April 18th, 2023

Detector & MDI meeting

Occupancy updates for Vertex Detector

based on $\sqrt{s}$ = 1.5 TeV model

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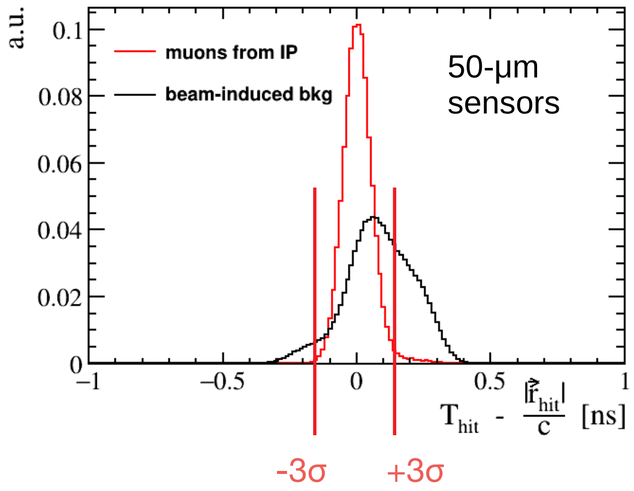
Introduction: vertex detector

BIB mitigation in the Vertex Detector is critical for the Muon Collider physics program

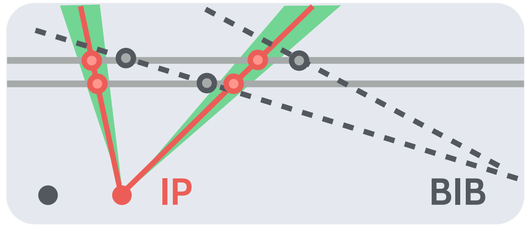
↳ used for track seeding → huge combinatorics during track reconstruction → CPU-time bottleneck

The 3 main handles for BIB-mitigation identified by now:

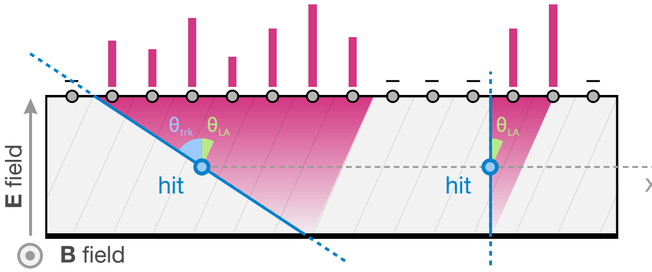
1. **Timing**
   using ultrafast Si sensors
   for narrow acceptance cuts



2. **Stub selection**
   using double-layer structure
   with ~2 mm spacing



3. **Cluster shapes**
   using charge sharing due to
   the Lorentz drift in B field



BIB mitigation in the Vertex Detector is critical for the Muon Collider physics program

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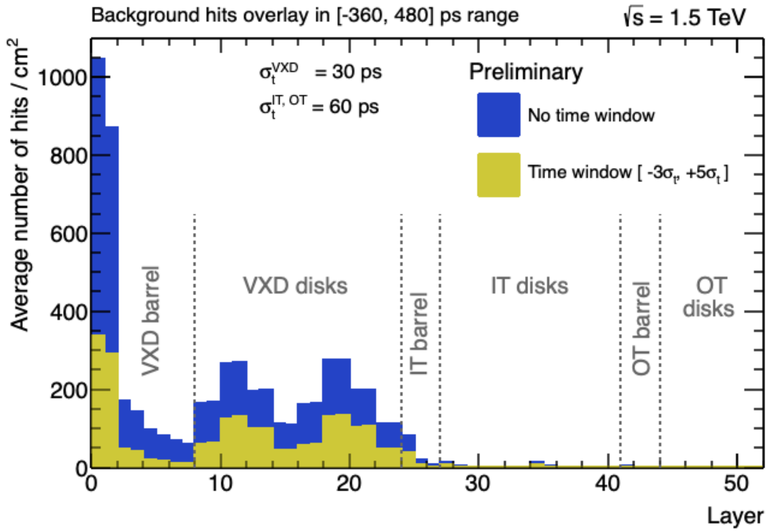
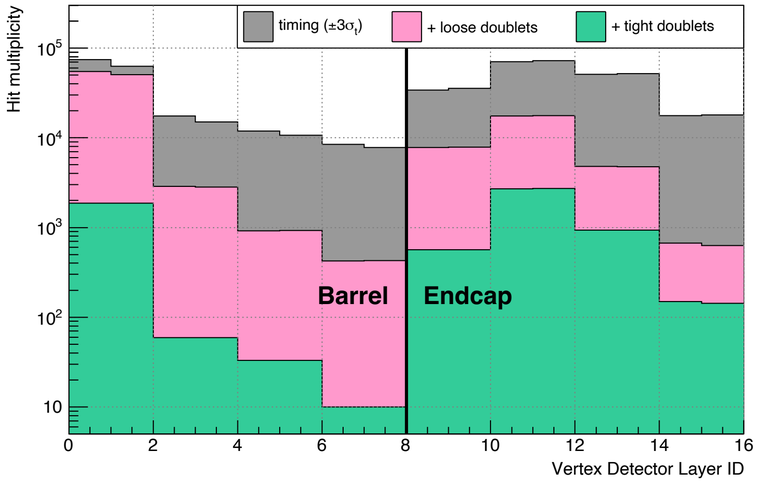
The 3 main handles for BIB-mitigation identified by now:

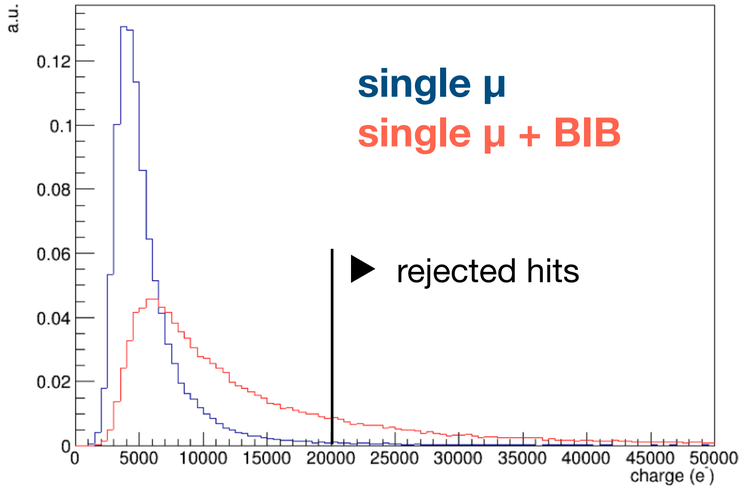
1. **Timing**
   using ultrafast Si sensors
   for narrow acceptance cuts

2. **Stub selection**
   using double-layer structure
   with ~2 mm spacing

3. **Cluster shapes**
   using fine pixel pitch
   and analog readout



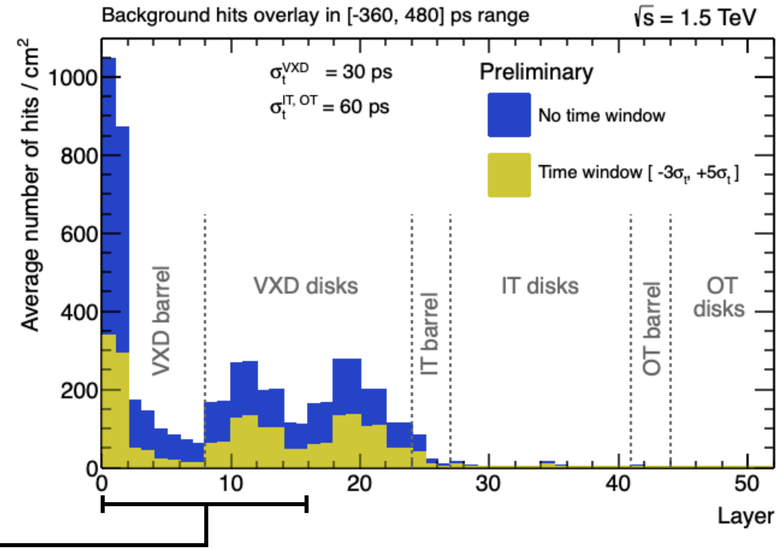




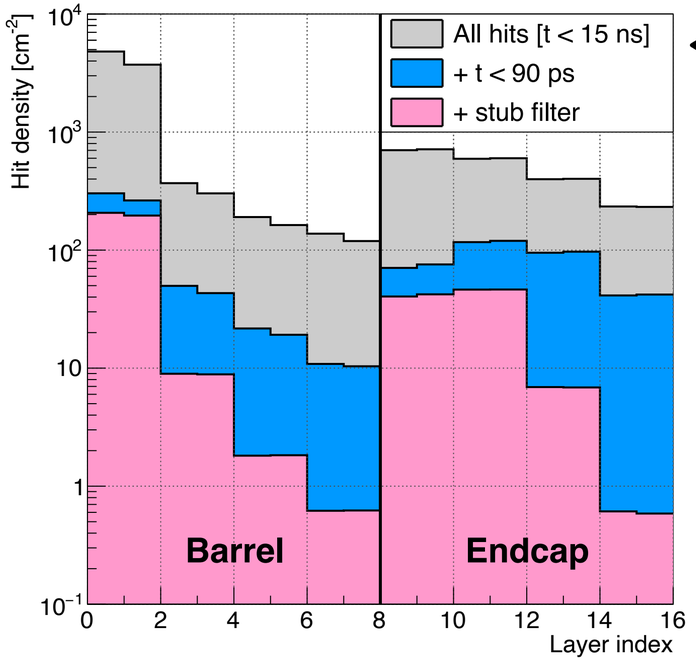
Updated occupancy: corrected default

Our old plot doesn't give enough credites to the power of timing

No time window **histogram has an implicit time window**
-360 ps < t < 480 ps from BIB overlay (due to high memory load)



An updated plot made with more reasonable **No time window**
-2 ns < t < 15 ns as suggested by Sergo Jindariani



Gives a good overview of the effect of each suppression stage

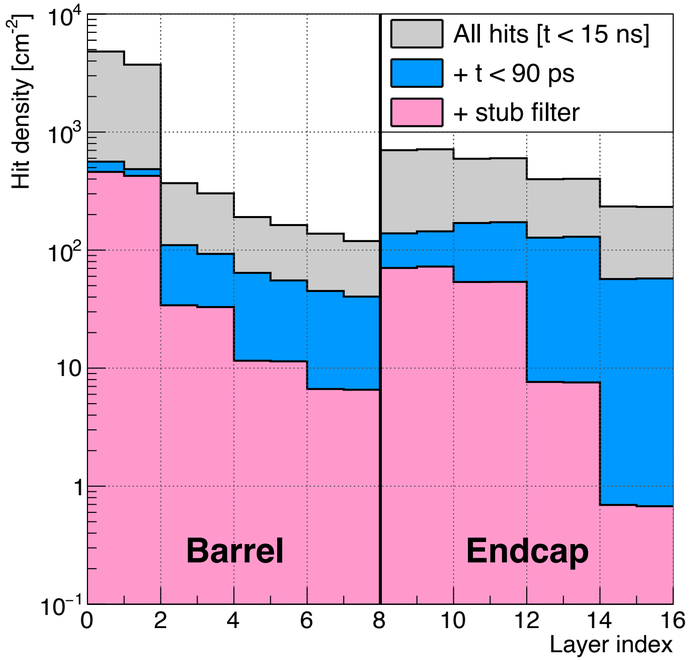
Eventually an additional step will be added: **cluster-shape filter**
↳ corresponding digitizer will be integrated in the next release

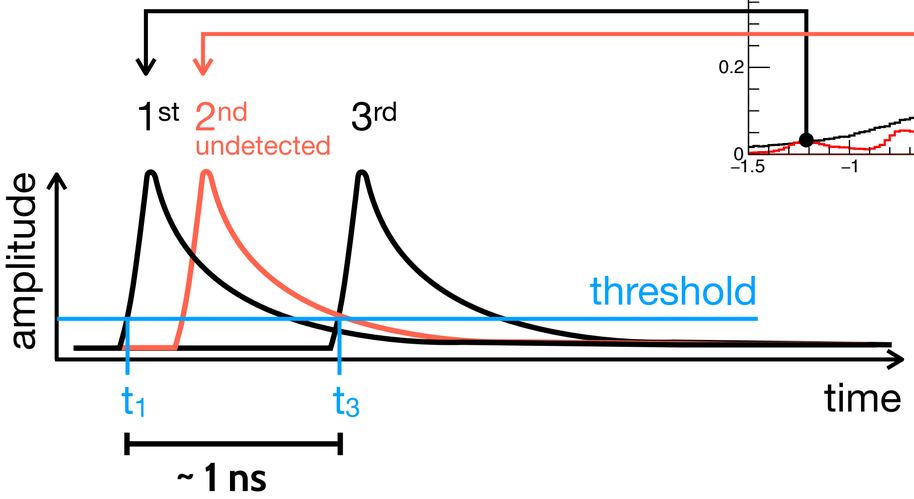
Updated occupancy: realistic timing

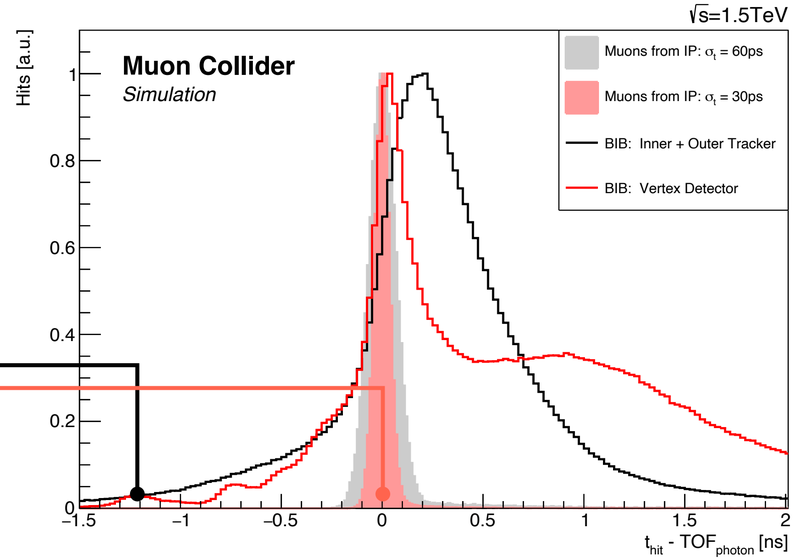
So far time filtering didn't take into account an important effect: **pulse duration in readout electronics**

A substantial fraction of BIB particles reach Si sensors before the expected signal from IP ▶

This effect is included by extending the acceptance time window
-2 ns < t < 90 ps to be conservative







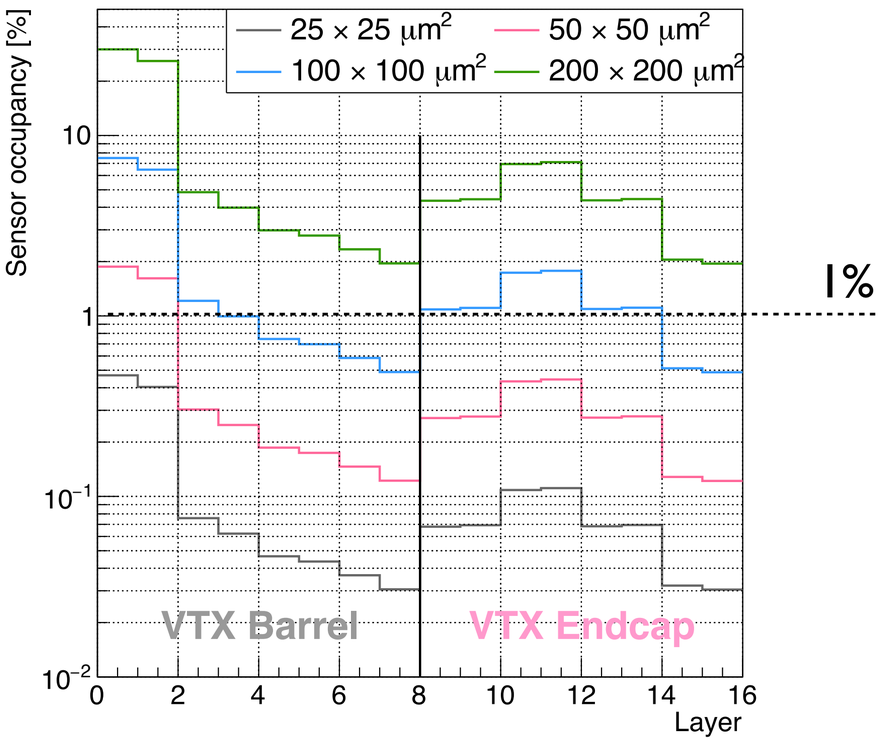
A hit from an early BIB particle makes the pixel "blind" to the potential signal particle arriving later

Conclusions

The hit-occupancy plot used to decide on the target pitch has been underestimated for the Vertex Detector
roughly by a factor 2, mostly in the Barrel

This has to be accounted for in the 10 TeV geometry

We should implement this effect in a more direct way
↳ include as pixel "dead time" in the new digitiser



NEXT STEP

Redo the occupancy plot with the new digitiser
taking into account all the relevant effects:

- spatial + time resolution
- charge sharing + noise
- pixel dead time