



Research

at

DESY

Th. Naumann

HERA

PETRA



X International Workshop on Advanced Computing and Analysis Techniques in Physics Research



ACAT05



May 22–27, 2005, DESY, Zeuthen, Germany

Thanks ...

Topics

I. Computing Technology and Environment for Physics Research

- Parallel and Vector Computing Technologies and Applications
- Distributed Computing: Tools for the GRID
- Data Fabric and Data Management
- Online Monitoring and Control
- Software Engineering
- Graphic User Interfaces, Common Libraries

II. Data Analysis - Algorithms and Tools

- Neural Networks and Other Pattern Recognition Techniques
- Evolutionary and Genetic Algorithms
- Advanced Data Analysis Environments
- Statistical Methods
- Detector and Accelerator Simulations
- Reconstruction Algorithms

III. Simulations and Computations in Theoretical Physics and Phenomenology

- Automatic Computation Systems:
from Processes to Event Generators
- Multi-loop Calculations and Higher Order Corrections
- Multi-dimensional Integration and Event Generators
- Intensive High Precision Numerical Computations Algorithms
and Systems
- Computer Algebra Techniques and Applications

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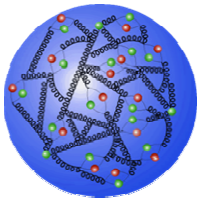


Staff: 1150

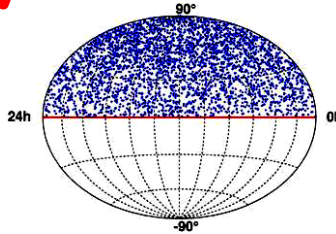
Budget: 158 M€

Hamburg/Zeuthen ~ 10/1

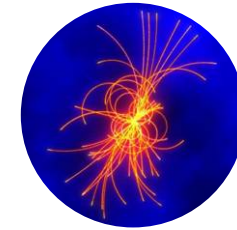
• Particle Physics



HERA

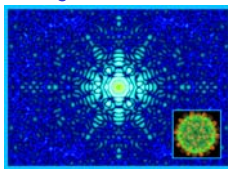


Astro-Particle Physics

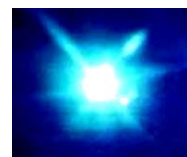


ILC

• Synchrotron Radiation



PETRA3



VUV-FEL



XFEL

- **Particle Physics Experiments**
H1+HERMES at HERA
- **Theoretical Physics**
Lattice supercomputing
- **ILC Project**
physics + detector studies

- **Particle-Astrophysics**
Baikal, AMANDA, IceCube
high energy cosmic neutrinos

- **Accelerator R&D**
develop components
for VUV-FEL + XFEL
- **PITZ:**
Photo Injector Test Facility Zeuthen



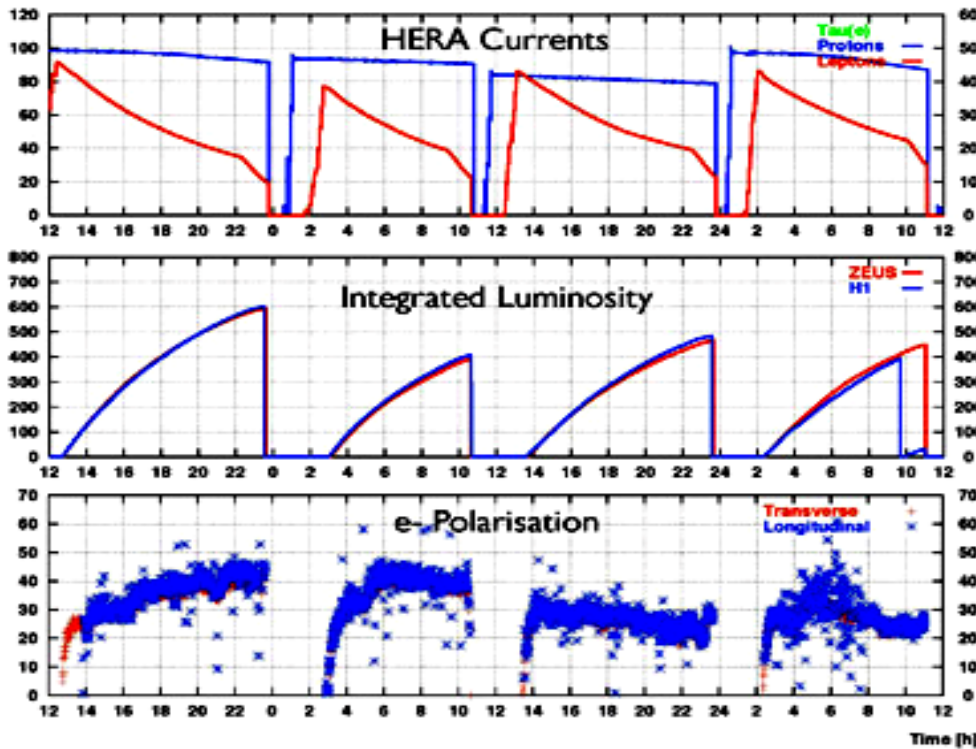
- Zeuthen well integrated in DESY
- rich program with specific flavors



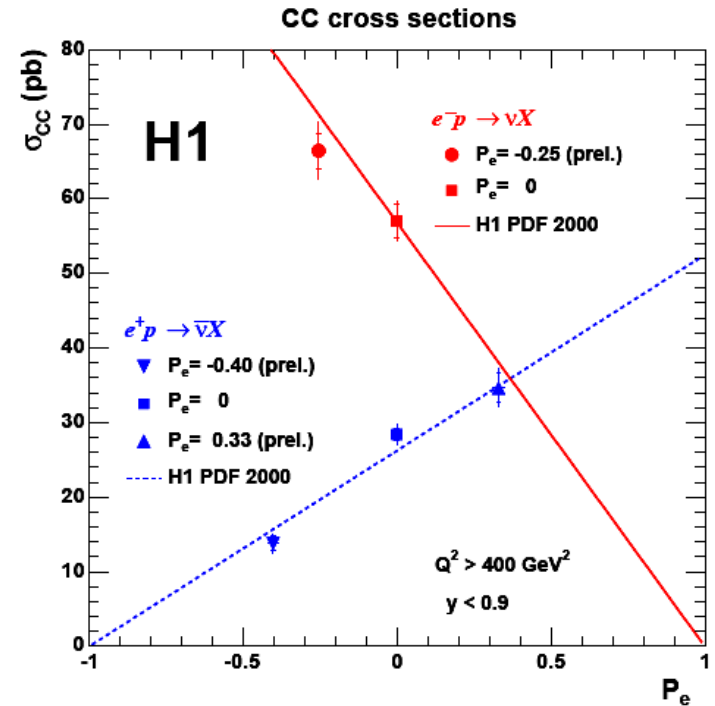
HERA



- **lumi upgrade:** background conditions + stability improved
- **2004:** 91 pb^{-1} highest lumi/year delivered so far
- **2005:** 90 pb^{-1} by now, $>1 \text{ pb}^{-1} / \text{day}$, $\sim 150 \text{ pb}^{-1}$ expected



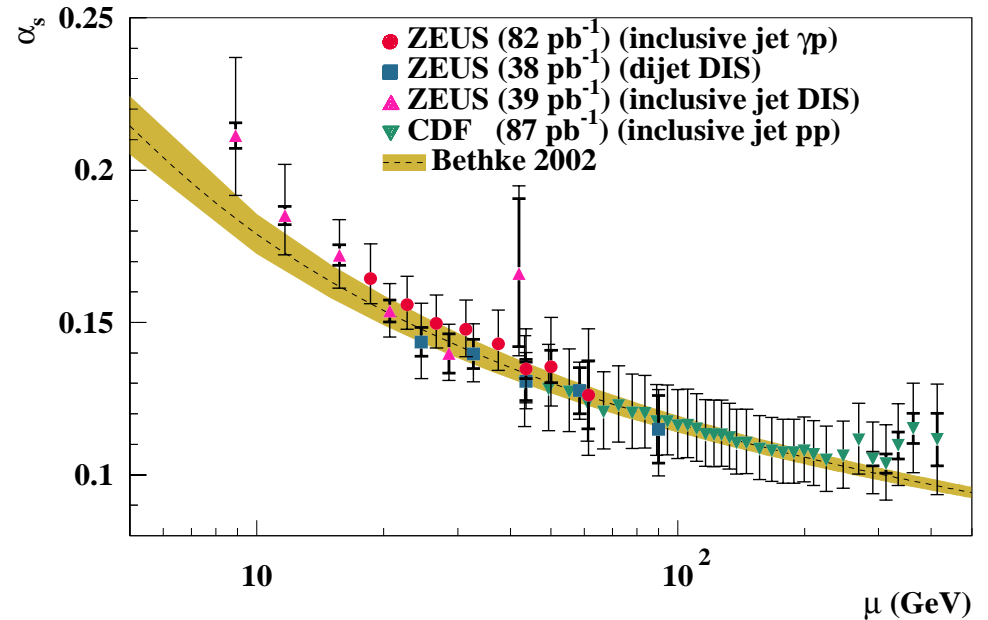
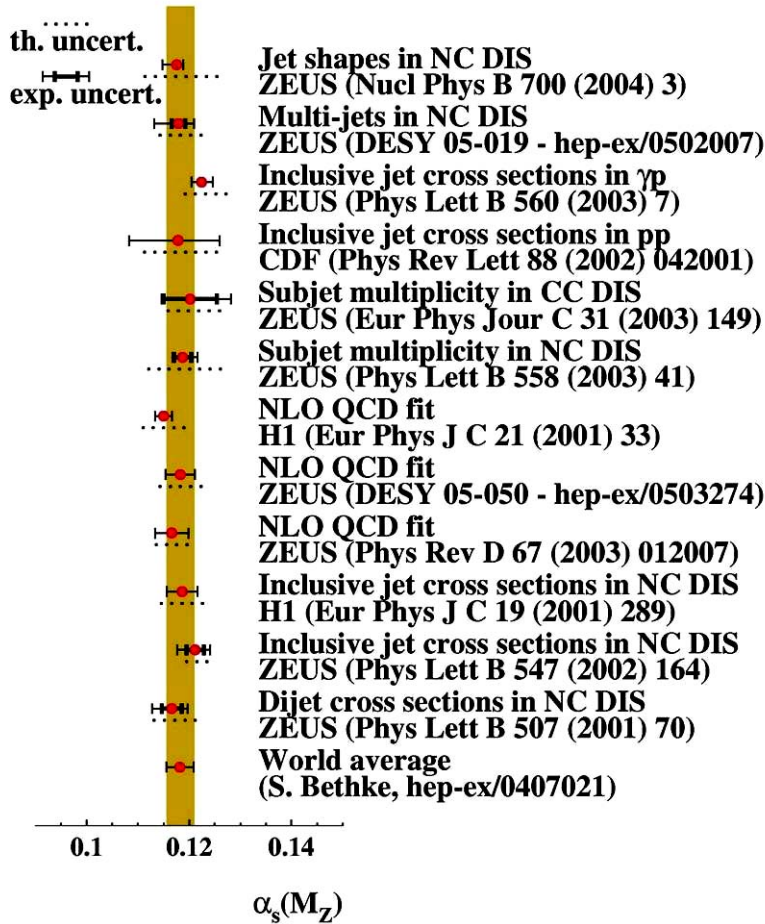
polarization **25-45%**



- **HERA end mid-2007:** $\sim 700 \text{ pb}^{-1}$ totally, about equally e^+ and e^-



Strong coupling α_s



$$\alpha_s(M_Z) = 0.1182 \pm 0.0027$$

need $\sim 1\%$ precision
from theory!



Loops+Legs 2004



β_1 1974

T. Jones
Liverpool

β_0 1973

D. Gross
Kavli Inst.

β_2 1981

O. Tarasov
DESY

β_3 1997

J. Vermaseren
NIKHEF

$$\beta_g = \frac{-g^3}{16\pi^2} \left(\frac{11}{3} N_c - \frac{2}{3} N_f \right)$$
$$\frac{-g^5}{(16\pi^2)^2} \left(\frac{34}{3} N_c^2 + \dots \right)$$
$$\frac{-g^7}{(16\pi^2)^3} \left(\frac{2857}{54} N_c^3 + \dots \right)$$
$$\frac{-g^9}{(16\pi^2)^4} \left(\dots \right)$$



QCD Perturbation Theory



with $f_0(x) = \frac{1}{x}$, $f_1(x) = \frac{1}{1-x}$. (4.3)

A useful short-hand notation is $H_{0,\dots,0,1,0,\dots,0,1,\dots,1}(x) = H_{2(n+1),2(n+1),\dots,2}(x)$. (4.4)

For $w \leq 3$ the harmonic polylogarithms can be expressed in terms of standard polylogarithms; a complete list can be found in appendix A of Ref. [45]. All harmonic polylogarithms of weight $w = 4$ in this article can be expressed in terms of standard polylogarithms, Nielsen functions [74] or, by means of the defining relation (4.2), as one-dimensional integrals over these functions. A FORTRAN program for the functions up to weight $w = 4$ has been provided in Ref. [75].

For completeness we recall the one- and two-loop non-singlet splitting functions [3, 8]

$$P_{qq}^{(1)}(x) = C_F(2P_{qq}(x) + 3\delta(1-x)) \quad (4.5)$$

$$P_{qq}^{(2)}(x) = 4C_F C_F (P_{qq}(x)) \left[\frac{67}{18} - \zeta_2 + \frac{11}{6} H_0 + H_{0,0} \right] + P_{qq}(-x) \left[\zeta_2 + 2H_{-1,0} - H_{0,0} \right] + \frac{14}{3} (1-x) + \delta(1-x) \left[\frac{17}{24} + \frac{11}{3} \zeta_2 - 3\zeta_3 \right] - 4C_F \gamma_E (P_{qq}(x)) \left[\frac{5}{9} + \frac{1}{3} H_0 \right] + \frac{2}{3} (1-x) + \delta(1-x) \left[\frac{11}{12} + \frac{1}{2} \zeta_2 \right] + 4C_F^2 (2P_{qq}(x) [H_{1,0} - \frac{2}{3} H_0 + H_2] - 2P_{qq}(-x) [\zeta_2 + 2H_{-1,0} - H_{0,0}] - (1-x) [1 - \frac{3}{2} H_0] - H_0 - (1+x)H_{0,0} + \delta(1-x) [\zeta_2 - 3\zeta_3 + 6\zeta_4]) \quad (4.6)$$

$$P_{qq}^{(2)\pm}(x) = P_{qq}^{(1)\pm}(x) + 16C_F (C_F - \frac{C_A}{2}) (P_{qq}(-x)) [\zeta_2 + 2H_{-1,0} - H_{0,0}] - 2(1-x) - (1+x)H_0 \quad (4.7)$$

Here and in Eq. (4.9) - (4.11) we suppress the argument x of the polylogarithms and use $P_{qq}(x) = 2(1-x)^{-1} - 1-x$. (4.8)

All divergences for $x \rightarrow 1$ are understood in the sense of ϵ -distributions. The three-loop splitting function for the evolution of the 'plus' combinations of quark densities in Eq. (2.2), corresponding to the anomalous dimension (3.8) read:

$$P_{qq}^{(3)\pm}(x) = 16C_F C_F \gamma_E (P_{qq}(x)) \left[\frac{10}{3} \zeta_3 - \frac{209}{36} - 9\zeta_4 - \frac{167}{18} H_0 + 2H_{0,0} - 7H_{0,0} - 2H_{0,0,0} + 3H_{1,0,0} - H_3 \right] + \frac{1}{2} P_{qq}(-x) \left[\frac{13}{2} \zeta_3 - \frac{5}{2} \zeta_4 - H_{-2,0} - 2H_{-1,0} - \frac{10}{3} H_{-1,0} - H_{-1,0,0} + 2H_{-1,2} + \frac{1}{2} H_{0,0} + \frac{1}{2} H_{0,0,0} + H_3 \right] + (1-x) \left[\frac{1}{6} \zeta_3 - \frac{257}{54} - \frac{43}{18} H_0 - \frac{1}{6} H_{0,0} - H_3 \right] \quad (4.9)$$

$$P_{qq}^{(3)\pm}(x) = 16C_F^2 C_F (P_{qq}(x)) \left[\frac{10}{3} \zeta_3 - \frac{209}{36} - 9\zeta_4 - \frac{167}{18} H_0 + 2H_{0,0} - 7H_{0,0} - 2H_{0,0,0} + 3H_{1,0,0} - H_3 \right] + \frac{1}{2} P_{qq}(-x) \left[\frac{13}{2} \zeta_3 - \frac{5}{2} \zeta_4 - H_{-2,0} - 2H_{-1,0} - \frac{10}{3} H_{-1,0} - H_{-1,0,0} + 2H_{-1,2} + \frac{1}{2} H_{0,0} + \frac{1}{2} H_{0,0,0} + H_3 \right] + (1-x) \left[\frac{1}{6} \zeta_3 - \frac{257}{54} - \frac{43}{18} H_0 - \frac{1}{6} H_{0,0} - H_3 \right] + (1-x) \left[2H_{-2,0} - \frac{31}{6} H_{-2,0} + 4H_{-2,0,0} + H_{0,0,0,0} + 35H_1 + 6H_1 \zeta_2 - H_{1,0} + \frac{5}{2} H_{2,0} \right] + (1+x) \left[\frac{17}{10} \zeta_3^2 - \frac{93}{4} \zeta_4 - \frac{81}{2} \zeta_5 - 15H_{-1,2} - 30H_{-1,1} - \zeta_2 + 12H_{-1,1} - \frac{1}{2} H_{-1,0} - 26H_{-1,0,0} - 24H_{-1,2} - \frac{19}{16} H_{0,0} - 28H_{0,0,0} + \frac{191}{8} H_{0,0,0,0} + \frac{85}{2} H_1 - 3H_{1,0,0} - 2H_{1,0,0,0} + 13H_3 \right] - H_4 + 4\zeta_2 + 33\zeta_3 + 4H_{-1,0} - 4H_{1,0,0,0} + 4H_2 + \frac{67}{2} H_{1,0} + 6H_{1,0,0} + 9H_{1,0,0,0} - 23H_{0,0,0} - 17H_{0,0,0,0} - 2H_3 - H_{2,0} - 4H_3 + \delta(1-x) \left[\frac{29}{24} - 2\zeta_2 \zeta_3 + \frac{9}{2} \zeta_4 + \frac{18}{5} \zeta_5^2 + \frac{17}{4} \zeta_5 - 15\zeta_6 \right] \quad (4.9)$$

The x-space counterpart of Eq. (3.8) for the evolution of the 'minus' combinations (2.2) is given by $P_{qq}^{(2)\pm}(x) = P_{qq}^{(1)\pm}(x) + 16C_F C_F (C_F - \frac{C_A}{2}) (P_{qq}(-x)) \left[\frac{13}{3} \zeta_3 - \frac{5}{2} \zeta_4 - 4H_{-1,0} - 4H_{-1,0,0} + 32H_{-1,2} - \frac{206}{9} H_{-1,0} + 44H_{-1,0,0} + \frac{22}{3} H_{-1,0,0} - 12H_{-1,0,0,0} - \frac{44}{3} H_{-1,2} \right] + (1-x) \left[\frac{1}{6} \zeta_3 - \frac{257}{54} - \frac{43}{18} H_0 - \frac{1}{6} H_{0,0} - H_3 \right] + (1+x) \left[\frac{17}{10} \zeta_3^2 - \frac{93}{4} \zeta_4 - \frac{81}{2} \zeta_5 - 15H_{-1,2} - 30H_{-1,1} - \zeta_2 + 12H_{-1,1} - \frac{1}{2} H_{-1,0} - 26H_{-1,0,0} - 24H_{-1,2} - \frac{19}{16} H_{0,0} - 28H_{0,0,0} + \frac{191}{8} H_{0,0,0,0} + \frac{85}{2} H_1 - 3H_{1,0,0} - 2H_{1,0,0,0} + 13H_3 \right] - H_4 + 4\zeta_2 + 33\zeta_3 + 4H_{-1,0} - 4H_{1,0,0,0} + 4H_2 + \frac{67}{2} H_{1,0} + 6H_{1,0,0} + 9H_{1,0,0,0} - 23H_{0,0,0} - 17H_{0,0,0,0} - 2H_3 - H_{2,0} - 4H_3 + \delta(1-x) \left[\frac{29}{24} - 2\zeta_2 \zeta_3 + \frac{9}{2} \zeta_4 + \frac{18}{5} \zeta_5^2 + \frac{17}{4} \zeta_5 - 15\zeta_6 \right] \quad (4.9)$

Of particular interest is the end-point behaviour of the harmonic polylogarithms at $x \rightarrow 0$ or $x \rightarrow 1$, where logarithmic singularities occur. In the limit $x \rightarrow 0$, the factors $\ln x$ are related to

$$-(1+x) \left[\frac{2}{3} H_{-1,0} + \frac{1}{3} H_1 \right] + \frac{1}{3} \zeta_2 + H_0 + \frac{1}{6} H_{0,0} + \delta(1-x) \left[\frac{5}{4} - \frac{167}{54} \zeta_2 + \frac{1}{20} \zeta_3^2 + \frac{25}{18} \zeta_4 \right] + 16C_F C_F^2 (P_{qq}(x)) \left[\frac{5}{6} \zeta_3 - \frac{69}{20} \zeta_4 - H_{-3,0} - 3H_{-2,0} - 14H_{-2,1} - 10H_{-2,2} + 3H_{-2,0} + 5H_{-2,0,0} - 4H_{-2,2} - \frac{151}{48} H_0 - \frac{41}{12} H_{0,0} - \frac{17}{2} H_{0,0} - \frac{13}{4} H_{0,0} - 4H_{0,0,0} - \frac{23}{12} H_{0,0,0} + 5H_{0,0,0,0} + \frac{2}{3} H_3 \right] - 24H_1 \zeta_2 - 16H_{1,-2,0} + \frac{67}{9} H_{1,0} - 2H_{1,0,0} + \frac{31}{3} H_{1,0,0,0} + 11H_{1,0,0,0} + 8H_{1,1,0,0} - 8H_{1,3} + 3H_4 + \frac{67}{9} H_2 - 2H_{2,0} + \frac{11}{3} H_{2,0} + 5H_{2,0,0} + H_{3,0} + P_{qq}(-x) \left[\frac{1}{2} \zeta_2^2 - \frac{67}{9} \zeta_2 + \frac{31}{6} \zeta_3 + 5H_{-3,0} - 32H_{-2,0} - 4H_{-2,1} - \frac{31}{6} H_{-2,2} + 21H_{-2,0,0} + 30H_{-2,2} - \frac{31}{3} H_{-1,0} - 42H_{-1,0} + \frac{9}{2} H_{0,0} - 4H_{-1,-2,0} + 56H_{-1,-1,0} - 56H_{-1,-1,0,0} - 56H_{-1,-1,2} - \frac{13}{4} H_{-1,0} - 42H_{-1,0,0} - H_{1,0} + 32H_{-1,3} - \frac{31}{6} H_{-1,0,0} + 17H_{-1,0,0,0} + \frac{11}{3} H_{-1,2} + 2H_{-1,2,0} + \frac{13}{12} H_{0,0} + \frac{29}{6} H_{0,0} + \frac{67}{9} H_{0,0,0} + 13H_{0,0,0} + \frac{89}{12} H_{0,0,0,0} - 5H_{0,0,0,0} - 7H_{0,0,0,0} - \frac{31}{6} H_3 - 10H_4 \right] + (1-x) \left[\frac{133}{36} - 4H_{0,0,0,0} - \frac{167}{4} \zeta_2 - 2H_{0,0,0} - 2H_{-1,0} + H_{-2,0} + 2H_{-2,-1,0} - 3H_{-2,0,0} + \frac{77}{4} H_{0,0,0} - \frac{209}{6} H_1 - 7H_1 \zeta_2 + 4H_{1,0,0} + \frac{14}{3} H_{1,0} \right] + (1+x) \left[\frac{43}{2} \zeta_2 - 3\zeta_3^2 + \frac{25}{2} H_{-2,0} - 31H_{-1,0} - 14H_{-1,1,0} - \frac{13}{3} H_{-1,0} + 24H_{-1,2} + 23H_{-1,0,0} + \frac{85}{6} H_{0,0} + 5H_{0,0,0} + \frac{1457}{48} H_0 - \frac{102}{36} H_{0,0} - \frac{155}{6} H_1 + H_{1,0} - 15H_3 + 2H_{2,0,0} - 3H_4 \right] - 5\zeta_2 - \frac{1}{2} \zeta_3^2 + 5\zeta_4 - 2H_{-1,0} - 7H_{-2,0} - H_{0,0} - \frac{37}{6} H_{0,0} - \frac{242}{9} H_0 - 2H_{0,0,0} + \frac{18}{5} H_{0,0} - 22H_{0,0,0} - 4H_{0,0,0,0} + \frac{28}{3} H_3 + 6H_4 + \delta(1-x) \left[\frac{15}{64} + \zeta_2^2 - \frac{205}{24} \zeta_2 - \frac{247}{60} \zeta_3 - \frac{211}{12} \zeta_4 + \frac{15}{2} \zeta_5 \right] + 16C_F C_F (P_{qq}(x)) \left[\frac{245}{48} - \frac{67}{18} \zeta_2 + \frac{12}{5} \zeta_3 + \frac{1}{2} \zeta_4 + \frac{104}{216} H_0 + H_{-1,0} + 4H_{-2,-1,0} - \frac{2}{3} H_{-2,0} - H_{-2,0,0} + 2H_{-2,2} - \frac{31}{12} H_{0,0} + 4H_{0,0} + \frac{389}{72} H_{0,0} - 2H_{2,0,0} - H_{0,0,0,0} + 9H_1 \zeta_3 + 6H_1 - H_{1,0} - H_{1,0,0} - \frac{11}{12} H_{1,0} - 3H_{1,0,0,0} - 4H_{1,1,0,0} + 4H_{1,3} + \frac{31}{12} H_{0,0,0} + \frac{11}{12} H_1 + H_4 \right] + P_{qq}(-x) \left[\frac{67}{18} \zeta_2 - \zeta_3^2 + \frac{11}{4} \zeta_4 - H_{-3,0} + 8H_{-2,0} + \frac{11}{6} H_{-2,0} - 4H_{-2,0,0} - 3H_{-1,0,0,0} + \frac{11}{3} H_{-1,0} - 1\zeta_2 + 12H_{-1,0} - 16H_{-1,0,0} - 16H_{-1,1,0} + 16H_{-1,-1,2} + \frac{67}{9} H_{-1,0} - 8H_{-2,2} + 11H_{-1,0,0} - \frac{11}{6} H_{-1,0,0} - \frac{11}{3} \zeta_2 - 12 - 8H_{-1,3} - \frac{3}{4} H_0 - \frac{1}{6} H_{0,0} - 4H_{0,0} - \frac{67}{18} H_0 - 3H_{0,0,0} + \frac{31}{12} H_{0,0,0} + H_{0,0,0,0} + 2H_{0,0} + \frac{1}{6} H_3 + 2H_4 \right] + (1-x) \left[\frac{1383}{108} - \frac{1}{2} H_{0,0,0,0} + 11H_1 - H_{-2,-1,0} + \frac{1}{2} H_{-1,0} - \frac{1}{2} H_{-2,0} + \frac{1}{2} H_{-2,0,0} + \frac{523}{36} H_{0,0} + H_{0,0,0} - \frac{13}{3} H_{0,0} + 2H_1 \zeta_2 - 2H_{1,0,0} \right] + (1+x) \left[8H_{1,0} + 4H_{-1,1,0} - \frac{1}{3} H_{-1,0} - 5H_{-1,0,0} - 6H_{-1,2} - \frac{1}{2} H_{-2,0} + \frac{3}{8} \zeta_2^2 + \frac{22}{3} H_1 + 8H_4 \right] + (1-x) \left[\frac{1367}{18} + \frac{1}{2} \zeta_2^2 + 2H_{-3,0} - 2H_{-2,0} - 4H_{-2,-1,0} - 10H_{-2,0} - 2H_{0,0} + 2H_{-2,0,0} + 2H_{0,0,0} + H_{0,0,0,0} + 8H_1 \zeta_2 + \frac{149}{3} H_1 \right] + (1+x) \left[52H_{-1,0} - 18\zeta_2 - 23\zeta_3 + \frac{26}{9} H_{-1,0} - 16H_{-1,0,0} - 32H_{-1,2} - \frac{481}{18} H_0 - 29H_{0,0} + 5H_{0,0,0} + 24H_1 + \frac{70}{3} H_2 \right] - 2\zeta_2 - 2\zeta_3 + 2\zeta_4 + 14H_{0,0,0} - 16H_1 \zeta_2 + 16C_F C_F (C_F - \frac{C_A}{2}) (P_{qq}(-x)) \left[\frac{20}{9} \zeta_2 - \frac{4}{3} H_{-2,0} - \frac{8}{3} H_{-1,0} - \frac{40}{9} H_{-1,0} - \frac{4}{9} H_{-1,0,0} + \frac{8}{9} H_{-1,2} + \frac{2}{9} H_{0,0} + \frac{20}{9} H_{0,0} + \frac{4}{9} H_{0,0,0} \right] - \frac{4}{3} H_1 + (1-x) \left[\frac{61}{9} - \frac{8}{9} H_1 \right] + (1+x) \left[2H_{0,0} - \frac{4}{3} H_{-1,0} + \frac{41}{9} H_{-1,0} - \frac{4}{9} H_1 \right] + 16C_F^2 (C_F - \frac{C_A}{2}) (P_{qq}(-x)) \left[9\zeta_2 - 7\zeta_3^2 + 12H_{-3,0} - 64H_{-2,0} - 16H_{-2,-1,0} - 6H_{-2,0,0} + 52H_{-2,0,0} + 56H_{-2,2} - 12H_{-2,0,0} - 72H_{-2,1,0} - 16H_{-1,2,0} + 96H_{-1,1,0} - 80H_{-1,1,0,0} - 96H_{-1,1,2} - 80H_{-1,0,0} - 44H_{-1,0,0,0} + 12H_{-1,2,0} + 8H_{-1,2,0} + 64H_{-1,3} + 3H_4 + 3H_5 \zeta_2 + 26H_{0,0,0} + 28H_{0,0,0} + 9H_{0,0,0,0} - 12H_{0,0,0,0} - 12H_{0,0,0,0} - 6H_1 - 4H_3 - 24H_4 \right] - (1-x) \left[15 + 8H_{-3,0} + 8H_{-2,0,0} + 61H_0 + 6H_{0,0} + 24H_{0,0,0} - 6H_{0,0,0,0} + 12H_1 \zeta_2 + 60H_1 + 8H_{1,0} \right] + (1+x) \left[24\zeta_2 + 57\zeta_3 + 10H_{-2,0} - 48H_{-1,0} - 4H_{-1,0,0} - 40H_{-1,0,0} - 48H_{-1,2} + 59H_{0,0} - 22H_{0,0} - 35H_{0,0,0} - 22H_3 - 4H_{2,0} - 44H_3 \right] + 9\zeta_2 - 4\zeta_3 - 4H_{-1,0} + 42H_0 - 38H_{0,0} + 14H_{0,0} - 16H_1 + 26H_{0,0,0} + 24H_3 \quad (4.10)$$

Finally the Mellin inversion of $\gamma_{qq}^{(2)\pm}(N)$ in Eq. (3.9) leads to the following result for the leading (third-order) difference $P_{qq}^{(3)\pm}(x)$ of the 'valence' and 'minus' splitting functions:

$$P_{qq}^{(3)\pm}(x) = 16\gamma_E \frac{e^{2\gamma_E}}{n_c} (1-x) \left[\frac{50}{3} - \frac{41}{12} \zeta_2 - \frac{5}{6} \zeta_3 - H_{-3,0} + H_{-2,0} - \frac{9}{4} H_0 + 2H_{-2,0} + \frac{1}{6} H_{0,0} - \frac{1}{2} H_{1,0} + \frac{91}{12} H_1 \right] + \frac{1}{2} (1+x) \left[H_{-1,0} - \frac{3}{2} H_{-1,0} + \frac{1}{2} H_{0,0} - \frac{13}{6} H_{-1,0} + \frac{1}{2} H_{-1,0,0} + 2H_{-1,2} - \frac{3}{2} H_{-2,0} + \frac{9}{2} H_{0,0} + \frac{29}{12} H_{0,0} + \frac{41}{12} H_{1,0} - H_2 \zeta_2 - \frac{1}{2} H_{2,0,0} - \frac{1}{2} H_4 \right] - \frac{1}{2} (1+x^2) \left[3H_{-1,2} + 2H_{-1,1,0} - 2H_{-1,0,0} - 2H_{-1,2} + H_1 \zeta_2 \right] + \frac{1}{2} \zeta_2^2 - 2H_1 - 2H_{-2,0} + 4H_{0,0} - 2H_{0,0,0} + 2H_1 \zeta_2 + \frac{91}{24} H_0 + \zeta_2 - \frac{9}{2} \zeta_3 - H_2 \zeta_2 - H_2 \zeta_3 - 2H_{0,0,0} + \frac{3}{8} H_{0,0} - \frac{3}{4} H_{0,0,0} + \frac{1}{2} H_{0,0,0,0} + H_{-2,0} - H_3 \quad (4.11)$$

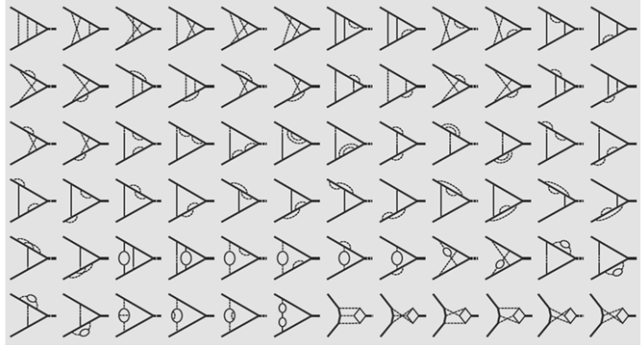
Of particular interest is the end-point behaviour of the harmonic polylogarithms at $x \rightarrow 0$ or $x \rightarrow 1$, where logarithmic singularities occur. In the limit $x \rightarrow 0$, the factors $\ln x$ are related to

1-2-3 Loops: Next-to-Next-to-Leading Order:

- splitting functions
- anomalous dimensions
- coefficient functions

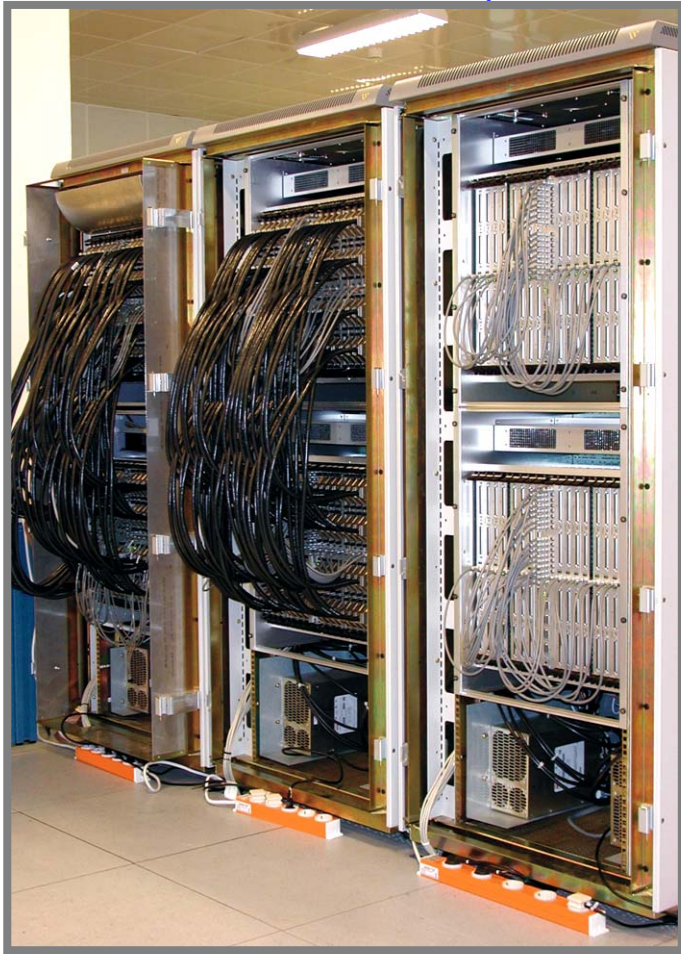
~ 10.000
Feynman
Diagrams :

	tree	1-loop	2-loop	3-loop
$q\gamma$	1	3	25	359
$g\gamma$		2	17	345
$h\gamma$			2	56
qW	1	3	32	589
$q\phi$	1	1	23	696
$g\phi$	1	8	218	6378
$h\phi$		1	33	1184
sum	3	18	350	9607



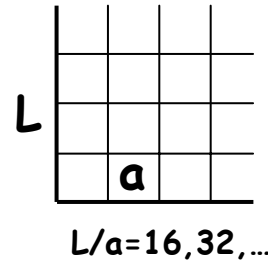
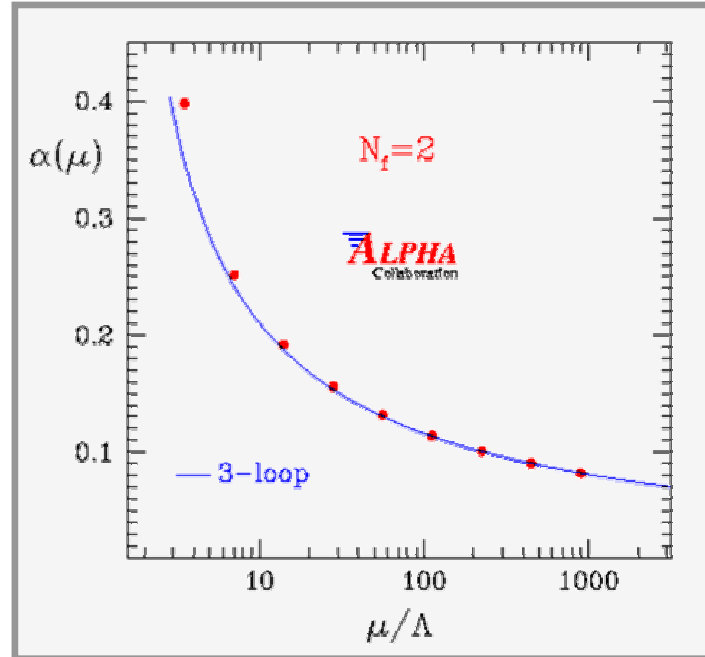
> 100.000 Integrals ...

APE Lattice Computers



APENext at DESY Zeuthen
2005/6: 3 TFlops

- simulate QCD on a lattice :



- degrees of freedom:
Color, Flavor, Quark Masses

$$\delta\alpha_s/\alpha_s = 1\% \quad \text{ok with expt. + 3-loop}$$



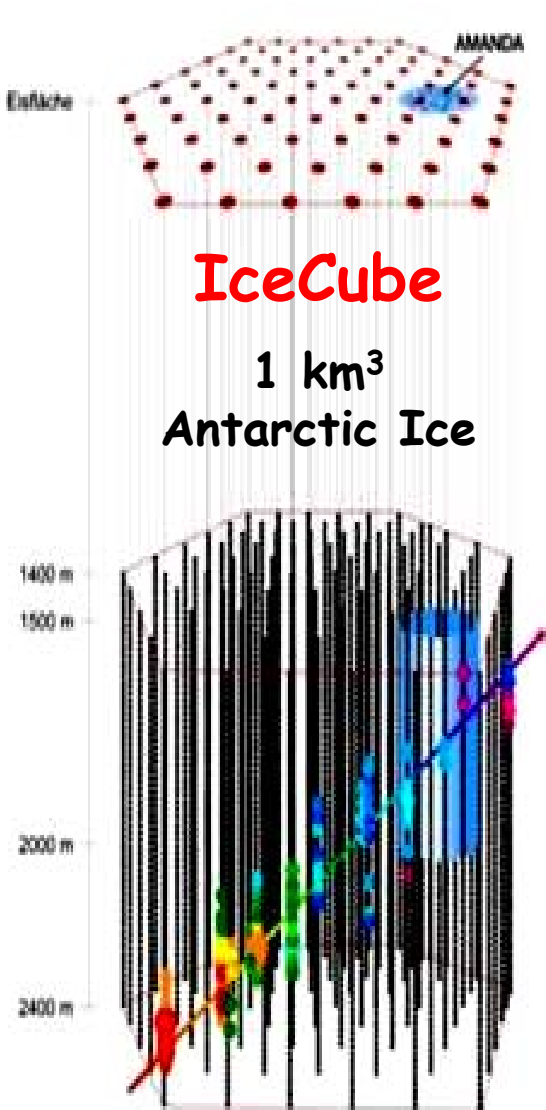
strategy group of Helmholtz institutes

DESY, GSI, AWI, DLR, FZJ, FZK

Ausbau des Supercomputing in der Helmholtz-Gemeinschaft
und Positionierung im europäischen Forschungsraum

- **needs** of diff. communities:
LQCD, astrophysics, biophysics, chemistry, climate
- FZJ-NIC → **HGF-HPC** → **German** → **European** ?
- **general vs dedicated** machines
- **large vs topical** centres

Neutrino Astro-Physics



Neutrino Astro-Physics

Amanda: many new results - sensitivity gets interesting

Search for Neutrino Point Sources



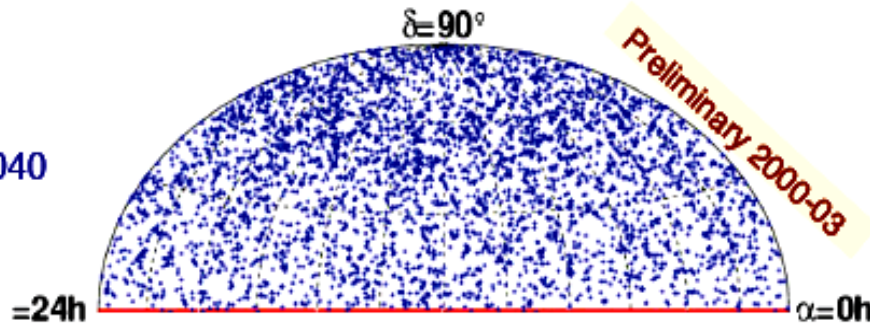
Select upgoing events: maximize $\uparrow \nu$ and minimize $\downarrow \mu$
Optimize cuts in each declination band optimizing for $E^{-2 \dots -3}$ signal spectrum
Sensitivity \sim independent of direction

Published analyses:

- 1997 data
Astrophys.J. 583(2003)1040
- 2000 data
PRL 92(2004) 071102

New preliminary results with different strategies:

- 2000-01 and 2002 data
- 2000-03 data: 3370 evts in 807 days
(sensitivity ~ 3 higher as 2000)



No clustering in skyplot observed \rightarrow
No evidence for steady point sources
(measurement compatible with atmospheric ν 's)

IceCube: Neutrino Astrophysics

First string deployed



2450 m deep in Antarctic ice
in January 05.


also: simulation, reconstruction, analysis

DOM Module Production



1300 of $60 \times 80 = 4800$ modules
assembled at DESY Zeuthen.

ILC: Global Design Initiative



First ILC Workshop
Towards an International Design of a Linear Collider

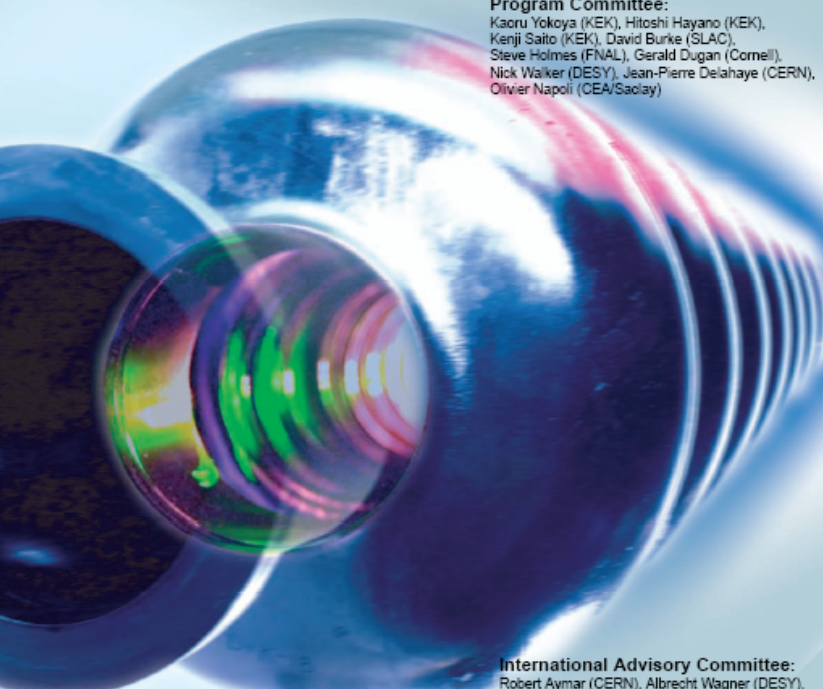
November 13th (Sat) through 15th (Mon), 2004
KEK, High Energy Accelerator Research Organization
1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan

Program Committee:
Kaoru Yokoya (KEK), Hitoshi Hayano (KEK),
Kenji Saito (KEK), David Burke (SLAC),
Steve Holmes (FNAL), Gerald Dugan (Cornell),
Nick Walker (DESY), Jean-Pierre Delahaye (CERN),
Olivier Napoli (CEA/Saclay)

Local Organizing Committee:
Yoji Totsuka (KEK)(Chair), Fumihiko Takasaki (KEK)(Deputy-chair),
Junji Urakawa (KEK), Kiyoshi Kubo (KEK), Shigeru Kuroda (KEK),
Nobuhiro Terunuma (KEK), Toshiyasu Higo (KEK), Tsunehiko Omori (KEK),
Toshiaki Tauchi (KEK), Akiya Miyamoto (KEK), Masao Kuriki (KEK),
Kiyosumi Tsuchiya (KEK), Shuichi Noguchi (KEK), Eiji Kako (KEK)

International Advisory Committee:
Robert Aymar (CERN), Albrecht Wagner (DESY),
Michael Witherell (FNAL), Yoji Totsuka (KEK),
Jonathan Dorfman (SLAC), Won Namkung (PAL),
Brian Foster (Oxford), Maury Tigner (Cornell),
Hesheng Chen (IHEP), Alexander Skrinsky (BINP),
Carlos Garcia Canal (UNLP),
Sachio Komamiya (Tokyo), Paul Grannis (SUNY)

<http://lcdev.kek.jp/ILCWS/>



**~220 participants
from all 3 regions
mostly accelerator experts**

HERA-LHC-ILC

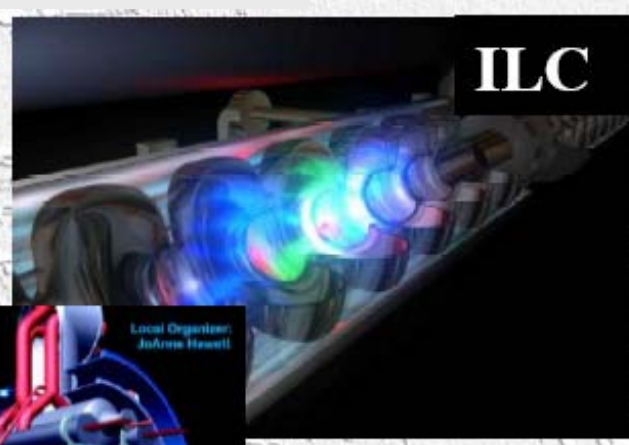
HERA



LHC



ILC



HERA AND THE LHC
A workshop on the implications of HERA for LHC physics

March 2004 - January 2005

Parton density functions
Multijet final states and energy flow
Heavy quarks
Diffraction
Monte Carlo tools

Workshop Meeting
March 26-27 2004
Midterm Meeting

**Final Meeting
March 21-24
DESY, Hamburg**

www.desy.de/hera/ih hera@ih.desy.de

LHC

Local Organizer:
John R. Howell

SLAC Workshop
23 March 2006

LHC/ILC Synergies

ILC

Organizing Committee:
Georg Wagner
Howard Haber
John Conway

<http://www.lppp.dur.ac.uk/~georg/ihc/>

DESY participation at the **LHC**:
the bridge from **HERA** to the **ILC**
DESY-CERN contacts start

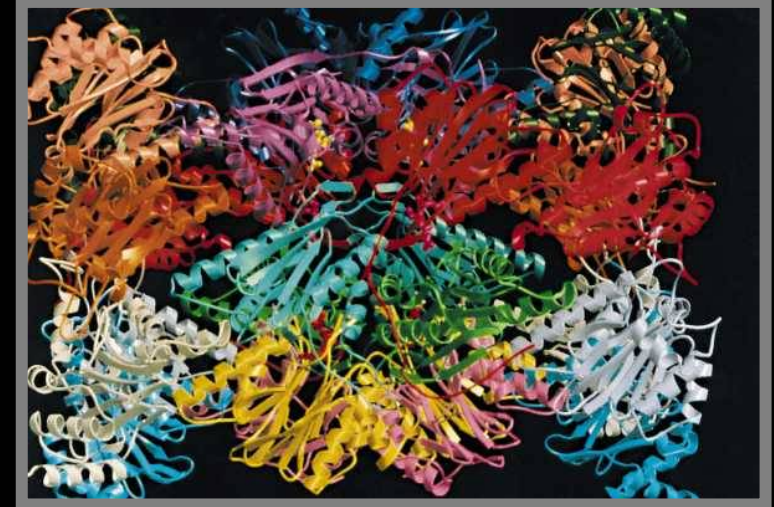
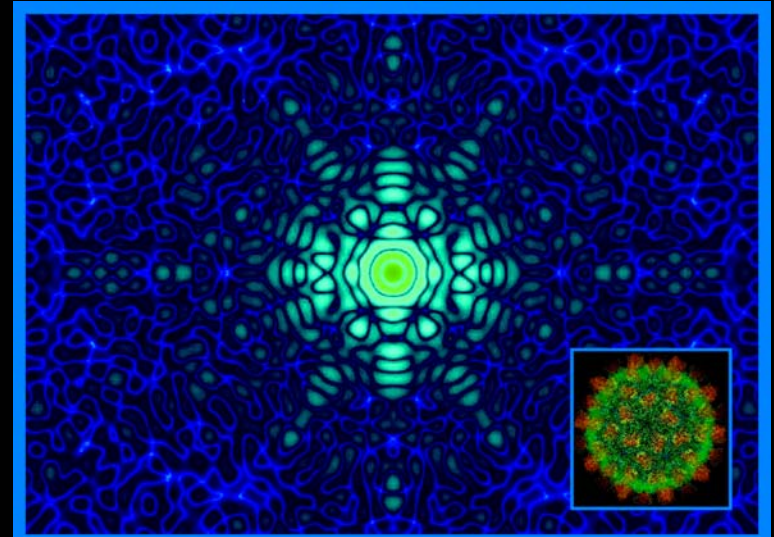
Synchrotron Radiation

use different features of laser in

- Atomic and molecular physics
- Biology
- Chemistry
- Material science
- High field and plasma physics

to produce

- movies of chemical reactions
- real-time studies of formation of condensed matter
- imaging of bio-molecules with atomic resolution



VUV-FEL

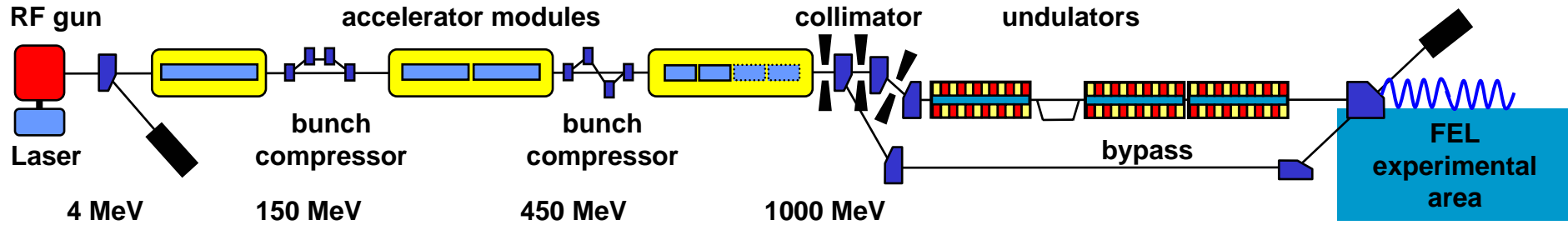




VUV-FEL



2005: start of user running $E = 250-1000 \text{ MeV}$ $\lambda = 24-6 \text{ nm}$



Wire scanner: 7 stations in undulator region built in **Zeuthen**
Gun: optimized in **Zeuthen** - good emittance

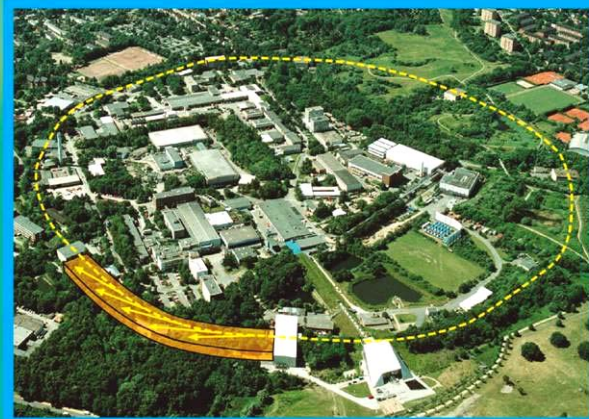
PETRA III



PETRA III

A Low Emittance
Synchrotron Radiation Source

Technical Design Report



DESY 2004 - 035

February 2004

super-brilliant
Synchrotron
Light Source

25.11.2004:

134 M€ allocated by BMBF,
German Ministry of Science

July 2007:

take over PETRA from HERA

Schenefeld
(Pinneberg district)

The European X-ray laser project XFEL

Planning status October, 2003

XFEL

— XFEL site ±50 m
- - - Options for expansion

1000 m

Schleswig-Holstein
Hamburg

Osdorfer
Born

PETRA

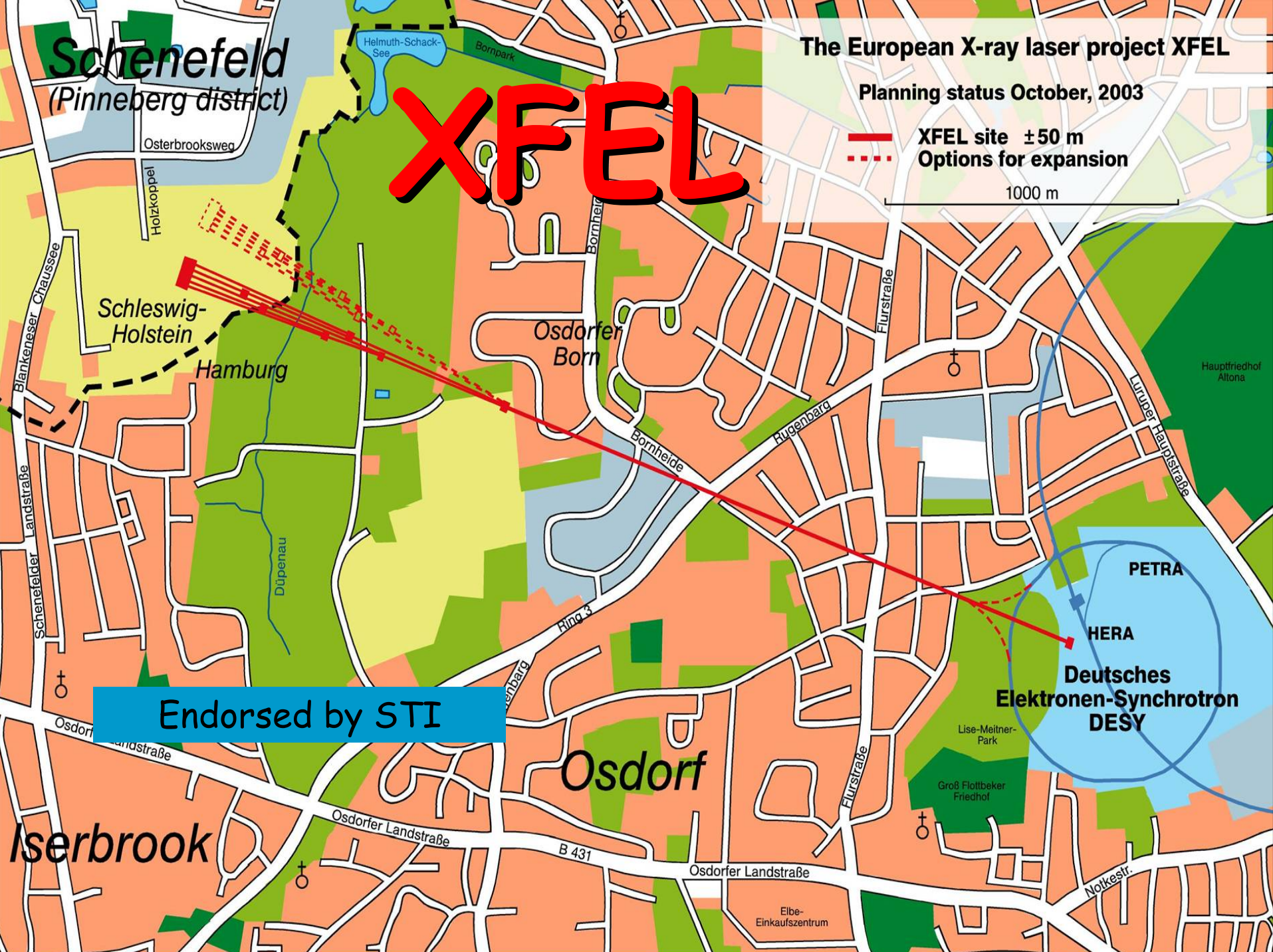
HERA

Deutsches
Elektronen-Synchrotron
DESY

Endorsed by STI

Osdorf

Iserbrook



European XFEL

- **Feb. 2003:** German govt.: XFEL as European project
Cost: 684 M€ (2000)
50% Federal govt.
+ ~10% from Länder HH + Schleswig-Holstein
+ ~40% from European Partners
- **Mar. 2005:** MoU for project preparation **signed by** 10 EU countries:
CH, DE, DK, ES, F, GR, IT, PL, UK, SE
- **Jan. 2005:**
Interim Report of Scientific and Technical Issues
Working Group on European XFEL Lab in Hamburg
Cost incl. R&D, escalation to 2012, contingency:
908 M€
- **May 2005:** Start of Plan Approval Procedure



XFEL Campus

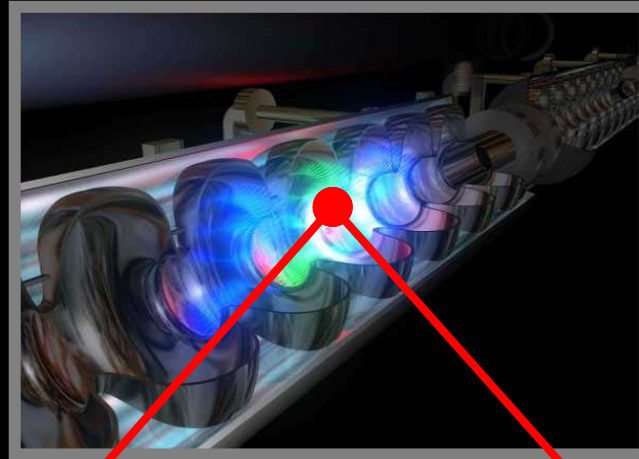




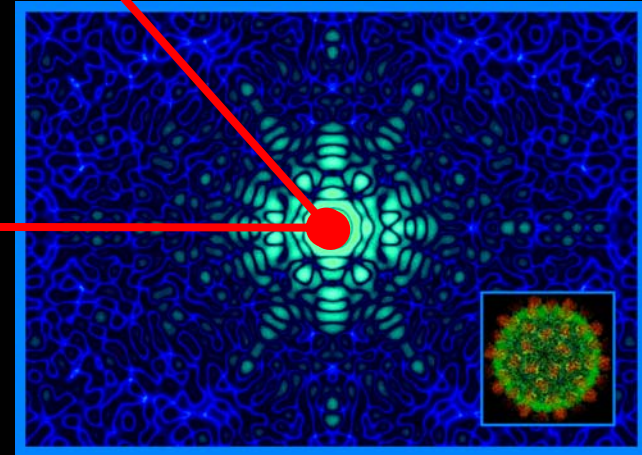
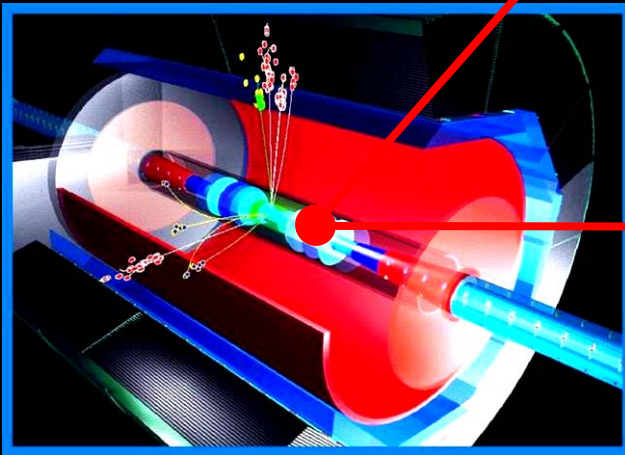
Synergy



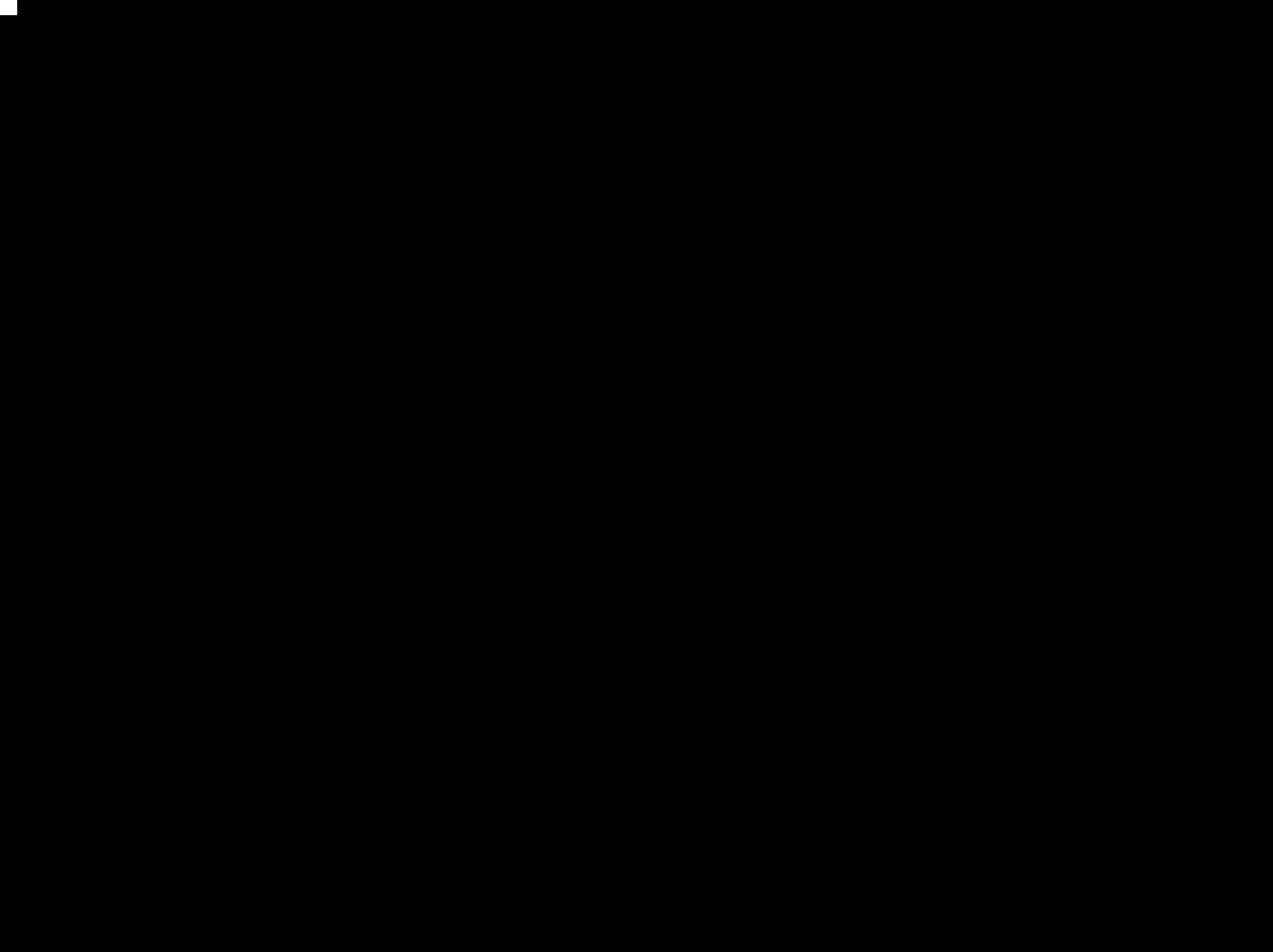
ILC



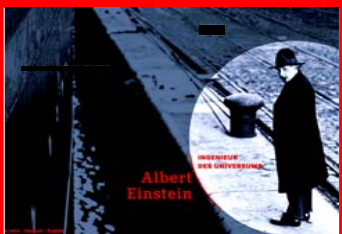





XFEL



industrial cavity production
operate+commission VUV-FEL and XFEL



ACAT 05

Start	<u>Monday, May 23</u>	<u>Tuesday, May 24</u>	<u>Wednesday, May 25</u>	<u>Thursday, May 26</u>	<u>Friday, May 27</u>	
09:00	Registration	<u>Plenary Session</u> Georgeot, Bertrand	<u>Plenary Session</u> Ramacher, Ulrich	<u>Plenary Session</u> Buchberger, Bruno	<u>Summaries</u> Brun, Rene Kiesling, Christian	
09:30		Coffee break			Coffee break	
10:00		Parallel Sessions	Parallel Sessions	Parallel Sessions		
10:30	<u>Opening</u> Naumann, Thomas				<u>Summaries</u> Fujimoto, Junpei	
11:00	<u>Plenary Session</u> Vermaseren, Jozef					<u>Conference Closing</u> Perret-Gallix, Denis
11:30	Lunch break					
11:45	Parallel Sessions	Parallel Sessions	Parallel Sessions			
12:00	Lunch break					
12:30	Parallel Sessions	 <p>Berlin</p>	Parallel Sessions	Parallel Sessions		
14:00	Parallel Sessions		Parallel Sessions	Parallel Sessions		
14:30	Coffee break		Coffee break			
15:00	Parallel Sessions	 <p>Welcome</p>	Parallel Sessions	<u>Invited Talk</u> Brandt, Siegmund		
15:30	Parallel Sessions		Trip + Banquet			
16:00		 <p>LOC/IAC</p>				
16:30						
17:00						
17:30						
18:00						
18:30						
19:00						
19:30						
20:00						
21:00						
22:00						

Physics in Berlin

- talk by **S.Brandt**, Thursday 16 h
- **World Year of Physics: Einstein exposition**



Kronprinzenpalais
Unter den Linden



**INGENIEUR
DES UNIVERSUMS**



Ratskeller Köpenick
Thursday 17.30-22.30 h



Captain
of
Köpenick



Dinner +
Boat Trip
to
Berlin



Future of ACAT

IAC
meeting



Wednesday
19 h



at
**Königliches
Schloßrestaurant**
in the
Kavalierhäuser
of
**Schloß
Königs Wusterhausen**

