PMTs:

Reco / Analysis Status & Future

CYGNO Analysis Meeting

David Marques

& PMT analysis working group

David Marques

CYGNO Reco & Analysis Meeting - 19 October, 2023

PMT – <u>Introduction</u>

- → Last PMT meeting we decided to move the PMT meetings to the official CYGNO Analysis and Reconstruction meetings, so here we are :)
- → Giorgio asked me to do a small recap of the status of PMT Reco/Analysis
 - And add the future plans for the PMT analysis / Upcoming analysis.

PMT tasks – <u>Resume Reco</u>

PMT Reco

- Reads waveforms
- Retrieves
 important
 parameters
- Working
- <u>Pietro merging it</u> with picture reco
- PMT Auto-reco will be nice

Calculates X, Y, L

Bayesian fit

- Works well for fast digitizer
- Should work for slow digitizer (I'm waiting for details)
- <u>Must be installed on</u>
 cloud
- Updates
 Stefano/Francesco?
- Or other solutions?

1-to-1 association

- Strongly dependent on Bayesian fit
- Other suggestions?
 - (for instance, basic fast version of fit that outputs only 3/4 points to compare with x_min, x_mean and x_max)
- Final tree with IONIZATION information under study (includ. Giorgio/Emanuele)

PMT Simulation

Some optimizations of the photon prograpation needed Simulation of different energies and different particles missing Simulation of multiple tracks per

image missing (for

association purposes)

PMT Reco

PMT tasks – <u>Resume Analysis</u>



<u>ongoing</u>

Ongoing (couple of days)

- Head-tail ideas are in proceedings
- Correlation between single waveform peaks for full 3D
 Reco of ER ⇒ <u>On hold</u>
- <u>I have the AmBe data</u>
 <u>reconstructed and will start</u>
 <u>looking at this soon</u>, focusing on
 pictures with *only one* event
 Bayesian fit disentangles tracks
 and allows for better dE/dx
 analysis

PMT Analysis

Longitudinal diffusion to be re-measured to be confirmed with Matteo's and officially accepted (<u>should be easy with TOT</u>)

PMT Work - 3D and cross-analysis



- 4. <u>3D reconstruction</u>
- 9. <u>Cross-analysis with camera's info</u>

⇒ <u>Next studies</u> ⇒ <u>Tilted cosmic rays analysis</u>

Setup:

- ightarrow Two scintillator bars are placed on top and bottom of LIME
- → LIME DAQ triggered by coincidence of two scintillators
 - Only certains angles (by geometry) are possible
 - 3 different scintillator position were used



Motivation & Math:

• This measurement presents a clear dataset with track with

well-defined orientation and energy deposit (MIP)

- We have a given <u>range of possible angles</u> of entering
 LIME (given by geometry of LIME + scintillators)
- We can superimpose it with the cosmic muons angle distribution at ground (∝ cos²(Θ)*) to get the theoretical angle distribution (Θ_{too}).
- PMT measures the Time over Threshold
 - Multiplied by v_{drift e-} gives the ∆z
- \circ Height of LIME (c1) is known (33 cm)
 - The tracks inclination (α) will be tan⁻¹ (c1/Δz)
- We can compare Θ_{teo} with α .
 - First CYGNO 3D analysis (on a distribution)
 - Gives us a measurement of PMT Reco / ToT efficiency *https://dx.doi.org/10.1088/1475-7516/2023/04/025

David Marques



- 4. <u>3D reconstruction</u>
- 9. <u>Cross-analysis with camera's info</u>

⇒ <u>Next studies</u> ⇒ <u>Nuclear recoil data set</u>

Setup:

- → AmBe source placed near LIME
- → LIME was shielded with Polyethylene, water and copper to block external radiation, thus creating a clean dataset

Motivation & Expectations:

- Clean dataset of NR obtained with a AmBe source ➡
 WIMP-like signals
 - 3D from ToT since they're straight tracks
 - Dual-sensor analysis (sCMOS + PMT)
 - dE/dx analysis ➡ PID for NR vs. ER
 - Track sense/direction from head-tail asymmetry
 - Paramount for CYGNO directional searches!









PMT – <u>3D & position & Head-tail exercise -1</u>



David Marques

PMT – <u>3D & position & Head-tail exercise -1</u>



CYGNO Reco & Analysis Meeting - 19 October, 2023

David Margues

PMT – <u>3D & position & Head-tail exercise -2</u>



CYGNO Reco & Analysis Meeting - 19 October, 2023

PMT – <u>3D & position & Head-tail exercise -2</u>



CYGNO Reco & Analysis Meeting - 19 October, 2023