# Performance Studies of Belle II SVD


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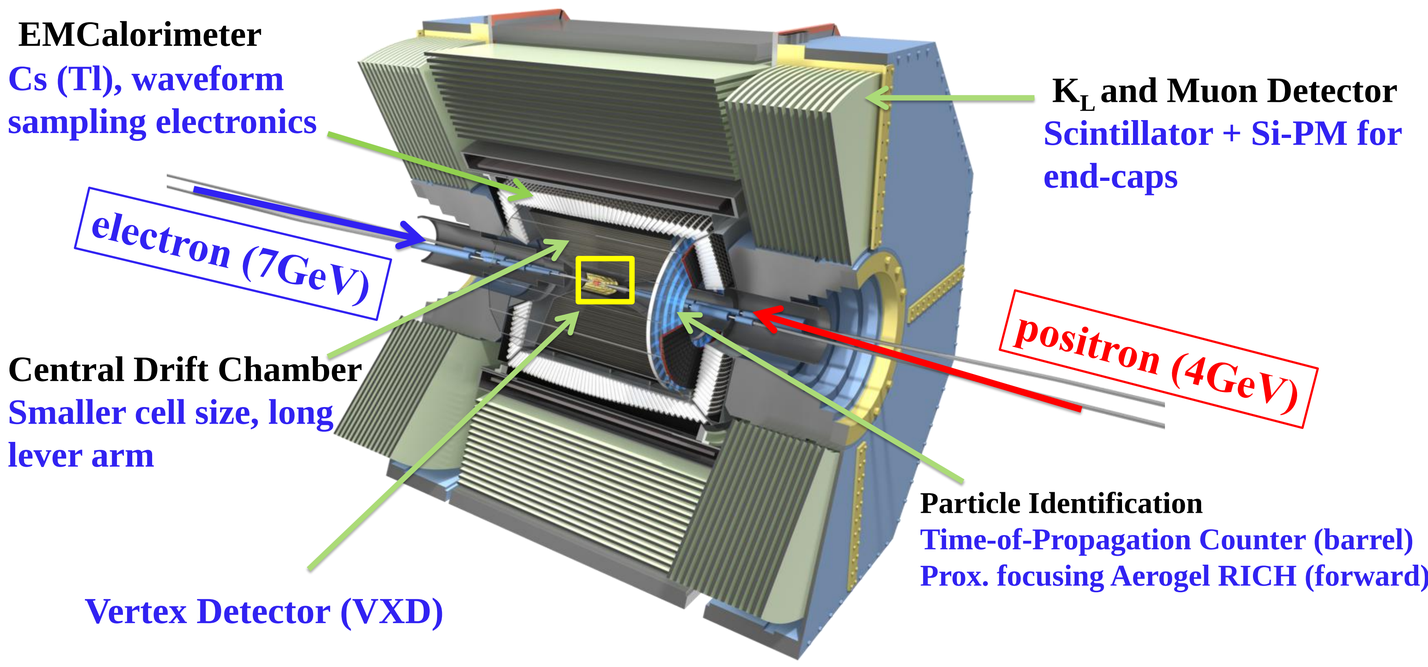
## Introduction

- Design luminosity of SuperKEKB: $8\times10^{35}$ $cm^{-2}s^{-1}$ that would enable Belle II to collect 50 $ab^{-1}$ of data, 50 times more than its predecessor (Belle).

➡ Leads to harsh background environment in the Belle II.

- To validate the performance of the SVD, a systematic study is needed in the offline reconstruction software.
- The excellent performance of the Belle II SVD will provide the measurements of CP asymmetry in the B-meson system with higher precision.
- To achieve the physics goals, reconstruction of tracks with a high efficiency and a good resolution is needed.

## Belle II Detector



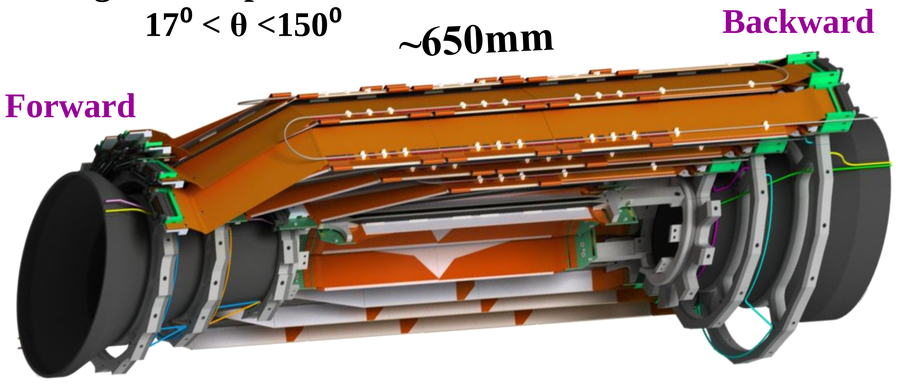

## Belle II Silicon Vertex Detector (SVD)

### SVD Structure

**Angular acceptance**
**$17^0 < \theta < 150^0$**

**~650mm**

**Forward** **Backward**

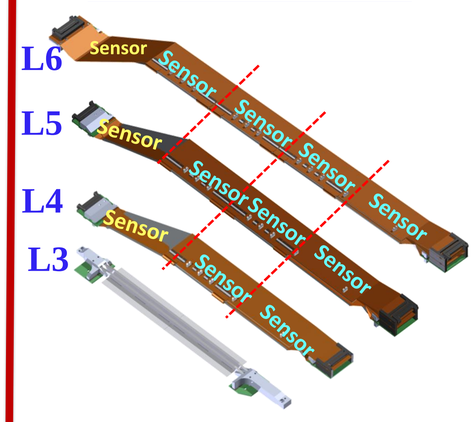


### Four Layer Structure

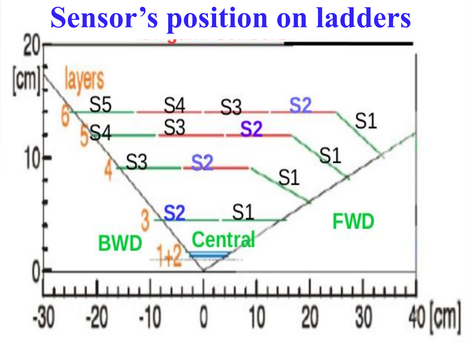


| Layer | Institute |
|---|---|
| 3 | University of Melbourne |
| 4 | TIFR Mumbai, INDIA |
| 5 | HEPHY Vienna |
| 6 | IPMU University of Tokyo |
| FW, BW | INFN Pisa |

### Ladder Structure

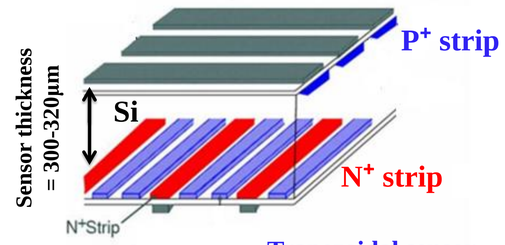



**Sensor's position on ladders**

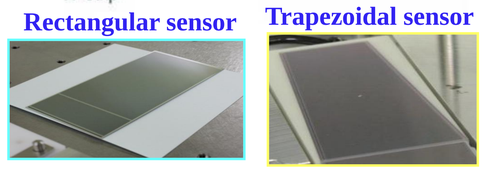



### Si –Sensors

Double Sided Si Strip Detector




**Rectangular sensor** **Trapezoidal sensor**



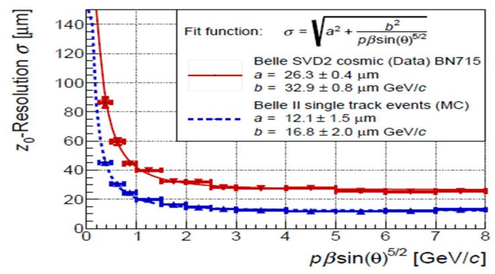
| No of Strips | Rectangular | Trapezoidal |
|---|---|---|
| # of *p*-strips | 768 | 768 |
| *p*-strip pitch (μm) | 75 (L3:50) | 50…75 |
| # of *n*-strips | 512 (L3:768) | 512 |
| *n*-strip pitch (μm) | 240 (L3:160) | 240 |
| Active area ($mm^2$) | 7030 (L3:4738) | 5890 |

Belle II SVD is shifted outward to a maximum radius of 140mm as compared to Belle.

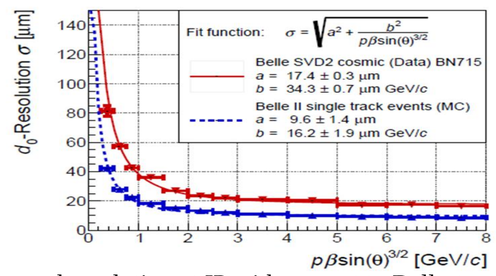
**Better vertex resolution**
**Low $p_T$ track finding efficiency**
**Improved $K_s^0$ reconstruction efficiency.**

### Impact Parameter Resolution

**Transverse ($d_0$)**




**Longitudinal ($z_0$)**



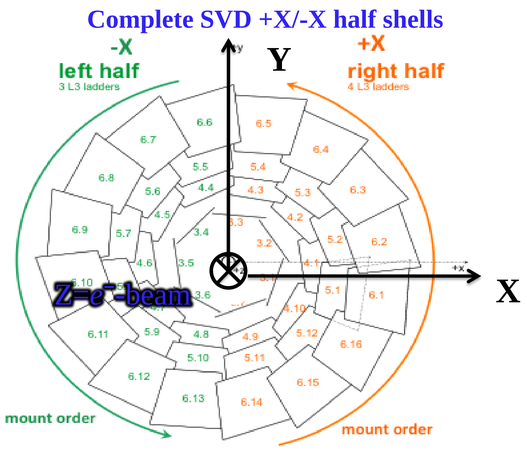

Improved resolution at IP with respect to Belle **(PTEP-2018).**

## Results: Commissioning Data Analysis

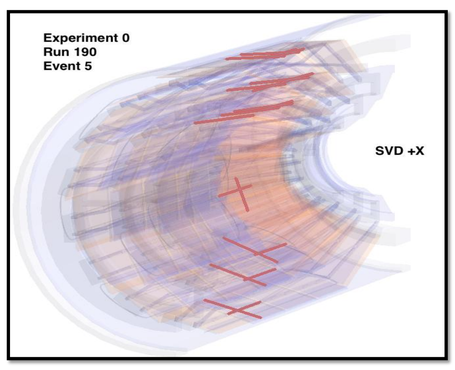
### Commissioning of the SVD

- The full SVD +X and –X half shells have been installed at KEK, Japan.
- Testing of full SVD with cosmic rays is carried out during the commissioning period from July 21 to September, 2018. (Collected: $30\times10^6$ cosmic events)
- Performance studies of the SVD using offline reconstruction software are in progress.

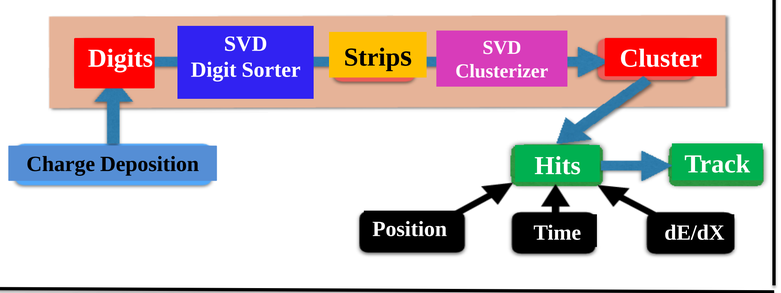
**Complete SVD +X/-X half shells**




**First cosmic event in SVD +X half (July 10, 2018)**



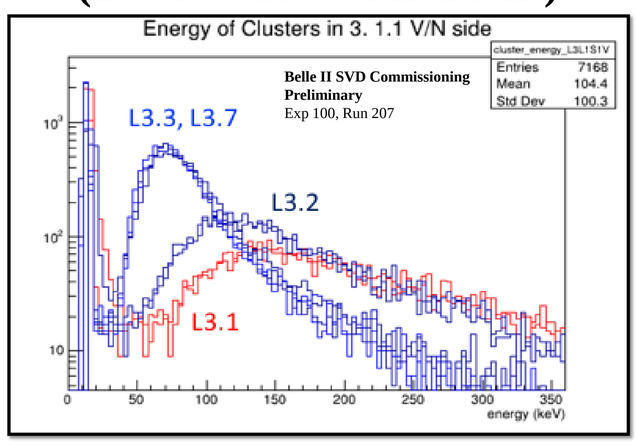

### Reconstruction Software (Framework)




### Information of Data:

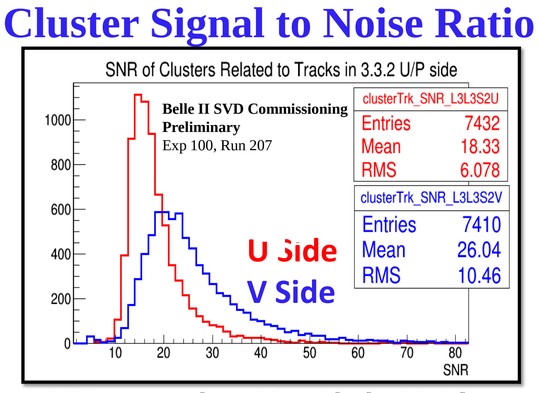
**Run no 702** (commissioning data) (July 2018)
**Trigger rate:** 4.7Hz, N(evt) = 382278
**SVD ladders:** +X half shell
**Module used:** SVDB4 Commissioning Analysis Module

### Cluster Energy (not associate with tracks)



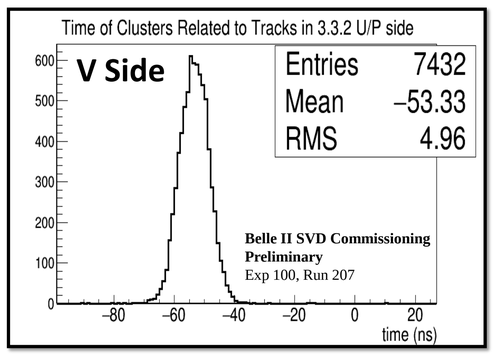

Distribution of the energy deposit in a horizontal silicon sensor ($t$=300μm) by a cosmic ray (~MIP) is peaking at 80keV. The deposit distribution for random-trigger events was peaking at ~20keV.

### Cluster Signal to Noise Ratio




S/N greater than 20, with the N side performing slightly better than the P side, as expected.

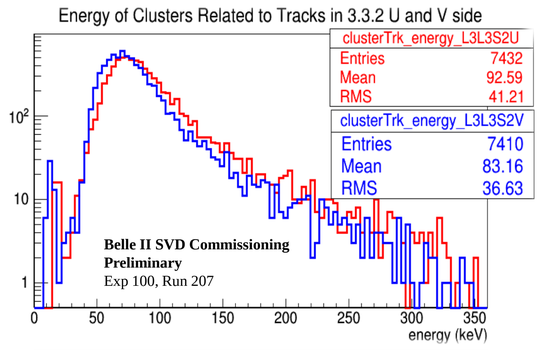
### Cluster Time




The RMS of cluster times is in the order of 4 ns, nicely matching the design expectation.

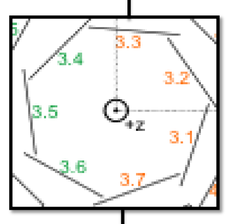
### Cluster Energy Distributions (Cluster associated with track)

**Horizontal Sensors (L3.Ld3.S2)**

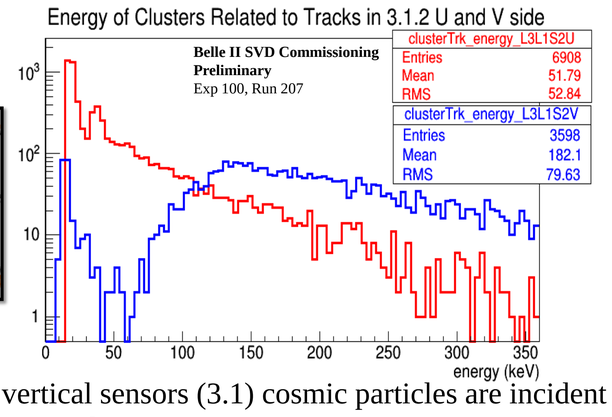



- The cosmic track is perpendicular to the sensors (3.3)
- Clusters are correctly reconstructed on both sides (U, V)
- Cluster energy are in agreement for both side.

**U Side**
**V Side**




**Vertical Sensors (L3.Ld1.S2)**




- For vertical sensors (3.1) cosmic particles are incident at large angles
- Hence deposit large energy on these sensors.
- Cluster energy for both sides are not in agreement.

## Summary

- Our detector has run smoothly during the commissioning period.
- Total $30\times10^6$ cosmic events are collected.
- Performance of SVD is evaluated with cosmic runs for each side/sensor.
- Cluster energy are in agreement for U and V side for horizontal sensors but this is not true for vertical sensor due to cosmic particles are incident at large angles on vertical sensors
- Cluster SNR (for cluster associated with tracks) > 20 for V side (expected).
- The RMS of Cluster time is in the order of 4ns, which is agreement with design parameter.


**Vertex-2018, Chennai, Oct 21 to 26, 2018**