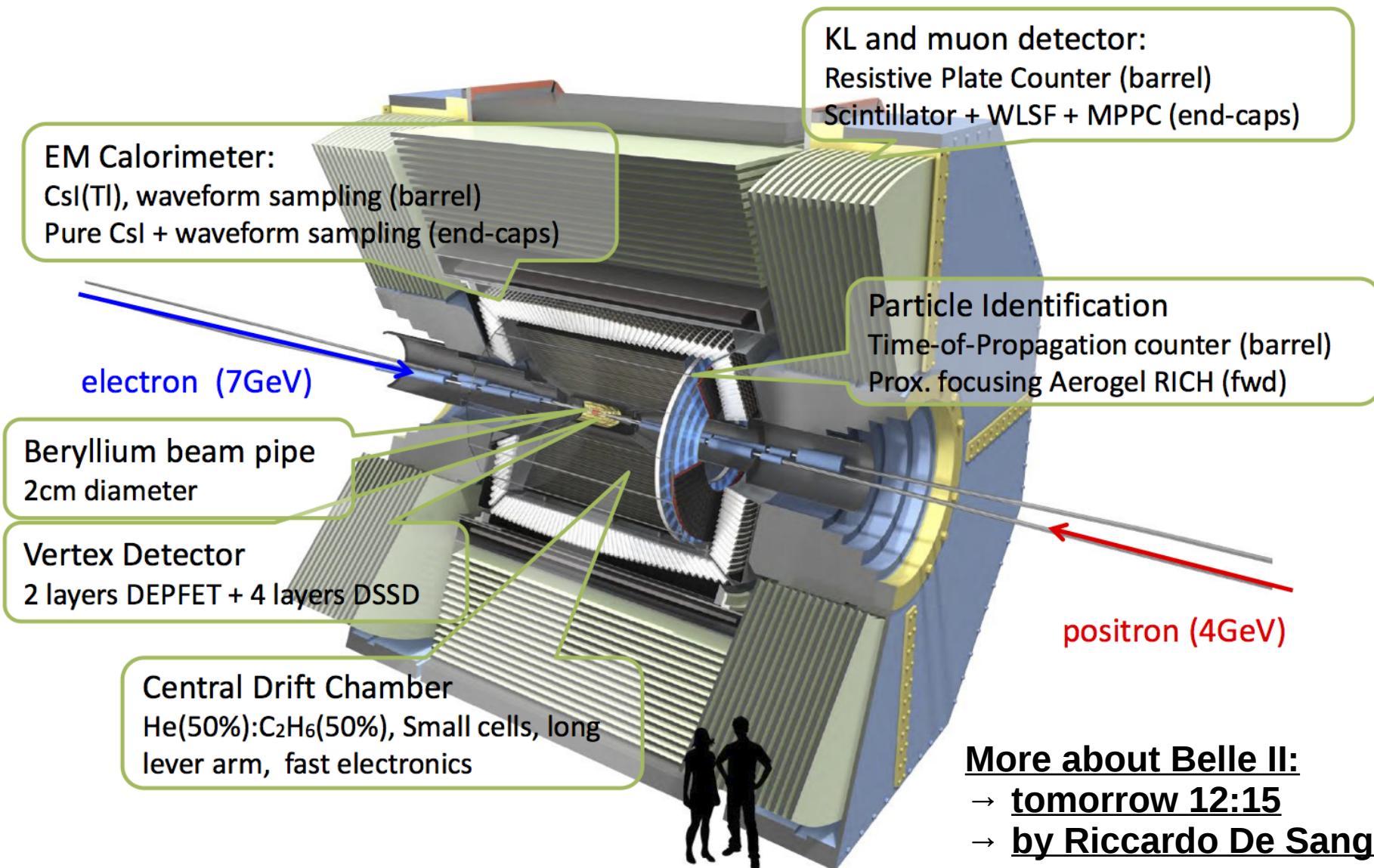


# An ATCA-based readout system for the Belle II Pixel Detector

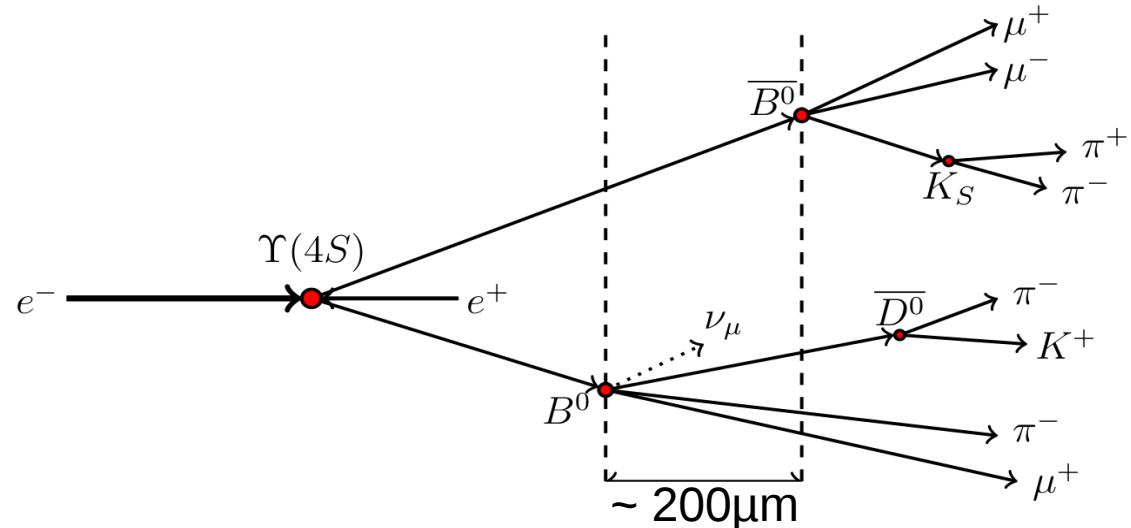
## Belle II Detector



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# An ATCA-based readout system for the Belle II Pixel Detector

CP violation measurement scheme at Belle II



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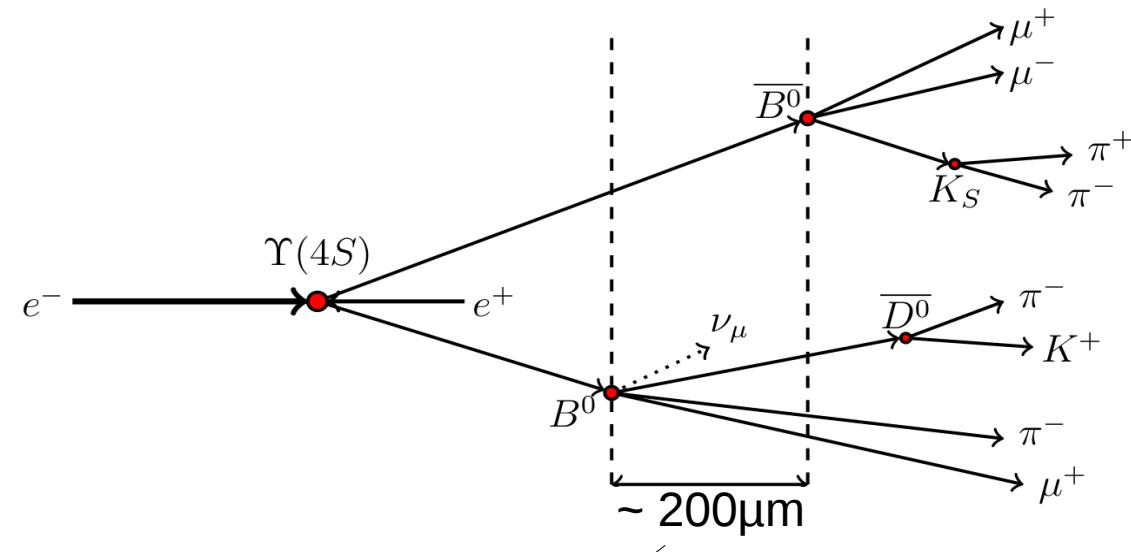


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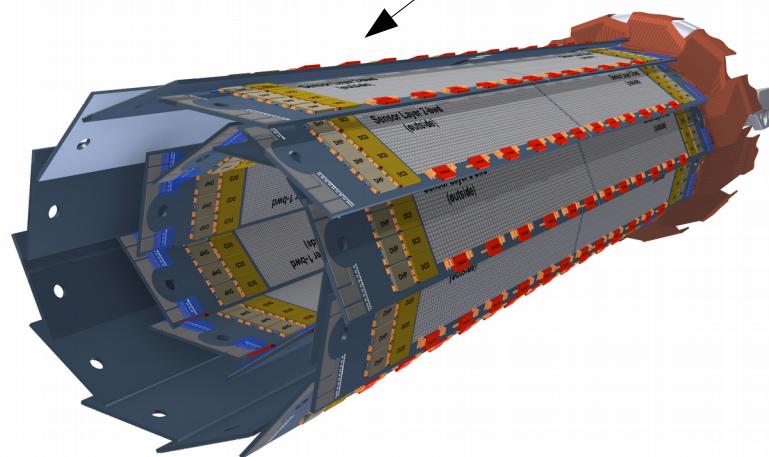
中国科学院高能物理研究所  
Institute of High Energy Physics  
Chinese Academy of Sciences

# An ATCA-based readout system for the Belle II Pixel Detector

CP violation measurement scheme at Belle II



To resolve this  
with high accuracy



Belle II Pixel Detector (PXD)

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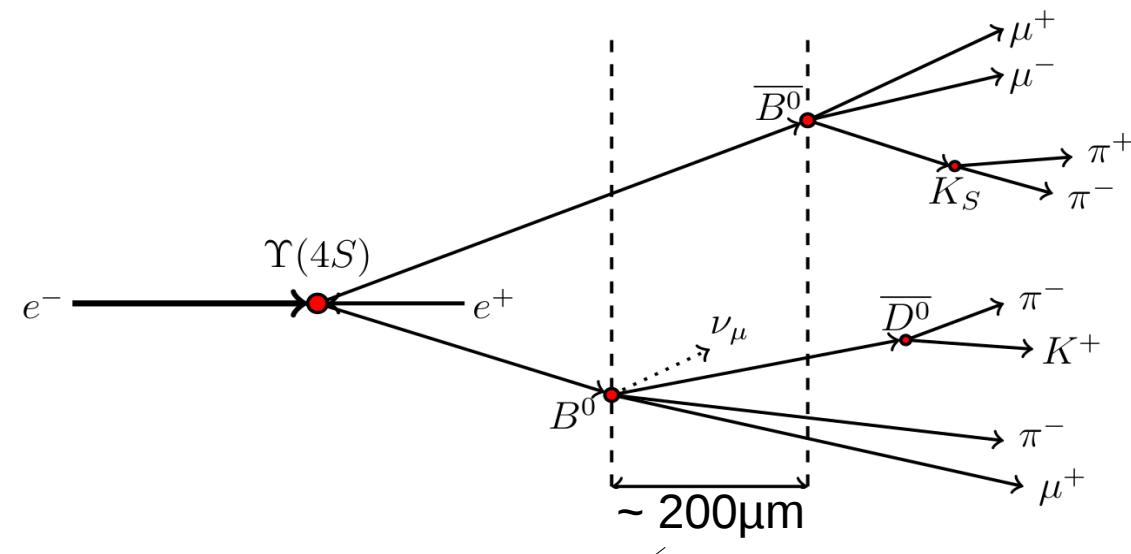


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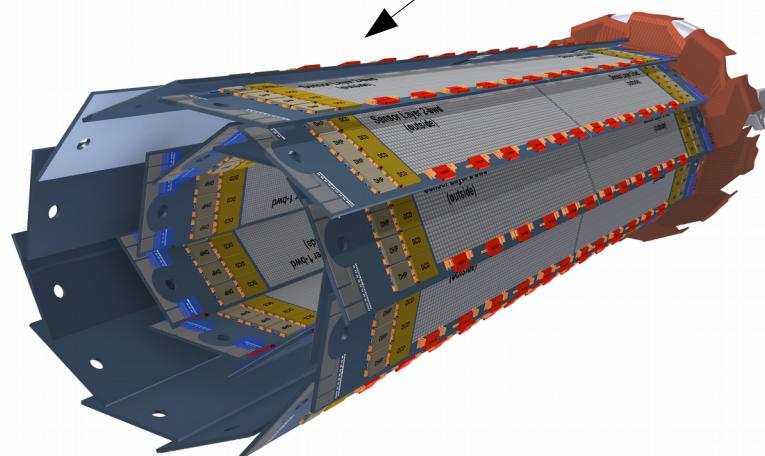
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# An ATCA-based readout system for the Belle II Pixel Detector

CP violation measurement scheme at Belle II



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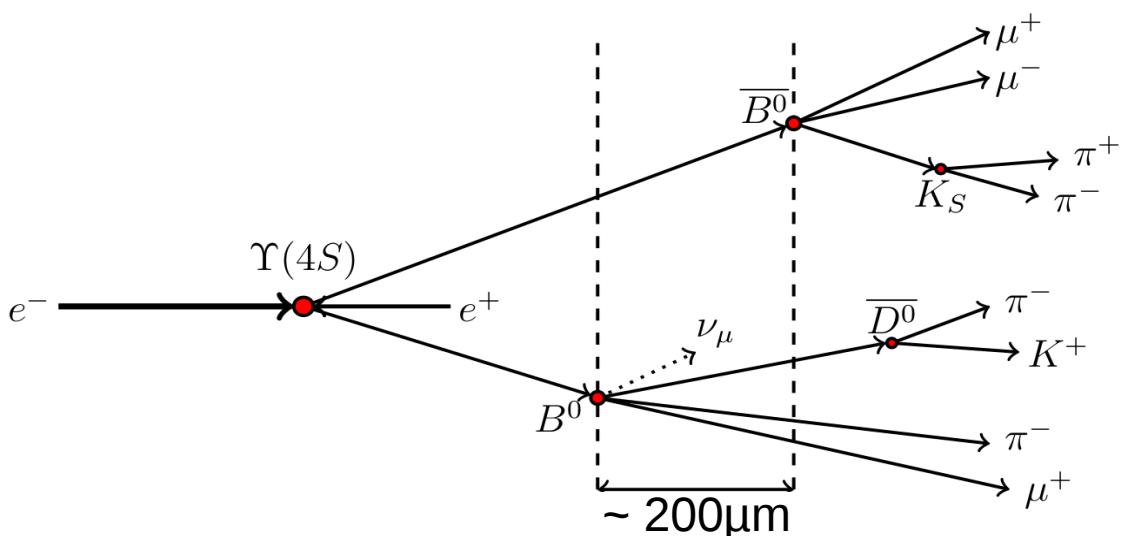


Belle II Pixel Detector (PXD)

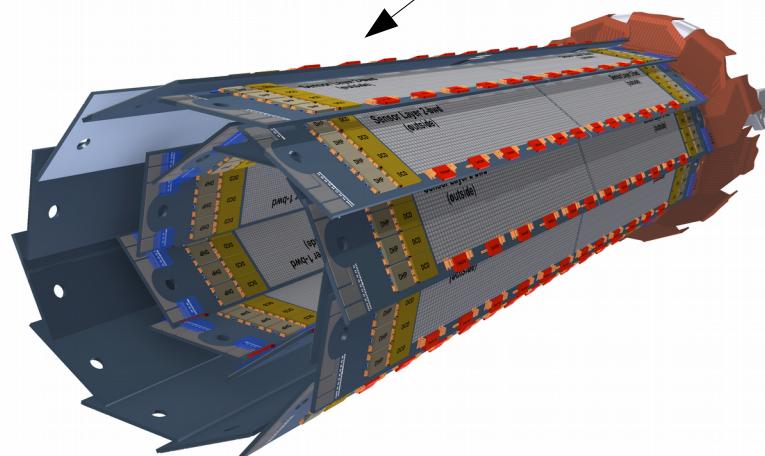
Close to the IP & 30kHz trigger  
→ huge background from  
 $\gamma\gamma$ -processes  
Bhabha scattering  
Beam-gas scattering etc.  
→ estimated data rate of 20GB/s !!  
→ reduction needed

# An ATCA-based readout system for the Belle II Pixel Detector

CP violation measurement scheme at Belle II

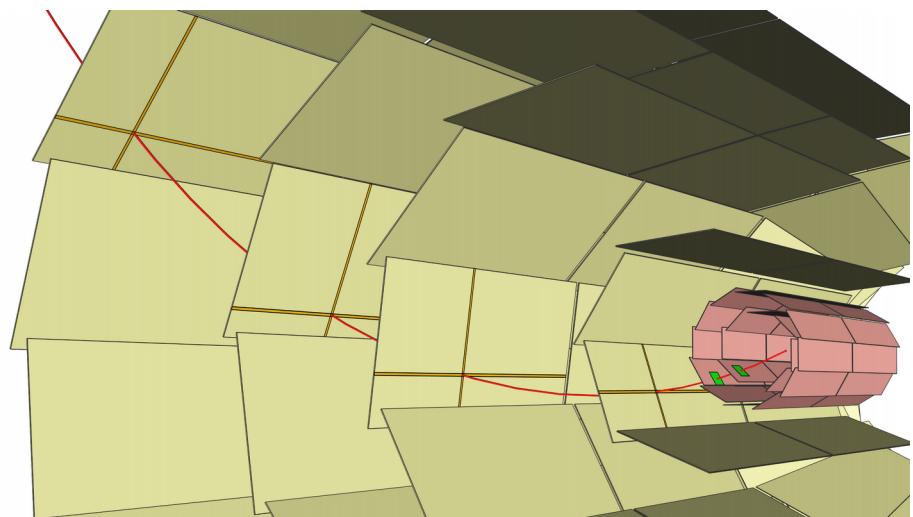


To resolve this  
with high accuracy



Belle II Pixel Detector (PXD)

Scheme of a particle track crossing the 6 layers of the VXD and defining 2 ROIs on the PXD surface



Close to the IP & 30kHz trigger  
→ huge background from  
 $\gamma\gamma$ -processes  
Bhabha scattering  
Beam-gas scattering etc.  
→ estimated data rate of 20GB/s !!  
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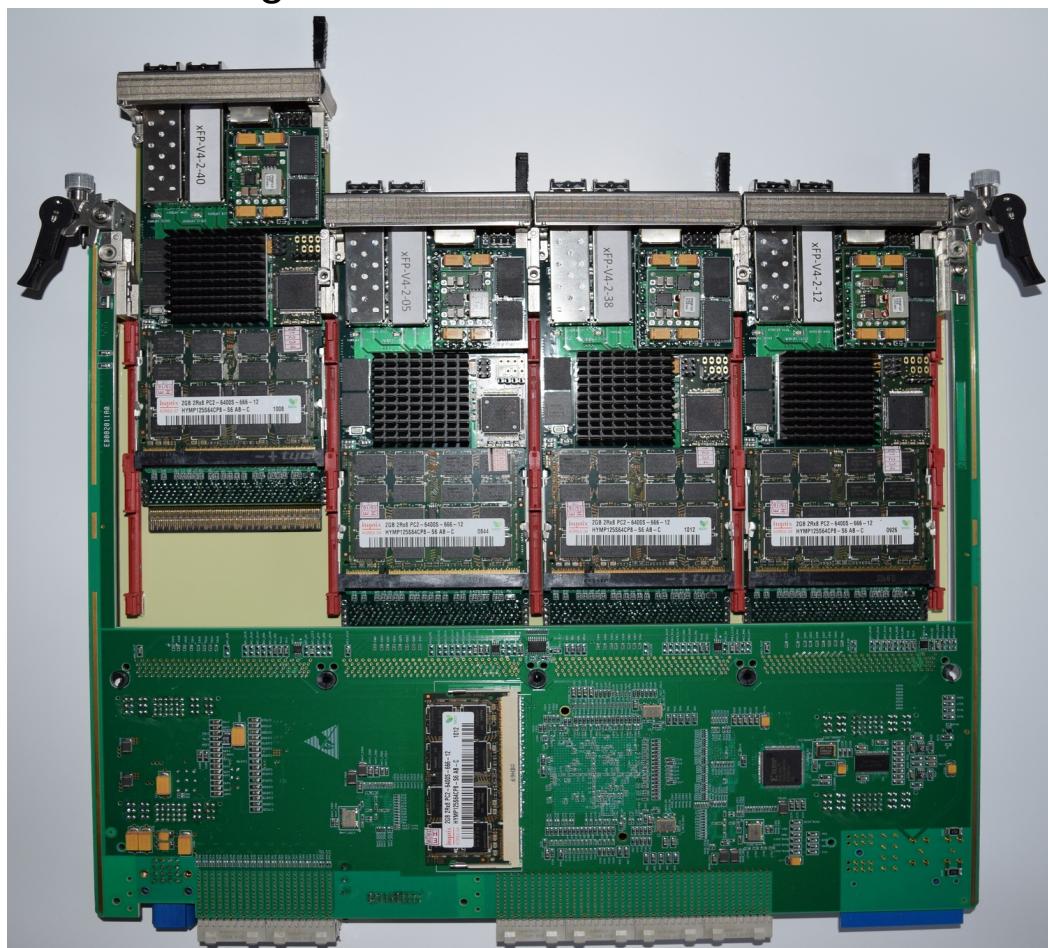
# An ATCA-based readout system for the Belle II Pixel Detector



ONSEN (ONline Selection Nodes) system

ATCA based hardware platform  
9 carrier boards, 33 AMC daughter boards  
Performs ROI selection to reduce background by factor of 30

One carrier board with 4 AMC daughter boards



# An ATCA-based readout system for the Belle II Pixel Detector

JLU Giessen:

- Thomas Geßler
- Dennis Getzkow
- Wolfgang Kühn
- Sören Lange
- Simon Reiter
- Klemens Lautenbach

JGU Mainz:

- Björn Spruck

IHEP Beijing:

- Zhen'An Liu
- Jingzhou Zhao

The Belle II Pixel Detector

Hardware components:

- 2 layers, inner at 14 mm and outer at 22 mm around beam-pipe
- In total 40 half-ladders, 16 on the inner layer and 24 on the outer layer
- Each half-ladder made up of  $768 \times 256$  pixels  $\Rightarrow \approx 8$  million pixels in total

Experimental challenges:

- Close to the beam pipe  $\Rightarrow$  high occupancy of  $\approx 25\%$
- Most of the hits correspond to background events
- Tau decay
- Beta-alpha scattering
- Gamma-gamma annihilation
- Beam gas scattering

Requirements:

- Data reduction of 30 is needed (saturation of event builder)
- ROI (Region Of Interest) selection to reduce background, two source
- DATCON (Data Acquisition Trigger Concentrator On-line Read) FPGA based, tracking with data of Silicon Strip Det.
- HLT (High Level Trigger): Software based, data of all Belle II subdetectors except PXD, is used for tracking - calculation time up to 5 s
- HLT decision time is kept (3/4 data reduction), DATCON RD is pixel data from DHC (Data Handling Concentrator) used to be handled in HLT arms.

State of the new data output option

Two independent tests performed:

- Connection to Event Builder via 10GbE Switch,  $> 900$  MB/s achieved ( $\approx 600$  MB/s required)

Combined Data Rate

Connection between Selector-Carrier and Selector-AMCs

Output trigger rate: 25 kHz (pulse), output data rate:  $\approx 51$  MB/s

No data corruption was found during the tests.

ONSEN (Online Selection Node) Hardware:

- Designed and assembled in cooperation between IHEP China, JLU Giessen and JGU Mainz
- 14-slot ATCA (Advanced Telecommunications and Computing Architecture) shelf with full mezz backplane
- 9 ATCA standard Carrier boards and 33 AMCs (Advanced Mezzanine Cards) with Xilinx Virtex-4 and Virtex-5 FPGAs, respectively
- Trigger rate 30 kHz (TTS 500 Hz per AMC card), input data rate 20 GB/s
- Untriggered monitoring ROI with delay of up to 5 s
- $\Rightarrow$  storage is needed (84 GB RAM)

ONSEN Focuses:

Results of the 2017 Test Beam Campaign at DESY

56th International Winter Meeting on Nuclear Physics, Bormio, Italy, January 22, 2018

Klemens.Lautenbach@physik.uni-giessen.de