Extended Emission of the Solar Flares on June 11 and 15, 1991

June 11, 1991

Extended emission of γ–rays $> 50 MeV$ was observed by EGRET for about 8 hours (Kanbach et al., 1993)

Extended emission of γ–rays in the $2.2 MeV$ line was observed by COMPTEL for about 4 hours (Ryan et al., 1993; Rank et al., 1993)

By a deeper analysis of the COMPTEL telescope mode data we now see a clear signal in the $2.2 MeV$ line for 3 CGRO orbits following the flare.

The $2.2 MeV$ emission after the impulsive phase shows a smooth decline and can be described by a 2-fold exponential decay.
The two time constants match well with the $> 50 MeV$ decay constants of EGRET.

June 15, 1991

Analysis of COMPTEL telescope data revealed extended emission in the $2.2 MeV$ line also for the June 15 flare. Although the flare happened during CGRO night, emission could be detected for several hours.

The emission looks very similar to the June 11 profile. We also fit it with a 2-fold exponential decay and get quite similar time constants.

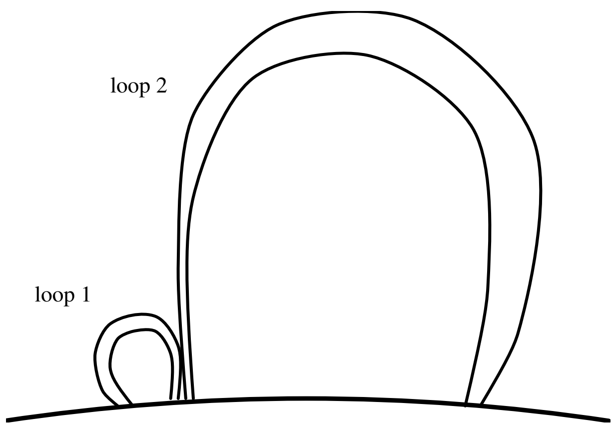
Conclusions

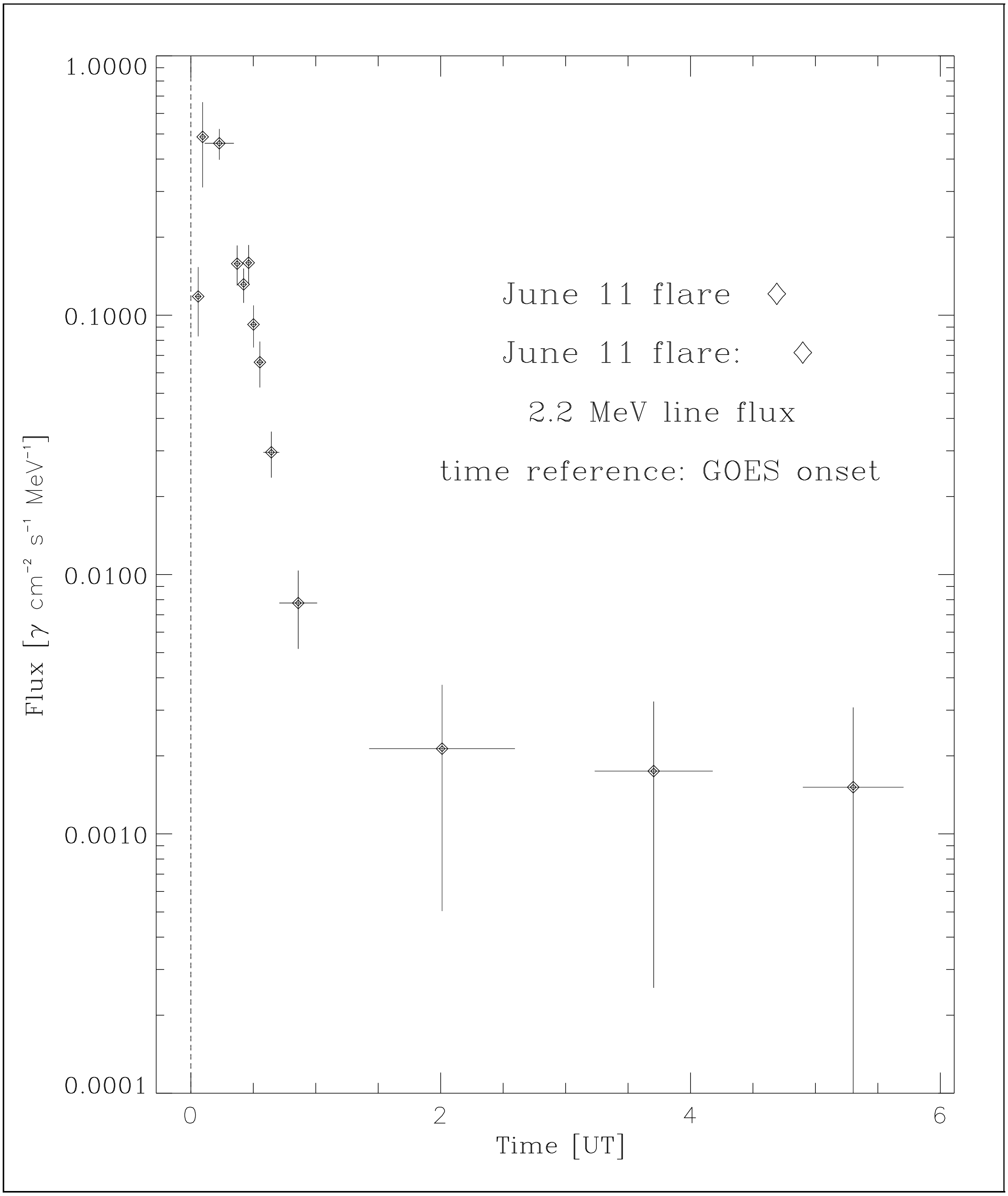
• The flares om June 11 and 15 show extended emission for many hours in both the $2.2 MeV$ line and pion related emission $> 50 MeV$.
The time profiles for both energy ranges are very similar and we get the same time constants within the error bar.

• The faster component of the EGRET time profile was so far explained by primary electron bremsstrahlung.
We can show, that this component is also nuclear in origin: The $2.2 MeV$ line reveals a similar time profile and the spectrum is very hard. Hence, also pions are produced simultaneously with the neutrons.

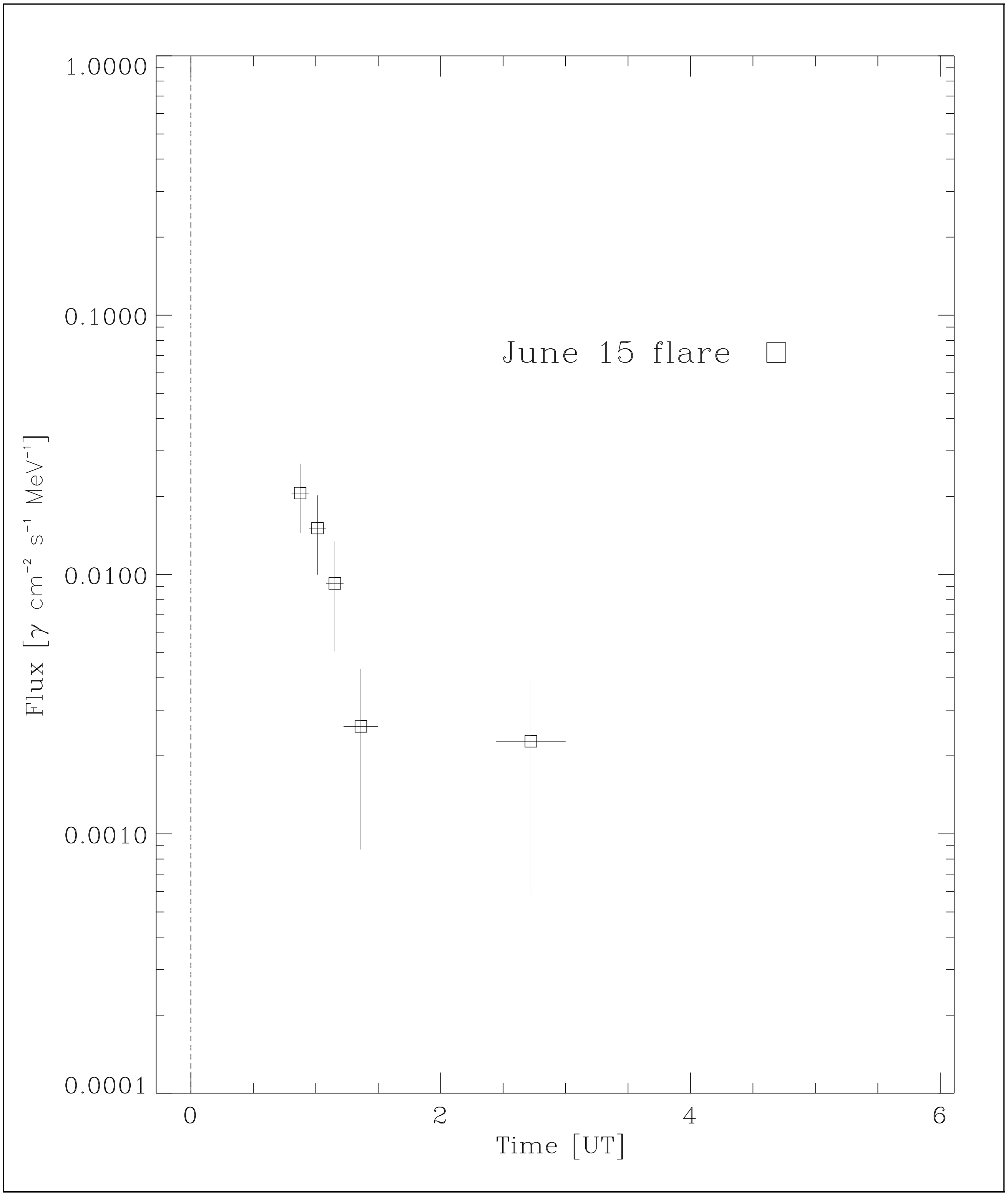
• The extended emission was explained by trapping of impulsively accelerated particles in non-turbulent magnetic loops. Such a model predicts different precipitation rates for particles with different energies.
While neutrons which create the $2.2 MeV$ line are mainly produced by protons of $\sim 100 MeV$, the pions originate from protons $> 400 MeV$. Therefore our observations are not in agreement with a trapping model. They give support to an explanation by continuous acceleration.

• The different decay times can be explained by particles that are in different magnetic structures: Particles in small loops would precipitate faster than others in large loops.
As both flares are very similar, the accelerated particles are probably populating identical magnetic structures.





1.0000
0.1000
0.0100
0.0010
0.0001
Flux [γ cm^{-2} s^{-1} MeV^{-1}]
0
2
4
6
Time [UT]
June 11 flare
June 11 flare:
2.2 MeV line flux
time reference: GOES onset


1.0000
0.1000
0.0100
0.0010
0.0001
Flux [γ cm^{-2} s^{-1} MeV^{-1}]
June 15 flare □
0
2
4
6
Time [UT]