Use of pixels for Si-tracking

Why?

Where?

What technologies?

Starting the discussion and brainstorming

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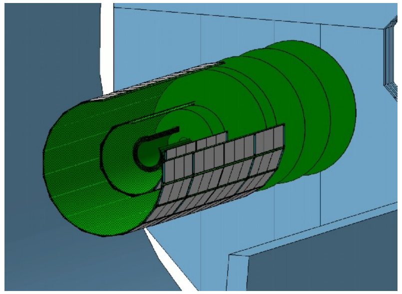
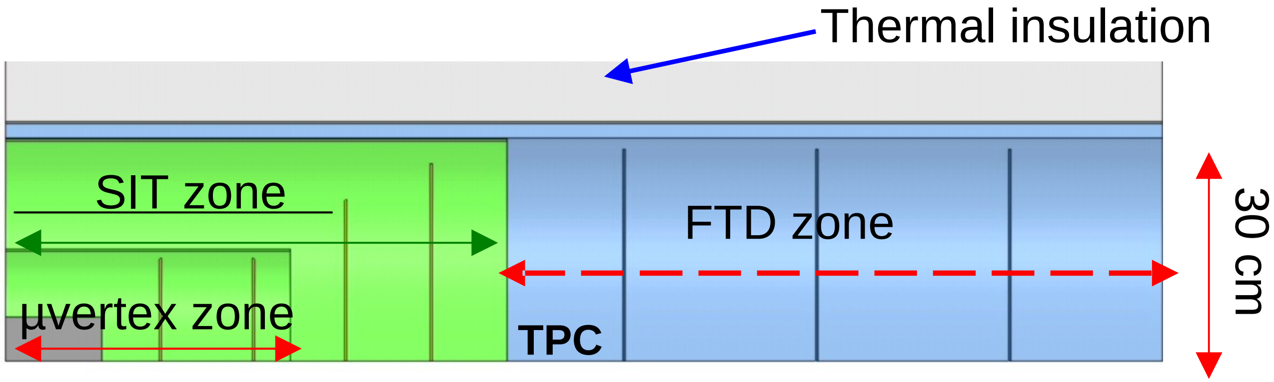
SiLC Meeting in Paris, Université Pierre & Marie Curie, February 2, 2006

WHY? detector performances & issues





Internal barrel + forward

Other components?
Outermost barrel layers?
Thus parts requiring
4μm spatial resolution
(see Mikael's talk)
&/or very high occupancy
Question:
Are ''large'' area of pixels at all feasible if yes what it is the most appropriate Pixel techno??

Microvertex zone includes: μvertex + 2 disks with same pixel technology

SIT zone includes: 2 or 3 Si layers + 2 disks strips and /or pixel techno

FTD zone includes: at least 3 more disks extending from 60cm to 150cm or up to the end of TPC length with eventually more disks

Nb of layers and disks & best sensor techno ?

Radiations & the very forward issue at ILC

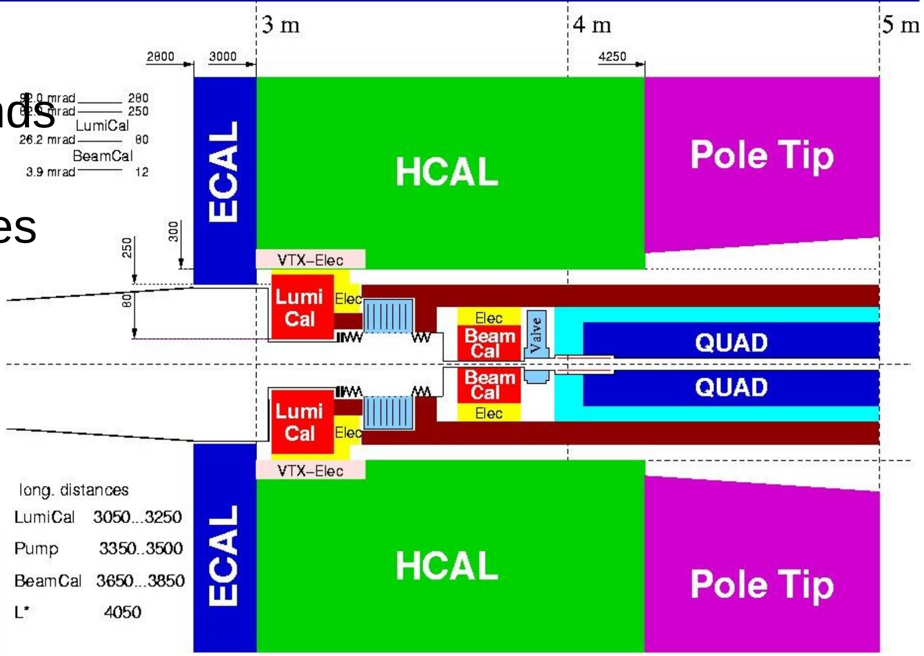
The VERY FORWARD DETECTION ZONE serves for:

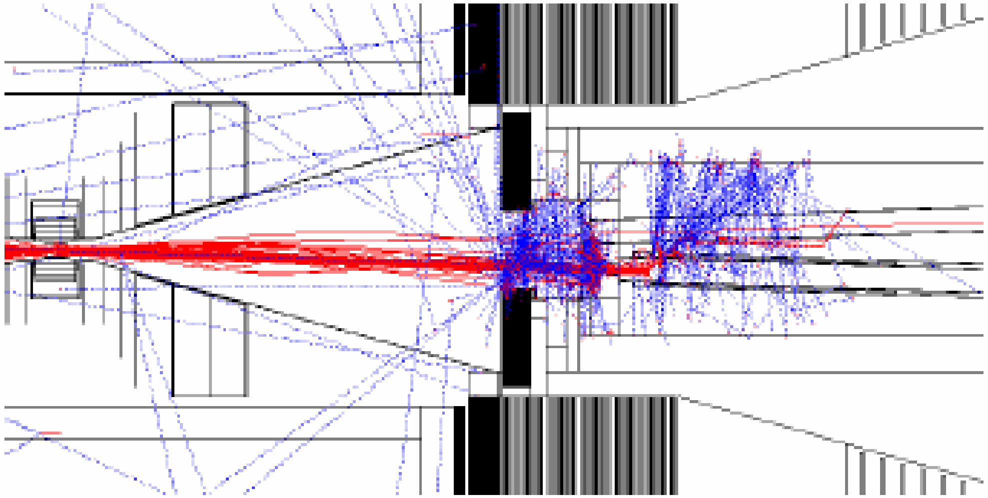
- **Measurement of Luminosity with precision O(<10^{-3}) using Bhabha scattering**
- **Detection of e- and γ at small polar angles (important for searches)**
- **Beam survey and monitoring**

Beamstrahlung or more correctly its collateral effects are the main cause of beam backgrounds affecting the detectors.

It depends on the beam parameters and causes an increase in number of hits in the detectors rather than radiation doses

NOTE that this is under study and no definite numbers are yet available!

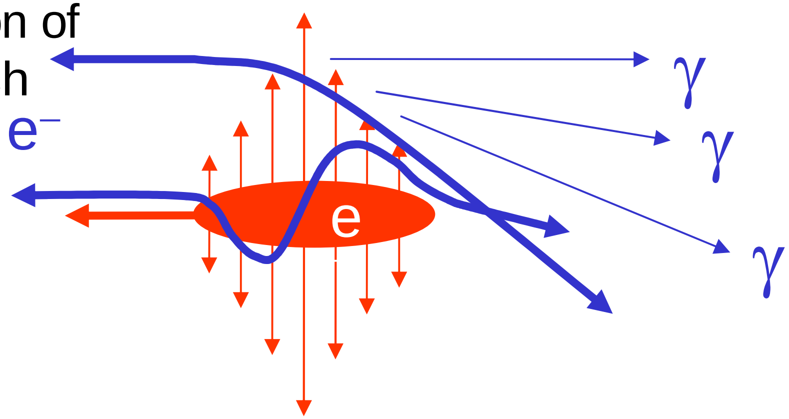




Simulated event in the LDC concept with the effect of local solenoid compensation included

Beamstrahlung & background sources @ILC

Beamstrahlung is a new phenomena @ILC: radiation of photons in the field created by the oncoming bunch

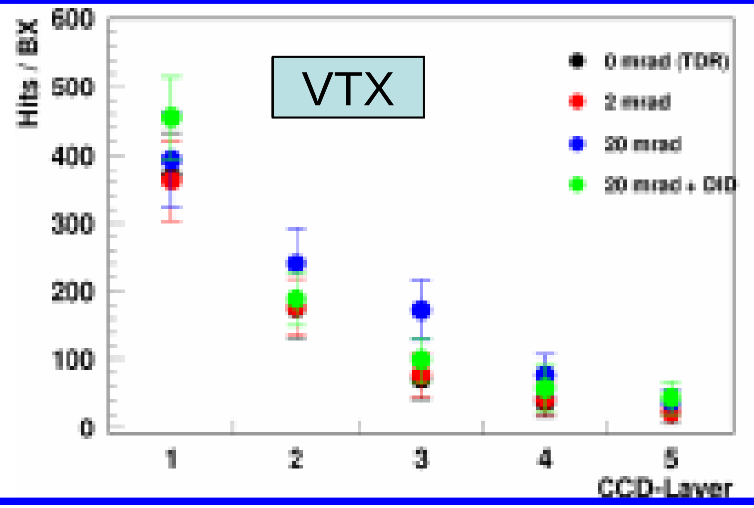


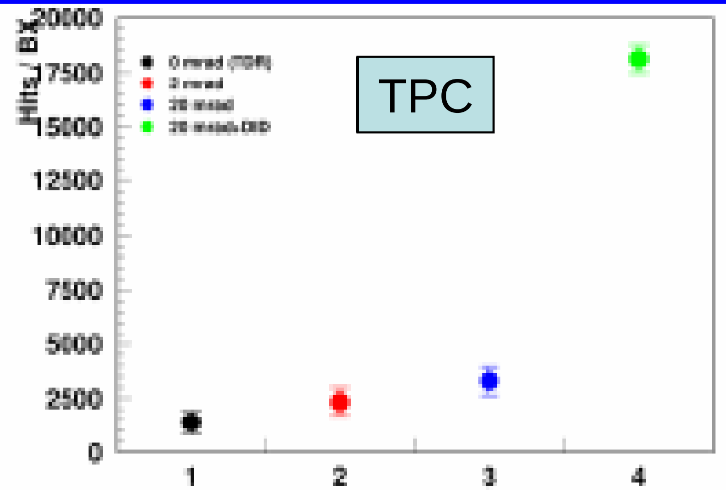
e^+e^- pairs are the main source of background

- beams have to be focused very strongly (σ_y = 5 nm)
- beam-beam interaction creates beamstrahlung
- beamstrahlung photons scatter to e^+e^- (10^5 / BX)
- e^+e^- crash into forward calorimeters and magnets
- lots of photons, neutrons, and charged particles are created close to the tracking detectors

Other sources are supposed to be negligible (beam dump, synchrotron radiation, radiative Bhabhas)

- energy loss of the beams (few %)
- production of large number of photons in the IP
- blowup of the beam spot



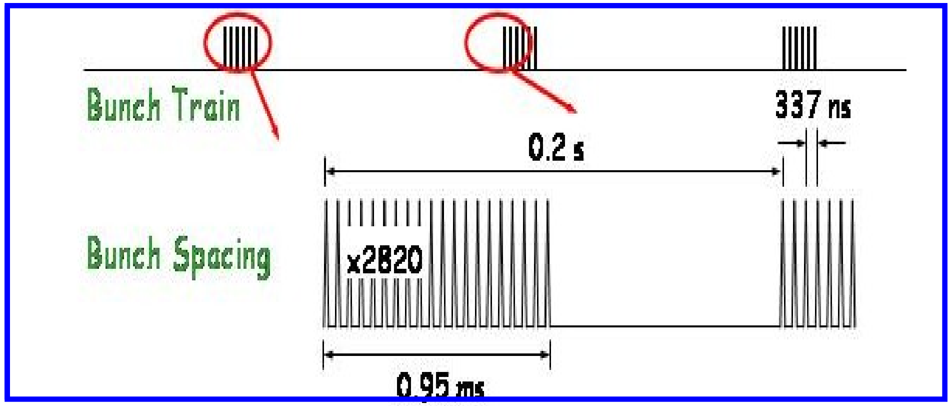


Pair induced background for 2 and 20 mrad crossing angle: very preliminary !!

Bunch Train Timing

It drives the electronics design from the Front-End to the DAQ

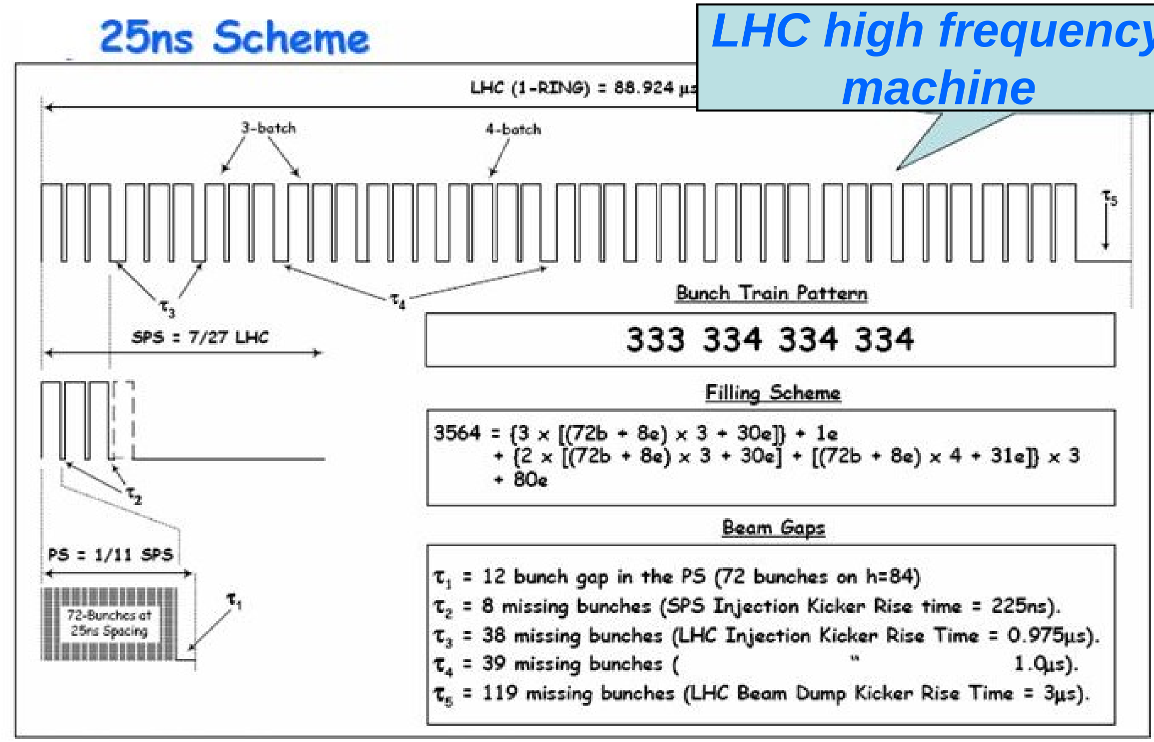
ILC low frequency machine



CLIC case:

Rep. Rate (Hz)	**150**
Bunches / pulse	**220**
Bunch spacing (cm)	**8**

240 ps/bunch, train duration =53 ns
6 ms in between pulse



LHC high frequency machine

Common feature at ILC &LHC:
bunch tagged FE electronics
(more difficult with CLIC!)
Possibility of ***power cycling*** at ILC

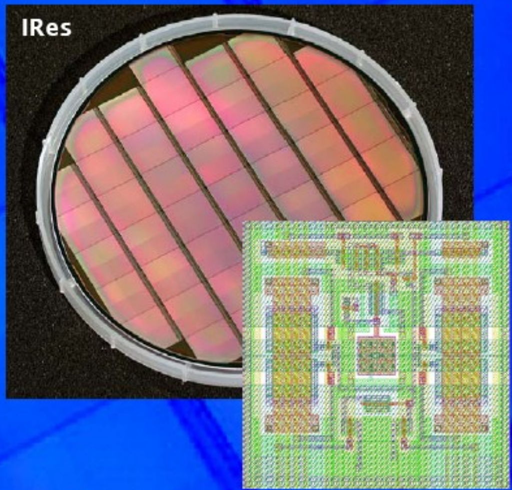
New pixel Technologies for Microvertex

CMOS

Integrate **sensitive cell and electronics in same substrate**

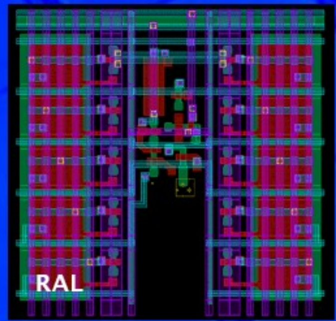
Various architectures developed:

Continuous Read-out:
Fast Column Parallel Architecture

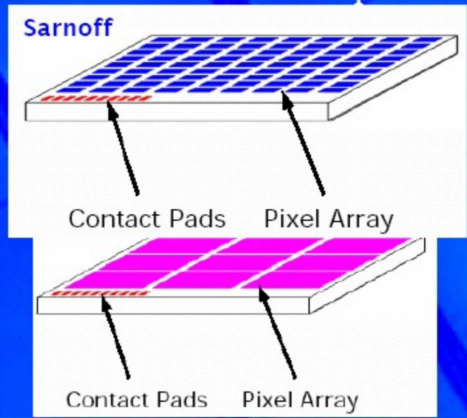


Delayed Read-out

Multi-memory Cell Pixels (FAPS)



Micro-Pixels
Macro-pixels



Beamstrahlung constraints:
(very preliminary thus be cautious with these nbs!)

<5hits/cm2/BX at 90°
(R0=15mm, 4T)

Impact on readout speed:

<25μs in L0

~50μs in L1 (R1~25mm)

Ionising damage

<50 kRad/yr

SOI

CMOS electronics

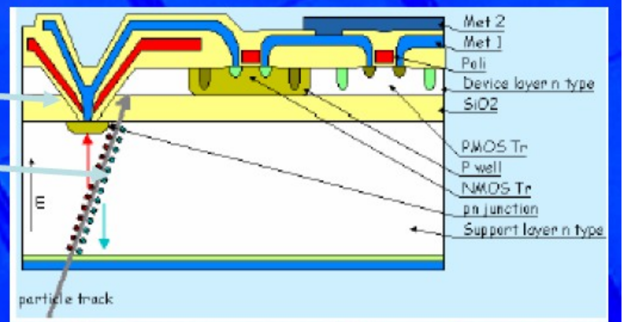
High resistivity fully depleted sensitive volume

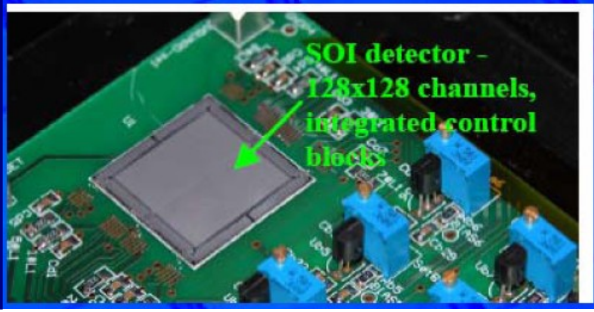
Not standard process

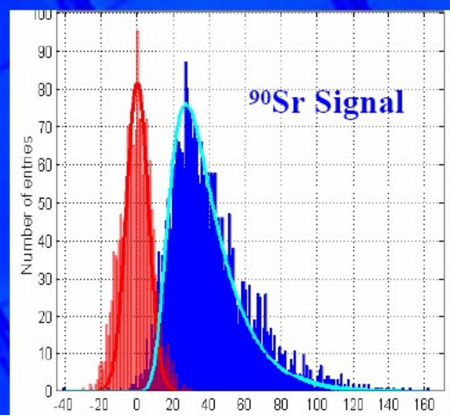
Development started 3 years ago

Proof of principle accomplished

ILC dedicated development being defined with partner company



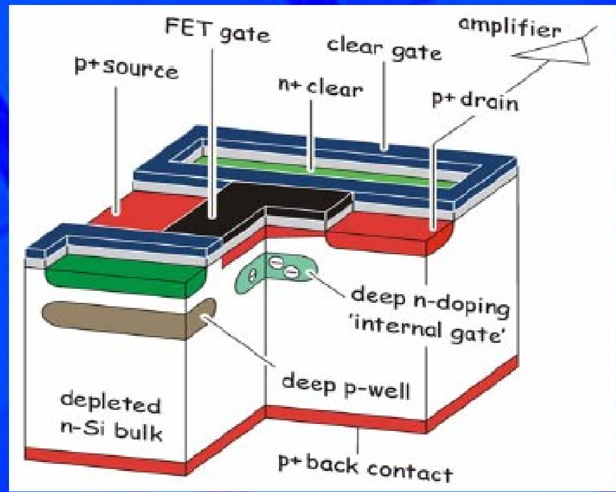




DEPFET Sensors

Europe, Bonn U., Mannheim U., MPI Munich, HLL (Germany)

DEPFET sensor-amplifier structure:
FET transistor on fully depleted and sensitive bulk;

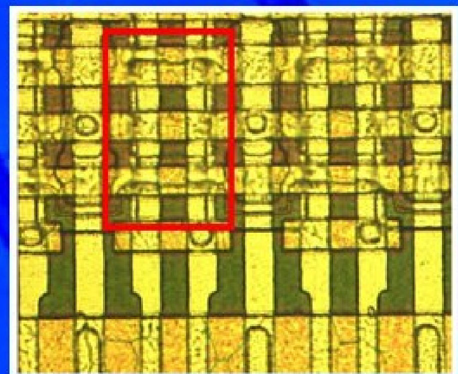


Small size, thick prototypes produced in MPI laboratory with complete silicon technology, **in house capability** to build all ILC VTX sensors;

Prototype Module electronics with nearly full functionality developed and tested with prototype sensors;

Readout and data sparsification with 20 frames/train;

Micrograph of prototype sensor
(128x64 pixel, double pixel cell 33 x 47 μm^2)



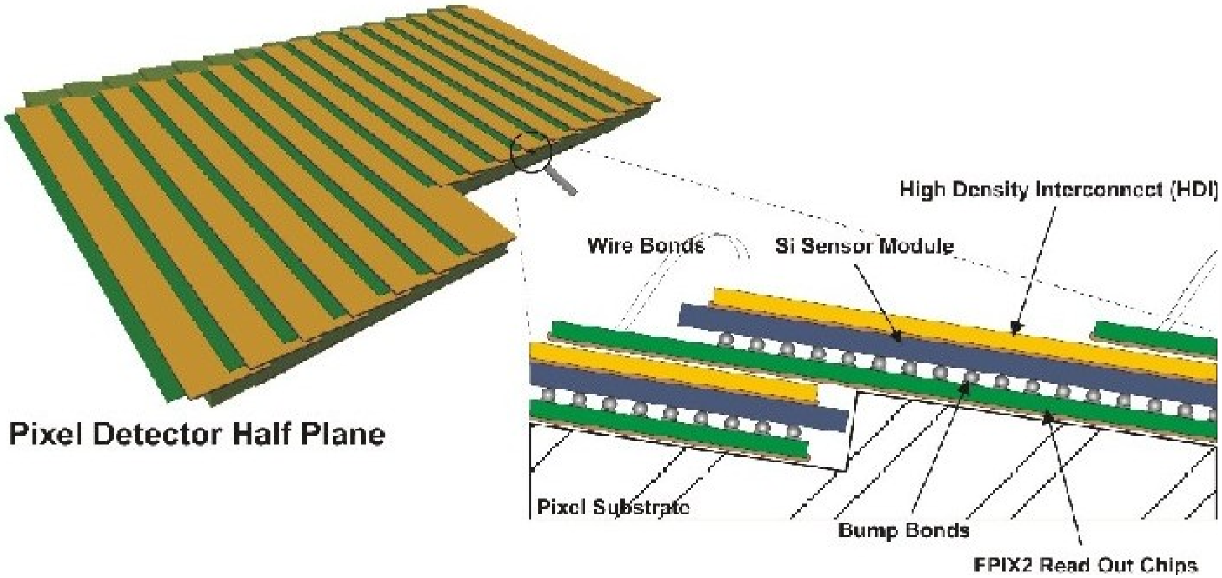
Radiation hardness to 1 Mrad ^{60}Co tested,
expect good neutron tolerance;

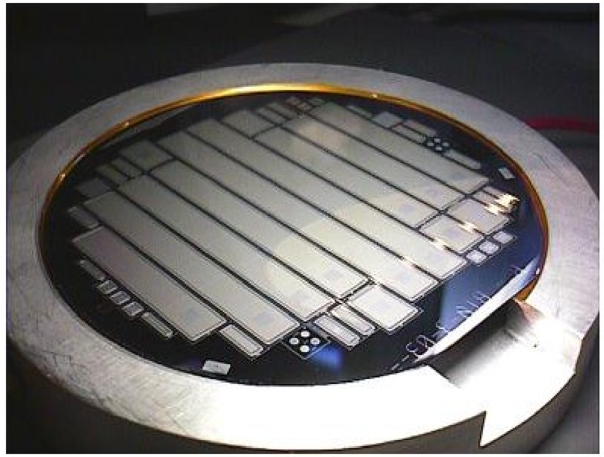
L**ow power consumption** (4W for full detector)
operate at **room temperature** with air flow cooling;

Operation of small size prototypes demonstrated;

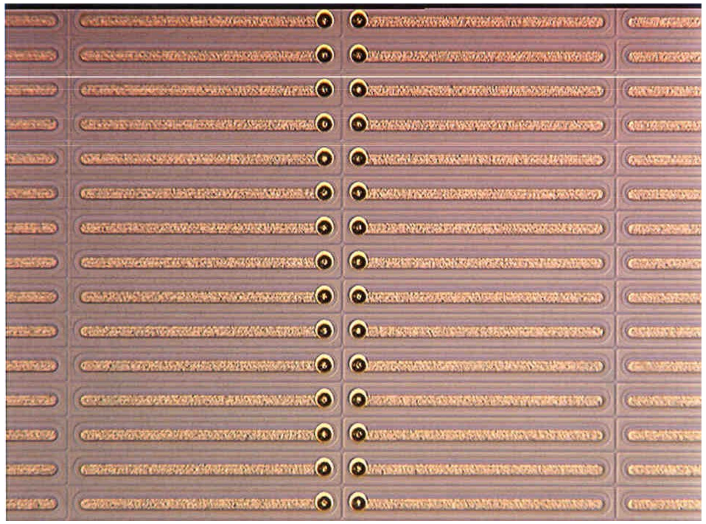
Current R&D to obtain fully engineered and tested system.

Hybrid Pixels: BTeV technology





Two types of bump-bonding technology are under investigation: indium and flux-less solder. Indium has been used so far on the prototype devices. We have started bench tests of solder bumped hybrids. Both technologies appear to have acceptable yield and robustness.



BTeV pixel detectors cont'd