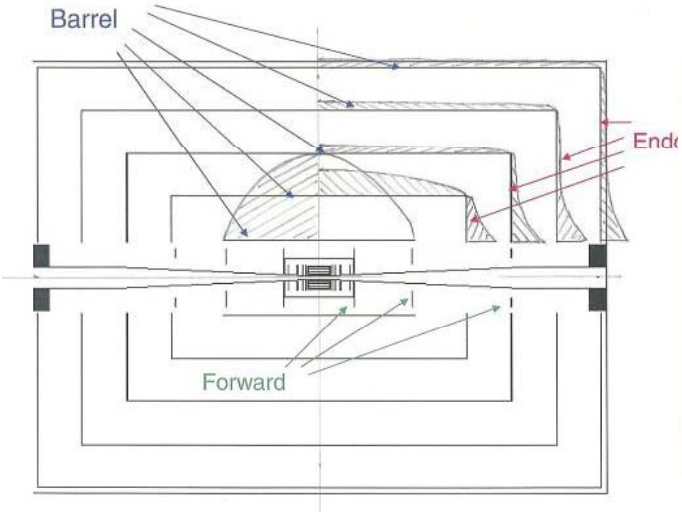
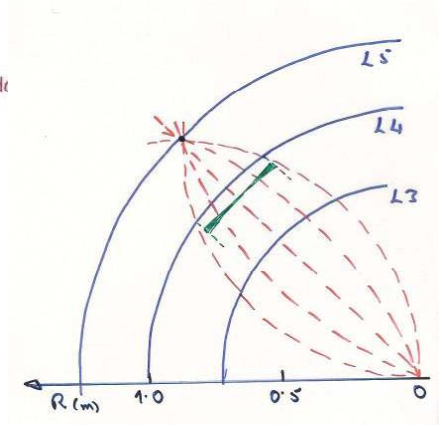
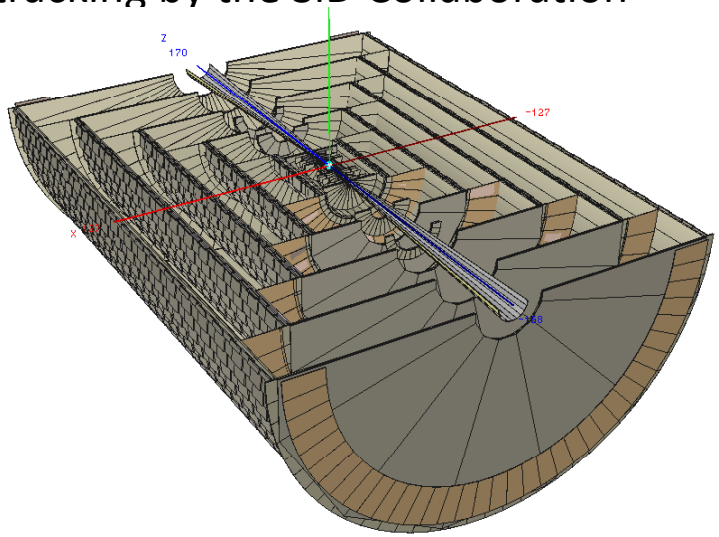
Advances since TILC08 on Silicon tracking front

- Presentation by M. Demarteau on the progress on Silicon tracking by the SiD Collaboration
- Progress on the all-pixel tracker by C. Damerell







- Review on SiLC progress by V. Saveliev with several dedicated presentations on new results on

  - Sensor R&D : new 3D planar sensors by VTT
    HPK Test structures tested at CERN test beam
  - Electronic R&D (DAQ session)
  - Alignment (M. Fernandez)
  - Simulations

NEW HPK test structures tested at CERN beam test June 08

W. Mitaroff for the Vienna team

strip width [µm]	intermediate strips
5	no
10	no
12.5	no
15	no
20	no
25	no
5	single
7.5	single
10	single
12.5	single
15	single
17.5	single
5	double
7.5	double
10	double
12.5	double

Sensor order at HPK contains several smaller sensors

A multi-geometry mini sensor:

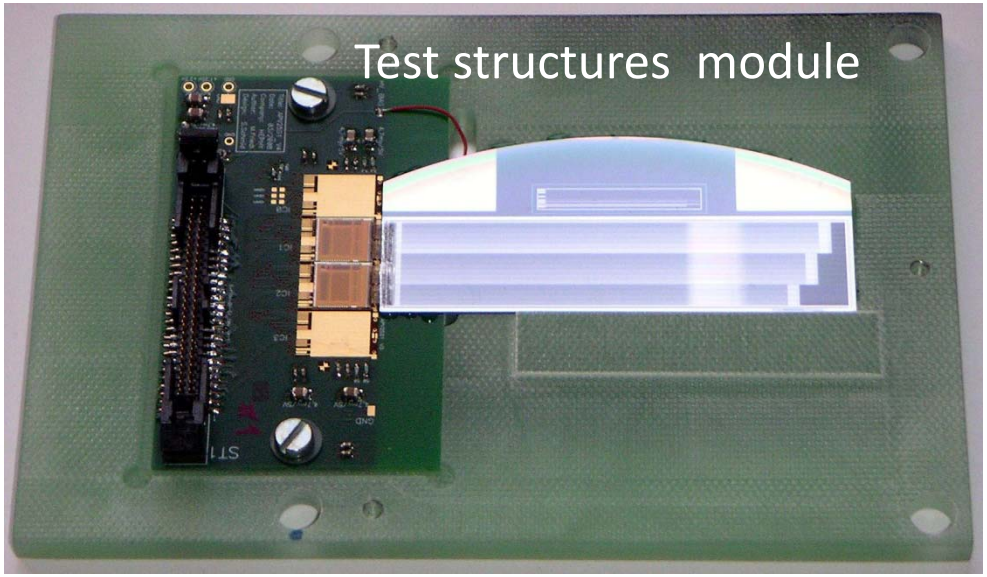
256 strips with 50um pitch

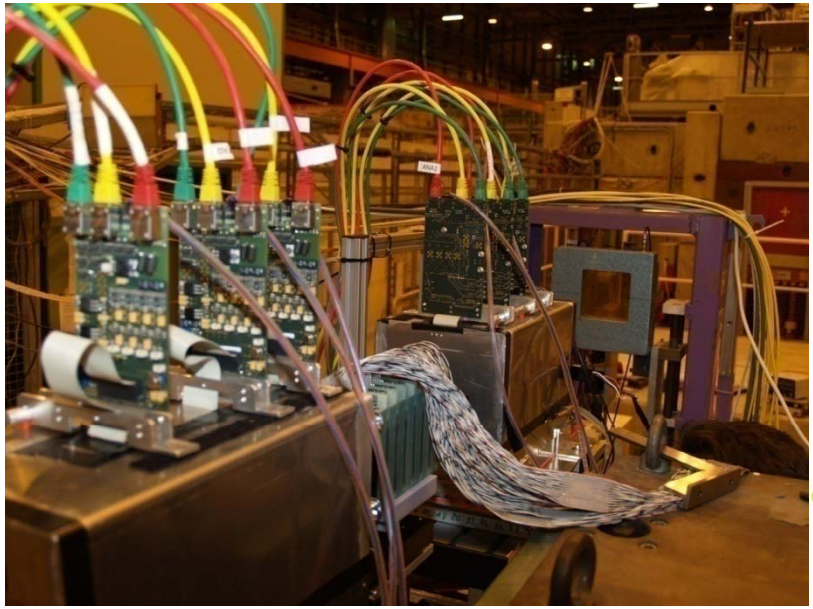
16 zones with 16 strips each

Layout constant within each zone

Strip width and **number of intermediate strips** vary between the zones

Test beam with EUDET telescope



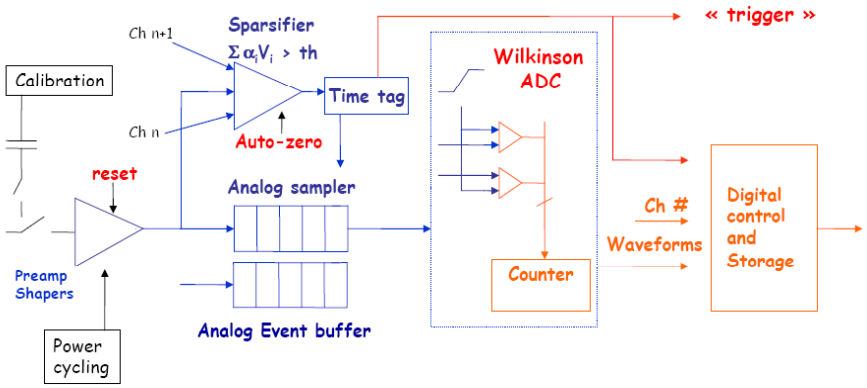


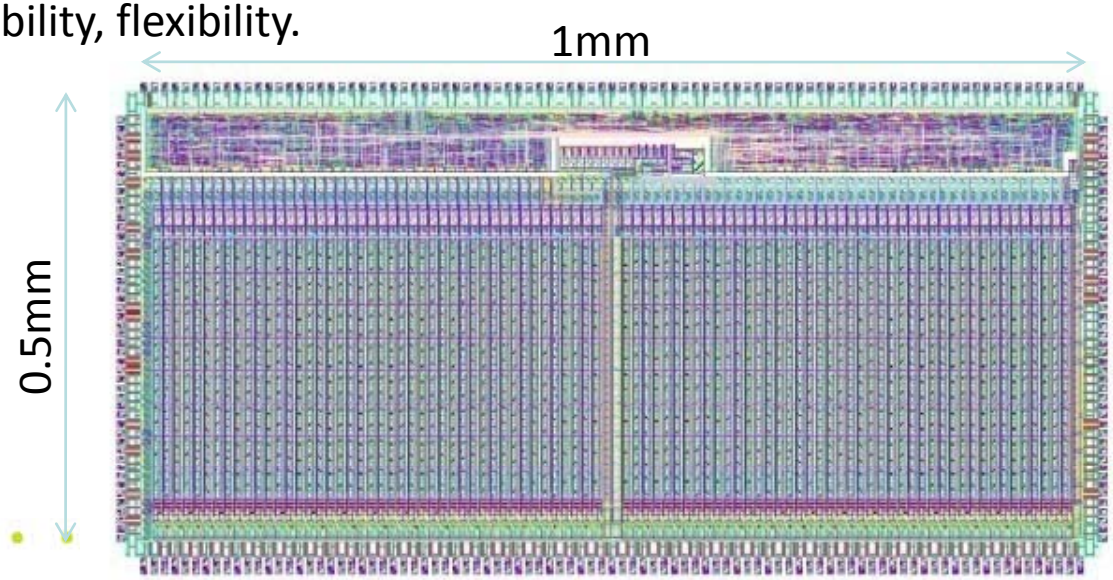
The new SiTR_130-88 chip (Barcelona, Paris)

(A. Savoy-Navarro)

Full readout chain integration in a single chip, presently 88 channels in 130 nm:

- Preamp-shaper
-Sparsification Trigger decision on analogue sums (3 adjacent channels)
- Sampling 8-deep sampling analogue pipe-line
-Analogue event buffering: Occupancy, 8 deep event buffer
- On-chip digitization 12-bit ADC
- Calibration and calibration management
- Power switching (ILC duty cycle)
- Digital control: operation fully programmable (all settings of chip operations), fault tolerance, robustness, reliability, flexibility.



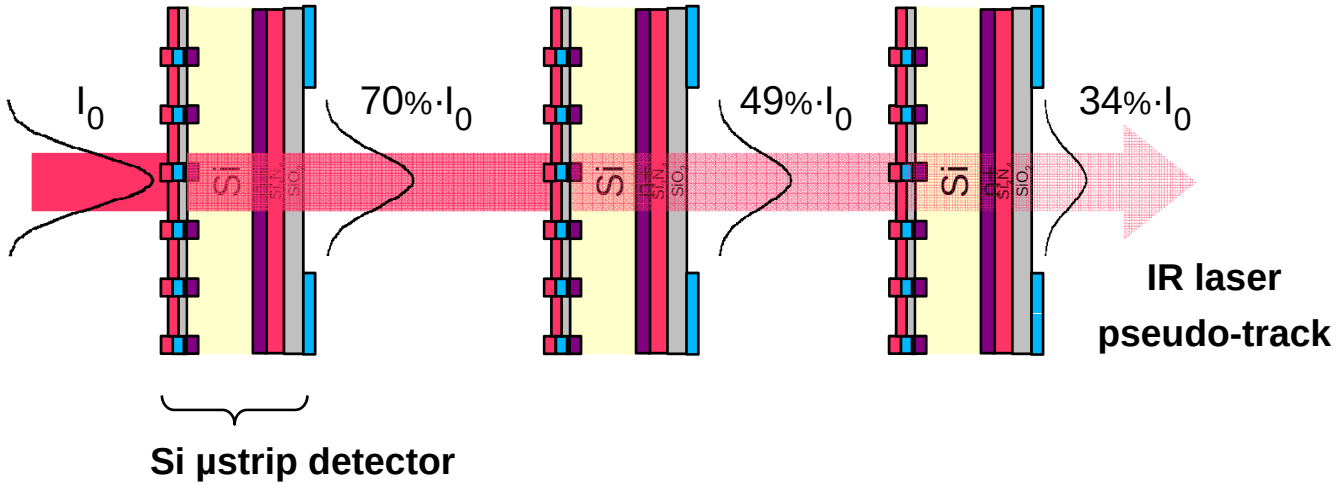


SiTR_130-88

- Just being sent to foundry
- To be bump bonded on microstrip sensor (HPK)

Alignment (IFCA-CSIC and CNM)

- Alignment of Si strip detectors made possible by opening a ϕ~1 cm hole in the Al backplane metal
- Goal is to improve transmittance (T) of Si in the IR to 70% (enough to align 10 sensors in a row)



Ohmic side:
Alignment
passage

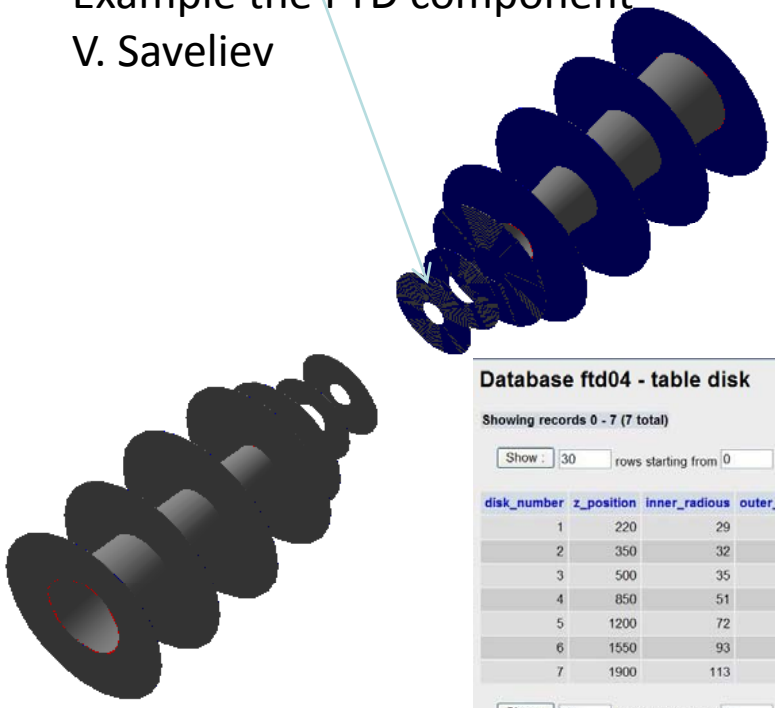
- Shown to the left a Hamamatsu sensor modified for alignment
- Simulation shows that narrowing the strip width to 10% of the pitch in the alignment hole ensures T~70%
- Proper choice of the layer thicknesses can still raise transmittance further up

Marcos Garcia

Progress on full simulation fronts:

- Full digitization package developed by Z. Drasal (see presentation)
- All Silicon components in the ILD detector implemented for the optimization (MOKKA)

Example the FTD component
V. Saveliev



Database ftd04 - table disk

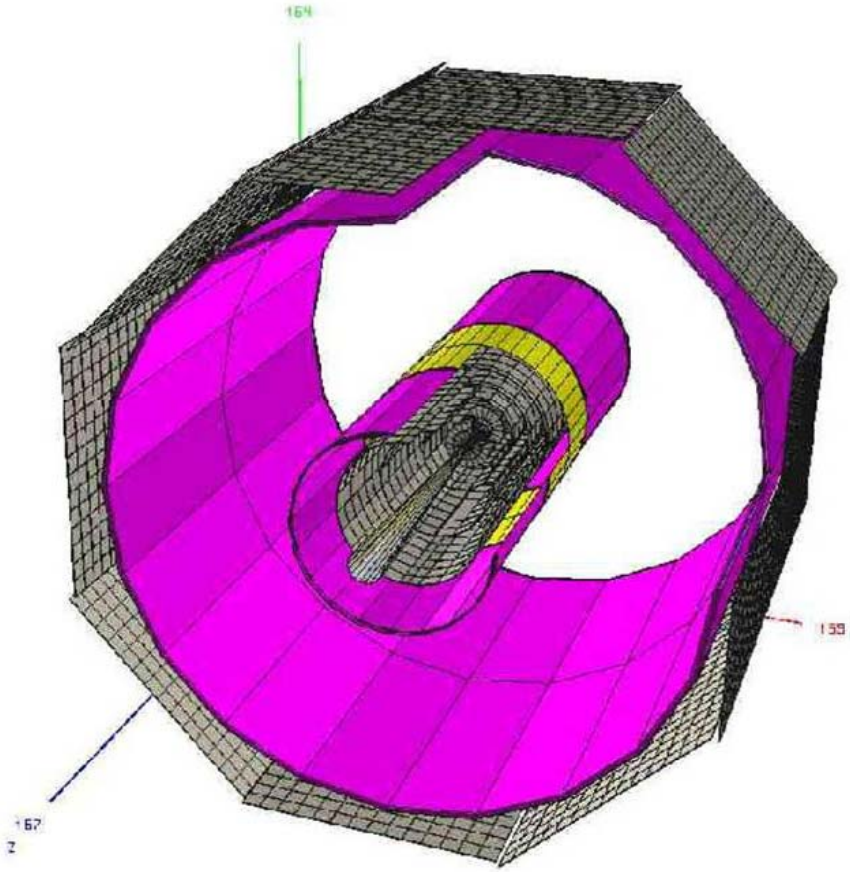
Showing records 0 - 7 (7 total)

Show : 30 rows starting from 0 Full Texts

disk_number	z_position	inner_radious	outer_radious
1	220	29	140
2	350	32	140
3	500	35	210
4	850	51	270
5	1200	72	290
6	1550	93	290
7	1900	113	290

Show : 30 rows starting from 0 Full Texts

Insert new row



ILC ROOT Simulation ILD Silicon tracking
A. Charpy (LPNHE) in collaboration with C. Gatto et al.

Ready for performance & integration studies for LOI's

Vertex Detector R&D for ILC

WWS-OC asked R&D Panel to review main technical areas during regional workshops last year – tracking in Beijing, calorimetry in DESY, and vertex detectors in Fermilab. Committee members for the latest review, 23-26 October:

Panel members: Chris Damerell, Hwanbae Park (chair)

External consultants: Yasuo Arai, Dave Christian, Masashi Hazumi, Gerhard Lutz, Pavel Rehak, Petra Riedler, Steve Watts

Regional representatives: Tim Bolton (North America), Chris Damerell (Europe), [Junji Haba (Asia)]

GDE R&D Board chair: Bill Willis

Local vertexing experts: Simon Kwan, Lenny Spiegel

Admin support: Naomi Nagahashi

Overview of the review

- **We reviewed 10 technical options, FPCCD, CPCCD, CMOS MAPS, deep n-well, CAP, DEPFET, ISIS, Chronopixels, SOI-based, 3D-based**
- **All options hold promise – we were unable to eliminate any of them, but bear in mind that there has already been some pruning of options (micropixel/macropixel and others)**
- **Not as bad as it sounds – will end up with 2 and possibly 4 technologies in the startup ILC, and others could eventually provide upgrade paths**
- **Several of these options have possible applications in other fields, such as x-ray sensors for astronomy and SR systems, and sensors for electron microscopy. Pixels (which enable creation of *pictures*) tend to be intrinsically multi-disciplinary**
- **Final version of our report can be found on ILC Wiki page, along with our earlier reports:**

  http://www.linearcollider.org/wiki/doku.php

Some general recommendations (from 34 pages)

Environmental issues

- ***Ongoing close coordination needed with MDI Group***
  - to control pair bgd (low-P final focus option may be the lesser of two evils)
  - to control neutron bgd from the current (less expensive but more risky) beam dump design
  - to control bgd related to wakefields in collimators (new UK studies)
  - overall, to preserve R_{bp} (in contrast to what happened at SLC)
- **Is high-Z liner needed,** and if so how thick? (results should come from studies of collimator wakefields and all other sources of beam tails)
- As well as background in the data, we need to be concerned about **radiation damage** effects
  - e^+e^- pairs cause ionisation effects (notably flatband voltage shifts) and bulk damage (point defects)
  - Neutrons from local energy deposition (~10^9 n/cm^2 .yr) and from beam dump (similar) cause major displacement damage clusters
  - Dark current and point defects can be overcome by cooling, but not cluster damage which generates multiple trap levels through the bandgap
  - Most sensor designs are believed sufficiently robust, but ongoing testing is vital
- **If one has been too optimistic or pessimistic about any of these issues, it may be possible to correct at first push-pull (if one has planned for it)**

Environmental issues (continued)

- **Time stability of IP position in x and y?**
  - **Good discussion at SiD mtg 14/4/08 (Tom M and Phil B). Hopefully we can specify ~1 μm stability over periods of ~1 hour. Depends on issues related to optical anchor, floor sinking after push-pull, etc, that have not yet been studied**
- **Need to monitor and eliminate beam-related and other machine-related RF during ILC commissioning, before detector installed**
  - **Sources (BPMs, kickers, pumps etc) can be pinned down by sub-ns timing from several wide-angle antennas (from ESA studies at SLAC)**
  - **Obvious that ~10^9 sensors of capacitance ~10 fF and thresholds ~100 e^- sampled during the bunch train may be challenging**
  - **A butterfly is more easily disturbed by a breeze blowing than is a large bird**
  - **Marvin Johnson's observations on Faraday cages**

Engineering issues

- **Careful design of small-radius mechanical system to preserve *wall thickness* of beampipe (0.4 mm beryllium)**
- **Long barrels vs short barrels+disks**
  - **will take a few more years to decide**
  - **excellent that two concepts (ILD and SiD) have different opinions**
  - **serial powering will work in favour of short barrels+disks**
  - **there will of course be fwd pixel disks – issue is whether inner ones should have ~3 μm or ~15 μm precision. Awaiting detailed physics studies when material budget at ladder ends can be reliably estimated**
  - **preference could change with future upgrade possibilities**
- **Layer 1 a different technology?**
  - **May be a good idea**
  - **3-D or chronopixels may be obligatory if one really needs bgd as low as 1 hit/mm^2 Awaiting detailed studies …**
  - **Special conditions for layer 1 would permit differences such as higher power**

Mechanics and alignment

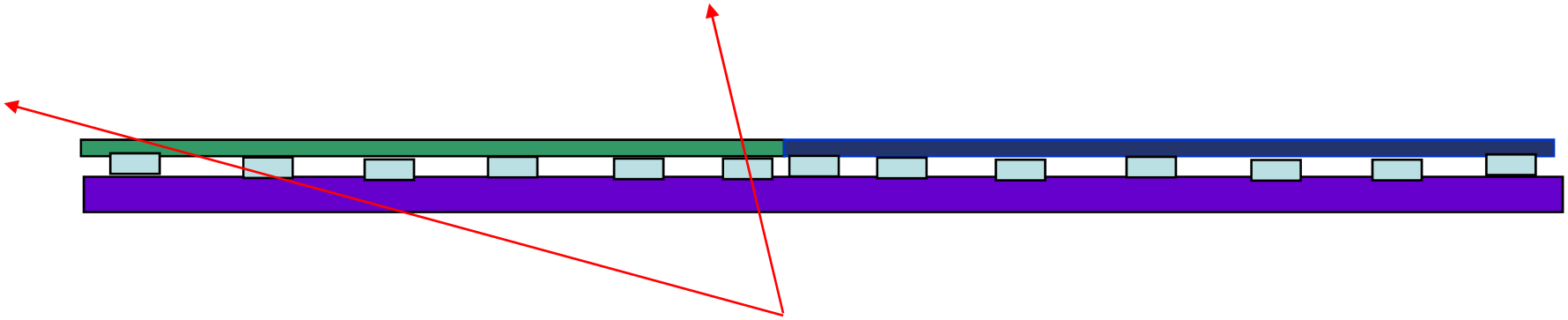
- **Material budget goal of 0.1% X_0 per layer**
  - within active volume, this is almost within reach for several technologies
  - material for services at ladder ends is far from defined for all technologies – several years away
- **Large sensors or mosaics of reticle-scale devices?**
  - penalty in material budget associated with mosaics depends on sensor technology
  - yield for large sensors may be higher than one infers from average over small devices
- **Fabrication of nested barrels**
  - Two approaches – monocoque or separate ladders
  - don't need to make these assemblies easily demountable
  - SLD's 307 Mpixels comprised 60 ladders, and experienced *zero* failed pixels
  - assembly procedure can decide sequence (layer 1 first or last) and sensor orientation (inward or outward facing)

- **Sensor attachment to substrates**

  - thinned sensors will be bowed, hence require a small flattening force, which **probably** increases: CCD –> CMOS –> SOI –> 3-D

  - assemblies don't need to be flat, but do need to be mechanically stable

  - instabilities at ends of sensors in SLD were negligible for polar angles near 90 degrees, but not at ends of angular coverage. This illustrates a general point:



  - adhesive pads? Probably no longer needed for cte mismatch, but have other advantages, eg avoiding adhesive at sensor edges
  - can use temporary shims for assembly and for secure, robust wire bonding

- **Optical survey and tracking-based alignment**
  - modern laser CMMs permit micron-level precision in depth, as well as in x,y
  - survey during assembly of nested cylinders at operating temperature could provide full 3-D map of sensor surfaces to the required precision
  - assembly onto beampipe with 3-point kinematic mounts, and care to minimise cable stresses, could preserve surveyed shapes for installed detector
  - similar procedure could be followed for the main tracker, mounted by similar low-stress supports from the ECAL
  - then these shapes will be preserved through multiple push-pull cycles
  - job of tracking-based alignment (muon-pairs being just as useful as at LEP/SLD, though not precisely back-to-back) is then purely to relate these two stable systems to one other, which is easy
  - Should be no need at all for Z-pole running for mechanical alignment after each push-pull, and this will apply equally to the tracking system if it is designed appropriately
  - major repairs and upgrades don't require beampipe bakeout. That is needed once only

- **Laser alignment between FF quad doublets is now considered to reference the 'bedrock' below. No need for a laser running through the IR close to VXD**

Electronics and electrical systems – shared issues

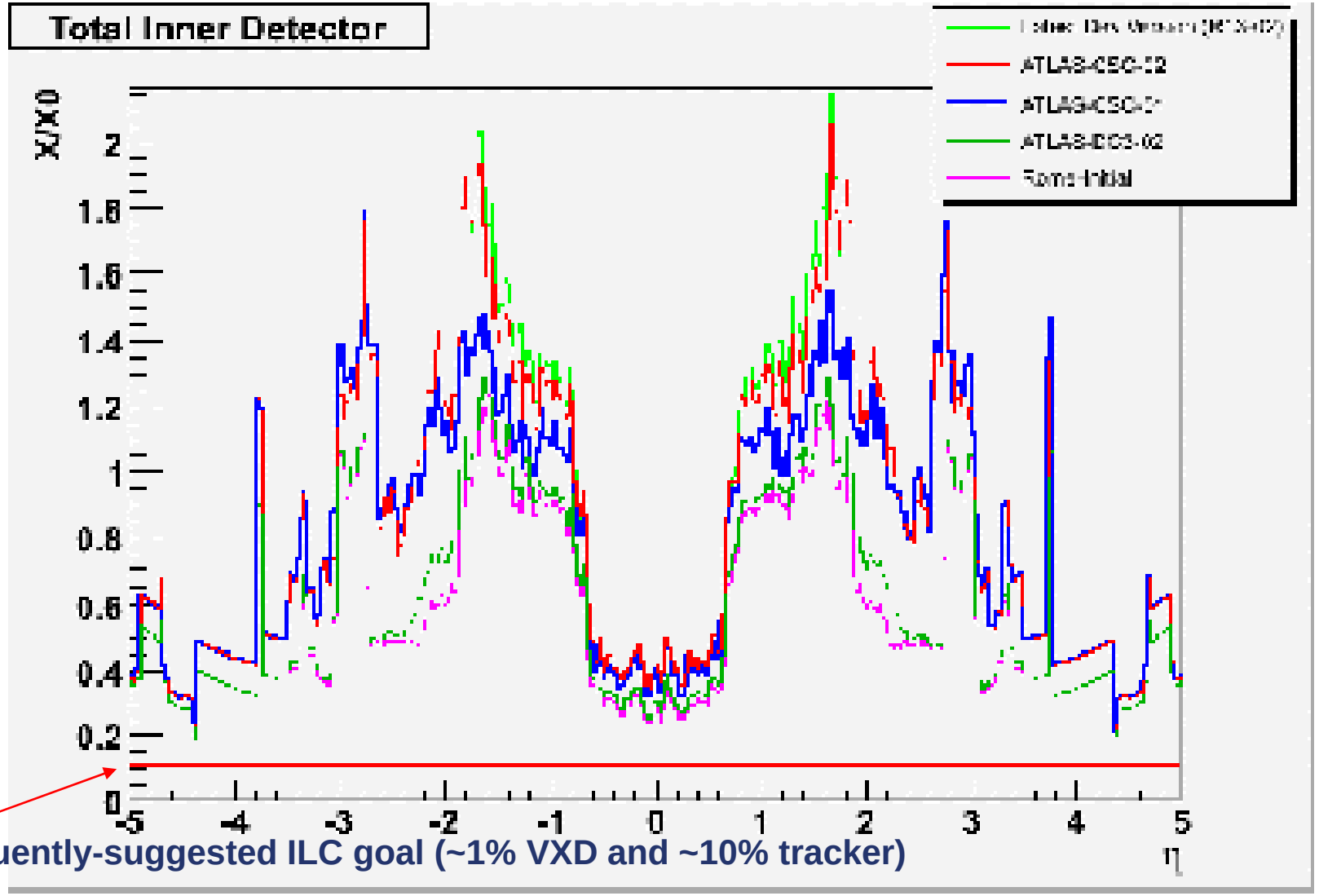
- **Correlated double sampling and extended row filter. Several technologies need to think more about it – could have significant power implications**
- **Power and cooling – serial power may help to greatly reduce material for all options. Much in common with studies under way for sLHC**
- **If using pulsed power, beware of Lorentz forces, transmitted to the delicate VXD support structure, creating unacceptable mechanical vibrations during the bunch train**

Installation and access

- **Push-pull helps. In the garage position, one can open the doors by 3 m. Then follow SLD procedure of rolling the tracker and removing the inner system of beampipe plus detectors, for major work or to install complete upgrade detector, in clean room**

Technology choices

- **Reviews of individual projects - see 18 pages of our report**
- **Regarding choices, this will take time - need to wait for fully serviced ladders in test beams, except where groups decide themselves to change direction**
- **Very important not to prematurely down-select or 'pick winners', despite pressure from funding agencies, …**
- **'For the LOI, ILD may have to focus' – absolutely so, but please present this as a 'working assumption'. Don't get frozen in to what may prove to be the wrong choice, and don't make this outcome self-fulfilling by discouraging alternatives**
- **Same comment should apply to tracking, until technologies have demonstrated their superiority in test beam operation**
- **Encourage more emphasis on engineering aspects – physicists tend to spend too long on sensor development, leaving insufficient time to optimise the overall systems**


Total Inner Detector
X/X0
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-5
-4
-3
-2
-1
0
1
2
3
4
5
η
ATLAS-CSC-02
ATLAS-DC3-02
Frequently-suggested ILC goal (~1% VXD and ~10% tracker)

Technology choice – past experience

- **SLC Experiments Workshop 1982 (just 8 years before physics startup)**
- **CCDs were 'too ambitious', not even proven as min-I detectors**
- **Fortunately, they didn't rush to take a decision**
- **Move ahead by two years …**

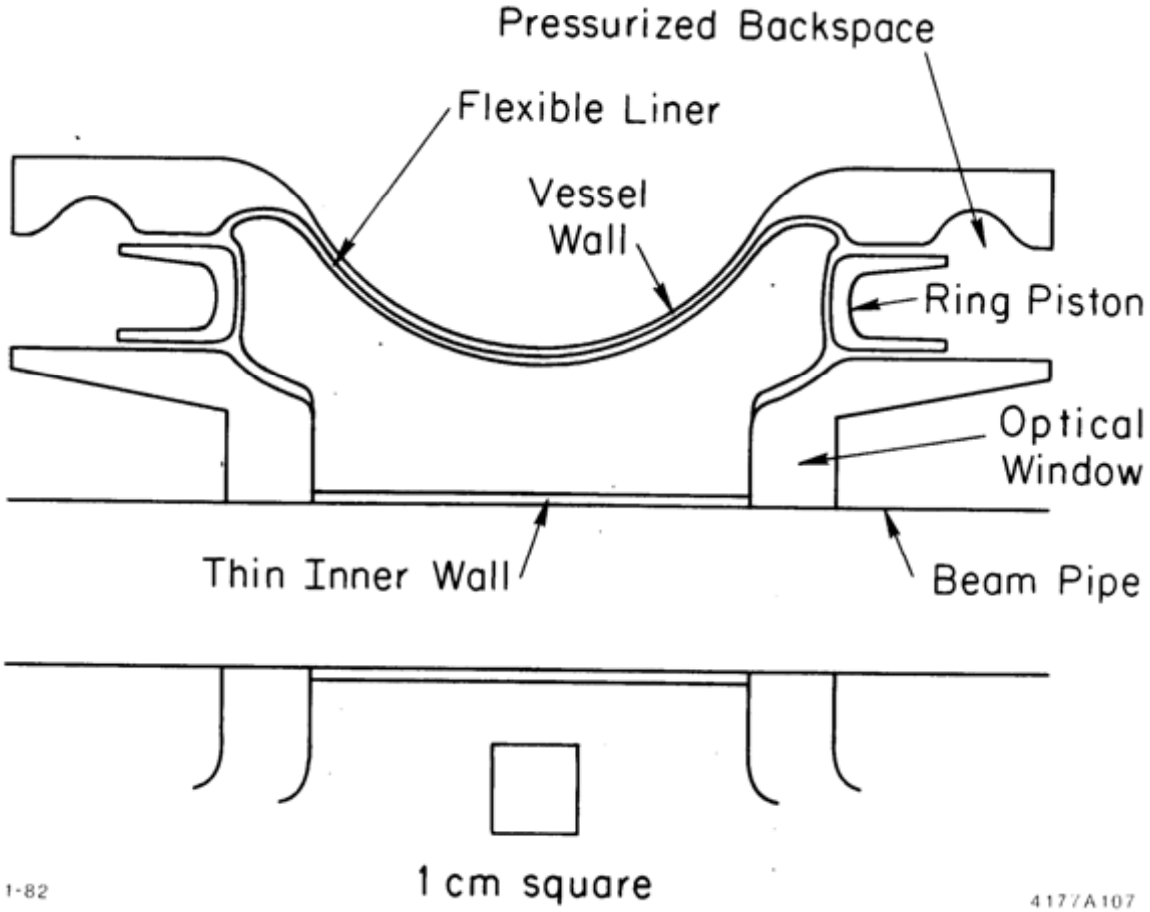
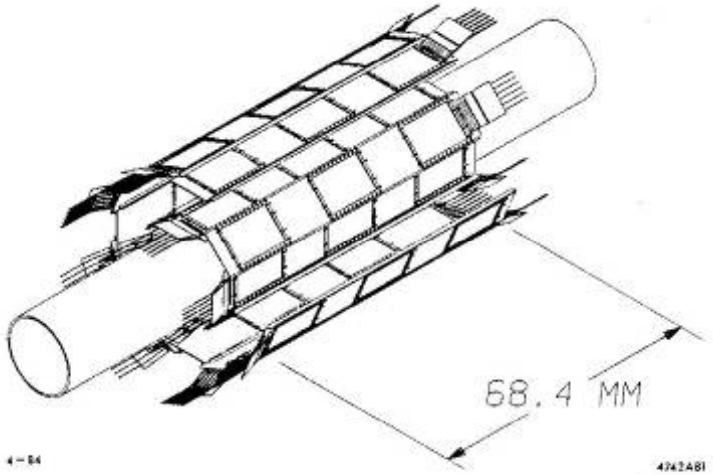
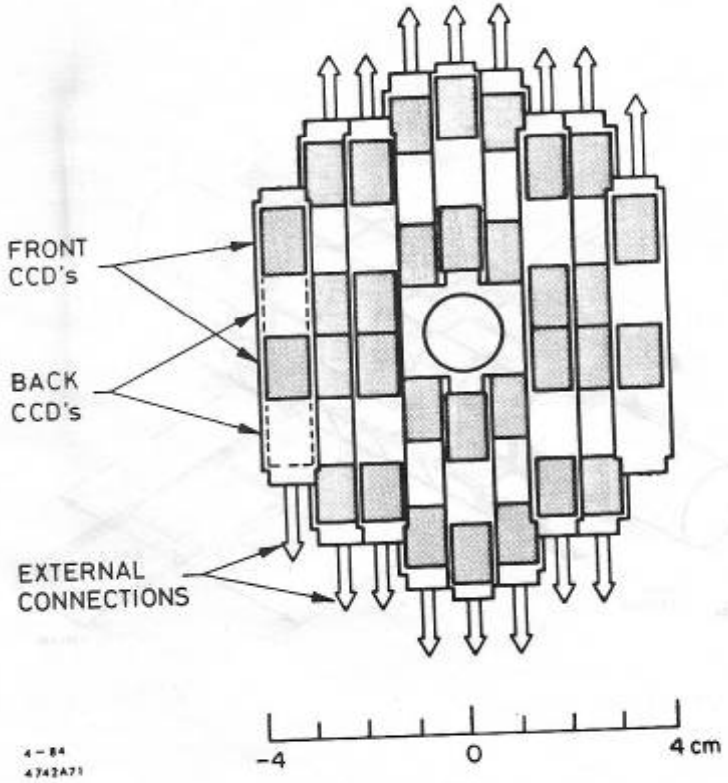


Fig. 7. Conceptual design of a propane bubble chamber vertex detector.

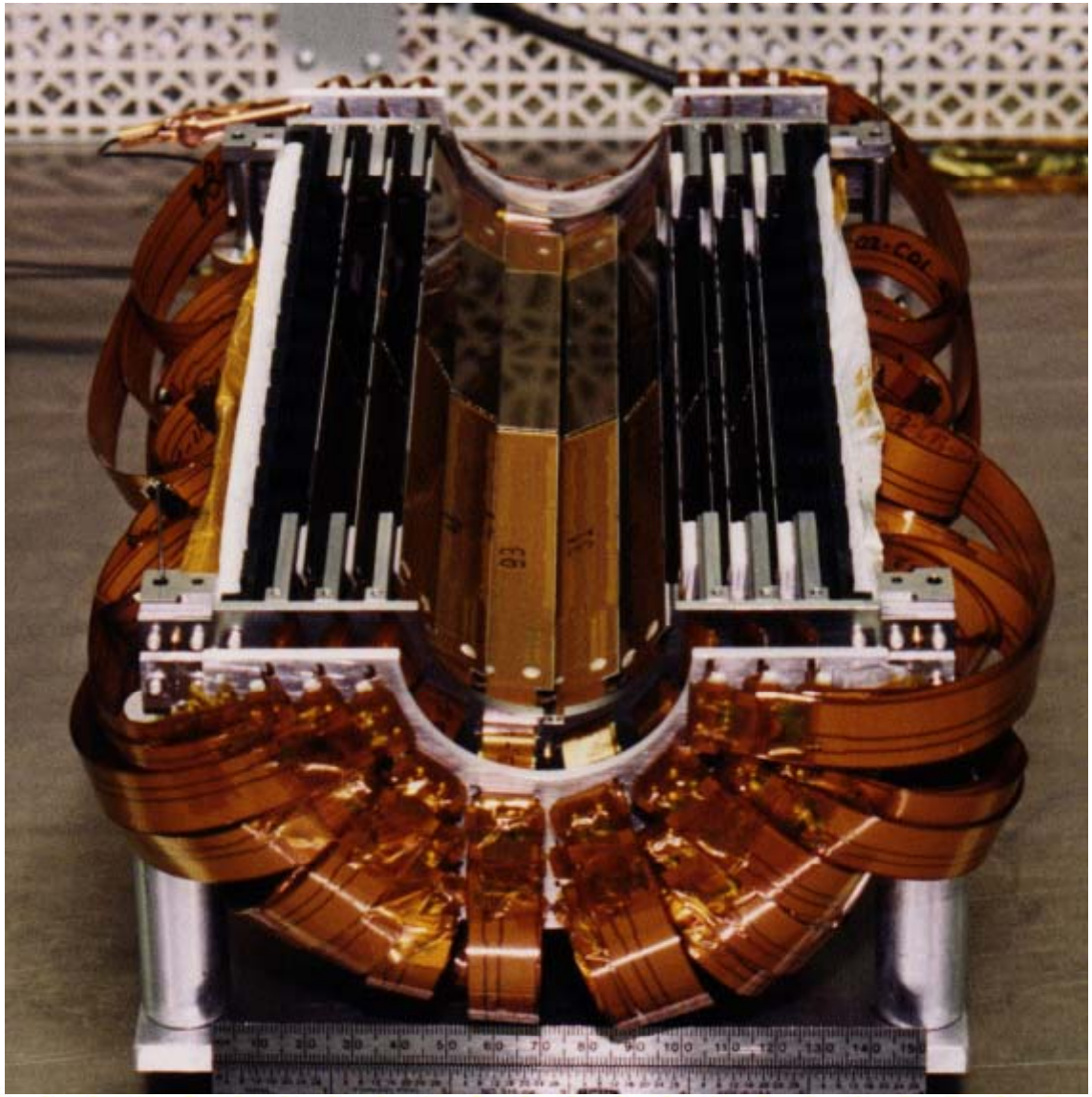
SLD's Vertex Detector Design in 1984 (thanks to Marty Breidenbach's vision)





Right choice, but still the wrong detector layout …

- **What was installed in 1993**
- **Ladder supports, connectors and services tipped the balance in favour of *long barrels without endcaps***
- **However, it should be possible to greatly reduce these end-of-ladder components in future, so the balance may change**



Shared infrastructure and coordination

- We suggest (supported by all groups who participated in the review) a single world-wide test facility, to be equipped as follows:
  - Test beam, ~100 GeV π^- , having the coarse time structure of ILC (1 ms on, 200 s off)
  - 3-5 T split coil solenoid of length and diameter ~0.5 m, with apertures in the return yoke for incident beam at θ_P = 90 degrees, and several oblique angles
  - Anechoic chamber for controlled measurements of noise immunity for all ladder assemblies
  - Optical equipment for measuring stability of supported, fully serviced ladders (including pulsed power, if relevant to that technology) in the solenoid field
  - etc, etc. There will surely be more
- We suggest setting this up via a Vertexing Coordination Group. One of their first jobs would be to find a lab prepared to host this for ~5 years (CERN or Fermilab?) and work together to build up these resources

- **Their main job would be to coordinate the R&D so as to provide objective reports on performance of prototypes made with different technologies, with uniform assessment of material budget including all mechanical supports, cooling and services**
- **There would be a sociological side benefit. As down-selects happen, those groups not chosen could find a natural home, helping their colleagues working on 'surviving' technologies**
- **This suggestion was reiterated at the ILC Vertex Detector Workshop in April in Como**
- **The fundamental question is whether the ILC vertex detector R&D is best organised as a world-wide resource, for the benefit of the ILC community, or should be divided up and 'owned' by the concepts**
- **One might perhaps learn from the 'technical areas' on the machine (such as SCRF) where the world-wide approach has been spectacularly successful**