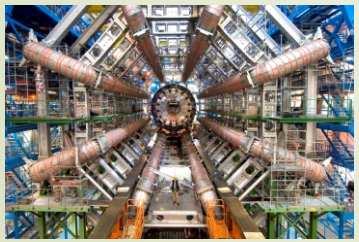
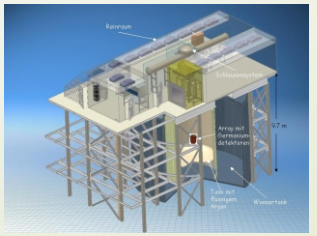
The “Max-Planck-Institut für Physik”

Dr. Iris Abt

and its Scientific Program





The Max-Planck-Society

The MPG is a public society to support sciences .

Employees	16873*
Scientists	5222
PHD students	1505
plus guests	4641

80 Institutes

3 Sections: CPT, BMS, GSHS

Employees	7165*
Scientists	2595
PHD students	712

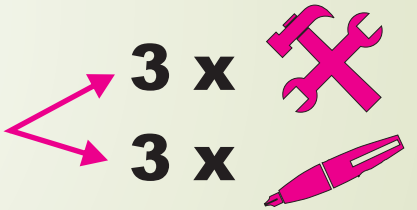
*as off 1.1.2011

Budget 2012: 1.46 Mrd Euro

The Max-Planck-Society

1917: Founded as Kaiser-Wilhelm-Institut
Direktor: Albert Einstein
1942: Direktor: Werner Heisenberg
1946: Refounded as Max-Planck-Institut
under Heisenberg in Göttingen
1958: Move to München

6 directors, i.e. 6 departments



Employees	**300**
Scientists	**140**
PHD students	**60**
plus guests	**30**

Large technical department, apprentices administration

Program

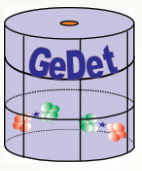
To find out what keeps the world together deep inside.

- **High Energy Physics**

ATLAS

PWA

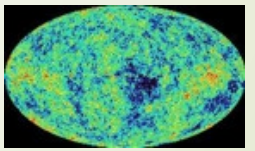
- **Neutrino- and Astroparticlephysics**



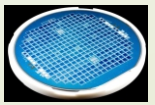
CRESST

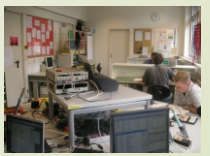
CAST

- **Detector Developement**

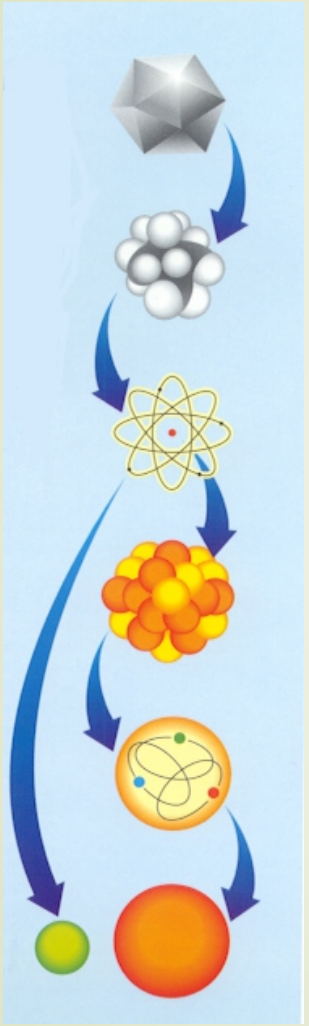


- **Technical Department and Semiconductorlab**





The Innermost



Crystal 1 cm

Molecule 10^{-7} cm
0,000000 1

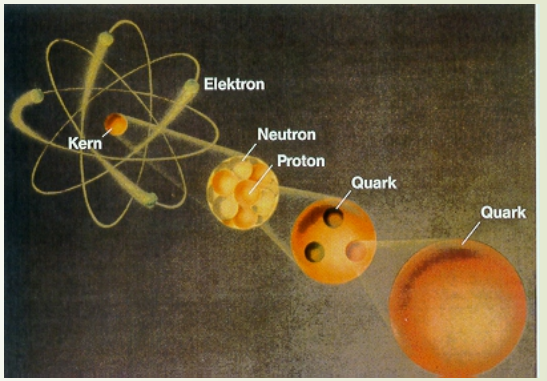
Atom 10^{-8} cm
0,000000 01

Nucleus 10^{-12} cm
0,000000 000001

Proton
Neutron 10^{-13} cm

Quarks
Elektrons $< 10^{-16}$ cm

The innermost is empty.



Everything we see is made out of 3 particles.

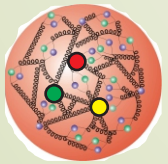
Chemical Elements

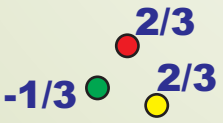
The chemistry of the elements is the physics of the electrons of the atoms.

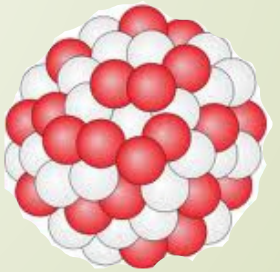
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	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	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	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	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo

Alkali metals | Alkaline earth metals | Lanthanides | Actinides | Transition metals
Poor metals | Metalloids | Nonmetals | Halogens | Noble gases

The nuclei are made of protons and neutrons, and they are made out of "colored" up and down Quarks and Gluons.

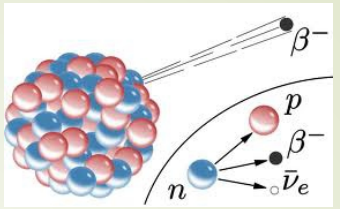


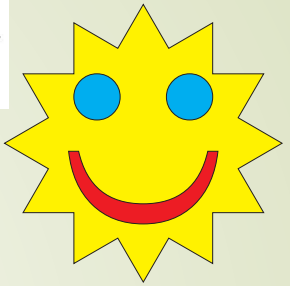




All you need for daily matters

ν	Neutrinos
e	Electrons





u	up	Protons
d	down	Neutrons

This would be enough to make us happy.

But…

- **there is a “heavy electron”, muon, abundant in cosmic ray showers**
- **in our labs we make heavy quarks**

Who has ordered this ? → **Standard Model**

Standard Model

matter

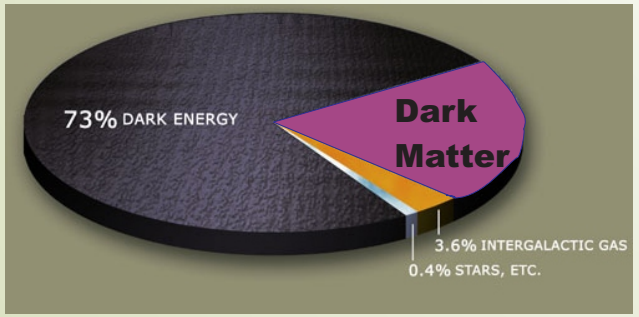
and

anti-matter

three generations

ν_e	ν_μ	ν_τ	**Leptons**
e	μ	τ	
u	c	t	**Barions**
d	s	b	

mass →



We only find matter in the universe, but it only accounts for 4% of its energy content.

Forces

Four forces in comparison				
Force	gravity	electroweak force		strong force
		weak	electromagnetic	
acts on	mass/matter	leptons quarks	electric charges	quarks/gluons
rel.strength	10^{-38}	10^{-5}	10^{-2}	1

Forces are transmitted by the exchange of bosons.

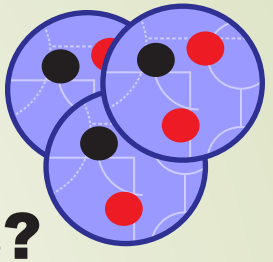
electromagnetism	photon
week force	$W^+ W^- Z$
strong force	gluons [8]
gravity	graviton

} Quantum-field-theories

Relativity

The Big Questions

- Why are there three generations with such different masses?
- What is mass in the first place?
- What kind of particles are neutrinos?



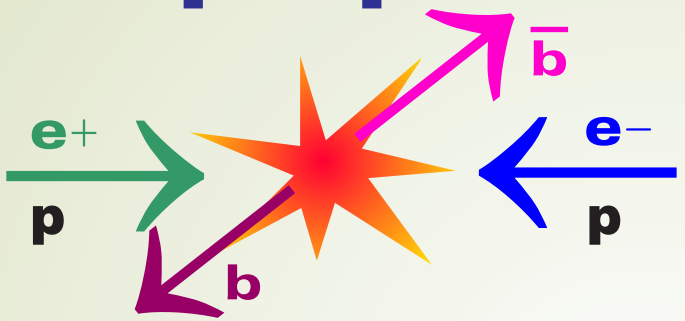
- Why are there four forces with such different strenghts?

- What is dark matter?
- What is dark energy?

What can we contribute to the answers?

Measurement Methods

Matter [anti-]matter collisions



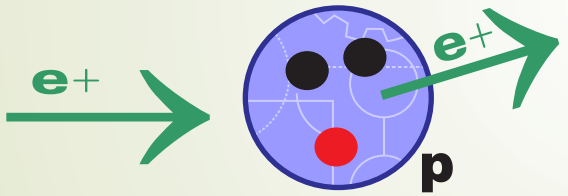
BELLE

ATLAS

generations

mass

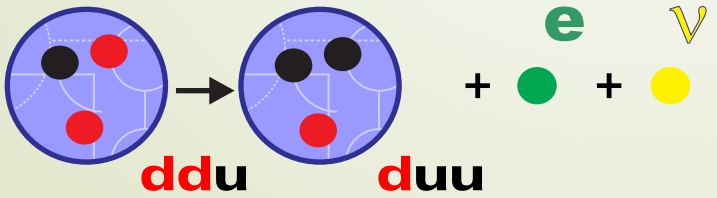
Investigate with a probe



H1 ZEUS

Forces and structure

Wait for a decay

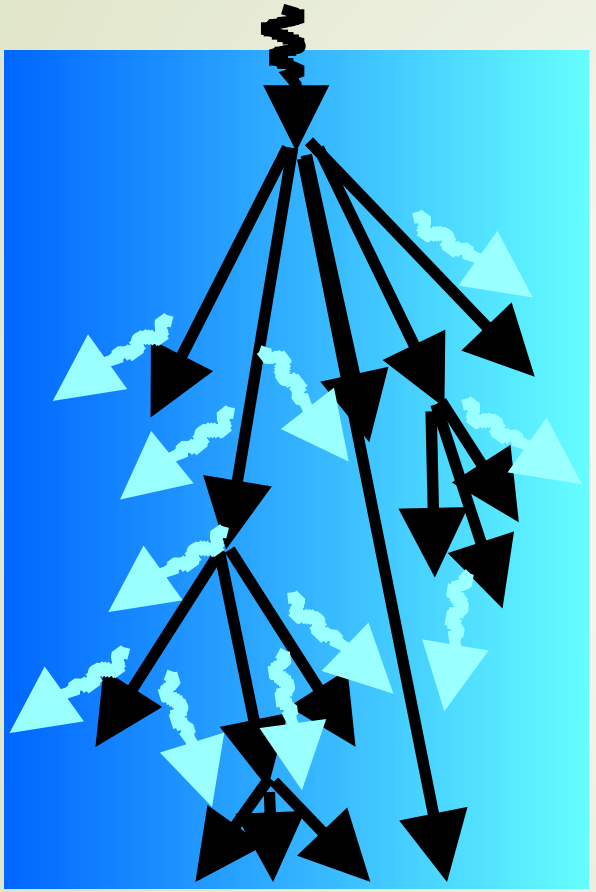


GeDet GERDA

neutrino physics

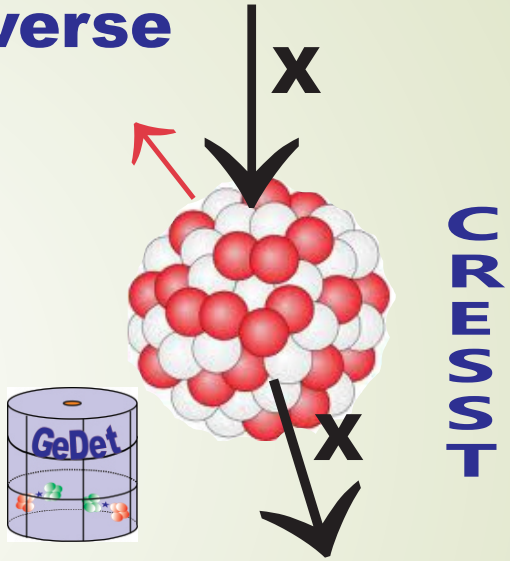
Measurement Methods

Wait for a messenger out of the depths of the universe



MAGIC

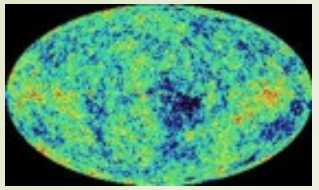
cta
cherenkov telescope array



Structure of the universe

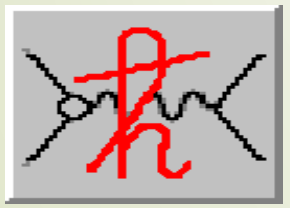
Search for dark matter

Theory



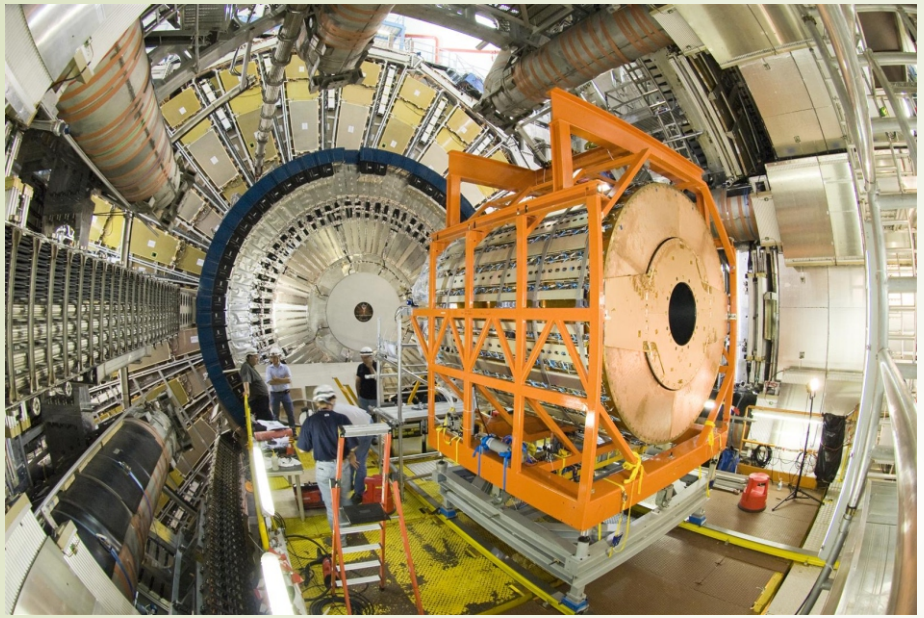
Structure of the universe, dark matter, neutrinos

String theory
Structure of matter at the smallest scale, i.e. Planck scale



Phenomenology
Cross sections and other observables

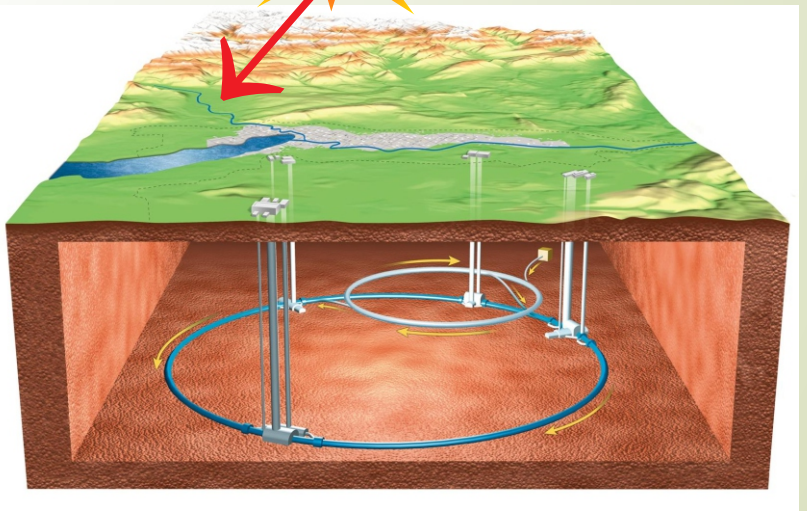
ATLAS



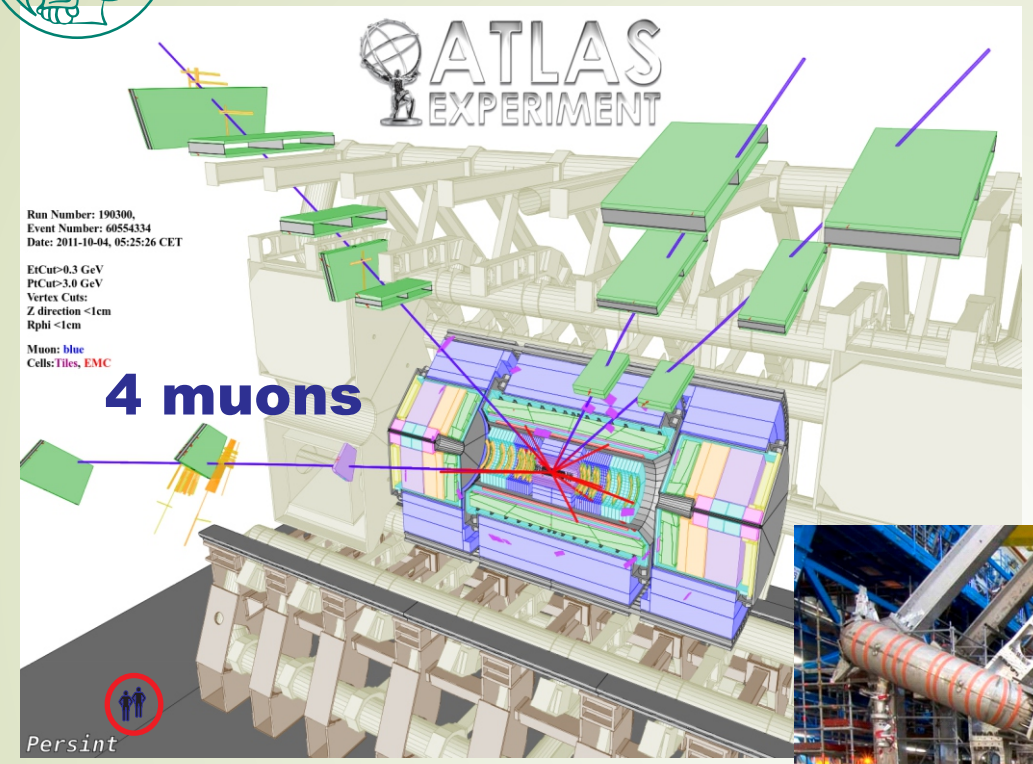
Proton
Proton
Colli-
sions

Search for Higgs and Super Symmetry

The Higgs is an excitation of the vacuum and helps to understand mass.

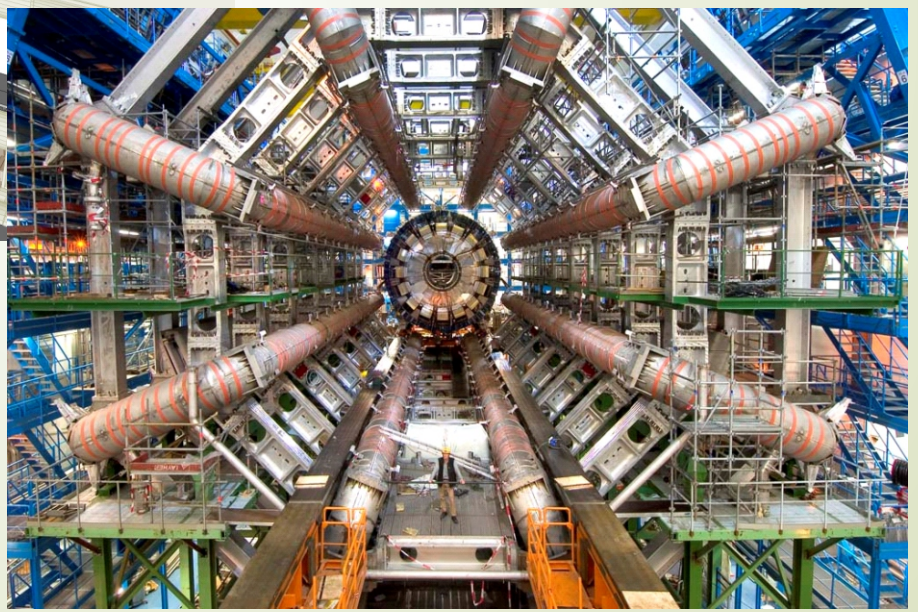


ATLAS



The detector is gigantic and built like an onion.

The collaboration has > 2500 physicists.

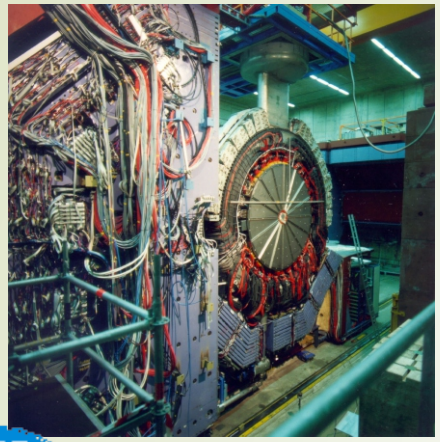


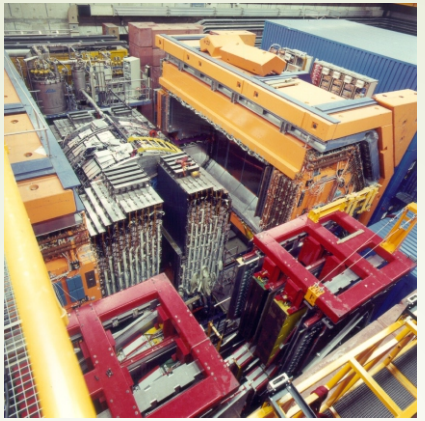
Such projects last decades.

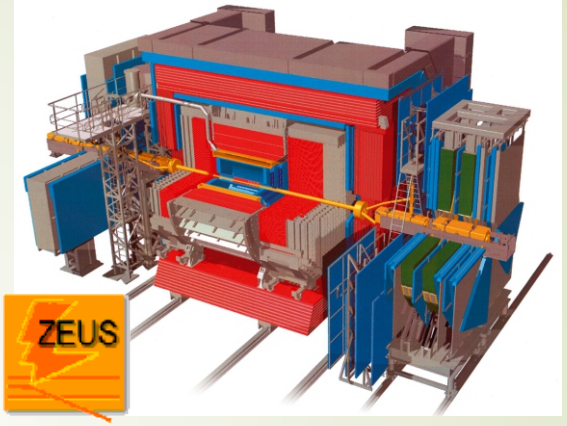
ATLAS

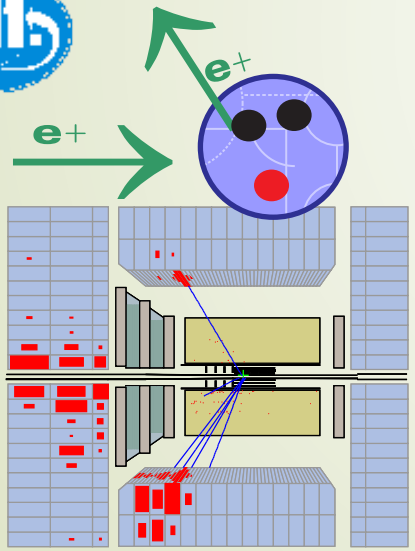
The MPI was in it from day one.

H1 and ZEUS

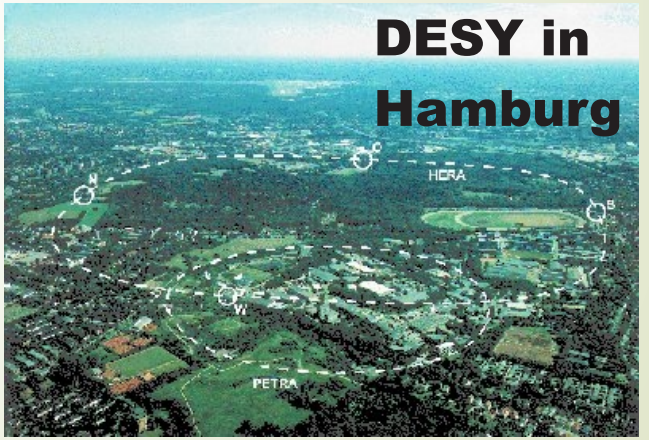








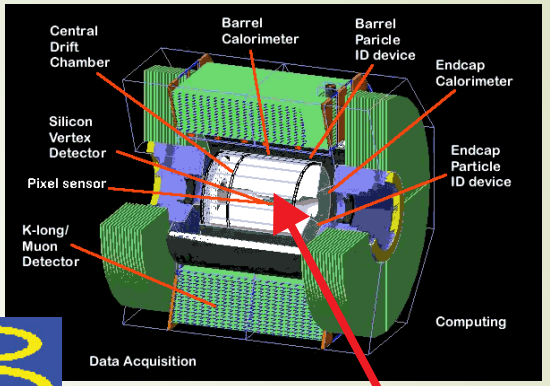
Electron
Proton
Scattering

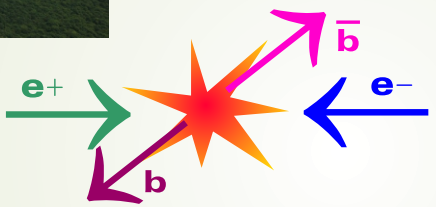


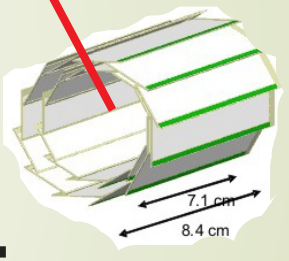
Structure of matter and forces

Belle

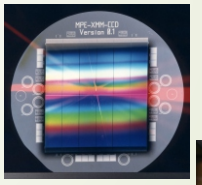
Belle in Tsukuba, Japan



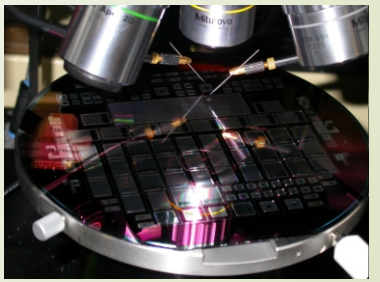




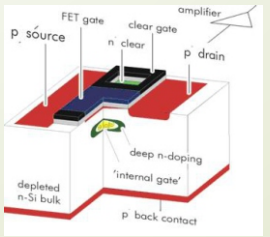
Differences between matter and anti-matter, questions about hierarchy of generations



HLL

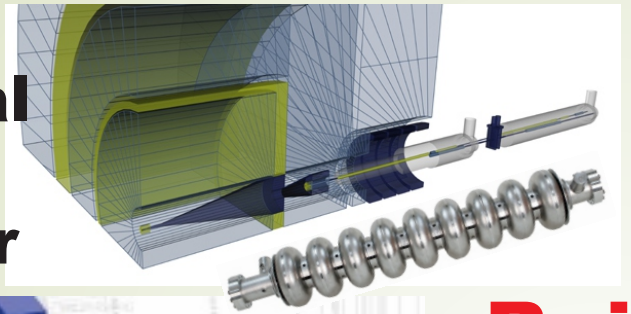


Depfet-Pixeldetectors

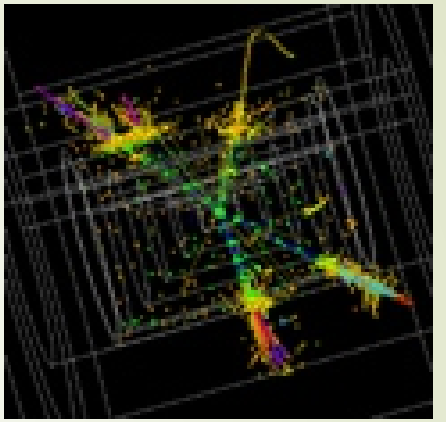


Accelerators

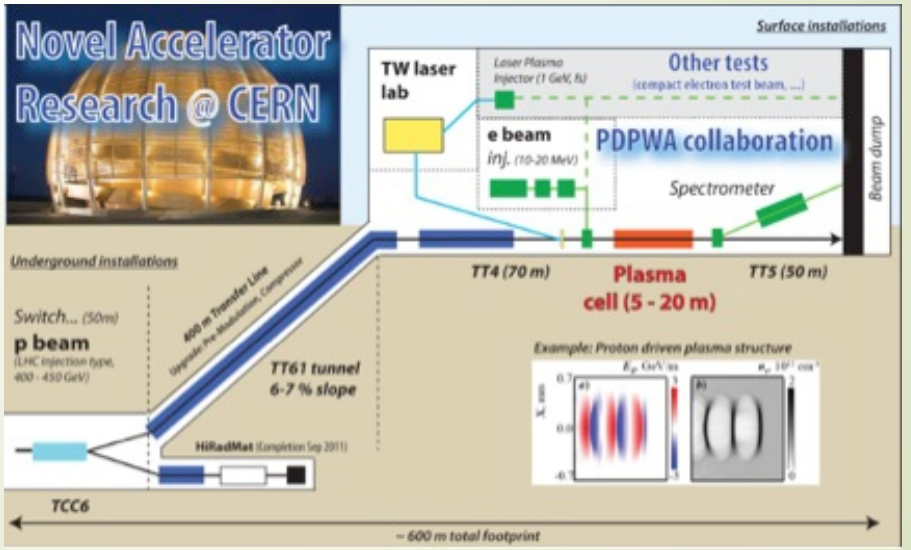
Inter-national Linear Collider



and detec-tors

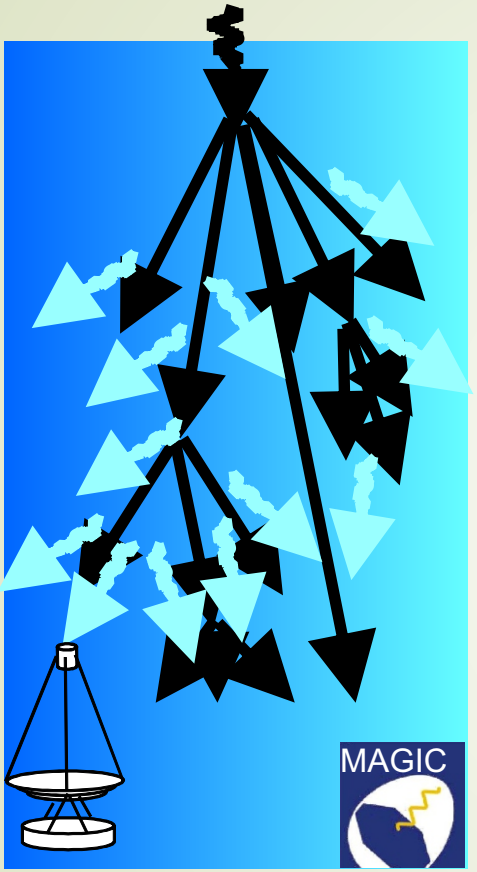


Build the Future

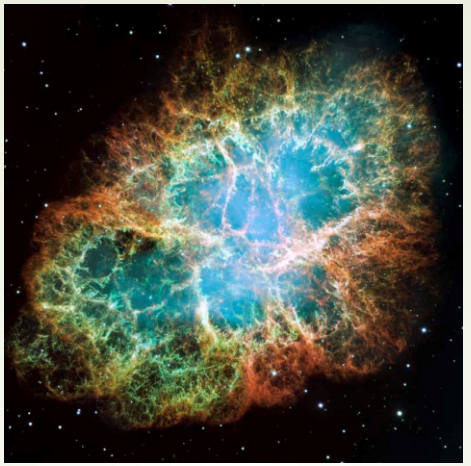


Acceleration through "Plasma Wake Fields"

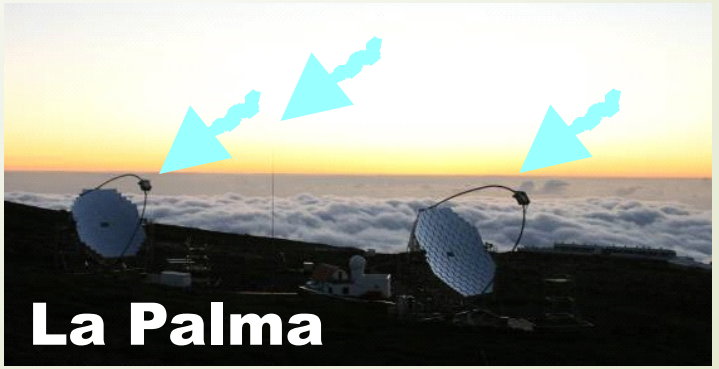
Magic and CTA



Observation of Čerenkov Lichts

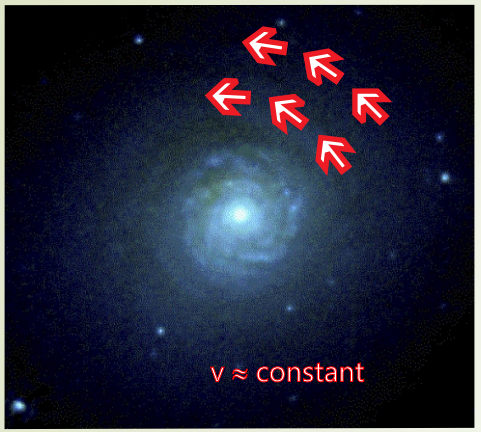


Where and how is cosmic radiation produced? Is dark matter involved ?

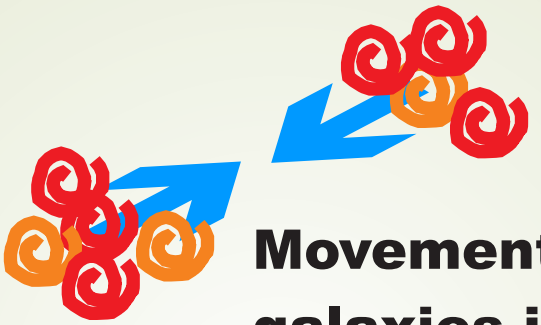


Dark Matter

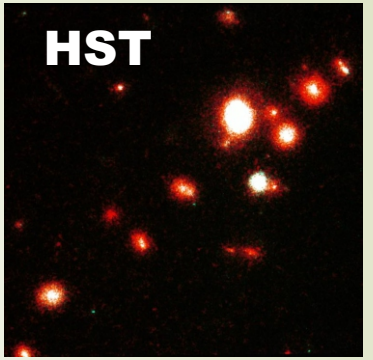
Why do we believe it exists?

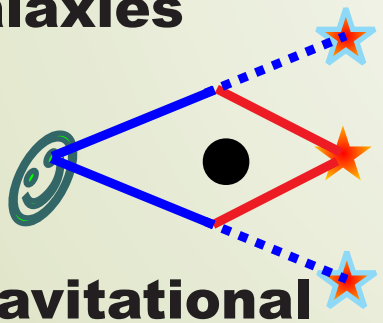


Movement of stars at the edge of galaxies

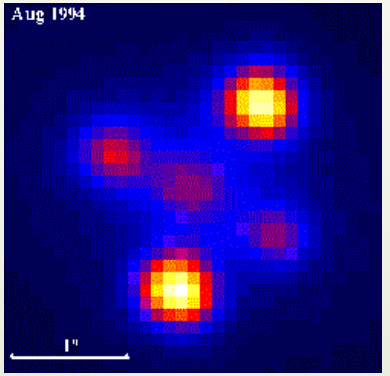


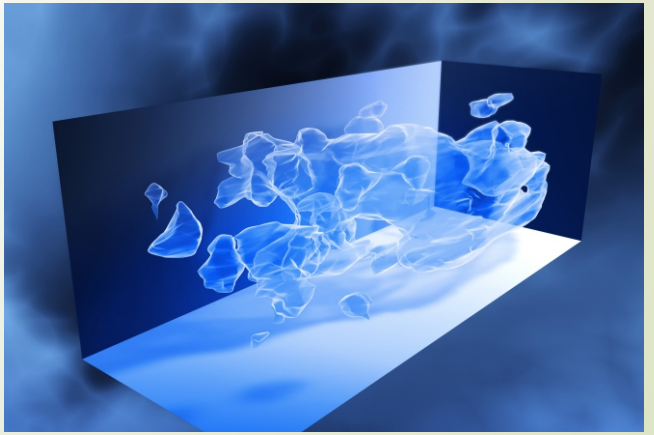
Movement of galaxies in galaxy clusters





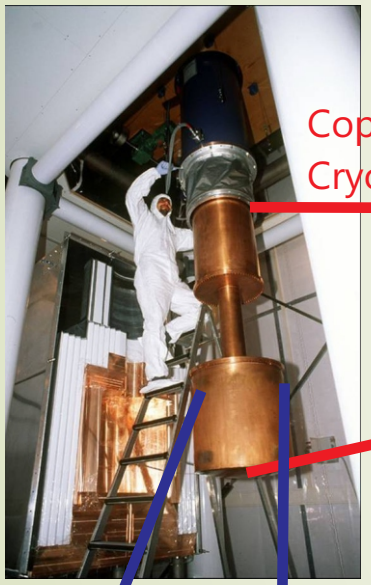
gravitational lenses

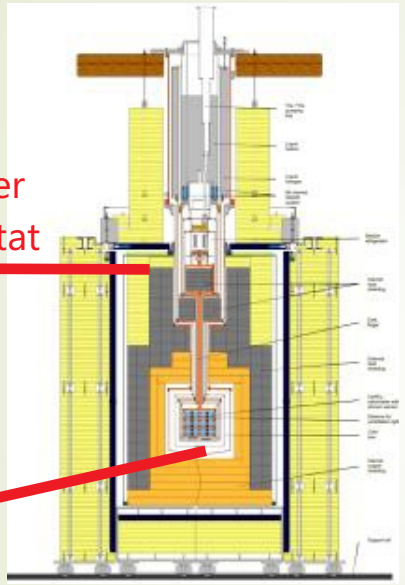




CRESST

Cryogenic Rare Event Search with Superconducting Thermometers

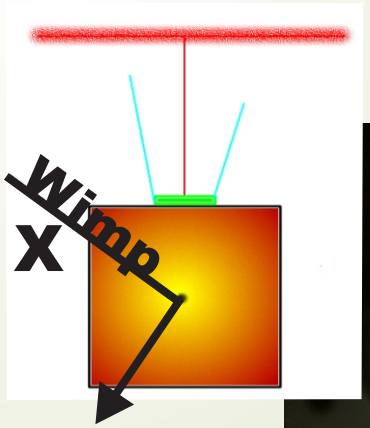




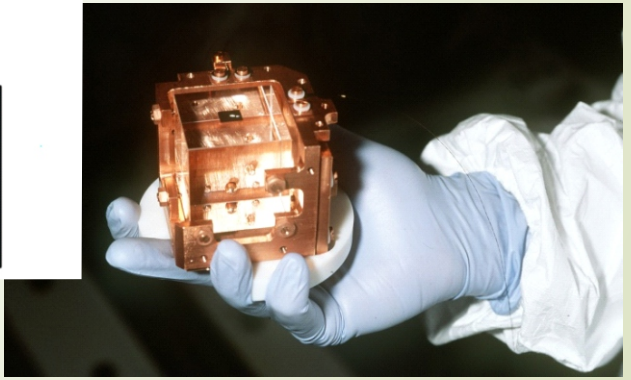
Tief im Berg
bei 0.012K

Search for dark matter

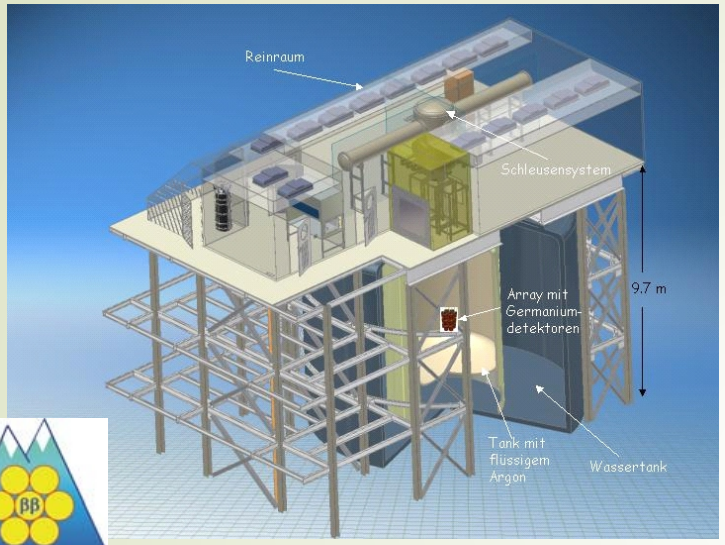
If the universe is full of it, we should also find some of it on earth....



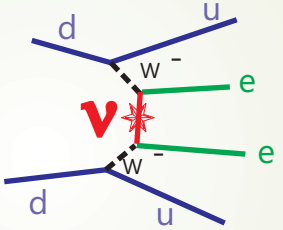
Protection against cosmic radiation



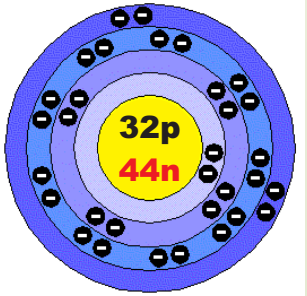
GERDA



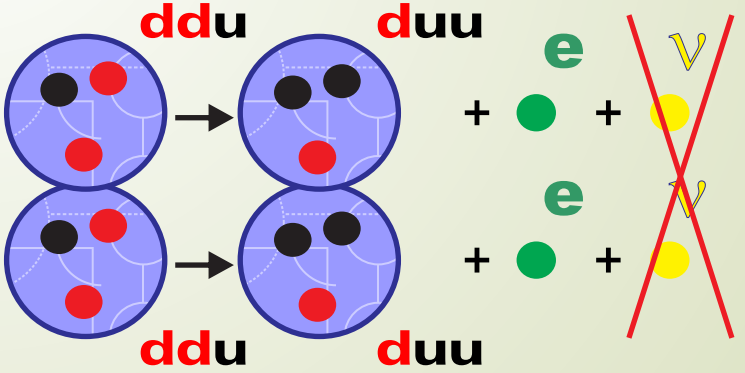
nature and mass of the neutrinos



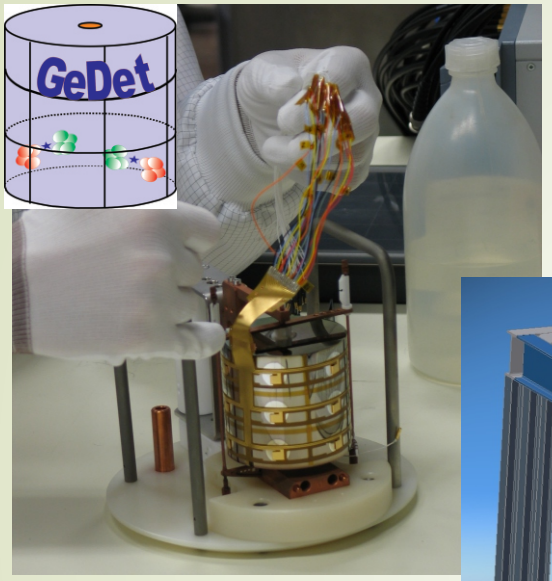
Are neutrinos their own antimatter?



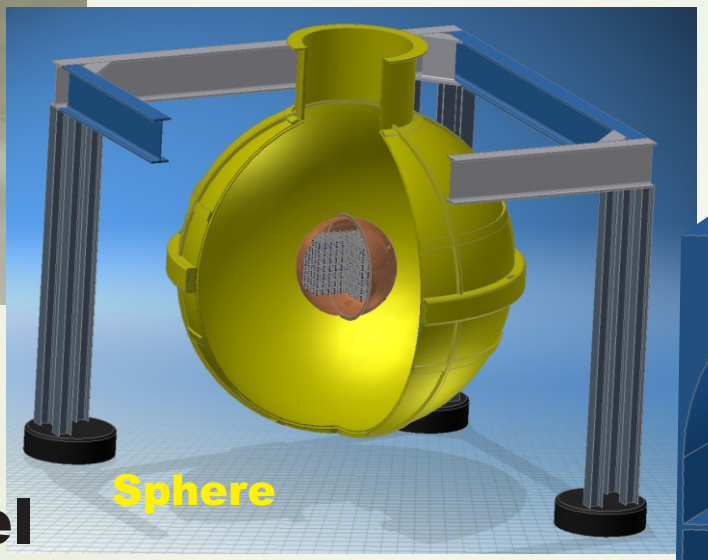
Search for neutrinoless double beta decay in germanium 76.

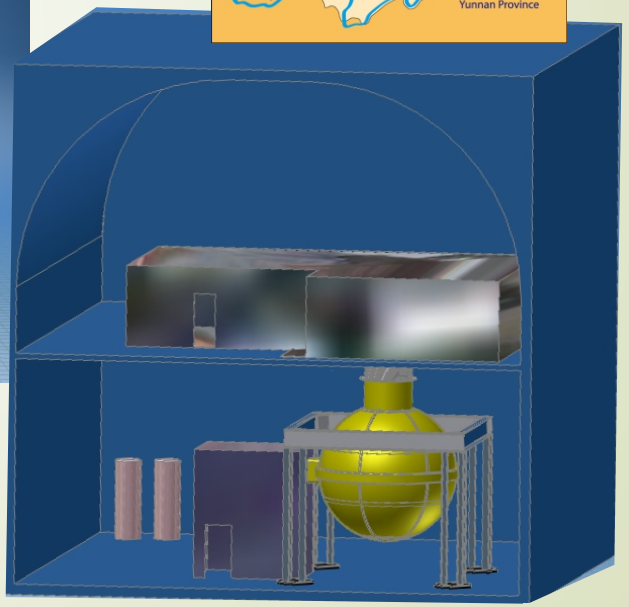


GeDet



Search for neutrinoless double beta decay and dark matter.

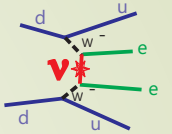


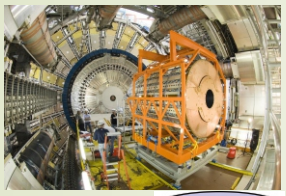


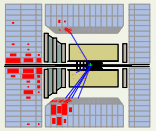
Developement of novel germanium detectors and future large scale detectors.

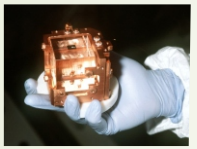
The MPI and its Program

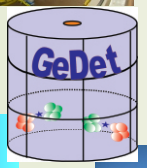
The MPI participates in international collaborations which work to answer the big questions of experimental and theoretical physics.

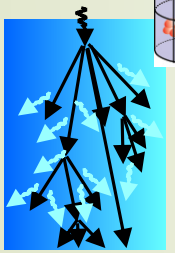


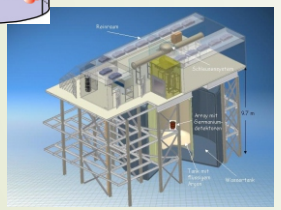




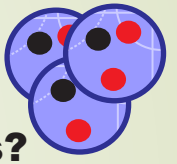






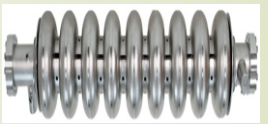


- Why are there three generations with such different masses?
- What is mass in the first place?
- What kind of particles are neutrinos?



- Why are there four forces with such different strenghts?

- What is dark matter?
- What is dark energy?



We also work on the technologies of the future.

And on the thoughts that will shape the future.