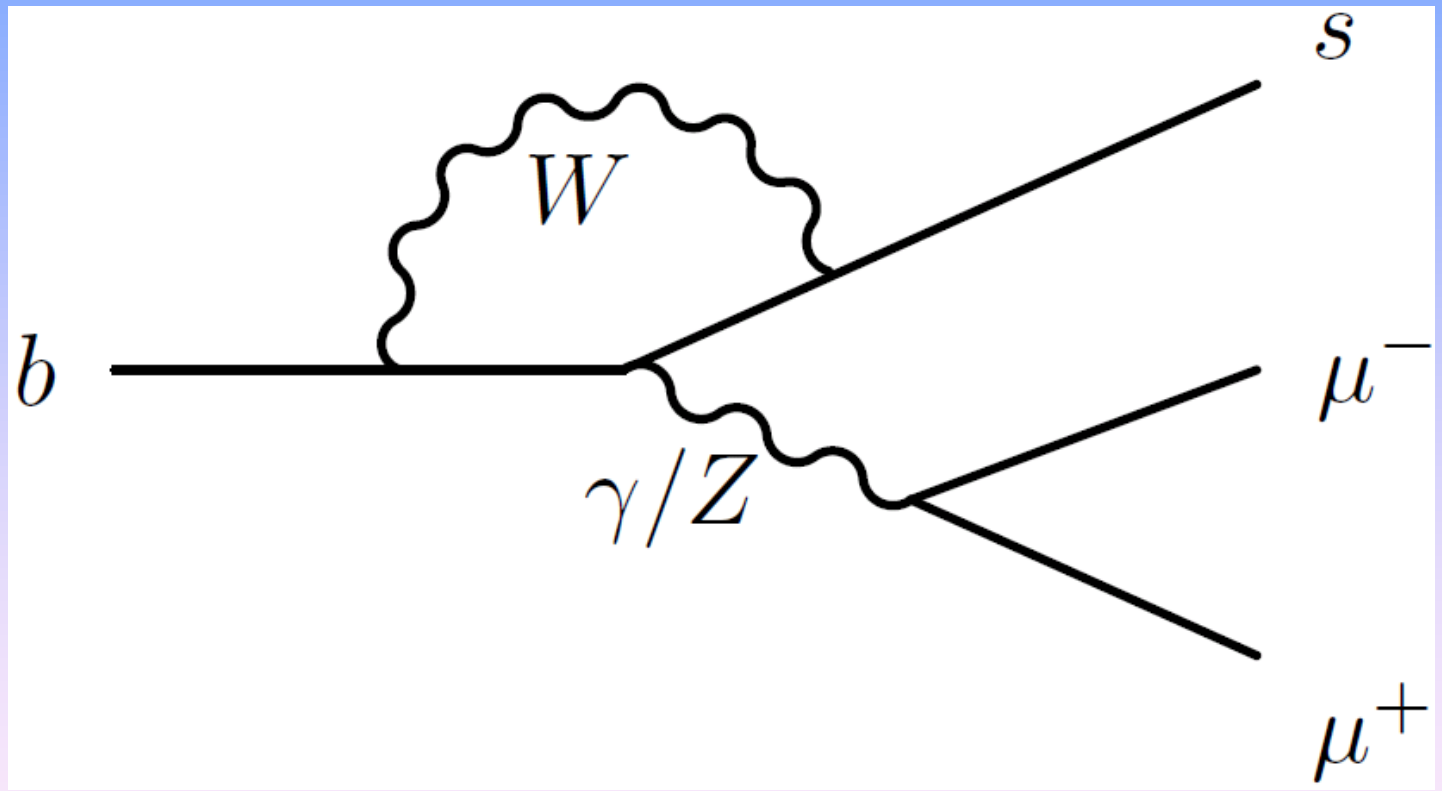
Martijn van Calmthout 29 juni 2018, 11:25

Maar de LHCb-metingen geven al jaren kleine hints dat er iets mis is met deze keurige lepton-universaliteit. En dat elektronen en muonen ergens diep van binnen toch net iets anders met quarks omgaan.

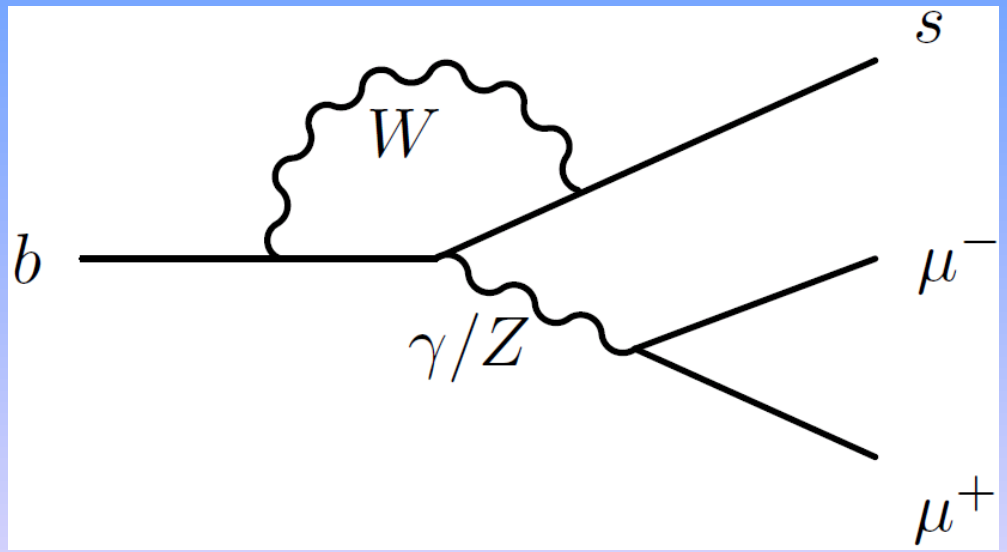


Beeld Rein Janssen

LHCb: hot topic



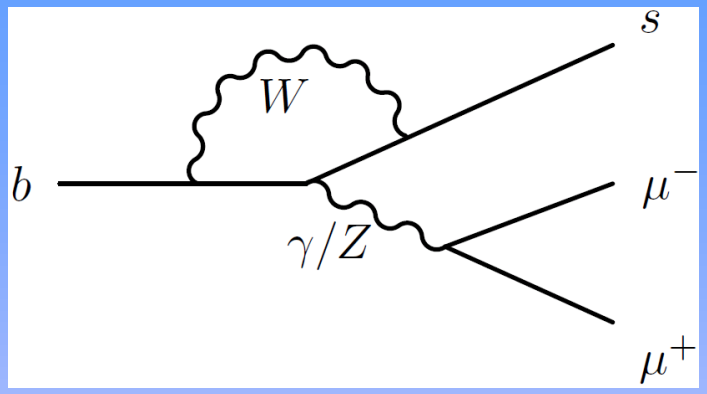
LHCb: hot topic



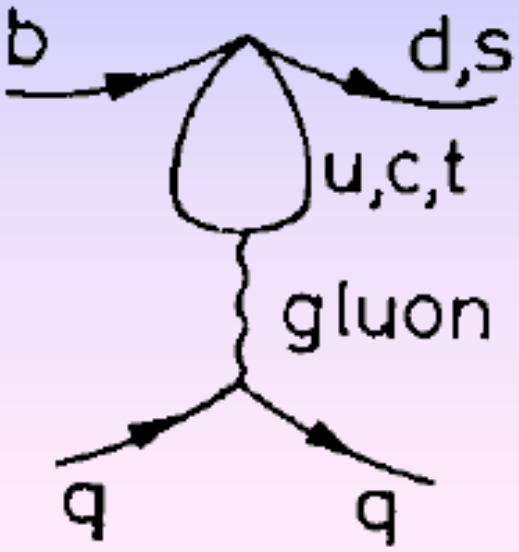
Flavour changing neutral current electroweak penguin

FCNC EWP

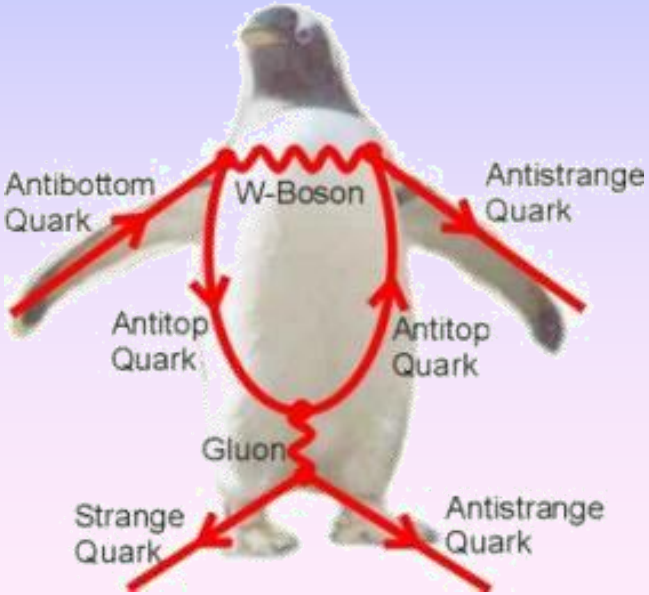
LHCb: hot topic



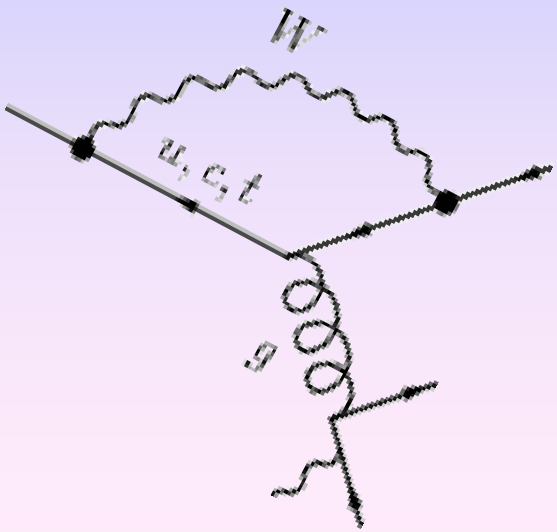
The original penguin:



A real penguin:

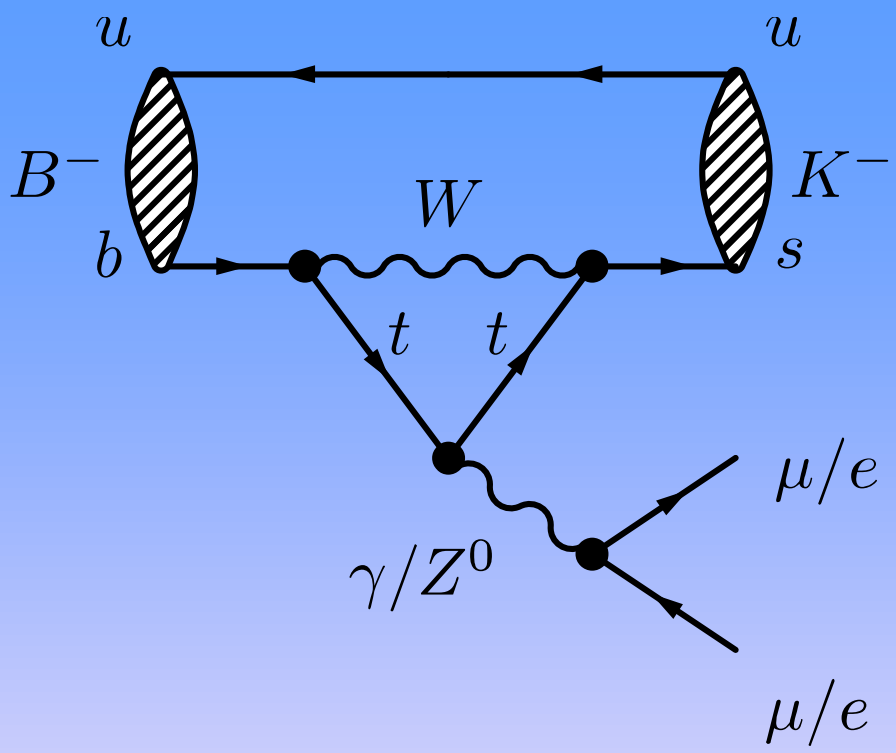


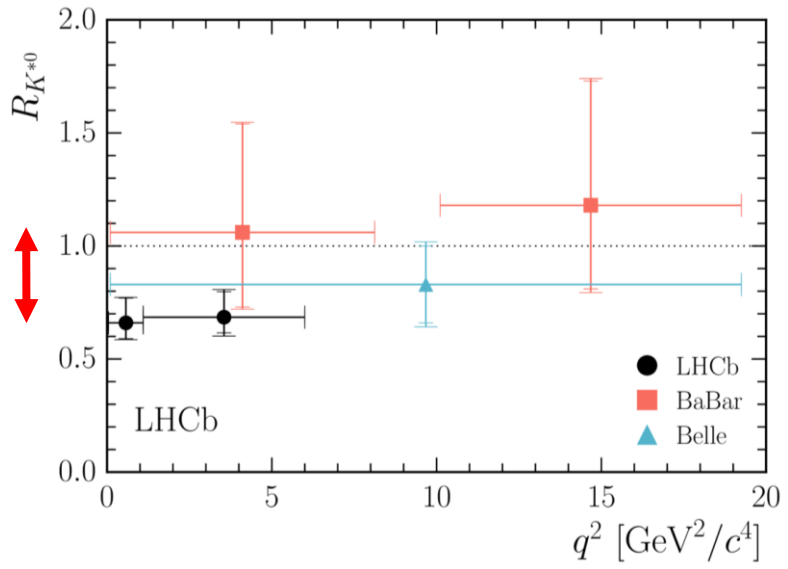
Our penguin:

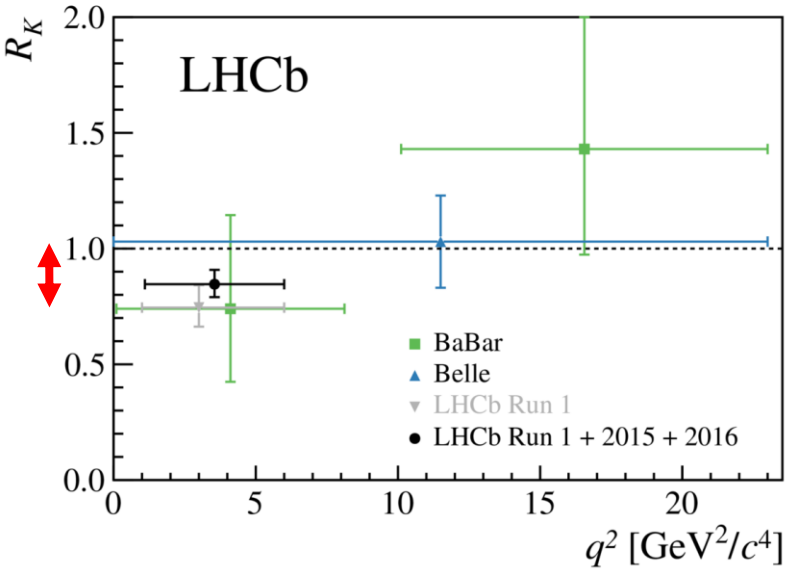


LHCb: hot topic

Electronen en muonen gedragen zich anders?

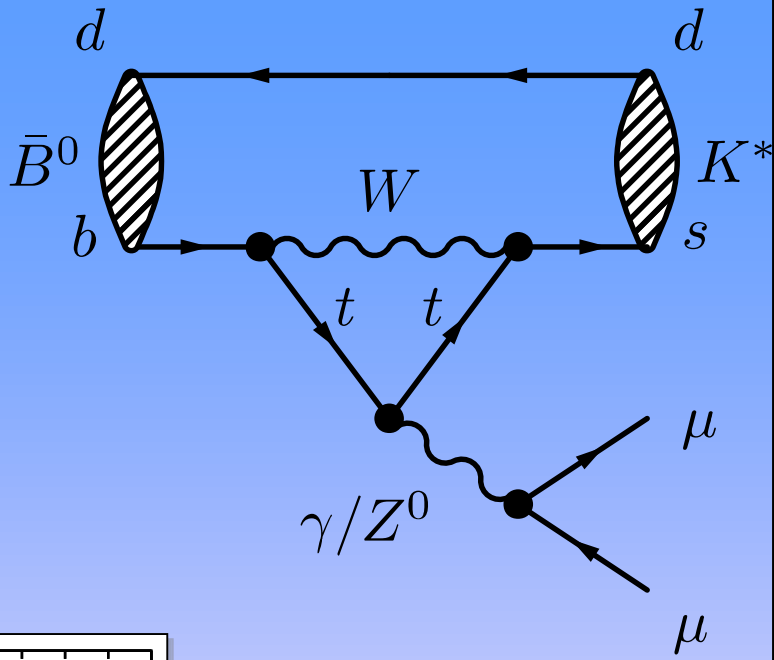


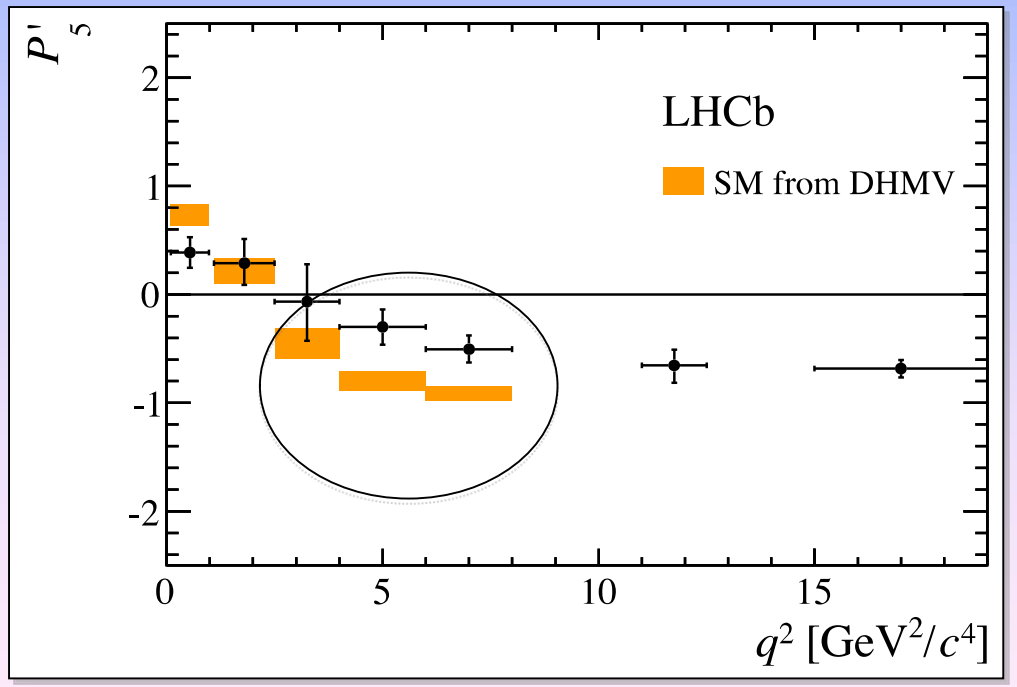




LHCb: hot topic

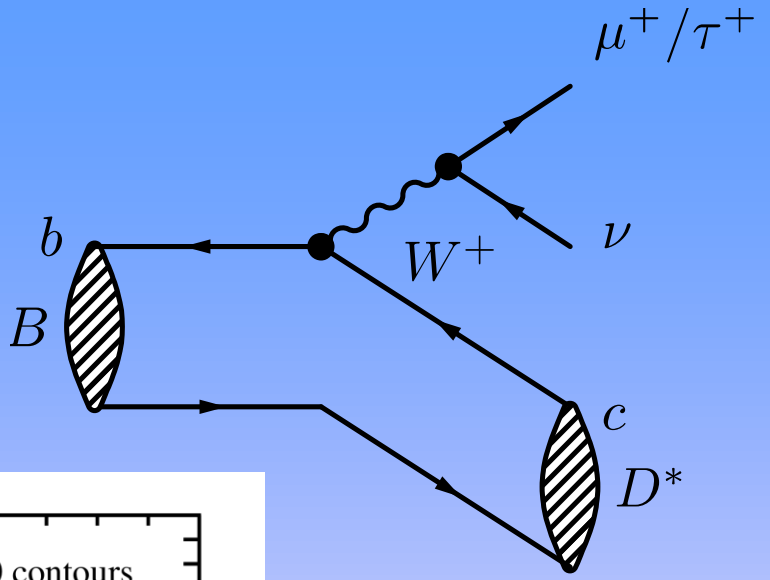
Ook hoekverdeling is anders…

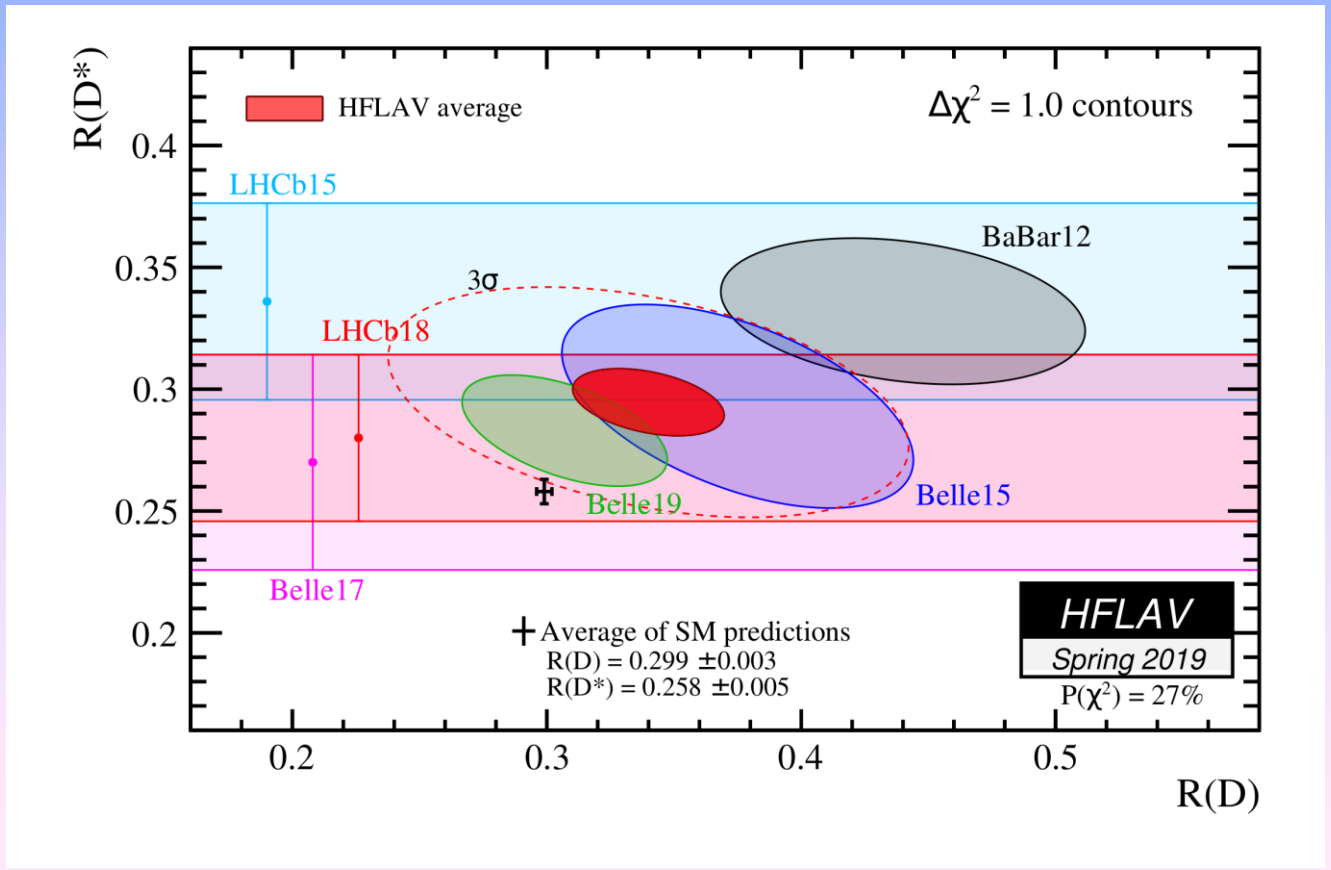




LHCb: hot topic

En muonen en tau-deeltjes gedragen zich anders??





LHCb: wat kan het zijn?

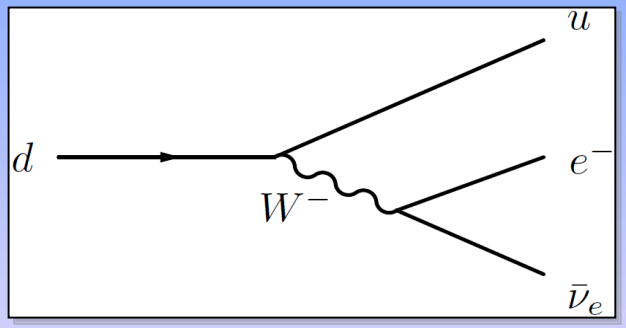
deVolkskrant

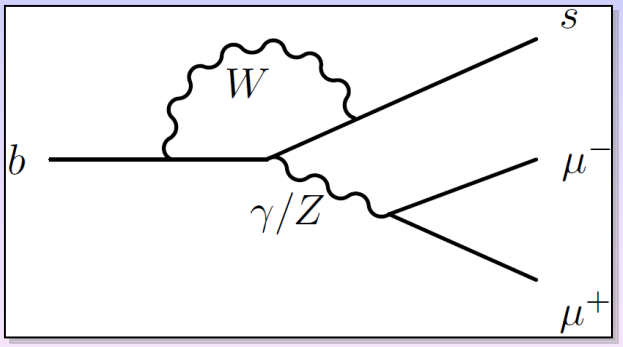
Moeder aller deeltjes: de zoektocht naar de leptoquark

Is het fundamenteelste deeltje in het universum altijd over het hoofd gezien? Komende week kan de wereld opgeschud worden, als natuurkundigen in Seoul hun resultaten bekendmaken. Leptoquark, onthoud dat woord.

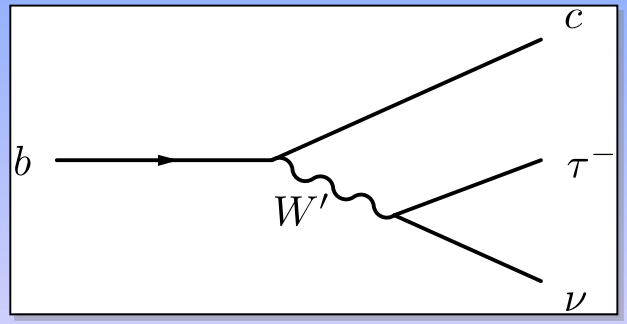
Martijn van Calmthout 29 juni 2018, 11:25

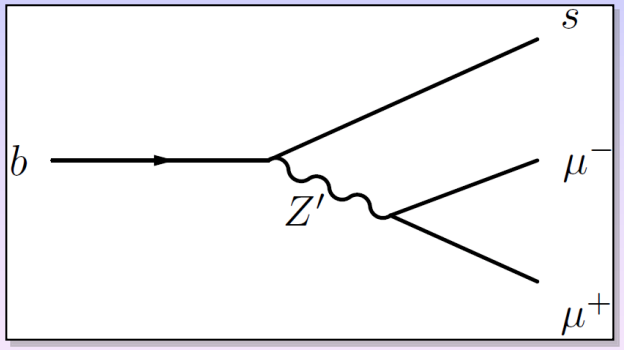
SM



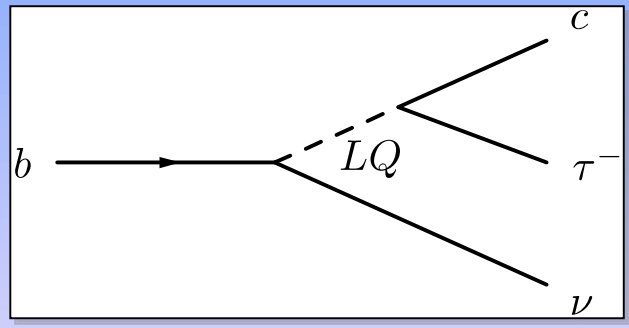


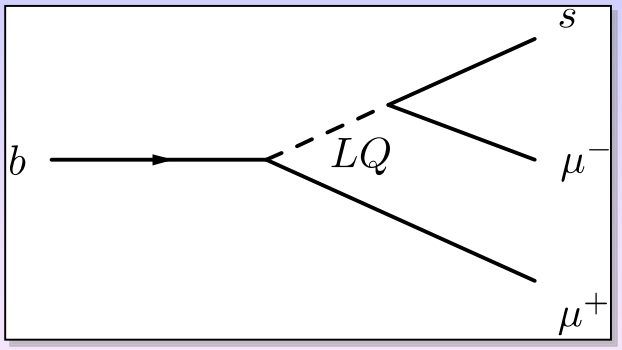
SU(2)'





Leptoquark





Leptoquark, onthoud dat woord.

M. Van Calmthout

LHCb zoekt naar nieuwe deeltjes om antwoorden te zoeken op grote vragen

II. Patronen??
(waarom massa's en koppelingen)

I. Anti-materie??
(waar is het gebleven)

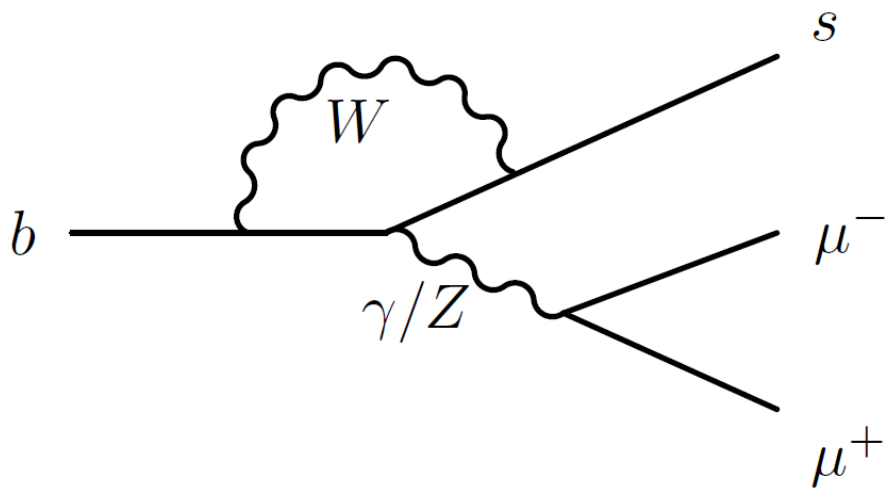
III. Donkere materie??
(wat klonterde de sterrenstelsels)

Take home message

1) LHCb zoekt verschillen tussen materie en antimaterie

1) LHCb kan zeer zware deeltjes vinden (maar alleen *virtueel*)

1) Nieuwe deeltjes helpen om grote vragen te beantwoorden



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