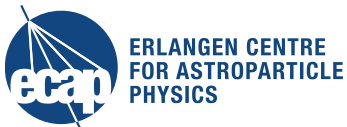


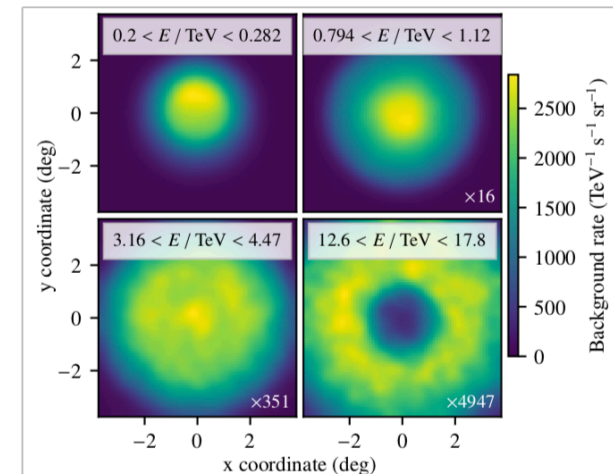
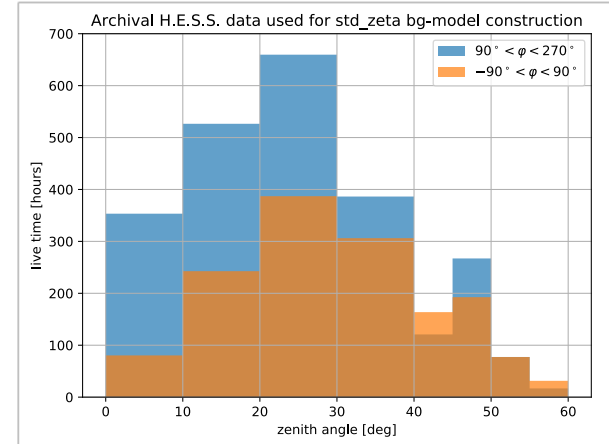
Smoothing of cosmic-ray background models

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

Gammapy Coding Sprint
15.07.2019, Erlangen
Andreas Specovius



- Bg from archival H.E.S.S. data
- Predict the residual hadronic bg **rate** per **solidangle**, **energy** and **time** as a function of **x**, **y** and **energy**
- Subject to statistical fluctuations
 - Get rid of them
—> smooth
 - Ensure:
 - Preserve **spatial curvature**
 - Positive **rates**



- **Total Variation** denoising:
Minimizes L1 norm of data
gradient

`skimage.restoration.denoise_tv_chambolle`

- **2-dim Gaussian Filter:**
Convolution with gaussian filter

`scipy.ndimage.gaussian_filter`

- **Kernel Density Estimation:**
Probability density estimation
using gaussian kernel

`scipy.stats.gaussian_kde`

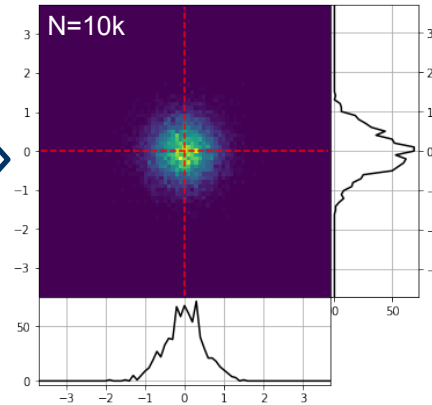
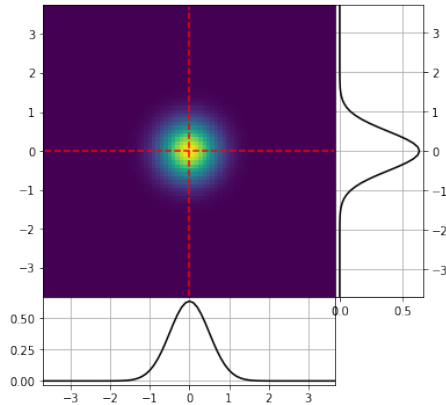
- **2-dim 3rd order Spline**

`scipy.signal.cspline2d(data, par)`

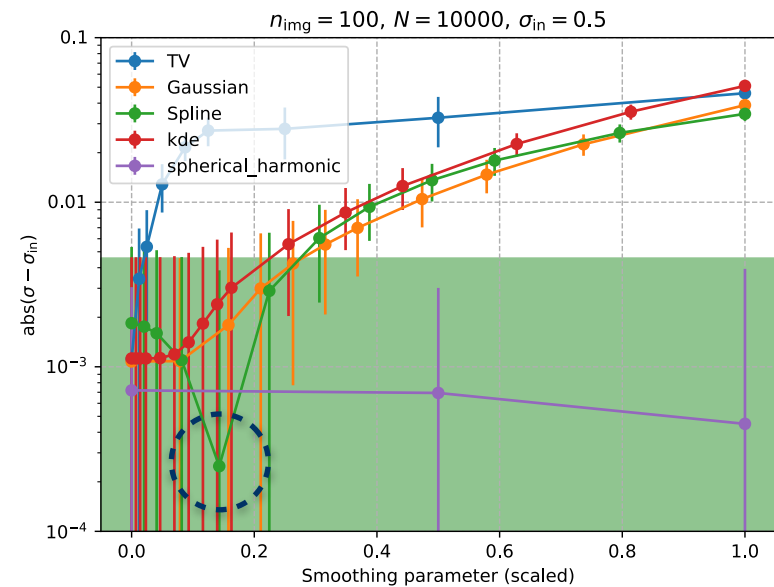
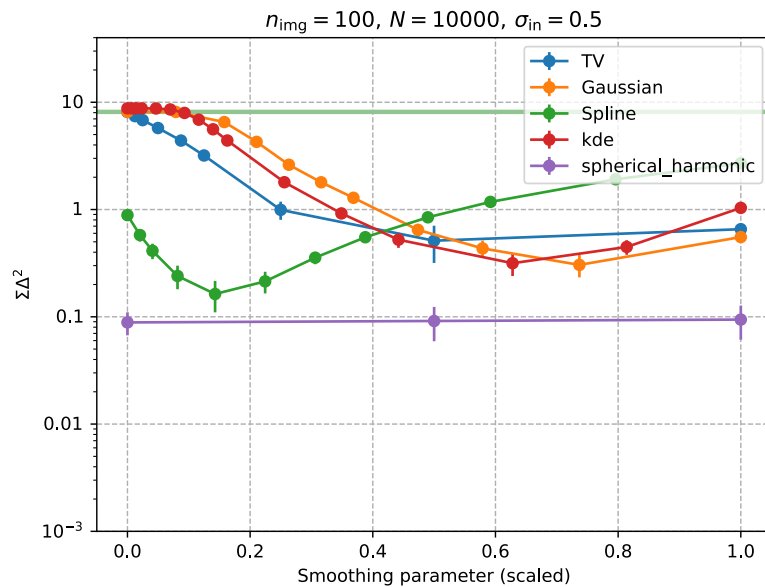
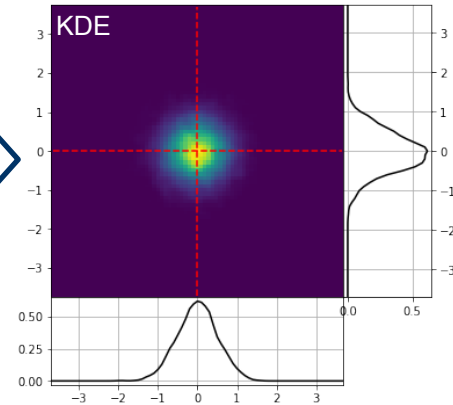
- **Spherical harmonics**
(analytical description)

Preserve the shape

true pdf



reco pdf



Better

Real raw data

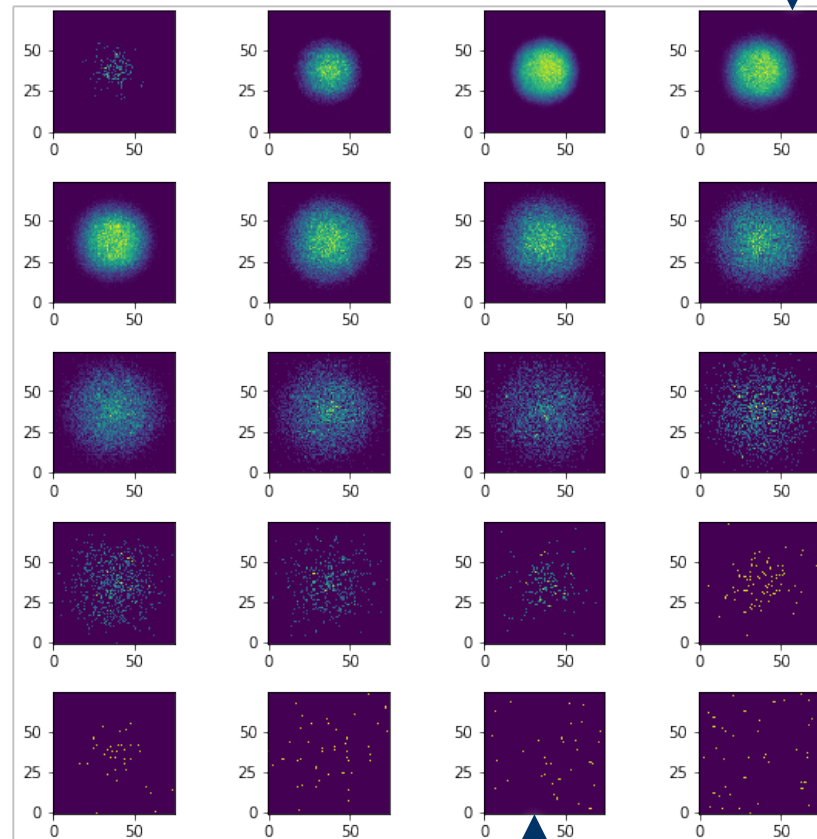
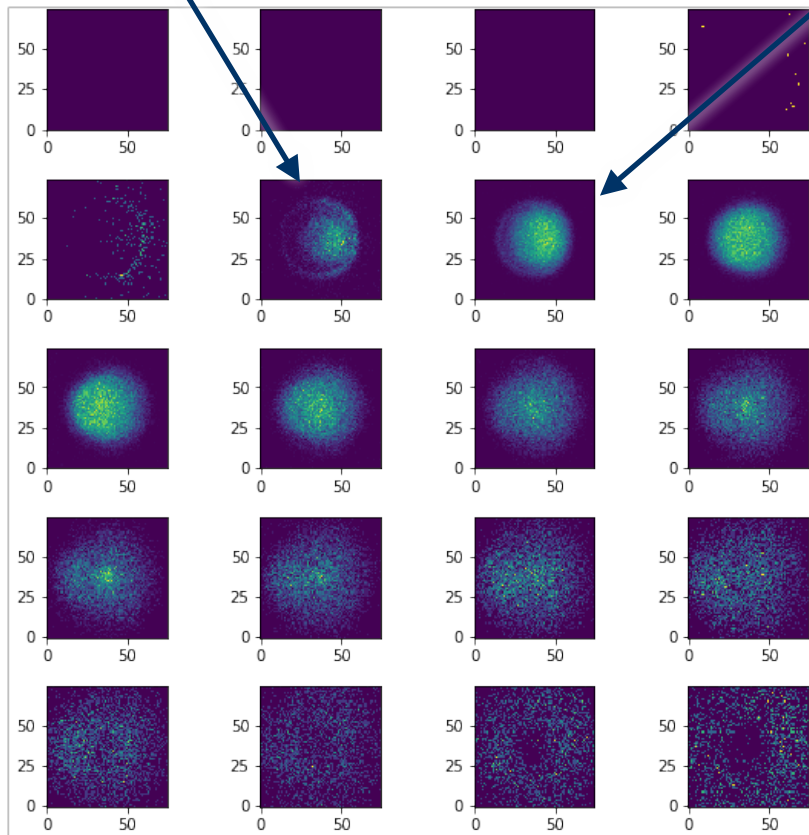
sub-structures

~60deg zenith

Moving gravity

Central spot

zenith



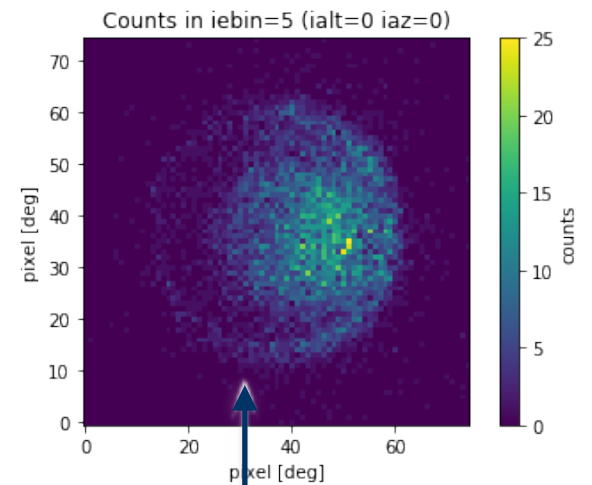
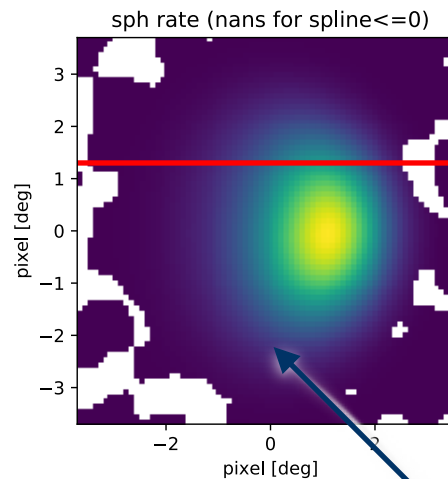
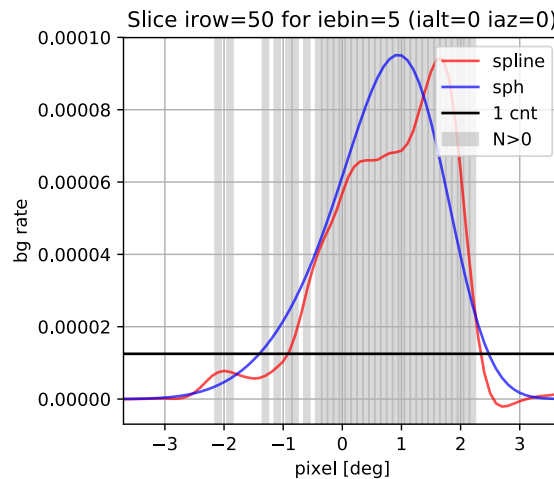
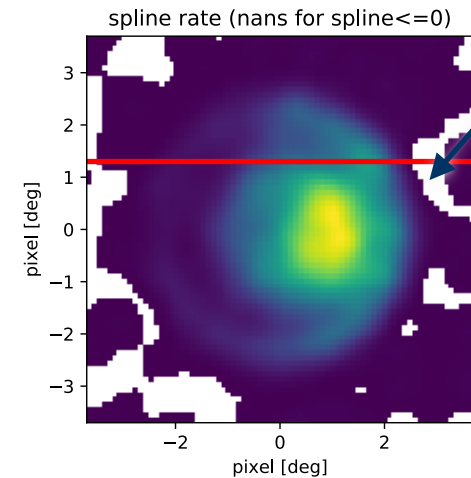
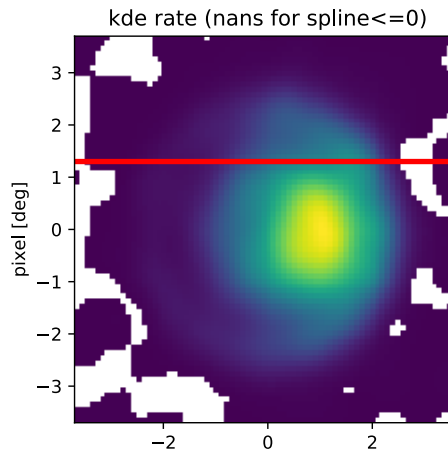
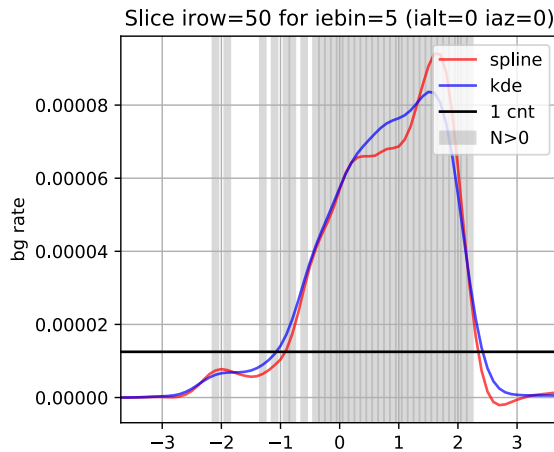
Smoothing capability still ok??

Donut

Low statistics

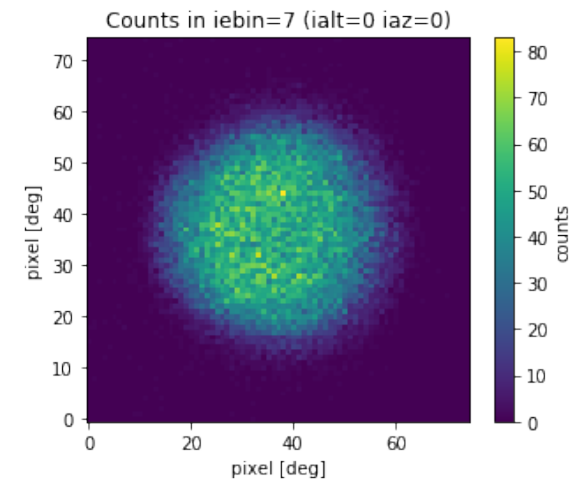
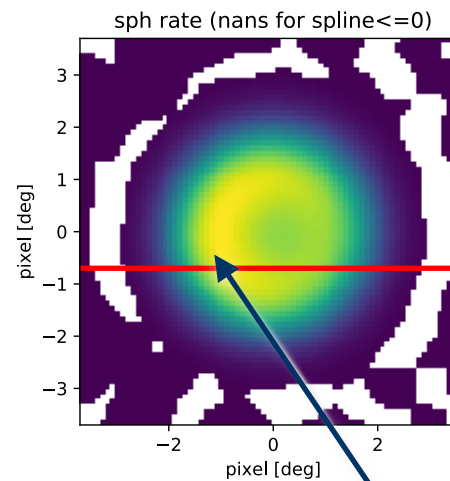
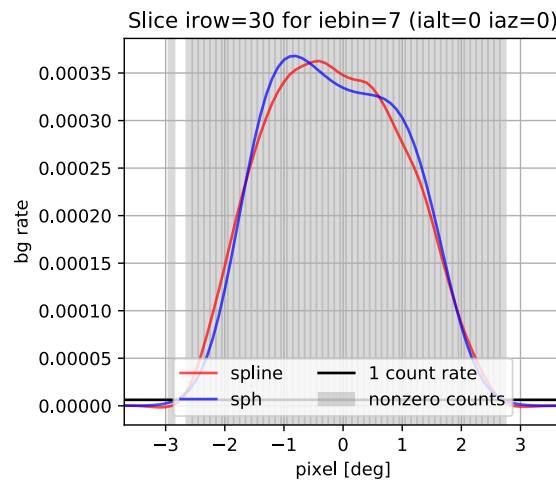
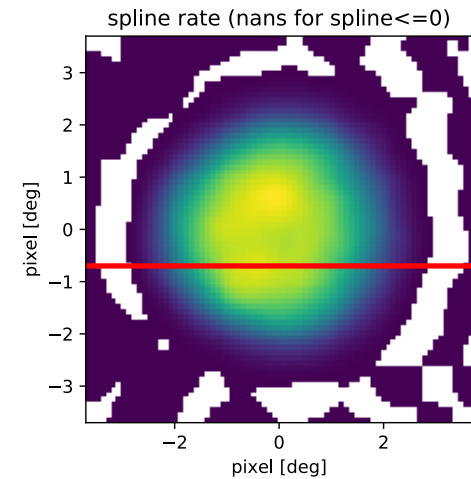
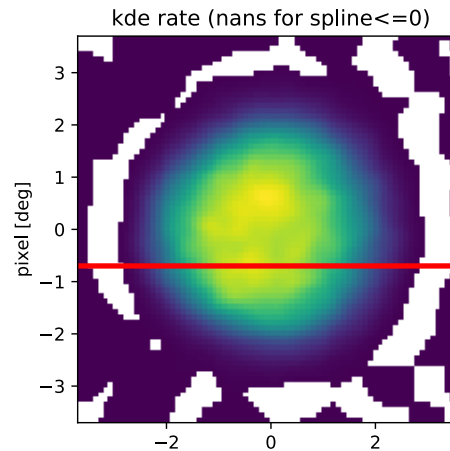
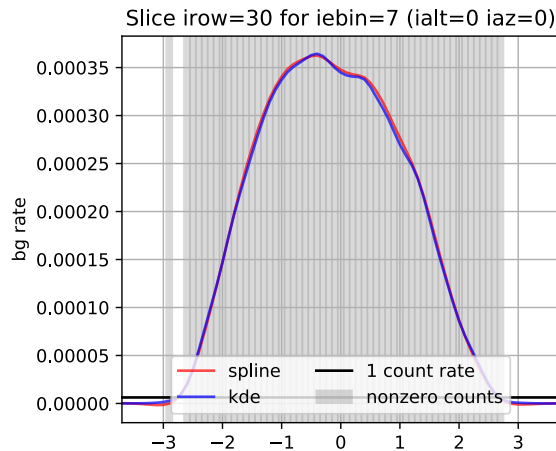
KDE by definition >0

Spline <0



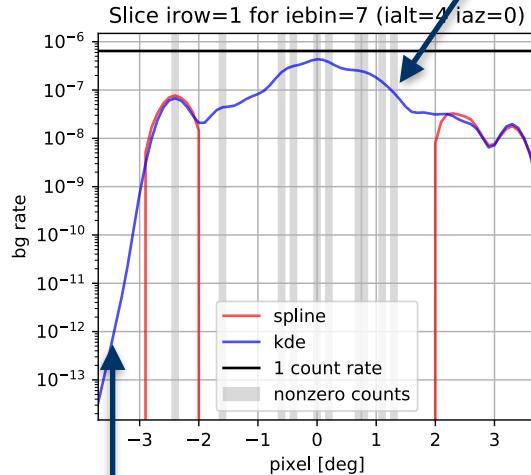
Substructures not recovered

Smoothed data

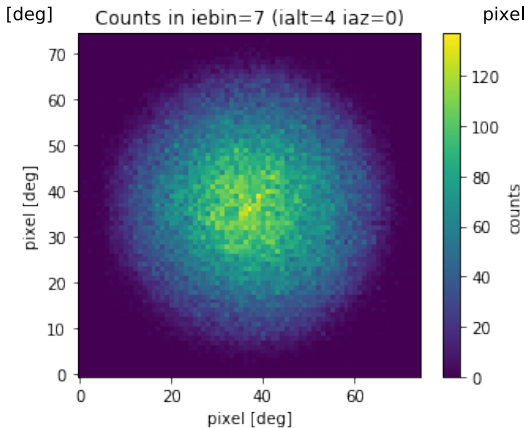
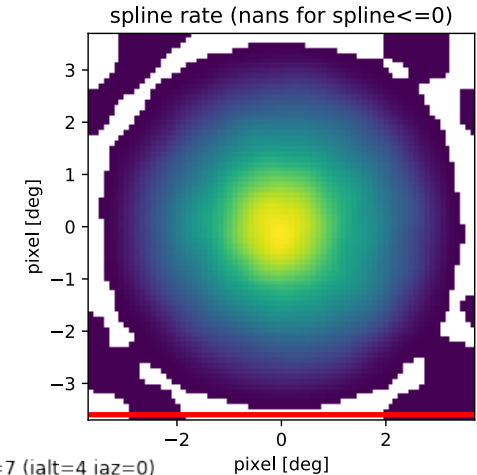
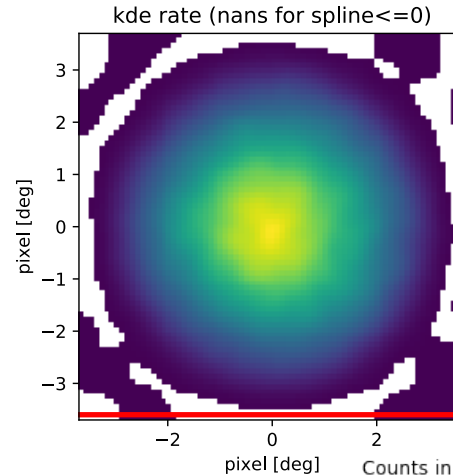


Dominant ring-like
feature “added”

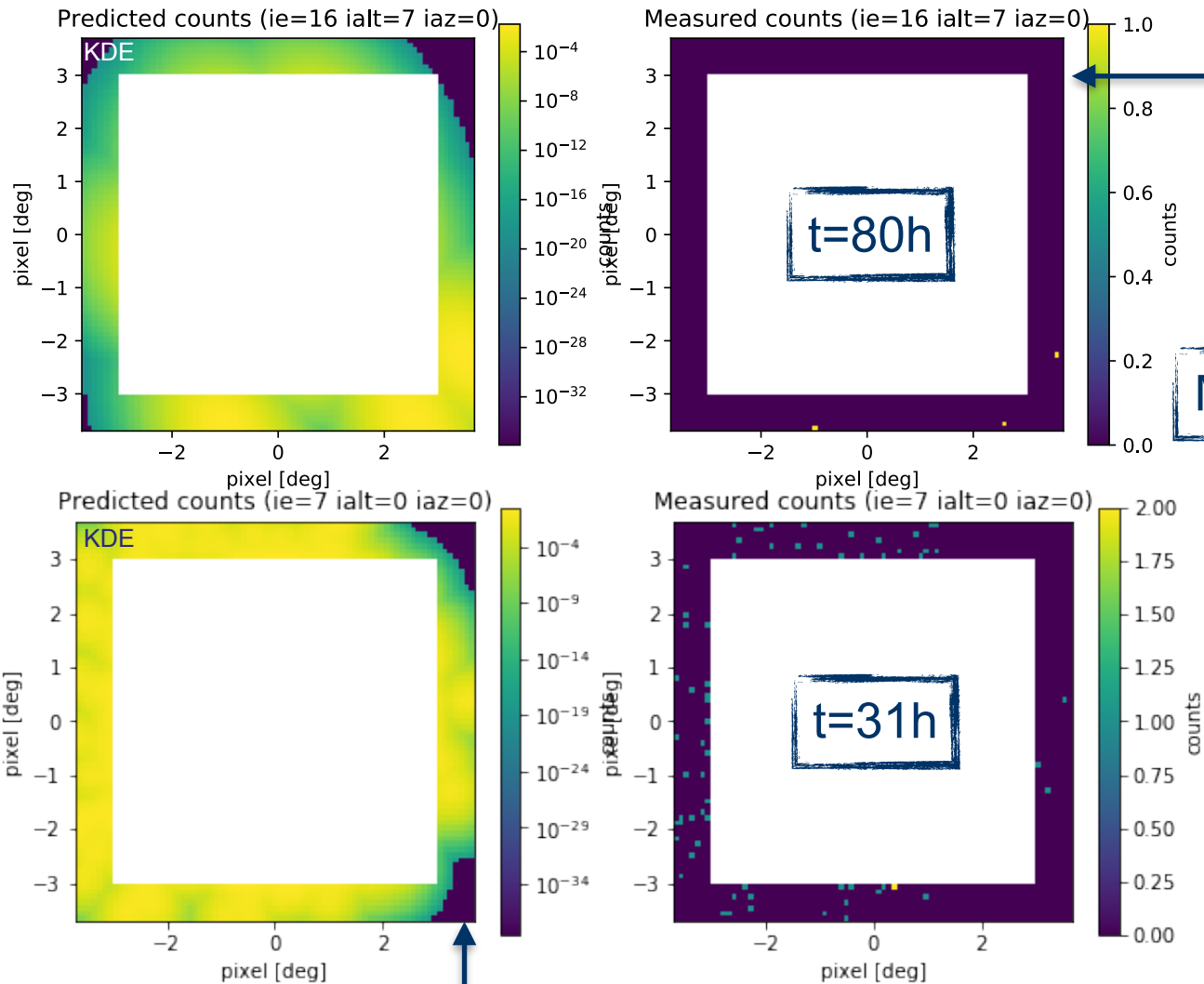
“Reasonable” shape of KDE
where Spline fails



But ... rate < 1 event
—> physically reasonable?



Smoothed data



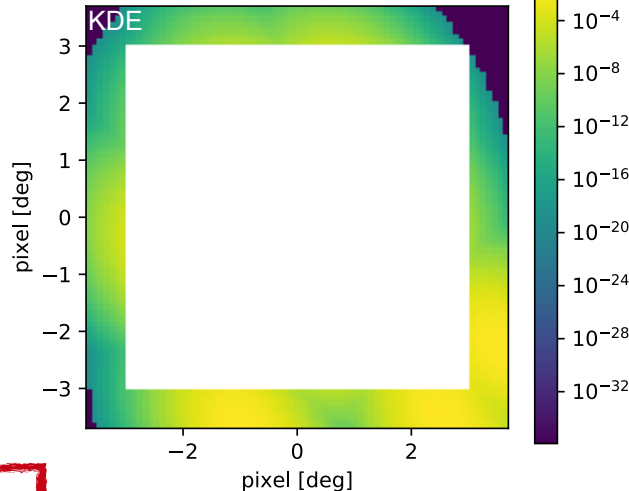
No more
statistics
to
“smooth”

Merge bins?

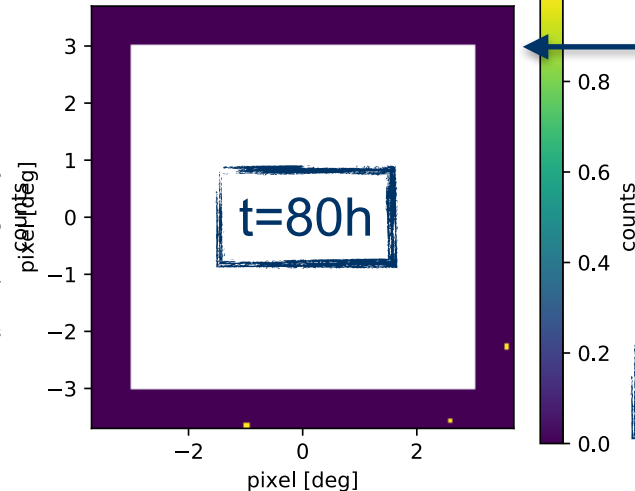
But ... rate < 1 event
—> physically reasonable?

Smoothed data

Predicted counts (ie=16 ialt=7 iaz=0)



Measured counts (ie=16 ialt=7 iaz=0)

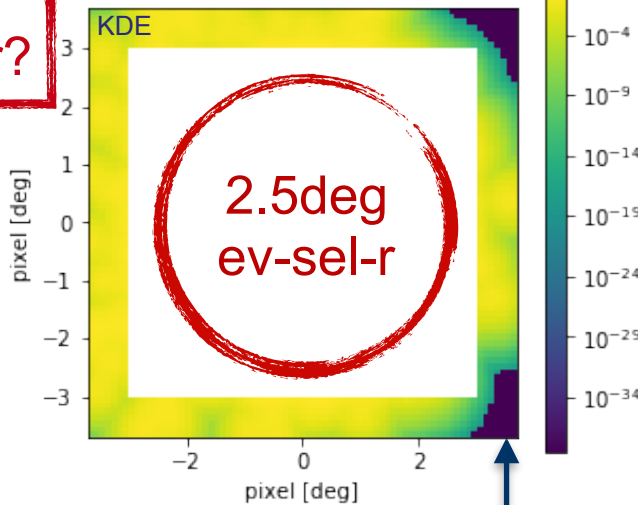


No more
statistics
to
“smooth”

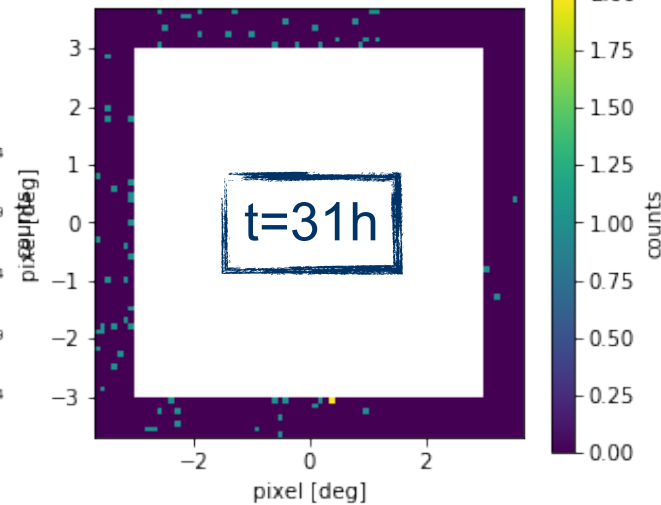
Merge bins?

... does it
even matter?

Predicted counts (ie=7 ialt=0 iaz=0)



Measured counts (ie=7 ialt=0 iaz=0)



But ... rate < 1 event
—> physically reasonable?

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Questions?

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3D template analysis

