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Coincidence analysis in ANTARES: potassium-40 and muons

Dmitry Zaborov
(ITEP, Moscow, Russia)

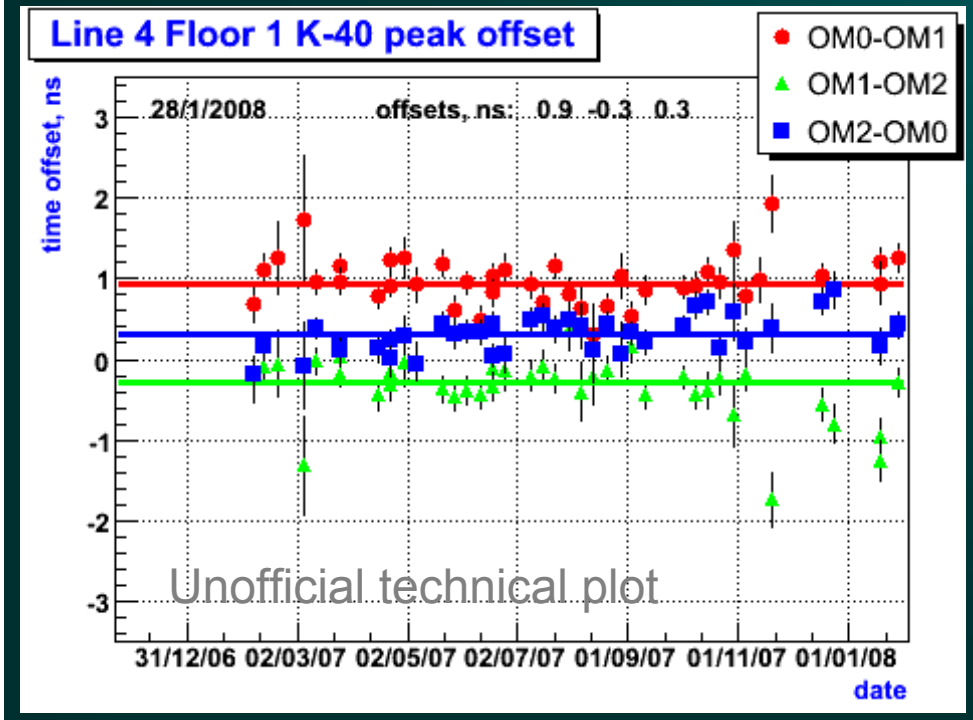
- Potassium-40 calibration technique
- Adjacent floor coincidences as very basic atmospheric muon signal

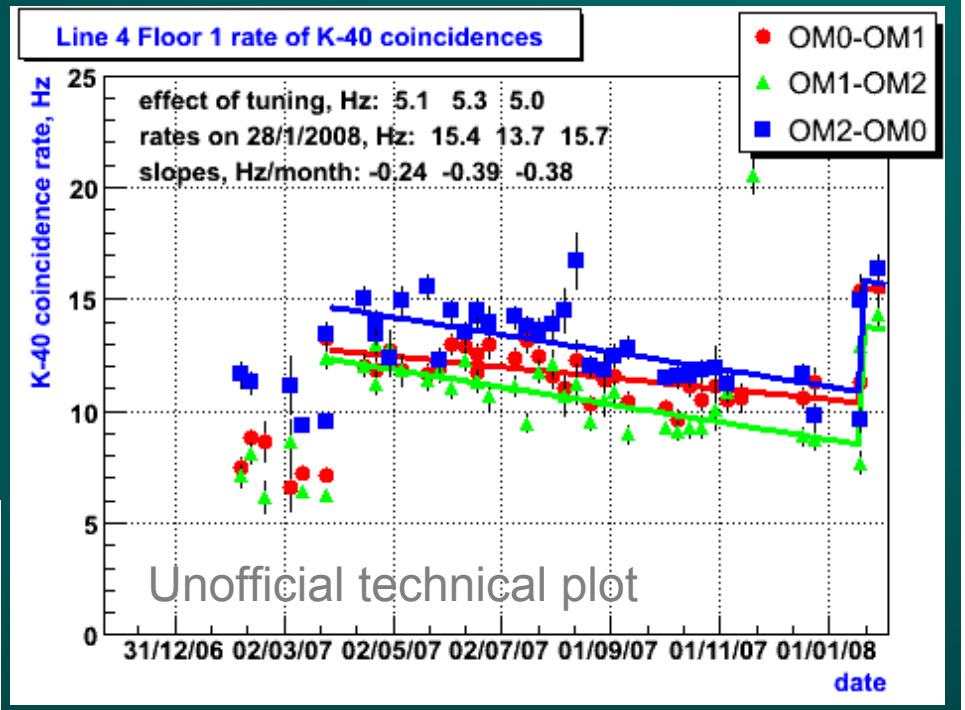
Example: calibration of one floor

Gradual decrease is probably due to PMT gain drift

Steep changes are threshold tunings

Time delays seem stable (within our accuracy)





K40 runs are taken once a week

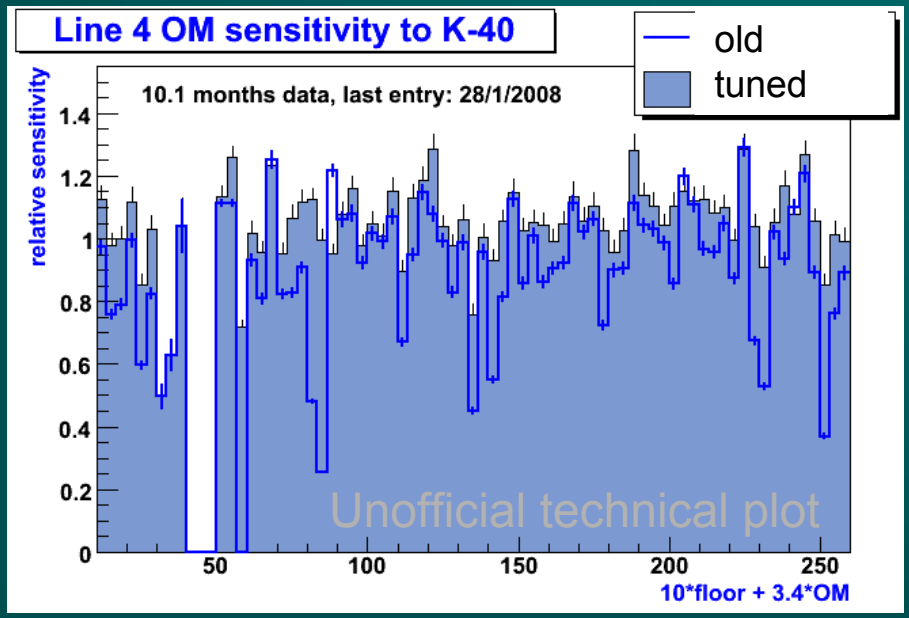
K40 trigger can run in parallel with other triggers (e.g. GRB trigger or directional triggers) and can be even used for physics analysis as is

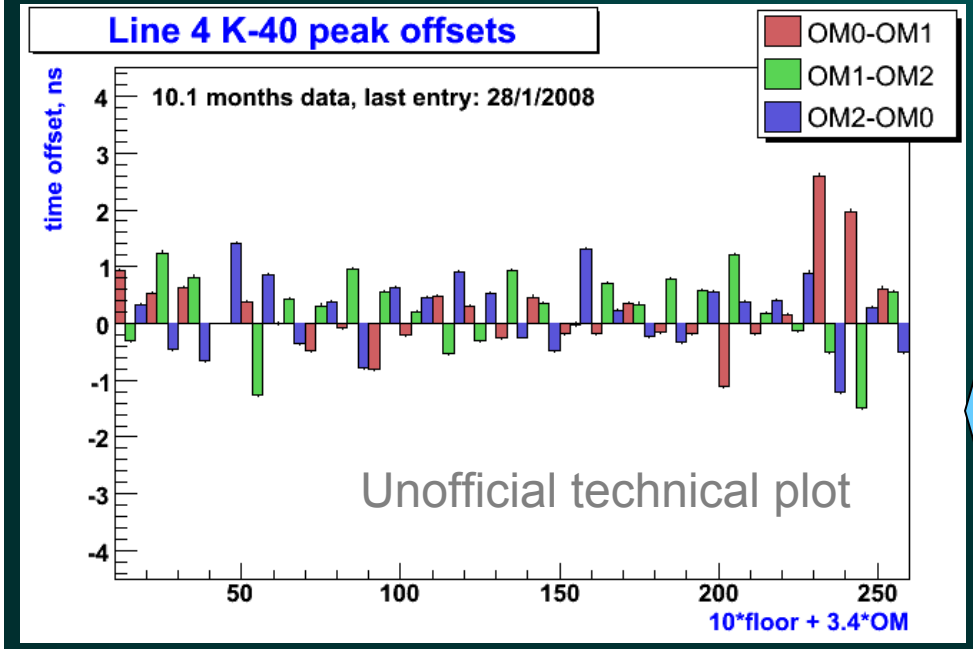
Example: calibration of one detector line

Three OM sensitivity factors s_i can be extracted using 3 equations

$$rate_{ij} = k * s_i * s_j \qquad I,j=1,2,3$$

factor *k* gives absolute scale;
k can be determined from Monte-Carlo
(or, in opposite, used to constrain parameters of Monte-Carlo)

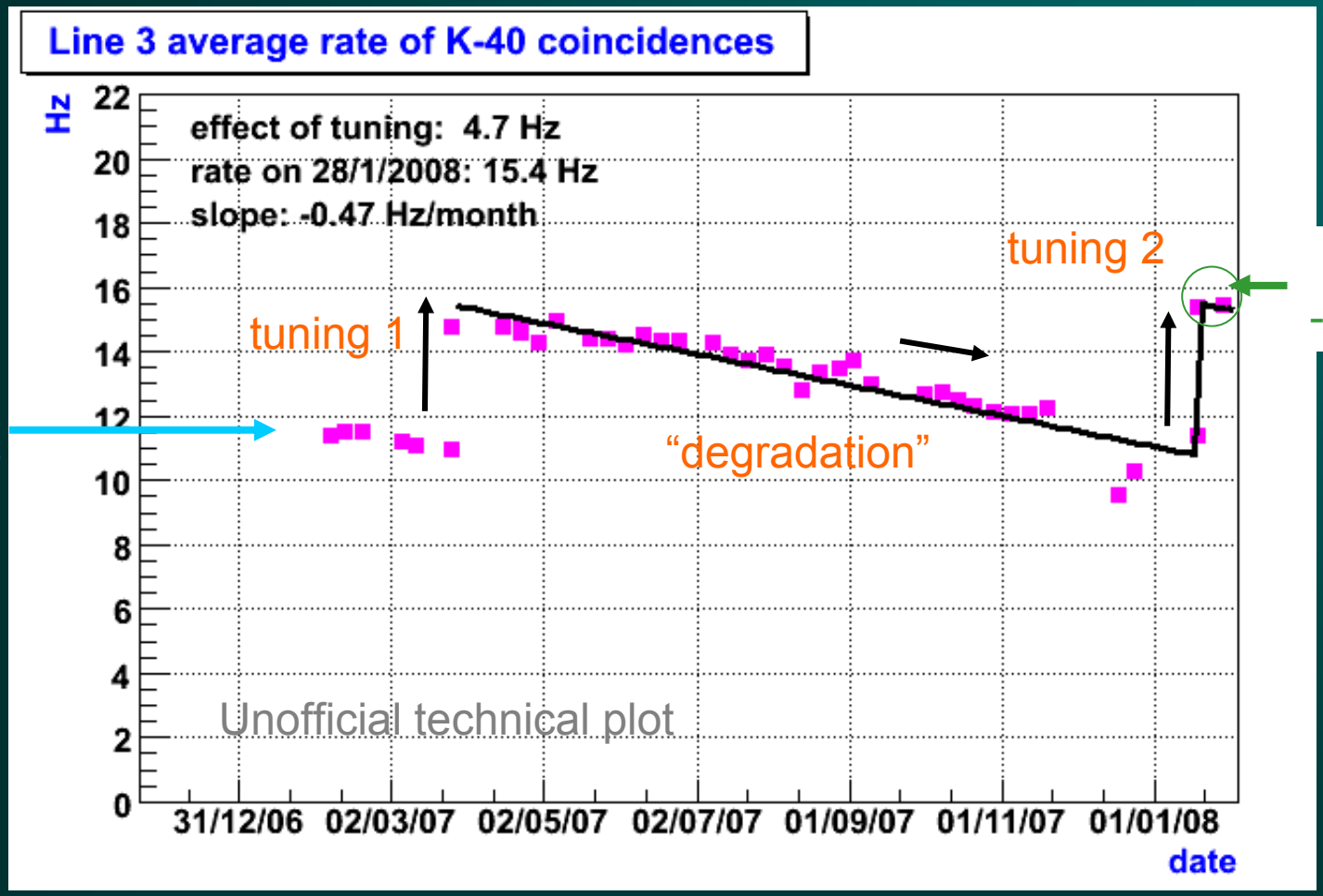




* No charge calibration used
* No walk correction included

OM-OM time offsets determined using K-40 (basically single photoelectrons) w.r.t "dark room" calibration (high amplitude laser pulses)

Time evolution of average K-40 coincidence rate



start at 12 Hz

tuning 2 -> 15.5 Hz

One year of "degradation" could be fully compensated by the tuning

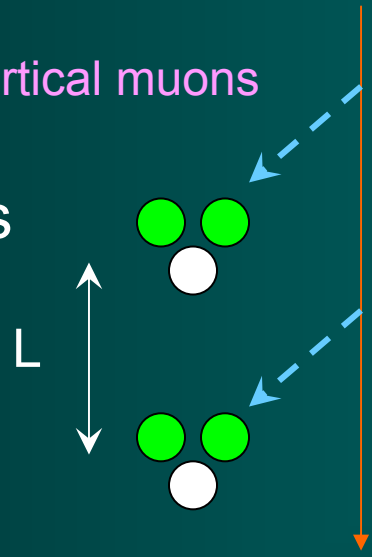
* Other Lines show similar behavior

Delay between adjacent floors (theory)

≈ fixed number for exactly vertical muons

$\Delta t = L / c \approx 50$ ns

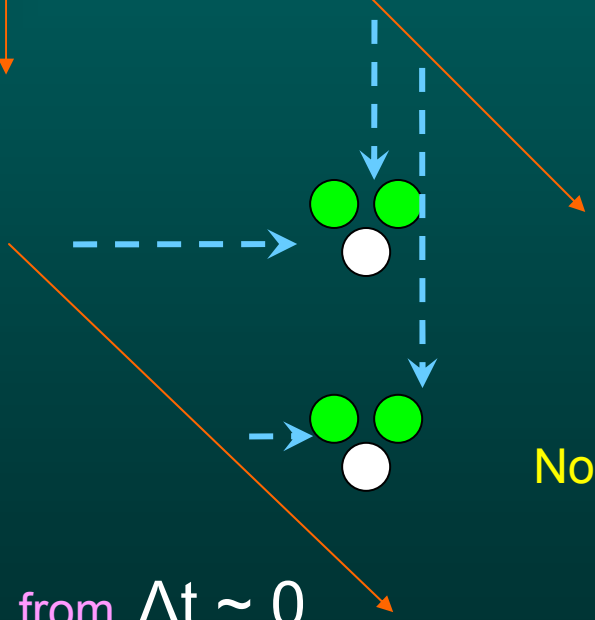
The most basic signal of physics events in ANTARES



a wide distribution in general

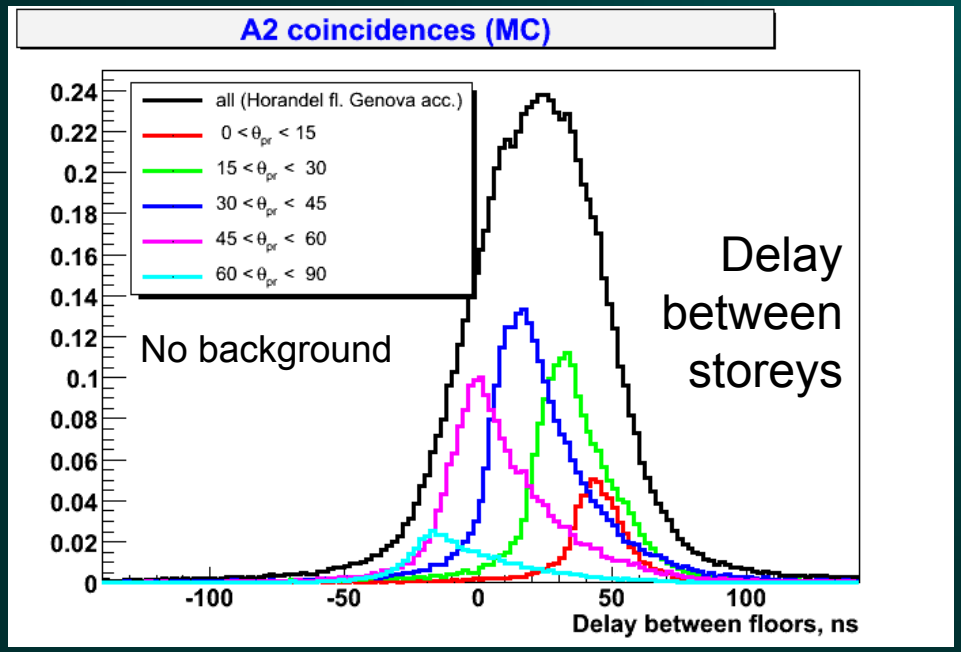
to $\Delta t \sim L\, n / c \sim 70$ ns

But light hits back of the OM

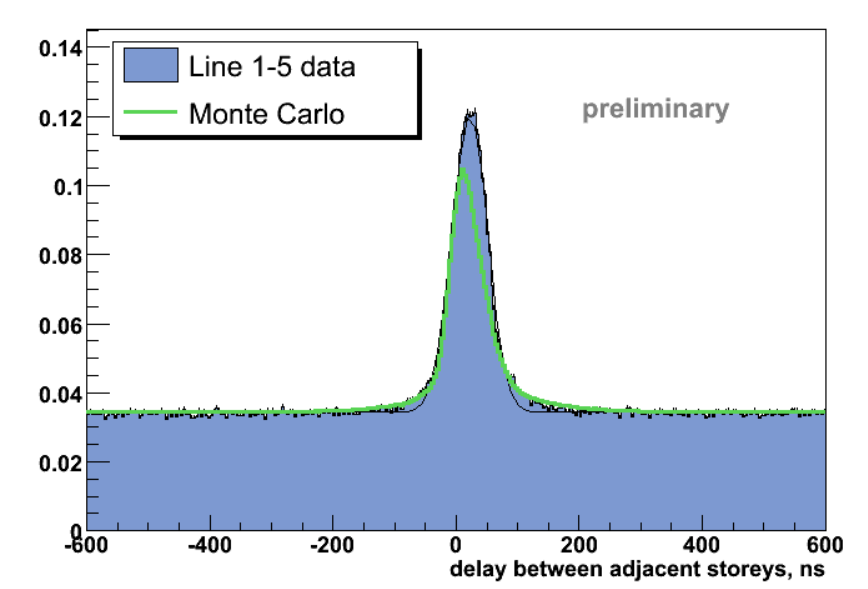


from $\Delta t \sim 0$

No systematic errors from trigger or reconstruction algorithms



Adjacent floor coincidences: measurement



Integral under the peak ~ muon flux

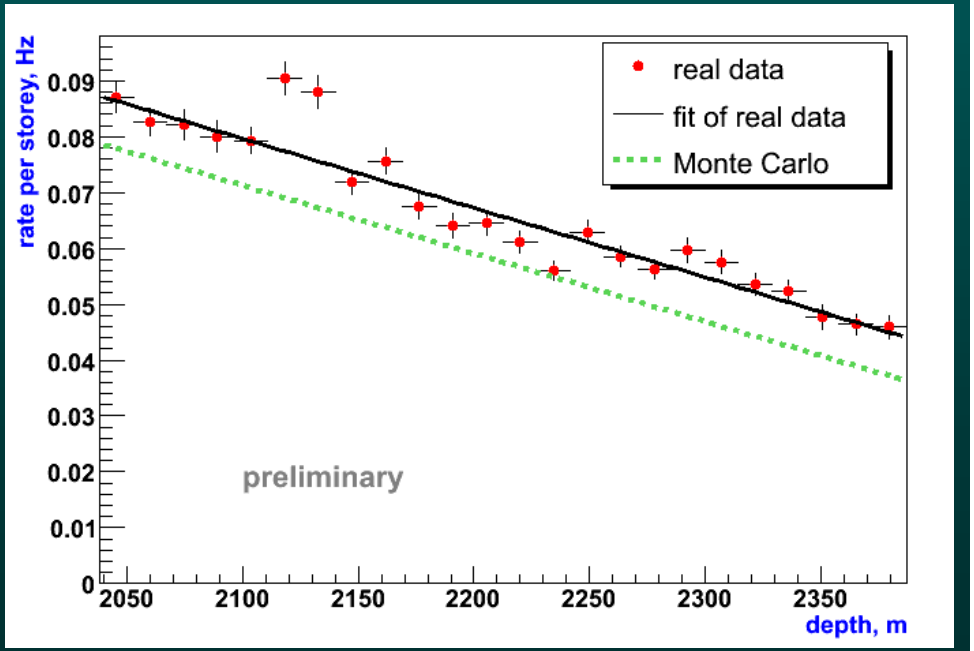
Shape is sensitive to angular acceptance of optical modules and angular distribution of muon flux

This plot is preliminary
Actual comparison of peak amplitude with Monte Carlo will be made after OM angular acceptance issues are fixed, OM efficiency is well known and all dead time corrections applied

Low energy threshold (compared to full reconstruction)

The analysis can be repeated for every detector storey separately

The effect of muon flux reduction with depth is directly (!) measured



Outlook

- A calibration technique using Cherenkov light from Potassium-40 decays in sea water has been developed
  - Sensitivity of optical modules is now controlled using K-40
  - K-40 is also a useful tool for time calibration
- A simple but powerful technique for atmospheric muon measurement is developed based on the idea of adjacent floor coincidences
  - First results allowed to reject one of the models of OM angular acceptance
  - Depth dependence and absolute normalization of atmospheric muon flux can be extracted using this new approach
  - Possibility to reject certain hadronic interaction models or (less likely) primary flux models is being investigated
  - Promising prospects to use adjacent floor coincidences in the trigger