

LHCb Outer Tracker

Shreya Roy, GSI

- Hit rates
- Occupancy
- Aging



UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386



Outer Tracker

The LHCb Outer Tracker story..

- 2004: start construction
- 2005: end construction
- 2008: installation in LHCb (2010-12, 2015-18)
- 2018: end of operation
- 2023: shipment to GSI, Darmstadt

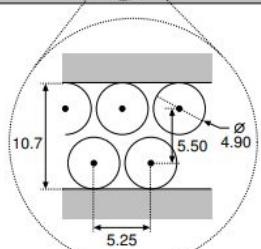
Final parameters

- Cathode: Kapton XC
- Anode: Gold + Tungsten (+1550 V)
- Panel: Rohacel
- Glue: Araldite Epoxy AY103
- Gas: Ar/CO₂/O₂ : 70/28.5/1.5

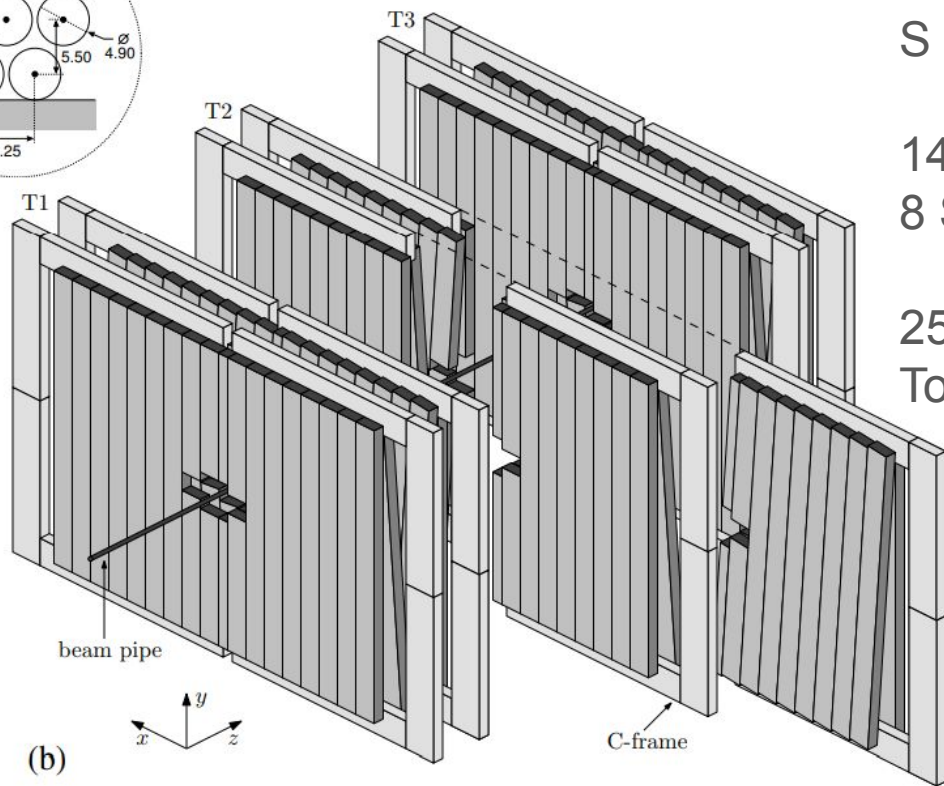




31.00



(a)



(b)

F type = 4.85m length
S type = 2.5m length

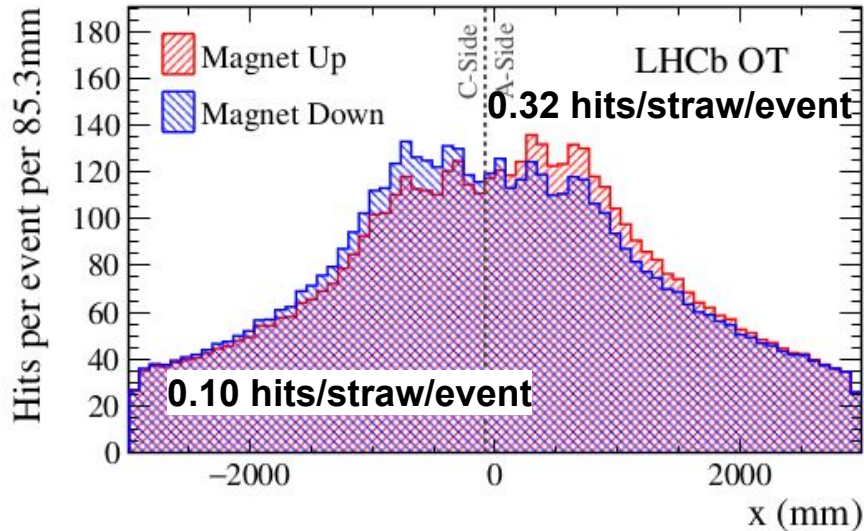
14 F/module
8 S/module

256 straws/module
Total 53760 straws

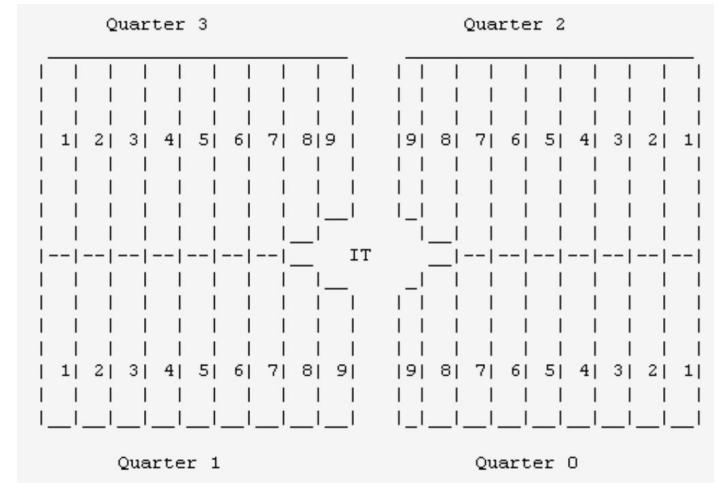
Figure 1. (a) OT module cross section, with distances in mm. (b) Arrangement of OT straw-tube modules in layers and stations.

Hit rates in LHCb in Run2

- pp collisions (COM energy 1.38 TeV)



P. d'Argent et al 2017 JINST 12 P11016

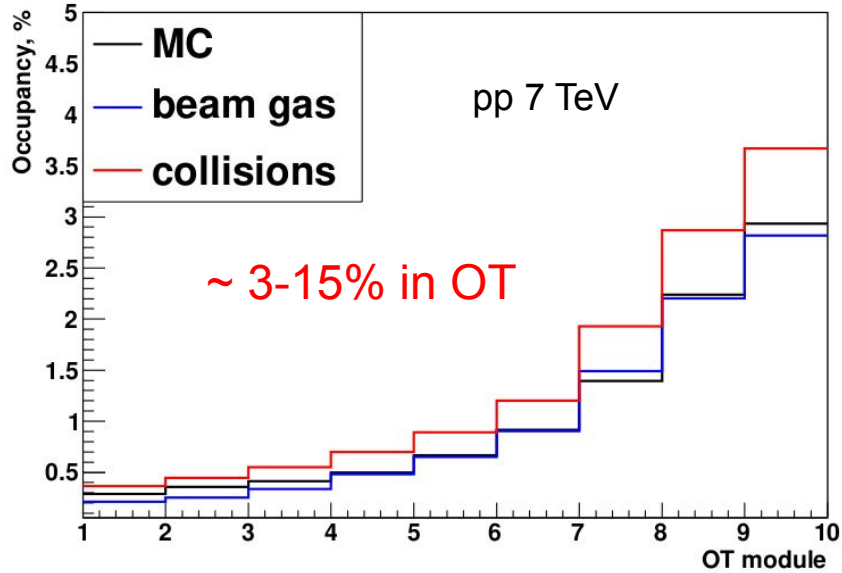


At the central region:
(LHCb) $0.32 \times 30\text{MHz} = 9.5 \text{ MHz/straw}$

At the sides:
(LHCb) $0.1 \times 30\text{MHz} = 3 \text{ MHz/straw}$

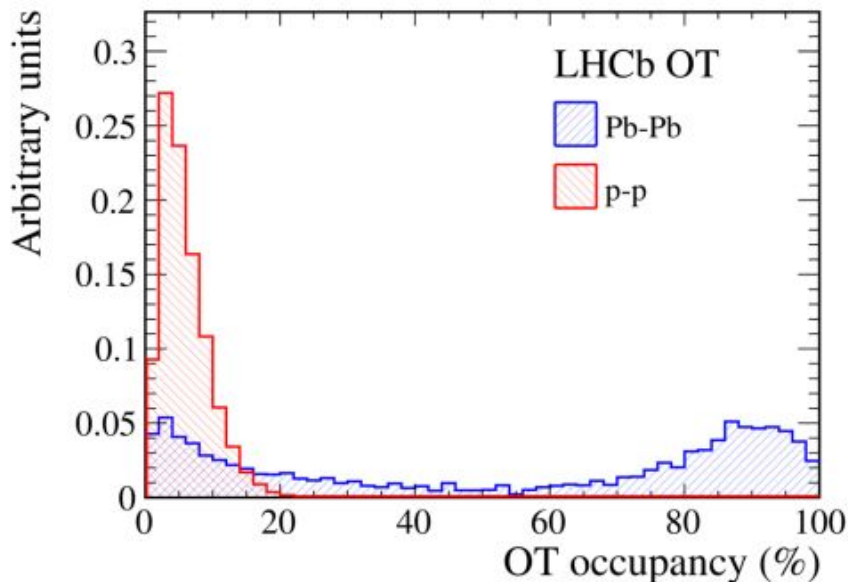
Occupancy in LHCb

LHCb Run 1 (2009)



OCCUPANCY IN PROTON AND LEAD COLLISIONS

- Average occupancy for pp -collisions in Run II (2015&2016) is 12.7%.
- Only 30 noise hits per event compared to ~ 6800 hits from particles
- Maximum particle flux: 168 kHz/cm²
- OT has been operated during Pb-Pb runs, but analysis limited to event centrality of 60%

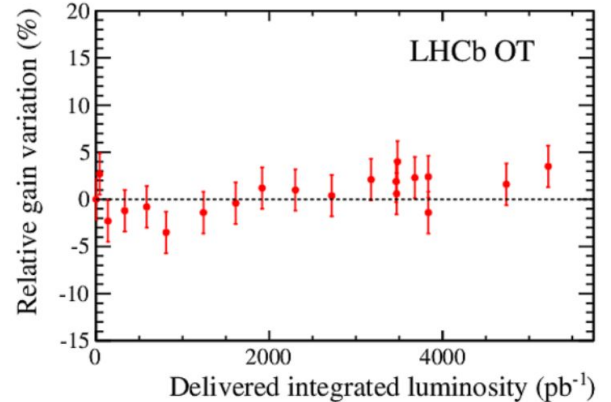
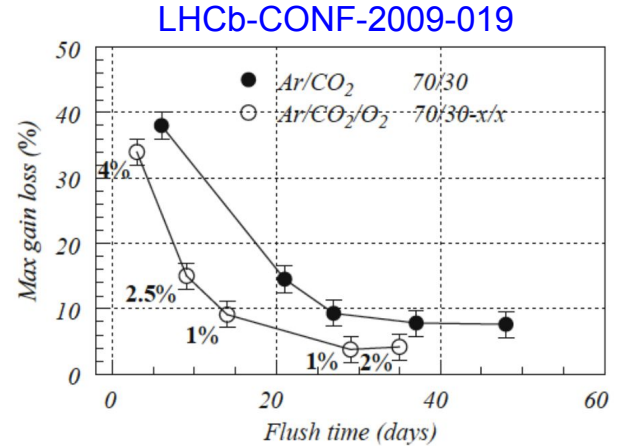


Aging status of the LHCb OT

- The culprit : Glue sample shows outgassing
- Solution : adding 1.5% Oxygen prevents deposits, (formation of O₃)some chemistry involved

Summary:

- High hit efficiency (>99%)
- Handled 10 MHz rates/straw
- Good resolution (~200 μm)
- No irradiation effects observed (~0.4 C/cm in hottest region)

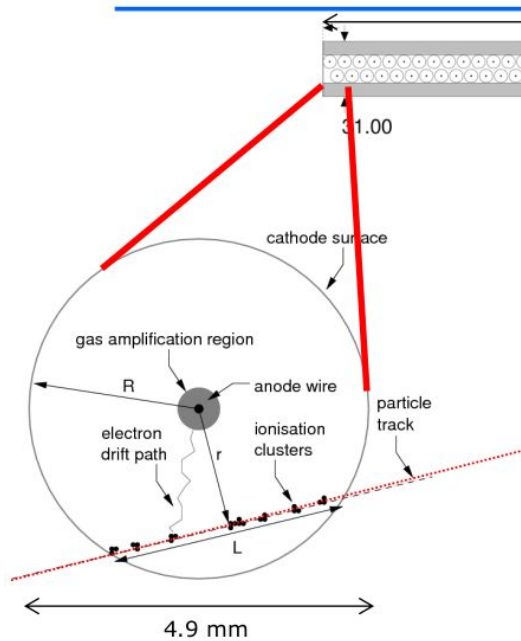


Picture LHCb OT (Dec 2024)



backup

Outer Tracker



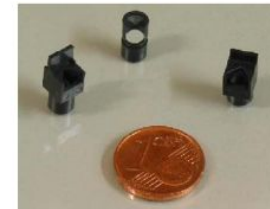
- Cathode: Kapton XC
- Anode: Gold + Tungsten (+1550 V)
- Panel: Rohacel
- Glue: Araldite Epoxy AY103
- Gas: Ar/CO₂/O₂ : 70/28.5/1.5

+ wire locators every 80cm
to hold anode wire at center:



Careful studies of all materials, prior to construction:

S.Bachmann et al.
The straw tube technology for the LHCb outer tracking system
NIMA 535(2004)171



Occupancy and hits

On average about 7000 straws per event are hit corresponding to an occupancy of about 13%, of which about 2/3 are caused by particles created in secondary interactions, and about 1/3 are caused by particles coming from the primary interaction.

The probability that a charged particle leaves a hit when traversing the straw close to the wire ($r < 1.25$ mm) is about 99.2%. The small gap between two straws (~ 0.35 mm) leads to an inefficiency of about 6.7%, and therefore typically 22 OT hits are expected for a charged particle traversing the entire OT detector, containing 24 monolayers

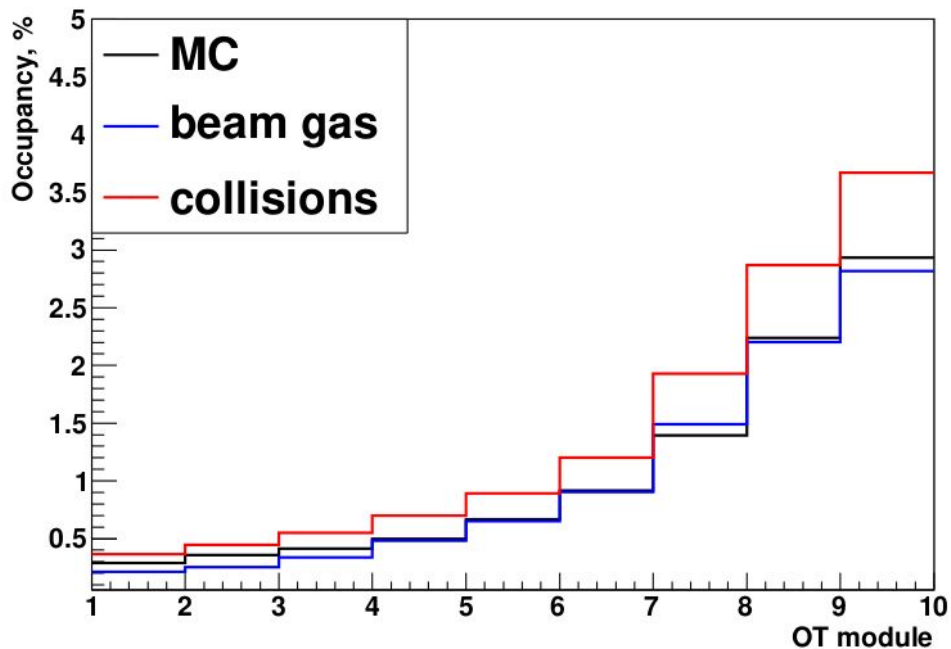
- 30 noise hits per event
- 8 dead channels out of 53760 straws

<https://cds.cern.ch/record/1635371/files/LHCb-PROC-2013-080.pdf>

Occupancies in modules

Occupancy = % firing channels, event averaged.

first beam collisions, run 062558



- For collisions occupancy is slightly higher.

Occupancy overall OT

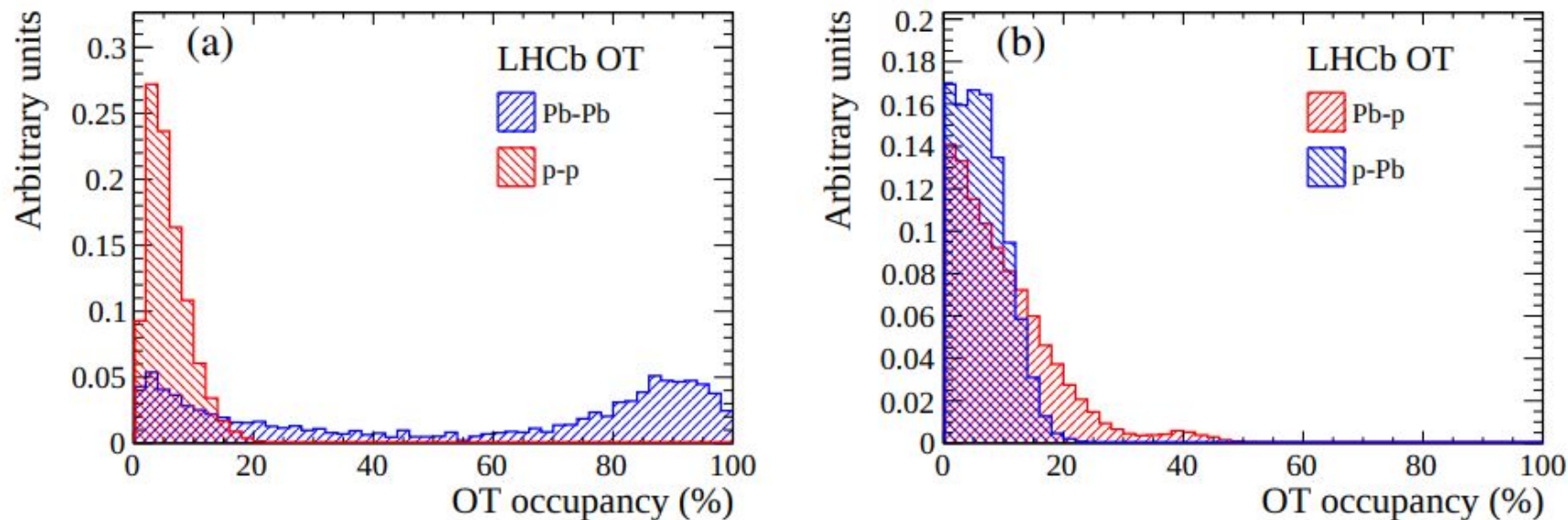


Figure 6. The average number of recorded hits (a) in minimum bias proton-proton and PbPb collisions and (b) p Pb and Pb p collisions.

Occupancy in LHCb OT

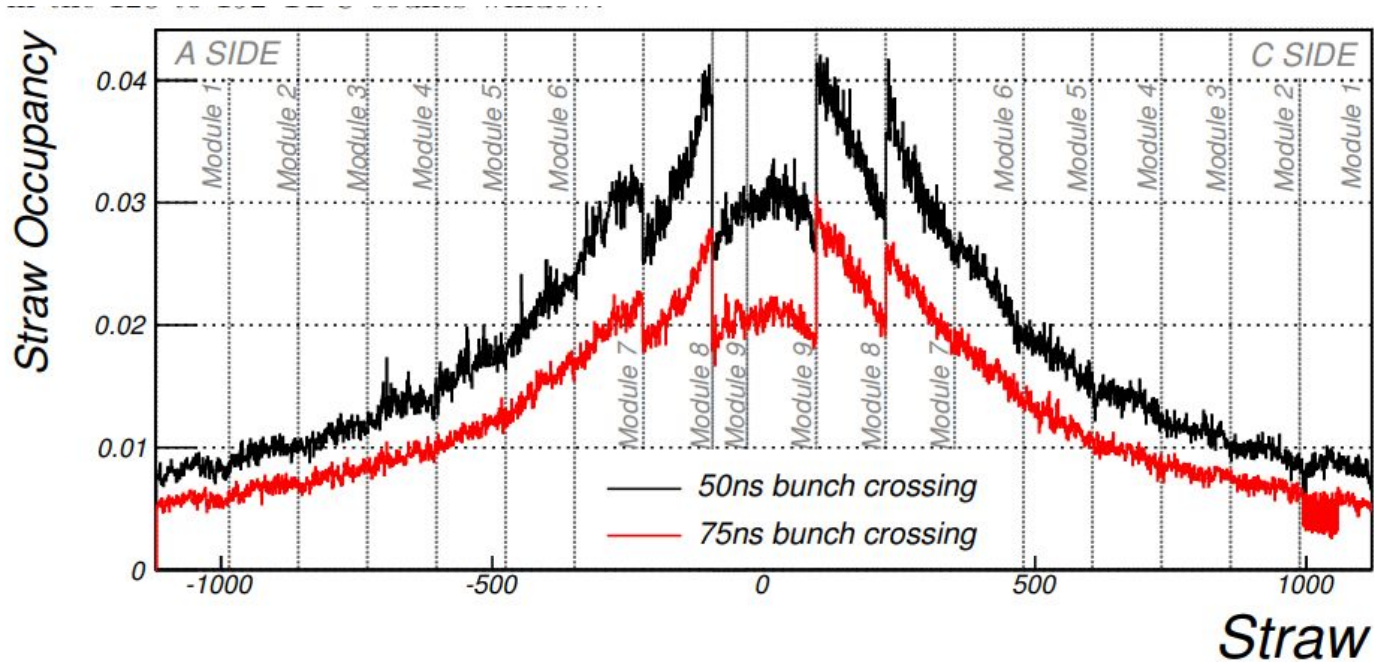
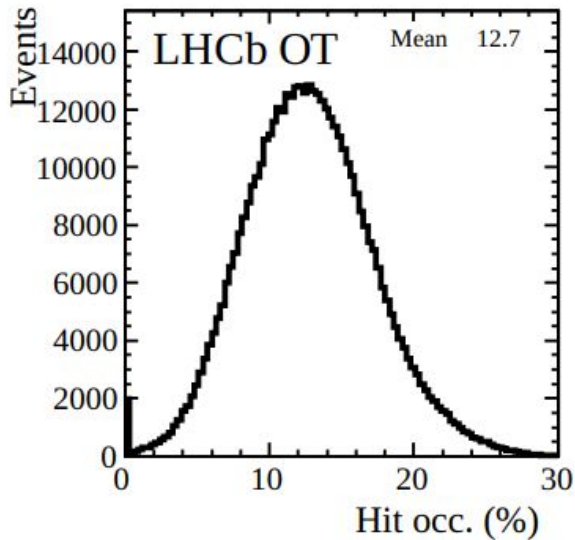
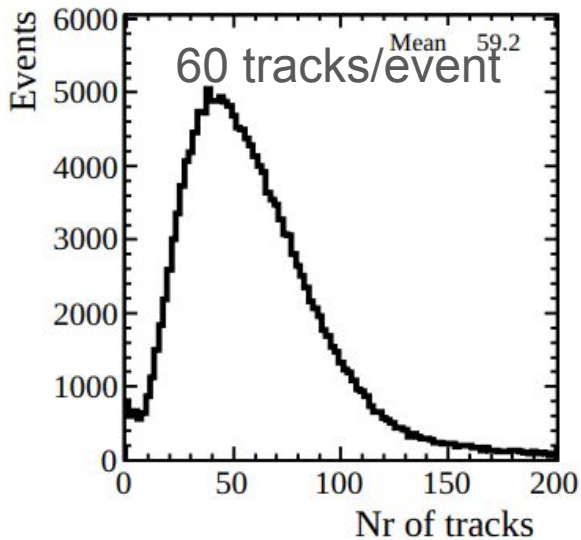


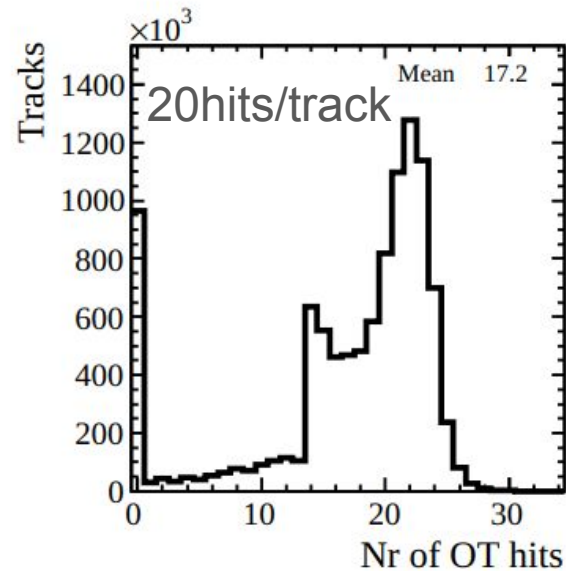
Figure 14: Straw occupancy for 75 ns bunch-crossing spacing in red, and 50 ns bunch-crossing spacing in black.



(a)



(b)



(c)

1200 hits per event in OT

Figure 3. Typical run conditions for a run in June 2012 (run 118335), with (a) hit occupancies per event around 13% and (b) 60 tracks per event with hits in both the Vertex Locator and the tracking stations (so-called “long” tracks). (c) The number of OT hits assigned to these long tracks peaks around 22. A fraction of the tracks do not have any OT hits assigned, as these tracks only traverse the inner silicon detector at large rapidity close to the beampipe.

Tracks

(Taken from LHCb group meetings)

General numbers:

	#tracks/evt	#hits/track
MC	9.5	18.9
BEAM GAS	5.1	16.2
COLLISIONS	8.2	16.5

