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# ADDENDUM TO PROPOSAL DRDC P53

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The recent advances in Si[1] and diamond[2] detector technology give hope of a simple solution to the radiation hardness problem for vertex trackers at the LHC. In particular, we have recently demonstrated that operating a heavily irradiated Si detector at liquid nitrogen ($LN_2$) temperature results in significant recovery of Charge Collection Efficiency (CCE). Among other potential benefits of operation at cryogenic temperatures are the use of large low-resistivity wafers, simple processing, higher and faster electrical signal because of higher mobility and drift velocity of carriers, and lower noise of the readout circuit. A substantial reduction in sensor cost could result.

Several CERN experiments are potential users of cold radiation hard tracking devices. The ATHENA collaboration needs a low-temperature position-sensitive detector. NA50 would benefit of a lead ion beam hodoscope using either pad or strip geometry; these devices must withstand a radiation dose several orders of magnitude higher than the LHC experiments. COMPASS collaboration (NA57) wishes to develop a two-sided 150 µm thick microstrip tracker; due to the reduced thickness no degradation in CCE is allowed. The inmost layers of the trackers in the LHC experiments use the present state-of-art silicon devices and radiation hardened electronics operating at –10 °C; these devices may have to be removed or replaced after a few years of operation at full luminosity. Cryogenic cooling could be considered as an option for this later stage replacement. The LHCb experiment in particular plans to operate their silicon tracker in vacuum around the beam pipe. They are actively participating in the proposed programme with view on increasing the lifetime of their vertex detector and on gaining in the physics performance by being able to approach the LHC beam even closer.

The first goal of the proposed extension of the RD39 programme is to demonstrate that irradiation at low temperature *in situ* during operation does not affect the results obtained so far by cooling detectors which were irradiated at room temperature. In particular we shall concentrate on processes and materials that could significantly reduce the final detector cost. The second goal is to demonstrate the operation of existing radiation-hard CMOS readout electronics at $LN_2$ temperature, and to measure discrete device characteristics at these temperatures, so that their parameters can be extracted and optimised circuits can be designed. The design and fabrication of optimised circuits, however, is not planned at this stage. The third goal is to demonstrate that low-mass cooling at $LN_2$ temperature is feasible at a reasonable cost, and that the electrical and optical feedthroughs of a large system can be mastered.

The manpower resources of the collaboration are drawn mainly from outside CERN. The collaborators all belong to approved CERN experiments or R&D projects. Most of the equipment exists in the present RD39 collaboration, in the University of Bern group, and in the other groups joining the collaboration; costs of the additional equipment are covered by existing funds in 1998. A common fund will be established for covering the needs of operation at CERN. The main items of the existing equipment are listed in Appendix 1, and the budget estimates for 1998 and 1999 are given in Appendix 2.

The Collaboration would like to request from CERN dedicated test beam time in X5 for 14 days in 1999, and parasitic beam time for an additional 14 days. Detector irradiation time may also be asked. Access to Central Computers is needed for the management of Web pages and for modest amount of data storage and analysis capacity. Cryogenic fluids and 10 $m^2$ space are requested from the CERN Cryolab.

[1]V.G. Palmieri et al., Nucl. Instr. and Meth. **A** (in press); Preprint BUHE-98-06.

[2]W. Adam et al., CERN/LHCC 98-20, Status Report/RD42, June 17, 1998

## APPENDIX 1: EQUIPMENT

### Cryogenics

The following Table shows the existing and planned cryogenic equipment for the RD39 programme. All apparatus are complete with thermometry, vacuum and flow instrumentation and controls.

| Name | Owner | Coolant | Type[a] | Chip carriers[b] | Status |
|---|---|---|---|---|---|
| RD39 Beam Cryostat | CERN, HUT | He, $LN_2$ | CF | SMSD, P | Existing |
| Helium bath insert | Bern | He | TD, I | HSPD, D, T | Existing |
| Oxford BL | Bern | He | B, I | D, T, HSPD, M | Existing |
| RD39 Low Mass Cryostat | CERN | $LN_2$ | CF | D, FE | Design |

[a] CF=Continuous Flow Refrigerator; B=Bath Cryostat; I=Demountable Insert; TD=Transport Dewar Mount.

[b] SMSD=Superconducting Microstrip Detector Carrier; P=Pad detector carrier; D=Detector Sensor Carrier; T=Trigger Sensor Carrier; HSPD=Hybrid Superconducting Pixel Detector Carrier; M=Microstrip readout compatible, FE=Front-End Electronics Cooling.

The last item is under design. After prototype tests, this type of cryostat may be produced in small series for use in several experiments at CERN and in the laboratories of the participating Institutes.

### Electronic instrumentation for sensor tests and slow controls

The following existing equipment for sensor tests are owned by CERN and University of Bern:

Silicon sensor measurement station: NI LabVIEW running in desktop PC, PCI-GPIB, PCI-ADC, PCI-DIO, EISA-DAC, GPIB Multimeters for sensor current and voltage, HP GPIB LCR Meter, GPIB HV bias supply.

Test beam DAQ and slow controls: NI LabVIEW running in portable PC, PCMCIA-GPIB, GPIB Extender, CAMAC-GPIB, CAMAC ADC, HP GPIB Pulse Generator, GPIB Multimeters for sensor current and voltage.

Additional equipment will be obtained from the CERN Electronics Pool and/or purchased by the participating Institutes. For the Pixel and Microstrip readout electronics work is planned in collaboration with other R&D projects and experimental teams at CERN.

## APPENDIX 2: BUDGET PLAN AND FUNDING

### Investments

The investment in new equipment will be covered directly by the participating Institutes from their existing funds for 1998. The following items are being planned:

| Item | Institute | Cost Estimate |
|---|---|---|
| Low Mass $LN_2$ refrigerator prototype for beam tests | CERN | 10 kSF |
| PCB Chip Carriers for various types of sensors | CERN, U. Bern | 20 kSF |
| Sensors | All Institutes | 70 kSF |

### Operating Cost Estimate

The Collaboration will set up a common fund for covering the following items needed in the course of the planned programme in 1998 and 1999:

| Item | Estimate (kSF) |
|---|---|
| Stores withdrawals (consumables) | 8 |
| Electronics pool costs | 11 |
| Subsistence for students | 16 |
| Printing costs (Preprints, Page fees, Status Reports) | 3 |
| Communications and Transport costs | 2 |
| Total | 40 |

### Funding of Operation

The Collaboration has agreed on the principle that the two main contributing Institutes will cover one half of the needs for common operating funds, and the remaining will be shared by the others in proportion to the number of Members of Collaboration of the Institute. This gives the following funding plan:

| Institute | Estimate (kSF) |
|---|---|
| CERN | 10 |
| University of Bern | 10 |
| All other Institutes (about 0.6 kSF/capita) | 20 |
| Total | 40 |