

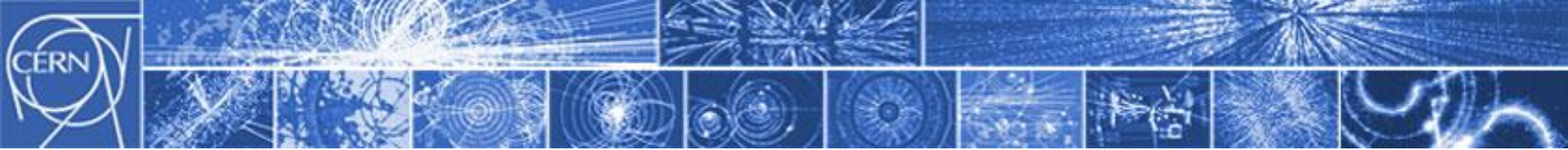
Welkom bij CERN

Waar het oneindig grote
en het oneindig kleine
elkaar ontmoeten.

Erik Heijne

Natuurkunde, Detektoren en Elektronica sinds 1973, en nu ook gids van CERN

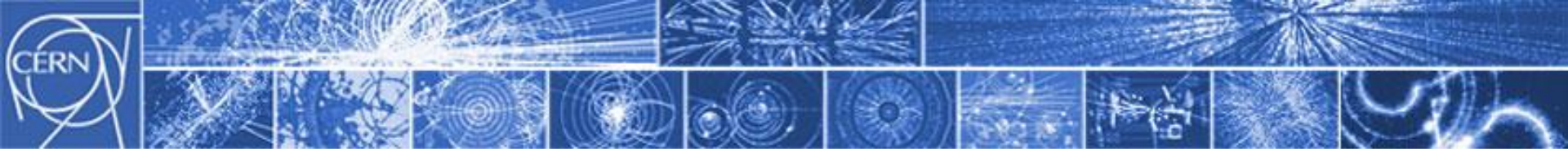
Presentatie gebaseerd op die van E. Bracke en F. Briard



Jullie **bezoek** op CERN

NNV Profielwerk 8-11 oktober 2019...

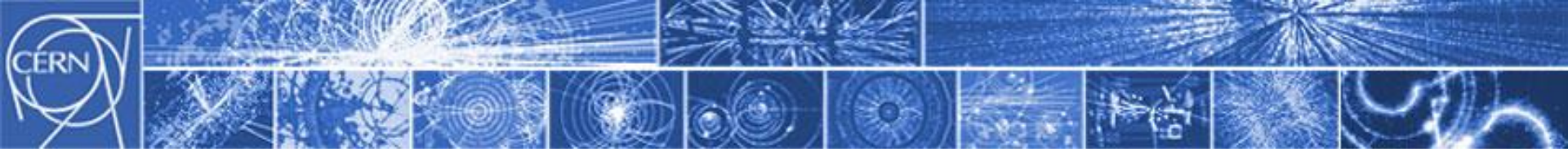
- Inleiding en algemeen over CERN Erik Heijne 45 minuten
- verder?



Jullie **bezoek** op CERN

Enige praktische zaken...

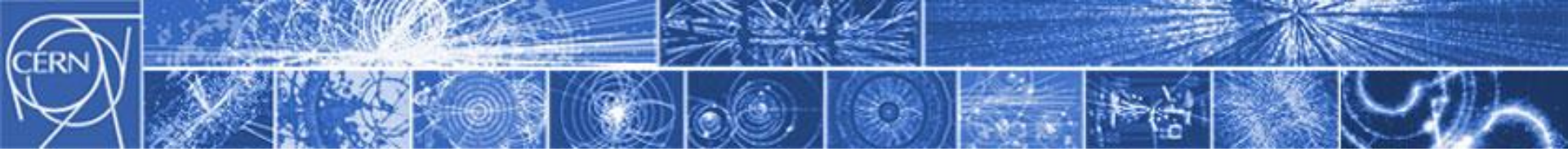
- Stel vragen!
- Je kunt alles fotograferen en filmen wat je ziet
- Zijn dagelijks open (Ma-Za 11h00-17h00):
 - CERN souvenir winkel
 - Permanente exposities: Microcosm en Globe d'Innovation



Jullie **bezoek** op CERN

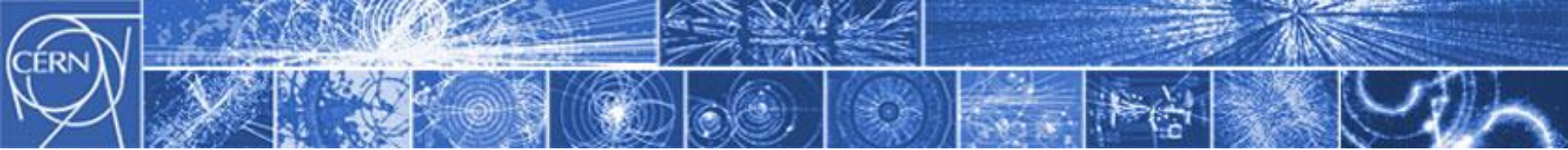
Tijdens rondgang...

- Zorg dat we bij elkaar blijven
- We meestal scherp getimed ...niet treuzelen
- Voor CERN zijn dit gewone werkdagen:
dus respect, stilte in de gebouwen s.v.p.



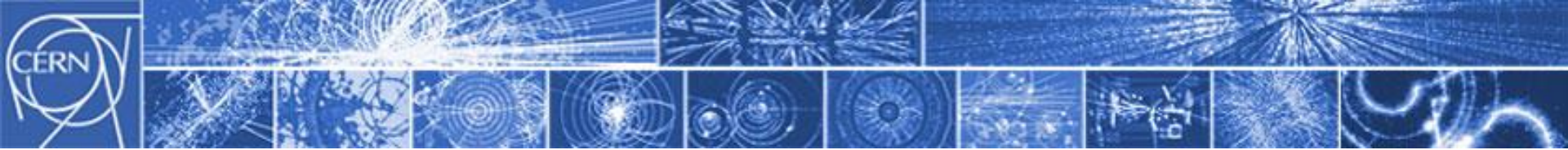
CERN...

Wat gebeurt
hier eigenlijk ?



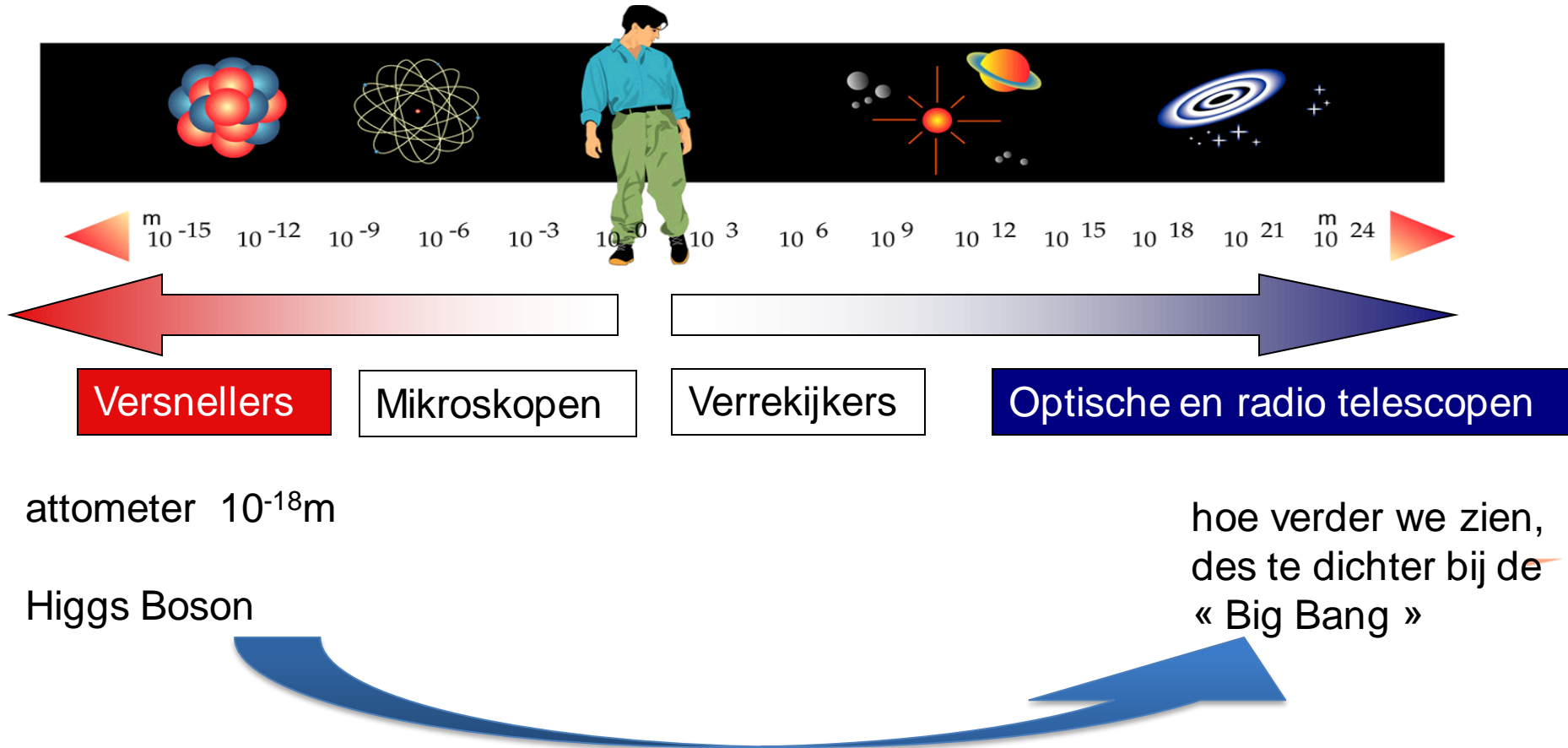
Grootste deel van CERN is ondergronds

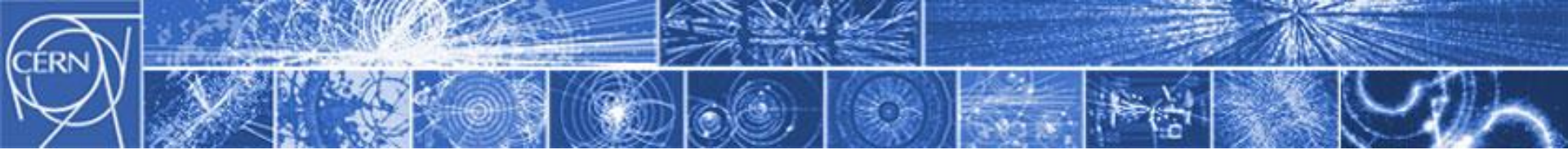




Elementaire Deeltjes en het Heelal van oneindig klein naar oneindig groot

Hoe begrijpen wij wat we zien om ons heen, dichtbij en veraf?





meter	1	mens	iedere stap x één duizendste
millimeter	10^{-3}	mier	
micrometer	10^{-6}	een haartje	
nanometer	10^{-9}	molecule	
atoom kern	picometer	10^{-12}	pion
proton	femtometer	10^{-15}	quark
(?)	attometer	10^{-18}	
zeptometer	10^{-21}		

nog kleiner ??? 'PLANCK' Lengte is 10^{-35}
Kleiner en kleiner...



Naar het kleinste

MILLI

10^{-3}

iedere stap 1/1000

MICRO

NANO

10^{-9}

PICO

FEMTO

10^{-15}

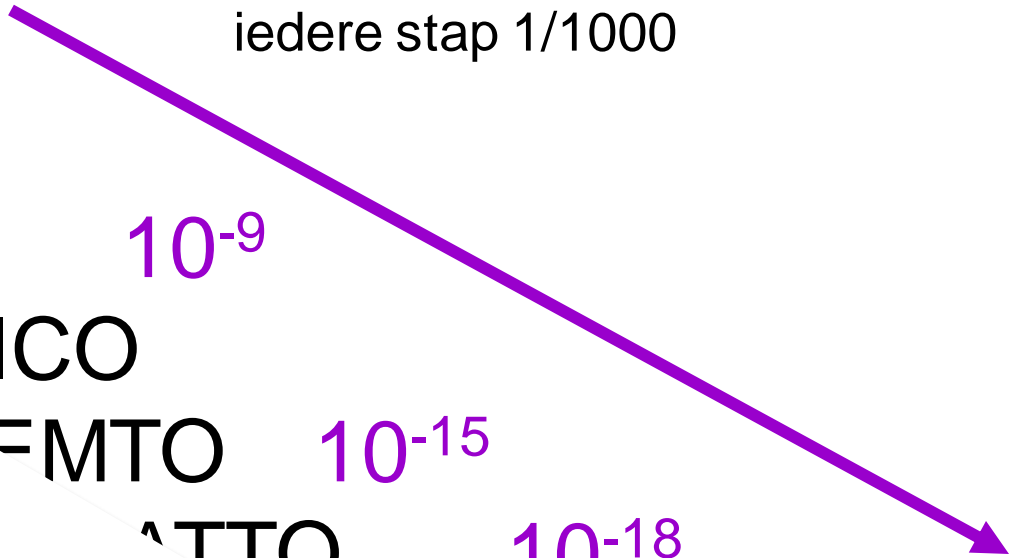
ATTO

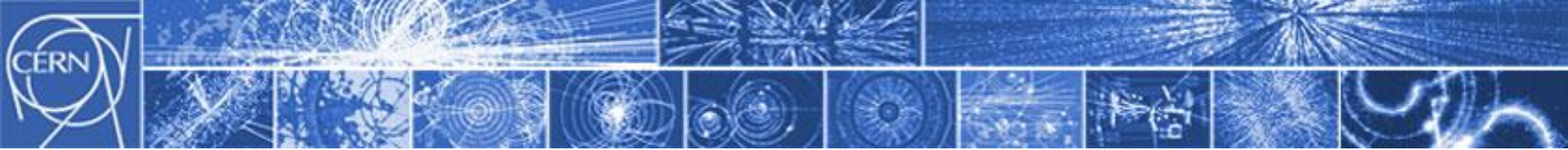
10^{-18}

ZEPTO

TO

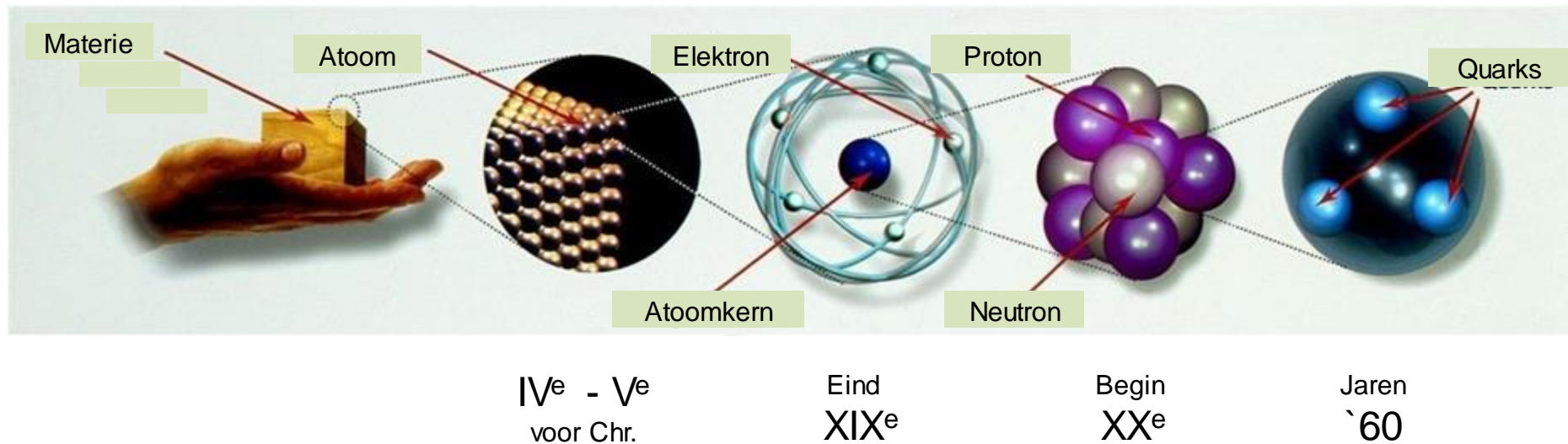
10^{-24}





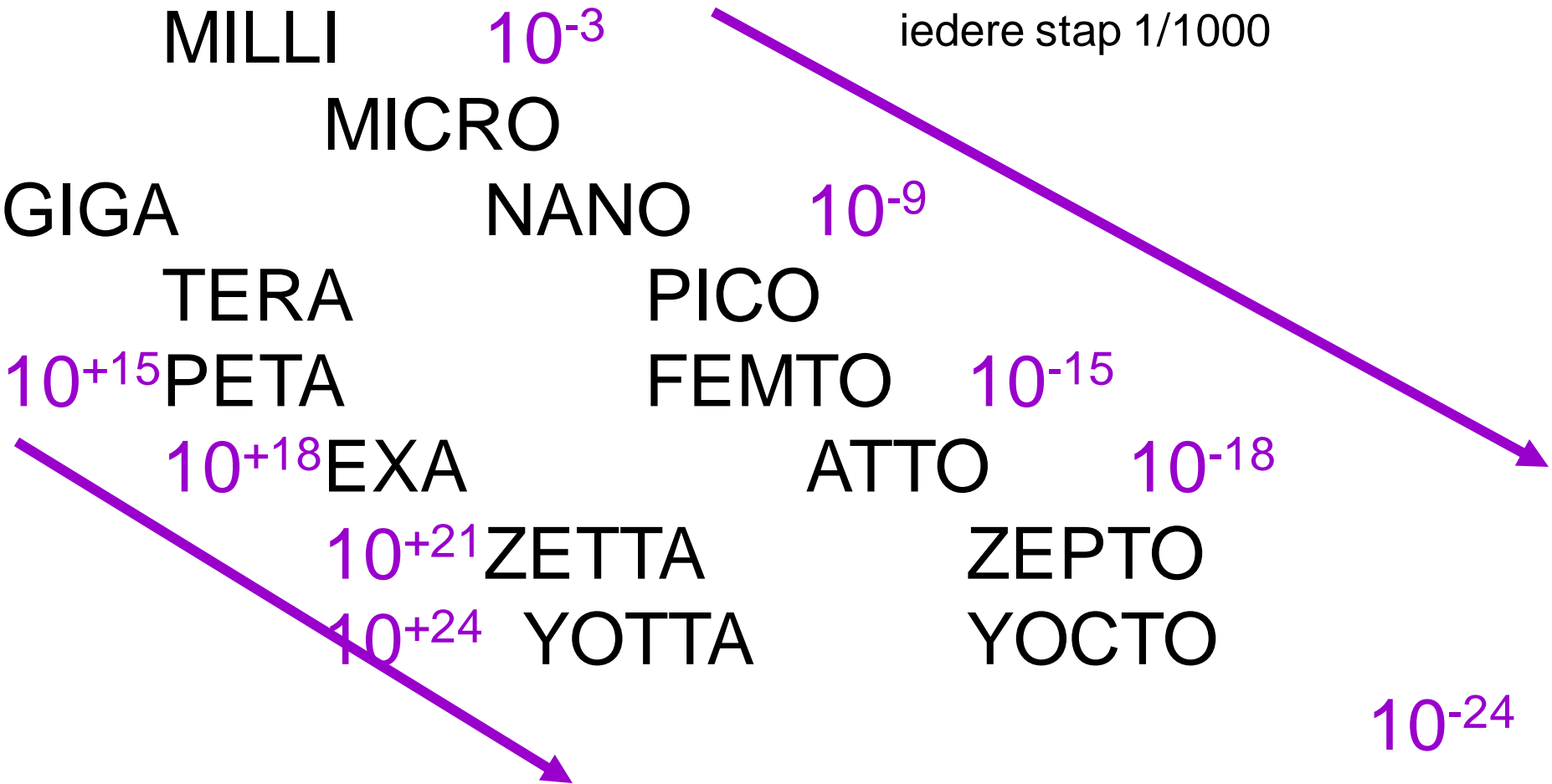
We doen **fundamenteel** onderzoek

Beantwoorden van fundamentele vragen...
...steeds opnieuw!





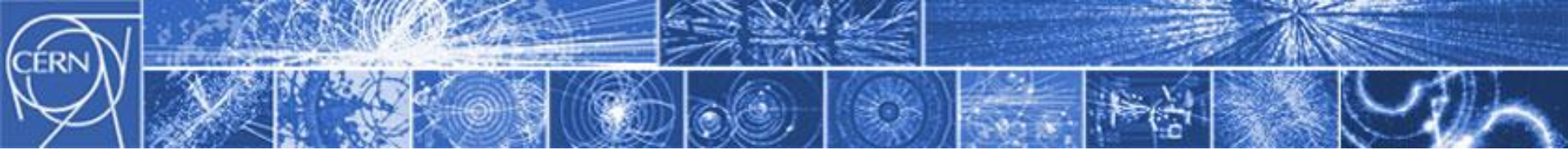
Naar het kleinste



iedere stap 1000

iedere stap 1/1000

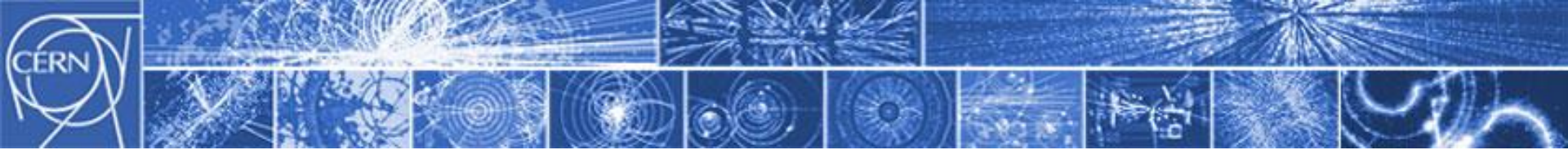
hoe kleiner, hoe groter het meet apparaat



Bestuderen van materie tot in het allerkleinste



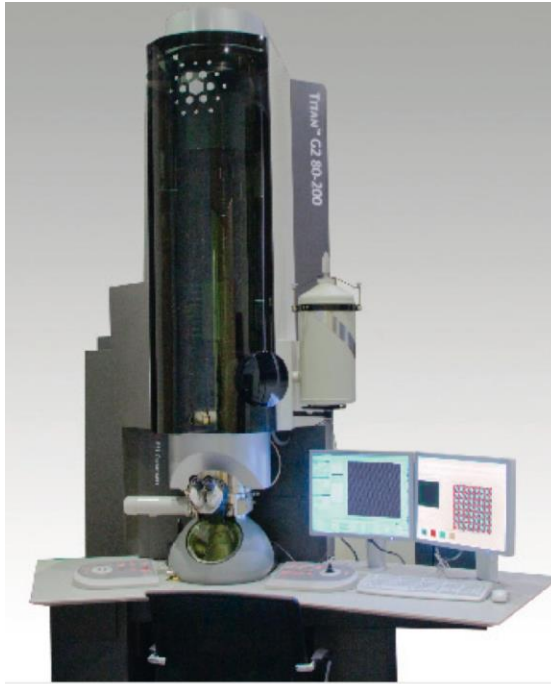
mikroskoop
gewoon licht



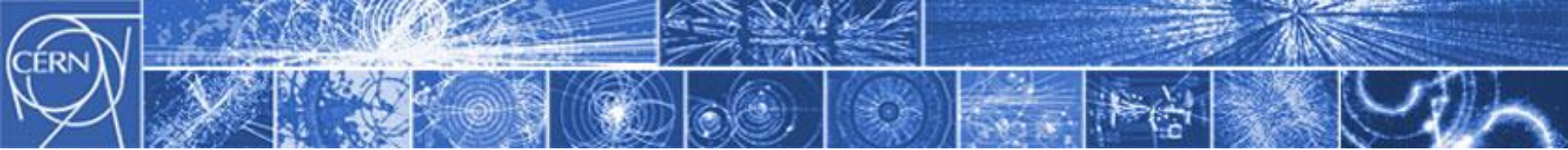
Bestuderen van materie tot in het allerkleinste



mikroskoop
gewoon licht



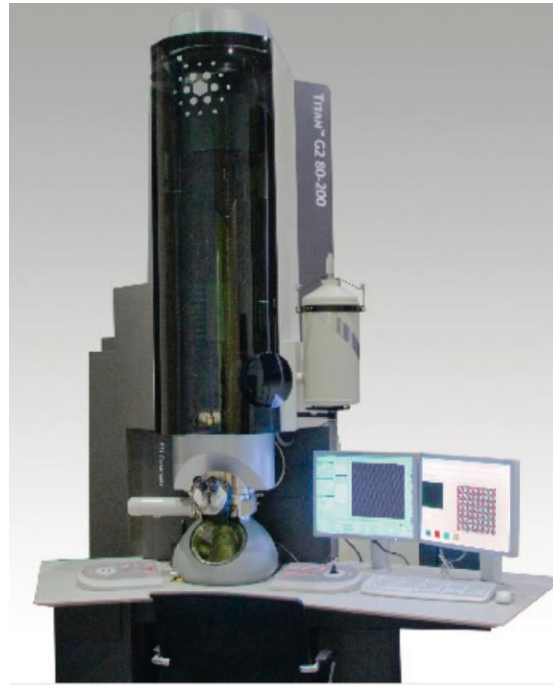
elektronen mikroskoop
met bundel van
~100 keV elektronen



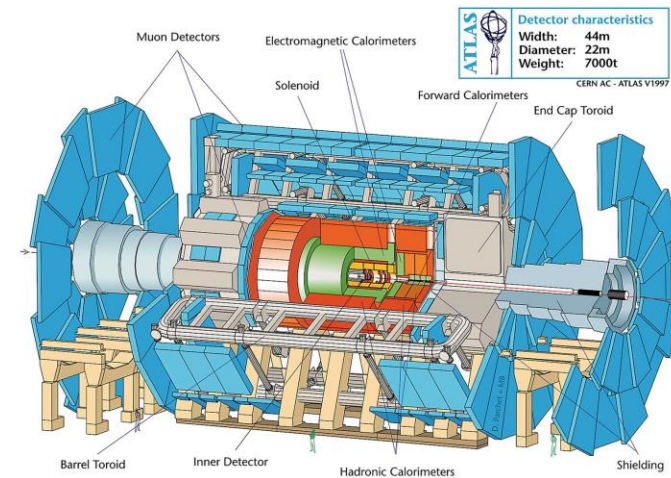
Bestuderen van materie tot in het allerkleinste



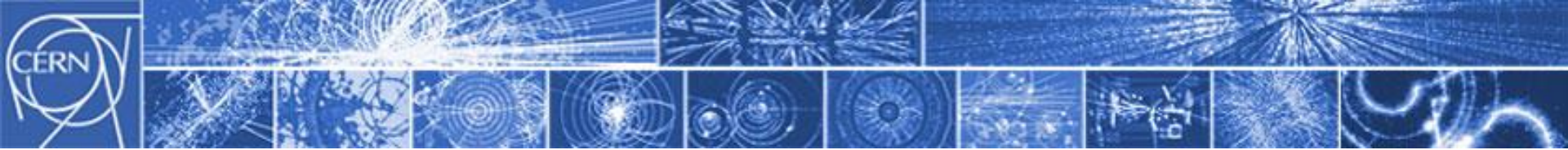
mikroskoop
gewoon licht



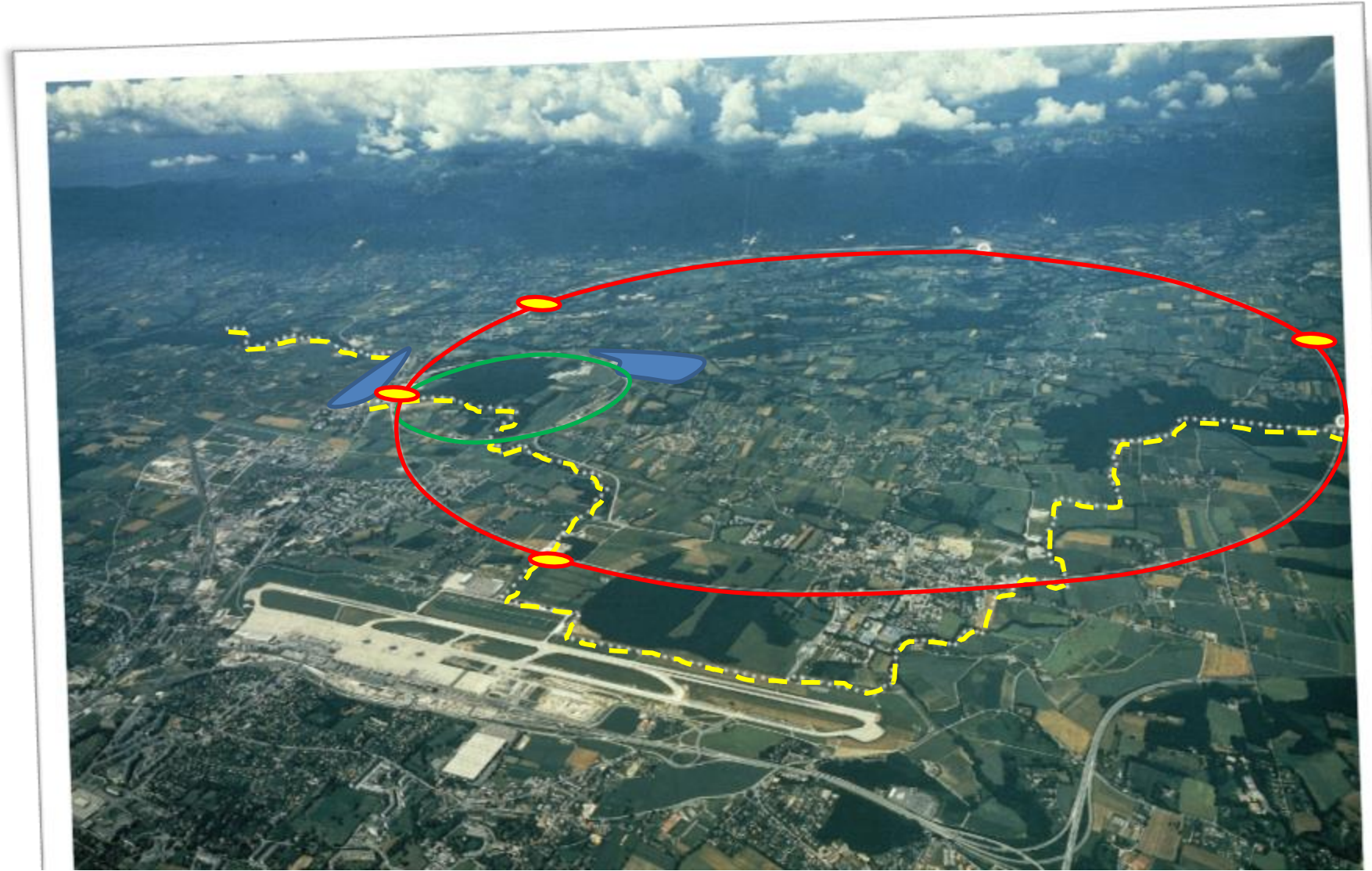
elektronen mikroskoop
met bundel van
~100 keV elektronen



'attoscope' **CERN**
protonen van 7 TeV

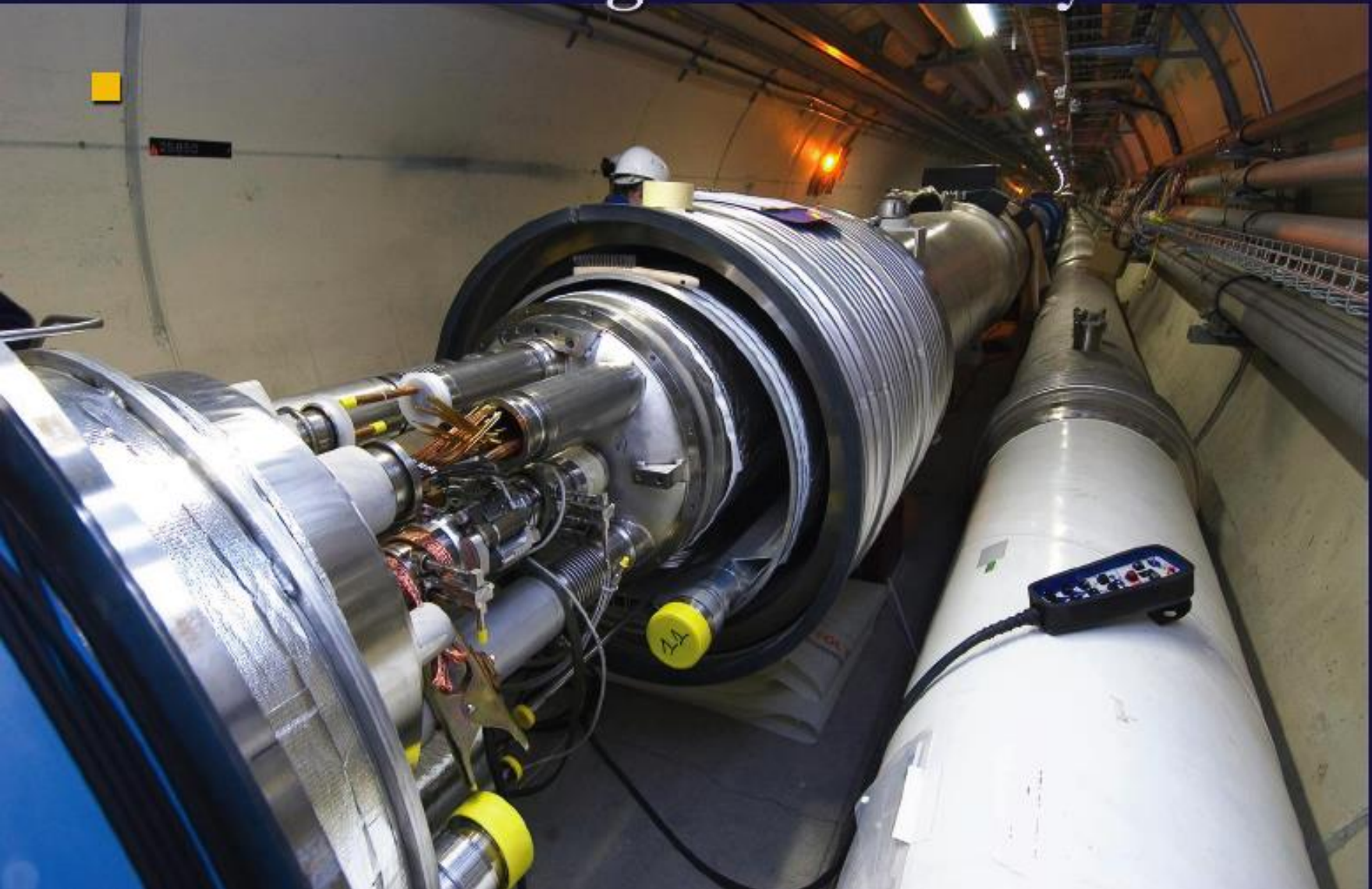


De **grootste** deeltjes versneller



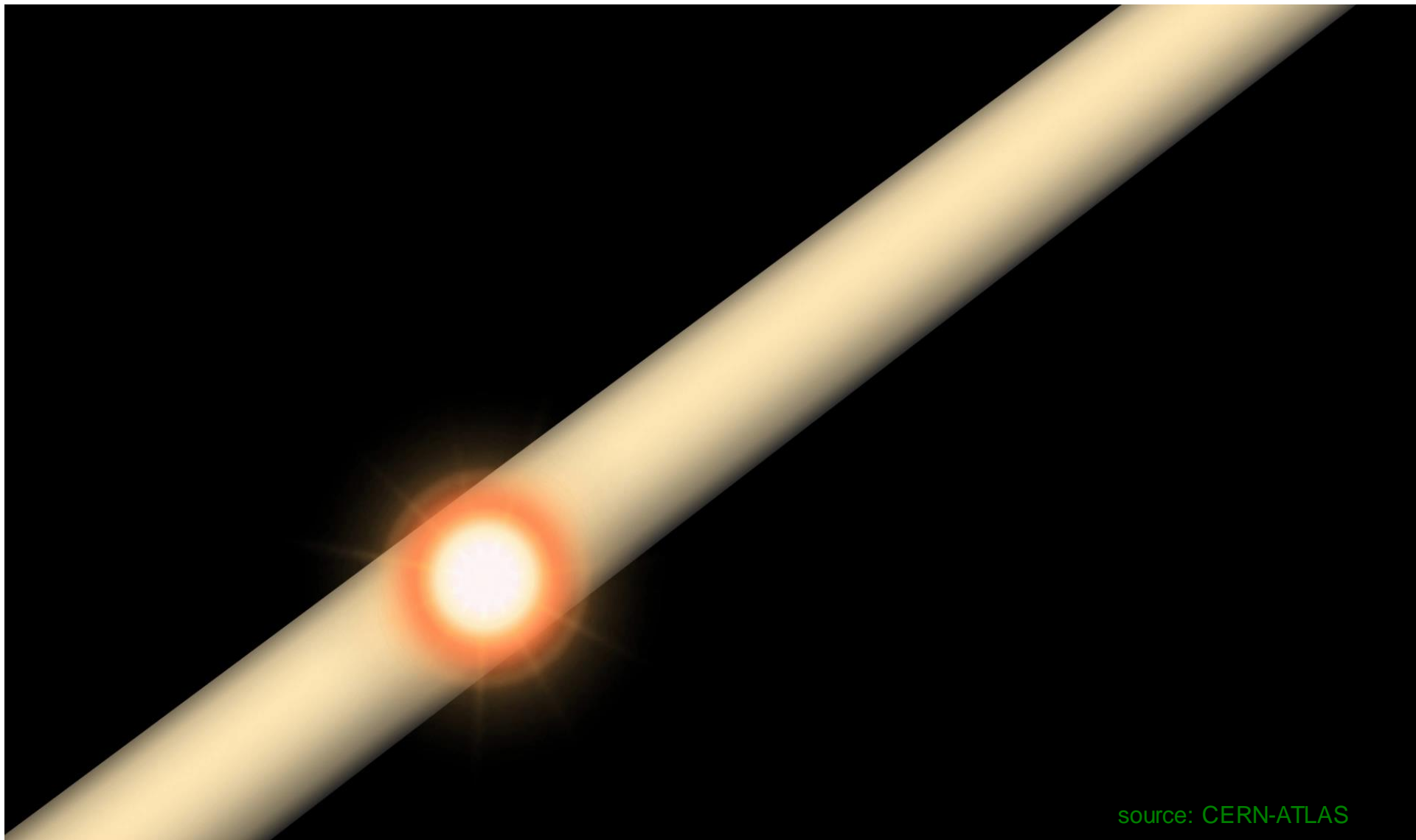


Large Hadron Collider (LHC) Magnets and Cryo-Line





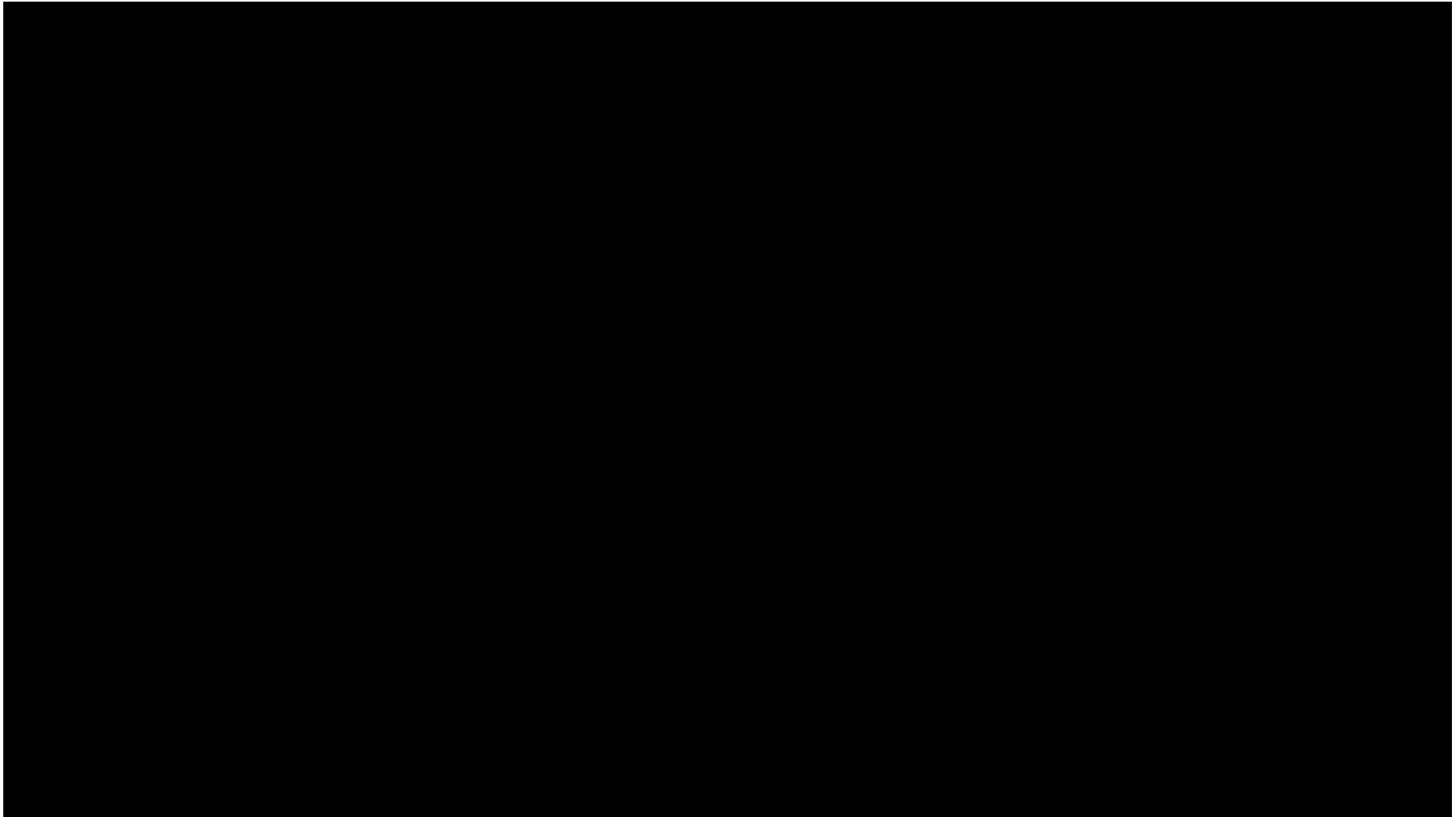
Animatie: keten van CERN versnellers



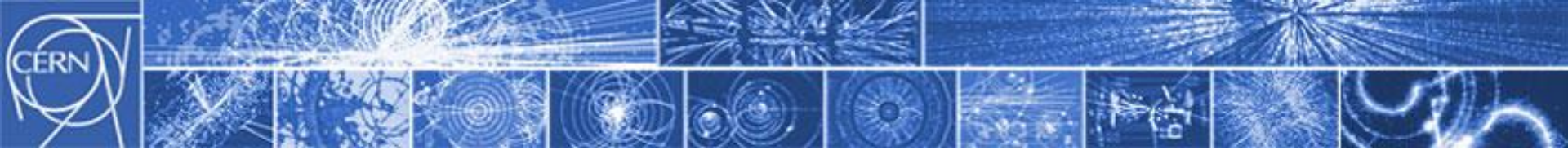
source: CERN-ATLAS



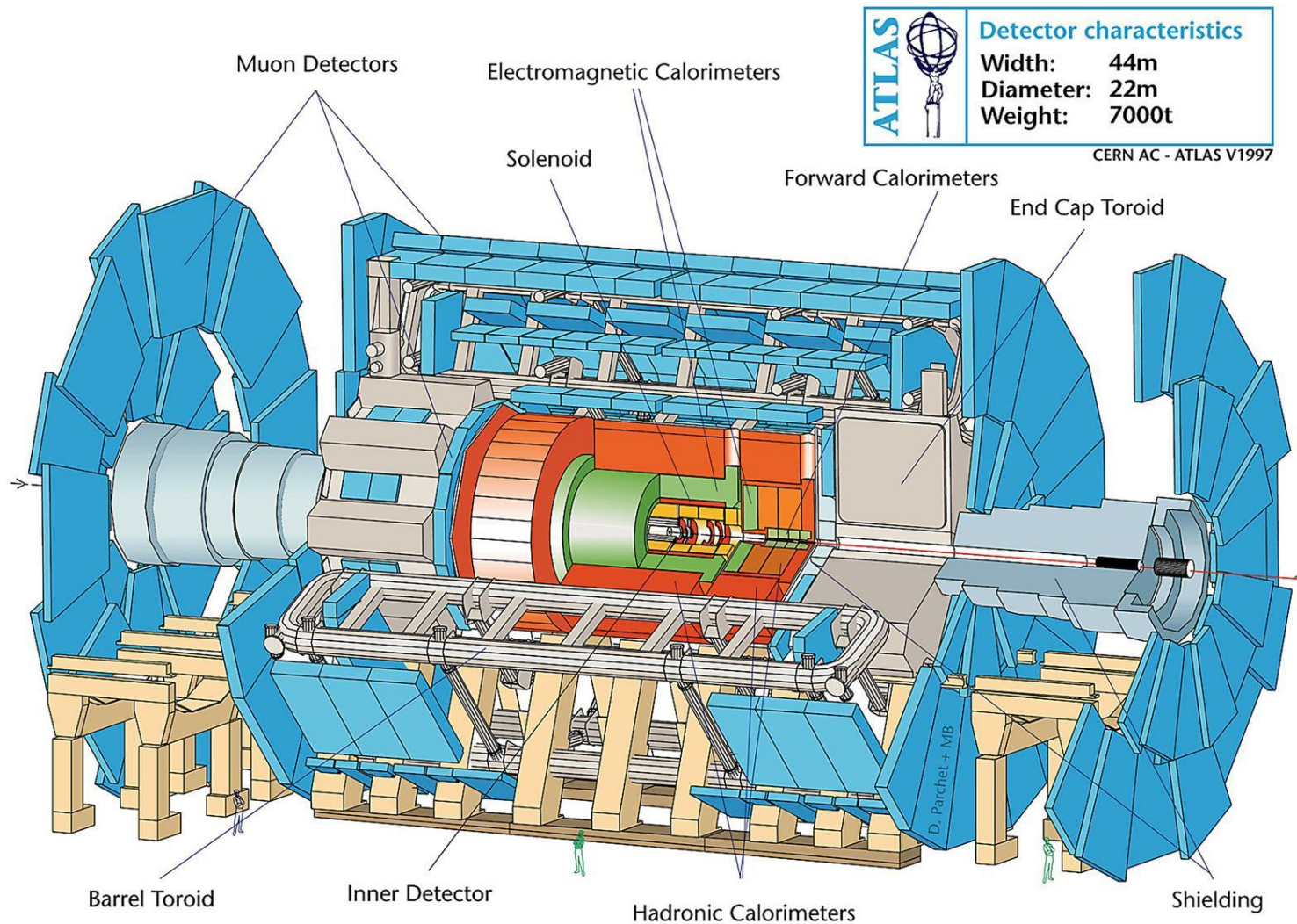
Nog eens de CERN versnellers

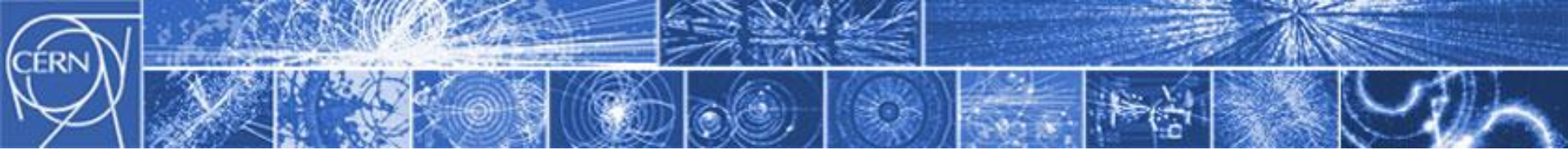


source: CERN-ATLAS

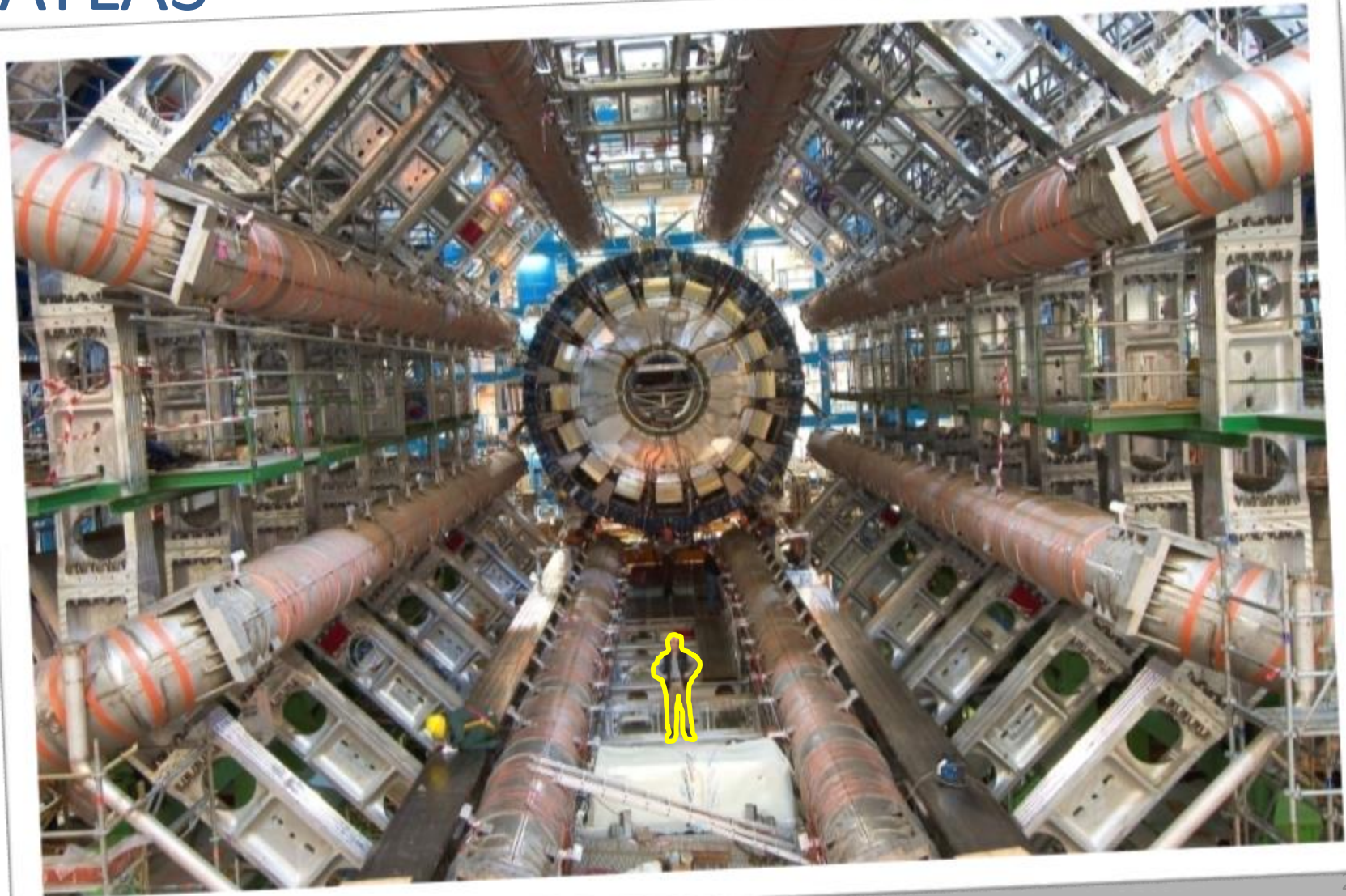


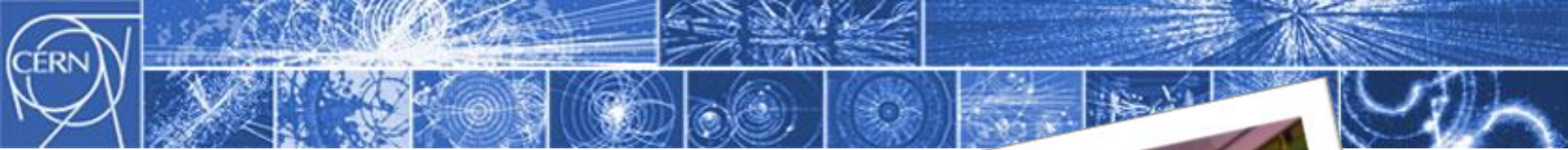
De meest complexe detectoren





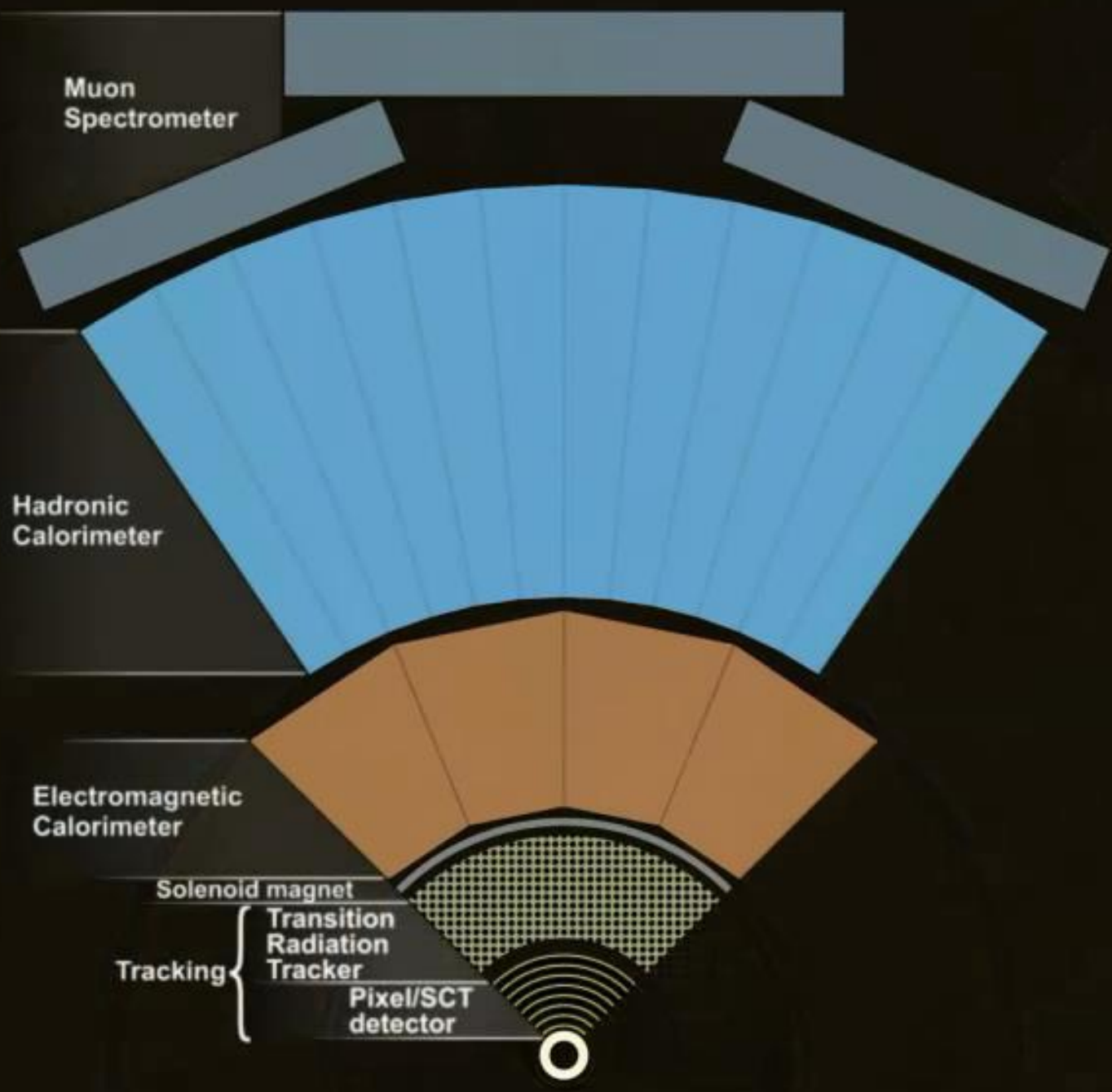
ATLAS





CMS





Muon Spectrometer

Hadronic Calorimeter

Electromagnetic Calorimeter

Solenoid magnet

Tracking

Transition Radiation Tracker

Pixel/SCT detector



ATLAS binnenste laag Si Pixel detectors



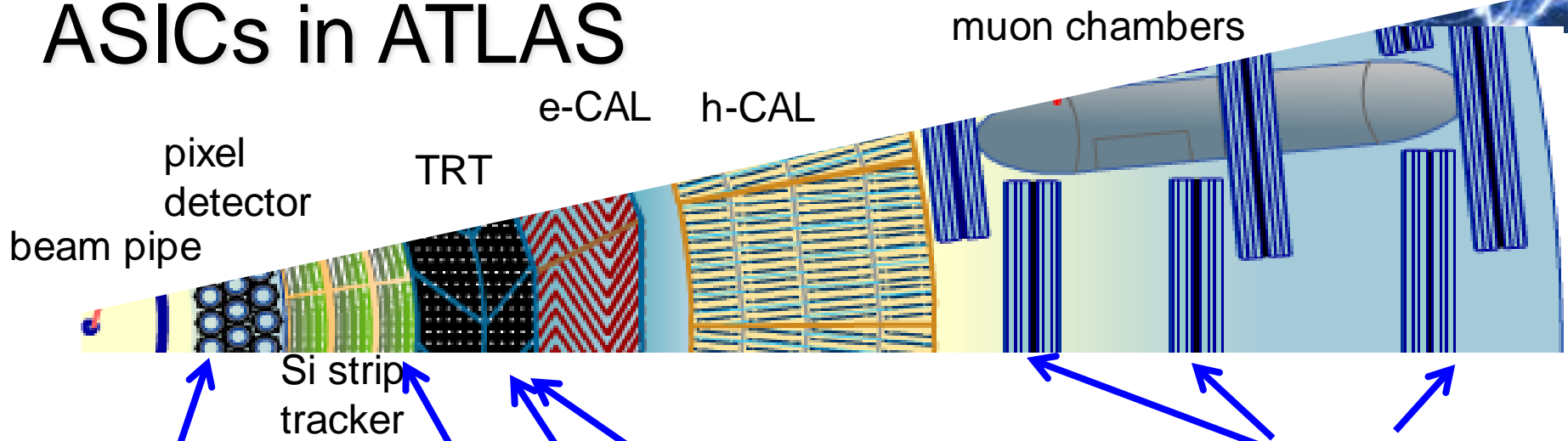
source: CERN- ATLAS

CMS Silicon Tracker
heeft van laag Si microstrip detektoren
nog in clean room

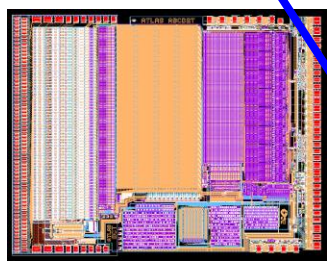




ASICs in ATLAS



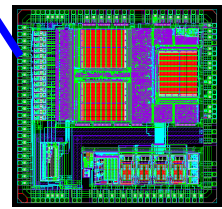
FE-I3 pix det
28 000 chips
80 M segments
1.7 m² Si sensor



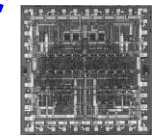
ABCD Si det
50 000 chips
6 M segments
60 m² Si sensor



ASDBLR TRT det
38 000 chips



DTMROC TRT det
19 000 chips



ASD muon det
148 000 chips

Chips to scale 1 cm

Total ATLAS
100 million sensor cells
appr. 800 000 chips
majority ASICs



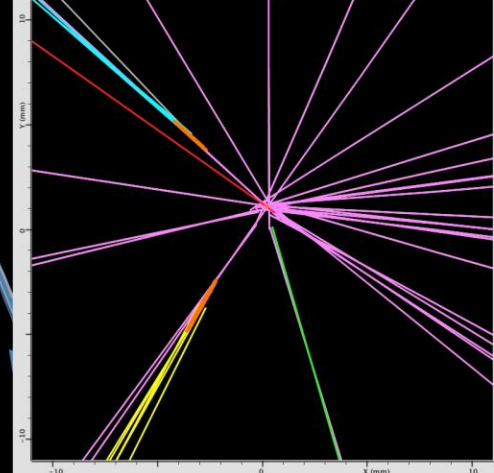
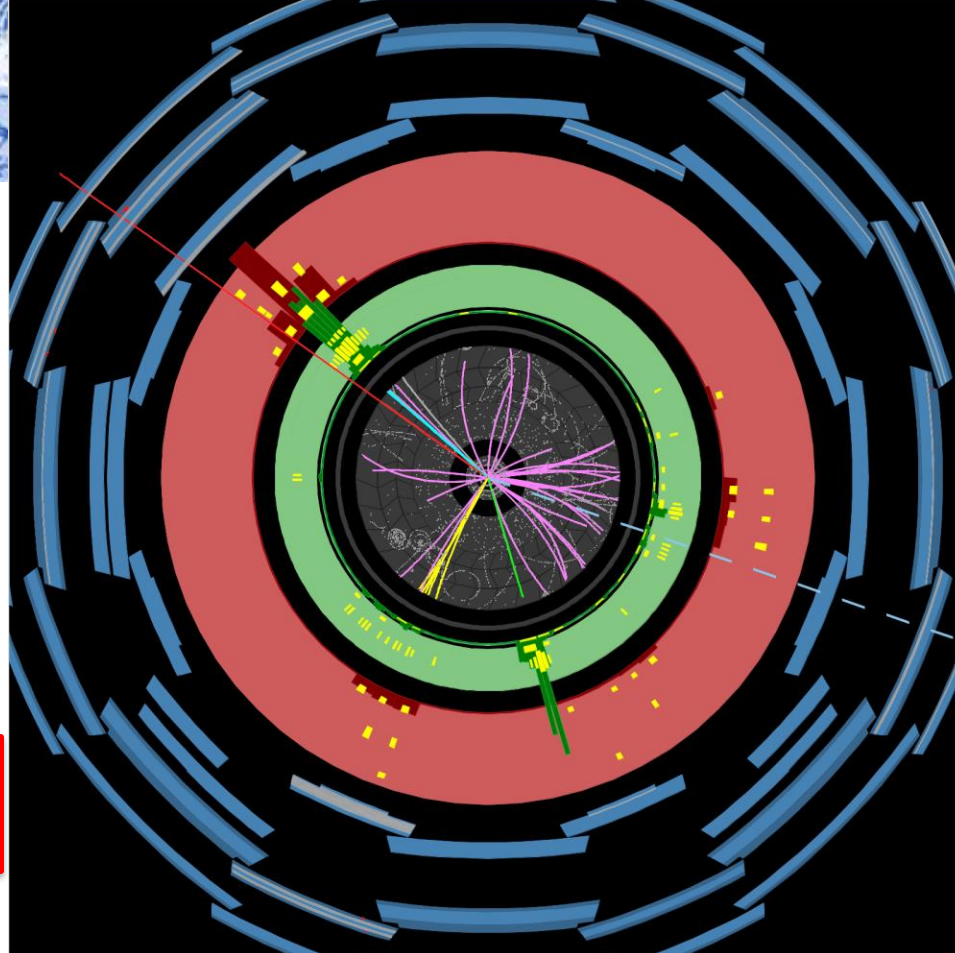
Imaging Now
All Electronic
with 3-D
Reconstruction

Many Tracks
and 2 “Jets”

40 million / sec

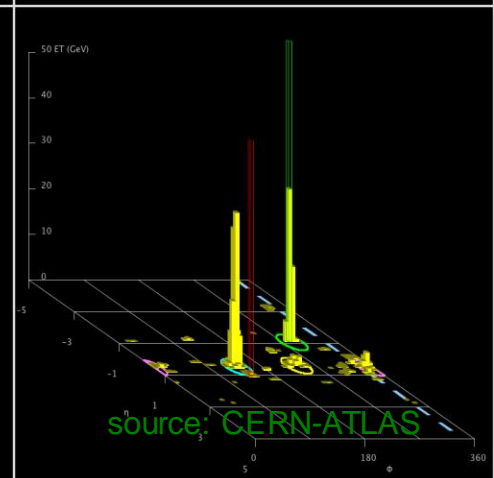
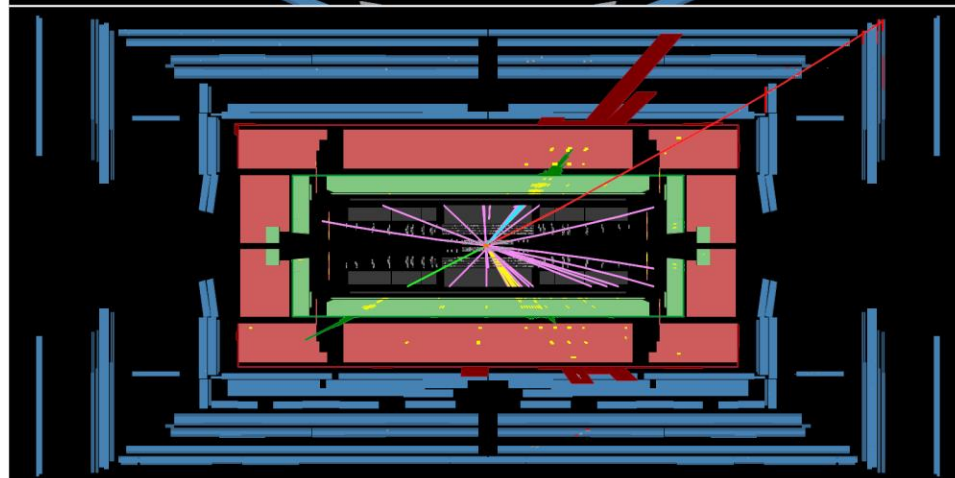
Secondary
Vertex:
a short-lifetime
particle is a
messenger for
something new

see blow-up



Run Number: 160958, Event Number: 9038972

Date: 2010-08-08 11:01:12 BST

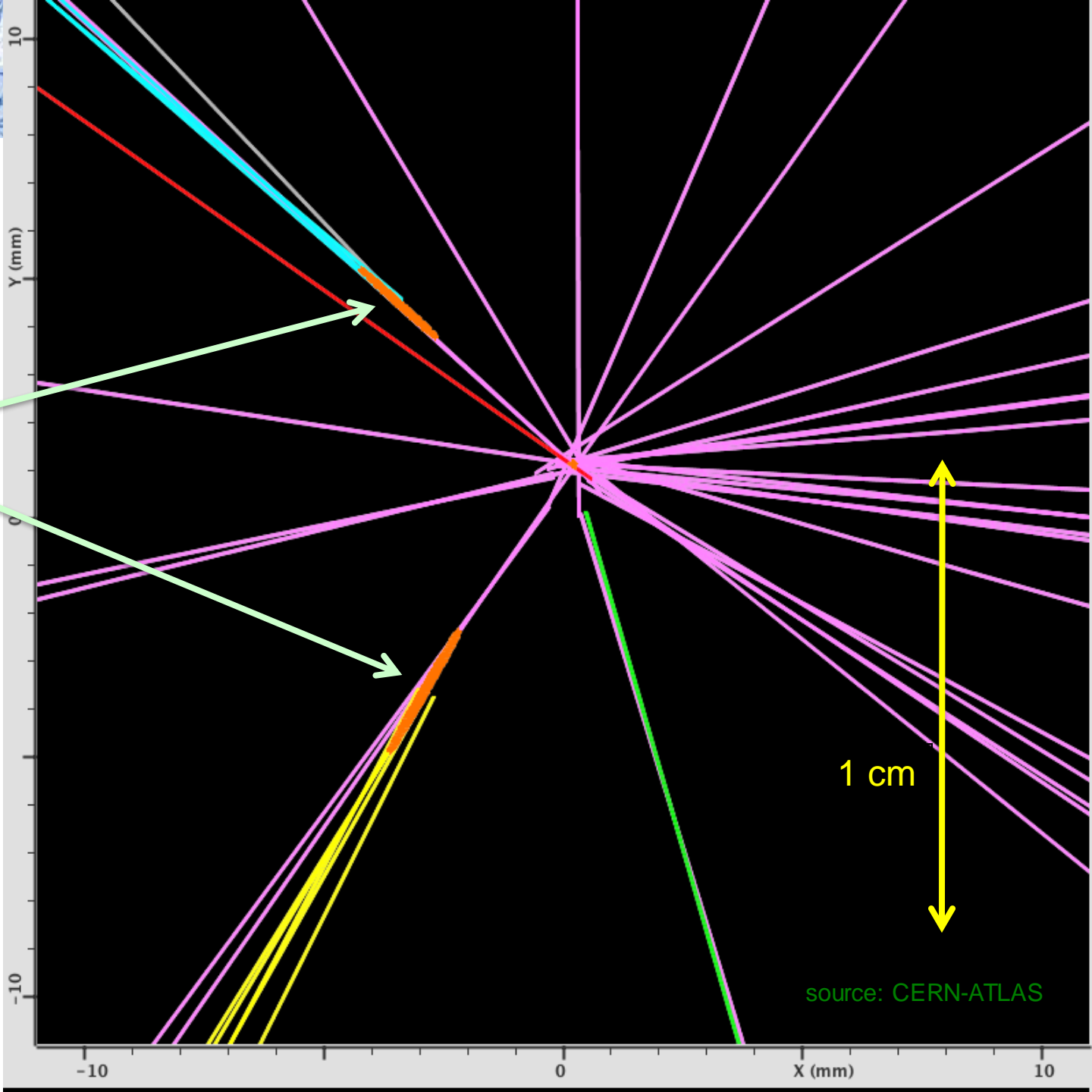




ATLAS
Blow-up
Details around
Primary Vertex

Two Secondary
Vertices

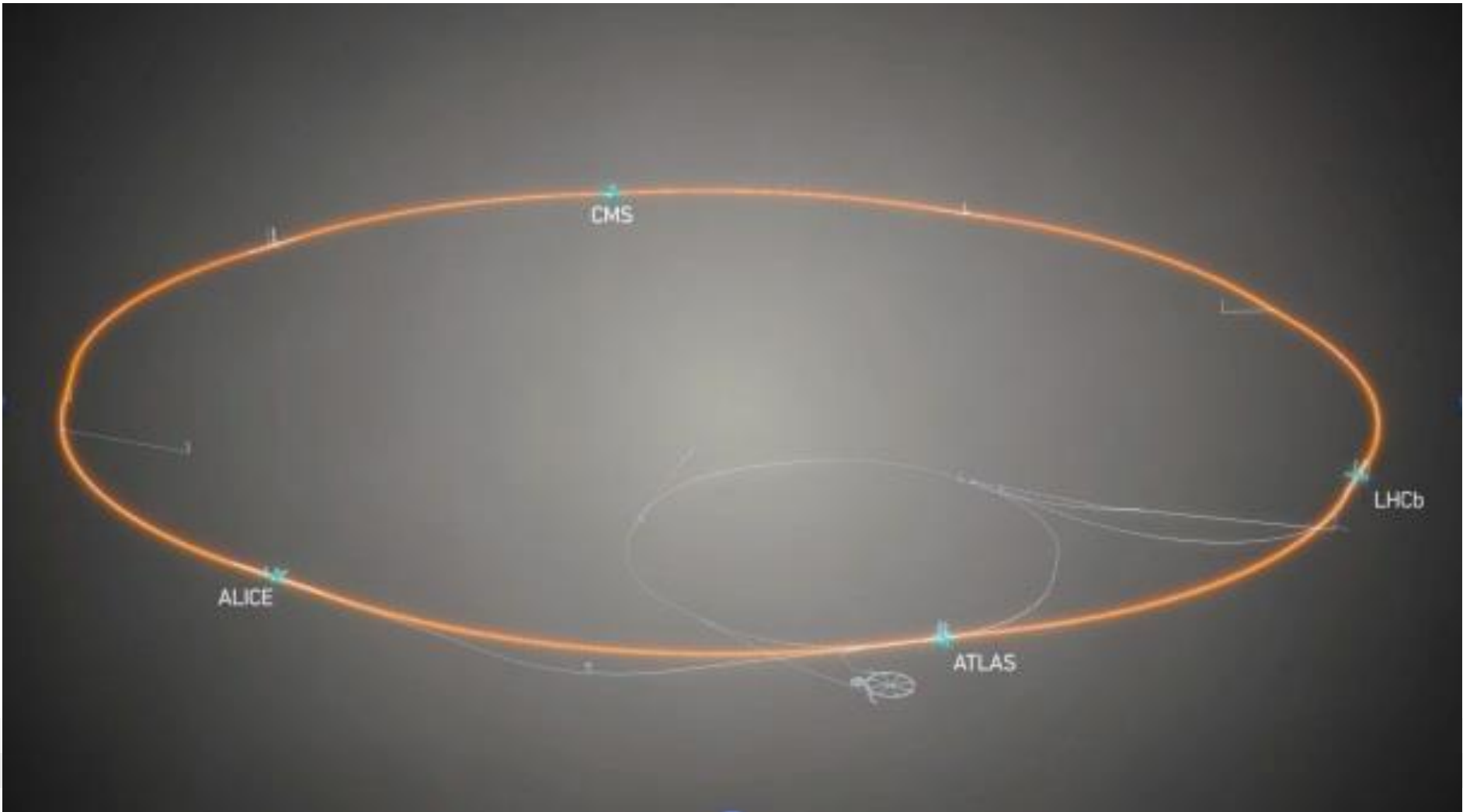
Note scale
1cm
all this is INSIDE
beam pipe \varnothing 7cm



source: CERN-ATLAS



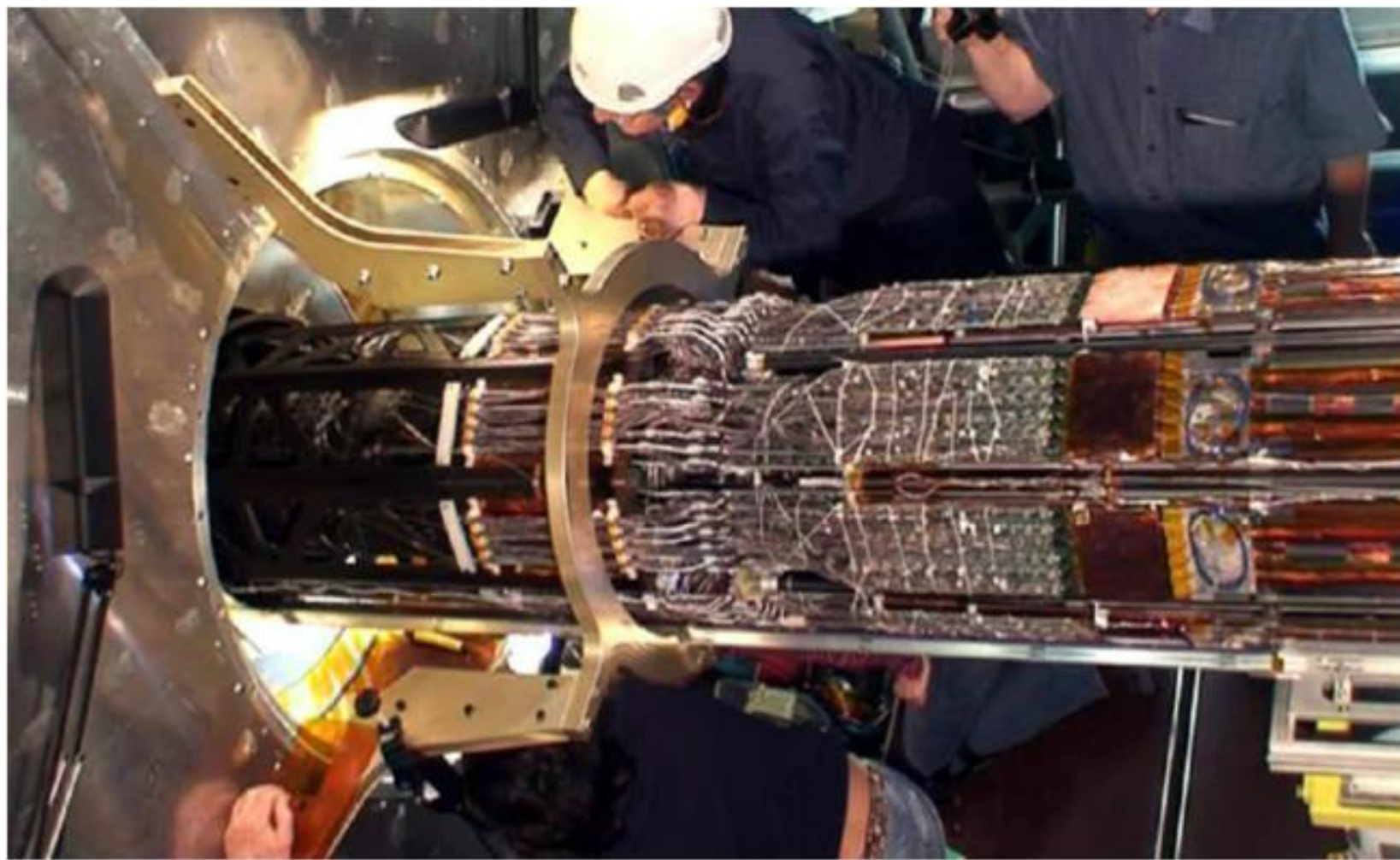
Animatie: opeenvolgende botsingen, iedere 25 ns



source: CERN

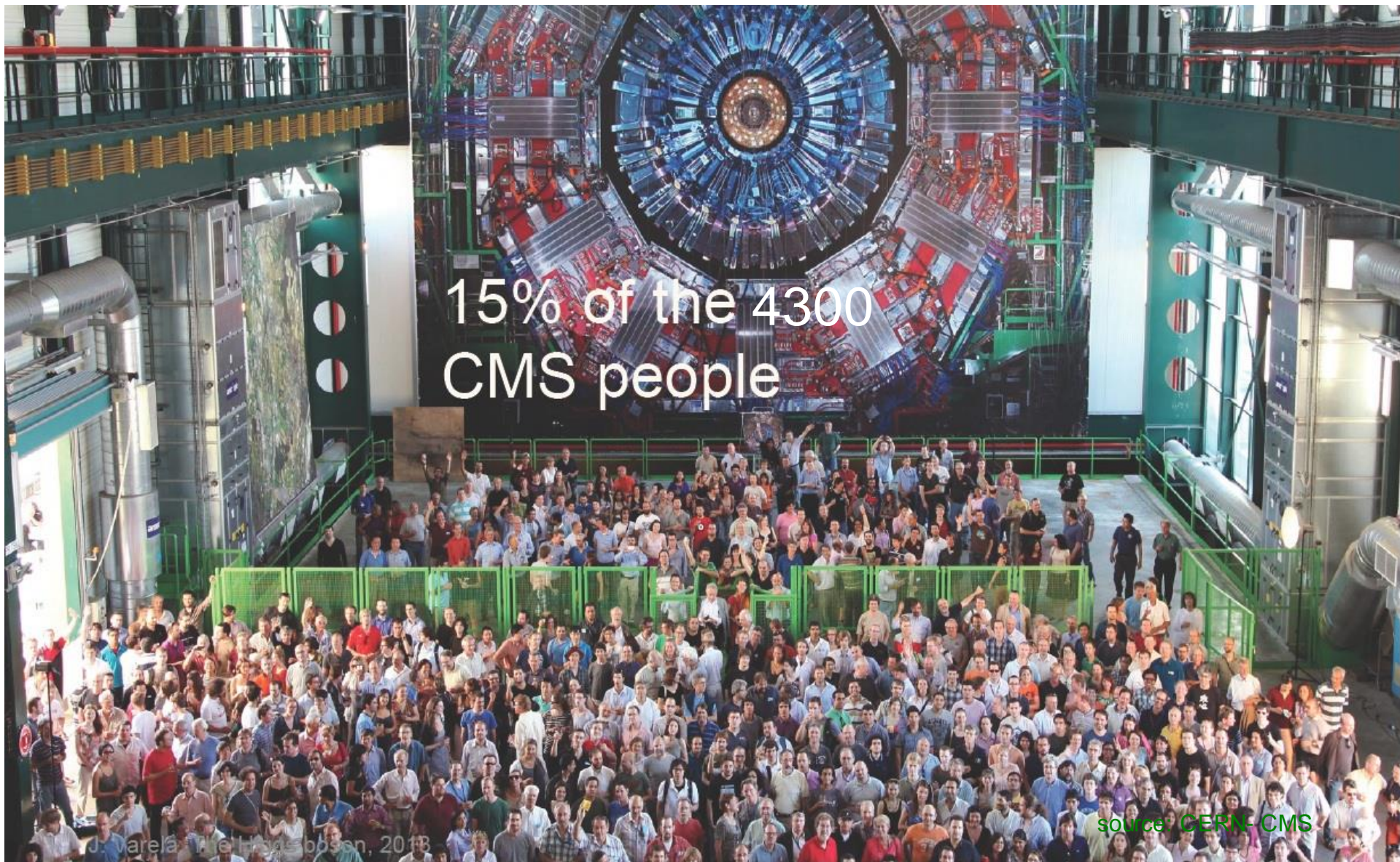


CERN
er zitten duizenden chips in elke detector





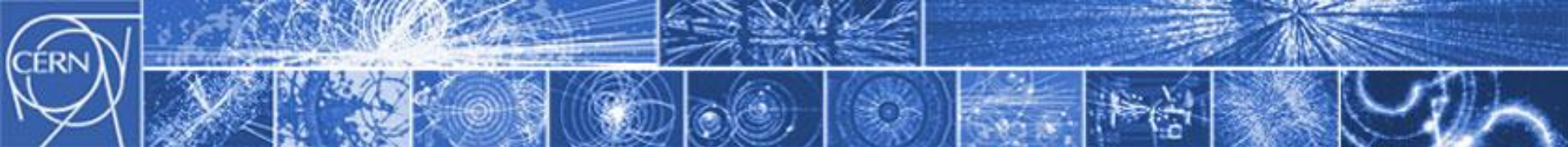
CMS Collaboratie



15% of the 4300
CMS people

J. Varela, The Hobbitsson, 2013

source: CERN-CMS



Het **grootste** laboratorium voor deeltjes fysica ter wereld

Jaarlijks budget
1153 MCHF (2016)
juist 1 Miljard €



22 Lid staten

Oostenrijk, België, Bulgarije, Tsjechische Republiek, Denemarken, Finland, Frankrijk, Duitsland, Griekenland, Hongarije, Israël, Italië, Nederland, Noorwegen, Polen, Portugal, Roemenië, Slowakije, Spanje, Zweden, Zwitserland, Groot Brittannië

2 Kandidaat lidstaten

Servië, Cyprus

2 Geassocieerde staten

Oekraïne, Pakistan, Turkije

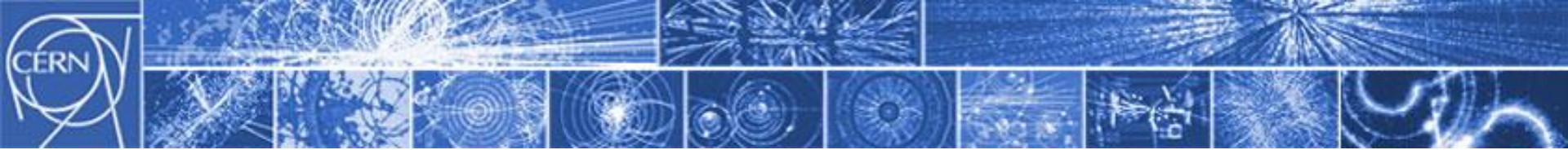
7 Observatoren bij de Council

India, Japan, JINR, USA, Russische Fédératie, Europese Commissie, UNESCO



Sinds 2013:





Ong. **10'000** mensen dagelijks aanwezig!



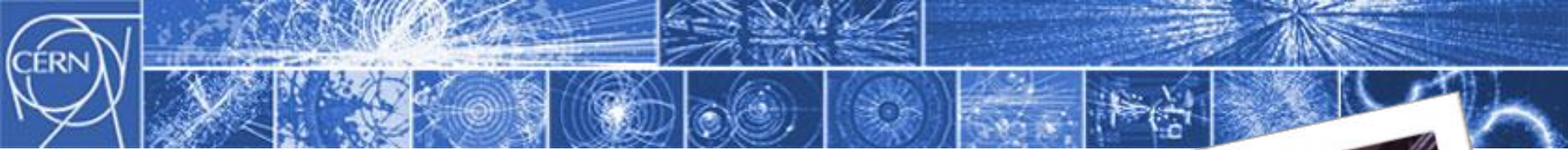
2560 Staf (slechts **81**'echte' deeltjesfysici)

1900 Associates en Fellows

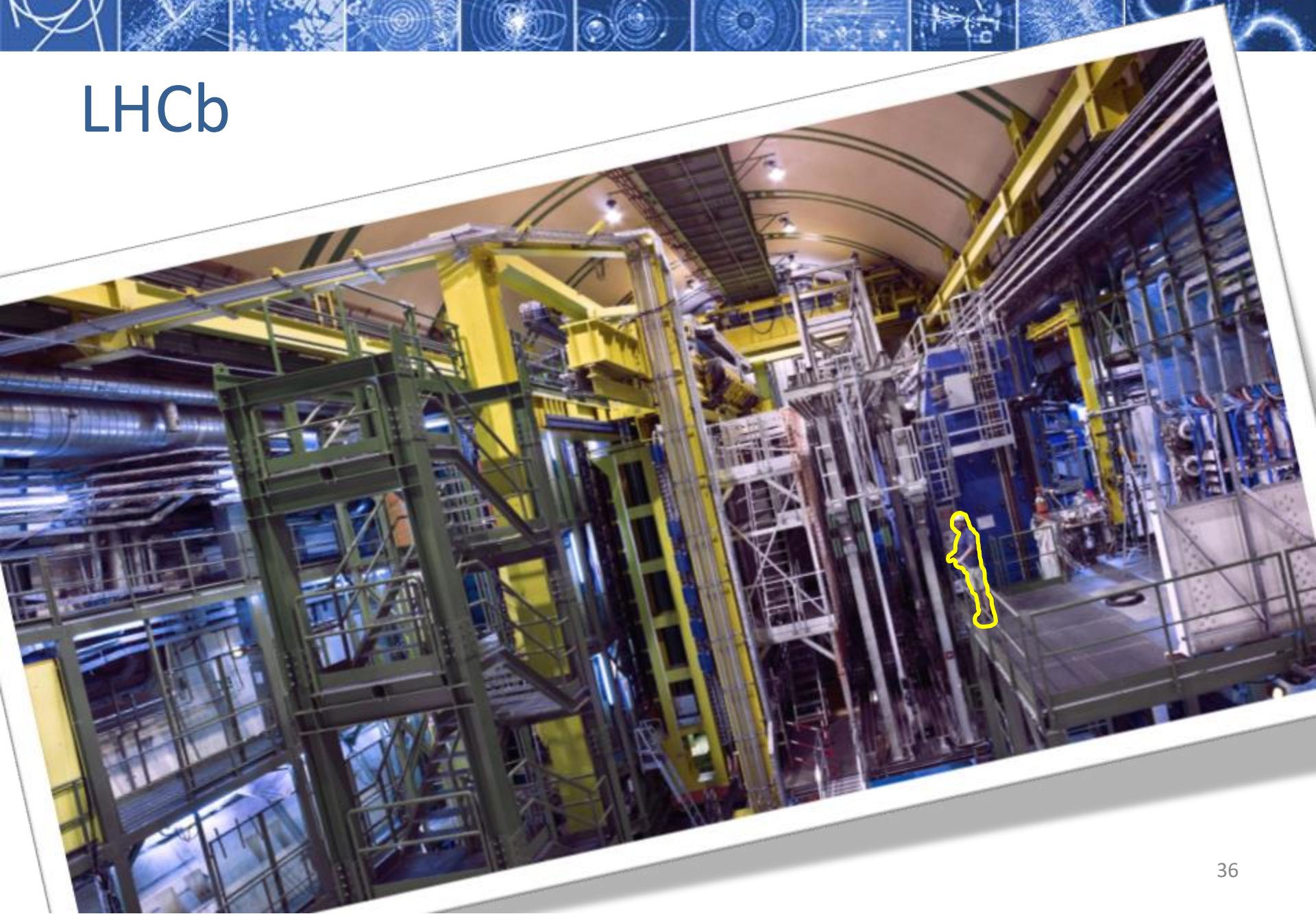
552 Technische Studenten met beurs

11800 Gebruikers (Externe Fysici)

~2000 Contract werkers



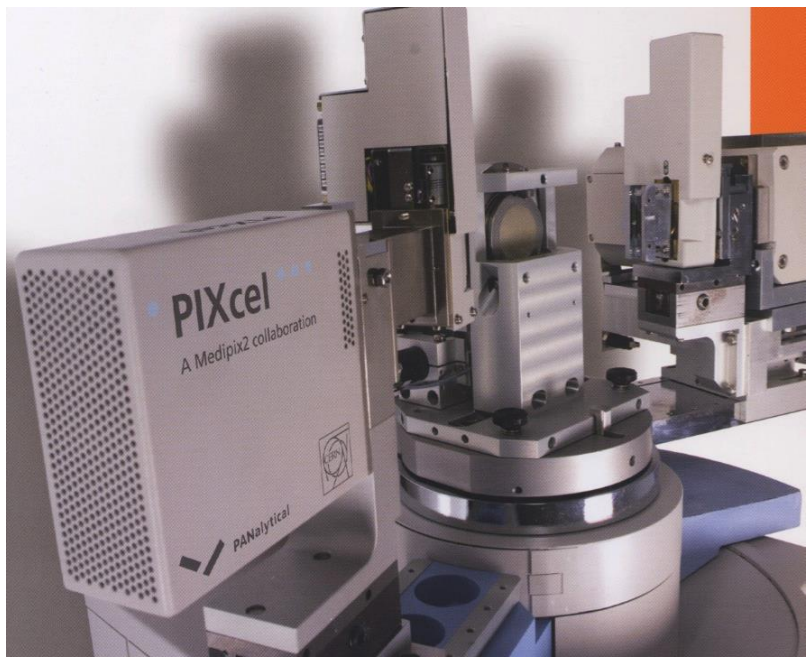
LHCb





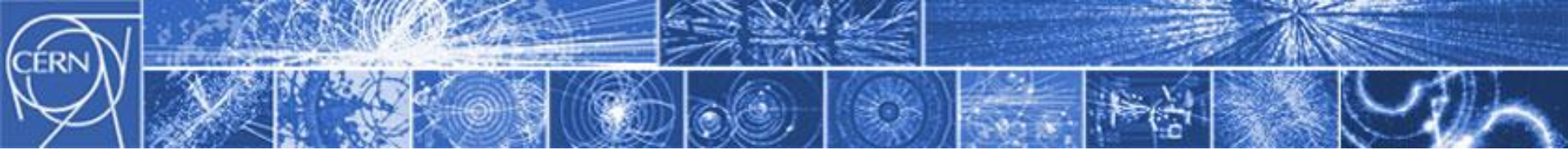
een "Spin-Off"

"PIXcel" detektor voor een Nederlands Röntgen Apparaat



ALMELO, NL

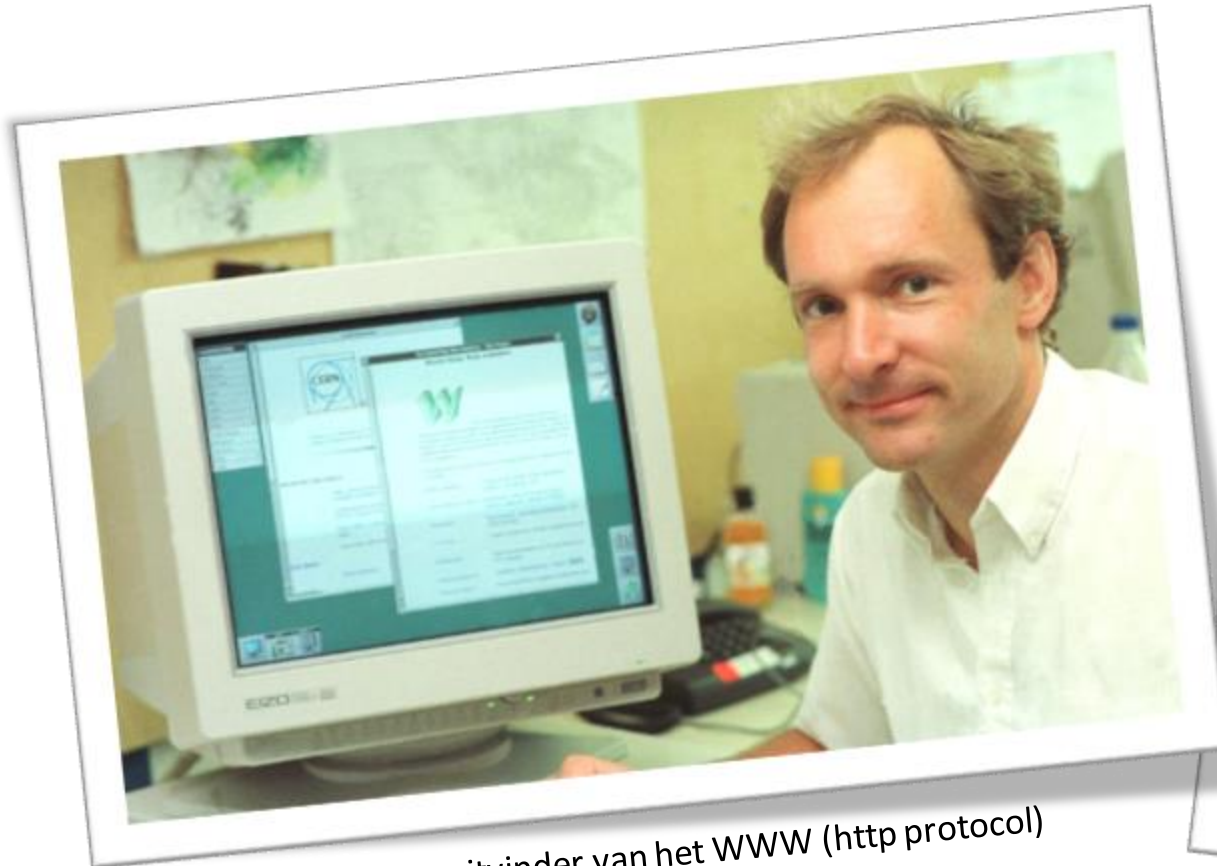




Toepassingen: het World Wide Web

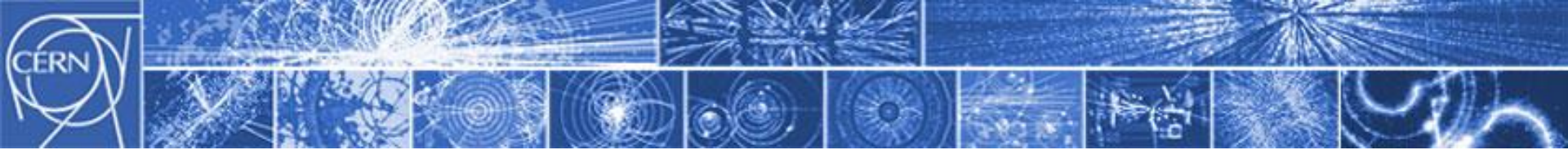
Ontwikkeld in 1989
met het idee van het
LHC project in het
achterhoofd!

Gratis aan de
mensheid ter
beschikking gesteld!



Sir Tim Berners-Lee, uitvinder van het WWW (http protocol)





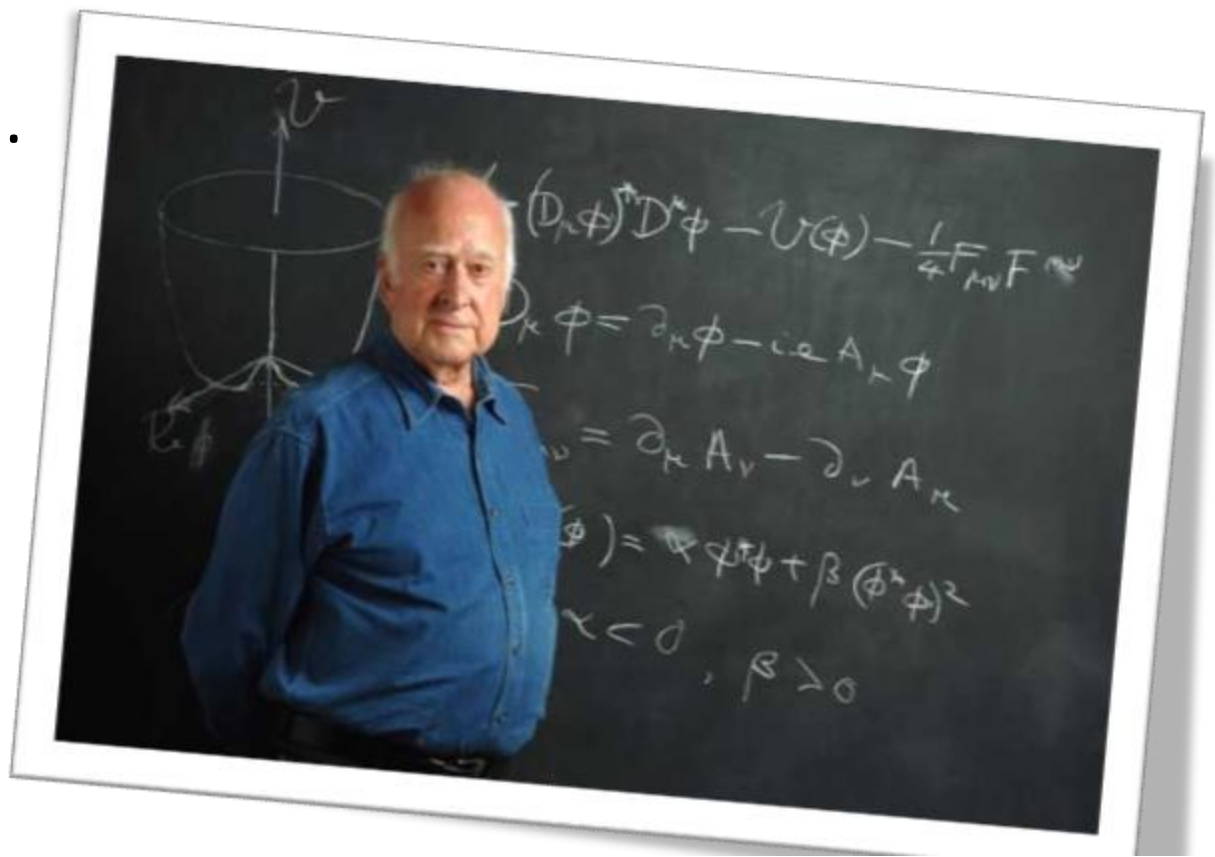
Fundamentele vragen

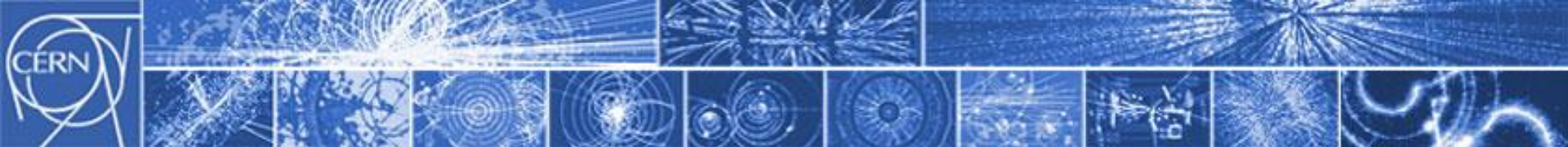
Waarom hebben deeltjes massa?

Newton kon het niet uitleggen,
maar wij ...
kunnen het nu bijna.



De Higgs Boson





Verificatie van theorieën: het Standaard Model

LEPTONS

QUARKS

GEWONE MATERIE

ELEKTRON



ELEKTRON NEUTRINO



UP



DOWN



MUON

TAU



POSITRON



ANTIPROTON



ANTINEUTRON



ANTIMUON



ANTITAU



ANTI-UP QUARK



ANTI-DOWN QUARK



ANTI-STRANGE QUARK



ANTI-CHARM QUARK



ANTI-BOTTOM QUARK

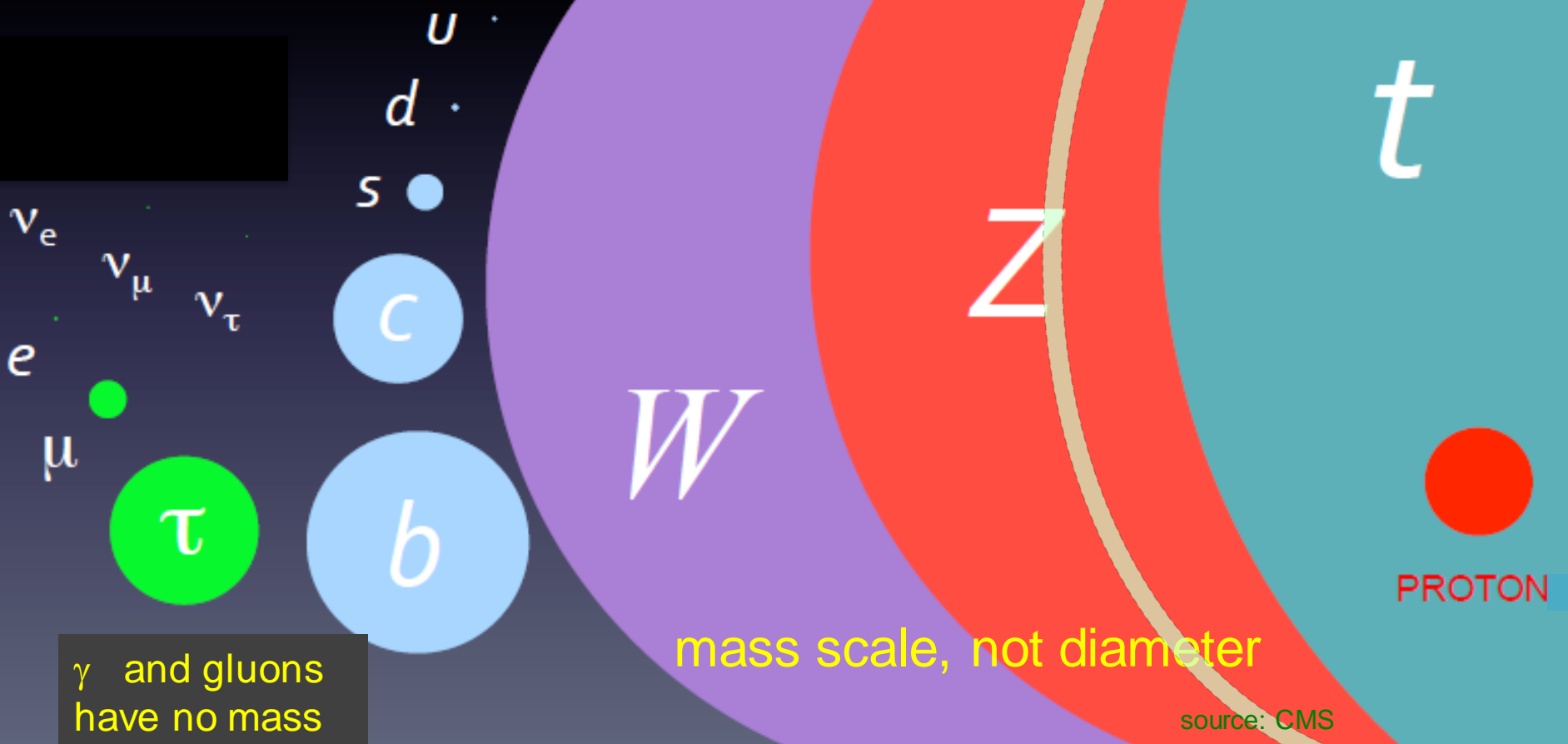


ANTI-TOP QUARK

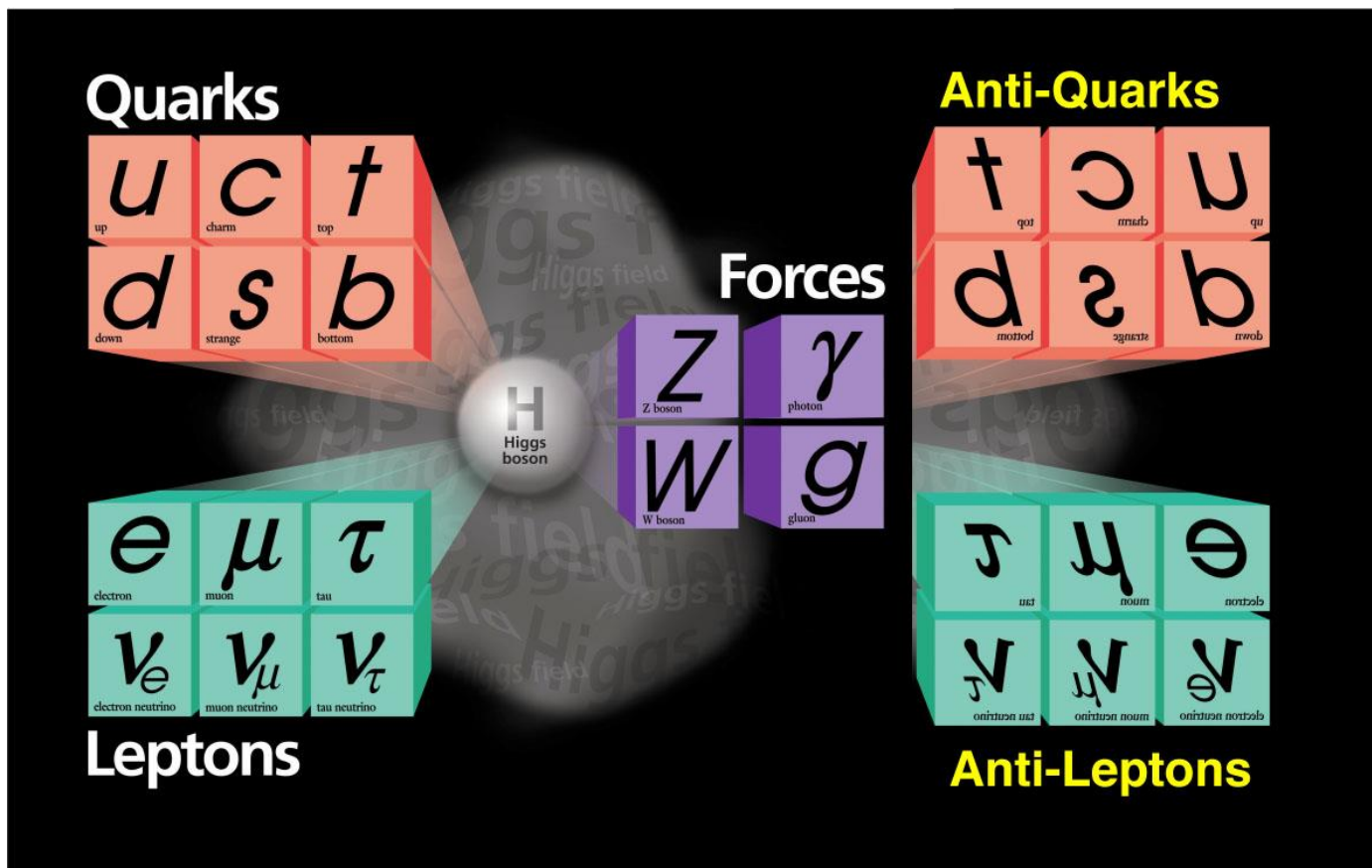
4

krachten

Hoe zit dat met massa?



het nieuwe Periodiek Systeem "Standard Model"



source: Fermilab

Er blijven nog talloze vragen: Waarom....



Periodiek Systeem van Elementen

1	IA																0															
1	H	IIA																5	6	7	8	9	10									
2	3	4																	13	14	15	16	17	18								
3	11	12	III B	IV B	V B	VI B	VII B	VII					IB	IB	13	14	15	16	17	18												
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36														
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54														
6	55	56	*La	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86														
7	87	88	+Ac	104	105	106	107	108	109	110																						

* Lanthanide Series

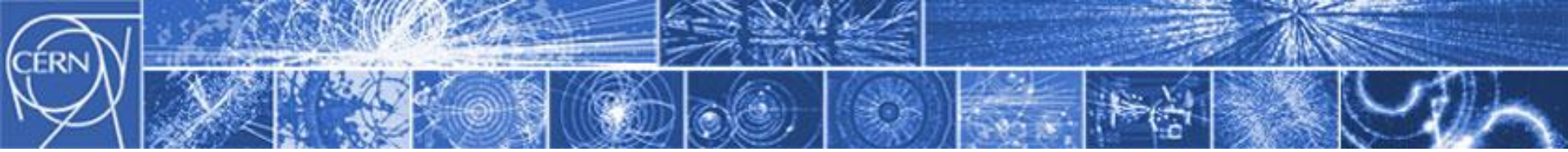
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

+ Actinide Series

90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Legend - click to find out more...

H - gas	Li - solid	Br - liquid	Tc - synthetic
Non-Metals	Transition Metals	Rare Earth Metals	Halogens
Alkali Metals	Alkali Earth Metals	Other Metals	Inert Elements



Fundamentele vragen

Waaruit bestaat de massa van het Heelal?

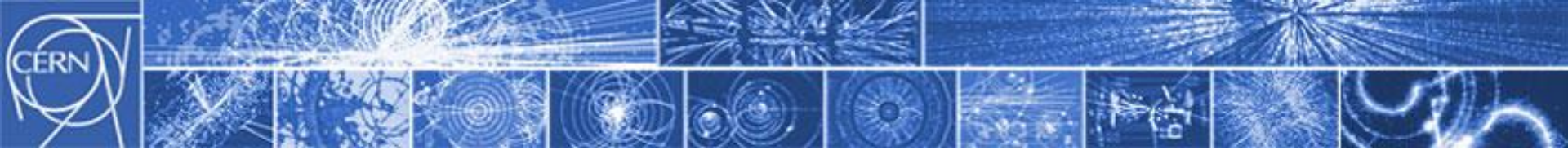
We zien slechts...

... 5% van zijn
geschatte massa!

Zwarte Materie?

Zwarte Energie?





In 2019 is CERN 65 jaar

Organisation

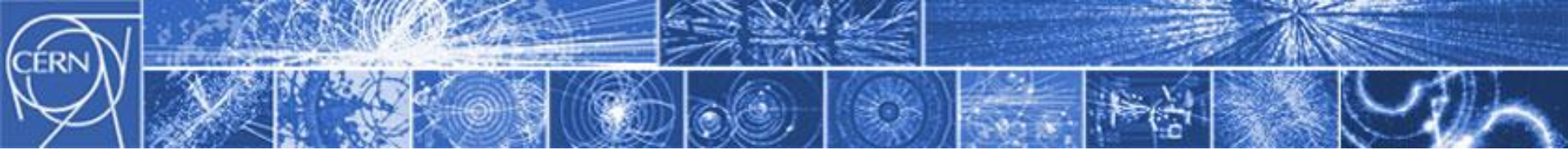
Européenne pour la

Recherche

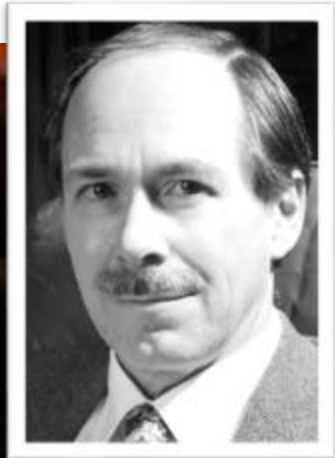
Nucléaire



1954

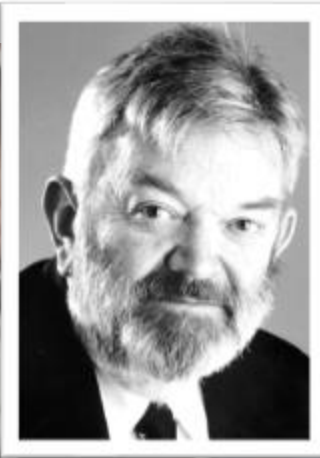


Nederland's bijdragen aan de theoretische fysica.



Gerardus 't Hooft
(Nobel 1979 samen met
Martinus Veltman)

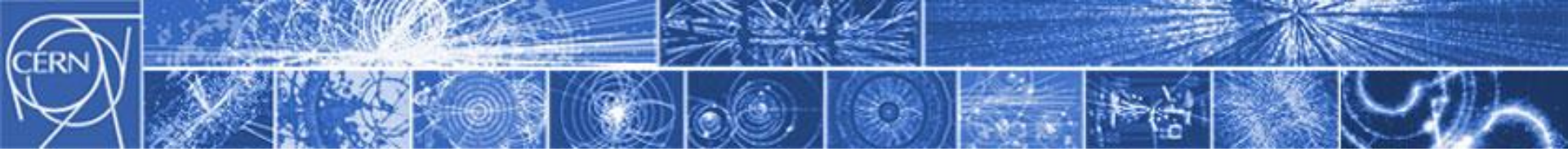
for elucidating the quantum structure of electroweak interactions in physics



Martinus Veltman
(Nobel 1979 samen met
Gerardus 't Hooft)

for elucidating the quantum structure of electroweak interactions in physics





CERN...

Op weg!