PPM-DU: what we have learned for Phase-I

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PPM-DU: a Qualification Project

- **Pre Production Model Detection Unit (PPM-DU)** deployed in the Capo Passero site, off-shore the Sicilian coast May 2014
- Main purposes:
 - 'Dry run' of marine operations string deployment, submarine connection, unfurling procedure
 - Validate the DU structure
 - Operation and data handling tools
 - Test the software architecture developed for the km³-scale detector
 - Improve our knowledge of the site (bioluminescence)
- Publication under preparation!

PPM-DU

- 2 DOMs with ETEL D783FLA PMTs
- 1 DOM with Hamamatsu R12199-02 PMTs
- LED beacon and piezo
- Deployed at the KM3NeT-It site at 3500m depth, 100 km off shore
- Operational since May 2014





PPM-DU: Integration and Deployment



- Integrated at Nikhef (Amsterdam) and CPPM (Marseille)
- Deployed at 3500 m depth at the site of Capo Passero (KM3NeT-It) in May 2014



Detector Status

- Since deployment, all DOMs are correctly working
- Few line power off/on to recover communication with a DOM
- Failures:
 - PMT14 DOM2 not active since deployment
 - PMT27 DOM3 was kept off in June-mid November: anomalous high rates —> Now recovered
 - Tiltmeter of DOM3 not working since deployment.
- LED beacons ok, they were seen by the Italian tower too.
- Laser beacon of the tower used to flash the PPM-DU: combined data have to be analyzed.

PPM-DU people

- Bari
 - Marco Circella: technical coordinator
- Bologna
 - Carmelo Pellegrino: automatic DAQ
- LNS
 - Simone Biagi: coordinator of operations and data handling
 - Rosa Coniglione: coordinator of data analysis
 - Agata Trovato: MC and tracking
- Napoli
 - Francesco Di Capua: low level data analysis
 - Natalia Deniskina: study on tracking algorithm (to be started)

Automatic DAQ

- Electronics inside DOMs inherited from Saclay group.
- DAQ software for communication with DOMs (inherited from Saclay) needs human direct control: not modifiable, source not available
- To bypass the problem, everything has been automatized:
 - Move, resize window, mouse click, grab text (GPS time info)
 - Time offsets calibrated (run duration, pause between clicks, crontab)
 - Creation/deletion of lock_files (avoid duplication of processes)
 - Store of run info into the Database (*autodaq-cp* dedicated user)
 - GPS info also stored locally, to allow data conversion/filtering

Data processing

PPM-DU Data Processing Chain



Data processing

File Type	Size per 30 min run	Size per day (36 runs)	DAQ/processing time	Туре
.rdat	15GB	540GB	30min	raw data (all)
.dat	5GB	180GB	12min	raw data (all)
.root	200MB	7.2GB	8min	filtered data

- .rdat —> .dat conversion: CLB_v2 data format more efficient
- Automatic 24h of data taking, timeouts arise from the need of a "hard" reset of CLBs (time reset), power cycle of PMTs

Data processing @Portopalo

- Triggering (~/scripts/auto_processing.sh)
 - L1 timeslices
 - -T 1 trigger (showers): only one L1 fires a trigger
 - L1 coincidence window 25ns

```
$JPP_BIN/converterv1Tov2 -t $START1 -u $START2 -v $START3 -d 0 -f INFILE -o OUTFILE
$JPP_BIN/JTriggerProcessor -d 1 -T 1 -@ "writeL1=1" -@
"trigger3DShower.numberOfHits=1" -@ "TMaxLocal_ns=25" -a /home/alex/ppmdu_data/
km3net ppm du timeoffsets corrected.txt -c 3 -f INFILE -o OUTFILE
```

- Data transfer to Lyon (~/scripts/auto_processing_sync.sh)
 - all .root files, all .xcfg files
 - three .dat files per day
- Local storage at Portopalo (~/scripts/auto_processing_delete.sh)
 - keep all .root and .dat for 7 days
 - keep three .rdat files for 14 days
 - keep .rdat and .dat files if the processing was not done or unsuccessful

PPM-DU: First Results



Single rates are evaluated from the distributions of time differences between consecutive hits. The tail of the time differences distribution is fitted with an exponential:

 $f(x)=p0^*exp(-p1^*dt)$ where p0 is a scaling factor, p1 is the single rate and dt is the time differences

- The PPM-DU provides useful information to characterize the marine site and to understand our detector
- Single rates show wether the PMTs are well calibrated and give hints on the total PMT efficiency
- One 30-min run

PPM-DU: Searching for Muons



- 2014 June-July, 52 hours of equivalent livetime
- L1 corresponds to a coincidence between two PMTs in 10 ns; multiple coincidences are selected inside the DOMs in a 130 ns time window
- The change of shape shows the region in which muons become to be dominant over the optical background

PPM-DU: Searching for Muons



- MC generated in Catania scaled by live-time
- Selection of 3-DOMs coincidences
- Sum of all coincidences on the three DOMs

Time Calibration in Sea Water

- LED beacons flash with adjustable frequency and intensity to calibrate in time PMTs inside the DOM and with other DOMs
- Intra-DOM time offsets (between PMTs) depend on the electronics and PMTs
- Inter-DOM time offsets (between DOMs) depend on the electronics plus cable lengths

 travel time of light in sea water must be taken into account in the calibration procedure
- Time accuracy ~1 ns



Time Coincidences between two DOMs

- 2014 June-July, 66 hours of equivalent livetime
- Data triggered to have L1 coincidences on the three DOMs
- MC normalized to data, only muon events
- Data are corrected with time offsets obtained with LED beacon calibrations



Bioluminescence studies

- Spike definition:
 - determine mean rate μ and standard deviation σ of each channel
 - spike: a set of successive bins in which the rate is higher than μ + 5 σ
 - here the bin size is dt = 1s
- Spike coincidence: > 1 spike on different PMTs in the same DOM



Bioluminescence studies (ii)



Time streams like the previous one, for PMTs 10, 14, 16, 30, 9.

Bioluminescence studies (iii)



Time streams like the previous one, for PMTs 15,22,23,24,28,29.

Bioluminescence studies (iv)



- Green: single peak
- Red: double peaks
- Yellow: double peaks, second peak higher

Light source moving from left to right

Directionality with the Multi-PMTs



- Data triggered to have at least a L1 coincidence on all the three DOMs
- MC contains only muon events (normalized to data)
- As 3-DOM-triggered events, all these events are only muons.
- Powerful rejection of optical background.

K40 Coincidences – DOM1



- K40 rate evaluated with L1 time window increased to 40ns.
- Every point represents a couple of PMTs in DOM1 considering all the possible combinations.

Summary

- The PPM-DU is active and taking data
- This qualification project paves the way to the forthcoming installation of 24 Detection Unit + 8 Towers in the Capo Passero area (KM3NeT-IT) and 7 Detection Unit in the Toulon site (KM3NeT-FR)
- All the subgroups in the KM3NeT collaboration (Mechanics, Electronics, Software, Data Analysis) can take profit from this prototype to get ready for the km³-scale neutrino telescope

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