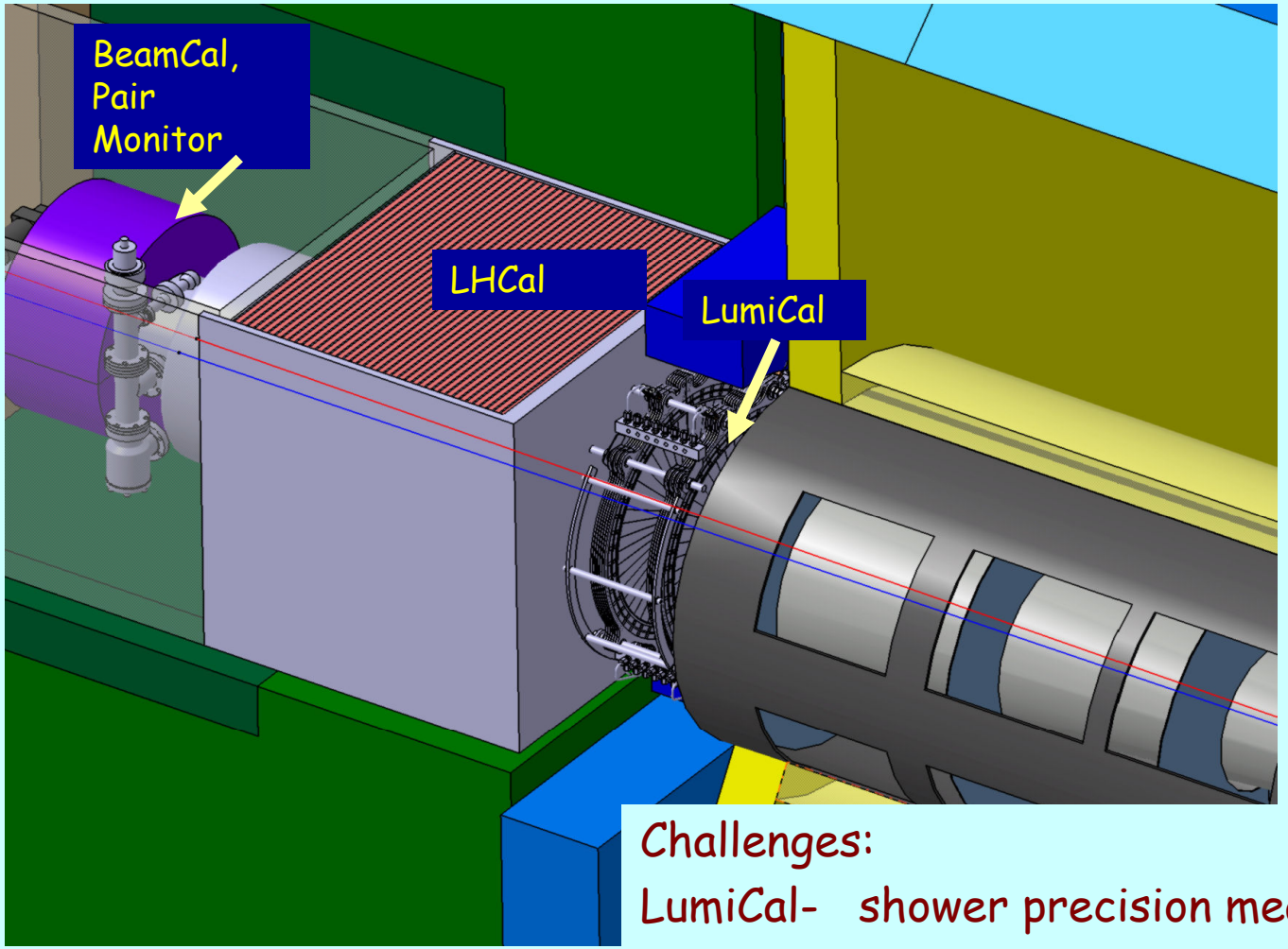
Forward Region Instrumentation

Wolfgang Lohmann

DESY

On behalf of the FCAL collaboration

Forward Region, ILD Detector



Challenges:

LumiCal- shower precision measurement

BeamCal – radiation hardness

Both - fast readout

Content

Recent Developments:

- Sensor Prototyping
- ASIC Development and Test
- System test

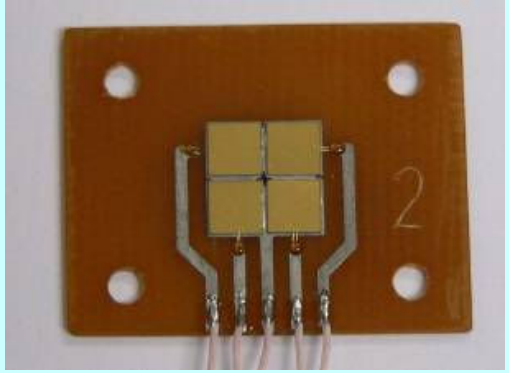
BeamCal Sensors, GaAs

- n-type (Te or Sn - shallow donor) GaAs grown by Liquid Encapsulated Czochralski (LEC) method in Siberian Institute of Physics and Technology (Tomsk, Russia)
  low-ohmic material, filling the electron trapping centers EL2+
- Cr (deep acceptor) diffusion
-> high-ohmic

Thicknesses 150 – 200 μm

Metallization:
V (30 nm) + Au (1 μm) from both sides

Irradiation in a 10 MeV electron beam, Doses up to 1.1 MGy

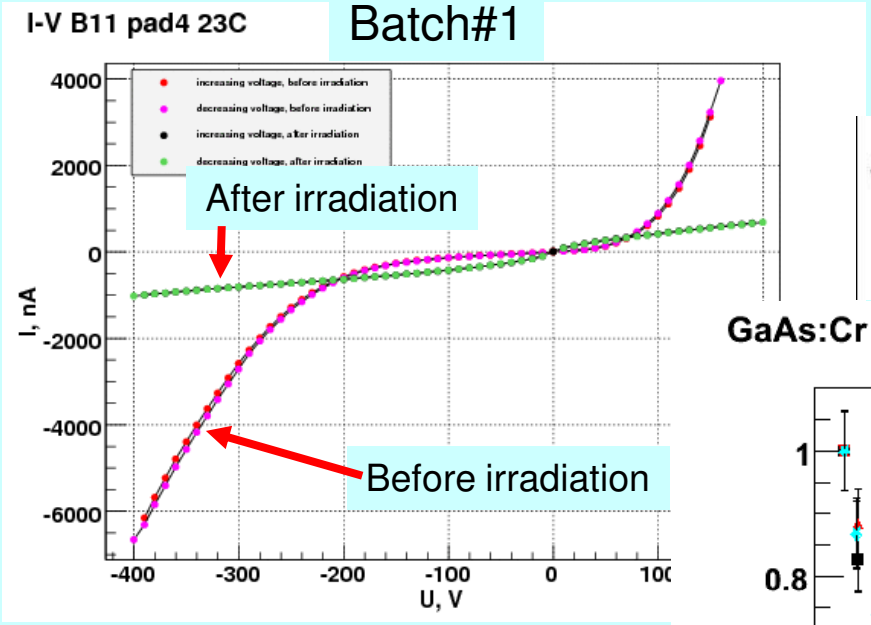


Initial n-GaAs	Fabrication method
№1, n ≈ (1 -1.5)*10^{17} $см^{-3}$,Te	Diffusion of Cr under temperatureT2
№2, n ≈ (5 - 6)*10^{16} $см^{-3}$, Te	Diffusion of Cr under temperature Tm
№3, n ≈ (1 - 3)*10^{16} $см^{-3}$, Sn	Diffusion of Cr under temperature T1
№4, n ≈ (2 - 5)*$10^{16}$$см^{-3}$, Te	p-ν-n- structure*

Notice T1 < Tm<T2.

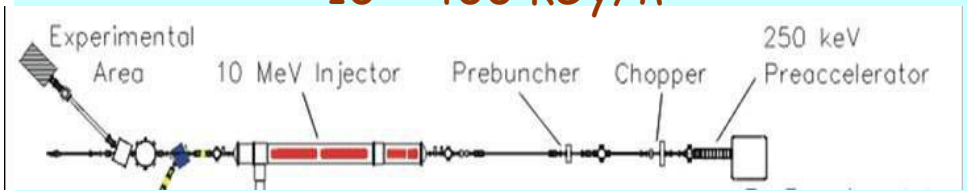
* - presence in the detector n- type low-resistance domain, all other detectors №1, 2, 3 had structure m-i-m: metal- insulator (high-resistance GaAs) –metal.

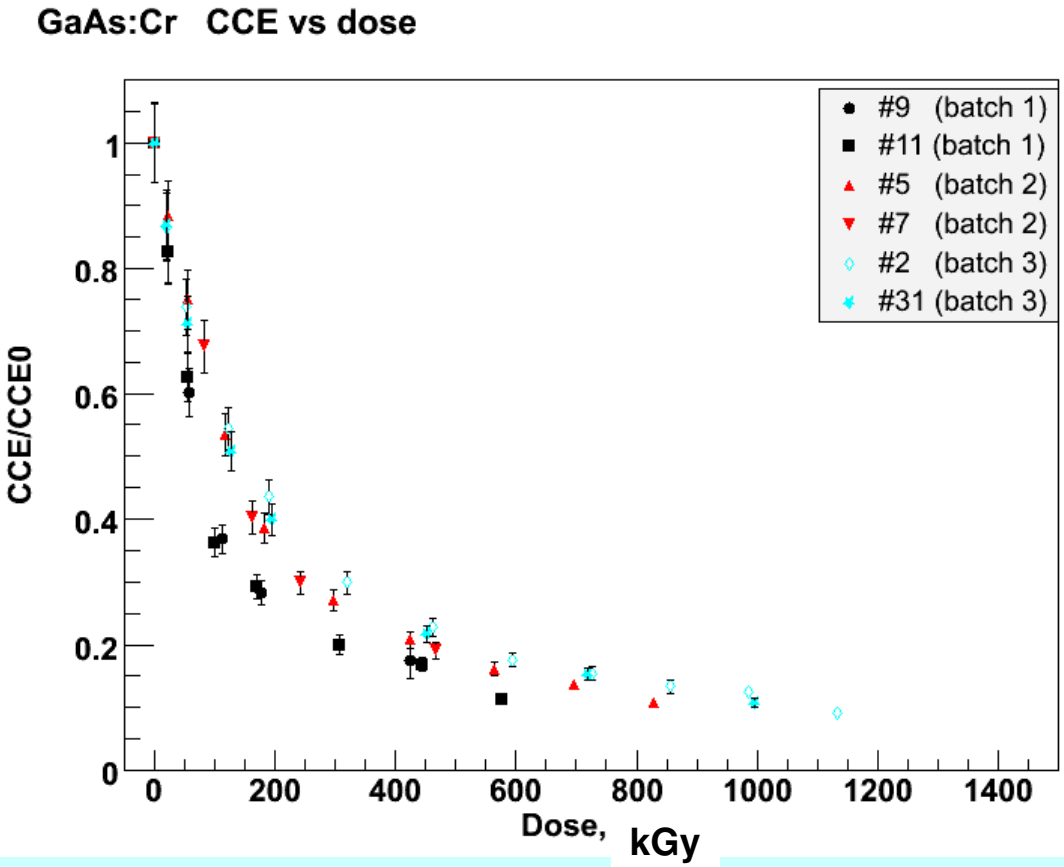
BeamCal Sensors, GaAs



Irradiation with an 10 MeV electron beam (DALINAC, TU Darmstadt)

10 – 400 kGy/h





Up to 500 kGy a mip signal is clearly seen

Sensors with a lower concentration of shallow donor and Cr as deep acceptor show better rad. tolerance

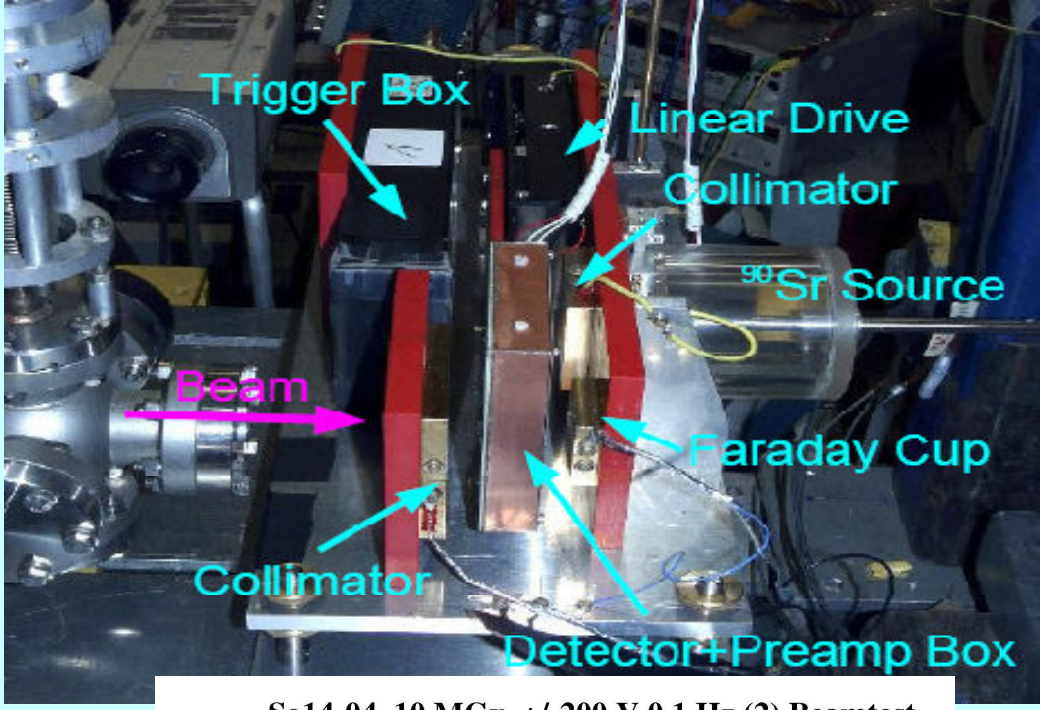
BeamCal Sensors, Diamond

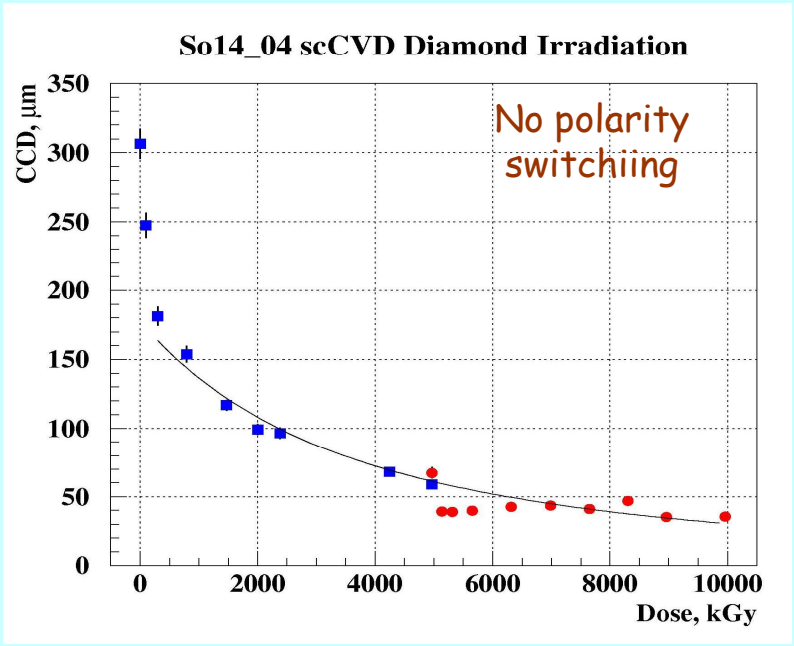
sCVD diamond (E6), 5x5x0.3 mm^3

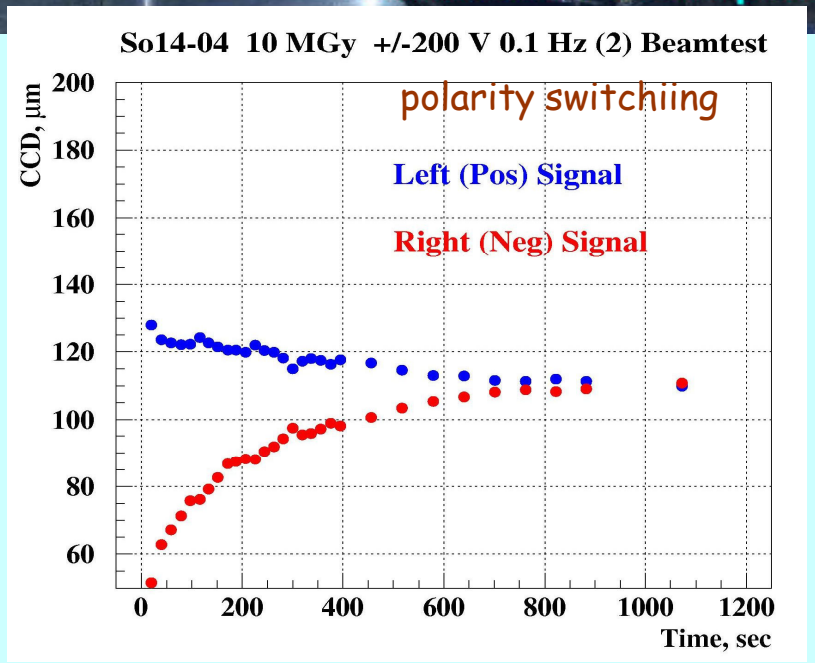
Irradiated in 2007 up to 5 MGy

2008: up to 10 MGy

New set-up, for switching polarity during the measurement







BeamCal Sensors, Sapphire

Band gap: 9.9 eV

(diamond: 5.5 eV, Si: 1.12 eV

Single crystal, 1x1 cm2,

cut 001

Wafer: 30 cm diameter)

Metallisation:

50/50/200 nm Al/Ti/Au

Ratio of the detector and Faraday cup currents

Charge collection efficiency: few %

~ 30 % of the initial charge collection efficiiency after 12 MGy

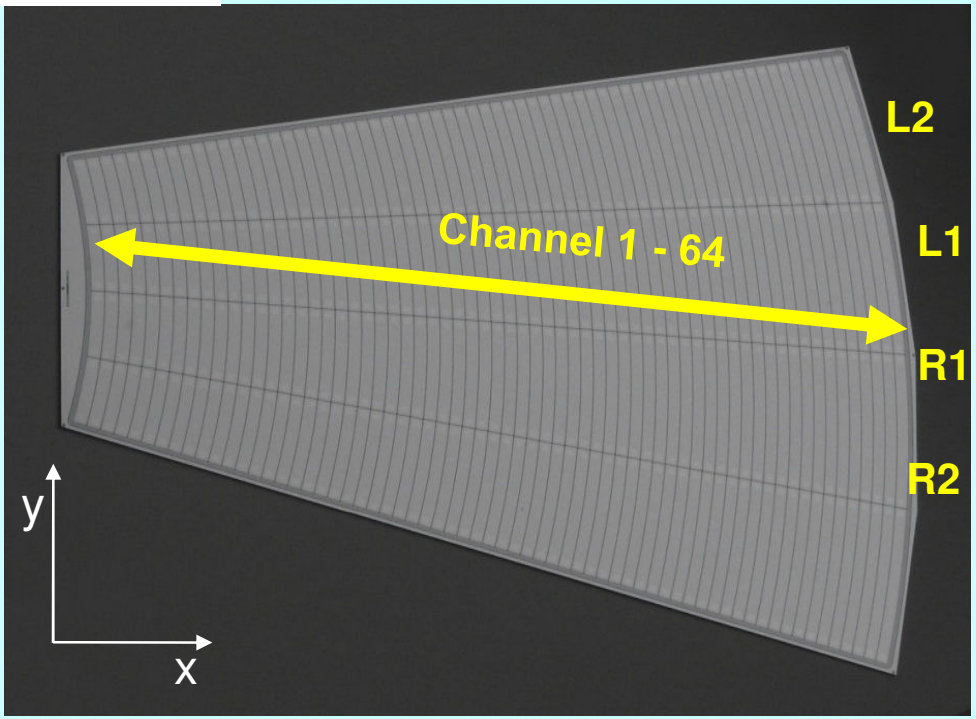
Sensor prototypes (LumiCal)

"Cracow-Design"

- High resistivity n-type Si
- 1,7mm p+ - strips
  with an Al-metallization
- Backplane: n+ implant
  and an Al-metallization
- 3 Guard rings

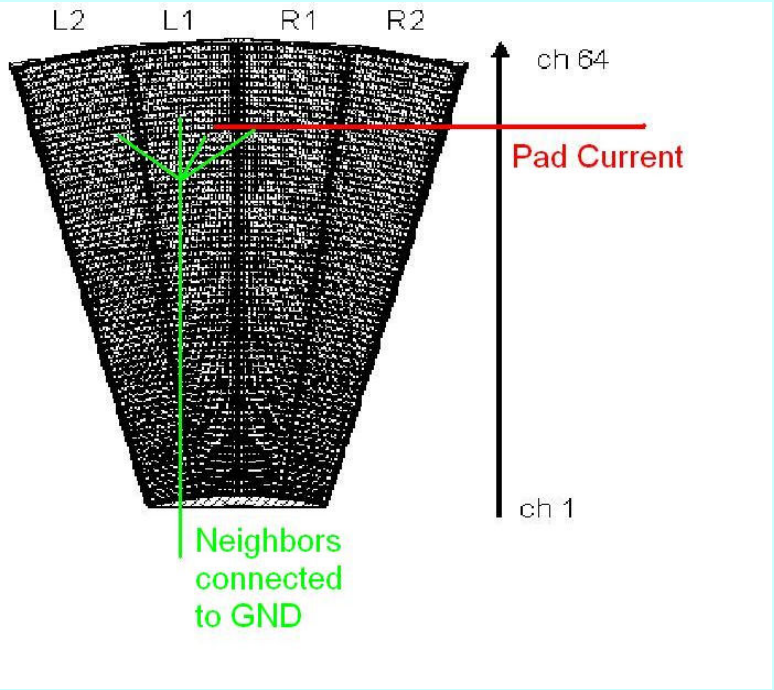
x-Size = 10,8cm
y-Size = 4…12cm
(6 Inch Wafers)

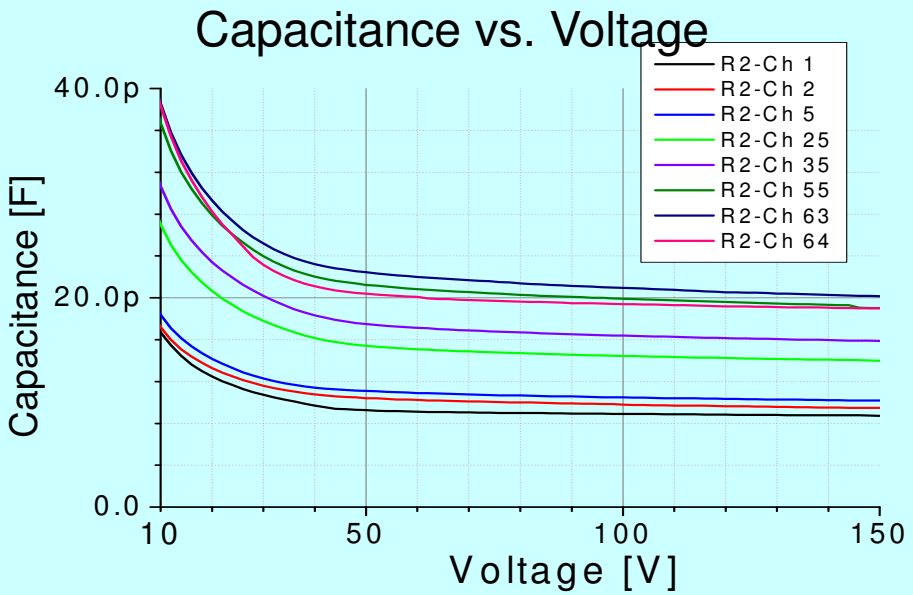
Hamamatsu
S10938-8380

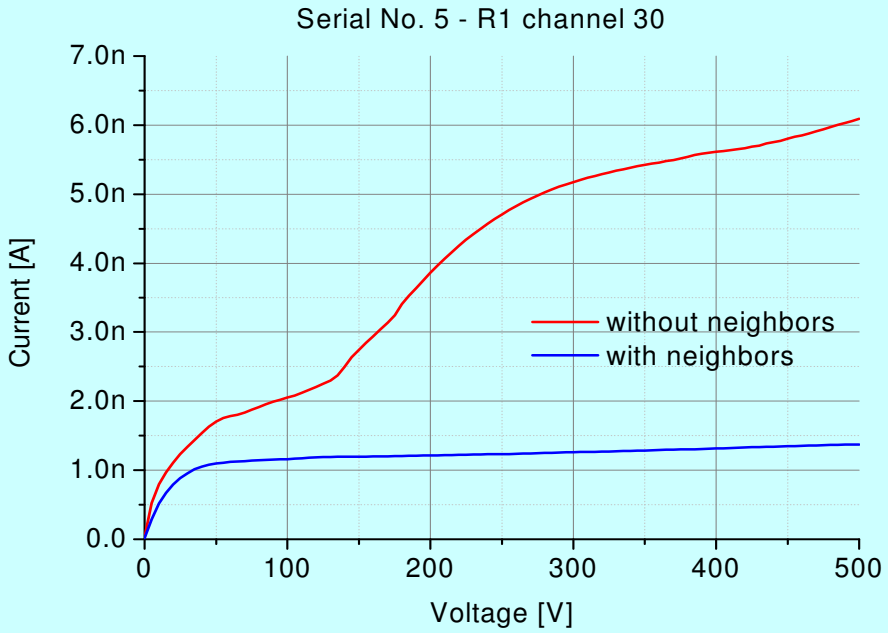


I(V) and C(V) measurements on Probe-stations in Tel Aviv, Cracow and DESY

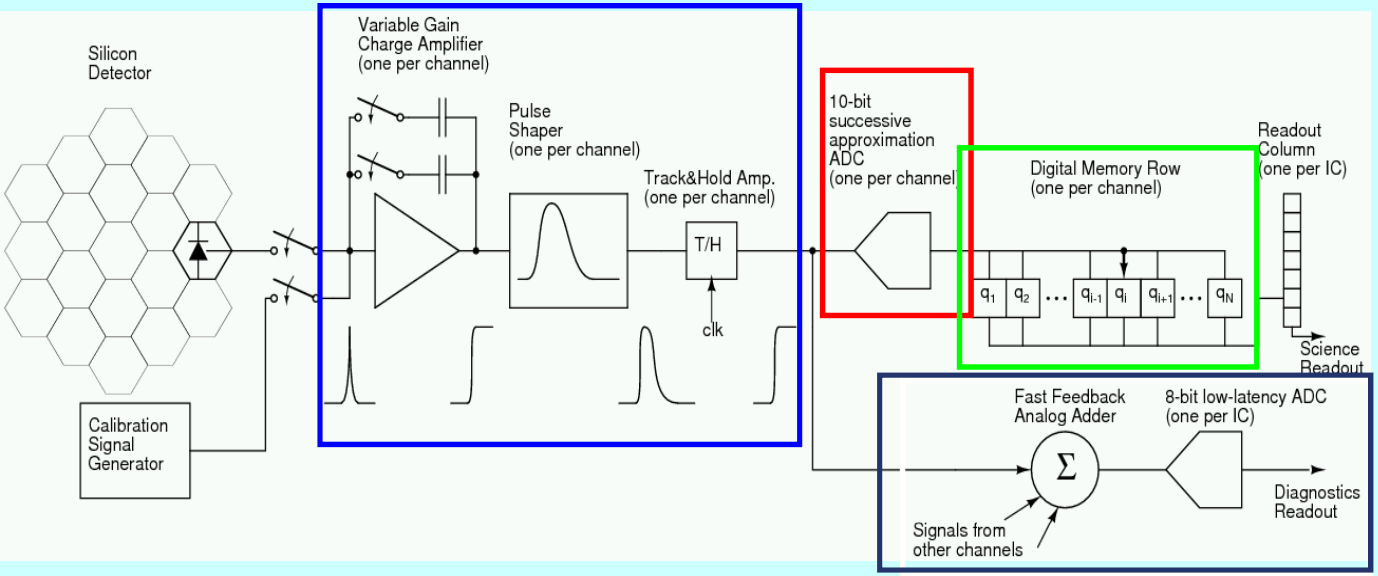
Sensor prototypes (LumiCal)







ASIC development, BeamCal

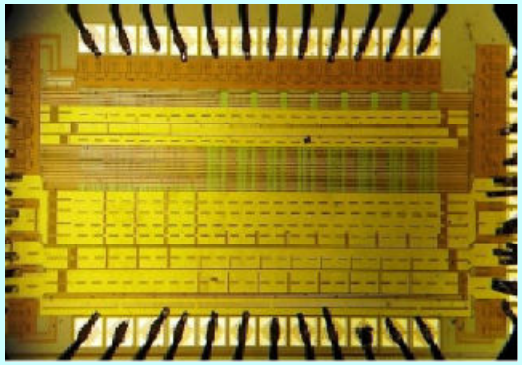


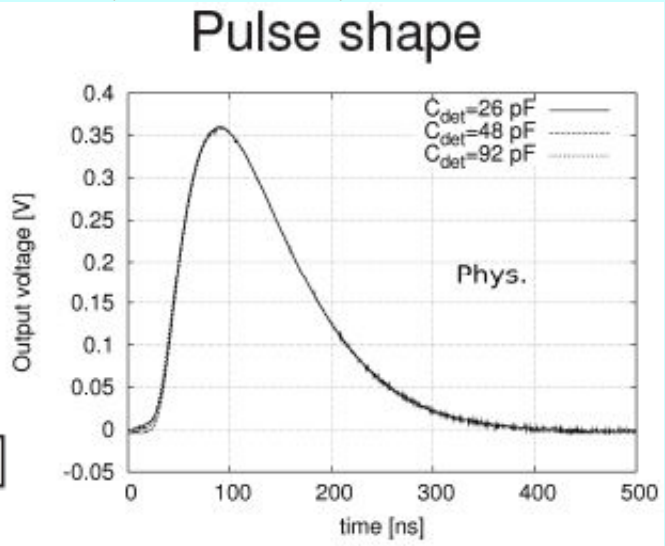
Design of a 32 channel prototype currently ongoing, First prototypes (smaller number of channels) will be ready in December

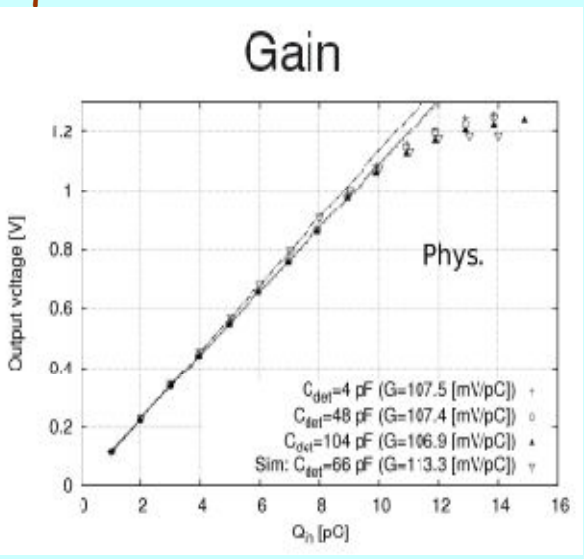
- Dual gain charge amplifier
  switchched capator filter
- ADC ASIC 10 bit successive approximation ADC (3.25 MS/s)
- Additional 8 bit low latency output (beam diagnostics

ASIC development, LumiCal

8 channel preamplifier ASIC, lab tests, matches the requirements







- $\mathrm{Noise}_{phys}[aC] = 522 + 2.08 \cdot C_{in}[pF]$
- $\mathrm{Noise}_{cal}[aC] = 48 + 4.65 \cdot C_{in}[pF]$

Power consumption per channel: 8.9 mW

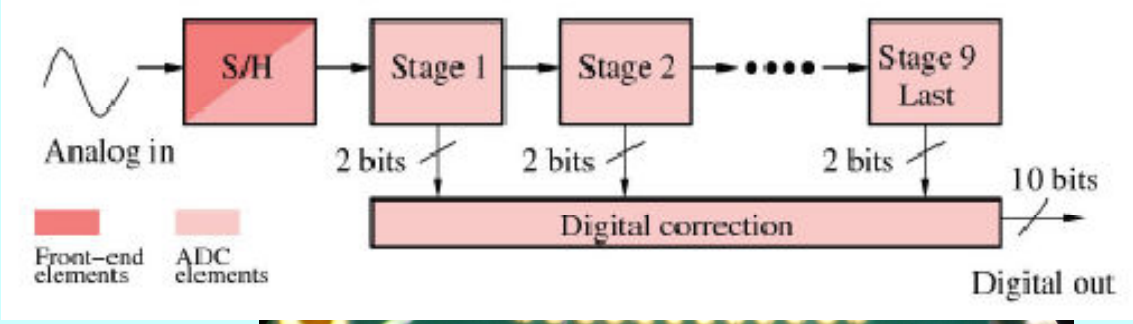
Mode	Gain [mV/fC]	Noise@50pF [fC]	Linearity [pC]	Rate [MHz]	Crosstalk [%]
Physics	0.107	0.62	10	3	≈1
Calibration	≈20	0.28	0.035	2.5	≈0.1

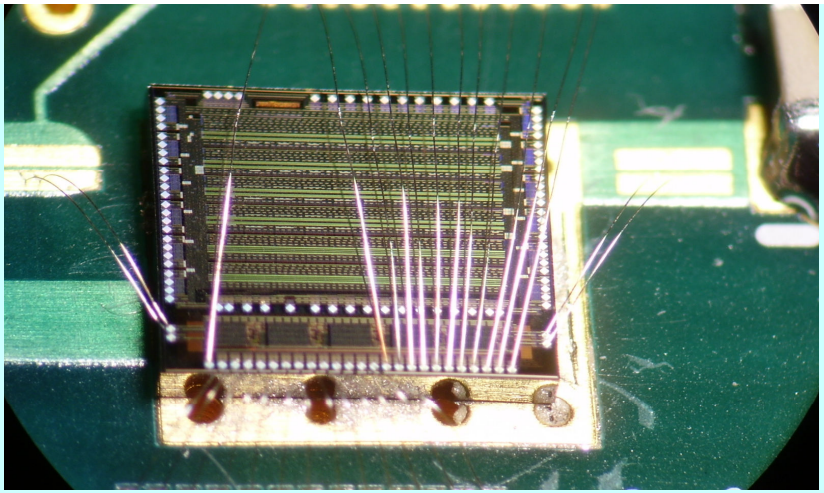
Ready for tests with sensors!

- Design of assembly with a sensor
- Test in the lab and testbeam
- Redesign after these tests

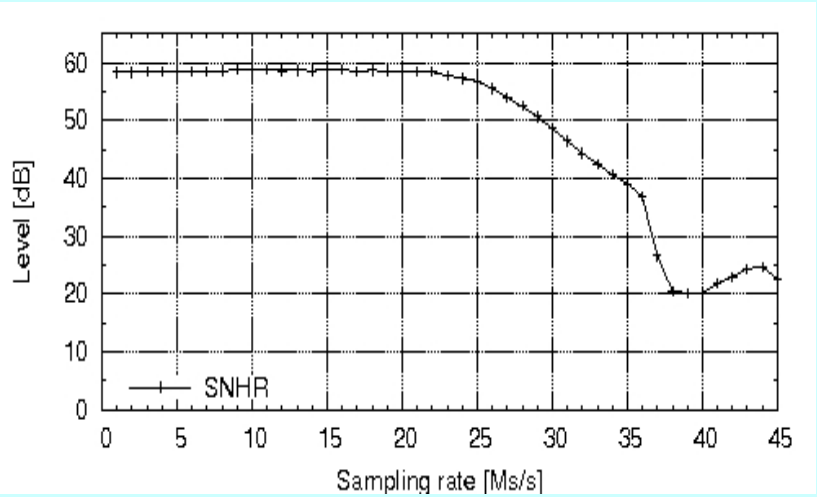
ASIC development, LumiCal

One channel ADC ASIC (differential pipeline architecture)

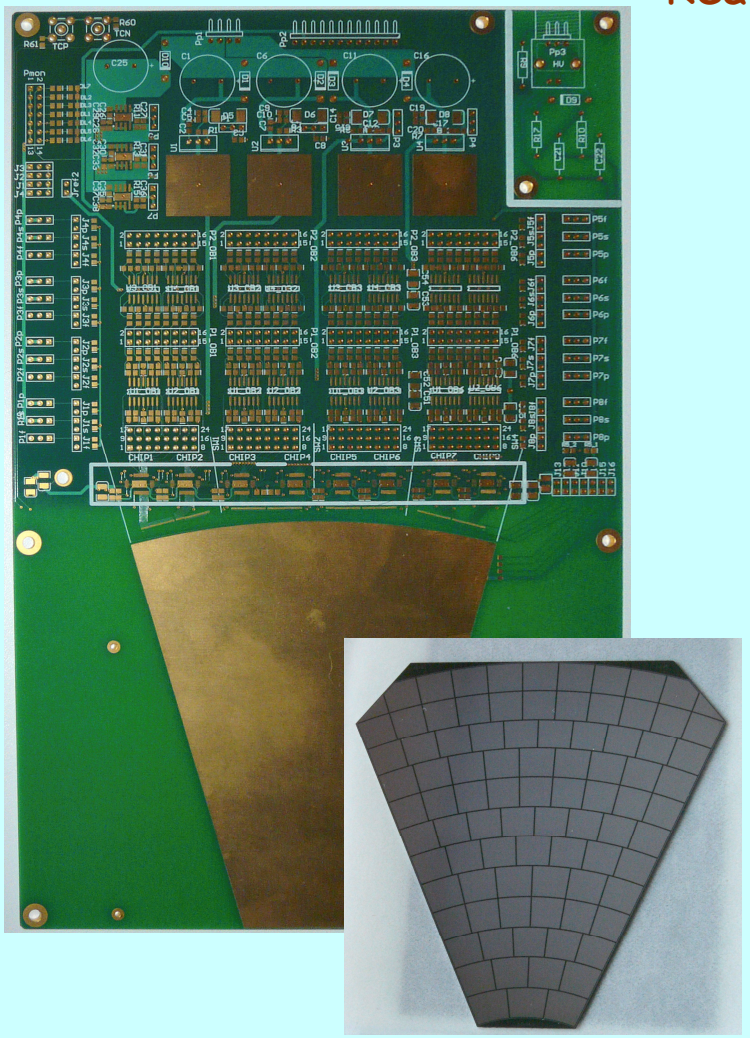




- New 10 bit ADC fully functional
- Stable operation up to 25 MHz
- Good static performance (DNL, INL, ENOB)
- Dynamic measurements just started
- Clock and power switching tests
- Preparation of a multichannel version



System Test in a beam

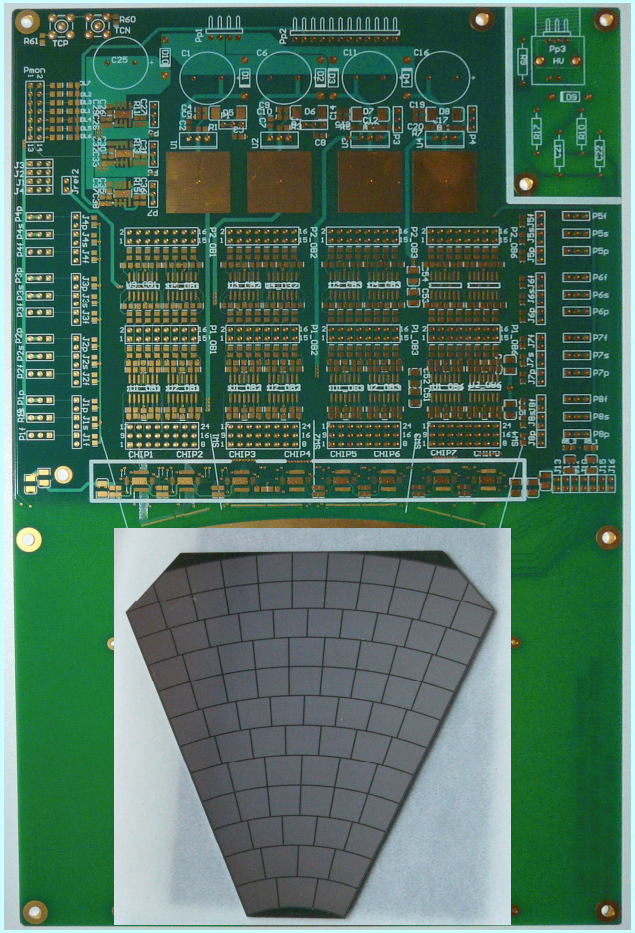


Template of a readout board, to be instrumented with FE ASICS

Readout/Fanout of sensors

- fine pitch PCB, (100…200μm for current few channel FE chips)
- flexible PCB to be designed. matters of crosstalk & capacitive load
- wire bonding or bump bonding to pads (wire bonding needs ~ 3mm gap between absorber tiles; conductive glueing also discussed)
- wire bonding to FE chip
- Silicon and GaAs sensor samples

System Test in a beam



Template of a readout board, to be instrumented with FE ASICS

Readout/Fanout of sensors

- state of the art fine pitch PCB, (100…200μm for current few channel FE chips
- matters of crosstalk & capacitive load
- wire bonding or bump bonding to pads (wire bonding needs ~ 3mm gap between absorber tiles; conductive glueing also discussed)
- wire bonding to FE chip
- Silicon and GaAs sensor samples
- Beam test planned 2010

Conclusions

- Investigation of the radiation hardness of GaAs, diamond and Sapphire up to 10 MGy. No baseline material for BeamCal so far

  diamond: too expensive

  GaAs : rad. tolerant up to 1 MGy

  Sapphire: studies just started

- Prototytping of Si sensors for Lumical successful
- FE ASICS ready for test with sensors
- System test in preparation
- ADC ASICS – prototypes under test

Goal up to 2012: demonstrate the functionality of a sensor plane sector