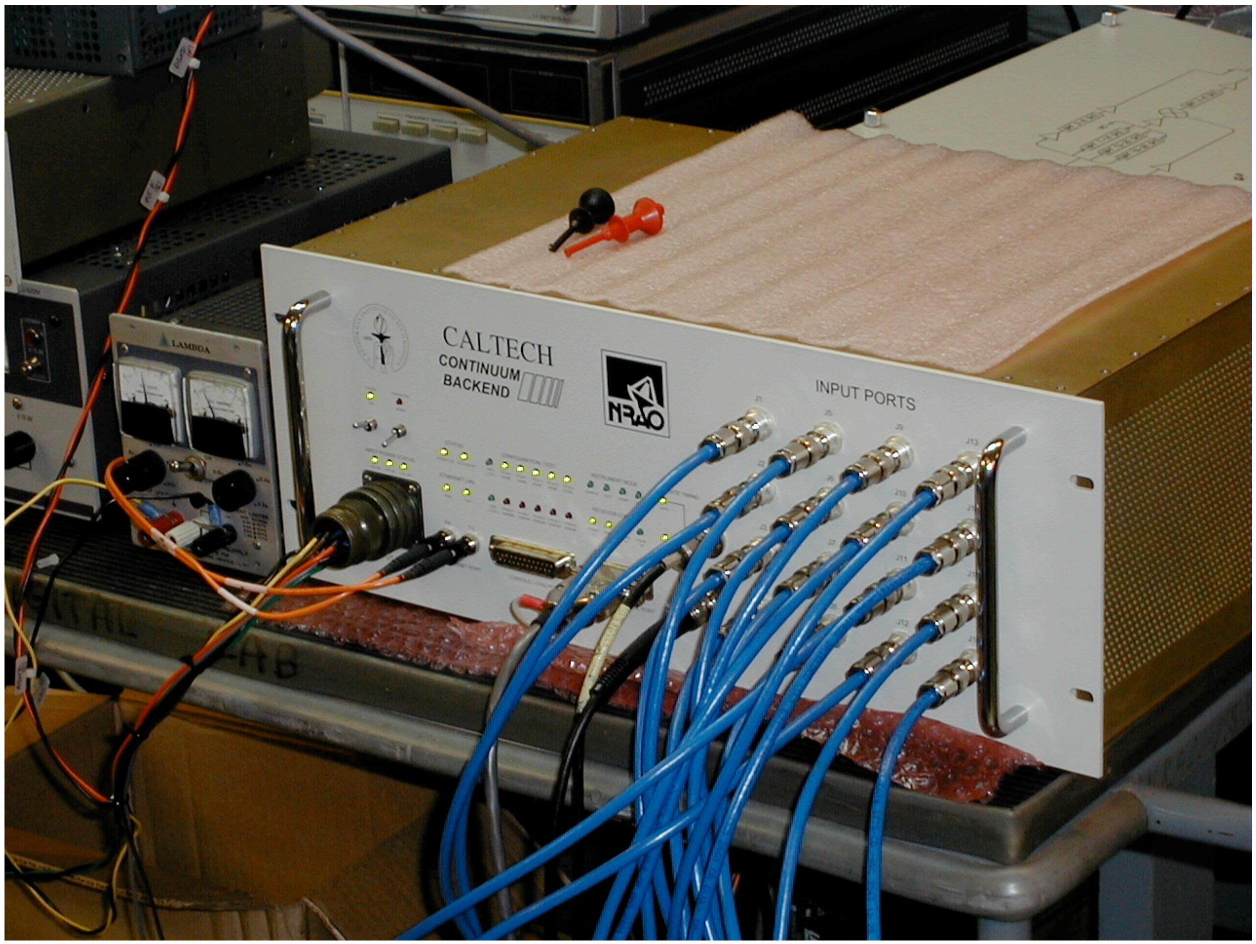
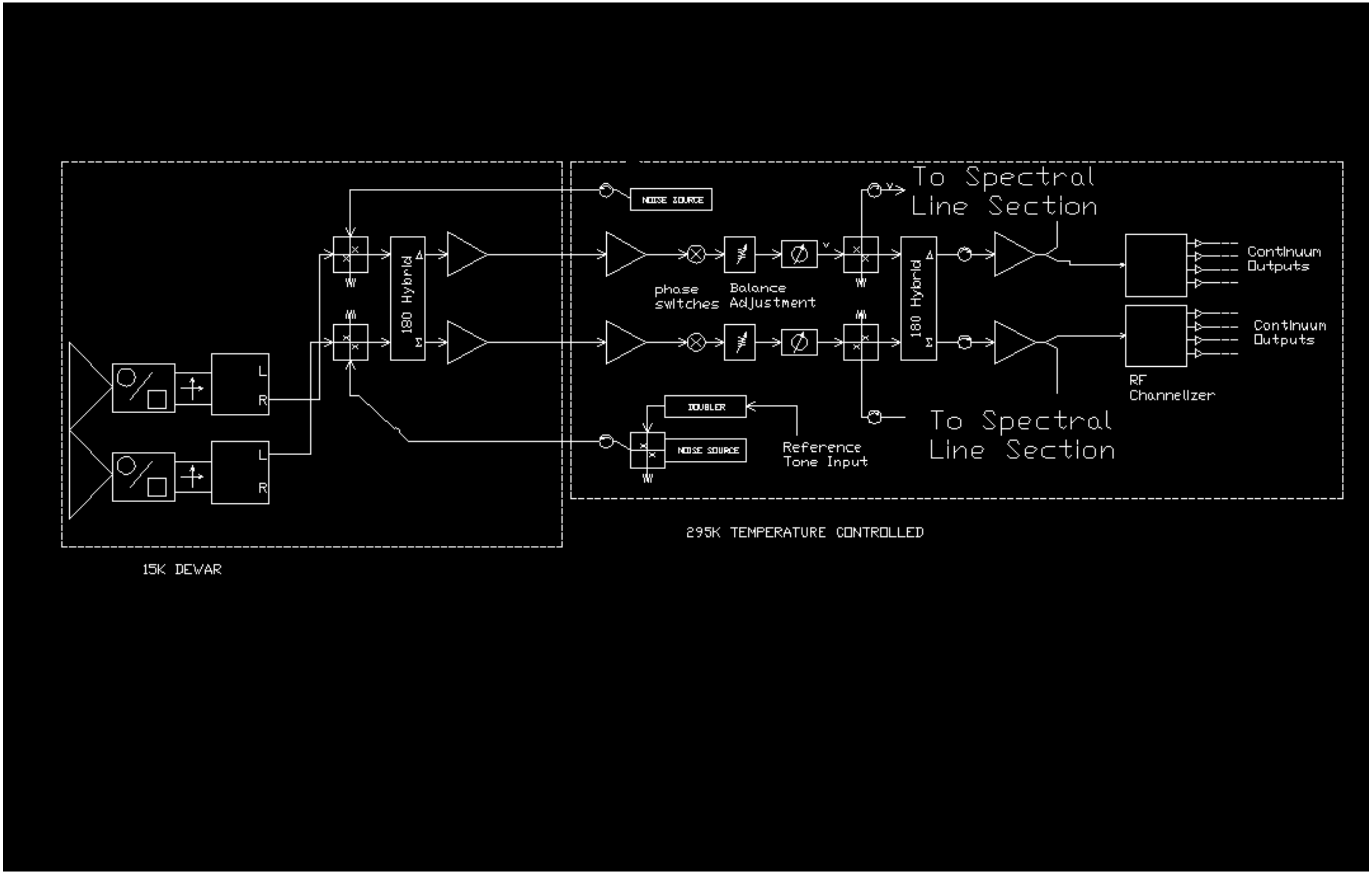
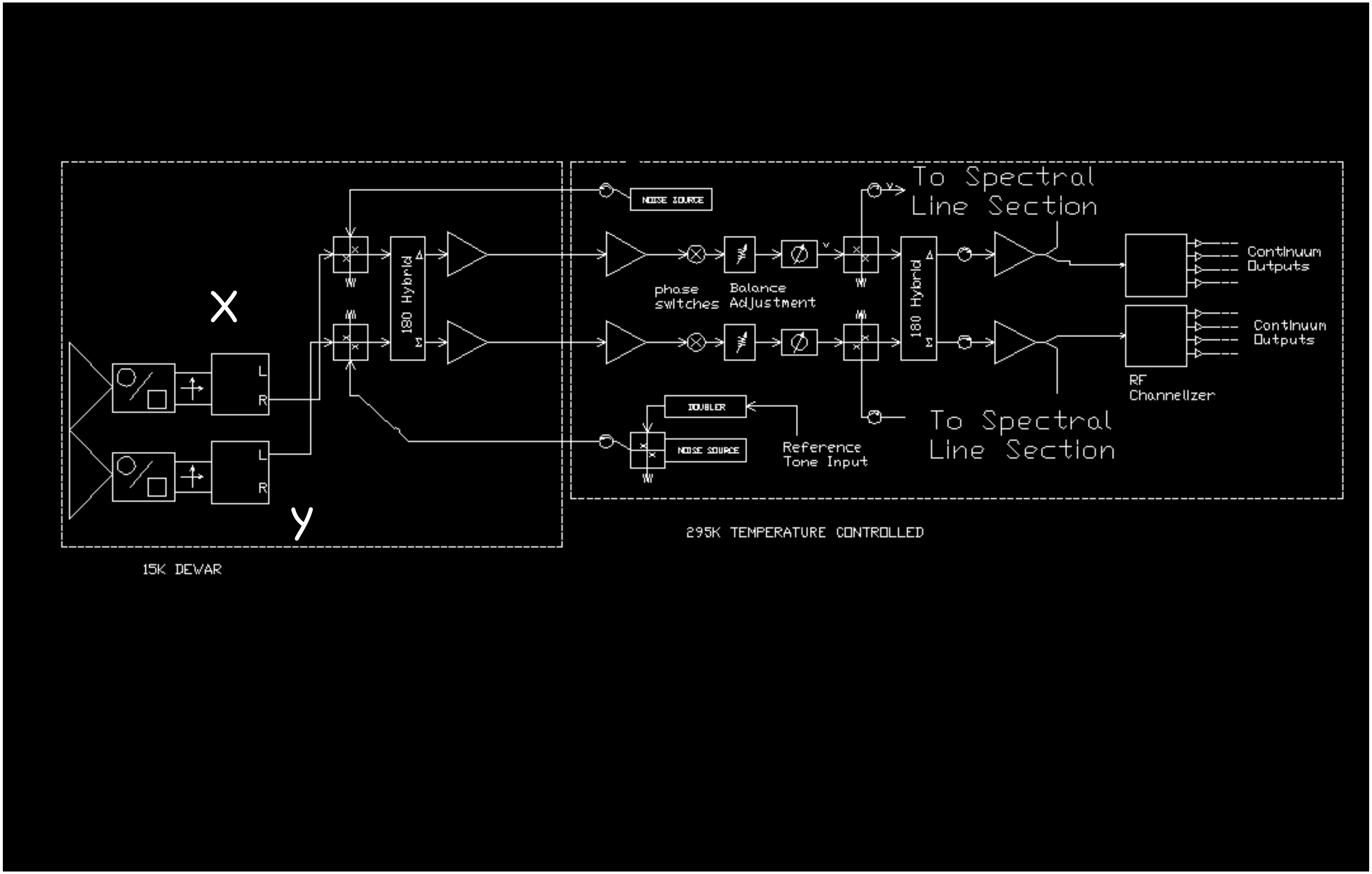
Everything You Ever Wanted to Know about the CCB but were Afraid to Ask



Brian Mason, 10mar08


NOISE SOURCE
To Spectral Line Section
180 Hybrid
phase switches
Balance Adjustment
Continuum Outputs
Continuum Outputs
RF Channelizer
DOUBLER
NOISE SOURCE
Reference Tone Input
To Spectral Line Section
295K TEMPERATURE CONTROLLED
15K DEWAR



X
Y
L
R
L
R
180 Hybrid
NOISE SOURCE
phase switches
Balance Adjustment
180 Hybrid
To Spectral Line Section
Continuum Outputs
Continuum Outputs
RF Channelizer
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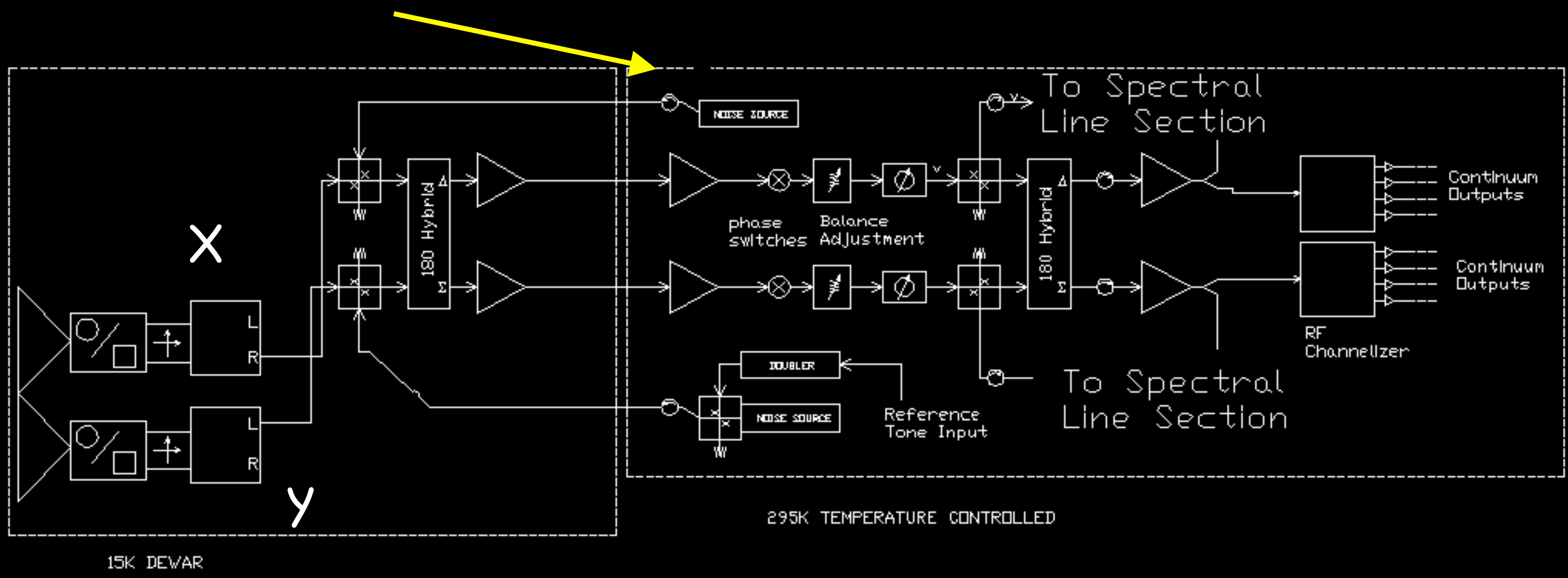
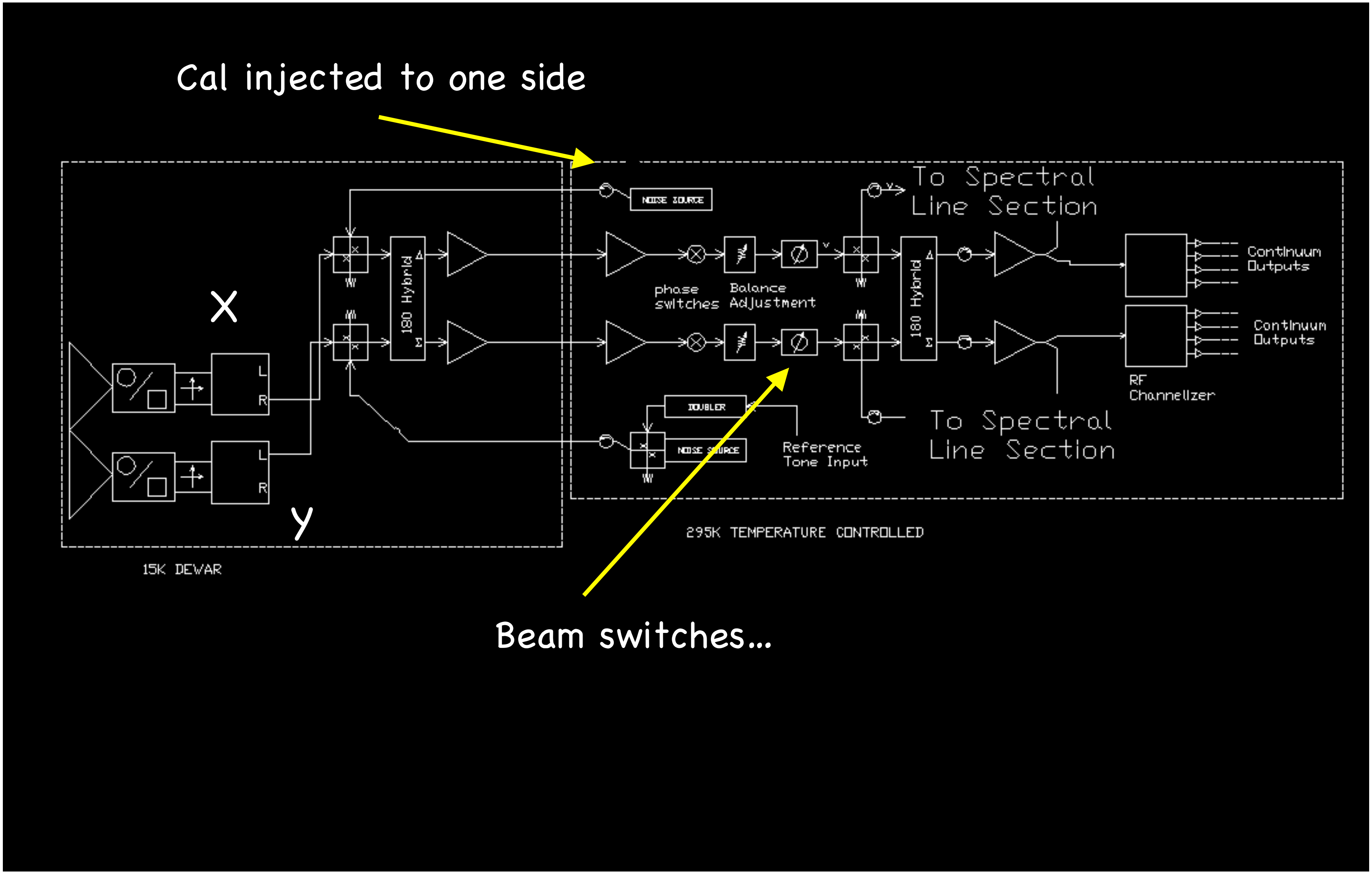
Reference Tone Input
To Spectral Line Section
295K TEMPERATURE CONTROLLED
15K DEWAR

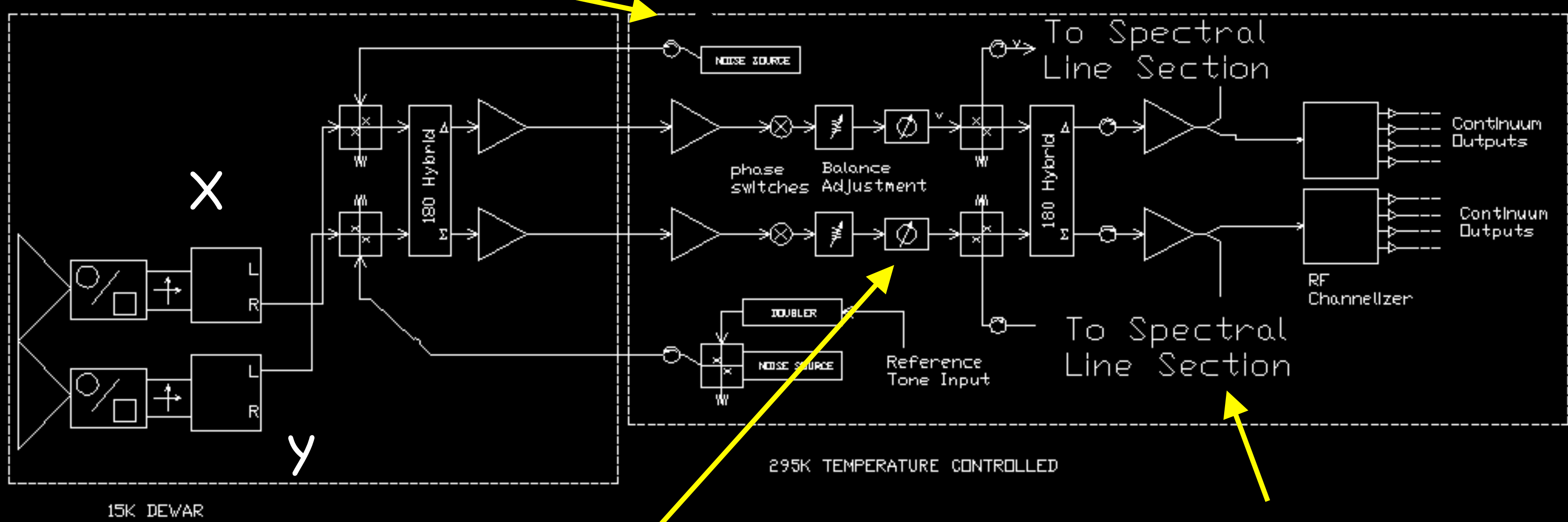
Cal injected to one side





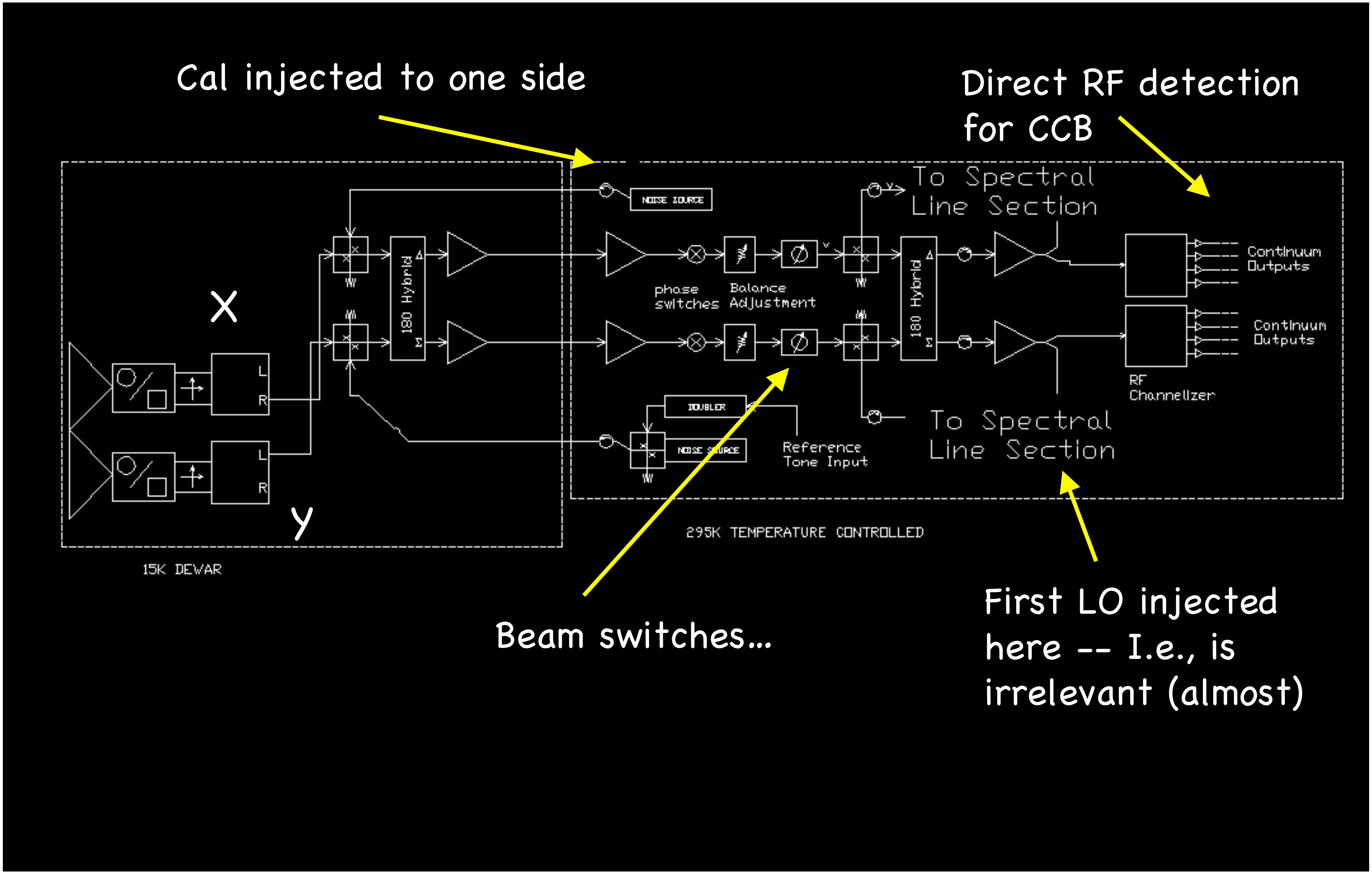
Cal injected to one side
X
y
15K DEWAR
NOISE SOURCE
180 Hybrid
phase switches
Balance Adjustment
To Spectral Line Section
Continuum Outputs
Continuum Outputs
RF Channelizer
DOUBLER
NOISE SOURCE
Reference Tone Input
To Spectral Line Section
295K TEMPERATURE CONTROLLED
Beam switches...

Cal injected to one side



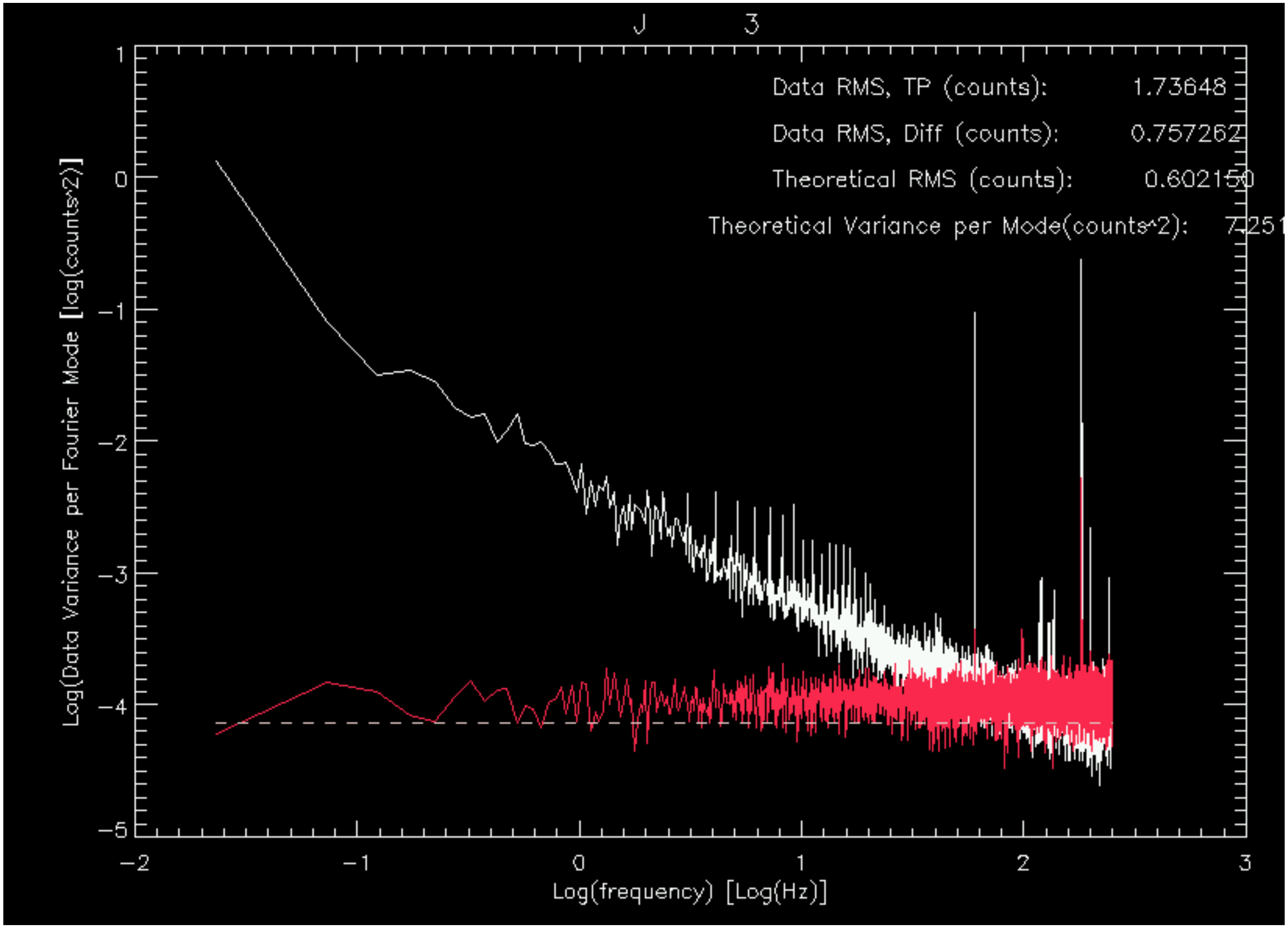
Beam switches…

First LO injected here -- I.e., is irrelevant (almost)



Cal injected to one side
Direct RF detection for CCB
NOISE SOURCE
To Spectral Line Section
Continuum Outputs
Continuum Outputs
X
180 Hybrid
phase switches
Balance Adjustment
180 Hybrid
RF Channelizer
DOUBLER
NOISE SOURCE
Reference Tone Input
To Spectral Line Section
y
295K TEMPERATURE CONTROLLED
15K DEWAR
Beam switches…
First LO injected here -- I.e., is irrelevant (almost)

Total Power vs Beamswitching



Total Power vs Beamswitching

The extra continuum stability of the Ka Receiver is only present in the beamswitched Data

Because of the Rx architecture, the total Power data has curious features (crosstalk)

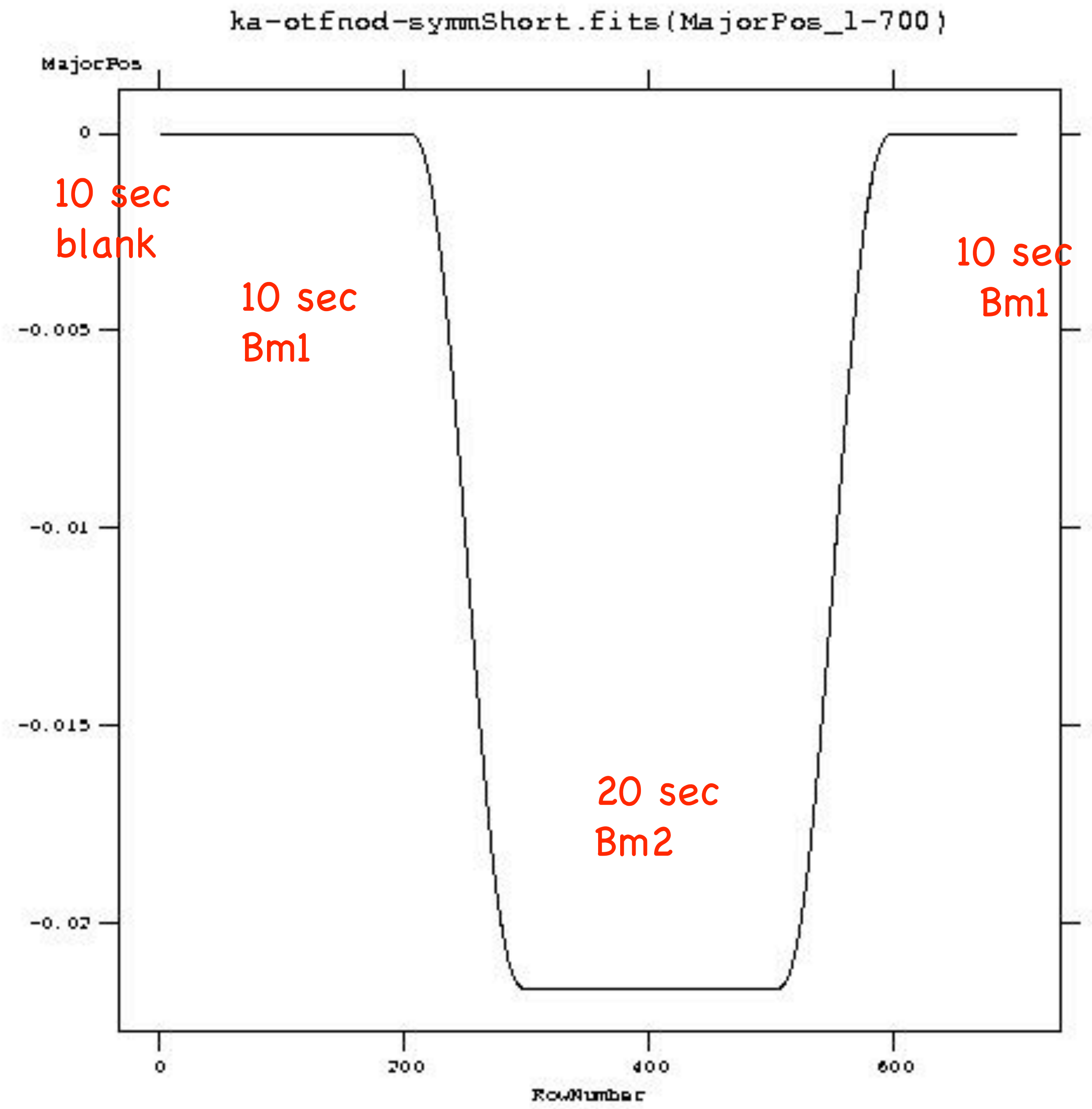
Total power continuum maps (?) would probably Be just as well done at K or Q band.

Setup & Configuration

- CCB directly controls receiver: no GBT switching signals
- Cals: on or off for an entire integration. Controlled by config_tool keywords
  - Ccb.cal_off_integs
  - Ccb.cal_XL_on_integs
  - Ccb.cal_YR_on_integs
  - Ccb.cal_both_on_integs -- peak/focus
- Beamswitch frequency: ccb.bswfreq (default=4 [kHz])
- Integration time: tint=0.005 [sec]. Longer for peak/focus (50 ms)
- Probably meaningless: vdef, vframe, pol, restfreq, nwin, etc.
- ~bmason/ccbPub/ccbbothcalslong.conf and ccbAXL.conf
- Need to deselect the now-dead first 8 channels -- ~bmason/ccbPub/deselectDeadCcbChans.py
- LO1 signals visible in data! Deactivate with ~bmason/ccbPub/killlo.py

Observing with CCB: Point Source Photometry

- Example SB: ~bmason/ccbPub/ccbObsCycle.turtle
- Basic Procedure: On-The-Fly NOD.
  - Trajectory stored in FITS file
  - SB uses readFitsTraj() and dotrajectory()
  - Default: 70sec: 10 blank; A/B/B/A @ 10 ea. W/10 sec slews


ka-otfnod-symmShort.fits(MajorPos_1-700)
MajorPos
0
-0.005
-0.01
-0.015
-0.02
0
200
400
600
RowNumber
10 sec
blank
10 sec
Bm1
20 sec
Bm2
10 sec
Bm1

Observing with CCB: Point Source Photometry

- Example SB: ~bmason/ccbPub/ccbObsCycle.turtle
- Basic Procedure: On-The-Fly NOD.
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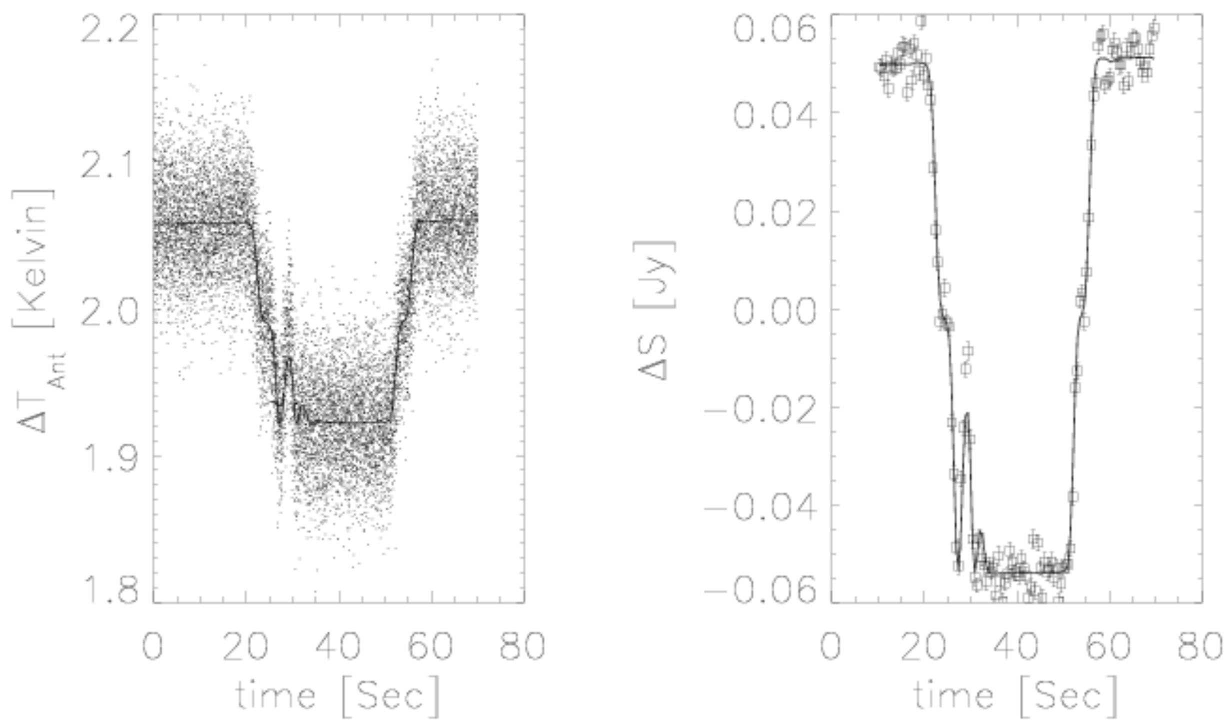
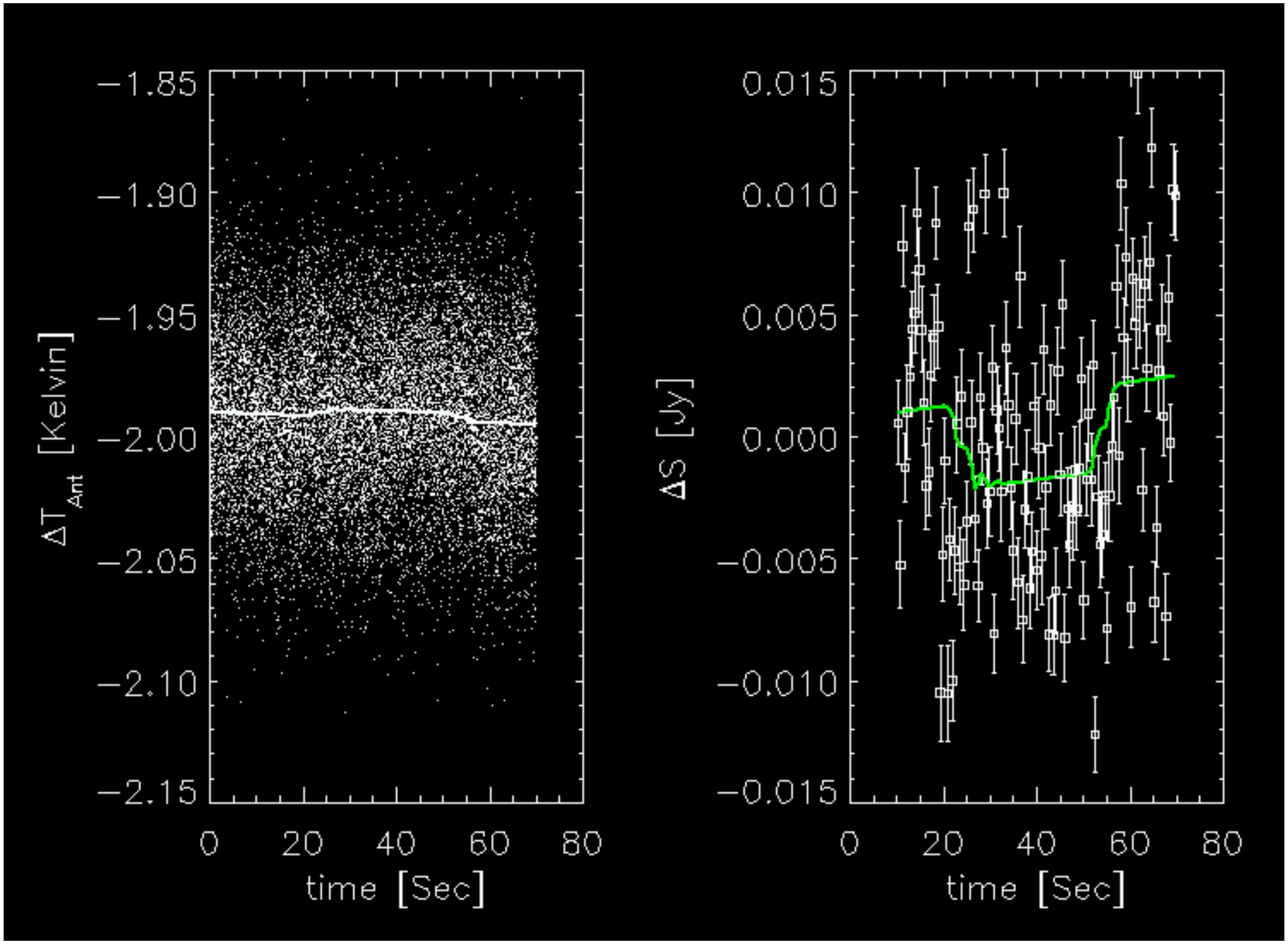
- Data Analysis
  - Given a position for the source of interest and knowledge of where the telescope was pointed as a function of time, a template response can be constructed and fit to the beamswitched data.
  - ~bmason/ccbPub/ccbidl
  - ~bmason/ccbPub/README.txt



2.2
2.1
2.0
1.9
1.8
ΔT_Ant [Kelvin]
0
20
40
60
80
time [Sec]
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
ΔS [Jy]
0
20
40
60
80
time [Sec]

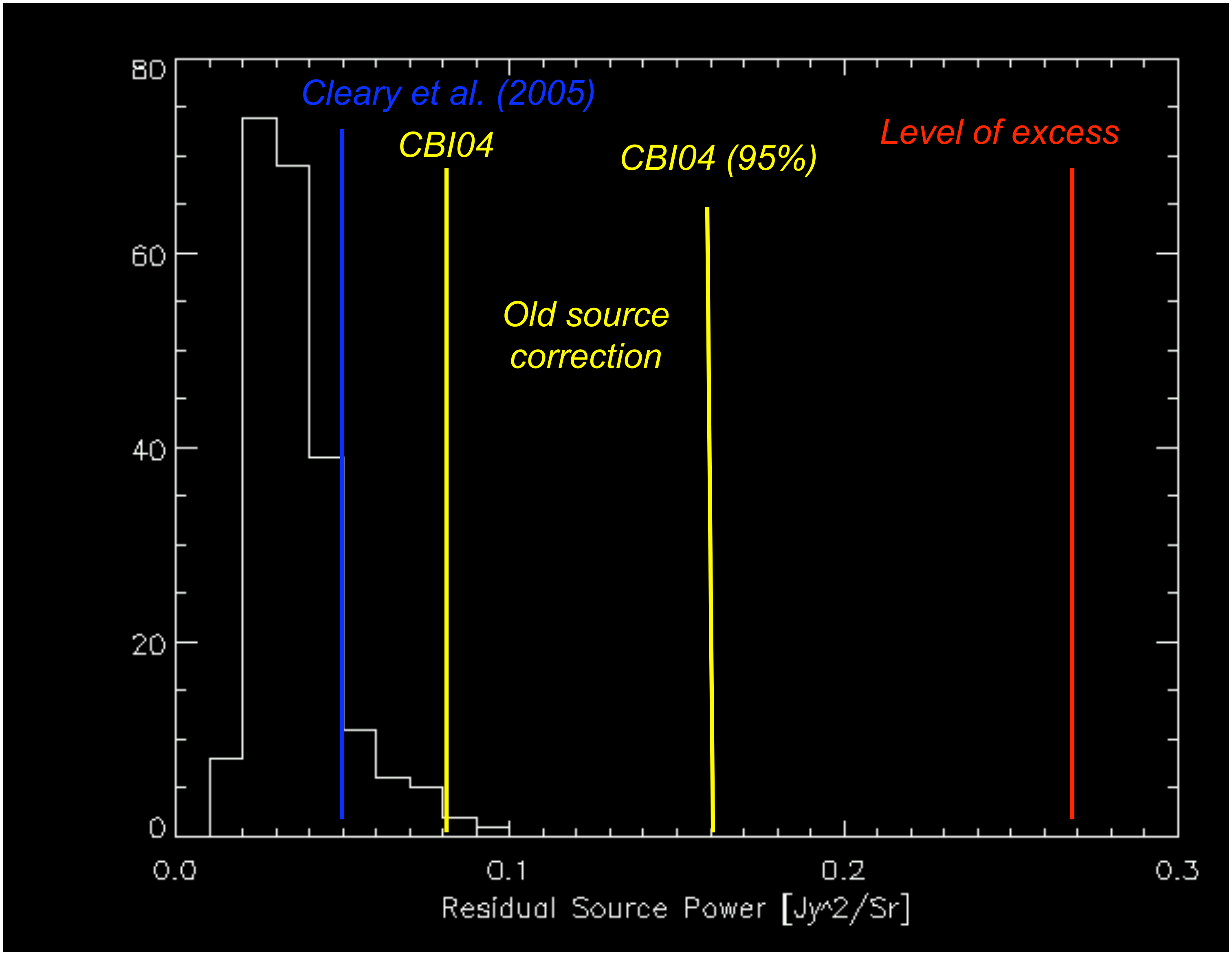


−1.85
−1.90
−1.95
−2.00
−2.05
−2.10
−2.15
ΔT_Ant [Kelvin]
0 20 40 60 80
time [Sec]
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
ΔS [Jy]
0 20 40 60 80
time [Sec]

Performance

- Typical RMS of 70 sec OTFNODs: 0.45 mJy
- Under very stable conditions one does considerably better: averaging repeated NODs and combining channels, noise integrates down to 80 uJy in 15 minutes (wall-clock)

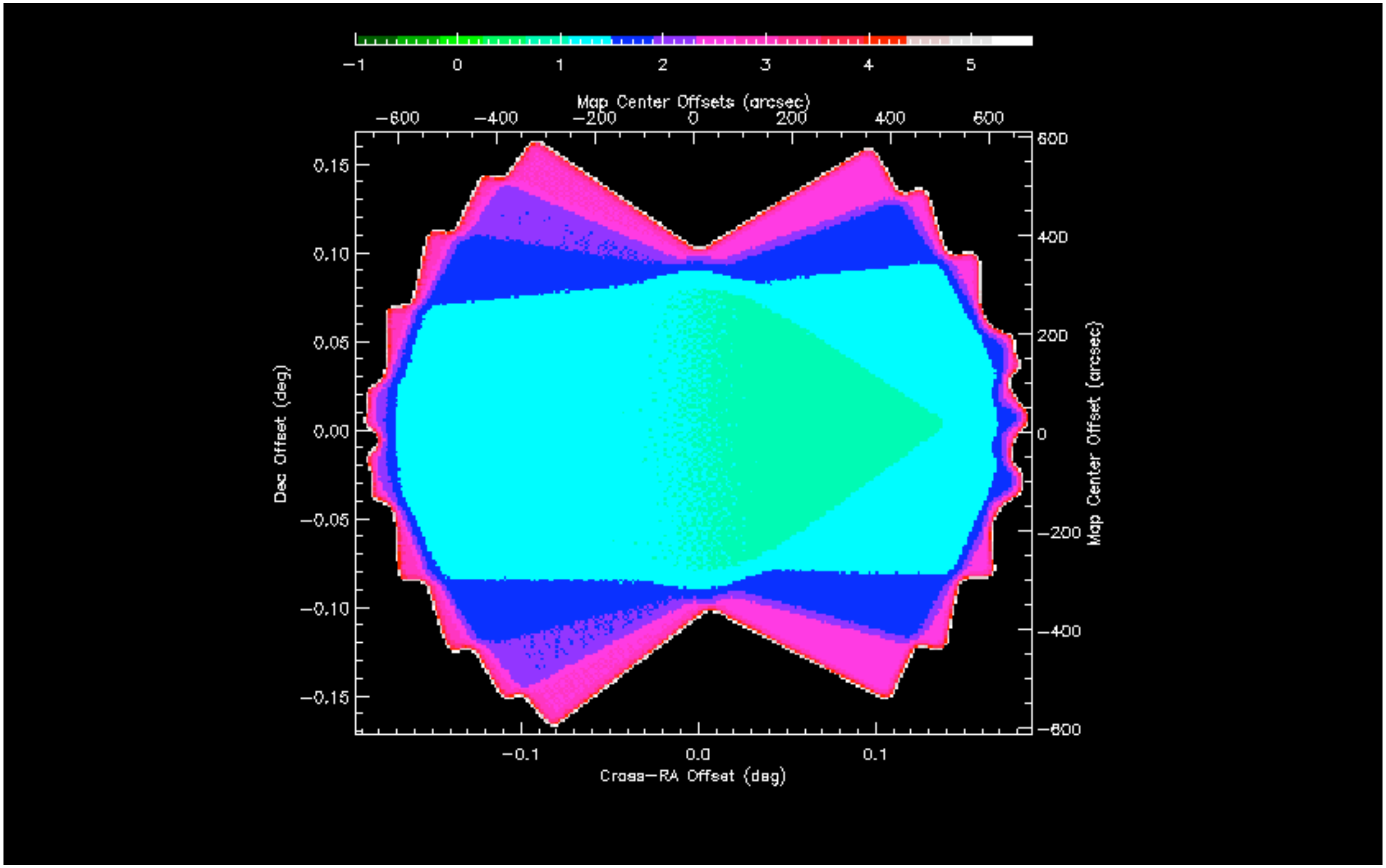
GBT + OVRO 30 GHz: Residual Source Contamination



Observing with CCB: Mapping

- Standard raster scans or custom rasters
- Data analysis under development: Beamswitching needs accounting for
  - EKH: BSM + Clive Dickinson (JPL) in IDL
  - OBIT: Bill Cotton
  - Probably want to scan in azimuth.
- Example SB: ~bmason/ccbPub/ccbMap.turtle

5 Hours of 20′x10′ Az/El Raster Scans



Observing with CCB: Calibration

- Standard Peak/Focus per PTCS recommendations (after 30 min of observing during day, after 45 min at night)
  - I use both cals and longer (50 ms) integration times for peak/focus to help out GFM
- Always include a source of known flux density (best are 3c286, 3c48, 3c147) if at all possible. A single peak/focus/OTFnod will suffice.

Calibration Cautions

- Many flat-spectrum AGN/QSOs are highly (5-10%) linearly polarized at 30 GHz (Linear Polarization is Bad for Continuum)
  - Since the switch to linear polarization this can contribute considerable uncertainty to your flux scale
  - Full Mueller Matrix needs to be derived (BSM & Clive Dickinson, in progress) to determine the extent of the problem and correct for it.
  - Even for linear polarimetry you'd rather cross-correlate native circular
- Tcals in database are not correct: calibration is directly to Jy from astronomical reference. (Good news: Cal signal is stable to a few percent on timescales of weeks)

- Look at ~bmason/ccbPub/README.txt and files therein; reduce some data
- More Info:
  - CCB FITS Specification (SPN 27)
  - Initial proposal for Ka/CCB design by Steve Padin
    - http://ww.gb.nrao.edu~/bmason/gbt-dev/padin_gbtrx.pdf
  - Contact me