Timing Efficiency Studies

for the mu3e experiment

07/05/2015

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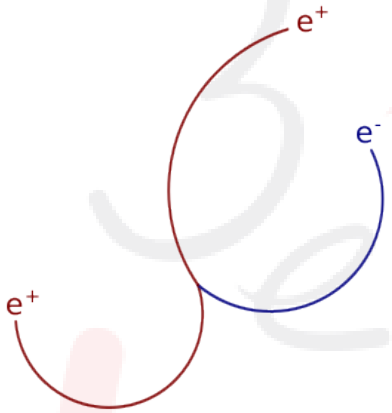
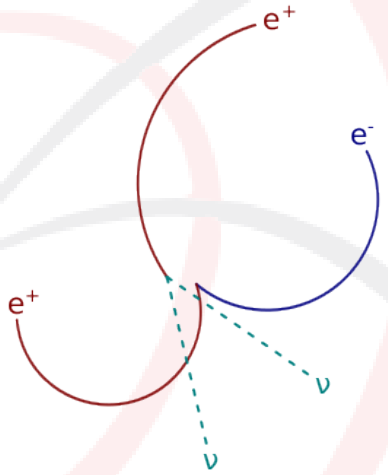
Signal and Background



signal decay



dominant background

1 Michel decay + electron/positron pair from the same vertex (e.g. Bhabha scattering)

Def.: *background efficiency* is the percentage of background events which are wrongly identified as signal decays

signal acceptance is the percentage of signal decays which are correctly identified

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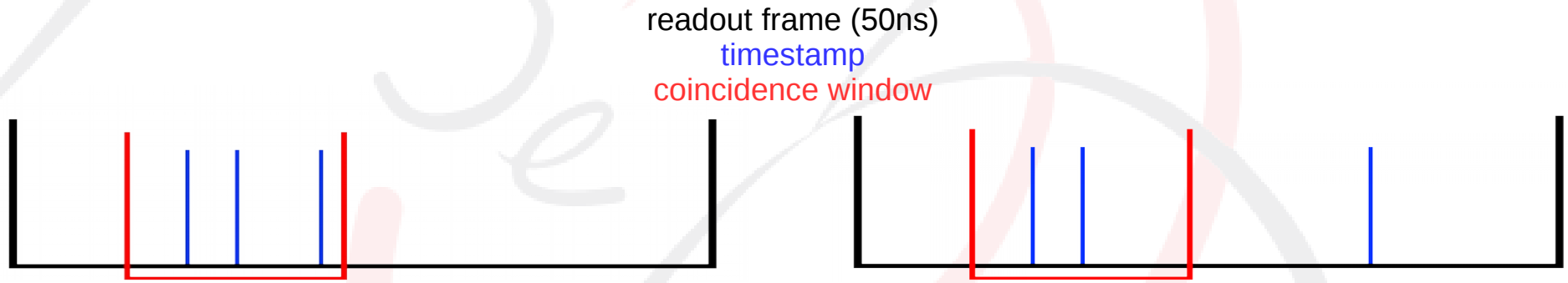
Single Coincidence Window

We make a cut on the time difference between the two outer timestamps:



identified as signal decay ***identified as background event***

→ size of coincidence window is a trade-off between signal acceptance and fake efficiency

Current goal: **signal acceptance of 90%**
background efficiency of <0.5%

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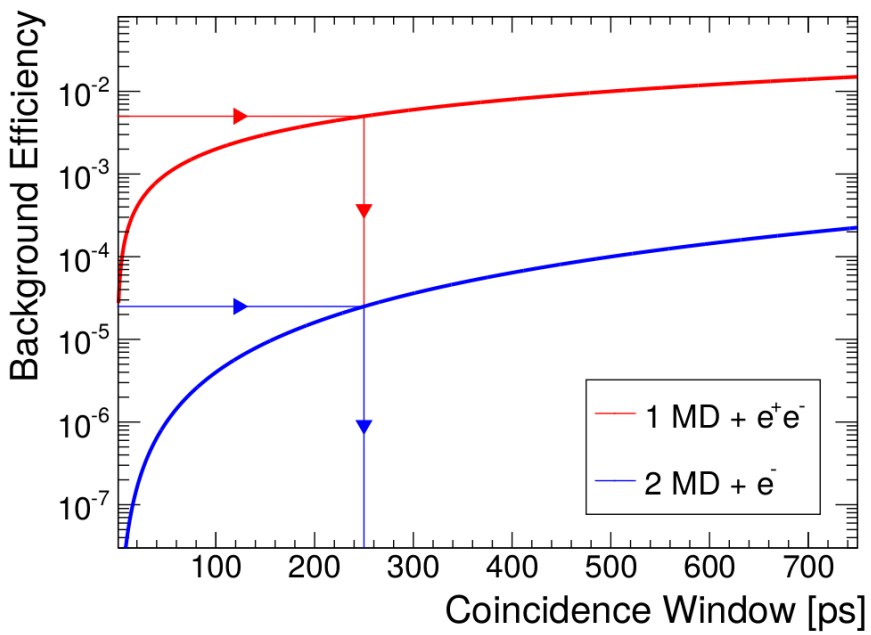
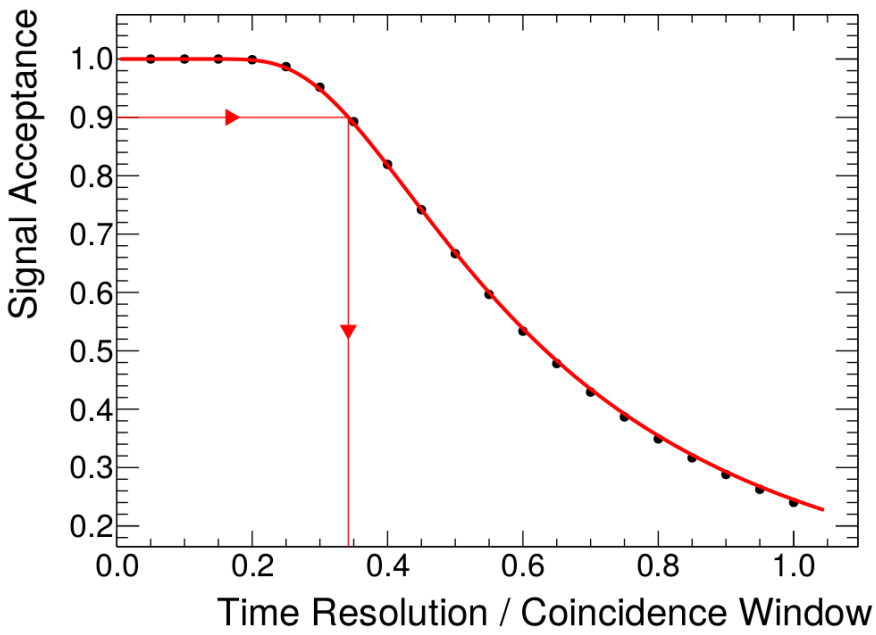
Single Coincidence Window

P. Eckert: The Mu3e Tile Detector, Heidelberg 2015





- Aimed background efficiency is achieved for CW of t_{cw} = 250ps
- Aimed signal acceptance is achieved for resolution of 0.34*t_{cw} = 85ps

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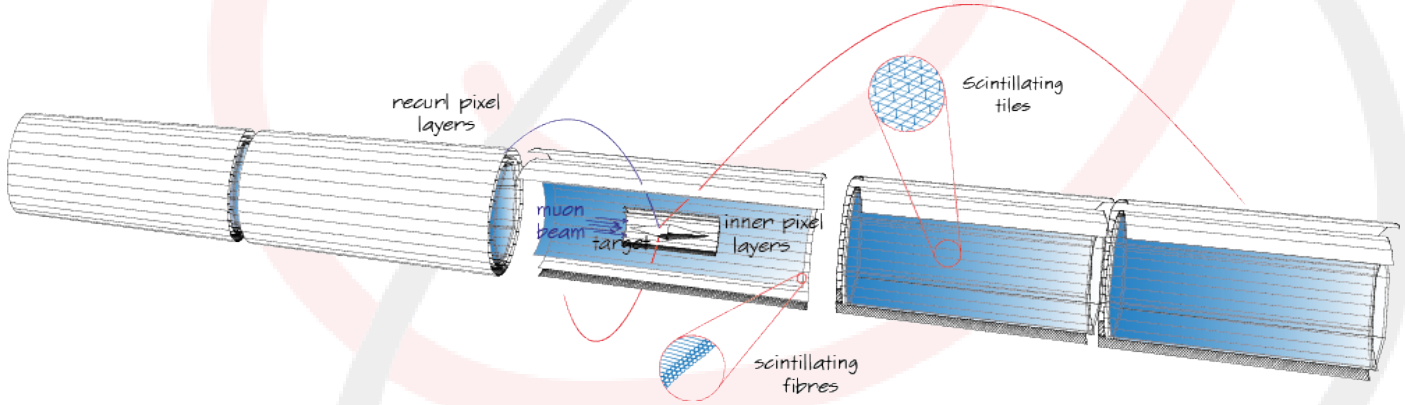
Resolution

required resolution: **85ps**
fibre detector: **~500ps**
tile detector: **~60ps**

→ resolution of the whole detector depends on the relative abundance of hits in the tile detector



- Simulation of O(10^6) mu3e decays to get tile hit rate of signal events
- Assumption: tile hit rate is similar for signal and background events

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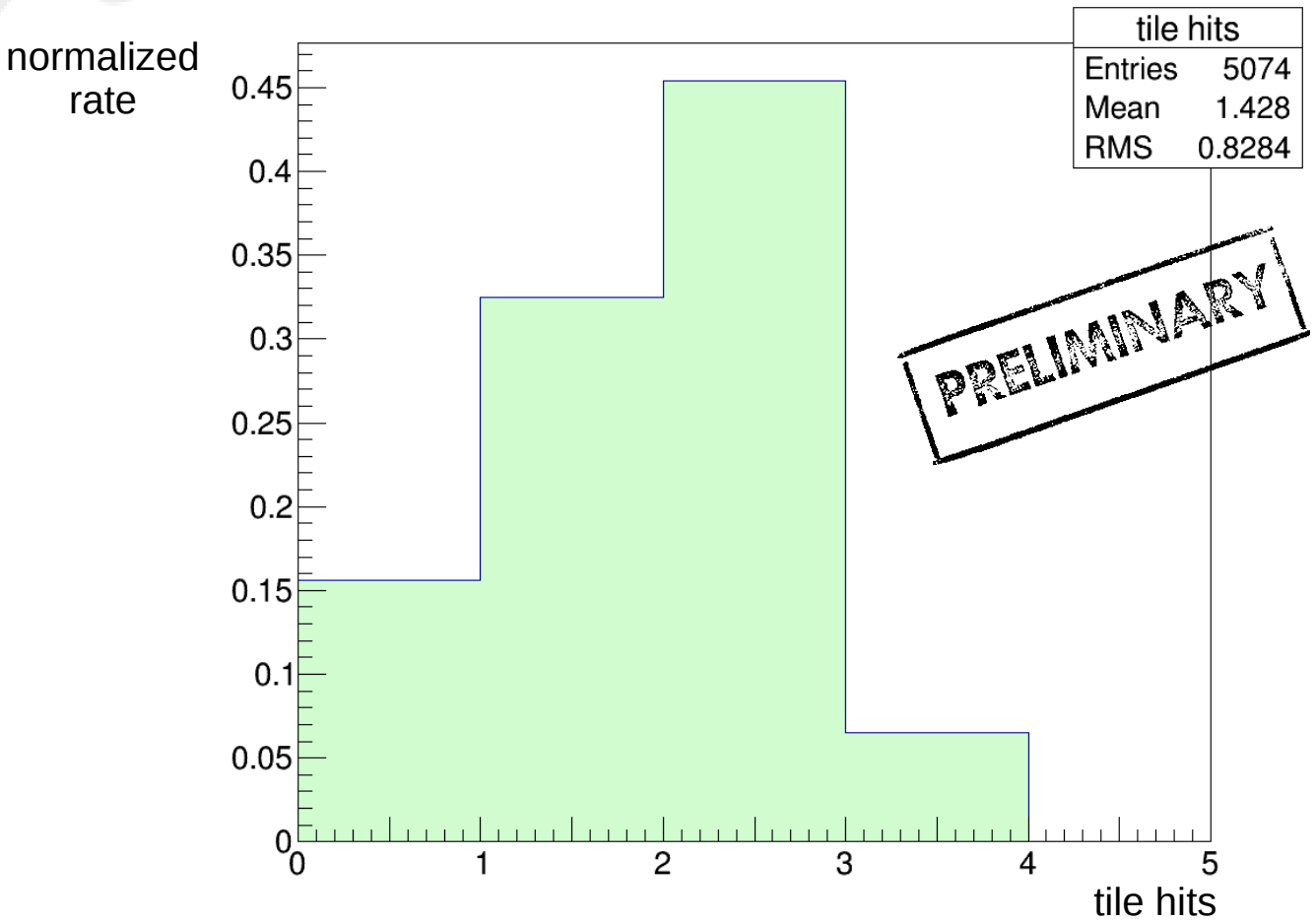
Simulation of Tile Hit Rate



→ on average ~47% of signal tracks in the fibre detector also hit one or more tiles

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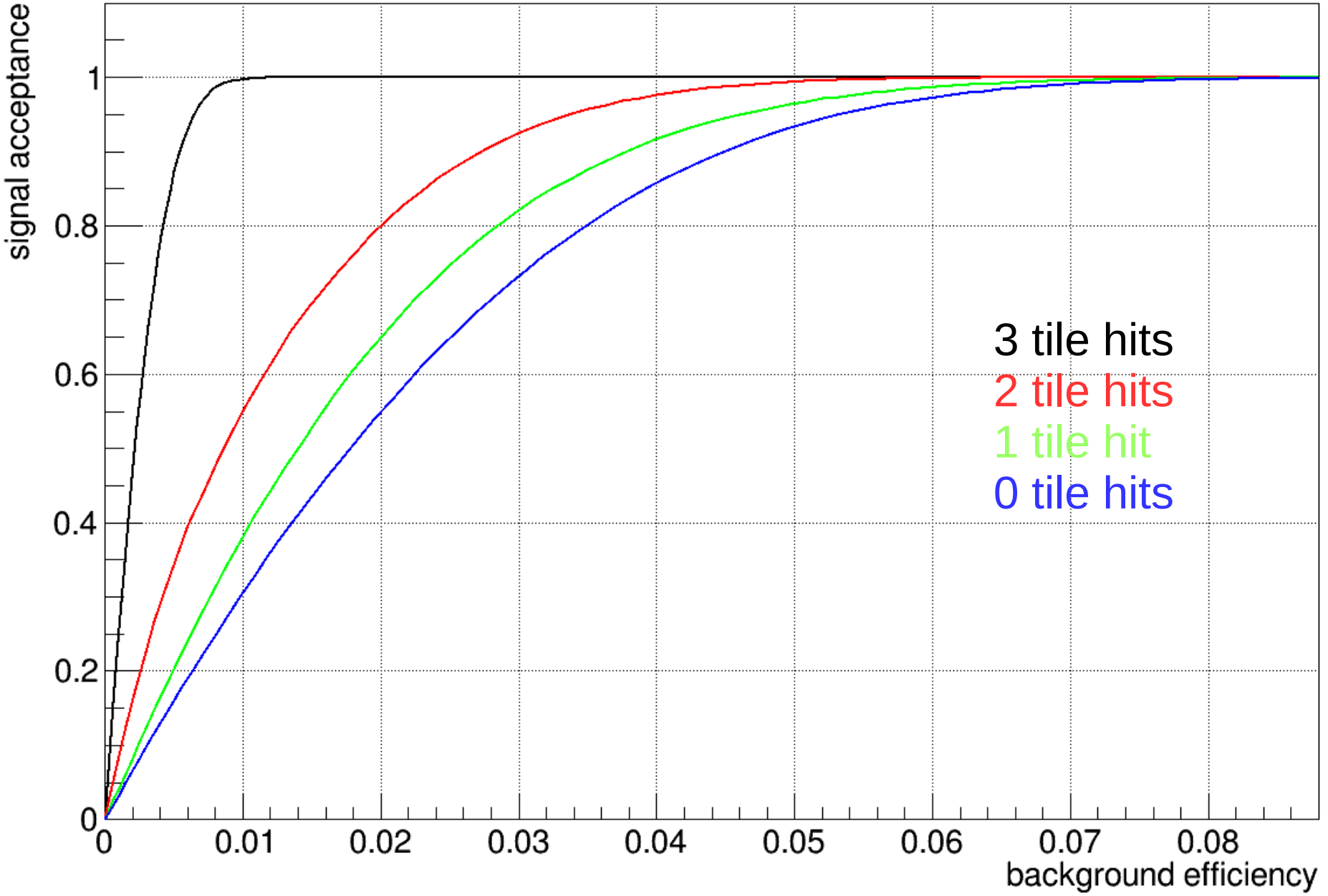

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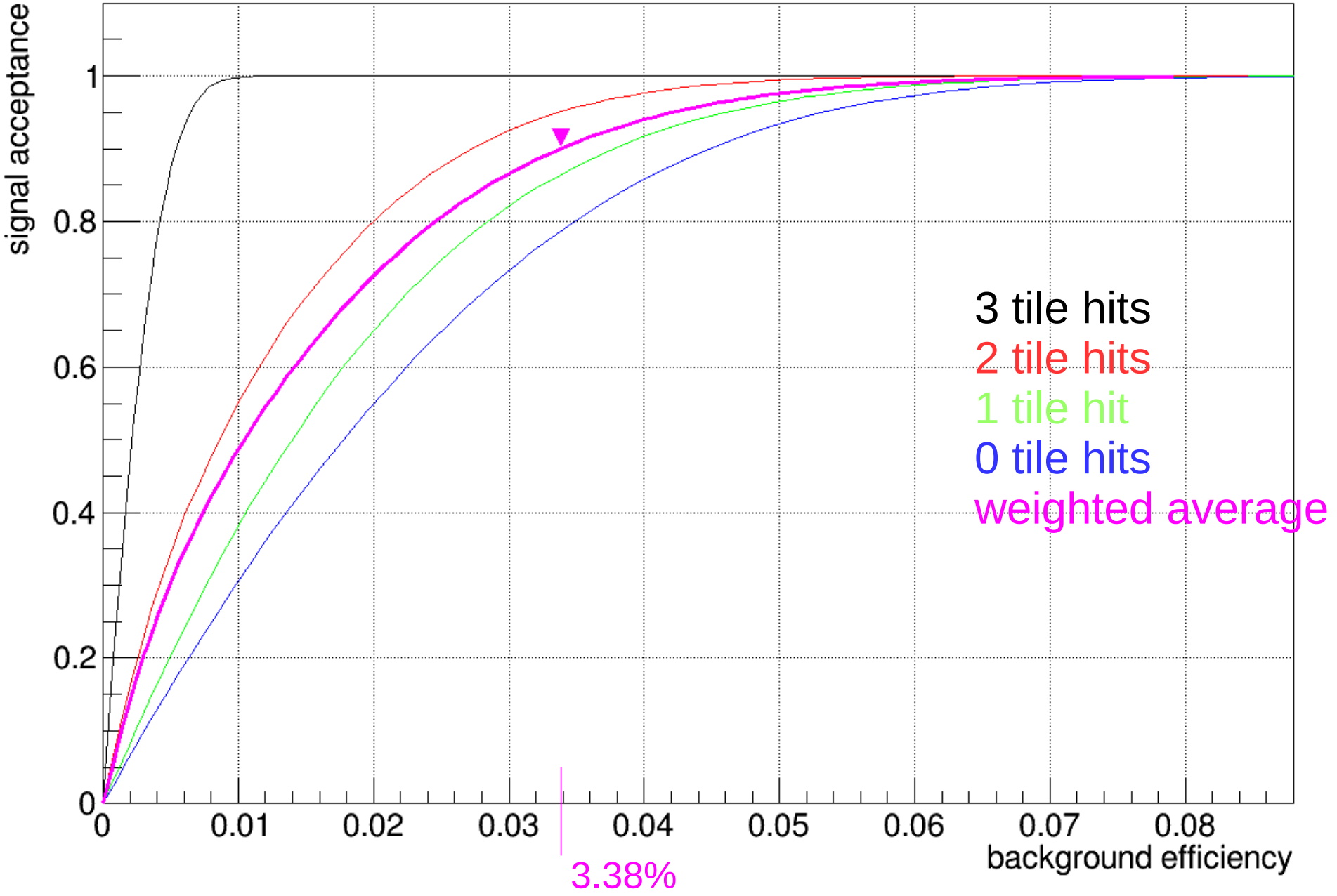

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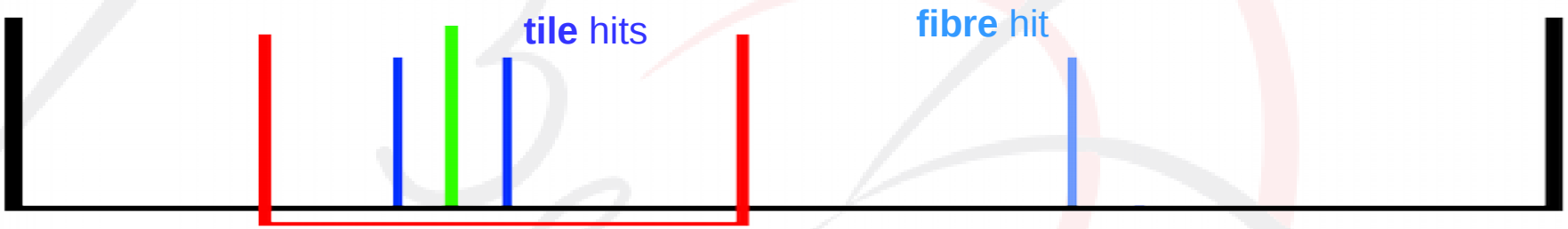
Optimization: Two Coincidence Windows



If the two timestamps from the tile detector are within a certain **first** (small) coincidence window, the average is calculated

The average is then checked against the fibre timestamp within a **second** (large) coincidence window

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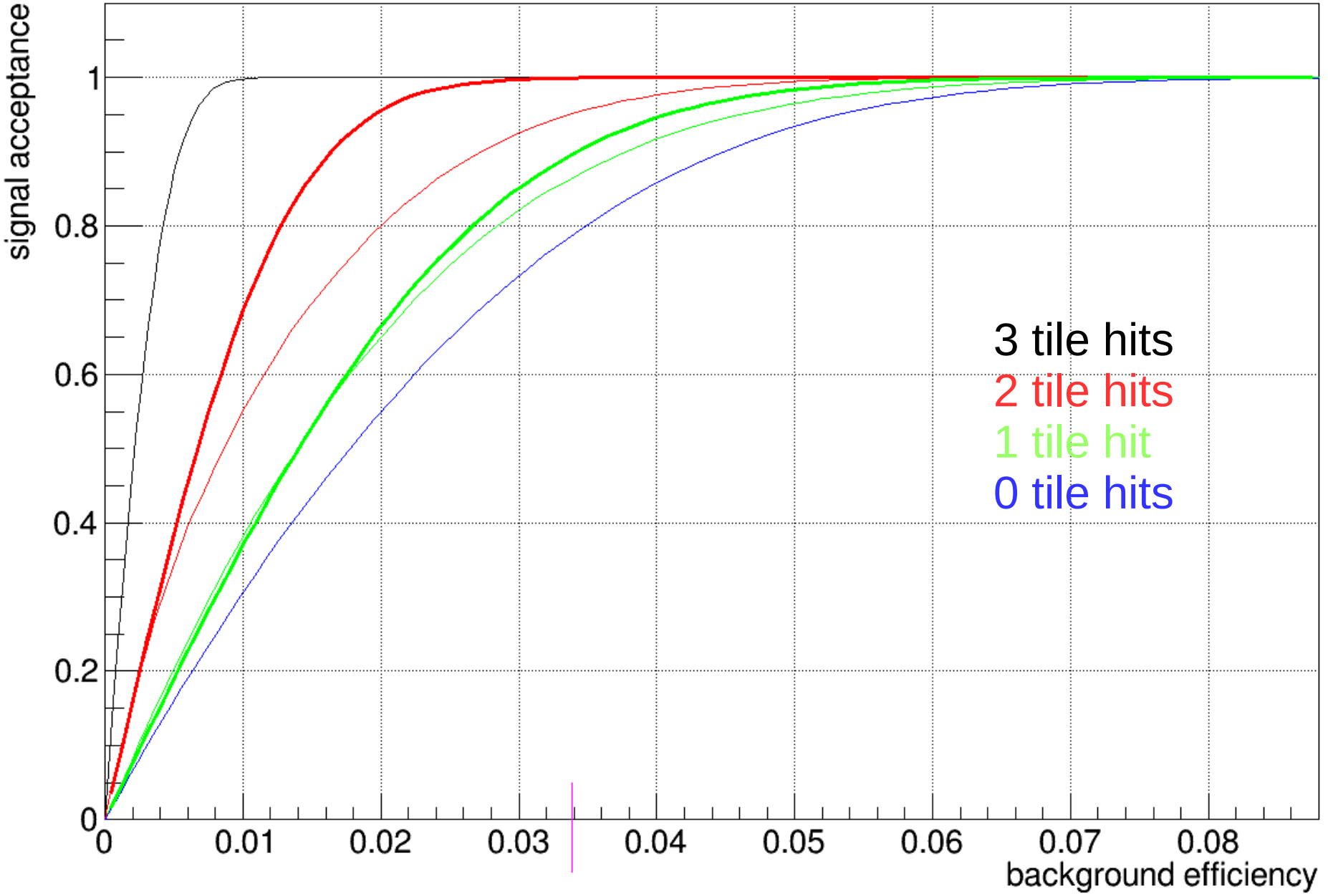

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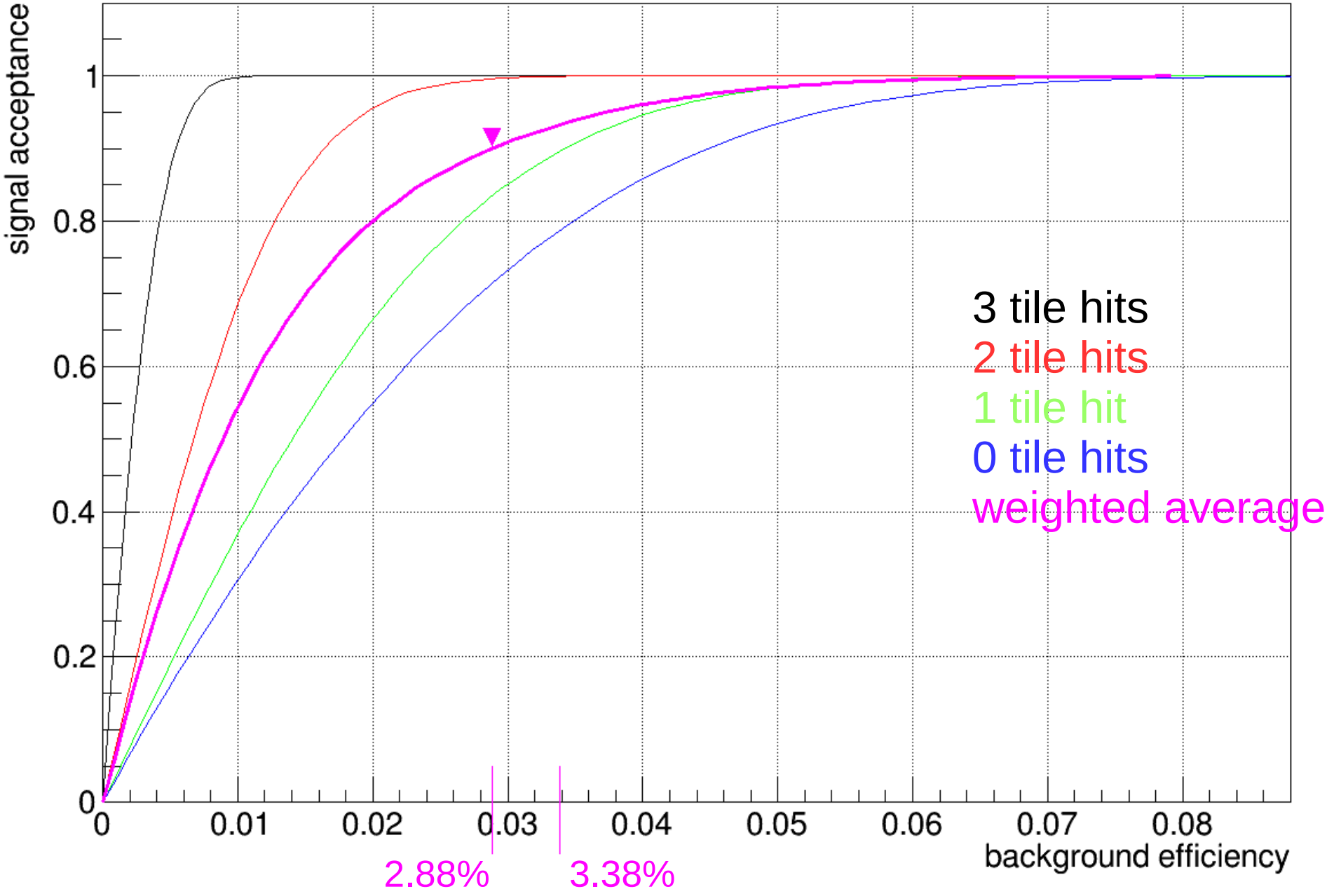

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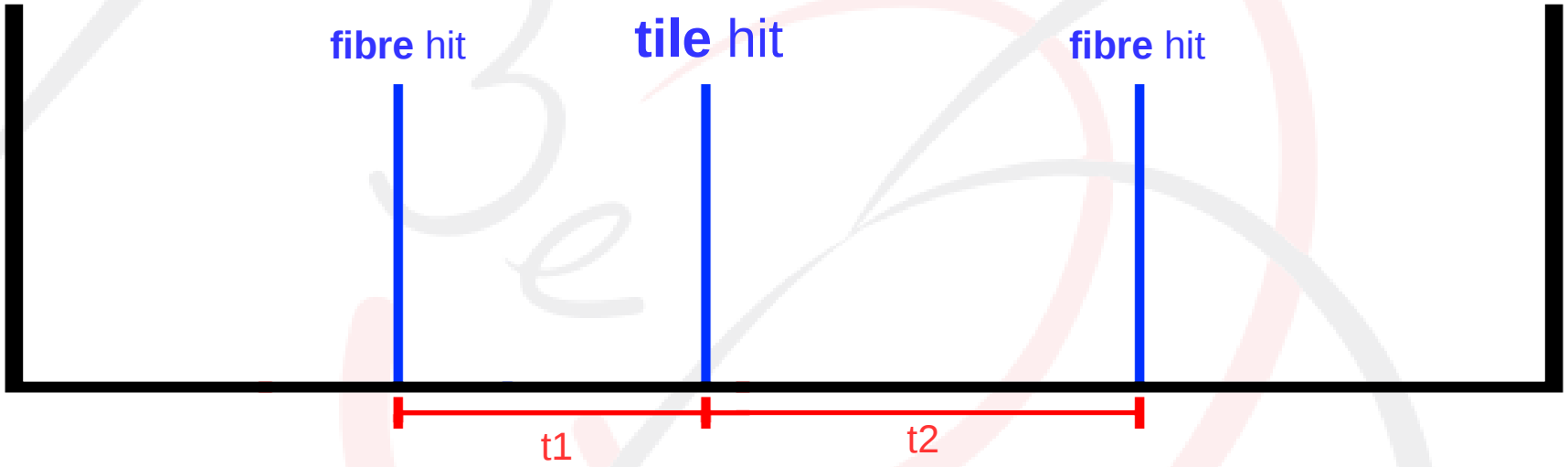
Optimization: Probability Cuts



- The time differences between the tile hit and the fibre hits are calculated
- t2 vs t1 is filled into a 2D histogram for each signal and background event types

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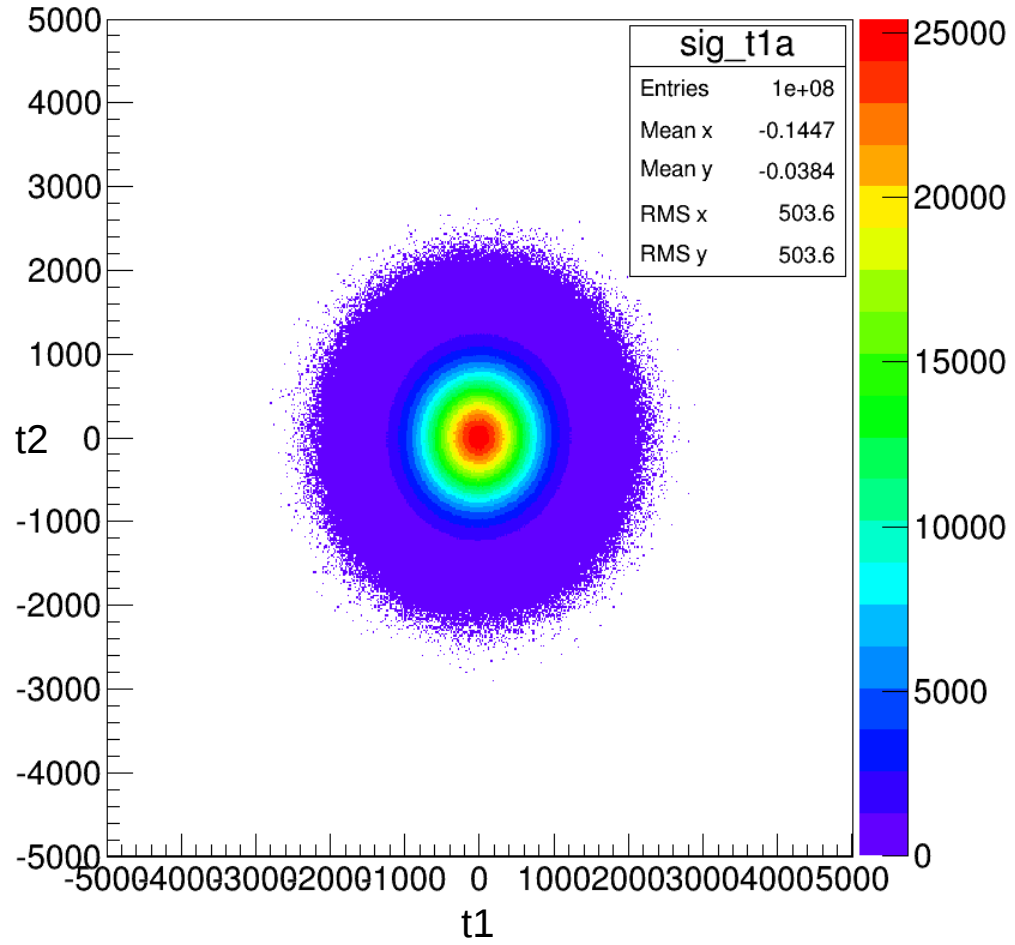
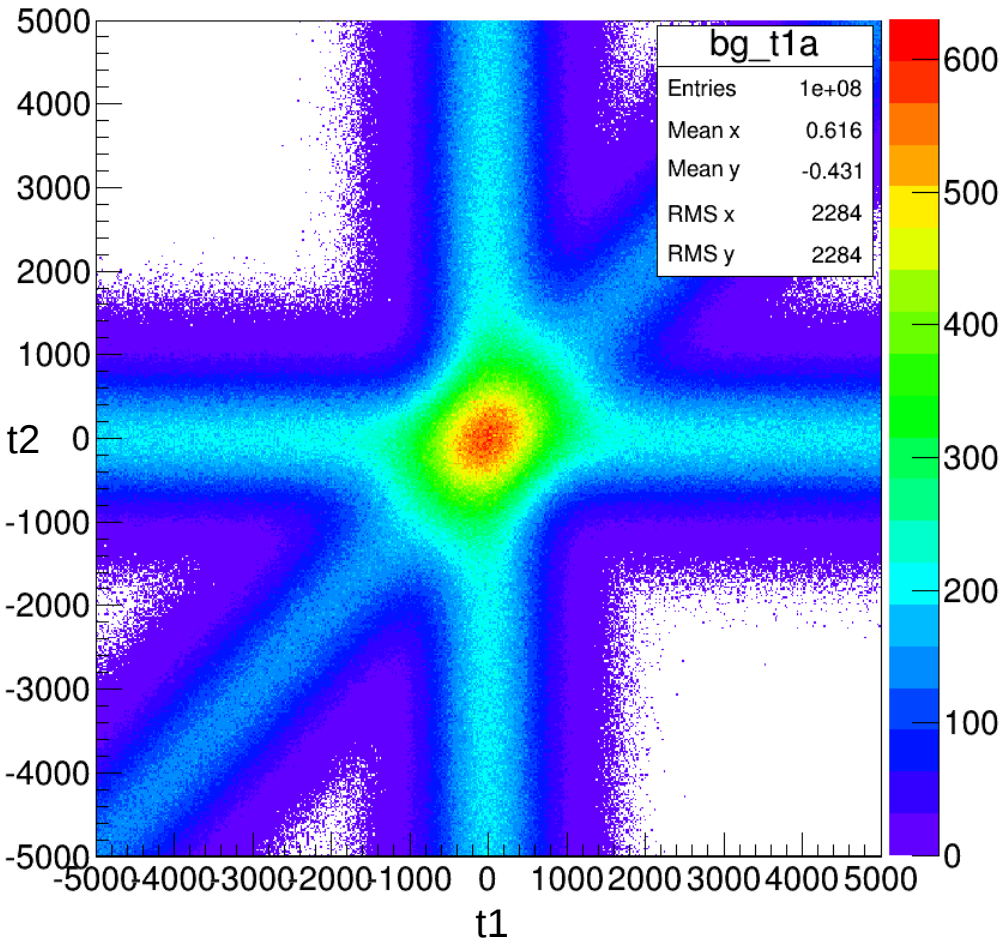
Optimization: Probability Cuts

signal decay



dominant background



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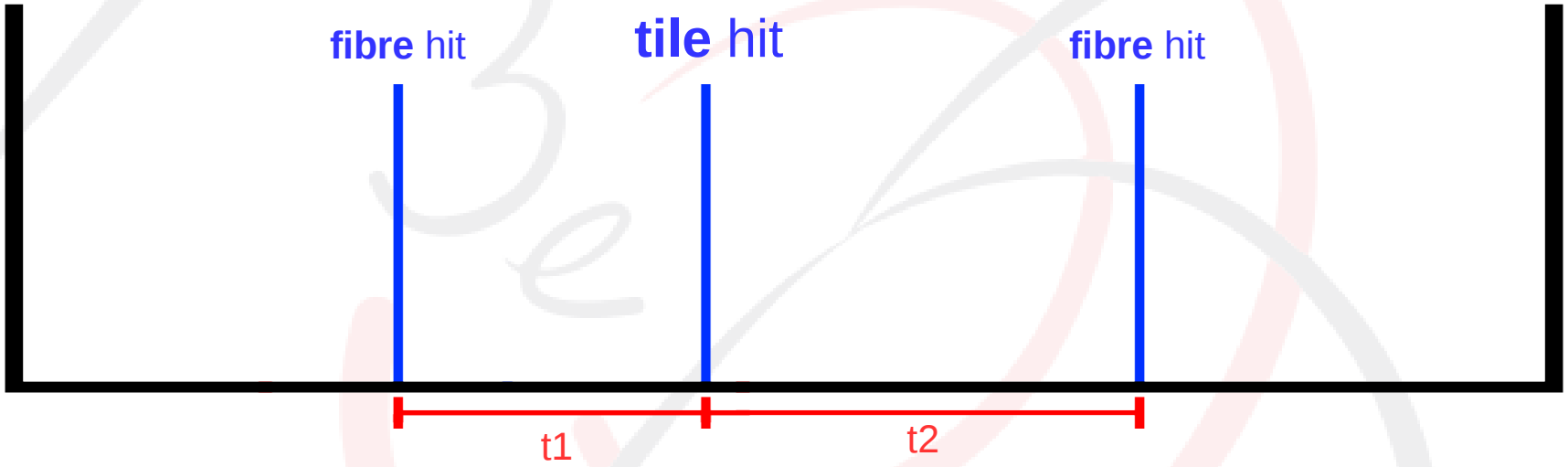
Optimization: Probability Cuts



- For events to be analyzed the probabilities for signal and background are determined from the histograms
- The quotient of signal and background probability is calculated
- Different cuts on the probability quotient yield different signal and fake efficiencies

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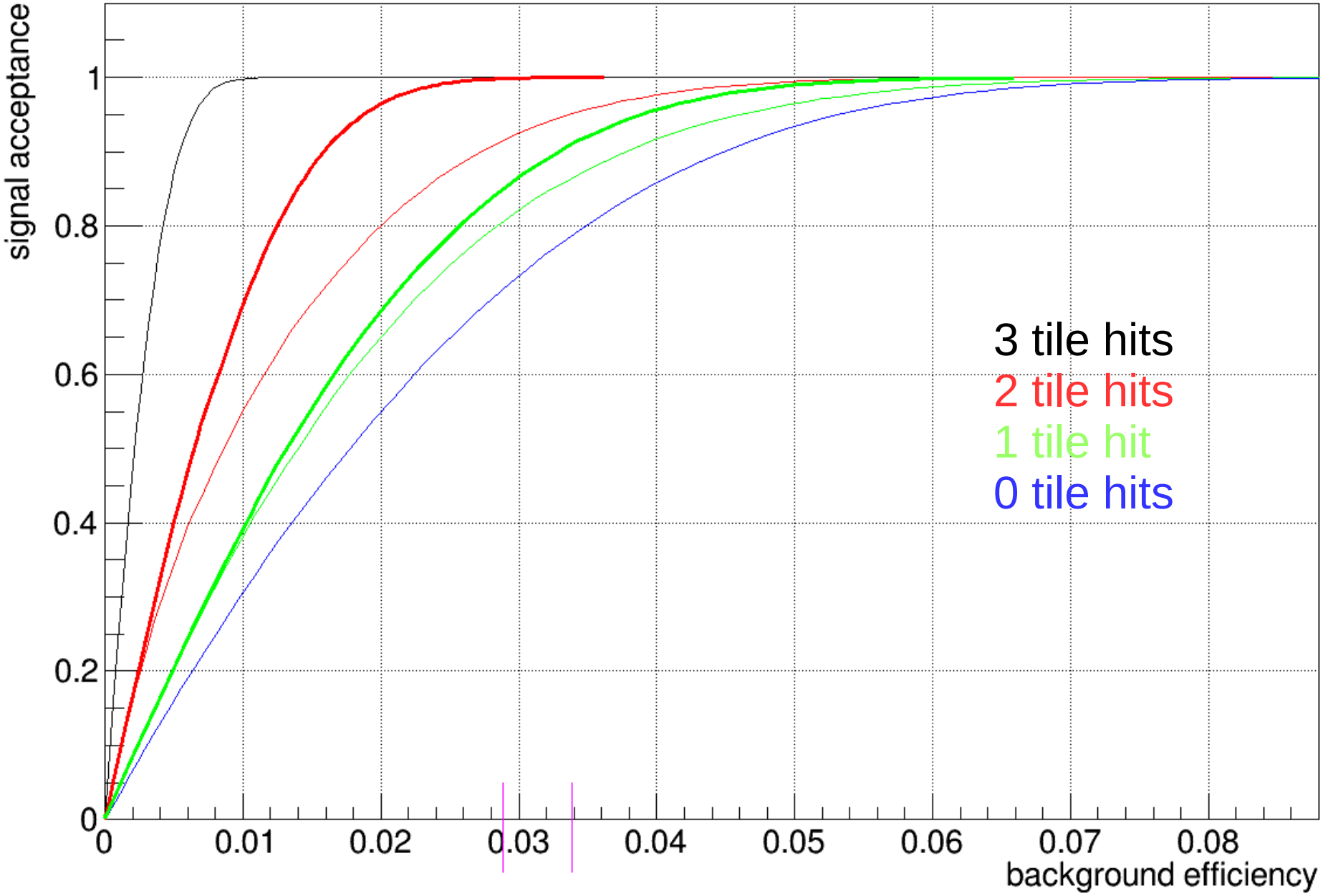

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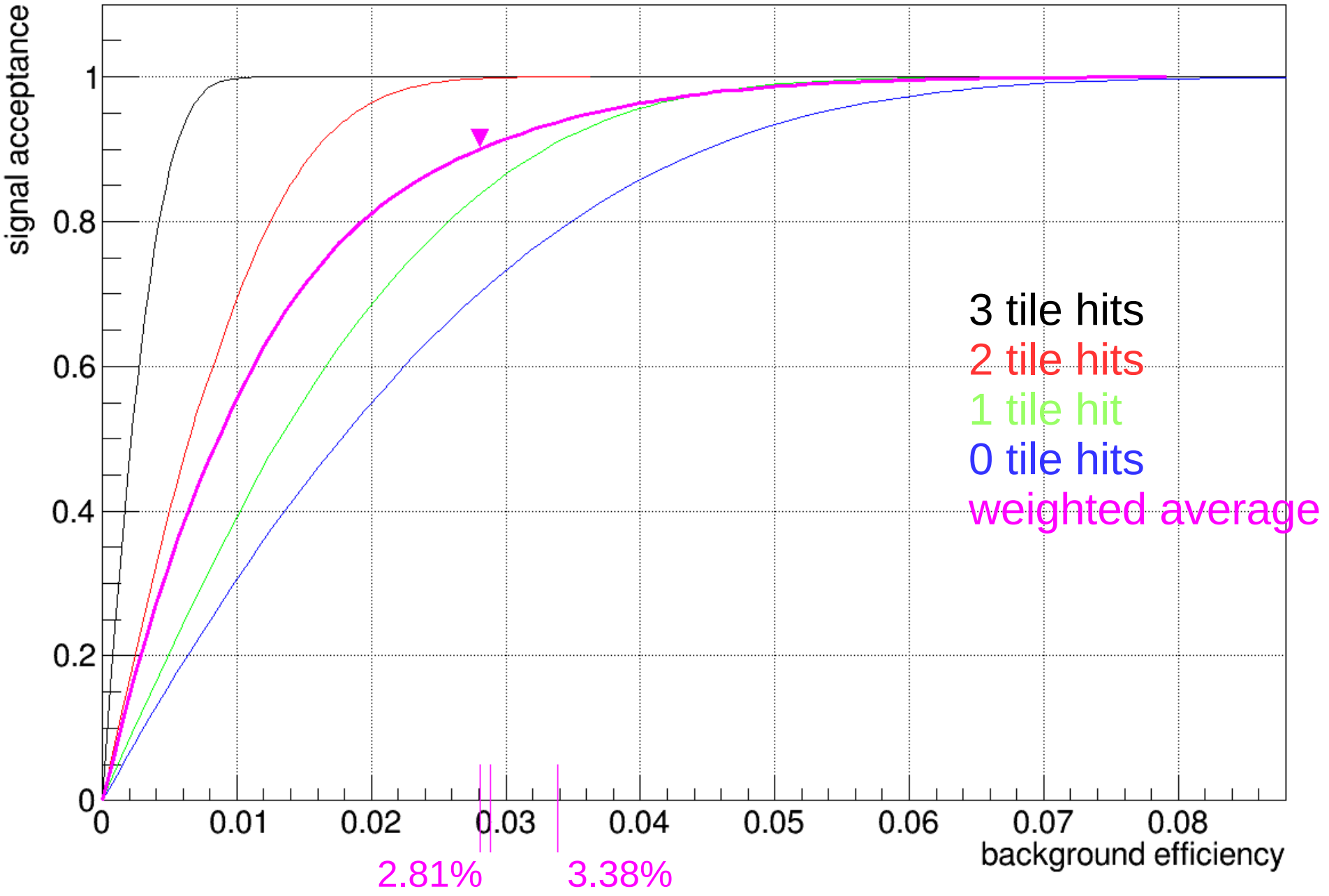

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Summary of Results

Development of optimized timing algorithms has lead to an improvement of the background efficiency:

method 1: 3.38% → 2.88% (impr. of ~15%)
method 2: 3.38% → 2.81% (impr. of ~17%)

...but: - bg efficiency still significantly higher than 0.5%
- method 2 quite slow compared to method 1

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Solution and Analysis Suggestions

- Enhance tile hit rate
  - → inhomogeneous magnetic field?
  - → additional electric field?
- Enhance resolution of the fibre detector
- ?
- Further analysis: detailed efficiency study using actual simulation data
  - → requires implementation of Bhabha scattering and track reconstruction