Datasim
A VLBI baseband data simulator

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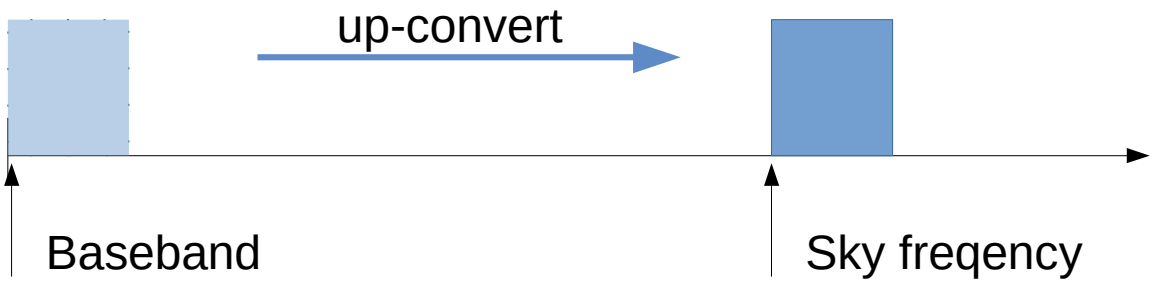
What is Datasim?

A VLBI baseband data simulator

- Part of the implementation is based on ‘anoise’ developed by Geoff Crew
- ASIAA presented ‘enoise’ at DiFX meeting in 2014 (designed by Cheng-Yu Kuo)
- ‘datasim’ (designed during DiFX meeting 2014 by Adam Deller, Walter Brisken and Chris Phillips)

Design principle

- Use functions implemented in DiFX
- Reverse engineering of how DiFX processes data
- Start from frequency domain
- Generate complex data samples at baseband
- Fourier transform the signal to time domain
- Up-convert the signal to sky frequency

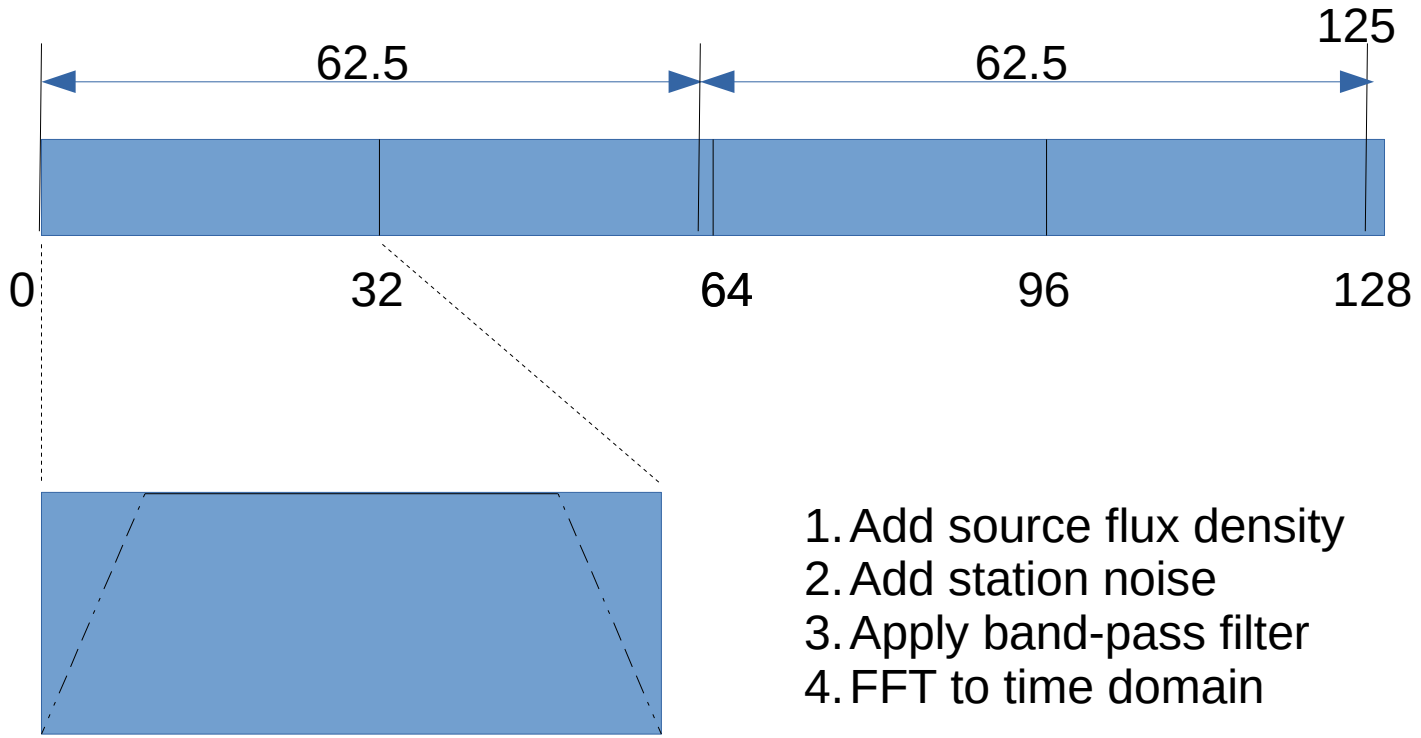


How does it work?

- Generate common signal in frequency domain
  - Calculate maximum frequency coverage of all subbands of all stations
  - For example, a 3 stations simulation:
    - 62.5 MHz * 2 and 32 MHz * 4 and 64 MHz * 2
  - Max. freq coverage 128 MHz
- Each subband copy its own part of the frequency data from common signal
  - Apply source flux density
  - Add station noise
  - Apply band-pass filter
  - Transform signal to time domain

How does it work? An example

Station 1: 62.5 MHz * 2
Station 2: 32 MHz * 4
Station 3: 64 MHz * 2
Spectral resolution: 0.25
Number of samples per sec: 512 M

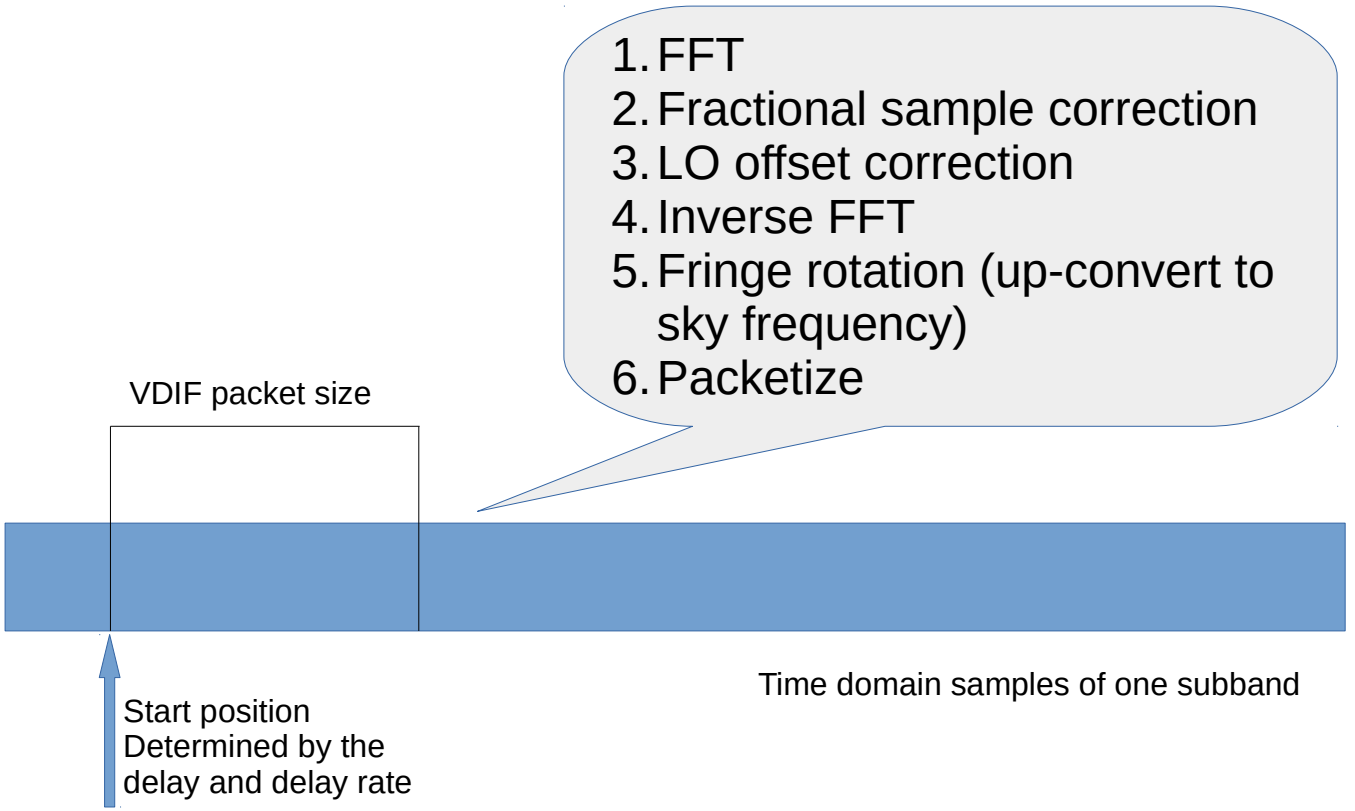


1. Add source flux density
2. Add station noise
3. Apply band-pass filter
4. FFT to time domain

How does it work? Cont'd

- Calculate delay and delay rate using DiFX function calls
- Based on the delay model, select where to start processing the time domain signal
- Process data in chunks of VDIF packet size
  - FFT
  - Fractional sample correction
  - LO offset correction
  - Inverse FFT
  - Fringe rotation (up-convert to sky frequency)
  - Convert complex signal to real signal
  - Packetize

How does it work? An example



How does it work? Cont'd

- Generate data in VDIF format for each subband of each station (single thread single channel)
- Combine each subband data into one final data file (vdifzipper)

How to use it?

- What you need to have?
  - Station description file
  - Target description file
  - Simulation description file
- Generate v2d and VEX file using script genv2dvex.sh
- Perform vex2difx and calcif2, because datasim uses the .input file as input

How to use it? Cont'd

Station Description File

station=SMA ; id=Sp ; site_position=-5464555.493 m : -2492927.989 m : 2150797.176 m

station=ALMA ; id=Al ; site_position=2225039.530 m : -5441197.629 m : -2479303.360 m

station=SMTO ; id=St ; site_position=-1828796.200 m : -5054406.800 m : 3427865.200 m

station=CARMA ; id=Cm ; site_position=-2397378.568 m : -4482048.670 m : 3843513.202 m

station=IRAM30 ; id=Im ; site_position=5088967.900 m : -301681.600 m : 3825015.800 m

station=SC-VLBA; id=Sc ; site_position=2607848.603 m : -5488069.582 m : 1932739.671 m

How to use it? Cont’d

Target Description File

source_name=M87 ; IAU_name=1230+123; ra=12h30m49.4233000s ; dec=12d23'28.043000"; ref_coord_frame=J2000

source_name=Sgra ; IAU_name=1745-290; ra=17h45m40.0410000s ; dec=-29d00'28.120000"; ref_coord_frame=J2000

source_name=3C84 ; IAU_name=0319+414; ra=03h19m48.1601000s ; dec=41d30'42.103000"; ref_coord_frame=J2000

source_name=3C279 ; IAU_name=1256-057; ra=12h56m11.1665000s ; dec=-05d47'21.524000"; ref_coord_frame=J2000

source_name=NRAO530 ; IAU_name=1733-130; ra=17h33m02.7057840s ; dec=-13d04'49.548190"; ref_coord_frame=J2000

source_name=NCP ; IAU_name=1733-130; ra=00h00m00.0000000s ; dec=89d59'59.000000"; ref_coord_frame=J2000

How to use it? Cont’d

Simulation Description File

SOURCE=M87

STATION="SMA, CARMA, SMTO"

BAND="64.0x4, 64.0x4, 64.0x4"

GAP="0.0, 0.0, 0.0"

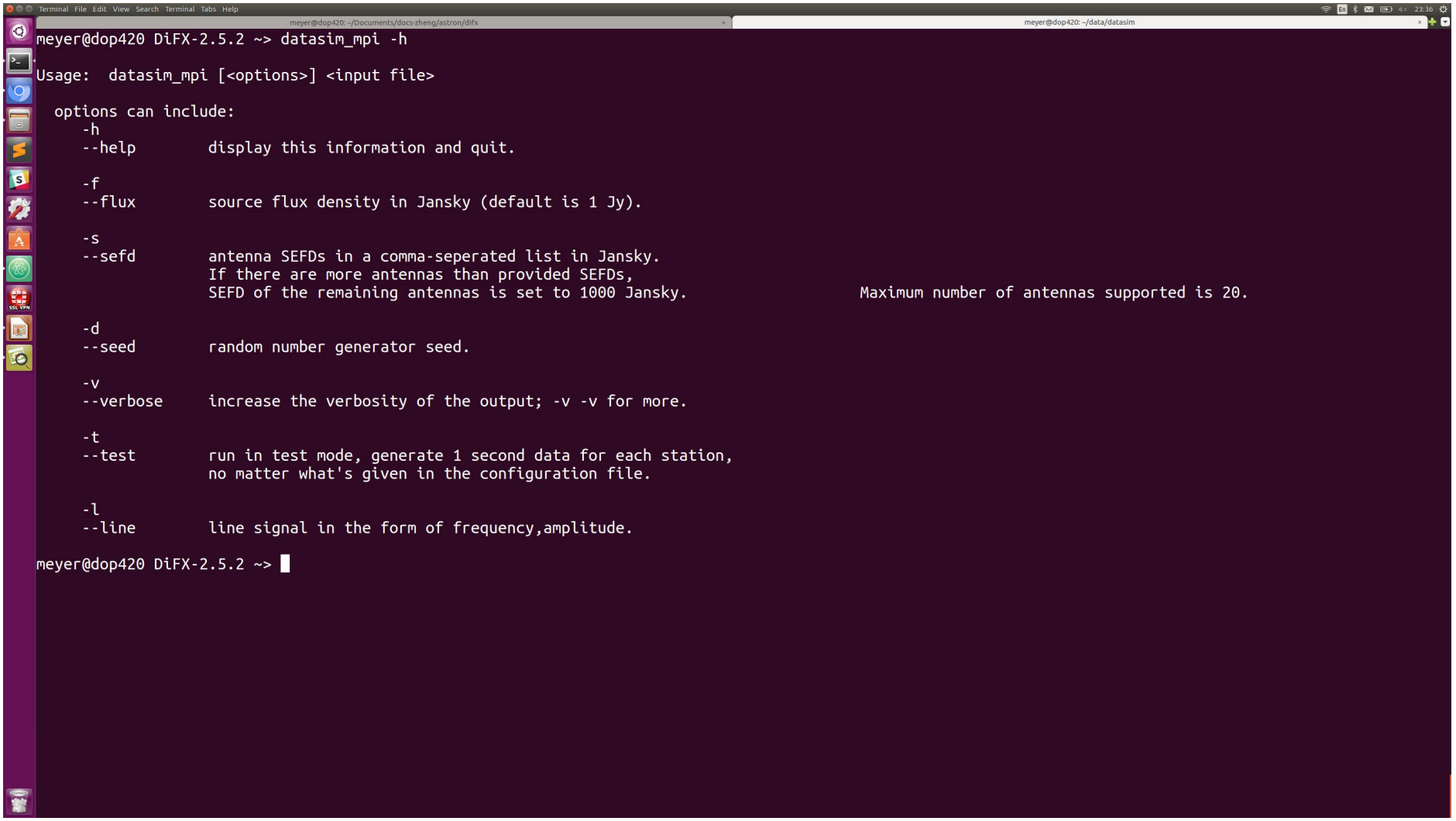
SHIFT="0.0, 0.0, 0.0"

START_TIME=2012y075d05h58m00s

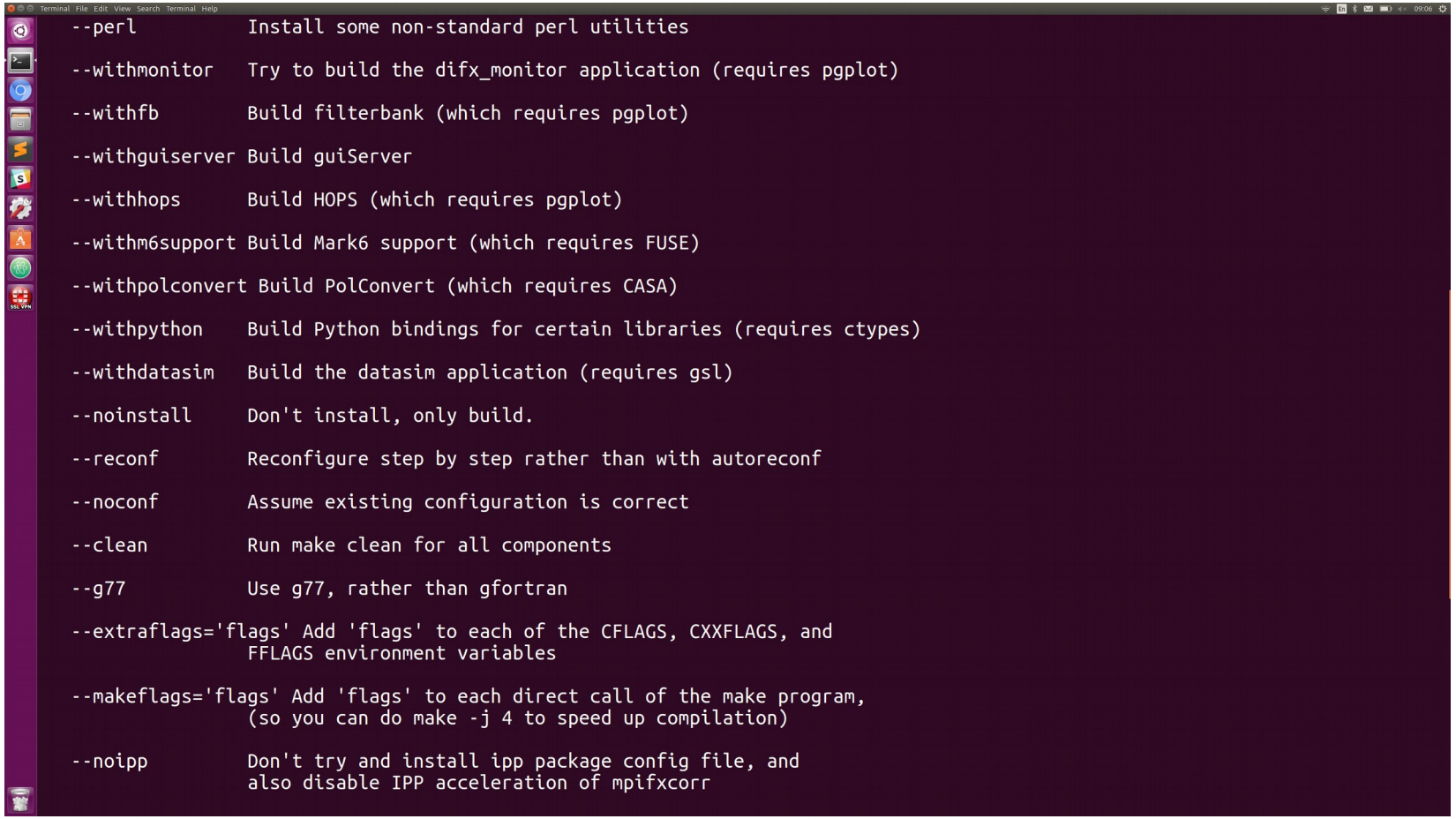
END_TIME=2012y075d05h58m04s

FREQ_OBS=230000.00

Datasim options



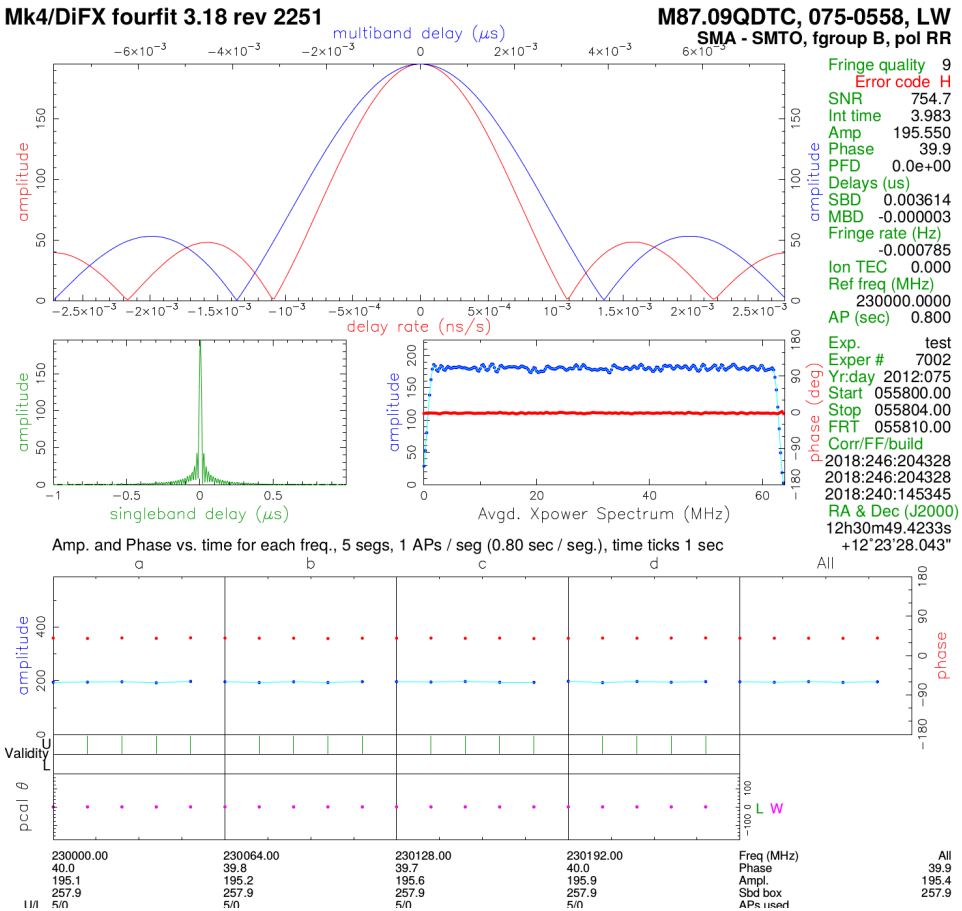
Install datasim



Current development

- Subband-based parallelisation (done)
- Documentation (this week?)
- The following has been implemented, but there are still some issues, hopefully to be fixed this week:
  - Simulate maser source
  - Time-based parallelisation

Results


Mk4/DiFX fourfit 3.18 rev 2251
M87.09QDTC, 075-0558, LW
SMA - SMTO, fgroup B, pol RR
multiband delay (μs)
delay rate (ns/s)
singleband delay (μs)
Avgd. Xpower Spectrum (MHz)
amplitude
phase (deg)
Fringe quality 9
Error code H
SNR 754.7
Int time 3.983
Amp 195.550
Phase 39.9
PFD 0.0e+00
Delays (us)
SBD 0.003614
MBD -0.000003
Fringe rate (Hz)
-0.000785
Ion TEC 0.000
Ref freq (MHz)
230000.0000
AP (sec) 0.800
Exp. test
Exper # 7002
Yr:day 2012:075
Start 055800.00
Stop 055804.00
FRT 055810.00
Corr/FF/build
2018:246:204328
2018:246:204328
2018:240:145345
RA & Dec (J2000)
12h30m49.4233s
+12°23'28.043"
Amp. and Phase vs. time for each freq., 5 segs, 1 APs / seg (0.80 sec / seg.), time ticks 1 sec
a
b
c
d
All
Validity
pcal θ
L W
230000.00
40.0
195.1
257.9
230064.00
39.8
195.2
257.9
230128.00
39.7
195.6
257.9
230192.00
40.0
195.9
257.9
Freq (MHz)
Phase
Ampl.
Sbd box
APs used
All
39.9
195.4
257.9

Future work

- Docker image with DiFX (without IPP optimization), datasim, hops installed
- Benchmarking
- Profiling and improve parallel implementation
- Implement paralleisation using MPI-3 shared memory