The Random Thoughts of Tim Jones

Friday 30th April

Discussion – UK Electronics & Integration Workshop

- What are the key technical challenges for the UK in these R&D areas?
- What are the organisational / logistical barriers for us?
  - Centralisation vs complete freedom?
  - Focus vs diversity?
  - Project-led versus blue-skies?
  - PP-focussed versus generic?
- How much is all this going to cost? Is it justified?
  - What is the likely UK participation in integration / electronics areas for future projects.
  - What is the length, breadth and scale of R&D activities leading to them?
  - Are there commonalities we can exploit?
  - What demonstrator / exemplar projects should we target, and when?
- How do we ensure and maintain efficiency?
  - Design and IP re-use
  - Commonalities between projects
  - Reduction of internal design competition
- What happens if we do nothing?
- What is the relationship with industry and other research areas?
- How do we convince people to act on this?
- How do we sustain a community?

Observations

- Electronics
  - Access to leading-edge processes (design rules, processing costs)
  - Rapid turn-round of prototype device testing
    - Development of test platforms (hardware & software)
    - Sub-teams testing different aspects of functionality in parallel
    - All sub-teams need something to test in every iteration
  - Effort from ASIC designers, PCB designers, FPGA programmers, DAQ Specialists, Assembly Techs, etc…

- Integration
  - Tends to follow constraints coming from other areas (eg power, required operating temperature) and has to accommodate full life-cycle (design, build, installation, commissioning, removal, renovation).
  - Very wide range of mechanics (design, materials, performance metrics)
    - 1m-scale vacuum chambers for LHCb VeLo machined from solid to low-mass CFRP sandwich structures for ATLAS ITk to Kapton™ ladders for Mu3e
  - Effort from Mechanical Engineers, Machinists, CFRP experts, Assembly Techs, metrologists, FEA Analysts, etc…

Both require a large community with a broad mix of expertise well matched to current UK capabilities.

Organisational / Logistical Barriers

- We have relied on the LHC/HL-LHC programme to fund R&D for ~ 20 years
  - **Project-led**, strongly **centralized** programme with **clear focus** with definite **PP** output.
  - Cross-community R&D programmes (eg CERN RDXX)

- Did anything get ‘left behind’?
  - I don’t know ….
    - At Liverpool we built apparatus for: NA62 K-tag, g-2 straw tracker, T2K, SBND, (Proto)DUNE, SK, LZ, Atom Interferometry, ALPHA, R3B, ISOL …
  - But I suspect the LHC programme attracted the best detector physicists, engineers & facilities and, if so, other areas might have struggled / could have been ‘better’.

- What happens after Phase 2 upgrades ?
  - ALICE is thinking about ITS inner layer replacement
  - LHCb is thinking about Timing Velo …
  - ATLAS – inner pixel system will be replaced during HL-LHC era
  - CMS ?

Cost / Justification

- Do nothing ?
  - Not being at the forefront of technical development will erode ability to supply state-of-the-art apparatus.
  - Apparatus construction leads to collaboration influence (probably true at all scales but larger collaborations need consolidated approach).
    - No UK ASIC design effort on any ASIC for ATLAS ITk upgrade.
    - FE ASIC development critical to global project evolution (time & money).
  - Many groups are already doing ‘something’ – so what’s the problem ?

- Future Participation
  - Should seek to play leading role in the development of on-detector ASICs
    - UK involvement in LHCb MT and Timing VeLo – I’m sure there are others.
    - FE / data concentrators & transmission / powering
    - What do we <u>not</u> do ?
  - Should continue to maintain/develop expertise in engineering design, integration & assembly technology
    - Advanced materials & manufacturing (additive)
    - Integrated services (mass reduction)

Ensuring & Maintaining Efficiency

- No clear to me what the metric would be !
  - Need to maintain ability to deliver ‘one-off’ systems to enable access to physics programmes.
  - We have a finite number of (say CG-funded) engineers – probably insufficient to single-handedly develop a complex ASIC or large-scale mechanical system.
  - Issue is probably that a fragmented approach would not give us the critical mass to allow control of a major project

- Re-use
  - Generic data concentrator / links could apply to multiple systems
  - Core features of an ASIC (eg pixel array) could be re-used with different i/o
  - ATLAS barrel strip stave core -> starting point for LHCb MT

- Internal (?) Design Competition
  - What do we mean by internal ?
  - To some extent ‘Competition’ could be a product of ‘Re-use’
    - If someone developed a super-ASIC that could be configured for every application then everything anyone else did would be ‘design competition’.
  - Need to strike a balance

Final Thoughts

- Industrial Collaboration
  - Even the largest systems we dream of are small by comparison with aerospace/defence/automotive/consumer goods
  - There aren't that many 'large' projects
  - Sales alone are not going to interest industry
  - Best bet might be to collaborate with 'systems integrators' to develop / share technology

- Sustaining a Community
  - Blend of physics-led and generic development has been successful in the past.
  - Short time-scale physics-led development provides 'full-cycle' training for PhD's & provides time-limited funding for engineers & technicians.
    - Also feeds into DAQ, M&O, data quality, reconstruction & physics analysis
  - Need a vibrant & well-funded generic R&D programme to sustain a large community with broad interests.