Test Beam: Di-muon Analysis

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Di-Muon DT Local Trigger Properties

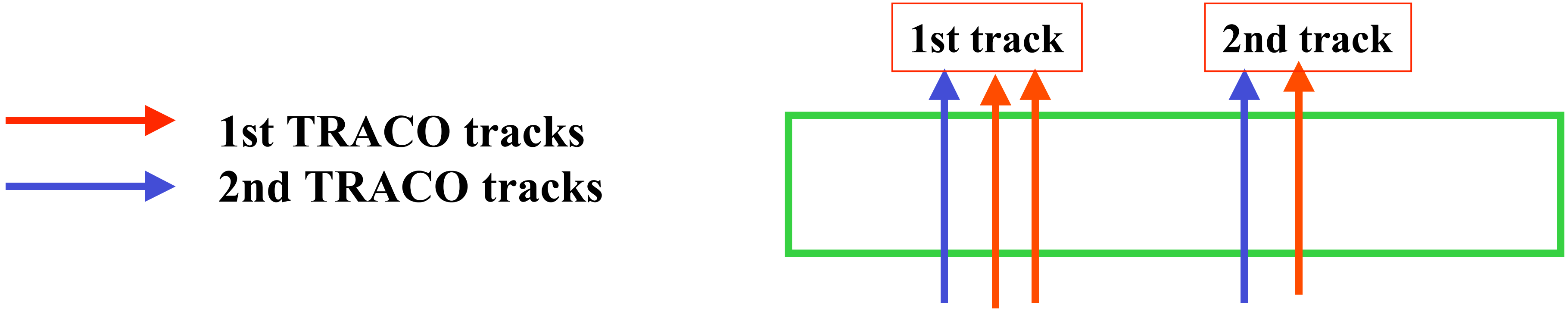
Di-Muon Selection

Results

The analysis is in progress

Presented by S. Marcellini; CMS week, 9-dec-2003

How Does the Local Trigger Perform the Sorting ?



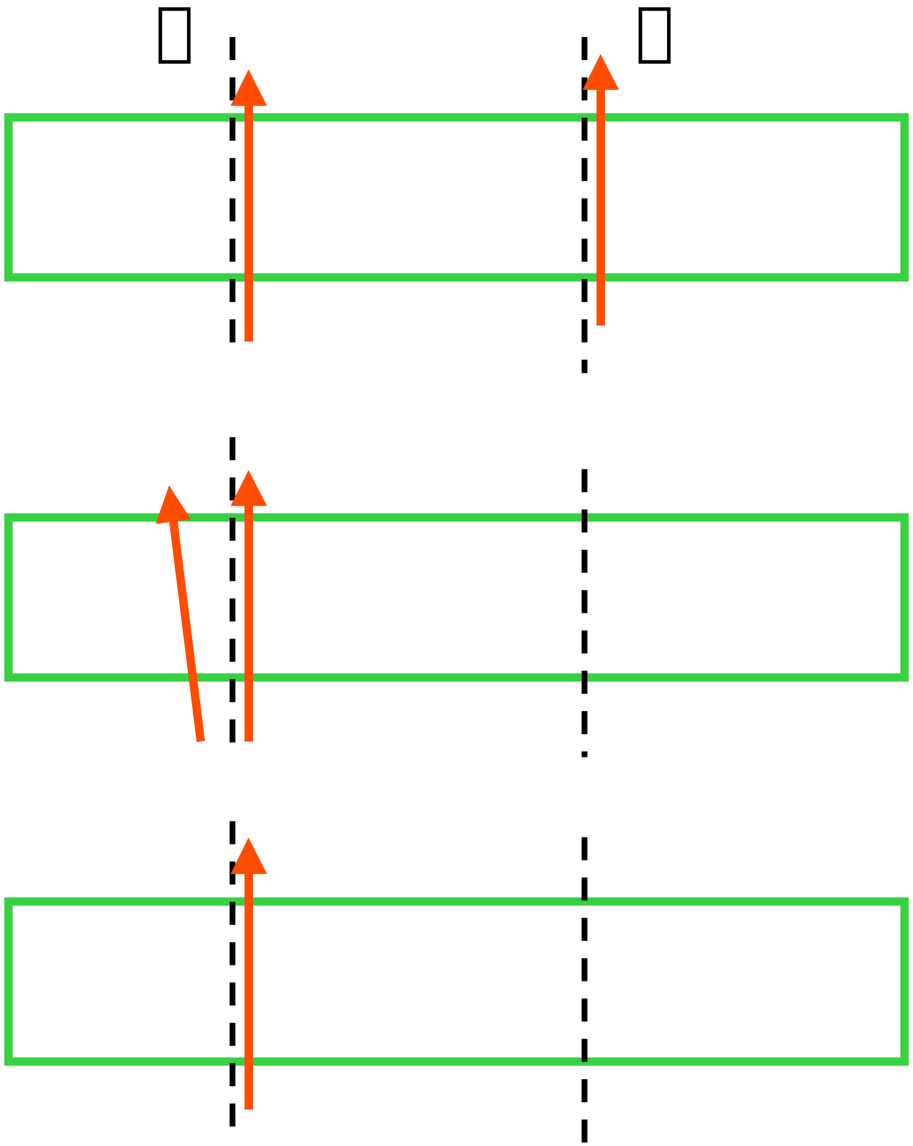
The sort 1 is performed and **the best track is found.**

A **ghost suppression** is performed, to identify ghosts and remove them form this phase of the sorting.

The 2nd best is found whithin the 1st tracks. This is called **"carry"**.

The "carry" is included whithin the second tracks and the **absolute 2nd best** track is found

Di-Muons: What do we expect from the local trigger ?



Case a) : both muons are correctly identified by the trigger as 1st and 2nd track, at the correct BX (or one at the correct BX and the other at the nearby BX)
This is the correct behavior of the system.

Case b) : Two triggers are delivered at the correct BX, as 1st and 2nd track, but the 2nd is a ghost of the first. One muon is missed by the local trigger

Case c) : Only a 1st track is delivered by the trigger at the correct BX, and again one muon is missed by the local trigger.

Di-Muon Event Selection

In each run, about 7 % of the events has two muons crossing the chamber, BUT almost all of them do not belong to the same beam shot (bunch crossing). They cross the chamber at different bunches, separated by 25 ns or more.

The track fitting can reconstruct both muons even if they belong to different bunches, but, on the other hand, the trigger treats them as events occurring at different time.

We are interested in di-muons crossing the chamber at the same time, (at the same bunch crossing) to test the trigger performance.

The di-muon selection should not bias, as far as possible, the di-muon sample itself.

General requirements on the event (also used by single muon analysis)

- There is a trigger scintillator hit (within ± 2ns around the peak)
- > 2 hits ``in time'' in the beam spot region.
- < 3 hits ``out of time'' anywhere in the chamber

To enrich the sample of di-muons (not necessary in time)

- > 6 hits in time both in Theta SL and in at least one Phi SL.
- < 12 hits in time in Theta SL (to reject splashes)
- 2 fitted tracks in Theta view, with χ^2/dof < 5 (again to reject splashes)

To enrich the sample of di-muons at the same BX

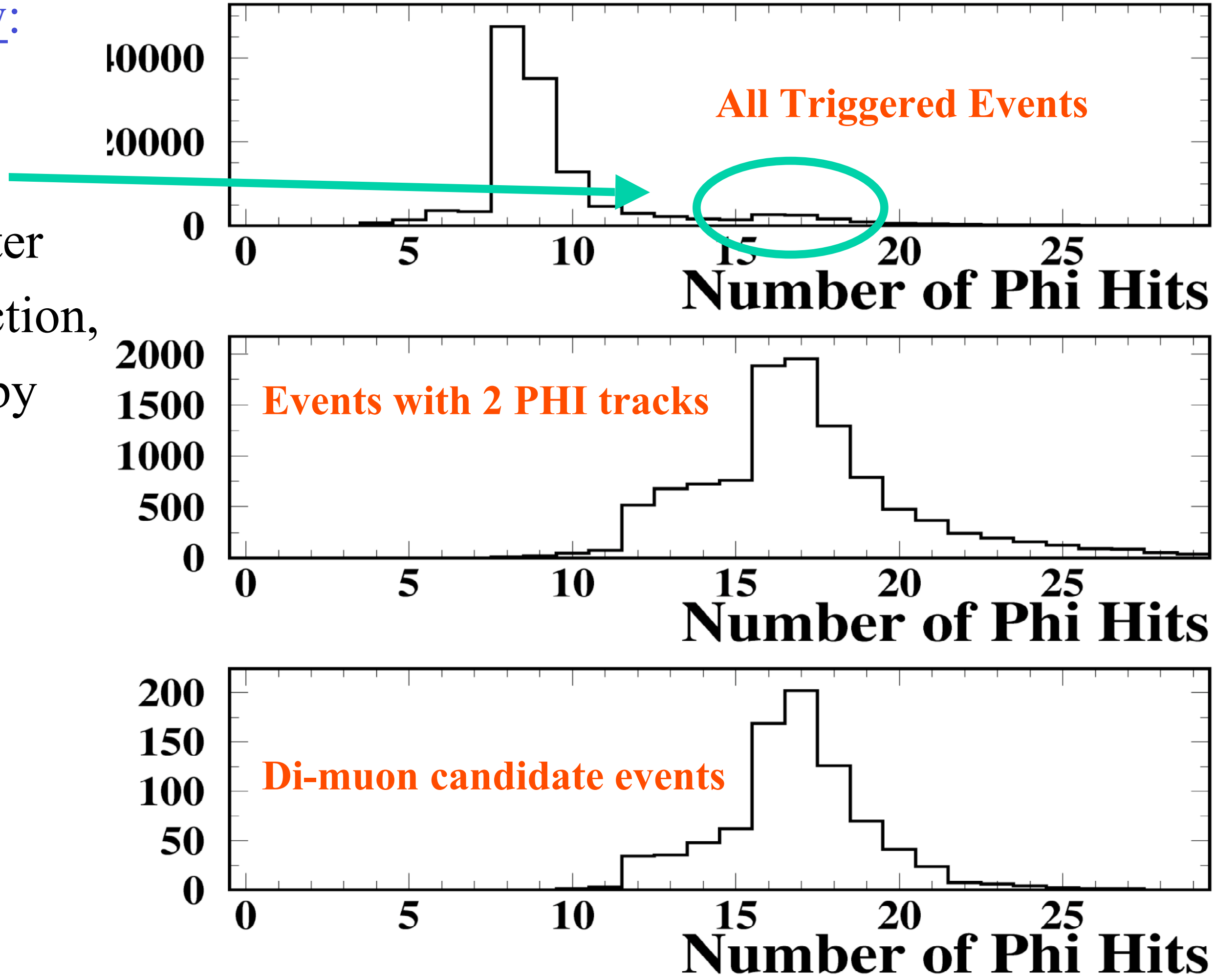
- 2 fitted tracks in Phi view with > 3 hits/track, and χ^2/dof < 10 (loose selection)
- No High Quality Triggers in Theta, out of correct BX (very efficient)

About 350 di-muon candidates in a 100 K event run, after the selection, and ~ 4000 over all the runs taken in the default configuration at any angle.

Di-Muon Event Selection: Number of Phi Hits

Hits in the Phi view:

The small bump of di-muons, visible after a general event selection, is further enhanced by the selection cuts



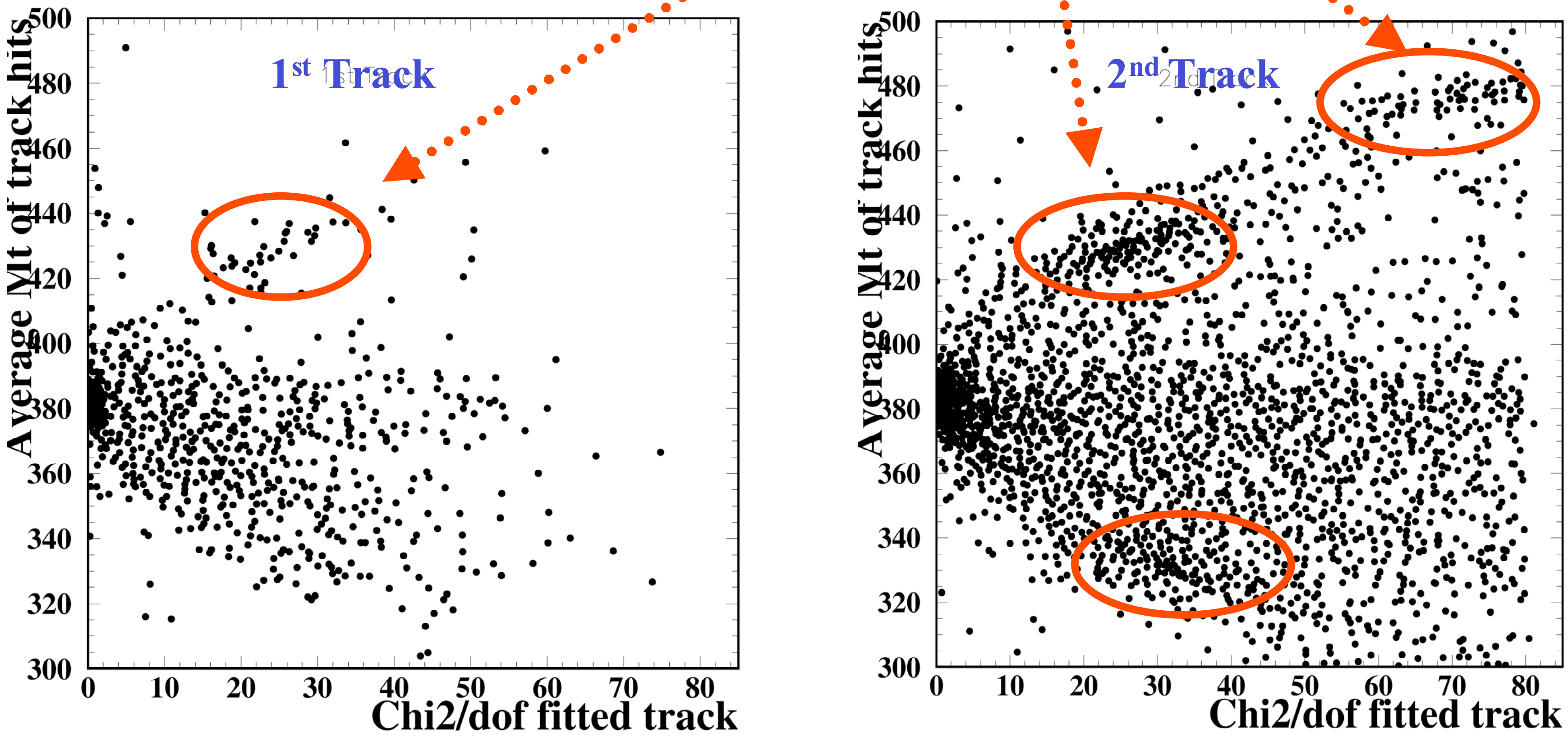
Di-Muon Event Selection: off time muons

The **Average Mean Timer** of the Phi tracks vs χ^2 /dof of the track fit, is ~ 380 ns (maximum drift time), and it shows blobs due to **muons at different BX,** shifted by 2*BX ~ 50 ns.

(Tracks are ordered according to their χ^2)

The 1st track is mostly in time

The 2nd one is more likely to belong to a different BX

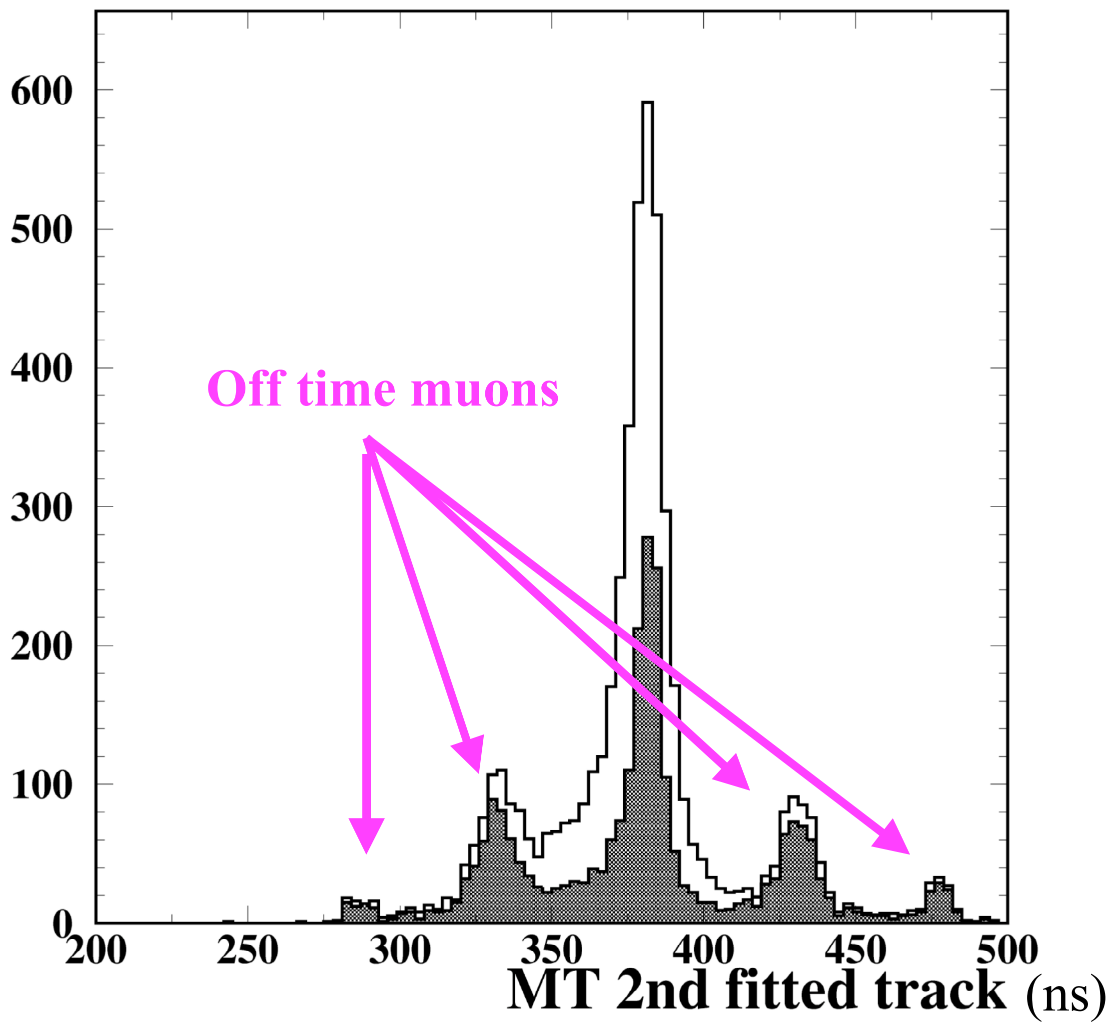


Di-Muon Event Selection: How to reject off time muons

The plot shows the average Mean Timer of the hits which belong to a fitted track in the Phi view.

Several off time muons in the di-muon sample are seen as peaks well separated from the maximum drift time (white histogram)

They are almost completely rejected by requiring
No High quality Theta triggers outside the correct BX
(shaded histogram are the events which do not pass the cut)



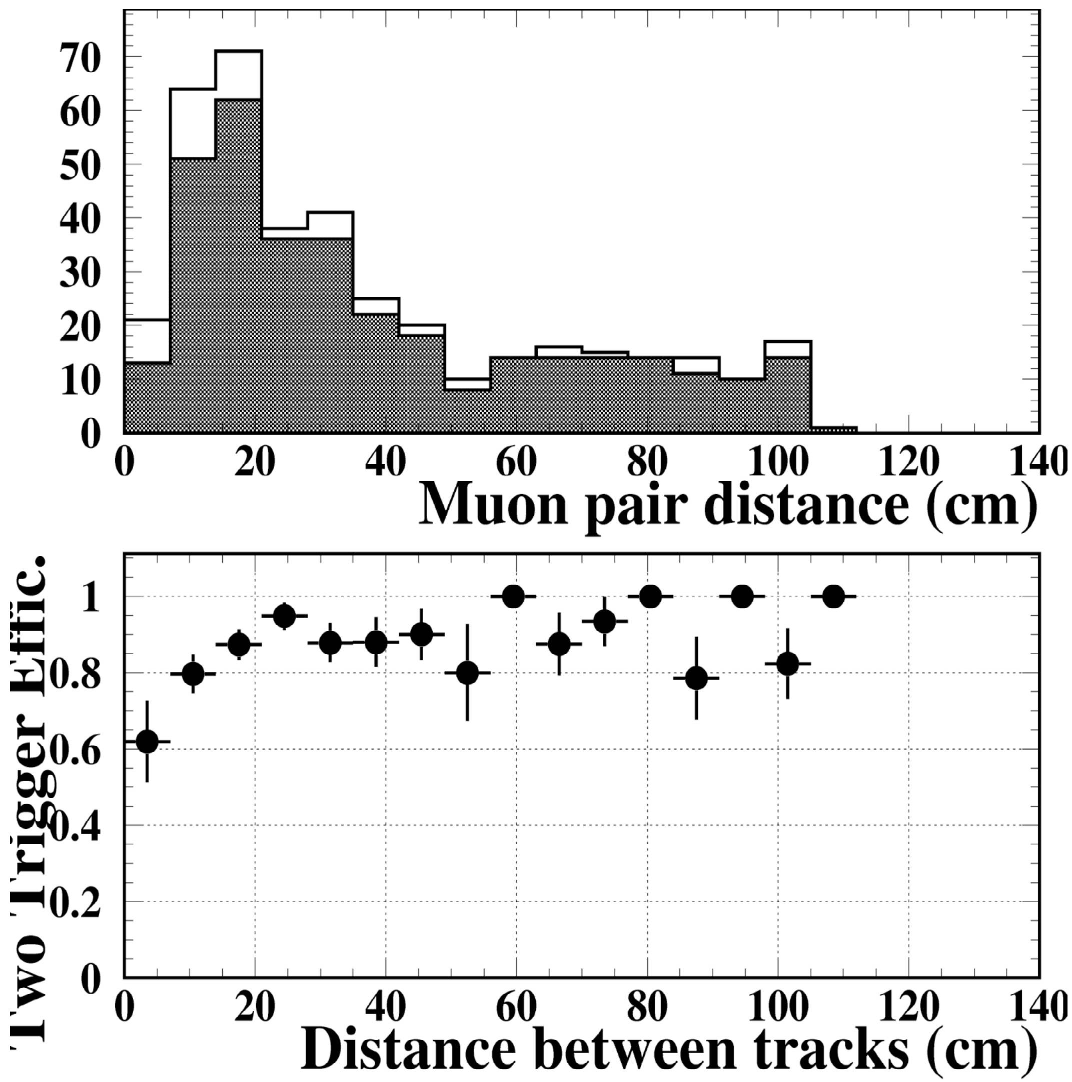
Di-Muon Efficiency: Two Triggers at Correct BX

-15 deg track inclination, as example

Distribution of muon pair separation in the chamber (white histogram) obtained from the track fit. Superismposed is the distribution of the same quantity for those events with 2 triggers recorded at the correct BX (shaded histogram)

The ratio of the two histograms above is shown here.

For close-by muons the efficiency is lower, due to the ghost suppression which can kill close-by triggers.
For well separated muons the efficiency is ~ 90 % or more.



Di-Muons: What do we expect from the local trigger ?

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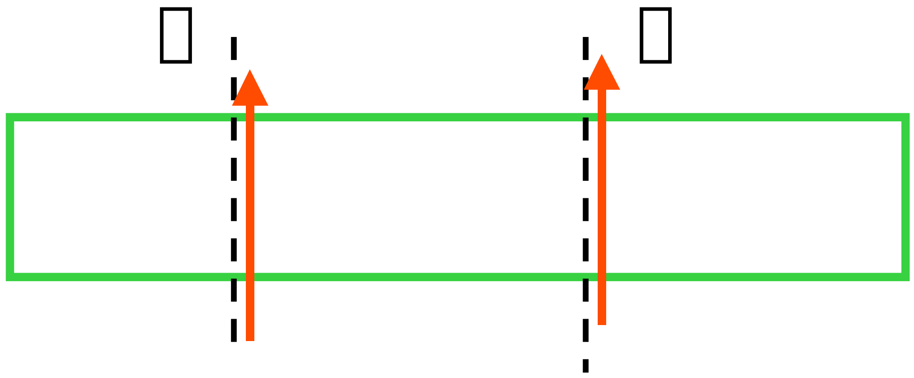
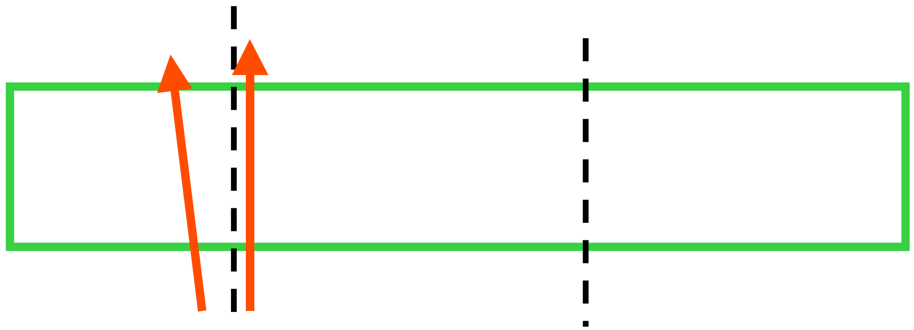
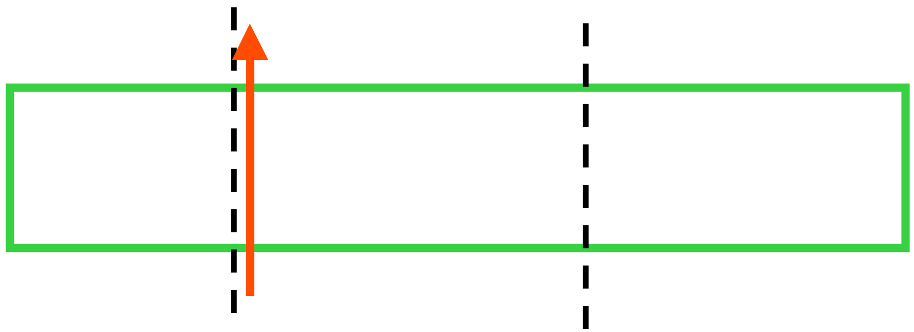
This is the correct behavior of the system.



Case b) : Two triggers are delivered at the correct BX, as 1st and 2nd track, but the 2nd is a ghost of the first. One muon is missed by the local trigger



Case c) : Only a 1st track is delivered by the trigger at the correct BX, and again one muon is missed by the local trigger.



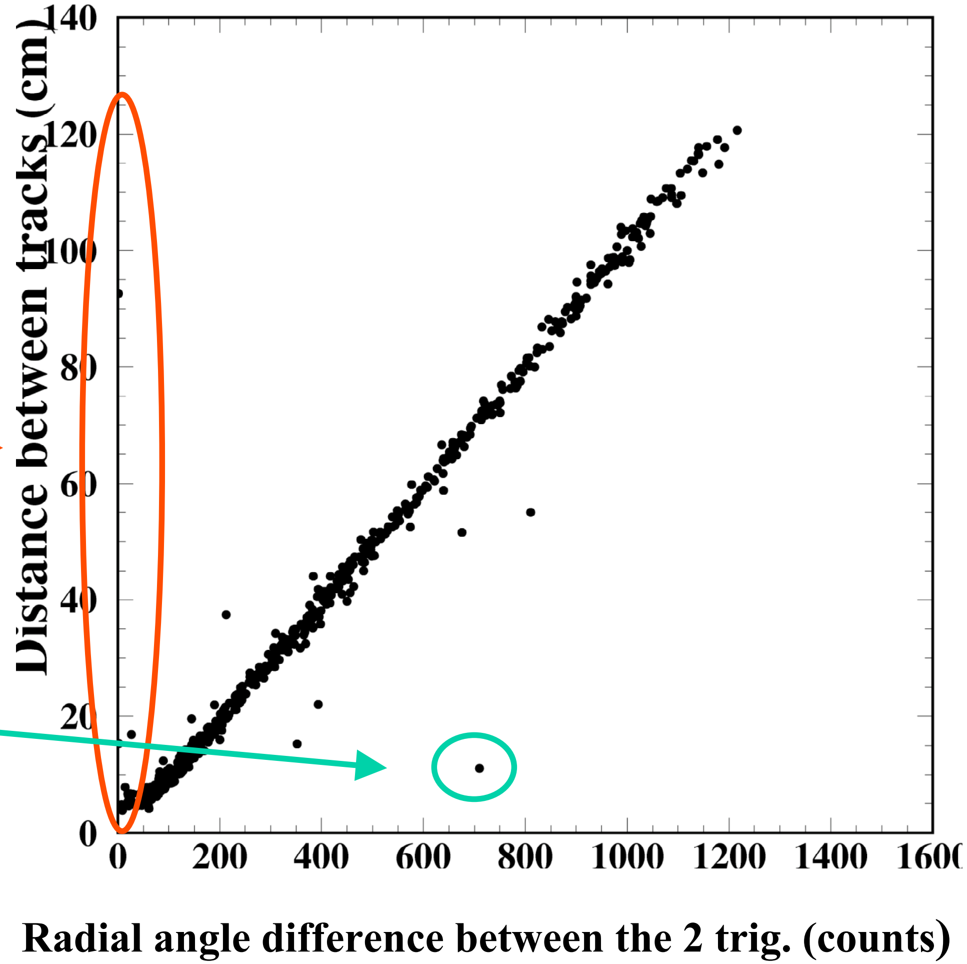
Di-Muons Identification (at correct BX)

Detecting 2 triggers is not enough: they also have to correspond to the two muons

In the sample with 2 Triggers at correct BX, there is a very good correlation between the distance of the tracks (from the fit) and the distance of the two triggers.

Ghosts are expected here:
(the 2nd trigger is a copy of the 1st).
They are almost absent.

The other points are mainly due to splashes and/or badly fitted tracks

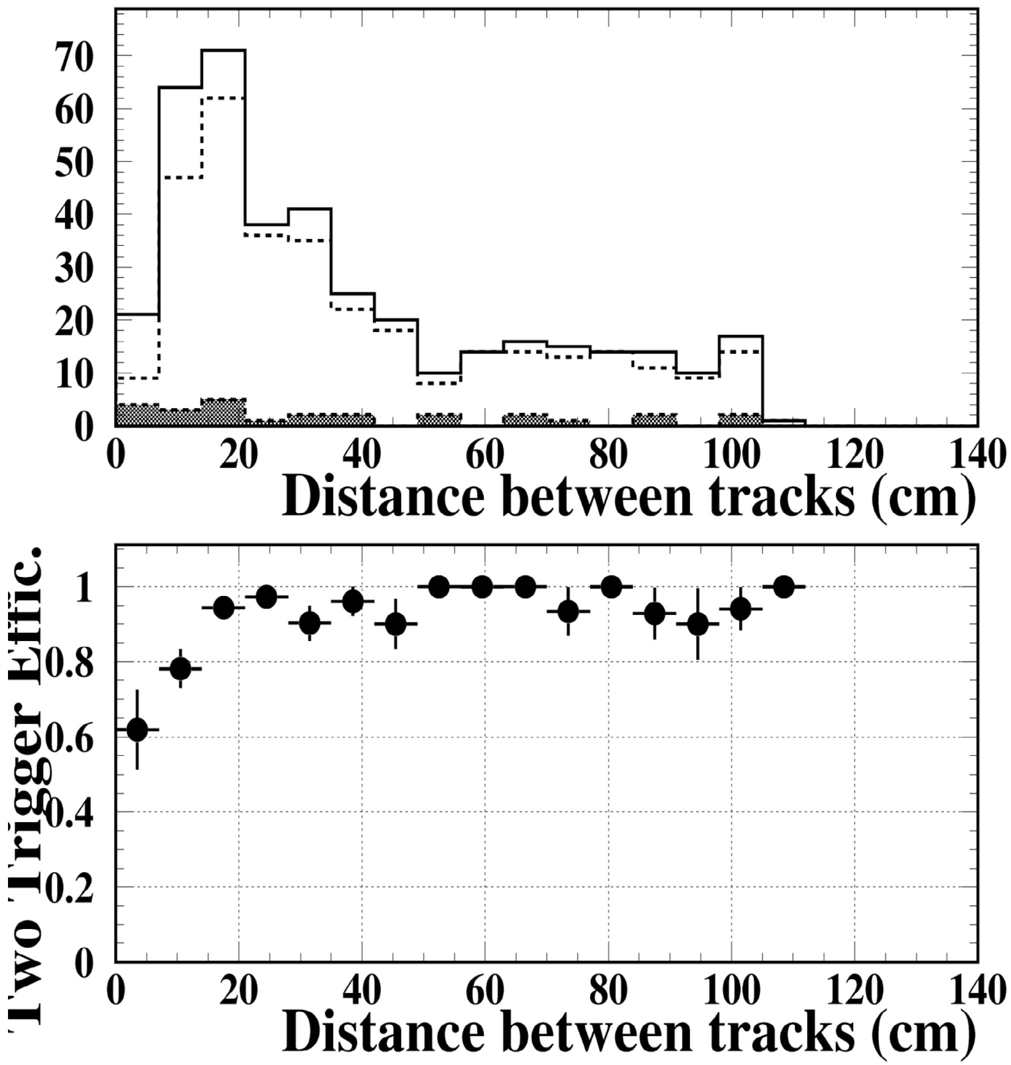


Di-Muon Efficiency

The **Track Finder** opens a window of **± 1 BX** around the ``correct BX'', when it searches for trigger segments to make a track.

Therefore even if only 1 trigger segment is found at correct BX, also nearby BXs can be used to find triggers.
The plot shows the distance between all the di-muon candidates (solid line), the case when 2 ``correct'' triggers are found at correct BX (dashed line) and the case when 2 ``correct'' triggers are found, one at the correct BX, and the other at the nearby BX (shaded histogram)

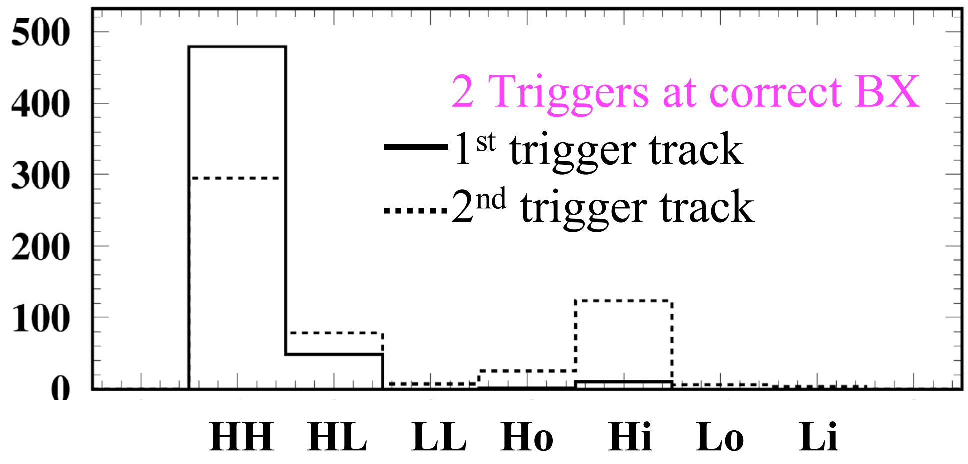
The **overall efficiency** to find 2 triggers, from the point of view of the Track Finder, is shown here.



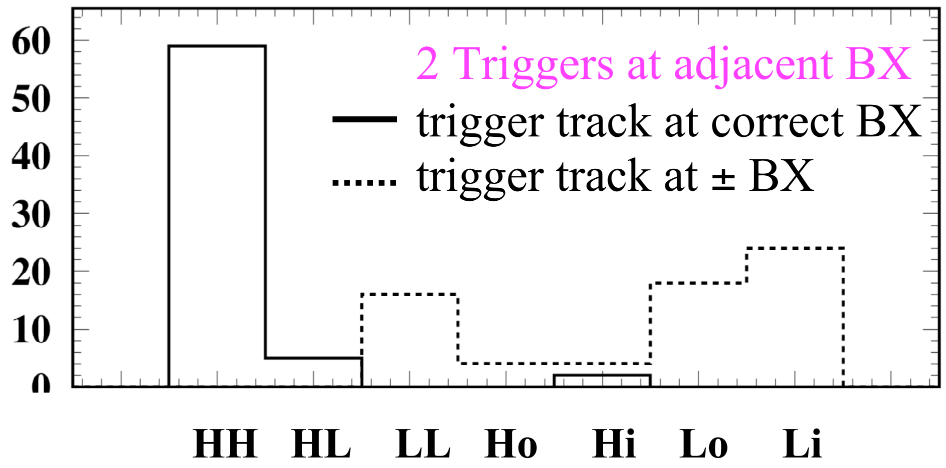
Di-Muon Efficiency: Track Quality

Quality of the trigger segments which provide correct identification of the muon.

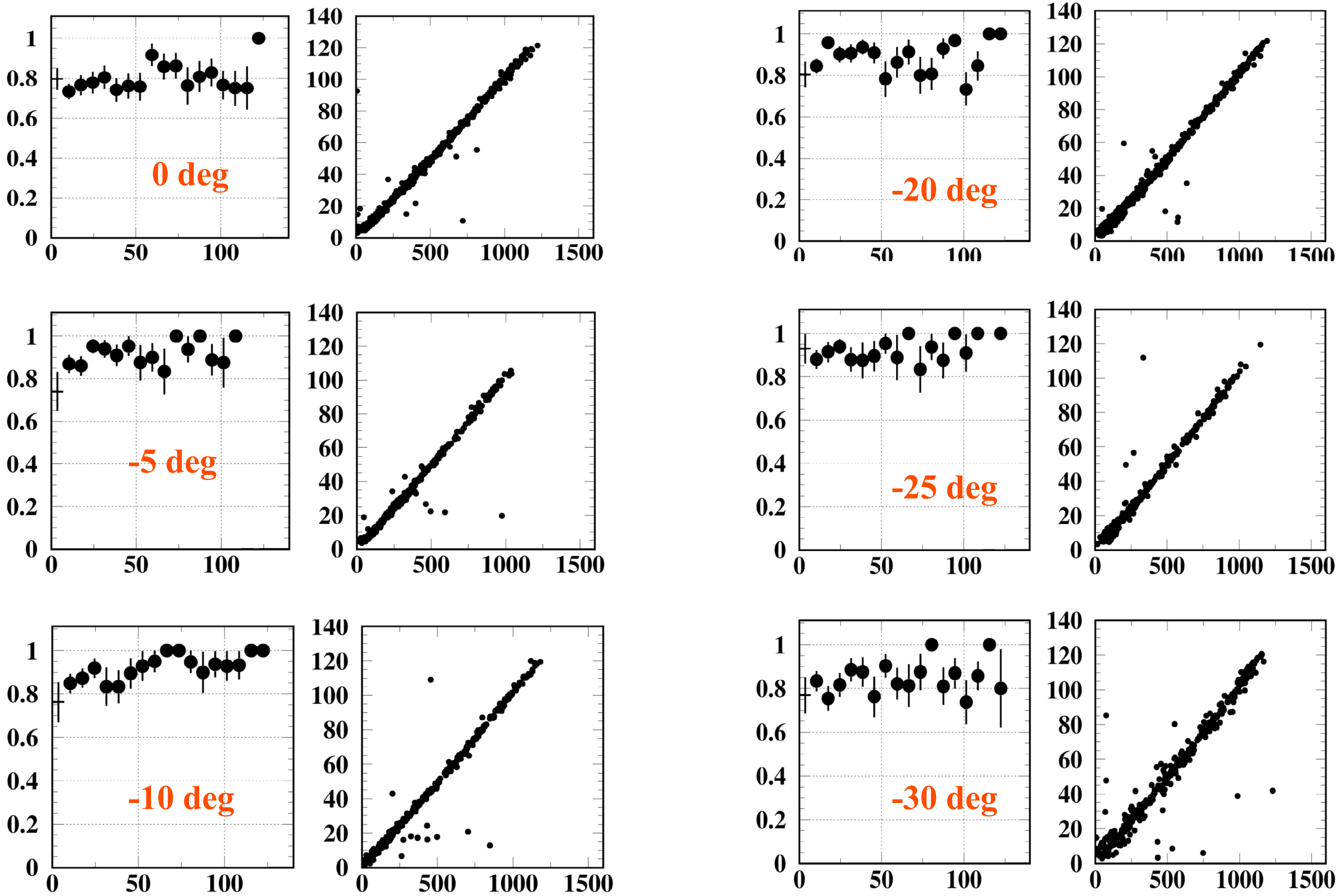
Good quality (H inner or Correlated) for both trigger segments. This makes us confident that the characteristics of the muon are well reproduced by the trigger as for single muons.



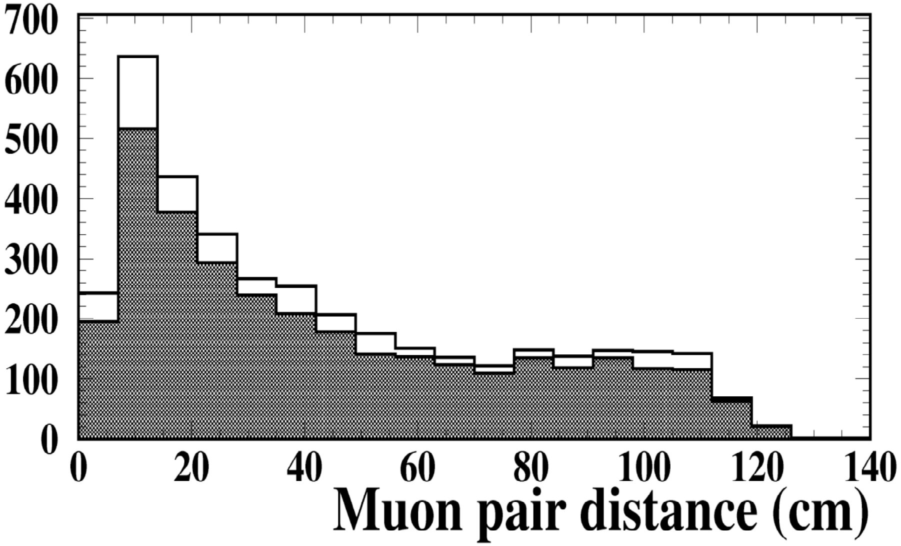
Two triggers at two BXs, one next to the other: both muons are correctly identified, but the trigger at wrong BX is manly a Low quality track.

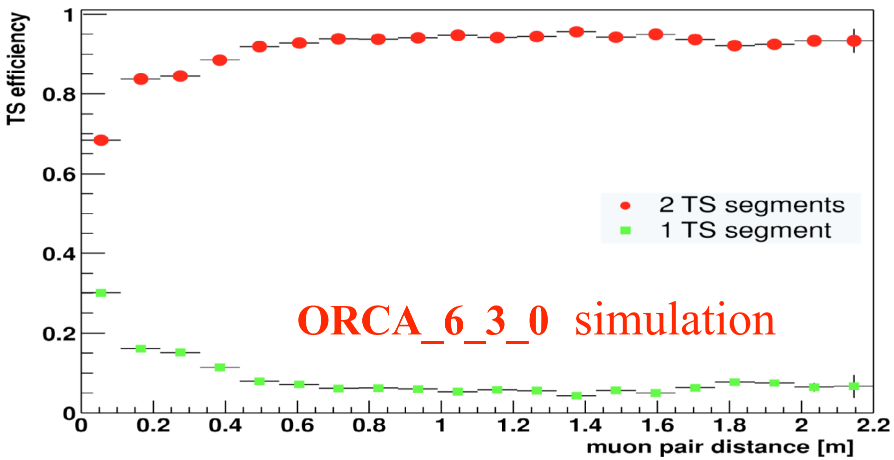


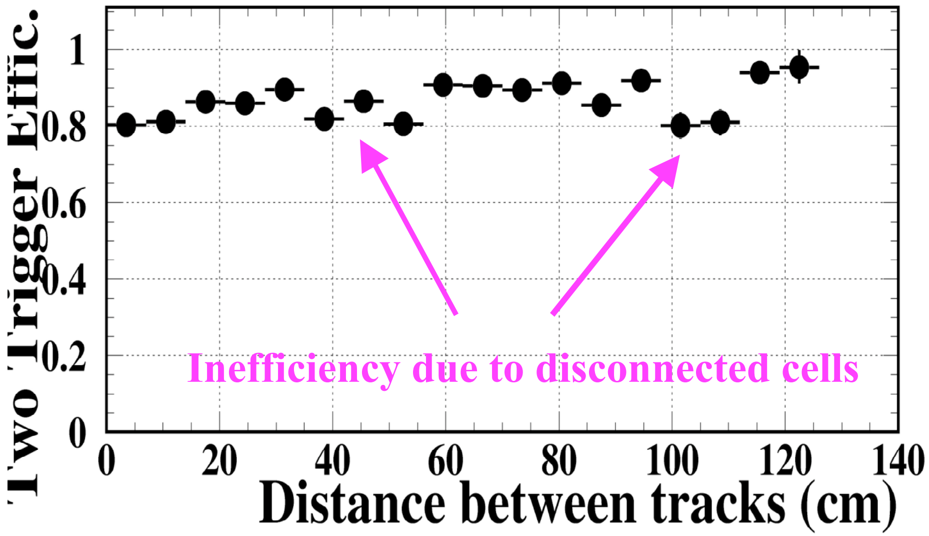
Two Triggers at Correct BX vs angle: Efficiency and correct id.

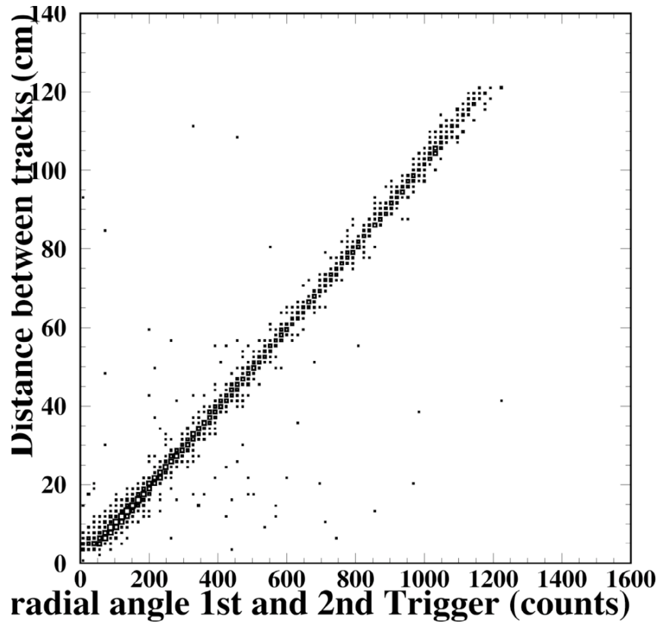


All Data Included, from 0 to –30 degrees





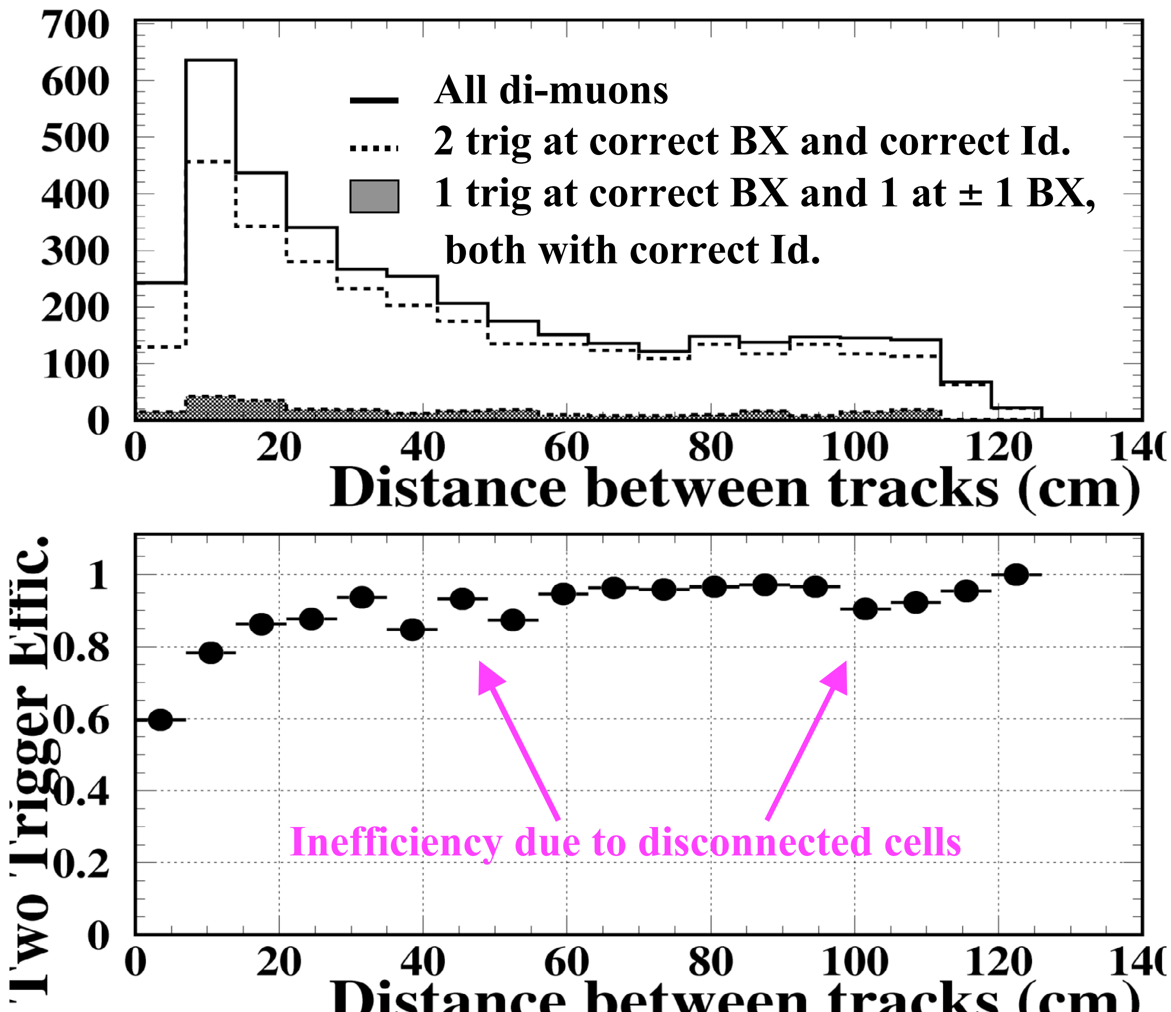




All Data Included, from 0 to –30 degrees

Including ± 1 BX around the correct one, as done by the Track Finder.

Only triggers which correctly identify the muon, in terms of position in the chamber, are included in the plots (i.e. only those which belong to the diagonal band of the plot which shows the correlation between the distance of the tracks and the distance of the triggers).



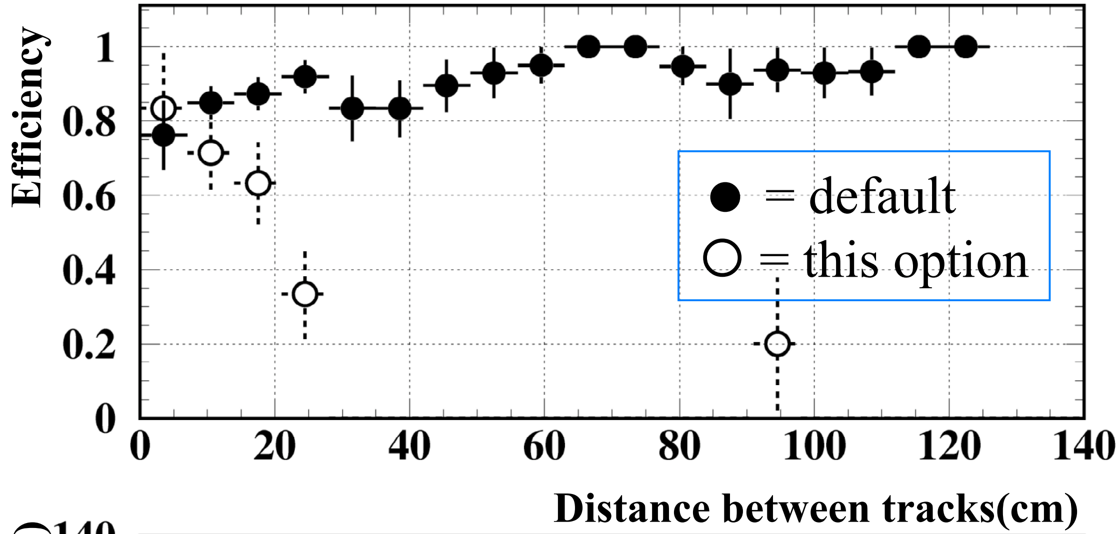
Trigger Server Different Set-up from default: T10def – Carry Disabled

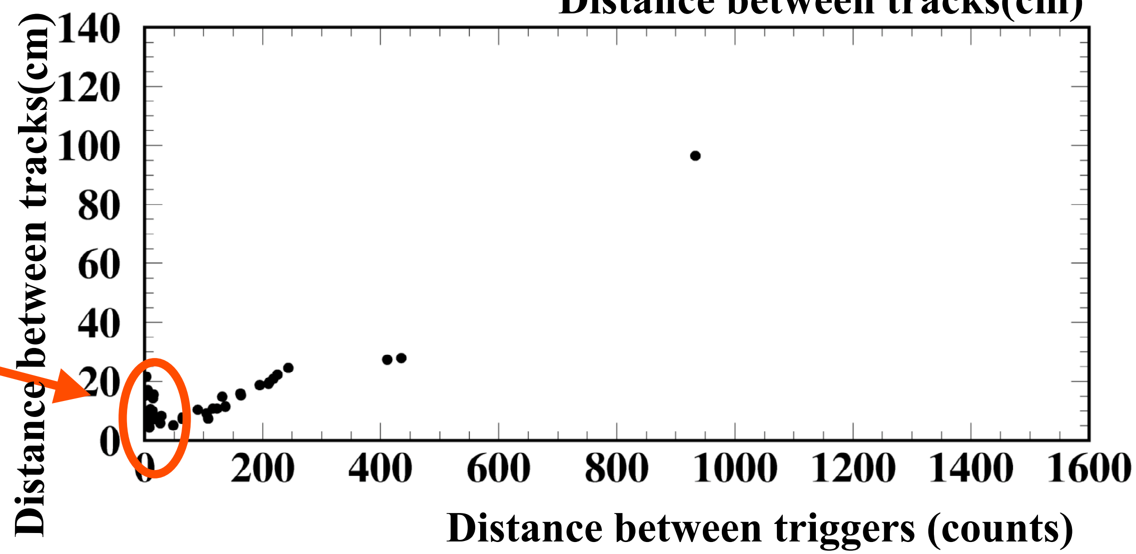
N.B. Set-ups different from default are studied with lower statistics.

When Carry is disabled,
the system selects the best of the 1st TRACO tracks and the best of the 2nd TRACO tracks.

Usually two muons give two ``1st tracks'',
and therefore, with this set-up, the 2nd track is lost (or, if not, is likely to be a ghost of the first track)

Without the carry the system will not trigger on close di-muons



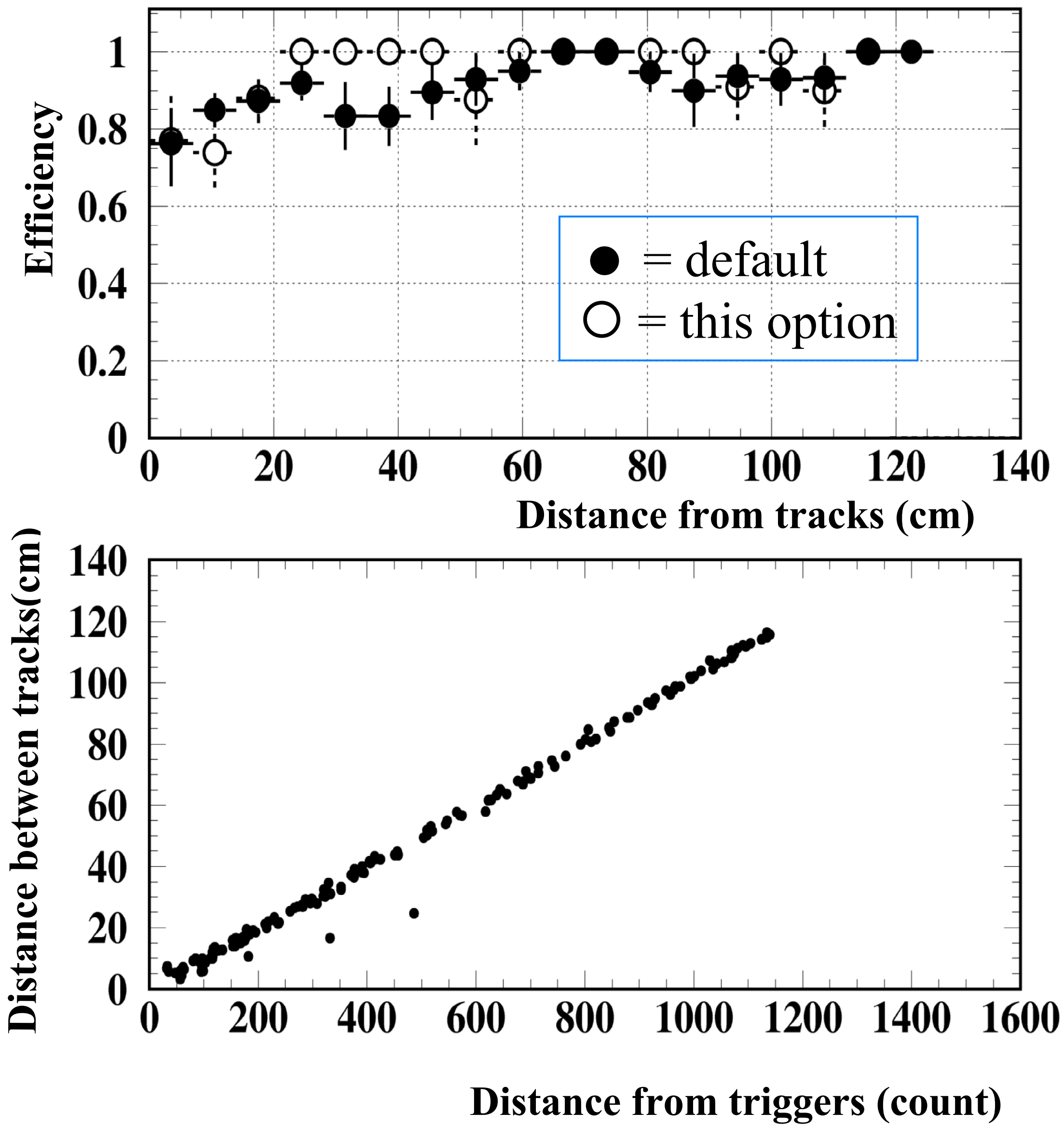


Trigger Server Different Set-up from default: T11def – Recover High Inner Enabled

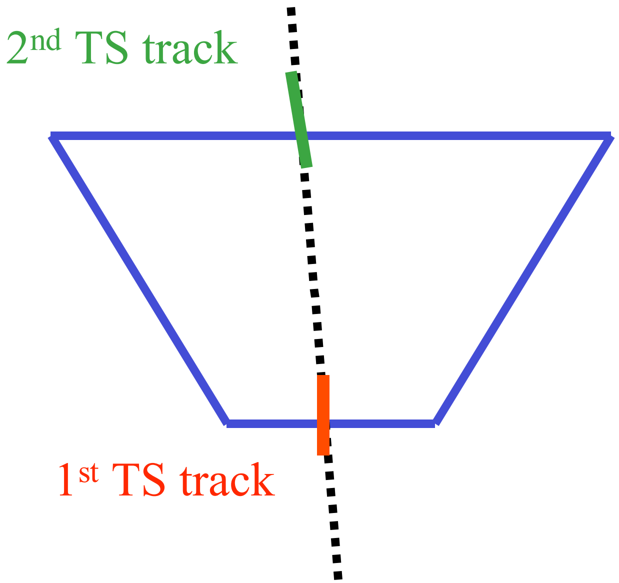
With di-muons there is a few percent probability to have triggers also at the BX next to the correct one.
When this occurs, the default always prefers a 1st track to a 2nd one, and this would kill the 2nd trigger at the correct BX

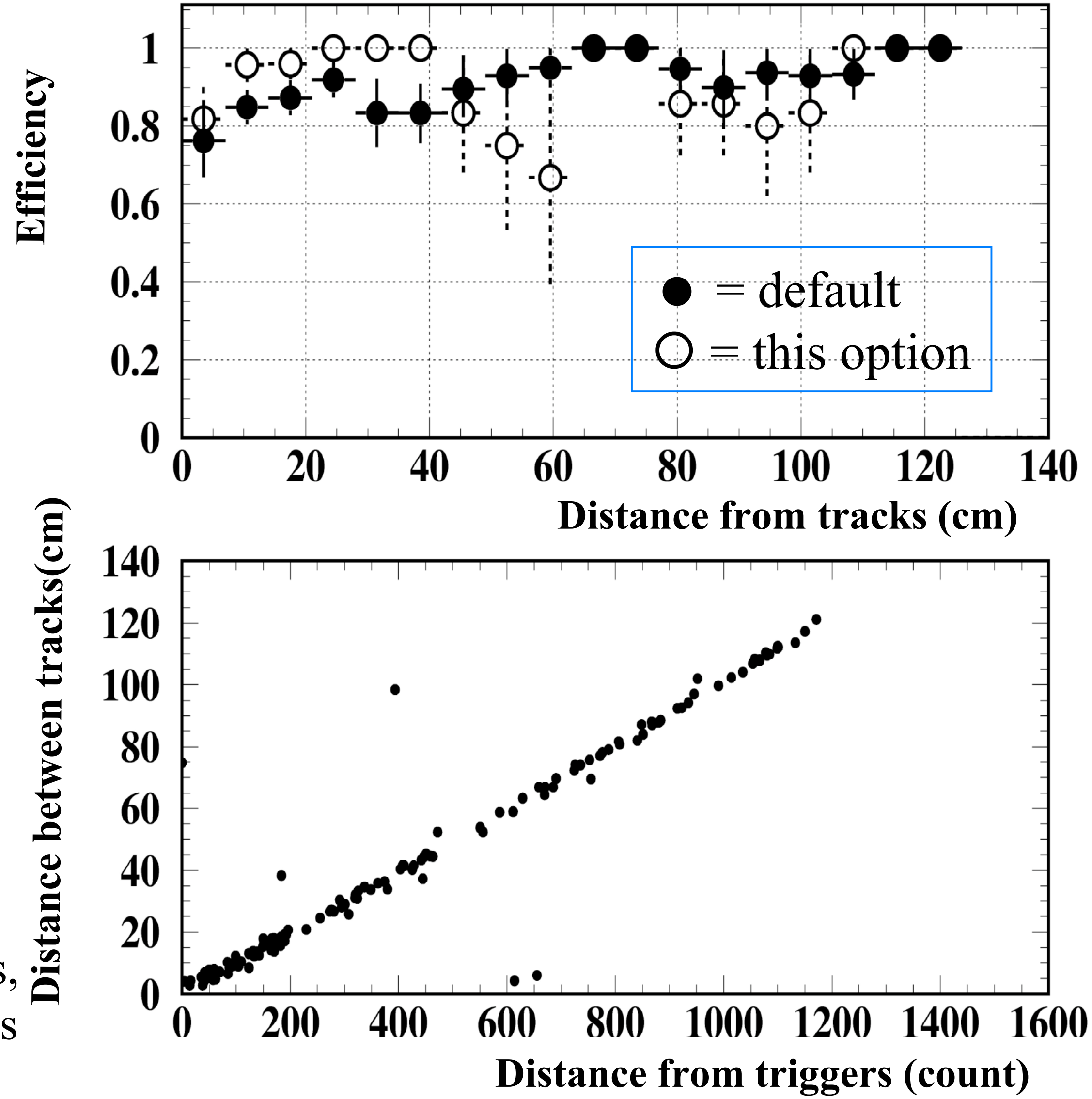
This option enables a comparison between a 2nd track at a given BX and a 1st track at the next BX, and it selects the ``best'' (according to their quality)

It is not the hardware default, but it gives the best performance, as also confirmed by previous simulations



Trigger Server Different Set-up from default: T12def – GHOST2=Disabled

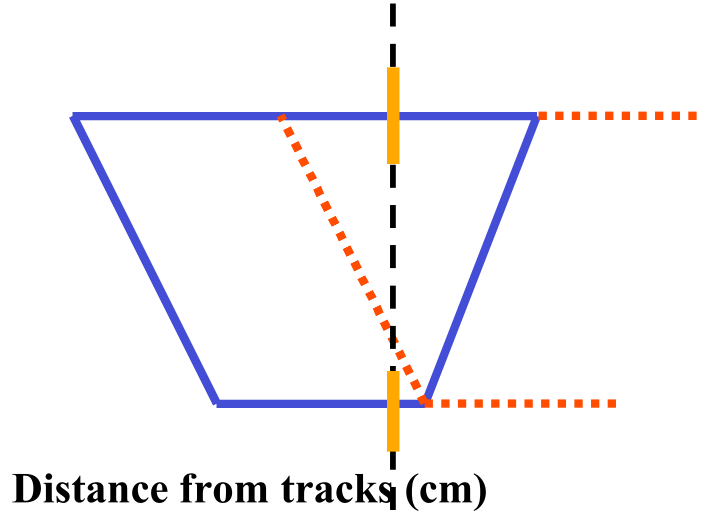




In the default, if the two TS segments are not correlated, the outer one is suppressed (if they are in the same TRACO) to avoid ghosts for single muons.
This is almost unrelevant for di-muons, as in this case most of the TS 2nd tracks are H inner or correlated.

Different Set-up from default: T13def – GHOST2=1 and 2 disabled

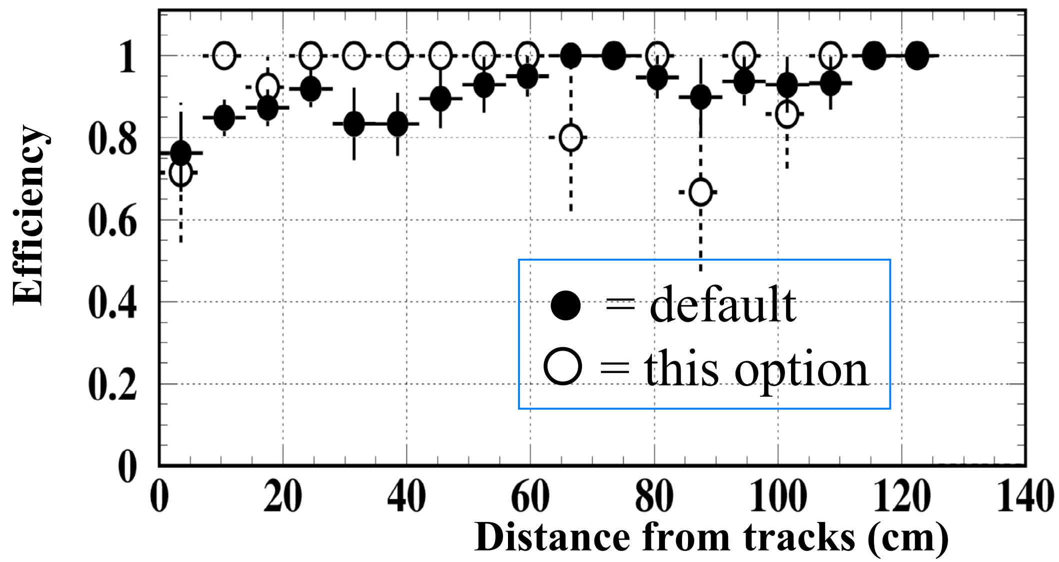
The outer segment is seen by two TRACOs independently (GHOST 1)

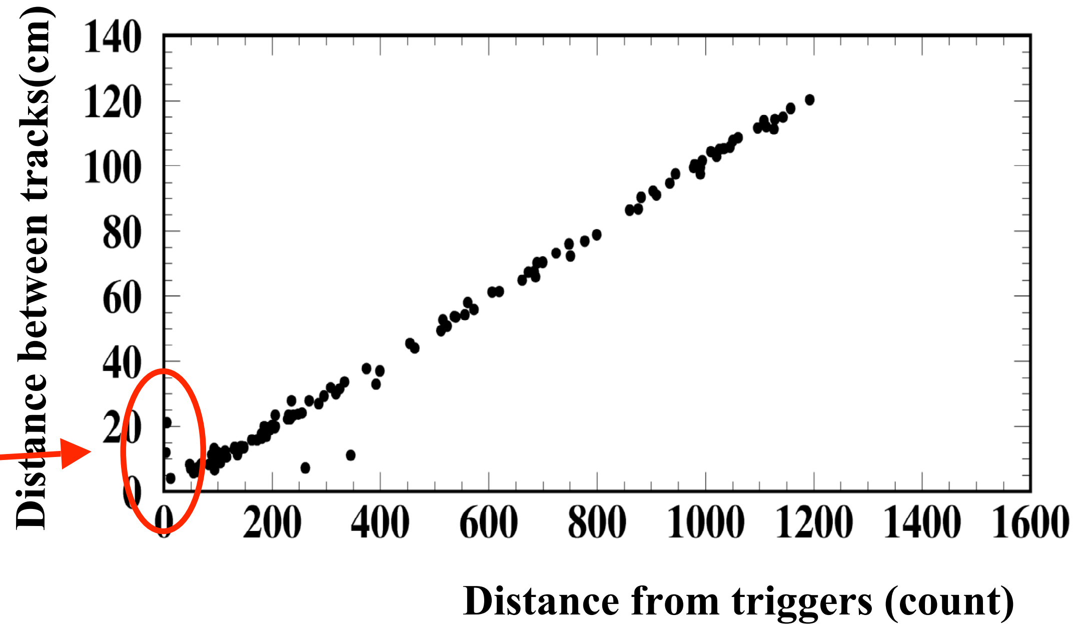


This is not the case for the inner segment

Again, since di-muons generally give H inner or Correlated tracks, ghost suppression is not crucial as it is for single muons.

Some ghosts are seen anyway.



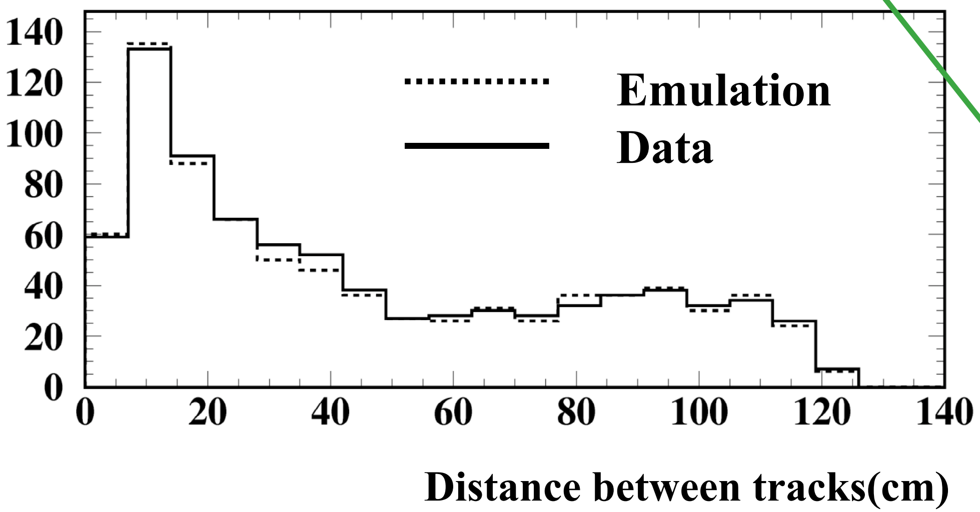


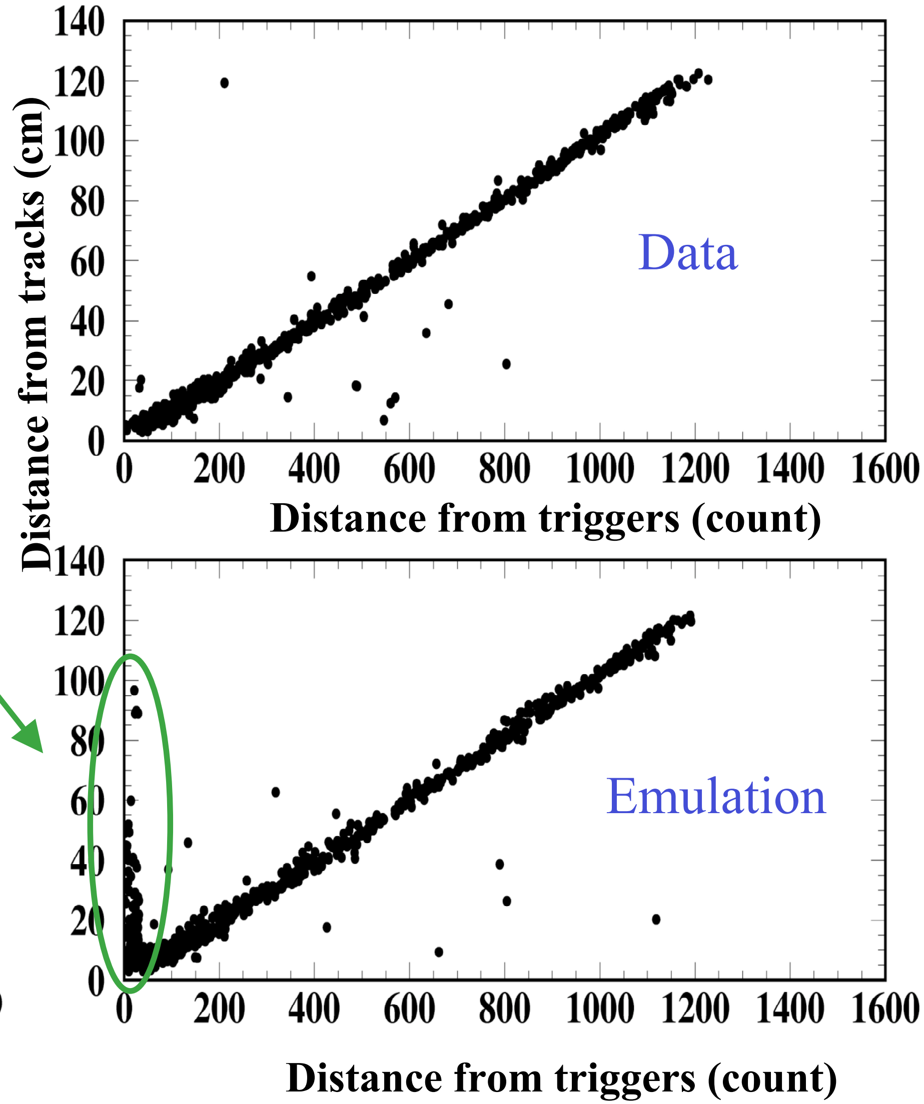
Data-Emulation Comparison: (0 degrees incident tracks)

The plot below shows the distribution of the two tracks separation for events which have two triggers at correct BX.

Good agreement between data and emulation.

The emulation has more ghosts in case of nearby tracks. This needs further study.



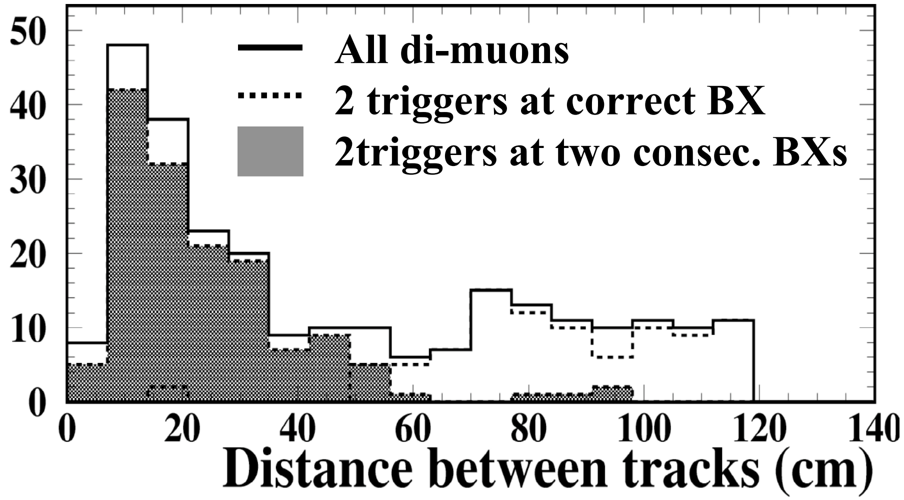


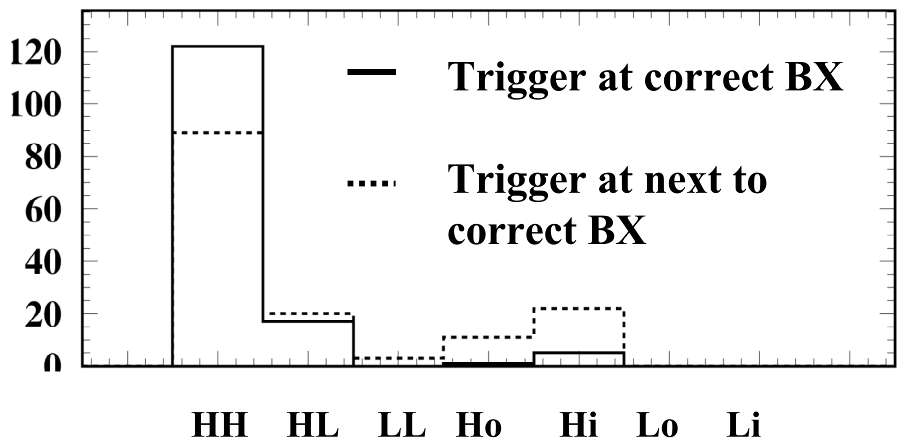
The Back-up Mode

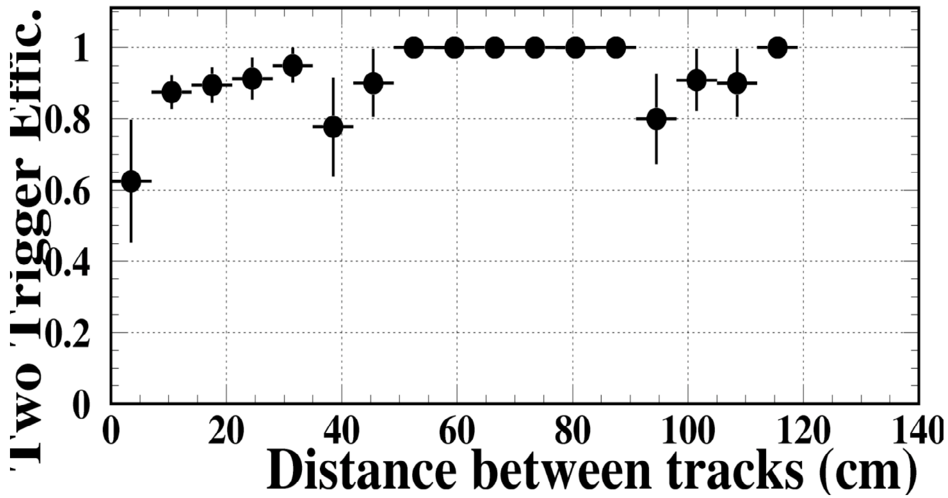
The back-up mode is a functionality of the TSM to recover possible failures of the TSMS (the chip which makes the sorting). **In this case a simpler sorting is still made, and also a simpler ghost suppression is implemented.**

Due to the different way the sorting is made, **the two correct triggers are not always available both at the correct BX,** but, for tracks passing through the same TRACO, or adjacent ones, are generally available in two consecutive BXs

We are still analysing data taken with different set-up options of the back-up mode.







Summary

The performance of the DT local trigger, based on BTI-TRACO-TS, matches the expectations and the requirements of the design.

Some more data to analyse.

A written note is in preparation.

Concerning di-muons, in the NEXT test beam:

1) **We need a better trigger (two sets of scintillators in coincidence, possibly with adjustable position, to select the mu pair with a known separation, and to be less dependent on the chamber hits in the di-muon selection)**

2) **We should also have some veto system against splashes on the chamber, which can easily fake a muon pair.**

3) **It will be important to check how a muon is reconstructed in two stations, to fully test the performance of the local trigger.**