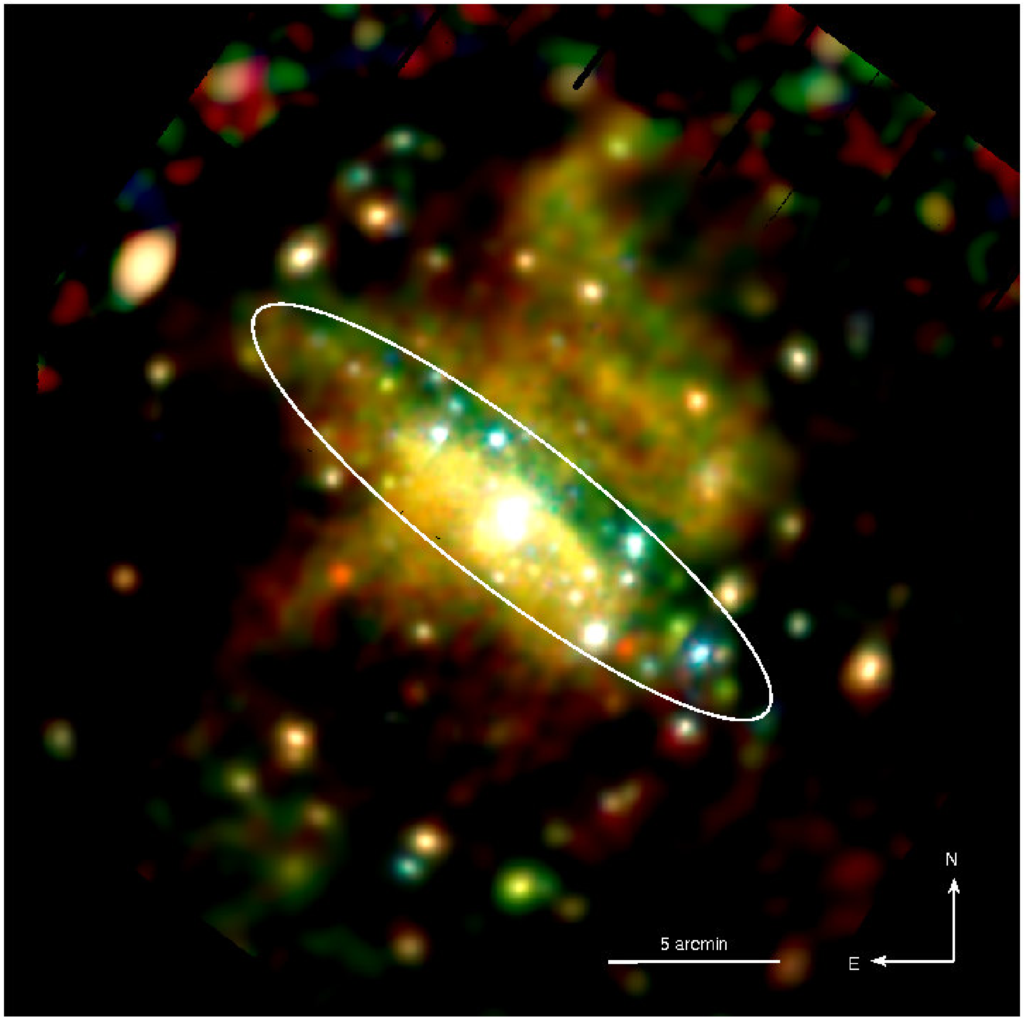
EPIC PN background spectra for low surface brightness sources

Michael Bauer (MPE),

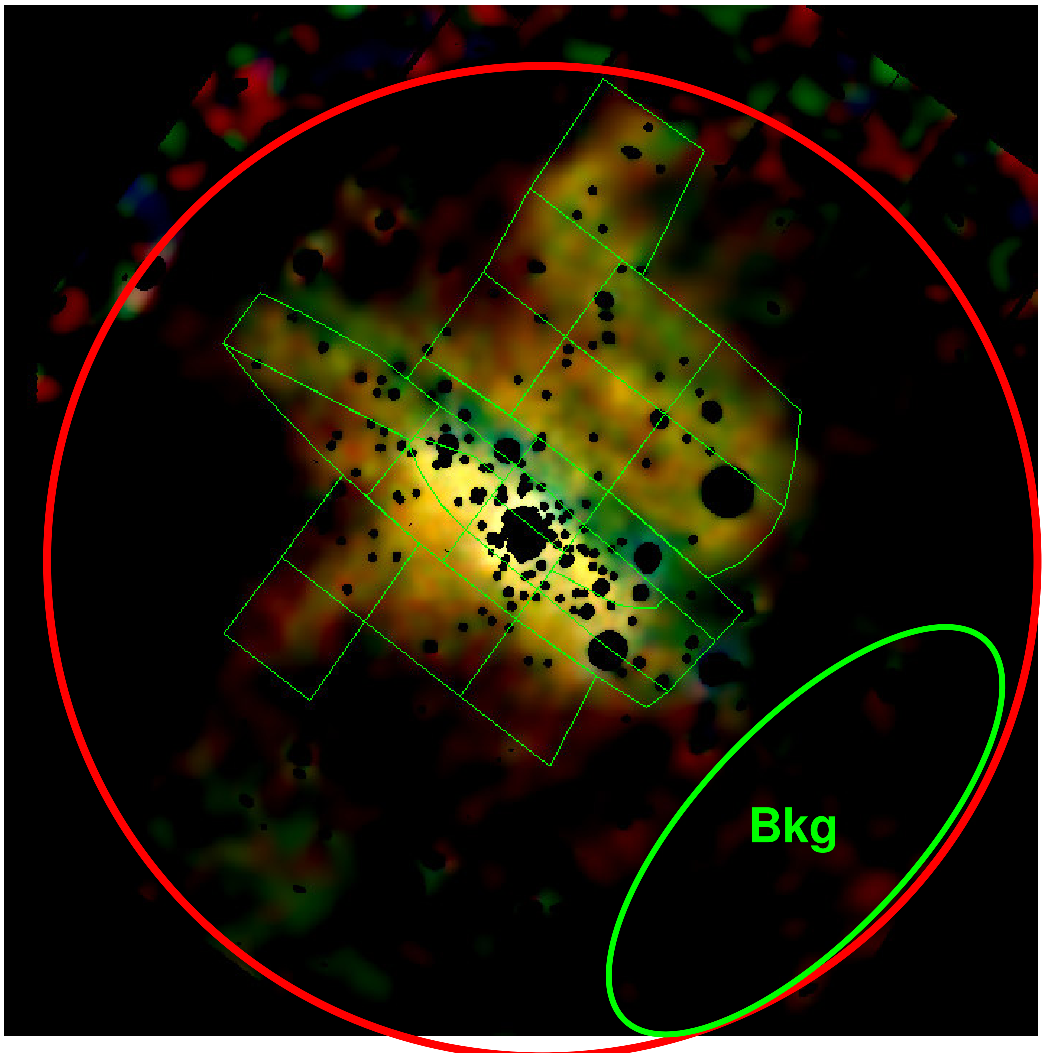
Wolfgang Pietsch (MPE) & Ginevra Trinchieri (INAF)

The halo emission in NGC 253



- Low surface brightness
  - background may dominate
- Background components:
  - sky background
  - detector background
  - Out-of-Time events (PN)

The halo emission in NGC 253



- remove point sources
- choose background region at the border of the field of view, but:
  - different vignetting
  - different detector background

Detector background

- use Filter Wheel Closed observations
  - with same detector mode and filter as in NGC 253 observation
  - observation date close to the NGC 253 observation to avoid different detector settings or different detector performance
  - correct for different particle radiation levels, by rescaling the count rate in the closed observation via the Rejected Line Counter from the House Keeping File (large detector area, no Out-of-Time event influence)

Out-of-Time events

- use Out-of-Time event files to extract spectra
- by subtracting the Out-of-Time spectrum and the detector background spectrum from the source spectrum, the Out-of-Time events from the detector background are subtracted twice!
  - -> Add Out-of-Time spectrum from the detector background again

Vignetting correction

- the sky background is vignetted, the detector background is NOT
- => first, subtract non-vignetted components from the spectrum in the background region
- determine the off-axis angle of the centre of source and background region
- correct counts in each channel in the background spectrum to have the same vignetting as the source region

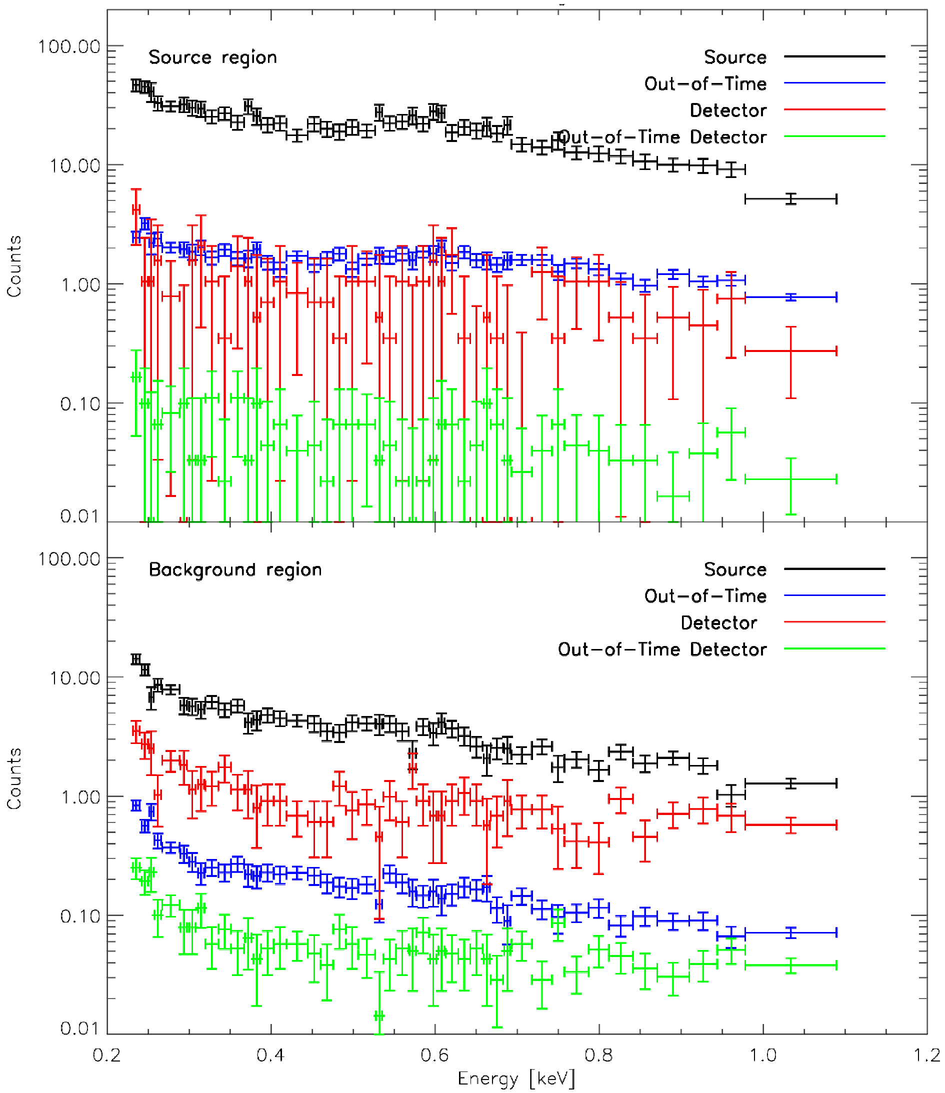
Total background spectrum

$$B(E) = \underbrace{S_{obs}^{OOT}(E) \times f}_{\text{Out-of-Time events}} + \underbrace{S_{det}(E)\frac{R_{obs}}{R_{det}}\frac{t_{obs}}{t_{det}}}_{\text{detector background}} - \underbrace{S_{det}^{OOT}(E)\frac{R_{obs}}{R_{det}}\frac{t_{obs}}{t_{det}} \times f}_{\text{detector Out-of-Time events}} +$$

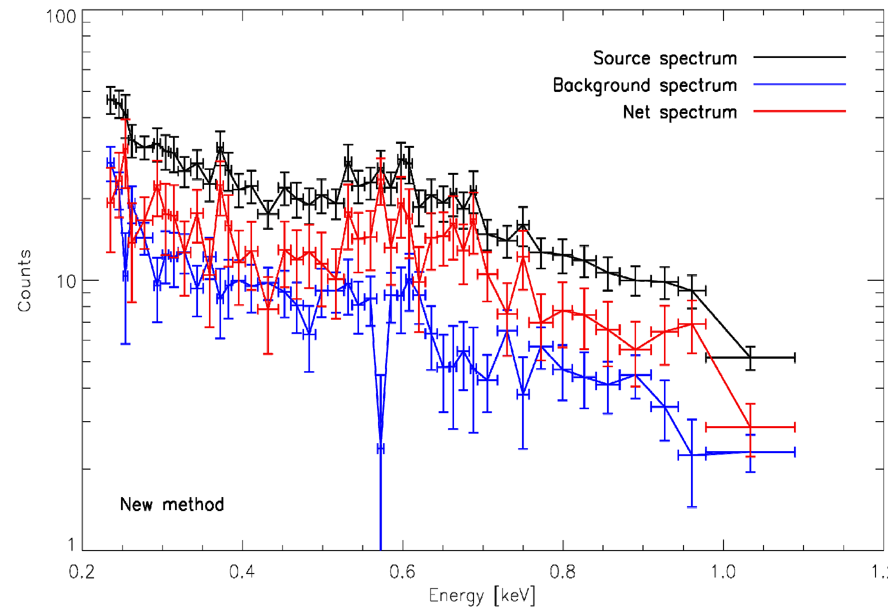
$$\underbrace{+\frac{V(E,\theta_S)}{V(E,\theta_B)}\frac{A_S}{A_B} \times \left(B_{obs}(E) - \underbrace{B_{obs}^{OOT}(E) \times f}_{\text{Out-of-Time events}} - \underbrace{B_{det}(E)\frac{R_{obs}}{R_{det}}\frac{t_{obs}}{t_{det}}}_{\text{detector background}} + \underbrace{B_{det}^{OOT}(E)\frac{R_{obs}}{R_{det}}\frac{t_{obs}}{t_{det}} \times f}_{\text{detector Out-of-time events}} \right)}_{\text{sky background}}$$

- source region: S, background region: B
- exposure time: t, area: A, vignetting: V, Rejected Line Counter: R, Out-of-Time event fraction: f

Example spectrum in the halo



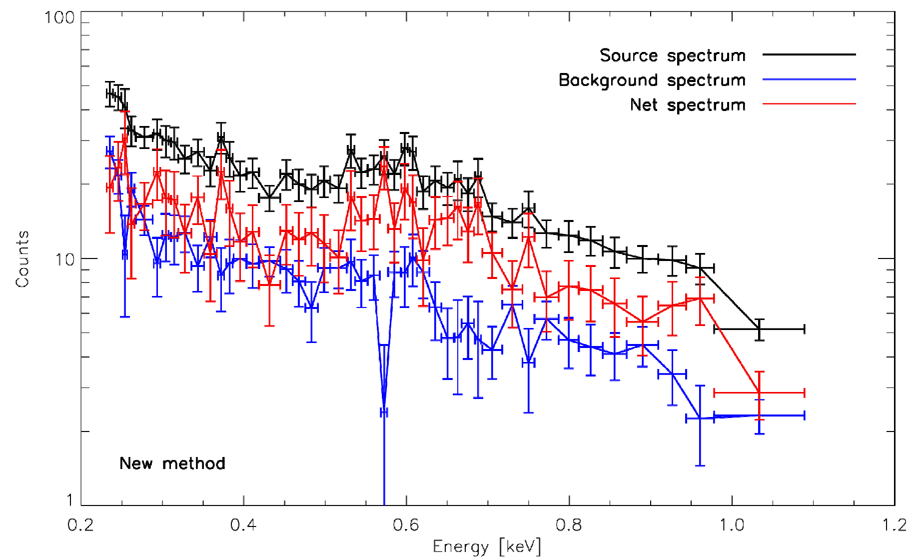
Combined:

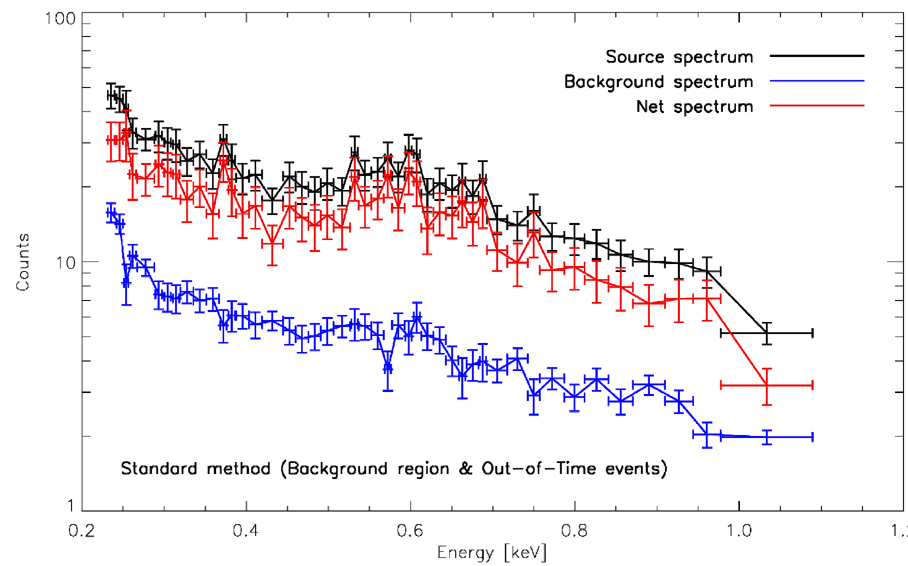


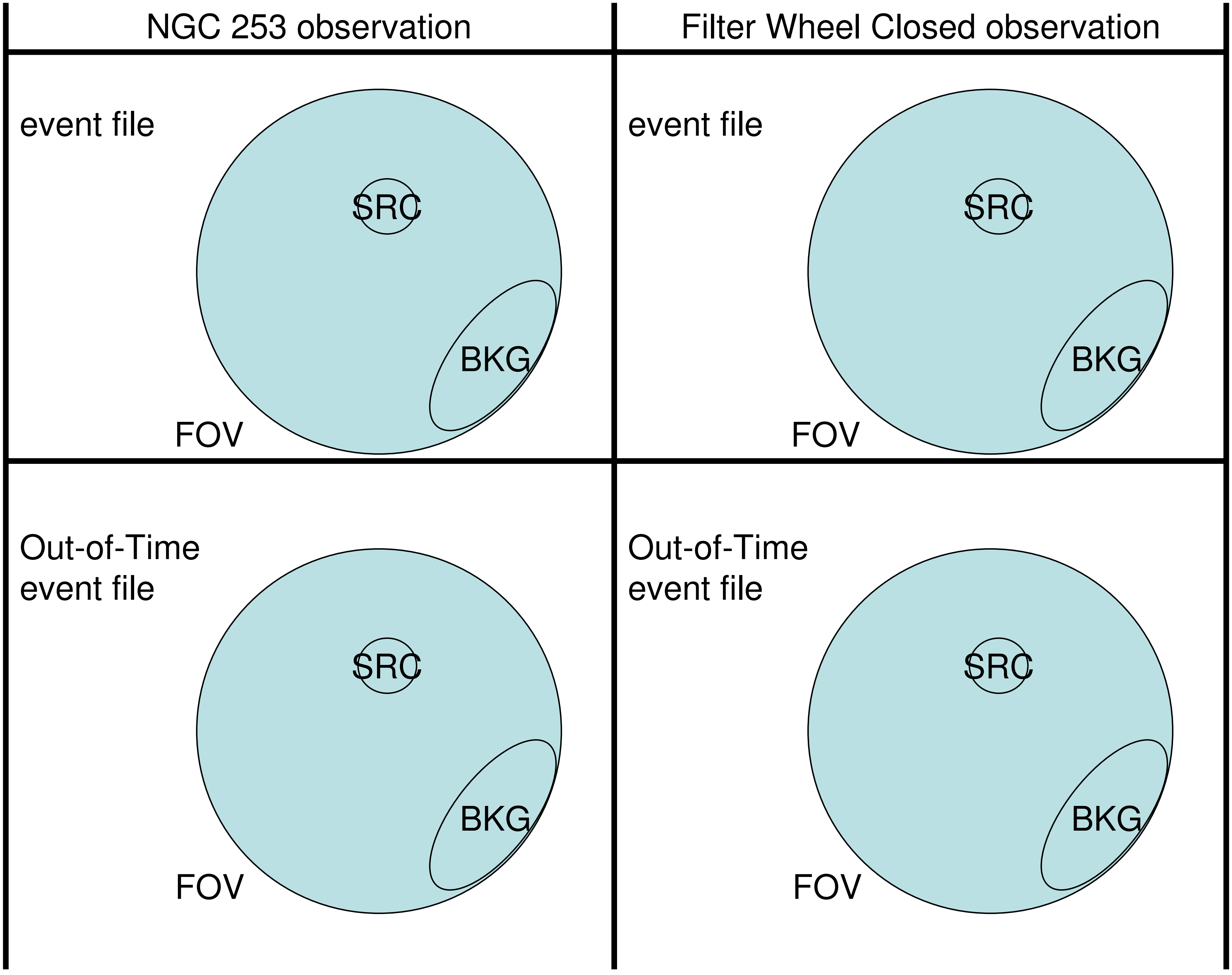
Example spectrum in the halo

Differences:

- conventional method requires additional power law component
- flux is higher in the conventional method, up to 22% (for low surface brightness)
- temperatures are consistent between both methods






NGC 253 observation
Filter Wheel Closed observation
event file
SRC
BKG
FOV
event file
SRC
BKG
FOV
Out-of-Time
event file
SRC
BKG
FOV
Out-of-Time
event file
SRC
BKG
FOV