In the beginning …

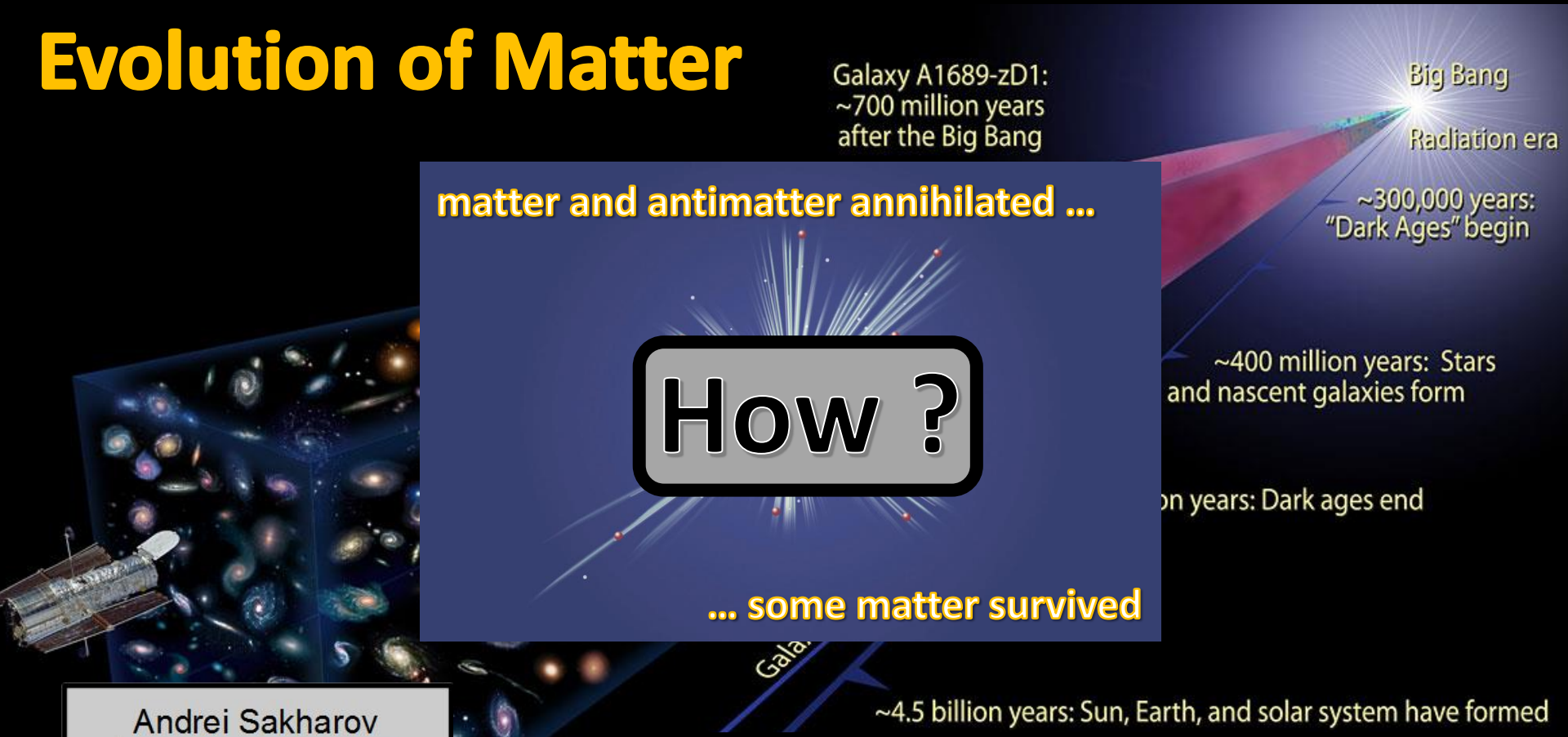
created matter and antimatter
in equal amounts

… the Big Bang

Today …

… we only find matter

Evolution of Matter

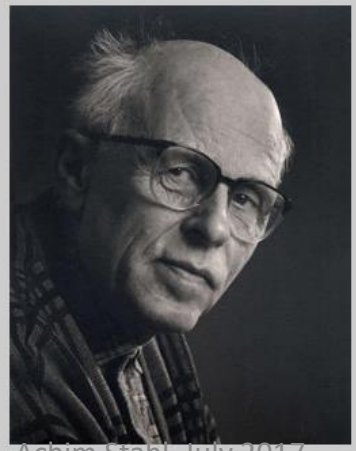


matter and antimatter annihilated ...

How ?

... some matter survived

Andrei Sakharov



1. Baryon-Number Violation — **theoretical ideas**
2. CP-Violation — **not enough !**
3. Thermal Non-Equilibrium — **understood**

Today …

Baryon to Photon Ratio:

$$\eta = \frac{n_B - n_{\bar{B}}}{n_\gamma} \approx 5 \cdot 10^{-10}$$

$$n_\gamma \approx 0.4/mm^2$$
$$n_B \approx 0.2/m^2$$
$$n_{\bar{B}} \approx 0$$

Standard Model fails by many orders of magnitude

… we only find matter

Concept of JARA-FAME

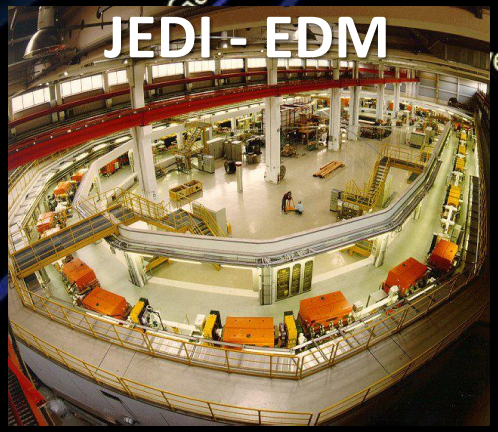
antimatter separated

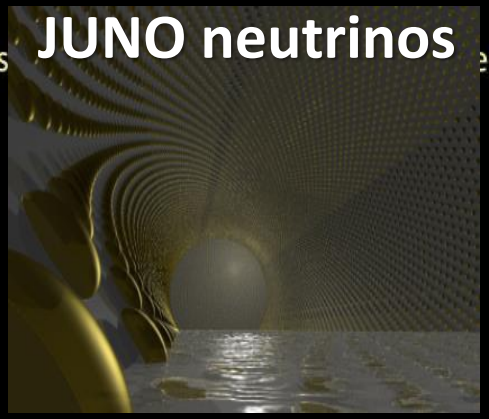
antimatter disappeared

More CP-violation needed !

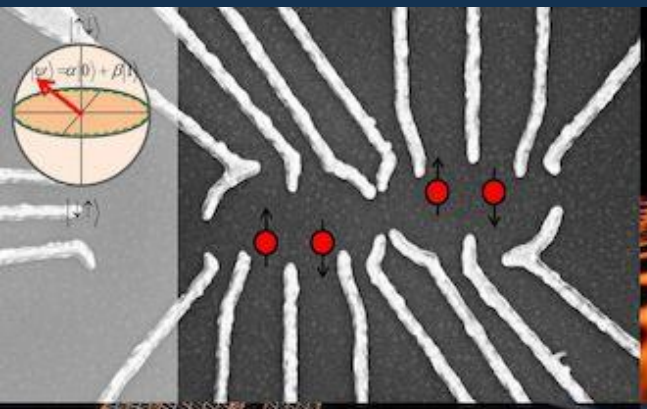
baryo-genesis

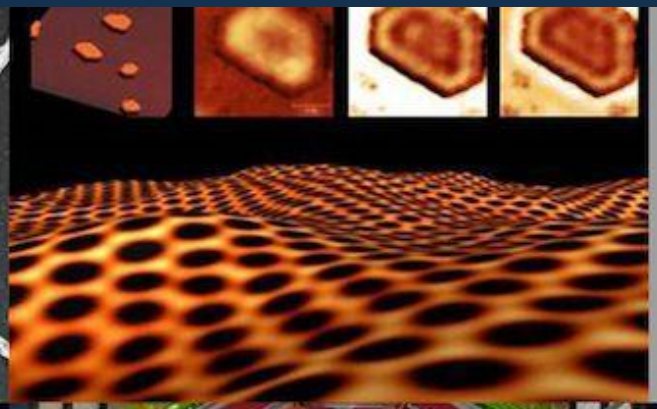
lepto-genesis

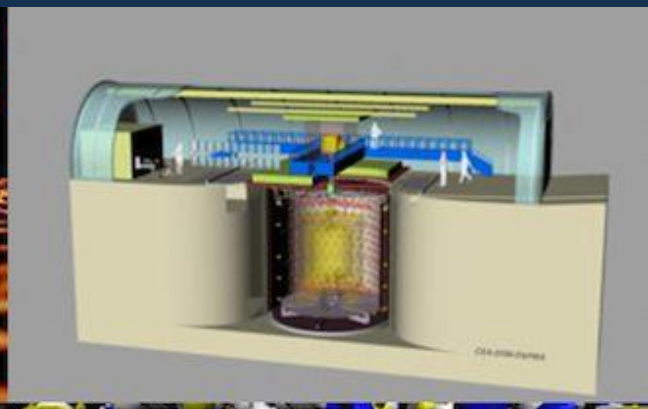


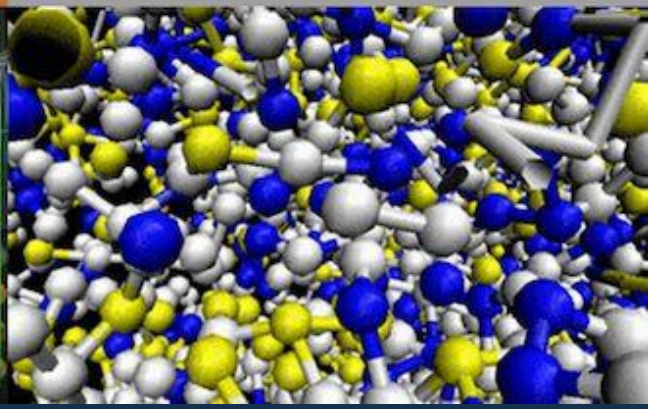


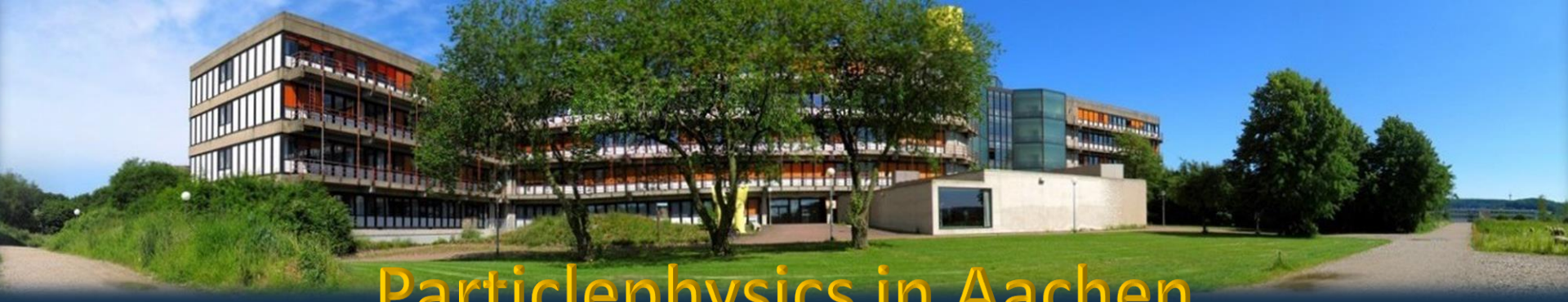
Physics in Aachen











Particlephysics in Aachen

experimental particle physics

Institute 1

Chair 1B

Prof. S. Schael
Prof. L. Feld

CMS/LHCb
AMS

Institute 3

Chair 3A

Prof. T. Hebbeker
Prof. M.Erdmann

CMS
Auger

Chair 3B

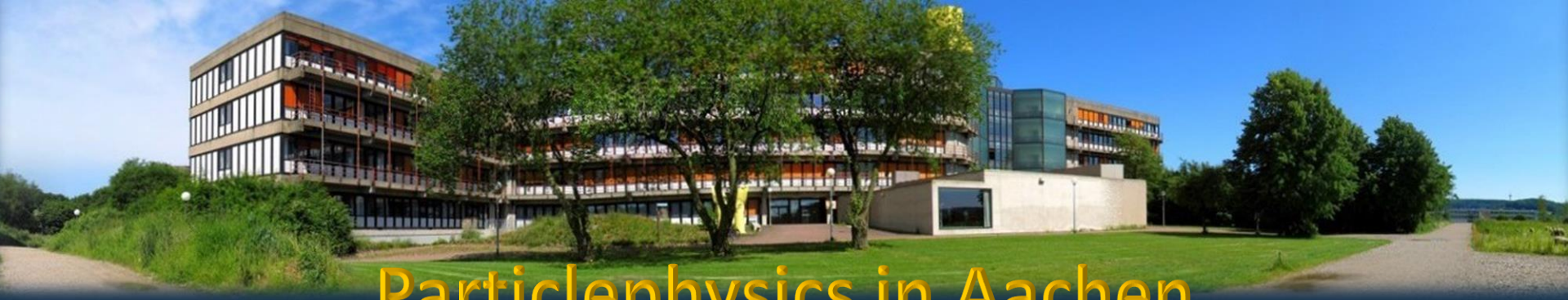
Prof. A. Stahl
Prof. C. Wiebusch
Prof. J. Pretz
Prof. L. Ludhova

CMS
IceCube, JUNO, Double Chooz, T2K, Borexino

theory

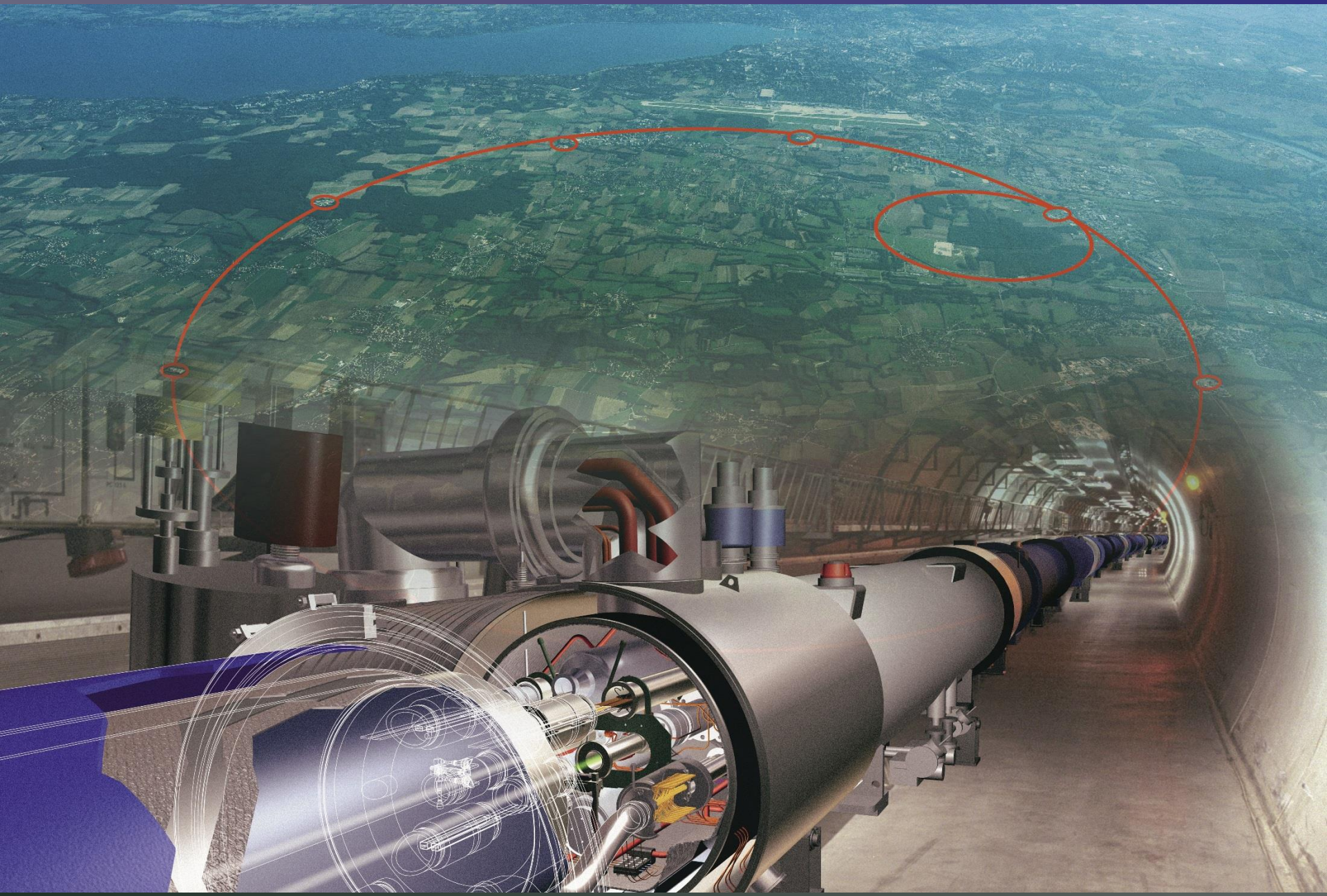
Institute for theoretical particle physics and cosmology

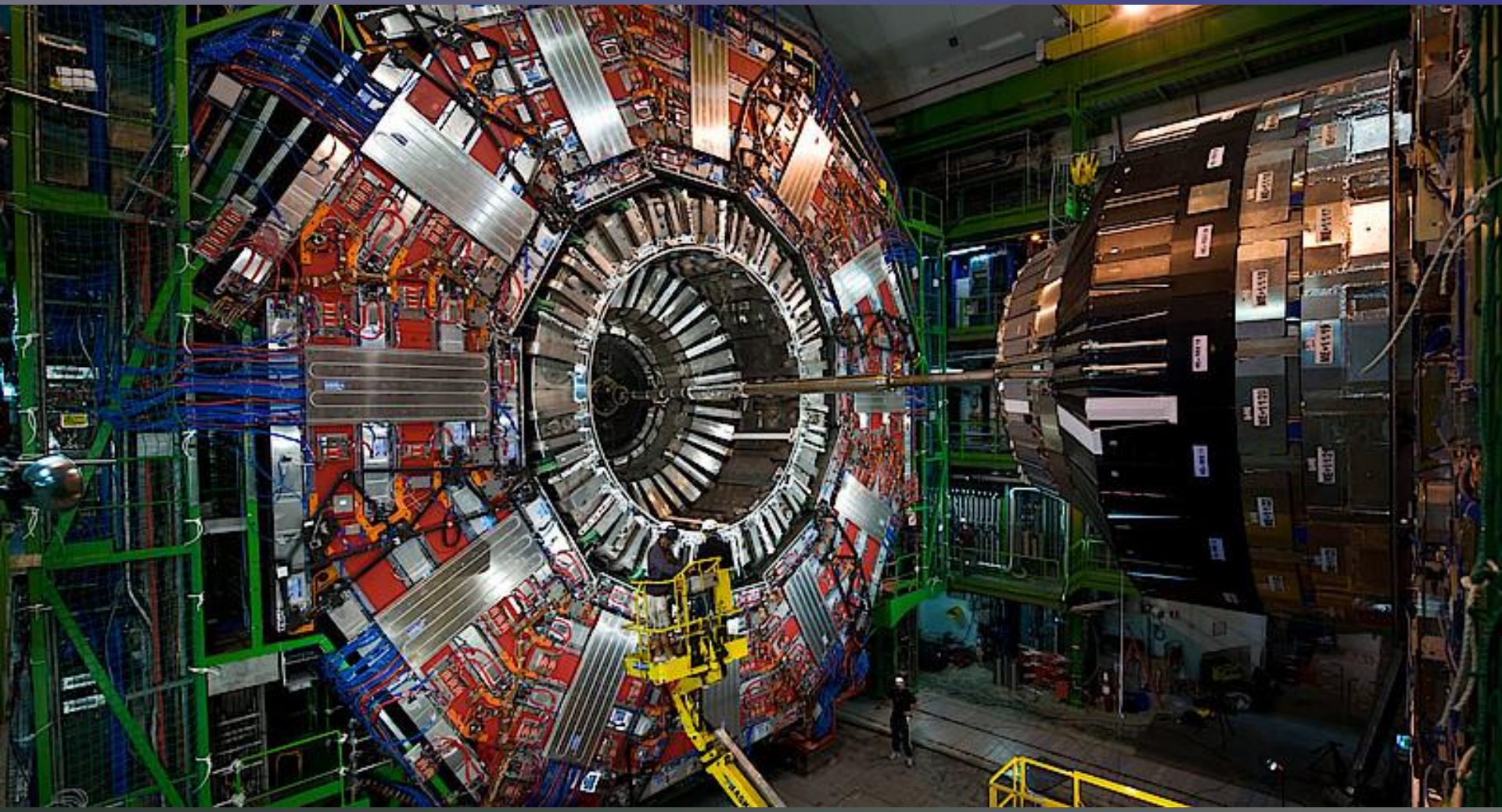
Prof. M. Krämer
Prof. J. Lesgourgues
Prof. M. Czakon
Prof. R. Harlander

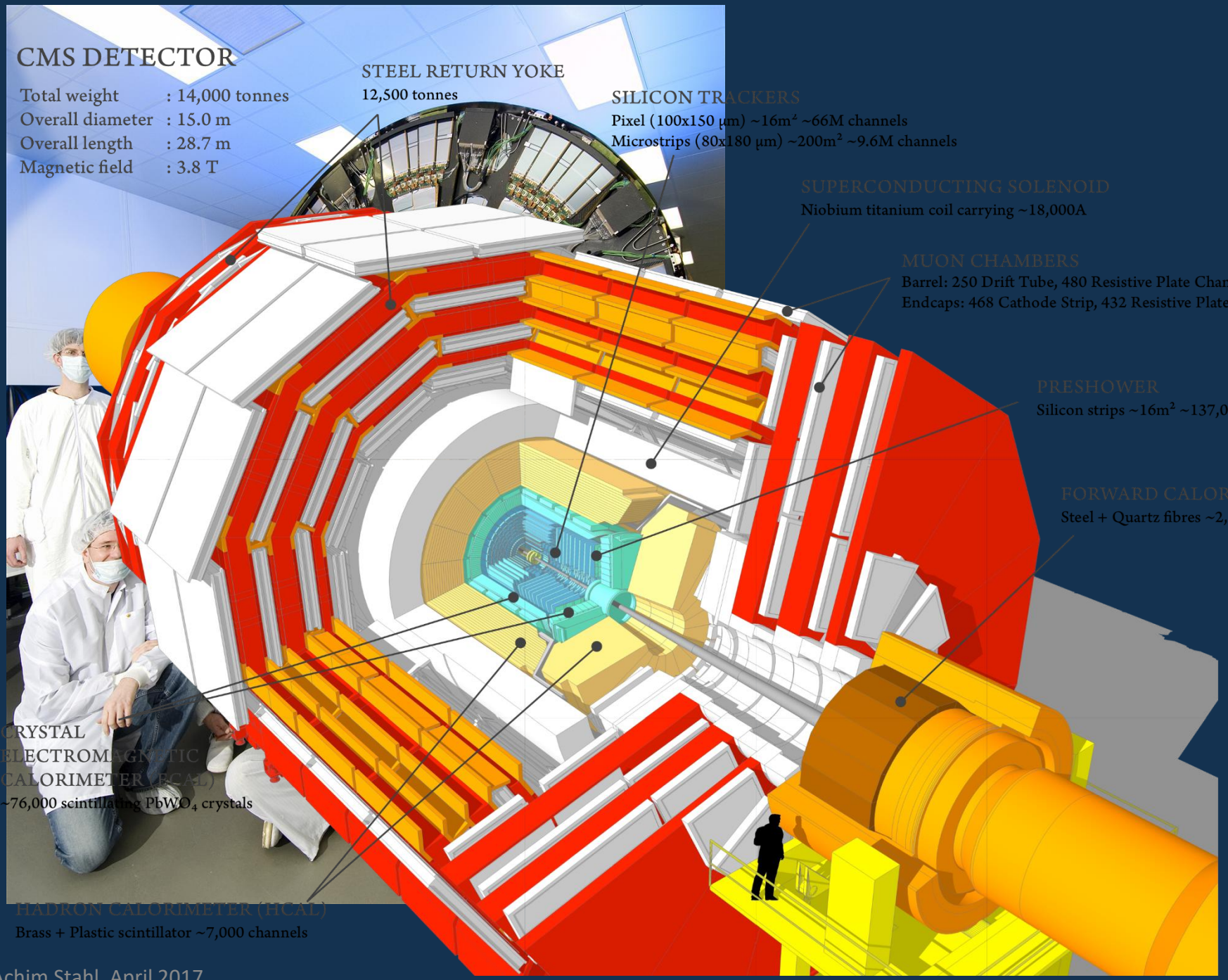


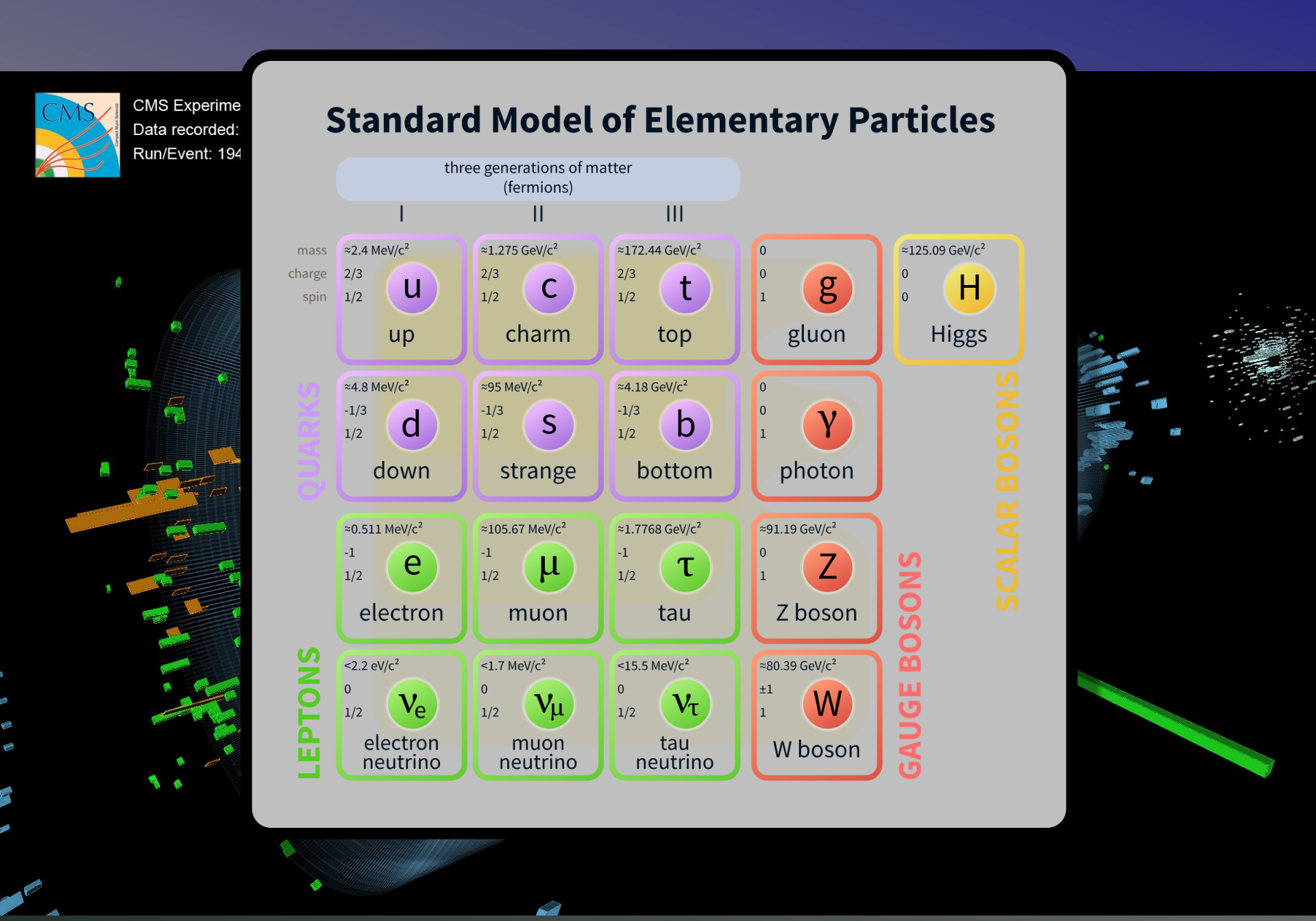
Particlephysics in Aachen

- CMS-Experiment at CERN
  - detector construction
  - data analysis with tau leptons
  - GRID computing
- Neutrino Experiments
- CP-Violation: EDM
- Medical Physics






CMS DETECTOR
Total weight : 14,000 tonnes
Overall diameter : 15.0 m
Overall length : 28.7 m
Magnetic field : 3.8 T
STEEL RETURN YOKE
12,500 tonnes
SILICON TRACKERS
Pixel (100x150 μm) ~16m² ~66M channels
Microstrips (80x180 μm) ~200m² ~9.6M channels
SUPERCONDUCTING SOLENOID
Niobium titanium coil carrying ~18,000A
MUON CHAMBERS
Barrel: 250 Drift Tube, 480 Resistive Plate Chambers
Endcaps: 468 Cathode Strip, 432 Resistive Plate Chambers
PRESHOWER
Silicon strips ~16m² ~137,000 channels
FORWARD CALORIMETER
Steel + Quartz fibres ~2,000 Channels
CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
~76,000 scintillating $PbWO_4$ crystals
HADRON CALORIMETER (HCAL)
Brass + Plastic scintillator ~7,000 channels



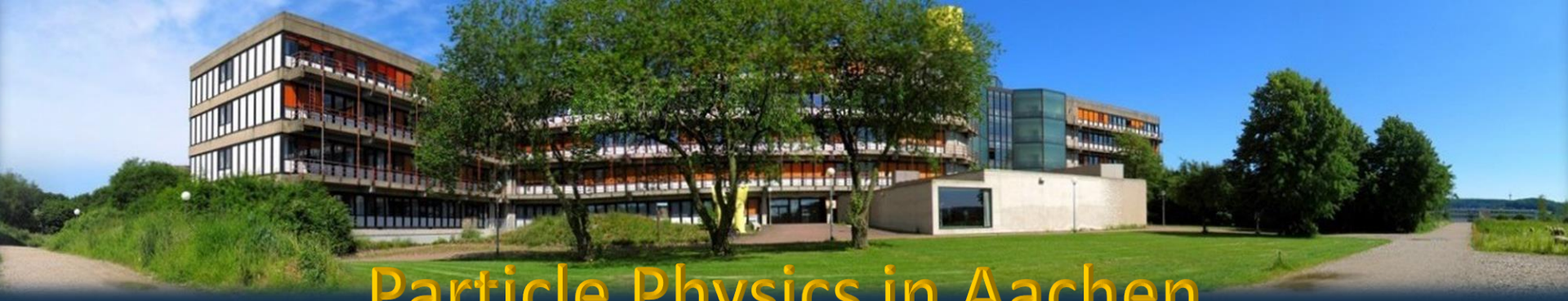
Standard Model of Elementary Particles

three generations of matter (fermions)

	I	II	III		
mass	≈2.4 MeV/c²	≈1.275 GeV/c²	≈172.44 GeV/c²	0	≈125.09 GeV/c²
charge	2/3	2/3	2/3	0	0
spin	1/2	1/2	1/2	1	0
QUARKS	u up	c charm	t top	g gluon	H Higgs
	≈4.8 MeV/c²	≈95 MeV/c²	≈4.18 GeV/c²	0	
	-1/3	-1/3	-1/3	0	
	1/2	1/2	1/2	1	
	d down	s strange	b bottom	γ photon	
	≈0.511 MeV/c²	≈105.67 MeV/c²	≈1.7768 GeV/c²	≈91.19 GeV/c²	
	-1	-1	-1	0	
	1/2	1/2	1/2	1	
LEPTONS	e electron	μ muon	τ tau	Z Z boson	
	<2.2 eV/c²	<1.7 MeV/c²	<15.5 MeV/c²	≈80.39 GeV/c²	
	0	0	0	±1	
	1/2	1/2	1/2	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

GAUGE BOSONS

SCALAR BOSONS



Particle Physics in Aachen

- CMS-Experiment at CERN
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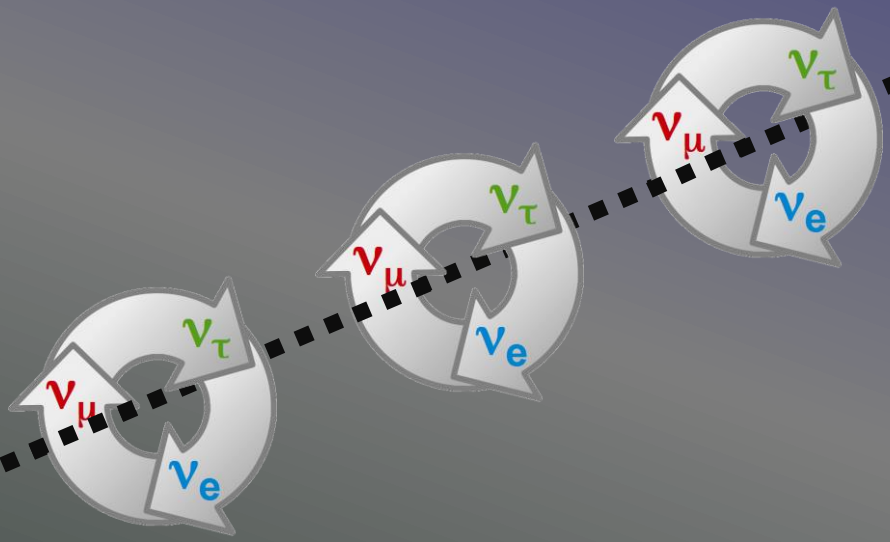
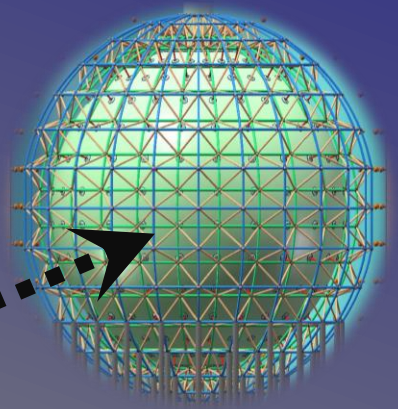
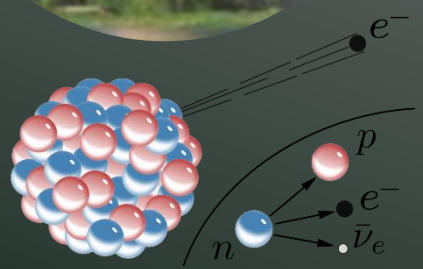
NEUTRINO OSCILLATIONS





$\bar{\nu}_e + p \rightarrow n + e^+$

inverse β-decay (IBD)



$E(\bar{\nu}_e) = 1 \ldots 10\ MeV$

Energy with $\bar{\nu}_e$:

$p \rightarrow n \quad 1.3\ MeV$

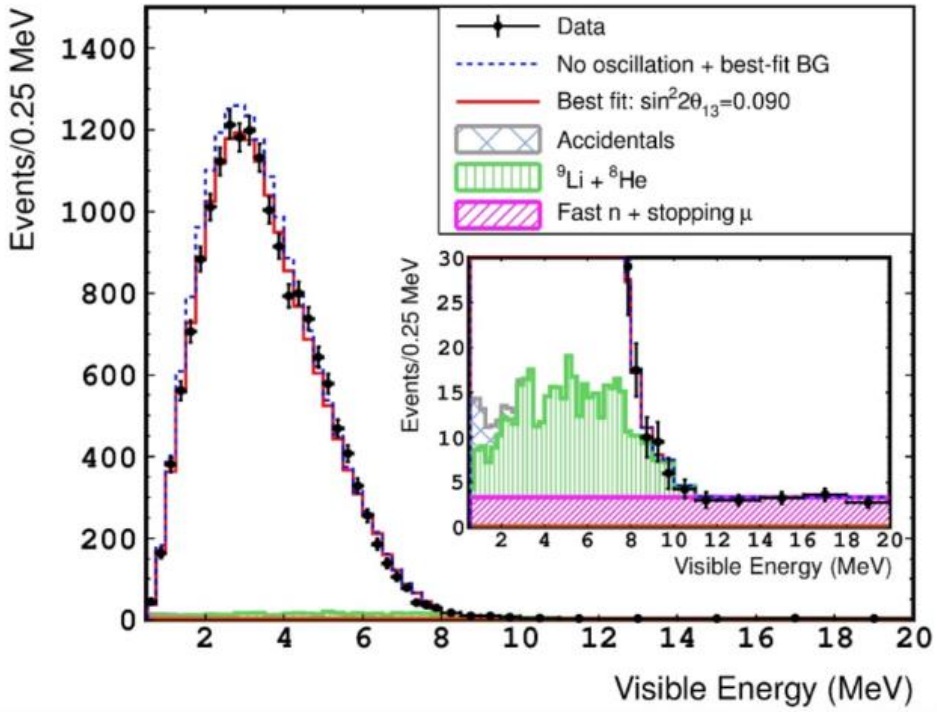
$m(e^+) \approx 0.5\ MeV$

Energy with $\bar{\nu}_\mu$:

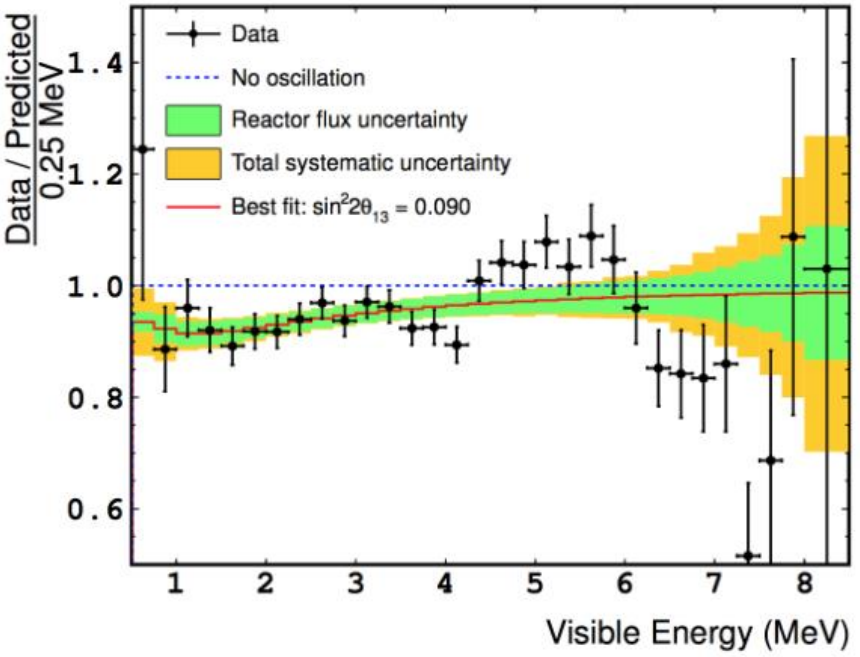
$p \rightarrow n \quad 1.3\ MeV$

$m(\mu^+) \approx 105\ MeV$


Near detector (~400 m)
~115 m.w.e.
Far detector (1050 m)
300 m.w.e.

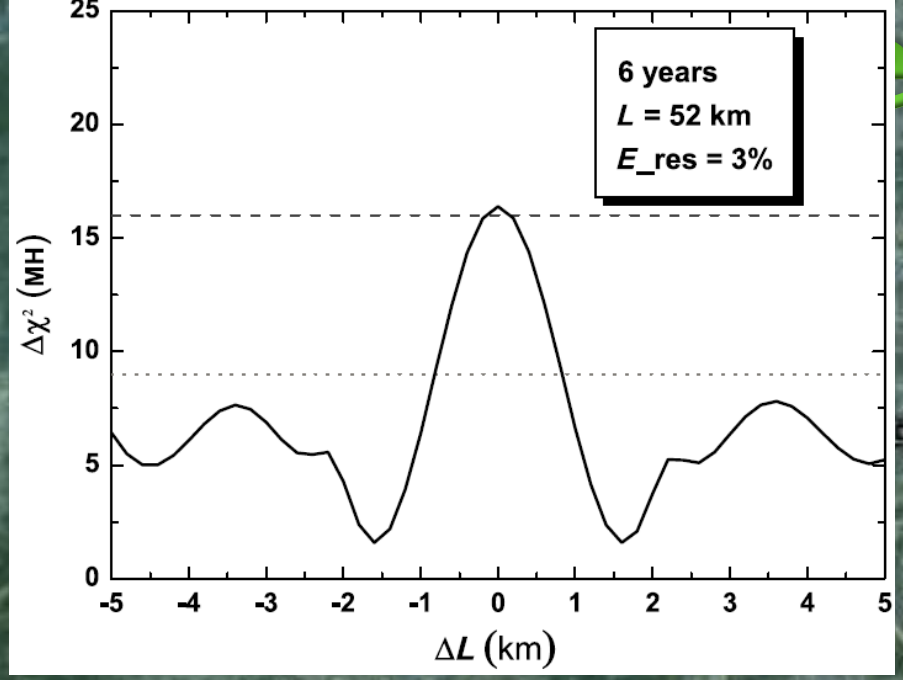


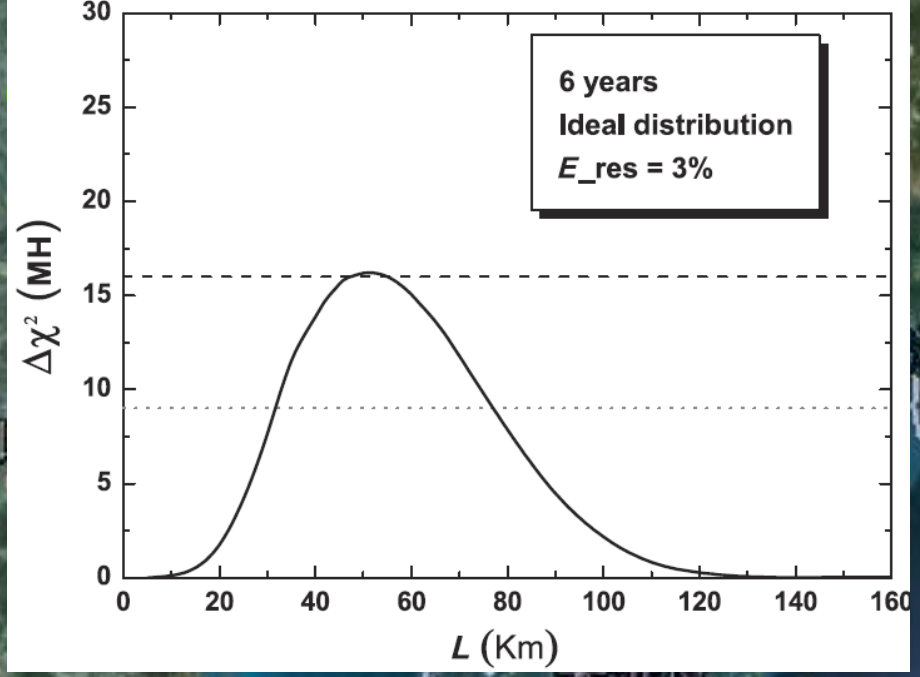
JHEP 1410 (2014) 086



The Site

Guangdong province
Jiangmen prefecture
Kaiping city





JUNO

台山阳江

55km

台山

55km

阳江

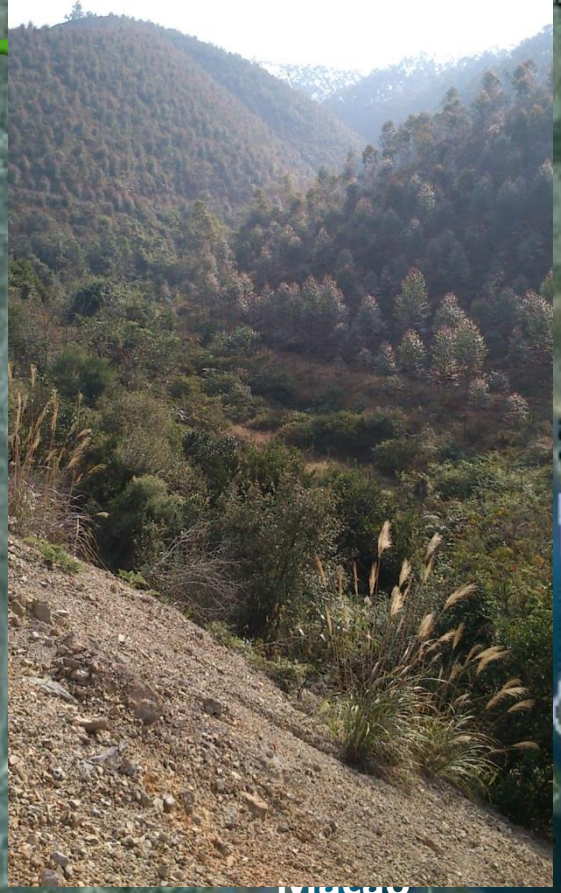
Taishan
18.4 GW

Yangjiang
17.4 GW

澳门

Macao

Hongkong

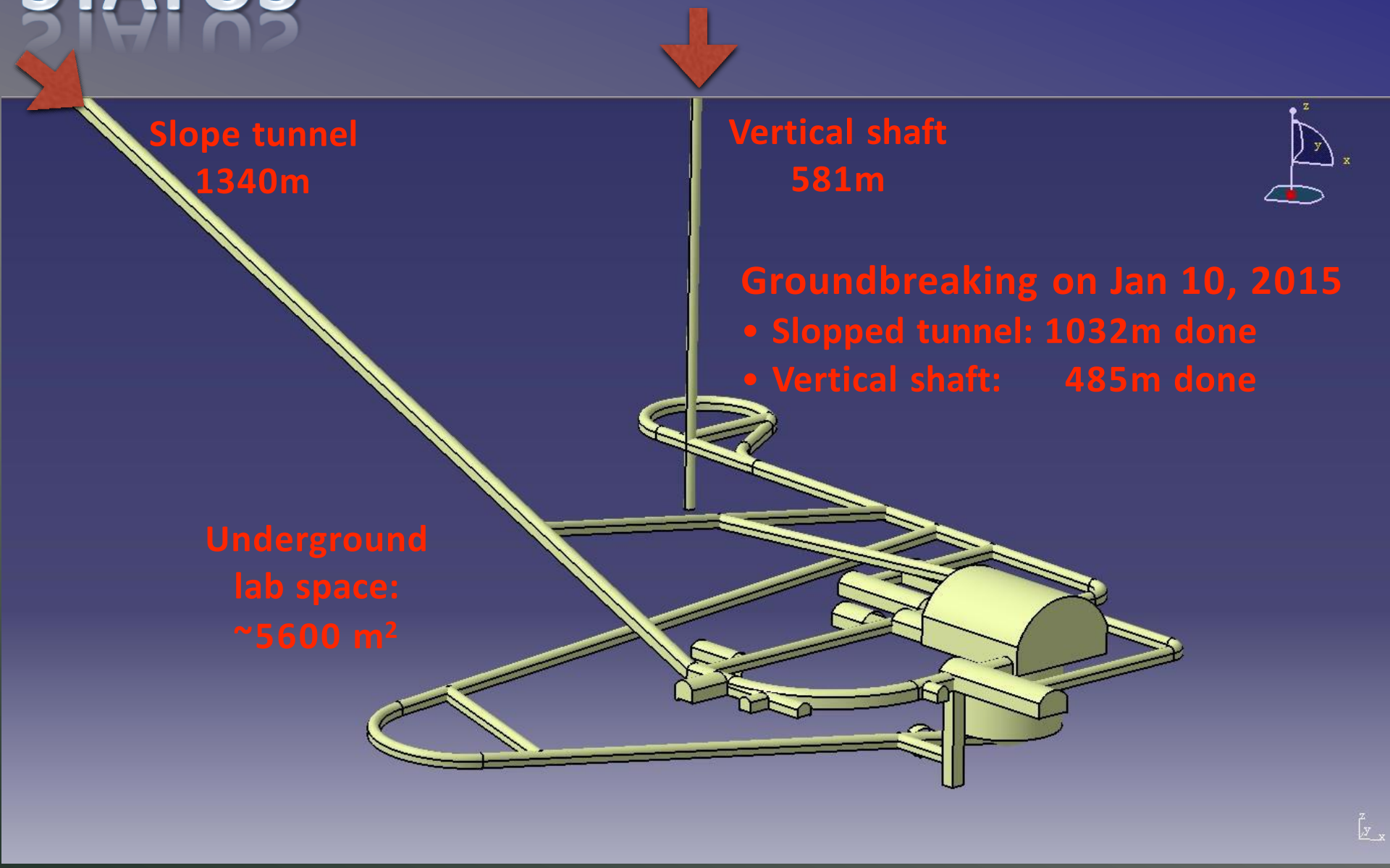


Hongkong

THE SURFACE LAB

STATUS

Civil engineering: Completion July 2018



Groundbreaking on Jan 10, 2015

- **Slopped tunnel: 1032m done**
- **Vertical shaft: 485m done**

THE JUNO PROJECT

Physics of JUNO

Mass Hierarchy

MC-studies:

>3 sigma in 4 years

(3% resolution @ 1 MeV)

ν-oscillations with reactor neutrinos:
Mass hierarchy
Precision Measurements

Others

Super Nova
- **Direct observation**
- **Diffuse Super Nova background**

Solar Neutrinos
- **Oscillation parameters**
- **Metallicity**

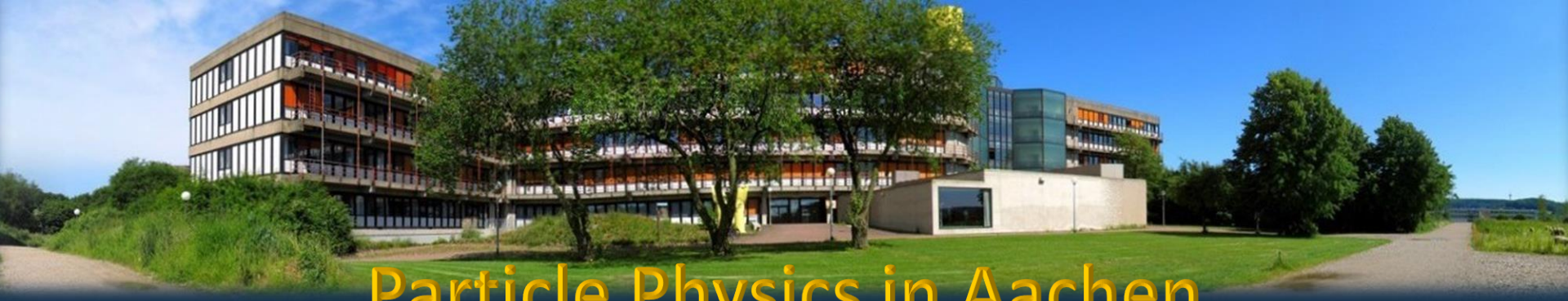
Atmospheric Neutrinos
- **Oscillations**
- **Mass hierarchy ?**

Geo Neutrinos
- **Models of the earth's interior**
- **Heat production → climate**

Nucleon Decay
- **i.e. $p \rightarrow K^+ \nu$**

Dark Matter
- **$\chi \rightarrow \nu\nu$**

Sterile Neutrinos
- **With radioactive sources**



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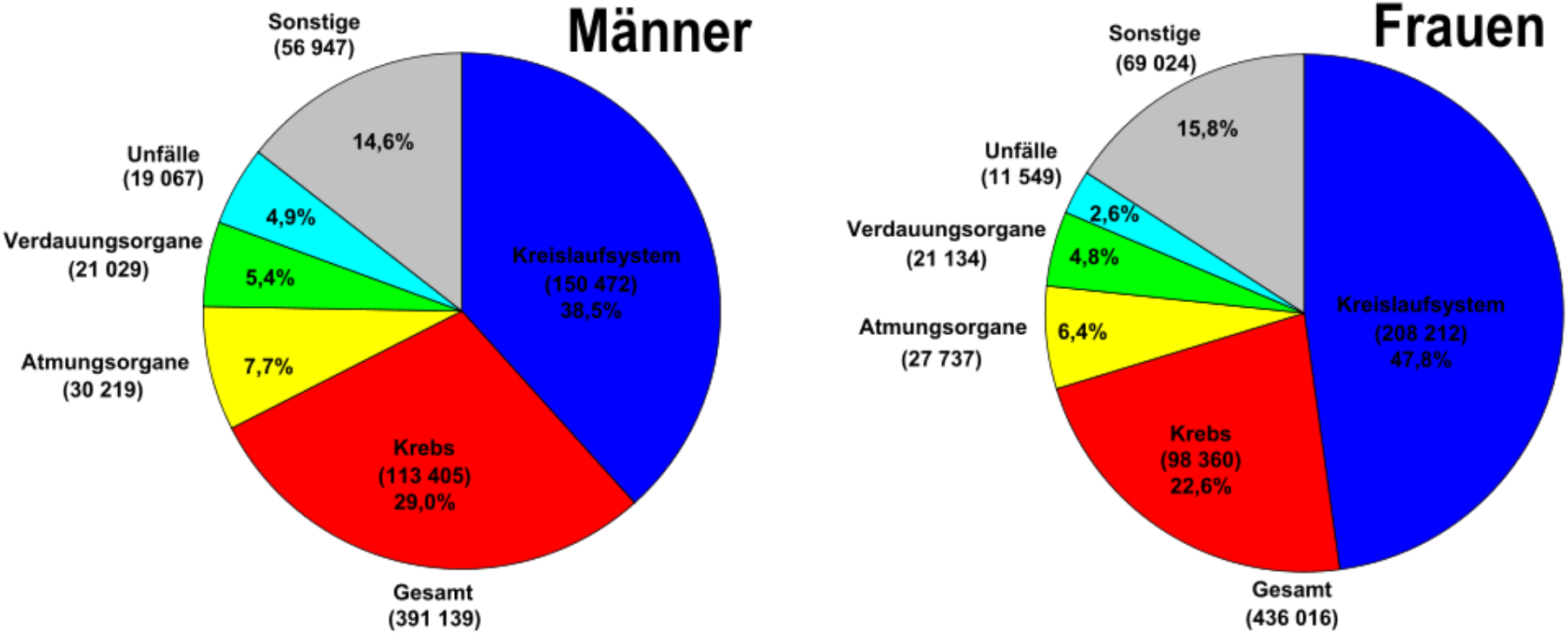
Radiation Therapy

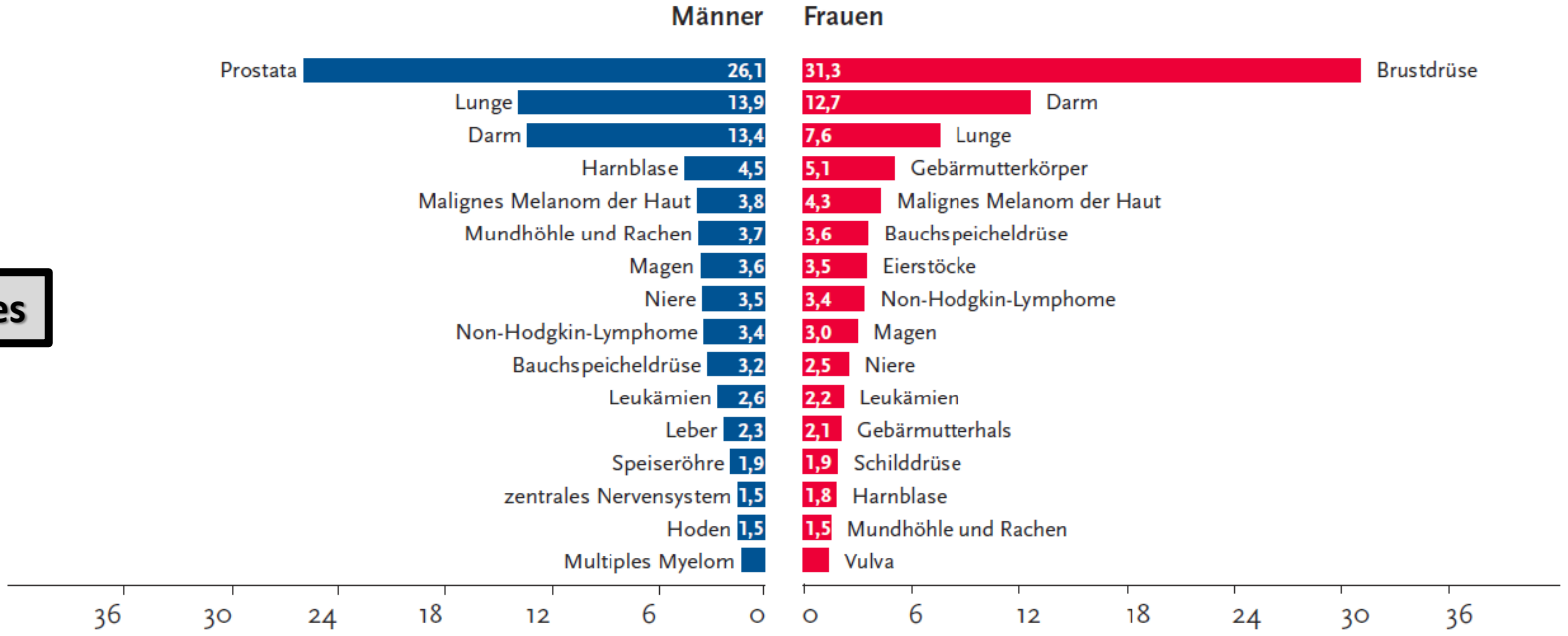
Achim Stahl, RWTH Aachen University

Die häufigsten Todesursachengruppen in Deutschland 2007

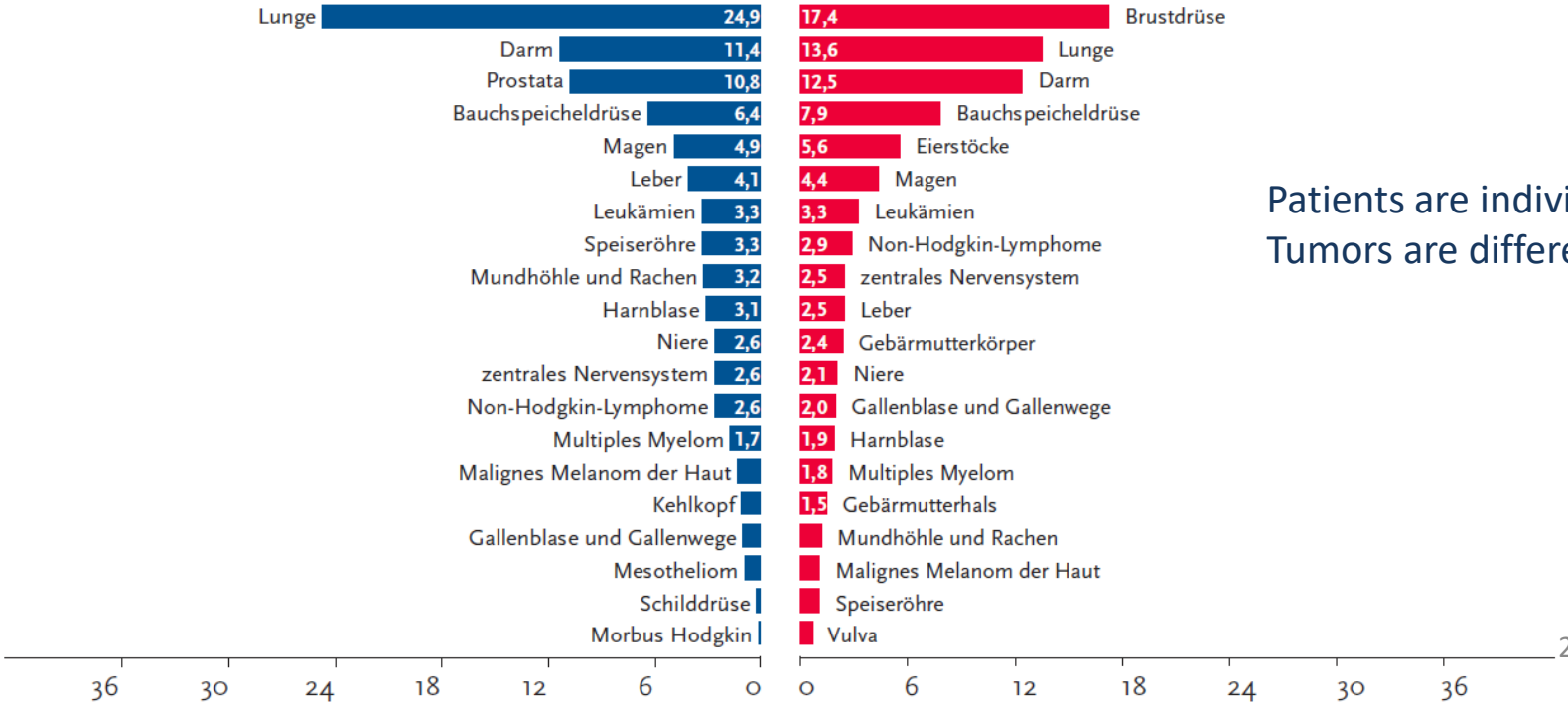


Tendenz: Sinkende Todesfälle für Herzinfarkte
und steigendes Lebensalter führen zu
einer Erhöhung der Krebstoten

Incidences

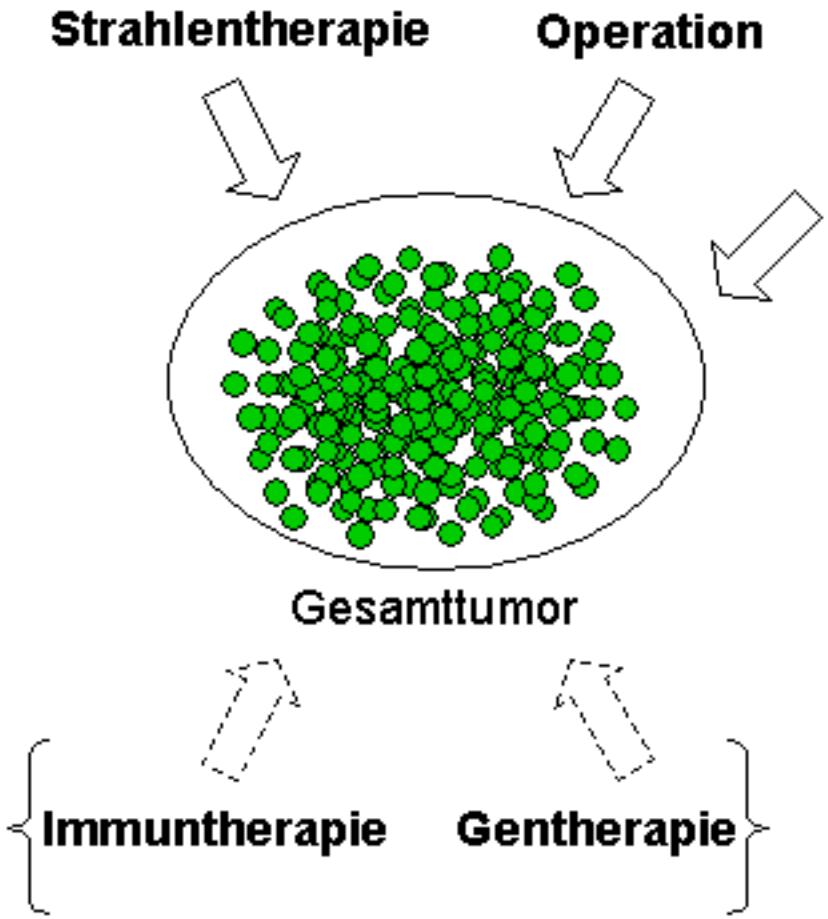


Death



Patients are individuals
Tumors are different

Behandlungsalternativen je nach Krebsart



Medikamentöse Therapien

Art	Wirkung	Zielzellen
Zytostatika	Zellteilung	TZ
Hormone	Zellteilung	TZ
Zytokine	Immun-modulation	IZ
Antikörper (monoklonale)	Außen an (Tumor)zellen	TZ, VZ, IZ
Signal-transduktions-hemmer	In den (Tumor)zellen	TZ, VZ

TZ … Tumorzellen
IZ … Immunzellen
VZ … Vaskularzellen

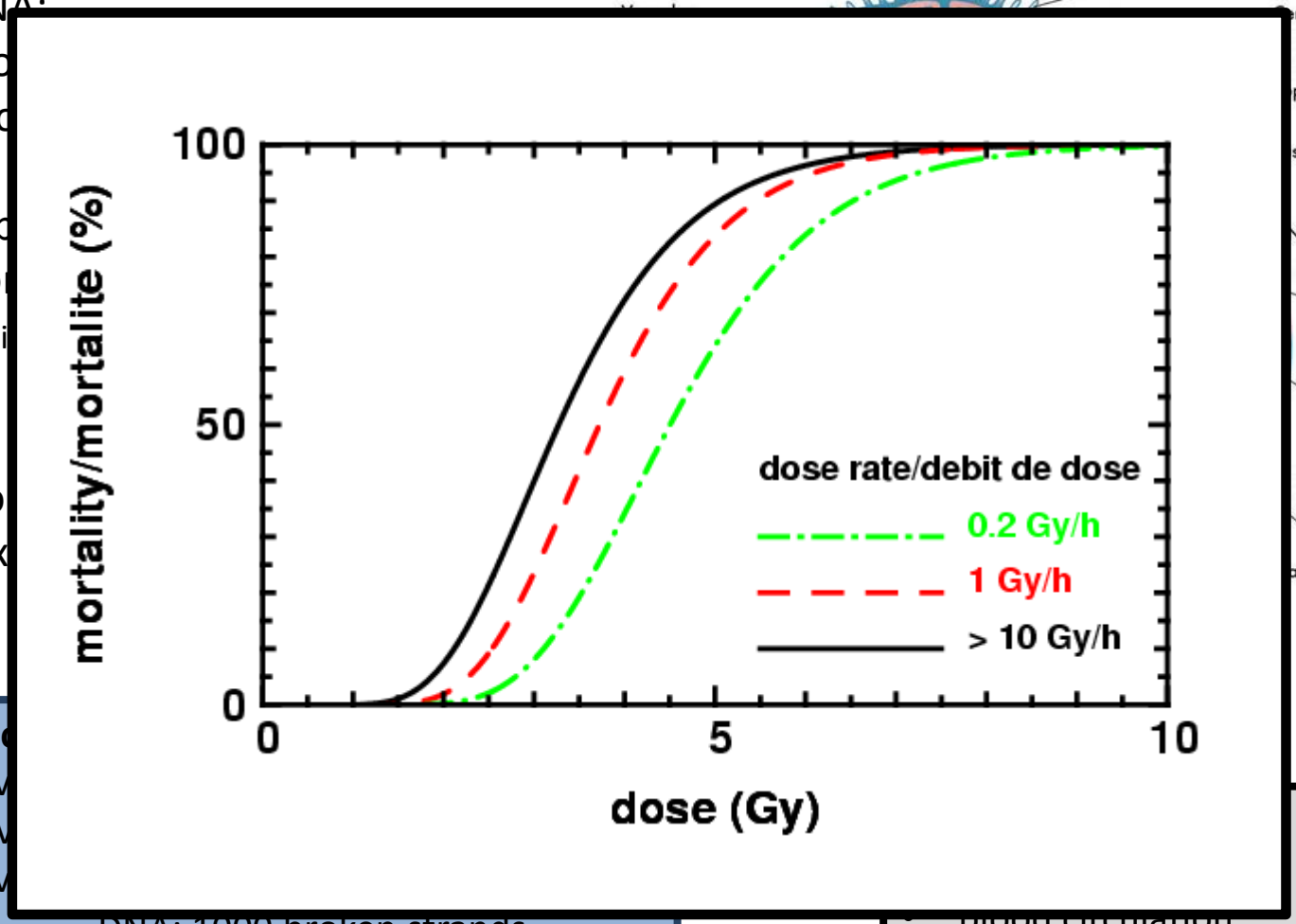
Balance“Cure“
against side effects!

Biological Effects of Radiation

On the DNA:
- death c
- mutatic

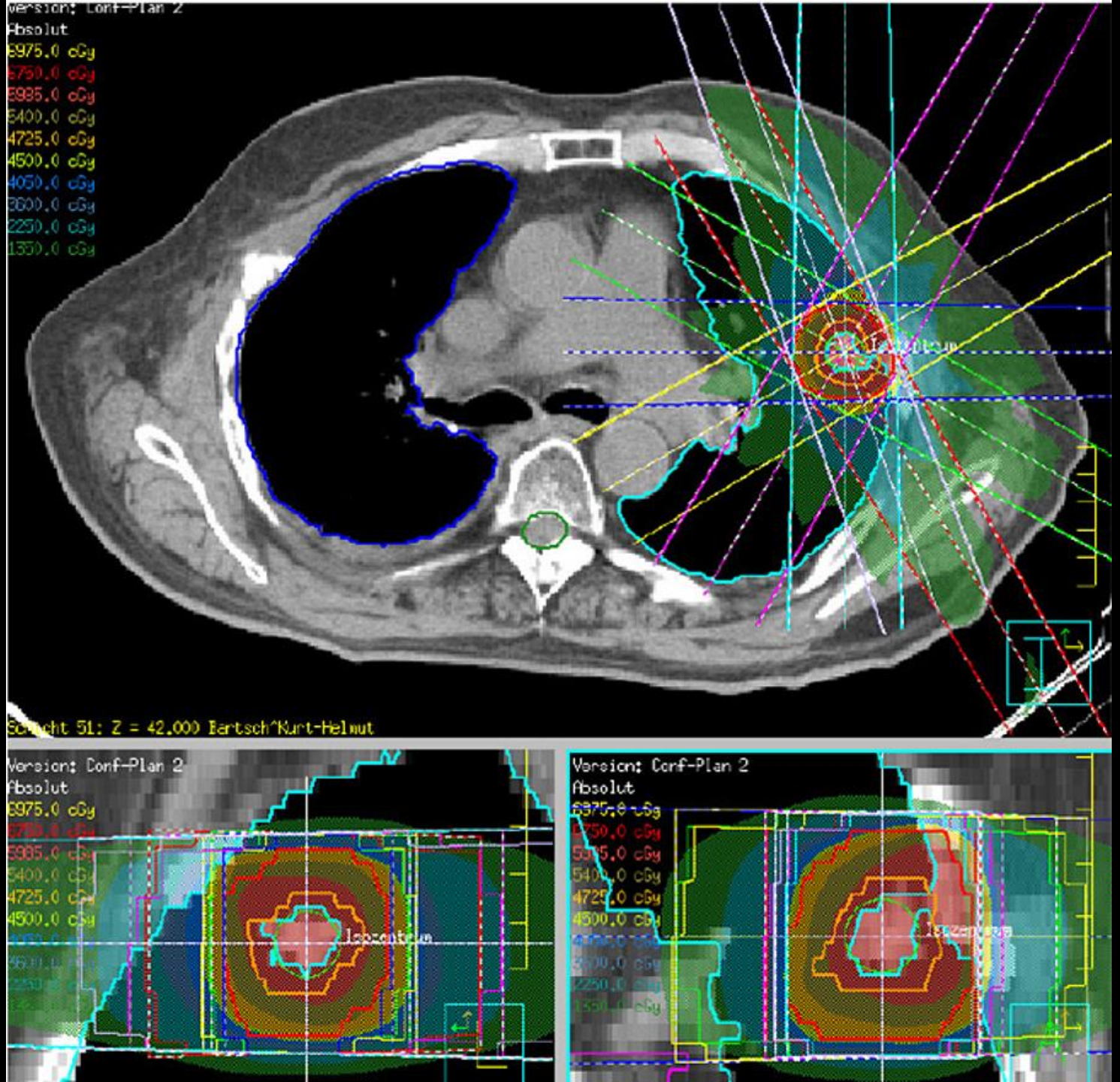
On other b
- no stro
  (destructi

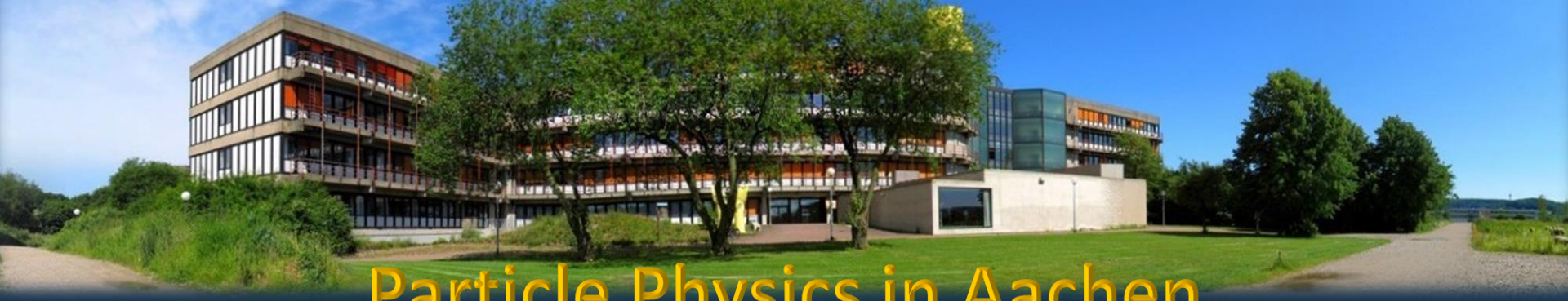
On H_2O
- Creatio
  cytotox



Impac
> 0 Sv
4 mSv
> 1 Sv
DNA: 1000 broken strands
40 broken double strands
~ 5 Sv Death of cells

- blood circulation
- oxygen concentration
- dosis time-profile


Absolut
Bartsch^Kurt-Helmut
Version: Conf-Plan 2
Absolut
Version: Conf-Plan 2
Absolut



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