GRWG MW-SubGroup

Lunar Calibration

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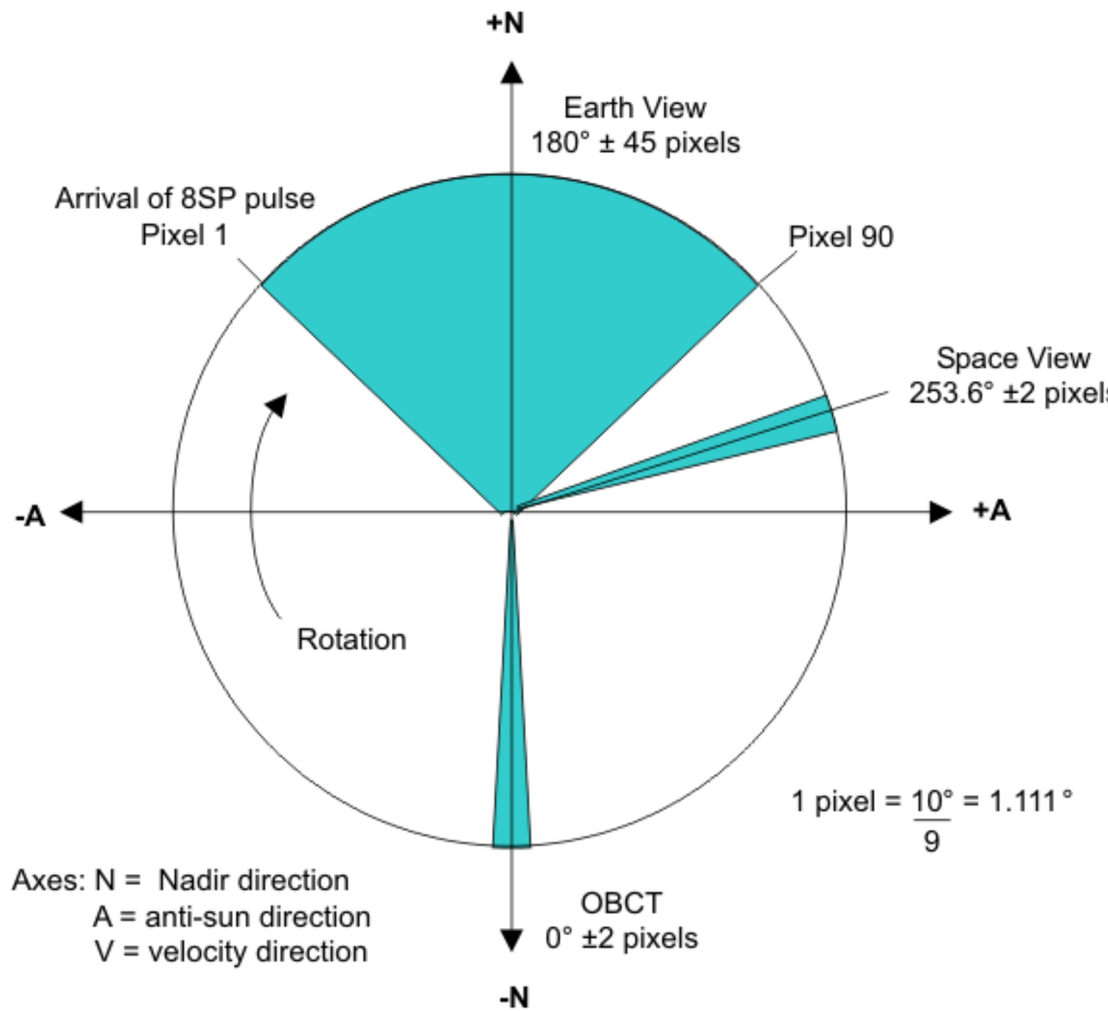
Presentation Outline

- Properties of Moon Intrusions in the DSV
- Time of Moon Intrusion => Pointing Accuracy
- Duration of Moon Intrusion => Beam Size
- Maximum Signal From Moon Intrusion => Photometric Stability
- Third reference level => Check non-linearity?
- Outlook

Topic 1 – Moon Intrusions

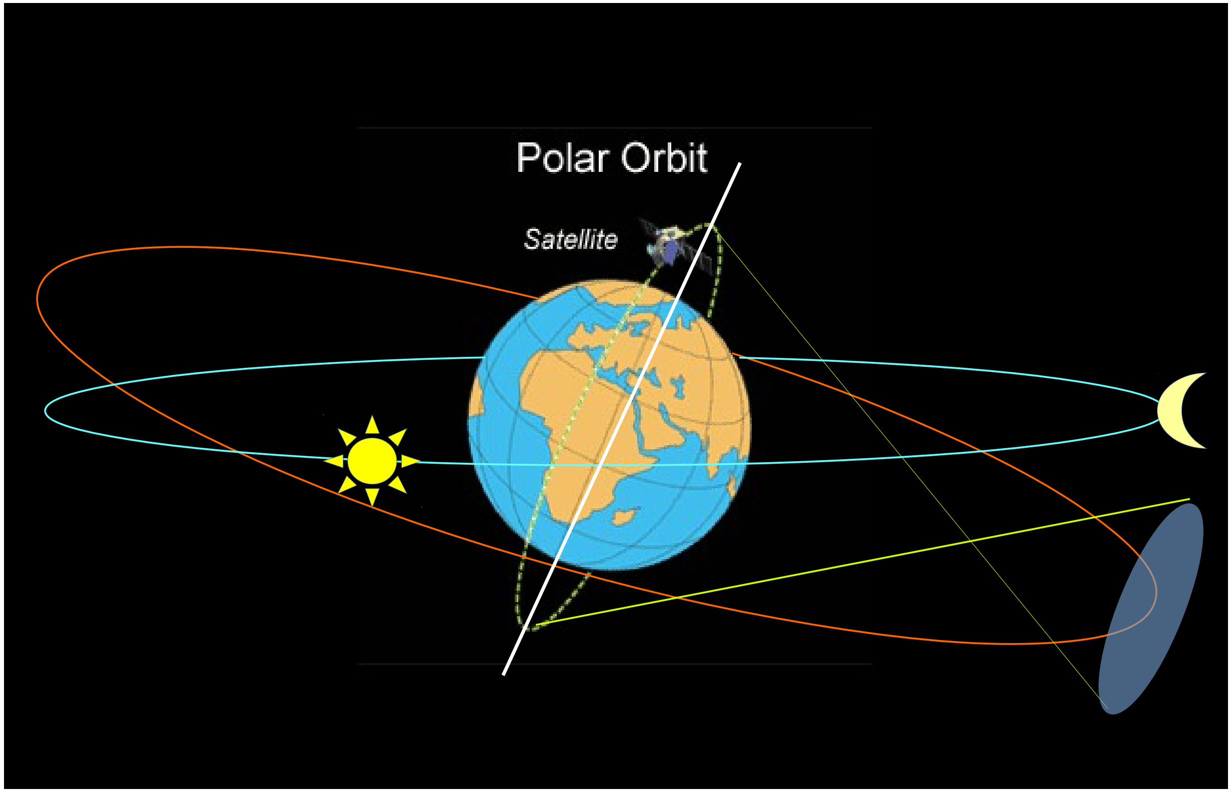
- *+A is the orbital axis of the satellite*
- *During one orbit the DSV direction describes a circle In the sky*
- *This circle has a radius of 270°- 253.6°*
- *Its circumference has a width of 4.4°.*



KLM User's Guide

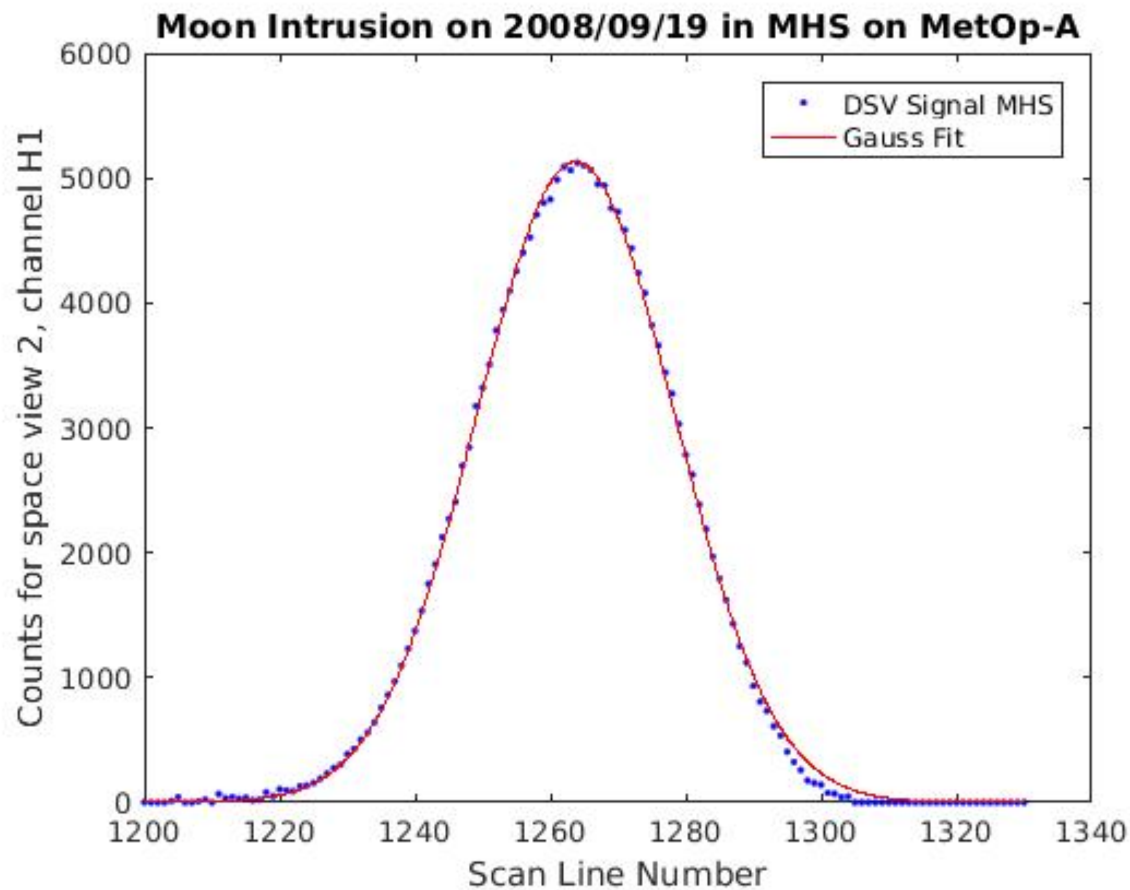
Topic 1 – Moon Intrusions

- *DSV: circle close to celestial equator*
- *Moon close to ecliptic*
- *Depending on season, the Moon moves through the DSV circle.*
- *Bigger circle => more intrusions*
- *Bigger beam => longer intrusions*



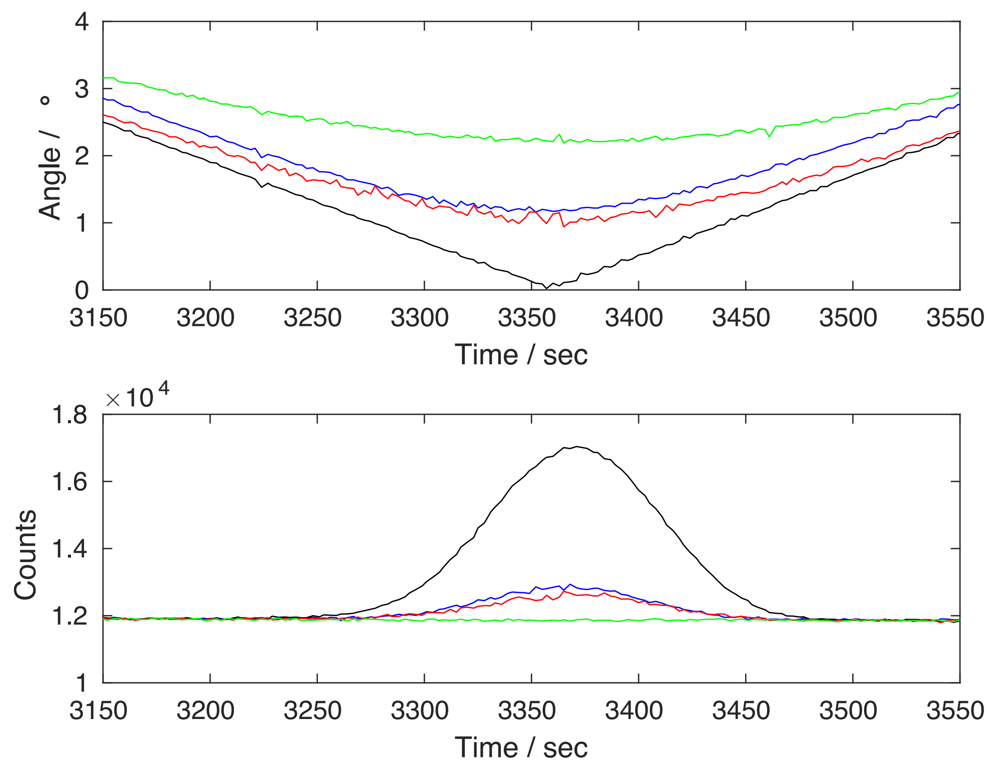
Topic 1 – Moon Intrusions

- *The "light" curve of the Moon in the DSV follows closely a Gaussian.*
- *A Gaussian has three parameters:*
- *Scan number of strongest signal => pointing accuracy*
- *Width => beam size*
- *Maximum signal => photometric stability*



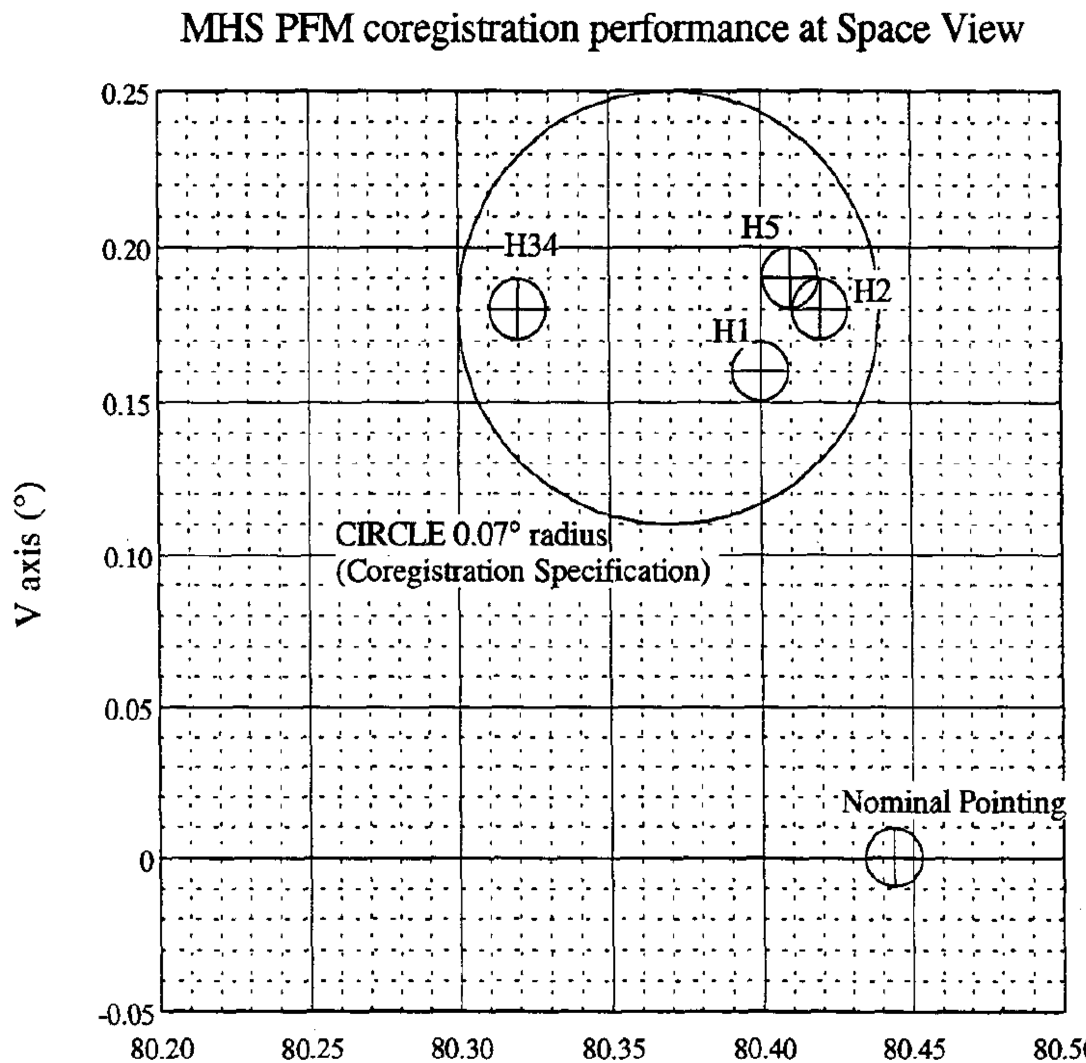
Topic 2 – Pointing Accuracy

- *Derive pointing error in cross-scan direction from diff. in positions of extreme angle and extreme signal*
- *Find error < 0.3°*
- *Derive pointing error in scan direction from fitting a Gaussian to maxima in three DSVs and comparison to AAPP min. angle*
- *Find error < 0.2° in few examples*



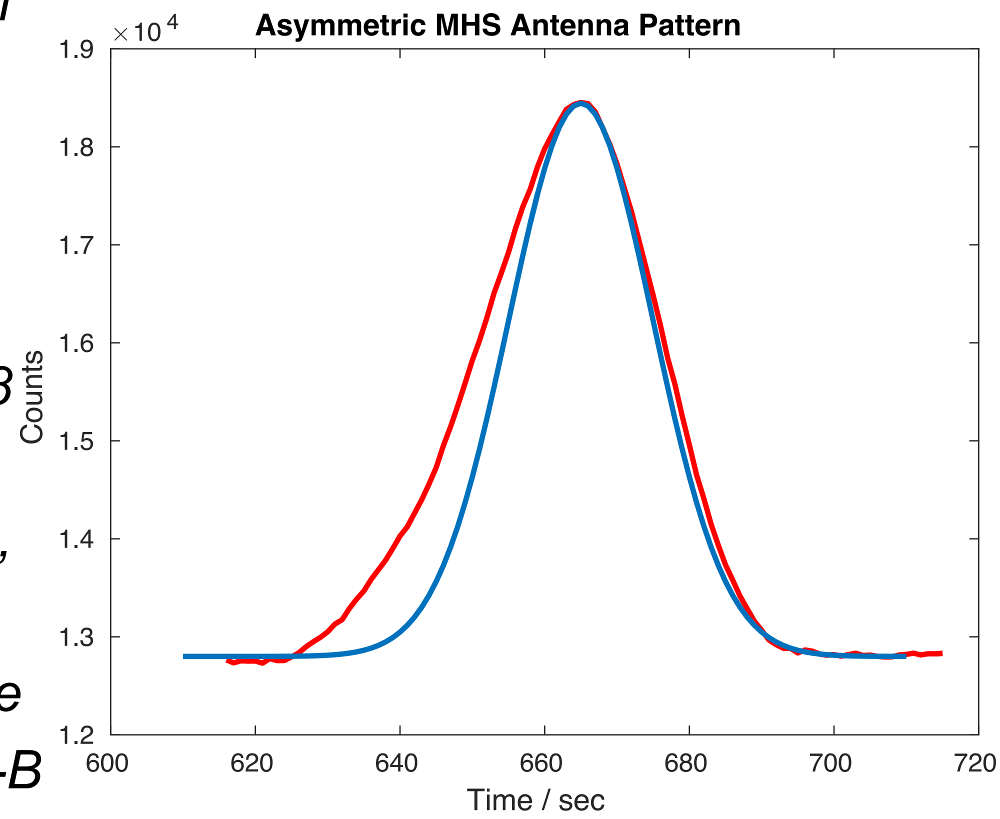
Topic 1 – Pointing Accuracy

- Check coregistration errors in scan direction in flight
- Spec still fulfilled?
- Check coregistration errors in cross-scan direction from fitting Gaussians to maxima in three DSVs
- Spec still fulfilled?
- Double-check with gain values (T_{moon} cancels out)



Topic 2 – Beam Size

- *Beam diameter in cross-scan direction from width of Gauss fit*
- *Not accurate enough in scan direction*
- *Comparison on ground vs. in flight for MHS on N18*
- *Ch 1: 1.09/1.10, ch 2: 1.03/1.03, ch 34: 1.05/1.17, ch 5: 1.05/1.15 (req. ✓)*
- *Asymmetric beam shape found with MHS on MetOp-B*

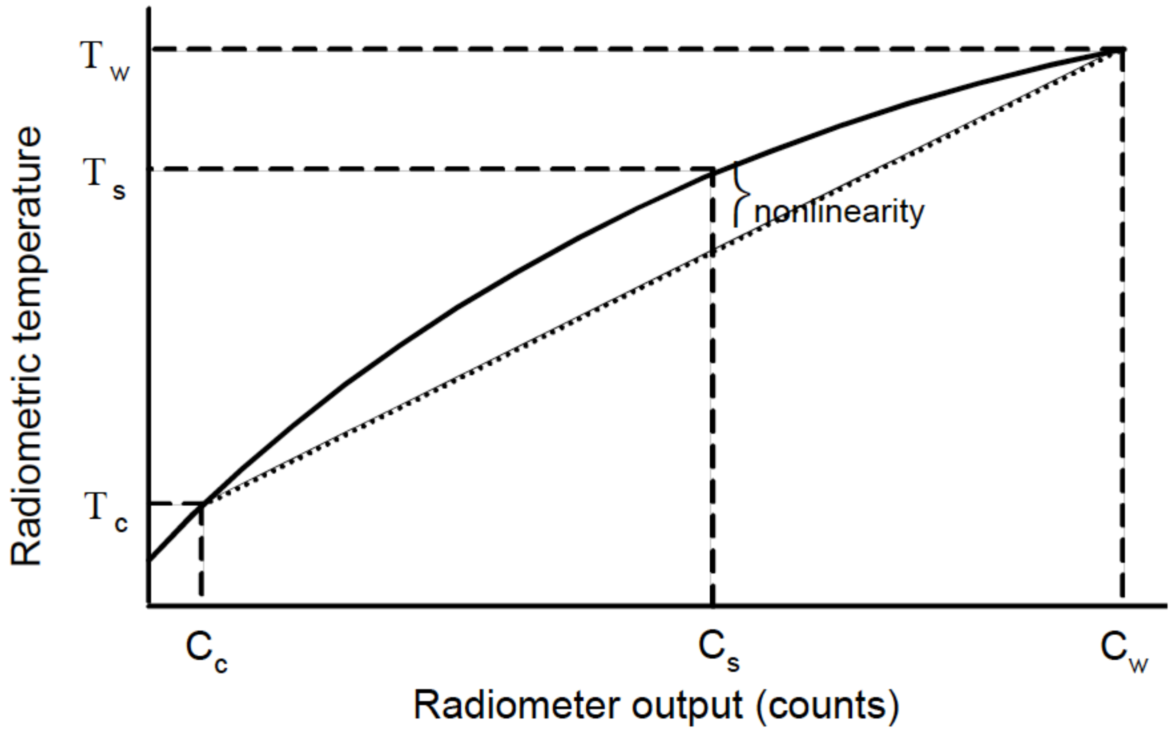


Topic 3 – Photometric Stability

- *Accuracy of maximum signal from Moon intrusion better than ±0.3% under optimum conditions*
- *Channel 1, Moon appears in the centre of the DSV*
- *Moon common reference for all satellites, past, present, and future*
- *Model needed to calculate* T_B = f(phase)
- *Keihm's model: 5% phase-dependent systematic error*
- *Mangum (1993) gives uncertainty of 9K for disk centre at 3 mm*
- *Model by Mo & Kigawa (2007) accurate to < 2% in limited range of phase angle*

Topic 4 – Non-Linearity

- *Divide counts by gain and flux from Moon and calculate ratio for different years*
- *Consider AMSU-B on NOAA-16, 2006/2001 - 1*
- *Ch 1: 0.5 %*
  Ch 2: 1.1 %
  Ch 3: 6 %
  Ch 4: 4 %
  Ch 5: 2.4 %



Summary

- *The Moon is a versatile tool for diagnostics of the performance of microwave sounders in flight.*
- *The "light curve" of the Moon intrusion can be fitted well with Gaussian*
- *From the fitted Gaussian get information about…*
  - *Asymmetries in beam pattern*
  - *FWHM*
  - *Pointing error in scan and cross-scan direction*
  - *Alignment of channels and deep space views*
  - *Radiometric temporal stability*
  - *Inter-band photometric calibration*
  - *Inter-calibration independent of time and equator crossing time*
  - *Non-linearity*

Concerns and Next Steps

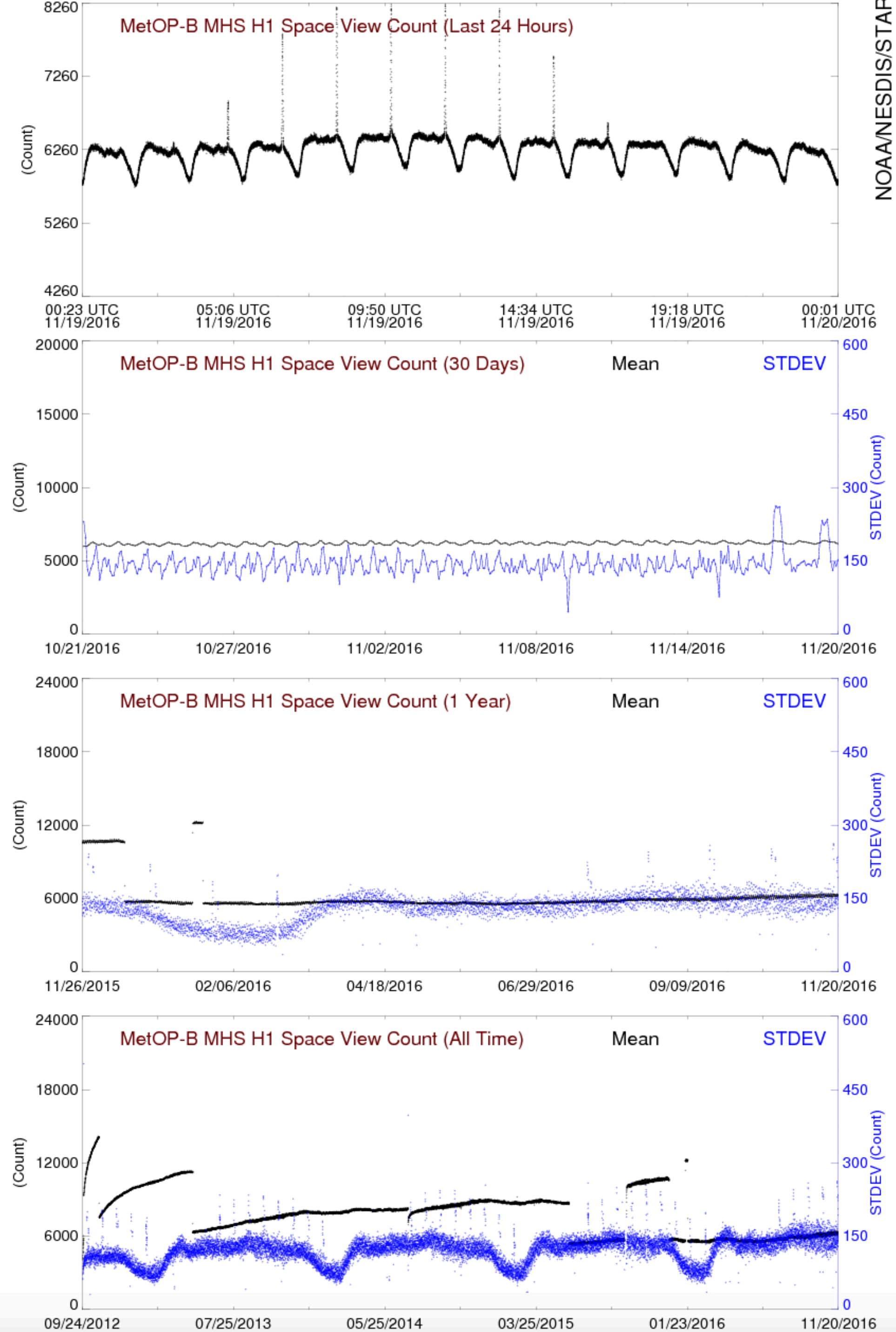
- *Careful analysis is laborious compared to that of SNOs.*
- *Beam size must have a diameter of one degree or smaller.*
- *Minor problems: inhomogeneous temperature distribution, libration, etc.*

- ✓ *Evaluate instrumental properties in flight and compare them to measurements on ground: values and uncertainties*
- ✓ *Refine model by Mo & Kigawa with AMSU-B (constrain thermophysical models - useful for radio astronomy?)*
- ✓ *Prepare for second generation instruments like ICI or MWI: smaller beam diameter will greatly increase signal-to-noise ratio.*

Back Up Slides

Time Pattern of Moon Intrusions

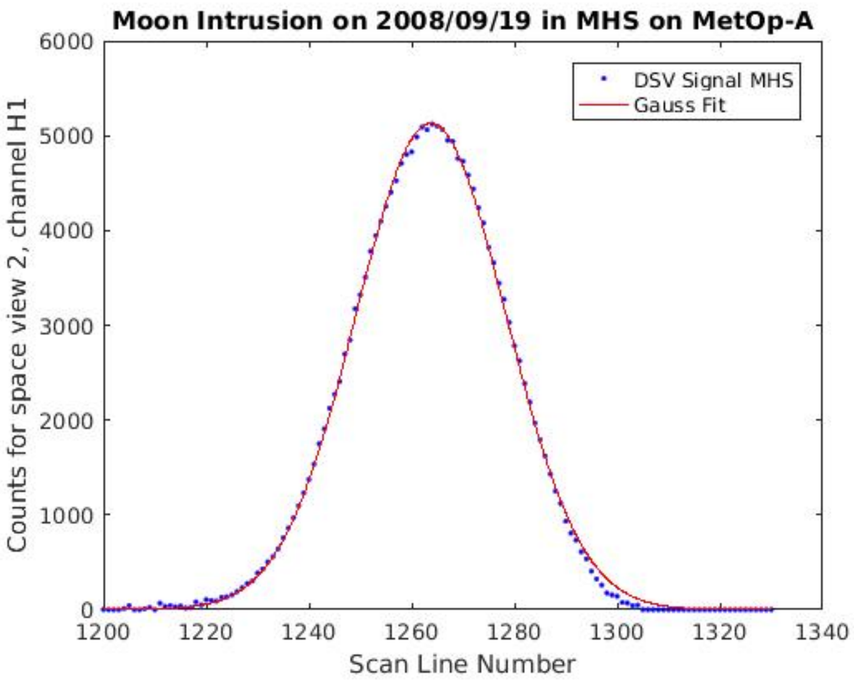
- Moon intrusions in the DSV happen at certain seasons.
- They occur usually in pairs (Moon crosses DSV circle).
- They affect of the order ten orbits in a row (MHS).
- They last only a few minutes for MHS, longer for AMSU-A.



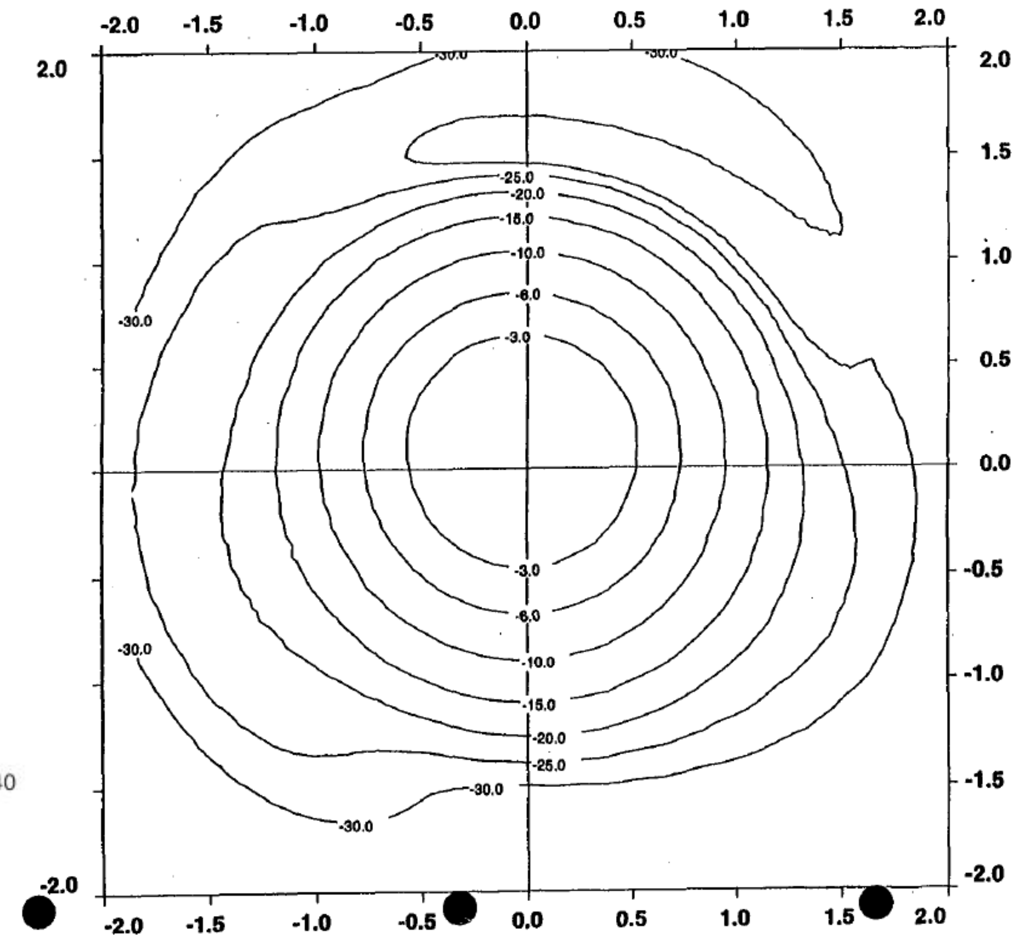
Back Up Slides

Asymmetries of the Beam Pattern and the Light Curve

Topic 2 – Beam Size



MHS FM2 H1 Space View

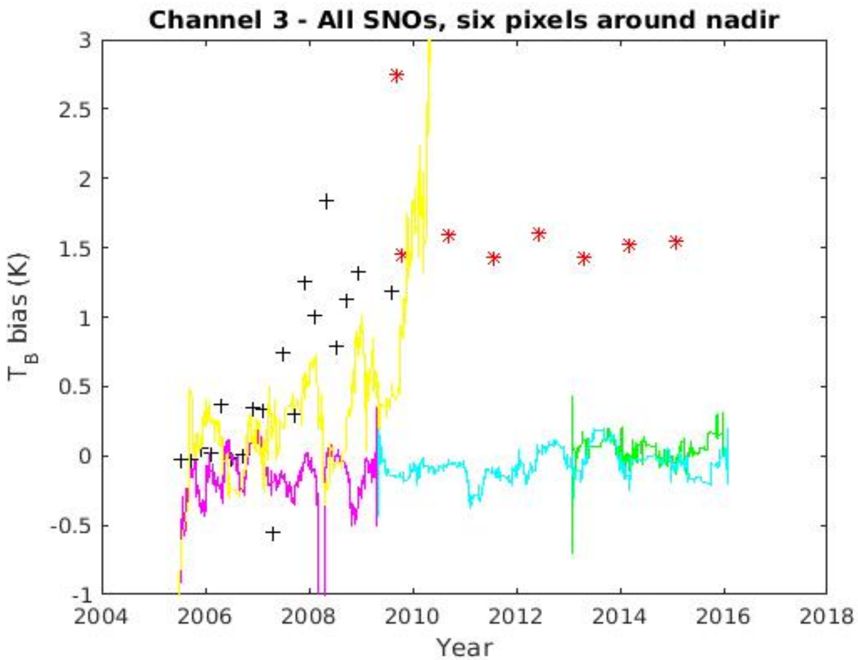


Back Up Slides

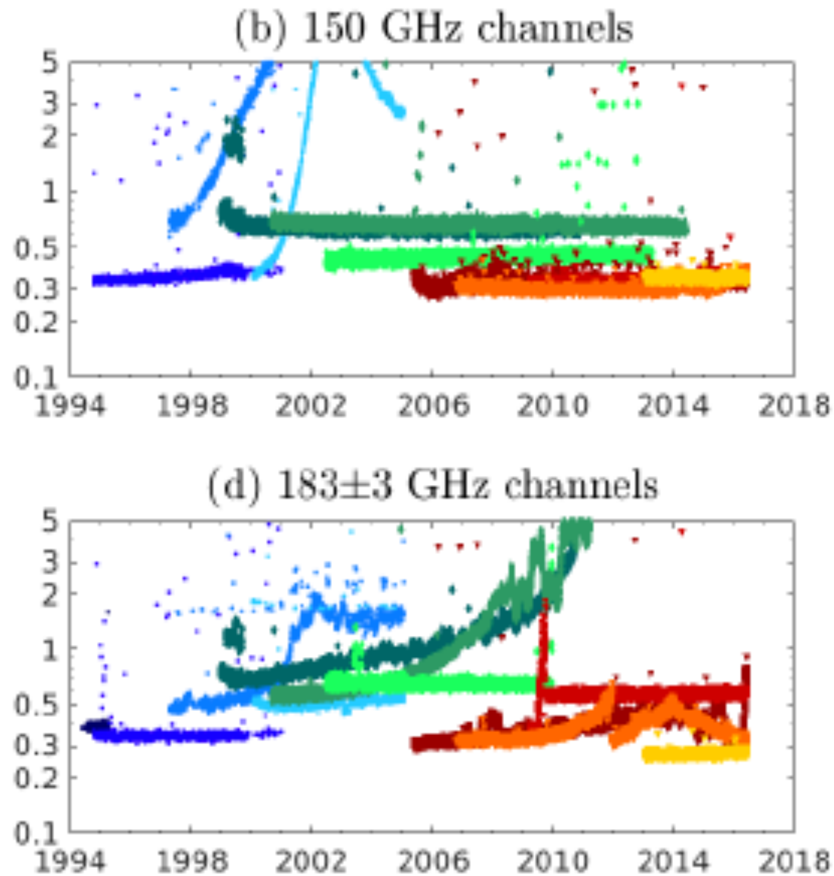
Decreasing Gain Causes Increasing Non-Linearity

Topic 4 – Non-Linearity

❖ *The performance of channels 3 - 5 deteriorates with time, whereas channels 1 and 2 remain stable. The error in photometry of channels 3 - 5 depends on the signal level.*



NEΔT



Hans et al., in preparation