

Updates:  
Simulation for the L1 trigger machine learning + plans

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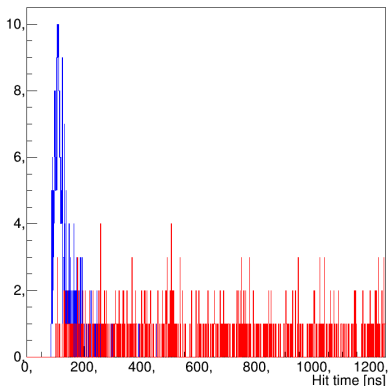
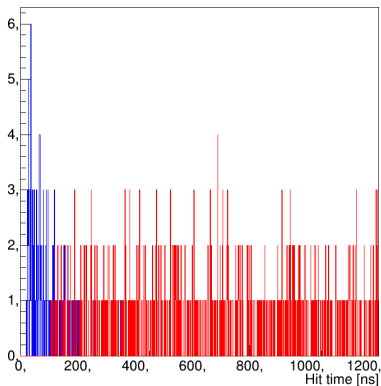
- ① detsim : generator + detector simulation
  - Simulated particles: electrons
  - Energy range: 50 keV to 350 keV
- ② elecsim : PMT response simulation + triggers
  - From photons hitting the PMT to p.e. signal
  - Simulates the Dark Noise and afterpulses → gives pulse type
  - Configuration parameters:
    - "-nHitsThreshold 0"
    - "-Trigger\_FiredPmtNum 0"
    - "-Trigger\_window 320"

(we want to use the ML trigger, not the usual JUNO trigger)

- Jobs are done: 100 files of 200 simulated signal events (2e4 signal events)
- For 200 signal events simulation,  $\sim 1300$  dark noise events
- Total signal+noise events:  $1.5 \times 10^5$
- Ratio of  $\sim 15\%$  signal  $\sim 85\%$  background
- Elecsim waveform files are very heavy: 14-16 GB per file
- Storage place has been created for us in the cluster with no quota:  
*/pnfs/iihe/juno/store/user/*
  - Both PA and myself have a directory there with writing permissions
  - Anyone can read the files of the production I made in  
*/pnfs/iihe/juno/store/user/mcolomer/output\_files/*

# Which variable is used for the ML?

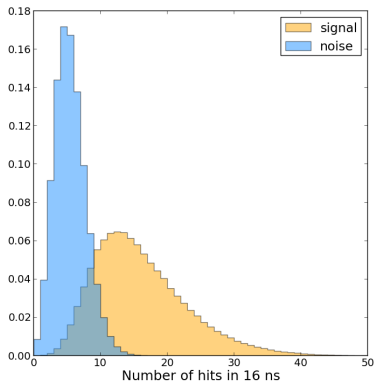
- Access the hit time distribution for the event hits!
- Count the number of hits in 16ns, in the first 320 ns trigger window
- No need of using the ADC and complicated variables



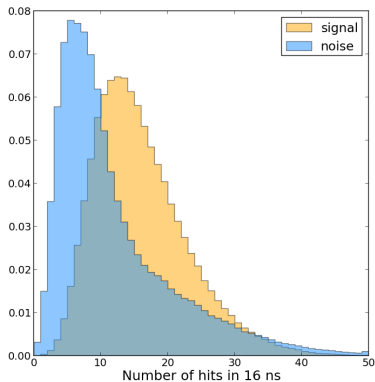
# Which variable is used for the ML?

- Number of hits in 16 ns obtained from time distribution
- Two options considered: with and without afterpulse hits

## ONLY DARK NOISE HITS

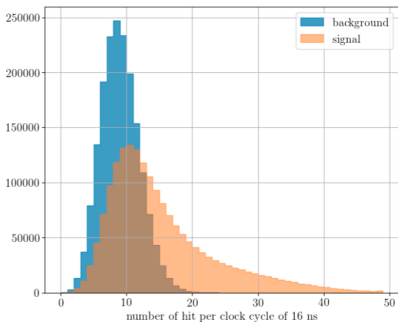
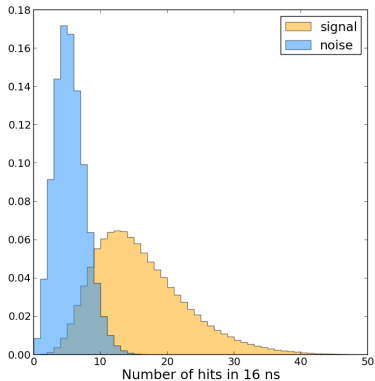


## WITH AFTERPULSE HITS



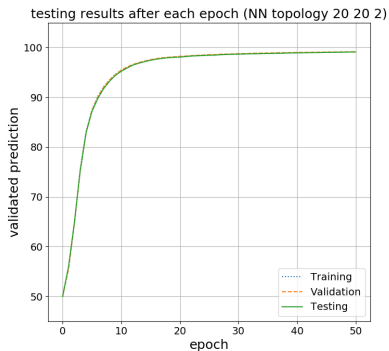
## Comparison with previous result

- Larger signal than in previous result due to extended energy range
- Smaller number of background hits with DN only using the full electronics compared to previous "by hand randomised" noise simulation
- h5 files ready to run the ML algorithm on the new simulation

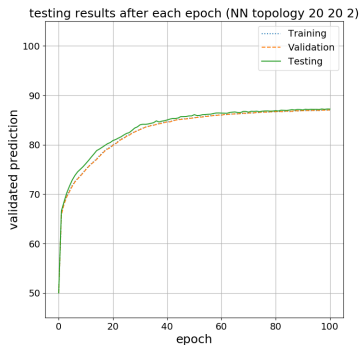


- I can reproduce PA's result using the same code and data file
- The code runs without problems with the new simulation file
- For comparison: 50-50% signal-noise and same stat as for the paper used
- Worst results obtained with new simulation (not expected if only DN)
- Same result obtained using ML with and without afterpulse hits (strange)

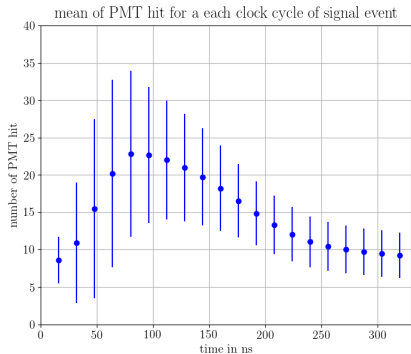
## PREVIOUS RESULT



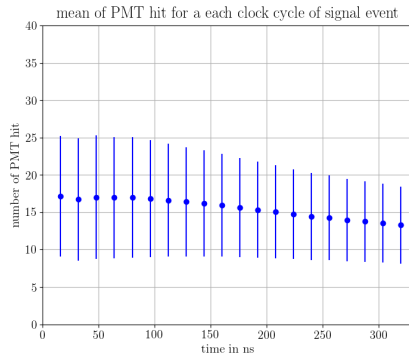
## NEW RESULT



## PREVIOUS RESULT



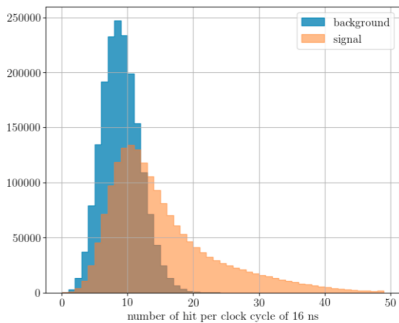
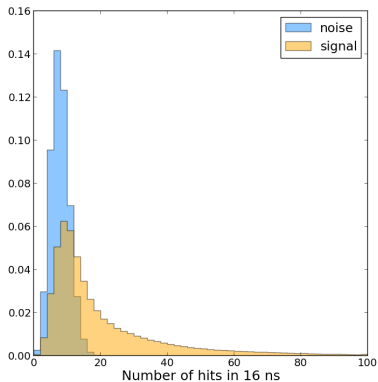
## NEW RESULT



- ▶ The issue has been found and corrected, bug when computing the 16 ns bins in the 320 ns clock cycle window

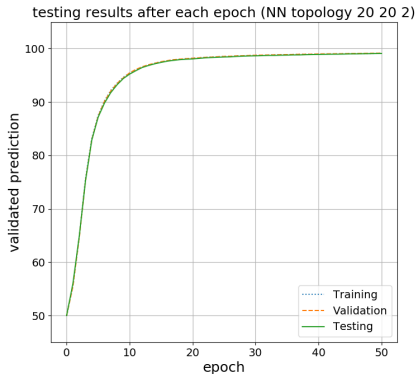


- More similar distributions now that the bug has been corrected

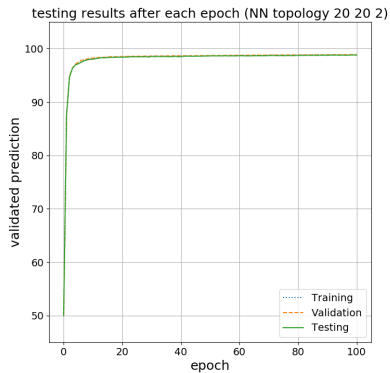


- ▶ Same performance found with new simulation of signal+DN

## PREVIOUS RESULT



## NEW RESULT



- run the analysis with afterpulses and compare performance
- compare performance with different signal-DN ratio than 50-50
- Use other signal than electrons

## Collaboration with Livia group: plans

- Organise working group within European institutes
- PhD students at Julich and Bratislava working on direction reconstruction (not available yet, relevant for many studies)
- Only detsim production is official and ready:  
working of elecim + waveform + reconstruction  
(we could help running the production for next steps)
- Goal: oscillations study combining atm neutrino measurement and reactor neutrinos result
- Meeting will be planned to distribute work and make schedule plans

- Idea: we could work on ML discrimination between electron and muon neutrinos and between atm neutrinos and atm muons (only background)
- Also, work on better understanding of the detector:
  - Issues in elecsim handling of high-energy events during the workshop
  - Proper evaluation of the systematics for the analysis with full GENIE/GEANT4 simulation
  - Evaluation of the maximum energy that can be proved by JUNO (access the few-GeV regime)
- Moreover, atmospheric neutrino study can be used for future cosmic (sub-)GeV neutrino analysis (less covered topic)

# Back-up

- Python environment where all needed packages for ML script are installed:  
*source/cvmfs/sft.cern.ch/lcg/views/setupViews.sh LCG\_98python3  
x86\_64 – centos7 – gcc10 – opt*

### PROBLEMS:

- It seems it does not allow to make/save plots using matplotlib (I have contacted the user support to see what happens)
- Python 3 is not compatible with ROOT6 (and Sniper/offline JUNO software) to read the JUNO EDML files:  
I have been reading the user files as python arrays with *uproot*
- Script to process simulation and produce h5 input files for ML ready