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

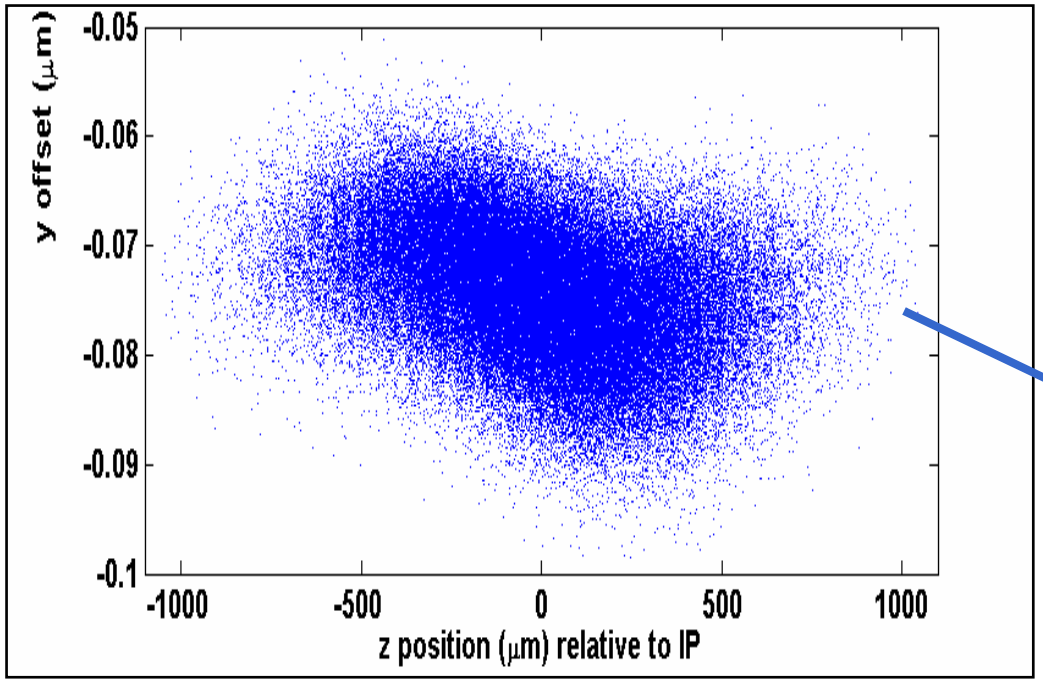
  Collimator wakefields

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

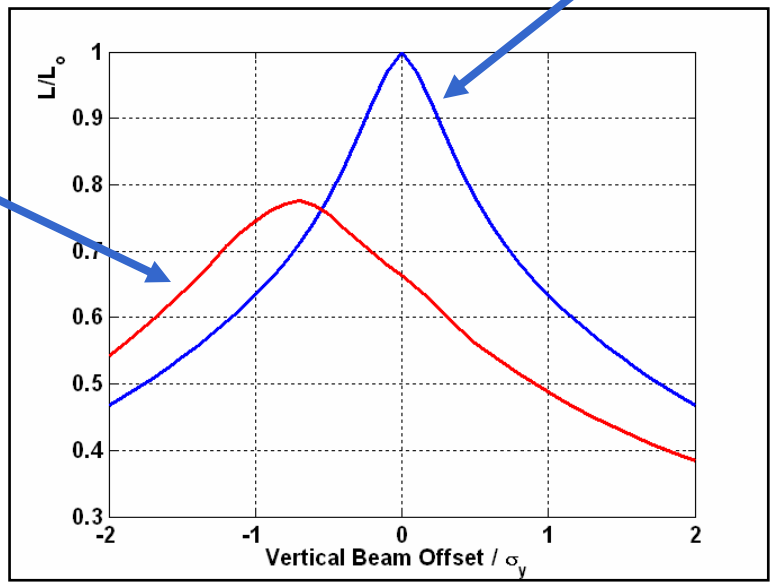
We welcome your guidance, suggestions + input

Example: banana bunches, impact on FB

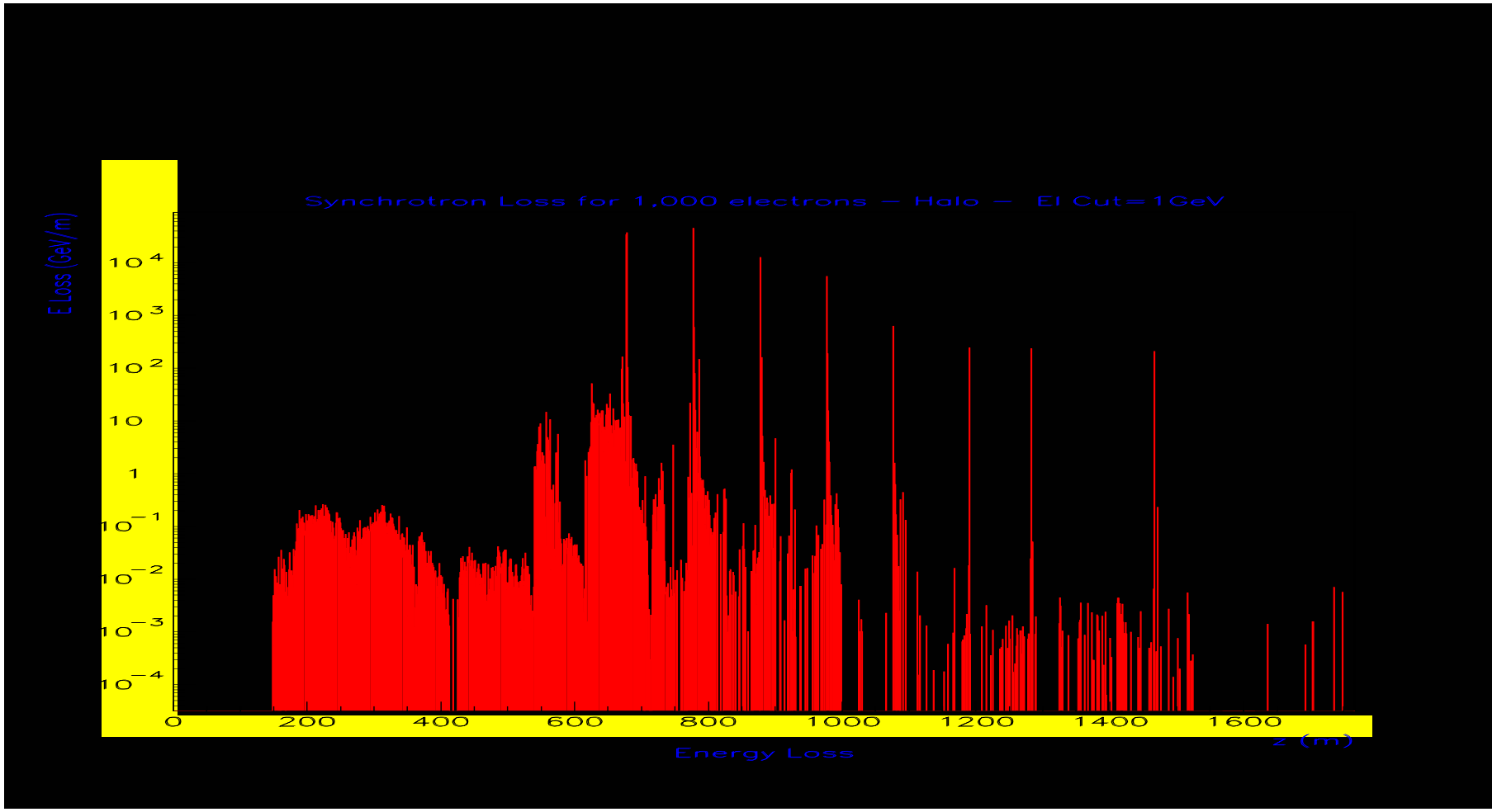
‘Banana’ bunch



Gaussian bunch



Tracking of halo energy deposition

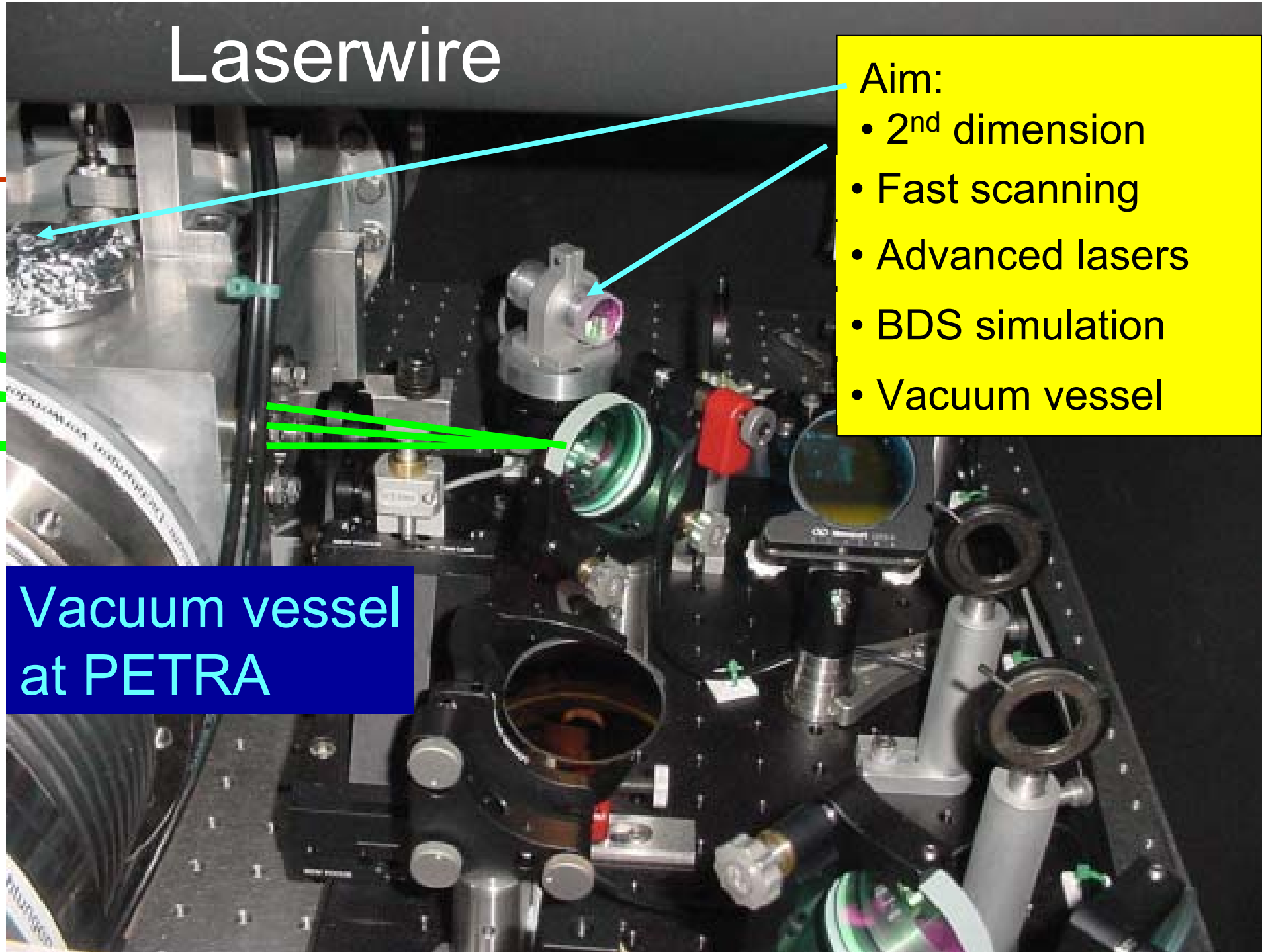


2. Advanced Beam Diagnostics

- **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

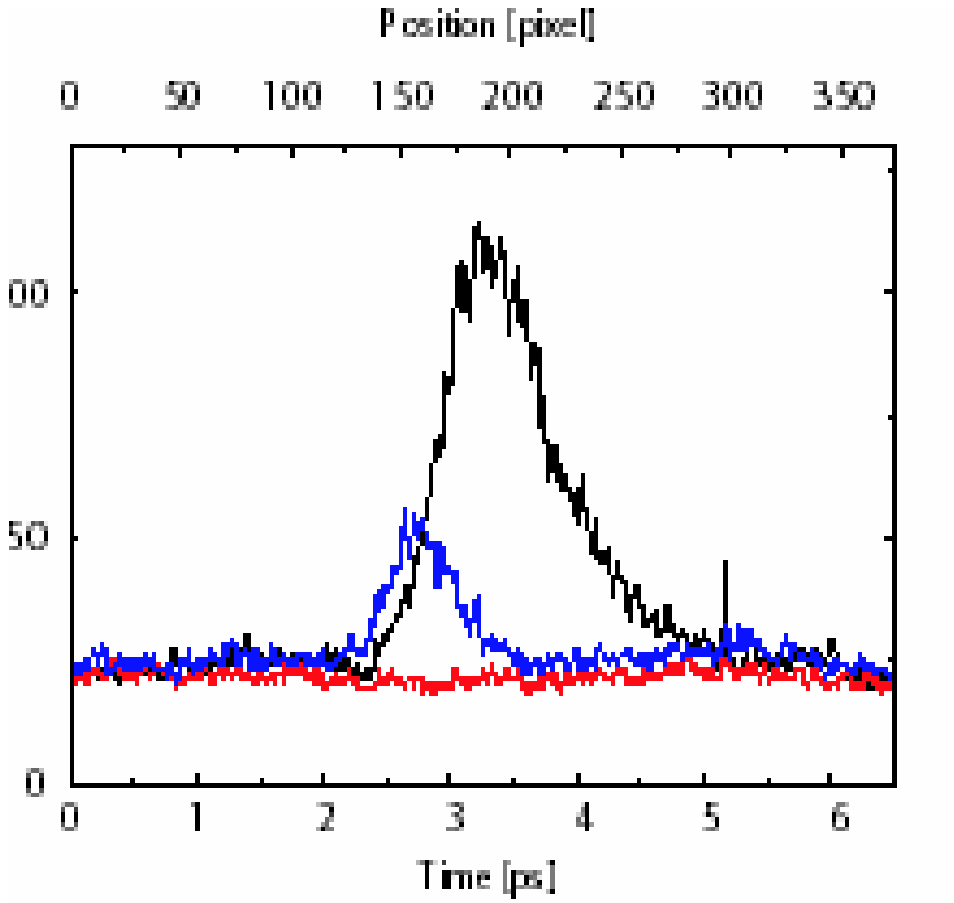


Aim:

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

Vacuum vessel at PETRA

2. Sub-ps bunch length measurement



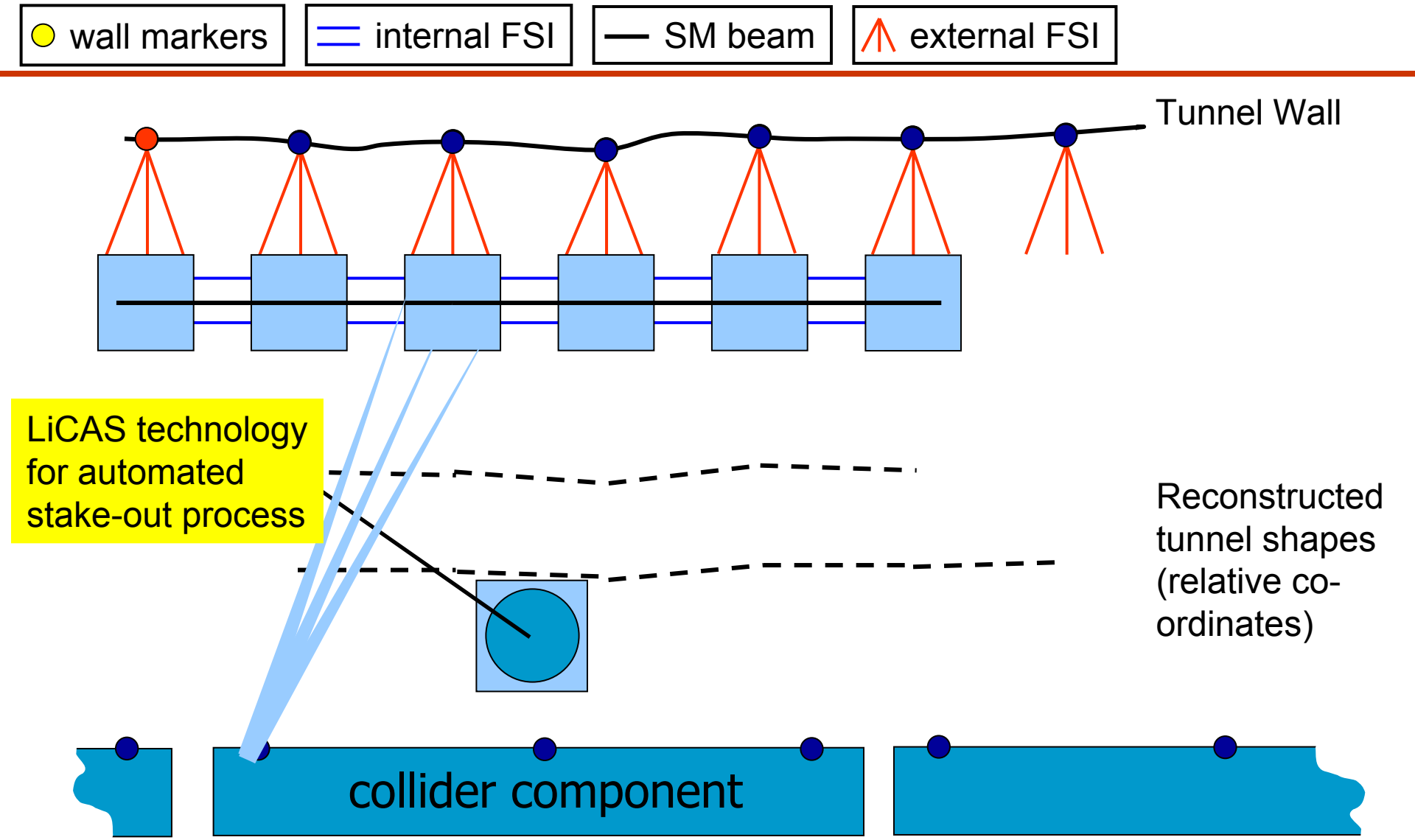
600 fs achieved.

Ongoing project

at FELIX;

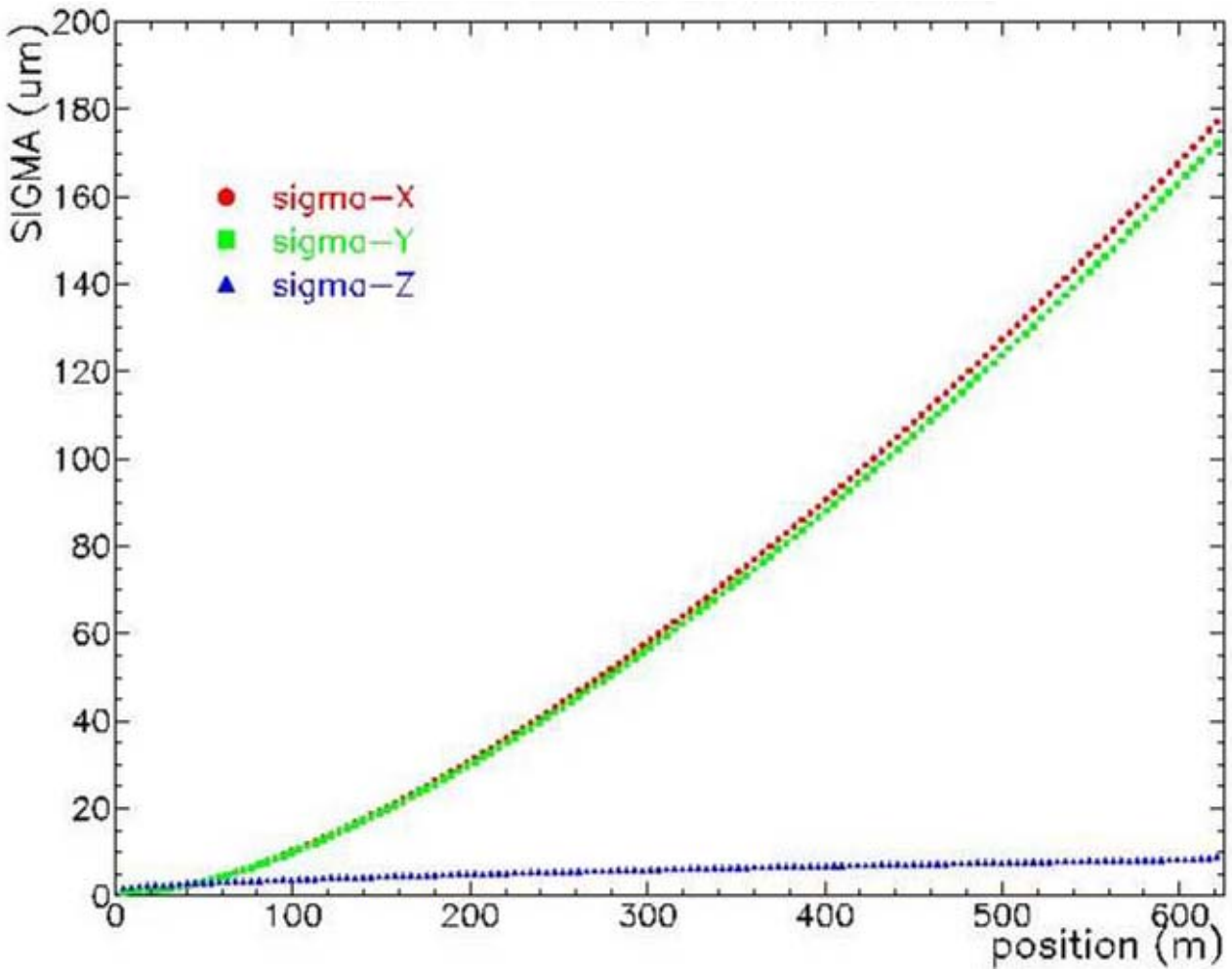
aiming for 200 fs

3. Alignment + Survey: LiCAS



LiCAS Simulation Results (TESLA)

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



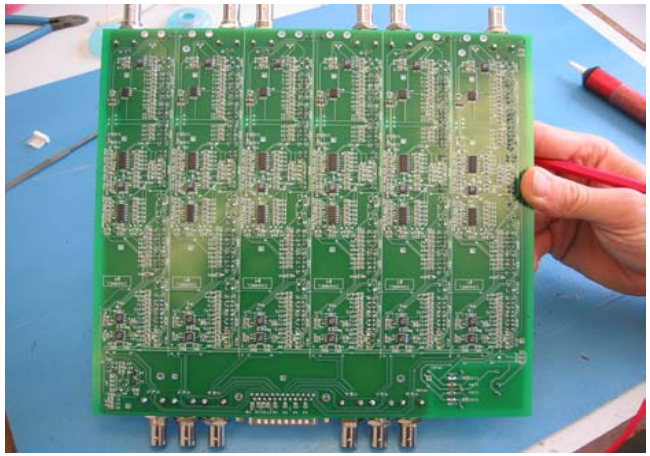
LiCAS Development

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

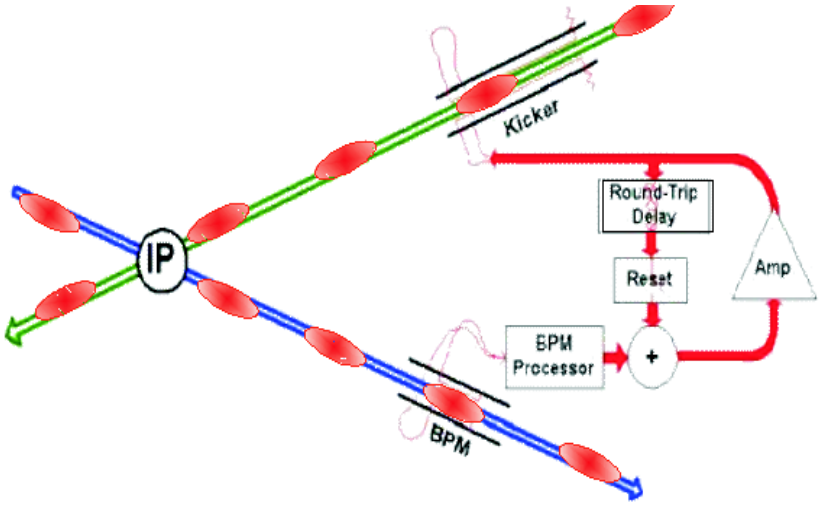


Prototype readout board

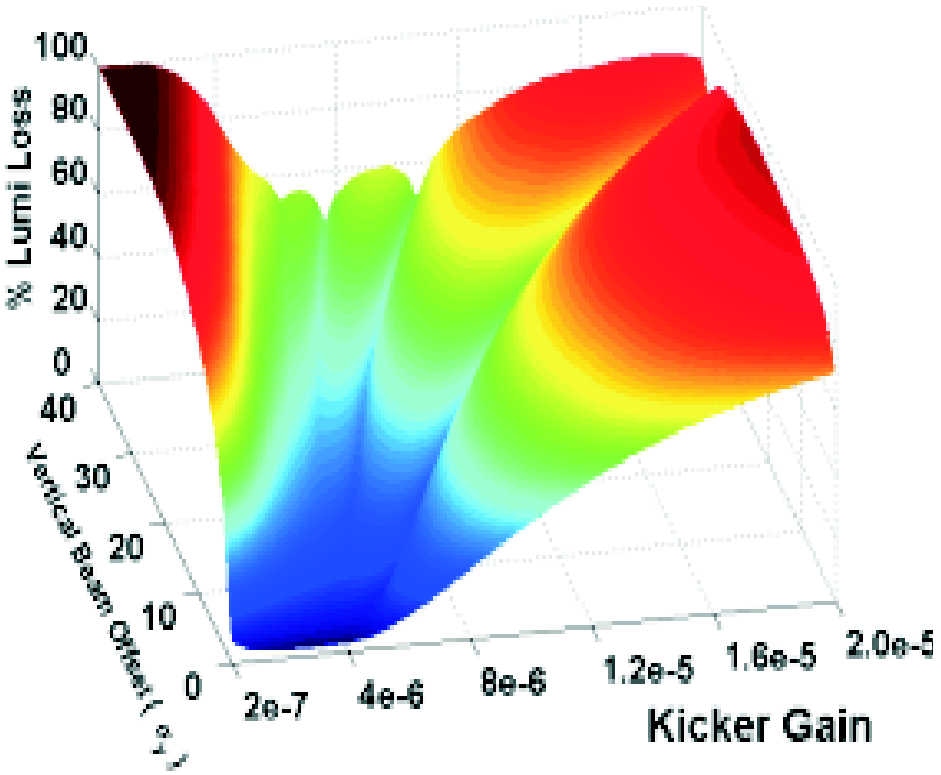
4. Final-focus Luminosity Stabilisation

- **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')

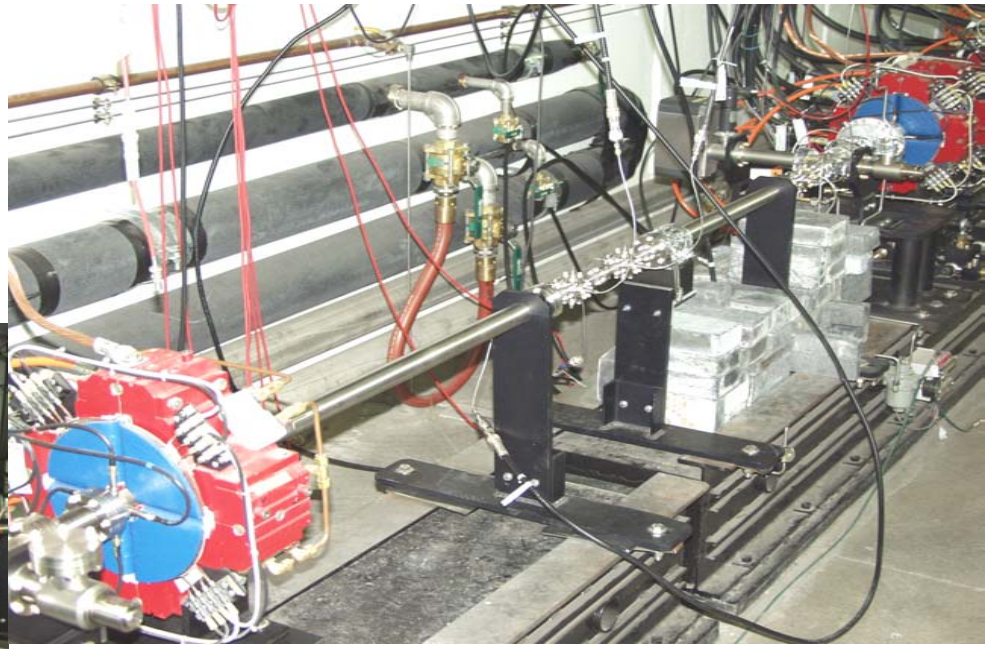


For small offsets (< 5 sigma), and appropriate gain: system can recover > 80% of design luminosity

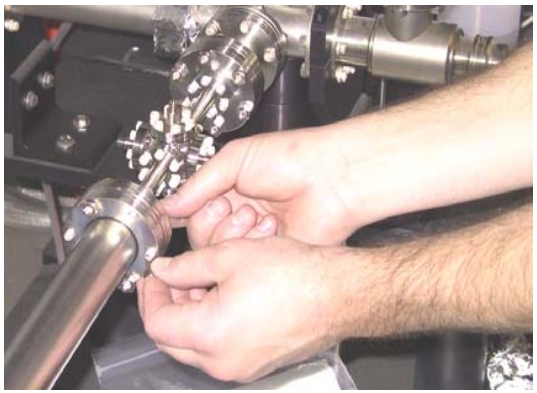


FONT prototype at SLAC NLCTA

Dipole and kickers



Advanced BPMs



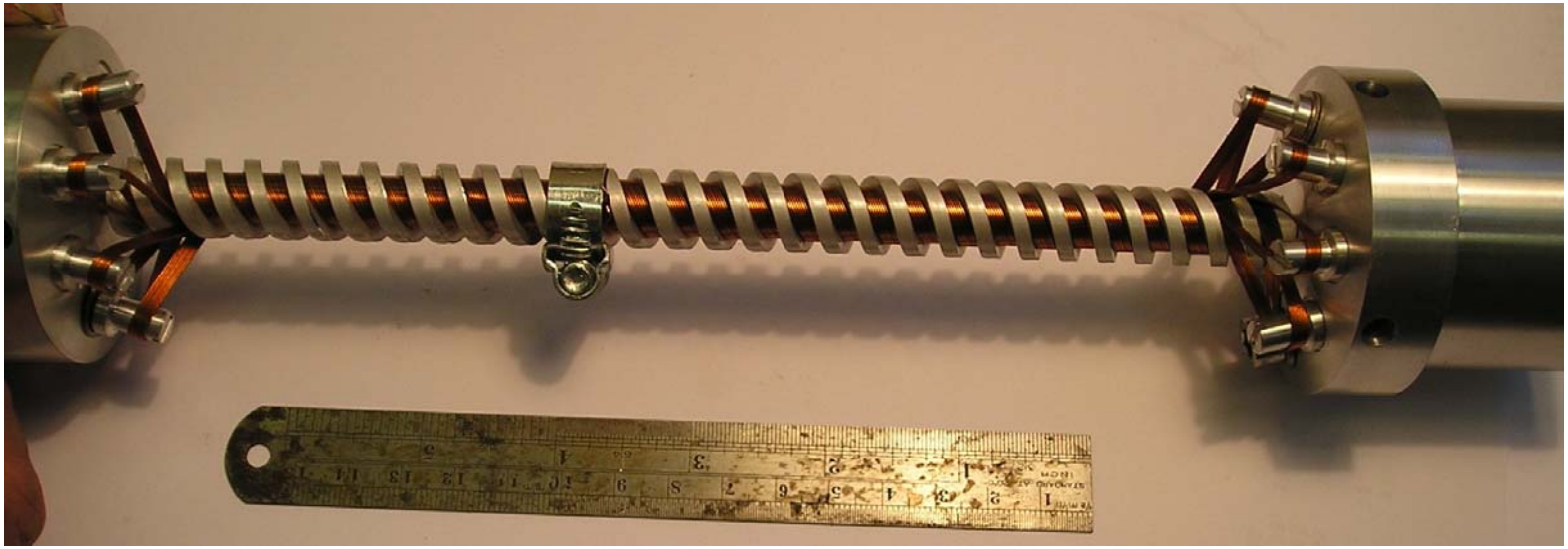
Integration of Stabilisation and Feedbacks

	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

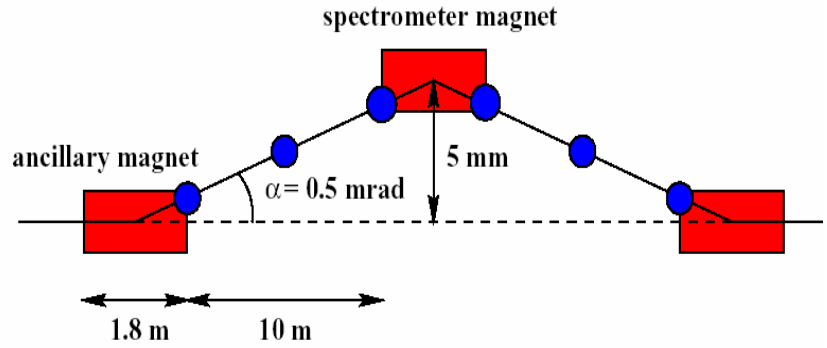
6.1 Measurement of Luminosity

Energy Spectrum (MOLES):

Absolute E (survey, alignment)

E jitter (fast BPMs)

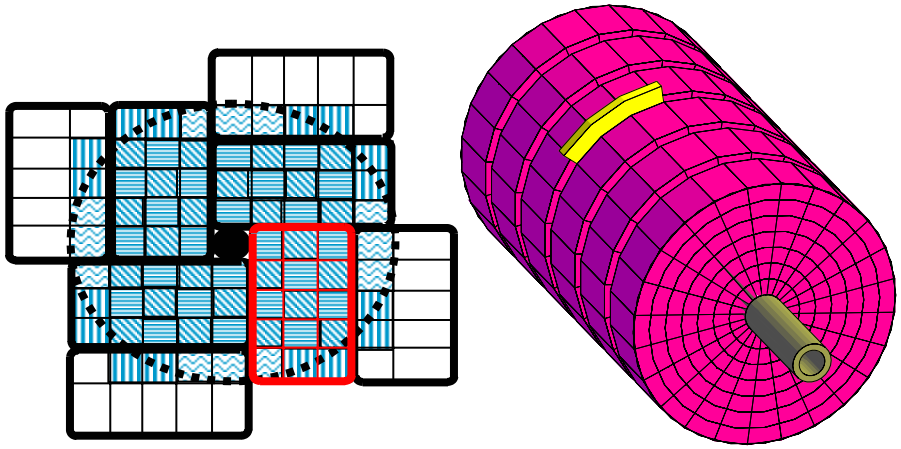
E dispersion (laserwire?)



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!

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!