DESY Overview

Welcome Summer Students 2011

Ilja Bohnet (member of the Directorate's Office)
on behalf of Helmut Dosch, Chair of the Board of Directors of DESY

DESY.

Deutsches Elektronen-Synchrotron DESY
- 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

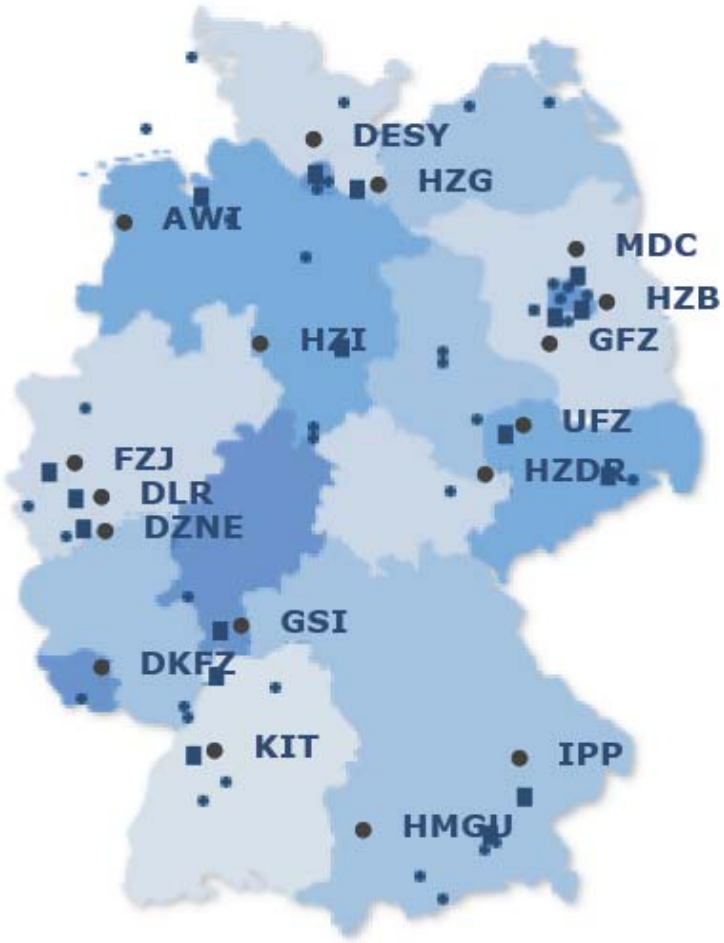
Base-Budget:	185 MEuro
Funding source:	90% federal, 10% state
Staff:	~1600 FTE in Hamburg and Zeuthen
Users:	~3000 (1500 from abroad) from 45 nations
	920 in particle physics, 2100 in photon science

DESY.

Hamburg.

Zeuthen.

DESY. Member of the Helmholtz Association



Research Centres: 17

Employees: ~ 24 000

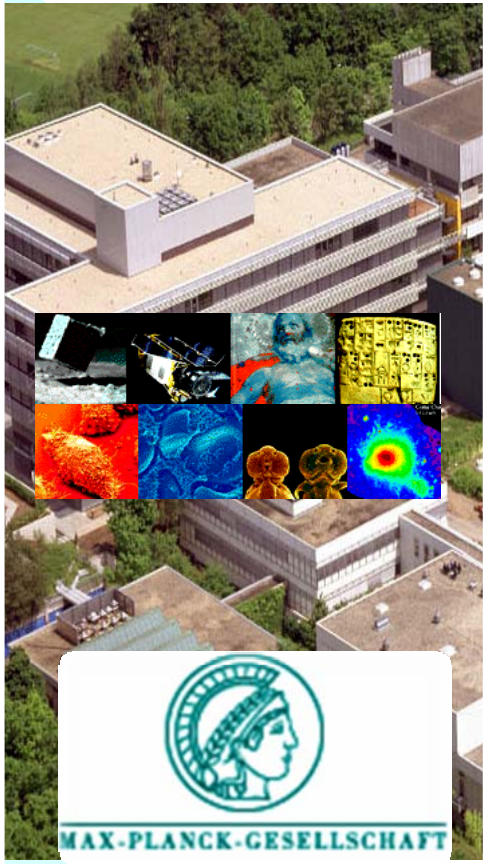
Budget ~ 2.400 Mio Euro

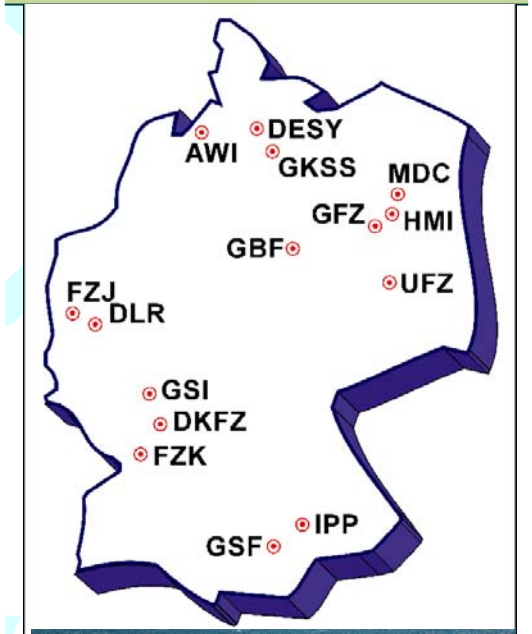
Research Fields:

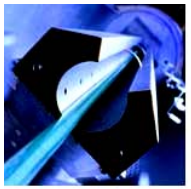
- Health
- Energy
- Earth and Environment
- Key Technologies
- → Structure of Matter
- Traffic and Space

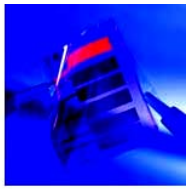
Research Landscape Germany

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**

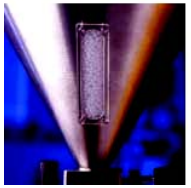


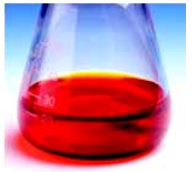






Your Pioneers in Polymers.





50 Years of DESY

in 2009:

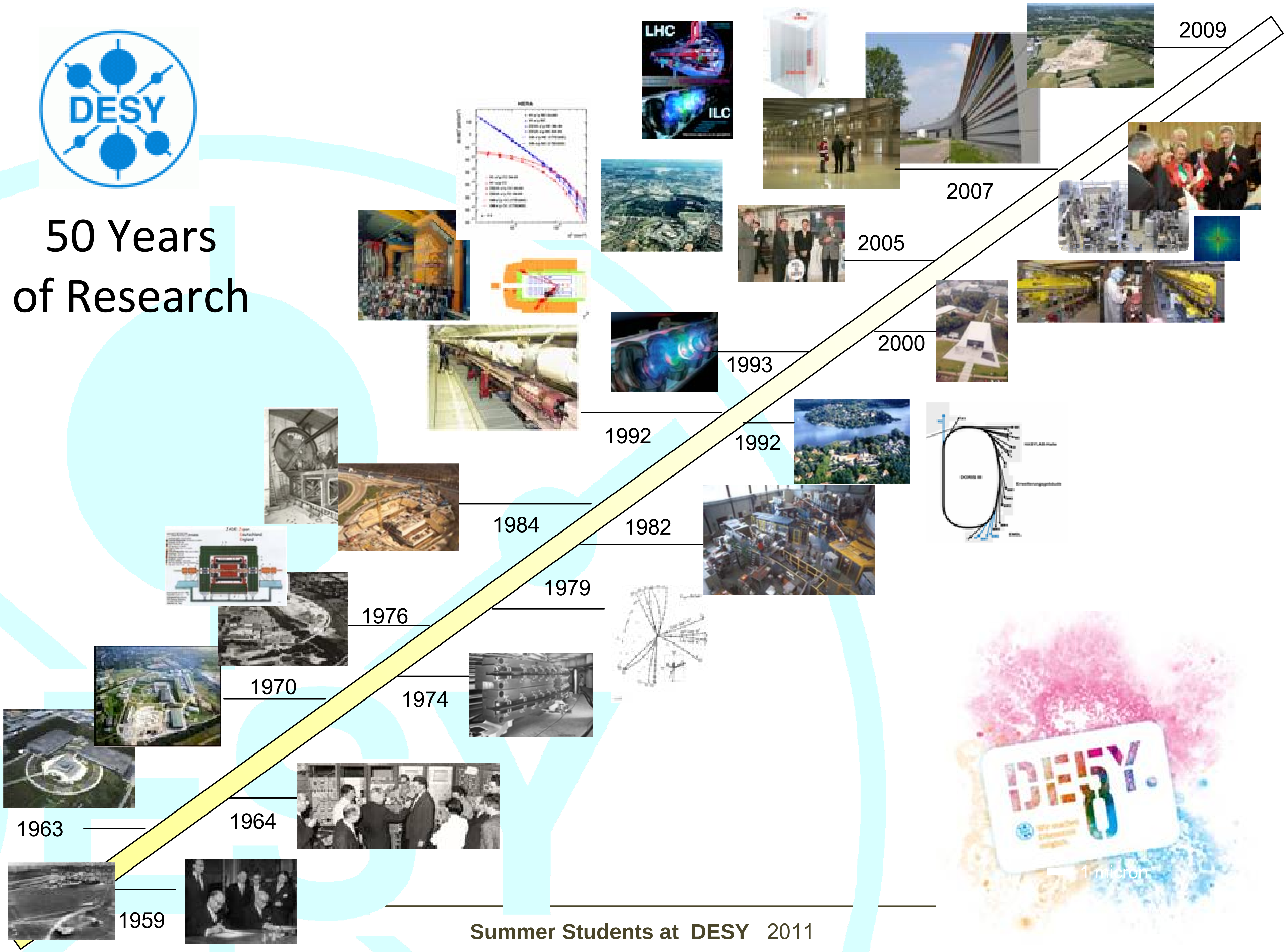
we celebrated 50 years of DESY

First operation of DESY in 1964

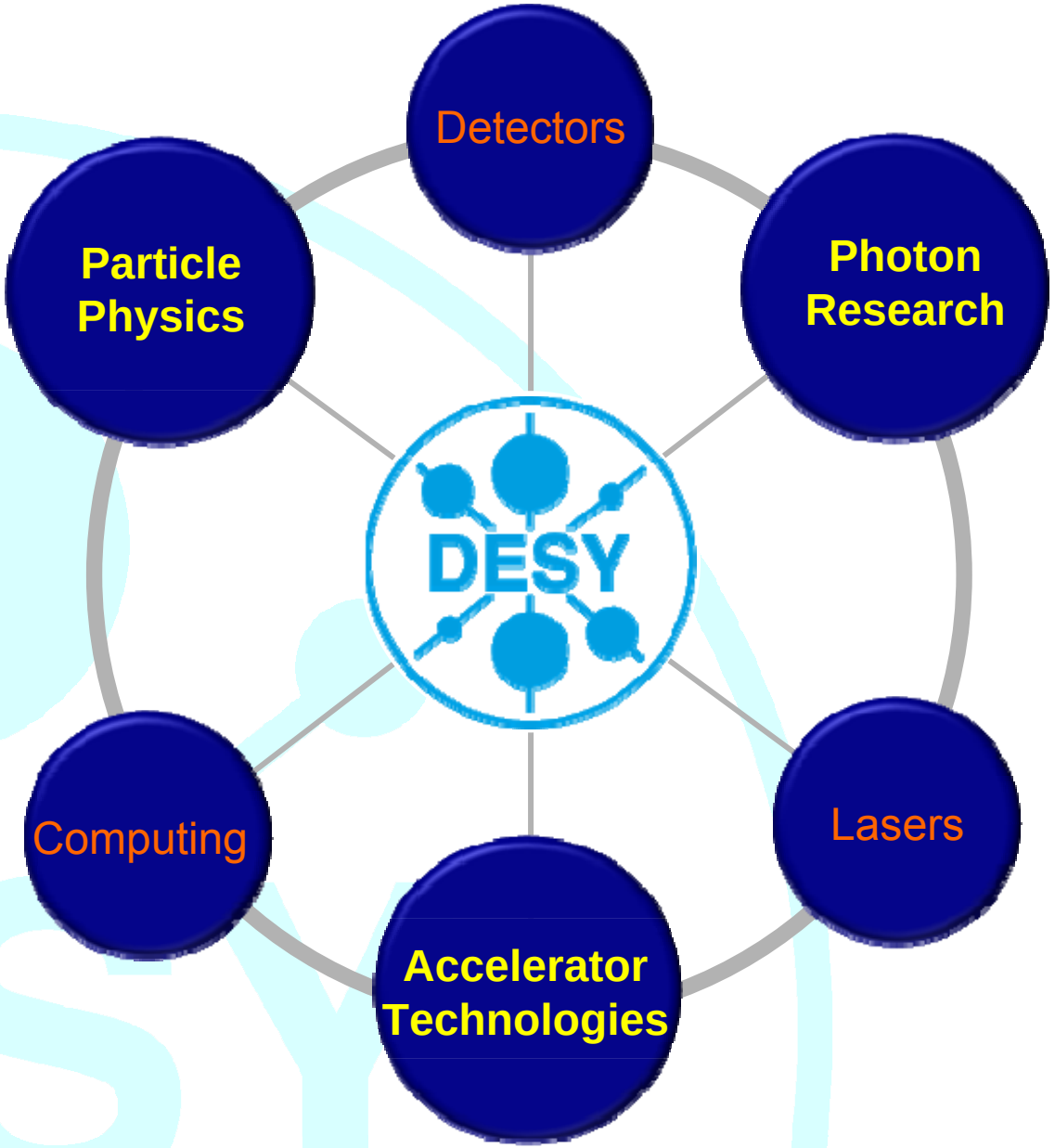
Minister Balke Max Brauer

18.12.1959

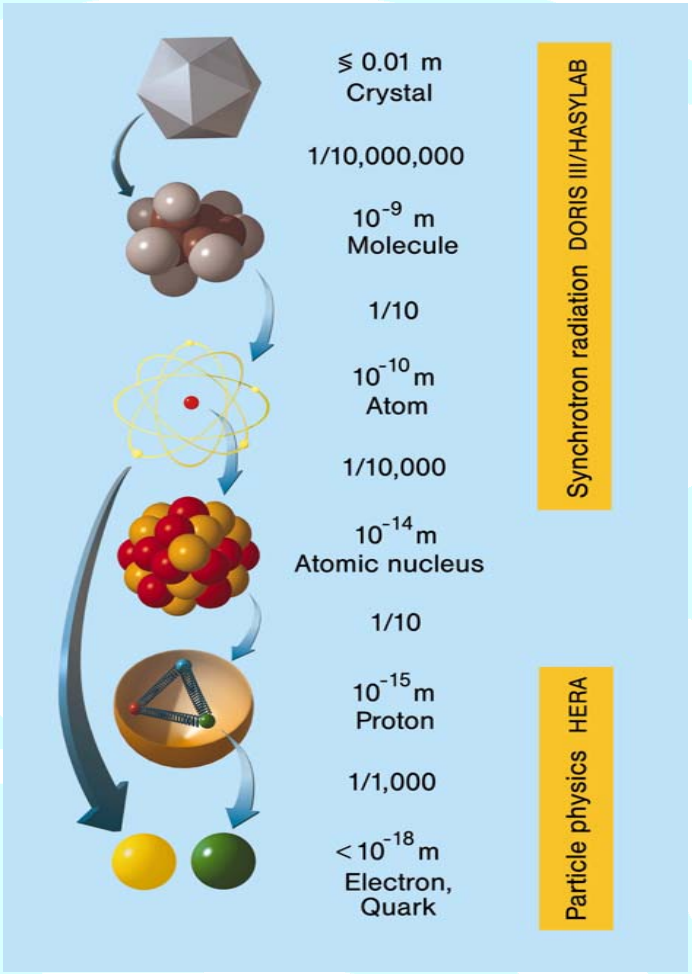
50 Years of Research



DESY Core Competence.



Key question – what is the structure of matter?



Synchrotron Radiation

- Study of the structure of matter from macroscopic to atomic scale

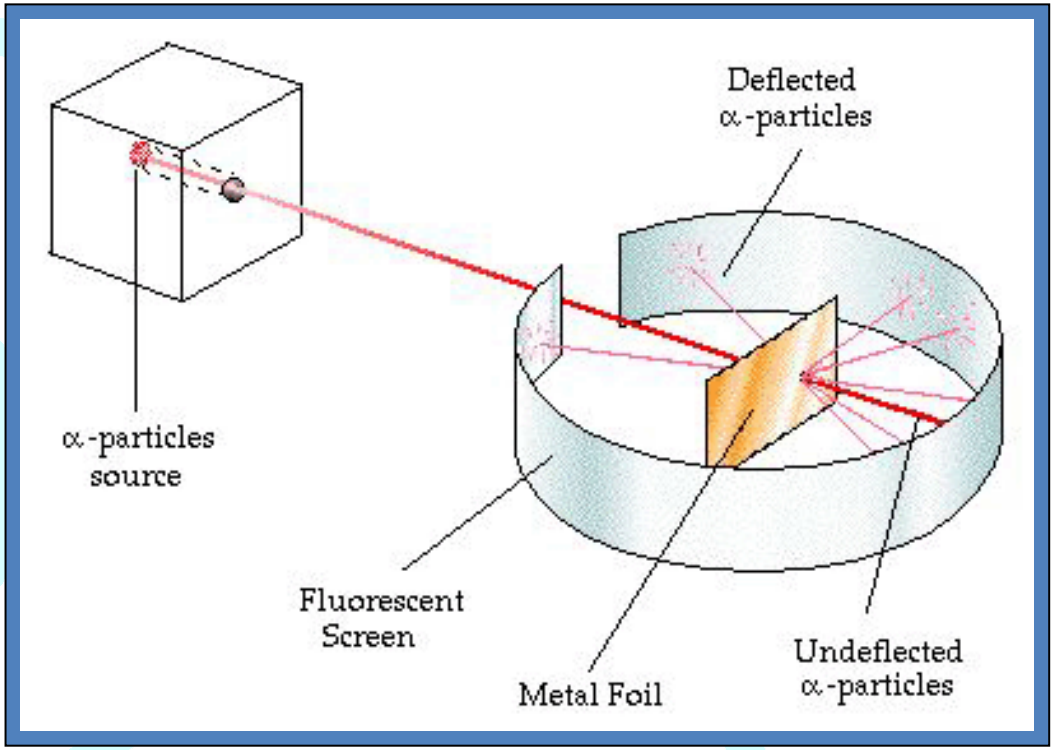
Elementary Particle Physics

- Structure of elementary particles and forces
- Astro-particle physics with neutrinos (IceCube at the South Pole)

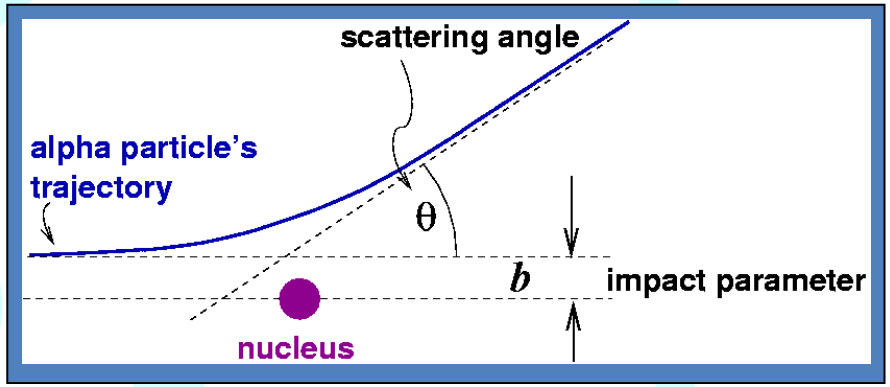
Principle – the scattering experiment.

Rutherford (1911)

and Geiger/Marsden

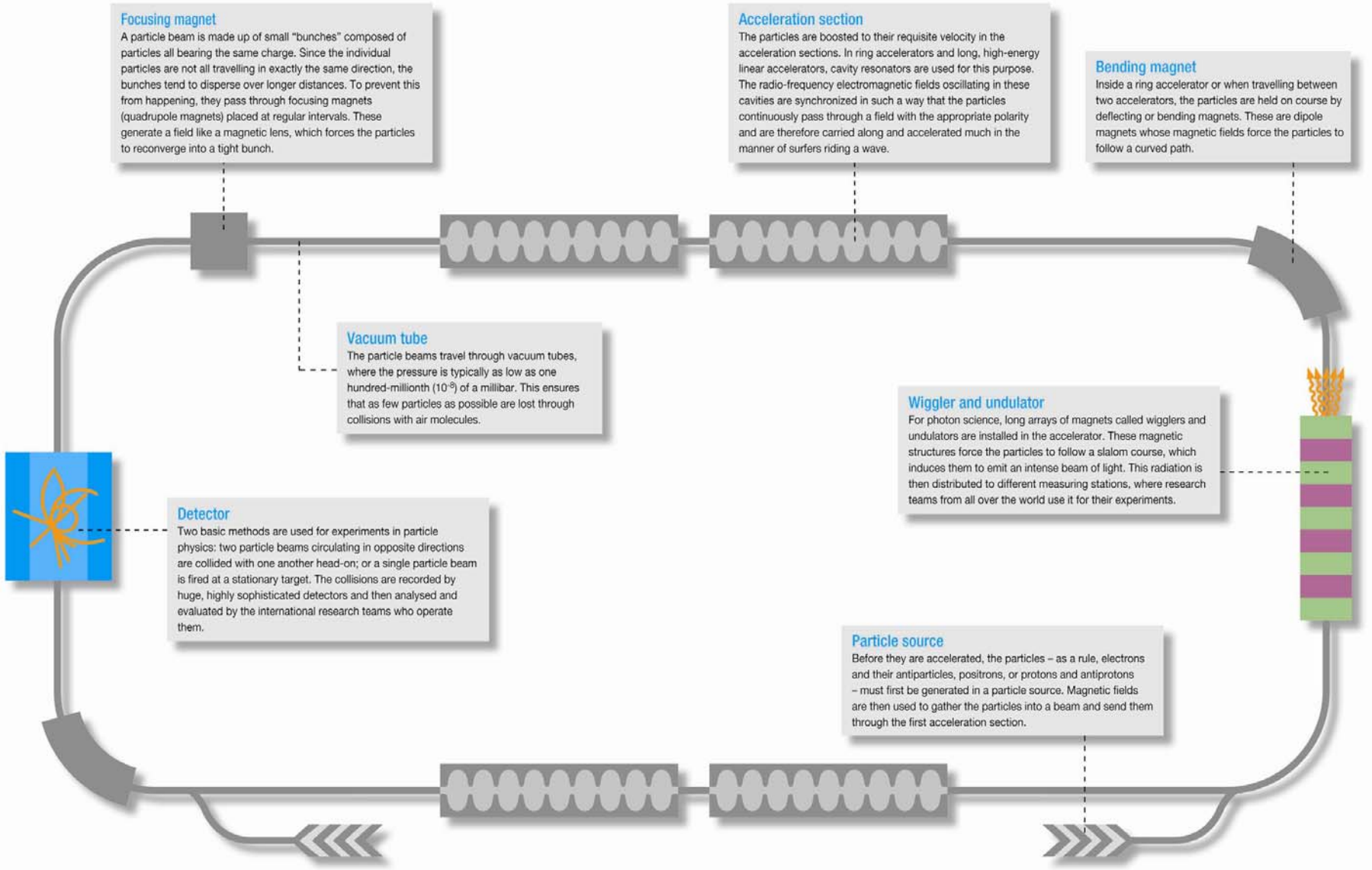


Source:
http://www.wiredchemist.com



Source:
http://www.pha.jhu.edu

Principle of a particle accelerator



Focusing magnet
A particle beam is made up of small "bunches" composed of particles all bearing the same charge. Since the individual particles are not all travelling in exactly the same direction, the bunches tend to disperse over longer distances. To prevent this from happening, they pass through focusing magnets (quadrupole magnets) placed at regular intervals. These generate a field like a magnetic lens, which forces the particles to reconverge into a tight bunch.

Acceleration section
The particles are boosted to their requisite velocity in the acceleration sections. In ring accelerators and long, high-energy linear accelerators, cavity resonators are used for this purpose. The radio-frequency electromagnetic fields oscillating in these cavities are synchronized in such a way that the particles continuously pass through a field with the appropriate polarity and are therefore carried along and accelerated much in the manner of surfers riding a wave.

Bending magnet
Inside a ring accelerator or when travelling between two accelerators, the particles are held on course by deflecting or bending magnets. These are dipole magnets whose magnetic fields force the particles to follow a curved path.

Vacuum tube
The particle beams travel through vacuum tubes, where the pressure is typically as low as one hundred-millionth (10^{-8}) of a millibar. This ensures that as few particles as possible are lost through collisions with air molecules.

Wiggler and undulator
For photon science, long arrays of magnets called wigglers and undulators are installed in the accelerator. These magnetic structures force the particles to follow a slalom course, which induces them to emit an intense beam of light. This radiation is then distributed to different measuring stations, where research teams from all over the world use it for their experiments.

Detector
Two basic methods are used for experiments in particle physics: two particle beams circulating in opposite directions are collided with one another head-on; or a single particle beam is fired at a stationary target. The collisions are recorded by huge, highly sophisticated detectors and then analysed and evaluated by the international research teams who operate them.

Particle source
Before they are accelerated, the particles – as a rule, electrons and their antiparticles, positrons, or protons and antiprotons – must first be generated in a particle source. Magnetic fields are then used to gather the particles into a beam and send them through the first acceleration section.

Beschleuniger bei DESY.

Die wichtigsten Anlagen

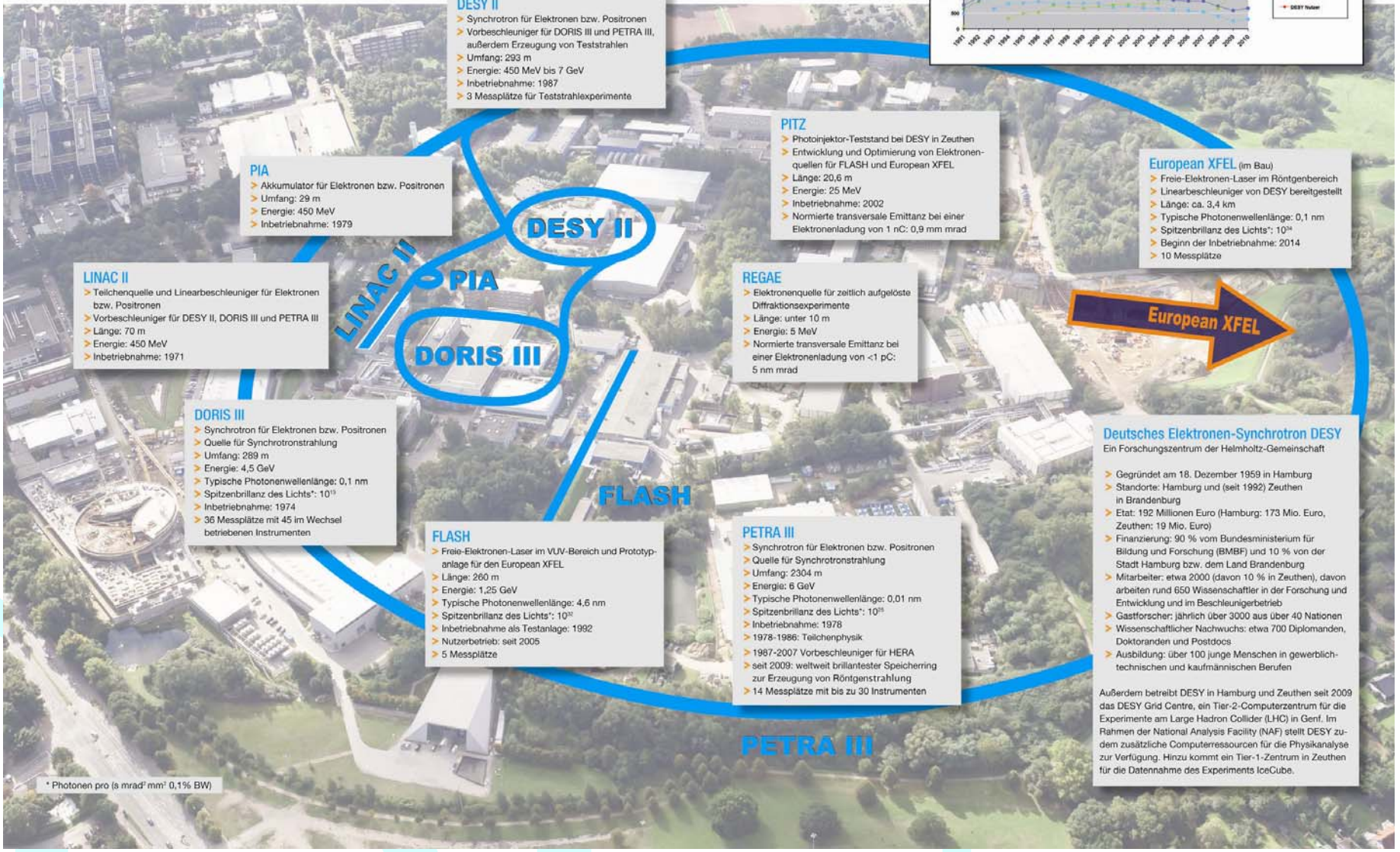
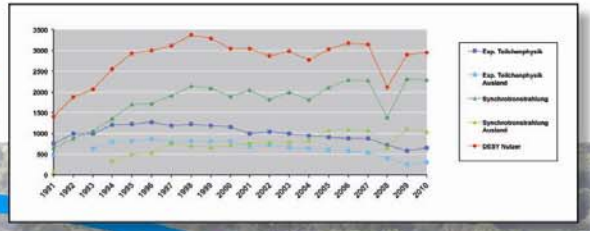


Abbildung 1
Externe Nutzer der DESY-Anlagen



DESY II
- Synchrotron für Elektronen bzw. Positronen
- Vorbeschleuniger für DORIS III und PETRA III, außerdem Erzeugung von Teststrahlen
- Umfang: 293 m
- Energie: 450 MeV bis 7 GeV
- Inbetriebnahme: 1987
- 3 Messplätze für Teststrahlexperimente

PIA
- Akkumulator für Elektronen bzw. Positronen
- Umfang: 29 m
- Energie: 450 MeV
- Inbetriebnahme: 1979

LINAC II
- Teilchenquelle und Linearbeschleuniger für Elektronen bzw. Positronen
- Vorbeschleuniger für DESY II, DORIS III und PETRA III
- Länge: 70 m
- Energie: 450 MeV
- Inbetriebnahme: 1971

DORIS III
- Synchrotron für Elektronen bzw. Positronen
- Quelle für Synchrotronstrahlung
- Umfang: 289 m
- Energie: 4,5 GeV
- Typische Photonenwellenlänge: 0,1 nm
- Spitzenbrillanz des Lichts*: 10^{13}
- Inbetriebnahme: 1974
- 36 Messplätze mit 45 im Wechsel betriebenen Instrumenten

FLASH
- Freie-Elektronen-Laser im VUV-Bereich und Prototypanlage für den European XFEL
- Länge: 260 m
- Energie: 1,25 GeV
- Typische Photonenwellenlänge: 4,6 nm
- Spitzenbrillanz des Lichts*: 10^{32}
- Inbetriebnahme als Testanlage: 1992
- Nutzerbetrieb: seit 2005
- 5 Messplätze

PETRA III
- Synchrotron für Elektronen bzw. Positronen
- Quelle für Synchrotronstrahlung
- Umfang: 2304 m
- Energie: 6 GeV
- Typische Photonenwellenlänge: 0,01 nm
- Spitzenbrillanz des Lichts*: 10^{35}
- Inbetriebnahme: 1978
- 1978-1986: Teilchenphysik
- 1987-2007 Vorbeschleuniger für HERA
- seit 2009: weltweit brillantester Speicherring zur Erzeugung von Röntgenstrahlung
- 14 Messplätze mit bis zu 30 Instrumenten

PITZ
- Photoinjektor-Teststand bei DESY in Zeuthen
- Entwicklung und Optimierung von Elektronenquellen für FLASH und European XFEL
- Länge: 20,6 m
- Energie: 25 MeV
- Inbetriebnahme: 2002
- Normierte transversale Emittanz bei einer Elektronenladung von 1 nC: 0,9 mm mrad

REGAE
- Elektronenquelle für zeitlich aufgelöste Diffraktionsexperimente
- Länge: unter 10 m
- Energie: 5 MeV
- Normierte transversale Emittanz bei einer Elektronenladung von <1 pC: 5 nm mrad

European XFEL (im Bau)
- Freie-Elektronen-Laser im Röntgenbereich
- Linearbeschleuniger von DESY bereitgestellt
- Länge: ca. 3,4 km
- Typische Photonenwellenlänge: 0,1 nm
- Spitzenbrillanz des Lichts*: 10^{34}
- Beginn der Inbetriebnahme: 2014
- 10 Messplätze

* Photonen pro (s mrad² mm² 0,1% BW)

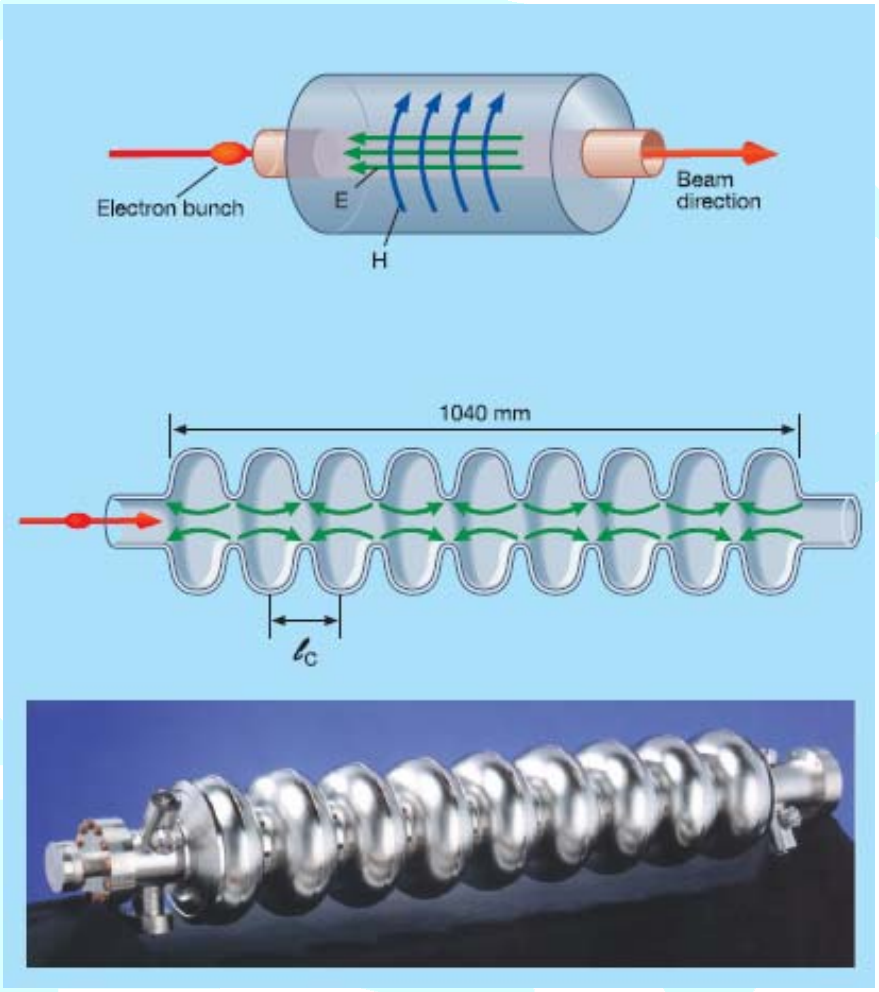
Deutsches Elektronen-Synchrotron DESY

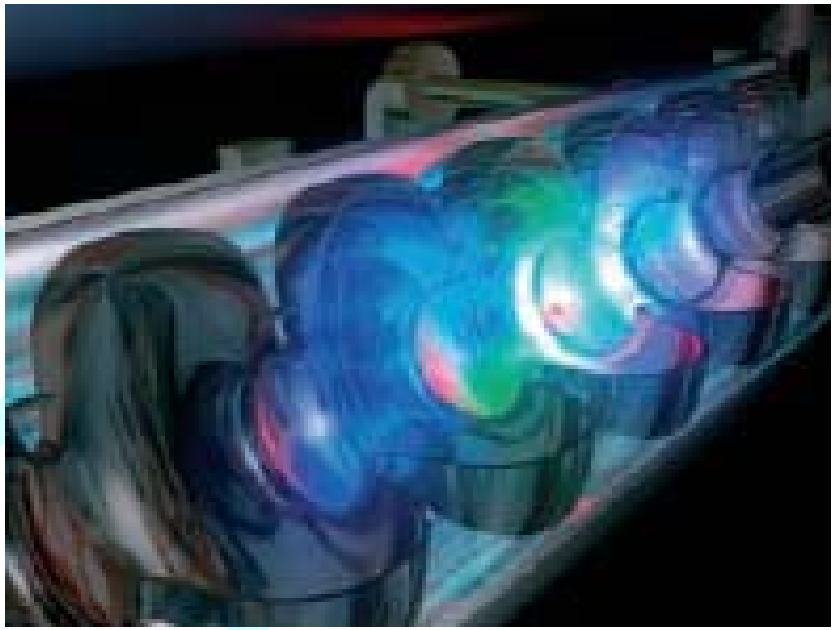
Ein Forschungszentrum der Helmholtz-Gemeinschaft

- Gegründet am 18. Dezember 1959 in Hamburg
- Standorte: Hamburg und (seit 1992) Zeuthen in Brandenburg
- Etat: 192 Millionen Euro (Hamburg: 173 Mio. Euro, Zeuthen: 19 Mio. Euro)
- Finanzierung: 90 % vom Bundesministerium für Bildung und Forschung (BMBF) und 10 % von der Stadt Hamburg bzw. dem Land Brandenburg
- Mitarbeiter: etwa 2000 (davon 10 % in Zeuthen), davon arbeiten rund 650 Wissenschaftler in der Forschung und Entwicklung und im Beschleunigerbetrieb
- Gastforscher: jährlich über 3000 aus über 40 Nationen
- Wissenschaftlicher Nachwuchs: etwa 700 Diplomanden, Doktoranden und Postdocs
- Ausbildung: über 100 junge Menschen in gewerblich-technischen und kaufmännischen Berufen

Außerdem betreibt DESY in Hamburg und Zeuthen seit 2009 das DESY Grid Centre, ein Tier-2-Computerzentrum für die Experimente am Large Hadron Collider (LHC) in Genf. Im Rahmen der National Analysis Facility (NAF) stellt DESY zudem zusätzliche Computerressourcen für die Physikanalyse zur Verfügung. Hinzu kommt ein Tier-1-Zentrum in Zeuthen für die Datennahme des Experiments IceCube.

The heart of the accelerator





Niobium

1.9 K

DESY: SCRF Technology

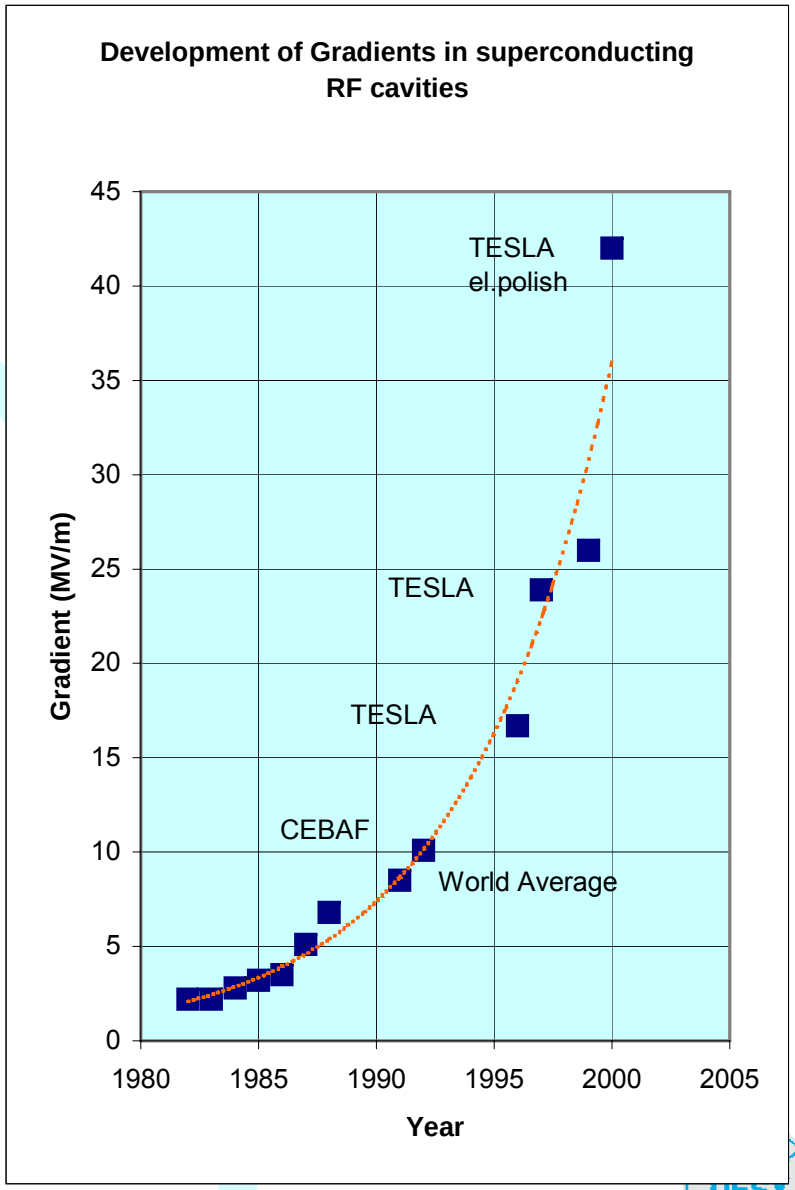
Development of superconducting Resonators

Superconducting RF-structures were developed in many countries

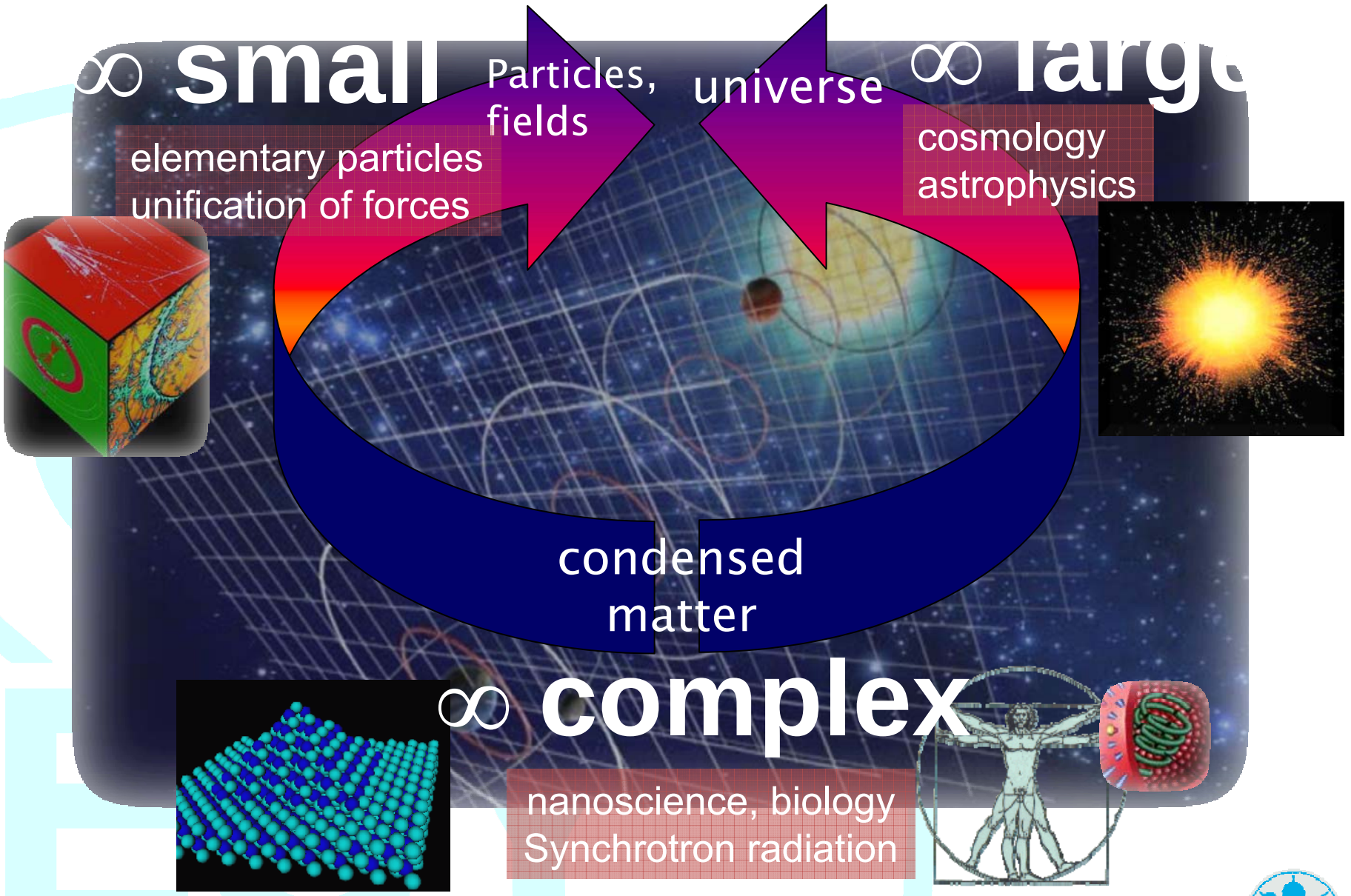
TESLA Collaboration (55 Institutes from 12 countries), centered at DESY, bundled ~ worldwide know-how and achieved signifianct progess:

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

Of large relevance for future accelerators such as XFELs and others

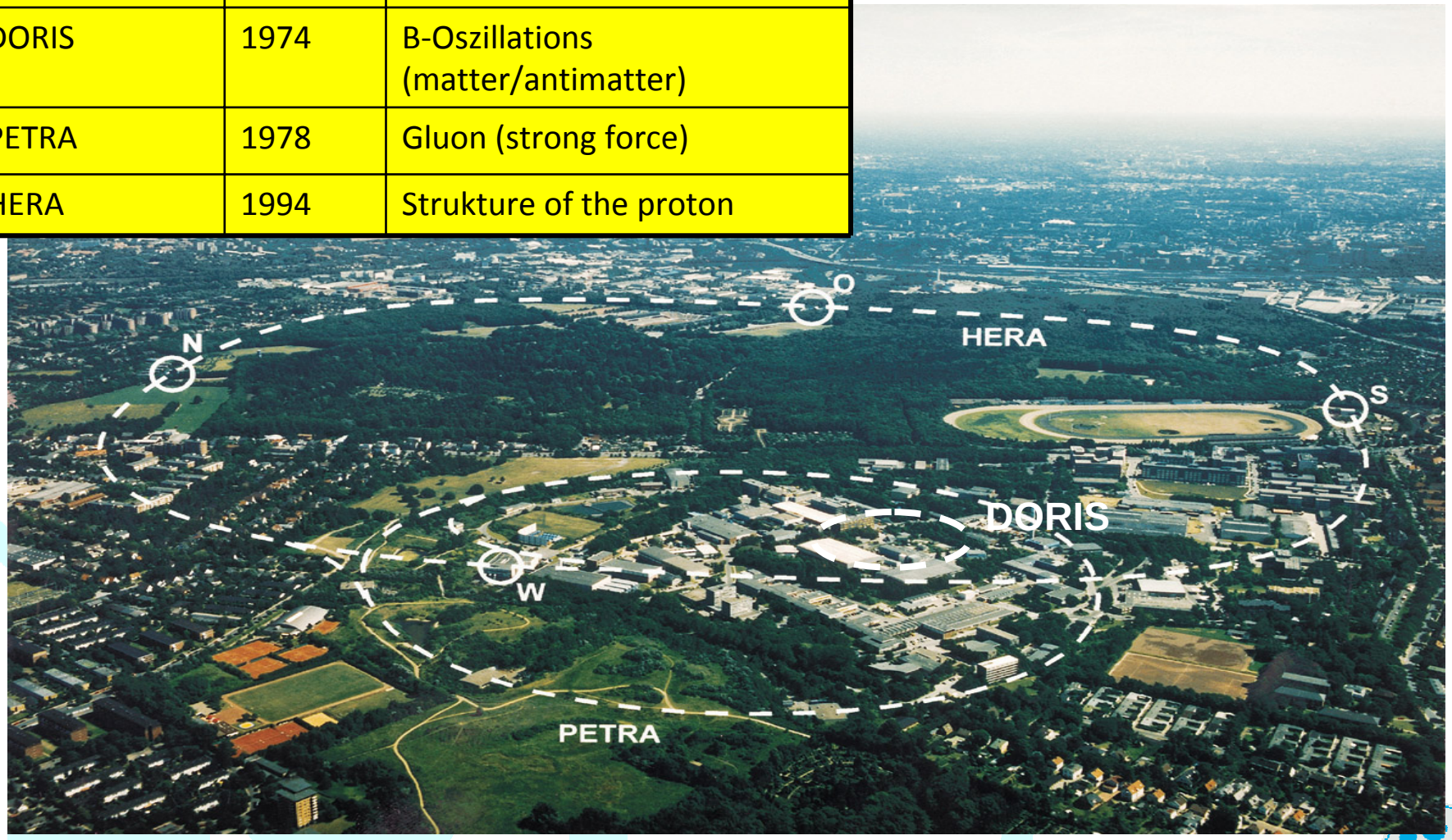


DESY Research.



HEP at DESY

Accelerator	Start	Important Discovery
DESY	1964	Test of QED (photon)
DORIS	1974	B-Oszillations (matter/antimatter)
PETRA	1978	Gluon (strong force)
HERA	1994	Strukture of the proton



Status of the Standard Model

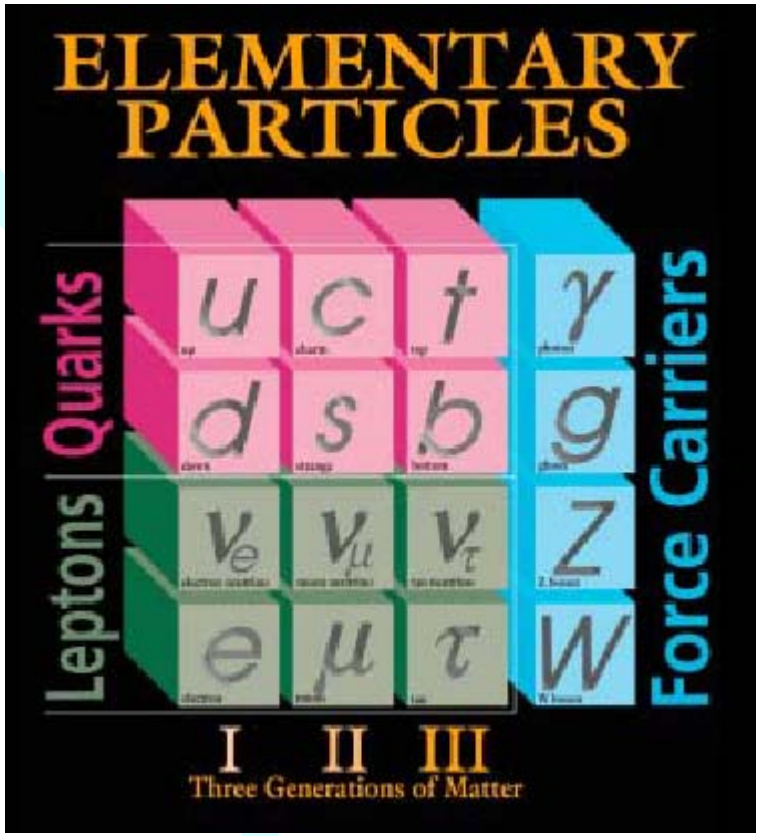
The physical world is

composed of Quarks and Leptons

interacting via force carriers
(Gauge Bosons)

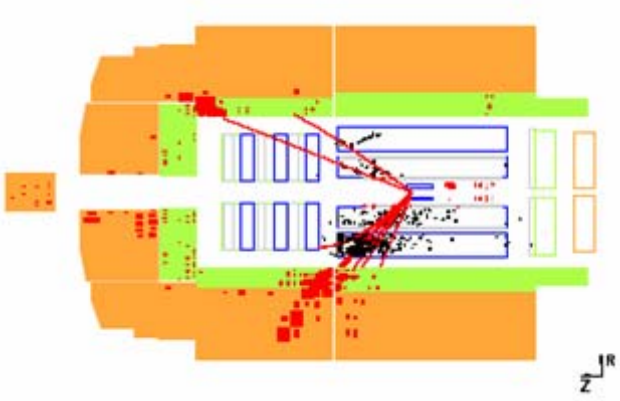
-> The “Standard Model”
has been tested to permille level in many experiments

-> Precise and quantitative description of subatomic physics

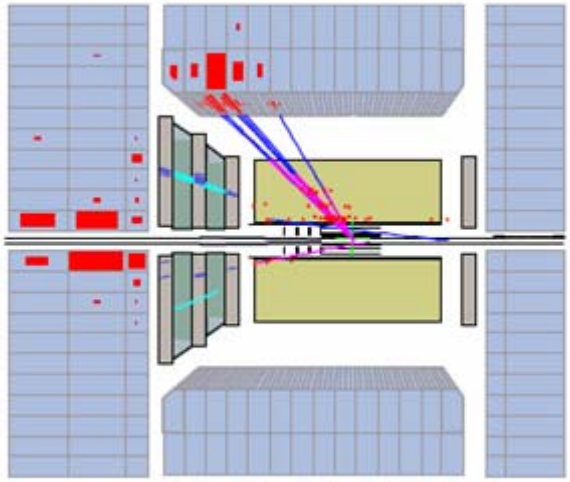


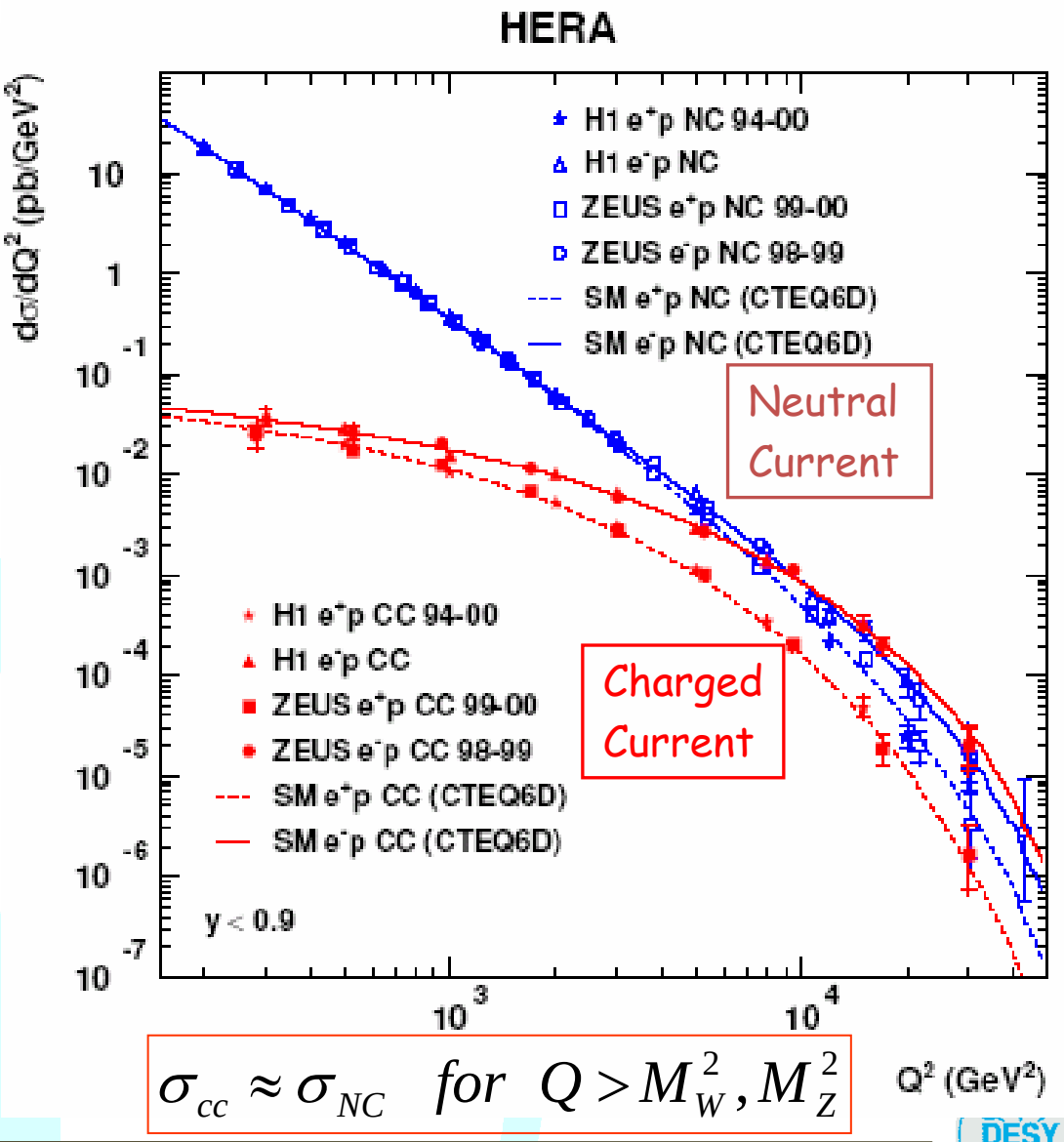
Towards the Unification of Forces

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



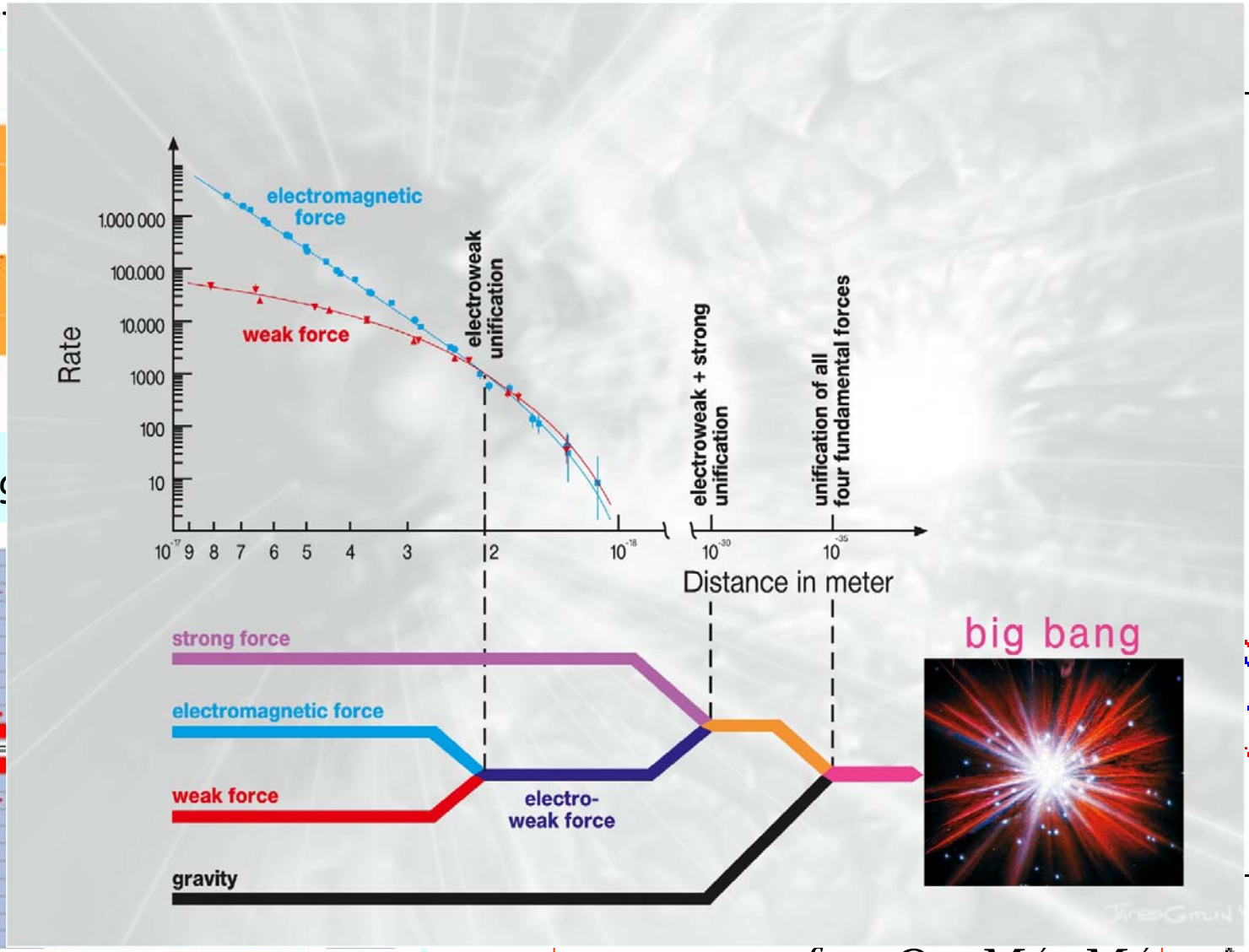
Charged current $e^+ p \to \bar{\nu} X$

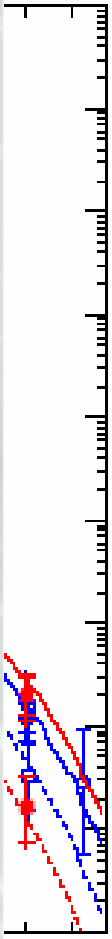




$$\sigma_{cc} \approx \sigma_{NC} \quad for \quad Q > M_W^2, M_Z^2$$

Towards the Unification of Forces



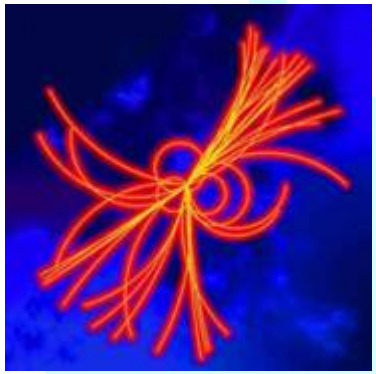


$$\sigma_{cc} \approx \sigma_{NC} \quad for \quad Q > M_W^2, M_Z^2$$

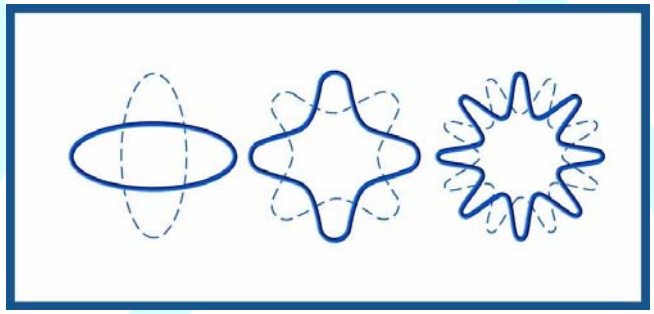
Q^2 (GeV^2)

Particle Physics – open questions

What generates Mass?
Search for the "Higgs".

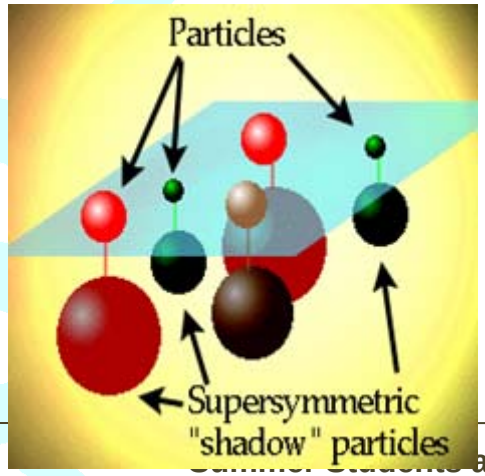


Is the world made out of "Strings"?



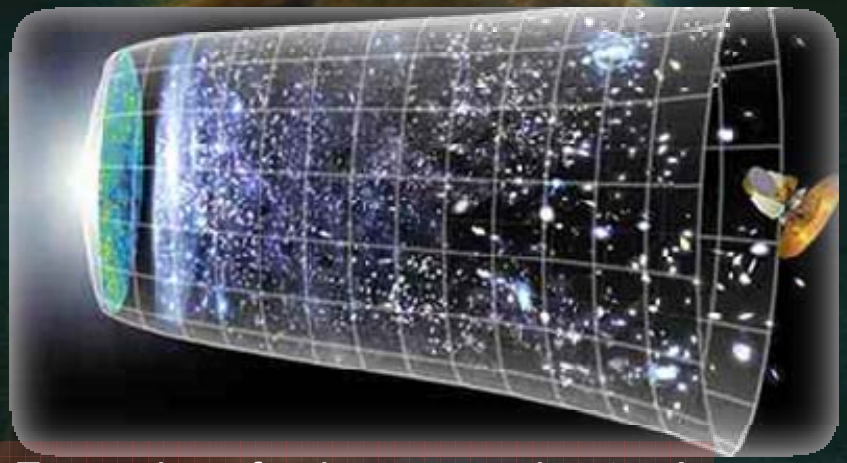
Do we understand the Universe?

Is there a „shadow world" of new particles?

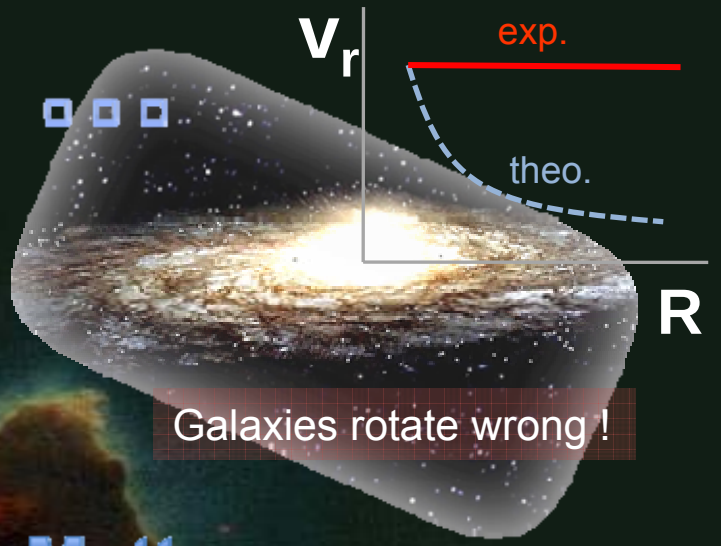


In how many dimensions do we live?

The big puzzle ...



Expansion of universe accelerates !



Galaxies rotate wrong !

The search for nonrelativistic nonbaryonic matter
beyond SM

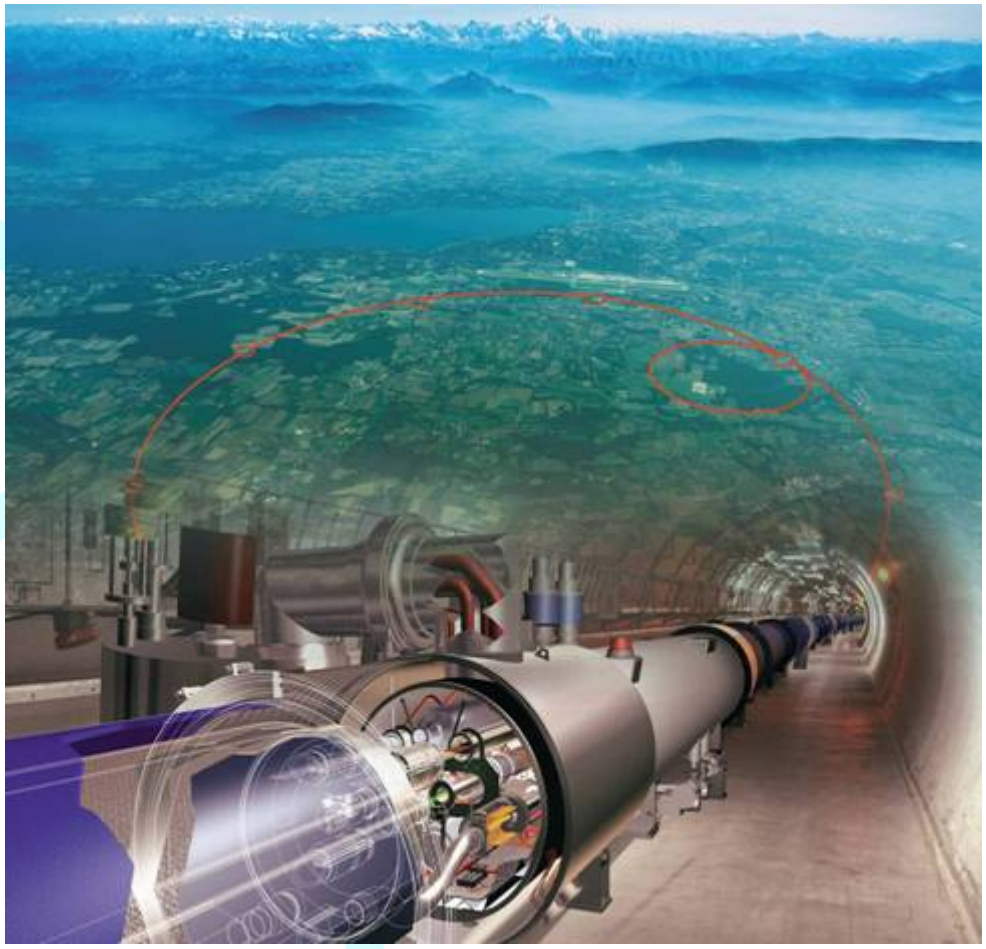
„The biggest mystery of this century“
Science 2003

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

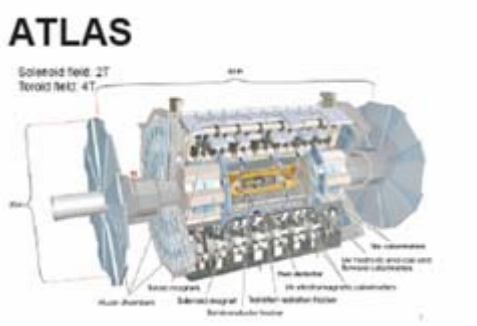
DESY participation at LHC (2010)

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

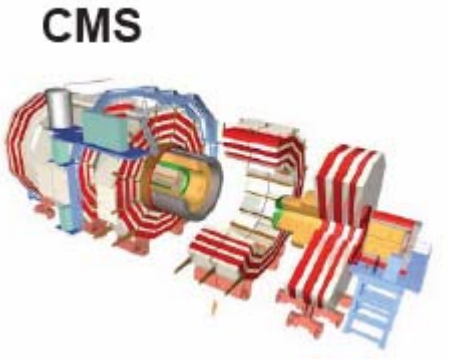


CMS Collaboration:

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

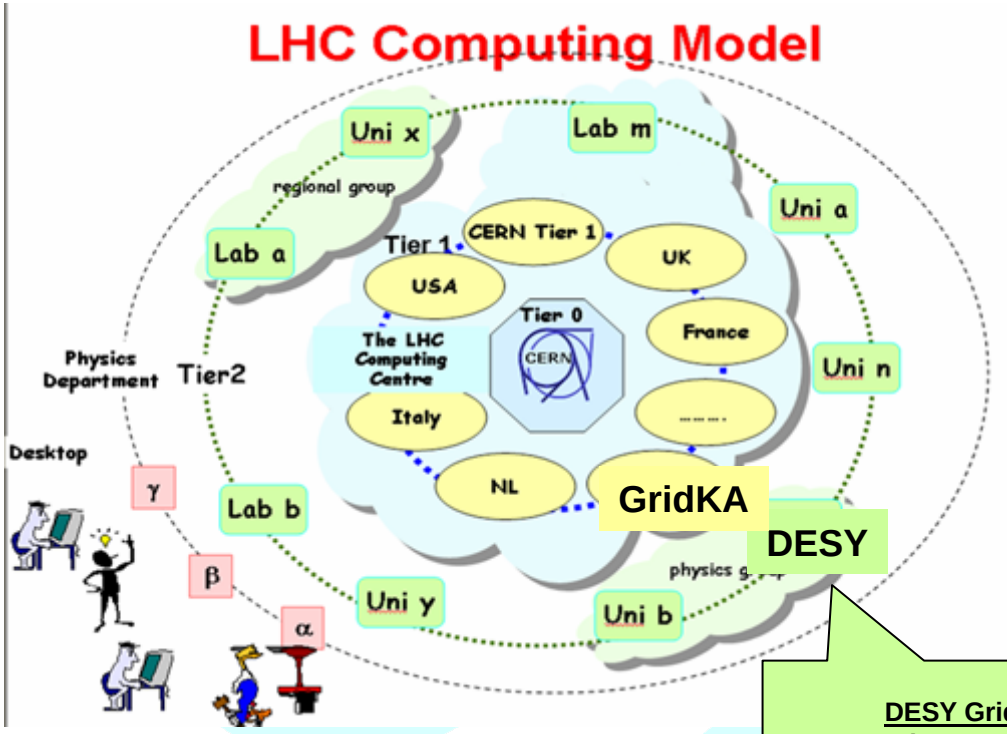
Focus:

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

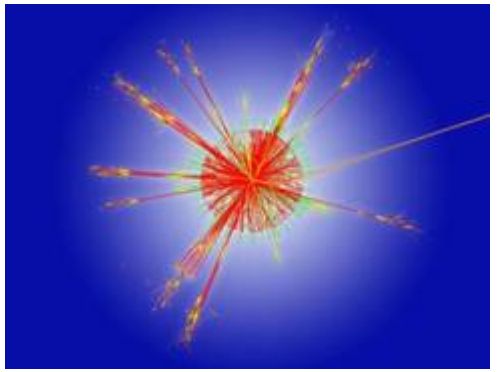


Participation in LHC detector upgrade projects

GRID Computing at DESY

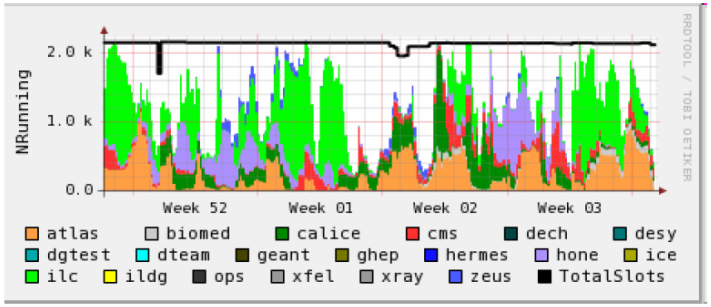


LHC Collisions at 40 MHz, recorded at ~100 Hz
Total RAW data by all LHC experiments:
15 PB/year



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

Jobs at DESY-HH Dec/Jan 2008/09



- 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

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:

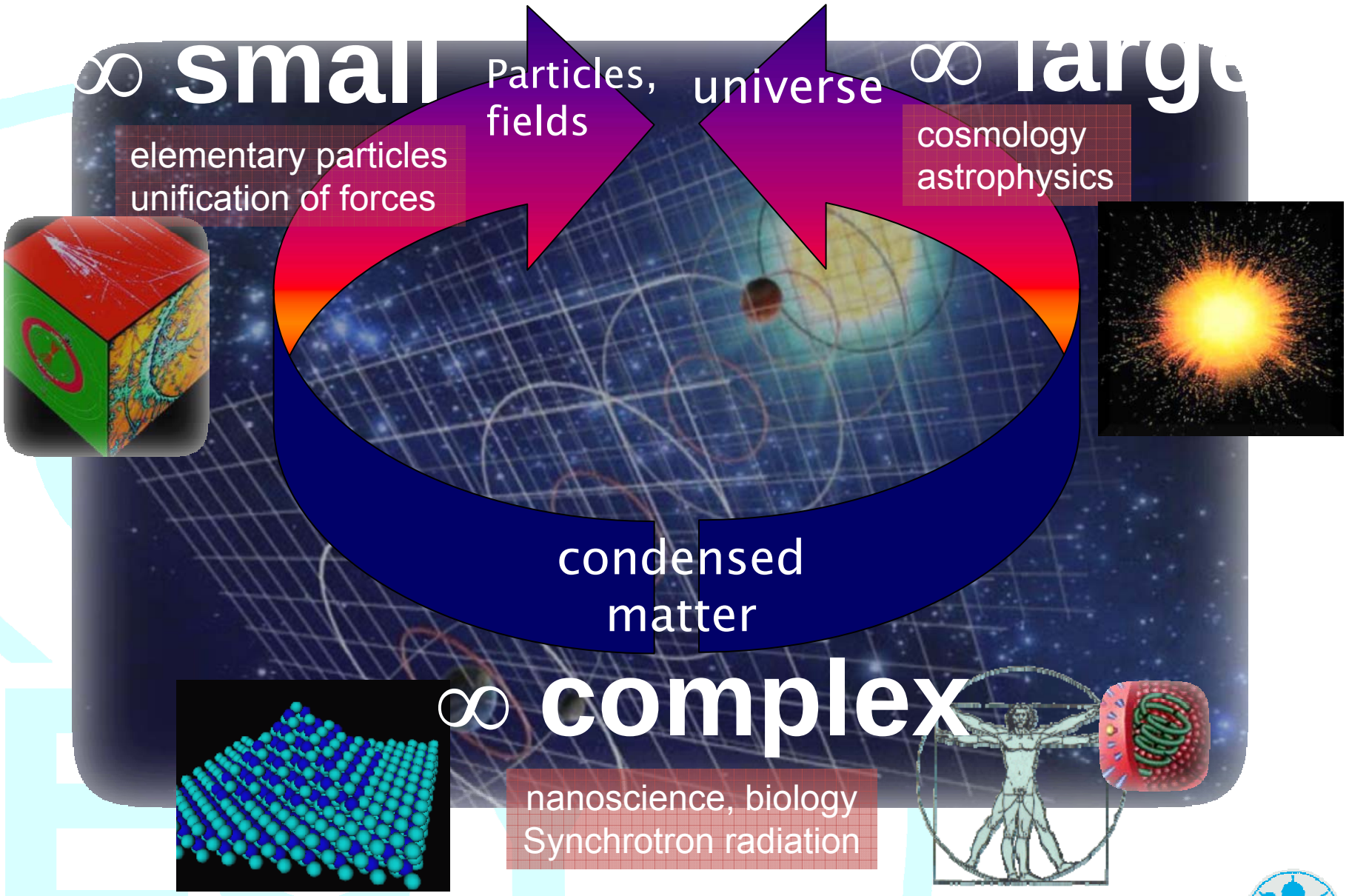
Alliance: a Network of complementary excellence between

2 Helmholtz Centres
17 Universities
1 Max Planck Institute

Key Elements

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

DESY Research.

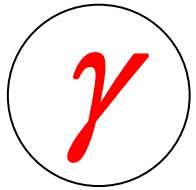


Strategy for Astroparticle Physics

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)

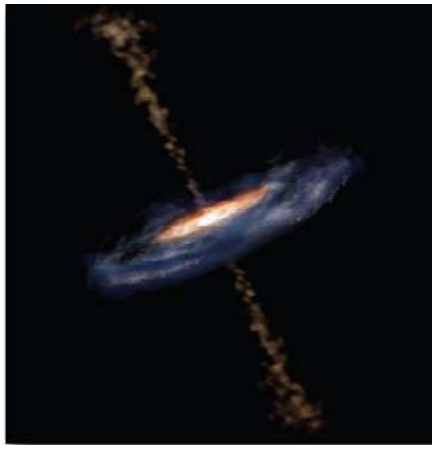
Combination of neutrino and high energy photon signals (multi-messenger principle)

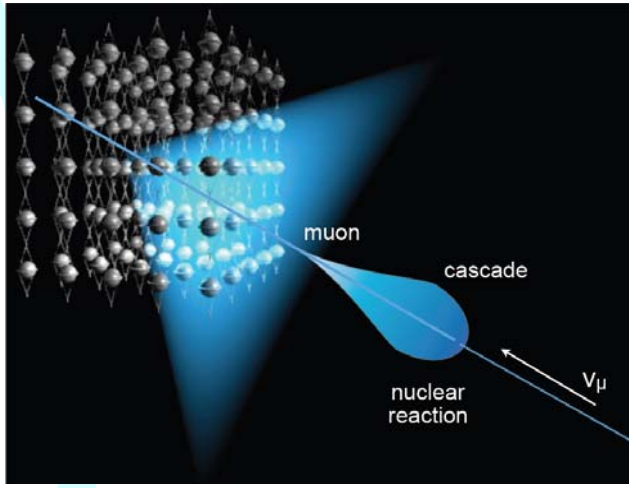
Close collaboration with German universities

Experimental astroparticle activities are presently mainly located in Zeuthen

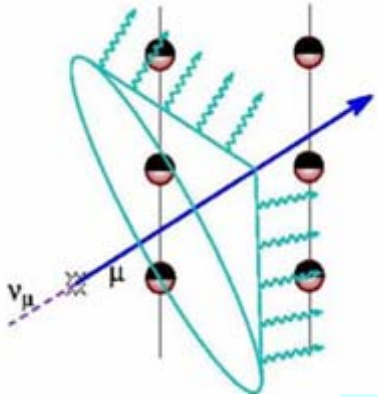
Neutrino Astrophysics

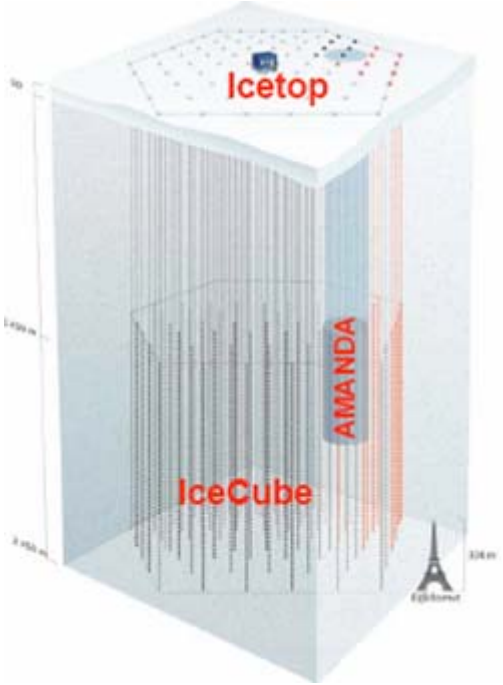
- high energy neutrinos from most violent astrophysical sources („cosmic accelerators“)
  - Supernovae remnants, Active galactic nuclei, gamma ray busts …
- neutrinos travel cosmic distances and point back to source
- detect Cherenkov light in ice emitted by charged particles (i.e. up-going muons) produced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

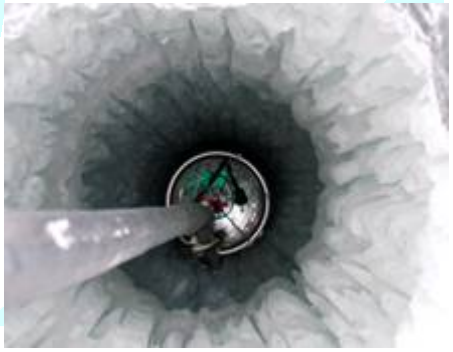


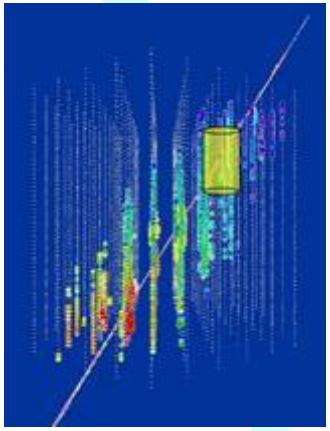


Neutrino Astrophysics





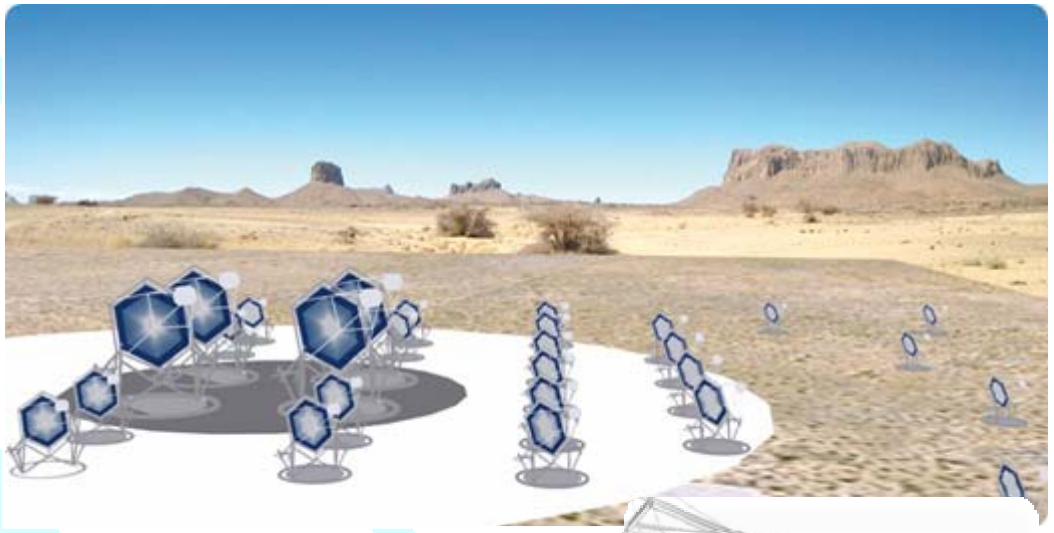


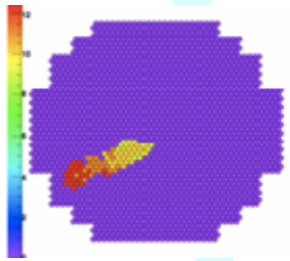


ICECUBE will have an active volume of 1km^3 antarctic ice by 2011 to detect neutrinos from cosmic sources

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

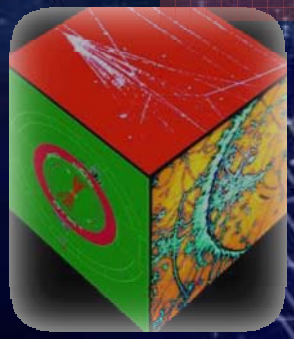




TRENDS in MODERN PHYSICS

∞ small

elementary particles
unification of forces



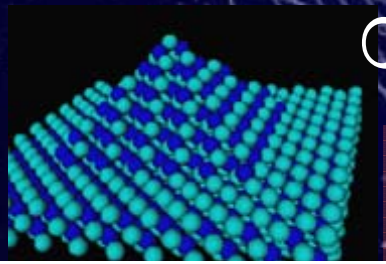
nano
cosmos

universe

∞ large

cosmology
astrophysics

condensed
matter

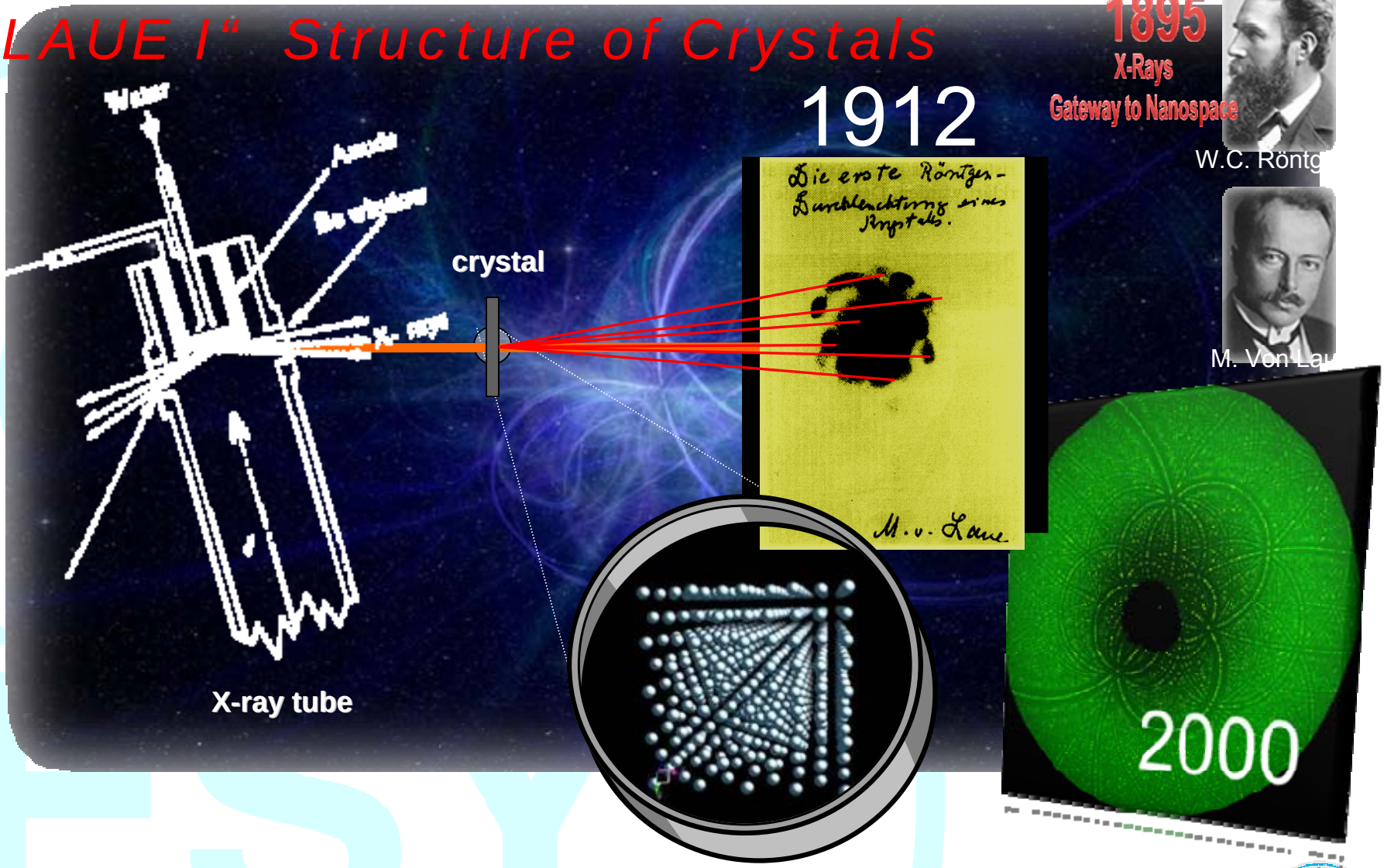


∞ complex

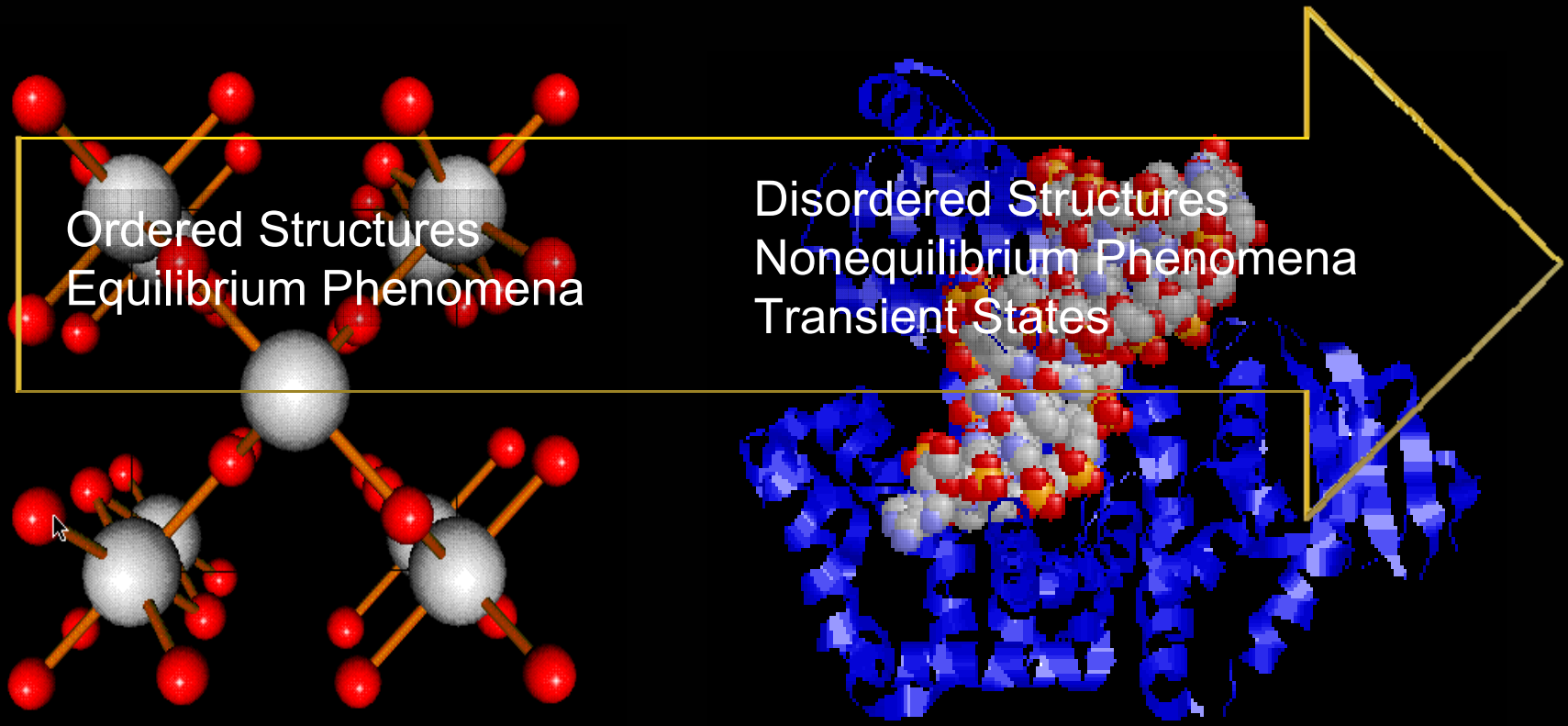
nanoscience & -technology
biology

1900-2000 Era of Ordered Matter

„LAUE I“ Structure of Crystals



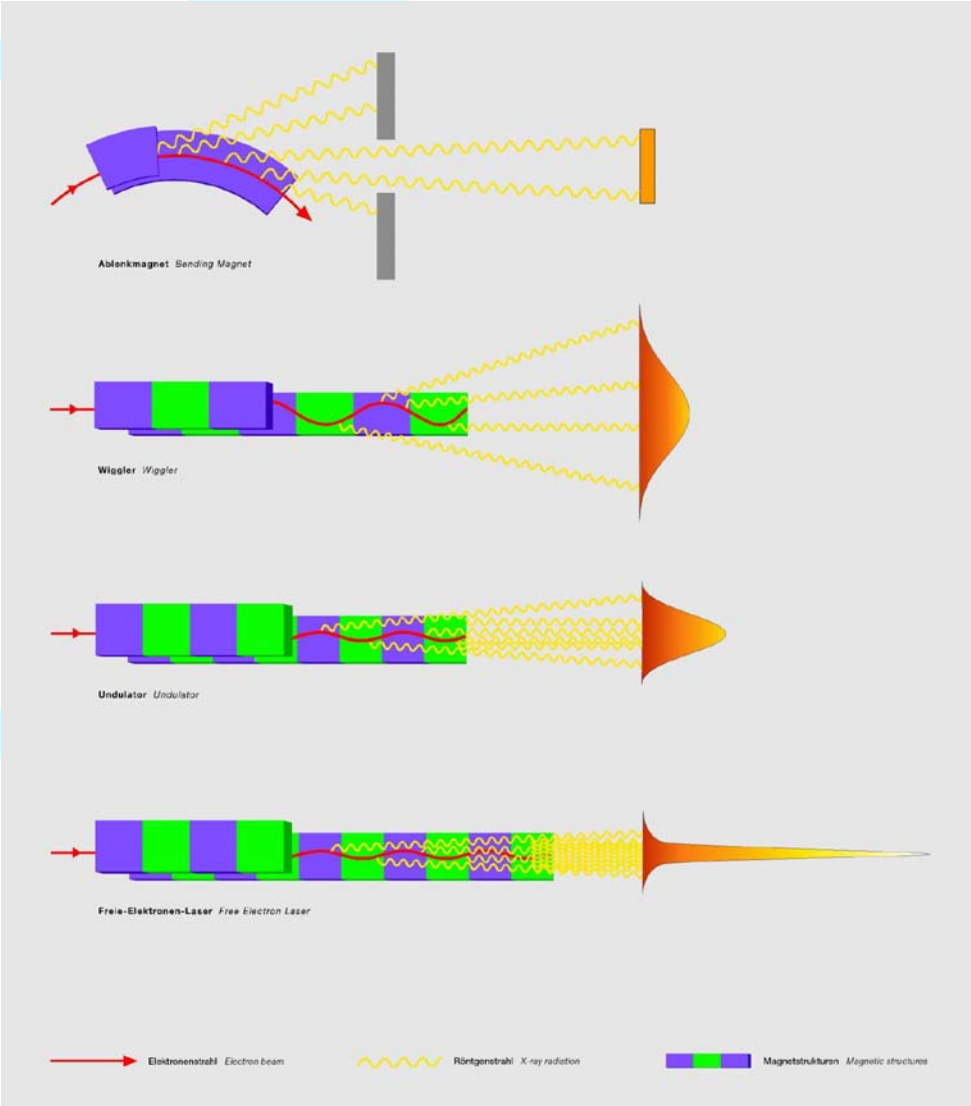
TRENDS in MODERN PHYSICS

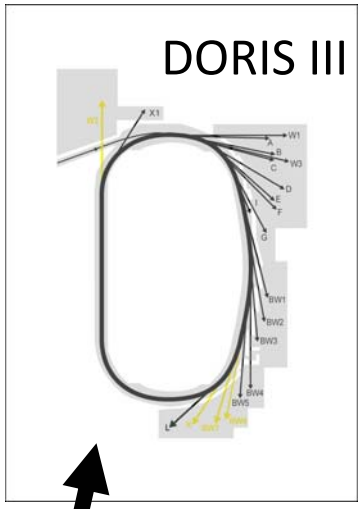


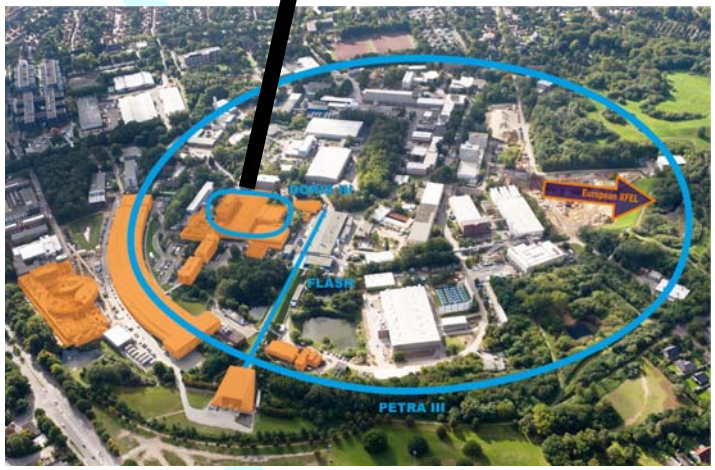
Era of Crystalline Matter | Era of Disordered Matter

1900 2000 future

Photon sources at DESY –
DORIS III, PETRA III, FLASH and briefly XFEL

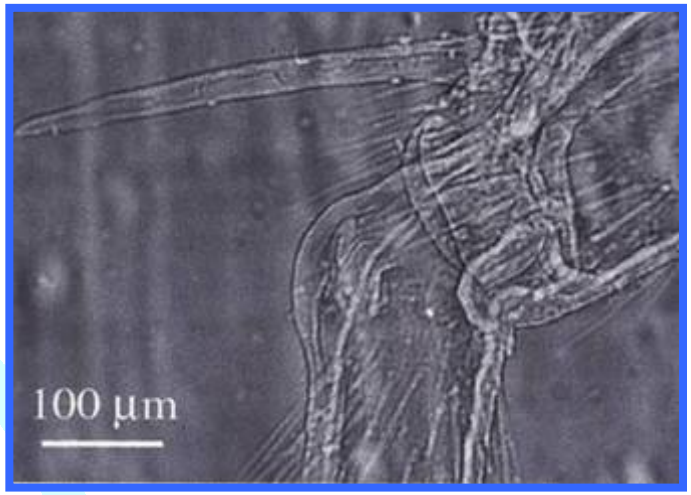




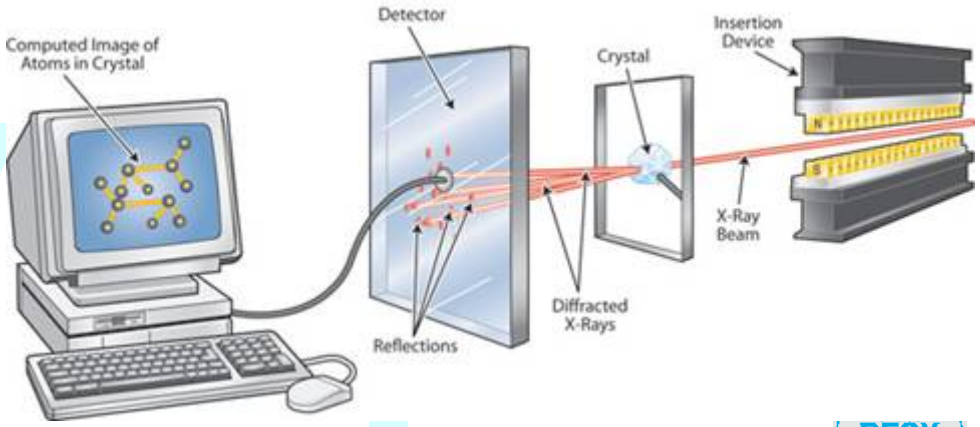


Some Applications:

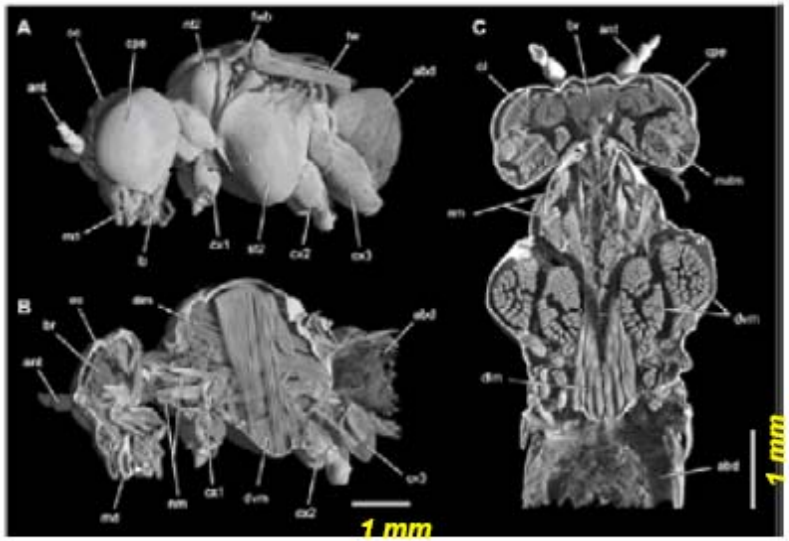
Die “Proteinfabrik”



Knee of a Spider



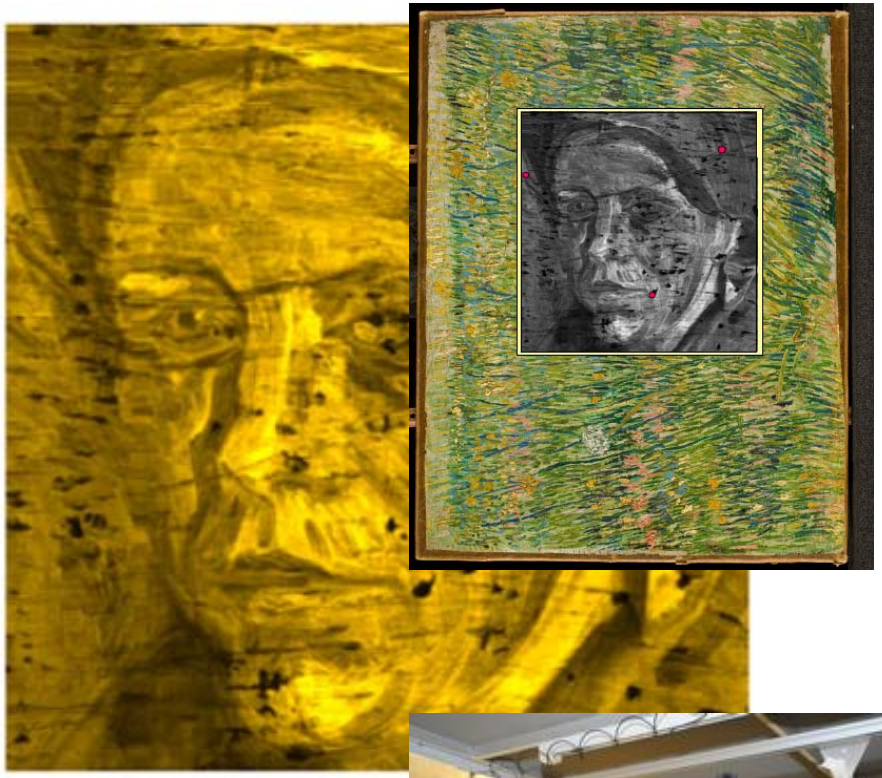
Examples for Research at DORIS



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)



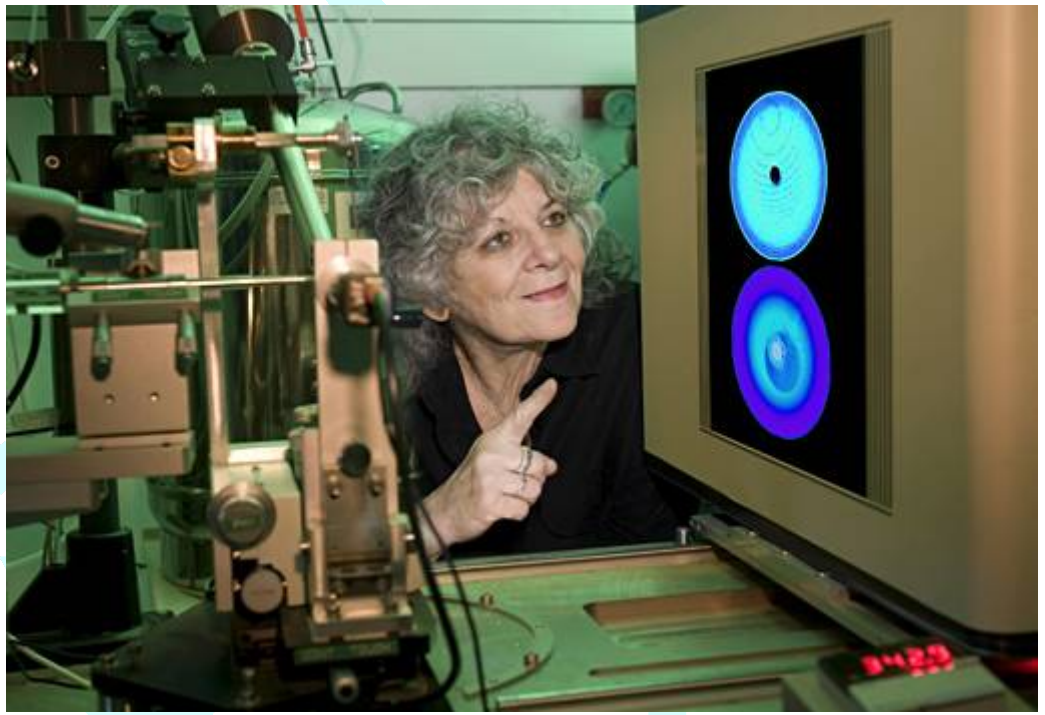
Painting: van Gogh

Boerin, Janssens et al. (s

DESY. Chemistry Nobel laureate 2009

Ada Yonath

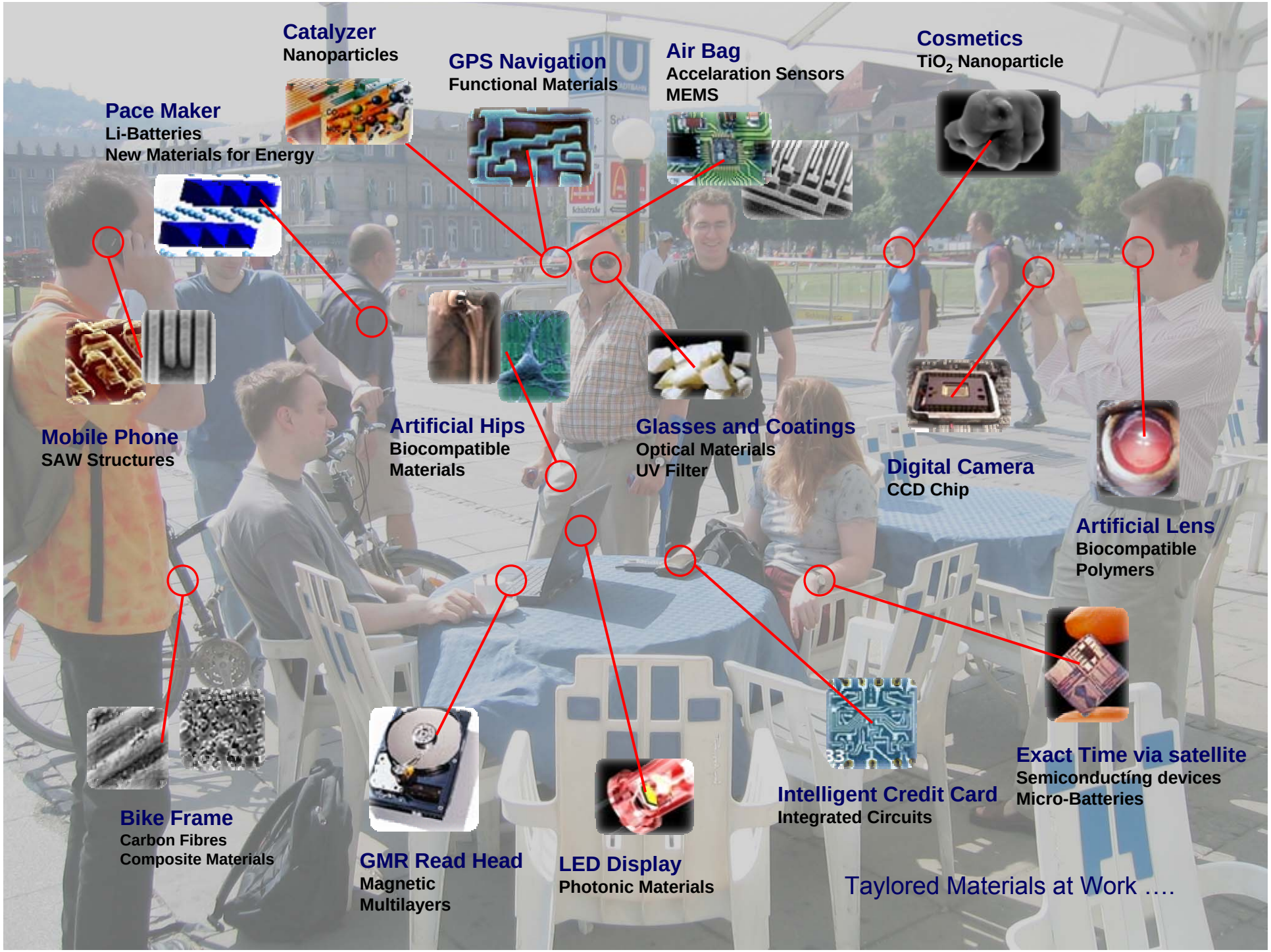
1986- 2004 Head of MPG Research Group – Structure of the Ribosome



DESY

Pioneering work at DORIS III /DESY

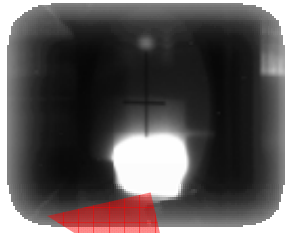

On a typical day in Europe ....


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
Semiconducting devices
Micro-Batteries
Taylored Materials at Work ….

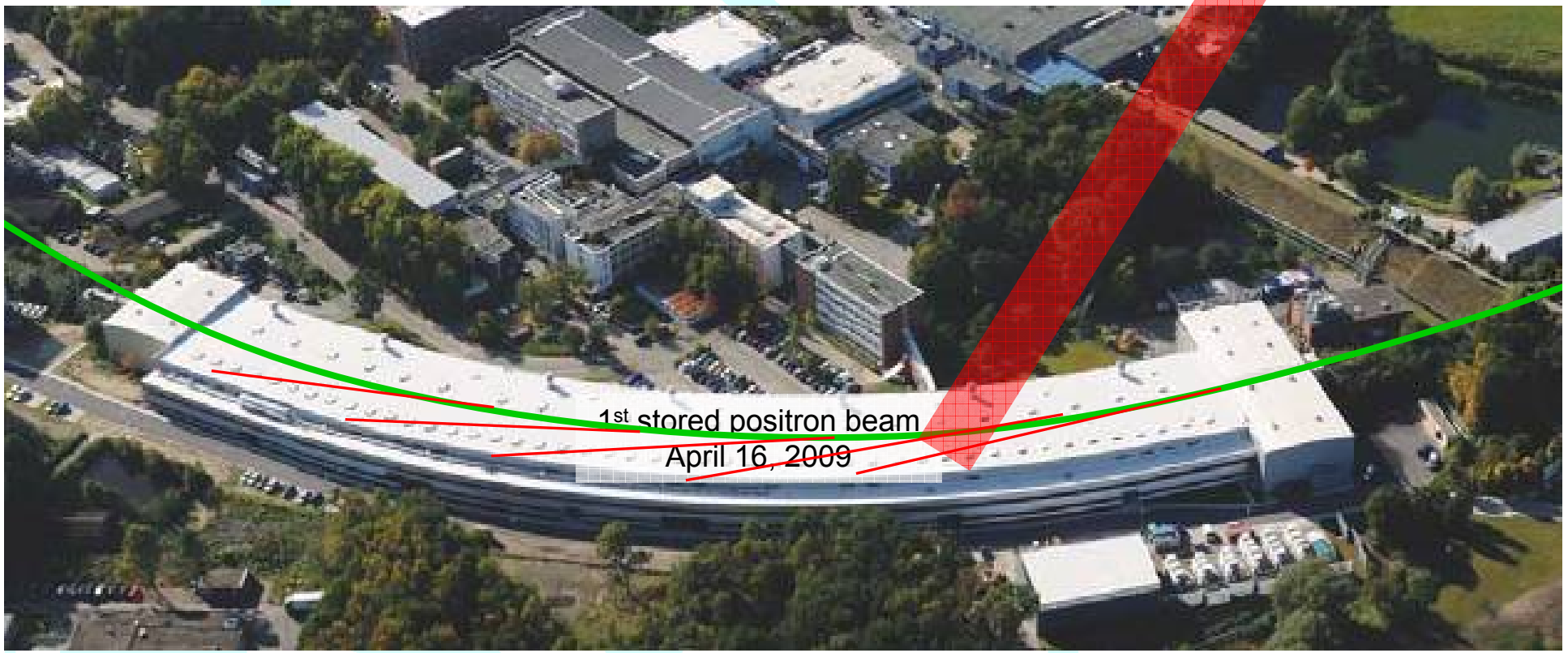
PETRA III

the most brilliant x-ray source ever built

1 nmrad

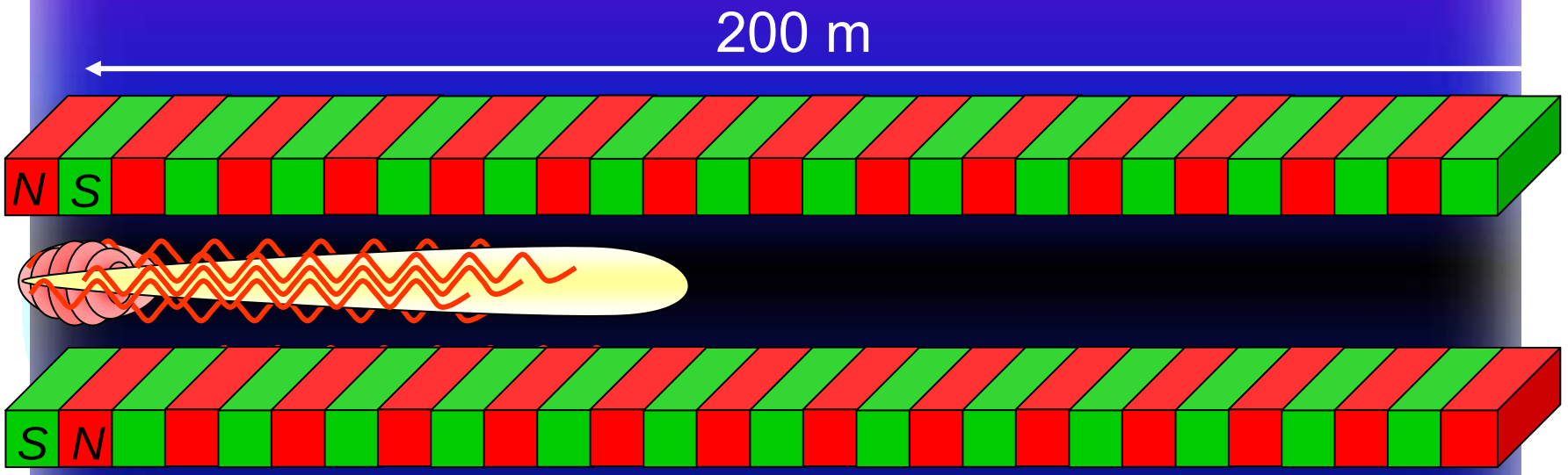


1st monochromatic light
July 17, 2009



X-ray Laser with free electrons

The SASE principle



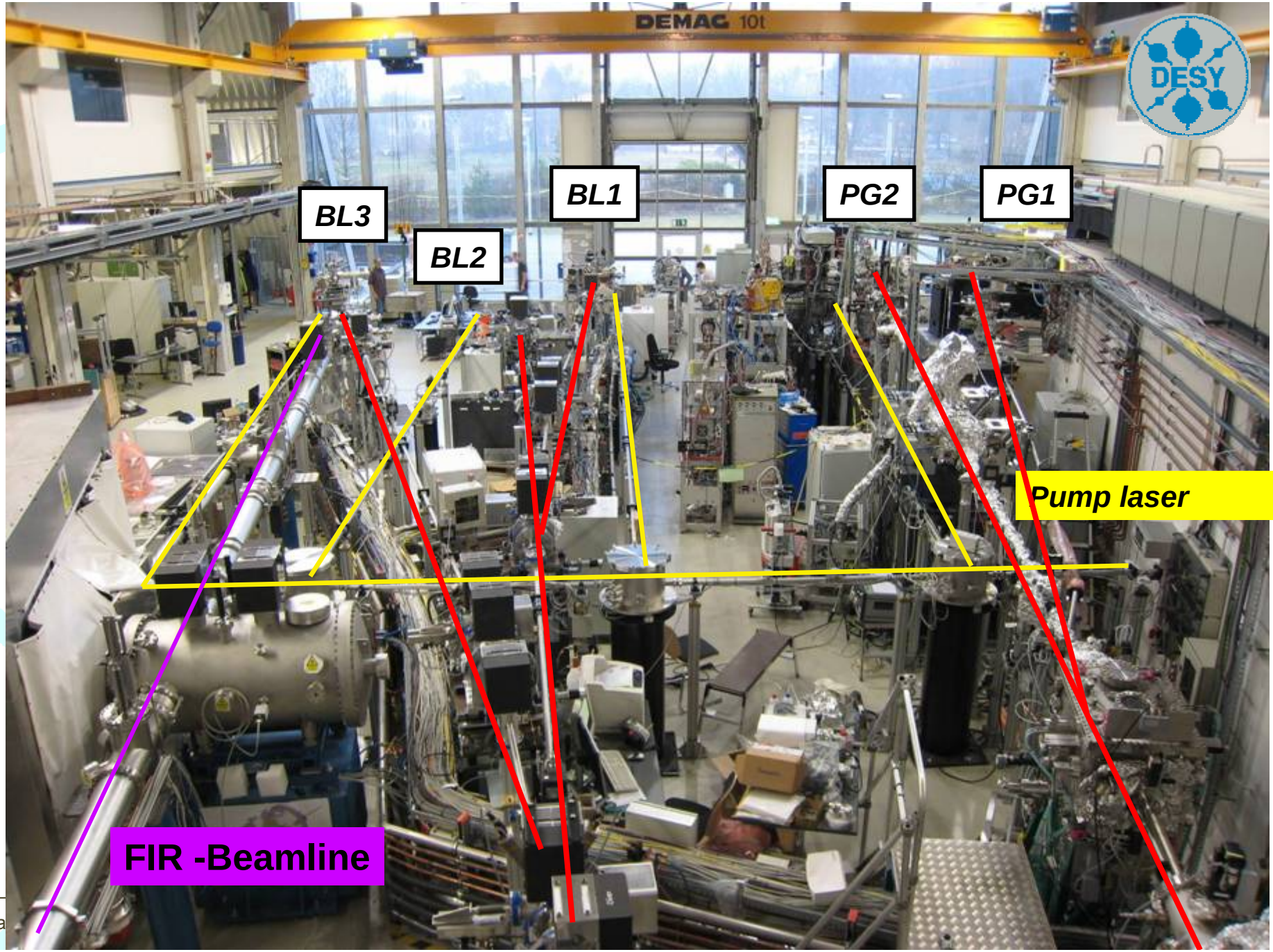
10^{10} e^- (1 nC)

Self-Organized Micro Bunching

Electron Bunch with 10 GeV

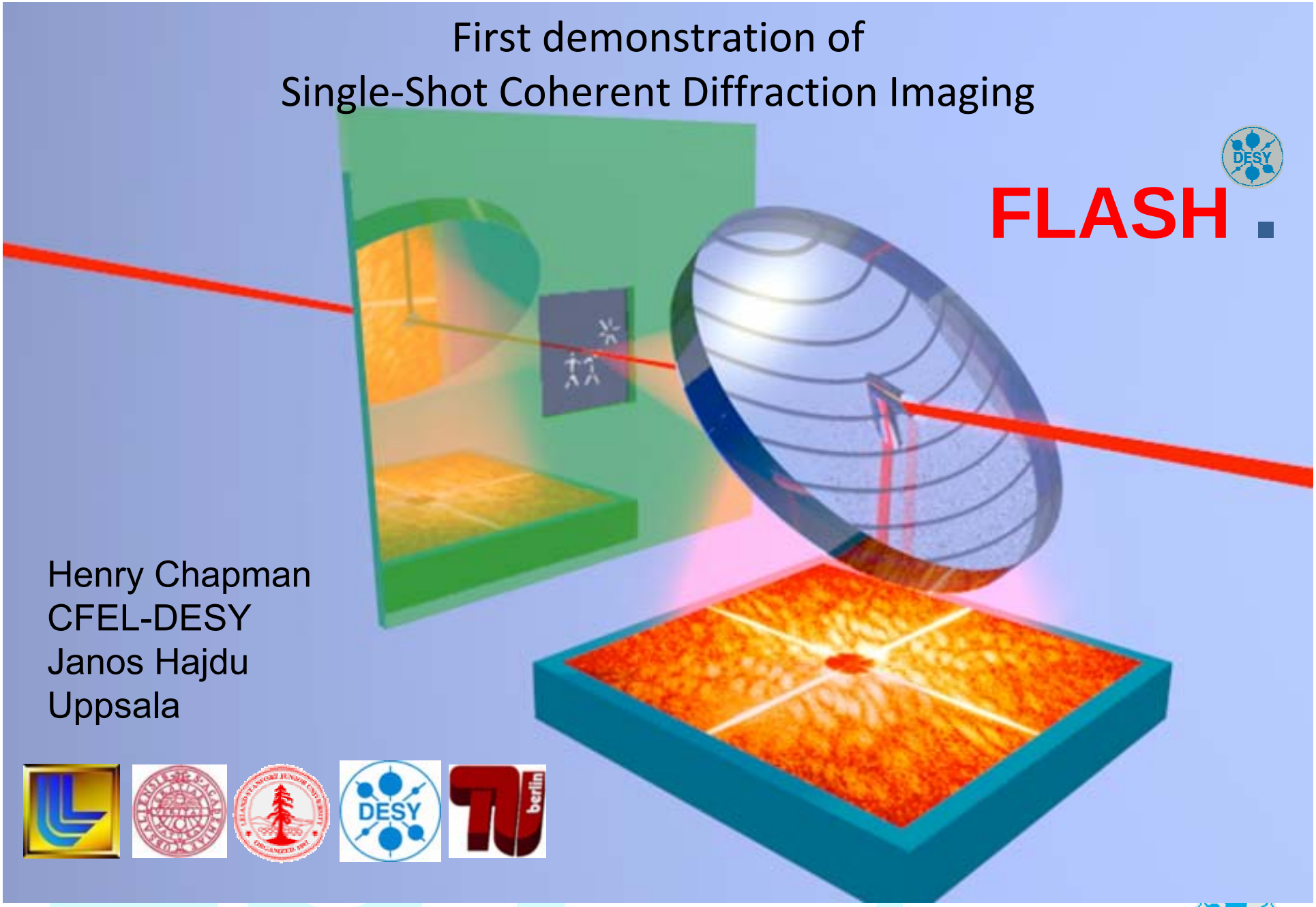
FLASH .

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


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

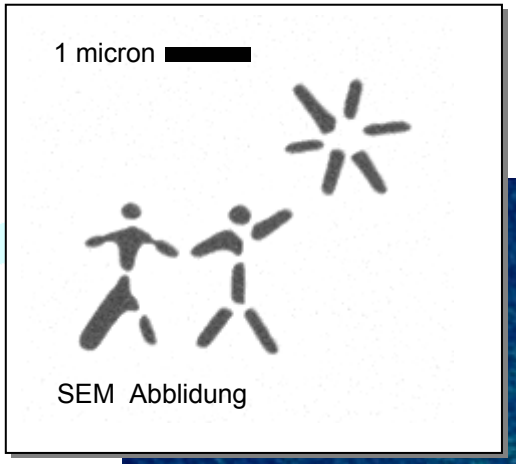
FLASH

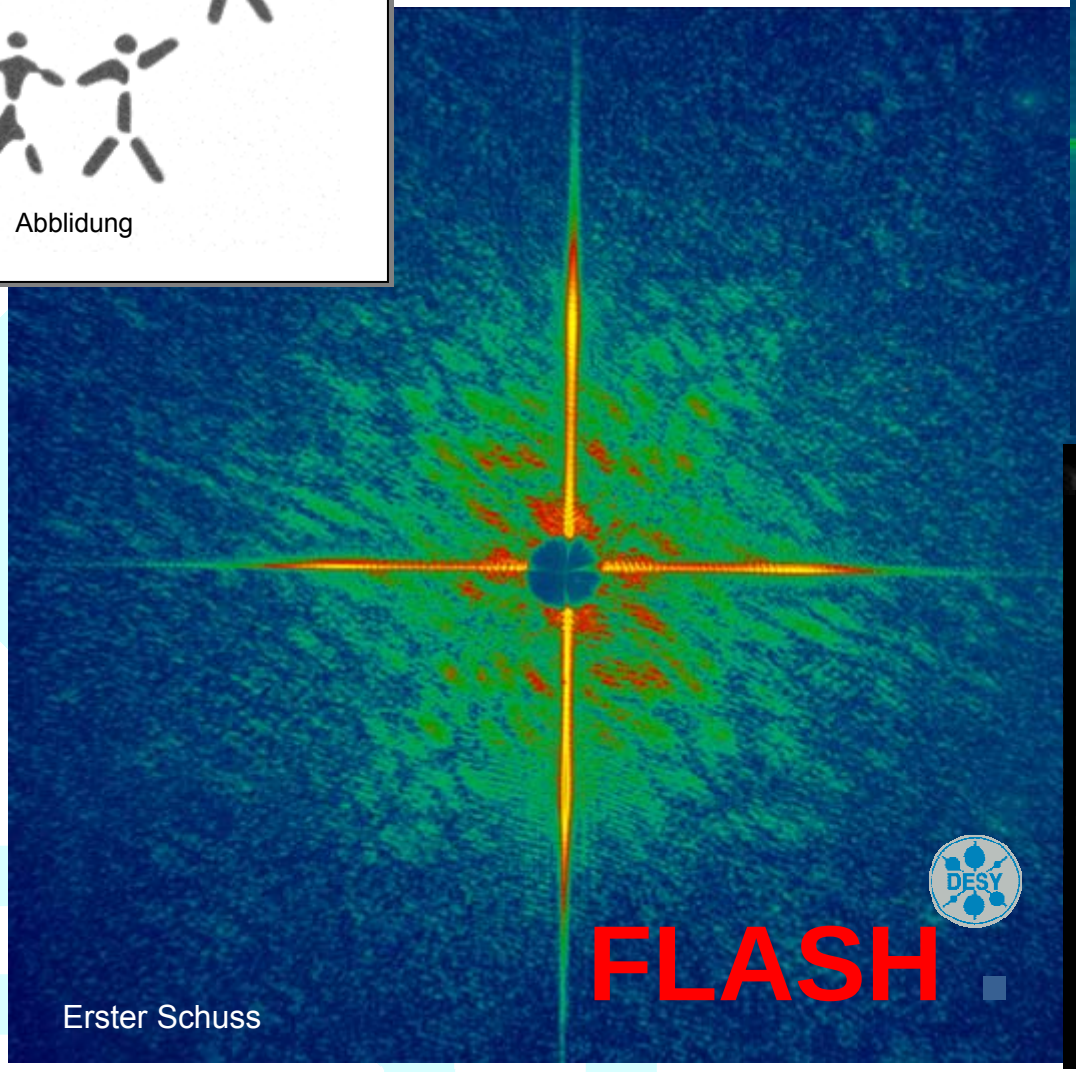
First demonstration of Single-Shot Coherent Diffraction Imaging

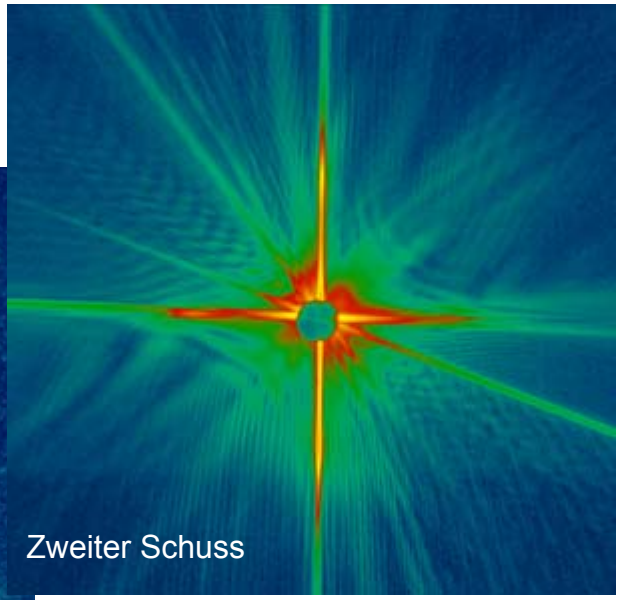


Henry Chapman
CFEL-DESY
Janos Hajdu
Uppsala

Image reconstruction from an ultrafast FEL diffraction pattern

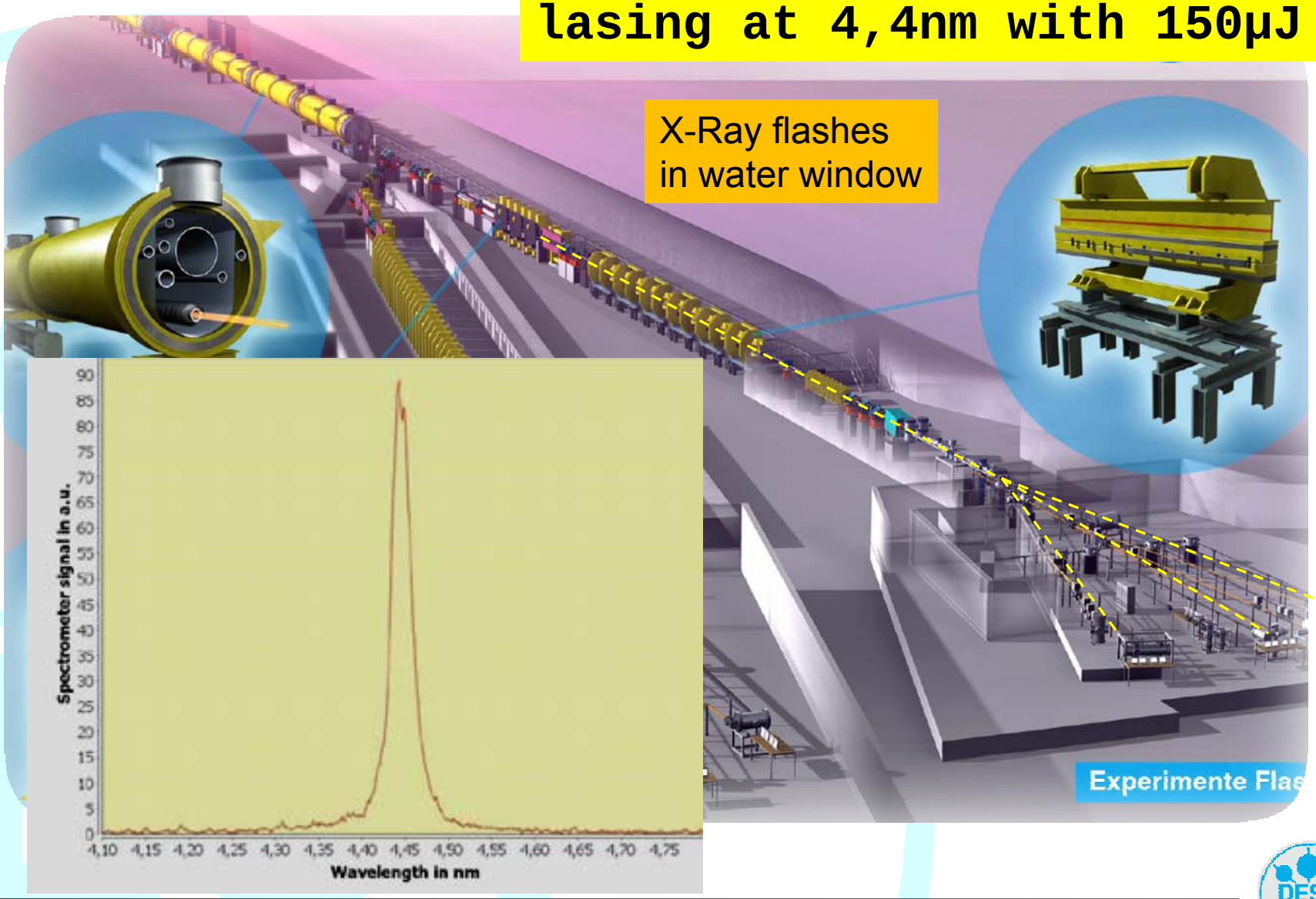




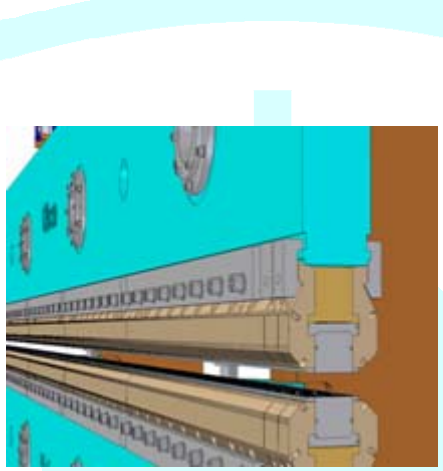


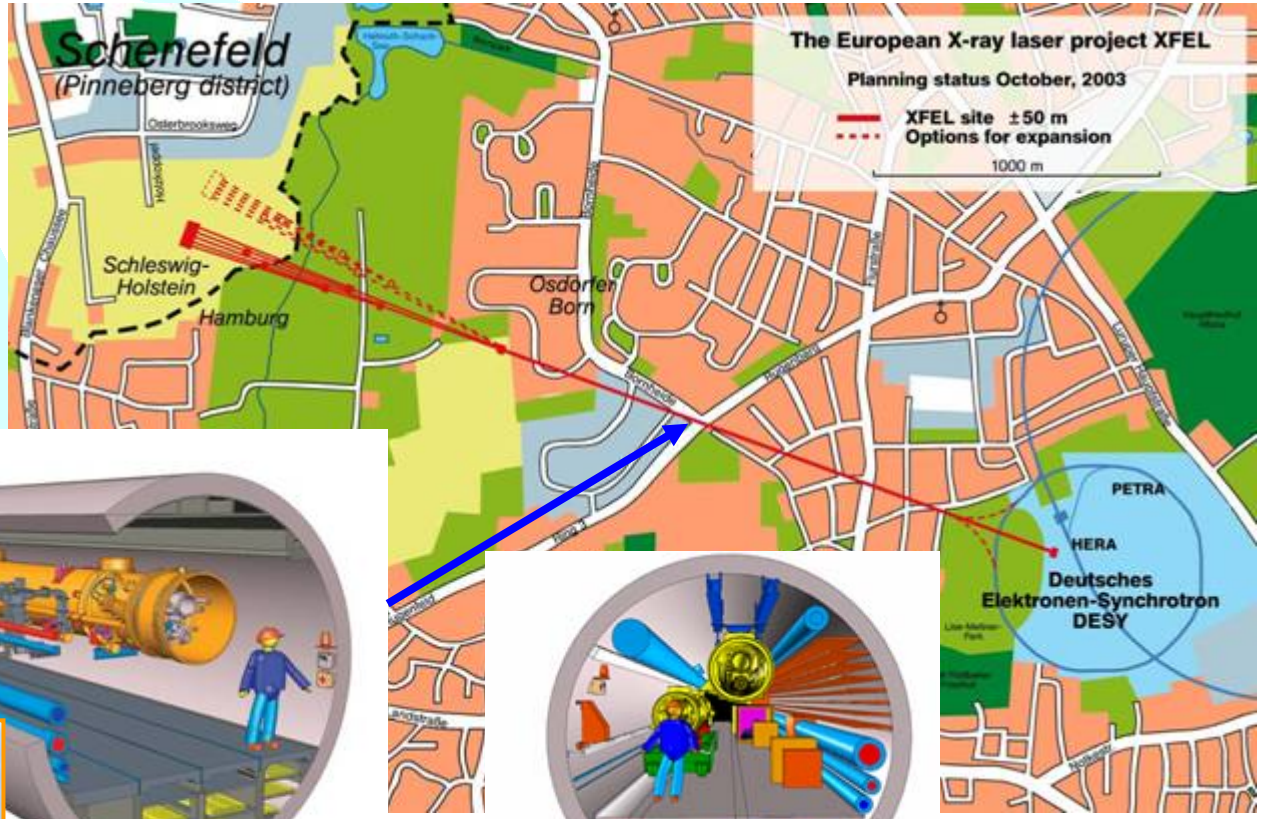
DESY News.

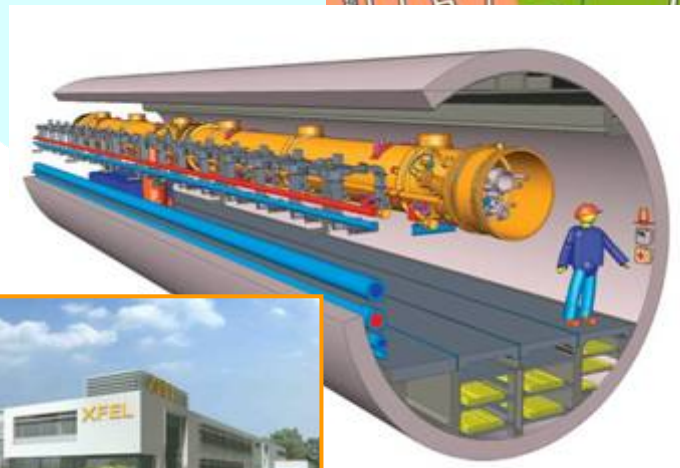
- **7.6.2010 ... sFLASH ... lasing at 4,4nm with 150µJ**



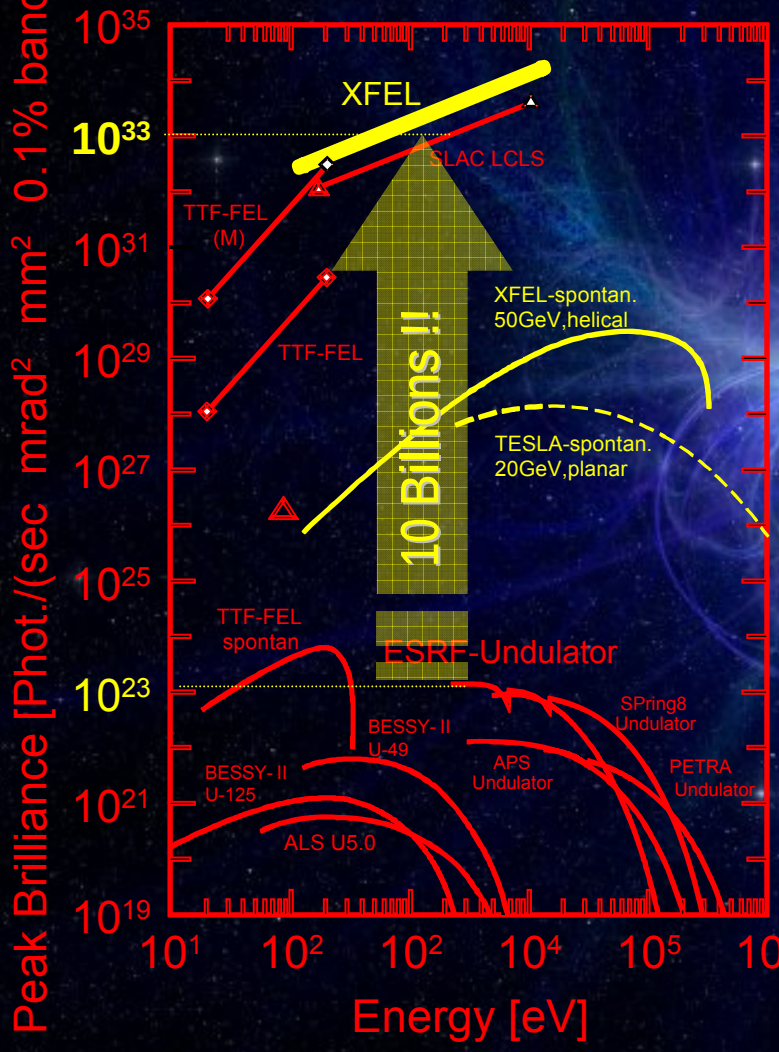
The European XFEL Project

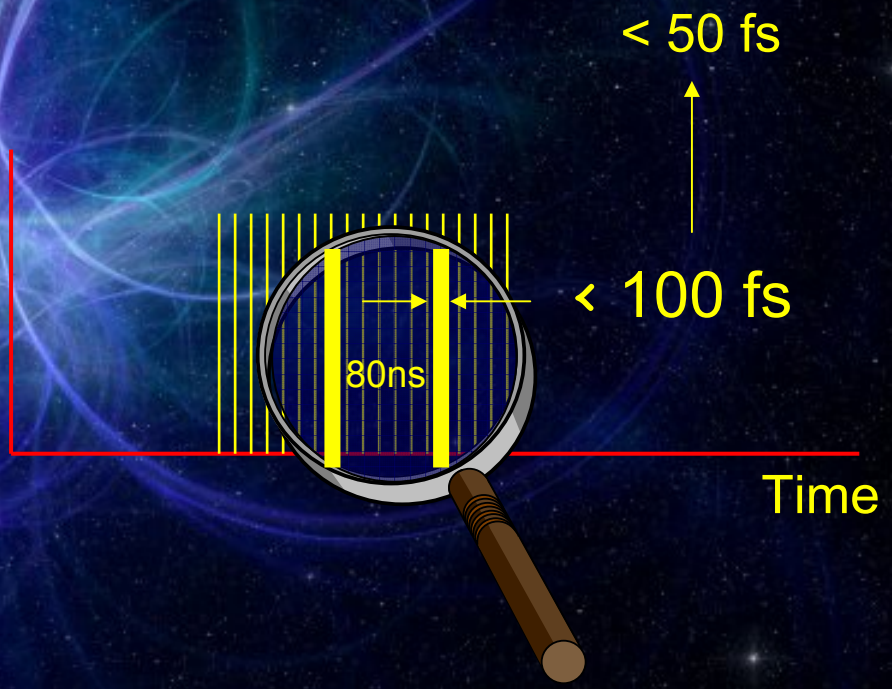




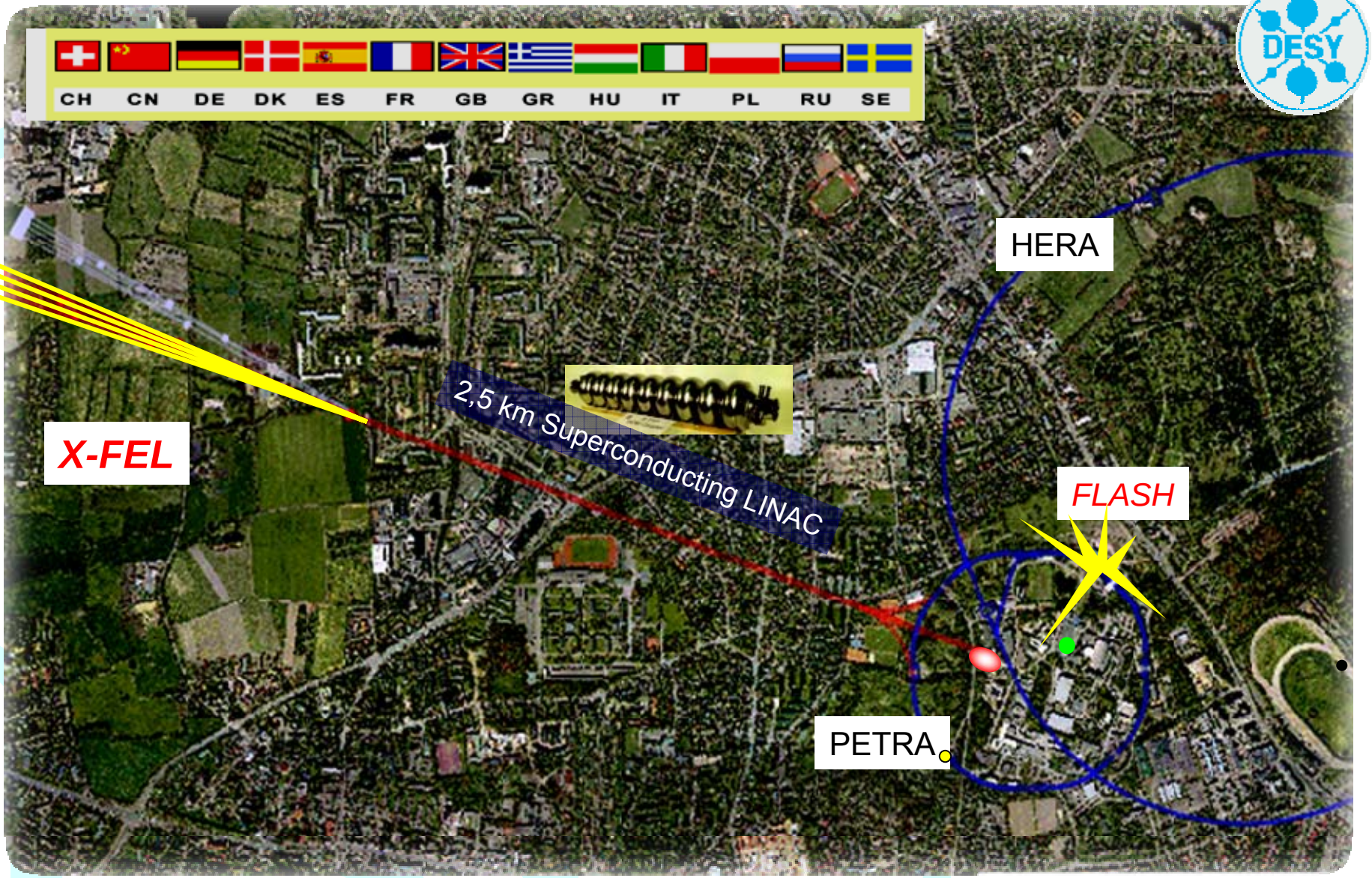


FREE ELECTRON LASER





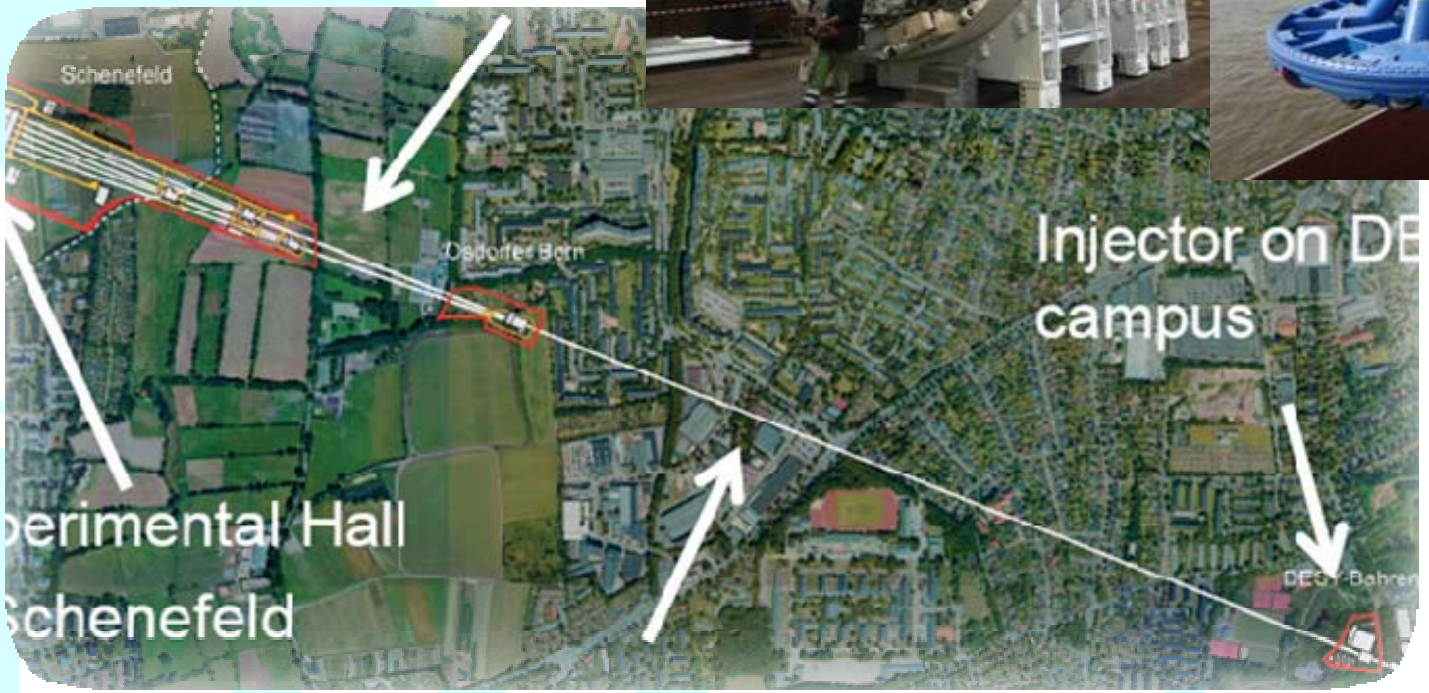
Femtosecond x-ray laser pulses
Life reports from Nanospace


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

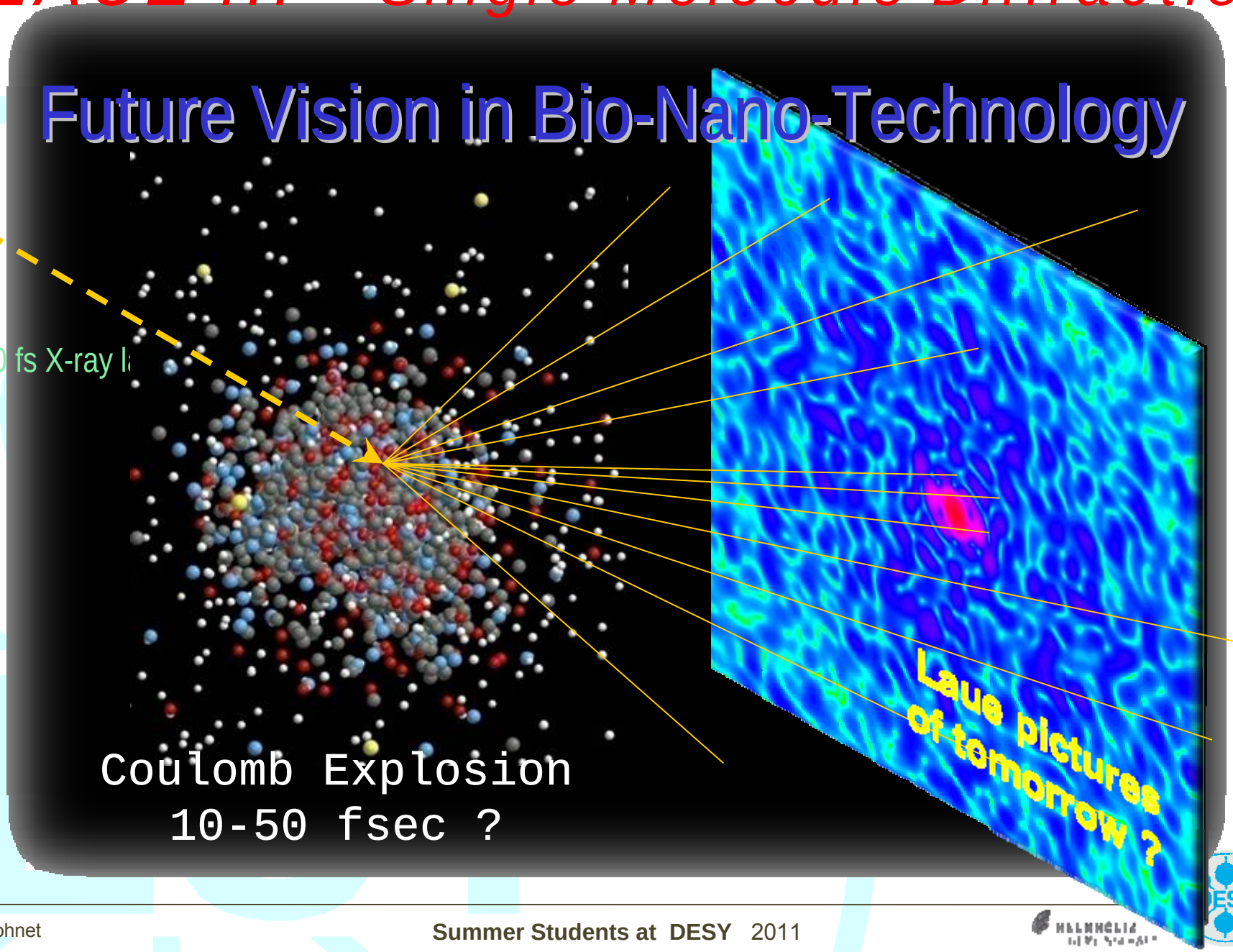
Accelerator.

XFEL Construction

European XFEL
„Baptizing“ the tunnel boring machine
30.6.2010



„LAUE III“ Single Molecule Diffraction



Finally …

Enjoy your stay at DESY
and in Hamburg …