TESLA

as an International Project

TESLA

The TDR

Part

1: Executive Summary

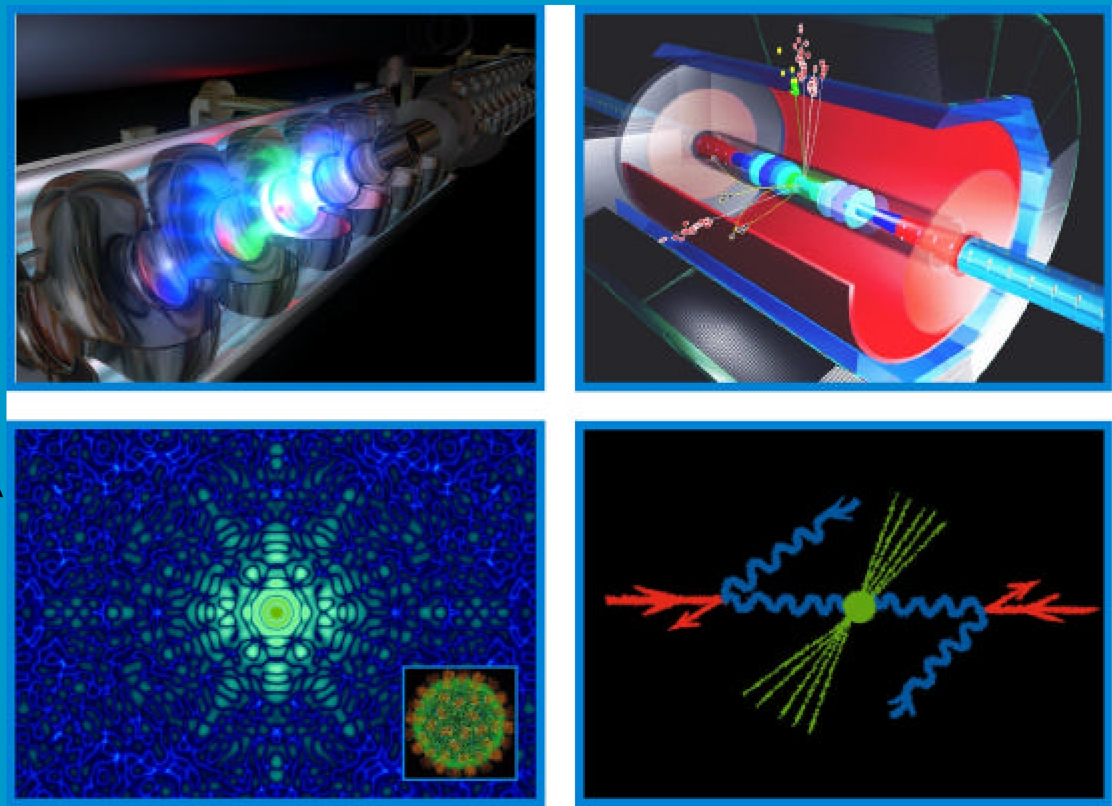
2: The Accelerator

3: Physics at an e+e- Linear Collider

4: A Detector for TESLA

5: The X-Ray Free Electron Laser

6: Appendices



Provides basis for scientific and technological evaluation, and costing

Thanks

- The TESLA Collaboration and their Funding Agencies:

- more than 40 Institutes in 10 countries

- major hardware contributions from France, Italy, USA and DESY

- Co-operation with CERN, Jlab, KEK on SC cavities

- The Study Groups:

ECFA/DESY Studies

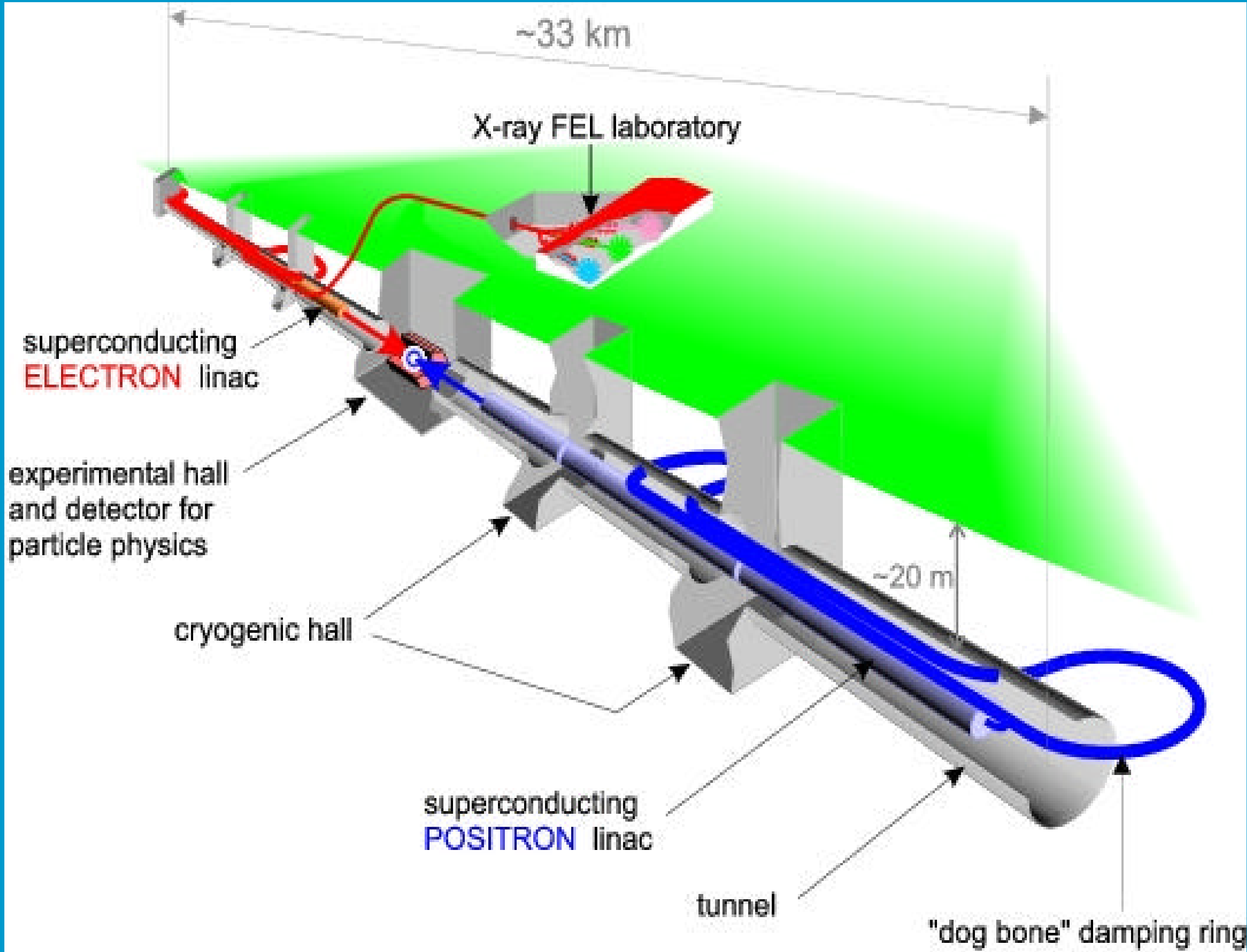
10 XFEL - Workshops

- The Editors

- The Authors of the TDR:

1134 authors from 36 countries

The Project


~33 km
X-ray FEL laboratory
superconducting
ELECTRON linac
experimental hall
and detector for
particle physics
cryogenic hall
~20 m
superconducting
POSITRON linac
tunnel
"dog bone" damping ring

The Vision and Challenge

Björn H. Wiik

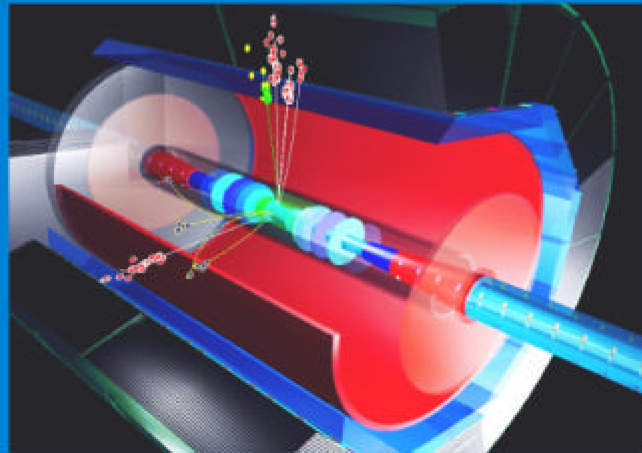
The Challenge
(1992)

2000 $/MV
for the complete
acceleration module

TESLA

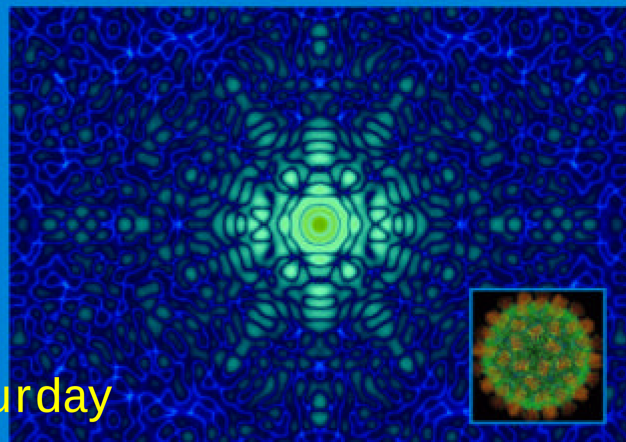
Motivation and Perspectives

Revealing the Innermost Secrets of the Universe



- The Origin of Mass
- The Way to Grand Unification
- The Link with Cosmology
- Other Options

New Insights into the Facets of Nature and Life



- Physics
- Chemistry
- Life Sciences

See M. Veltman, H. Dosch, and speakers on Saturday

TESLA

on the Road Map of Particle Physics

Basic Questions of Particle Physics

- What is matter ?
- What are the forces ?
- What happened in the very early universe ?

Where do the experimental answers lie?

- At high energies
- In precision measurements

How to get them?

• Large Hadron Collider	energy reach	under construction at CERN
• Lepton Collider	precision	

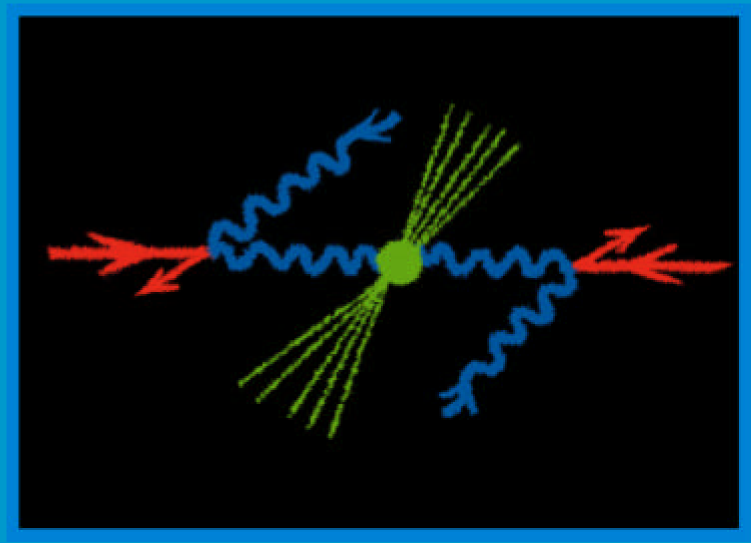
- Specific machines (B-factories, neutrino factories...)

Physics and experience teach us that we need these different tools to answer the essential questions.

Other Options for Particle Physics

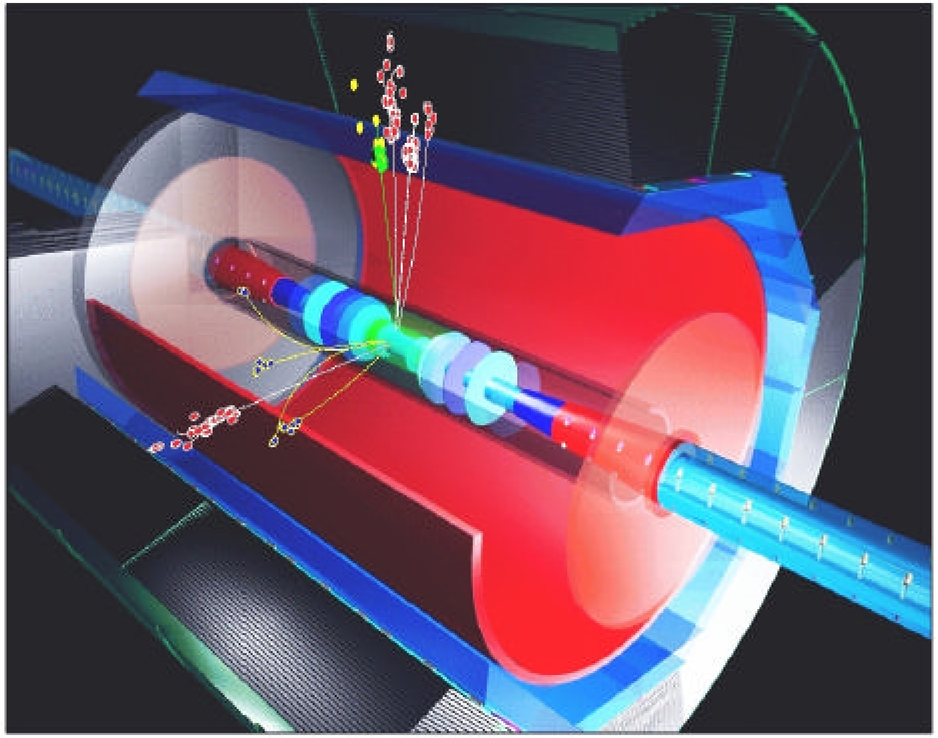
TESLA as

- Photon-Photon Collider
- Electron-Electron Collider
- Colliding electrons from TESLA with protons in HERA (THERA)
- Using polarised electrons from TESLA for fixed target experiments (TESLA-N)
- Using electrons (25 GeV) from TESLA and the electron ring of HERA for nuclear physics experiments (ELFE)



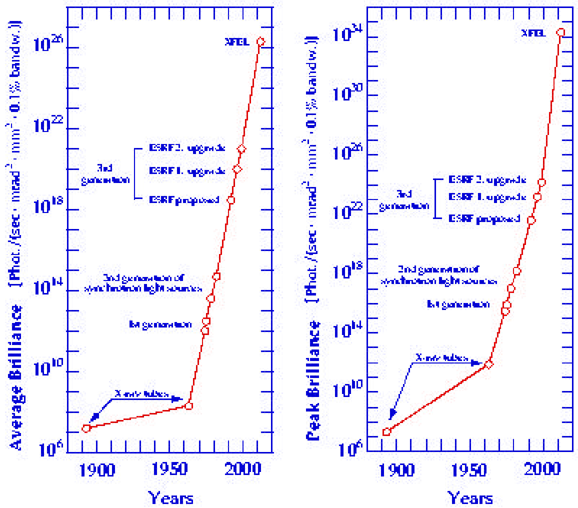
These options are not part of the baseline design and for the largest part not costed

Detector for Particle Physics



- Large detector for
  - Optimal tracking
  - Optimal energy flow
- High central magnetic field (4T)
- High granularity ECAL
- High granularity HCAL
  - Both inside the coil!
- Instrumentation down to very small angles: hermeticity!
- Iron return yoke instrumented as muon system

as Light Source



- High intensity
  10^{19} photons/s
  10^{16} W/cm^2 on 1 μm^2
- Short pulse length
  10^{13} photons in 100 fs
- Tunable wavelength
- Coherent radiation

Scientific Applications of a 0.1 nm Laser

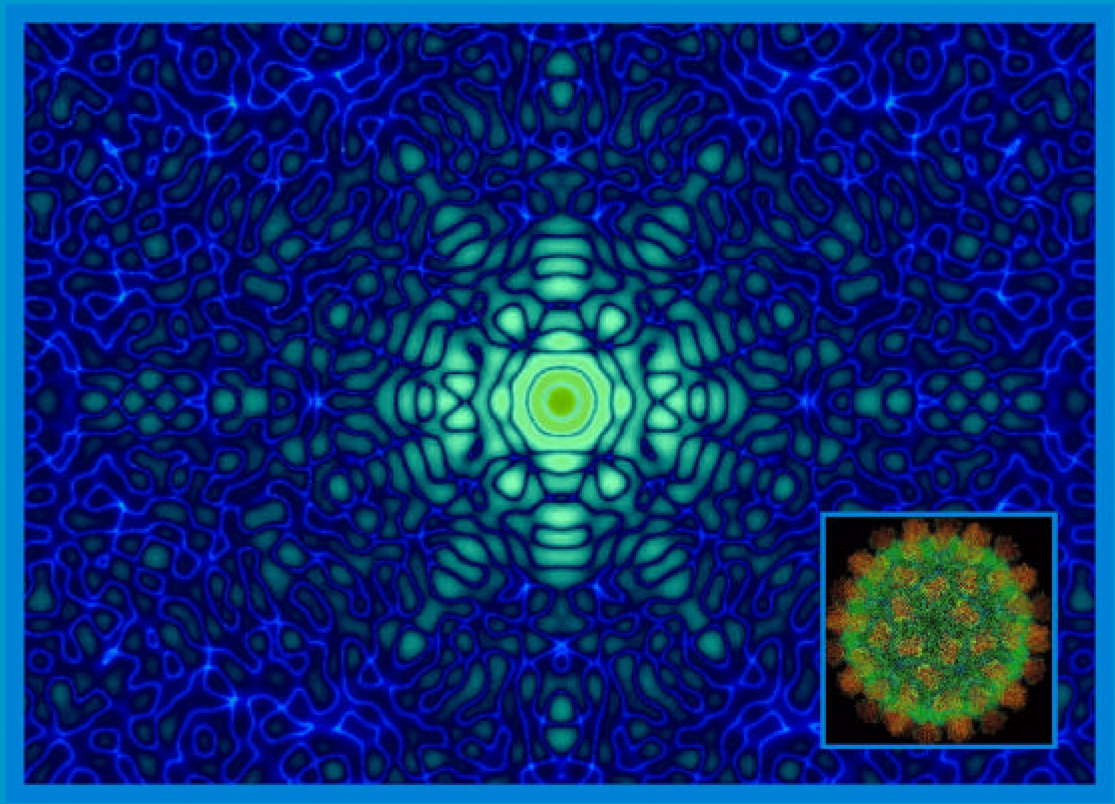
Pictures of single macro-molecules

dynamic behaviour of electrons in chemical bonds

movies of chemical reactions

real-time studies of formation of condensed matter

imaging of bio-molecular assemblies with atomic resolution



Fields of Application: Atomic and molecular physics, Material science, Biology, Fundamental plasma physics

Goals and Milestones

- develop superconducting technology for an e+e- collider @ 500 GeV, to be extended to 800 GeV
- use linear accelerator as driver of an X-FEL

- Routine production of cavities exceeding 25 MV/m
- Using a new surface treatment, gradients of > 40 MV/m have been reached, giving access to energies of 800 GeV
- Construction of the TESLA Test Facility TTF 1, stable operation for > 8 600 hours
- Successful demonstration of the SASE FEL principle < 100 nm
- Successful development of other components like klystrons and RF couplers

Accelerator Strategy

- The present technology, as realised at TTF, is adequate to build a collider for 500 GeV and an FEL:
  - 25 MV/m @ $Q > 5\ 10^9$ is reached routinely
  - operation of SC linear accelerator is very stable
  - SASE principle works at short wave lengths

Beyond the baseline design:

- Steps taken to reach higher energies (800 GeV):
  - build cavities with high gradients (35 MV/m)
  - increase filling factor
  - reduce Lorentz force detuning

Cost Review - Introduction

The cost review contains the three elements of the base line design:

1) 500 GeV Linear Collider with 1 Interaction Region
2) Incremental costs for the XFEL and the XFEL laboratory
3) One detector for Particle Physics

Cost Review - Collider

500 GeV Linear Collider baseline design with 1 Interaction Region — 3136 million Euro

Cost estimate for all major components based on TTF experience and obtained from studies made by industry,

assuming three years peak production time + one year start up

no contingency (as for LEP and HERA)

Year 2000 prices

The challenge of 2000$/MV has been met

TESLA and Industry

Companies involved in TTF/TESLA

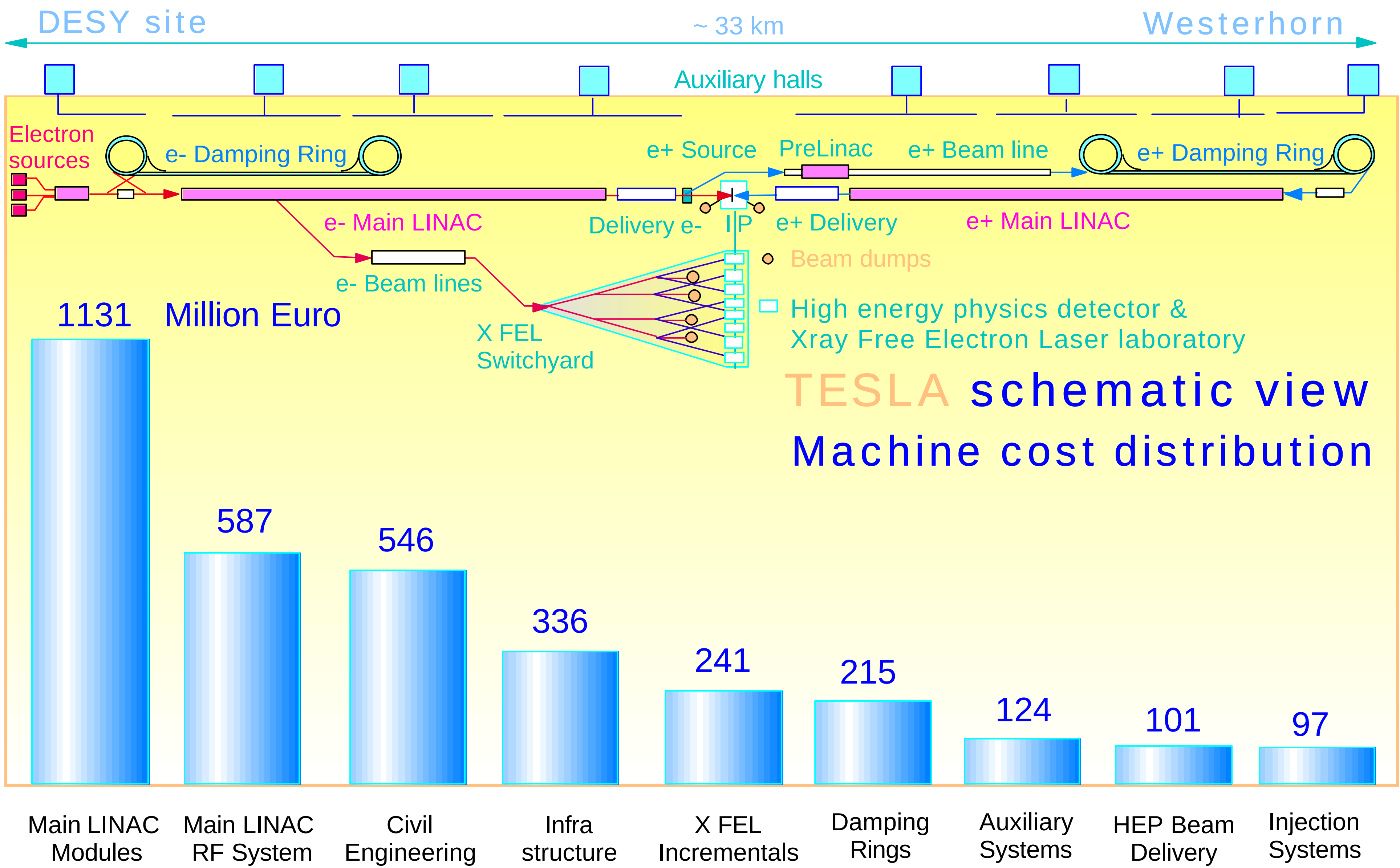
(construction, cost estimates, development etc.)

from Germany	450
from abroad	45

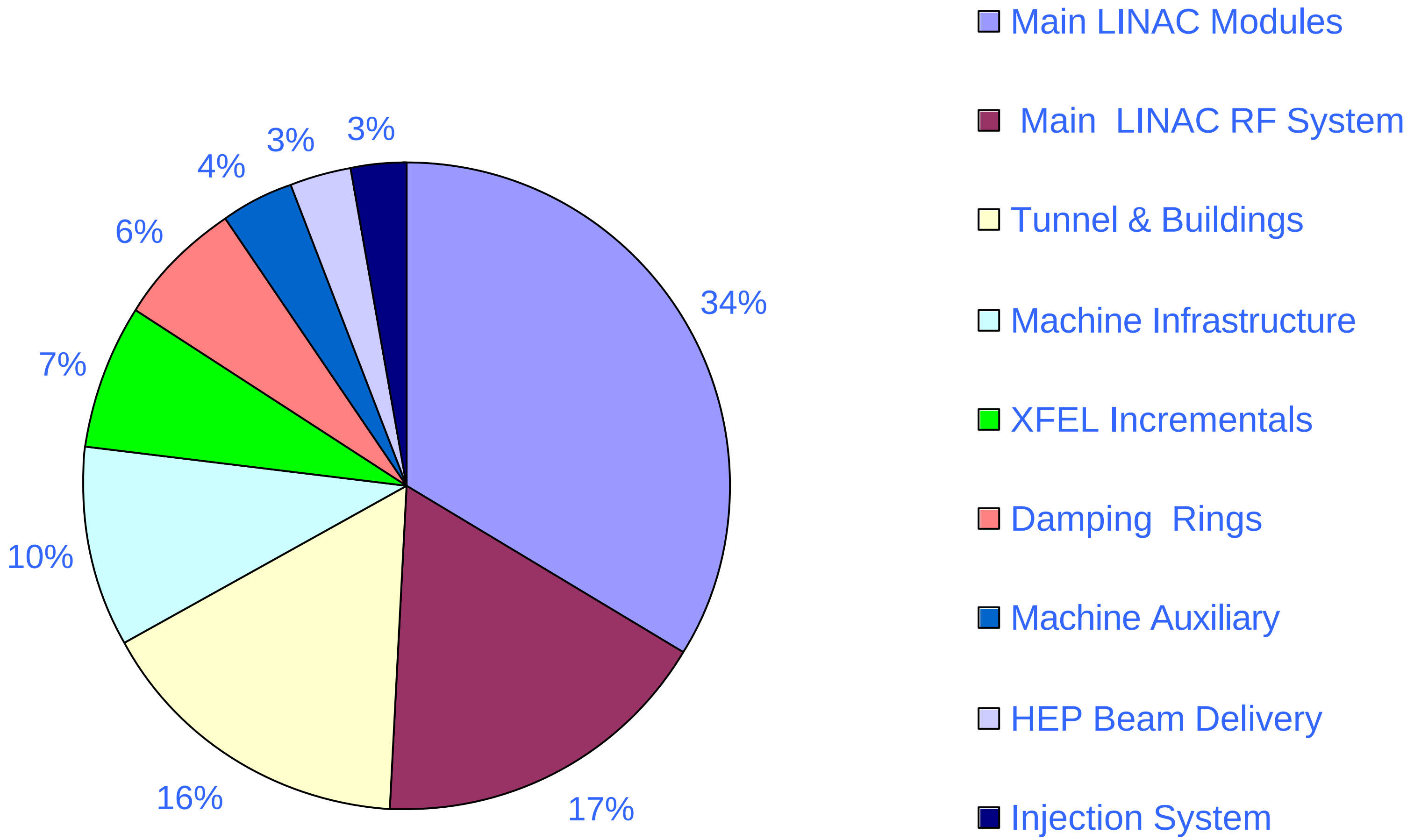
Cost Review (2)

Cost Estimate for Collider and X-FEL Increment was structured in 4 layers:

			Items
Layer	1	Machine parts or facilities	9
	2	Machine subgroups	40
	3	Equipment groups	400
	4	Equipment types	3000


DESY site
~ 33 km
Westerhorn
Auxiliary halls
Electron sources
e- Damping Ring
e+ Source
PreLinac
e+ Beam line
e+ Damping Ring
e- Main LINAC
Delivery e-
IP
e+ Delivery
e+ Main LINAC
Beam dumps
e- Beam lines
High energy physics detector &
Xray Free Electron Laser laboratory
X FEL Switchyard
TESLA schematic view
Machine cost distribution
1131 Million Euro
587
546
336
241
215
124
101
97
Main LINAC Modules
Main LINAC RF System
Civil Engineering
Infra structure
X FEL Incrementals
Damping Rings
Auxiliary Systems
HEP Beam Delivery
Injection Systems

TESLA Budget distribution - relative -



TESLA

Cost Review - XFEL Lab

		531 million Euro
Accelerator	RF gun, 500 MeV linac, upgrade of 50 GeV linac to 10 Hz (RF, cryo), bunch compressor, beam lines etc, diagnostics, civil construction	241 million Euro
XFEL Lab	Undulators, beam lines, experi-ments	290 million Euro

5 laser beam lines with 3 experiments each

5 other beam lines with 1 experiment each

TESLA

Manpower Requirement

DESY accelerator staff amounts to ~ 450

Additional Personnel needed for the different stages of the project (8 years)

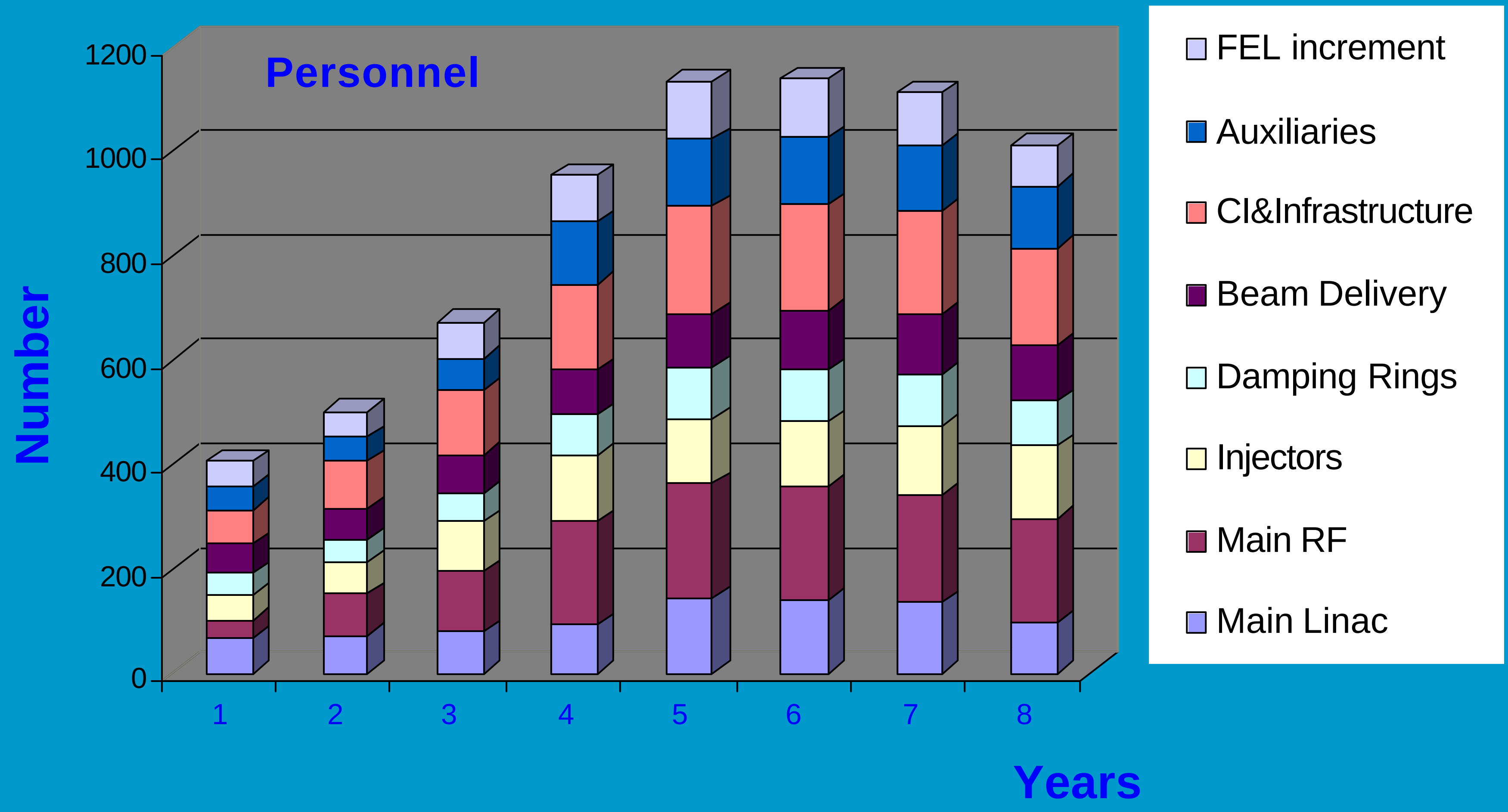
3500 person-years

(design, procurement, fabrication, assembly, testing, installation, commissioning)

calculated on the basis of TTF and HERA

manpower for fabrication in industry is included in the investment cost

Manpower / Year



Maintenance and Operation

Operation

- electrical power (155 MW / 5000 h/y)	39 MEuro
- Klystrons (78/y)	7 MEuro
- Helium loss (30%)	0.7 Meuro
- Water etc	
	~ 50 MEuro

Maintenance

- 2% of 3136 MEuro	62 MEuro
- 2% of 241 Meuro	5 MEuro
	~ 70 MEuro

Total/year	120 MEuro
% of Investment	3.6 %

TESLA

Cost Review - Detector

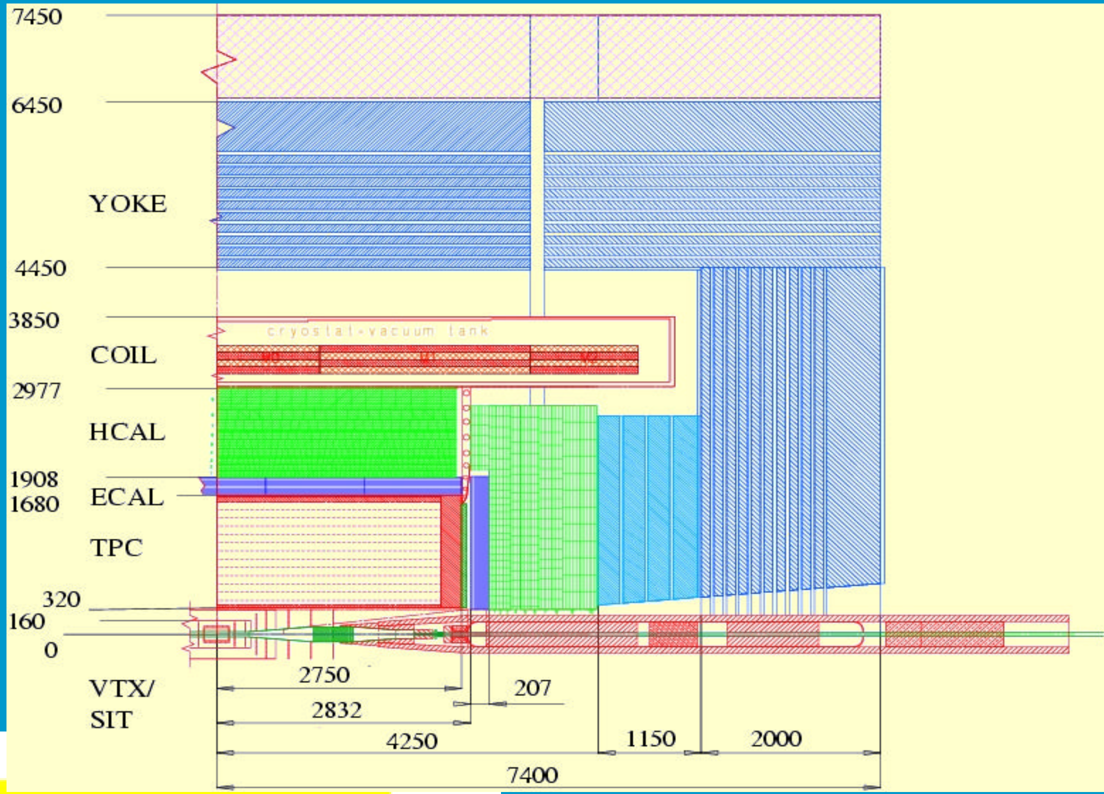
A Detector for Particle Physics — 210 million Euro

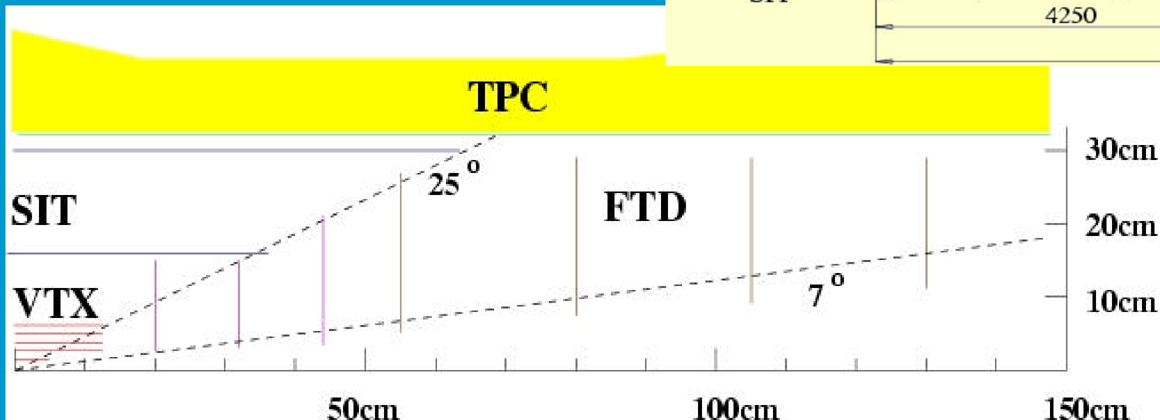
Cost estimate based on experience with experiments at LEP and HERA and those under construction at the LHC

Depending on choice of technology, including DAQ, beam energy measurement and polarimetry

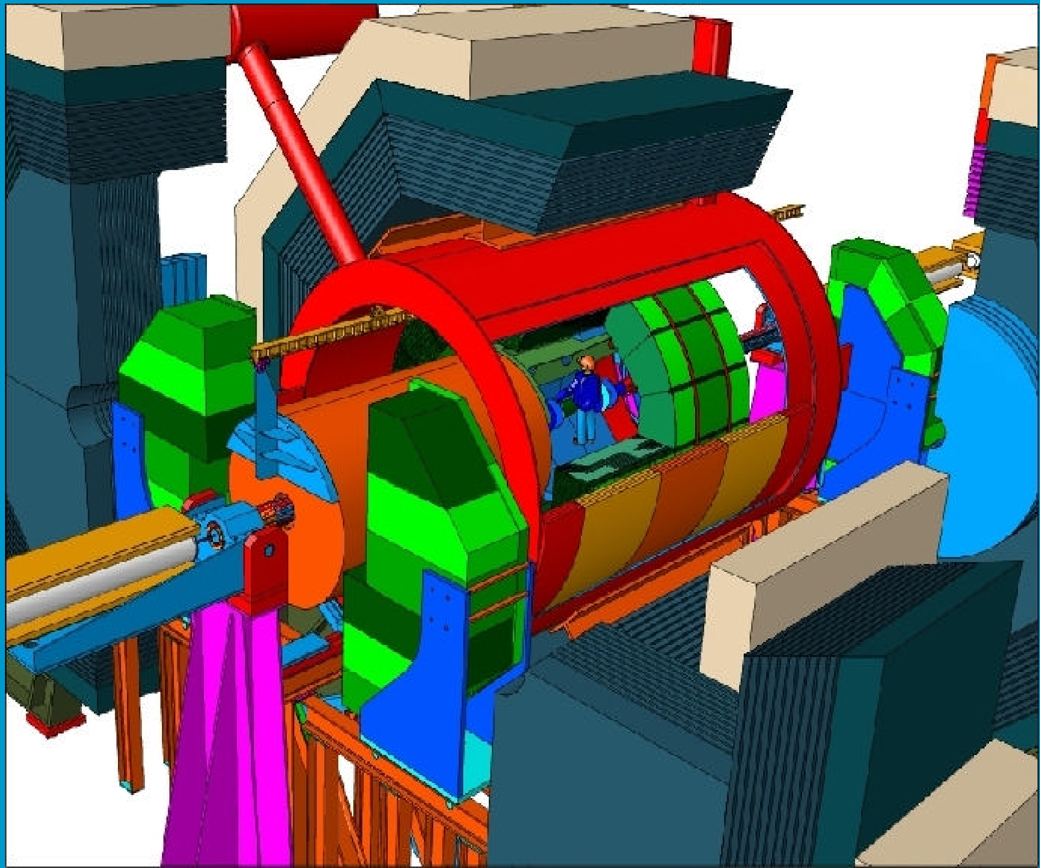
The price bracket is mainly due to the choice of the electromagnetic calorimeter — 160 - 280 MEuro

Detector

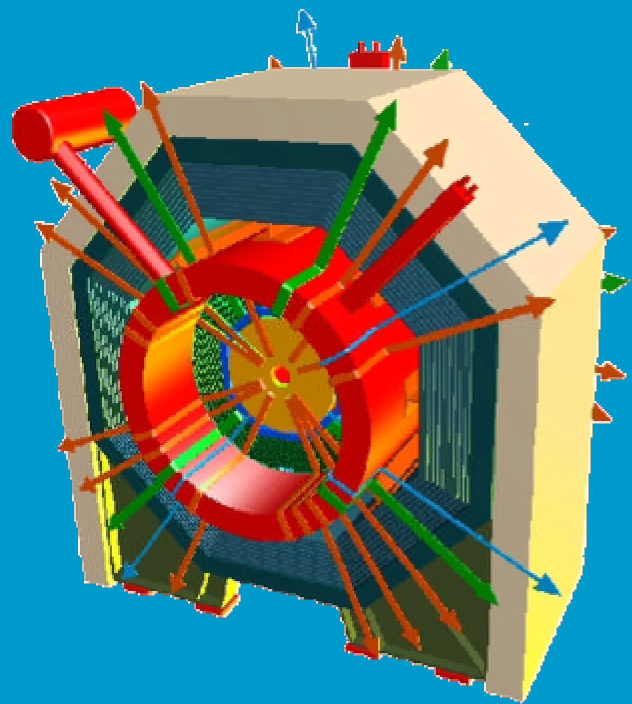

7450
6450
YOKE
4450
3850
cryostat+vacuum tank
COIL
2977
HCAL
1908
1680
ECAL
TPC
320
160
0
VTX/
SIT
2750
207
2832
4250
1150
2000
7400


TPC
SIT
VTX
FTD
25°
7°
30cm
20cm
10cm
50cm
100cm
150cm

Detector Mechanics



First conceptual version of detector moving and installation:



Proposed cable routes out of the detector

Cost Summary

500 GeV Linear Collider	3,136 million Euro
X-FEL increment and laboratory	531
Detector for particle physics	210
Sum	3,877 million Euro

Time Scales

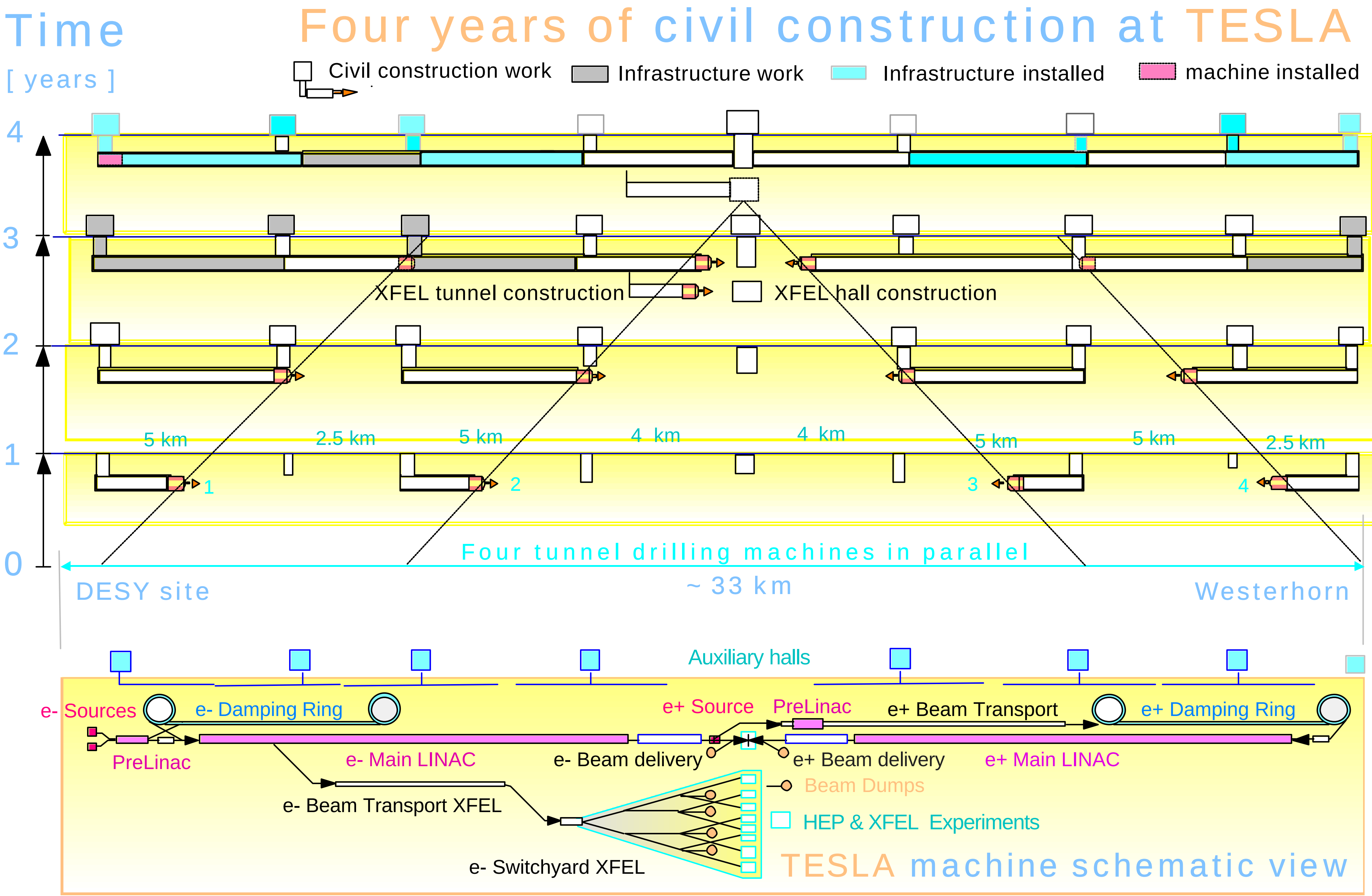
The construction time of TESLA is 8 years

This estimate is based on industrial studies and

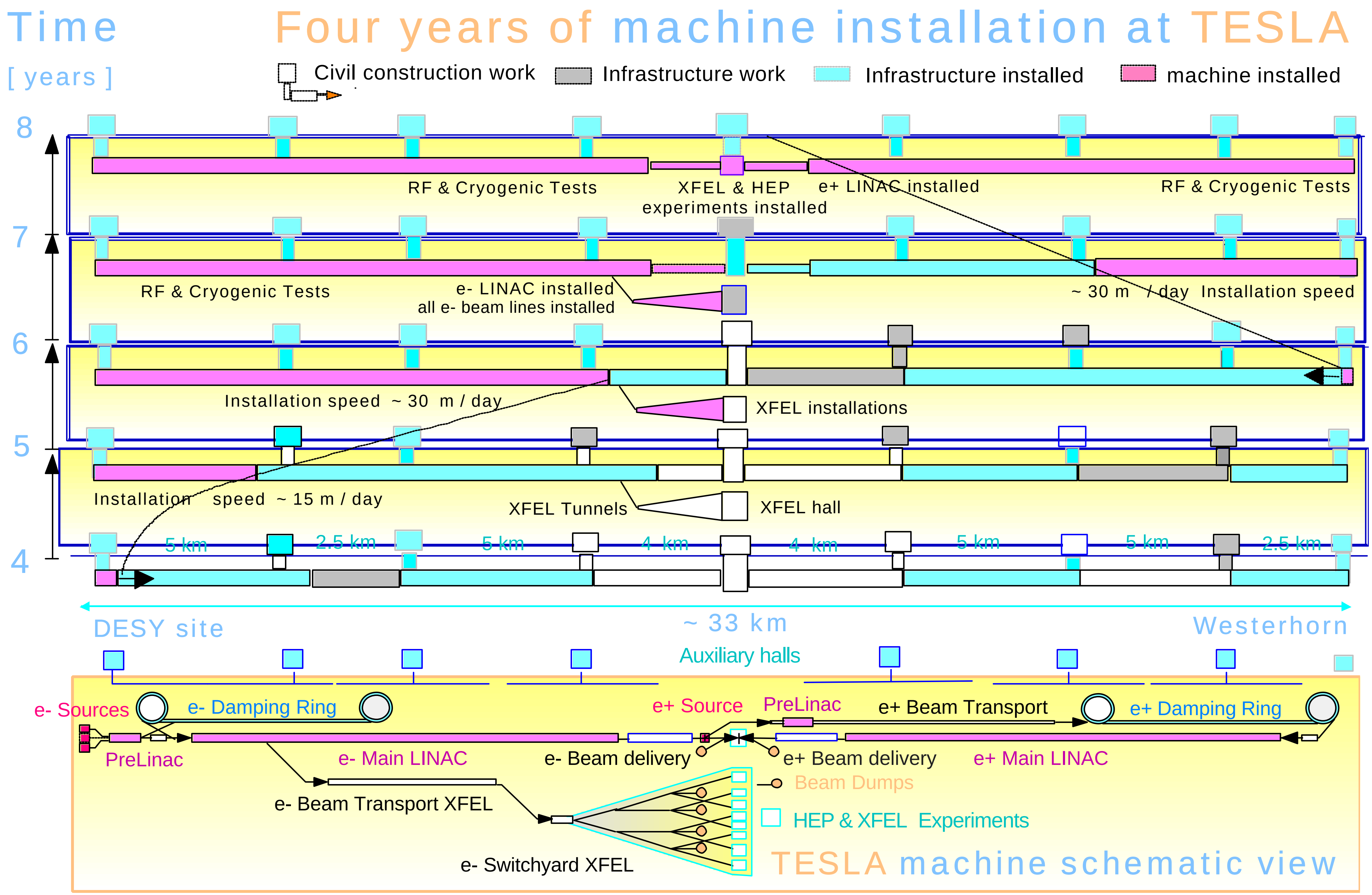
the experience gained from the construction of HERA and the TESLA Test Facility

The detail schedule is given on the following two plots for

- civil engineering
- machine installation



Time
[years]
Four years of civil construction at TESLA
Civil construction work
Infrastructure work
Infrastructure installed
machine installed
4
3
2
1
0
XFEL tunnel construction
XFEL hall construction
5 km
2.5 km
5 km
4 km
4 km
5 km
5 km
2.5 km
1
2
3
4
Four tunnel drilling machines in parallel
DESY site
~ 33 km
Westerhorn
Auxiliary halls
e- Sources
e- Damping Ring
e+ Source
PreLinac
e+ Beam Transport
e+ Damping Ring
PreLinac
e- Main LINAC
e- Beam delivery
e+ Beam delivery
e+ Main LINAC
Beam Dumps
e- Beam Transport XFEL
HEP & XFEL Experiments
e- Switchyard XFEL
TESLA machine schematic view



Time
[years]
Four years of machine installation at TESLA
Civil construction work
Infrastructure work
Infrastructure installed
machine installed
8
7
6
5
4
RF & Cryogenic Tests
XFEL & HEP experiments installed
e+ LINAC installed
RF & Cryogenic Tests
RF & Cryogenic Tests
e- LINAC installed
all e- beam lines installed
~ 30 m / day Installation speed
Installation speed ~ 30 m / day
XFEL installations
Installation speed ~ 15 m / day
XFEL Tunnels
XFEL hall
5 km
2.5 km
5 km
4 km
4 km
5 km
5 km
2.5 km
DESY site
~ 33 km
Westerhorn
Auxiliary halls
e- Sources
e- Damping Ring
e+ Source
PreLinac
e+ Beam Transport
e+ Damping Ring
PreLinac
e- Main LINAC
e- Beam delivery
e+ Beam delivery
e+ Main LINAC
Beam Dumps
e- Beam Transport XFEL
HEP & XFEL Experiments
e- Switchyard XFEL
TESLA machine schematic view

TESLA

as an International Project

The OECD Megascience Forum (1995) distinguishes four organisational models for future accelerators:

1. National and regional facilities:
Built, financed and operated by the host country or host region,
planning, project- definition done in international co-operation.

2. 'HERA-model':
Large facilities not financed by one country or one region alone,
host receives contributions - mostly in kind - from participating countries,
planning and project-definition are done in international co-operation,
host country or institution is responsible for the operation.

3. Very large projects
Construction and operation realised through contributions in shares,
partners contribute through components or subsystems (as in major detectors),
facility would be the common property of the participating countries,
these would also share the responsibility and cost for operation.

4. Very large projects in the frame of an international organisation like CERN.

Global Accelerator Network

We propose to build TESLA according to model 3, as a world-wide network:

The project is open for participation of international and national research and academic institutions

Makes project part of the national programs of the participating countries

How ?

- Design, construction, and testing of components is done in participating inst.,
- capital investment is done under the responsibility of the participating institutions/countries,
- maintain and run accelerators to a large extent from participating institutions

Why ?

- Make best use of world-wide competence, ideas, resources,
- maintain scientific and technical culture in home labs,
- remain attractive for young scientists,
- contribute to and participate in large, unique projects,
- the site selection would become a less critical issue.

Put accelerator at an existing lab: make optimal use of existing experience, manpower and infrastructure

TESLA

ICFA Study on Global Accelerator Network

Global Considerations (A. Astbury et al.):

HEP collaborations work on consensus

- takes time
- can produce cost over-runs
- too many funding sources involved

Accelerator collaboration

- lab structure needed
- host nation is essential
- will bear a major fraction of cost

Technical Considerations (F. Willeke et al.):

- Project requires a central management
- Host lab will have safety responsibility
- In principal all operations can be carried out remotely (LEP, HERA experience)
- local staff of approx. 200 people needed

(TTF is controlled from Saclay)

ALMA

An example from Astronomy:

The Atacama Large Millimeter Array (ALMA)

• Merger of the major millimeter array projects into one global project:

- European Large Southern Array
- U.S. Millimeter Array,
- possibly the Japanese Array.

• Largest ground-based astronomy project of the next decade

Project of Limited Duration

TESLA as Project of Limited Duration

Initial project duration should be 25 years,
including 8 years of construction.

After 10 years of operation a possible extension of the project should be decided upon.

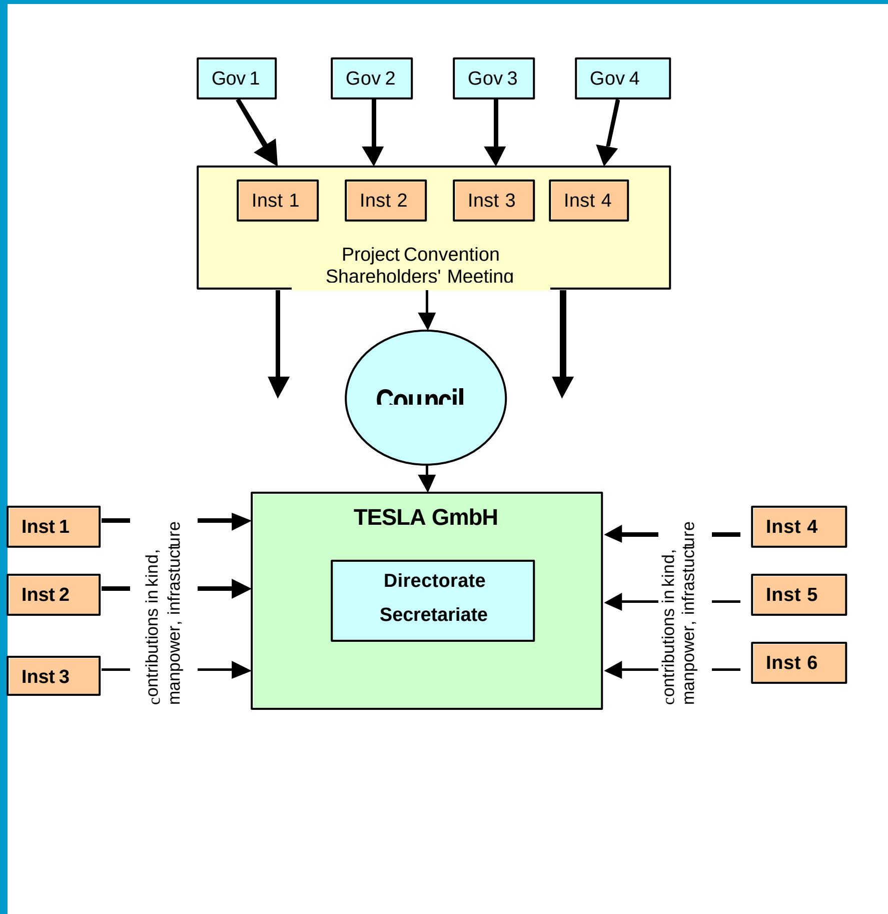
International Project Convention

TESLA as an international project:

Can only be realised on the basis of a long term involvement of the participating institutions and countries,

Basis for the project should therefore be an agreement between the participating countries or institutions (Project Convention) :

intention
- to construct and operate TESLA,
- to finance the project,
- to set up a project organisation



Specific Role of the Host Laboratory

The Host Lab will

- make its infrastructure, personnel and services available to the project.

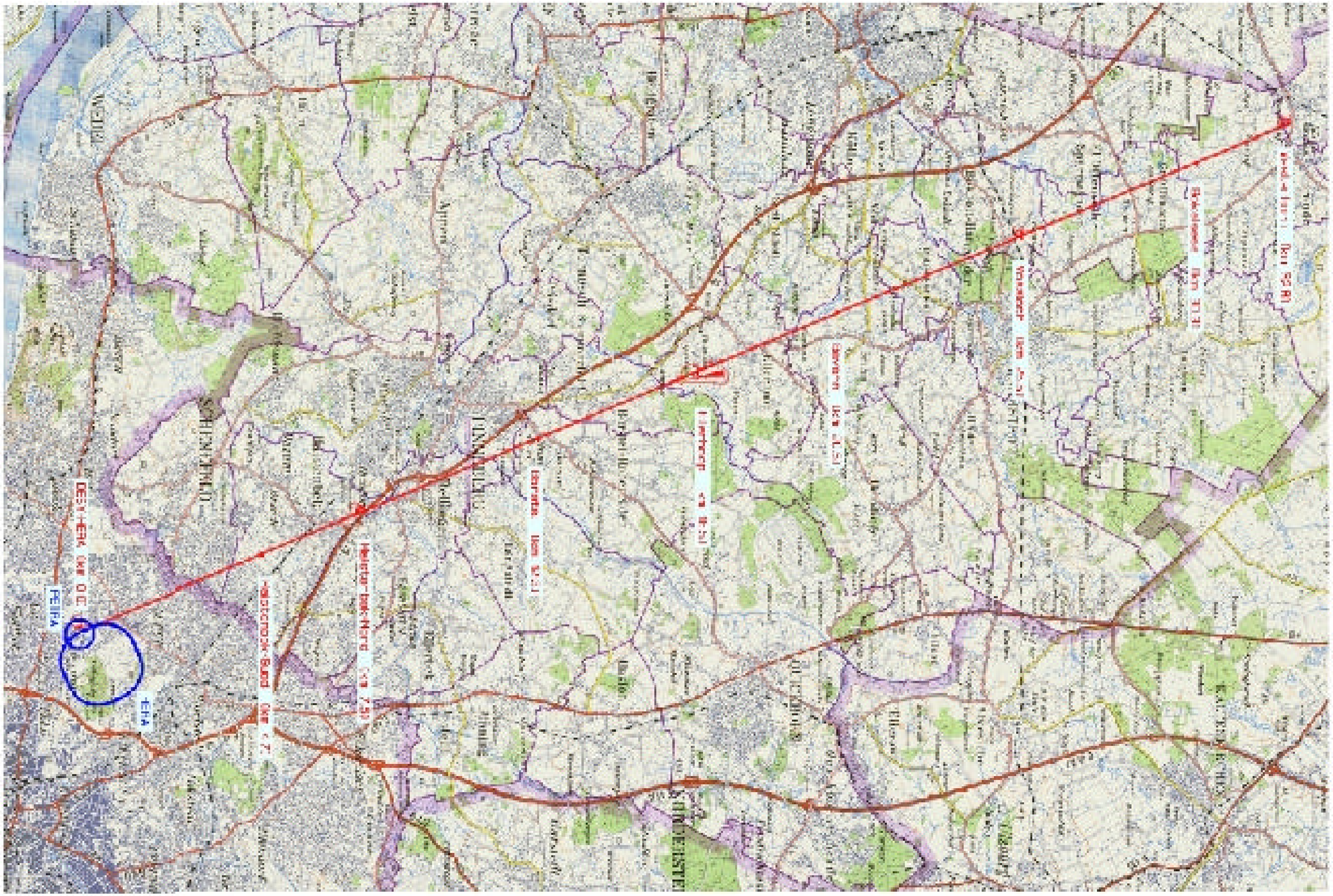
- assumes the responsibility for e. g.

• security, radiation safety
• site- and facility management
• technical infrastructure
• guest-services
• co-ordination of external communication/ media service.

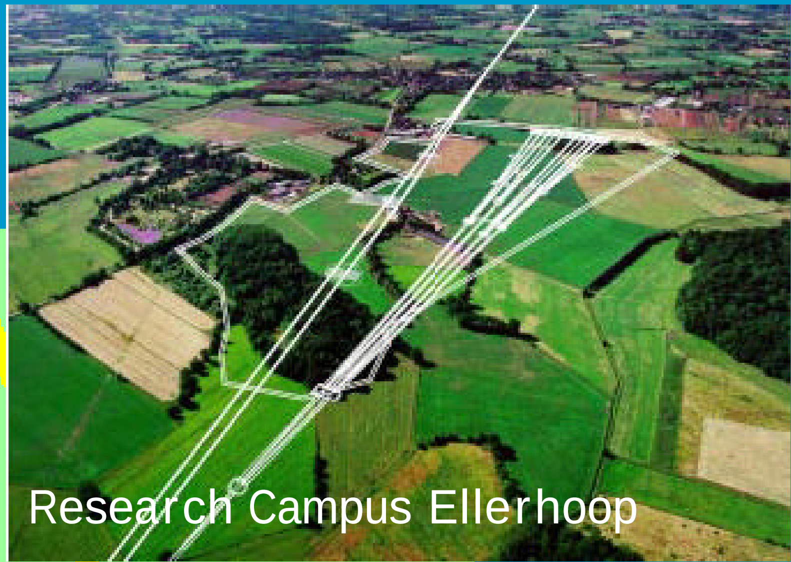
The contract between the project management and the host laboratory must clearly define the respective responsibilities and obligations.

To ensure a close and smooth co-operation between the project management and host laboratory a steering committee is proposed.

Site Consideration



Site Issues



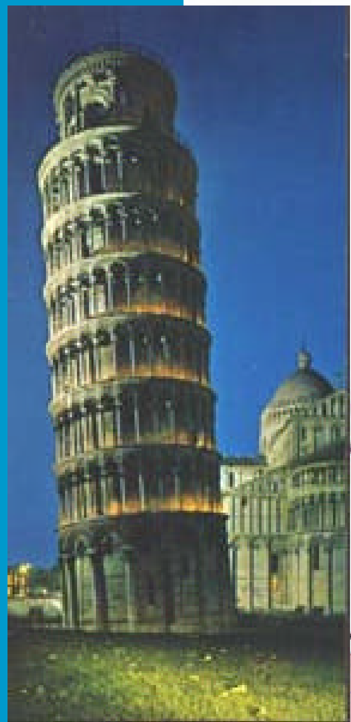
Two independent radiological evaluations

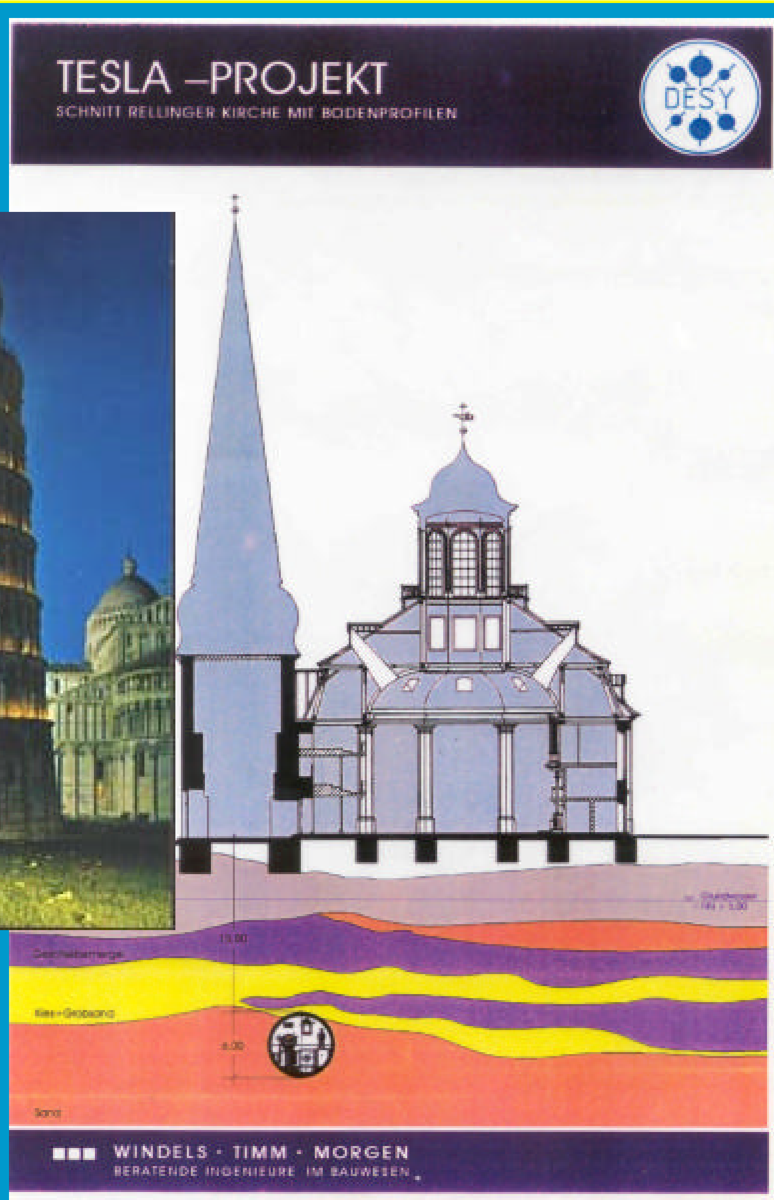
Preparation of environmental impact study

Agreement between the states Schleswig-Holstein and HH for joint legal procedure

Regular information of all persons living along TESLA

The Church in Rellingen





Pfarrer A. Knuth:

This kind of basic research asks the same questions as religion: Where do we come from?

TESLA

Next Steps - Evaluation

- Submission of TDR for evaluation in Germany by German Science Council
- ECFA Study on long-term perspectives of particle physics in Europe,

  with similar studies in Asia and the USA
- ICFA Technical Review of Linear Collider Technologies

in parallel

- Continued operation of the TESLA Test Facility TTF1
- Extension to TTF2

Next Steps - Science and Technology

You have seen the result of many years of successful R & D by the TESLA collaboration

however:

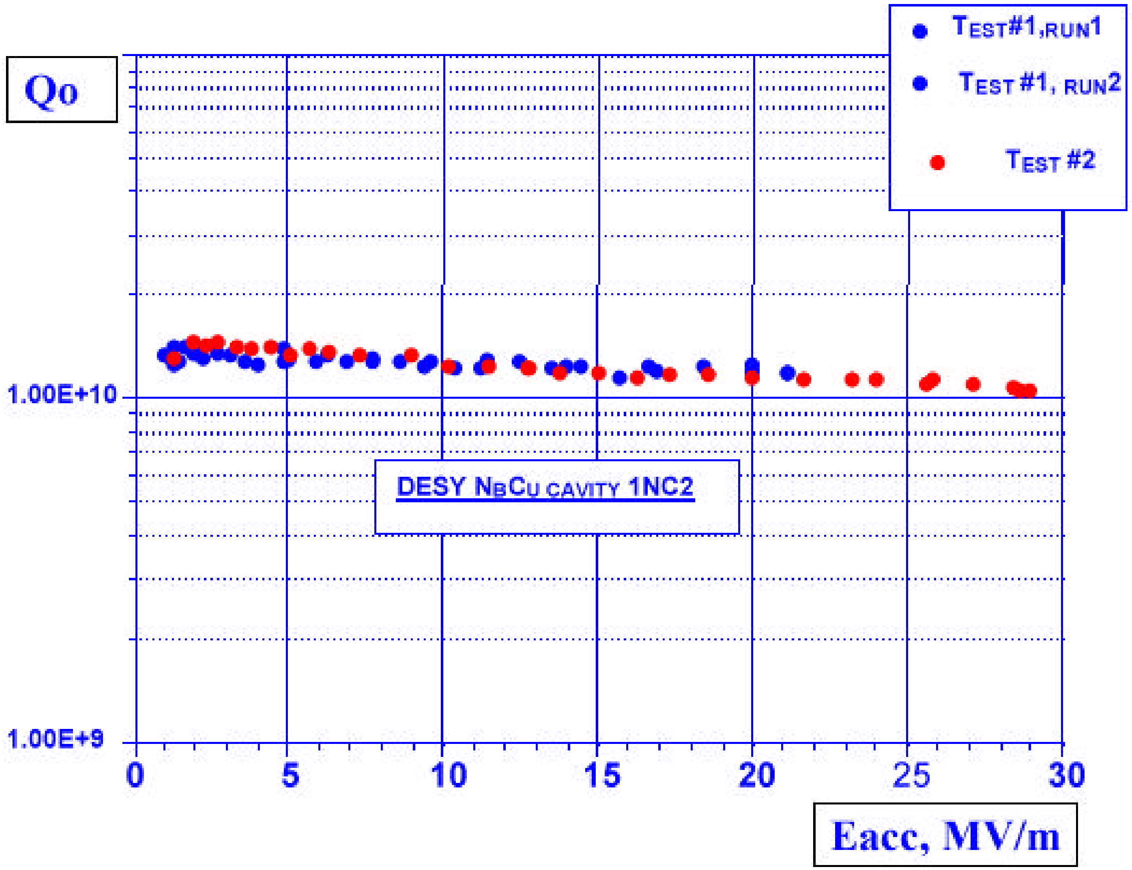
This is not the end of R & D,

important and challenging topics lie ahead

The TESLA collaboration is still growing (PSI, Jefferson Lab)

Feel invited to join

R & D on Cavities



DESY NbCu clad cavity: test 1- after 90µm BCP, test 2- add. 80µm BCP.

TESLA

How to Proceed

Scientific community world-wide has to agree that the scientific potential of an electron-positron LC in the energy range of 500 - 1000 GeV is excellent and complementary to LHC and that it therefore requires a timely realisation (ECFA, HEPAP, Japan).

One must set up a way to identify a common accelerator technology and unite behind it (ICFA Technical Review).

Convince all interested governments to invest in a joint international project, e.g. through the mechanism of a Global Accelerator Network.

The Choice of site will be primarily a political decision, determined by which country/region is willing to host the facility. The host has to make a major investment and a long term commitment.

Conclusion

DESY therefore proposes to

- the international scientific community,
- the German federal government,
- the northern German states

to build TESLA in the vicinity of Hamburg