AFTER @ LHC

First simulations with a LHCb-like forward detector for AFTER

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The work just starts …

Probing the Strong Interaction at A Fixed Target ExpeRiment with the LHC beams

ÉCOLE DE PHYSIQUE des HOUCHES

12-17 January, 2014

Outline

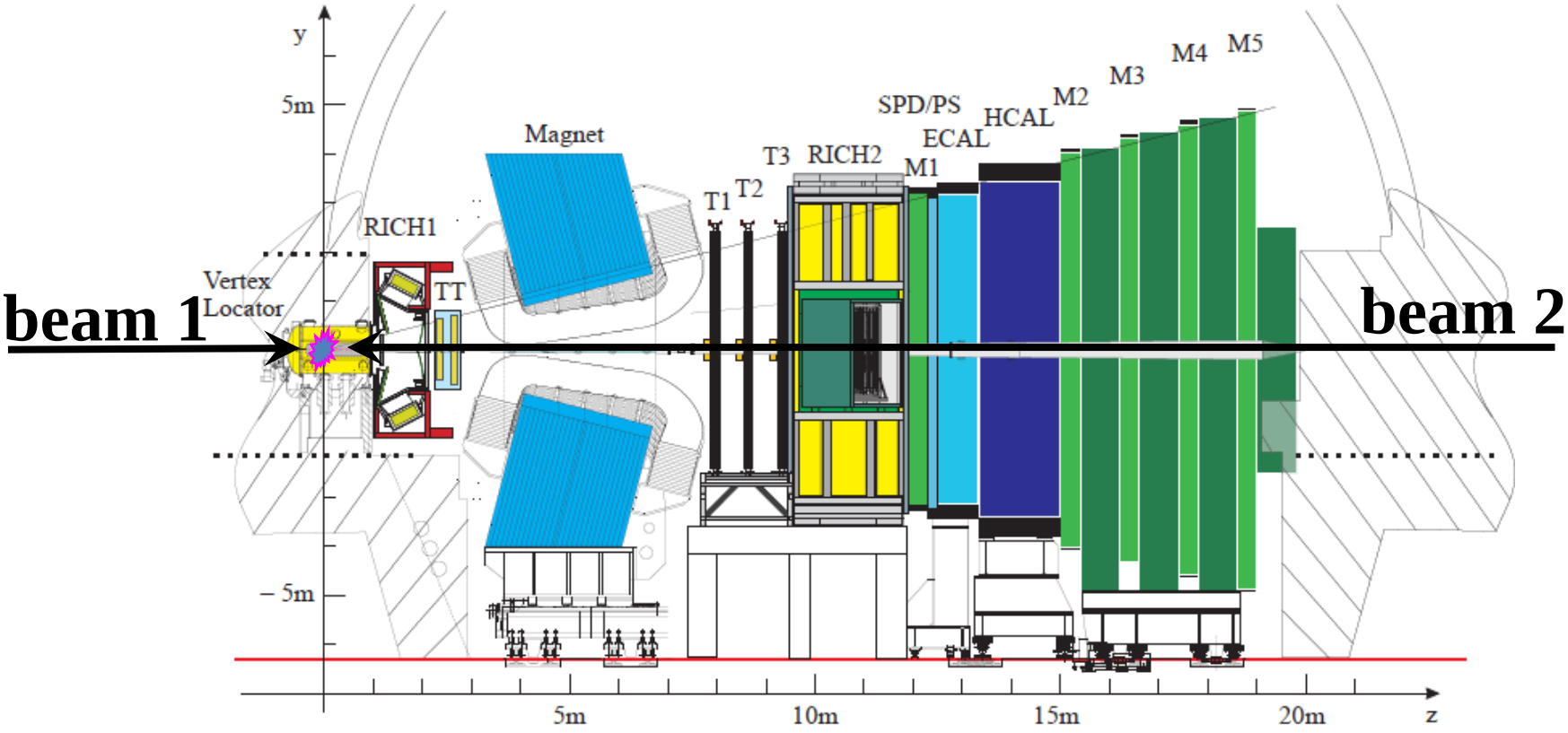
- The LHCb detector
- The VELO upgrade
- Simulation with HIJING: generator level
- Full simulation with the LHCb detector
- Summary and next-to-do

LHCb detector

JINST 3 (2008) S08005

A forward spectrometry
dedicated to beauty and charm physics

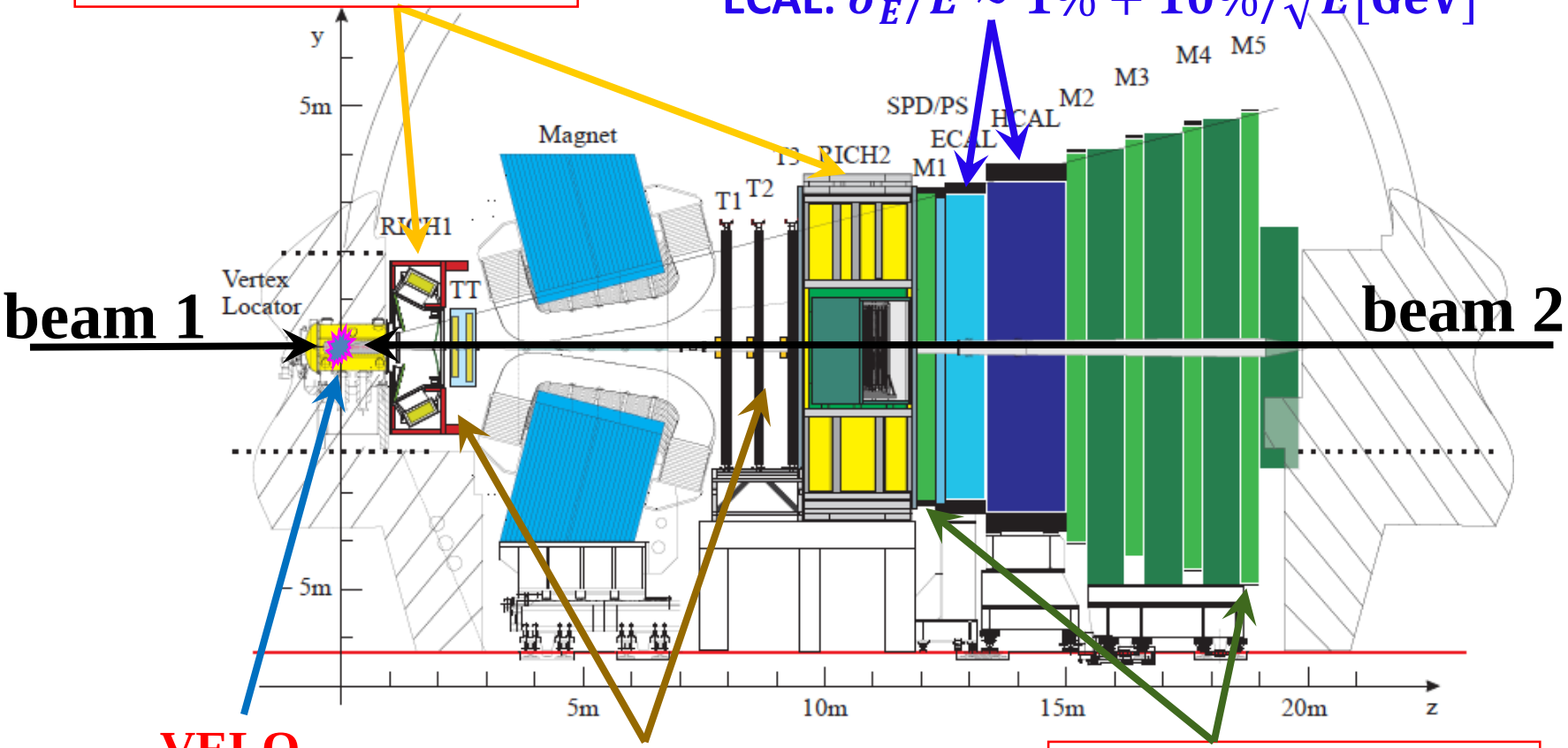
Pseudorapidity acceptance
$2 < \eta < 5$



LHCb detector

RICH1 & RICH2
$\epsilon(K \to K) \sim 95\%$
$\pi \to K$ **mis-id:** $\sim 5\%$

Calorimeters
ECAL: $\sigma_E/E \sim 1\% + 10\%/\sqrt{E[\text{GeV}]}$

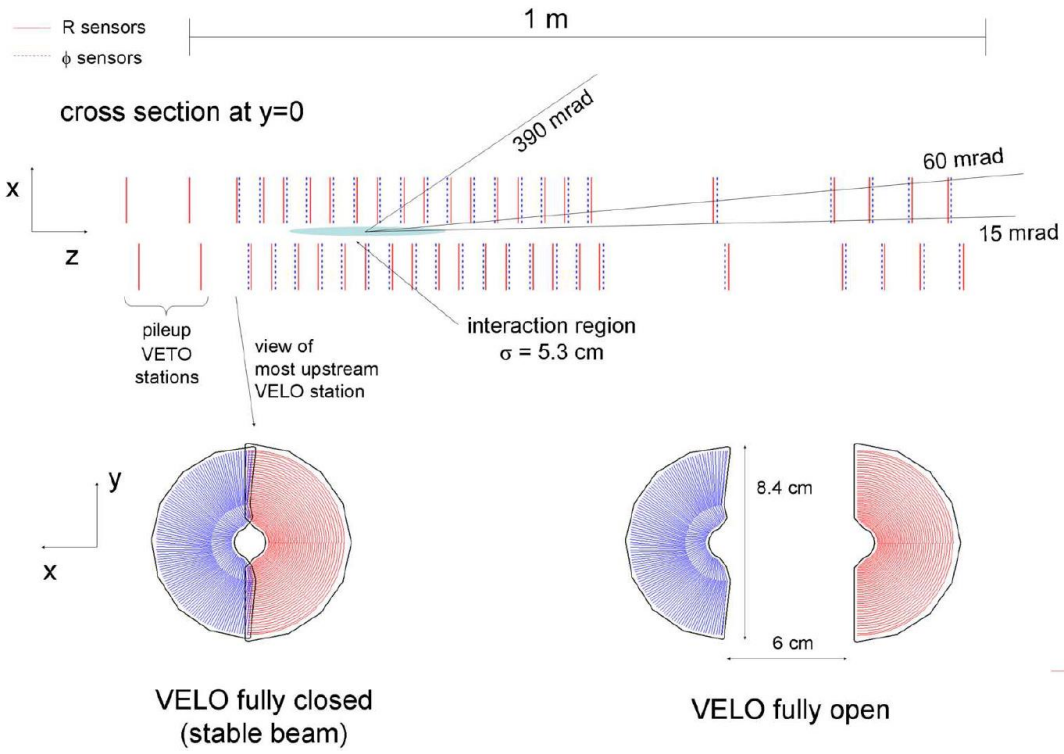


VELO
$\sigma_{IP} \sim 20\ \mu m$
for high-p_T **tracks**

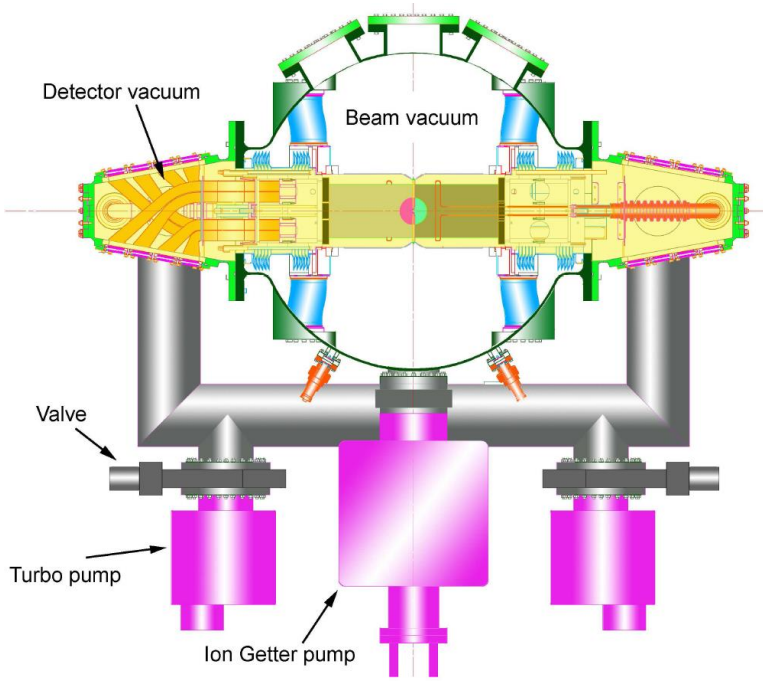
Tracking System
$\Delta p/p = 0.4\%@5\ \text{GeV}/c$
to $0.6\%@100\ \text{GeV}/c$

Muon System
$\epsilon(\mu \to \mu) \sim 97\%$
$\pi \to \mu$ **mis-id:** $1 \sim 3\%$

LHCb Vertex Locator (VELO)



- PV resolution
  $\sigma_{x,y} \sim 10\ \mu m$
  $\sigma_z \sim 50\ \mu m$
- SV resolution
  $\sigma_{x,y} \sim 20\ \mu m$
  $\sigma_z \sim 200\ \mu m$

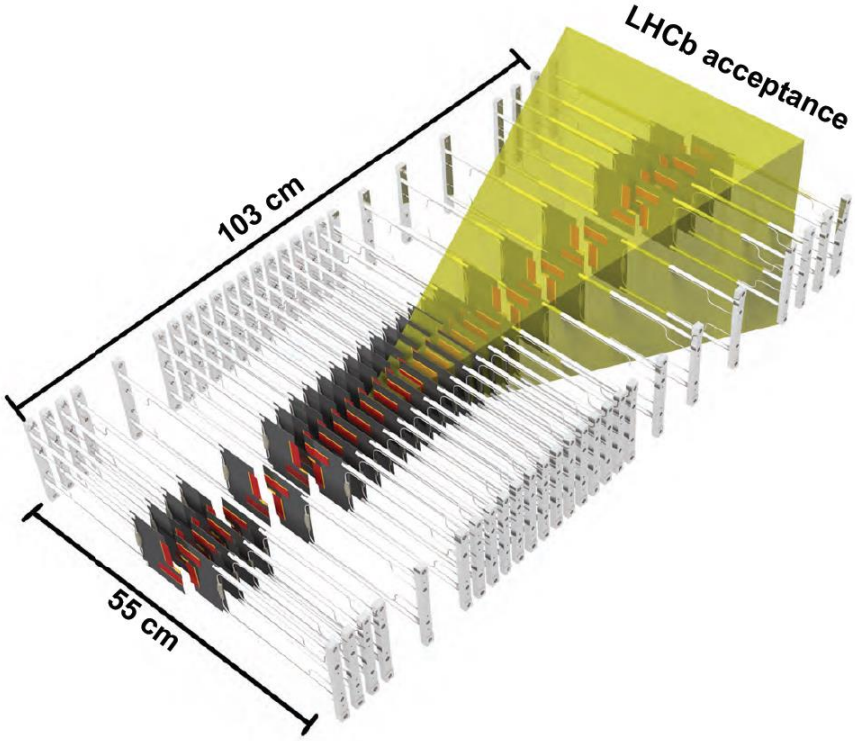


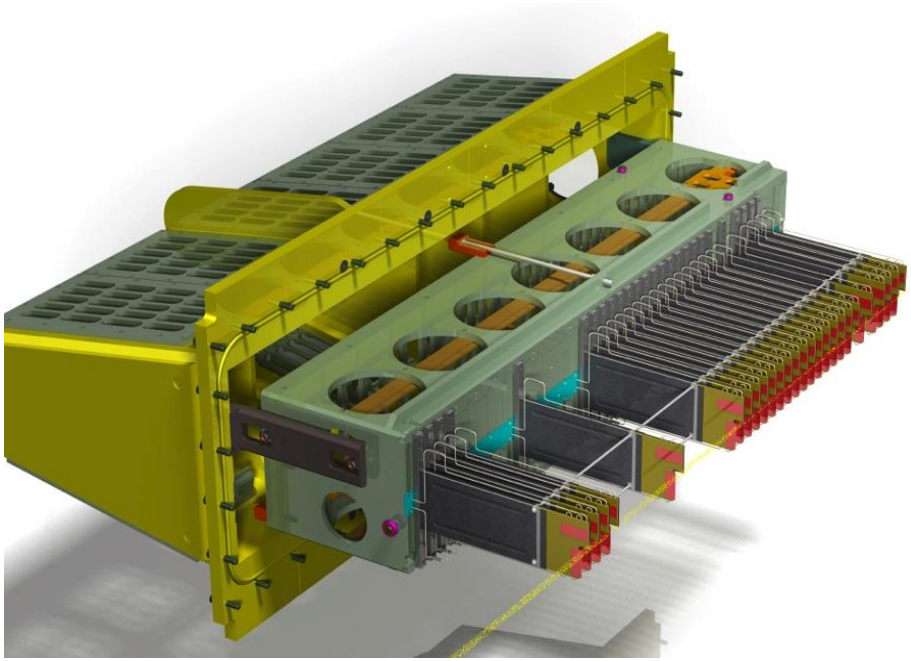
- Required to distinguish Secondary Vertex of b(c)-hadron decay from PV
- Silicon strip detector
- Distance to beam axis: 5 mm
- Removable in y direction during injection

LHCb VELO upgrade

LHCb-TDR-013

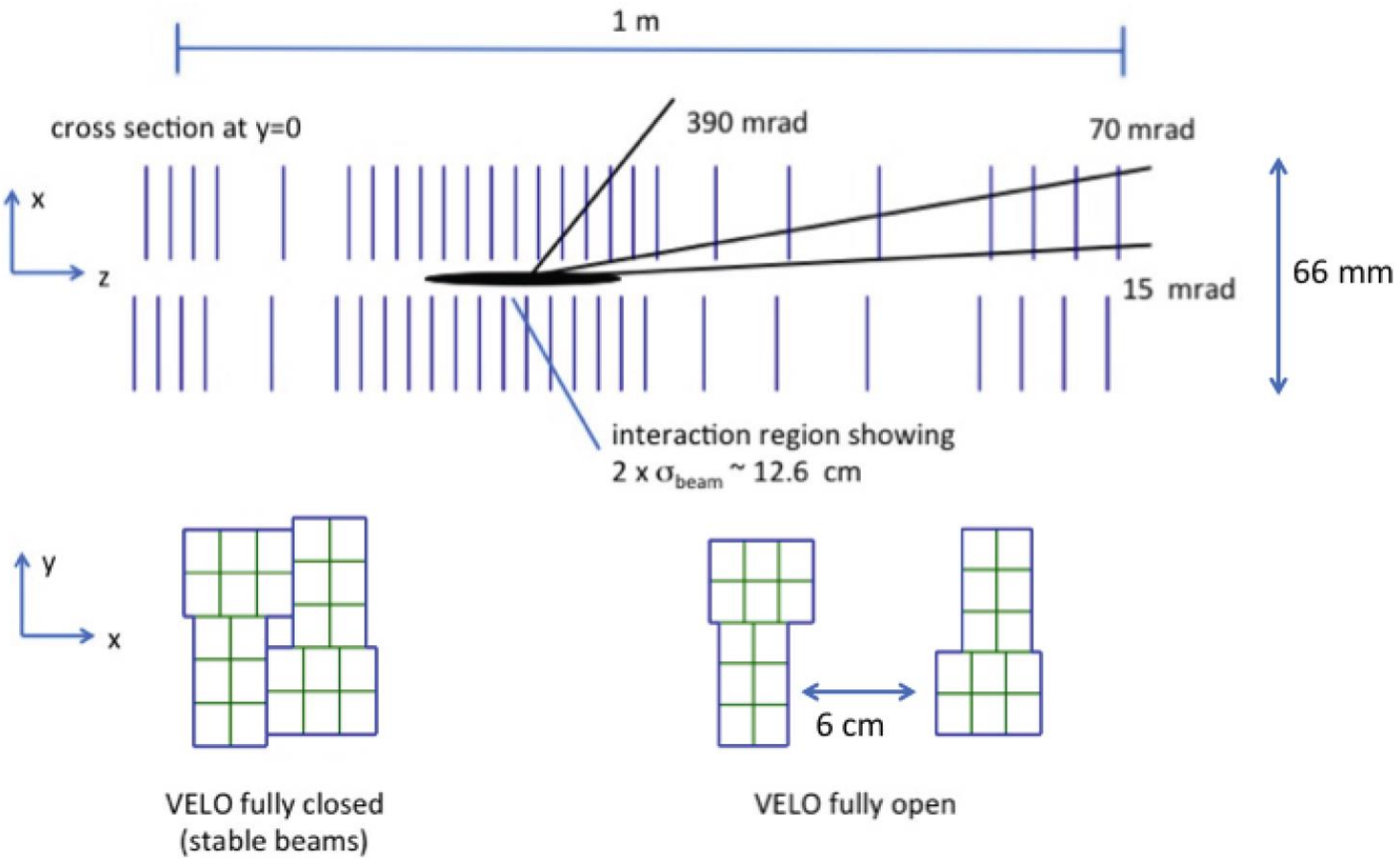
- A lightweight hybrid pixel detector capable of 40 MHz readout at $\mathcal{L} = 2 \times 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Totally 41 M pixels





LHCb VELO upgrade

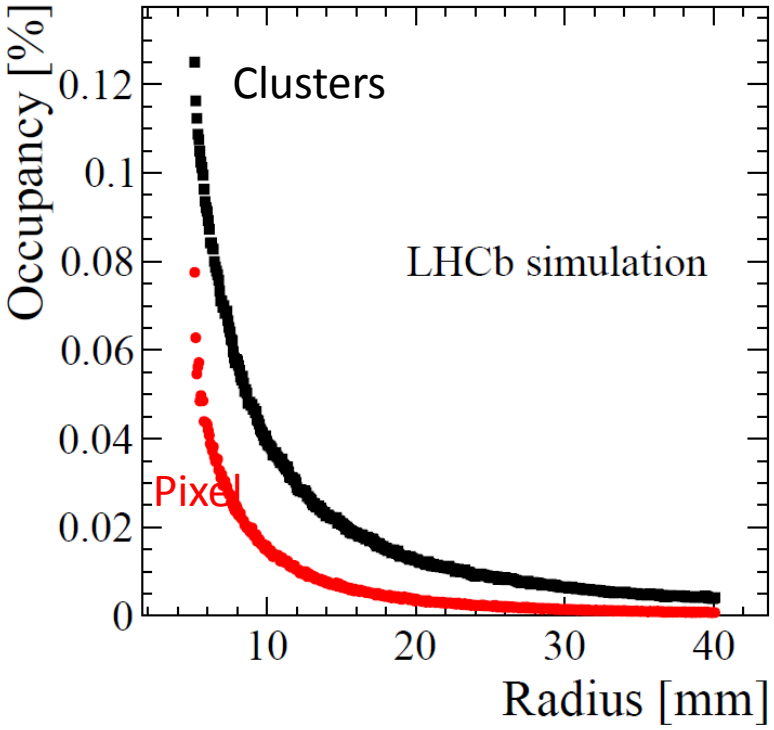
- Pixel size: $55 \times 55\ \mu m^2$
- Minimum distance to beam axis: 5.2 mm

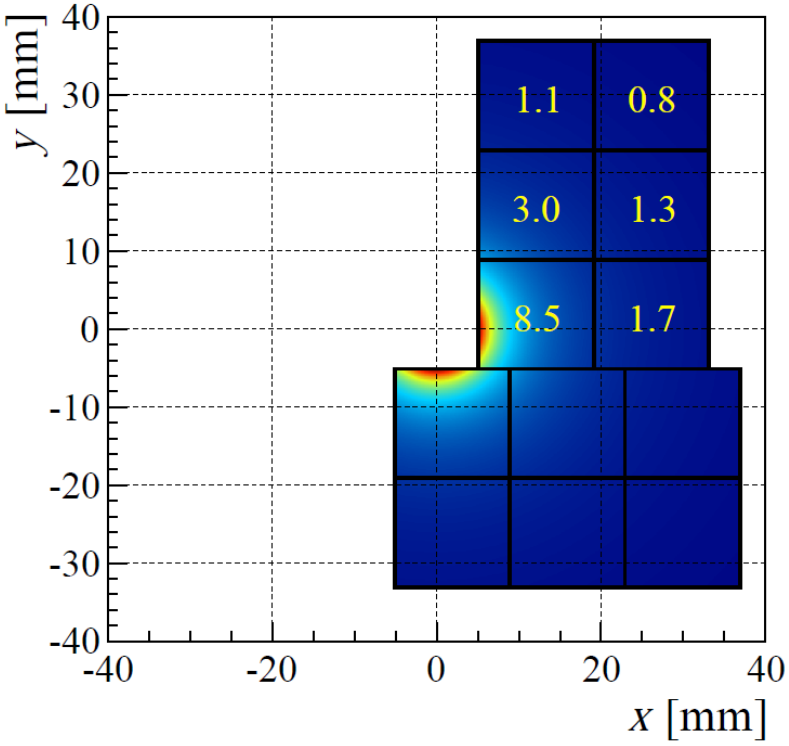


LHCb VELO upgrade: Occupancy

- The occupancy decreases as a function of radius
- Pixel Occupancy defined as

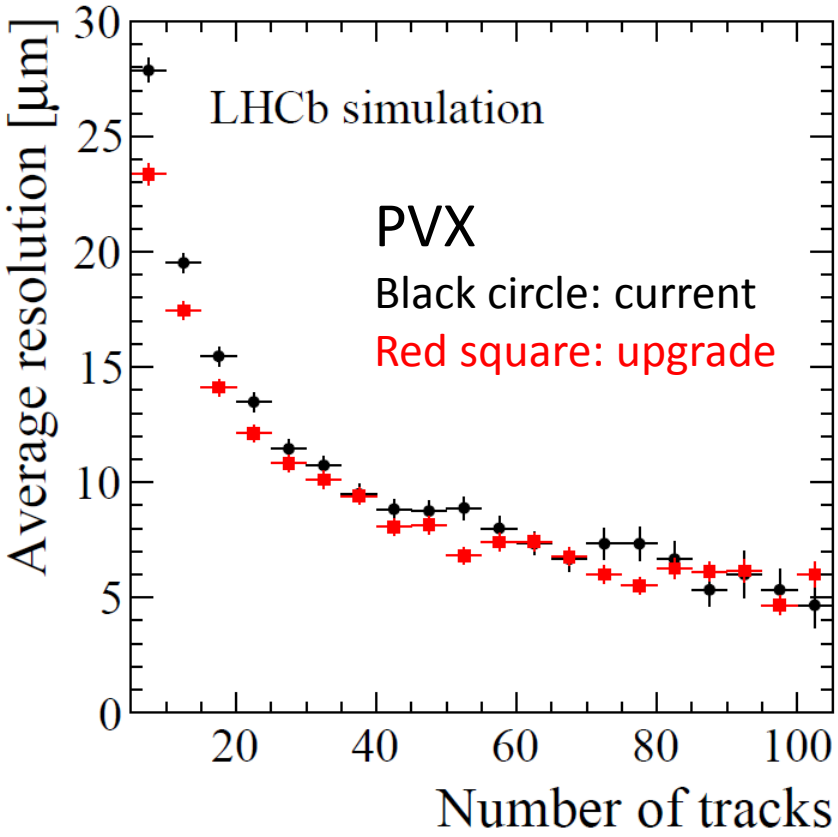
$$\frac{\#\ of\ hits}{\#\ of\ pixels}$$

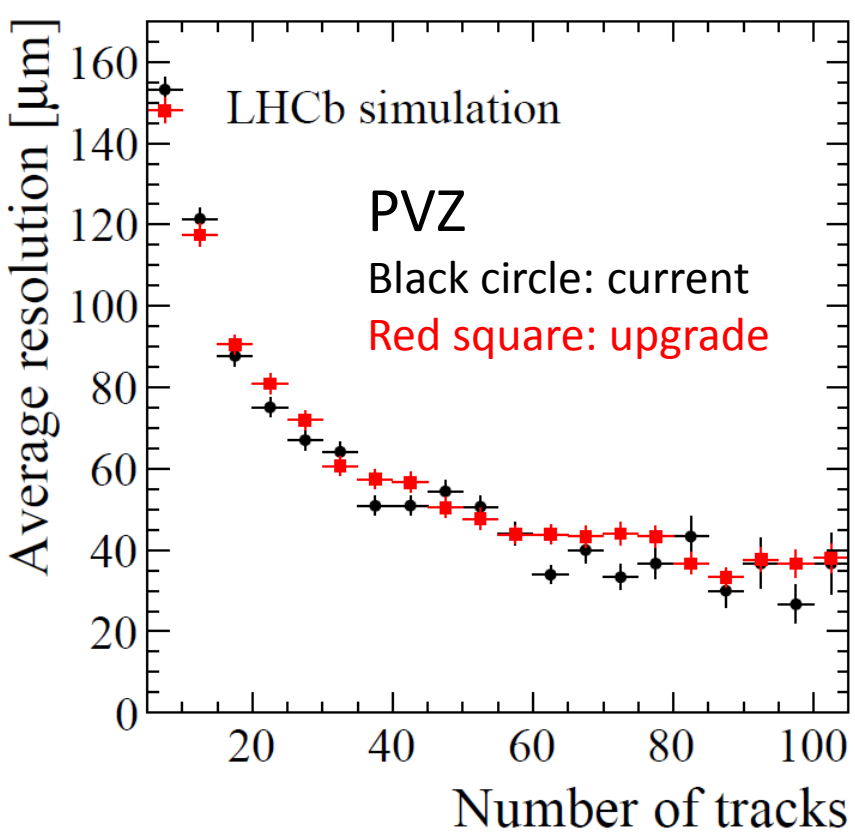




LHCb VELO upgrade: PV resolution

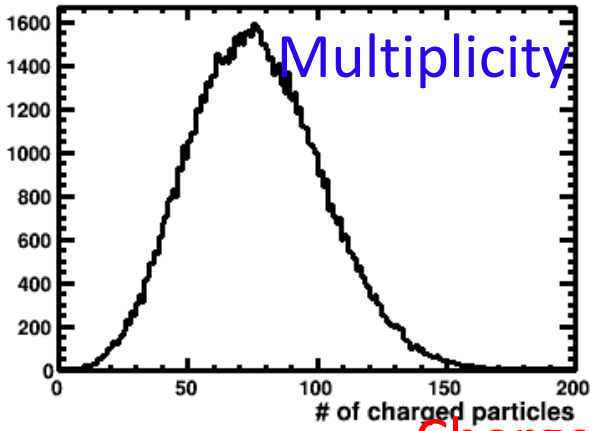
- PV resolution as a function of number of tracks
- Similar performance as current VELO

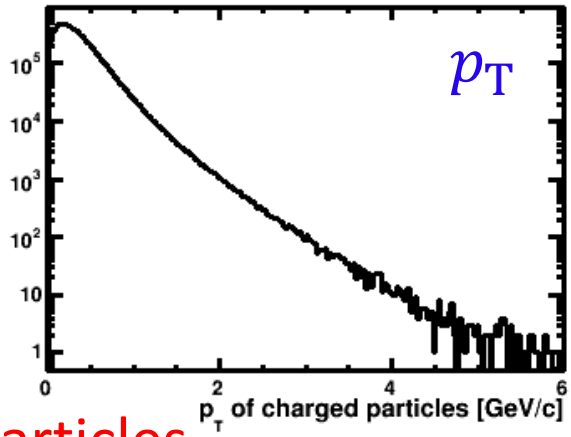




Simulation with HIJING: charged particles

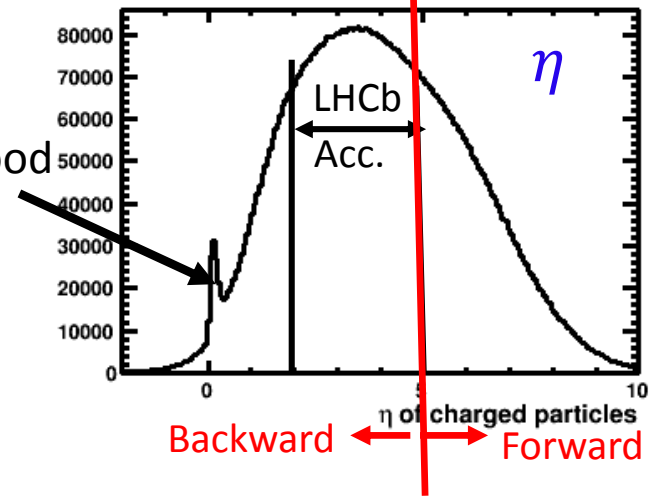
- HIJING version: 1.383bs.2
- p + Pb (target), E_beam=7 TeV, 10,000 events generated
- No pile-up (number of interaction fixed to be 1)

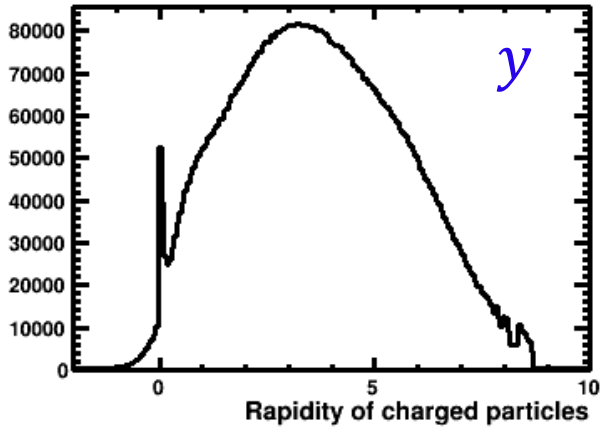




Charged particles

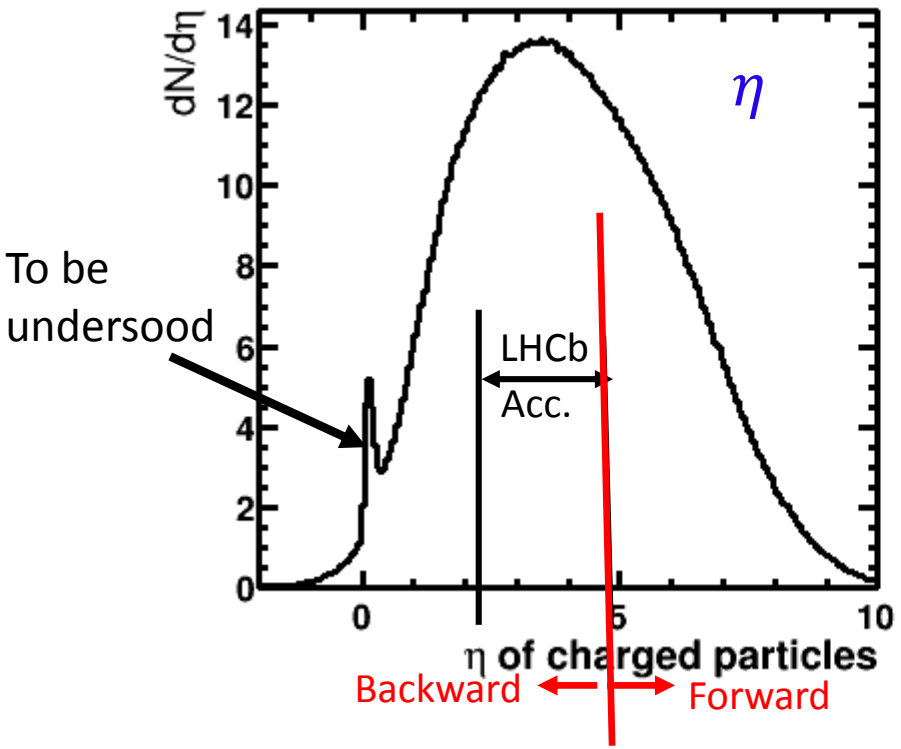
To be undersood

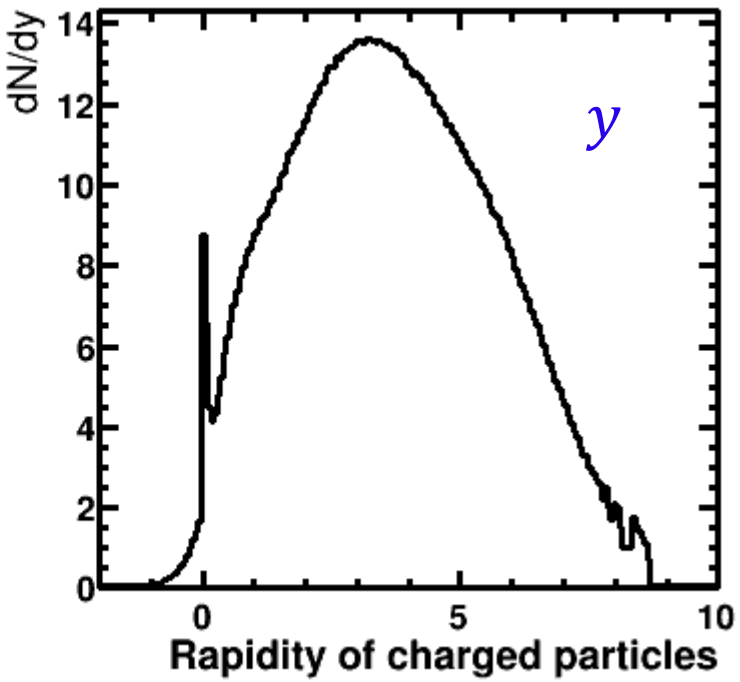




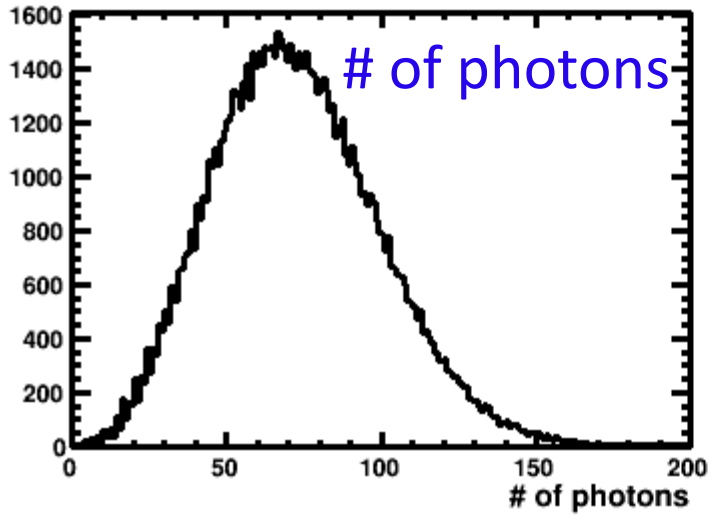
Simulation with HIJING: charged particles

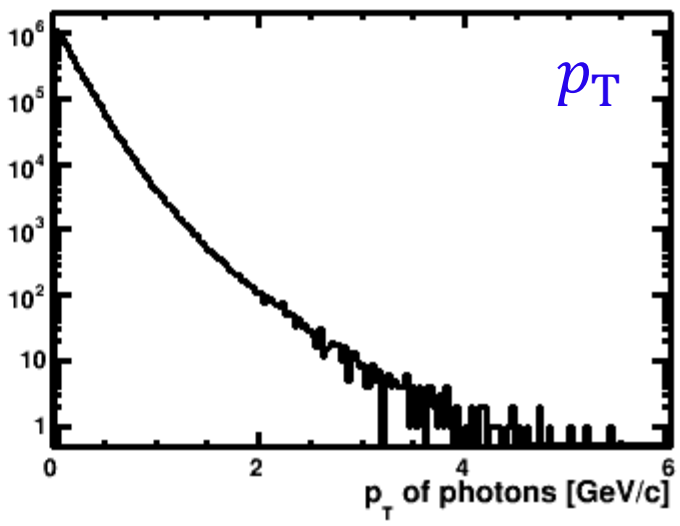
- $\frac{dN}{d\eta}$ as a function of η
- $\frac{dN}{dy}$ as a function of y

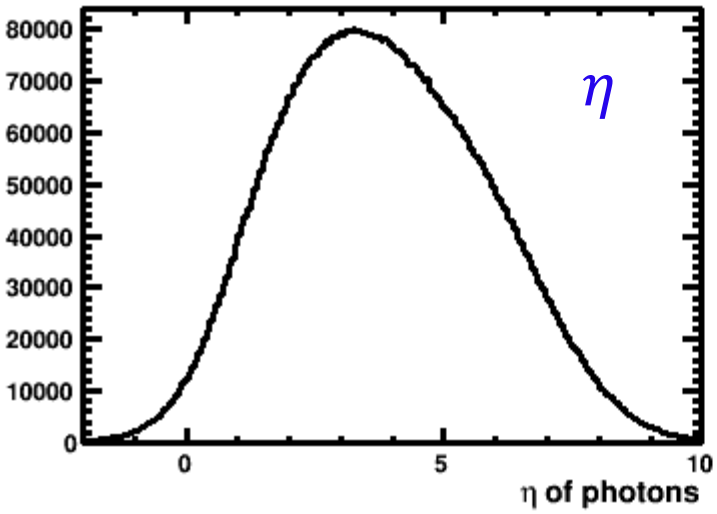


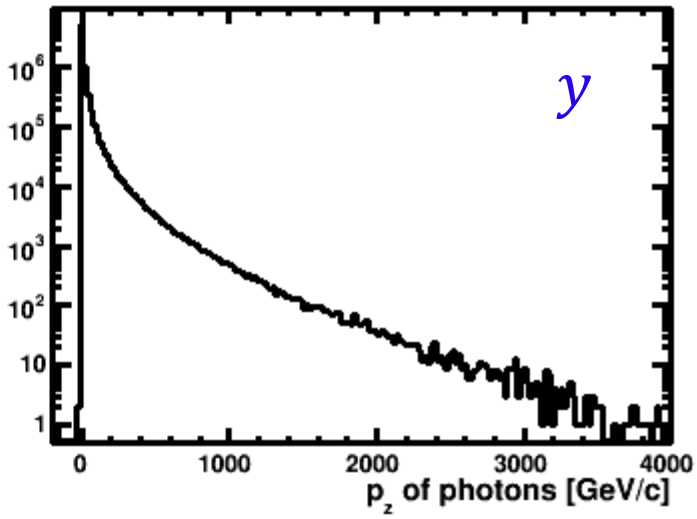


Simulation with HIJING: photons





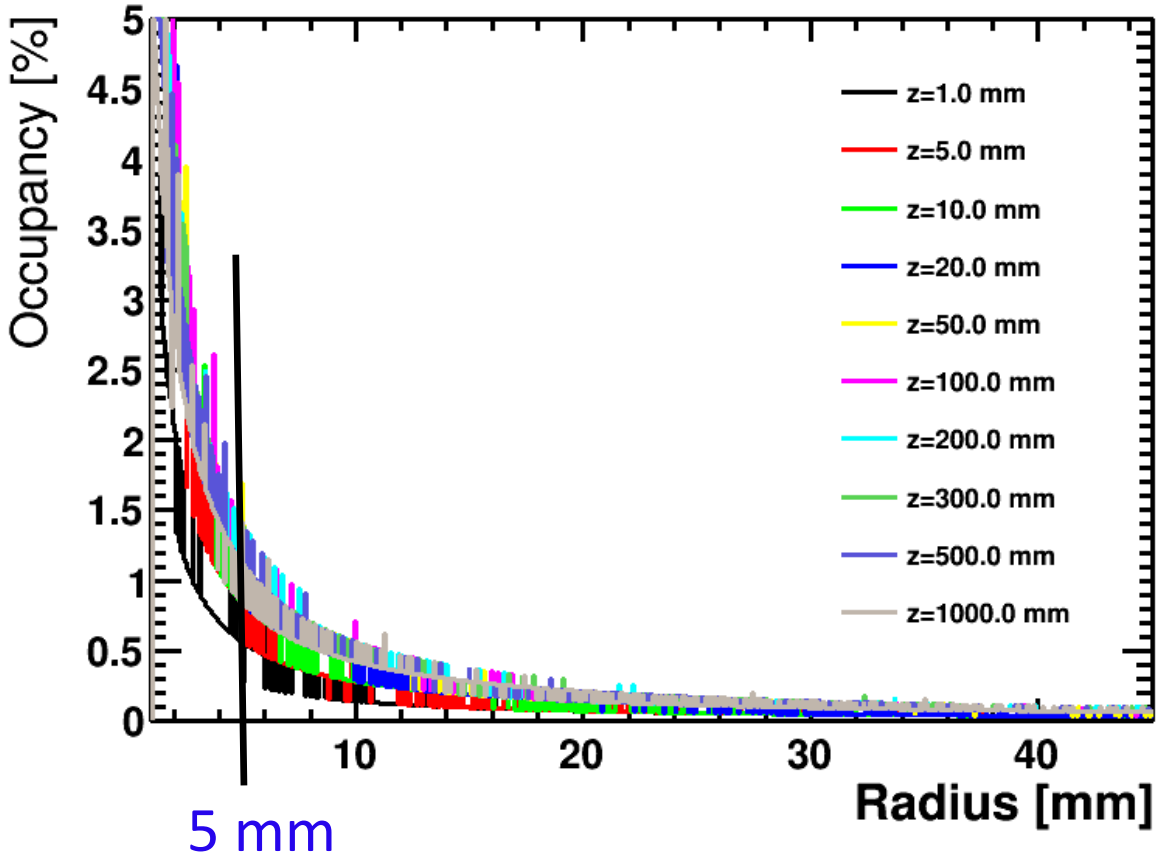




Simulation with HIJING: pixel occupancy

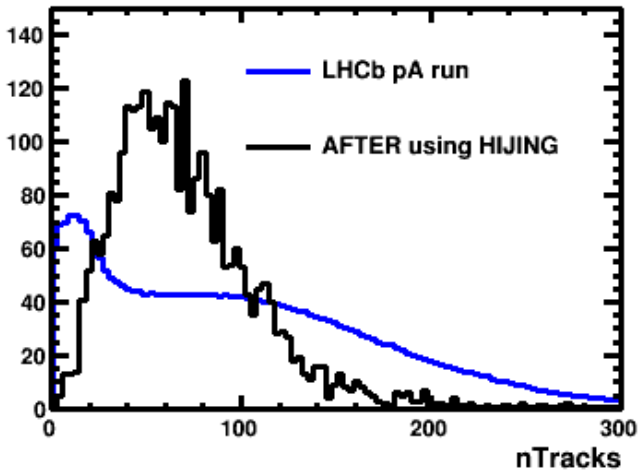
- Pixel occupancy at various z position as a function of radius
- Maximum occupancy adopted
- Seems quite high, but more investigation needed

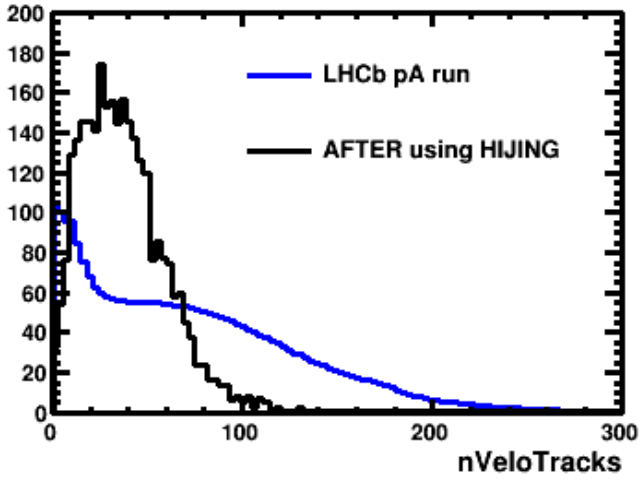
  HIJING gives too high multiplicity? or definition of occupancy?

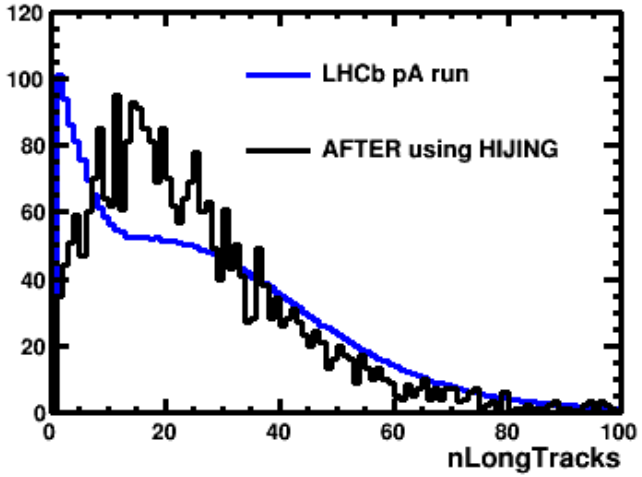


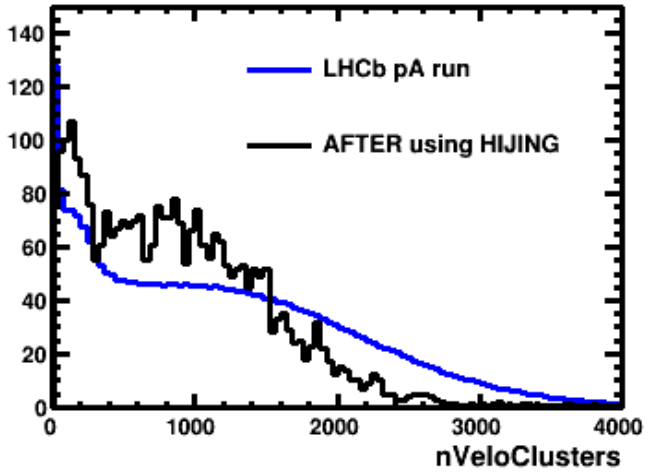
Full simulation in LHCb detector: multiplicity

- 3,000 events generated by HIJING, current LHCb detector used
- compared to LHCb pA run

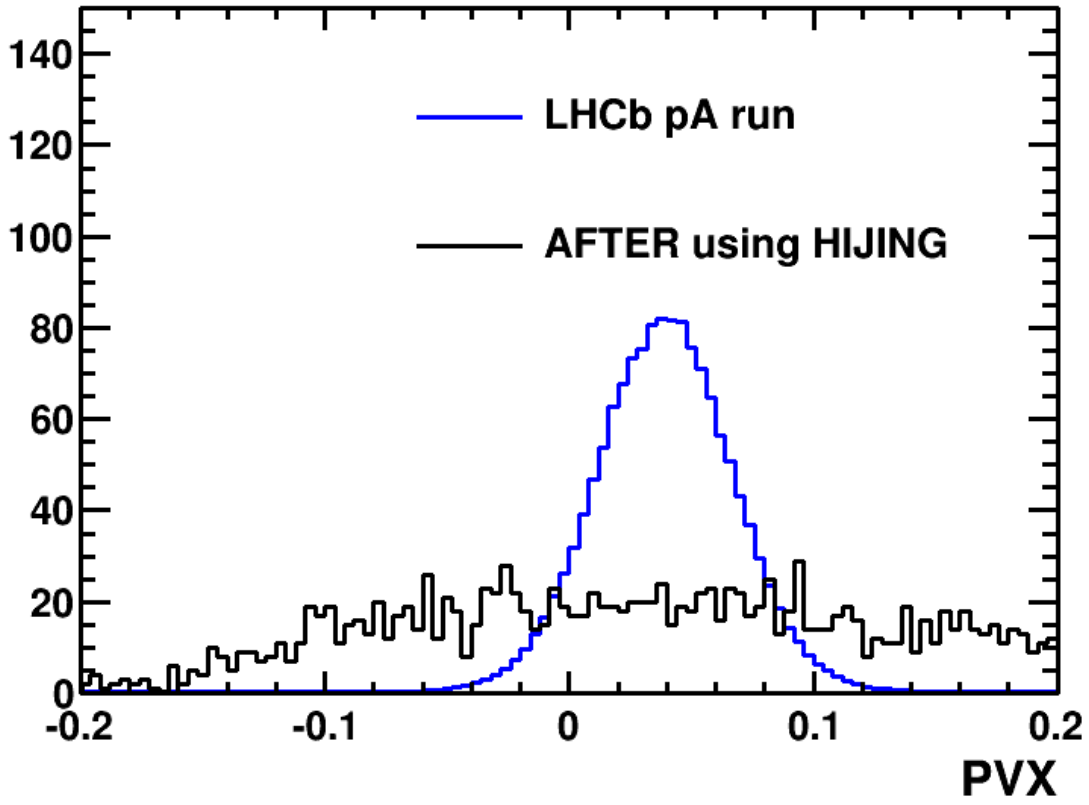






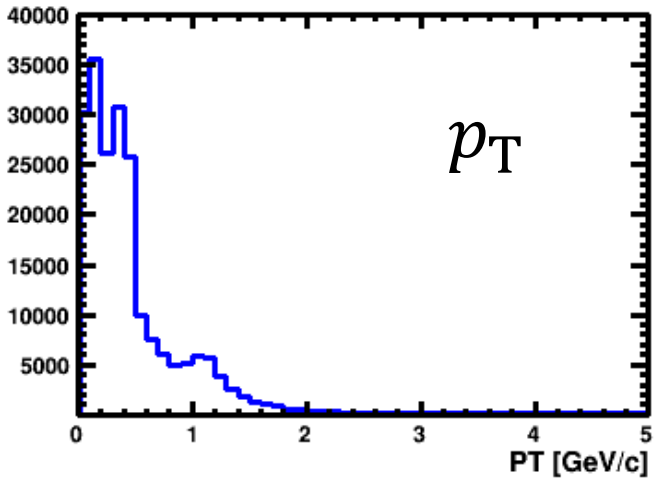


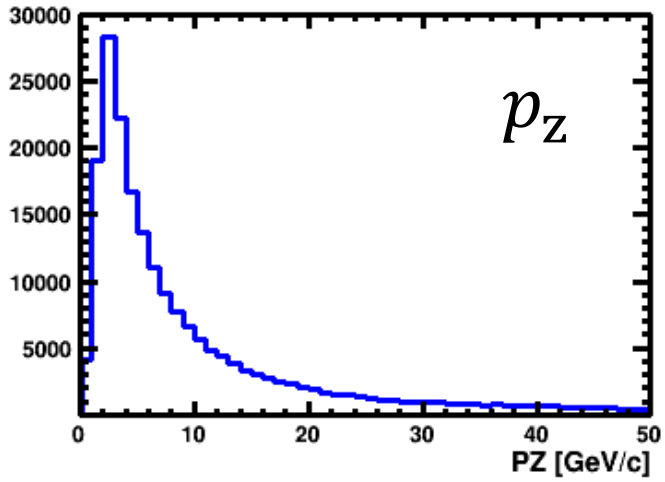
Full simulation in LHCb detector: PV

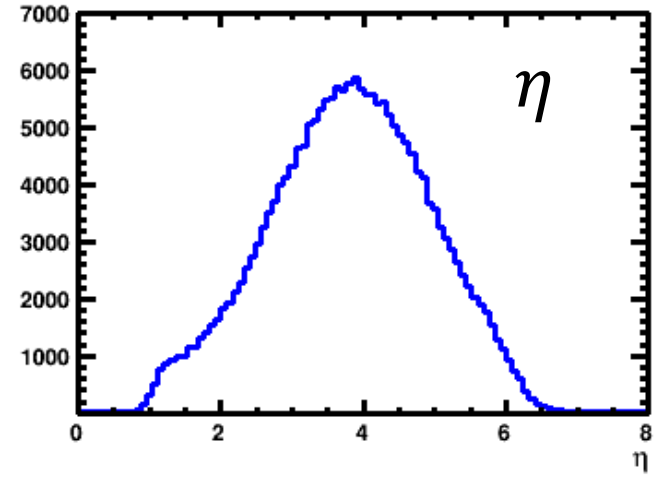


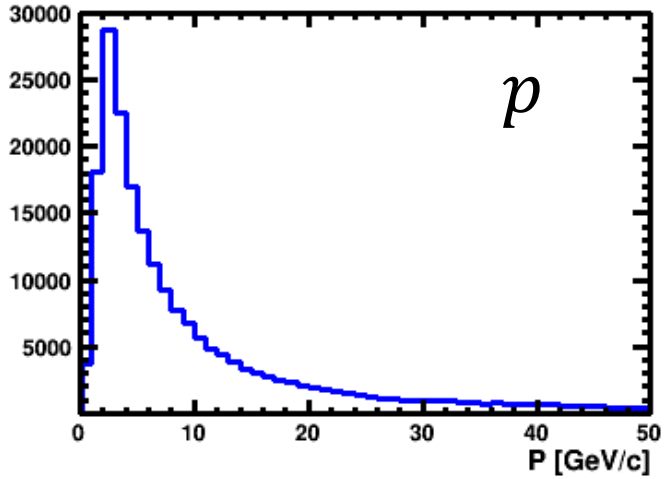
- Cannot directly compare
- because in the Simulation, interaction point uniformly distributed in z direction inside VELO

Full simulation in LHCb detector: Kinematics









- η exceeded (2,5) because the large roaming of interaction points in z direction.

Summary and next-to-do

- The simulation just started using HIJING
- The occupancy of the vertex detector is estimated
  - ✓ Need to understand the occupancy and the HIJING multiplicity
- A full simulation in the LHCb detector is tried
  - Multiplicities are comparable with LHCb pA run
  - Some tunes are needed to make a reasonable comparison for PV resolution, kinematic distributions, etc.
- Update of HIJING to new version is needed
- Comparison with other generators is also in need

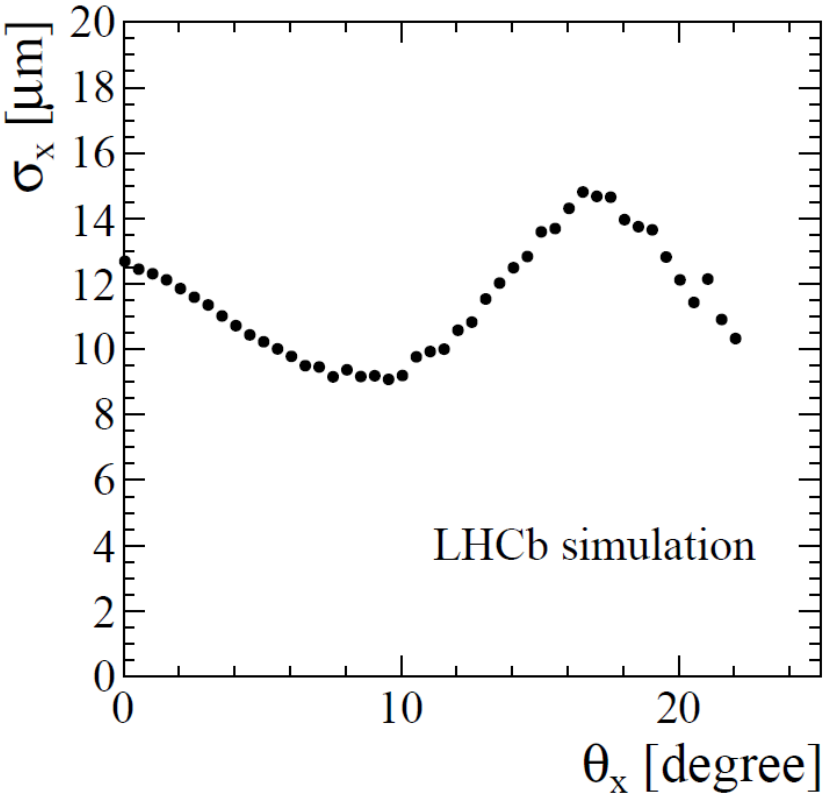
Thank you!

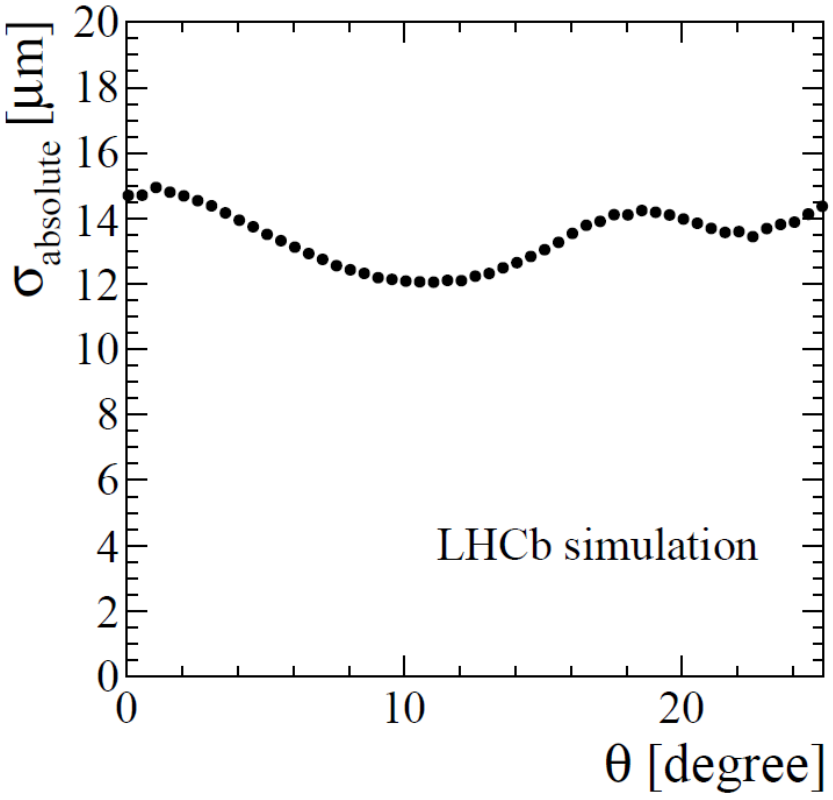
Backup slides

VELO upgrade parameters

Table 3: System parameters of the VELO upgrade.

# modules	52
# ASICs per module	12
# ASICs total	624
# silicon sensors	208
silicon sensor thickness	200 μm
# pixels	41 M
pixel dimensions	55×55 μm^2
position of first station upstream	-289 mm
position of last station downstream	751 mm
radiation level at 5.1 mm radius	1.1 - 1.8 $\times 10^{14}$ 1 MeV n_{eq}/ fb^{-1}
radiation level at 50 mm radius	1.7 - 2.6 $\times 10^{12}$ 1 MeV n_{eq}/ fb^{-1}
Total active area	1243 cm^2
Peak total data rate	2.85 Tbit/s
# optical links	1664


σ_x [μm]
20
18
16
14
12
10
8
6
4
2
0
0
10
20
θ_x [degree]
LHCb simulation


$\sigma_{absolute}$ [μm]
20
18
16
14
12
10
8
6
4
2
0
0
10
20
θ [degree]
LHCb simulation