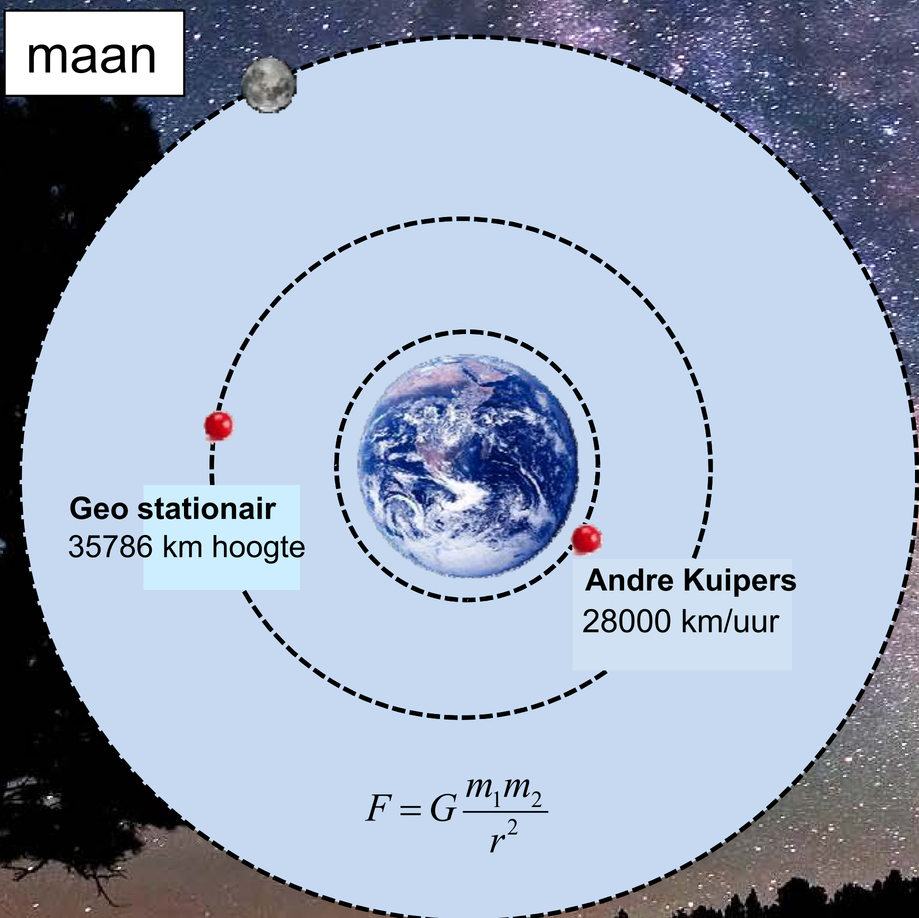
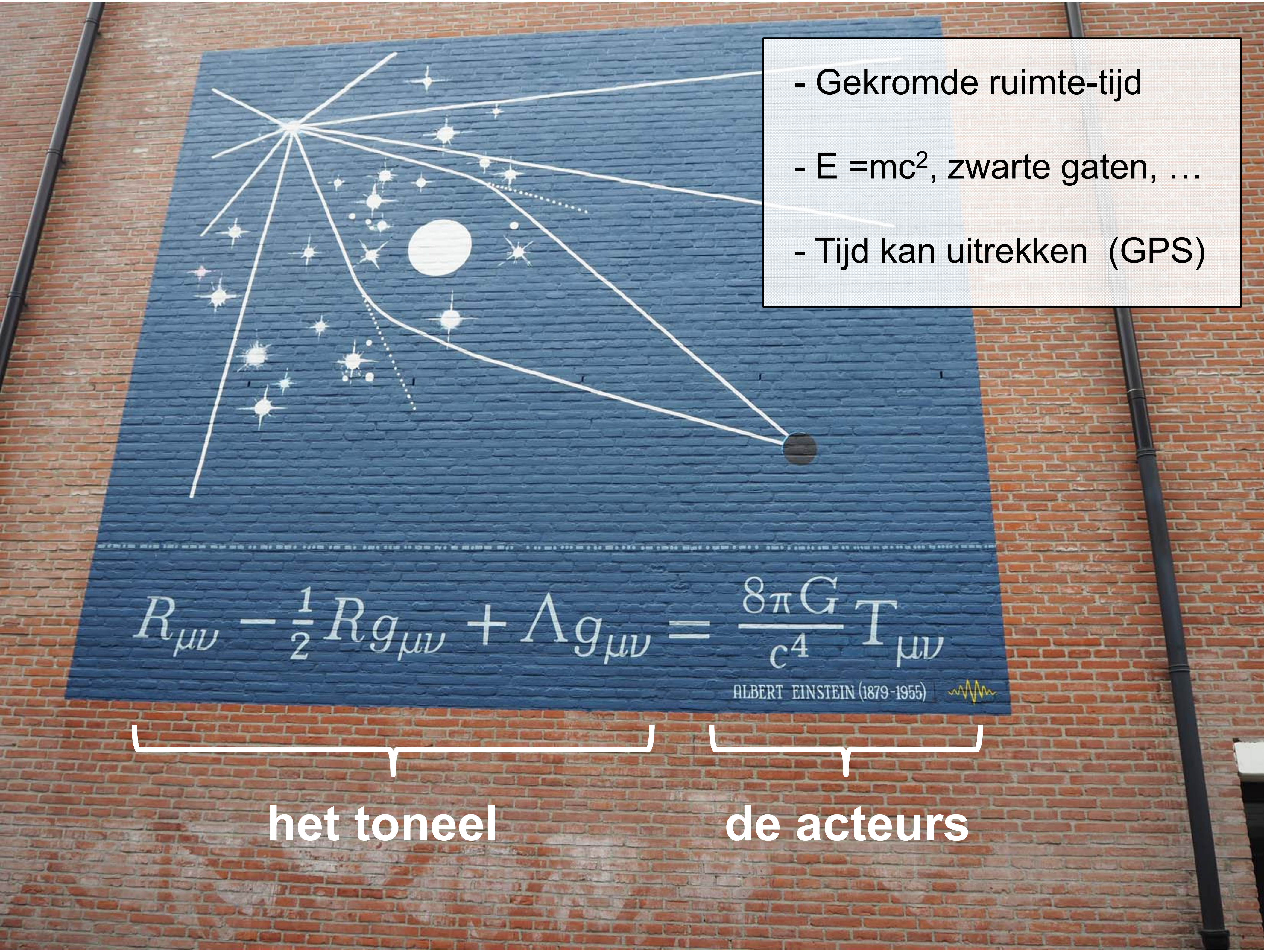
De magische wereld van het allerkleinste

Viva Fysica, 26 januari 2017

Ivo van Vulpen

Wereld van het allergrootste



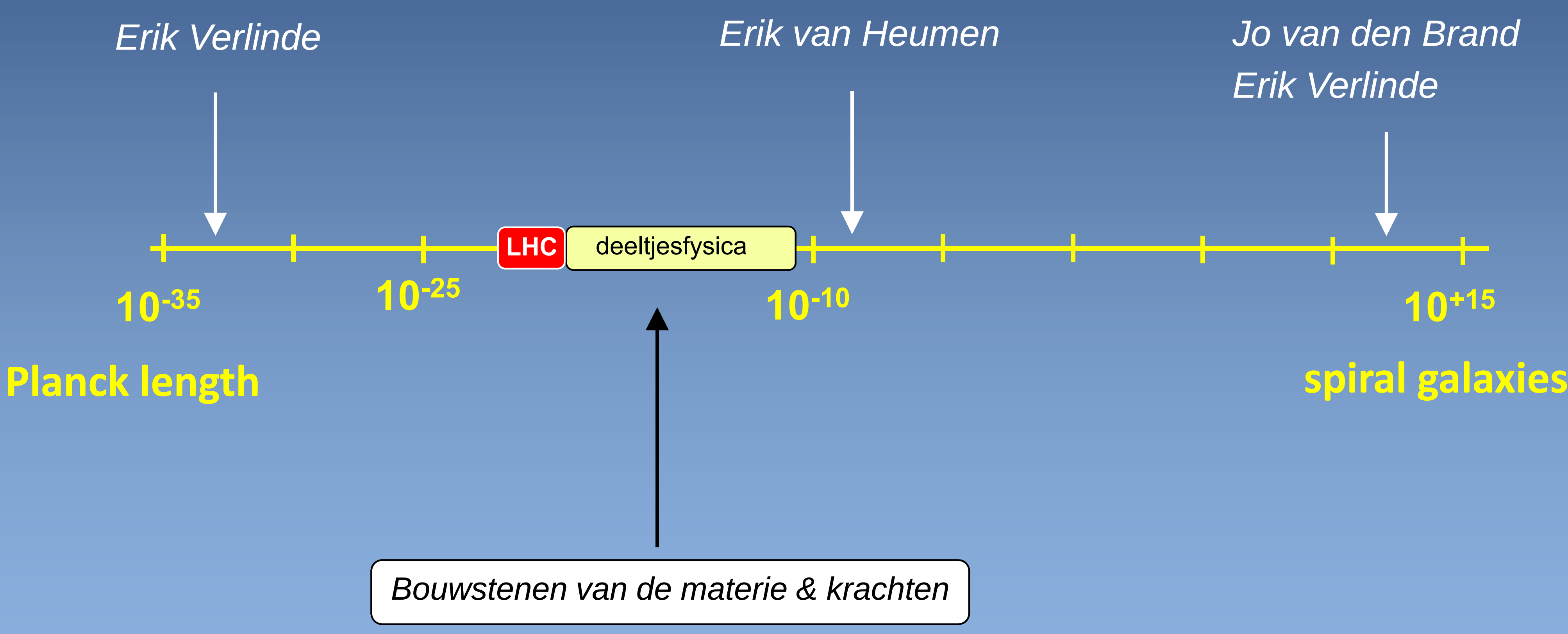


- Gekromde ruimte-tijd
- E =mc^2, zwarte gaten, …
- Tijd kan uitrekken (GPS)

het toneel

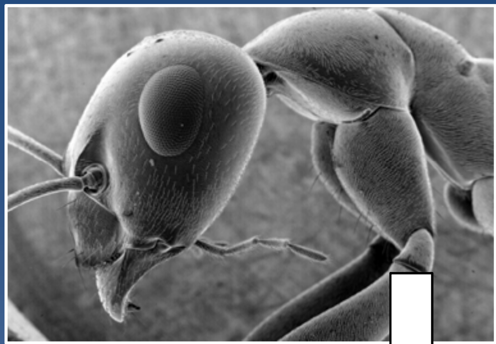
de acteurs

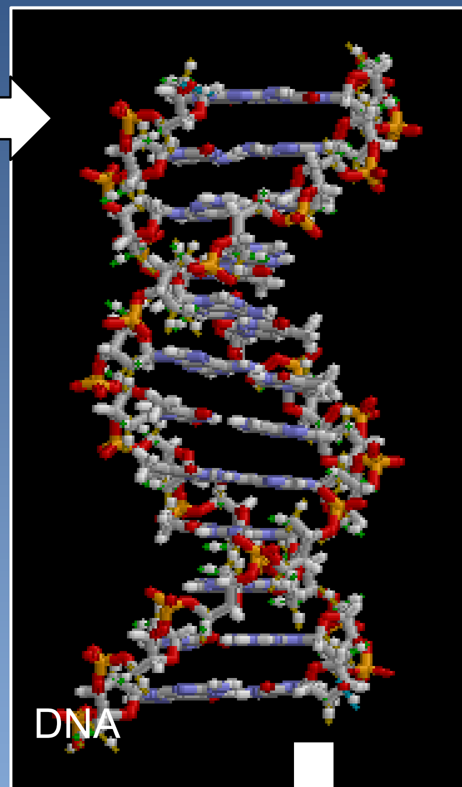
Afstandsschalen in de natuur

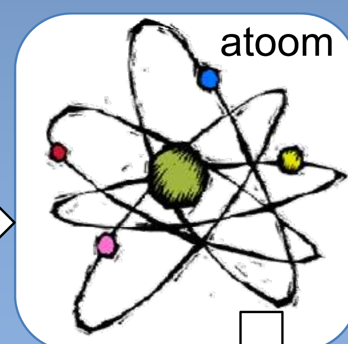


CERN in Genève, Zwitserland

Zoektocht naar de elementaire bouwstenen van de natuur







de wereld van de quantummechanica

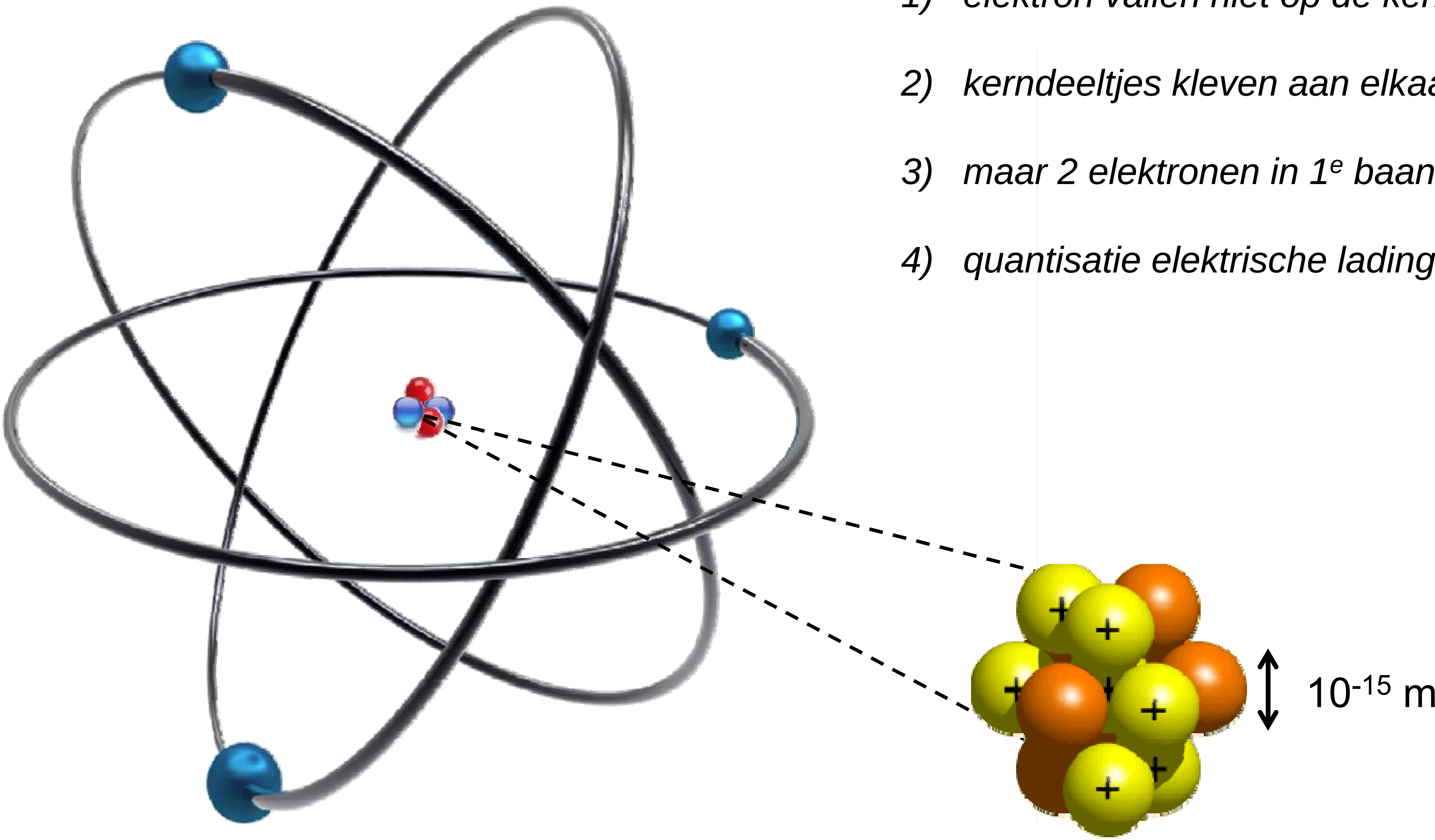
atoomkern

Wereldrecord: 10^{-20} [m]

kleiner en kleiner

Waarom, … waarom, … waarom ?

De wereld van het atoom



1) *elektron vallen niet op de kern*
2) *kerndeeltjes kleven aan elkaar*
3) *maar 2 elektronen in 1e baan*
4) *quantisatie elektrische lading*

$$\Psi_{nlm}(r,\theta,\varphi) = R_{nl}(r)\ Y_l^m(\theta,\varphi)\ \chi_{s,s_z}$$

Ivo van Vulpen @IvovanVulpen · Oct 5

Wow!!! **Quantum mag weer** (en kwantum ook @sensemolen). Ge-wel-dig. Handjes op elkaar voor de @taalunie. @onzetaal @maresep @michelvanbaal

Taalunie @taalunie · 3m

@onzetaal @IvovanVulpen @maresep @michelvanbaal Conclusie: in de volgende release van woordenlijst.org zullen alle vormen >>

Taalunie @taalunie · 50s — View translation

@onzetaal @IvovanVulpen @maresep @michelvanbaal met 'kwantum'/'quantum' dubbel opgenomen zijn. Motivatie: de twee vormen komen in >>

Taalunie @taalunie · 18s

@onzetaal @IvovanVulpen @maresep @michelvanbaal de praktijk veel naast elkaar voor.

Quantum onderzoek in 2016

Standaard Model

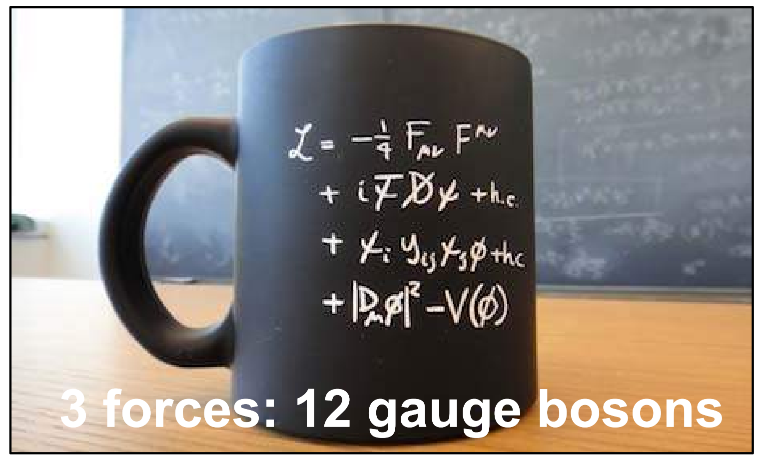
The Standard Model

Elementary particles

up-quark	u	c	t
down-quark	d	s	b
elektron	e	μ	τ
neutrino	ν_e	ν_μ	ν_τ

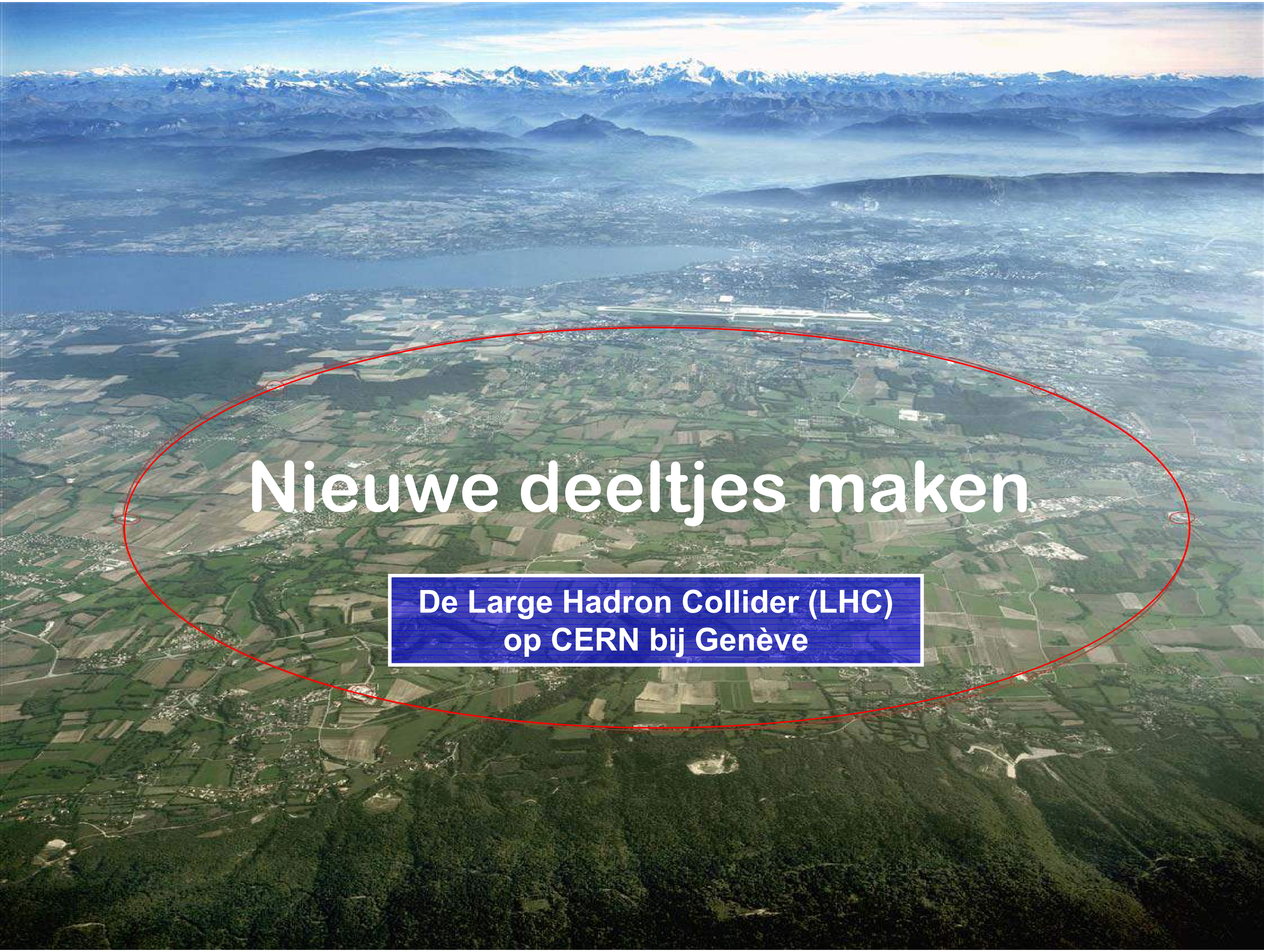
muon

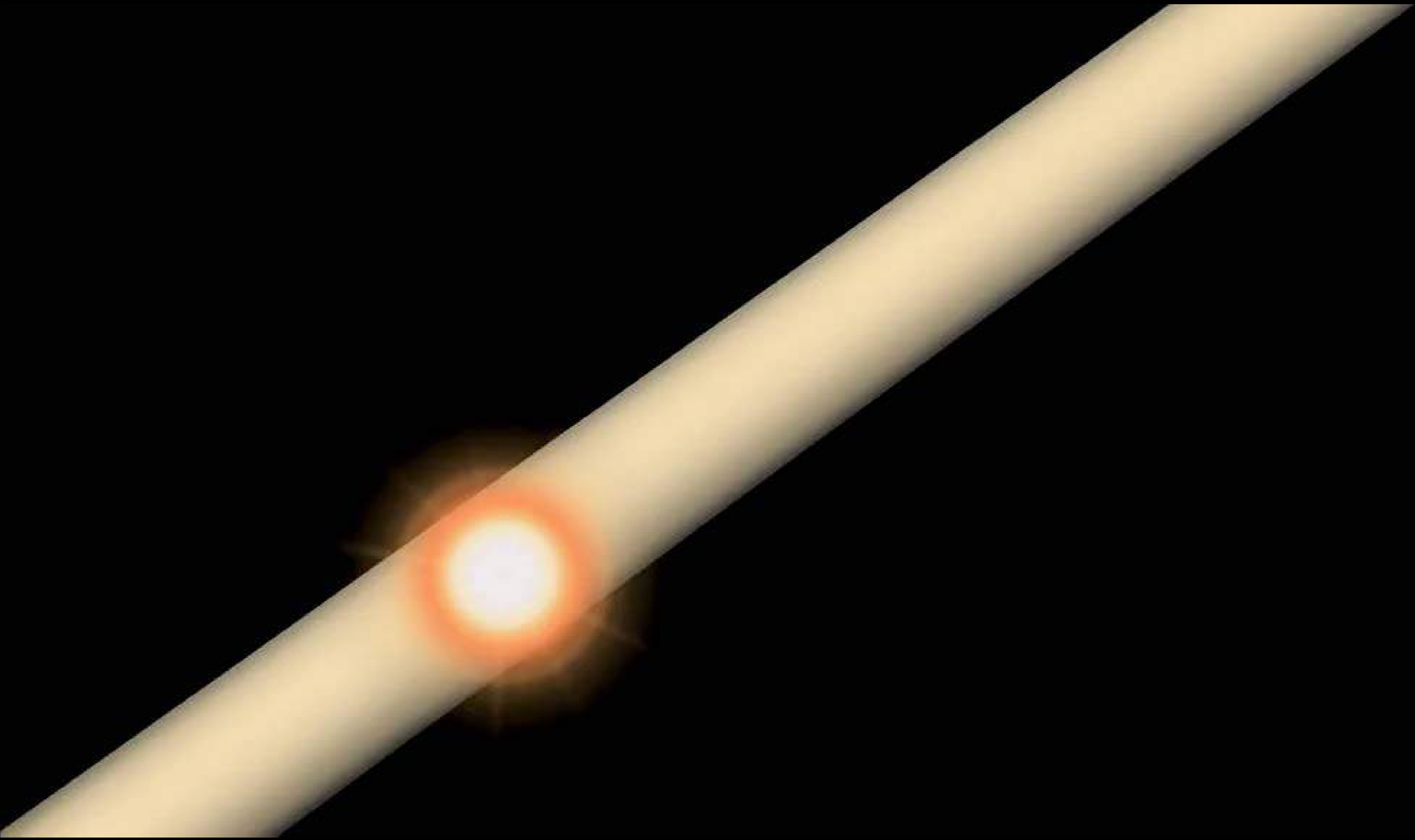
Interactions

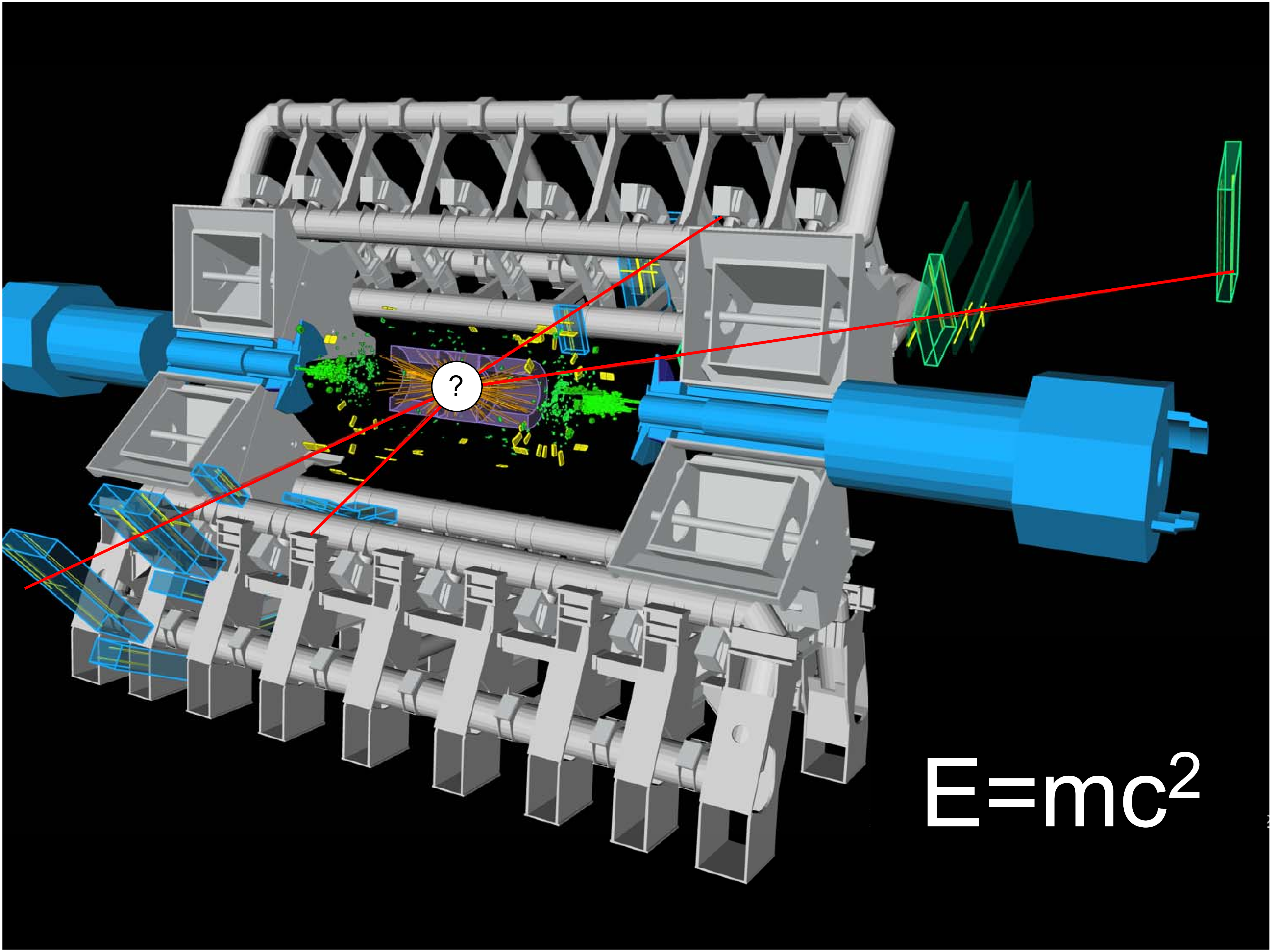


Standaard Model raar ? Gerri Eickhof, … die is pas raar

$$E = mc^2$$

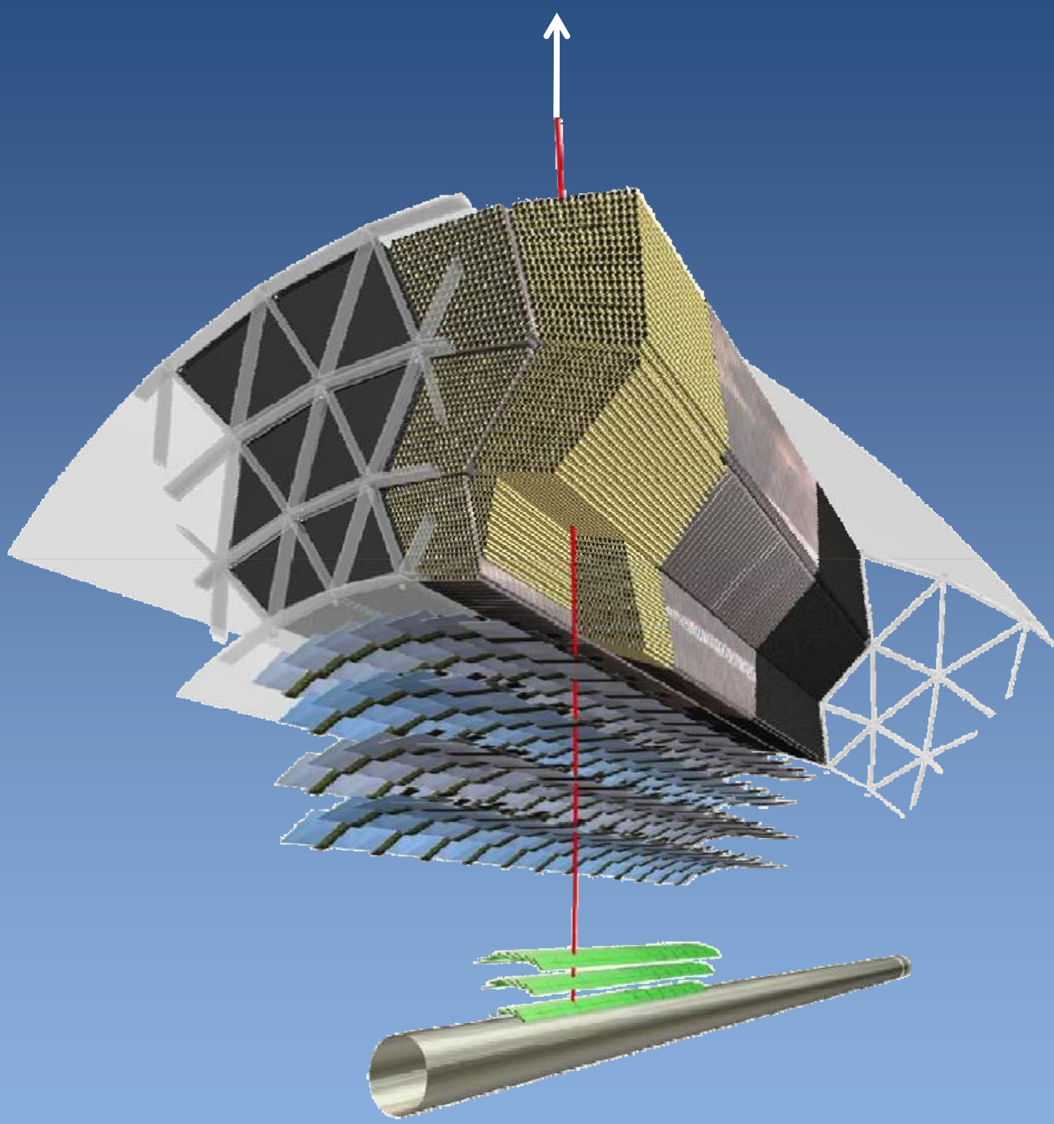

Nieuwe deeltjes maken
De Large Hadron Collider (LHC)
op CERN bij Genève




?
$E=mc^2$

Iets reconstrueren uit overblijfselen

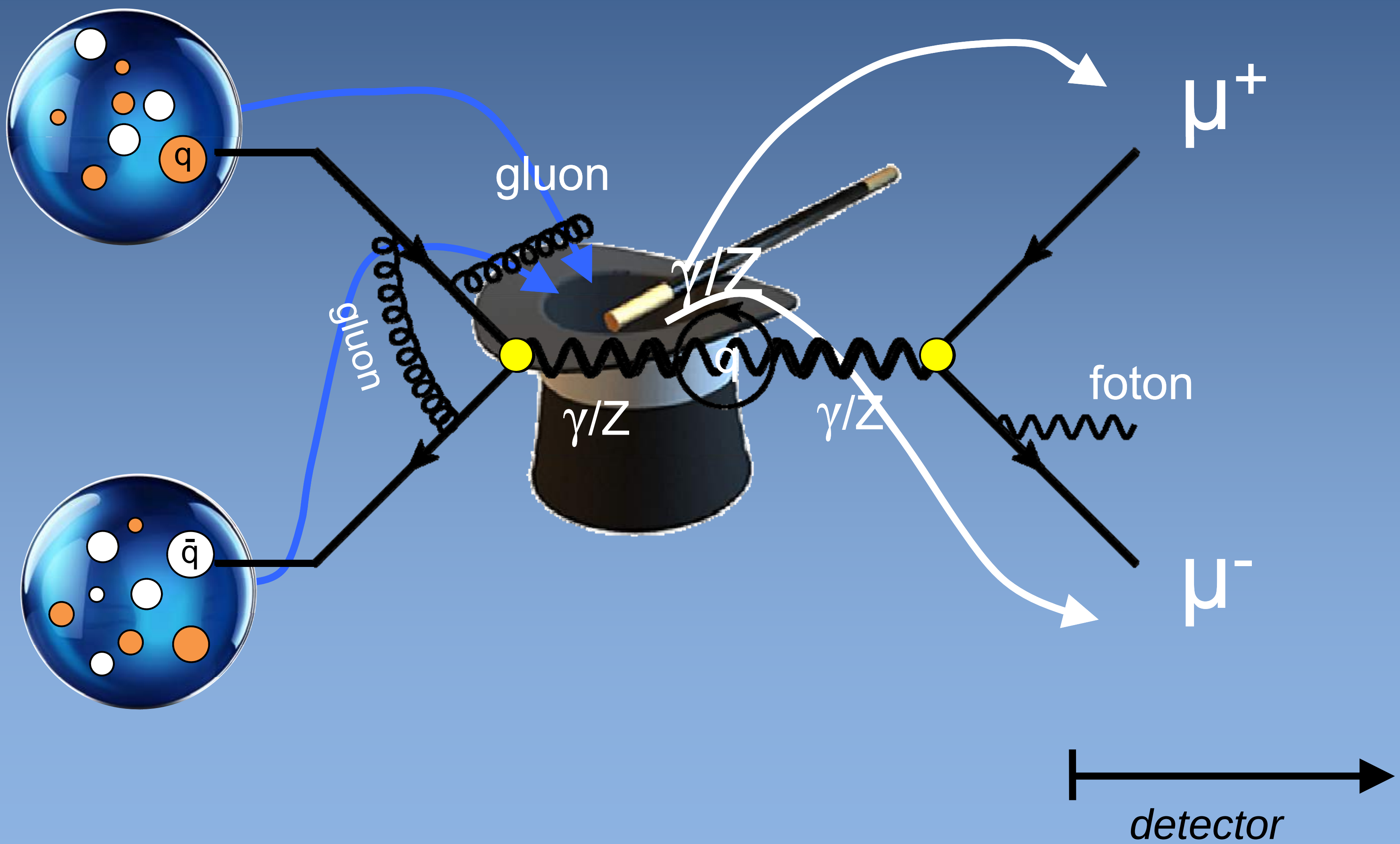
muon of electron ?

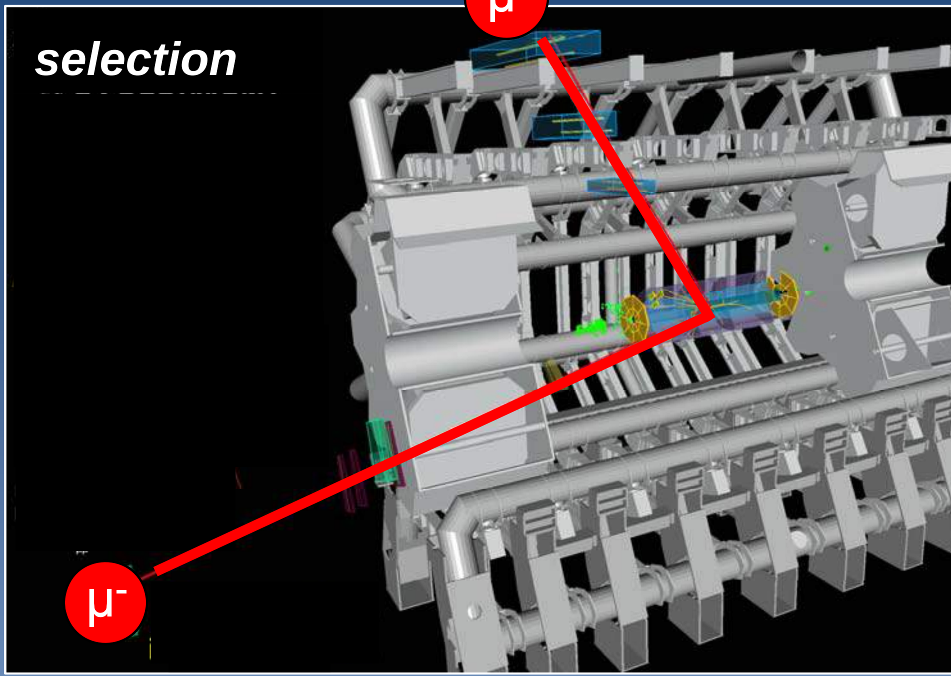


konijn of mens ?

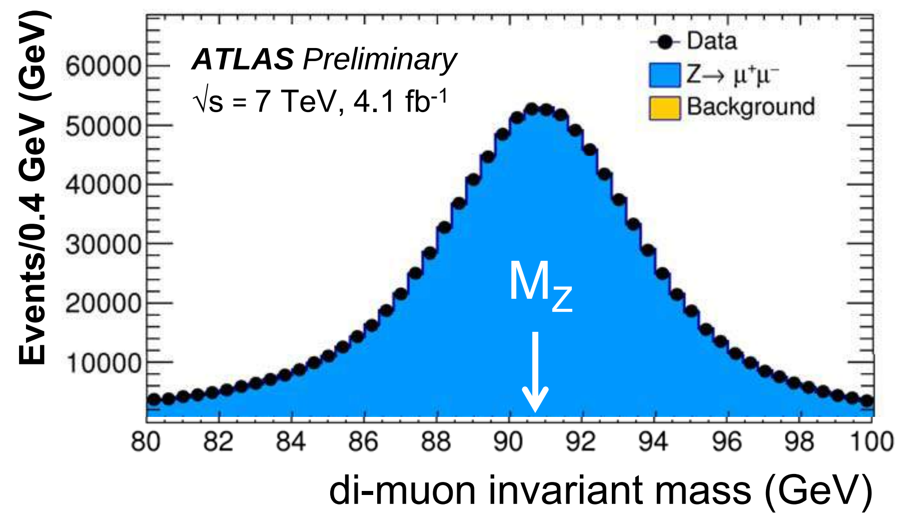
Identificatie

Transitions in the Standard Model

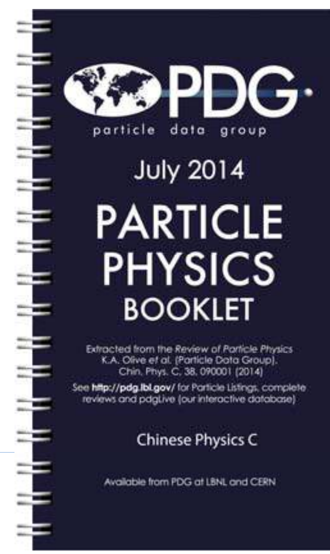




data vs simulations



Heavy particle production: the Z-boson

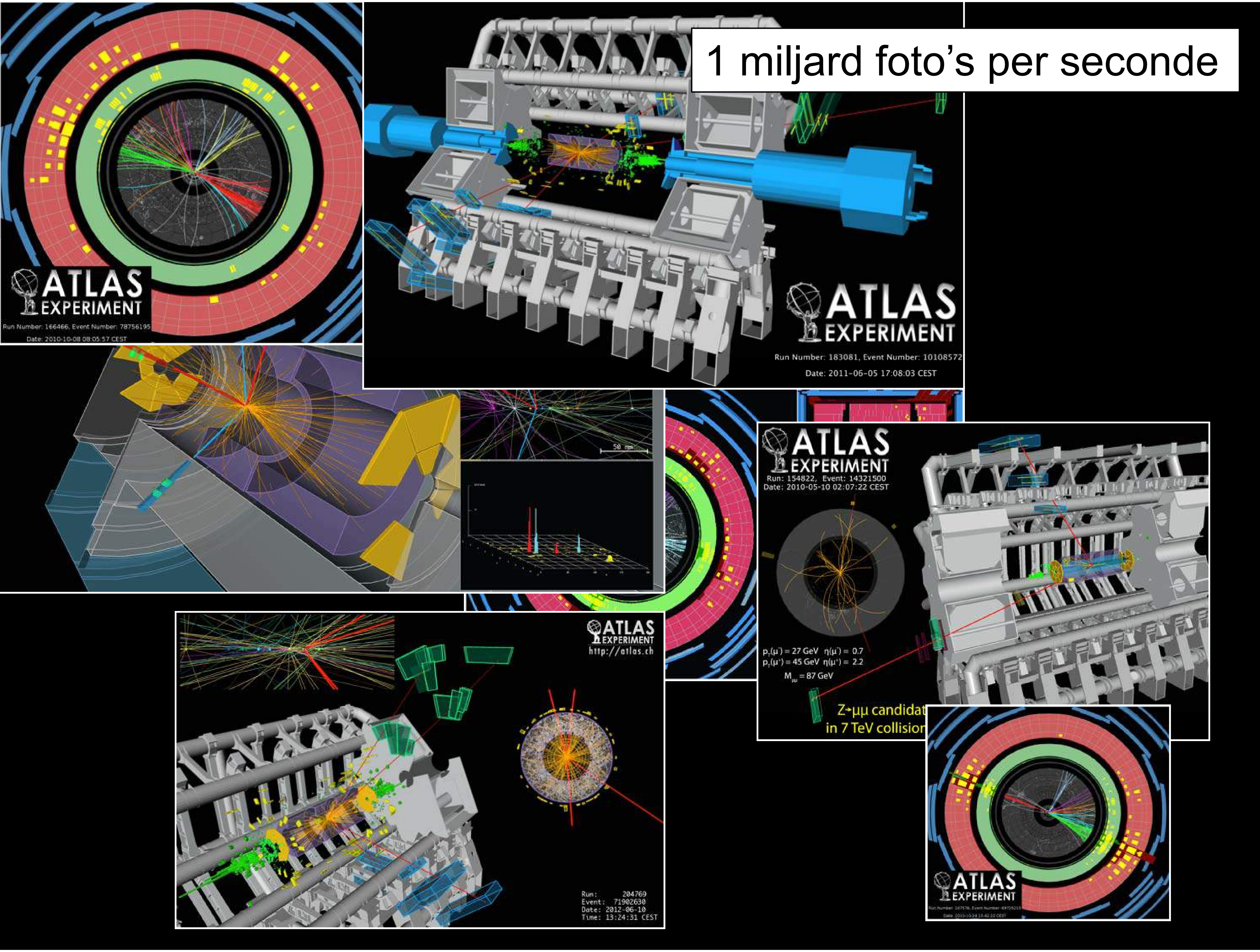


model parameters

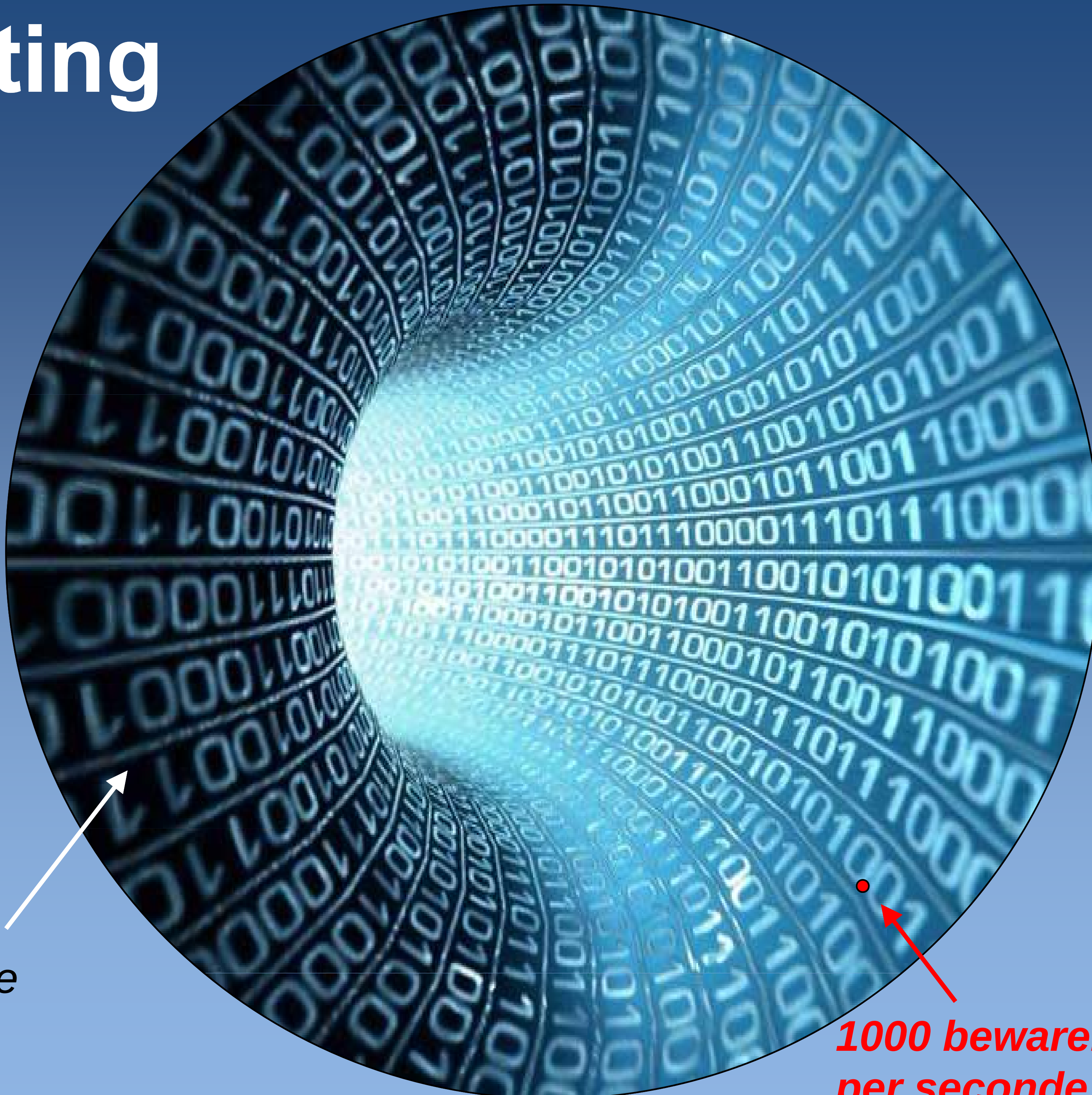
M_Z = 91.1876 ± 0.0021 GeV

Γ_Z = 2.4952 ± 0.0023 GeV

1 miljard foto's per seconde



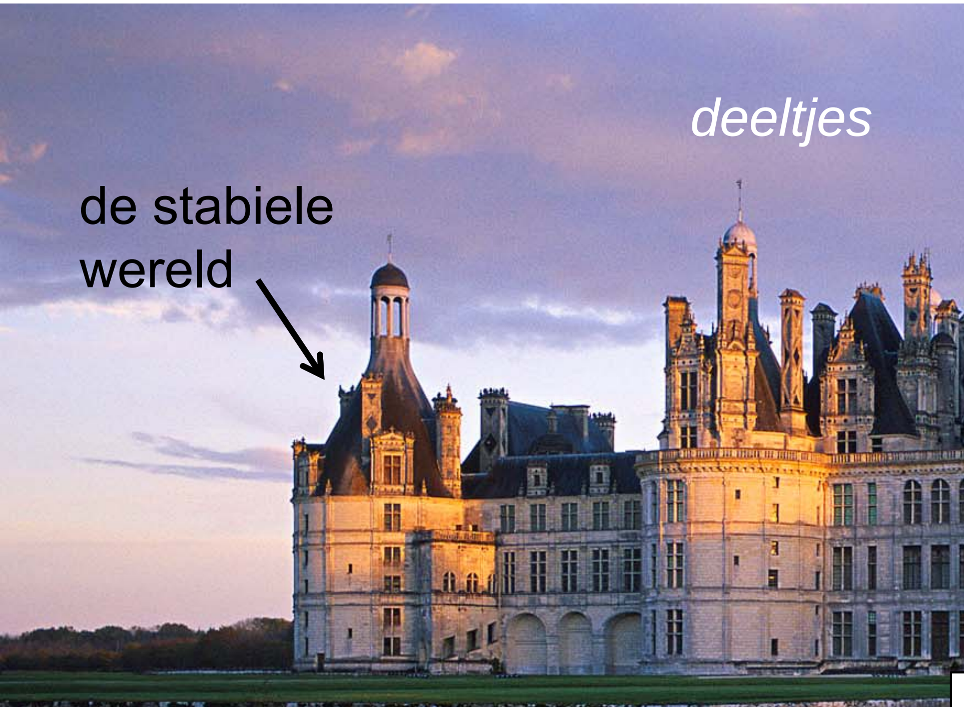
computing



1.000.000.000
foto's per seconde

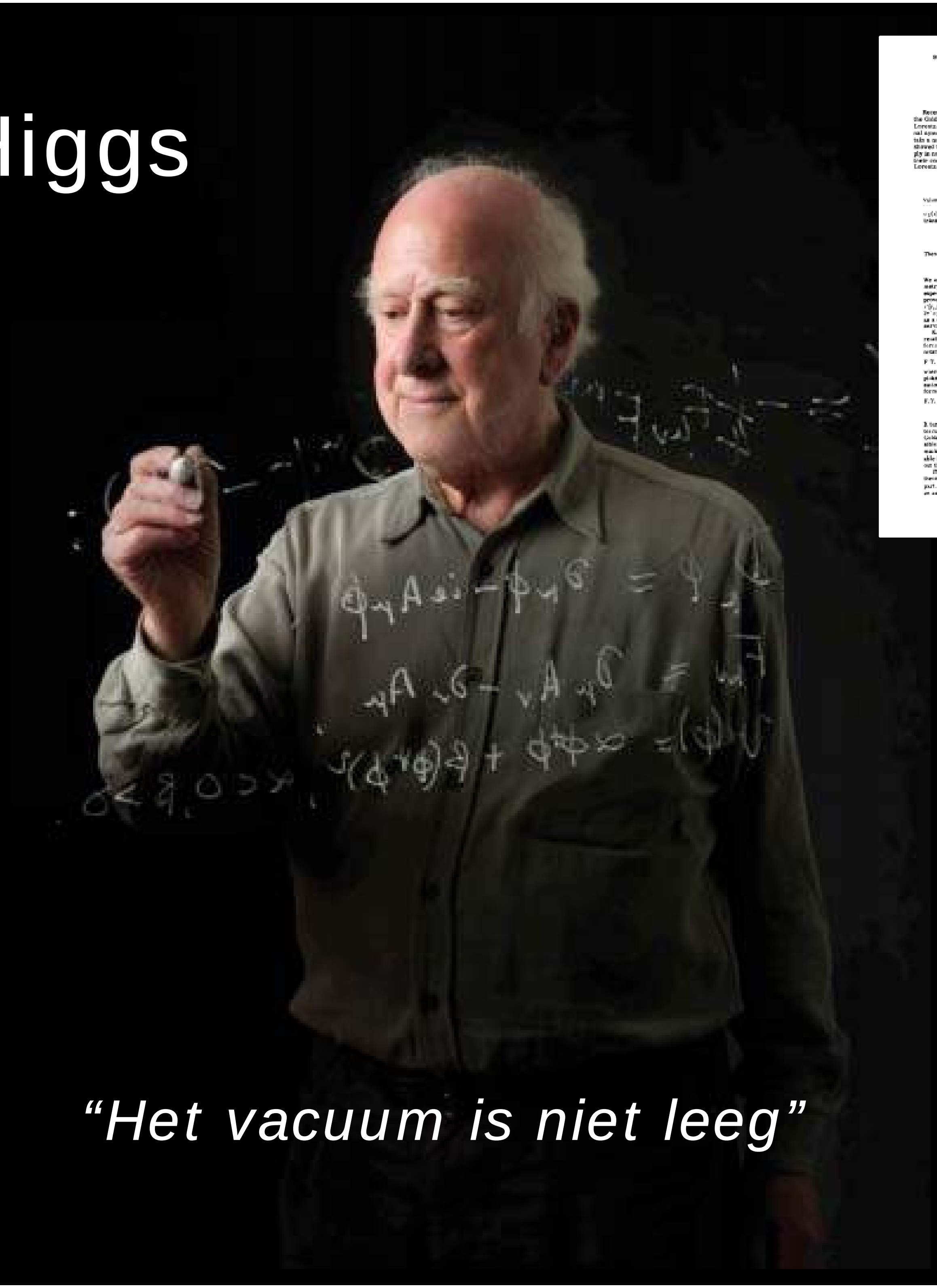
1000 bewaren
per seconde

Higgs boson



Het Standaard Mod

Peter Higgs



BROKEN SYMMETRIES, MASSLESS PARTICLES AND GAUGE FIELDS

P. W. HIGGS

Received 27 July 1964

Recently a number of people have discussed the Goldstone theorem [1,2]: that any solution of a Lorentz-invariant theory which violates an internal symmetry operation of that theory must contain a massless scalar particle. Klein and Lee [3] showed that this theorem does not necessarily apply in non-relativistic theories and implied that their considerations would apply equally well to Lorentz-invariant field theories. Gilbert [4], however, gave a proof that the failure of the Goldstone theorem in the nonrelativistic case is of a type which cannot exist when Lorentz invariance is imposed on a theory. The purpose of this note is to show that Gilbert's argument fails for an important class of field theories, that in which the conserved currents are coupled to gauge fields.

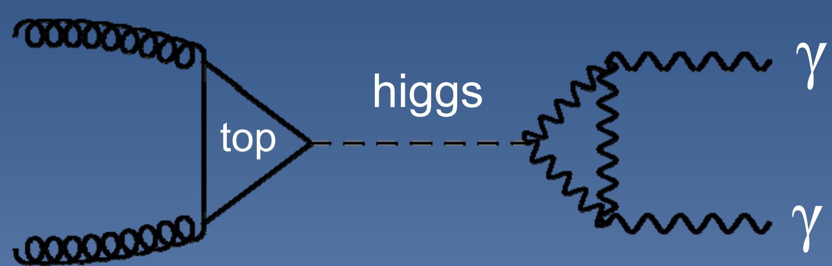
Following the procedure used by Gilbert [4], let us consider a theory of two hermitian scalar fields

PHYSICS LETTERS

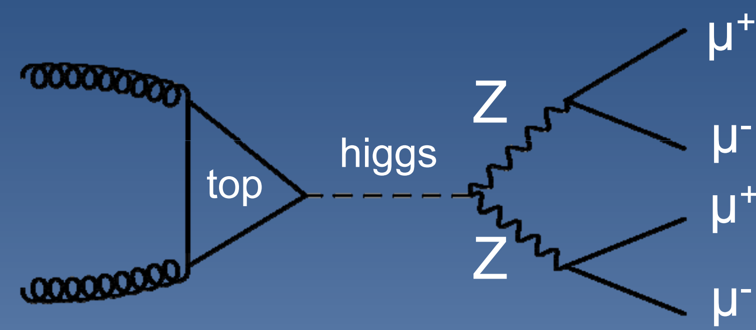
1964, 1 pagina

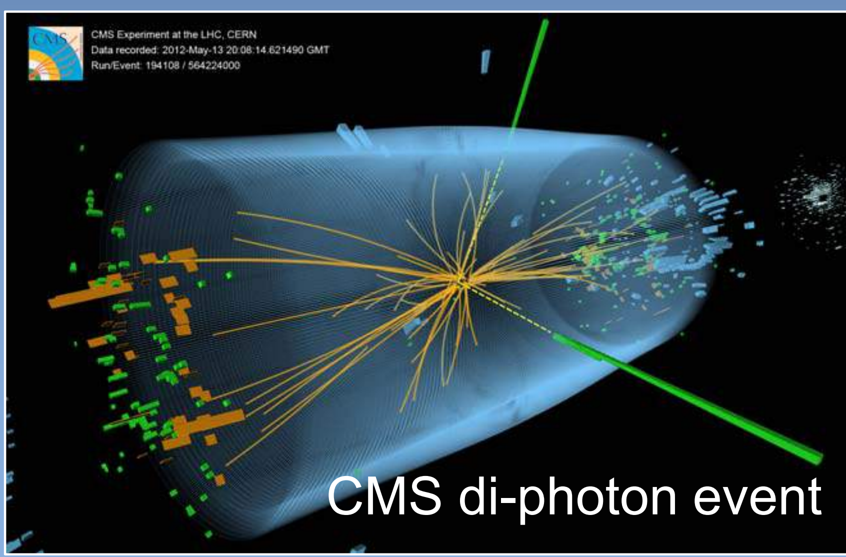
“Het vacuum is niet leeg”

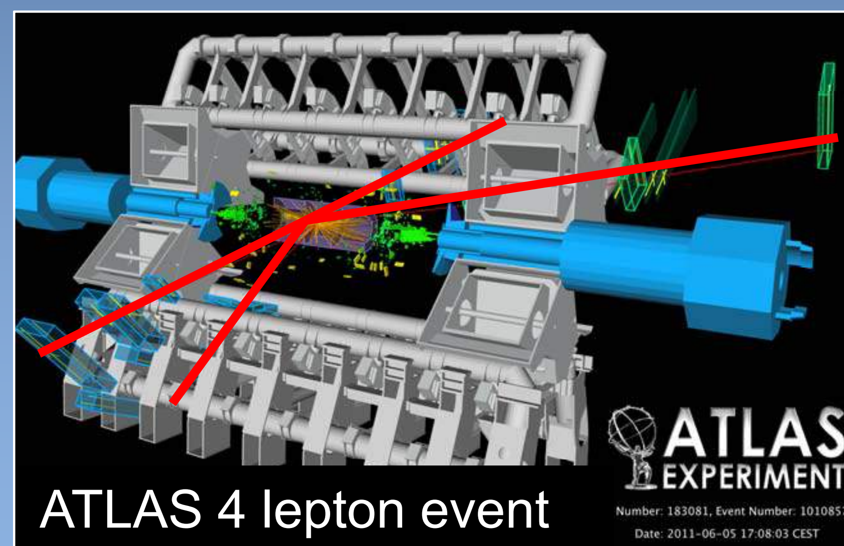
Higgs boson decay to 2 photons



Higgs boson decay to 4 leptons

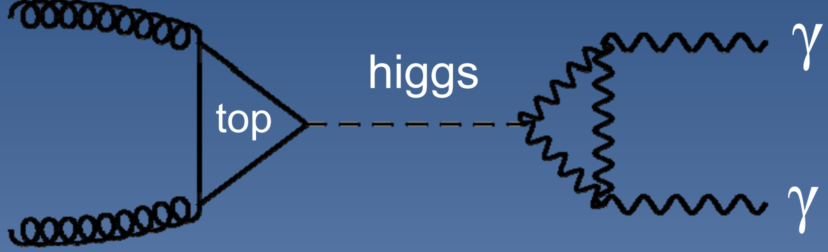


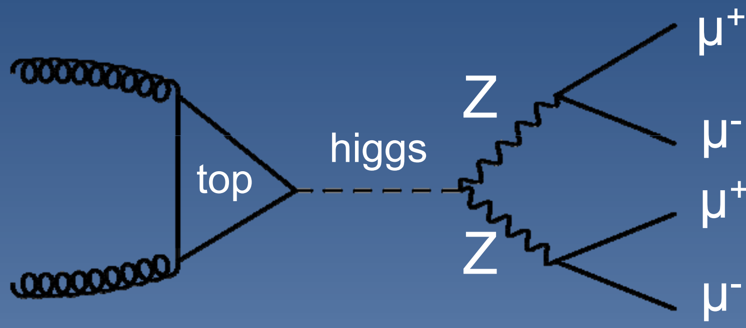


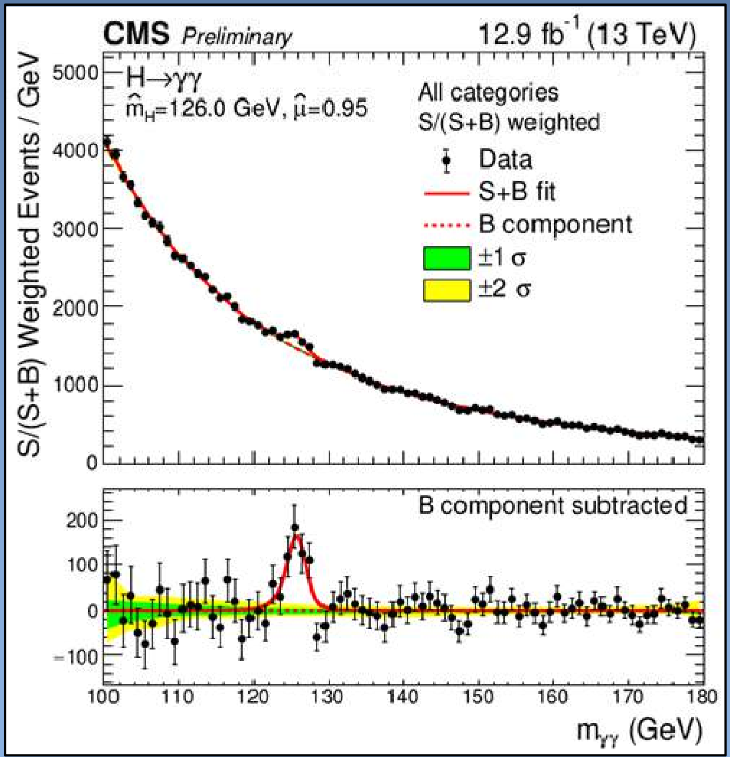


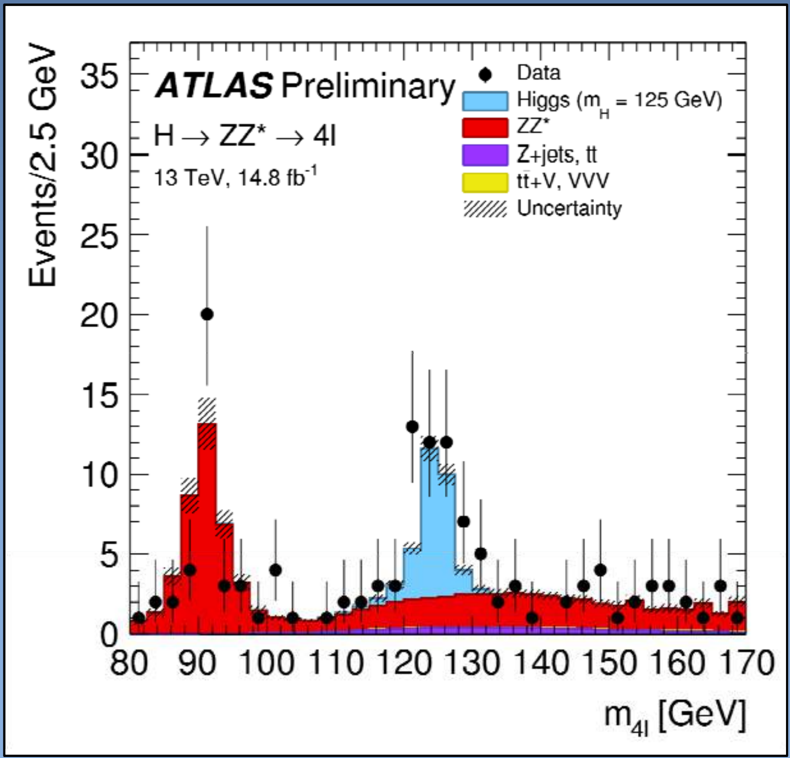
Higgs boson decay to 2 photons

Higgs boson decay to 4 leptons





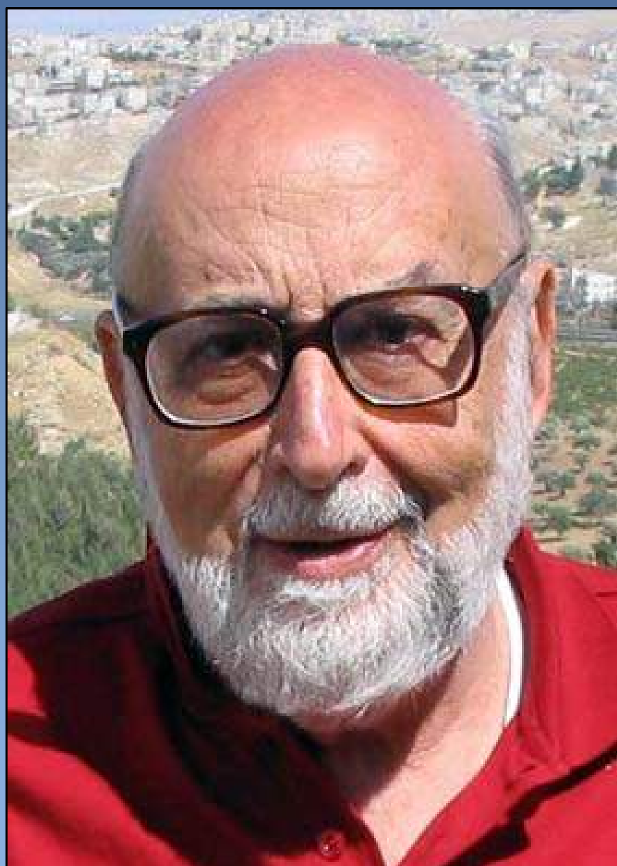




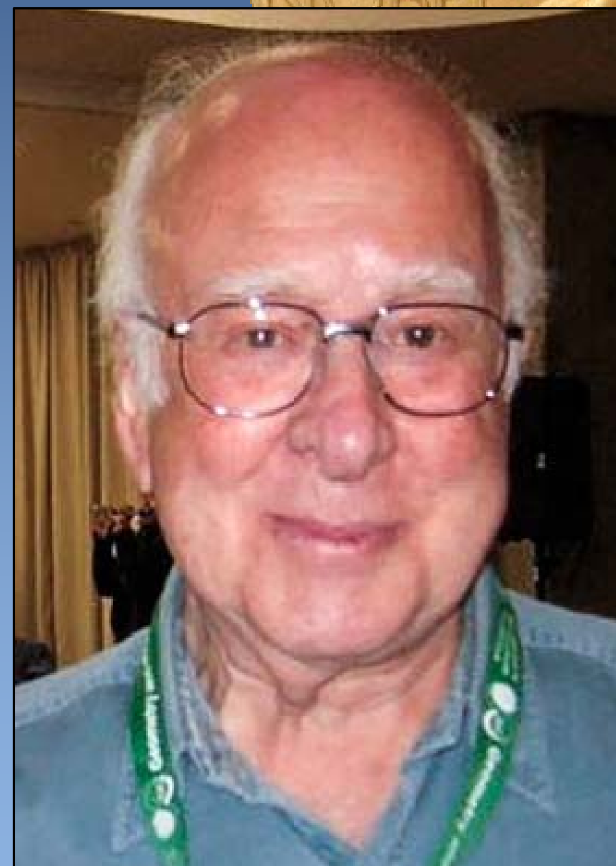
ATLAS+CMS: $m_h = 125.09 \pm 0.21(\text{stat}) \pm 0.11(\text{syst})$ GeV

Nobelprijs natuurkunde 2013

“Er is een Higgs-veld in het vacuum”



François Englert

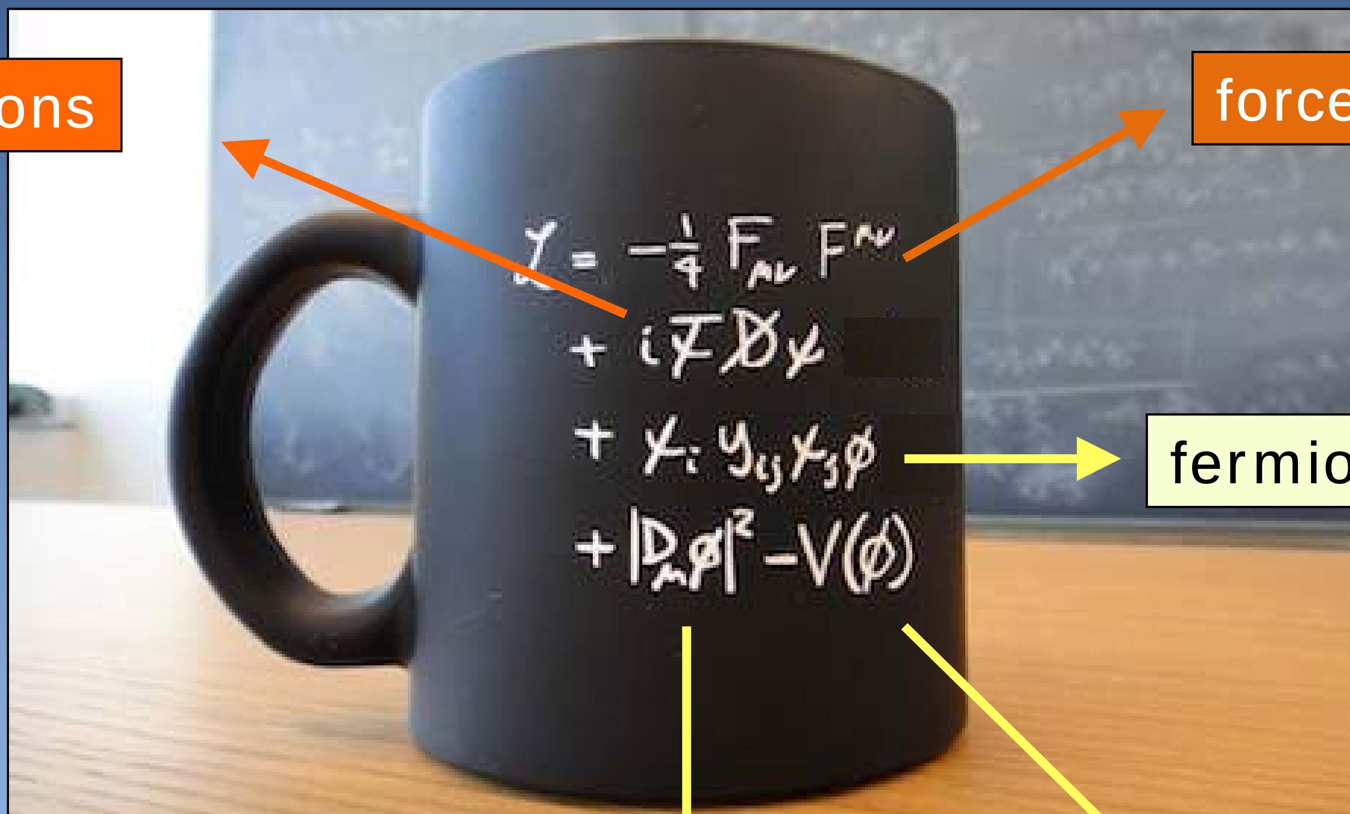


Peter Higgs

Structure of the Standard Model

interactions

force carriers



fermion masses

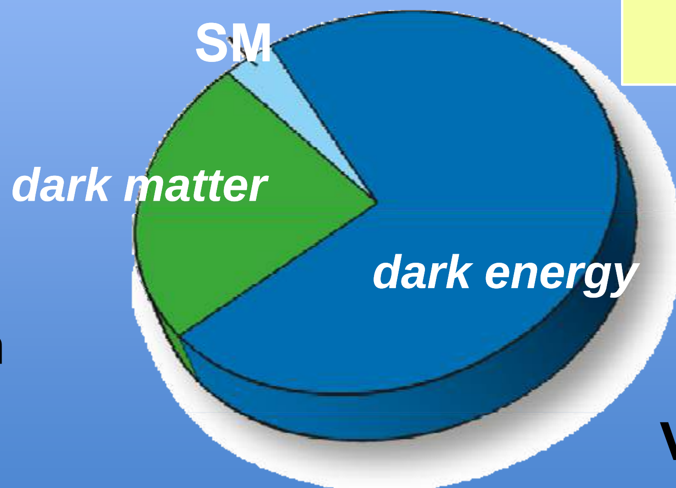
gauge boson masses

Higgs boson

de problemen

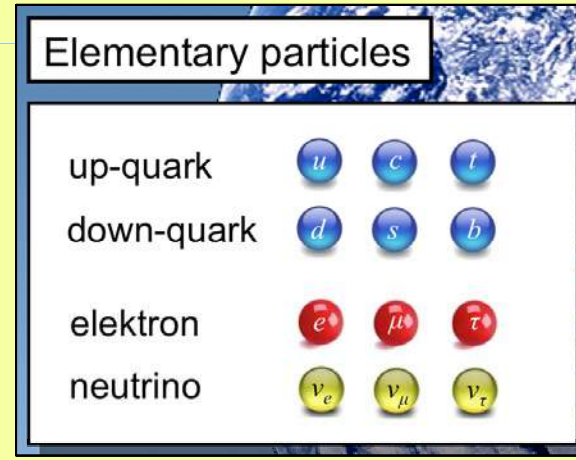
Standard Model problems

Baryogenesis:
Asymmetry between matter and anti-matter



Dark Matter:
No DM candidate in the Standard Model

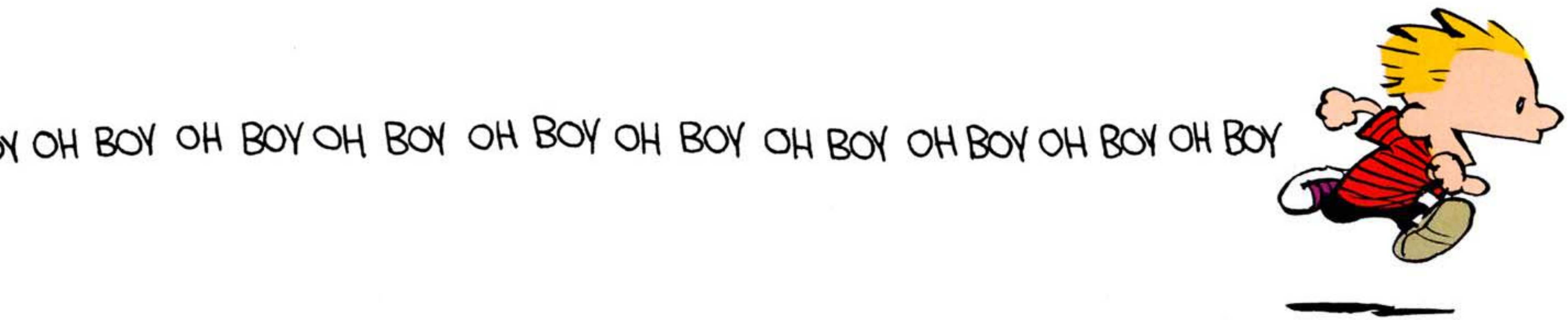
Some more problems



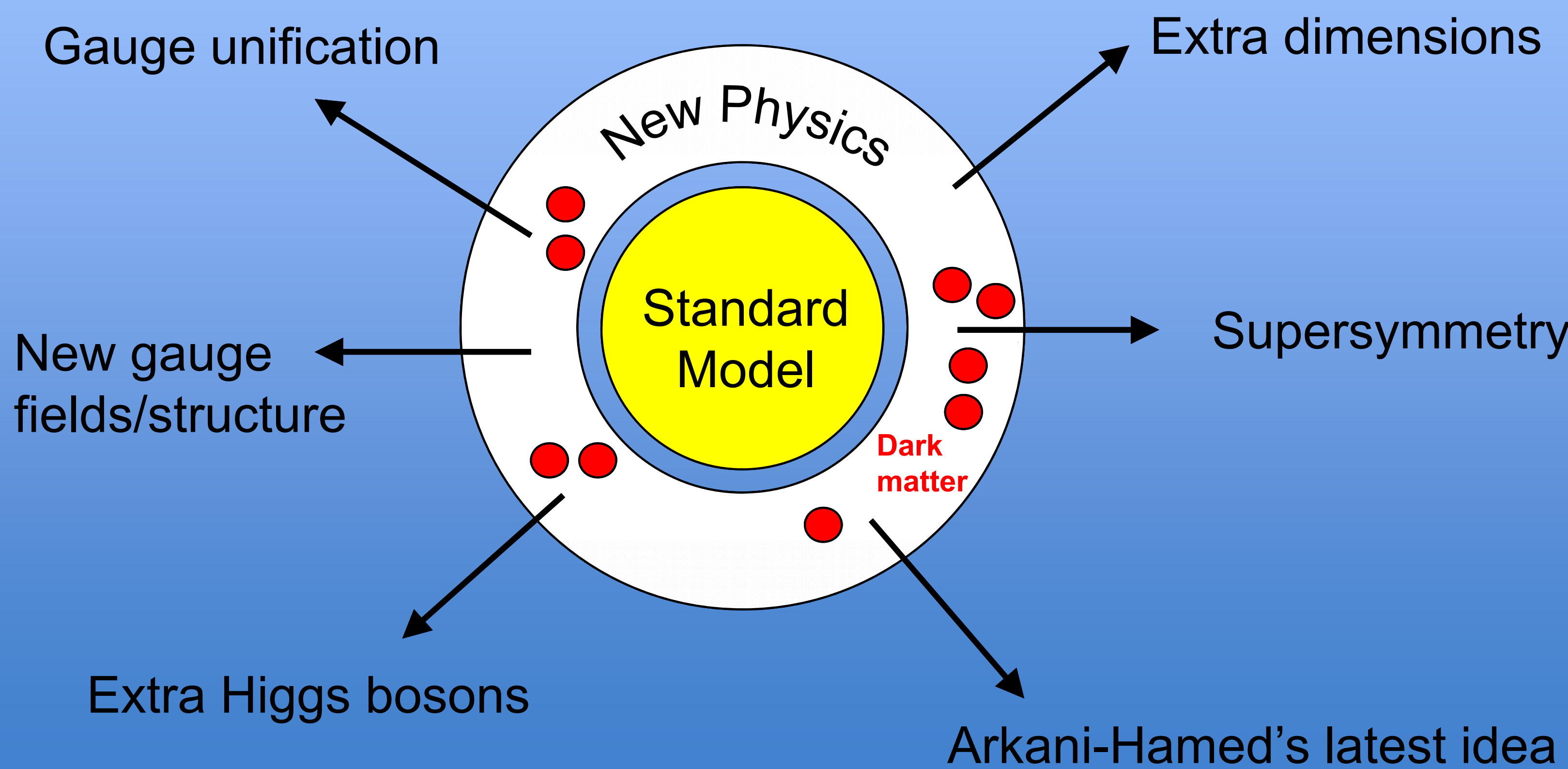
Vacuum energy:

$$\frac{\text{prediction (Higgs)}}{\text{observation}} > 10^{50}$$

Heerlijk … een probleem!



Standard Model is not the final theory



Most models predict new phenomena/particles ~ 1 TeV

De oplossing ?

bekende deeltjes

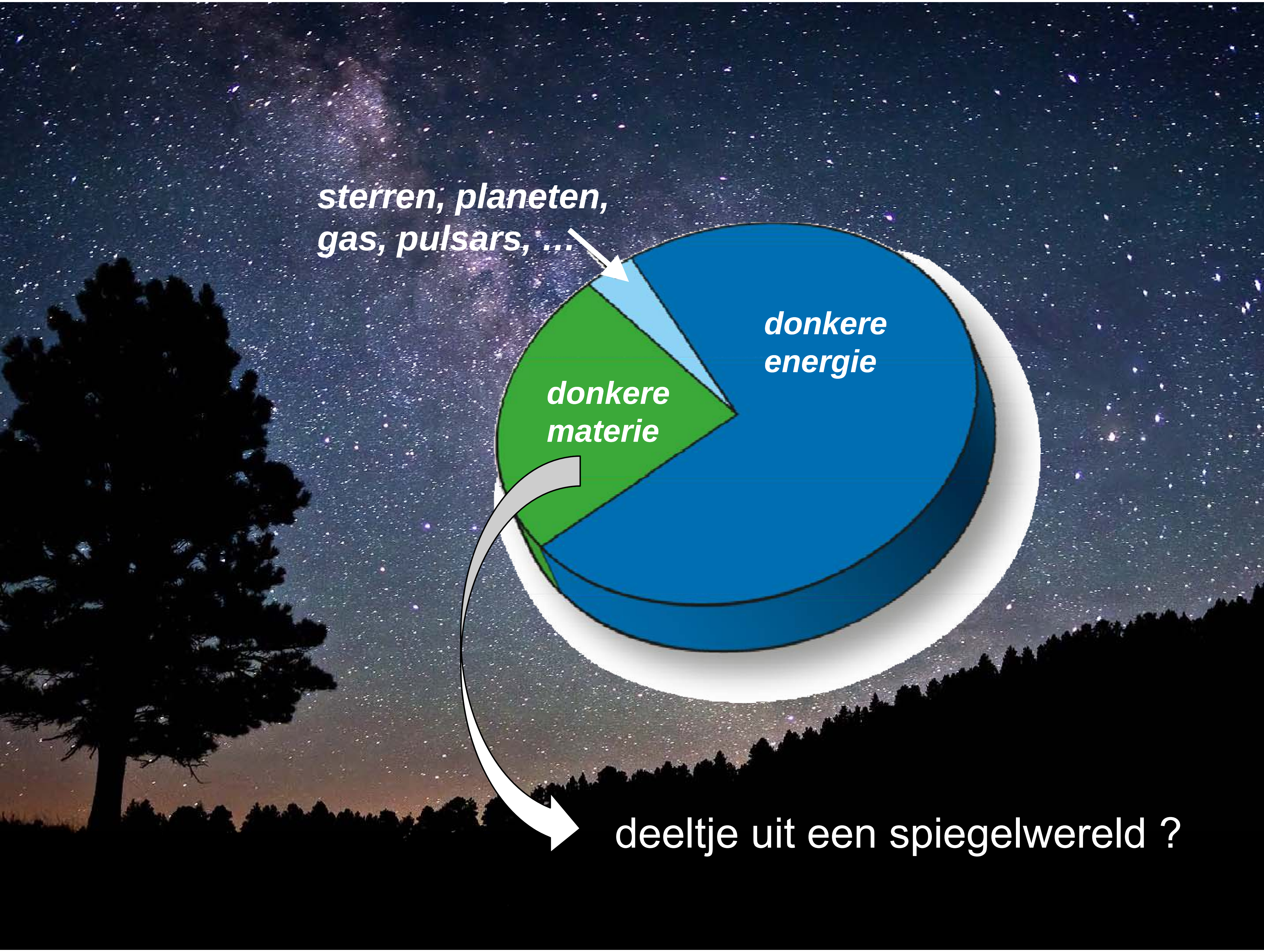
fantasie deeltjes

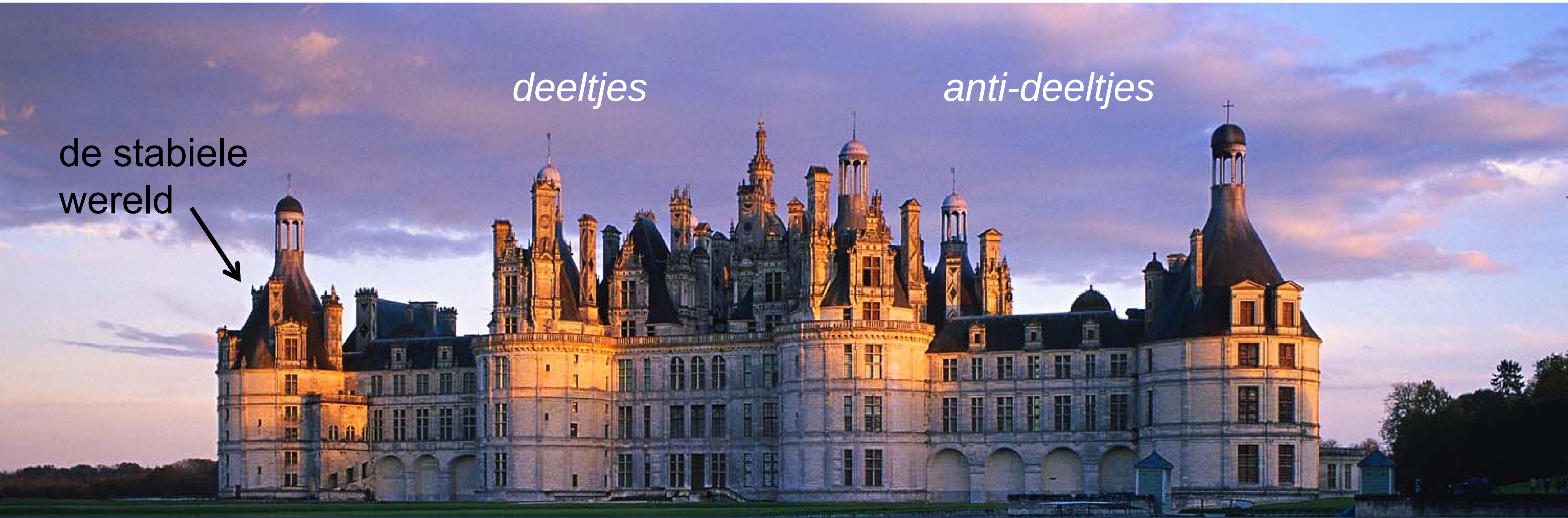
donkere materie deeltje ?

Liu Bolin

Donkere materie

Supersymmetrie – model met een natuurlijke plek voor donkere materie


sterren, planeten,
gas, pulsars, …
donkere
energie
donkere
materie
deeltje uit een spiegelwereld ?

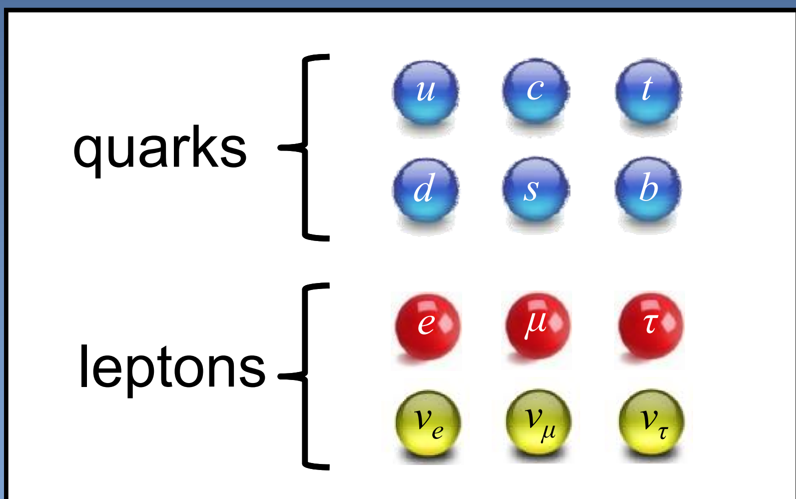


Bestaat er een verborgen spiegelwereld ?

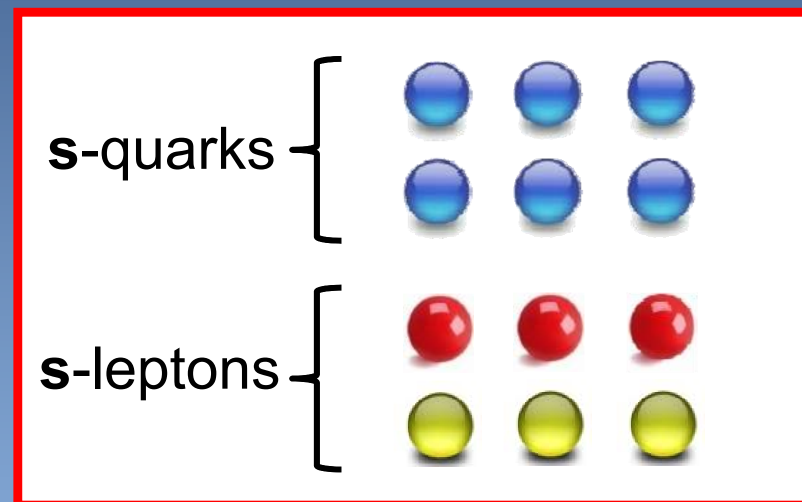
Supersymmetry

FERMIONS

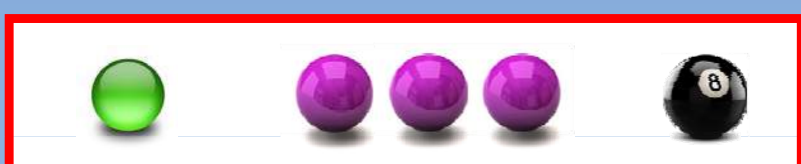
BOSONS



quarks and leptons



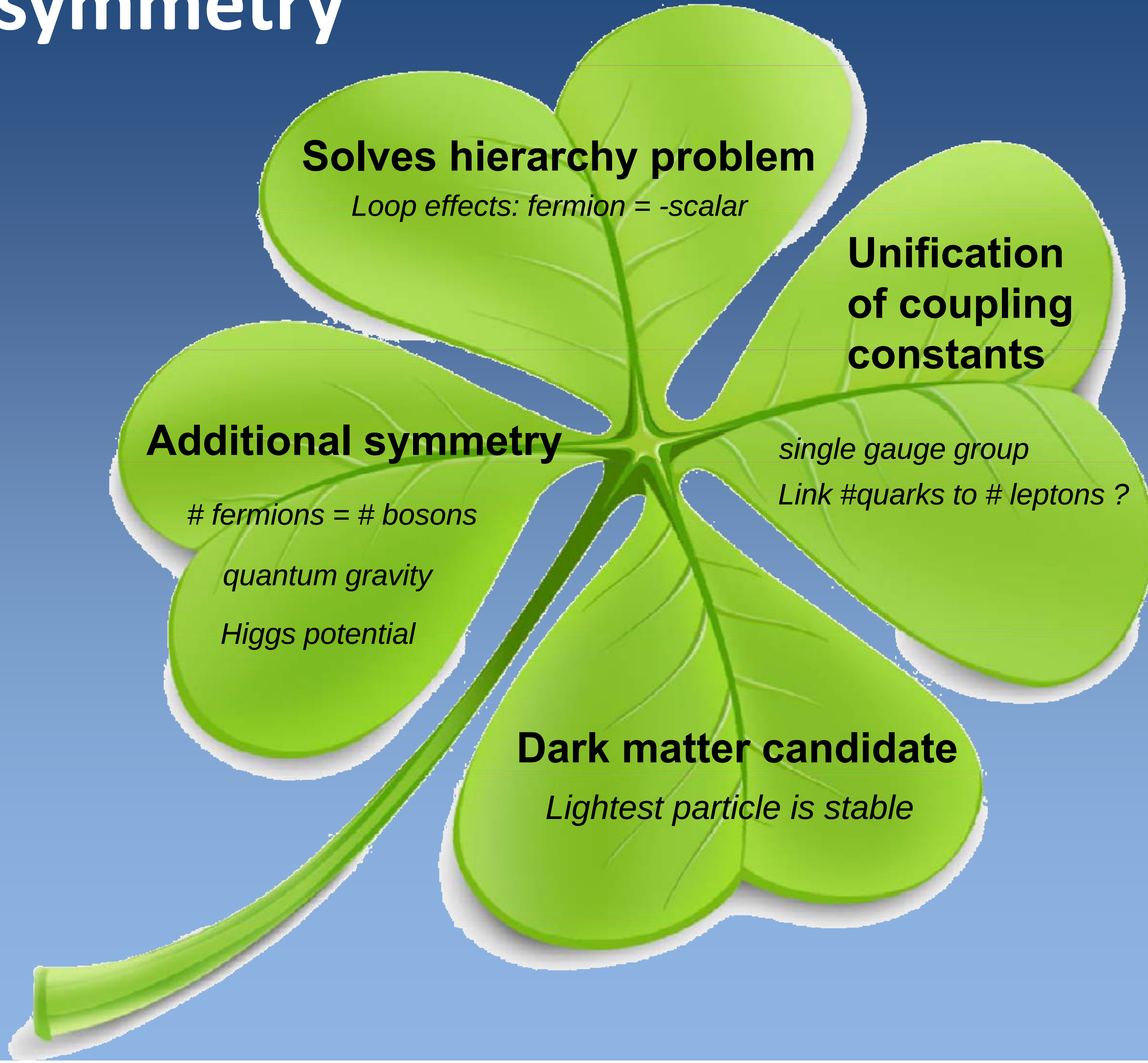
squarks and sleptons



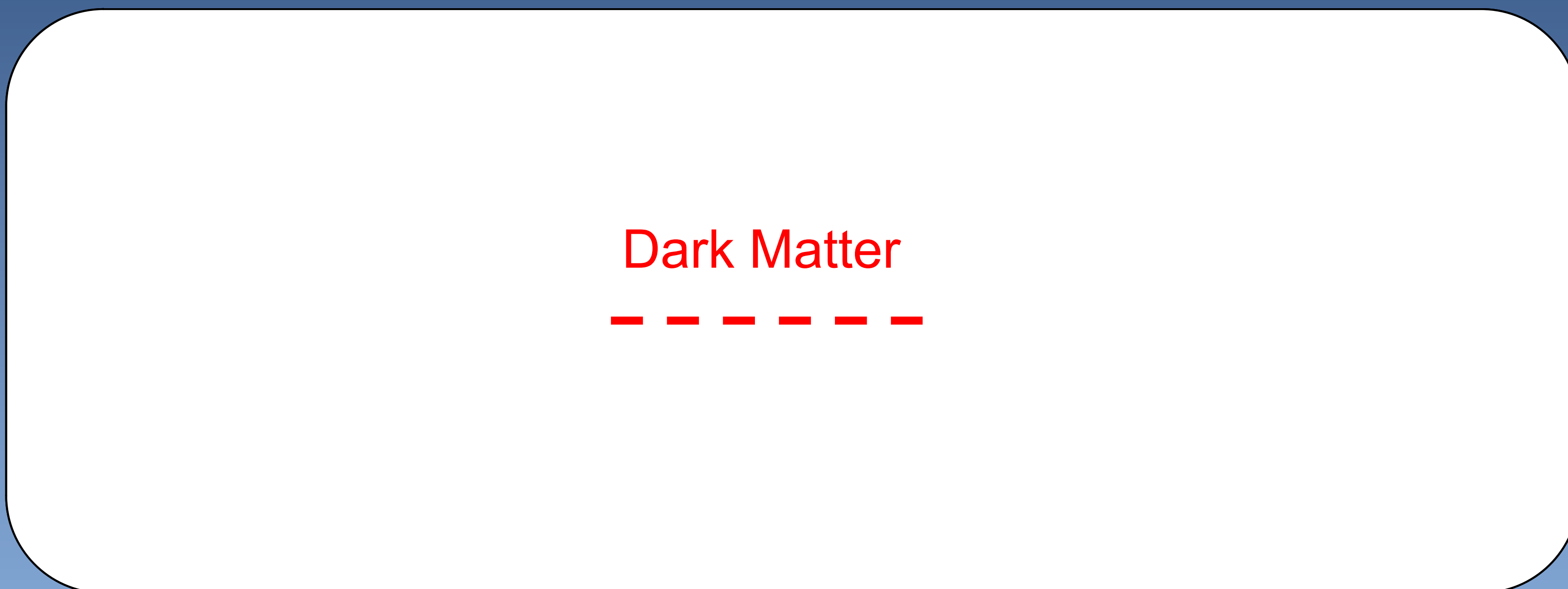
gaugino's

gauge bosons

Supersymmetry



Looking for new particles



Can we produce it at the LHC ?

does it couple to SM particles

Can we see it at the LHC ?

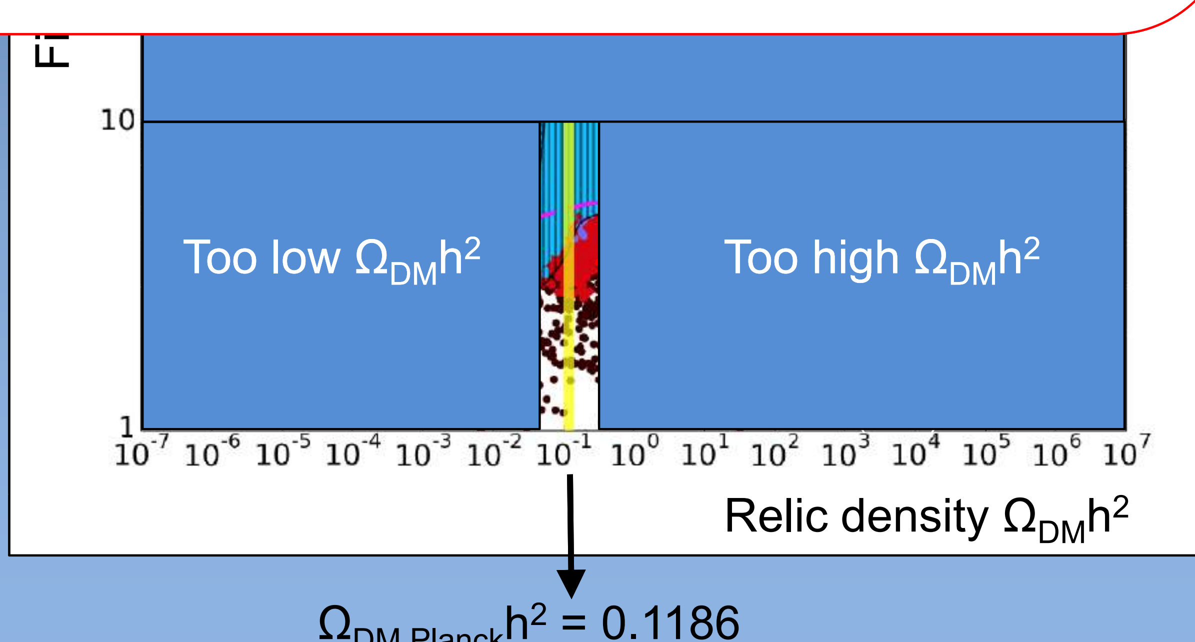
not directly

Open SUSY parameter space

Signalen die we tot nu toe nog niet hebben kunnen zien
… maar de komende 2 jaar (misschien) wel:

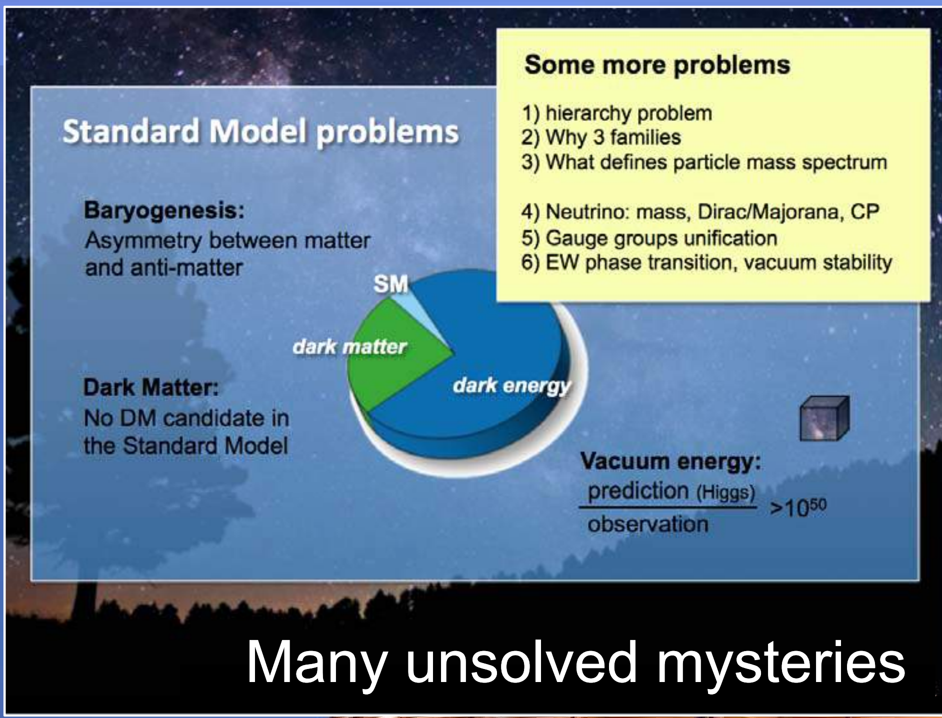
- *we snappen de detector beter*
- *we weten nu precies waar we moeten zoeken*
- *we krijgen 10x(100x) meer data*

- *we hebben een lichting scholieren die allemaal natuurkunde gaan studeren om ons te helpen.*



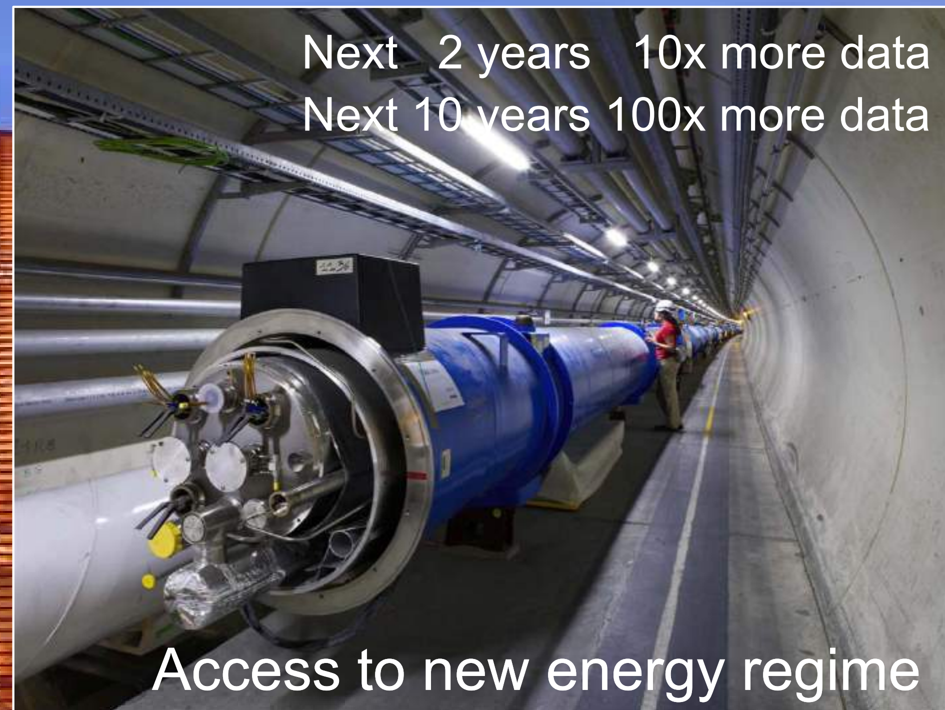

ATLAS experiment

Schatgraven bij de LHC. Nu!



Many unsolved mysteries

Next 2 years 10x more data
Next 10 years 100x more data



Access to new energy regime

Exciting times for (dark matter) searches at the LHC !

@IvovanVulpen