韓国におけるDSSDの開発

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Contents

- Introduction
- DSSD sensor
- Test of DSSD
- Summary
E07 experiment @ J-PARC and DSSD
(from nakawaza-san’s slide)

# $10^3$ (E373) ==> $10^4$ $\Xi$-stops

$\Lambda$–$\Lambda$ Interaction, H-dibaryon, $\Xi$-Nucleus Interaction, Inside Neutron Stars (Quark-star?)

$\implies$ 3-dimensional Nuclear chart

Strange matter / N-star

Strangeness

$S = 0$

$S = -1$

$S = -2$

$\Lambda, \Sigma$ hypernuclei

$35$

Double hypernuclei / hypernuclei

1.7 GeV/c $K^-$

Diamond ($^{12}$C) Target

Hyperball-J (Ge detectors)

Emulsion Stack

SCIFI Block

DSSD

K$^+$
We aim to set Silicon detectors close to the emulsion plate!
DSSD sensor
By Double Silicon Strip Detector (DSSD), we can detect X-Y position with one circuit board.

We are now collaborating with Prof. Hwanbae Park in Kyungbook university to produce DSSD.
Detector

- Layout

- Sensor Cost
  -- Masking: total ~30,000,000 won
  -- 6” Wafer (x 18): 3,000,000 won
  -- processing cost: ~15,000,000 won

- APV25 chip & APVDAQ VME module

- Assembly configuration by REPIC
Design of AC-coupled DSSD

1. PIN – diode structure
2. coupling capacitor read-out
3. biasing resistors
4. guard-ring
5. p-stop
6. double-metal

From Dr. Kah’s slide
AC-coupled SSSD

**AC-SSSD1**
- Area: 35 x 35 mm²
- Readout strips: 64
- Strip pitch: 500 µm

**DC-SSSD1**
- Area: 35 x 35 mm²
- Readout strips: 32
- Strip pitch: 1000 µm

**AC-SSSD2**
- Area: 38 x 28 mm²
- Readout strips: 256
- Strip pitch: 100 µm

**AC-SSSD1**
- Area: 38 x 28 mm²
- Readout strips: 128
- Strip pitch: 200 µm

**DC-SSSD**
- Area: 38 x 28 mm²
- Readout strips: 128
- Strip pitch: 200 µm

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From Dr. Kah’s slide
## Dimensions of the AC-DSSD

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>n-side</th>
<th>p-side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor size</td>
<td>73620 μm x 37760 μm</td>
<td></td>
</tr>
<tr>
<td>Strip length</td>
<td>71630 μm</td>
<td>35770 μm</td>
</tr>
<tr>
<td>Strip width</td>
<td>20 μm</td>
<td>40 μm</td>
</tr>
<tr>
<td>Number of strips</td>
<td>512</td>
<td>1024</td>
</tr>
<tr>
<td>AC pad</td>
<td>256 μm x 72 μm</td>
<td>256 μm x 72 μm</td>
</tr>
<tr>
<td>DC pad</td>
<td>136 μm x 36 μm</td>
<td>98 μm x 48 μm</td>
</tr>
<tr>
<td>Biasing pad</td>
<td></td>
<td>240 μm x 100 μm</td>
</tr>
<tr>
<td>Guard-ring pad</td>
<td></td>
<td>240 μm x 100 μm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Designed values</th>
<th>n-side</th>
<th>p-side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biasing resistance</td>
<td>8.8 MΩ</td>
<td>8.8 MΩ</td>
</tr>
<tr>
<td>Coupling capacitance</td>
<td>247 pF/strip or 123 pF/strip</td>
<td>247 pF/strip or 123 pF/strip</td>
</tr>
</tbody>
</table>

By Kha Dongha kah@knu.ac.kr
Wafer design

DSSD-1
DSSD-2
DSSD-3

~7cm

~3.5cm

Strip direction

p-side

~70um pitch strip

n-side

By Kha Dongha kah@knu.ac.kr
n-side

73620 μm

Strip length : 71630 μm

37760 μm

By Kha Dongha kah@knu.ac.kr

2-N-sub pad (7150 x 60)
8x2-Guard-ring pad (240 x 100)
8x2-Bising pad (240 x 100)
1024-DC pad (98 x 48)
1024-AC pad (256 x 72)
1024x2-AC pad (256 x 72)
DSSD sensor produce

dicing

sensors

By Korean venture company (SENS)
DSSD leak current - estimate

**V-I graph**

Dep. voltage ~80 V – most are useless
DSSD leak current - estimate

V-I graph

Sensors 2A (1B, 6B) may be used
Capatitance

Sensors 2A (& 1B) could be used
APV25 chip

- Analogue pipeline chip for readout of Silicon detectors developed by CMS
- Handle 128 channels
- Consists of CR-RC shaper (τ:50nsec), amplifier, pipeline (192cells), multiplexer
- Input: Clock, Trigger
  Output: bi-directional current (multiplexed)

DSSDの写真

N-Side

P-Side
Readout Module

- “APVDAQ” VME module developed by Belle group
- 128 ch multiplexed signals are transferred by 30 m category 7 LAN cable (yellow cable in the right picture)
- Readout by FADC on the board (10bit, 40MHz sampling)
Data acquisition with sampling mode

APV25 chip has a function of data sampling.

By fitting the data points, we can know peaking time.

We can exclude accidental hits by timing!
Raw Data (sample)

Raw Data from a APV25 chip which contains 128 ch’s information

![Raw Data from a APV25 chip]
SSD

- (Single Side) Silicon Strip Detector

- Sensor
  - ATLAS sensor
  - Strip: 768ch, 80μm pitch
  - Effective area: 64mm
  - Radiation tolerance: >$3 \times 10^{14}$
  - (Typical operation voltage): $\sim +70V$

- Readout chip
  - APV25-s1 chip (developed by CMS)
  - Each chip has 128 ch of pre-amp and shaper and use serial transfer by multiplexer
Performance of SSD
-- Beam rate dependence

Timing resolution

Efficiency

If the beam spot size is a few cm (φ), SSD can work under 10 MHz.
Test of DSSD
IV曲線

N側に+の電圧を与えた場合（P側の場合もほとんど同じ）
Comparison of Pedestal distribution

P-side APV Chip 1

RMS
Non bias
Bias 80V
Case of SSD

Strip

P-side APV Chip 2

RMS

Strip

N-side APV Chip 1

RMS

Strip

N-side APV Chip 2

RMS

Strip
P側読み出し時の“信号”イベント

信号と思われるイベントは現在のところ単なるfluctuation ……
まとめ

・韓国・慶北大学と共同してDSSDセンサーを開発した。

・データの読み出しがその他の他はこれまでのところ問題ない。

・但しセンサーの評価として、ノイズが大きく（リーク電流が大きい）、また有意な信号はまだ検出できていない。

・今後については慶北大学とも連絡をとりながらどうすすめるかを検討中。
Results of KEK-E373

NAGARA event (1)

Track data (lengths, angles and PID)

<table>
<thead>
<tr>
<th>point</th>
<th>track#</th>
<th>length [μm]</th>
<th>θ [degree]</th>
<th>φ [degree]</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>#1</td>
<td>8.1 ± 0.3</td>
<td>44.9 ± 2.0</td>
<td>337.5 ± 1.8</td>
<td>double-hypernucleus</td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td>3.2 ± 0.4</td>
<td>57.7 ± 5.2</td>
<td>174.9 ± 2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td>88.6 ± 0.5</td>
<td>156.2 ± 0.5</td>
<td>143.0 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>#4</td>
<td>9.1 ± 0.3</td>
<td>77.7 ± 1.6</td>
<td>115.9 ± 0.8</td>
<td>single-hypernucleus</td>
</tr>
<tr>
<td></td>
<td>#5</td>
<td>82.1 ± 0.6</td>
<td>122.8 ± 1.0</td>
<td>284.2 ± 0.7</td>
<td>stopped in base</td>
</tr>
<tr>
<td></td>
<td>#6</td>
<td>13697</td>
<td>81.0 ± 0.5</td>
<td>305.5 ± 0.2</td>
<td>π⁻</td>
</tr>
<tr>
<td>C</td>
<td>#7</td>
<td>742.6 ± 0.6</td>
<td>138.5 ± 0.2</td>
<td>322.1 ± 0.3</td>
<td>stopped in D-Block</td>
</tr>
<tr>
<td></td>
<td>#8</td>
<td>5868 ± 20</td>
<td>52.2 ± 1.2</td>
<td>123.7 ± 0.7</td>
<td>scattered before stopping</td>
</tr>
</tbody>
</table>

1. Single-Λ (TK#4)

- image of TK#7 in D-Block [gave K.E.]
- => Both of charge for TK#7 and #8 should be an unit.
- (exceeding Q-value of non-mesonic decay)
- => Single-Λ = He nucleus

2. TK#6 was a π⁻ by measurement of dE/dx and topology of its end point (with Auger electron).

H.Takahashi et al., PRL87 (2001) 212502
N側読み出し時の“信号”イベント
Data Suppression

- DAQ trigger accept rate ~ 20 Hz (4SSDs)
- ~ 1Khz @ J-PARC K1.8 beamline

- Most of data is null: a few hits within 768 ch

Discard the null data before readout

Last year, we developed this data suppression system, And test it at RCNP experiments first time
DSSDの測定の様子

・DSSDの読み出し面に対してシンチを配置して宇宙線及び線源によるコインシンデントリガーを生成

・ただしバイアスはGNDをその他から切り離した

DSSDの下に線源(Sr90)を設置
読み出しAPVチップの領域

P-side

N-side