Newly Funded LC R&D Programmes in Europe

G. A. Blair
Royal Holloway Univ. of London
September 1st 2004

- UK LC-ABD Programme
- EUROTeV
- ILC/Summary

UK funding for accelerator science for particle physics 2004 - 2007

UK funding agency, PPARC, secured from Govt. £11M for 'accelerator science' for particle physics, spend period April 04 – March 07

Called for bids from universities and national labs; large consortia were explicitly encouraged

Bids peer-reviewed and preliminary new allocations made Oct 21 2003:

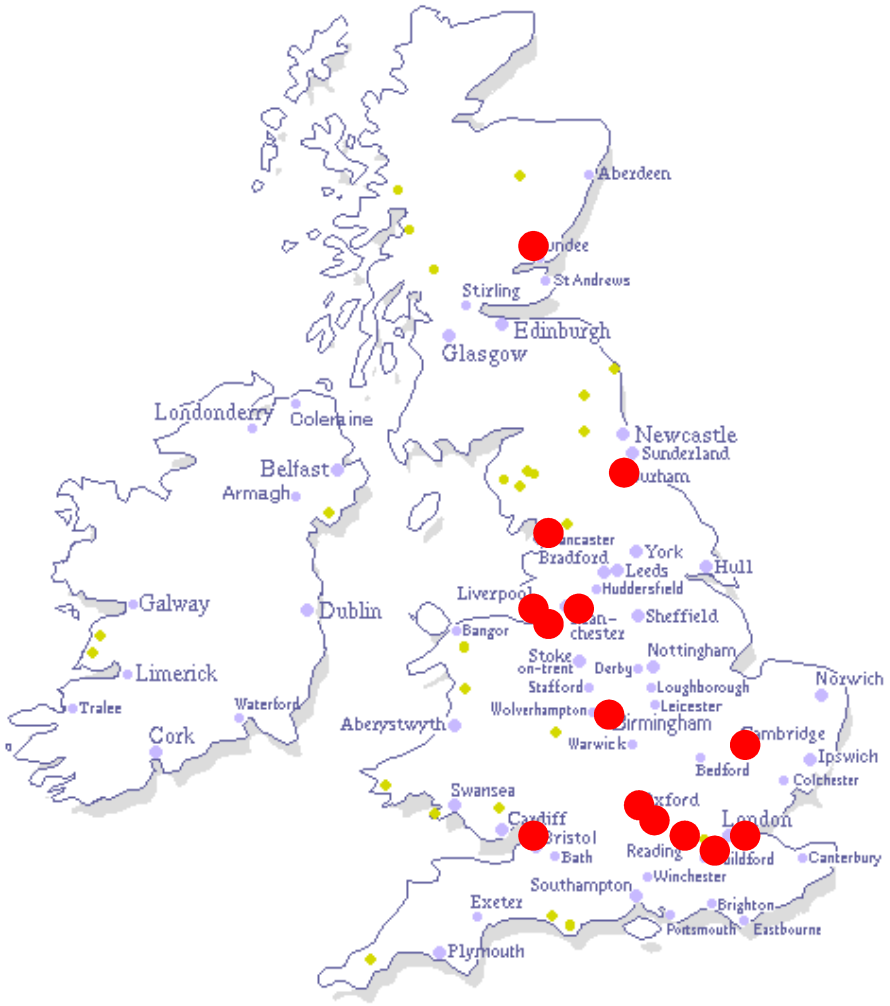
Funding (http://www.pparc.ac.uk/Nw/accelerators.asp)

- LC-Beam Delivery £9.1M
- UKNF £1.9M
- 2 university-based accelerator institutes:
  - Oxford/RHUL
  - Cockroft: Liverpool, Manchester, Lancaster, NW dev. agency.

£1.5M input to from CCLRC for complementary LC programme

LC-ABD Collaboration

- Abertay
- Bristol
- Birmingham
- Cambridge
- Durham
- Lancaster
- Liverpool
- Manchester
- Oxford
- Queen Mary, Univ. London
- Royal Holloway, Univ. Of London
- University College, London
- Daresbury and Rutherford-Appleton Labs;



41 post-doctoral physicists (faculty, staff, research associates)
+ technical staff + graduate students

LC-ABD Work Packages

UK coherent effort towards the ILC **Beam Delivery System**

- WP1: Lattice Design and Beam Simulations — D. Angal-Kalinin (CCLRC)
- WP2: Advanced Beam Diagnostics; — G. Blair (RHUL)
- WP3: Alignment and Stabilisation; — A. Reichold (Oxford)
- WP4: Final Focus Luminosity Stabilisation; — P. Burrows (QMUL)
- WP5: Technology; — M. Poole (CCLRC)

PI/PM G.B. / P. Burrows

1. BDS Lattice Design and Beam Simulations

Bristol, B'ham, Daresbury, Lancaster, Liverpool, Manchester, Oxford QMUL, RAL, RHUL, UCL

1.1 BDS Lattice design:

Understand design issues, contribute to global development + optimisation:

working with Saclay on latest TESLA IR optics

very interested in: collimation system, extraction line, diagnostics layout…

1.2 Beam transport simulations, backgrounds + collimation:

Cradle-to-grave simulations; database of TESLA train Xings, pairs, FB

64 cpu Grid cluster at QMUL for production jobs (30-40 cpu-hours)

BDSIM: development and application.

Halo production and tracking through BDS:

Collimator wakefields + optimisation of spoiler + collimator design

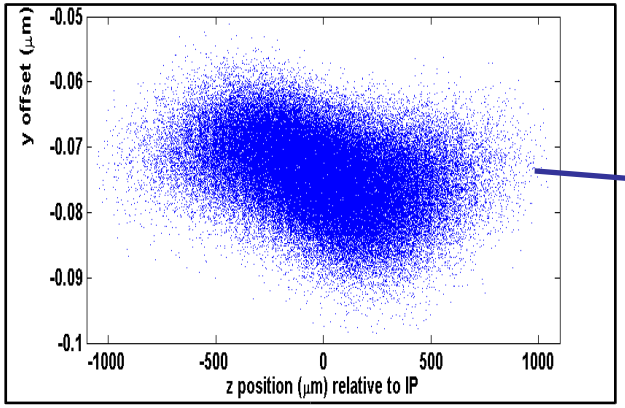
Backgrounds in IR: pairs, gammas, n: -> VXD, calorimetry, FB system …

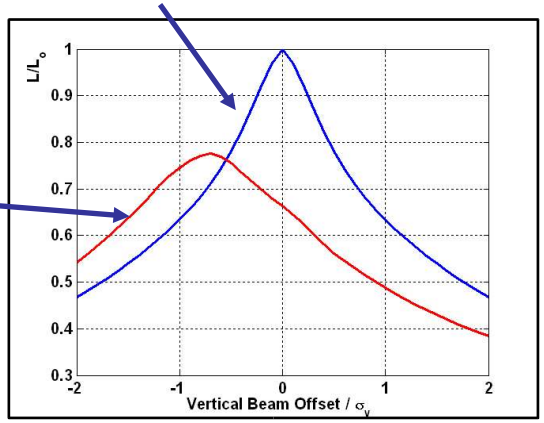
Examples:

banana bunches, impact on FB

'Banana' bunch (PLACET/MERLIN)

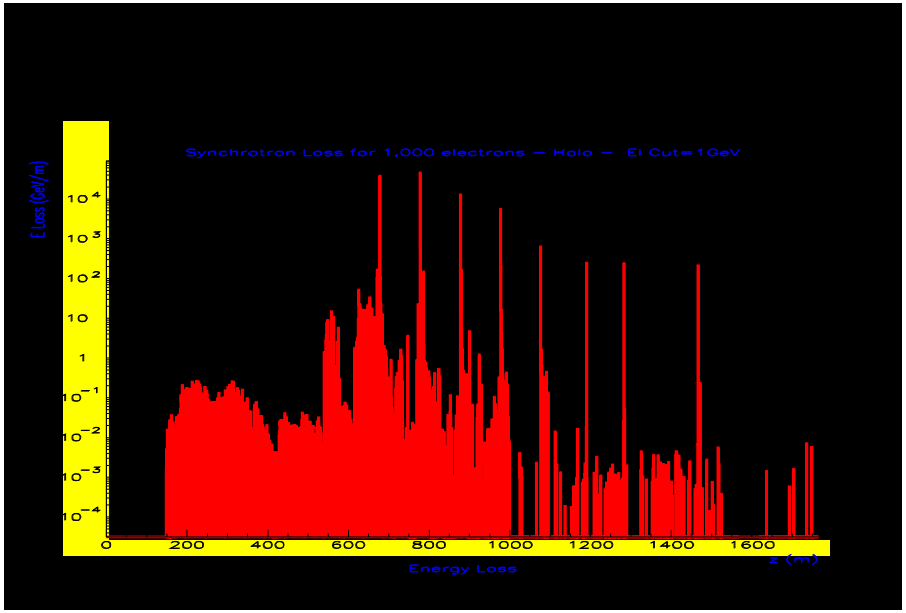
Gaussian bunch





Tracking of halo energy deposition (BDSIM)

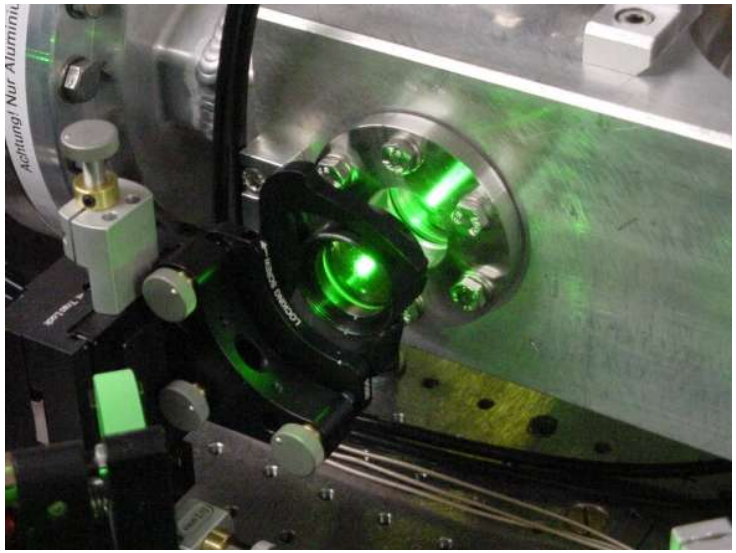
Muon Production,
Synchrotron radiation,
Neutrons,
Collimation design …



2. Beam Diagnostics

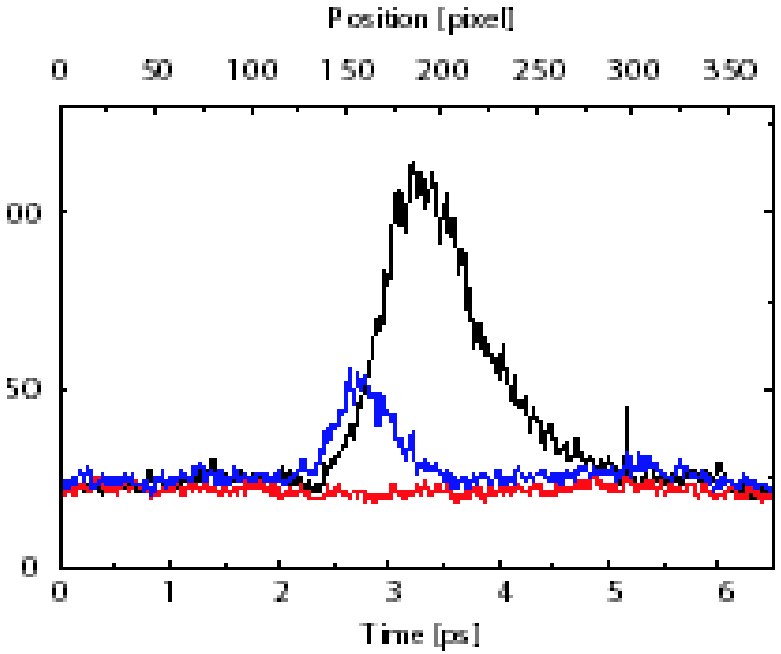
2.1 Laserwire (UK: RHUL, UCL, Oxford, RAL):

Ongoing collab. PETRA laser-wire
UK: laser scanning system + optics
Mode-locked laser system
BDSIM: backgrounds, layout
ATF:fast scanning, micron spot-sizes
Details in BDIR session on Friday



2.2 Bunch length/profile (Abertay, DL Oxford):

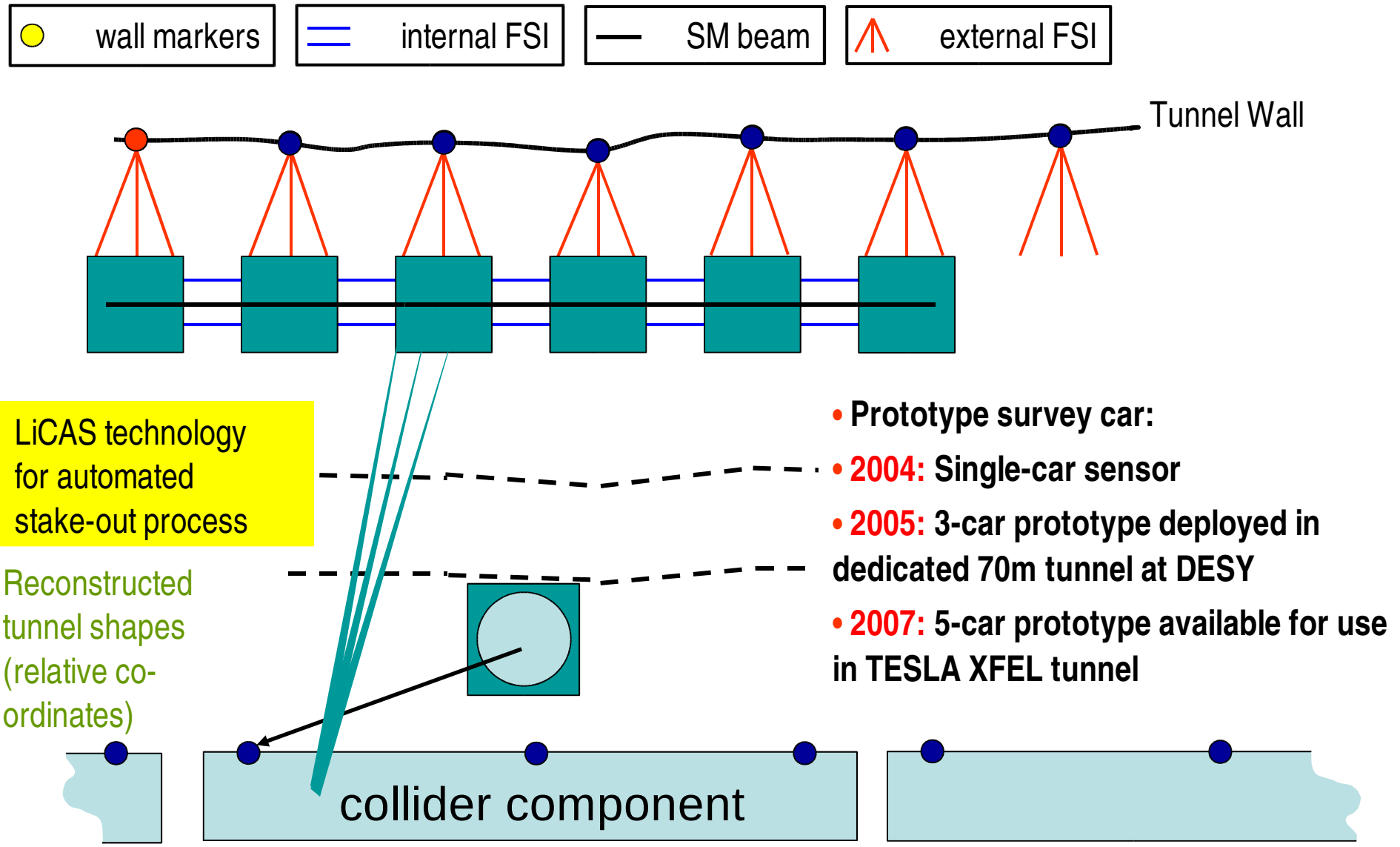
Very successful EO expt. at FELIX
600fs achieved; aiming for 200fs
R&D on Smith-Purcell radiation bunch profile monitor (Frascati)
possible deployment at FELIX



2.3 Polarisation (Liverpool, DL, Durham):

Pol. Tracking simulation + studies

3. Alignment + Survey: LiCAS (Oxford)



- **Prototype survey car:**
- **2004: Single-car sensor**
- **2005: 3-car prototype deployed in dedicated 70m tunnel at DESY**
- **2007: 5-car prototype available for use in TESLA XFEL tunnel**

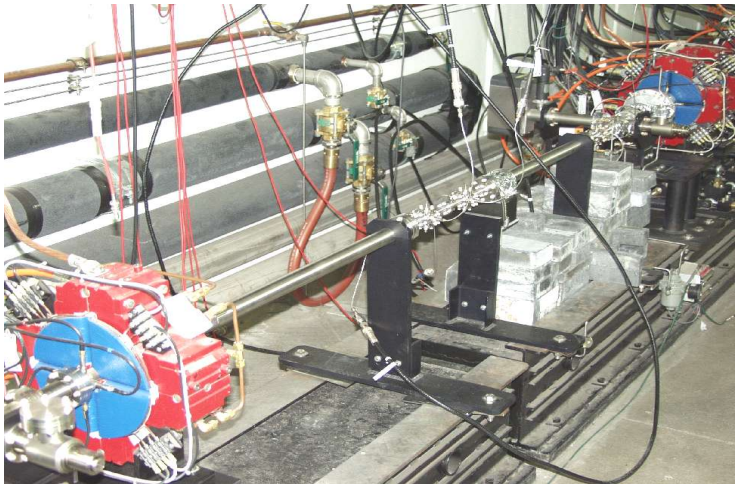
4. Final-focus Luminosity Stabilisation

(QMUL, Oxford, Daresbury)

Beam-based feedback:

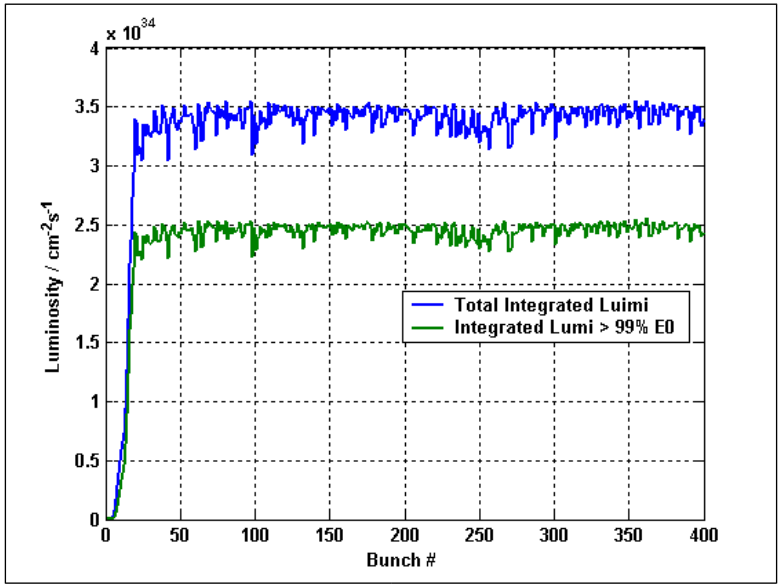
intra-train FB as complement to 'IP FB' (train-train) + active mech. stabilisation schemes

FONT prototype at SLAC NLCTA

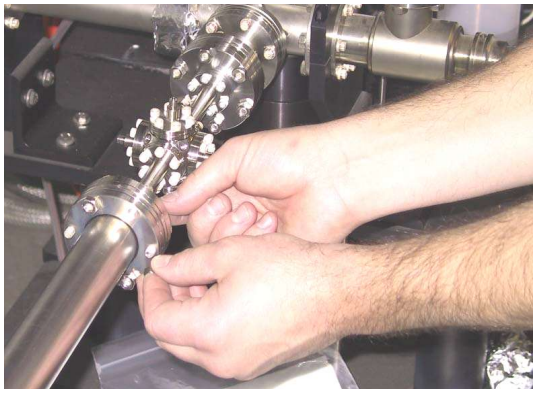


intra-train FB for J/NLC, TESLA, CLIC

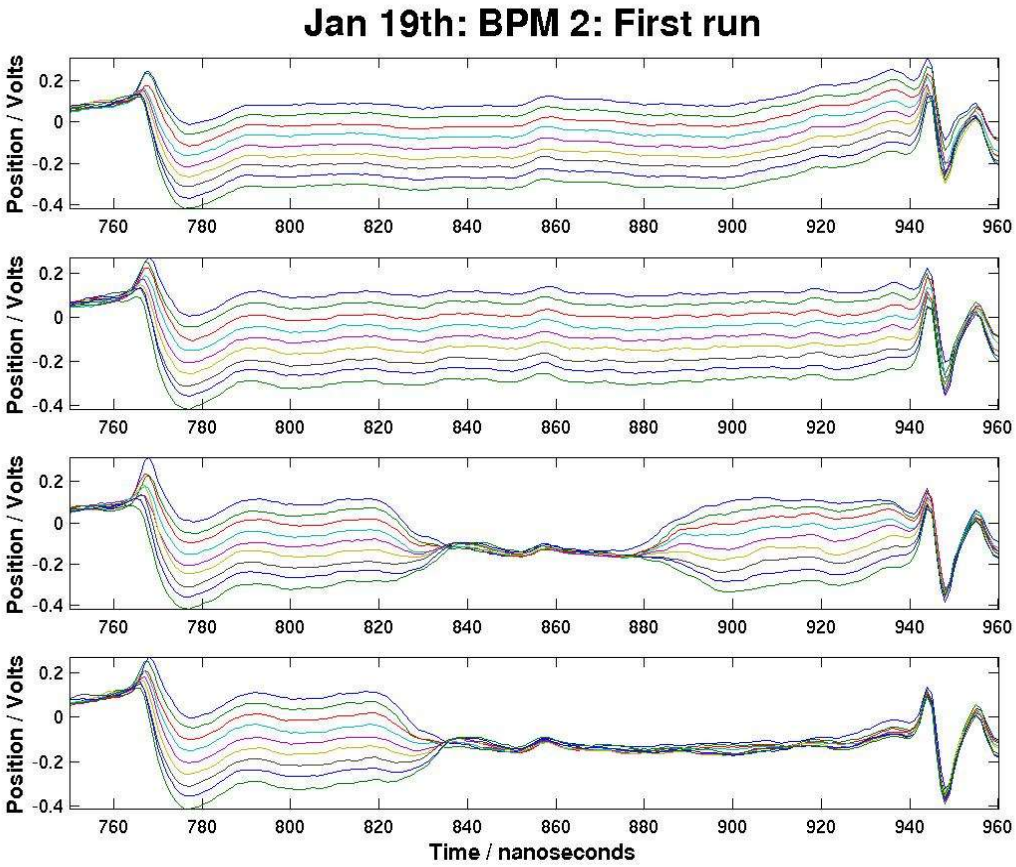
Optimised Lumi (TESLA)



Advanced BPMs



FONT2 initial results: feedback mode



Beam starting positions

Beam flattener on

Feed forward on

Feedback on

Future: Digital techniques for SC machine
Advanced BPM R&D
Implementation at ATF

5. Polarisation, Positron Source Undulator + Crab Cavity

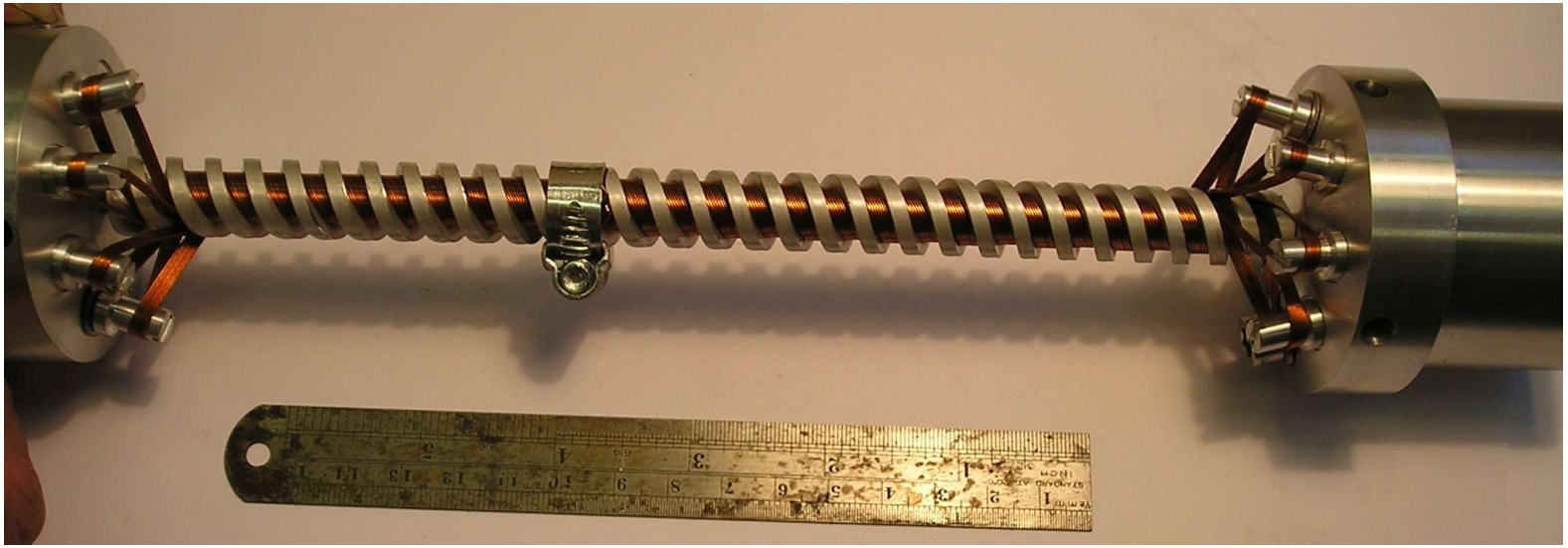
(Daresbury, Durham, Liverpool)

5.1 e+ source undulator design:

Baseline method for TESLA

Polarised e+ -> helical undulator (E166 expt)

Design work for TESLA helical undulator in progress:



Detailed engineering design, prototyping, test with beam

5.2 Crab cavity design (for IR with crossing angle):

Overlap of interest with angle FB systems; UK RF company interest

6.BPM Spectrometry (Cambridge, UCL)

6.1 Measurement of Luminosity

Energy Spectrum (MOLES):

Absolute E (survey, alignment)

E jitter (fast BPMs)

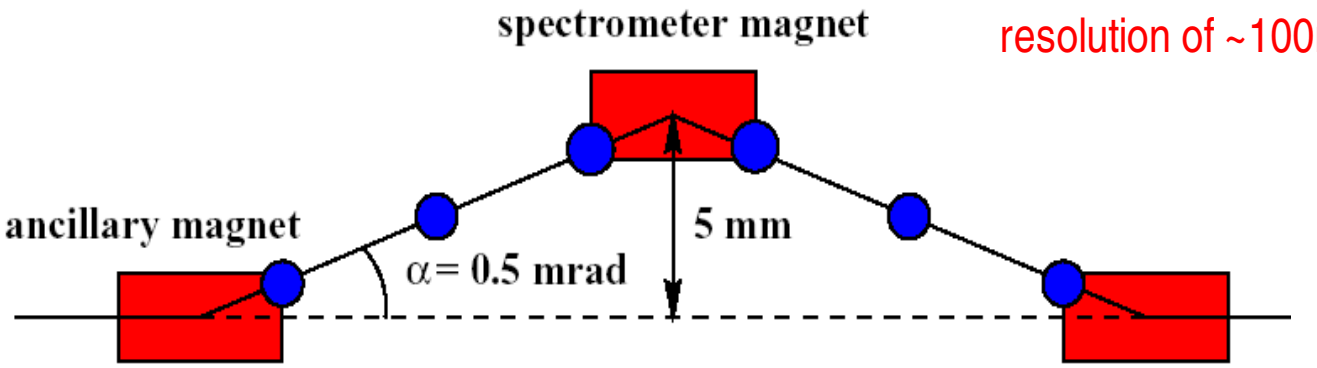
E dispersion (laserwire?)

Design Considerations:

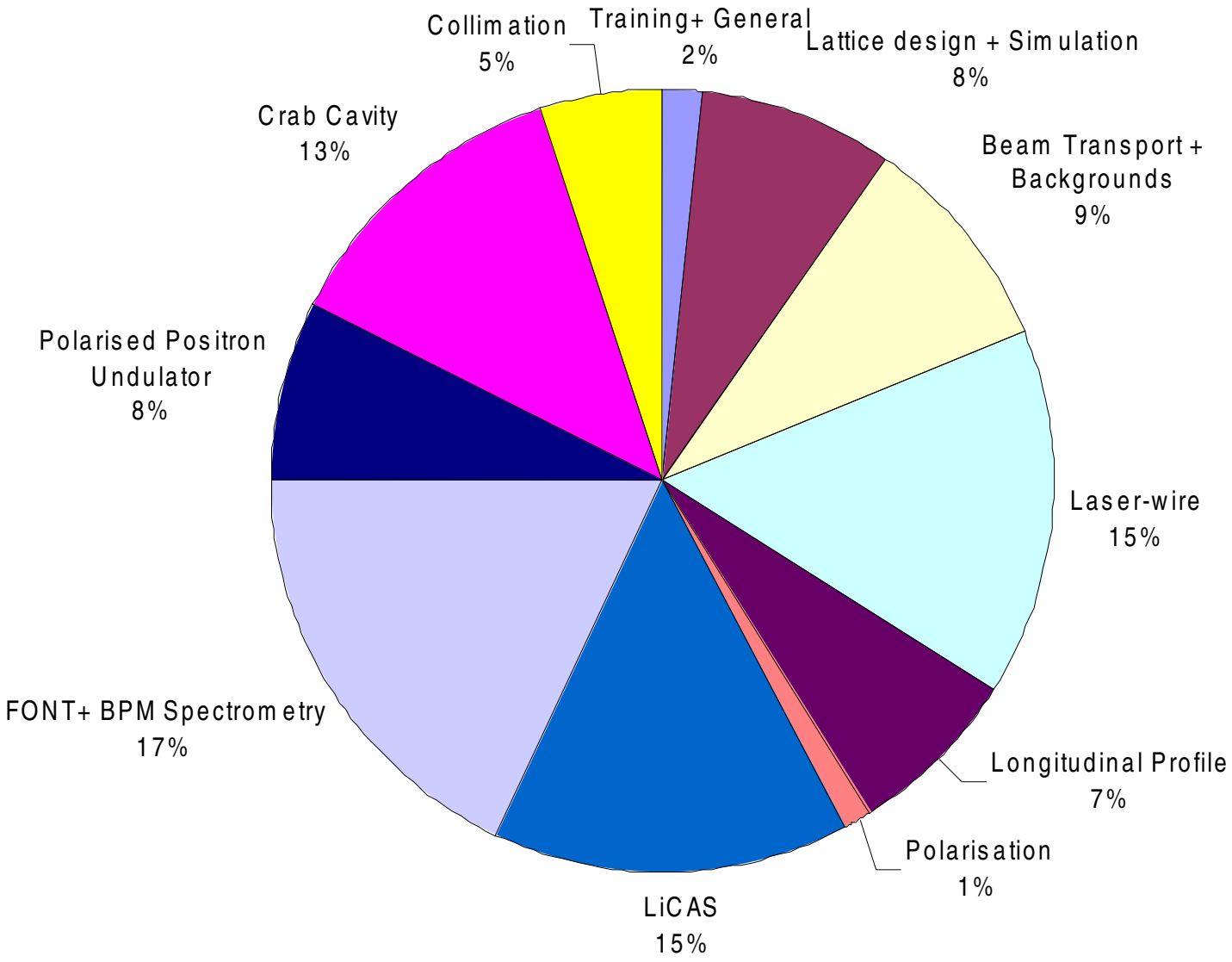
- limit SR emittance growth
  - 360mrad total bend $\Rightarrow$ 0.5%
- available space in lattice
  - no modifications necessary, yet
- 10m drift space maximum one can consider for mechanical stabilization, alignment
- 37m total empty space allows for BPMs outside of chicane to constrain external trajectories
- *Tiny* energy loss before IP

1.2MeV @ 250
11.9MeV @ 500

$\Rightarrow$ Constraints lead to a required BPM resolution of ~100nm (Resolution $\oplus$ Stability)

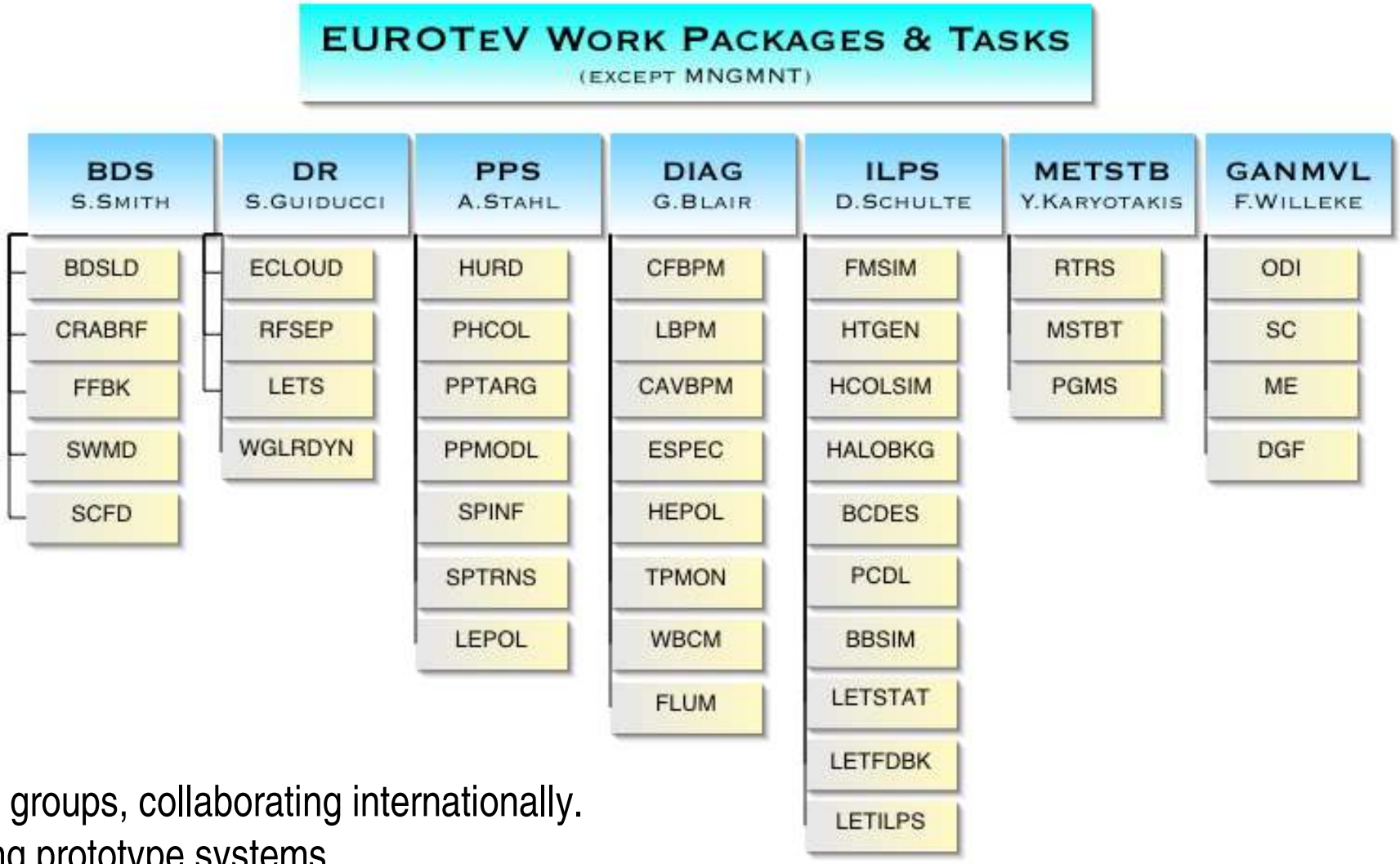


Overview of LC Projects



Essentially independent of Linac technology

European Design Study Towards a TeV Linear Collider



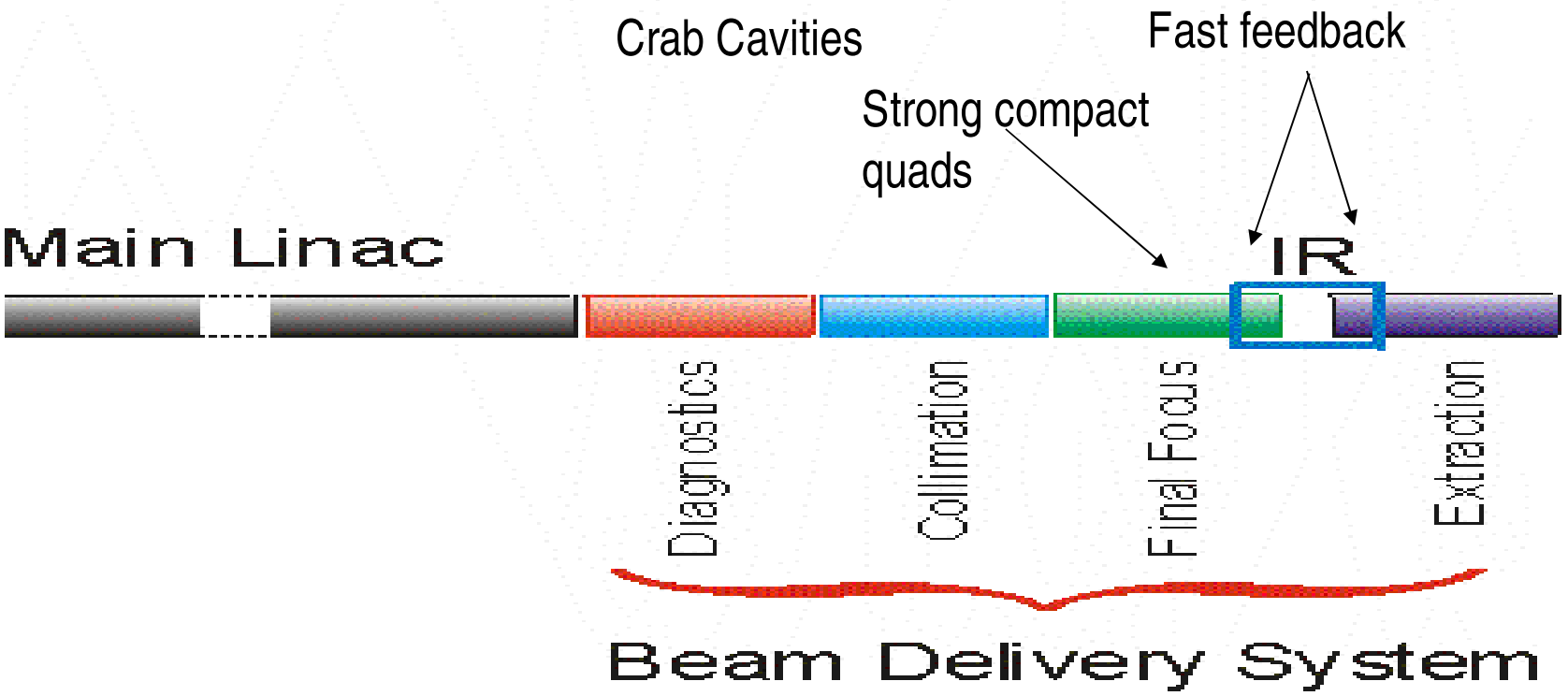
Output:

- Strong groups, collaborating internationally.
- Working prototype systems
- International test beam work
- RAs, technical staff and students gaining essential experience.

Aim will be to include the work in the ILC design effort.

WP 2: Beam Delivery System

Coordinator: Susan Smith, CCLRC Daresbury Laboratory



Goals

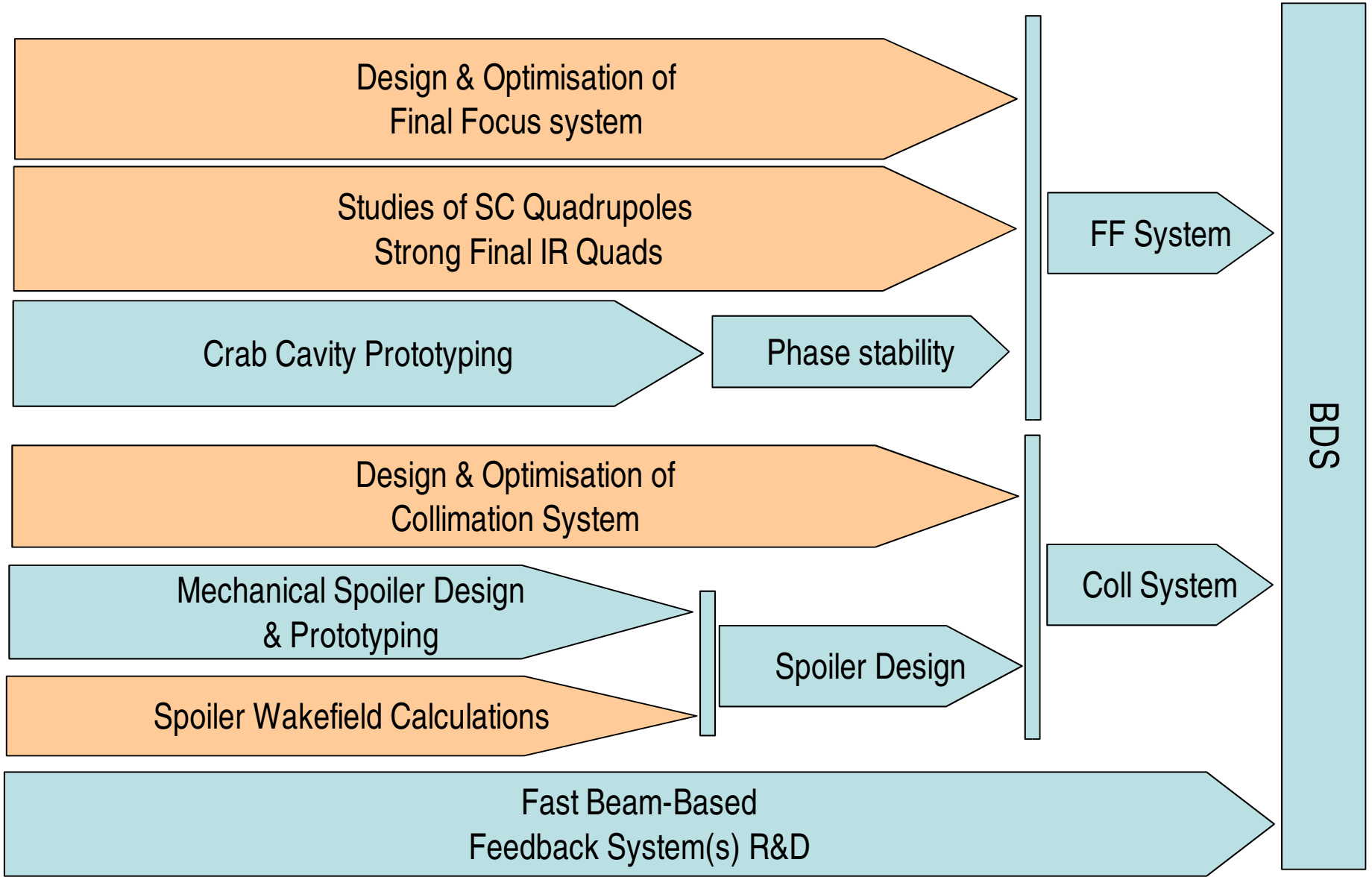
- Develop and evolve a BDS optics design to allow the specification of beam delivery system components in conjunction with the output of the DIAG and BDYN WPs
- Progress the design concept of critical components of the BDS, specifically the final focus quadrupoles, the collimation systems, fast feedback systems and the crab cavity system

Participants:

Daresbury and Rutherford Lab (CCLRC), CERN, Saclay (CEA),

Uni Manchester (UMA),Uni Lancaster (ULAN), Queen Mary Uni.London(QMUL), TU Darmstadt (TEMF)

BDS Goals


Design & Optimisation of
Final Focus system
Studies of SC Quadrupoles
Strong Final IR Quads
Crab Cavity Prototyping
Phase stability
FF System
Design & Optimisation of
Collimation System
Mechanical Spoiler Design
& Prototyping
Spoiler Wakefield Calculations
Spoiler Design
Coll System
Fast Beam-Based
Feedback System(s) R&D
BDS

WP 3: Damping Ring

Coordinator: Susanna Guiducci, LNF-INFN, Frascati

Tasks

3. Low emittance tuning algorithms
4. e-cloud simulations
5. e-cloud vacuum
6. RF deflectors

Participating Institutes

Institutes	Acronym	Country	Coordinator	Scientific Contact
CCLRC Rutherford Appleton Laboratory	CCLRC	UK	Susan Smith	Deepa Angal-Kalinin
CERN	CERN	CH	Gilbert guignard	Daniel Shulte
Deustches Elektronen Synchrotron	DESY	DE	Eckhard Elsen	Rainer Wanzenberg
INFN Laboratori Nazionali di Frascati	INFN-LNF	I	Susanna Guiducci	Susanna Guiducci

- Comparative study of the different DR designs to identify the common accelerator physics issues.
- Focus the study on the achievement of low emittance:
  - Low emittance tuning algorithms:.
  - Effect of e-cloud instability in the positron ring.
- Try to design a “test lattice” , which can be used to study the common features (emittance tuning , dynamic aperture optimization, e-cloud)
- Push the lattice design to explore the minimum achievable emittance. Explore the feasibility of the smaller emittance required for multi-TeV collider.
- Study possible applications of the multifrequency RF deflectors. Explore the possibility of using them to compress the bunches time structure at injection.
- The DS will be concentrated on the optimization of the DR for the SC technology.

Participating Institutes

Tasks	Institute	Role
	CCLRC	Vacuum Design
	CERN	Benchmark code, simulation
e-cloud	DESY	Simulation, application to DR configuratyions.
	INFN-LNF	SEY measurement
	CCLRC	Emittance tuning algoritms
Low emittance	DESY	Low emittance tuning, benchmarking simulations
	INFN-LNF	Comparative study of different designs.
RF deflectors	INFN-LNF	applications, impedance calculations

WP 4: Polarised Positron Source

Coordinator: Jim Clarke, CCLRC Daresbury Laboratory

Task ID	Task	Description
HURD	**Helical Undulator R&D**	evaluation of superconducting and permanent magnet technologies • design and testing of 1-4m prototype of chosen technology • undulator vacuum system R&D
PHCOL	**Photon Collimator Design**	conceptual design of photon collimator including Monte Carlo simulations • specification of baseline parameters • full engineering design of collimator
PPTARG	**Conversion Target Design**	Monte Carlo simulation of target performance • optimisation of target parameters • specification of baseline parameters • full engineering design of rotating target system

PPMODL	**Source Performance Modelling**	overall source design (lattice) • development of sophisticated computer model including photon production, target conversion and spin tracking • optimisation of design • errors and tolerance studies • estimates of particle loss rates and radiation damage
SPINF	**Spin Rotation and Flip System Design**	conceptual design of tuneable post-DR spin rotation and flipper system • modelling of errors and systematic errors • tolerance studies • mitigation of systematics between spin states [WP6]
SPTRNS	**Spin Transport Studies**	implementation of spin transport into LC modelling codes • studies of spin transport from DR to IP • investigation of spin tuning at the IP • impact of machine errors and luminosity tuning and feedback on IP polarisation [WP6]
LEPOL	**Low-Energy Polarimeter R&D**	conceptual design of low-energy polarimeter for use at the source • Monte Carlo studies of performance • prototype construction and testing with beam

WP 5: Diagnostics

Coordinator: Grahame Blair, RHUL

- Bunch profile
- Confocal Resonator Pick-up.
- Post Collision Diagnostics
- Energy spectrometry based on high-precision BPMs.
- High Energy Polarimetry.
- Fast beamstrahlung monitor
- Beam Phase Measurement
- Wide Band Current Pickup
- Precision Beam Position Monitor
- Beam tests at CTF3

Laser-wire

- Oxford — Laser-wire; laser, mechanics and optics
- RHU
- DESY

Scanning systems and electronics for the laser-wire. Optical design and data analysis. Simulation of laser-wire systems in the beam diagnostics section.

BPM Spectrometry

- UCL
- Cambridge

Studies of upstream spectrometer for beam energy determination. Development of BPMs. Integration of beamline spectrometry into
Beam delivery system.
Determination of the luminosity spectrum.

- DESY

Studies of fast **beamstrahlung monitor** for IP beam characterisation

- CERN **Precision beam position monitor**

  Develop a BPM with <100 nm resolution, <10 μm precision, <15ns rise-time, with an aperture >4 mm for beam position monitoring in LC main beam and beam delivery system with the performance required from beam dynamics studies.

  Beam tests

  Tests in the existing test facility (CTF) of profile monitors such as Laser wire prototype.

Precision beam phase measurement

- Precise phase stability of the main beam with respect to the RF is required for all linear colliders.
- CLIC requires the phase error to be less than 15fs rms in order to limit luminosity loss.
- This precision is more than an order of magnitude better than has currently been achieved both for phase reference distribution and for beam/RF phase measurement.
- Both strategy and technology need to be found.

- CERN

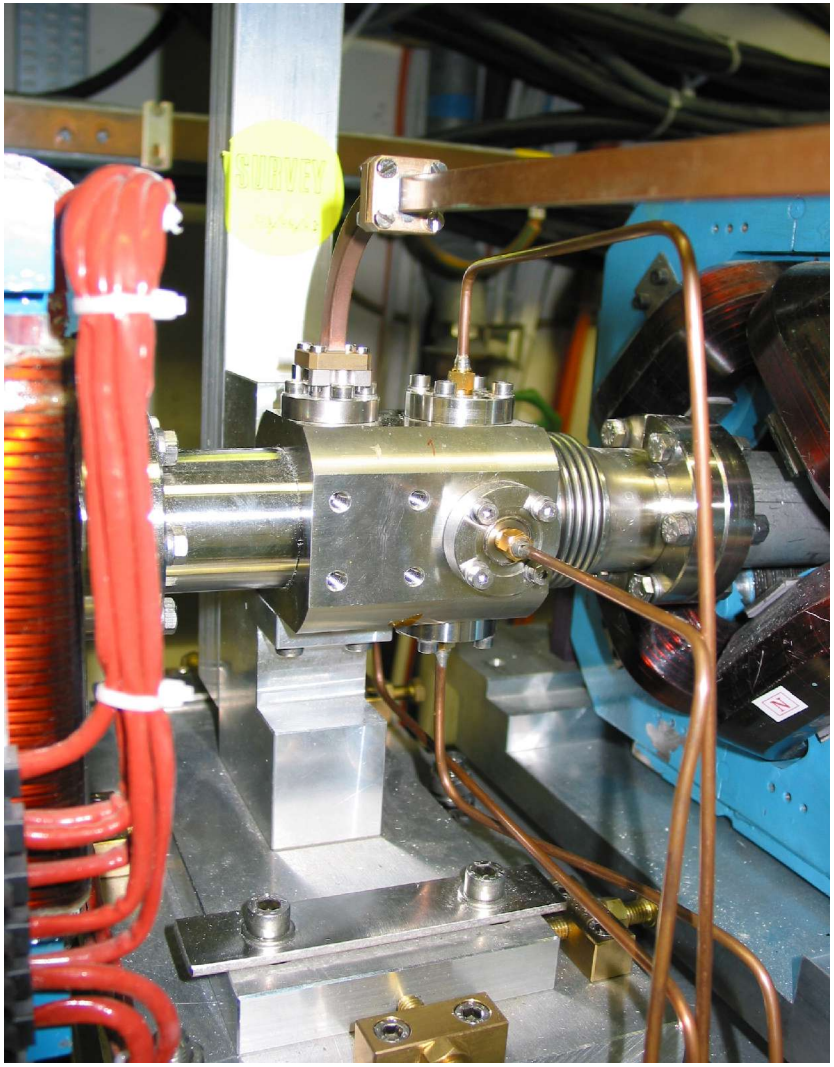
Wide band beam current pick-up

Develop a beam current monitor with ≈ 20 GHz bandwidth for measurement of intensity and longitudinal position bunch to bunch

Provide a signal for machine set-up and for equalizing bunch-charge and -spacing.

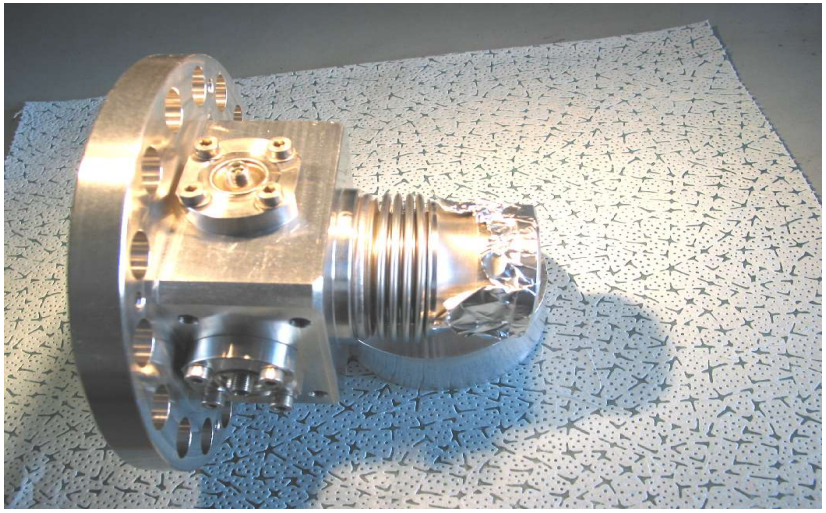
Applicable to LC main beams, drive beams and damping rings.

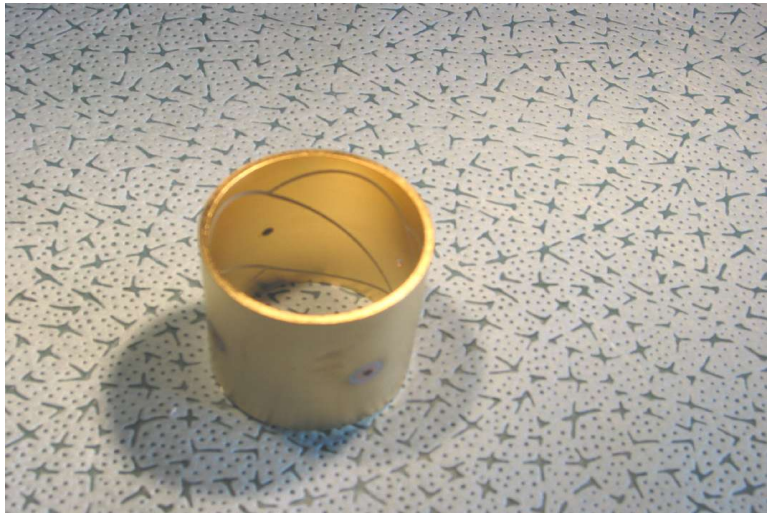
Button PU

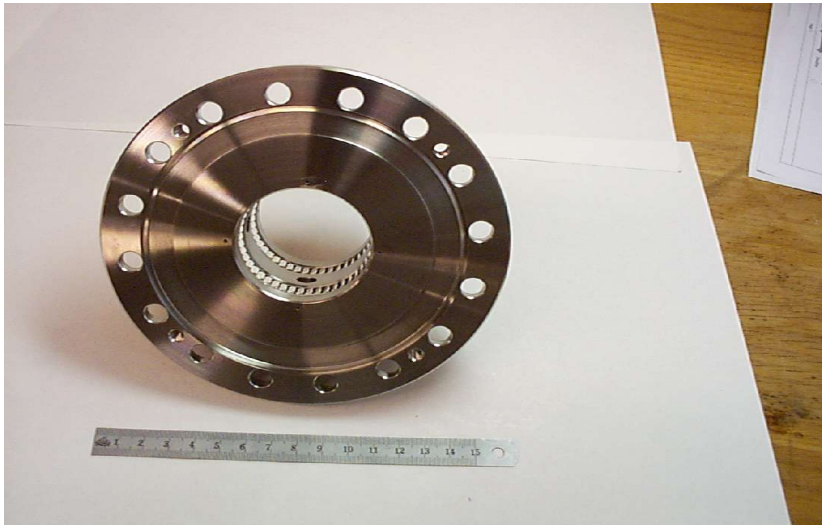


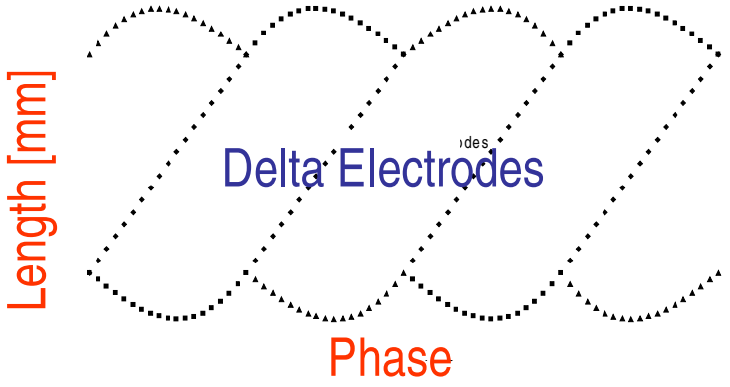
- CERN

Electrostatic PU



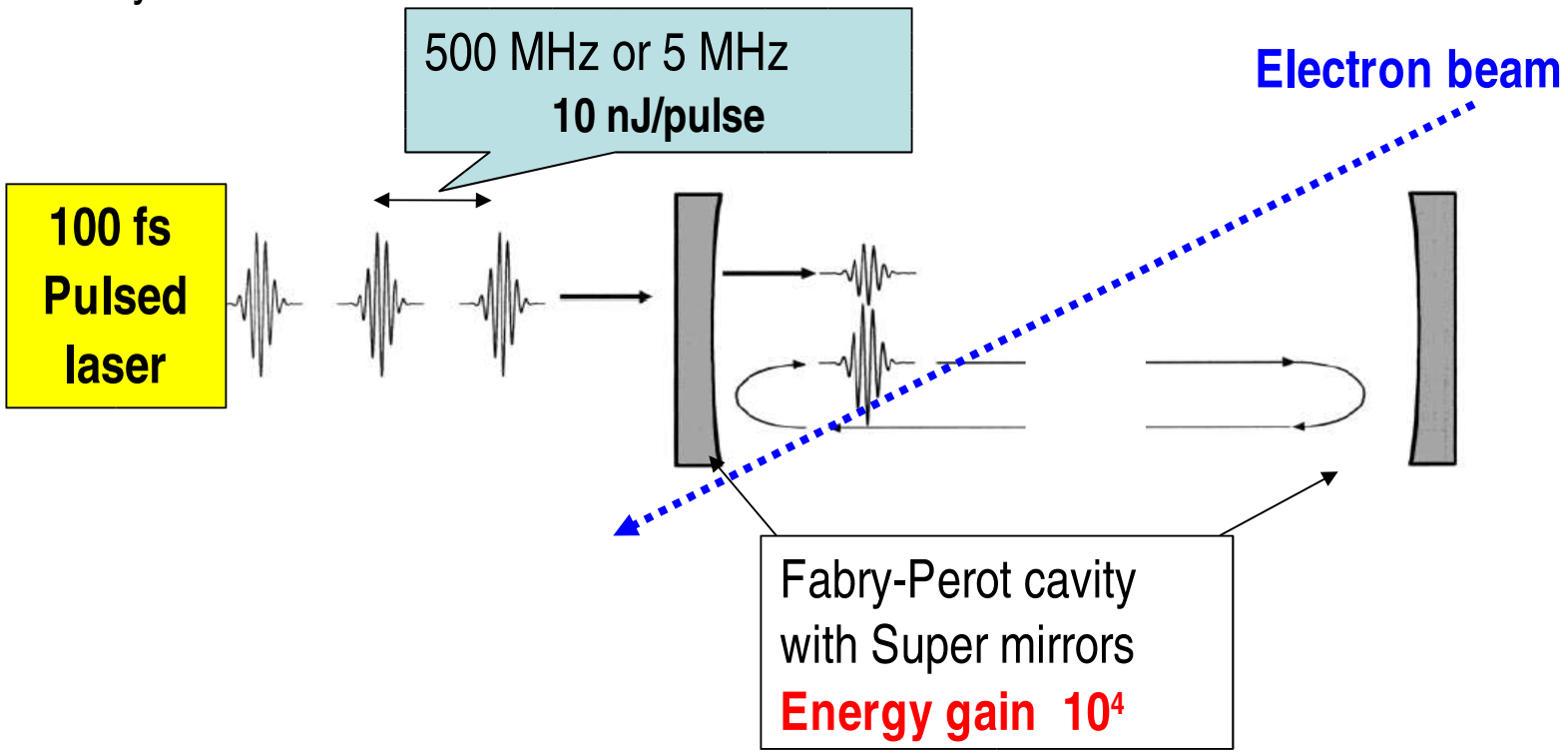






Laser amplification cavity for ILC polarimeter

- Orsay

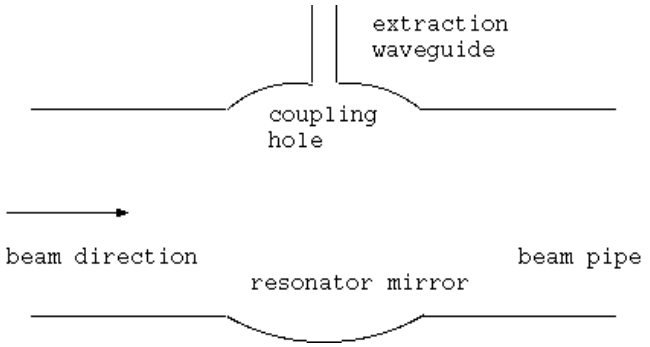


Proposed R&D :

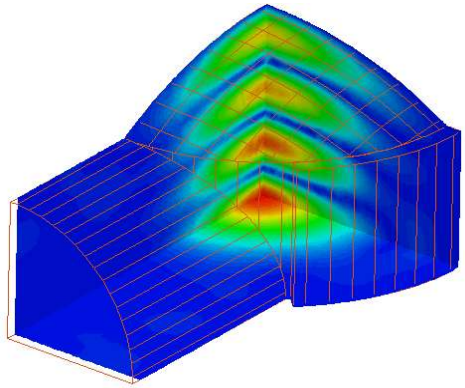
2. Resonance of a high gain Fabry-Perot Cavity with a fs laser
3. Realization of a specific confocal cavity

CFBPM: Confocal Resonator Monitor

- **Uppsala University (+ CERN)**
- **Problem:** High frequency waveguide modes perturb measurements with short bunches in CTF3.
- **Objective:** Design and test monitor that interacts with the direct quasi-TEM like field of the bunch, but is insensitive to waveguide modes.
- **Idea:** Laser resonator does not radiate orthogonally to axis. By reciprocity external fields do not couple into resonator.
- **Solution:** Passive confocal resonator monitor perpendicular to the direction of the beam.



- Simulations with HFSS and GDFIDL.



- Position sensitive: compare excitation of modes with zero or maximum on the beam axis.

WP 6: Integrated Luminosity Performance Studies

Coordinator: Daniel Schulte, CERN

Task ID	Task	Description
FMSIM	**Failure Mode & Effect Simulations**	determination of set of key failure modes (FM) • simulation of FMs using sophisticated LC modelling codes • evaluation of impact of FMs on accelerator performance / design • specific attention to BDS spoiler protection [WP2]
HCOLSIM	**Halo Collimation Simulations**	simulation of post-linac beam halo collimation • estimation of collimator efficiency • optimisation of collimation system [WP2] • impact of luminosity tuning on halo collimation efficiency
HALOBKG	**Halo Related Background Studies**	simulations of muon and neutron production in collimator sections • estimates of impact of physics detector performance • design of 'muon spoiler' systems [WP2]

LETSTAT	**LET static beam-based alignment and tuning studies**	development of sophisticated models of the LC from DR to IP • further development of beam-based alignment algorithms • simulations of algorithms with a complete set of machine errors • impact of upstream on downstream tuning • identify / specify diagnostics requirements [WP2,5,7] • understand tuning time-scales
LETFDBK	**LET Dynamic Feedback Studies**	simulations of beam-based feedback systems in the presence of time-dependent environmental effects (e.g. ground motion) [WP7] • studies of intra-train and repetition rate based feedback • beam-beam feedback • fast luminosity feedback [WP2]• interaction of feedback systems • optimisation of stabilisation algorithms and number of feedback stations
LETILPS	**Fully Integrated LET Studies**	integration of codes from LETSTAT and LETFDBK to produce full time-dependent tuning model ('flight simulator') • studies of the impact of dynamic errors and feedback on static tuning algorithms • full simulations of true luminosity performance in the presence of many static and dynamic errors [WP2,5,7]

HTGEN	**Halo and Tail Generation**	study of potential sources of halo and tail generation in the LET • development of analytical models of halo • estimates of halo population • development of computer models for halo/ tail generation • simulation studies of halo/tail generation • explore possibilities for benchmarking
BCDES	**Bunch Compression Design**	conceptual design of bunch compression system suitable for multi-TeV colliders • conceptual design of path length tuning chicane • basic parameter optimisation • performance simulation
PCDL	**Post-Collision Diagnostics Lattice**	tracking simulations with emphasis on location of possible post-IP diagnostics • evaluation of physics potential of post-IP diagnostics • design of extraction line for mult-TeV collider[WP2,5]
BBSIM	**Beam-Beam Simulation Code Development**	benchmarking of physics processes in GUINEA-PIG against known and trusted physics generators • implementation of spin transport into GUINEA-PIG

WP 7: Metrology and Stabilisation (METSTB)

Coordinator: Jean 'Yannis' Karyotakis, LAPP

Task 1: Survey and Alignment

- Provide Metrology and Alignment process for the complete collider (3-step process)
- Step 1: Rapidly perform collider reference survey with maximal automation (Metrology, RTRS=Rapid Tunnel Reference Surveyor)
- Step 2: Survey collider components against reference (automated stake-out instrument (s))
- Step 3: Adjust collider geometry allowing safe insertion of beams (Alignment)
- Provide rapid, accurate measure of geometry after adjustment with minimal reduction of up-time (Diagnostic function)

- **Task 2: Stabilisation**
  - Mechanically stabilise most critical components (**FF**, possibly other parts of BDS, i.e. chromaticity correction section)
  - Find optimal combinations of,
    - passive measures (damping, foundations, site choice)
    - sensors (optical, inertial),
    - actuators (piezo, electro-static, motor, ?),
    - feed-back algorithms (multiple sensors, frequency range, synch. with other feedback system)
    - vibration models (6D solid, internal degrees of freedom, vibration FEA)
  - Demonstrate system performance on realistic geometry FF-mock up
- **Synergies between tasks:**
  - Combine survey technology (FSI) with optical stabilisation sensors to give accurate absolute FF placement

- **Task 3: Ground Motion Spectra Cataloguing**
  - **Perform ground motion studies at potential LC sites around the world**
  - **Develop state-of-the-art spectrum measurement system with nm resolution**
  - **Develop software for analysis**
  - **Characterise vibration spectra with respect to identified vibration sources (e.g. 'cultural' noise)**
  - **Provide public database of spectra measurements for the LC community**

provides important input to simulations performed as part of WP6: ILPS

Participating Institutes

- LAPP: Inertial sensor development Inherit CERN equipment to set up common stabilisation test bed. Develop feedback algorithms (engineering department at LAPP)
- Oxford. Survey+alignment – FSI, LSM. Stabilisation: Optical sensor R&D, MSI/FSI, DAQ.

WP 8: Global Accelerator Network Multipurpose Virtual Laboratory (GANMVL)

Coordinator: F. Willeke, DESY

Task ID	Task	Description
ODI	Overall Design and Integration	analysis of user needs taking into account human aspects of remote communications • development of coherent overall design of MVL
SC	System Components	implementation of immersive audio/video control • plug and play mechanism for virtual instruments • integration of accelerator control systems • creation of the user interface
ME	Mechanical and Electrical Design	design and fabrication of MVL set-up
DGF	Demonstration of GAN and Far Remote Operation	performing and evaluating far remote accelerator operations • accelerator studies • remote trouble shooting • remote assembly of components • evaluation of psychological and sociological issues of the Global Accelerator Network

NOTE:

All tasks are currently under active review

Final proposal is being finalised

Summary

- Active UK programme in LC accelerator R&D
- EUROTeV proposal is currently being finalised
- UK and EUROTeV proposals highly synergetic
- Strong Coherent European effort building
- This effort will dove-tail with the global effort; many projects already do so
- Particle physicists are getting taking part in accelerator R&D
- It is not too late for newcomers to get involved too!

… and there's plenty to do!