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ADDENDUM TO THE 19/3/01 LCFI PPESP PROPOSAL

ADDITIONAL OXFORD CONTRIBUTIONS

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Discussions following the LCFI presentation to the PPESP have revealed important contributions that Oxford could make to mechanical aspects of the vertex detector R&D. This addendum describes these contributions, the resources required, and the manpower that could be made available. The proposed programme takes advantage of the expertise and equipment that has been acquired in the course of our developments for the ATLAS SCT. The first step is studies of the mechanical properties of unsupported thinned CCDs. Later this can be expanded to other aspects of the overall mechanical design.

Years 1+2: Mechanical properties of unsupported thinned CCDs

The thin unsupported silicon represents a new challenge in both its static and vibrational properties. We are already participating in experimental studies of its static properties at RAL and the future use of the Oxford WhiPM[1] system to continue these studies was mentioned in the LCFI proposal. We now propose to augment this work with theoretical studies (finite element analysis) of both the static and vibrational properties and experimental study of the vibrations using the Oxford ESPI system[2], which is ideally suited for this purpose.

Vibrations of the thinned CCDs, perhaps driven by the cooling gas flow, could affect the positional accuracy of the detector. Wing Lau has already made some simple FEA calculations and shown that the resonant frequency of a thinned CCD is increased by a substantial factor by curving it about its long axis. Achieving this by curving the ladder blocks which hold it at each end would lead to difficulties connecting to the readout chips. However a more complicated curved surface may come "for free" even with flat supports, caused by the stresses induced in silicon when it is processed to make a CCD. Since these issues may affect the feasibility of the unsupported thinned CCD, they should be investigated by calculations and measurements as soon as possible.

[1]WhiPM = White light Profile Measurement, uses a light source of short coherence length and a moving mirror to map the static surface profile of an object.

[2]ESPI = Electronic Speckle Pattern Interferometry, analyses a time-sequence of interference patterns to measure changes in the surface profile of an object to an accuracy of about 1 micron (set by the wavelength of the laser light). It was designed for studies of the ATLAS SCT barrel and can image an object of about 0.5 m in a single frame (2 frames were used for the SCT). The current system has measured vibrations between 11 and 1000 Hz, with the upper limit set by the electronics and the lower limit by the means of exciting the vibrations. These limits can probably be extended if needed.

During the first two years we would make FEA calculations of the mechanical behaviour of the CCDs under the expected influences of stress inherent to the processed silicon, tension applied by the support system, cooling gas flow, and thermal effects. These calculations will be thoroughly compared to static and vibrational measurements of tensioned processed silicon. Some rough measurements of the effect of gas flow will be made, but detailed measurements will probably take a more elaborate setup and more time.

To do this requires manpower and some funding. Wing Lau (mechanical engineer) can start contributing of order 30% of his time to the project, primarily on FEA studies and supervision of students. Glenn Christian (D.Phil. student) could expand his measurement programme from the currently-planned WhiPM to include vibrational measurements using ESPI, possibly supported by a new student in October (depending on the students' interest and the availability of funding). Brian Hawes, Todd Huffman, and Richard Nickerson can only contribute a small amount of time, but their experience with the ATLAS barrel and the WhiPM and ESPI systems will make their advice extremely valuable and greatly aid a quick start-up. During course of this period we expect to be able to bring some electronics engineering support (which experience shows is needed to support our laser metrology), a small amount of technical support, and to start an RA 50% on the project.

The main funding required is for a replacement laser for the ESPI system because the current one has become very unreliable. Modern solid-state lasers are much more reliable than our current type, with at least triple the lifetime, but cost more, with current quotes at £47k instead of £35k. Our ATLAS group still has some need for ESPI but cannot afford a new laser and would try to get by with repairs to the old one. However this becoming very inefficient especially when manpower costs are considered. Therefore we request £25k towards the purchase of a solid-state laser, with the rest to be paid from our Rolling Grant (and compensated for us by the more efficient use of our staff using a reliable laser). In addition we need £3k for a dedicated frame grabber for the ESPI system (the current ATLAS one is shared between different systems). Clearly a piece of processed silicon is required, at a cost of about £1k. We estimate total consumables costs of £5k, including the silicon and allowing for the fact that at least mechanical parts will need to be made by outside companies during this first period because our workshop is dominated by urgent ATLAS work. The total funds requested for the first two years comes to £33k, of which £30k is needed in the first year.

Following years: Further aspects of the mechanical design

In the following years the studies of the CCDs will continue as needed and the scope of the mechanical studies will expand to cover the overall structure. The available manpower will increase, as roughly estimated in table 1. We cannot now specify details or costs, but indicate some possibilities in the following.

The initial vibrational measurements will be made at room temperature, but may need to be repeated at the operating temperature. If the initial gas flow studies indicate that this is important, a setup will need to be designed and built to study this carefully. If the electronics turns out to need evaporative LN cooling, the effect of this on vibrations will also need to be studied.

The overall mechanical structure of the vertex detector needs to be optimised and its vibrational and thermal properties studied. Our experience in designing the ATLAS barrel structure can be very useful here.

Table 1: Manpower in %FTE in April-March years.

Name	category	01/2	02/3	03/4	04/5	comments
Devenish	faculty	10	20	30	30	
Huffman	faculty	10	10	10	10	ATLAS experience and advice
Nickerson	faculty	10	10	10	10	ATLAS experience and advice
Myatt	faculty	20	15*			*retires Oct. 03
Burrows	Adv.Fell.	30	40	(50)	(50)	Adv. Fell. thru Feb. 03
White	RA	10	5*			*post ends Oct. 02
RA	RA		20*	50	50	*start uncertain (Apr02-Jan03)
Christian	student	100	50*			*studentship ends Oct. 02
Student	student	50*	100	100	50	*Oct. 01 start uncertain
Student	student			50	100	
Hawes	elec. eng.	10	10	20	50	ATLAS experience and advice
Lau	mech.eng.	30	50	100	100	(may be partially other eng.)
Elec. Eng.	elec. eng.	10	20	40	80	
Tech. Supp.	tech.	10	20	100	100	mech./elec. workshop support

Table 2: Funds requested in £k in April-March years

Item	01/2	02/3
laser	25	
frame grabber	3	
consumables	2	3
Total	30	3