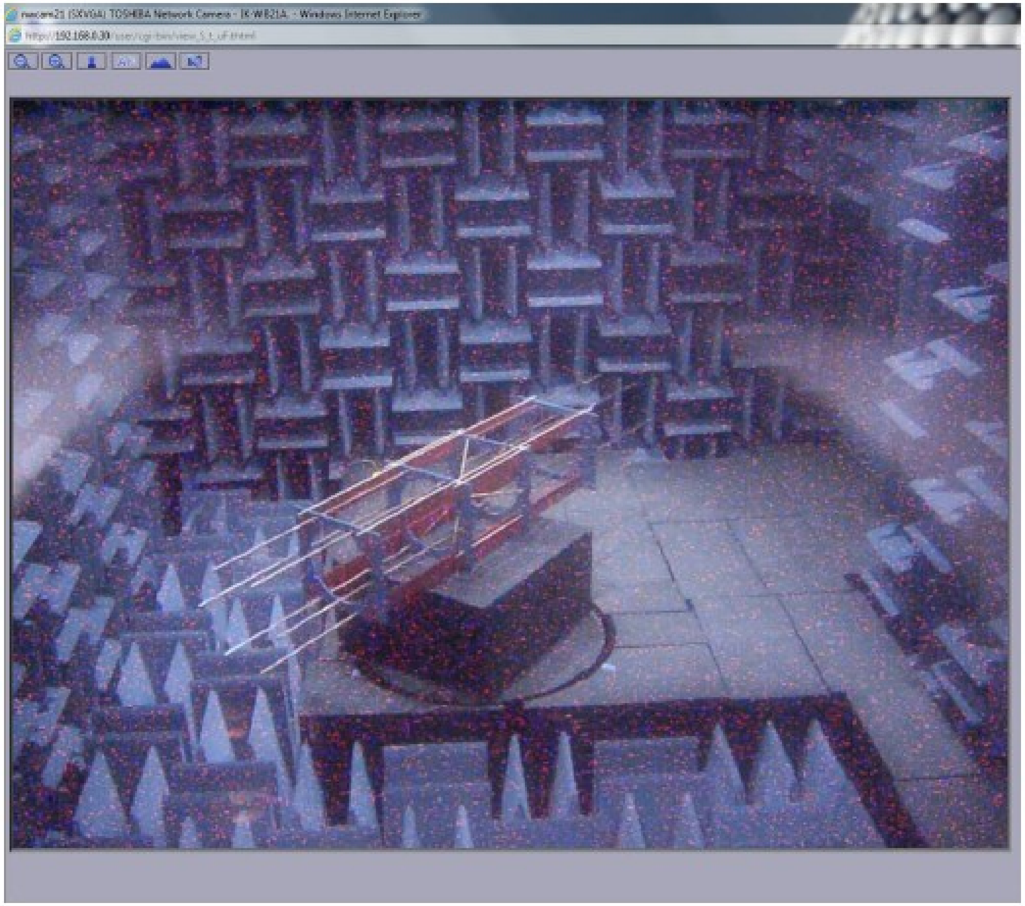
Surface Rx, status&plans (dzb, sn)



Anechoic chamber: after considerable tuning of feedpoint
VSWR<3.5 from 30 MHz → 900 MHz
Testbed surface Rx bandwidth: 25 → 300 MHz
ARA01: 25 → 150 MHz (diplexed)

Surface Rx rationale

- What do the surface antennas get us?
  - *Veto of down-coming signal*
  - *Possible radio-from-CR signals*
  - *Possible radio-from-TR signals*
  - *Surface point to extract n(z) (see Andrew/Ilya work thus far extrapolates n(z) only based on 20-m δz)*
- Results from Testbed & ARA01 (Allison et al., 2012)
  - *Galactic noise studies*
  - *Solar flare observations*

And....

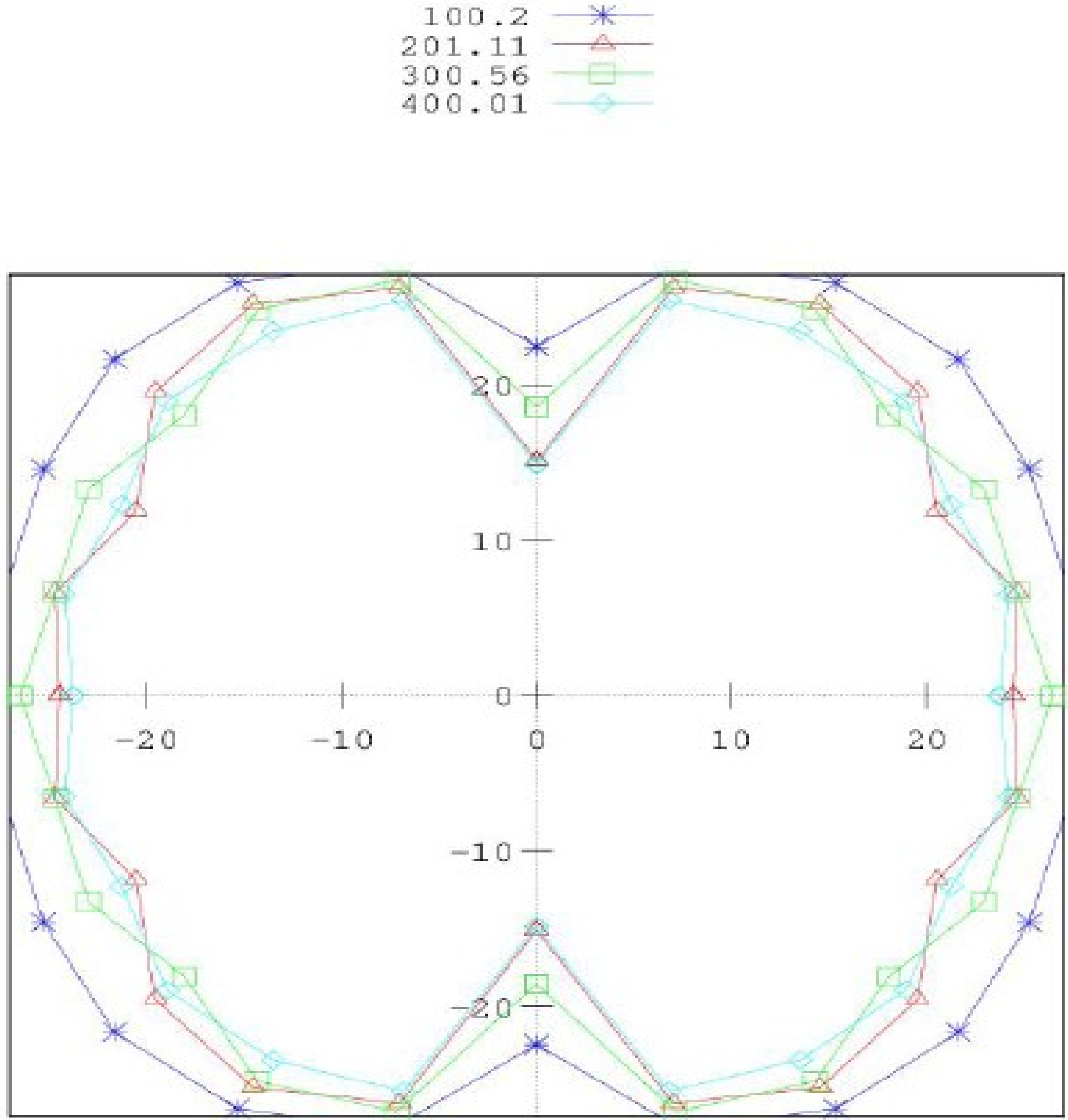
- Recall testbed review: "*Quantify bkgnds from down-coming signals mis-reconstructed as upcoming*"
  - Although evidently not a problem for Thomas' ARA02/ARA03 analysis.
- Thomas et al http://xxx.lanl.gov/pdf/1503.02808.pdf :
  - TR due to CR showers impacting surface (although how come we haven't seen these yet?):

The emission from such a cosmic-ray air shower is calculated to be of similar strength as the Askaryan radio signal obtained from an in-ice cascade induced by a GZK-neutrino of similar energy. Furthermore, the polarization of the transition radiation will be similar to the polarization of the Askaryan signal. It follows that without directional information or a surface veto, it will be very hard to distinguish between both signals.

Surface Antennas hardware, overview

- Simplified version of in-ice antennas
  - No drilling (obviously)
  - No optical fiber; all signals carried over coax
- Although all based on the 'fat-dipole' design, slight evolution from:
  - testbed (UH)→ARA01 (Achen)→ARA02/ARA03 (KU)
    - ARA01 multiplexed 2 channels to have response <150 MHz.
    - ARA02/ARA03, dedicated channels, doubled bandwidth in effort to provide overlap with in-ice antennas
    - N.B. Same signal channel gain as ARA01!

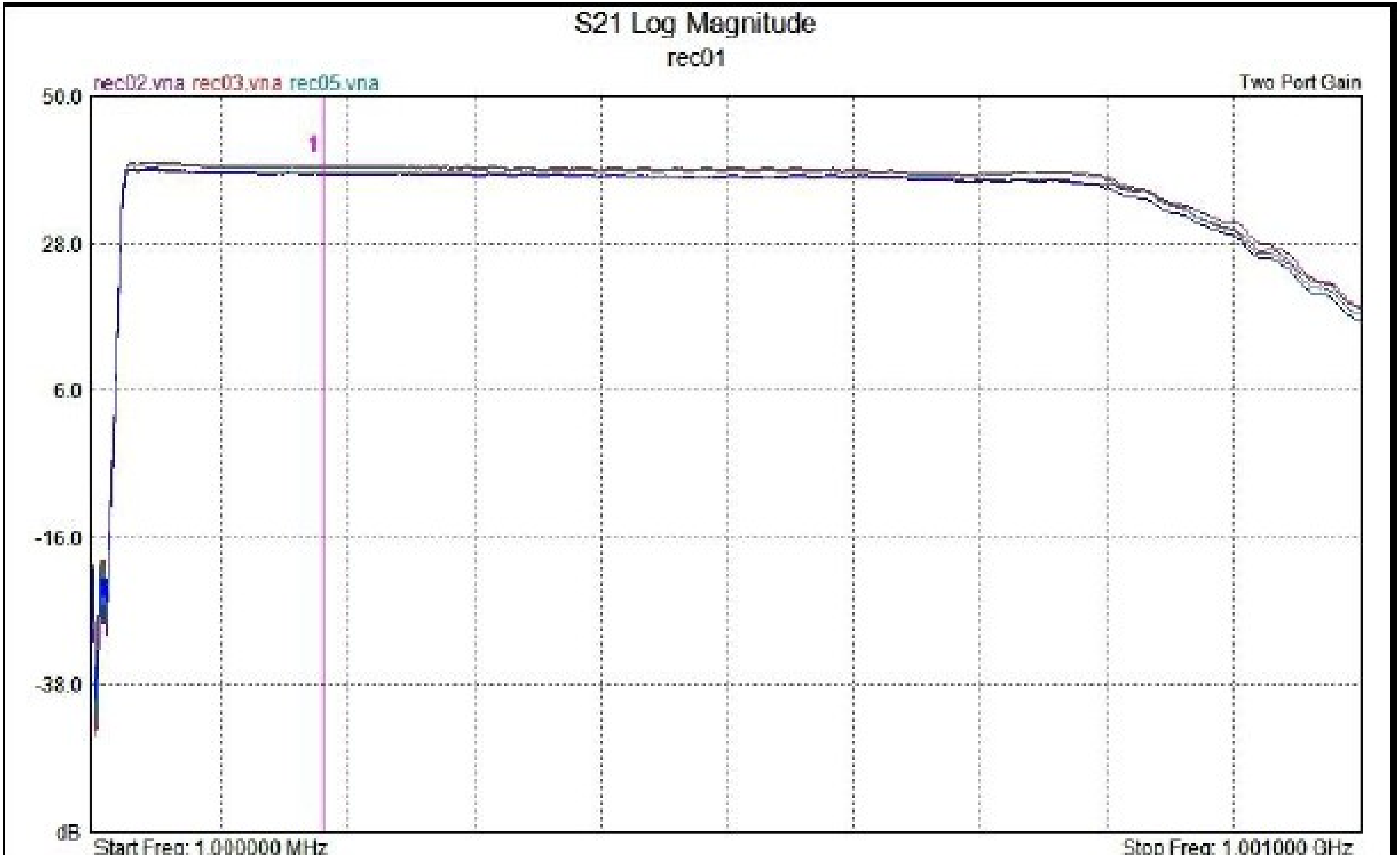
A2/A3 surface Rx hardware reminder



Azimuthal gain pattern in-air
Roughly frequency-independent (anechoic chamber)

Front-end S21~36 dB (SHP-25)

Receiver S21~38 dB (SHP-25)



Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	☐	■	181.000 MHz	38.29 dB	- -	- -

Full ch. gain (incl. 3 dB splitter)~71 dB

Each channel individually verified

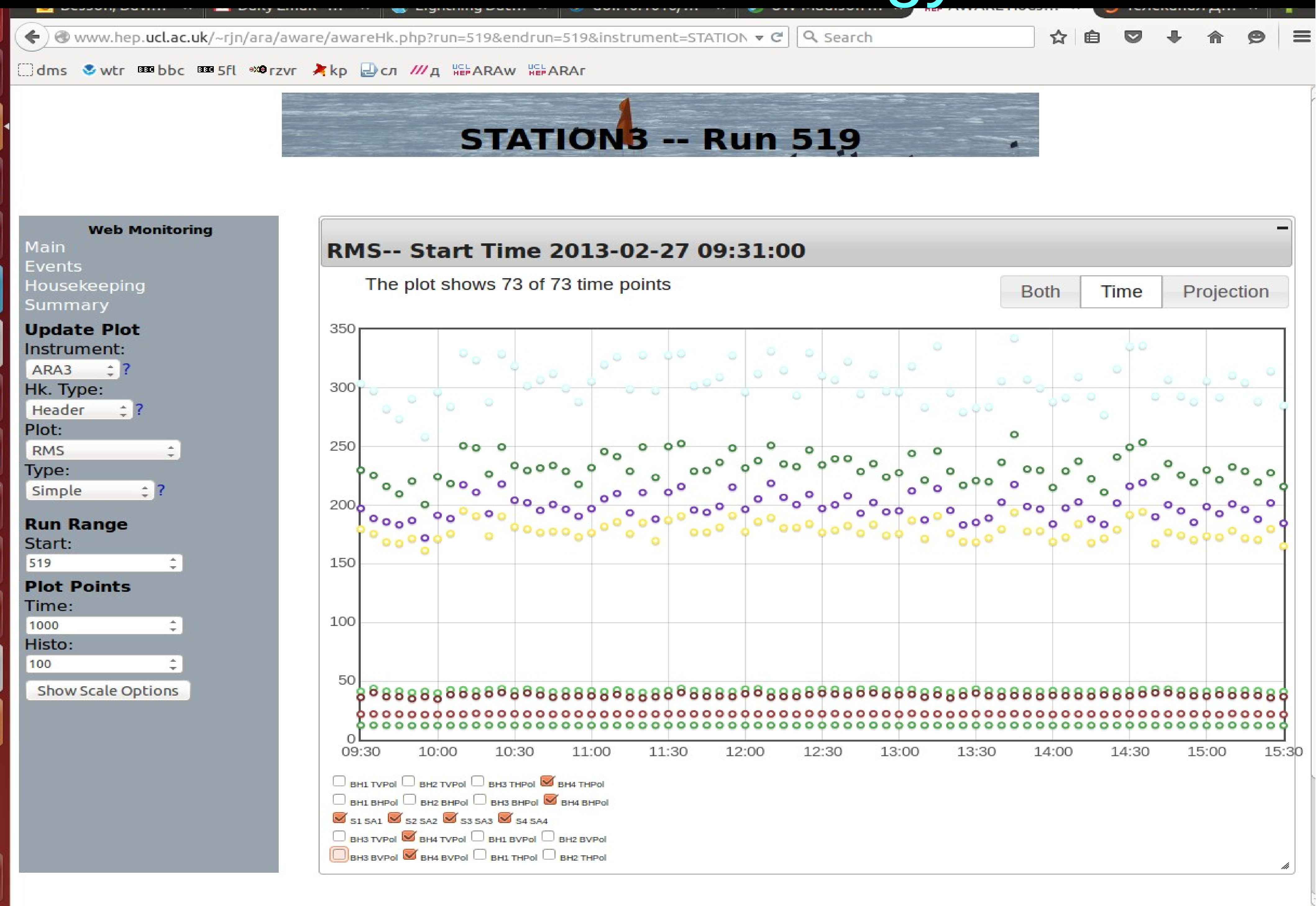
http://ara.physics.wisc.edu/docs/0006/000608/001/TestPlan.pdf

	Input	Atten	Input to Front End	Front End Amp	Output From Front End	Atten	Input to Receiver	Receiver Amp	Output From Receiver	Splitter Board	Final Output
dB	-4.98	-60	-64.98	36	-29.98	-32	-60.98	38	-22.98	-4	-26.98
Volts	3.98		0.004		0.251		0.006		0.501		0.316

So, assuming 20 uV at input (thermal+system) => expect ~80 mV rms for each surface antenna

(purposely set on high side in order to improve chances of triggering on downcoming CR)

Some archaeology



Web Monitoring

Main
Events
Housekeeping
Summary

Update Plot

Instrument: ARA3 ?

Hk. Type: Header ?

Plot: RMS

Type: Simple ?

Run Range

Start: 1926

Plot Points

Time: 1000

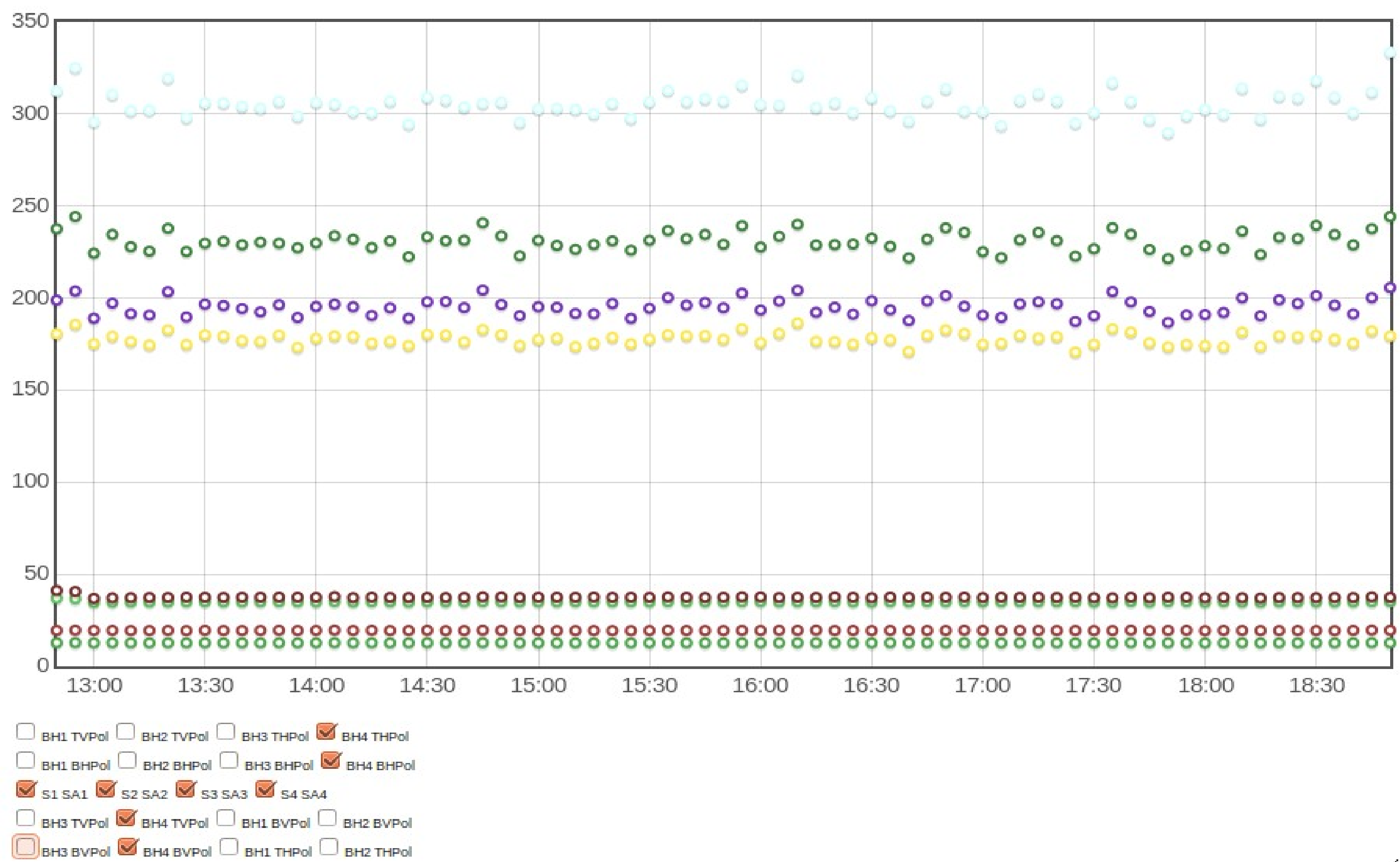
Histo: 100

Show Scale Options

RMS-- Start Time 2013-12-31 12:50:00

The plot shows 73 of 73 time points

Both | Time | Projection



www.hep.ucl.ac.uk/~rjn/ara/aware/awareHk.php?run=1978&endrun=519&instrument=STATIO

dms wtr bbc 5fl rzvr kp сл д ARAw ARAr

STATION3 -- Run 1978

Web Monitoring

Main
Events
Housekeeping
Summary

Update Plot

Instrument: ARA3 ?

Hk. Type: Header ?

Plot: RMS

Type: Simple ?

Run Range

Start: 1978

Plot Points

Time: 1000

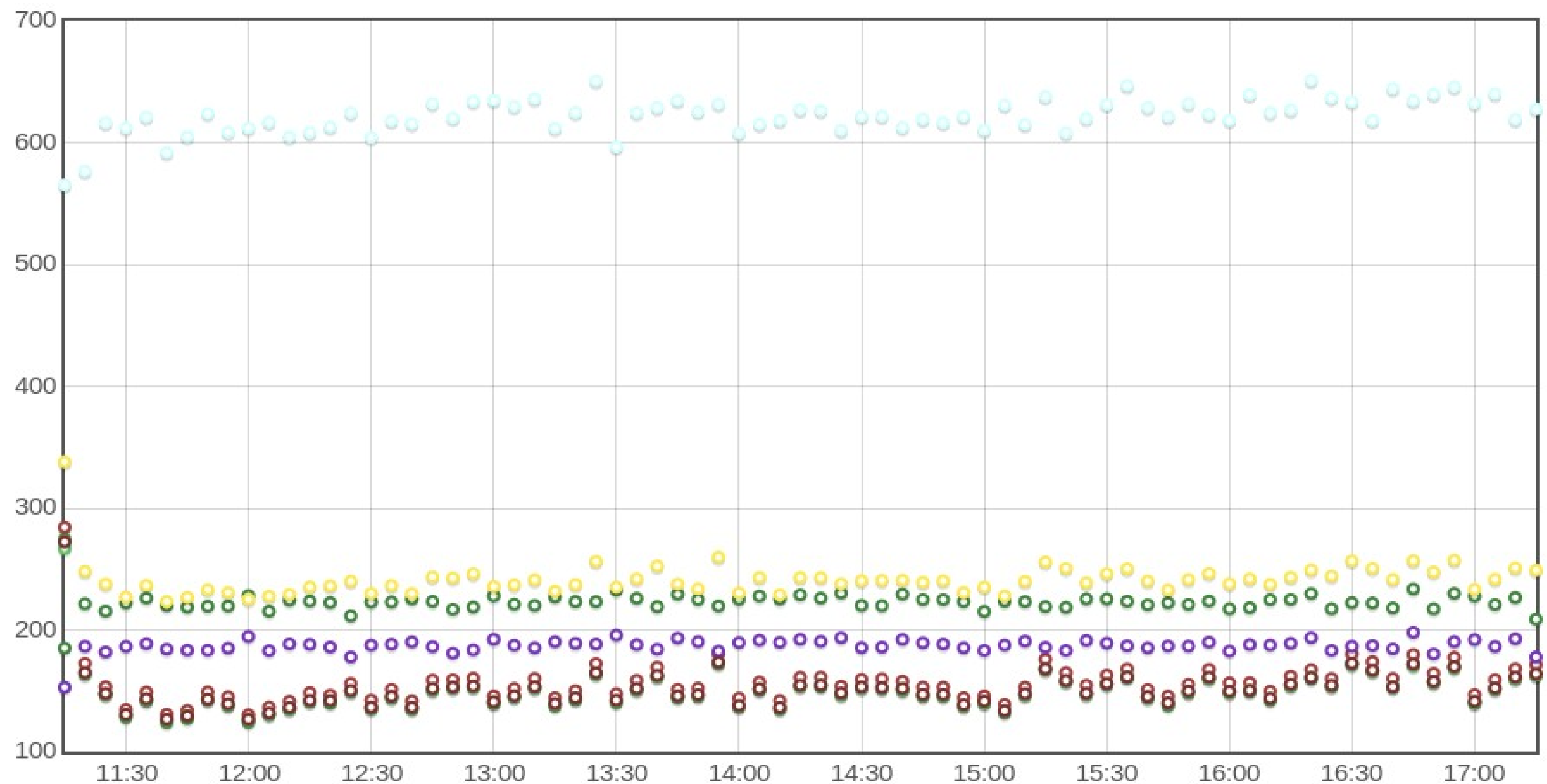
Histo: 100

Show Scale Options

RMS-- Start Time 2014-01-10 11:19:00

The plot shows 73 of 73 time points

Both | Time | Projection



BH1 TVPol BH2 TVPol BH3 THPol BH4 THPol
BH1 BHPol BH2 BHPol BH3 BHPol BH4 BHPol
S1 SA1 S2 SA2 S3 SA3 S4 SA4
BH3 TVPol BH4 TVPol BH1 BVPol BH2 BVPol
BH3 BVPol BH4 BVPol BH1 THPol BH2 THPol

www.hep.ucl.ac.uk/~rjn/ara/aware/awareHk.php?run=2307&endrun=519&instrument=STATIO

dms wtr bbc 5fl rzvr kp сл д ARAw ARAr

STATION3 -- Run 2307

Web Monitoring

Main
Events
Housekeeping
Summary

Update Plot

Instrument: ARA3 ?

Hk. Type: Header ?

Plot: RMS

Type: Simple ?

Run Range

Start: 2307

Plot Points

Time: 1000

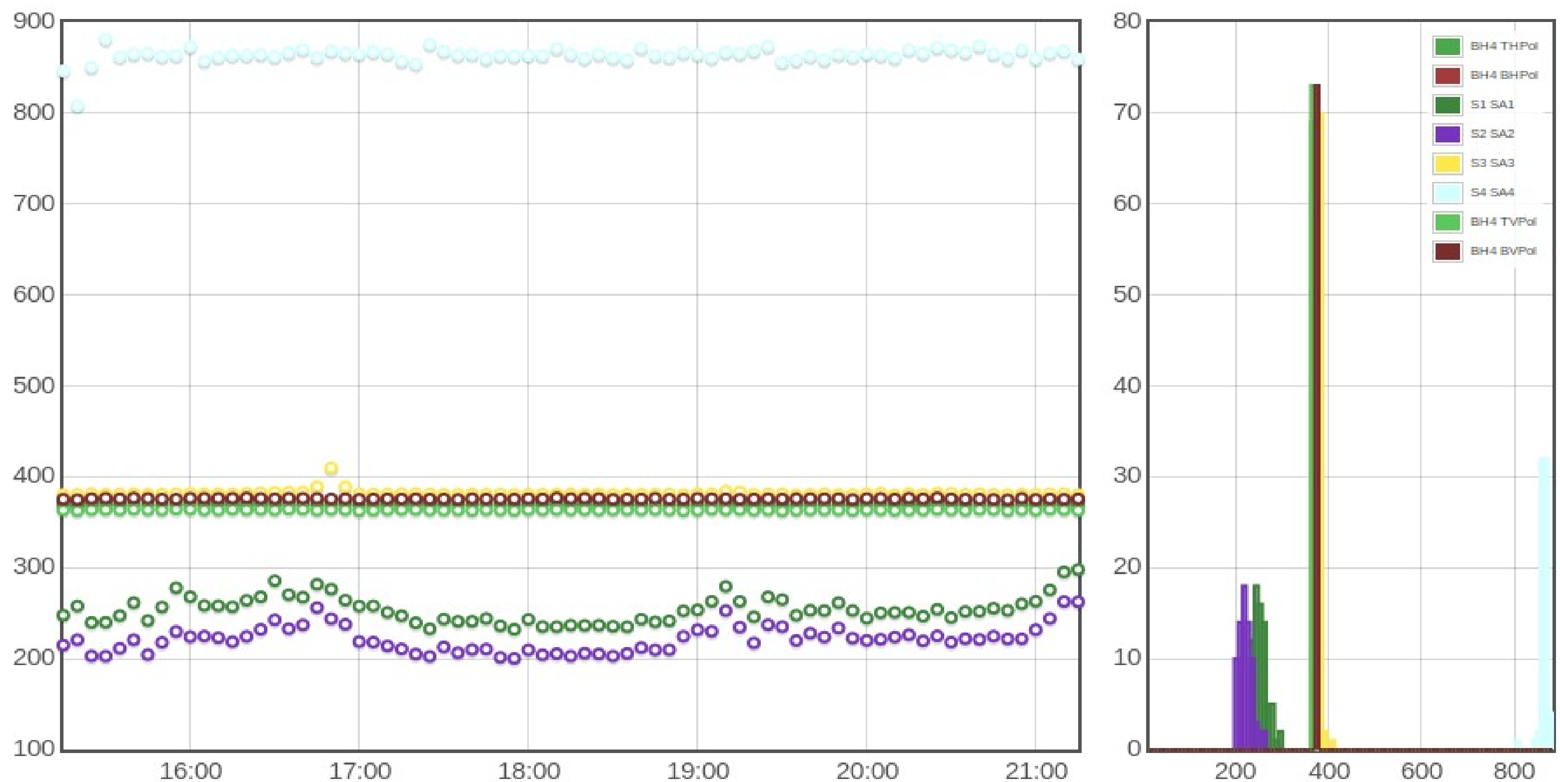
Histo: 100

Show Scale Options

RMS-- Start Time 2014-03-10 15:16:00

The plot shows 73 of 73 time points

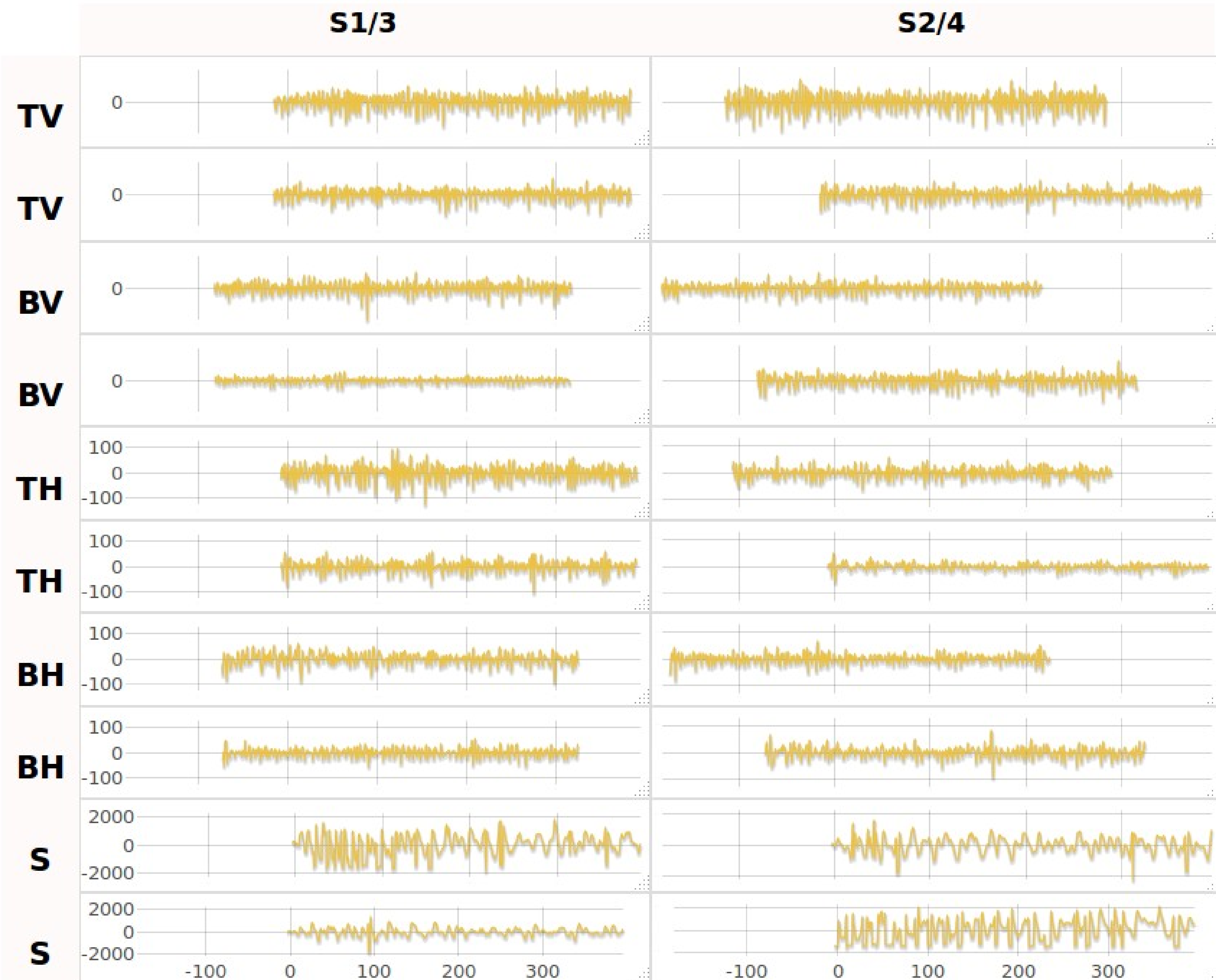
Both | Time | Projection



BH1 TVPol, BH2 TVPol, BH3 THPol, BH4 THPol (checked)
BH1 BHPol, BH2 BHPol, BH3 BHPol, BH4 BHPol (checked)
S1 SA1 (checked), S2 SA2 (checked), S3 SA3 (checked), S4 SA4 (checked)
BH3 TVPol, BH4 TVPol (checked), BH1 BVPol, BH2 BVPol
BH3 BVPol, BH4 BVPol (checked), BH1 THPol, BH2 THPol

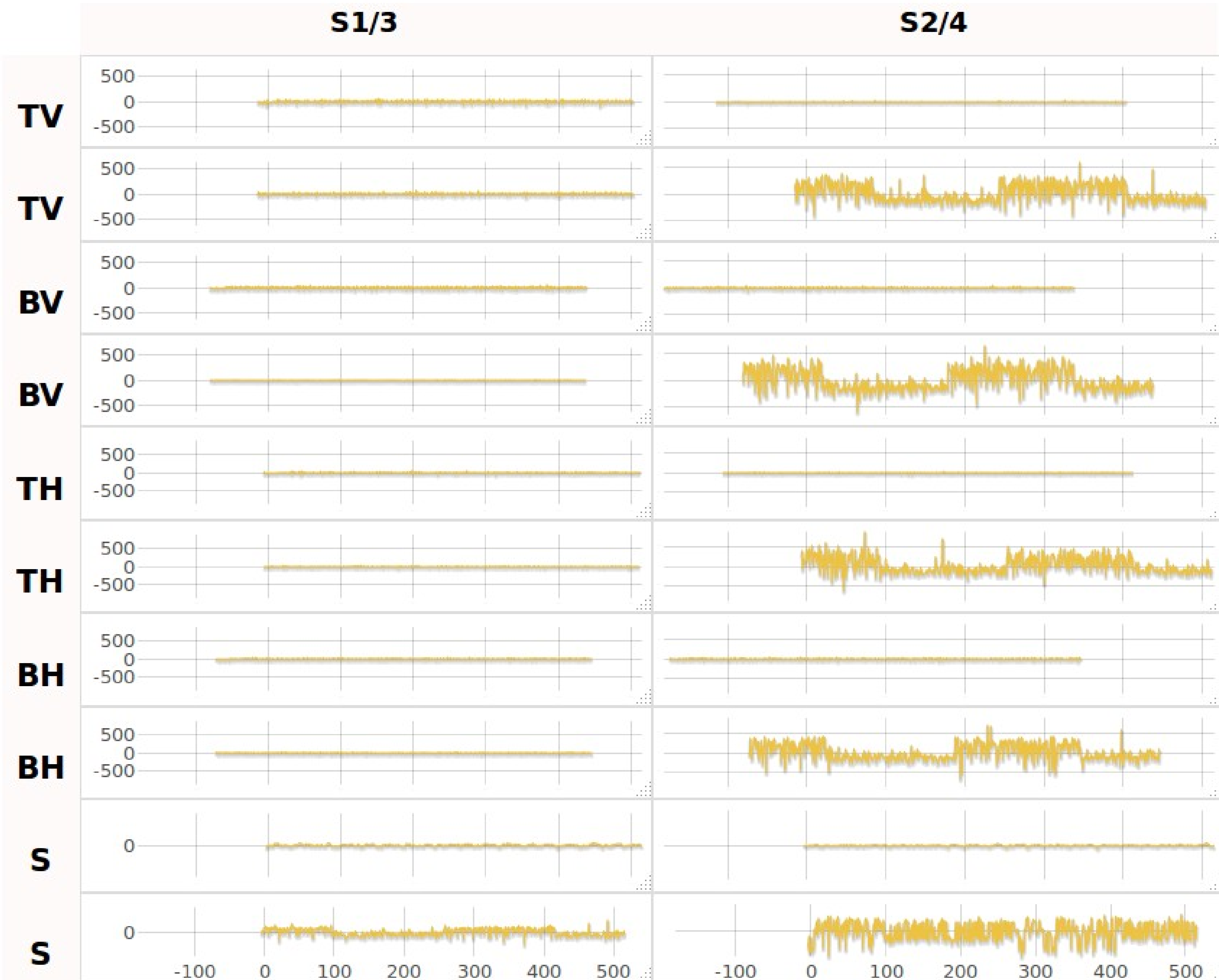
STATION3 -- Run 1000

Event: 494 -- Time: 2013-06-21 20:48:00 -- Trigger: 49454017.000000

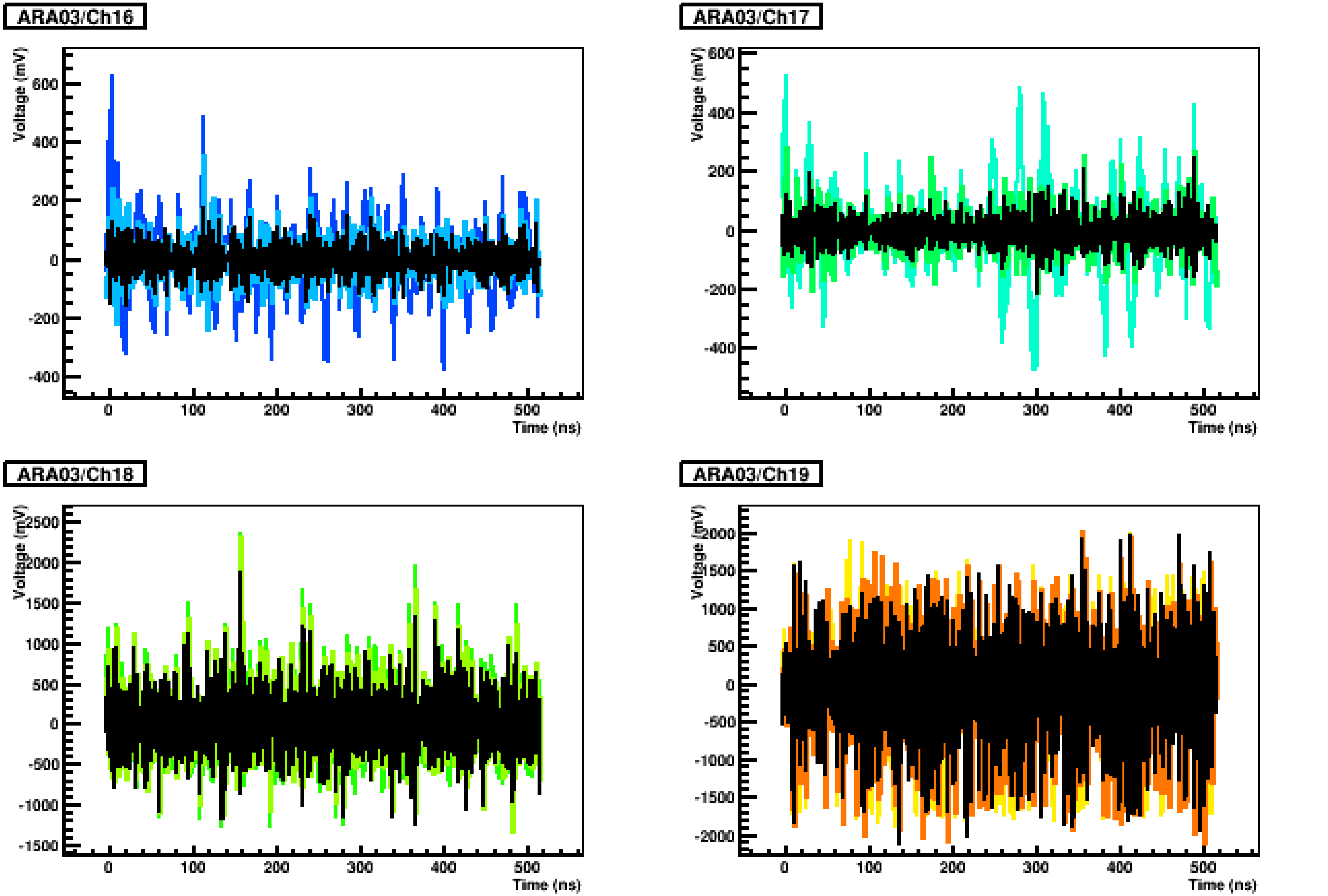


STATION3 -- Run 4891

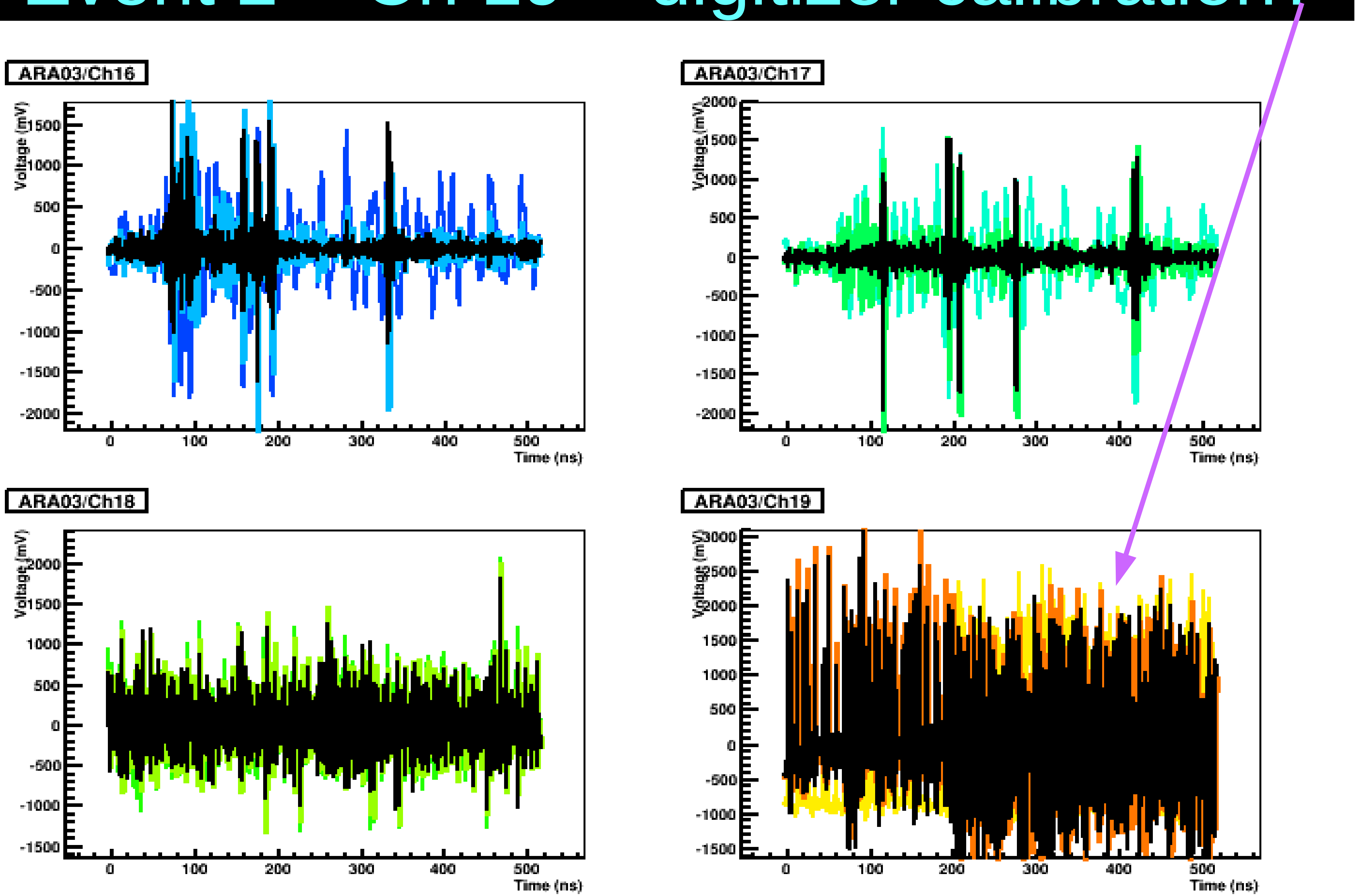
Event: 275 -- Time: 2015-07-13 12:17:46 -- Trigger: 81873826.000000



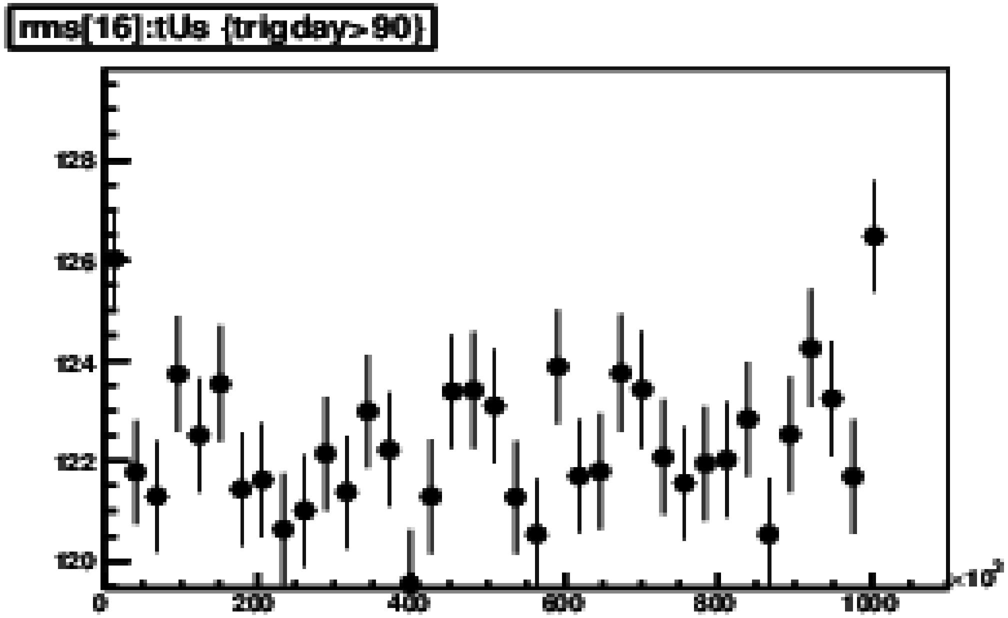
A3 2015 waveforms (>100 MHz & >200 MHz HPF overlaid)

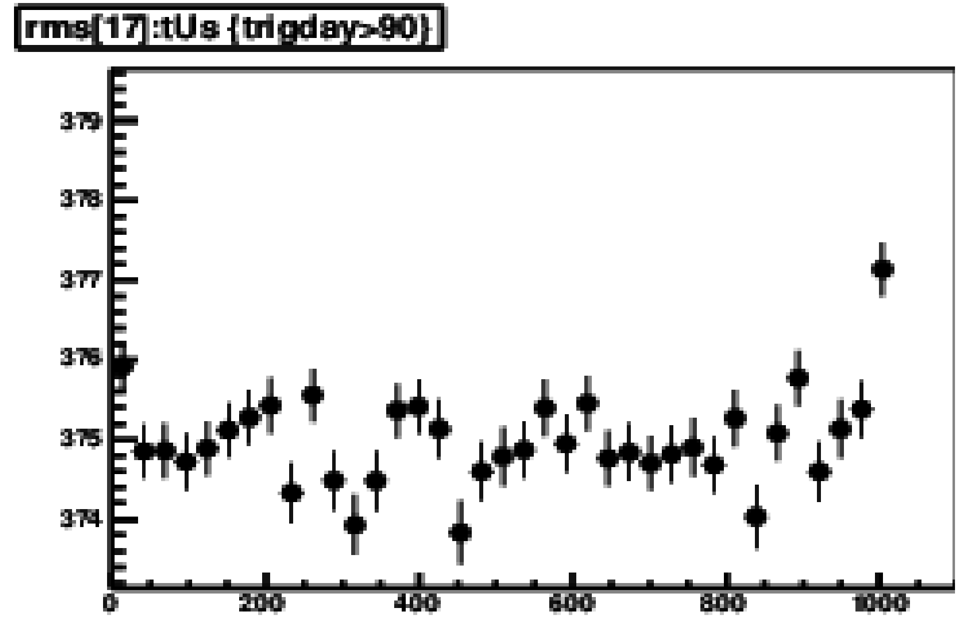


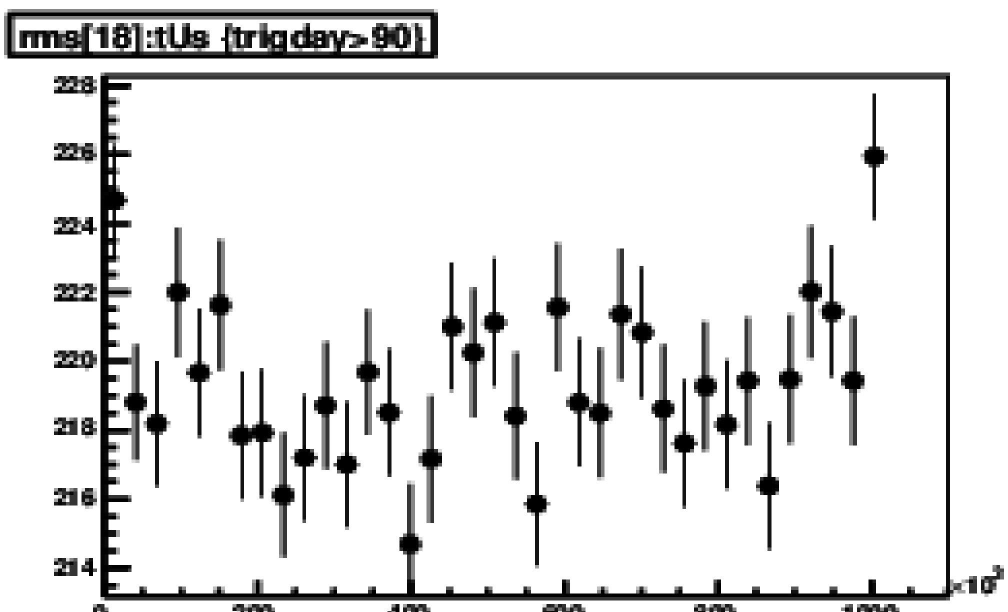
Event 2 – Ch 19 – digitizer calibration?

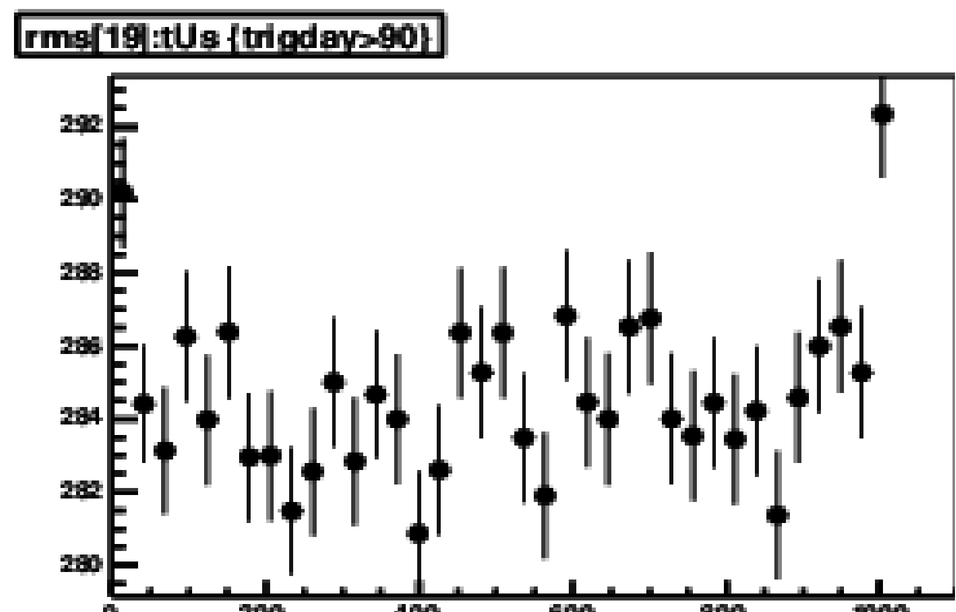


2015 A2/<Vrms> vs. unixTimeUs – maybe seeing 'tail' of CP signal...

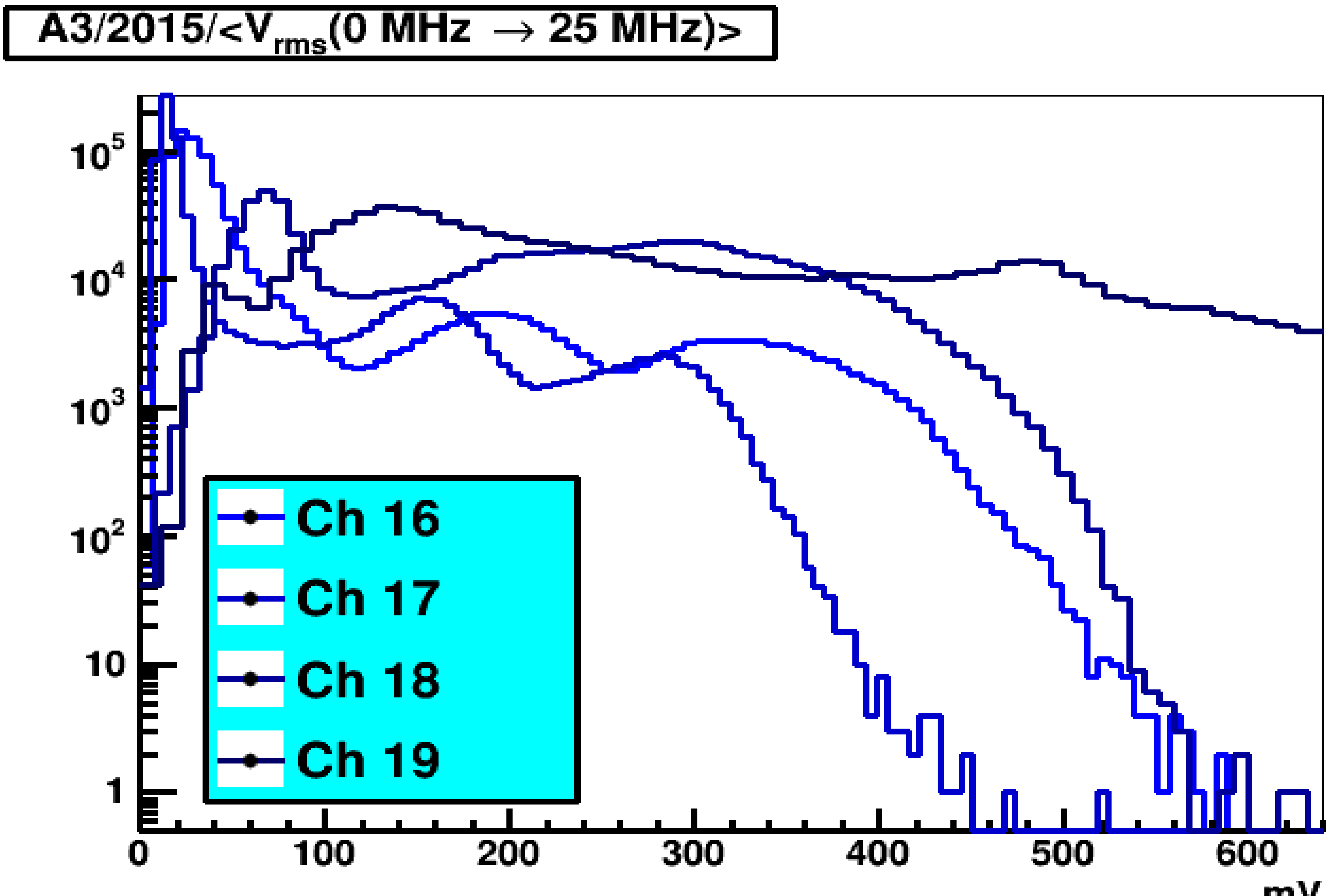




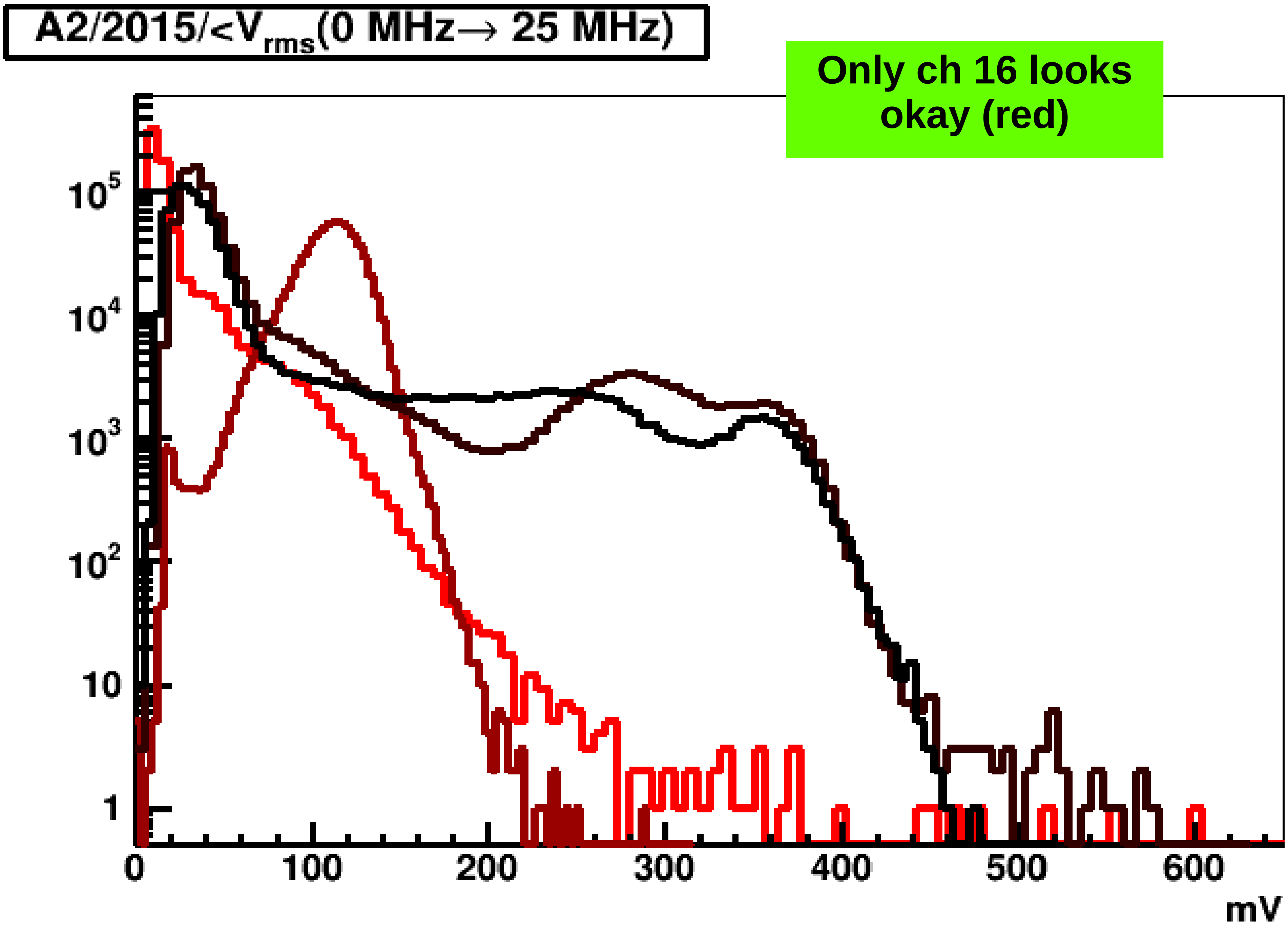




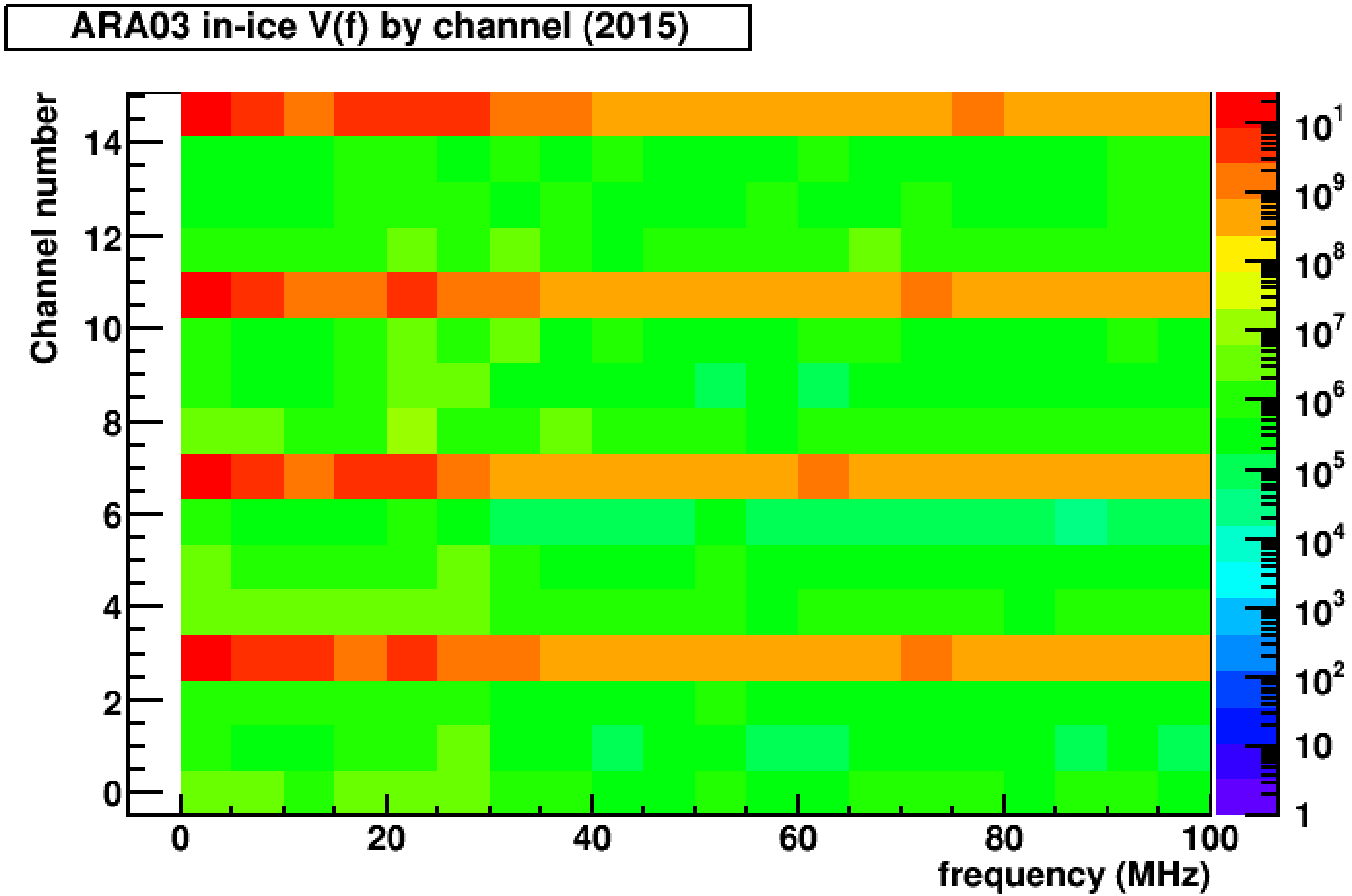
Why do some waveforms look crummy? A3 out-of-band noise, below 25 MHz



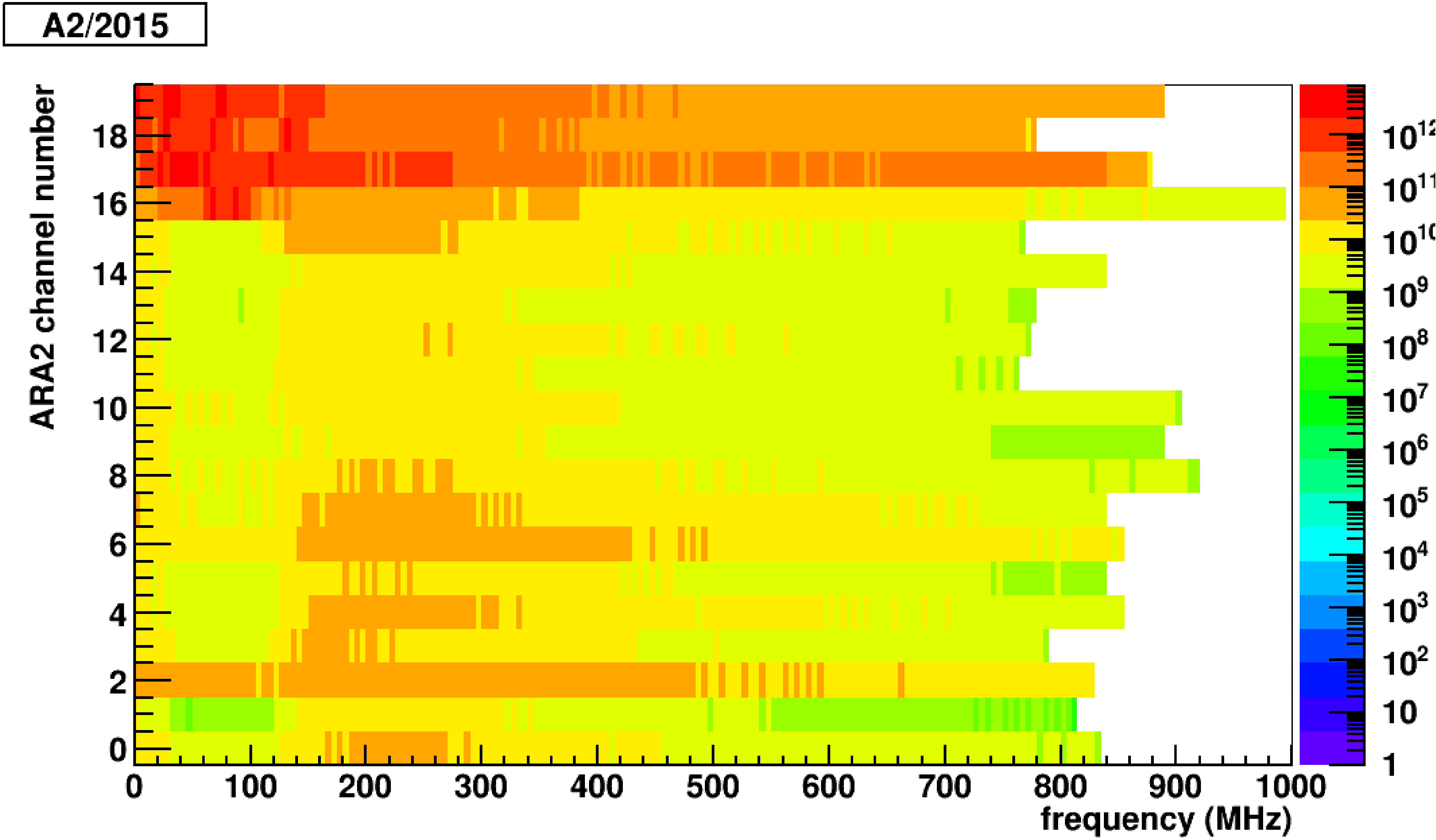
A2 out-of-band noise



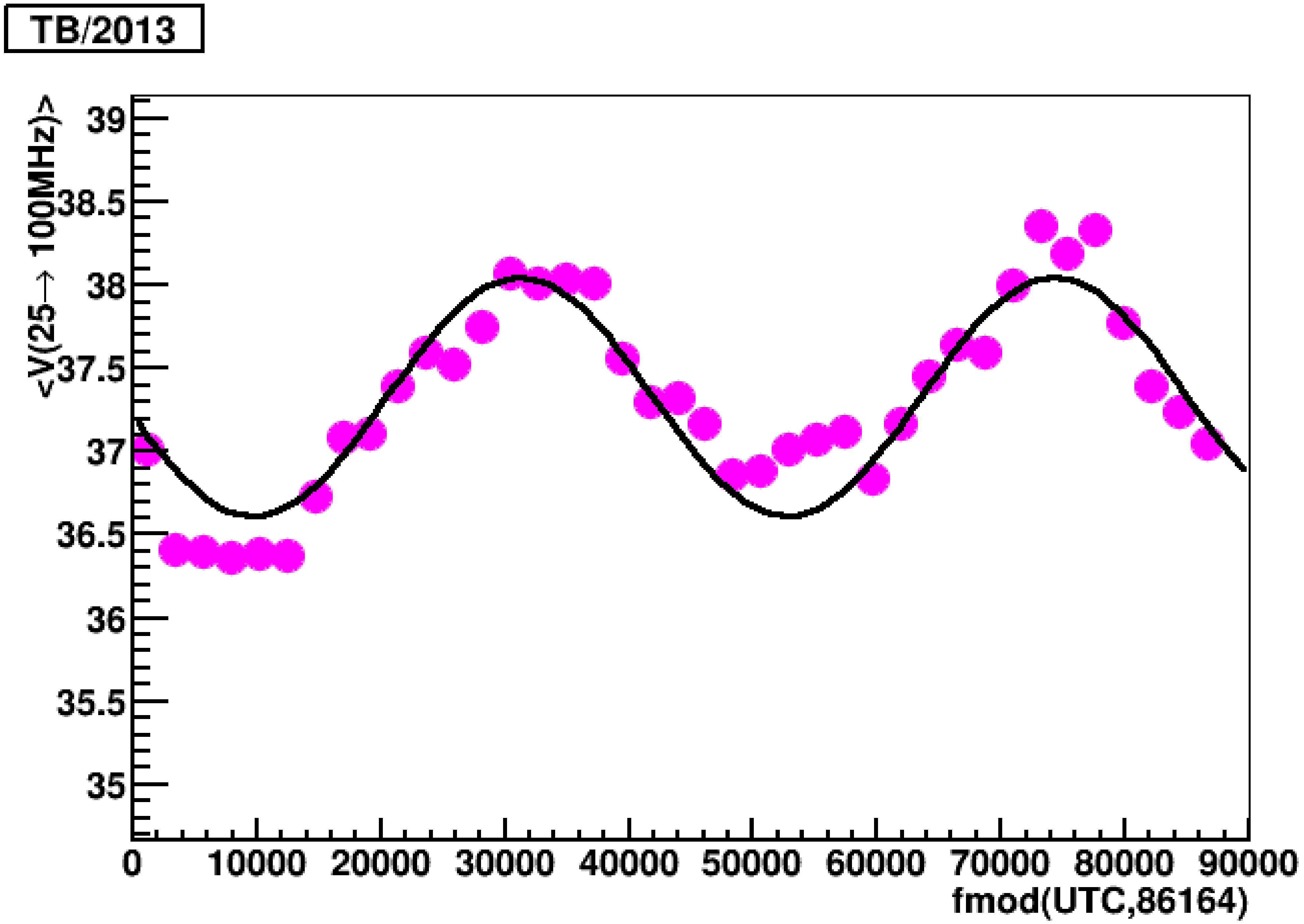
A3 in-ice (note BH4 channels!)



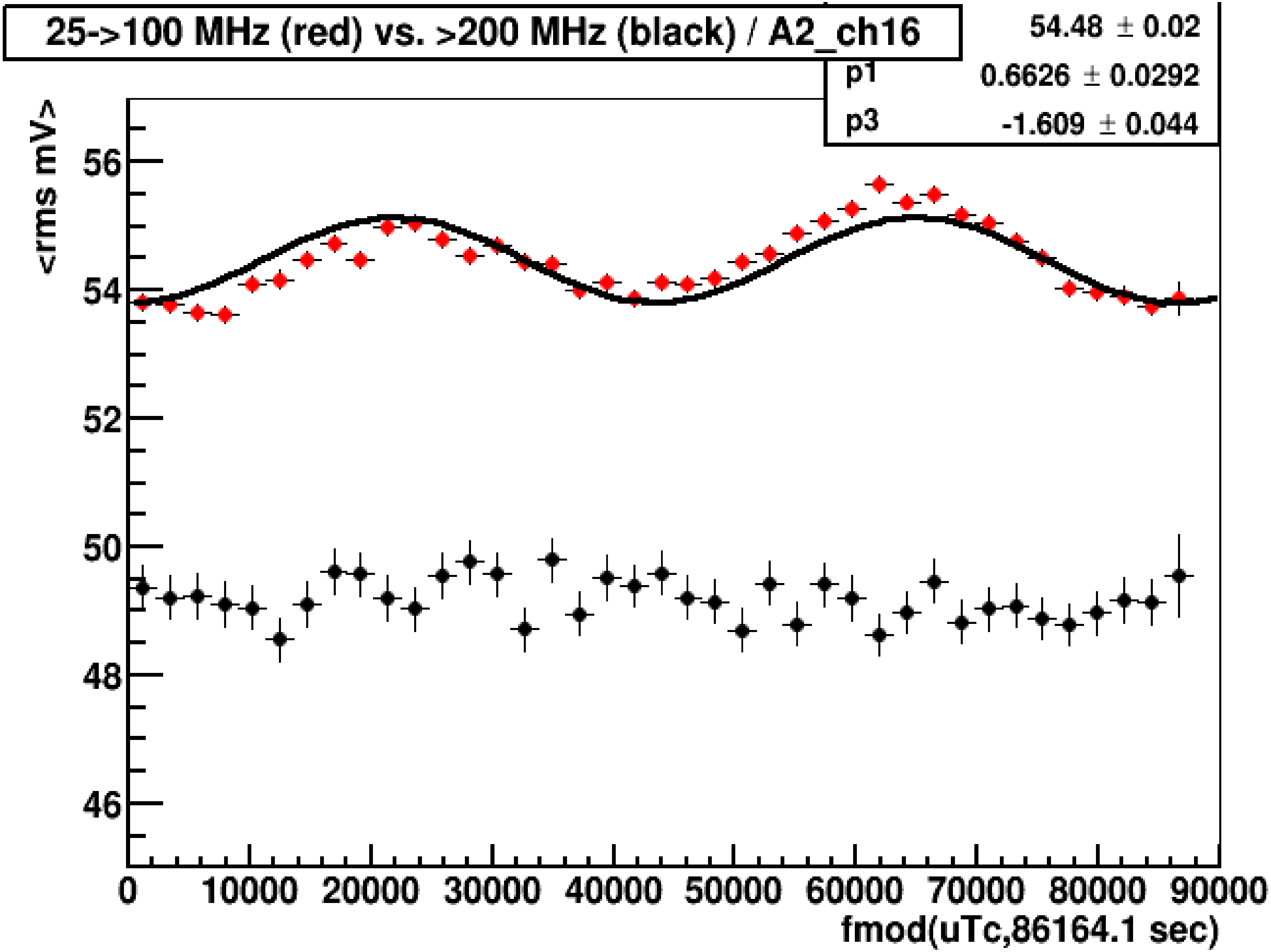
A2 2015 in-ice



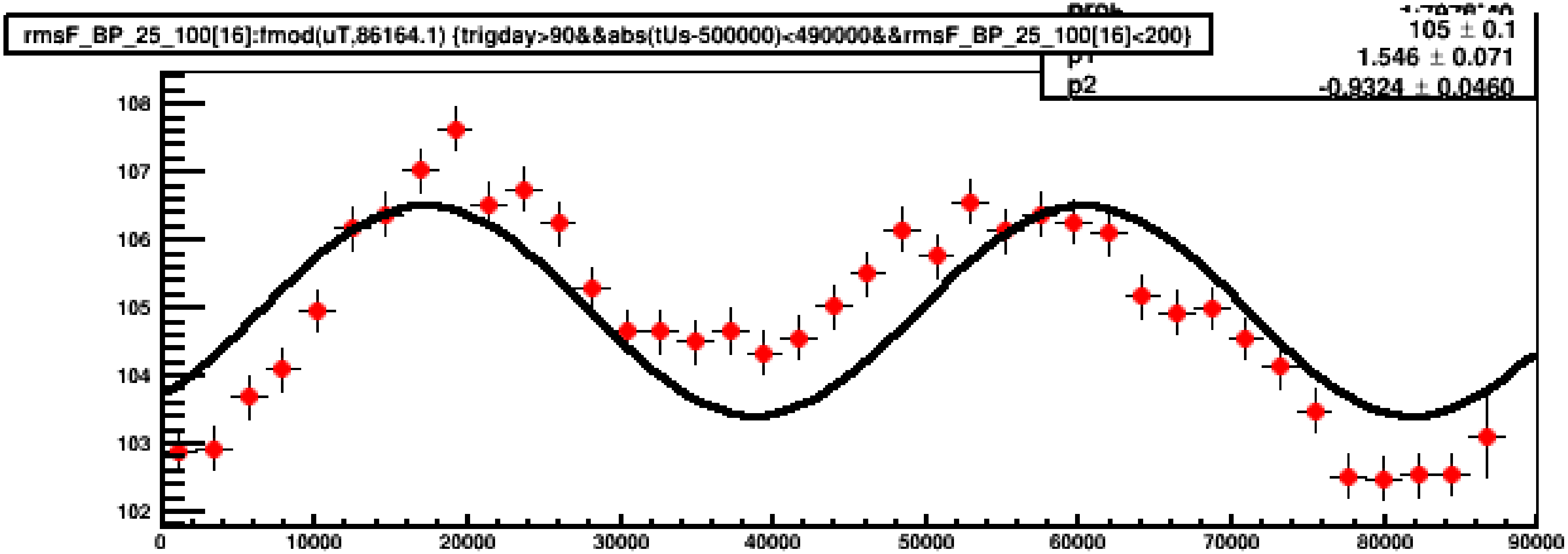
Testbed galactic correlation

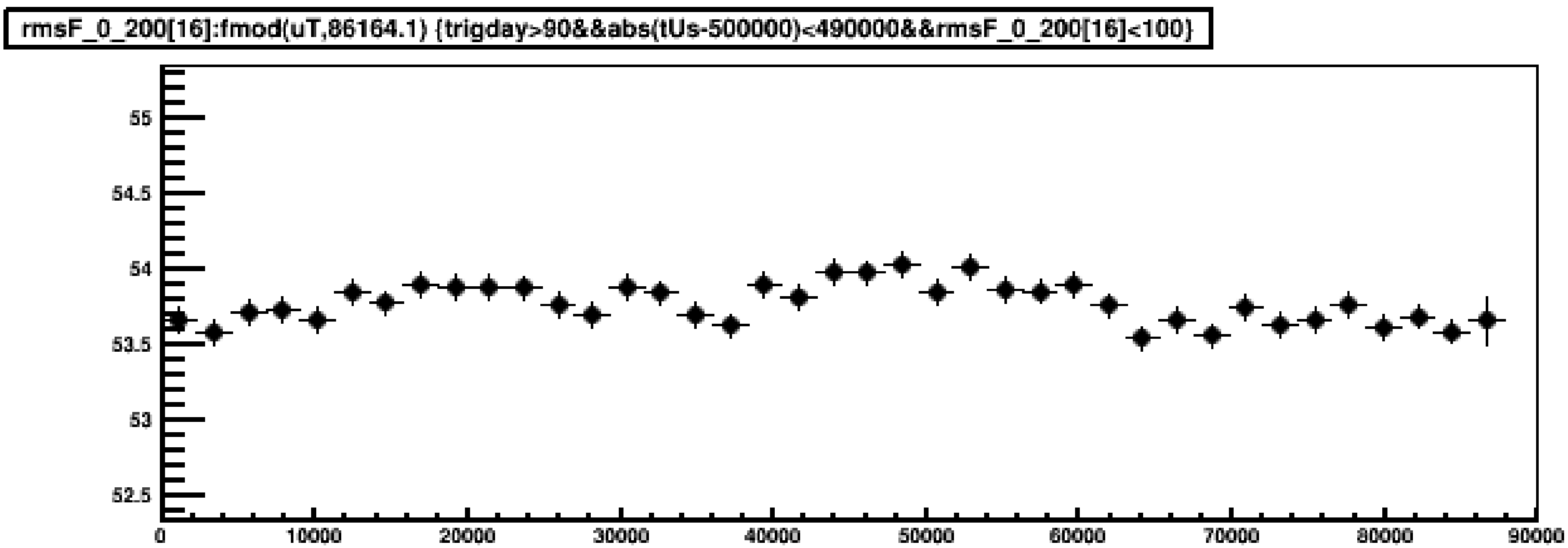


A2 galactic correlation? 25-100 MHz (top) vs. >200 MHz (bottom)

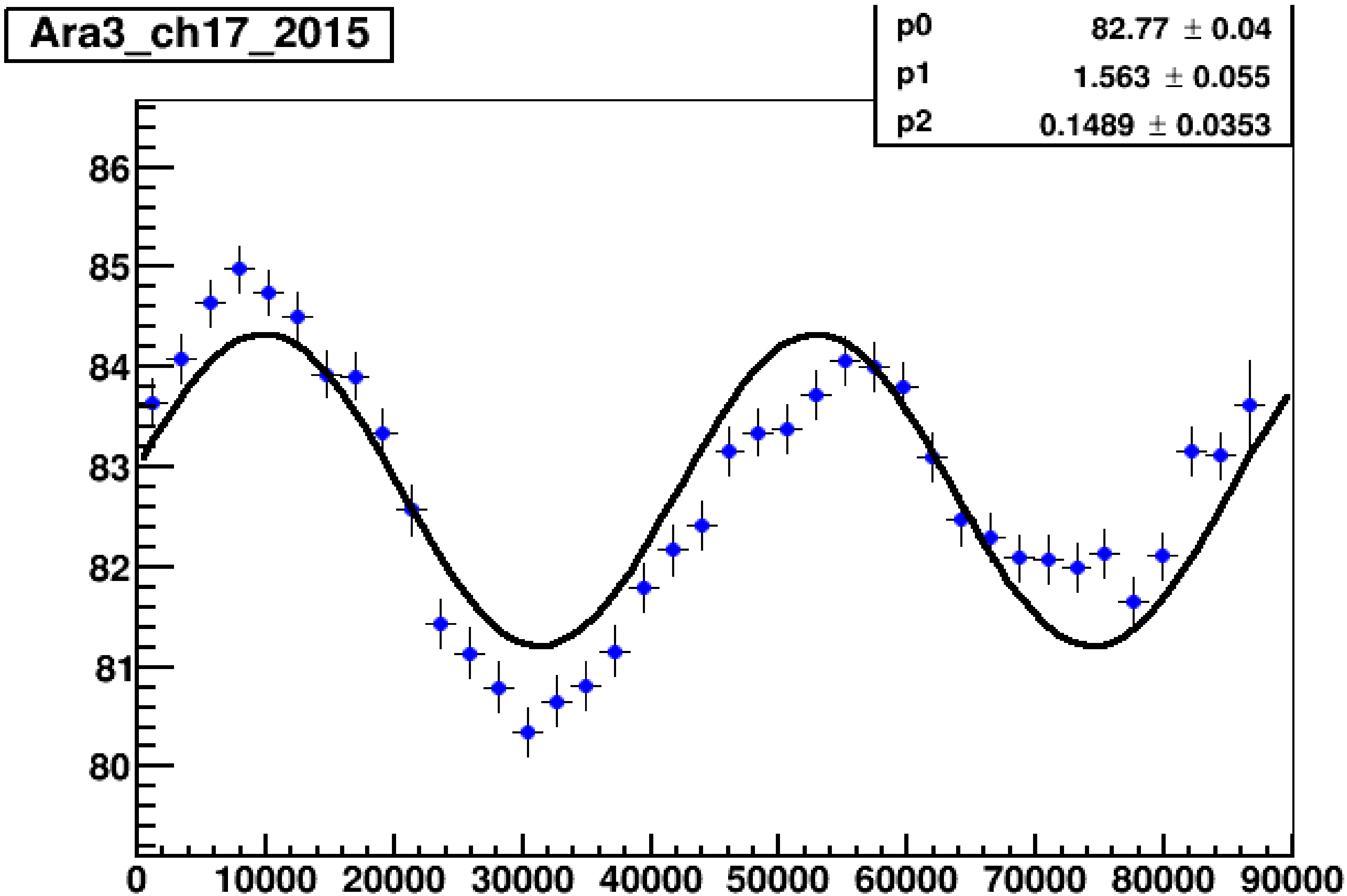


A3/Ch16: 25-100 MHz (top) vs. >200 MHz (bottom)



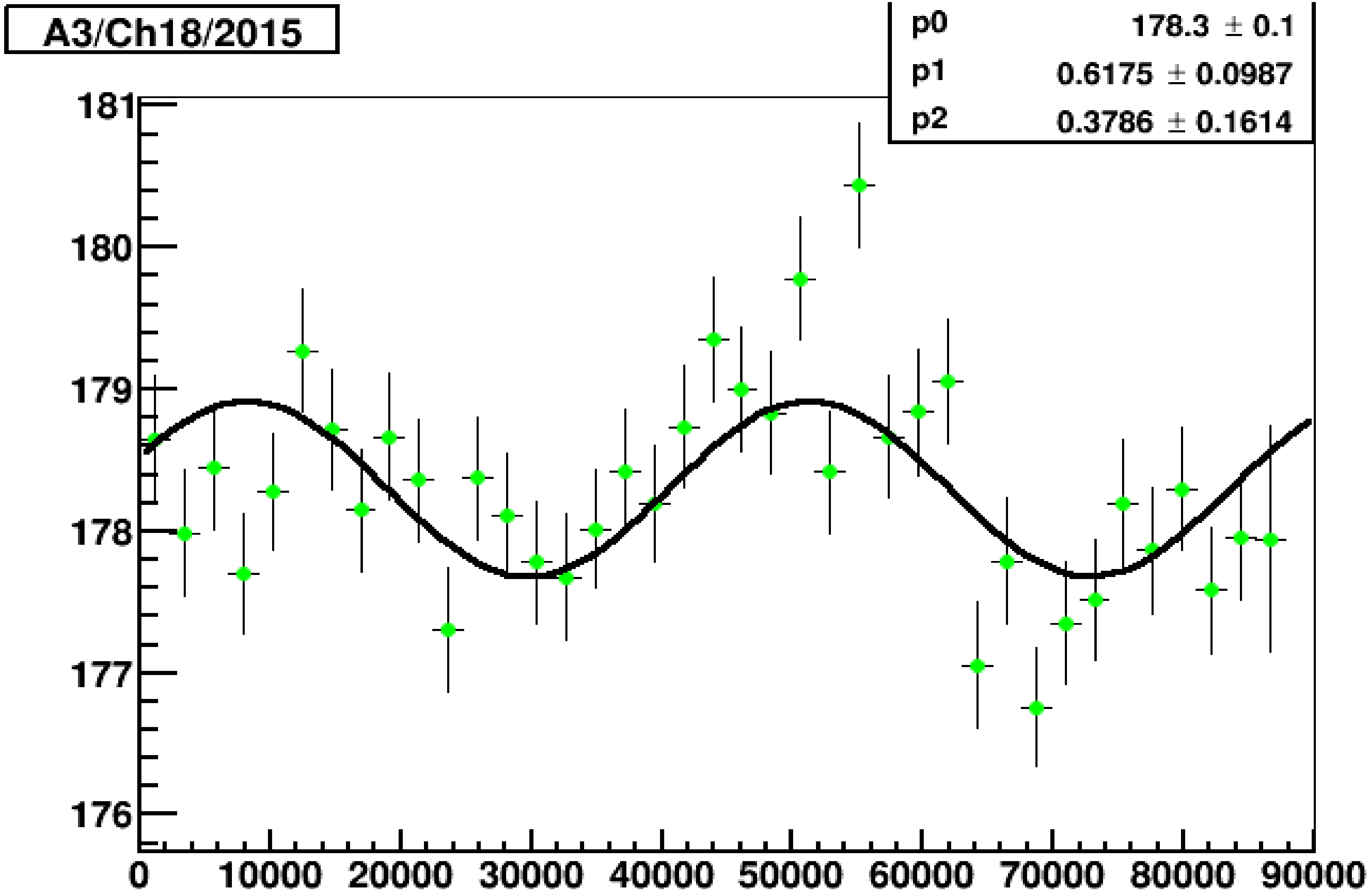


A3/Ch17

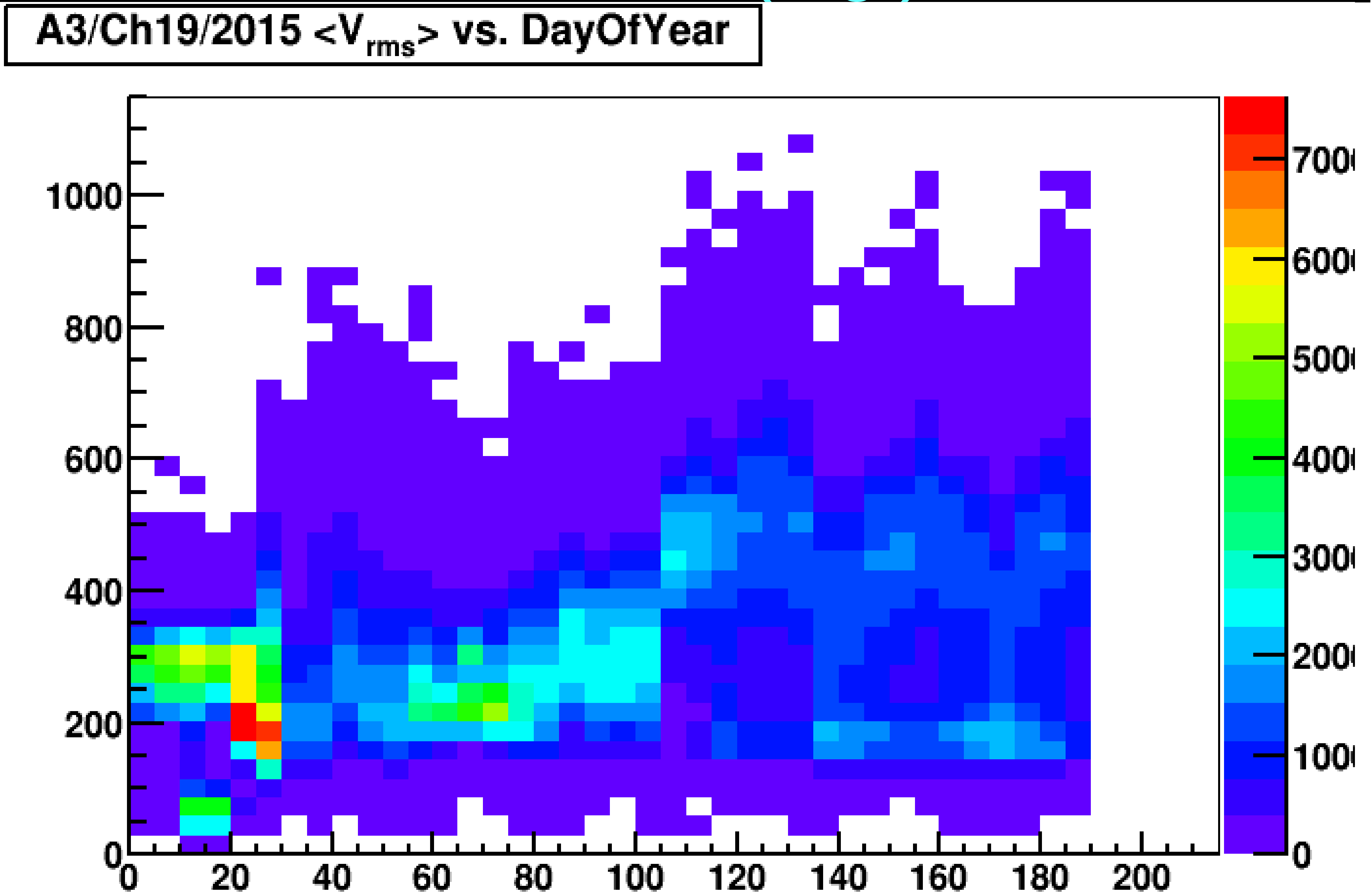


Ara3_ch17_2015
p0 82.77 ± 0.04
p1 1.563 ± 0.055
p2 0.1489 ± 0.0353
86
85
84
83
82
81
80
0
10000
20000
30000
40000
50000
60000
70000
80000
90000

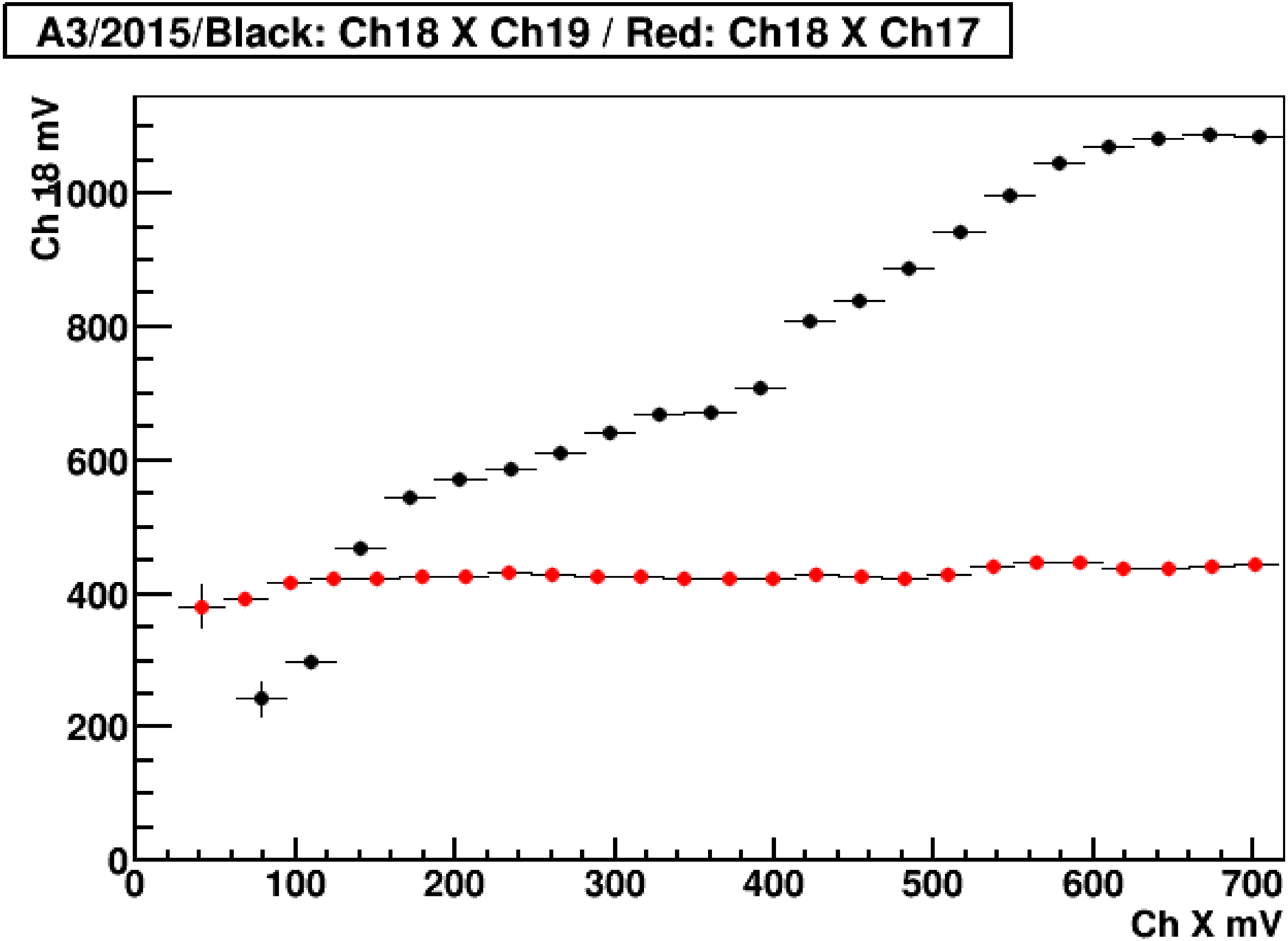
A3/Ch18


A3/Ch18/2015
p0 178.3 ± 0.1
p1 0.6175 ± 0.0987
p2 0.3786 ± 0.1614
181
180
179
178
177
176
0
10000
20000
30000
40000
50000
60000
70000
80000
90000

A3/Ch19 (n.g.)


A3/Ch19/2015 <V_{rms}> vs. DayOfYear
0
200
400
600
800
1000
0
20
40
60
80
100
120
140
160
180
200
0
100
200
300
400
500
600
700

Correlations b/w channels



Action Item #1

- Re-create signal chain and see if we can reproduce anomalously high low-frequency power in the lab
- However, the fact that this seems to show up in A3 BH4 suggests that this is a problem with the DAQ itself or calibration rather than the front-end or receiver electronics.
  - SA3 & SA4 & BH4 all input to the same DDA
  - Probably something that we'd like to figure out before 16-17 deployment, although
    - Understanding this perhaps requires more work than we have person-power
    - Accdg to patrick, we will likely not using the same digitizer for 2016-17, so maybe it doesn't matter for the future, anyway.

What else is needed to have useful surface Rx data?

- Modify read-out firmware to stagger readout of surface antennas by programmable delay (sasha)
  - Was not a big problem for the testbed since delays smaller
- Problem:
  - for veto, want surface trigger with delayed in-ice readout
  - For neutrinos, want in-ice trigger with delayed surface readout
- Near-term test:
  - For cal pulser events, delay surface antenna readout, accumulate enough data to verify that in-ice antennas work and also get an n(z) estimate.
- General solution (with no understanding of the feasibility):
  - *Read-out surface triggers and in-ice triggers independently, track and record GPS time for each.*

If we had someone who could update the firmware, it would also be good to:

- Take noise data at regular intervals (transmitter firmware)
- Modify ICL rooftop pulser so that it fires once every ten minutes, for clock synchronization of all ARA clocks
- (redundantly,) synch all stations to gpsd

What else could we do with big surface antennas? “RADAR shower detection”

- If density (and mobility) of free charges sufficiently high, charges collectively behave as a plasma
  - Threshold density correlates with threshold primary energy initiating a shower
- TARA: Telescope Array Radar
  - Search for in-air radar reflections from 40 kW, 54.1 MHz Tx in conjunction with Telescope Array
    - In this case, free charge due to ionization
    - $\rho > \rho_c$ at r<1 cm from shower core => radar xsect σ_{radar} ~ 200 cm^2
  - No signals found...
    - Either free-charge being `attached' to $O_2$ and/or $N_2$, or reflective response of plasma `damped' through collisions with air molecules
- What about in-media (Kael, Thomas, Krijn)

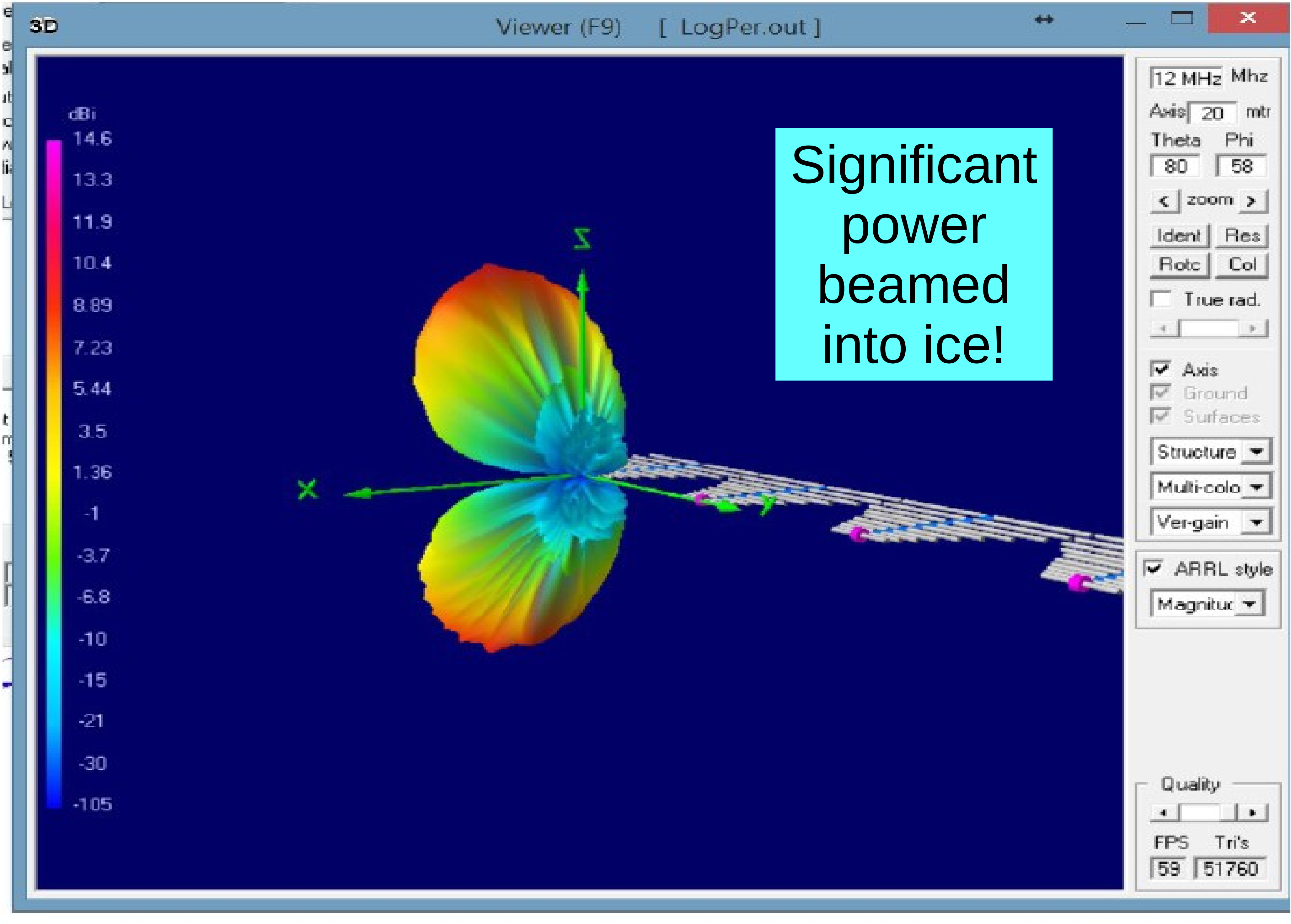
In-ice detection

- Look for reflections from:
  - In-ice showers
  - Muon bundles
  - CR cores impacting surface
    - Accompanied by strong TR
- But we need a strong transmitter at tens of MHz frequency...

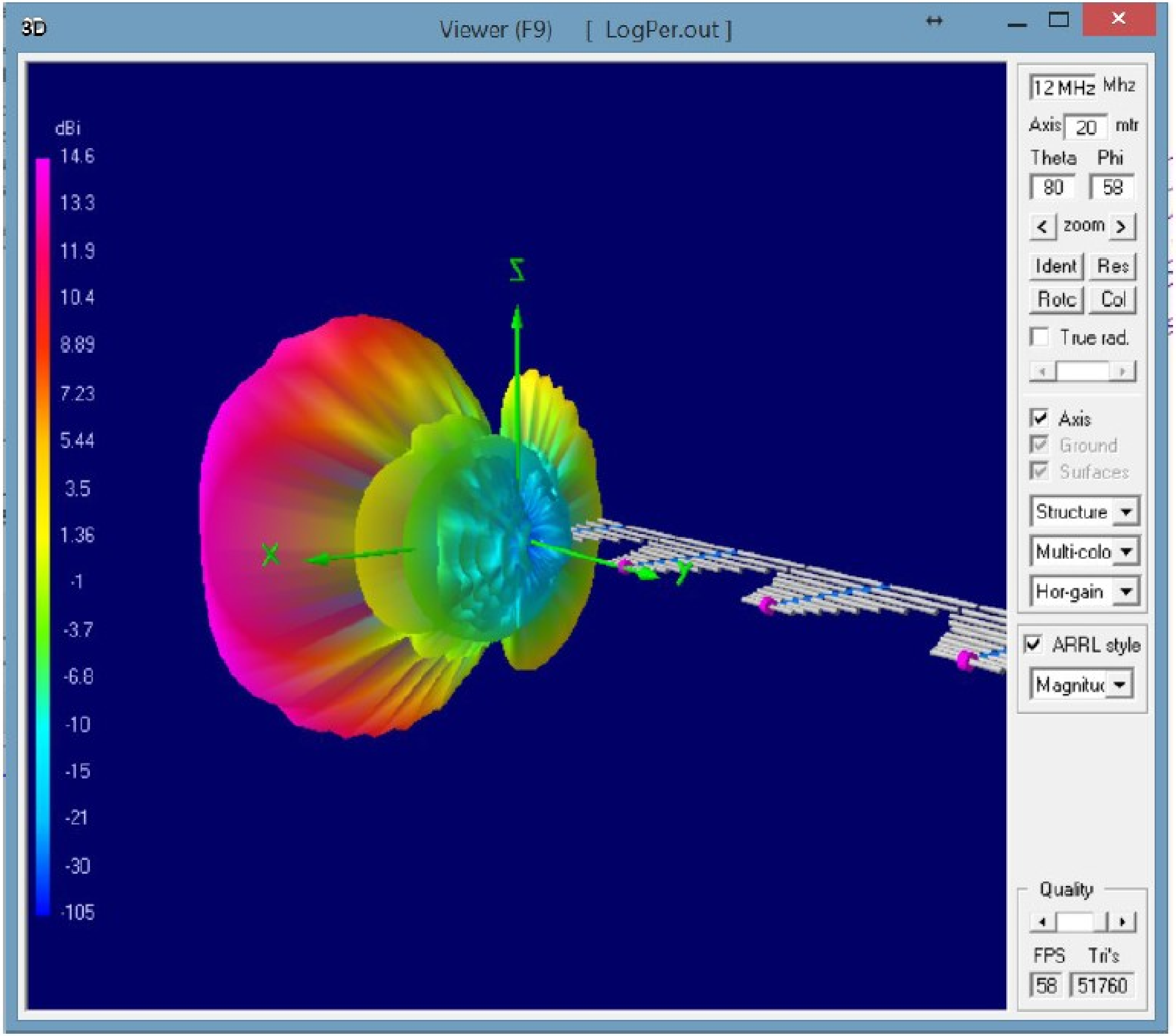
Super DARN

- 10 MHz signal; 10 kW
  - But only 4% duty cycle
    - Limited by their ability to pull heat out of the system

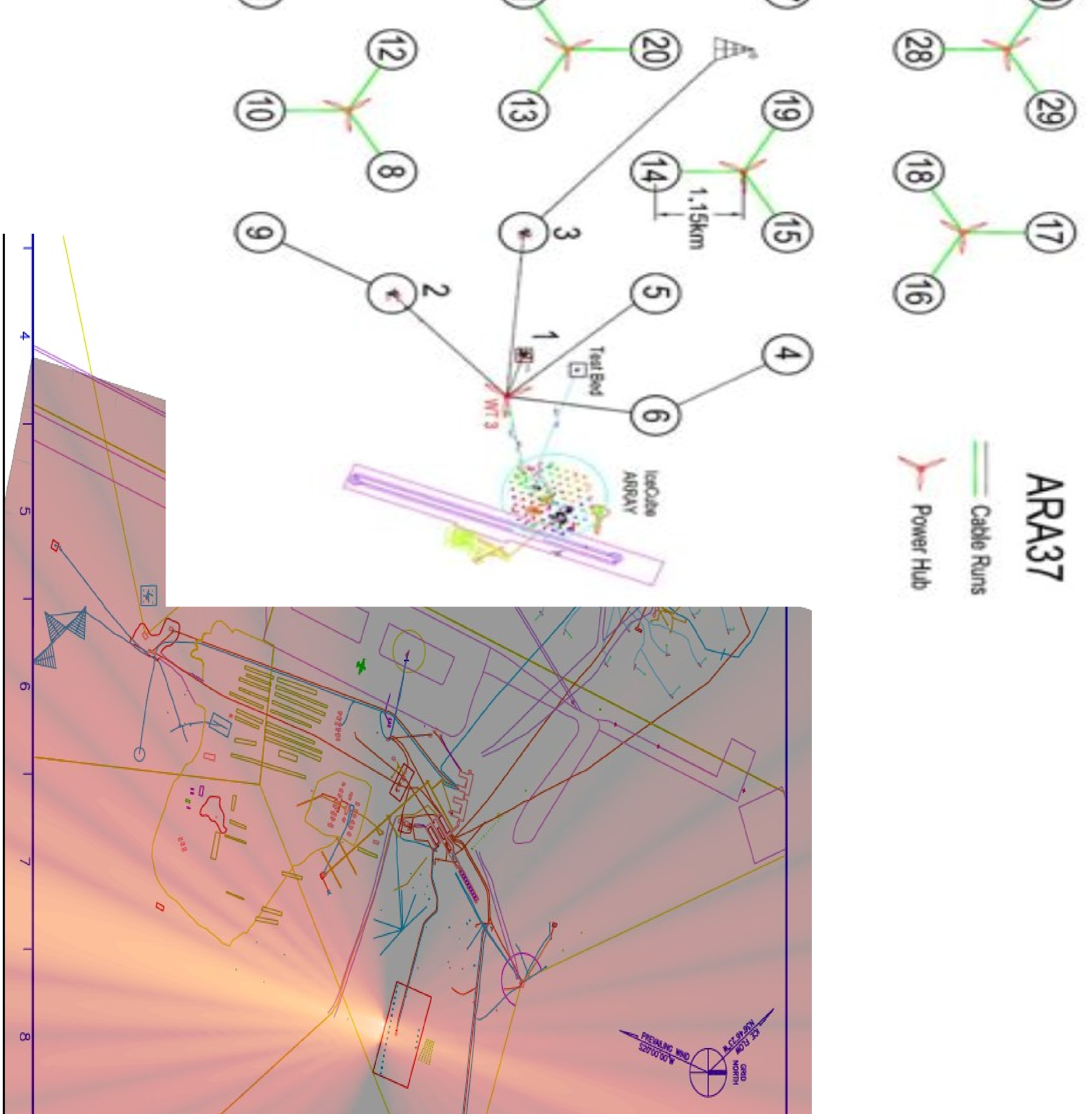
Vpol


3D
Viewer (F9) [LogPer.out]
dBi
14.6
13.3
11.9
10.4
8.89
7.23
5.44
3.5
1.36
-1
-3.7
-6.8
-10
-15
-21
-30
-105
Z
X
Y
Significant power beamed into ice!
12 MHz Mhz
Axis 20 mtr
Theta Phi
80 58
zoom
Ident Res
Rotc Col
True rad.
Axis
Ground
Surfaces
Structure
Multi-colo
Ver-gain
ARRL style
Magnituc
Quality
FPS Tri's
59 51760

Hpol

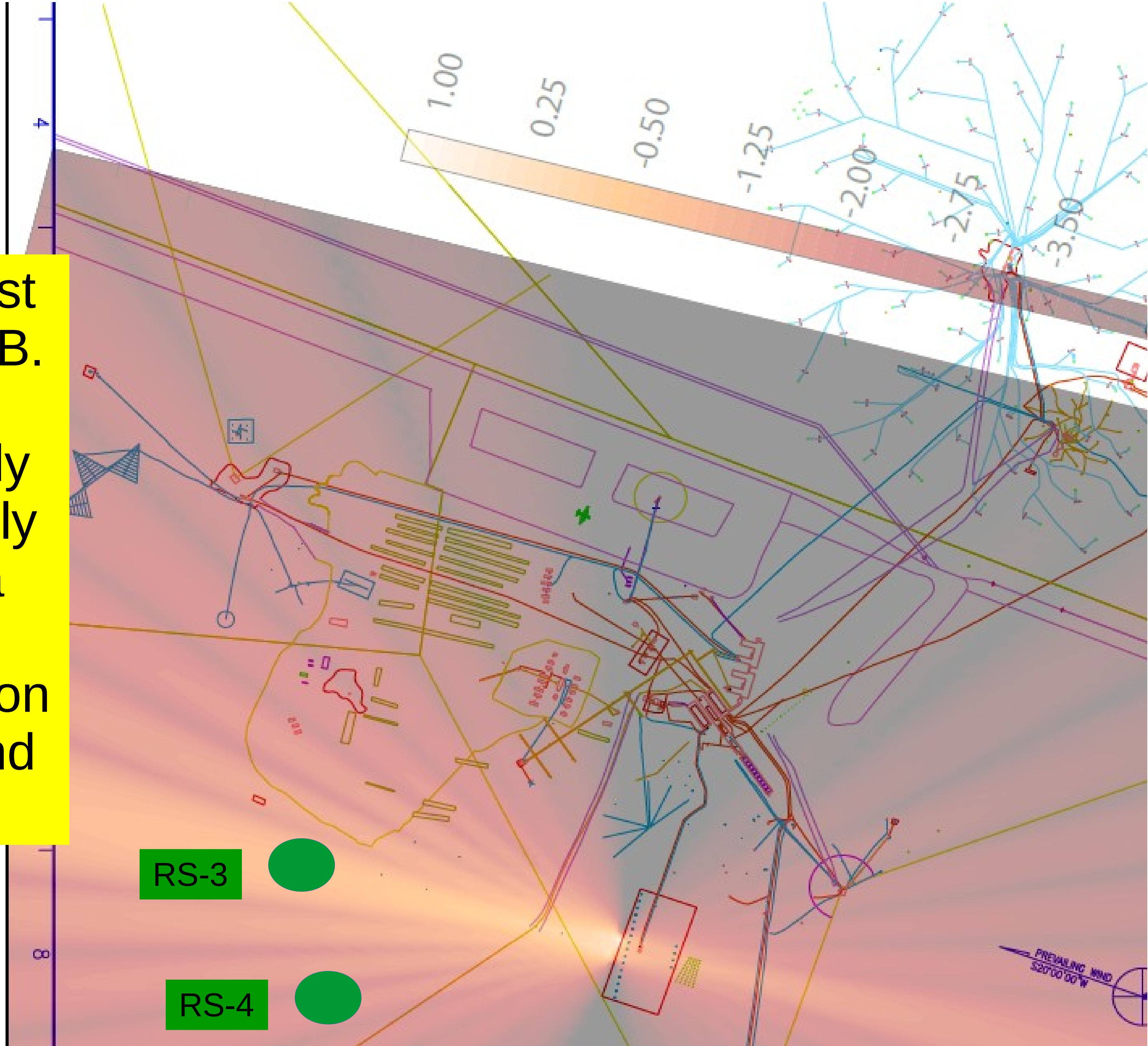


Significant power beamed into ice!



ARA purposely in null of SuperDARN beam

Proposed test locations (N.B. This would occur entirely independently of ARA, via separate communication with Jean and Vladimir)



What we would like to do in 2016-17

1. Take dedicated full-station data w/ surface Rx trigger.

2. Experiment with surface antenna $\delta\tau$ staggering wrt in-ice triggers to optimize use as veto w/ SN firmware.

    1. Tune on CP, ICL pulser and deep pulsers

3. Understand why there is so much low-frequency power in the surface antennas (& A3 BH4)