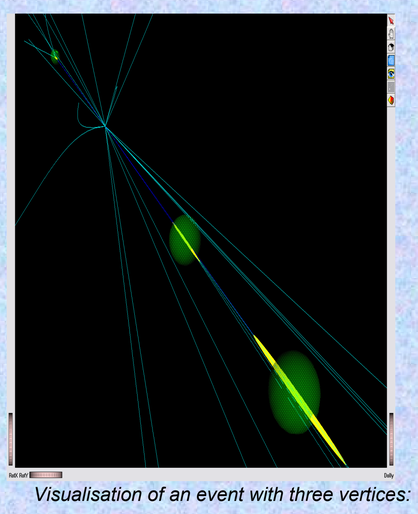
Linear Collider Flavour Identification

LCFI

Oxford Physics



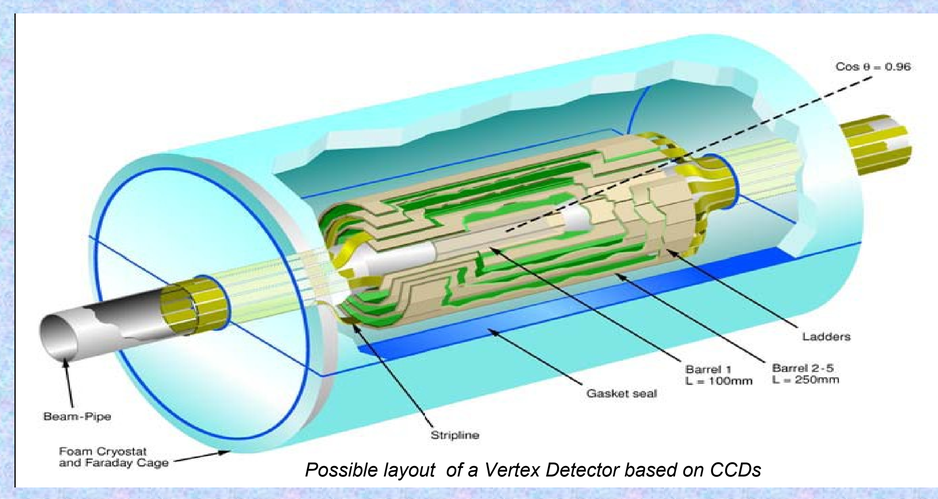
Visualisation of an event with three vertices: primary (e^+e^- collision), secondary (B meson decay) and tertiary (D meson decay)

Long-lived particles like b- and c-quarks can be identified through displaced vertices reconstructed in a precise Vertex Detector.

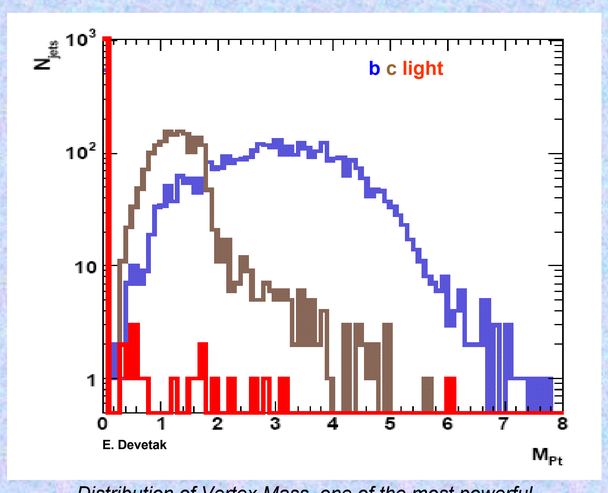
LCFI develops sensor technologies, readout electronics, mechanics and software algorithms for the Vertex Detector at the International Linear Collider.

Requirements:

- Resolution 3 μm
- 1 Giga channels of 20×20 μm pixels in five layers
- Low material budget 0.1% X_0 per layer
- Fast readout



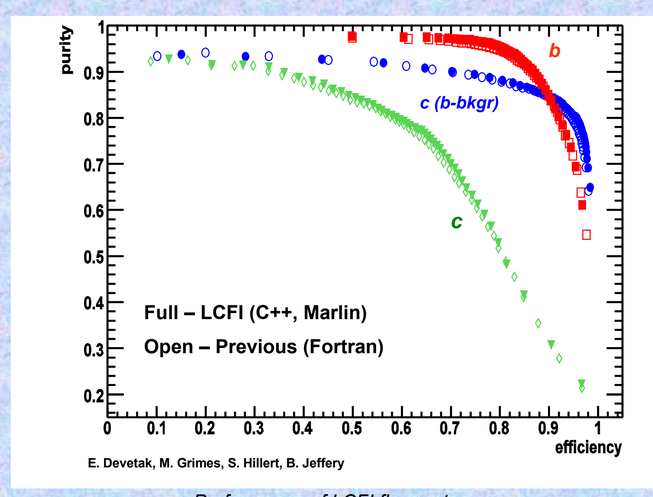
Possible layout of a Vertex Detector based on CCDs



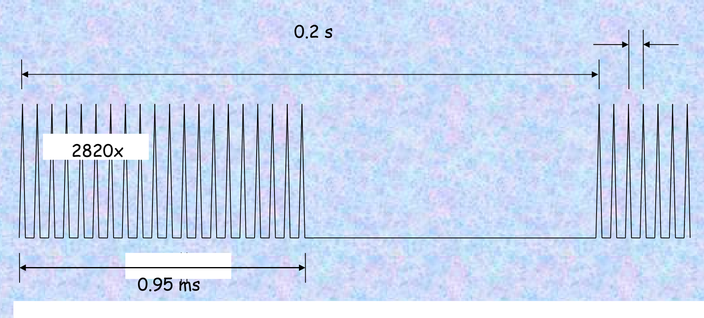
Distribution of Vertex Mass, one of the most powerful flavour discriminants, for various quark flavours

Flavour identification is a cornerstone of the ILC physics program which includes precise measurements of Higgs and other new particles.

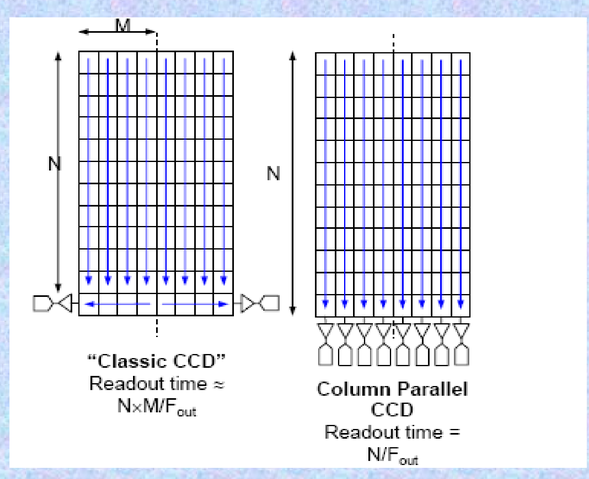
LCFI developed algorithms of vertex reconstruction to determine flavour and charge of quarks in jets. Multiple flavour variables are combined into a Neural Net to maximize the sensitivity. The predicted performance considerably exceeds the previously achieved parameters.



Performance of LCFI flavour tagger: Purity vs Efficiency curves for di-jet production at 500 GeV



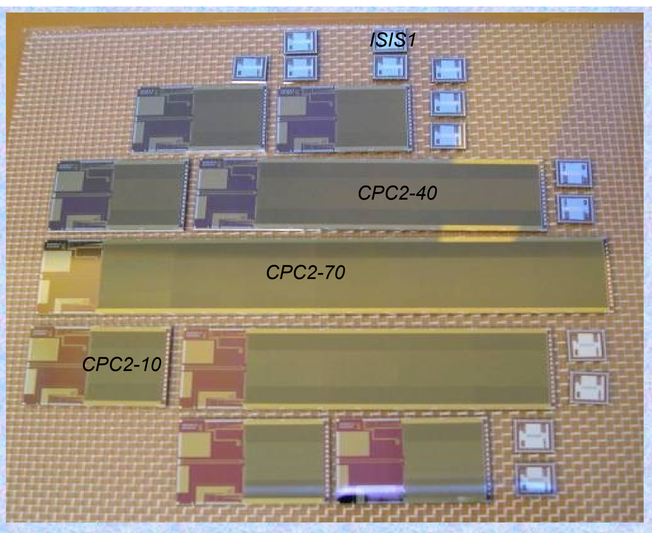
ILC beam structure: trains of 2820 bunches collide 5 times per second. It is necessary to read out Vertex Detector 20 times per train – dictated by hit occupancy in sensors.



Comparison of traditional CCD and Column Parallel CCD

LCFI is developing CCD (Charged Coupled Device) based sensors with column readout which allows to shorten the readout time by orders of magnitude. Despite 'parallel processing' the readout rate is still challenging : 50 MHz clock to achieve a 20 kHz/frame rate.

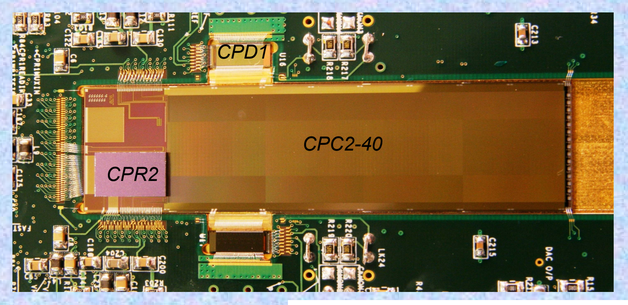
Main difficulty of Column Parallel CCD (CPCCD) is to provide a clock with a large current to the sensors.



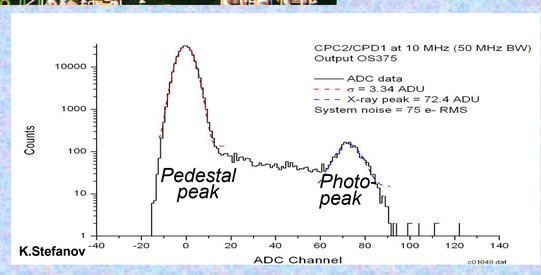
Diced wafer with CPC2 and ISIS1 devices

LCFI achieved a number of milestones for CPCCD:

- Produced and successfully tested large area sensors CPC2
- Produced CPR2 - ASIC chip for CPC2 with sparsified readout of 128 channels
- Tested CPD1 – ASIC chip capable to provide a 20 A clock current
- Designed CPC-T prototype sensors with reduced capacitance to decrease the required clock current



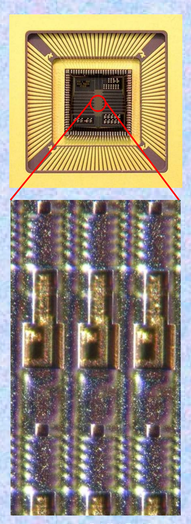
CPC2-40 sensor with mounted CPR2 and two CPD1 chips



Amplitude spectrum of 5.9 keV ^{55}Fe X-rays in CPC2 at 10 MHz

Storage Sensors is an alternative to CPCCD: each pixel has a 'memory' filled up during collisions and read out between trains at slow rate.

LCFI developed and tested first prototypes of ISIS storage sensors with 160x40 μm^2 pixels, each with 5 storage cells.



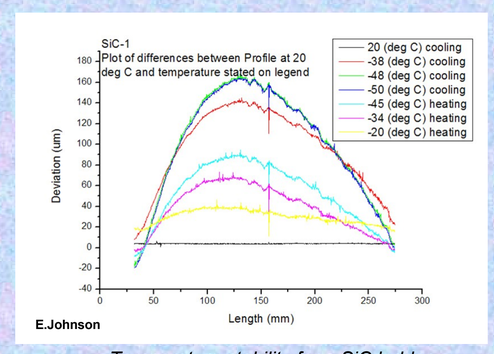
Fragment of ISIS device with five storage cells

Foam is a promising option to provide thin 0.1% X_0 ladders.

Foam types under study:

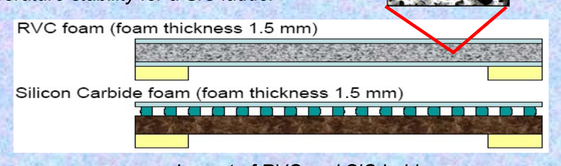
- 3% fill factor RVC (Reticulated Vitreous Carbon) foam
- 6% fill factor SiC (Silicon Carbide) foam

We built and tested several ladder prototypes based on foams.



Temperature stability for a SiC ladder

Microstructure of RVC foam



Layout of RVC and SiC ladders

Learn more at the LCFI Collaboration web pages

http://hepwww.rl.ac.uk/lcfi/

LCFI Participating Institutions

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