Status of shower reconstruction with ANTARES

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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HADRONIC VERTEX SHOWERS

The ShAuerReco reconstruction algorithm for hadronic showers

Likelihood function for the timing information

$$-\ln(P^T) = -\frac{1}{900}\sum_{i=1}^{900}\ln[p_i^T(x,y,z,E,t)]$$

Likelihood function for the amplitude information

$$-\ln(P^A) = -\frac{1}{900}\sum_{i=1}^{900}\ln[p_i^A(x,y,z,\Theta,\Phi,E)]$$

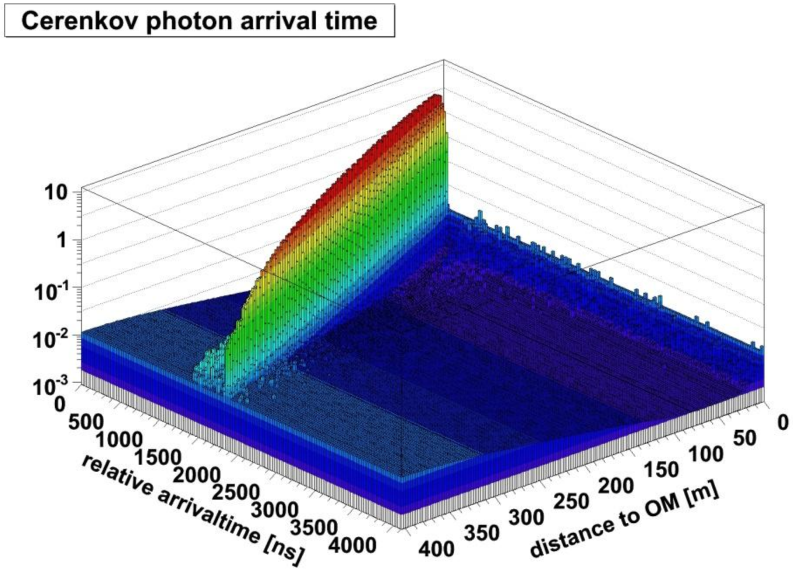
Combined likelihood function

$$-\ln(P) = -W_A * \ln(P^A) - W_T * \ln(P^T)$$

Used minimizer in the ShAuerReco: Simulated Annealing

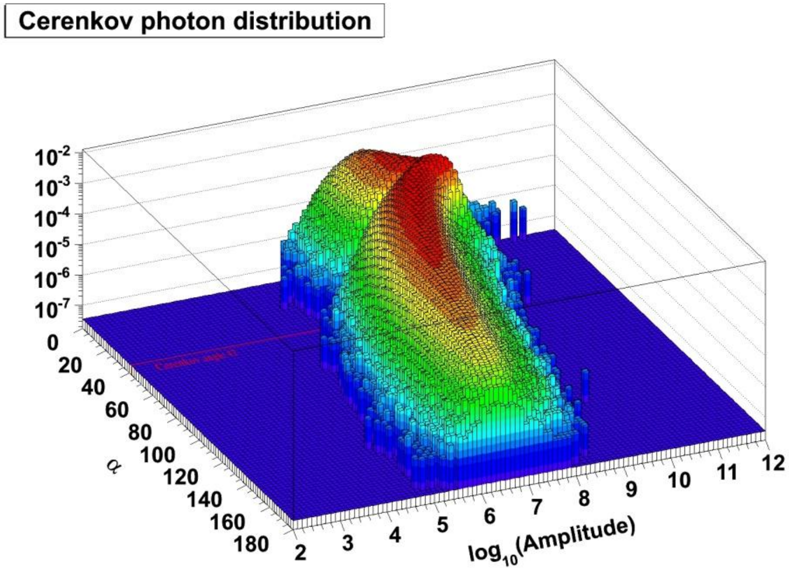
The ShAuerReco reconstruction algorithm for hadronic showers

Likelihood function for the timing information



In shower events the Čerenkov photons are emitted radially from the interaction vertex.

Likelihood function for the amplitude information



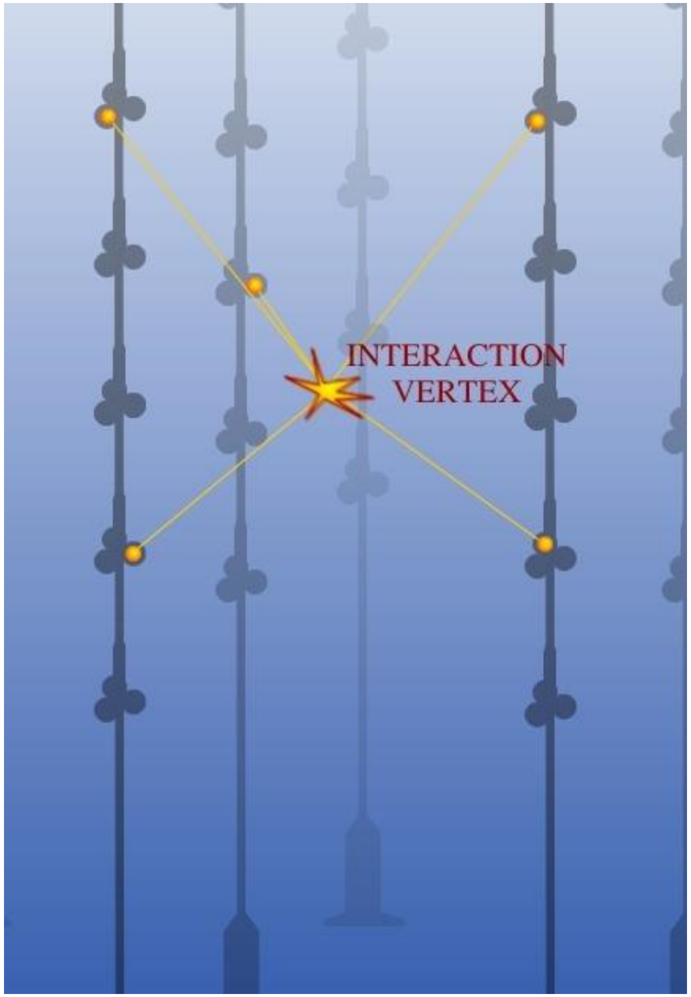
The light distribution is more isotropic than that of muon track events.

Event selection

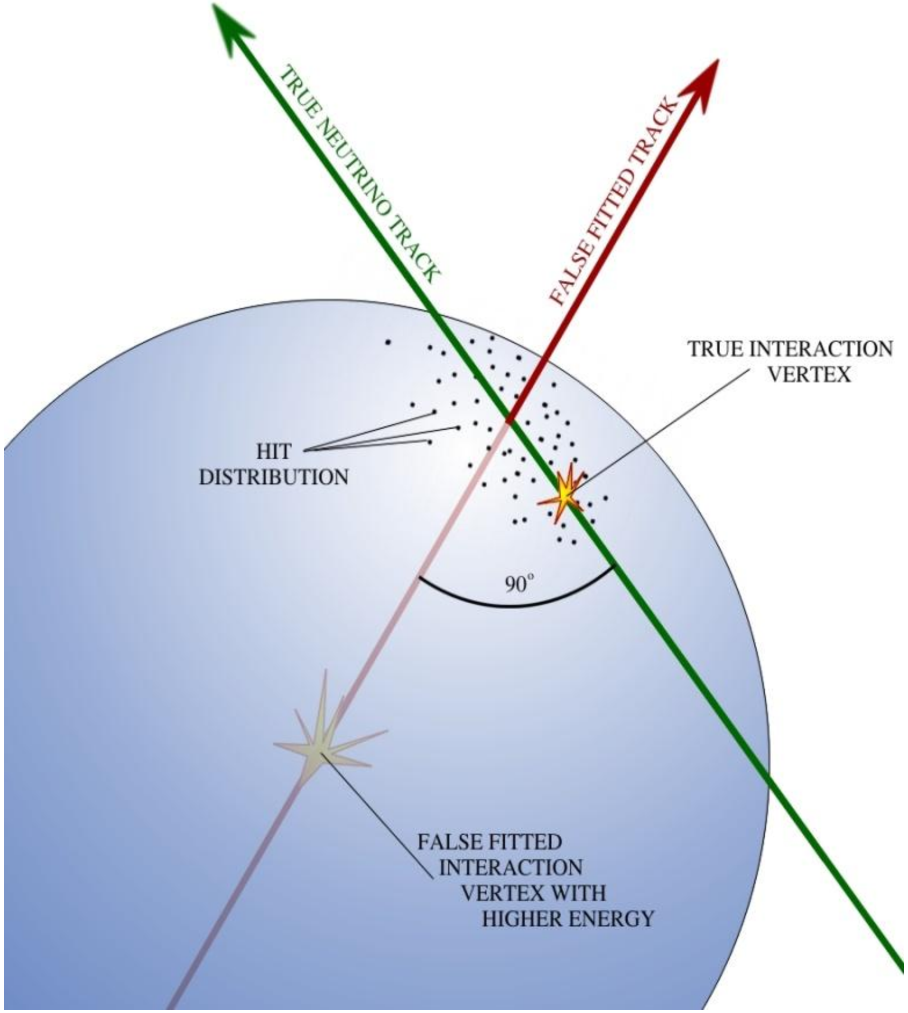
- Only hits with
  an amplitude > 3 pe

- At least 5 hits on
- 5 different storeys
- 3 different strings

Reconstruction tested to work with background rates up to 300 kHz.

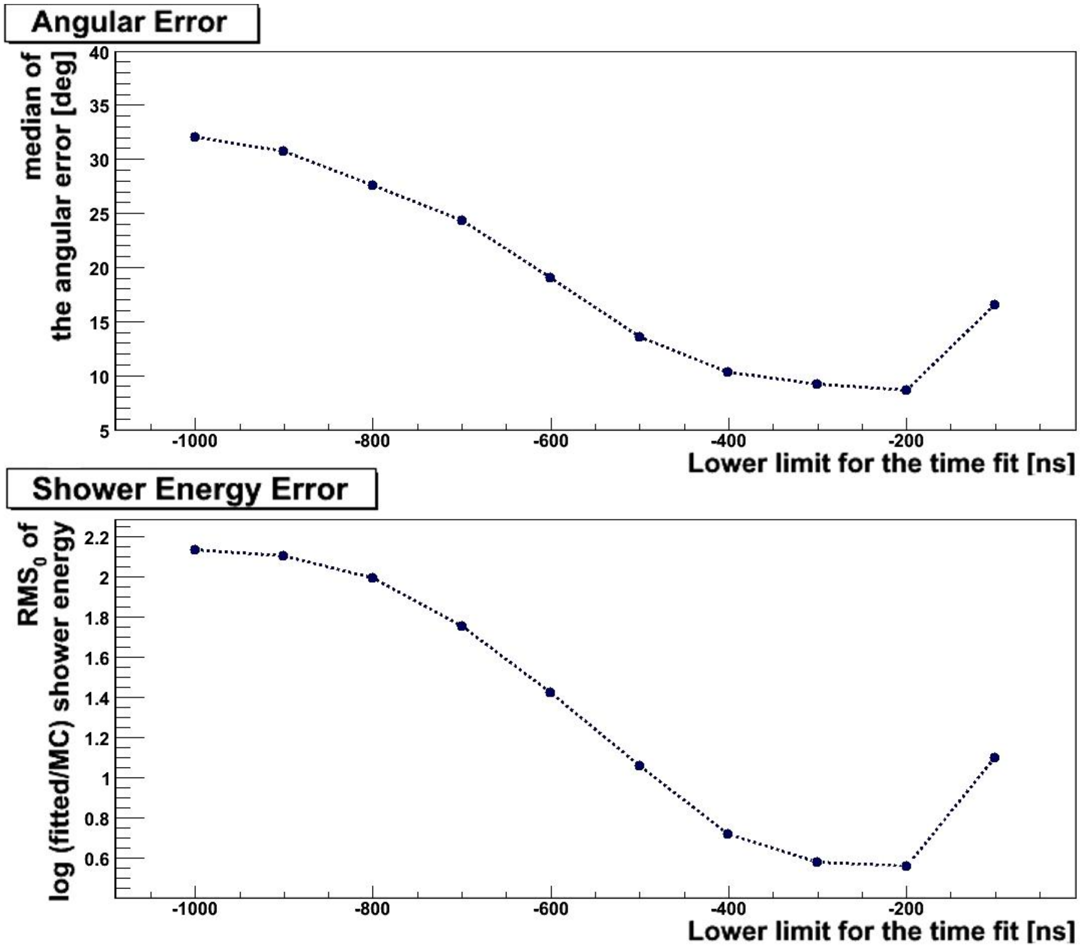


Problem with too large search spaces for the fit



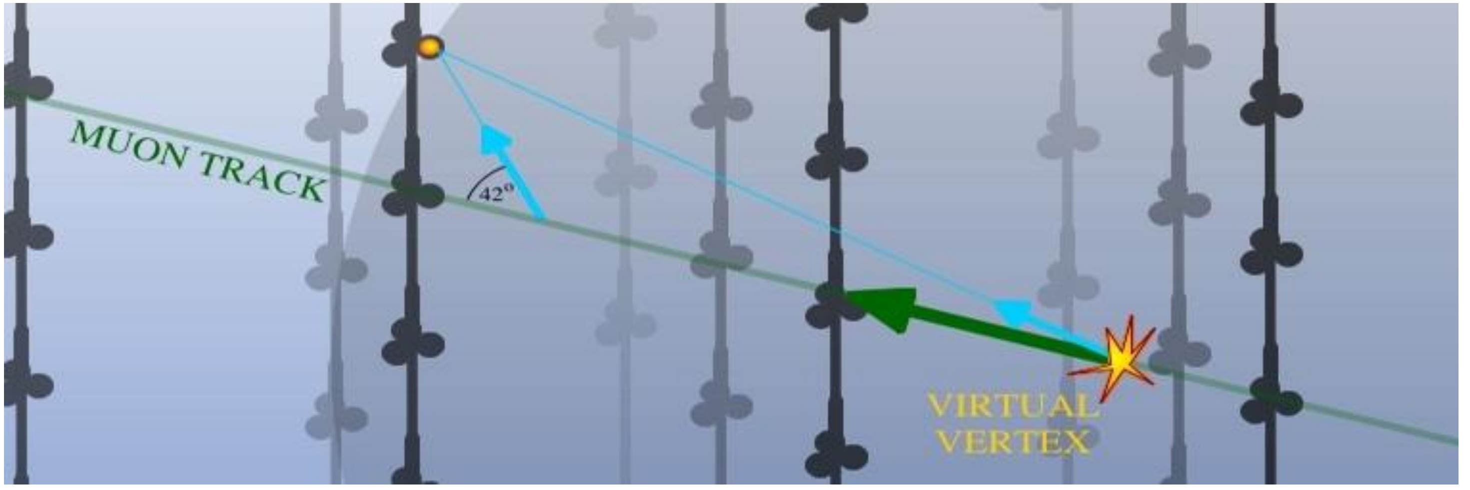
Too large search spaces offer ambiguities in the possible event signature.

Optimization of the search spaces for the fit



Too large fit boundaries can decrease the quality of the reconstruction enormously.

Spherical Shower Parameter as cut criterion for event selection

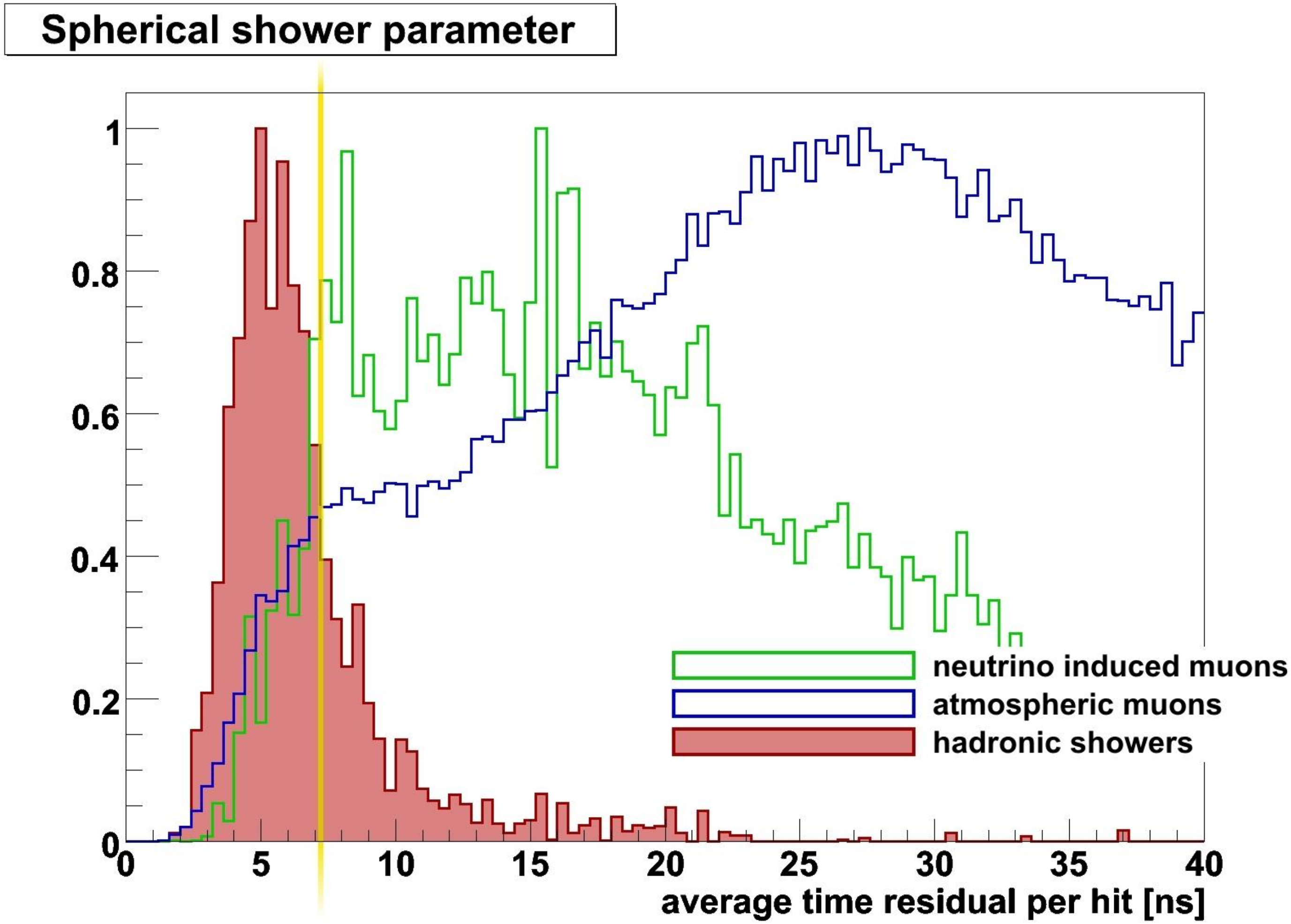


For each OM the arrival time of the Čerenkov-photons is calculated, assuming a spherical light propagation from the vertex.

$$t_{arr} = \frac{|\vec{r}_{om} - \vec{r}_{vertex}|}{v_{photon}}$$

Photons induced by muon tracks arrive at the OM earlier than a shower induced photon would hit the OM.

Spherical Shower Parameter as cut criterion for event selection



MC Reconstruction quality and purity for the ANTARES 12 line detector

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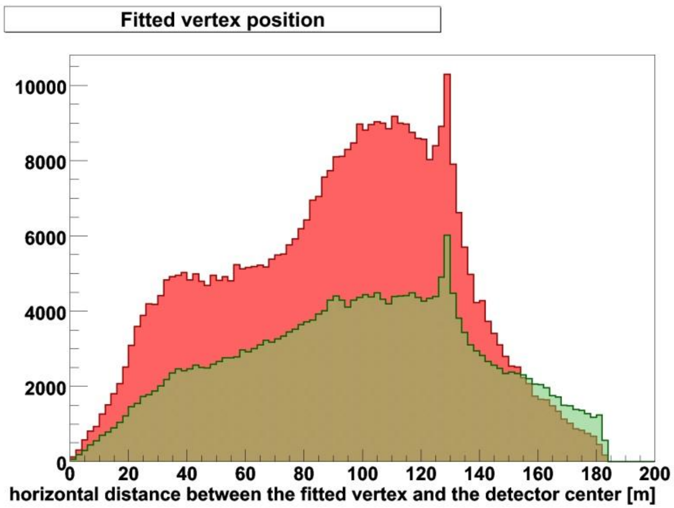
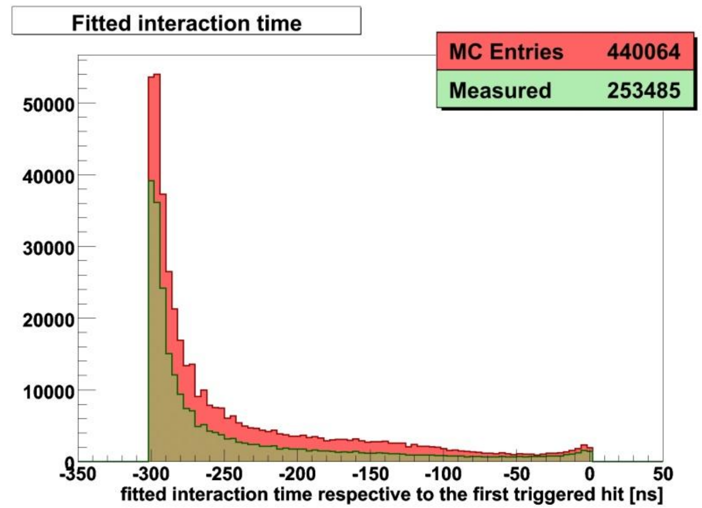
- Reconstruction errors after various quality and purity cuts:

Direction	Vertex	Energy (log)	Showers / year	Efficiency	Purity
7 °	2,5 m	0,4	49	3,0 %	1,1 %

- A reliable cut to supress the whole muon event background has not been found yet.

First comparison between MC and real data





MC data is in good agreement with the real measured data.

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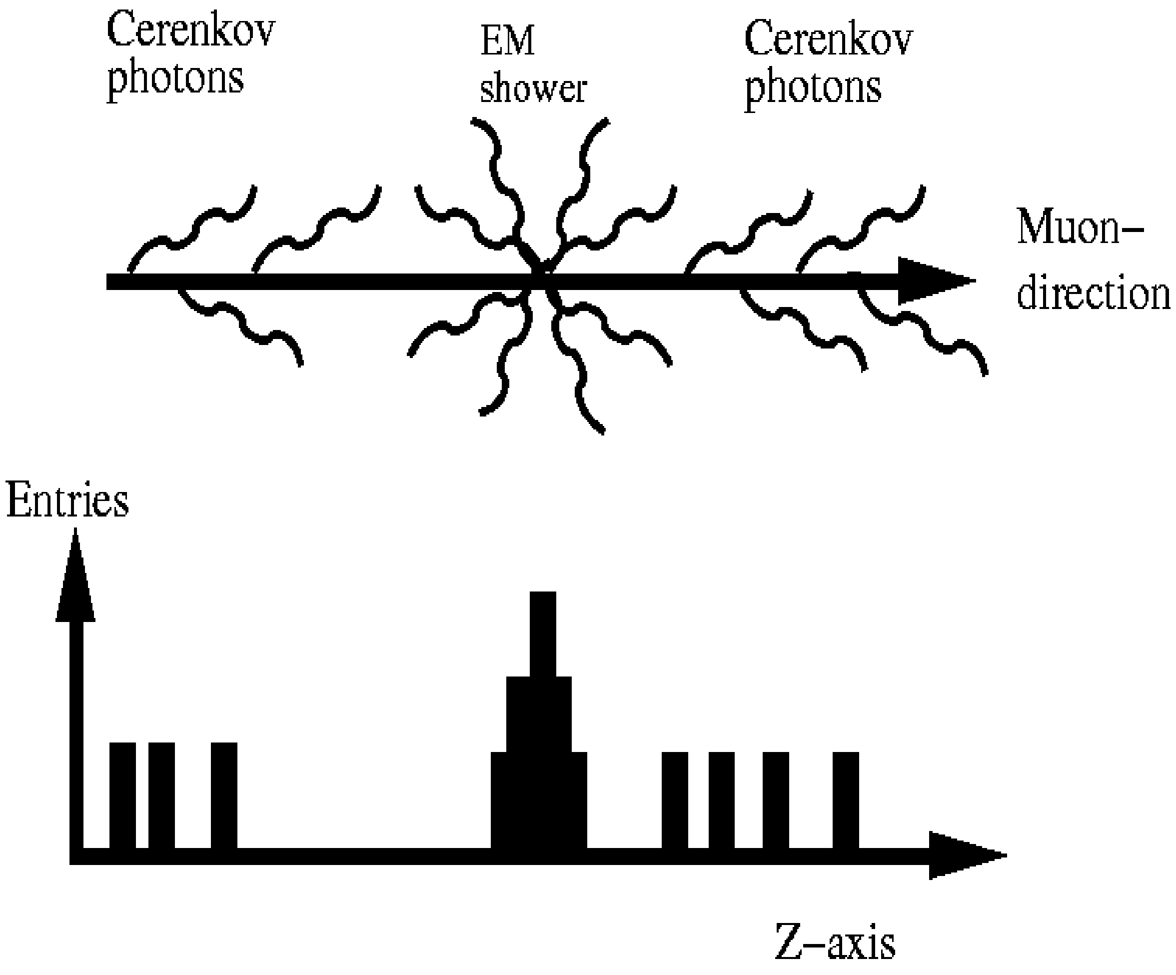
EM-SHOWERS ALONG THE MUON TRACK

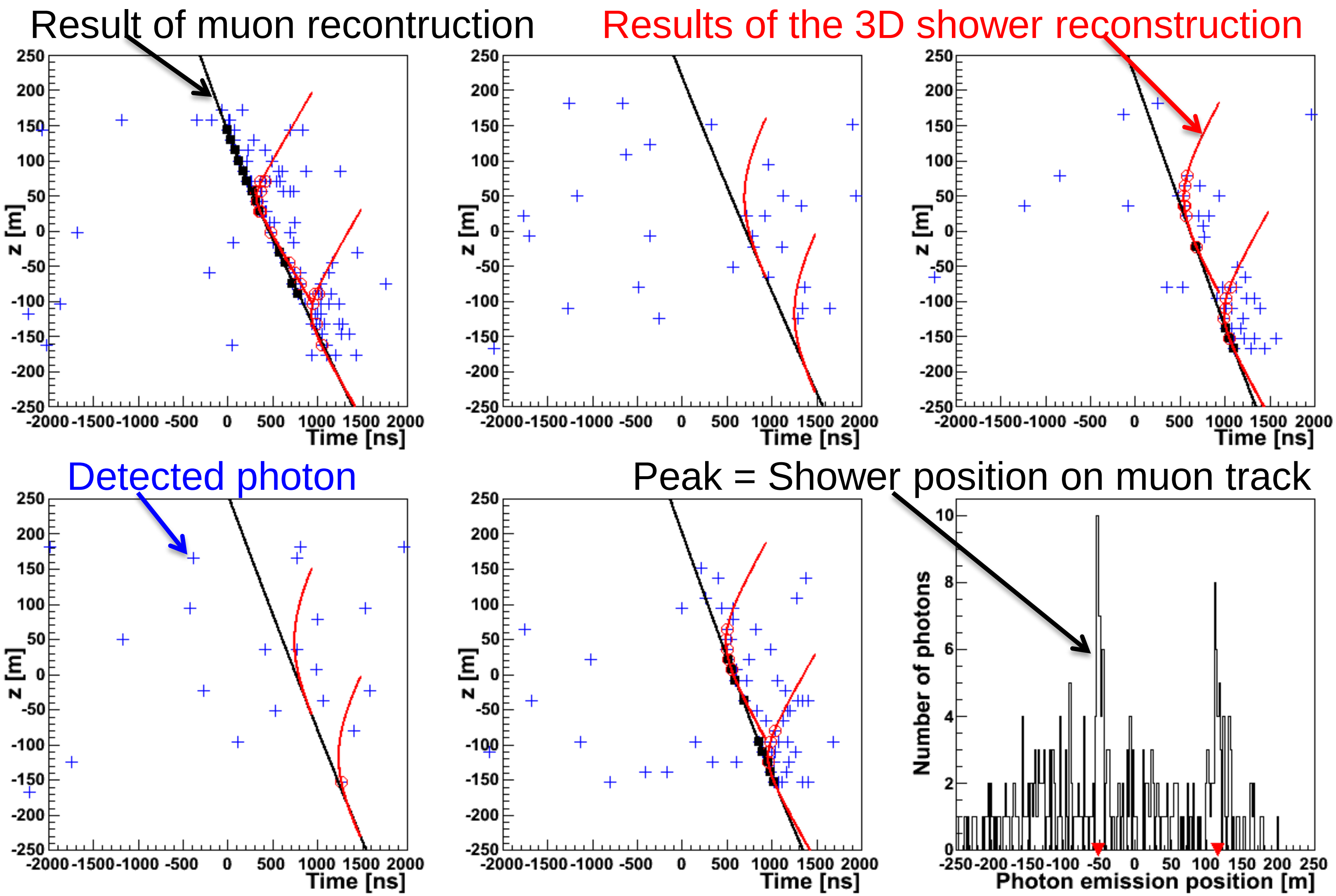
Identification method

Simple idea:

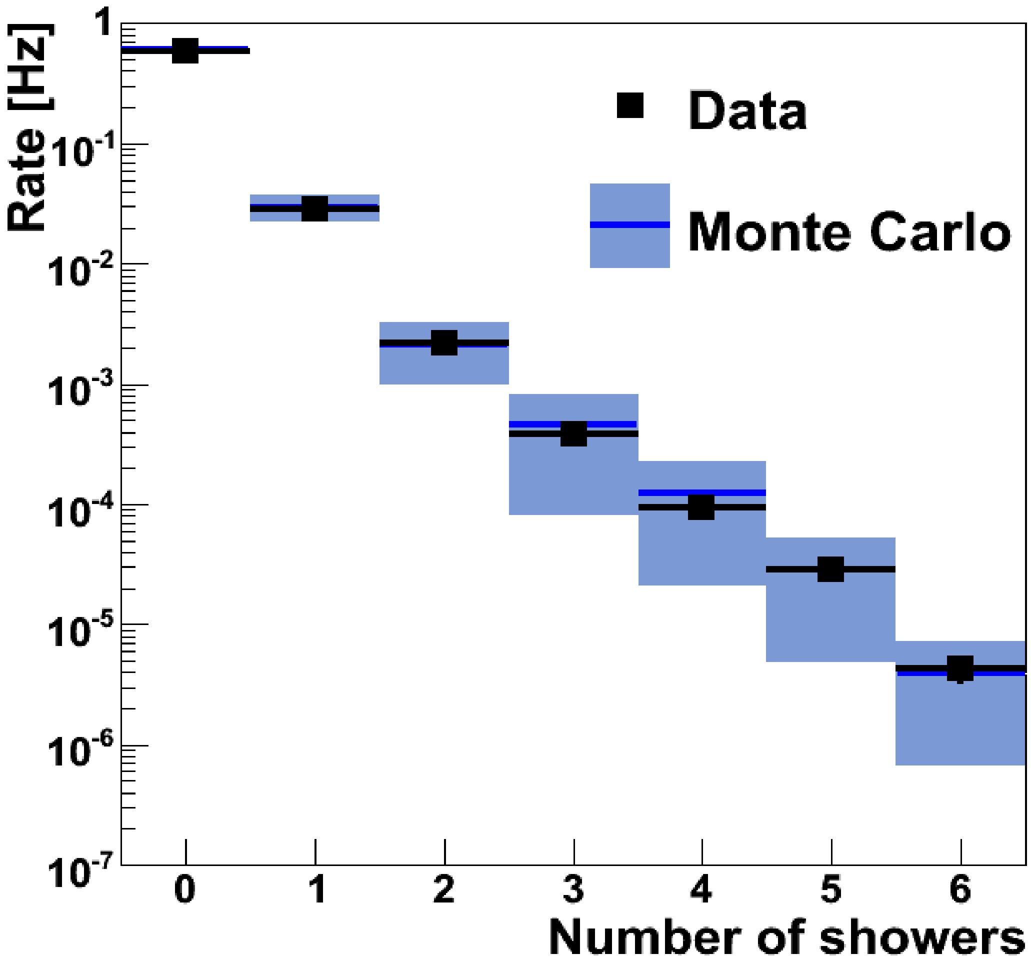
1. Reconstruct muon trajectory
2. Project photons onto muon track
3. Peak signals shower position



Example of a downgoing muon with two showers



Muon event rate as function of shower multiplicity



- No reconstruction efficiency included
- Systematic errors from MC

Summary and outlook

- The shower energy of hadronic showers can be reconstructed with an error of 0.4 magitudes
- The efficiency of the algorithm for hadronic shower reconstruction has to be increased.
- A reliable cut criterion to supress the muon background has to be found.
- The algorithm for the reconstruction of the positions of em-showers along the track is validated in simulation.
- Good agreement between data and simulation.