Results of the unbinned search for dark matter with the ANTARES neutrino telescope

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Unbinning method

- The "unbinned" analysis method has been applied to the Dark Matter analysis using the ANTARES data reconstructed with the AAFit and the BBFit reconstruction method.
- The first step of this analysis is to produce several random skies (pseudo experiments or PE) with a varying number of inserted fake signal events.
- For the produced background one uses the statistics of the measured data, for the fake signal one uses the detector point spread function (PSF) and statistics obtained from the monte carlo data and simulated signal spectra.

Likelihood Function

- A fundamental element of the "unbinned" analysis method is the likelihood function, which gives a likelihood value for PE to contain n_s signal events.
- The likelihood function is normally taken logarithmic and has the form:

$$\log(L) = \sum_i \log\left(\frac{n_s}{N} S_i(\alpha, N_{hits}, \beta) + \left(1 - \frac{n_s}{N}\right) B_i(dec, N_{hits}, \beta)\right)$$

- N is the total number of events, B_i is the likelihood density for the ith event to be Background as produced from the monte carlo data, S_i the corresponding likelihood density for the ith event to be signal.

Test Statistics

- The logarithmic likelihood function then gets maximised over the n_s parameter.
- The maximum value is then used to construct the test statistics (TS):

$$TS = \log\left[L^{max}\right] - \log\left[L(n_s = 0)\right]$$

- The values of the TS vary for different PE but generally depend on the amount of fake signal events inserted, which is used to calculate limits.

TS distributions

- For a given average number of fake signal events the TS values will not always be the same.
- The distribution of TS values will depend on the average number of inserted fake signal events.
- If in 90% of the cases the TS value for a average of n inserted fake signal events is above the median of the TS distribution for the case of 0 inserted fake signal events, than n is the 90% C.L. limit on the number of detected events.

Example for W^+W^- channel

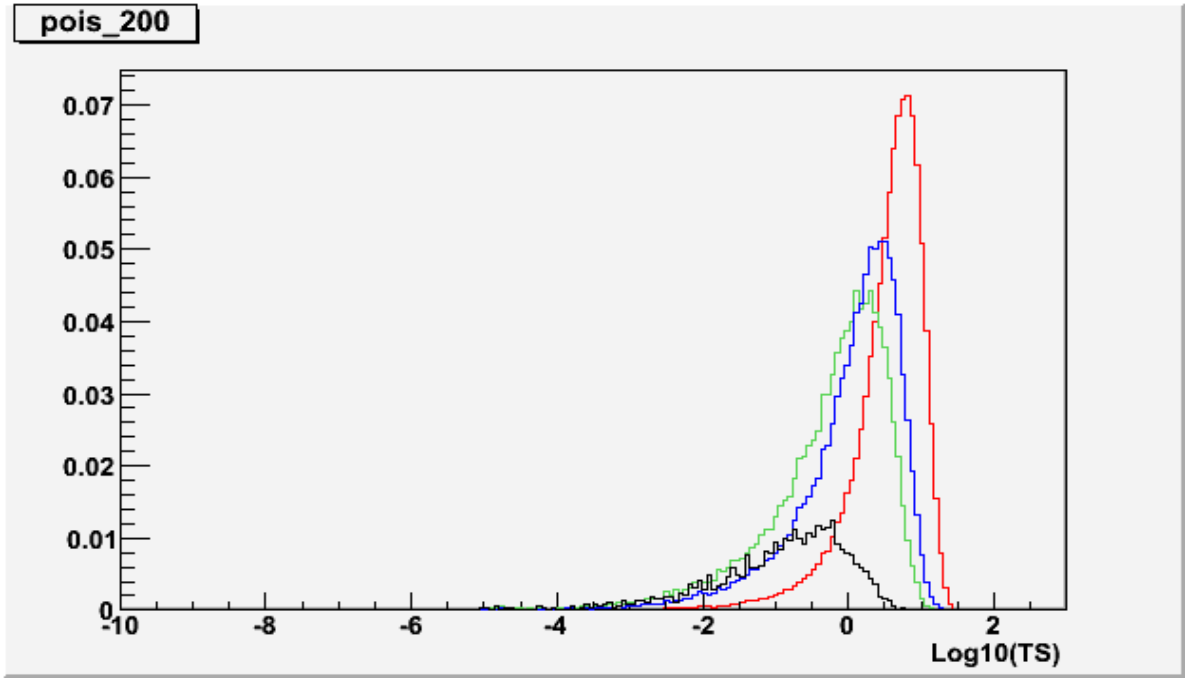

Figure : TS distributions for the W^+W^- Channel and $m_\chi = 0.5\,TeV$. The cut $\beta < 1$ has been used Black: Background, Green: 3 fakes, Blue: 5 fakes, Red: 10 fakes

Point Spread Function

- The PSF is calculated from the monte carlo simulation data producing a histogram of the angular distance between simulated true and reconstructed tracks .
- At low angles the produced PSF tends to be unstable, resulting in perticularly big problems for low WIMP masses.

Example Plots for the W^+W^- channel

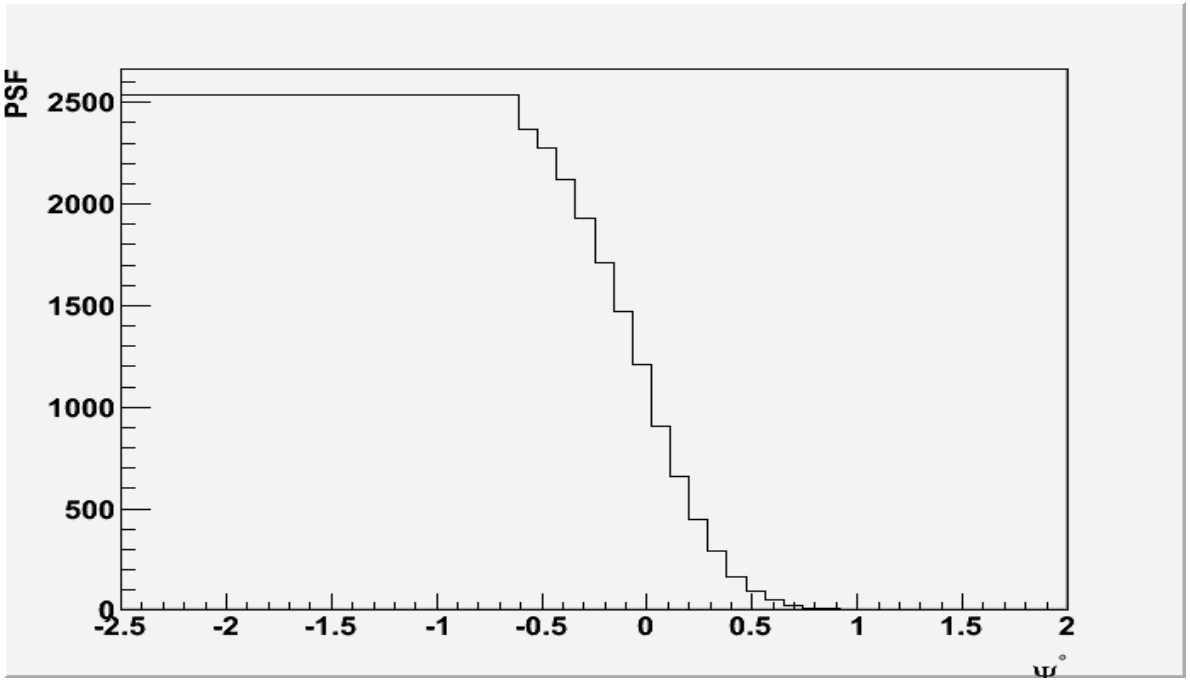

Figure : PSF for the W^+W^- Channel and $m_\chi = 0.5\,TeV$. The cuts $\lambda > -5.4$ and $\beta < 1$ have been used

Effective Area

- The effective area is produced using the monte carlo simulation data as well.
- The raw effective area per neutrino energy is converted into a acceptance per WIMP mass by convolving it with the neutrino spectrum of the given mass.
- The variation of the effective aria dominates the behaviour of the sensitivities.

Example for W^+W^- channel

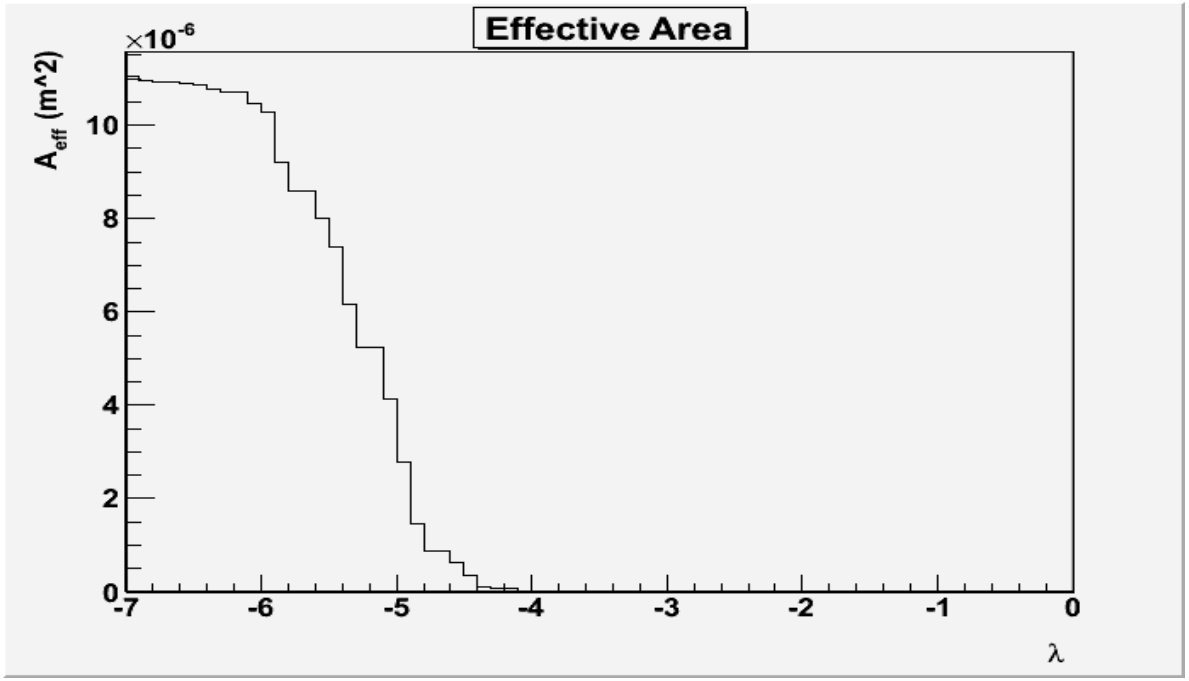

Figure : Effective area for the W^+W^- Channel and $m_\chi = 0.5\,TeV$. The cut $\beta < 1$ has been used

Fluxlimits

- The first preliminary limits on the neutrino flux from the galactic centre have been produced for the AAFit and BBFit Data.
- The flux limits show agreement with the results of the binned analysis performed by Guillaume Lambard.

Fluxlimits

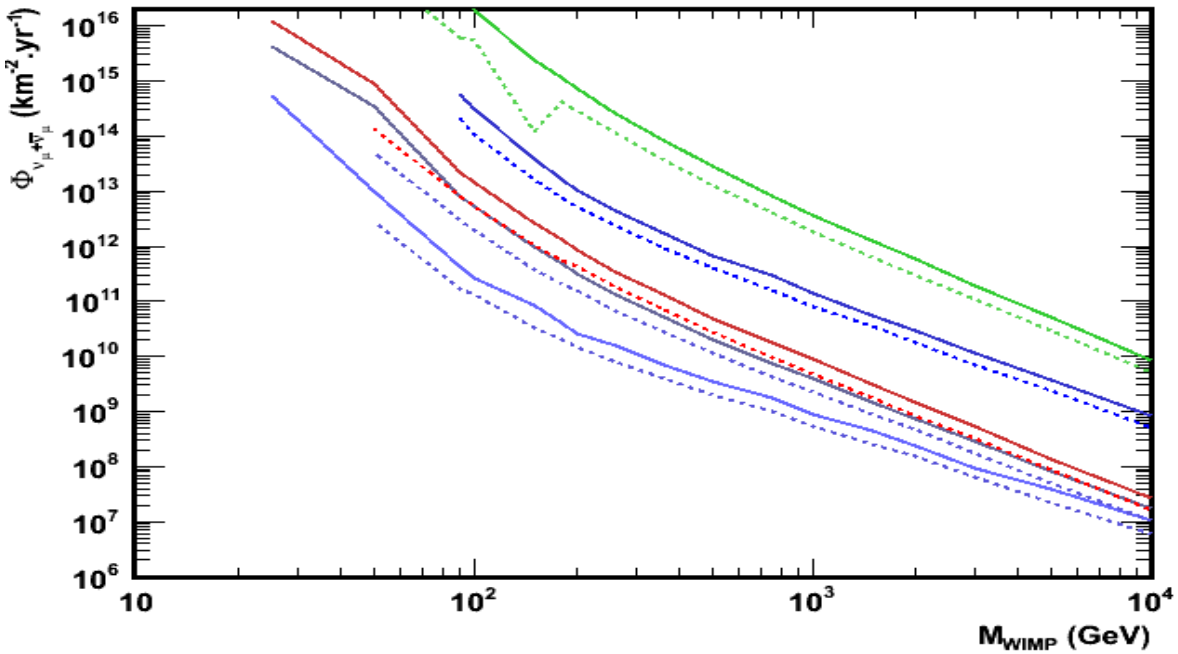

Figure : Flux limits derived from the AAFit Data, Dashed: unbinned search; Solid: binned search by Guillaume Lambard Green: $b\bar{b}$, Red: $\tau^+\tau^-$,Blue: W^+W^-, Gray: $\mu^+\mu^-$, Light blue: $\nu\bar{\nu}$

Fluxlimits

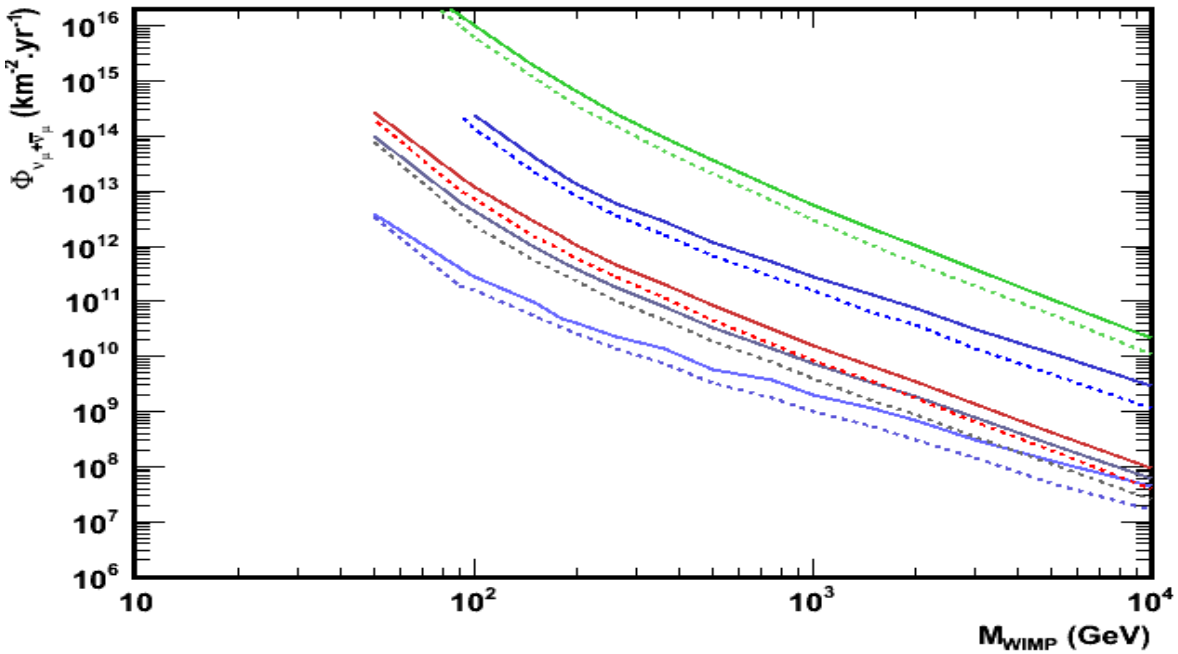

Figure : Flux limits derived from the BBFit Data, Dashed: unbinned search; Solid: binned search by Guillaume Lambard Green: $b\bar{b}$, Red: $\tau^+\tau^-$,Blue: W^+W^-, Gray: $\mu^+\mu^-$, Light blue: $\nu\bar{\nu}$

Summary

- The unbinned method shows reasonable limits for the ANTARES data sets
- The PSF production shows problems specifically for low WIMP masses
- Improvements can still be done (Using single line events from the ANTARES data, loosening the horizon cut, treating sources as extended...)