DESY – Research Strategy in a Global Context

Summer Students 2007

Albrecht Wagner

Deutsches Elektronen-Synchrotron

DESY is a Member of the HELMHOLTZ GEMEINSCHAFT

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

Provide access for national and international users

Internationally used, nationally funded Research Institute

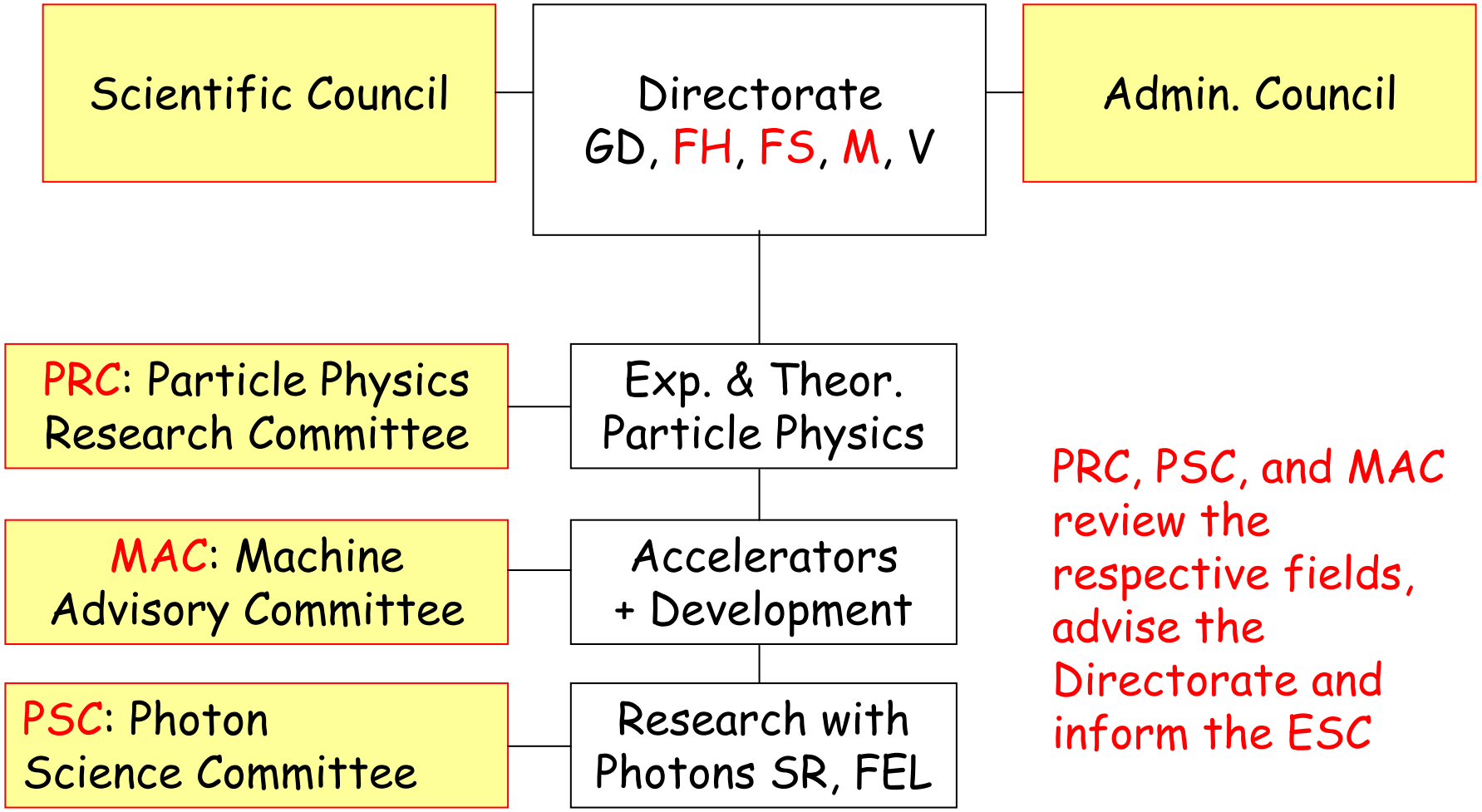
Base-Budget:	170 MEuro (2005)
Staff:	1560 FTE in Hamburg and Zeuthen
Users:	3000 (1500 from abroad) from 45 nations
	920 in particle physics, 2100 in photon science

DESY in Hamburg und Zeuthen

DESY -Hamburg

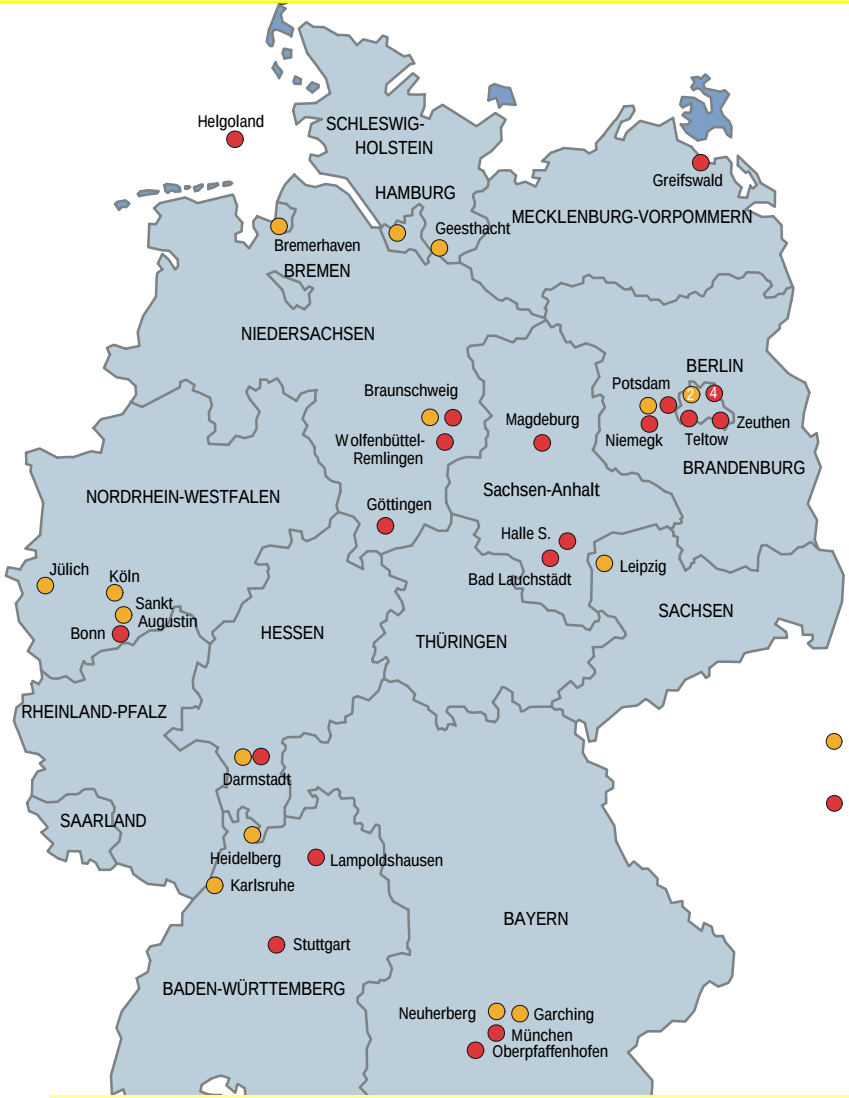
DESY -Zeuthen

DESY Management Structure and Advisory Boards



PRC, PSC, and MAC review the respective fields, advise the Directorate and inform the ESC

DESY, a Member of the Helmholtz Association



Research Centers: 15

Employees: ~ 24 000

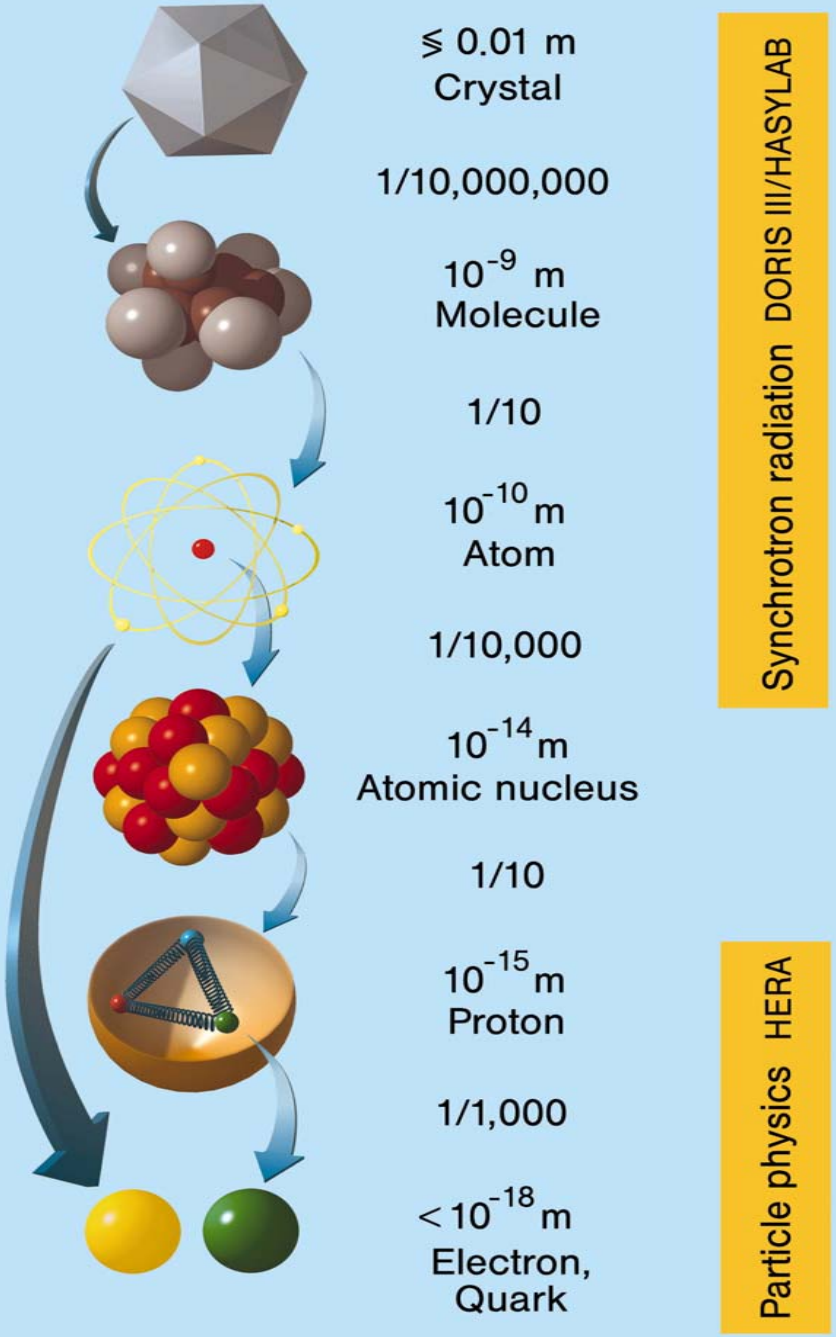
Funding (Bill. Euro) ~ 2,2

Research Areas:

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

Programme oriented funding:
Five year programme planning, strategic review -> funding

DESY - Research

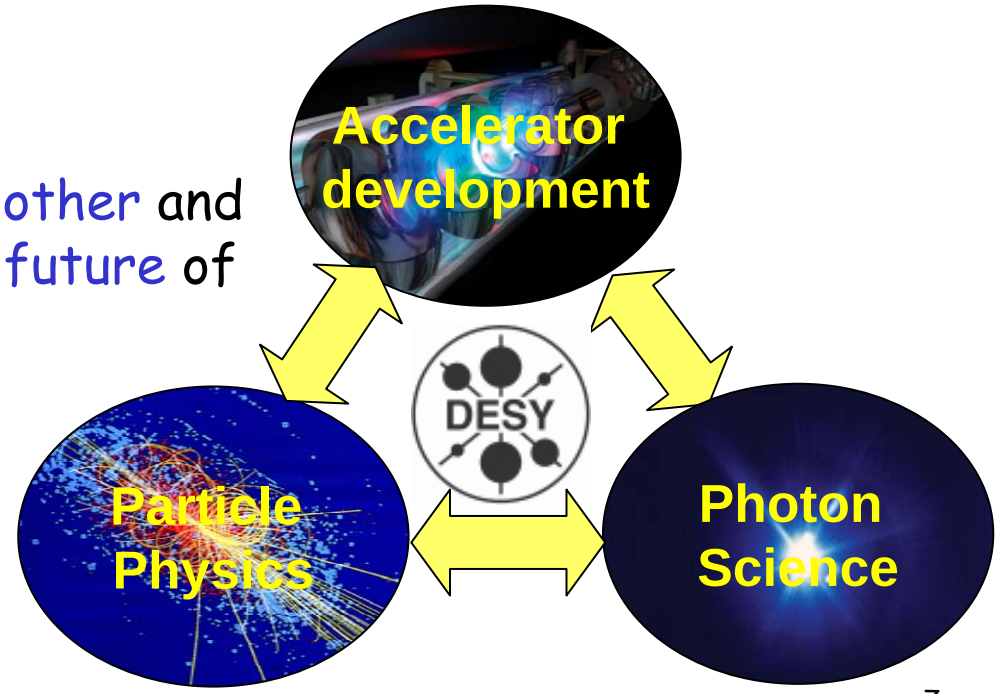


- Study of the structure of matter from macroscopic to atomic scales
- Analysis of the fundamental building blocks and forces (discovering the quantum universe)
- Theory in particle physics and cosmology
- Astroparticle physics with neutrinos (experiments at South Pole)
- Accelerator and detector R&D

DESY

- DESY has a long successful history in three areas of basic science and high tech :
  - Particle physics (one of 5 laboratories world wide),
  - Research with X-rays (synchrotron radiation, FELs) and
  - Accelerator development.

- These topics stimulate each other and constitute the basis for the future of the laboratory.



Strategy for Accelerator Development

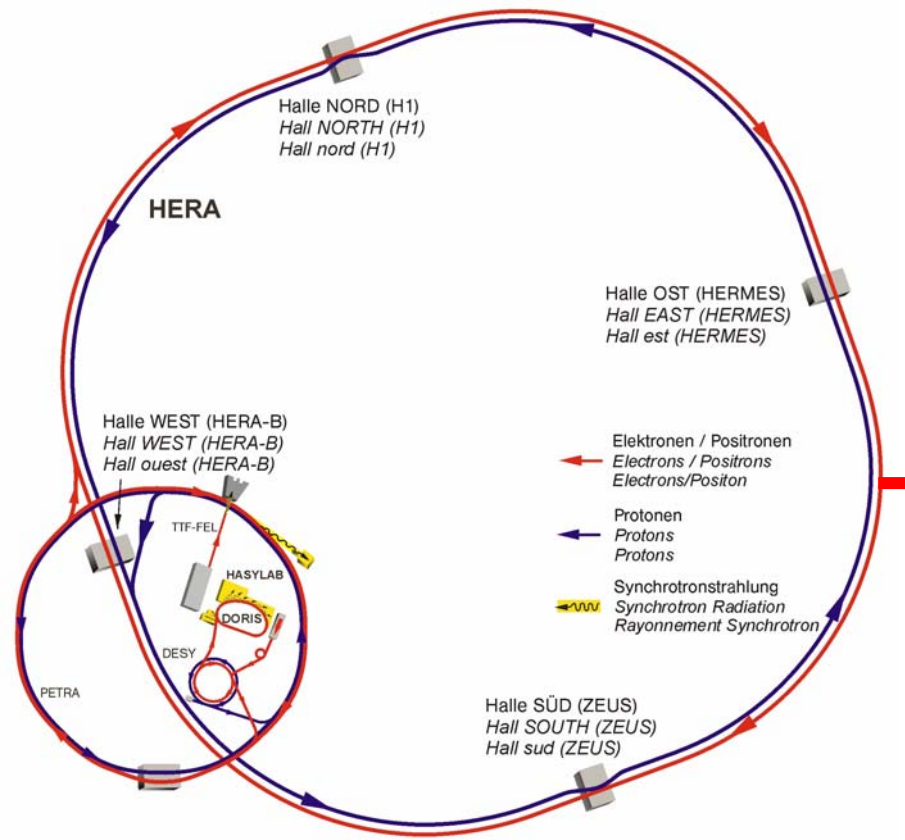
Strategy:

- Further strengthening of know-how in accelerators, driven by science needs:
  - Accelerator technology development (SCRF, electron sources)
  - Operation of synchrotron light sources
  - Development and operation of Linac driven Light sources (FLASH, XFEL)
  - International Linear Collider development
- Exploiting the synergy between projects and technologies

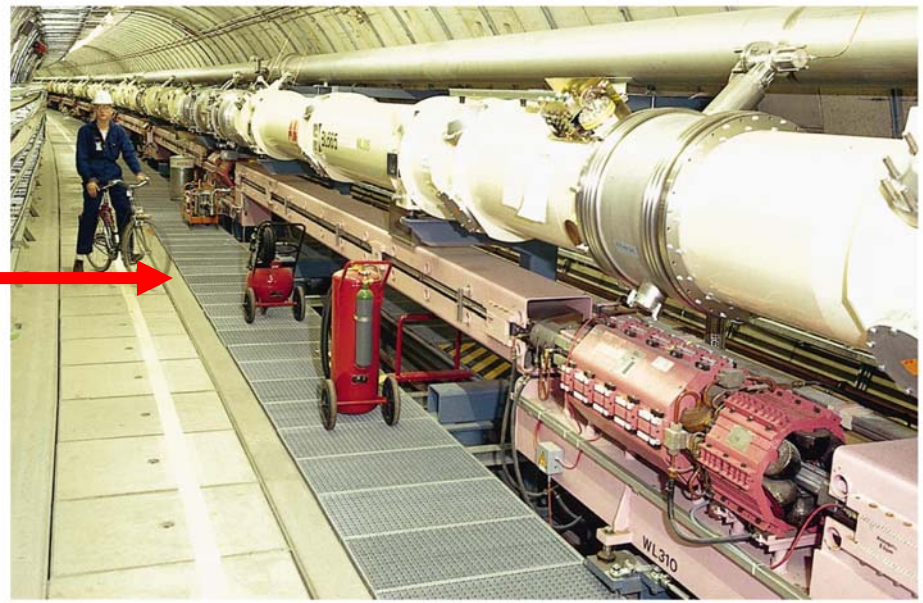
DESY's Accelerators - today

DESY operated until 30 June 2007 16 km of accelerators for:

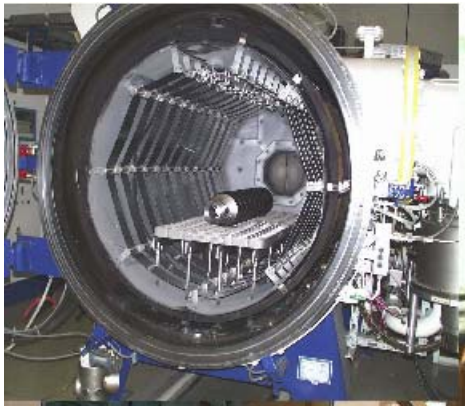
- Particle physics
- photon science



HERA



TESLA Technologie



The Improvement of SC Cavities

SC RF structures for accelerators were developed in many countries

The TESLA collaboration, centred at DESY combined ~ all the world expertise in SC, thus leading to major progress:

>25-fold improvement in performance/cost in 10 years

Major impact on next generation light sources (XFEL, ERL) , proton accelerators etc

Development (schematic) of gradient in SCRF cavities

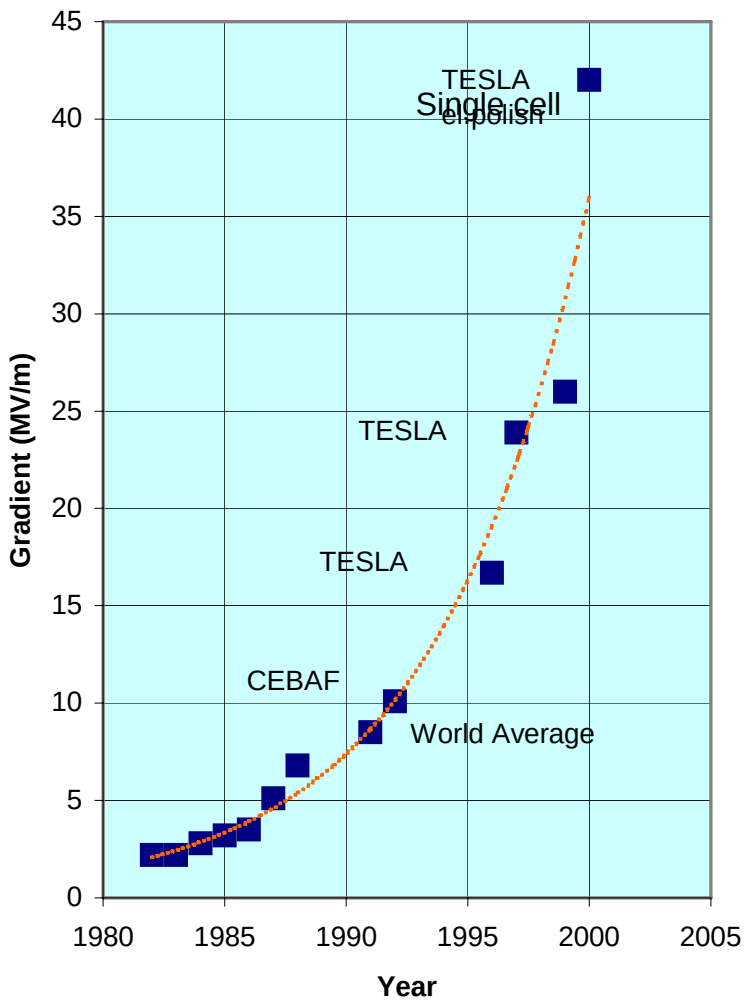
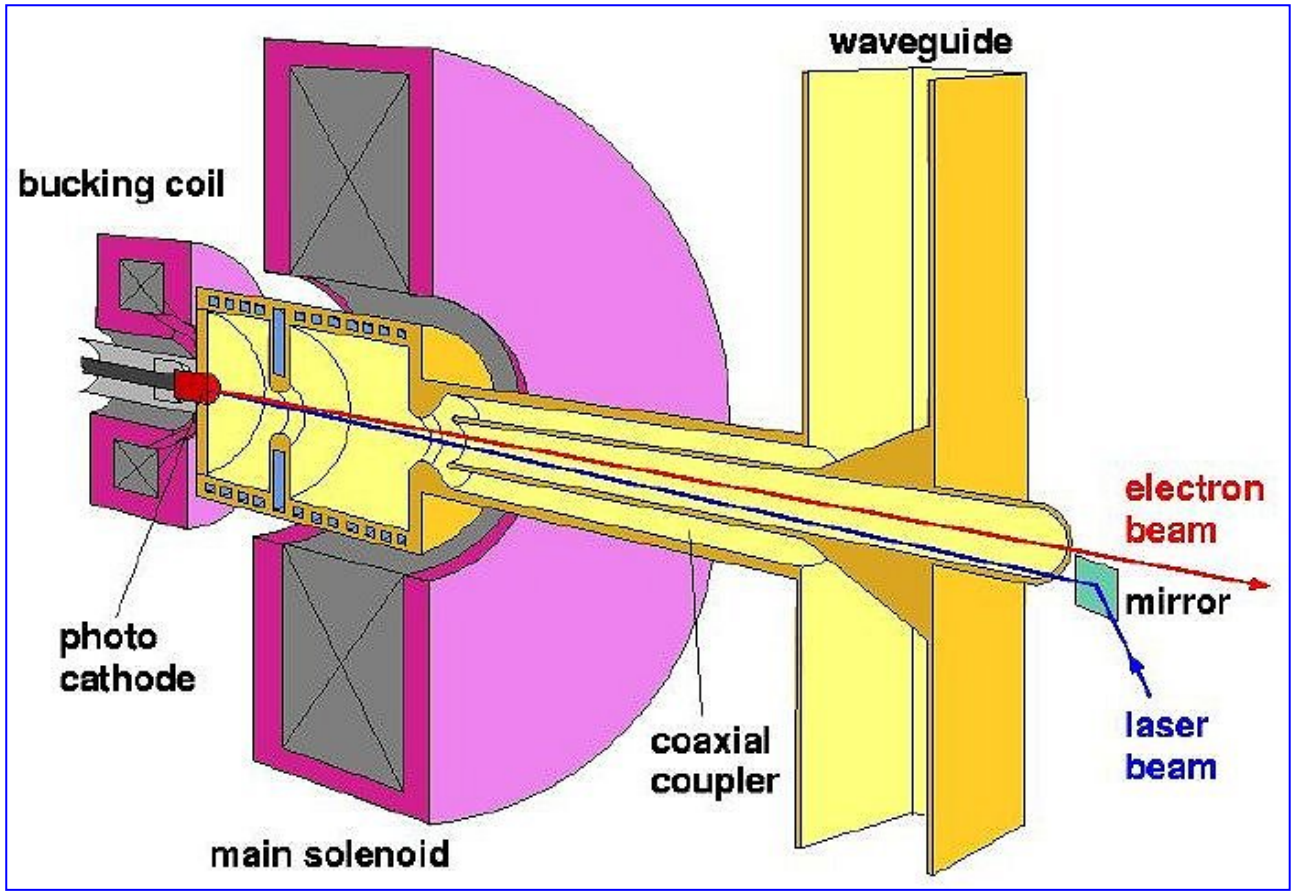


Photo Injector Test Facility at Zeuthen - PITZ

- PITZ is a test facility at DESY Zeuthen for research and development on laser driven electron sources for Free Electron Lasers (FEL) and linear colliders.



Research with Photons

Strategy:

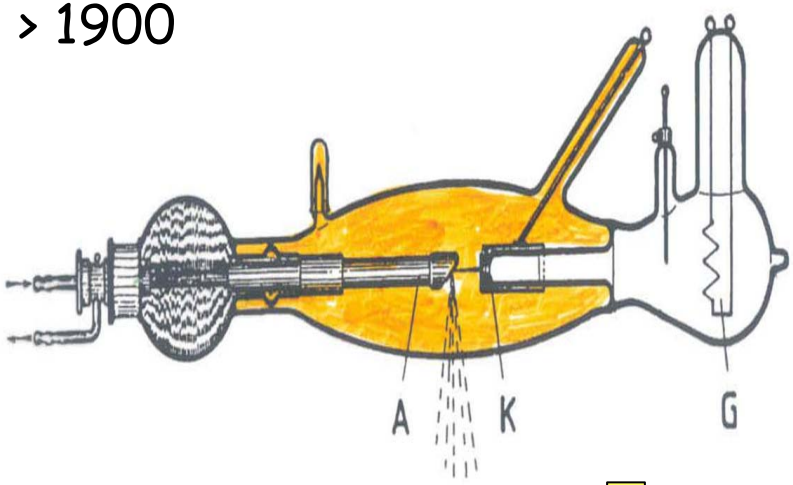
- Make leading edge research possible in physics, chemistry, material science, biology etc. through unique light sources:

- Synchrotron light sources
  - DORIS
  - PETRA III
- Linac driven light sources
  - VUV-FEL - FLASH
  - Participation in European XFEL

- FLASH, PETRA and the XFEL are or will be unique facilities on a world scale

The Development

> 1900

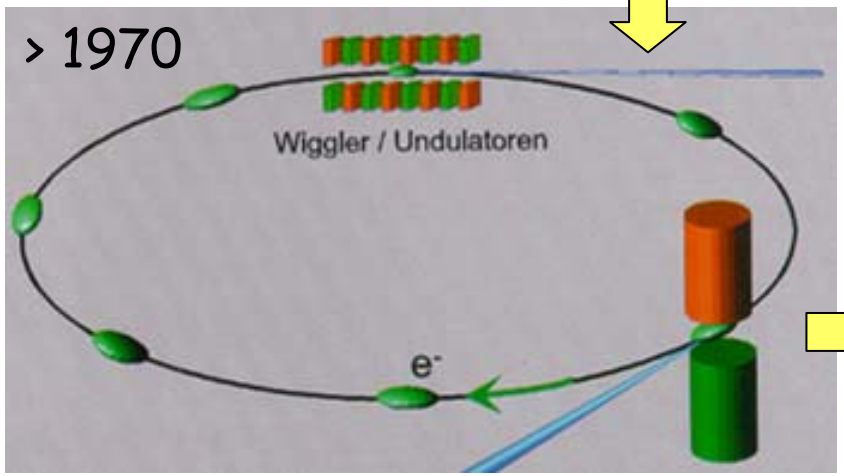


X-ray Tubes

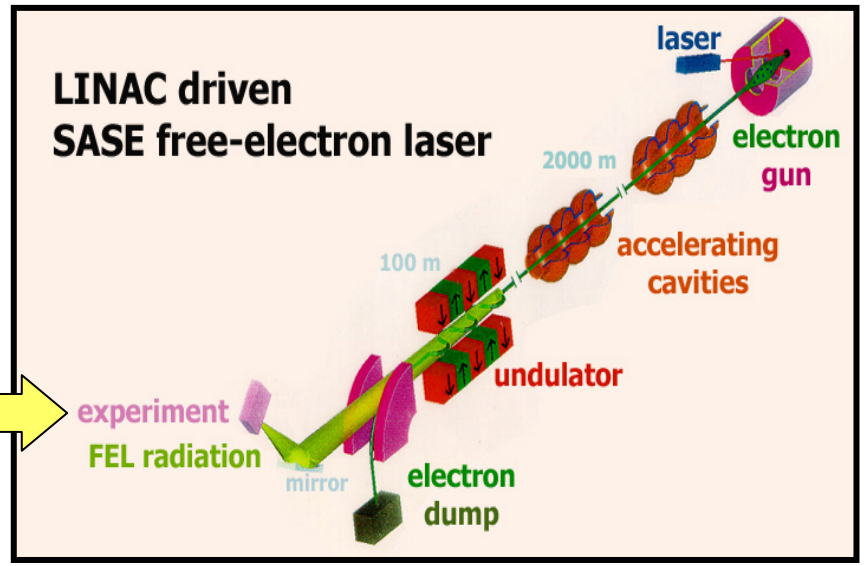
Synchrotron radiation

XFELs

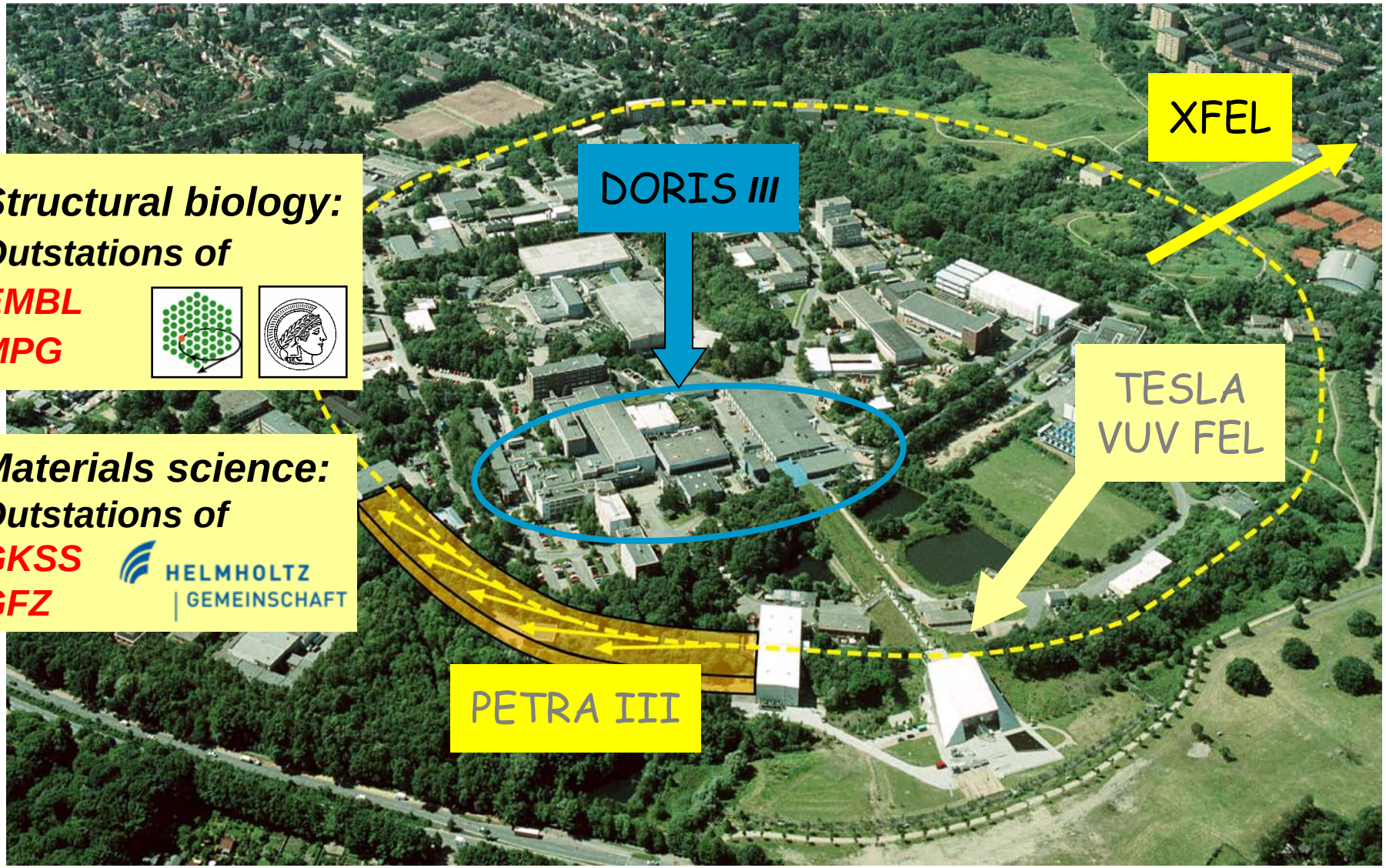
> 1970



> 2000



Research with Photons

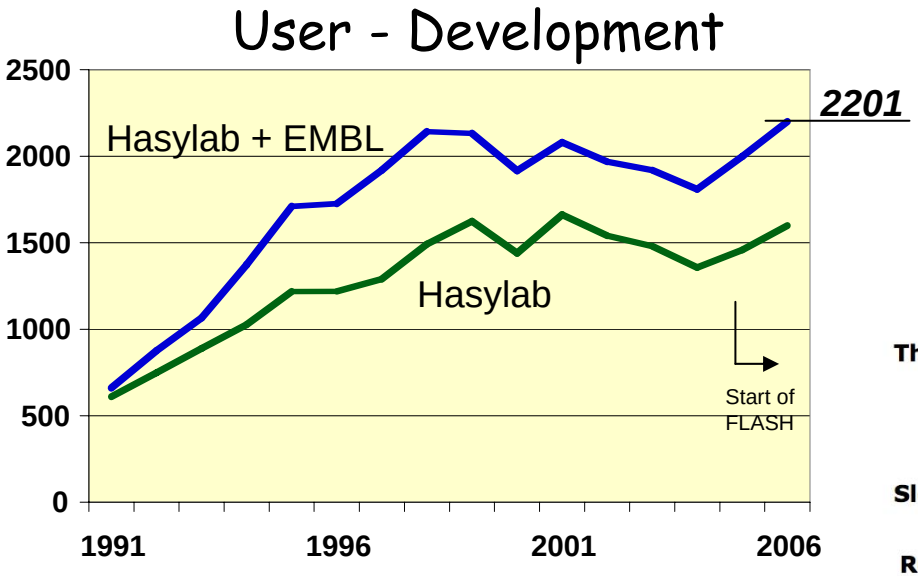


Structural biology:
Outstations of
EMBL
MPG

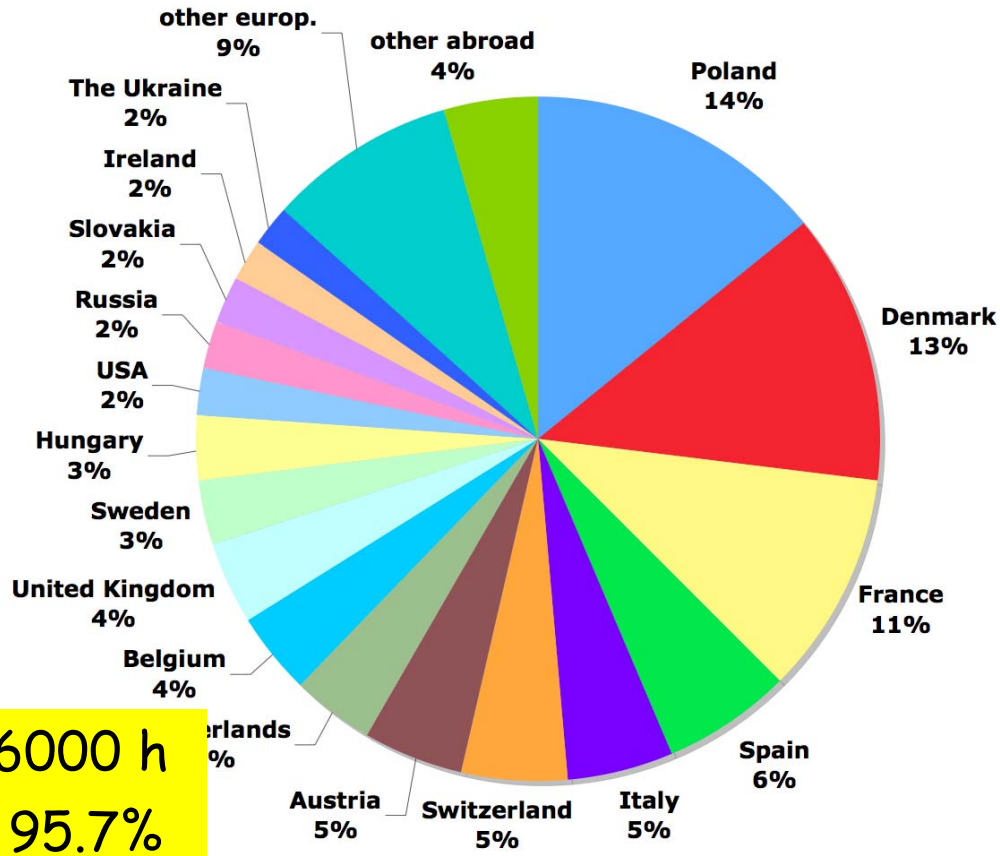
Materials science:
Outstations of
GKSS
GFZ

HELMHOLTZ GEMEINSCHAFT

Photon Science Users



Distribution of international Users (2006)



In 2006 at Hasylab:

German Users: 928

Internat. Users: 771

No. of Nations: 40

DORIS beam time (2006): ~6000 h

Availability: 95.7%

PETRA III

A new high performance light source for European users, nationally financed

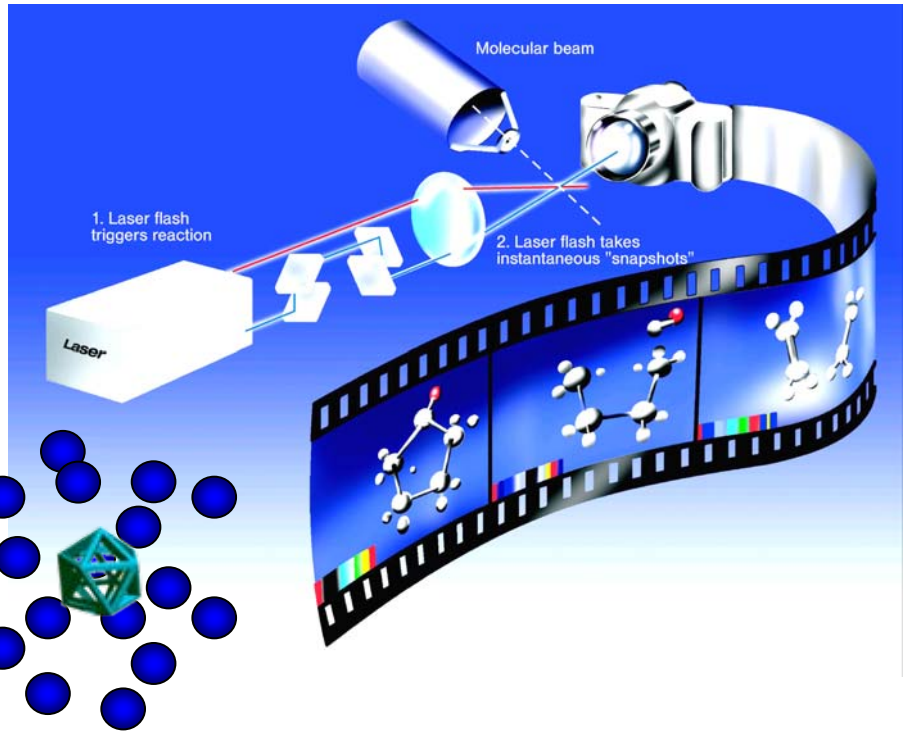
very high brilliance and very low emittance SR source, mainly for hard X-rays

Worldwide smallest emittance: 1 nmrad

Undulators: 14

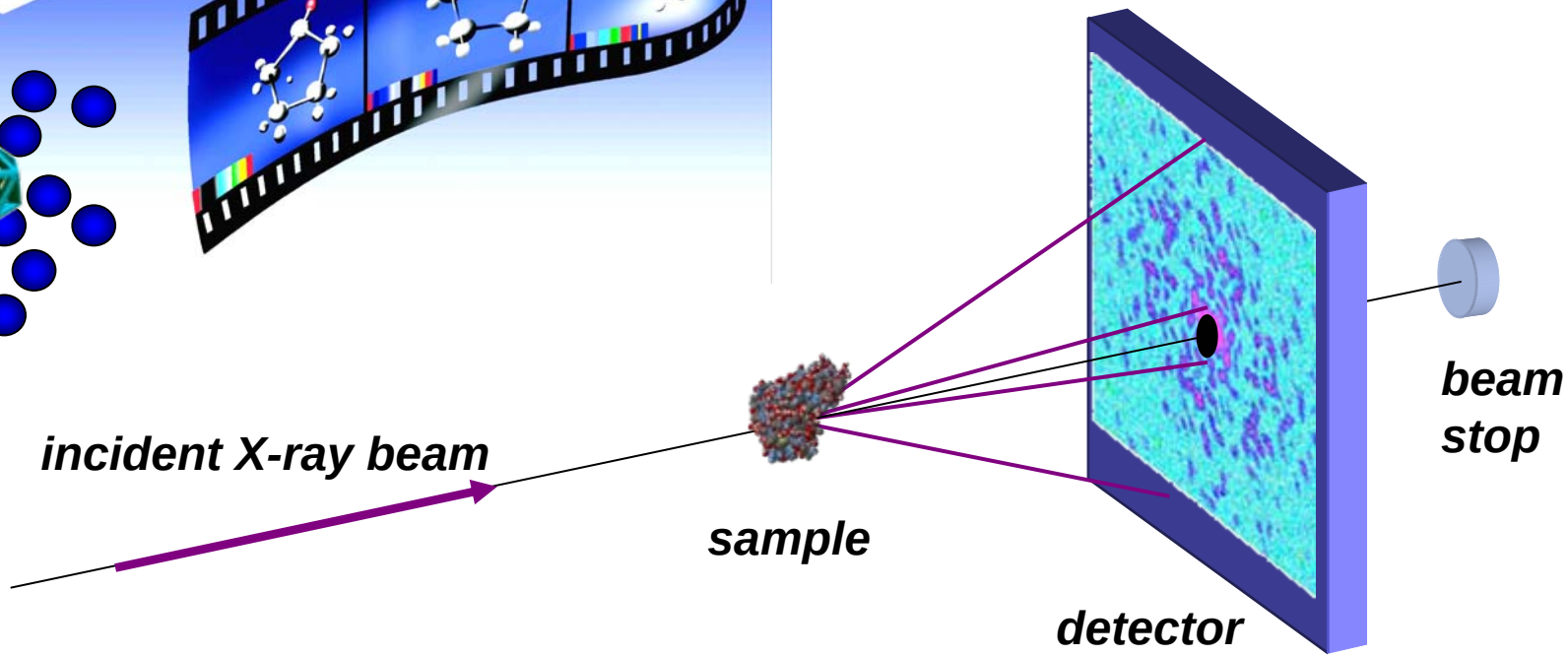
Photon energy [keV]

Diffraction: From Static to Dynamics



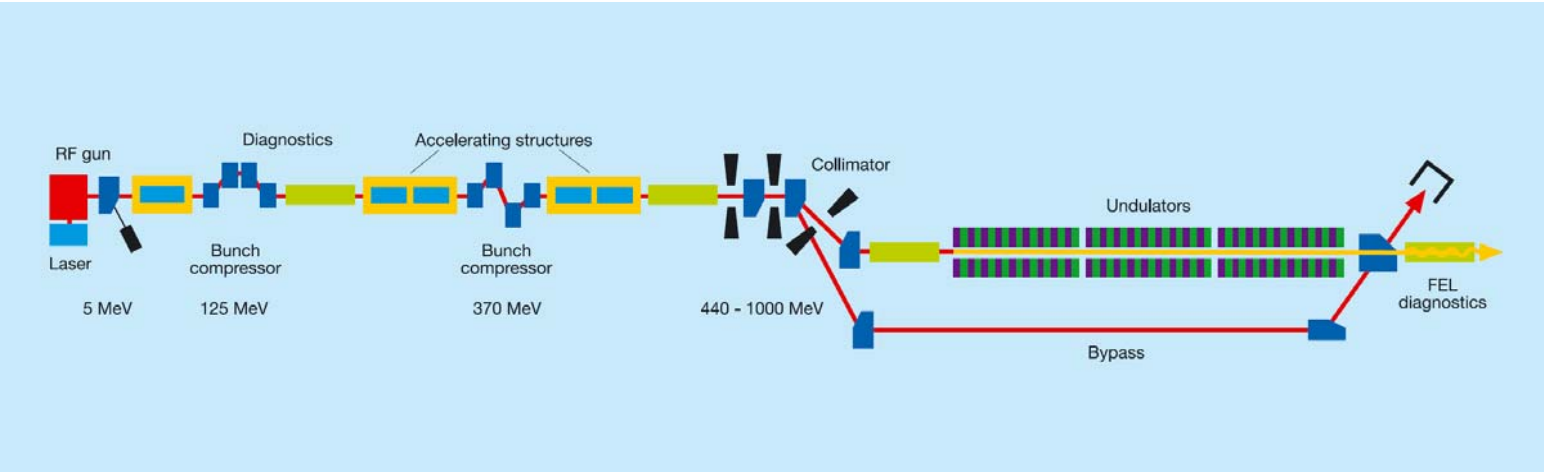
Realtime holograms of motion of atoms, molecules and electrons

on nature's time scale

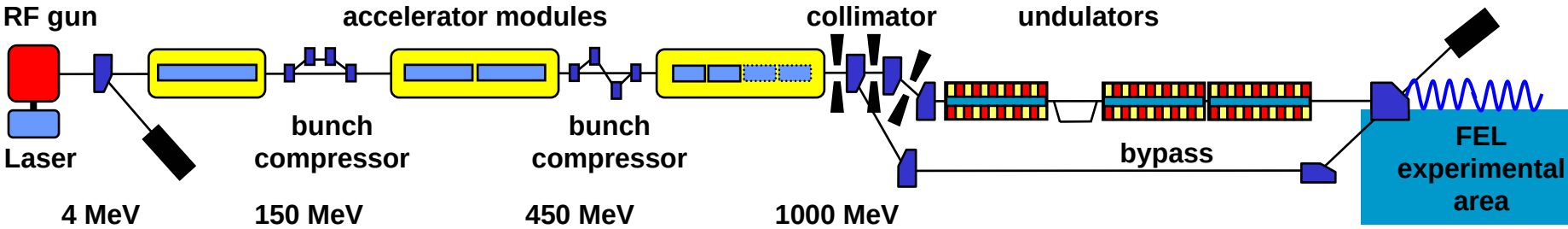


FLASH

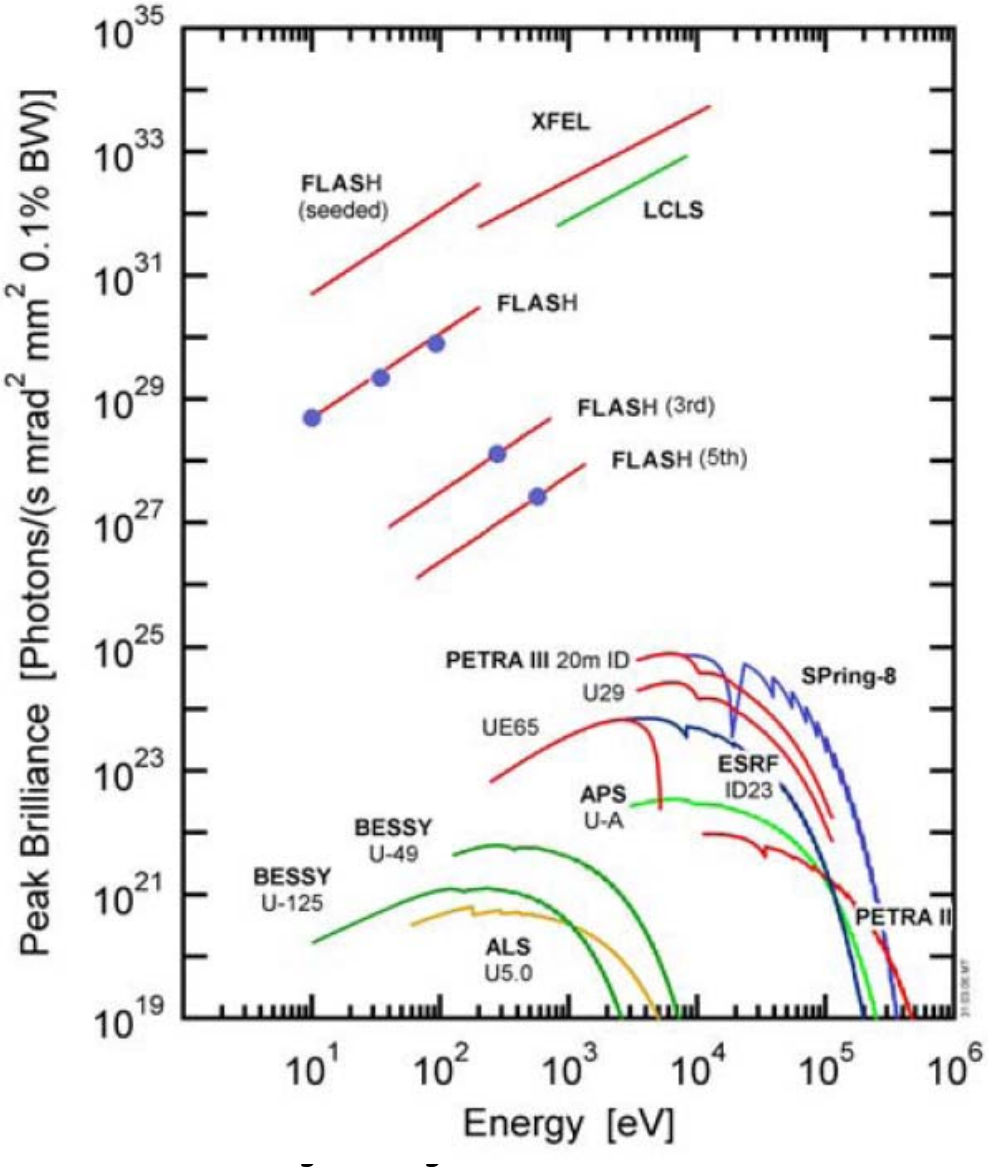
- FLASH is worldwide the first Free Electron Laser producing ultra-intense, ultra-short, coherent radiation in the EUV and soft X-ray domain
- FLASH offers thereby unique research possibilities to understand non-equilibrium states of Matter at Atomic Resolution in Space and Time
- FLASH is in all respects (accelerator technology, beam physics, FEL-process and user operation) a pilot facility for the European XFEL



The FLASH FEL as Prototype for the XFEL



Peak Brilliance at FLASH (measured) and XFEL



Peak brilliance of XFELs vs. 3rd generation SR light sources

Blue dots = experimental performance of VUV-FEL

Radiation contains a pronounced contribution of higher harmonics, shorter wavelengths

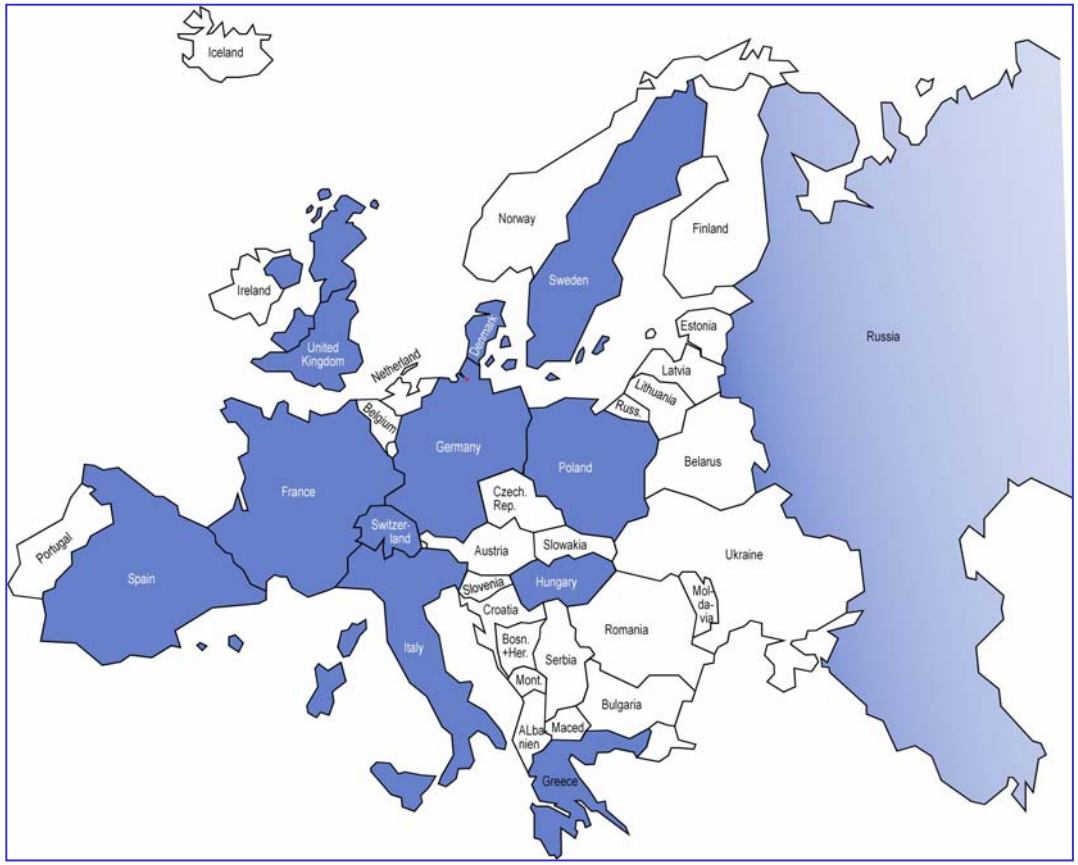
Unique selling point for XFEL:
Very high average brightness

The European XFEL

- Proposal Oct. 2002 – X-ray FEL user facility with 20 GeV superconducting linear accelerator in TESLA technology
- Approval by German government Feb. 2003 as European Project
- Commitment for 60% of funding (Bund & Länder Hamburg, Schleswig-Holstein), 40% European & international partners

Status of European XFEL Project

- At present: preparatory phase at European Level (scientific/technical & administrative/financial)
- 13 countries have signed a Memorandum of Understanding for the preparatory phase (China, Denmark, France, Germany, Greece, Hungary, Italy, Poland, Russia, Spain, Sweden, Switzerland, United Kingdom).

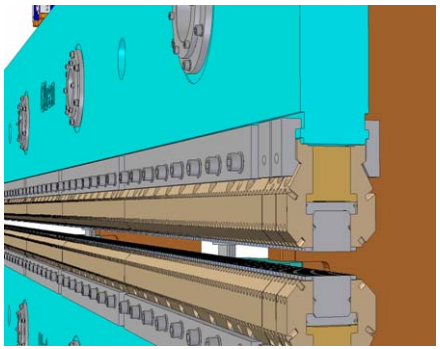


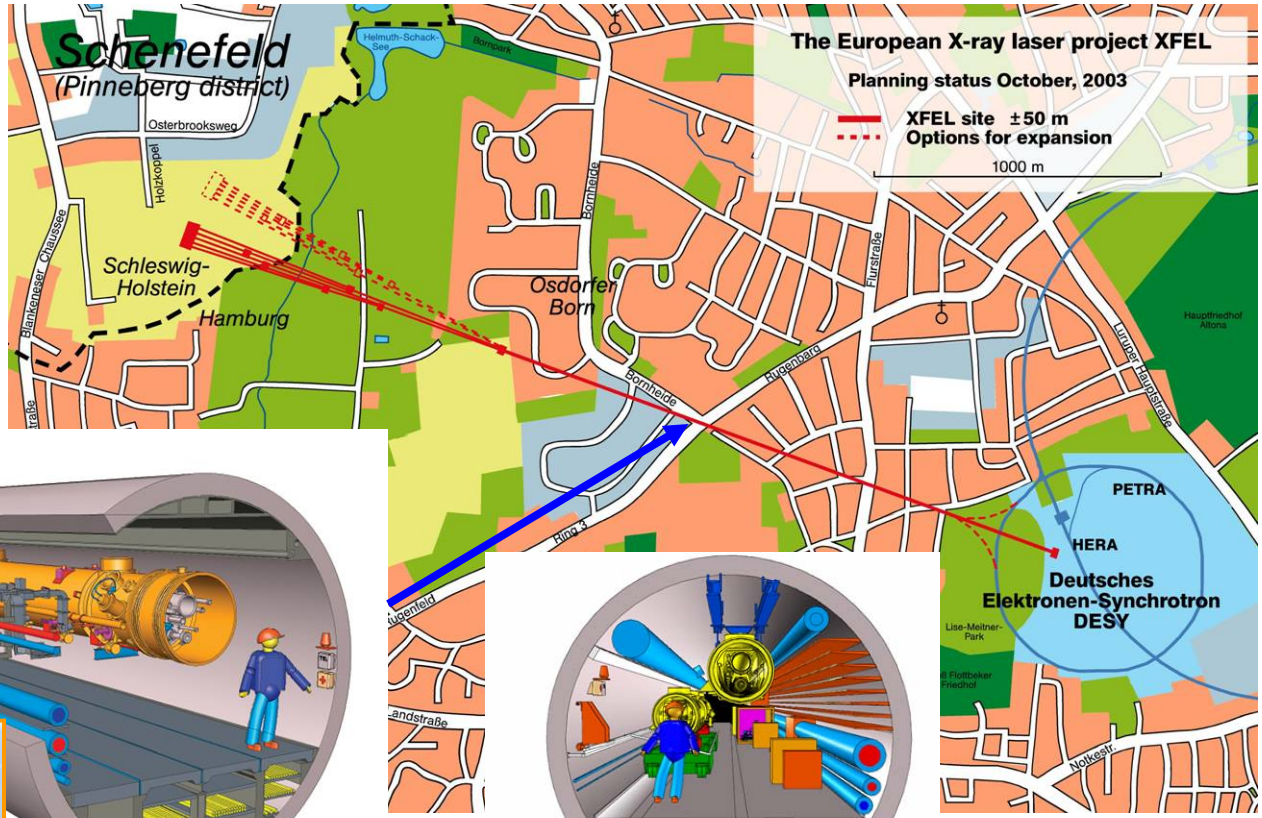
XFEL – Official Launch

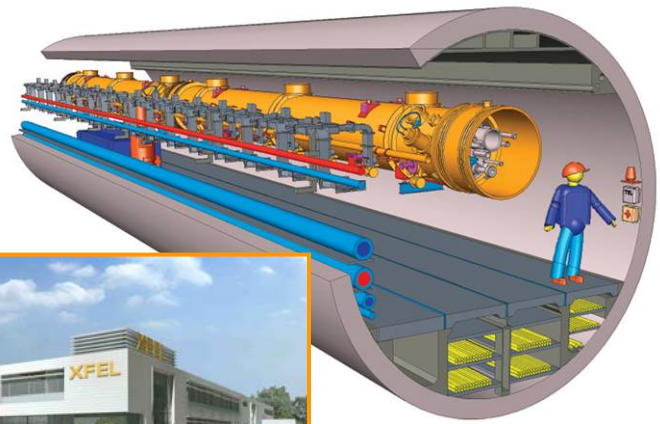
- XFEL Launch on 5 June 2007

First beam in 2013,
all beamlines operational in 2015

XFEL

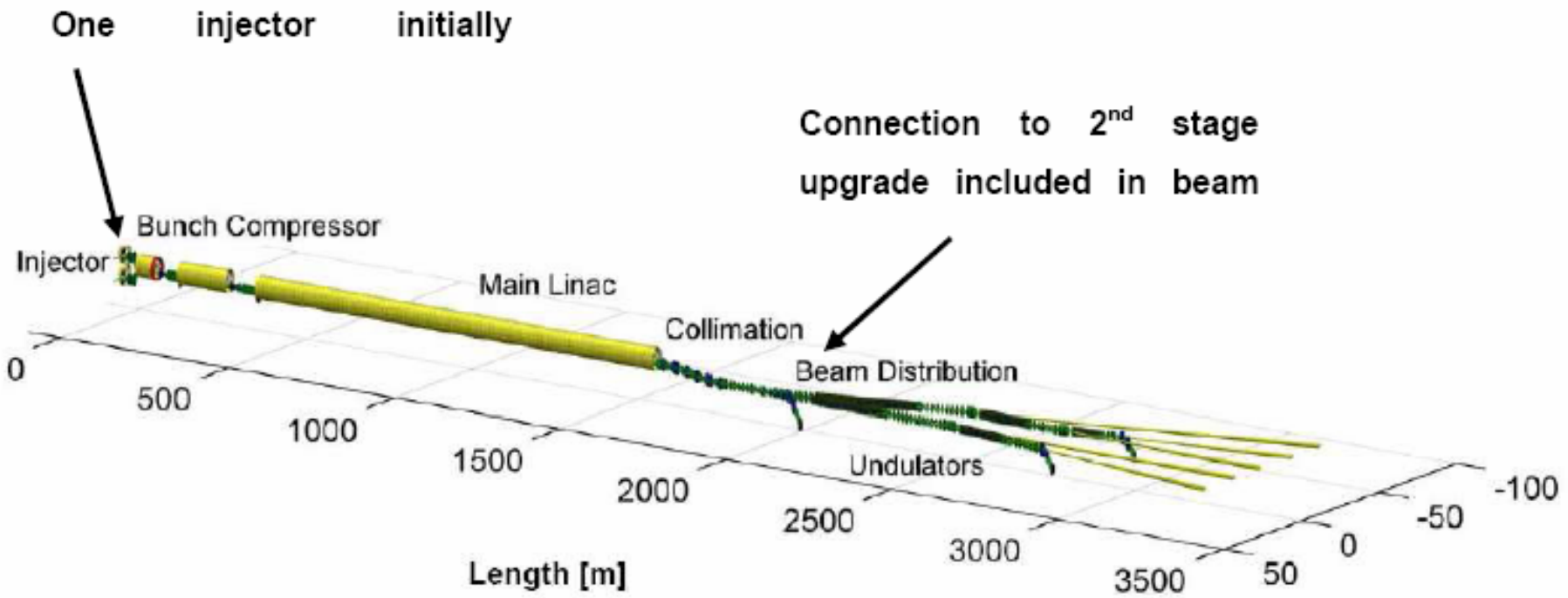



3.4km
Schenefeld
(Pinneberg district)
Osterbrooksweg
Holzkoppel
Blankeneser Chaussee
Schleswig-
Holstein
Hamburg
Helmuth-Schack-
See
Bornheide
Osdorfer
Born
Flurstraße
Hugenbarg
Ring 3
Lurupe Hauptstraße
Hauptfriedhof
Altona
The European X-ray laser project XFEL
Planning status October, 2003
XFEL site ±50 m
Options for expansion
1000 m
PETRA
HERA
Deutsches
Elektronen-Synchrotron
DESY
Lise-Meitner-
Park
Nolkestr.



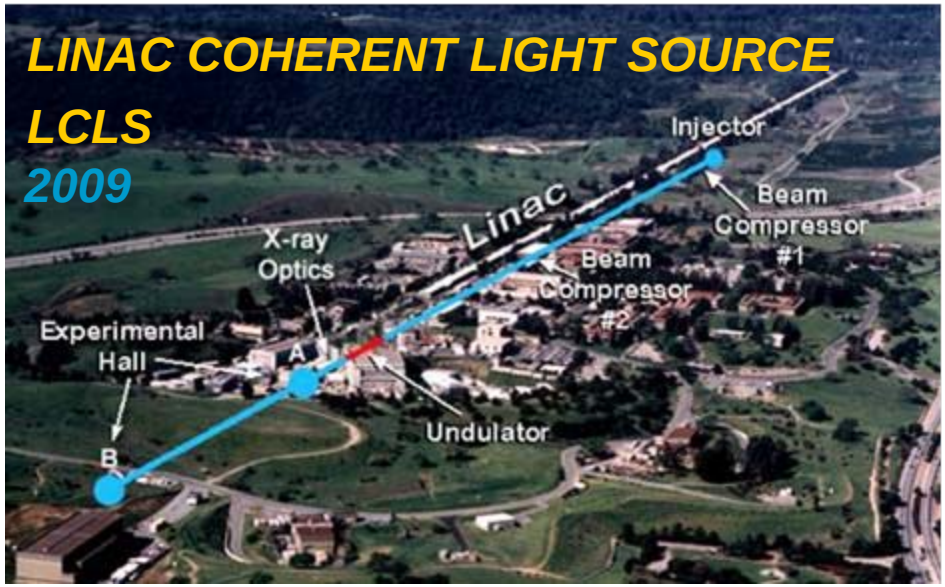

XFEL

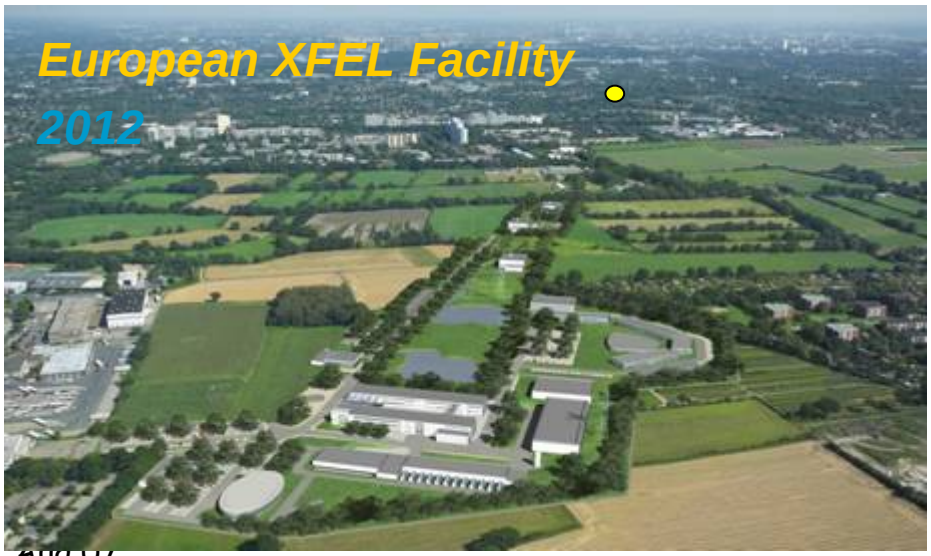
Layout of the European XFEL



Energy for 0.1nm wavelength *(max. design energy)*	17.5 GeV *(20 GeV)*
# of installed accelerator modules	116
# of cavities	928
Acc. Gradient (104 active modules) at 20 GeV	23.6 MV/m
# of installed RF stations	29
Klystron peak power (26 active stations)	5.2 MW

Hard X-ray SASE Free Electron Lasers



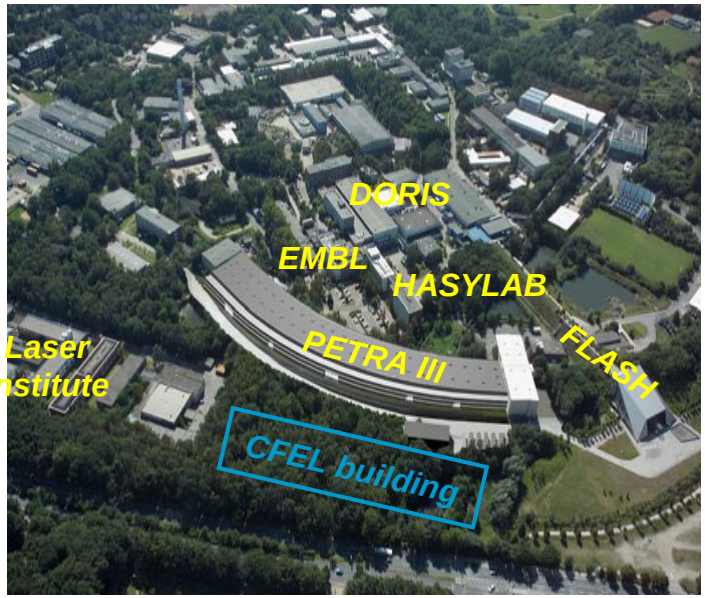


Center for Free-Electron Laser Science

- CFEL
  - Bundles and focuses competences for research and applications of FELs
  - Will have a strong interdisciplinary component
  - Will stimulate a broad application of FEL-technologies in science
  - Provides a platform and base for German users
  - Provides training and education

- First two (W3) offers
  (DESY/Uni) and (MPG/Uni)

- CFEL-building (donated by HH) in 2010



Center for Free-Electron Laser Science

Center for Free-Electron Laser Science (CFEL)

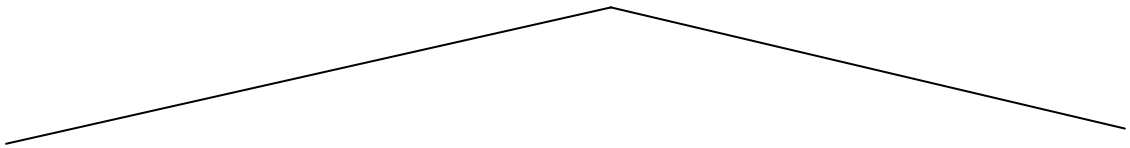
MPG, DESY, and University of Hamburg

MPG	MPG	MPG	DESY	DESY	DESY	Univ. HH
Advanced Study Group I	**Core Group I** **Experim.**	**Core Group II** **Experim.**	**Core Group III** **Theory**	**Core Group IV** **Experim.**	**Core Group V** **Experim.**	**Advanced Study Group II**
Ullrich	*Junior Research Group I*	*Junior Research Group II*	*Junior Research Group III*			**Wurth** Johnson
Rost						Drescher
Strüder						Klanner
Schlichting						Rübhausen
Techert						Roßbach Khan

geplant ~300 Leute

Future Perspectives: Centre in Structural Biology

- Helmholtz Centre and Partners



Helmholtz Centres:	Partners:
DESY	EMBL
HZI	MPG
Other Helmholtz Health Centres	Universities (HH, Lübeck,..)
	WGL – Borstel, ..

EMBL HH Outstation Review, Feb 07:

Panel strongly endorses for EMBL HH to become incorporated in new HH centre for structural biology …

Strategy for Particle Physics

Strategy:

- remain a leading and attractive particle physics lab
- maintain a strong theory group in particle physics

- HERA running until mid 2007
  data analysis (far) beyond 2009

- LHC participation in ATLAS and CMS, Tier2 centre

- ILC centre at DESY (central role through all phases
  and in all aspects)

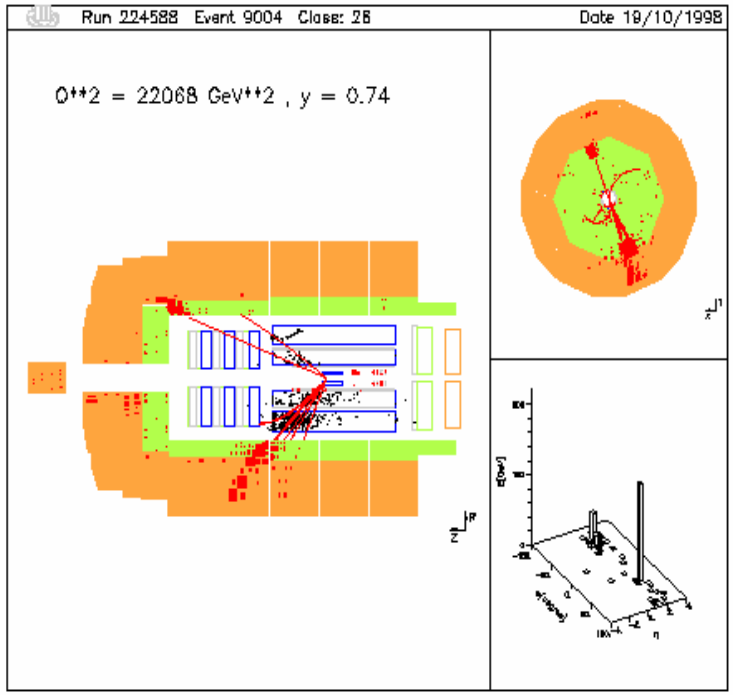
- fulfill role towards German Universities in particle physics

HERA

HERA: Microscope - unique world-wide - with a resolution of 1/1000 of proton radius (10^{-18} m)

Questions:

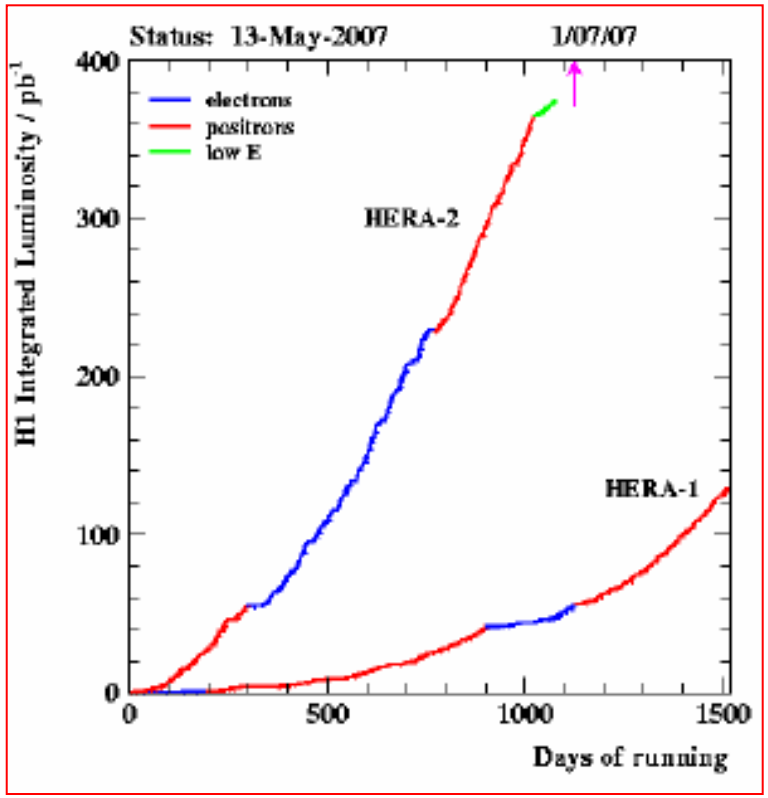
- How big are electron and quark
- What is the proton made of
- Which properties do the fundamental forces have
- What is the origin of spin
- Are there new phenomena



First collisions in 1992

End of Operation 2007

HERA



HERA data taking ended on 30 June 2007

Terascale and Cosmology

Increasing energy corresponds to earlier times in the universe.

True also in collisions in accelerators

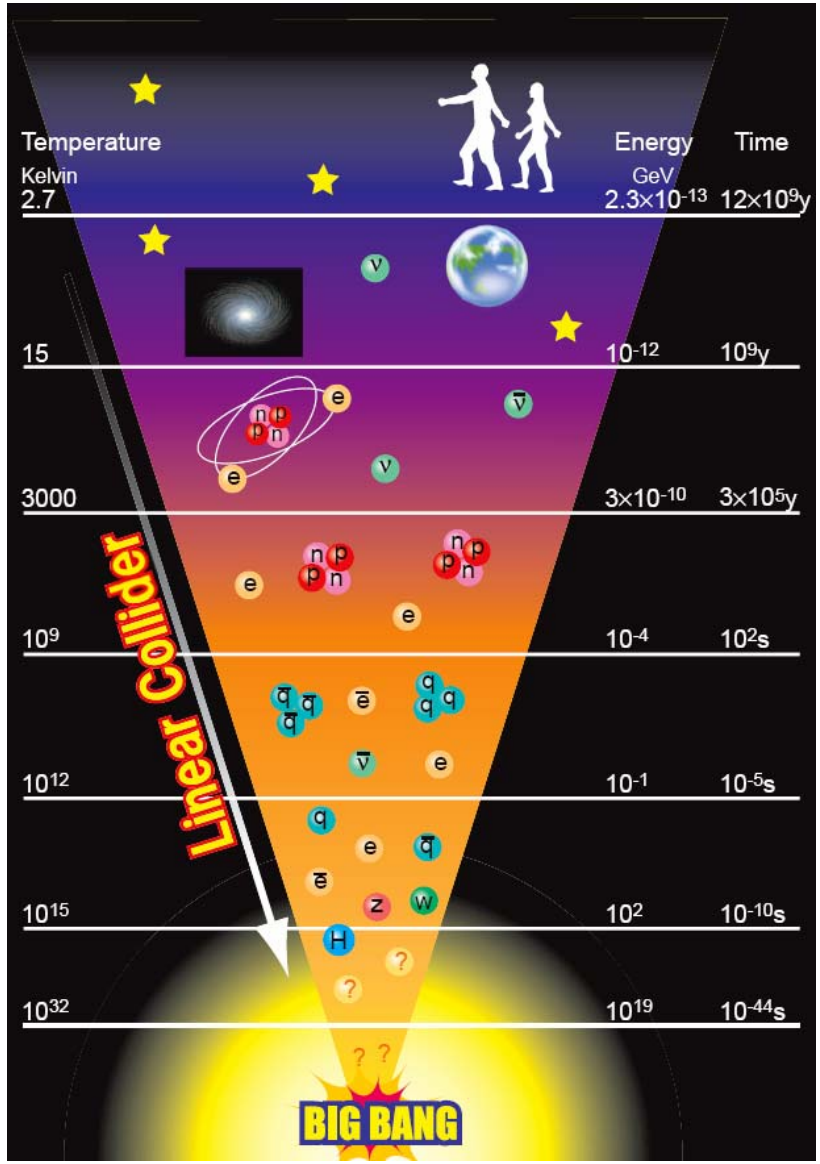
The Terascale (1 TeV) corresponds to 10^{-12} s after the Big Bang.

Expect dramatic new discoveries there.

The accelerators probing the Terascale

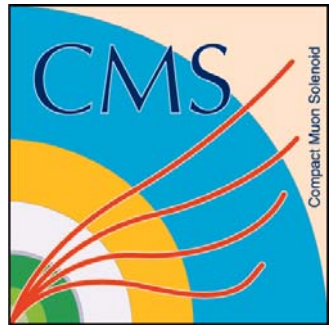
- Large Hadron Collider (LHC) and
- International Linear Collider (ILC)

are like telescopes viewing the earliest moments of the universe.



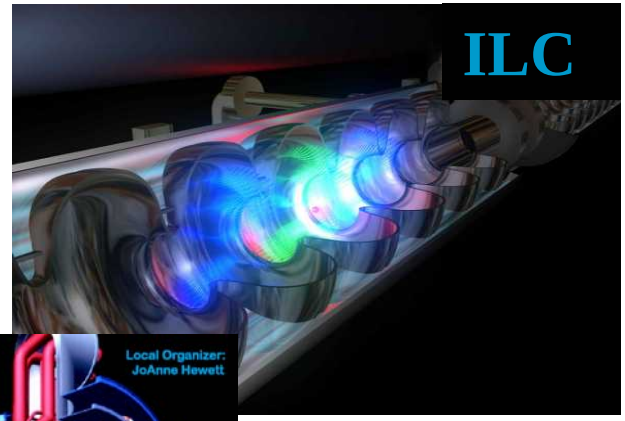
DESY at the LHC - A bit of History

- In Spring 2005 DESY decided to participate in the LHC experimental program
- During summer 2005 a group evaluated the possibilities
- Both experiments (ATLAS & CMS) welcomed the participation of DESY
- In November 2005 DESY decided to join both ATLAS and CMS



Participation in the LHC

- Natural continuation of HERA programme
- Ideal preparation for physics at the ILC
- Synergy also with/for DESY theory group



TIER2 Analysis Centre for ATLAS and CMS

Active participation in ATLAS and CMS

Theory and apeNEXT

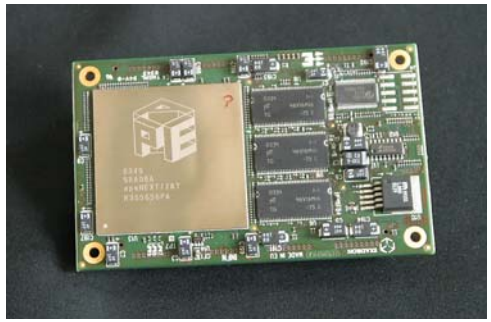
Developed in international cooperation (D, F, I), massif parallel architecture.

Optimized for special computing requirements in Lattice Gauge theories

First apeNEXT rack in fall 2005 in Zeuthen.

Today three racks installed in Zeuthen a computing performance of 2.5 TFlops

Simple pocket calc:	~10 Flops
modern PC:	~10^9 Flops
apeNEXT (Zeuthen):	2.5×10^{12} Flops



DESY is part of Helmholtz Computing Initiative/Strategy

International Linear Collider

- Worldwide technology decision in 2004: TESLA Technology
- „Baseline" Design Configuration
  - Many elements of the Main Linac correspond to the XFEL design (except gradient)
  - FLASH and XFEL experience and future work (industrialization)

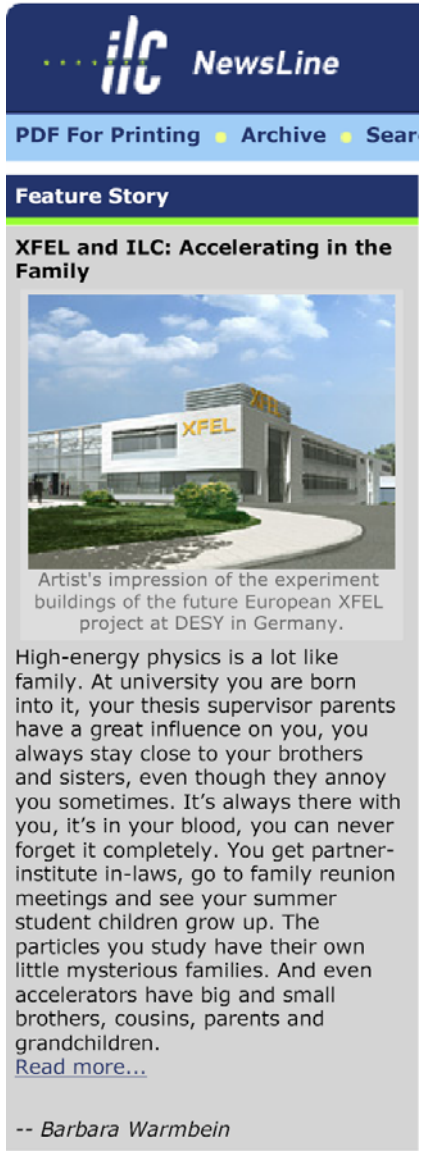
- DESY actively involved in Global Design Effort
- Reference Design Report including costs were presented in February 2007

Internationaler Linear Collider Activities at DESY

DESY ILC Project Group combines

- Theory
- Detector development
- Accelerator
  - Close contact to XFEL, synergy

Important support by EU
DESY coordinates EuroTeV, EuDet
EU-research programmes


ilc NewsLine

PDF For Printing • Archive • Sear

Feature Story

XFEL and ILC: Accelerating in the Family

Artist's impression of the experiment buildings of the future European XFEL project at DESY in Germany.

High-energy physics is a lot like family. At university you are born into it, your thesis supervisor parents have a great influence on you, you always stay close to your brothers and sisters, even though they annoy you sometimes. It's always there with you, it's in your blood, you can never forget it completely. You get partner-institute in-laws, go to family reunion meetings and see your summer student children grow up. The particles you study have their own little mysterious families. And even accelerators have big and small brothers, cousins, parents and grandchildren.
Read more...

-- Barbara Warmbein

ILC@DESY: SCRF

- Major contribution remains synergetic activities with the XFEL
  - High-gradient EP programme
  - Module 6 represents state-of-the-art, and will be tested on new Module Test Stand.
  - Current industry studies for XFEL prototypes will provide critical information for ILC, and prepare European industrial base.
  - Tunnel installation considerations using XFEL mock-up will also be of benefit
  - European ILC cryomodule cost estimate is the most mature of the regions, and has been re-evaluated in light of XFEL experience.
  - Klystron and modulator development (again strong industrial involvement)

ILC@DESY: SCRF

- FLASH linac provides unique facility for TESLA technology studies
  - General operational experience
  - Diagnostics development
    - eg HOM measurements, a good example of international collaboration with ILC groups
- LLRF development
  - Large overlap and good collaboration with ILC community.
- Alternative cavity R&D
  - Single crystal and large-grain material R&D (XFEL funded)
  - Hydroforming and spinning of cells
- And the list goes on….

Strategy for Astroparticle Physics

Strategy:

Experimental Scientific Focus: Origin of high energy cosmic rays, through neutrino messengers

- Analysis of data from Baikal and Amanda
- 3. year deployment of Icecube has just started (7 strings so far)

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

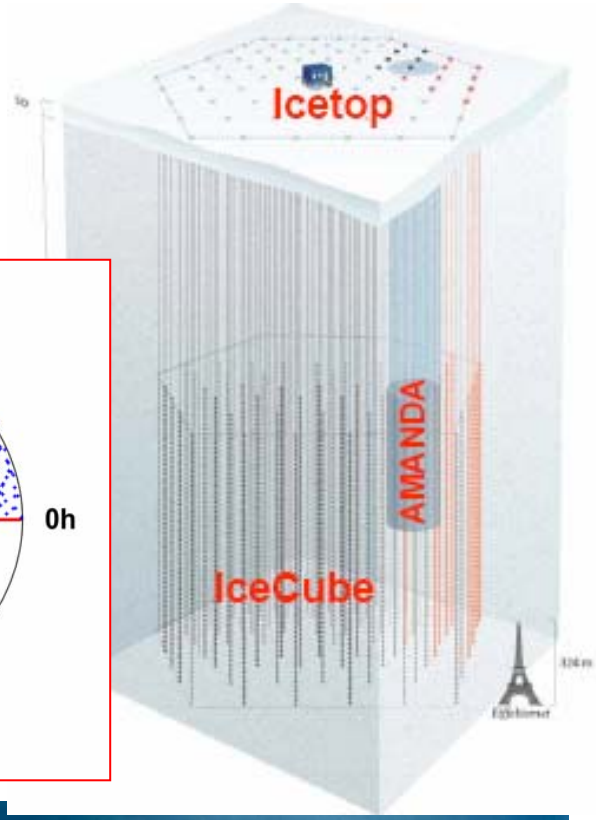
Close collaboration with German universities

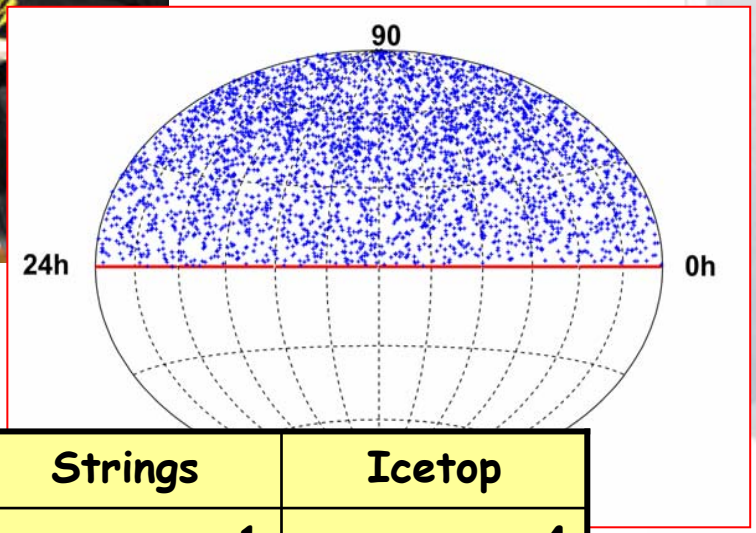
Experimental astroparticle activities are presently mainly located in Zeuthen

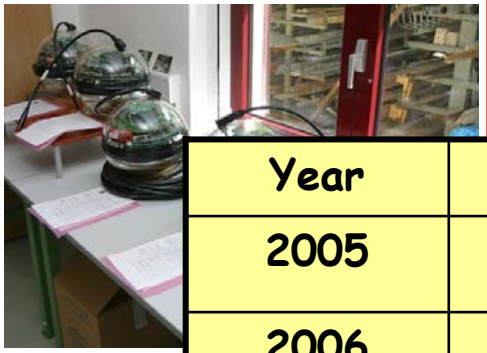
Theory in HH: Linking particle physics and cosmology

Neutrino Astrophysics

Icecube





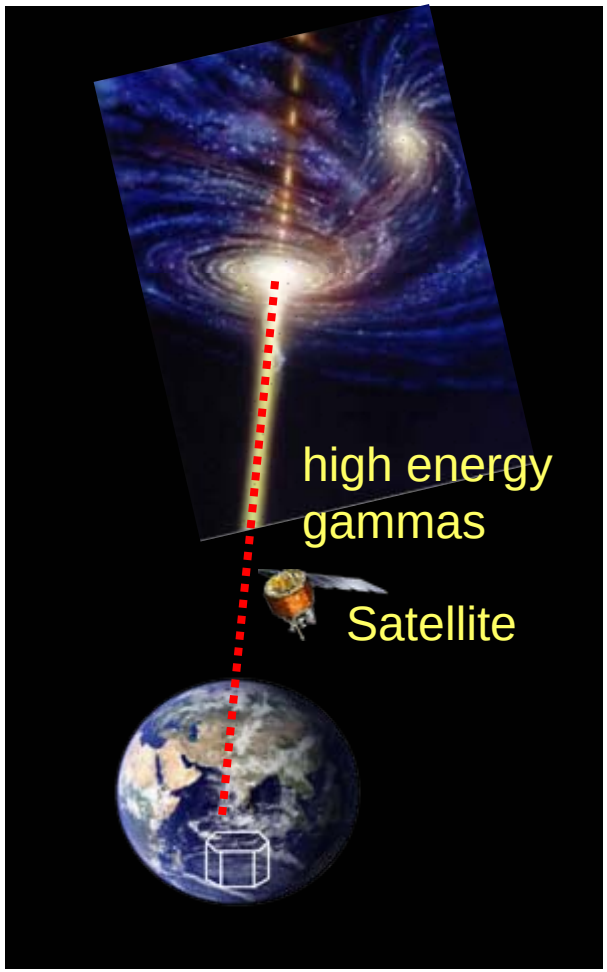


Year	Strings	Icetop
2005	1	4
2006	8	12
2007	12-14	10
2011 Sum	70-80	70-80

ICECUBE will i
antactic ice to

IceCube

DESY-Zeuthen group is committed to produce 1300 optical modules (DOM) in total. 260 have been produced in 2006, more than scheduled.



Multi-Messenger Point Source Studies

- Search for coincident neutrino and high energy gamma signals from point sources in IceCube and γ - telescopes
- Increase discovery potential of IceCube

Summary Particle /Astroparticle Physics

- HERA has entered the finishing year with great strength
- LHC involvement progressing
- The operation of FLASH and the preparation of the XFEL construction continuously provide important input for the ILC
- SCRF development
- Detector R&D is being pursued in international collaborations
- Astroparticle physics with Icecube

Summary: Photon Science on the DESY Campus

- DESY in-house research at its user facilities (DORIS, FLASH)
- Institute for Experimental Physics of Hamburg University
- EMBL Hamburg Outstation
- MPG Unit for Molecular Structural Biology
- Institute for Laser Physics of Hamburg University

- Centre for Free Electron Laser Studies (DESY, MPG, Uni HH)
- HGF Bio-Centre at DESY
- Partnership with the European XFEL Facility

… all using a variety of excellent light sources

Research Facilities at/with Involvement of DESY