## Making of Detector for HEP

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Lecture-2

## What we will be discussing in next two classes !!



### **Readout Electronics**

Electrical pulse to number

Schematic of the steps for the readout electronics



## Where we end !!

## What we discuss in today's lecture?



## **Physics Goal and observable**





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## **Simulation with Event Generator**

#### **Results from HIJING**







## Information about the source



## Information for the conceptual design

#### Informations we have



#### Block of material: Preferably compact and highly dense.



$N(X_R) = 2^{XR}$	$E(X_R) = E\gamma / 2^{XR}$
$  N(\Lambda_R) - Z^{m}$	









## How should be the conceptual design?



	1.	It should be a calorimeter.
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- Must have **compact & high density** material 2.
- Should have fine segmentation (Ideally)\* 3.
- The depth may be about **20 X**<sub>R</sub> 4.
- The transverse size R<sub>in</sub> = 6cm, R<sub>out</sub> = 80cm 5.

 $\checkmark$  The fine segmentation need optimization.

✓ Cost and physics motivation should be weighted

Important to note: Tracking need three precise points

**Next Step: Geometry and performance simulation** 

## **Optimized configuration**

	viewer-1 (OpenGLImmediateX)
• 20 GeV/c π <sup>0</sup>	
decaying to $2\gamma$	

#### **GEANT** Simulation

Materials used in the GEANT4

 $\Box$  Absorber: – Tungsten (X<sub>R</sub> =0.35 cm , R<sub>M</sub> =0.93 cm)

#### □ Active Material: - Silicon

- High Density
- Good energy resolution
- Insensitive to magnetic field
- Technologically easy to find

#### □ Size of detector

- PAD detectors of 1 cm<sup>2</sup> area
- Pixels detectors of 1 mm<sup>2</sup> area

#### Other materials

PCB, air gap, electronics, cooling arrangements, support structures

## **Optimized configuration**

#### **GEANT** Simulation



## **Optimized configuration**





![](_page_18_Picture_1.jpeg)

![](_page_18_Figure_2.jpeg)

STEP-1: TB-1

![](_page_18_Figure_5.jpeg)

![](_page_19_Figure_0.jpeg)

![](_page_20_Picture_1.jpeg)

A Segments of 5'

#### Energy : 5 → 60 GeV for electron 120 GeV pion as MIP

![](_page_20_Picture_3.jpeg)

![](_page_20_Figure_4.jpeg)

![](_page_20_Picture_5.jpeg)

- 1. Break down voltage > 500V
- 2. Leakage current ~ 10nA/cm<sup>2</sup>
- 3. Capacitance at full depletion ~40pF/cm2
- 4. Full depletion voltage 40V
- 5. Dead space b/w 1 cm<sup>2</sup> pads ~ 110um
- 6. Cross Talk probability ~ 10%
- 7. Depletion width ~ 300um

![](_page_21_Figure_1.jpeg)

![](_page_21_Figure_2.jpeg)

![](_page_21_Figure_3.jpeg)

 ${}^{50}_{E_0} (GeV)$ 

![](_page_22_Figure_1.jpeg)

![](_page_22_Figure_2.jpeg)

![](_page_23_Figure_0.jpeg)

Energy : 20 → 120 GeV for electron 120 GeV pion as MIP

# 6x 6 array of silicon PAD of 1 cm sq.

![](_page_23_Picture_3.jpeg)

![](_page_23_Picture_4.jpeg)

![](_page_24_Figure_0.jpeg)

The Prototype fabrication and test are successful

![](_page_25_Figure_0.jpeg)

## End of Lecture-2

In case you have query Mail to sanjibmuhuri@vecc.gov.in

![](_page_27_Figure_0.jpeg)

#### **Measured quantities**

Identity, mass, energy, momentum, track......

![](_page_28_Picture_0.jpeg)

![](_page_28_Picture_1.jpeg)

![](_page_28_Picture_2.jpeg)

1000 times smaller compare to the energy of a Bee

![](_page_28_Picture_4.jpeg)

1 GeV => 1.6 x 10<sup>-10</sup> J

1.16 x 10<sup>13</sup> Kelvin temperature

	Intrinsinc Spatial	Time	Dead
Detector Type	Resolution (rms)	Resolution	Time
Resistive plate chamber	$\lesssim 10 \text{ mm}$	$1 \text{ ns} (50 \text{ ps}^a)$	
Streamer chamber	$300 \ \mu m^b$	$2~\mu { m s}$	$100 \mathrm{\ ms}$
Liquid argon drift [7]	${\sim}175{-}450~\mu{\rm m}$	$\sim 200~{\rm ns}$	$\sim 2~\mu { m s}$
Scintillation tracker	${\sim}100~\mu{ m m}$	$100 \text{ ps}/n^c$	10  ns
Bubble chamber	10–150 $\mu m$	$1 \mathrm{ms}$	$50 \text{ ms}^d$
Proportional chamber	50–100 $\mu m^e$	2  ns	20-200 ns
Drift chamber	$50100~\mu\mathrm{m}$	$2 \text{ ns}^f$	20-100  ns
Micro-pattern gas detectors	$3040~\mu\mathrm{m}$	$< 10 \ {\rm ns}$	10-100  ns
Silicon strip	pitch/ $(3 \text{ to } 7)^g$	few $ns^h$	$\lesssim 50 \ {\rm ns}^h$
Silicon pixel	$\lesssim\!10~\mu{ m m}$	$\mathrm{few}\;\mathrm{ns}^h$	$\lesssim 50 \text{ ns}^h$
Emulsion	$1~\mu{ m m}$		

**Table 35.1:** Typical resolutions and deadtimes of common charged particledetectors. Revised November 2011.

Material(Z)	Density(g/cm <sup>3</sup> )	$X_R$ (cm)	$R_M$ (cm)	$\lambda_I$ (cm)	$\left(\frac{dE}{dx}\right)_{mip}$ (Mev/cm)
Fe(26)	7.774	1.757	1.719	16.77	11
Cu(29)	8.92	1.436	1.568	18.79	13
Pb(82)	11.34	0.56	1.60	17.59	13
W(74)	19.25	0.35	0.93	9.946	22
U(92)	19.05	0.31	1.009	11.03	21