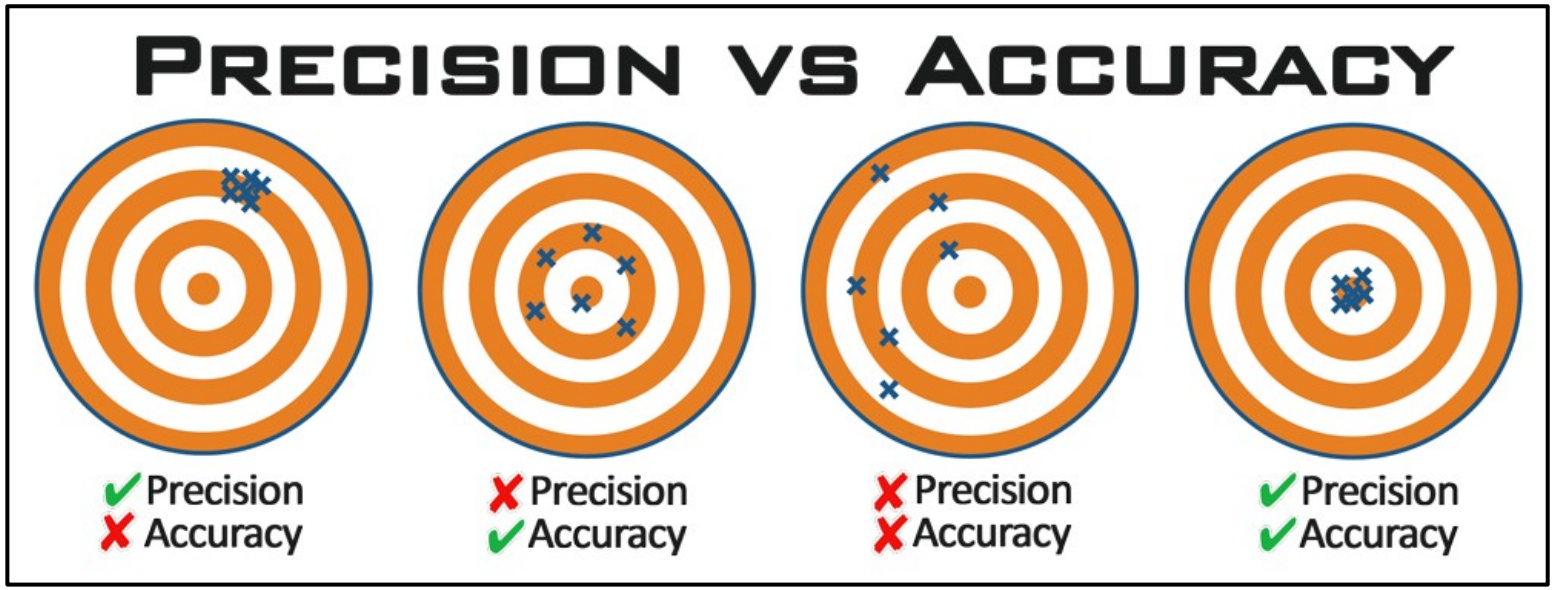
CBPM 12W triplet gain study

CBPM group

MS meeting: March 2, 2023

Turn-by-turn beam position precision

We care most of about turn-by-turn beam position **precision**: if the beam position were not to change, how **repeatable** is its measurement? We want to know well how orbits compare to each other.



typical at CESR:

precision: $O(10)$ micron
accuracy: $O(100)$ micron

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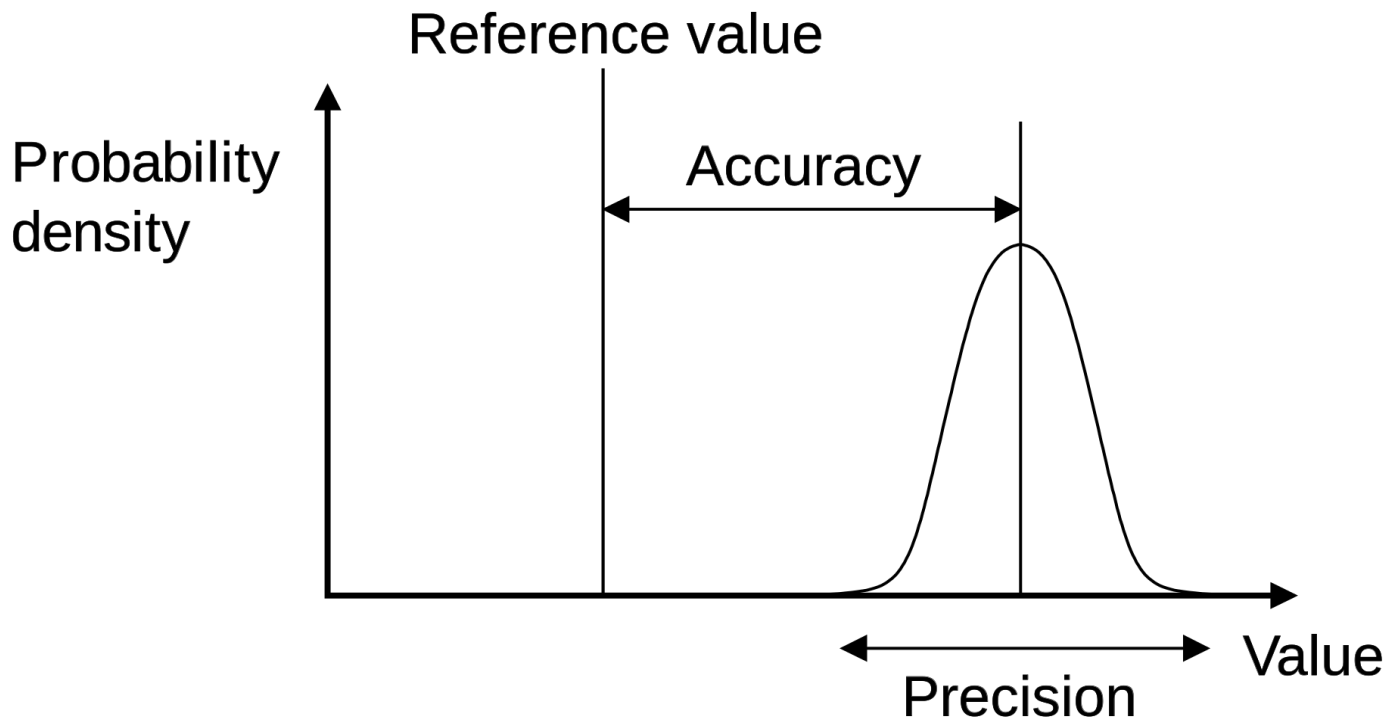
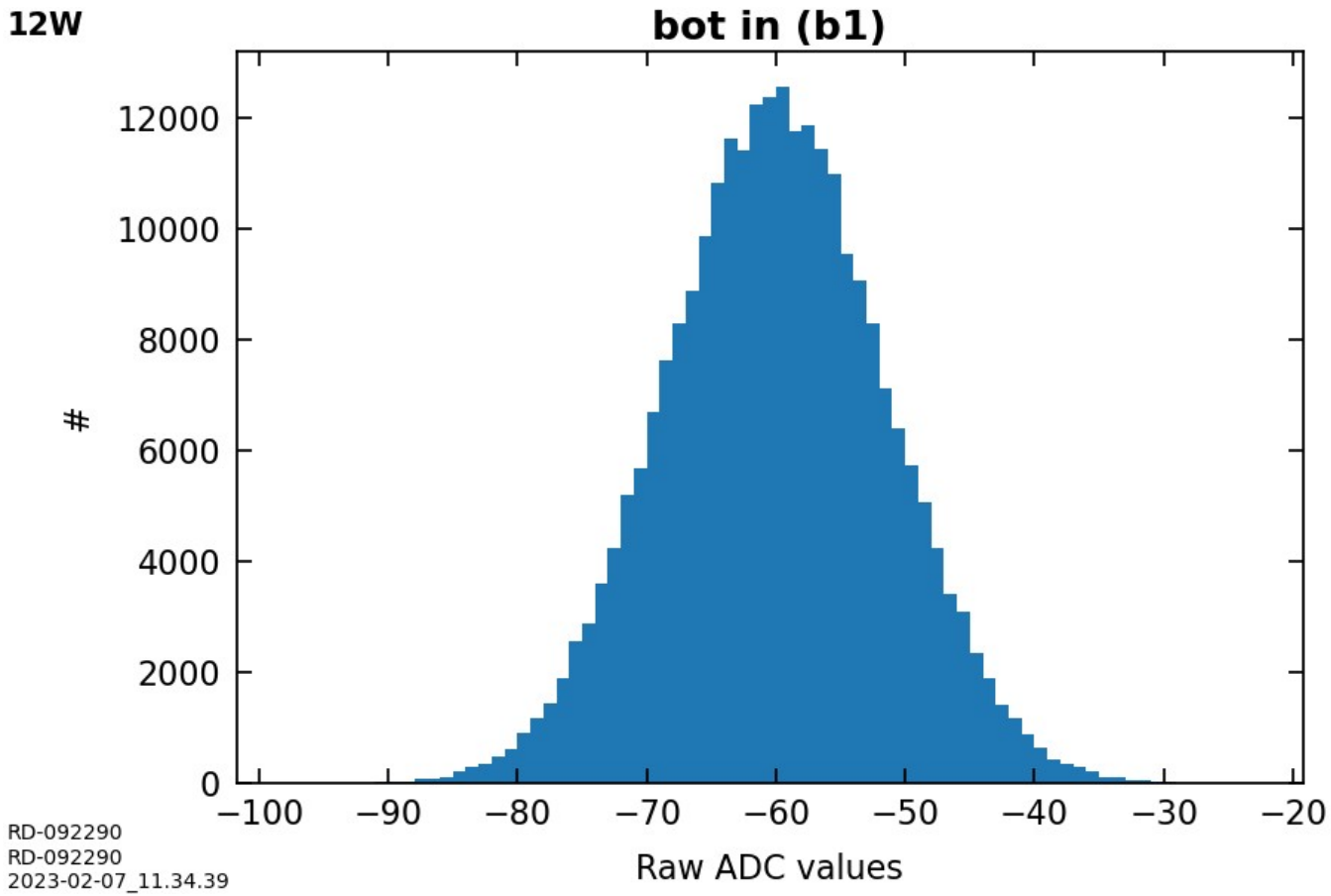


precision is defined as the **standard deviation** of a set of data points

Signal-to-noise ratio and precision

One of the dominant factor limiting the precision is the Signal-to-Noise ratio of the digitized CBPM button signals. Typical RMS noise is 9-18 ADU:



fixed gain mode

Improving signal-to-noise ratio

After investigating, **Bob** found that the current CBPM setup is not maximizing the signal-to-noise ratio. He proposed to:

1) drop analog input gain by 7 via removal of a single resistor (per channel)

2) crank the current of train 1 – bunch1 from 0.7 mA to to 5 mA (7 x 0.7 mA)

This will result in reducing the input noise while preserving the same signal amplitude → better signal-to-noise ratio.

Expected improvement: factor 3

Machine study time has been allocated to demonstrate the feasibility

Two-part plan

Detailed plan available here. In a nutshell, using the CBPM triplet at 12W:

Part 1: instr elog 2060, 2061, 2064

- ✗ collect pedestal and beam data for nominal hardware configuration (0.7 mA)

Part 2: instr elog 2066, 2068

- ✗ Collect pedestal and beam data for resistor-removed configuration (5 mA)

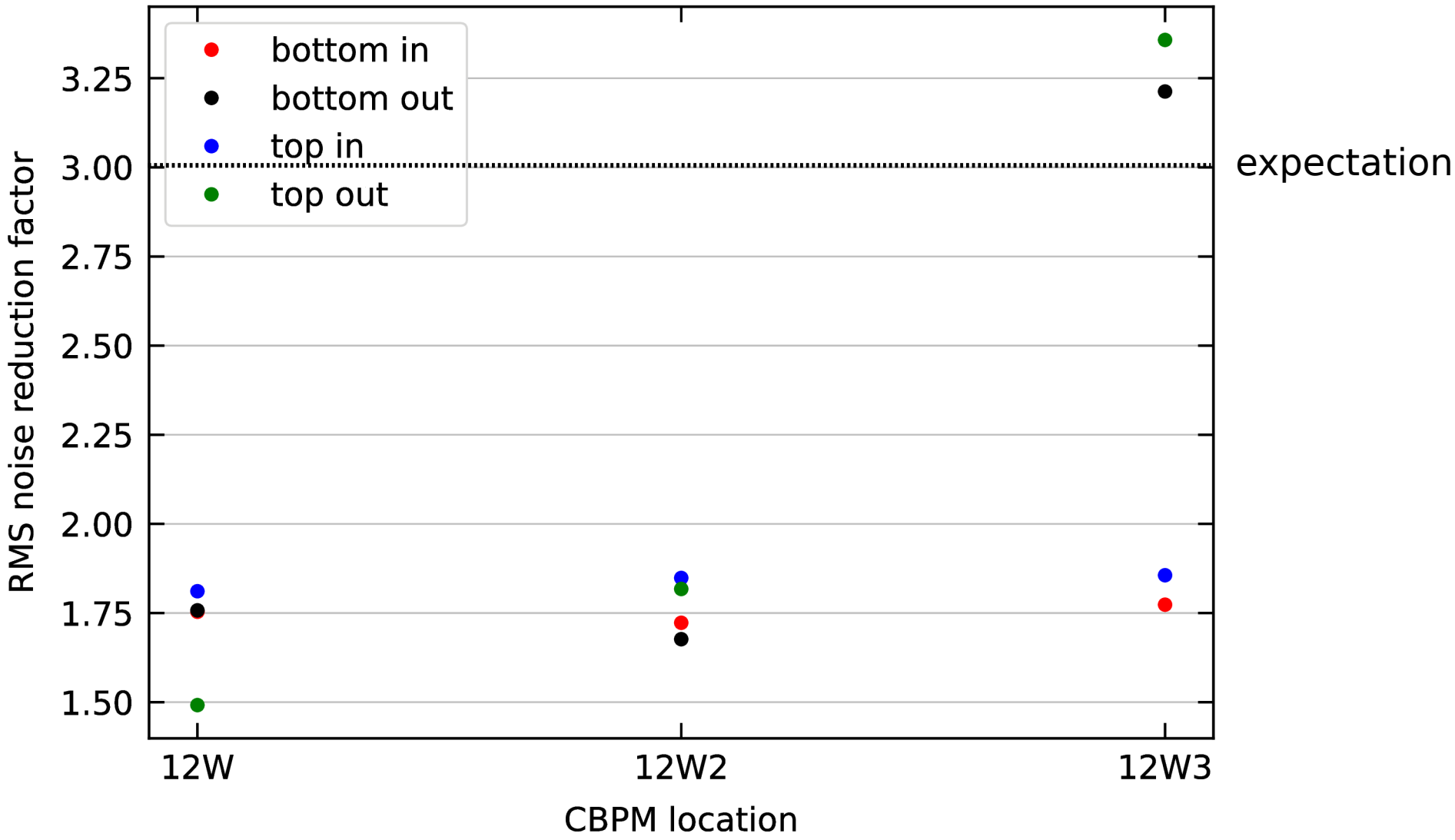
Compare following figures:

- ✗ RMS noise
- ✗ signal-to-noise ratio

→ Let's look at some highlights

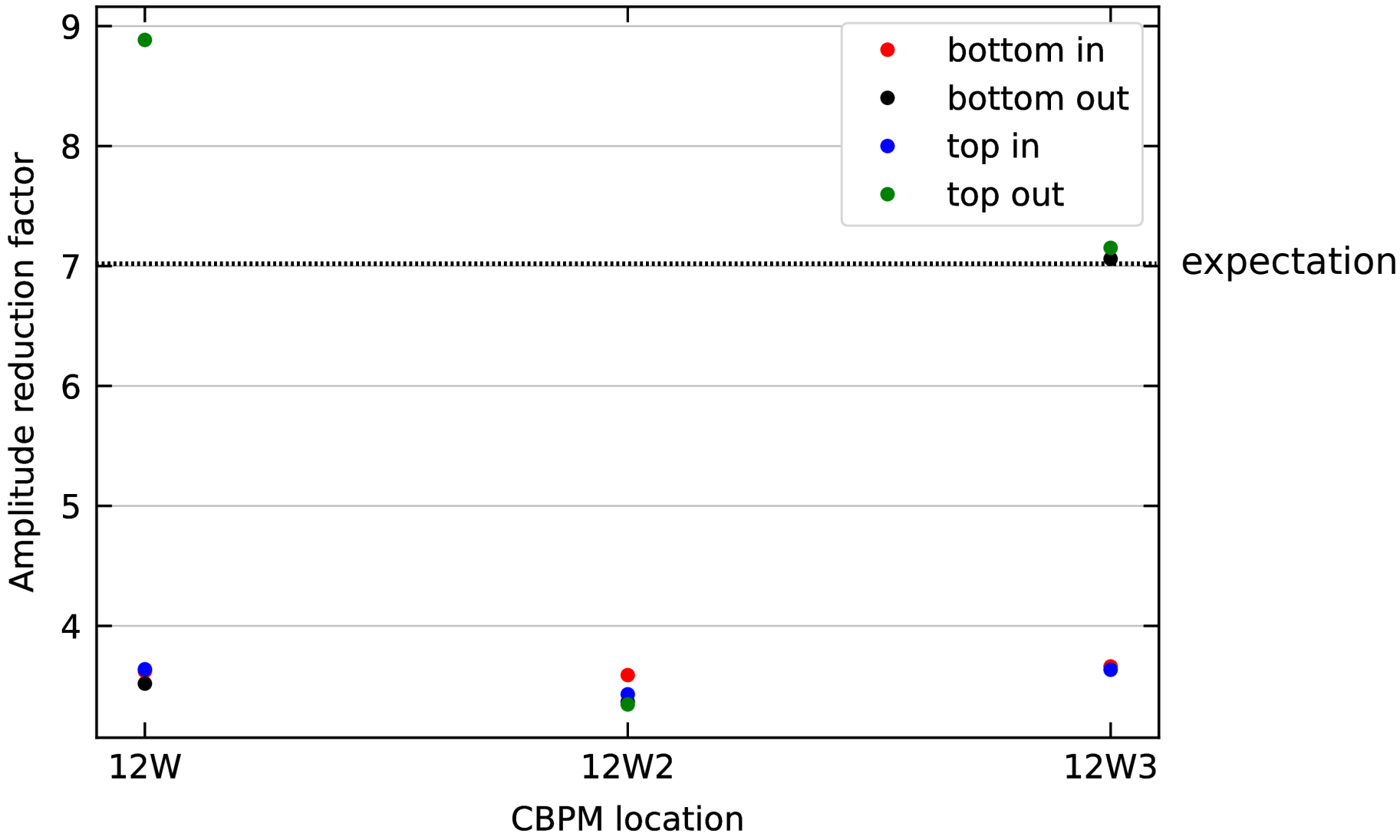
RMS noise reduction

Expected noise reduction by a **factor 3**



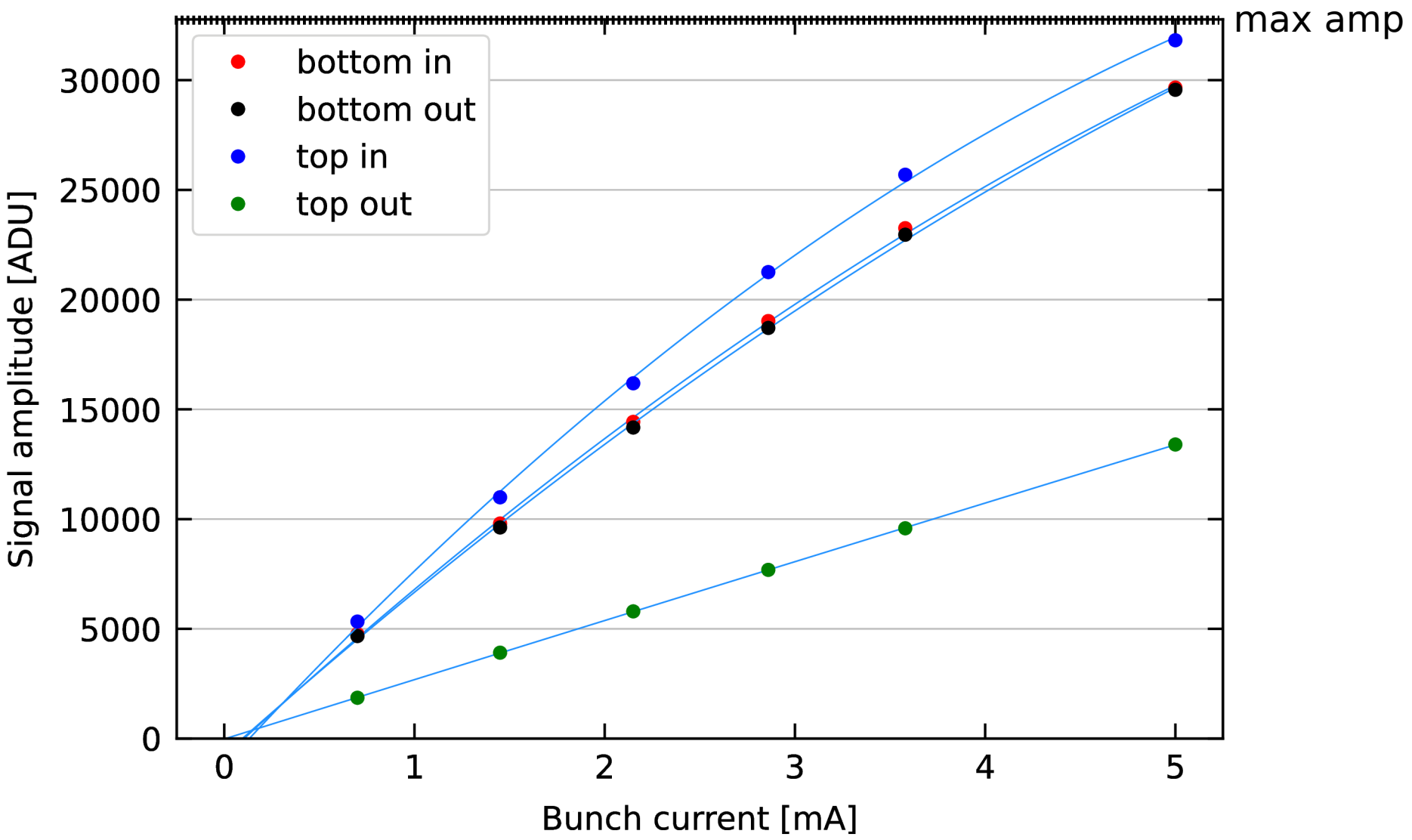
Signal amplitude reduction

Expected amplitude reduction by **factor 7**



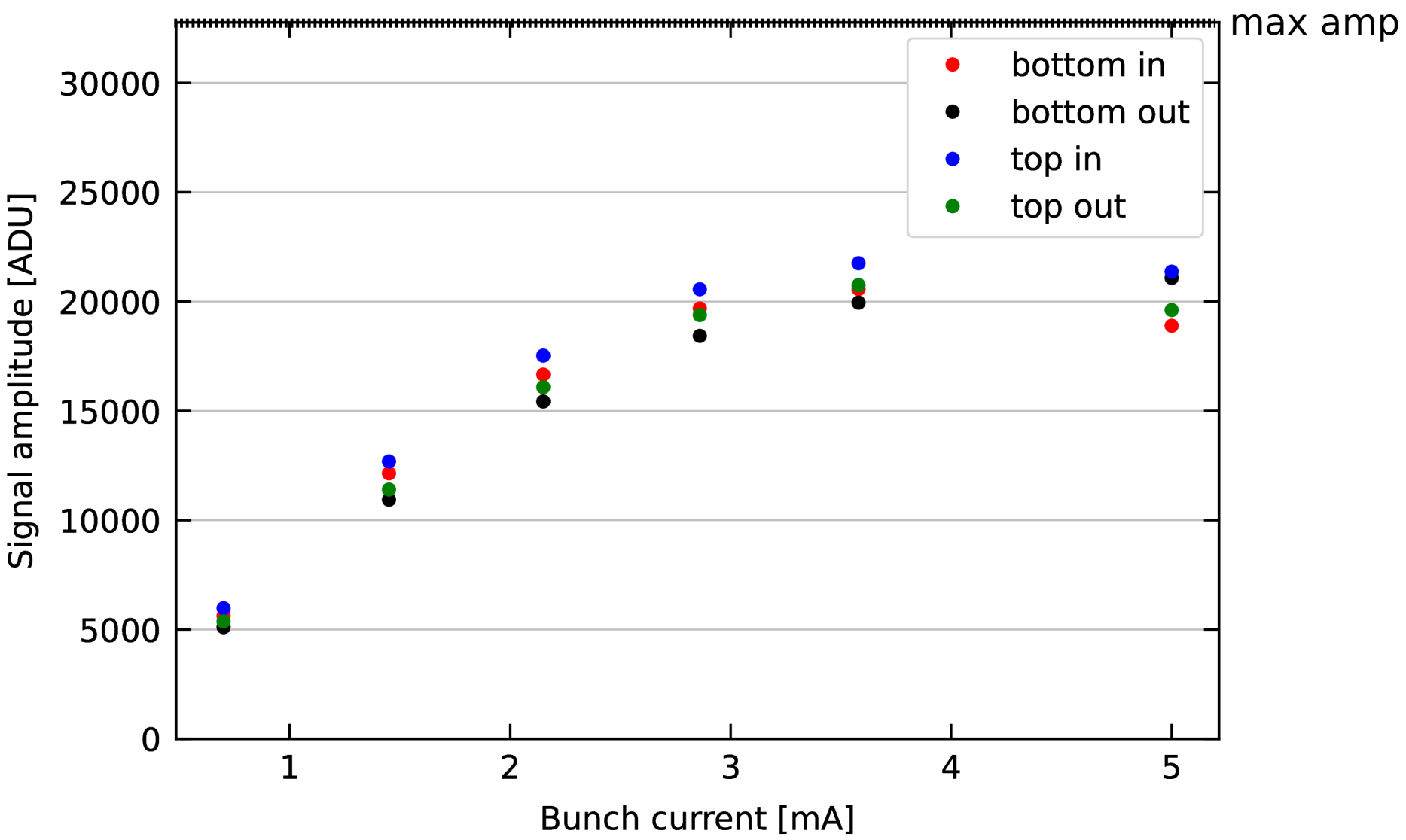
Signal amplitude vs bunch current

12W – 2nd order polynomial fit (w/o uncertainty)



Signal amplitude vs bunch current

12W2 is saturating at higher current



More data and investigation

Tunnel investigation (Feb 21, 2023):

- ✗ 12W2 1.2 GHz input filters missing (see isntr elog 2069) → filters installed
- ✗ various measurements (voltage, resistors etc.) did not reveal the culprit(s)

Machine study time (Feb 22, 2023):

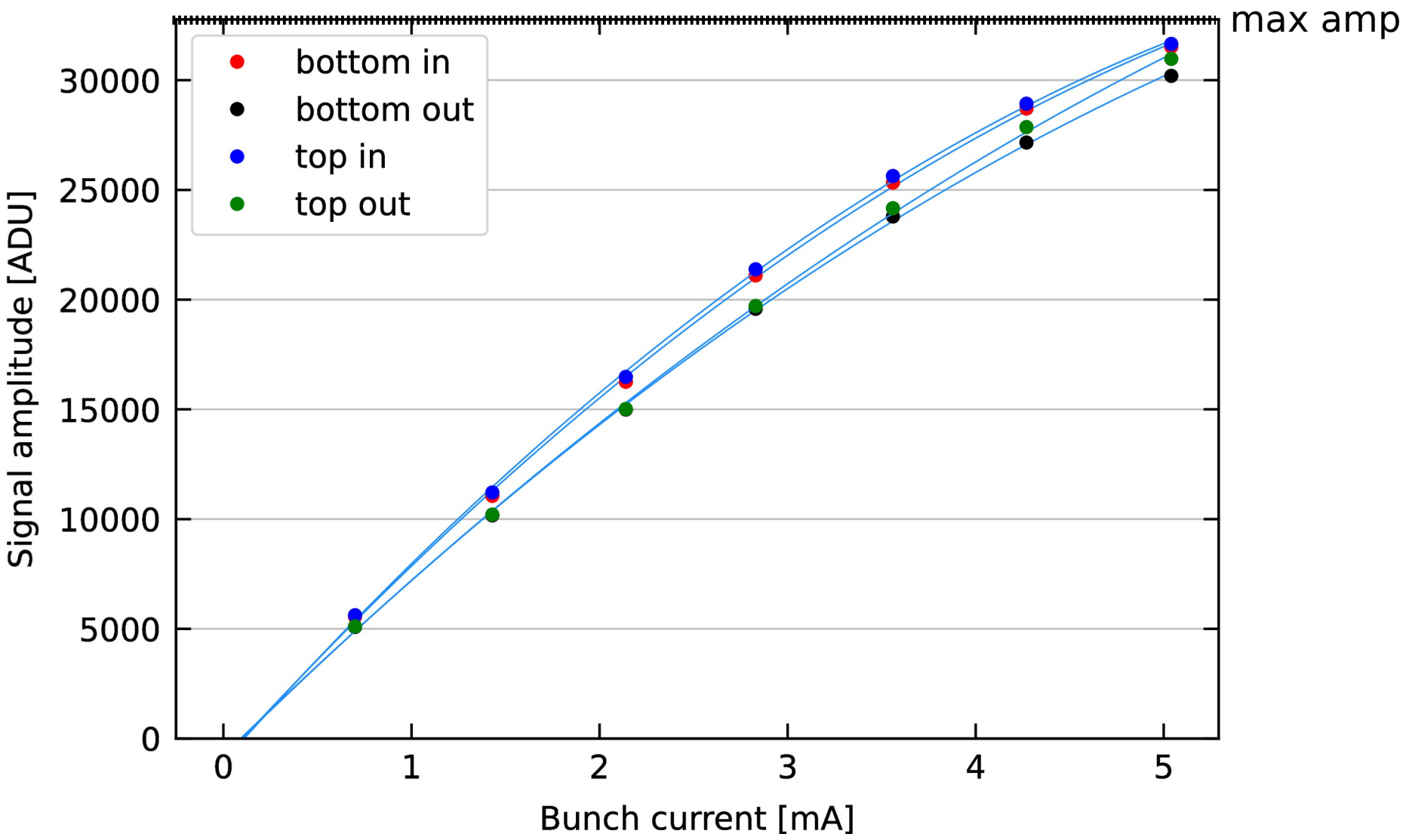
- ✗ collect data for 12W2 at both 0.7 mA and 5 mA current (see instr elog 2073)

Machine study time (Feb 23, 2023):

- ✗ 4-hour block became available to us and we used it well: instr elog 2075
- ✗ new bunch current scan: this time timing modules for each current step

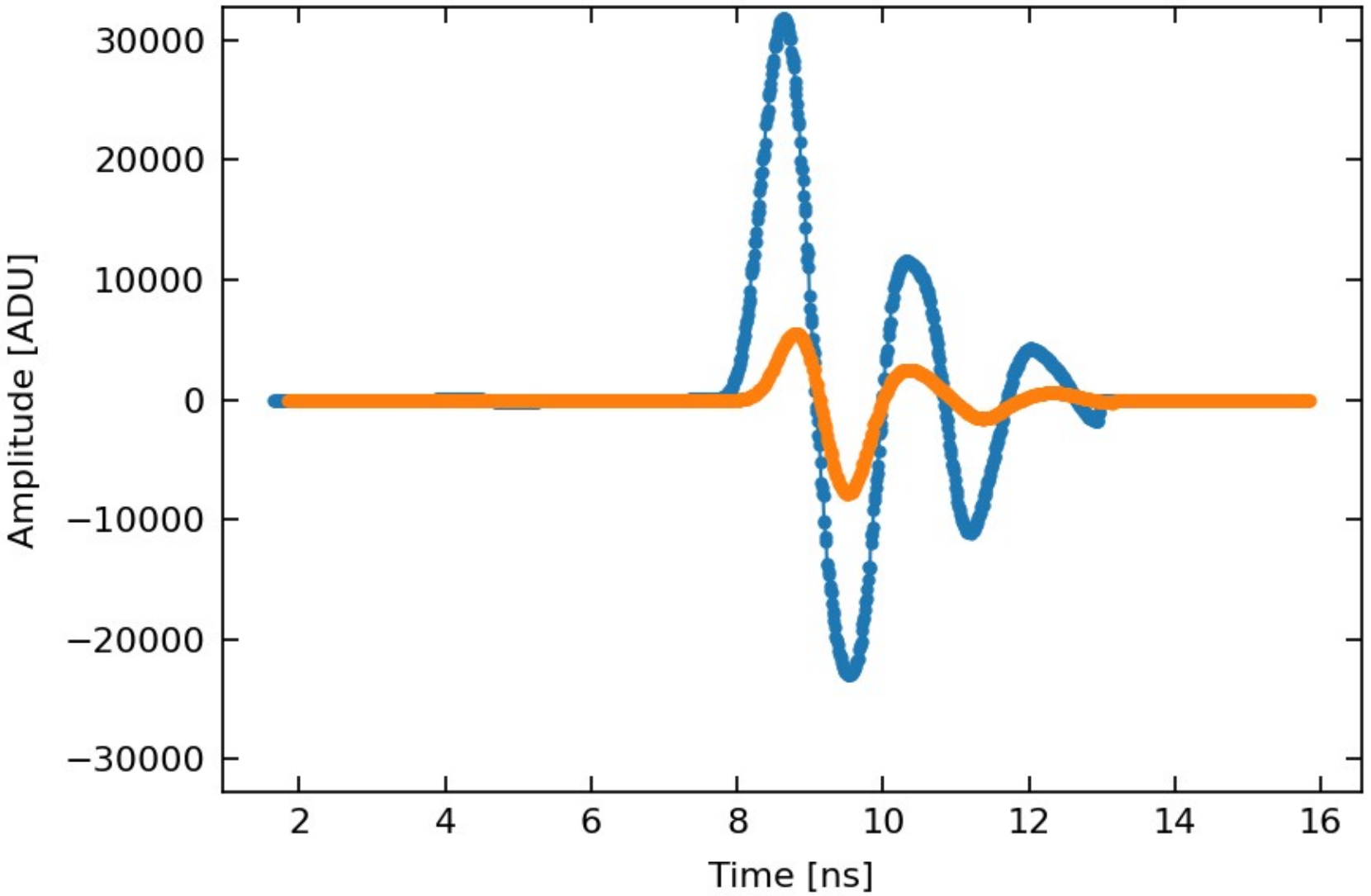
Signal amplitude vs bunch current

12W2 is saturating no more with 1.2 GHz filter installed



Analog waveform

Sweep of the sampling time to reconstruct waveform (**0.7 mA**, **5 mA**)



And now?

One working hypothesis is that something is not right with the differential signal fed to the ADC

12W triplet boards are on the bench and thoroughly scrutinized for issues, e.g.:

- ✗ if the common-mode voltage of the differential amplifier drifted too far from its specs → we expect the type of issues we are seeing
- ✗ radiation, aging... could cause this type of damage

Stay tuned...

Additional materials

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