FFT CRT Pixel-Level Simulation

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FFTCRT ~ Optical CCDs

- One exposure is a set of samples (nTimes) of all receivers (nx X ny), observing a signal sky temperature with a noise temperature.
- The FFT generates nTimes/2 2-dimensional images (one for each frequency bands) that are nTheta X nPhi pixels.
- This simulation is an implementation of John Marriner's paper.

Specify the FFT Telescope

- Assume a regular grid; define the number of receivers and spacing.
- Define the sampling time for one exposure and the number of time samples
- Each receiver has a complex gain(frequency) and beam pattern(theta,phi)
- The noise temperature is specified for each receiver.

Specify the Sky

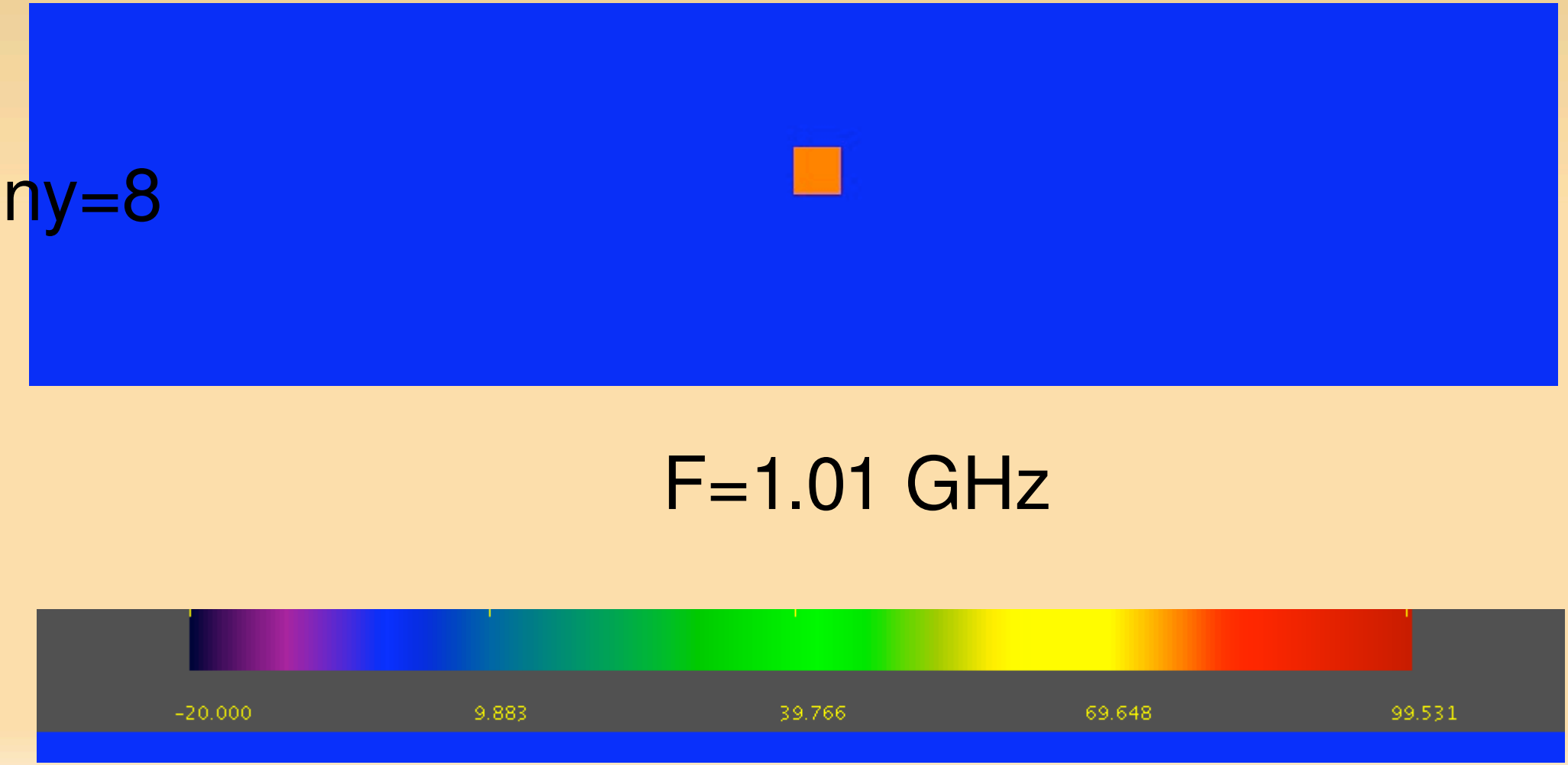
- Returns the temperature vs. frequency and (ra,dec)
- Implemented for testing:
  - Constant power law in nu at all ra,dec
  - Point source power law at specified ra,dec
  - Delta function in nu at specifice ra,dec
- Implemented for signal
  - Global Sky Model, smooth fit to 11 frequencies at 1 degree resolution, by Angelica de Oliveira-Costa
  - BAO signal generated by Nick Gnedin

One Pointing

- Place a FFT telescope at a (long,lat) position
- Observe at a sidereal time
- For each frequency, calculate strength and error in each theta,phi bin
- Write these as a FITS image

Delta in ra,dec and frequency

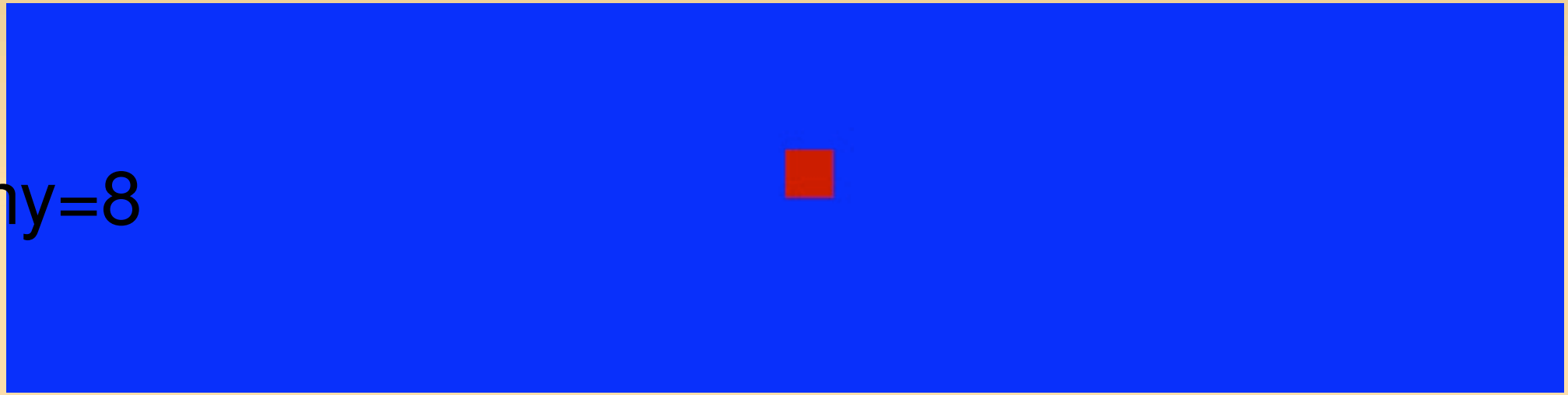
nx=32



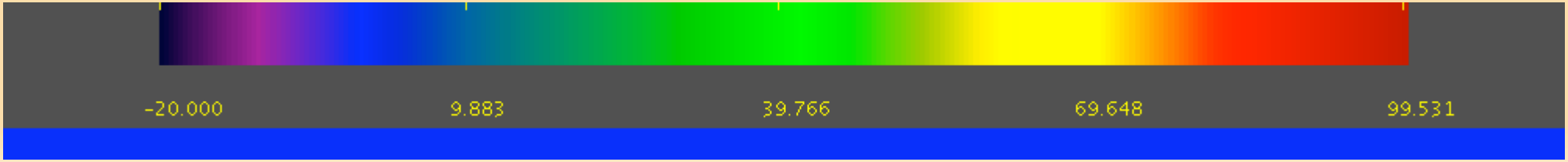
F=1.01 GHz

Delta in ra,dec and frequency

nx=32

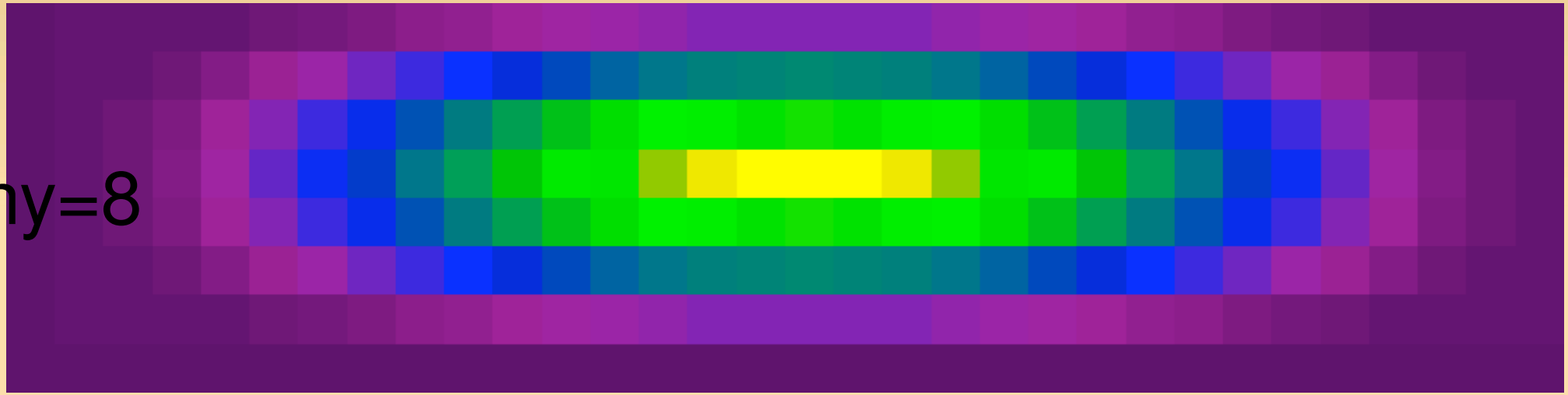


F=1.45 GHz

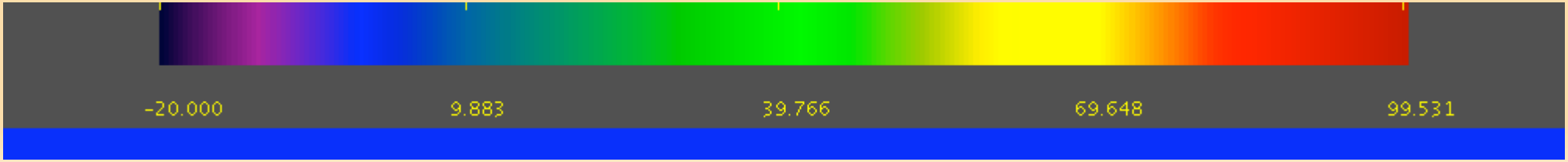


Power Law in frequency

nx=32

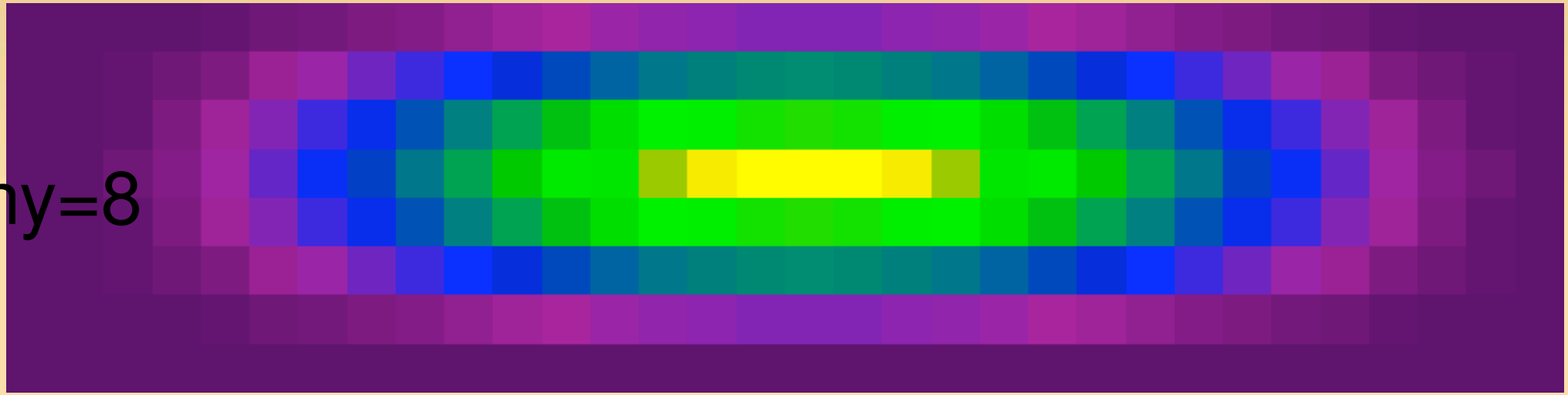


F=1.01 GHz

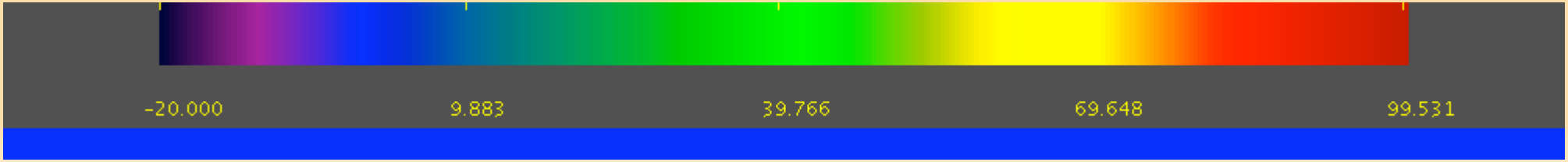


Power Law in frequency

nx=32

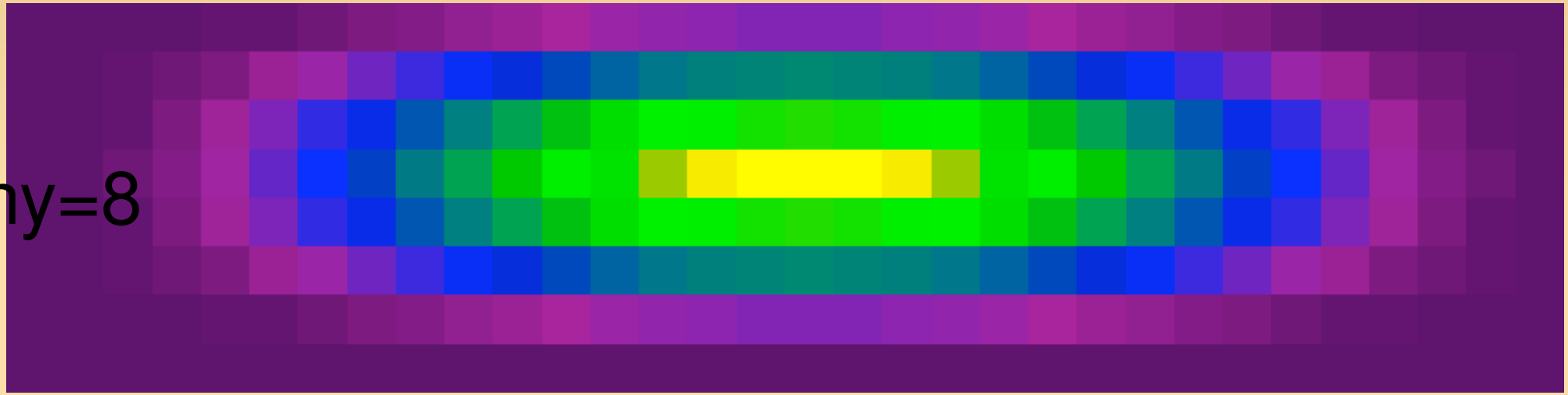


F=1.08 GHz

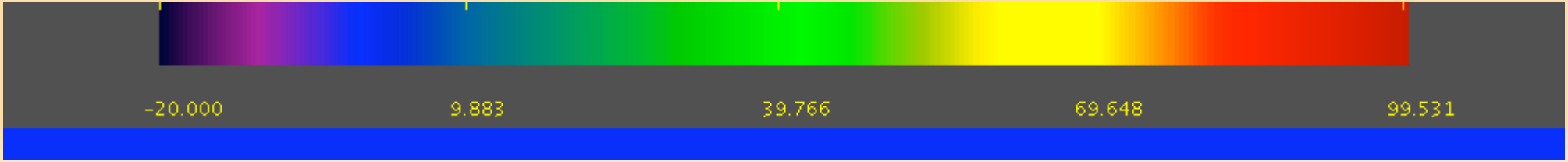


Power Law in frequency

nx=32

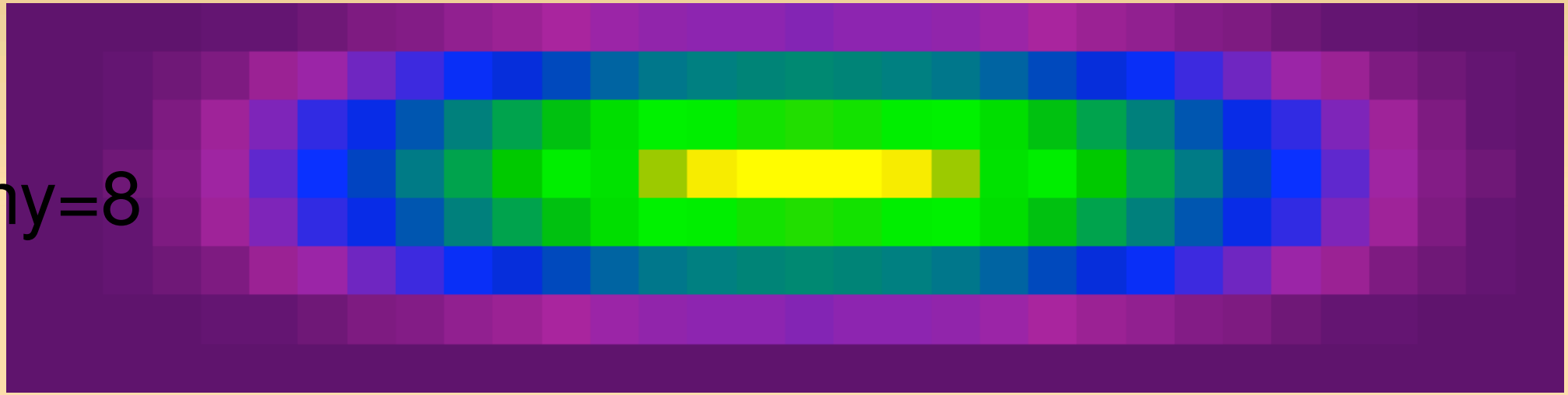


F=1.14 GHz

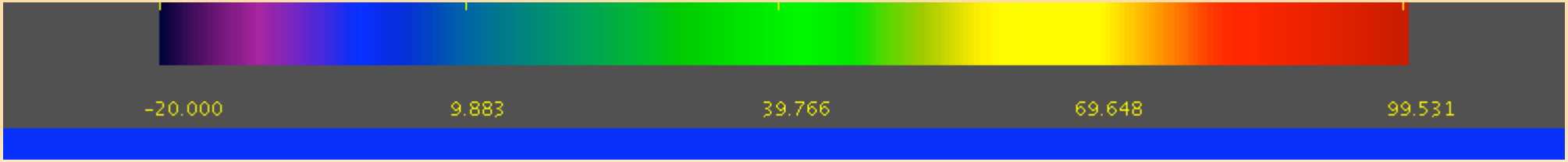


Power Law in frequency

nx=32

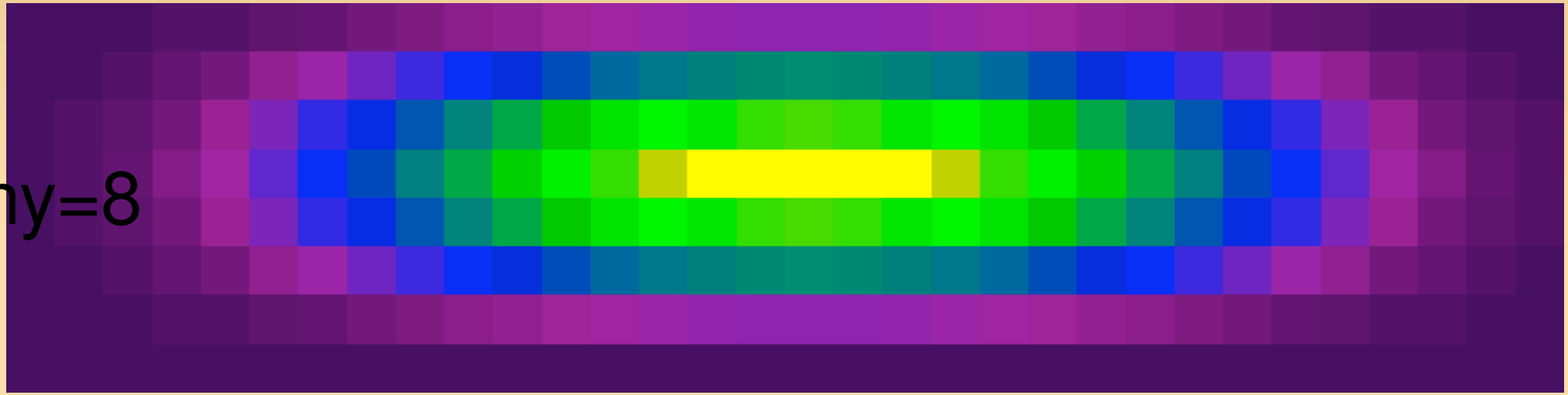


F=1.20 GHz

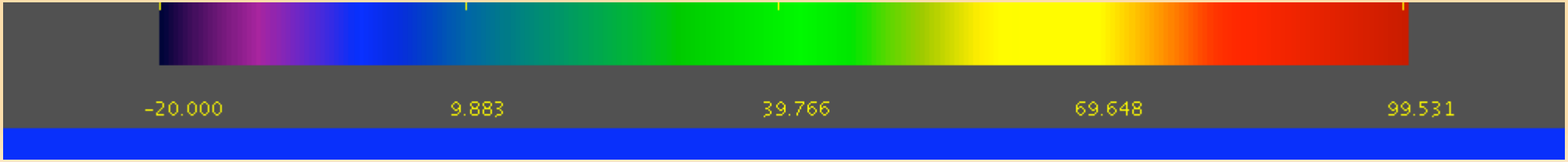


Power Law in frequency

nx=32

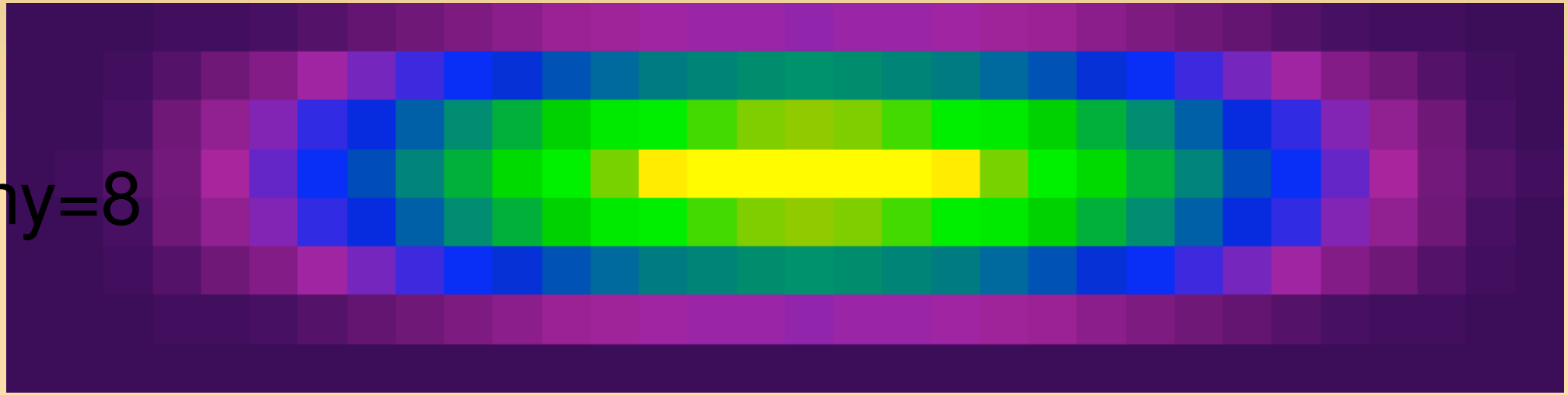


F=1.27 GHz

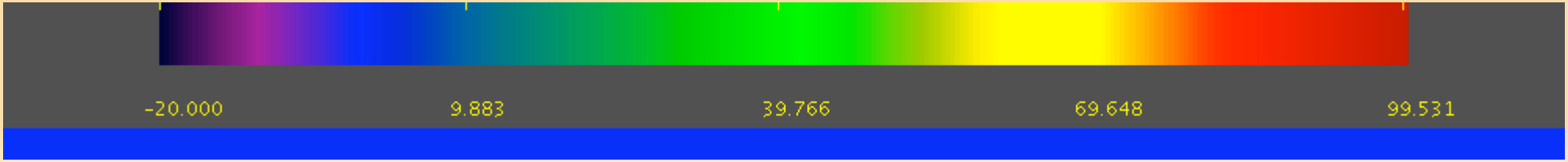


Power Law in frequency

nx=32

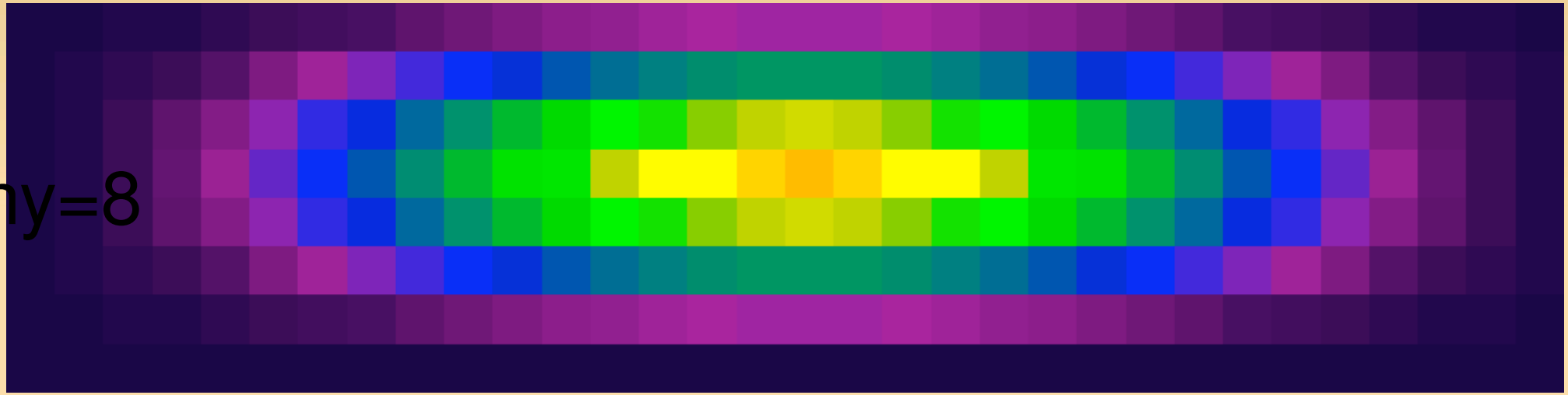


F=1.33 GHz

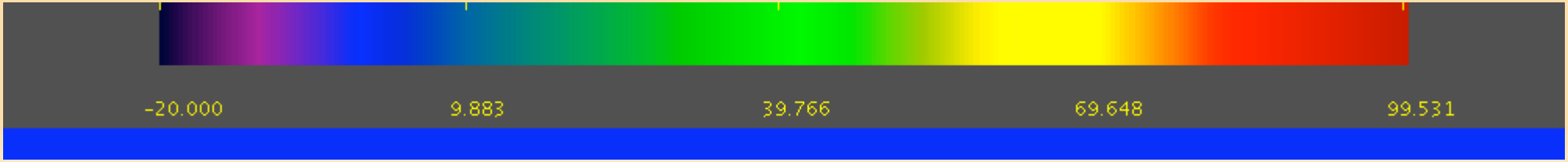


Power Law in frequency

nx=32

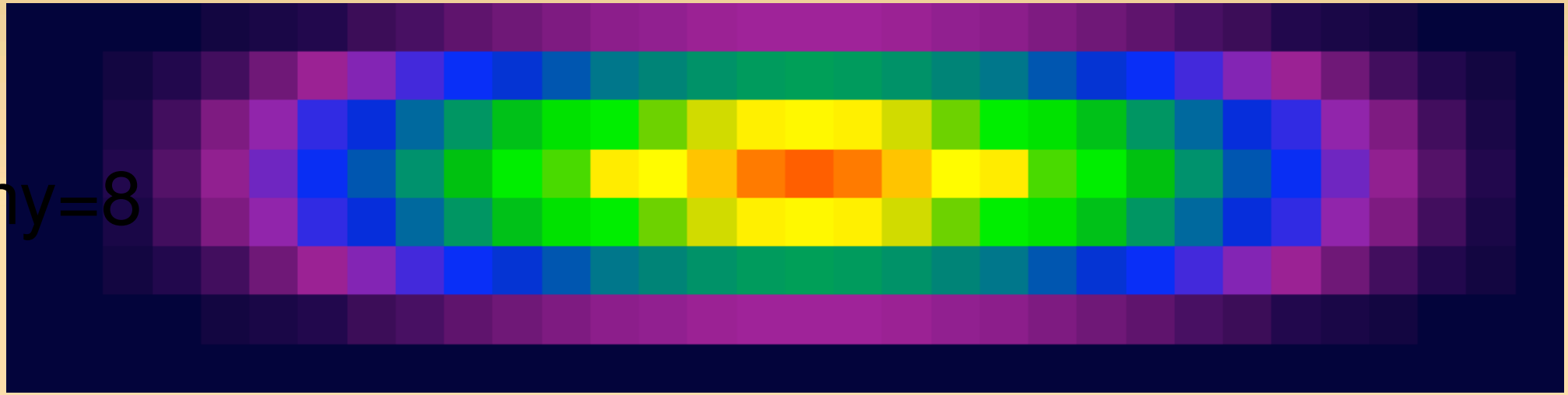


F=1.39 GHz

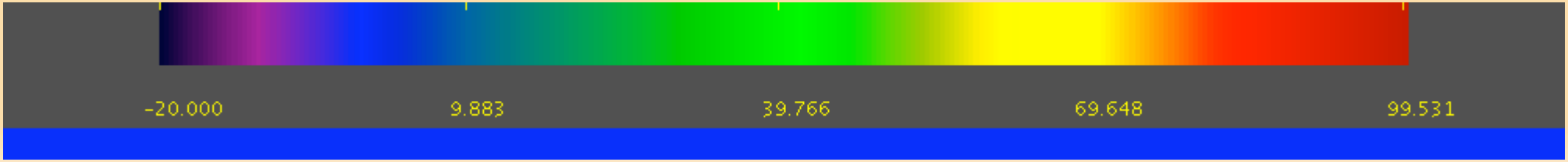


Power Law in frequency

nx=32



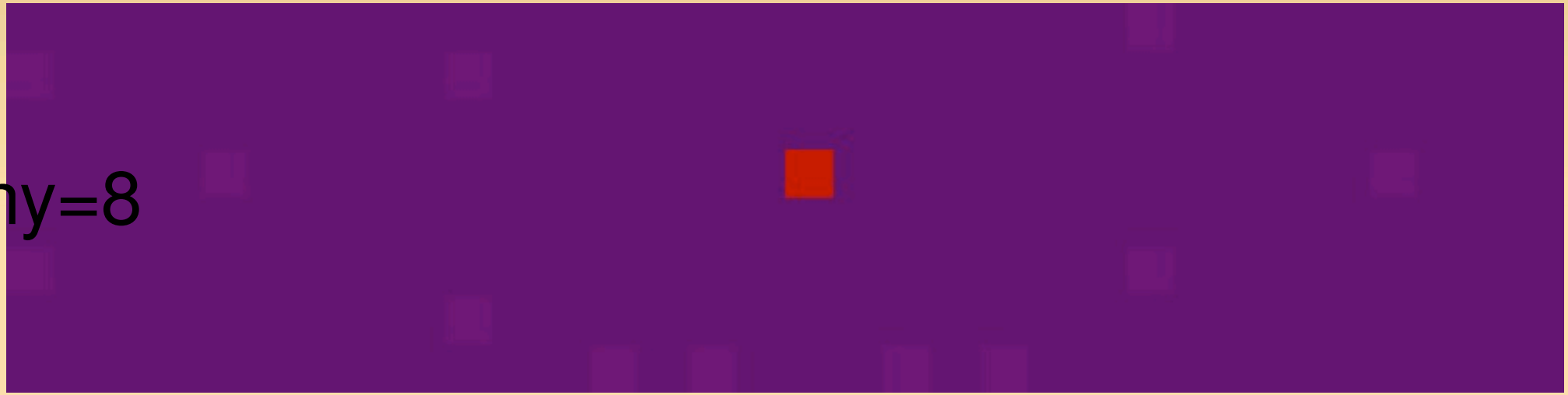
F=1.45 GHz

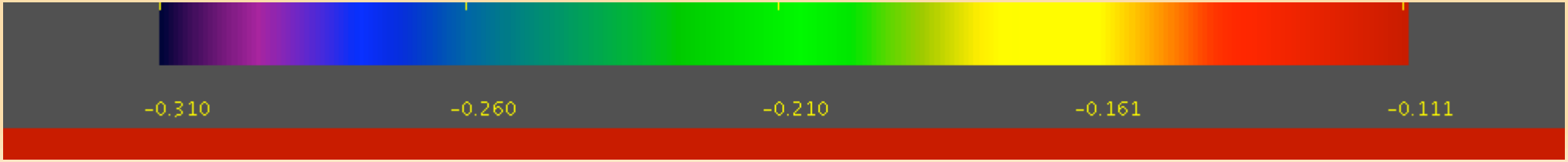


point source
1% gain variation

nx=32

ny=8

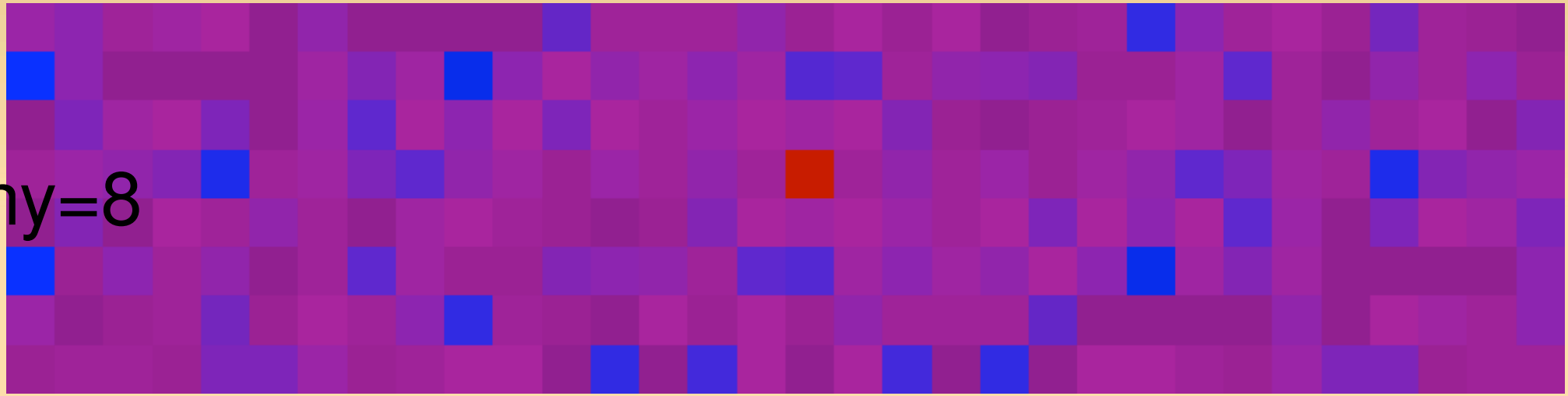


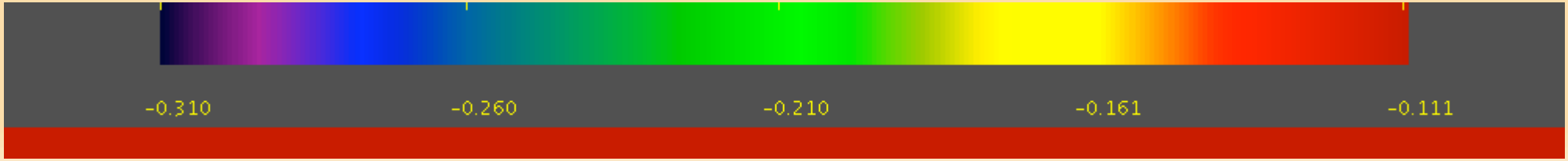


point source
10% gain variation

nx=32

ny=8

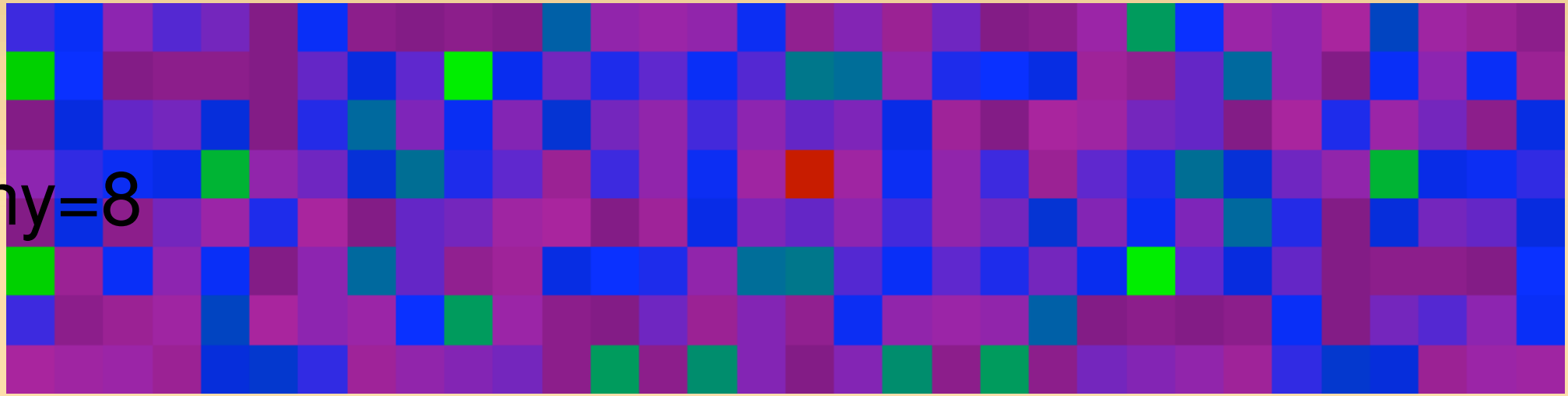


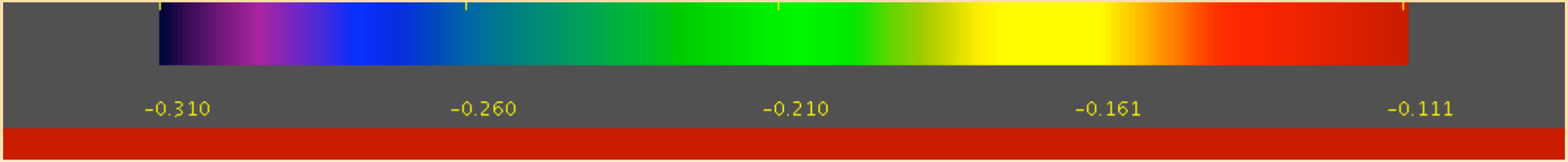


point source
20% gain variation

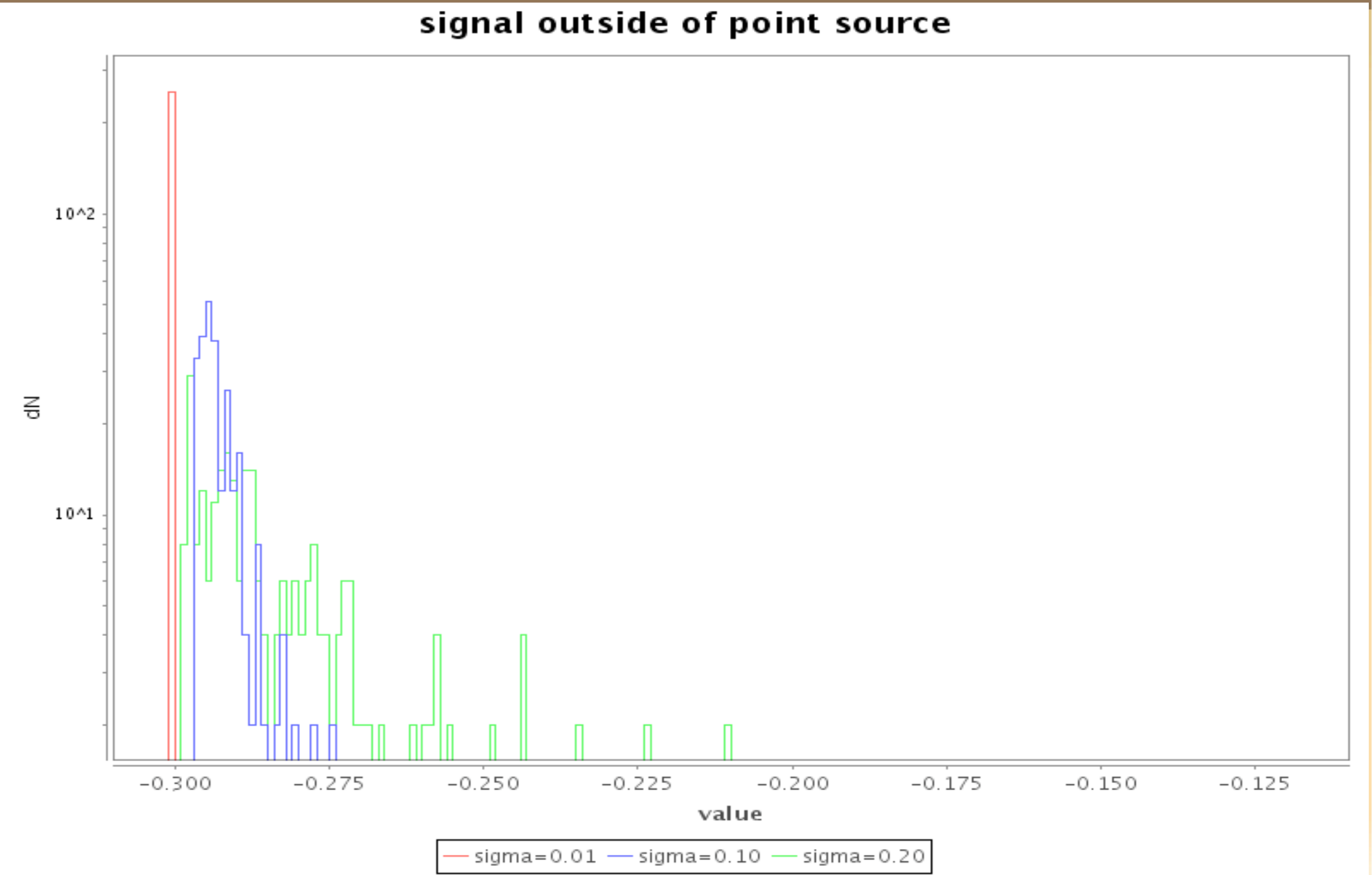
nx=32

ny=8





Point Source with Gain Variation



Summary

- FFT Radio Telescope Simulation ~ multi-band CCD imaging
- “full” array takes 40 minutes per frequency slice per exposure
- Grid resources @ FNAL could simulate survey in ~ week
- Reasonable sky signals: Global Sky Model and/or BAO signal from Nick Gneddin
- Code available to collaboration to repeat/extend these studies.