# A photomultiplier tube model for the water Cherenkov detectors of LAGO

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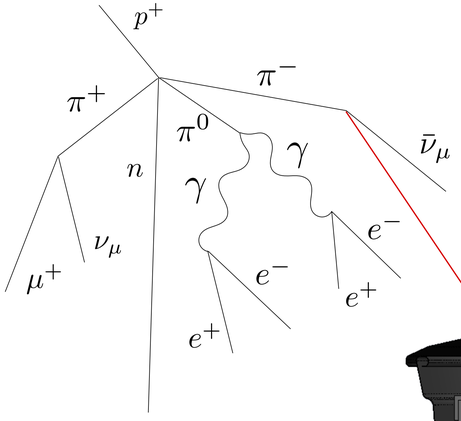
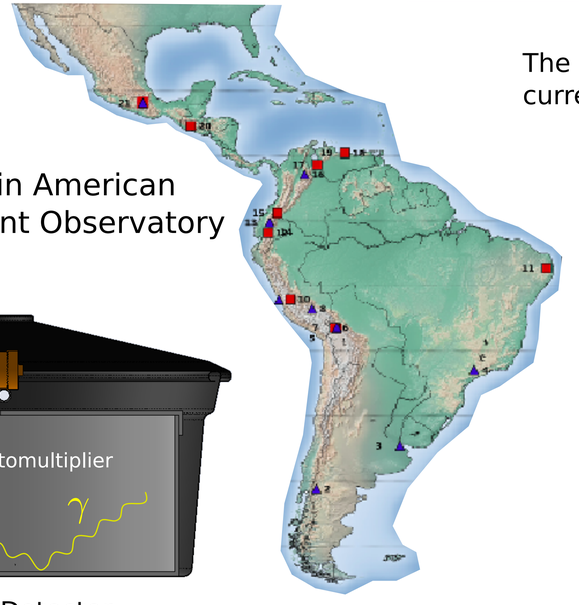
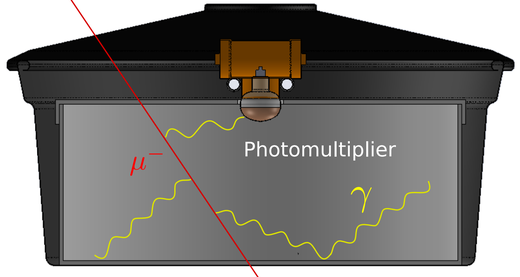
## Intro




Extensive Air Shower



Latin American Giant Observatory

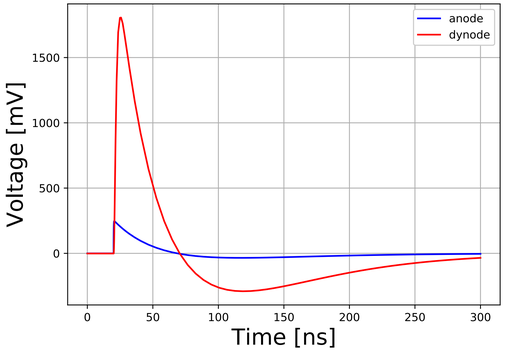



Water Cherenkov Detector

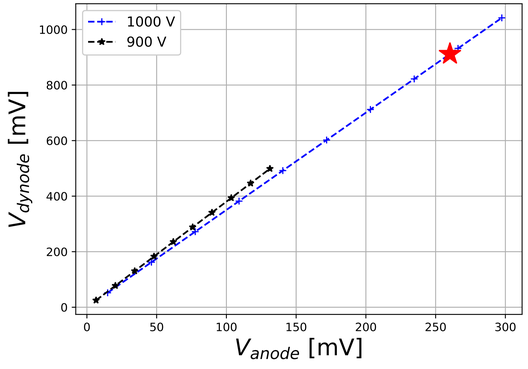
## Results

The estimated and measured VEM charge differ by 4%

Pulse shape




Linearity




VEM, Vertical Muon Equivalent

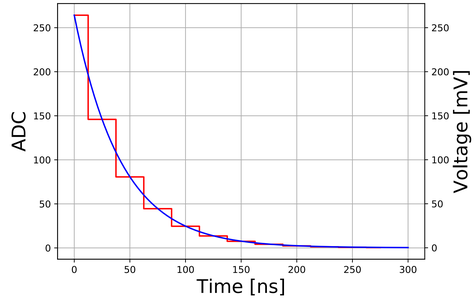
## Model

Mathematical Model

PSpice Model

The PMT model takes the number of dynodes ( $N$), the bias voltage ($V_B$), the photocathode current ($I_k$), the inter-dynode bias fraction ($\epsilon_i$), and intrinsic parameters ( $k, \alpha$ )

VEM anode signal




Anode current

$$I_a = I_k k^N (V_B \varepsilon)^{N\alpha}$$

ith-Dynode current

$$I_{d,i} = I_k \frac{(kV_B^\alpha)^N \left(\prod_{i=1}^{N} \epsilon_i\right)^\alpha}{(kv_i^\alpha)^{N+1-i} \left(\prod_{i=1}^{N+1-i} \epsilon_i\right)^\alpha}, \quad i = 1, 2, \cdots N$$

VEM photocathode current