GLC Detector

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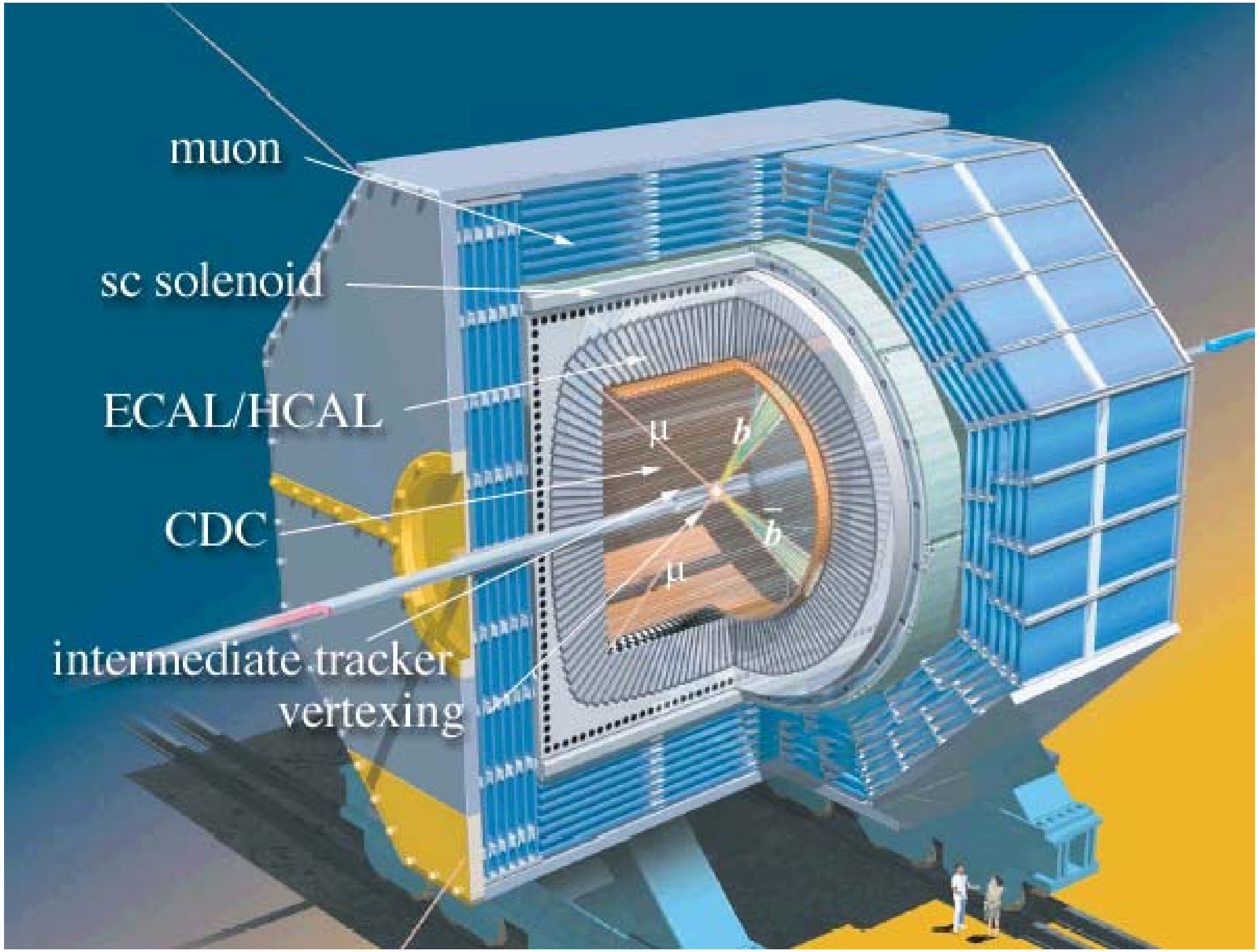
JLC: New names were solicited over internet
(EPOC, ILIAD, TYPHOON etc. etc.)

Naming committee of ACFA (chair: Prof. Namkung)
2003 May: officially renamed JLC $\rightarrow$ GLC

GLC machine parameters

version	‘A’	‘Y’
E_{CM}	535 GeV	501 GeV
pulse rep. rate	150 Hz	
#bunch/pulse	95	190
bunch separation	2.8 ns	1.4 ns
pulse duration	266 ns	
pulse to pulse	6.67 ms	
#particle/bunch	0.75×10^{10}	0.70×10^{10}
σ_x	277 nm	239 nm
σ_y	3.39 nm	2.55 nm
σ_z	90 μm	80 μm
full crossing angle	6∼8 mrad	
Luminosity	9.84×10^{33}/cm^{2}s	27.0×10^{33}/cm^{2}s

Generic GLC detector



Evolution of GLC Detector Pradigm

Driven mostly by the solenoid field and the final focus design

- **Solenoid field:**

  Keeps the pair backgrounds tightly around the beamline.
  2 Tesla $\rightarrow$ 3 Tesla

  Shrinks the size of CDC
  ($\rightarrow$ the whole detector shrinks)

- **Short final focus design:**
  (by Raimondi&Seryi)

  FInal focus section $1800 \rightarrow 500$m ($E_b = 500$ GeV)
  IP-QC1 distance (ℓ^*): 2m $\rightarrow$ 4.3m

  Changes the IR design (easier in general)

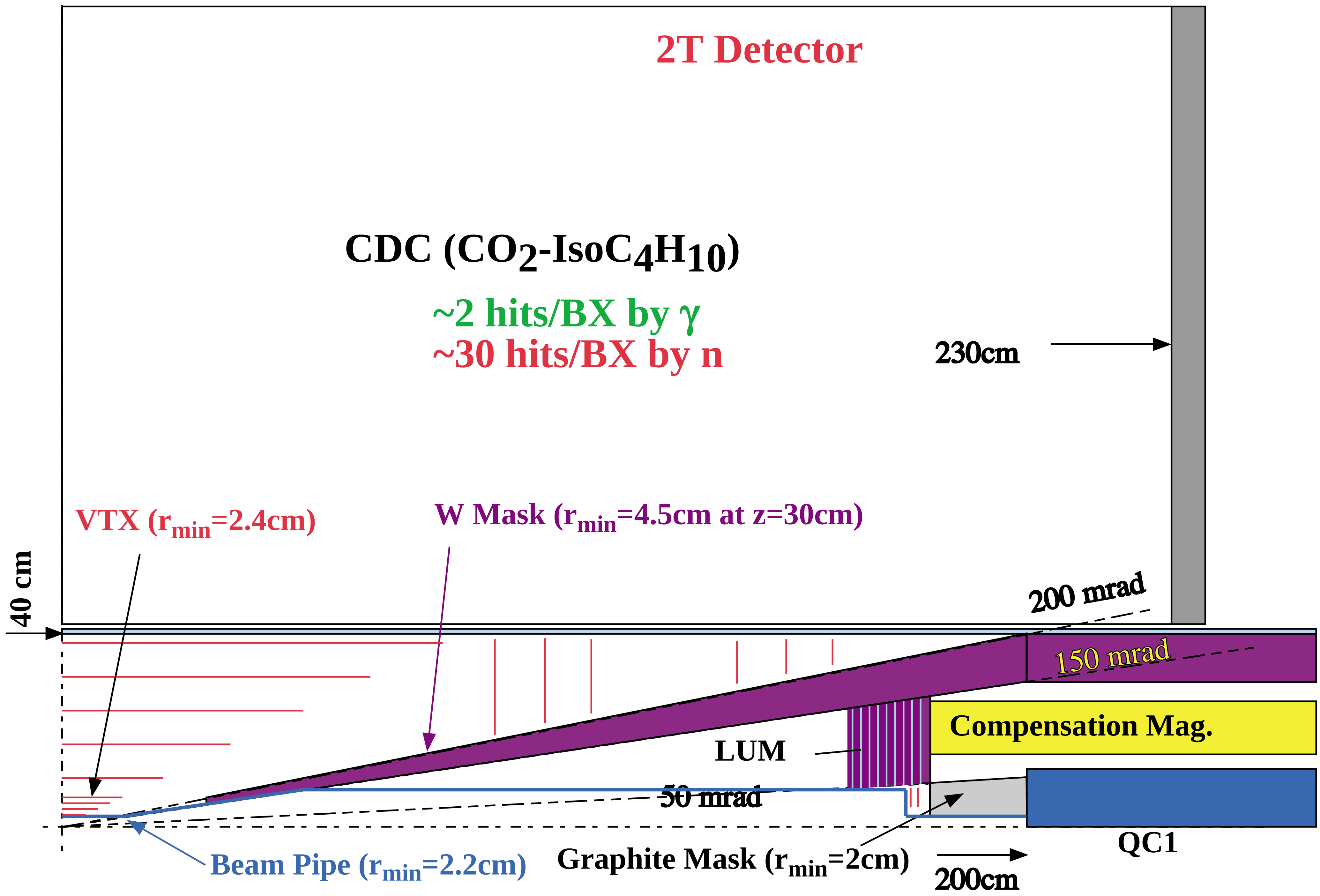
Simulation

Generation of pair background:

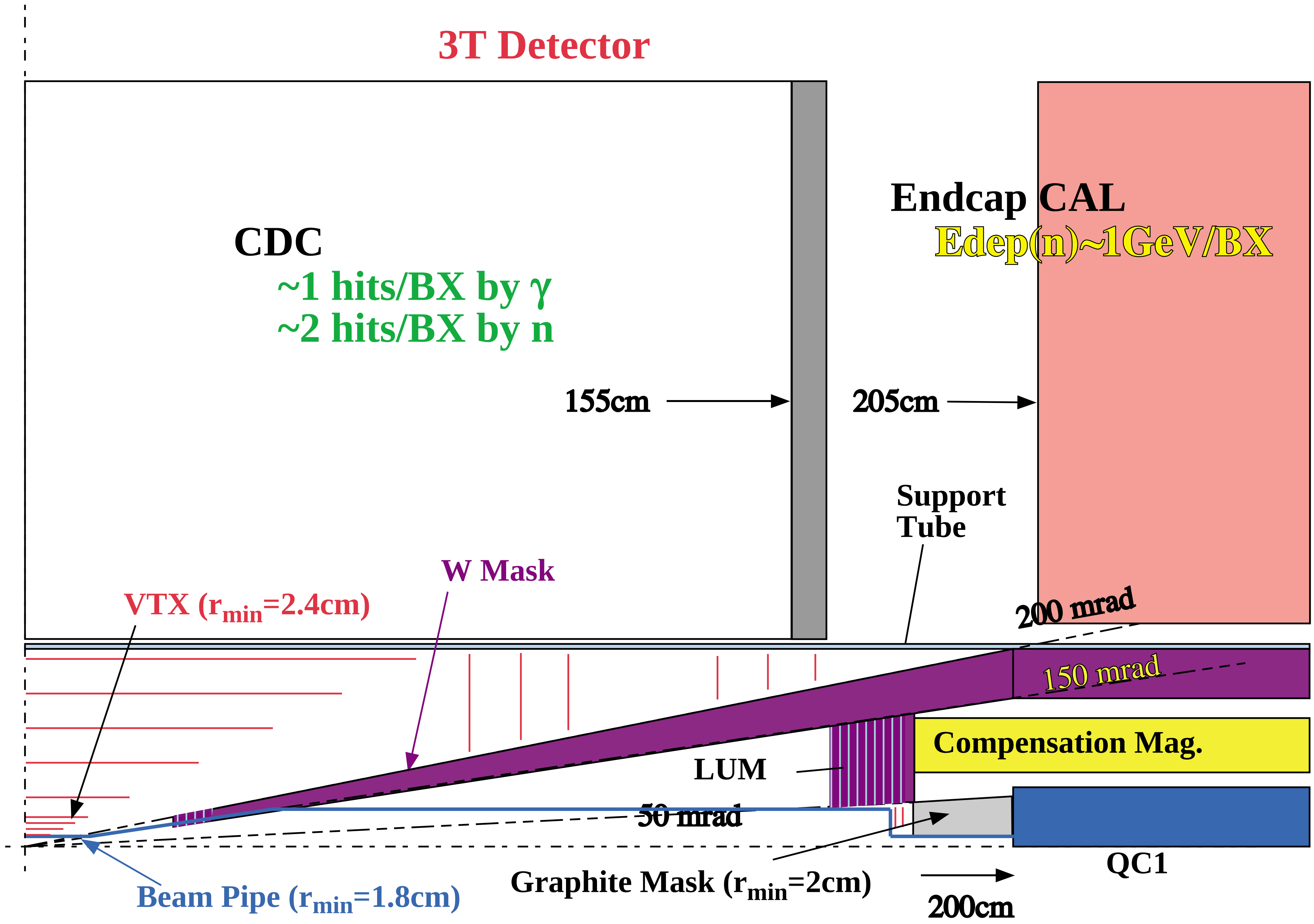
- **CAIN**
- **Ebeam=250GeV**
- **"A" option ("Y" option)**

Detector Simulation:

- **JIM (based on GEANT3)**
- **Ecut for γ: 10 keV**
- **Ecut for n: 1 keV**
- **B field of compensatiom mag. & QC included**

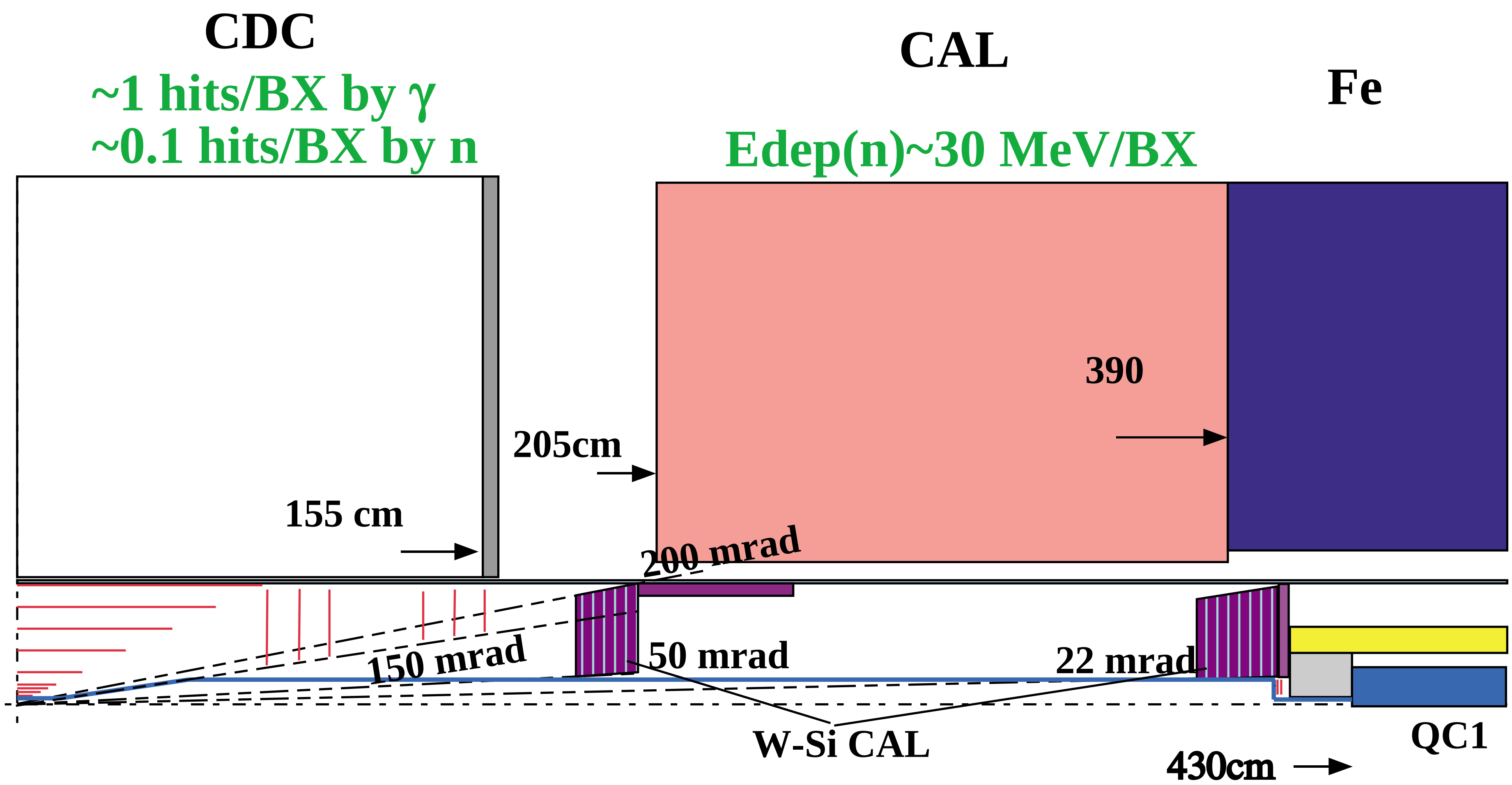


2T Detector
CDC (CO_2-IsoC_4H_{10})
~2 hits/BX by γ
~30 hits/BX by n
230cm
VTX (r_{min}=2.4cm)
W Mask (r_{min}=4.5cm at z=30cm)
40 cm
200 mrad
150 mrad
Compensation Mag.
LUM
50 mrad
QC1
Beam Pipe (r_{min}=2.2cm)
Graphite Mask (r_{min}=2cm)
200cm



3T Detector
CDC
~1 hits/BX by γ
~2 hits/BX by n
Endcap CAL
Edep(n)~1GeV/BX
155cm
205cm
Support
Tube
W Mask
VTX (rmin=2.4cm)
200 mrad
150 mrad
Compensation Mag.
LUM
50 mrad
QC1
Graphite Mask (rmin=2cm)
Beam Pipe (rmin=1.8cm)
200cm

3T *l**=4.3m Detector



Impact of the new optics (*l**=4.3m) on the detector

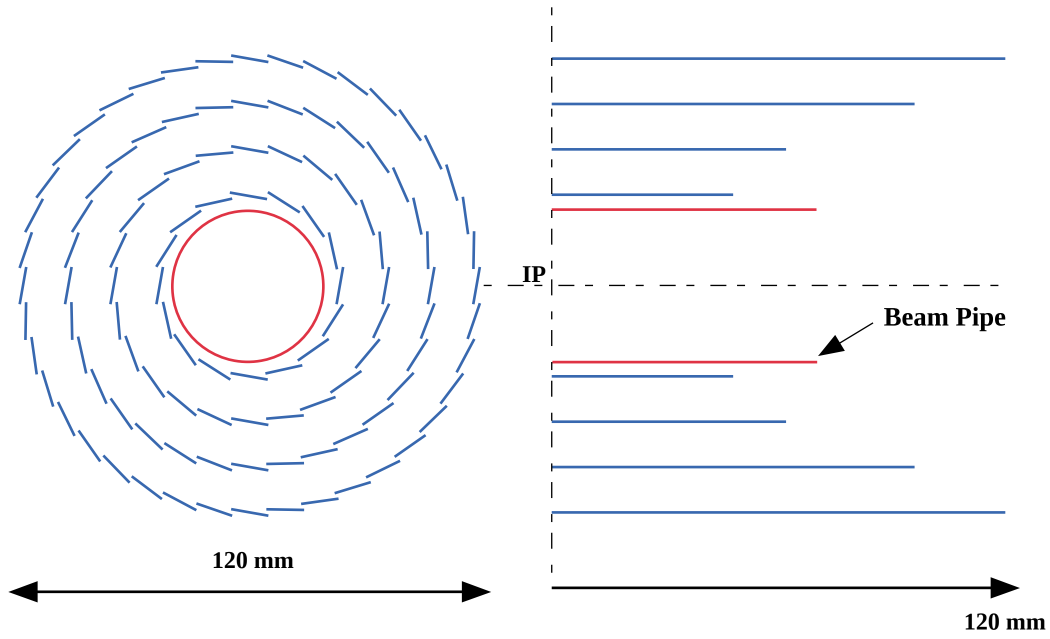
- Huge W-mask NOT needed
- Background hit much smaller (CDC, CAL)
- No need for Compensation magnet (?)
  if the B field @4.3m is weak enough
  or Super conducting QC1 is adopted
- Better forward coverage for calorimetry
- Smaller R_{min} of CDC and CAL possible

Detector Model	CDC hits / BX (γ)	(n)	CAL Edep (GeV / BX) (γ)	(n)	θ_{min} (mrad)
2T	2	30	~0	0.6	50
3T (*l**=2 m)	1	2	~0	0.9	50
3T (*l**=4.3 m)	1	0.1	0.01	0.03	22

Vertex Detector

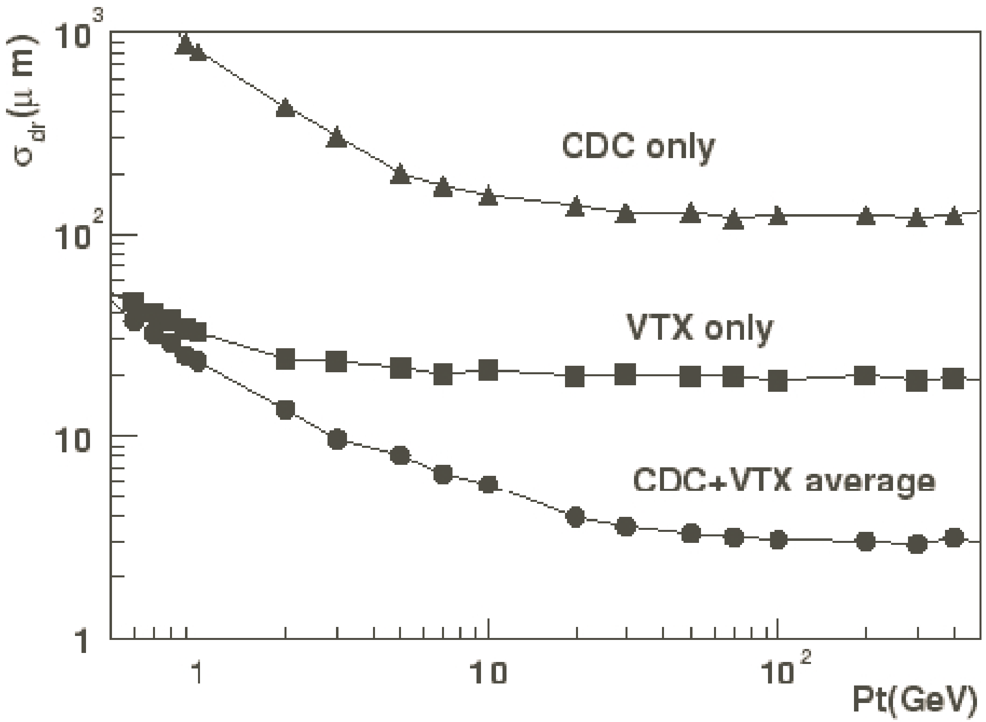
Present Design Parameters in JIM (JLC full Simulator)

- **4 layers of CCDs at r = 24, 36, 48, 60 mm**
  - **--Another layer at smaller r ?**
- **Angular coverage of $|\cos\theta|<0.9$**
- **Wafer thickness of 300 μm**
  - **-- Thinner wafer ?**
- **Pixel size of 25 μm^2**
- **σ = 4 μm**
- **$\delta^2=7^2+(20/p)^2/\sin^3\theta$ [μm]**

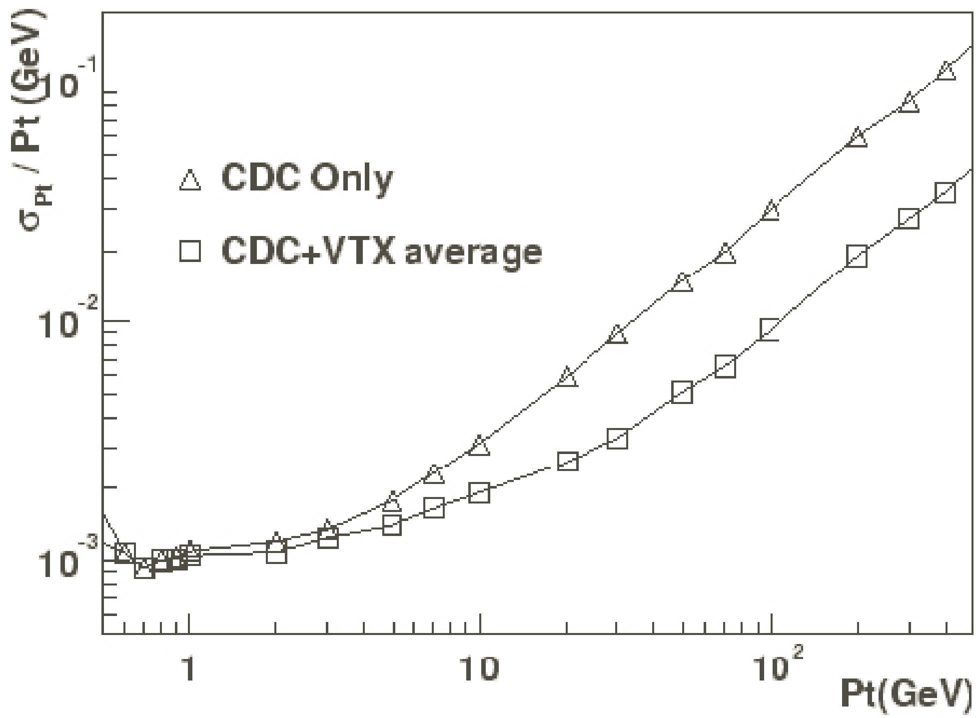


Expected Performance of CCD Vertex Detector

Impact parameter (2D) resolution



Momentum resolution



Better than 7µm expected by VTX alone at large Pt due to high resolution CDC

$$\sigma_b = \frac{\sigma_{in} r_{out}}{r_{out}-r_{in}} \oplus \frac{\sigma_{out} r_{in}}{r_{out}-r_{in}} \oplus \frac{0.014 r_{in}}{p\beta}\sqrt{\frac{Xr}{\sin^3\theta}}$$

R&D Status & Plan of CCD Vertex Detector

1) Spatial resolution

- Resolution of <3μm has been confirmed with test beam
- Laser beam (1064 nm) scanner with 2μm spot size (Niigata Univ.)

2) Study of distortion of CCD wafers

Thinner wafer is desireble
--- 20μm is enough for particle detection
--- but how to support?
Thermal distortion shoud be reasonably small
and has repeatability

Idea of C.Damerell's group: 50μm wafer stretched from both ends
-> proposed in TESLA TDR
Another idea: Partially thinned wafer like SHOJI in traditional Japanese house

System of distortion measurement has been constructed

3) CCD radiation hardness

The result of our study so far using ^{90}Sr irradiation is;

CCD can survive > 3 years with

B	**=**	**2T**
Rmin	**=**	**24 mm**

Machine parameter "A" (Standard Luminosity)

But it is preferable to have

Rmin	**<**	**24 mm**

High Luminosity ("Y") Option

-> Study of radiation hardness should be continued

Issues to be studied:

- Effect of readout speed
-> Fast readout (~10MHz) is needed

- How to inject the "Fat Zero Charge"

- Radiation damage effect on the spatial resolution
-> @Niigata Univ.

- Radiation damage by high energy (>10MeV) electrons
-> Sooner or later

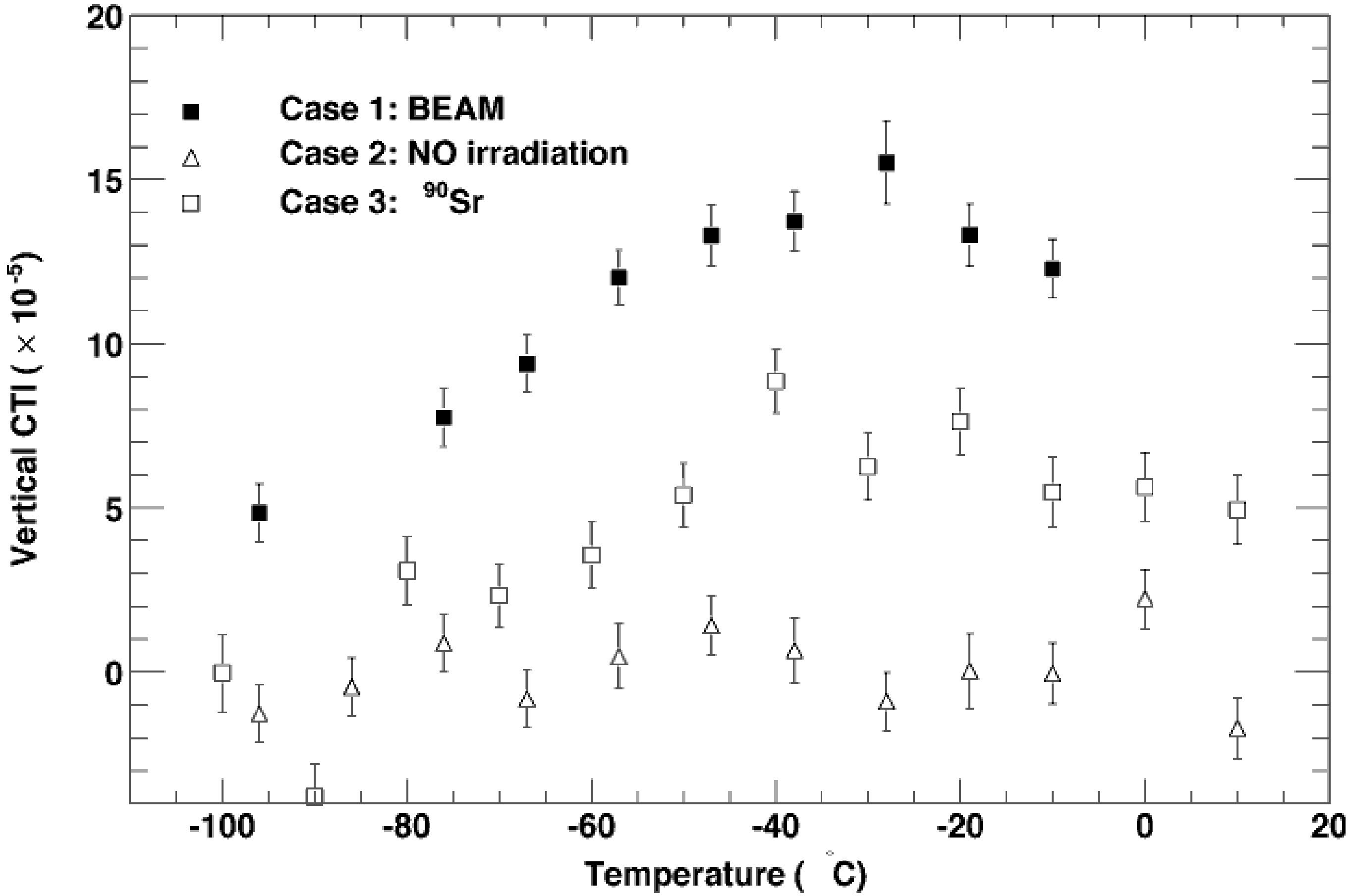
4) Fast readout electronics

CCD Signal Processor chip for Digi-Cam

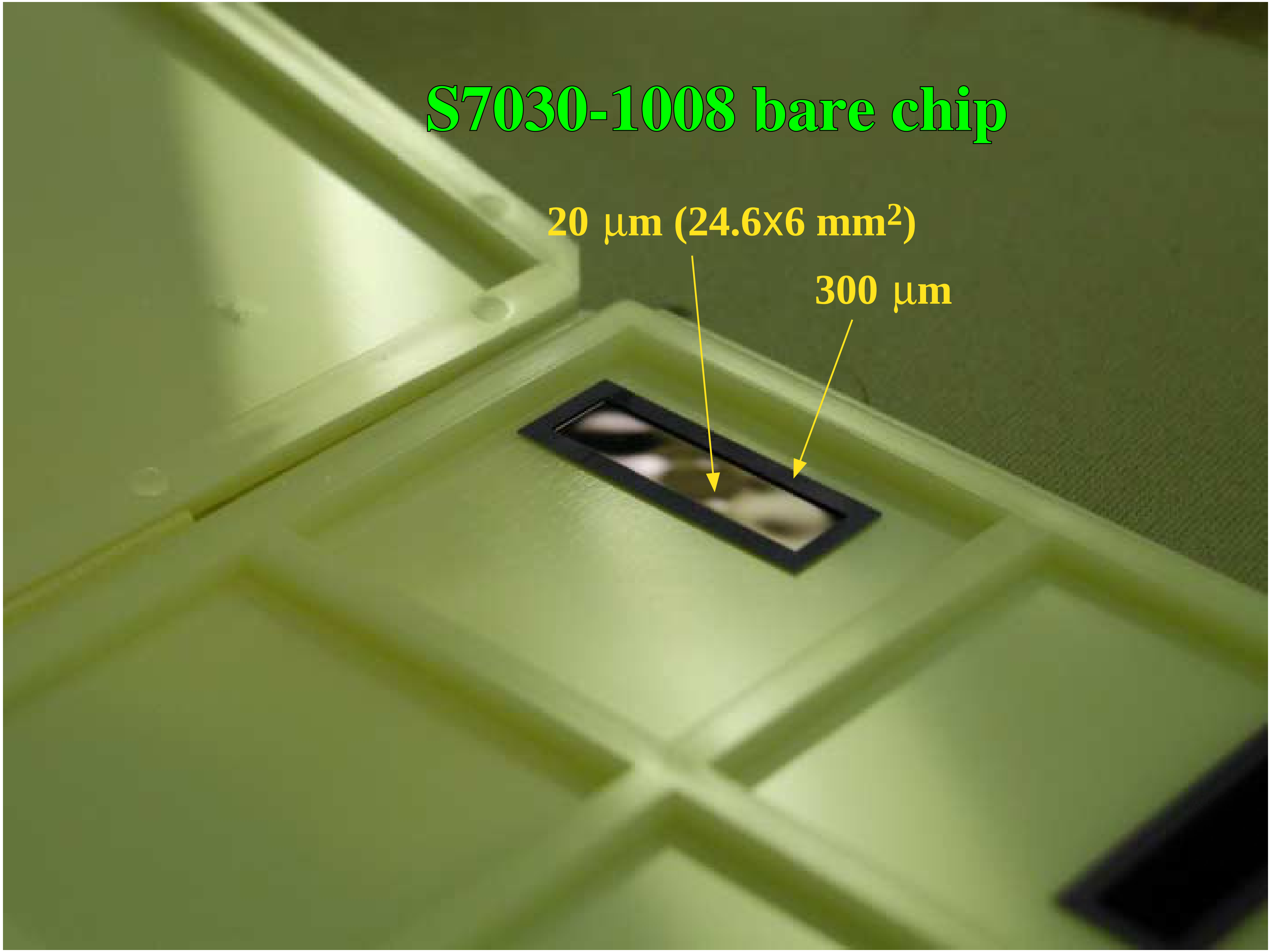
- **Correlated double sampler**
- **Variable gain amp**
- **10bit/40MHz or 12bit/20MHz ADC**

These functions in 9x9 mm^2 chip size by $6/chip

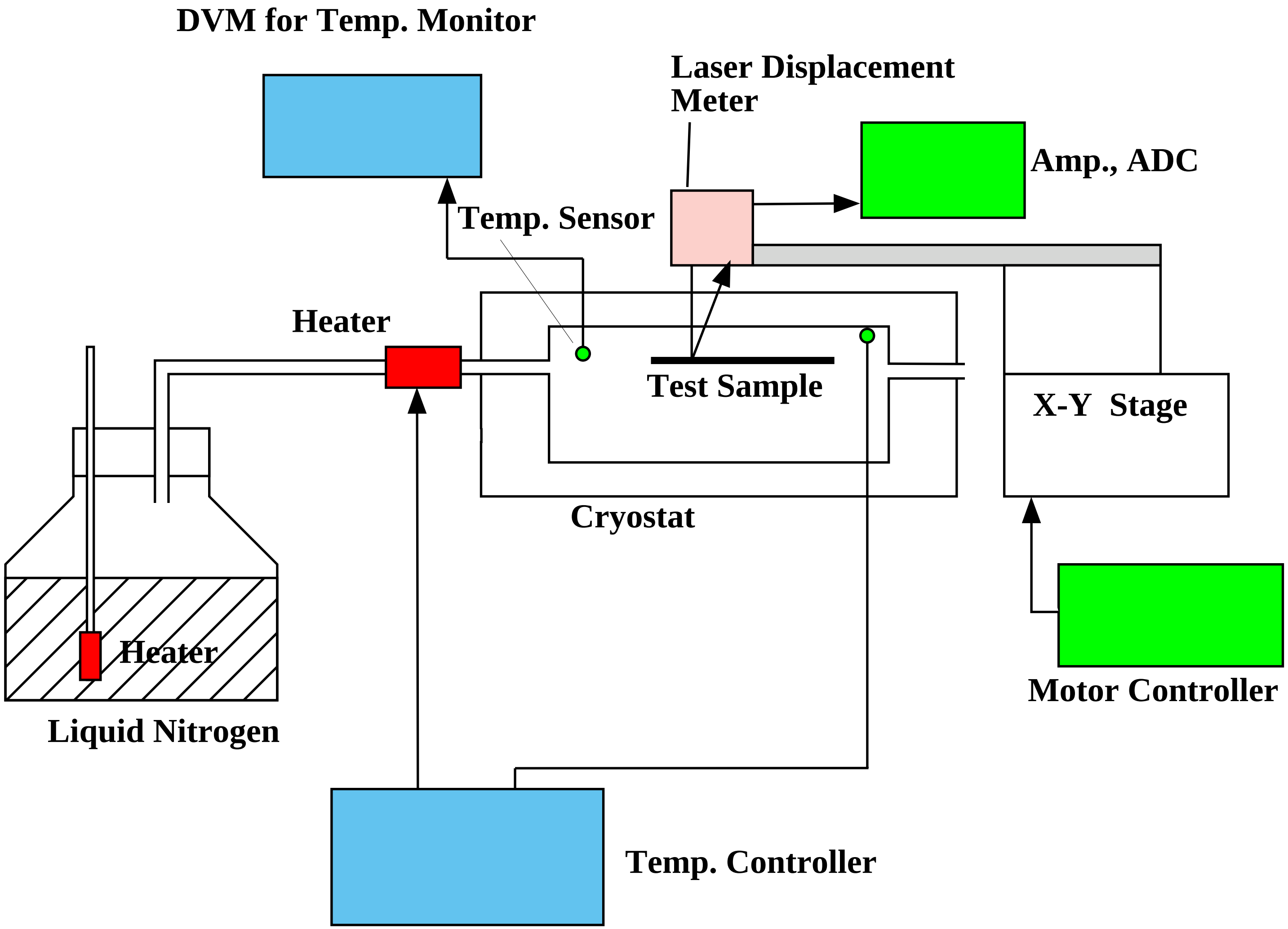
Vertifcal CTI

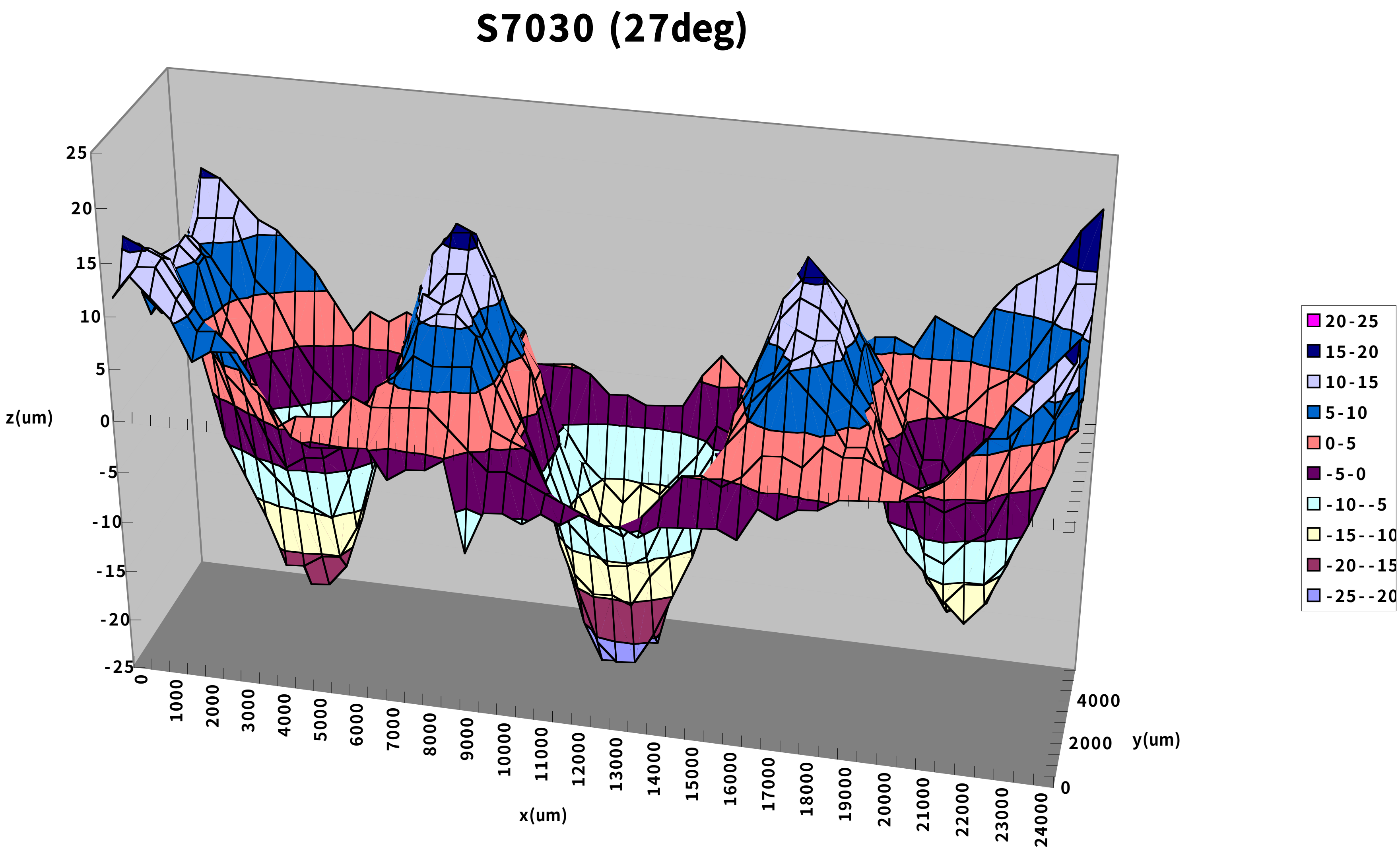


(Beam = 150 MeV electrons. Sr90/beam both $6 \times 10^{10}/\text{cm}^2$.)

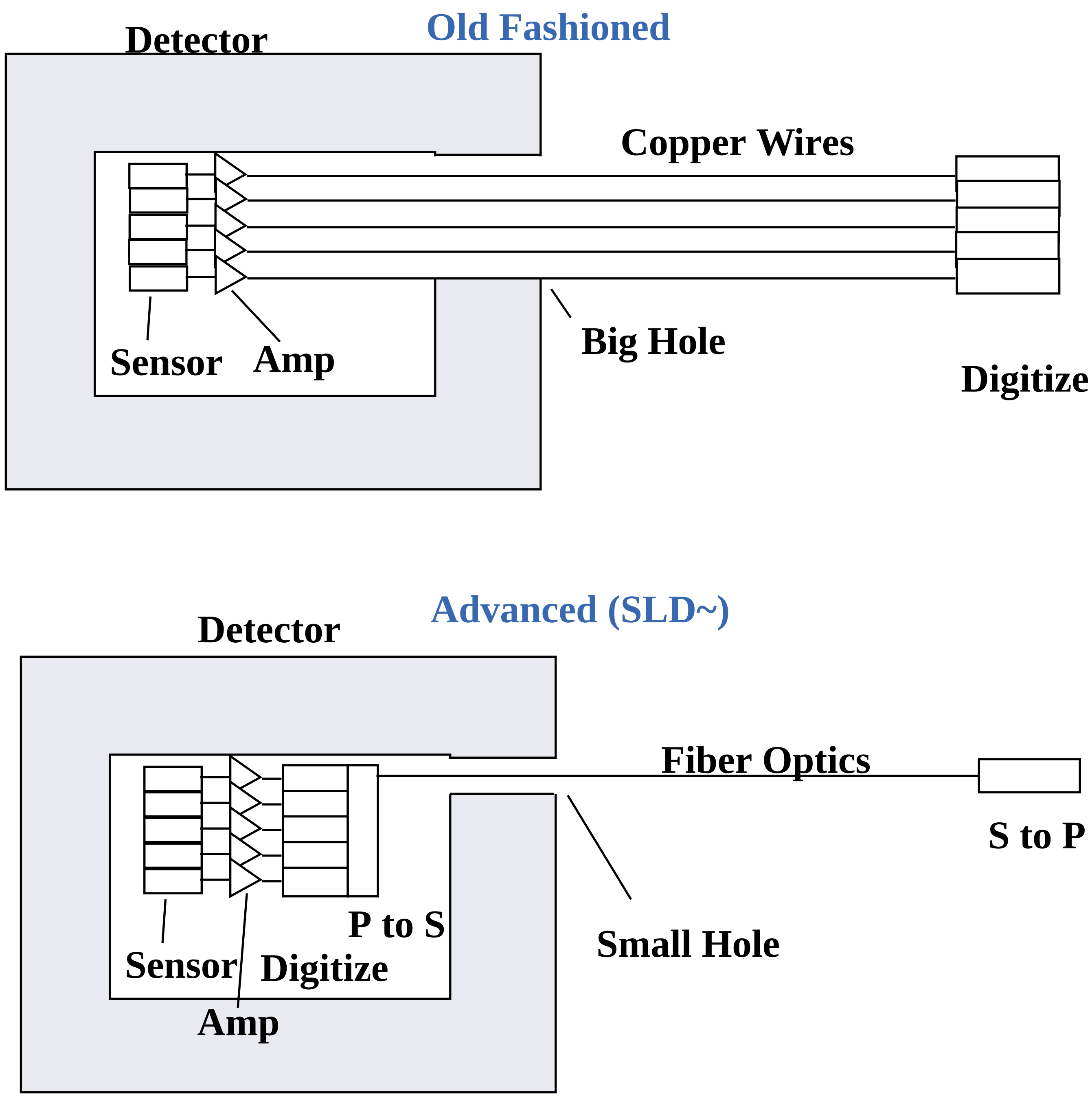

S7030-1008 bare chip
20 μm (24.6x6 mm2)
300 μm

Measurement System





S7030 (27deg)
z(um)
25
20
15
10
5
0
-5
-10
-15
-20
-25
x(um)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
21000
22000
23000
24000
y(um)
0
2000
4000
20-25
15-20
10-15
5-10
0-5
-5-0
-10--5
-15--10
-20--15
-25--20



Old Fashioned
Detector
Copper Wires
Sensor
Amp
Big Hole
Digitize
Advanced (SLD~)
Detector
Fiber Optics
S to P
P to S
Sensor
Digitize
Amp
Small Hole

	SLD (VTX3)	JLC
# of pixels	307 M	> 320 M
Readout time	200 ms	6 ms
R.O. frequency	5 MHz	20 (40) MHz
# of r.o. ch	384	> 2600 (1300)
Throughput	15 Gbps	> 500 Gbps
Fiber Optics	960Mbps x 16	3.4 Gbps (IEEE1394b) x 150 ??

Current CDC Parameters (R&D)

Mini− jet cell structure (5 anode wires /cell)

Gas mixture CO_2 (90%) − C_4H_{10}(10%)

σ_{xy} = 85 μm

2−Tesla option

R_{in} = 45 cm

R_{out} = 230 cm

L = 460 cm (Length of the chamber)

B = 2 T

n = 80 (Number of sampling points)

3−Tesla option

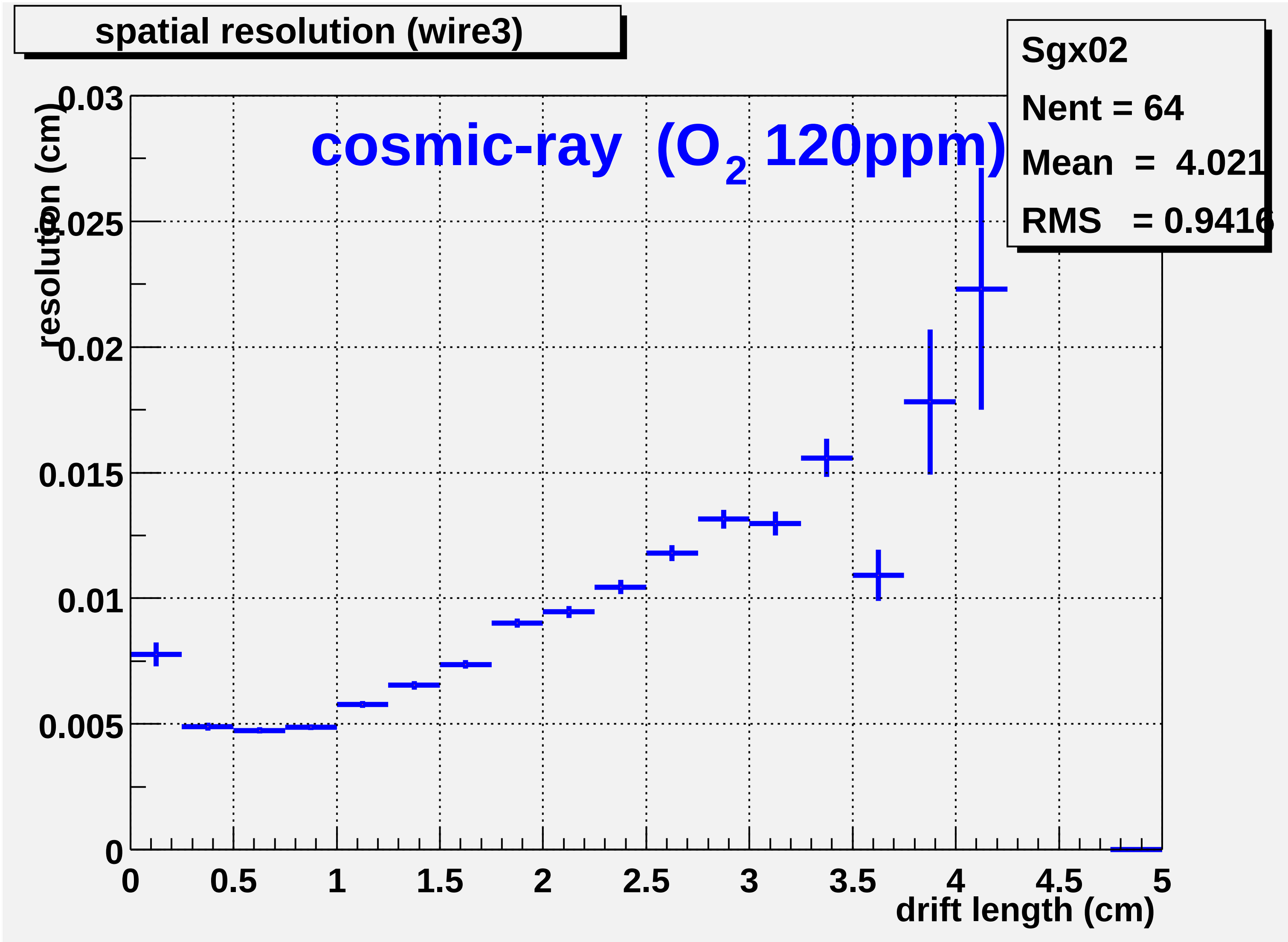
R_{in} = 45 cm

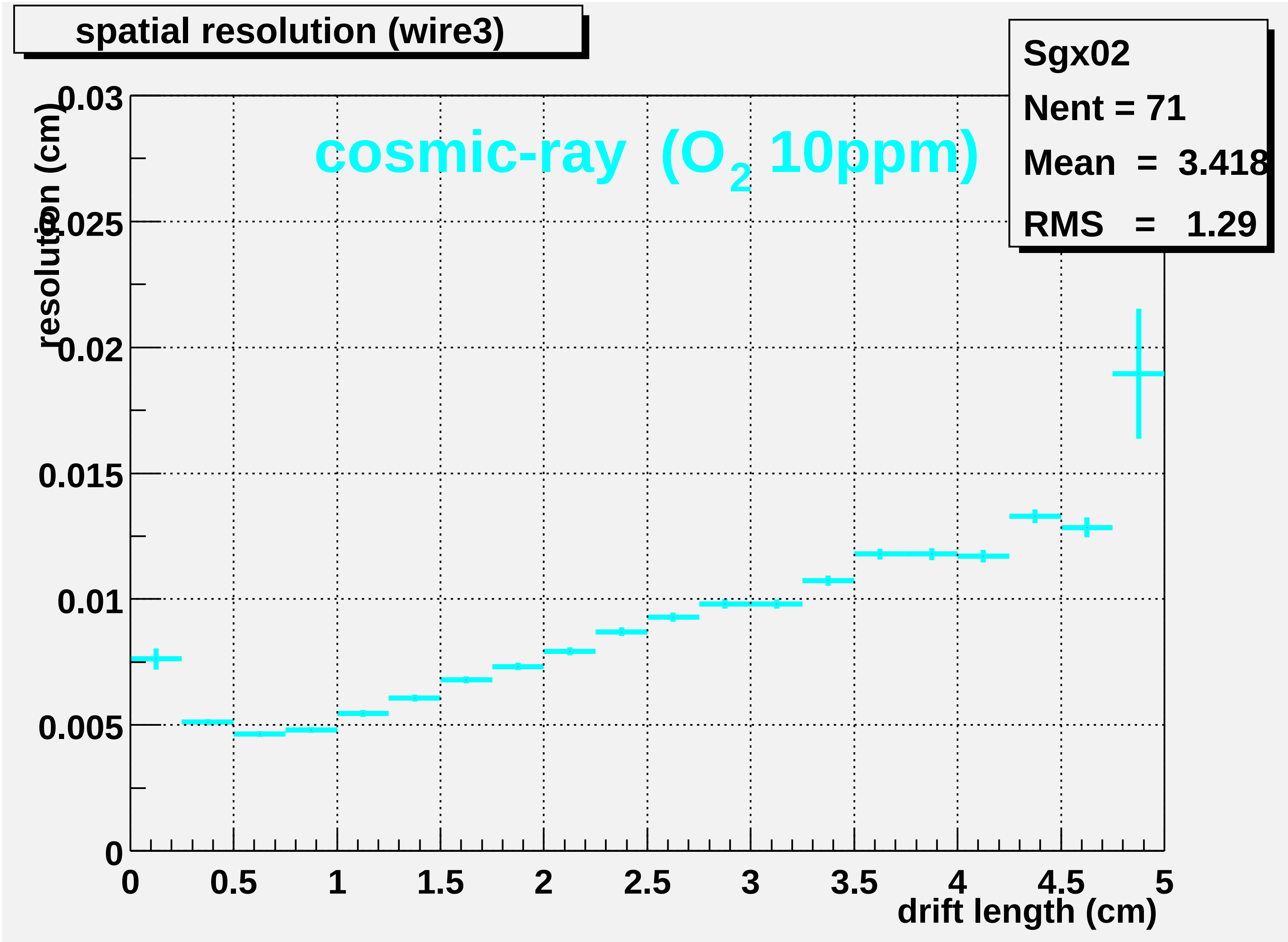
R_{out} = 155 cm

L = 310 cm (Length of the chamber)

B = 3 T

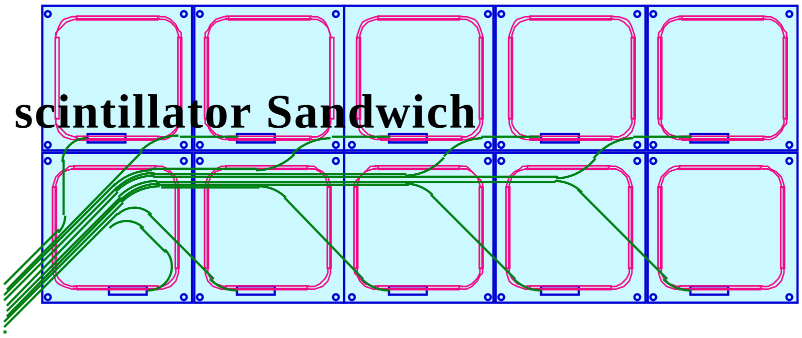
n = 50 (Number of sampling points)


spatial resolution (wire3)
Sgx02
Nent = 64
Mean = 4.021
RMS = 0.9416
cosmic-ray (O2 120ppm)
resolution (cm)
0.03
0.025
0.02
0.015
0.01
0.005
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
drift length (cm)


spatial resolution (wire3)
Sgx02
Nent = 71
Mean = 3.418
RMS = 1.29
cosmic-ray (O2 10ppm)
resolution (cm)
0.03
0.025
0.02
0.015
0.01
0.005
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
drift length (cm)

Calorimeter

Baseline Design



- **Structure : Lead/Plastic scintillator Sandwich**

  EM : Pb/Sci=4mm/1mm

  had : Pb/Sci=8mm/2mm

- **Scheme : Tile/Fiber**

  with hardware compensation

- **Granularity : as small as reasonably achievable**...under study

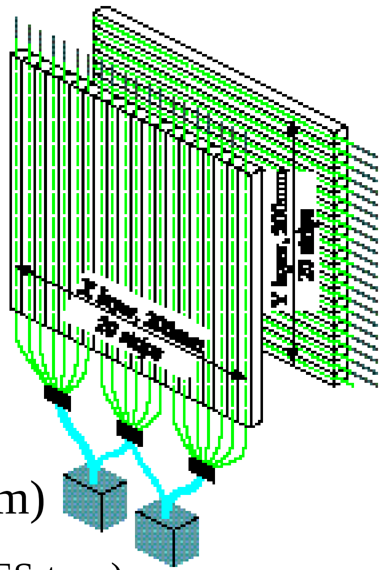
  Baseline Rect-Tile

  EM : 4cm x 4cm (24mrad) x 3 longitudinal samplings

  had : 14cmx14cm (72mrad) x 4 longitudinal samplings

  Strip-EM option

  1cm-wide strip-array (x-y layers) x ~20 longitudinal samplings



- Shower Max Detector

  Baseline : 1cm-wide strip-array (x-y layers)

  Option : 1cm x 1cm Si-pad

Performances

- Single-particle response (measrured with testbeam)

  $\sigma_E/E = 15.4\%/\sqrt{E} + 0.2\%$ for electrons (ZUES-type)

  $\sigma_E/E = 46.7\%/\sqrt{E} + 0.9\%$ for pions

  $\sigma_X = 2\sim3$mm even at over 50GeV

  pion rejection = 1/1400 at $\varepsilon_e = 98\%$

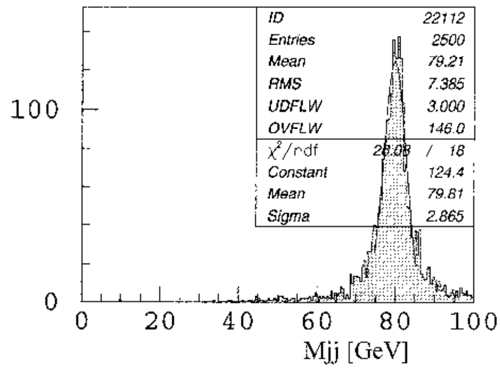
- **Jet response : under simulation study**

Recent Activities

[I] Granularity Optimization with Full Simulation

Analysis of quick-simulation data gives very good performance

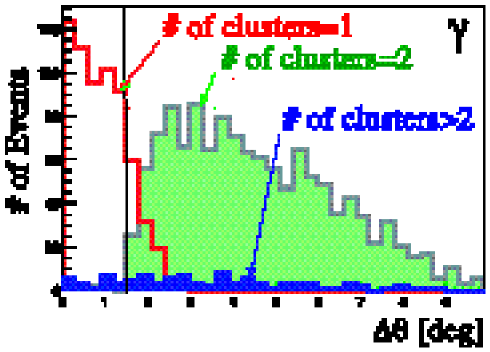
... but it is not the end of the story.

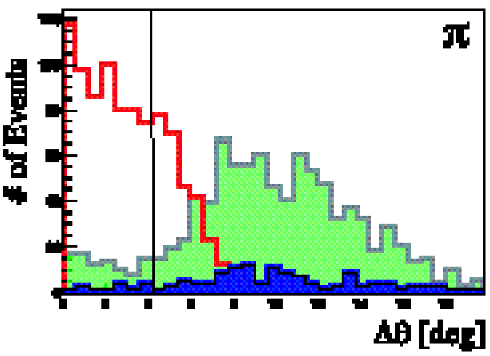


1) Construction of full-simulator

- Done for baseline design (Rect-Tile).
- not yet for optionl design (strip-EM).

2) Shower clustering ; in progress but very difficult

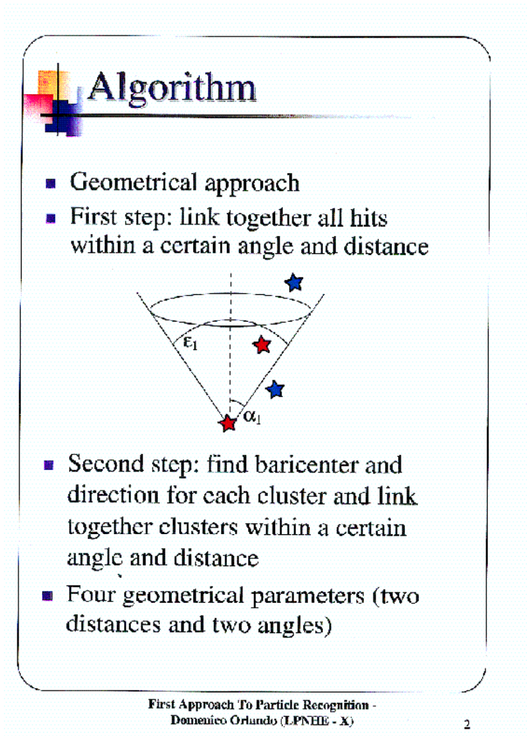




a) hadron shower clustering

<--- • 2D-JADE ; not successful yet

- 2D-contiguous ; not successful yet
- 3D-contiguous ; not successful yet
- **Super-cluster = French method not yet tried (below)**



b) decomposition of overlapping showers

under study including its necessity itself

c) track-cluster association

under study including 1st principle ;

whether one-to-one or plural-to-one

Coming R&D plans

1) Further full-simulation studies on granularity optimization

2) Beam tests of fine-granularity EM module

includes

- Strip-EMC
- Rect-Tile EMC
- Direct-readout SHmax
- Optimum photon detectors for each

3) Lead alloy and structures

- Further studies on alloys and hybrid materials
  Make test pieces of SUS-Pb sandwich
- Engineering studies on structure

4) Mass production of tiles and fiber assemblies

- Tiles ; Design optimization for "moldable" tiles
  MEGA-tile structure, groove cross section, etc.
- Fiber assemblies ; low-cost heat-splicing, mirroring, etc.

Summary/Concluding Remarks

1. The name change: JLC $\rightarrow$ GLC
2. New an longer IR seems promissing, but details needs to be studied.
3. Steady progresses on each front, but holes exist:
   Forward tracker, Intermediate tracker, particle ID.
4. Other options need to be studied: TPC, digital calorimeter.
5. Still more efforts needed for jet reconstruction study.