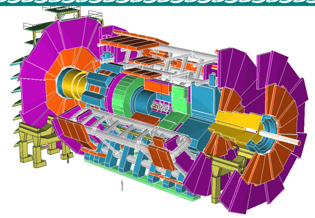


WBS 1.1.1.6

Beam / System Test Support

US ATLAS Pixel Review, LBNL, 8th November 2001

John Richardson
Lawrence Berkeley National Laboratory

WBS 1.1.1.6.1: Test Beam Support

Overview of H8 Testbeam Facility at CERN

The H8 beamline, (part of the SPS NA complex at CERN), is used principally by the ATLAS sub-detector users: Pixels, SCT, TRT, Tilecal, Lar & Muons.

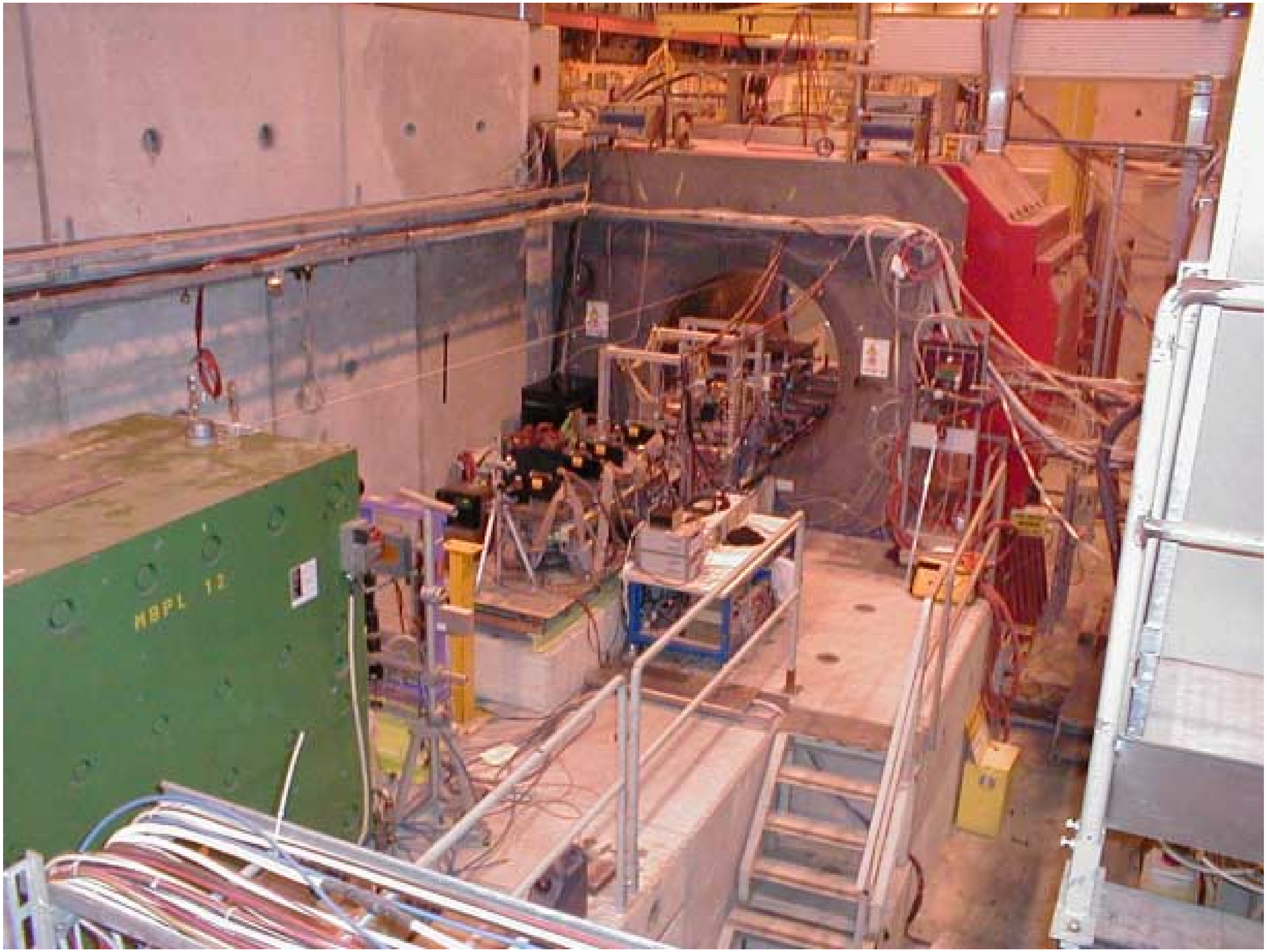
H8 is a versatile source of high energy particles (pions, muons, electrons) with available momenta of up to ~200GeV and intensities up to 10^7 s^{-1}.

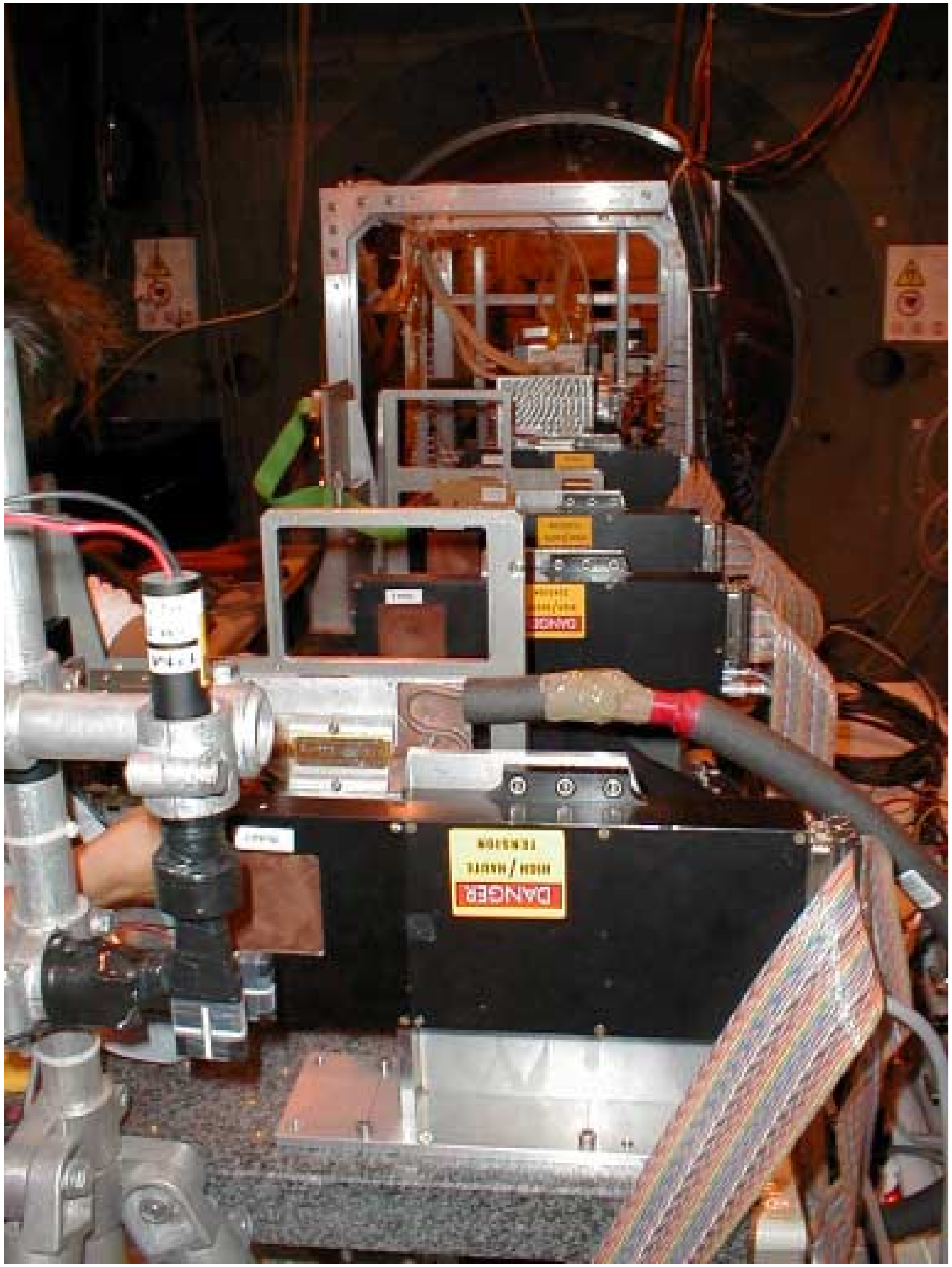
The facility is usually available from ~April to ~September and each of the user groups would typically be assigned 2-3 'main user' weeks plus a similar amount of 'co-user' beam time.

This facility has proven invaluable to the Pixel effort in recent years providing us with a means of studying various aspects of the FE electronics performance with realistic charge spectra (e.g. timewalk). It has also enabled the collaboration to make very detailed investigations of performance aspects of various prototype sensor designs (e.g. charge collection efficiency).

H8 should, over the next couple of years, continue to be a very important tool in our Pixel-module evaluation armoury. However we need to invest in a comprehensive overhaul in order to maximise its potential for the future.

Layout in H8:

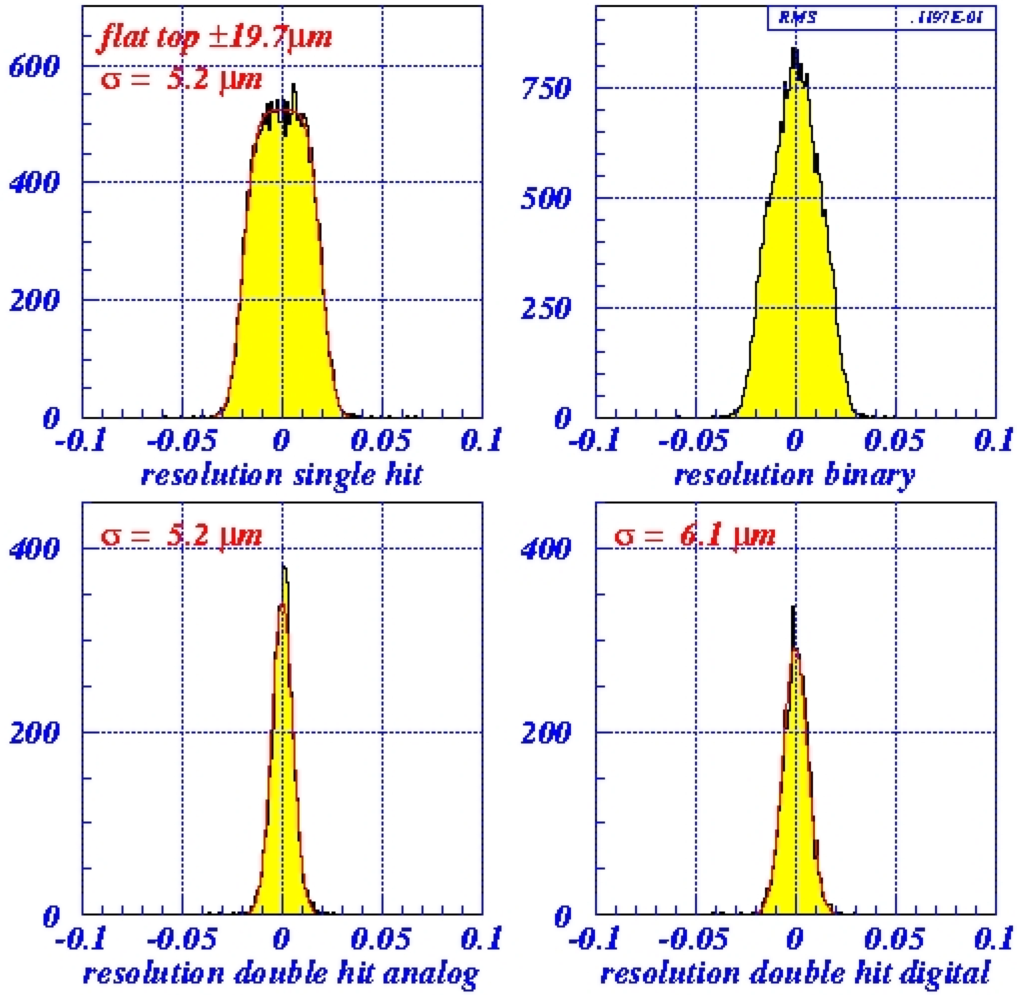




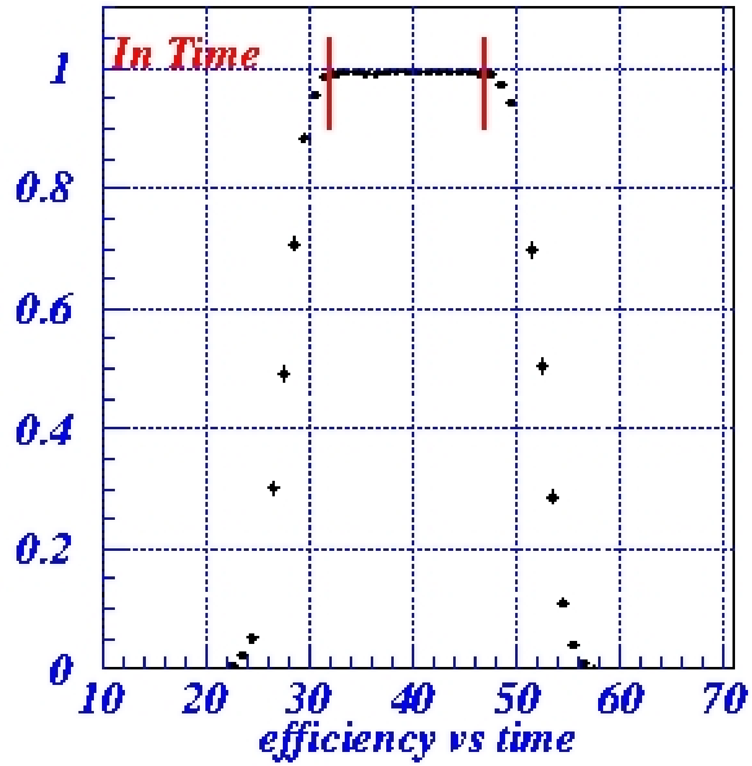
IV

Examples of H8 studies on assemblies with FE-B readout.... (1998-2000)

Resolutions:

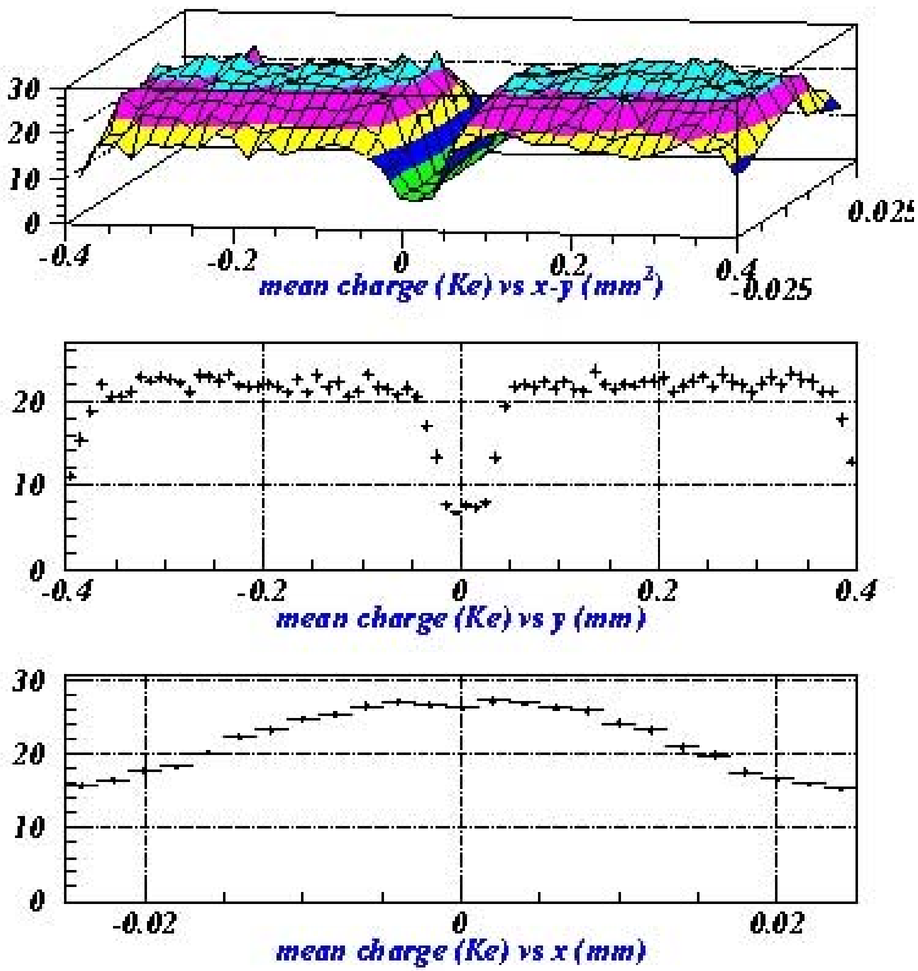


In-time Efficiency:

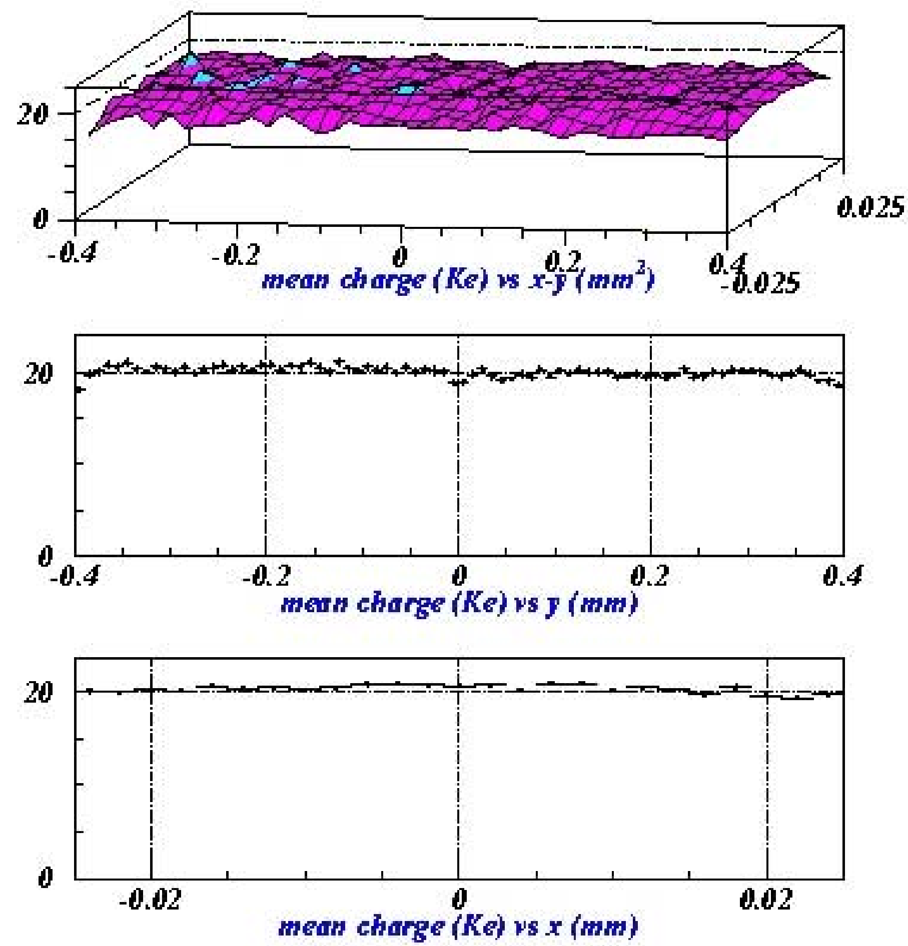


Charge-collection efficiency:

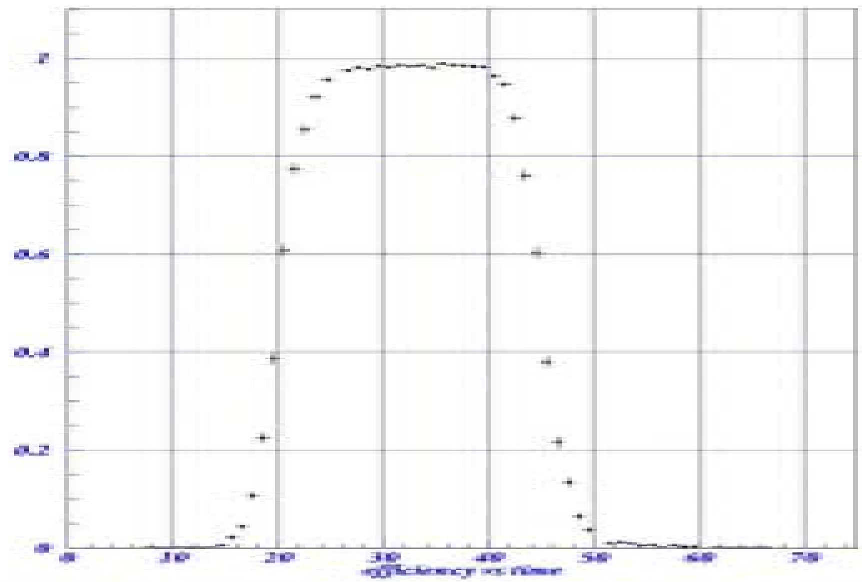
Old (prototype-1) design (ST2)

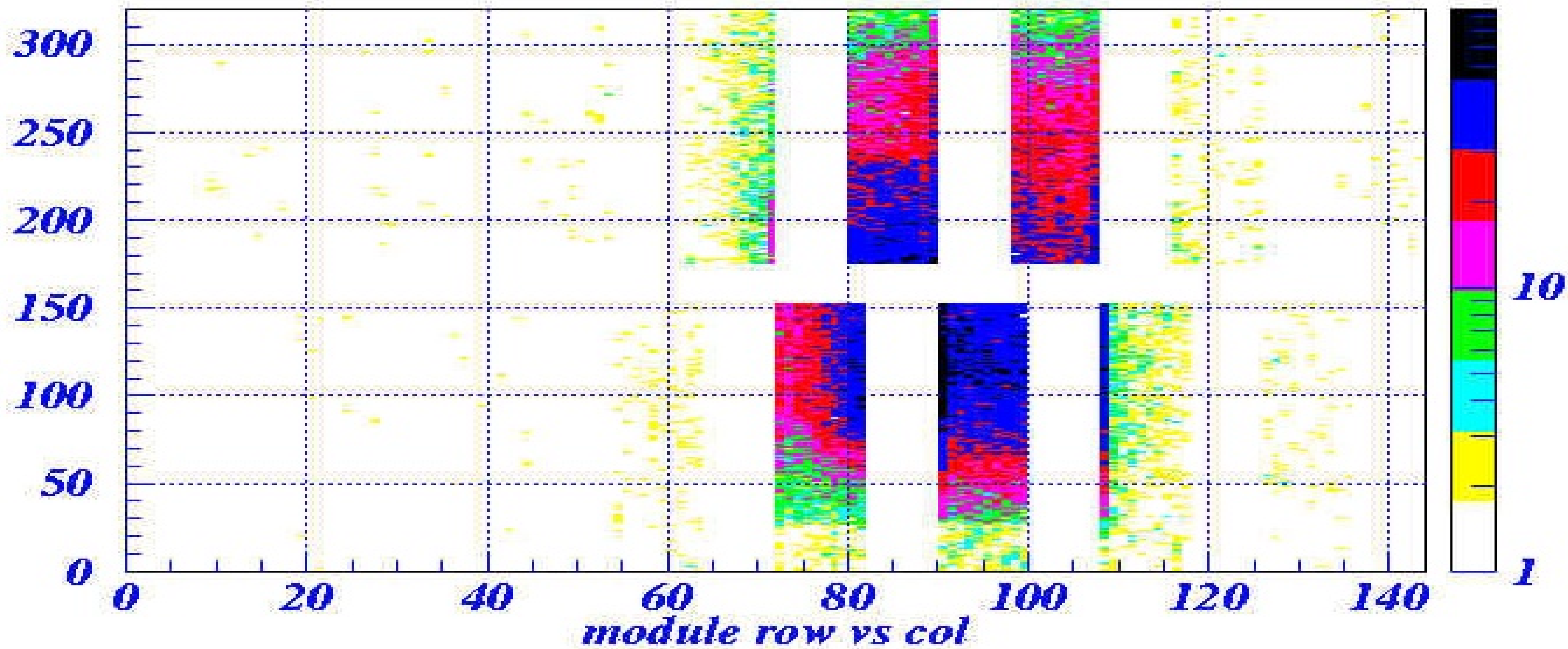


New (baseline-type) sensor design:



Full-size flex module; efficiency measurement and in-beam hitmap:





Upgrade Issues

Up to now the pixel implementation in H8 has been chiefly oriented towards detailed testing of single-chip assemblies incorporating a single FE chip + mini detector and small numbers of full-size modules with rad-soft electronics. With the existing mechanics there is only provision for mounting two devices-under-test at a time.

For 2002 and beyond as we move closer to production the emphasis will shift towards testing large numbers of complete modules instrumented with FE-I and MCC-I.

This has implications for most of the infrastructure components. Major upgrades are required for:

- **Support mechanics**
- **Cooling system**
- **Off-detector electronics support (from PLL readout -> ROD implementation)**
- **DAQ software**
- **Online monitoring software**
- **Data storage**
- **Power supplies**
- **Cabling**

etc....

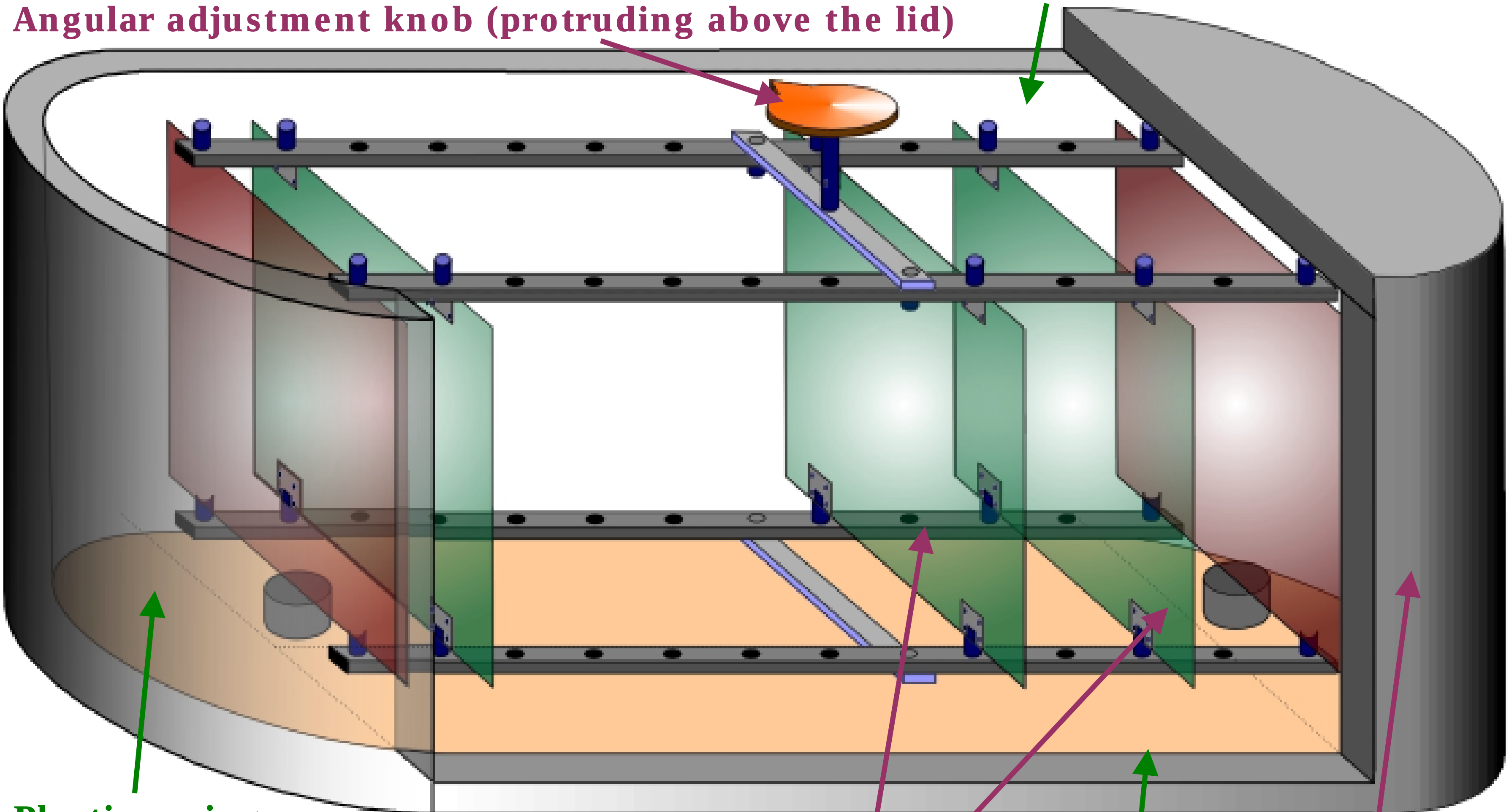
Mechanics

Main considerations are:

- **The ability to test multiple modules at the same time whilst providing x, y, phi and theta adjustment freedom along with a dry cool environment which has the capacity to remove the heat generated by the modules, providing a minimum temperature of ~-10C for irradiated module performance studies.**
- **Mechanical versatility in order that modules in various guises as well as sectors and single chip assemblies can be tested using the same infrastructure.**
- **Maximal simplicity in mounting devices in order to reduce lost beam time. The current mechanics impose an inordinate amount of time to install modules.**
- **Versatile/interchangable bulkhead ports for dedicated cooling channels for sectors e.g. and electrical connections to local support electronics (e.g. PCCs) and high voltage supplies.**
- **Integrated temperature monitoring.**
- **Remote control for x & y adjustments to avoid the need to take access for positional scans across modules**
- **Compatibililty with prototype readout chains (pigtail/PP0-type interface etc.)**

Back of the box incorporating interchangable bulkhead plate for N2 gas, electrical connections and optional auxiliary ‘private’ cooling loops

Angular adjustment knob (protruding above the lid)



Plastic casing

Module/sector/single-chip board support plates.

Thick insulating walls

Floor of the box incorporates the ‘wiggly’ liquid cooling channel

Data Acquisition

Before Y2001 the Pixel testbeam DAQ was based on the RD13 system, this system was already out of date by 2000 and no longer supported by the authors. Also the local expert within pixels had left the collaboration.

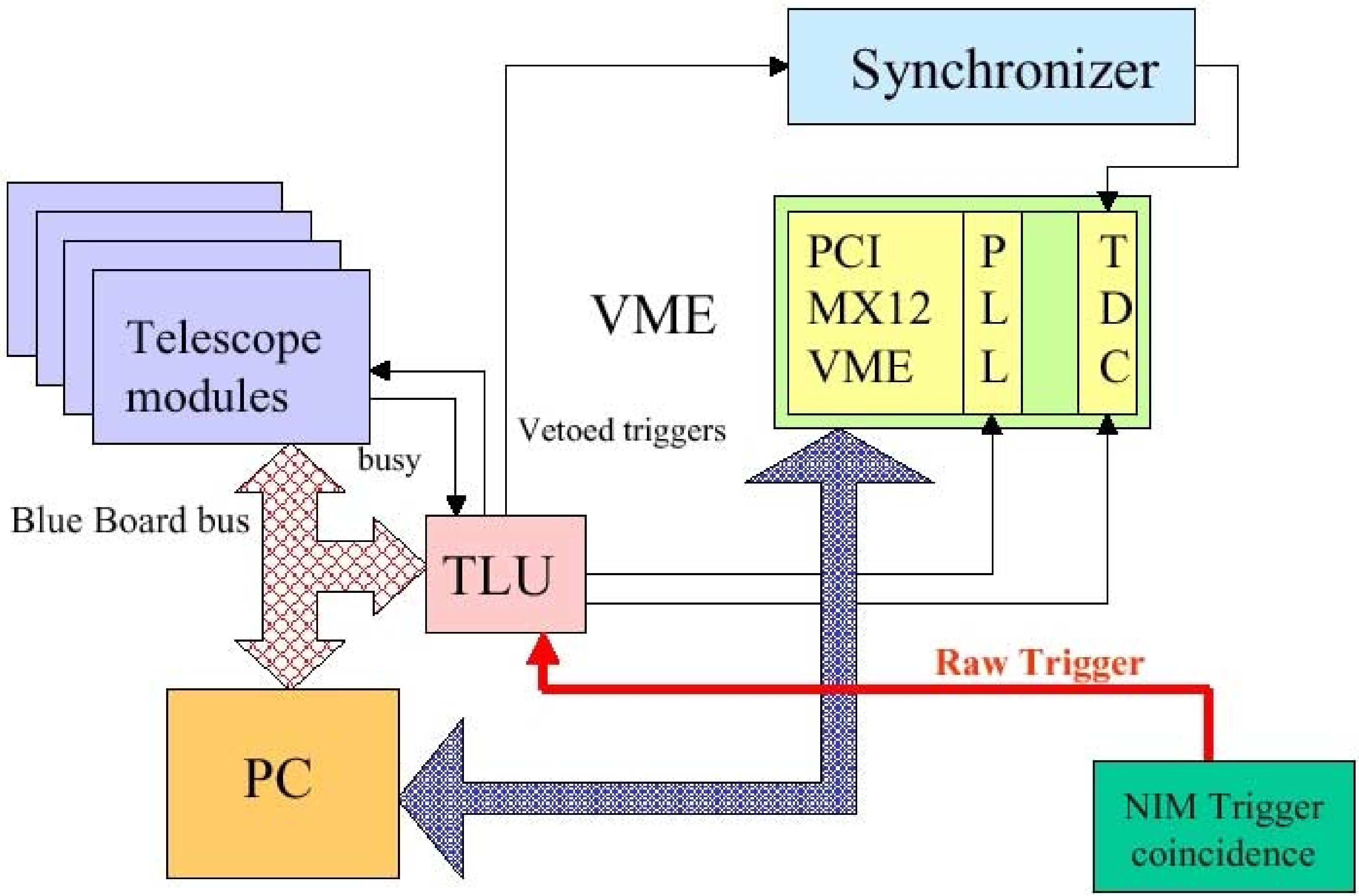
The Bonn University group had independently developed a 4-stage telescope system for their own testbeam facility at Bonn. This turned out to be so well conceived and implemented that to adapt it for use in H8 was irresistable. The first Pixel run period in 2001 (June) was used to make this upgrade.

In fact fairly advanced DAQ software had been written for the telescope along with monitoring code so the path of least resistance for data taking in 2001 was simply to throw away the RD13 system entirely and modify the Bonn DAQ code to read out pixel modules through VME.

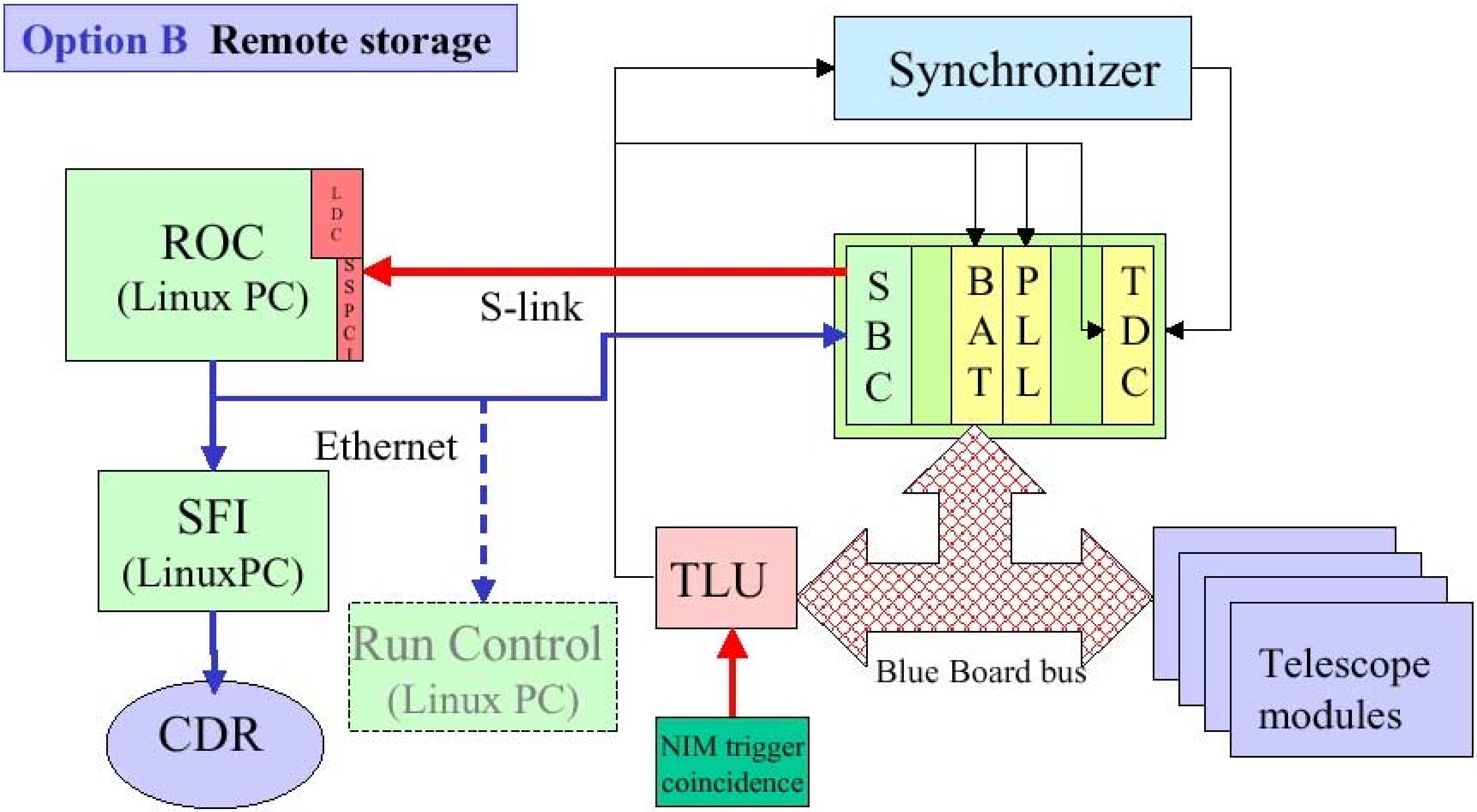
This worked extremely well for 2001 needs where only 2 pixel readout chains were in use. However, while this proved to be a useful stop-gap, for the future we need to come into line with the official ATLAS DAQ developments. Furthermore we need a system which is inherently designed for readout of large numbers of modules and which is supported in an organised way. The Bonn software was written by a student who will probably leave the collaboration soon.

The second major upgrade for 2002+ running then is to move over to a stripped down version of DAQ-1 which is geared towards testbeam data taking. This has already been successfully achieved by 2 sub-detector groups (TileCal and Muons) with more complex testbeam architectures than that required by Pixels.

2001 Pixel H8 Setup



2002 Set-up.....


Option B Remote storage
Synchronizer
ROC
(Linux PC)
LDC
SSPCI
S-link
S
B
C
B
A
T
P
L
L
T
D
C
Ethernet
SFI
(LinuxPC)
CDR
Run Control
(Linux PC)
TLU
NIM trigger
coincidence
Blue Board bus
Telescope
modules

A team of ~5 people has already been assembled within pixels to work on the adaptation of the DAQ-1 skeleton code into a working Pixel testbeam system in time for 2002 running (which begins in May). This looks fairly ambitious but not insurmountable.

Also the procurement of the requisite hardware components (SBC, ROC PC etc.) has begun at CERN.

Other Upgrades

Currently we share the cooling infrastructure (programmable chiller unit + heat exchanger) with the SCT testbeam. We now need to become independent by investing in our own solution. (Almost all of the 2002 beam time is running with the SCT.)

Much of the trigger logic in use in the Pixel system is now quite dated and is becoming less reliable. We need to invest in a whole set of new logic units in order that valuable beam time is not lost in the future due to unreliable trigger components.

We also need to expand our geometrical trigger options by assembling some new scintillator counters.

Financial Aspects

List of all 2002 H8 requirements to which the US would contribute ~20%:

Mechanics

The mechanics upgrade items are an LBL 'in-kind' contribution. It is mostly a custom development which will be based upon Newport components, (e.g. x-y and theta stages etc..). In particular it will be very beneficial to have some degree of positional automation (current system is purely manual) to minimise valuable downtime while the beam is running. This adds a significant amount to the cost.

Controller/Driver unit: ~$3K

2X motorised linear stages: ~$6K

2X manual rotation stages: ~$1.3K

Graduated rotation adjustment stage: ~$1.7K

Miscellaneous accessories: ~$4K

Total ~$16K

Cooling

Huber air-cooled chiller unit $3.3K

Heat exchanger: may be custom made ~$0K

Miscellaneous accessories: ~$1K

Total ~$4.3K

Data Acquisition Hardware

The hardware requirements for the DAQ-1 upgrade are well understood and the procurement has already begun for some items. Still debating whether to use Slink which contributes ~5.5kCHF to the expenditure;

Single-board computer ~$3K

S-Link ~$4.5K

ROC PC ~$2.5K

Data Collector PC ~$2K

Monitoring PC (optional) ~$2K

Total ~$14K

Telescope Back-up

The firm 'IDEAS' in Norway in considering commercialising the Bonn telescope which would be very much to our advantage since we can then purchase back up modules. We would ideally buy 2 of these which are likely to cost ~$20k each.

2 Telescope back-up modules ~$40K

Total ~$40K

Trigger Upgrades

Need 2 additional PM/scintillator assemblies and overhaul of all NIM logic

2 PM tubes ~$1.5K

NIM logic ~~$8K

Total ~$9.5K

Power Supplies

To match the mechanical capacity of ~16 modules would require 8 LV bench supplies with factor-2 multiplicity. Agilent E3646 is a good match ~$800 each. For HV need to investigate possible solutions;

8 LV bench supplies ~$6.4K

HV supplies ~~$5K

Cables etc. ~$1k

Total ~~$13k

Grand total for 2002: ~$100K

WBS 1.1.1.6.2: System Test Support

'System test' refers to a dedicated infrastructure for testing n modules mounted together in close proximity on realistic support structures. This is a vital and necessary stage in the overall qualification of the detector modules themselves along with the servicing scheme.

Many issues may appear in a multi-module system which would otherwise not have been detected by single-module level testing alone. For example it provides the opportunity to address issues associated with grounding/shielding arrangements, along with putting the cooling scheme through its paces with realistic power loads. One can investigate the effect of providing power through realistic cables e.g. on aspects of module performance along with studying variations in powering multiplicities.

To date we have not had sufficient numbers of electrical modules at our disposal to begin composing serious system type tests. The closest thing in existence right now at LBL is a prototype sector containing 2 FE-B flex-2 modules with prototype-2 sensors. One of these modules (fabricated with Compunetics flex) does not exhibit the expected noise behaviour even when operated alone so there is a limit to what we can learn with this set-up.

However once the new wave of FE-I and MCC-I chips appear early next year we anticipate ramping up our prototype module production very quickly in order that system issues may begin to be properly addressed starting in ~ the Spring with a view to having first working systems by Summer 2002.

Implementations

The timescale for ROD distribution is a fairly good match to the needs of the Pixel multi-module testing requirements, therefore there it was unnecessary to develop 'intermediate-scale' off-detector readout electronics to expand our capabilities beyond the single-module capacity PLL set-up. (Unlike the case for SCT where the Mustard/CLOAC/SLOG system bridged the gap in the absence of RODs).

Pixel system tests will therefore be ROD-based from the beginning. Other components of an ultimate system test will however not realistically be ready on the same timescale, e.g. opto-links, full DCS etc..

With this in mind need to follow a staged approach whereby the initial realisation would comprise a ROD with simple custom BOC card incorporating electrical transceivers for copper clock and signal links (LVDS).

At the module end we would begin with a real PP0 panel (with special electrical daughter board for copper link compatibility) and real Type-0 cables. Later on we would extend the services to include PP1 + Type-1 cables then PP2 with Types 2/3/4 cables.

Initially we could begin with e.g. simple GPIB control for bench LV supplies. The ROD would be addressed using a NI/VXI interface and single host PC.

The next phase (~early 2003) would then introduce real power supply prototypes, full DCS system and real opto-links with optical BOC and PP0. Then one could imagine easing towards the final DAQ implementation by moving over to a DAQ-1-like system.

Outlook

The overall strategy for system test developments within Pixels is still being debated; many details are still to be decided upon.

A clear and detailed proposal for the initial 2002 implementations will be prepared in time for the December pixel week when detailed cost estimates etc. will be presented.

Number of individual test system stations for 2002 is likely to be driven by availability of RODs, anticipate 2-3 boards being made available to Pixels by July 2002 in addition to 1 board already in existence. Need 1 ROD for opto-link development which would proceed in parallel to initial electrical system test establishment. This will leave 2-3 for system-test sites.

In early 2003 additional RODs could be made available to Pixels for multi-module systems. These systems would develop into the macro-assembly site test facilities (a la SCT).

In the longer term the focus of the collaboration will converge towards the '10% commissioning system' planned for SR building before final installation.

Financial Aspects

Detailed cost estimates yet to be evaluated, however can start to make first estimates for initial 2002 requirements (per set-up) at the scale of a half-stave/sector test:

Power Supplies

3X Agilent E3546A LV supply + 2X Agilent E3548A ~$4.6K

6 channels of HV with ~10nA accuracy current measurement ~~$10K

Total for 3 set-ups:~ $44K

VME Crates

Require 9U crates for ROD compatibility, ~$10K each

Total for 2 set-ups: ~$20K (1 in existence already @ LBL)

Computing etc.

1 desktop PC ~$3K

NI-VXI interface hardware $3.5K

PCI-GPIB interface hardware ~$1K

NI Measurement Studio software package ~$2K

Total for 3 set-ups: $28.5K

Grand total for 2002: ~$100K