FPCCD option of ILD vertex detector

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Outline

- FPCCD VTX design parameter
- FPCCD sensors
- Support structure

FPCCD VTX design parameter

Layer	R (mm)	|Z| (mm)	|cosθ|	Pixel size (μm)
1	16	62.5	0.97	5
2	18	62.5	0.96	5
3	37	125	0.96	10
4	39	125	0.95	10
5	58	125	0.91	10
6	60	125	0.9	10

- Pixel size of outer layers
  - It was 5μm, but changed to 10μm

  ➔ Reduction of number of readout channels and power consumption

Power consumption

- Assumptions

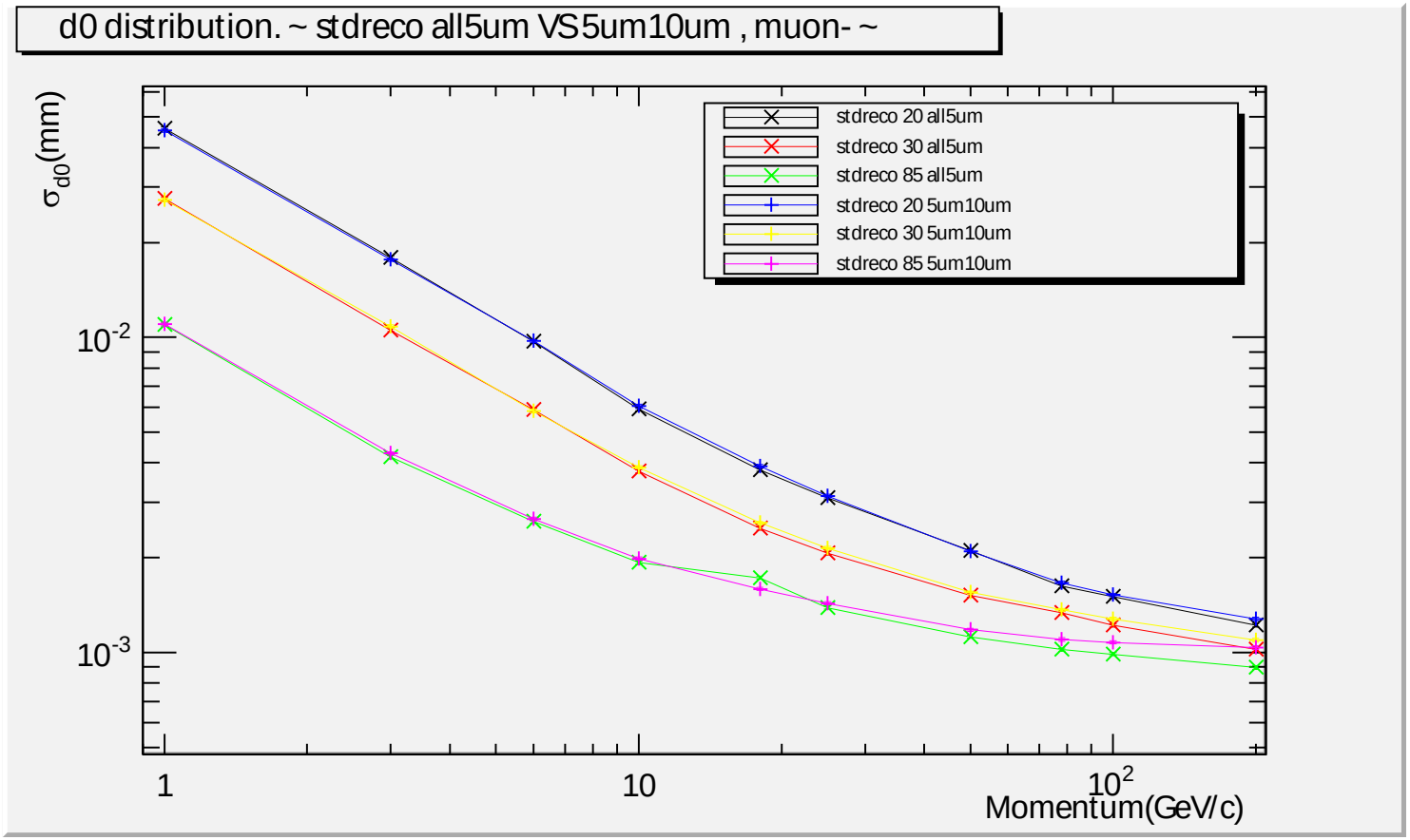
Readout frequency	10 Mpix/s
Readout time	200 ms
Clock timing	Same for inner and outer layers
Vertical shift time	40 us/line
Power consumption	15 mW/ch
Chip size (in/out)	11x62.5mm^2 / 22x125mm^2
Number of chips (in/out)	40 (=10x2x2) / 112 (=(11+17)x2x2)

- Results

Pixel size (in)	Pixel size (out)	# of ch/chip (in)	# of ch/chip (out)	# of ch (total)	Power consumption
5 um	5 um	28	56	7392	111 W
5 um	10 um	15	15	2280	34 W

Expected IP resolution

- Increase of pixel size of outer layers does not affect the IP resolution



Pixel occupancy

- Simulation results for pixel occupancy at 1TeV (statictics:10BX)
- Increase of occupancy due to decrease of # of pixels (1/4) is less than x4

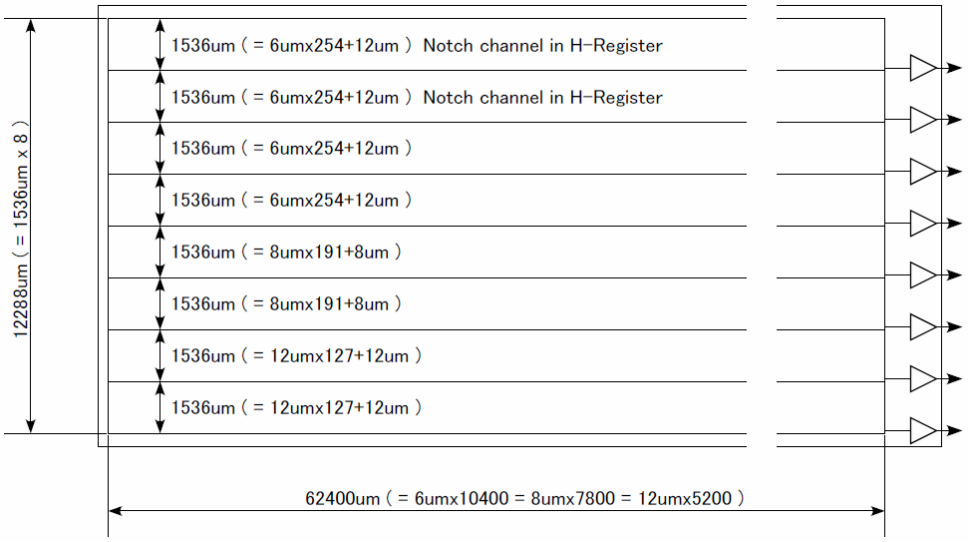
Layer	Occupancy for 5um (%)			Occupancy for 10um (%)		
	Direct	B.S.	Total	Direct	B.S.	Total
1	5.1	14.5	19.6			
2	3.1	7.3	10.4			
3	0.18	0.06	0.24	0.41	0.14	0.55
4	0.15	0.06	0.20	0.33	0.13	0.46
5	0.033	0.014	0.047	0.075	0.032	0.107
6	0.029	0.017	0.046	0.064	0.039	0.104

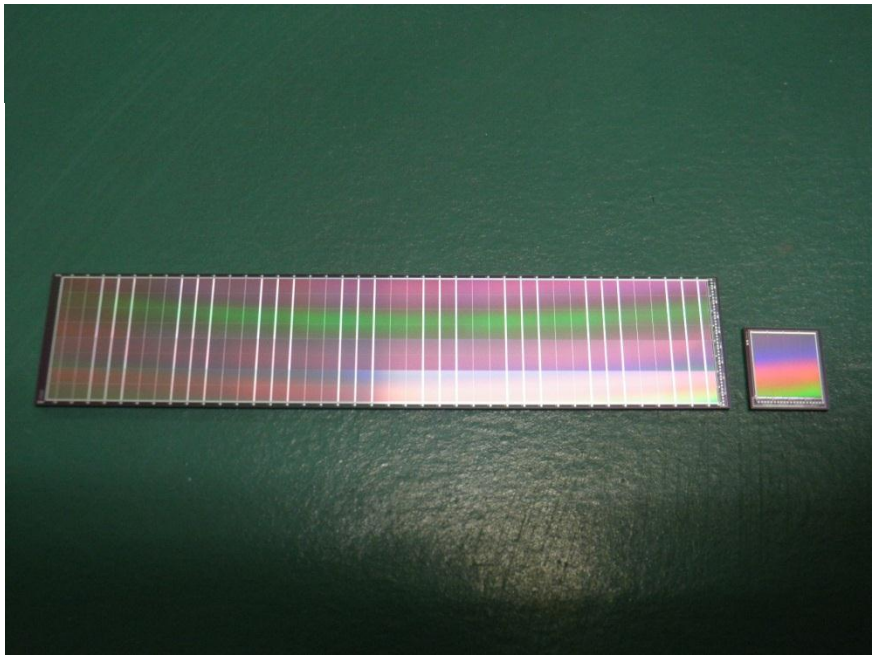
FPCCD sensors

- Small prototype in FY2012
  - 6mm square image area
  - 6um pixel size
  - 4ch/chip with different horizontal shift register size: 6x6, 6x12, 6x18, 6x24 um^2
  - It works except for the channel with 6x6um^2 horizontal shift register

FPCCD sensors

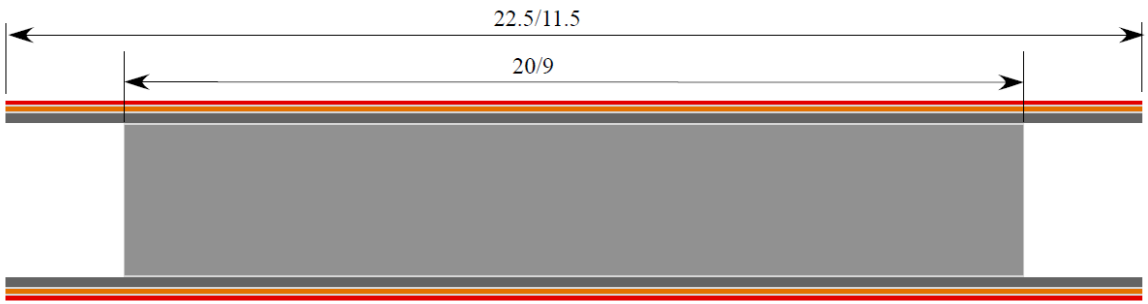
- Large prototype
  - 62.4x12.3mm^2 image area ~ Real size prototype for inner layers
  - 8ch/chip with several pixel sizes: 4chx6um, 2chx8um, 2chx12um
  - Si wafer has been made, but waiting for packaging





Support structure

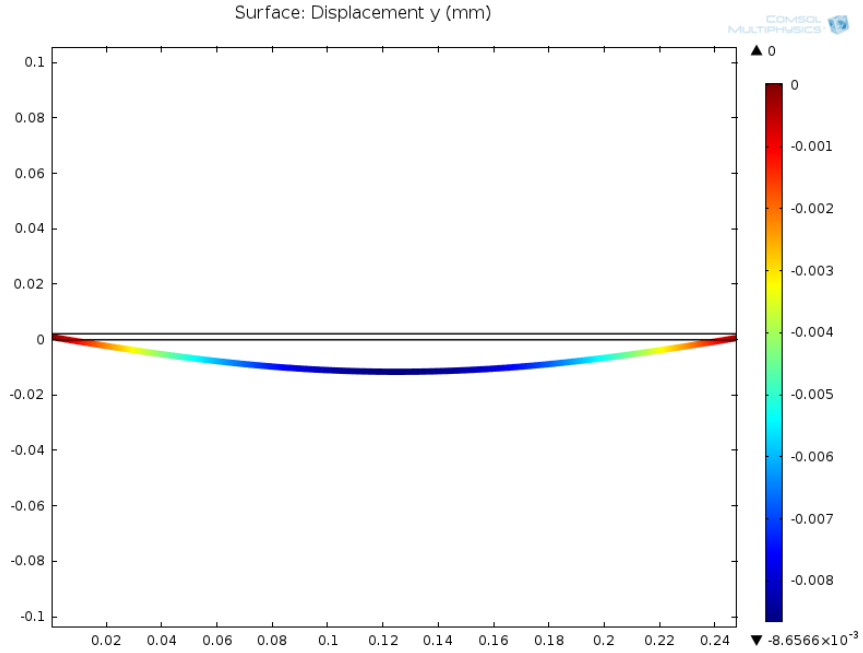
- Ladder design
  - Ladder has a tricky shape to allow overlapping of sensors with adjacent ladder
  - Material budget ~0.3%X_0/ladder = 0.15%X_0/sensor layer



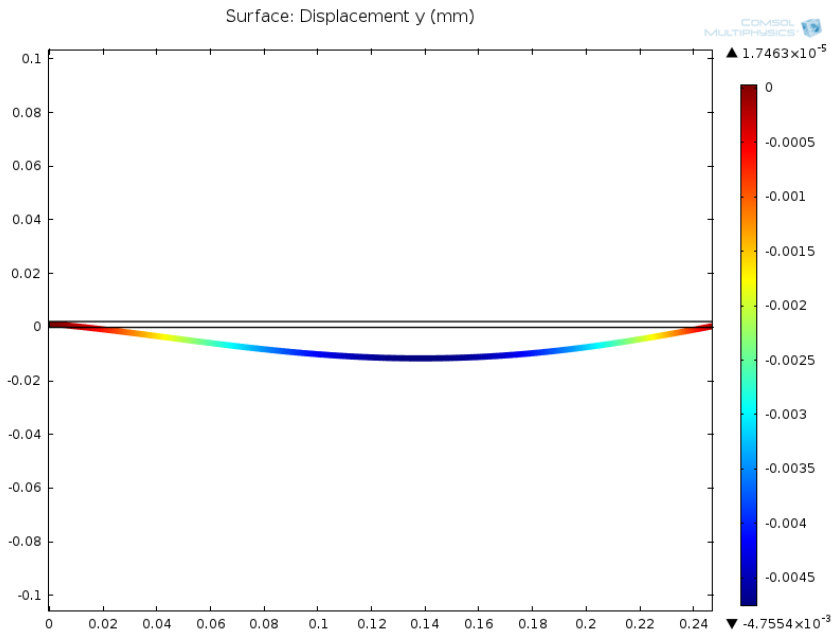
		t (μm)	Total t (μm)	X0 (%)
Si		50	50	0.0534
Epoxi		10	2000	0.0028
FPC	Cu	9		0.0125
	Kapton	51		0.0179
Epoxi		10		0.0028
CFRP		100		0.0383
Epoxi		20		0.0056
RVC		1600		0.0300
Epoxi		20		0.0056
CFRP		100		0.0383
Epoxi		10		0.0028
FPC	Cu	9		0.0125
	Kapton	51		0.0179
Epoxi		10		0.0028
Si		50	50	0.0534
Total			**2100**	**0.2966**

Support structure

- Ladder deformation by self weight
  - Simplified geometry of 50um Si sensors (200um gap between two sensors) + CFRP sheets and RVC core



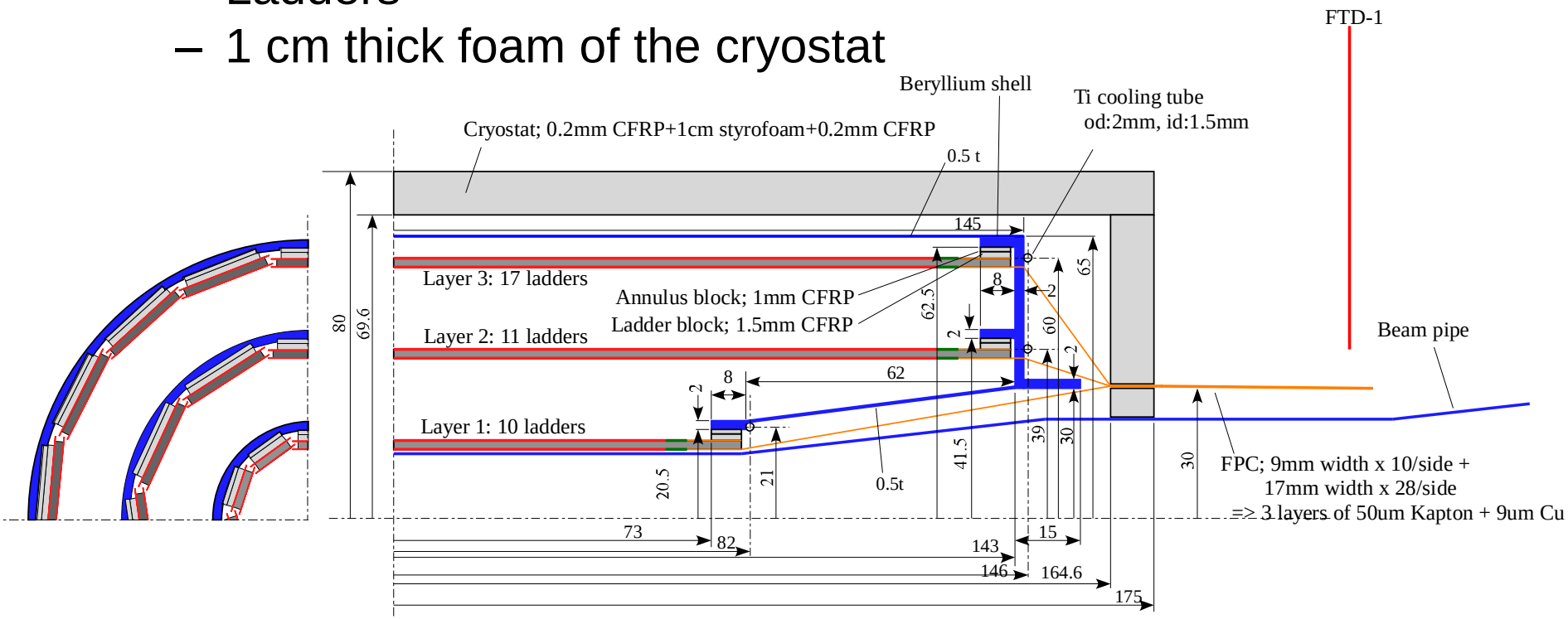
Two edges support:
Maximum deformation ~ 8.66 um



One edge fix, one edge support:
Maximum deformation ~ 4.76 um

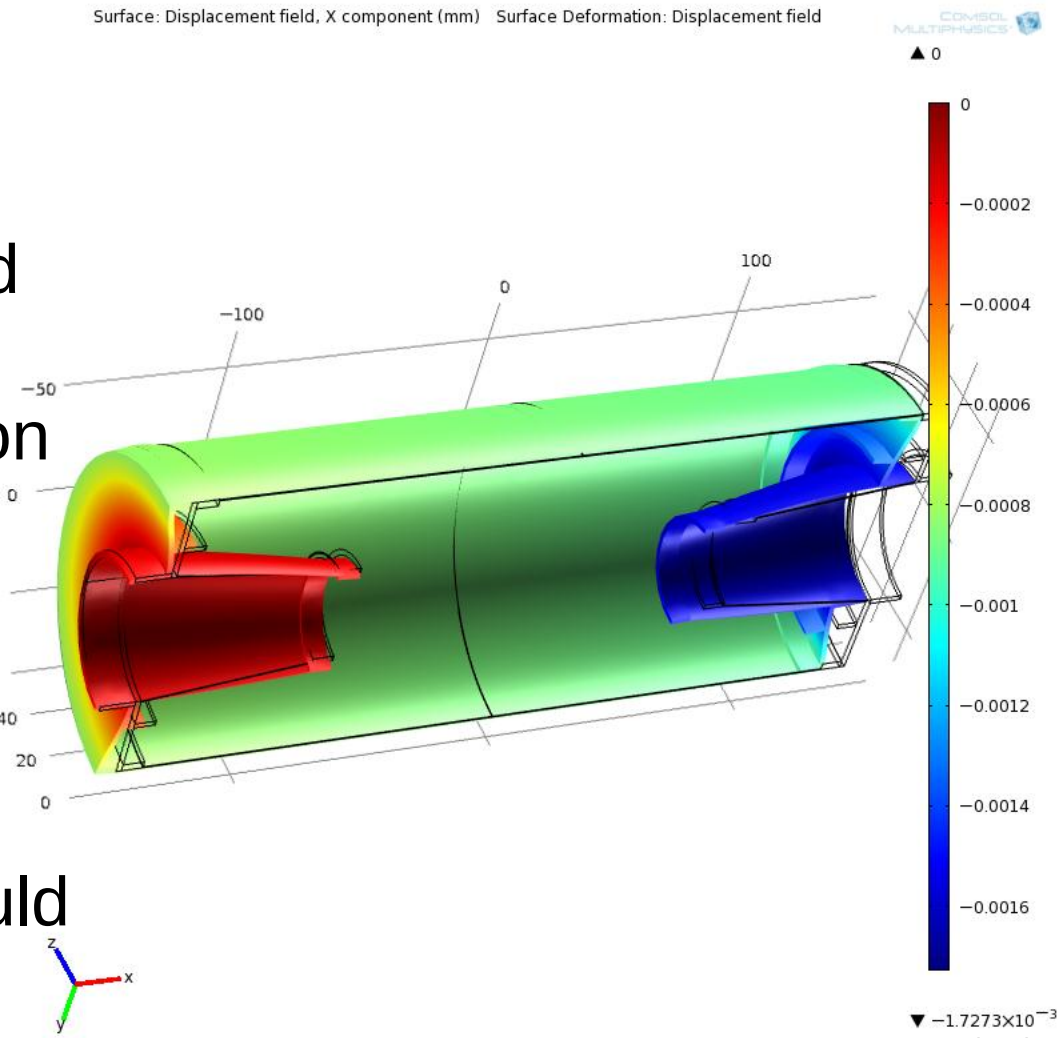
Support structure

- Design in ILD simulation model
  - Similar to SLD vertex detector
  - 2 mm thick Be end plate, 0.5 mm thick Be support shell
  - Kapton+Cu flexible cables
  - Ladders
  - 1 cm thick foam of the cryostat



Beryllium support shell

- FEA calculation of deformation
  - 1kgf (9.8N) is applied in z-direction
  - Maximum deformation is less than 2μm
  - Total weight is less than 500g → max force caused by the friction at the kinematic mount would be less than 500gf



Summary

- FPCCD vertex detector design for DBD
  - 3 sets of double-layer ladders: total 6 layers
  - Rin=16mm, Rout=60mm
  - Pixels size is 5um for inner two layers and 10um for outer 4 layers: Impact parameter resolution is almost same as the all 5um pixel case
  - Material budget ~ 0.3%X0/ladder = 0.15%X0/layer
  - Ladders are supported by a Beryllium support structure: 2mm-thick end-plate and 0.5mm-thick cylindrical support shell
  - The support structure is enclosed in a rigid foam cryostat and operated at −40℃
- Sensor R&D status
  - A small size prototype with 6um pixel size has been made and it works
  - Almost real size large prototype with 6 – 12um pixel size has been made: to be tested soon
  - Detailed characterization is expected in coming 1~2 years