DESY Overview

Welcome Summer Students 2010

Helmut Dosch.
Chair of the Board of Directors of DESY

DESY.

DESY – Deutsches Elektronen Synchrotron
- founded 1959 -

Mission: Development, construction, operation and scientific exploitation of accelerators

Provide access and services for national and international users

Internationally used, nationally funded Research Institute

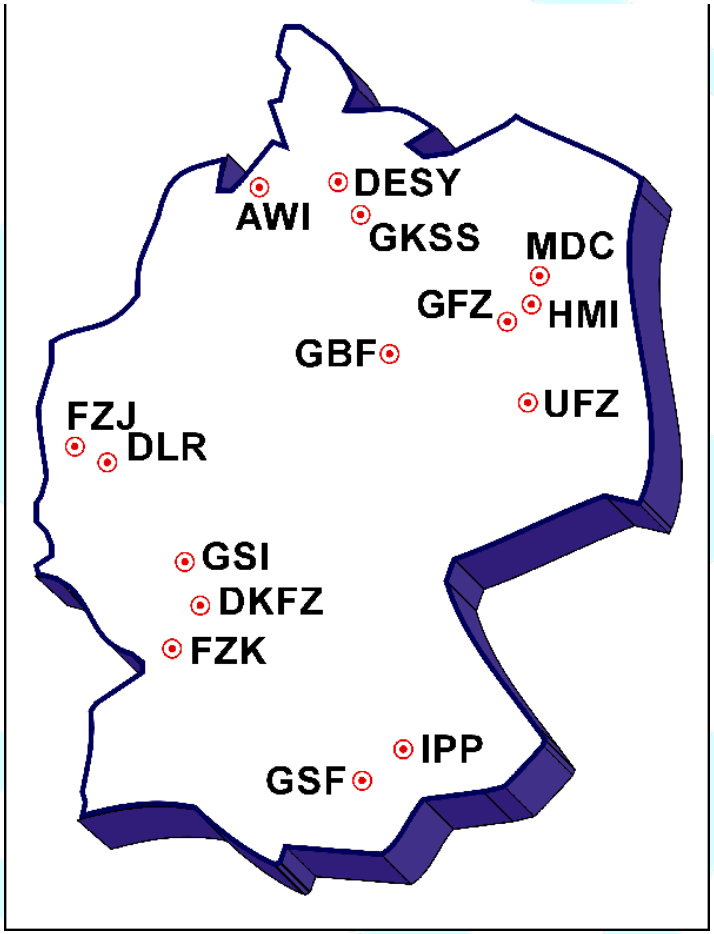
Base-Budget:	185 MEuro
Funding source:	90% federal, 10% state
Staff:	~1600 FTE in Hamburg and Zeuthen
Users:	~3000 (1500 from abroad) from 45 nations
	920 in particle physics, 2100 in photon science

DESY.

Hamburg.

Zeuthen.

DESY. Member of the Helmholtz Association



Research Centres: 17

Employees: ~ 24 000

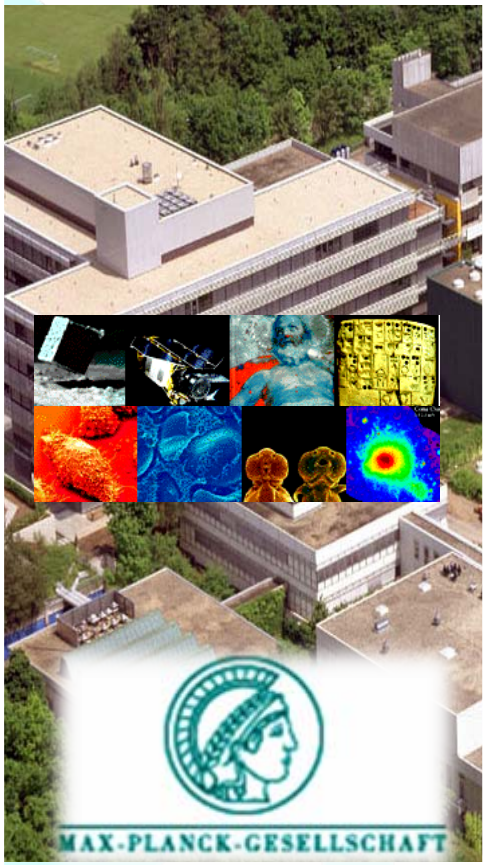
Budget ~ 2.400 Mio Euro

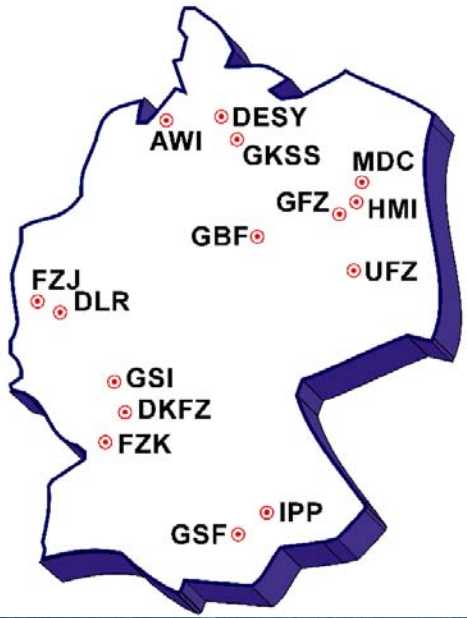
Research Fields:

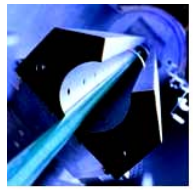
- Health
- Energy
- Earth and Environment
- Key Technologies
- Structure of Matter
- Traffic and Space

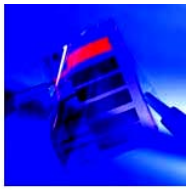
Research Landscape Germany

Universities	Max-Planck-Gesellschaft	Helmholtz Association	Fraunhofer Society
Land 100	Federal St. -Land 50:50	Federal St. -Land 90:10	Federal St.-Industry ≈ 65:35
Federal St. : Excellence Initiative	Fundamental Research	Research Infrastructure	Applied Research
Research-Education	no research policy requirements	Strategic Research	Knowledge Transfer, TT
1,4 Bio EUR	**1,3 Bio EUR**	**2,5 Bio EUR**	**1,3 Bio EUR**

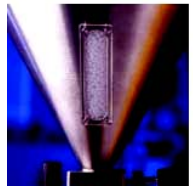








Your Pioneers in Polymers.



DESY Management and Boards.

E. Weckert
Director
Photon Science

J. Mnich
Director
Particle Physics

R. Brinkmann
Director
Accelerators

C. Scherf
Director
Administration

H. Dosch
Director
General

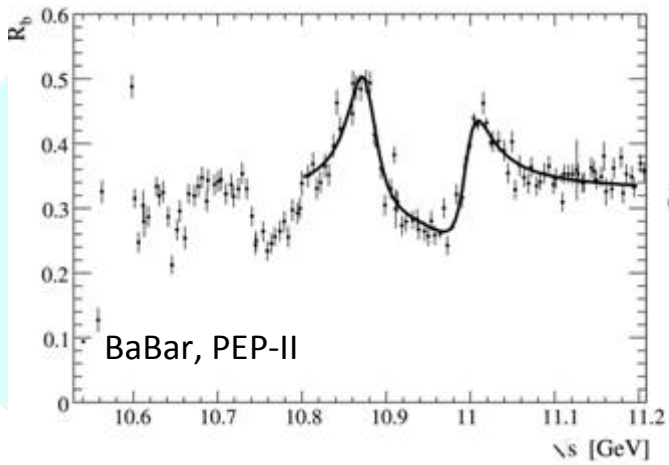
U. Gensch
DESY- Zeuthen

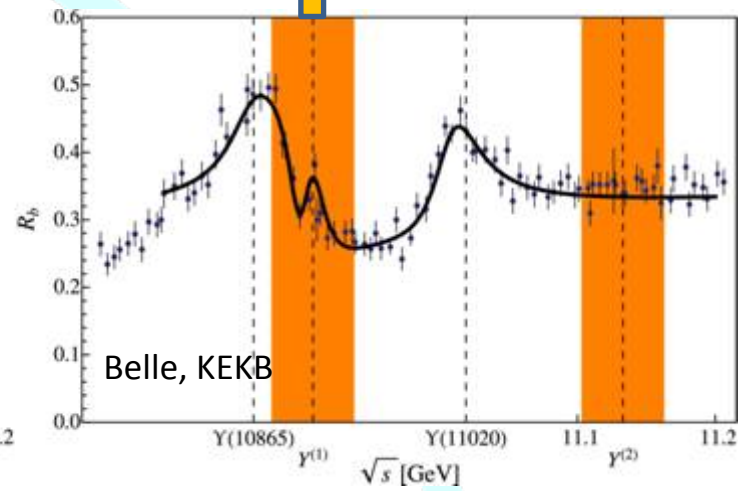
DESY Core Competence.

Scientific Highlights. Unusual collective Phenomena: 1/ QCD: TETRAQUARKS

Ahmed Ali, Christian Hambrock (DESY)

Analysis of BaBar and BELLE Data:
evidences for tetraquark states





PRL 104, 162001 (2010) PHYSICAL REVIEW LETTERS week ending 23 APRIL 2010

Tetraquark Interpretation of the BELLE Data on the Anomalous $\Upsilon(1S)\pi^+\pi^-$ and $\Upsilon(2S)\pi^+\pi^-$ Production near the $\Upsilon(5S)$ Resonance

Ahmed Ali* and Christian Hambrock†
Deutsches Elektronen-Synchrotron DESY, D-22607 Hamburg, Germany

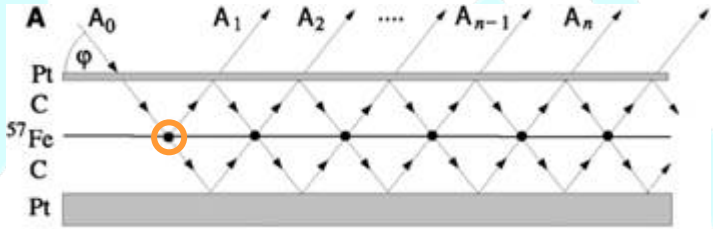
M. Jamil Aslam‡
Physics Department, Quaid-i-Azam, University, Islamabad, Pakistan
(Received 31 December 2009; published 19 April 2010)

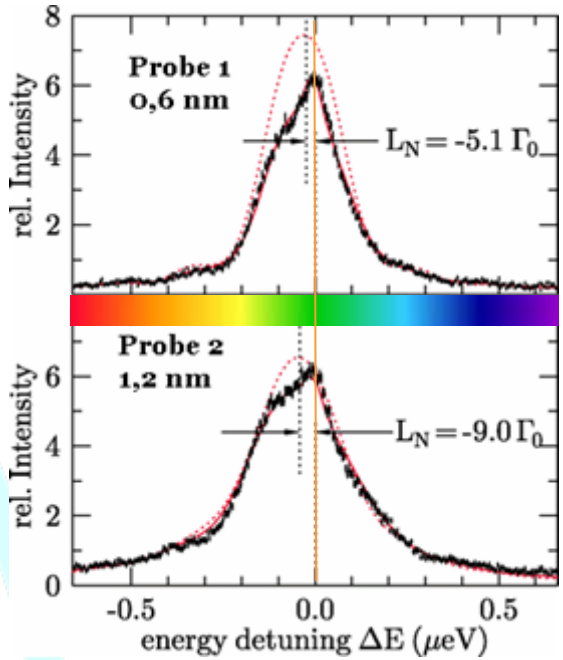
Scientific Highlights.

Unusual collective Phenomena: 2/ QED Lamb-Shift in Nanostructures

Ensemble of identical atoms behave differently than a single atom under irradiation of light. DESY provides evidence of effect predicted 35 years ago.

Original Artikel: R. Röhlsberger et al. *'Collective Lamb Shift in Single-Photon Superradiance'*, Science 4 June 2010: Vol. 328. no. 5983, pp. 1248 - 1251





Die gemessenen Röntgenpulse zeigen eine Rotverschiebung, die der kollektiven Lamb-Verschiebung entspricht.

PHYSICS

The Lamb Shift—Yesterday, Today, and Tomorrow

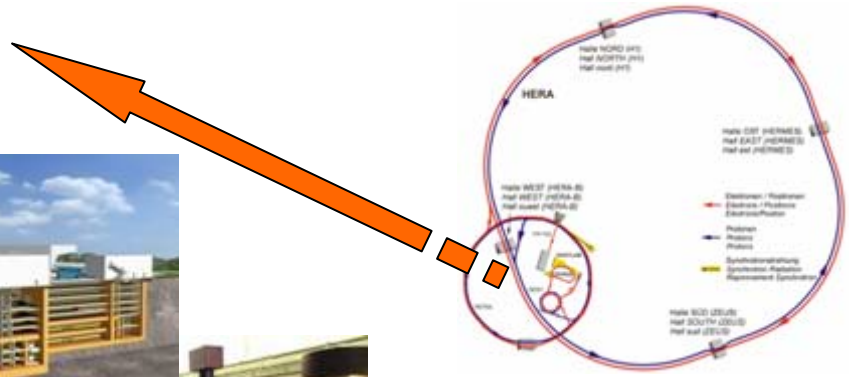
Quantum field effects are magnified by collective interactions between many atoms.

Marlan O. Scully[1] and Anatoly A. Svidzinsky[2]

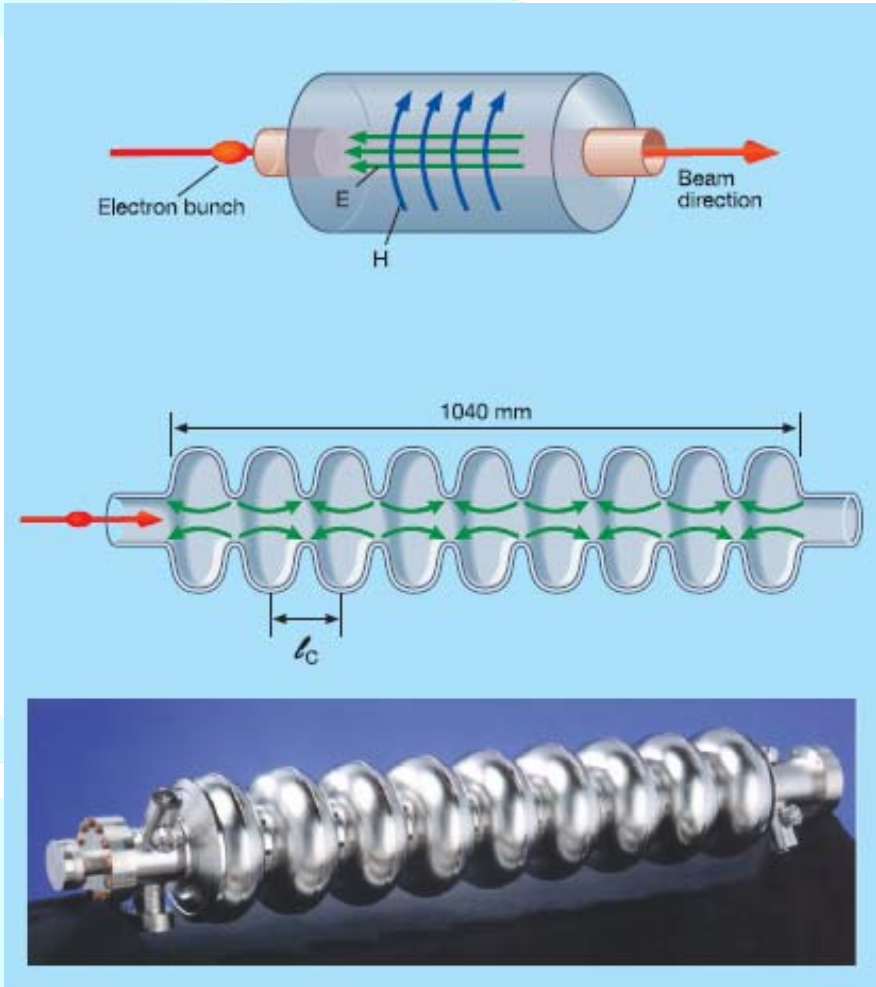
The study of the emission and absorption of radiation is the royal road that led Planck to quantum mechanics and Einstein to the concept of the photon. The experiment of Röhlsberger *et al.* atom jumps to an excited state and a virtual photon is emitted, followed quickly by the reverse process in which the atom jumps back to the ground state and now absorbs a photon (see the first figure, panel A). These $2S_{1/2}$ state was directed onto a detector (see the first figure, panel B). When an atom in the excited state struck the surface, an electron was emitted. The beam was then investigated by means of microwaves, which

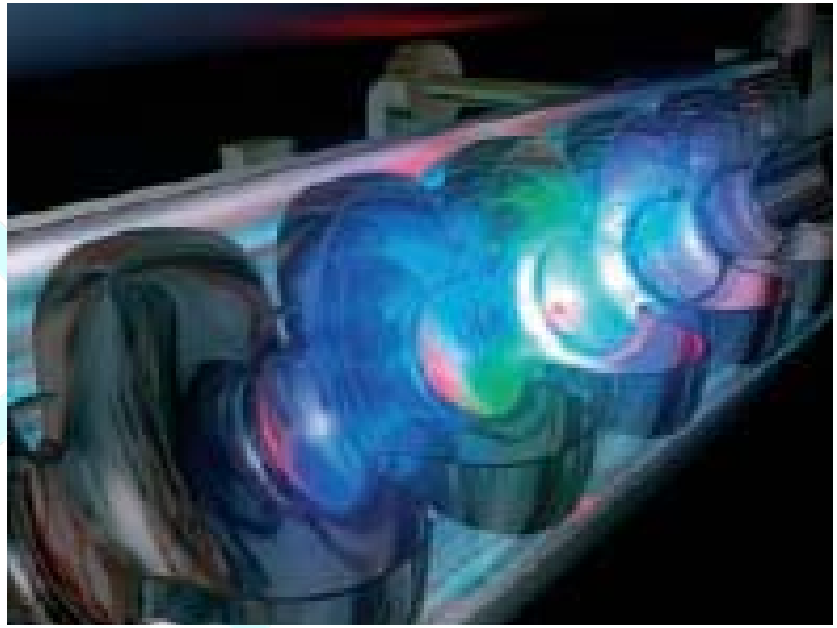
DESY Accelerators

- LINAC/Pre-accelerators
- DESY II
- DORIS
- HERA until 2007
- FLASH
- PETRA III
- XFEL under construction



The heart of the accelerator

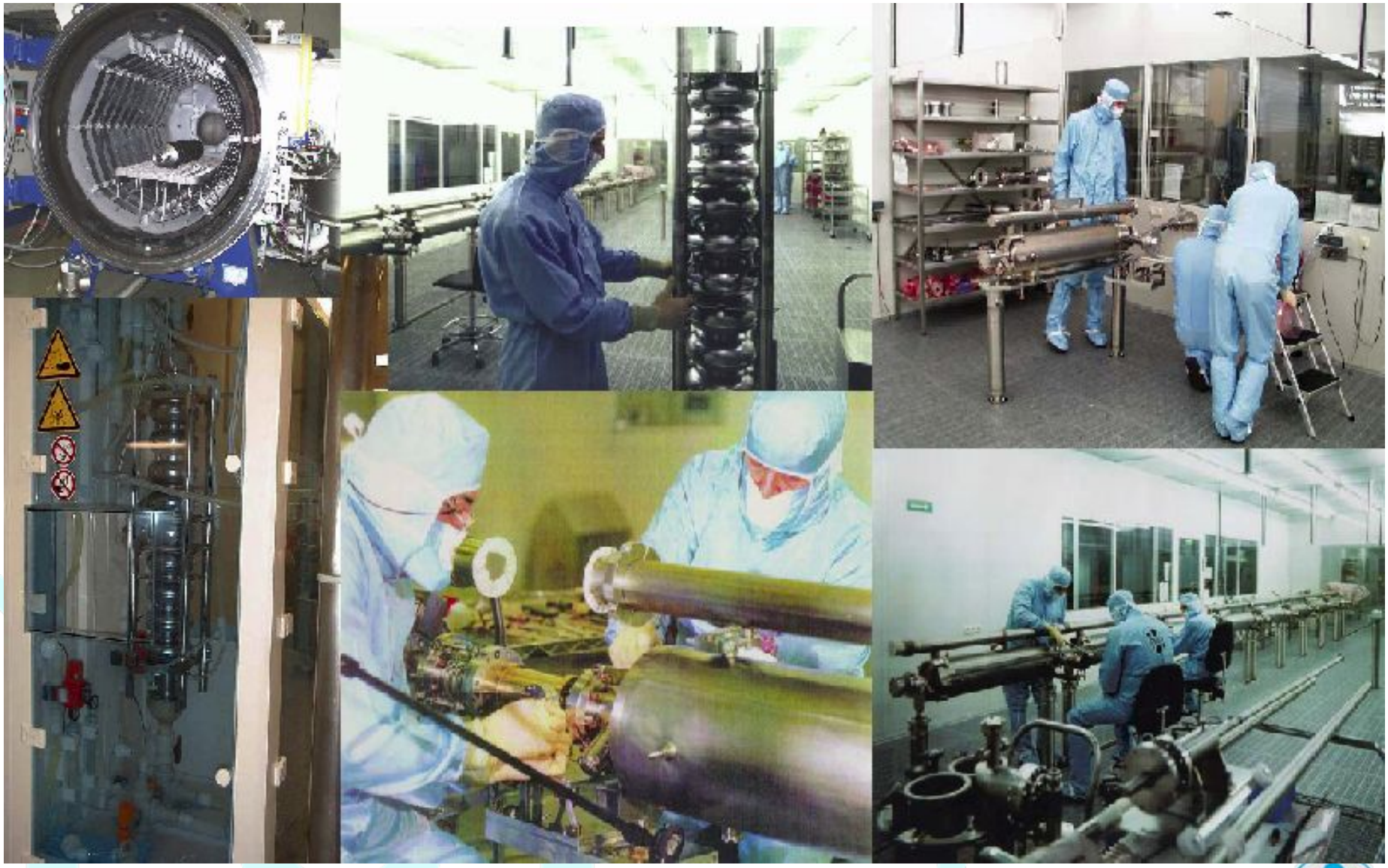




Niobium

1.9 K

DESY: SCRF Technology



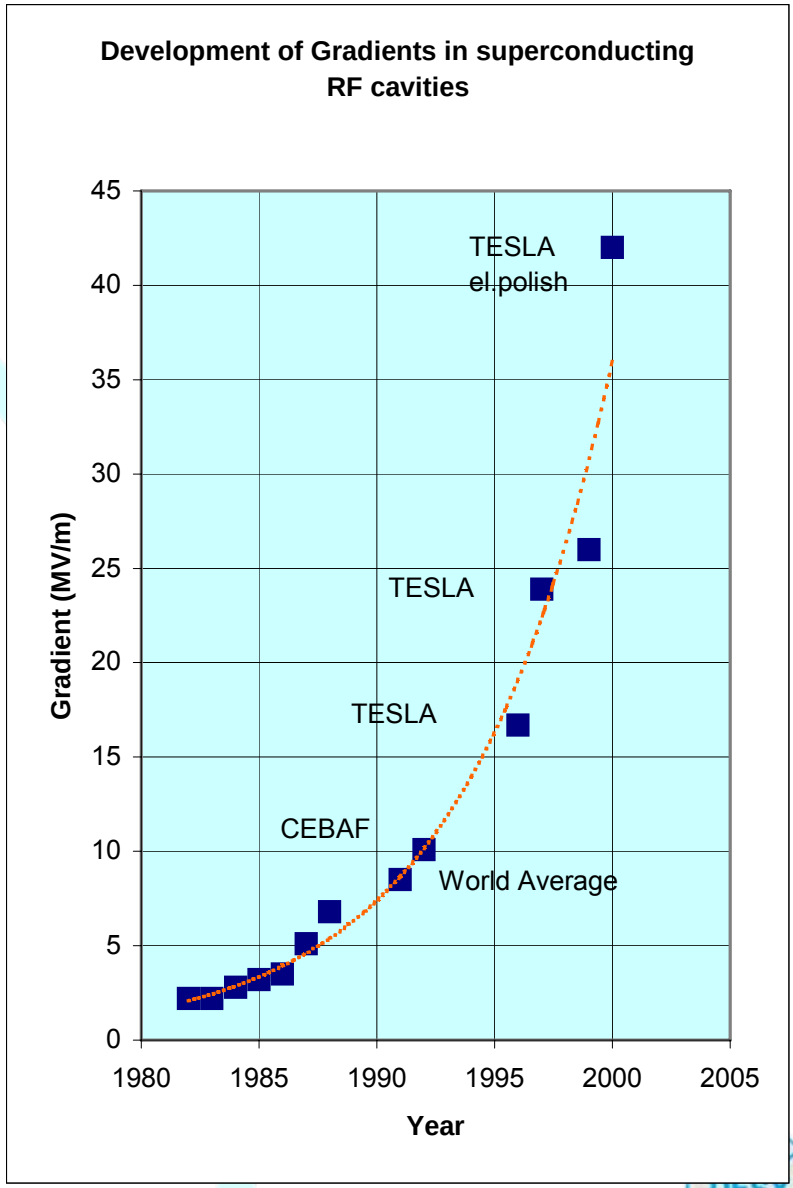
Development of superconducting Resonators

Superconducting RF-structures were developed in many countries

TESLA Collaboration (55 Institutes from 12 countries), centered at DESY, bundled ~ worldwide know-how and achieved signifianct progess:

>30-fold improvement of acceleration/cost performance over 10 years

Of large relevance for future accelerators such as XFELs and others



∞ small

elementary particles
unification of forces

Particles, fields

universe

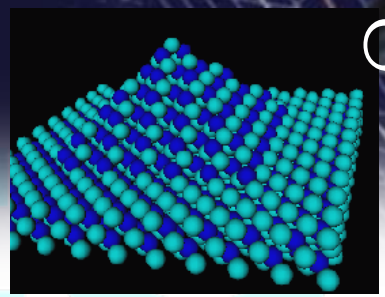
∞ large

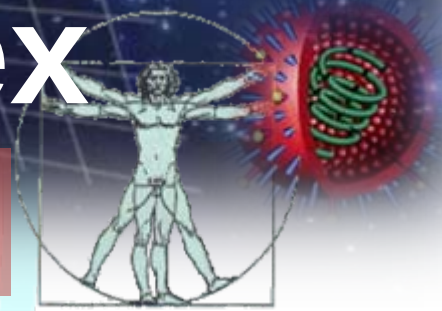
cosmology
astrophysics

condensed matter

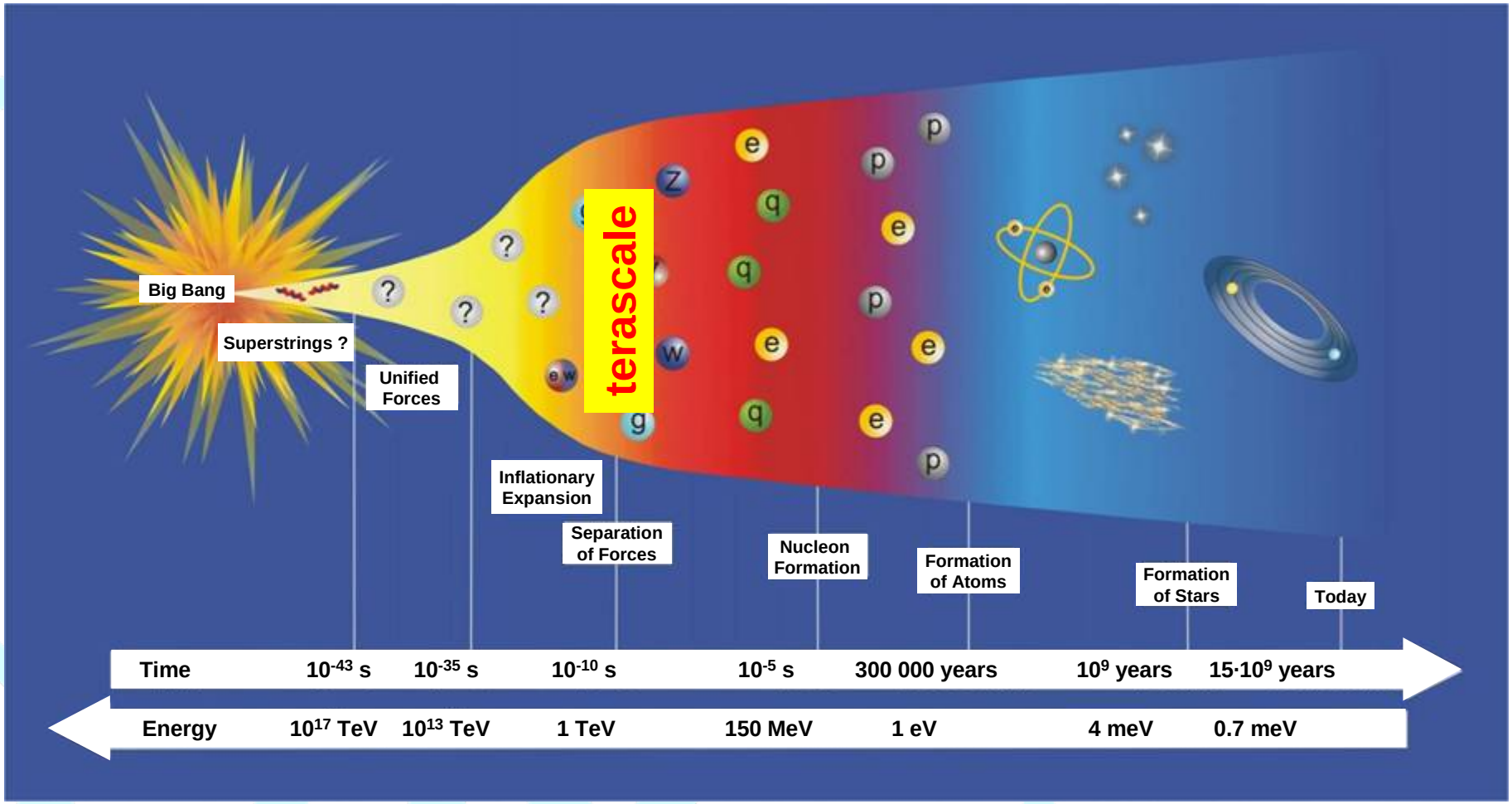
∞ complex

nanoscience, biology
Synchrotron radiation





Particle Physics as telescope to the early universe



Particle physics at highest energies, at the „Energy Frontier“ (LHC, ILC)
Expect breakthrough in understanding of mikrocosmos and of early universe
(Physics at the Terascale)

Status of the Standard Model

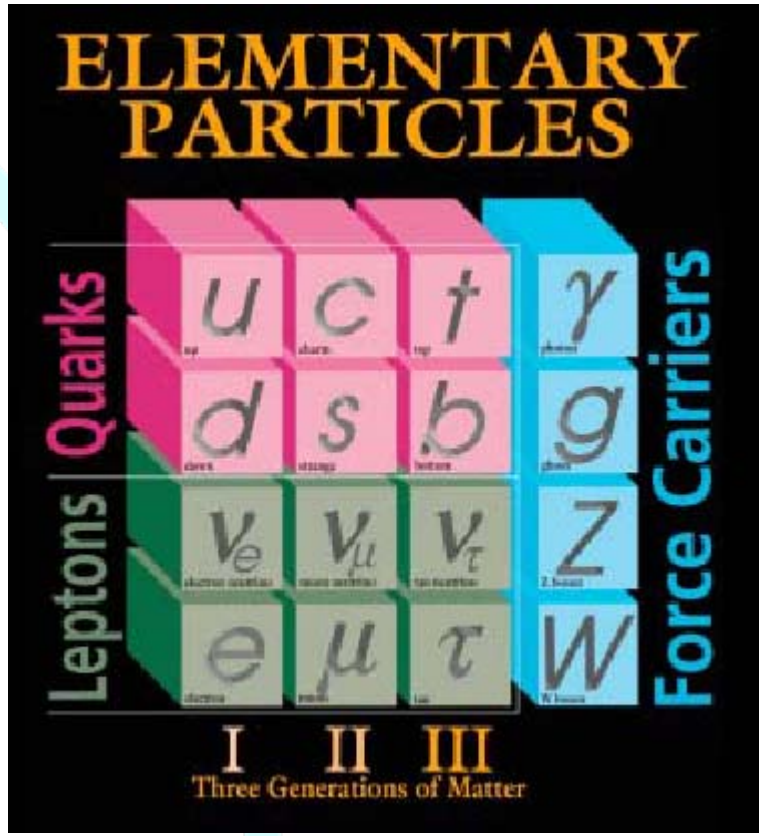
The physical world is

composed of Quarks and Leptons

interacting via force carriers
(Gauge Bosons)

-> The “Standard Model”
has been tested to permille level in many experiments

-> Precise and quantitative description of subatomic physics

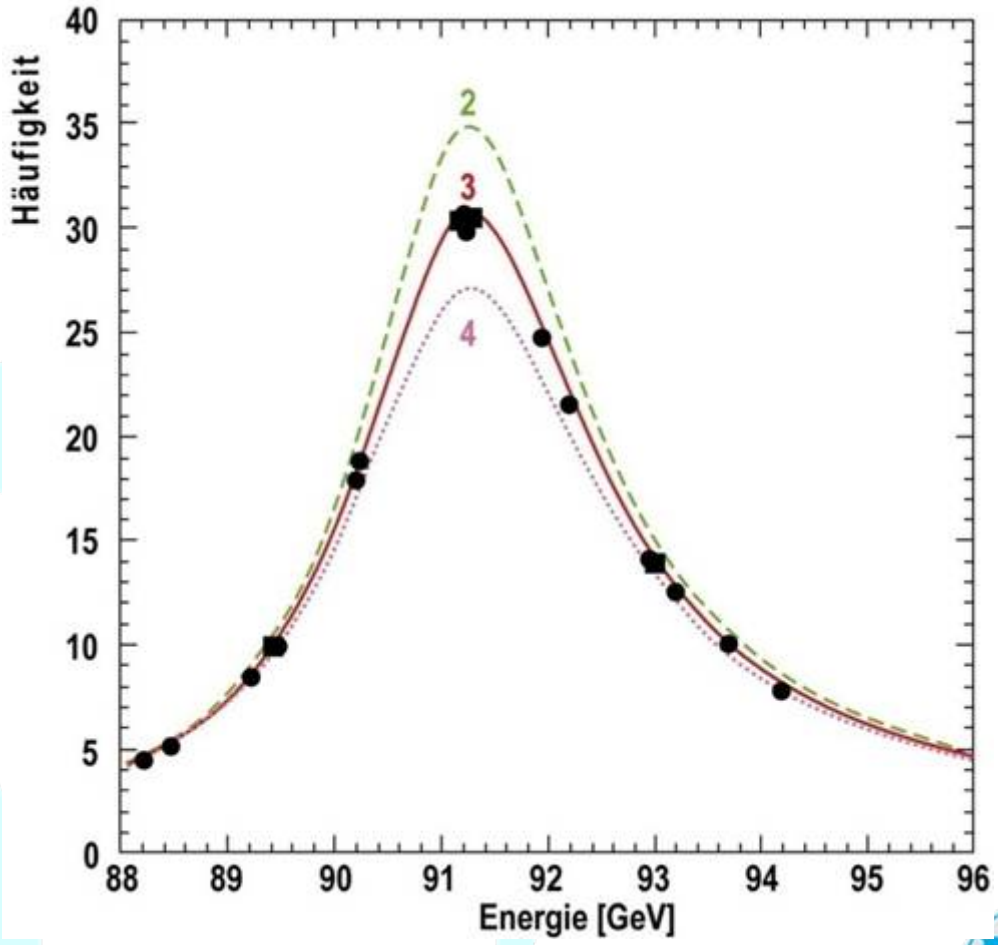


Three Generations

Decay width of the Z-boson

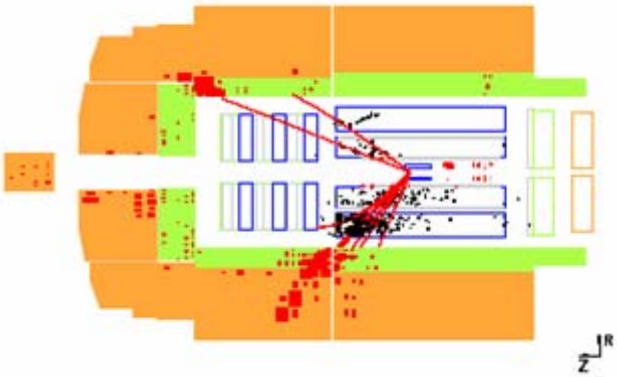
Measurement of the number of generations of quarks and leptons (LEP)

$N = 2.994 \pm 0.012$

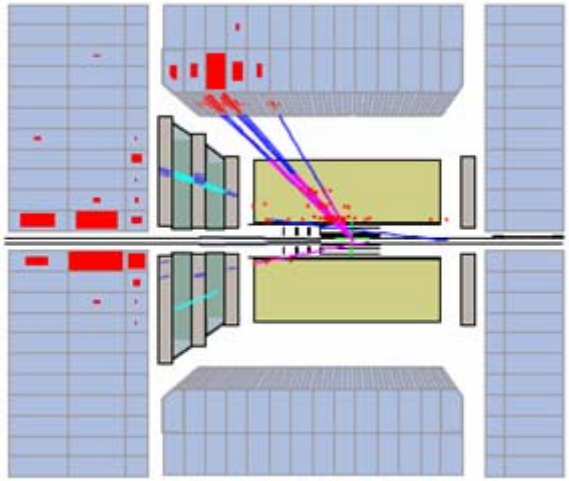


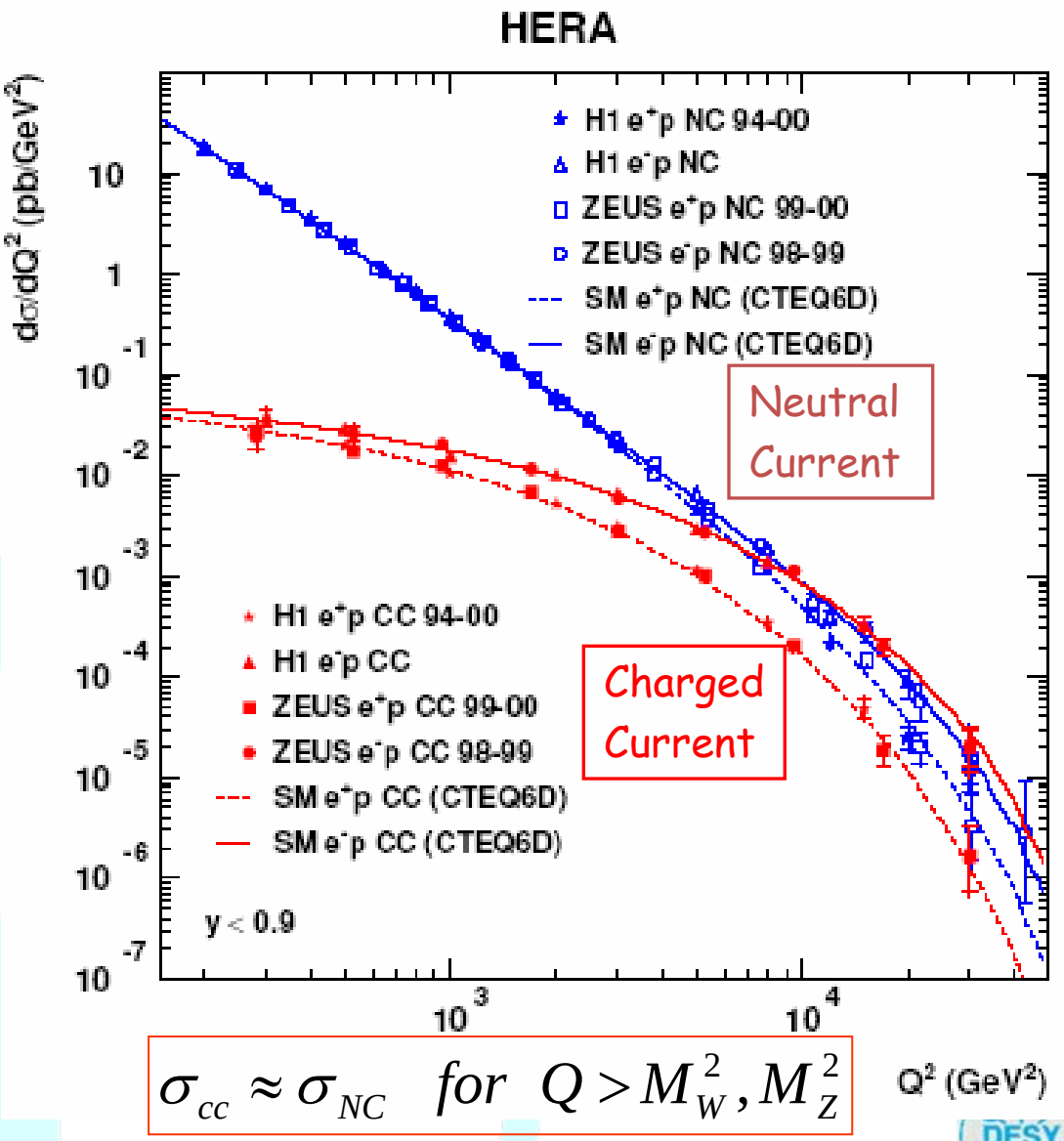
Towards the Unification of Forces

Neutral current $e^+ p \to e^+ X$



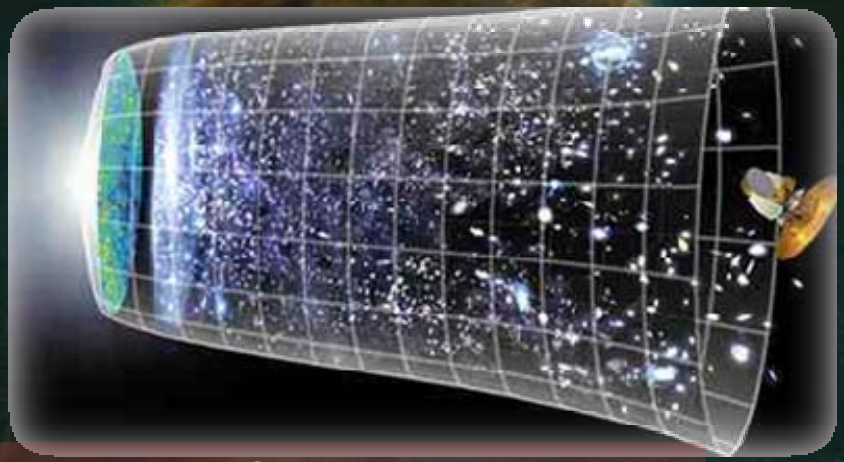
Charged current $e^+ p \to \bar{\nu} X$



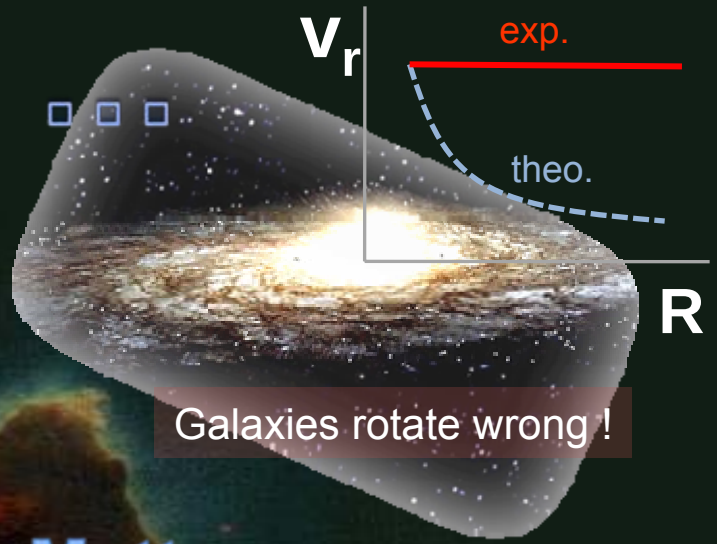


$$\sigma_{cc} \approx \sigma_{NC} \quad for \quad Q > M_W^2, M_Z^2$$

The big puzzle ...

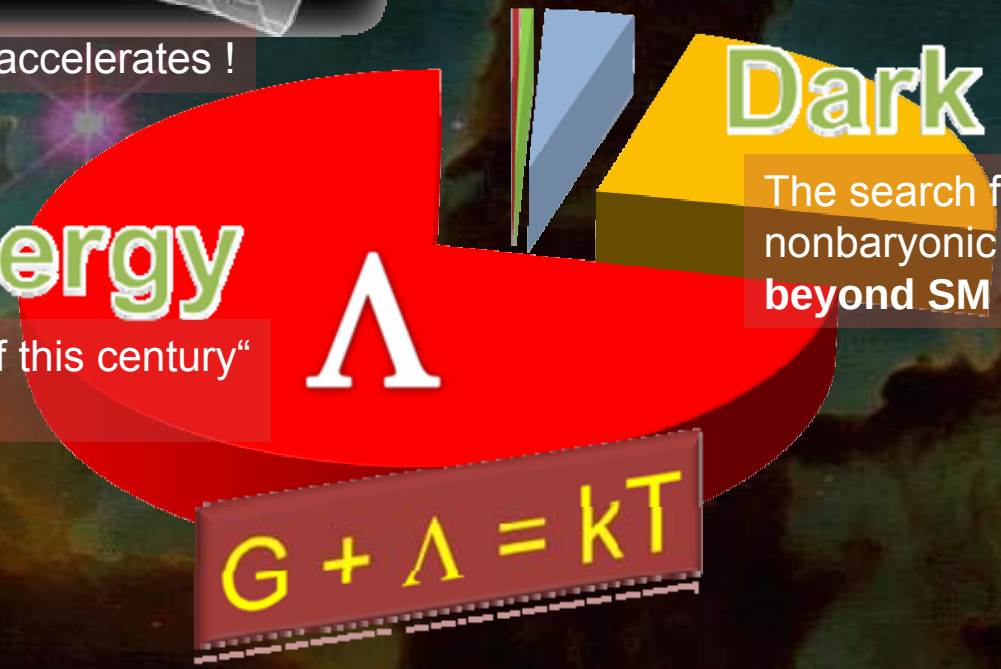


Expansion of universe accelerates !



Galaxies rotate wrong !

Known Matter



Dark Matter

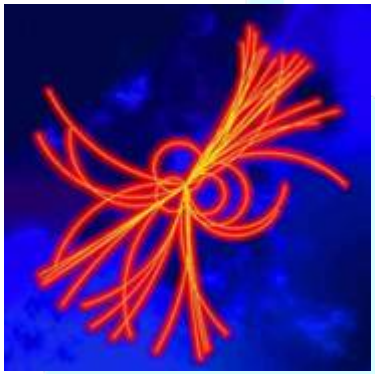
The search for nonrelativistic nonbaryonic matter
beyond SM

Dark Energy

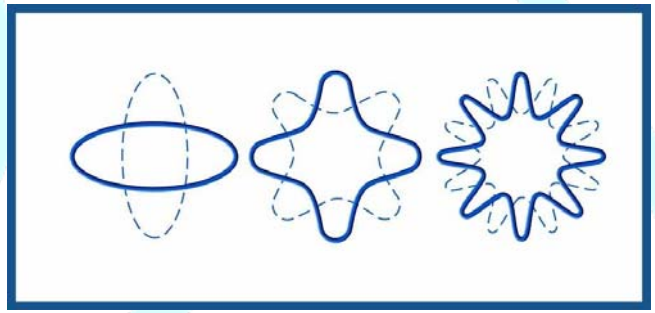
„The biggest mystery of this century“
Science 2003

Particle Physics – open questions

What generates Mass?
Search for the "Higgs".

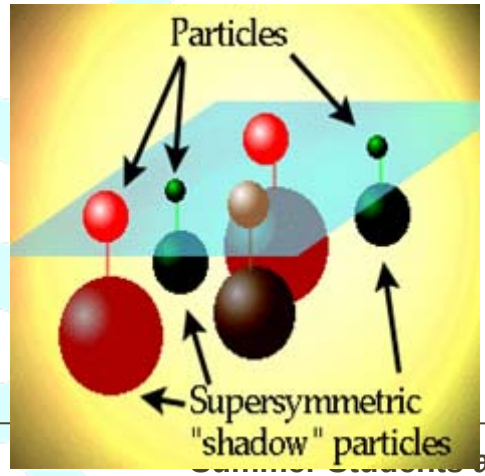


Is the world made out of "Strings"?



Do we understand the Universe?

Is there a „shadow world" of new particles?



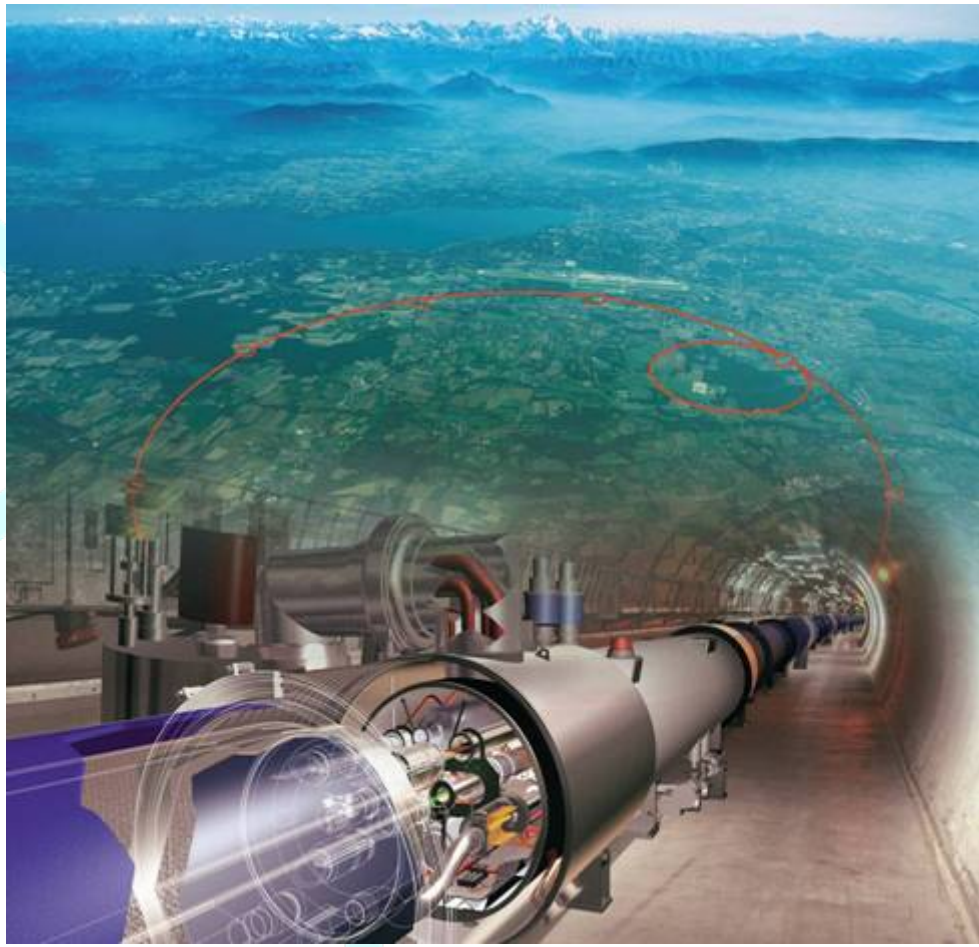
In how many dimensions do we live?

Large Hadron Collider LHC

- Large Hadron Collider LHC at CERN/Geneva
- circular machine

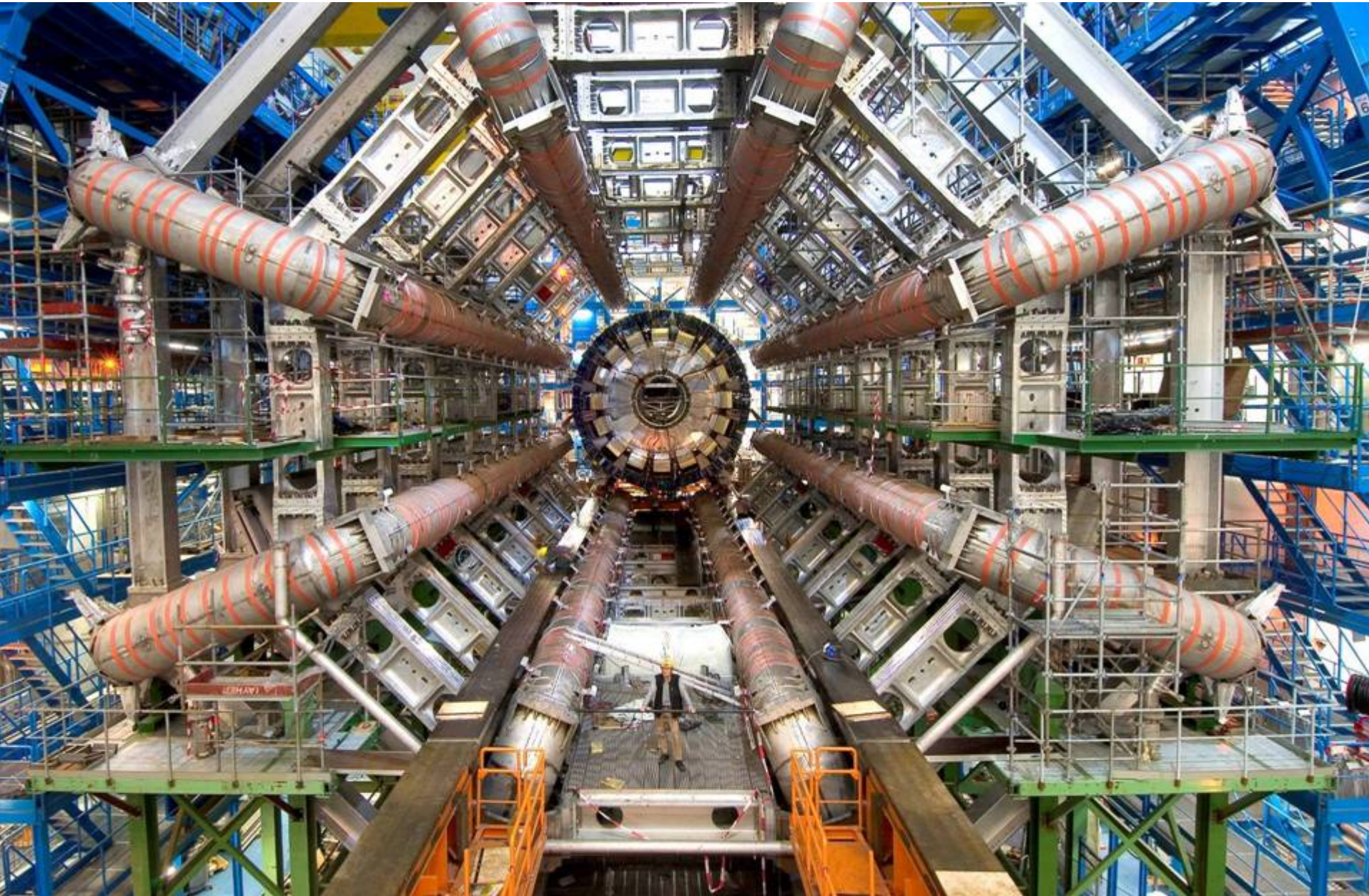
  27 km circumference
- proton-proton collisions at

  7 TeV (later at 14 TeV) energy
  - 800 million quark/gluon collisions per second
  - 15 Petabyte of data/year (GRID)
- LHC re-start spring 2010 and is our essential tool to explore the Terascale



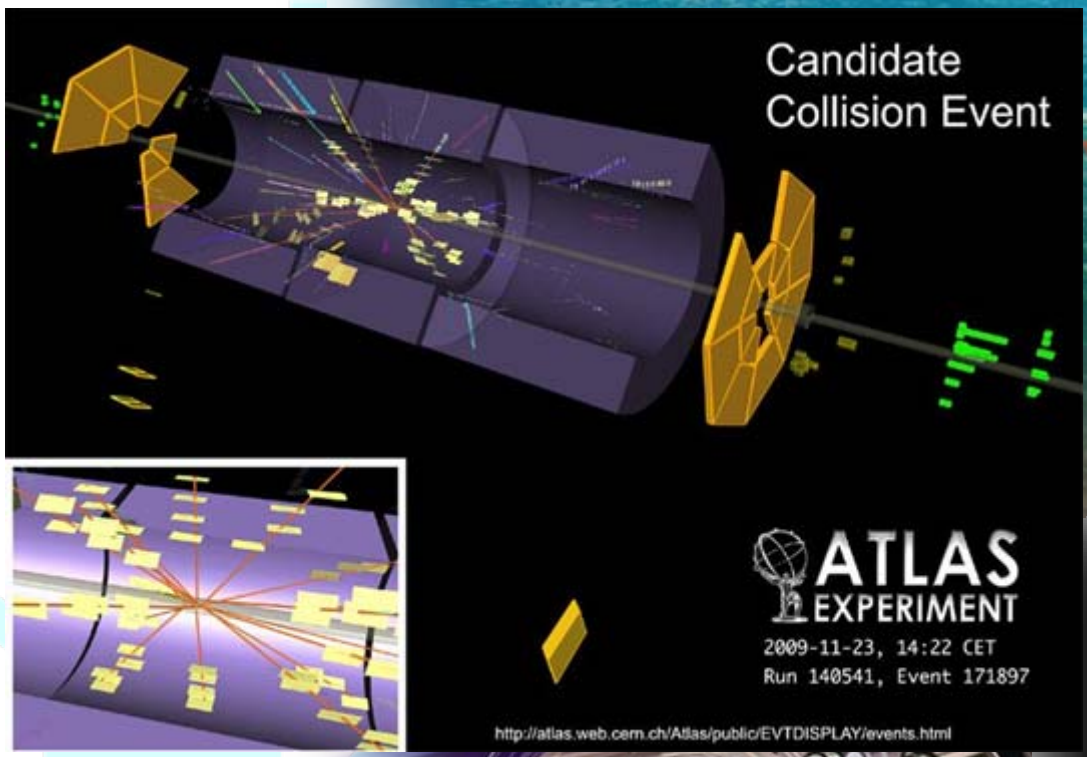
HERA results are vital for LHC predictions

the largest and most complex detectors

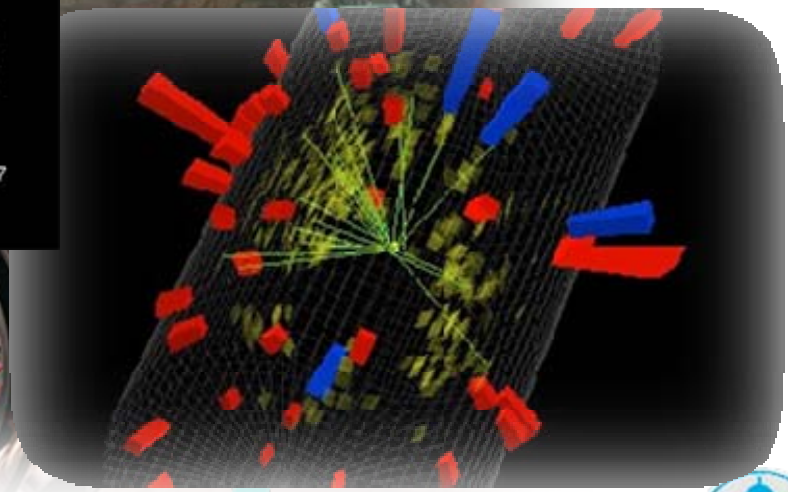


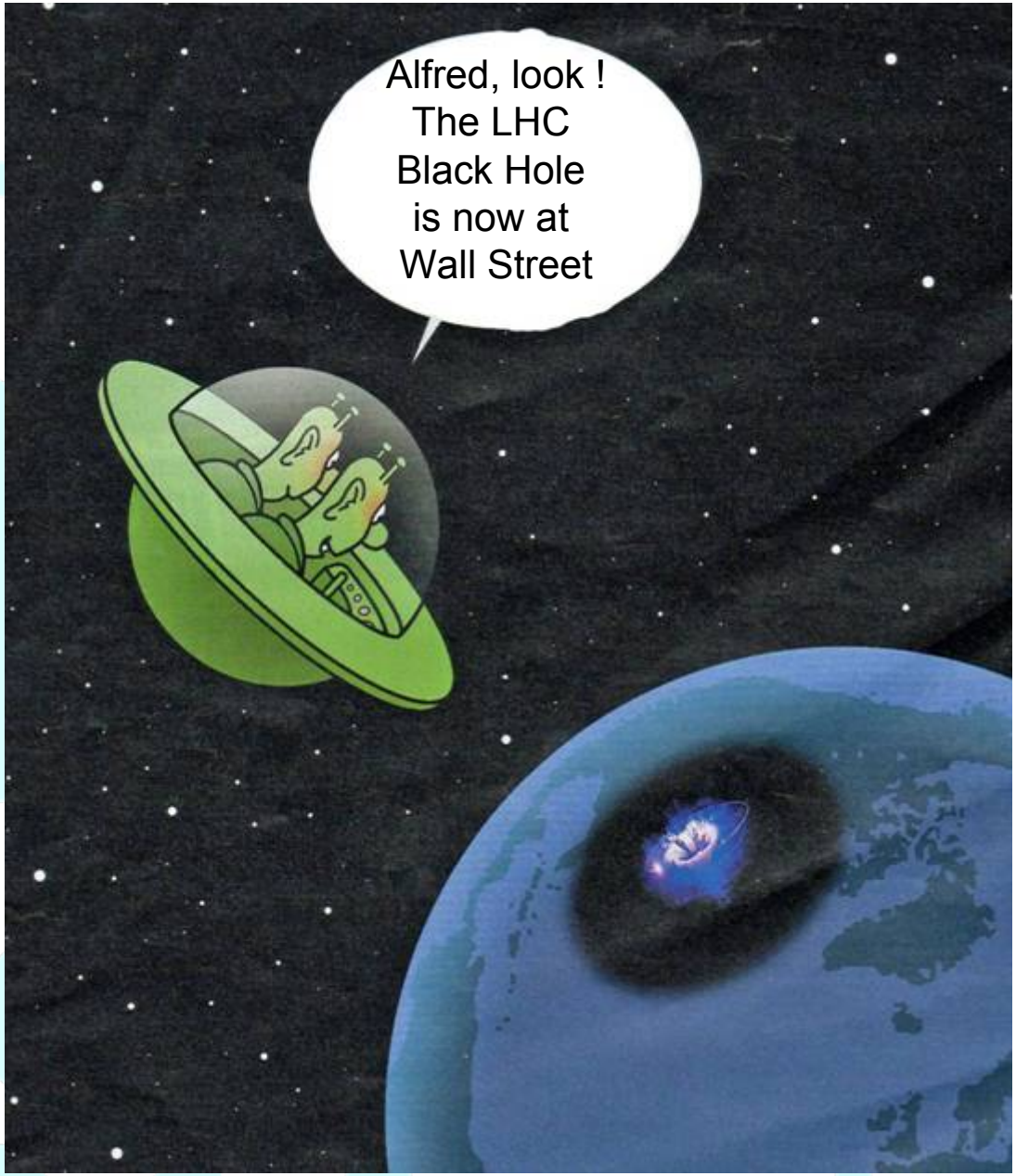
Successfull Restart LHC

Geneva, 30. March 2010.
Proton collisions at 7 TeV at 13:06 MEZ



CMS collision



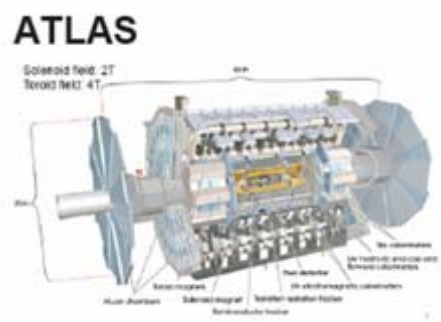

Alfred, look !
The LHC
Black Hole
is now at
Wall Street

DESY participation at LHC

ATLAS Collaboration:

11 Scientists, 15 Postdocs, 12 PhD-Students, 2 Helmholtz YIG
Computing HH and Zeuthen, ATLAS remote Control room
TIER-2: Worldwide LHC Comp Grid, NAF

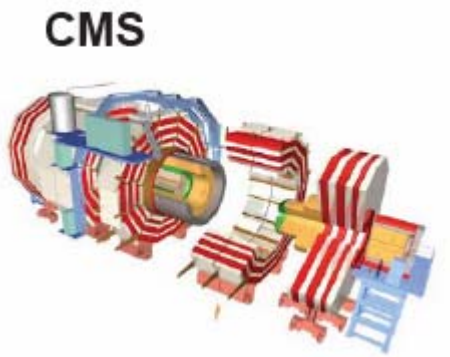
Arbeitsschwerpunkte:
„High Level Trigger“, Lumi-Detector ALFA (Teststrahl CERN Ltg. DESY)
ATLAS Data management Core-Activities



CMS Collaboration:

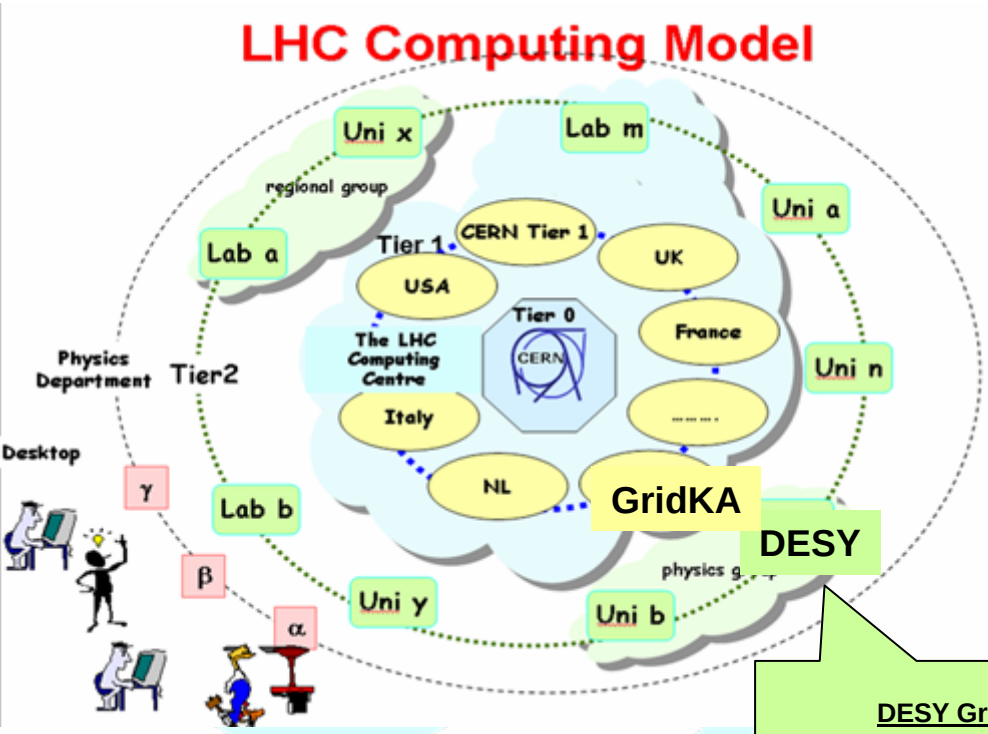
16 Scientists, 9 Postdocs, 8 PhD-Students
2 Helmholtz-YIG Higgs SUSY
TIER-2 (DESY-Aachen)

Focus:
Coordination, CMS-Management Board, Calibration, Alignment (Tracking detector)
Castor Calorimeter, presently CMS tests mit cosmics

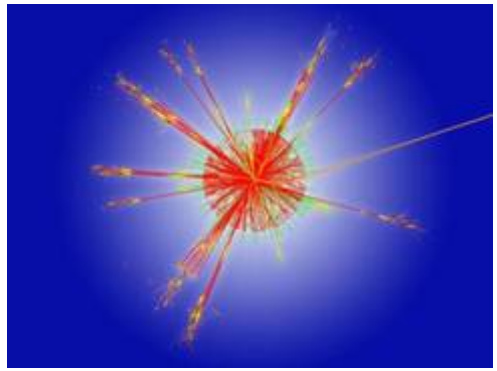


Participation in LHC detector upgrade projects

GRID Computing at DESY



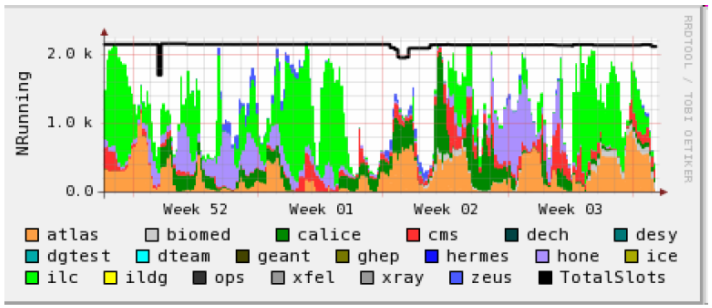
LHC Collisions at 40 MHz, recorded at ~100 Hz
Total RAW data by all LHC experiments:
15 PB/year



DESY Grid:
Serves Atlas, CMS & LHCb
ILC & Calice
HERA-Experiments
XFEL, ...

- DESY (in HH and Zeuthen) provides GRID services & Resources for numerous communities (virtual Organizations)
- NAF provides (interactive, grid, batch) services for entire german particle physics community

Jobs at DESY-HH Dec/Jan 2008/09



HEP in Germany – Future Challenges

- End of HERA: -> turning point for HEP in Germany
- Particle physics at the energy frontier is becoming global in all its areas
- Stay competitive with high impact → restructure HEP in D

Join all forces of complementary excellence in all areas (analysis, computing, detector, accelerator) in a long-lasting structure and strong sustained infrastructures:

Alliance: a Network of complementary excellence between

2 Helmholtz Centres
17 Universities
1 Max Planck Institute

Key Elements

- Physics Analysis
- Detector Development
- GRID Computing
- Accelerator Science

∞ small

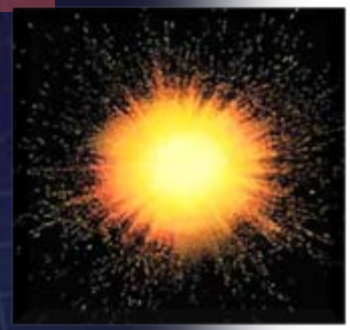
elementary particles
unification of forces

Particles, fields

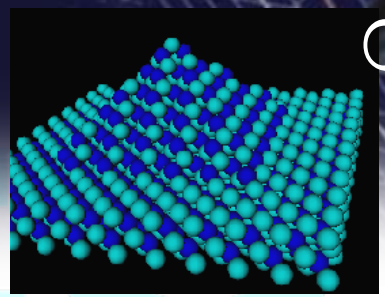
universe

∞ large

cosmology
astrophysics

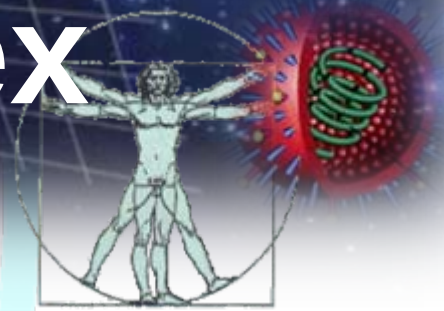


condensed matter



∞ complex

nanoscience, biology
Synchrotron radiation

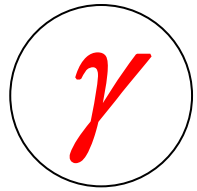


Strategy for Astroparticle Physics

Mission: Understanding Structure and Evolution of matter in the early phase of the universe, origin of high energy cosmic rays, …

messengers from the early universe: neutrinos and gammas

- Neutrino telescopes:
  - Baikal (pioneering) and Amanda – both finished, analysis on-going
  - IceCube (southpole), deployment until 2011
- Gamma telescope
  - In future large area Cherenkov telescope (CTA)



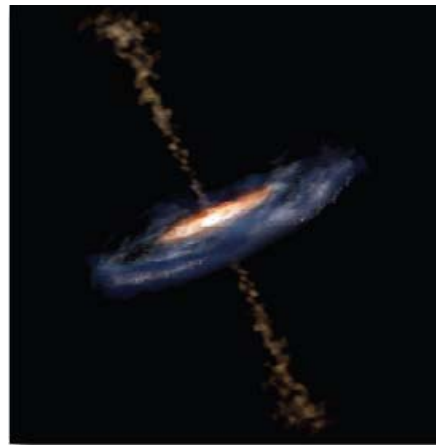
Combination of neutrino and high energy photon signals (multi-messenger principle)

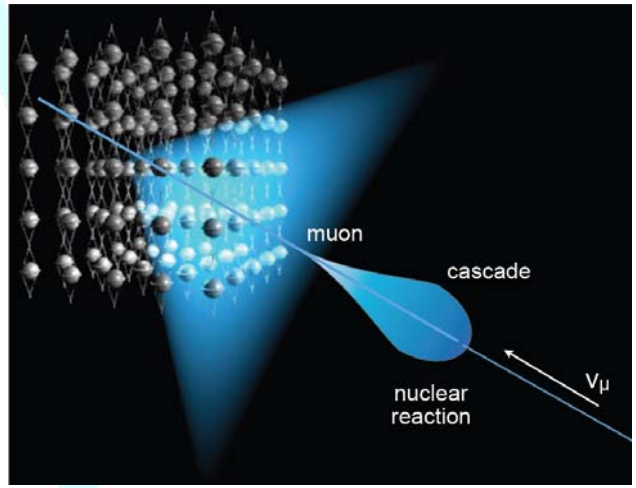
Close collaboration with German universities

Experimental astroparticle activities are presently mainly located in Zeuthen

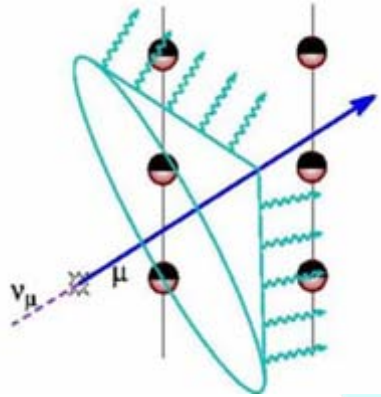
Neutrino Astrophysics

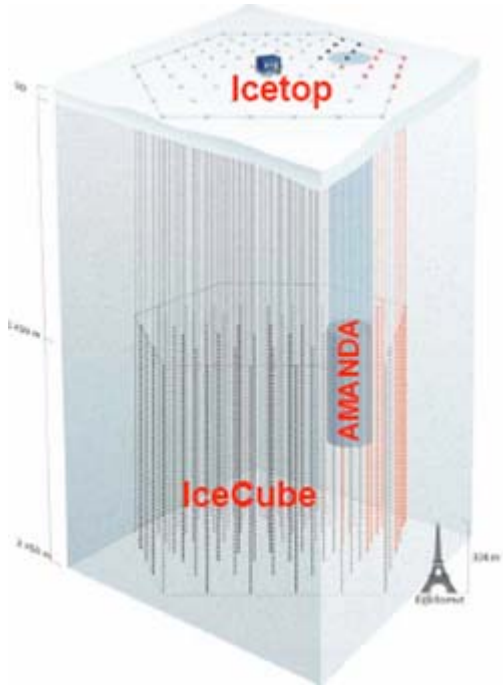
- high energy neutrinos from most violent astrophysical sources („cosmic accelerators“)
  - Supernovae remnants, Active galactic nuclei, gamma ray busts …
- neutrinos travel cosmic distances and point back to source
- detect Cherenkov light in ice emitted by charged particles (i.e. up-going muons) produced by neutrino interactions using earth as filter
- Search for cosmic neutrino point sources

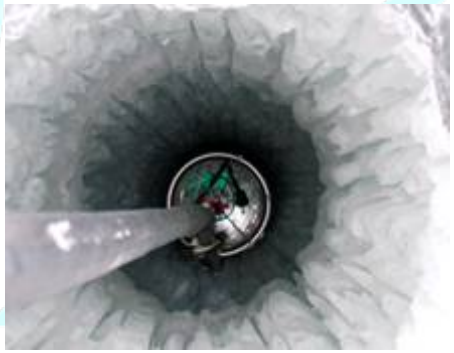


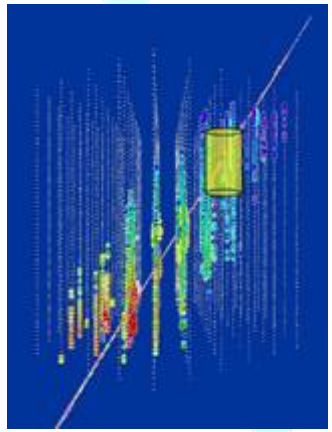


Neutrino Astrophysics





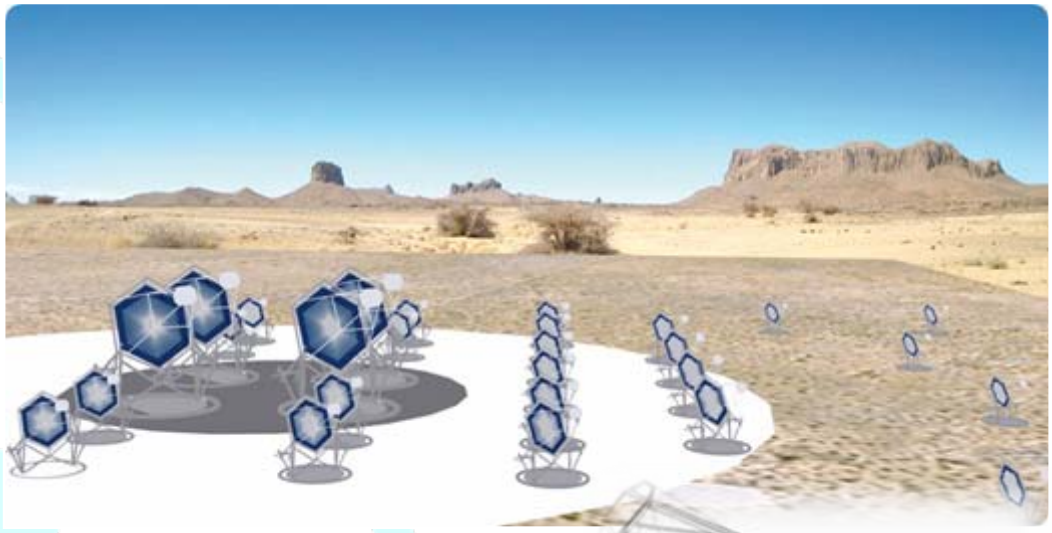


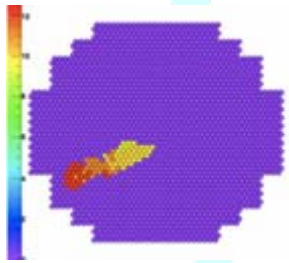


ICECUBE will have an active volume of 1km^3 antarctic ice by 2011 to detect neutrinos from cosmic sources

Cherenkov Telescope Array

- TeV gamma rays propagate straight and are easy to detect – ideal tracer for cosmic processes
- detect Cherenkov light from air showers produced by interactions of TeV gamma‘s in the atmosphere
- Array of imaging telescopes for large field of view and to enhance pointing resolution
- DESY work on 12m prototype telescope
- start construction by 2012





TRENDS in MODERN PHYSICS

∞ small

elementary particles
unification of forces

nano
cosmos

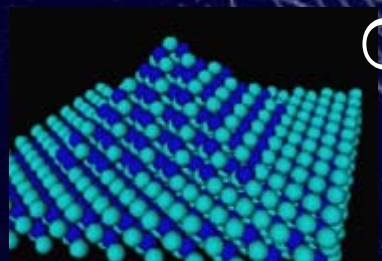
universe

∞ large

cosmology
astrophysics

condensed
matter

∞ complex



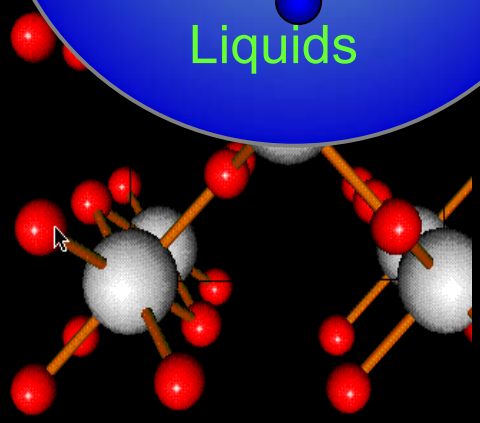
nanoscience & -technology
biology

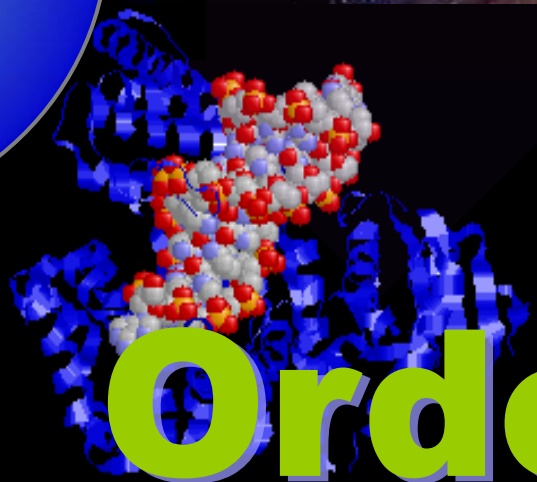
Order from Disorder in Nature

$e^{\text{Energy/Entropy}}$

Nano Space

Liquids

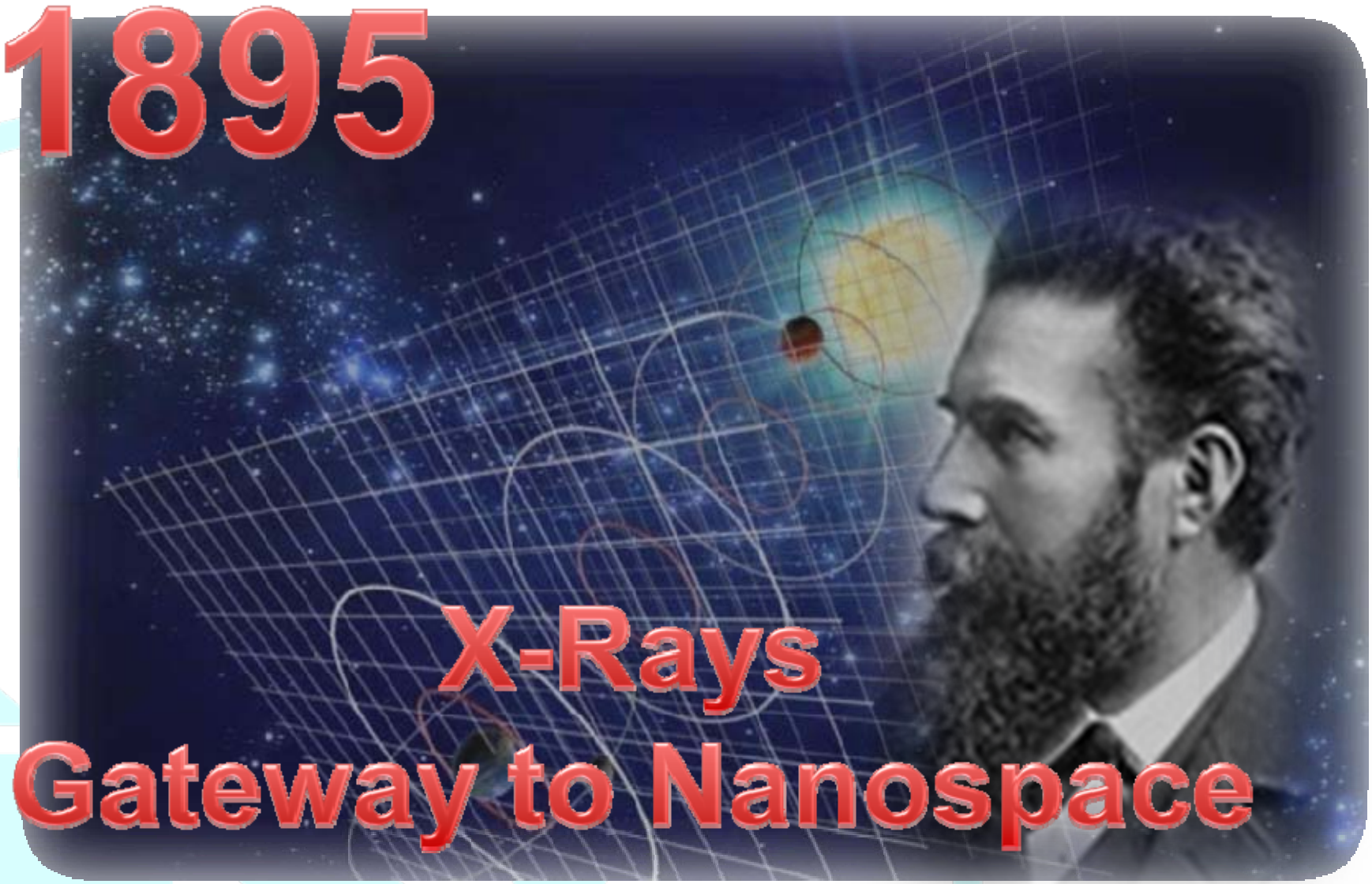




Tera Space

Quark Gluon Plasma

Order


1895
X-Rays
Gateway to Nanospace

1900-2000 Era of Ordered Matter

„LAUE I“ Structure of Crystals

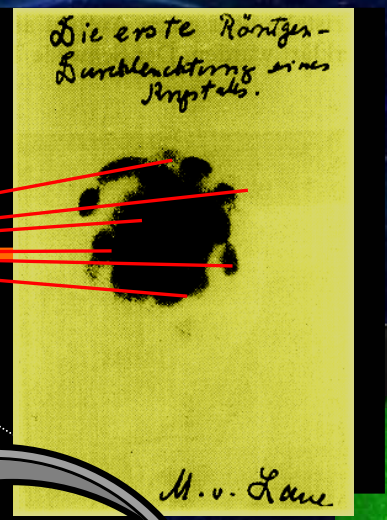
1912

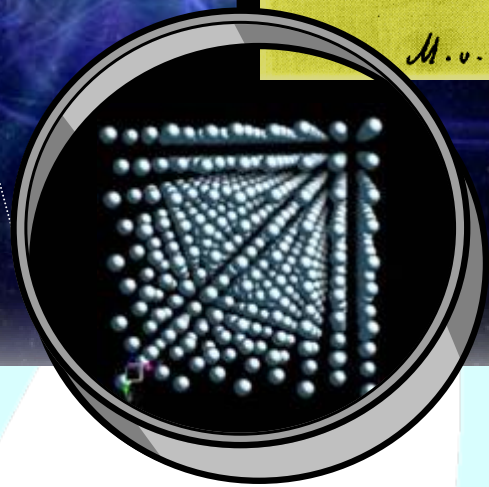
W.C. Röntgen

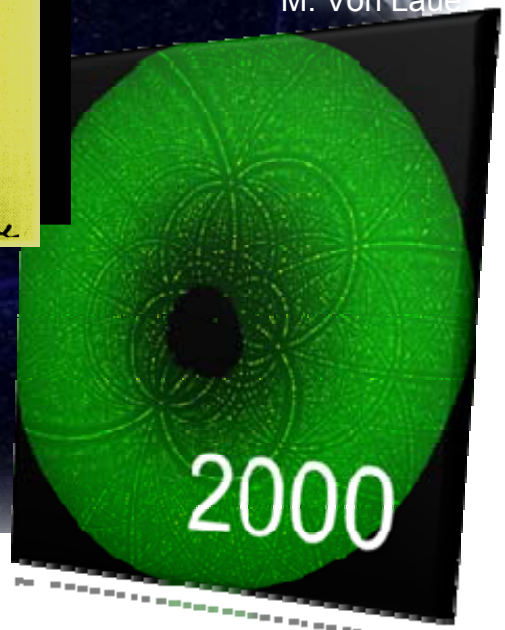
M. Von Laue

crystal

X-ray tube

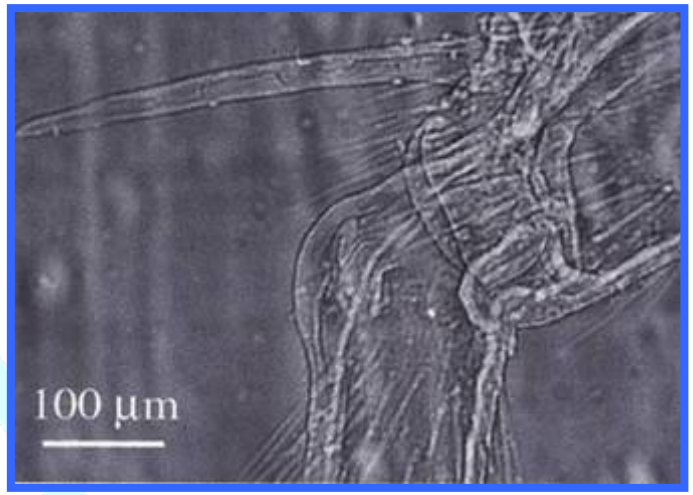




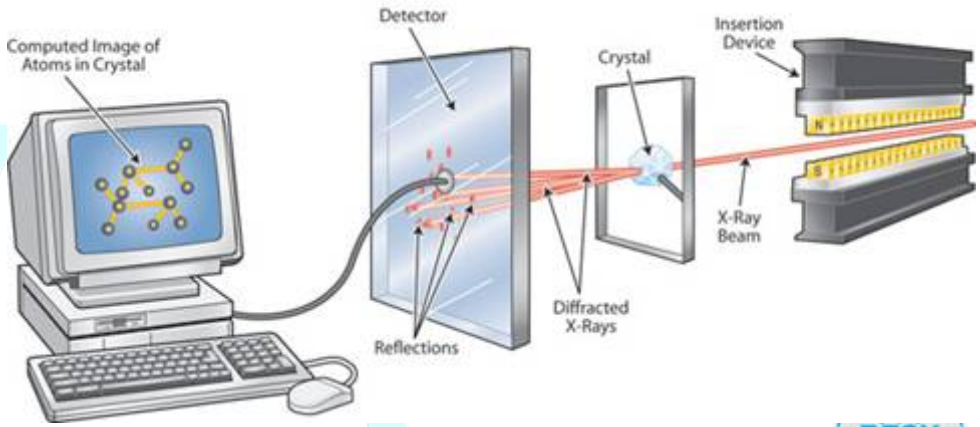


Some Applications:

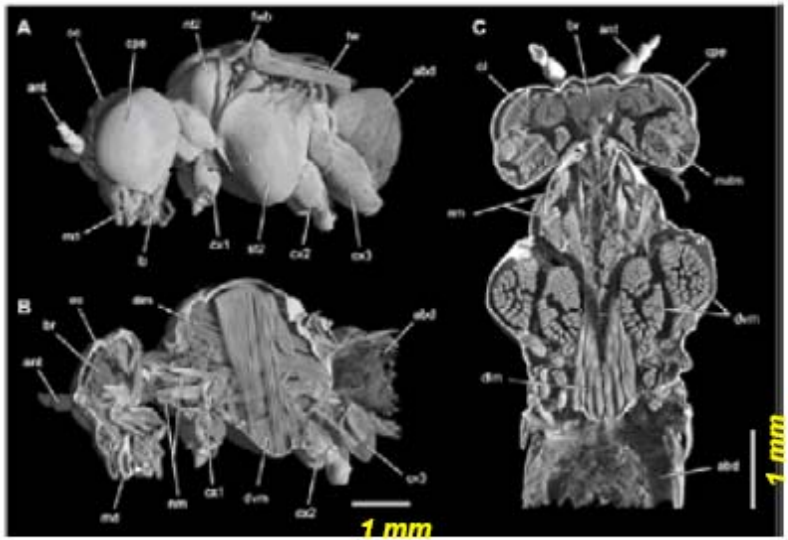
Die “Proteinfabrik”



Knee of a Spider



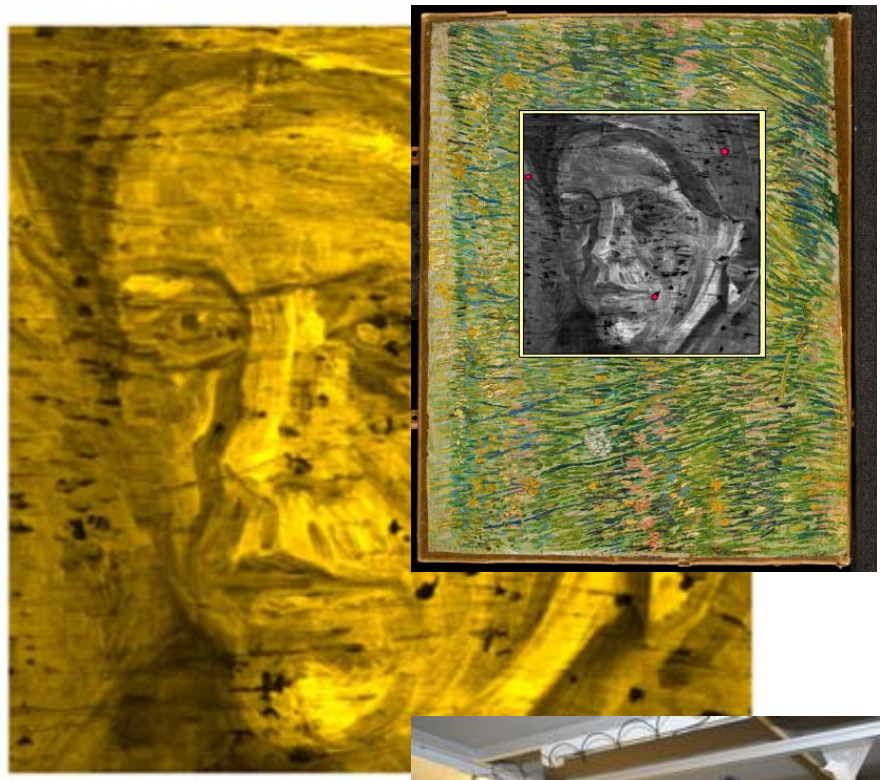
Examples for Research at DORIS



8 keV at BW2

Volume rendering of the head and thorax of the sawfly Tenthredo vespa.

F. Friedrich, H.W. Pohl, F. Hünefeld, F. Beckmann, J. Herzen and R.G. Beutel (HASYLAB Ann. Rep. 2007)



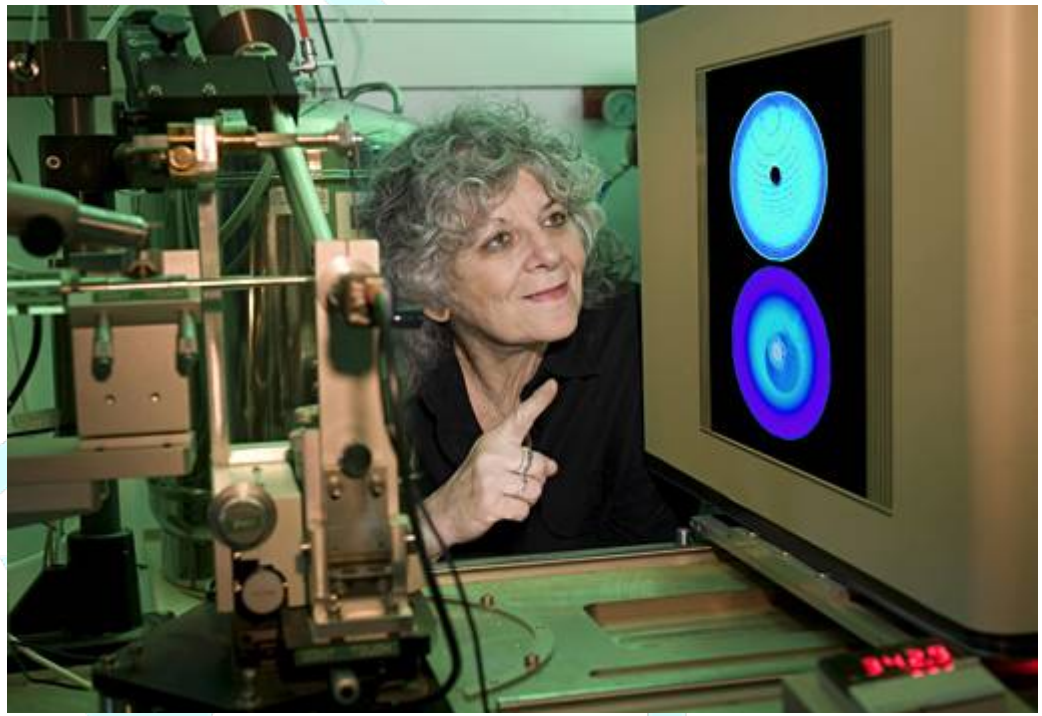
Painting: van Gogh

Boerin, Janssens et al. (s

DESY. Chemistry Nobel laureate 2009

Ada Yonath

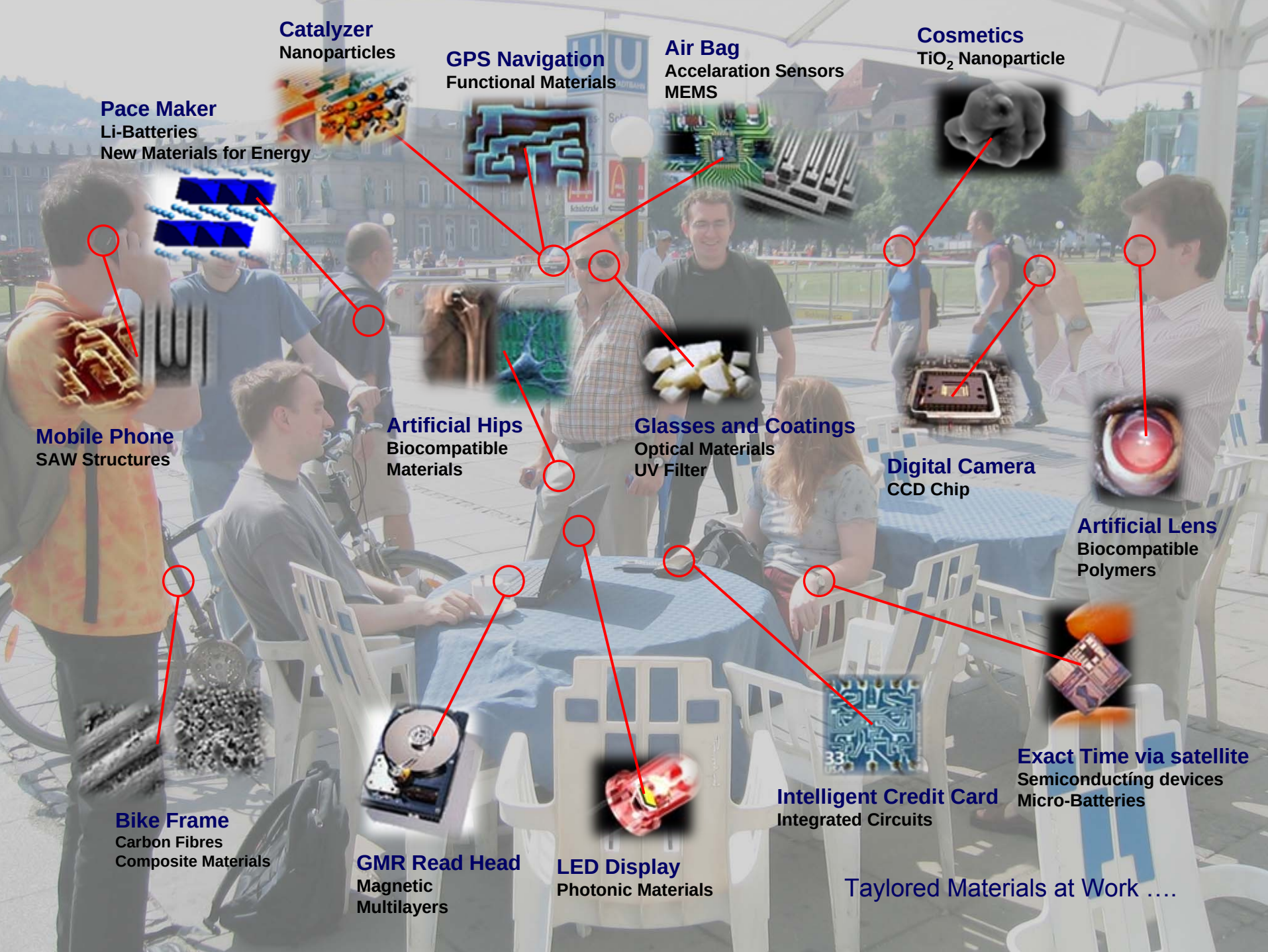
1986- 2004 Head of MPG Research Group – Structure of the Ribosome



DESY

Pioneering work at DORIS III /DESY


On a typical day in Europe ....

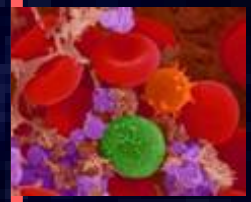

Catalyzer
Nanoparticles
GPS Navigation
Functional Materials
Air Bag
Accelaration Sensors
MEMS
Cosmetics
TiO_2 Nanoparticle
Pace Maker
Li-Batteries
New Materials for Energy
Mobile Phone
SAW Structures
Artificial Hips
Biocompatible
Materials
Glasses and Coatings
Optical Materials
UV Filter
Digital Camera
CCD Chip
Artificial Lens
Biocompatible
Polymers
Bike Frame
Carbon Fibres
Composite Materials
GMR Read Head
Magnetic
Multilayers
LED Display
Photonic Materials
Intelligent Credit Card
Integrated Circuits
Exact Time via satellite
Semiconductíng devices
Micro-Batteries
Taylored Materials at Work ….

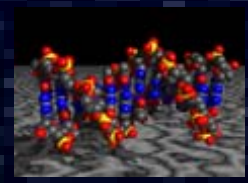
TRENDS in MODERN PHYSICS

nature

invisible

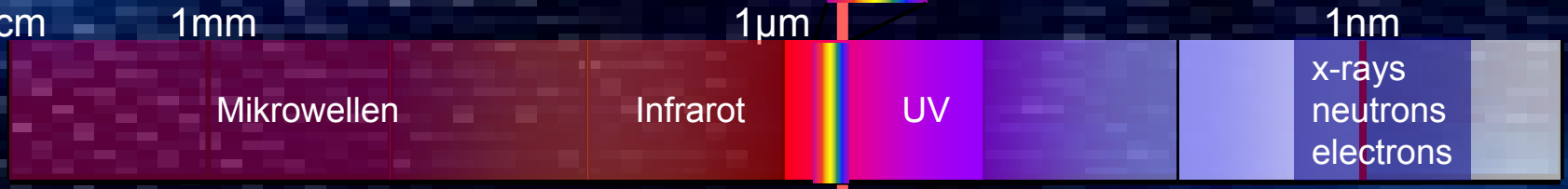




light

1 nanometer

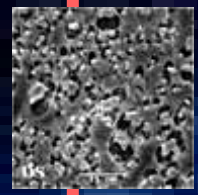
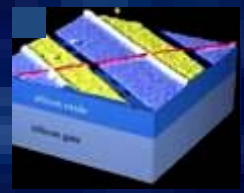
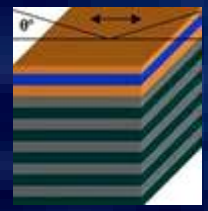


Microtech

Nanotech

man made



„Size matters“

GRAND CHALLENGES II

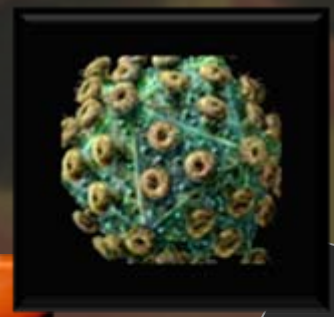
Sustainable **Energy** & **Water** Technology

Reduction of **Environmental** Pollution
Stopping **Climate Change**

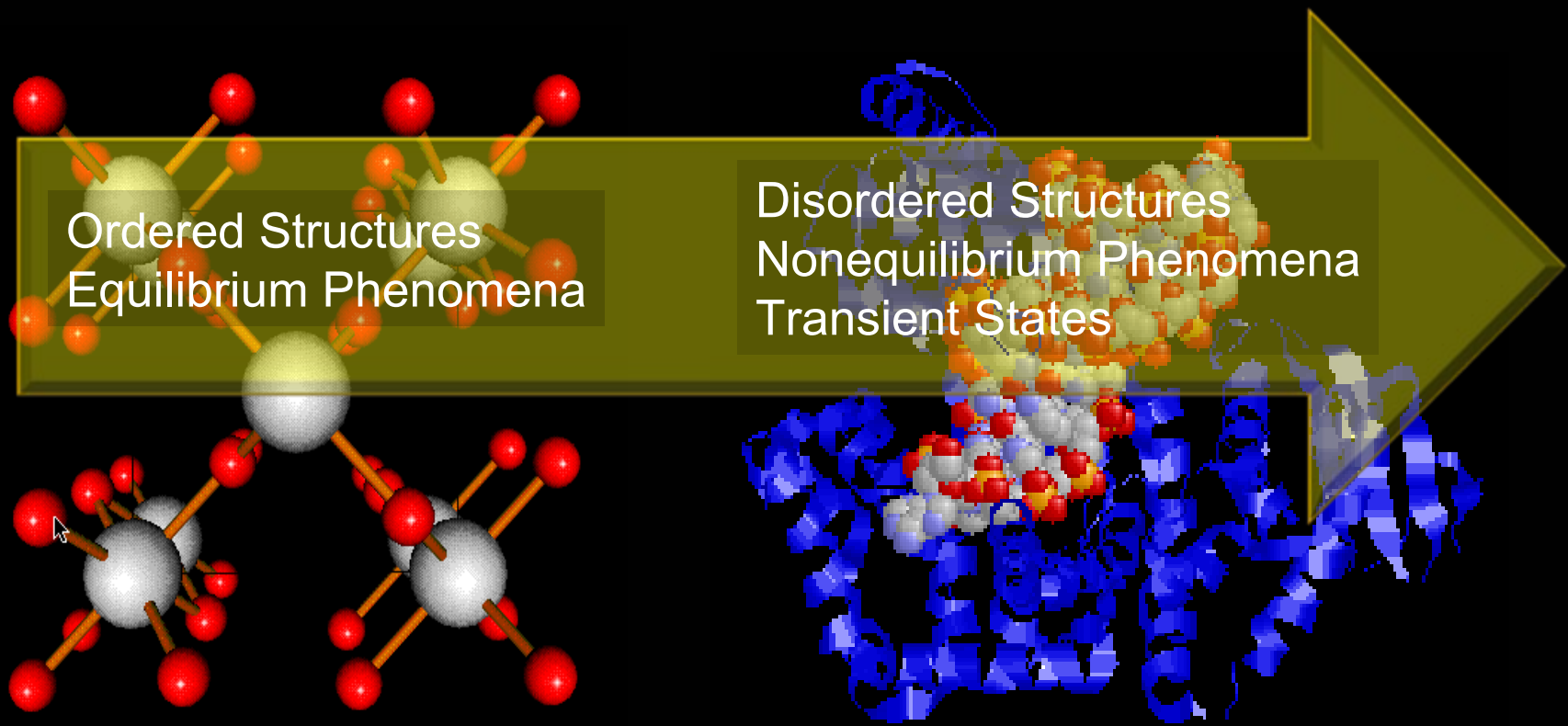
Fighting Vexing **Deseases**

IT **beyond CMOS**

Safety



TRENDS in MODERN PHYSICS

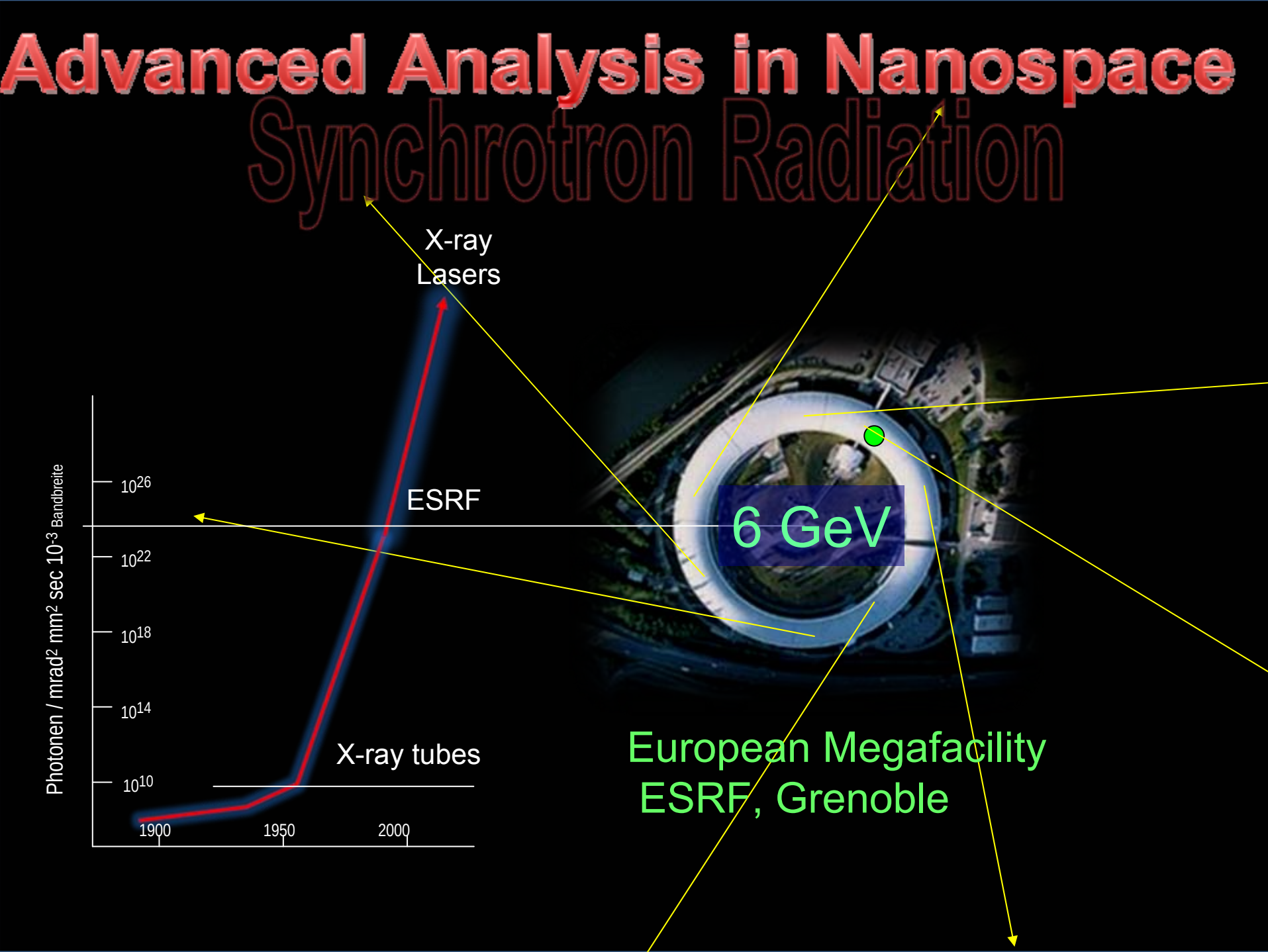


Era of Crystalline Matter | Era of Disordered Matter

1900 2000 future

Advanced Analysis in Nanospace

Synchrotron Radiation



PETRA III

the most brilliant x-ray source ever built

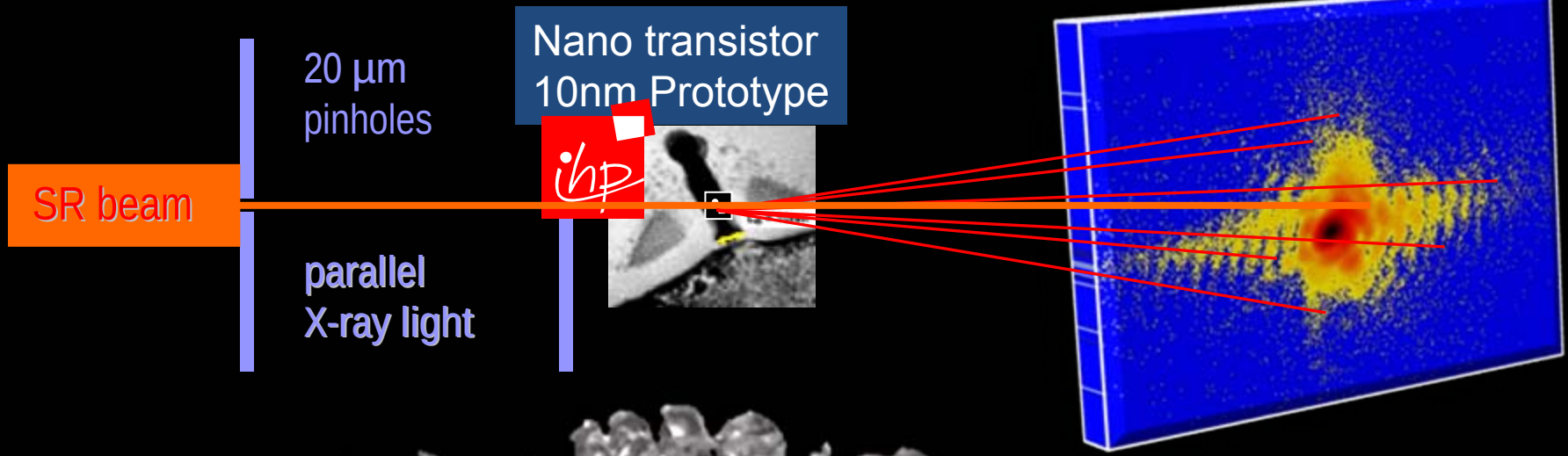
1 nmrad

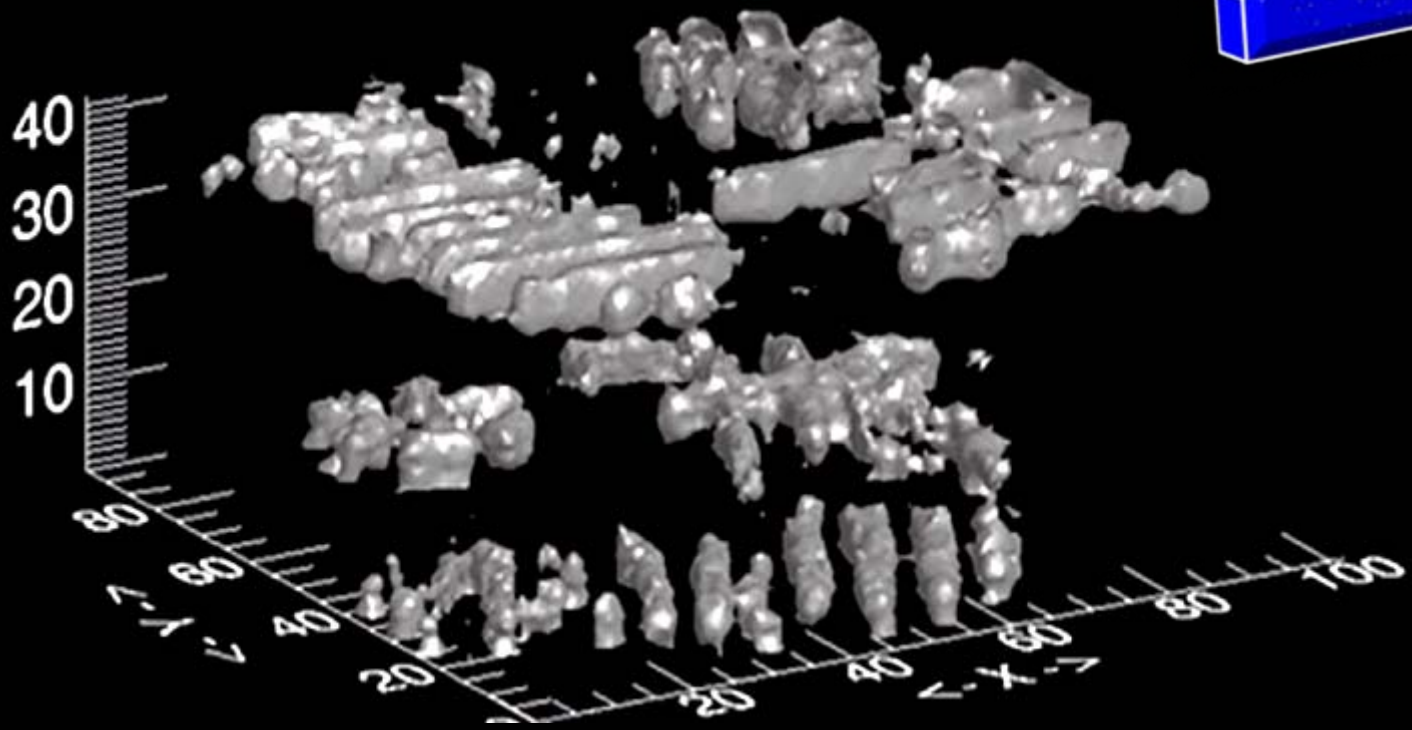
1st monochromatic light
July 17, 2009

1st stored positron beam
April 16, 2009

2000 + Era of Disordered Matter

„LAUE II“ 3d image of nanostructure





Dream of Mankind
Realtime **holograms** of the **motion** of atoms, molecules and electrons

300K

Nano length

$L = 1\ nm$

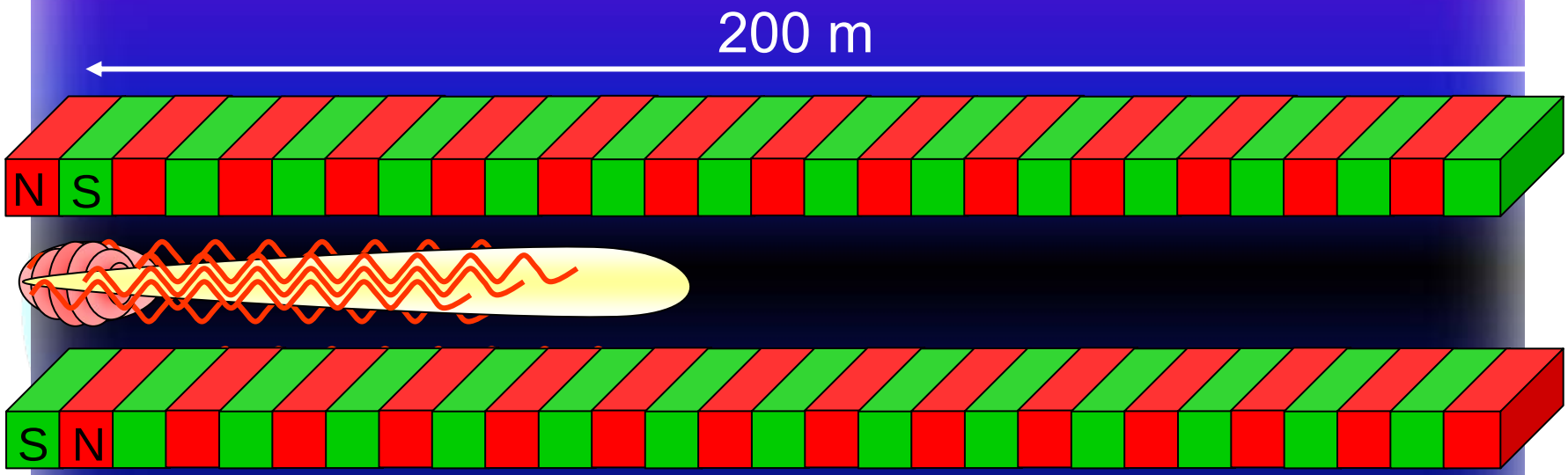
Nano time

$$t = L \sqrt{\frac{u_p}{2k_B}} \sqrt{\frac{A}{300K}} \approx 100\ fsec$$

Molecular holographic snapshots:
NEED: x-ray **Laser** fsec pulses !

X-ray Laser with free electrons

The SASE principle



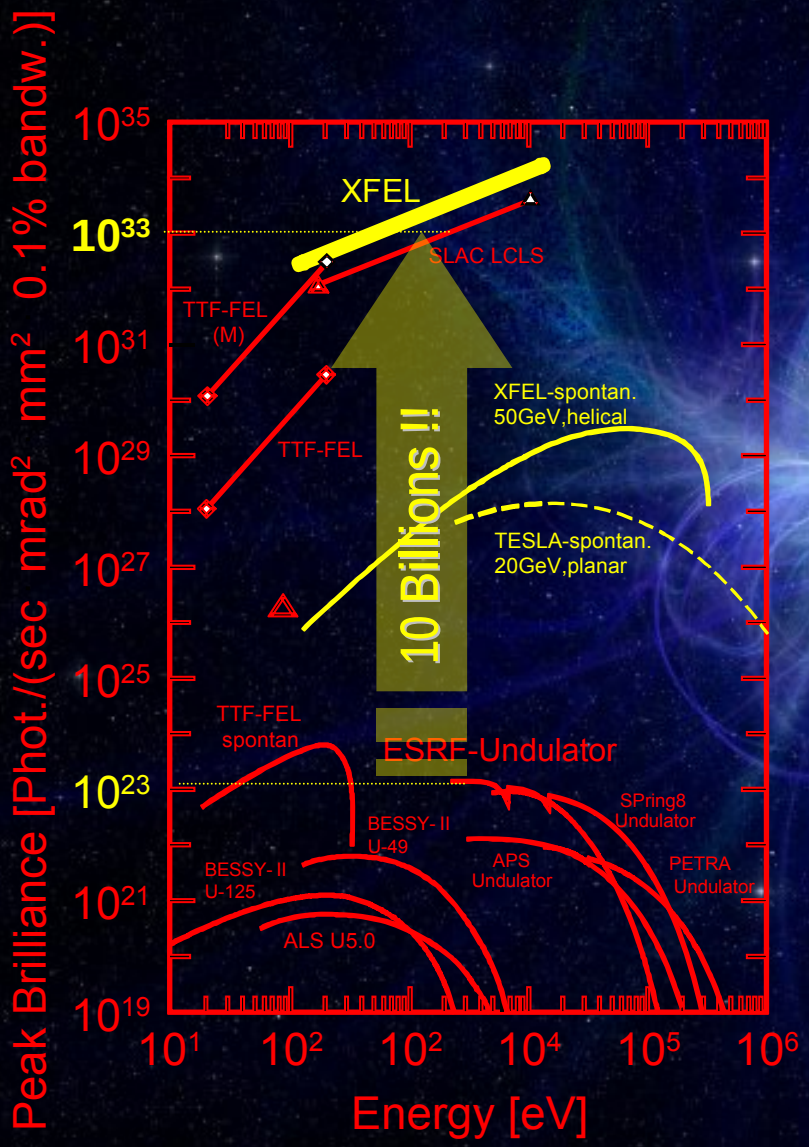
10^{10} e^- (1 nC)

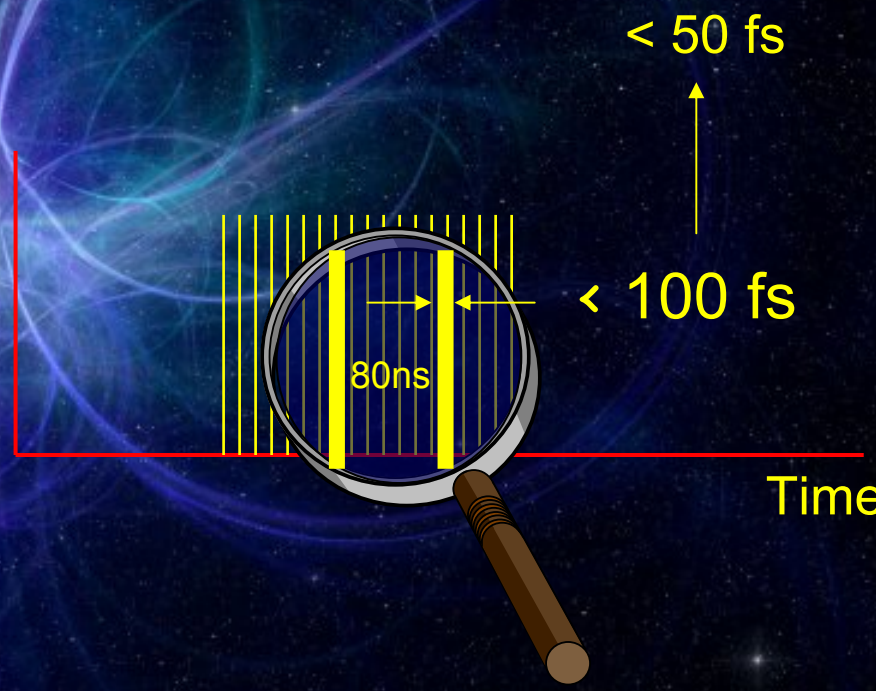
Self-Organized Micro Bunching

Electron Bunch with 10 GeV

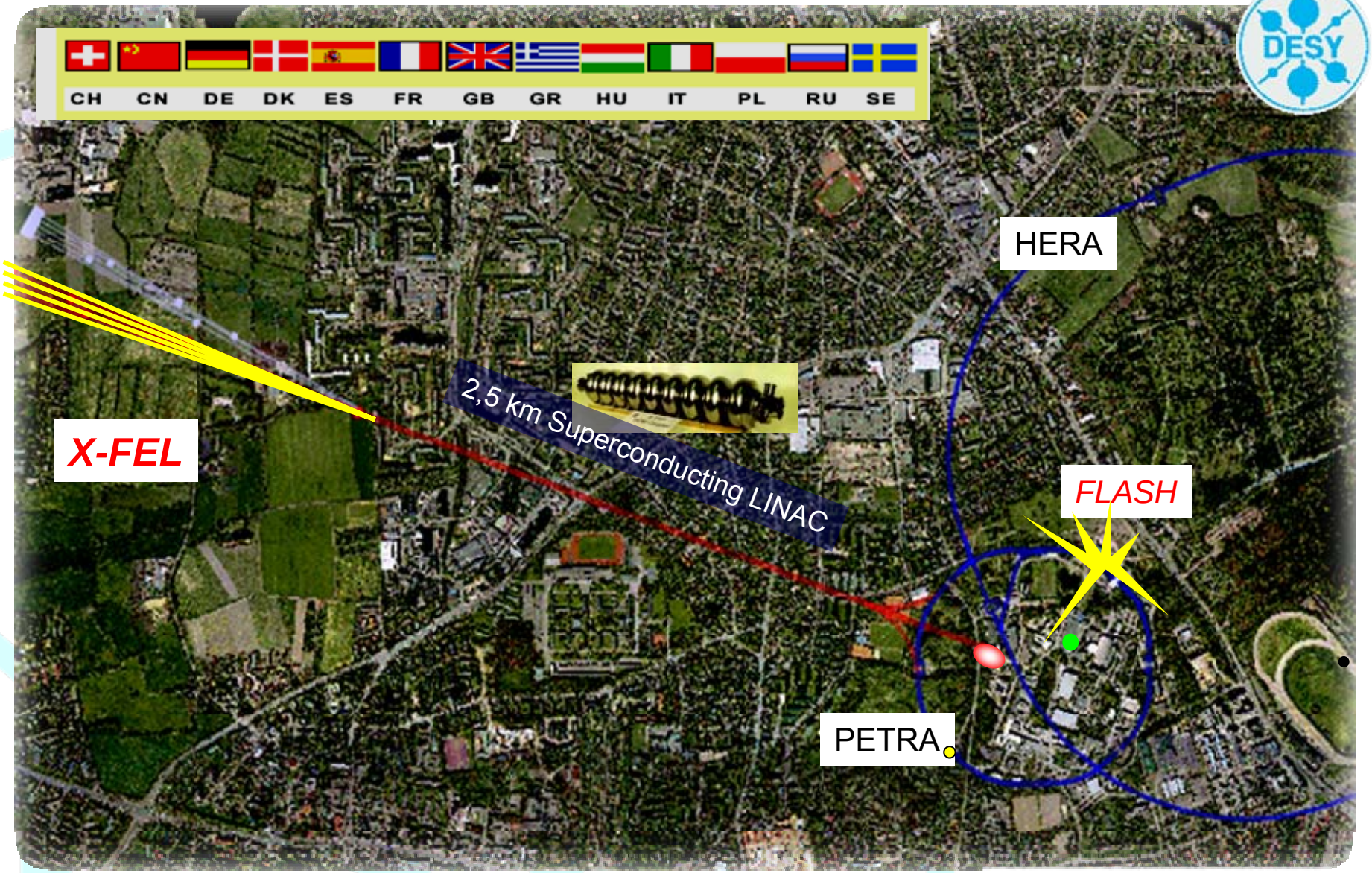
$$I_{X\text{-}Rays} = \begin{cases} N\cdot & \text{chaotic} \\ N^2\cdot & \text{coherent} \end{cases}$$

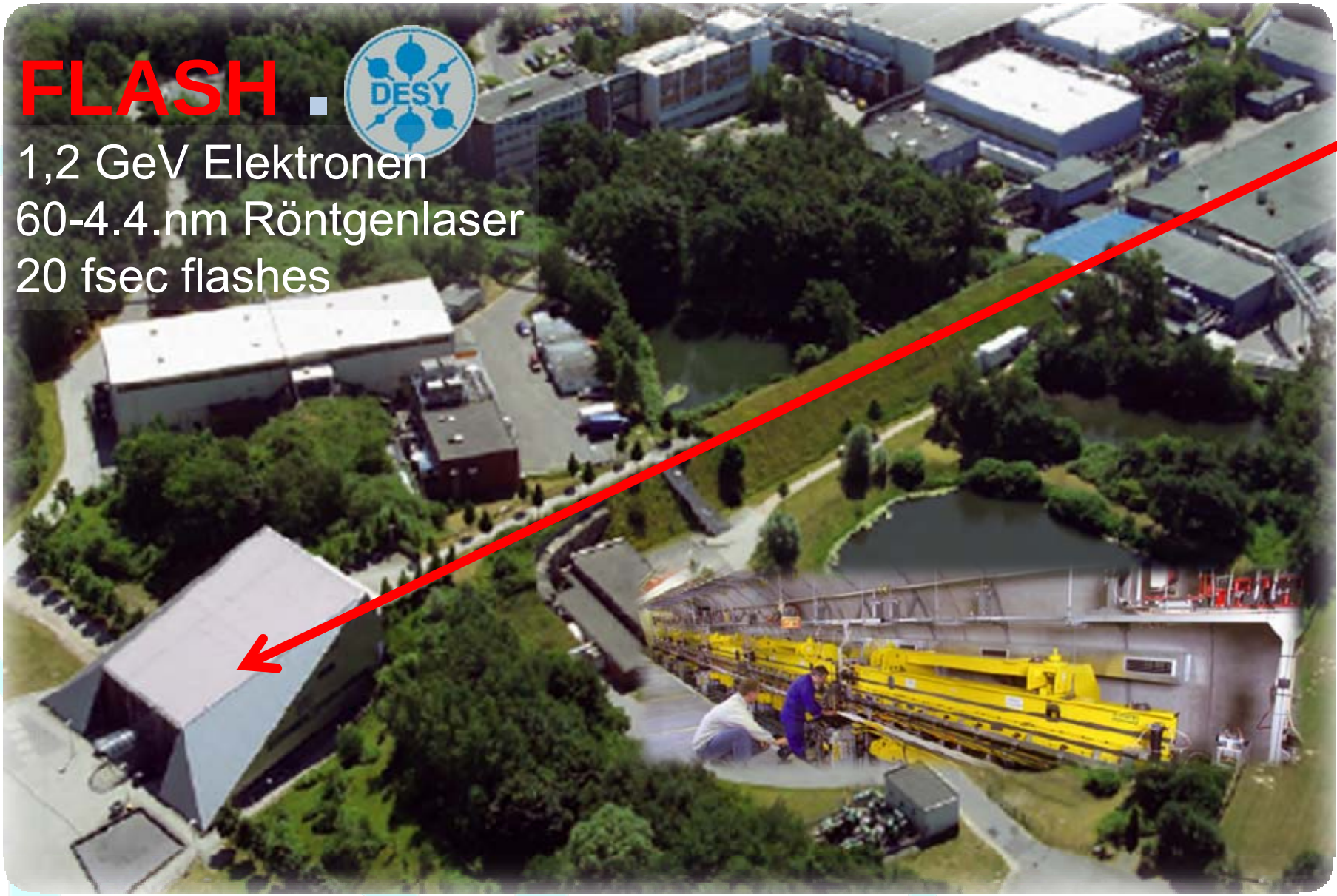
FREE ELECTRON LASER

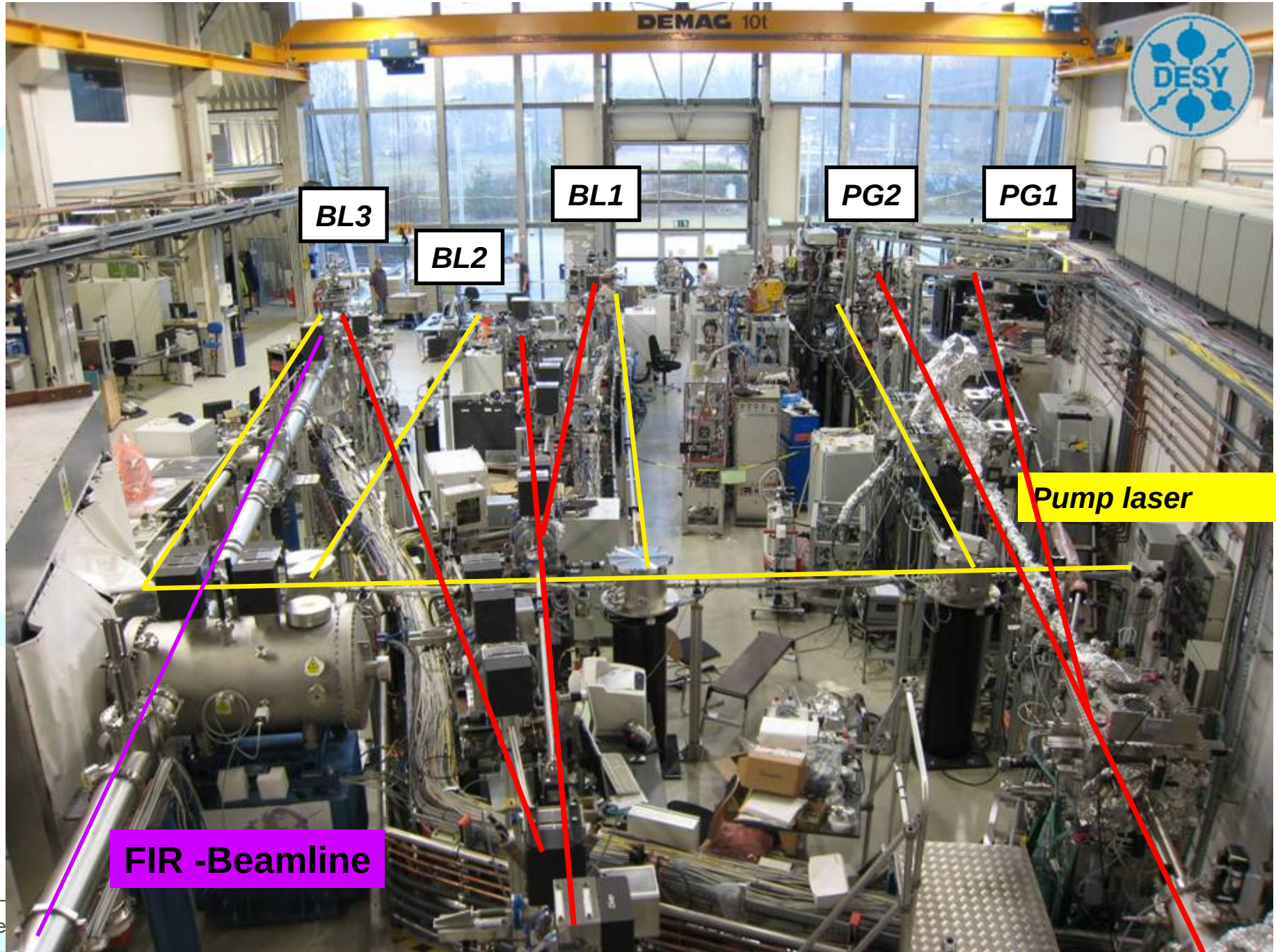




Femtosecond x-ray laser pulses
Life reports from Nanospace


CH CN DE DK ES FR GB GR HU IT PL RU SE
HERA
X-FEL
2,5 km Superconducting LINAC
FLASH
PETRA

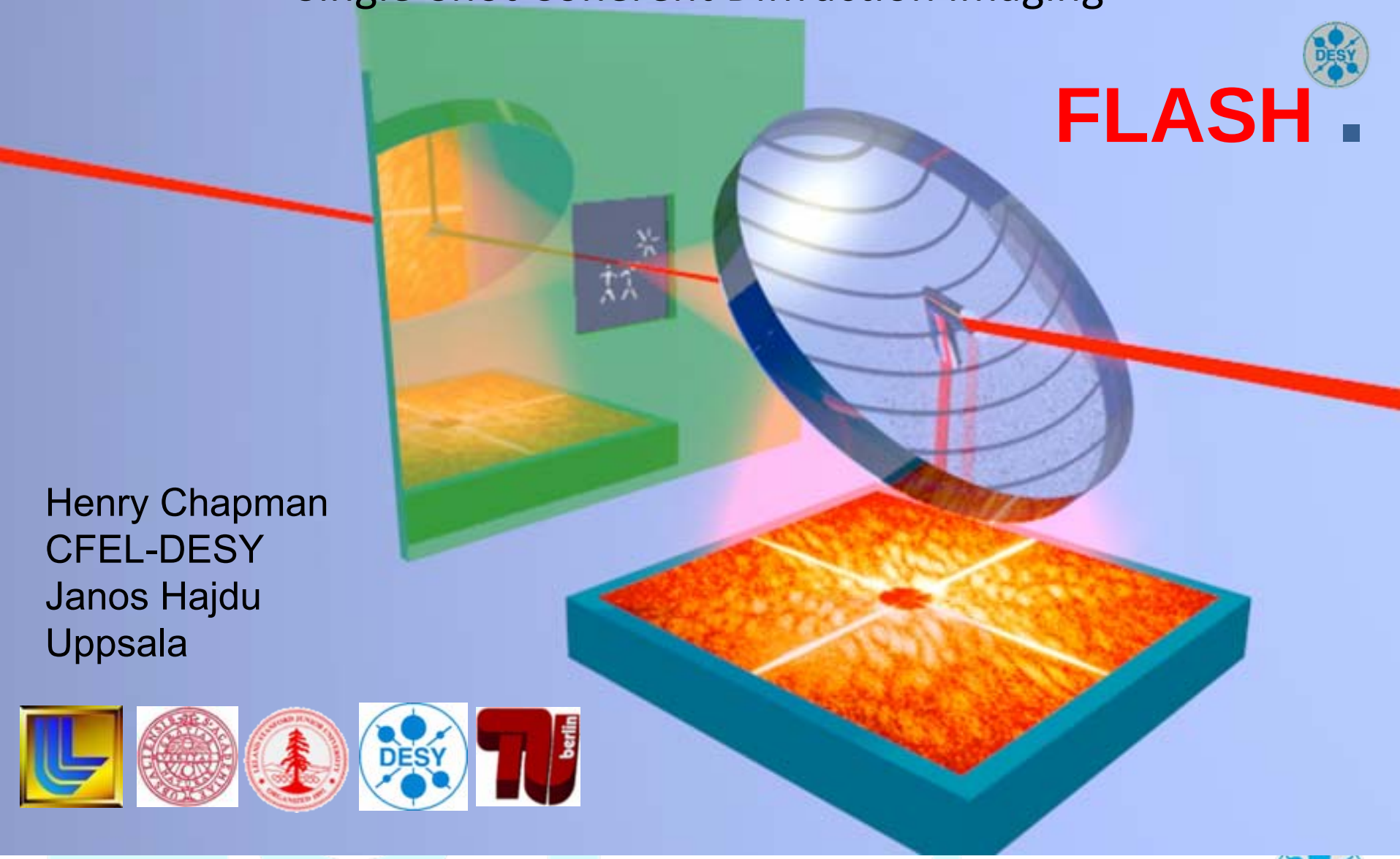

FLASH .
DESY
1,2 GeV Elektronen
60-4.4.nm Röntgenlaser
20 fsec flashes


DEMAG 10t
DESY
BL3
BL2
BL1
PG2
PG1
Pump laser
FIR -Beamline

FLASH

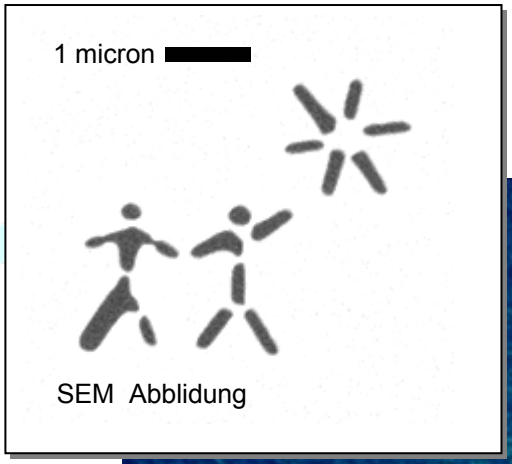
Erste Demo von
Single-Shot Coherent Diffraction Imaging

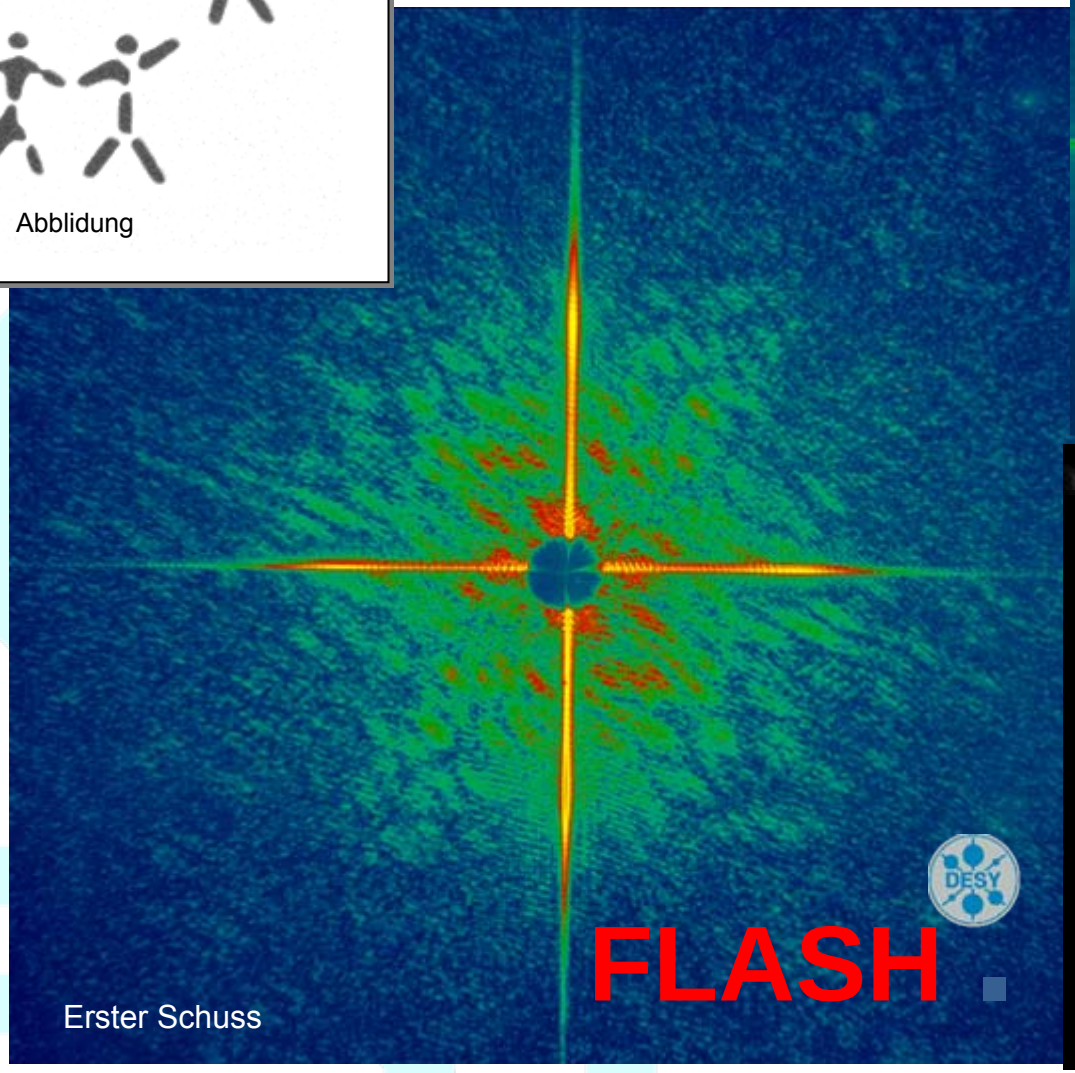
FLASH

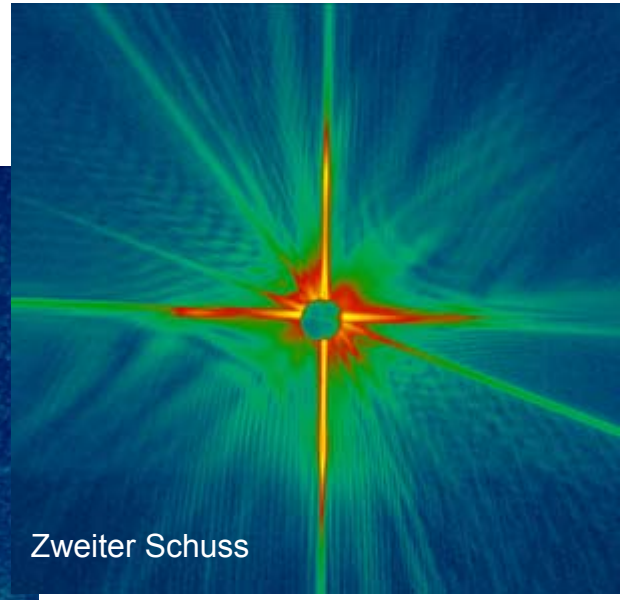


Henry Chapman
CFEL-DESY
Janos Hajdu
Uppsala

Image reconstruction from an ultrafast FEL diffraction pattern

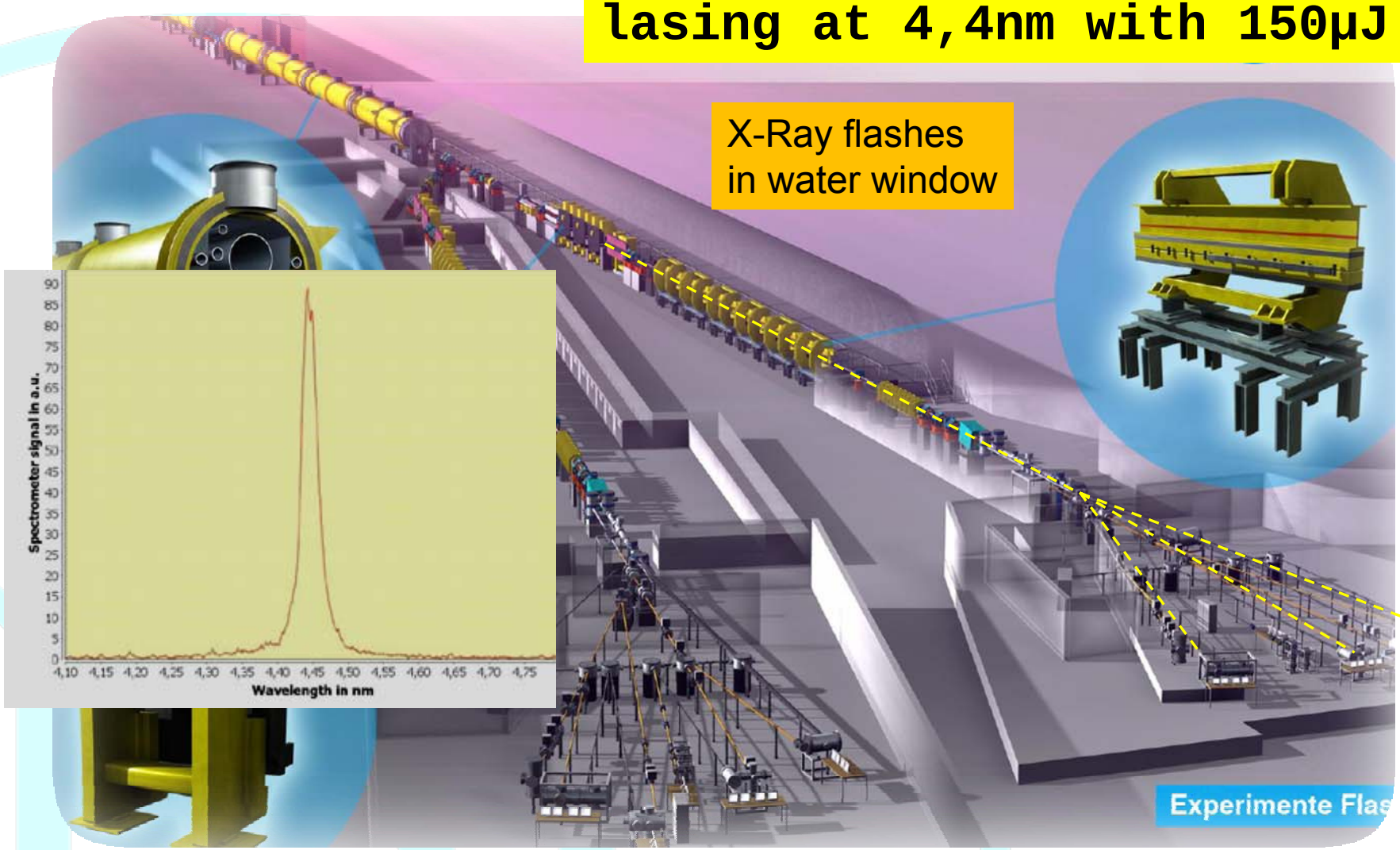




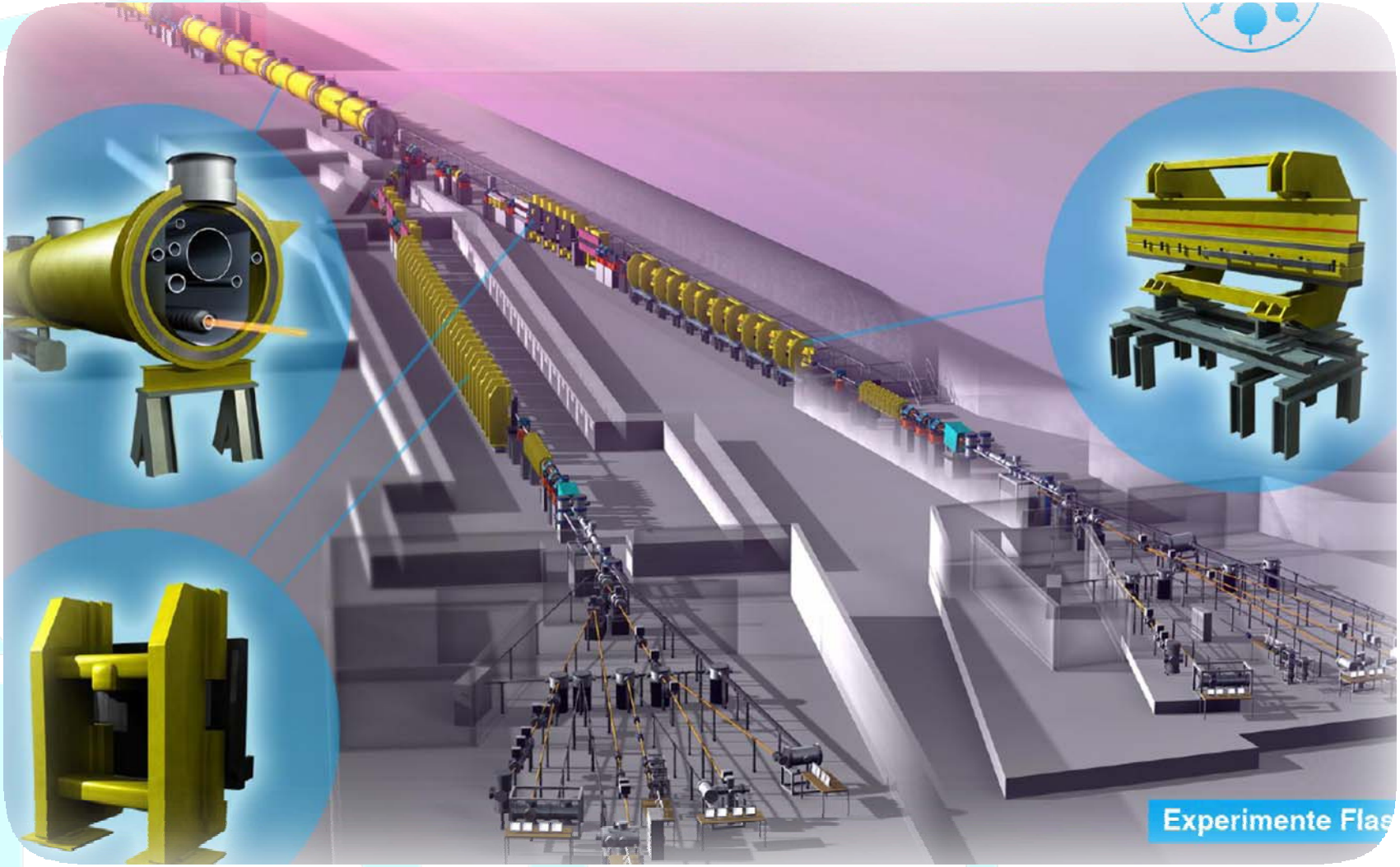


DESY News.

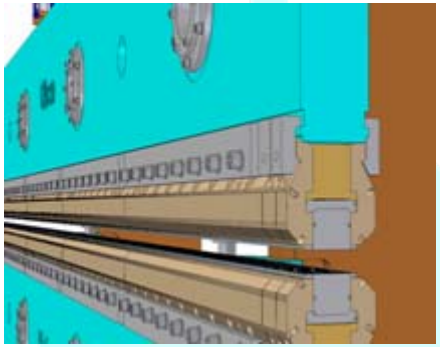
- **7.6.2010 ... sFLASH ... lasing at 4,4nm with 150µJ**

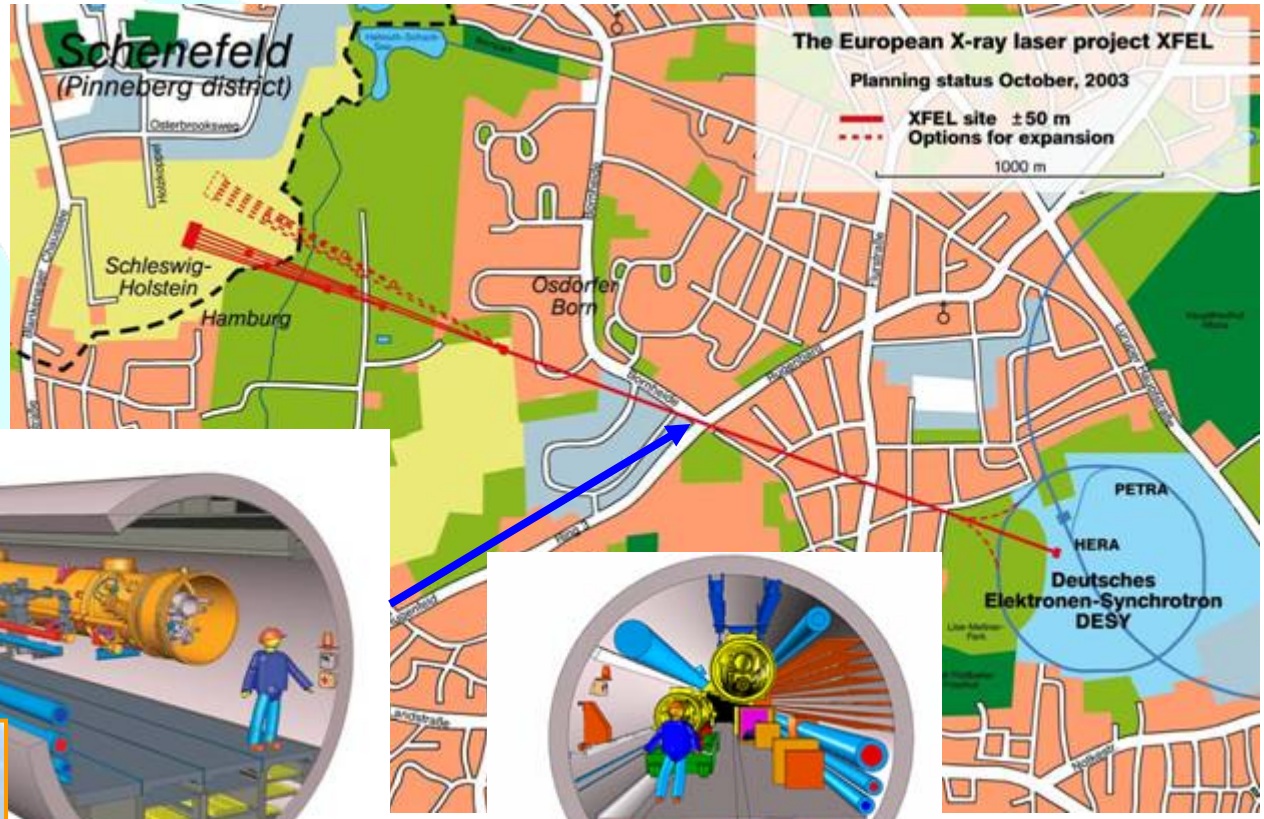


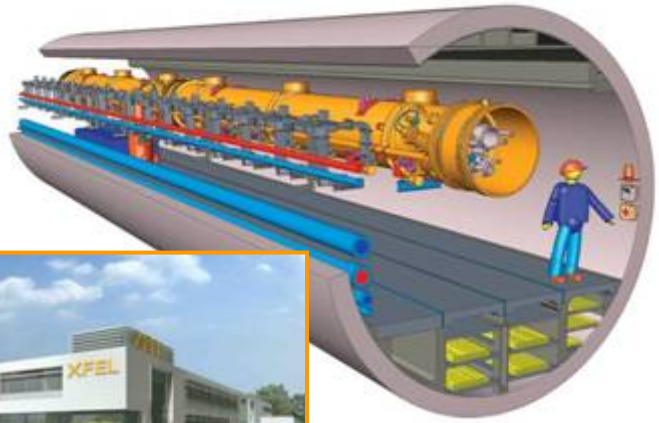
FLASH II Upgrade



The European XFEL Project

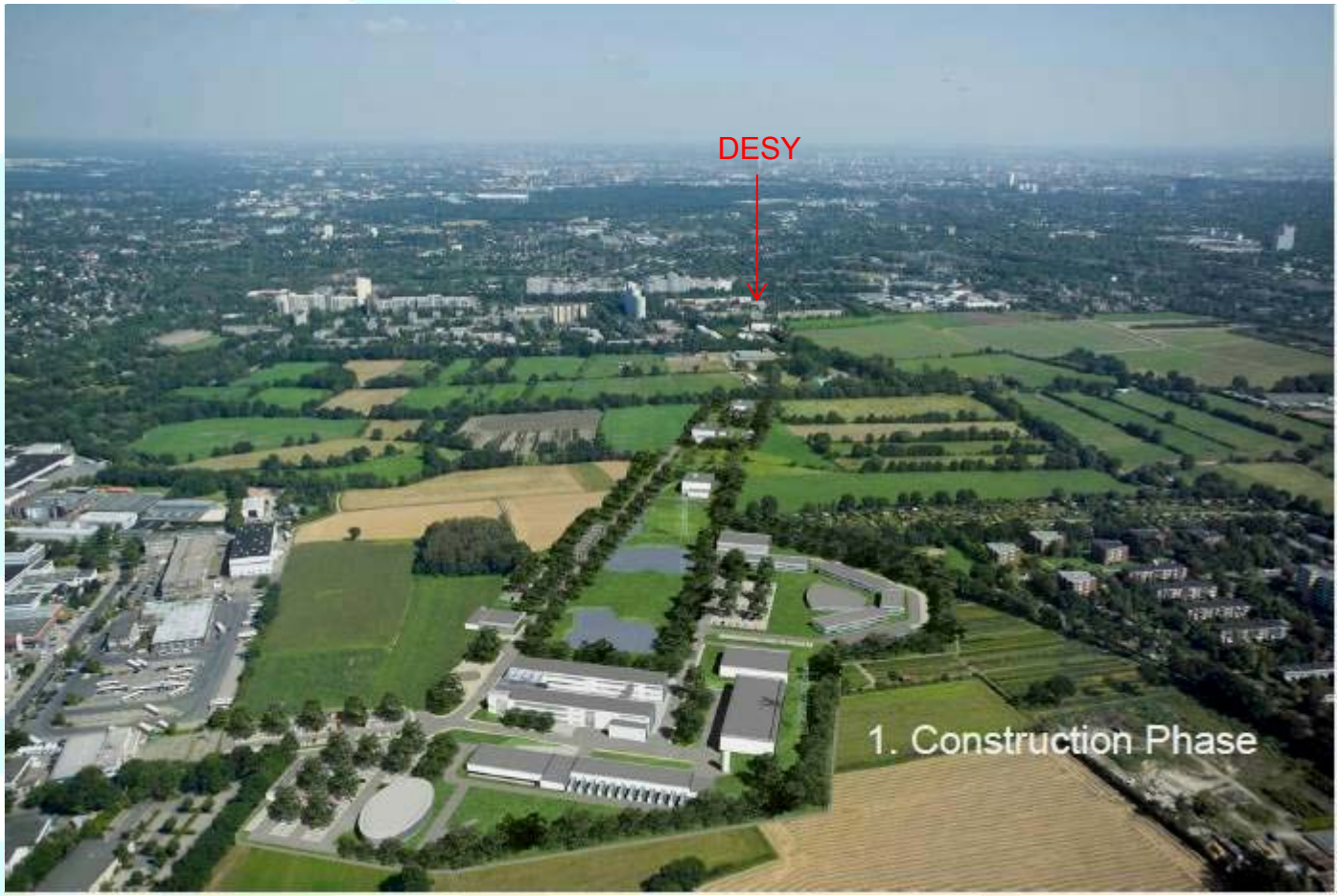






Accelerator.

XFEL Construction

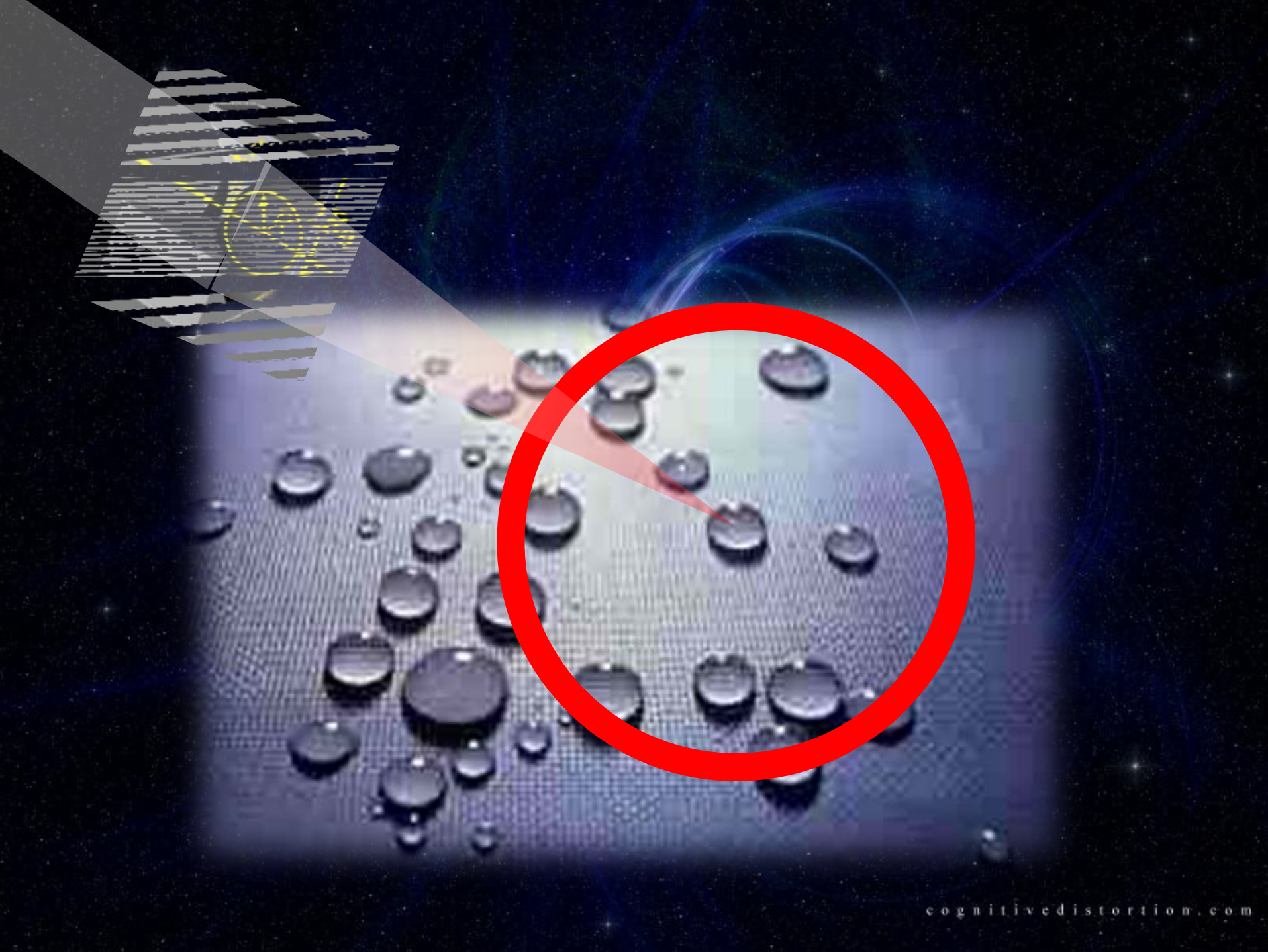


European XFEL
„Baptizing“ the tunnel boring machine
30.6.2010


European
XFEL
DESY


European
XFEL


European
XFEL
DESY


cognitivedistortion.com


Water
XFEL
FLASH

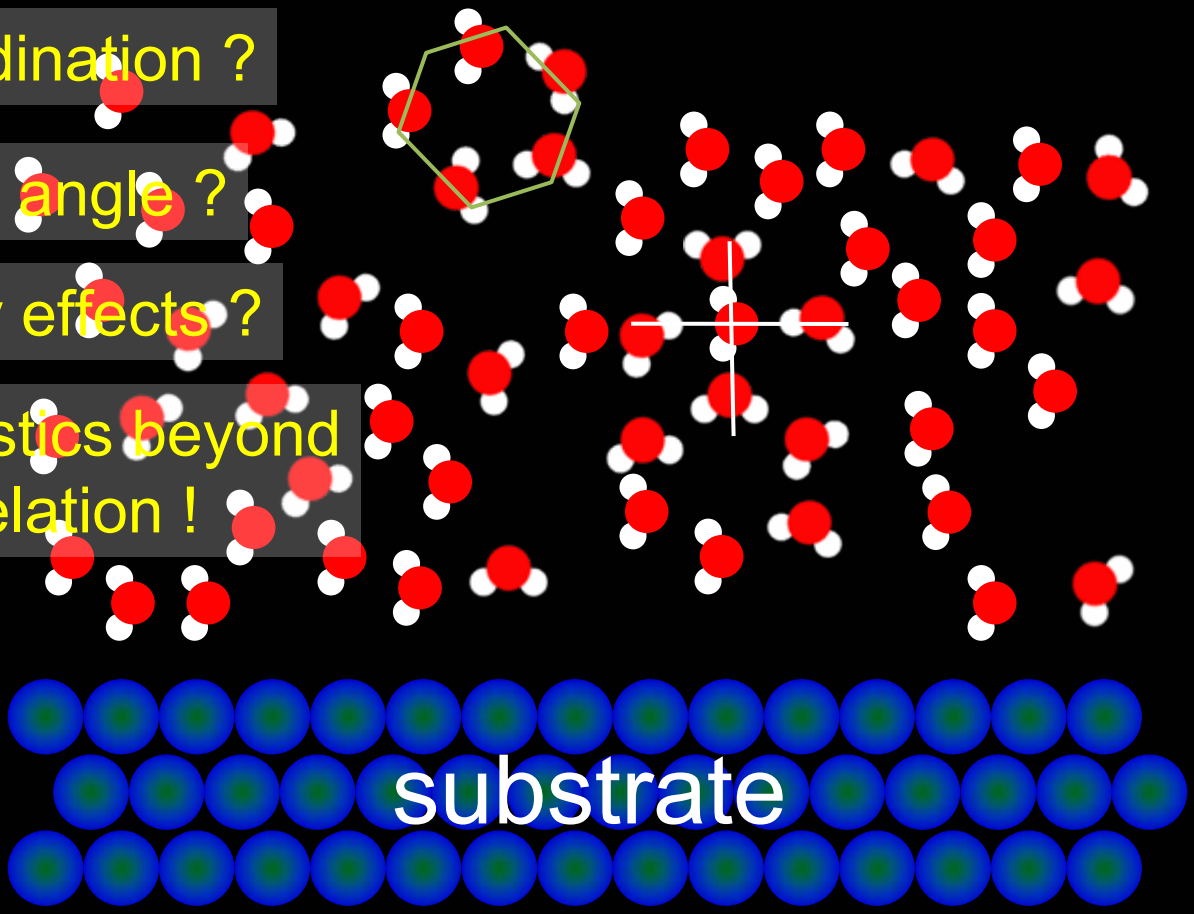
Coherent snapshot diffraction from liquid

Local coordination ?

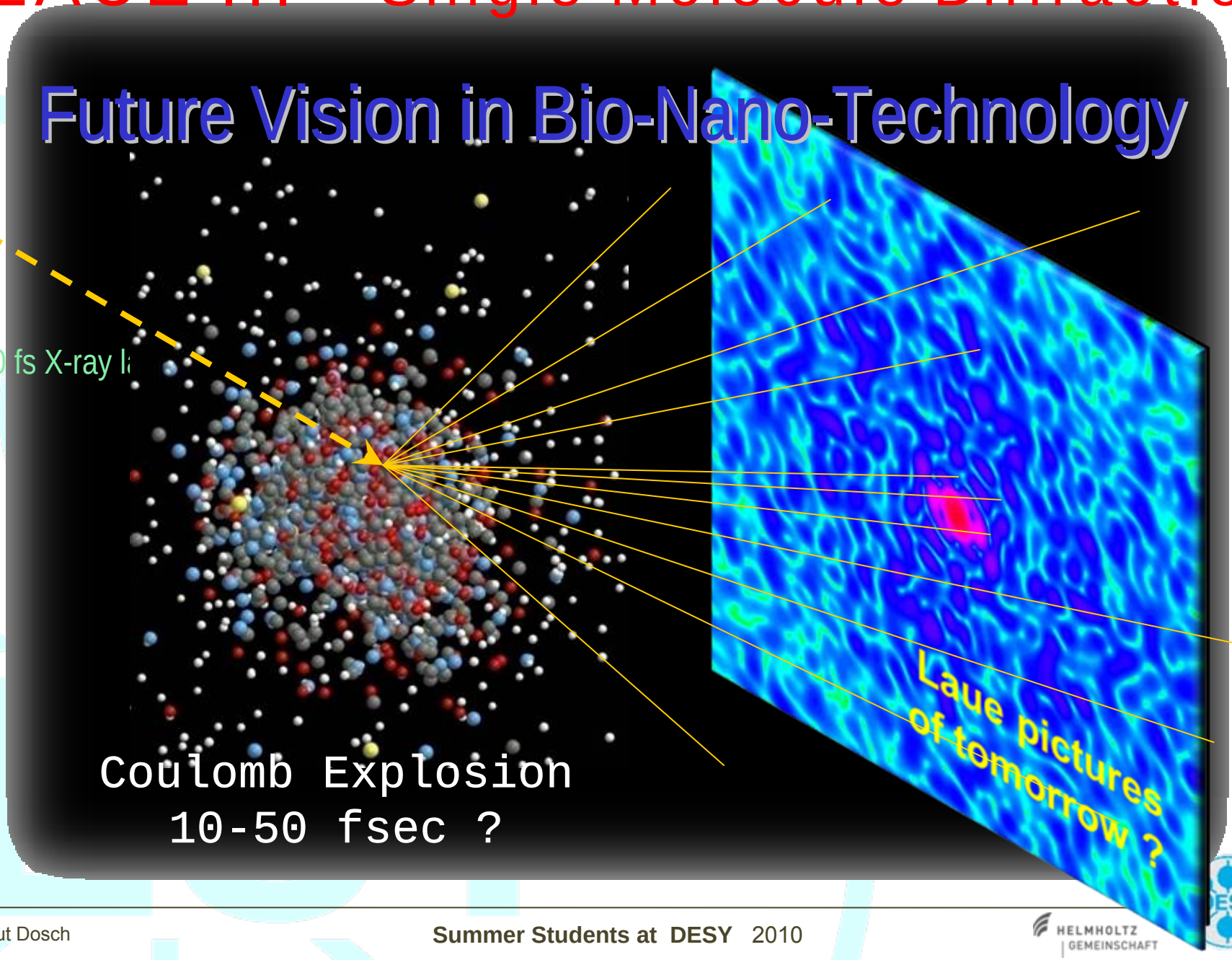
Local bond angle ?

Many-body effects ?

Novel statistics beyond pair correlation !



„LAUE III“ Single Molecule Diffraction



Grand Challenges for Megafacilities

50 Years of DESY

in 2009:

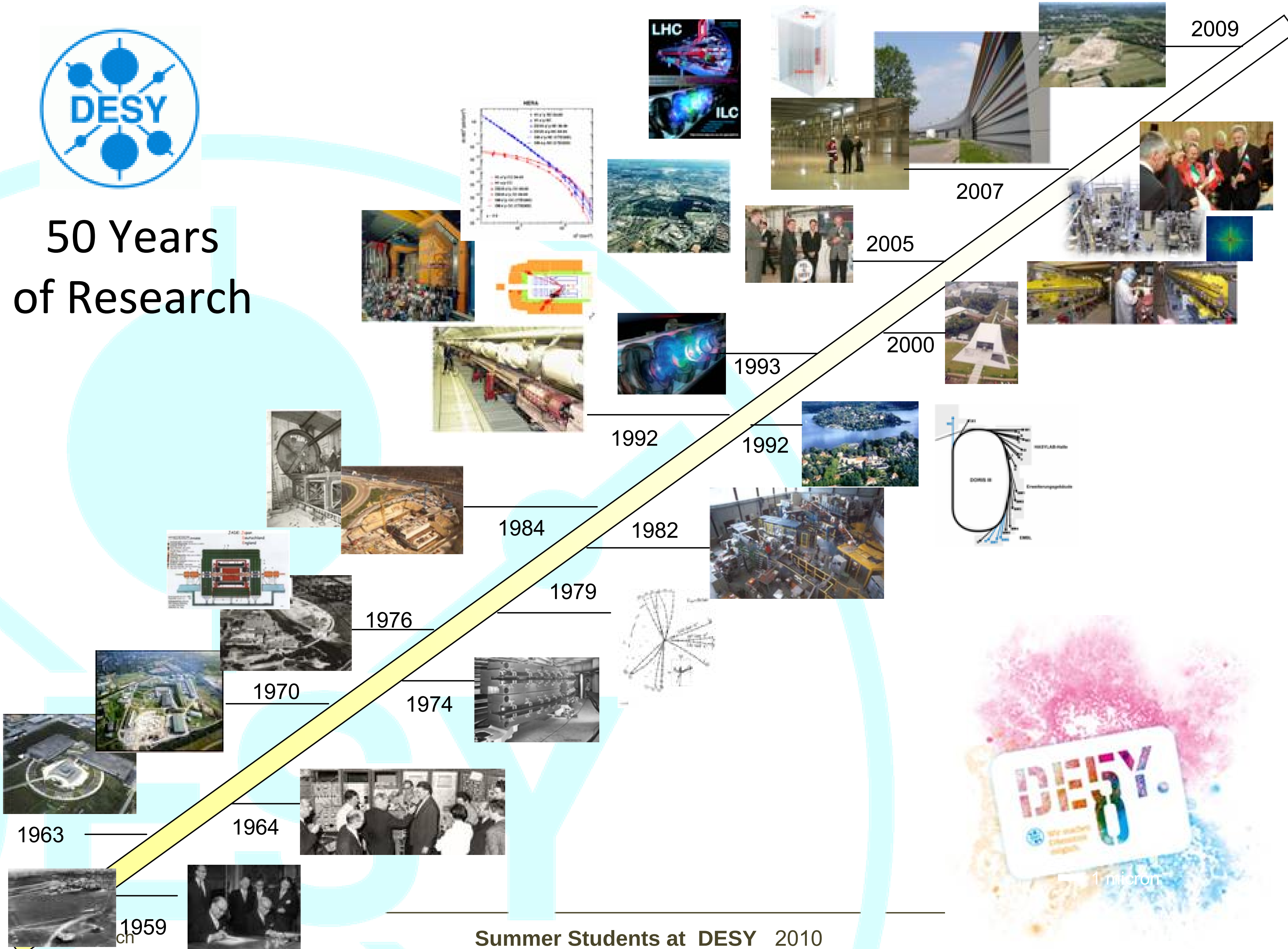
we celebrated 50 years of DESY

First operation of DESY in 1964

Minister Balke Max Brauer

18.12.1959

50 Years of Research



Finally …

Enjoy your stay at DESY
and in Hamburg …