Status report on the work about light signal simulation

Anne CHAPPUIS – Isabelle DE BONIS – Dominique DUCHESNEAU – Laura ZAMBELLI

WA105 SB Meeting

08 February 2017

Laboratoire d'Annecy-le-Vieux
de Physique des Particules

Introduction

- At last talk at SB meeting (7 December 2016):

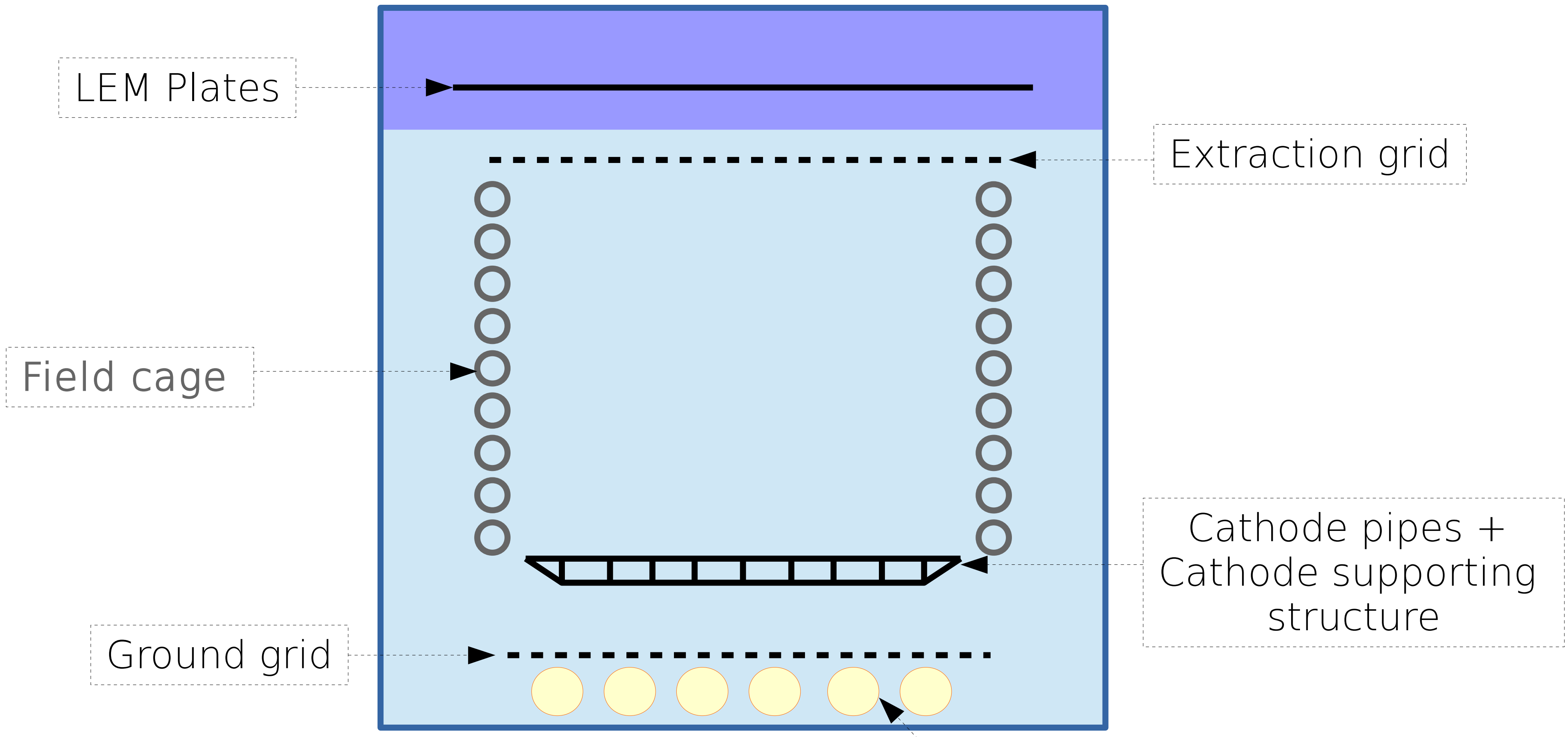
Impact of the updated geometry on light signal collection

→ Loss of 60% of collected photons (due to the absorption on cathode wires and cathode supporting structure)

- We have continued to update the implemented geometry (extraction grid and ground grid)
- We have focused on the production of preliminary light maps

- Outline:
  - Impact of the ground grid on light signal
  - Preliminary maps
  - First results obtained with QScan

Status of the implemented geometry (LightSim)



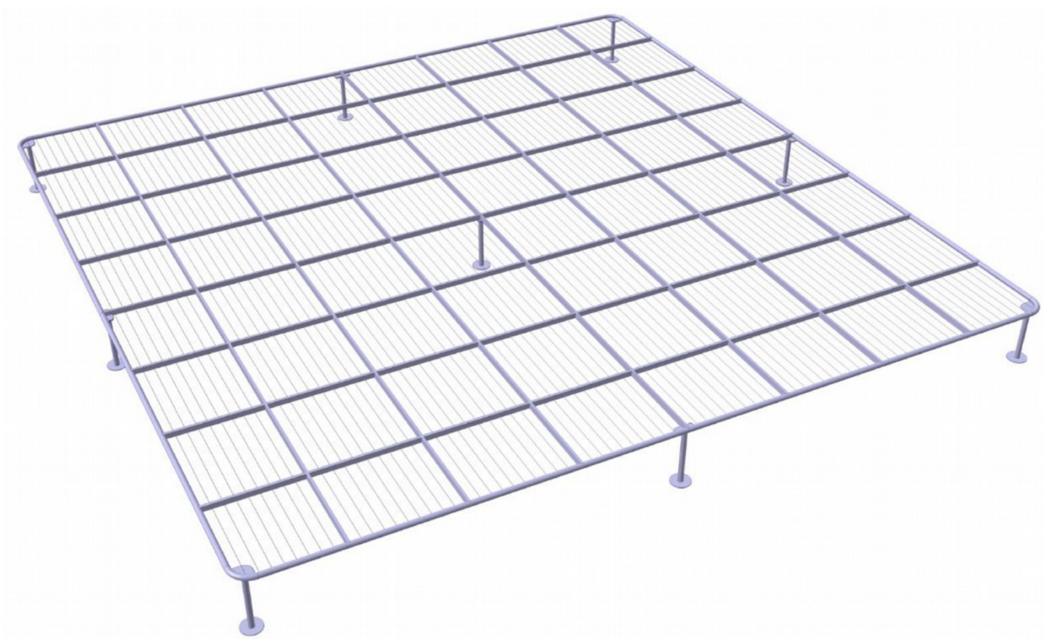
PMT array

- 6x6 **TPB-coated** PMTs
- Spaced by **1m** or **65cm**

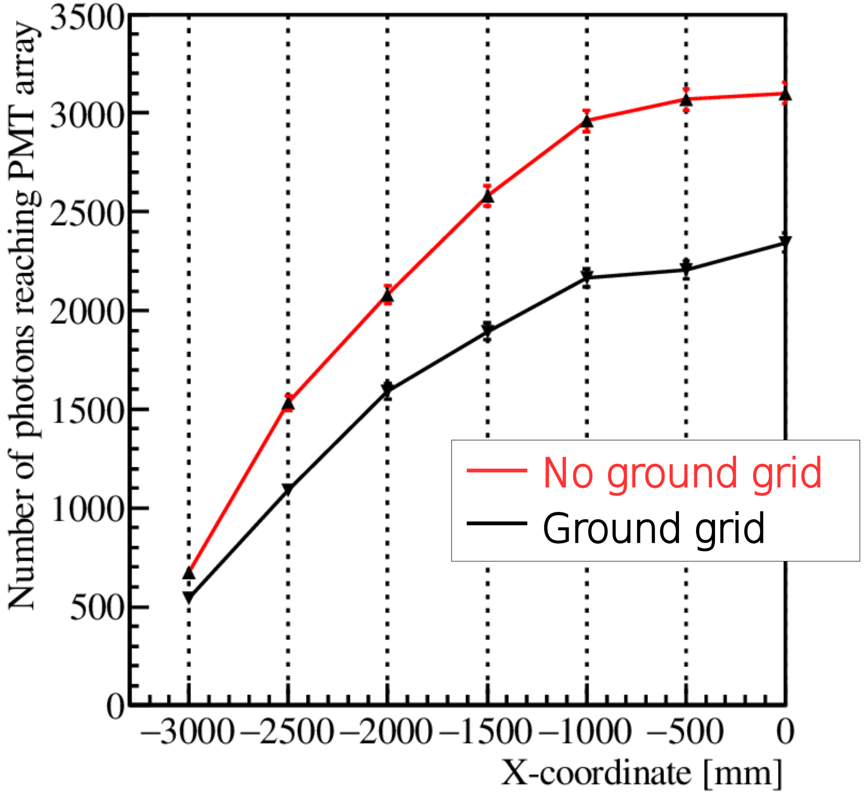
Ground grid impact on light signal

→ Implementation of the ground grid (above PMTs)

Reminder: scintillation photons are **totally** absorbed by stainless-steel



Photons generated ~1m above the cathode pipes
(PMT every 1m^2)



Average loss of photons: 26% (PMTs spaced by 1m)
24% (PMTs spaced by 65cm)

Study done with 1mm-radius wires → have to be redone with 2mm-radius.

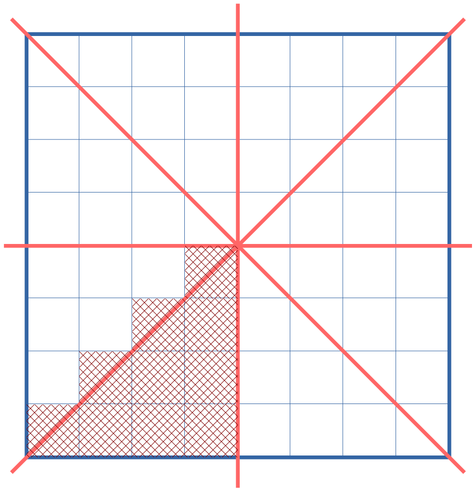
Preliminary maps

→ Now that the detector geometry is updated and nearly fixed, it gives the possibility to produce the preliminary maps.

- Preliminary LAr maps:
  - Large voxels definition: 250mmx250mmx250mm
  - Number of voxels: 24x24x29 = 16704 voxels
  - Cover a volume about 6mx6mx7m (from the LAr surface to the PMT array)
  - Number of generated photons per voxel: 10^7

- Preliminary GAr maps:
  - Only one voxel in Z (photons generated between the LEM plates and the LAr surface)
  - Voxel definition: 250mmx250mm (576 voxels)
  - Number of generated photons per voxel: 10^8

✔ To save time, photons are generated in ~1/8 of the detector, then we use the X-Y symmetry of the detector to reconstruct the whole map.



→ Simulation of 2262 voxels instead of 16704

Preliminary maps

Goals of these **preliminary maps**:

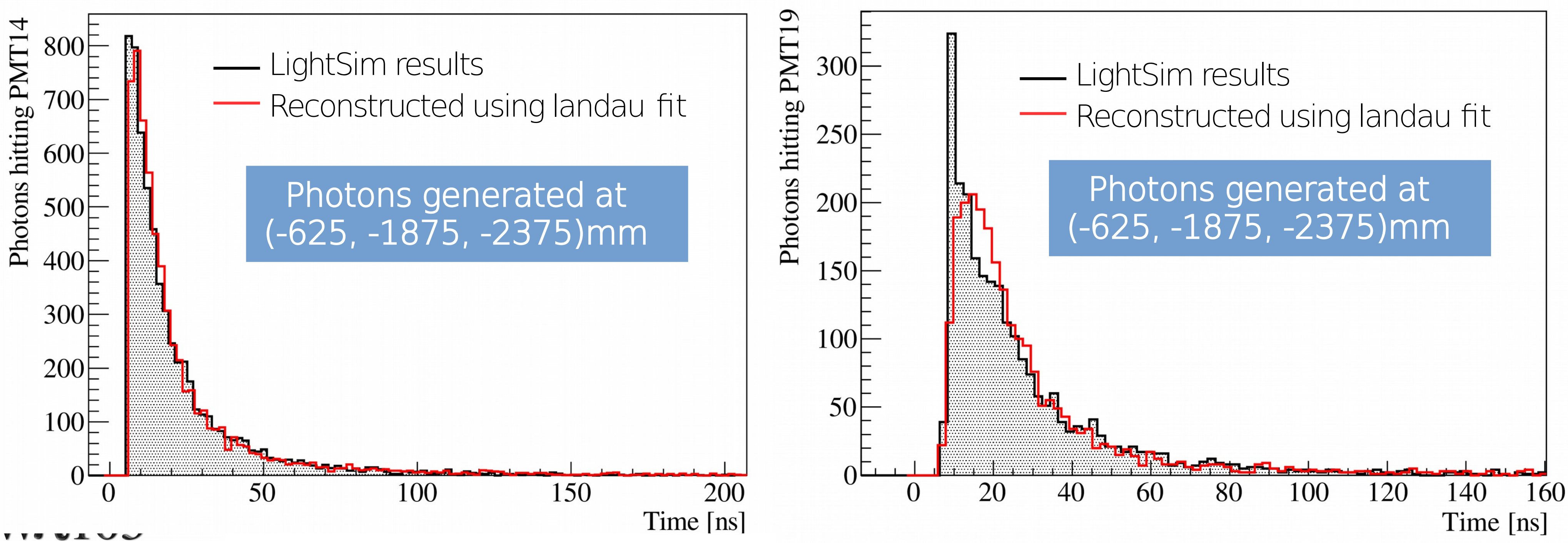
- **Validation** of the production procedure
- First studies with the **updated geometry** in **QSCAN** (specially PMTs configuration)
- Study of the final **voxel definition**
- Study of the **time distribution** parametrisation

For these maps: the **time distribution** is reconstructed using a **landau fit** (WA105 SB Meeting, 7 July 2016)

(**Reminder**: for the **old maps**, reconstruction using an **exponential** fit)

→ **Satisfactory** in most cases

→ Has to be **optimized** for remaining cases

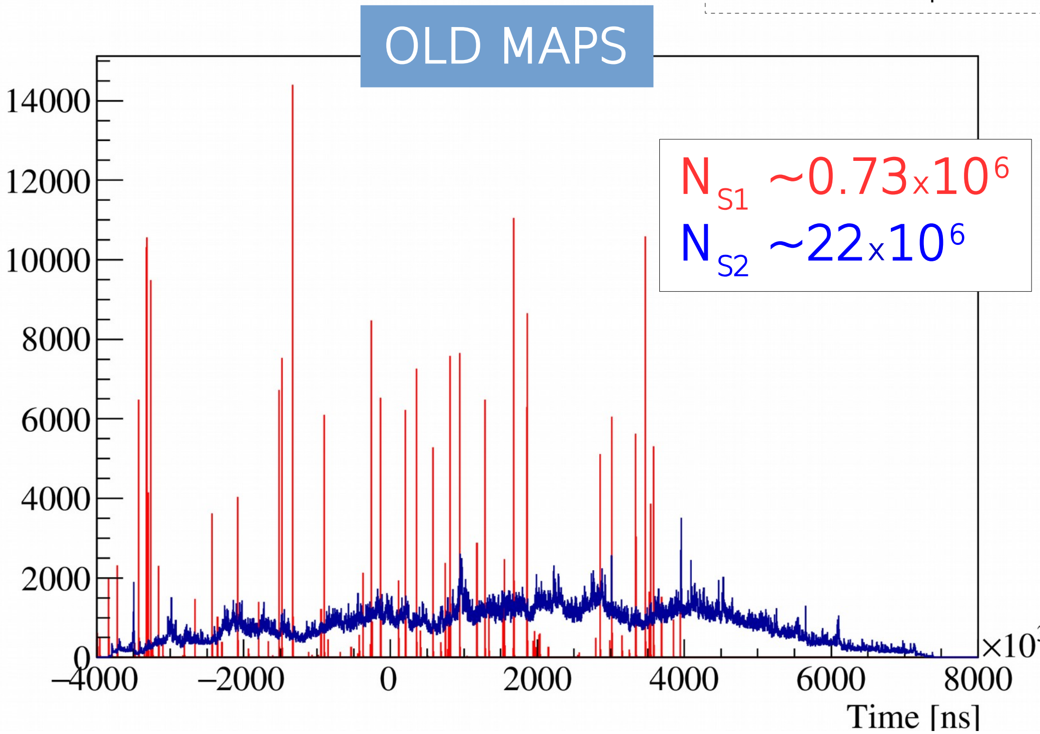


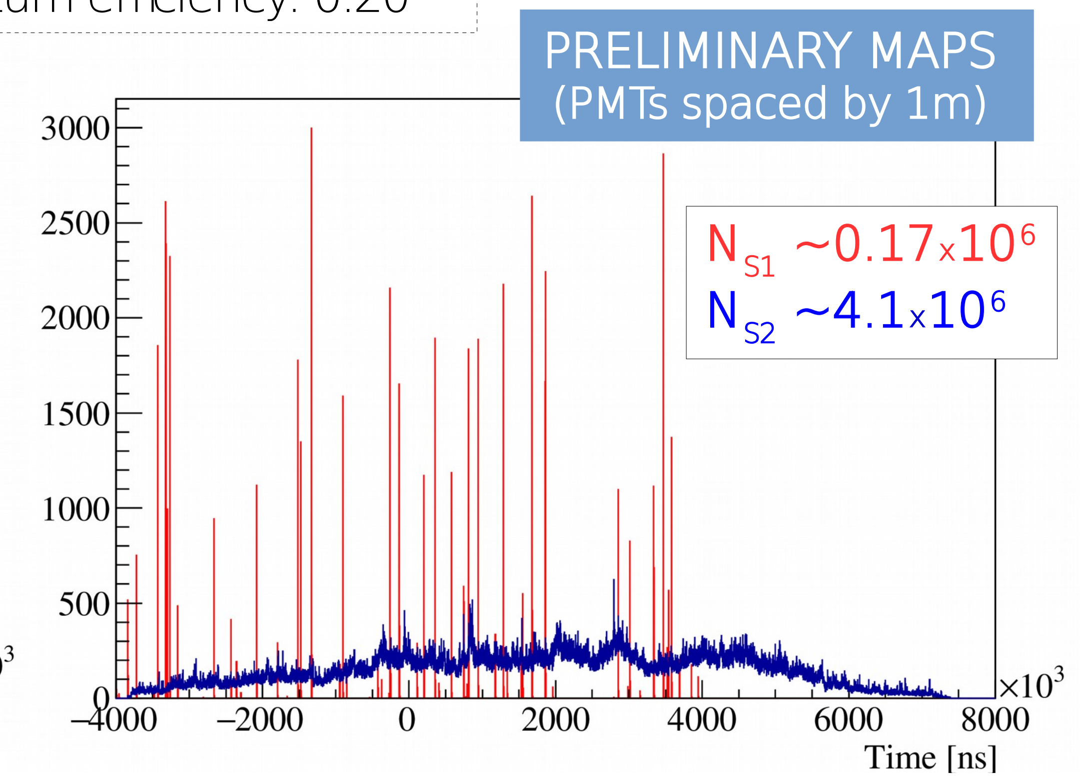
First results on cosmic muons (with QScan)

→ We implement these maps in QSCAN and look at the signal induced by cosmic muons (in 8ms)

Study done with:

- Infinite absorption length
- Electroluminescence gain G=300
- PMT quantum efficiency: 0.20





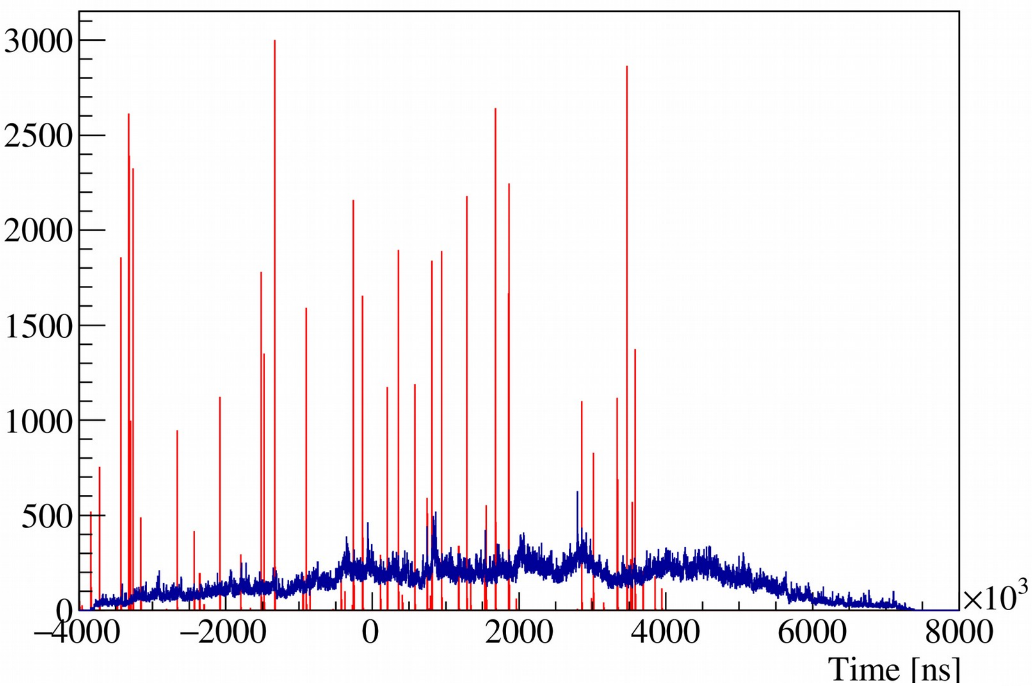
→ Important **loss** of photons (mostly due to the **absorption** on cathode pipes and cathode supporting structure)

→ The ratio between N_{S1} and N_{S2} photons is **similar**

Impact of the PMT configuration on light signal

Comparison between the signal induced by cosmic muons for PMTs spaced by 1m and 65cm

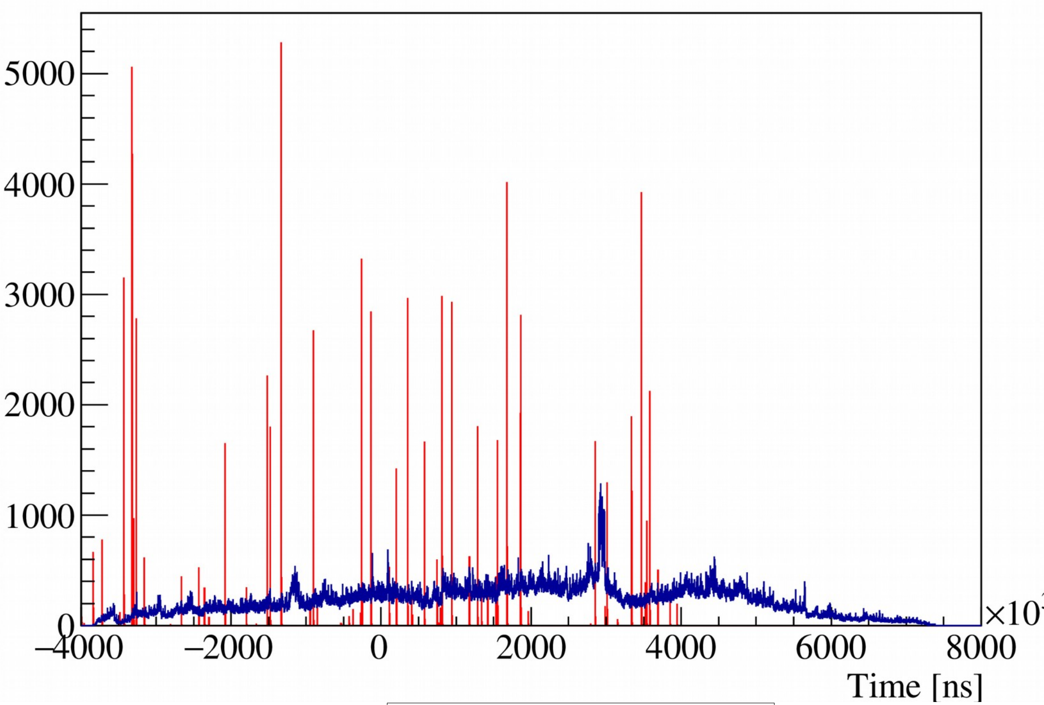
PMTs spaced by 1m



N_{S1} ~0.17x10^6

N_{S2} ~4.1x10^6

PMTs spaced by 65cm



N_{S1} ~0.26x10^6

N_{S2} ~6.2x10^6

→ Configuration with PMTs spaced by 65cm: the number of collected photons increases

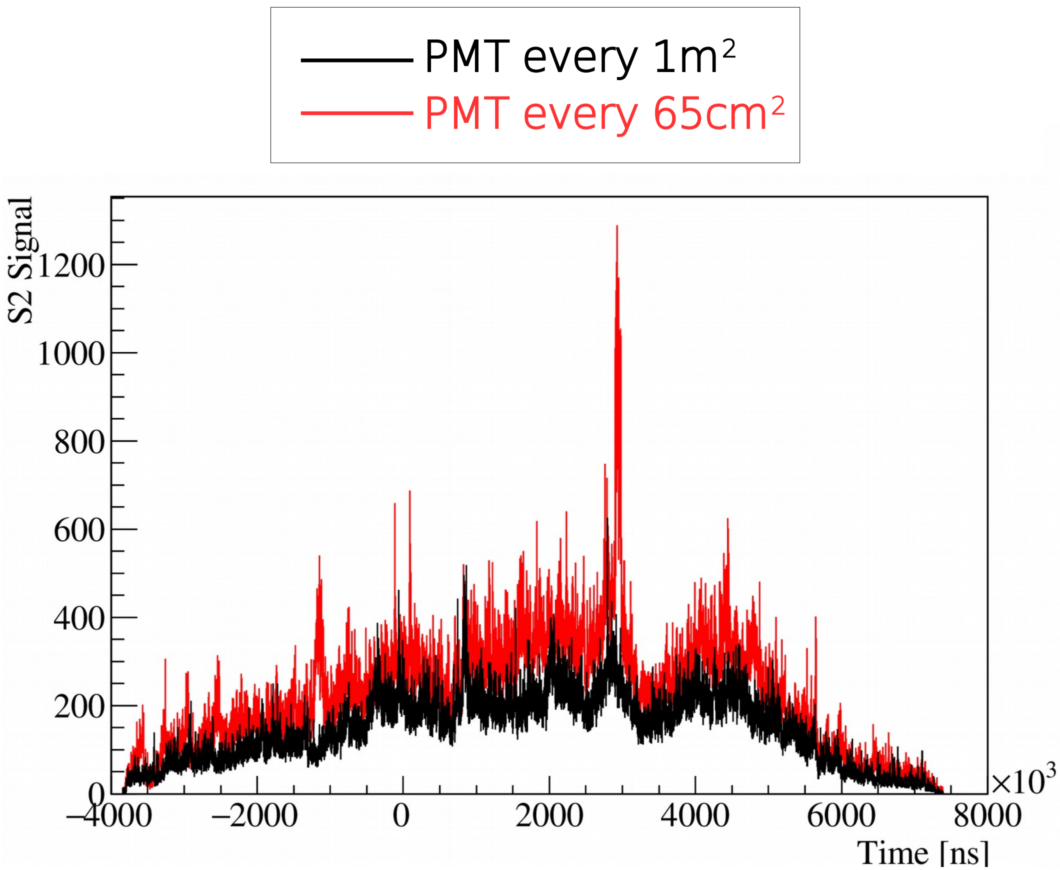
→ The ratio between N_{S1} and N_{S2} photons is similar

WA105

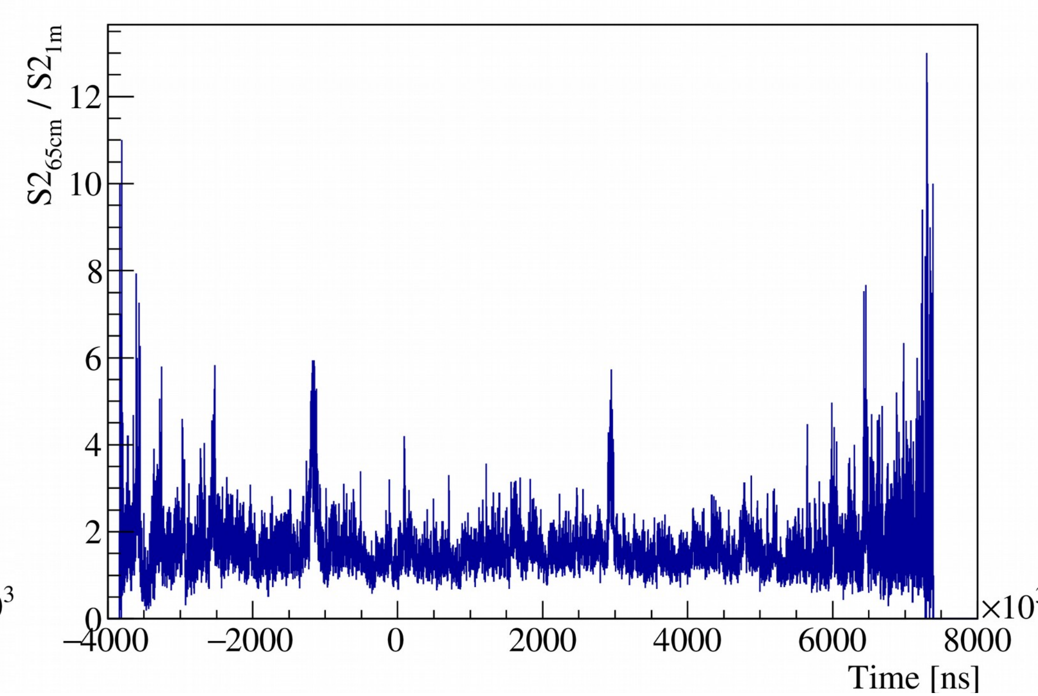
Impact of the PMT configuration on S2 signal

Comparison between S2 signal induced by cosmic muons for the two PMT configurations.

→ Ratio between the two histograms



Ratio between $S2_{65cm}$ and $S2_{1m}$



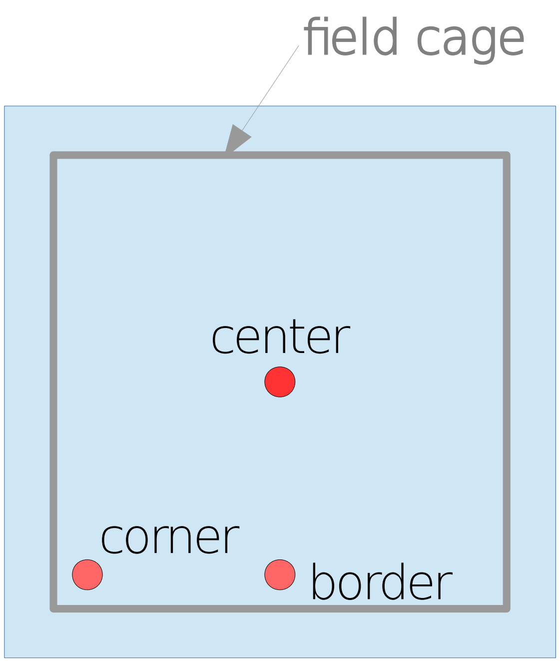
→ The ratio between $S2_{65cm}$ and $S2_{1m}$ is constant wrt time

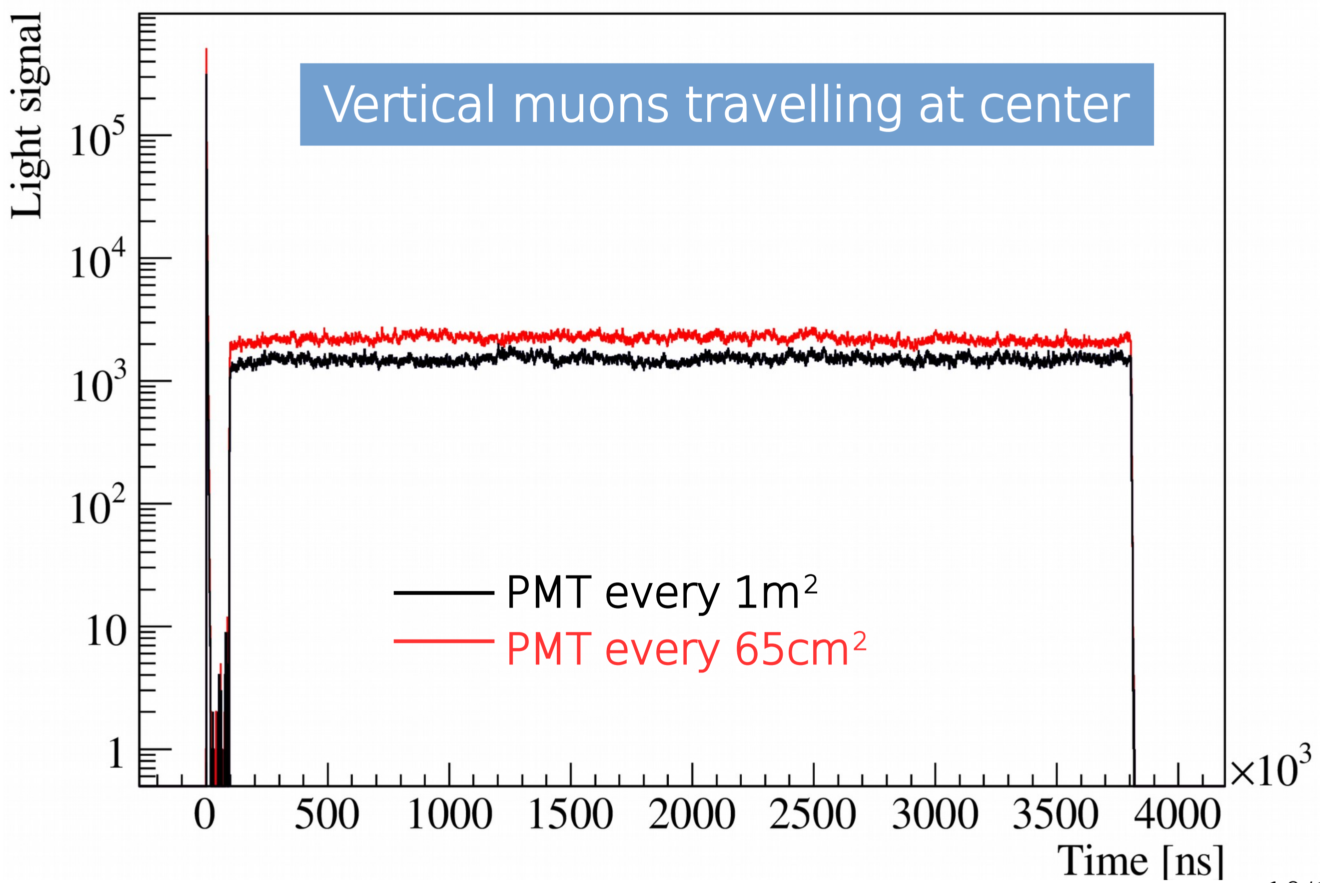
Signal (S1+S2) induced by vertical muons

PMTs spaced by 65cm: increase of the number of collected photons, specially at the detector **center**.

→ But **risk** to lose the tag efficiency for muon travelling in the detector edges ?

→ Study of the signal induced by 100 vertical muons travelling at 3 different positions in the detector

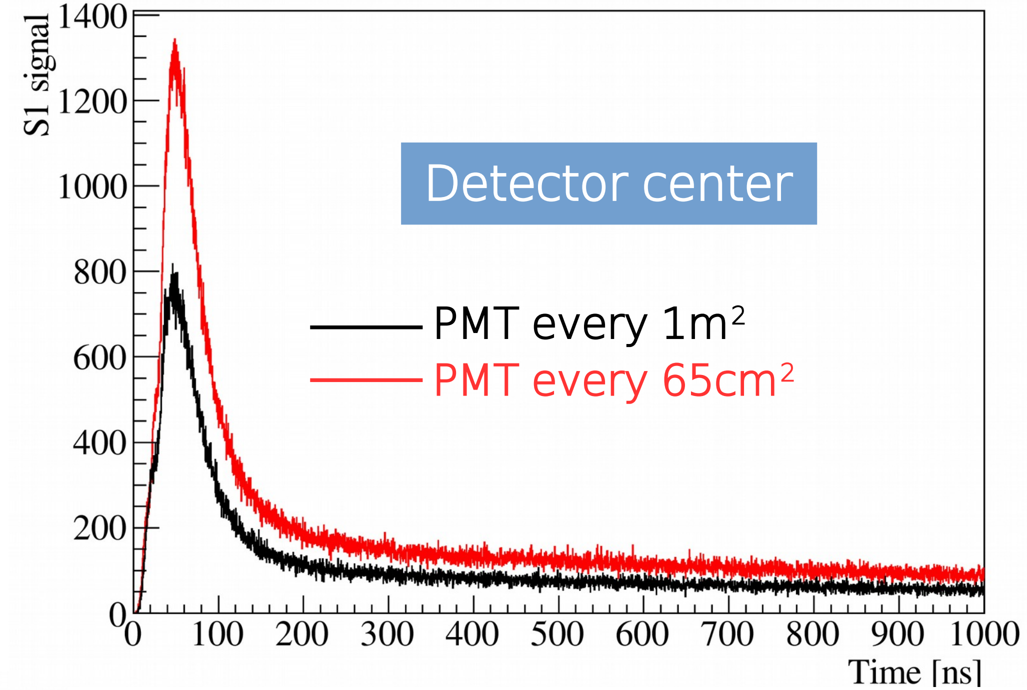


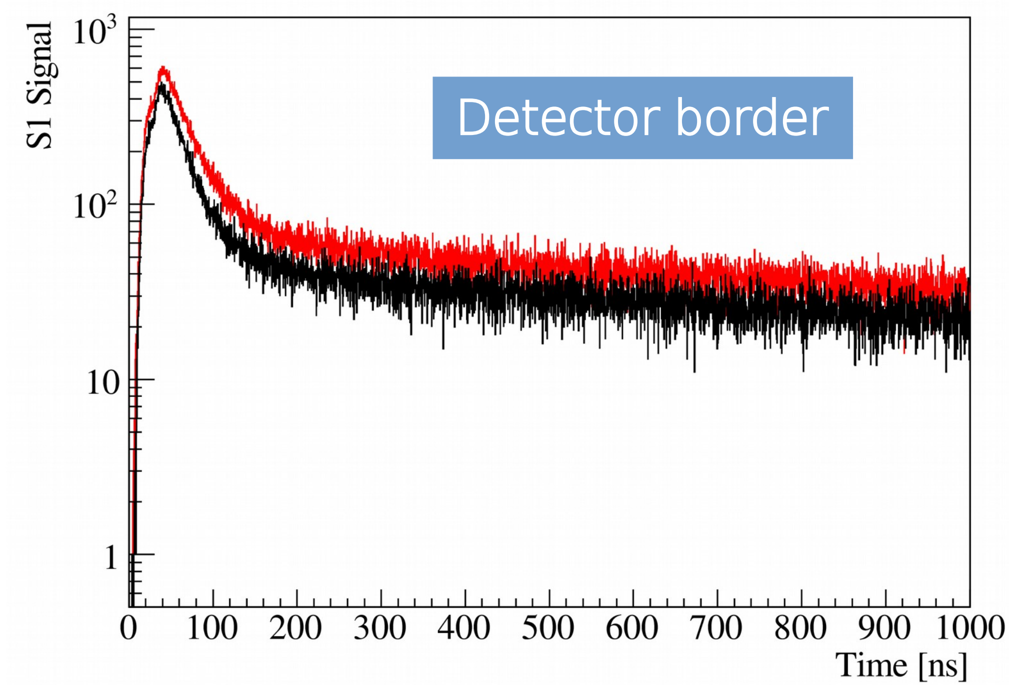


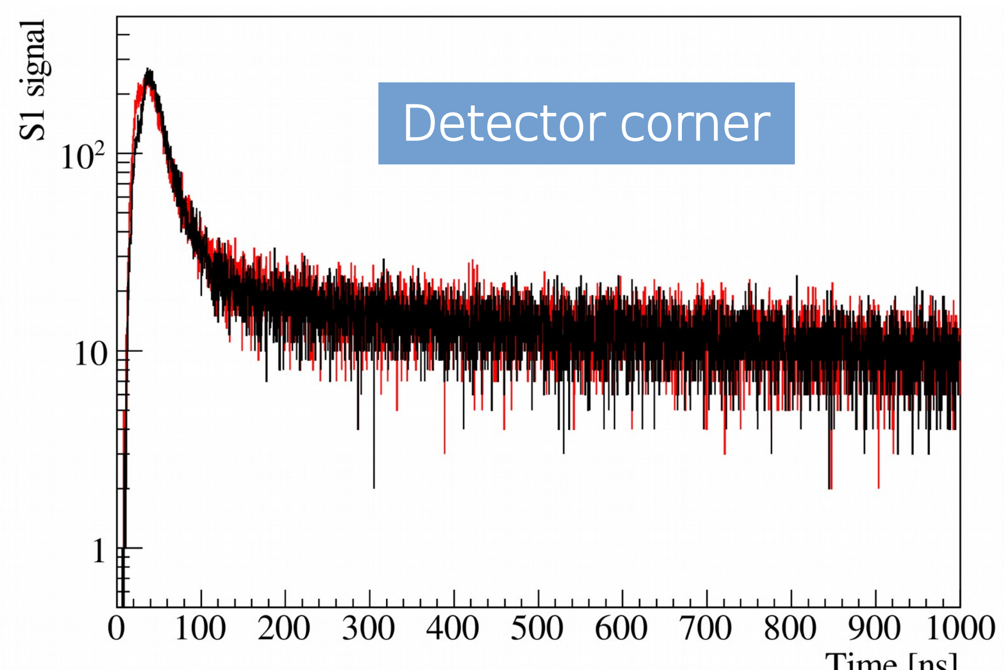
S1 signal induced by vertical muons

→ We look at the effect of the PMT configuration on S1 signal

- The difference between the two configurations decreases when the muons get closer to the detector edges
- In the worst case (muon in the detector corner), the two configurations are equivalent.







Conclusion

- Preliminary maps have been **produced**
  - The implementation of the procedure is complete
  - First studies with QScan

    → Signals S1 and S2 induced by cosmic muons
    → PMTs positioning (with cosmic muons and vertical muons)

- With PMTs spaced by 65cm:
  - Globally increases the number of **collected photons**
  - For muons travelling near the field cage: no significant loss of collected photons (wrt PMTs spaced by 1m)

→ To continue the cosmics study, the PMTs positioning needs to be decided

Which configuration (1m, 65cm, or a mix ?)

Perspectives

Short-term

- Cosmics tagging
  - **Threshold** method (developed last year by Marie and Alessandra)
- Light maps
  - Updated pre-maps with **last geometry adjustments** (PMTs positioning, ground grid wire radius, etc)
  - Optimization of the **time distribution parametrization**
- 3x1x1 light maps
  - Begin the **implementation of the 3x1x1 geometry** in LightSim

Medium-term and long-term

- Cosmics tagging
  - Using the signal collected **PMT by PMT**
  - Efficiency **dependence** wrt important parameters (electroluminescence gain, absorption length, etc)
- 3x1x1 maps
  - **Produce** light maps for the 3x1x1 demonstrator
  - Comparison between **simulations** and **light signal data**
    - Study of **electroluminescence gain** (crucial for S2 simulation)
    - Study of parameters which are crucial for the **light propagation** (absorption length)
    - Difference between **direct TPB coating** and **TPB plate** above PMT