Instrumentation of the very forward region at future linear colliders

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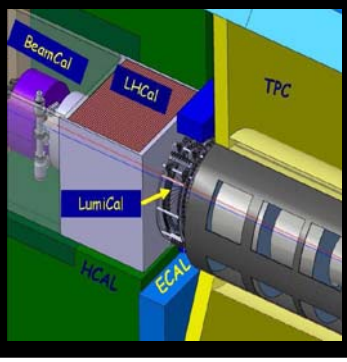
- Requirements for very forward region at future linear colliders (ILC / CLIC);
- high precision in luminosity measurement (10^{-3} for nominal ILC, 10^{-4} for ILC GigaZ, 10^{-2} for CLIC) → **LumiCal**;
- very forward angular coverage (below 10 mrad) & background rejection for SUSY searches → **BeamCal**.

→ **Precision in measuring Bhabha scattering events;**
- high accuracy in mechanical construction and alignment of LumiCal;
- high accuracy for polar angle & energy reconstruction; → fine granularity in LumiCal sensors required.

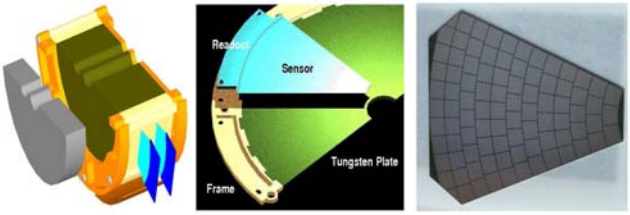
→ **Beamstrahlung at high energy e^+e^- colliders;**
- severe background of e^+e^- pairs → doses to BeamCal of several MGy/year → radiation hard sensors required (GaAs / CVD diamond);
- monitor collision parameters by measuring e^+e^- pairs in BeamCal & possibly also with a Pair-Monitor.

Very forward region of the ILD detector



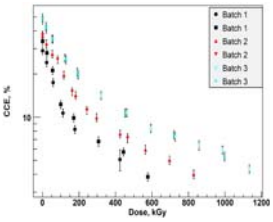
BeamCal mechanical design & sensor material

- Two types of sensor materials are considered: **GaAs** (most of BeamCal) and **CVD diamond** (the innermost part, adjacent to the beam-pipes).



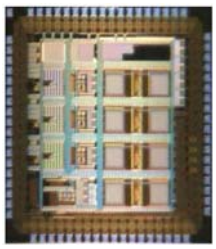
- Left: A half-cylinder of BeamCal; tungsten absorber (brown), interspersed with sensor layers; mechanical frame (orange); front-end electronics (blue); upstream graphite shield (gray). **- Middle:** A half-layer of an absorber disk assembled with a sensor sector and the front-end read-out. **- Right:** GaAs sensor prototype (~0.3 cm^2 pads).

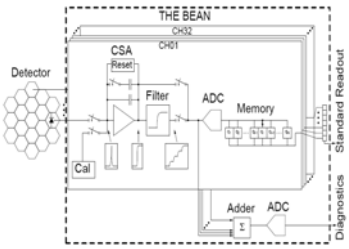
- Charge collection efficiency (CCE) for **GaAs** sensors; the CCE is larger for lower donor concentrations (Te for batches 1 and 2 and Sn for batch 3).



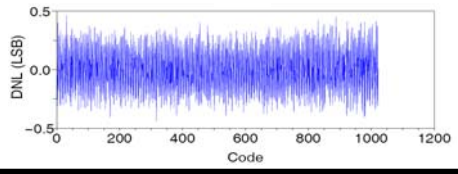
BeamCal readout

- Instrumented **ASIC**.



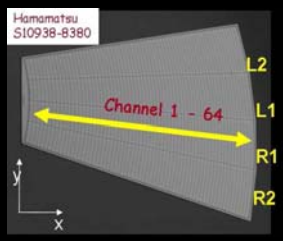


- ADC **Differential Nonlinearity**.

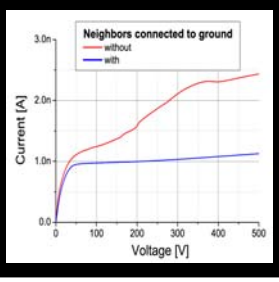


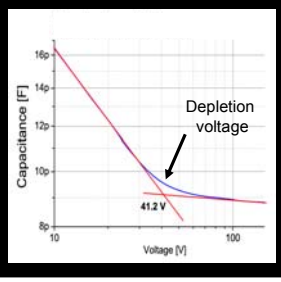
LumiCal sensors

Sensor prototype;
- high-ohmic n-type silicon, 300μm thick;
- p^+ side segmented in the polar and azimuthal directions; backside fully metalized;
- pads connected using a Kapton PCB; thin copper strips lead the signals to the FE electronics, positioned at the outer radius of the calorimeter.

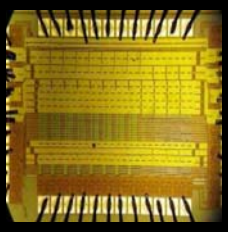


- I-V **(left)** and C-V **(right)** measurements for a single pad.

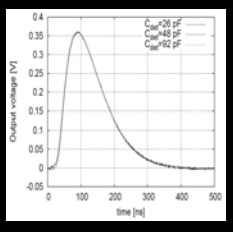


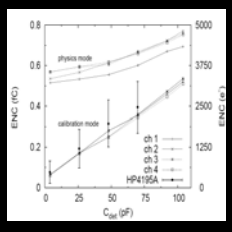


- Prototype of a 0.35 μm LumiCal CMOS **FE ASIC**.

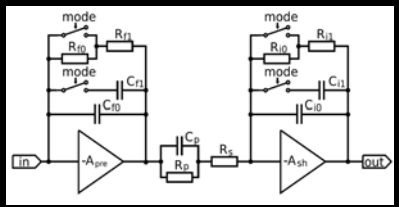


- FE Output pulses in physics mode (**left**) and **equivalent noise charge** (**right**) as a function of input capacitance.

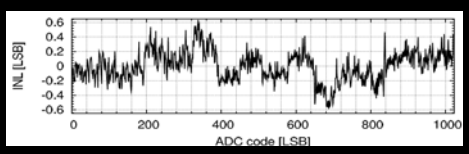


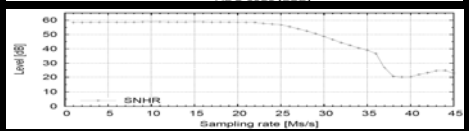


LumiCal readout

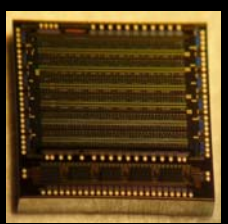


- Block diagram of a single front-end channel. Possibility for a "physics" and a "calibration" mode.



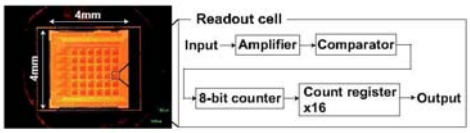


- ADC **Integral Nonlinearity** (INL) and **signal-to-noise ratio**.



- Prototype of a 0.35 μm LumiCal CMOS **ADC ASIC.**

Pair-monitor readout



- **Readout ASIC** and schematic diagram of the circuit in a readout cell.