Photometric starfield subtraction from PUNCH images

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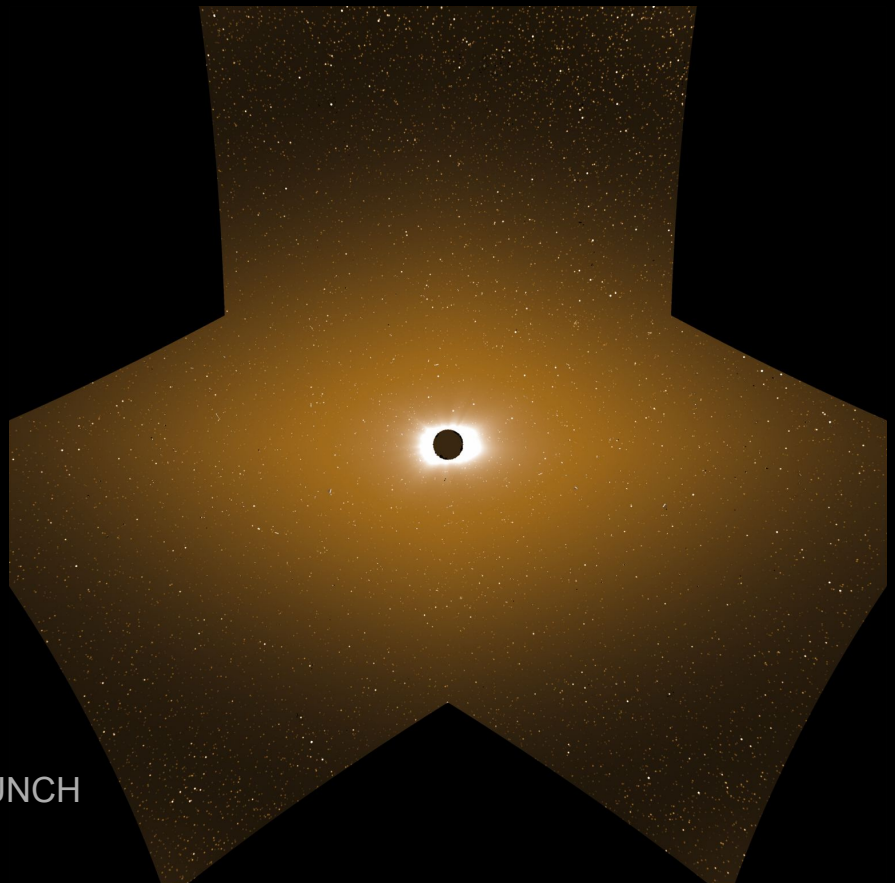
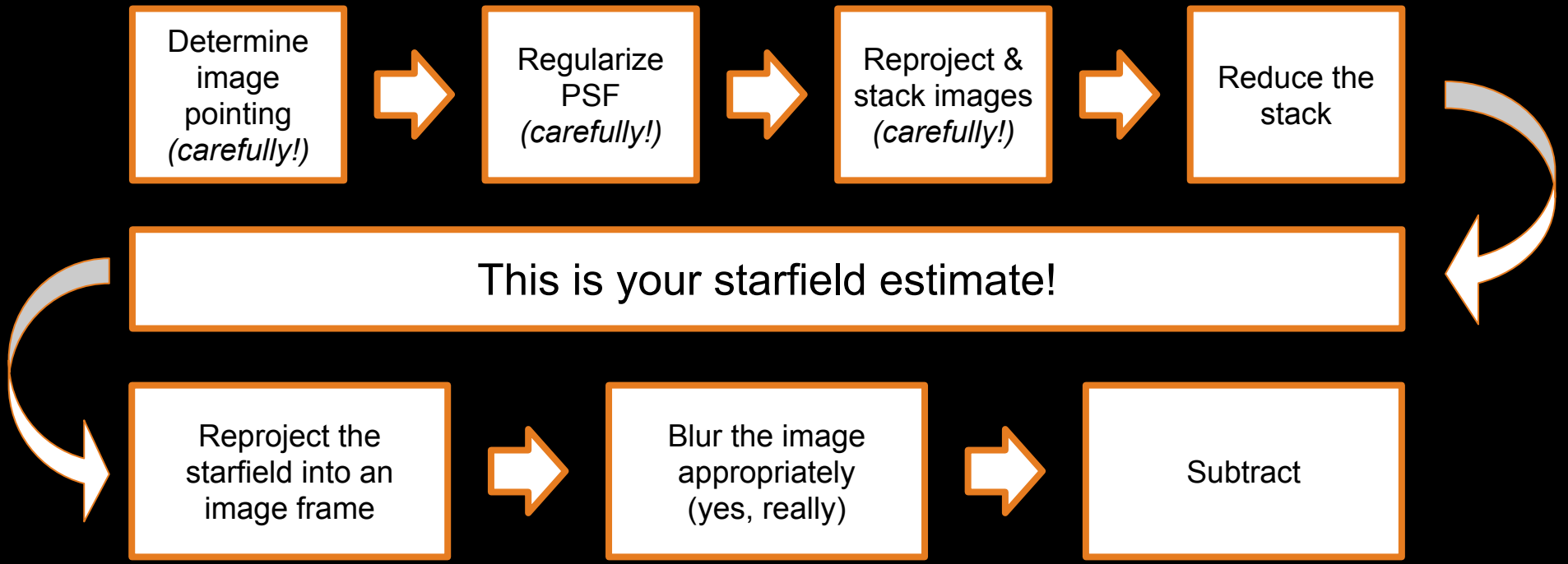
Motivation: There are stars in space



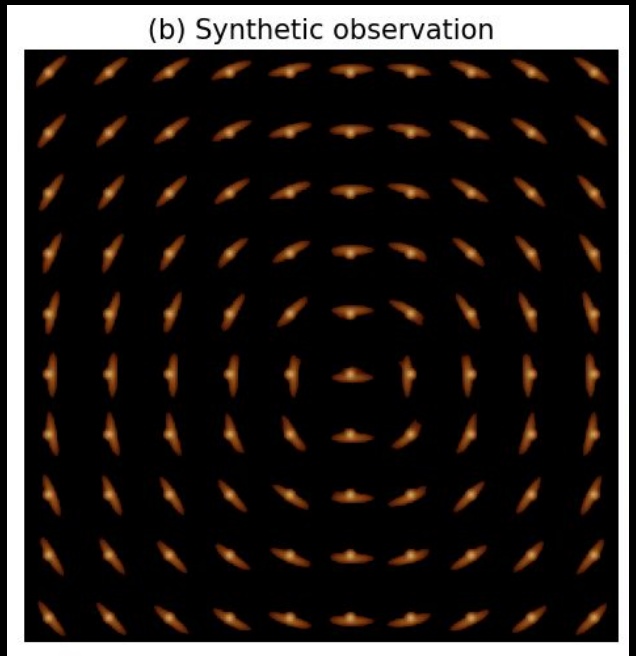
Synthetic PUNCH
L2 mosaic

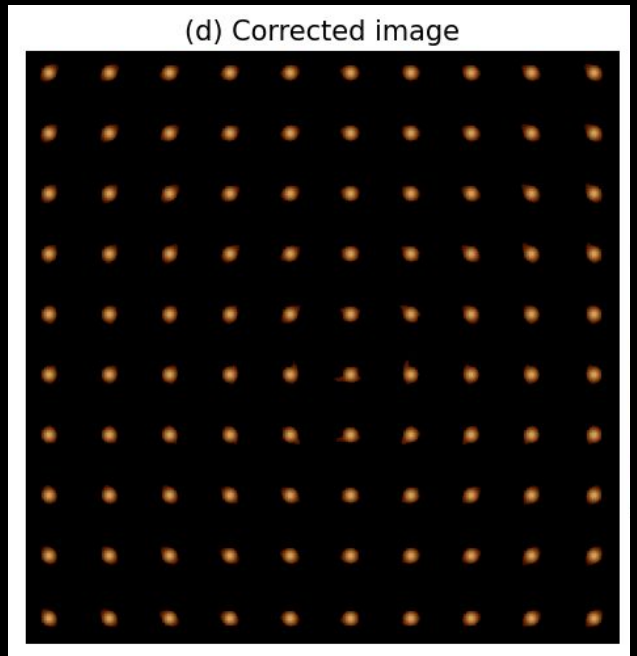
How we remove the stars



Regularizing the PSF

Stars must have *exactly* the same shape in all images to stack properly





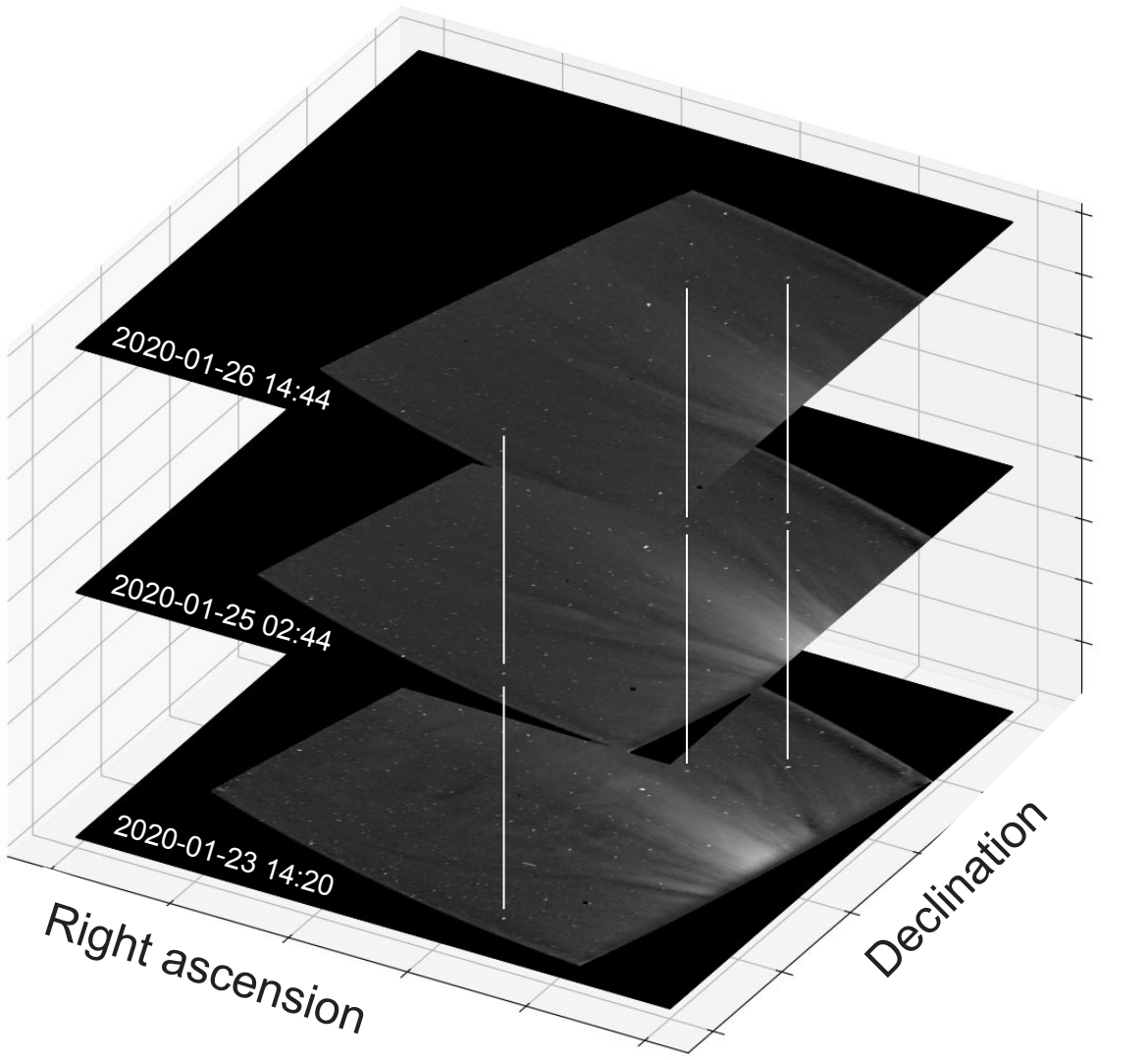
Reprojecting & stacking images

Into an all-sky celestial frame

Instrument FOV pans through frame, but stars are fixed

Anti-aliased, flux-conserving *adaptive reprojection*

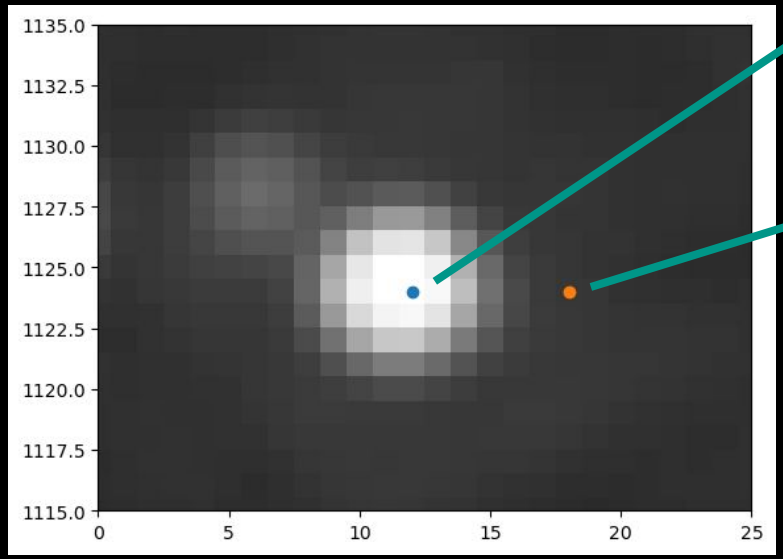
Example data: WISPR L3, ENC 4

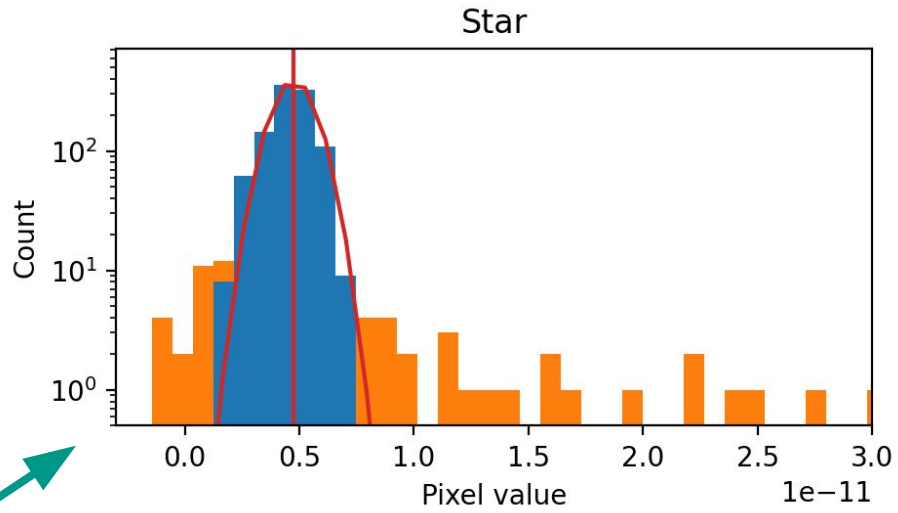


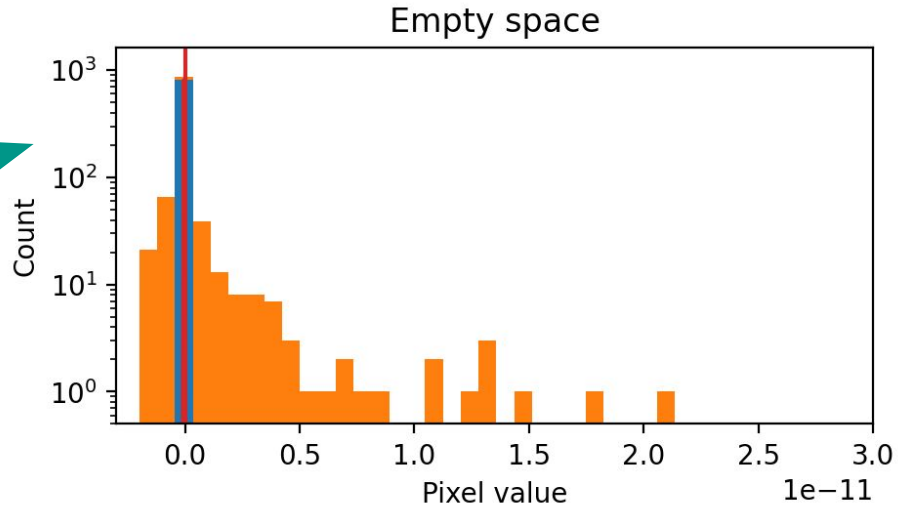
Reducing the stack

Gaussian fit to inlier values

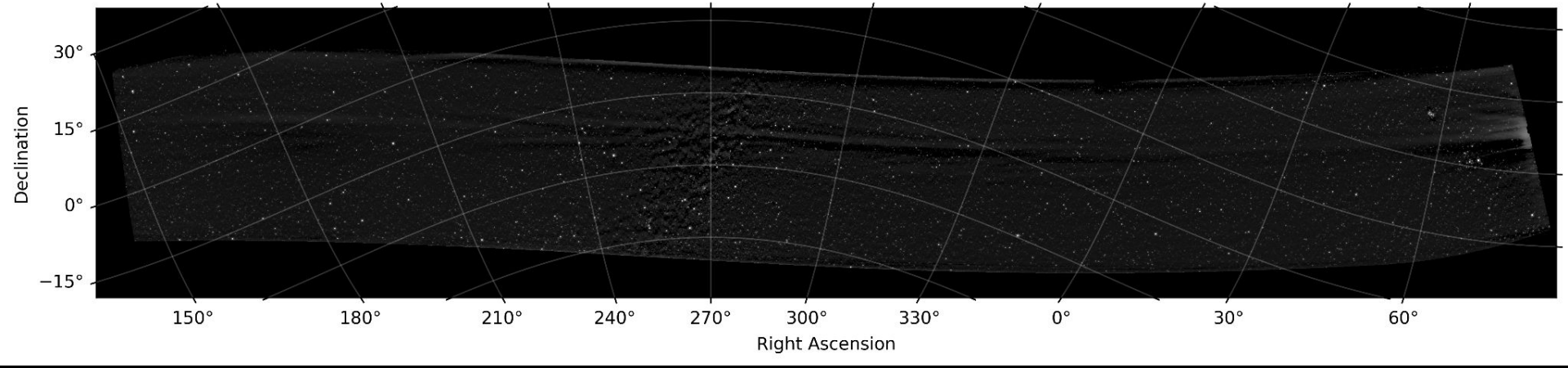
Other options include
low-percentile value





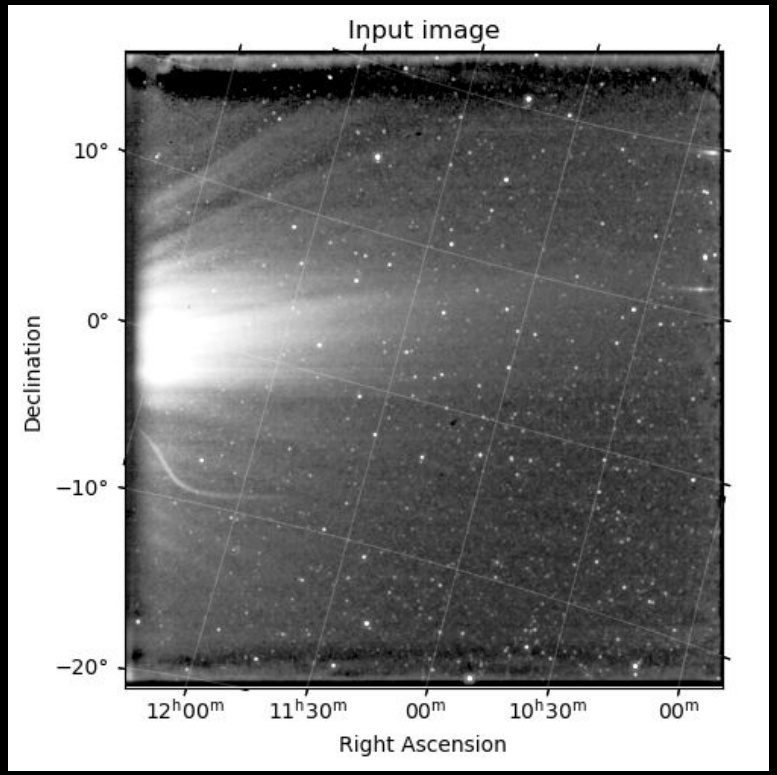


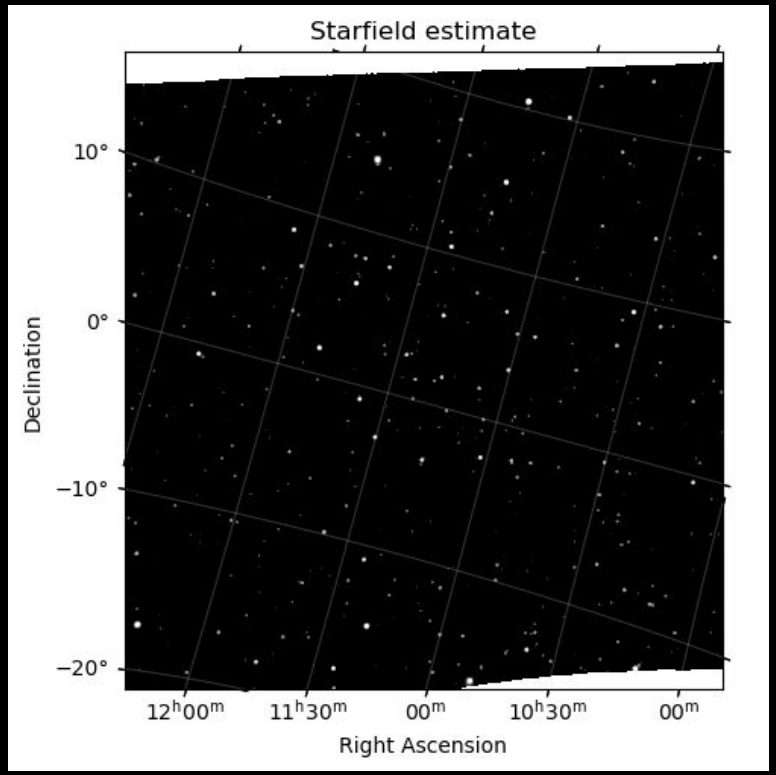
Now we have a starfield estimate!



Of order 18000 x 36000 pixels

Reproject back to an input image





Example data: WISPR L3, ENC 10, 20211117

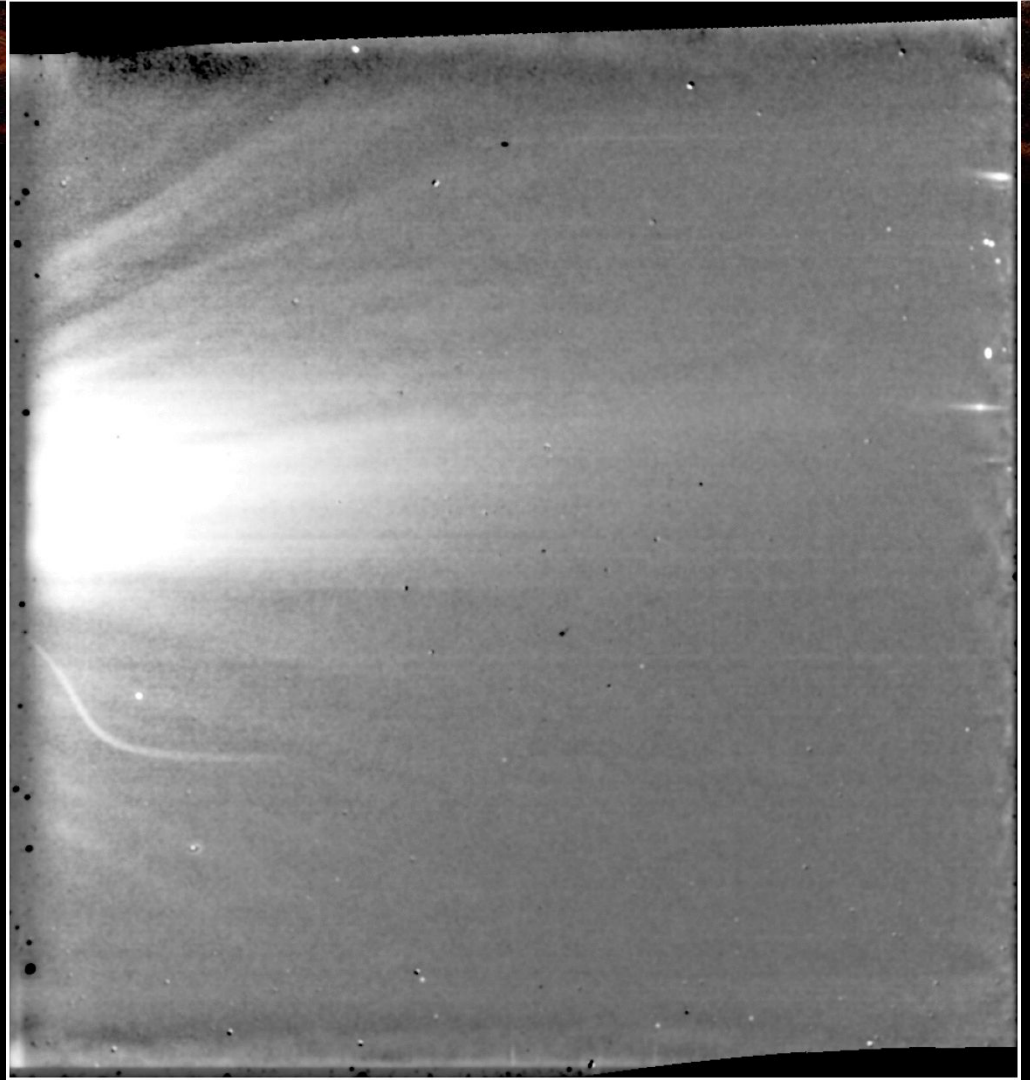
Blur the input image

Only by a few pixels

Matches anti-aliasing blur in reprojected starfield

Example data: WISPR L3, ENC 10, 20211117

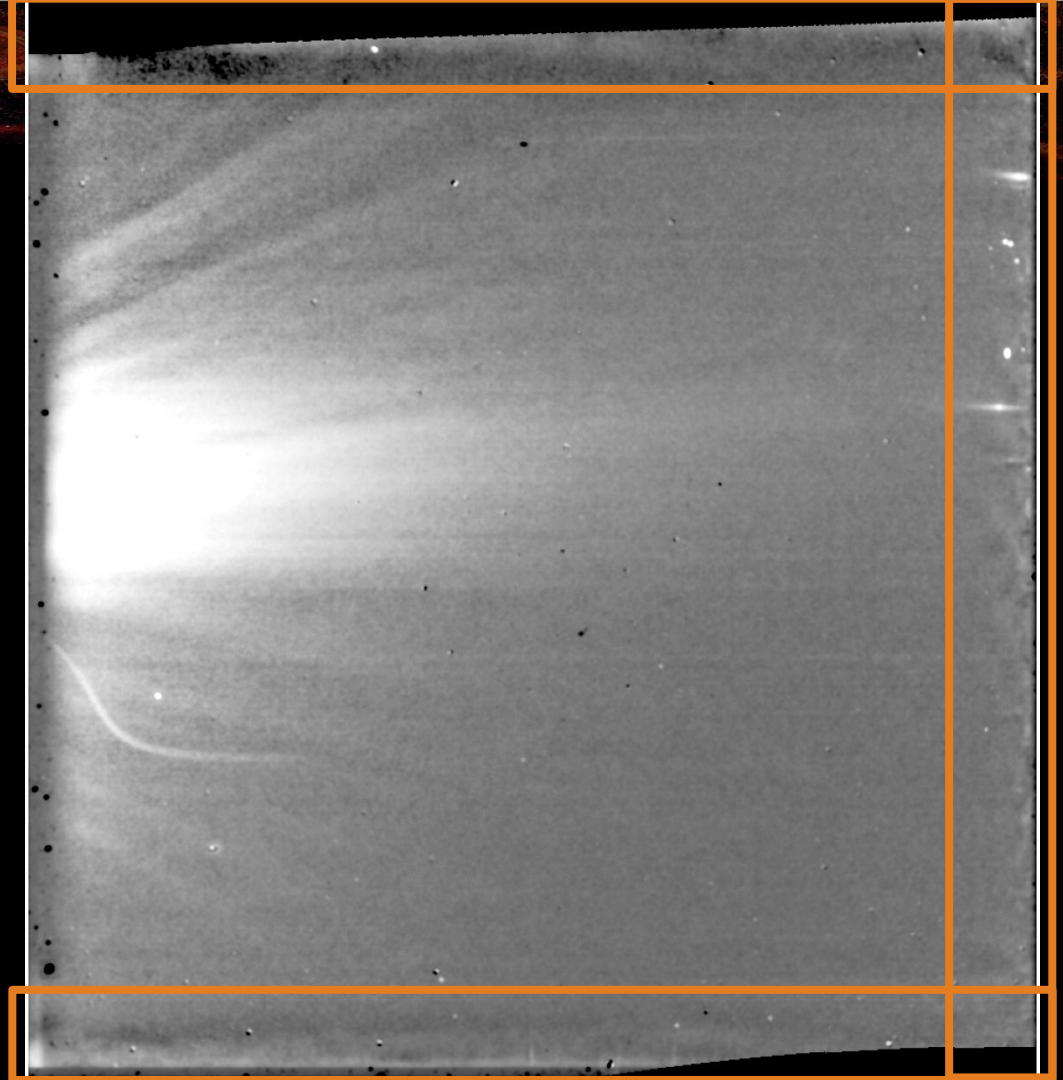
Subtract!



Example data: WISPR L3, ENC 10, 20211117

Subtract!

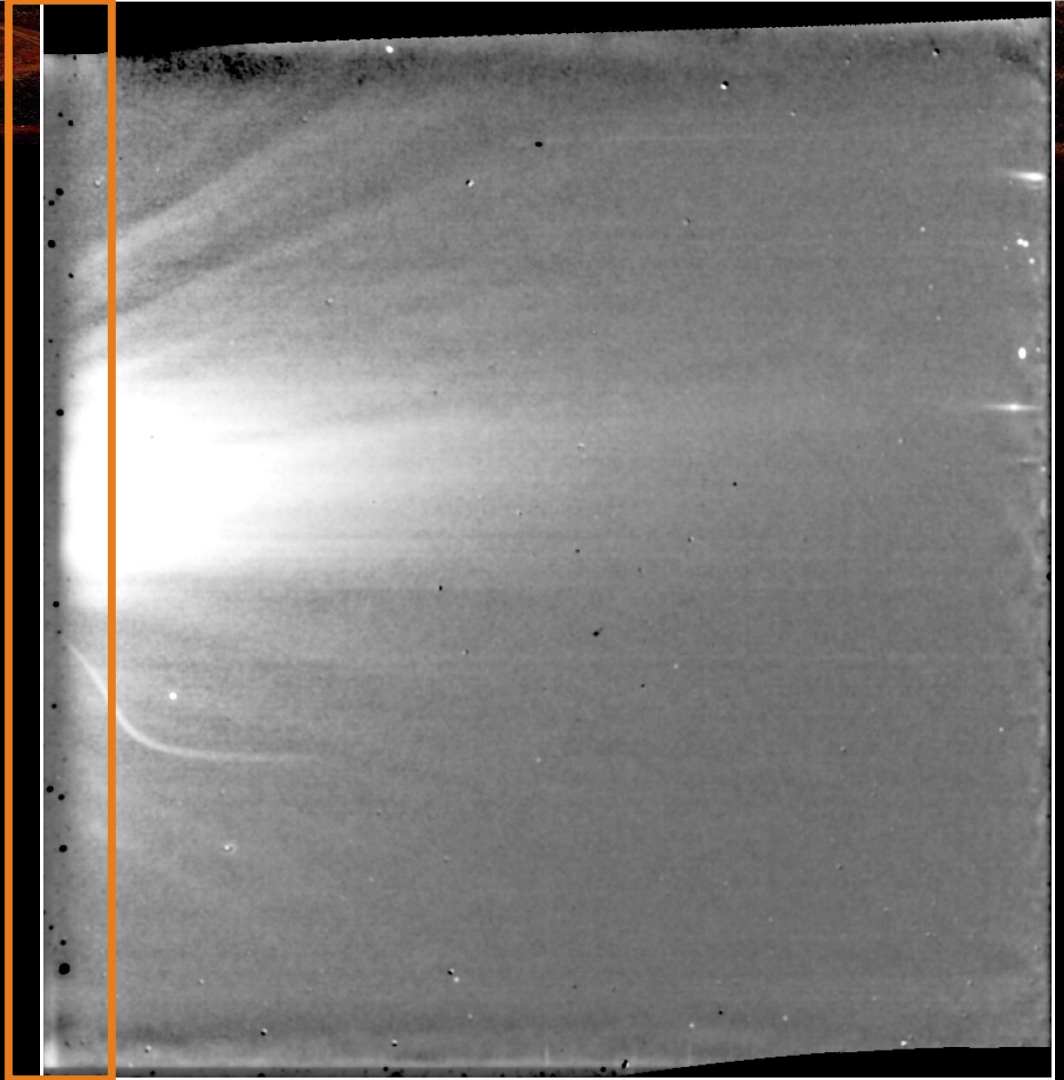
Various edge effects



Example data: WISPR L3, ENC 10, 20211117

Subtract!

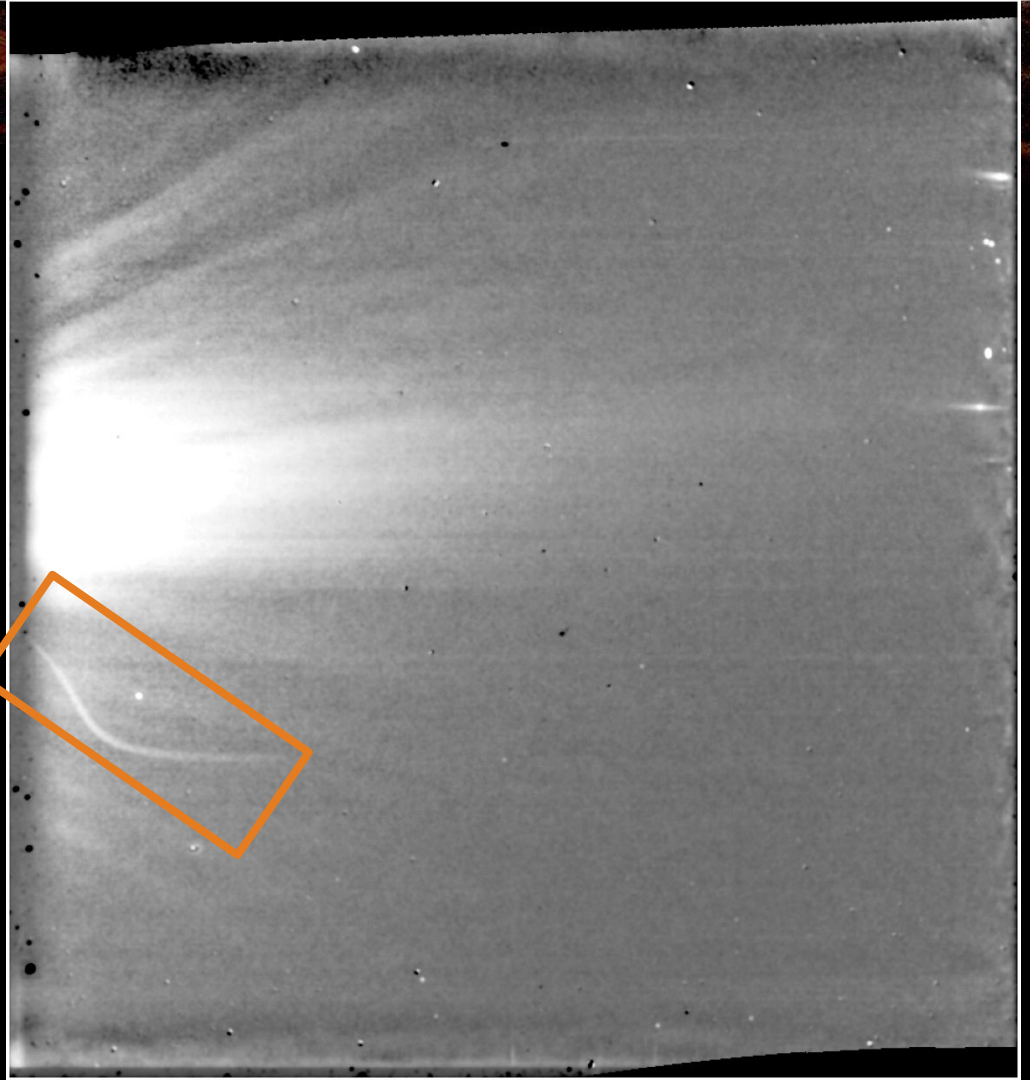
Vignetting causes big oversubtraction



Example data: WISPR L3, ENC 10, 20211117

Subtract!

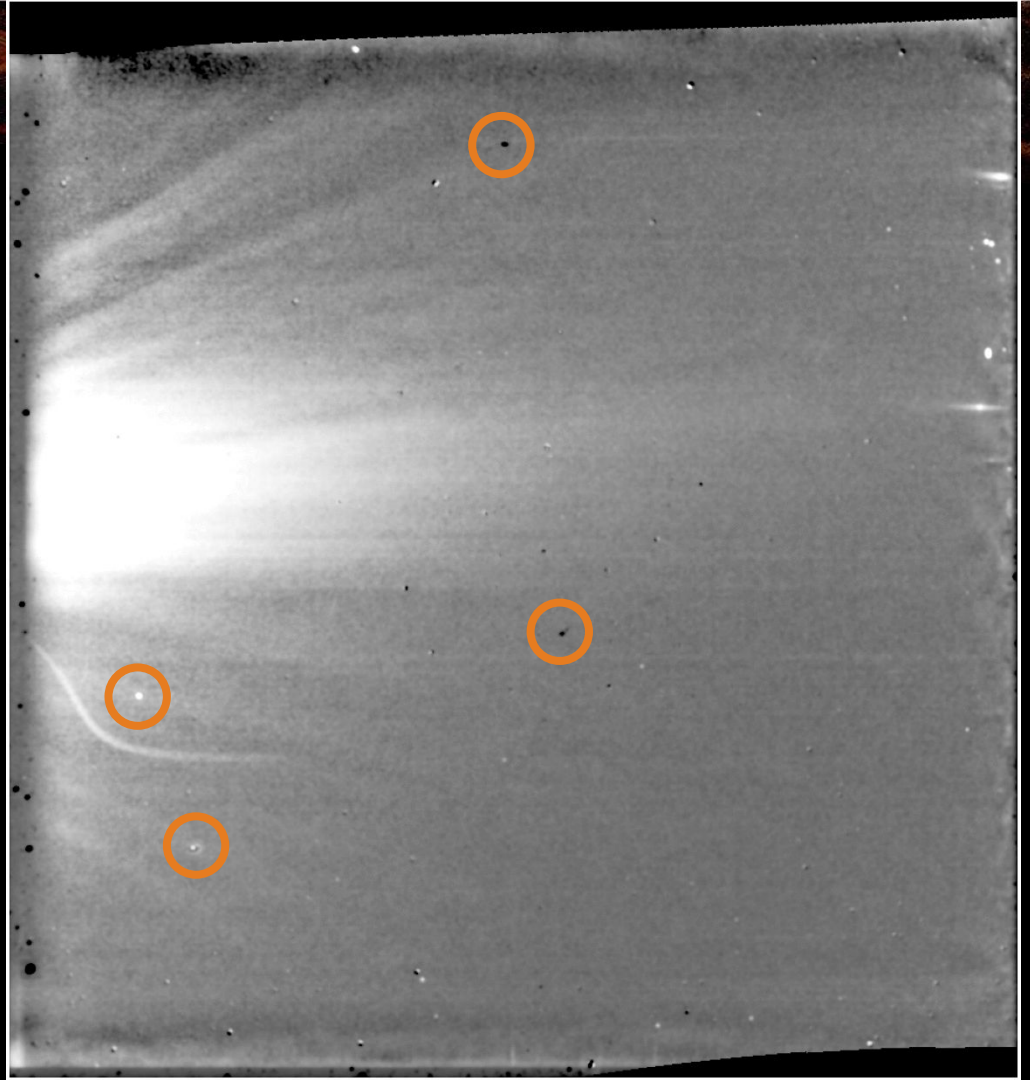
Debris streak and other transients unaffected



Example data: WISPR L3, ENC 10, 20211117

Subtract!

Detector/lens flaws



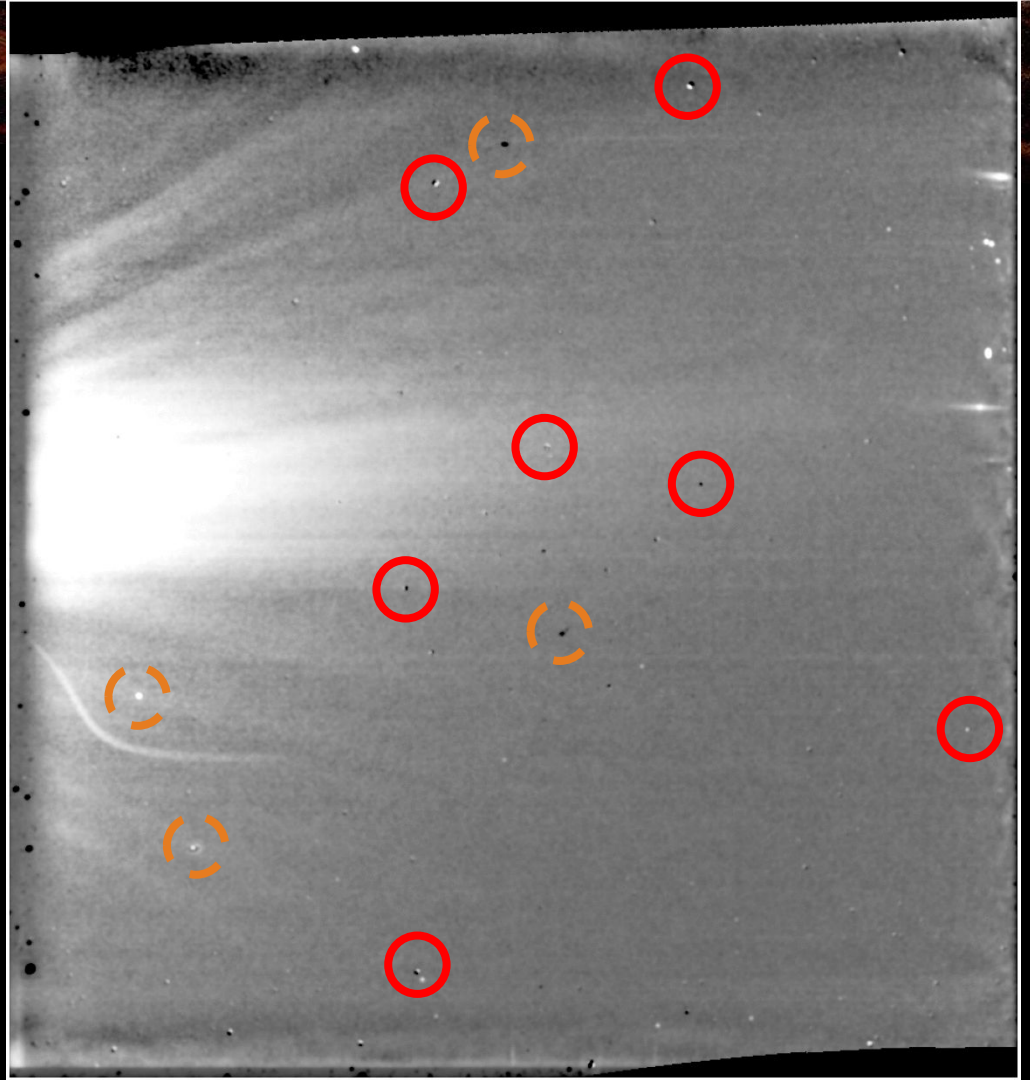
Example data: WISPR L3, ENC 10, 20211117

Subtract!

Detector/lens flaws

Subtraction misses on brightest stars

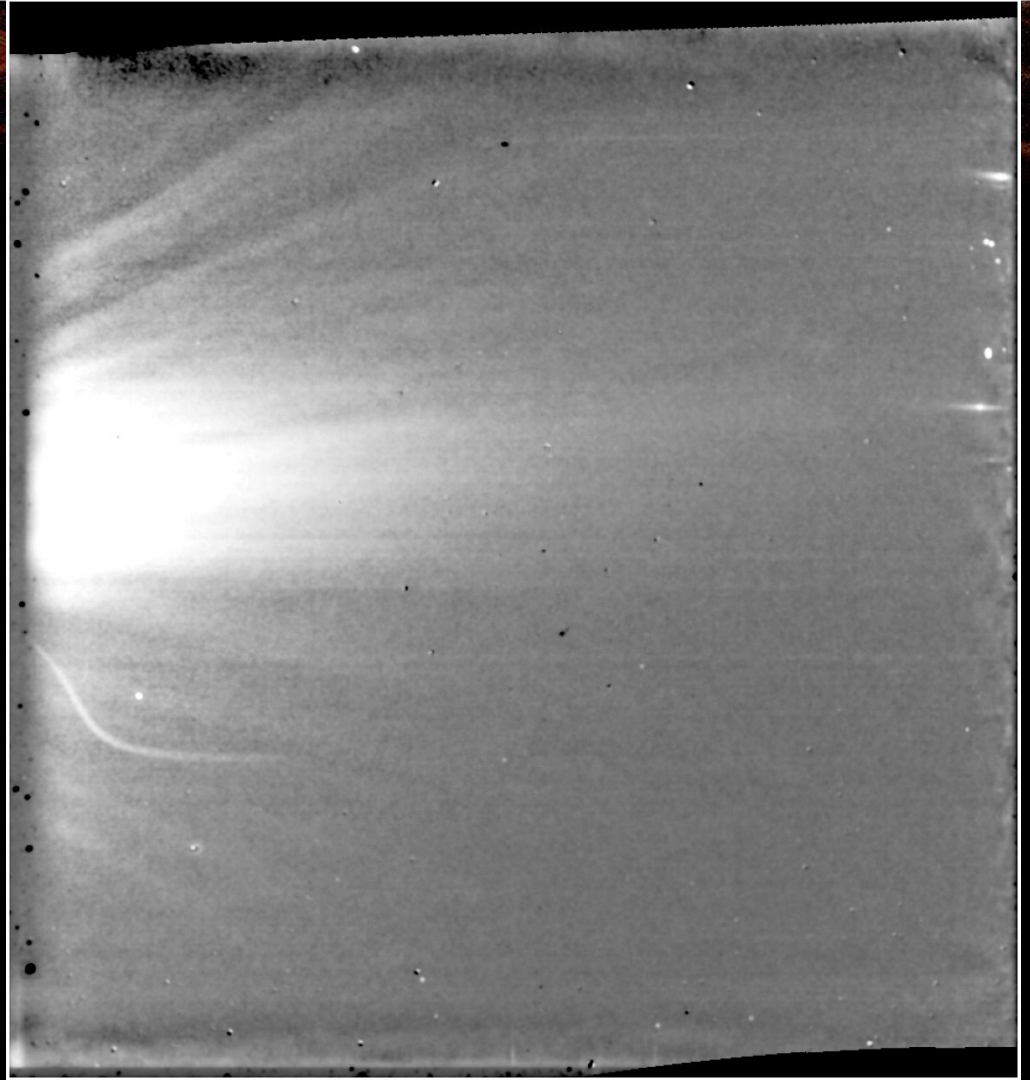
- High brightness magnifies any small error
- Expect a ~√N residual



Example data: WISPR L3, ENC 10, 20211117

Subtract!

But! Most stars just ✨ vanish ✨

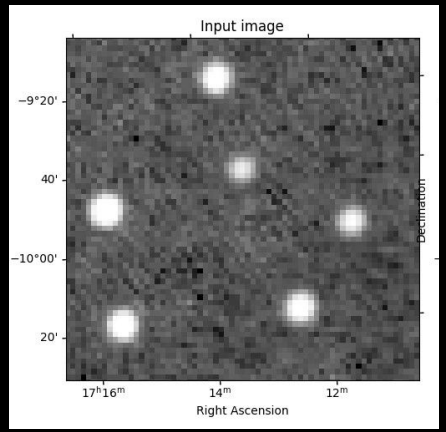


Example data: WISPR L3, ENC 10, 20211117

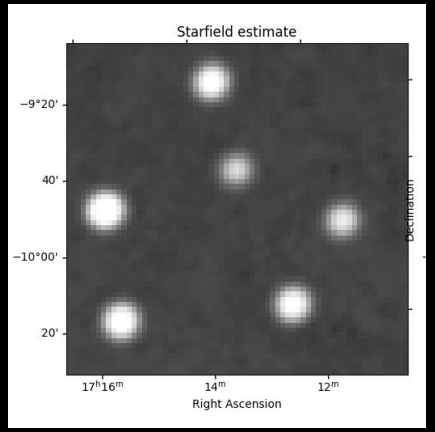
PUNCH Outlook

- Starfield removal is part of L3 pipeline
- Slower FOV motion → more samples / star → better quality than with WISPR
- Plans for secondary removal step to handle residuals

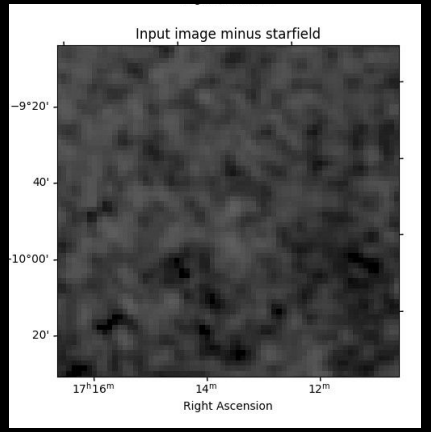
Synthetic PUNCH data:



Level 2(ish) Image



Starfield Model



Level 3 Image