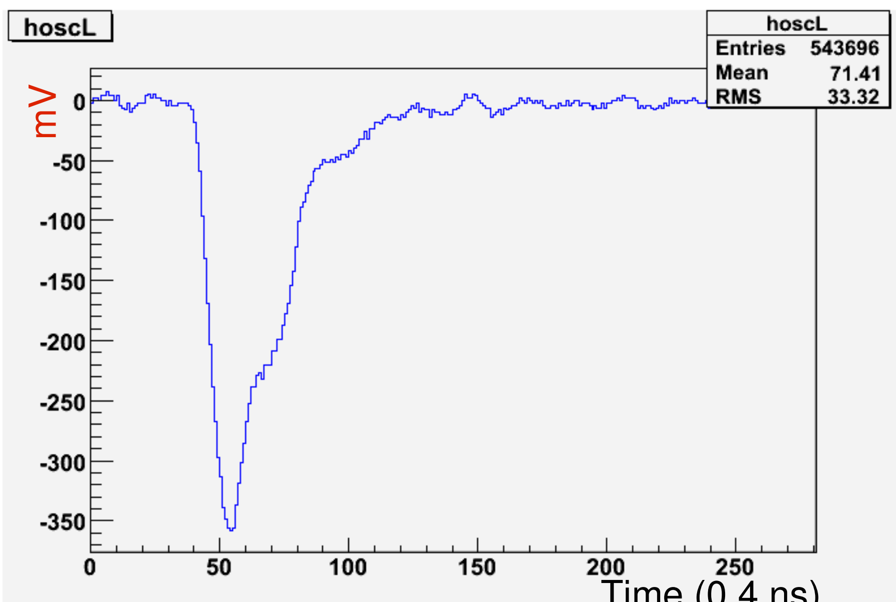
First results from the analysis of the time structure of the PWO signals

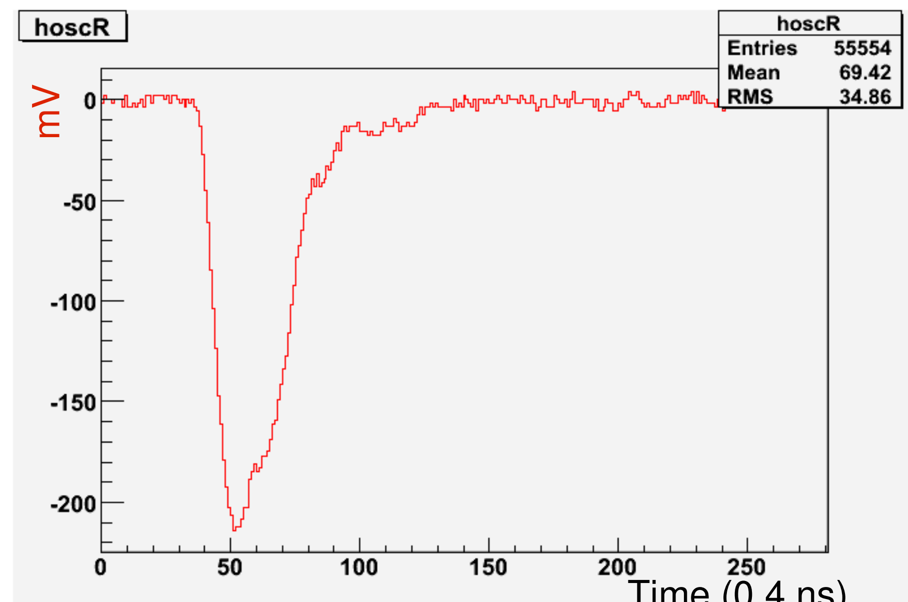
The oscilloscope waveforms

We started studying the main characteristics of the oscilloscope data;

In particular the angular scan with 70 GeV pions was analysed (runs 497-532);

In the plots, two examples of the waveforms acquired on both ends of the single PWO crystal are shown for the symmetric configuration (i.e. 0 degrees);

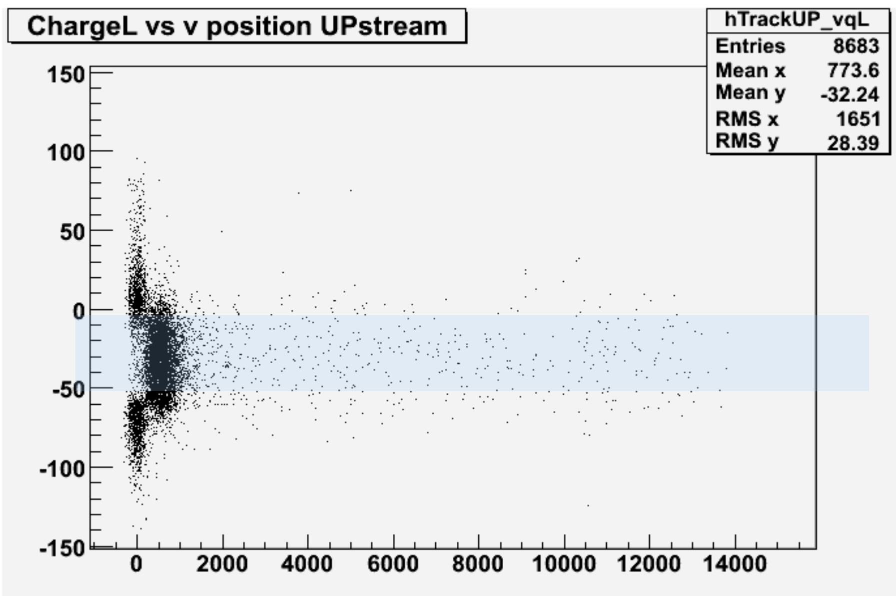


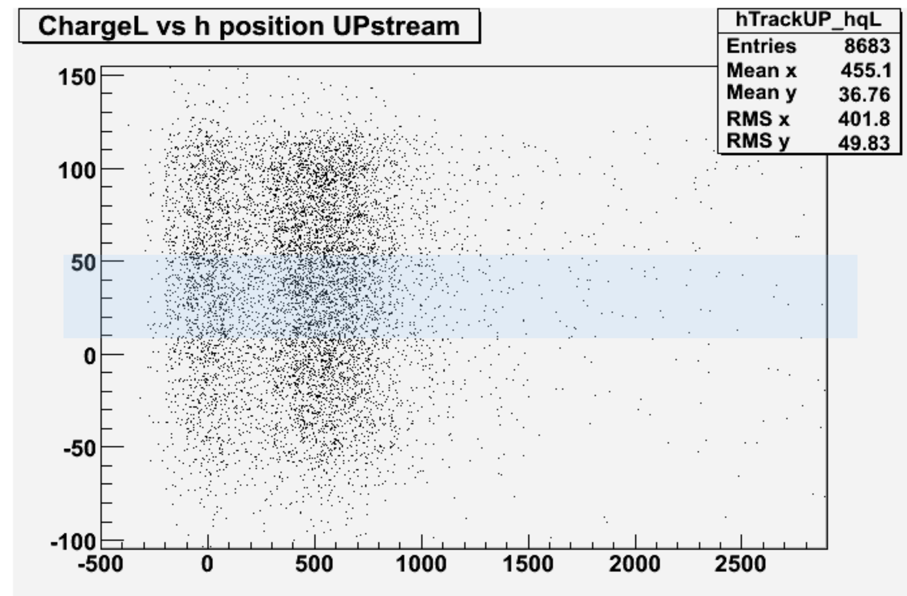


UPStream Tracker cuts

Some cuts were performed in order to get only “central” events;

One single hit in the UP tracker was required in the highlighted regions;



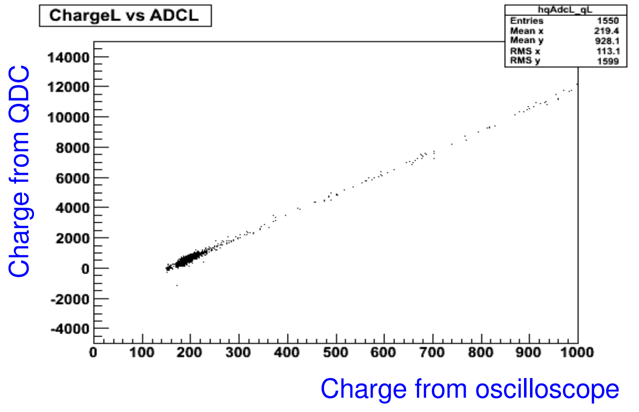


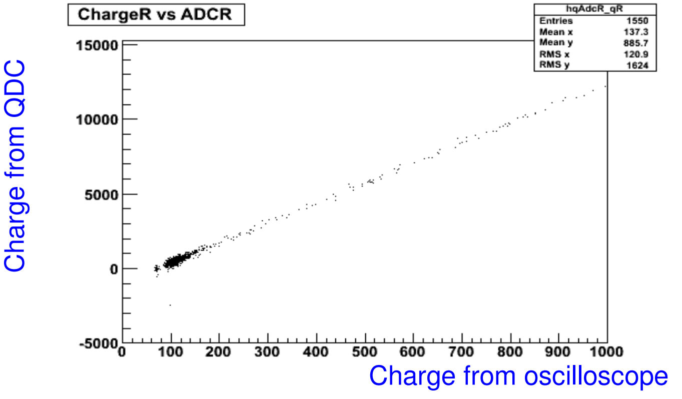
Similar cuts were performed on DOWNStream trackers

Shower cuts

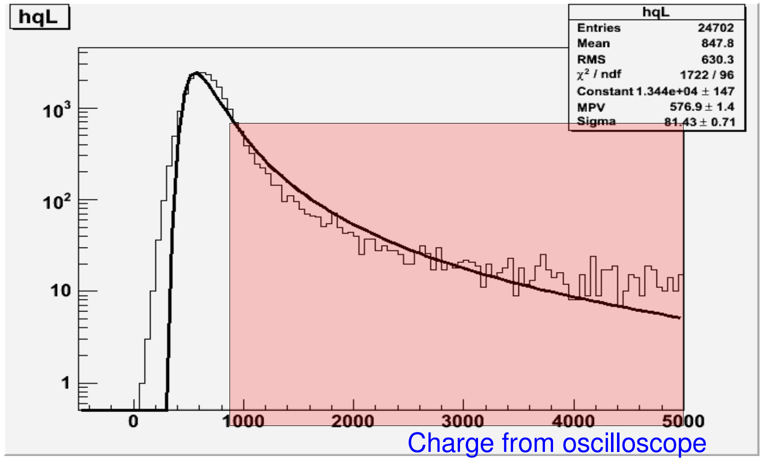
We've also tried to cut out the showering pions;

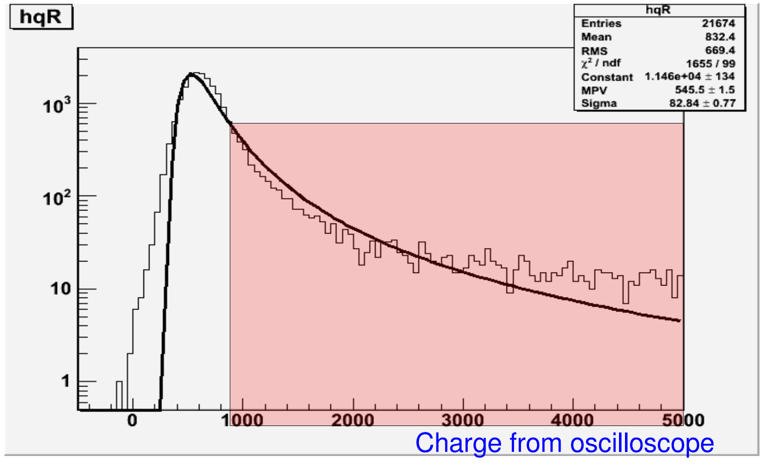
The correlation between the charge measured by the QDC and the one evaluated by integrating the oscilloscope signals was very good;





I used the second one. Examples of the distribution found are shown in the plots below;



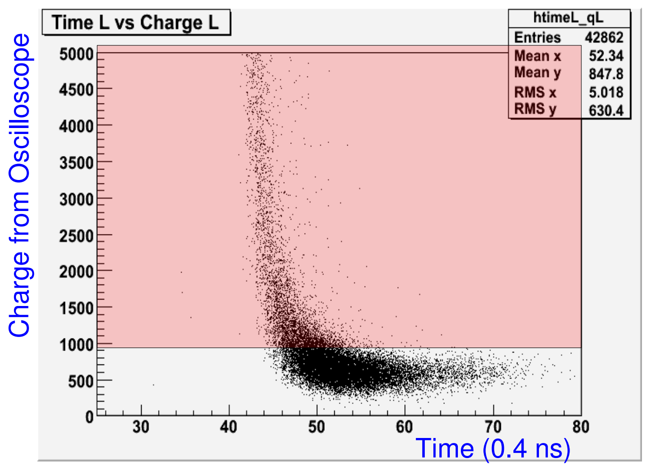


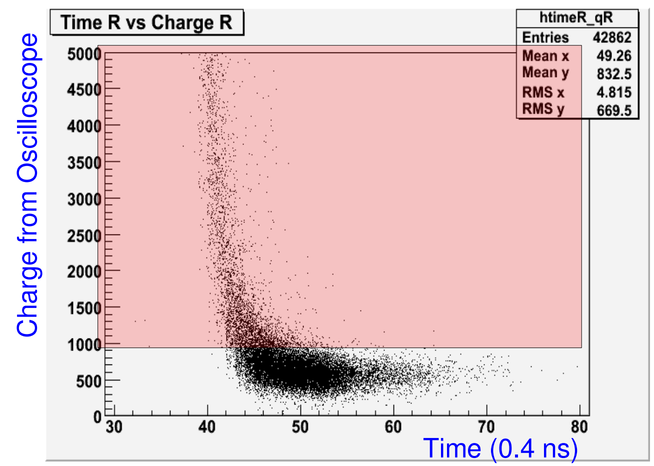
Landau fit and cut at MPV + 3 Sigma

Signal threshold crossing time

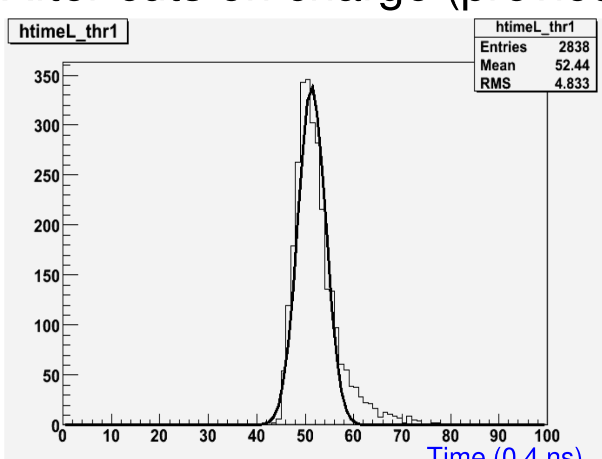
The time of a threshold crossing was studied for different threshold values on both sides

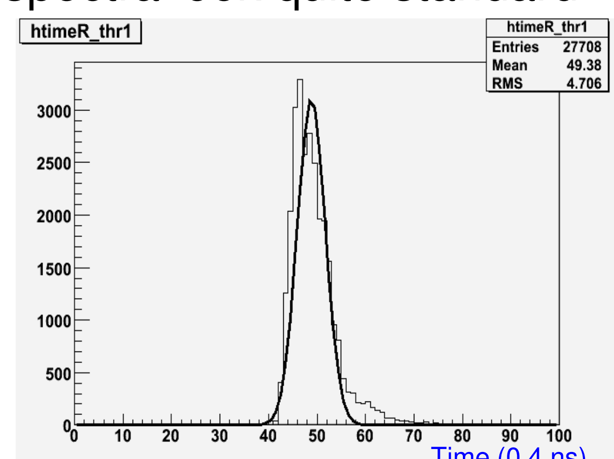
For very high charges (showers) a small crossing time was found.





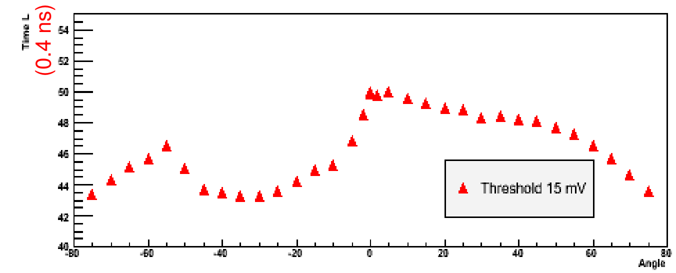
After cuts on charge (previous slide) the time spectra look quite standard

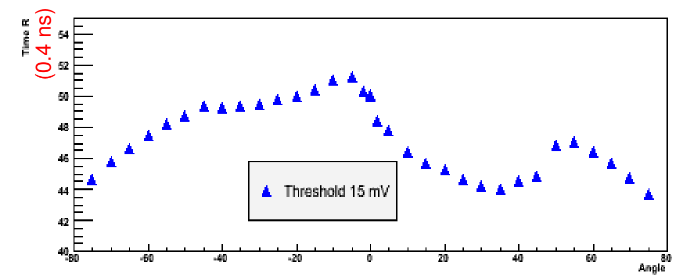


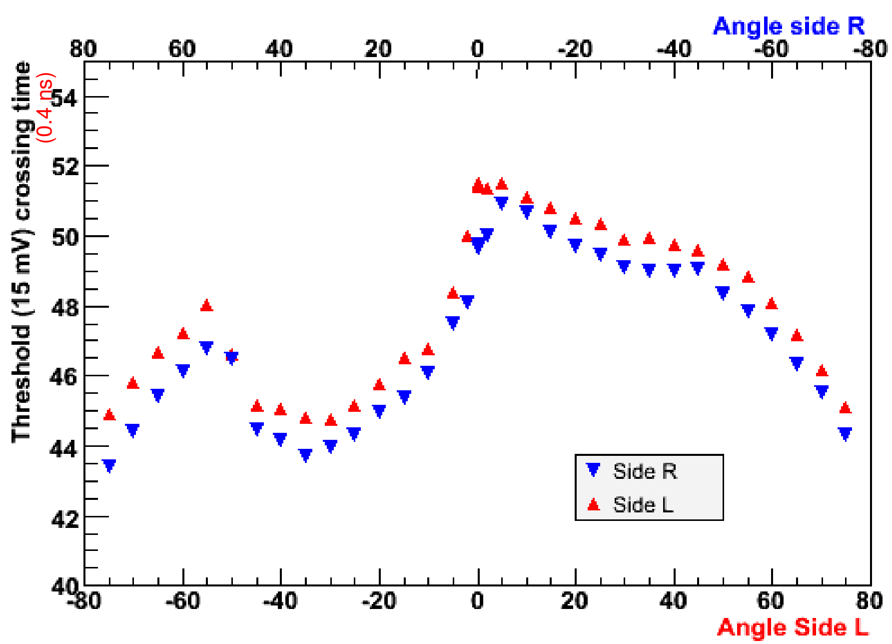


Crossing time vs angle

The threshold crossing time was studied as a function of the crystal angle;
On each side a minimum for the Cherenkov angle was found;
The crossing time decreases also while increasing the angle maybe for slewing effects due to the increase of the path length;



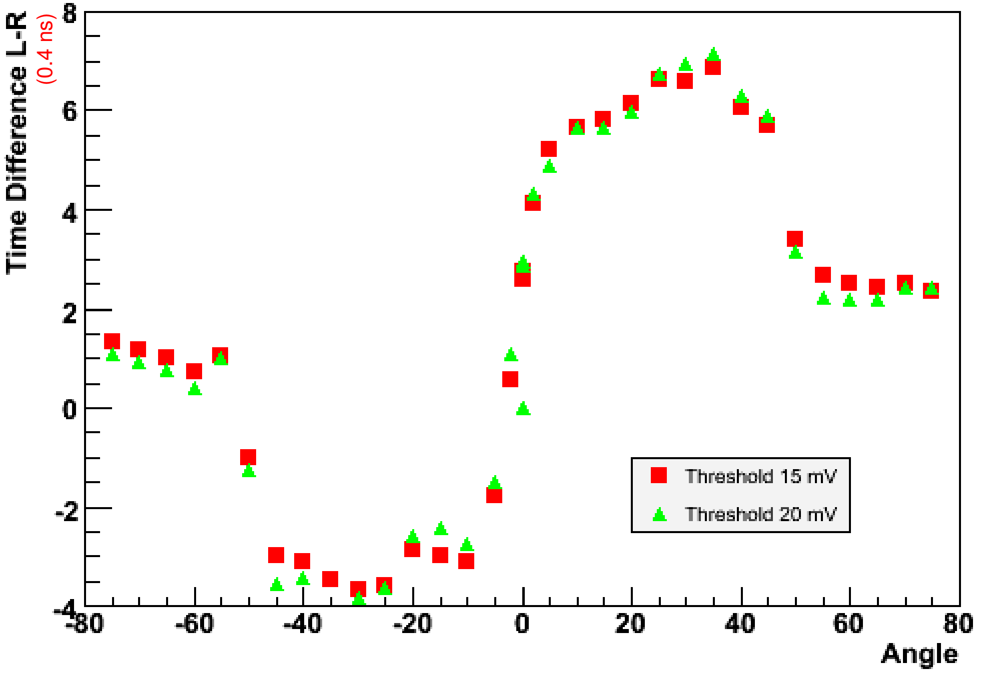


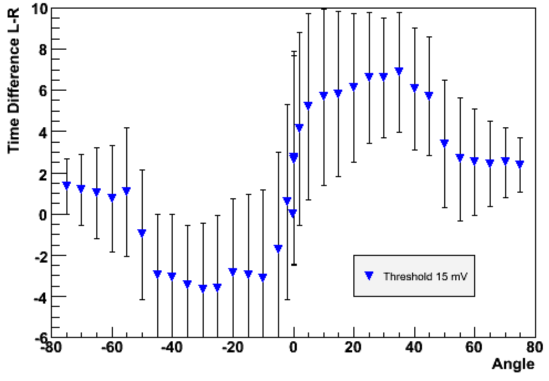


The behaviours of the crossing time of the two sides are very similar

Crossing time difference vs angle

The difference between the crossing times on Left and Right sides event by event is shown in this plot.
The effects on large angles due to the increase of path length disappear.



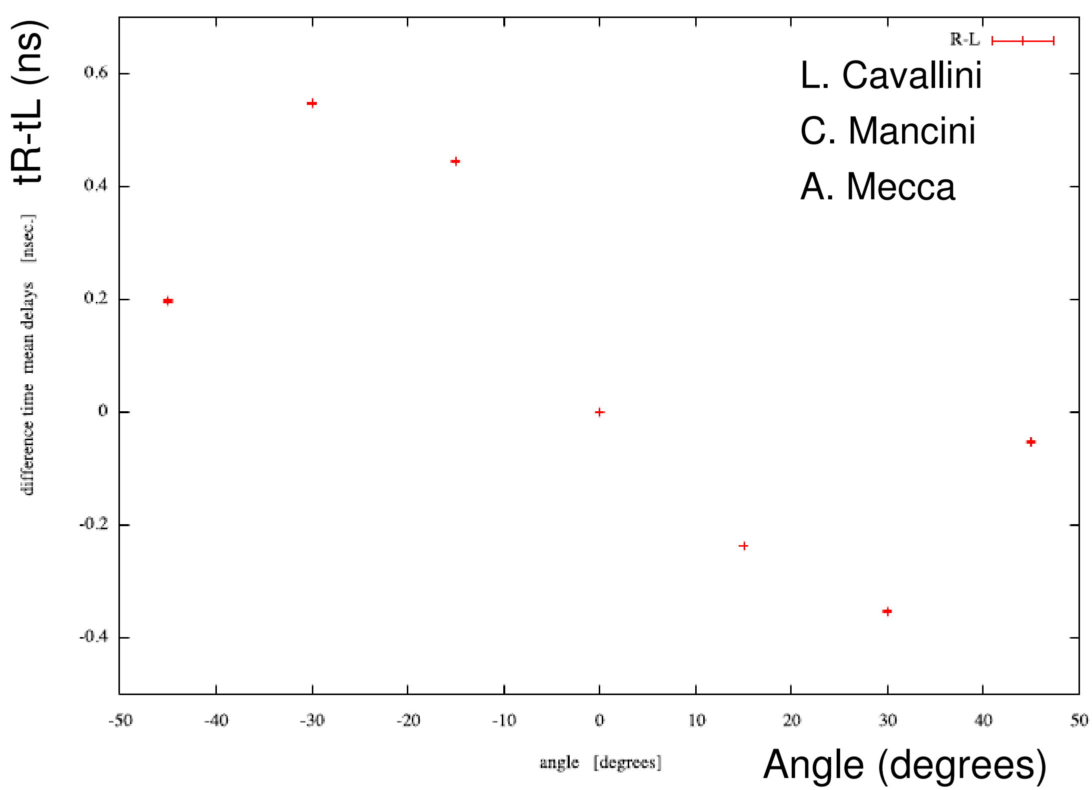


Unfortunately the errors on the crossing times (and their difference) are quite larges, maybe because of the small number of photons

Crossing time at work

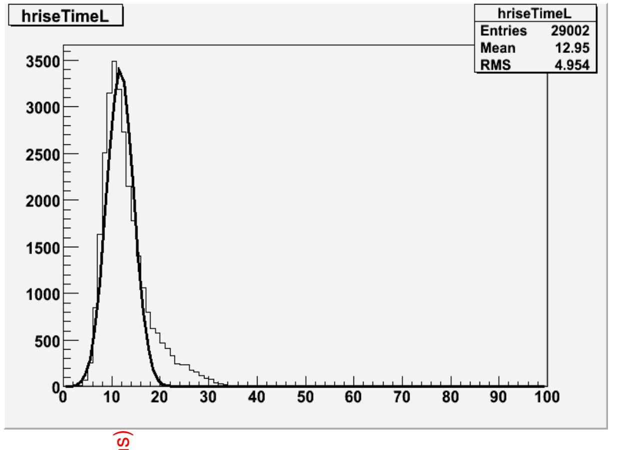
Undergraduate students have tried to measure the difference between the crossing time in a PWO crystal by means of a standard CAMAC modules (a discriminator and a TDC with 1 ns time resolution) and cosmic rays;

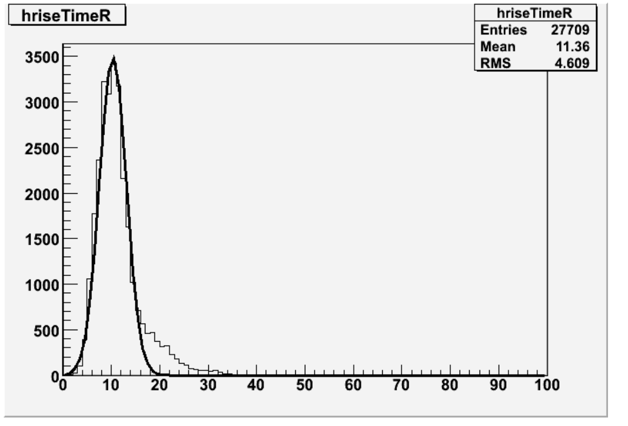
Although a very simple setup they measured a time “asymmetry” of about 1 ns;

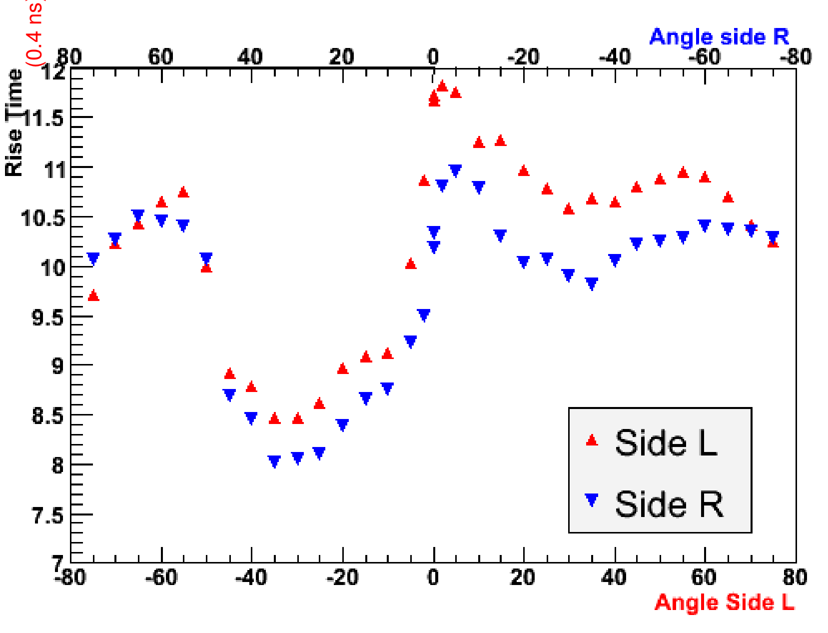


Rise time

An other interesting variable is the signal rise time (i.e. the time needed to go from the 10% to the 90% of the signal amplitude);



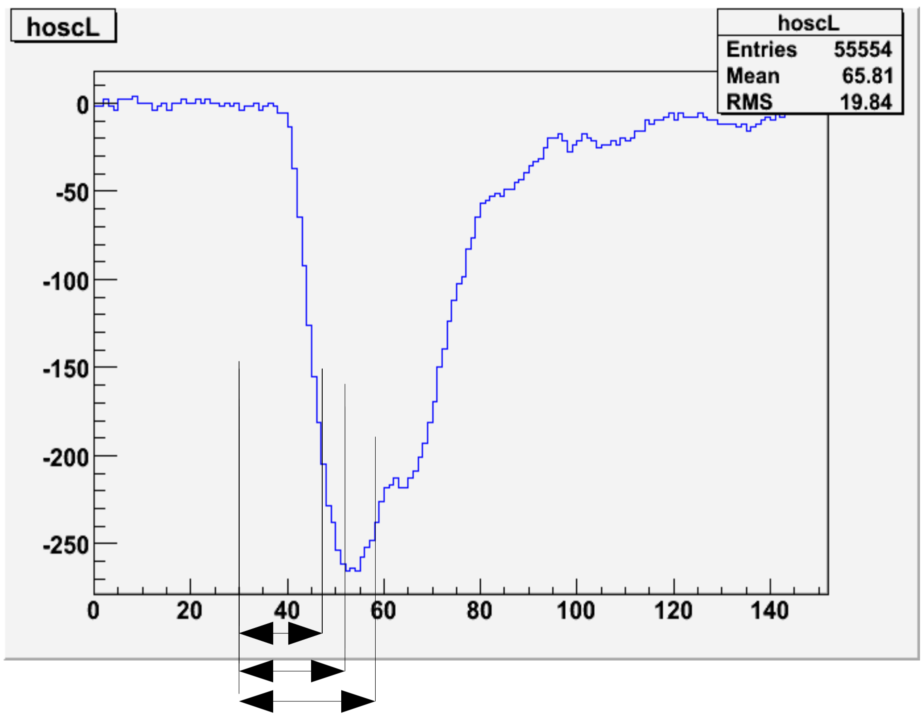




A minimum in the rise time was found on both sides for the Cherenkov angles. Also for the anti-Cherenkov angle a second minimum was found maybe due to reflected photons.

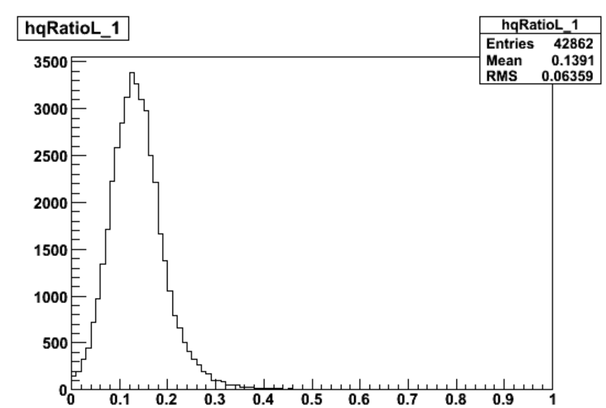
Charge ratio

An interesting variable to evaluate the Cherenkov contribution to the total light yield can be the ratio between the light seen in the first few instants of the signal and the total one;



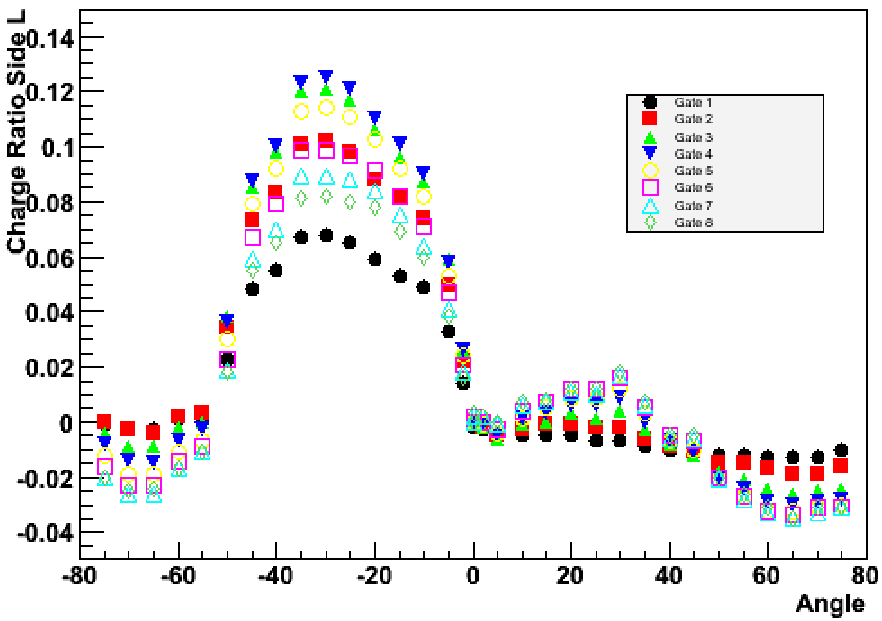
This ratio was evaluated for different gates always starting from a fixed bin of the scope signal (bin 30 in this case). For each gate value we expect an increase of the ratio while the Cherenkov light reaches the PMT because the signal becomes faster and higher;

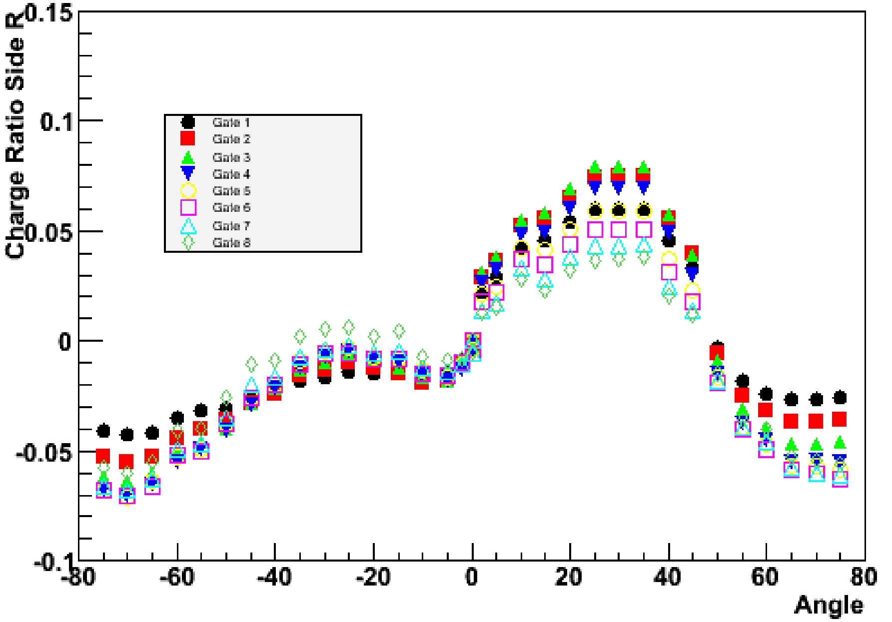
In the histogram is shown an example of the distribution of this ratio for a fixed gate in the symmetric run (0 degrees). An RMS of 30% of the mean value was found.



Charge ratio

In the plots below the behaviour of the charge ratio as a function of the crystal angle for different values of the gate width are shown;



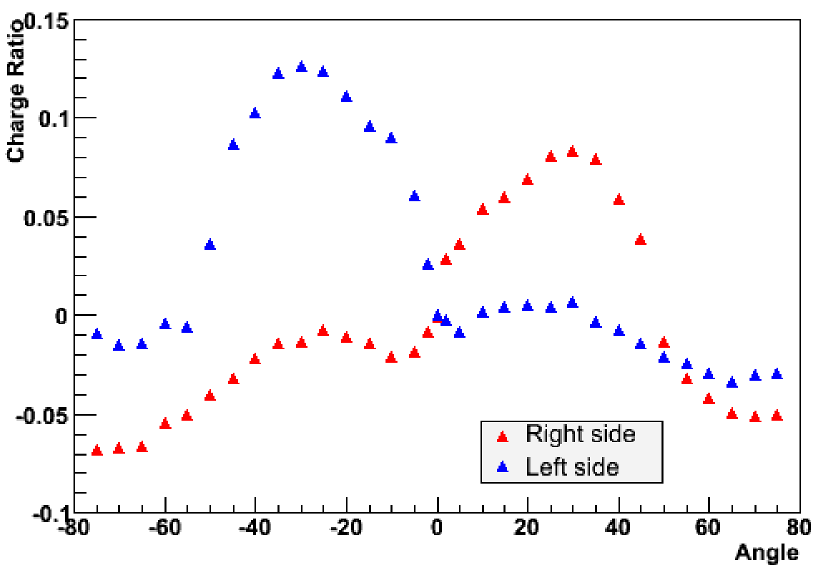


Maxima are visible at the Cherenkov angles;

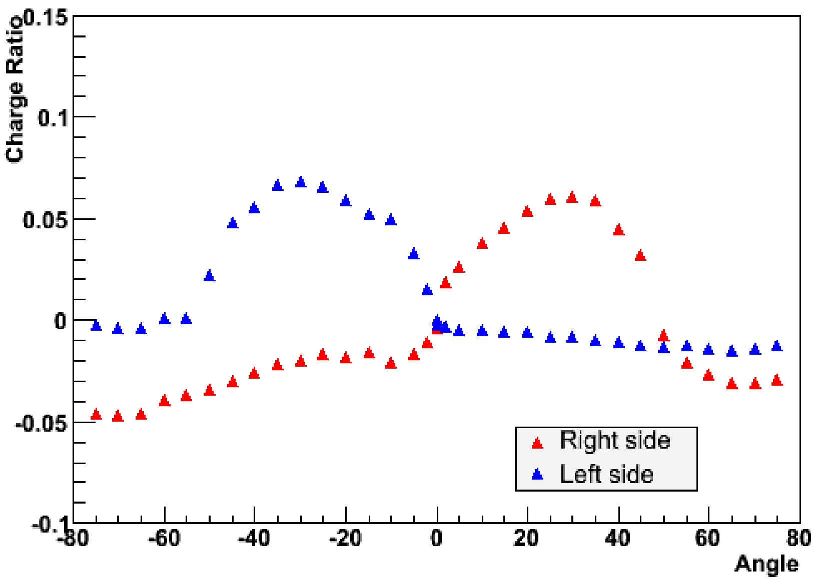
Charge ratio

In the plots below the charge ratio for both sides is shown for two different gates

When the gate that maximises the effect is shown a second peak on the anti-Cherenkov angle appears maybe due to photons reflected on the "right side"

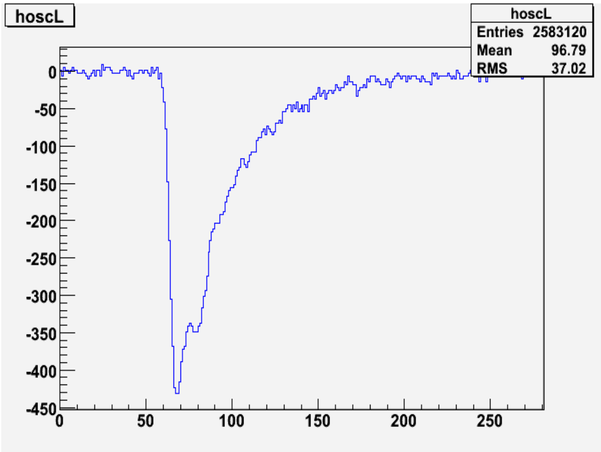


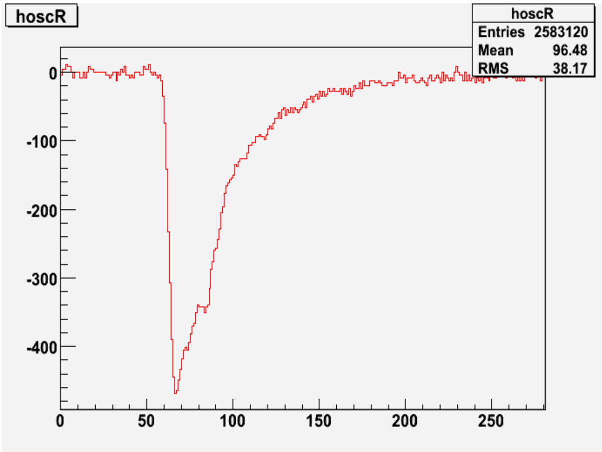
For shorter gates the absolute effect is smaller but no second peaks are visible.



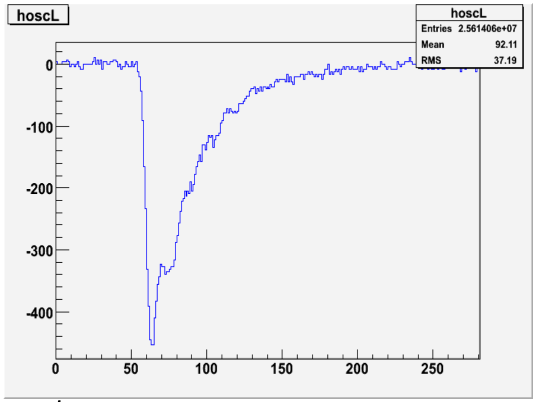
Crystal array

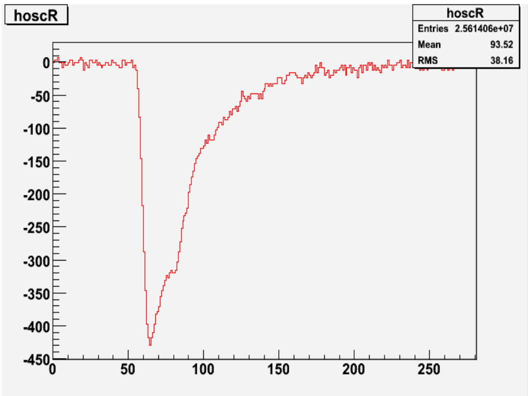
Two examples of the signals on the two sides of the crystal array are shown in the plots for 0 degrees...





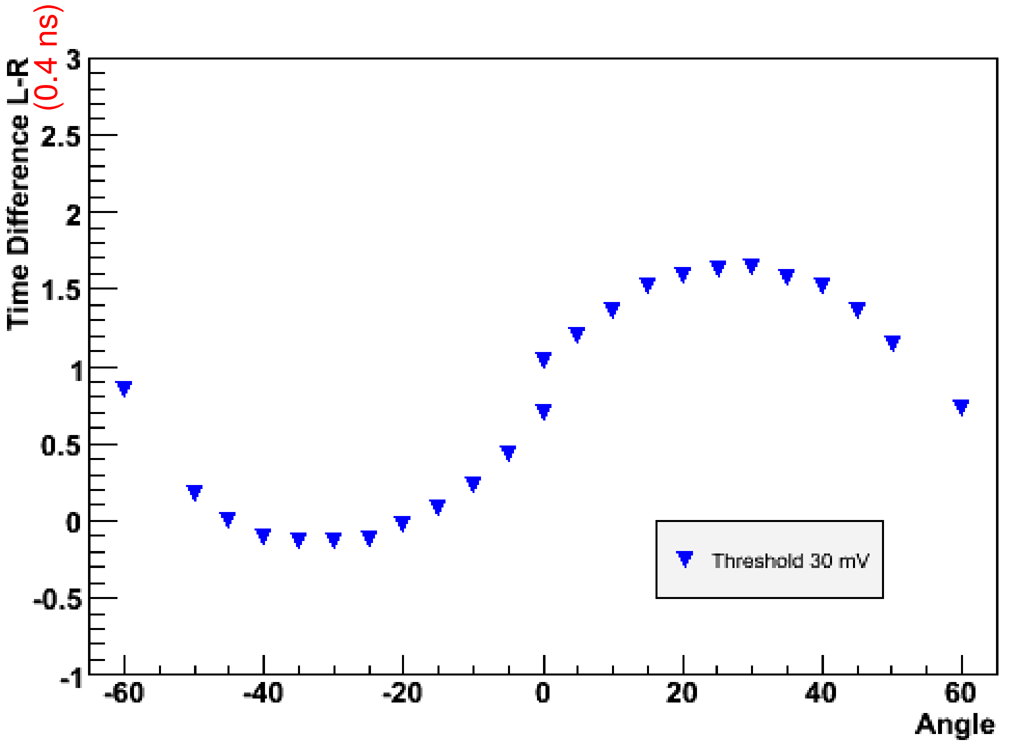
... and for 30 degrees. The second peak shouldn't be due to the Cherenkov light.



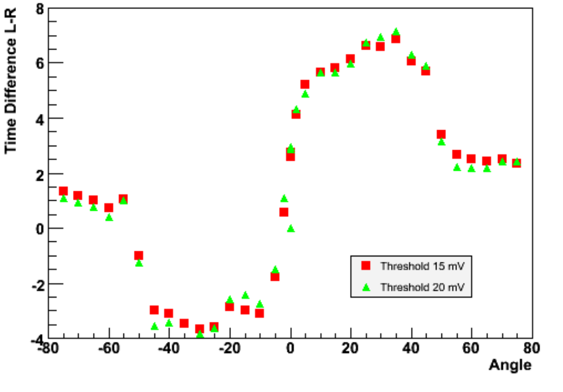


Time difference

The difference between the crossing time of the signals on the two sides is shown below

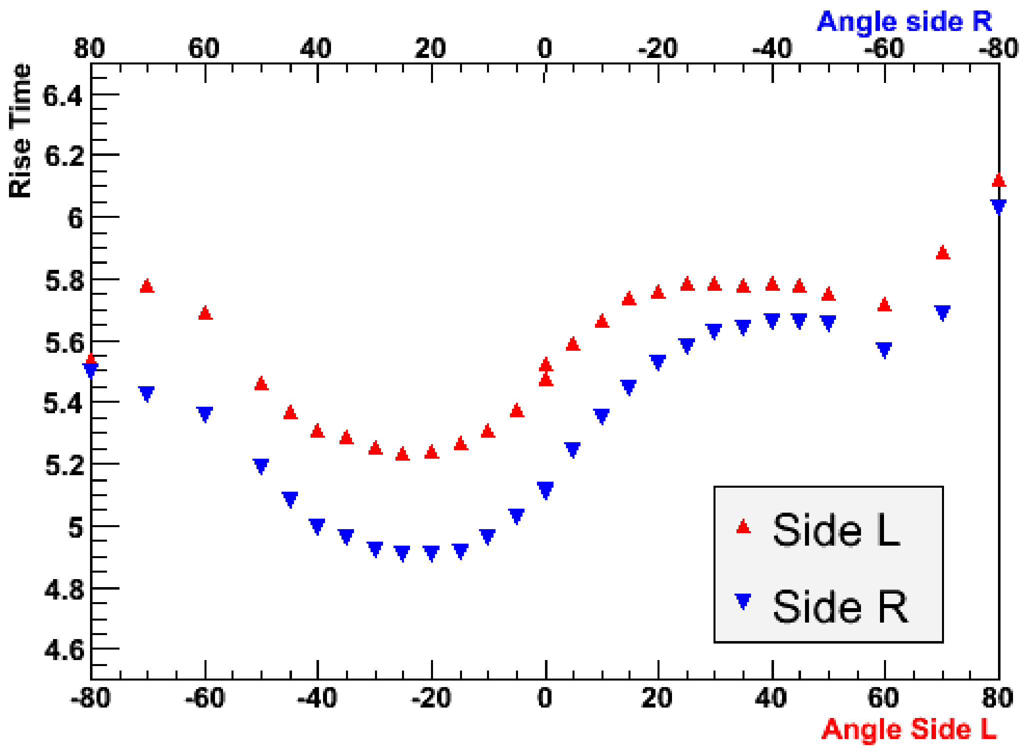


The effect of the Cherenkov light is smaller than the one of the single crystal, but still visible.

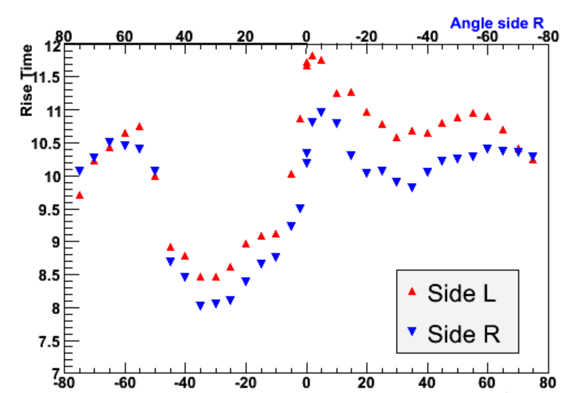


Rise Time

The signal rise time is sensitive to the Cherenkov contribution;



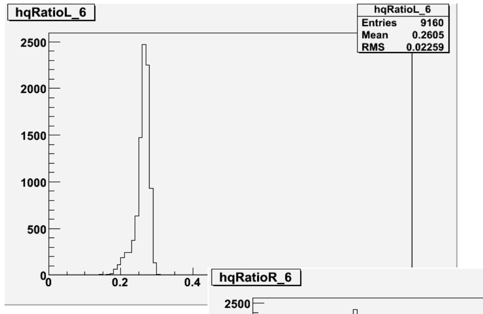
Also in this case the effect is smaller than the one of the single crystal

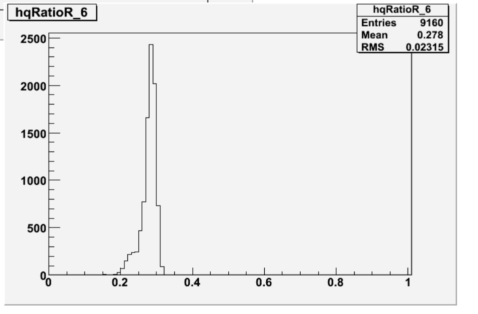


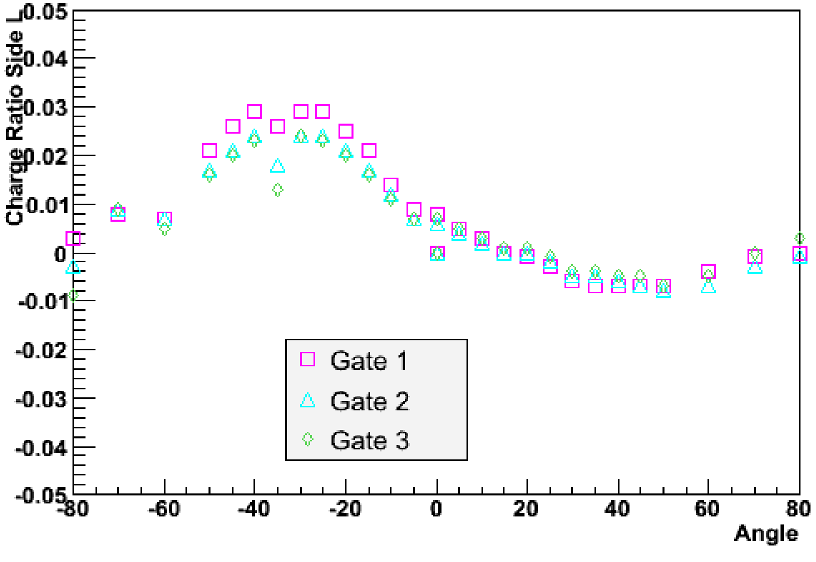
Charge Ratio

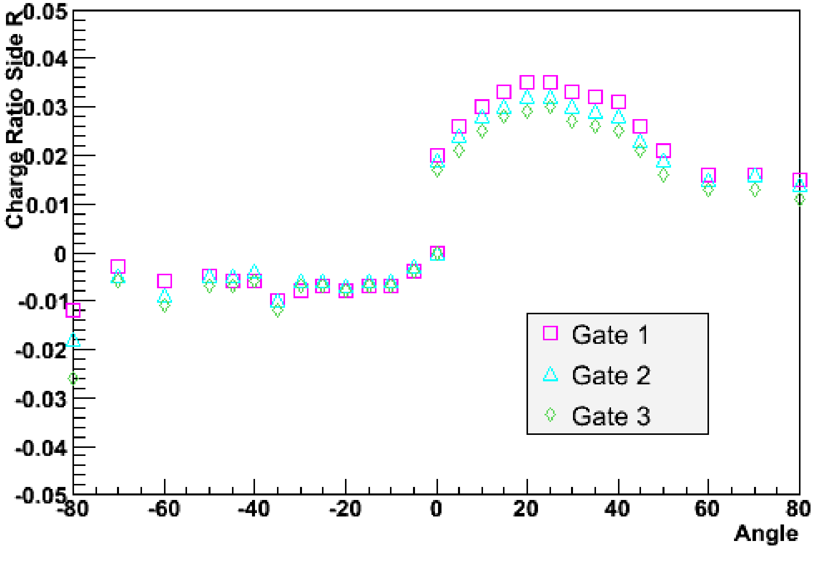
The charge ratio is still a variable sensitive to the Cherenkov light for the crystal array;

The RMS is of the order of 10% of the mean values (in the single crystal was 30%);









Conclusion and future steps

Several variables sensitive to the effects of the Cherenkov light have been studied both in the single crystal and in the ECAL array;

The prompt Cherenkov photons give rise to a fast signal whose time characteristics (threshold crossing time and rise time) can give information about the presence and the amount of Cherenkov light;

The use of the charge ratio, which sums the above effects of the signal timing and the effect on the total charge, can represent a novel way to assess the Cherenkov light contribution to the total light yield;

We now would like to find a way to correlate one of the sensitive variables shown with the EM fraction in the ECAL array;