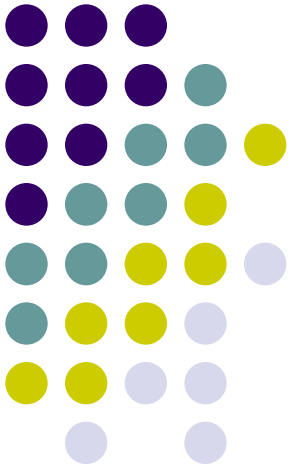
FCAL task status report

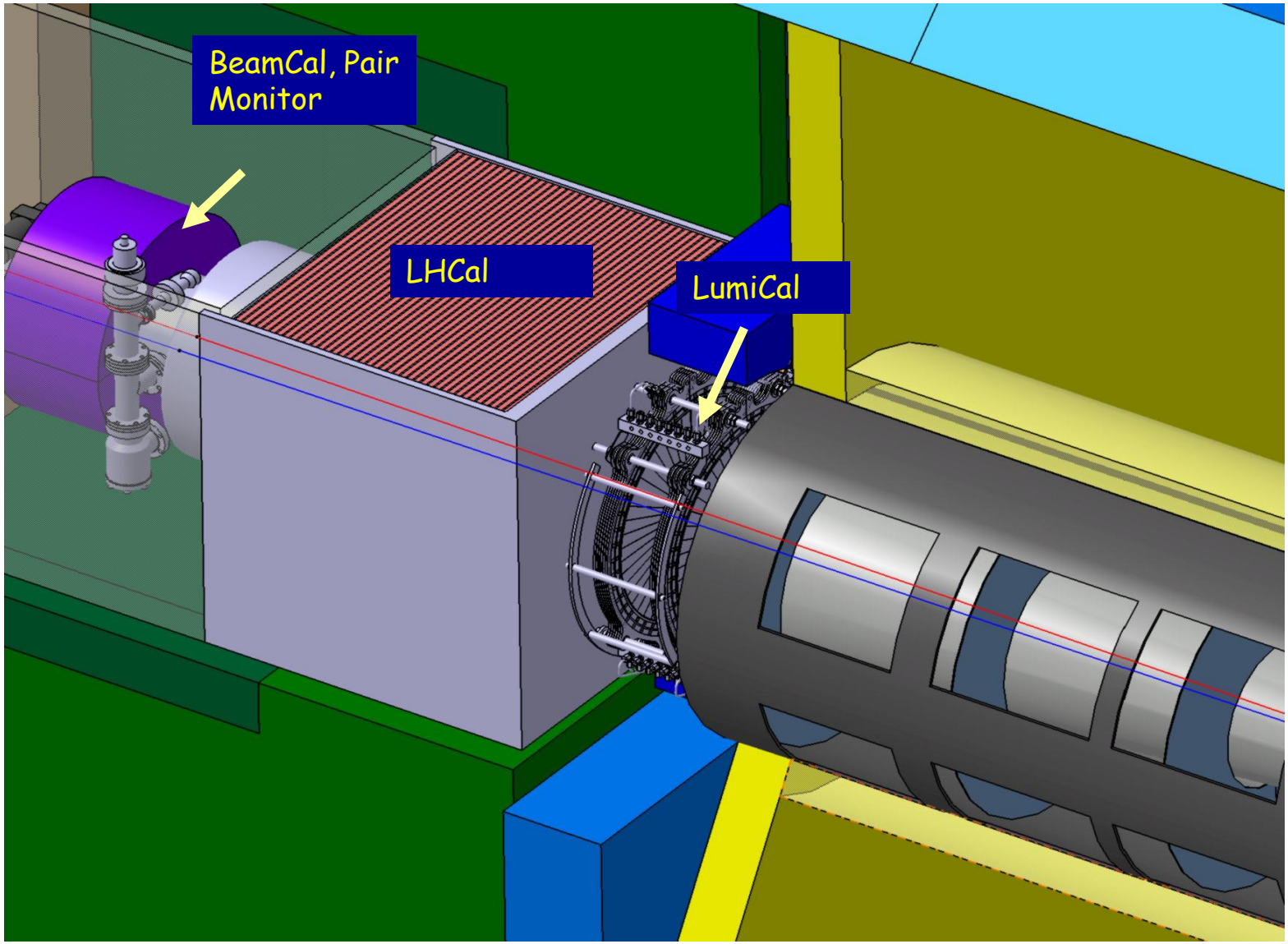
Sergej Schuwalow

DESY/UNI-HH

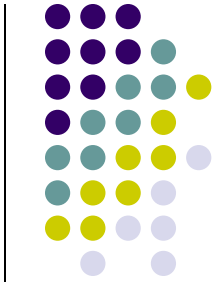


On behalf of the FCAL collaboration

Very Forward Region of the ILD Detector



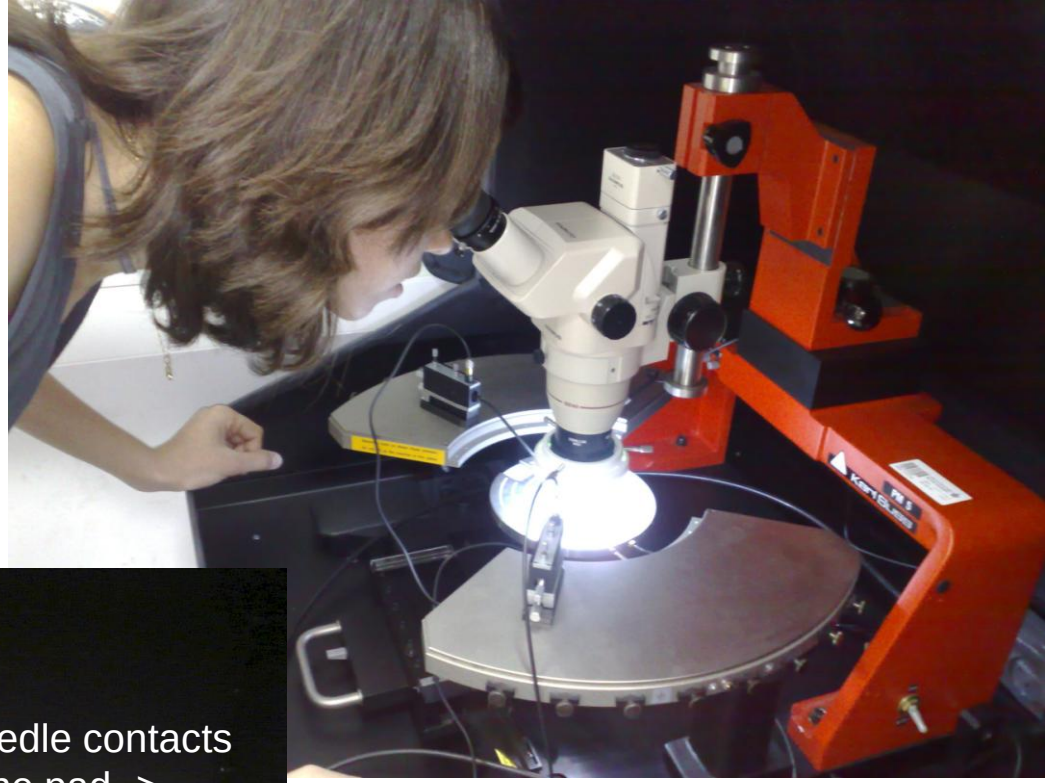
Outline

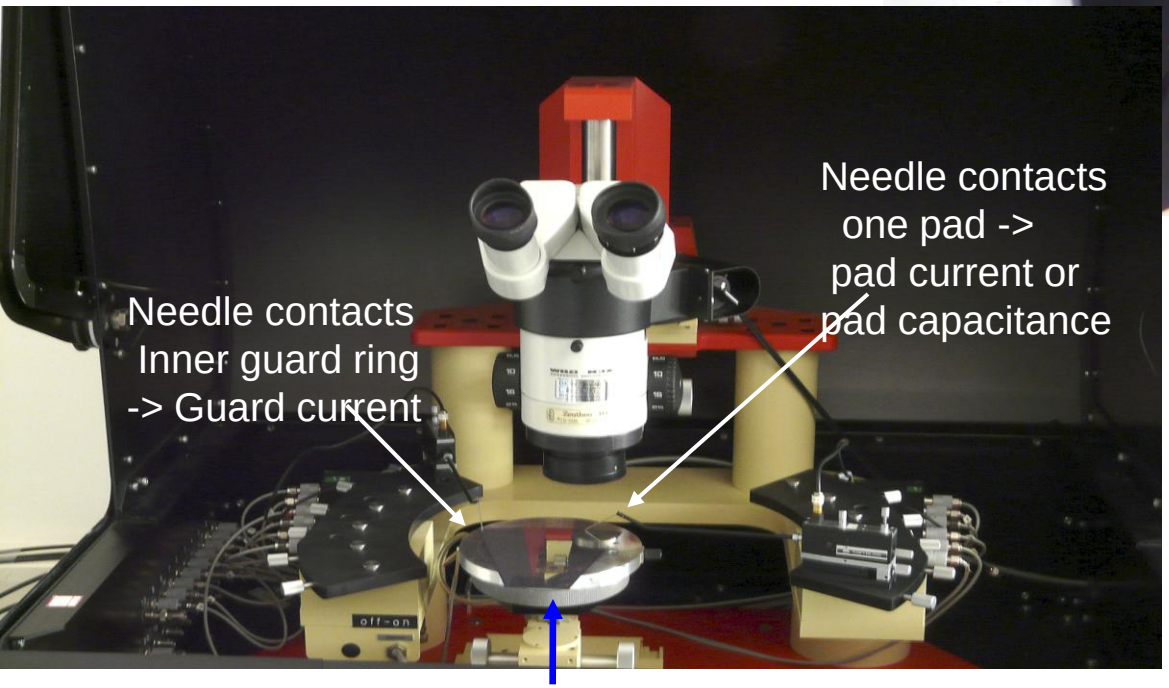


- Infrastructure:
  - Probe stations, tests of LumiCal sensors
  - ^{90}Sr setup – sensor tests at the lab
  - high intensity beam measurements
- LumiCal sensor prototypes
- Laser Alignment System
- BeamCal sensor tests
- Readout electronics
- ADCs – recent developments **New!**
- System test at DESY testbeam, Aug 2010
- Future: full system test at the beam (FP7)

Infrastructure: Probe Stations

Tel-Aviv University



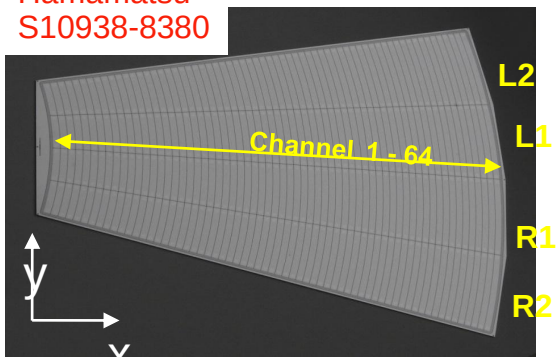


Backplane contacted via Al table ('+' of high voltage)

DESY - Zeuthen

LumiCal Sensor Tests

Hamamatsu
S10938-8380

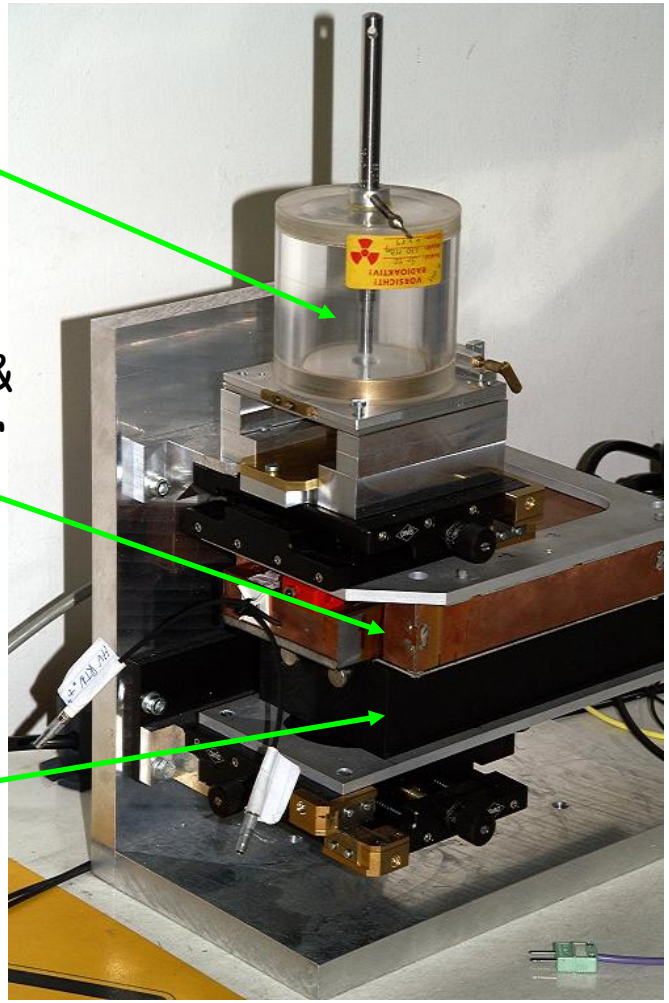


Infrastructure: BeamCal sensor tests in the lab

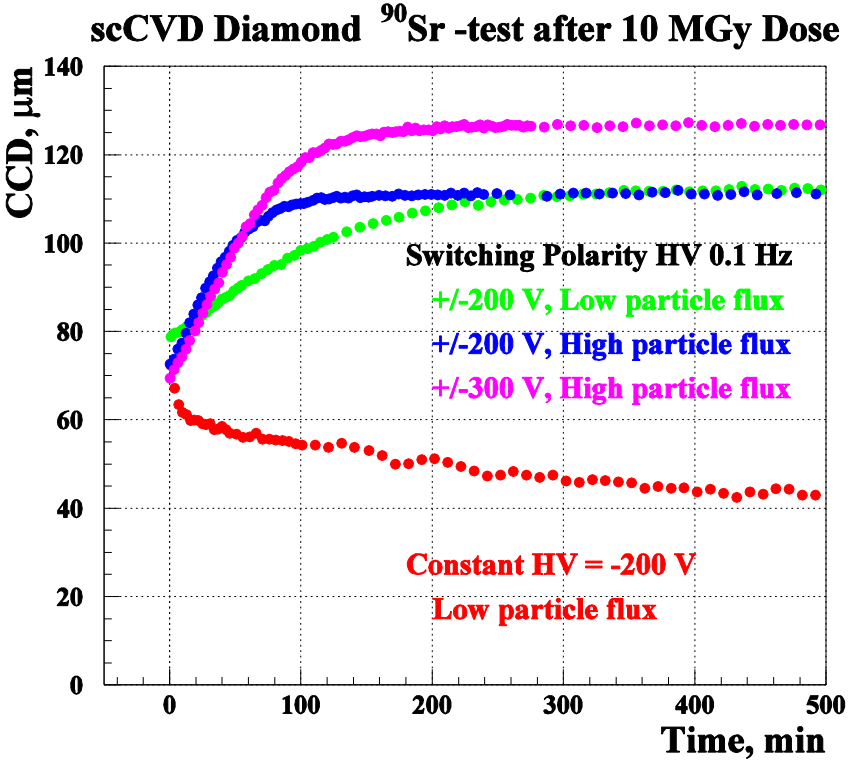
^{90}Sr Source

Sensor box & Preamplifier

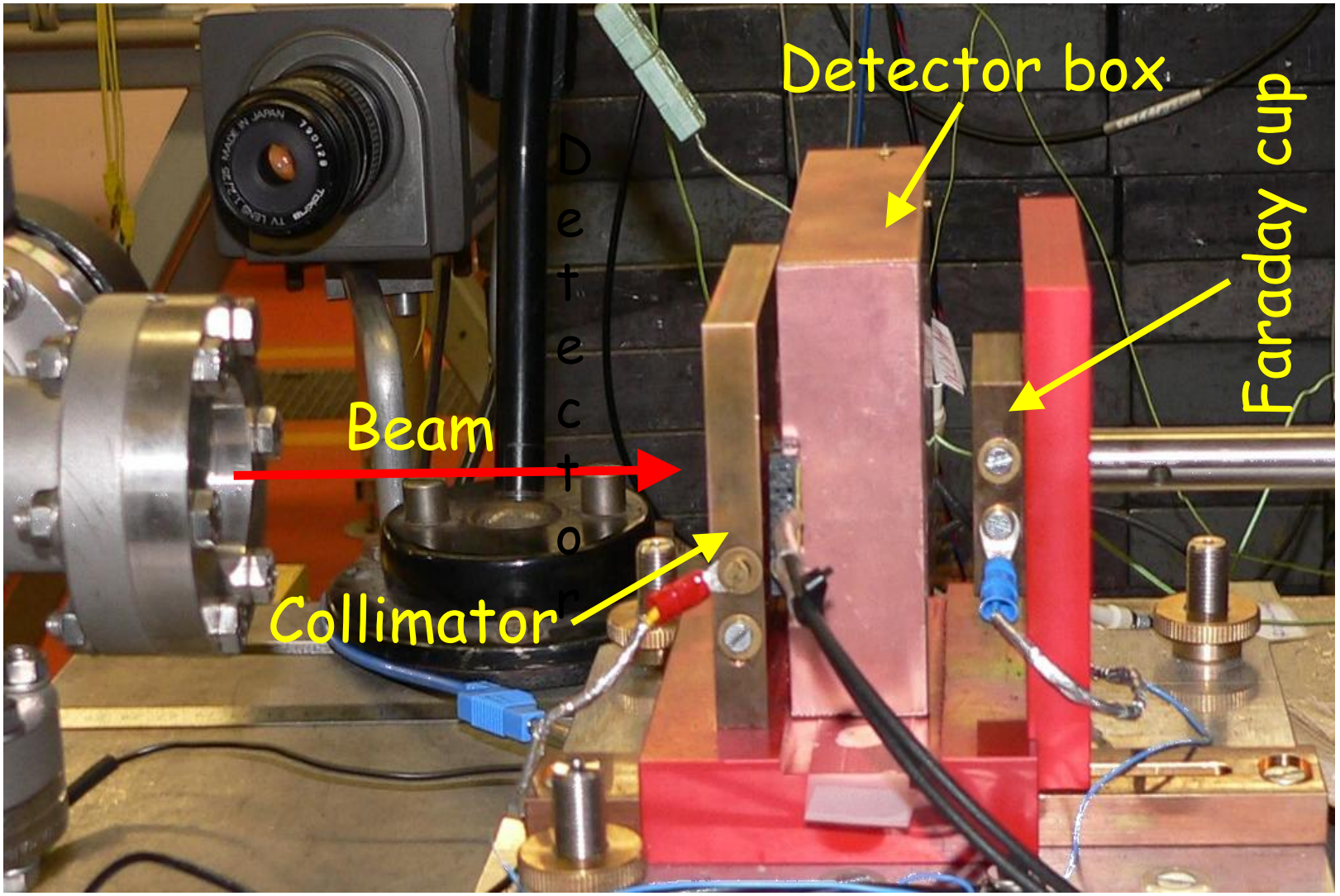
Trigger box



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

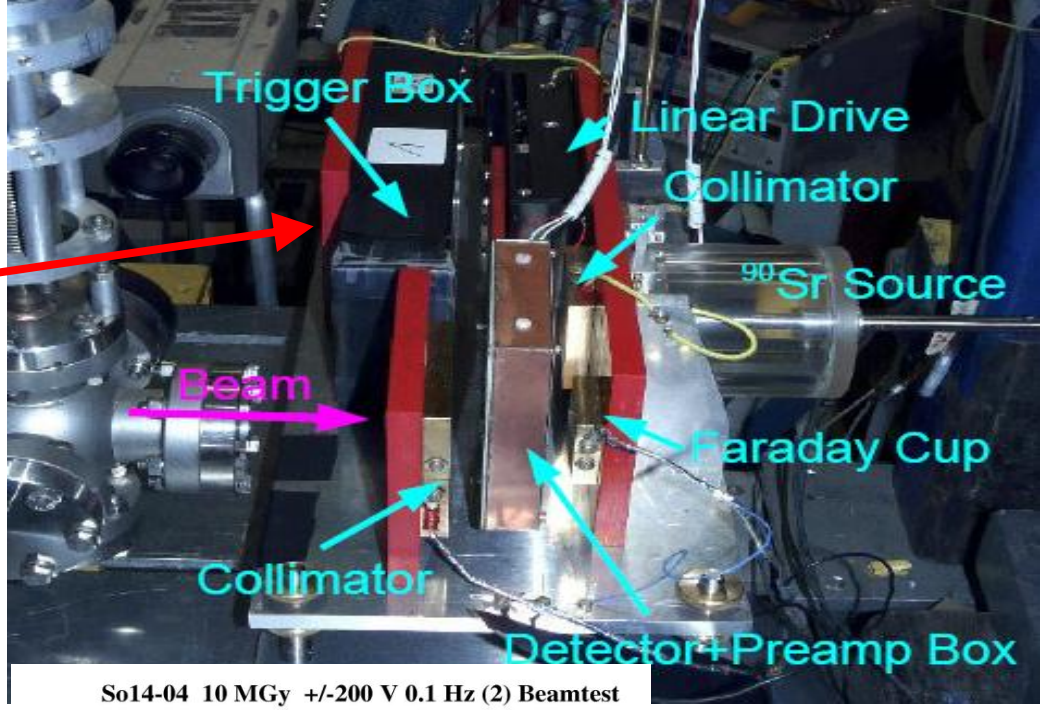


Infrastructure: High dose irradiation at the beam



Infrastructure: BeamCal Sensors study at the beam

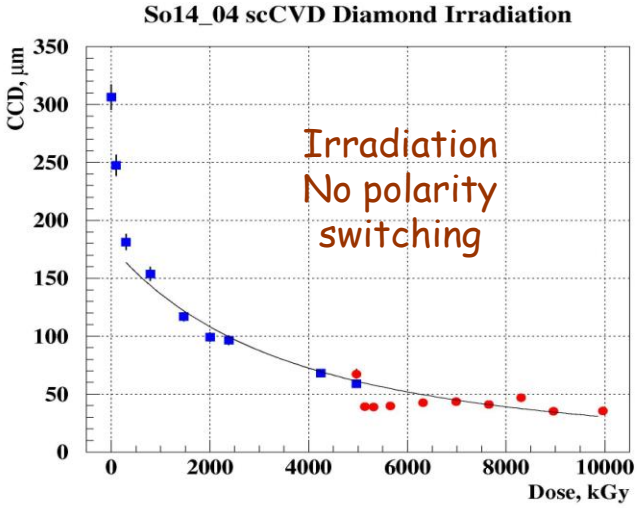
Setup for Beam Pumping Measurements

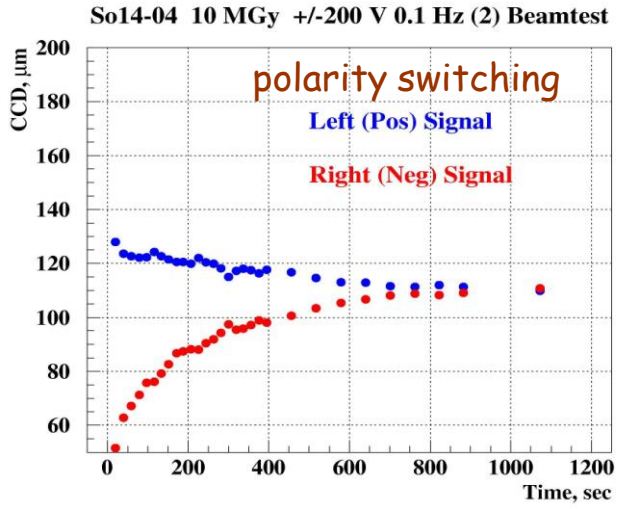


scCVD diamond (E6), 5x5x0.3 mm^3

Irradiated in 2007 up to 5 MGy

2008: up to 10 MGy





Infrastructure summary: EUDET-Report-2009-08 VFCAL task status report

Sensor prototypes (LumiCal, deliverable)

EUDET-Memo-2009-07 J.Blocki, W.Daniluk, E.Kielar et al., Silicon Sensors Prototype for LumiCal Calorimeter

"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

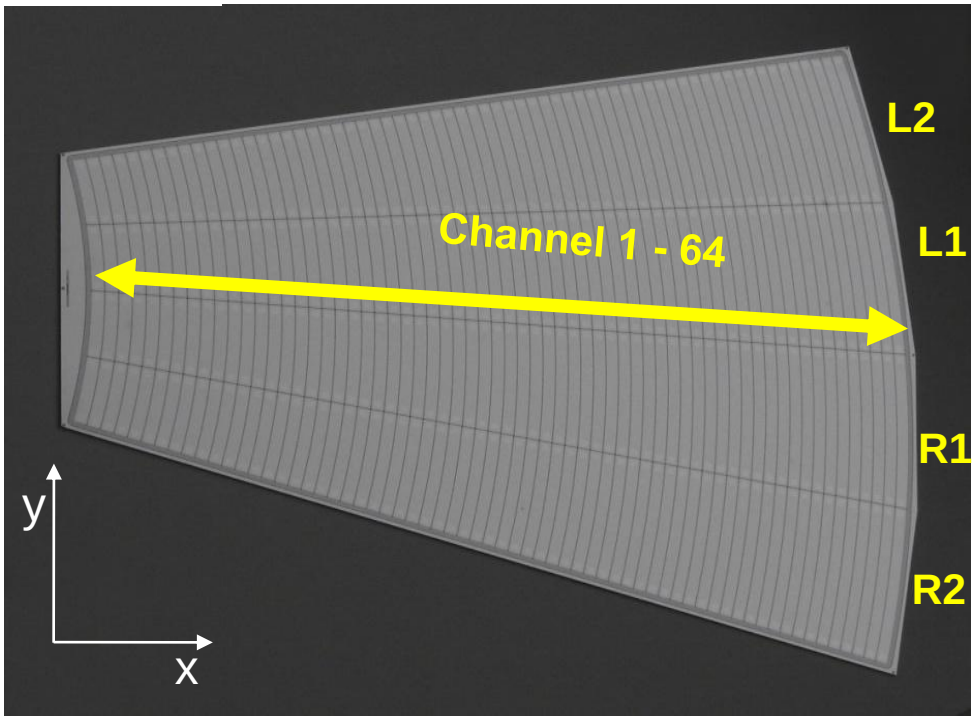
x-Size = 10,8cm

y-Size = 4…12cm

(6 Inch Wafers)

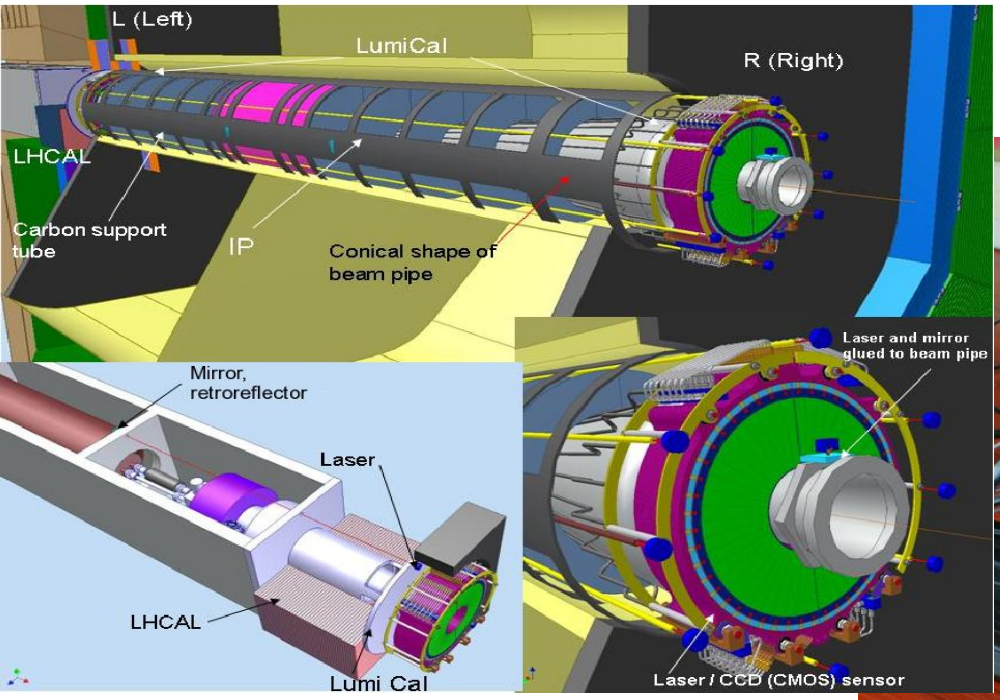
40 sensors produced by Hamamatsu Photonics

Hamamatsu
S10938-8380

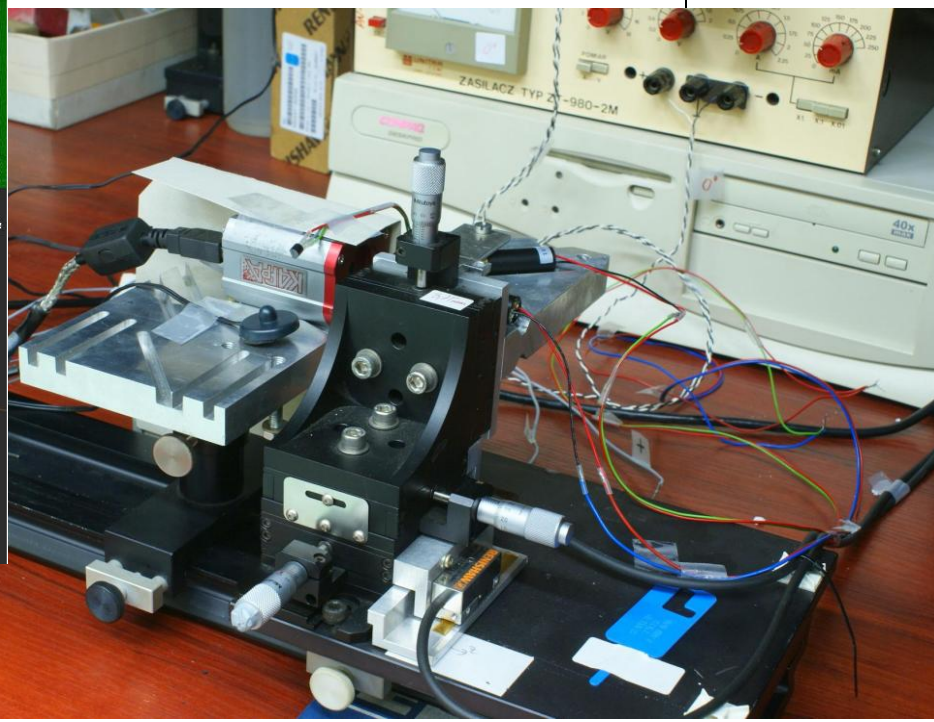


I(V) and C(V) measurements on Probe-stations in Tel Aviv, Cracow and DESY

Laser Alignment system (LumiCal)



LAS prototype



EUDET-Report-2008-05
W.Daniluk et al., Laser Alignment System for LumiCal.

EUDET-Report-2009-08
VFCAL task status report, S.Schuwalow for FCAL Collaboration

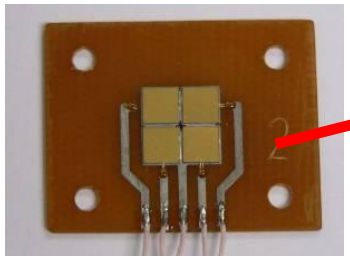
BeamCal Sensors example

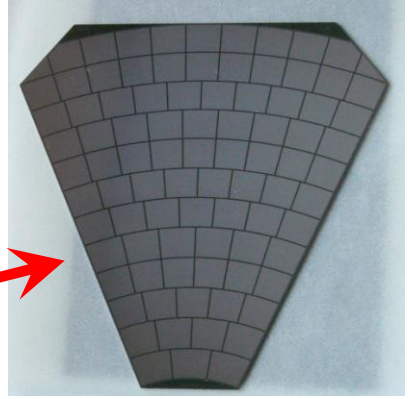
Baseline: GaAs

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 (up to 1 MGy)

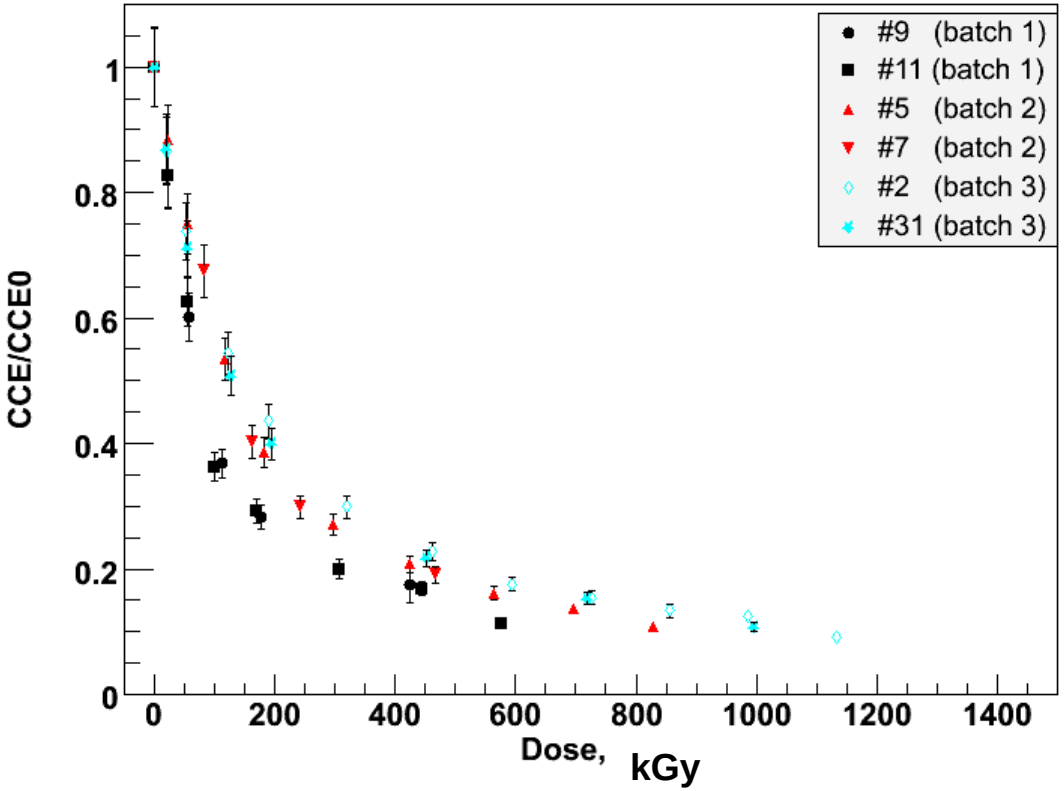
GaAs





BeamCal sector prototype

GaAs:Cr CCE vs dose



BeamCal Sensors, Sapphire

Band gap: 9.9 eV

(diamond: 5.5 eV, Si: 1.12 eV)

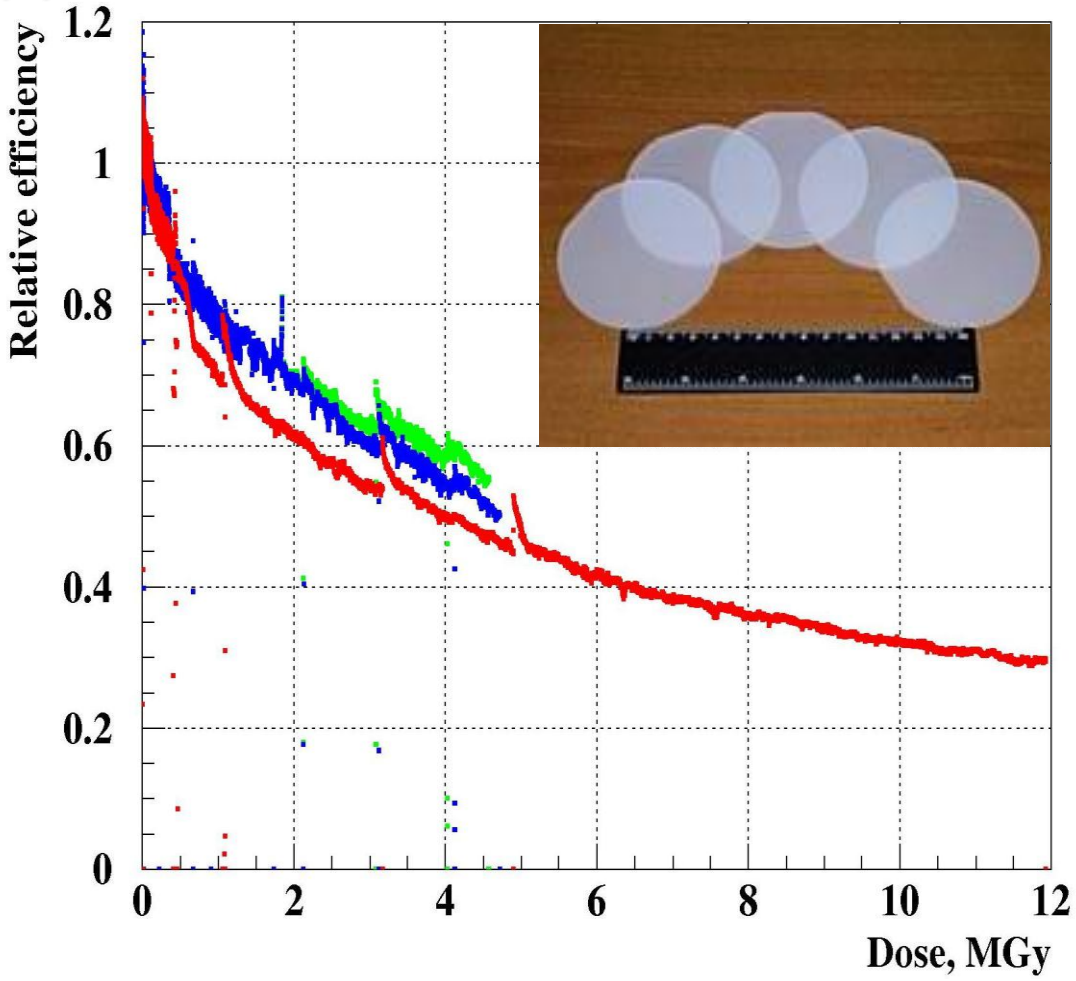
Single crystal, 1x1x0.05 cm^3

Wafer: up to 30 cm diameter

Metallization: Al 200 nm or

50/50/100 nm Al/Ti/Au

Normalized ratio of the detector and Faraday cup currents



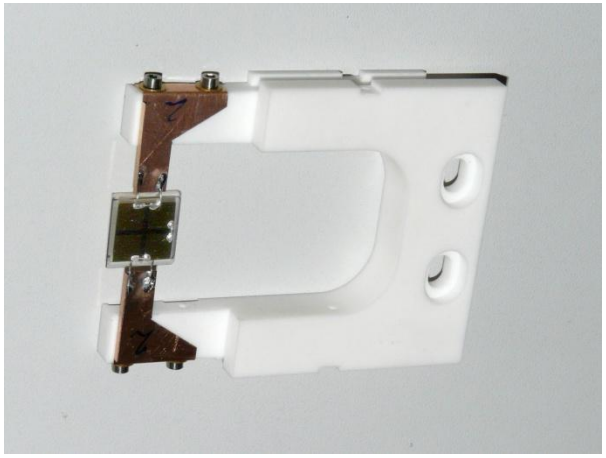
Charge collection efficiency: few % for nonirradiated samples

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

Test in PITZ

Electron beam, 14.5 MeV, bunches

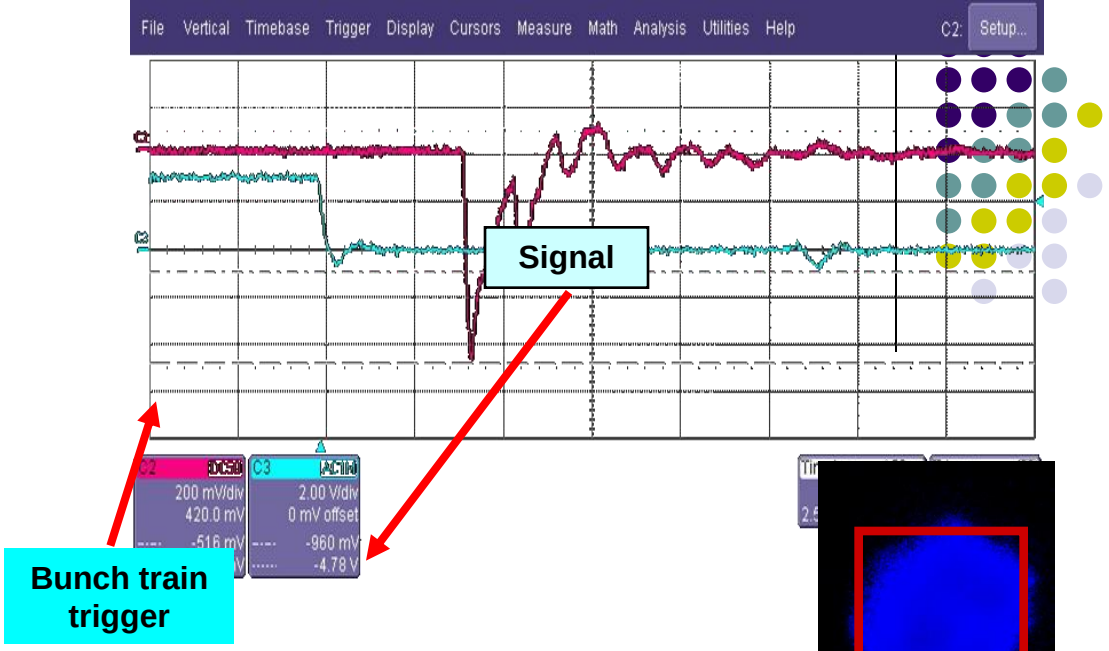
Diamond sensor was installed in the vacuum of the beam pipe

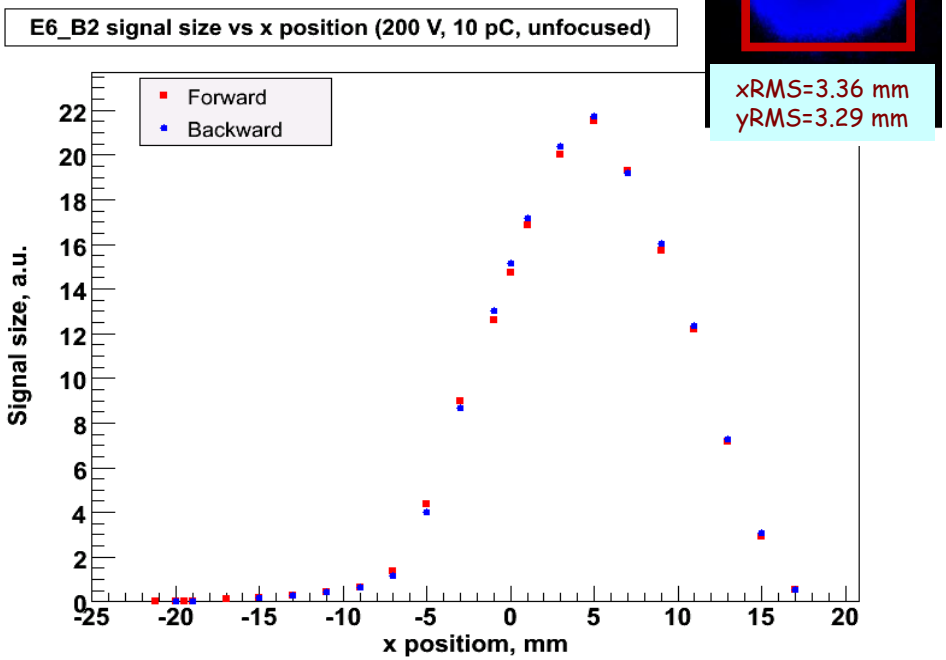


Moving the sensor through an electron beam,

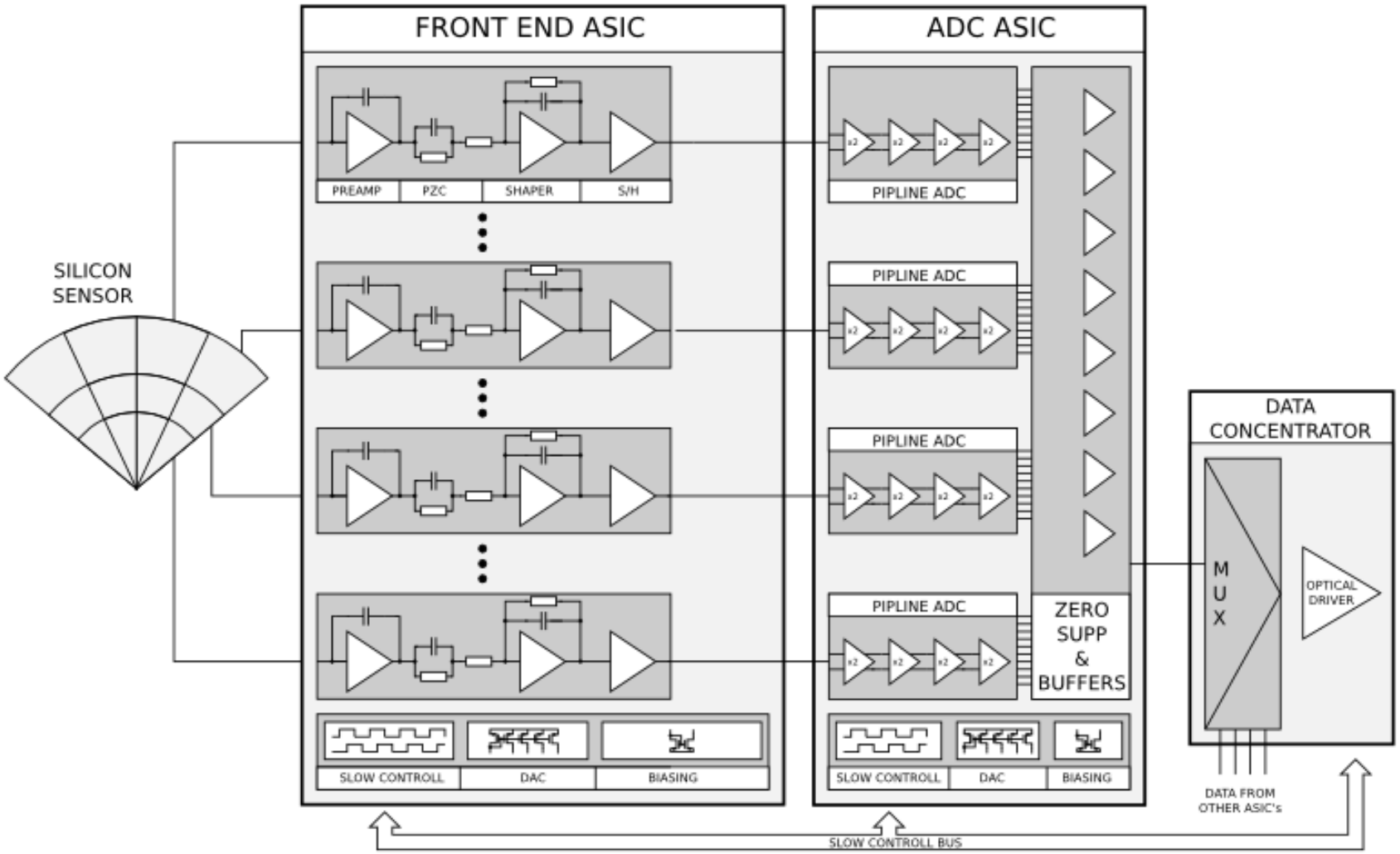
Bunch charge 1 pC – 1 nC,
Beam spot: few mm²
Beam profile

EMI doesn't disturb operation

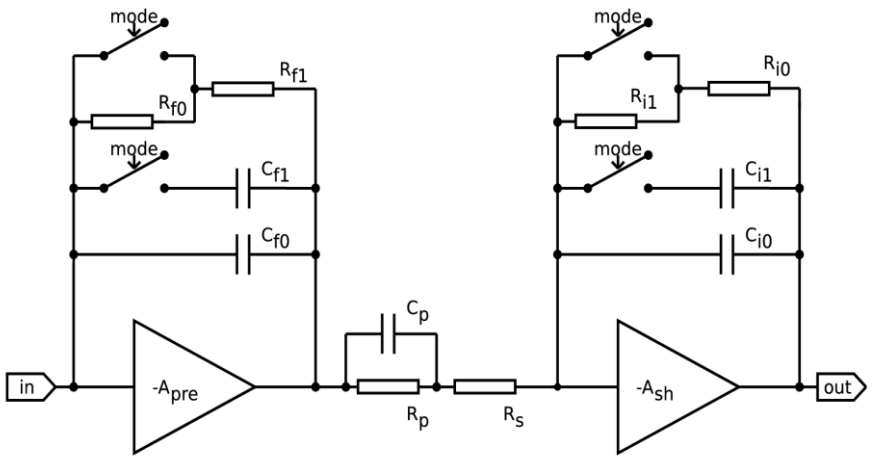


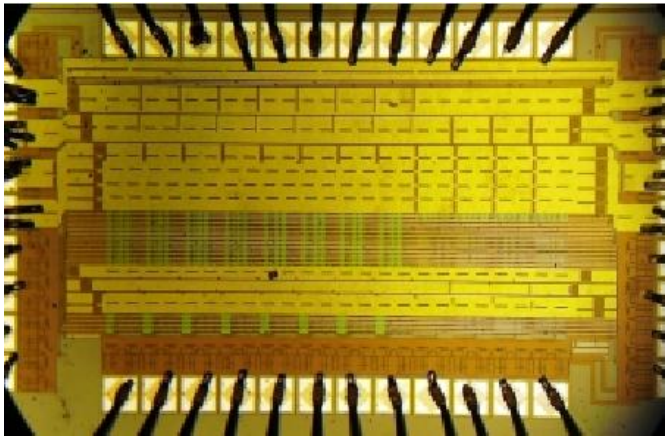


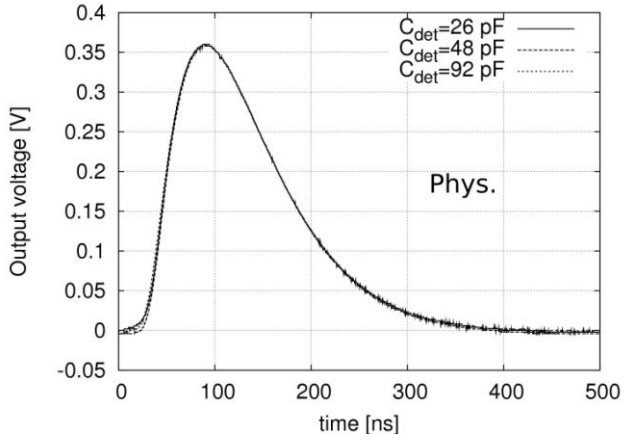
LumiCal readout architecture



Preamplifier&PZC&Shaper

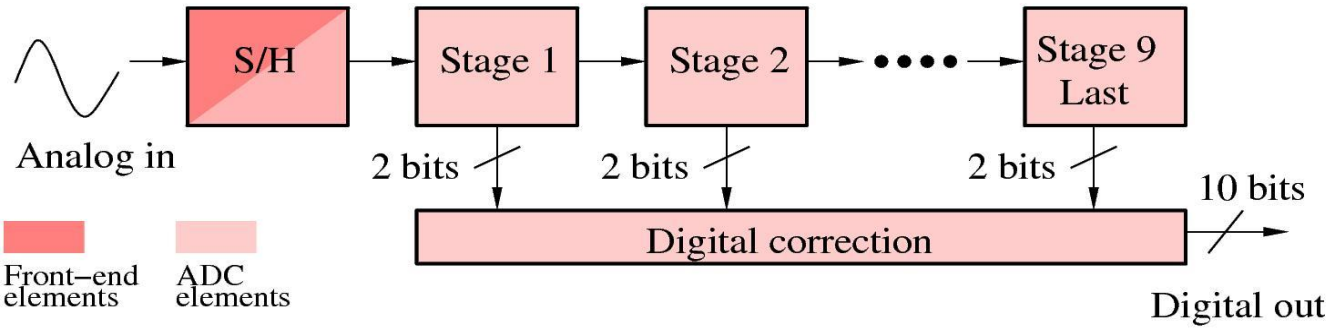






- ASIC with 8 channels
- Variable gain (MIPs and high input charge up to ~ 10pC)
- C_{det} range ~ 0-500 pF
- 1^{st} order shaper T_{peak} ~ 60 ns
- Power consumption < 9 mW/chan

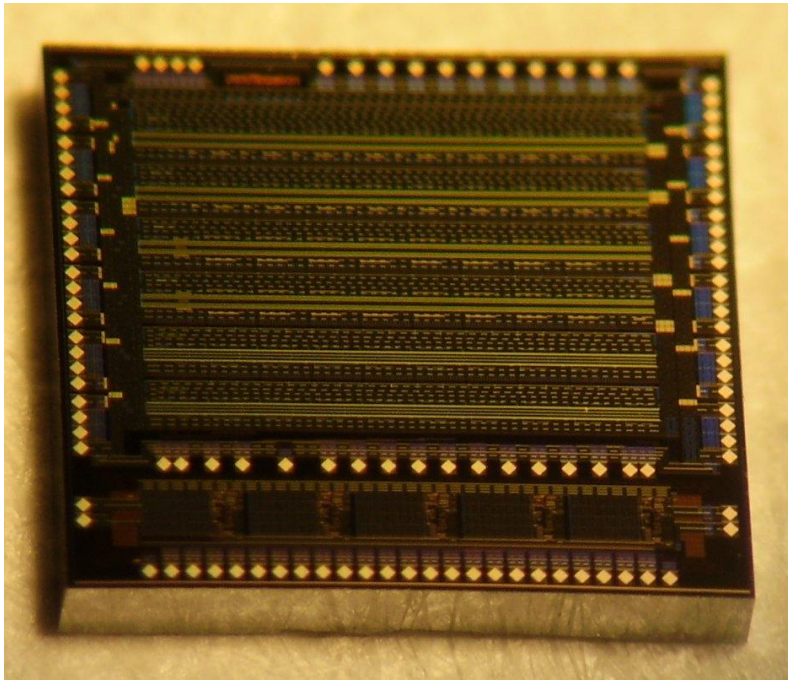
Single channel 10 bit pipeline ADC



- 1st prototype: 8 stages (fully functional)
- 2nd prototype of complete ADC (photo)

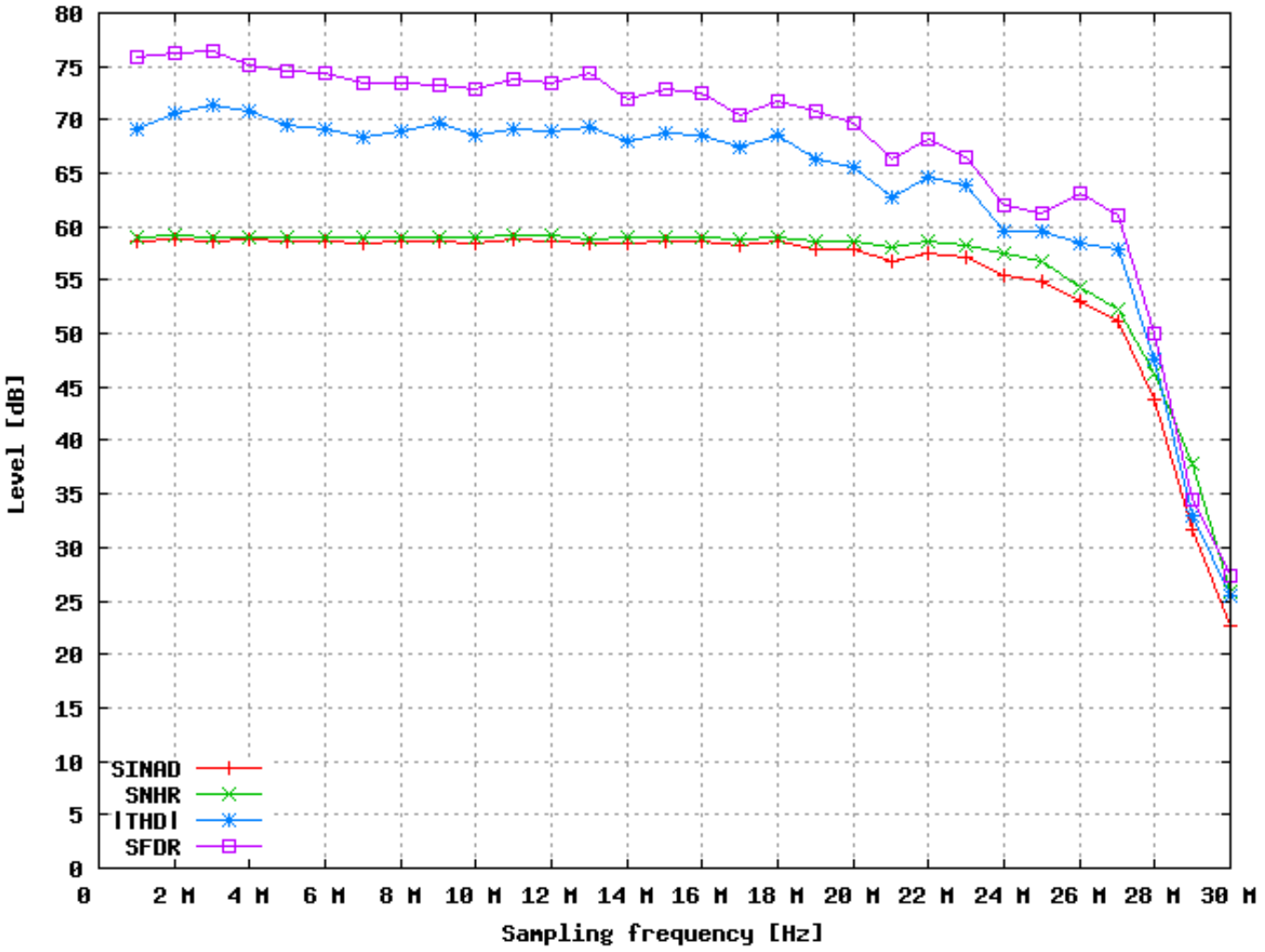
  - 9 stages + S/H
  - digital correction
  - clock and power switching
  - external reference voltages

- 2nd prototype fully functional, tests completed



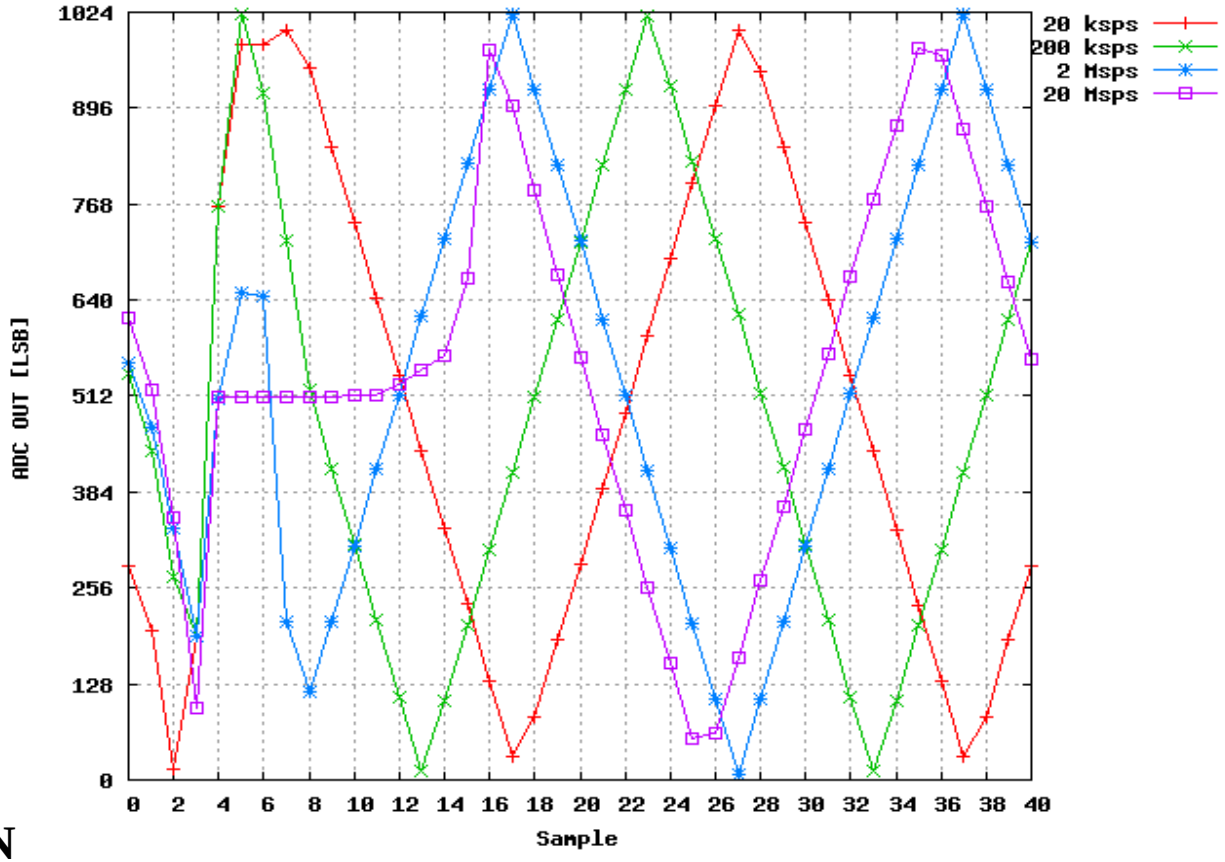
0.35 μm AMS

ADC dynamic measurements



Good dynamic performance ENOB ~ 9.5 bit

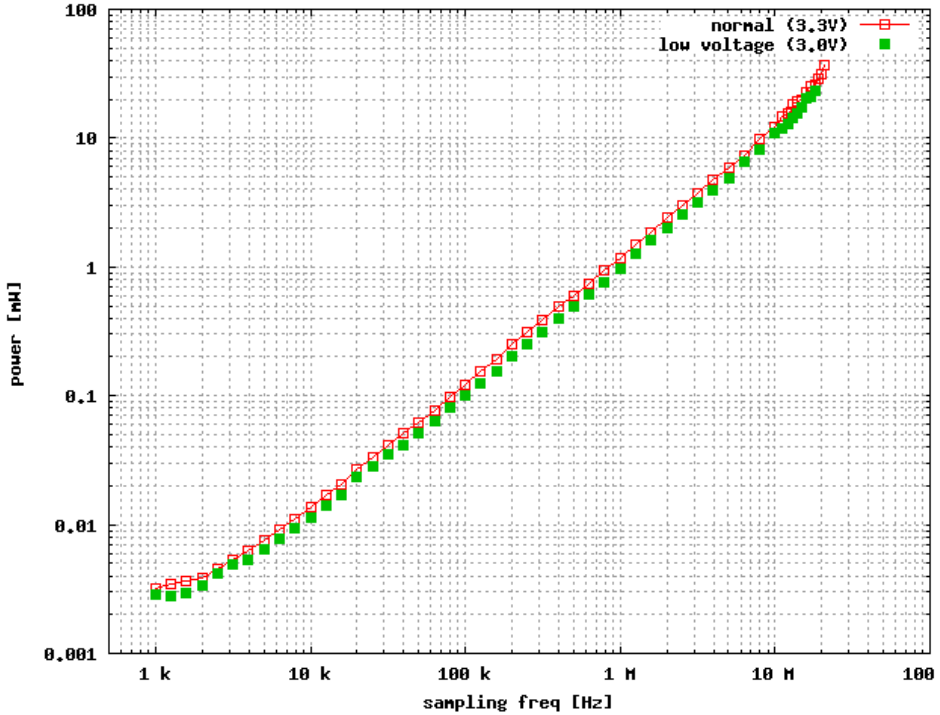
ADC – power OFF/ON

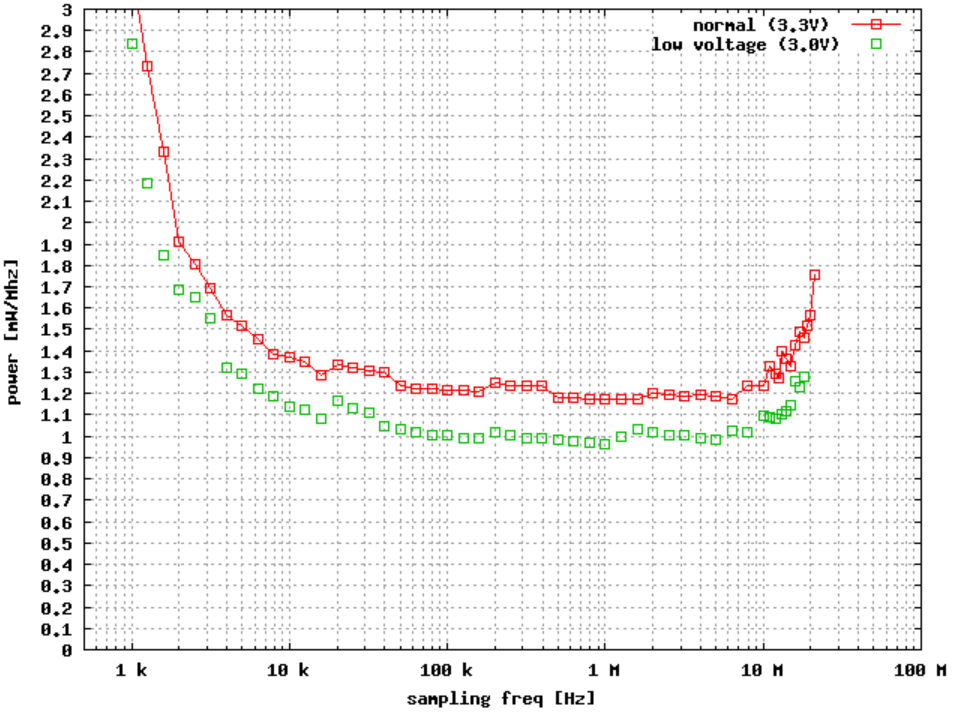


Power ON at t=0

Depending on sampling frequency 8-16 clocks needed for switching ON

ADC power consumption

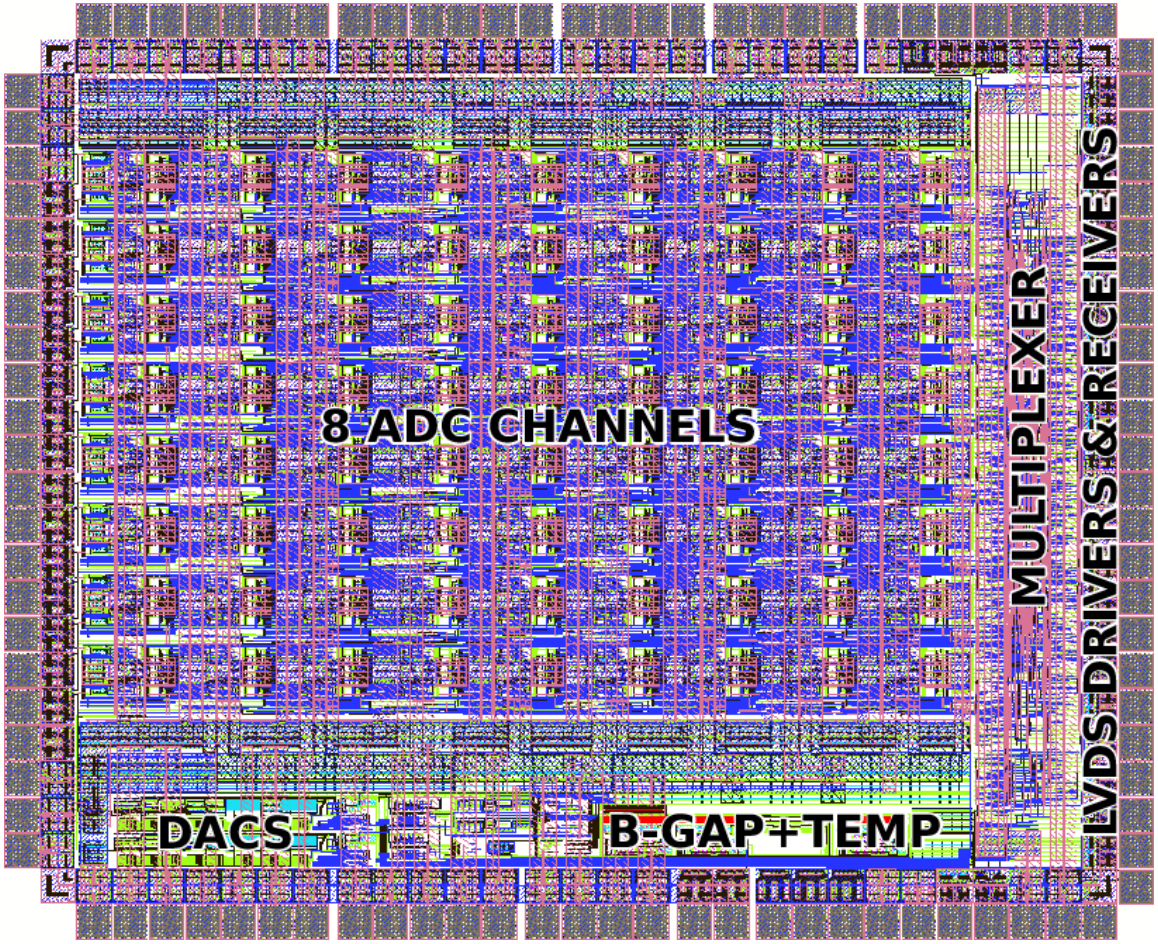




Presently power consumption about 1 mW/MHz (Nyquist input frequency, including output buffers)

The tests confirmed that ADC fulfils all specifications and may be used in multichannel readout

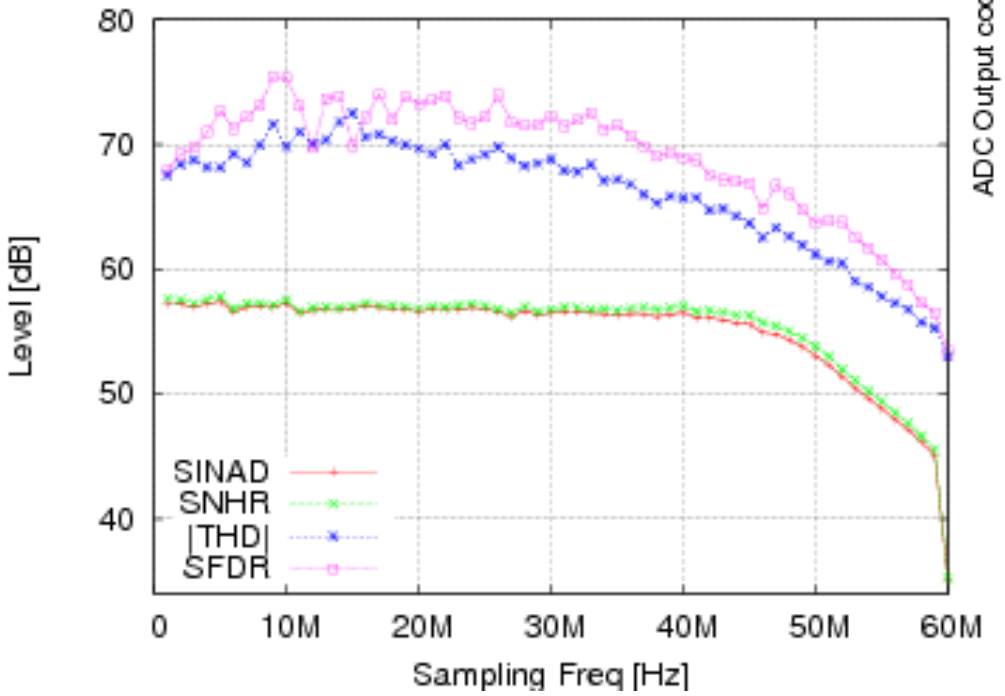
Multichannel ADC

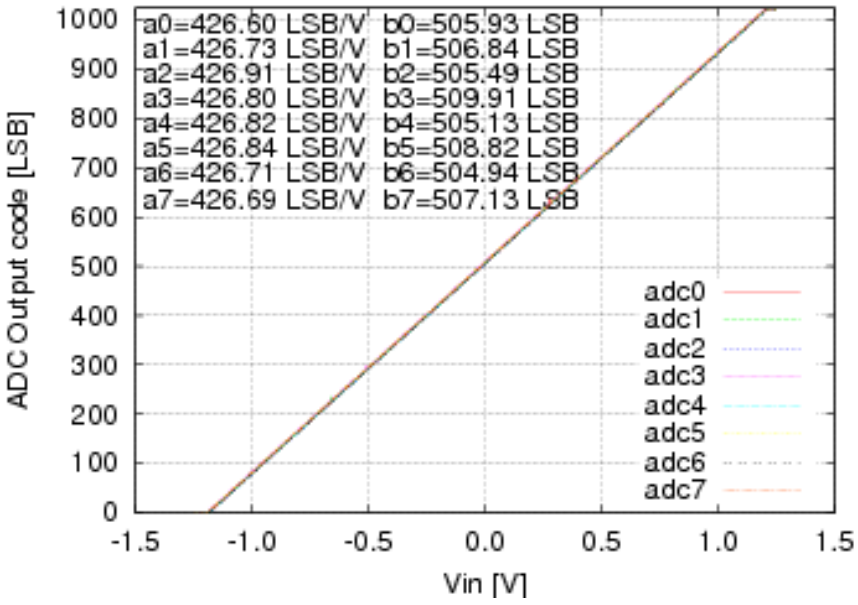


- The first measurements show that all 8 channels are working properly and the overall performance seem to be similar to single channel version or slightly better

Multichannel ADC – preliminary results

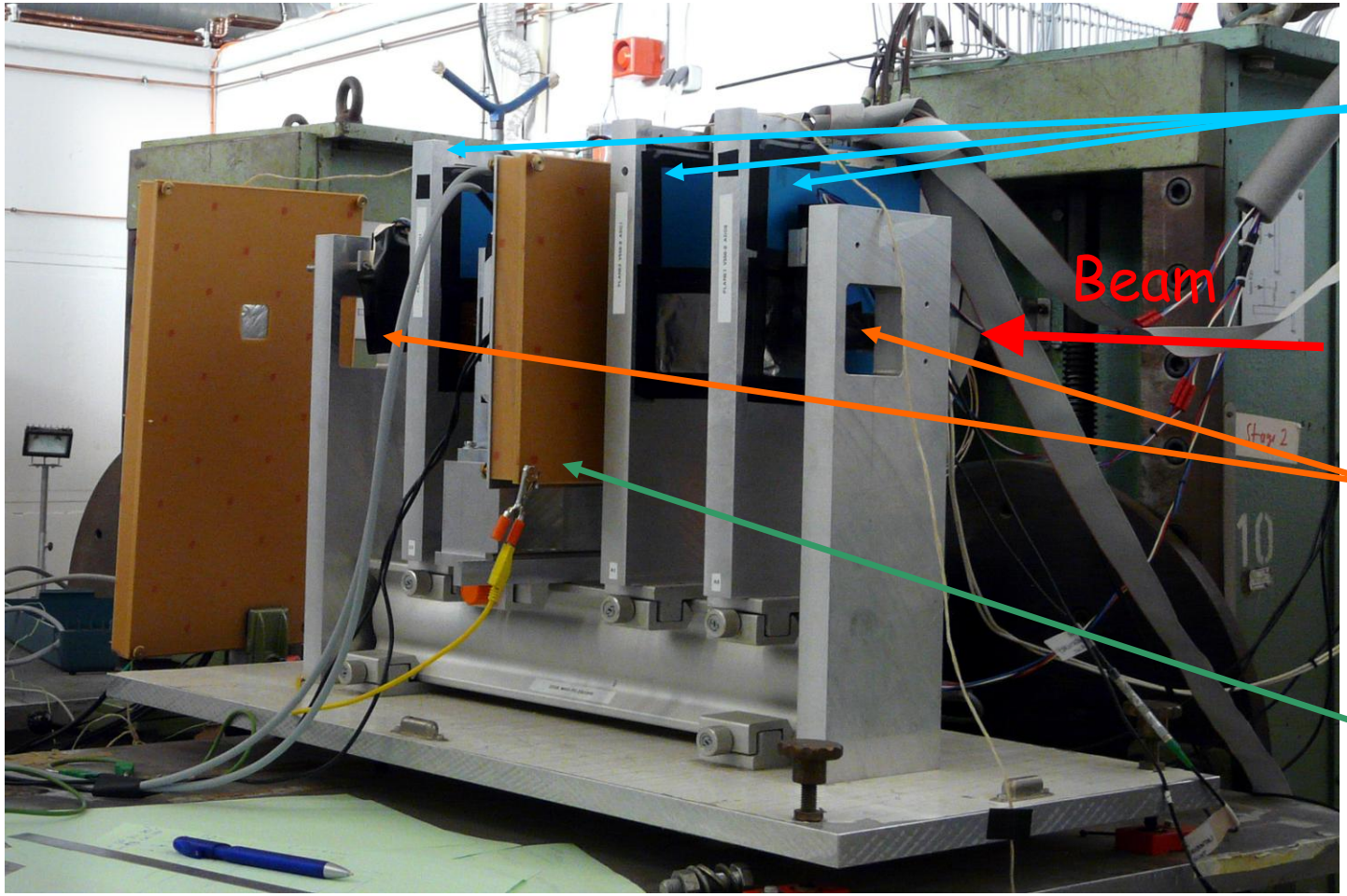
- Gain and offset spread <1%
- Higher maximum sampling frequency





System tests: testbeam @ DESY, August 2010

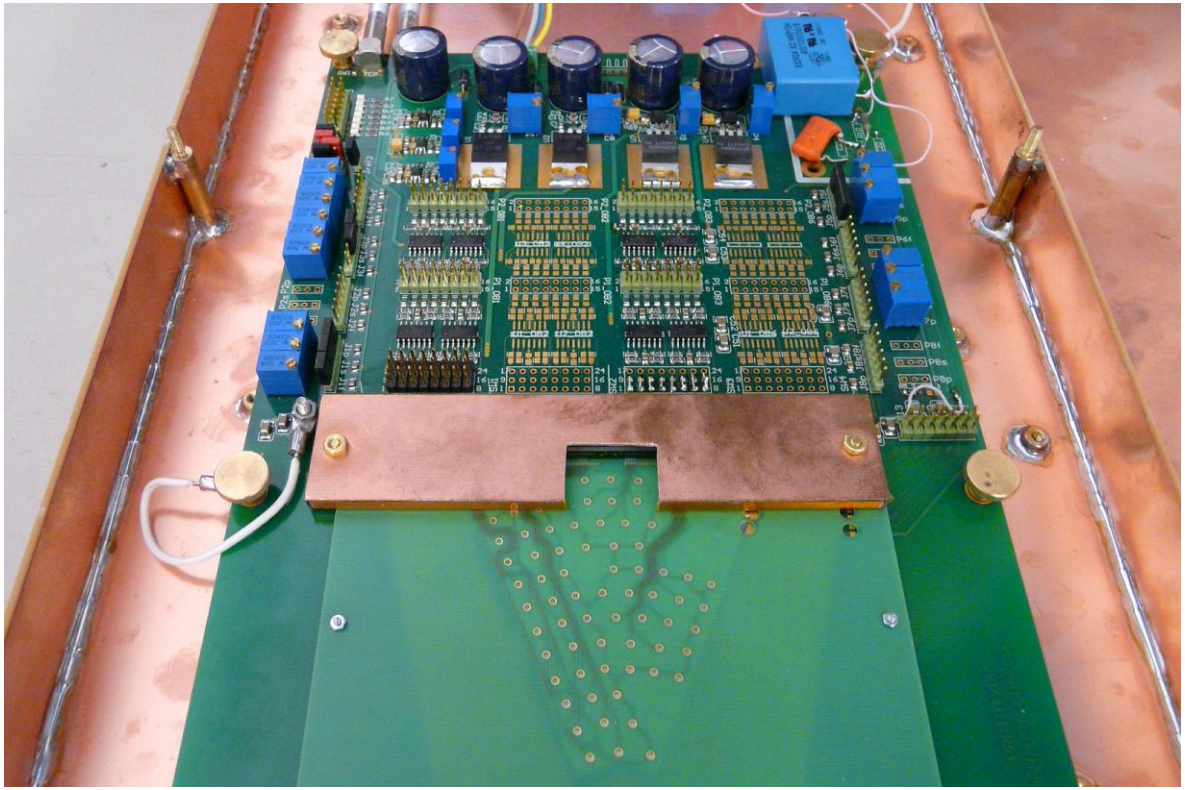
4.5 GeV electron beam



System tests: testbeam @ DESY, August 2010

Precise XY-table

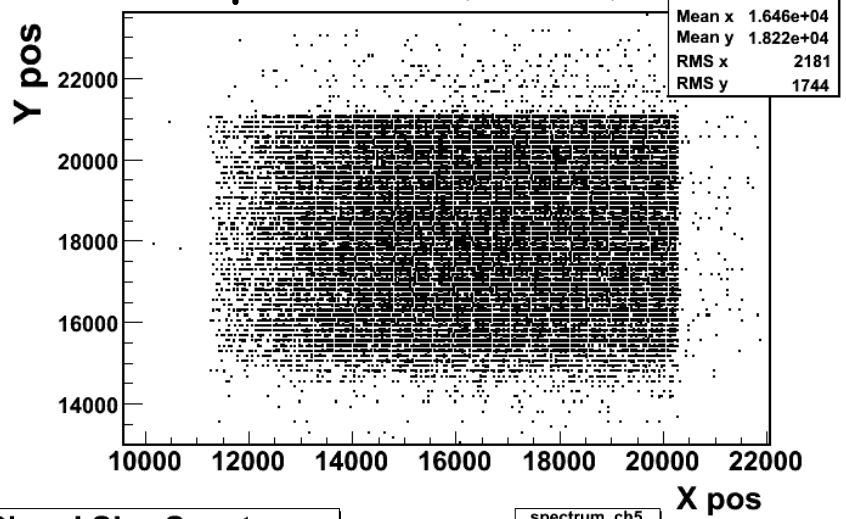
Detector box (BeamCal sensor installed)



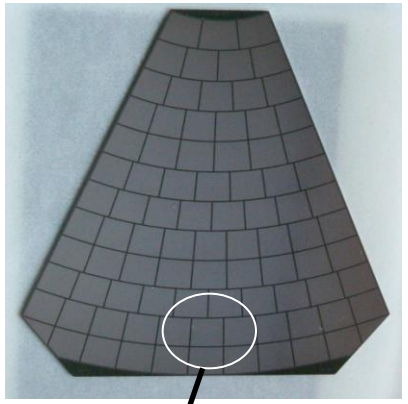
Similar box for the LumiCal sensor

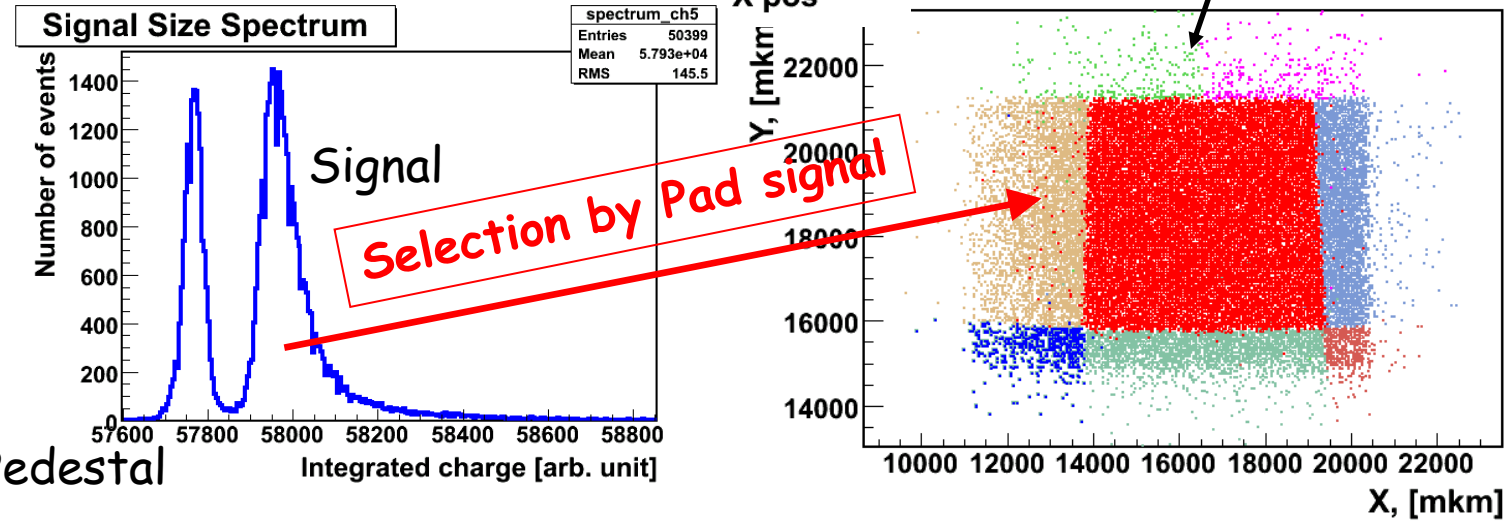
System test: testbeam @ DESY, August 2010
First results for BeamCal sensor prototype

Beam XY profile (mkm)



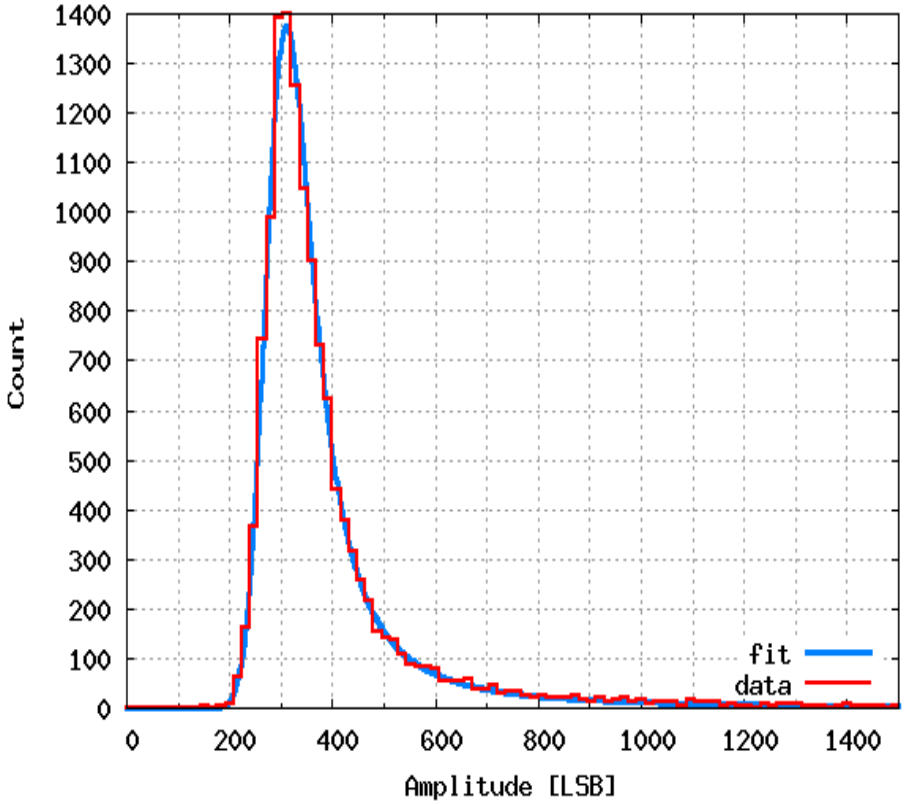
GaAs sensor



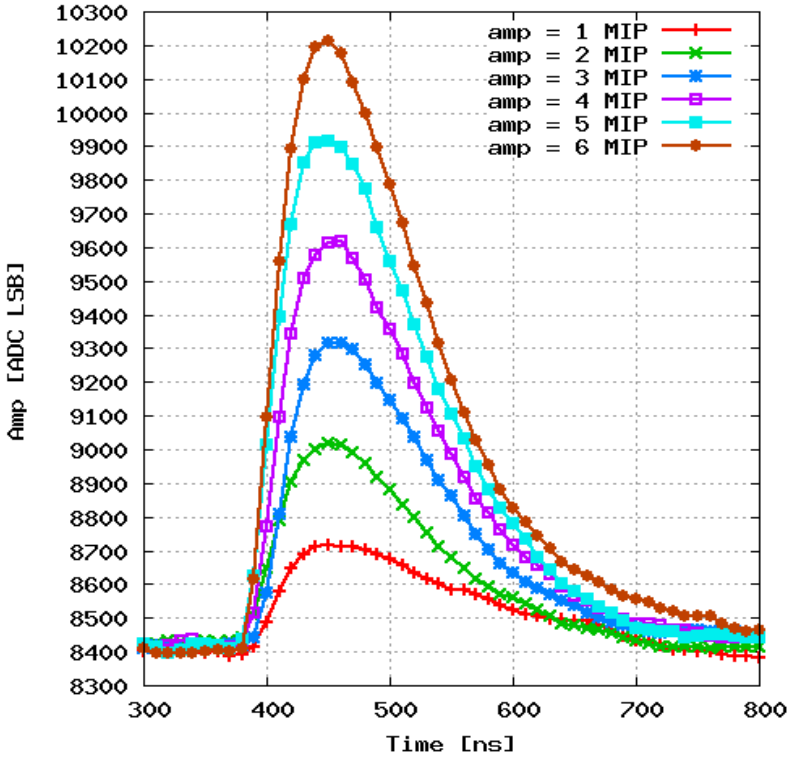


LumiCal testbeam results

runs without tungsten absorber



Energy deposition in single channel fits Landau distribution

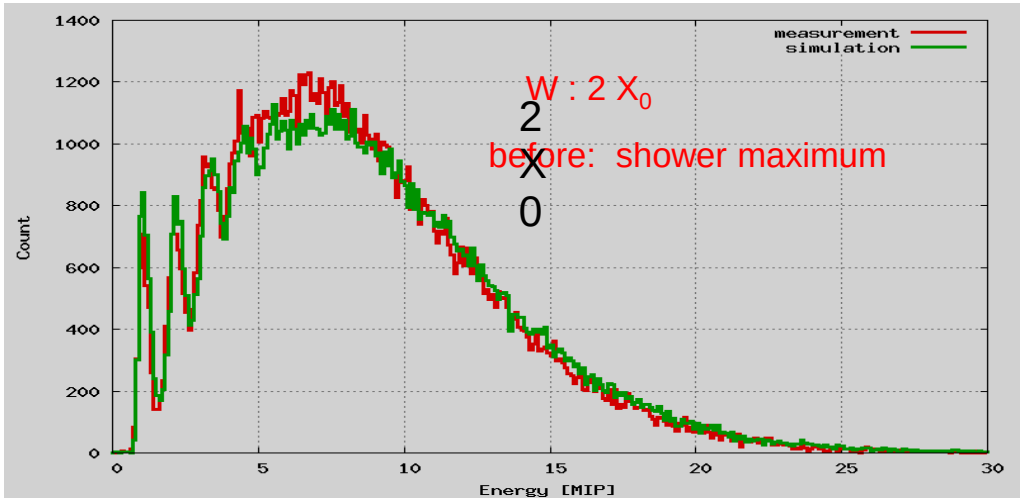


Time response of single front-end channel

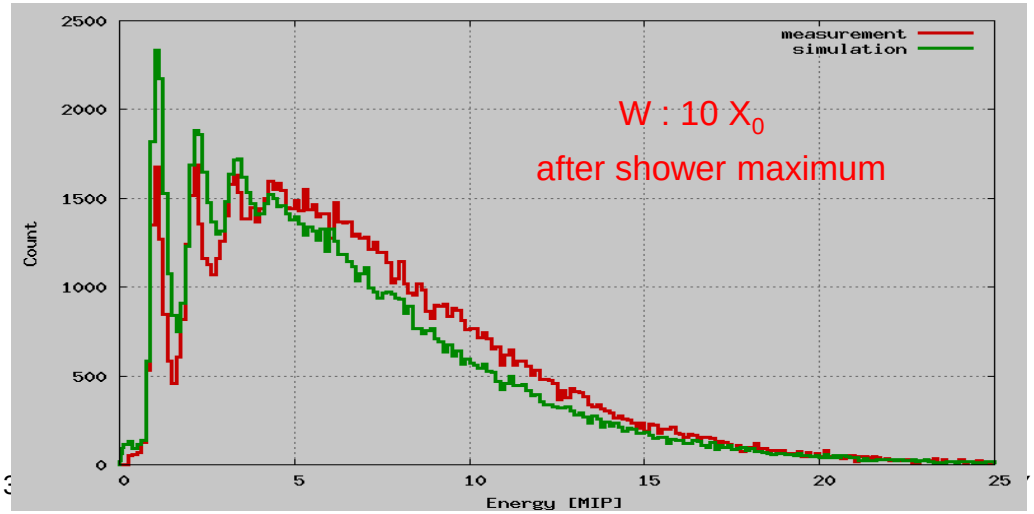
LumiCal testbeam results

Data and MC : different thickness of tungsten absorber

Preliminary results



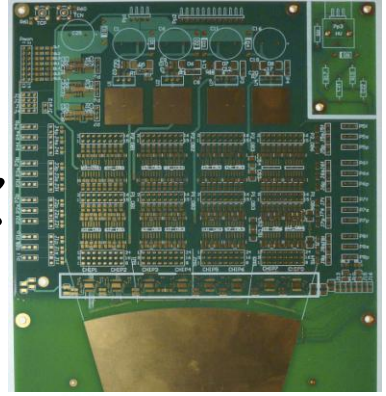
MC distributions
are sensitive to a value of an air gap between absorber and sensors used in simulation
(a few cm)



The observed differences between data and MC are under study.
Wrong value of air gap in MC?

Next: 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

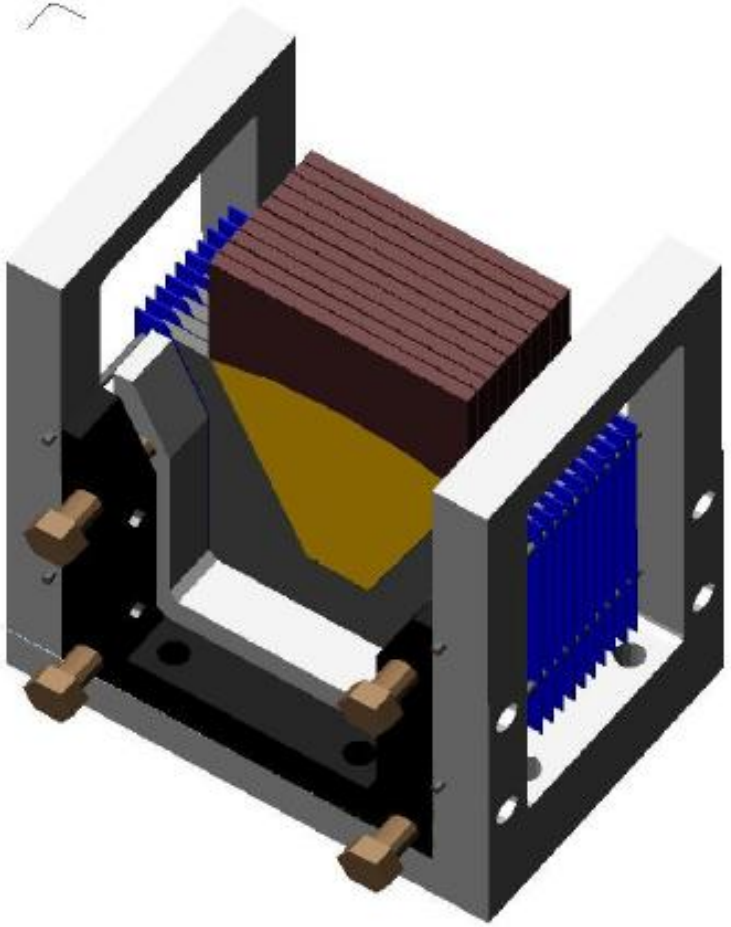
Multichannel FE and ADC ASICS to instrument 10 consecutive sensor layers

Tools to assembly 10 sensor sectors

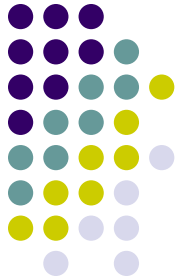
Optical position control of the sensor sectors wrt the tungsten frame

DAQ (common with other components)

Power pulsing (common developments)

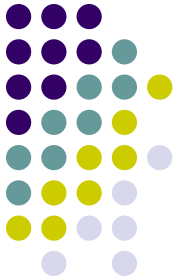


Conclusions



- Infrastructure for VFCAL sensors evaluation is ready
- Prototyping of Si sensors for LumiCal successful. Sensors are tested using probe stations at Cracow, DESY and Tel-Aviv
- Laser Alignment System prototype completed
- FE ASICS are ready and tested with sensors
- System test (sensors+fanout+FE) at DESY testbeam done
- ADC ASICs – second submission successful, first prototypes of multichannel version are under test
- Investigation of the radiation hardness of GaAs, Diamond and Sapphire BeamCal sensor prototypes done up to 12 MGy dose
- NEXT: FCAL Module system test at the beam in future (FP7)

Backup slides



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