European Design Study Towards a Global TeV Linear Collider

2005-2007

Total Expected Budget (k€)	Requested EU Funding (k€)
29136	11252

General Context

There is consensus that the next large accelerator facility is an e+e- linear collider, concurrently operating with the Large Hadron Collider p-p collider now being constructed at CERN and due to start operation in 2007.

OECD ministers noted this worldwide consensus and agreed that:

- planning and implementation of such a large, multi-year project should be carried out on a global basis,
- and should involve consultations among not just scientists, but also representatives of science funding agencies from interested countries.

ICFA formed the International Linear Collider Steering Committee (ILCSC) to promote and coordinate the realisation of such an LC: attention to outreach, technology, and organisation of the project.

General Context (continued)

ITRP (International Technology Recommendation Panel) is currently considering which linac technology should be adopted, with a recommendation towards the end of 2004.

ECFA and HEP community expressed their strong support for the realisation of the LC. Physics will determine the path:

- **Sub-TeV LC crucial if Higgs Particle and Super-symmetry found at the LHC, as precision tool and lepton S-s partner source**
- **Extension to the multi-TeV range would eventually open the way to the energy scale of Grand Unification of forces and extra space-dimensions.**

EUROTeV activities are part of the Global Design Efforts towards a *world linear collider*.
EUROTeV will strongly connect to the existing linear collider network ELAN formed in the CARE proposal.

Design Study Objectives

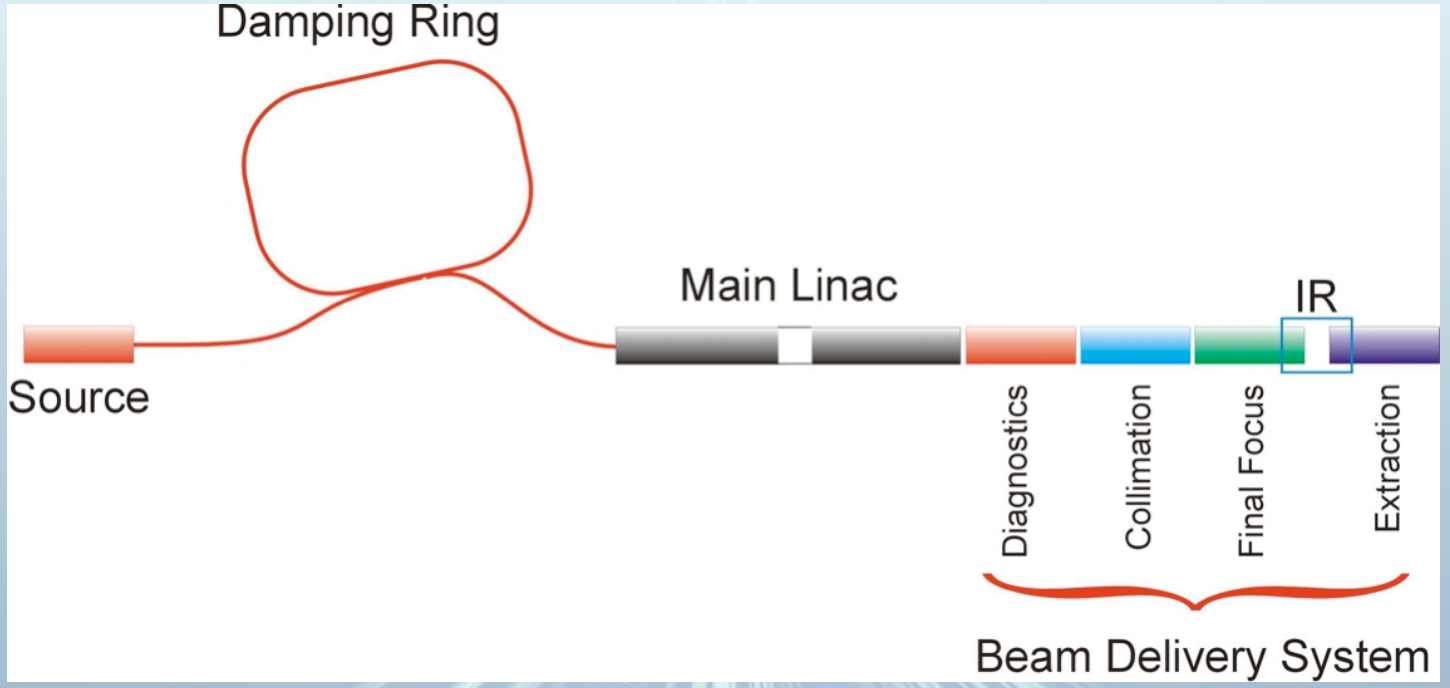
ILC-TRC reviewed the existing LC designs and concluded – early 2003 –
- no fundamental technological grounds prohibiting any of the designs
- many critical R&D topics to be addressed before such a facility could be constructed.

ILC-TRC identified many critical R&D items, common to all designs, and *largely independent* of the choice of linac technology (sub-systems excluding the main linacs):

Source (specifically e+);
Damping Rings;
Bunch Compression;
Beam Delivery System;
Novel Diagnostics systems,
Computer modelling (simulations) of the luminosity performance.

EUROTeV proposal focuses on these high ranking topics.

EUROTeV Topics

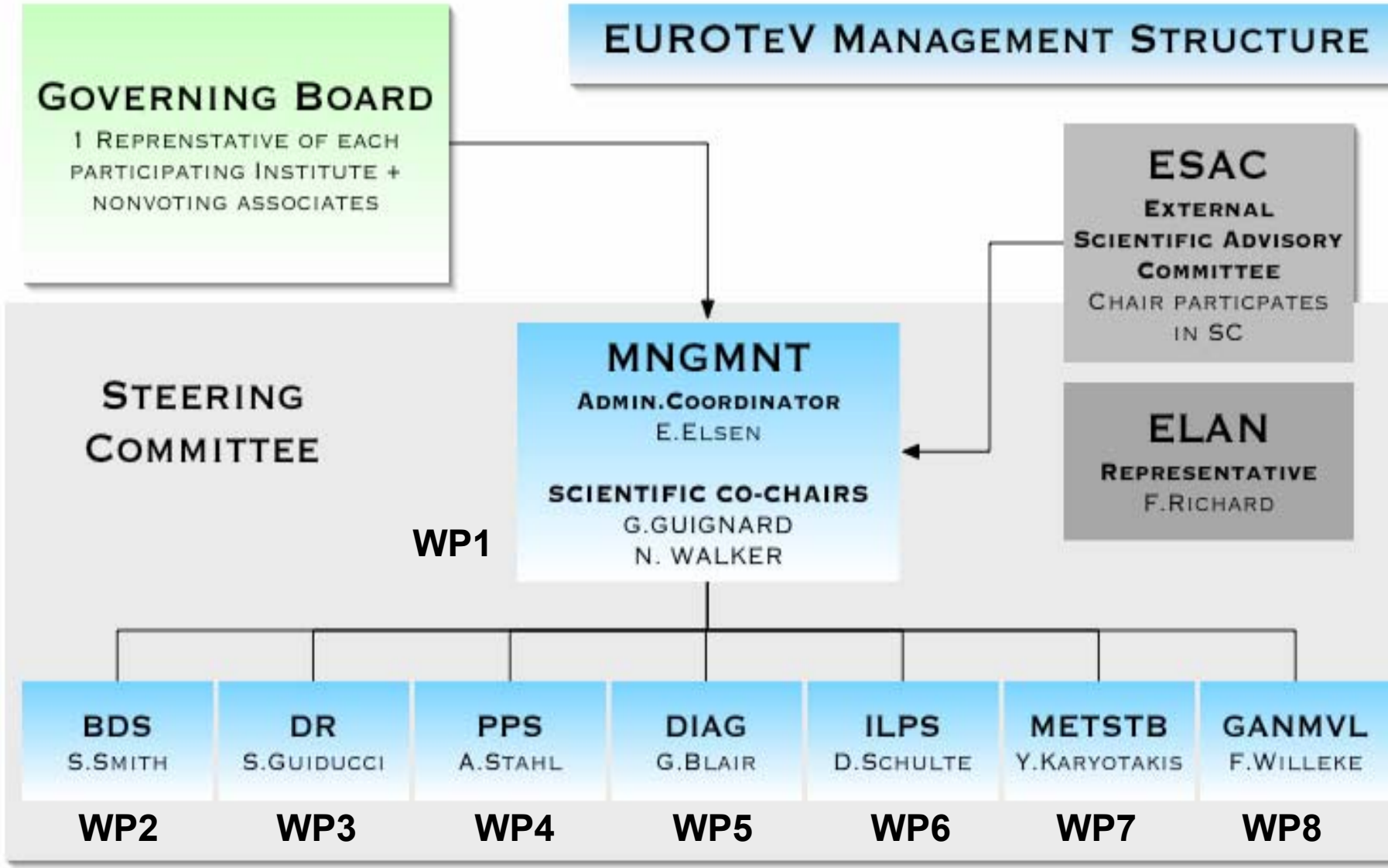


- concentrate on topics that are (largely) independent of technology choice
- match the topics to the expertise available in the participating laboratories

No	Participating Organisation (name, city, country)	Short name	Short description
1	Deutsches Elektronen-Synchrotron, Hamburg and Zeuthen, D	DESY	One of the leading institutes in the world for high energy physics, accelerator physics and research with photons.
2	Council for the Central Laboratory of the Research Councils, Chilton, Didcot, UK	CCLRC	Leading accelerator laboratories in the UK
3	Commisariat à l'Energie Atomique, DSM/DAPNIA/SACM, Gif-sur-Yvette, France	CEA	Leading french organisation for research, development and innovation in the fields of energy, defense, information technologies, commuinication and health.
4	European Organization for Nuclear Research CERN, Geneva, CH	CERN	One of the leading institutes in the world for high energy physics and accelerator physics.
5	Sincrotrone Trieste SCpA, Trieste, IT	ELETTRA	Multidisciplinary synchrotron light laboratory.
6	Fraunhofer Gesellschaft zur Förderung der angewandten Wissenschaft, Institut für graphische Datenverarbeitung, Darmstadt, D	FHG	Leading Institute for computer graphics.
7	Gesellschaft für Schwerionenforschung, Darmstadt, D	GSI	One of the leading institutes in the world for reseach with heavy ions and acclerator research.
8	Instituto Nazionale di Fisica Nucleare, Italy	INFN	Leading italian organisation for Nuclear and subnuclear physics.
9	Laboratoire de l'Accélérateur Linéaire, CNRS/IN2P3, Orsay, FR	LAL	One of the leading french insitutes for particle physics research (PPR).
10	LAPP Annecy, Annecy le Vieux, FR	LAPP	One of the leading french institutes for PPR.
11	Paul Scherrer Institut, Villigen, Switzerland	PSI	Leading swiss institute for particle physics, accelerator research and research with synchrotron radiation.
12	Royal Holloway and Bedford New College, Egham, UK	RHUL	UK university.
13	Technische Universität Darmstadt, Darmstadt, D	TEMF,TUD	German technical university.

No.	Partcicipating Organisation (name, city, country)	Short name	Short description
14	Humboldt Universität zu Berlin, Berlin, Germany	UBER	German university.
15	Cavendish Laboratory, University of Cambridge	UCAM	UK university.
16	University College London, London, UK	UCL	UK university.
17	Lancaster University, Lancaster, UK	ULANC	UK university.
18	University of Liverpool, Liverpool, UK	ULIV	UK university.
19	The Victoria University of Manchester, Manchester, UK	UMA	UK university.
20	Universität Mannheim, Mannheim, Germany	UMH	German university.
21	Universita degli Studi di Udine, Udine, Italy	UNIUD	Italian university.
22	The Chancellor, Masters and Scholars of the University of Oxford, Oxford, UK	UOXF.DL	UK university.
23	Uppsala Universitet, Uppsala, Sweden	UU	Swedish university.

Associate Organisation (name, city, country)	Short name	Associated to	Short description
Institute for Particle Physics Phenomenology, University of Durham	IPPP	ULIV	UK university.
Queen Mary, University of London	QMUL	CCLRC	UK university.


EUROTeV MANAGEMENT STRUCTURE
GOVERNING BOARD
1 REPRENSTATIVE OF EACH PARTICIPATING INSTITUTE + NONVOTING ASSOCIATES
ESAC
EXTERNAL SCIENTIFIC ADVISORY COMMITTEE
CHAIR PARTICPATES IN SC
ELAN
REPRESENTATIVE
F.RICHARD
STEERING COMMITTEE
MNGMNT
ADMIN.COORDINATOR
E.ELSEN
SCIENTIFIC CO-CHAIRS
G.GUIGNARD
N. WALKER
WP1
BDS
S.SMITH
DR
S.GUIDUCCI
PPS
A.STAHL
DIAG
G.BLAIR
ILPS
D.SCHULTE
METSTB
Y.KARYOTAKIS
GANMVL
F.WILLEKE
WP2
WP3
WP4
WP5
WP6
WP7
WP8

Work Package 2: Beam Delivery System

Coordinator Institute: CCLRC

- Develop and evolve a BDS optics design to allow the specification of beam delivery system components in conjunction with Diagnostics (WP5), Integrated Luminosity Performance (WP6), and Metrology and Stabilisation (WP7)
- Progress on the design concept of critical components of the BDS, specifically the final focus quadrupoles, the collimation systems, fast feedback systems and the crab cavity system

Participants:

Daresbury and Rutherford Lab (CCLRC), CERN, Saclay (CEA), Uni Manchester (UMA),Uni Lancaster (ULANC), Queen Mary Uni London(QMUL), TU Darmstadt (TEMF)

WP2 Activities

Beam transport from the exit of the main linacs to the IP
and finally to the main beam dump.

- **BDS primary functions**:
  - post-linac beam halo collimation;
  - strong beam demagnification at the IP to the nm beam heights;
  - post-linac diagnostics (emittance,polarisation,energy spectrometry).
- **BDS critical items (ILC-TRC)**:
  - design of the post-linac collimation system;
  - prototyping of fast beam-based feedback systems;
  - engineering design of crab-crossing RF cavity systems;
  - studies of superconducting final doublet quadrupoles in the presence of strong fields.

WP2 subdivision in tasks
1. BDS Lattice Design
2. Crab Cavity RF System Design
3. Fast Beam-Based Feedback System Design
4. Spoiler Wake-fields & Mechanical Design
5. Superconducting Final Doublet Technology R&D

Beam Delivery System - BDS

Work Package 3: Damping Rings

Coordinator Institute: INFN - LNF

- Try to design a “test lattice” , which can be used to study the common features (emittance tuning, e-cloud, dynamic aperture optimization), independently of the LINAC technology choice.

- Push the lattice design to explore the minimum achievable emittance. Explore the feasibility of the smaller emittance required for multi-TeV collider.

- Once the technology has been chosen the DS will be focused on the optimization of the DR for the chosen technology.

Participants:

CCLRC Daresbury, CERN, DESY, INFN-LNF Frascati

WP3 activities

- **DR primary functions**
  - study the production of the tiny vertical emittances needed for high luminosity, with requirements beyond current ones
    - minimum cross-plane coupling,
    - small residual vertical dispersion,
    - short damping times

- **DR critical items (ILC-TRC):**
  - simulation and experiments on the electron cloud, R&D on suppression techniques;
  - applications of RF separators to DR injection/extraction; compression of the bunch time structure at injection.
  - wiggler fields non linearity on Dynamic Aperture (DA);
  - simulations of low emittance tuning algorithms, experiments in existing rings.

WP3 subdivision in tasks
1. Studies of Electron Cloud and other Instabilities
2. Application of RF Separators to DR
3. Low Emittance Tuning Simulations
4. Wiggler Field Modelling and Impact on Dynamic Aperture

Damping Rings - DR

Work Package 4: Polarised Positron Source

Coordinator Institute: DESY

- PPS refers to a system based on a helical undulator, where circularly polarised photons (10 MeV) generated from a high-energy electron beam in the undulator produce longitudinally polarised electron-positron pairs in a thin target.

Participating Institutes:

CCLRC Daresbury/Rutherford, DESY Hamburg/Zeuthen,
ULIV Univ. of Liverpool, UBER Humboldt University Berlin,

WP4 activities

- **PPS primary functions:**
  R&D for both polarised and non-polarised sources
  (a conceptual design of a non-polarised sourcebased
  on a planar undulator exists).

- **PPS specific items:**
  - design of the spin rotation and spin flipper systems;
  - design of the photon collimator;
  - optimisation of parameters for polarisation and positron yields;
  - understanding of the systematic polarisation errors;
  - engineering design and full simulation of the system;
  - location and performance specifications of the required
    diagnostics (low-energy polarimeter).

WP4 subdivision in tasks
1. Helical Undulator R&D
2. Photon Collimator Design
3. Conversion Target Design
4. Source Performance Modelling
5. Spin Rotation and Flip System Design
6. Spin Transport Studies
7. Low-Energy Polarimeter R&D

Polarised Positron Source - PPS

Work Package 5: Diagnostics

Coordinator Institute: RHUL

- focuses on the critical devices needed for getting the ambitious predicted luminosity performance
- concentration on TRC-priority diagnostics, linac-technology independent, post collision diagnostics

- this WP will produce as an output;
  - strong groups collaborating internationally
  - working prototype systems
  - international test beam work (in CTF3 and PETRA)
  - technical staff and students gaining in-the-field experience

Participating Institutes:
CERN, DESY, ORSAY, OXFORD, RHUL Royal Holloway, UCL London, UCAM Cambridge, UPPSALA Univ.

WP5 activities

- **DIAG primary functions:**
  R&D on novel beam diagnostics; several existing designs of these devices either are at the conceptual stage, or require a performance currently beyond that available.

- **DIAG specific items:**
  - development of a beam profile monitor based on laser Compton scattering (laser-wire) and production of a robust and reliable prototype for emittance tuning and monitoring;
  - R&D towards critical beam position, frequency and charge monitors, capable of resolving individual bunches;
  - high-energy magnetic chicane spectrometers to measure beam energy to an accuracy better than 10-4;
  - development of precision laser-based polarimeters, and fast luminosity monitors (critical for LC tuning).

WP5 subdivision in tasks
1. Confocal Resonator BPM
2. Laser-Based Beam Profile Monitor
3. Precision Cavity BPM
4. Precision Energy Spectrometer
5. Precision High-Energy Polarimetry
6. Timing & Phase Monitoring
7. Wide-Band Current Monitor
8. Fast Luminosity Monitoring

Diagnostic - DIAG

Work Pack 6: Integrated Luminosity Performance Studies

Coordinator Institute: CERN

- **ILPS** deals with preservation of ultra-small vertical emittances during transport and acceleration from the damping ring to the IP

- **ILPS primary tasks**:
  - provide the required reliable computer models to study the machine performance with various static and dynamic imperfections;
  - model beam halo generation, and performance of the halo collimation needed to shield the physics detector from unacceptable background;
  - join the two studies (codes), seeking for the impact of errors, luminosity tuning and feedbacks on halo-induced background and background tuning.

Participating Institutes:
CCLRC, CERN, DESY, LAL Orsay, RHUL Egham,
UMA Univ. Manchester, PSI Switzerland, Uppsala Univ.

- **ILPS critical study items**:

  - beam-based alignment as well as emittance and luminosity tuning procedures, for very tight tolerances are required on field quality and alignment, beyond those achievable with optical survey techniques;

  - dynamic effects of ground motion and vibration on the luminosity, compensation through mechanical stabilisation and beam-based feedback systems;

  - Impact of dynamic effects on the initial beam-based alignment and tuning procedures, reducing their effectiveness (ILC-TRC);

  - full simulations of the tuning, including the dynamic effects and their compensation, to reliably predict the integrated luminosity performance

WP6 subdivision in tasks
1. Failure Mode & Effect Simulations
2. Halo Collimation Simulations
3. Halo Related Background Studies
4. LET static beam-based alignment and tuning studies
5. LET Dynamic Feedback Studies
6. Fully Integrated LET Studies
7. Halo and Tail Generation
8. Bunch Compression Design
9. Post-Collision Diagnostics Lattice
10. B-B Simulation Code Development

Integrated Luminosity Performance Studies - ILPS

Work Pack 7: Metrology and Mechanical Stabilisation

Coordinator Institute: LAPP

- Study of the ground motion and cultural noise
- Develop alignment methods and instrumentation that allow for a rapid high precision alignment of the complete accelerator
- Develop an active stabilization method and instrumentation at a nanometer level for the final focus magnets
- Extend usability of the stabilization to other critical magnets in the BDS by developing cost effective lower resolution derivatives of the FF system solutions

Participants: CCLRC, DESY, LAPP, Oxford Univ.

- **METSTB primary developments:**
  - fast, reliable and accurate survey techniques and monitoring of component locations;
  - active stabilisation techniques of critical components (e.g. final doublet);
  - measurement of ground vibration spectra at various potential LC sites around the world, and their subsequent characterisation (‘cultural noise’).

- **METSTB specific tasks:**
  - develop a laser interferometer based mobile survey system (Linear Collider Alignment System, LICAS) suitable for rapid and accurate survey;
  - perform studies of active and passive stabilisation techniques for critical components, including industrially available products;
  - develop state-of-the-art vibration spectrum measurement techniques, and apply them to cataloguing and characterising ground motion spectra from many sites around the world (central database with the results).

- Results form critical input to beam dynamics simulation work in WP6.

WP7 subdivision in tasks
1. Rapid Tunnel Reference System
2. Mechanical Stabilisation Technology
3. Precision Ground Motion Spectra

Metrology and Stabilisation - METSTB

Work-package 8: Global Accelerator Network using a multipurpose Virtual Laboratory

Coordinator Institute: DESY

- refers to advanced means of communication necessary to support efficient collaboration.

- **GANMVL primary functions:**
  design and build a novel collaboration tool and test it on existing accelerator collaborations. The tool is a mobile communication centre providing immersive video and audio capture, a reproduction of an accelerator control room, a laboratory workplace environment or an accelerator hardware installation.

Participants:
DESY, ELETTRA Trieste, FHG (Graphics) Darmstadt, GSI Darmstadt, INFN, UMH Univ. Mannheim, UNIUD Univ. Udine.

- **GANVIL specific goals:**

  - connect to standard measurement equipment (scopes, network analyzers etc.) and to elements of accelerator controls

  - make these connections available to a remote client.

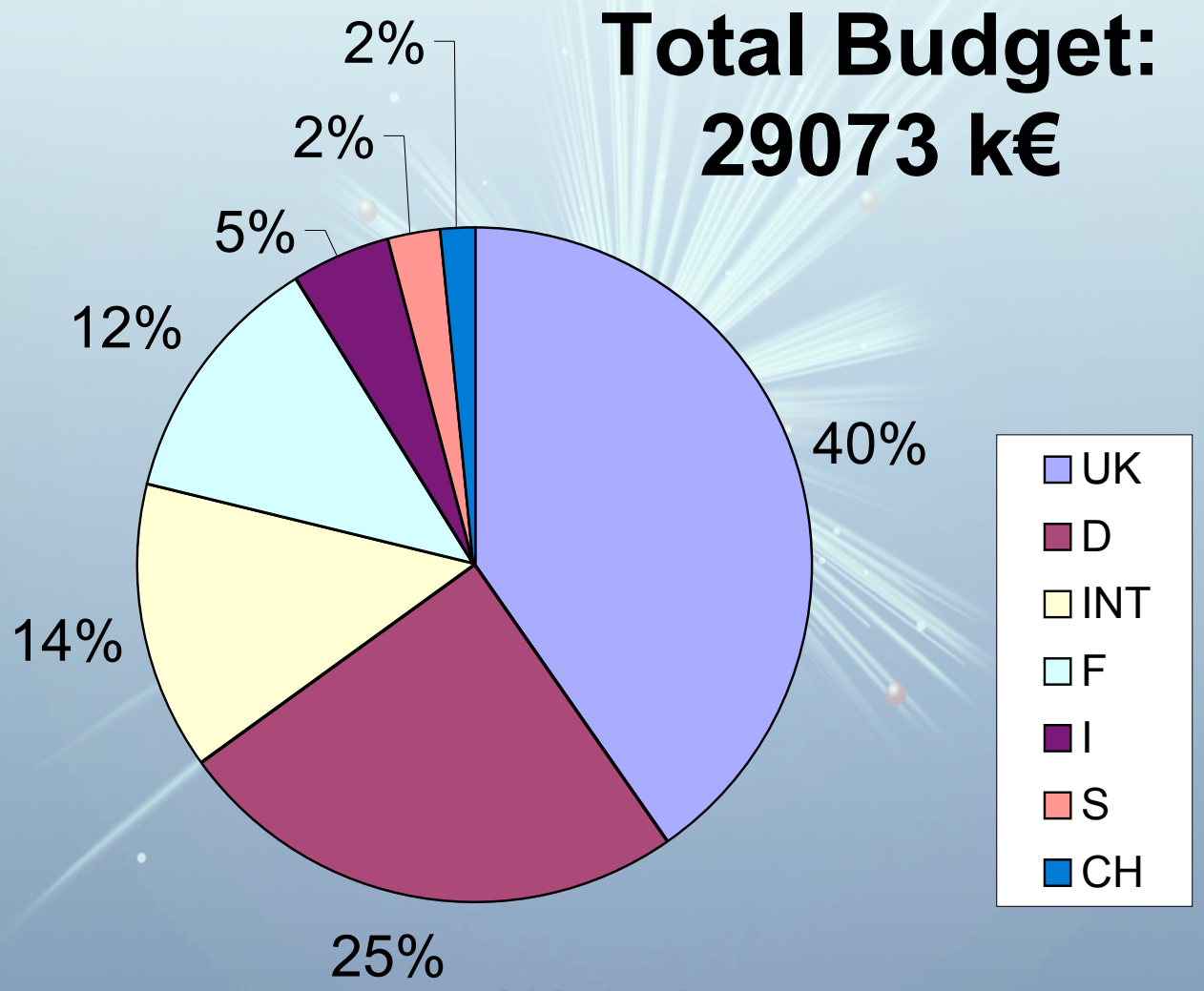
  - enable the remote user to participate in accelerator studies, assembly of accelerator components, hardware trouble shooting or analysis of on-line data;

  - provide valuable experience of a new way in designing, building and operating large accelerator complexes, address the psychological and sociological issues

WP8 subdivision in tasks
1. Overall Design and Integration
2. System Components
3. Mechanical and Electrical Design
4. Demonstration of GAN and Far Remote Operation

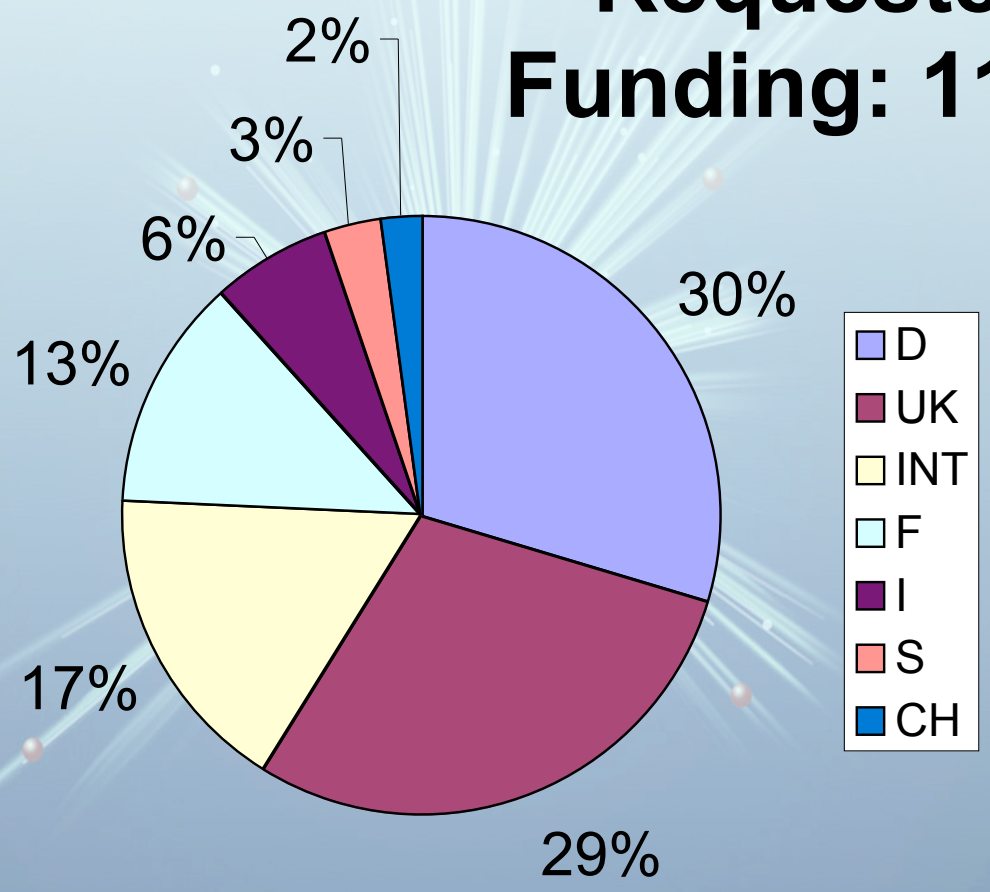
Global Accelerator Network - GANMVL

Financial Dimension



Requested EU Contribution

Requested EU Funding: 11252 k€



Institute	Cost model	Total inc. Travels for Assoc. k€	Req. Contr. inc. Travels for Assoc. k€
CCLRC	FC	3672	1212
CEA	FC	693	288
CERN	AC	4015	1903
DESY	AC	5178	2394
ELETTRA	FC	504	252
FHG	FC	777	389
GSI	FC	140	60
INFN-LNF		*526*	*252*
INFN-Mi		*200*	*112*
INFN-Ro2		*49*	*41*
INFN Total	AC	775	404
LAL	FC	1877	823
LAPP	FC	971	319
PSI	FC	511	255
RHUL	AC	601	336
TEMF,TUD	AC	492	246
UBER	AC	466	185
UCAM	AC	340	116
UCL	AC	560	125
ULANC	AC	698	293
ULIV	FC	1066	356
UMA	AC	392	156
UMH	AC	118	59
UNIUD	AC	111	54
UOXF.DL	AC	3365	689
UU	AC	702	337
IPPP	AC	71	
QMUL	FC	1040	
TOTAL k€		29136	11252

Conclusion

- European laboratories…
  - have demonstrated considerable interest in swiftly completing the remaining research towards a worldwide LC
  - have been able to allocate considerable resources around a Design Study that will help to advance the required research
  - have exposed the LC to the highest European political levels
  - are requesting considerable funds from the European Union
- Bid was submitted March 3, 2004
  - Expect feedback by July 2004
- Effort is well integrated into the worldwide global design effort (GDI)