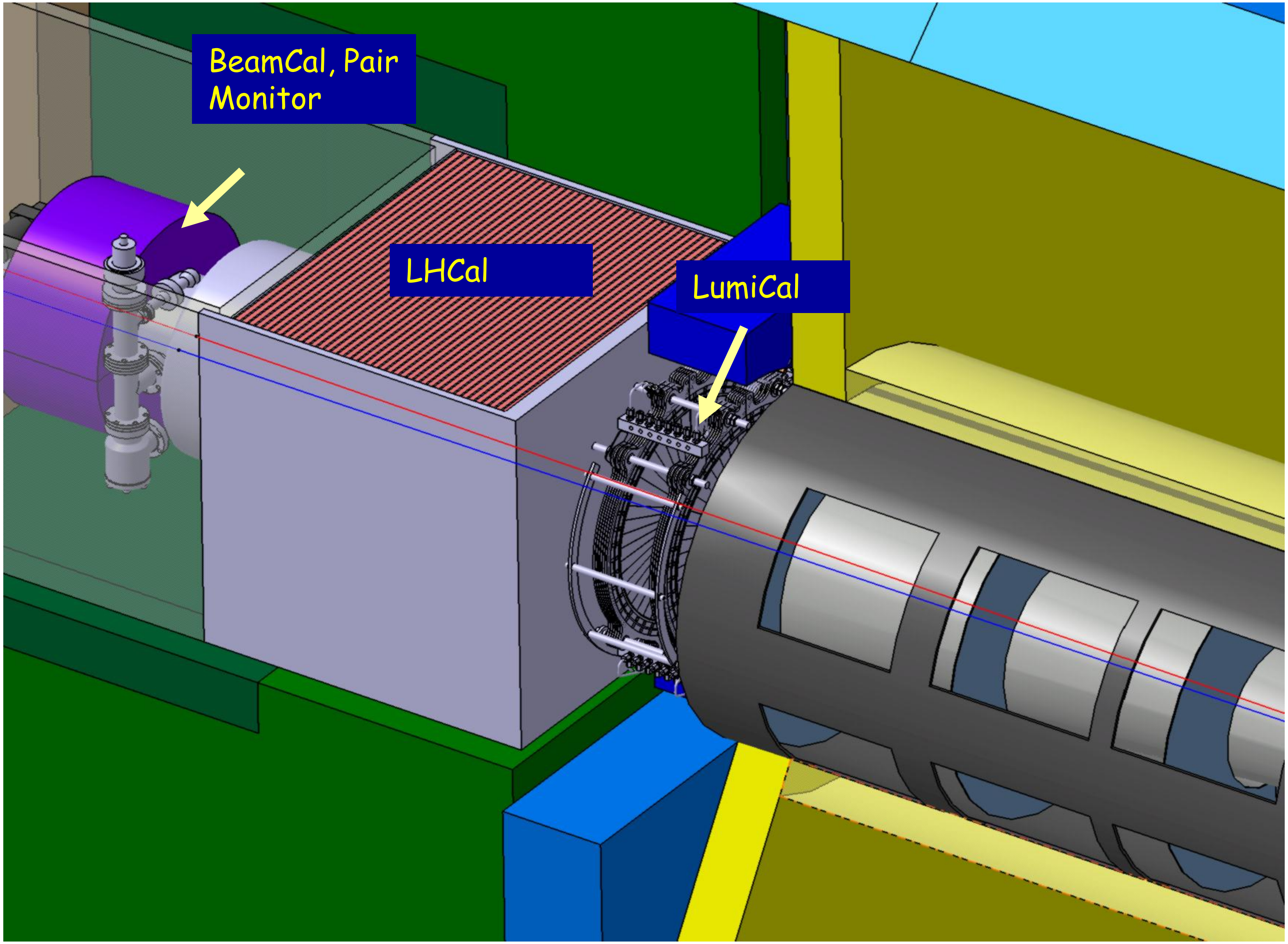
VFCAL task status report

Sergej Schuwalow

DESY

On behalf of the FCAL collaboration

Very Forward Region of the ILD Detector

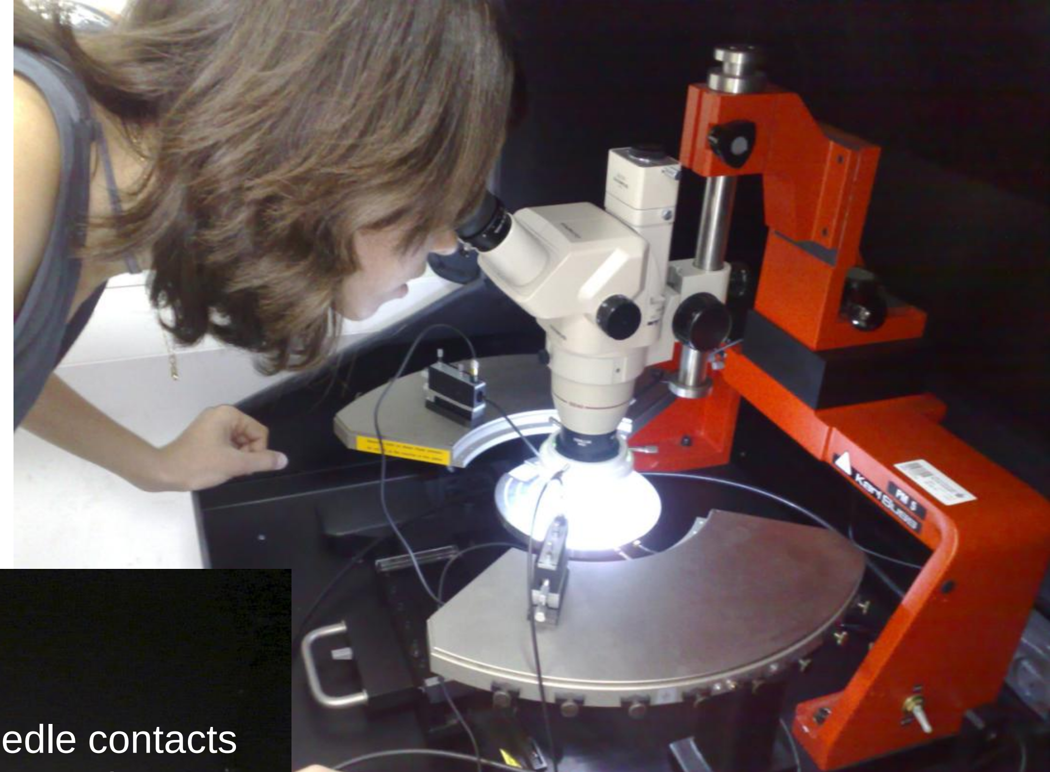


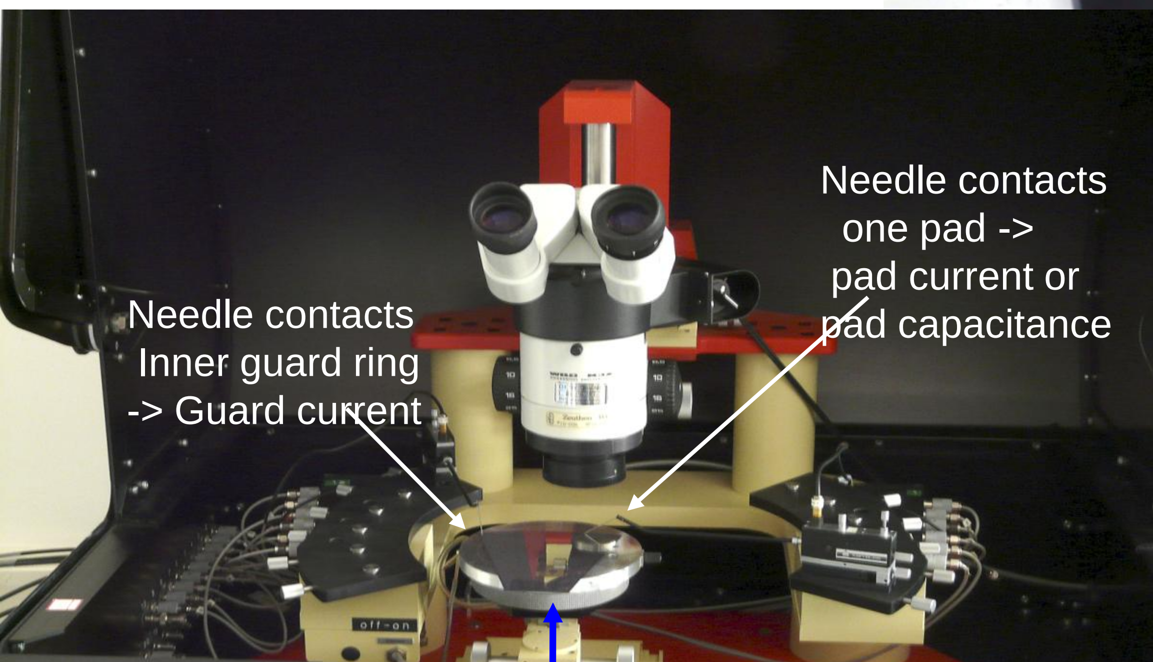
Outline

- 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



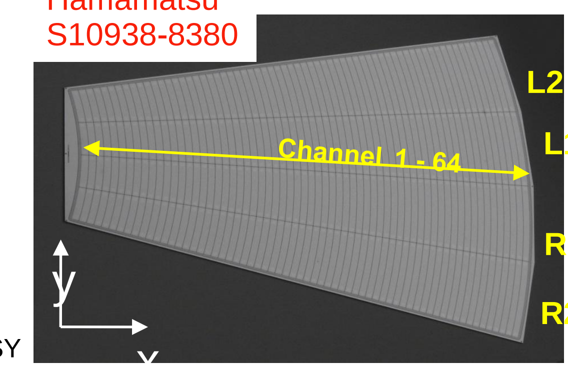


Backplane contacted via Al table (‘+’ of high voltage)

DESY - Zeuthen

LumiCal Sensor Tests

Hamamatsu
S10938-8380

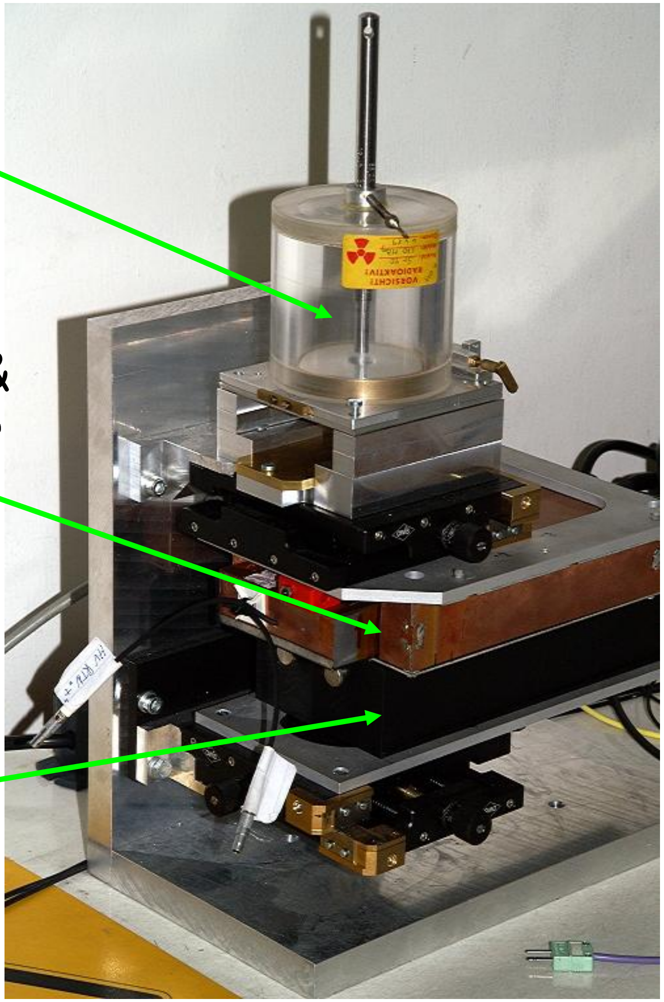


Infrastructure: BeamCal sensor tests in the lab

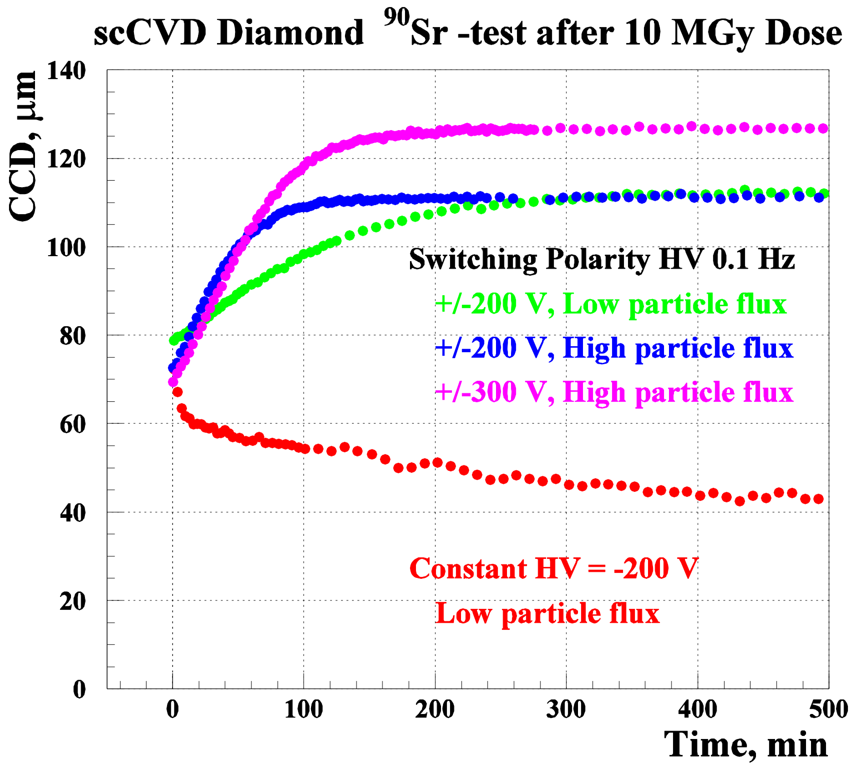
^{90}Sr Source

Sensor box & Preamplifier

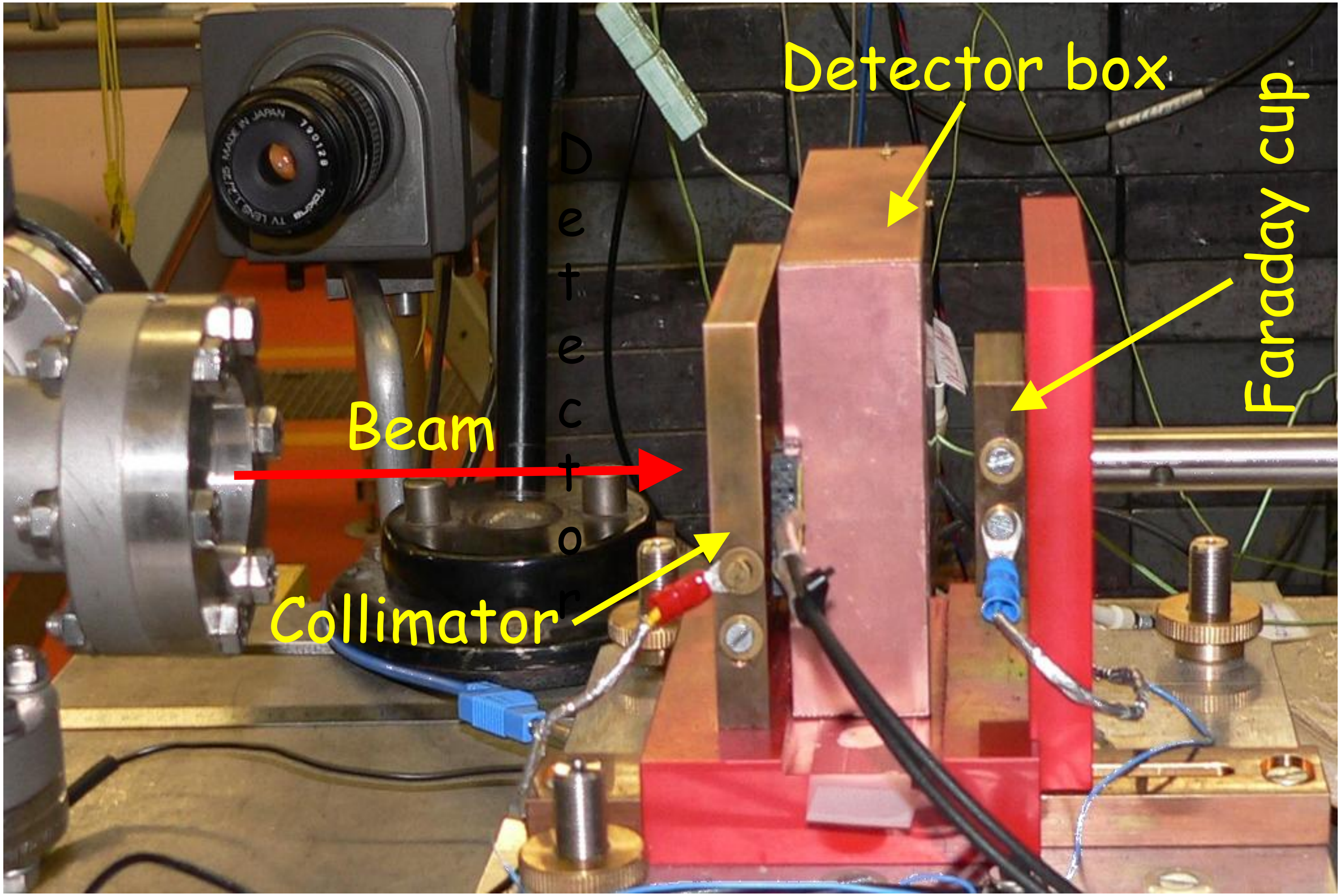
Trigger box



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

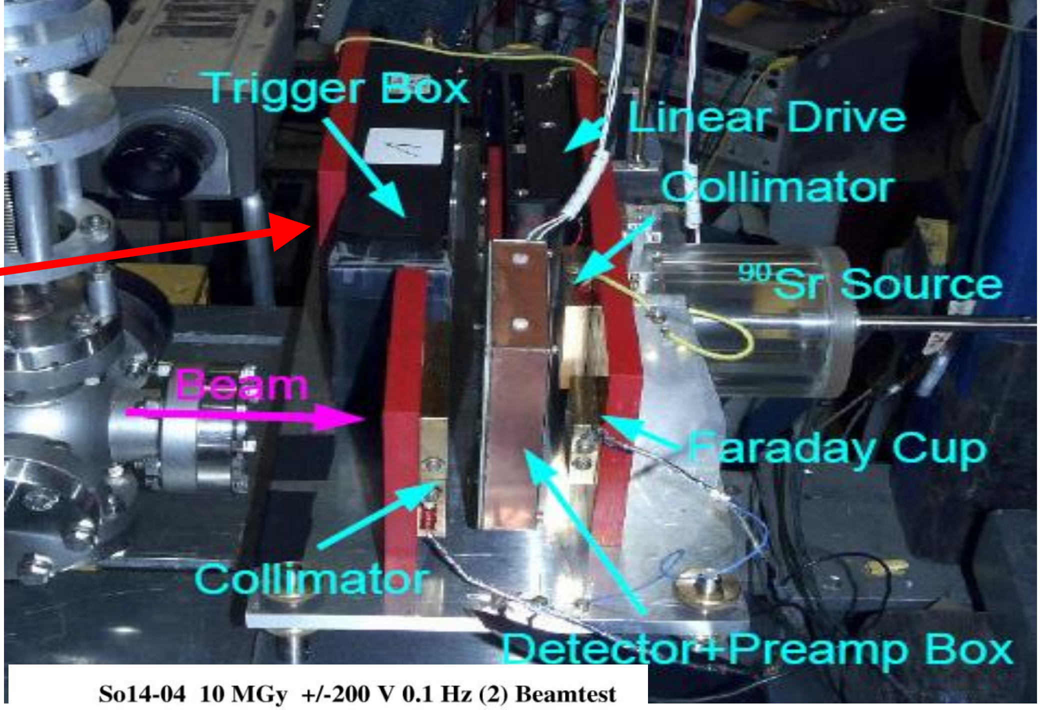


Infrastructure: High dose irradiation at the beam



Infrastructure: BeamCal Sensors study at the beam

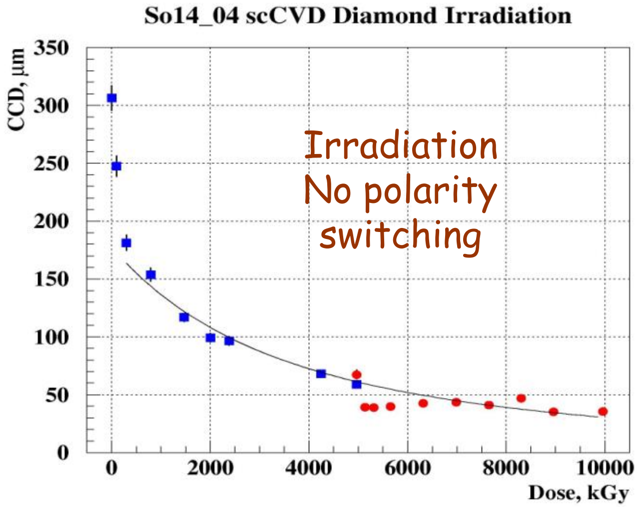
Setup for Beam Pumping Measurements

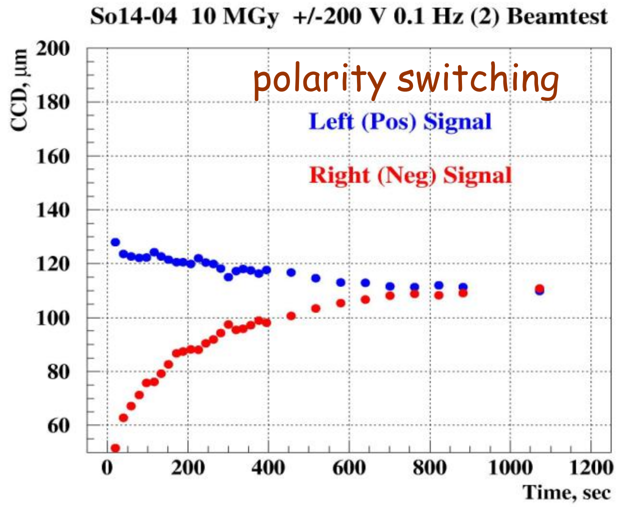


scCVD diamond (E6), 5x5x0.3 mm^3

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)

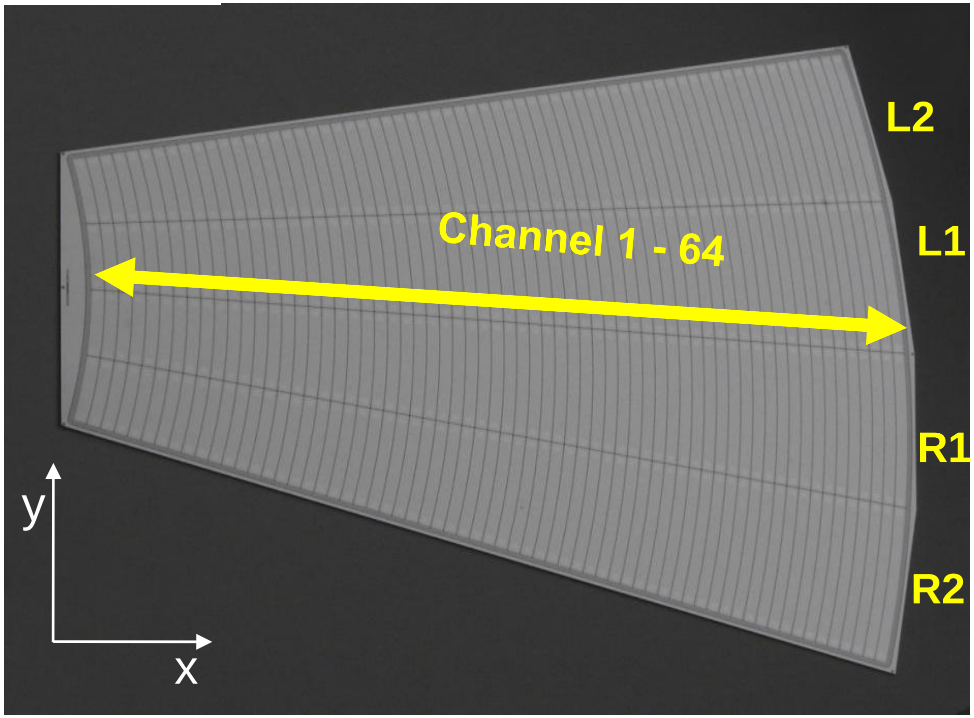
EUDET-Memo-2009-07 J.Blocki, W.Daniluk, E.Kielar et al., Silicon Sensors Prototype for LumiCal Calorimeter

"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

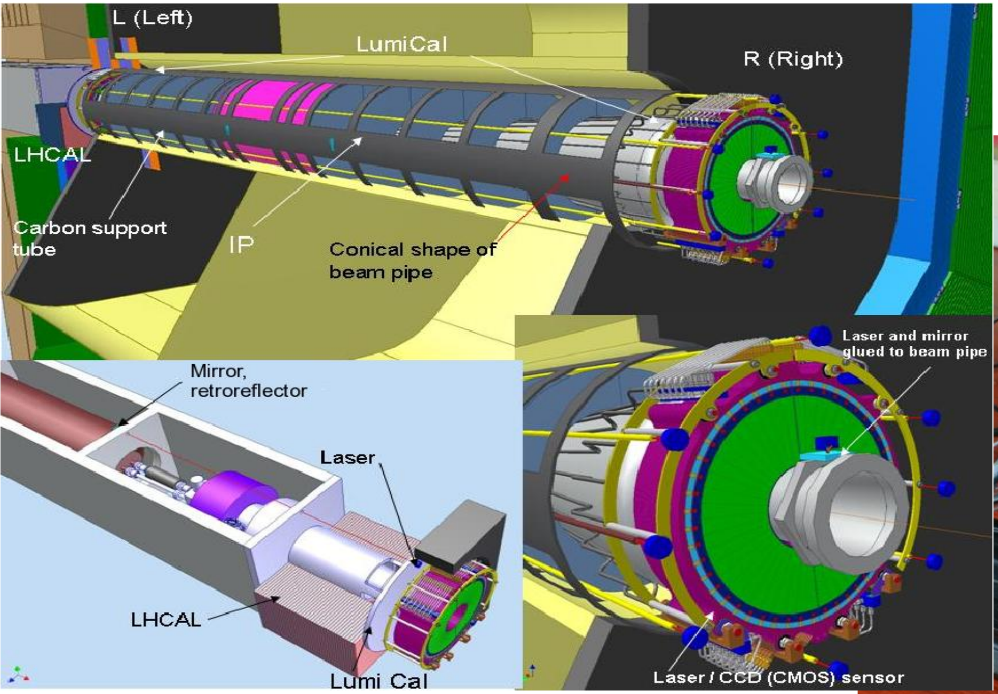
x-Size = 10,8cm
y-Size = 4…12cm
(6 Inch Wafers)
40 sensors produced by Hamamatsu Photonics

Hamamatsu S10938-8380

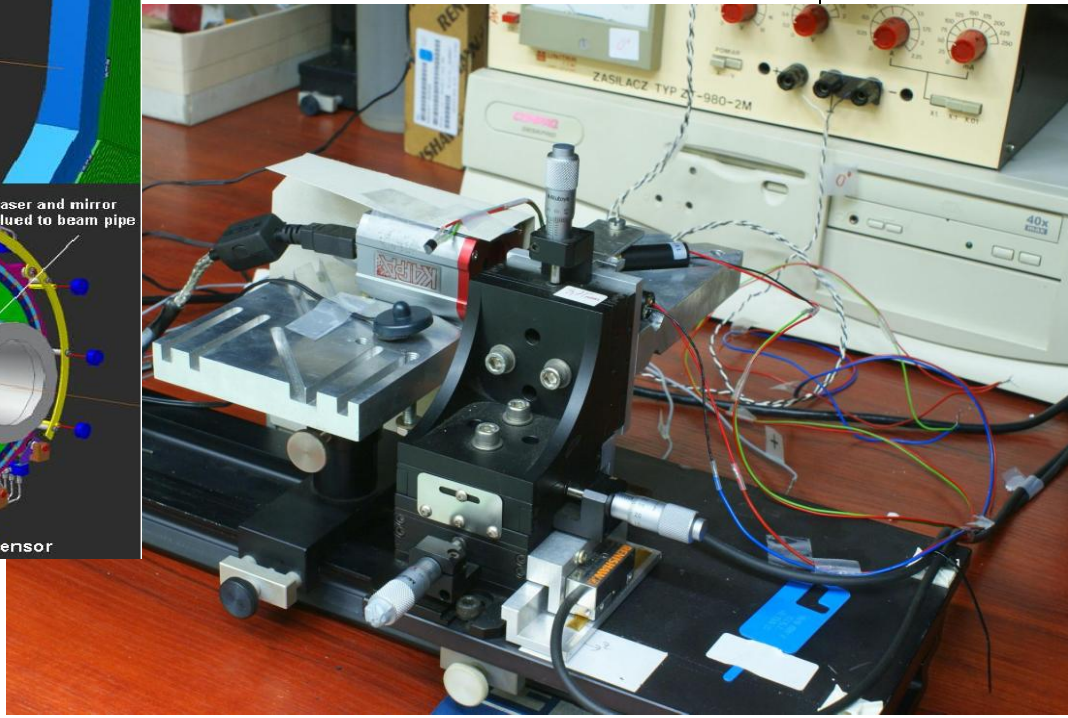


I(V) and C(V) measurements on Probe-stations in Tel Aviv, Cracow and DESY

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

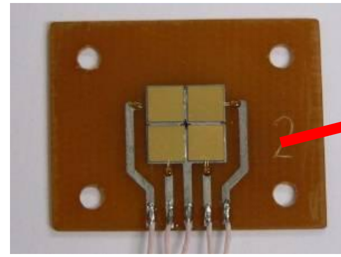
BeamCal Sensors example

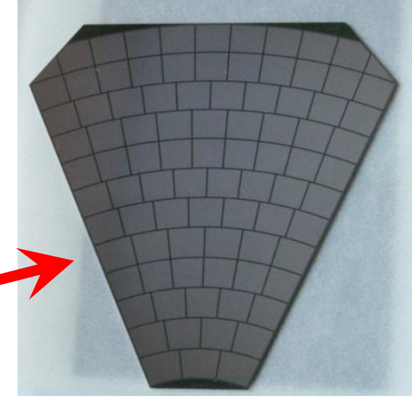
Baseline: GaAs

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)

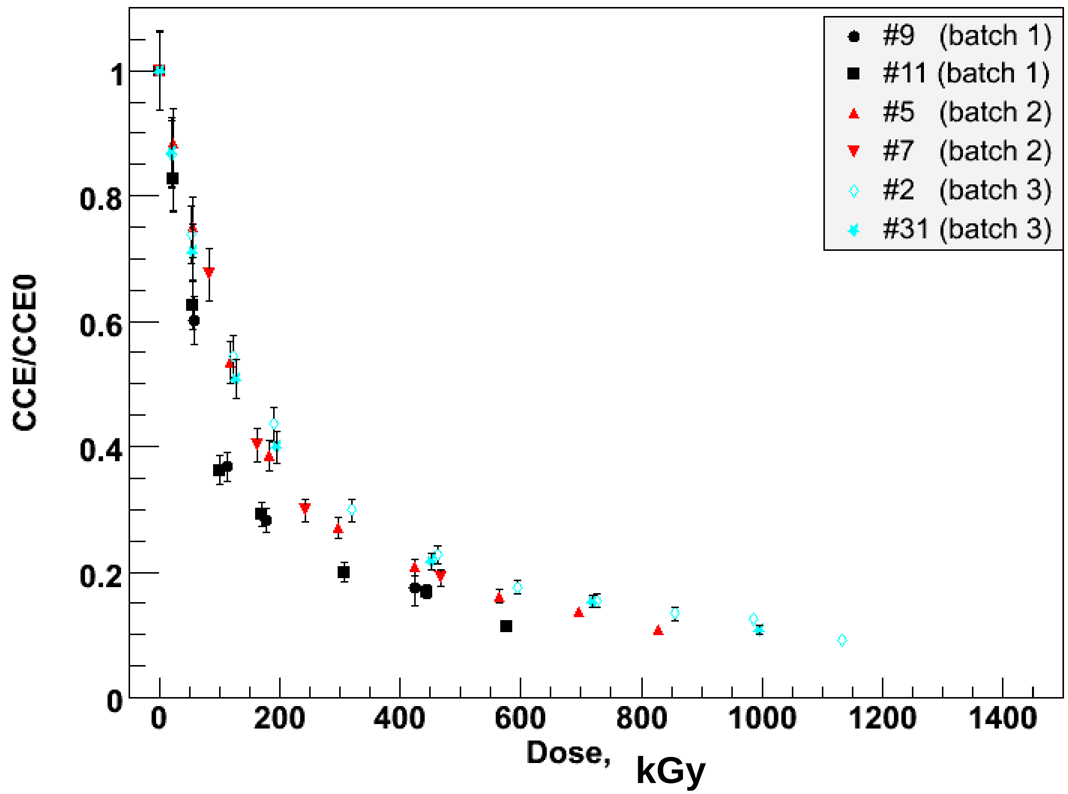
GaAs





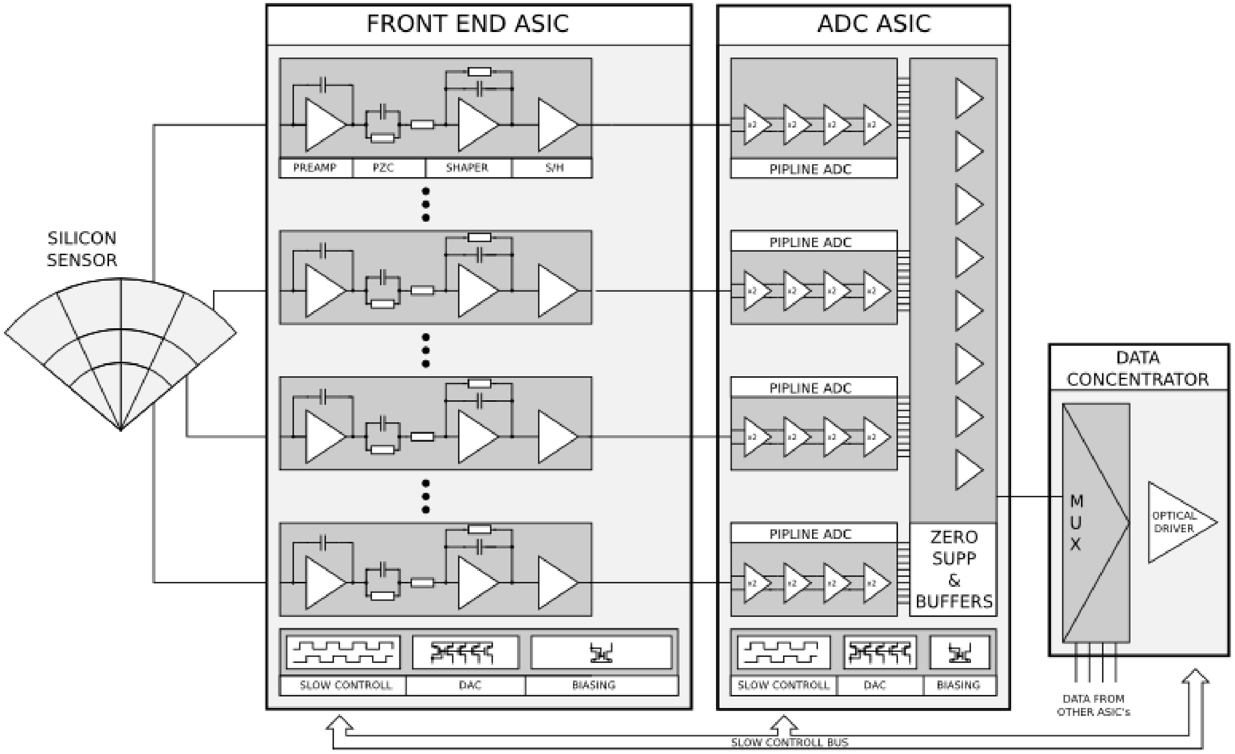
BeamCal sector prototype

GaAs:Cr CCE vs dose

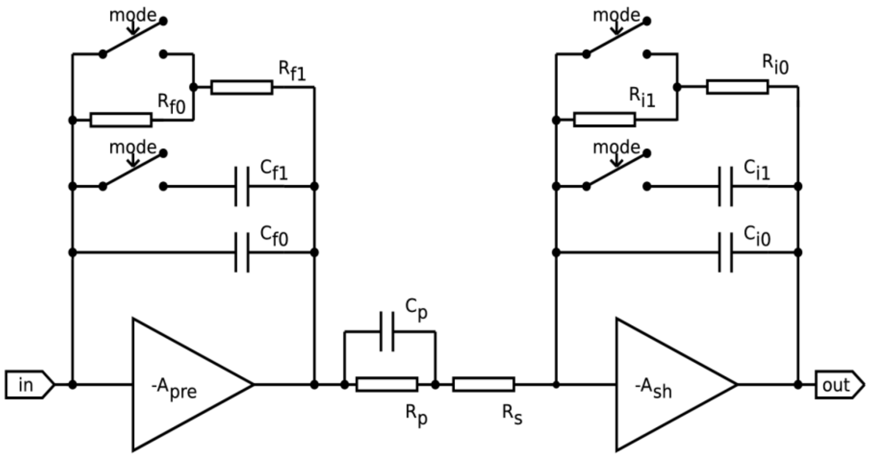


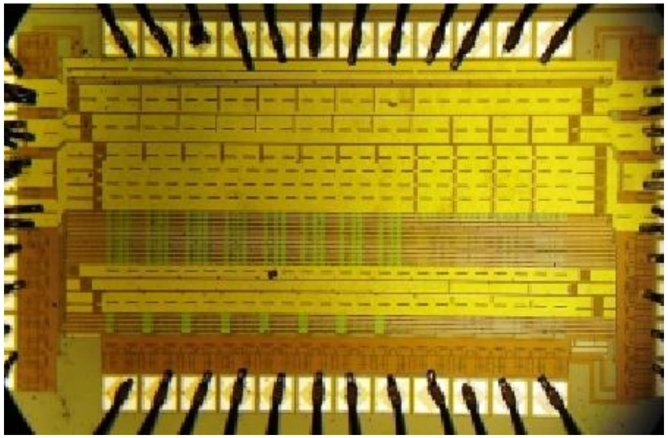
Readout architecture for luminosity detector at ILC

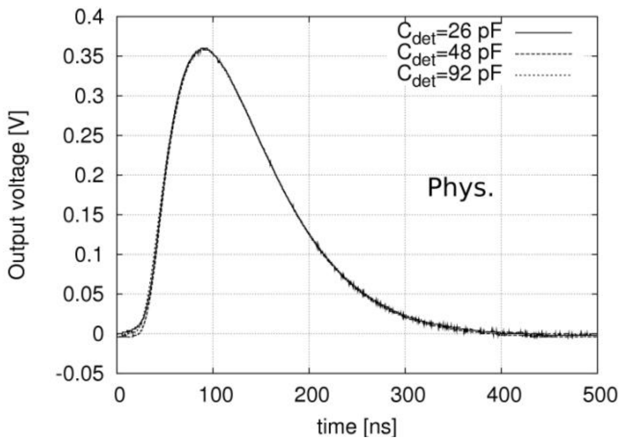
- Prototypes in AMS 0.35 µm
  - 8 channels front-end (already presented)
  - 1 channel ADC (measurements completed recently)
  - 8 channels ADC (measurements just started)



Preamplifier&PZC&Shaper

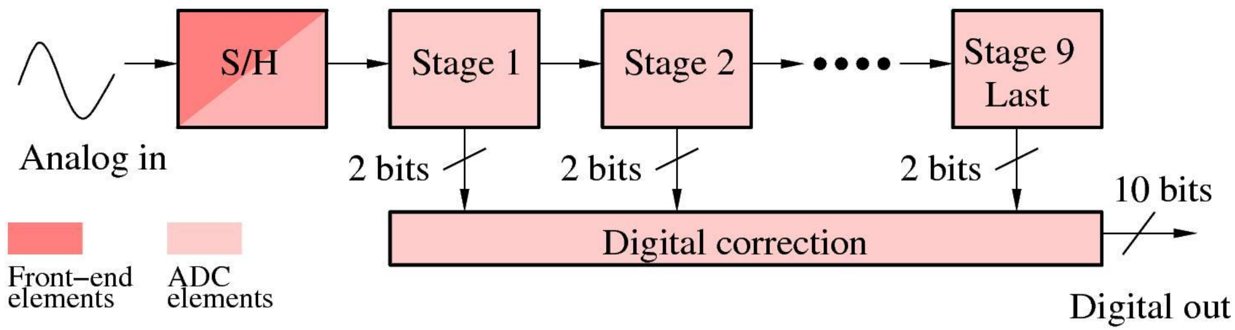




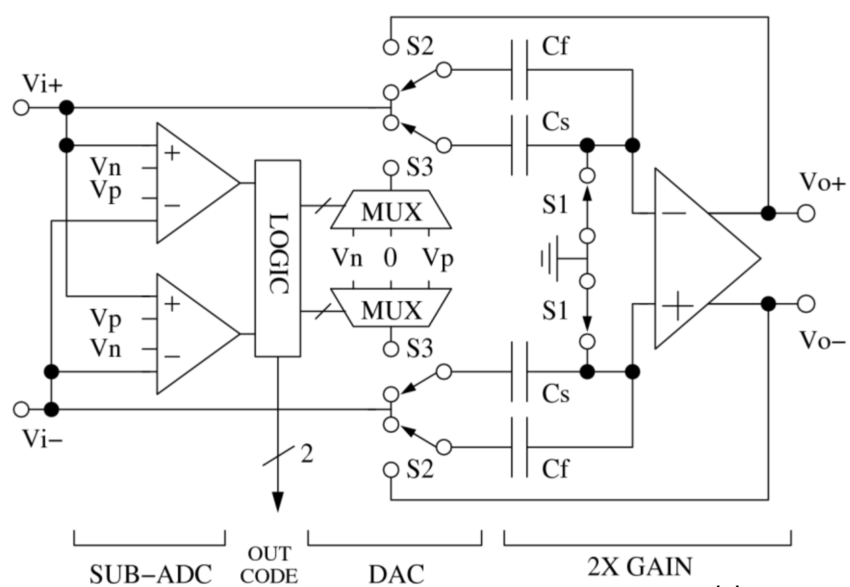


- ASIC with 8 channels
- Variable gain (MIPs and high input charge up to ~ 10pC)
- C_{det} range ~ 0-500 pF
- 1^{st} order shaper T_{peak} ~ 60 ns
- Power consumption < 9 mW/chan

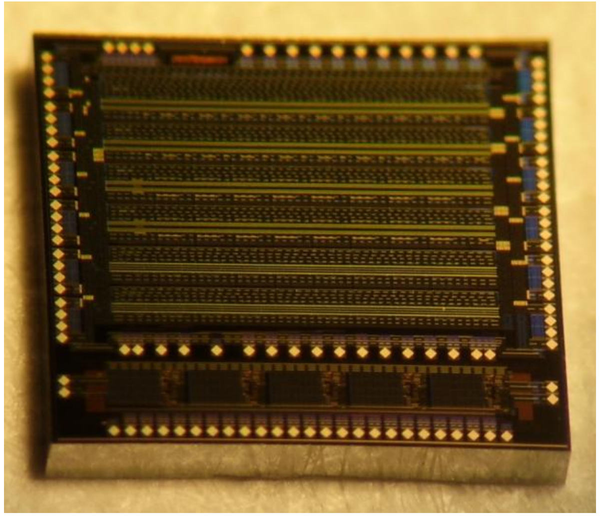
Design of 10 bit pipeline ADC

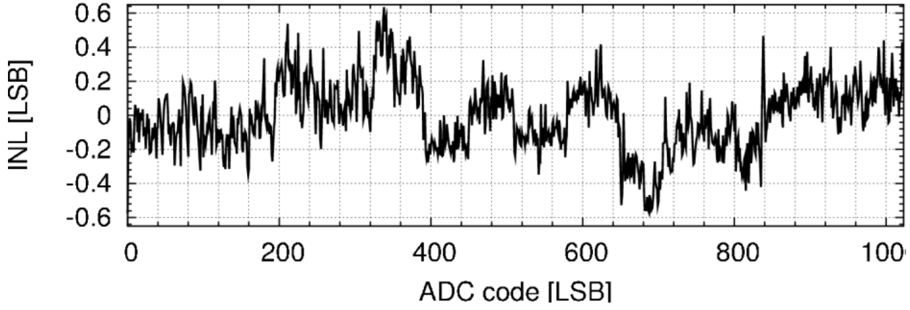


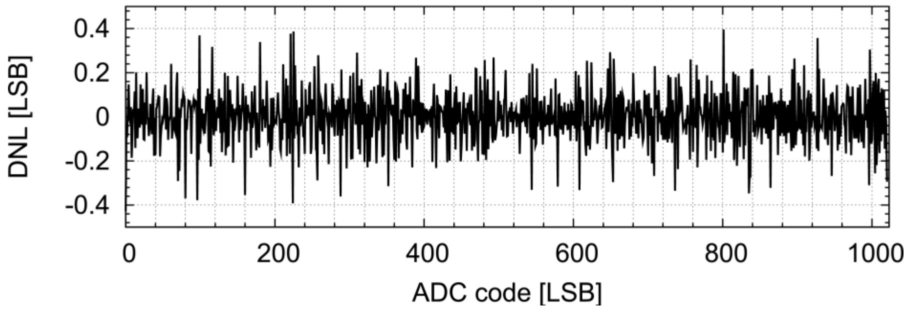
- 10 bit pipeline ADC 1.5 bit/stage
- Variable sampling frequency up to ~25 Ms/s
- Scalable power consumption
- Fully differential
- Power switching OFF/ON (ILC, CLIC beam timing)
- Present version in 0.35 µm AMS

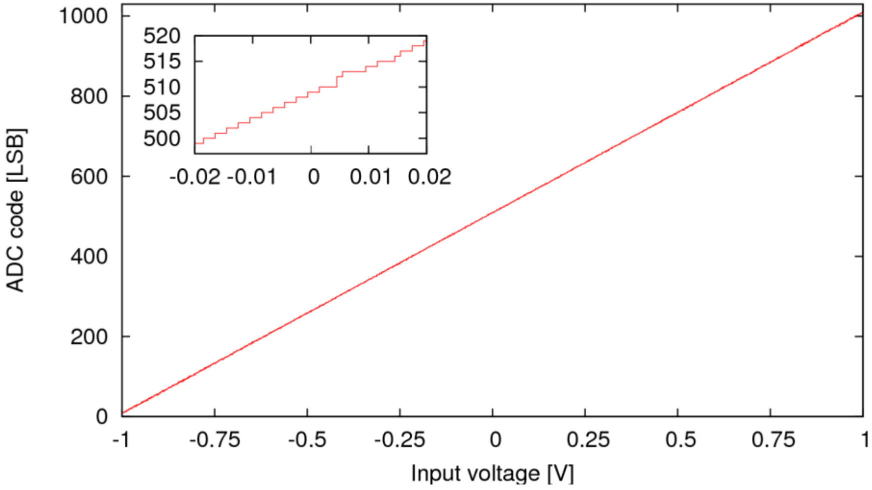


ADC static measurements





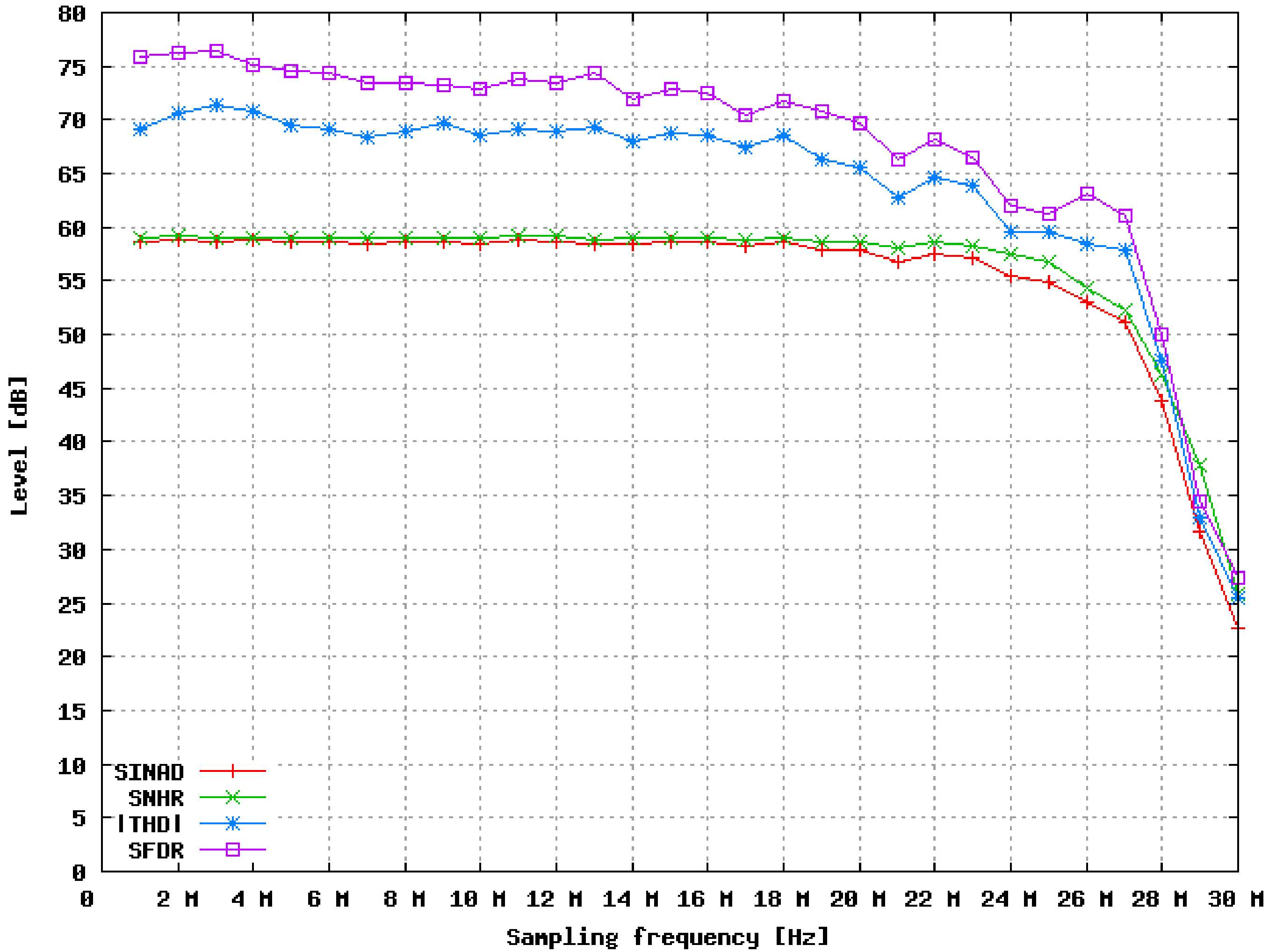




Very good linearity

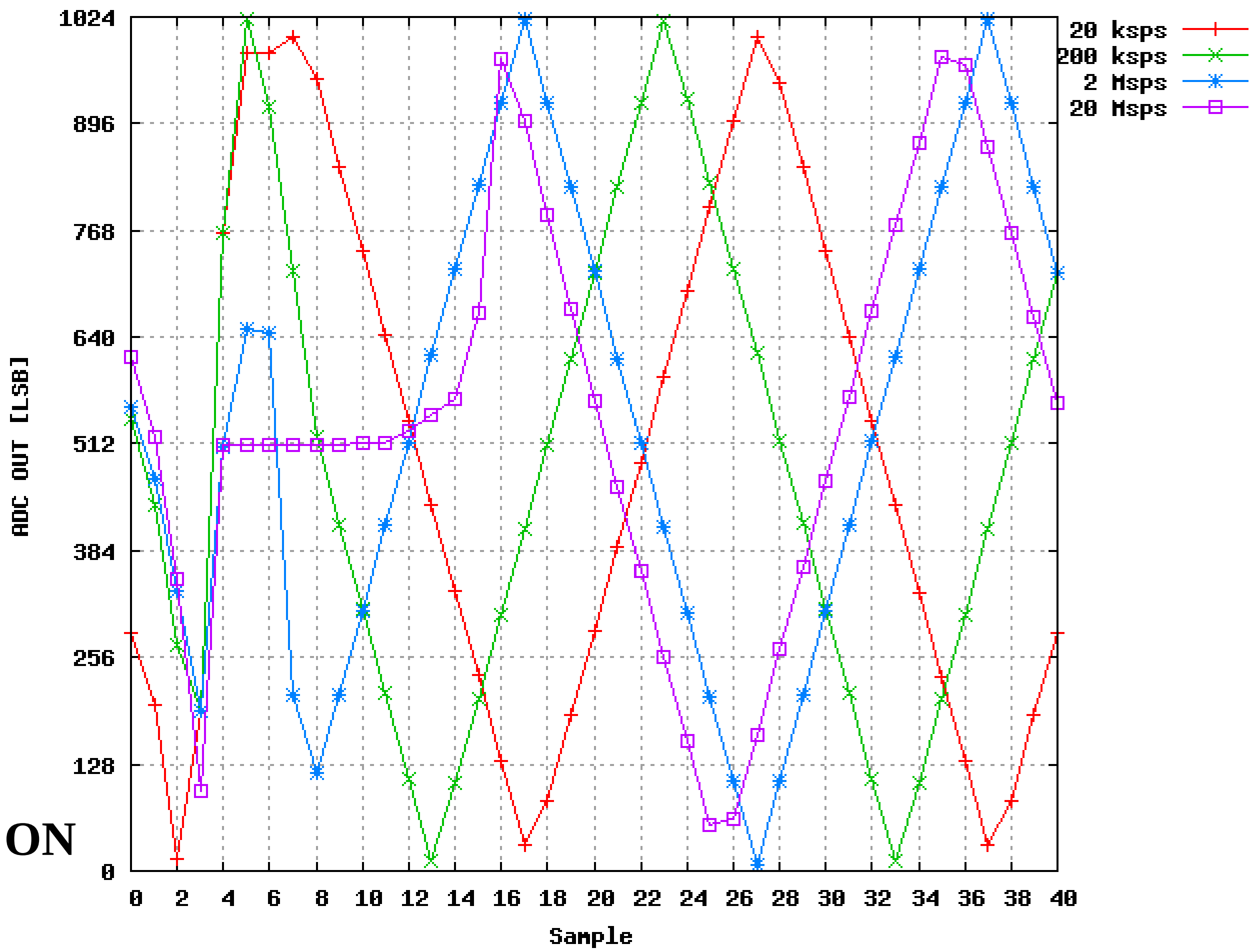
INL < 1LSB, DNL < 0.5 LSB

ADC dynamic measurements



Good dynamic performance ENOB ~ 9.5 bit

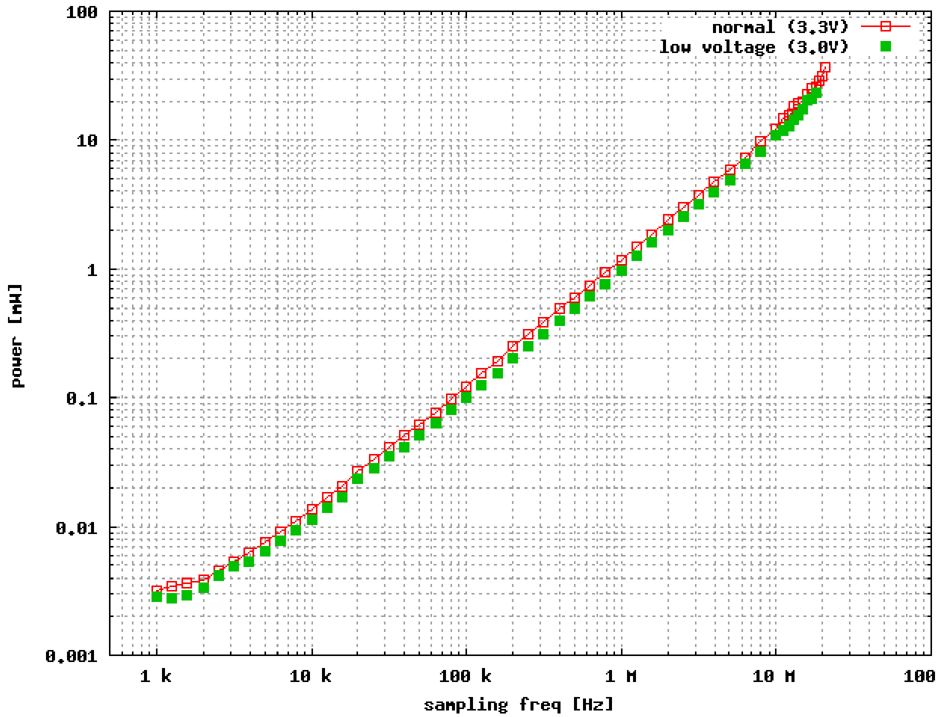
ADC – power OFF/ON

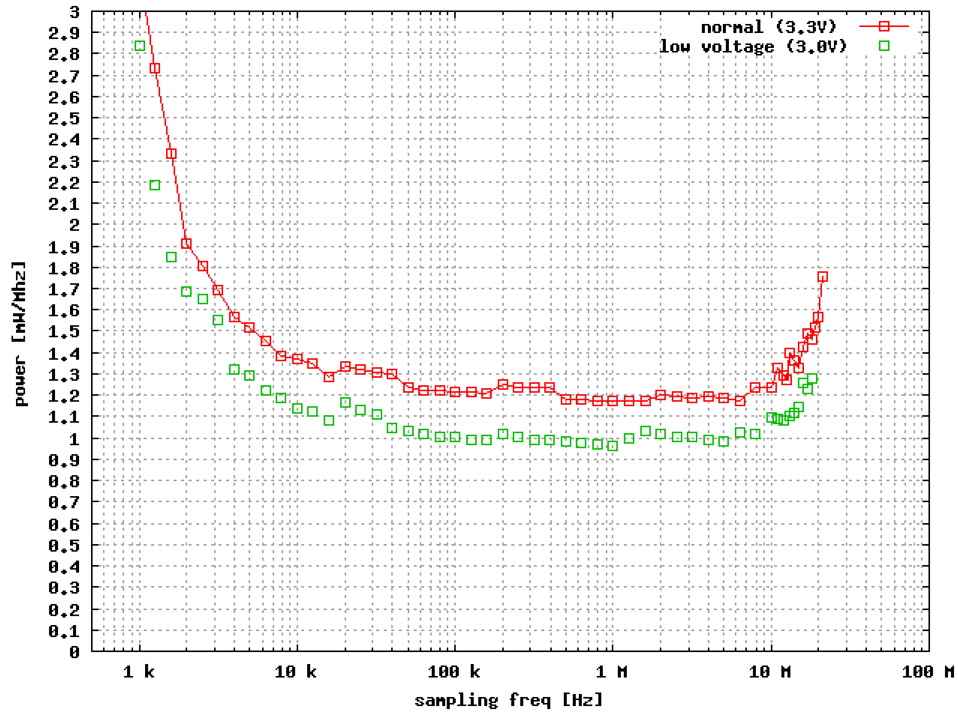


Power ON
at t=0

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)

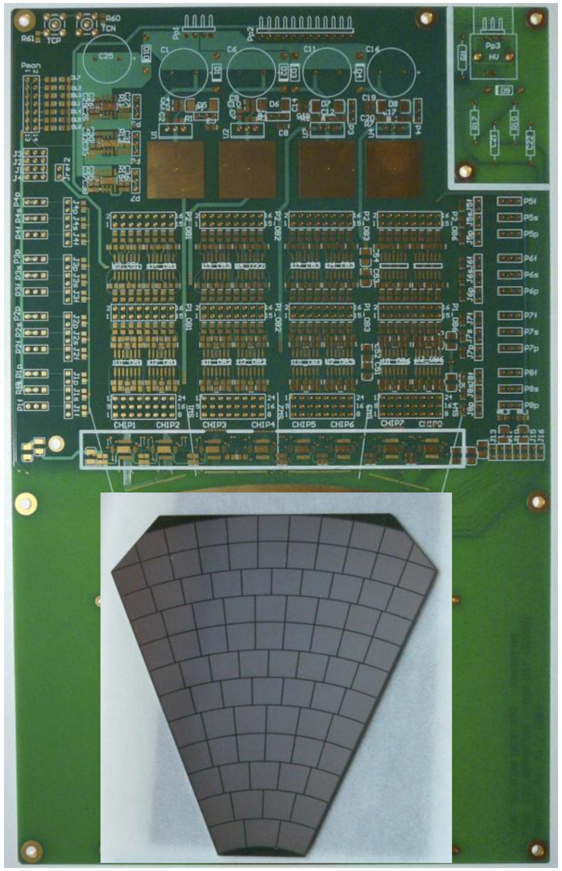
The tests confirmed that ADC fulfils all specifications and may be used in multichannel readout

Multichannel ADC

- An 8 channels ADC with 200um pitch was designed and the prototypes were produced recently
- In addition to previous design (containing: power ON/OFF, temperature sensor, fast LVDS – tested to > 800MHz) the ASIC contains DACs allowing automatic power scaling
- The measurements have been just started and quantitative results will be available soon...
- 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

System Test (Sensors,Fanout,FE electronics)

(Last year slide)



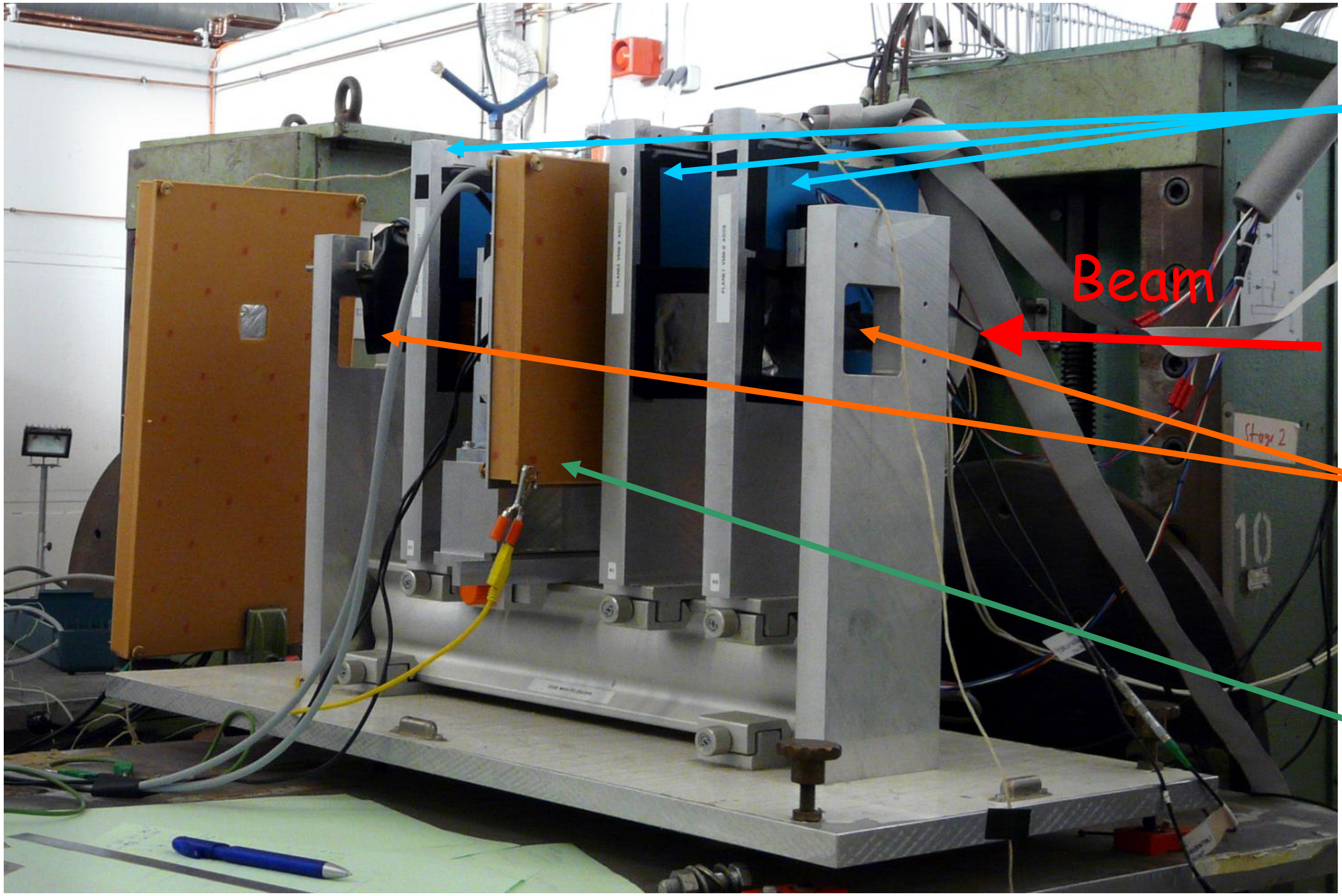
Template of a readout board, to be instrumented with FE ASICS

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

System tests: testbeam @ DESY, August 2010

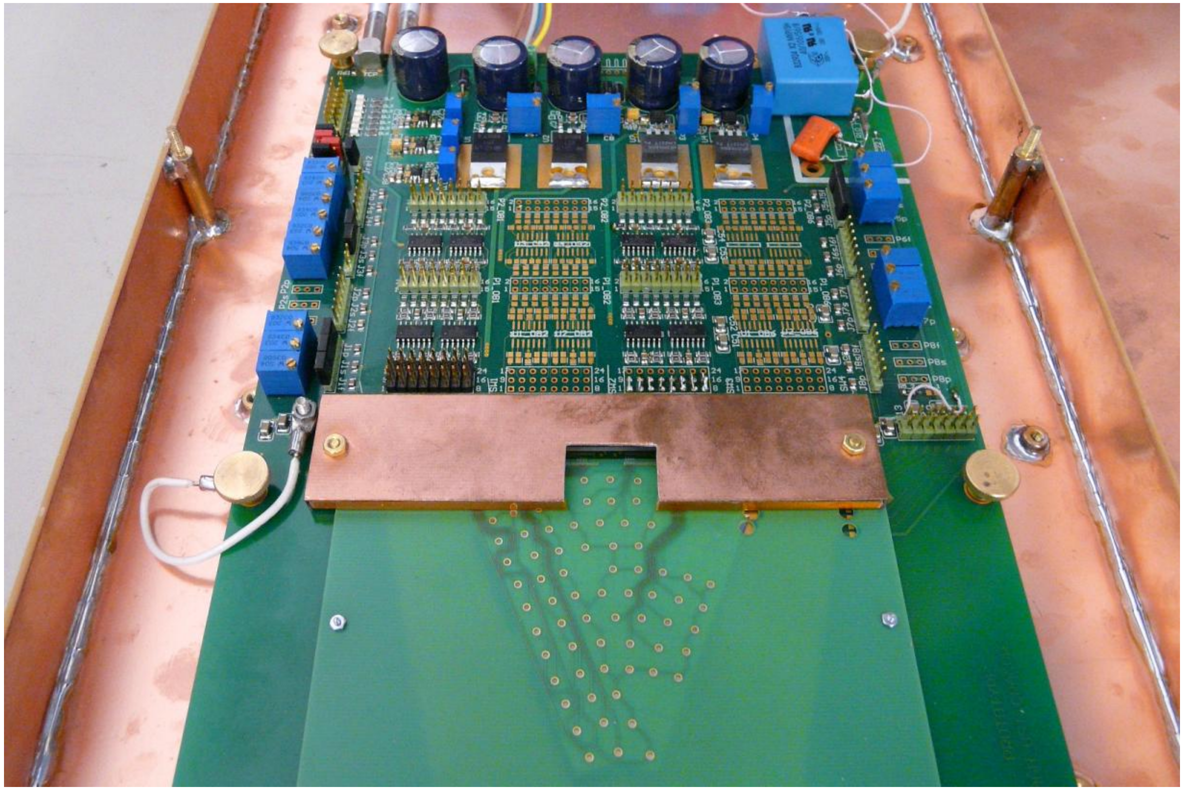
4.5 GeV electron beam



System tests: testbeam @ DESY, August 2010

Precise XY-table

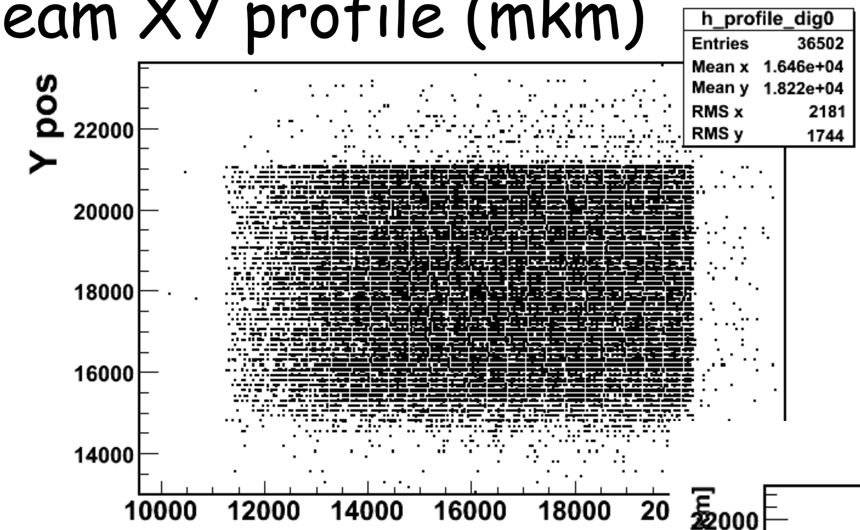
Detector box (BeamCal sensor installed)



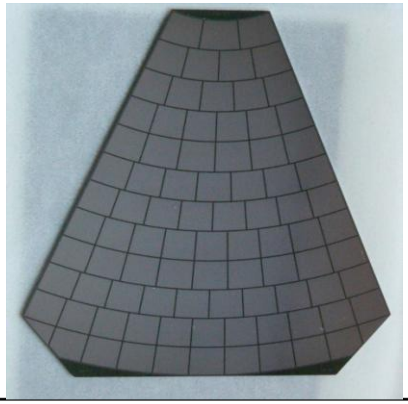
Similar box for the LumiCal sensor

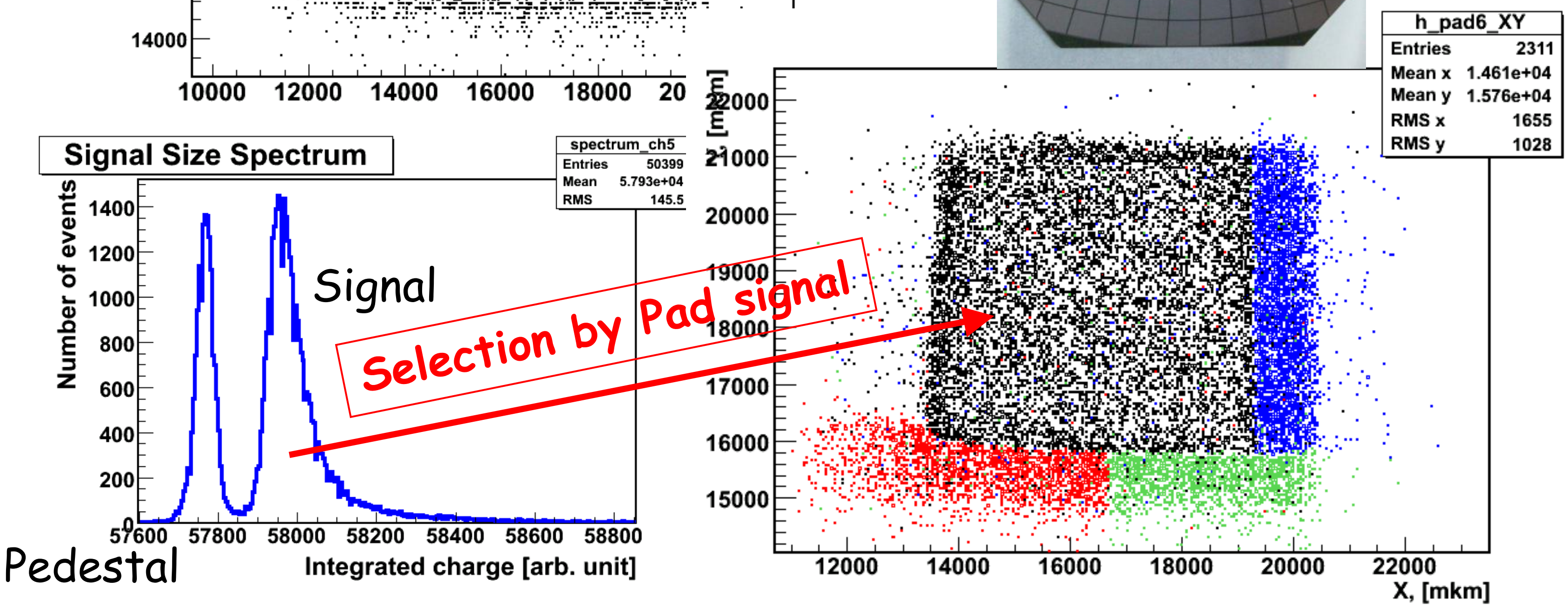
System test: testbeam @ DESY, August 2010
First results for BeamCal sensor prototype

Beam XY profile (mkm)



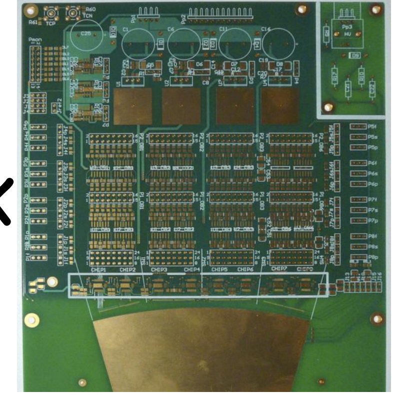
GaAs sensor

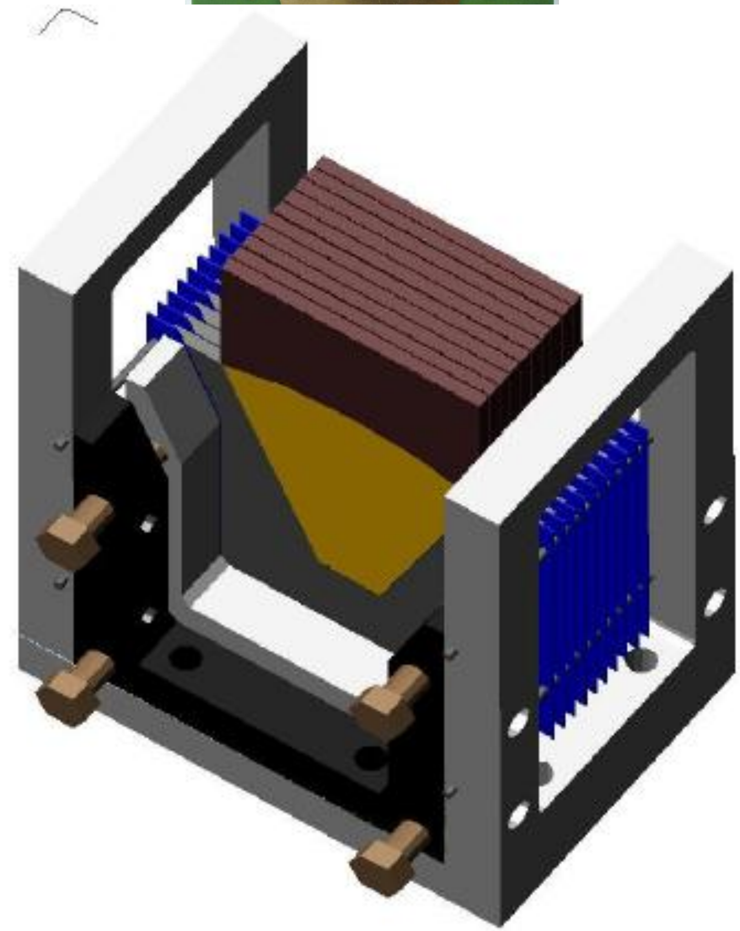




Next: System test in a beam with FCAL module -> FP7

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

BeamCal Sensors, GaAs

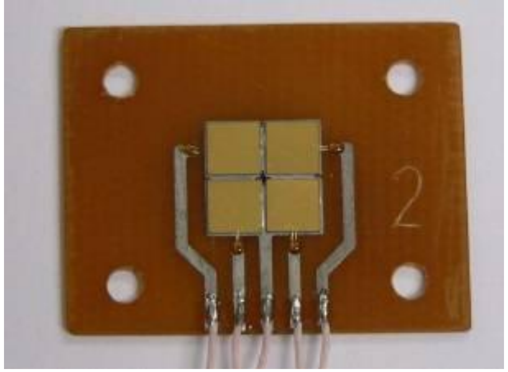
- n-type (Te or Sn - shallow donor) GaAs grown by Liquid Encapsulated Czochralski (LEC) method in Siberian Institute of Physics and Technology (Tomsk, Russia)
- low-ohmic material, filling the electron trapping centers EL2+
- Cr (deep acceptor) diffusion

-> 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 ≈ $(1 - 1.5) \cdot 10^{17}$ см$^{-3}$,Te	Diffusion of Cr under temperatureT2
№2, n ≈ $(5 - 6) \cdot 10^{16}$ см$^{-3}$, Te	Diffusion of Cr under temperature Tm
№3, n ≈ $(1 - 3) \cdot 10^{16}$ см$^{-3}$, Sn	Diffusion of Cr under temperature T1
№4, n ≈ $(2 - 5) \cdot 10^{16}$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, Sapphire

Band gap: 9.9 eV

(diamond: 5.5 eV, Si: 1.12 eV)

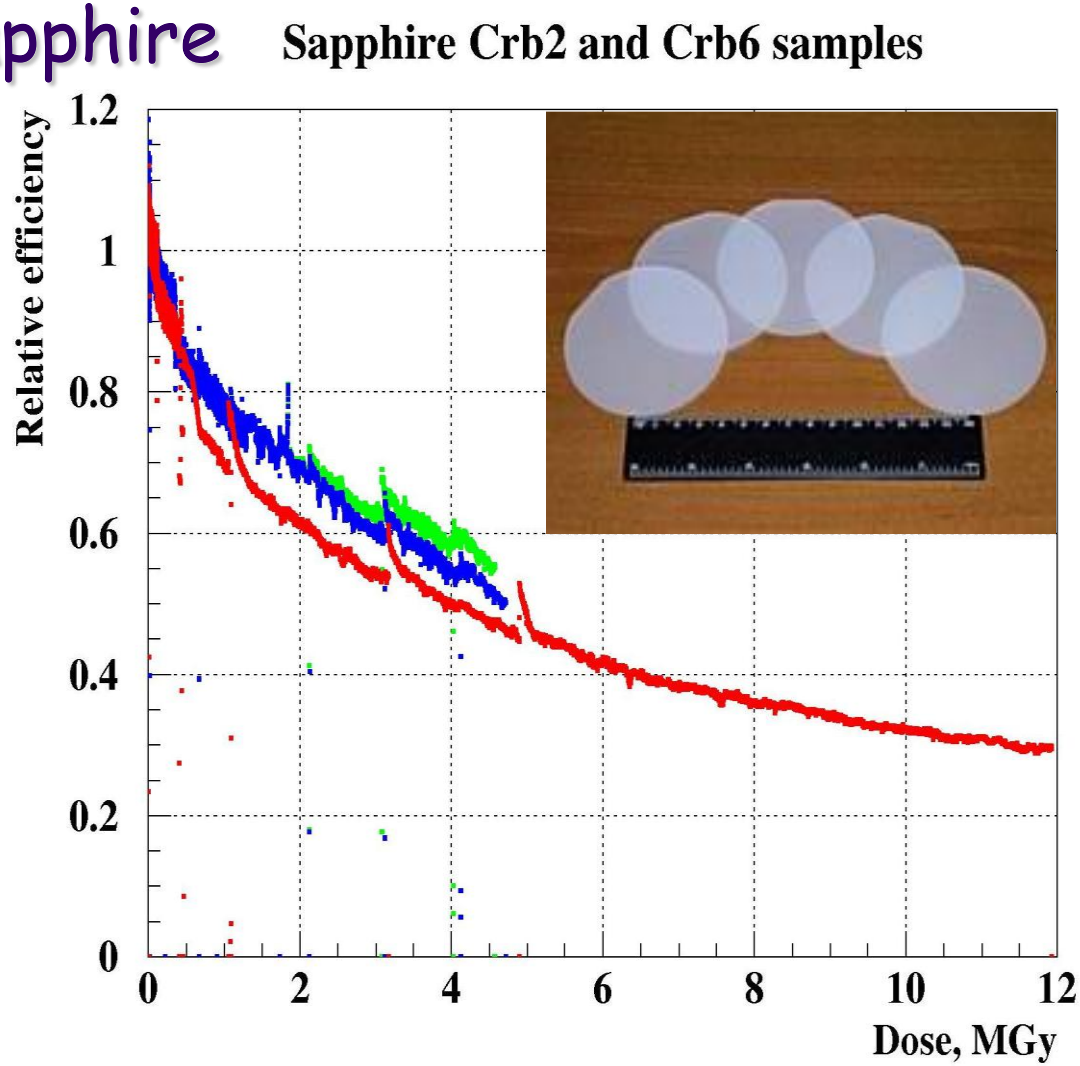
Single crystal, 1x1x0.05 cm^3

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



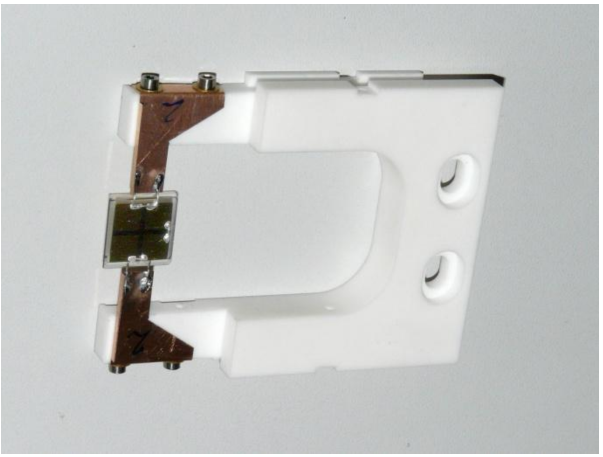
Charge collection efficiency: few % for nonirradiated samples

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

Test in PITZ

Electron beam, 14.5 MeV, bunches

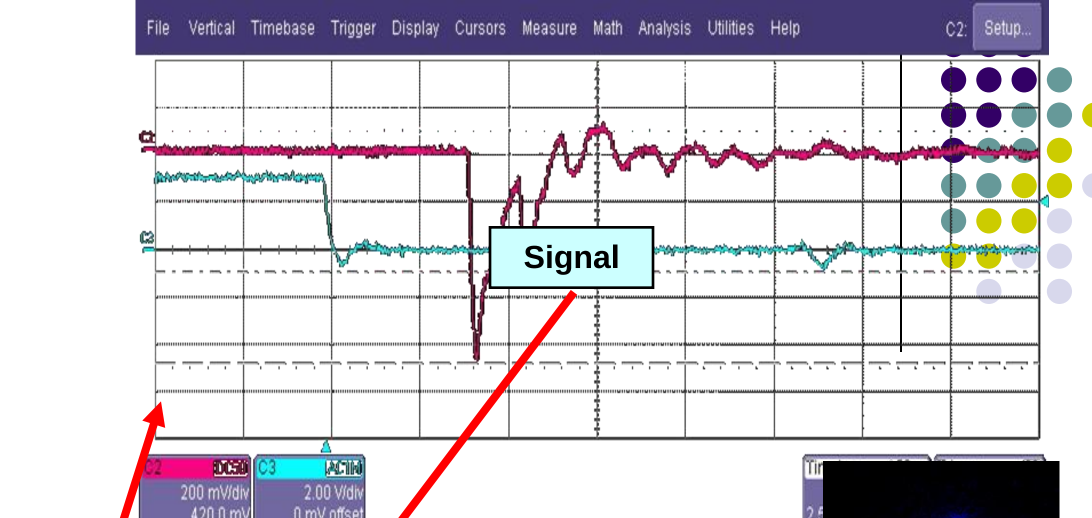
Diamond sensor was installed in the vacuum of the beam pipe

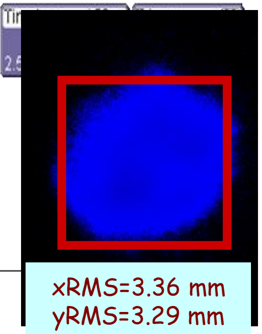


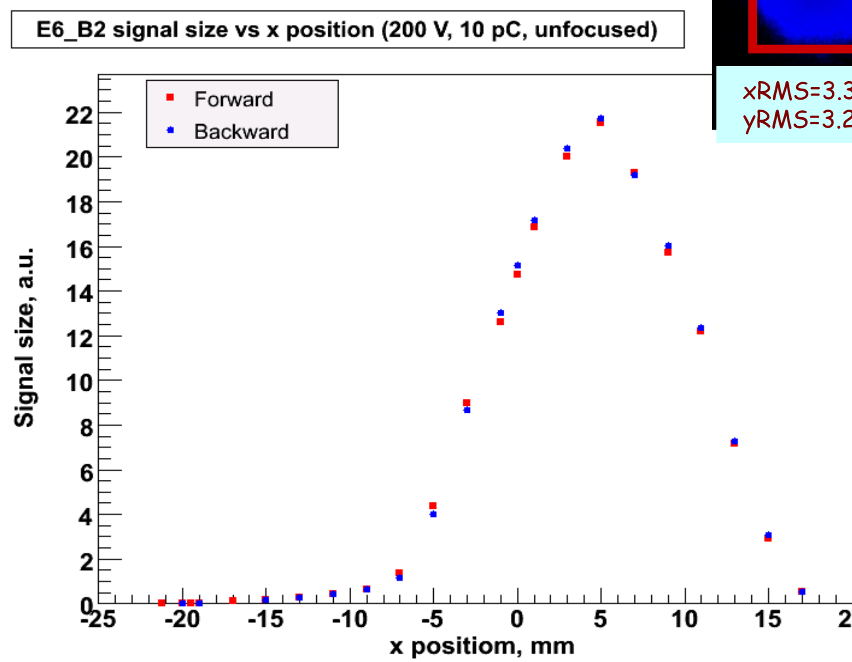
Moving the sensor through an electron beam,

Bunch charge 1 pC – 1 nC,
Beam spot: few mm^2
Beam profile

EMI doesn't disturb operation



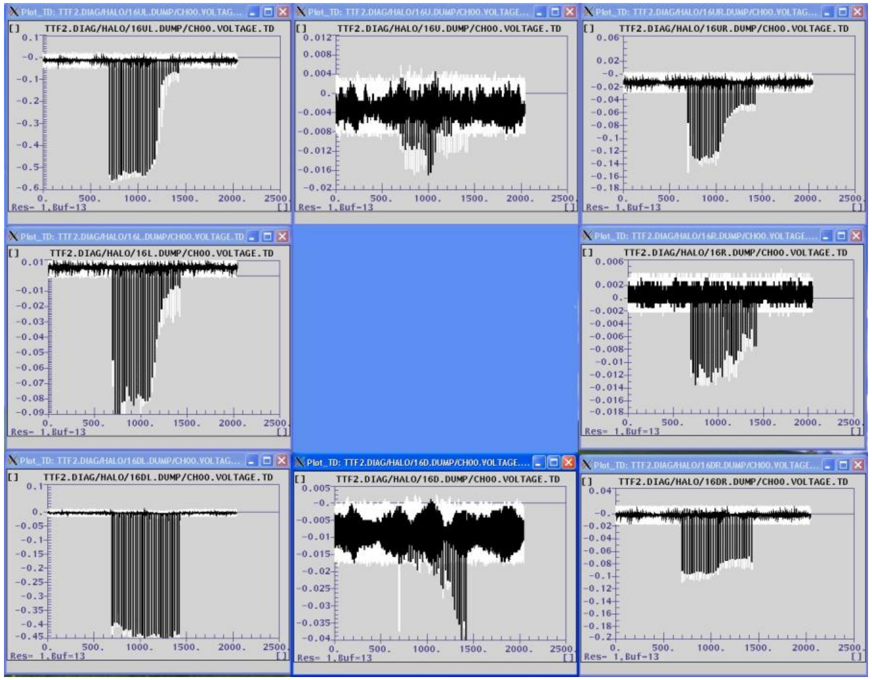


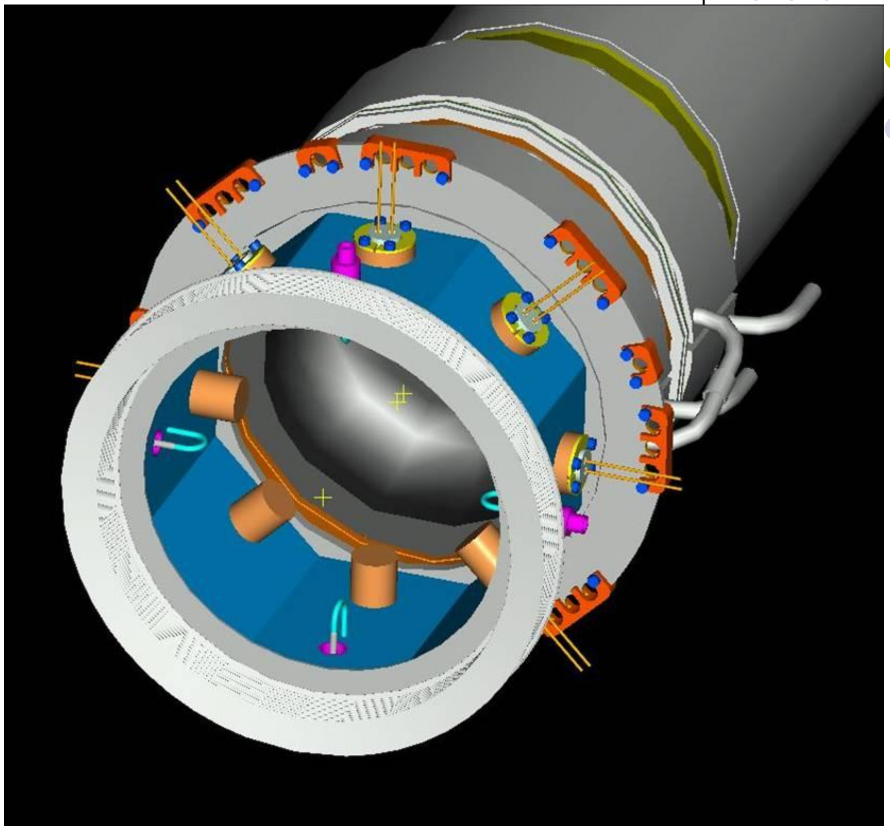


Application at FLASH

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





Design of 10 ADC...

- The second ADC version contains:
  - 9 pipeline stages plus S/H stage
  - Power ON/OFF feature
  - Bandgap based precise voltage reference plus temperature sensor
  - LVDS transmitter and receiver I/O circuits simulated up to about 1 GHz