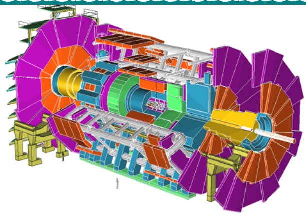

WBS 1.1.1.6.1

Beam Test Support

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WBS 1.1.1.6.1: Beam Test 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.

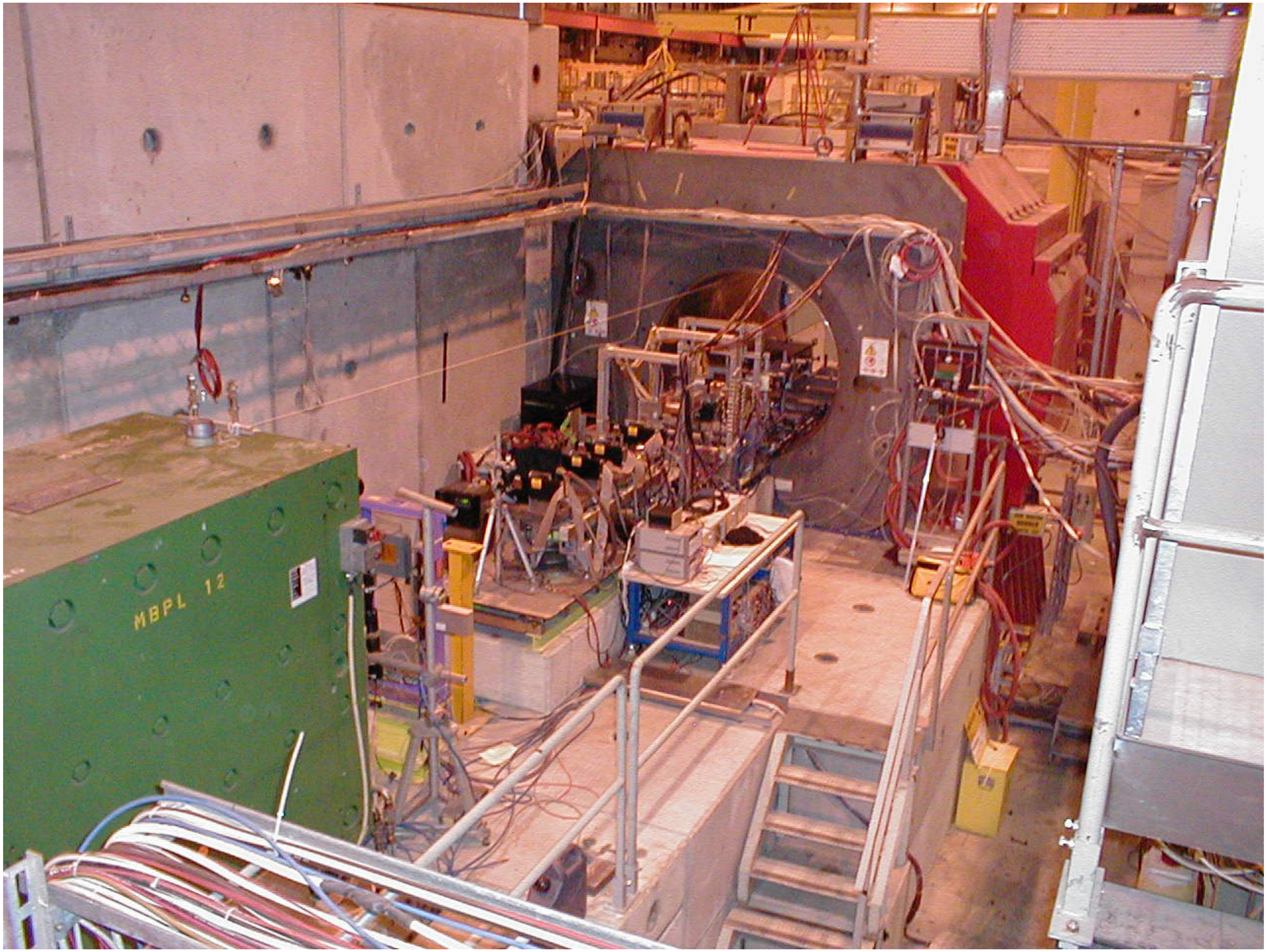
H8 is a versatile source of high energy particles (pions, muons, electrons) with available momenta of up to ~200GeV and intensities up to 10^7 s^{-1} .

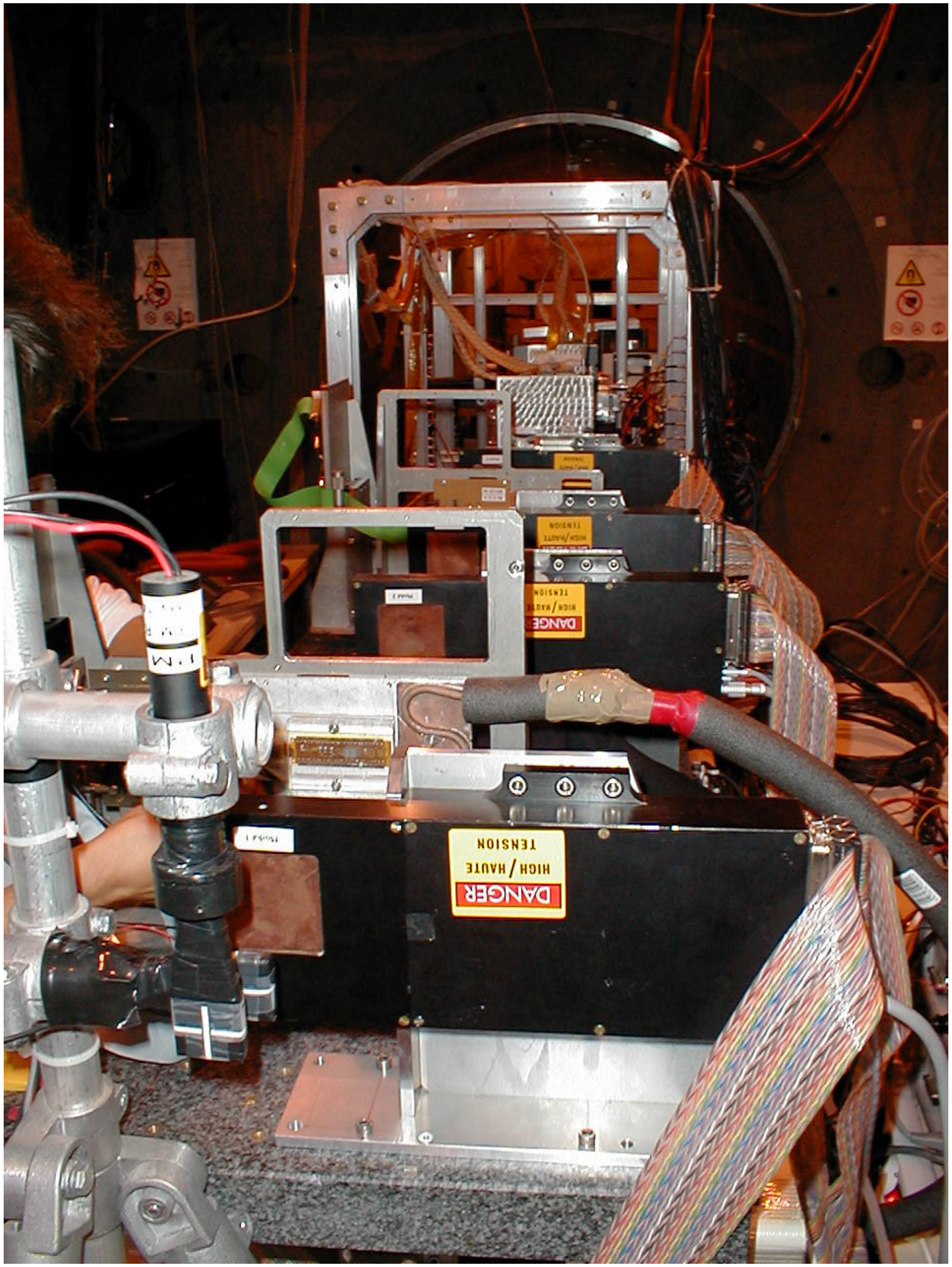
The facility is usually available from ~April to ~September and each of the user groups would typically be assigned 2-3 'main user' weeks plus a similar amount of 'co-user' beam time.

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:





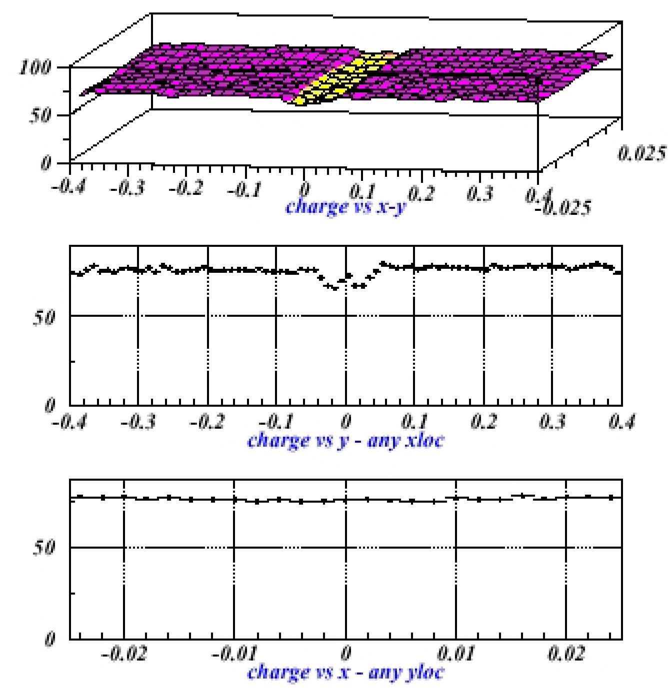
IV

Examples of H8 studies on assemblies with FE-I readout…. (2002)

Charge collection

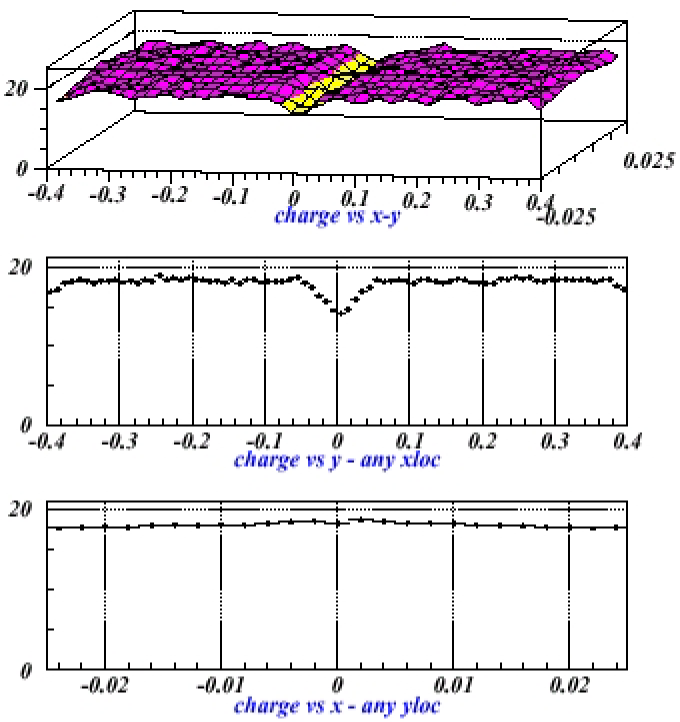
- **Before irradiation a charge loss is visible in the bias dot region.**
- **A smaller loss appears also at the opposite edge.**
- Unfortunately no ToT calibrations for unirradiated devices (received after leaving from Milano).
- **No news till now.**

IZM A, run 1268



Charge collection (irradiated)

AMS 310b, run 1290



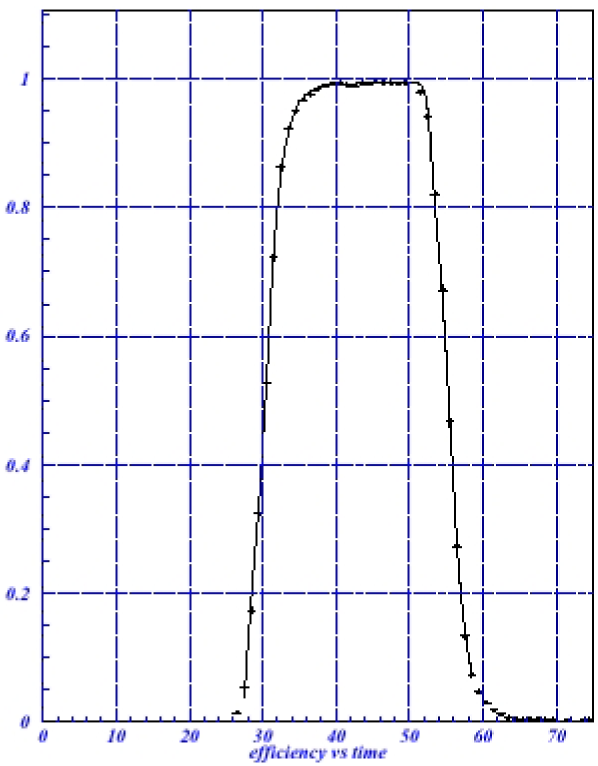
- **After irradiation a significant charge loss is visible along the whole bias grid.**
- **Also the loss at the opposite edge increases.**
- On-site ToT calibrations (in low charge mode) are very useful in properly evaluating the collected charge.

In-time efficiency study

- Before irradiation efficiency is well above 99%.
- In this example:
  - efficiency 99.3%
  - no hits[1] 0.4%
  - late hits 0.3%
- plateau size is about 10 ns.
- No difference between Tesla and CiS devices.

[1] It includes events with hits outside the 80 µm x 800 µm matching window.

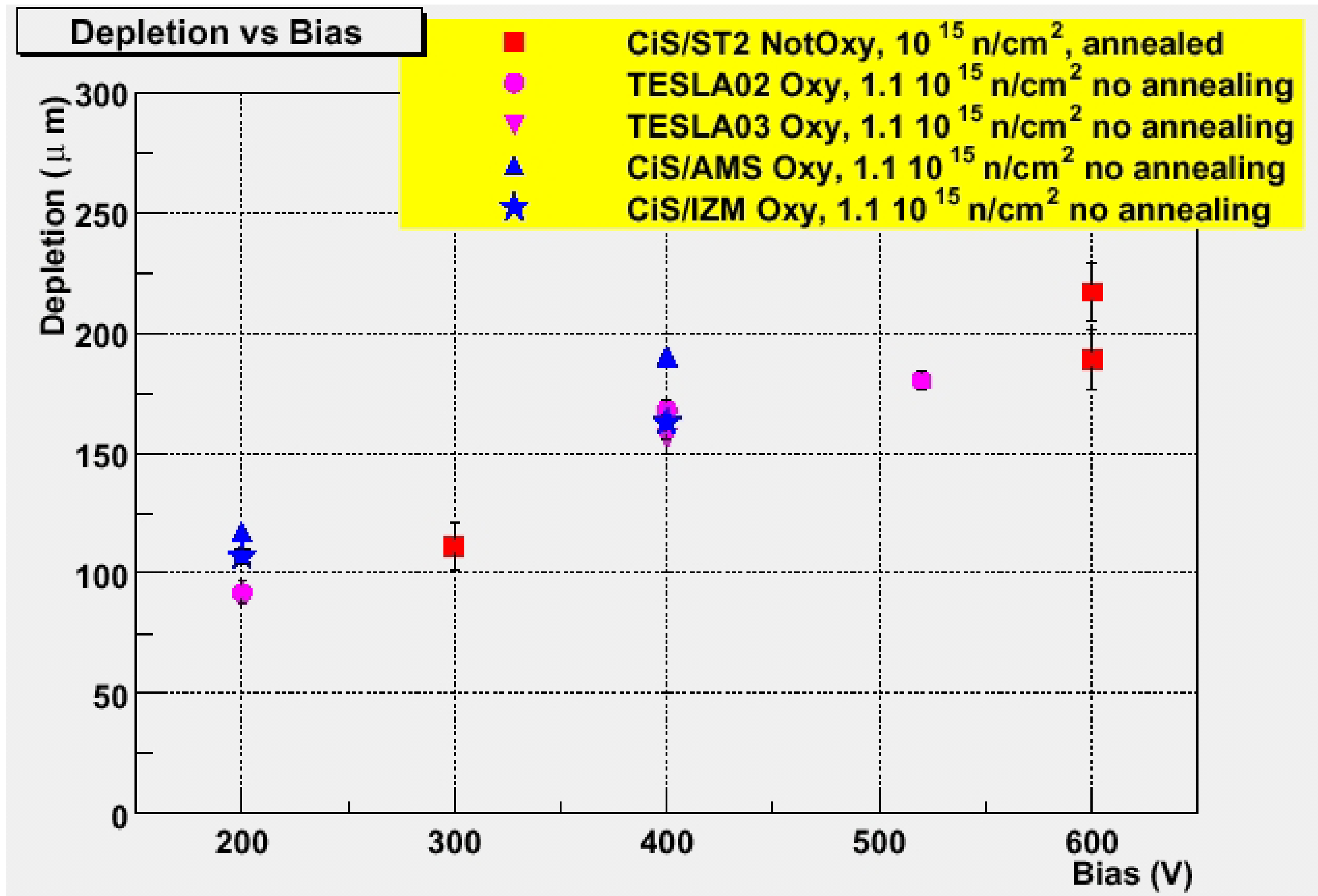
GE 09, unirr. Tesla sensor, run 1319



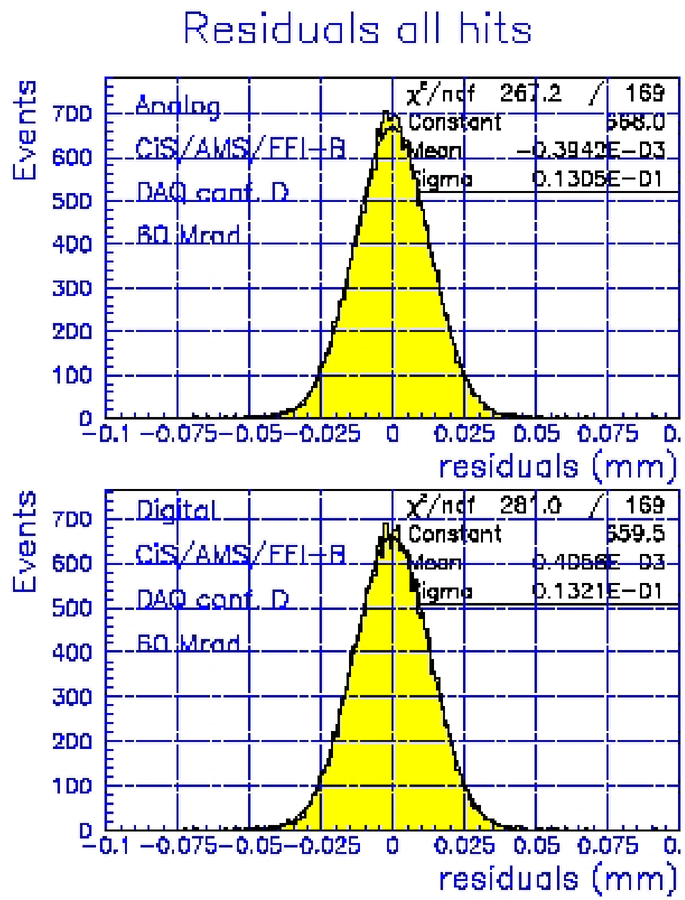
Efficiency table

Device	Conf.	ε [%]	0 hits	late	t_0 [ns]	τ [ns]	σ [ns]
GE 04		99.2	0.5	0.3		1.4	0.9
GE 09		99.3	0.3	0.4		1.6	1.1
AMS 310b	A	97.4	1.2	1.4	24.4	3.2	1.3
(60 MRad 600 V)	B	97.7	1.3	1.0	23.0	2.7	1.0
	D	97.9	1.2	0.9	21.1	2.5	0.6
IZM F	A	92.6	2.7	4.7	7.1	5.7	1.7
(60 MRad 400 V)	B	94.1	2.9	3.0	4.5	4.3	1.0
	D	91.3	5.2	3.2	2.9	4.5	1.0
Tesla 03	A	93.6	2.1	4.3	23.2	5.0	1.7
(60 MRad 400 V)	B	96.4	1.4	2.2	19.8	4.1	1.2
	D	89.7	7.2	3.1	18.5	4.5	1.2

Depletion measurements



Spatial resolution



An irradiated ST2 bonded to a FEB had a resolution of 13.7 μm (gaussian fit) in 1998

Upgrade Issues

Up to 2002 the pixel implementation in H8 was 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 2001 mechanics there was only provision for mounting two devices-under-test at a time.

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

This had implications for most of the infrastructure components. Major upgrades were 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 were:

- **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.)**

Cold box created at LBL designed to address these issues and successfully commissioned in May/June testbeam:

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.

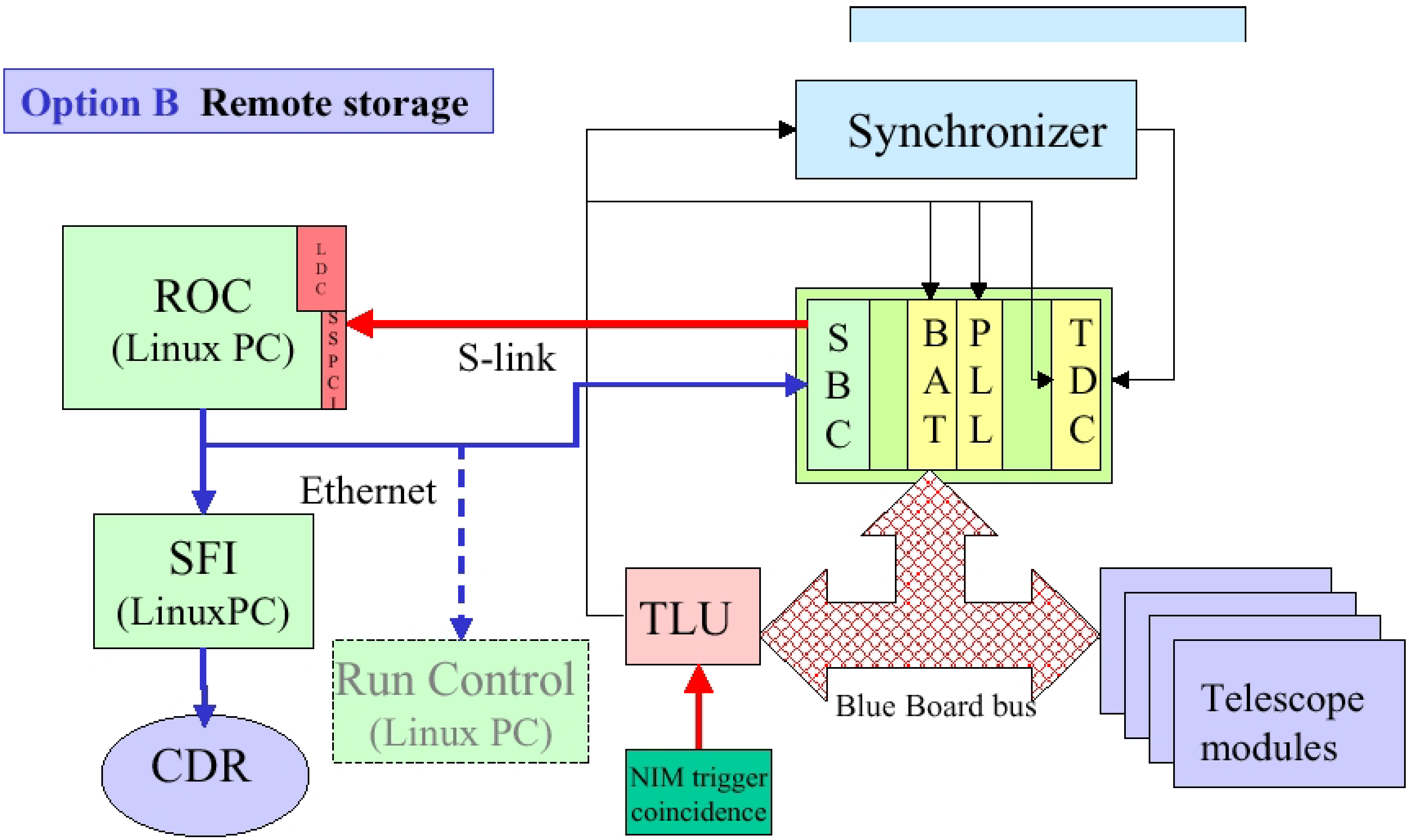
The Bonn University group had independently developed a 4-stage telescope system for their own testbeam facility at Bonn. This turned out to be so well conceived and implemented that to adapt it for use in H8 was irresistable. The first Pixel run period in 2001 (June) was used to make this upgrade.

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 old 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, we needed to come into line with the official ATLAS DAQ developments. Furthermore we needed a system which was inherently designed for readout of large numbers of modules and which was supported in an organised way. The Bonn software was written by a student who left the collaboration.

The second major upgrade for 2002+ running then was to move over to a stripped down version of DAQ-1 which was geared towards testbeam data taking.

Pixel DAQ-1 Set-up…..



Other Upgrade Points

Until 2002 we shared the cooling infrastructure (programmable chiller unit + heat exchanger) with the SCT testbeam. Now in the process of purchasing out own chiller unit.

Have also invested in trigger components to replace ageing parts. Need to provide replacement NIM modules for spares.

Need also to invest quite heavily in LV and HV power supplies for operating multiple modules

2002/2003 Financial Breakdown

List of all 2002/2003 H8 requirements, updated from Nov. 01:

Mechanics

The mechanics upgrade items were an LBL 'in-kind' contribution. It was mostly a custom development.

Controller/Driver unit: Purchased (LBL)

2X motorised linear stages: Purchased (LBL)

6X manual rotation stages: Purchased (LBL)

Large custom cold box development: Now commissioned (LBL)

Total cost > $20K

Cooling

2 X Julabo HD50 chiller units $10.5K One currently being bought (Germany)

Heat exchanger: ~$0K Exists (LBL)

Total cost ~$21K

Data Acquisition Hardware

The hardware requirements for the DAQ-1 upgrade:

Single-board computer ~$3K Purchased

S-Link ~$4.5K Purchased

ROC PC ~$2.5K Purchased

Data Collector PC ~$2K Purchased

Monitoring PC (optional) ~$2K Purchased

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 Components to be Purchased by Bonn

Total ~$40K

Trigger Upgrades

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

2 PM tubes ~$1.5K Purchased (CPPM)

NIM logic ~~$8K

Total ~$9.5K

Power Supplies

Still very short of LV supplies and relying on loans to data taking with >2 readout chains. Agilent E3646 is a good match ~$800 each. For HV need to investigate possible solutions;

8 LV bench supplies ~$6.4K

HV supplies (e.g. ISEG 8-channel unit ~$10K)

Cables etc. ~$1k

Total ~~$14k

Grand total for 2002/2003 is currently >/~ $125K

2003-2004 Testbeam Priorities

Our experience to date with the new Deep Submicron readout electronics in beam is still severely limited. Need to gain much more experience with unirradiated and irradiated single chip assemblies and modules.

In 2003 there should be a beam testing programme for studying many modules with the next generation front-end (FE-I2). Plan is to irradiate 8 full modules in the Spring of 2003 and to evaluate them fully in H8 in subsequent availability periods. Also need to test many unirradiated modules from several institutes and with several permutations of assembly type (i.e. bump technology, flex vendor, sensor vendor..).

All of the same detailed studies performed for FE-I1 in 2002 must be repeated in 2003 for FE-I2.

We have only just begun to examine the implications of the 'laboratory-evaluated' analog-behaviour aspects of FE-I1 on the relevant performance issues for modules in the experiment (i.e. in-time efficiency and noise occupancy etc.)

In order to fully appreciate and understand what to expect from modules in ATLAS at various levels of radiation degradation requires a huge effort in terms of laboratory evaluation, testbeam data taking (under a broad variety of conditions) and simulation.

While the 2003 programme will answer many fundamental questions about the performance of FE-I2 with the production sensors, it will be insufficient to develop a full and complete picture of the projected Pixel module performance-profile in ATLAS.

We will need therefore to continue the Pixel testbeam work throughout the 2004 SPS season. The infrastructure which was foreseen for 2002/03 is now almost fully developed, however we need to be prepared for additional expenditure to see us through 2004.

There will be a desire to attempt operation of fully populated sectors (and maybe staves) in 2004, to gain in-beam experience with such objects. The existing mechanics will support sectors but further development in the areas of cooling support and power provision will be required. To operate staves certainly will require further mechanical development. May wish to readout through RODs which would require investment in cables etc.

In summary, we need to take advantage of the 2004 SPS year to finalise our understanding of Pixel modules. It's difficult to try to itemise the expenses at this stage but there will undoubtedly be maintainance costs and additional requirements. A realistic estimate is probably at the $50K level.