Dark Current Measurements at XBox2

1 September 2017

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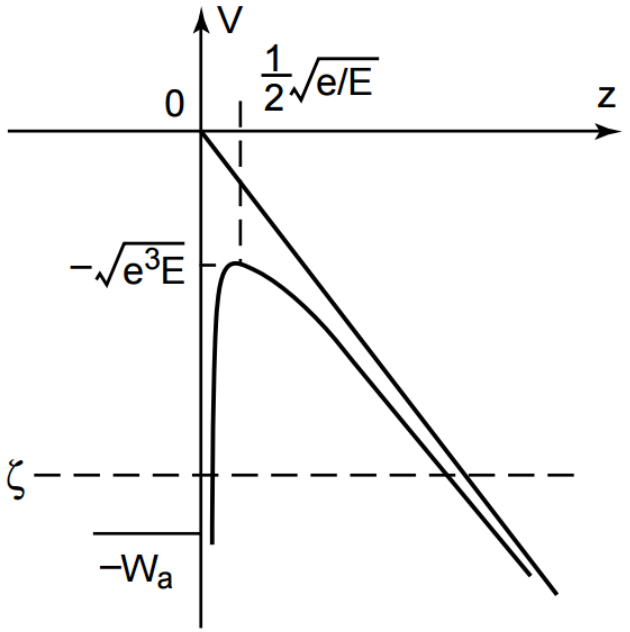
Dark Current

- Electrons emitted from the Cu surface at high fields.
- Captured by Faraday cups at each end of structure.
- Exponential field dependence.
- $\beta = E_{actual}/E_{simulated}$

Field-emitted current for RF field:

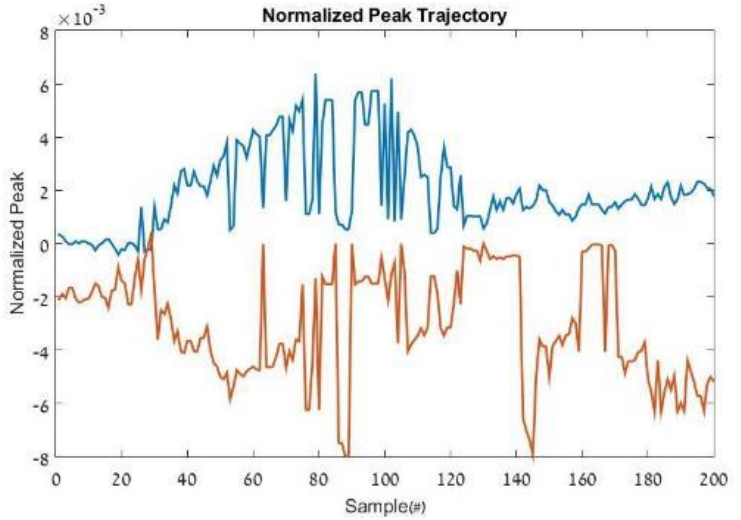
$$I_F \propto \frac{A_e(\beta E_0)^{2.5}}{\phi^{1.75}} exp\left(-\frac{6.53\times10^9\times\phi^{1.5}}{\beta E_0}\right) \text{A}$$

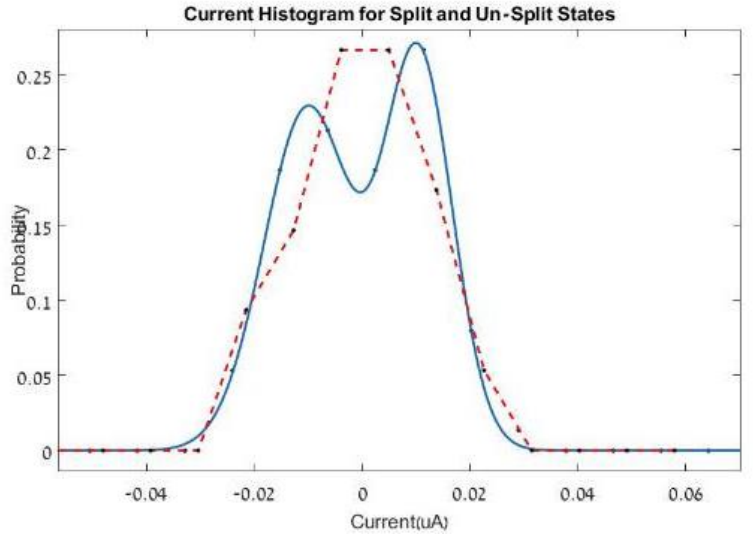
Potential energy diagram at the surface of a conductor:



Fluctuations Observed in DC System

- DC system: two electrodes at high E fields – no RF phenomena.
- Bimodal distribution of currents observed – more prominent when close to breakdown.
- ≤ 1ns timescales
- Data taken with tip-plate geometry, most likely single emitter site.

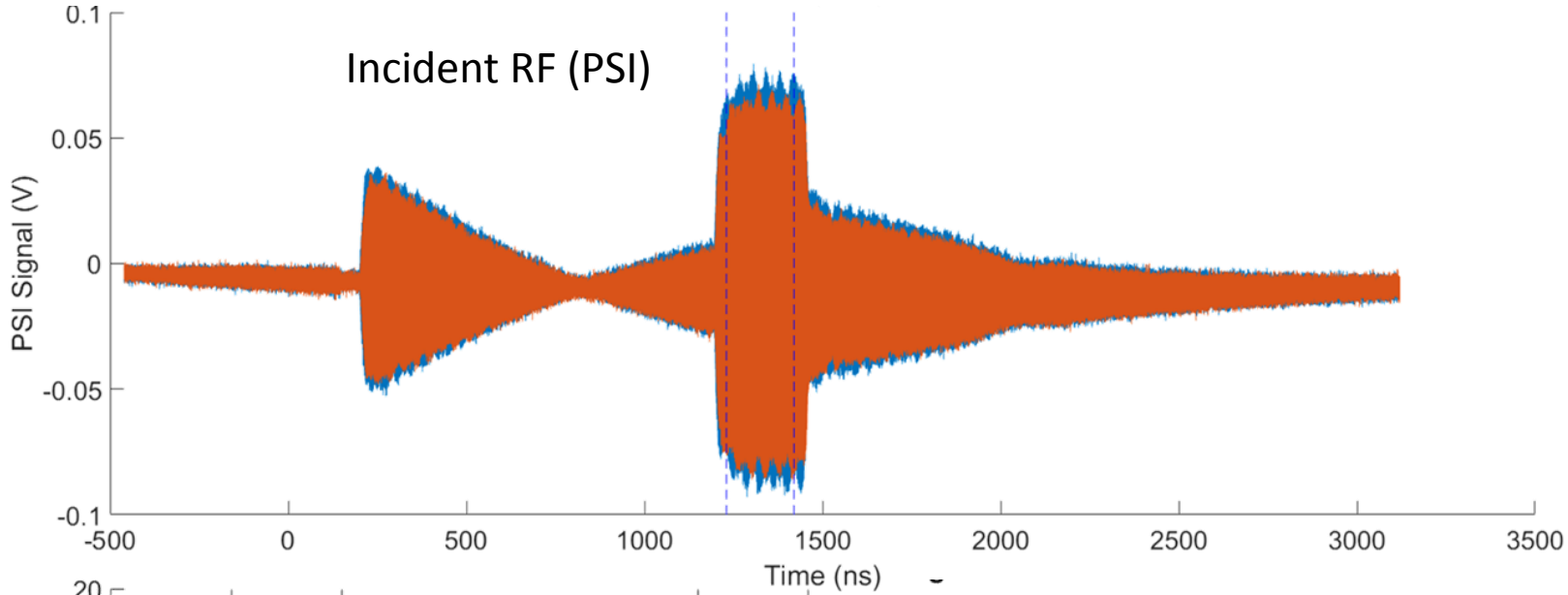


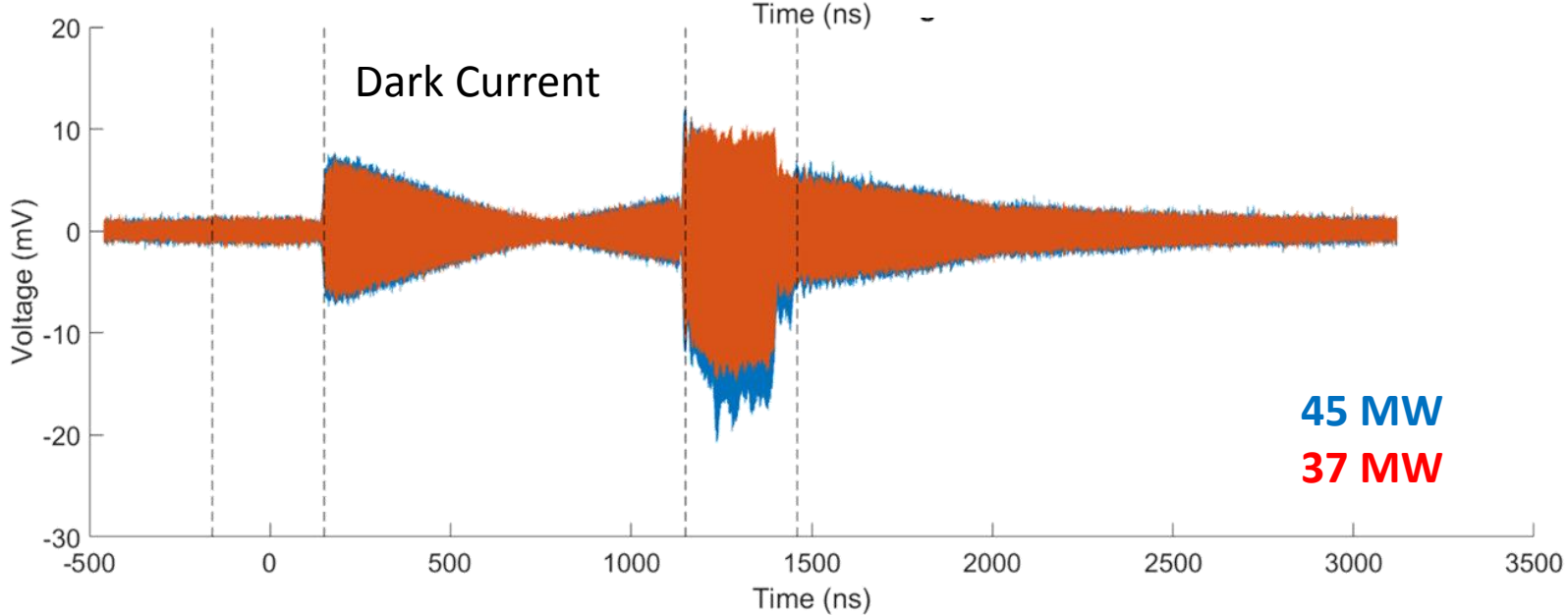


Plots courtesy of Sagy Lachmann

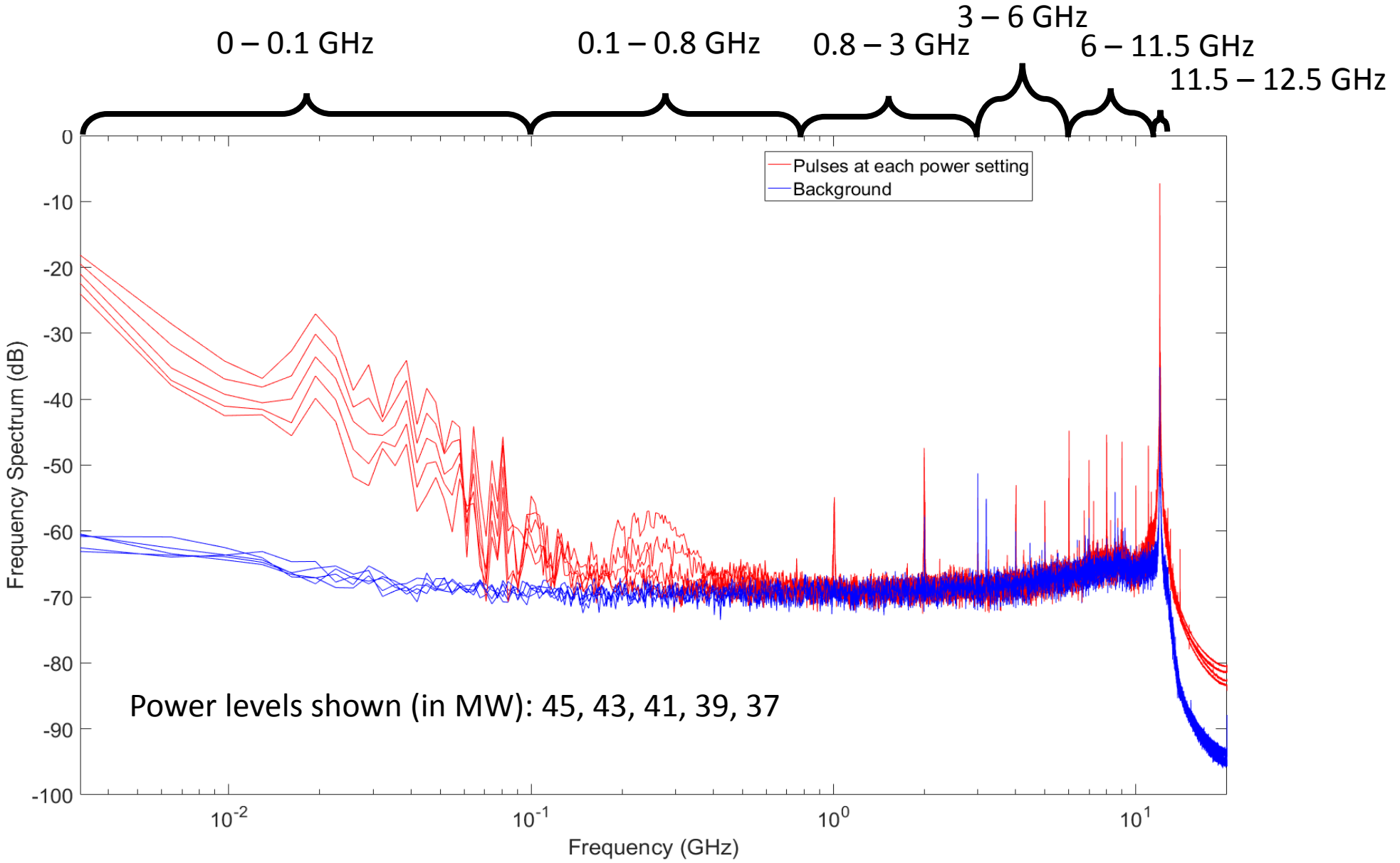
Raw Signals at XBox 2

- Measurement taken at XBox 2: TD26CC_R05 structure, same as XBox 1. Currently running flat at 51 MW.
- DSA91204 scope (40 GS/s 12 GHz)
- Both incident RF and dark current measured directly by scope.
- Significant crosstalk from PSI signal



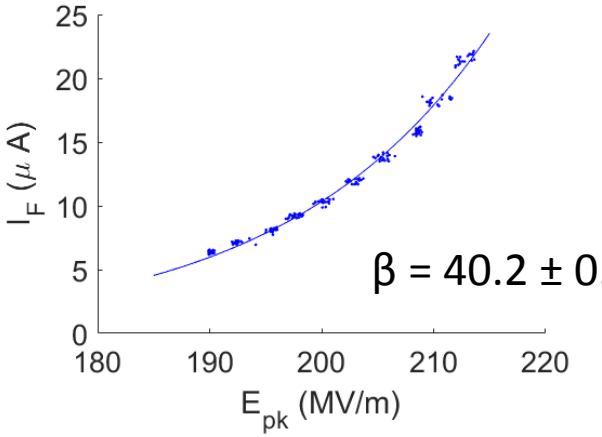


Frequency Spectrum



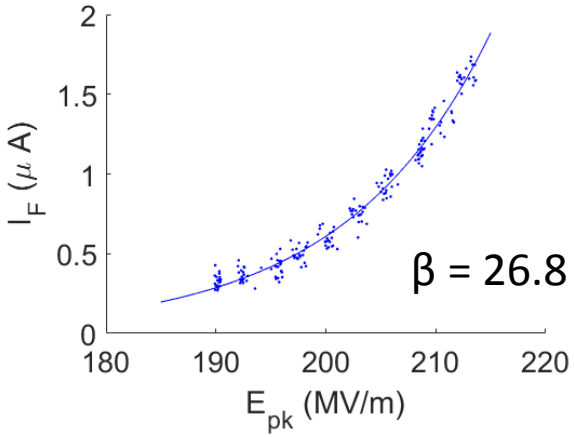
Dependence on Power

0 – 0.1 GHz



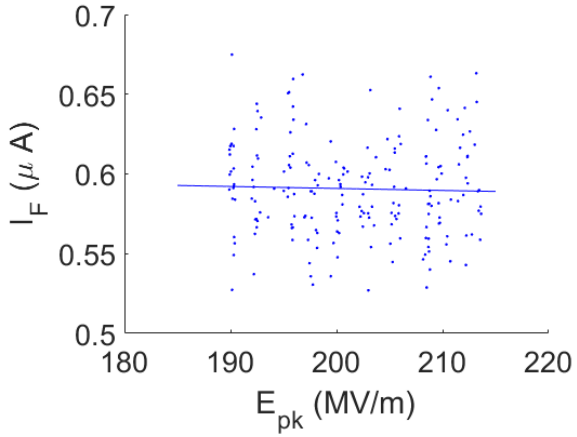
β = 40.2 ± 0.4

0.1 – 0.8 GHz

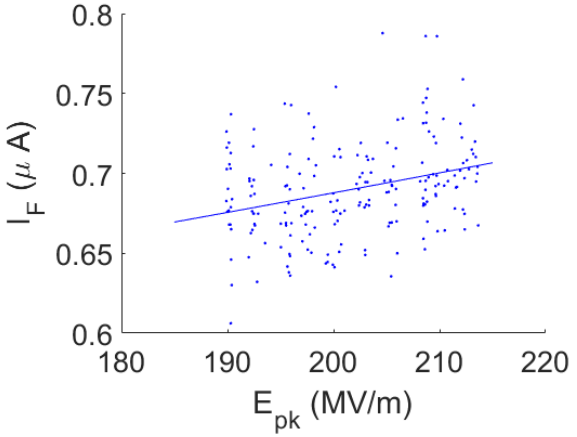


β = 26.8 ± 0.5

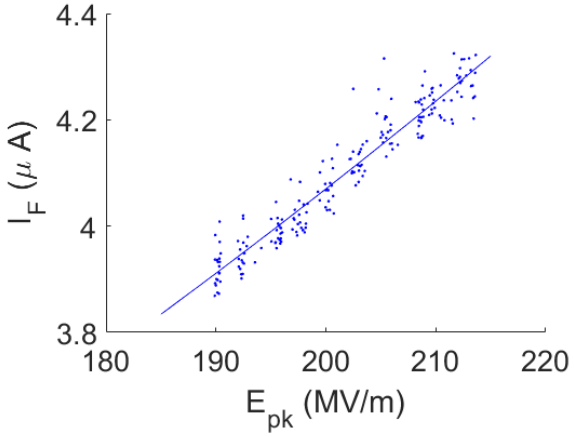
0.8 – 3 GHz



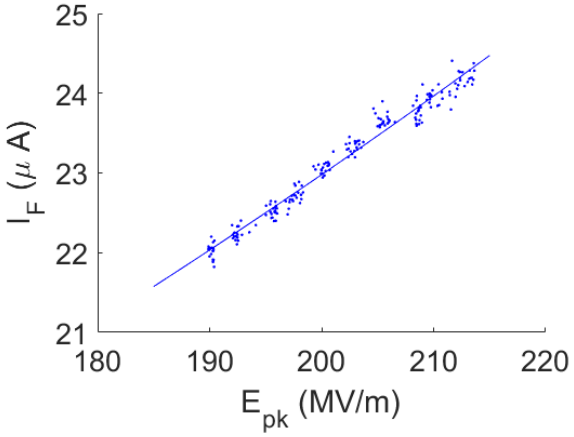
3 – 6 GHz



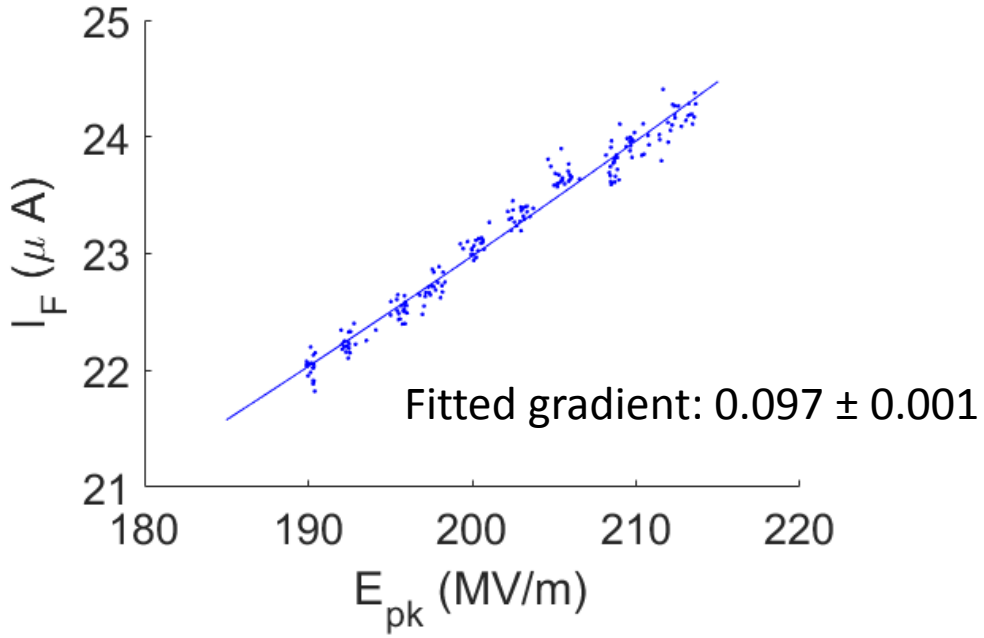
6 – 11.5 GHz



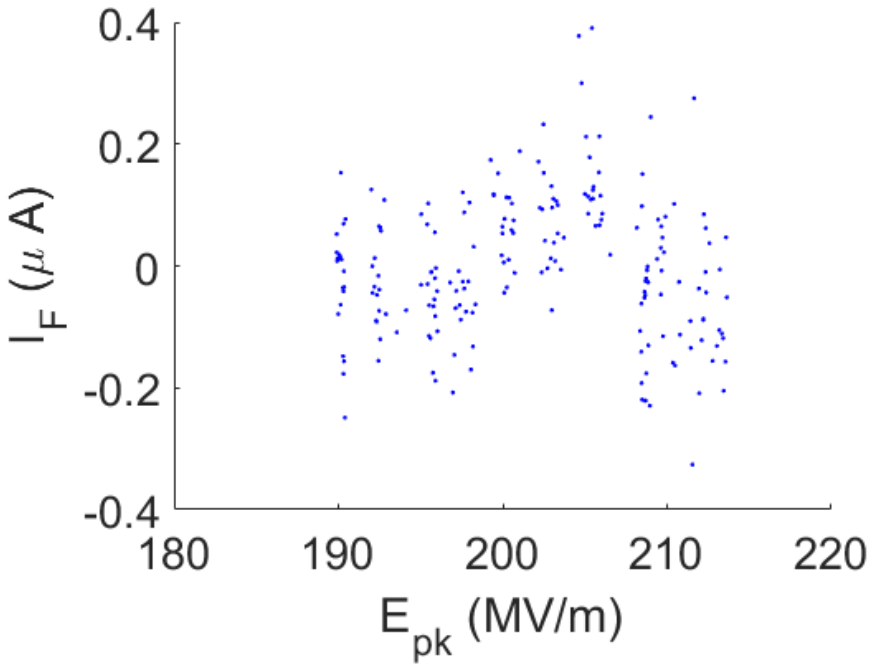
11.5 – 12.5 GHz



Looking for Evidence of Bunching



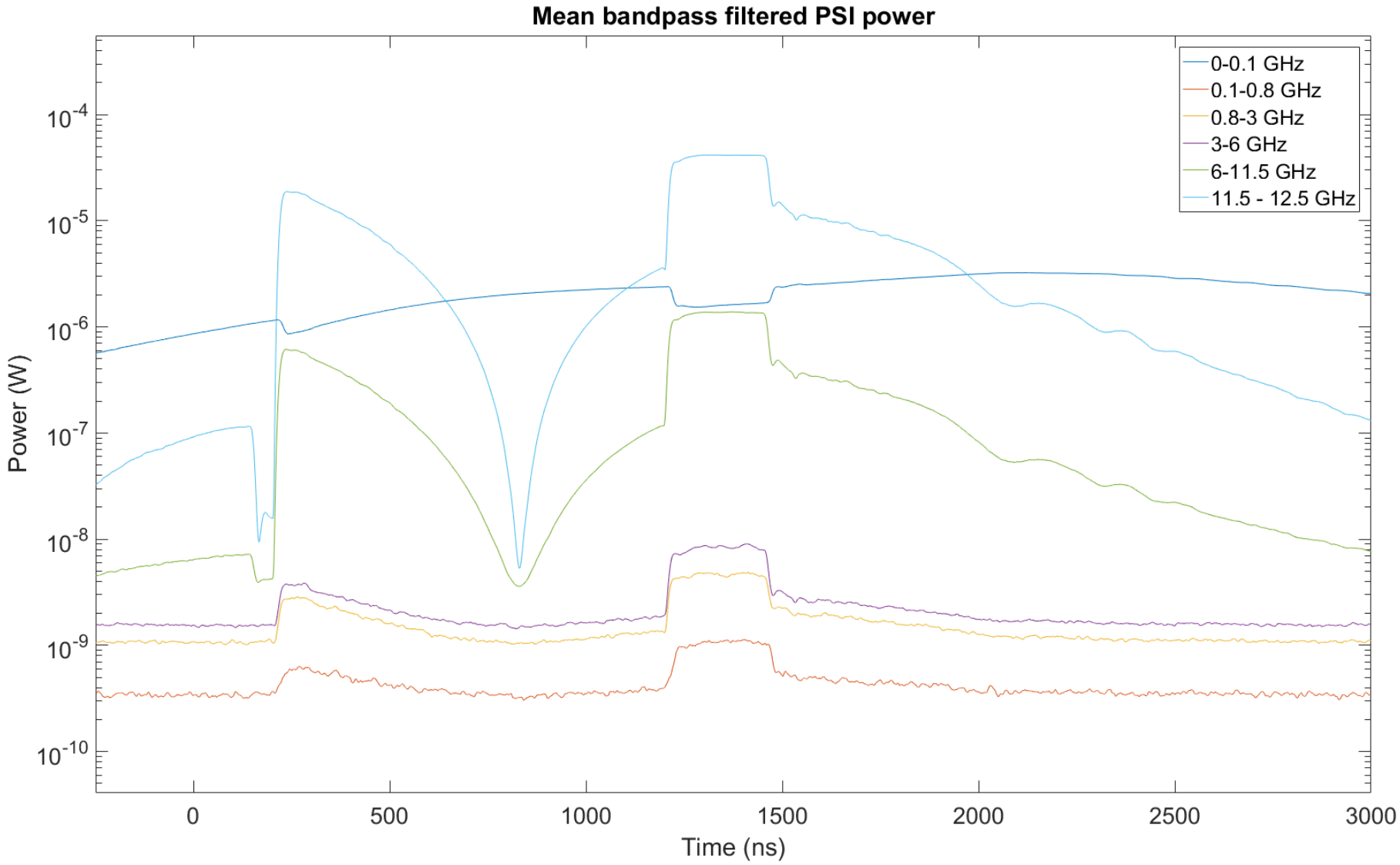
DC vs peak field in
11.5 – 12.5 GHz bin



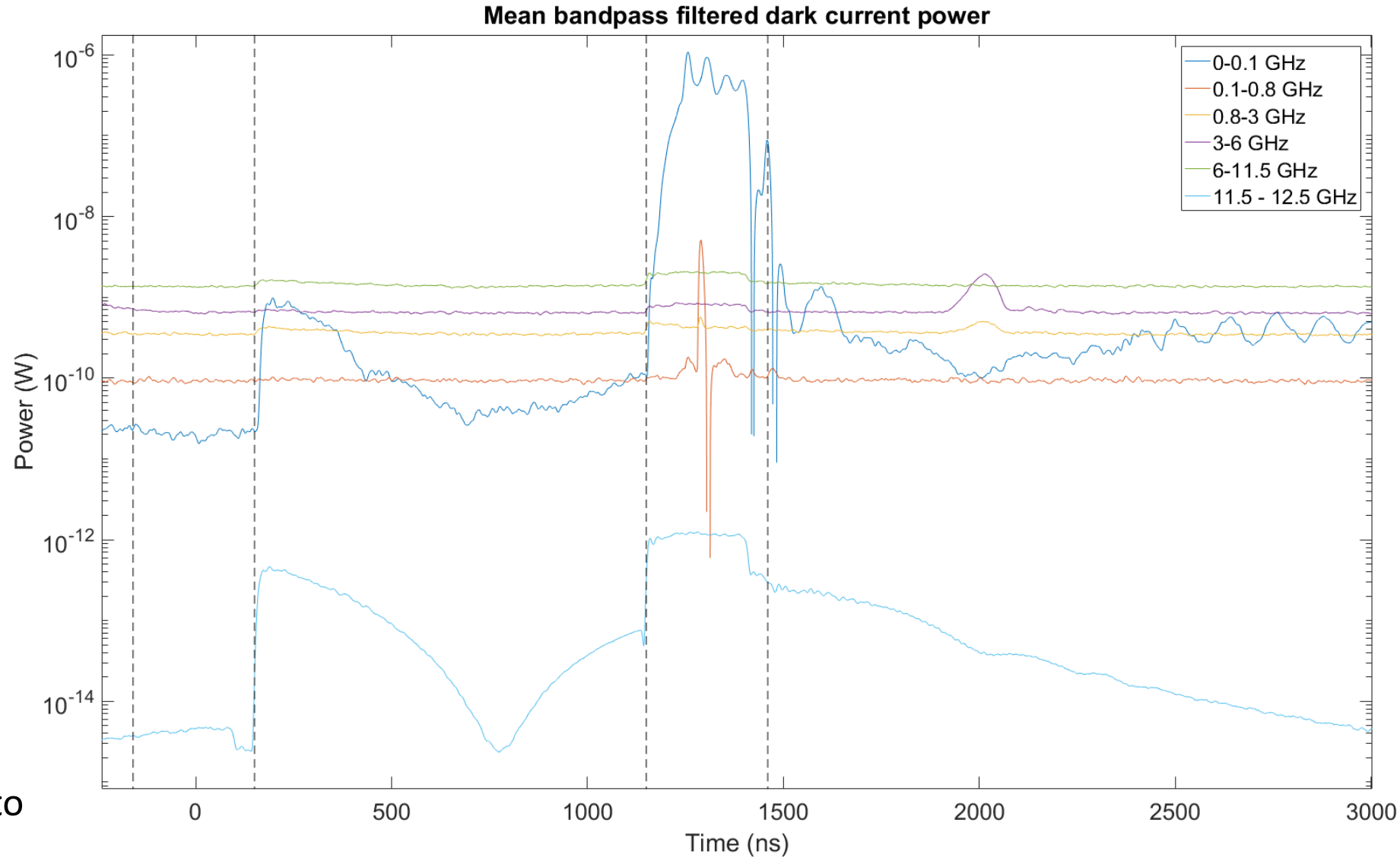
Residuals after subtracting fitted
linear function

Variation with Time

Ensemble average of pulses at 45 MW setpoint.



Variation with Time

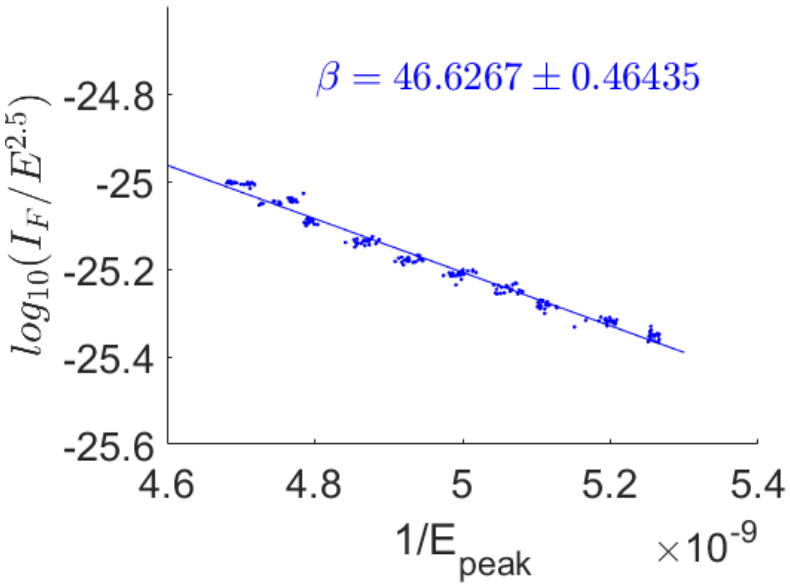


Ensemble average of all pulses at 45 MW setpoint.

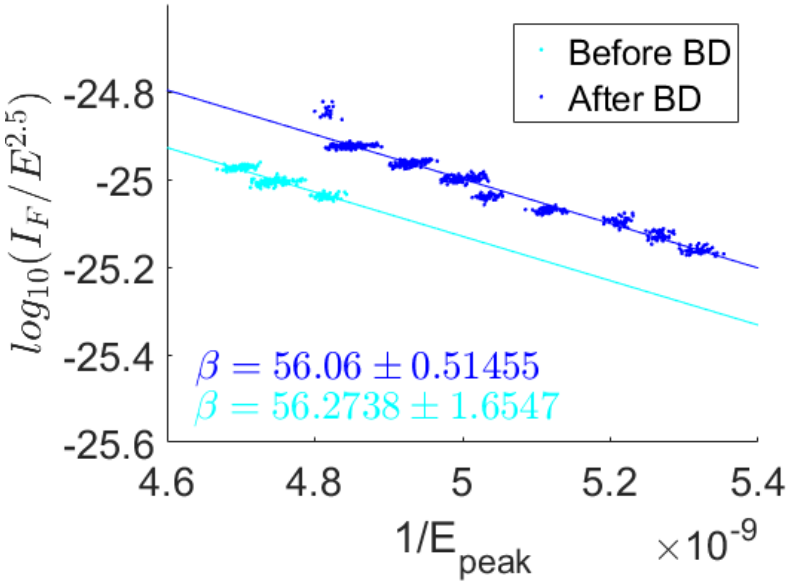
This dataset taken with hardware BW limitation to 10 GHz to maximize sensitivity.

Breakdowns

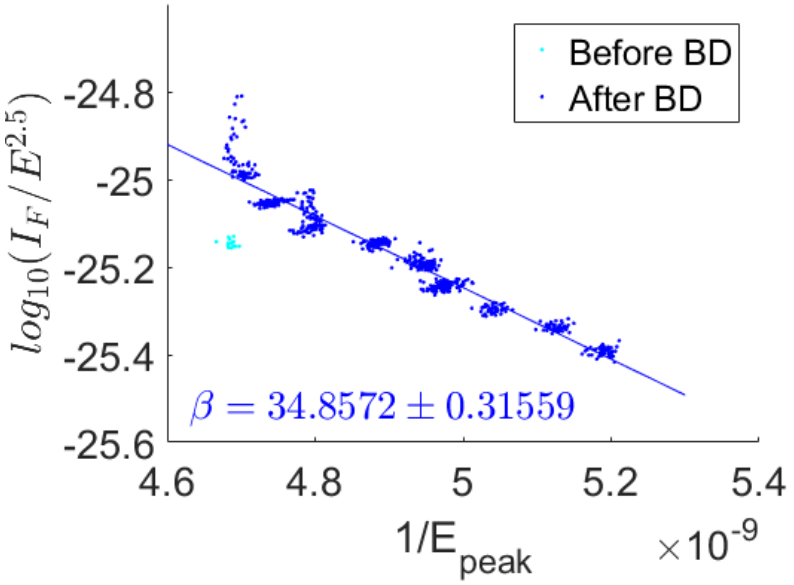
F-N power scans. Decreasing power in all cases.



3/8/2017



4/8/2017 – a.m.
HW bandwidth limitation
to 10 GHz

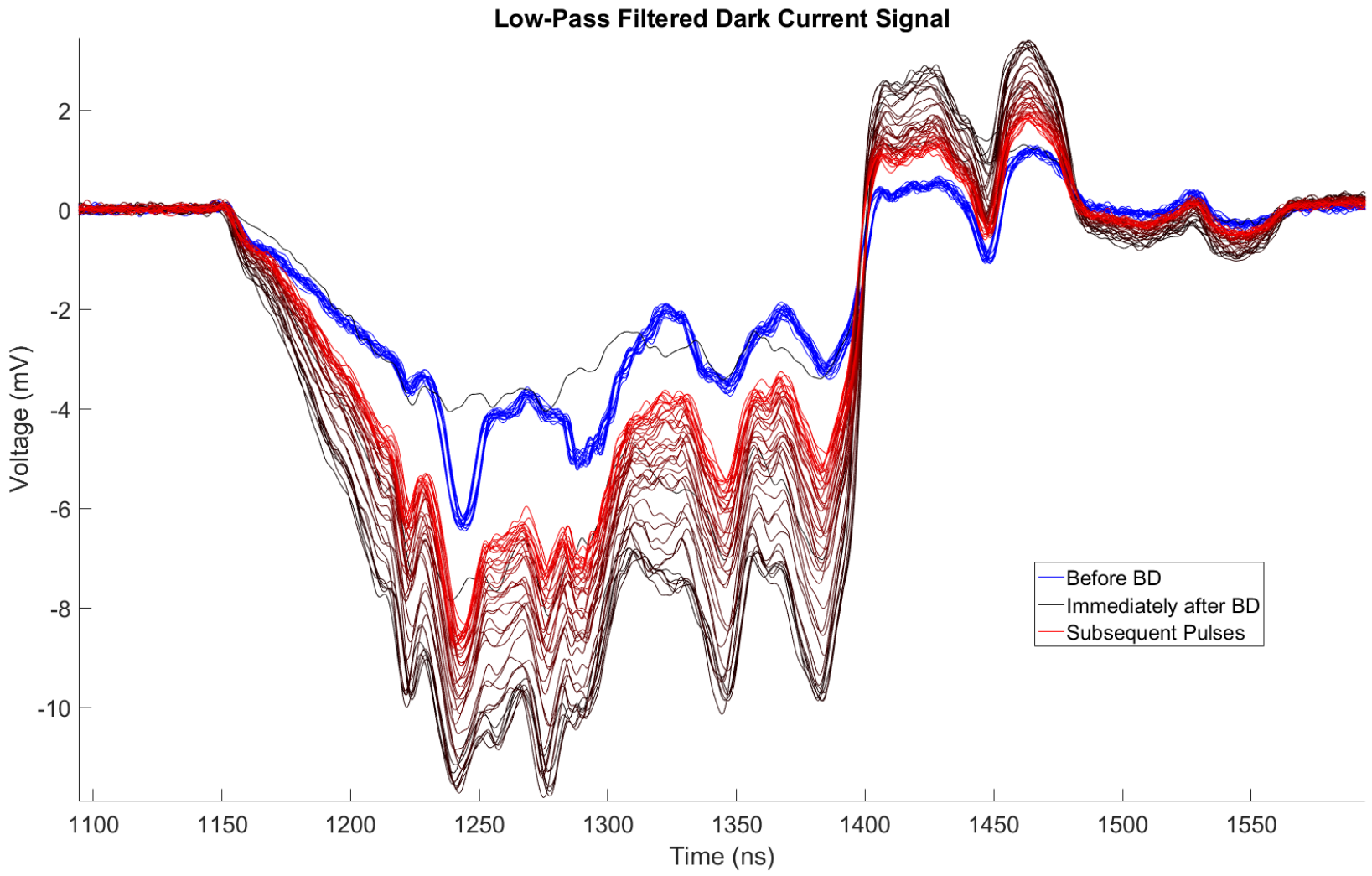


4/8/2017 – p.m.

Breakdowns

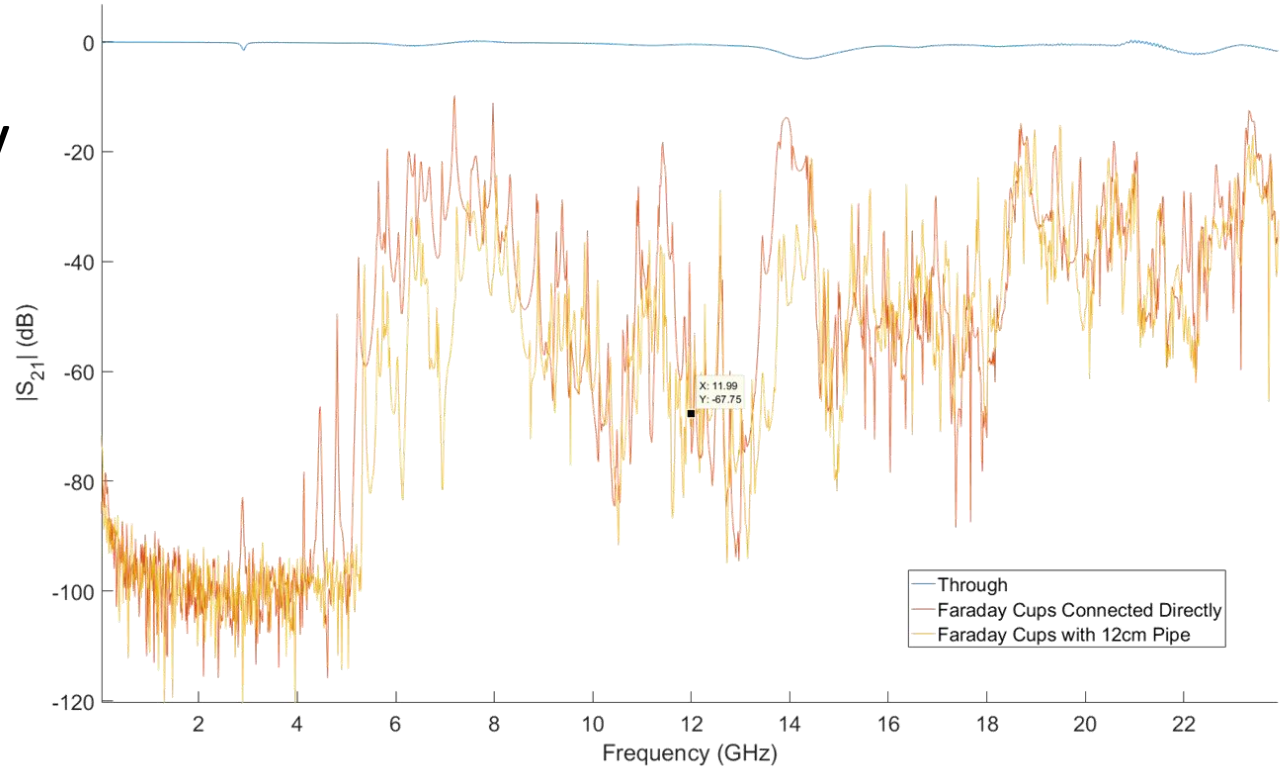
Noticed ‘cloud’ of points with unusually high dark current immediately after BD.

Colour gradient from black to red shows order of pulses in time.



Next Steps

- Checking bandwidth of Faraday cups with measurements and simulations.
- Designing and assembling analogue front end for better sensitivity and robustness.
- Measurements at current DC system. (plate-plate)



VNA measurement of 2 Faraday cups back to back.