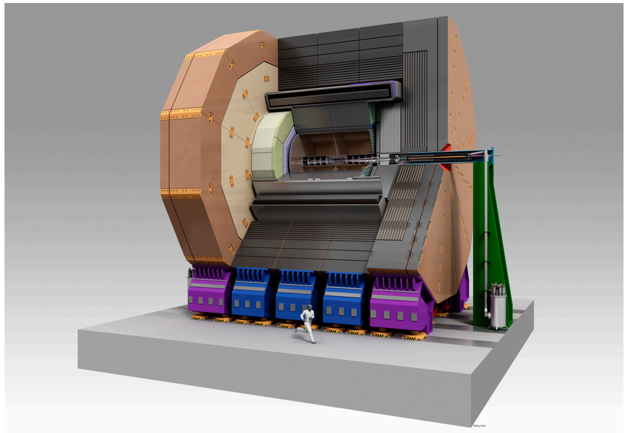

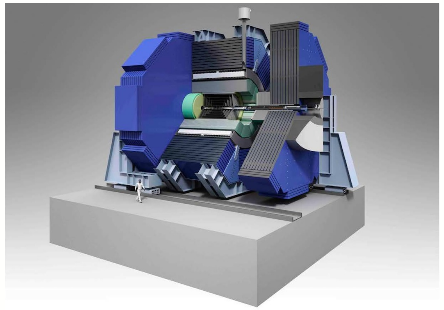

Status of Trigger/DAQ Work Package

V Boisvert

U of Liverpool, 1st February 2016

Reminder of DAQ WP

4.4 DAQ and Online Systems (Bristol, Liverpool, RHUL, STFC-RAL, Sussex, UCL, Warwick)

A two-fold strategy to position the UK as the lead group for a future final DAQ system is proposed: first, re-engage with the ILC detector community by participating in test beams that are foreseen over the next two years, and second, carry out necessary and critical R&D on emerging DAQ technologies applied to ILC detectors. This will allow us to have access to data from important test beams and contribute to physics publications. This approach is delivered over the following activities:

Minimal programme (all institutes): The requested travel resources will allow the UK to participate in the ILC DAQ design studies, covering the full timing loop of an ILC detector (from the machine interface to the fast-controls distribution) and addressing the readout challenges of an ILC environment (channel count, detector complexity, etc.). Several crucial readout studies are also foreseen: zero suppression scenarios, impact of peak data rates, buffering schemes and background studies. UK institutes intend to commit $\sim$1.7 FTE of effort (including academics) towards specification and design of the online system and associated software, building partly upon expertise gained from the LHC experiments.

Main goal: i) publish a detailed LC detector DAQ architectural design document, establishing the UK intellectual leadership in this area.

Extended programme: An additional £50k per annum would allow support of UK involvement in the DAQ for beam tests of ILC sub-detectors. Although the 2015 CERN and DESY schedules for test beams have not

Reminder of DAQ WP

yet been released, the ILC detector communities are already planning important test beams that might even combine various sub-detectors, thereby testing more thoroughly the sub-detectors performance and gaining critical experience of combining the respective DAQ systems into a single event building process. Implementation and participation in these activities are likely to be crucial in establishing a central UK role in the definition and implementation of common DAQ components for ILC, as well as allowing us to prototype online software systems. These areas are not yet well covered by existing collaborations, presenting a valuable and immediate opportunity. Practical experience gained at test beams will inform the design of the architecture for the ILC central DAQ, and parallel technical developments on emerging data-handling technologies.

- *Test beams and online software (Bristol, RHUL, Sussex, UCL)* (0.7 FTE): We will provide key hardware, firmware and software components. Existing UK hardware platforms (CALICE DAQ, Bristol TLU) are already in use, but will require further development. Likewise, existing common software frameworks (EUDAQ, XDAQ) will require adaptation, enhancement and support, building upon existing UK-LHC experience. The funds requested are: £20k/annum hardware for FPGA cards, μTCA crate, PC chassis, RAID controller cards, etc. and £15k/annum travel costs to provide staff and expertise during the test beams.

  Main goals: i) Contribute critical pieces of DAQ hardware to be used in future test beam experiments; ii) provision of software for online reconstruction, monitoring and event classification; iii) participation in the operation of the test beam campaigns foreseen by the ILC detector community, providing expert assistance running the DAQ/online systems; and iv) lead the DAQ/online design for the ILC detector concepts.

Reminder of DAQ WP

- *DAQ R&D (Bristol, RHUL, STFC-RAL, UCL)* (0.3 FTE): We will build upon our experience of cutting-edge trigger and DAQ systems from the LHC upgrades to establish the suitability of emerging technologies for ILC use. The technical design of the central DAQ will take place later in the construction phase, but architectural choices on interfaces and data flow must be taken relatively soon, and will not be easy to revisit later. The funds requested are: £15k/annnum hardware: FPGA cards, ADC cards, HDMI cables, SFP transceivers, etc.

  Main goals: Publish characterisation studies of newer architectures (e.g. TCA, Scalable Readout System) applied to the ILC DAQ; and ii) lead the ILC detector concept decisions on DAQ hardware architecture.

In recognition of our expertise, UK researchers have recently been appointed to lead the AIDA-2020 DAQ WP (focused on ILC detectors). The activities described above will be critical in maintaining and expanding this leadership. This R&D will position the UK at the heart of the ILC DAQ design and construction and underpins contributions both to individual sub-detectors and to the machine itself.

DAQ WP over last year

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- Created LCUK-DAQ mailing list in February 2015
- Had first meeting on 6th February 2015
- Strong UK contingent at ALCW in April 2015 at KEK
- AIDA 2020 Kick-off meeting in June 2015
- LCWS15 2-6 November 2015 in Whistler, Canada

Bristol, UCL, Sussex: AIDA 2020 WP5

- Advanced European Inftrastructures for Detectors at Accelerators
- 24 countries + CERN
- Kick-off meeting 3-5th June 2015 at CERN
    - http://indico.cern.ch/event/382133/
- EUDAQ workshop 22-25 November 2015 at DESY
    - https://indico.cern.ch/event/455029/
- AIDA WP5 meeting in Orsay on February 4th 2016
    - M Wing and D Cussans are WP managers

Matthew Wing (UCL) on behalf of

WP5 groups: University of Bristol, DESY Hamburg, Institute of Physics AS CR Prague, University of Sussex, UCL

AIDA-2020 WP14 Calorimeter Meeting — 27 January 2016

Outline

- Overall concept of work-package
- Outline of tasks
  - Task 5.1 Scientific coordination
  - Task 5.2 Interface, synchronisation and control of multiple-detector systems
  - Task 5.3 Development of central DAQ software and run control system
  - Task 5.4 Development of data quality and slow control monitoring
  - Task 5.5 Event model for combined DAQ
- Milestones and deliverables
- Summary and next steps

Overall concept of workpackage

This workpackage will provide a common data acquisition (DAQ) system for use by Linear Collider detectors in beam tests to characterise their properties.

- Priority is to ease running of two or more detectors together in a common beam test.
- Should allow more physics and technical understanding to be extracted. Understand performance of detector and/or validation of reconstruction algorithms for individual and multiple detectors.
- Clear and strong links with other parts of the programme on software, calorimetry, test beam facilities.
- In principle useable by any detector; hardware designs, firmware and software will be freely available.
- A common DAQ system will provide standard interfaces to allow any Linear Collider detector to be read out using the system to be developed here.
- Provide run control, data sanity and quality checks.
- Convert data to common format for ease of analysis.
- Important to have all detectors interfaced/integrated.
- As a by-product, learning about a future Linear Collider DAQ.

Task 5.2 Interface, synchronisation and control of mulitple-detector systems

Principal task for definitions, specifications and hardware, all to be able to run multiple different detectors together.

• Specification of interfaces for the common DAQ: trigger logic unit (TLU); clock and control card (CCC); and potentially other DAQ systems.

• Harmonise timing and synchronisation signals ⇒ correlation of different detectors.

• Compatibility between TLU and CCC and development of their firmware.

• Extend TLU for extra functionality, e.g. injecting trigger and synchronisation data to front-end electronics. Hardware, firmware and software changes.

• Provide TLUs for combined beam tests as well as laboratory set-ups.

• Set up different beam tests, integration to common DAQ and expert support.

• First aspect of task is definition of interface standards and technical document detailing these so any detector can use synchronisation system.

• Completion of beam tests with multiple detectors.

• Task responsibles; **Bristol**, UCL.

TLU aims

- Provide a hardware mechanism for synchronising multiple devices in a common beam test.
- Provide easy interface to beam scintillators.
  - Lower cost more compact NIM crate
- Backwards compatible (at interface level) with EUDET JRA1.

TLU status

- ~30 EUDET TLUs in use and no spares left. 10 AIDA mini-TLUs made for testing.
- Issues:
  - "Bug" in mini-HDMI connector pin-out
  - mini-HDMI has proven unreliable in use.

From D. Cussans (Bristol)

TLU plans

- Effort is now increasing:
  - ~20% of engineer at UCL started working (Samer Kilani)
  - Recruiting physicist/engineer at Bristol to work 50% on AIDA-2020
- Gather requests for AIDA-2020 mini-TLU.
- Produce batch of bug-fixed mini-TLUs for distribution Q2/2016.
  - Cost basis to be decided. WP5 has funds for "full" TLUs installed in beam-lines as AIDA-2020 deliverable, but not mini-TLU.
- For next batch of mini-TLUs:
  - Full-size (more robust) HDMI connectors.
  - Ability to accept clock from CALICE CCC or LHCb Timepix clock/sync fanout on standard HDMI cable (instead of hand-made custom cables with clock separated from trigger/busy/sync).
- Tests to perform:
  - Chain CALICE CCC and one or more mini-TLU to check for stability of clock ("jitter peaking")
  - Test timing precision of TDCs with beam particles.
- Design and produce full TLU—more trigger inputs for DUT interfaces (WP5 deliverable)

Task 5.3 Development of central DAQ software and run control systems

- Combining data from different detectors using common EUDAQ software. Interface to detector-specific DAQ systems. EUDAQ appears to be suited to the common DAQ task:

  - Successfully used for beam telescope and the multitude of detectors it has been run with.

  - Undergoing development (e.g. scalability) and supported.

  - Need to thoroughly assess suitability and have a software suited to our needs for linear collider detectors.

- Development of central run control.
- Development of online checks of data sanity, e.g. trigger or event rate and event size.
- Provide computing hardware for common DAQ.
- Tests of common DAQ system with single components.
- Use of common DAQ for combined beam tests with continued development and maintenance.
- Task responsibles; **DESY, UCL**, Bristol, Prague, Sussex.

EUDAQ as the basis

- EUDAQ has been in use for many years, built out of EUDET and the beam telescope,

with many common beam tests behind it.

- Had a EUDAQ mini-workshop in November:
- https://indico.cern.ch/event/455029/
- EUDAQ2.0 will be the basis:
  - More flexibility in the data format.
  - Increasing track rate by more than 2 orders of magnitude.
  - Easier combination of different devices.
  - Resolved scalability issues.
  - Stay backward compatible with EUDAQ1.x
  - Cross platform.
- New post-doc being hired to work on central DAQ, run control, etc.

Task 5.4 Development of data quality and slow control monitoring

- Development of near-online checks of data quality: for individual detectors and coincidences between different detectors.
- Interface to slow control systems of different detectors providing a common and synchronised slow control monitor of various conditions.
- Continued development and maintenance of system.
- Task responsibles; **Prague, DESY, Sussex**, UCL.

Current progress

- Identifying key program structures and data flow
- Developing plan of final online monitoring structure
- Developing logical structure for showing calorimetry monitoring data only when a calorimeter is used (compatibility a priority)

Monitoring structure

- EUDAQ currently functions with 'events' which makes sense for beam telescope-type detectors.
- Different set of 'primitives' must be determined for calorimeters
- In-depth knowledge of detectors and test beams so that common elements can be abstracted into code.

From Tom Coates (Sussex)

Short-term goals

- Develop list of useful histograms
- Collect and understand any already-written code for AHCAL beam test.
- Develop structure of monitoring for calorimetry.

Medium-term goals

- Successfully interpret AHCAL test/dummy data with new code in EUDAQ online monitor
- Code ready for AHCAL beam test in May/June.
- Code generalised enough to begin expanding to other detectors.

Long-term goals

- Generalise online monitoring framework to be compatible with other CALICE beam tests.
- Create default histograms for unrecognised calorimeters.
- Devise collections of histograms for known test beams.

Task 5.5 Event model for combined DAQ

- Define concept of an event for online data, i.e. combine data from different detectors with different integration times.
- Match event model (LCIO) to online as well as offline data.
- Develop uniform and consistent model for data structure.
- Also needed for data sanity and quality checks, in Task 5.3, and near-online checks, in Task 5.4, related to multiple-detector information.
- Information to be gathered on various detector event structures.
- Test on e.g. AHCAL + beam telescope test beam.
- Task responsibles; **DESY**, UCL.

Task leaders

- Task 5.1 Scientific coordination: D. Cussans & M. Wing
- Task 5.2 Interface, synchronisation and control of multiple-detector systems: D. Cussans
- Task 5.3 Development of central DAQ software and run control system: M. Wing
- Task 5.4 Development of data quality and slow control monitoring: F. Salvatore
- Task 5.5 Event model for combined DAQ: A. Irles

Personnel

- Bristol:
  - D. Cussans, New EE being hired, mechanical engineering effort
    - EE post interviews next week. Will work 50% on AIDA-2020 for 4 years.
- DESY:
  - A. Irles, K. Krueger, F. Sefkow, also EUDAQ people
- Prague:
  - J. Cvach, J. Kvasnicka (also at DESY)
- Sussex:
  - C. Chavez Barajas, T. Coates, F. Salvatore
- UCL:
  - S. Kilani, M. Wing, New post-doc being hired

Oxford physics (from Armin Reichold)

- Funding from Oxford's EPSRC Impact Acceleration fund
- Collaboration with 2 industrial partners: VadaTech (large manufacturer of microTCA components) and Etalon AG (potential industrial customer of a microTCA.4 based DAQ system)
- Project aims to reduce the overall development effort necessary for high speed digitisers with custom signal processing and fast online computation. Increase use of commercial technology like Fast FPGA with PCIe links, fast ADCs, etc. such that development focuses on custom signal conditioning and HEP specific applications
- microTCA4 platform chosen
- Pilot project: rear transition module for VadaTech's latest generation of fast multi-channel ADC products, will accept mezzanine cards, Oxford will develop one for detection of low level analogue optical signals for interferometry applications, and also study performance of getting data off crate
- System up and running, development was meant to start October with commercial availability by March 2016.

RHUL

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- Started development of standalone data generator for testing DAQ chain: PCI express card based on an FPGA prototype card. Under software control arbitrary patterns and timing can be generated. Initial output interface will be CERN GBT link but other interfaces can be supported
- Long-standing idea: Mimosa high rate DAQ development: need to find out DESY's plans, and plan to get some new RHUL person power for this. Interested in the upcoming CMOS workshop and Beam telescope meeting.
- Paper studies involving rates/design: still to do by myself with Bristol

Conclusions

- AIDA 2020 has now started in earnest and DAQ activities will focus on practical test beams of ILC detectors (Bristol, UCL, Sussex)
  - First test beam: AHCAL in May/June
- This year should also push for developments on
  - More generic DAQ along the lines of Oxford microTCA investigations
  - ILC specific paper studies
- More regular meetings

Backup

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Oxford

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The effort I mention below started on the periphery of the usual stream of PP related DAQ activities but may well be of interest to many PP based project.

With funding from Oxfords EPSRC Impact Acceleration fund, Oxford Physics have started a collaboration with two industrial partners (VadaTech, a large manufacturer of microTCA components and Etalon AG, a potential industrial customer for a microTCA.4 based DAQ system developed in Oxford)

The project is strategically aimed at a reduction of the overall development effort necessary for high speed digitisers with custom signal processing and fast online computation. The idea is to increase the use of commercially available digital technology (Fast FPGA based DAQ with PCIe links, fast ADCs, online computation and buffering, managed crates, power and cooling) and to focus hardware developments more on the custom signal conditioning or serial interconnection technology specific to HEP applications.

After a long search we have chosen the microTCA.4 platform. MicroTCA.4 has been largely designed for the particle and accelerator physics marked. It provides the benefits of the larger ATCA platform (scalable architecture, very fast I/O, protocol agnostic backplane, remotely managed hardware, redundancy if needed, robustness) with much smaller overheads and more flexibility for setting up systems of small to medium scale (less expensive, variable crate sizes, more relevant components to chose from, strongly supported by our DESY colleagues,). MicroTCA.4 is also supported by a larger market of manufacturers of components relevant to physics applications.

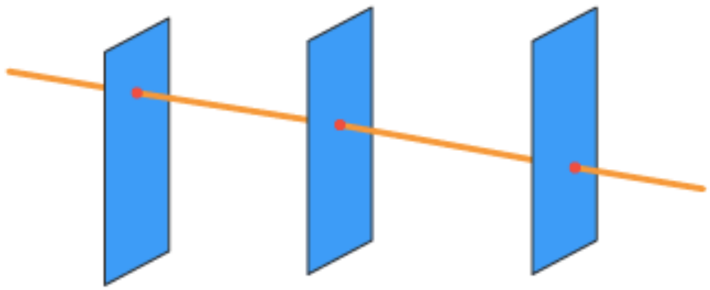
For our pilot project we have entered into the development of a novel rear transition module for VadaTech's latest generation of fast multi-channel ADC products (the AMC523 and MRT523, 12 channels, 125 MHz simultaneously sampling ADC, 2x250 MHz DAC, large Kintex7 FPGA, 2 GB of DRAM buffer, backplane link with PCIe-x8 Gen3 or dual x4 or dual GbE supported in firmware, direct optical SFP+ front-side links up to 6.6 Gbps, variety of trigger and clock sources).

The new MRT523 will accept mezzanine cards that carry the analogue section of the signal conditioning system. The mezzanine will be designed to be isolated from the complexities of the microTCA.4 compliant management and digital infrastructure aspects making it easy to develop. Oxford will develop the first mezzanine which will detect low level analogue optical signals for interferometry applications and VadaTech will modify their existing MRT523 into the mezzanine carrier format. Oxford will also study the performance of various methods for getting the data off the crate including PCIe bus extension with multiple optical SFP+ links, in-crate computing and collection of data in the compute AMC with subsequent 10 GbE downlinks and FPGA based direct optical links from each ADC card.
I have no fancy pictures of this as it just a crate with components in it put I provide some links to the underlying commercial hardware here:
AMC523: http://www.vadatech.com/product.php?product=384&catid_now=0&catid_prev=0
MRT523: http://www.vadatech.com/product.php?product=385&catid_prev=265&catid_now=167
UTC004 (shelf manager and PCIe extension point): http://www.vadatech.com/product.php?product=305&catid_now=0&catid_prev=0
PCIe bus expansion: http://www.vadatech.com/product.php?product=298&catid_prev=139&catid_now=69
In-crate compute unit: http://www.vadatech.com/product.php?product=334&catid_now=0&catid_prev=0

We have the system up and running and are starting custom mezzanine development at the beginning of October aiming at commercial availability of the new MRT and custom mezzanine by end of March 2016.

Monitoring Structure

- EUDAQ currently functions with 'events'. Each event includes:
  - Several detector planes, each composed of pixels
  - Particle passes through the planes, activating pixels on each plane
- Path and speed of particles reconstructed from information



University of Sussex

Monitoring Structure

- Event-based structure makes sense for beam telescope-type detectors, however the event concept has no relevance to calorimeters
- New set of 'primitives' must be determined – elements that allow meaningful online analysis of the data
- Requires in-depth knowledge of several testbeams so that common elements can be abstracted into code

University of Sussex

Purpose of this talk

- Remind people of the basic idea/goals of the Common DAQ workpackage (WP5).
- Give the status of the current thinking and progress.
- Invited by Roman and Frank to start discussions of how to interface various calorimeters to a common DAQ.
- Have a WP5 meeting next week in Orsay to further define the standards and interfaces of the common DAQ, open to all detectors.
- The questions we are asking the detectors to address are:
  - Does detector XYZ use the TLU, if so which version, and if not how can they interface to it ?
  - Does detector XYZ use EUDAQ software ? if so, which version and is it used for all DAQ purposes ? If not, can you estimate what needs to be done to do so ?
  - Do you convert detector XYZ data to LCIO format ? If so, what does this entail ? If not, what needs to be done ?
  - What do you think the common DAQ system should do ?
  - What are the plans of detector XYZ group for common beam tests, i.e. tests with other detectors ?

Task 5.1 Scientific coordination

Along similar lines to other workpackages:

- Coordinate and schedule the execution of the workpackages tasks.
- Monitor the work progress (milestone and deliverable reports, follow-up on the workpackages budget and the use of resources).
  - First milestone/deliverable in month 15, end of July 2016: document defining of detector interface standards with common DAQ.
- Reporting to the project management.
- Organise workpackages meetings and disseminate information.
  - After kick-off meeting, had EUDAQ meeting, Nov/2015, in DESY, another WP5 meeting in Orsay on 4/Feb.
- Carried out by workpackages coordinators and task leaders.
  - Have instituted task leaders.
- Foster and coordinate links with other workpackages, in particular: WP3, software; WP10, beam test facilities; WP14, calorimeters; WP15, upgrade of test beams.
- Task responsibles; **UCL, Bristol**.

Project management – deliverables

List of deliverables

Deliverable Number [14]	Deliverable Title	Lead beneficiary	Type [15]	Dissemination level [16]	Due Date (in months) [17]
D5.1	Interface definition	30 - UCL	Report	Public	15
D5.2	Trigger Logic Unit ready	31 - UNIBRIS	Demonstrator	Public	30
D5.3	Data acquisition software	30 - UCL	Report	Public	30
D5.4	Data acquisition hardware	31 - UNIBRIS	Demonstrator	Public	30
D5.5	Online event data model	9 - DESY	Report	Public	30
D5.6	Common DAQ system used in combined beam tests	30 - UCL	Report	Public	45

First deliverable (and milestone)

- D5.1 Definition of interface standards for the common DAQ system which will describe how the detector DAQ system connects to the common DAQ. (Task 5.2)
- D5.2 The TLU hardware, including interface to CCC, will be ready, along with first versions of firmware and software for testing and integration with detector systems. (Task 5.2)
- D5.3 A software, including EUDAQ interfaces, run control, data monitoring and slow control will be available for common detector test-beams. (Tasks 5.3, 5.4)
- D5.4 As well as the TLU and software, the computing infrastructure, principally PCs, disks and networking, will be ready. (Tasks 5.2, 5.3)
- D5.5 Definition of the online event data model, i.e. the concept of an event for detector systems having very different integration times, compatible with the offline software and in coordination with WP3. (Task 5.5)
- D5.6 The DAQ system will be in use in common test-beam campaigns and the final description of the implementation and performance results will be presented in a report. (Tasks 5.1, 5.2, 5.3, 5.4, 5.5)

Project management – milestones

Number	Definition	Beneficiary	Month	Verification
MS25	Definition of detector interface standards with common DAQ (Definition of interface standards for the common DAQ system which will describe how the detector DAQ system connects to the common DAQ, Task 5.2)	UCL	15	Report to StCom
MS43	Trigger logic unit (TLU) design ready (This will include the design of the interface to the CCC as well as firmware block diagrams and implementation plan,Task 5.2)	Bristol	21	Report to StCom
MS46	EUDAQ interfaces to other DAQs available (EUDAQ interfaces to other DAQs available for integrating different software and hence different detector systems into the central common system, Task 5.3)	DESY	24	Test running results
MS47	Online event data model available (Definition of the online event data model, i.e. the concept of an event for detector systems having very different integration times, compatible with the offline software and in coordination with WP3,Task 5.5)	DESY	24	Test running results
MS62	Development of run control ready (Development of run control ready, incorporating controls for data taking, the ability to send and receive configuration data and receive status messages, Task 5.3)	UCL	27	Test running results
MS66	TLU hardware, firmware and software ready for tests beams (The hardware, along with the interface to the CCC, as well as the firmware and software will be ready for integration by detector systems, Task 5.2)	Bristol	30	Test running results
MS67	Data quality monitoring tools ready (Data quality monitoring tools ready, comparing quantities as soon as possible after data taking but as accurate as possible as offline to expected distributions, Task 5.4)	UCL	30	Test running results
MS68	Slow control system ready (Slow control system ready to monitor environmental conditions from the various detector systems, providing a synchronised picture of the conditions, Task 5.4)	Prague	30	Test running results
MS80	Common DAQ system ready for combined test beams (Tasks 5.1, 5.2, 5.3, 5.4, 5.5)	UCL	36	Test running results

Summary and next steps

Presented introduction to workpackage on developing a common DAQ system for use by Linear Collider detectors in common beam tests.

We have natural links to other workpackages and these are crucial for our workpackage.

Discussions with detector groups on requirements.

Start documenting all of this very soon and continually develop.

Our first milestone and deliverable on the interface definition is very important.

Project management – groups, resources and effort

Budget split up as follows:

Institute	Total cost (kEUR)	EU contribution (kEUR)
Bristol	374	150
DESY	250	90
Prague	59	25
UCL	404	210
Total	1086	475
Sussex	102 (direct costs)	50 (from UCL's 210)

Group of expert institutes, well resourced to do the job at hand.