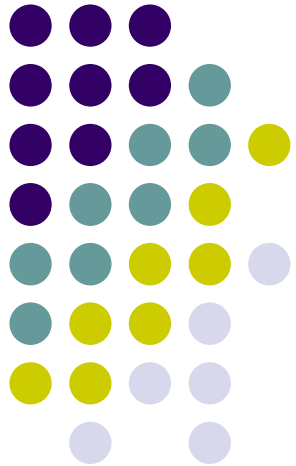
VFCAL task status report

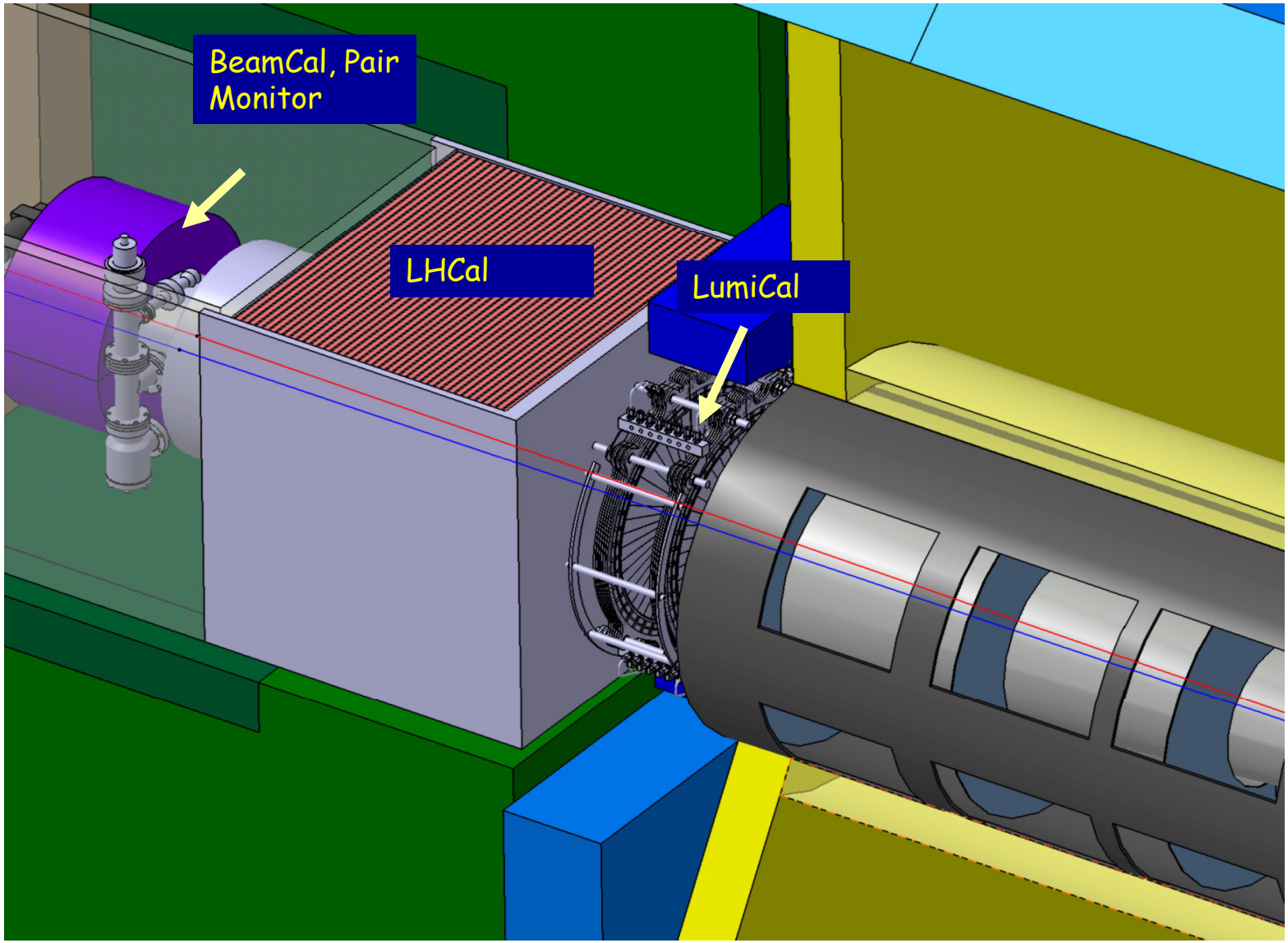
Sergej Schuwalow

DESY

On behalf of the FCAL collaboration



Very Forward Region of the ILD Detector

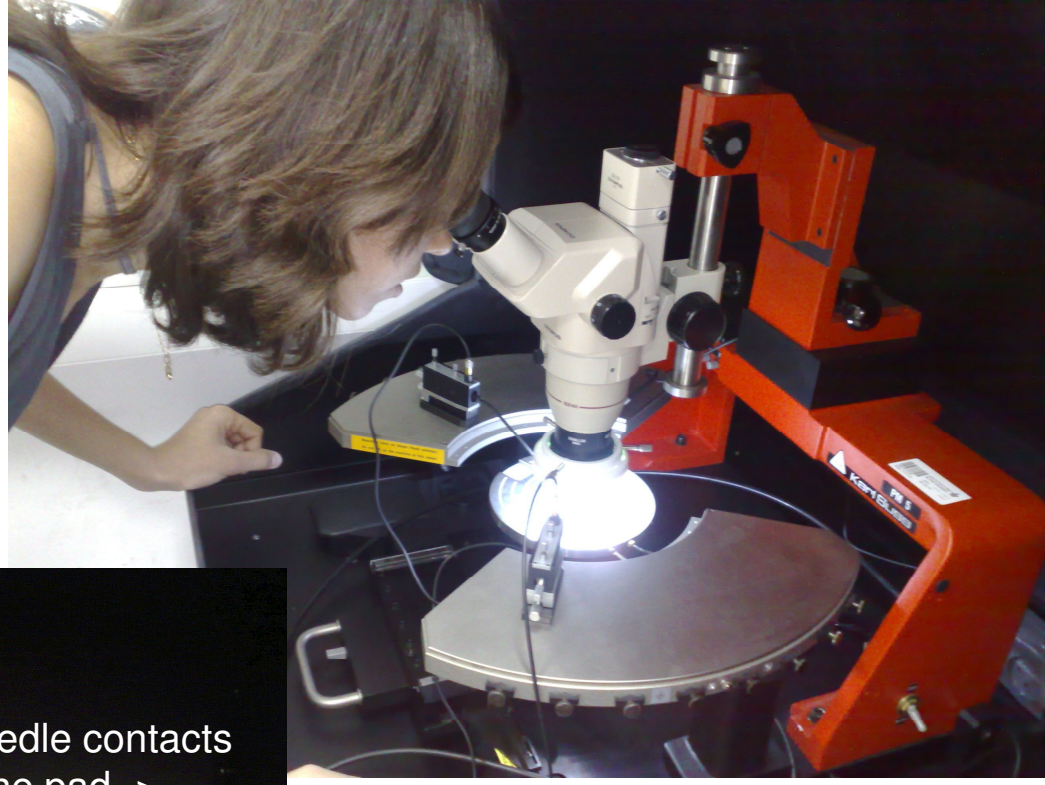


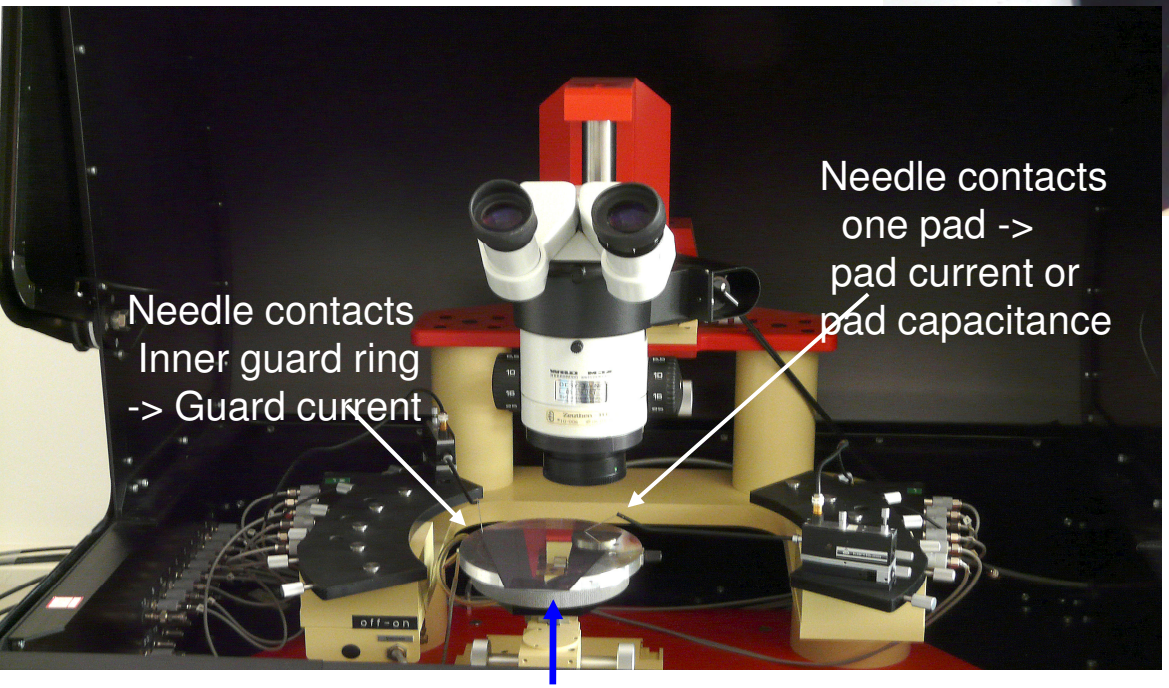
Outline

- Probe stations, tests of LumiCal sensors
- LumiCal ASICS – status, preparation of system tests
- Laser Alignment System
- BeamCal sensor tests in the lab
- High dose sensor irradiation at the beam, new developments
- Test at PITZ, sensor application at FLASH
- System test at the beam (FP7)

Probe Stations

Tel-Aviv University,
see talk of Iftach Sadeh





DESY - Zeuthen

LumiCal Sensor Tests

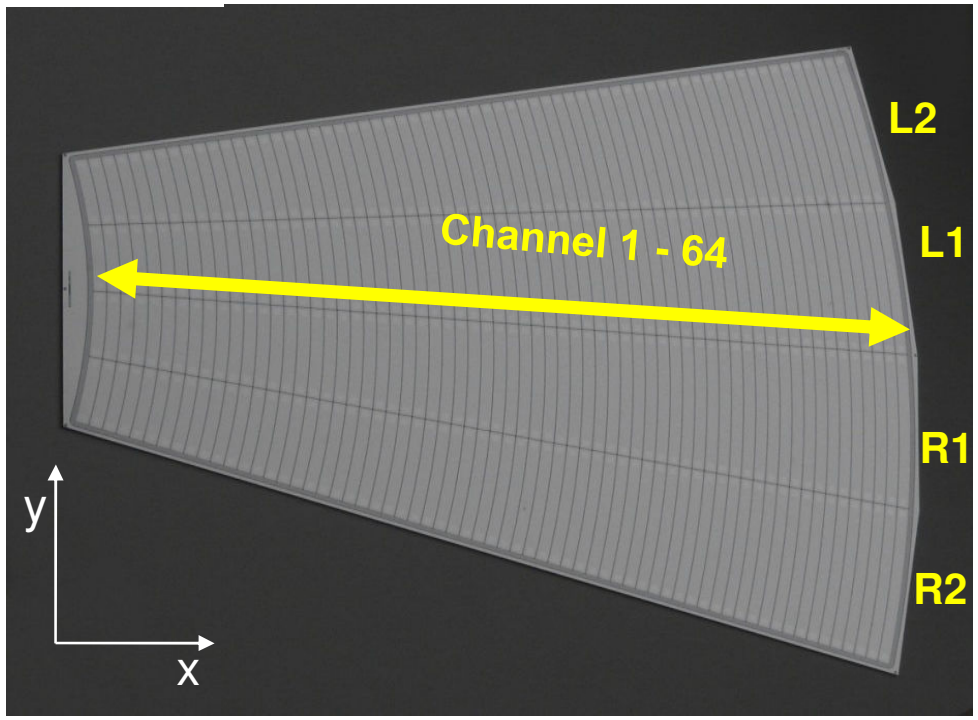
Sensor prototypes (LumiCal, deliverable) – see talk of Leszek Zawiejski

"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

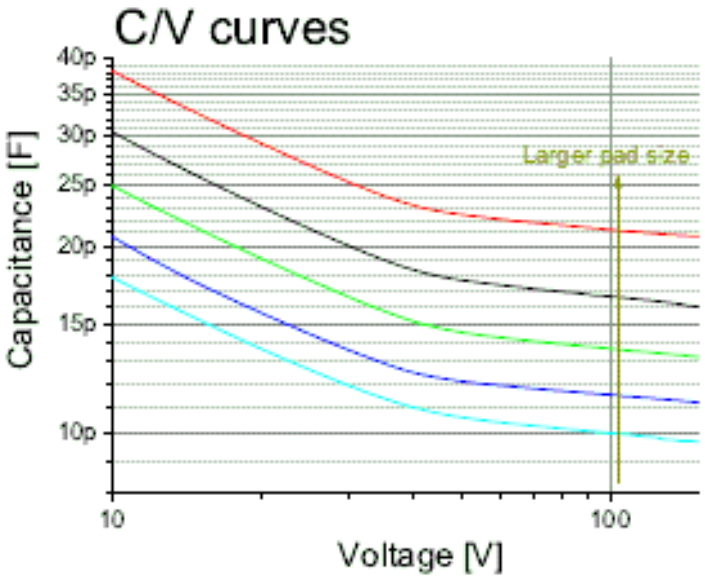
x-Size = 10,8cm
y-Size = 4…12cm
(6 Inch Wafers)

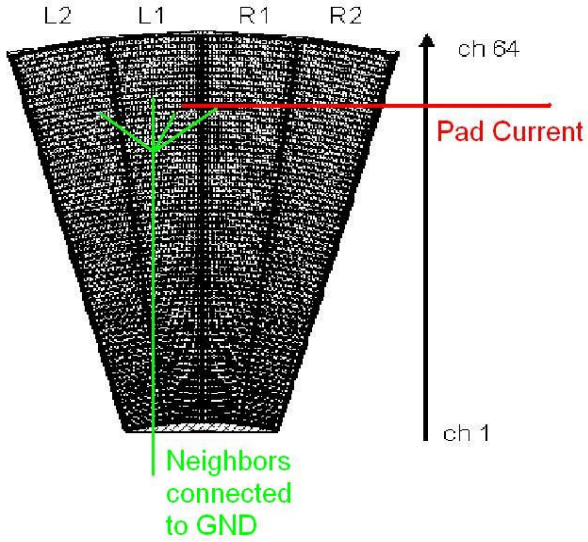
Hamamatsu
S10938-8380

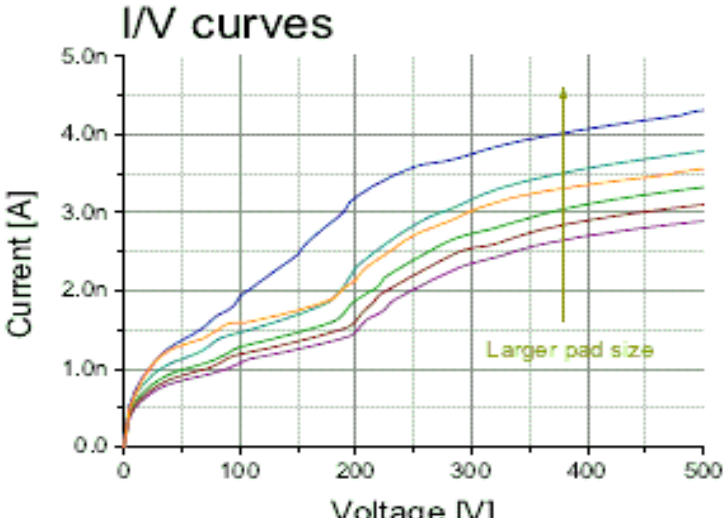


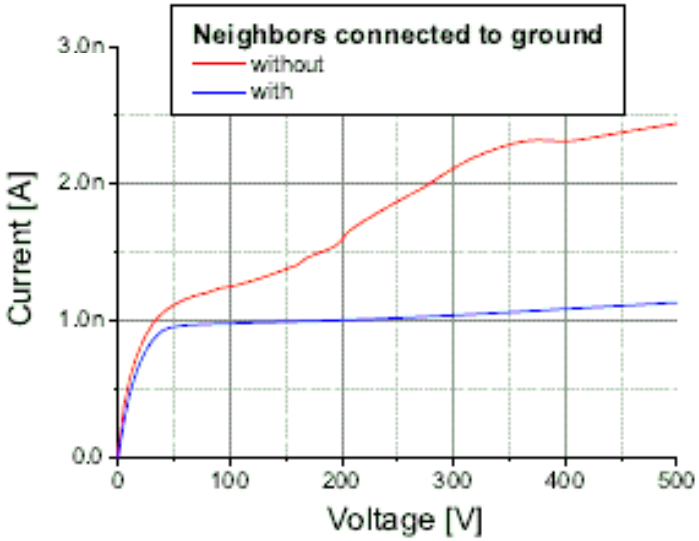
I(V) and C(V) measurements on Probe-stations in Tel Aviv, Cracow and DESY

LumiCal sensor prototype tests





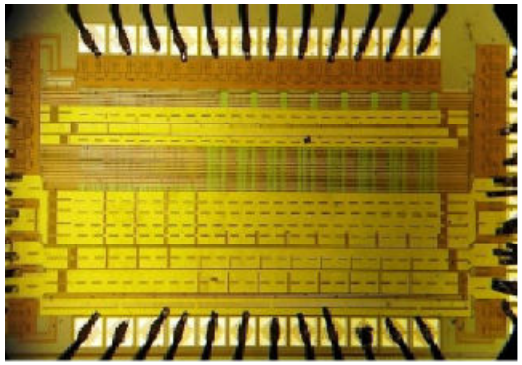




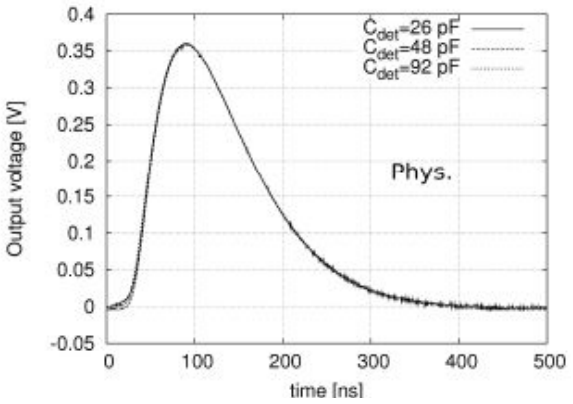
(b) I-V curve for a single pad with and without connected neighbors.

ASIC for LumiCal – see Marek Idzik talk

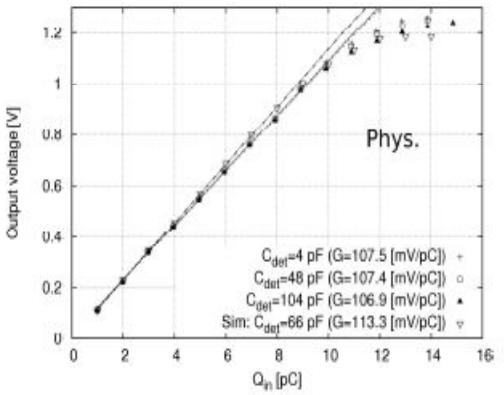
8 channel preamplifier ASIC, lab tests, matches the requirements



Pulse shape



Gain



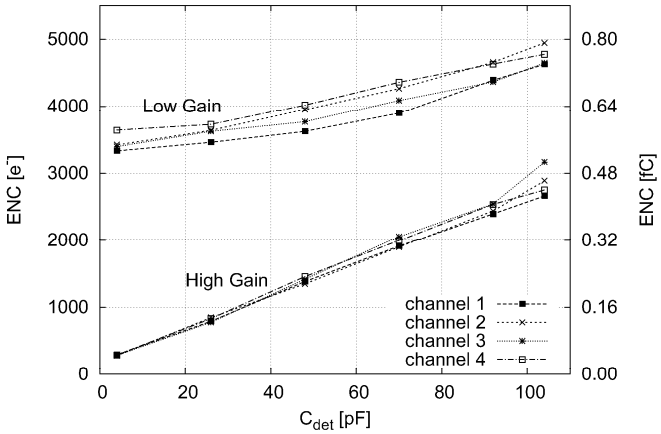
Mode	Gain [mV/fC]	Noise@50pF [fC]	Linearity [pC]	Rate [MHz]	Crosstalk [%]
Physics	0.107	0.62	10	3	≈1
Calibration	≈20	0.28	0.035	2.5	≈0.1

Power consumption: 8.9 mW

Ready for tests with sensors!

- Design of assembly with a sensor
- Test in the lab and testbeam

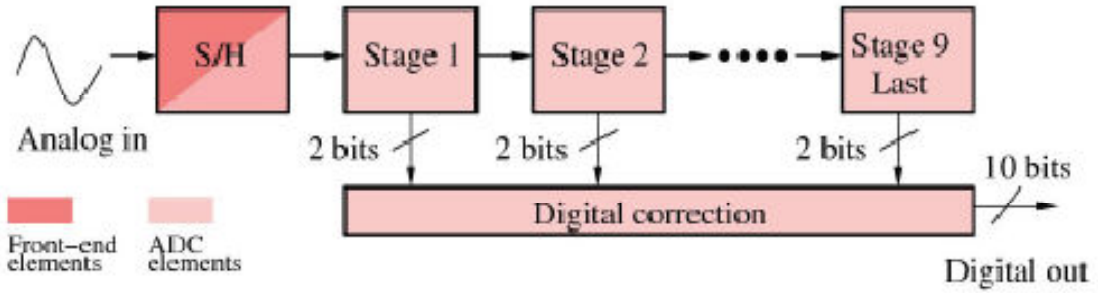
Noise



$Noise_{phys}[el] = 3300 + 13 \cdot C_{in}[pF]$

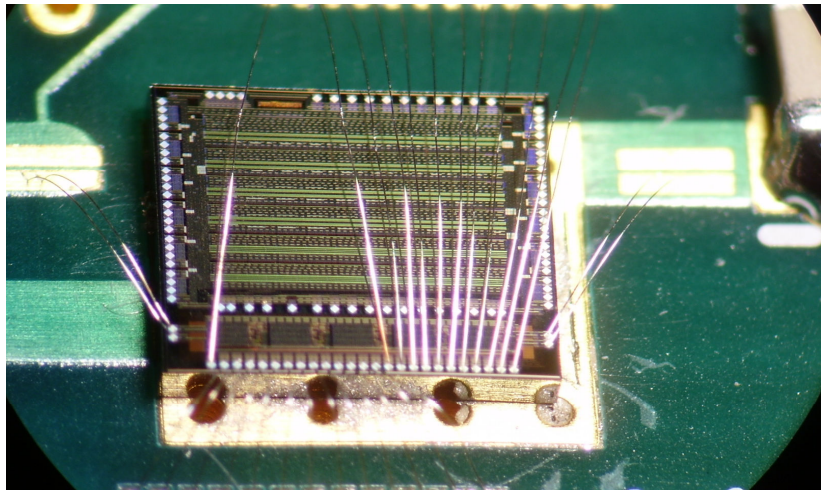
$Noise_{calib}[el] = 170 + 26 \cdot C_{in}[pF]$

ASIC development, LumiCal deliverable, See M.Idzik talk



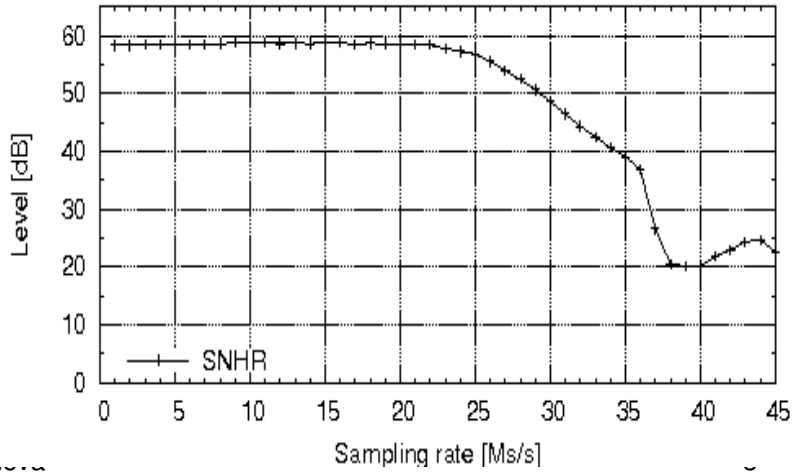
One channel 10-bit ADC ASIC

(Fully differential pipeline architecture)

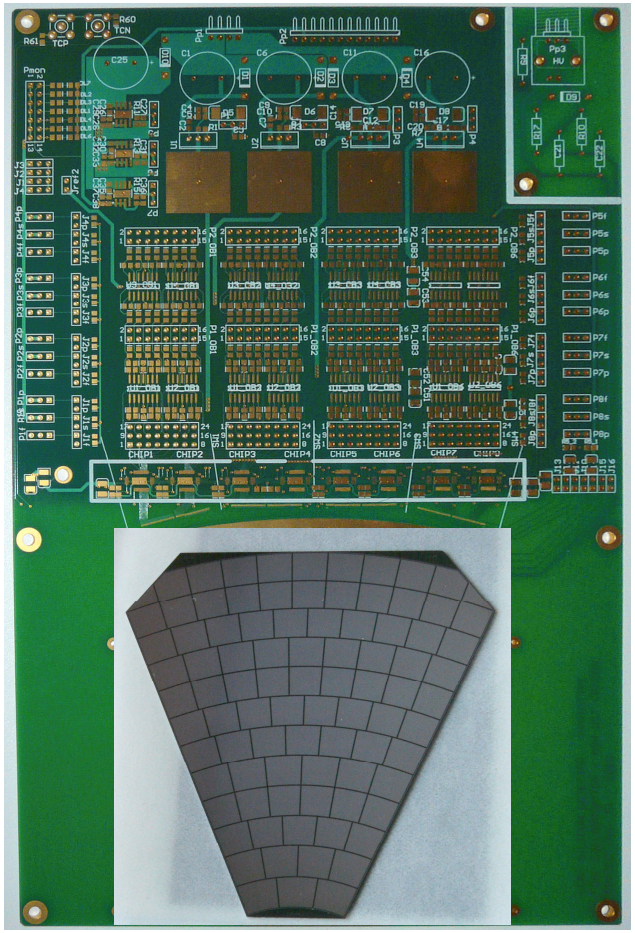


- New 10 bit ADC fully functional
- Stable operation up to 25 MHz
- Good static performance (DNL <0.5 LSB, INL <1 LSB)
- Dynamic measurements just started, SNHR = 58.4 dB (9.4 bits)
- Clock and power switching tests to be done
- Preparation of a multichannel version

SNHR



System Test (Sensors,Fanout,FE electronics)

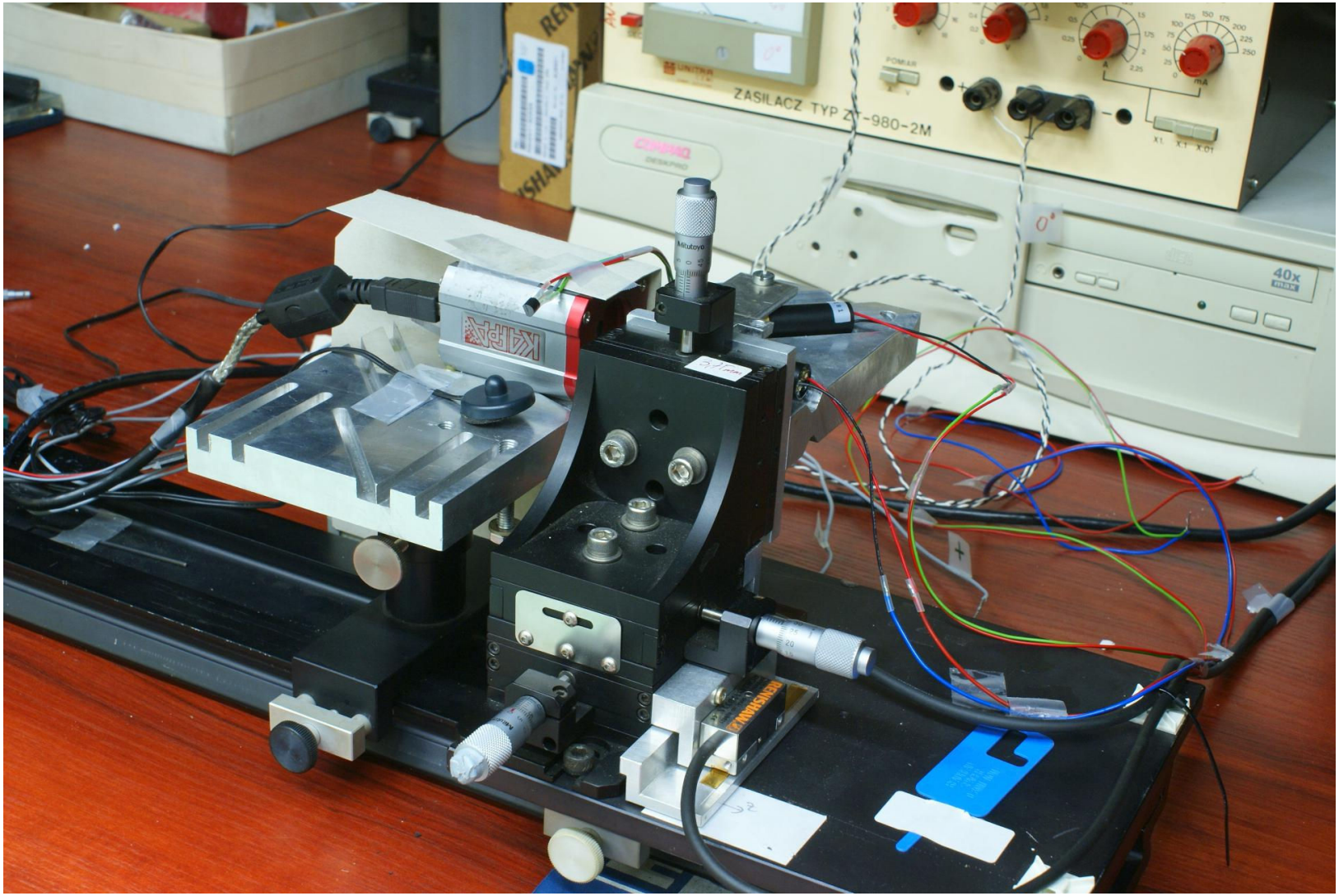


Template of a readout board, to be instrumented with FE ASICS

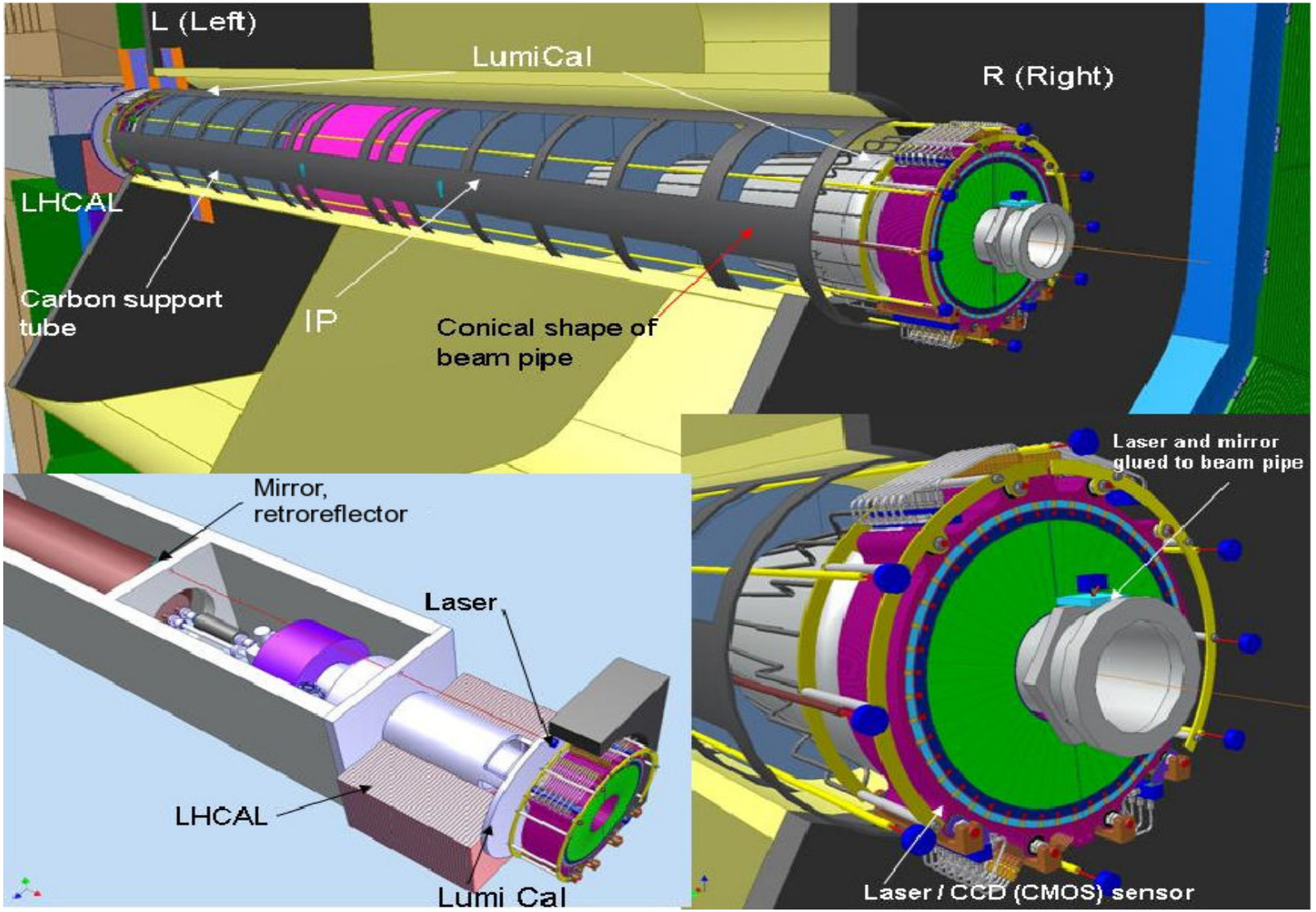
Readout/Fanout of sensors

- 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

Laser Alignment system (LumiCal) prototype

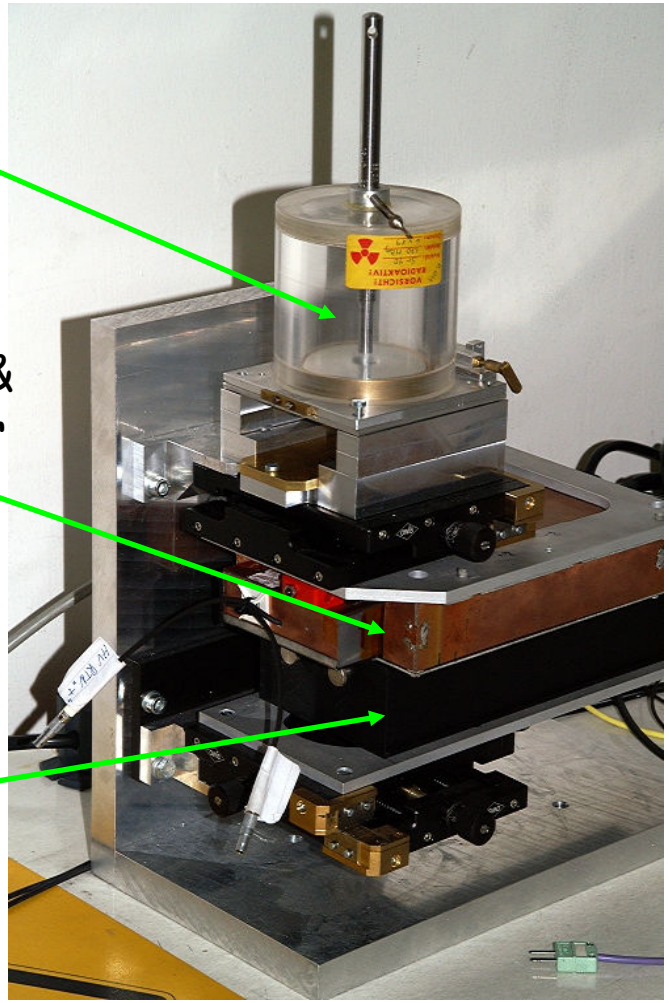


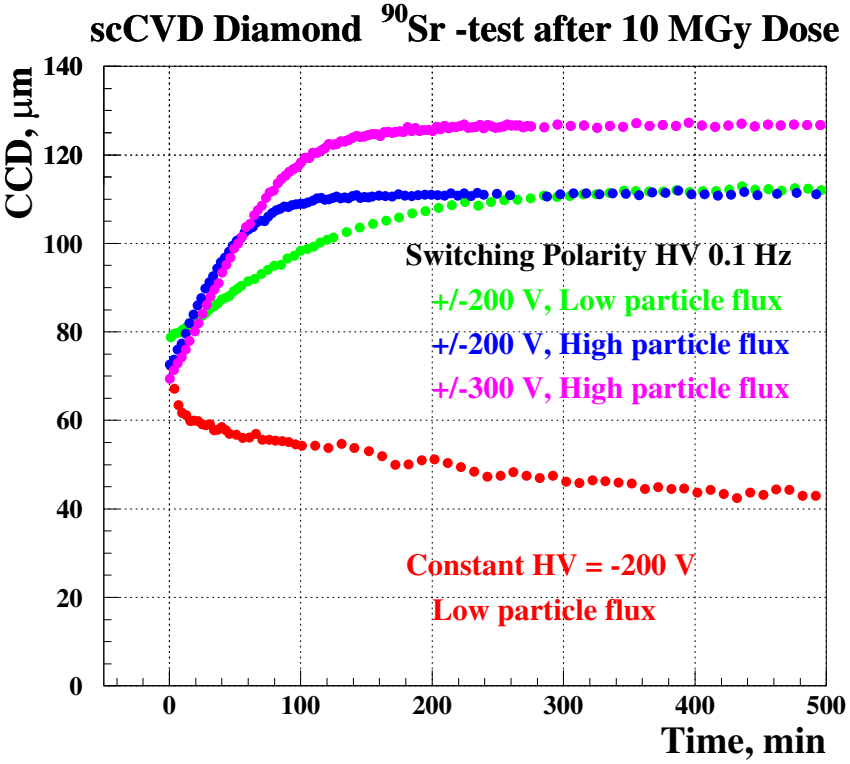
Laser Alignment system (LumiCal)



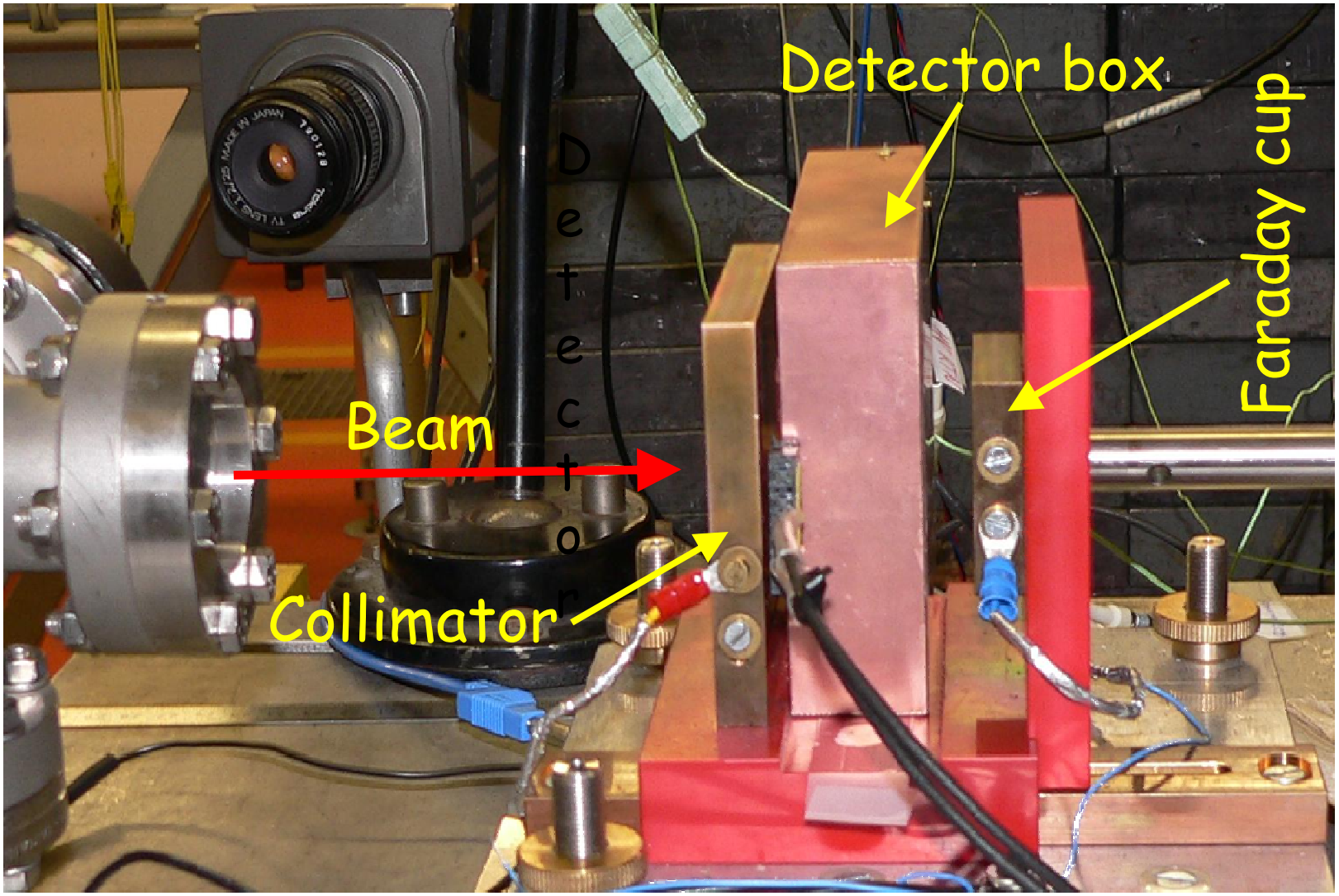
BeamCal sensor tests in the lab

Detailed study of the rad. damaged sensors
Influence of various operation conditions





High dose irradiation at the beam



BeamCal Sensors, GaAs

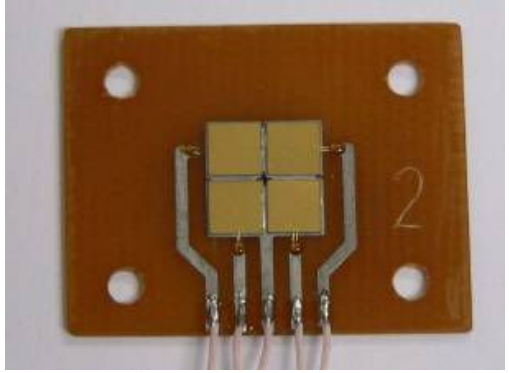
- n-type (Te or Sn - shallow donor) GaAs grown by Liquid Encapsulated Czochralski (LEC) method in Siberian Institute of Physics and Technology (Tomsk, Russia)
- low-ohmic material, filling the electron trapping centers EL2+
- Cr (deep acceptor) diffusion

-> high-ohmic

Thicknesses 150 – 200 μm

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

Irradiation in a 8,5 MeV electron Beam, Doses up to 1.5 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.

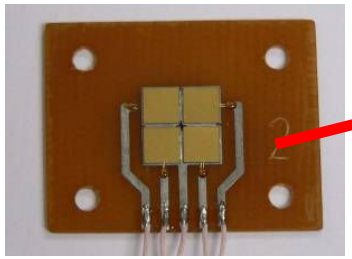
* - presence in the detector n- type low-resistance domain, all other detectors №1, 2, 3 had structure m-i-m: metal- insulator (high-resistance GaAs) –metal.

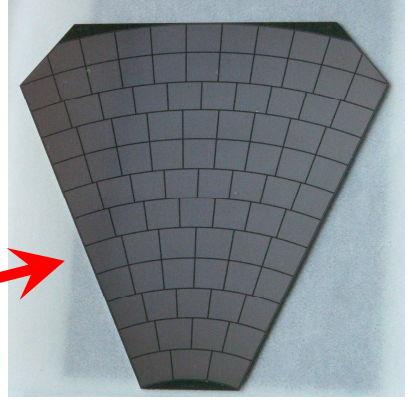
BeamCal Sensors

Up to 600 kGy a MIP signal from all sensors is clearly seen

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

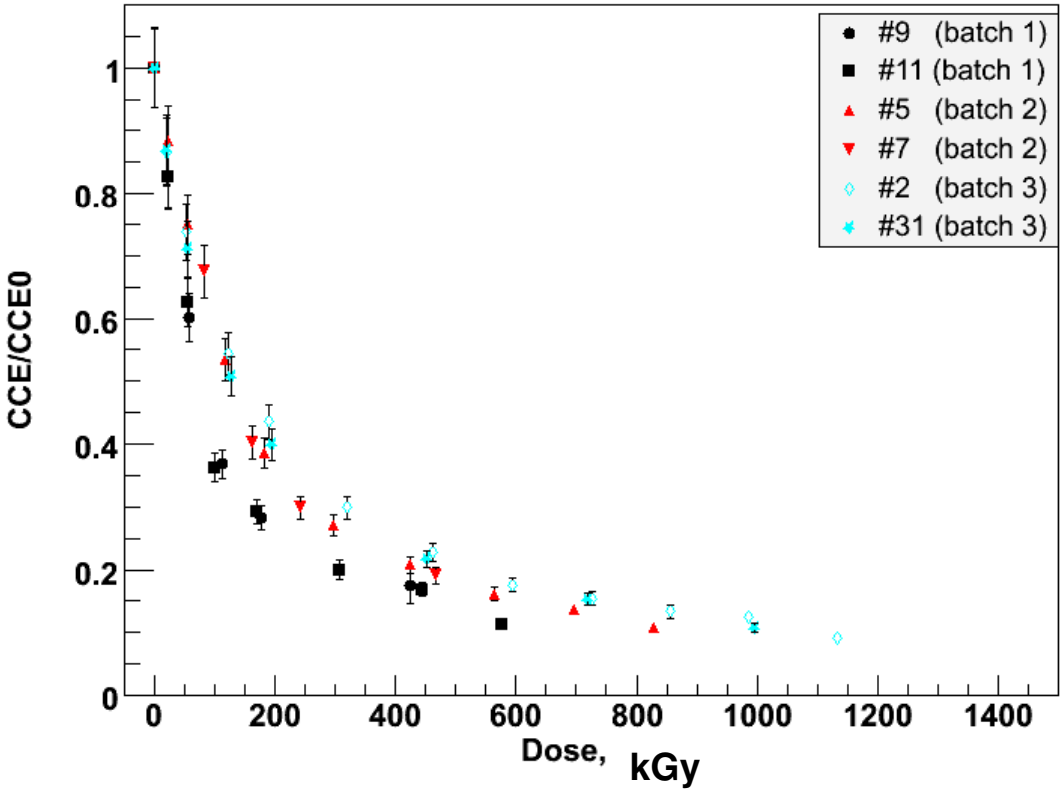
GaAs





BeamCal sector prototype

GaAs:Cr CCE vs dose



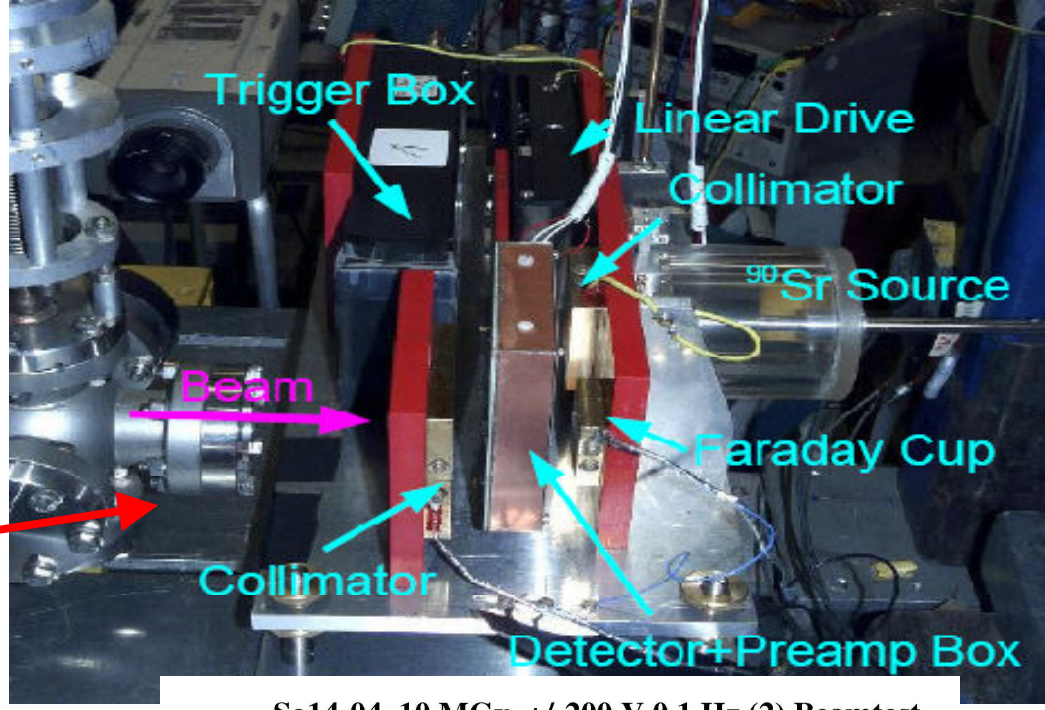
BeamCal Sensors, Diamond

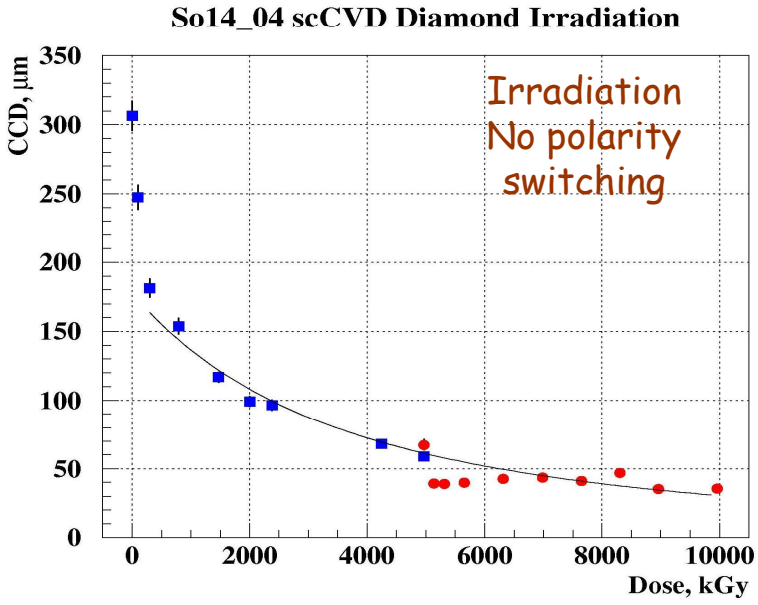
scCVD diamond (E6), 5x5x0.3 mm^3

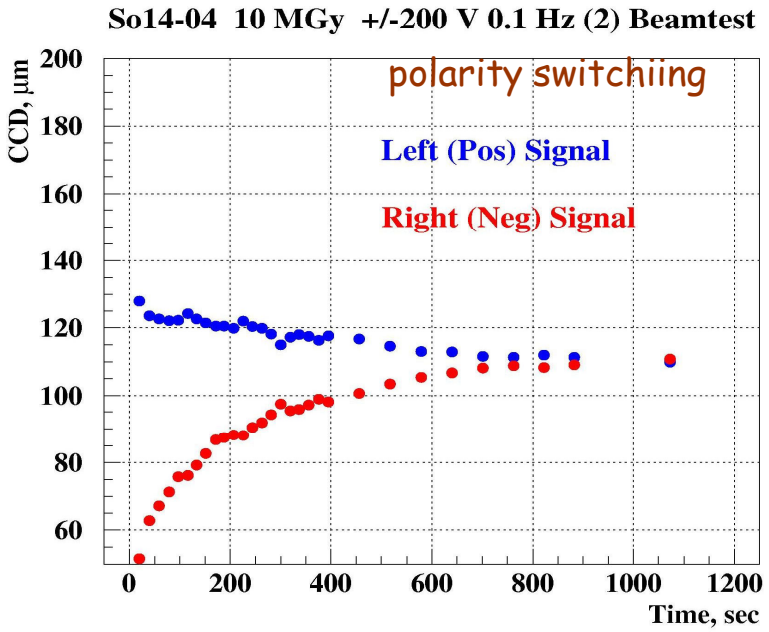
Irradiated in 2007 up to 5 MGy

2008: up to 10 MGy

New setup for beam pumping measurements







BeamCal Sensors, Sapphire

Band gap: 9.9 eV

(diamond: 5.5 eV, Si: 1.12 eV)

Single crystal, 1x1x0.05 cm^3

Wafer: up to 30 cm diameter

Metallization: Al 200 nm or

50/50/100 nm Al/Ti/Au

Ratio of the detector and Faraday cup currents

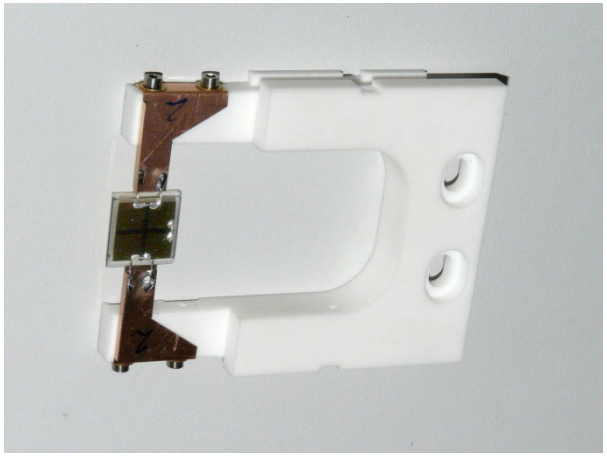
Charge collection efficiency: few %

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

Test in PITZ

Electron beam, 14.5 MeV, bunches

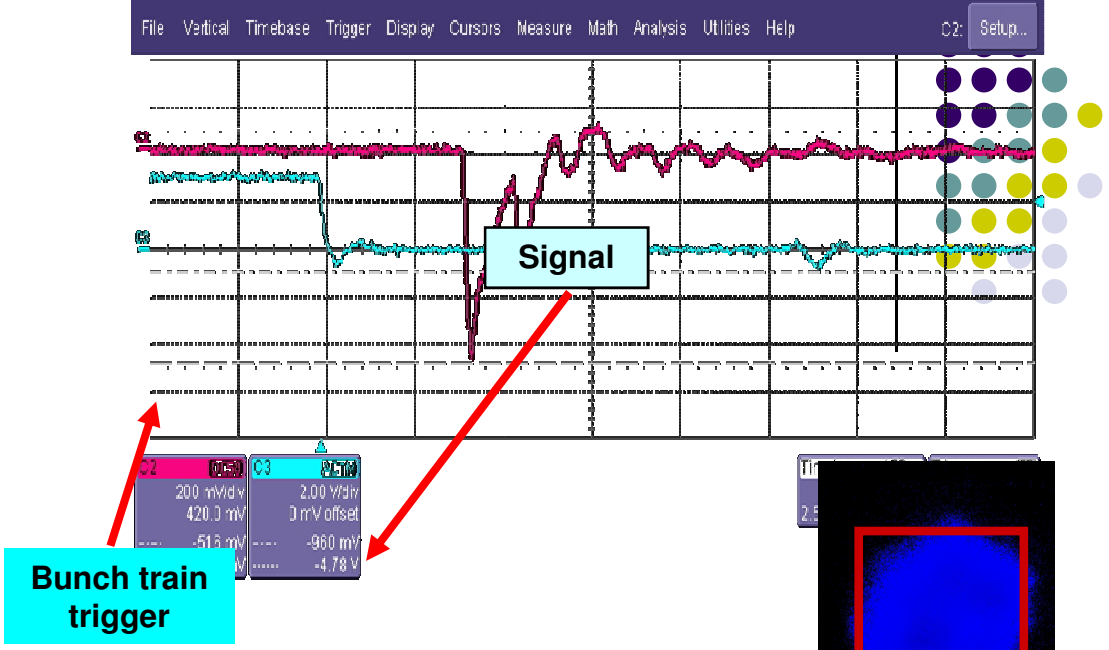
Diamond sensor was installed in the vacuum of the beam pipe

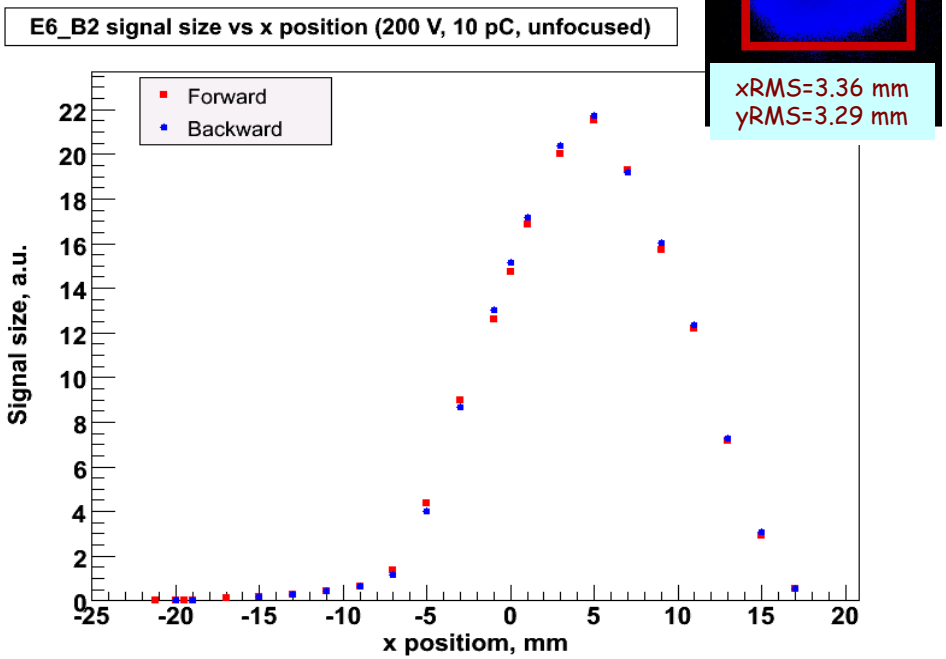


Moving the sensor through an electron beam,

Bunch charge 1 pC – 1 nC,
Beam spot: few mm²
Beam profile

EMI doesn't disturb operation

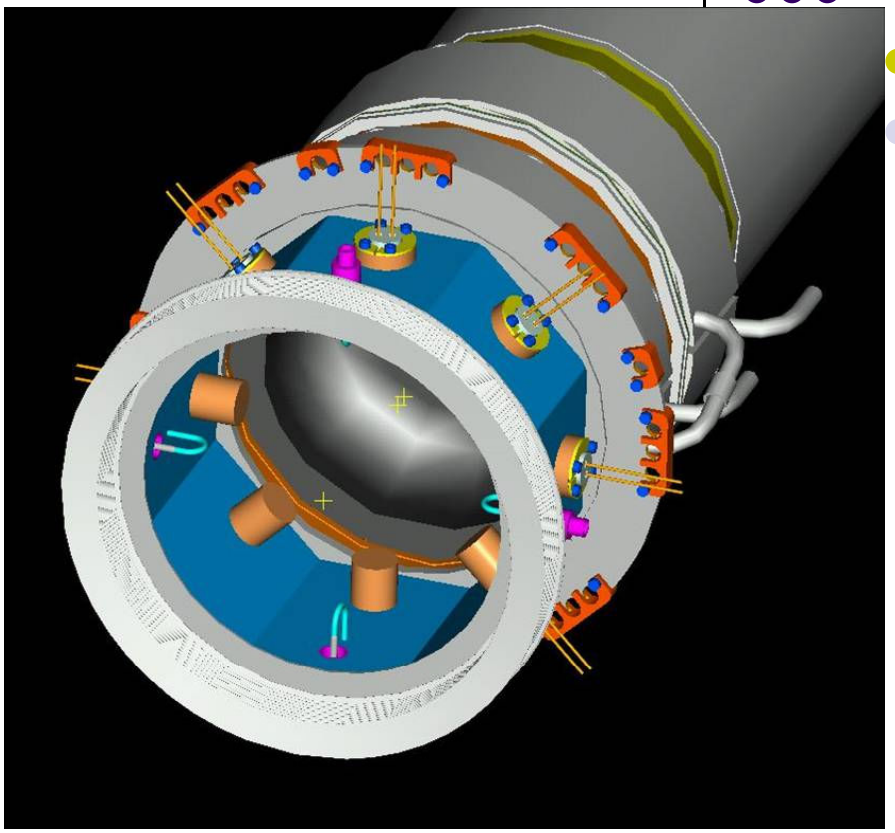


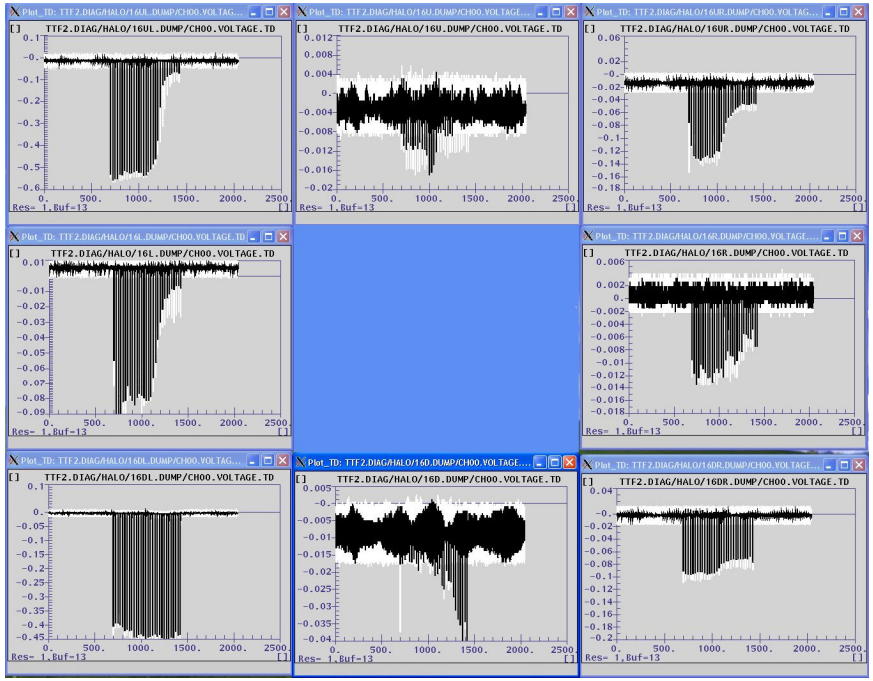


Application at FLASH

FCAL designed, constructed and installed a Beam-Condition Monitor at FLASH (4 diamond and 4 sapphire sensors

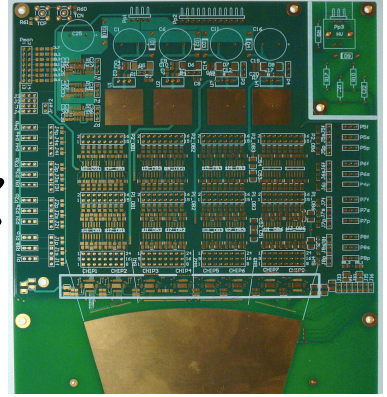
Operation in the "9 mA" run of FLASH was successful





System test in a beam with FCAL module -> FP7

10x



Infrastructure to verify performance simulations:

A flexible tungsten absorber structure, depth 10 X_0, precise mechanics

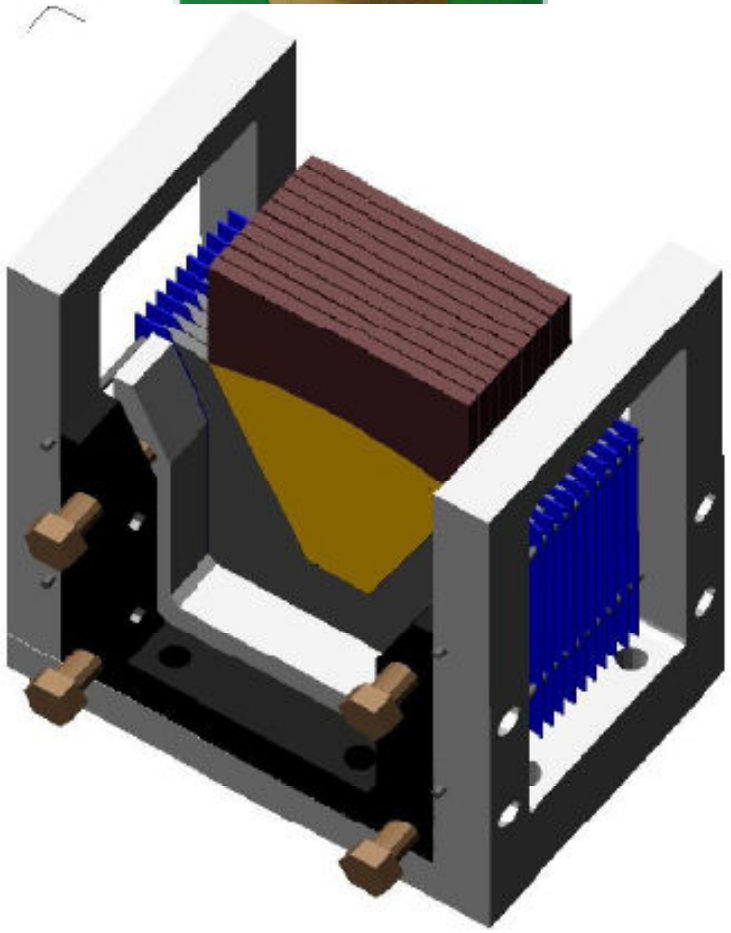
Multichannel FE and ADC ASICS to instrument 10 consecutive sensor layers

Tools to assembly 10 sensor sectors

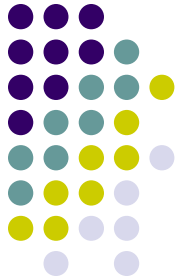
Optical position control of the sensor sectors wrt the tungsten frame

DAQ (common with other components)

Power pulsing (common developments)



Conclusions



- Prototyping of Si sensors for LumiCal successful. Sensors are tested using probe stations at Cracow, DESY and Tel-Aviv
- FE ASICS ready for test with sensors
- System test in preparation
- ADC ASICS – second submission successful, prototypes under test
- Investigation of the radiation hardness of GaAs, diamond and Sapphire up to 12 MGy
- First test of a diamond sensor in a bunched electron beam (PITZ)
- Application of diamond and sapphire sensors at FLASH
- System tests at the beam in future (FP7)