Interpretation of HEC Chip Results

HEC PAS meeting
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- Linearity Measurement with the Oscilloscope
- Linearity Measurement with the Network Analyzer
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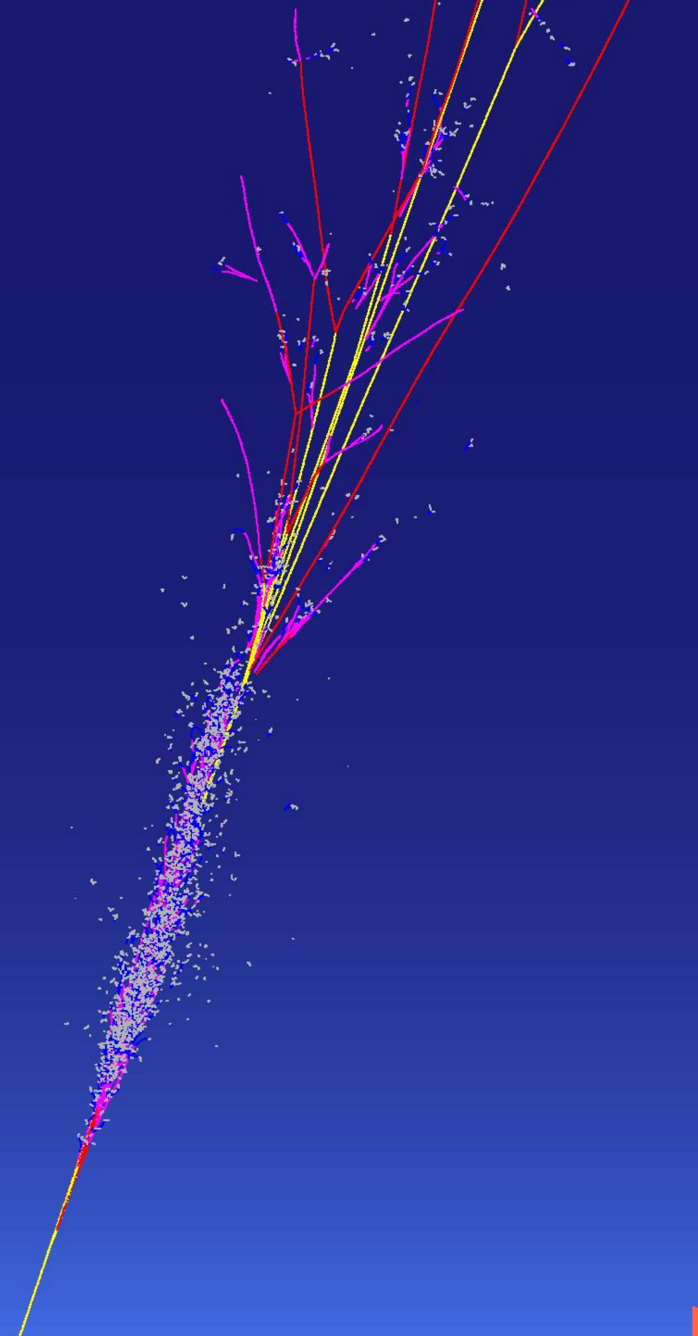


Introduction

- In the neutron irradiation tests in Rez several methods were used to evaluate the GaAs HEC chip's performance:
  - direct pulsing with a single 400 ns exponential pulse to test linearity
  - S-Parameter measurements with a Network Analyzer (NA) mainly for gain
  - fixed frequency power sweeps with the NA for linearity
- The methods are described in the Diploma Thesis of Sava Potrebic

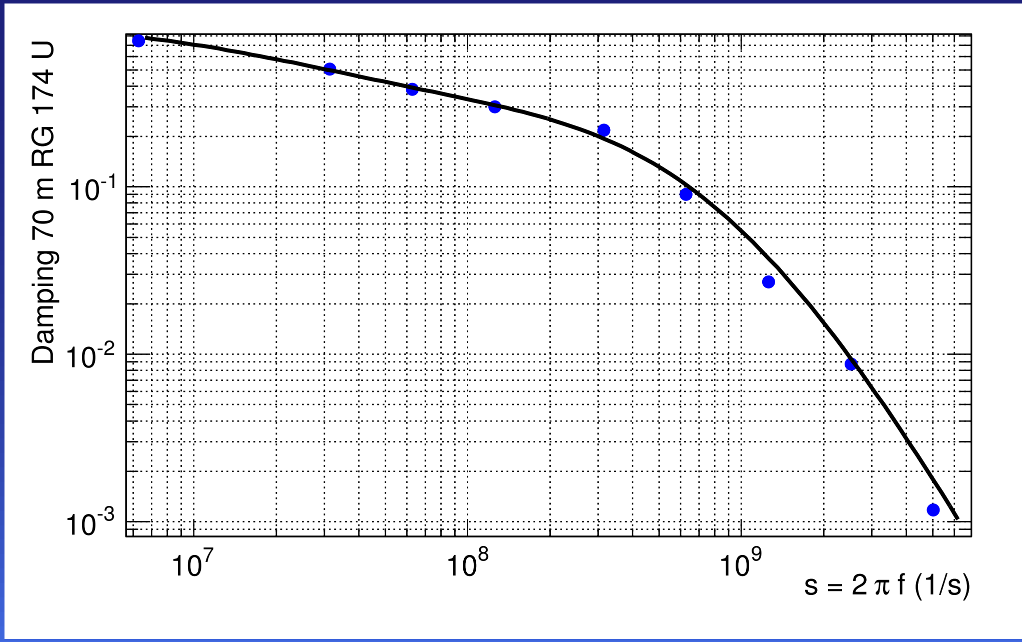
  `http://www.mppmu.mpg.de/~savche/DIPL1.pdf`
- In that thesis the results appear to be non compatible
- Together with Olaf Reimann a better understanding of the Rez data was achieved
  - different impacts of 35 m coax cable
  - limitations of fixed frequency NA power sweeps
  - different dynamic ranges of the HEC chip in the positive and negative
- An attempt is made to take all the effects into account and compare the results
- Some recommendations how to adjust the setup for future tests are outlined in the end

S-Paramter Measurements

- S-Parameters measure the frequency dependency of the HEC chip
- Especially interesting is S_{21} which can be interpreted as the gain of the system
- The coax cable effects are calibrated out automatically by the NA – so S_{21} shows the gain of the HEC chip without any cable effects
- However one has to keep in mind that still the probing of the system is done with continuous sine waves and not single pulses of just one polarity

Oscilloscope Method

- A pulse signal ($400\,\mathrm{ns}$ exponential) is sent to the HEC chip over a $35\,\mathrm{m}$ coax cable and monitored near the pulser with an oscilloscope
- The output of the HEC chip travels back the cable and is split to be a) measured directly with the oscilloscope and b) after the warm shaper.
- The input signal to the HEC chip is thus identical to the monitored input times the expected damping of $35\,\mathrm{m}$ cable
- The output signal has to be multiplied by 2 and again corrected for the damping of $35\,\mathrm{m}$ cable
- The total correction is thus $2/\mathrm{damping}(70\,\mathrm{m}, \mathrm{Pulse})$.

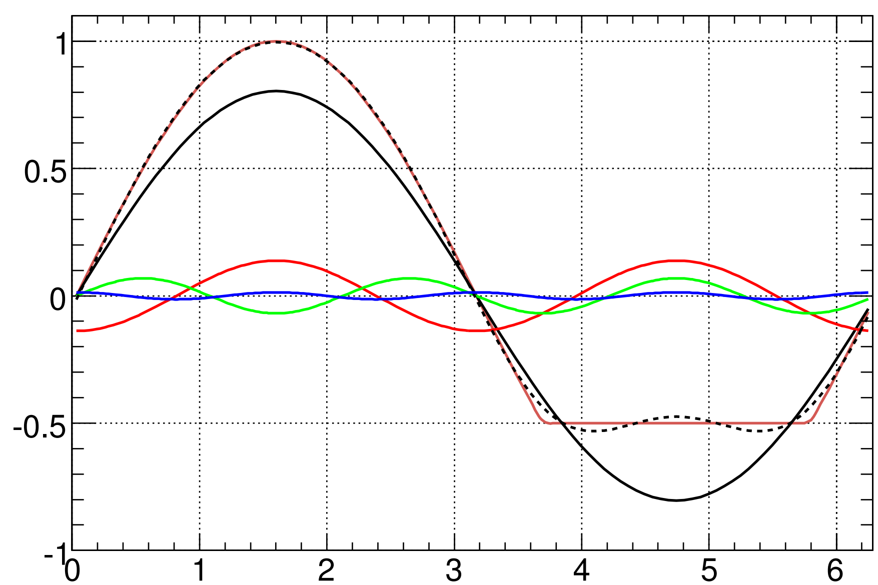


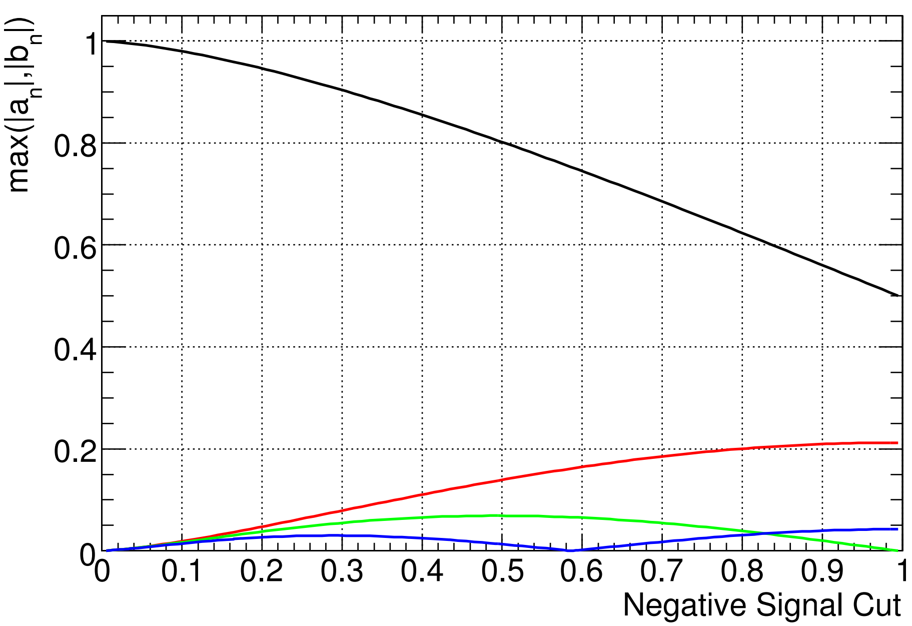
Network Analyszer Power Sweep

- Fixed frequency sine waves from the NA are varied in amplitude and sent to the HEC chip over $35\,\mathrm{m}$ of coax cable
- The output of the HEC chip travels back the cable and is analyzed by the NA at the same frequency as the input signal
- The total correction is thus $1/\mathrm{damping}(70\,\mathrm{m}, \mathrm{Fixed\ Freq.})$.
- But the obtained gain is valid for a fixed frequency only!
- If the HEC chip limits the sine one one or both sides the ground frequency gets suppressed

Effect of Cut Sine Wave

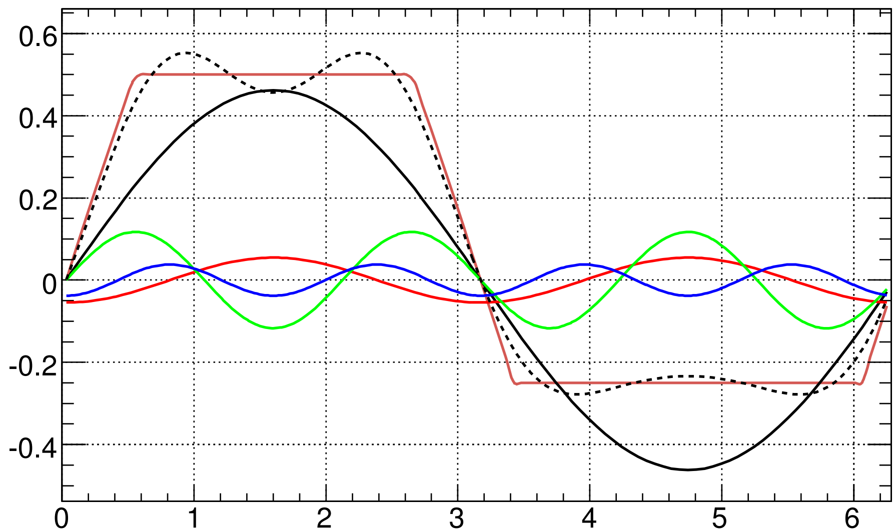
- What "sees" the NA if the sine wave is limited on one or two sides?
- The left plot shows a sine wave (brown) where the negative signal is limited at 50% of the amplitude
- The NA probes the ground frequency (black) which appears with reduced amplitude (80%)
- Higher harmonics (red, green, blue) start to play a role
- Fourier coefficients as a function of lost negative signal (right plot)

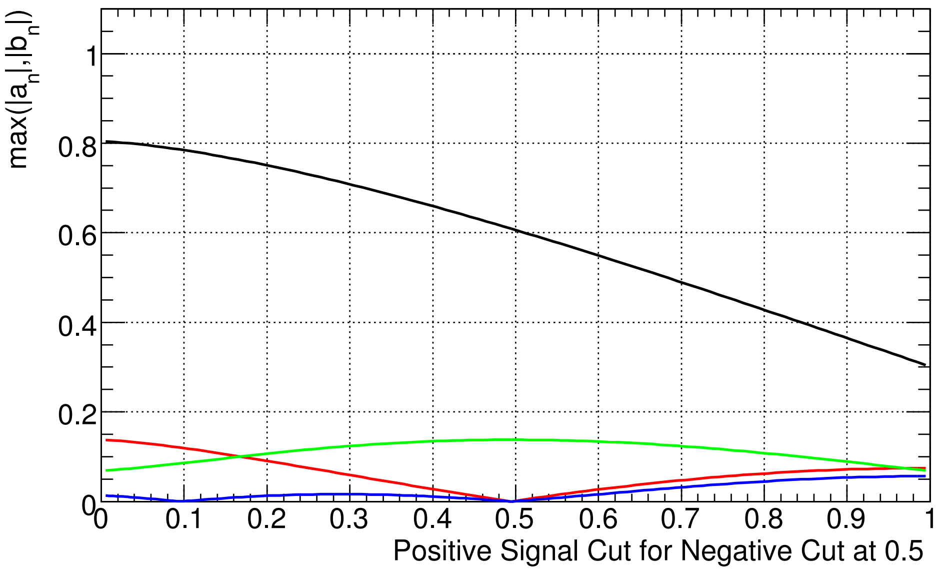




Effect of Cut Sine Wave

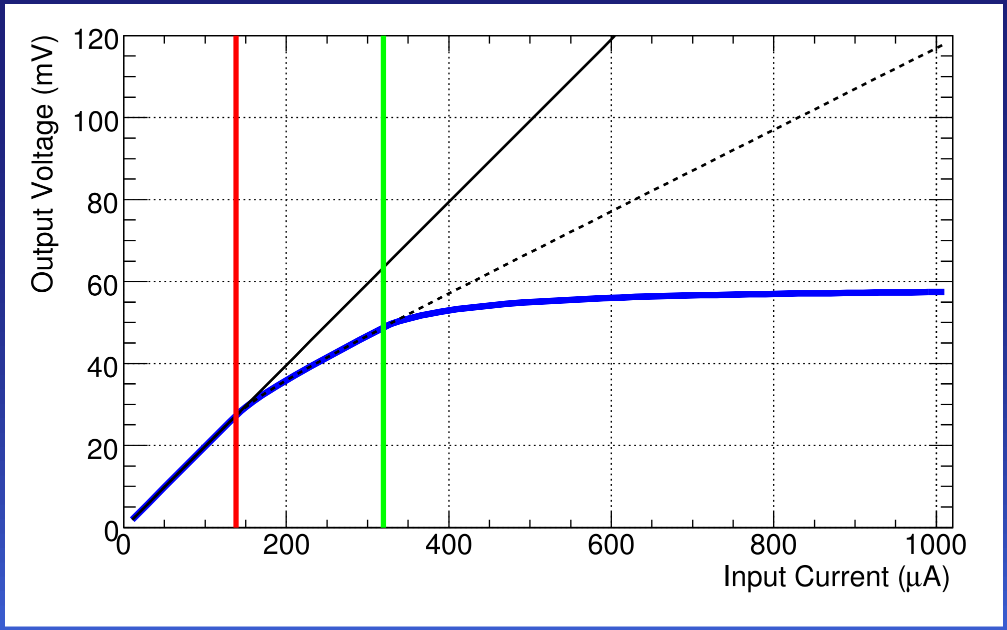
- The effect gets larger if also the positive signal is limited
- The left plot shows again a sine wave (brown) where the negative signal is limited at 25% of the amplitude and the positive at 50%.
- The ground frequency (black) is further reduced (45%)
- Fourier coefficients as a function of lost positive signal at 50% lost negative signal (right plot)





Effect of Cut Sine Wave

- Assume 2 fixed thresholds for the negative and positive signal (i.e. both are independent of the input amplitude)
- If the input signal is below both thresholds the system is linear at nominal gain
- Beyond the lower threshold the system is still linear but with reduced gain
- Beyond the higher threshold the system saturates



Consequences for next Irradiation Tests

- Measure S-Parameters from used Cables directly
  - then we don't need to backward engineer the expected damping from lenght and cable specs
- Use frequencies of $1\,\mathrm{MHz} - 10\,\mathrm{MHz}$ for NA Power Sweeps and also measure 2^{nd}, 3^{rd}, 4^{th} harmonic
  - this allows to see the relevant frequency range
  - higher harmonics show thresholds more direct
- Measure also higher harmonics for the S-Parameter studies
  - higher harmonics should stay at 0
  - if not, the system is already non-linear (amplitude too large)
- Explore the usage of X-parameters (i.e. non-linear S-parameters)
  - this helps probably not for the HEC chip but for the other transistors ...
- Given that the HEC chip always reaches the negative saturation first we can probably not rely on the positive saturation extracted by the NA method
  - we still have to use the oscilloscope method to extract linearity ...