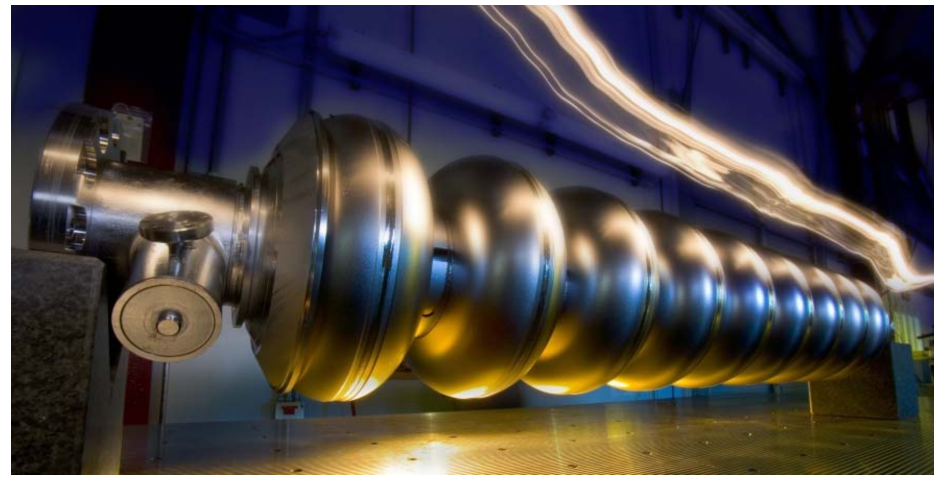
International Collaboration with High Energy Accelerators

IPAC'10 The 1st International Particle Accelerator Conference

The 1st International Particle Accelerator Conference
Kyoto, Japan / May 23-28, 2010



Albrecht Wagner
DESY and Hamburg University

Kyoto, 24 May 2010

IPAC 2010

- IPAC 2010 marks the first of a series of new conferences that will combine the success of three predecessor conferences in America, Asia and Europe in a common platform of truly global character
- This will enhance the international scientific exchange and the worldwide dissemination of knowledge in the field
- Joining forces is the most appropriate way to address the global needs in times of larger, more complex and more expensive projects
- ICFA proposed in 2006 to combine PAC, APAC and EPAC. This was agreed by the three conference organizations
- My thanks to the three conference organizations and our Japanese colleagues who offered to host this first conference

ICFA and Accelerators

International Committee for Future Accelerators (ICFA)

- Mission: Facilitate the international collaboration in the construction and operation of accelerators for particle physics
- ICFA works largely through panels, three of which deal directly with accelerator issues:
  - Beam Dynamics Panel
  - Panel on Advanced and Novel Accelerators
  - International Linear Collider Steering Group

ICFA and Accelerators

ICFA classification (1993) of different organisational models for the construction and operation of particle physics accelerators and experiments:

- *National or regional facilities:* (e.g. DESY, SLAC and KEK)
- *'Larger' facilities which cannot be funded by one country or region* (HERA model)
- *Very large projects needing a collaboration of several countries with comparable share of the total construction and operation cost* (European XFEL)
- *Very large projects in the frame of an international organisation* (LHC)

- This talk will focus on the experience gained with the last three models

Why Collaborate Internationally on Experiments?

- Experimental particle physicists form collaborations, to cope with size, complexity, and cost of their experiments.

- United in a common scientific approach
- Sharing the responsibility for building and operating their complex detectors and for analysing the data.
- Collaborations have grown with the energy of the accelerators, by about a factor 6 every ten years. In addition they became more and more international.
- Growth handled successfully by applying the lessons learned during one step to the next one.
- Nevertheless, doing science in very large collaborations remains a challenge.

Why Collaborate Internationally on Accelerators?

Similar reasons -> more international collaboration in the construction of large accelerators:

- Size and cost of projects increased and the necessary funding could no longer be borne by one country.
- Scientific challenges related to the development of new acceleration technologies called for pooling the world-wide know-how.
- Political climate concerning basic research has changed. Basic research is seen as something one should tackle in international collaboration, as no immediate financial return is expected and the risk is shared.
- Time gap between new projects increases as projects become bigger.

Therefore laboratories are faced with the problem of providing interesting work for their highly skilled staff, an incentive to engage also in outside projects.

Challenges

There are also challenges related with this approach:

- A world-wide coordination of accelerator related R&D work needs to be organised.
- A scientific consensus concerning the performance parameters has to be reached.
- In certain cases a choice of the most adequate accelerator technology needs to be made.
- The potential conflict between priorities (laboratory versus outside project priorities) needs to be dealt with. For obvious reasons the management of a laboratory will tend to give higher priority to in-house projects.
- The question of responsibility and management control becomes more complicated.

In case of very large experiments and detectors these challenges have been met successfully in the past. Can the detector model be applied to accelerator projects?

Modes and Phases of Collaborations on Detectors

- Research and Development (detection methods and technologies)
- Design and construction of a common detector (responsibility for individual sub-detector lies with a sub-set of the collaboration. Each group carries the full responsibility for its component. Overall coordination of construction is typically with host laboratory).
- Maintenance and operation of detectors (remains with the groups responsible for construction). The same is true for upgrades and improvements.
- Analysis of data done by individuals and coordinated according to scientific questions.

Operation costs are shared

Modes and Phases of Collaborations on Accelerators

Collaborations on accelerators have in principle similar phases:

- Research and Development of accelerator technologies
- Design and construction of new facilities
- Maintenance and operation of facilities which were built in a collaborative effort
- Analysis of the performance and development of improvement programmes.

The first two phases have worked very well in the past, while the last two phases so far have not been implemented except in a few small-scale tests.

Models for International Projects - HERA

HERA, an electron/positron – proton collider was built between 1986 and 1991 and operated between 1992 and 2007.

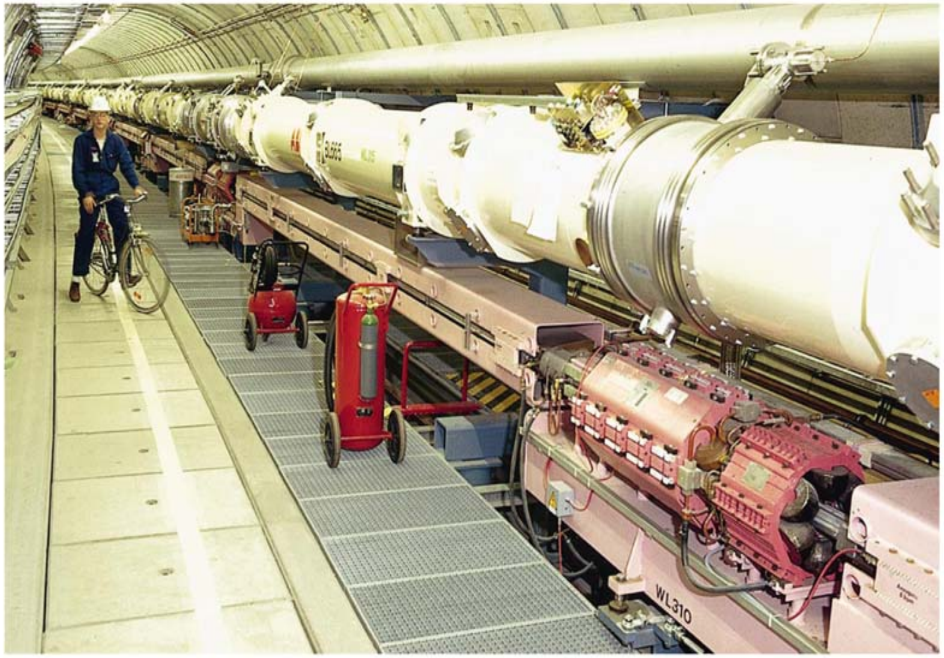
25 % of construction funds were provided by international partners

Ten countries from Asia, North America and Europe contributed components

Two countries (China and Poland) contributed mainly through manpower performing work on various machine components.

Operation was paid by Germany

Became known as ‚HERA model'



HERA Lessons

The success was a result of the direct cooperation between DESY and the partner laboratories and institutes

Partners were responsible to get necessary funding in their countries

Early link during development phase, continuing during construction phases between producers and responsible DESY experts.

Measurement and quality control of all components at DESY.

Accounting was done in an artificial unit - "HERA-Mark". (Possible cost overruns were therefore at the risk of the producing laboratory)

The institutes were fully involved in the planning and construction of HERA as well as in the advisory bodies of DESY.

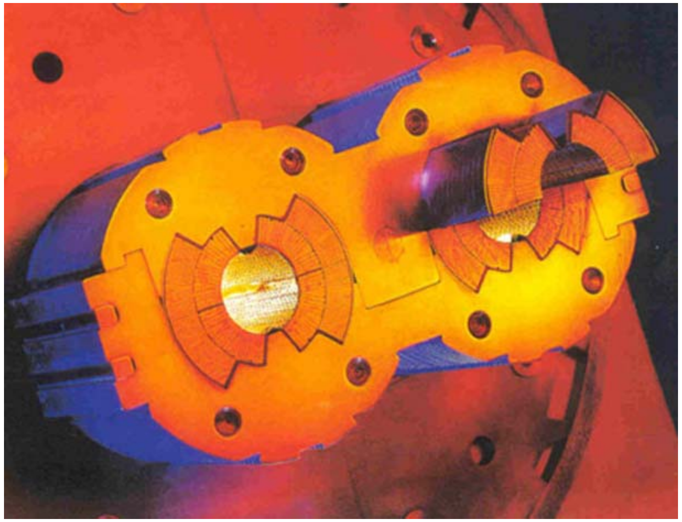
But: an involvement during the operation phase would have been desirable

The Large Hadron Collider in Geneva

proton-proton collider, under construction in the LEP tunnel

E = 14 TeV

Accelerator and experiments built with substantial international contributions, well beyond CERN member states



The external contribution to the LHC machine from Canada, India, Japan, Russia and USA corresponded to about 12 % of the total project cost. About half was in cash and half in-kind. France and Switzerland as host countries made special contributions

Examples of In-Kind Contributions to the LHC

- Canada : LHC: twin-aperture quadrupole magnets for "beam cleaning"), injector chain
- India: superconducting sextupoles, amounting to half of the total LHC corrector magnets; magnet support jacks.
- Japan: much of the basic material (steel and superconducting cable), quadrupoles, and compressors for cooling superfluid helium.
- Russia: magnets for the beamlines linking the SPS synchrotron to the LHC and insertion magnets.
- US: superconducting quadrupoles and their cryostats for beam intersections, superconducting dipoles for beam separation and cryogenic feed boxes.

This complex collaboration was successful as the impressive start of luminosity operation illustrates.

LHC Lessons

- International collaboration through "in kind contribution" worked well for LHC accelerator

  Very important example -> IR (Interaction Region) magnets

  Largest in kind contribution to the LHC machine, about 150 MCHF

  Contributed by KEK, Fermilab, BNL and LBNL

  Components critical for the LHC

- A few weak points:

  Each partner has optimized own contribution, no global optimization, e.g.

  Inner triplet quadrupoles: two families (one designed and built by FNAL and the other by KEK) with different current and power supplies -> unnecessarily complicated and expensive.

  Maintenance and spare components were not included in the agreement

TESLA Project

- Initial focus: 500 GeV e+e- Linear Collider,
- Later integration of X-ray free electron laser → TESLA TDR (2001)
- TESLA Test Facility as prototype of:

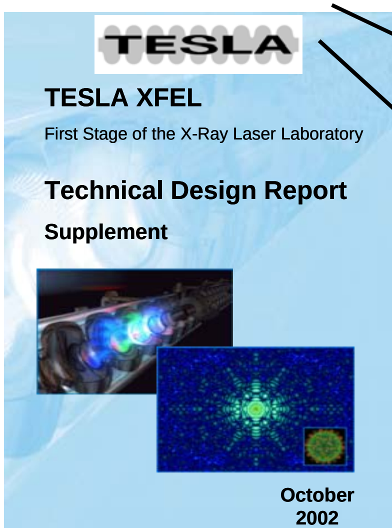
TESLA

TESLA **T**echnology **C**ollaboration *international cooperation on sc technology R&D*

International **L**inear **C**ollider *global effort towards 0.5 – 1 TeV next generation e+e- collider*

European XFEL Project

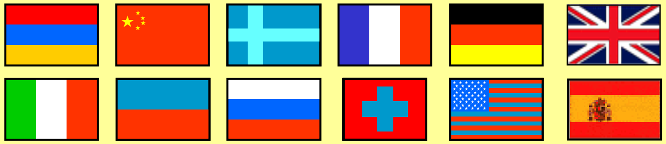
FLASH VUV-FEL



TESLA Test Facility Linac

Early building block in a world-wide effort to advance linear accelerators based on SCRF.

Common effort located at DESY of almost all laboratories using s.c. accelerating cavities



- > 50 partners from 12 countries

More than 75 cavities with gradients up to **35 MV/m**

The outside contributions corresponded to about 25% of the project cost.

TTF linac built as integrated systems test to demonstrate that a SC linear collider can be built and operated with high reliability

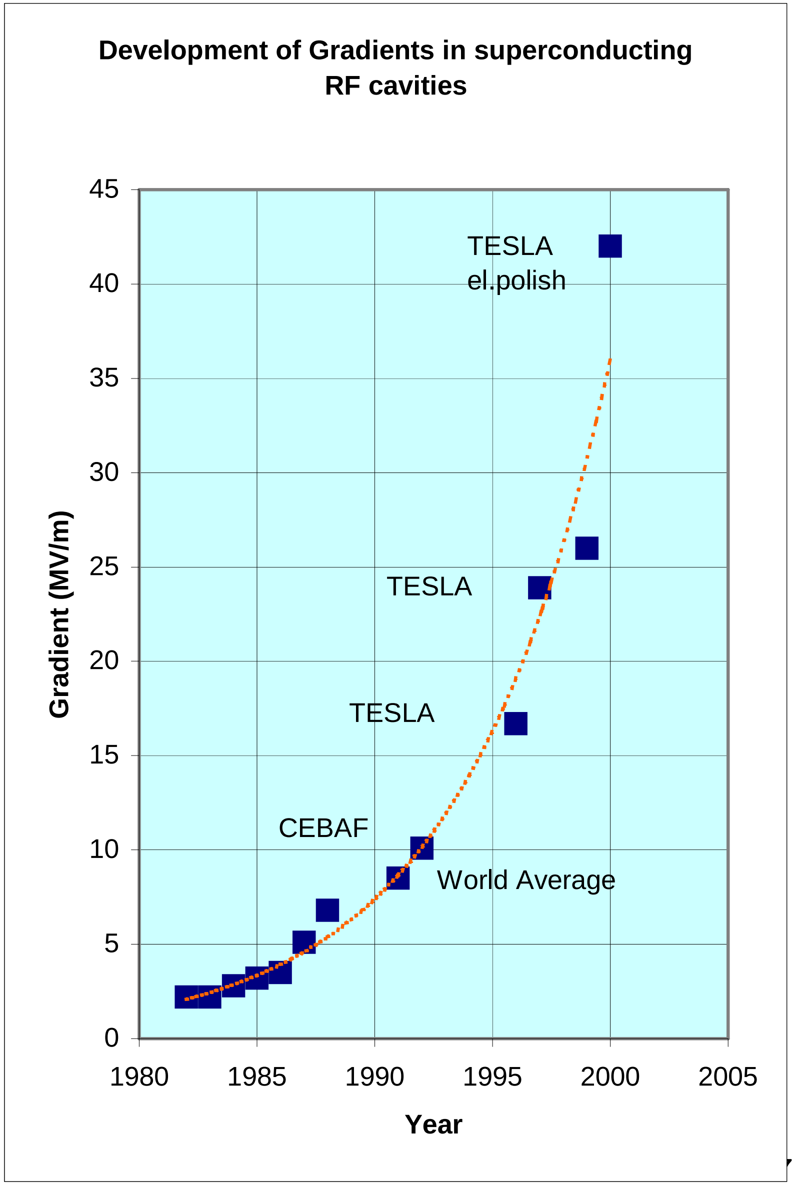
International Collaboration in Accelerator R&D

SC RF structures for accelerators were developed in many countries

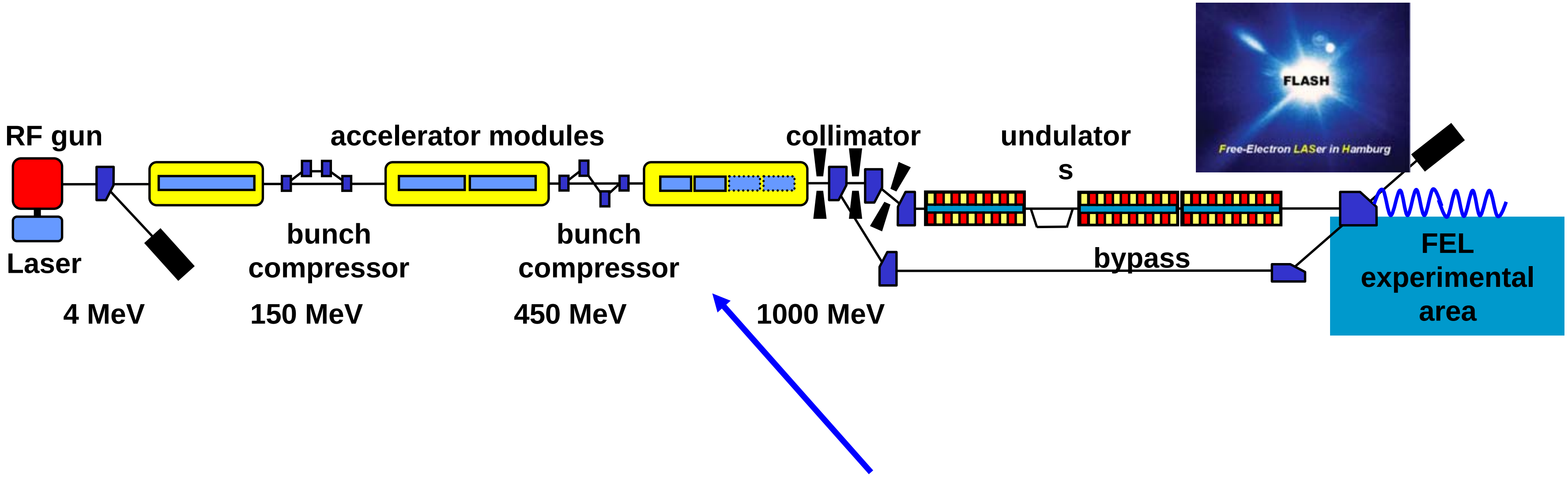
The TESLA collaboration, centred at DESY combined ~ all the world expertise in SC, thus leading to major progress:

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

Major impact on next generation light sources (X-ray lasers), proton accelerators etc.



The FLASH VUV FEL facility at DESY



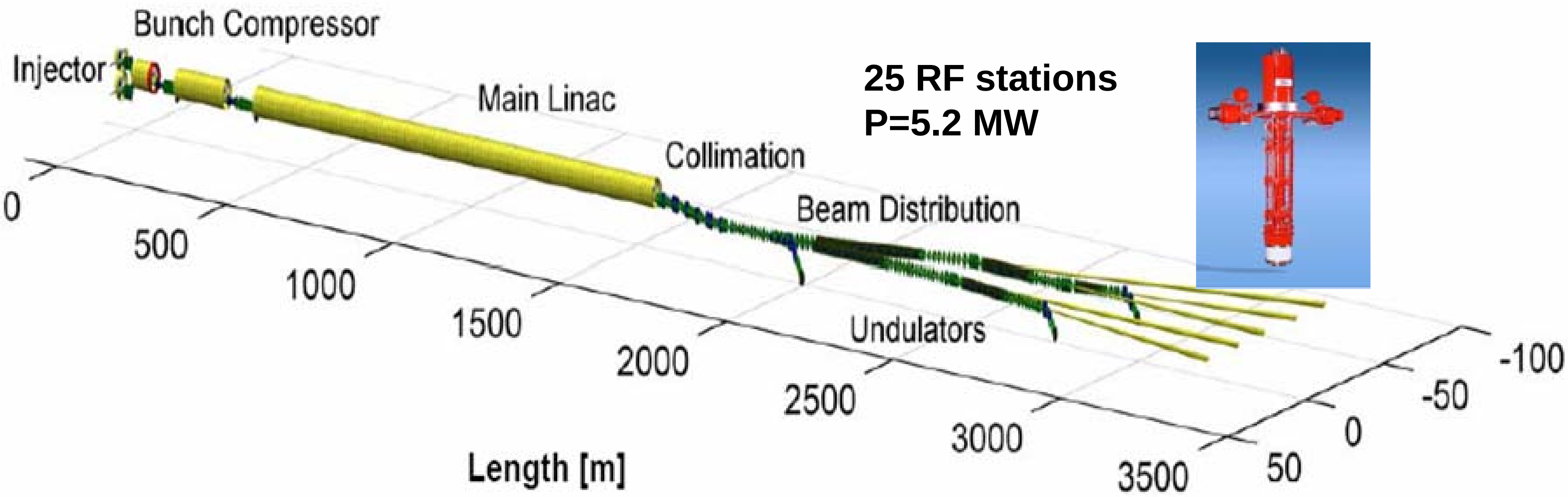
6 accelerator modules routinely in operation (now -> 7)

Pilot facility regarding practically all aspects (accelerator technology, beam physics, FEL process, user operation) of the XFEL

The European XFEL

100 accelerator modules

800 1.3 GHZ cavities
g=23.6 MV/m



25 RF stations
P=5.2 MW

The accelerator complex is built by a consortium of 17 institutes from 9 countries. About 62 % of the accelerator cost is carried by Germany, 38 % by the other countries.

Collaborative Effort on Accelerator Modules

Vessel & cryostat

IHEP/Beijing

DESY

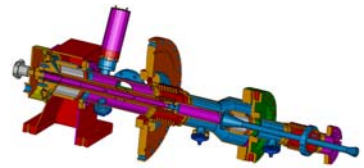
CEA/Saclay

INFN/Milano

RF power coupler

DESY

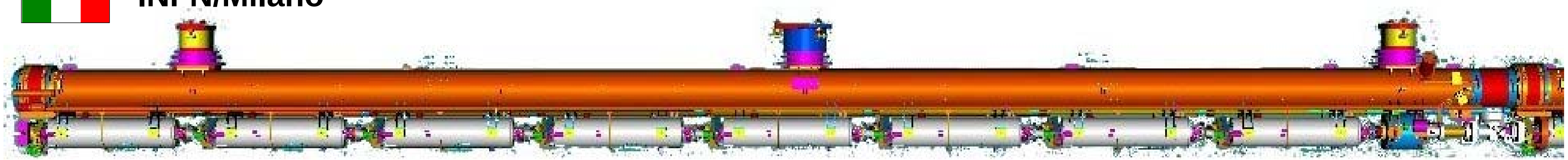
LAL/Orsay

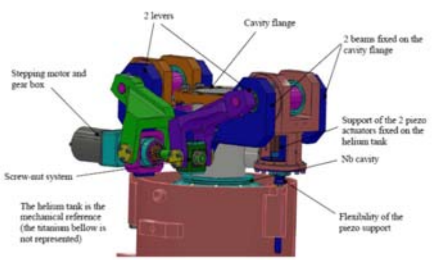


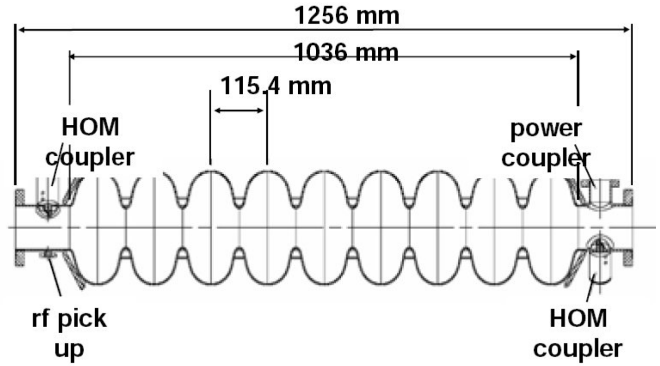
Superferric magnet

DESY

CIEMAT/Madrid







BPM

DESY

CEA/Saclay

PSI/Villigen

HOM absorber

Soltan Inst/Swierk

Freq. tuner

DESY

INFN/Milano

s.c. cavities

DESY

INFN/Milano

European XFEL Lessons (so far)

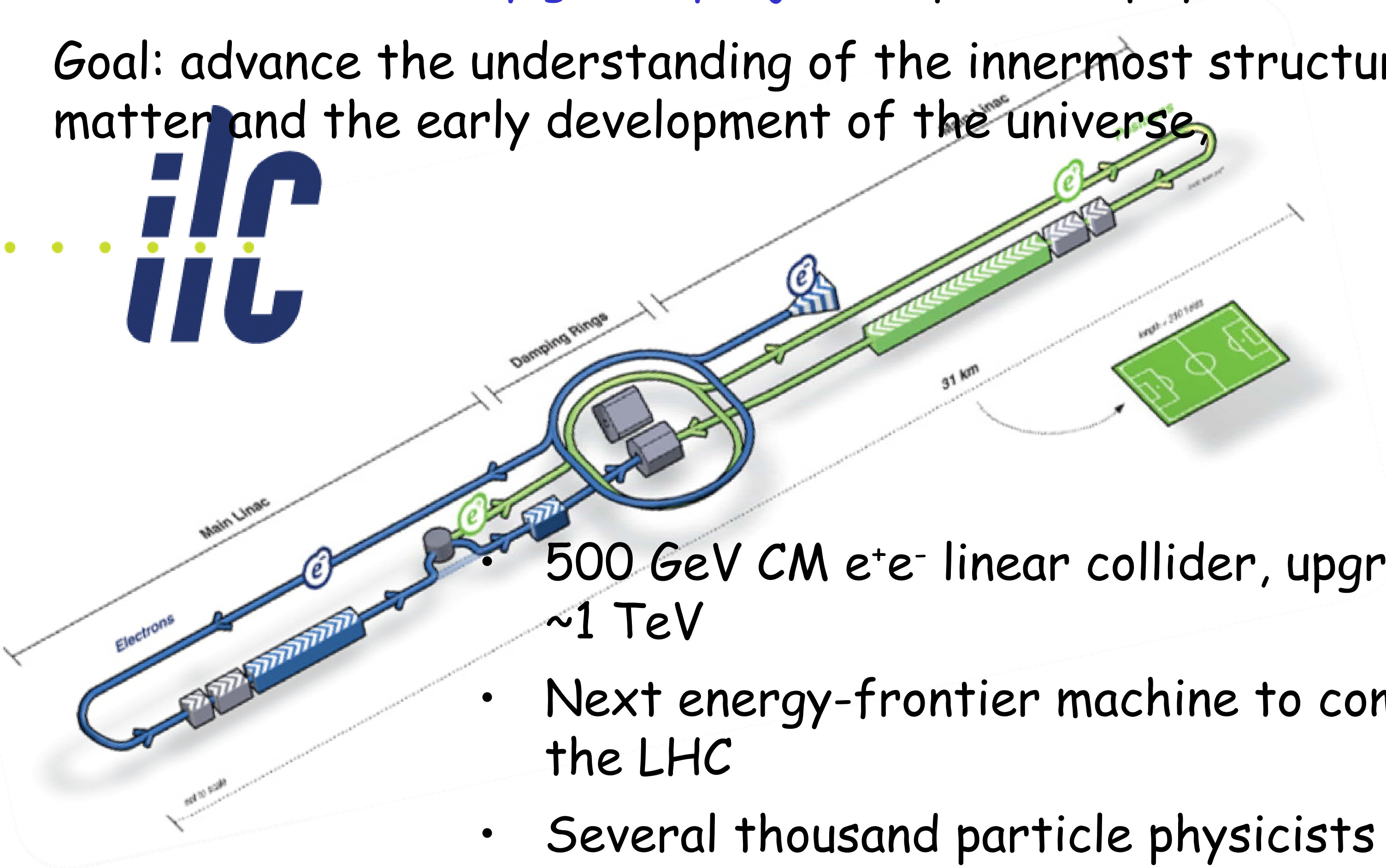
- Many partners have already collaborated on TTF, -> basis of understanding and trust
- At technical level the collaborations works very as one team.
- But: A major construction project faces constraints which differ from the R&D phase:

  Difference in willingness of the partners to deal with risks, escalation - all related to the financial aspects of the project.
- A strong host laboratory is helpful and can re-assign contributions, provided it can cope with its own budget constraints.
- Therefore being a host for a major international project puts substantial constraints on the infrastructure support.
- Model used for detectors: Common Fund, spent for common items or as risk budget.
- However, so far partners prefer in-kind contributions and try to minimize cash contributions.

Towards a Global Project - ILC

Most ambitious truly global project in particle physics so far.

Goal: advance the understanding of the innermost structure of matter and the early development of the universe,



- 500 GeV CM e^+e^- linear collider, upgradeable to ~1 TeV
- Next energy-frontier machine to complement the LHC
- Several thousand particle physicists and accelerator scientists around the world have coordinated their work during the past 15-20 years (NLC/JLC, CLIC, TESLA…)

ICFA and the ILC

ICFA has been helping guide international cooperation on the Linear Collider since the mid 1990's.

Major early steps:

1995: First ILC Technical Review Committee (TRC) Report,

1999: ICFA Statement on Linear Collider

2002: ICFA commissioned the second ILC TRC Report,

2004: ICFA unanimously endorsed the ITRP's (International Technology Review Panel) recommendation

To provide this guidance, ICFA set up the International Linear Collider Steering Group (ILCSC) in 2002 to promote the construction through world-wide collaboration.

Together with representatives of the Funding Agencies ILCSC provides the oversight over the Global Design Effort.

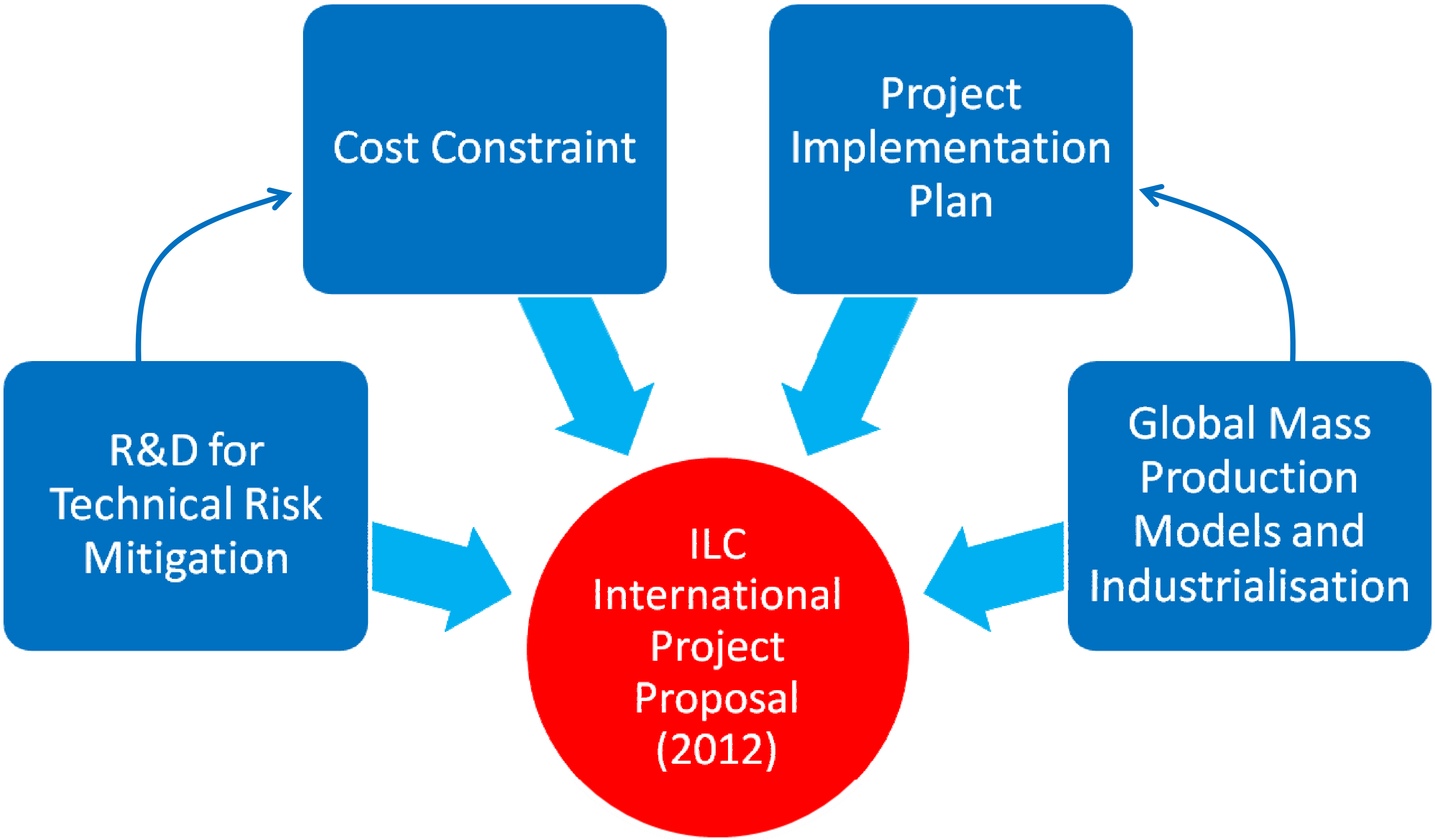
The Global Design Effort - GDE

In 2005 ICFA appointed a director (Barry Barish) for the Global Design Effort (GDE) and the regions (Asia, Europe and the North America) nominated their regional directors.

The GDE

- defined the Baseline Design (2005),
- completed the conceptual design with a cost estimate (Value costing, including first iteration cost reduction) (2006)
- wrote a Reference Design Report (RDR) (2007)
- restructured for Technical Design Phase (2008), envisaging the final planning for the TDR in 2010.
- will produce an ILC Project Proposal by 2012.
- launched a discussion about the approval process, on international governance, site selection, and funding models, in order to ease and speed up the approval process.

Global Design Effort – the Work Structure



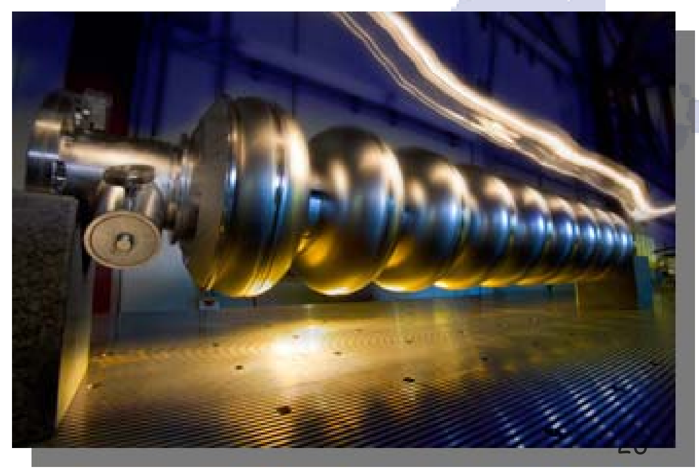
Needs to be internationally balanced.
Considerations of potential sites (and site hosts).

Global SCRF Technology

The GDE is a global effort with regionally balanced teams

It has successfully coordinated high-gradient SCRF work across the regions. This includes the build-up of the corresponding technology know-how in industry.

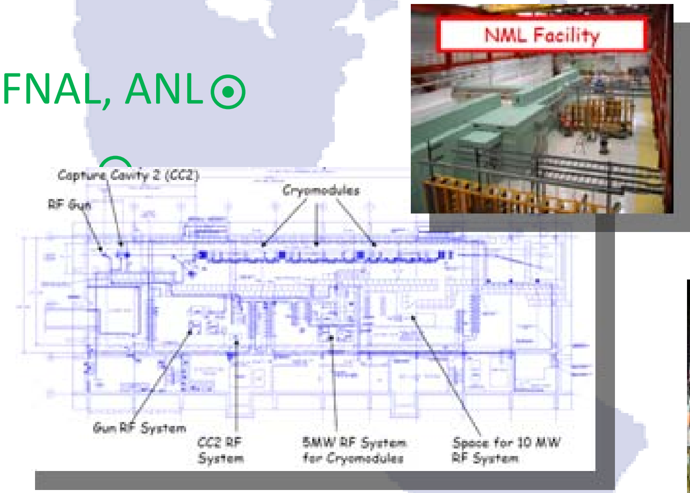
- Established SRF
- Emerging SRF



Albrecht Wagner, IPAC Kyoto 2010

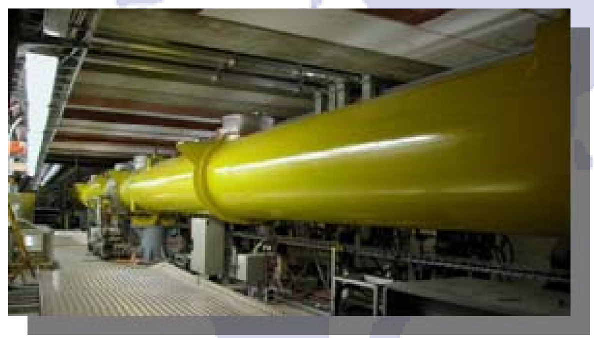
Global SCRF Test Infrastructure

FNAL, ANL



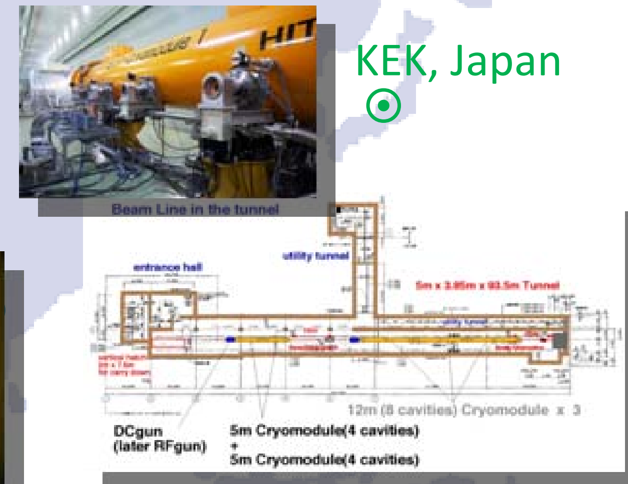
NML facility
Under construction
first beam 2010
ILC RF unit test

DESY



TTF/FLASH
~1 GeV
ILC-like beam
ILC RF unit
(* lower gradient)

KEK, Japan



STF (phase I & II)
Under construction
first beam 2011
ILC RF unit test

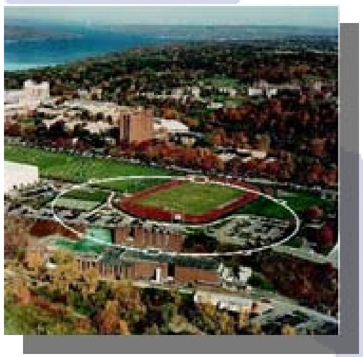
Global (Non-SRF) Beam Test Facilities

Critical R&D on Damping Rings and Final Focus

Cornell

KEK, Japan

INFN Frascati



CesrTA (Cornell)
electron cloud
low emittance

DAϕNE (INFN Frascati)
kicker development
electron cloud

ATF & ATF2 (KEK)
ultra-low emittance
Final Focus optics

GDE as a Virtual Organisation: Pros & Cons

- Pros
  - Recognised by funding agencies as a only truly Global Project
  - Independence from a single (traditional) Accelerator Lab
    - Allows robustness
    - Weathered US and UK financial crisis in 2008
  - Equality of collaborators

- Cons
  - No (or little) direct control over funding
  - Reliance on laboratory/institutes 'good will' for support
  - No centrally geographically located team
    - 'virtual' lab

Pro and a Con

GDE is in itself an experiment in how future global HEP projects could be organized

World-wide CLIC & CTF3 Collaboration

37 Institutes from 19 countries, involving 23 funding agencies

CLIC/CTF3 Multi-Lateral Collaboration

Organized as a Physics Detector Collaboration
With Collaboration Board and Spokesperson
MoU with addenda describing specific contribution (& resources)

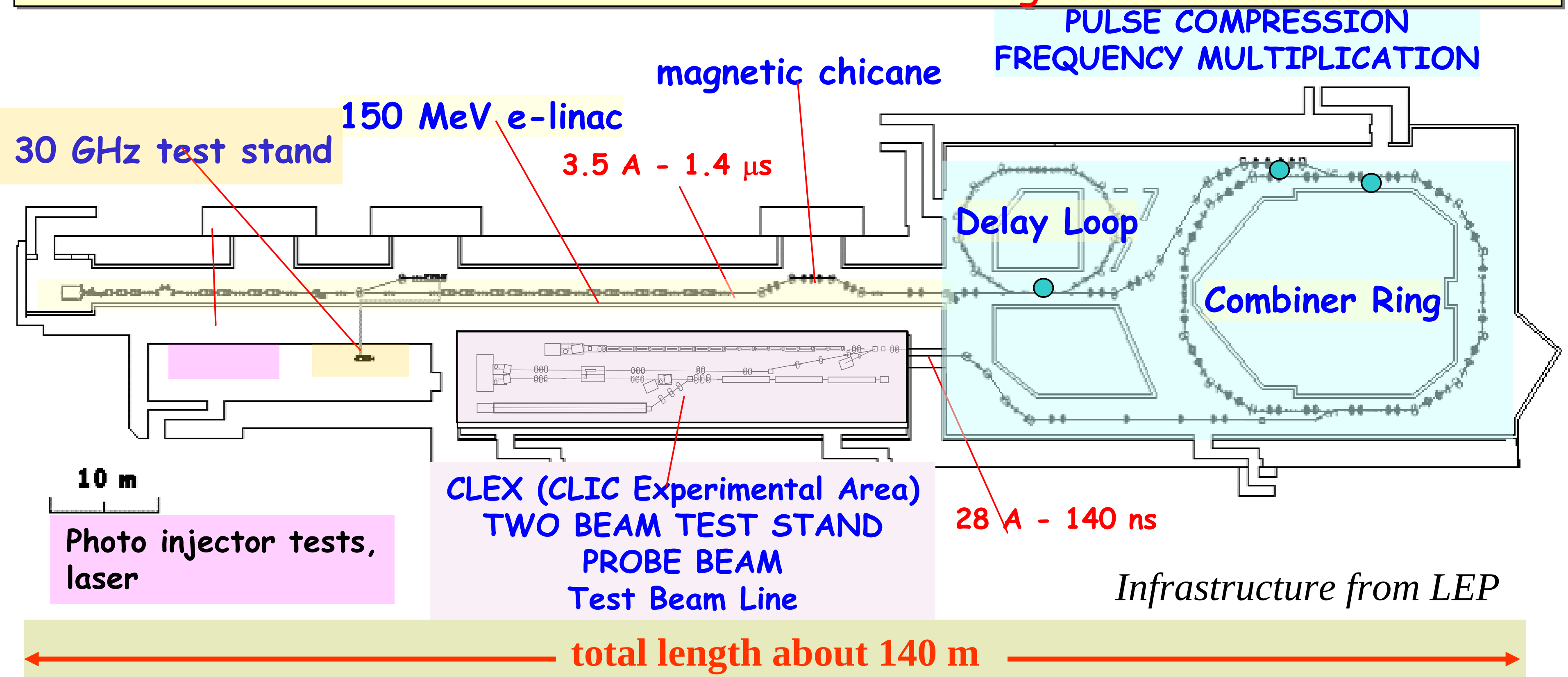
Members (full responsibility of work packages and providing corresponding resources):

- 20 CERN members with additional voluntary contributions:
- 16 institutions (CERN non members) with voluntary contributions:
  China, India, Japan, Pakistan, Russia, Turkey, Ukraine, USA

Addressing major CLIC technology issues: CLIC Test Facility (CTF3)

To demonstrate

- Drive Beam generation
- RF Power Production and test Power Structures
- Two Beam Acceleration and test Accelerating Structures



Overall Lessons Learned

Accelerators in the past were mainly built by one laboratory, but increasingly with contributions from other partners.

From the examples presented and others (e.g. NLC) one can conclude:

- R&D collaboration work well and are highly productive
- Construction as collaborative effort remains a challenge due to financial aspects
- Engagement of partners in M&O has so far not happened and remains a challenge

What could be done to overcome the hurdle of long term engagement in a project which most likely is not located in the own laboratory?

A Possible Model for Global Collaboration - 1

- A world-wide collaboration of accelerator laboratories and institutes to build, operate, utilise and upgrade a new large accelerator facility, following the example of major detector collaborations in particle physics.
- Scientists and engineers form a network to integrate their scientific and technical knowledge, ideas and resources, and focus them on a common project - a merger of worldwide competence.
- In addition, the participating institutes would build and operate regional projects at home while being actively engaged in a common project elsewhere.
- Partners would contribute through components or subsystems, and would share the responsibility and cost for operation.
- The facility would be the common property of the participating countries,

A Possible Model for Global Collaboration - 2

- All of the participants could demonstrate a visible level of activity, thus maintaining a vital community of scientists and engineers, and attracting students to the field of accelerator research and development.
- Network approach could facilitate the problem of site selection for new large accelerator facilities.
- A shared responsibility for remote operation is technically feasible.
- As remote control rooms for the LHC detectors have shown this can lead to a very effective around-the-clock operation. Clearly for accelerators much more stringent safety requirements have to be taken into account.

A Look Forward

- Important to continue to develop new accelerators and to maintain accelerator expertise worldwide
- Size and cost of future large accelerators will most likely outstrip the resources of a single region, and building them will require a new approach.
- Most promising is the framework of an international collaboration. A collaboration for a major accelerator facility must meet the following challenges:
  - Maintain and foster the scientific culture of all participating laboratories;
  - Maintain the visibility and vitality of each partner.
  - All participating countries must be willing to invest and to commit themselves through long-term agreements.
  - Aspects, such as national visibility, political and public identification with the project and obtaining the necessary "corporate identity" have also to be taken into account.

Outlook

- Much thought is given to new accelerator technologies
- More needs to be done in preparing the necessary conditions for global projects.
- Here, ICFA and the community of accelerator builders will have to work together to generate the best ideas.
- Conferences like IPAC are a perfect forum for such discussions.
- I wish IPAC a splendid and successful future.

… even PR for language classes uses accelerators ..

A clear sign for international collaboration…