FCAL Report

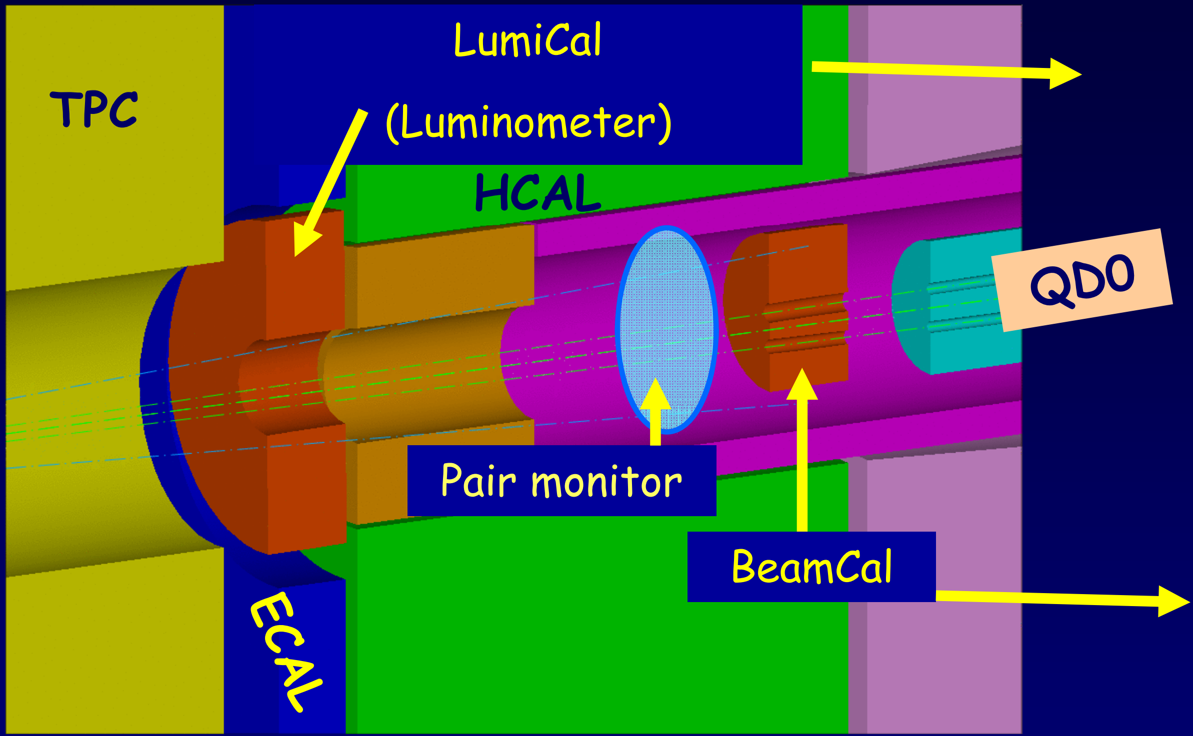
W. Lohmann, DESY

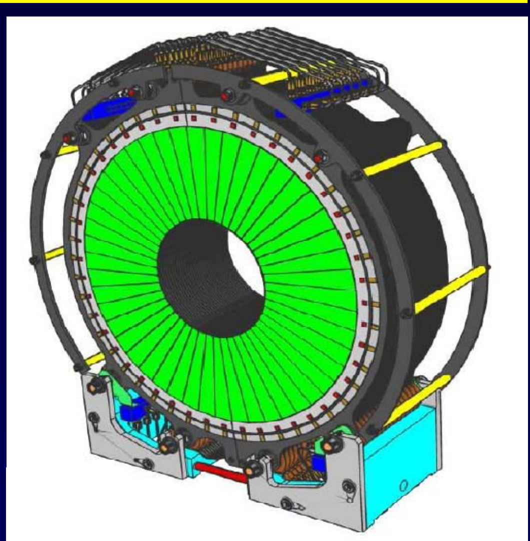
- Challenges and Design
- Sensors and Sensor Studies
- FE ASICS development
- Data Transfer, Infrastructure

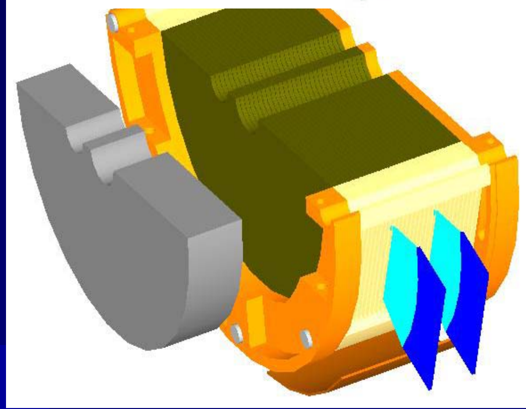
Labs involved: Argonne, BNL, Vinca Inst, Belgrade, Bukharest Univ. of Colorado, Cracow UST, Cracow INP, JINR, Royal Holloway, NCPHEP, Prague(AS), LAL Orsay, Tuhoku Univ., Tel Aviv Univ. , West Univ. Timisoara, Yale Univ. DESY (Z.)

Associated: Stanford Univ. IKP Dresden
Guests from : CERN

Calorimeters in the very forward region (example ILD, 14 mrad)







Challenges

LumiCal: -control of position on ~100 µm level
-control of the inner acceptance radius on ~µm level

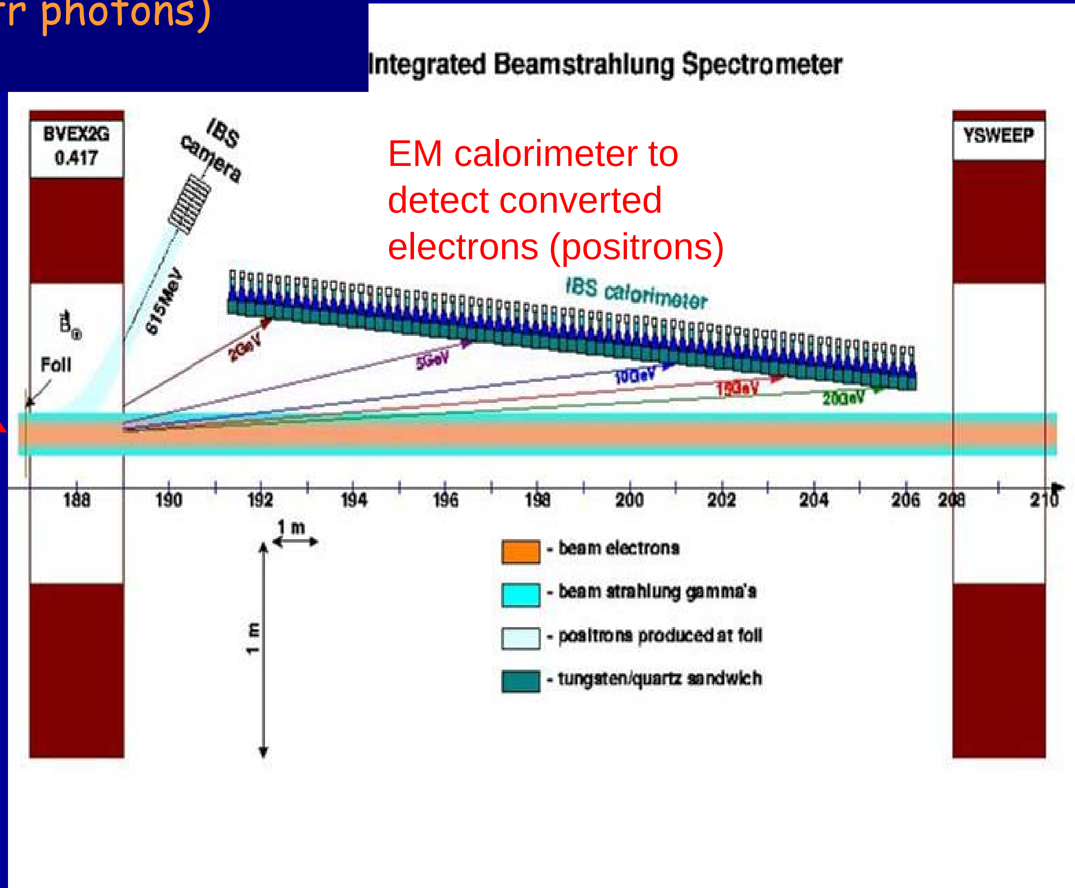
BeamCal: -radiation hard sensors (~10 MGy/year)
Both: -compact (smallest possible Moliere radius)
-readout after each BX

Pair monitor: fast pixel device, harsh radiation conditions

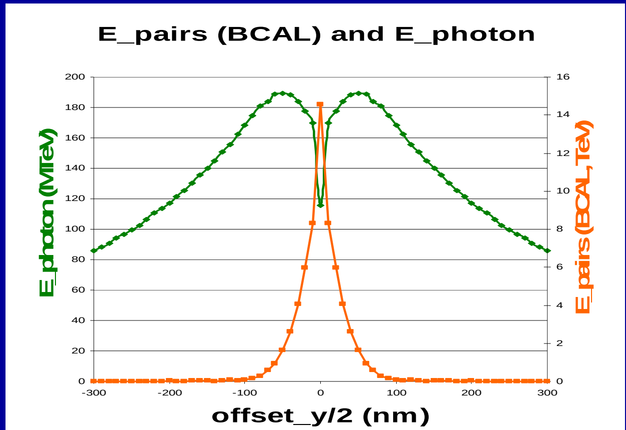
one more calorimerter, GamCal

~ 180 m from IP
< 5 mrad aperture (beamstr photons)

Thin foil to convert beamstrahlung photons



Dedicated Functions

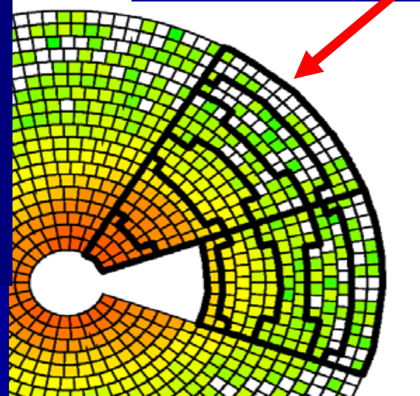


BeamCal, Pair Monitor, GamCal

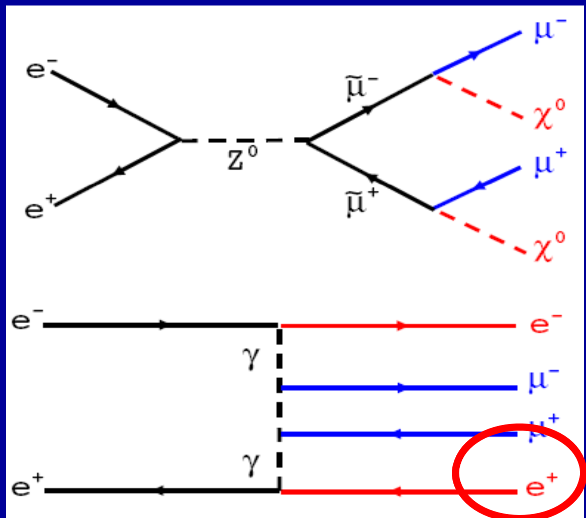
Fast feedback for beam tuning, beam diagnostics using beamstrahlung;

Beamparameter determination on percent level

Fast analog summation of pad-groups



BNL, DESY, JINR,

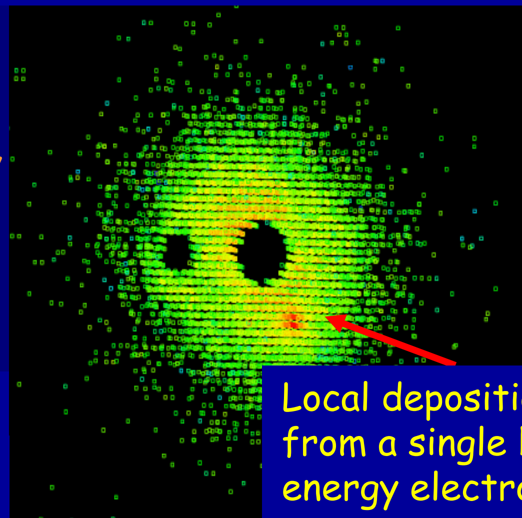


BeamCal

Hermeticity,
Electron veto at low angles,

Mask for the inner detectors

UCB

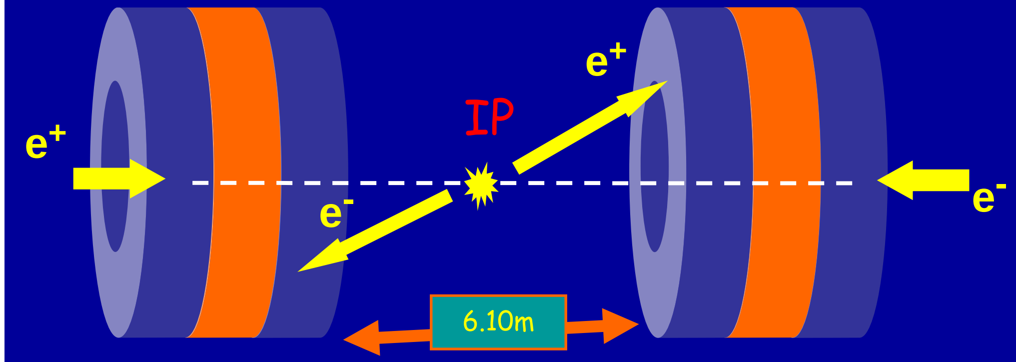


Local deposition from a single high energy electron

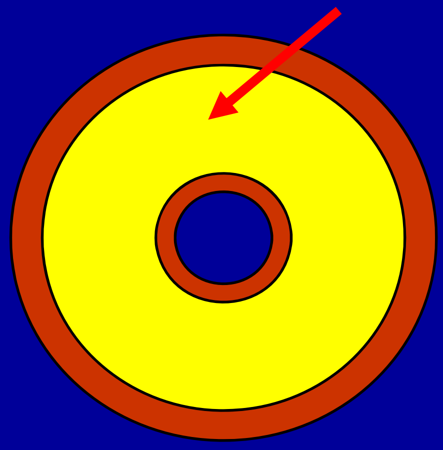
Dedicated Functions

Precise Luminosity measurement

Gauge process: $e^+ e^- \rightarrow e^+ e^- (\gamma)$



Fiducial volume for event counting

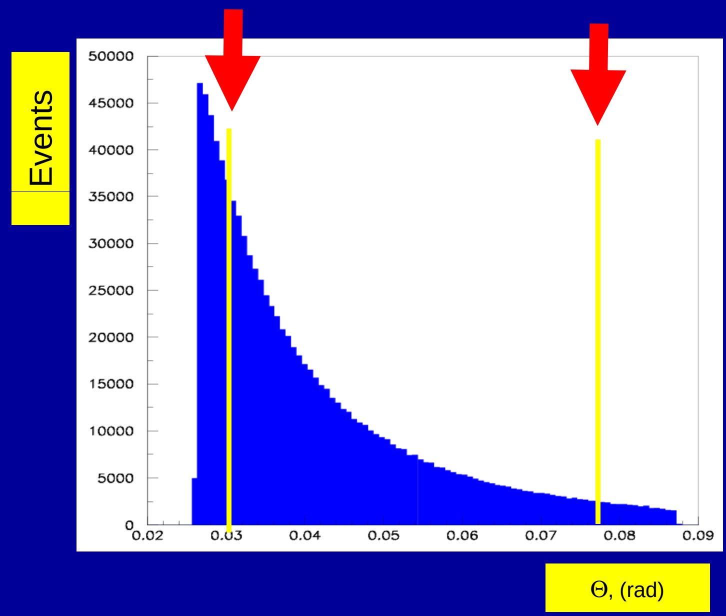


$\mathcal{L} = N / \sigma$

Count Bhabha events

From theory

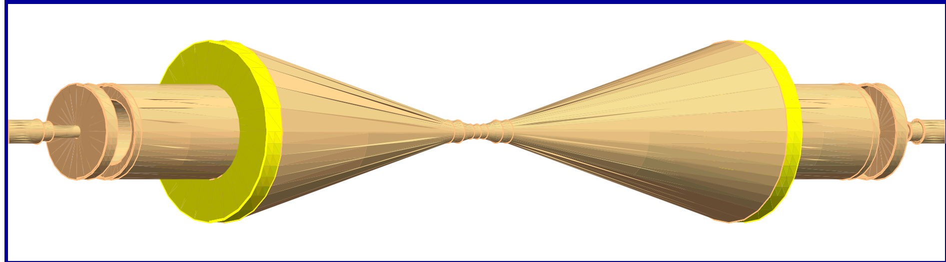
Goal: Precision $<10^{-3}$



Cracow, Tel Aviv

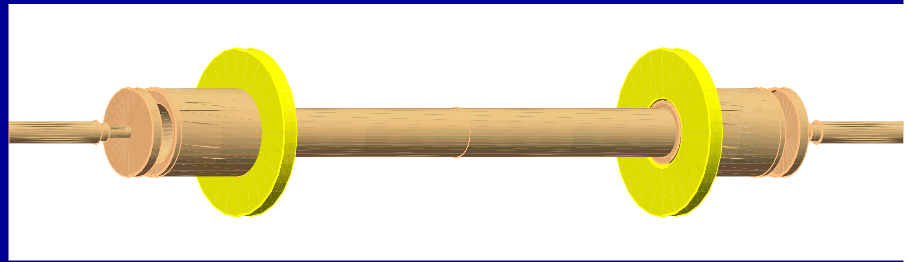
Beampipe Design

Conical, central part Be



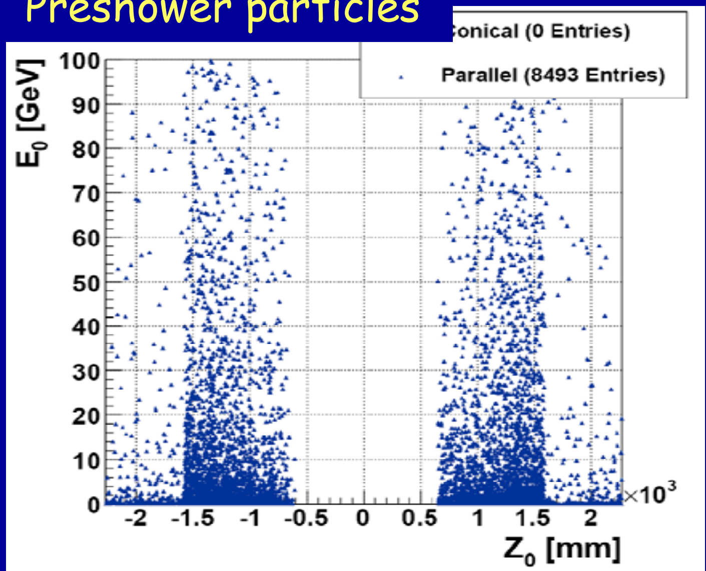
Pro: minimum material in front of LumiCal
Contra: vacuum, HOM, mechanics

Cylindrical, full Be, inner radius 5.5 cm
(14 mrad crossing angle)



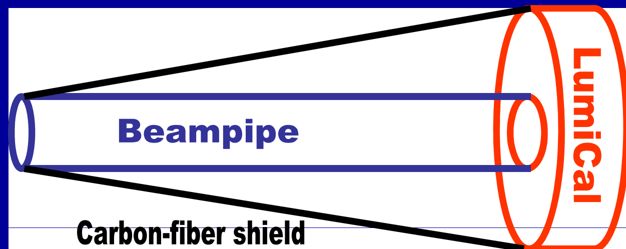
Pro: facilitates mechanics, vacuum
Contra: material in front of LumiCal, pre-showering, electron measurement?

Preshower particles



Difference in the Bhabha count rate:
(1 ± 2) x 10^{-4}; uncritical !

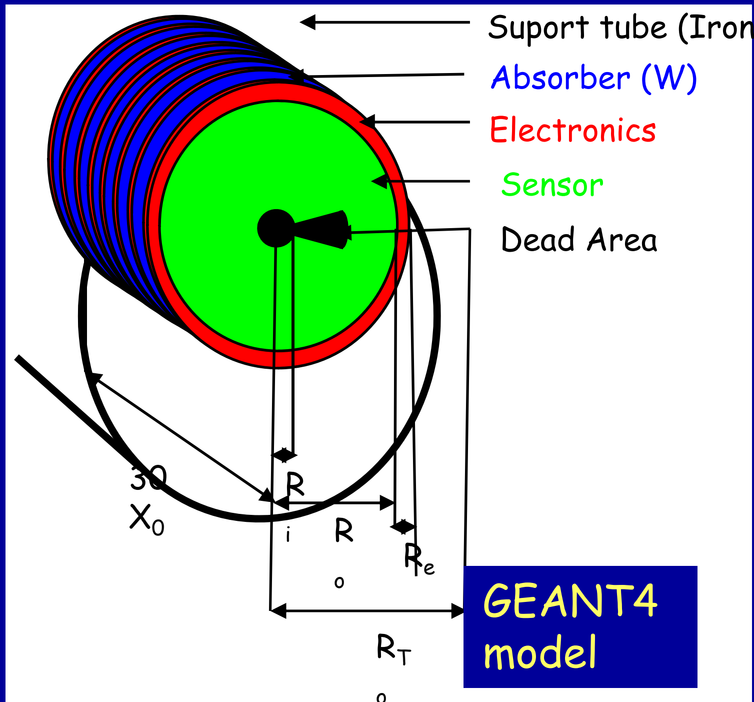
However: don't use the 'free space' for other purposes!



Possible solution

Tel Aviv

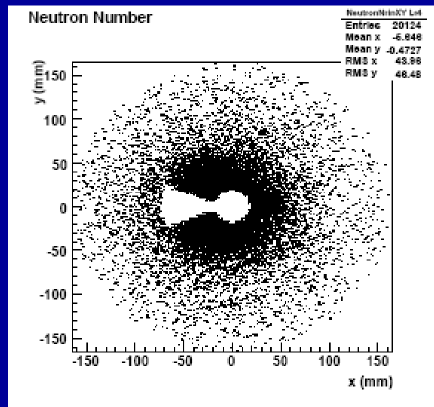
Radiation Dose and neutron fluxes

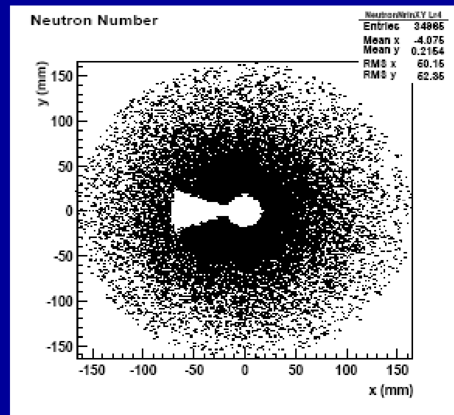


Electromagnetic dose for FE electronics:

< 100 Gy /year

Neutron flux inside sensors:





Neutron flux through FE electronics:

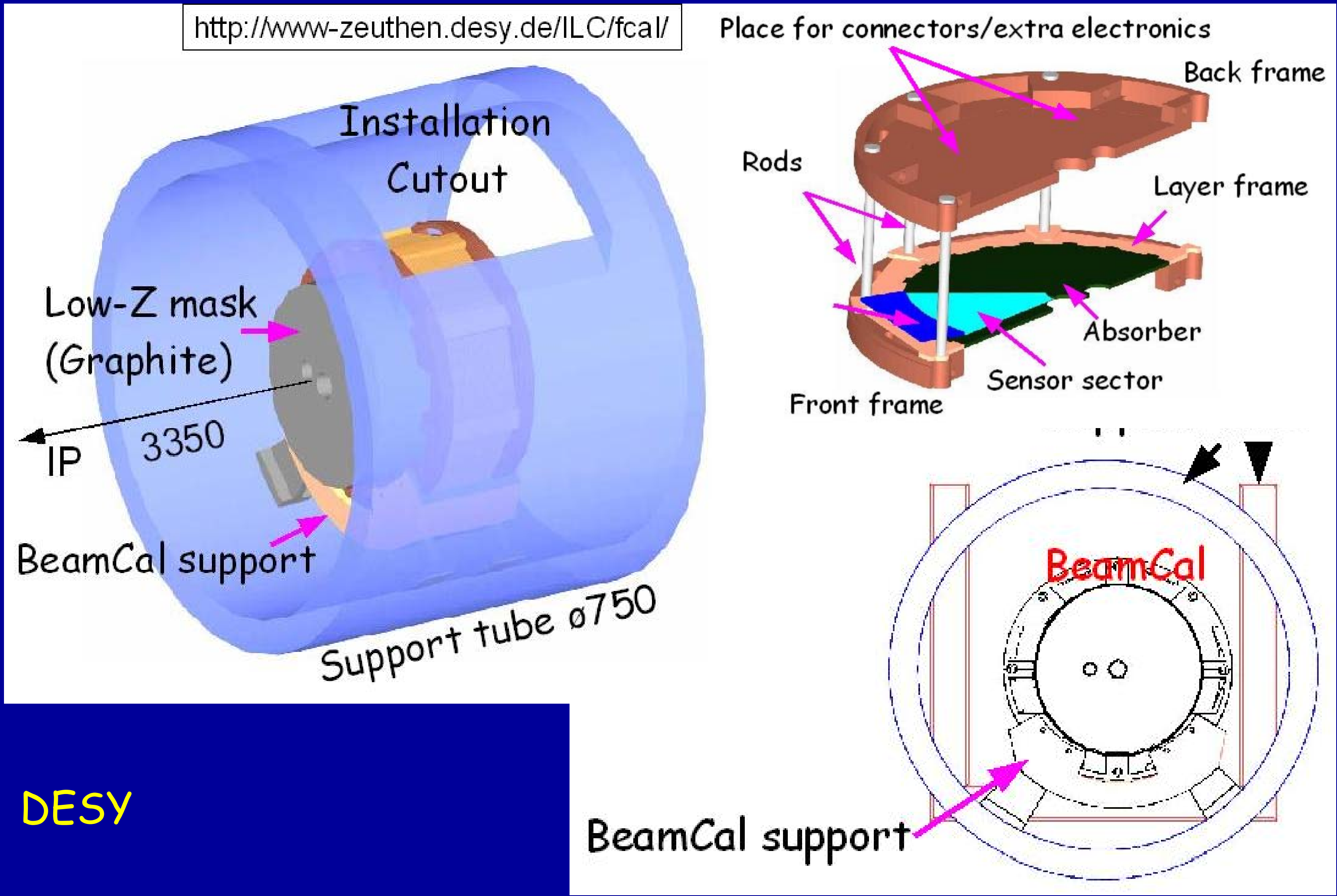
10^{10} neutrons/mm^2/year

Two different 'physics lists'

10^{12} neutrons/mm^2/year
(needs more detailed studies)

IFIN HH

BeamCal Mechanics



DESY

Sensor R&D BeamCal

pCVD diamonds:

- radiation hardness under investigation (e.g. LHC beam monitors, pixel detectors)
- advantageous properties like: high mobility, low ε_R = 5.7, thermal conductivity

GaAs:

- semi-insulating GaAs, doped with Sn and compensated by Cr
- produced by the Siberian Institute of Technology

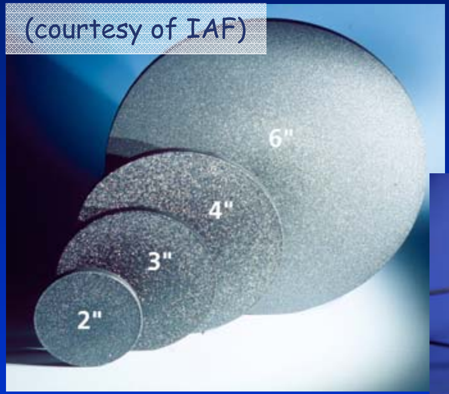
SC CVD diamonds:

- available in sizes of mm^2

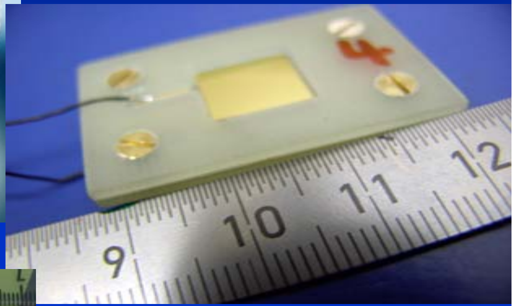
Radiation hard silicon

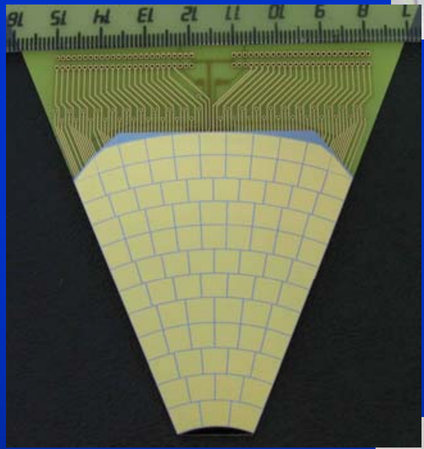
CVD: Chemical Vapor Deposition

DESY, JINR



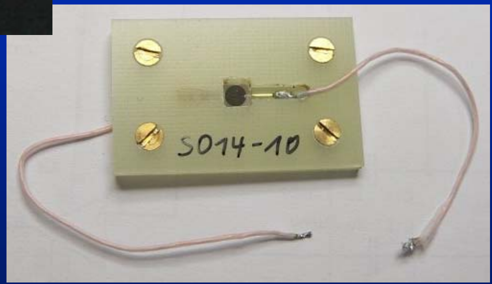
polycrystalline CVD diamond





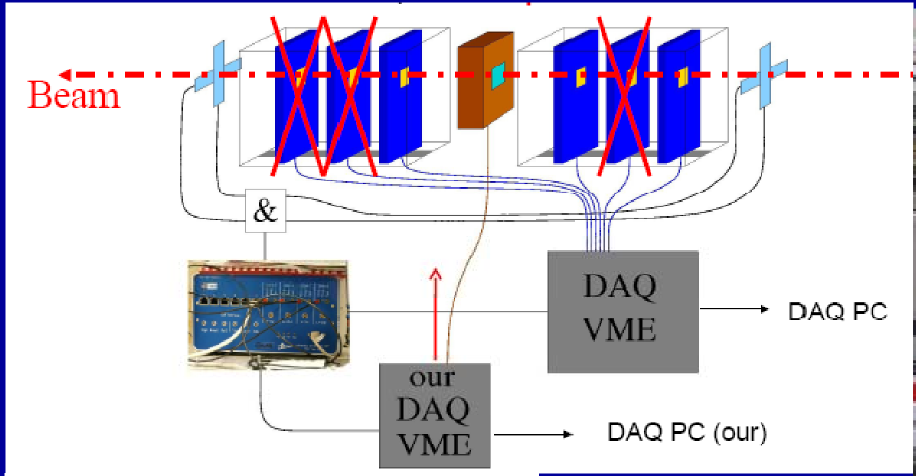
GaAs

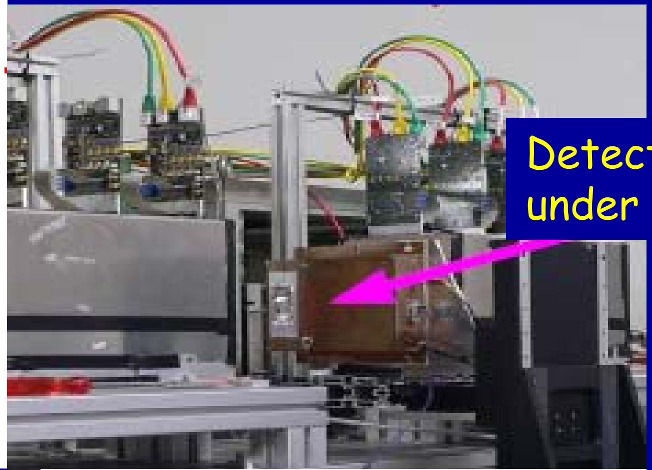
Single crystal CVD diamond



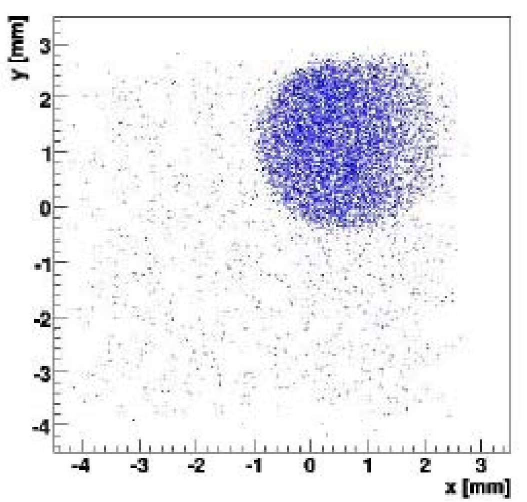
Sensor Tests

Testbeam equipment for sensor performance studies using the EUDET telescope





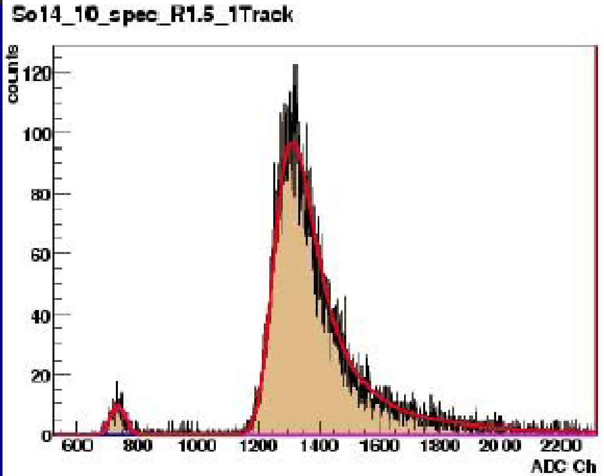
Detector under test



Reconstructed hits with detector signal

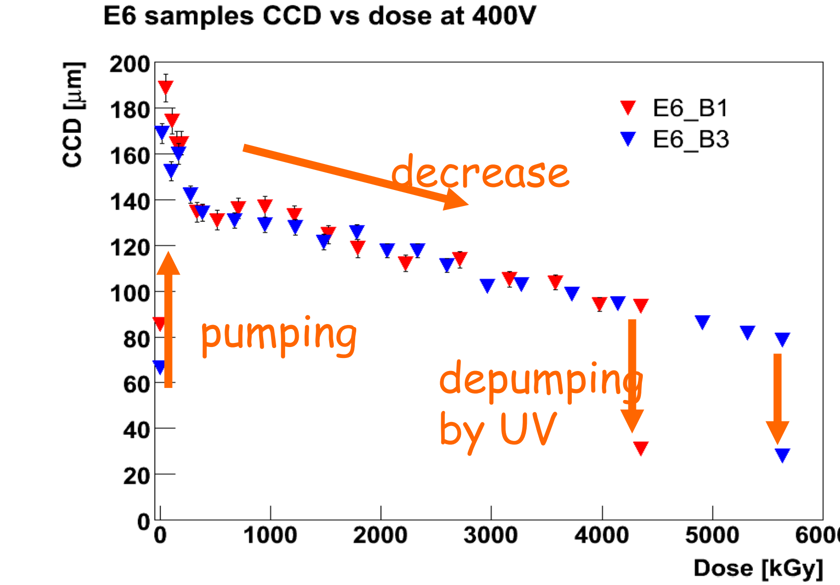
Goal: precise measuremnt of the reponse of sCVD diamonds; Reference sensor

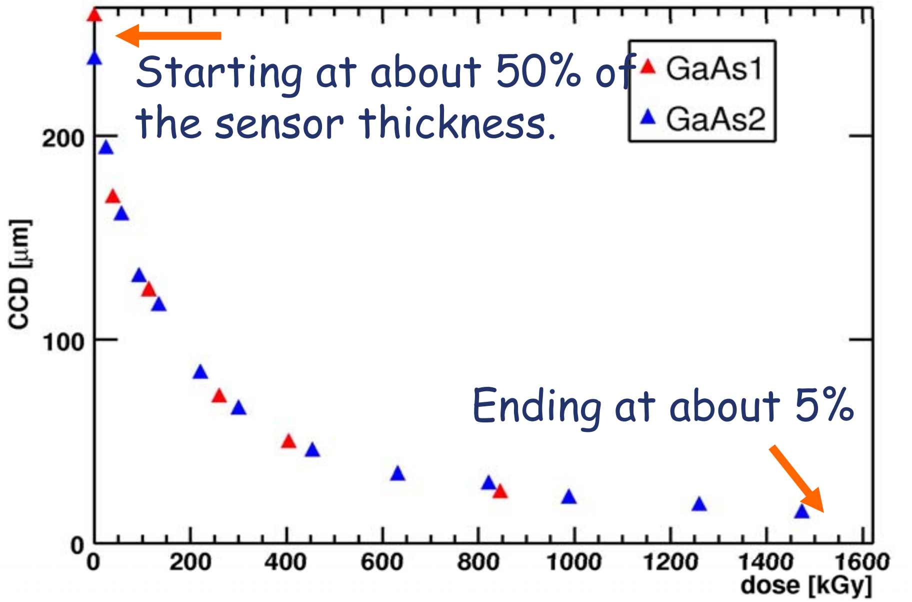
Data analysis in progress

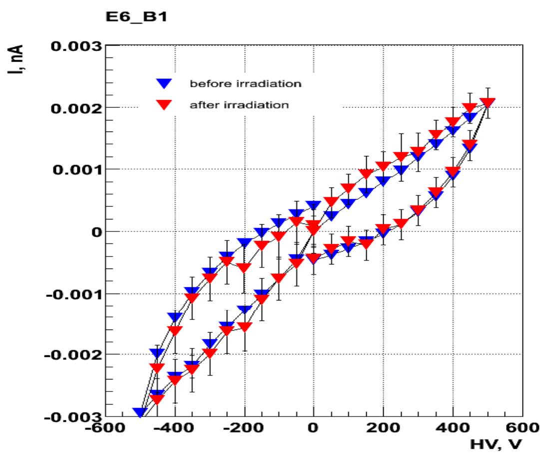


Sensor response with the track pointing to active detector area

Sensor irradiation tests

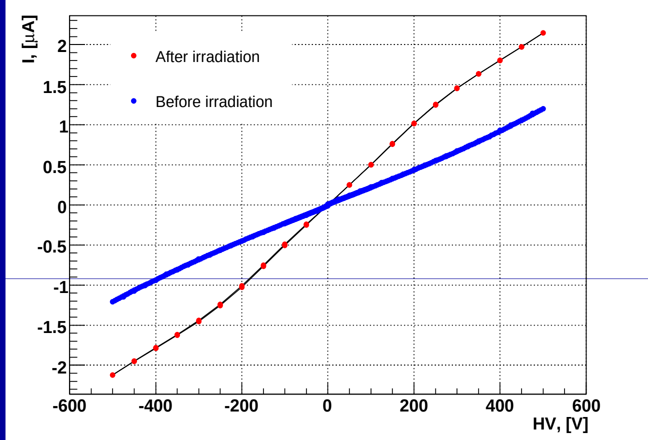




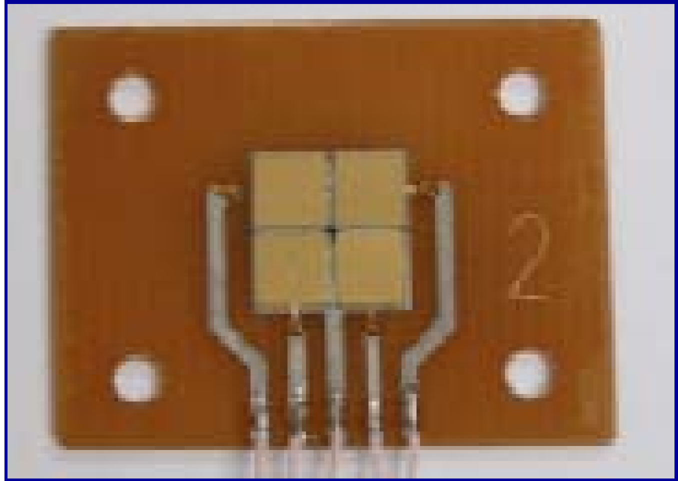


CVD diamond sensors:
Smooth degradation
No increase of leakage current.

GaAs: acceptable increase of the leakage current



Sensor tests



A new batch of GaAs sensors with Cr concentrations between 10^{16} and 10^{18} was recently delivered, Lab tests completed

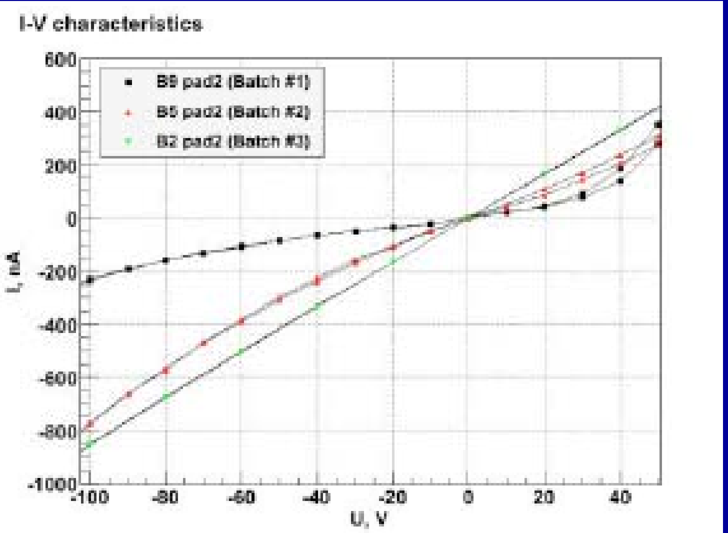
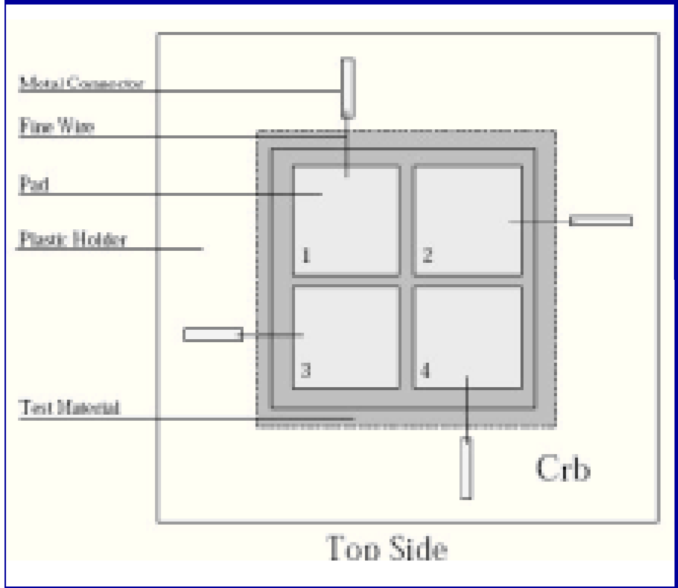
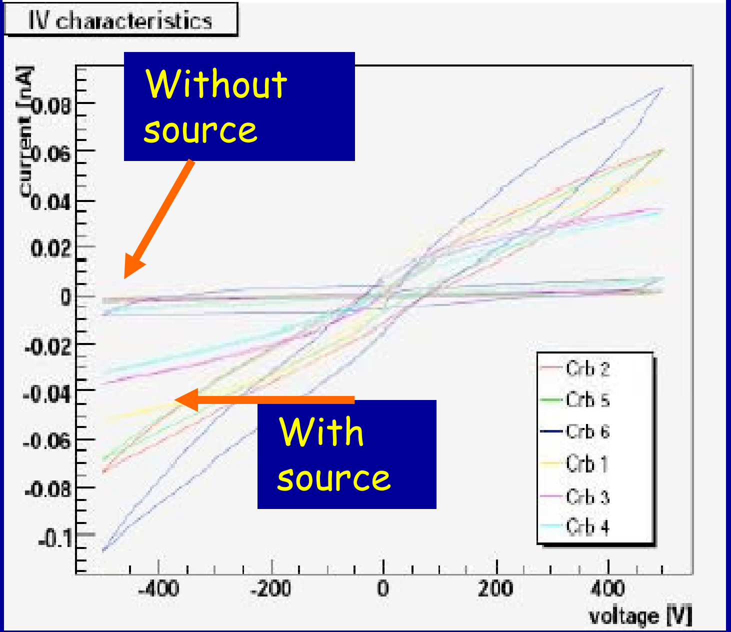


Figure 2. I-V characteristics for the sensors with different Cr concentration (linear part)



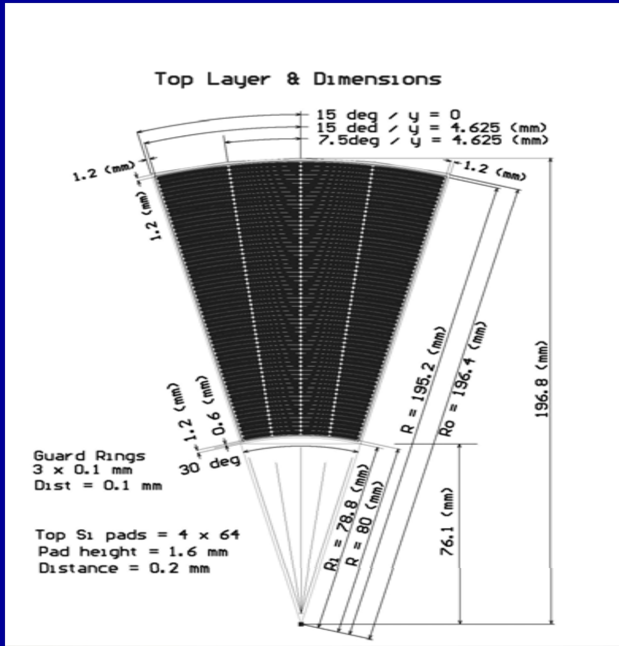
Sensors made of single crystal quartz and sapphire show promising sensitivity to ionising irradiation

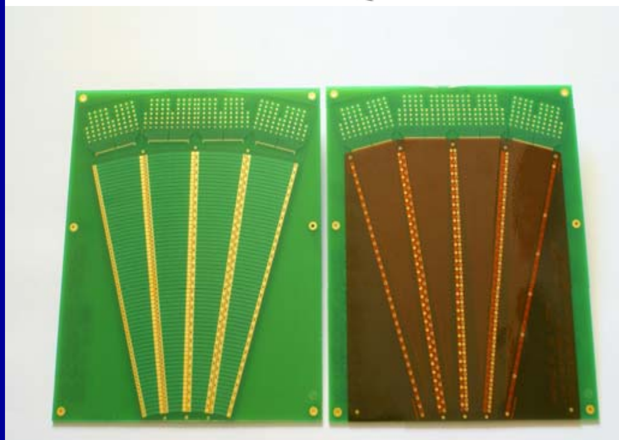


Testbeam investigations in December !

DESY, JINR

Sensor Production



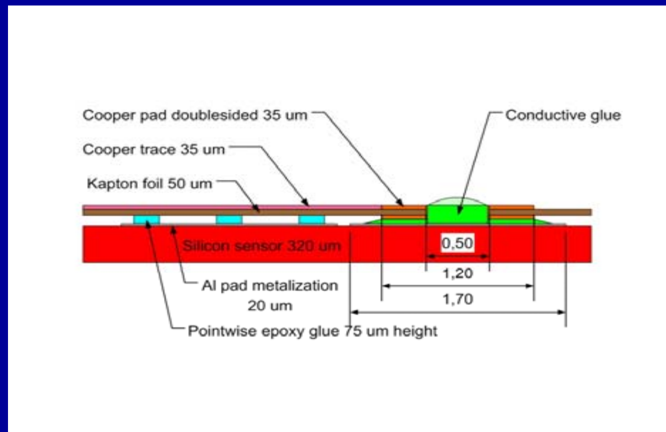


N-type silicon, p⁺ strips, n⁺ backplane,
Crystal Orientation <100>
320 μm thickness ± 15 μm
Strip pitch: 1800 μm
Strip p⁺ width: 1600 μm
Strip Al width: 1700 μm

Masks for prototypes ready (Hamamatsu)

Prototype sensors just ordered

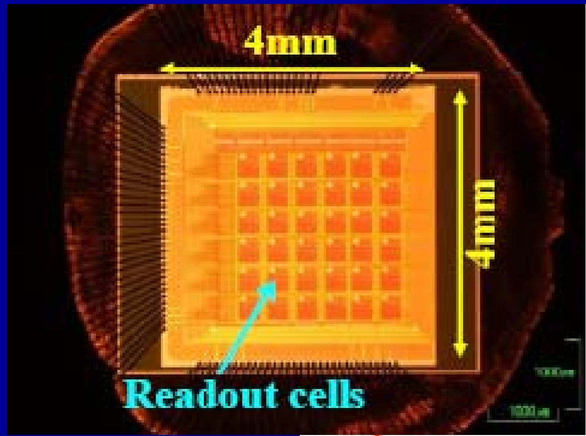
In parallel: development of the fanout

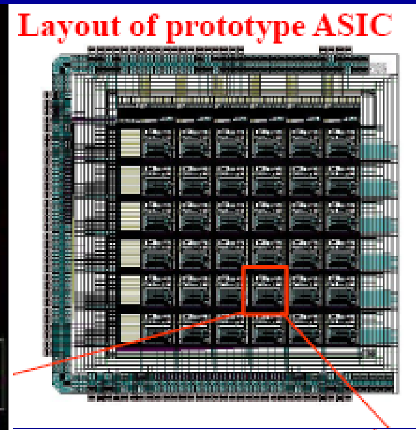


INPAS Cracow, Tel Aviv U.

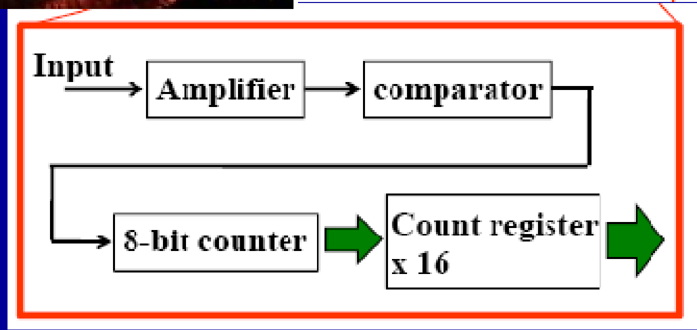
FE Electronics

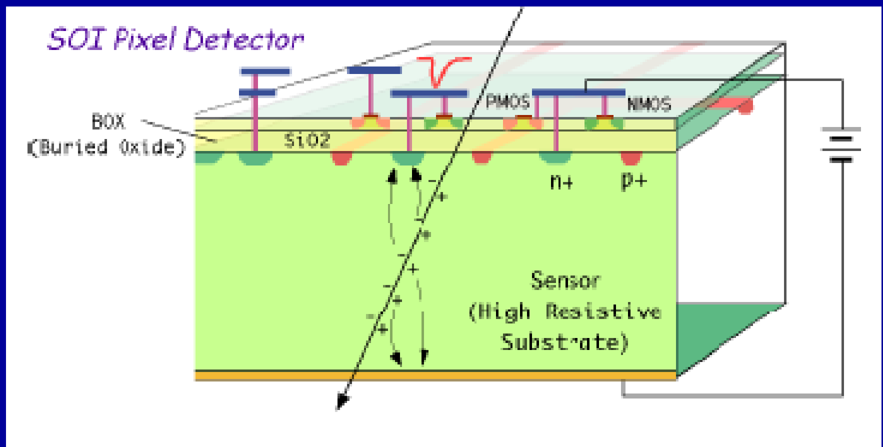
ASIC for the pair monitor
.25 mm TSMC technology
# of pixel: 36
Pixel size: 400 x 400 mm2
Bump bonding to a sensor





Prototype produced and successfully tested





Pair monitor will use SoI technology,
Sensor and readout ASIC embeddd in the same wafer;

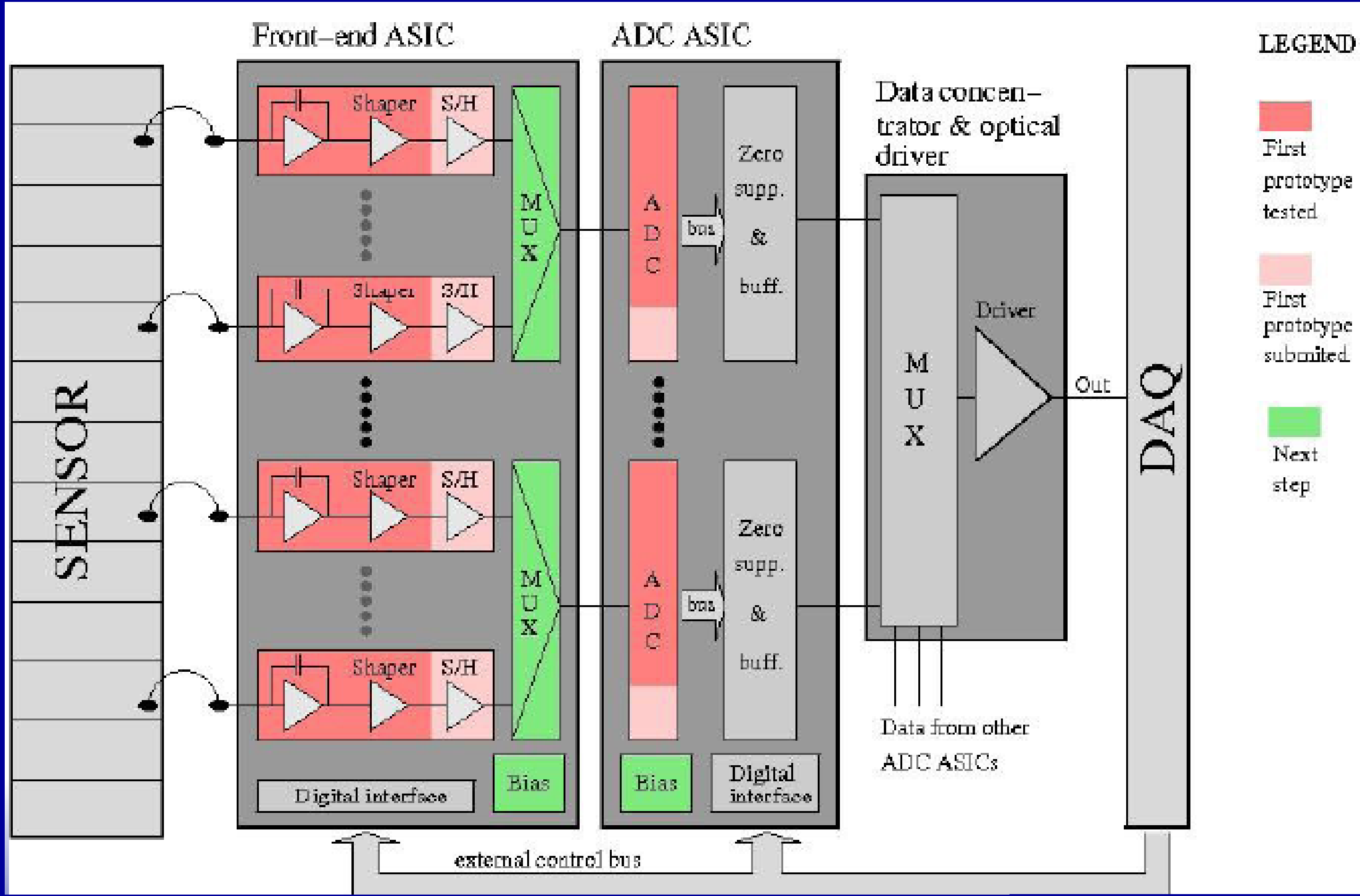
prototype 2009

Tohoku Univ.

FE Electronics, LumiCal

- One FE ASIC will contain 32 – 64 channels, 10 bit
- One ADC will serve several channels (MC simulations not finished)
- AMS 0.35 µm technology
- prototypes of the FE ASIC and ADC ASIC available,

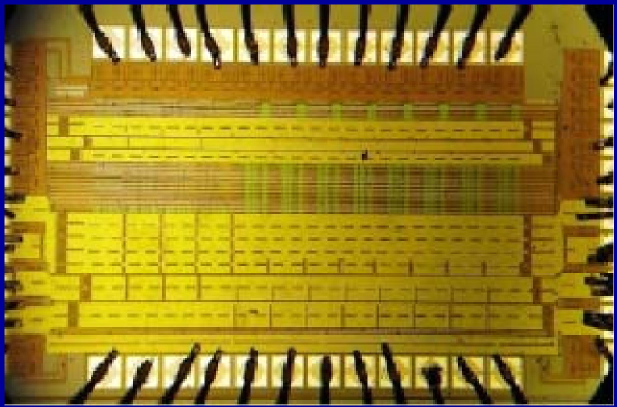
Tests of the FE ASICS so far promising.

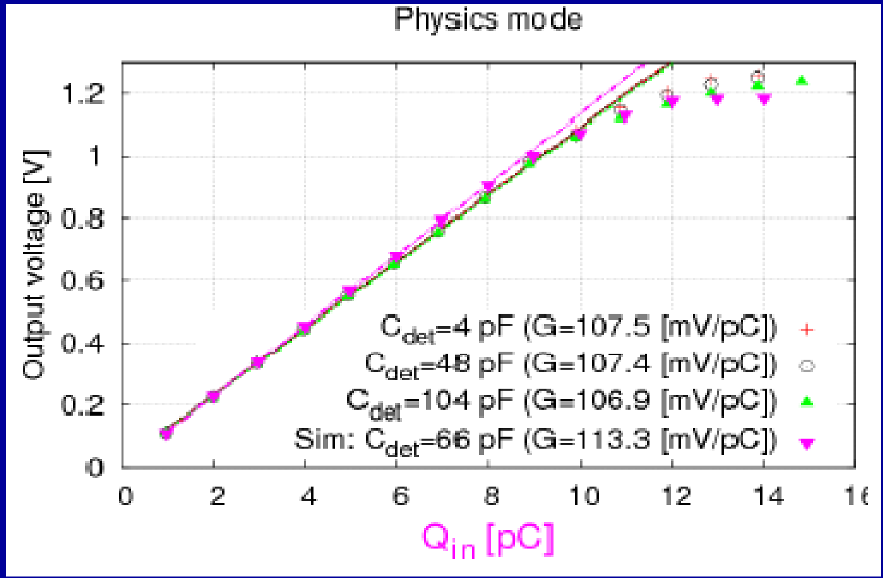


Cracow UST

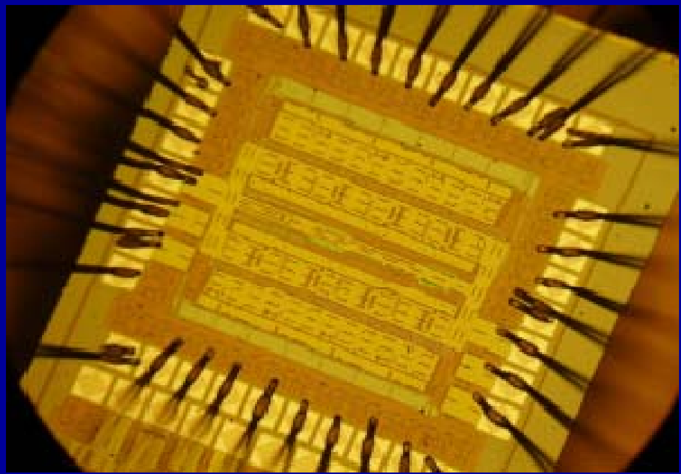
FE Electronics, LumiCal

FE Asic:
8 channles per chip, 4 with MOS feedback resistance, 4 with passive Rf feedback





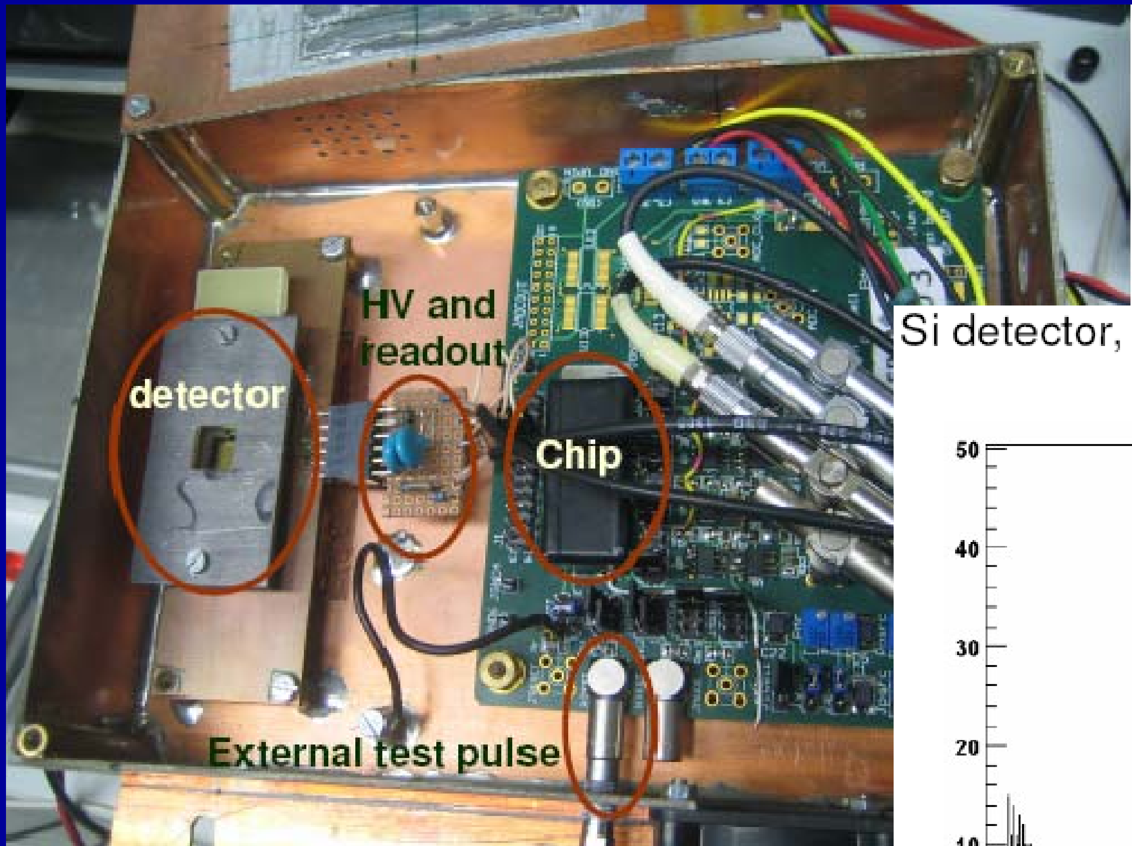
ADC Asic:
- Pipeline architecture
- 10 bit resolution
- Maximum sampling rate 35 MHz

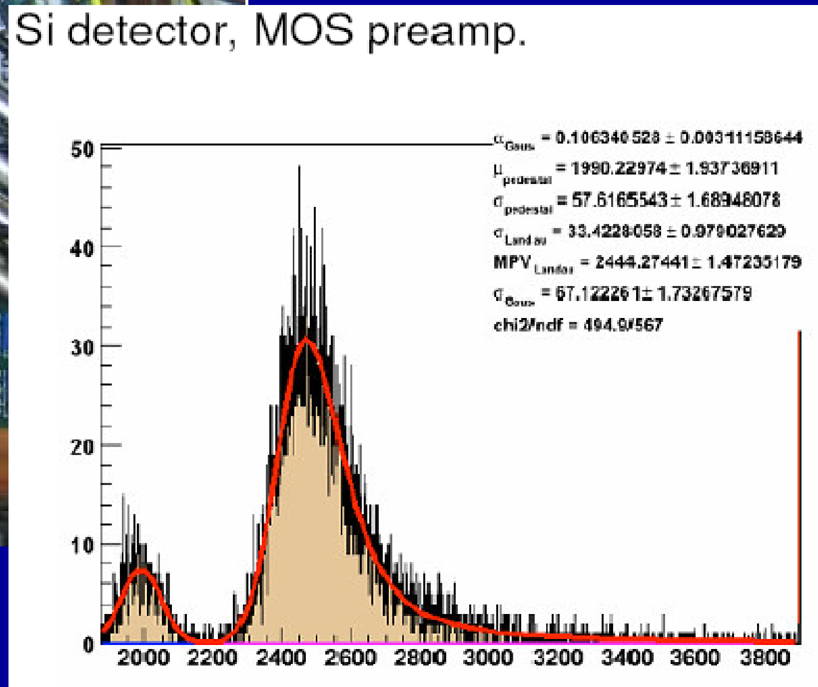


First prototypes needed improvement,
Submission ADC and DAC Sept. 2008
Prototypes expected Nov. 2008

FE Electronics, LumiCal

First successful tests of the analog part with a single pad sensor



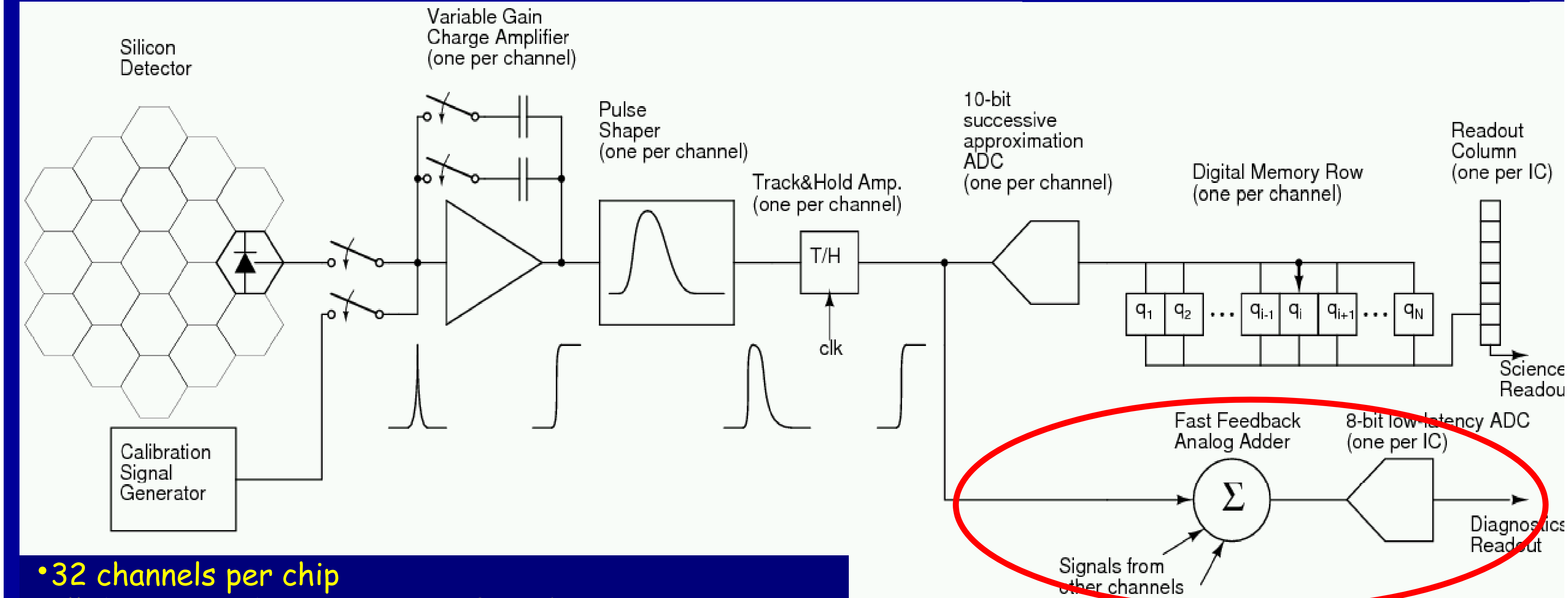


DESY

FE electronics, BeamCal

Dedicated FE electronics for BeamCal, based on KPiX (see talk by Herbst in the DAQ session)

Digital Buffering during bunch train, readout in between trains

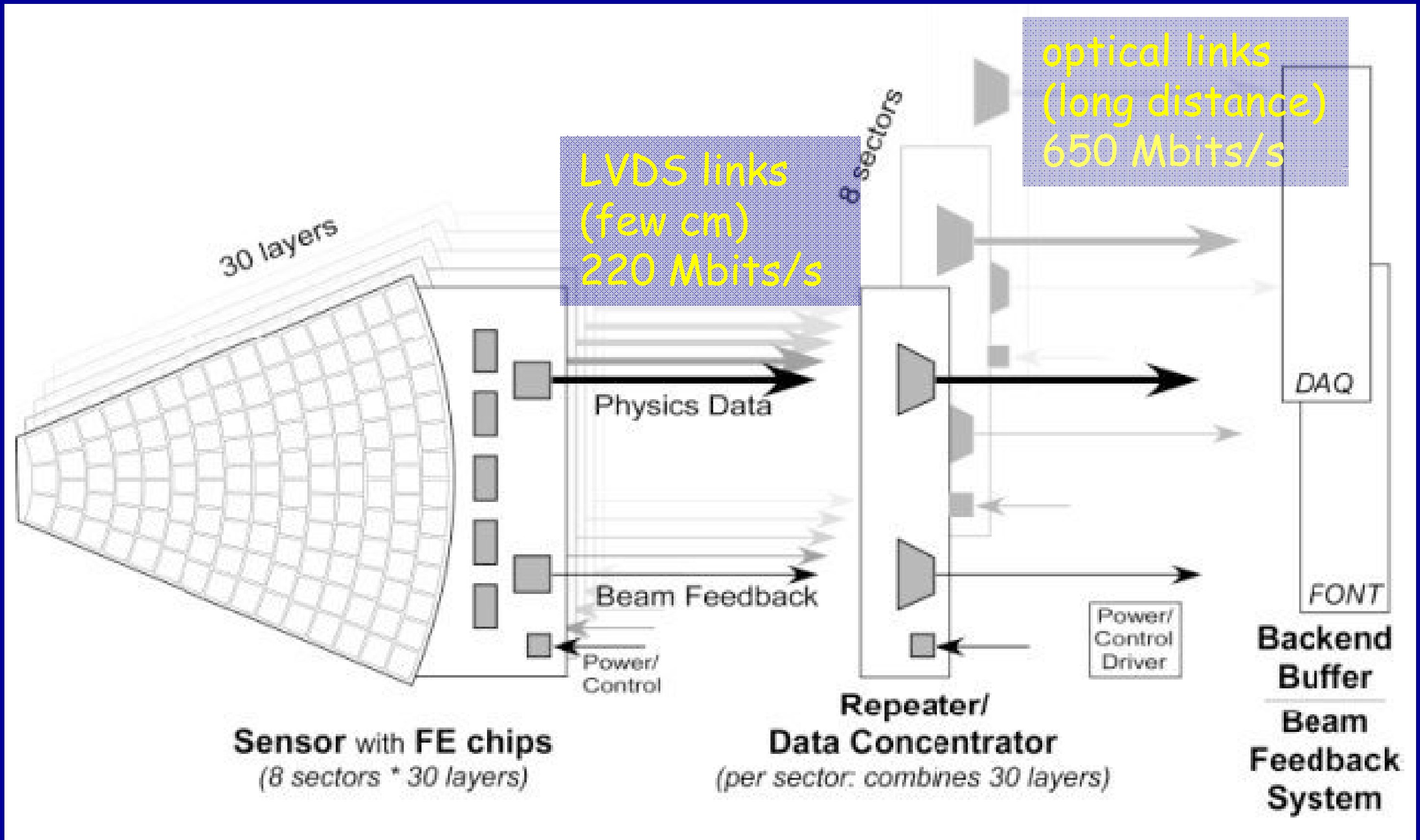


- 32 channels per chip
- all data is read out at 10 bits for physics purposes;
- Low latency output, sum of all channels is read out after each bx at 8 bits for beam diagnosis (fast feedback)
- Prototype in 0.18-μm TSMC CMOS technology

Fast analog adder for groups of pads used for fast feedback

SLAC-Stanford

Data Transfer



First step: concept based commercial components
Second step: dedicated prototype for a system test

IKP TU Dresden

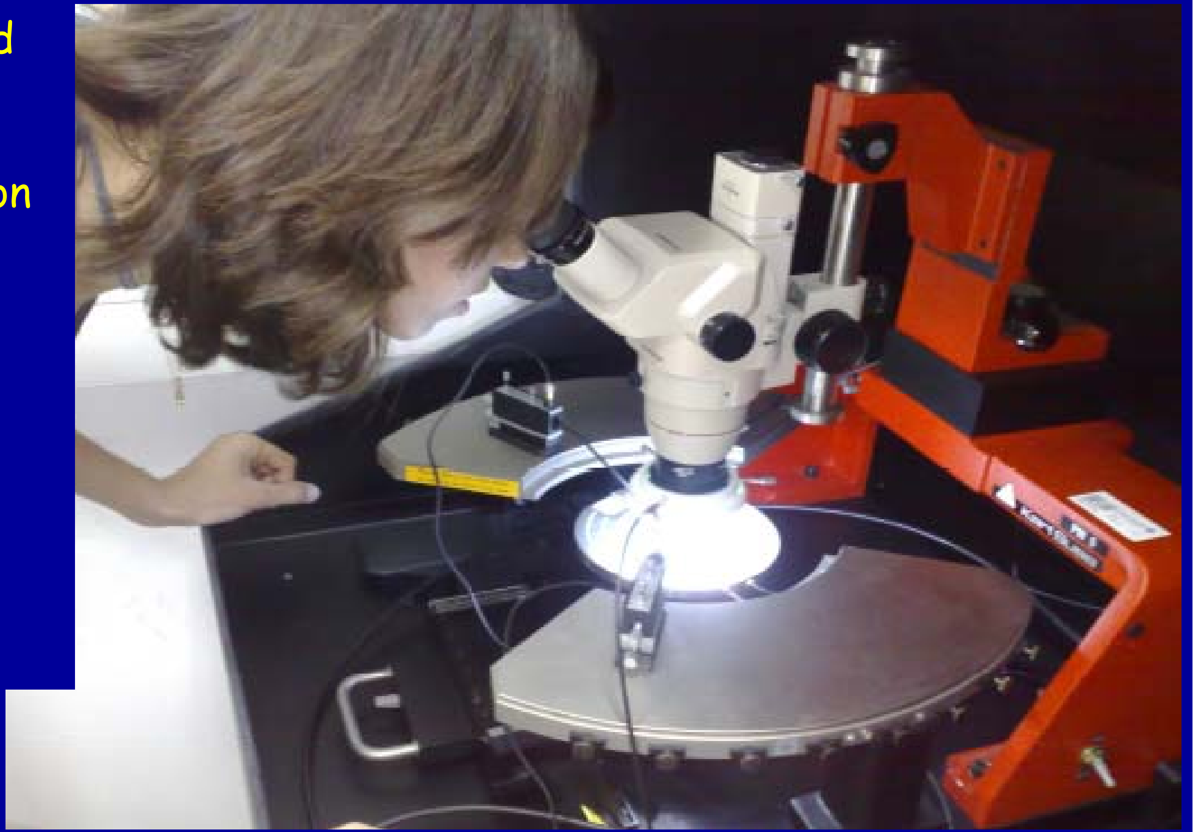
Infrastructure

A dedicated silicon lab is created in Tel Aviv:

- Computer monitored prob station
- Computer supported I(V), C(V) measurements

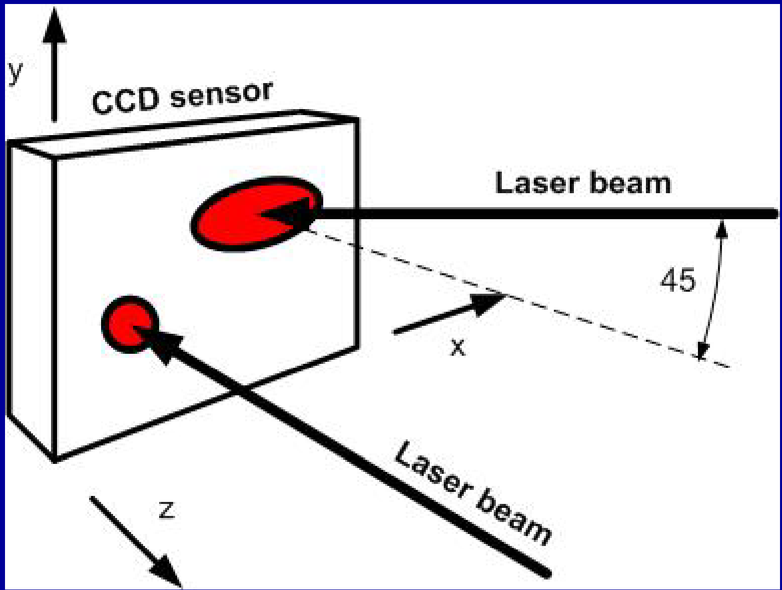
in preparation:

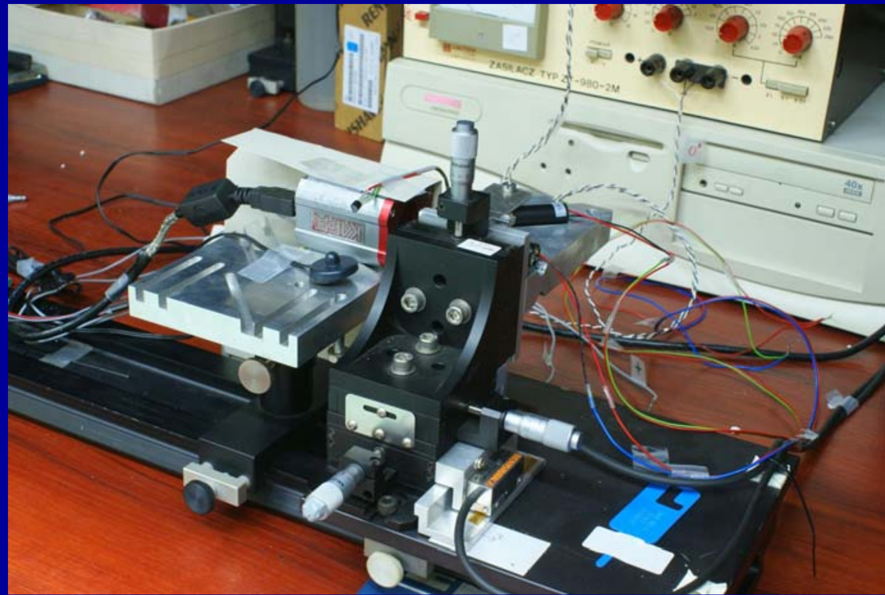
- clean room
- spectroscopic set-up



A dedicated HEP lab building is designed for detector R&D, planned to be ready mid 2009

Laser Position Monitoring





Over short distances accuracies reached:
Displacements in the x-y plane: +-0.5 μm
Displacements in z direction: +- 1.5 μm

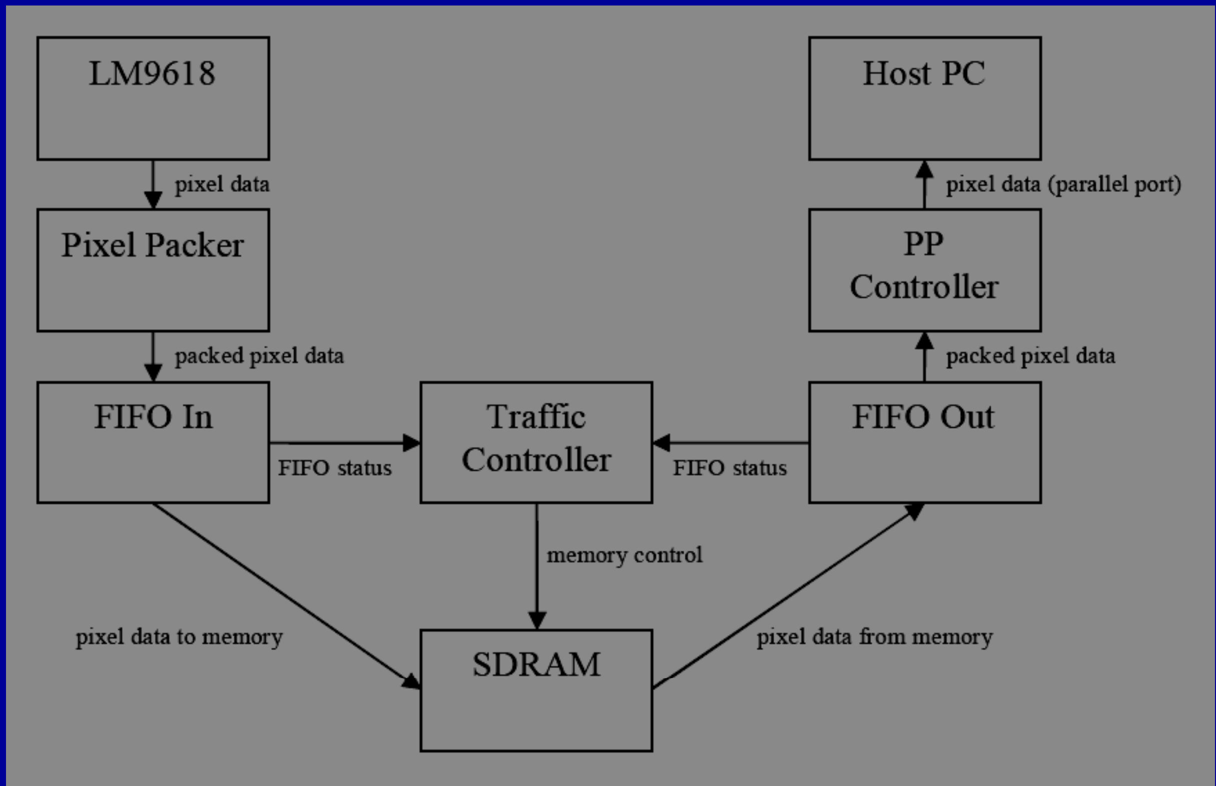
INP PAS Cracow

Laser Position Monitoring

Scheme of the readout and monitoring electronics

Dedicated CMOS sensor

Displacement calculations



Conclusions

Priority topics within FCAL:

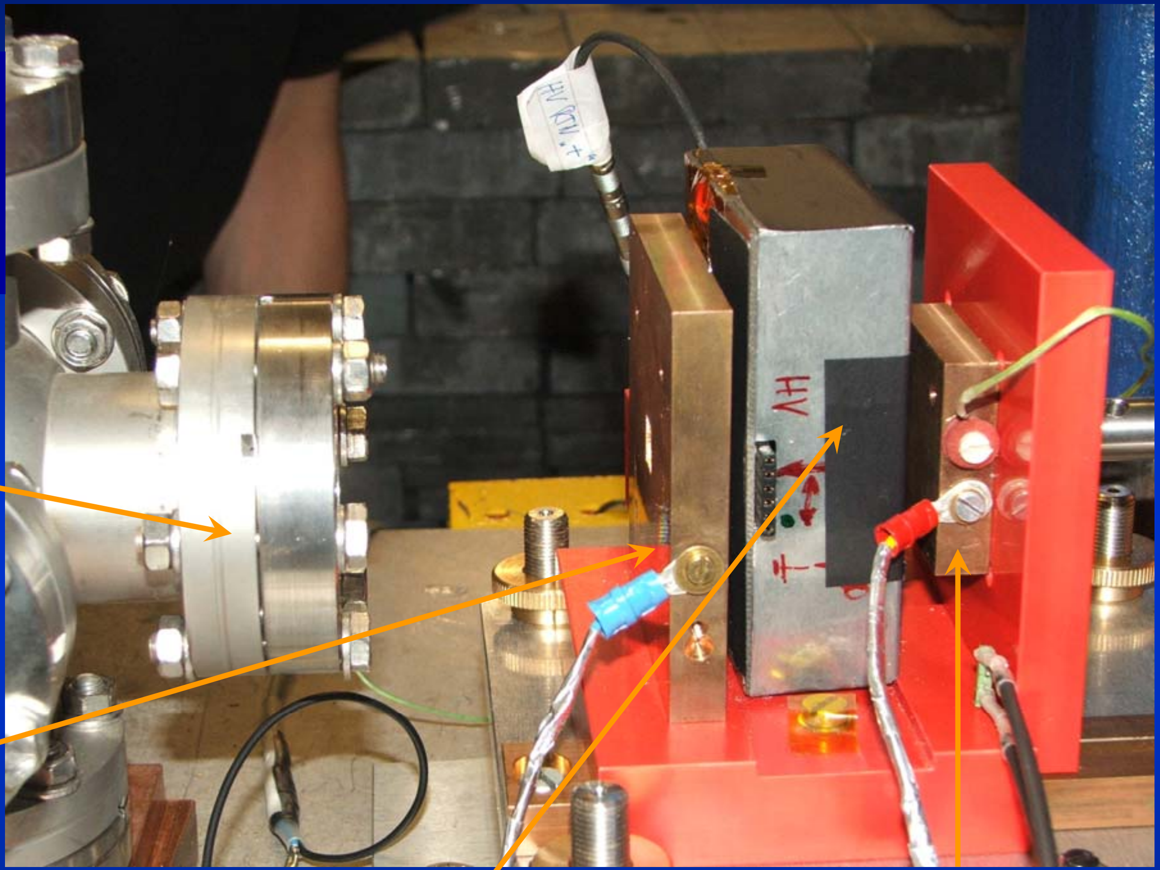
- Large area radiation hard sensors for calorimetry (BeamCal)
- Precise position measurement of electromagnetic showers (Sensors for LumiCal)
- ASICS with high readout speed, large dynamic range, large buffering depth and low power dissipation, allowing fast feedback for luminosity optimisation
- Prototyping and test of more complex subsystems

backup

Test Beam Equipment and sensor tests

Setup used for radiation hardness tests at the SDALINAC accelerator

TU Darmstadt



exit window of beam line

collimator (I_{Coll})

sensor box (I_{Dia}, T_{Dia}, HV)

Faraday cup (I_{FC}, T_{FC})

Completed and more comfortable: more efficient use of the beam