Instrument Estimated Performance (Not Really)

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- Overview
- Observing Scheme
- Observables Calculation
- Calibration
- Requirements
- Unpleasant Details
- Key Questions

Overview

- Read:

  -Science Plan

  -Instrument Performance Document

Overview

- Observables

  -Dopplergrams

  -LOS magnetograms

  -Vector magnetograms

  -Intensity images

  -Etc.

- Observables made from filtergrams

  -Ground processing only

  -Allows for better calibration

  -Allows for reprocessing, if needed (better not too often)

  -Low on-board complexity

Observing Scheme

• Repeat same sequence of filtergrams (framelist) during normal operations

• Filtergram properties

-Wavelength

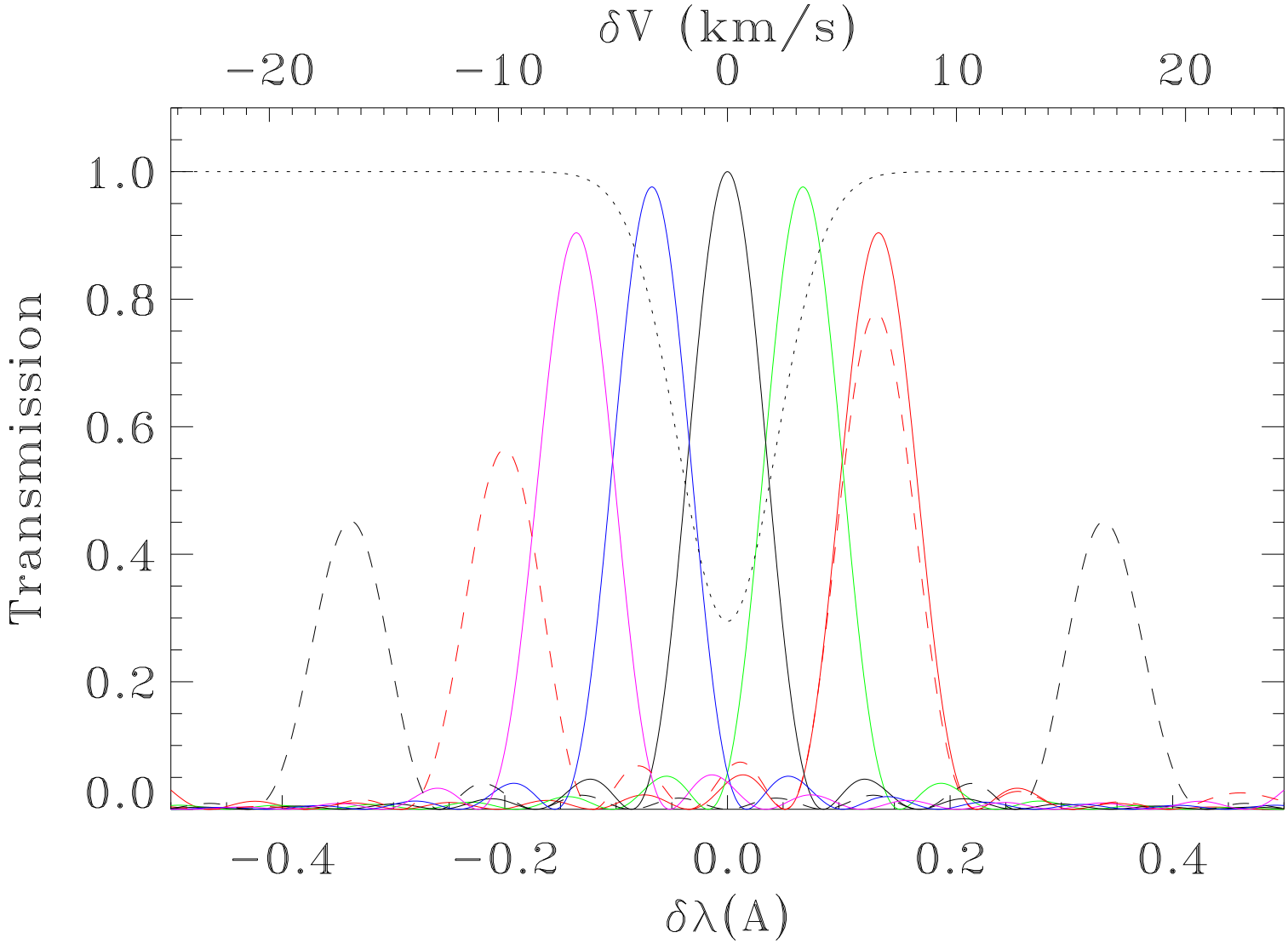
-Polarization state

-Camera

-Observing mode

-Exposure time

-...


δV (km/s)
−20
−10
0
10
20
1.0
0.8
0.6
0.4
0.2
0.0
Transmission
−0.4
−0.2
0.0
0.2
0.4
δλ(A)

Framelist options

- Cadence

  -40-50s Doppler required

  -Integer multiple (1, 2 or 3) for vector

- Combine data from two cameras?

  -For Doppler? For vector?

- 5, 5.5 or 6 wavelengths?

  -Dynamic range versus noise versus systematics

  -Which order? Retune 0, 2 or 4 times daily?

- Polarization scheme

  -Q, U and V separate or combined?

  -Which order?

  -Watch out for acceleration effects!

5 Position Framelist

Time(s)	0	...	32	40	...	72
Tuning	I1	...	I5	I1	...	I5
Doppler pol.	L R	L R	L R	L R	L R	L R
Vector pol.	1 2	1 2	1 2	3 4	3 4	3 4

5.5 Position Framelist

Time(s)	0	...	32	40	45	...	77	85
Tuning	I1	...	I5	IC	I1	...	I5	IC
Doppler pol.	L R	...	L R	C	L R	...	L R	C′
Vector pol.	1 2	...	1 2	C	3 4	...	3 4	C′

6 Position Framelist

Time(s)	0	...	40	48	...	88
Tuning	I1	...	I6	I1	...	I6
Doppler pol.	L R	L R	L R	L R	L R	L R
Vector pol.	1 2	1 2	1 2	3 4	3 4	3 4

Option 1

Time(s)	0	...	32	40	...	72
Tuning	I1	...	I5	I1	...	I5
Doppler	L R	L R	L R	L R	L R	L R
Vector	1 2	1 2	1 2	3 4	3 4	3 4

Option 2

Time(s)	0	...	32	40	...	72	80	...	112
Tuning	I1	...	I5	I1	...	I5	I1	...	I5
Doppler	L R	...	L R	L R	...	L R	L R	...	L R
Vector	A B	...	A B	C D	...	C D	L R	...	L R

L=LCP, R=RCP, 1, 2, 3 and 4 combinations of I, Q, U and V,
A=I-Q, B=I+Q, C=I-U, D=I+U.

Option 3

Time(s)	0	...	32	40	...	72
Tuning	I1	...	I5	I1	...	I5
Doppler	L R	L R	L R	L R	L R	L R
Vector	A B	A B	A B	C D	C D	C D

Option 4

Time(s)	0	...	32
Tuning	I1	...	I5
Camera 1	1 2	1 2	1 2
Camera 2	3 4	3 4	3 4

Observables construction

- Multiple steps
  -Make I, Q, U, V, LCP, RCP
  -Average in time, if needed
  -Make physical observables
- I, Q, U, V construction
  -Linear combinations of filtergrams
  -Flat field and polarization corrections
  -Correct for solar rotation (spatial interpolation)
  -Correct for acceleration effects(temporal interpolation)
  -Fill gaps
- Temporal averages
  -May be required for vector inversions

- Velocity algorithm

  -MDI-like:

$$V = f(\sum c_i I_i, \sum d_i I_i)$$

  -For suitable f, c and d (f$\approx$ atan)

  -Combine 2 MDI-like?

  -Fancier?

- LOS field

  -MDI-like: $B = c(V_{LCP} - V_{RCP})$

  -Fancier?

- Vector algorithm

  -Fast algorithm

  -Full inversion

Calibration

- Ground based

  -Various types of distortion

  -Filter characterization

  -Polarization characterization

  -...

- On orbit

  -Test sequences run at various times

- Data analysis

  -New algorithms need to be developed

Calibration challenges

- Much more data
- Much larger dynamic range
  -More demanding
  -But may use daily variation
- Need to consider polarization
  -Experience from Solar-B
- But calculations may be redone!
  -Better not too often...

Requirements

General

Requirement	Origin
Pixel size: 0.5”	MRD 1.3.1, 1.3.2, CPS
CCD size: 4096x4096	MRD 3.2.2.1, CPS
Resolution: 1.5”	MRD 1.3.1, 1.3.2
Resolution: 1.0”	Goal. Science Plan.
Field of View: 2000”	CPS
Field of View: 2012”	Internal.
Timing: 10^{-6} stability, 100ms abs.	MRD 3.2.3.1/3

Doppler Velocity

Requirement	Origin
Cadence: 50s	MRD 1.6.1, CPS
Cadence: 40s (40s, 45s, 48s, 50s possible)	Goal. Internal.
Completeness: 99% for 95% of time	CPS.
Noise: 25 m/s	MRD 1.5.1
Noise: 13 m/s	Goal. Internal.
Systematics: 10 m/s	Goal. Science Plan.
Disk averaged noise: 1 m/s	Science Plan.
Disk averaged noise: 0.1 m/s	Goal. Science Plan.
Non-white: 0.01 m/s above 500μHz	Goal. Internal.
Velocity scale: 1%	Goal. Internal
Dynamic range: $\pm$6.5 m/s	MRD 1.5.1.1, CPS
Dynamic range: $\pm$3 kG	MRD 1.5.1.1
Dynamic range: $\pm$4 kG	Goal. Science Plan.

Vector Field

Requirement	Origin
Cadence 300s	MRD 1.6.3, CPS
Cadence: Half Doppler	Goal. Science Plan.
Dynamic range: ± 3 kG	Internal.
Dynamic range: ± 4 kG	Goal.
Polarimetric noise: 0.3% in 10 minutes	MRD 1.5.5, CPS
Polarimetric noise: 0.22% in 10 minutes	Goal. Science Plan.
Pol. syst. (calibrated): 1% Q, U, V crosstalk.	Internal.
Pol. zero point noise: 1% Q, U, V crosstalk.	Internal.
Pol. zero point noise: 0.2% Q, U, V crosstalk.	Goal. Internal.

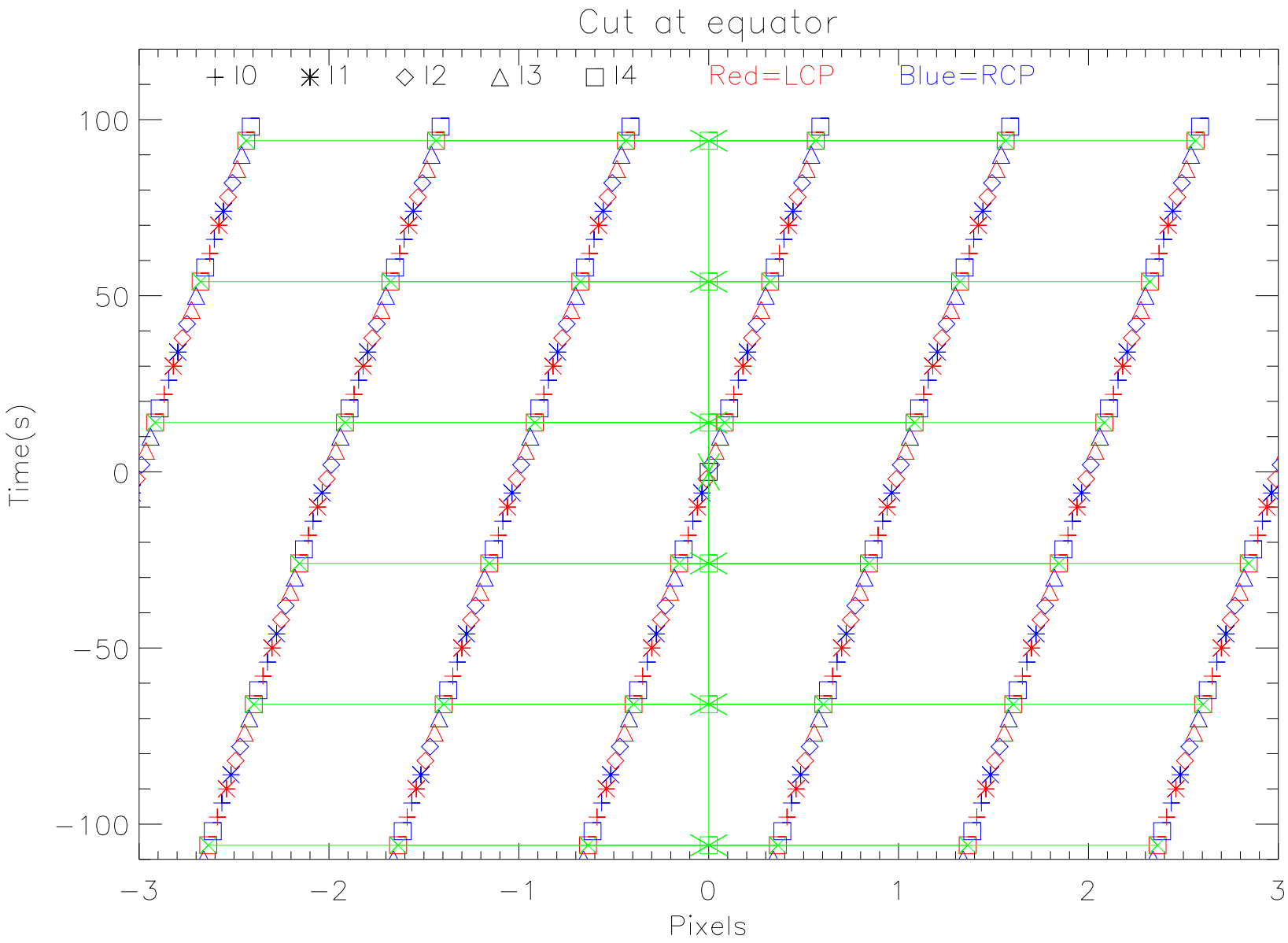
LOS Field

Requirement	Origin
Cadence: Same as Doppler	MRD 1.6.2, CPS
Noise: 5G in 10 minutes	MRD 1.5.3
Noise: 17G in 50s	MRD 1.5.3, CPS
Noise: 10G in 50s	Goal. Science Plan.
Zero point: 0.3G in 50s	MRD 1.5.2
Zero point: 0.2G in 50s	Goal. Internal.
Dynamic range: $\pm$6.5 m/s	Internal.
Dynamic range: $\pm$3 kG	Internal.
Dynamic range: $\pm$4 kG	Goal. Internal.
Pol. syst. (uncal.): 5% Q, U, V crosstalk.	Goal. Internal.

Continuum Intensity

Requirement	Origin
Cadence: Same as Doppler	Science Plan.
Noise: 0.3%	Science Plan.
Flat field: 0.1% (small scale)	Science Plan.
Flat field: 0.01% (small scale)	Goal. Science Plan.

Unpleasant Details



Spatial Interpolation

- The Sun rotates by about 0.3 pixels in 50s!
  -Must interpolate
  -Must know P-angle
- No problem! Algorithm exists
  -Nyquist almost fulfilled
  -Errors much less than photon noise
  -Algorithm is fast
  -Uses several points around target
  -Thanks to Rasmus!

Temporal Interpolation

- Samples taken far apart

  -40s-50s for Doppler, 40s-150s for Vector

- Nyquist is violated!

- Mostly using differences a few seconds apart

- Algorithm exists

  -Fine for a few seconds

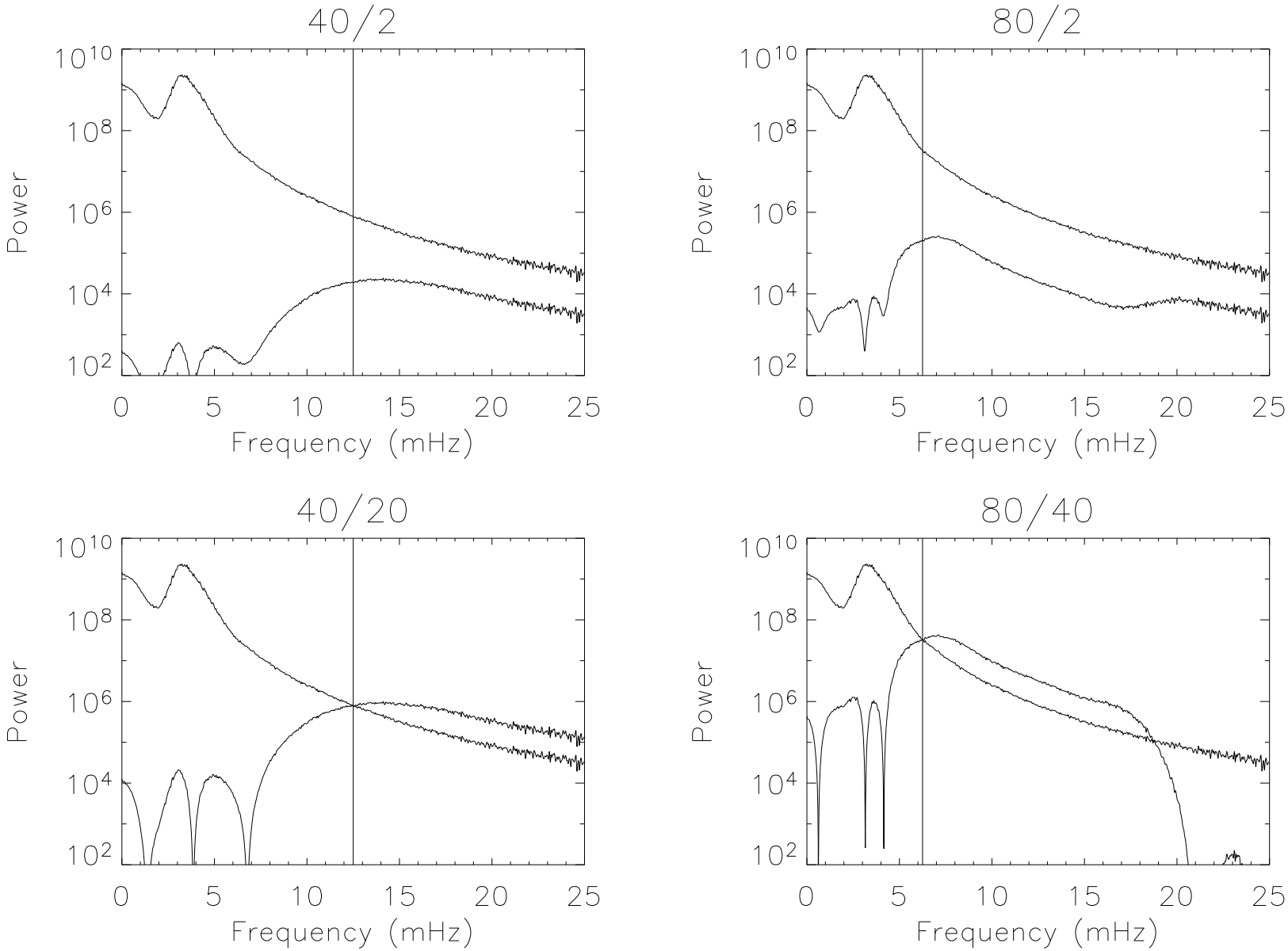
  -Marginal for half period

- Better options exist

  -Some fairly complex

  -Part of inversion code

- Temporal averaging helps


40/2
80/2
40/20
80/40
Power
Frequency (mHz)
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
0
5
10
15
20
25

Gap Filling

- Gaps will be frequent

  -On average about one missing packet (half a row) missing from each filtergram

- Several options exist

  -Interpolate filtergrams spatially

  -Interpolate filtergrams in time

  -Interpolate observables

  -Calculate observables given incomplete data

  -Something else

  -Combinations of the above

  -Don't bother

Key Questions

- Framelists

  -Number and order of wavelengths?

  -Retunings?

  -Order of polarizations?

  -Combine data from cameras?

- Observables

  -Want all quantities all the time (like linedepth)?

  -Want temporal averages?

  -Spatial averages?

  -Different algorithms available? On demand?

More Questions

- Interpolations

  -Order and complexity?

  -Same for quick and final products?

- Gap filling

  -When to do interpolations?

  -How fancy should algorithms be?

  -Needed for all variables?

  -Available with or without?