Precision Effects of Calibration in the Imaging Pipeline

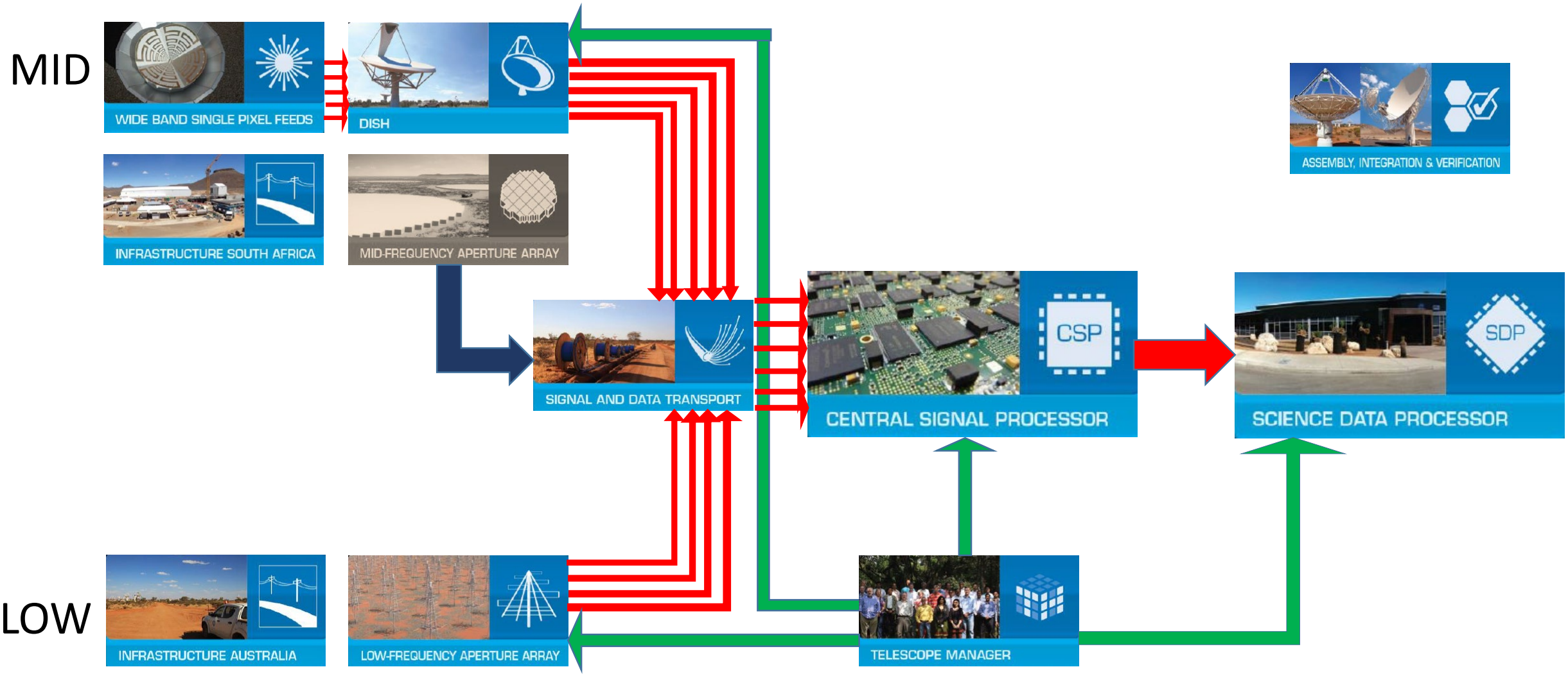
14 February 2019

Anthony Griffin, AUT

HIGH PERFORMANCE COMPUTING RESEARCH LAB

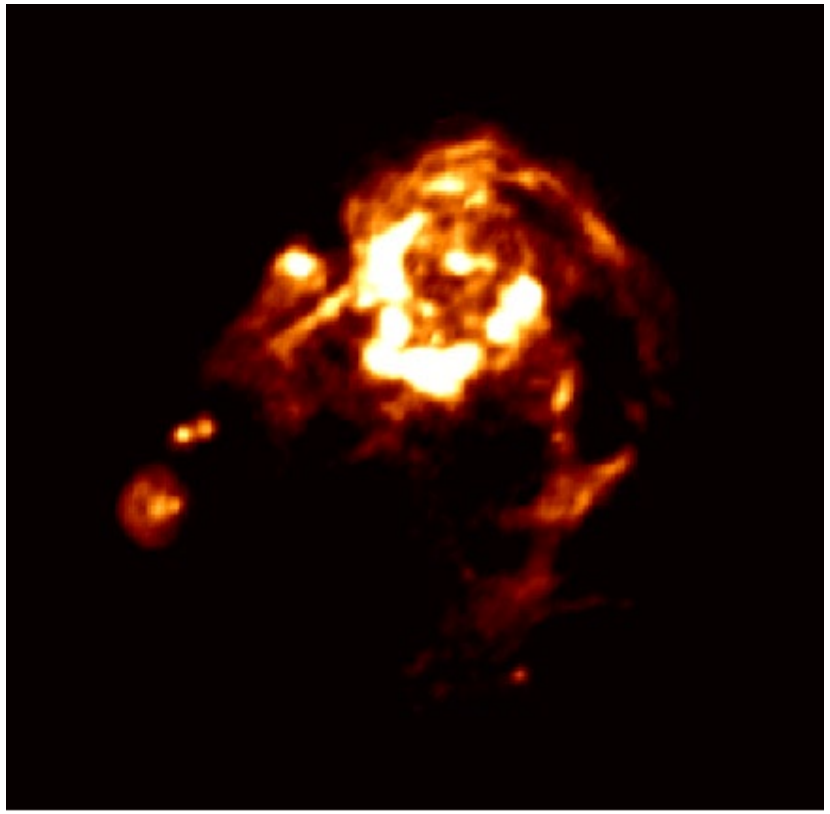
SCHOOL OF COMPUTER & MATHEMATCIAL SCIENCES

SKA Phase One Data Flow and Consortia Teams

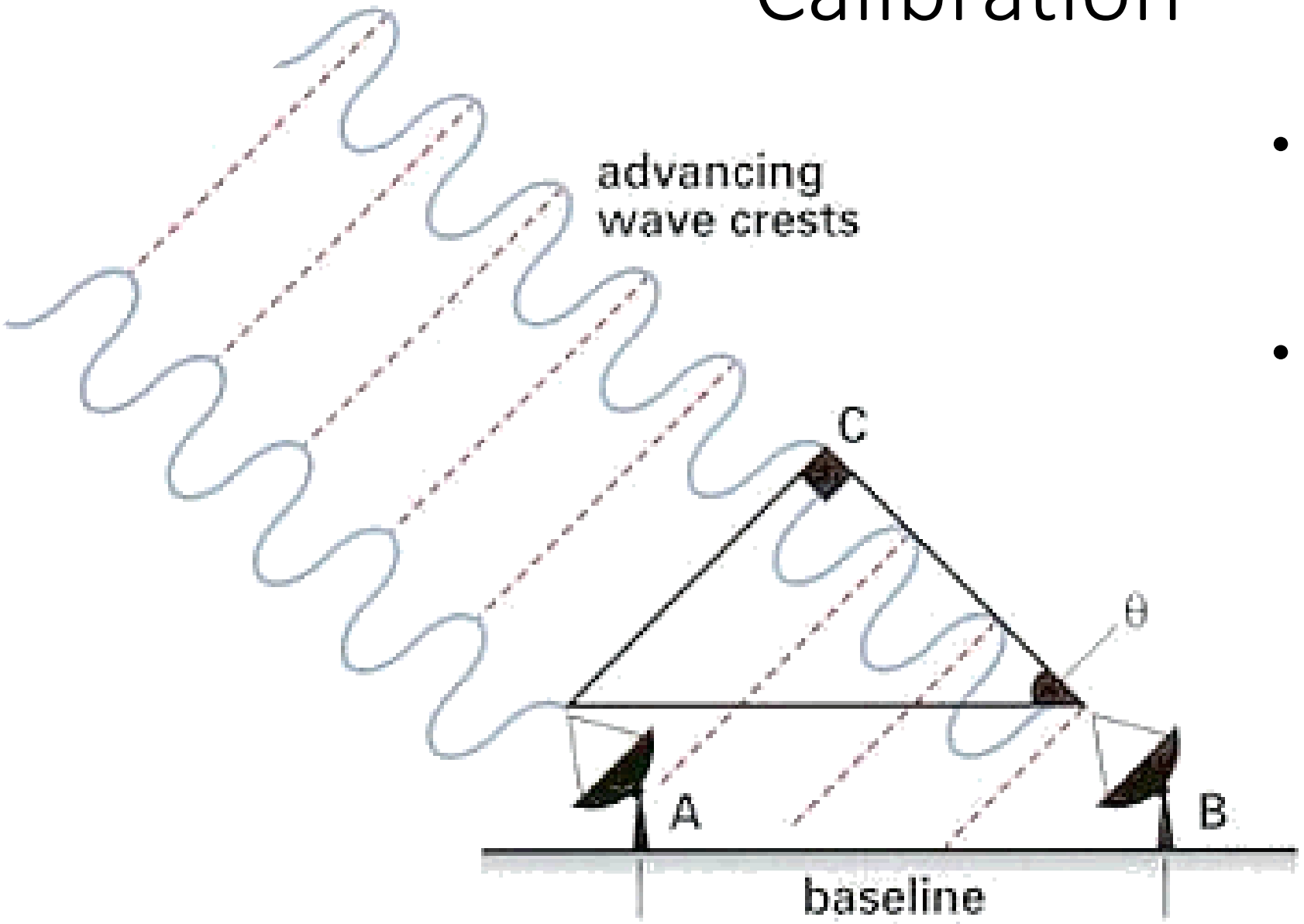


Imaging Pipeline

- Major function of the Science Data Processor (SDP)
- Takes the output of the Channel Signal Processor (CSP)
  - Visibilities (uv-plane)
  - (Measurements of the sky in the Fourier domain)
- Processes the Visibilities
- Produces an image of a region of the sky

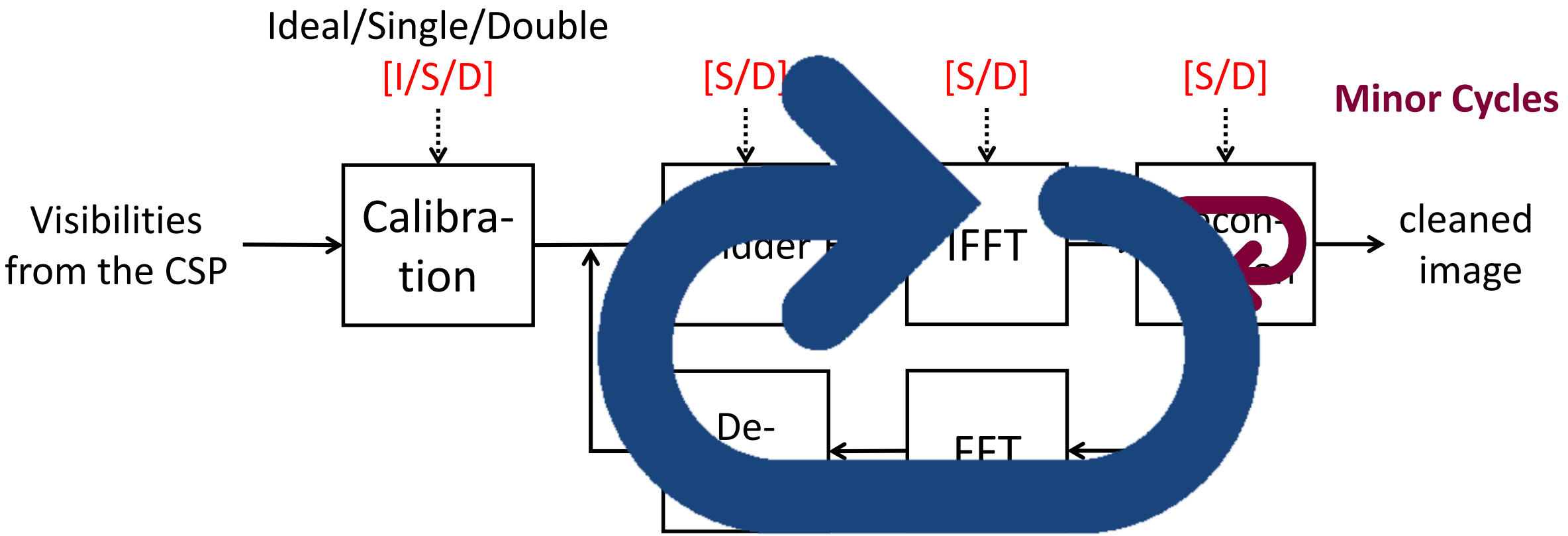


Calibration



- Many things need to be calibrated in a radio inteferometer.
- So far we are just looking at amplitude calibration.

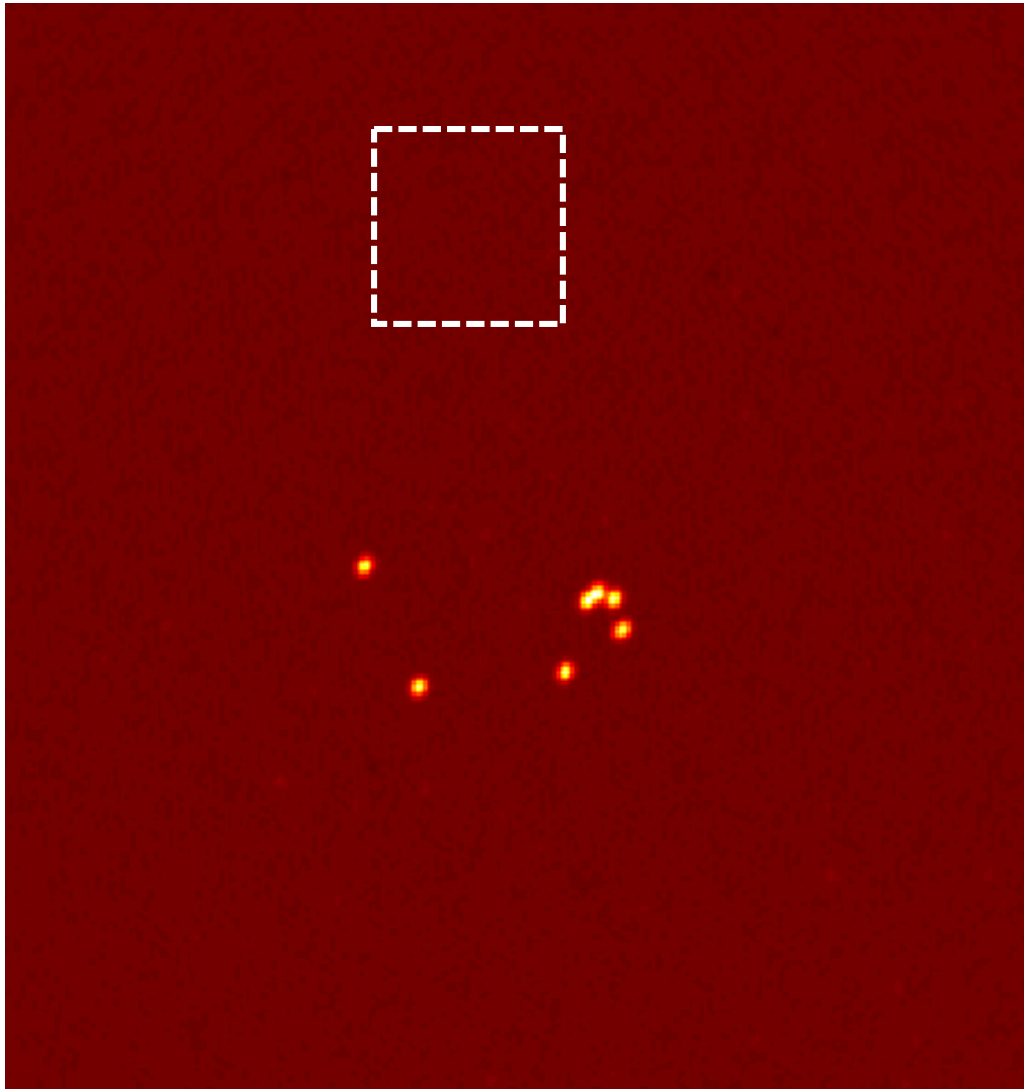
Precision Options in the Model



- IDDD is the best possible
- For example, DSDD vs DDDD shows the effect of gridding in single precision

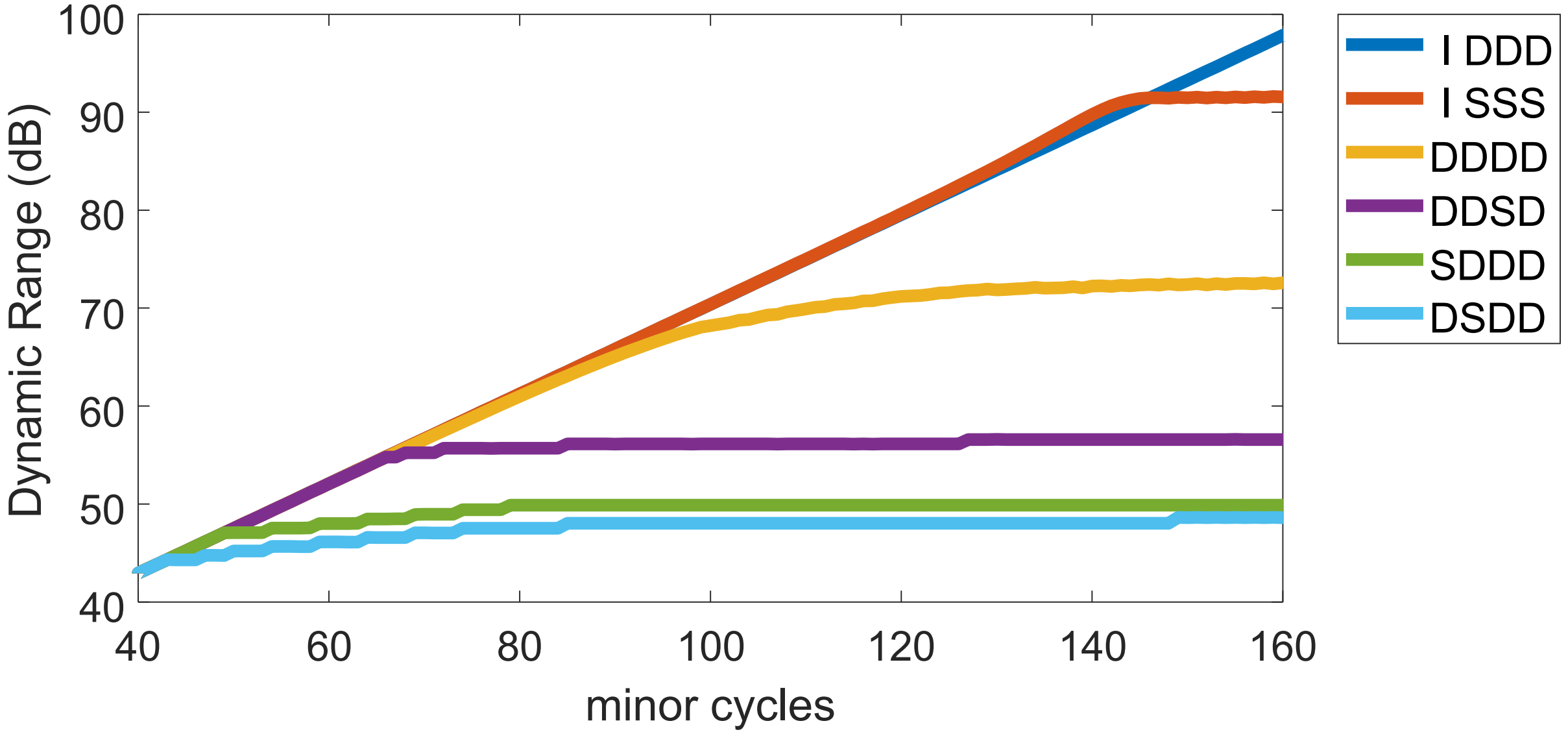
Dynamic Range

$$\text{Dynamic Range} = \frac{\text{Peak Value}}{\text{Energy in a Patch}}$$



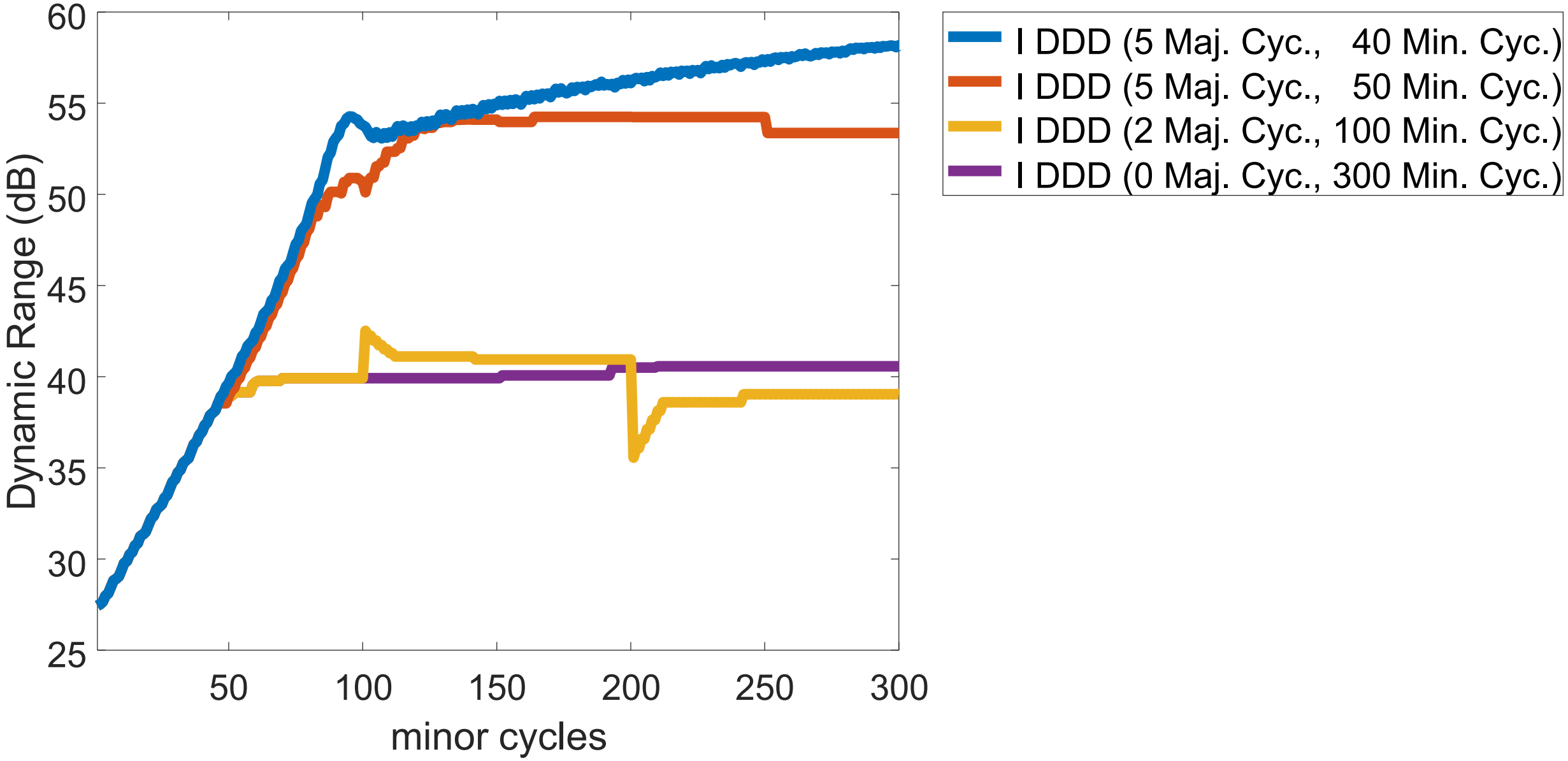
Simulation Parameters

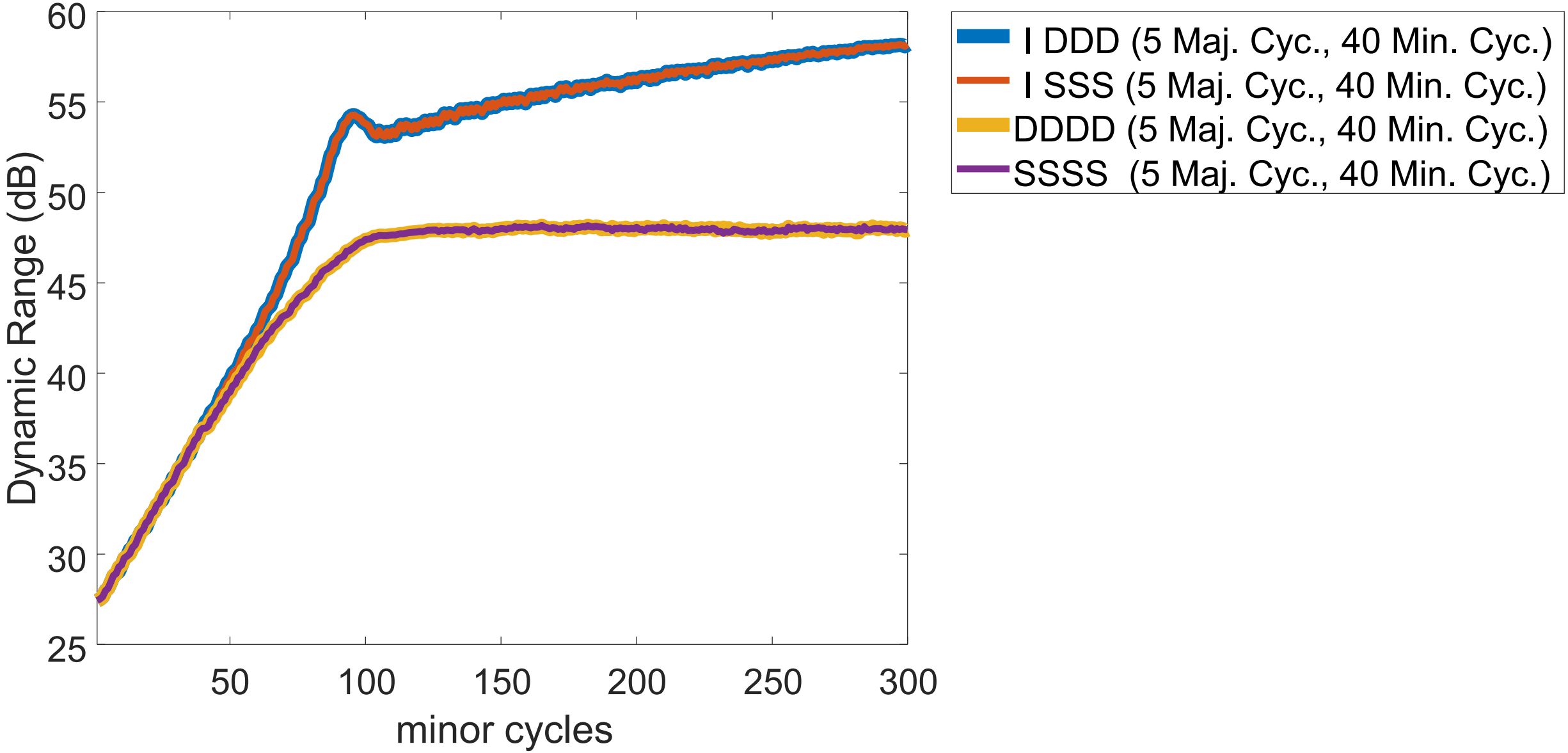
- SKA-LOW -> 512 receivers – 130,816 baselines
- 1 second observation time
- 1 source at the phase centre
- 1 fine channel
- 200 cycles of Högbom cleaning, with a gain of 0.1
- Amplitude calibration with an SVD solver


100
90
80
70
60
50
40
Dynamic Range (dB)
40
60
80
100
120
140
160
minor cycles
I DDD
I SSS
DDDD
DDSD
SDDD
DSDD

Simulation Parameters

- SKA-LOW -> 512 receivers – 130,816 baselines
- 1 second observation time
- 2 sources
  - 1 close to the phase centre, the other further away, neither on a pixel
- 1 fine channel
- 5 major cycles and 40 minor cycles of Högbom cleaning
  - a gain of 0.1
- Amplitude calibration with an SVD solver


60
55
50
45
40
35
30
25
Dynamic Range (dB)
50
100
150
200
250
300
minor cycles
I DDD (5 Maj. Cyc., 40 Min. Cyc.)
I DDD (5 Maj. Cyc., 50 Min. Cyc.)
I DDD (2 Maj. Cyc., 100 Min. Cyc.)
I DDD (0 Maj. Cyc., 300 Min. Cyc.)


60
55
50
45
40
35
30
25
Dynamic Range (dB)
50
100
150
200
250
300
minor cycles
I DDD (5 Maj. Cyc., 40 Min. Cyc.)
I SSS (5 Maj. Cyc., 40 Min. Cyc.)
DDDD (5 Maj. Cyc., 40 Min. Cyc.)
SSSS (5 Maj. Cyc., 40 Min. Cyc.)

Conclusions and Future Work

- Single precision on calibrated data does have some effect on Dynamic Range (DR) in the final image
- In the extreme case (point source at phase centre)
  - FFTs in single precision result in a DR ceiling of about 57 dB
  - Gridding in single precision results in a DR ceiling of about 48 dB
- No change in the two source test
- These are preliminary results!
- Longer observations
- More complicated skies
- More realistic Calibration algorithms
  - Self-cal, Stef-cal, etc