SSM Calibration

Ground & Onboard Calibration Aspects

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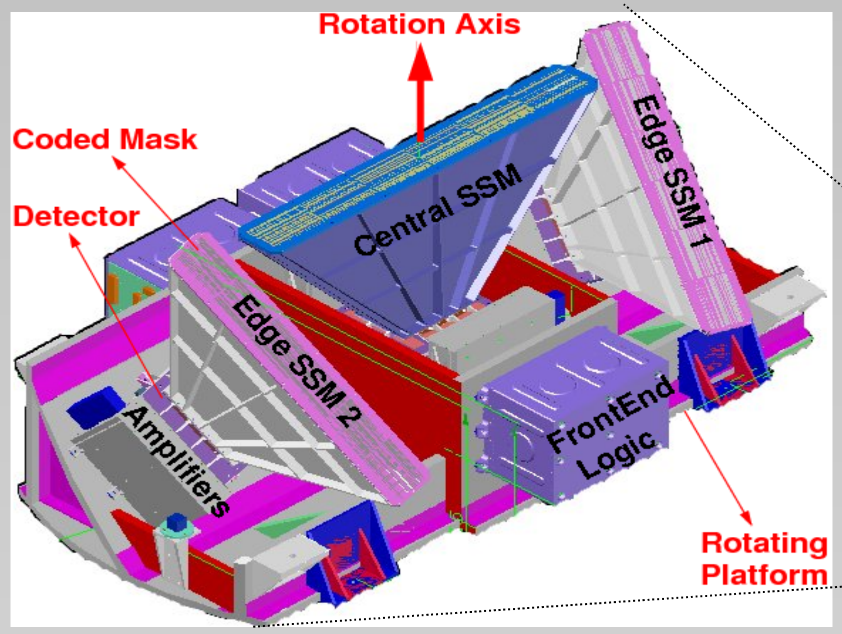
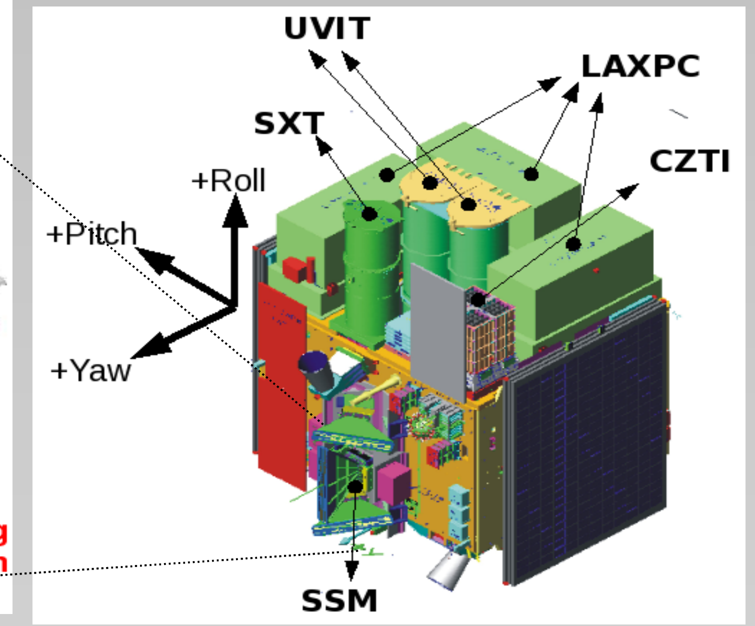
AstroSat Calibration Meeting

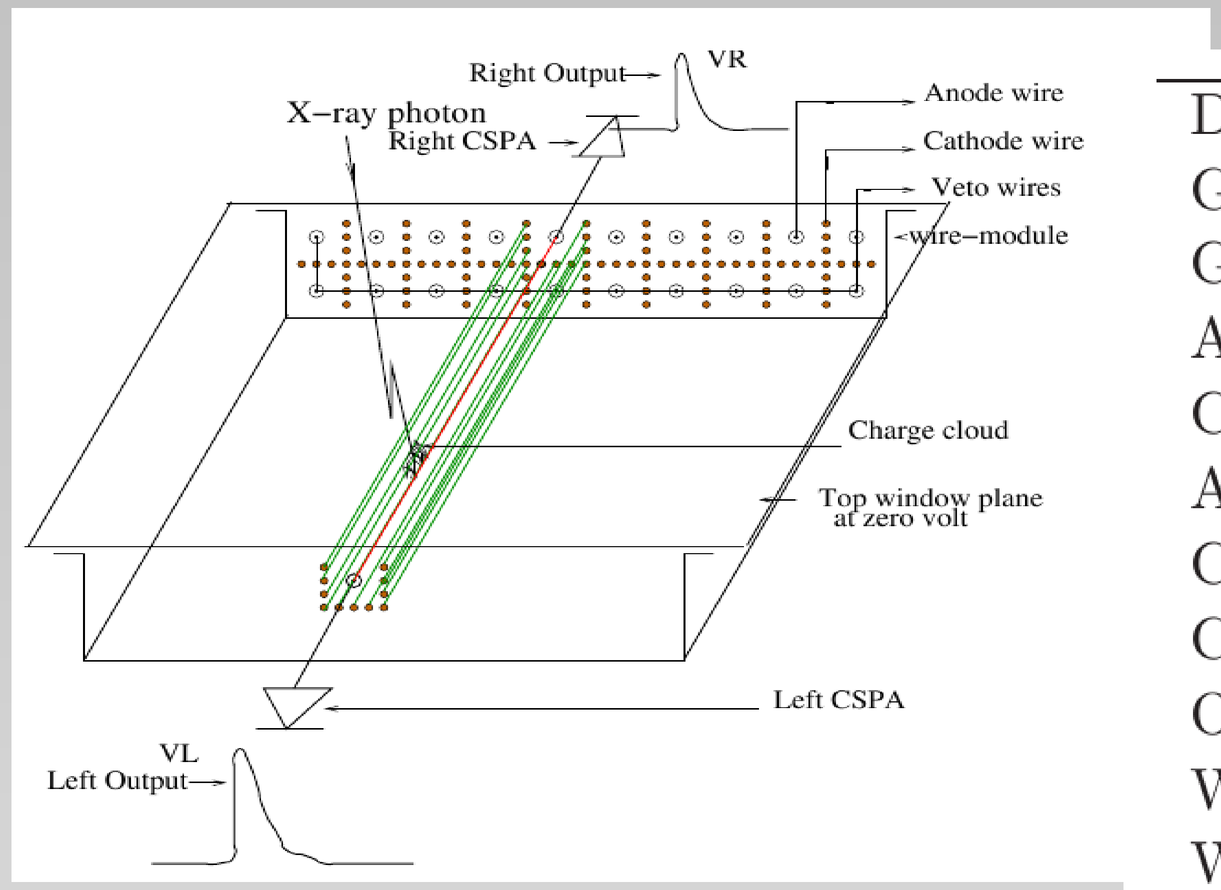
23 Aug 2022

Instrument Details

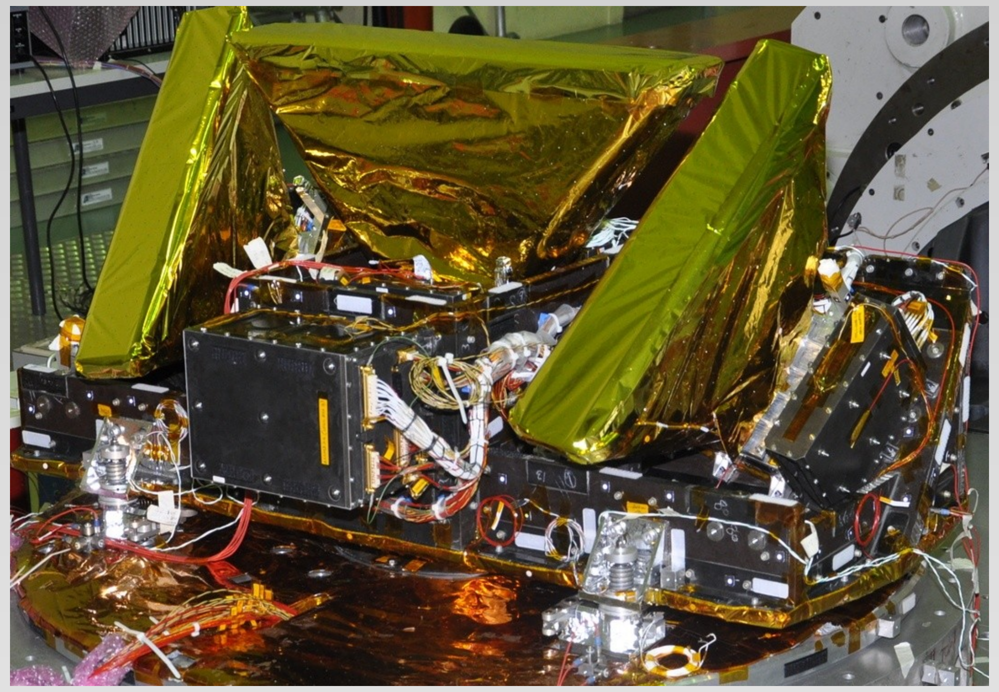
Position sensitive Porpotional counters with 1D coded mask for imaging

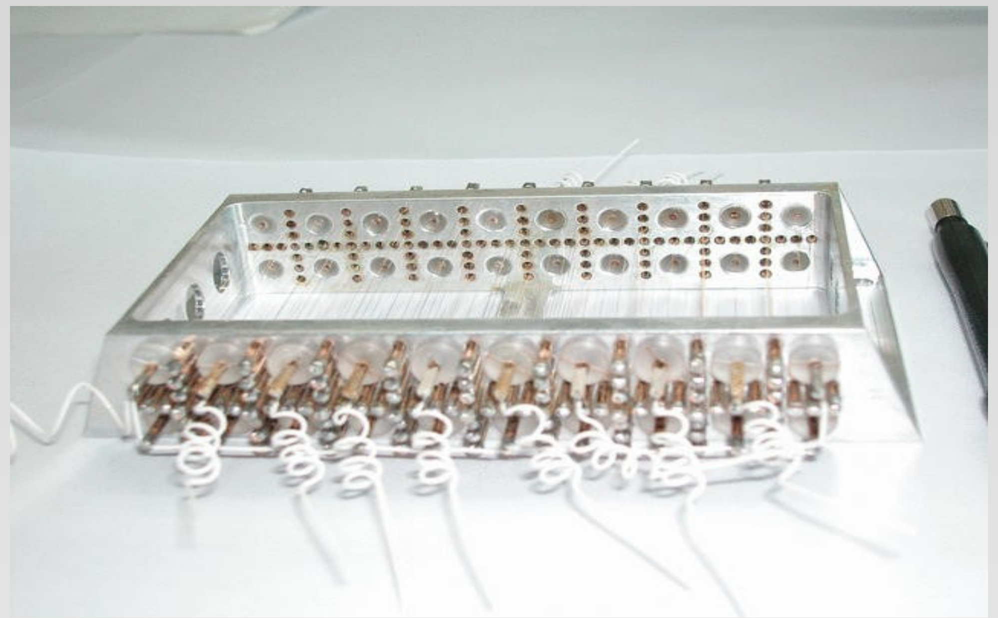






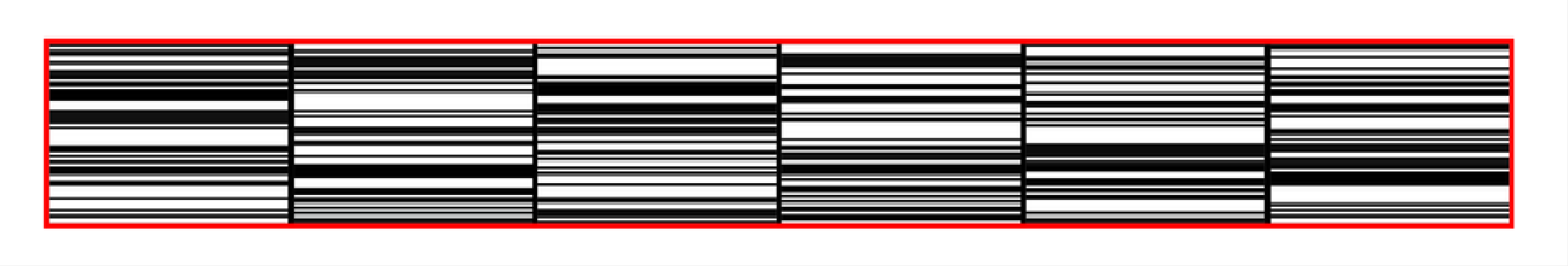
Detector	Position-sensitive gas proportional counter
Gas mixture	25% Xe + 75% P-10
Gas pressure	800 torr
Anode wire	Carbon coated quartz
Cathode wire	Gold-coated tungsten
Anode diameter	25 microns
Cathode wire diameter	75 microns
Cell size	1.2 × 1.25 sq_cm
Operating Voltage	1500 Volts
Window	Aluminized Mylar
Window thickness	25 microns





- To detect and locate transient X-ray sources

- *Wide field 1-D coded-mask imaging*
- *3 almost identical SSM units*
- *Mounted on a rotating platform*
- *FOV of each SSM ~ 100 x 20 sq deg*



Imaging with SSM
Ground Calibration

- Caldb includes
  - Calibration constants - Position - Charge Ratio - Relation
  - Position Resolution along the anode (8 anodes in each SSM unit)
  - Anode Response along the length
  - Edge effects
  - Collimator Response

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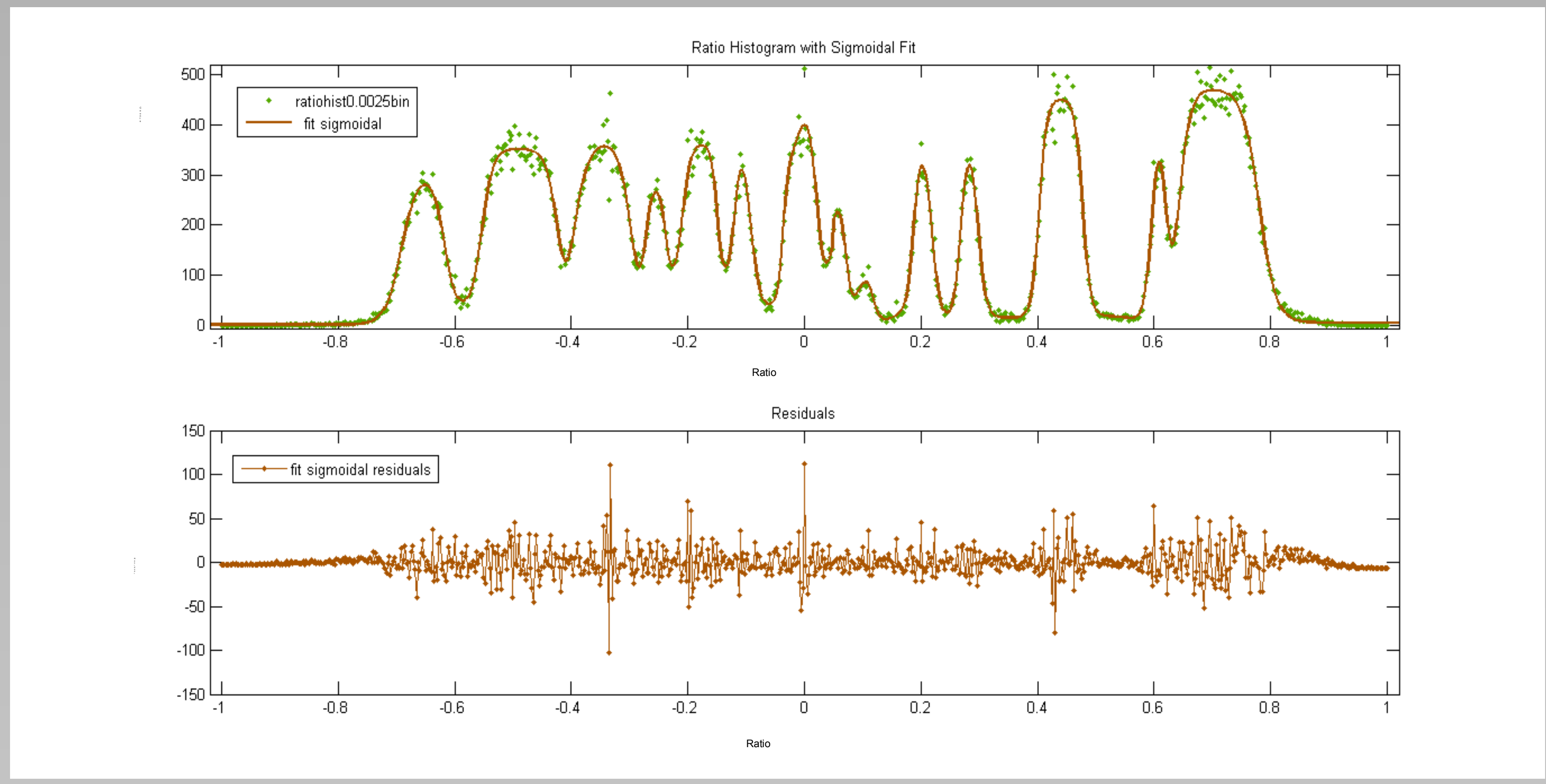
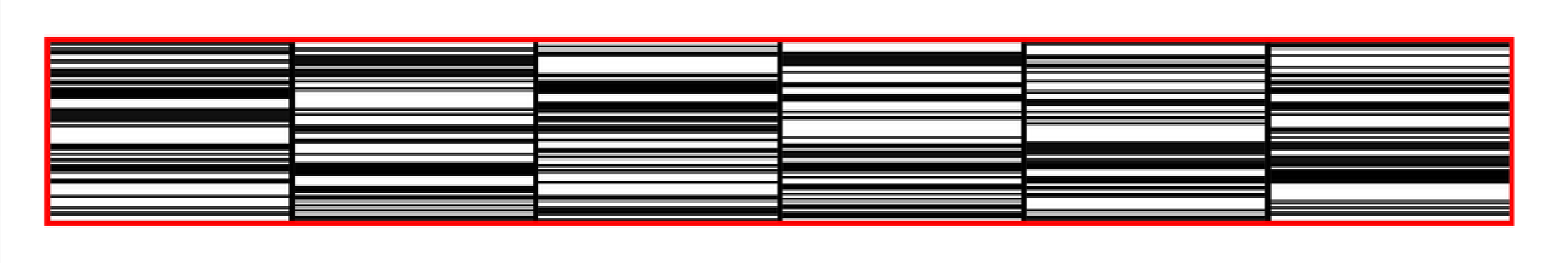


Calibration Constants

Position - Charge Ratio Relation

- Anode Ratio Histogram - obtained experimentally with coded-mask pattern
- Charge Ratio mapped against Position
- Fitted with G(x)=(p*x+q)/(x+r)
- To obtain p,q,r as the calibration constants
- Using the calibration constants, position of every event recorded in SSM is obtained and binned to get the Detector Position Histogram

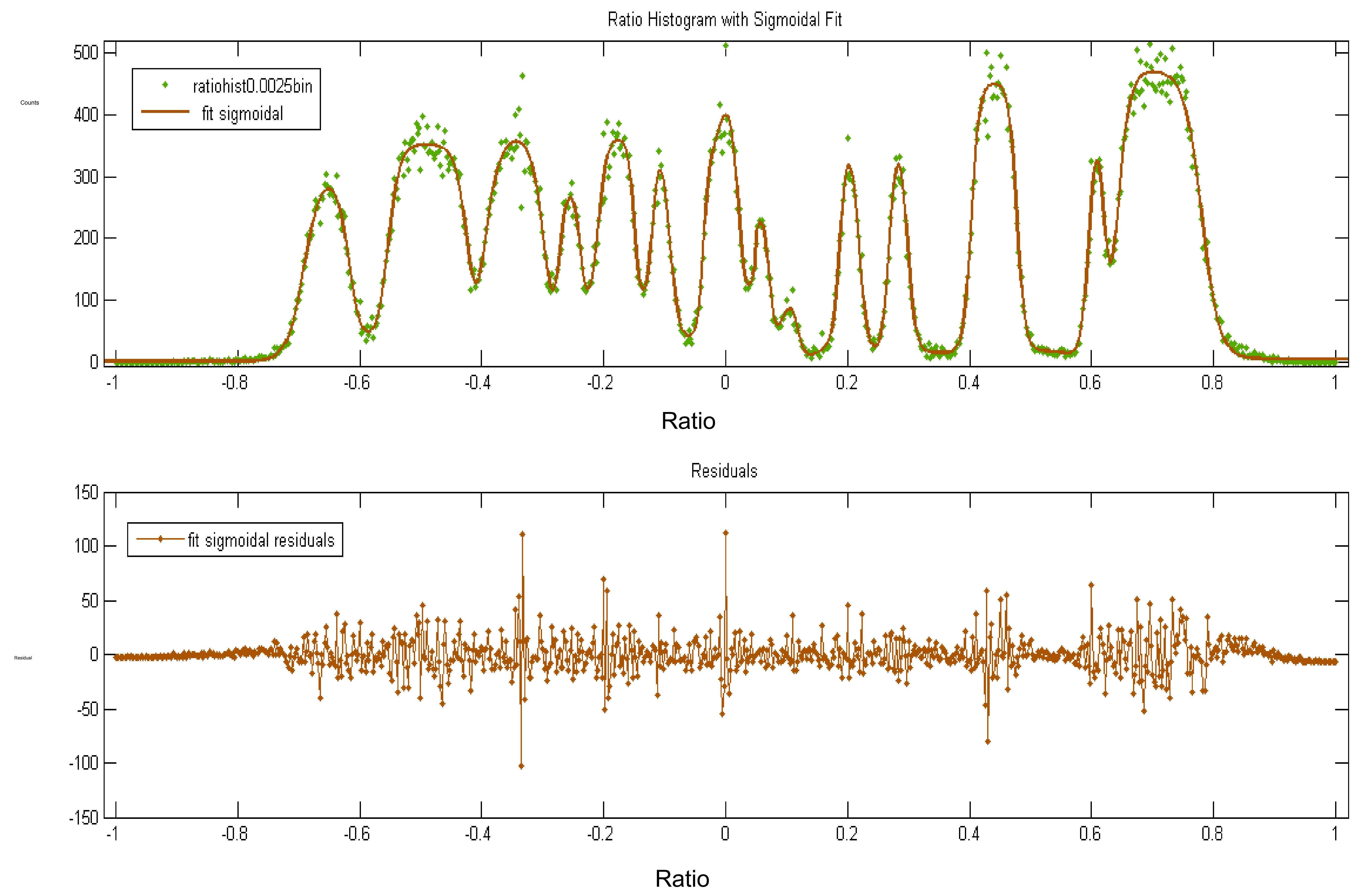


Anode Ratio Histogram

- **Deriving the calibration constants**
  - ARH (x);difference of two sigmoidal functions
  - S(x)=a1/(1+exp(-(x-b1)/c1))-a2/(1+exp(-(x-b2)/c2))
  - Multiple of such functions (S(x)) are used to fit the ratio distribution of anode wire A1 obtained by shining X-ray gun through coded mask on SSM FM2 detector. As there are 14 openings the function used will be

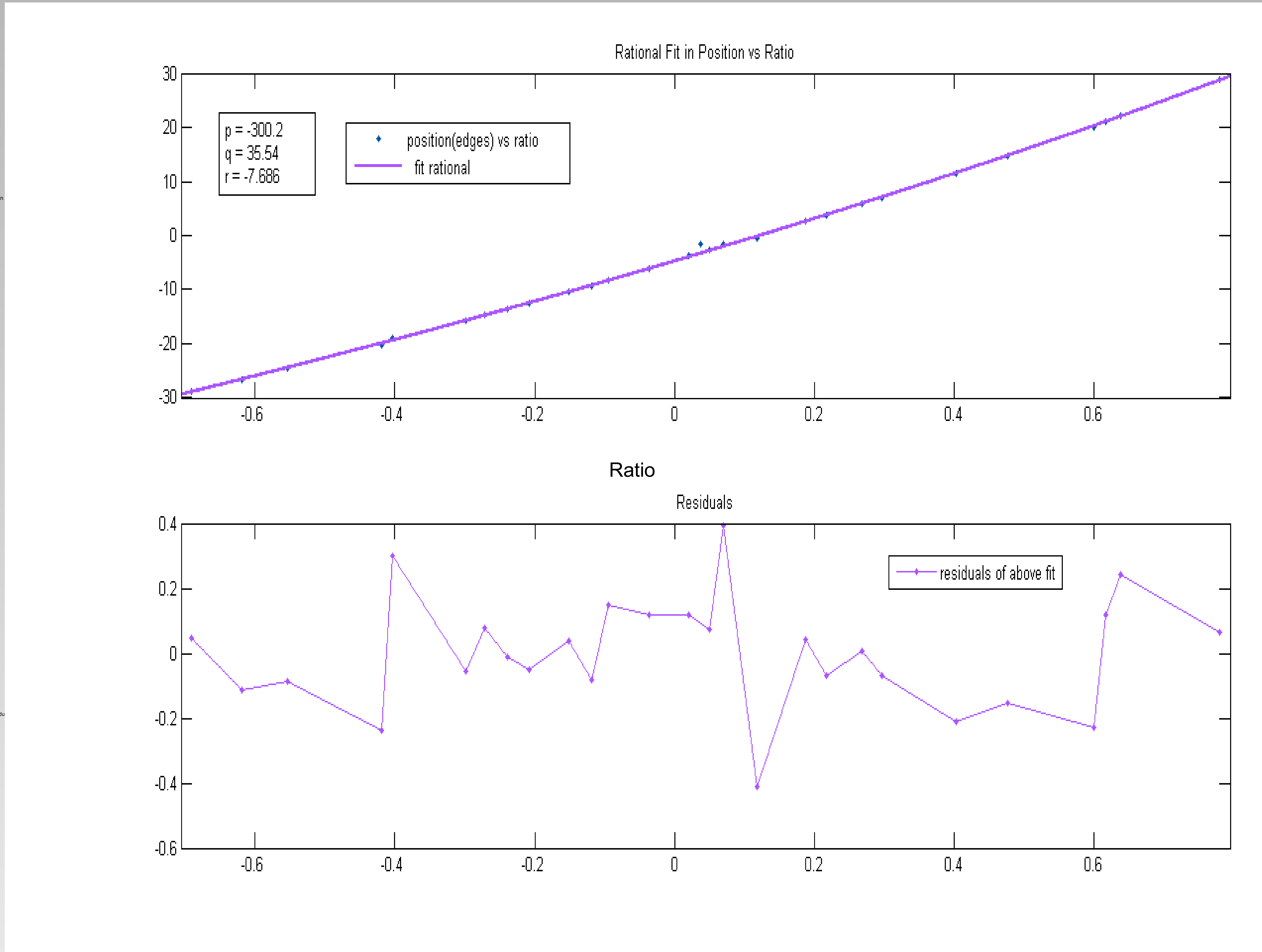
S(x)=S1(x)+S2(x)+.....+S14(x)

  - Figure shows the ratio distribution with sigmoidal fit.



Charge Ratio - vs- Position

- Charge Ratio mapped with Position
- Fitted with g(x) a function
- G(x)=(p*x+q)/(x+r)
- This gives the calibration constants for one anode which are p,q and r
- The same is repeated for all 8 anodes to derive the calibration constants for every SSM unit



Ratio

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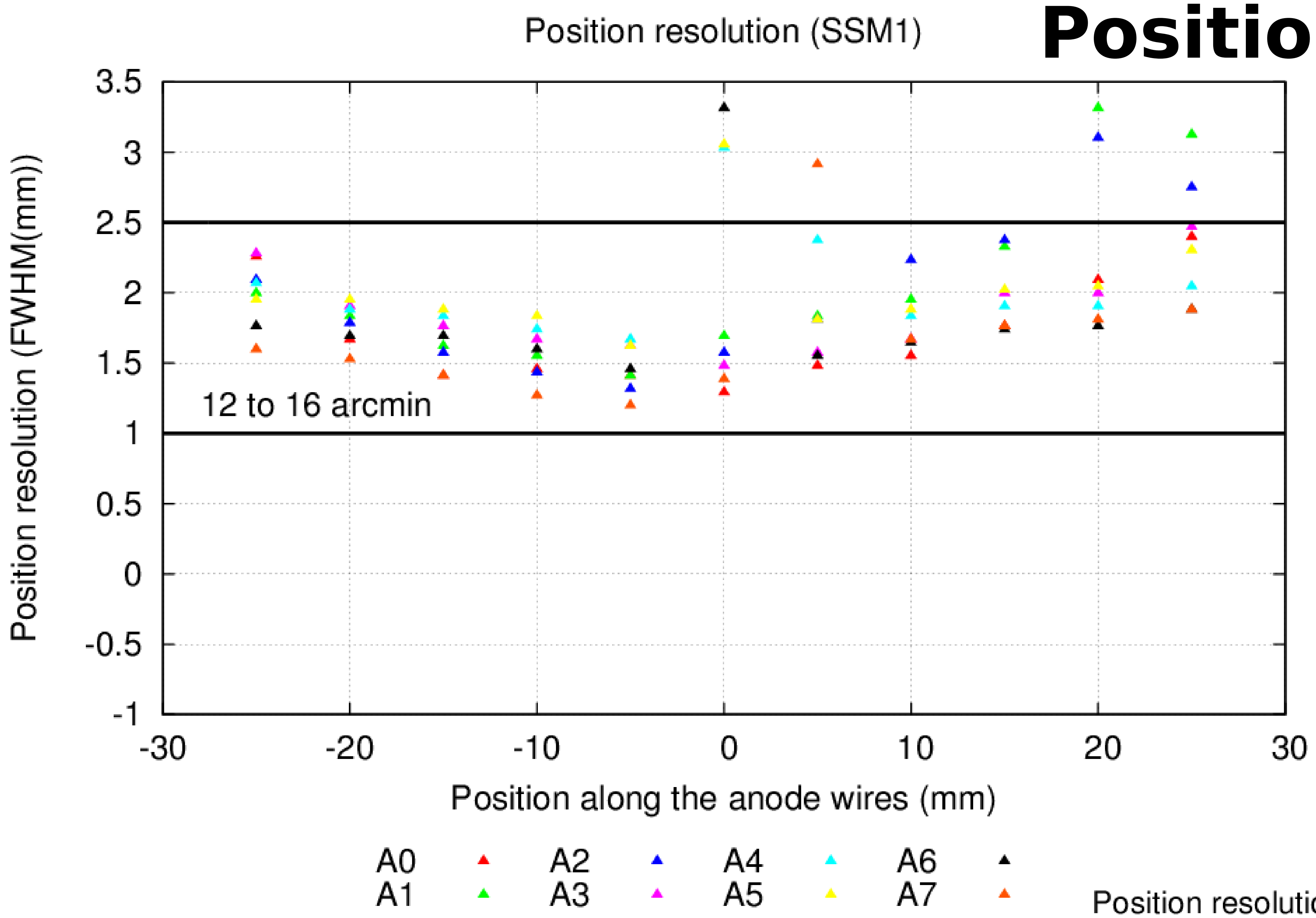
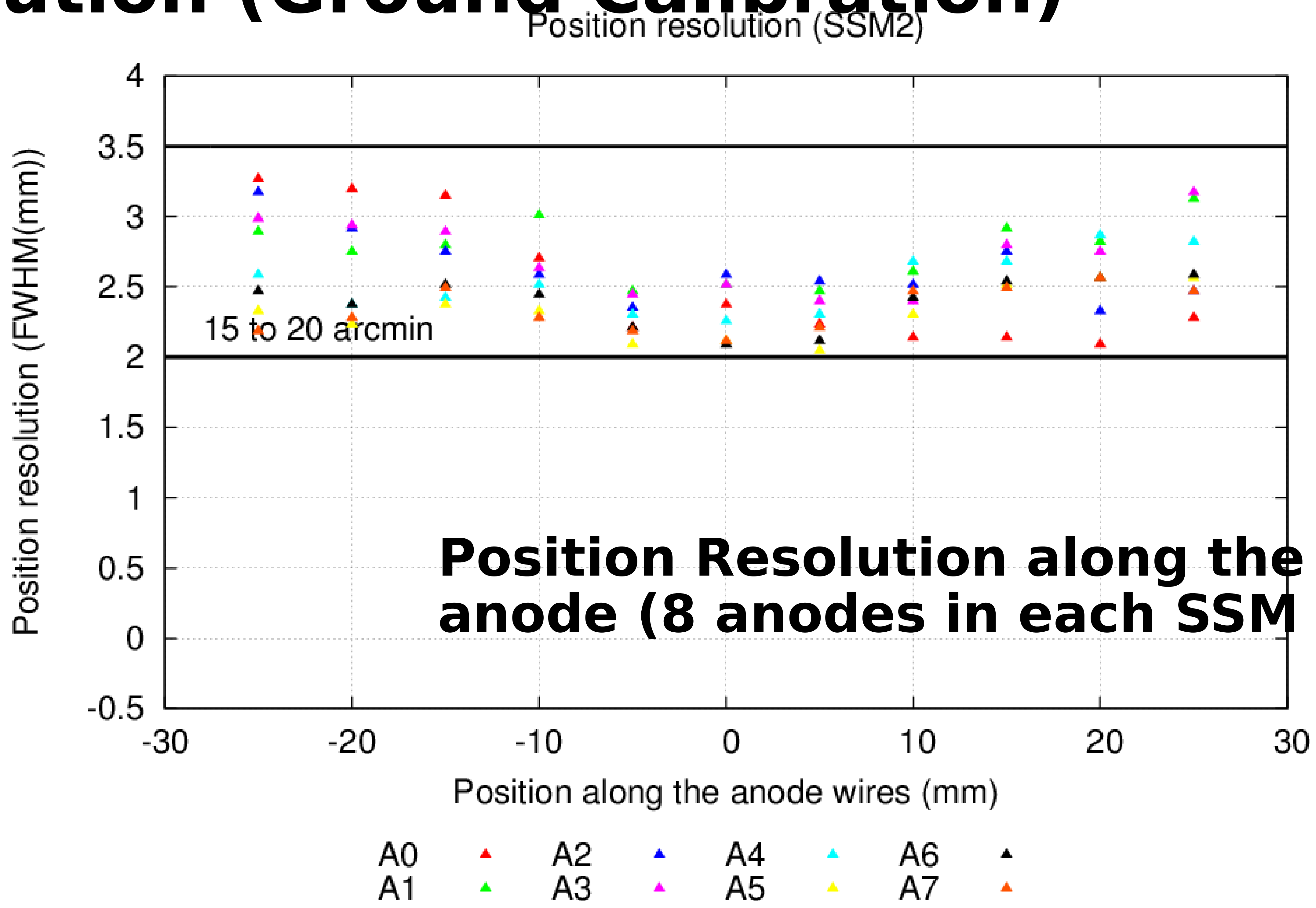
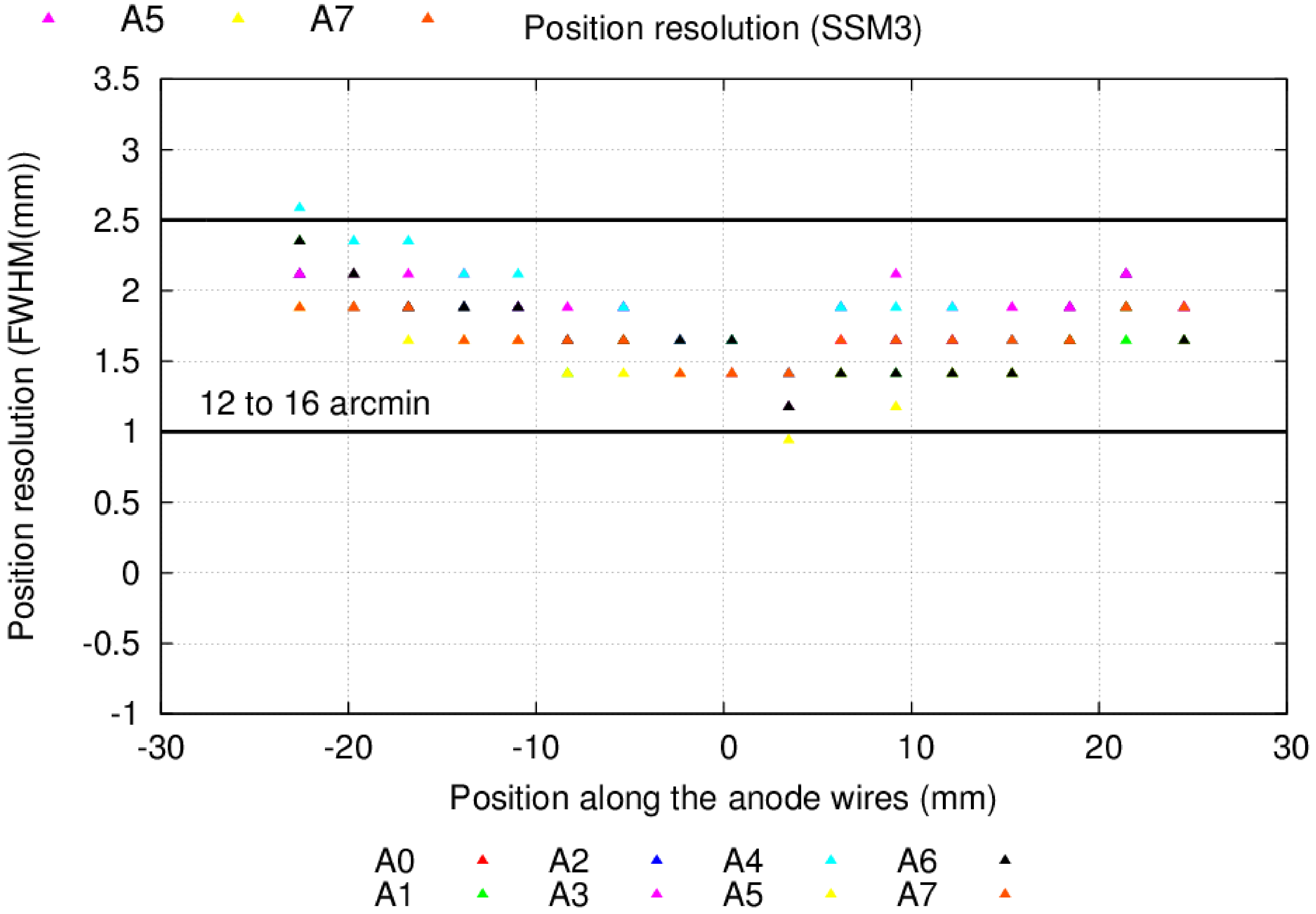
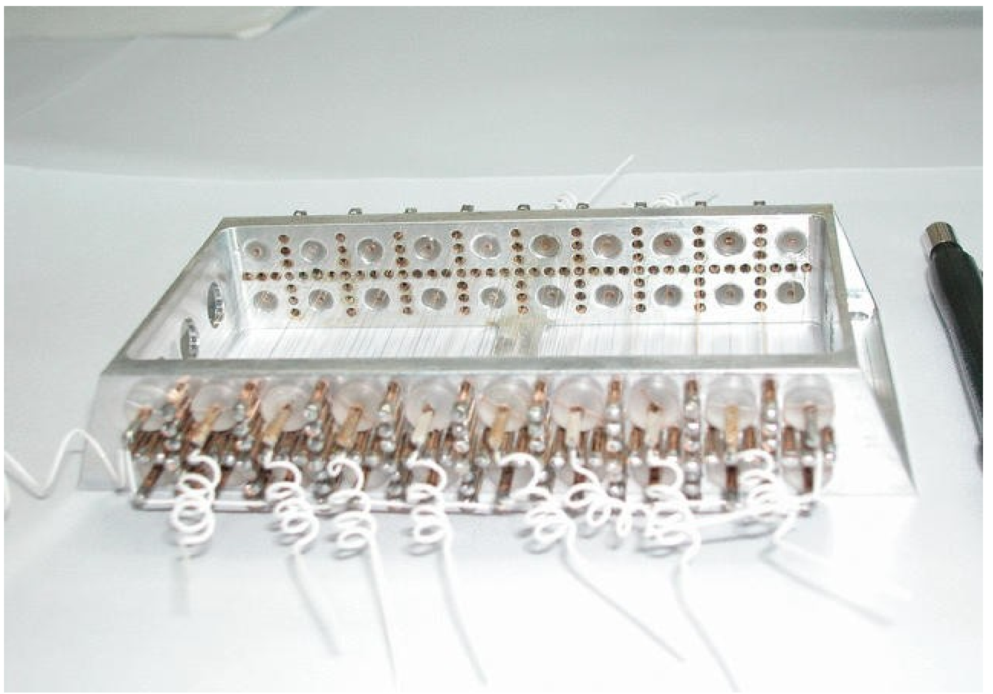
Position resolution (Ground Calibration)

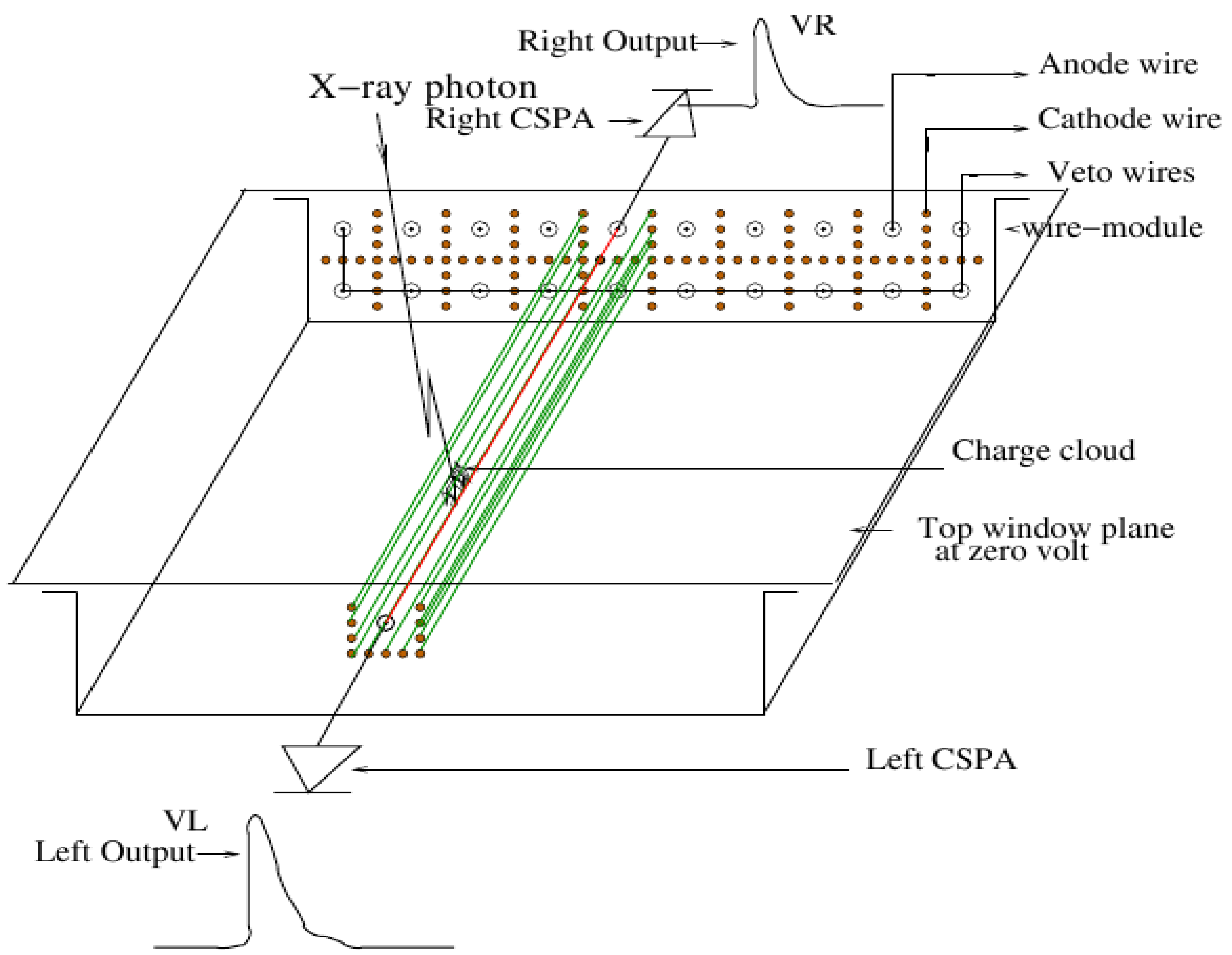




Position Resolution along the anode (8 anodes in each SSM unit)







Imaging with SSM
Ground Calibration

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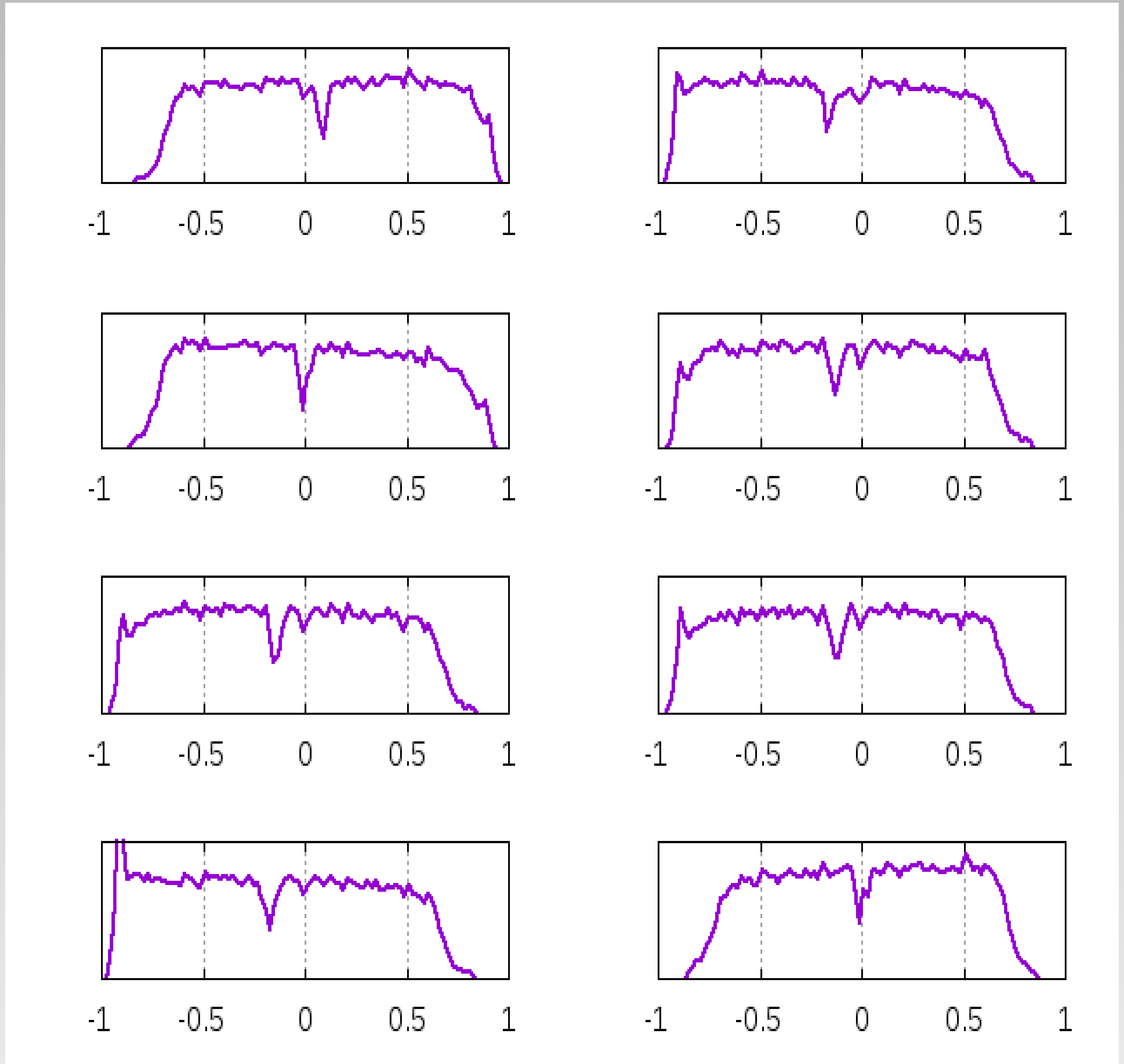
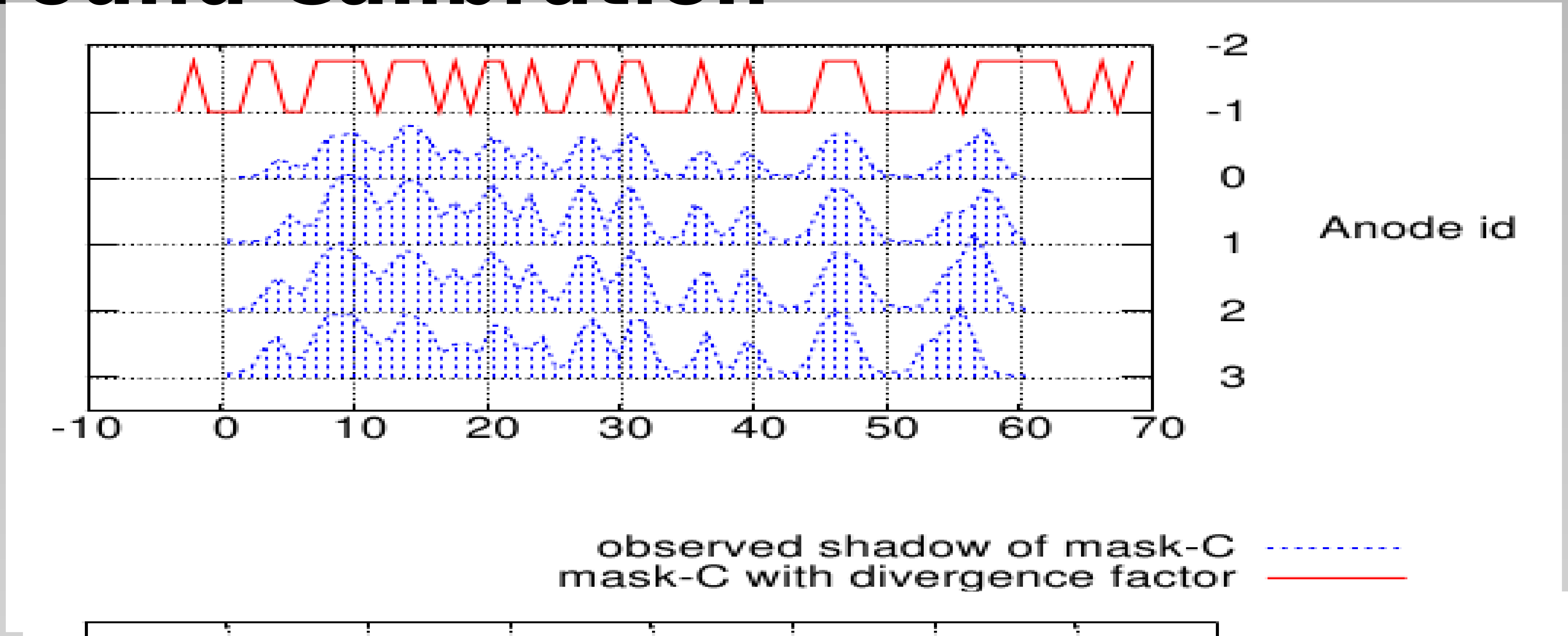
Anode Response (Ground Calibration)

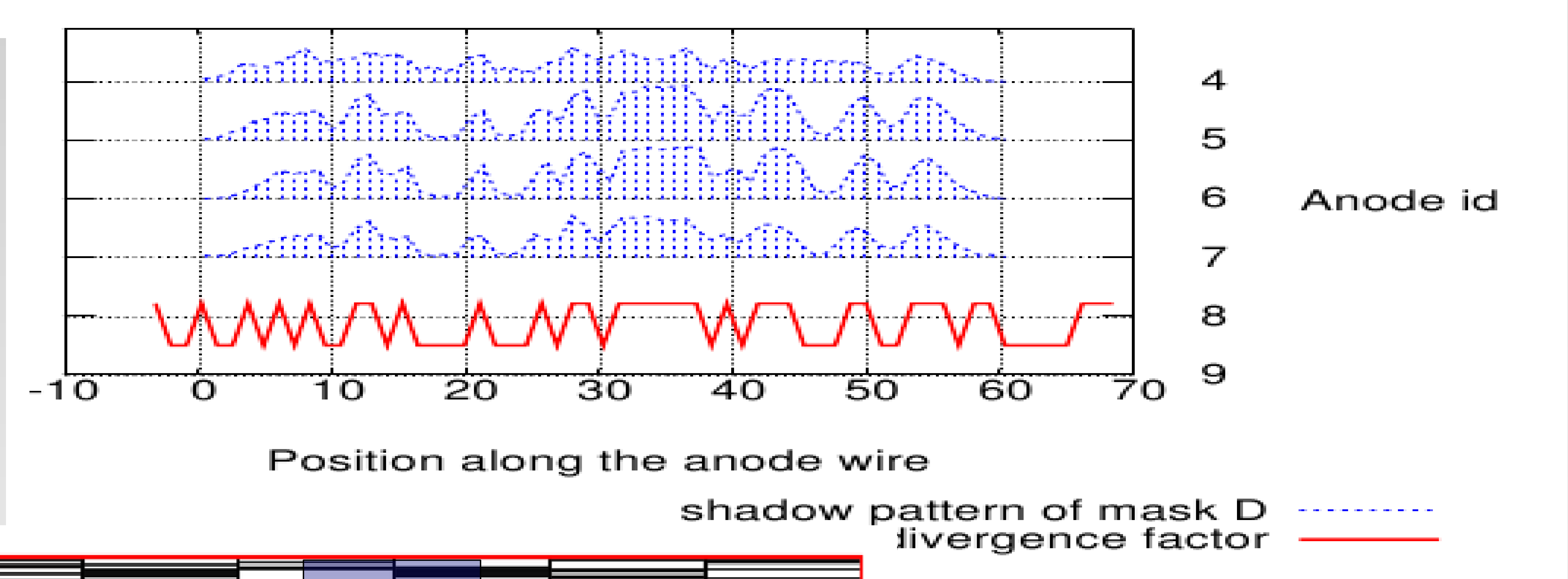


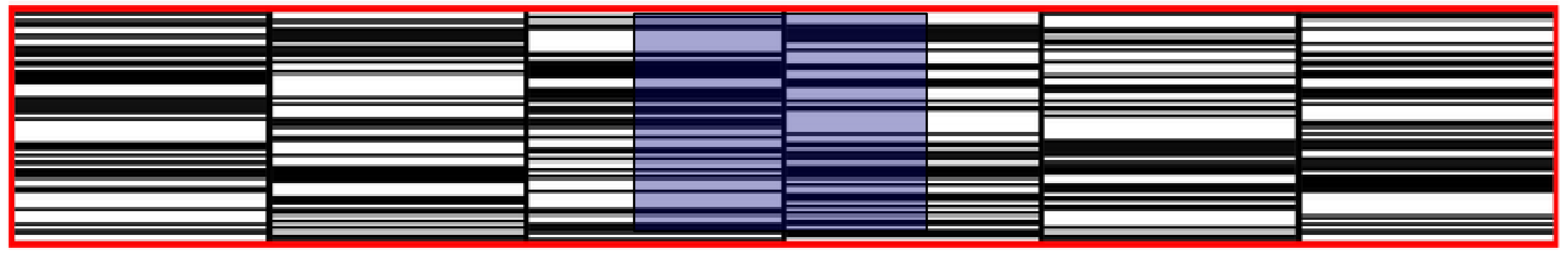
- Detector plane is illuminated with X-ray source uniformly
- Anode responses for one of the flight model – Ratio vs normalised counts
- Edges of the anode have lower gains and hence the efficiency of recording a photon drops at the edges
- Central dip is due to the calibration wire at the mechanical centre of the anode wire

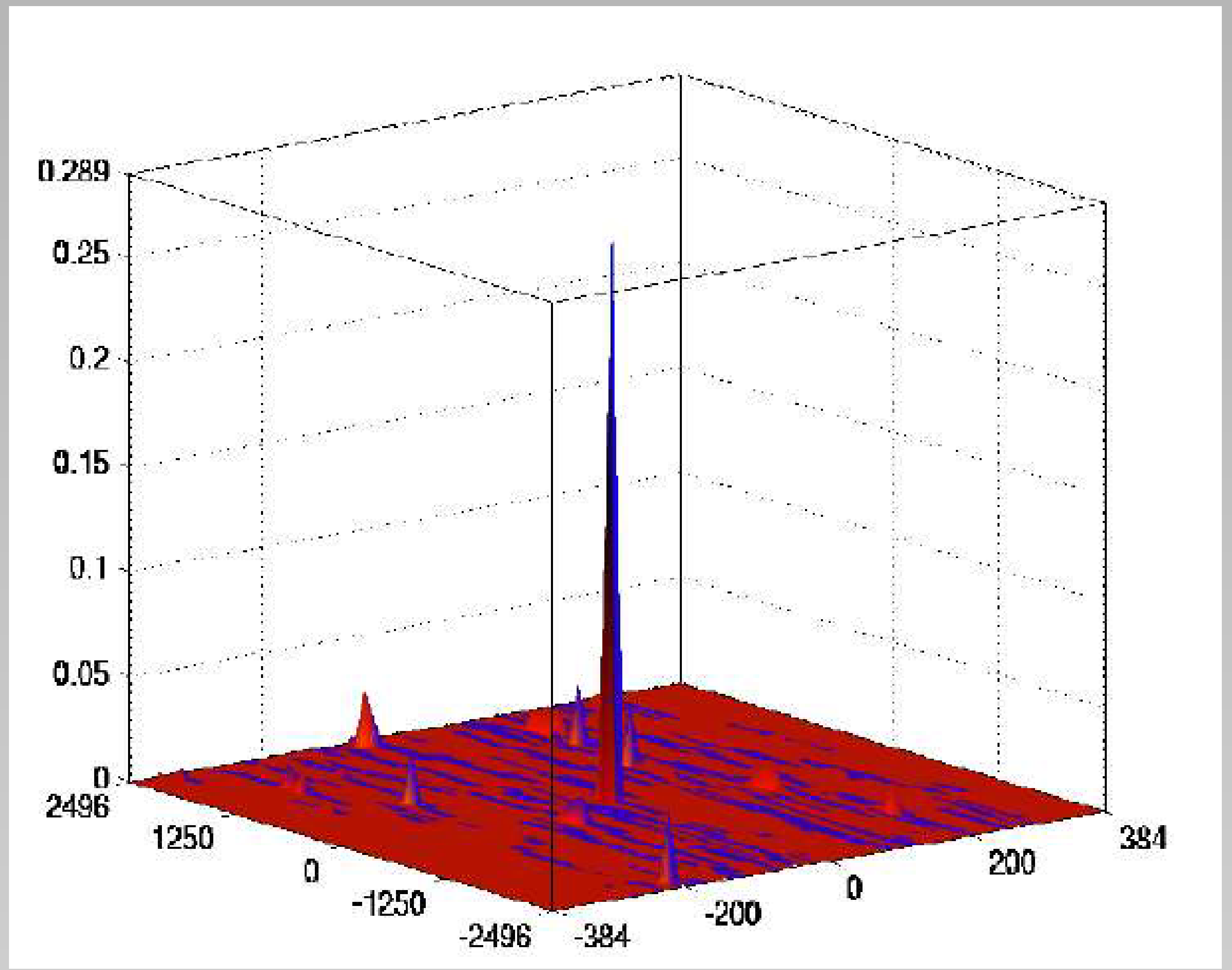
Imaging with SSM

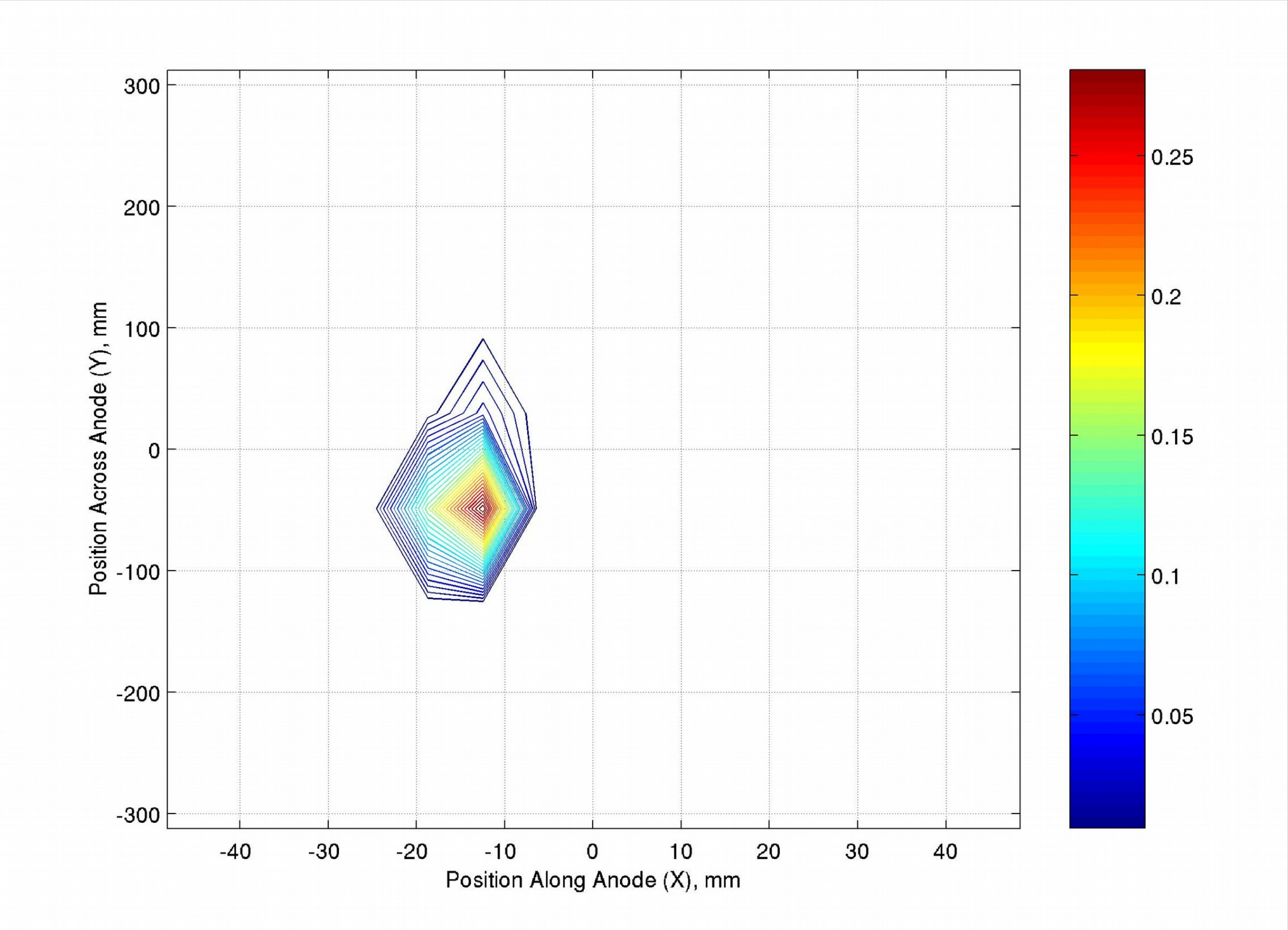
Ground Calibration









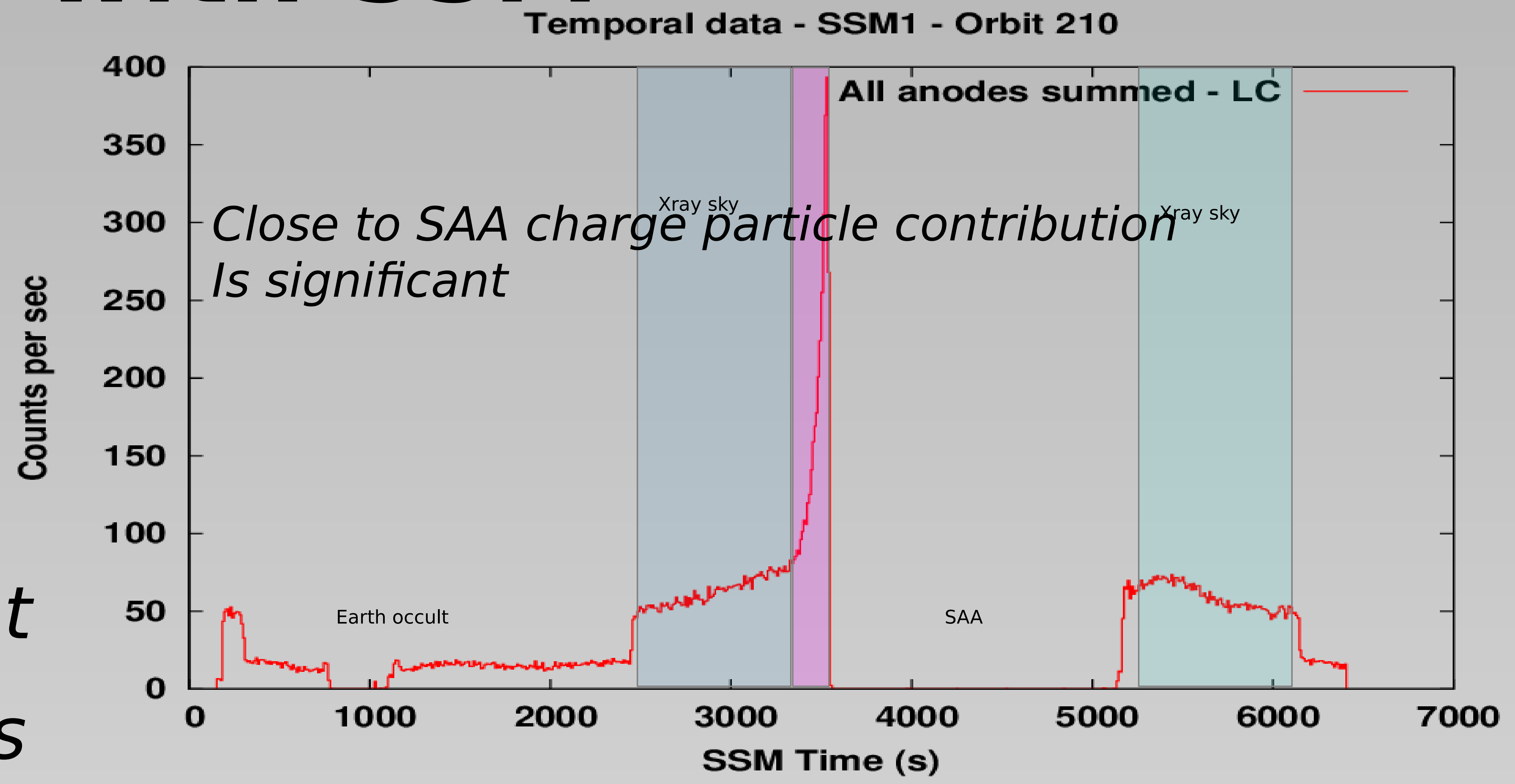


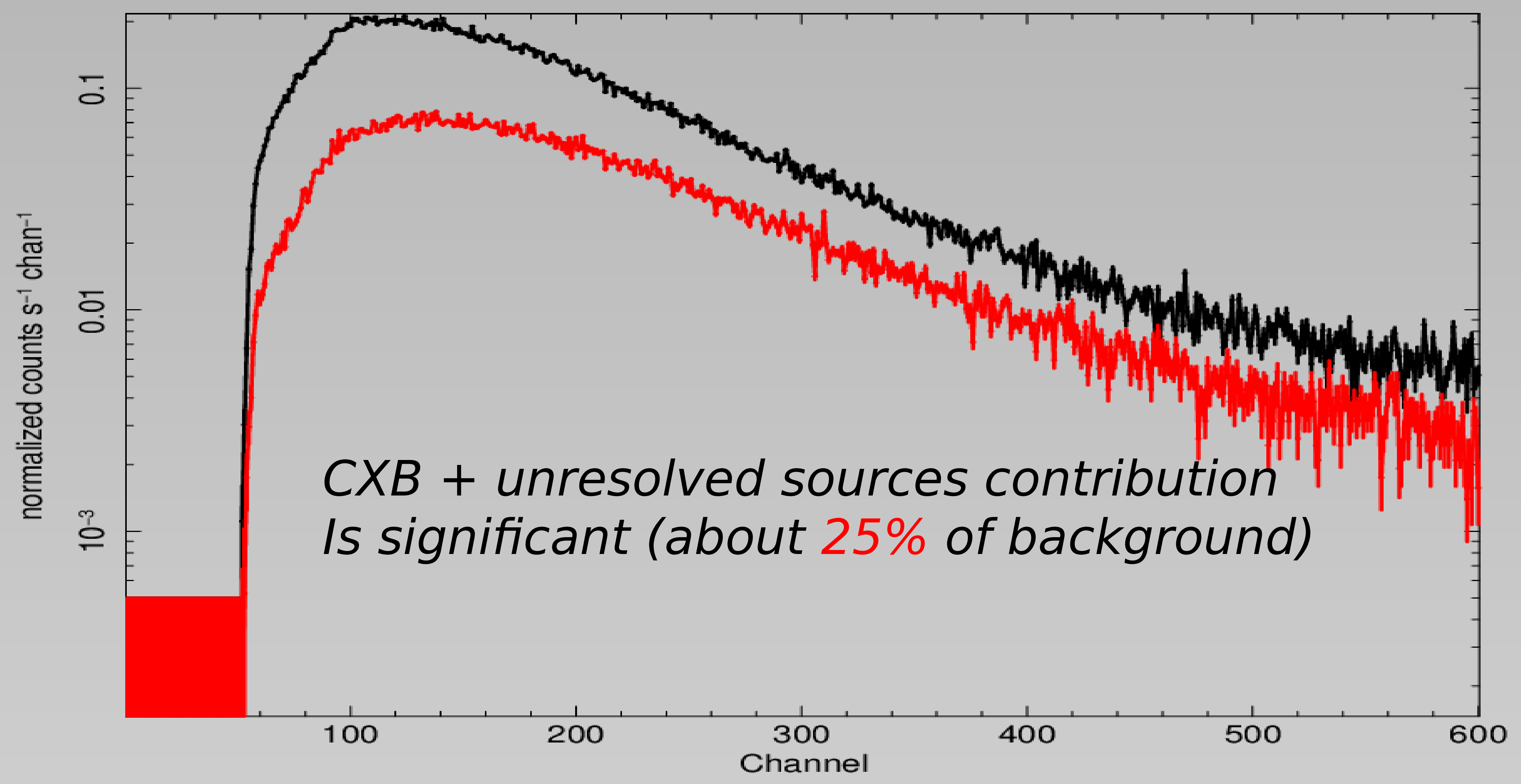
Source peak at the expected location; Pixel size 6 mm at 2 m height corresponds to 12 arcmin angular resolution.

Onboard Calibration

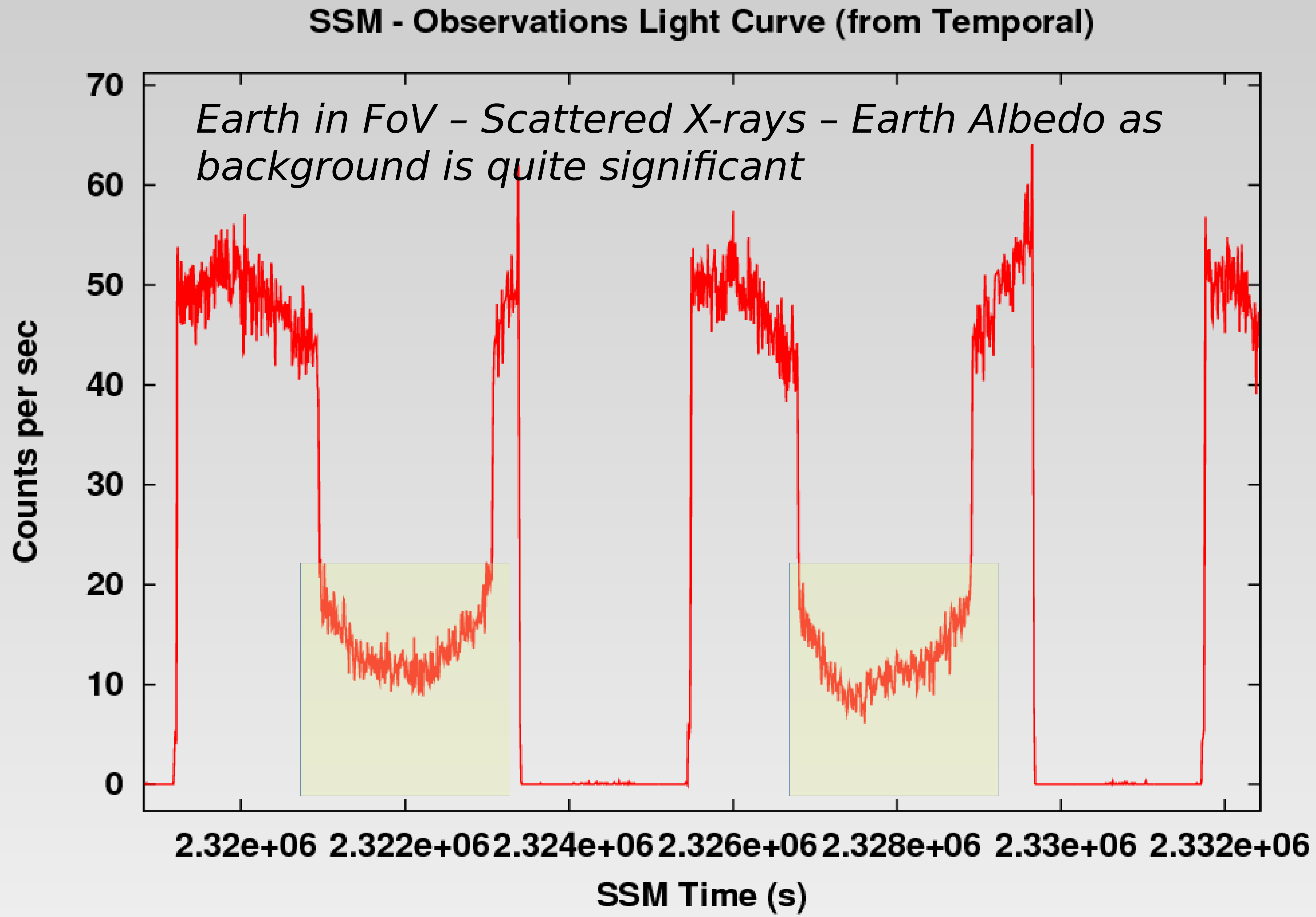
Imaging with SSM

In Black - Crab spectrum with other unresolved sources + bkgd FOV: 100 X 22 sq deg
In Red – Faint field observations – considered bkgd



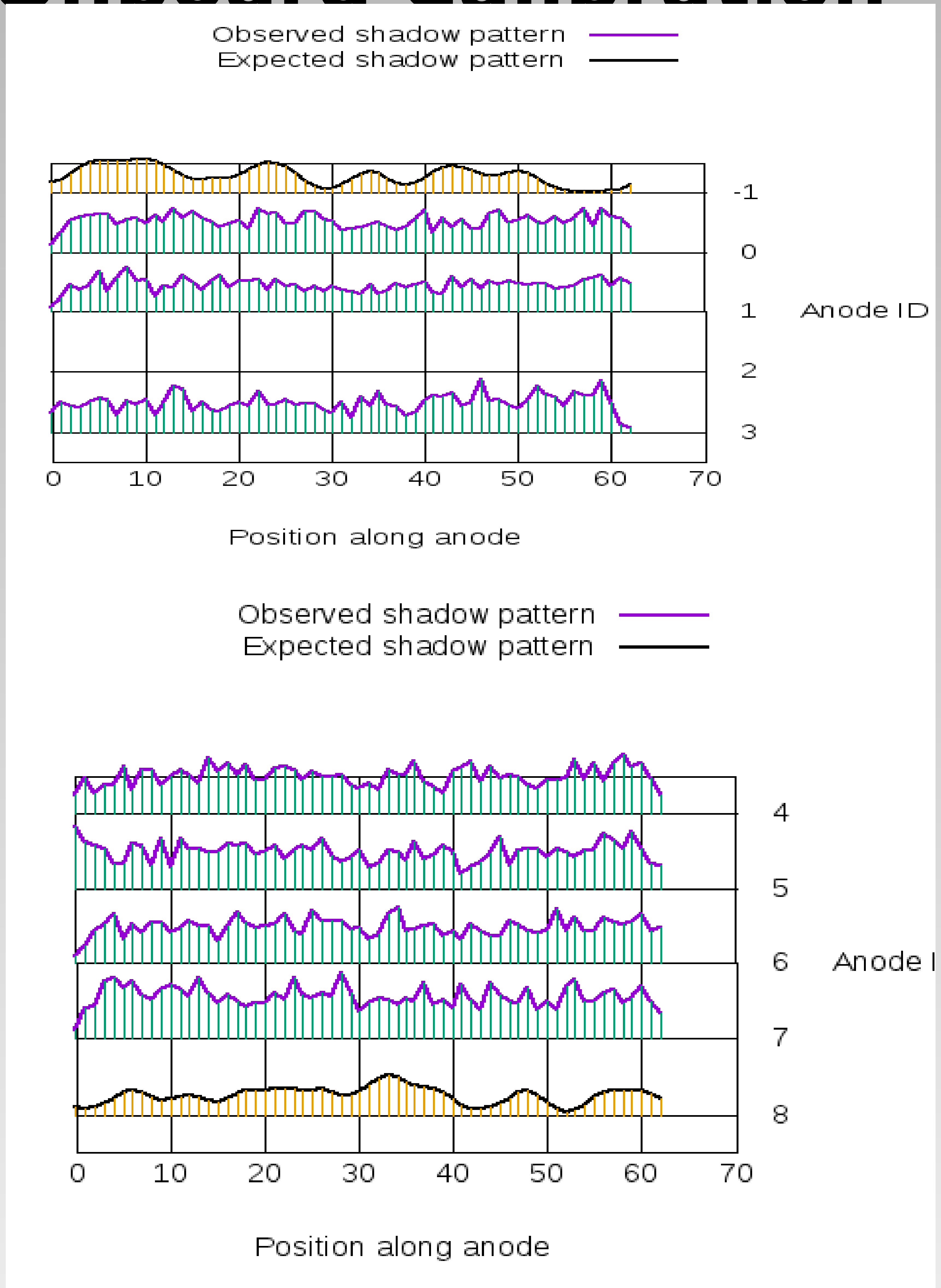


- Source incident
  - X-ray sources
  - CXB
  - Earth in FOV
  - Charge Particles
  - Scattered Photons from S/C and SSM elements
- Instrument aspects
  - Calibration constants – position estimates
  - Position Resolution
  - Anode Response
  - Edge Effects
  - Shift in central dip + broadening overtime



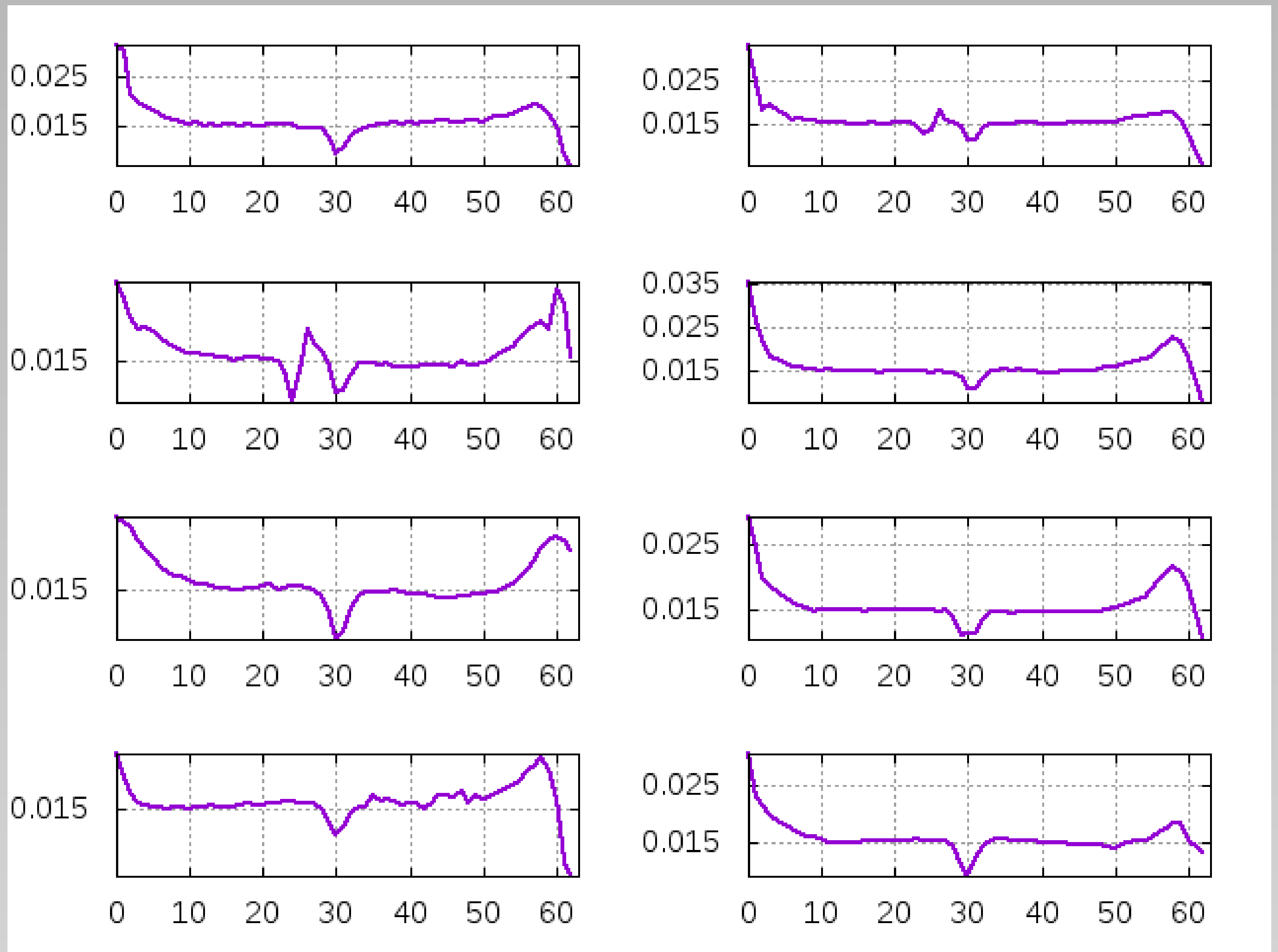
Imaging with SSM

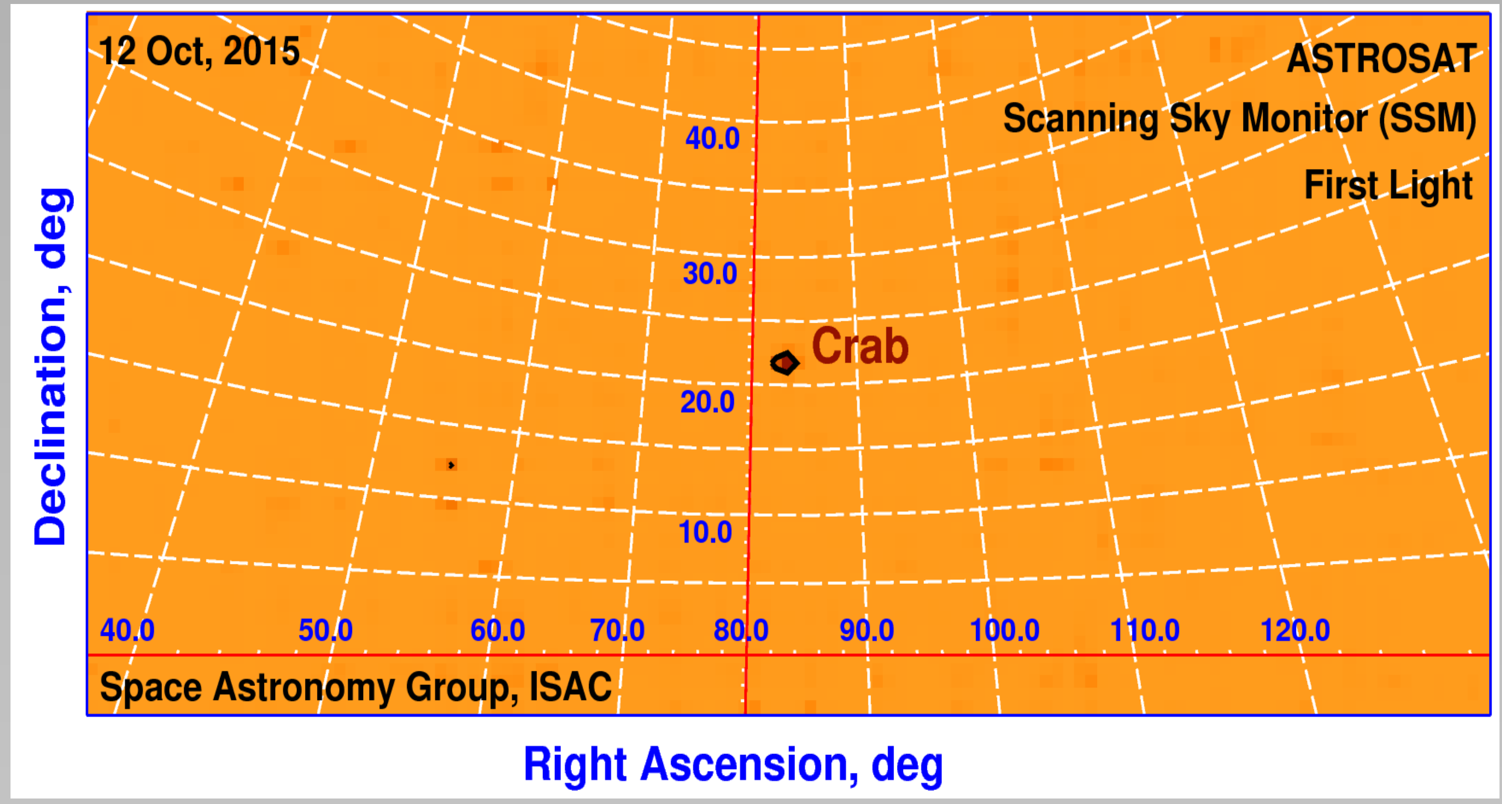
Onboard Calibration

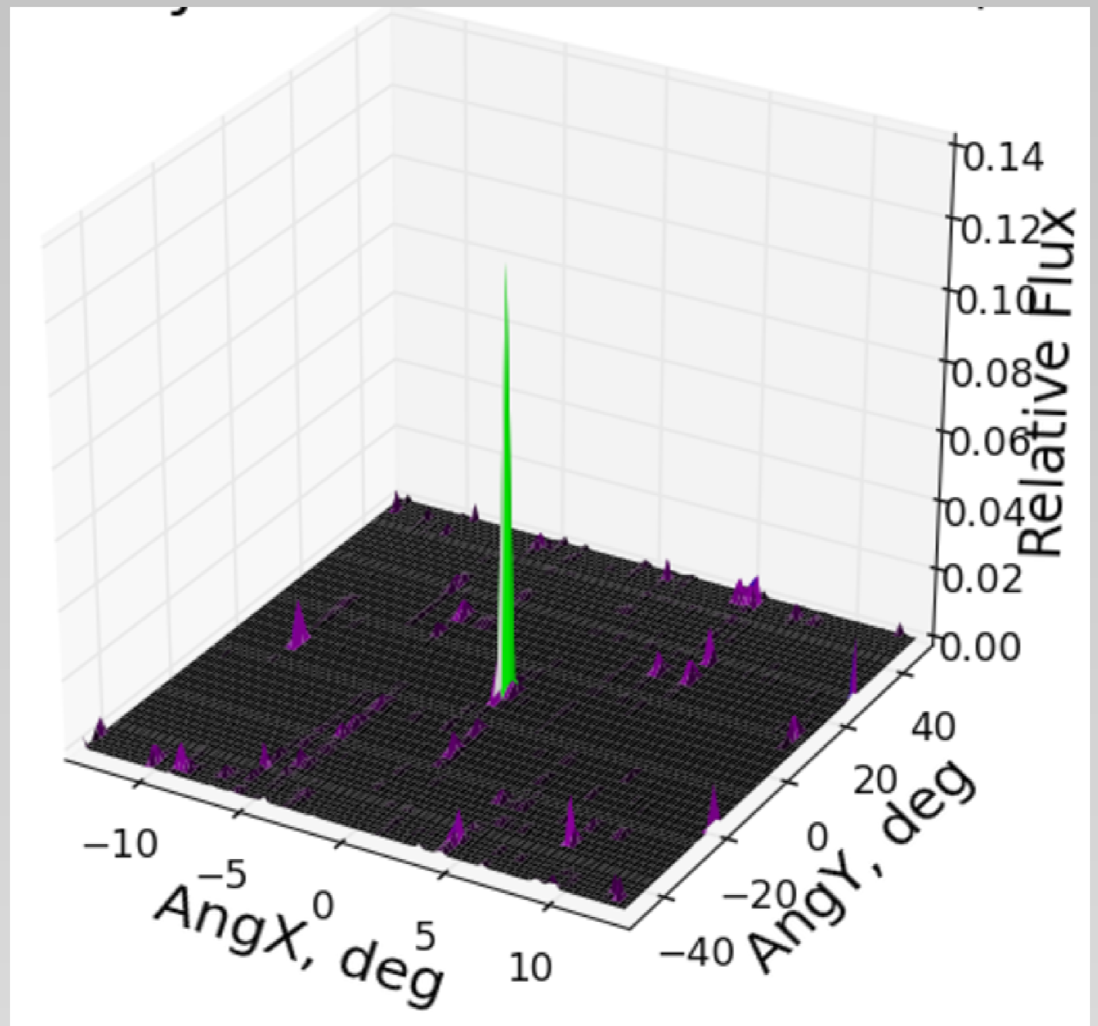


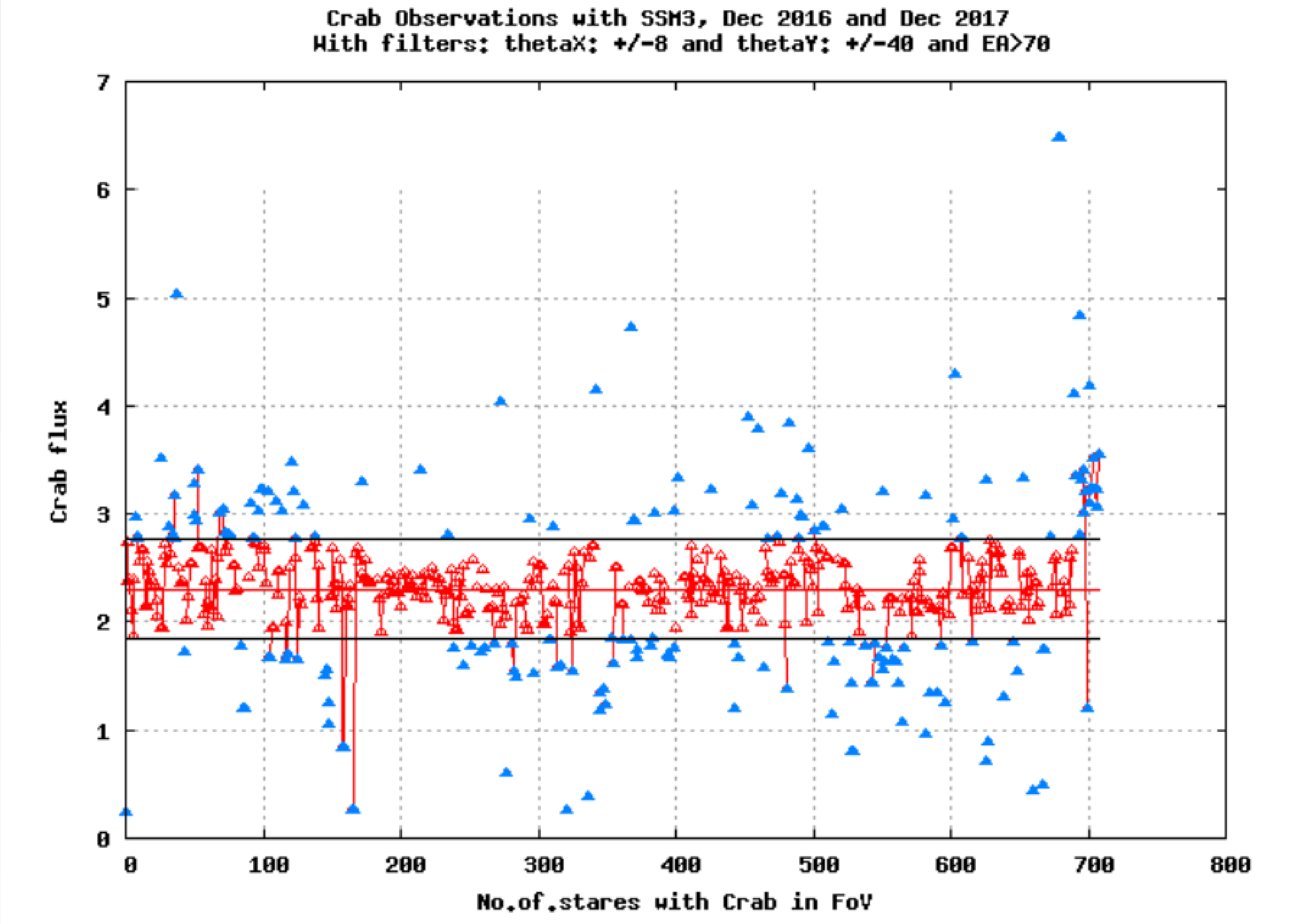
Crab observed vs expected shadow

Background with faint field





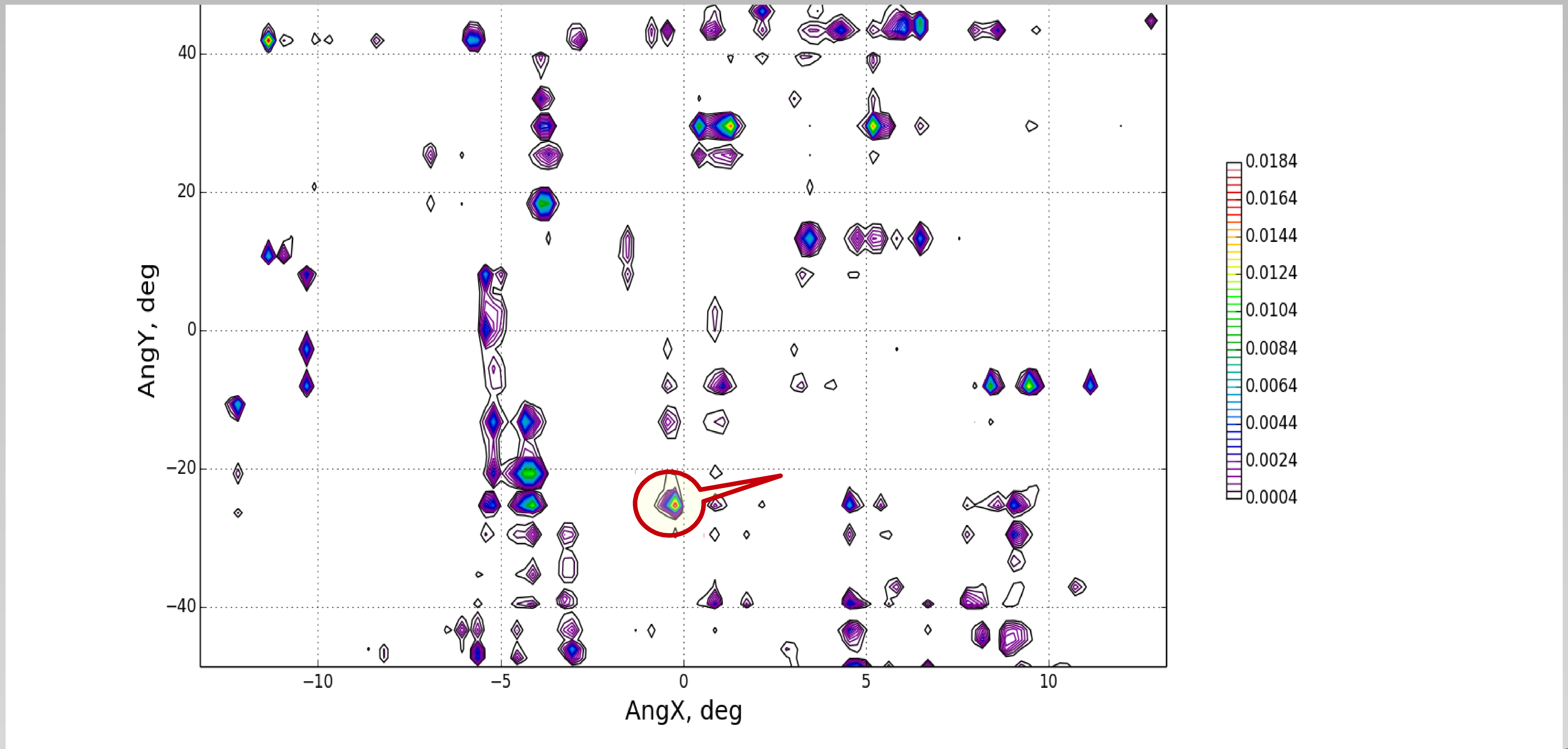


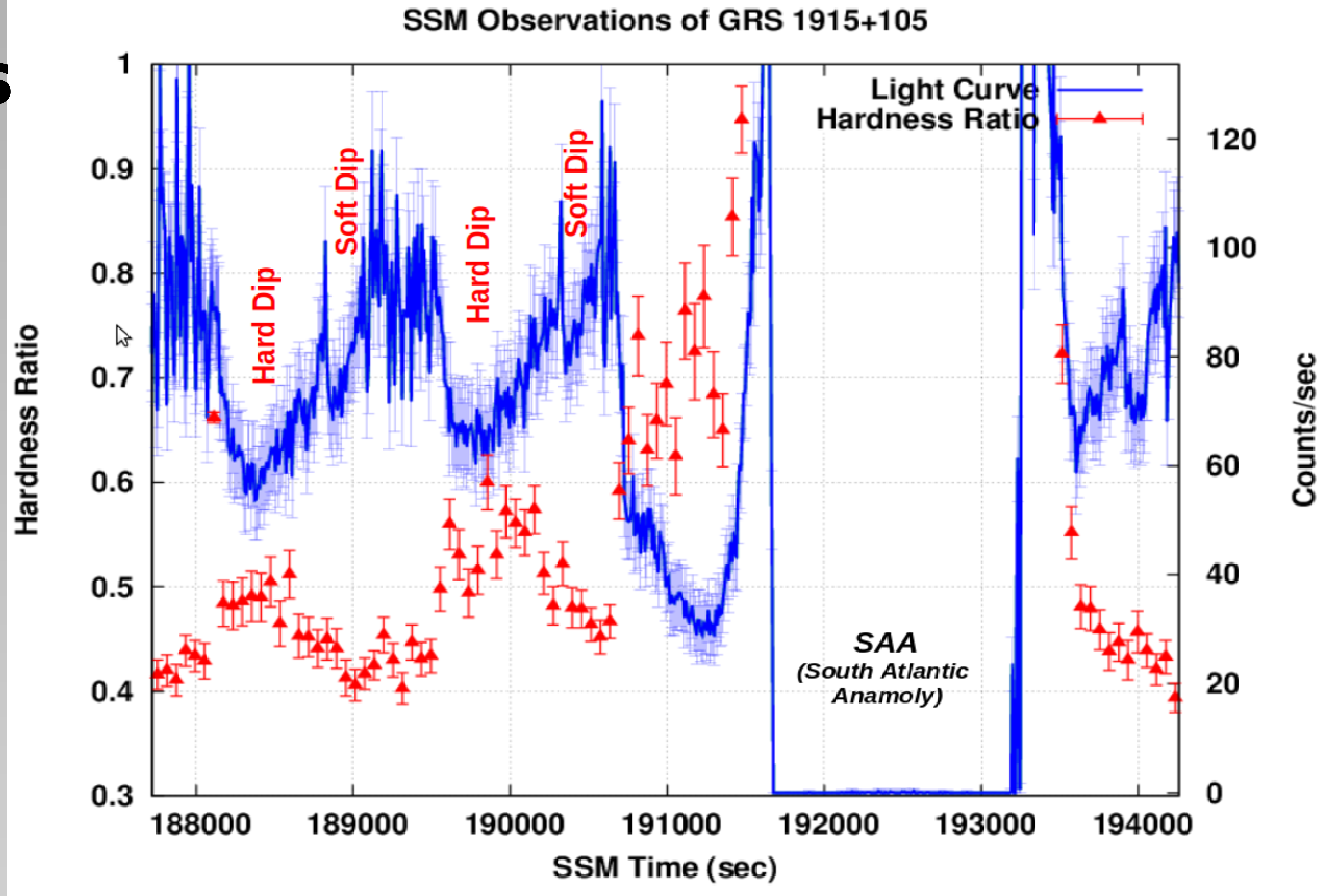


Best obtained flux for Crab is with a variation of +/- 20%

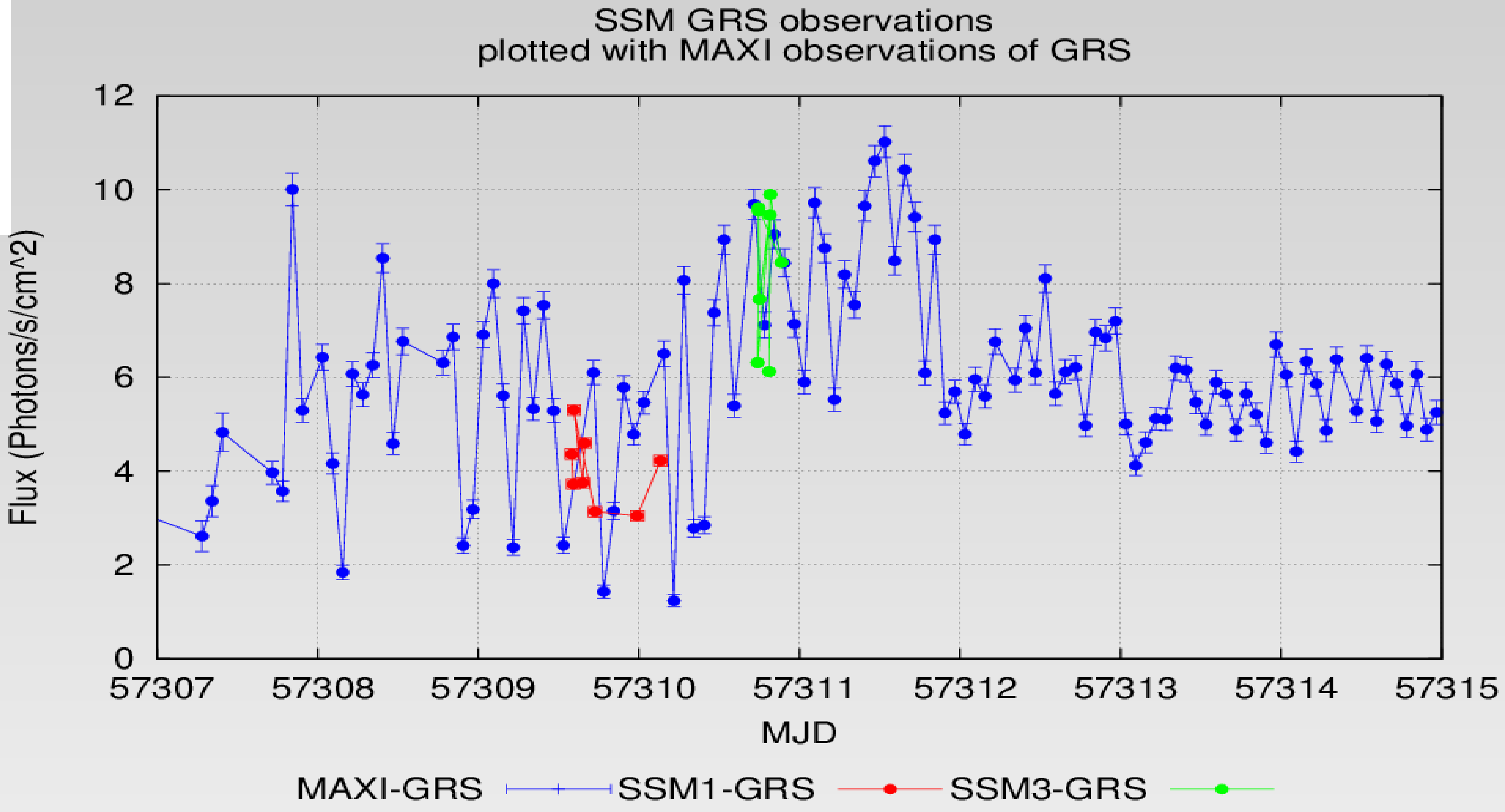
FoV has Crab as the only bright source

Onboard Imaging with SSM – crowded fields GRS 1915+105 observations



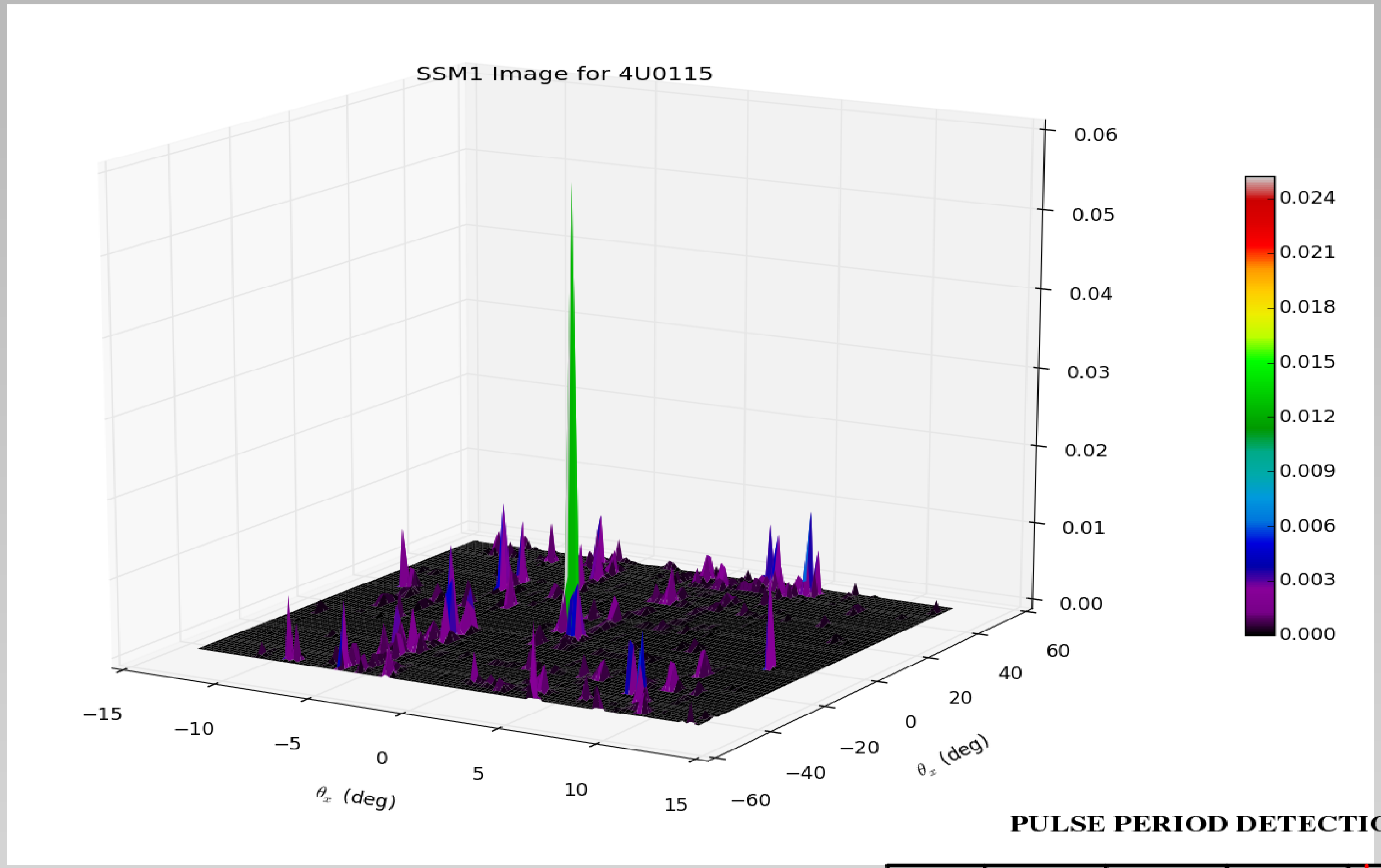


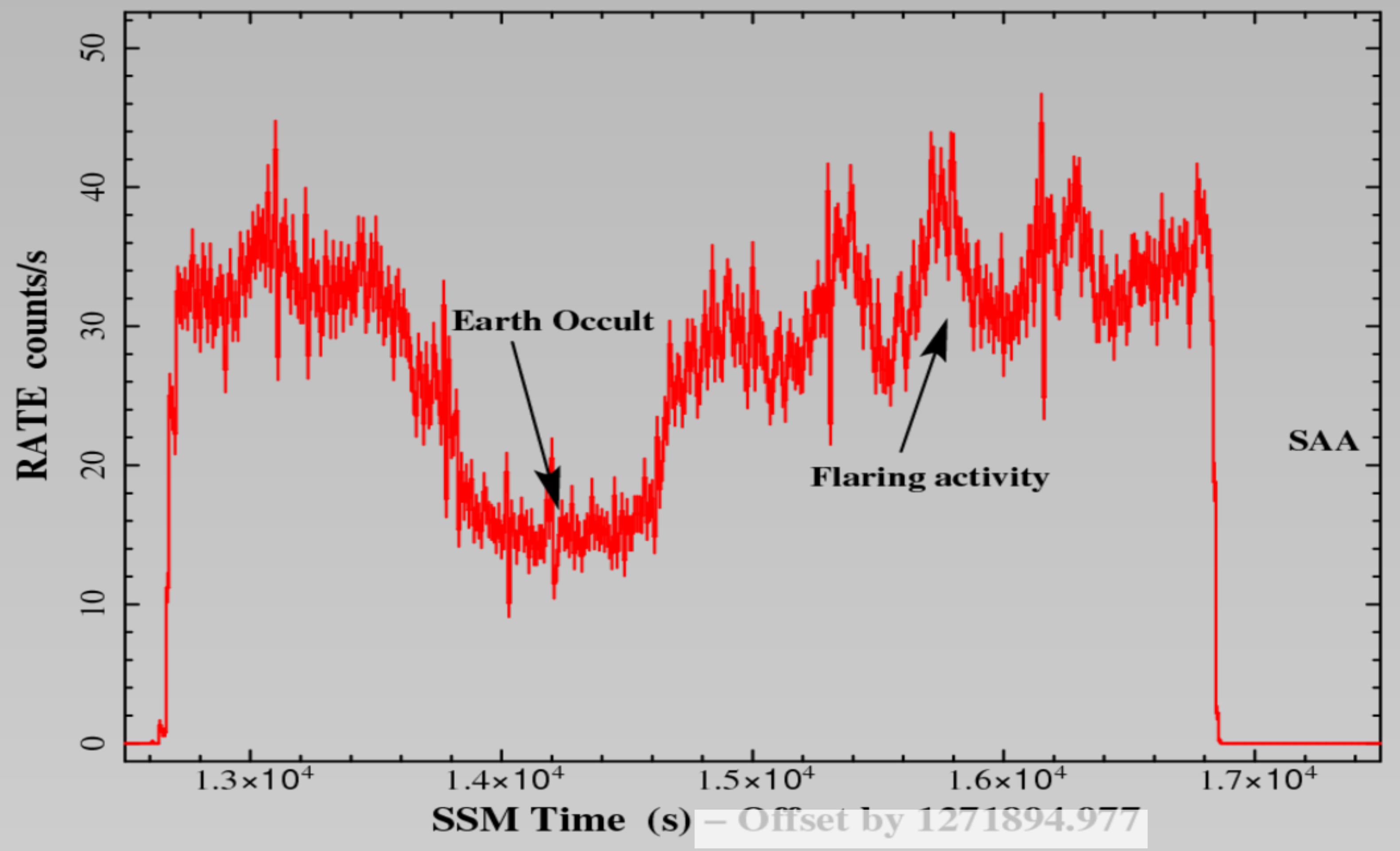
- *GRS 1915+105 at (-1,-25) in SSM1 FOV*

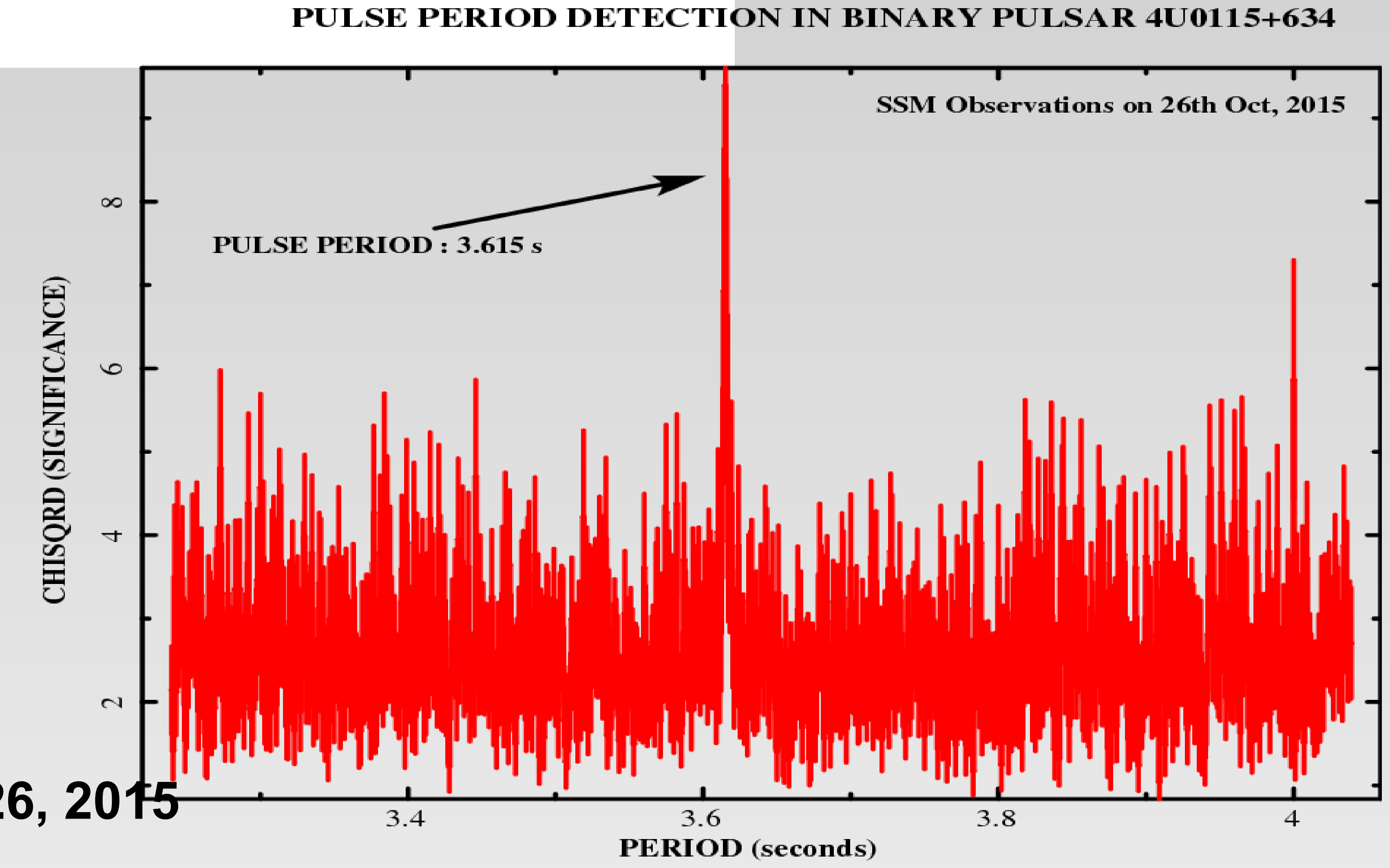


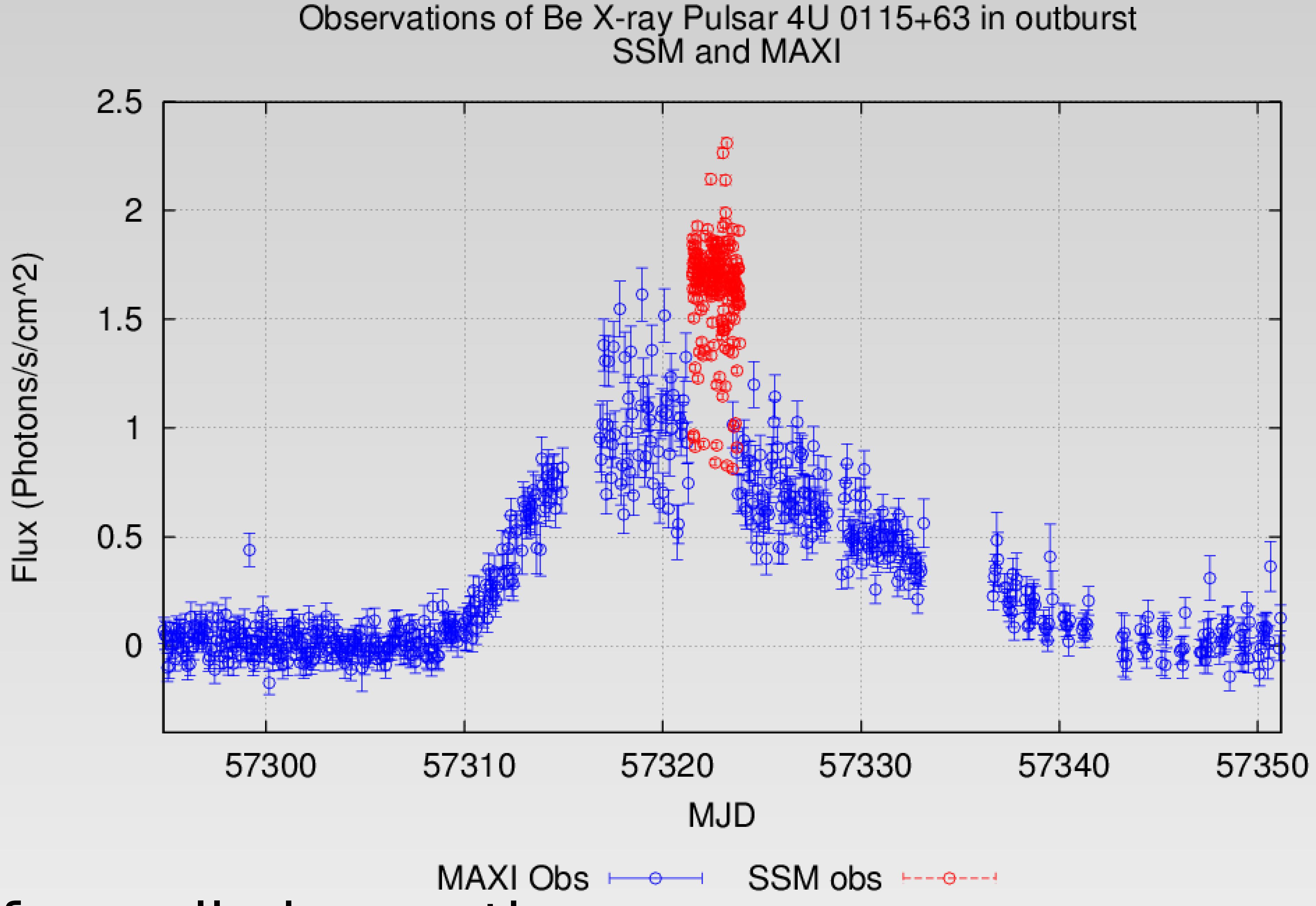
Flux for sources in crowded fields
- larger flux variation
- depends on the number of sources
- also no.of bright sources in the FoV

SSM Observations of a binary pulsar 4U0115+63









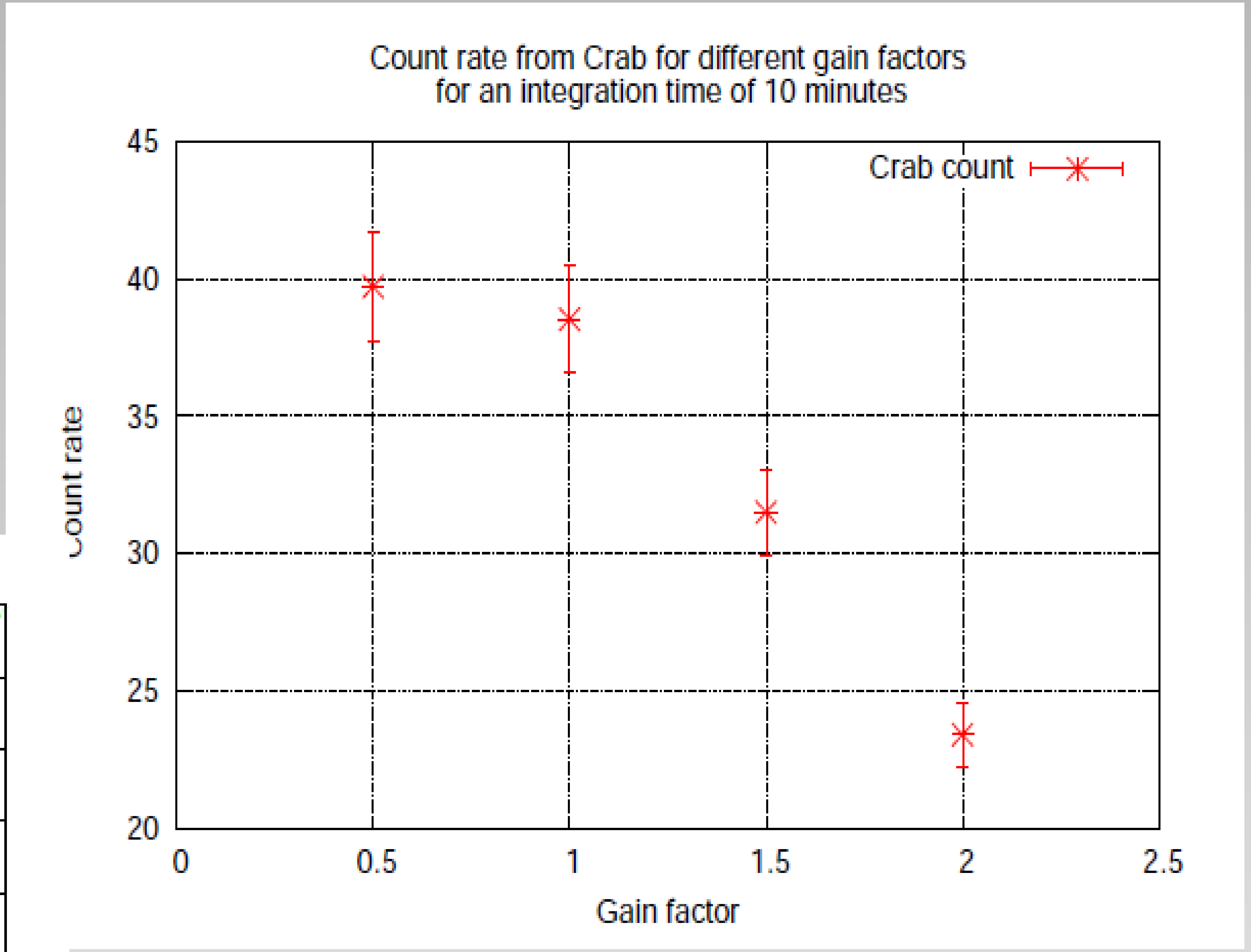
- **Observed on October 26, 2015**

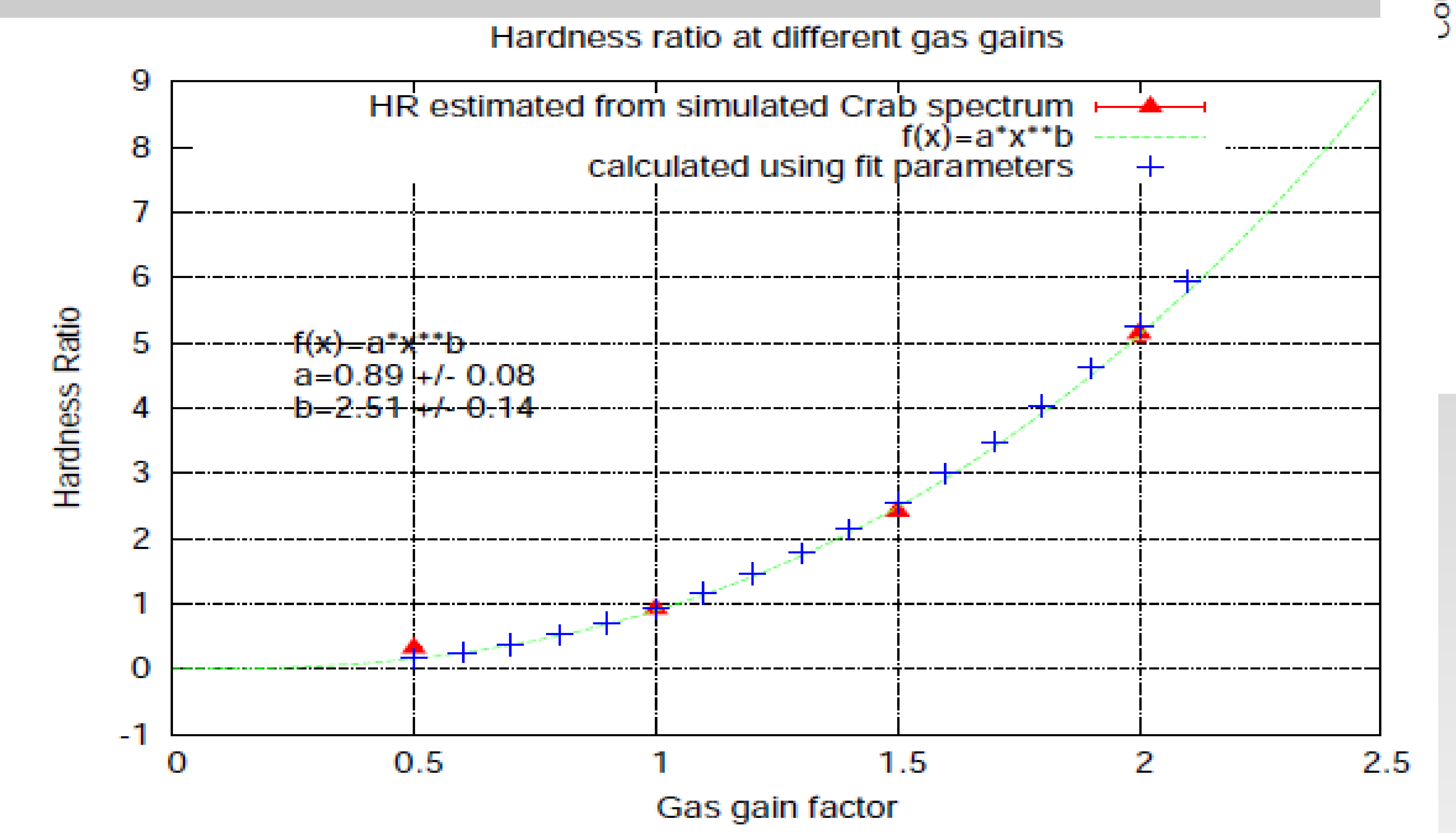
Light curves of bright sources (~few hundred mCrab) are being studied from all observations

Detector Gain Variations

Ground Simulations

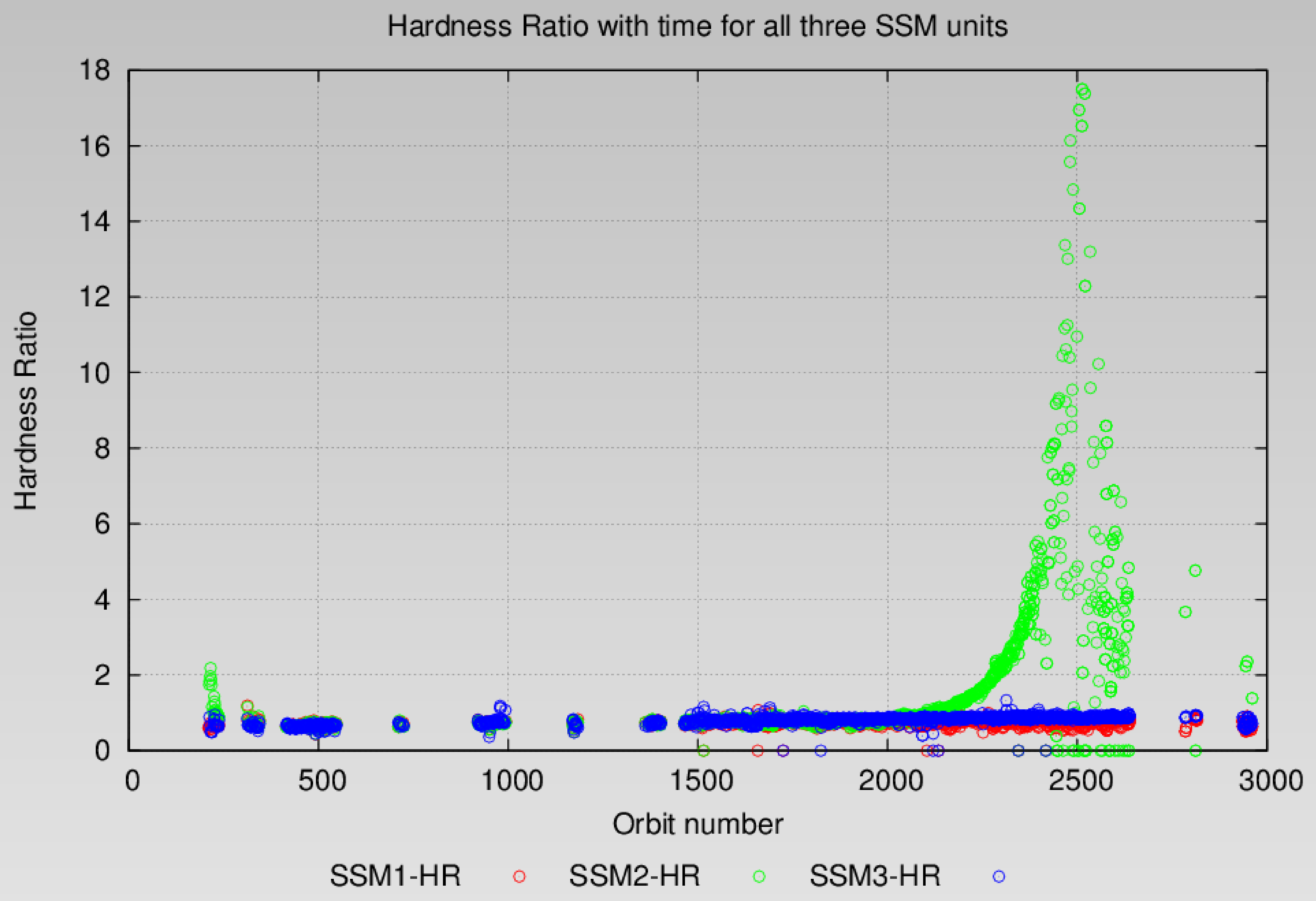
Hardness Ratio and count rate
as an indicator of Gain change
- studies carried out pre-launch

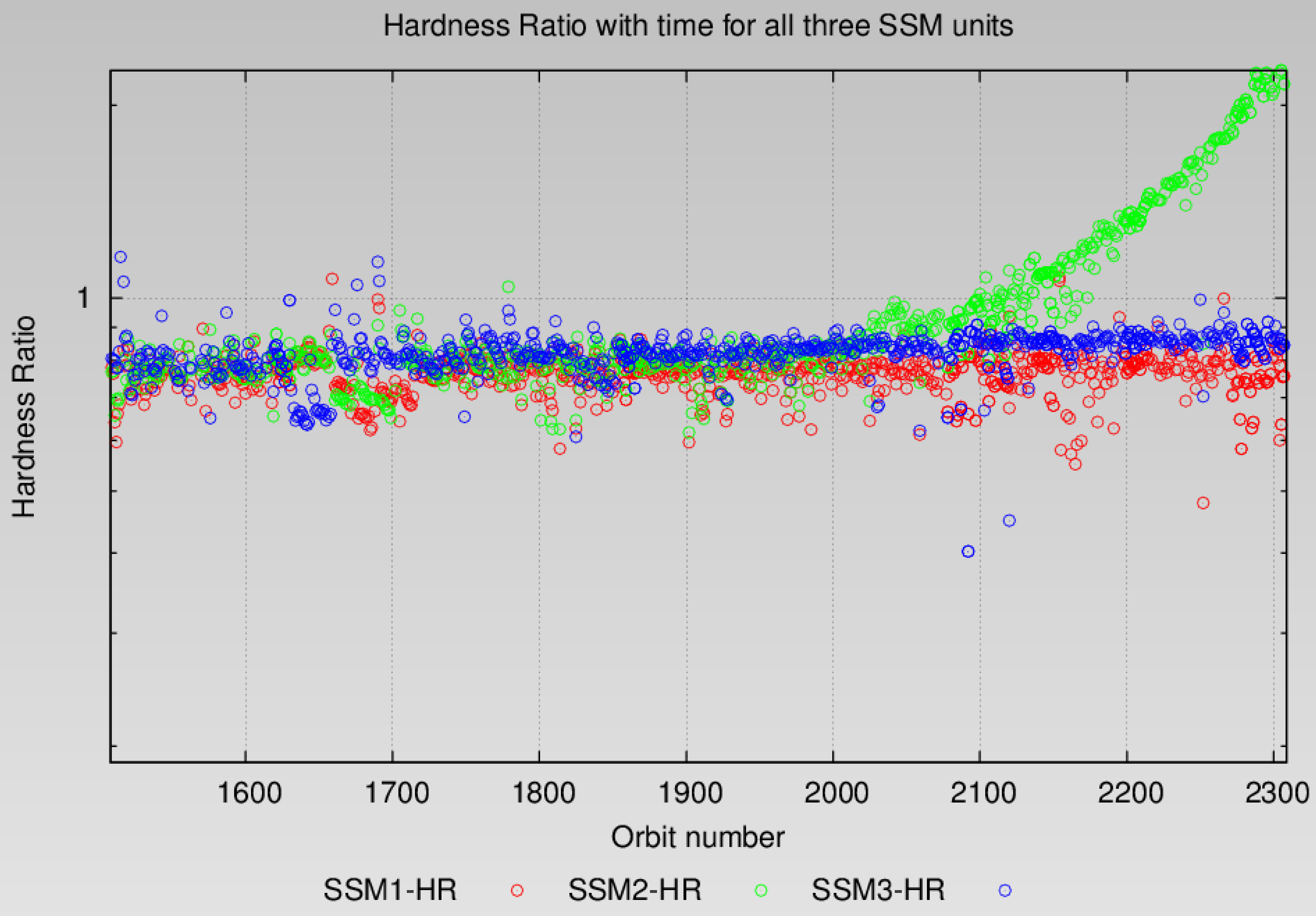




Detector Gain Variations

SSM2 Gain Changes onboard





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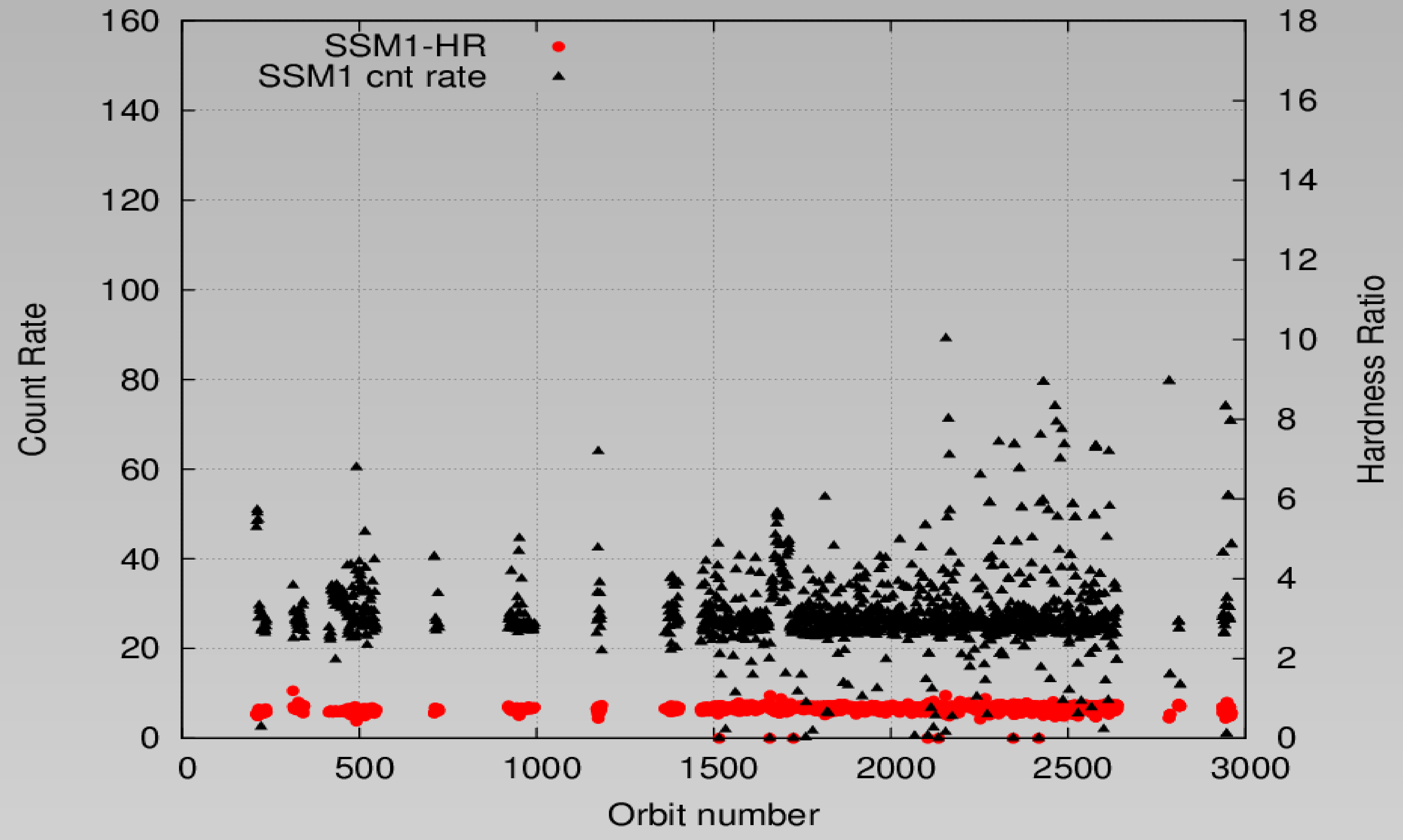

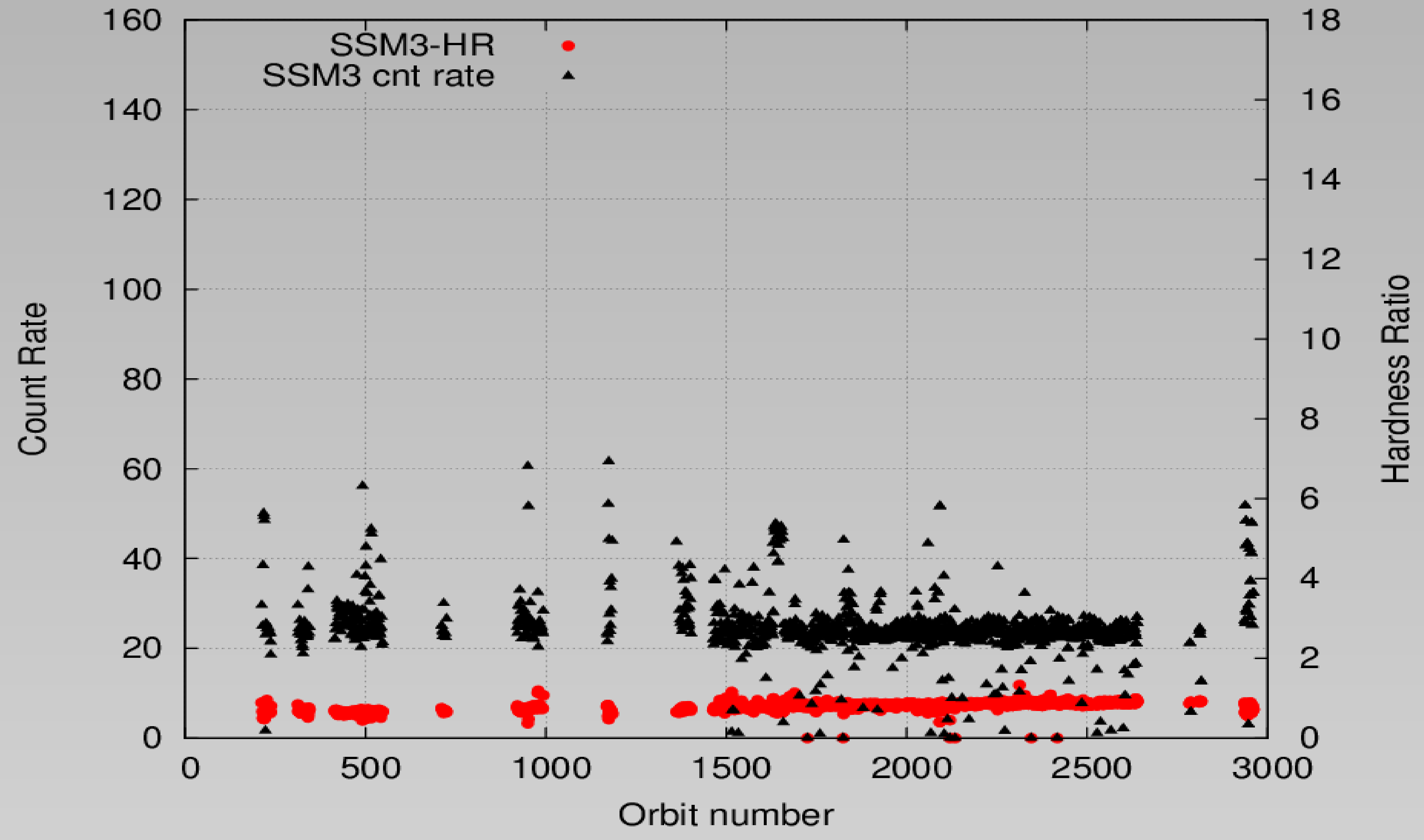

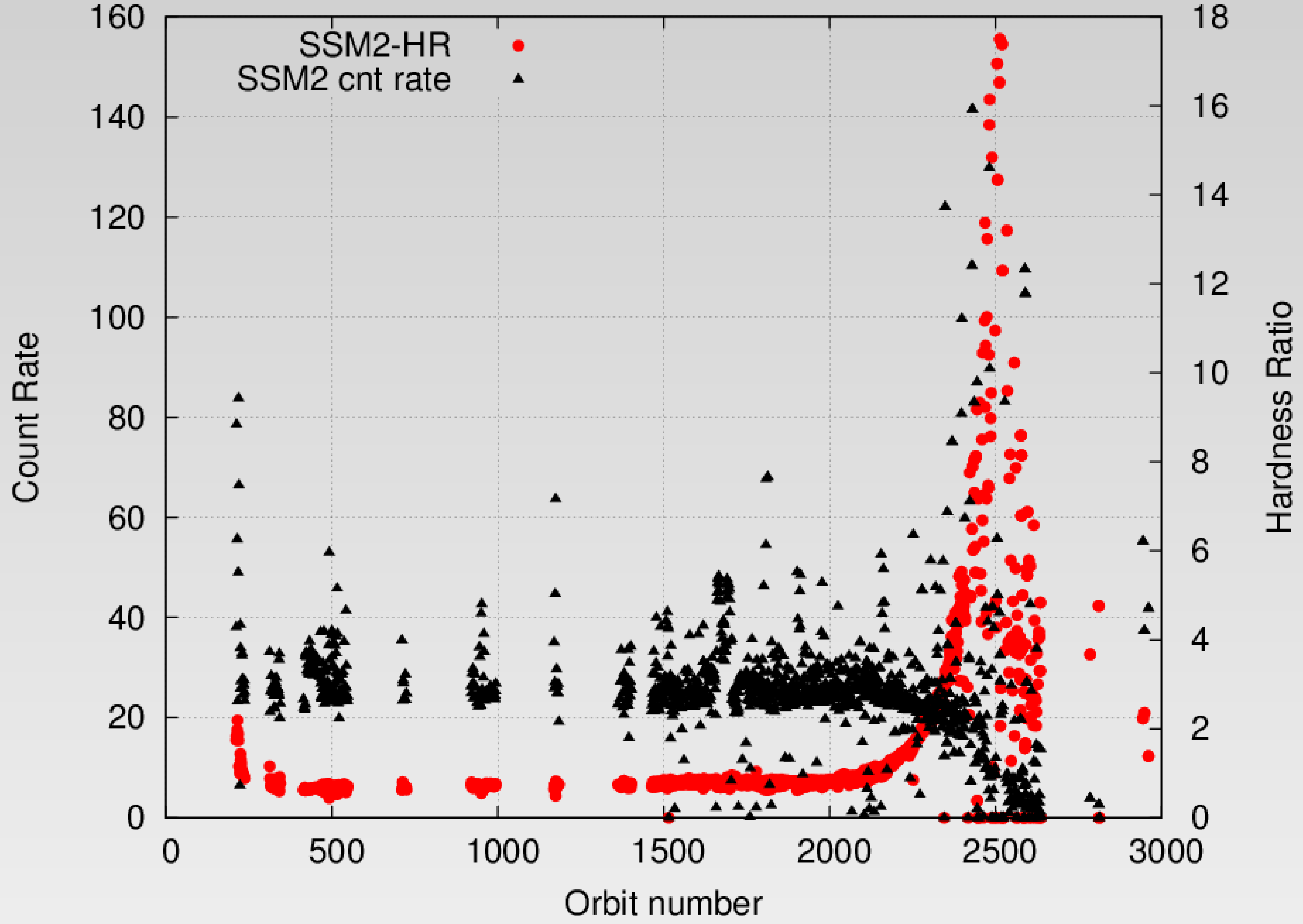

Present Status

- SSM2 switched OFF
- SSM1 reduced HV and reduced efficiency - almost close to Switch OFF
- SSM3 operating as before - slight gain change observed
- Light curves of bright sources (~few hundred mCrab) are being studied from all observations

Over to

Abhilash on Detailed onboard Calibration

Followed by

Ravishankar on Onboard Image Processing aspects

Thank You