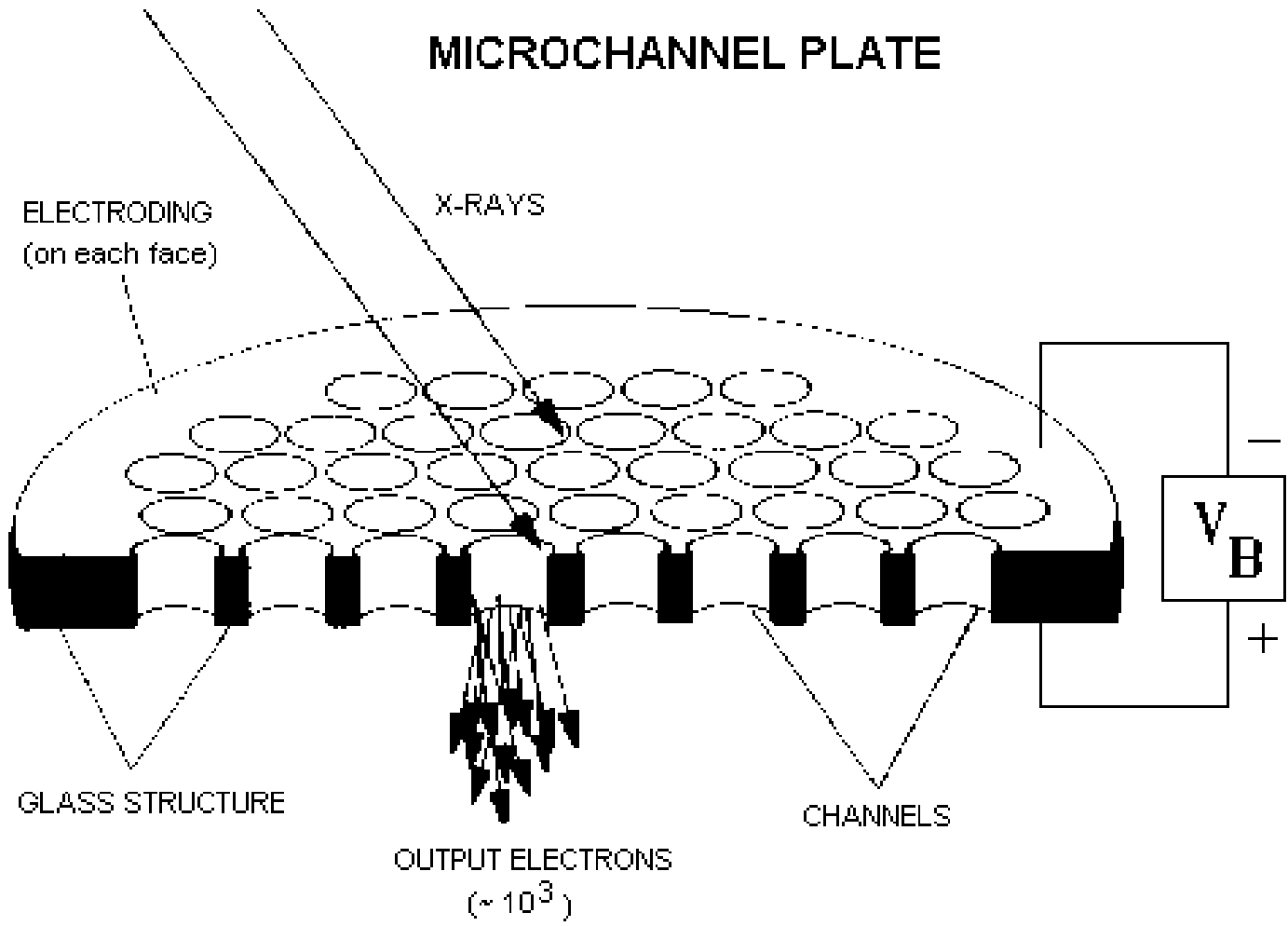# Studies of the Point-Spread Function of the Chandra High Resolution Camera
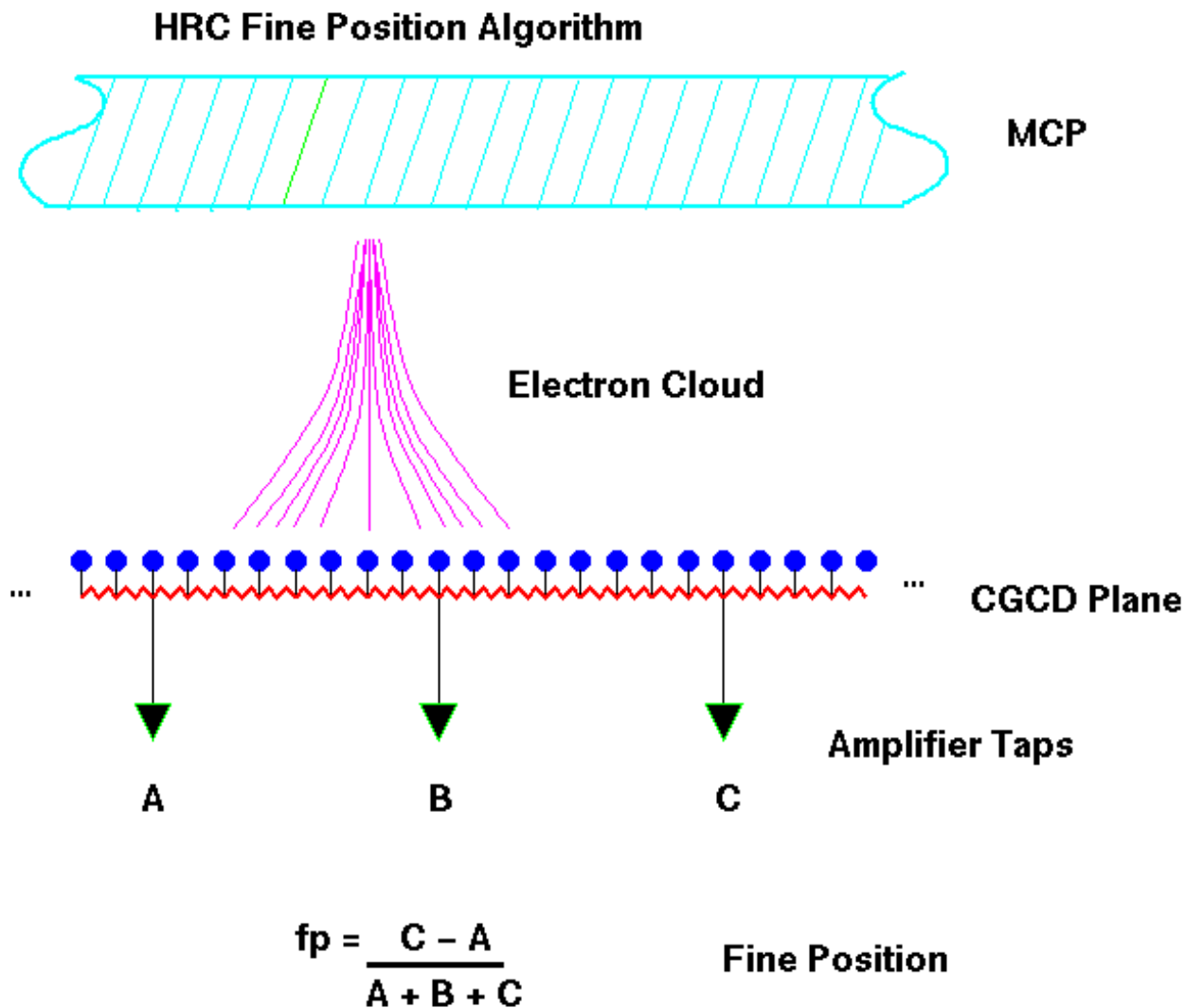
Michael Juda

Margarita Karovska

- Overview of HRC event positions
- Non-ideal performance issues
- Fits with ray-trace-PSF kernel
- Deconvolutions
- Areas for future work

HRC Event Positions

- HRC uses MCPs to convert X-ray to charge
  - Channel size/pitch determines ultimate possible resolution
    - 10/12.5 microns HRC-I
    - 12.5/15 microns HRC-S
  - Subsequent processing by 2nd MCP and read-out likely to add "blur"
- Charge-cloud from back of the MCPs "imaged" on crossed-grid
  - Charge-cloud centroid determined per axis with "three-tap" algorithm
  - Centroid position must be adjusted due to "gaps" from incomplete charge collection
  - Each axis may have its own resolution
- Laboratory measurement on "flight-like" system had FWHM of 20-25 microns

MICROCHANNEL PLATE

ELECTRODING
(on each face)

X-RAYS

GLASS STRUCTURE

CHANNELS

OUTPUT ELECTRONS
($\sim 10^3$)

V_B

HRC Fine Position Algorithm

MCP

Electron Cloud

CGCD Plane

Amplifier Taps

A   B   C

$$fp = \frac{C - A}{A + B + C}$$ **Fine Position**

- "Gaps" due to centroid algorithm
  - De-gap correction applied to shift positions to close the gap
- Electronic ringing in amplifier strings for a subset of events
  - If not corrected produces "jets"
  - Affected events can be identified
  - Partial signal correction made (1 of 3 signals per axis)
  - De-gap correction attempts to fix impact of residual distortions
- Non-matching gains/offsets in amplifier strings
  - Not observed at component level
  - De-gap correction attempts to fix the induced distortions
- Impact may differ on each axis

- Perform 2-D Gaussian fits to on-axis source as a characterization of detector PSF
  - Ray-trace results used as kernel in *sherpa*
  - Results from several ray-traces at pointing offsets that followed the observation dither were combined to produce kernel
- Fit images generated from events with standard filtering and with additional filtering
  - Additional filtering rejected events with AMP_SF = 3 as these can be affected by amplifier ringing
- Allow for elliptical shape in detector PSF
  - Axes can have differing resolutions
  - Axes can have differing non-ideal artifacts
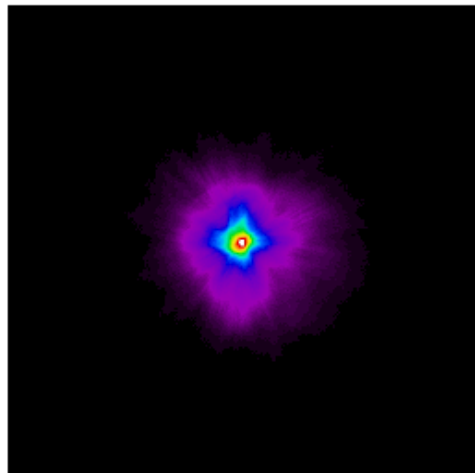- Fit a few on-axis observations around the nominal aimpoint
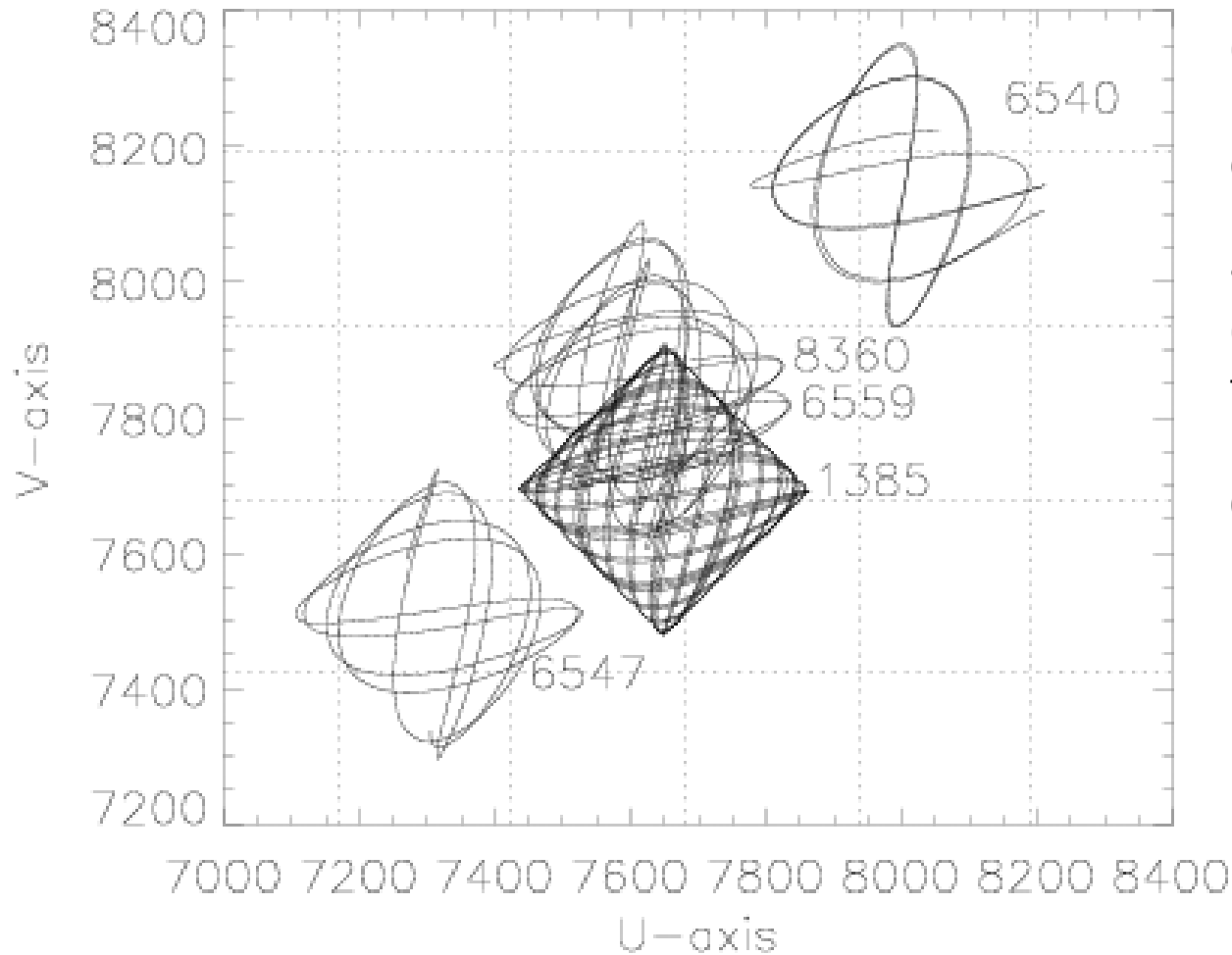
- ObsIDS 1385, 6559, & 8360 have nominal observing parameters
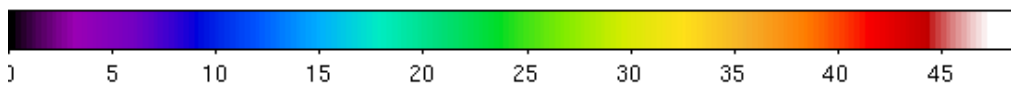- ObsIDs 6540 & 6547 use SIM translation to probe different detector region

AR Lac (ObsID 1385) - Std Filter
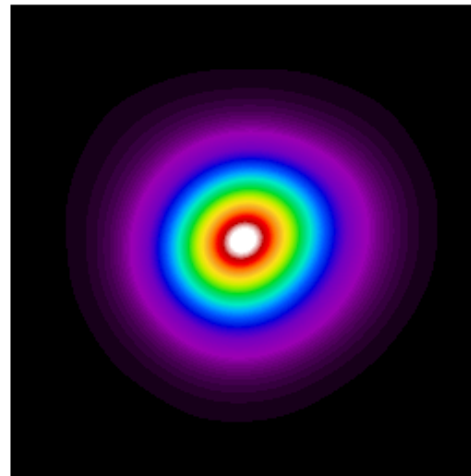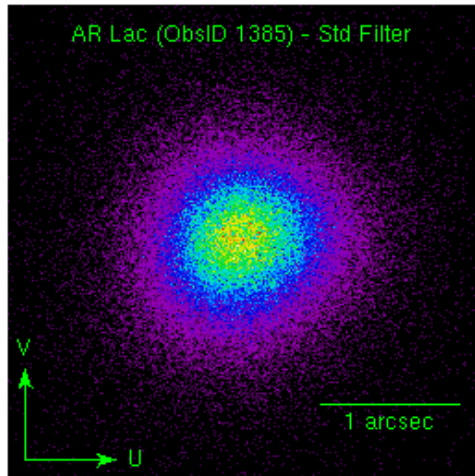
1 arcsec

UL: Observation
LL: Ray-trace kernel
UR: Model
LR: Smoothed Residuals

Fit Results:
• FWHM = 4.81+/-0.02 pixels
       = 0.633+/-0.003 arcsec
• Ellipticity = 0.209+/-0.006
• Theta = 31+/-1 degrees

2-D Gaussian Fit Results

CXC

Events with Standard Filtering

ObsID	FHWM (pixels)	Ellipticity	Theta (Degrees)
1385	4.808 -0.024/+0.019	0.209 -0.006/+0.005	30.2 -0.8/+0.9
8360	4.684 -0.024/+0.025	0.115 -0.006/+0.007	69.1 -1.9/+1.5
6559	4.833 -0.021/+0.038	0.149 -0.008/+0.007	66.6 -1.4/+1.8
6540	5.241 -0.025/+0.024	0.197 -0.005/+0.005	77.4 -0.9/+0.9
6547	4.912 -0.026/+0.024	0.179 -0.006/+0.006	80.9 -1.2/+0.9

Events with Standard Filtering & No AMP_SF=3

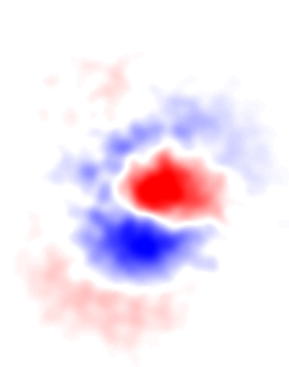| ObsID	FHWM (pixels)	Ellipticity	Theta (Degrees)
1385	4.776 -0.050/+0.047	0.202 -0.013/+0.013	23.8 -2.0/+2.1
8360	4.535 -0.032/+0.023	0.109 -0.008/+0.007	69.5 -2.1/+2.1
6559	4.548 -0.029/+0.029	0.140 -0.008/+0.008	74.4 -1.7/+1.7
6540	5.070 -0.027/+0.031	0.194 -0.006/+0.007	80.1 -1.1/+1.1
6547	4.820 -0.030/+0.029	0.173 -0.008/+0.007	81.9 -1.3/+1.3

Added filtering reduces the fit FWHM

AR Lac (ObsID 1385)

Capella (ObsID 8360)

Capella (ObsID 6559)

Capella (ObsID 6540)
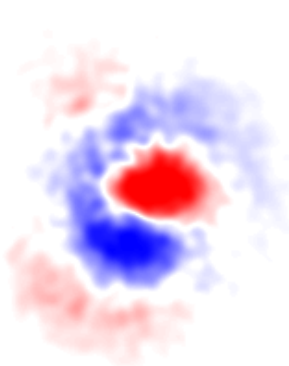
Capella (ObsID 6547)
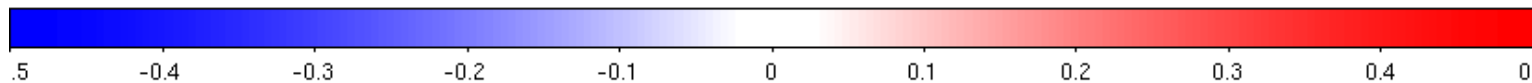
- 2-D Gaussian fits have systematic residuals
  - 2-D Gaussian not a good model for the HRC-I PSF
    - Data more peaked than model
- Perform a Richardson-Lucy deconvolution of data with the ray-trace kernel
  - 100 iterations
  - Goal is to show the "possible" artifacts and instrumental effects.

AR Lac (ObsID 1385)

Capella (ObsID 6559)

1 arcsec

Capella (ObsID 8360)
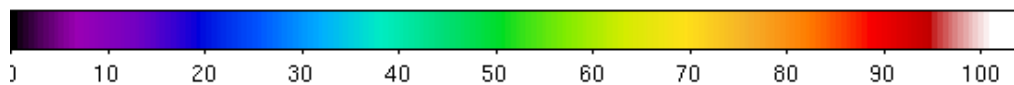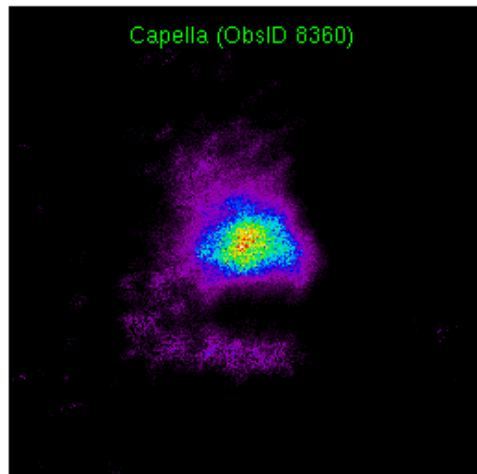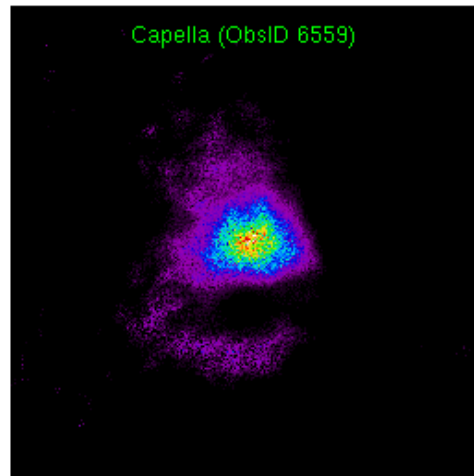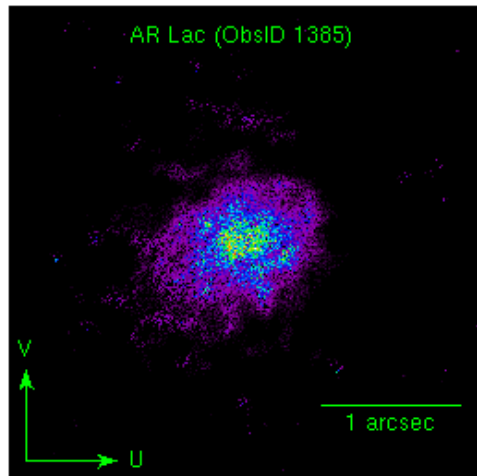
- Three observations at nominal aimpoint
- Tight central peak with halo
- "Bar" at -V appears in two Capella observations
  - ~1-2% the surface brightness of the peak
  - ~6 pixels (~38 μm) from peak

- Understand origin of "bar" in deconvolved Capella images
  - Related to location on detector axis?

- Investigate improved HRC-I PSF model
  - Core + Halo
  - MCP responds to X-ray input with a "top-hat" PSF