UK LC-ABD Collaboration

UK Beam Delivery System Plans

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Background and Context

- UK particle physics community has strong interest in Linear Collider!
  Top priority ‘beyond LHC’: invested VXD ($4M) and calorimetry ($2M)

- UK Linear Collider accelerator seed-corn projects funded 1999-2003 by
  PPARC/CCLRC at level of c. $300k/yr:
    Laserwire beam size monitor (RHUL, UCL)
    Intra-train feedback (Oxford, QMUL, DL)
    Collimator wakefields (Brunel, Manchester)
    FSI alignment system (Oxford)
    TESLA e+ source undulator (DL)

  Simulations:
  - damping ring -> IP beam transport + FB (Oxford, QMUL)
  - halo/collimator interactions and particle tracking (RHUL)
  - TESLA BDS lattice (DL)

- Longitudinal bunch profile programme funded from other sources

- Daresbury operates SRS light source (RF, instrumentation, controls …)

- These efforts allowed development of expertise in number of areas
2004 - 2007

• UK funding agency, PPARC, secured from Govt. $18M 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

• 5 bids received: LC Beam Delivery System (LC-ABD)  
  Neutrino Factory (UKNF)  
  CLIC (CERN)  
  RF development (Lancaster Univ)  
  electron cloud (Liverpool Univ)

  A total of c. $40M was requested

• Bids peer-reviewed and preliminary allocations made Oct 21 2003:  
  LC-ABD recommended to receive $11M  
  UKNF received $2.5M  
  $4.5M reserved for national university-based accelerator institute
LC-ABD Collaboration

- Consortium comprises: Abertay, Bristol, Birmingham, Cambridge, Durham, Lancaster, Liverpool, Manchester, Oxford, Queen Mary, Royal Holloway, University College; Daresbury and Rutherford-Appleton Labs; spokespersons: Blair, Burrows

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

- Bid divided into 6 ‘work packages’:
  - Lattice design and beam simulations
  - Advanced beam diagnostics
  - Alignment and stabilisation
  - Final focus luminosity stabilisation
  - Technology
  - Machine detector interface

Each work package divided into ‘tasks’

- Peer review was done on task-by-task basis
  - Our original request was for $22M; $11M awarded -> not all tasks were funded

- I will discuss (mainly) what was funded!
1. BDS Lattice Design and Beam Simulations

- **1.1 BDS Lattice design:**
  Understand design issues, contribute to global development
currently 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)
  Halo production and tracking through BDS
  Collimator wakefields
  Backgrounds in IR: pairs, gammas, n: -> VXD, calorimetry, FB system …

**We welcome your guidance, suggestions + input**
Example: banana bunches, impact on FB
Tracking of halo energy deposition
2. Advanced Beam Diagnostics

• **2.1 Laserwire:**
  Ongoing collaboration on PETRA laserwire project
  UK building laser scanning system (multidirection?)
  Simulations: halo backgrounds, diagnostics layout
  (interest in Shintake system but not funded)

• **2.2 Bunch length/profile measurement:**
  Very successful electro-optic bunch length expt. at FELIX
  600fs achieved; aiming for 200fs
  R&D on Smith-Purcell radiation bunch profile monitor (Frascati)
  possible deployment at FELIX
Laserwire

Aim:
- 2nd dimension
- Fast scanning
- Advanced lasers
- BDS simulation
- Vacuum vessel

Vacuum vessel at PETRA
2. Sub-ps bunch length measurement

600 fs achieved.
Ongoing project at FELIX;
aiming for 200 fs
3. Alignment + Survey: LiCAS

LiCAS technology for automated stake-out process

Reconstructed tunnel shapes (relative coordinates)

collider component

Tunnel Wall

wall markers  internal FSI  SM beam  external FSI
LiCAS Simulation Results (TESLA)

Achieves goal for TESLA of 200 micron transverse alignment over 600m

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ALCPG Workshop, SLAC: BDIR Working Group, 09/01/04
LiCAS Development

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

Prototype readout board
4. Final-focus Luminosity Stabilisation

- **Beam-based feedback:**
  Worked primarily on intra-train FB as complement to ‘IP FB’ (train-train) + active mech. stabilisation schemes

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

- **FONT: Feedback On Nanosecond Timescales**
  2 generations of prototype intra-train FB systems tested at NLCTA. Proof of principle for warm machine: electronics latency c. 35ns
  80-90% of luminosity recoverable

- **Deploy next (3rd) generation FONT system in ATF extraction line at KEK:**
  stabilising ATF beam (1GeV) at 1 micron level equivalent to stabilising LC beam (1000 GeV) at 1 nanometre level

- **Deploy BPMs + electronics in proposed SLAC A-line facility: e+e- bgds**

- **Simulate angle + Lumi FBs, interplay between FONT + IP FBs + mech. FBs**
FONT Luminosity Recovery (NLC ‘H’)

For small offsets ($< 5$ sigma), and appropriate gain: system can recover $> 80\%$ of design luminosity.
FONT prototype at SLAC NLCTA

Dipole and kickers

Advanced BPMs
Integration of Stabilisation and Feedbacks

Timescales/frequencies:
- Survey + alignment: year (complete), weeks (local)
- Beam-based alignment: weeks – days
- Slow-orbit beam feedbacks: hours – minutes
- Active stabilisation schemes: seconds – milliseconds
- Pulse-pulse beam feedbacks: milliseconds
- Intra-train beam feedbacks: microseconds (TESLA)
  nanoseconds (J/NLC, CLIC)

Need to understand, through performance simulation, hand-over between these systems: avoid: feedback ‘competition’
  frequency ‘shuffling’
5. ‘Technology’

• 5.1 e+ source undulator design:
  Baseline method for TESLA, in consideration for NLC
  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:
  Overlap of interest with angle FB systems; UK RF company interest
6. Machine Detector Interface

6.1 Measurement of Luminosity Energy Spectrum (MOLES):
Absolute E (survey, alignment)
E jitter (fast BPMs)
E dispersion (laserwire?)

6.2 Small-angle fast calorimetry:
PbWO4 + vac photodiodes:
Rad hard + fast (no local amp)

6.3 IR layout + integration

None of these were funded!

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ALCPG Workshop, SLAC: BDIR Working Group, 09/01/04
Summary and Outlook

• Embarked on a substantial UK BDS work programme

• Have expertise in some areas, learning in many others

• Aiming to build a strong, coherent UK design team:
  intellectually interested in BDS
  aim to prepare UK funding agencies for a UK LC contribution

• Collaborating w. European partners via ‘Framework 6’ programme:
  EU funded LC ‘network’ to facilitate interactions
  Drafting ‘design study’ proposal for LC design work (CERN, DESY)

• We want to expand on existing collaborations: we value your input!