Status report on cosmic muon event tagging with light signal

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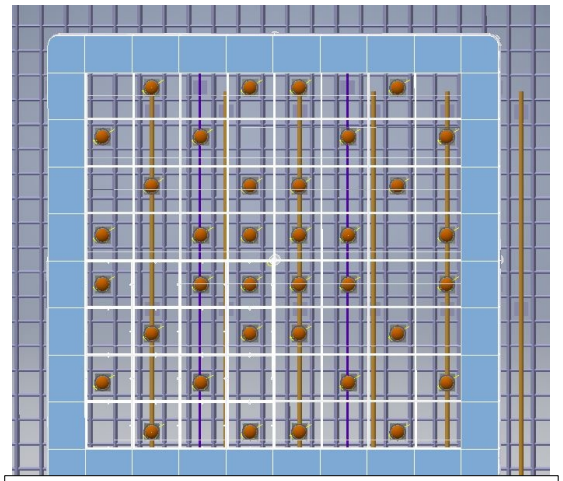
Introduction

- We work on the cosmic muon event tagging using **light signal** information
- The light signal is simulated with QScan (using the light maps available at /sps/hep/lbno/dataset/LightMap)

- Outline:
  - **Peak search** algorithm to tag S1 peaks & first results
  - Algorithm **efficiency**
  - **Next steps**

Study done with:

- **PMT quantum efficiency**: 0.20
- Electroluminescence gain **G=300**
- **PMT** and **electronics response** not taken into account
- **400ns** sampling
- λ_{Abs}=30m
- **Sum** of the **36 PMT** signals

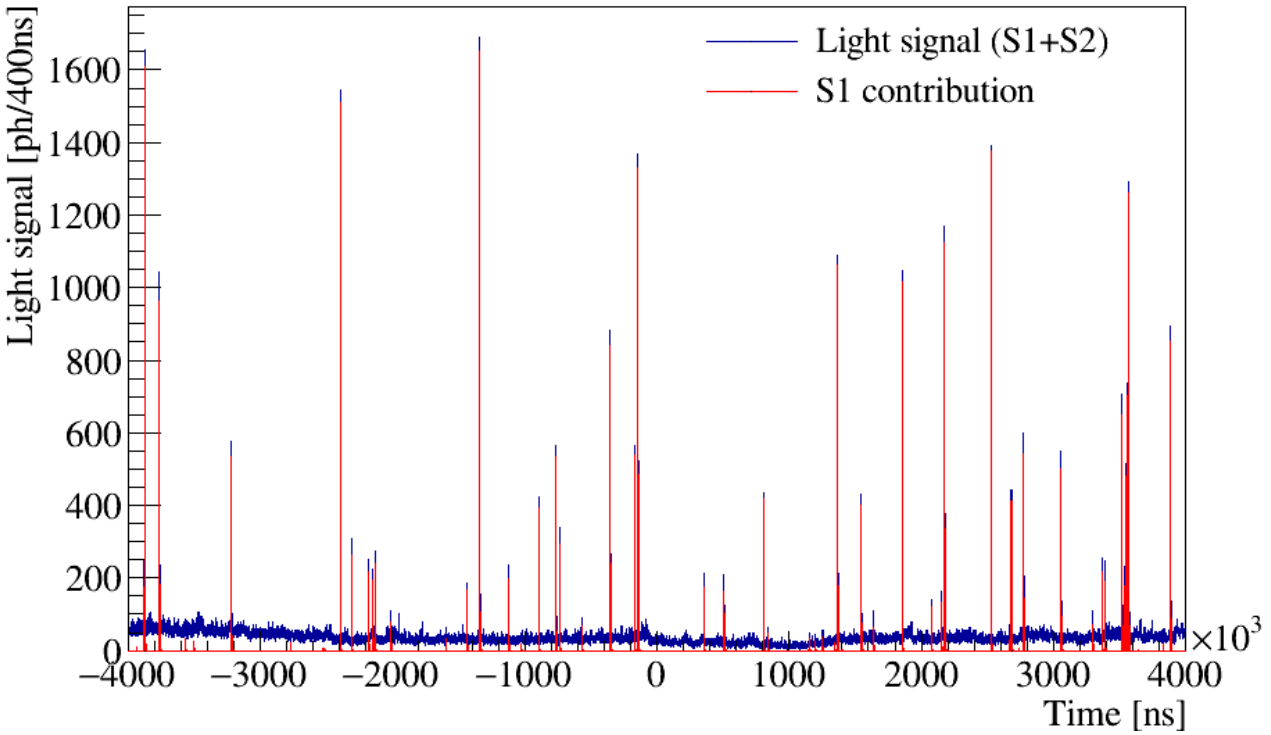


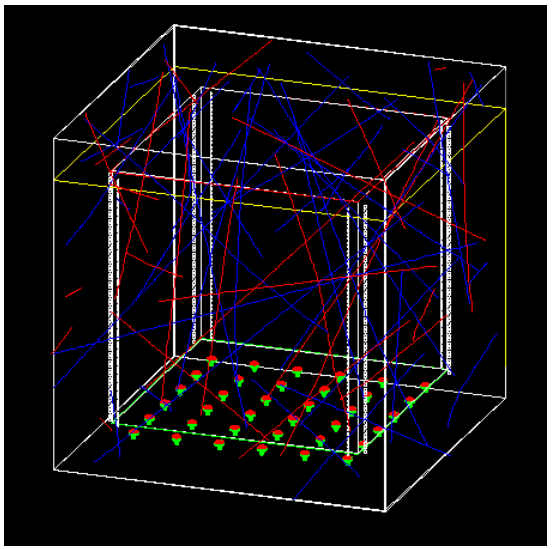
PMTs non-uniformly spaced

Light signal induced by cosmic muons

- Cosmic muons are generated (CRY library) within a (-8ms, +4ms) time window
  - We look at the signal within a (-4ms , +4ms) time window

1 event: light signal within the (-4ms, +4ms) window





Cosmic muon tracks

Preliminary study with 10 events:

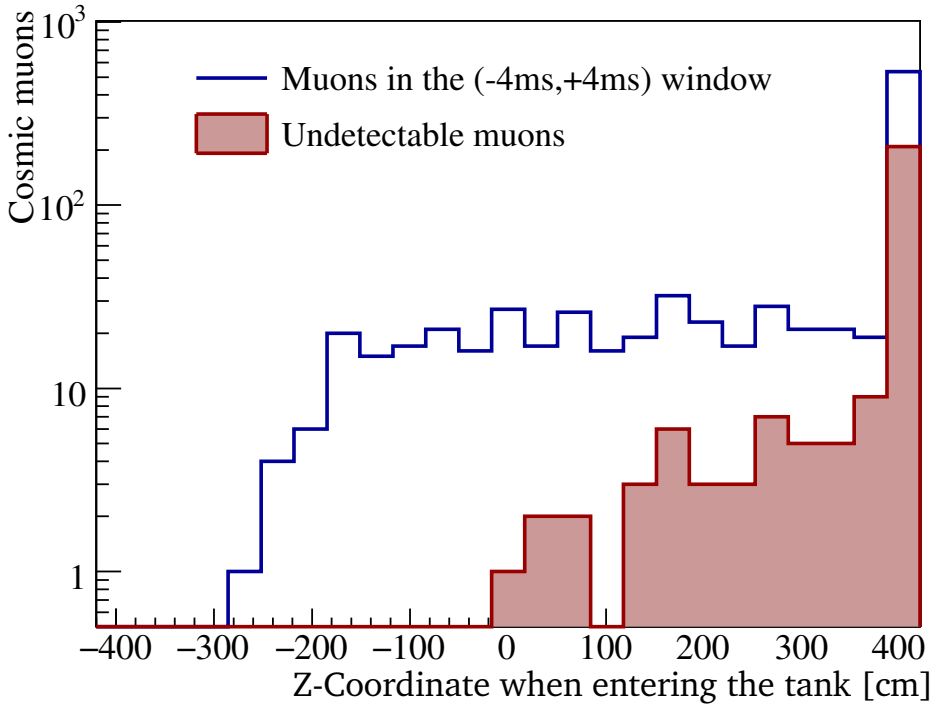
- ~137 muons/event within the (-8ms, +4ms) window → S2 background (~constant)
- ~90 muons/event within the (-4ms, +4ms) window → S1 peaks within the window
- From the simulation, we know the muon characteristics (Energy, momentum, start time...)

Fraction of muons depositing photons on PMT array

In this study:

- Detectable muon: muon inducing S1 signal
- Undetectable muon: muon which doesn't induce a S1 signal

- A lot of photons don't reach the PMT array (mostly due to the absorption in LAr and absorption on stainless-steel components)
- If all the photons produced by a muon are absorbed, this muon can't be detected using the light signal



→ Most of the muons that can't be detected enter the detector by the top

71.8% of muons are detectable

Peak search algorithm

The aim is to tag the S1 peaks

1. Look for **bins** with a number of photons above a given threshold
2. Does **not** search a new peak until finding at least N_{bin_below} consecutive bins **below** the threshold
3. To reject S2 **fluctuations** tagged as S1 peaks:

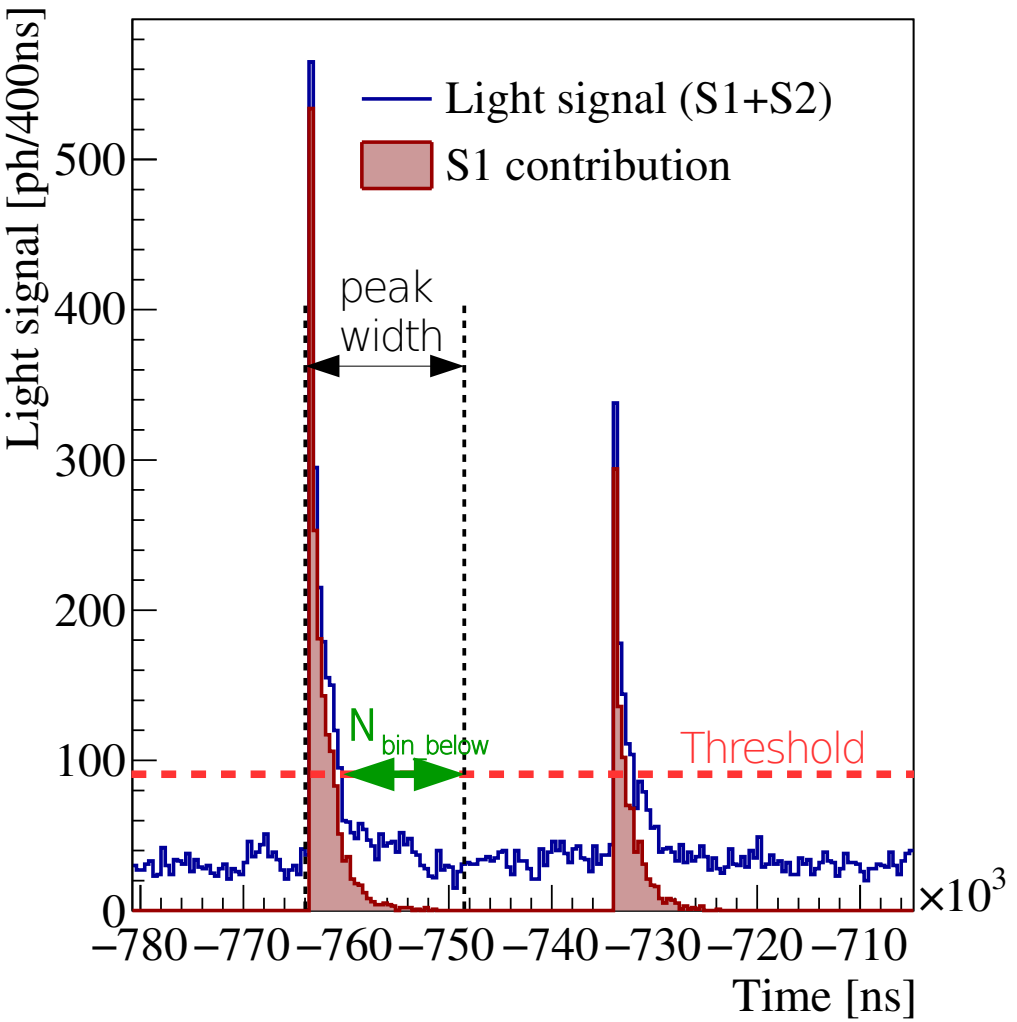
   Look at the ratio between the peak maximum and the peak width (#bins)

   If ratio>$ratio_{Cut}$: the peak is tag as S1 peak

   (basic approach, under study)

3 parameters:

- Threshold
- N_{bin_below}
- $ratio_{Cut}$ (temporary)



The algorithm efficiency can be estimated by matching the found peaks with generated muons

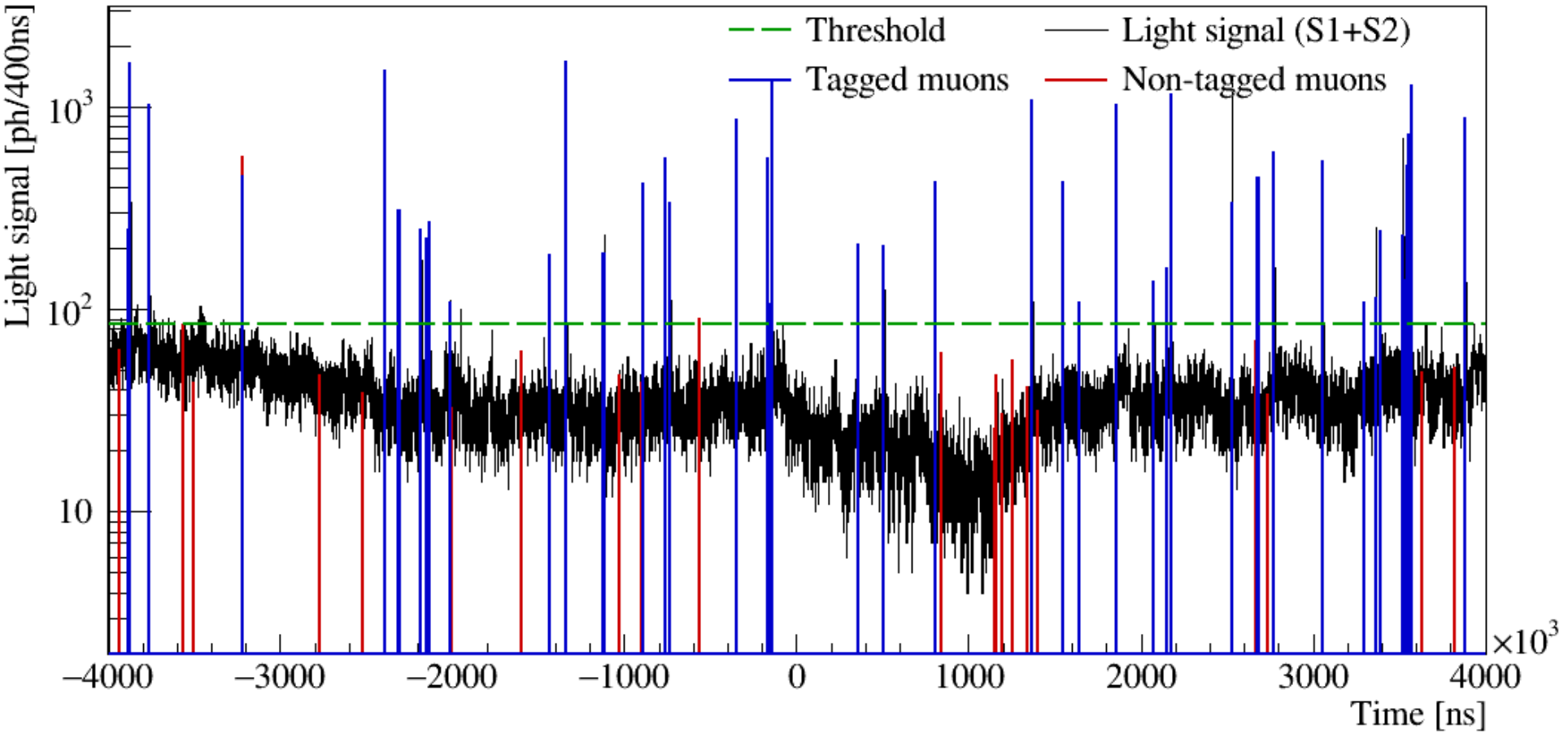
Peak search algorithm – Example on 1 event

(could be optimized)

- Threshold=85ph/bin
- N_{bin_below}=15bins
- $ratio_{Cut}$=1ph/bin

Example: results on 1 event with :

- 86 muons generated in the (-4ms, +4ms) window
- 65 detectable muons

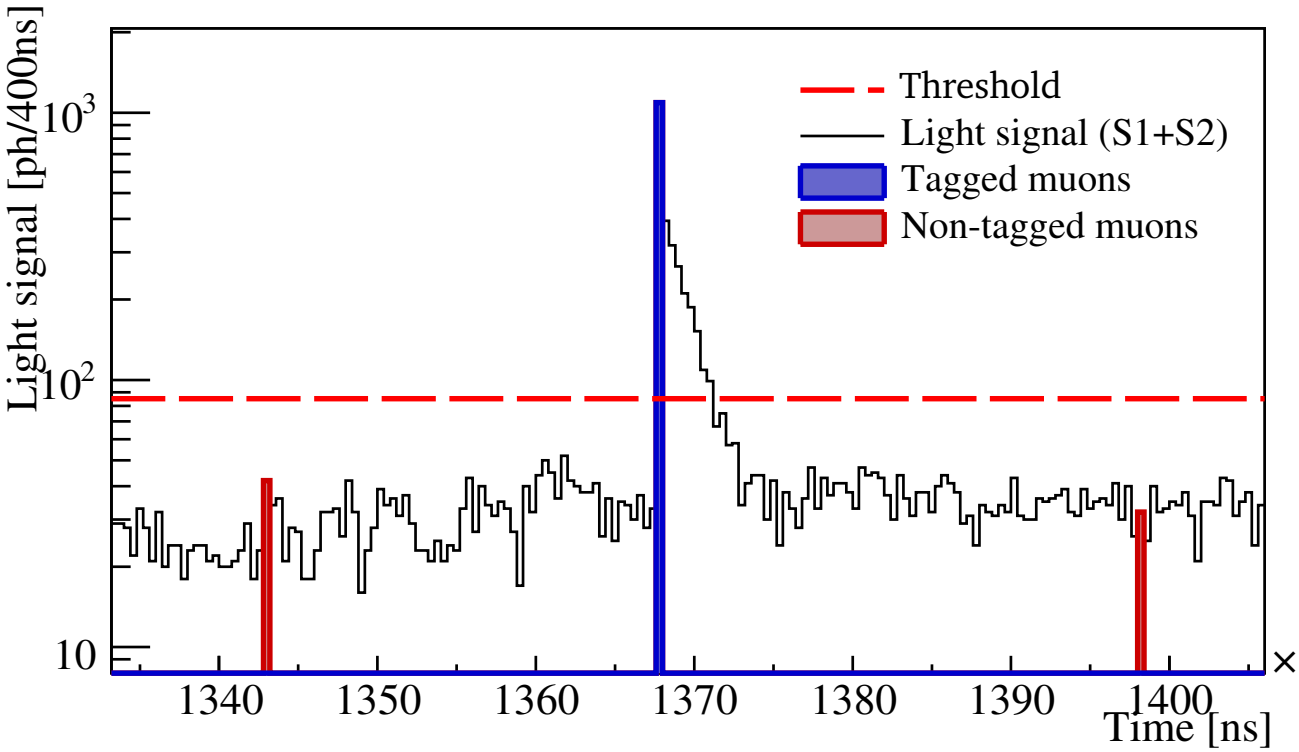


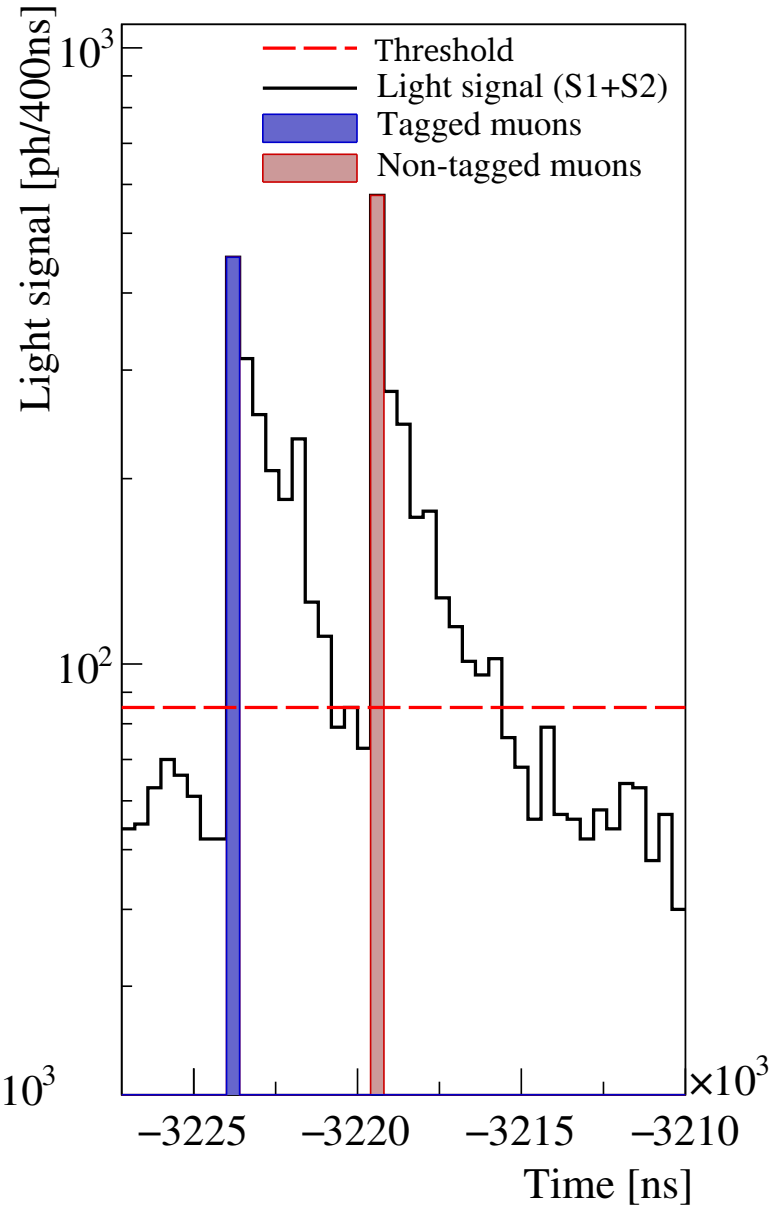
→ 1 false peaks and 43 tagged muons (66% of detectable muons)

Peak search algorithm efficiency

S1 peaks that are not tagged for the time being:

- S1 peaks below threshold
- S1 peaks embedded in the S2 fluctuations
- S1 peaks close in time to another S1 peak



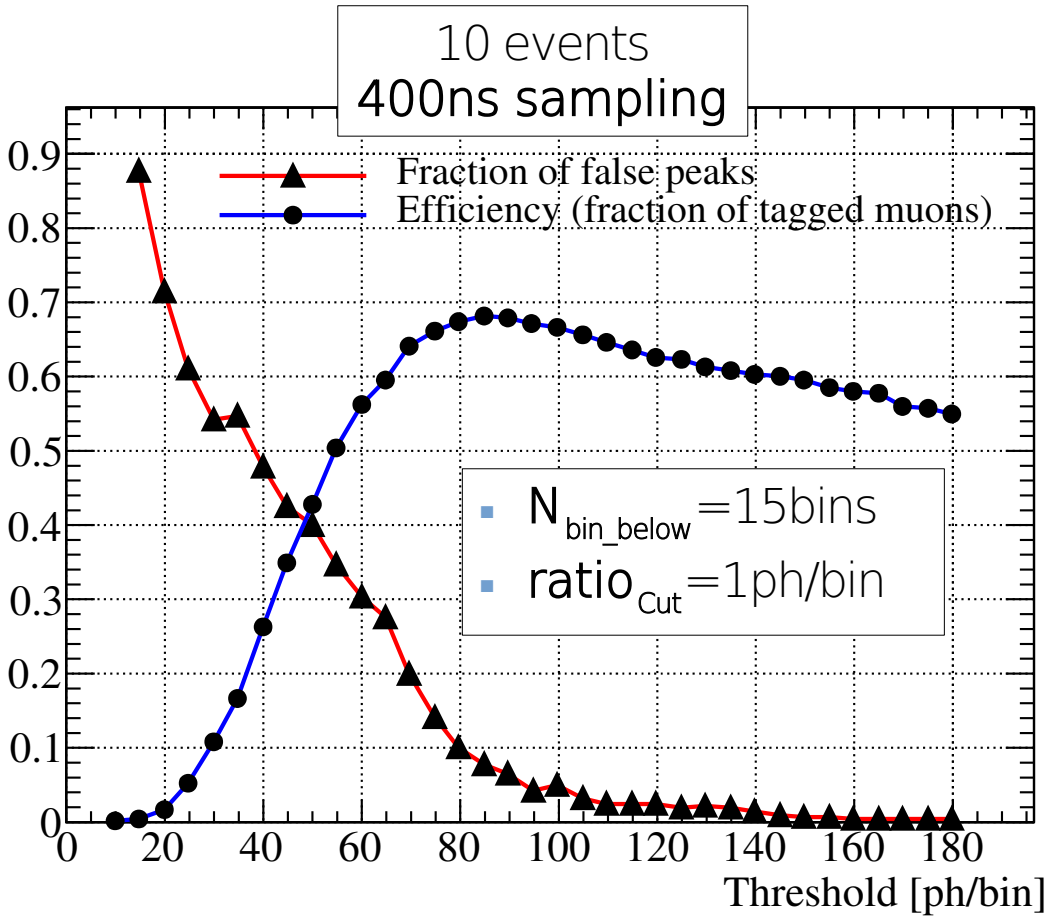


Peak search algorithm efficiency

Dependence on the threshold

Efficiency = #peaks matching a muon / #detectable muons

Fraction of false peaks = #peaks that don't match a muon / #found peaks



Maximum efficiency ~70% for a threshold ~80ph/bin (have to be optimized)

Peak search algorithm efficiency

Efficiency = #peaks matching a muon / #detectable muons

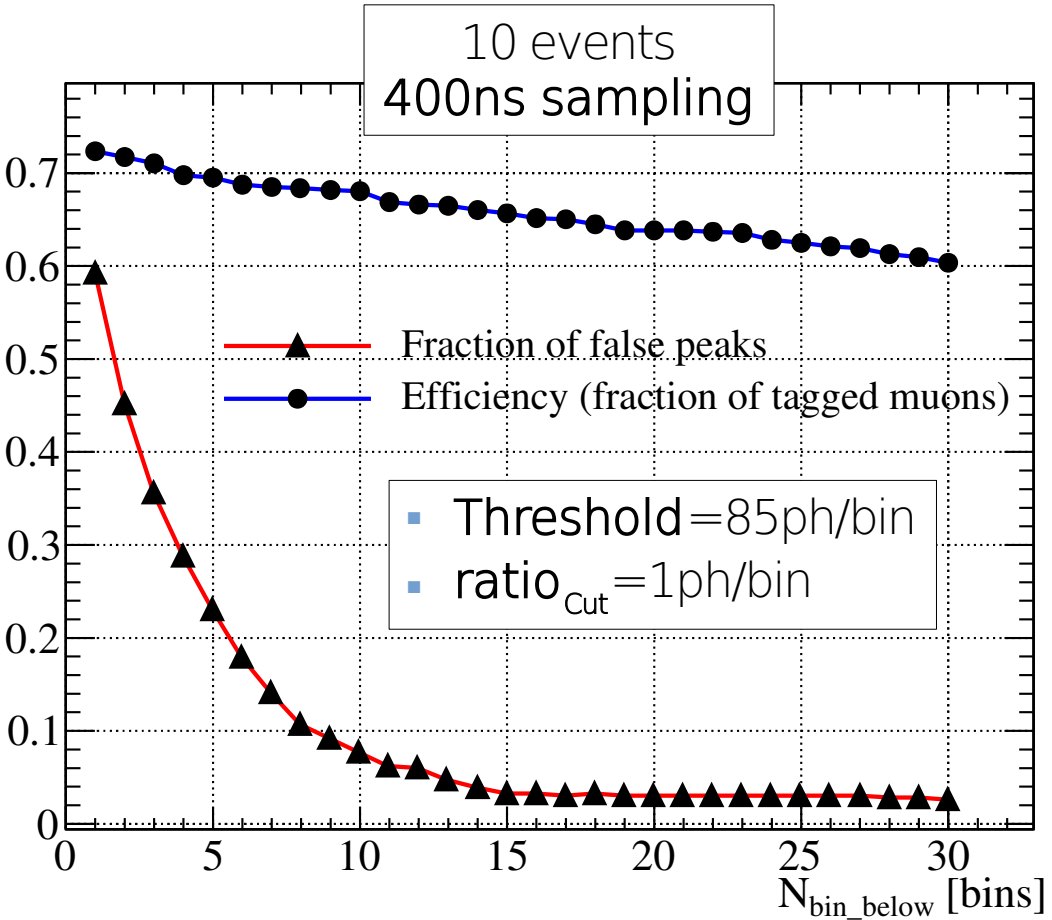
Fraction of false peaks = #peaks that don't match a muon / #found peaks

We need to find a condition to restart the peak search after finding a peak

→ N_{bin_below}

Number of consecutive bins < Threshold before search for a new peak

- Must be >1 to avoid tagging S1 peak fluctuations as new peaks
- If it's too large, risk to miss S1 peaks close in time to other peaks



Fraction of false peaks < 10% for N_{bin_below} > 9bins

(have to be optimized)

Conclusion and next steps

- ~30% of the cosmic muons can't be detected with the light signal (S1 photons don't reach the PMT array)
- A peak search algorithm has been developed:
  - For the time being, use of 3 parameters: threshold, N_{bin_below}, $ratio_{Cut}$
  - With this algorithm and 400ns sampling:

    Tagging of ~65% of the detectable muons

    ~45% of the muons generated in the (-4ms, +4ms)

Next steps

- Increase the number of events
- Parameters optimization
  - For the threshold, perform an estimation of S2 background
  - Studies on the missed muon characteristics
- Use the S1 peak shapes (exponential) to:
  - Find a good criteria to reject false peaks (Can replace N_{bin_below} and $ratio_{Cut}$ parameters)
  - Improve the efficiency for muons close in time
- Taking into account the PMT and electronics responses