

suggestions for pmt system for LARFCS

We have 3 PMTs that are TPB coated. They are 2 inch with bases already soldered on the pins.

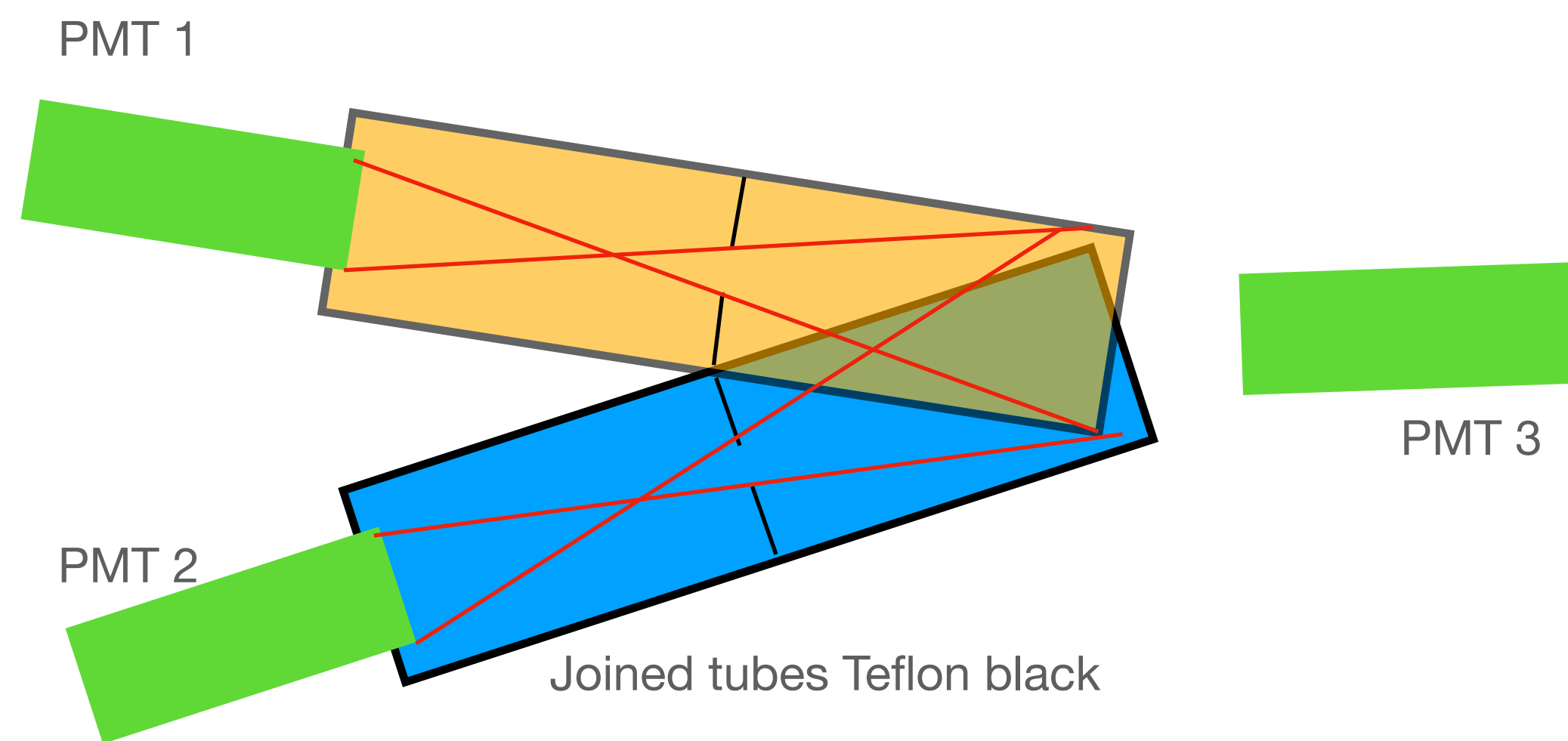
Goals

Need to define some goals (previous slides are attached)

- The LAr scintillation pulse is known to have two components: 6 ns and 1.5 micro-seconds.
- However, in measurements with liquid scintillation and PMTs, the fits require an intermediate component of 200-300 ns for a proper fit.
- The intermediate component is inconsistent from various measurements. It could be due to differences in cable lengths and mismatching of impedances.
- ***Our goal is to obtain a clean measurement of the two scintillation components with clear indication of any dispersion from cables and electronics.***

Some requirements

- Measurement of a light pulse should be unbiased from trigger. Trigger should be external.
- Measurement of light pulse should be some a well defined geometrical size/region of LAr
- Measurement should not be contaminated by reflections, and light from TPB of other tubes, etc.
- PMT should get the light from a reasonably collimated beam in a well defined region.



The volume is about 100 ml.

This has a rate of ~ 0.1 Hz of Argon 39.

But we do not know the radioactivity rate, it will be interesting to measure this.

PMT 3 is for trigger and it is outside the tubes. It should be at a different elevation.

The angle between PMT1 and PMT2 needs to be arranged to minimize light cross talk, but define the fiducial volume precisely.

The aperture can be narrowed to keep the cross talk and reflections minimum.

A second aperture to define the area on the PMT should be considered.

Cosmic Trigger can be made between PMT1 and PMT 3, and the data from PMT 2 analyzed.

We should also take data with trigger between PMT 2 and PMT 3 for confirmation.

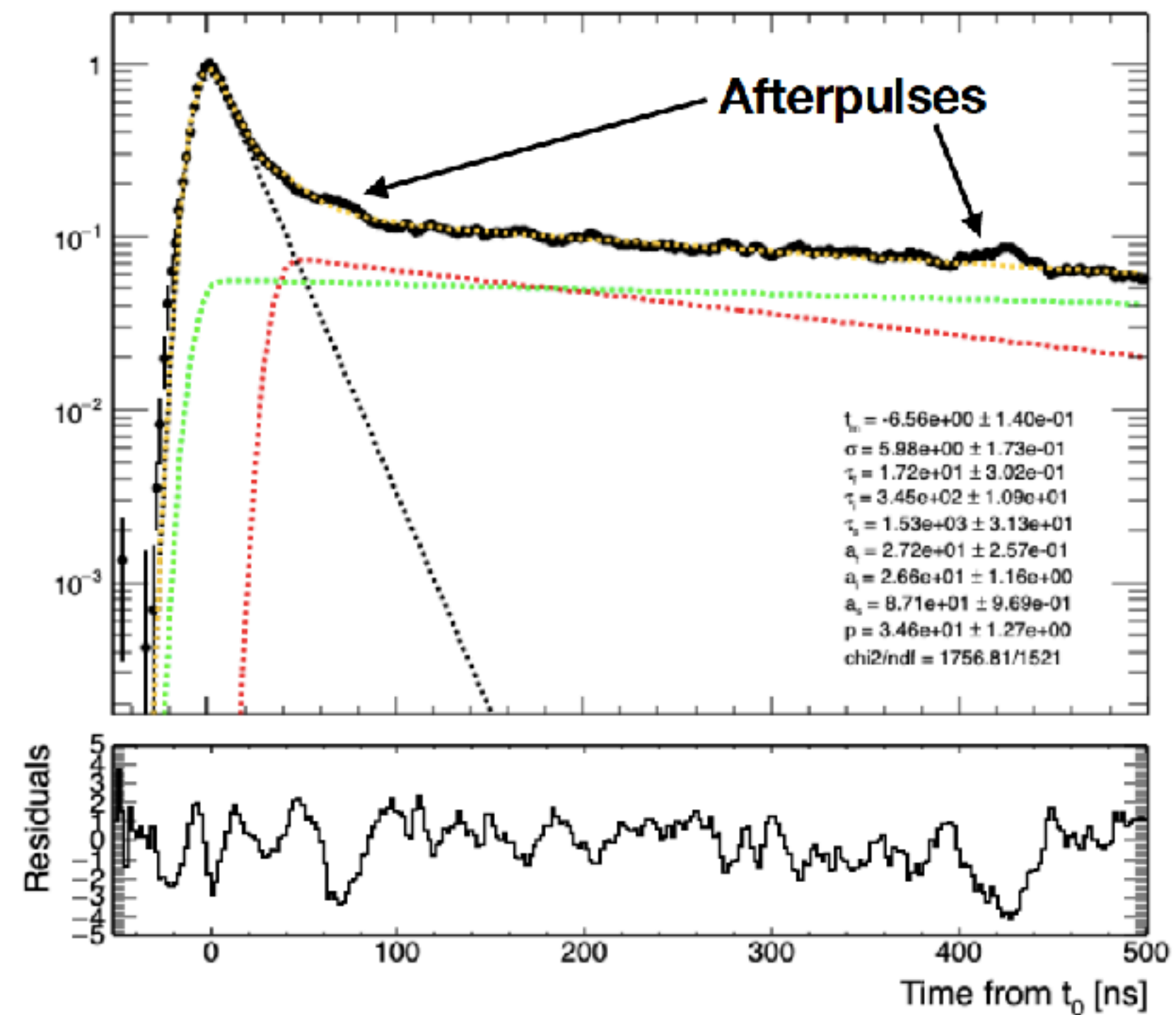
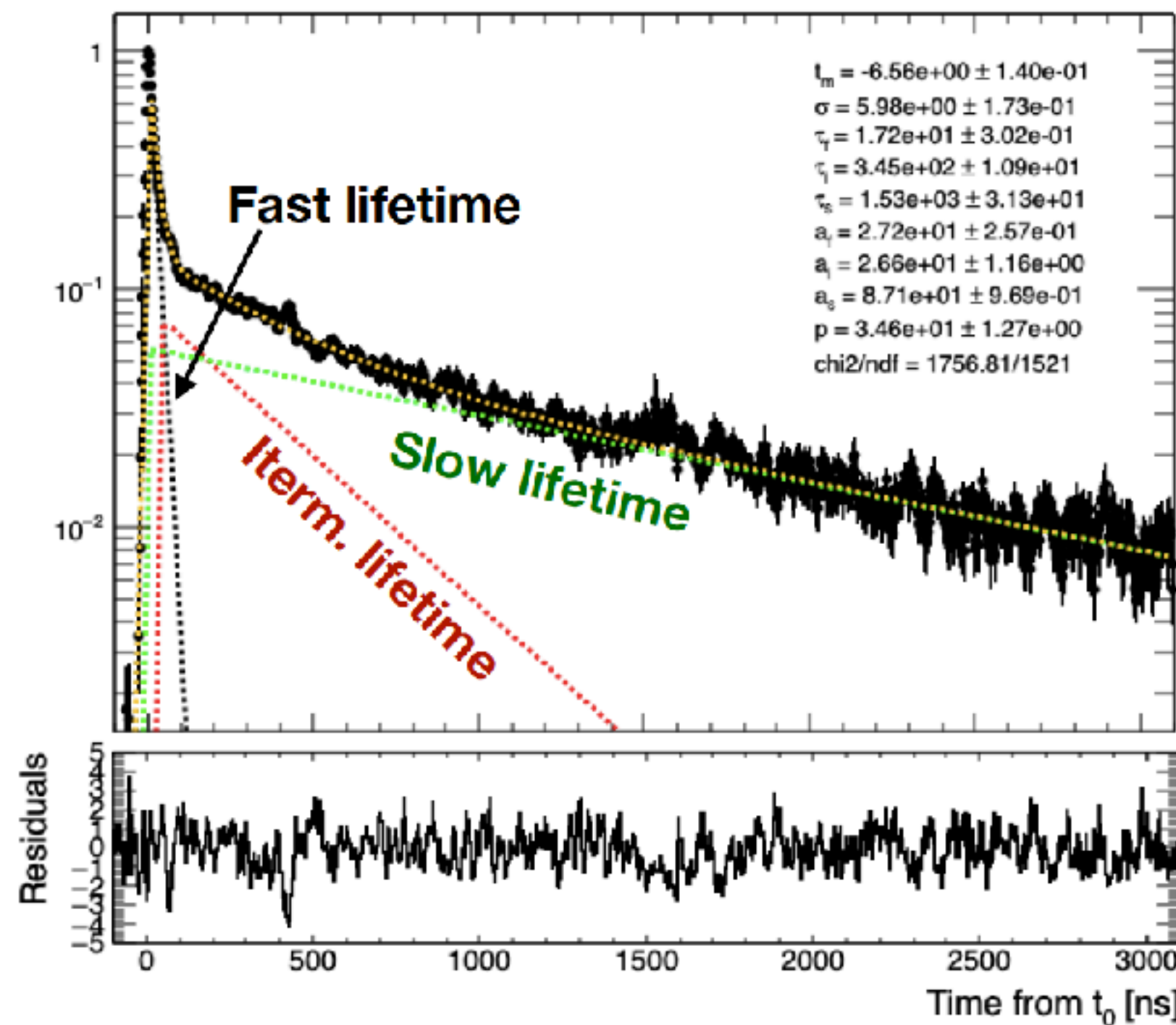
A trigger between PMT 1 and PMT 2 with veto on PMT 3 might be useful to get Argon 39.

Some notes regarding the intermediate lifetime component observed in scintillation pulses

Could it be simply due to the cable dispersion ?

- Fit function: scintillation decay + gaussian (t_m, σ) for detector effects

$$f(t) = \sum_{j=f,i,s} \frac{A_j}{2\tau_j} \exp \left[\frac{1}{2} \left(\frac{\sigma}{\tau_j} \right)^2 - \left(\frac{t - t_m}{\tau_j} \right) \right] \left[1 - \operatorname{erf} \left(\frac{1}{\sqrt{2}} \left(\frac{\sigma}{\tau_j} - \frac{t - t_m}{\sigma} \right) \right) \right].$$



Andrea's fit: the intermediate lifetime appears to be ~ 300 ns. And therefore the power spectrum should have addition around ~ 3 MHz. Was the t_0 made different for each component in the fit? Seems odd?

	0kV (before 13/08)	40 kV	75 kV	0kV (after 13/08)
# PMTs	150/153	153/154	153/153	152/154
t_0 [ns]	-7.6 ± 0.5	-6.8 ± 0.4	-6.5 ± 0.6	-7.5 ± 0.4
σ [ns]	6.3 ± 0.5	5.5 ± 0.5	5.8 ± 0.5	6.1 ± 0.5
τ_{fast} [ns]	21 ± 2	19 ± 2	18 ± 3	21 ± 2
τ_{int} [ns]	323 ± 41	323 ± 17	313 ± 67	319 ± 48
τ_{slow} [ns]	1604 ± 101	1451 ± 90	1394 ± 179	1572 ± 98
A_{fast}	0.15 ± 0.01	0.19 ± 0.02	0.18 ± 0.02	0.15 ± 0.01
A_{int}	0.12 ± 0.02	0.15 ± 0.02	0.17 ± 0.03	0.12 ± 2
A_{slow}	0.72 ± 0.02	0.65 ± 0.01	0.64 ± 0.04	0.72 ± 0.02
f_{90}	$0.23 \pm 3\%$	$0.28 \pm 3\%$	$0.28 \pm 3\%$	$0.23 \pm 3\%$

WEST cryostat

RG316/U Cable data from the specifications.

<i>Electrical parameters</i>			
<i>Impedance</i>	<i>50</i>	<i>Ohm</i>	
<i>Capacitance</i>	<i>96.46</i>	<i>pF/m</i>	
<i>Velocity</i>	<i>0.69</i>	<i>c</i>	
<i>inner conductor diameter</i>	<i>0.51</i>	<i>mm</i>	
<i>dielectric diameter</i>	<i>1.52</i>	<i>mm</i>	
<i>conductor resistivity</i>	<i>3.00E-08</i>	<i>Ohm-m</i>	<i>Copper is 1.68E-8. This fits data better</i>
<i>mu-r</i>	<i>1.00</i>		<i>relative permeability of conductor</i>
<i>mu0</i>	<i>4*Pi*10^-7</i>	<i>Henry/m</i>	<i>permeability</i>
<i>attenuation const.</i>	<i>1.1447E-06</i>	<i>1/(Sqrt(Hz)*m)</i>	<i>attenuation constant</i>

We will use the attenuation constant to model the cable by using $\text{Exp}[-\text{Sqrt}(\omega)*\text{Length}*\text{const}]$

Cable data technical parameters

<i>Technical parameter</i>		
<i>Total diameter with jacket</i>	<i>2.59</i>	<i>mm</i>
<i>weight</i>	<i>0.01</i>	<i>kg/m</i>
<i>Inner conductor strands</i>	<i>7</i>	<i>strands</i>
<i>Inner conductor material</i>	<i>copper clad steel with silver plating</i>	<i>Don't know the thickness of cladding or plating</i>
<i>Outer conductor</i>	<i>Silver plated copper braid</i>	
<i>Shield outer diameter</i>	<i>2.06</i>	<i>mm</i>
<i>Jacket color/material</i>	<i>Tan FEP</i>	
<i>dielectric</i>	<i>PTFE</i>	
<i>dielectric const</i>	<i>2.02</i>	
<i>loss tangent</i>	<i>0.00022</i>	
<i>operating voltage</i>	<i>900</i>	<i>volts</i>
<i>dielectric max voltage</i>	<i>2000</i>	<i>volts</i>
<i>outer jacket max</i>	<i>2000</i>	<i>volts</i>
<i>temp range</i>	<i>-55 to 200</i>	<i>celsius</i>

Cable data for 37 meter length of cable with BNC and MCX connectors.

<i>frequency</i>	<i>measured ratio attenuation</i>	<i>-20Log10(att) dB</i>	<i>dB Cable spec 37 m</i>	<i>dB Calculation from model</i>
<i>1</i>	<i>0.959</i>	<i>0.364</i>		<i>9E-04</i>
<i>1000</i>	<i>0.949</i>	<i>0.446</i>		<i>0.029</i>
<i>10000</i>	<i>0.949</i>	<i>0.451</i>		<i>0.092</i>
<i>100k</i>	<i>0.933</i>	<i>0.598</i>		<i>0.292</i>
<i>500k</i>	<i>0.876</i>	<i>1.154</i>		<i>0.652</i>
<i>1Mhz</i>	<i>0.847</i>	<i>1.445</i>		<i>0.922</i>
<i>5 Mhz</i>	<i>0.743</i>	<i>2.581</i>		<i>2.061</i>
<i>10 Mhz</i>	<i>0.697</i>	<i>3.133</i>		<i>2.915</i>
<i>30 Mhz</i>	<i>0.575</i>	<i>4.800</i>		<i>5.049</i>
<i>40 Mhz</i>	<i>0.509</i>	<i>5.858</i>		<i>5.830</i>
<i>50 Mhz</i>	<i>0.470</i>	<i>6.562</i>	<i>9.106</i>	<i>6.519</i>
<i>100Mhz</i>			<i>13.35</i>	<i>9.219</i>
<i>400Mhz</i>			<i>25.49</i>	<i>18.40</i>
<i>1 Ghz</i>			<i>46.13</i>	<i>29.20</i>
<i>3 Ghz</i>			<i>70.70</i>	<i>50.50</i>

- *Measured up to 50 Mhz*
- *The specs from Pasternak are >50 Mhz*
- *The measurements appear better than the specs.*
- *We are most interested in the 10-250 Mhz region.*
- *In the interesting region, the model appears to be an o.k. fit.*

My model is probably not very good since the cable must have coated strands. But it will illustrate the point.

Perform simulation

Totalpe = 1000

T_short = 6 ns

T_long = 1500 ns

early/late = 0.3/0.7

For the single pe pulse,

t1 = 1.5 ns

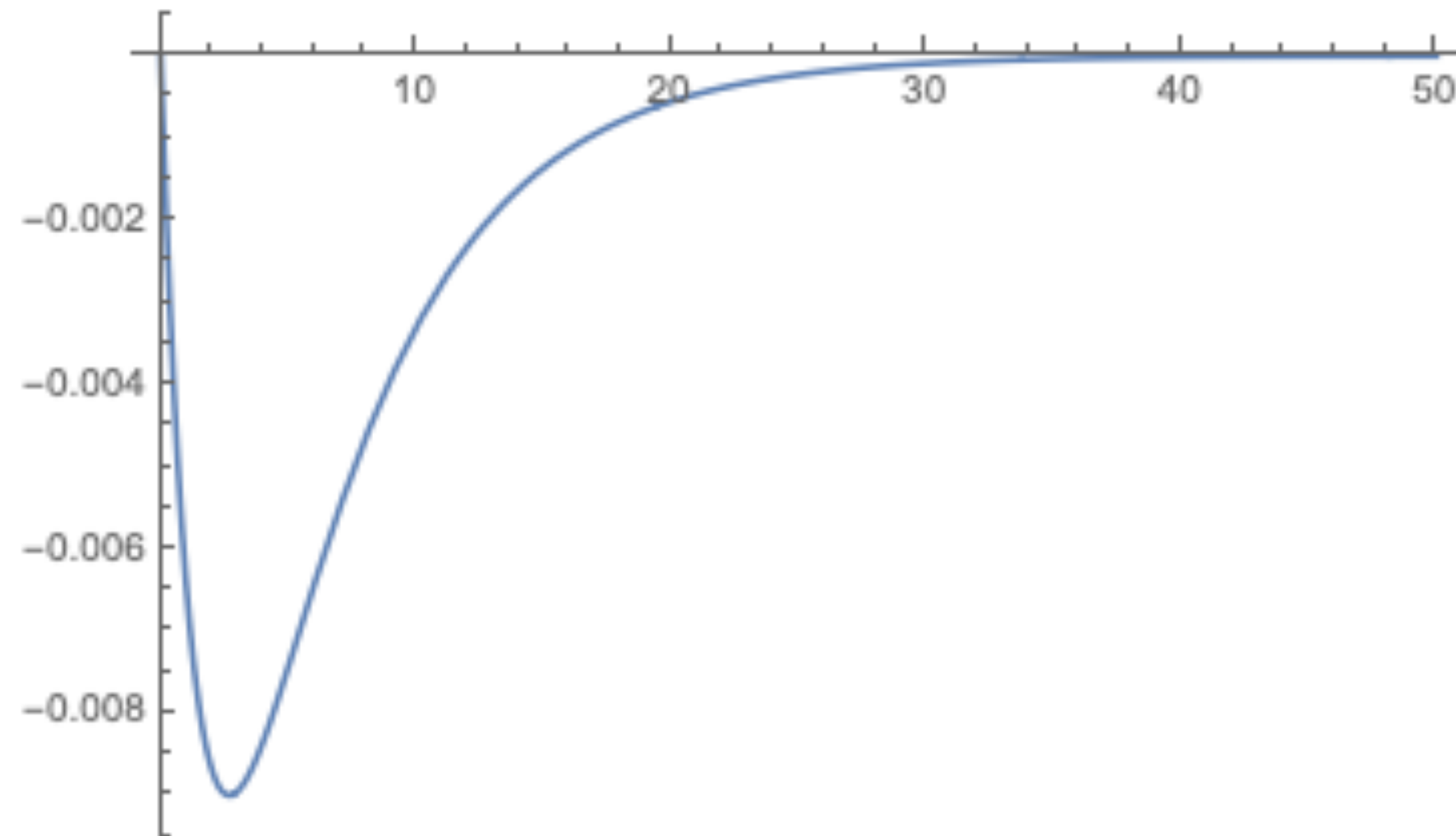
t2 = 5.6 ns

gain = 10^7

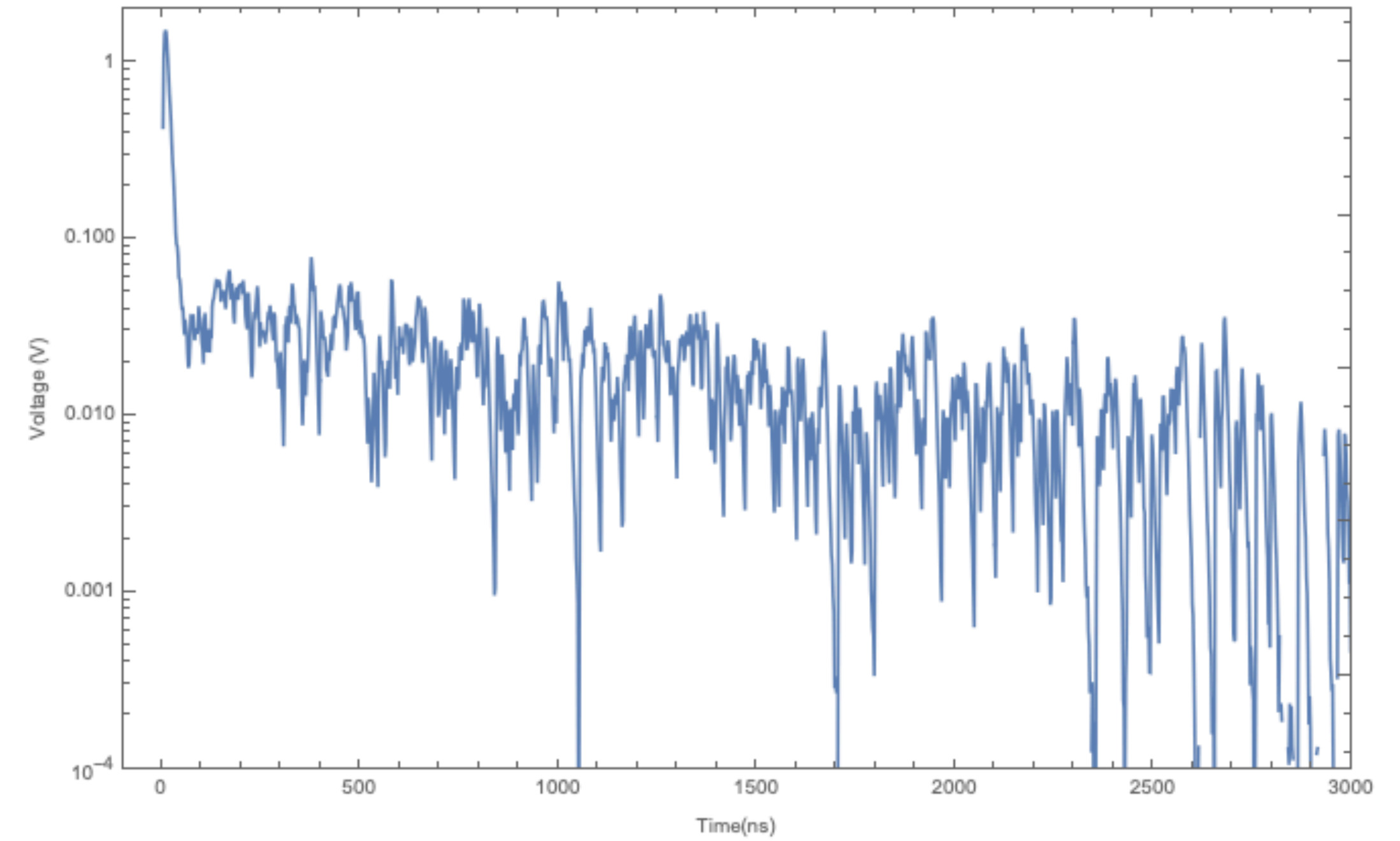
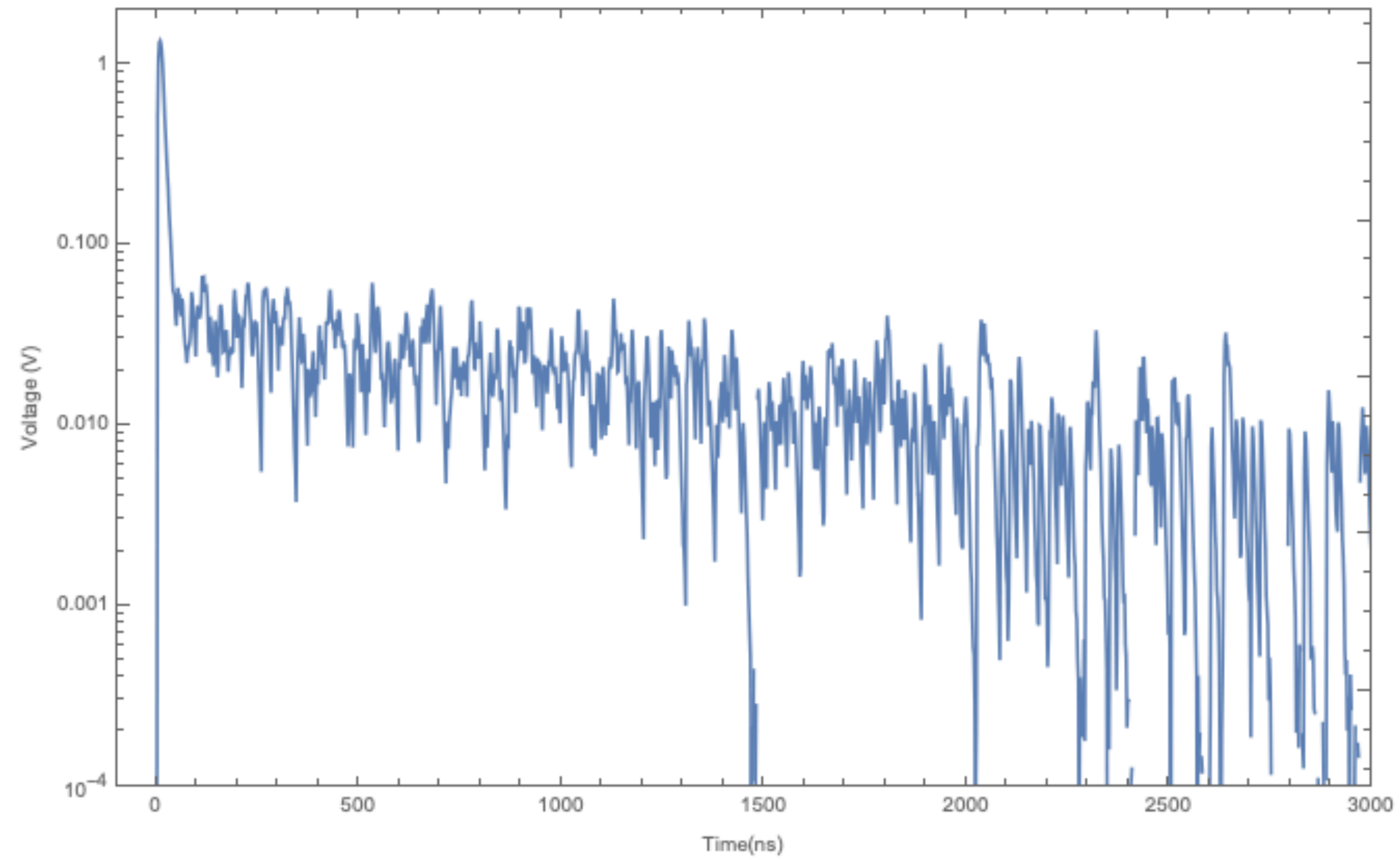
gain fluctuation = 0.4

noise = 0.2 mV (RMS)

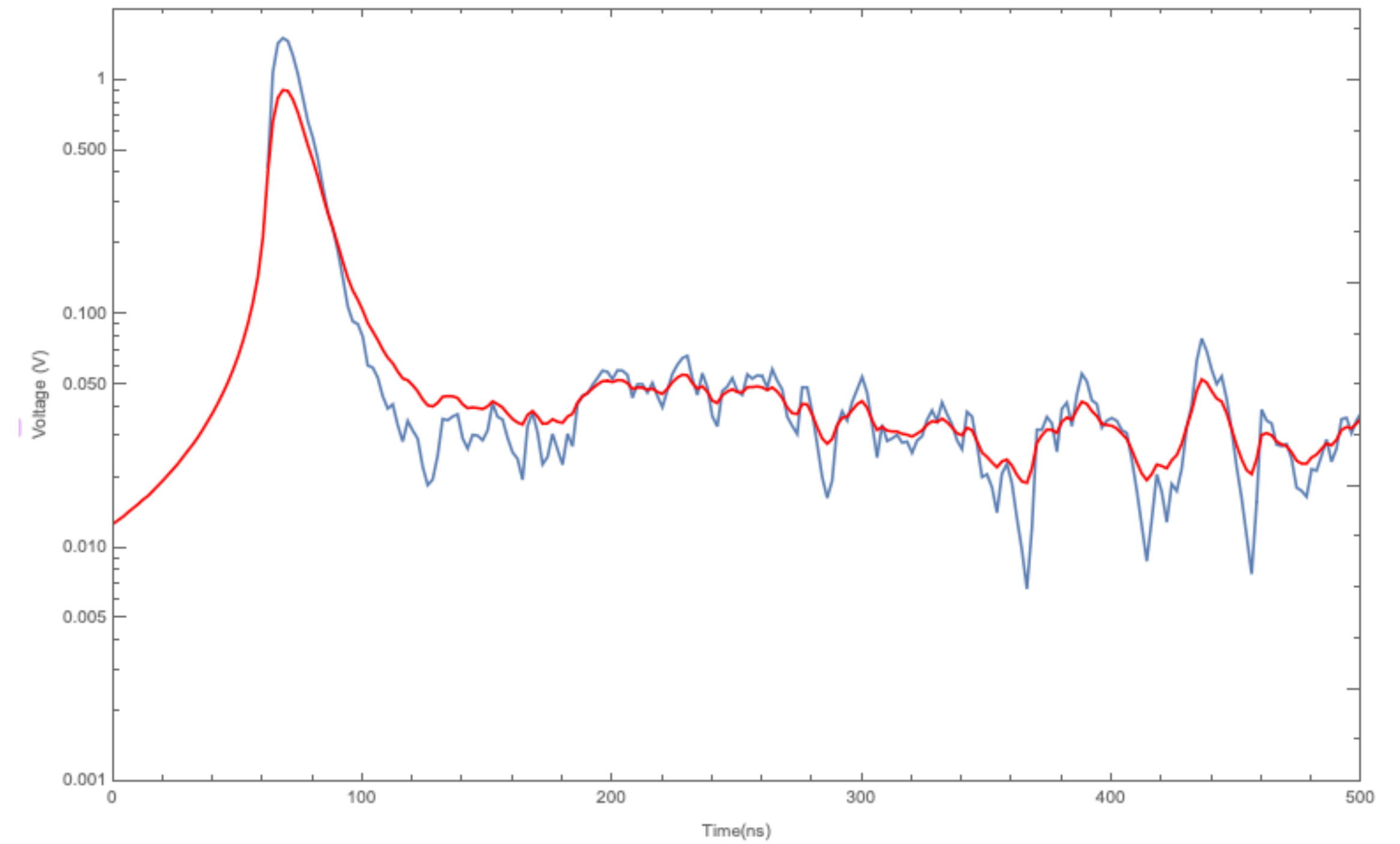
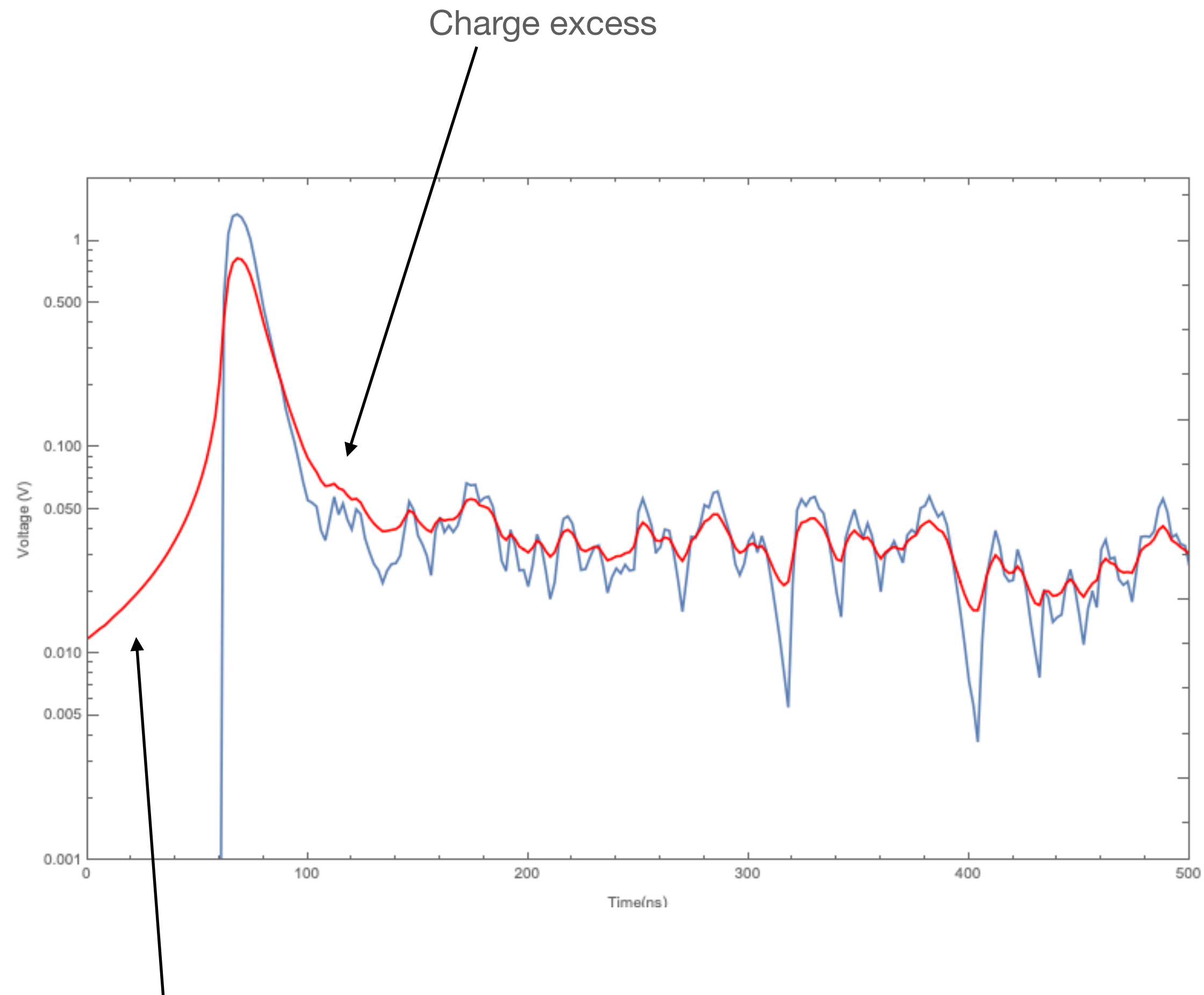
for 2 ns sampling.



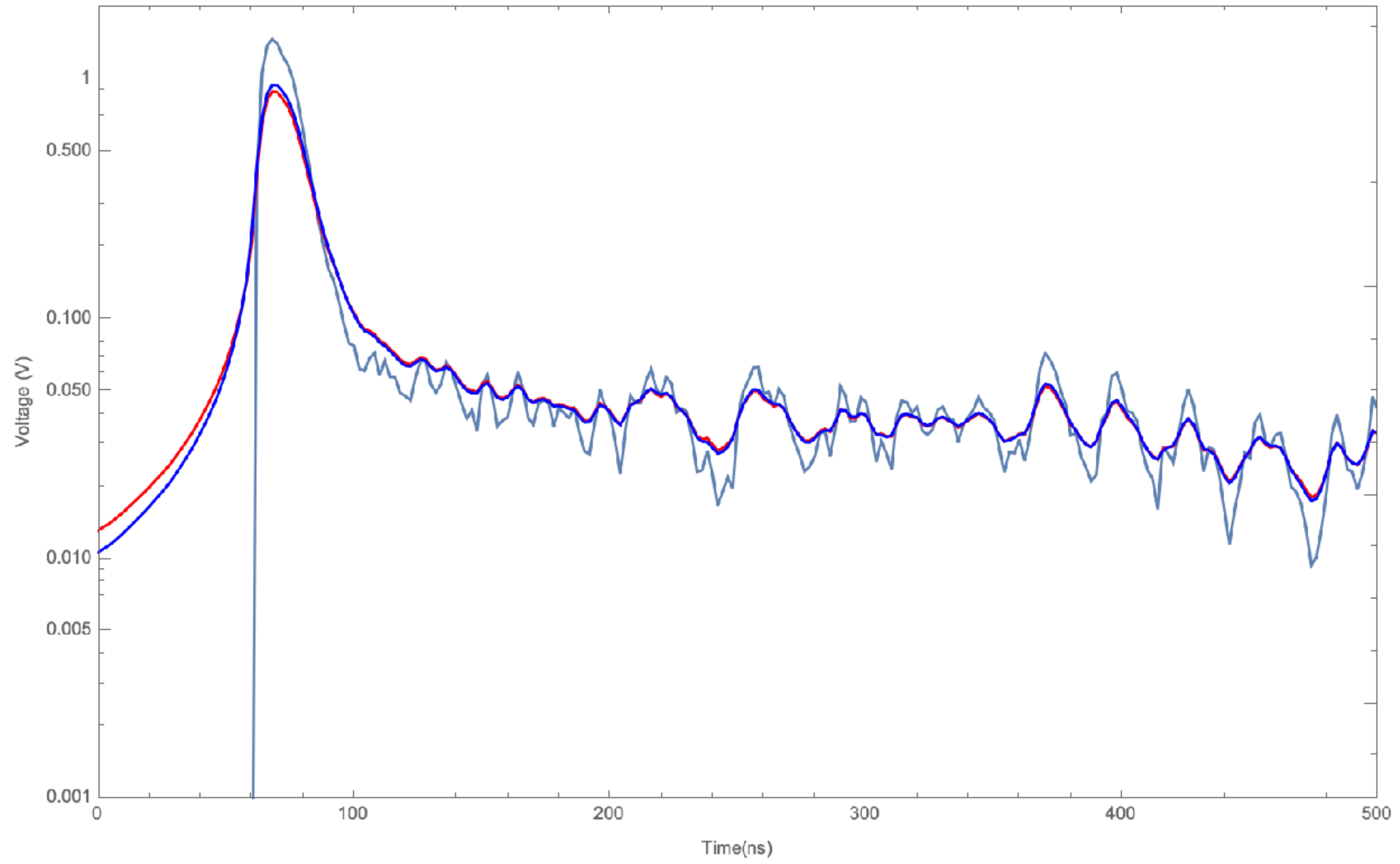
1000 pe raw pulse before cable. Two examples



After 44 meter of RG316 with my model.



Probably too much here due
poor model at low frequencies. Also phase
shift is not included in this model.



Blue is with a phase shift.

conclusion

- The excess charge in “intermediate lifetime “ state could be simply because of dispersion in the cable.
- This makes sense since different experiments appear to have a different result.
- to make the fit properly we have to utilize an accurate cable model.