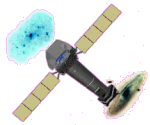
XRT Point Spread Function in Slewing Mode



XMM
EPIC
MOS

Andy Read (amr30@star.le.ac.uk)
EPIC CAL/OPS Meeting
Mallorca, Spain 26-27/10/06

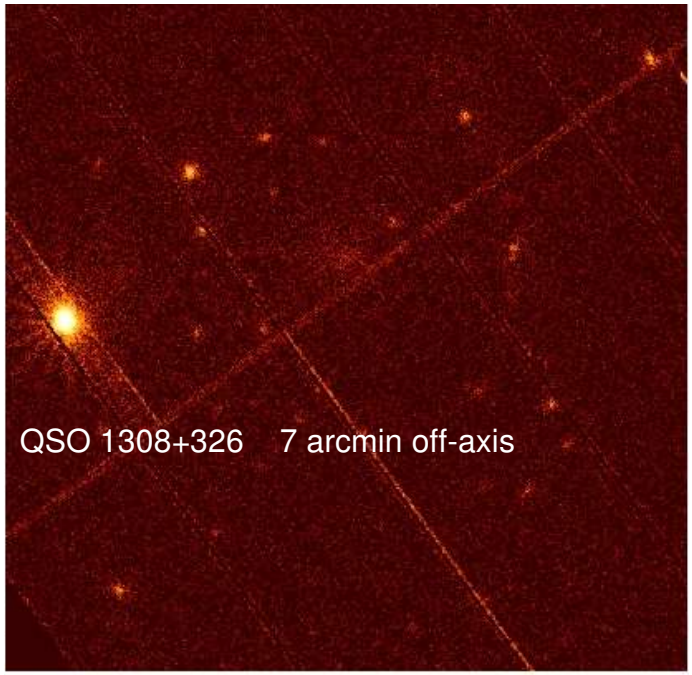
University *of* Leicester

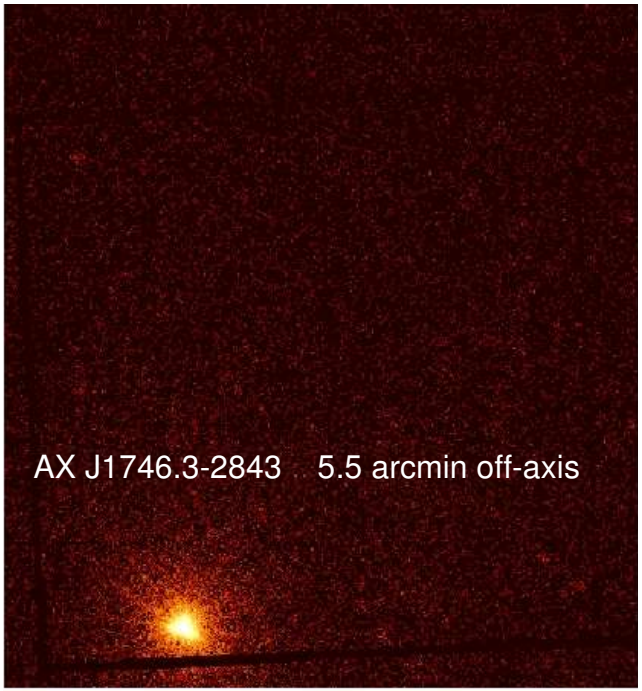
Off-Axis PSF

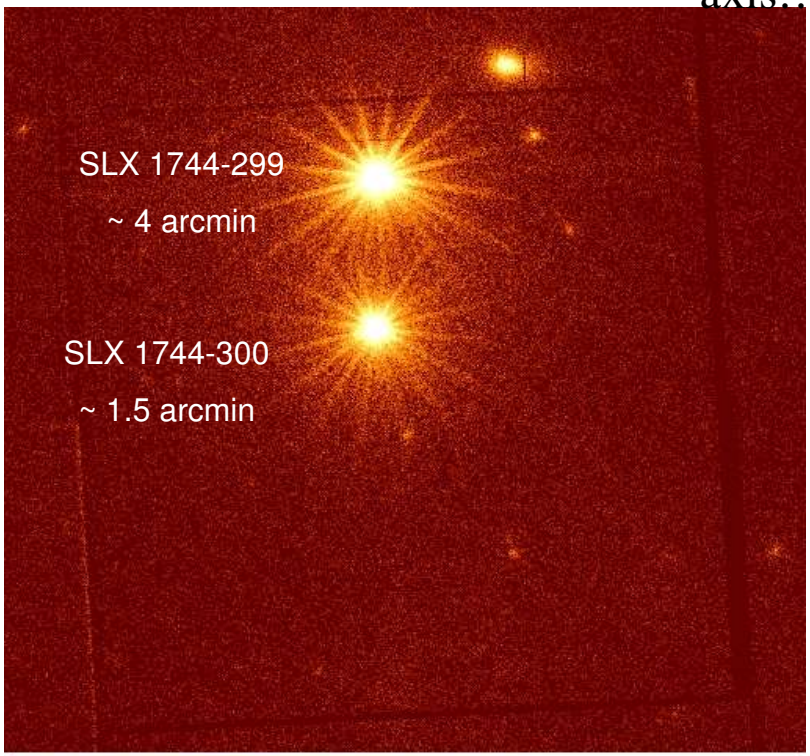
A few suitable off-axis sources are now appearing in the XMM archive…

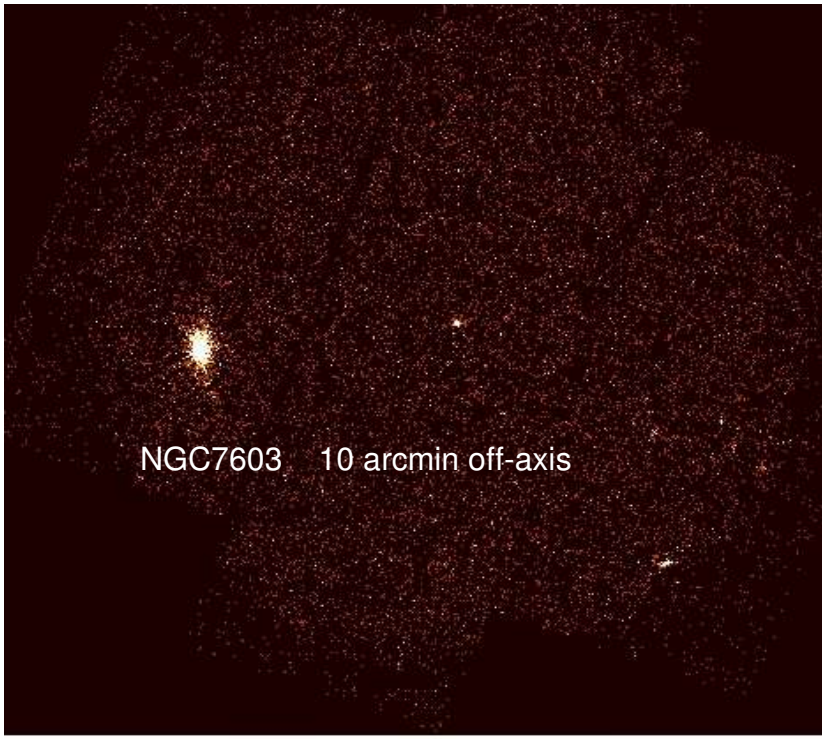
Work ongoing…

Sources both on- and off-axis… moving sources…



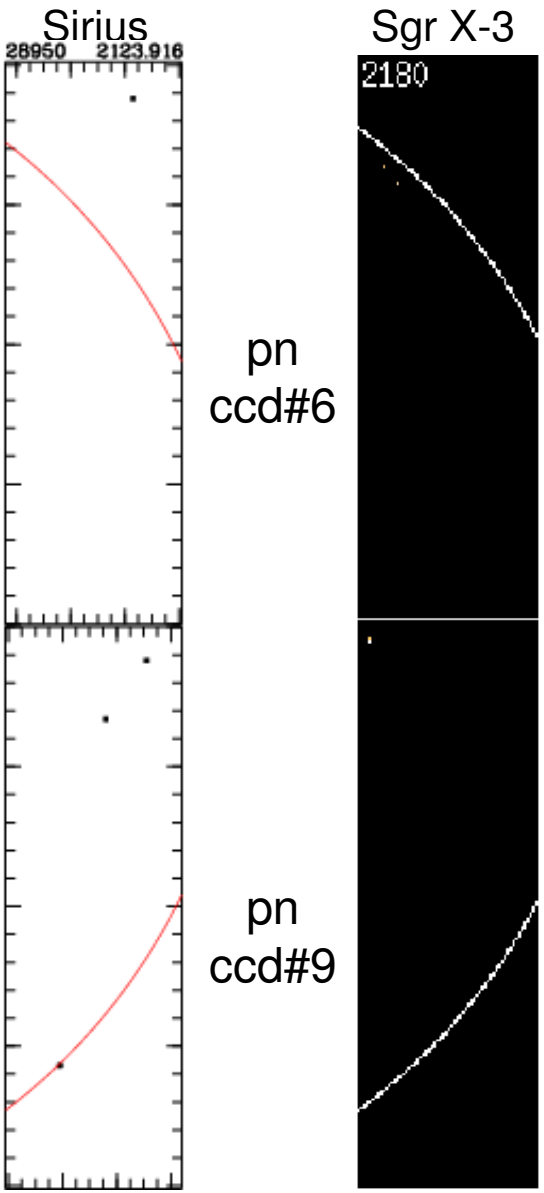






EPIC PSFs For the Slew & Slow-Slew Survey, Incorporating New Modes

- Based on present understanding (from slew event files)
- Any arbitrary, straight, constant-speed path of a source through any EPIC detector



EPIC PSFs For the Slew & Slow-Slew Survey, Incorporating New Modes

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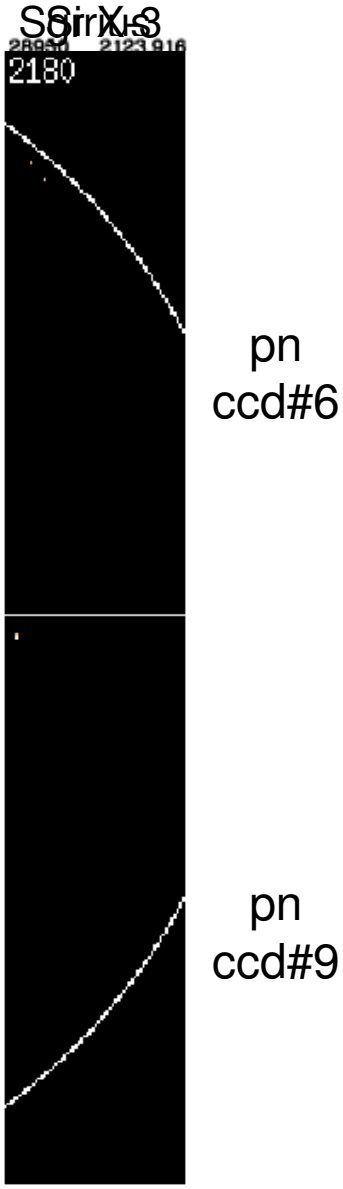
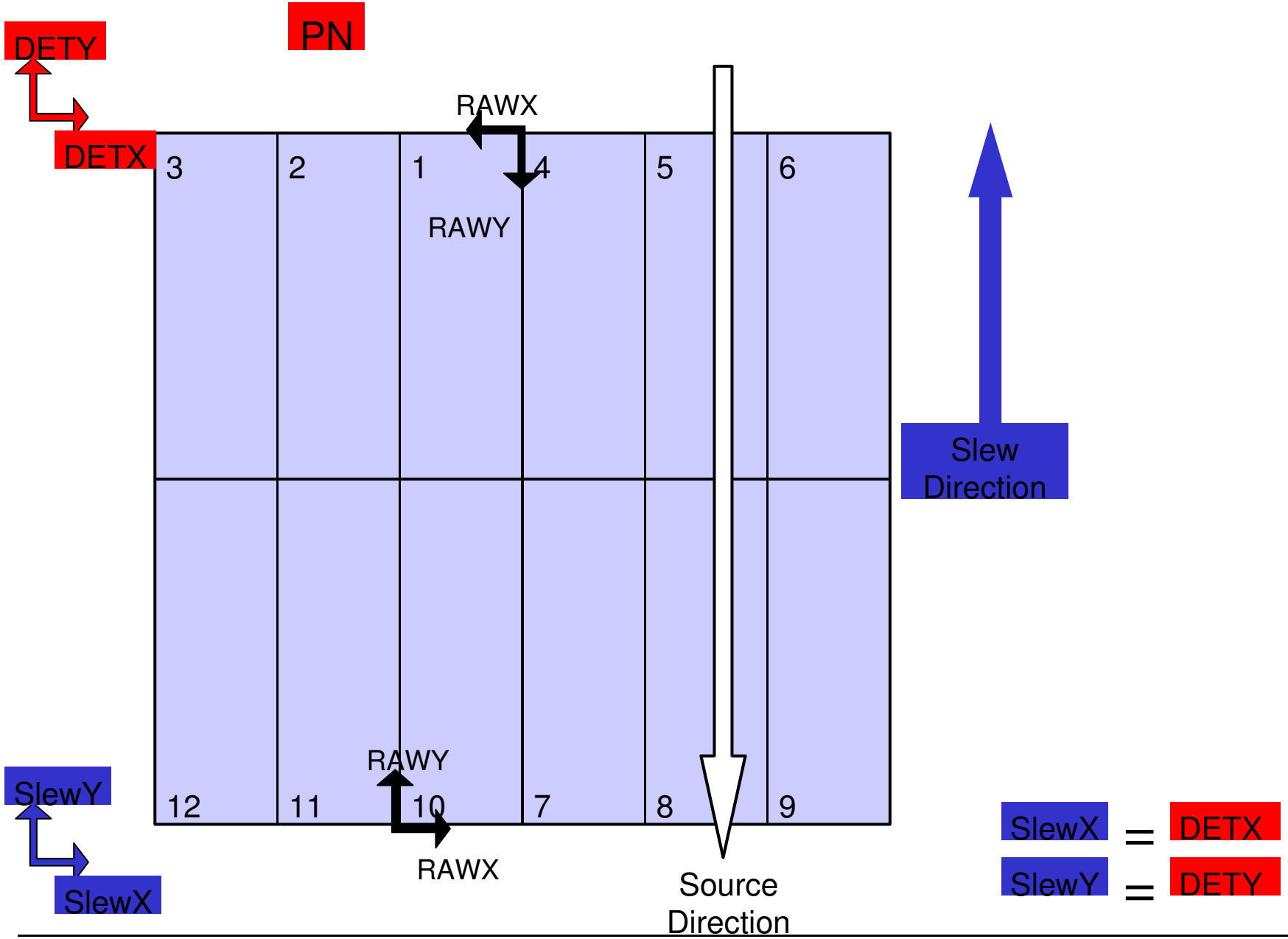
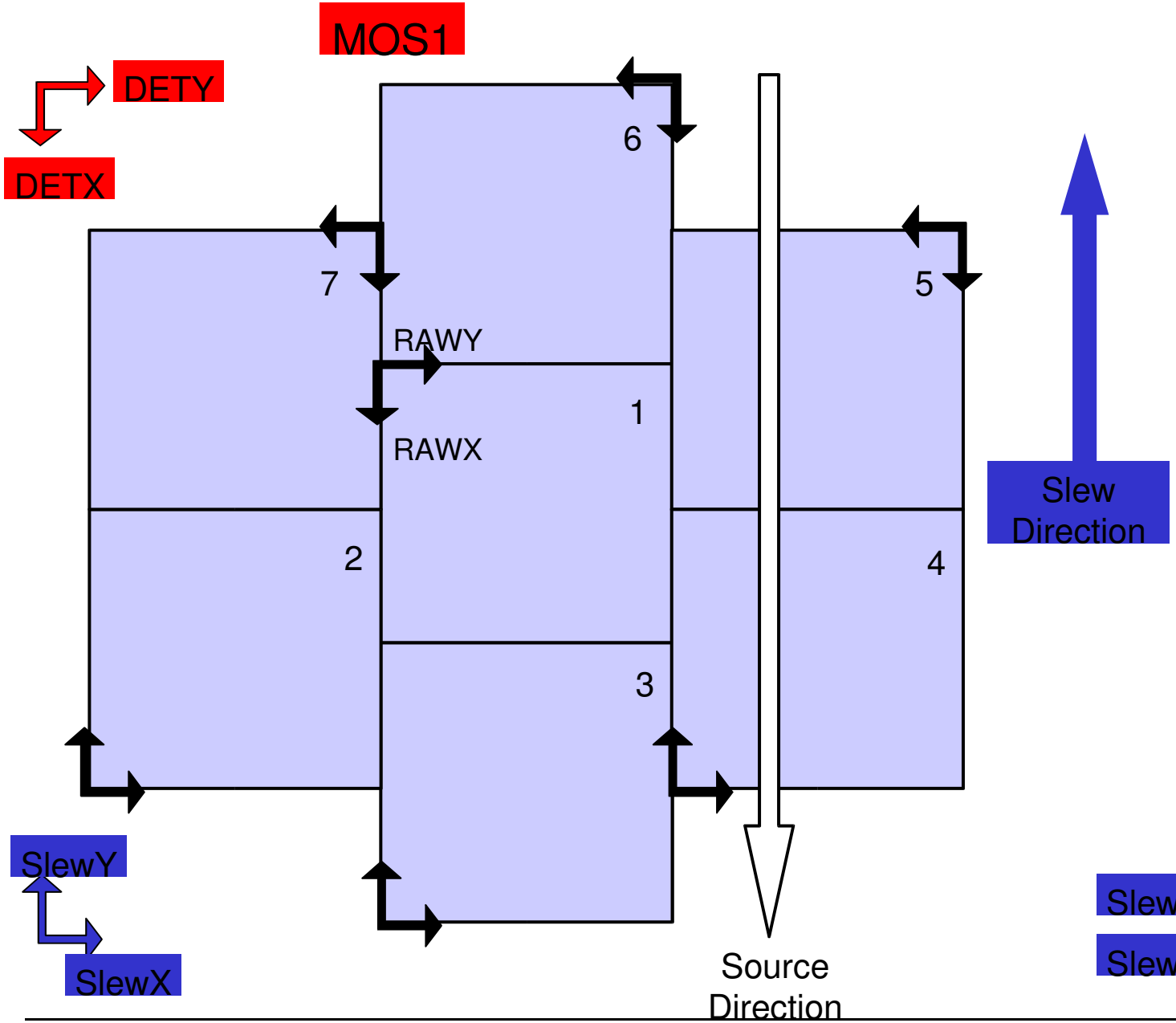
- Any arbitrary, straight, constant-speed path of a source through any EPIC detector

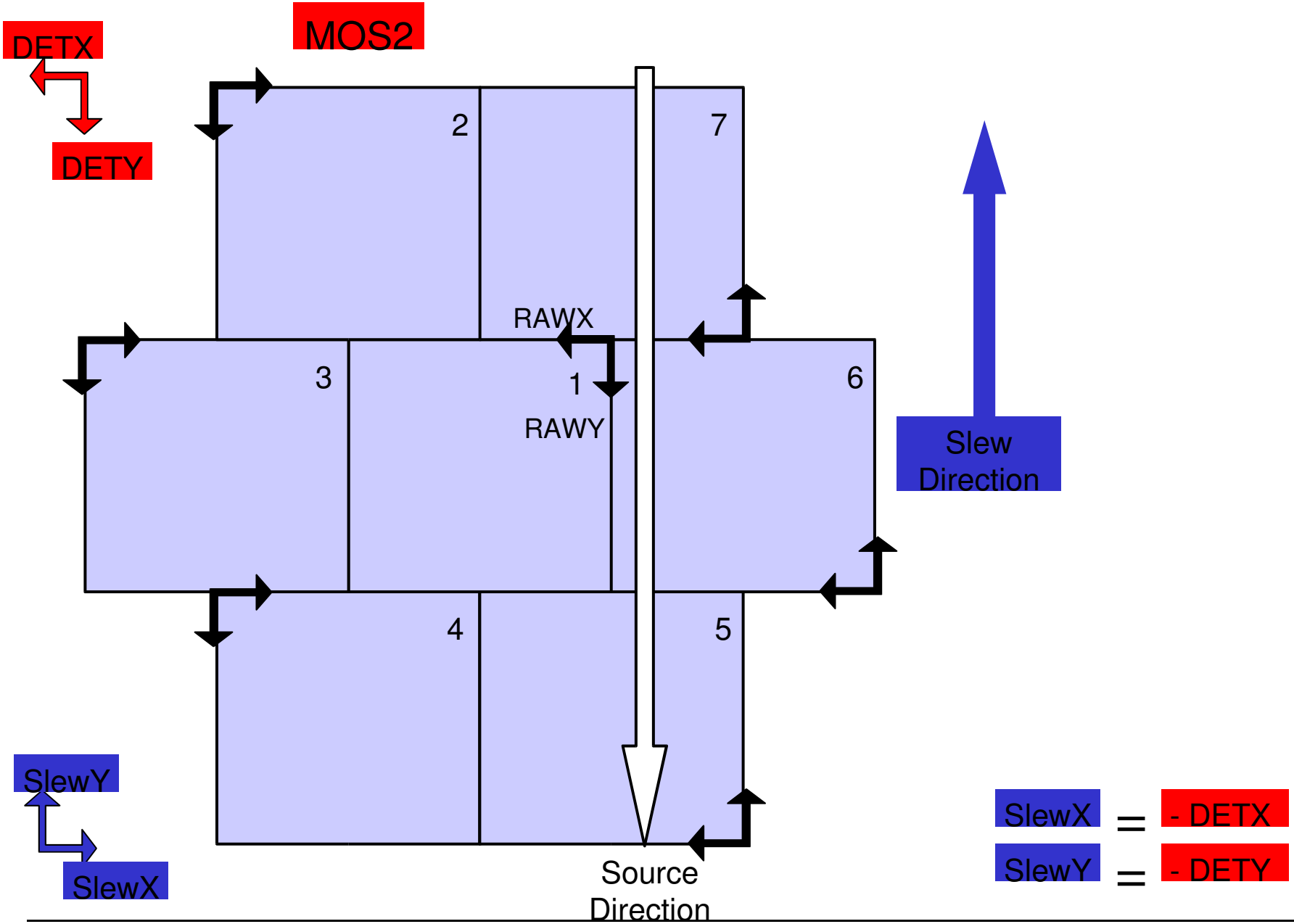


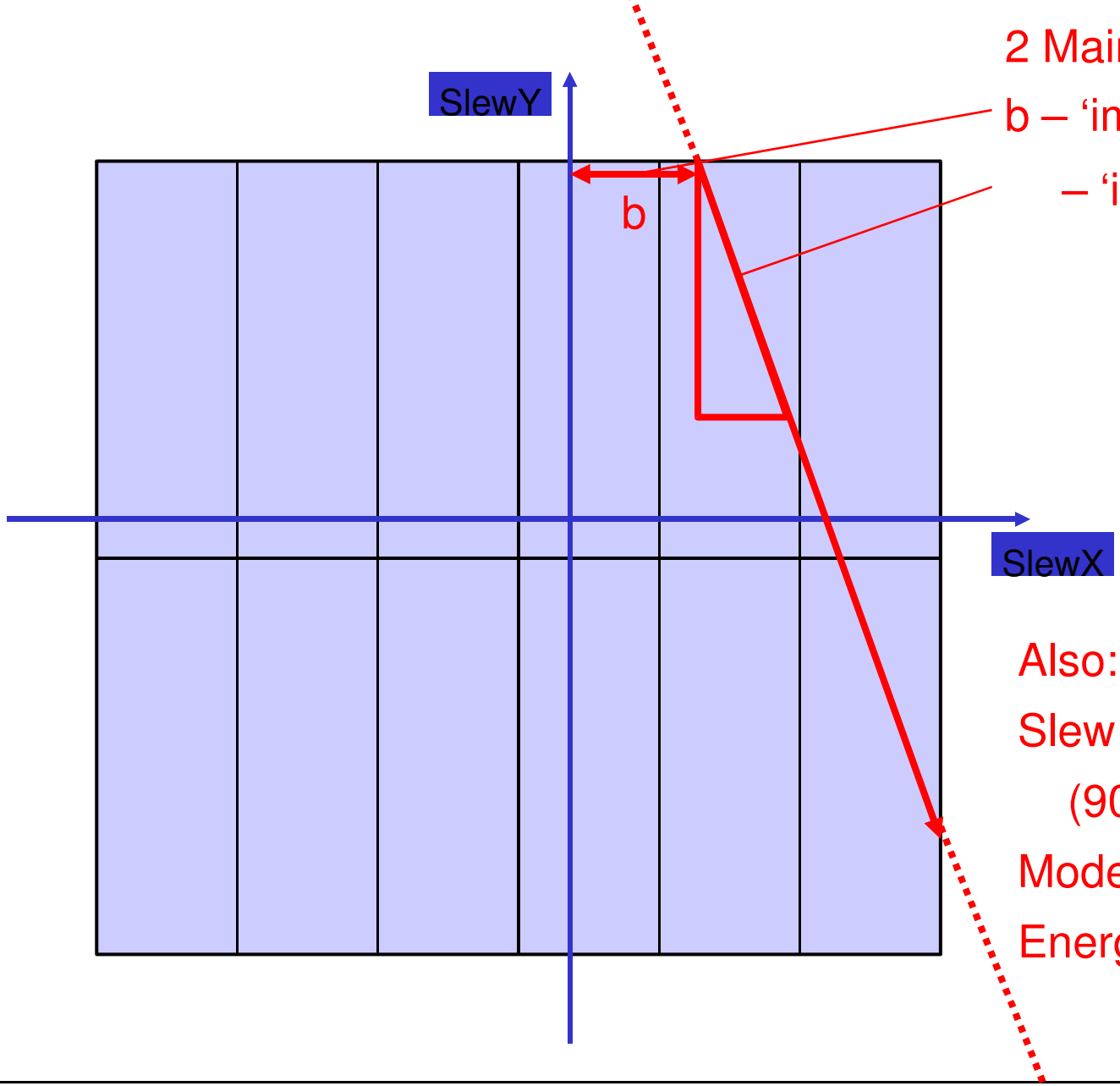

PN
DETY
DETX
RAWX
RAWY
3
2
1
4
5
6
12
11
10
7
8
9
RAWY
RAWX
SlewY
SlewX
Slew Direction
Source Direction
SlewX = DETX
SlewY = DETY



SlewX = DETY

SlewY = - DETX


MOS2
DETX
DETY
2
7
RAWX
3
1
6
RAWY
Slew Direction
4
5
SlewY
SlewX
Source Direction
SlewX = - DETX
SlewY = - DETY



2 Main Parameters

b – 'impact parameter'

– 'impact angle'

Also:

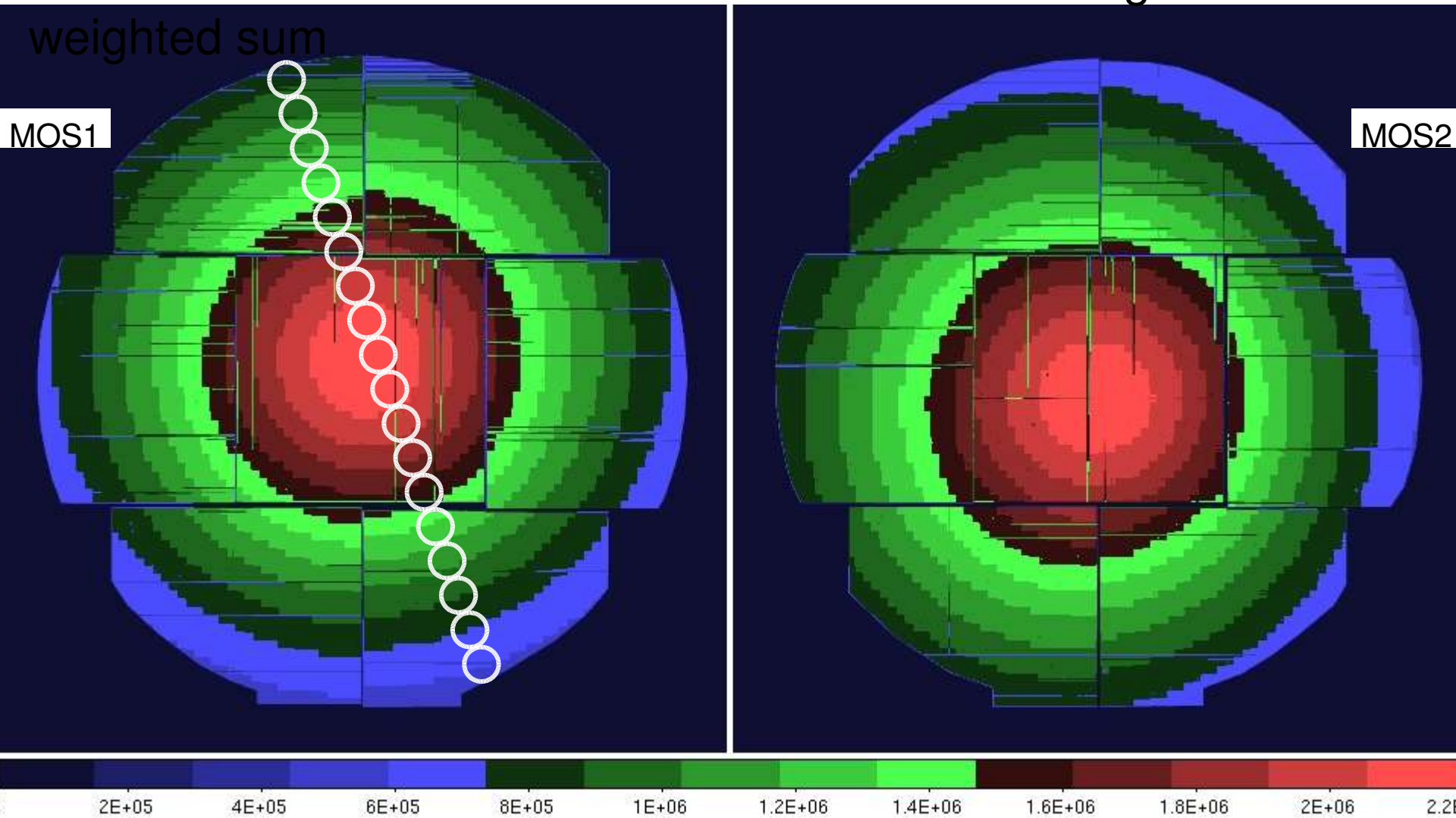
Slew speed

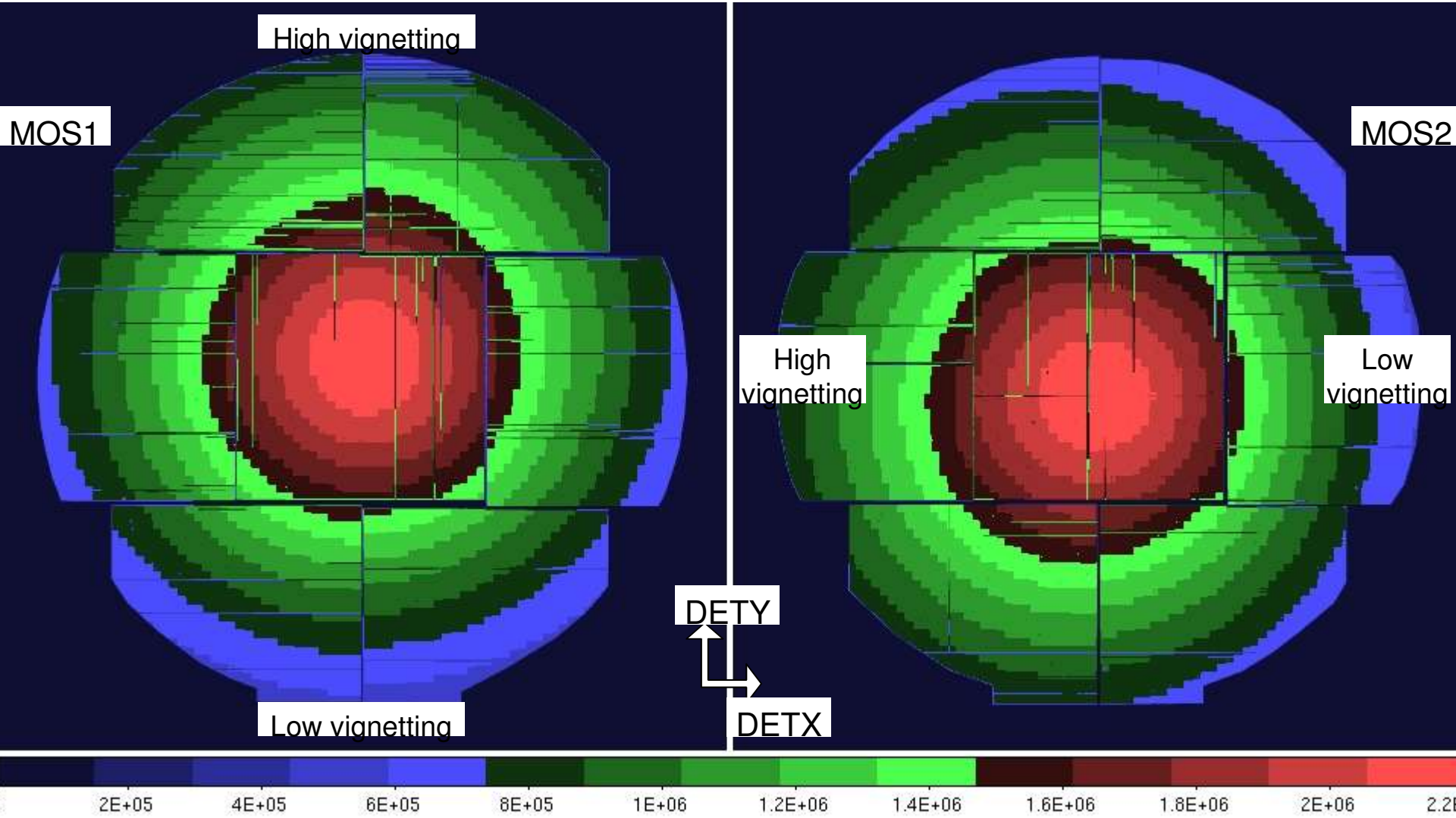
(90°/hr, 30°/hr)

Mode (FF, eFF, 3x3)

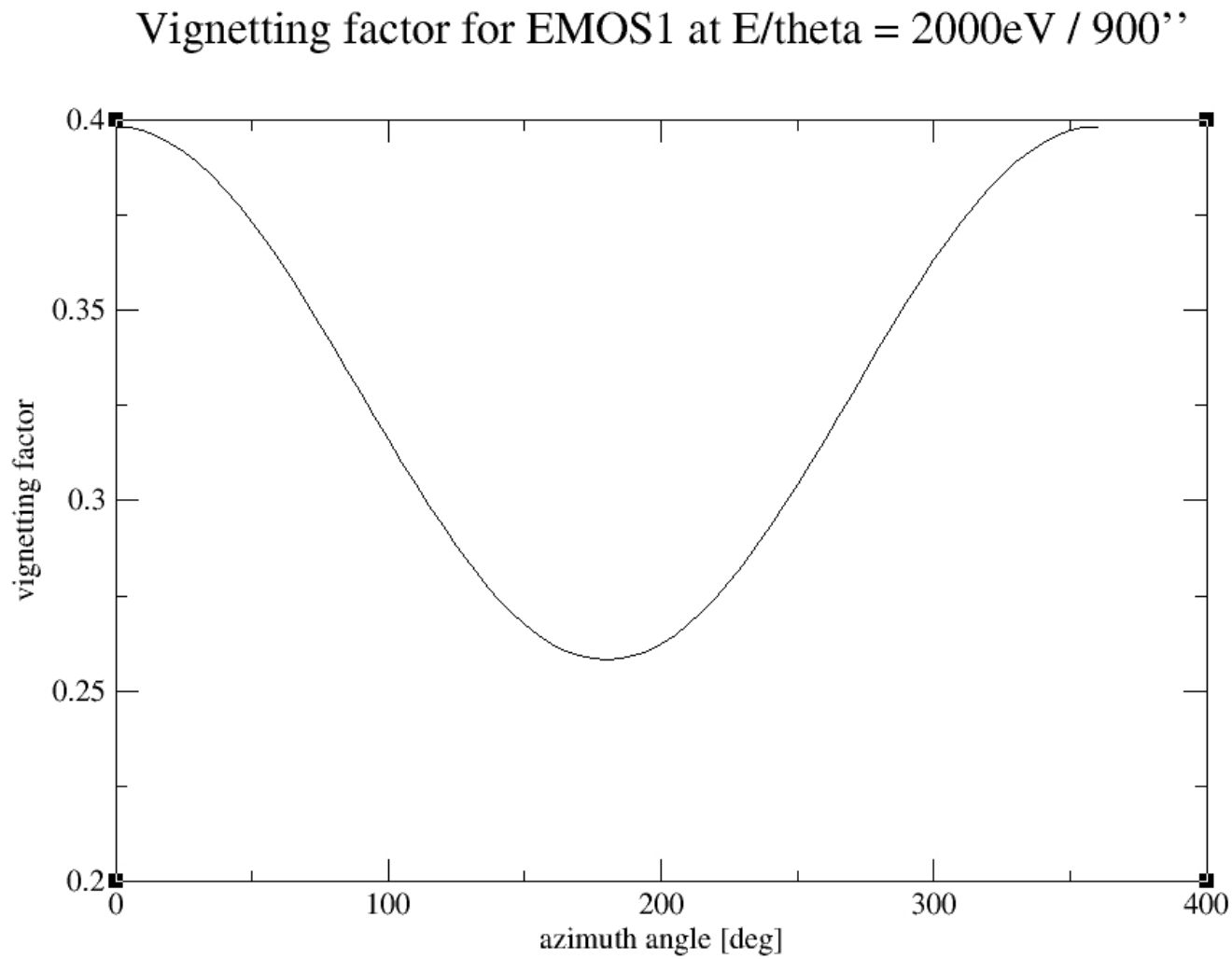
Energy …

- Vignetting must be taken into account – central PSFs contribute more to final summed PSF – calculate vignetted-weighted sum

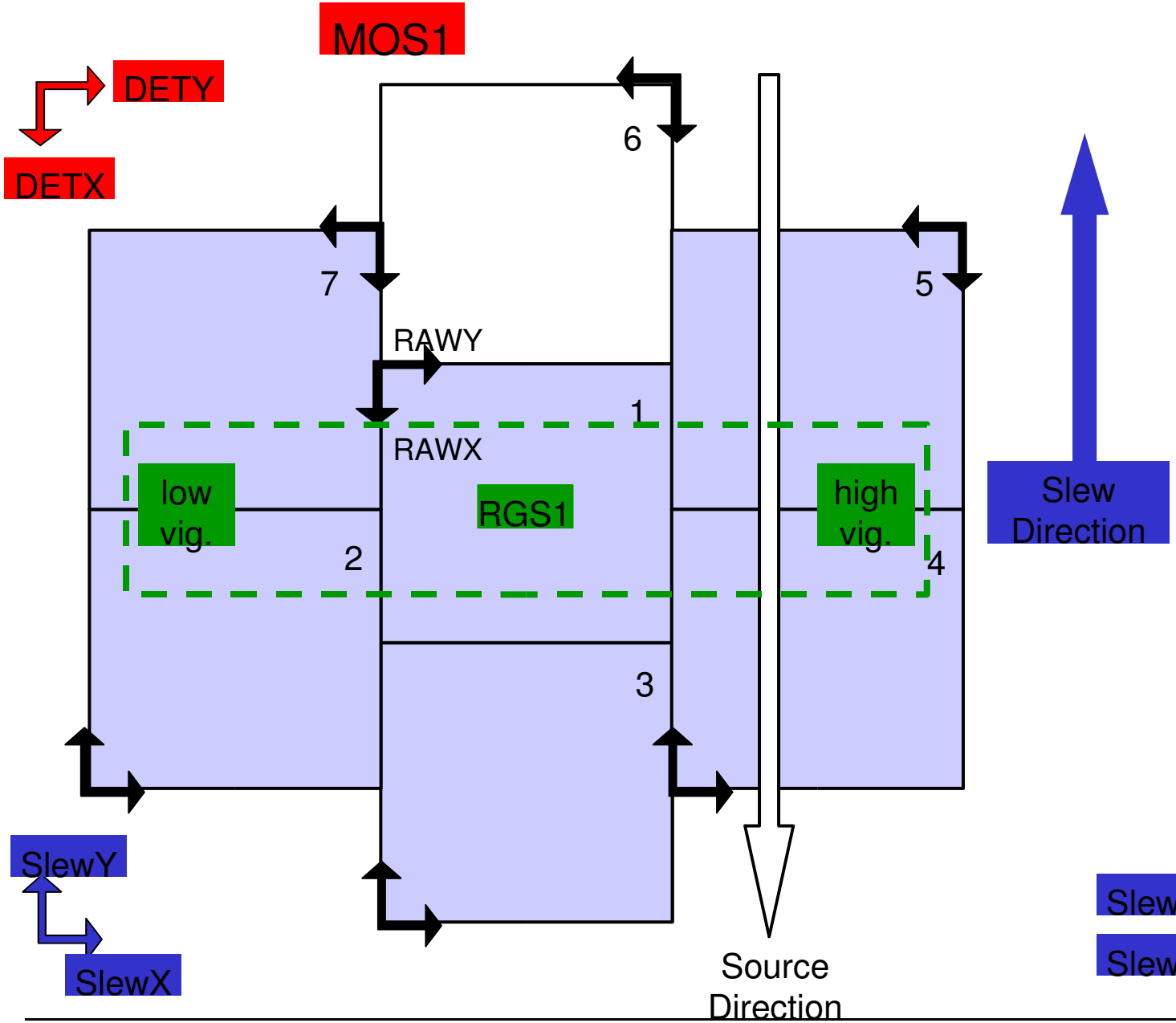



High vignetting
MOS1
MOS2
High vignetting
Low vignetting
DETY
DETX
Low vignetting
2E+05
4E+05
6E+05
8E+05
1E+06
1.2E+06
1.4E+06
1.6E+06
1.8E+06
2E+06

- RGAs cause azimuthal variations in off-axis vignetting in the MOSs

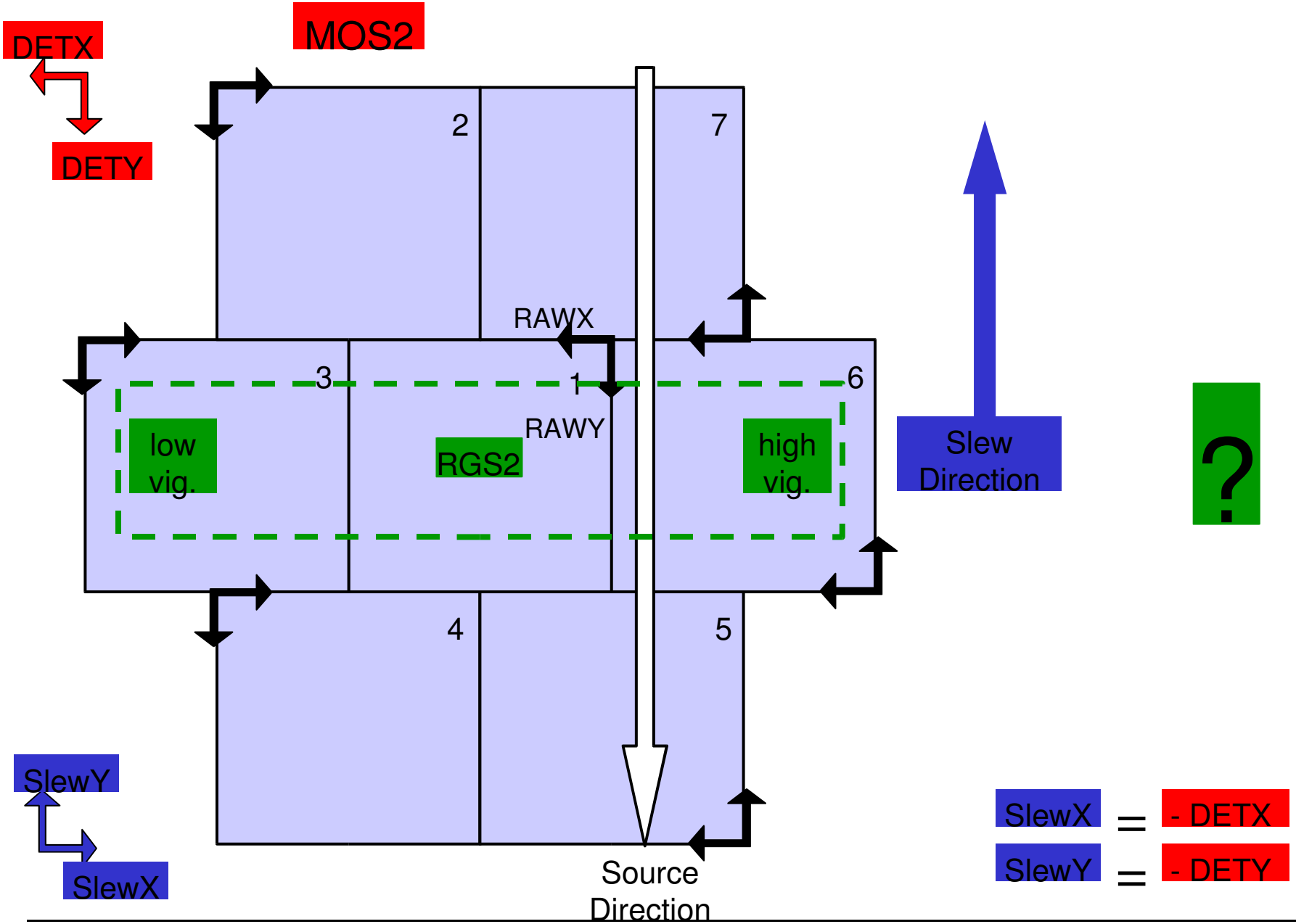


- MOS2 function is identical
- Implies, with exposure maps, detector positions of low/high vignetting

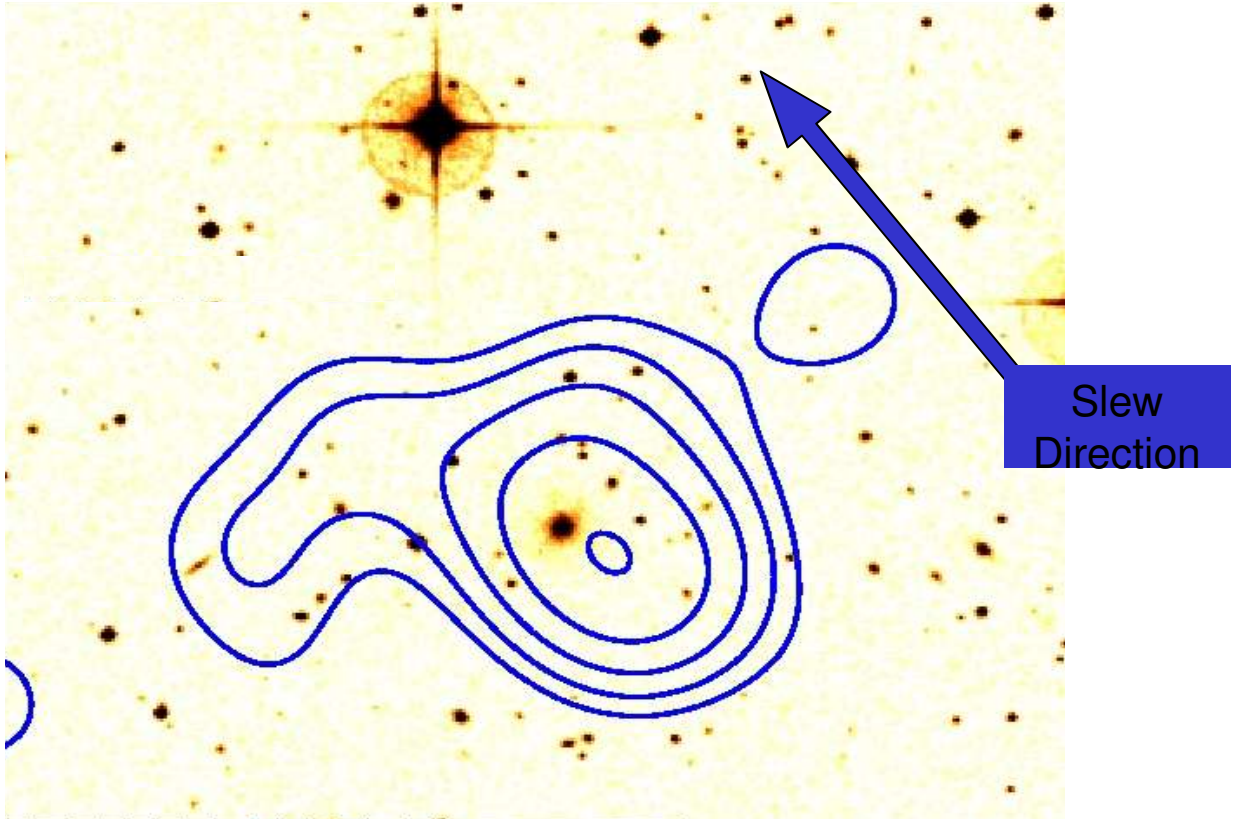


SlewX = DETY

SlewY = - DETX


DETX
DETY
MOS2
2
7
RAWX
3
1
6
RAWY
low vig.
RGS2
high vig.
Slew Direction
?
4
5
SlewY
SlewX
Source Direction
SlewX = - DETX
SlewY = - DETY

‘Frame-blurring’ – within a single frame the source can travel an appreciable distance



pn extended full frame –
‘frameblur’ of 18 arcseconds

- PSF at each point is blurred (stretched) in the slew direction, depending on slew-speed & mode

Instrument	Mode	Frame time (sec)	Slew speed (deg/hr)	'Frameblur' (arcsec)
PN	FF	0.073	90	6.57
			30	2.19
	eFF	0.20	90	18.0
			30	6.0
	LW	0.048	90	4.32
			30	1.44
MOS1/2	FF	2.6	90	234.0
			30	78.0
	LW	0.9	90	81.0
			30	27.0
	3x3	0.4	90	36.0
			30	12.0

Instrument	Mode	Frame time (sec)	Slew speed (deg/hr)	'Frameblur' (arcsec)
PN	FF	0.073	90	6.57
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	LW	0.048	90	4.32
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MOS1/2	FF	2.6	90	234.0
			30	78.0
	LW	0.9	90	81.0
			30	27.0
	3x3	0.4	90	36.0
			30	12.0

Instrument	Mode	Frame time (sec)	Slew speed (deg/hr)	'Frameblur' (arcsec)
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			30	1.44
MOS1/2	FF	2.6	90	234.0
			30	78.0
	LW	0.9	90	81.0
			30	27.0
	3x3	0.4	90	36.0
			30	12.0

PSFs that are used :

- 2-D PSFs – ‘medium’ CCF PSFs – Images – fn(instr, E, theta, phi) – used in SAS source-searching

- 1-D PSFs – ‘extended’ CCF PSFs – King profile (r0, alpha) – fn(instr, E, theta) – used in ARF generation/spectral fitting

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- 2-D PSFs – ‘medium’ CCF PSFs – Images – fn(instr, E, theta, phi) – used in SAS source-searching

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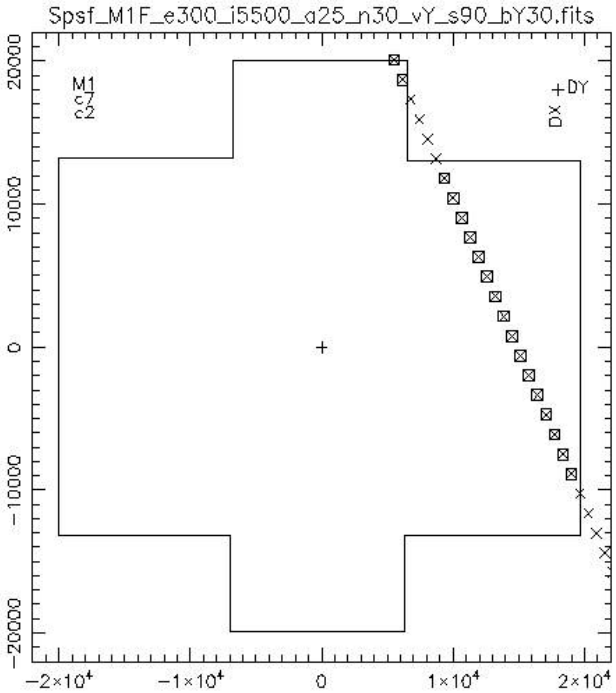
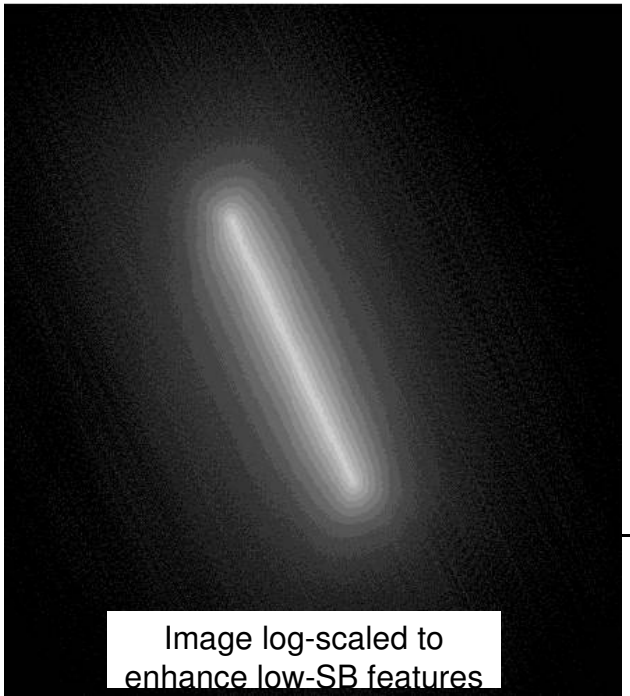




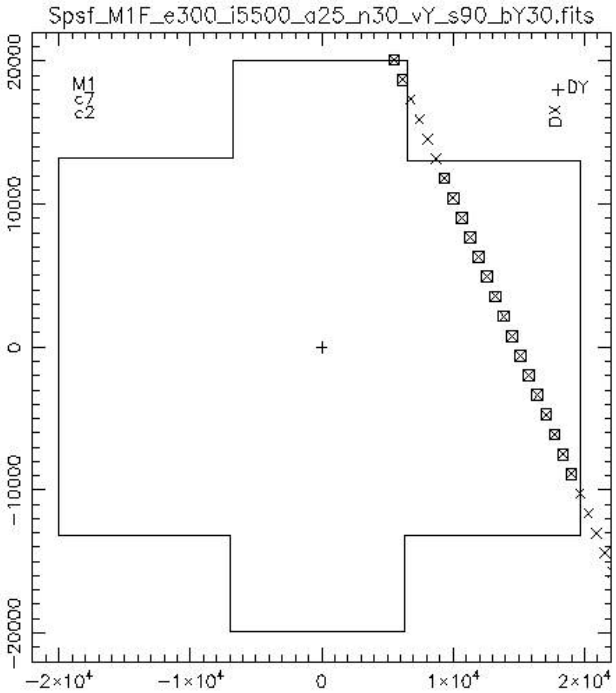
- Source path calculated (e.g. b=5500, =25°, for MOS1, Full-Frame, slew-speed=90°/hr)
- Step through n small intervals of source path – Is the source on the detector (Y/N)?
- For each 'Y'

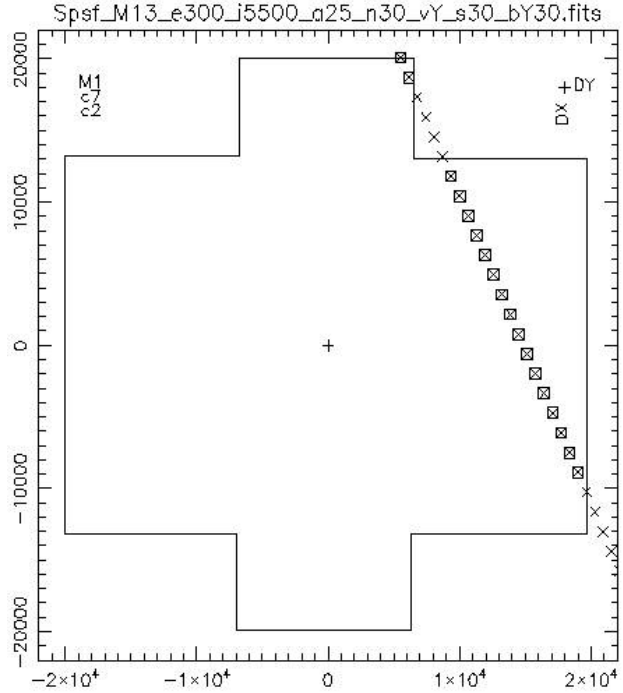
  - Interpolate and rotate appropriate PSF (position, energy, instrument, mode etc.) from CCF 2-D images (512 x 512, 1.1")

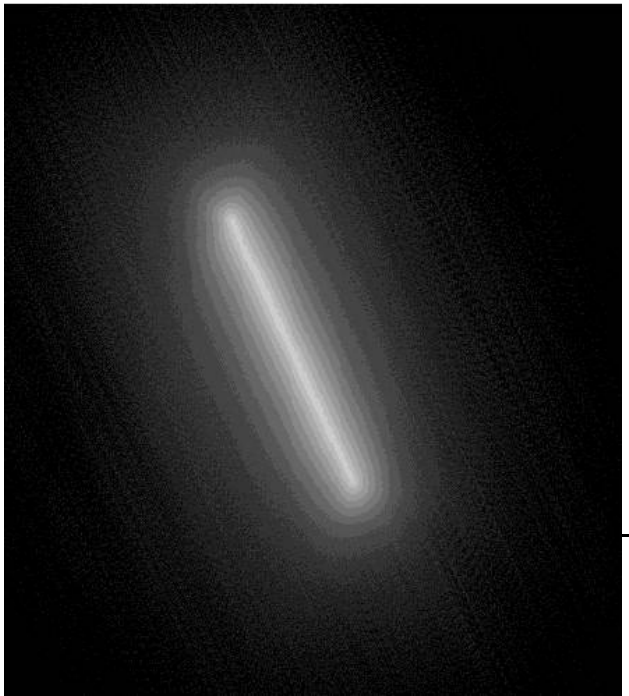
  - Obtain vignetting (pos, E, instr. etc.), and weight PSF image by vignetting

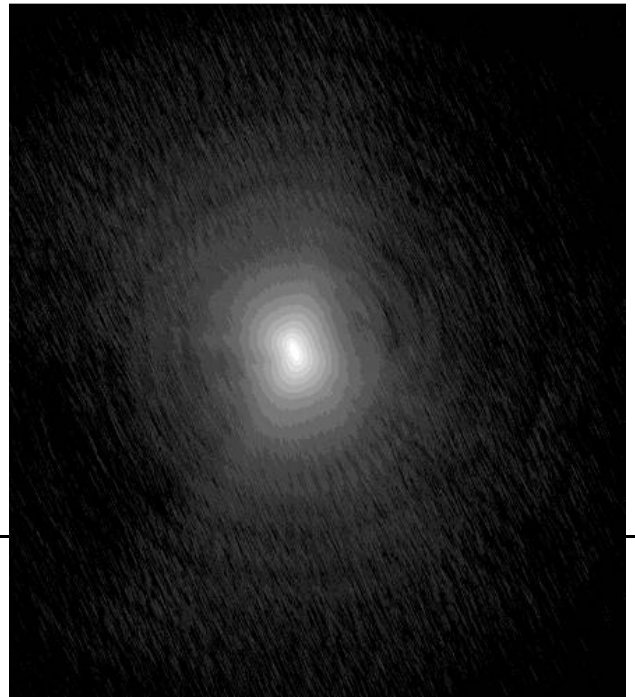
  - Stretch PSF for 'frameblurring' (instrument, mode, slew-speed)
- Add PSFs for whole source path and normalise 2D image (512 x 512, 1.1") (sum over image = 1)

- MOS1, Full-Frame, slew-speed=90°/hr - 4 PSF – unusable…



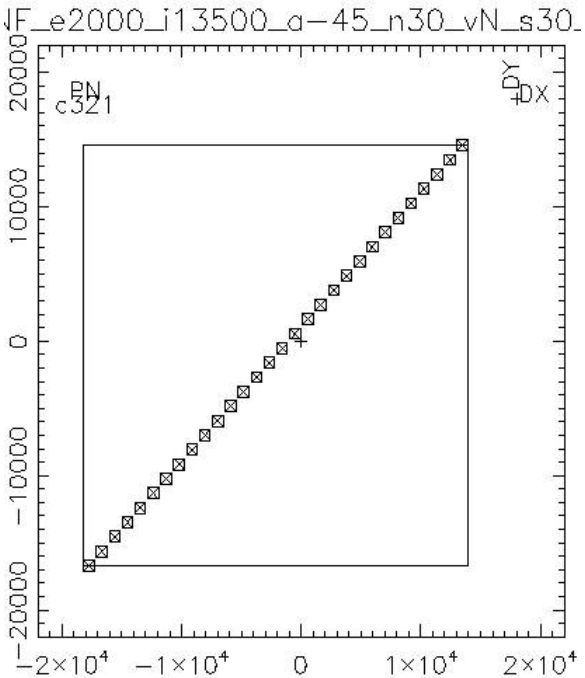




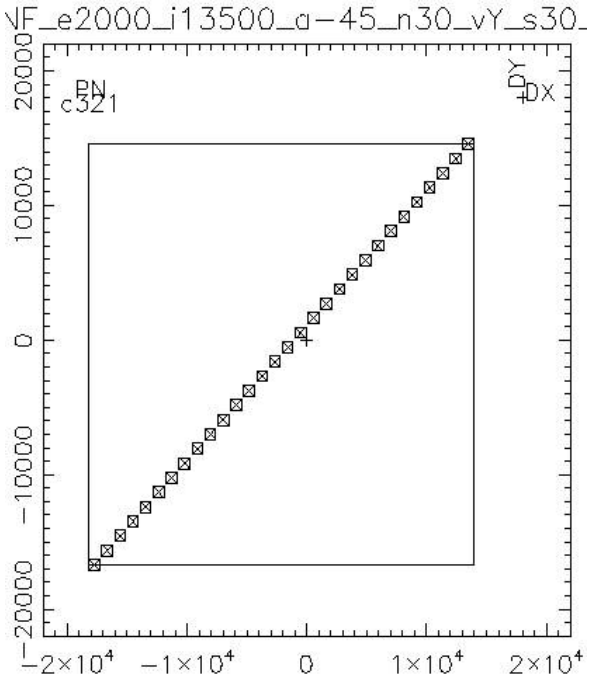


- MOS1
- 3x3 mode
- slew-speed=30°/hr
- 12“ PSF
  - very usable…

University of Leicester

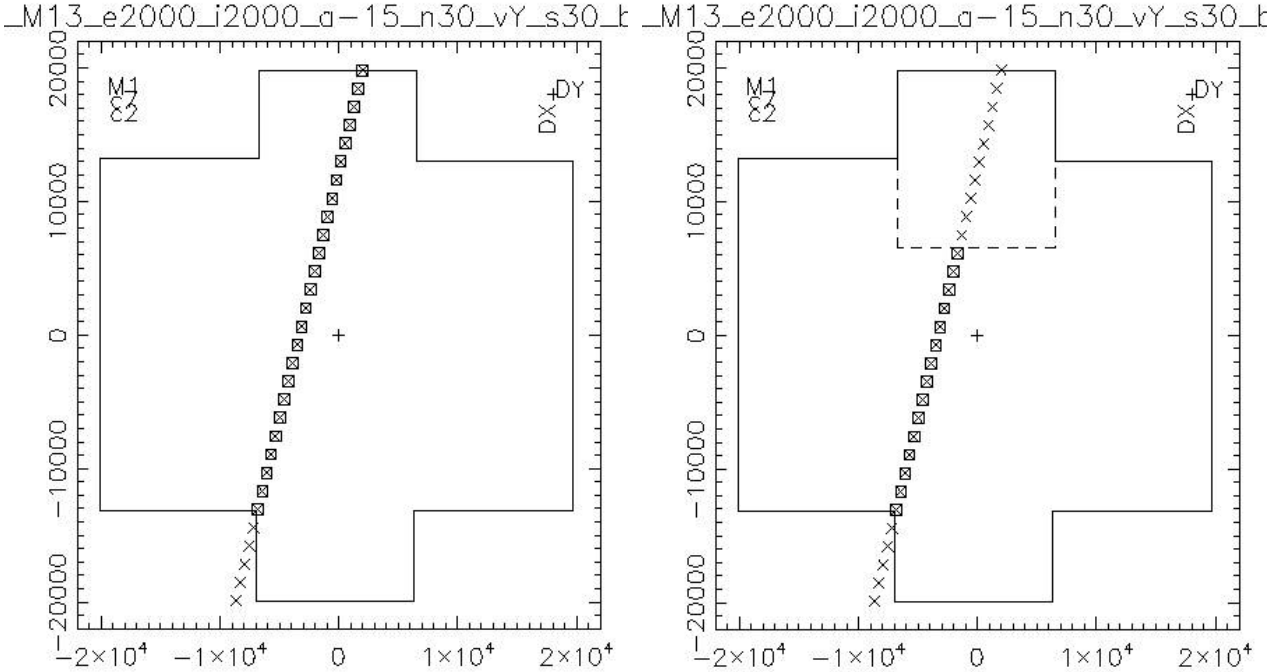


No Vignetting

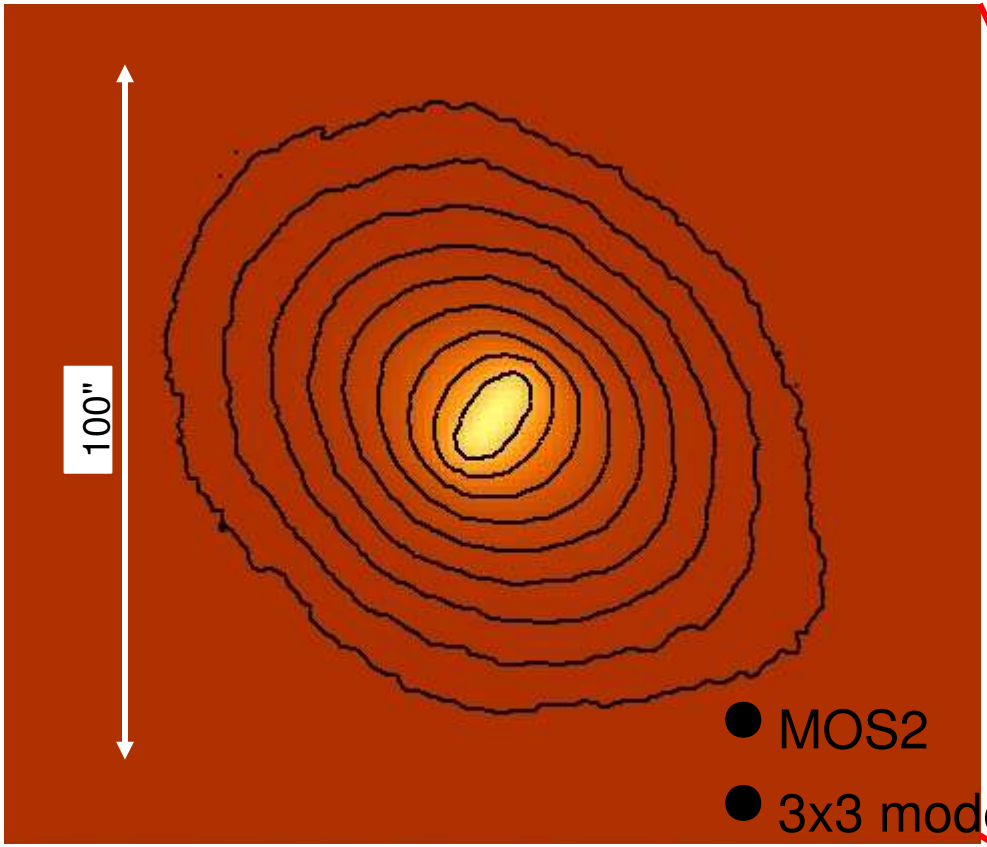


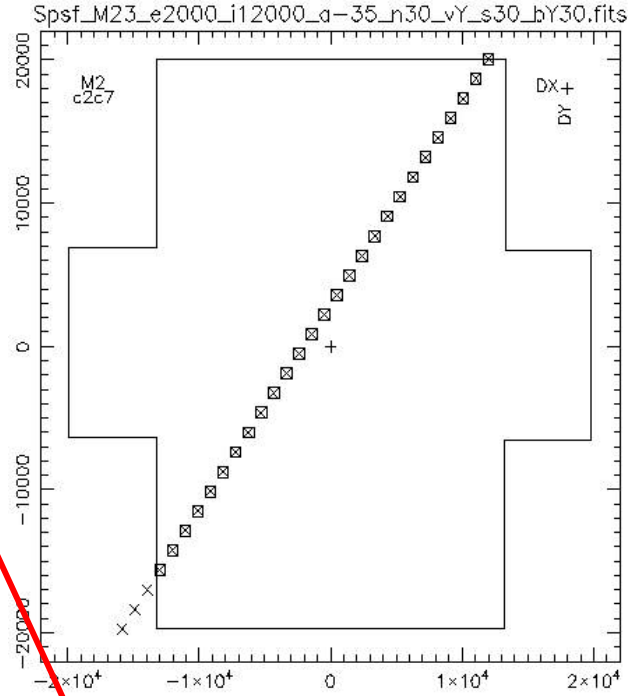
Vignetting

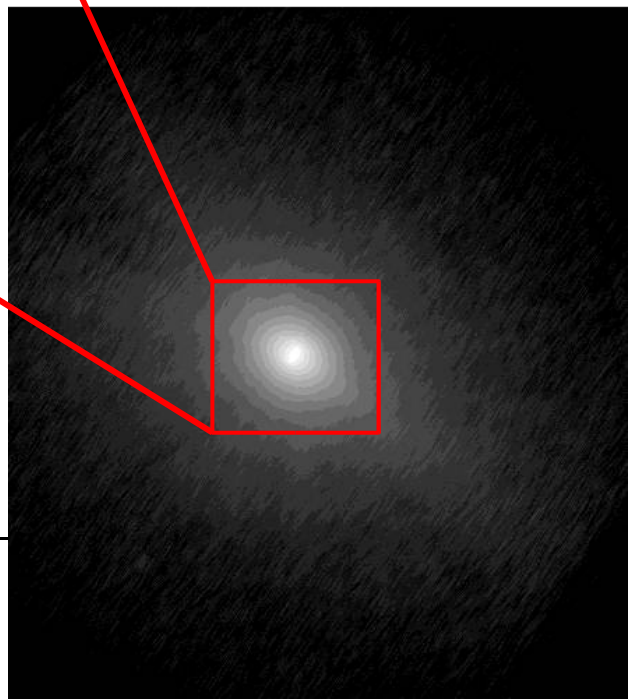
- Need for Vignetting :
- e.g. PN, b=13500, =-45°, for PN, Full-Frame, slew-speed=30°/hr)
- Larger contribution from off-axis PSFs (elongation in perpendicular-to-slew direction) when vignetting not correctly taken into account



- Loss of CCD6
- MOS1
- 3x3 mode
- slew-speed=30°/hr







- MOS2
- 3x3 mode
- slew-speed=30°/hr
- 12" PSF blurring

- Outer parts of PSF due to off-axis PSFs
- Inner parts of PSF due to frameblurring

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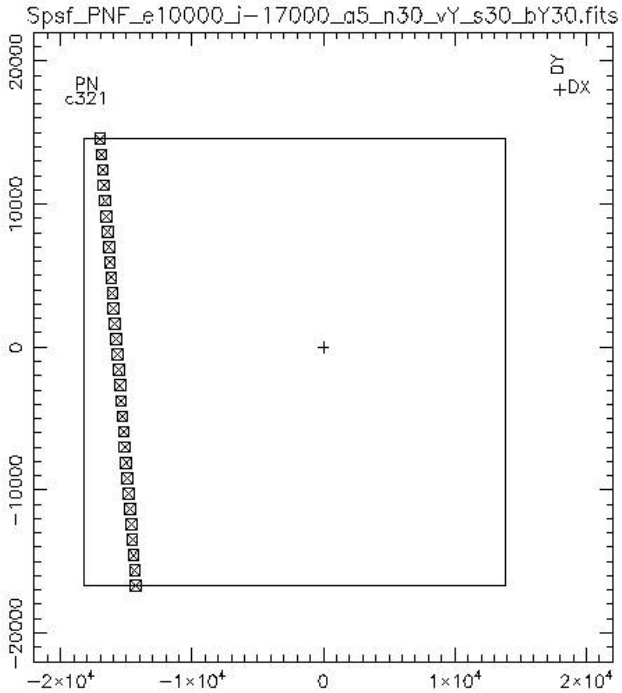
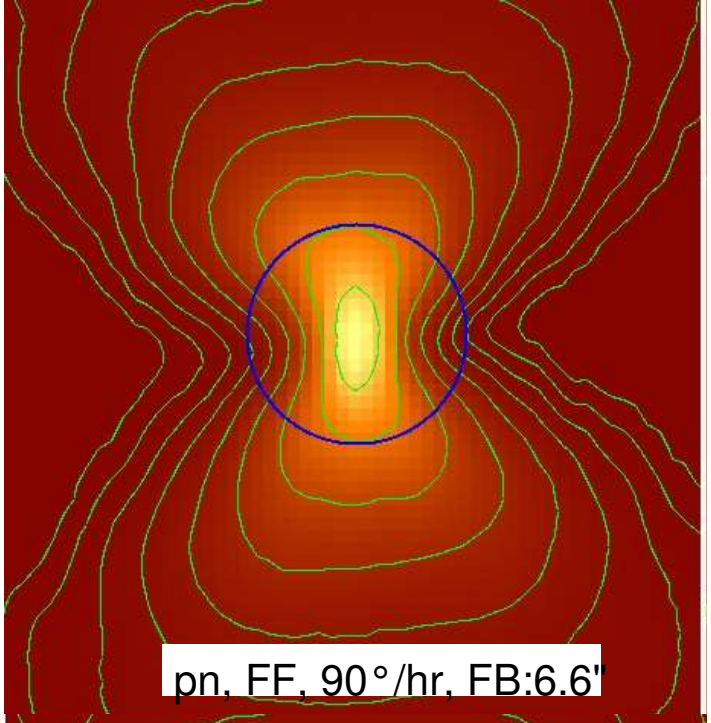
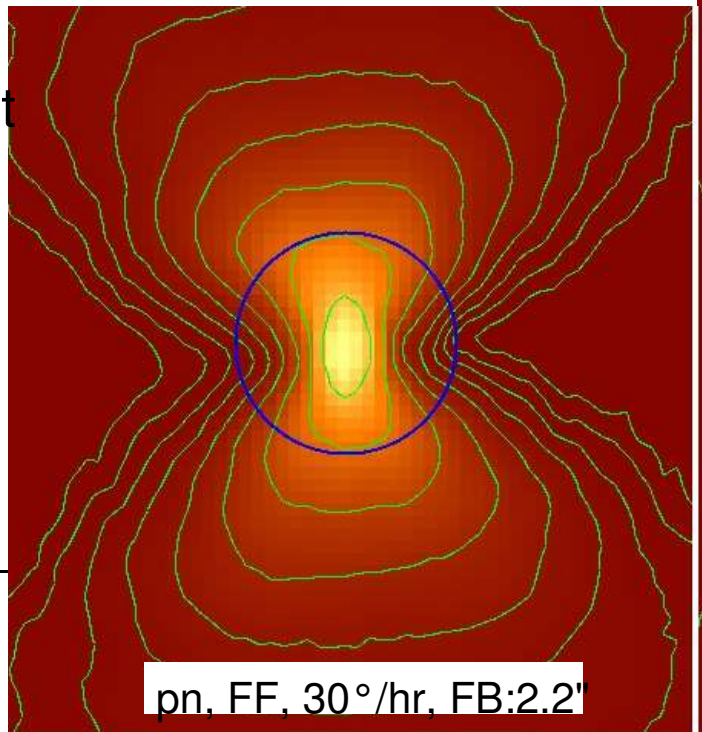
EPIC CAL/OPS Meeting
Mallorca, Spain 26-27/10/06

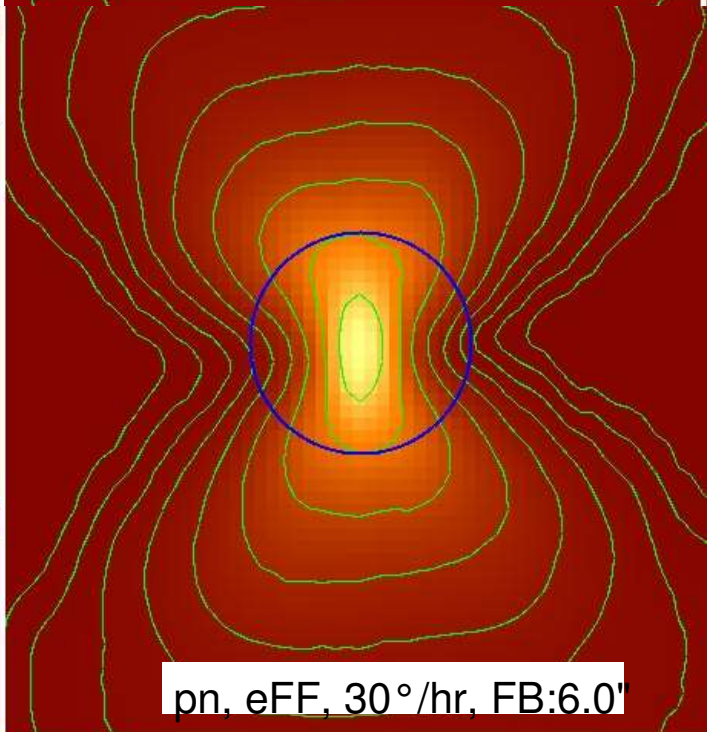
- pn
- e.g. b=-17000 =5°
- (zoom-in on PSF)

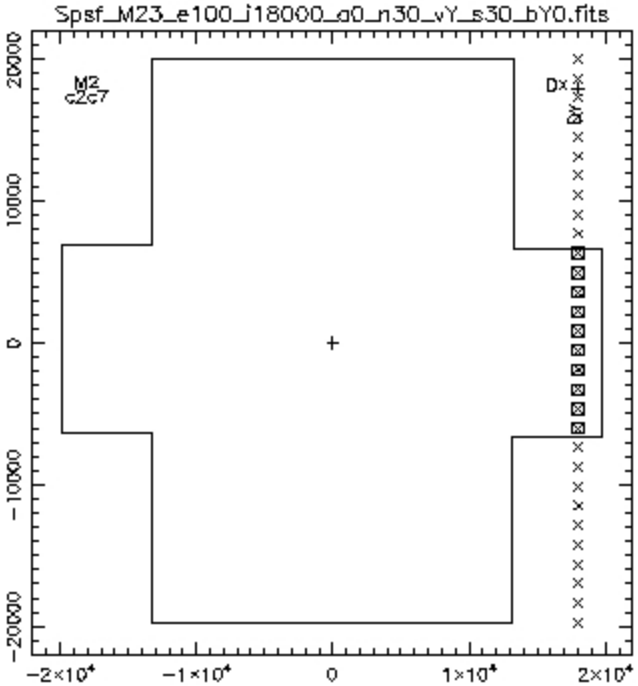


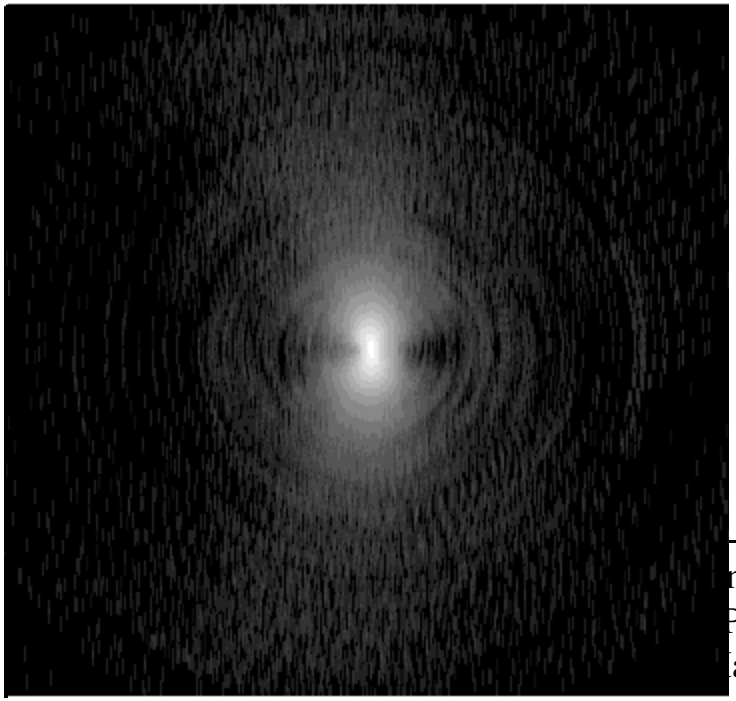


- All PSFs compact (short frame times)
- FF 30°/hr best
- eFF 30°/hr ≈ FF 90°/hr









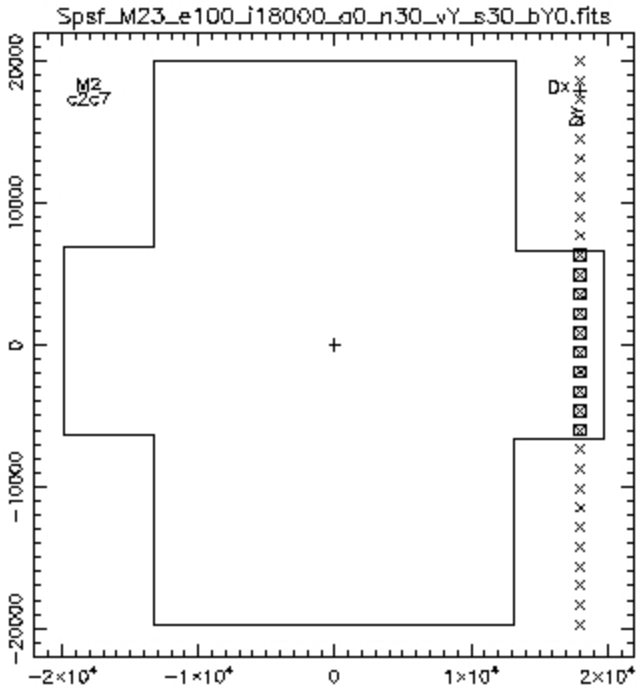
CCF Files

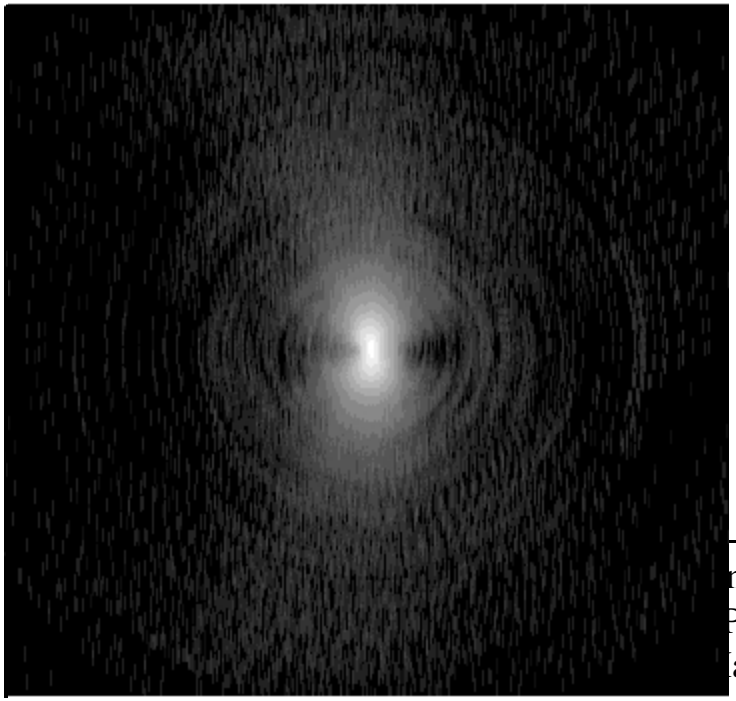
- Possible CCF 2-D PSF images
- For each instrument, mode, energy…

  2-D PSF as

  Function of b (impact parameter)

- If (impact angle) not equal to ~0, then would need several times more images as function of b and





CCF Files

- Possible CCF 2-D PSF images
- For each instrument, mode, energy…

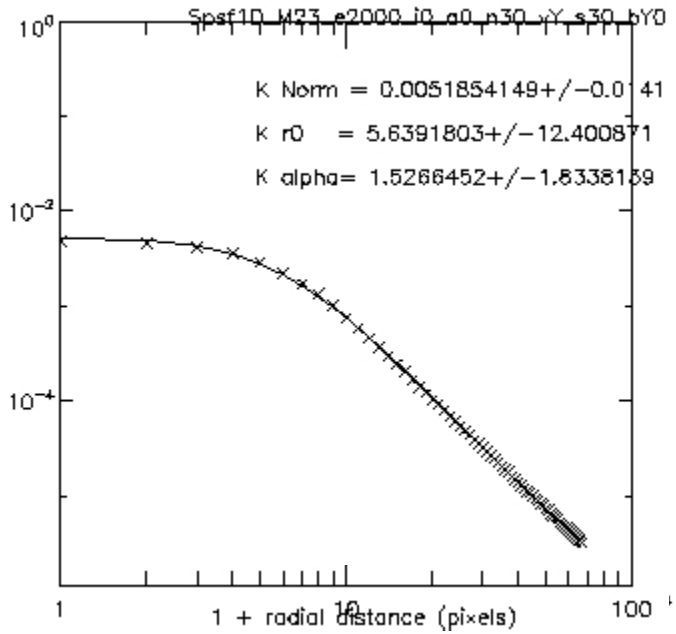
  2-D PSF as

  Function of b (impact parameter)

- If (impact angle) not equal to ~0, then would need several times more images as function of b and

- (note large ‘jump’ in PSF shape at edges of detector as path moves from 1 CCD to 3 CCDs)

- 1-D PSFs – ‘extended’ CCF PSFs – King profile (r0, alpha) – fn(instr, E, theta) – used in ARF generation/spectral fitting



- Vignetting – King parameters of final PSF are closer to those of central PSF than edge PSFs
- Frameblurred PSFs are wider (larger r0, flatter alpha) than the non-FB PSFs

- Source path calculated (e.g. b=0, =0°, for MOS2, 3x3 mode, slew-speed=30°/hr)
- Step through n small intervals of source path – Is the source on the detector (Y/N)?
- For each 'Y'

  - Obtain 1-D King parameters (r0, alpha) (position, energy, instrument) from CCF

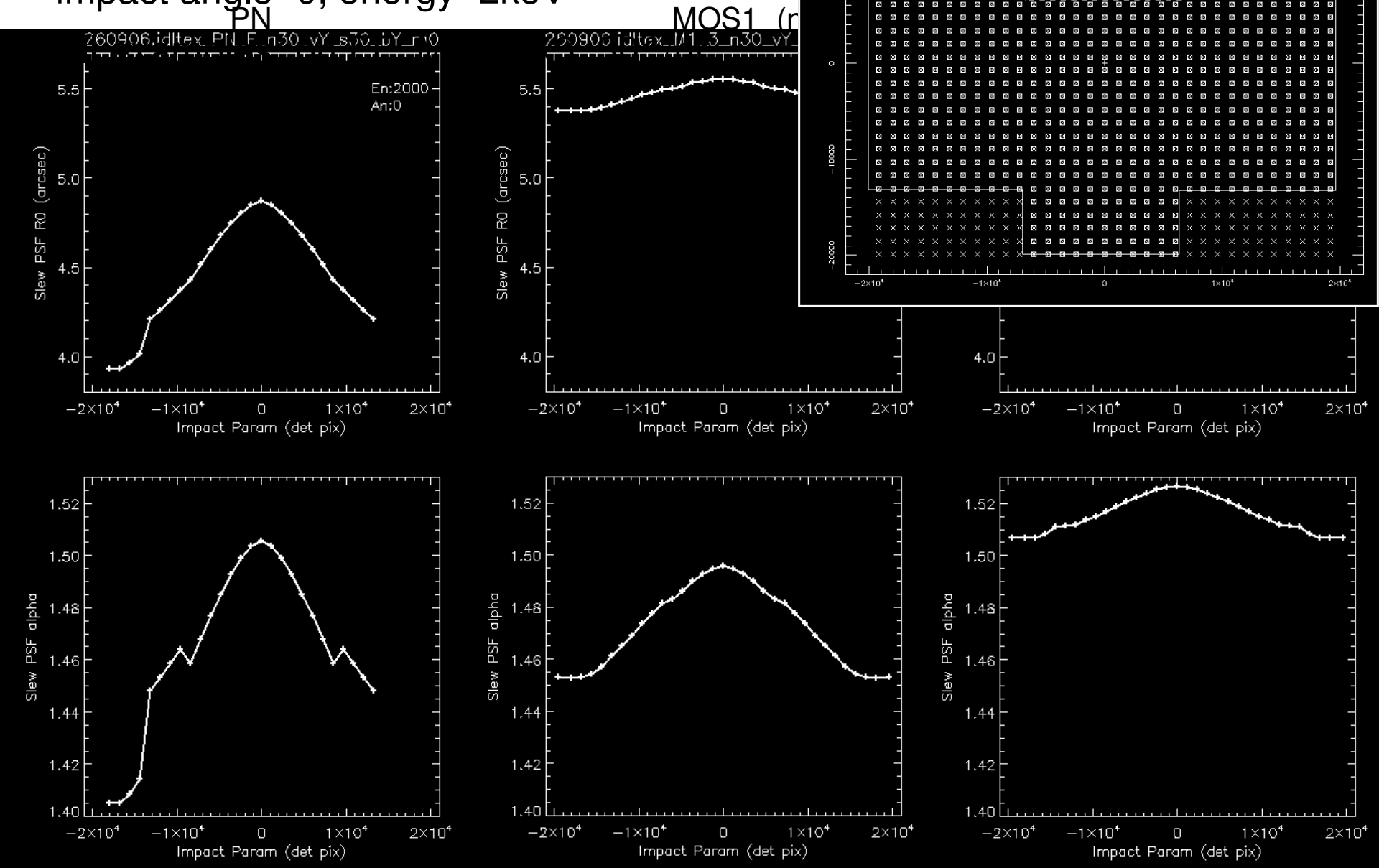
  - Create a 2-D image of (circular) PSF

  - Obtain vignetting (pos, E, instr. etc.), and weight PSF image by vignetting

  - Stretch PSF image for 'frameblurring' (instrument, mode, slew-speed)
- Sum weighted PSFs for whole source path
- Fit 2D summed PSF image with a King profile to give r0, alpha for whole source path

- Note: frameblurred PSFs are now non-circular (visible?) – Fitted King profiles look very good

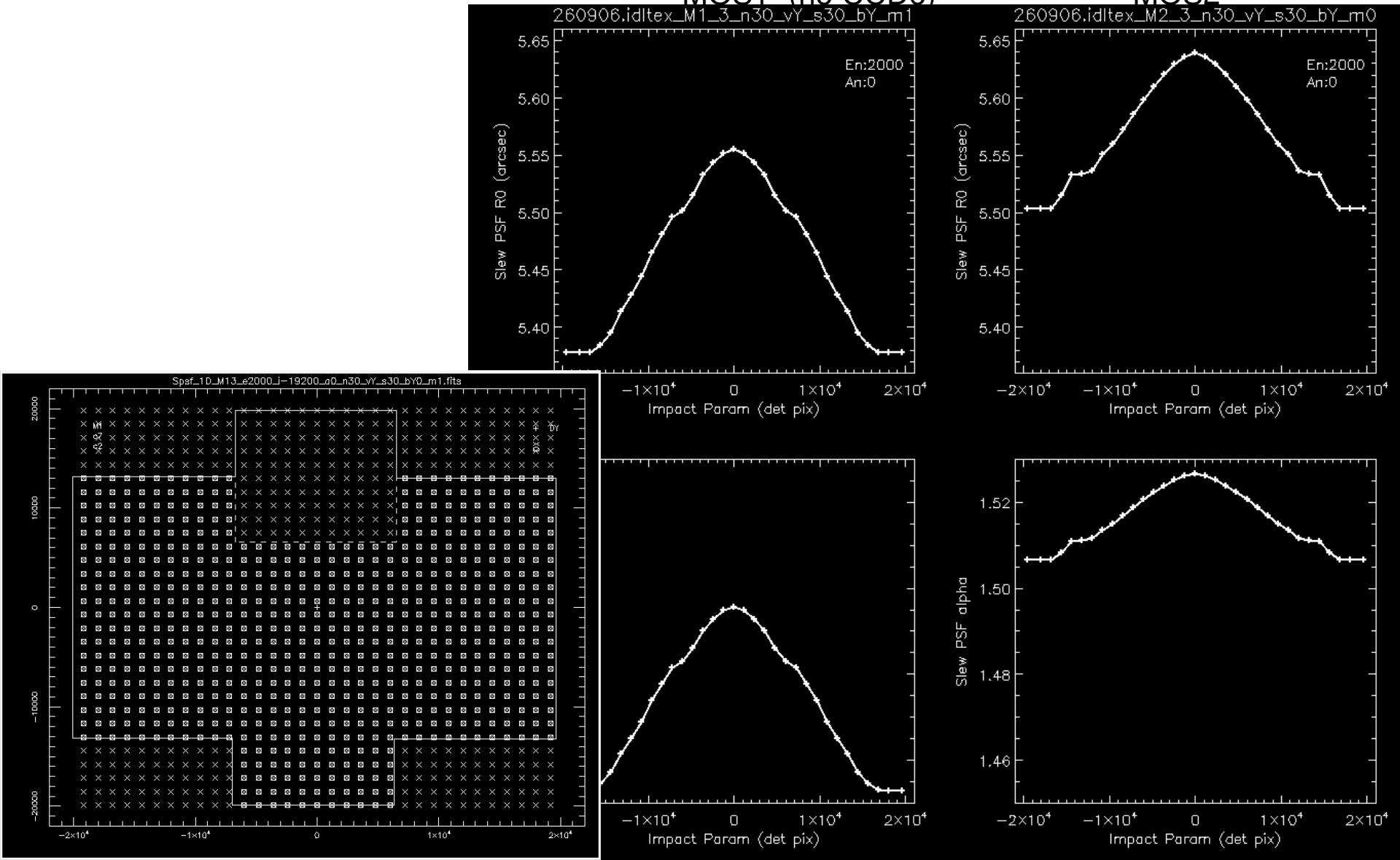
- r0 and alpha as function of impact parameter
- impact angle=0, energy=2keV



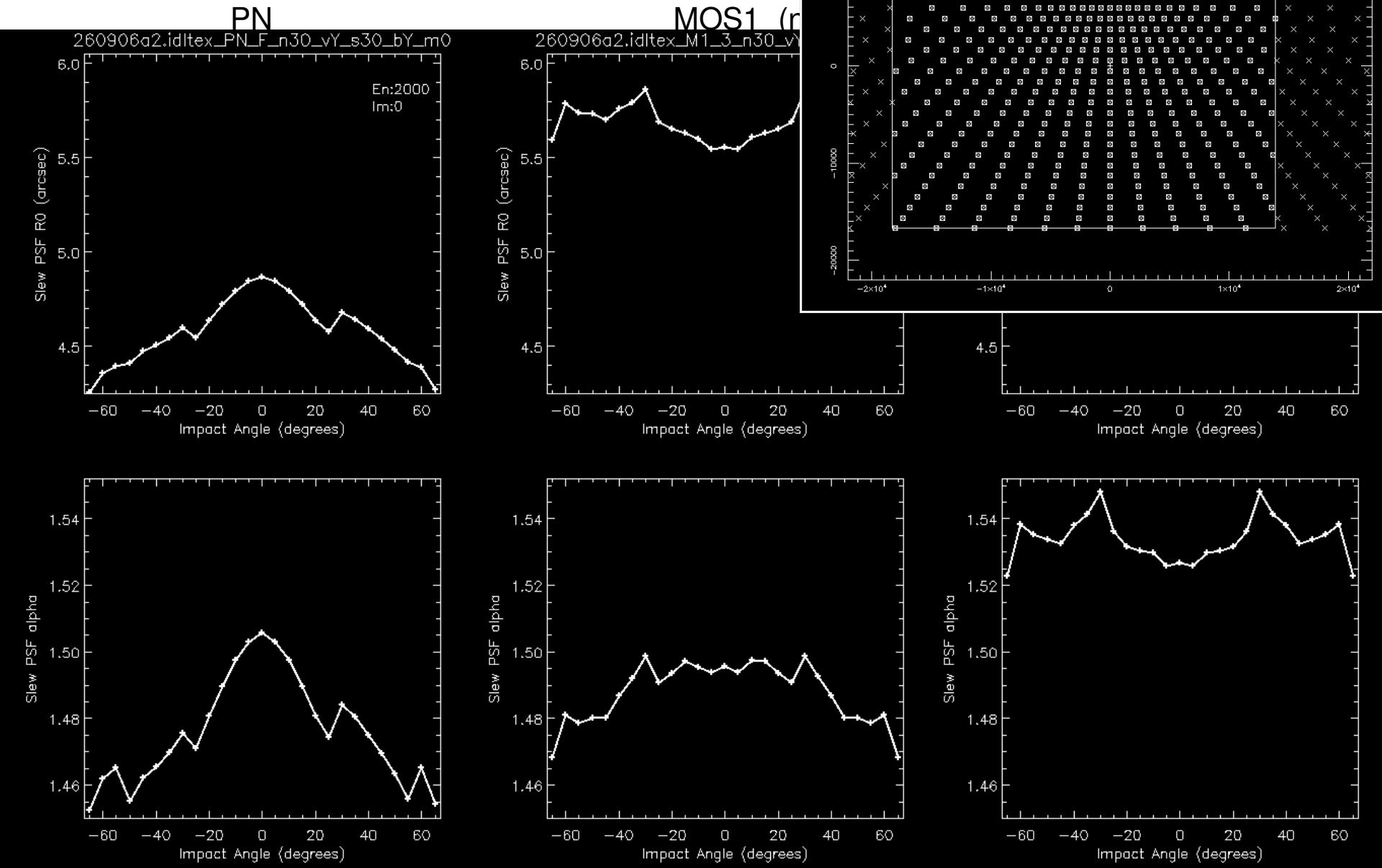
- r0 and alpha as function of impact parameter (zoom)
- impact angle=0, energy=2keV

MOS1 (no CCD6)

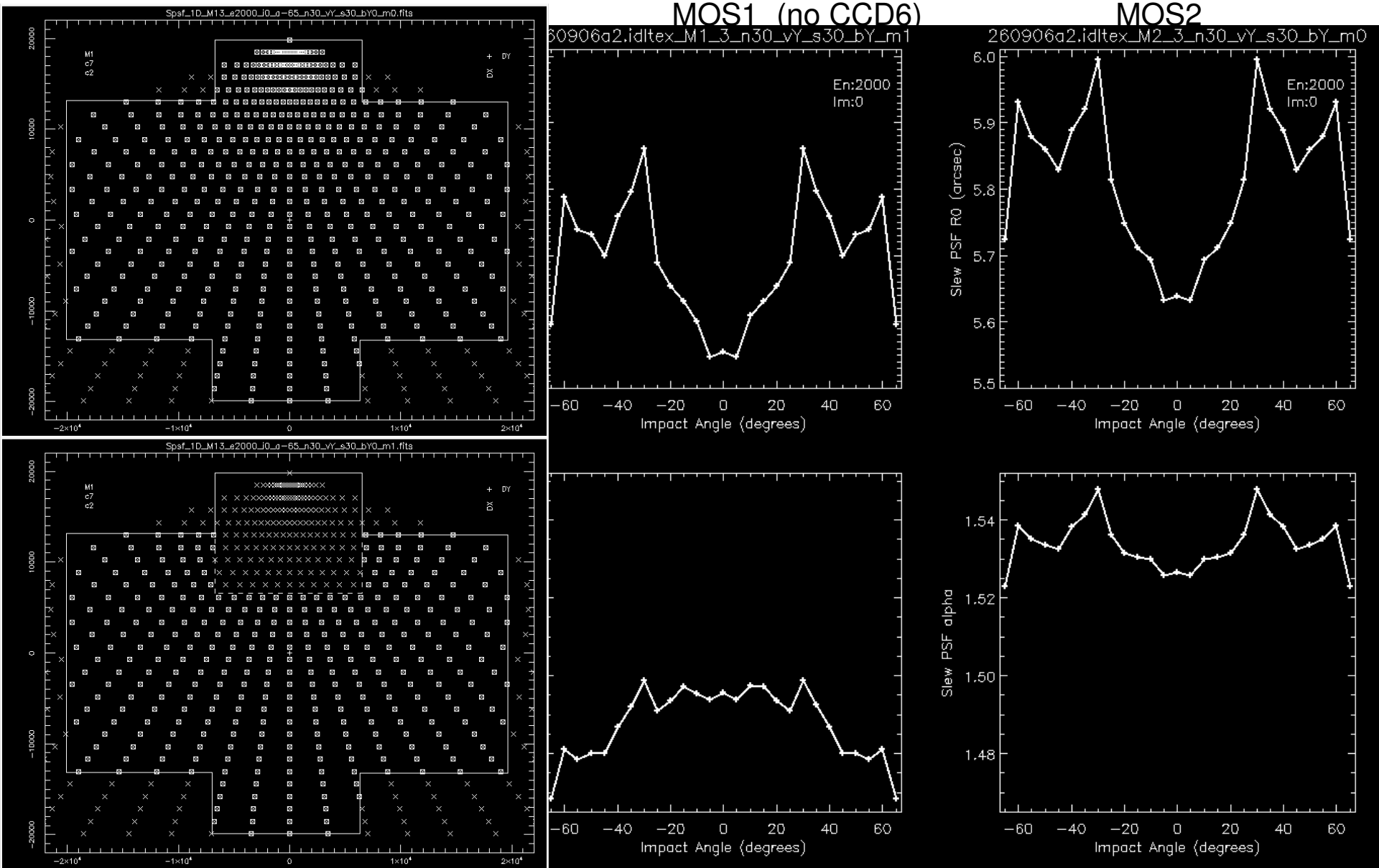
MOS2



- r0 and alpha as function of impact angle
- impact parameter=0, energy=2keV

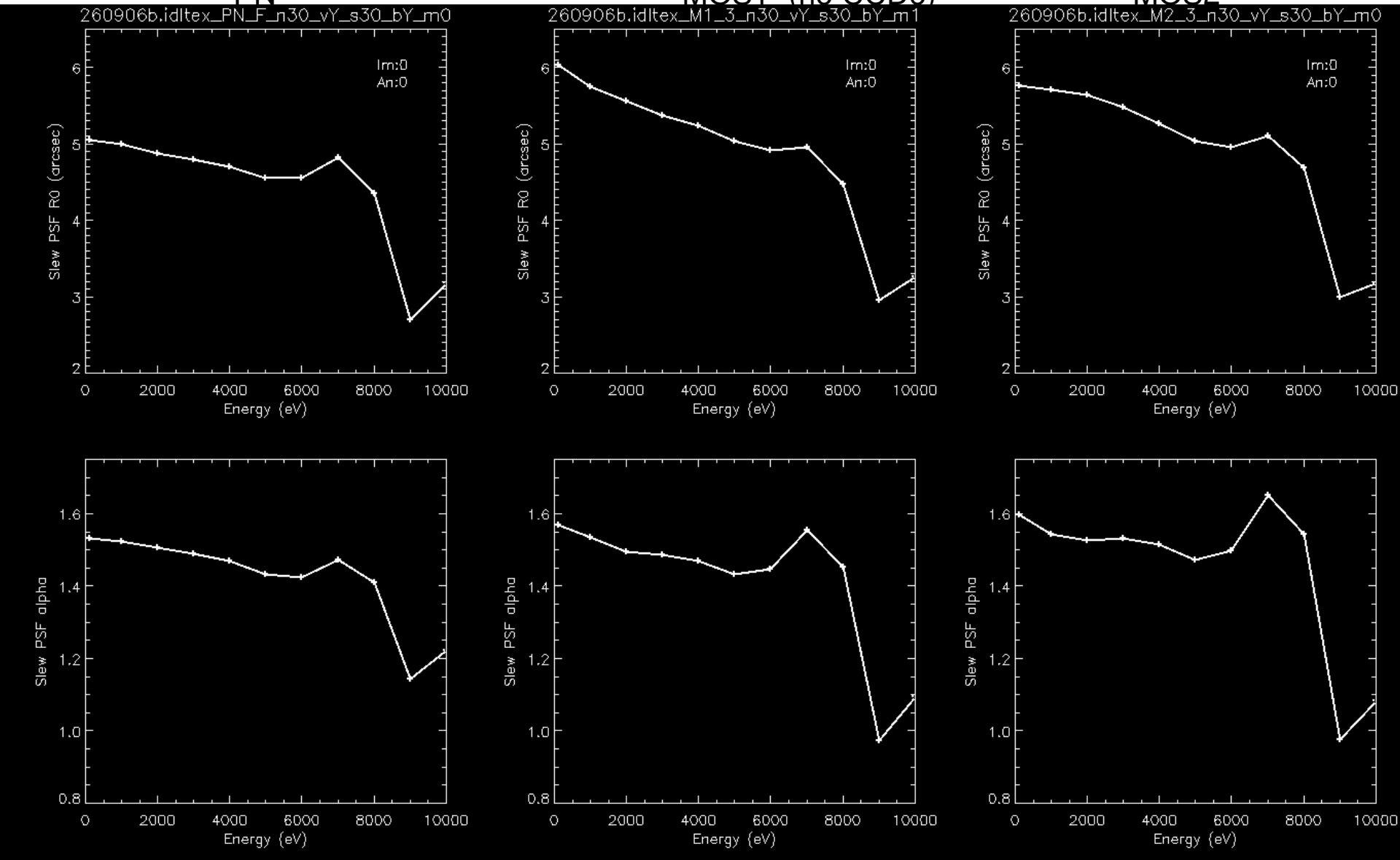


- r0 and alpha as function of impact angle (zoom)
- impact parameter=0, energy=2keV



- r0 and alpha as function of energy
- impact parameter=0, impact angle=0

PN | MOS1 (no CCD6) | MOS2

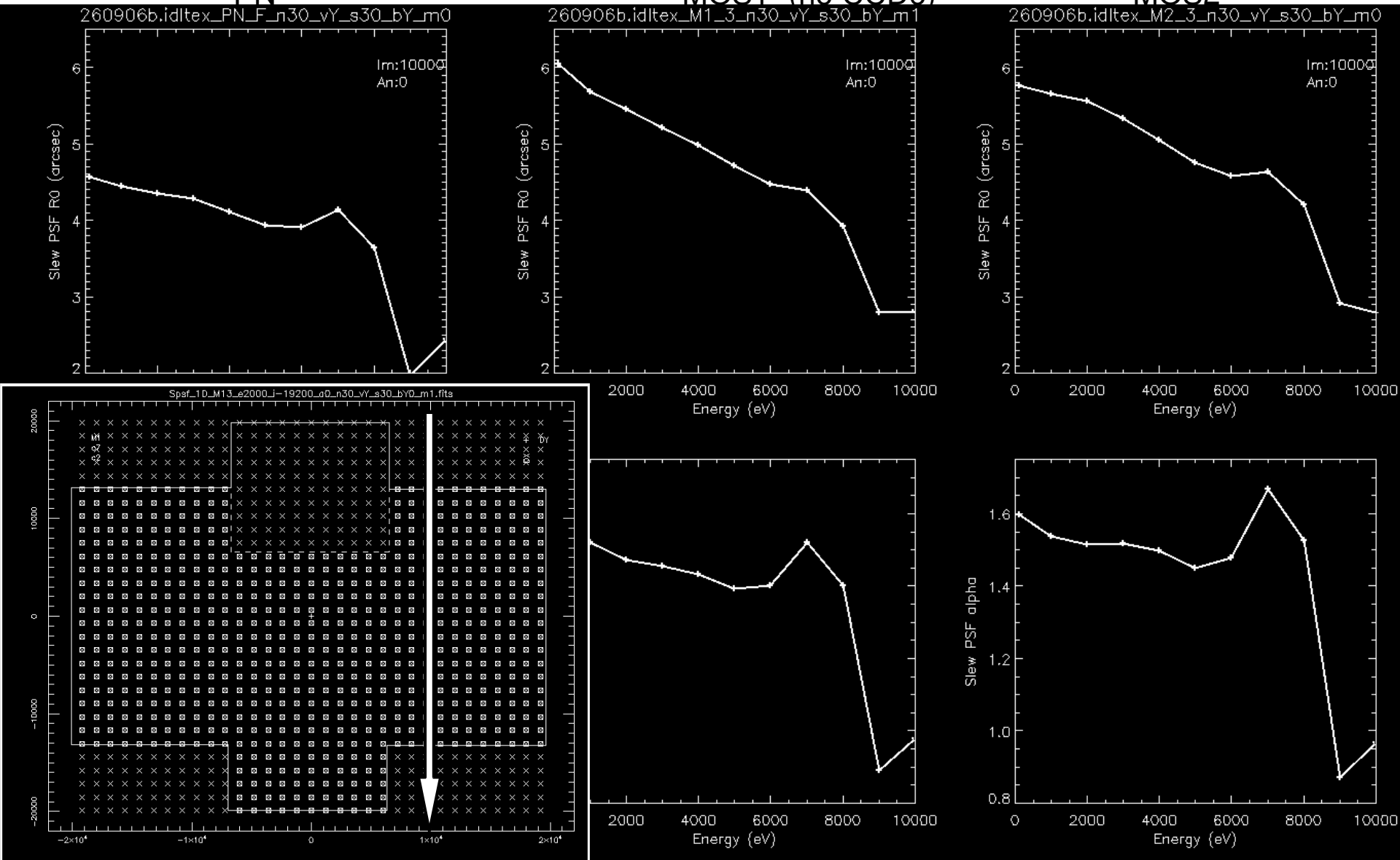


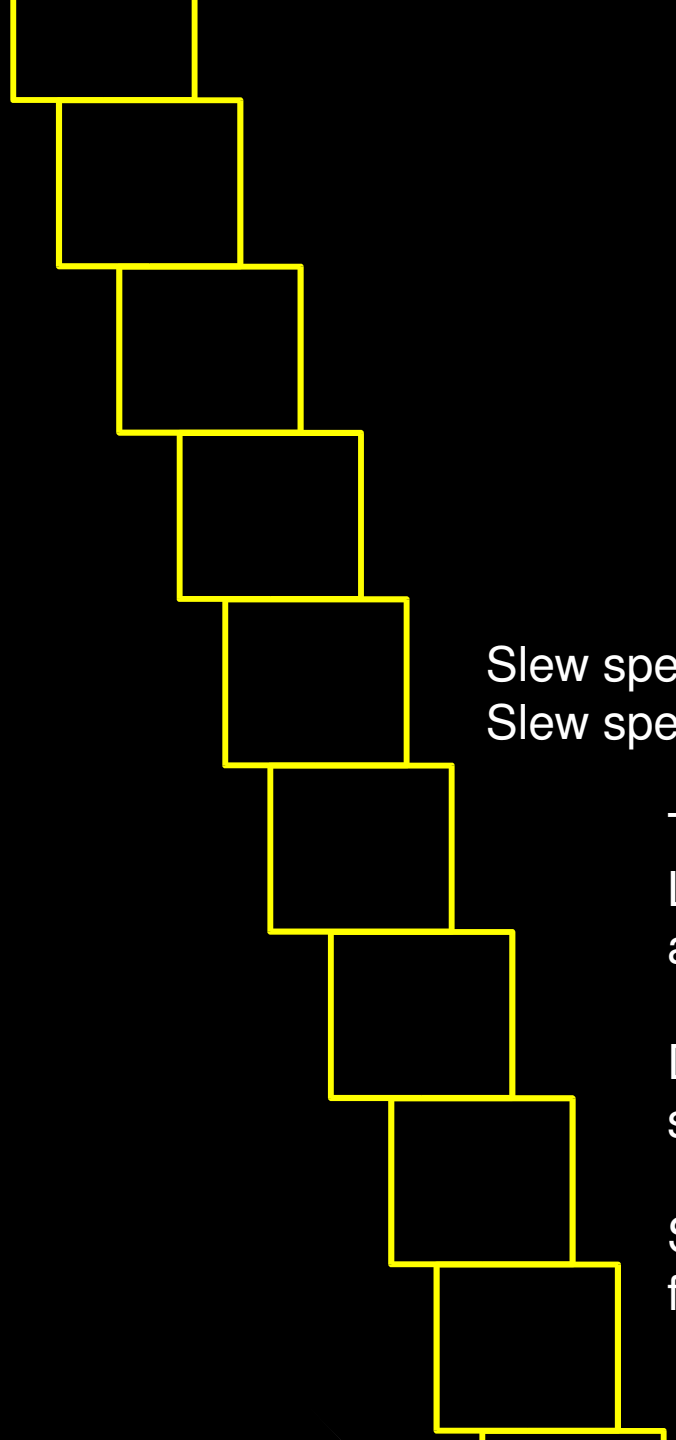
- r0 and alpha as function of energy
- impact parameter=10000, impact angle=0

PN

MOS1 (no CCD6)

MOS2





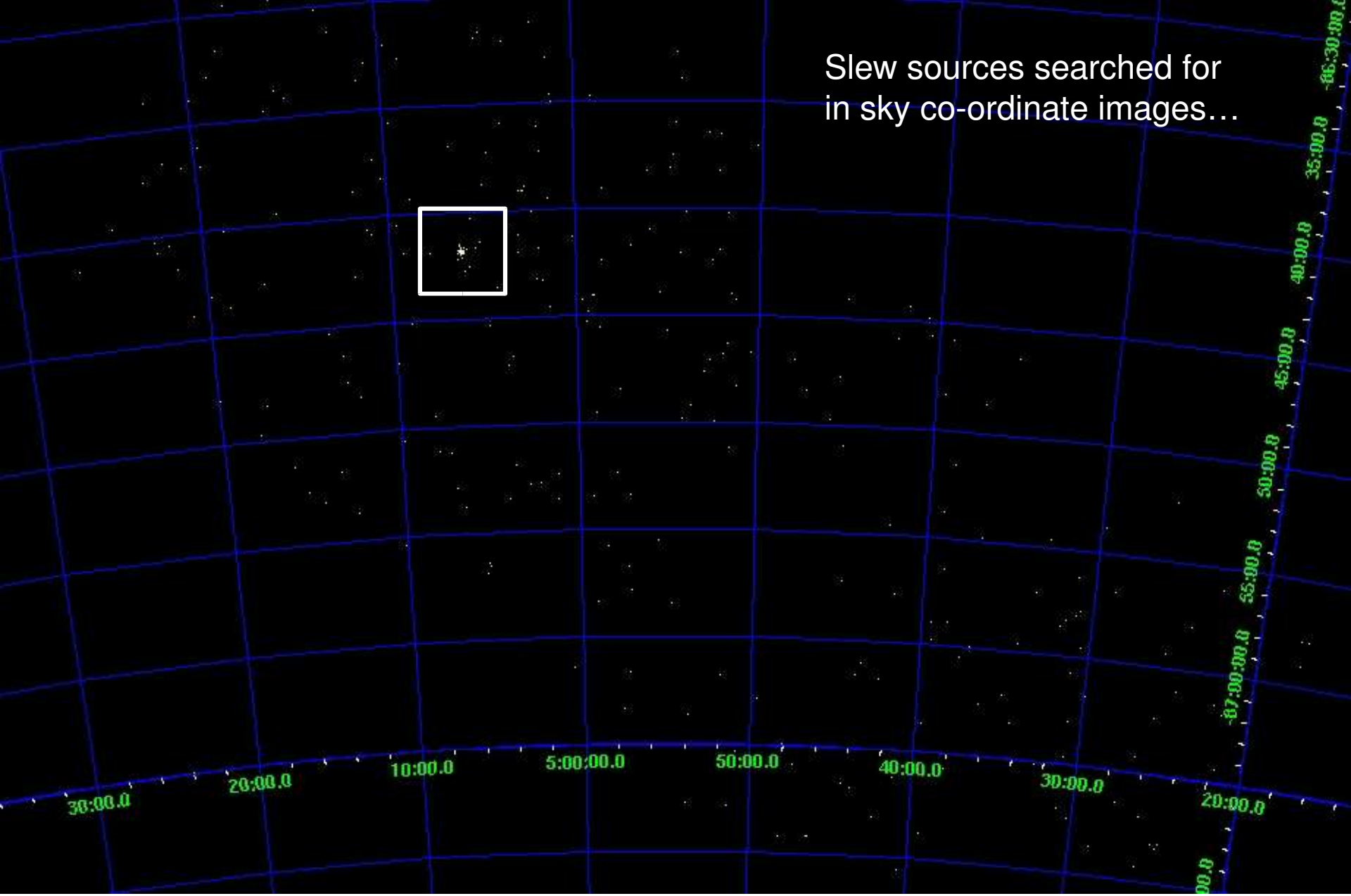
Slew speed = 90°/hr : on-source time <~12 s (mean ~8 s)
Slew speed = 30°/hr : on-source time <~36 s (mean ~24 s)

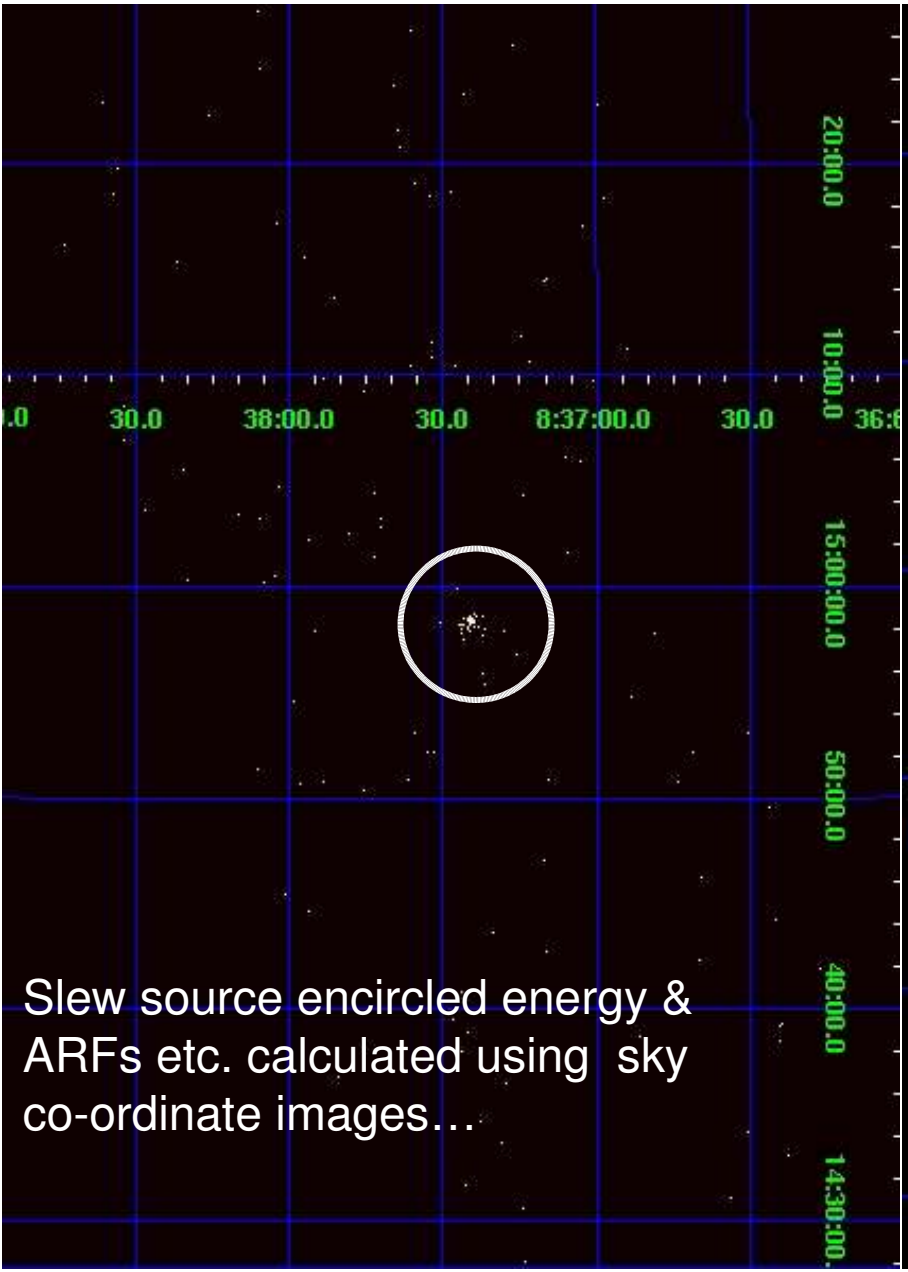
Tangential projection not valid over whole slew. Long slews need to be subdivided to maintain astrometry.

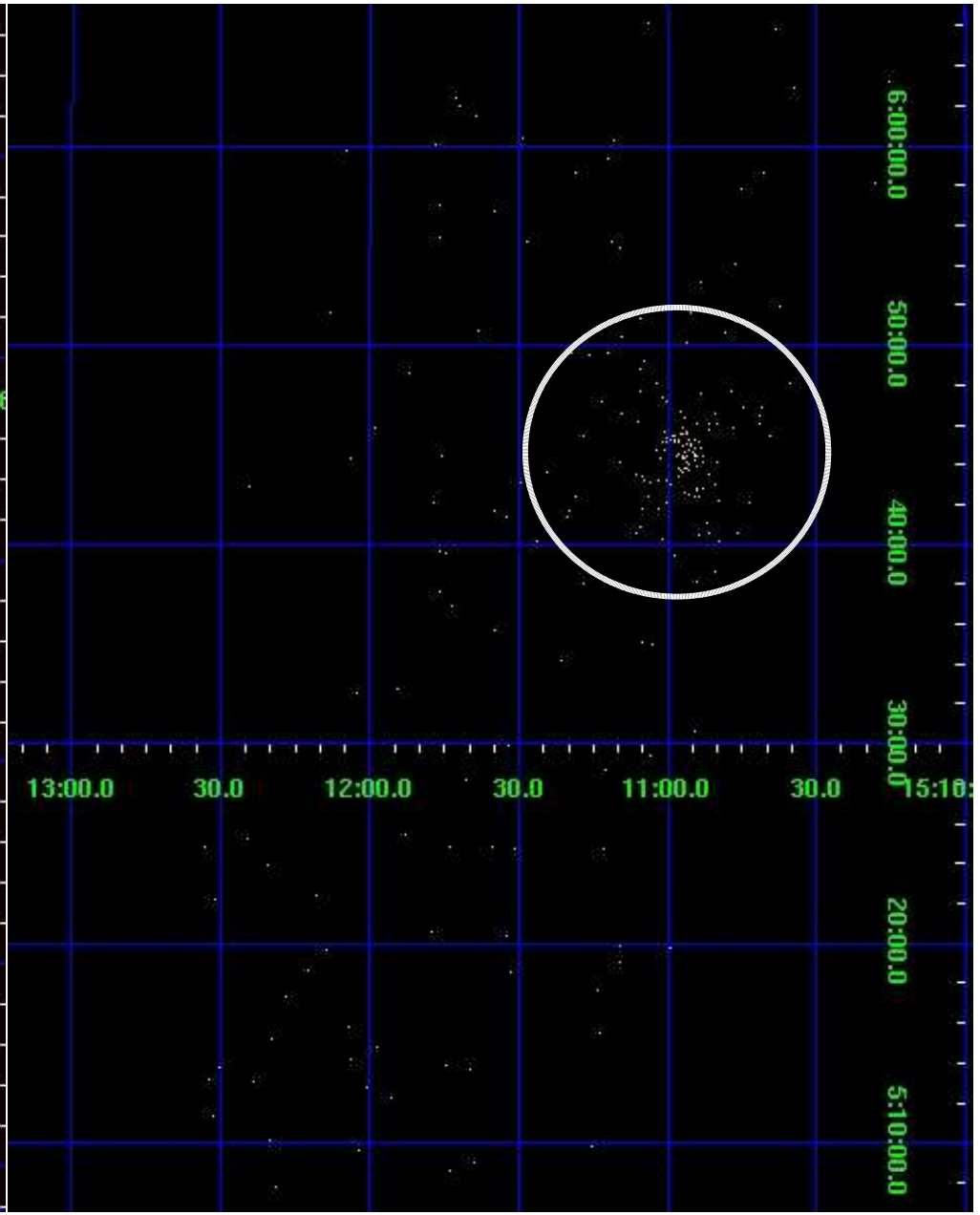
Divide slew into ~1 deg^2 images and recalculate sky positions.

Source search using near-standard pipeline tuned for ~zero background + New CCF files

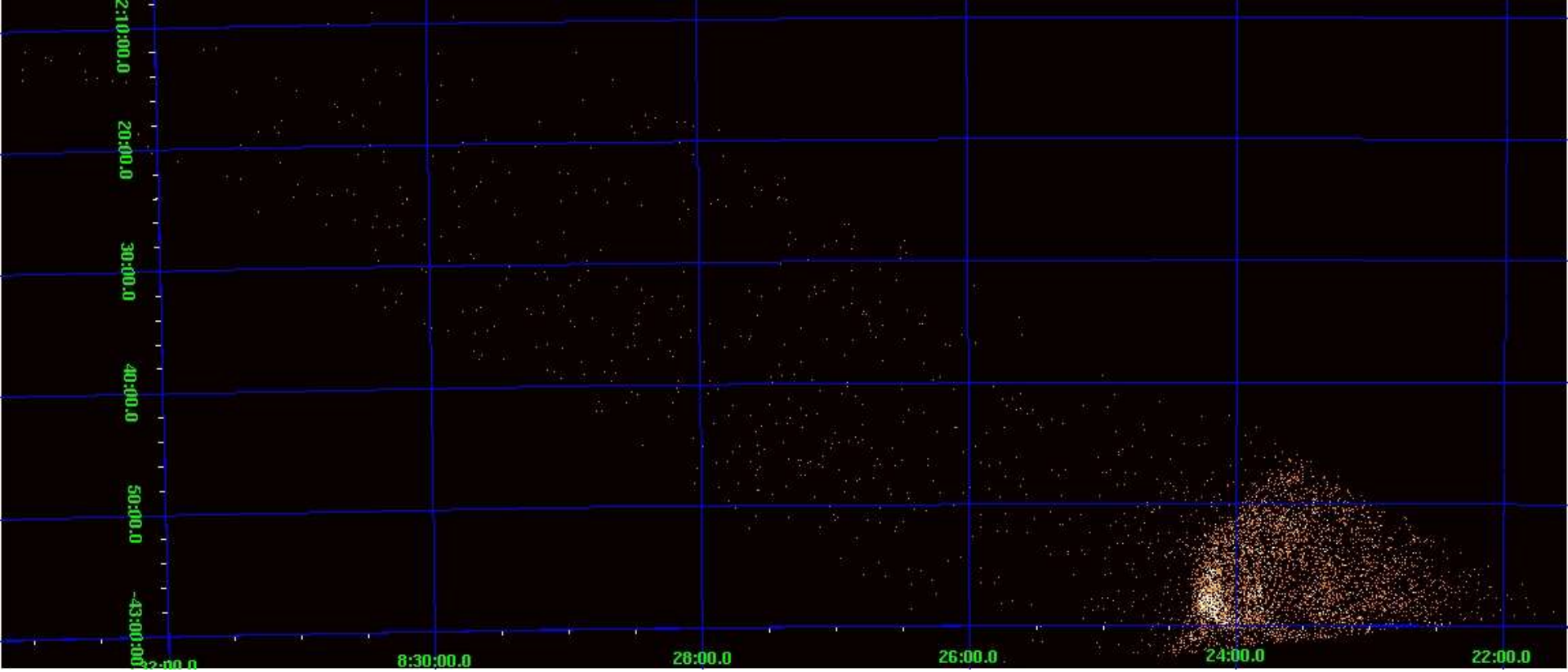
Slew sources searched for in sky co-ordinate images…







Slew source encircled energy & ARFs etc. calculated using sky co-ordinate images…

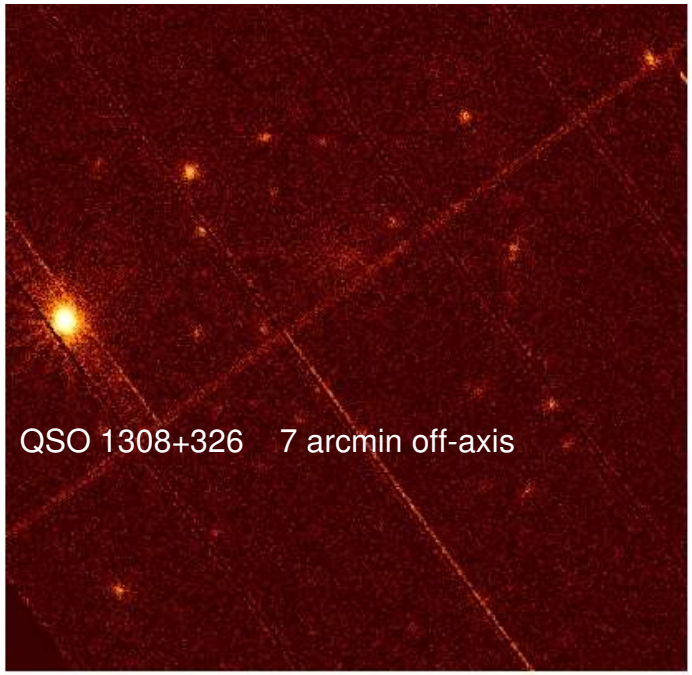


- Detector-Sky issues ?
- For pointed observations, sky and detector images are closely related… for slews, this may not be the case…
- When the source-searching finds a candidate source, how does it know what PSF is appropriate (i.e. what b,) ?
- Similarly for arfgen – how does it know what the appropriate PSF is ?

- Closing thoughts…

Azimuthal MOS-RGA vignetting variations not included

Will always be ~0? If not, may need a whole extra dimension of CCF entries (easy to produce)



- Slewing-mode PSFs (1-D & 2-D) calculated using current CCF pointed PSFs
- Improvements in pointed PSFs, especially off-axis (ongoing) lead easily & directly to improved slewing-mode PSFs