Forward CALorimetry Status

for FCAL Collaboration

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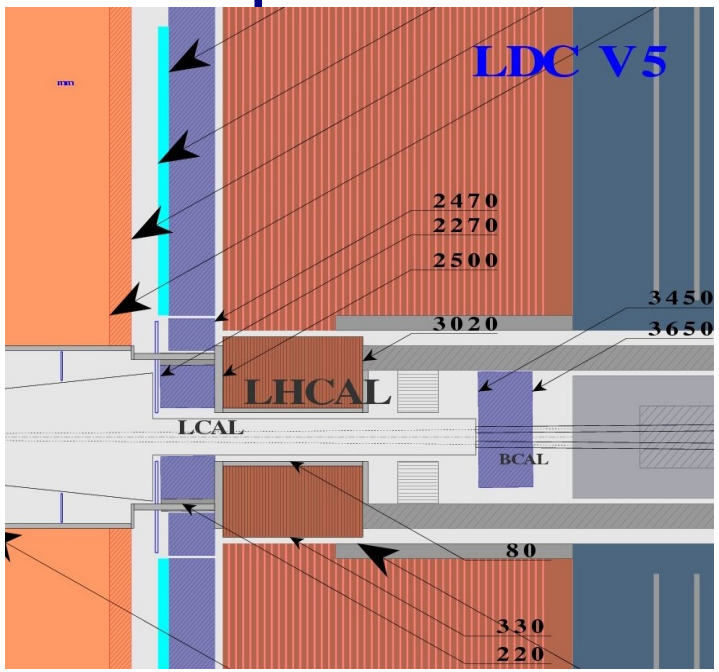
Overview

- *Tasks of FCAL region*
- *LumiCal and BeamCal current designs :*
  - *placement, geometry, segmentation*
- *LumiCal Alignment System*
- *FE and read-out electronics requirements*
  - *timing*
  - *memory*
  - *ADC resolution*
  - *data stream*
- *FCAL new components*
  - *LumiCal Si-Tracker*
  - *Pair Monitor*

Tasks of FCAL collaboration

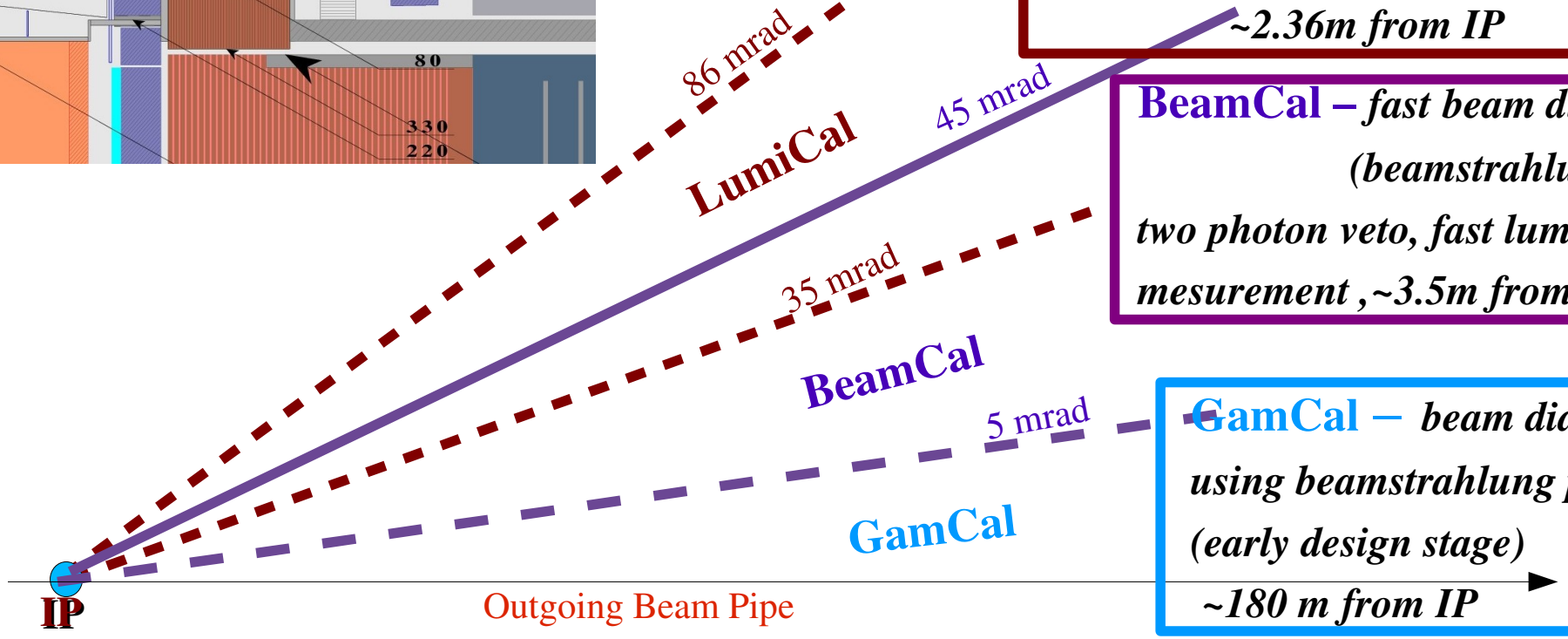


- *Instrumentation of Very Forward Detector region for ILD and SiD*

LumiCal - *high precision luminosity measurement ($\Delta L/L < 10^{-4}$) - two photon veto ~2.36m from IP*

BeamCal – *fast beam diagnostics (beamstrahlung pairs two photon veto, fast luminosity mesurement ,~3.5m from IP*

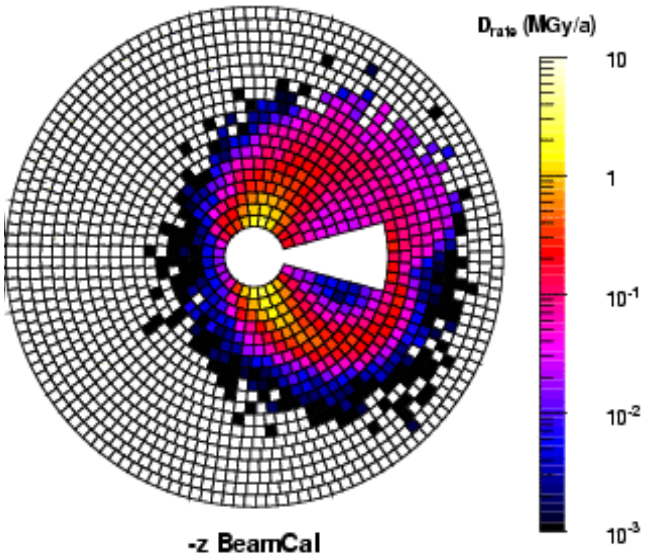
GamCal – *beam diagnostic using beamstrahlung photons (early design stage) ~180 m from IP*

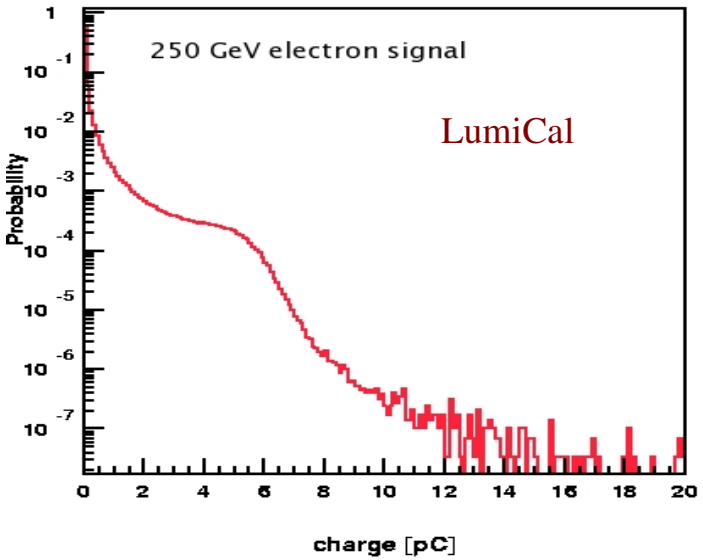


FE electronics - requirements

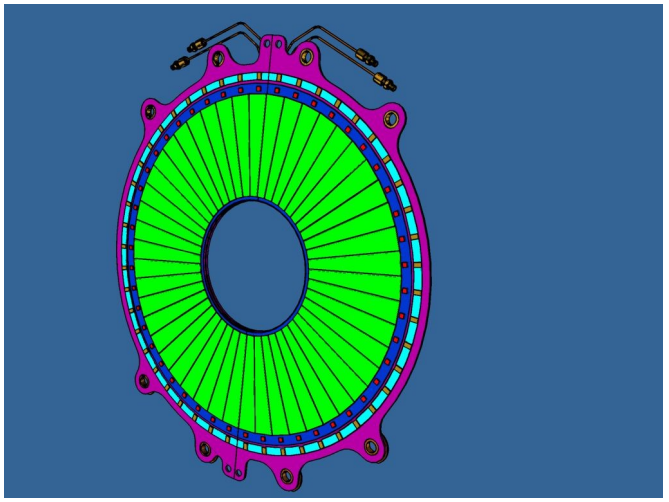
Challenges :

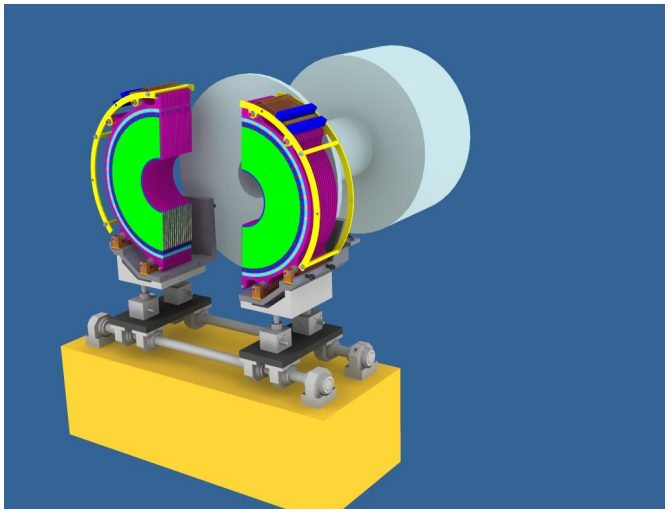
- high accuracy
- high occupancy (beamstrahlung)
- large dynamic range of signal (1fC – 10 pC)
- high radiation dose (BeamCal ~100 Mrads/year)
- fast read-out





LumiCal Current design





Segmentation:

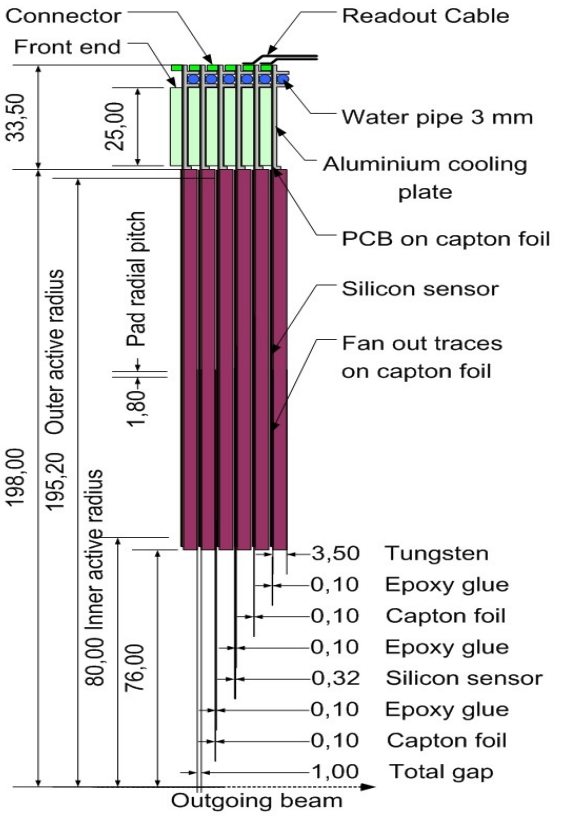
- 64 rings (r)
- 48 sectors (phi)
- ~3k cells/plane

Geometry:

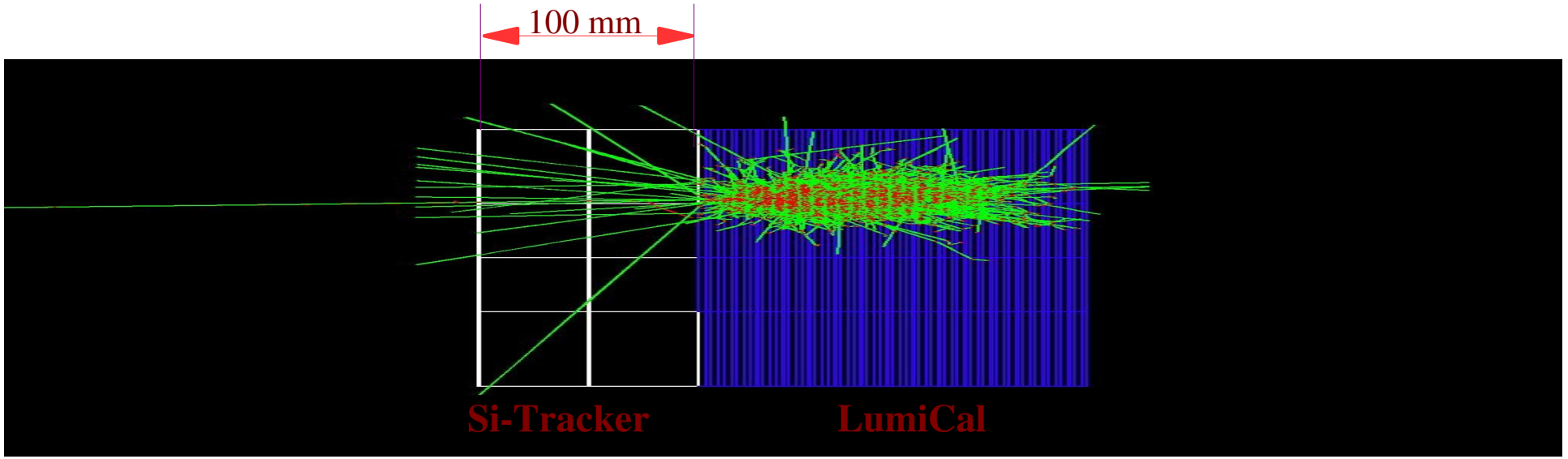
- 30 layers of $1X_0$:

  - 3.5 mm absorber and
  - 0.32 mm sensor (Si)

- 80mm < R < 195mm
  (225 mm electronics,
  235 mm support,
  cables, cooling tubes)
- 35-86 mrad aperture



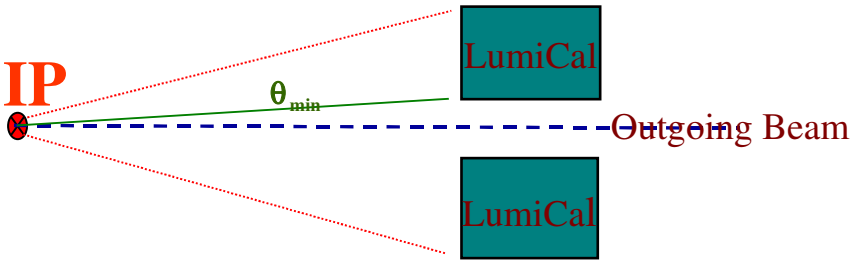
New FCAL Component - LumiCal Si Tracker



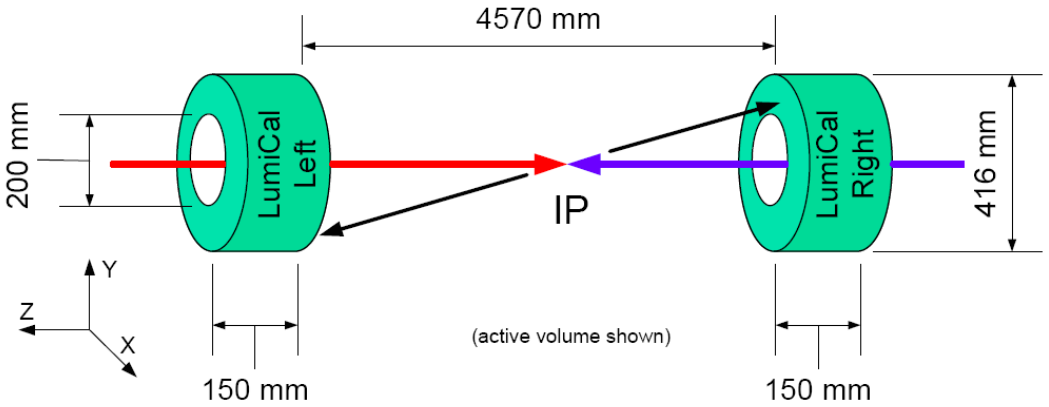
- Improvement of luminosity measurement by combining LumiCal and Si-Tracker info
- Two silicon layers (0.250 mm each) in front of LumiCal
  - 1643 cylinders (0.07 mm r-pitch), 1000 sectors (6 mrad φ - pitch) → ~2x16M channels
- Simulation done (clean environment : stand-alone LCAL, single electrons beam, no beamstrahlung, no backscatters) indicate improvement in accuracy of polar and azimuth angle by factor ~7.
- Status – design and optimization study is ongoing

LumiCal Alignment Monitor (LAM)

Single (L/R) LumiCal alignment



Relative(L-R) LumiCal alignment



X, Y position with respect to the beam must be known with accuracy better than ~700 μm (optimal ~100 -200 μm) (LumiCal centered on outgoing beam)

Requested accuracy on distance between two parts of LumiCal better than ~60 -100 μm

Solutions under development :

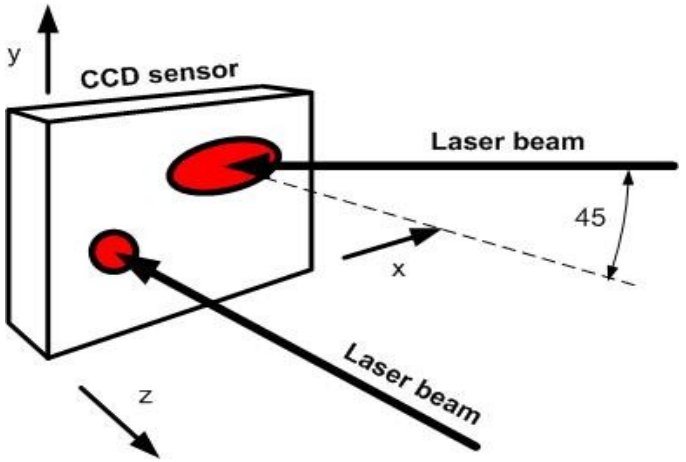
1. Laser Alignment System (LAS)

- ***CCD read-out***
- ***Frequency Scanning Interferometry***

2. Spanned Wire Alignement System (SWS)

(for local relative planes displacement)

LAM Systems

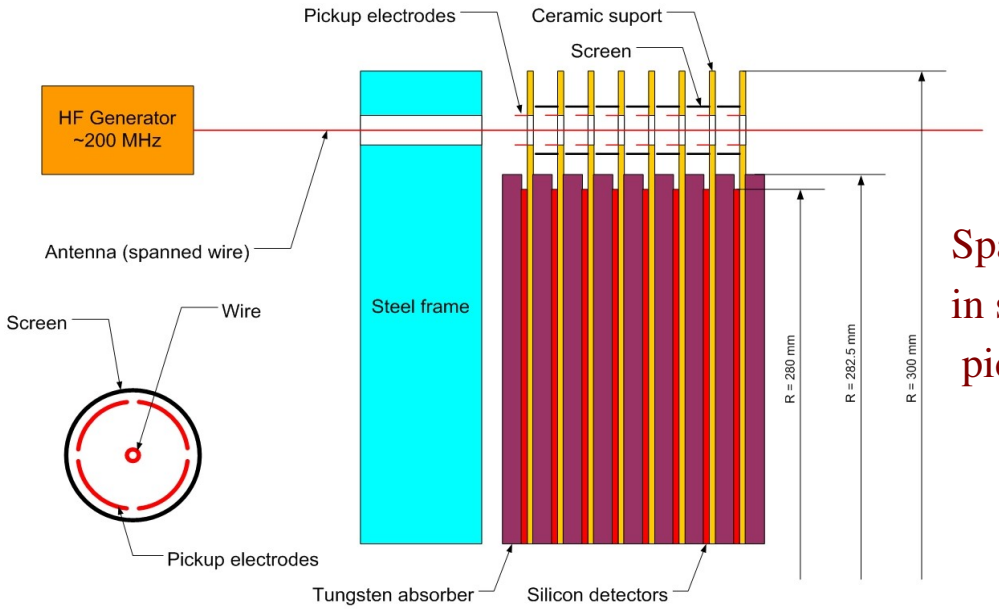


Two laser beams (one perpendicular, second 45° to sensor plane) allow to measure XY translation in one sensor

σ_X : ± 0.5 µm

σ_Y : ± 1.5 µm

L/R and L-R alignment



Spanned wire going through the holes in sensor planes working as antena and pickup electrodes to measure the position

Internal Plane Alignment

LumiCal FE

Requirements:

- *large on-board memory (~50 hits/cell)*

  (if "once per train" read-out)

- *time to process a hit < 300 ns*

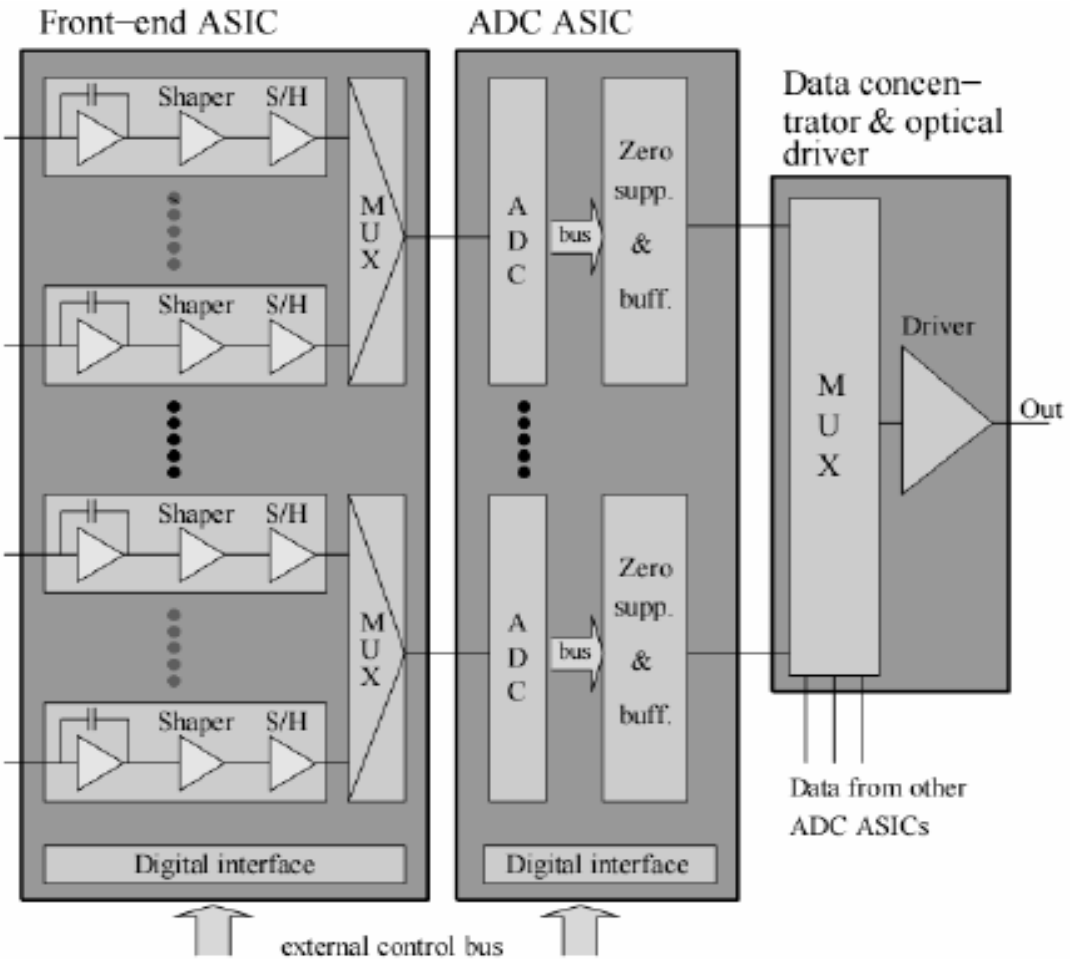
- *switchable 10 bits ADC*

  0.8-800 fC in calibration mode

  0.01-10 pC physics mode

- *speed of data transfer*

  between trains ~ 15 Mb/s



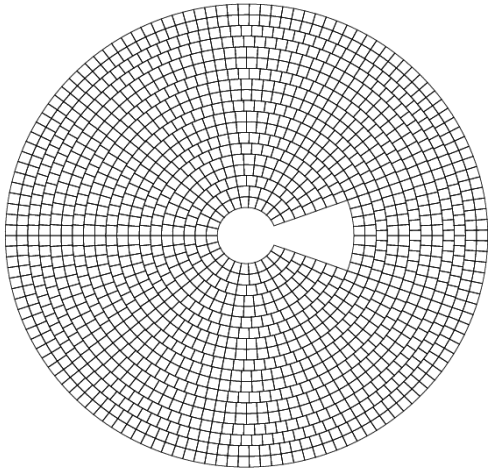
Summary - LumiCal

- Mechanical Design : – work in progress,
  need detailed study of cooling,
  assembling/disassembling method and accuracy
- Sensor Design: – advanced, work in progress
  - prototype sensors ready by end of this year
  - "dummy" sensors have to equipped and tested with fun-out – can be used also for FE electronics testing
  - test beam prototype design started
- Laser Alignment System: - laboratory prototype functional achieved required accuracy (± 1 μm in X,Y and ±2 μm in Z)
  - work in progress on
    integration with ILD.
    relative alignment both parts of LumiCal.
    internal sensor positions,
    compactness and dedicated read-out

Summary – LumiCal (cont.)

- FE Electronics: – first prototypes of FE channels and pipeline ADC stages designed, produced, tested and found fully functional
  - FE parameters measurements completed – found in good agreement with simulations. Measurement with sensors and fan-out still needed.
  - final FE not yet decided
  - setup for ADC measurements established
  - pipeline ADC measurements completed. Small nonlinearities found, sources identified
  - improved version of ADC being prepared for submission
  - DAC's design almost completed
  - next submission September 2008
- Simulation and Reconstruction Software: - fully functional and integrated with ILC
  - reconstruction tools functional – still need work
  - need to develop simulation of realistic electronic soon will start

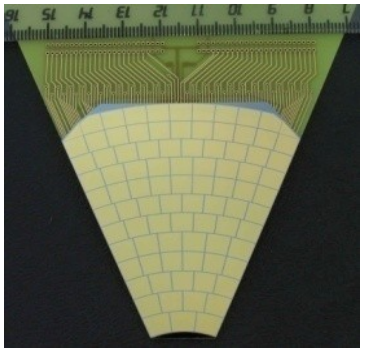
BeamCal Current design

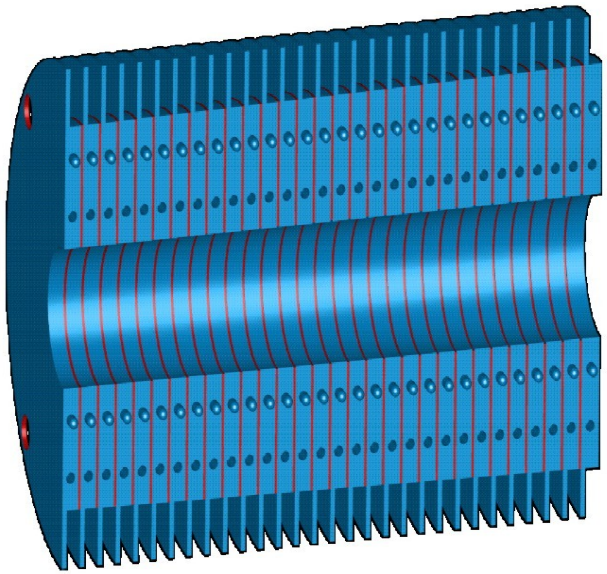


Segmentation:

- 17 rings (r)
- 8 sectors (phi)
- 140 cells/sector

Sensor



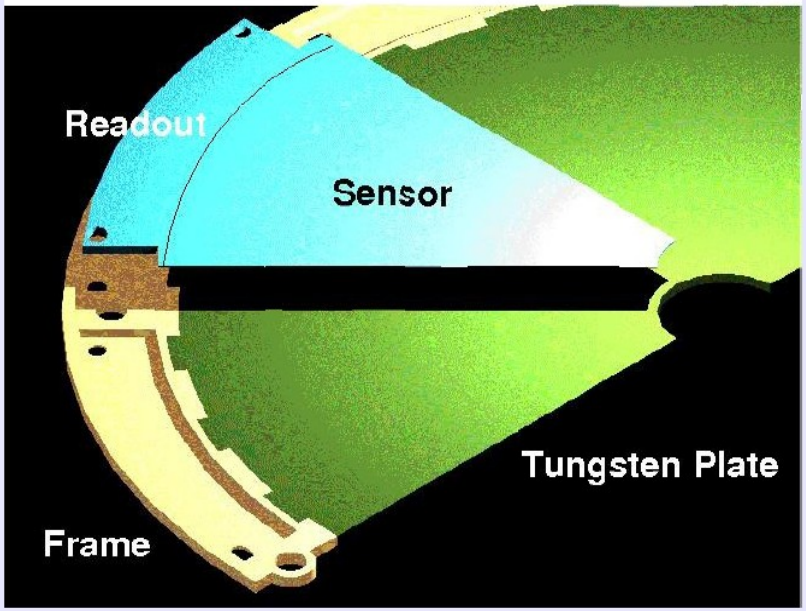


Geometry:

- 30 layers of $1X_0$:

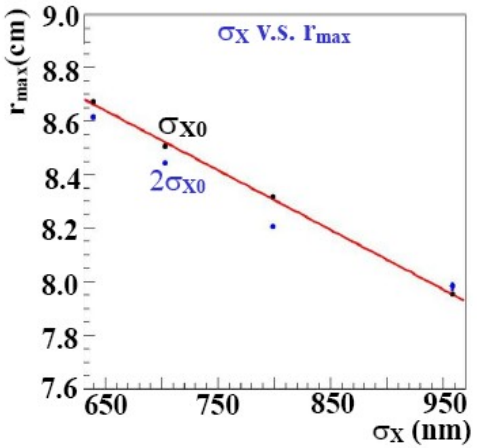
  - 3.5 mm absorber and
  - 0.3 mm diamond sensor (GaAs/Si)

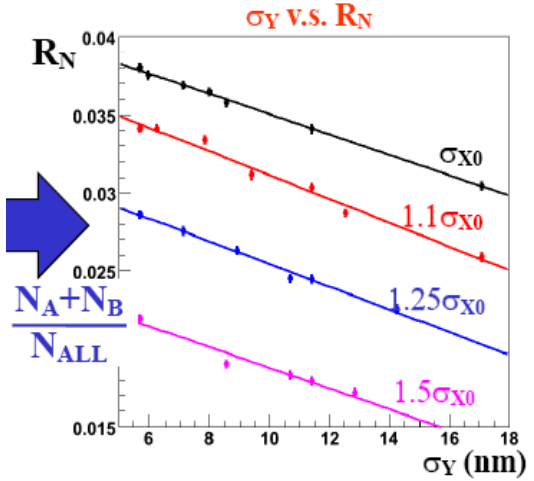
- 20mm < R < 165mm (175 mm electronics, 225 mm support tube)
- 5-45 mrad aperture

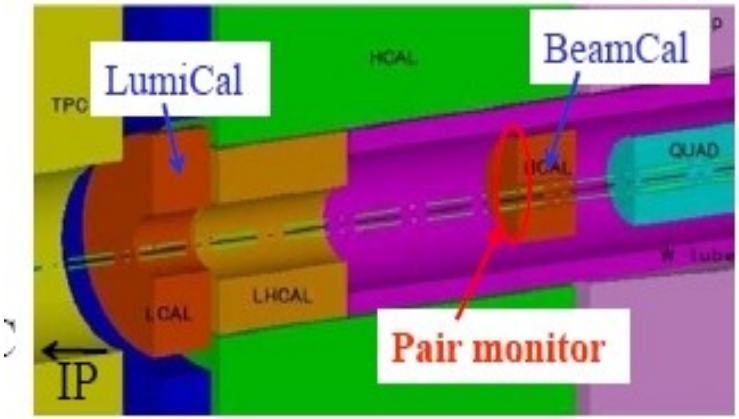


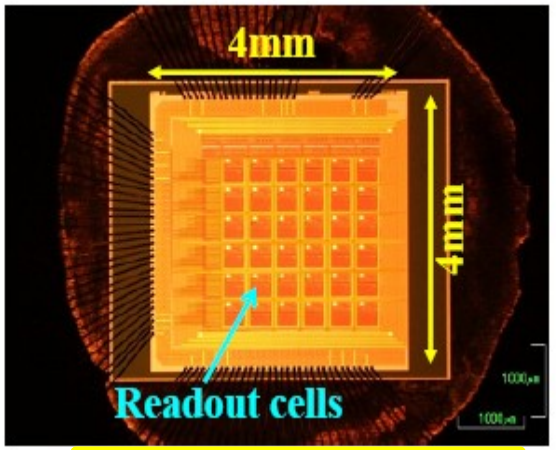
New FCAL Component - Pair Monitor

- Monitoring beam profile using BeamStrahlung Pairs
- Number of hits and their R positions carry info about σ_X and σ_Y of the beam









sensor prototype
6x6 =36 pixels
ASIC bump bonded

- Design – 0.2 mm Si plane with 0.4x0.4 mm^2 pixels

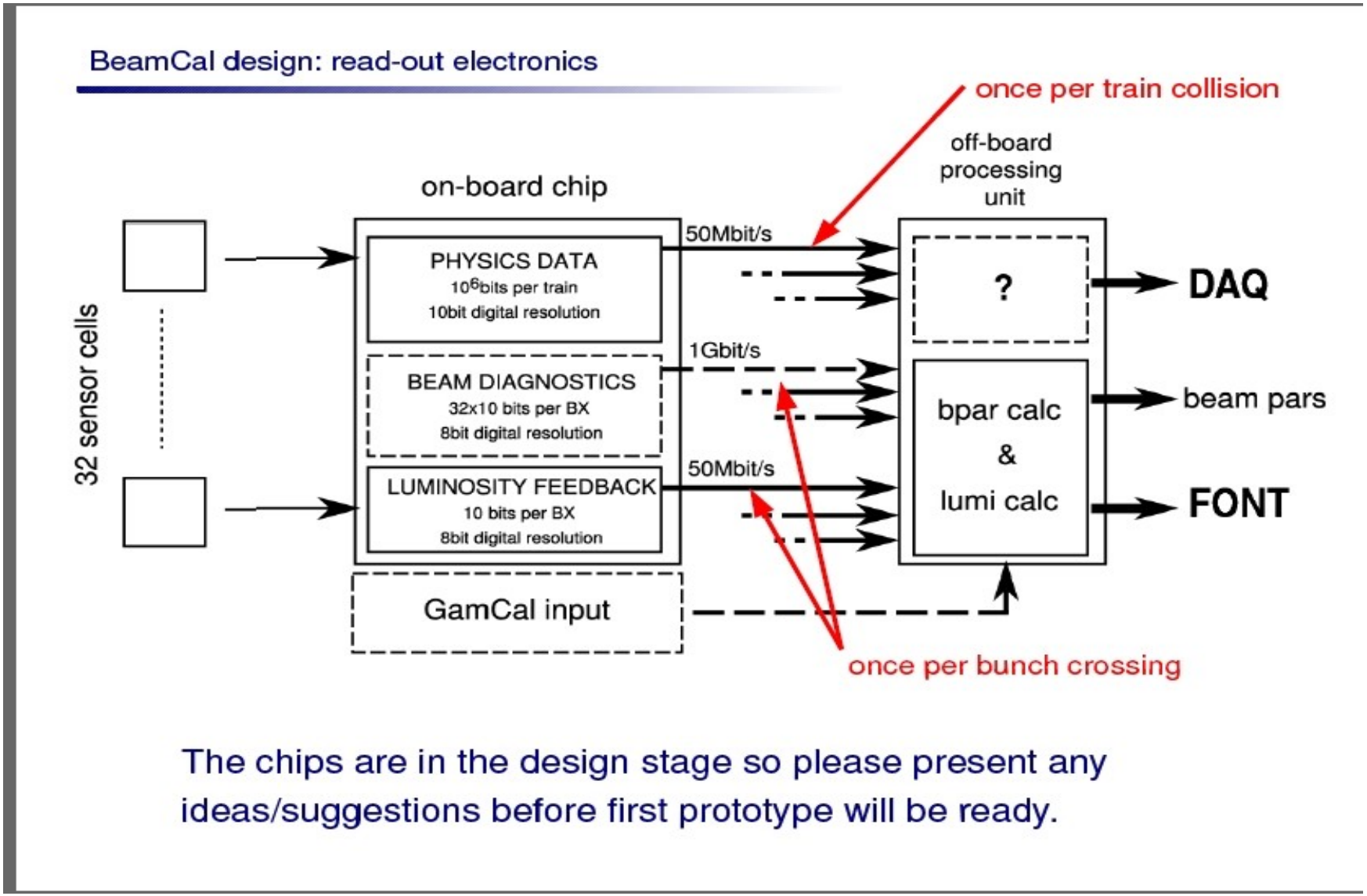
Status : - study of the concept is ongoing

- MC simulation: $\Delta\sigma_X/\sigma_X < 5\%$ → (OK)

$\Delta\sigma_Y/\sigma_Y \sim 15\%$ → needs improvement

- ASIC read-out prototype developed and tested (OK)

BeamCal FE



The chips are in the design stage so please present any ideas/suggestions before first prototype will be ready.

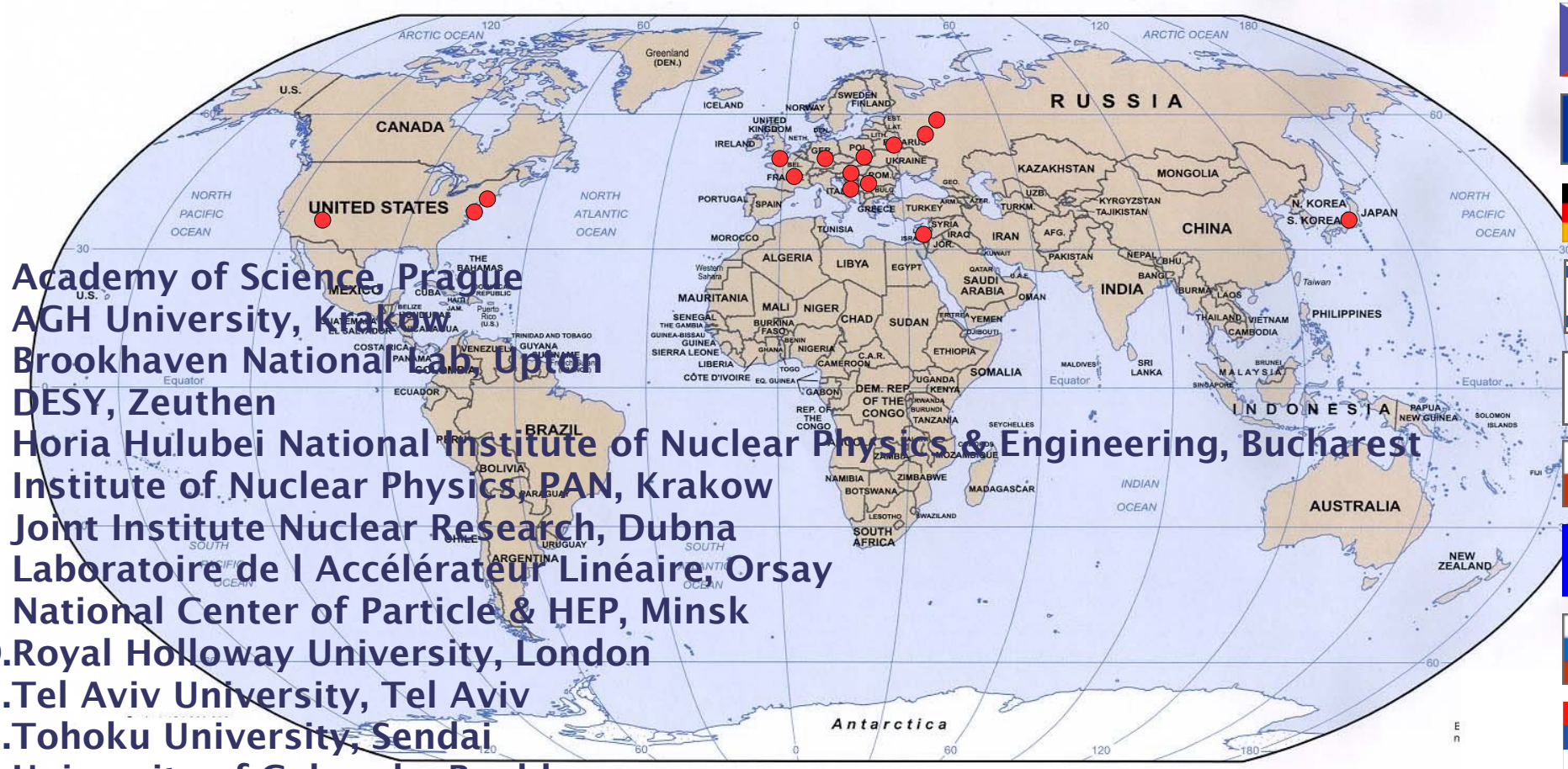
Summary - BeamCal

- Mechanics : designed , work in progress
- Sensors : - geometry, granulation designed
  - extensive studies to find radiation hard material for sensors
    pCVD, sCVD, GaAs and radiation hard Si tests ongoing,
    most promising so far seams to be polycrystalline CVD
    (available on wafer scale, still operating after 5-6Mgy)
- FE and Read-Out electronics: - under development
  - plan to have BeamCal sector prototype
    within 4 years
- Software: - MC almost ported to ILC (mokka)
  - functioning code to retrieve beam parameters
    (More-Penrose Method)

Collaboration
High precision design

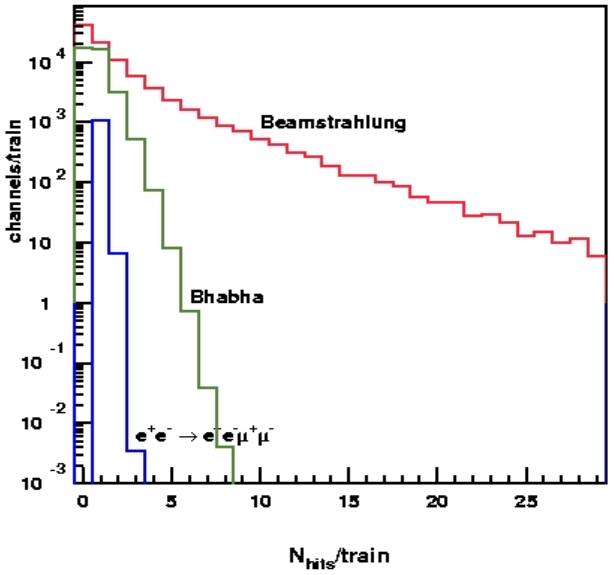
END

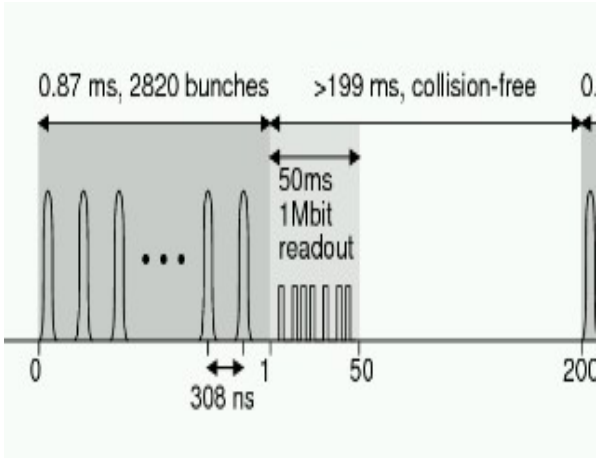
FCAL Collaboration – 16 institutes from 12 countries

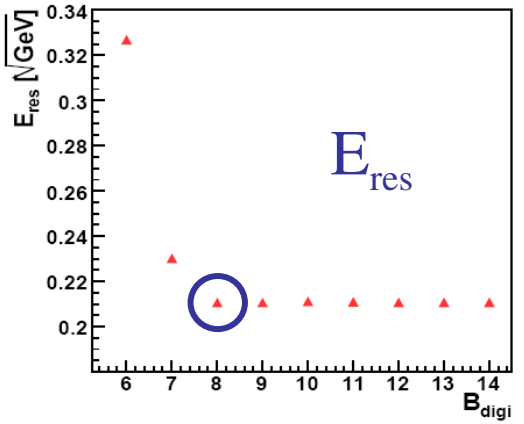


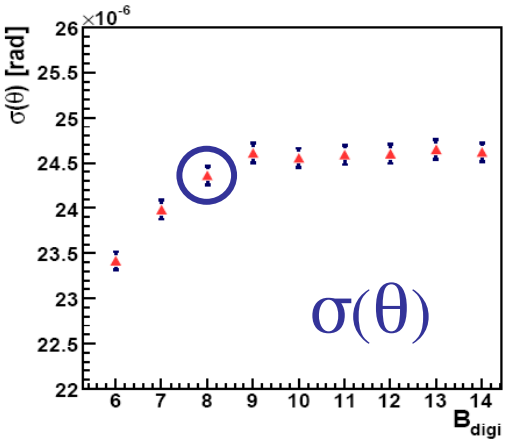
1. Academy of Science, Prague
2. AGH University, Krakow
3. Brookhaven National Lab, Upton
4. DESY, Zeuthen
5. Horia Hulubei National Institute of Nuclear Physics & Engineering, Bucharest
6. Institute of Nuclear Physics, PAN, Krakow
7. Joint Institute Nuclear Research, Dubna
8. Laboratoire de l Accélérateur Linéaire, Orsay
9. National Center of Particle & HEP, Minsk
10. Royal Holloway University, London
11. Tel Aviv University, Tel Aviv
12. Tohoku University, Sendai
13. University of Colorado, Boulder
14. VINCA Inst. of Nuclear Sciences, Belgrade
15. West University of Timisoara, Timisoara
16. Yale University, New Haven

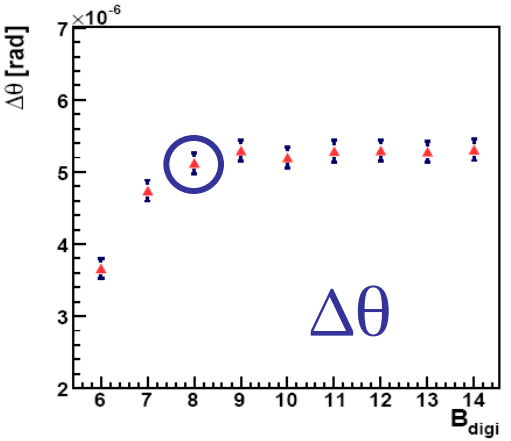
MC results for LumiCal FE







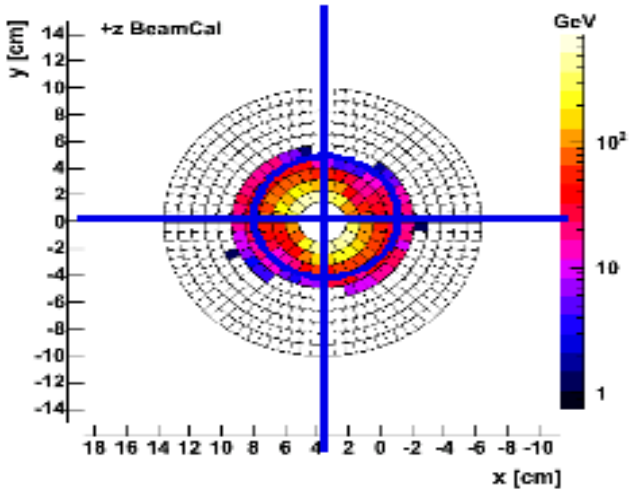




More-Penrose Method

Moore Penrose Method

$$\begin{pmatrix}\text{Observables}\end{pmatrix} = \begin{pmatrix}\text{Observables}\end{pmatrix}_{nom} + \begin{pmatrix}\text{Taylor Matrix}\end{pmatrix} \begin{pmatrix}\Delta \text{ BeamPar}^{*}\end{pmatrix}$$



- observables:
  - total energy
  - first radial moment
  - inv. radial moment
  - l/r, u/d, diag asymmetries
  - E(ring ≥ 4) / Etot
  - E / N
  - phi moment
  - inv. phi moment
  - f/b asymmetries
  - total photon energy (extern)

- beam parameters (diff and av)
  - bunch sizes
  - emittance
  - beam offsets
  - waist shifts
  - bunch rotations
  - profile rotations
  - number of particles

02/March/2008 C.Grah: BeamCal 20