Recent LOFAR Observations of Pulsar B0329+54:

HDF5, PRESTO, RFI, and single pulse detections

Jason Hessels

(Universiteit van Amsterdam)

LOFAR CS1 Meeting, April 23rd, 2008

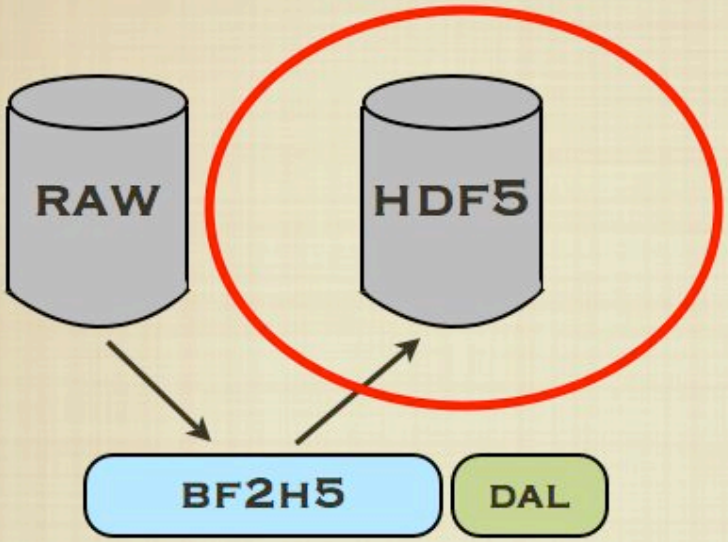
HDF5 format and PRESTO

- HDF5: flexible file format for raw beam-formed (and other?) data. Extensive LOFAR header structure defined.

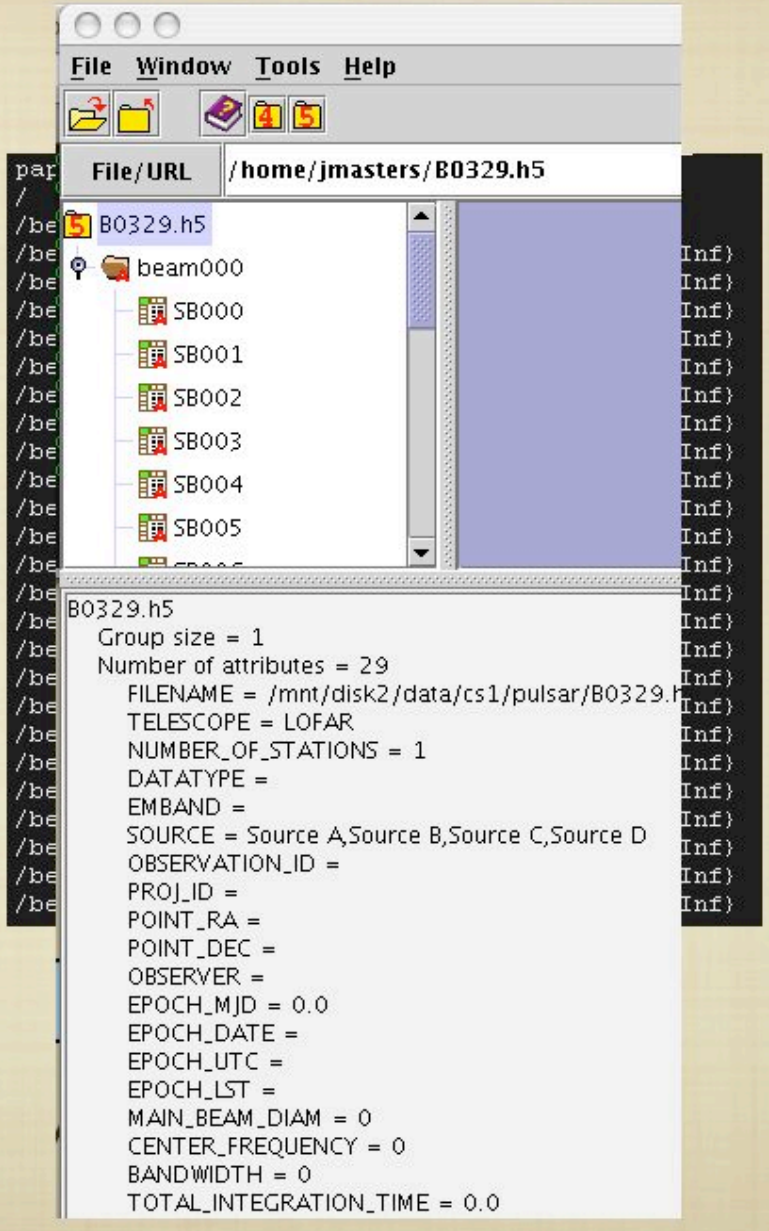
- PRESTO: important, well-tested, suite of pulsar and single-pulse search and timing software (many MSPs and bursts discovered). No reinventing the wheel!

- pydal: Joe Masters' library of routines to read LOFAR HDF5 data (built from C++ DAL).

Current Status

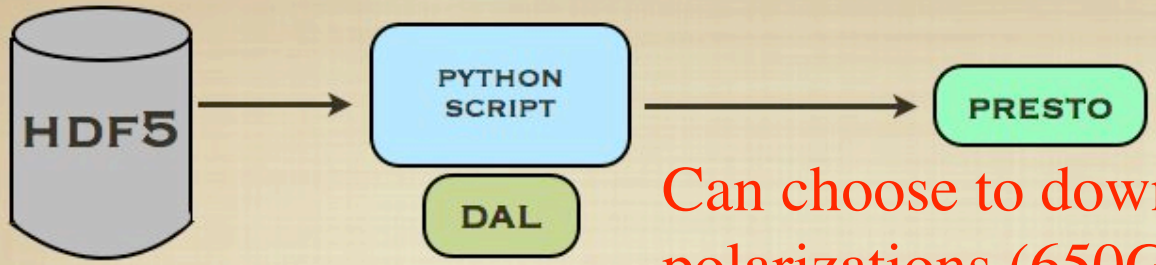


- DAL
  - C++ API
  - PYTHON API



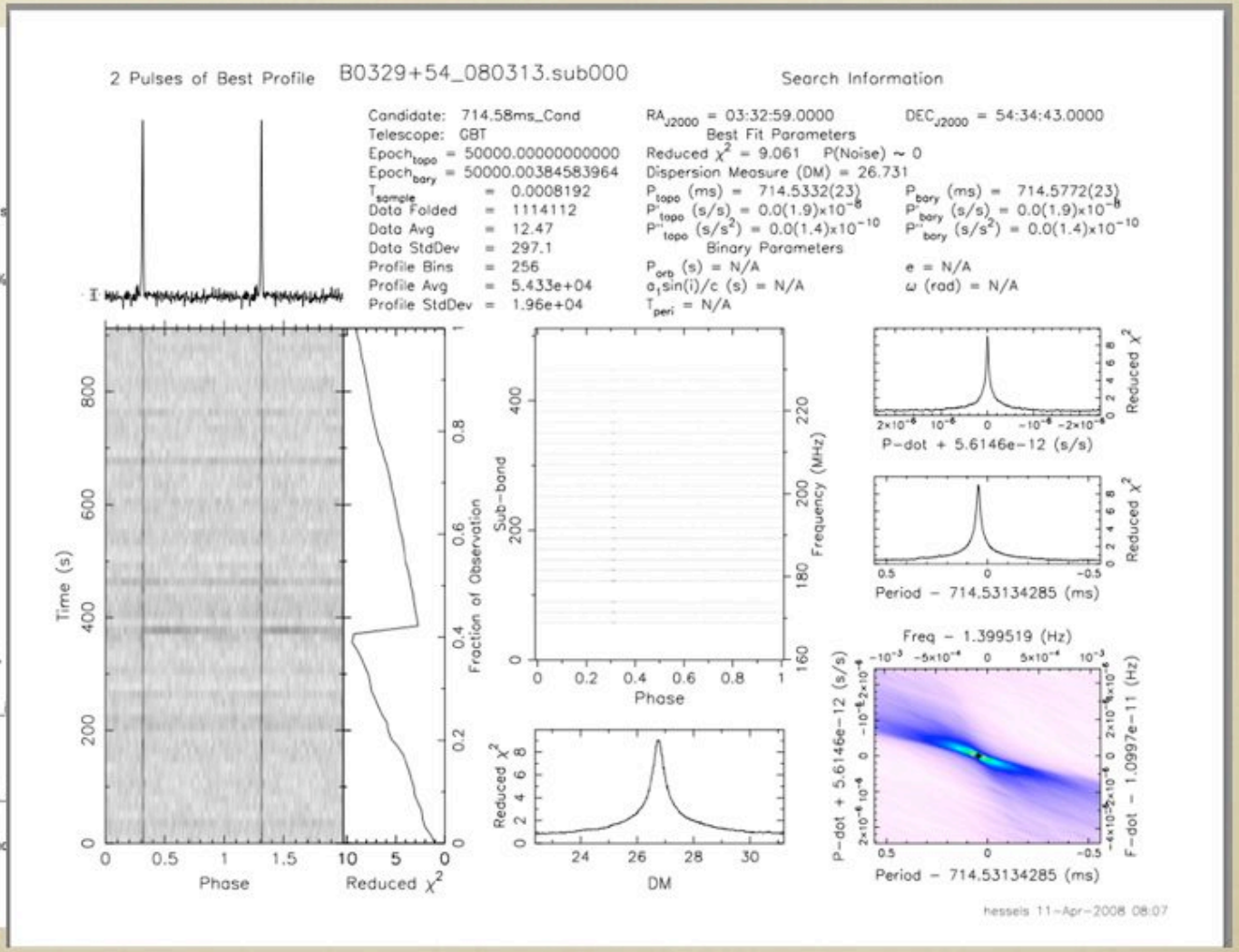
HDF5 QUICK LOOK

```
$ python
> from pydal import *
> file = BeamFormed("myfile.h5")
> file.summary()
> beam = file.getBeam(0)
> data = beam.getSubbandData_XY( 5, 0, 100 )
> file.number_of_beams()
> file.point_ra()
> file.number_of_samples()
```



Can choose to downsample and sum polarizations (650GB --> 3GB)

```
#! /usr/bin/env python

from pydal import *
from scipy import *
import sys
from pylab import *

def downsample(vector, factor):
  """
  downsample(vector, factor):
    Downsample (i.e. co-add consecutive numbers) a short s
      of a vector by an integer factor.
  """
  if (len(vector) % factor):
    print "Lenght of 'vector' is not divisible by 'factor'=%d!" %
    return 0
  newvector = reshape(vector, (len(vector)/factor, factor))
  return add.reduce(newvector, 1)

# The BeamFormed object represents the file.
#  The parameter is the name of the beam-formed file.
if (len(sys.argv) > 1):
 file = BeamFormed(sys.argv[1])
else:
 print "Please provide a beam-formed hdf5 file as input."
 sys.exit(1)

# get beam 0
beam = file.getBeam(0)

n_samples = 512 * 128

for subband in range(24):
    start = 0
    downsampled_data = array([],'f')
    for count in range(2200):
        data = beam.getSubbandData_XY( subband, start,
        xx_intensity = abs(data[0])
        yy_intensity = abs(data[1])
        tot_intensity = sqrt(xx_intensity*xx_intensity + yy_

        data = downsample( tot_intensity, 128 )
        start += n_samples

        downsampled_data = concatenate( (downsampled_


    tmpfile = "B0329+54_080313_subband%02d" % subband
    fileobj = open(tmpfile, mode='wb')
    fileobj.write(downsampled_data)
    fileobj.close()
    print "Wrote ",tmpfile
```



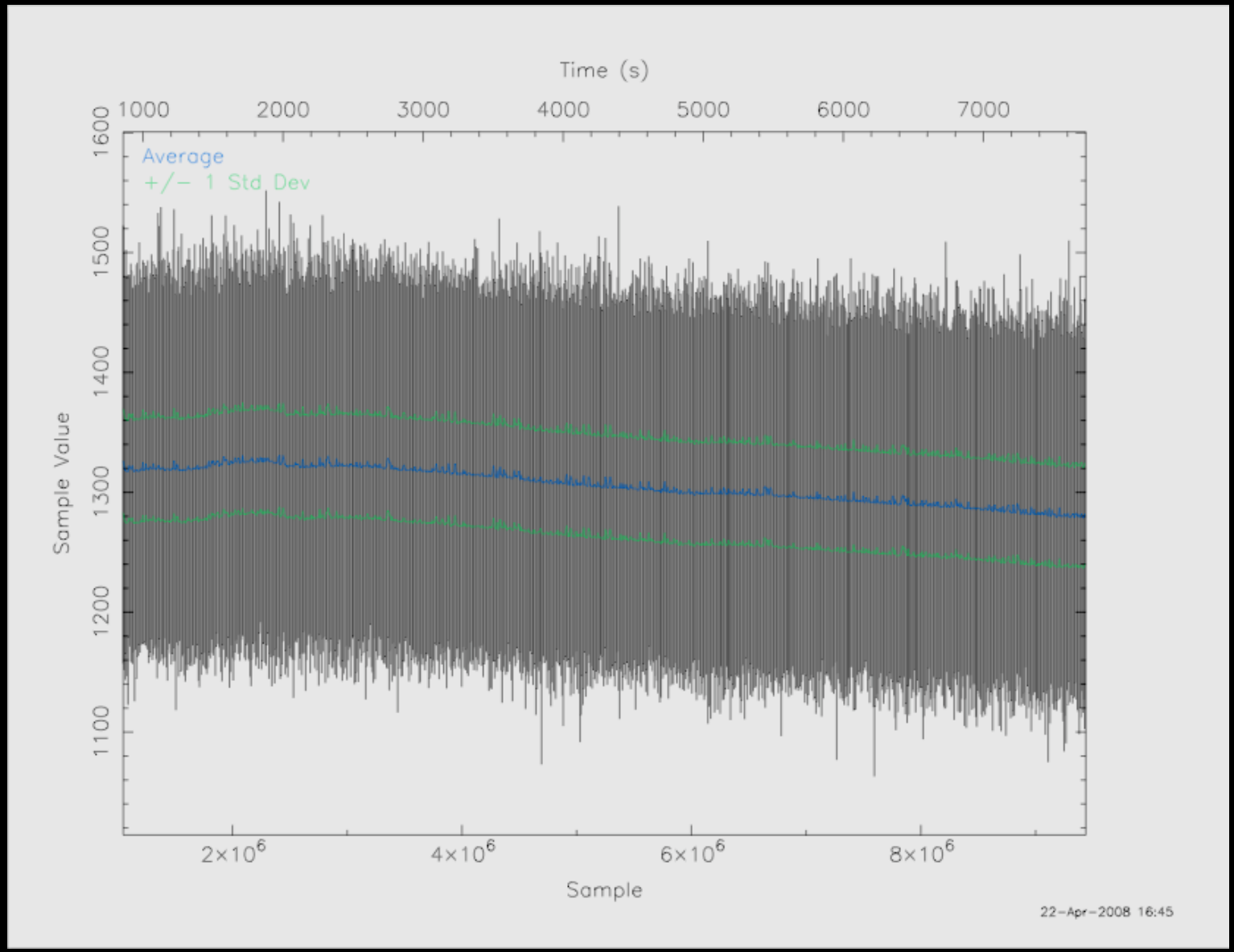
Pulsars in the beam-formed "transit" data

Pulsar	Period (ms)	DM (pc/cm^3)	S_{400} (mJy)	Comments
B0329+54	714.5	26.8	1500	Single pulses!
B0355+54	156.4	57.1	46	Too weak?
B0450+55	340.7	14.5	59	Too weak?

6 HBA tiles, 48 subbands between 160-240MHz

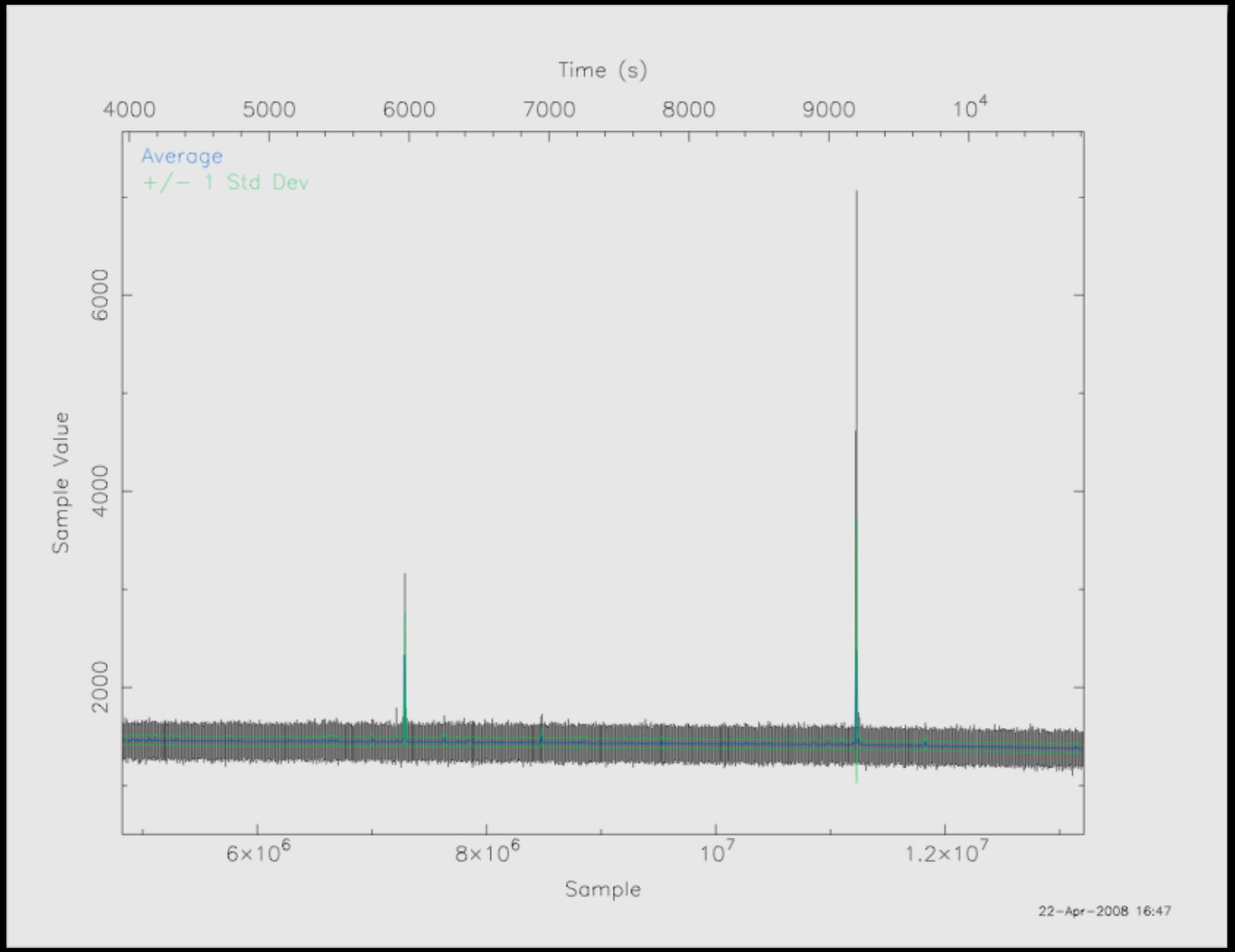
3hr on 080411 and 080417

RFI situation



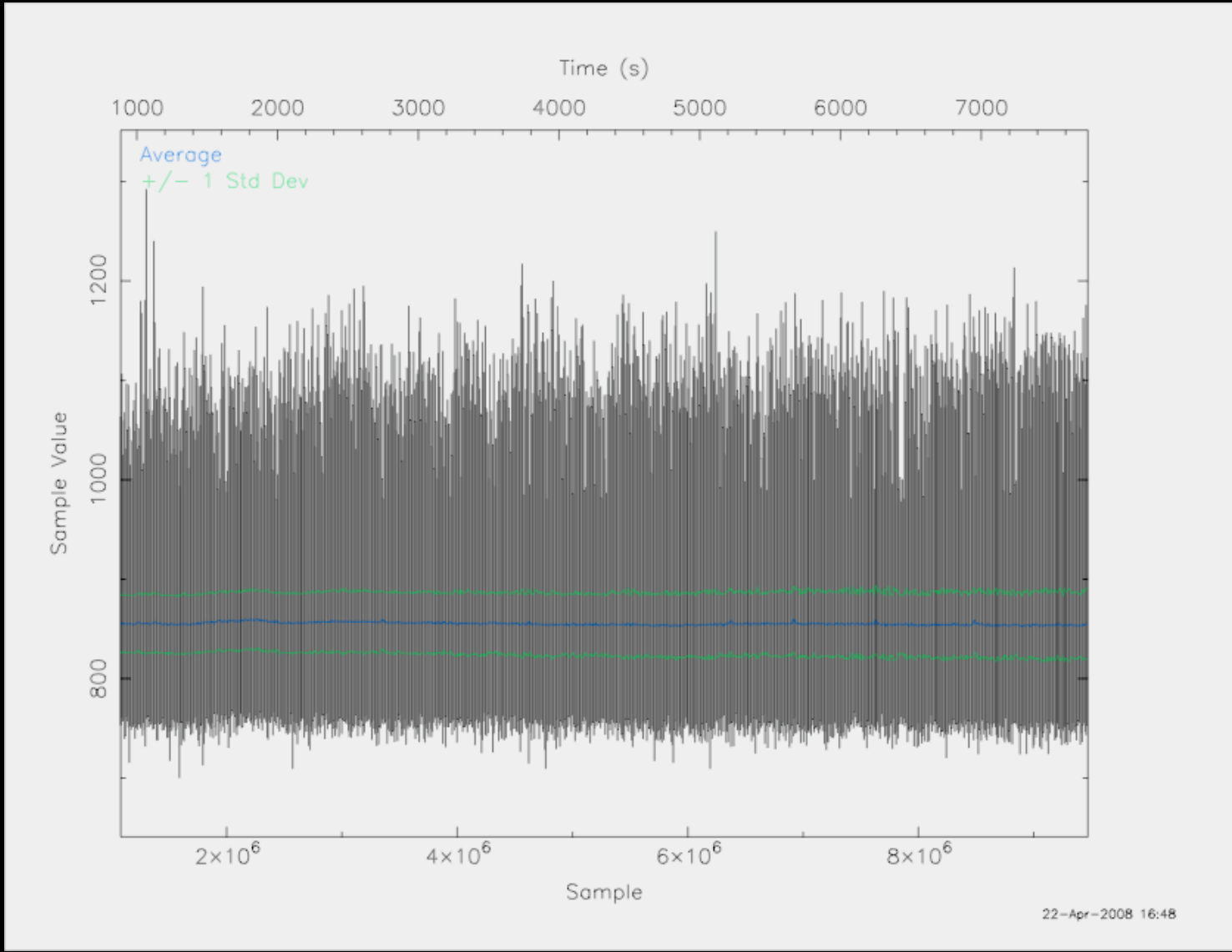
Relatively clean: e.g. subband 073

RFI situation



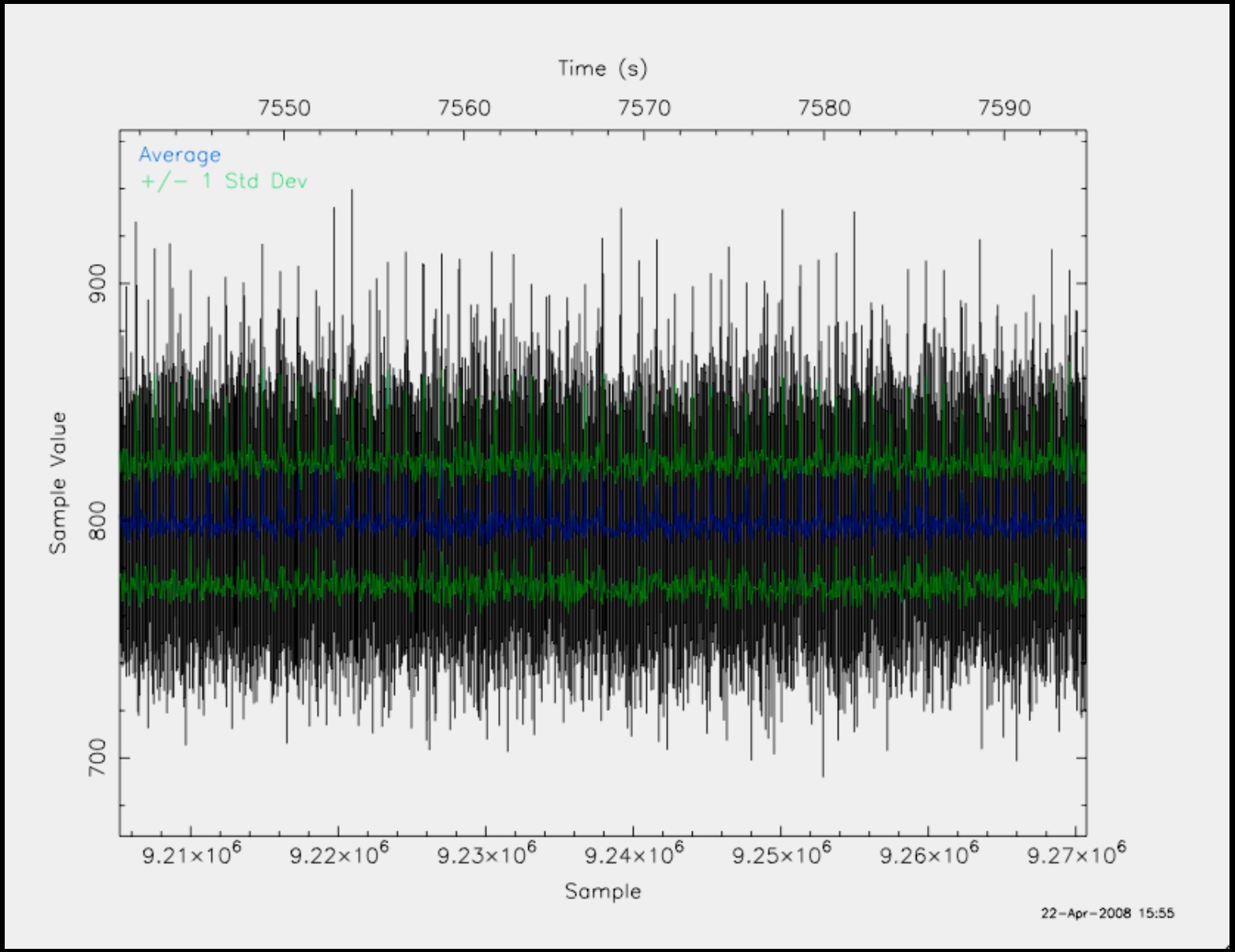
Very bright RFI bursts: e.g. subband 097

RFI situation



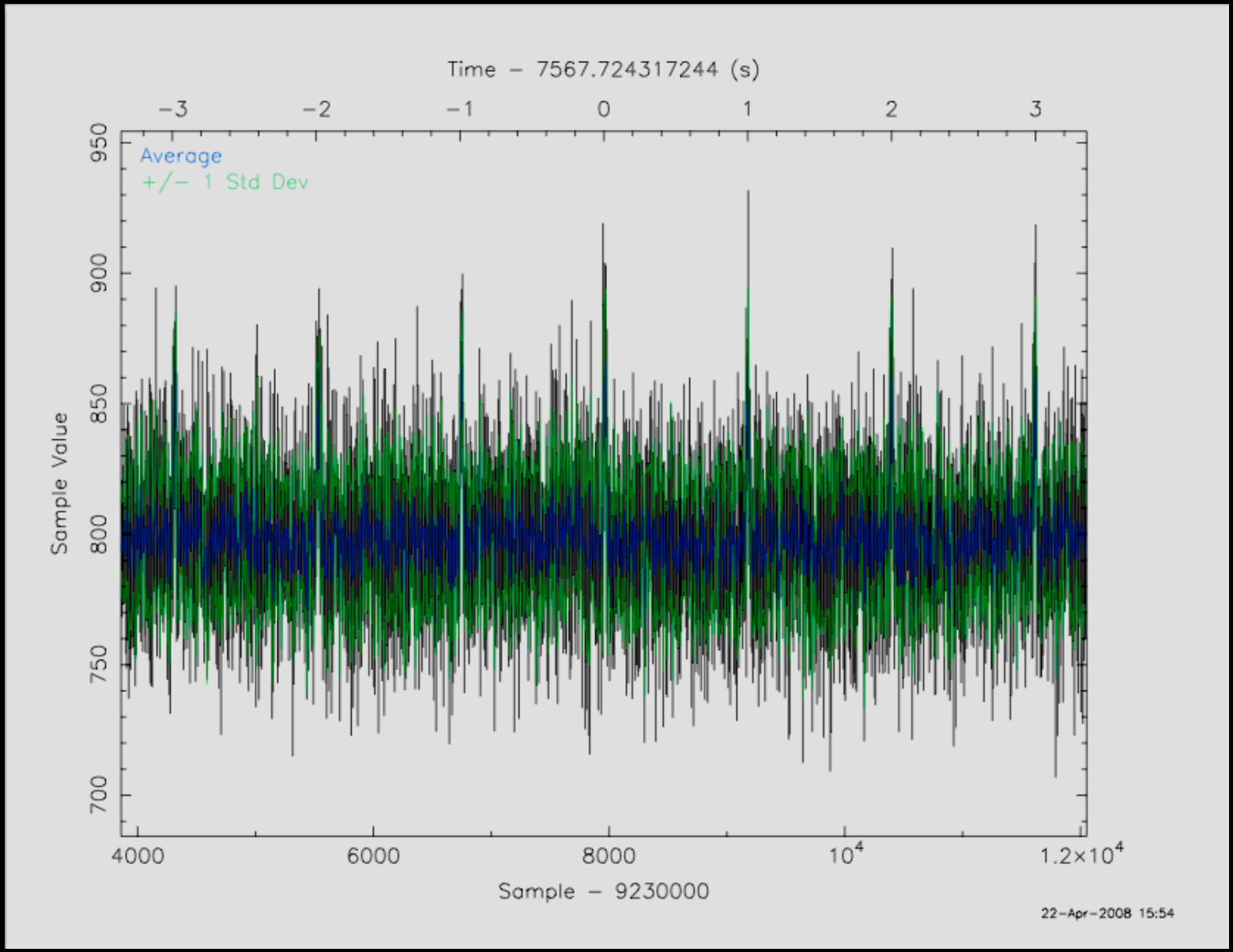
"Forest" of RFI bursts: e.g. subband 383

1-s Tick?



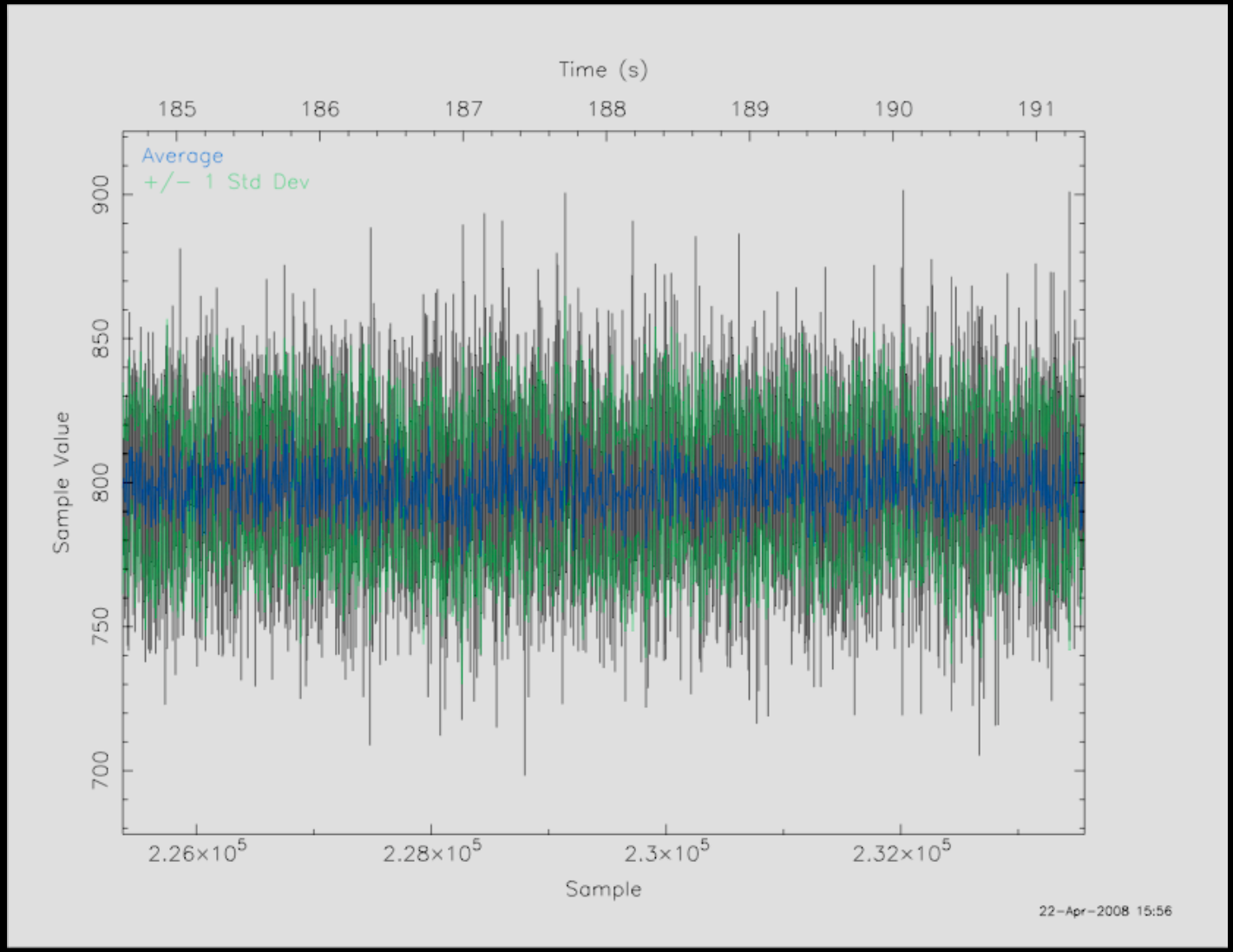
Can appear in otherwise “clean” subband

1-s Tick?



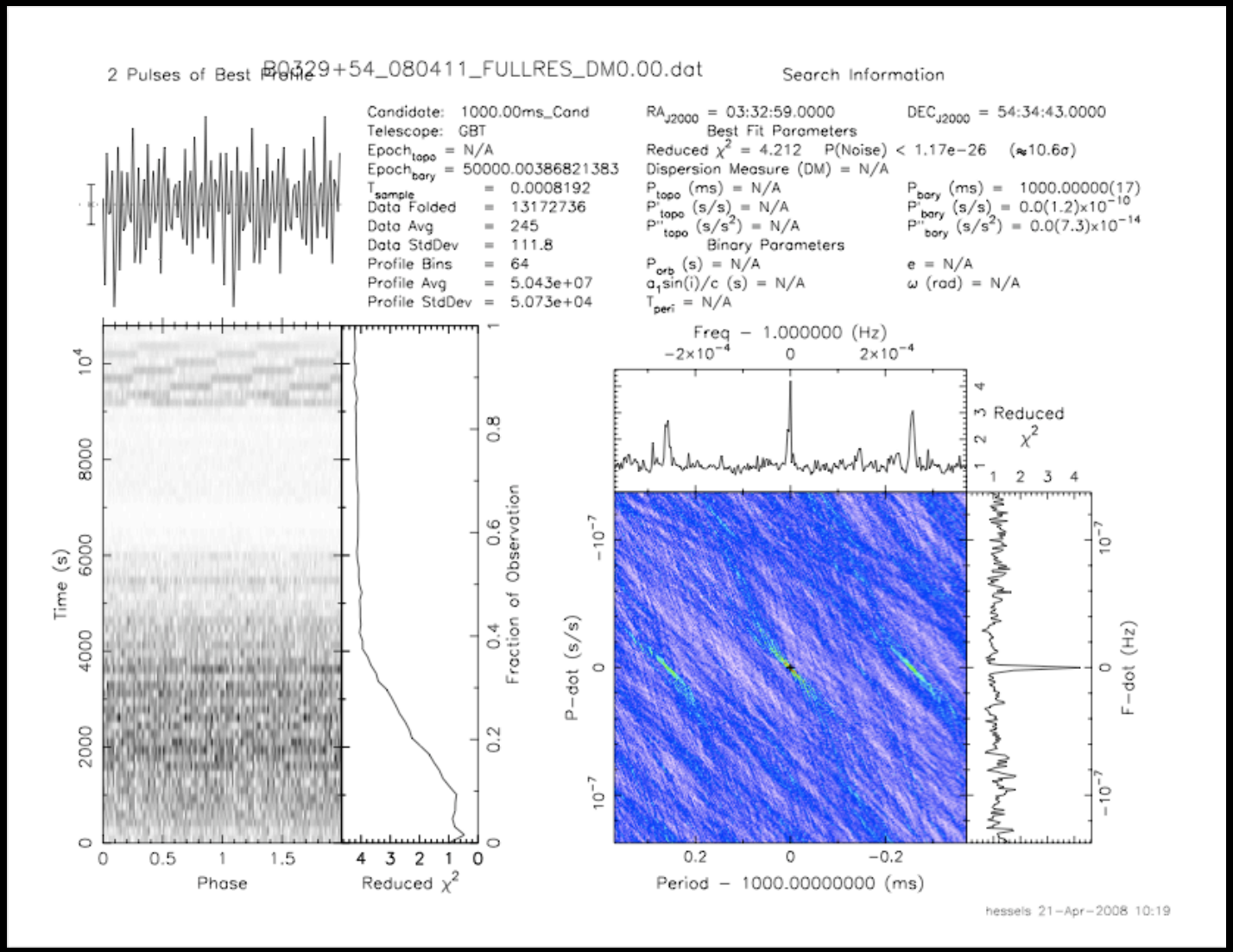
Related to size of data blocks?

1-s Tick?



Comes and goes?! (same subband as previously)

1-s Tick?

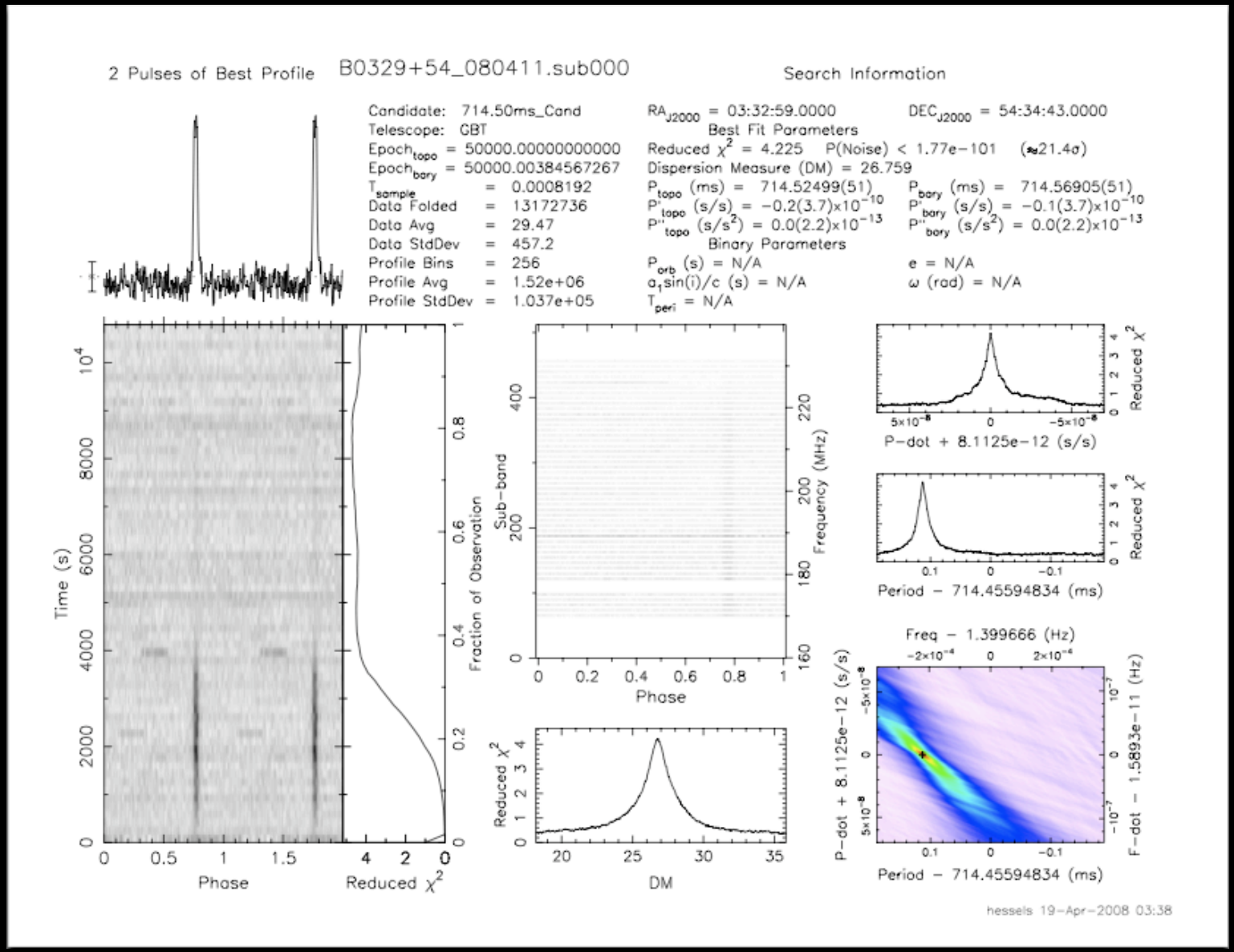


Large variation in baseline

RFI Excision

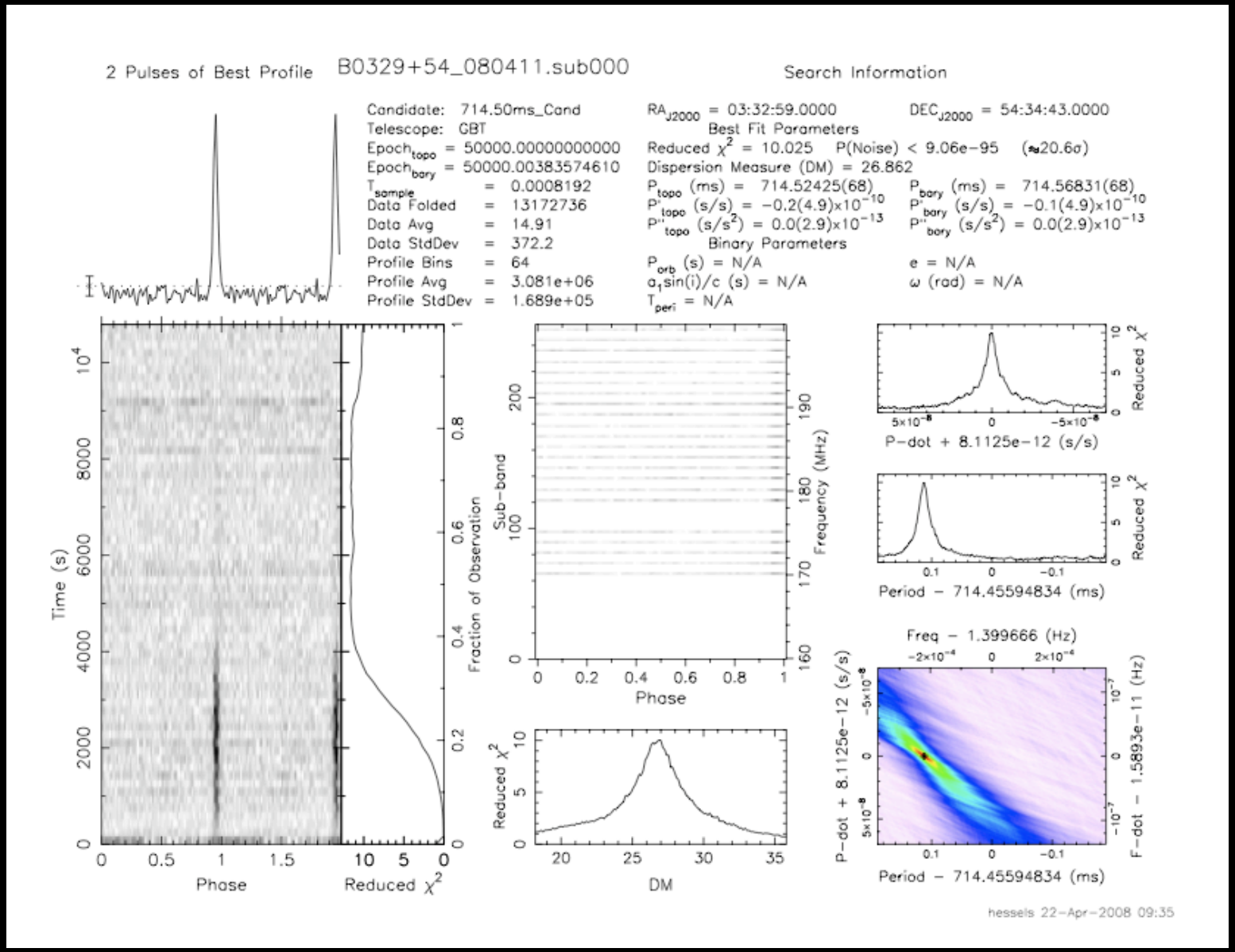
- Looked at each of 48 subbands by eye.
- Only used subbands that looked relatively “clean” (a little more than half).
- Much more sophisticated RFI excision will be done in future (remove narrow band, or short timescale RFI) using e.g. PRESTO routine “rfifind”.
- Important for all projects to characterize RFI background.

B0329+54 Folded



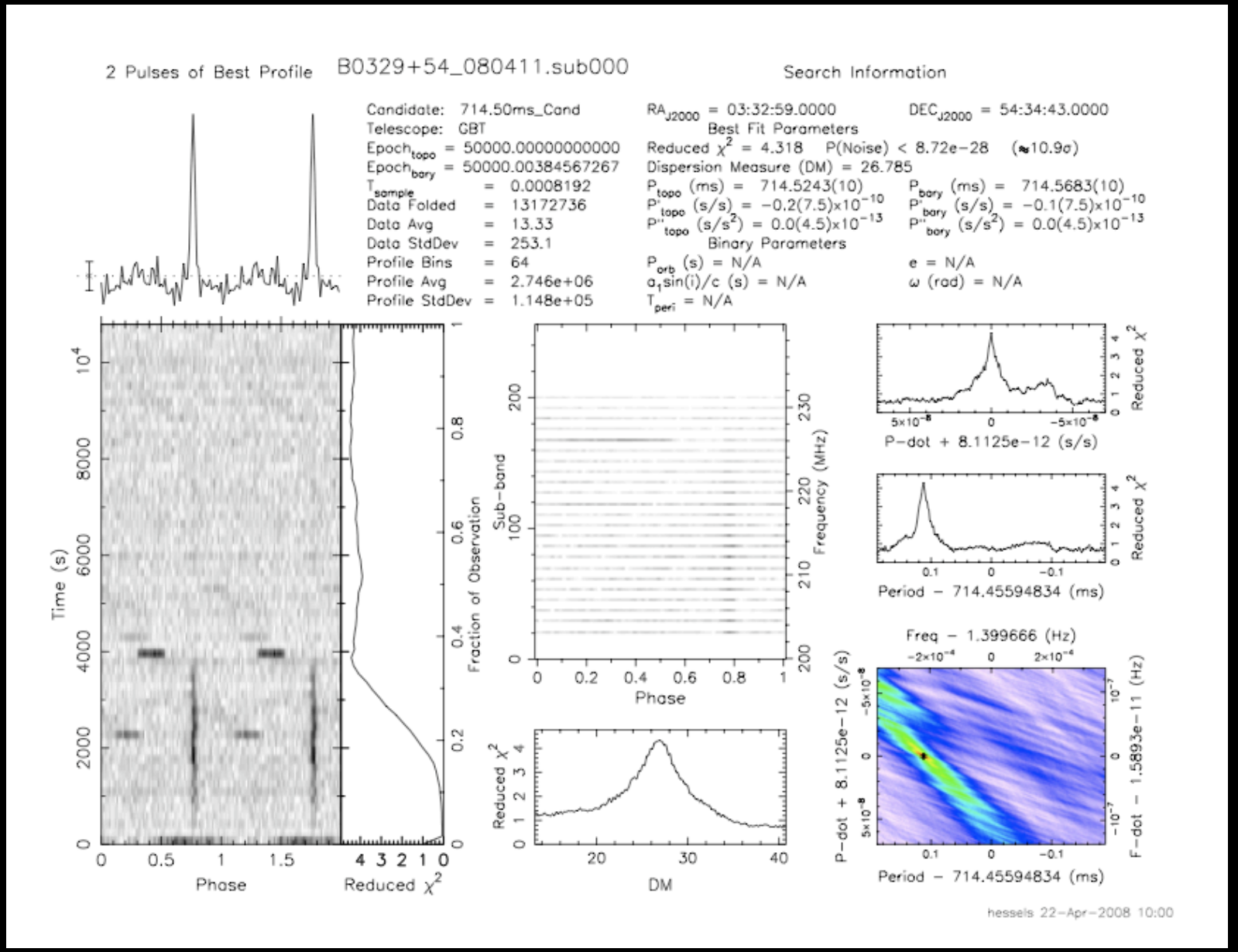
All 48 subbands - 080411 - 160-240MHz

B0329+54 Folded



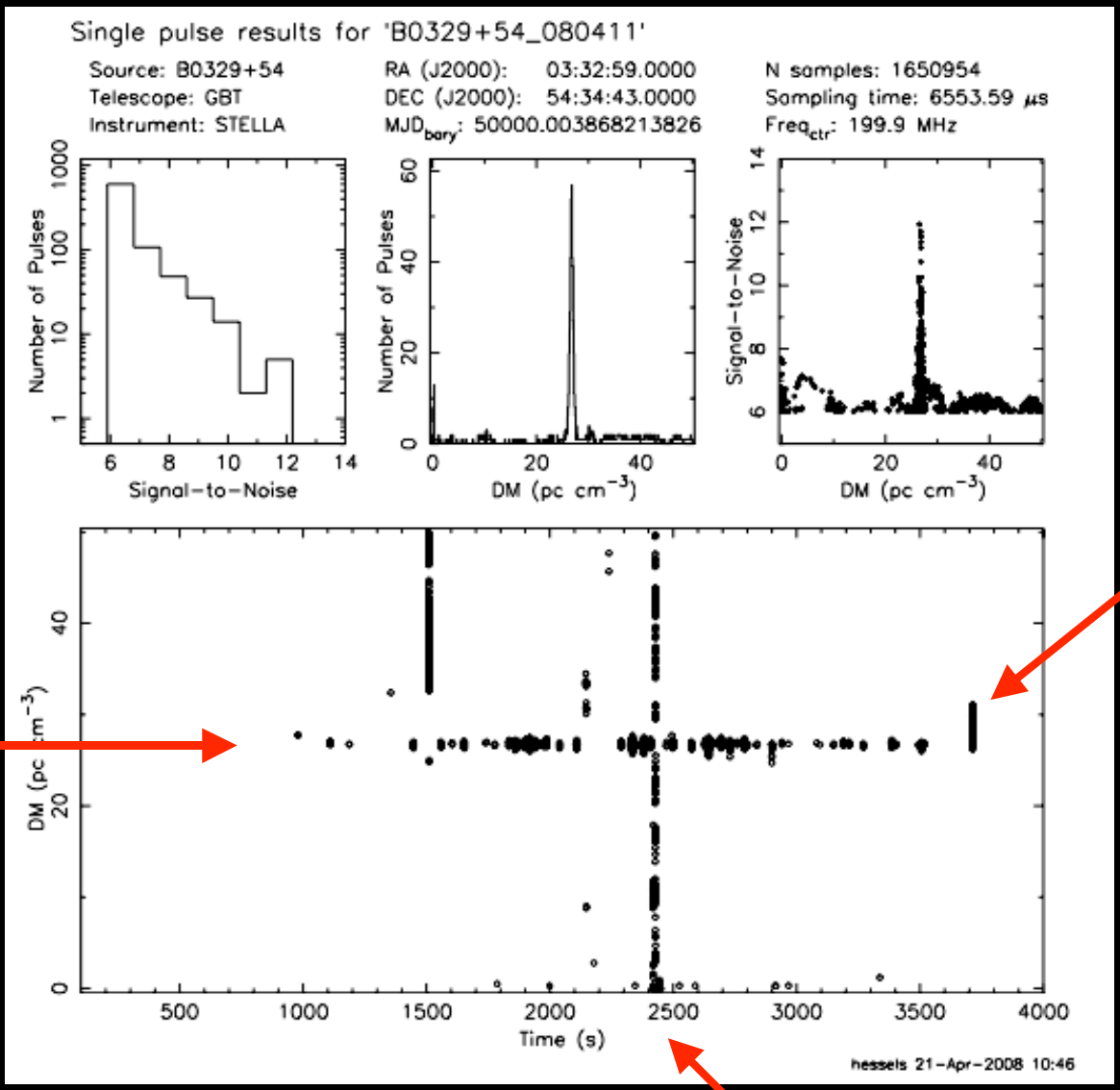
Lower ~24 subbands - 080411 - 160-200MHz

B0329+54 Folded



Upper ~24 subbands - 080411 - 200-240MHz

B0329+54 Single Pulses!



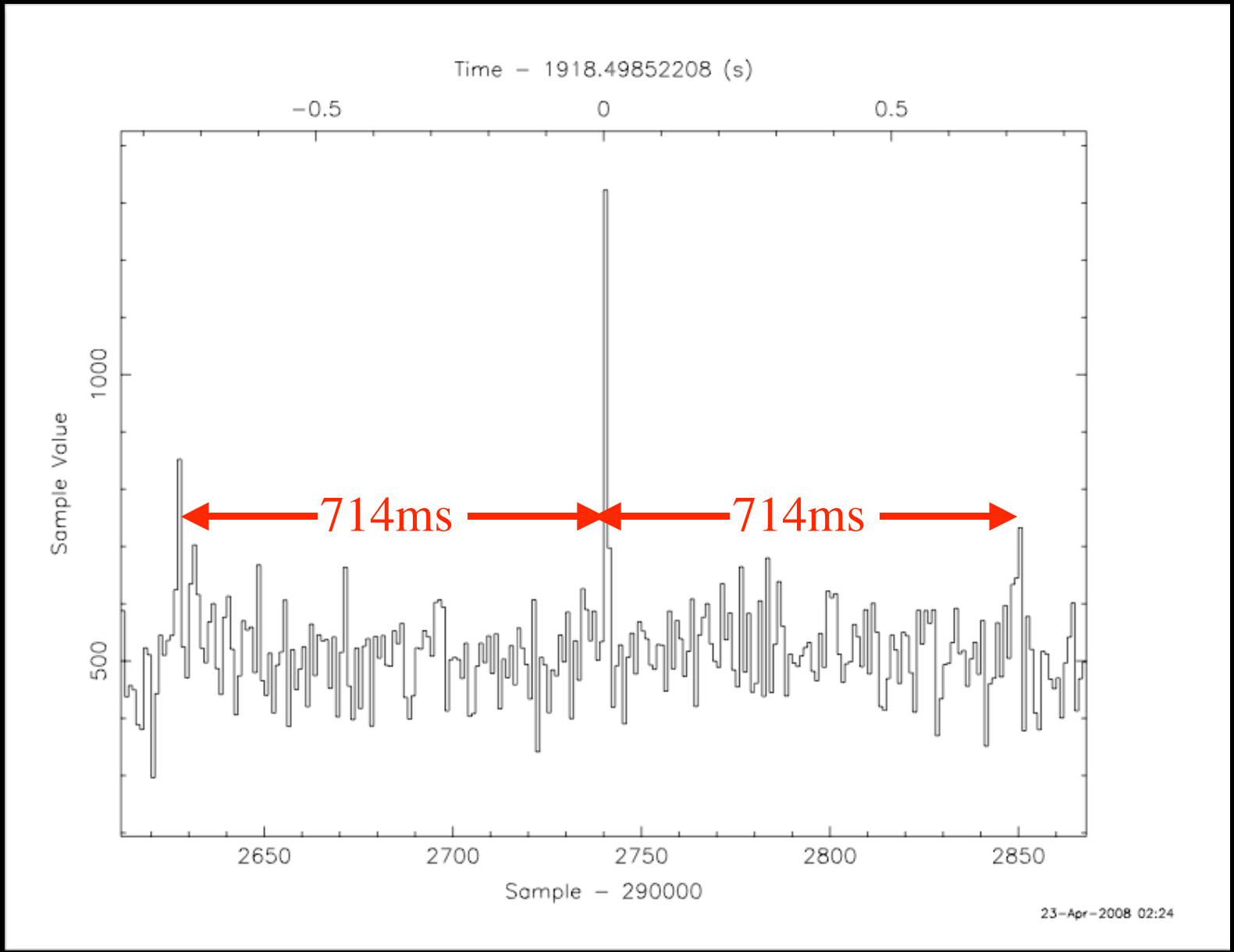
B0329+54 DM = 26.8 pc cm^{-3}

Puzzling DM = 28.1 pc cm^{-3}

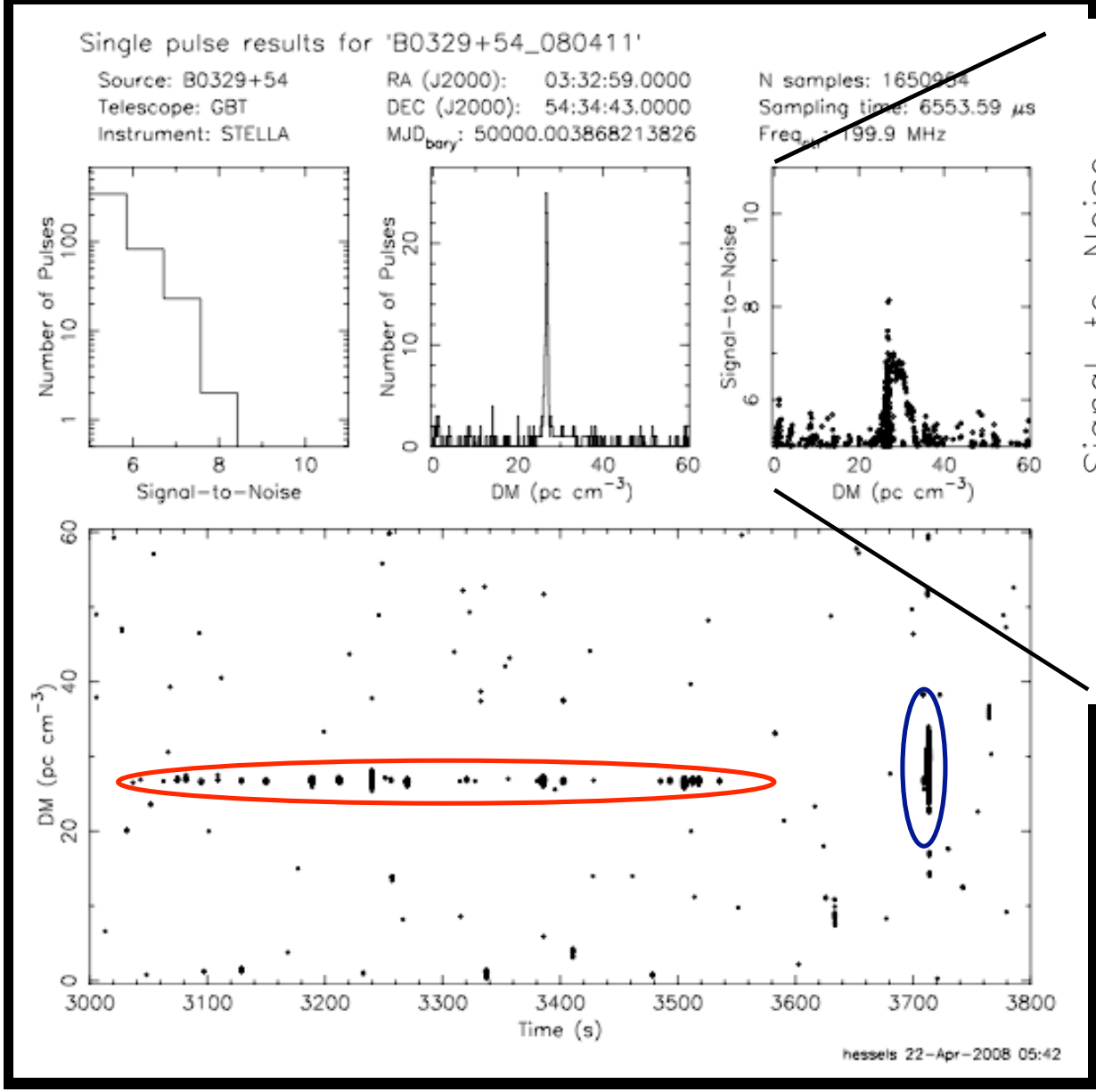
500 trial DMs with 6.5ms time resolution

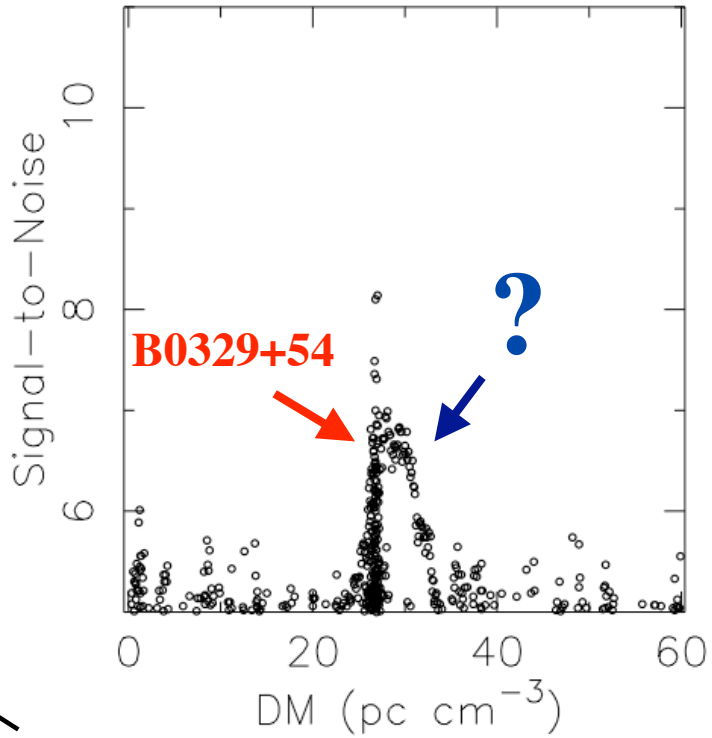
Interference

B0329+54 Single Pulses!

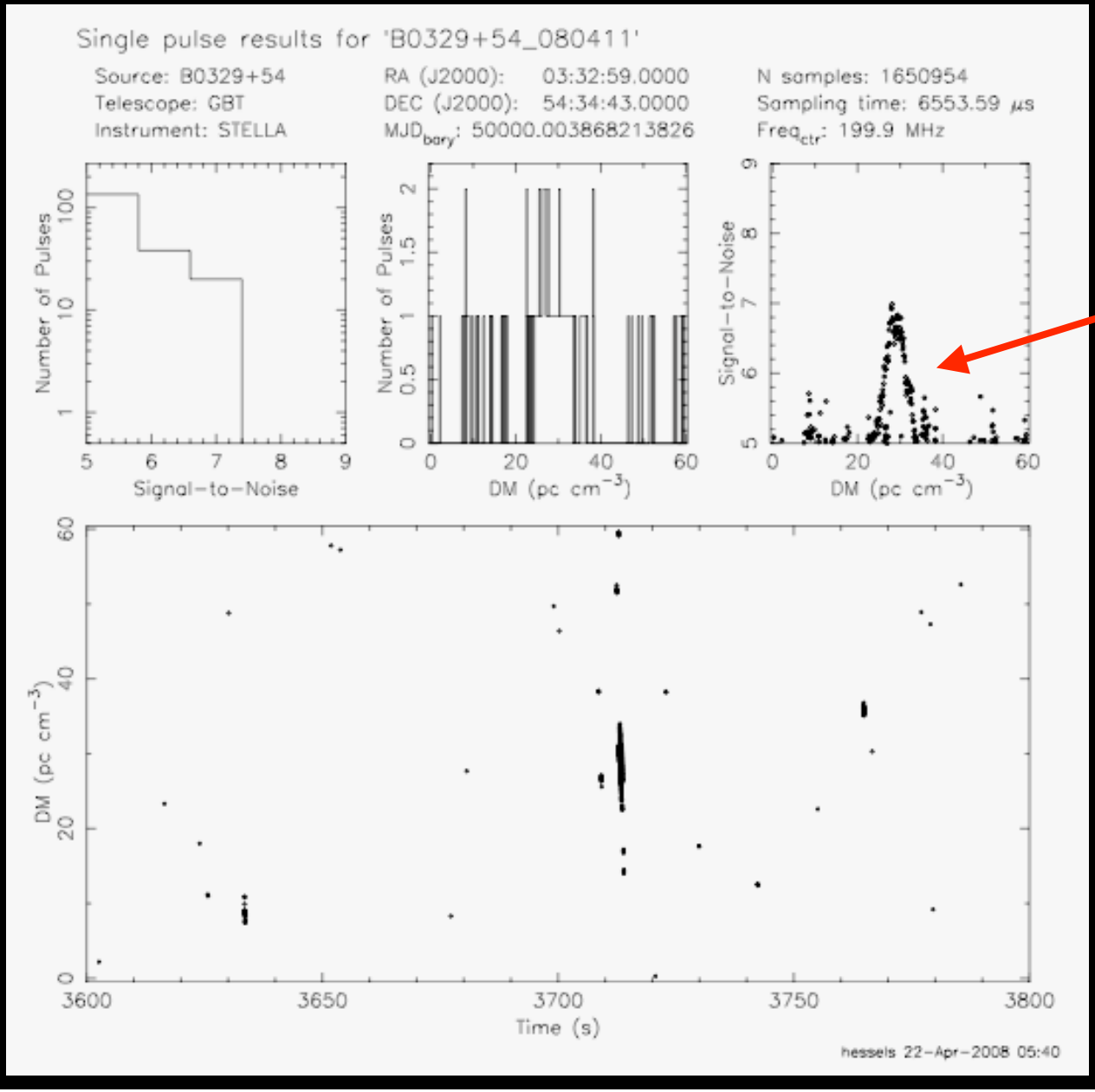


B0329+54 Single Pulses



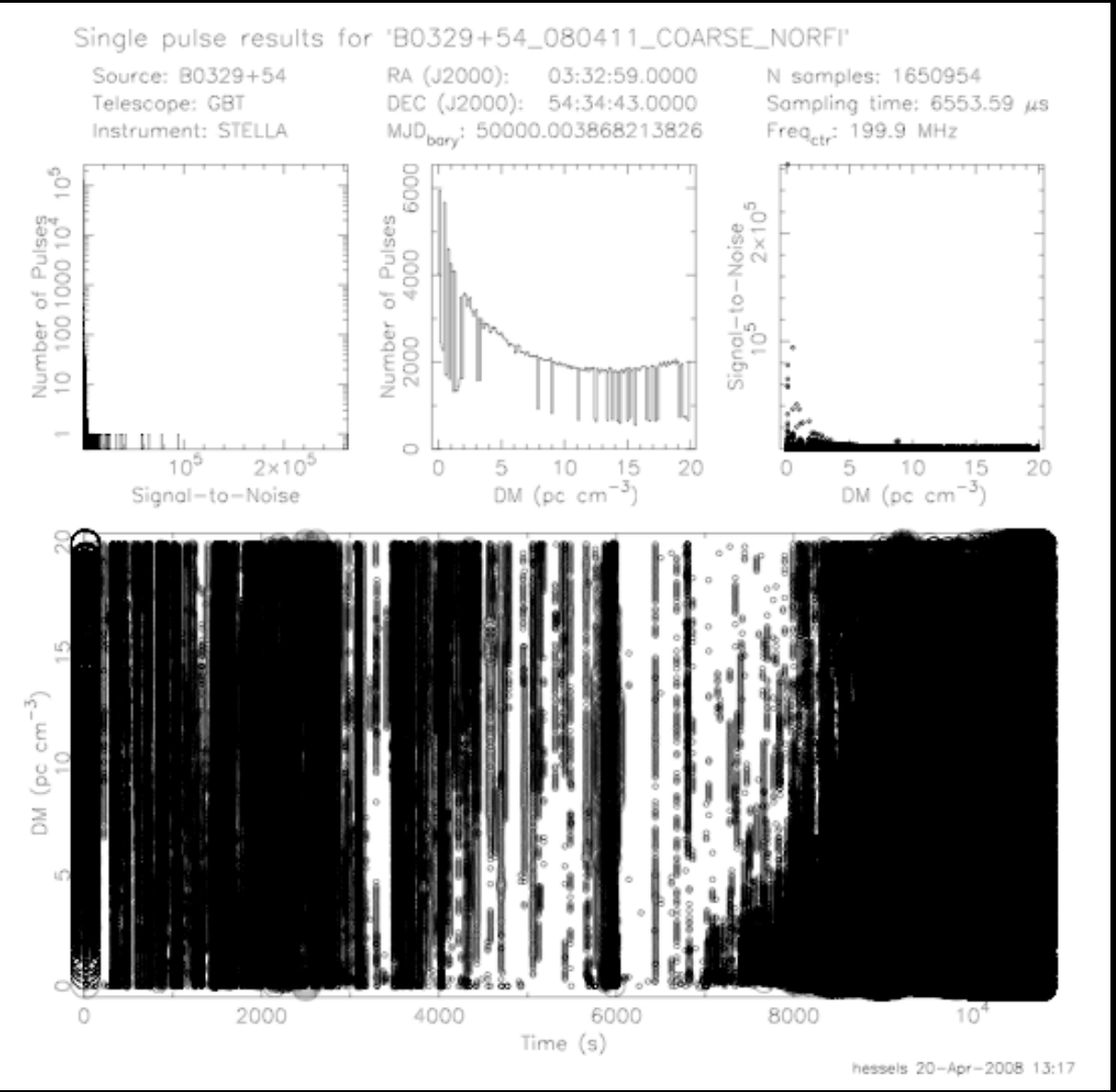


B0329+54 Single Pulses



Looks dispersed

B0329+54 Single Pulses



Without RFI excision (using all 48 subbands indiscriminantly)

To Do:

- Figure out 1-s pulses
- Characterize RFI better
- Excise RFI better
- Characterize beam shape
- Varify timing and frequency stamps.
- Search for new bursts, at higher DMs and higher resolution.
- Determine nature of DM 28.1 pc cm^{-3} burst.