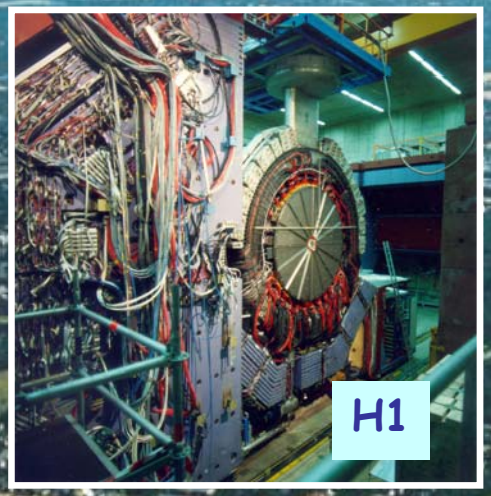
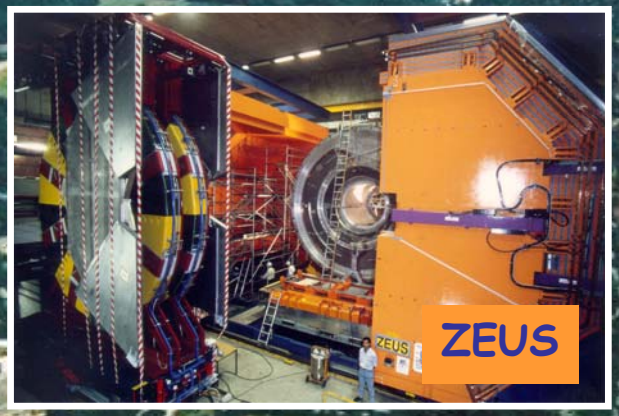
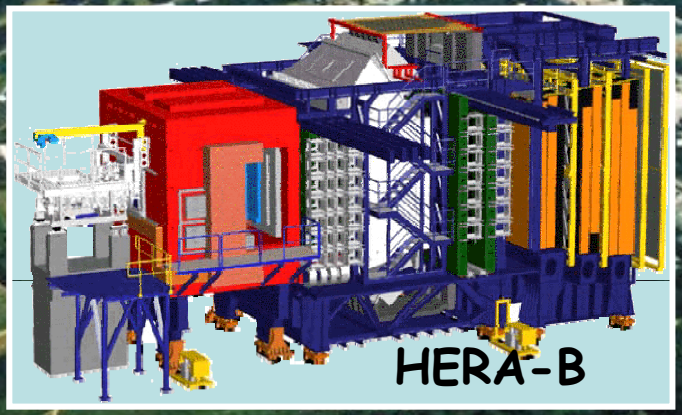
HERA and beyond



HERA

PETRA





Particle physics at DESY

HERA and beyond

- HERA – the end of an era
  - Some results
- Particle Physics at DESY after HERA

F. Willeke on 30 June 2007 at 23:30

The Beginning

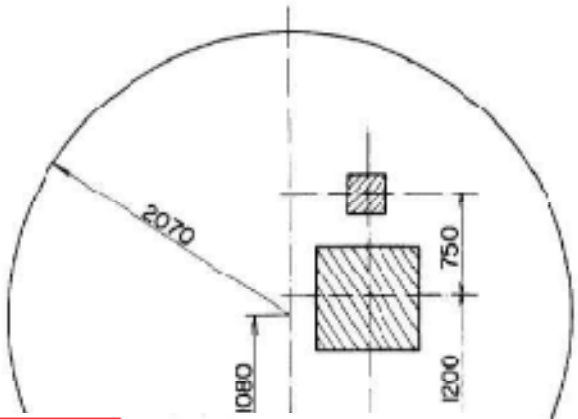
IEEE Transactions on Nuclear Science, Vol.NS-24, No.3, June 1977

AN e-p FACILITY IN THE CERN SPS

R. Billinge, H. Hoffmann, A. Hofmann, K. Hübner, A. Hutton,
K. Johnsen, E. Jones, B.W. Montague, B.H. Wiik*, C. Zettler
CERN
Geneva, Switzerland

CHEEP

A 25 GeV electron (or positron) storage ring installed in the SPS tunnel above the proton synchrotron would provide e-p collisions with a luminosity in the range of 10^{31} to 10^{32} cm^{-2} s^{-1}. The collisions would normally take place at an intermediate plateau of the SPS-cycle up to 270 GeV, and could be followed by acceleration and extraction of the proton beam for fixed target experiments. The feasibility of such a facility is demonstrated and the essential features presented.



ECFA recommends strongly the construction of this machine at DESY and welcomes the possibility of its being used by the European community."

The recommendation was unanimously approved.

27th Plenary
ECFA, 9.5.1980

A Model for International Projects - HERA

Accelerator was built with man-power and in-kind contributions from Italy, France, Poland, China
➔ 1/3 of the investments contributed from outside (excluding buildings)
HERA model

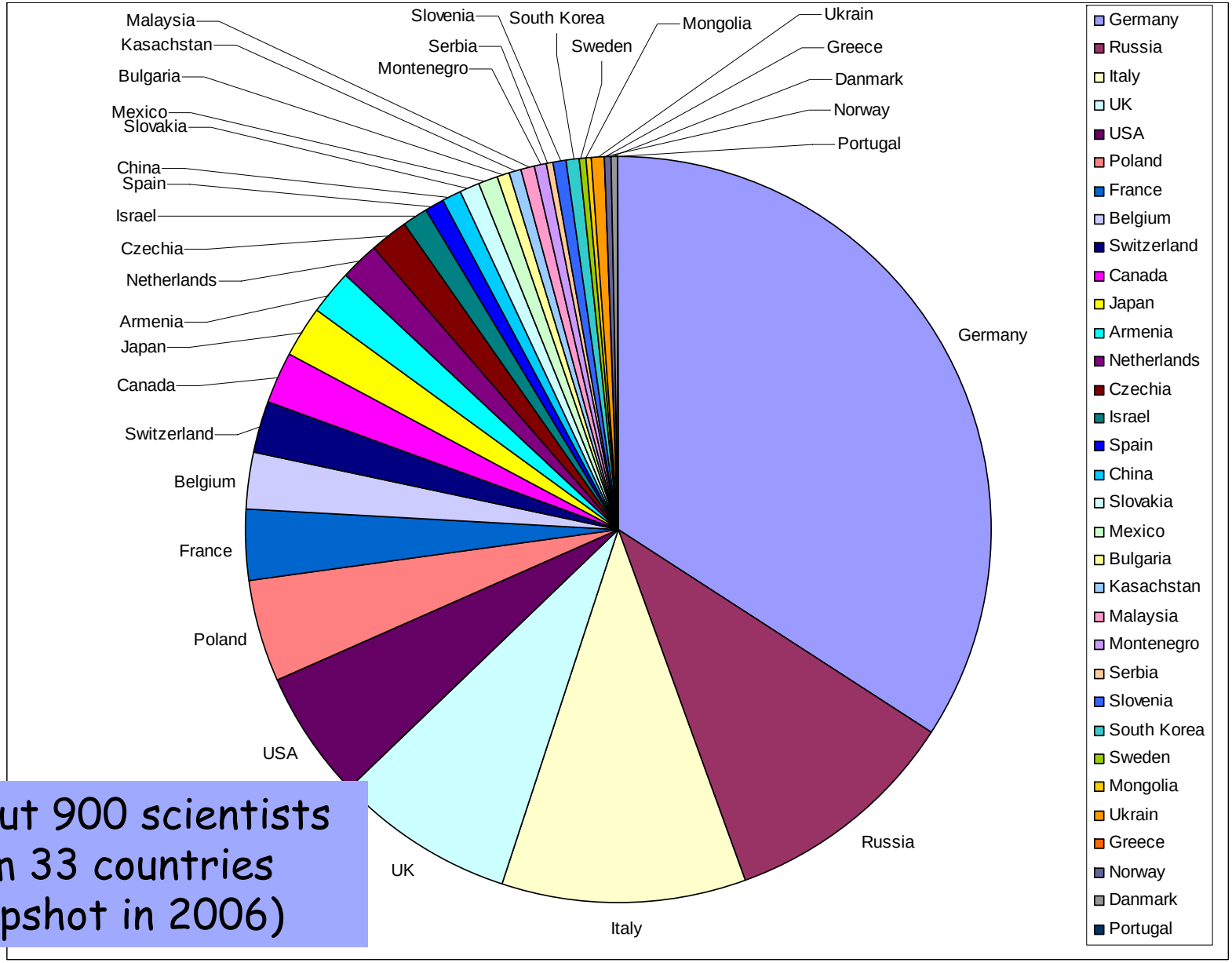
Operation is paid by Germany

Experiments were build by large international collaboration

Major international contributions to all experiments

Operation cost are shared

Particle Physics Users



About 900 scientists from 33 countries (snapshot in 2006)

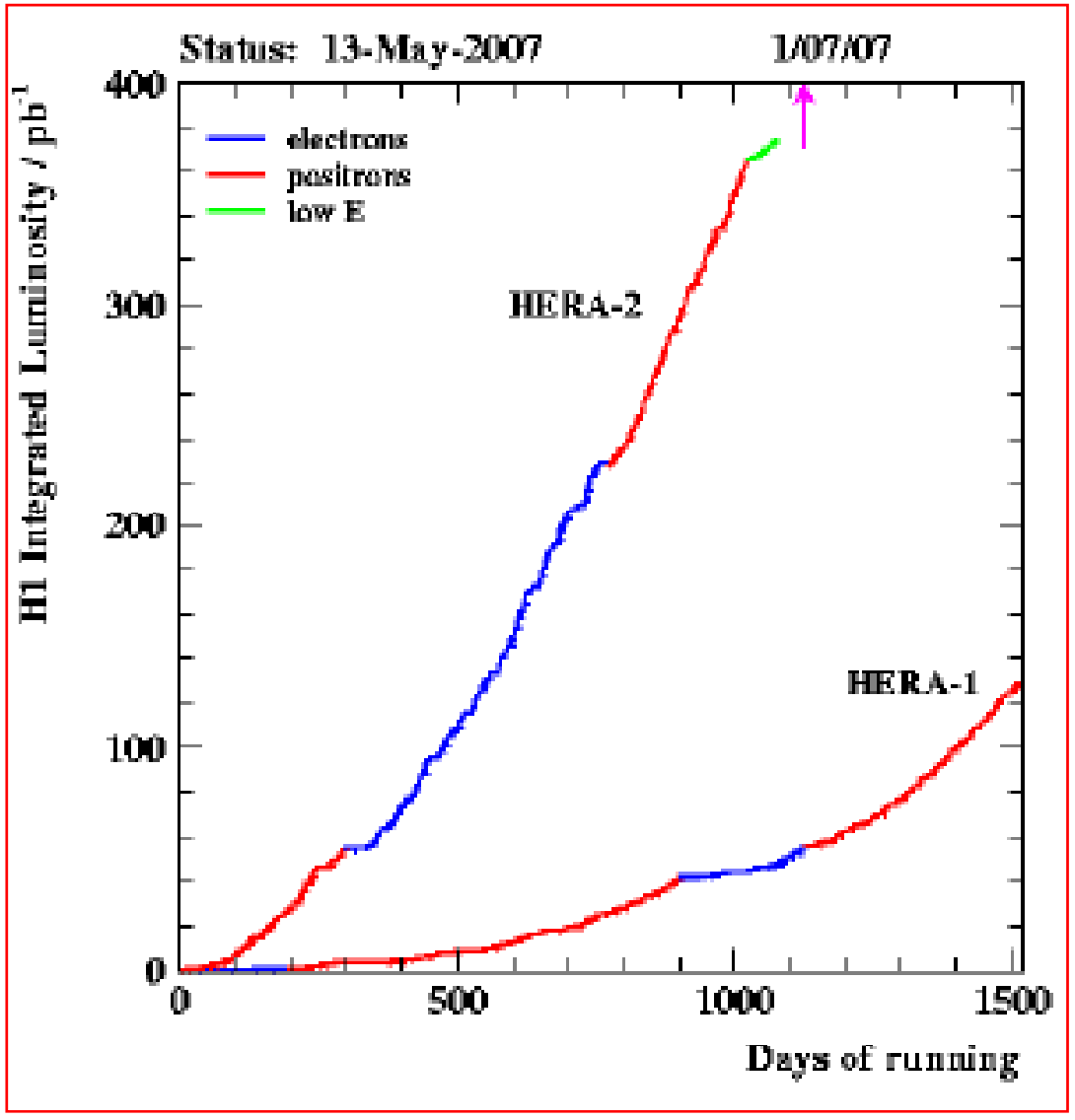
Some Milestones of HERA Construction

- 1980 Support by ECFA
- First contacts with neighbours
- 1981 Proposal
- 1984 Official 'go ahead'

- 1984-87 Civil Construction
- 1988-90 Mass production SC magnets
- 8.1988 first stored e-beam
- 9.1990 Installation completed
- 4.1991 Commissioning of p-ring at 40 GeV
- 10.1991 Collider commissioning

- 1992 Start of luminosity operation
- 6.2007 End of run

HERA Harvest



Overall luminosity goal reached

Low energy run added and successful

Many lessons learned during

- Operation and
- Luminosity upgrade

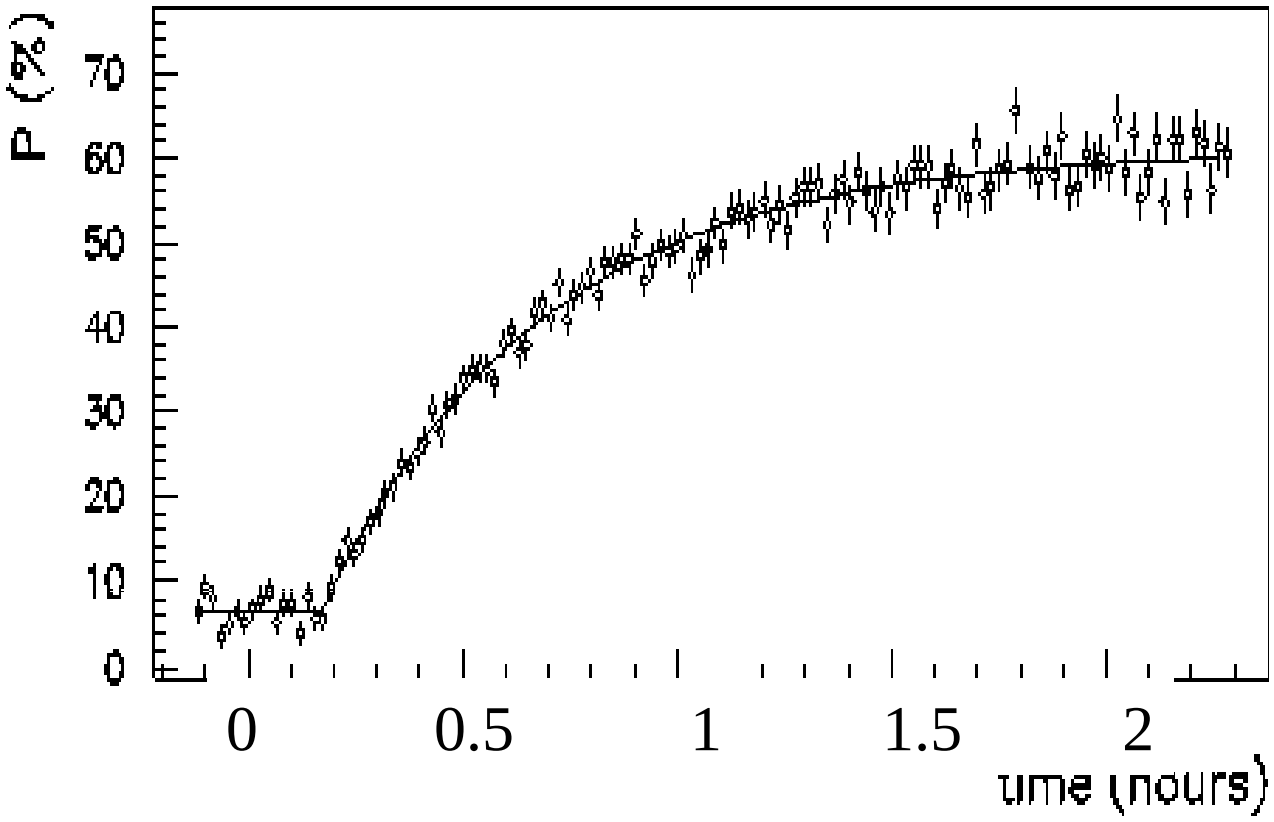
They should find their way into LHC commissioning and operation

Polarisation

In HERA the electron beam becomes polarised due to synchrotron radiation (Sokolov-Ternov effect)

Spin rotators turn the spin from transverse to longitudinal for HERMES

They were used for HERMES, H1 & ZEUS



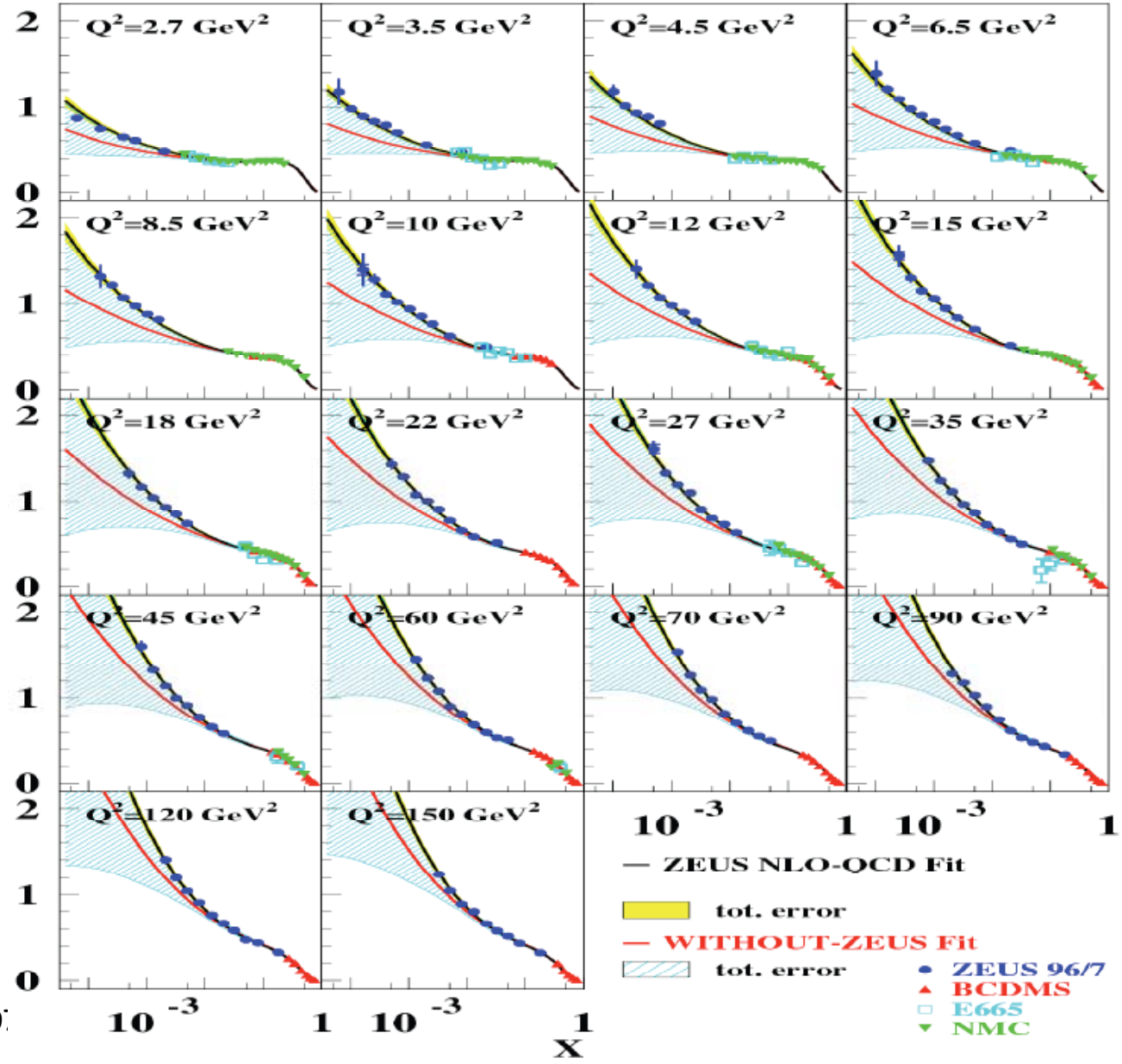
Impact of HERA on Knowledge of SFs

F_2 vs x for different Q^2 without/with HERA

First HERA result:
Density of soft partons (gluons) in proton rises steeply with decreasing x

Lesson: QCD works

Knowledge of SFs is of vital importance for LHC physics



Albrecht Wagner, P ECFA, 30.11.0

A Combined Fit to Data

Combined fit to H1/ZEUS data

Experiments 'cross-calibrate' each other

Systematic errors largely compensate

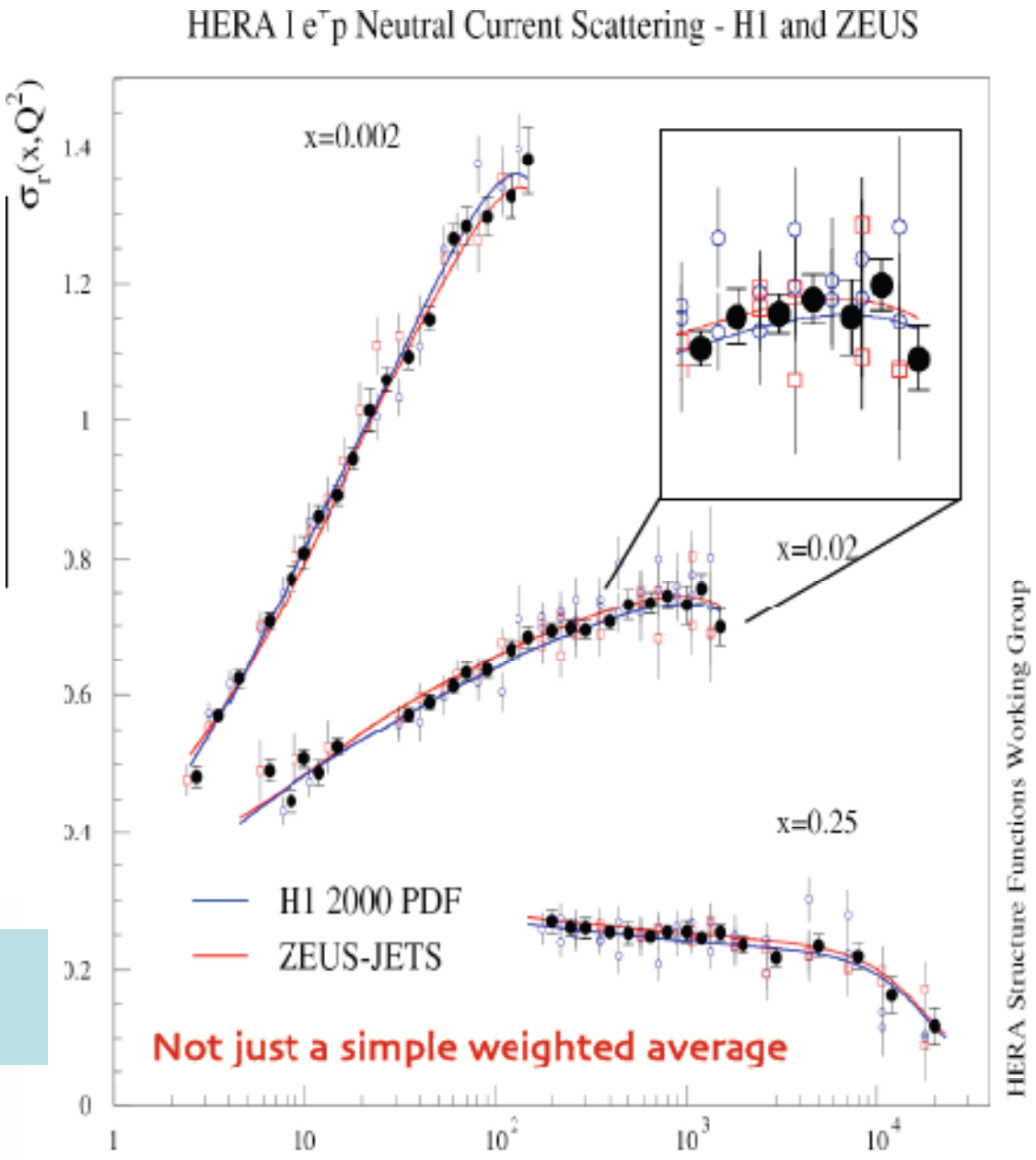
Gain in accuracy > sqrt 2

Lesson:

Complementary design of experiments pays off

now 7 combined working groups established

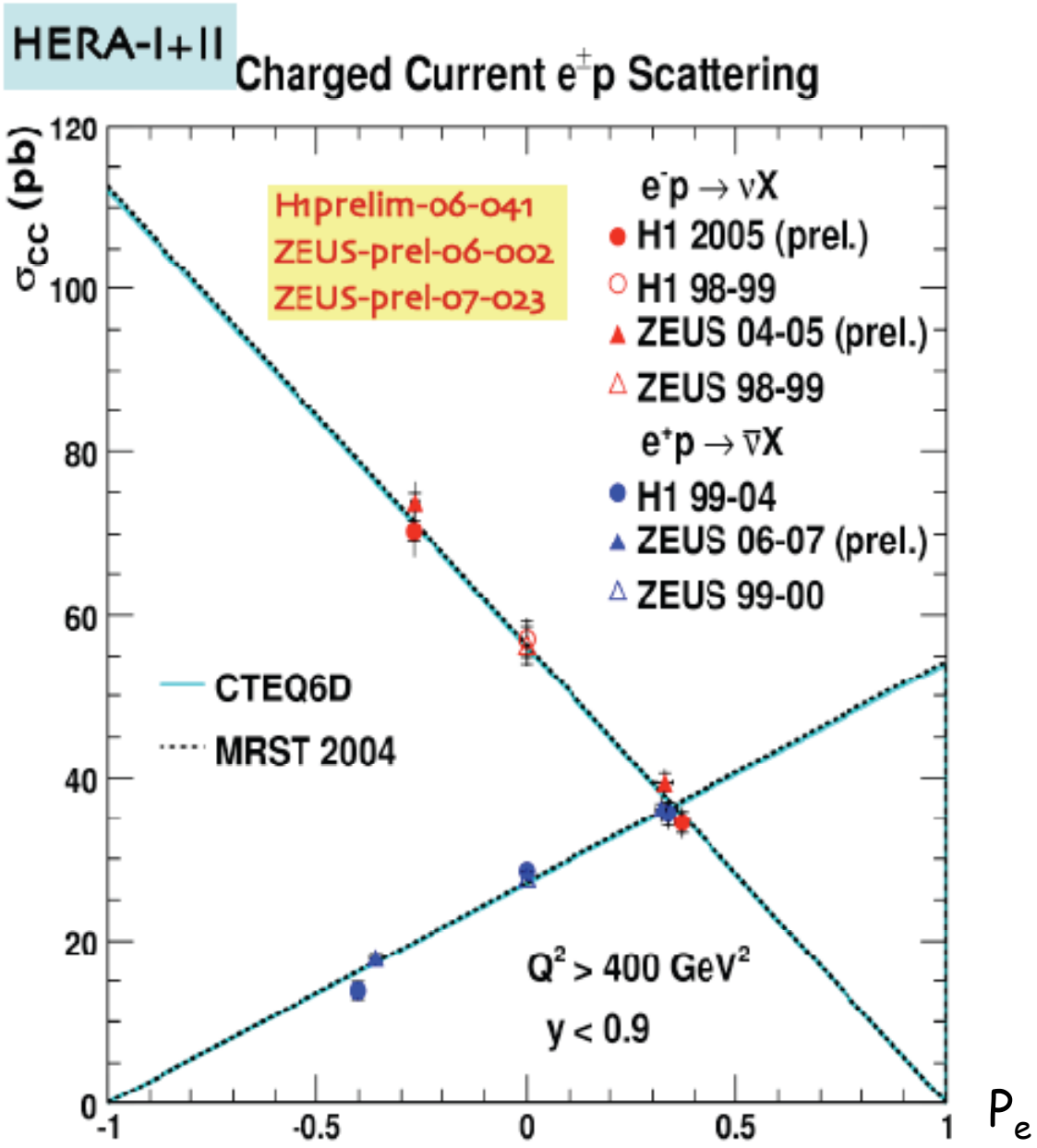
Albrecht Wagner, P ECFA, 30.11.07



Polarisation Dependence of CC cross section

H1/ZEUS:

- Polarised beams of e^+/e^- allow textbook measurements of charged current
- No right handed CC observed, in agreement with Standard Model



Searching beyond the Standard Model

HERA also sensitive to many kinds of new physics - leptoquarks, R-violating Supersymmetry, etc., but not Higgs (only light particles).

For many of these HERA is comparable to or more sensitive than LEP, Tevatron.

Some signals for unexpected physics:

- Leptoquarks
- high p_T leptons

They came and went, and were all statistical fluctuations which went away with more accumulated data

Lesson:
Statistics of small numbers needs to be watched

Two Fixed Target Experiments

HERMES: What makes the Proton spin?

With polarised electrons + by tagging quark types, HERMES determines contribution of different quarks to p-spin

Goal: Flavour separation of quark and antiquark helicity distribution

In addition: Measurements of other SFs, (e.g. transversity), L_q, ΔG

HERMES achieved significantly more than promised

HERA-B: Goal was 1st observation of CP violation in B decay

Advantages of hadronic option: high bb rate, existing accelerator

Challenge: For every interesting bb event, there are $10*10^9$ uninteresting events

Bad surprises: rapid aging of tracking chambers, -> additional R&D -> 2 year delay, leading to redefining the scope

Several measurements of particle production properties to help complete the picture of hadronic (pA) interactions (s, c, b)

100 students completed PhDs with HERA-B data

Summary

- HERA has operated for 15 years
- The luminosity goals were reached
- It has provided a wealth of data, in support of the Standard Model
- Many results will enter the text books
- The data from HERA concerning the proton structure will be of major importance for LHC
- Highly cited

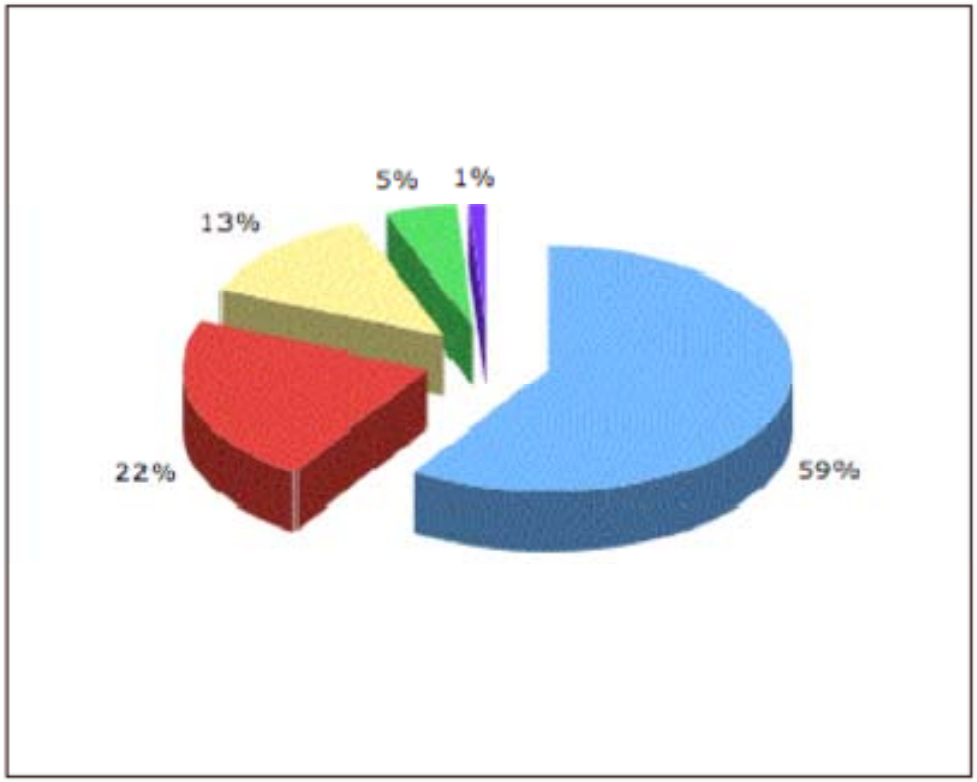
HERA Fest

More than 1,000 Physicists
About 1,000 Ph.D.'s
About 400 Physics Publications

Career Impact

Students in ZEUS

Total of 346 diploma and 343 Phd students - some overlap among them (information from the majority of the Institutes). For some of these (239) we know that:



141 are Postdocs or staff

53 are Professors

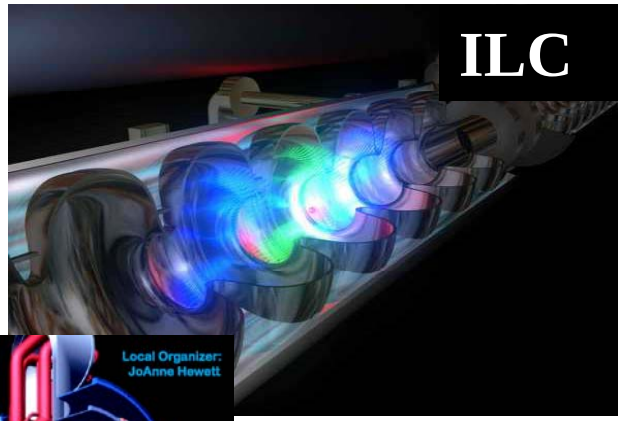
31 have leading positions outside HEP

11 founded a company with <10 people (limited info)

3 founded a company with>10 people (limited info)

DESY after HERA - Participation in the LHC

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



Active participation in ATLAS and CMS

DESY/CMS group

- General:
  - Management involvement: 2 Scientists
  - Coordination tasks: 5 Scientists
  - The group continues to grow, presently:
    2 dipl., 7 PhD students, 5 PostDocs, 21 staff
- Activities:
  - Higher Level Trigger
  - Data Quality Monitoring
  - Computing & Software
  - Tracker Alignment (close coll. Uni HH)
  - Participation in construction & installation of the CASTOR Calo
  - Beam Radiation Monitor
  - Physics
  - Coming up: R&D sLHC

DESY/ATLAS group

- General:
  - ALFA (absolute Lumi measurement), MC generator support.
  - Young investigator group joined.
  - The group continues to grow, presently:
    13 dipl., 7 PhD students, 13 PostDocs, 11 staff, 1 J.Prof (Uni HH)
- Activities:
  - Trigger configuration
  - Trigger monitoring
  - Development of showering simulation algorithms
  - Technical maintenance of MC generator interfaces
  - Participation in construction & installation of ALFA
  - Distributed data management: exercising ATLAS grid tools (e.g. GANGA) & providing extensive user feedback
  - Physics
  - Coming up: R&D sLHC

Computing for LHC-Experiments: Tier2

- 3 average Tier 2's (Atlas) and 1.5 average Tier 2 (CMS) are requested for Germany

- DESY commitment: 1 av. Tier 2 for CMS
- 1 av. Tier 2 for Atlas
- 1 av. Tier 2 for LHCb

- Aachen commitment: 0.5 average Tier 2 (CMS)
- Uni. of Freiburg, Wuppertal, LMU Munich & MPIfP (Atlas)
- Desy's Tier 2 is distributed between Hamburg and Zeuthen

- Set up a National Analysis Facility

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 to improve on:

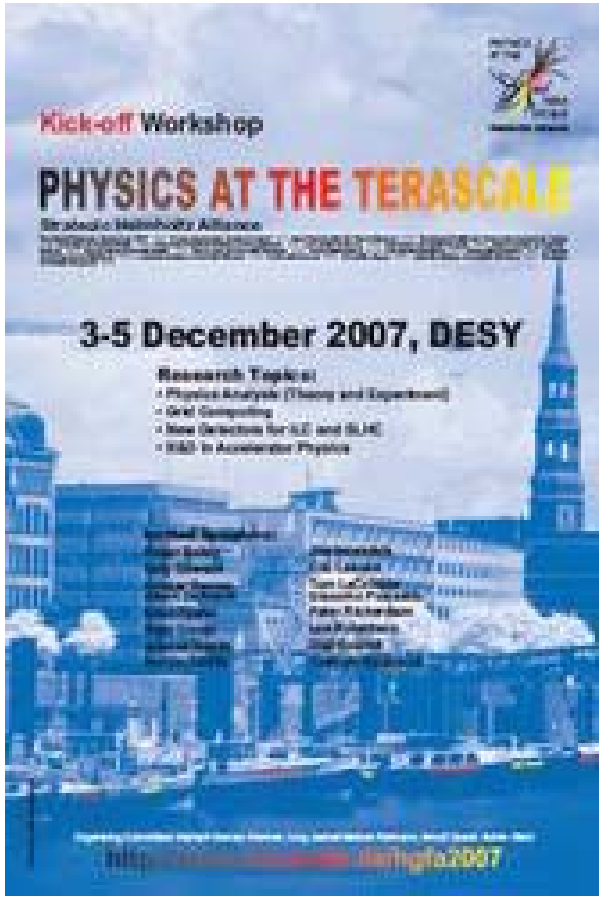
Helmholtz Alliance
Physics at the Terascale

Approved	May 2007
Started	July 2007
Kick-off Workshop	3-5 December 2007

Creates strong network between German University groups and DESY:

- establishes DESY as analysis centre in D for LHC analysis and ILC preparation
- DESY as partner in a Grid backbone
- DESY as partner in detector infrastructure
- DESY helping to establish accelerator physics courses at Universities

DESY's particle physics activities are embedded in the framework of this Alliance



Related Recent News

October 2007

Helmholtz-Russia Research Group (HERA + LHC + ILC)

November 2007

Two new Young Investigator Groups (Helmholtz) approved

- ATLAS (in Zeuthen) in collaboration with HU Berlin
- CMS (in Hamburg) in collaboration with Univ. HH

HiGrade negotiations with EU (FP7)

International 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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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

DESY ILC Activities

R&D activities:

- Infrastructure (test beam)
- Pixel
- TPC
- analog HCAL
- FCAL

Detector concept:

ILD (with increased collaboration with Japan)

DESY activities are funded from many sources:

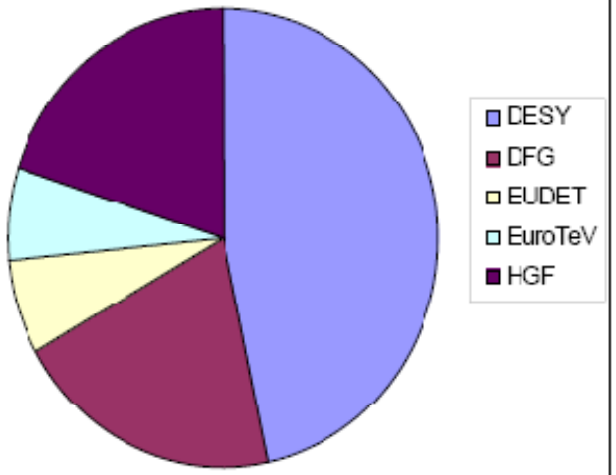
funding

- DESY own funds
- 2.5 young investigator groups (1.5xHGF, 1xDFG)
- EUDET
- HGF-Alliance

Distribution of physicists manpower at DESY-HH

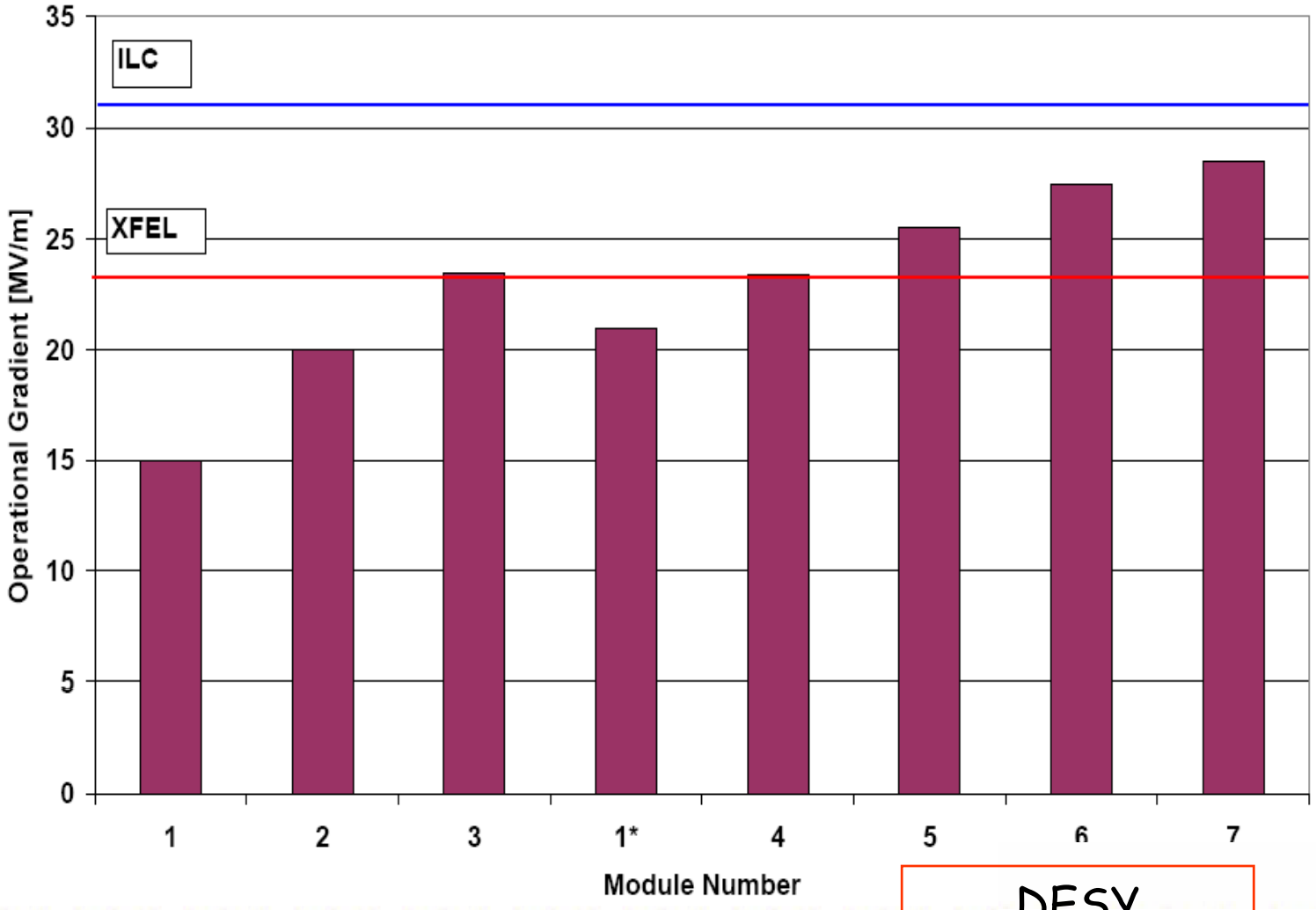
(students not included)

Detector group (HH only)



All activities: DESY 60% / third party 40%

Module Test – Results



DESY

Research with Photons

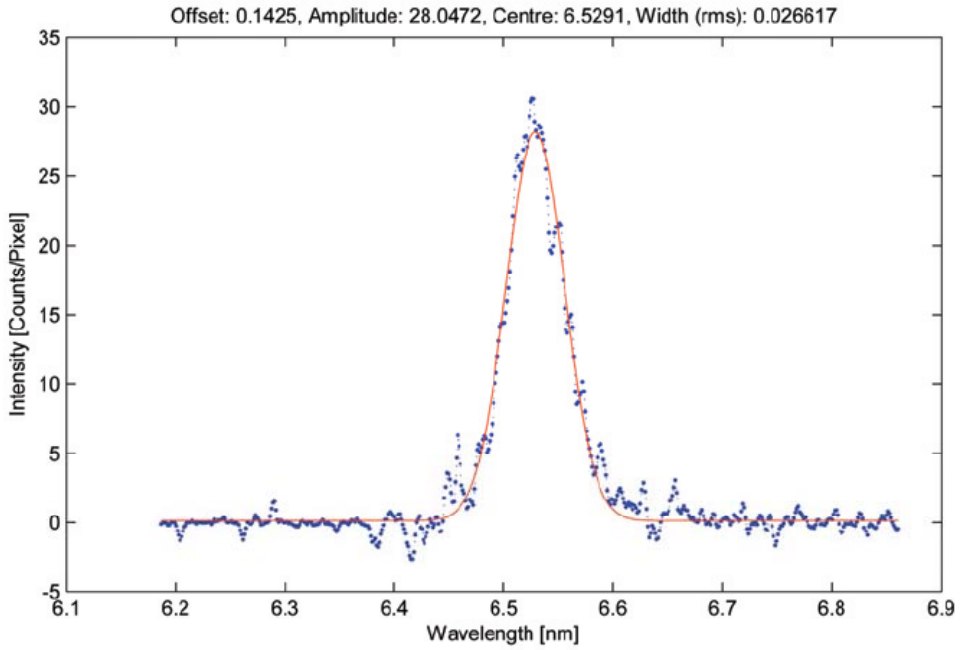
Make leading edge research possible in physics, chemistry, material science, biology etc. through unique light sources:

- 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

Lasing at 6.5 nm

FLASH accelerator was upgraded to 1 GeV, leading to …



centre: 6.5 nm
5 fs(!) pulse length (to be verified)
Intensity some μJ

A new world record

… and the best:

- first lasing at 80 nm (TTF1) took months
- first lasing at 6.5 nm instead of the previously reached 13 nm took hours

This demonstrates the scalability of the concept towards the XFEL.

XFEL – Official Launch

- XFEL Launch on 5 June 2007

First beam in 2013,
all beamlines operational in 2015

XFEL: which ILC questions are answered?

- how to build a 100 accelerator module linac using TESLA Technology
- how to industrialize the SCRF on a 5% ILC scale
- how to extrapolate from TTF / FLASH by a factor of 20
  Remark: ILC eq. 20 XFEL
- how to start and organize an international project based on in-kind contributions

Particle Physics 2010-2014

- DESY is member of the Helmholtz Association and with all its programs in the research area 'Structure of Matter'
- Five year funding period, presently 2005-2009
- Next funding period: 2010-2014
- In 2008 the programs (e.g. particle physics) will be defined, for evaluation in early 2009
- The key elements of the program 'Particle Physics' are:

Particle Physics Program 2010-2014

- Strong participation in 2 LHC experiments (ATLAS and CMS). Completion of precision analysis of HERA data
- Expansion of Tier2 centres and analysis centre at DESY.
- Theory in close connection with experiments, particle/astroparticle theory. string theory, lattice gauge theory (Zeuthen)
- Continued development of high gradient SCRF cavities for ILC, exploiting the synergy with the XFEL
- Detector development for sLHC and ILC, contributing to XFEL detectors
- Helmholtz-Alliance ‚Physics at Terascale'.

The program is based on the ‚European Strategy for Particle Physics', which itself is part of the ESFRI Road Map.

Future Particle /Astroparticle Physics @ DESY

- HERA has finished with great strength

- LHC involvement steadily increasing
- Helmholtz- Alliance is establishing a new structure for particle physics in Germany
- It creates novel network of excellence between all Helmholtz-, University- and MPG-institutes working at the energy frontier across the whole of Germany

- 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