Detector geometry, simulation and reconstruction

Belle II CMOS Upgrade, 17-18 Dec. 2019

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Upgrade software

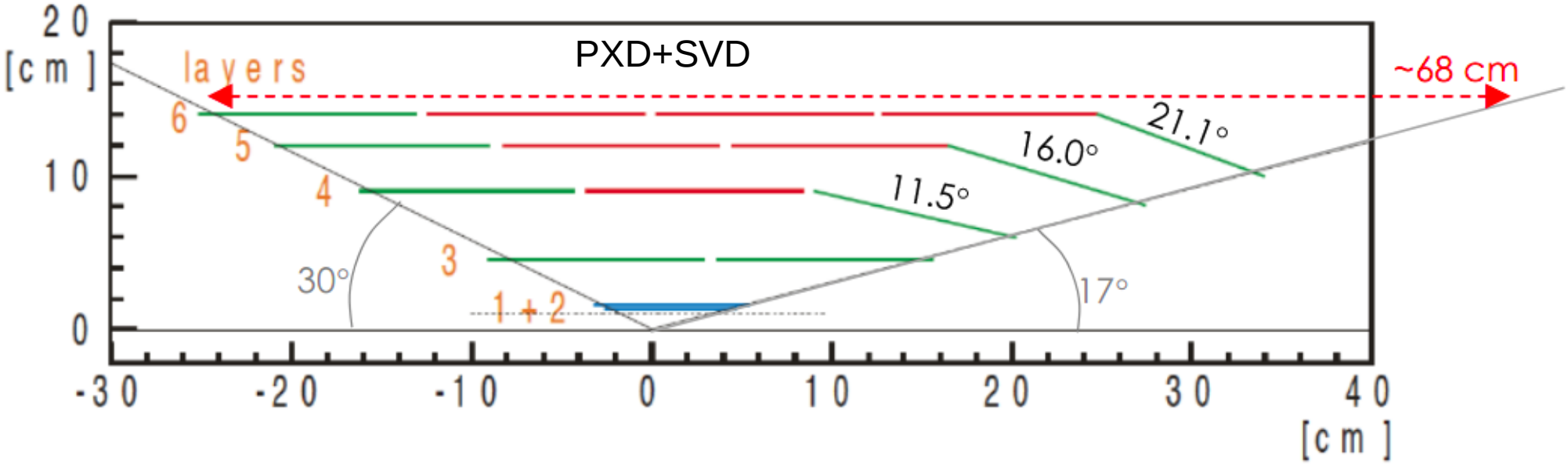
- During last B2GM, we had first meeting to discuss software efforts needed for the vxd upgrade in Belle II core software (basf2)
- Goals:
  - Layout optimization for VTX→ inputs for design decisions (geometry, technology)
  - Explore (robustness of) track finding for very high backgrounds in SuperKEKB or possible upgrade of SuperKEKB.
  - Perform physics benchmarking; not only impact parameter resolutions.

- **Heavy task**, but we do not start from zero:
  - Belle II has a pixel detector (PXD) fully integrated into basf2

    simulation → digitization → bg overlay→ clustering → trackfinding/fitting → analysis
  - Lot of work was invested into PXD+SVD standalone trackfinding in Belle II software based on ideas of R. Fruehwirth. Just need to interface it.
  - Interface to Belle II bkg. simulations and strategy to overlay background on signal for most realistic benchmarking.

Initial steps

- Simple geometry with cylinders to replace PXD & SVD in Belle II.
  - Keep current volume of Belle II tracking detector (PXD & SVD)
  - First two layers like PXD (radii 14mm and 21mm, beam pipe)
  - Outer layers with radii up to 135mm (outermost SVD layer)

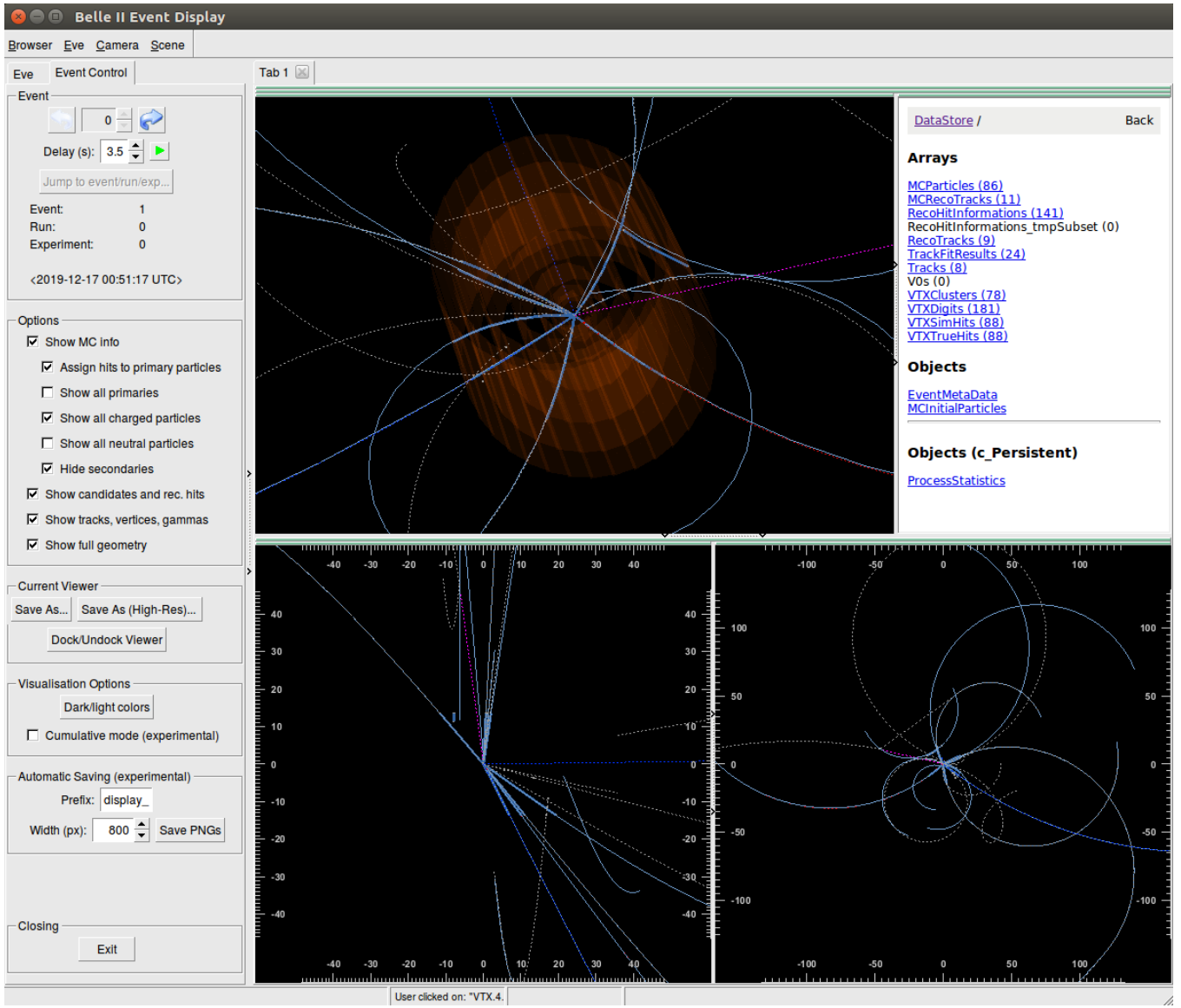


Initial steps II

- Upgrade branch with new vtx package in basf2 repository:
  - Add VTX specific data containers (based on PXD, done)
  - Add VTX specific simulation and recontruction code (modified PXD, done)
  - Interface VTX hits to MC trackfinding & fitting (done)
  - Integrate VTX hits into standard trackfinding (in progress)

- Early VTX implementation is up and running:
  - 5 and 7 layer VTX with 40x40x40μm^3 pixels and binary readout are implemented (for testing).
  - Simulated VTX response to background particles and physics generators (digits, clusters)
  - Find tracks (using MC truth info) and fit tracks using reconstructed clusters
  - Now able to deliver impact parameter resolutions for each layout option

Getting software in shape



- Event display with BBar

- Just 7 layer VTX

- VTX objects, RecoTracks, Tracks and TrackFitResults

Organization

- Task force with members form Strasbourg, Pisa, Bonn, Göttingen.
- Upgrade mailing list, confluence page, agira ticket
- Thomas Lück as contact person to software group

- Most urgent task now is interface to standalone tracking with the vertex detector (VXDTF2).

Issues in Epic

BII-5632	VTX specific containers	IN REVIEW	Tristan Fillinger
BII-5633	SensorInfoMap for VXD upgrade package	CLOSED	Tristan Fillinger
BII-5716	Create dedicated branch for upgrade code	CLOSED	Thomas Kuhr
BII-5737	Modify VXDTF2 to be more flexible	OPEN	Thomas Lueck
BII-5738	Modify CKF to be more flexible	IN PROGRESS	Christian Wessel
BII-5850	Problem with >31 ladders geometry	OPEN	Thomas Lueck
BII-5978	Enable MC track finding and fitting with VTX hits	IN REVIEW	Benjamin Schwenker
BII-5989	Validate VTX digitizer	OPEN	Benjamin Schwenker

Discussion points / milestones

- Progress on integrating VTX into track finding may be a bottleneck. Discuss possibility for newcomers to help.

- Find a (short) list of most interesting pixel detector technologies, add digitizer for them and start to validate them (cluster size vs. angle, point resolution vs. angle).
  - One can spend lots of time here, but we do not need to model resolution to tenth of microns
  - Our main concern are speed and material budget and efficiency after irradiation
  - Use data from old test beams / requests for test beams?

- Geometry options to explore: Slanted sensors, timing layer, double layer (like Plume)?

- Boill down to 1-2 detector geometries to study more detail for tracking performance and physics benchmarking
  - Guided by fast toy simulations
  - But in the end we need to define fixed conditions (aka global tags) and produce background samples

- For physics benchmarking, we need to find a list of channels to look at. Preferably based on existing analysis that are affected by vertex detector?
  - Impact of binary tracking on charged particle ID (no dE/dx) ?
  - Efficiency for tracking slow pions
  - Performance of Full Event Interpretation?