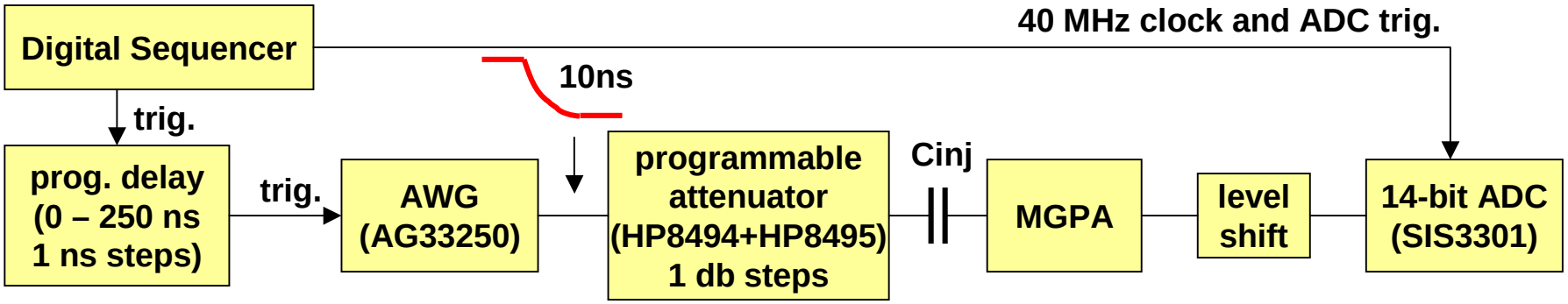
MGPA Linearity

Non-linearity measurements in the lab

- hardware description
- method
- results

Mark Raymond (Dec.2004)

Linearity test bench



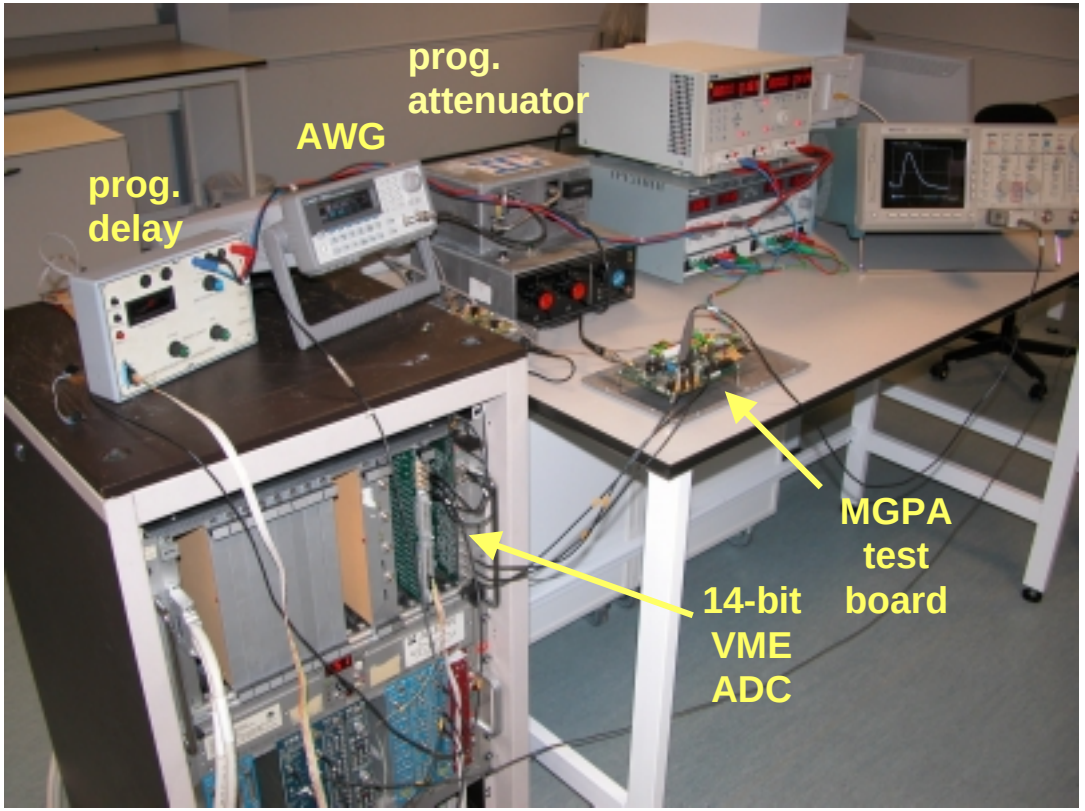
LabView automated

use prog. attenuator, rather than changing amp. of AWG O/P to avoid contribution from AWG O/P stage linearity

14-bit ADC -> negligible INL and DNL contribution to measurement

for MGPA test board use either
- RAL PCB with socket
  - easy chip exchange

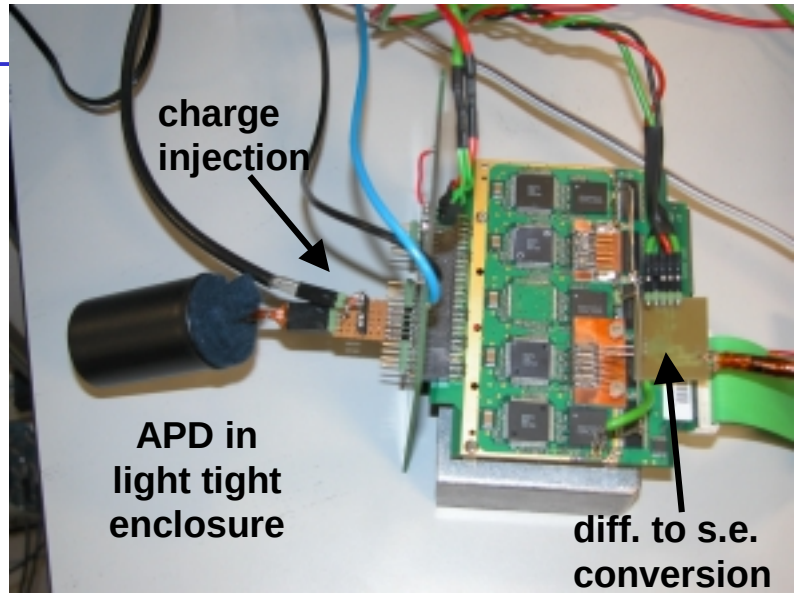
or
- VFE card
  - verify performance in final configuration

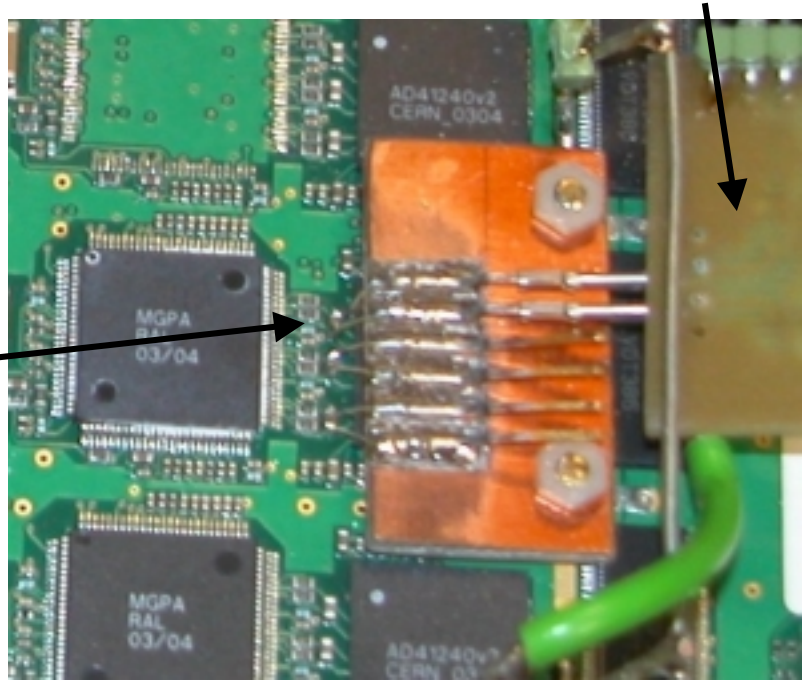


MGPA test board photos

RAL board with socket

modified VFE card (latest version)

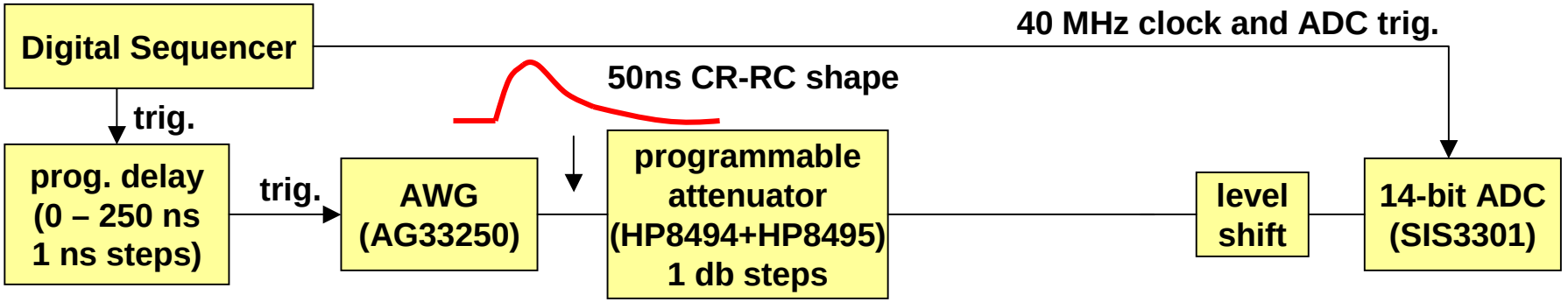




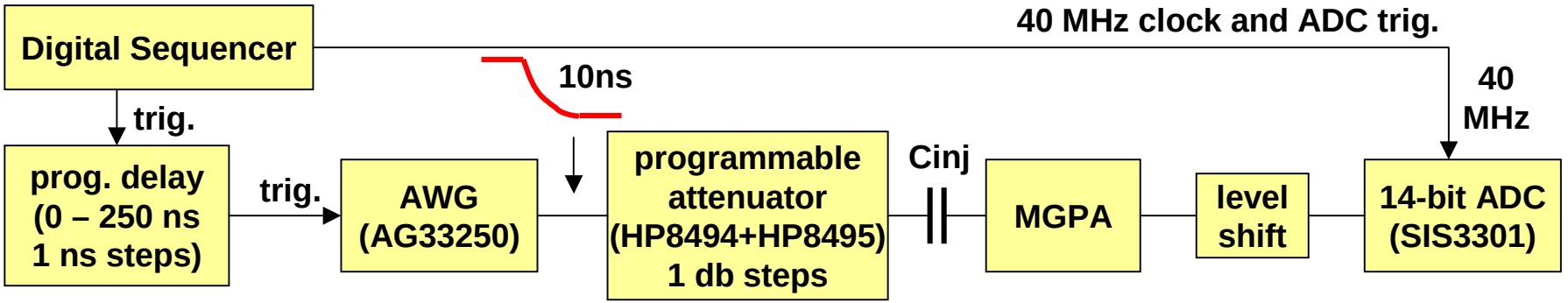
differential
MGPA O/P
signals accessed
between MGPA
and ADC

Linearity measurement procedure

1) remove MGPA test board and characterise system
   => make precision measurement of attenuator steps

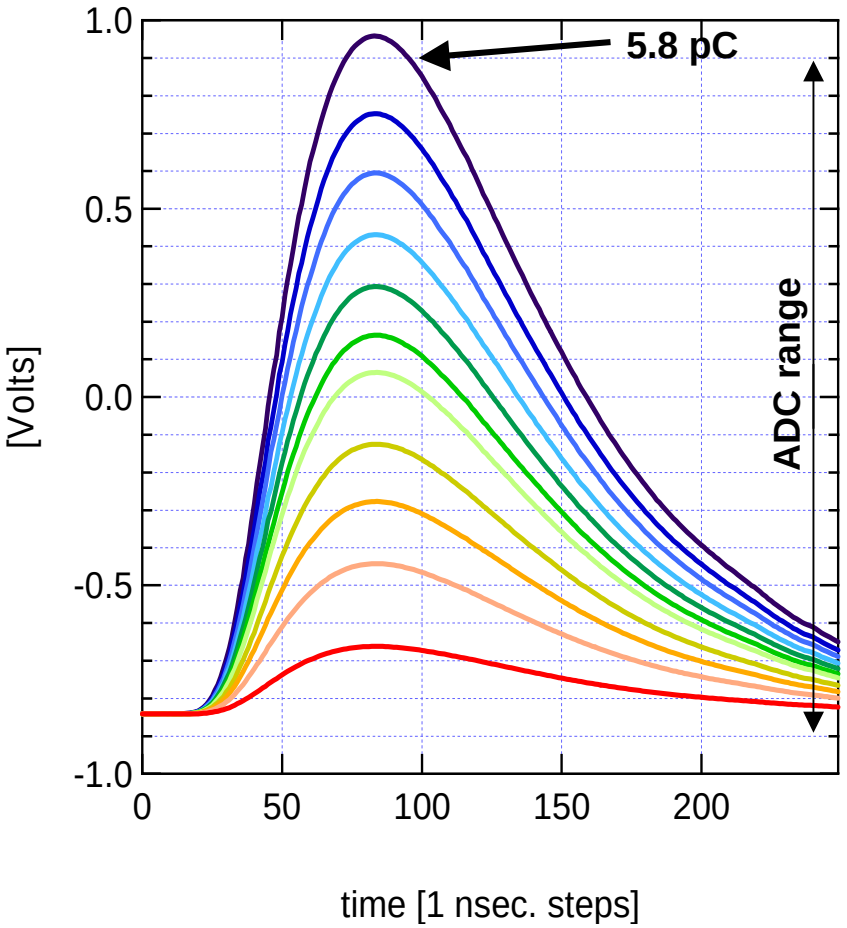


2) replace MGPA and measure pulse shapes for different signal sizes



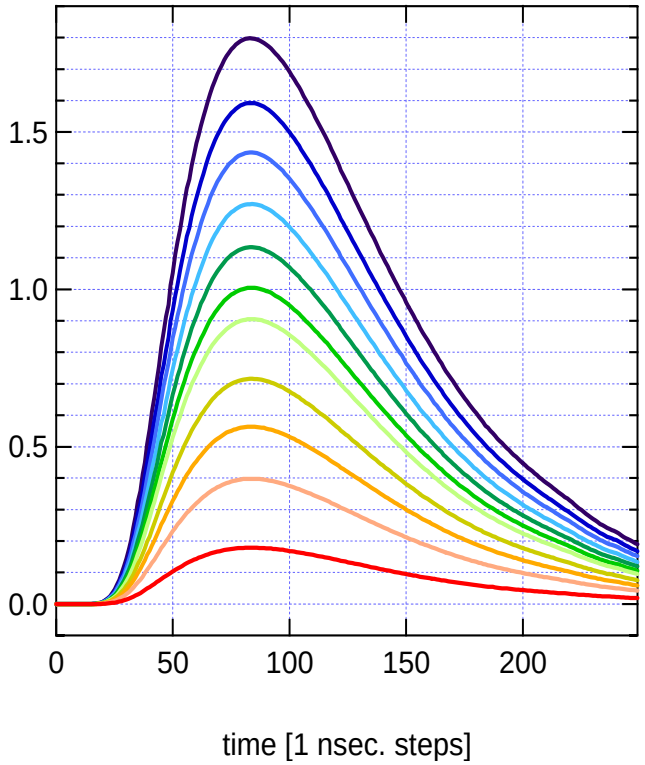
pulse shapes measured with 1ns resolution by sweeping time of charge injection using prog. delay

Typical non-linearity measurement (1)



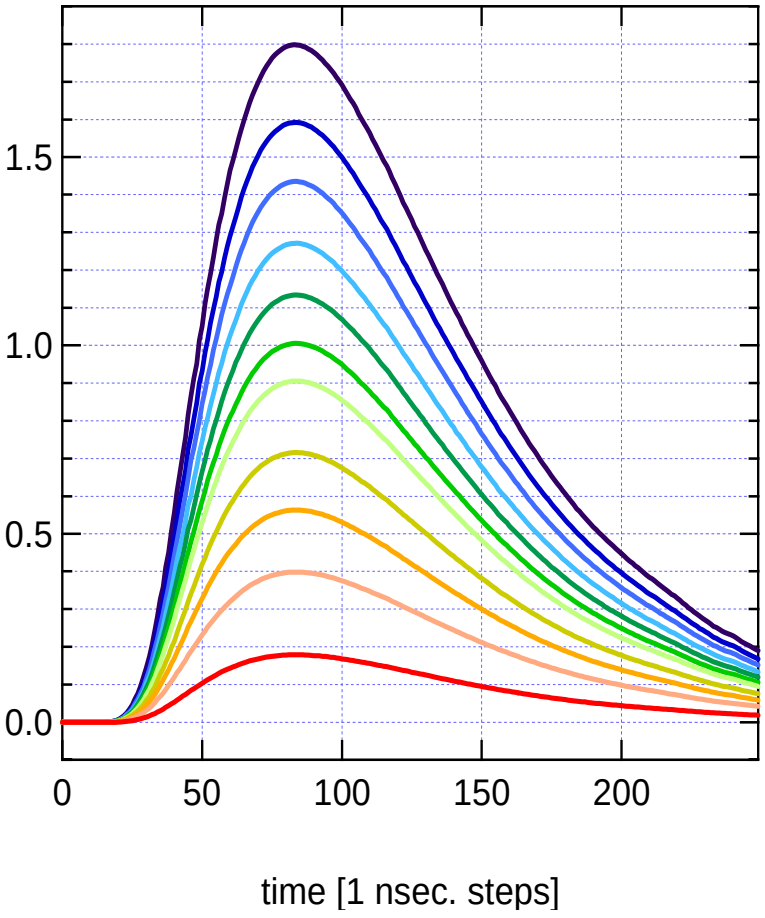
high gain channel (VFE card)
180 pF Cin added
fullscale signal = 5.8 pC
signal sizes not linearly spaced because of logarithmic attenuator steps

subtract pedestals



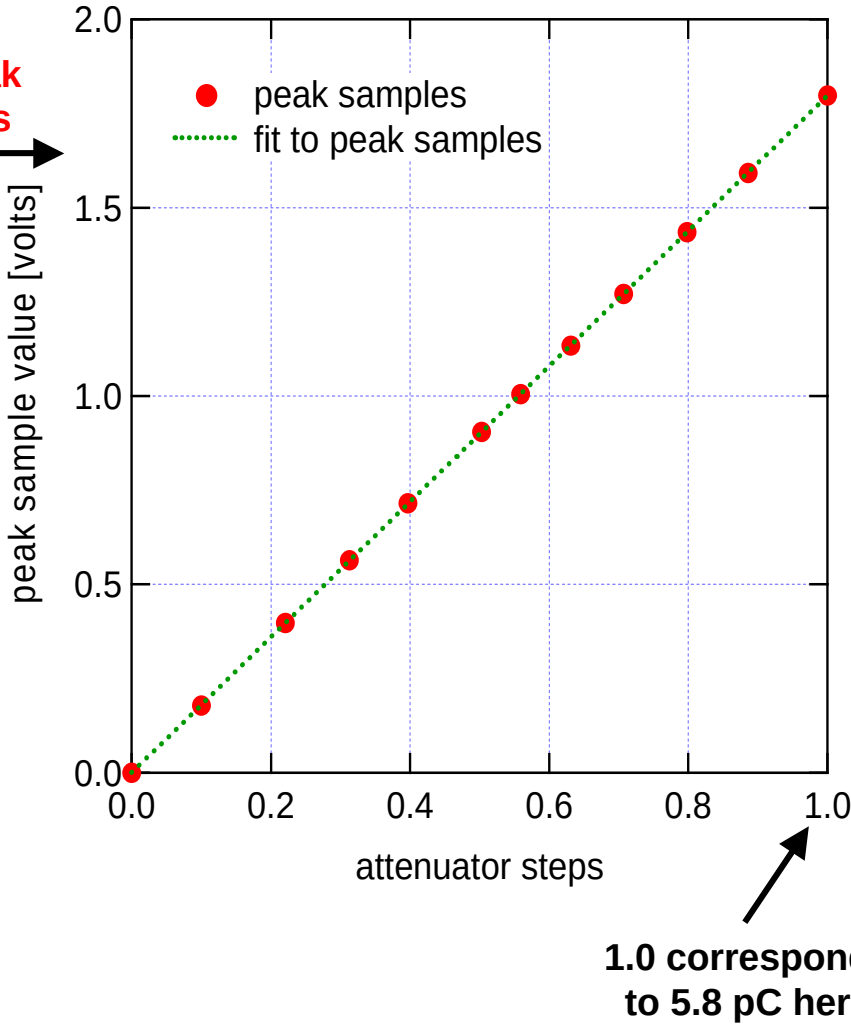
Typical non-linearity measurement (2)

pedestal subtracted pulse shapes



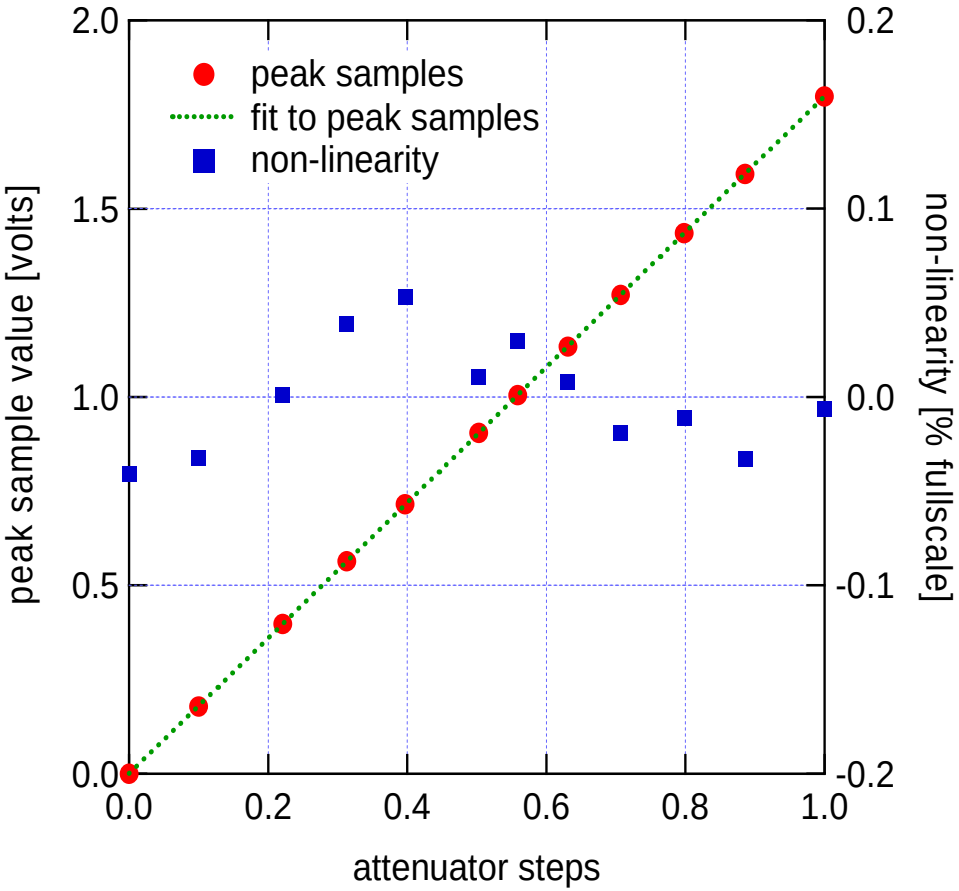
take peak samples and fit

peak sample vs. attenuator value



1.0 corresponds to 5.8 pC here

Typical non-linearity measurement (3)

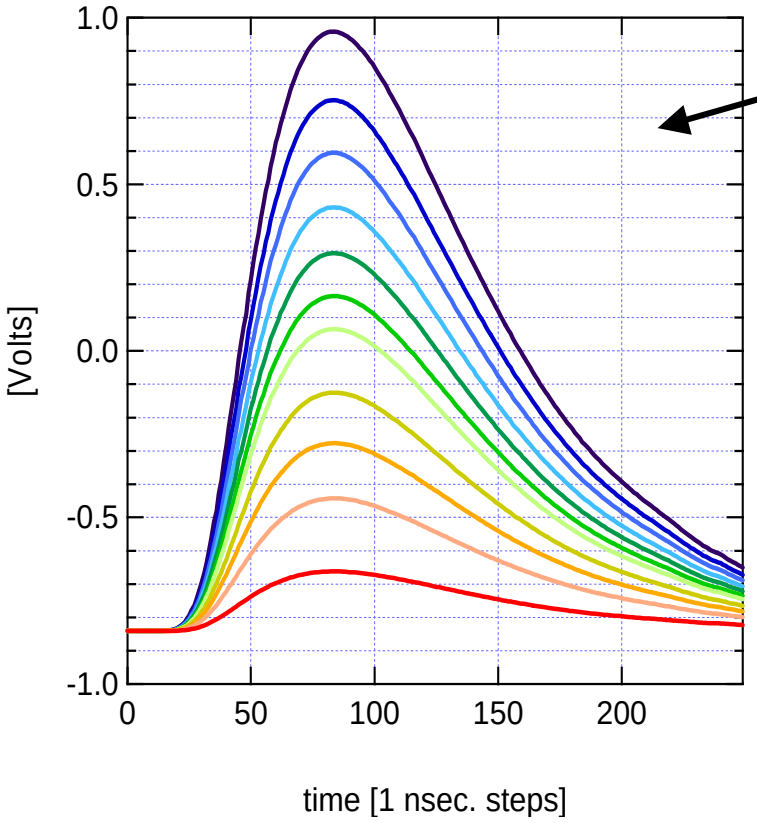


finally calculate linearity

Non-linearity [% fullscale] =

$$\frac{\text{peak pulse ht. – fit (to pk pulse ht)}}{\text{fullscale signal (1.8 V)}} \times 100$$

Pulse shape matching

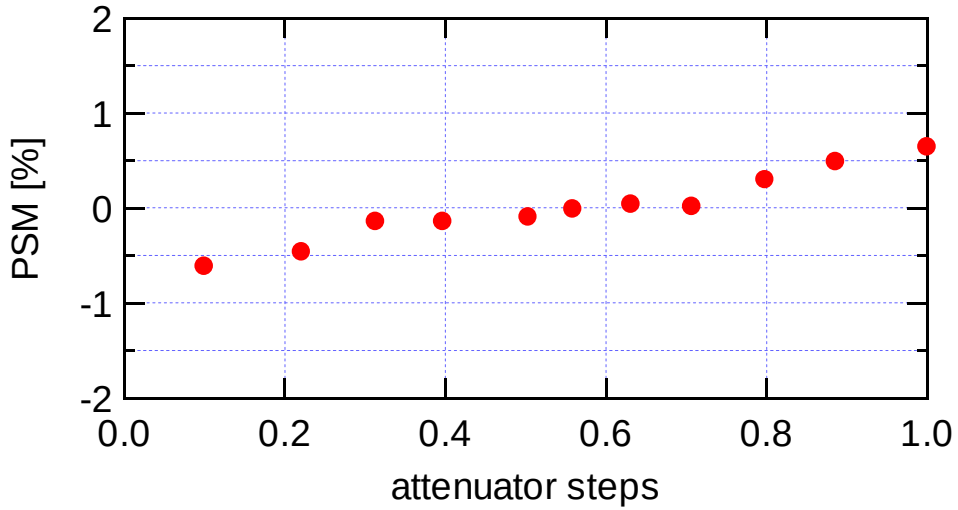


can also calculate pulse shape matching for same data

PSMF = peak sample value / sample 25ns before

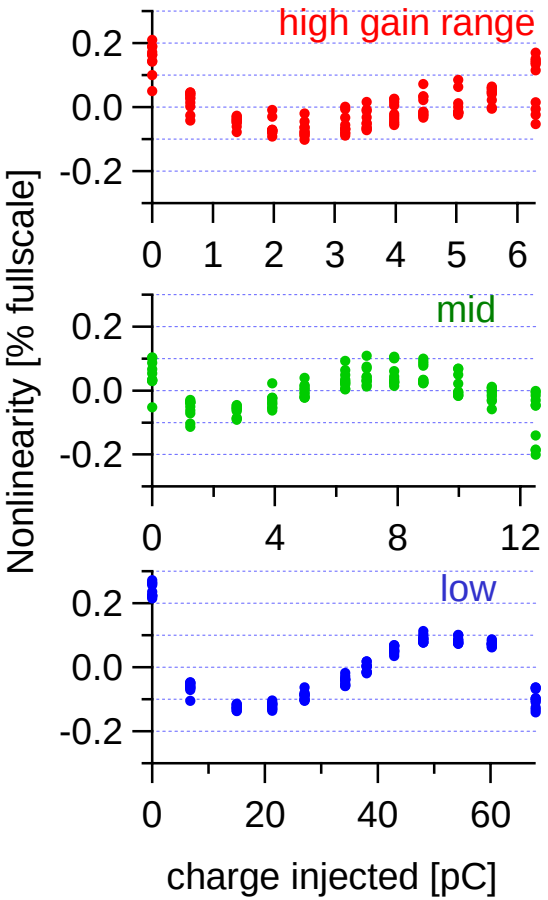
Pulse Shape Matching = (PSMF – Average PSMF) / Average PSMF

Average PSMF = average over all pulse shapes



Some non-linearity results (old)

MGPA Version 1



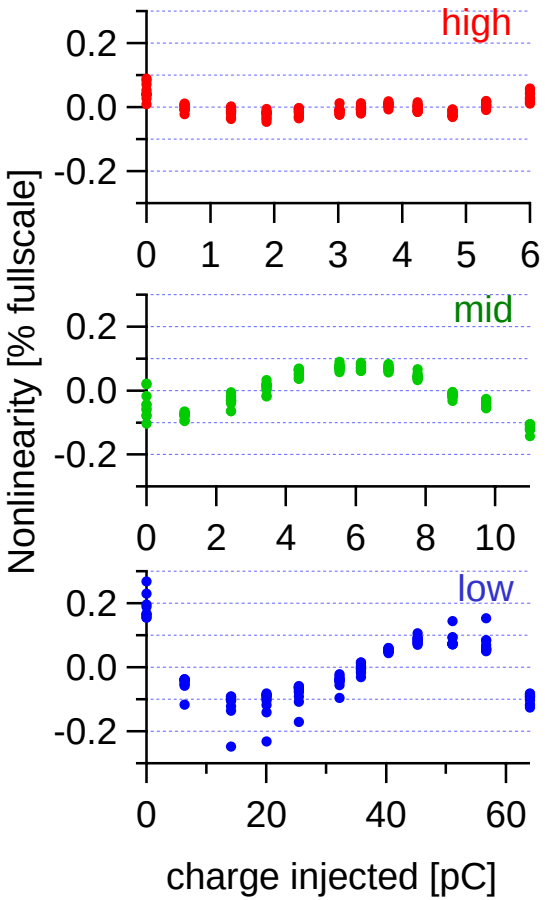
10 chips measured for each MGPA version

v. similar results V1 cf. V2

nonlinearity within (or close to) ± 0.1% specification

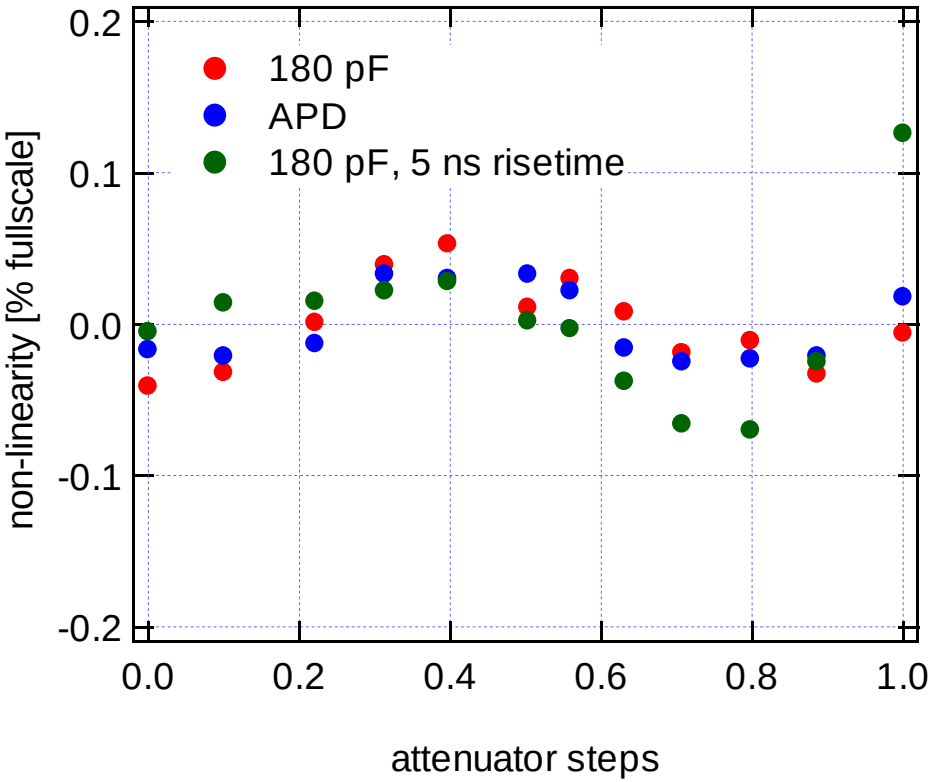
these measurements made on RAL card using simulated APD capacitance

MGPA Version 2



New results

Hi gain channel non-linearity measured on VFE card



Why is non-linearity worse in H4 beam?
(noticeable fall-off for small signals on high gain channel)

Could there be an APD effect?

No – no significant difference between 180 pF and APD biased at 350 V

Could signal risetime be shorter than expected?

No - changing charge injection 10ns -> 5ns doesn't make much difference
(at least for high gain channel)

Final thoughts

non-linearity measured using procedure described here does not explain test beam results
results here within or very close to +/- 0.1% spec.

method used here will not include any contribution from ADC, but don't expect to be significant

could test beam linearity studies be more sensitive to pulse shape?

PSM within design spec. but does tend to show similar trend to test beam linearity plots