The forward calorimetry for future linear colliders – big challenge in detector building.

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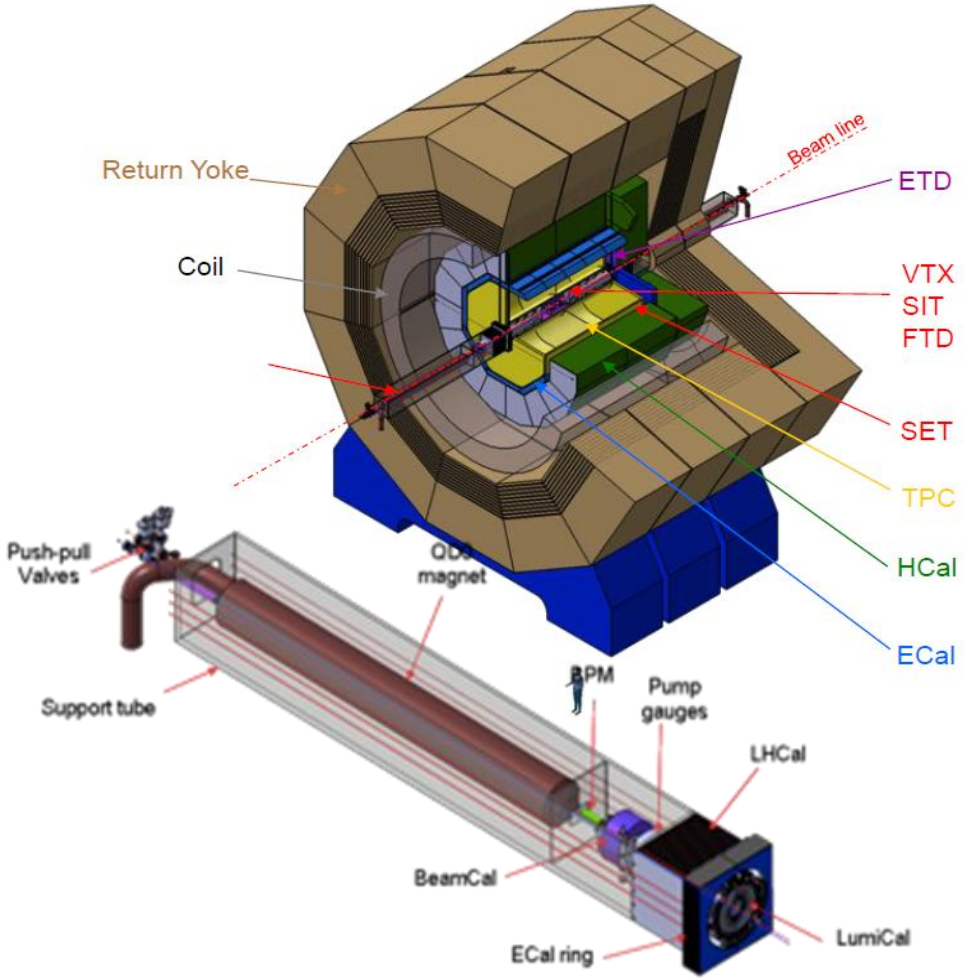
Challenges of Forward Region

for ILC and CLIC

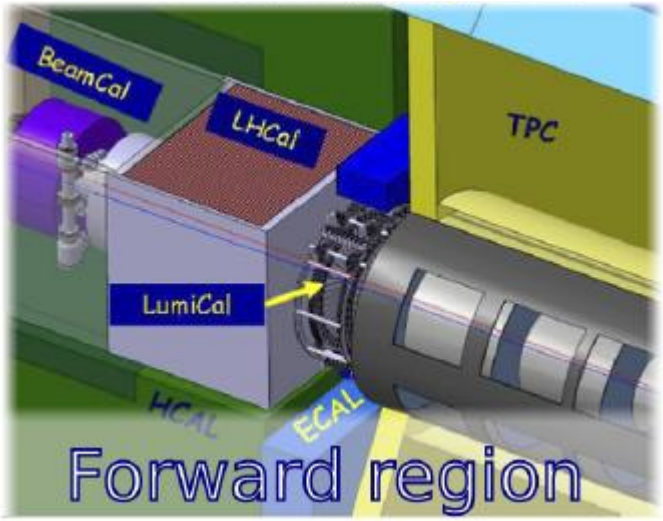


LumiCal

precise luminosity measurement
(10^{-3} at 500 GeV @ ILC, 10^{-2} at 3 TeV @ CLIC)

BeamCal (and Pair Monitor)

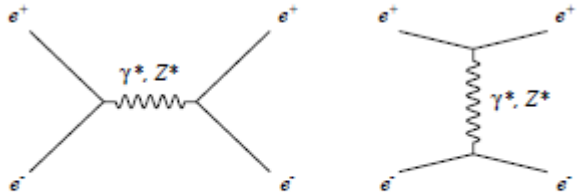
- low polar angle electron tagging
- beam tuning and beam diagnostics
- fast feedback using special futures of the ASICs



Challenges:

- high precision (LumiCal),
- radiation hardness (BeamCal),
- very fast read-out (both)

Luminosity measurement



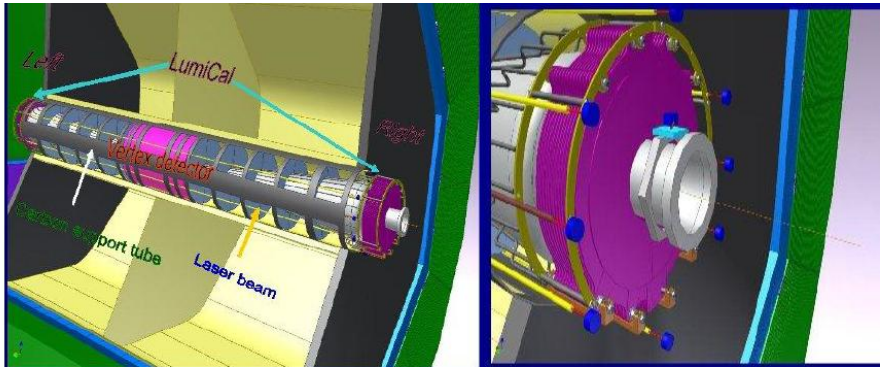
Feynman diagrams of Bhabha scattering process

Luminosity:

$$L = \frac{N_B}{\sigma_B} \qquad \sigma_B \approx \frac{32\pi\alpha_{em}^2}{s}\frac{1}{\theta^3}$$

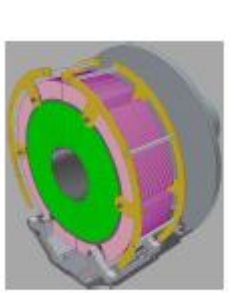
Source	Value	Uncertainty	Luminosity Uncertainty
σ_θ	2.2×10^{-2} [mrad]	100%	1.6×10^{-4}
Δ_θ	3.2×10^{-3} [mrad]	100%	1.6×10^{-4}
a_{res}	0.21	15%	10^{-4}
luminosity spectrum			10^{-3}
bunch sizes σ_x, σ_z,	655 nm, 300 μm	5%	1.5×10^{-3}
two photon events	2.3×10^{-3}	40%	0.9×10^{-3}
energy scale	400 MeV	100%	10^{-3}
polarisation, e^-, e^+	0.8, 0.6	0.0025	1.9×10^{-4}
total uncertainty			2.3×10^{-3}

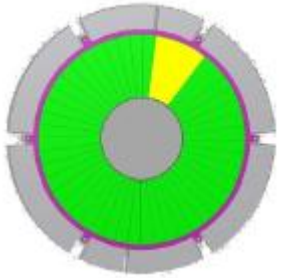
Systematics of luminosity measurement at 500GeV



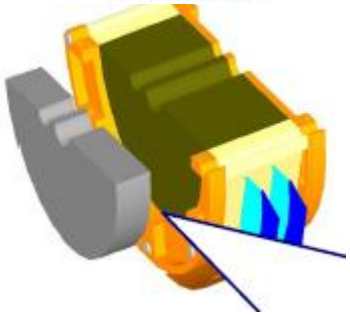
Detector design

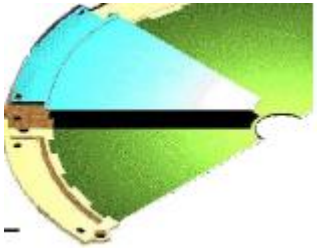
		Unit	ILC	CLIC_ILD
LumiCal	geometrical acceptance	mrad	31-77	38-110
	fiducial acceptance	mrad	41-67	44-80
	z(start)		2450	2654
	number of layers(W+Si)		30	40
	number of channels		~180k	~250k
BeamCal	geometrical acceptance	mm	5-40	10-40
	z(start)		3600	3281
	number of layers(W+Sensor)	mm	30	40
	graphite layer thickness		100	100
	number of channels		~62k	~84k





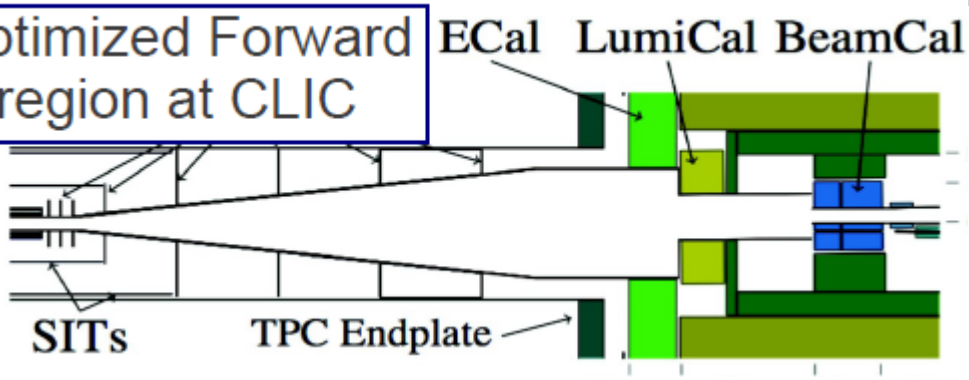
Mechanical structure of the LumiCal





Pair Monitor

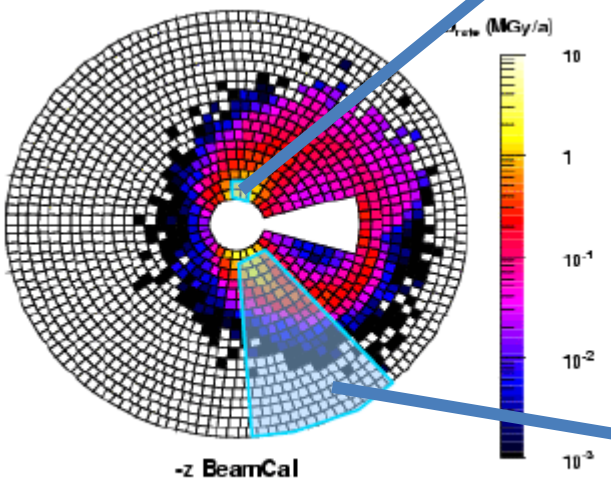
Optimized Forward region at CLIC



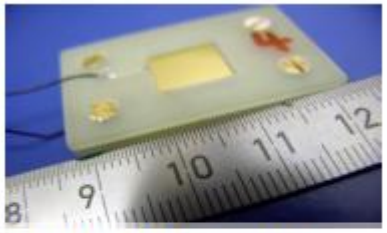
- detector radius 10cm
- pixel size 400x400 μm2
- total number of pixels ~ 200k

BeamCal – Radiation Hard sensors

Very high radiation load
(up to 1MGy per year)

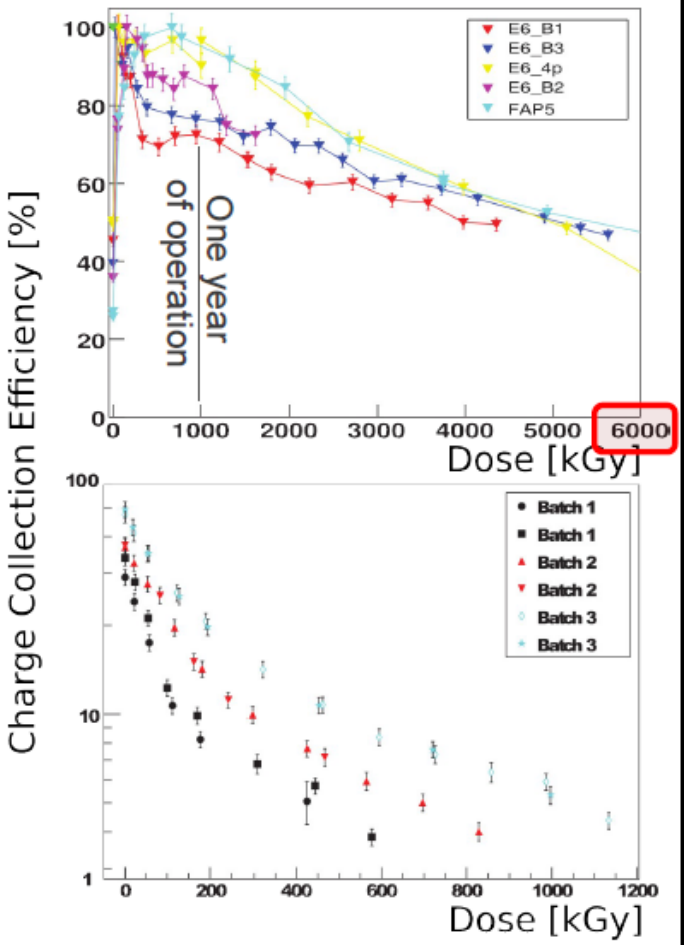


Dose in BeamCal sensor per year



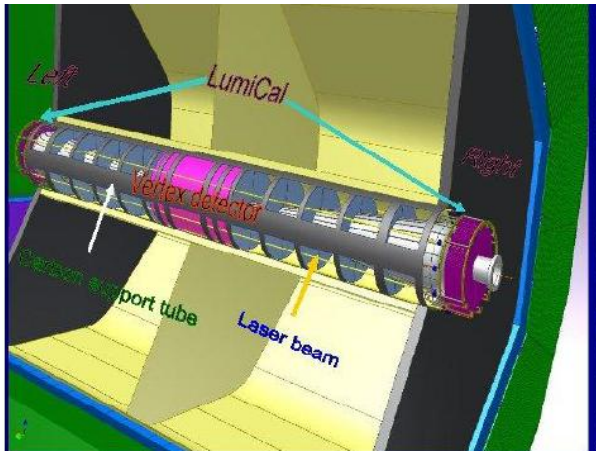
pCVD Diamond
- 1 x 1 cm2
- 200-900 μm thick
- Leakage <1pA/cm^2

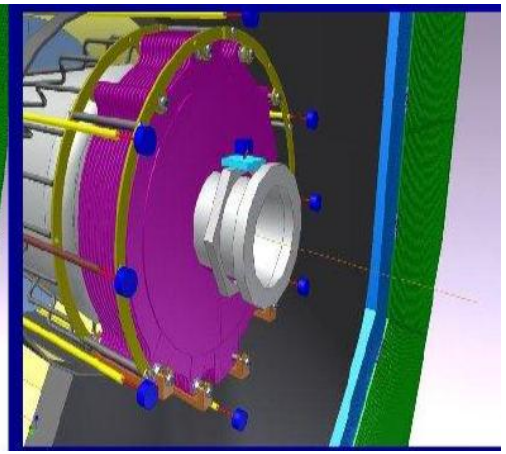
GaAs sensor prototype
- 500 μm thick sensor
- 87 pads (20 - 40mm^2)
- Leakage ~ 7nA/mm^2



Precision LumiCal alignment

High accuracy in luminosity measurements at ILC/CLIC ($\Delta L/L \sim 10^{-3}/10^{-2}$) require precisely measurement of the luminosity detector displacements:
less than 500 μm in X,Y directions , 100 μm in Z direction and
a few microns for internal silicon sensor layers



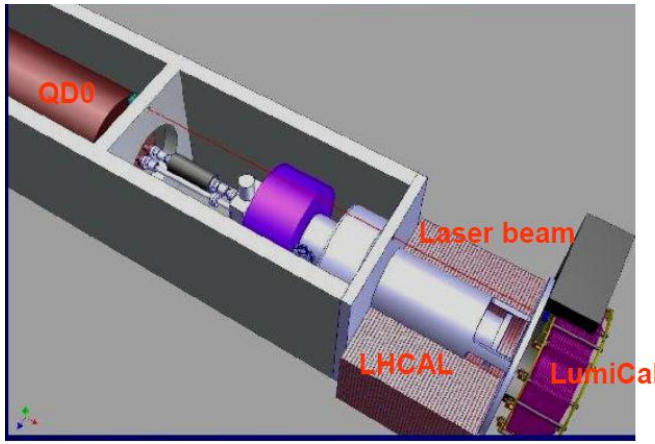


Good reference points
for position measurement
of LumiCal can be:

- QD0 magnet
- Beam Position Monitors
- also beam pipe

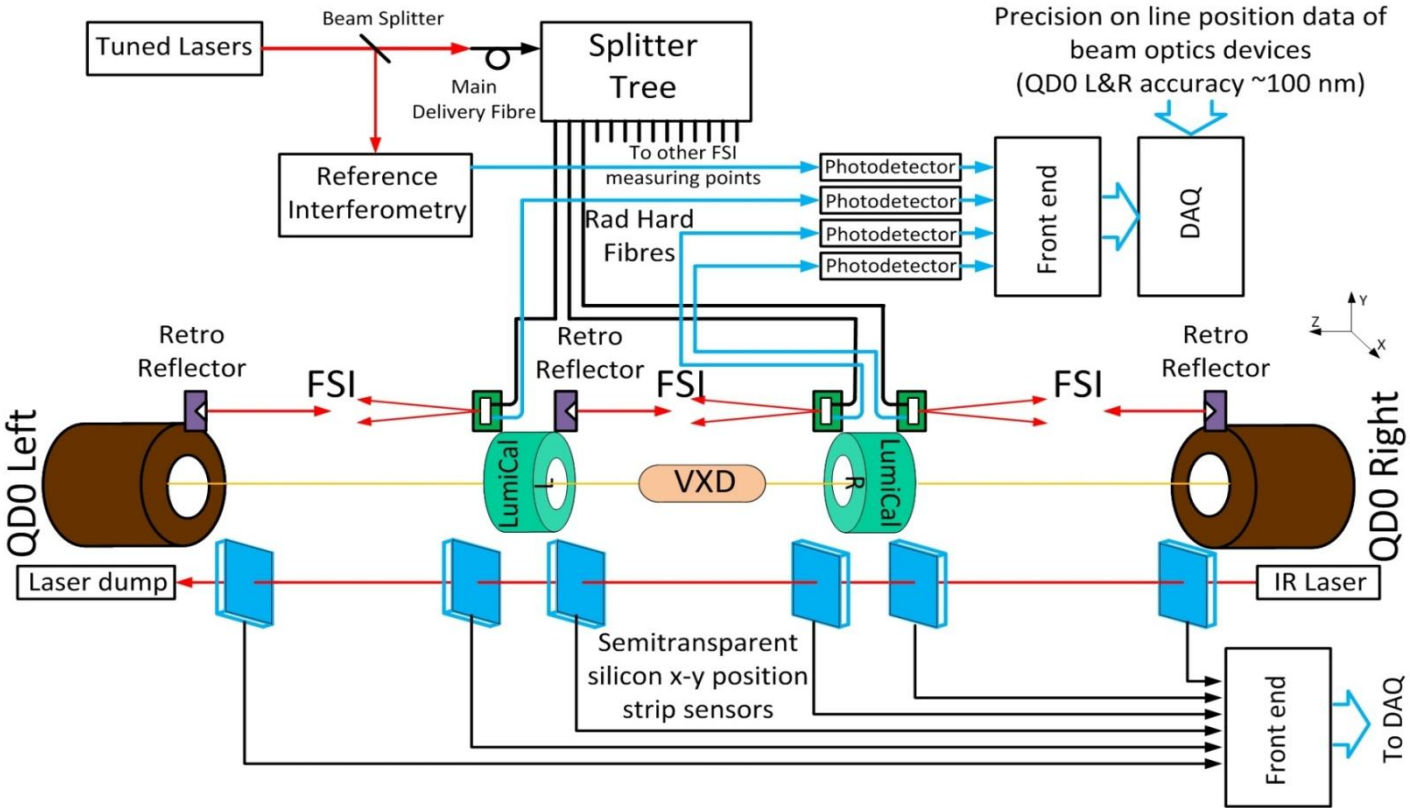
The measurements of absolute distance between
Left and Right
LumiCal calorimeters

The measurements of the relative distances to QD0 in X,Y and Z directions



Design of LAS system

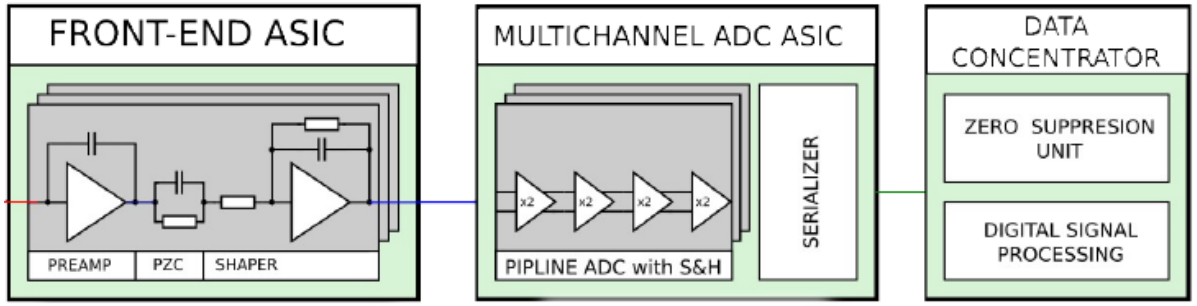
The laser alignmet system will contain the main components:
- infra-red laser beam and semi-transparent position sensitive detectors (PSDs)
- tunable laser(s) working within Frequency Scanning Interferometry (FSI) system



FSI – will be used for measurements of the absolute distance between LumiCal calorimeters by measurement of interferometer optical path differences using tunable lasers (by counting the frenges

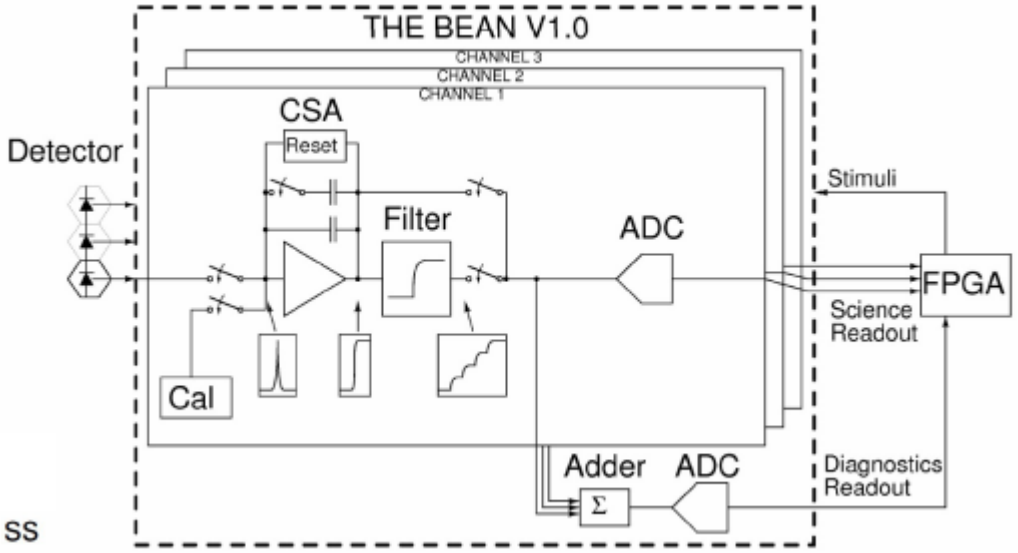
Semi-transparent sensors : LumiCal displacements of the internal Si layers and detectors relative positions

LumiCal & BeamCal readout



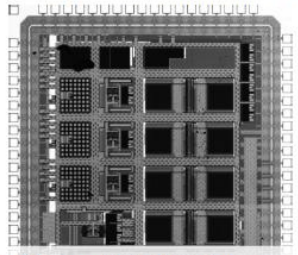
8 channel Front-End ASIC
- Preamp. + PZC + CR-RC
- $T_{peak} \approx 60$ ns
- C_{det} up to 100pF
- Switched gain: ~2fC <Qin<10 pC
- Event rate up to 3 MHz

8 channel 10-bit ADC ASIC
- 1.5 bit pipeline architecture
- Digital serializer
- F_{max} 25 Ms/s (9.7 ENOB)
- Power: ~1.2mW/chan/MHz
- Power pulsing embedded



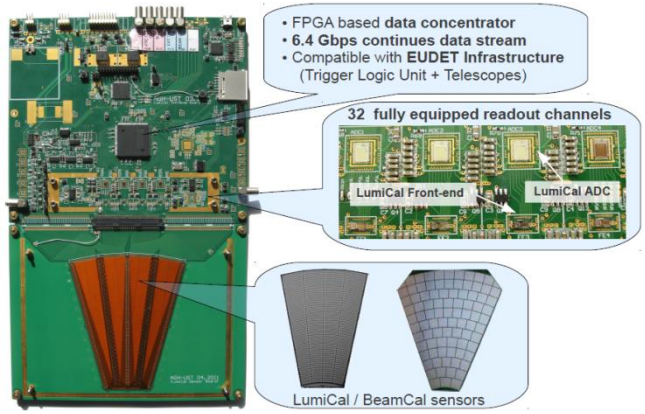
- Charge sensitive preamplifier (CSA) Gated reset for quick baseline restoration
- Switched-Capacitor filter
- ADC : 10-bit SAR ADC
- Analog adder to provide fast feedback

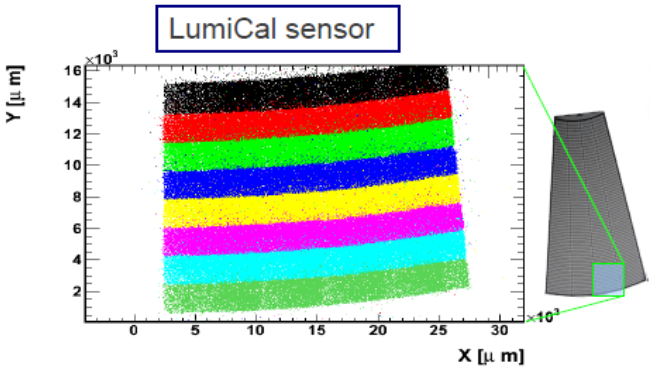
Prototype ASIC Micrograph

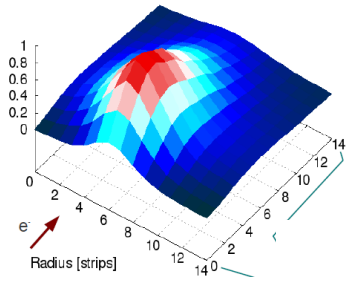


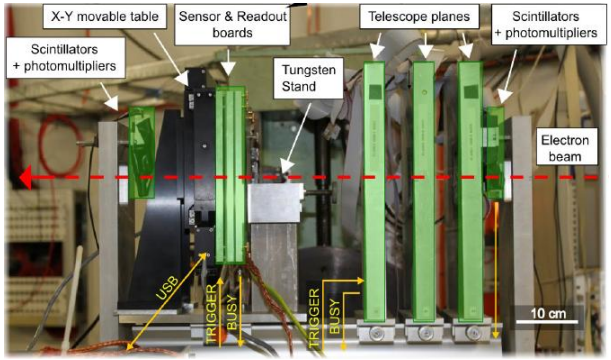
180-nm TSMC process

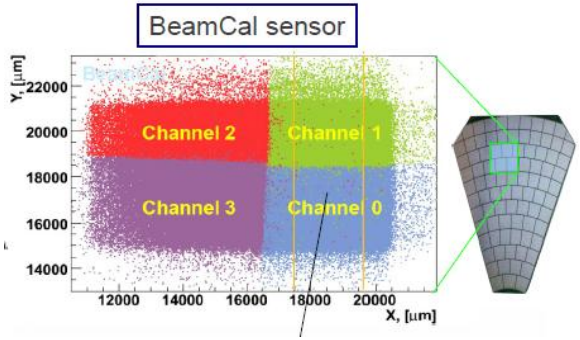
Testbeam results

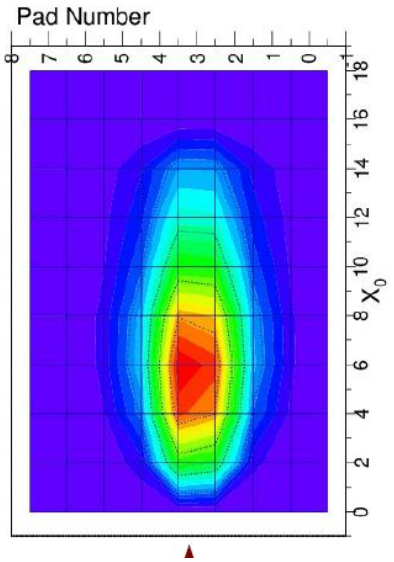












Summary

Challenges for Very Forward Region:

- High precision – precision mechanics, laser alignment system
- High radiation dose – radiation-hard sensors
- High occupancy – fast, ASIC based low power readout

Thank for your attention