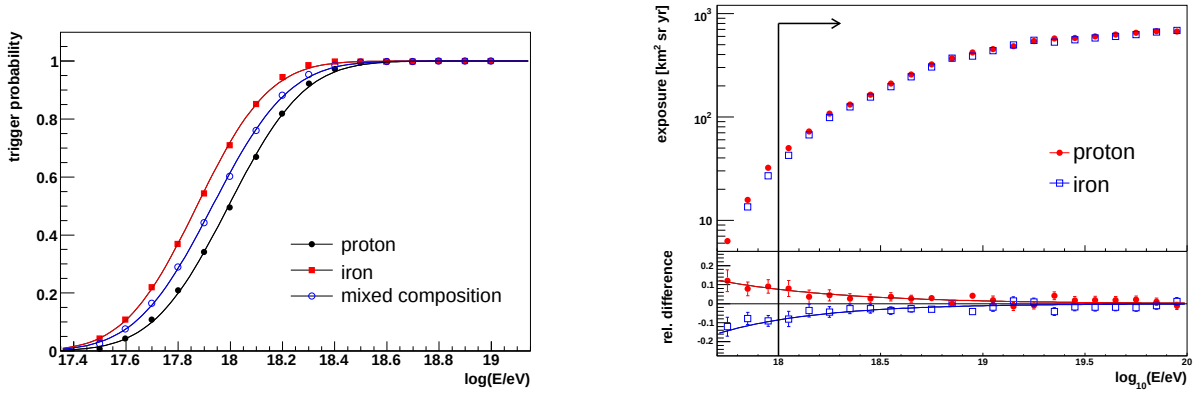
F. Schüssler (2009-03-18)

$\mathrm{P(FD|SD)}$, exposure structures

1 $\mathrm{P(FD|SD)}$

The difference between data and MC in the $\mathrm{P(FD|SD)}$ analysis might be not related to a mass composition bias. The SD trigger favors a heavy composition whereas a light composition is favored by the event selection for the hybrid energy spectrum (see Fig. 1).



(a) 3ToT (b) hybrid exposure

Figure 1: Dependencies of the primary mass composition.

This seems to be not the origin of the discrepancy of the conditional probability $\mathrm{P(FD|SD)}$ between data and MC (see Fig. 2).

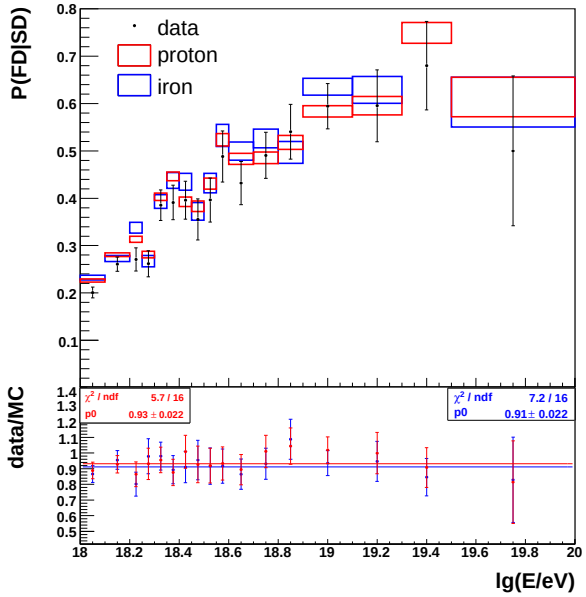
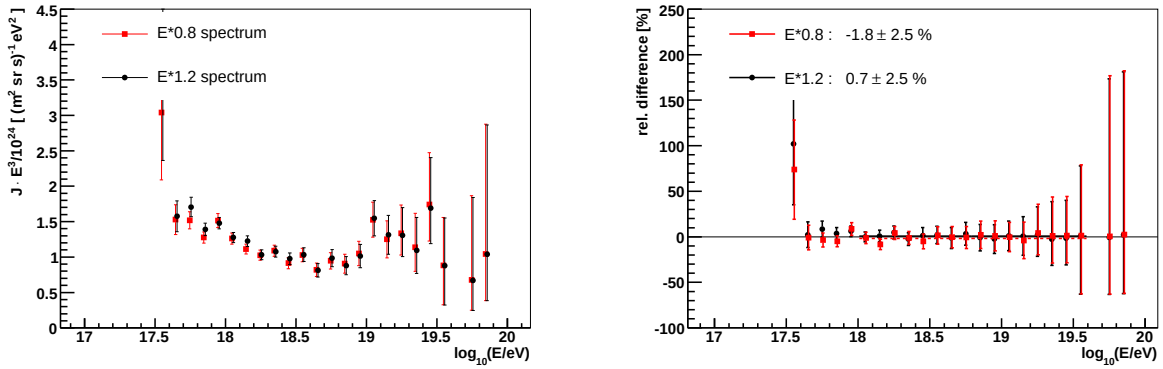


Figure 2: $\mathrm{P(FD|SD)}$ for different primary masses (M. Unger).

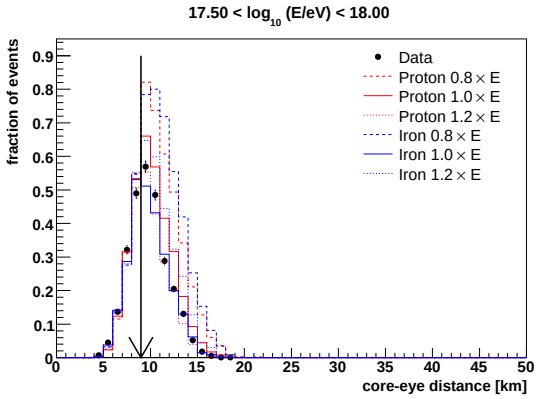
Another possible explanation for the observed difference might be a bias in the SD energy reconstruction below saturation. The dependence of hybrid spectrum on the exact energy scale is reduced (removed?) by applying fiducial distance cuts. As illustrated in Fig. 4, the selection criteria are chosen in a way that no systematic uncertainty is remaining even for extreme assumptions of primary masses and energy shifts.

The final independence of the spectrum of the energy scale is demonstrated by artificially shifting the energy of the simulated showers by $\pm 20\%$. All cuts are applied on these modified events and the exposure is derived. As can be seen in Fig. 3, the derived energy spectrum is in fact independent of the energy shift. The SD energy bias is therefore also not able to explain the $\mathrm{P(FD|SD)}$ difference.

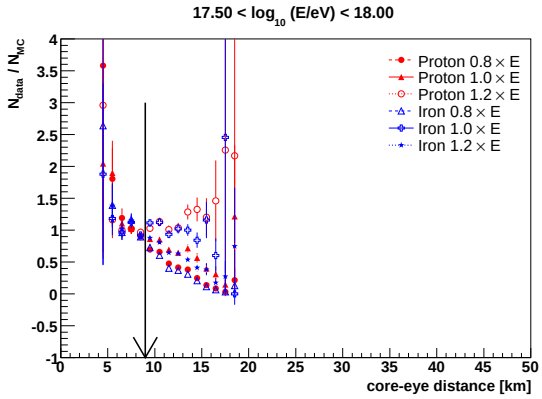


(a) spectrum (b) difference

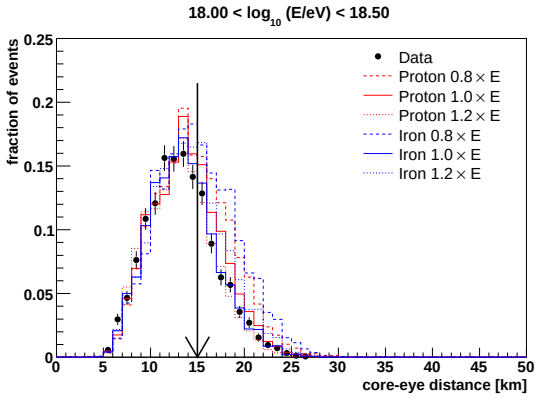
Figure 3: Changing the energy assignment of the MC showers by $\pm 20\%$ does not affect the energy spectrum.



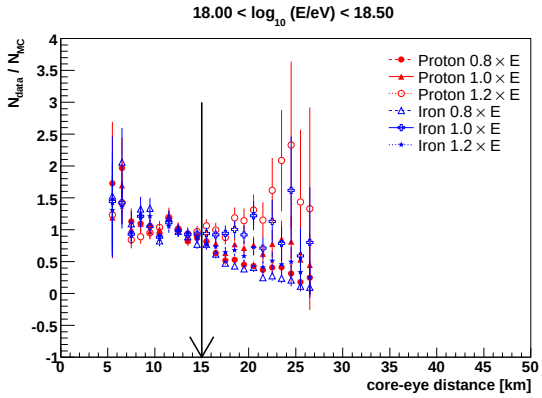
(a)



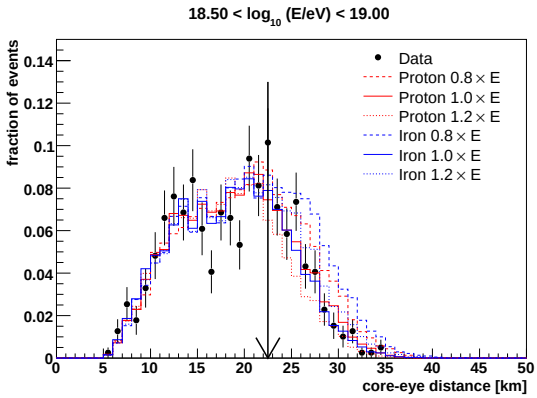
(b)



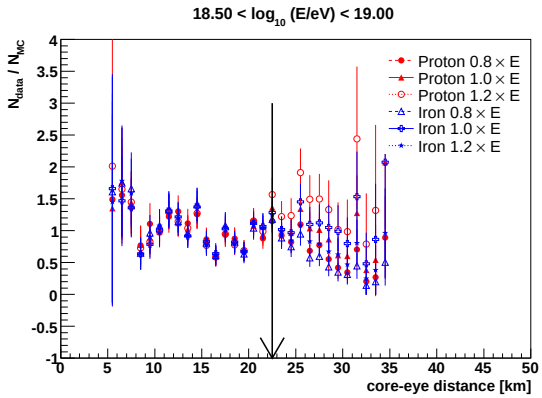
(c)



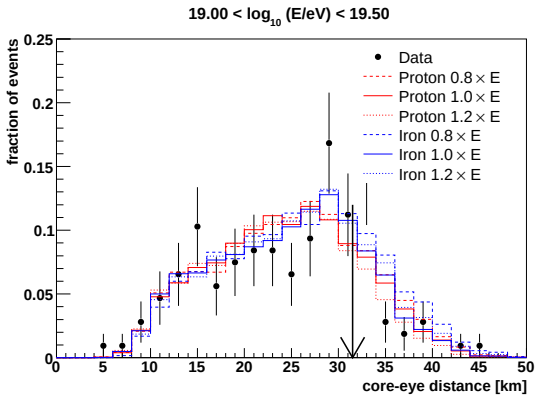
(d)



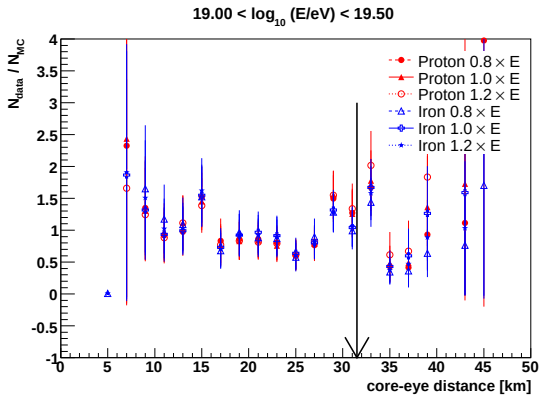
(e)



(f)



(g)



(h)

Figure 4: The systematic uncertainty of the energy scale and primary mass composition is not converting into a systematic uncertainty of the hybrid spectrum.

2 Exposure structures

The observed structures of the hybrid exposure are thought to be of physical origin [1]. Here we check the influence of the growing surface array including its holes and borders. Based on the T2-files a toy-MC has been set up. It takes into account the time dependent status of the array and the fiducial distance definitions around each fluorescence detector. The time period corresponds to the one used for the hybrid spectrum (12/2005 - 05/2008). In this first approach, the time dependence of the FD uptime is not taken into account, i.e. each time interval is sampled equally.

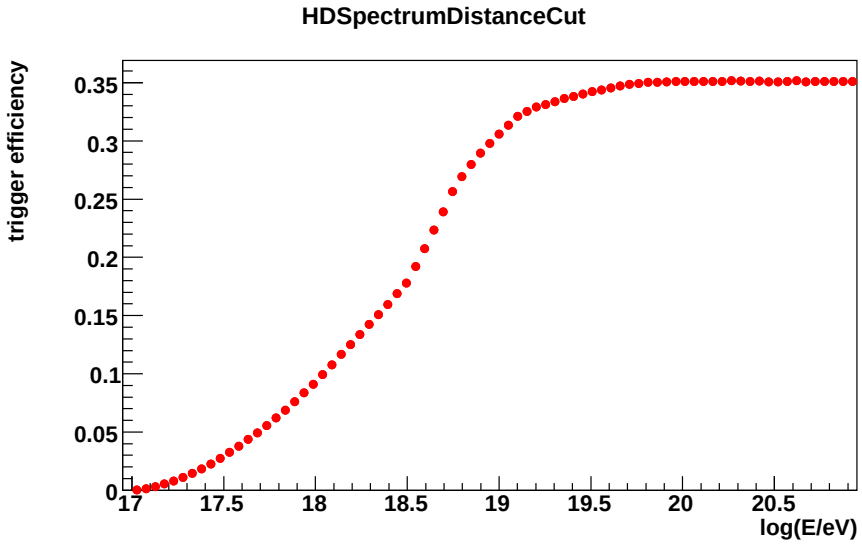


Figure 5: Toy MC simulating the time dependence of the surface array.

The increase of the slope visible at $10^{18.5}$ eV is directly related to the definition of the fiducial volume. The definition used for the hybrid spectrum reads:

$$D_{\max}[\mathrm{km}] \leq \begin{cases} 24 + 12(\lg(E/\mathrm{eV}) - 19) & \lg E/\mathrm{eV} < 18.5 \\ 24 + 12(\lg(E/\mathrm{eV}) - 19) + 6(\lg(E/\mathrm{eV}) - 18.5) & \lg E/\mathrm{eV} \geq 18.5 \end{cases} \quad (1)$$

Removing the additional term above $10^{18.5}$ eV, the original photon limit distance cut is obtained. The energy dependence of the surface array efficiency is shown in Fig. 6.

Another structure (a flattening) at around 10^{19} eV is also observed. A similar flattening is also present in the hybrid exposure. This gives another hint on the physical origin of the exposure structures.

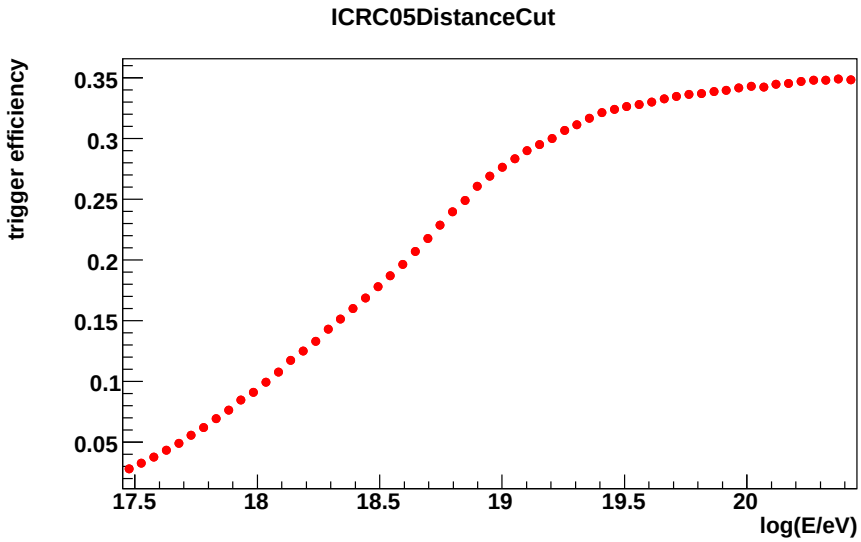


Figure 6: Toy MC simulating the time dependence of the surface array.

References

[1] F. Schüssler. Details of the Hybrid Exposure. http://www-ik.fzk.de/~fabian/HybridSpectrum/Exposure/Material/Fabian_ExposureFluctuations.pdf.