Development of Low Noise / Low Power Preamplifier for Low Gain Photosensors

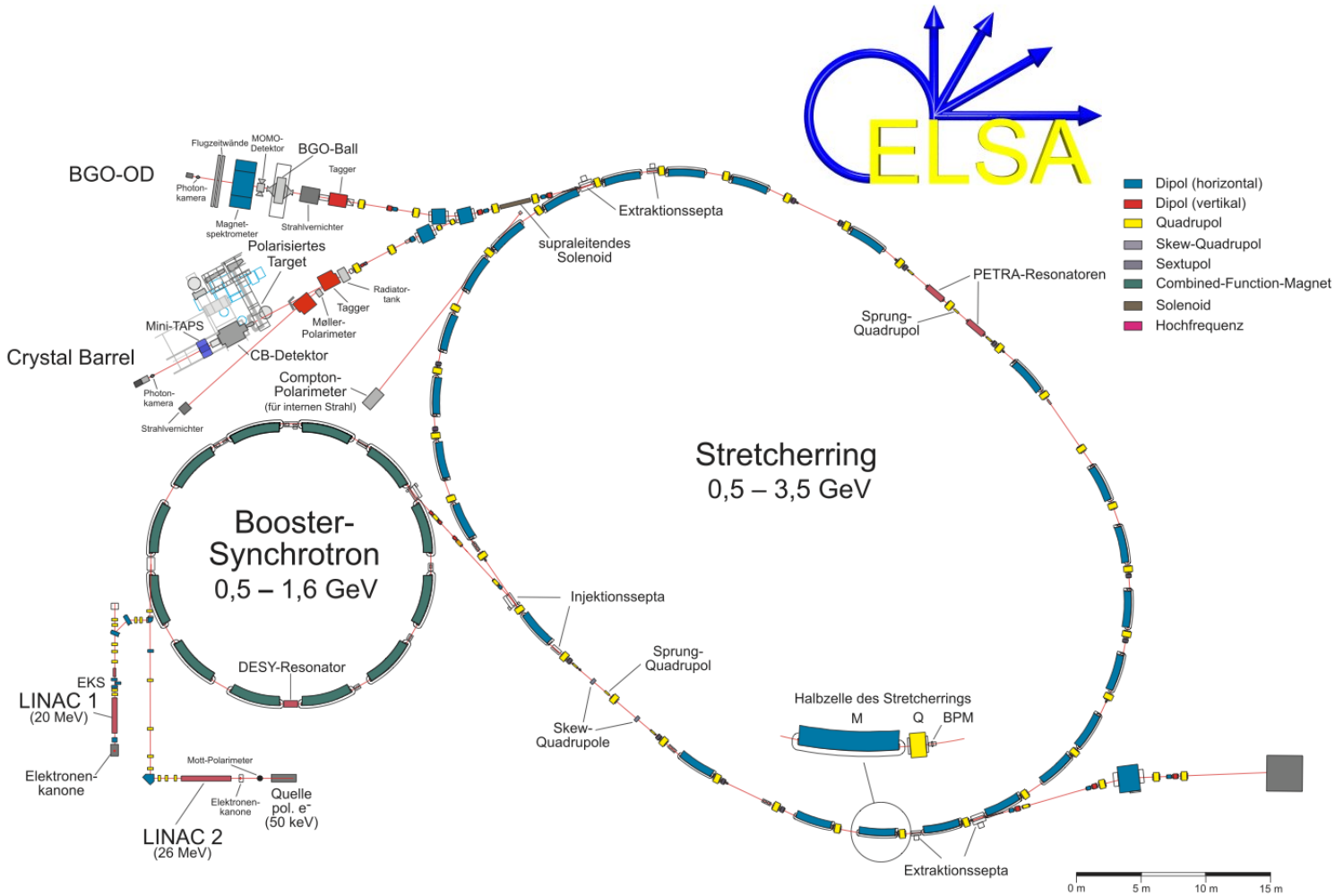
Irakli Keshelashvili

/* University of Basel */

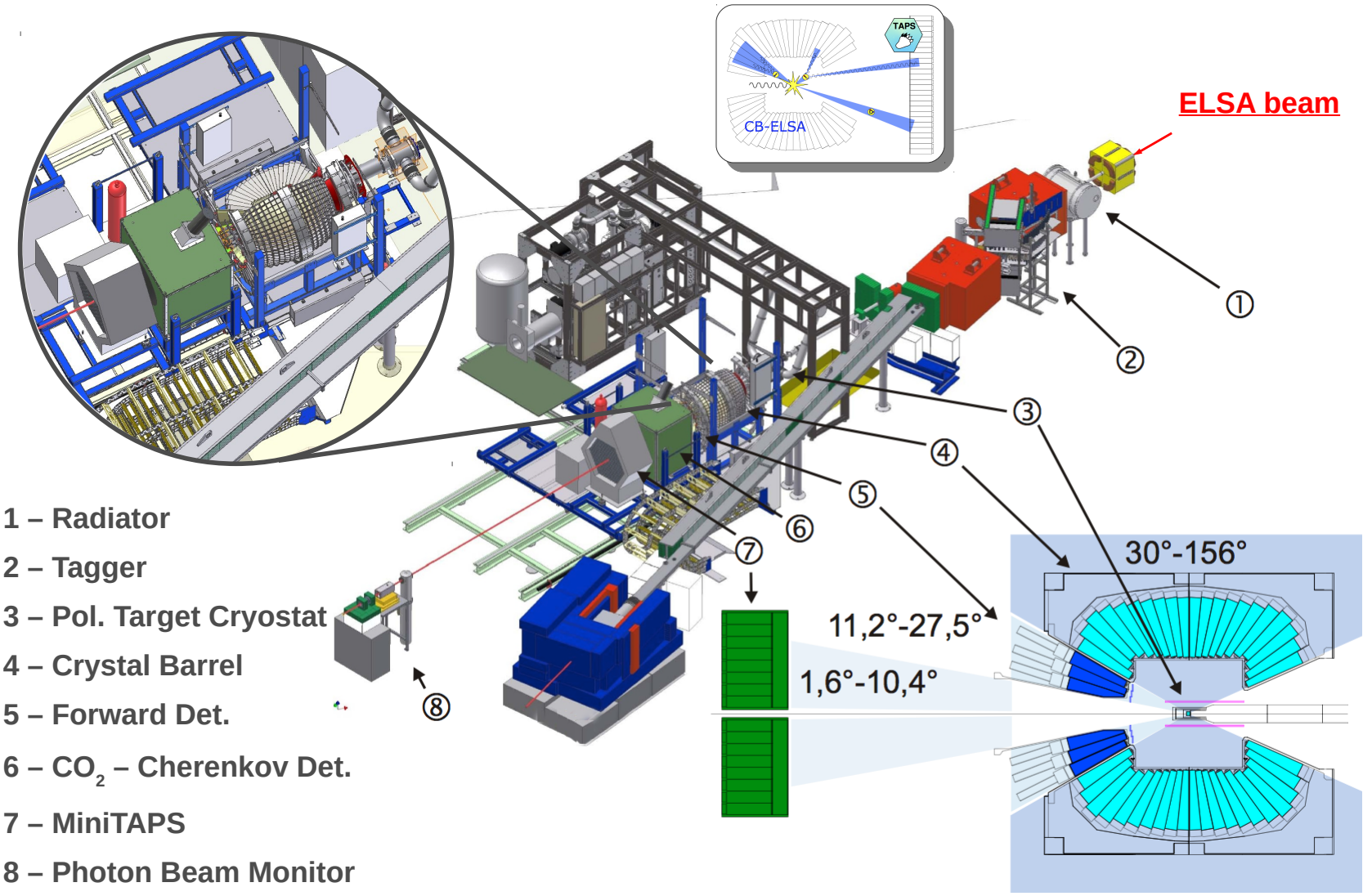
– Forschungszentrum Jülich –

July 11, 2014

Electron Stretcher Accelerator – **ELSA**



The Crystal Barrel / TAPS Detector at ELSA



1 – Radiator
2 – Tagger
3 – Pol. Target Cryostat
4 – Crystal Barrel
5 – Forward Det.
6 – CO_2 – Cherenkov Det.
7 – MiniTAPS
8 – Photon Beam Monitor

Crystal Barrel / TAPS @ ELSA (Uni. Bonn)

Material: CsI (Tl)

Crystal size: $(6^0 \times 6^0) \times 30$ cm

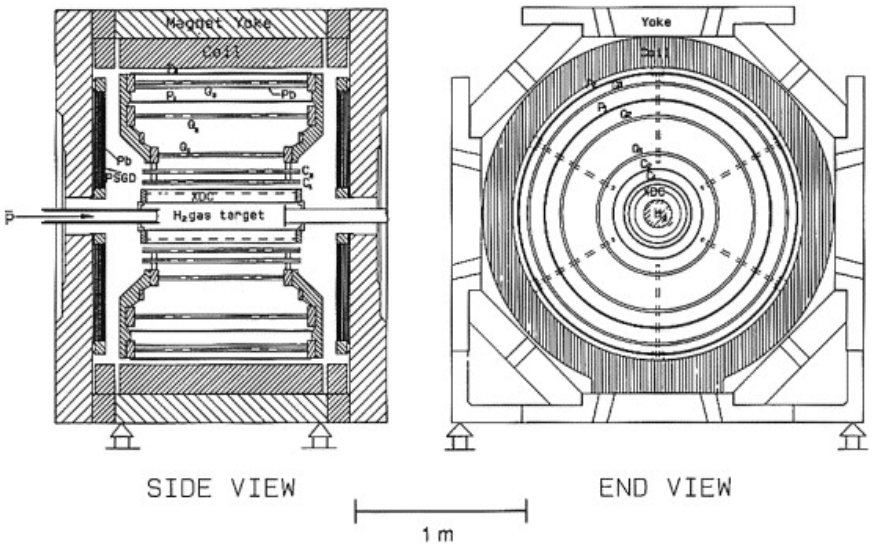
Thickness: 16.1 X_0

Energy res.: 0.5/E 1.6/√E 0.35%

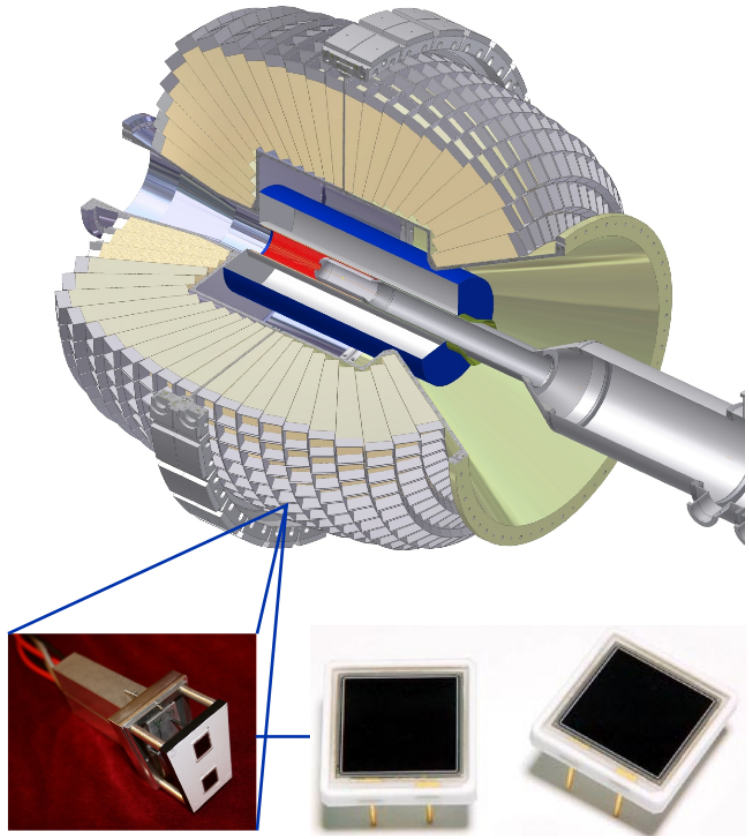
Time res.: I level trigger: PIN no / APD YES!

# of crystals: 1380 (**2760 LNP PreAmps**)

Coverage: 98% 4π



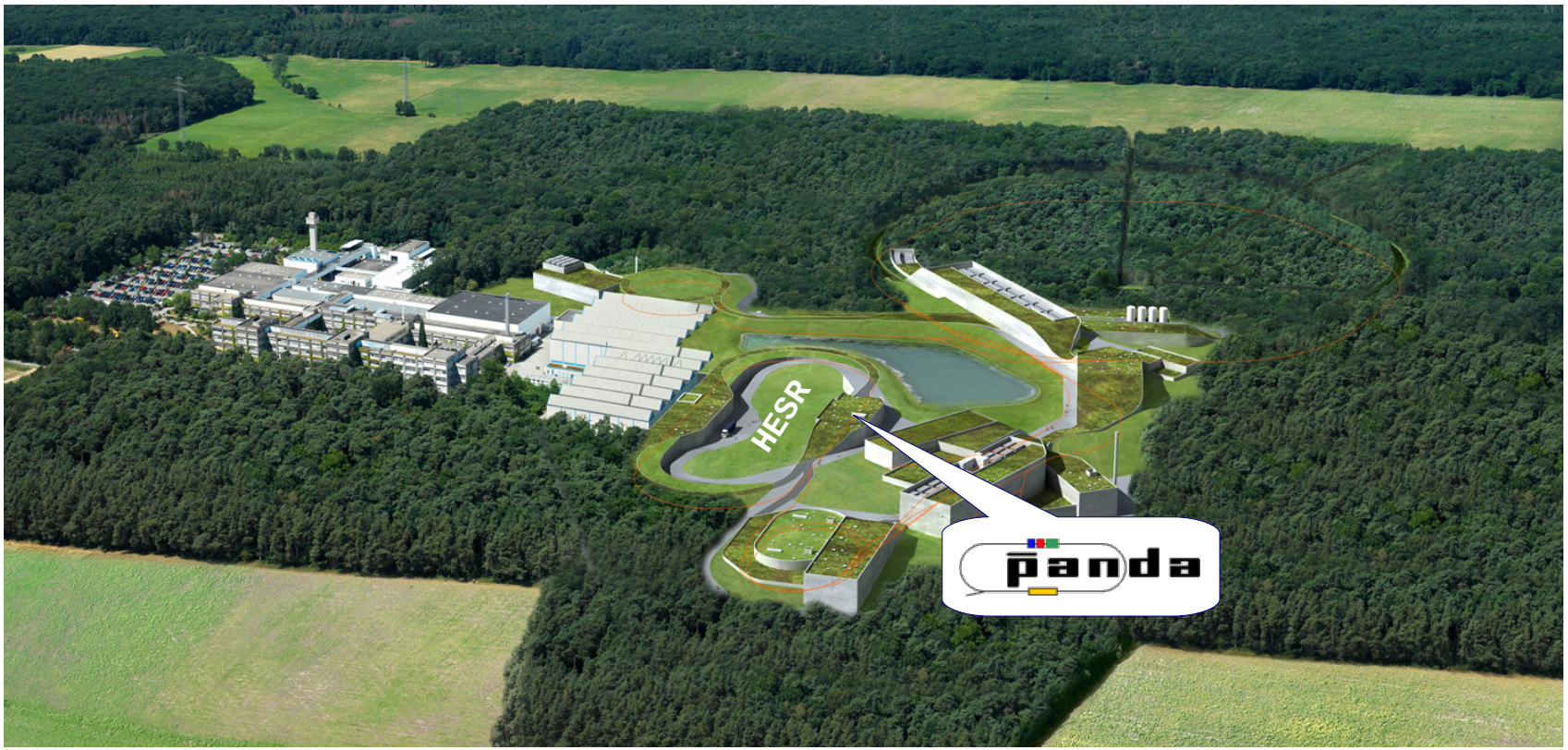
PIN --> APD



Future Project – HESR @ FAIR

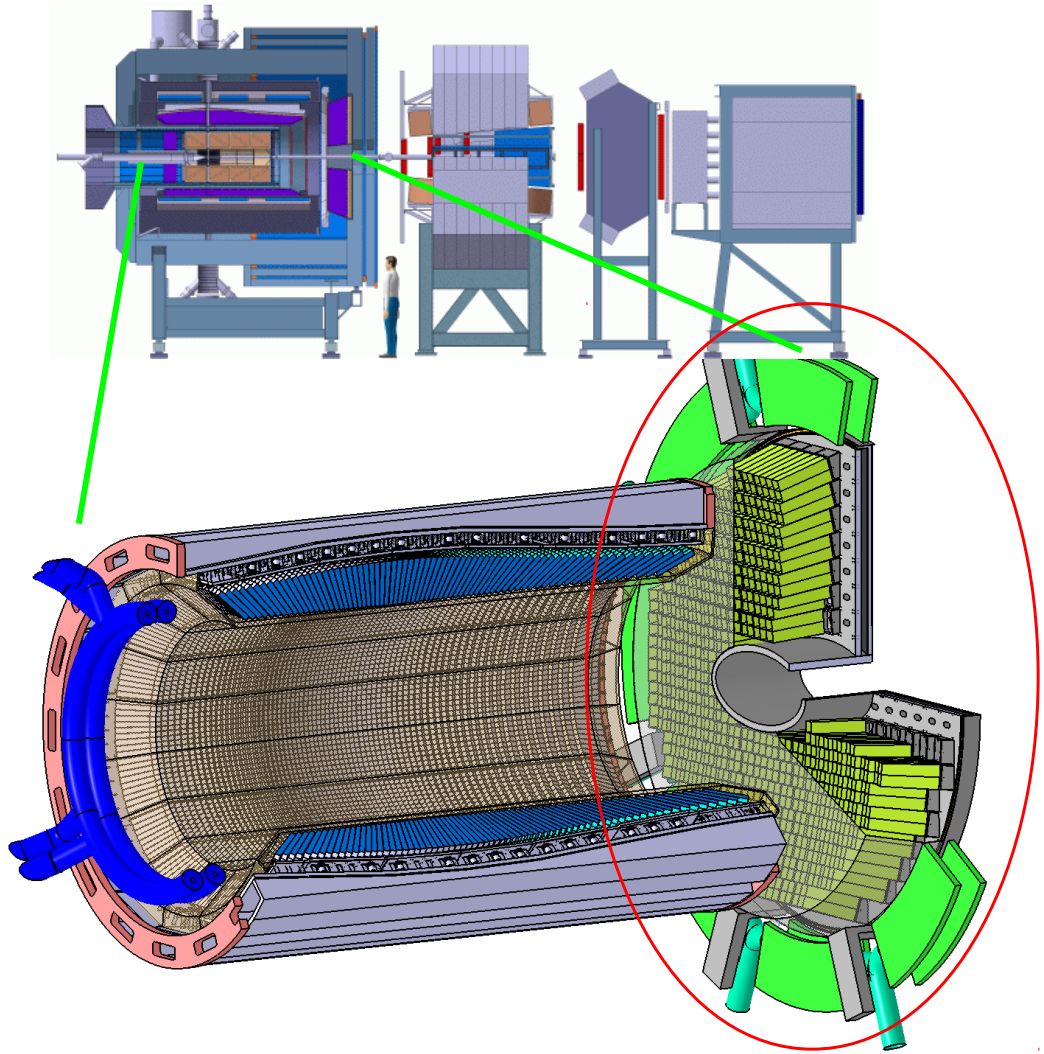
FAIR (Facility for Antiproton and Ion Research)

HESR (High Energy Storage Ring)

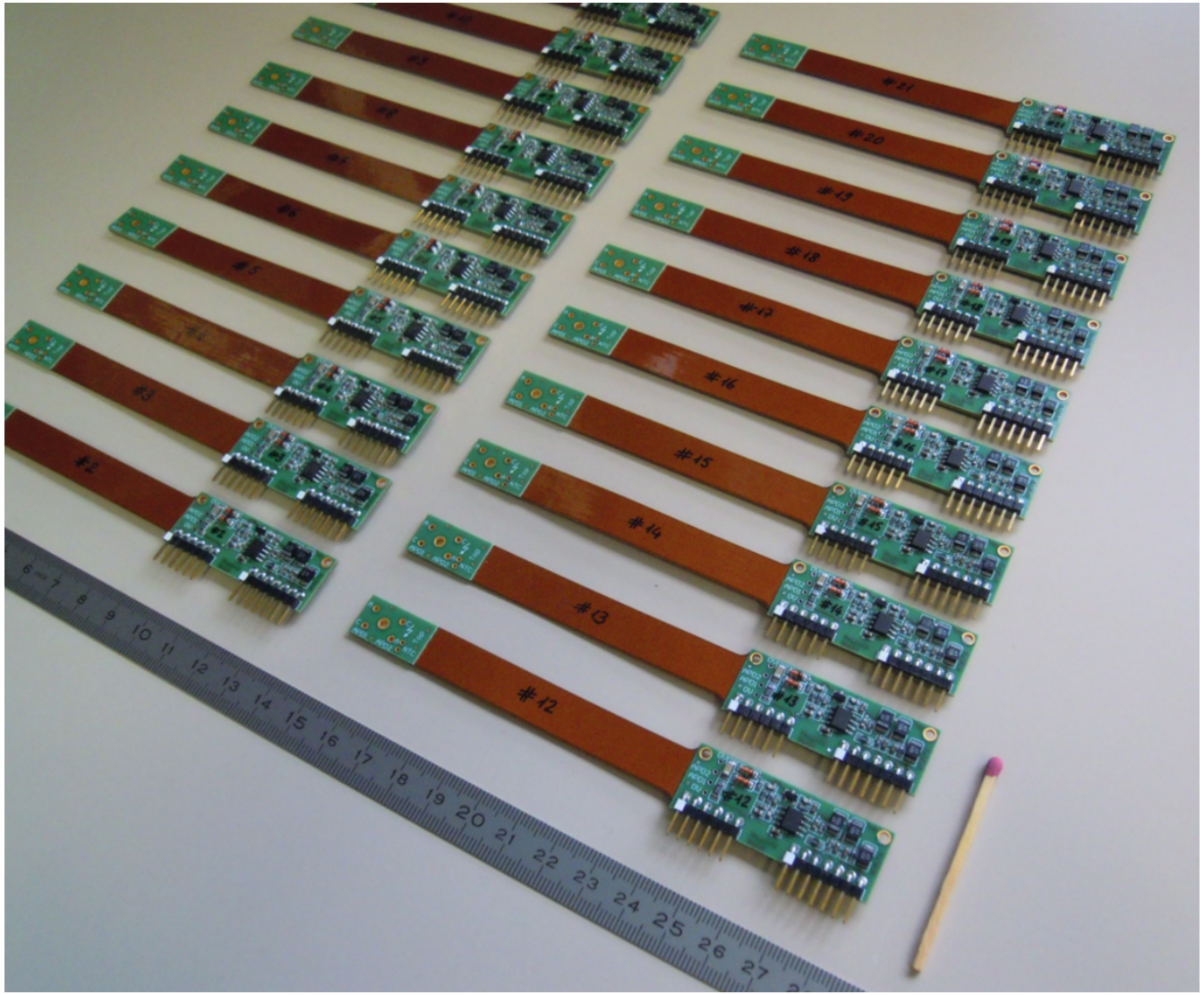


PANDA Fw. EMC @ HESR

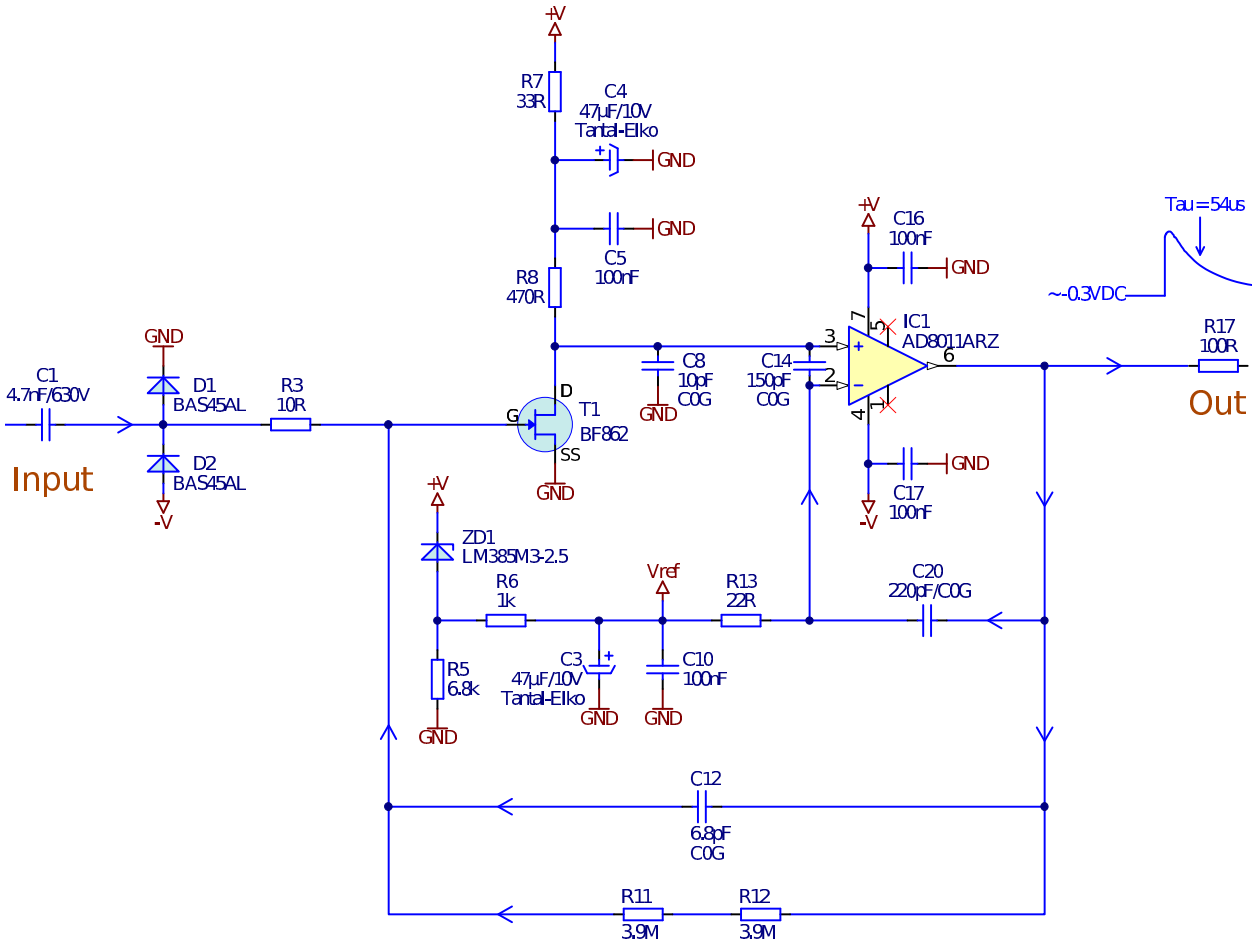
Material:	$PbWO_4$ (-25C°)
Crystal size:	2 cm x 2 cm x 20 cm
Thickness:	22 X_0
Energy res.:	1.54% / √E/[GeV]+0.3%
Time res.:	< 2 ns
#Fw. crystals:	3600 (Tot.: 15552)
Very Fw.:	1 VPTT & 1 Preamp
Rest:	2 LAAPD & 2 Preamp
Coverage:	96% 4π



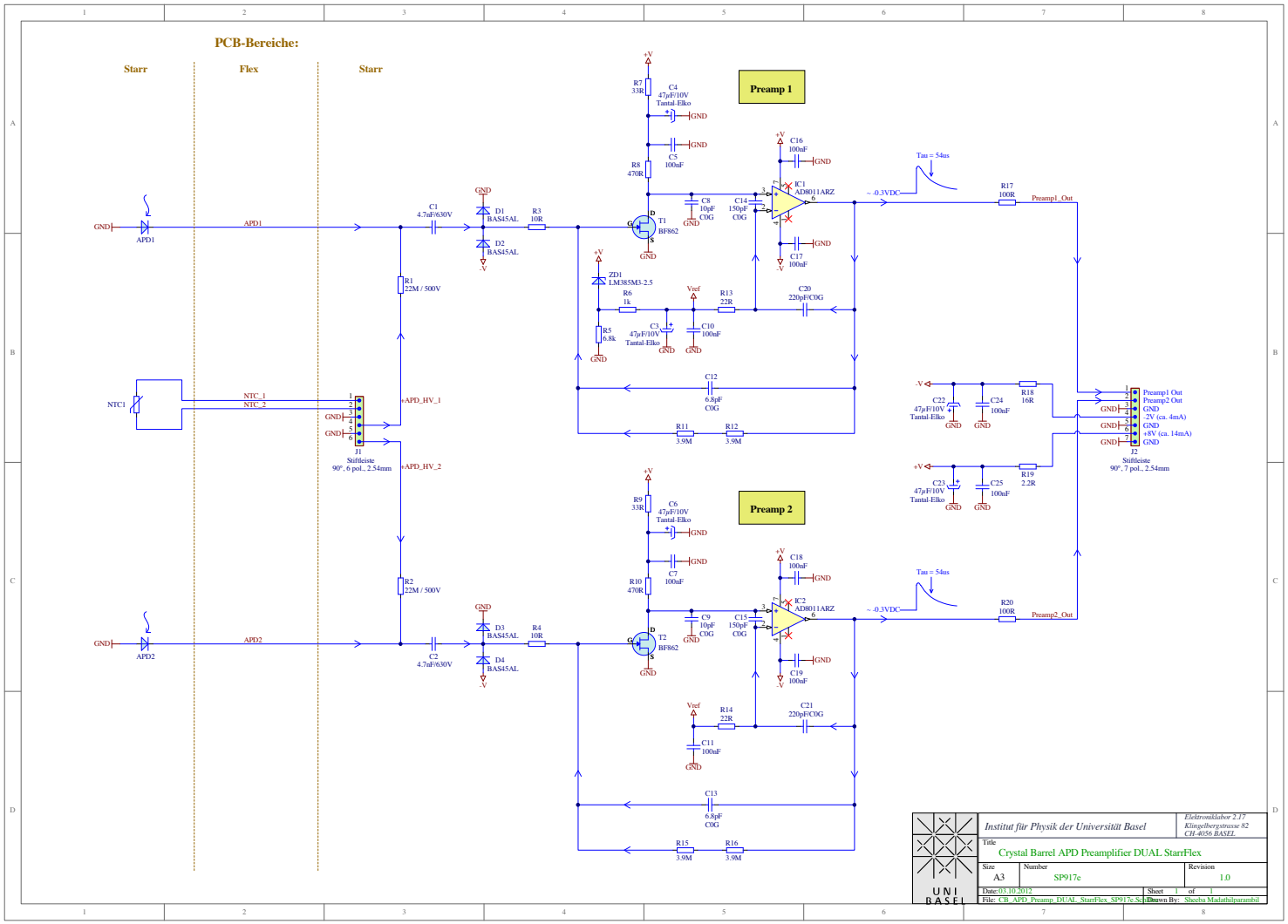
Basel LNP PreAmp's for Crystal Barrel



Electronic Circuit of Basel LNP



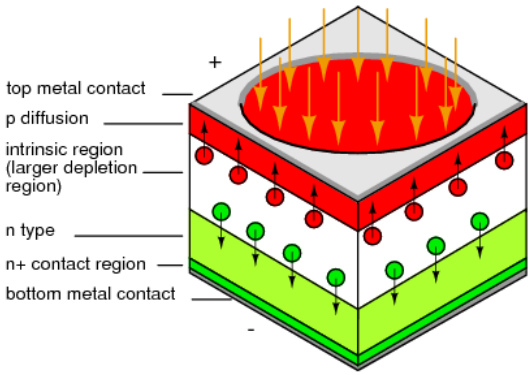
Electronic Circuit for Crystal Barrel upgrade (APD)



Photosensors

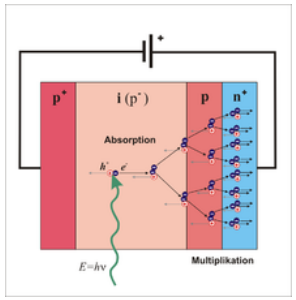
PIN

P-Intrinsic-N



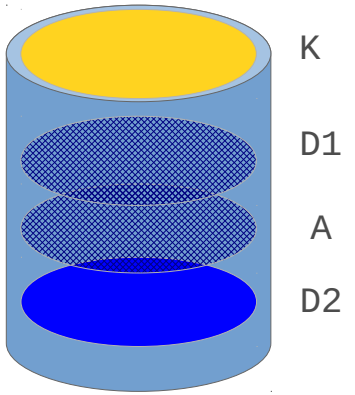
APD

Avalanche photodiode



VPTT

Vacuum Photo-Tetrode



Motivation

- No access to preamplifier modules
- Best LNP's - minimal calibration - PHYSICS

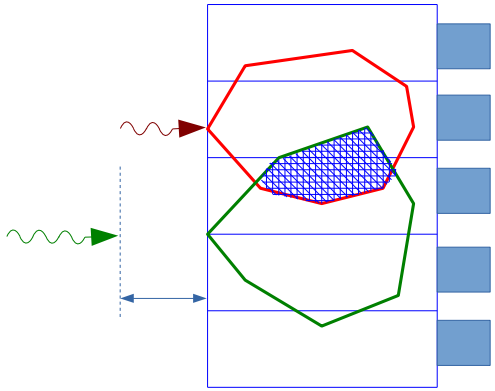
Motivation

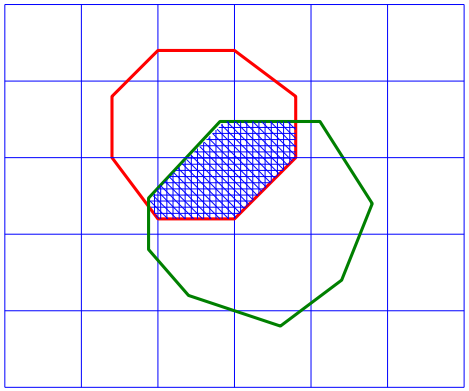
- No access to preamplifier modules
- Best LNP's - minimal calibration - PHYSICS
- Automatisation 4 large # of preamplifiers - Tot: 10'000
- Qualitative/quantitative test of all PreAmps

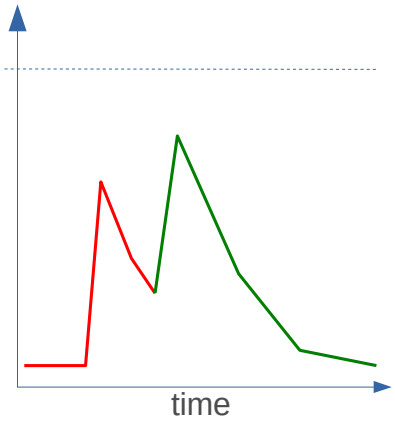
Motivation

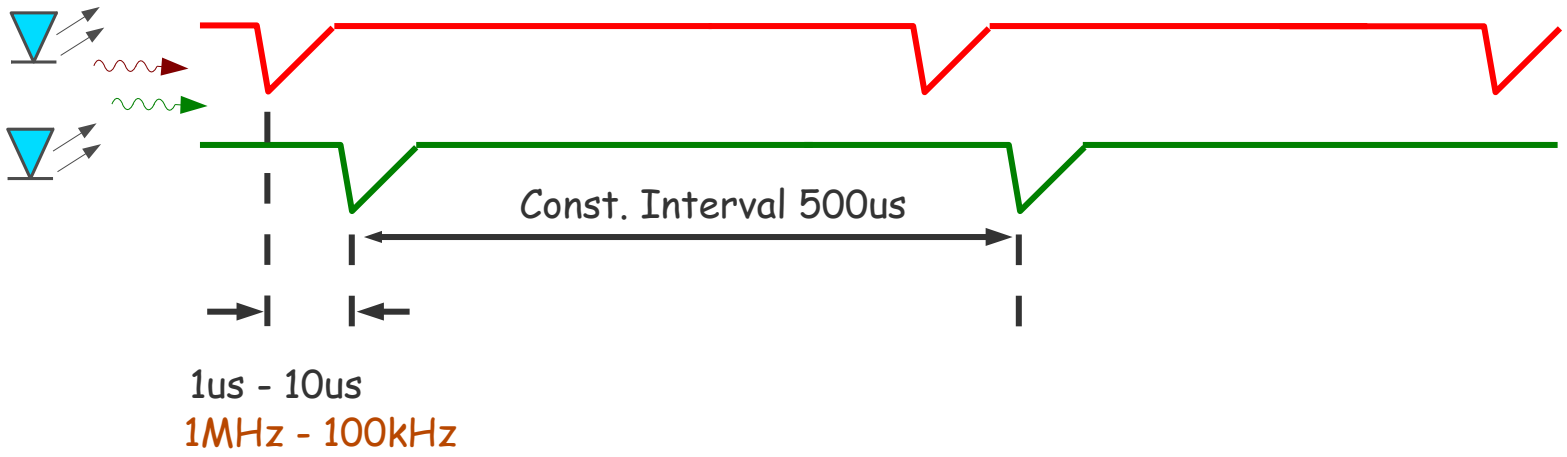
- No access to preamplifier modules
- Best LNP's - minimal calibration - PHYSICS
- Automatisation 4 large # of preamplifiers - Tot: 10'000
- Qualitative/quantitative test of all PreAmps
- HV, Power, Signal shape, Gain, Linearity, Noise

Pile-Up Test (relevant for PANDA)

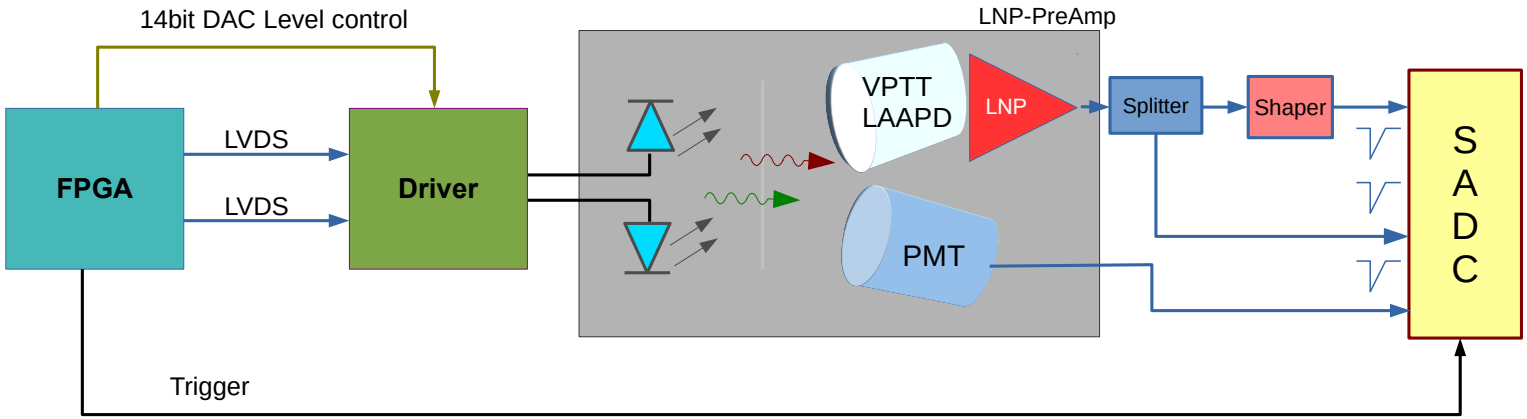




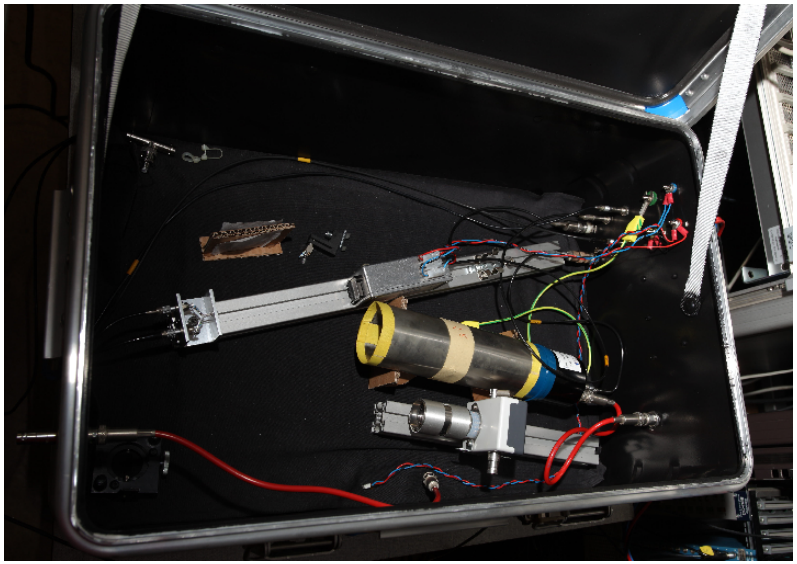




Pile-Up Test Setup for VPTT

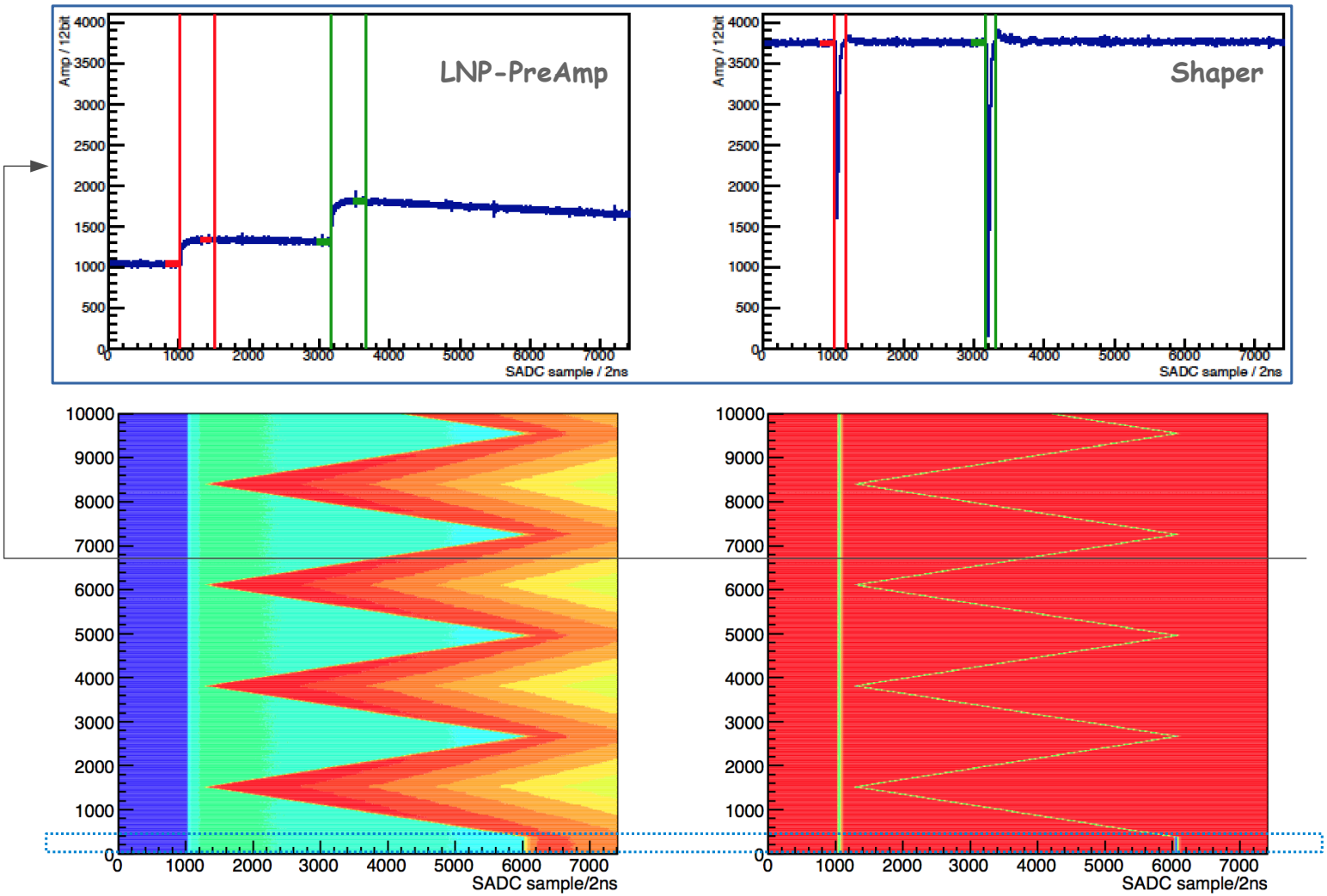


Xilinx Spartan-3AN
LED driver/signal

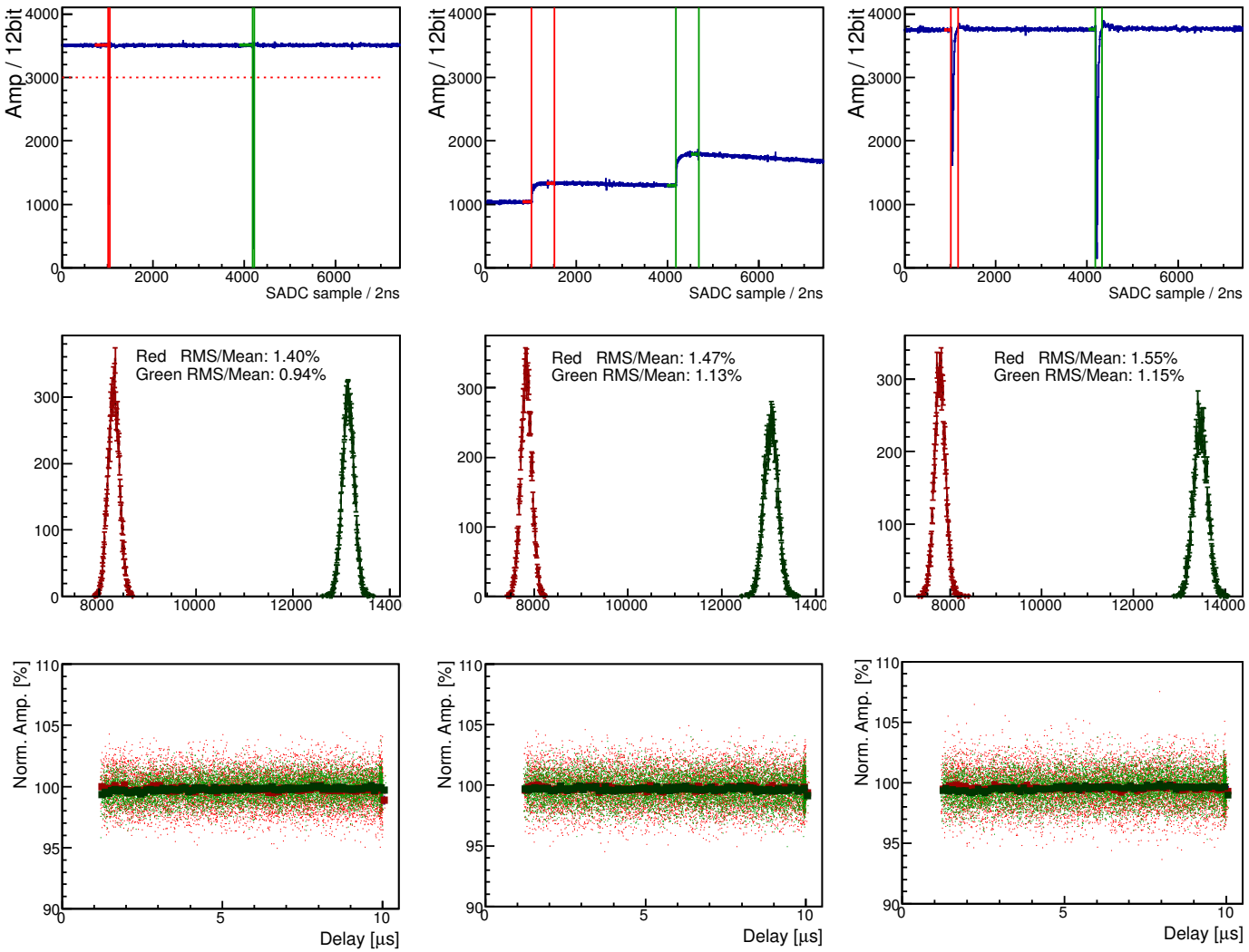


Struck 500MS/s 12bit
500MHz VME SADC

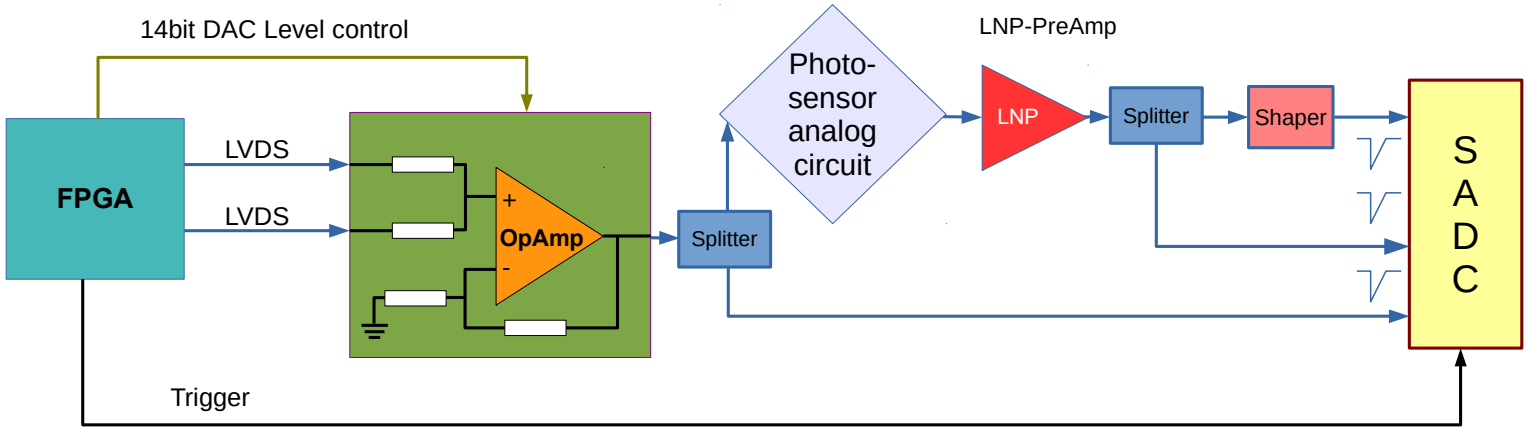
Pile-Up Data Structure



Pile-Up Test (PMT, **VPTT**, Shaper)



Pile-Up Test Setup using Generator

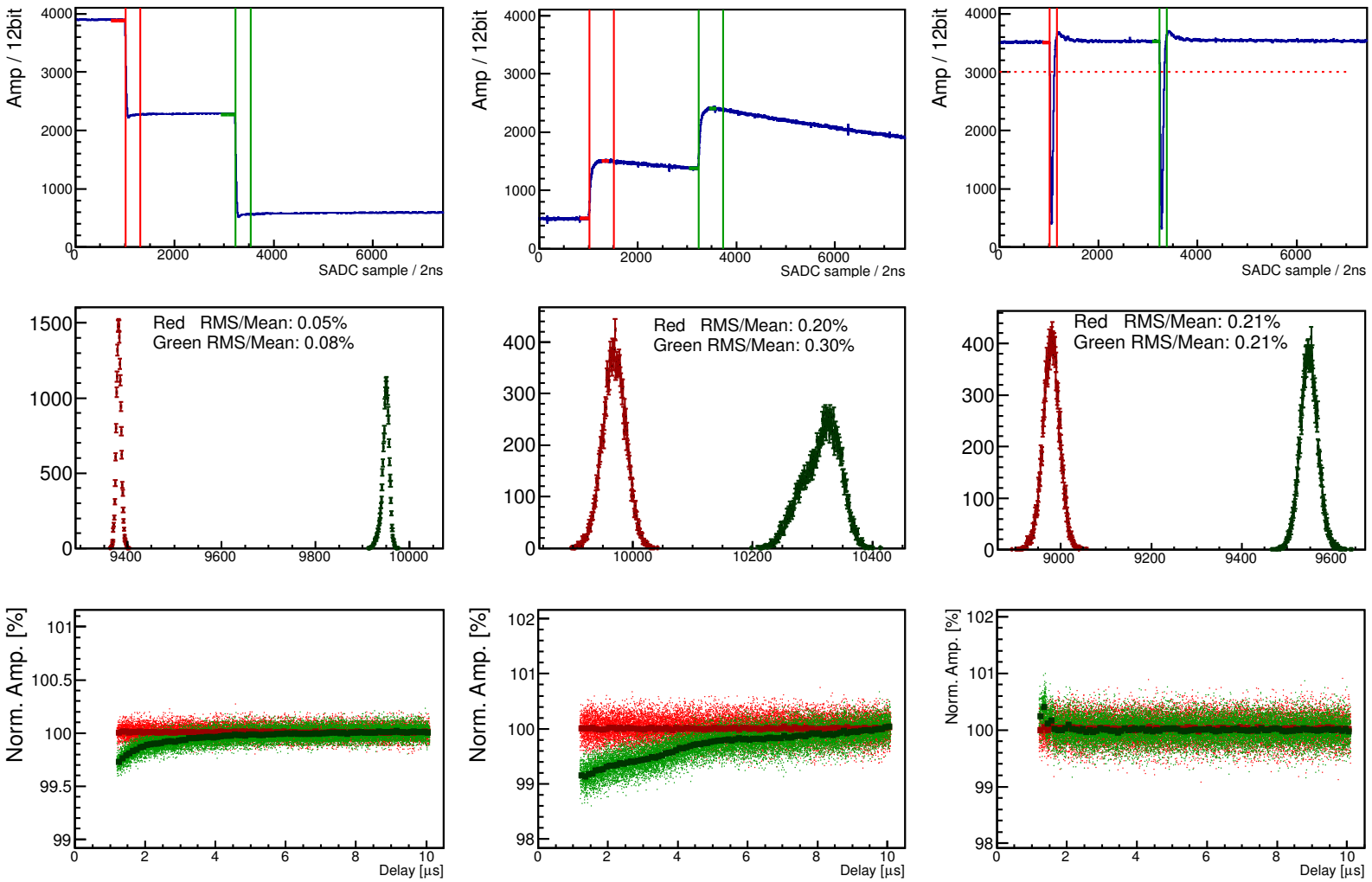


Xilinx Spartan-3AN
LED driver/signal

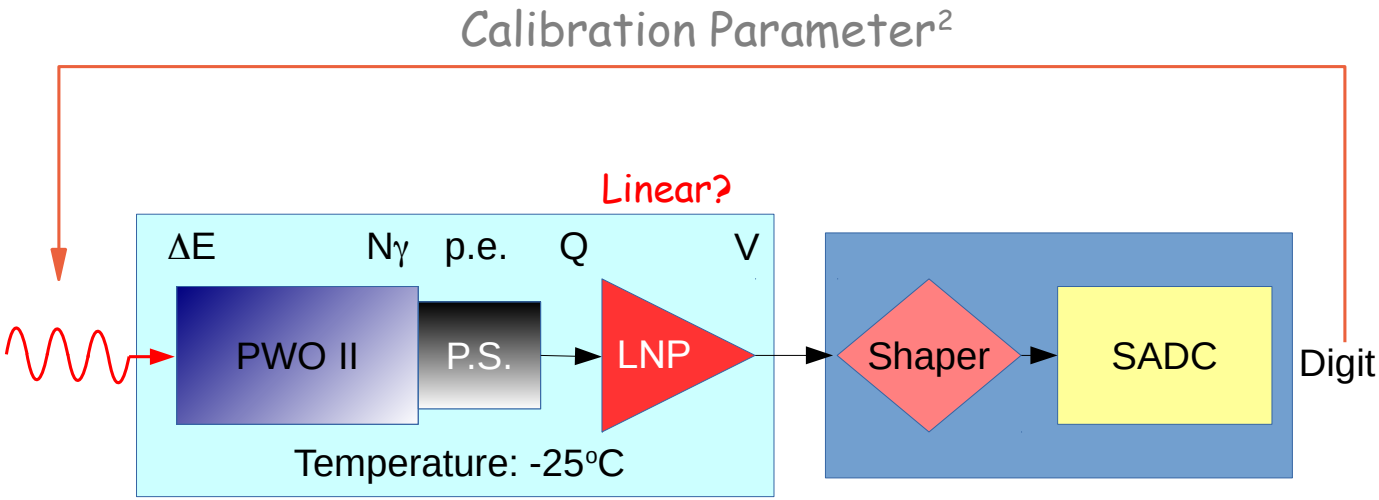
Small VME DAQ system
C++/ROOT based

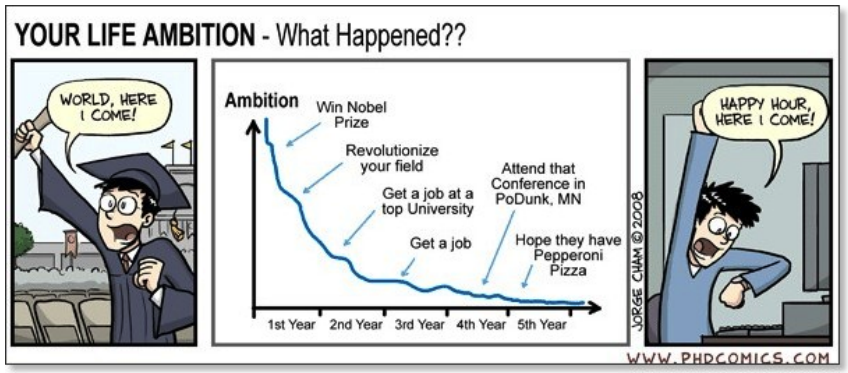
Struck 500MS/s 12bit
500MHz VME SADC

Double Burst Test using Generator

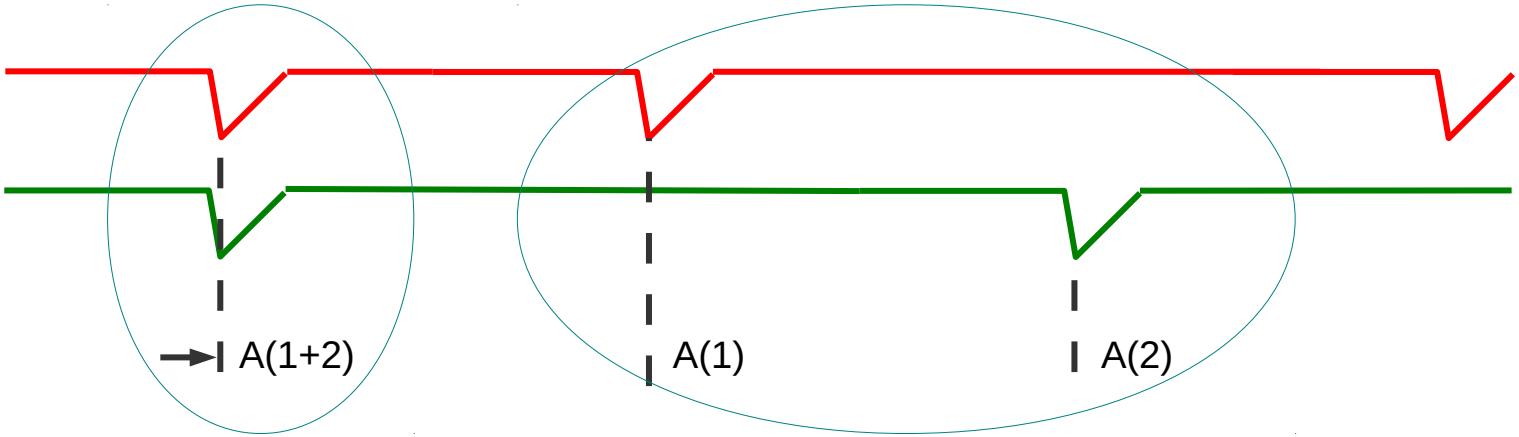


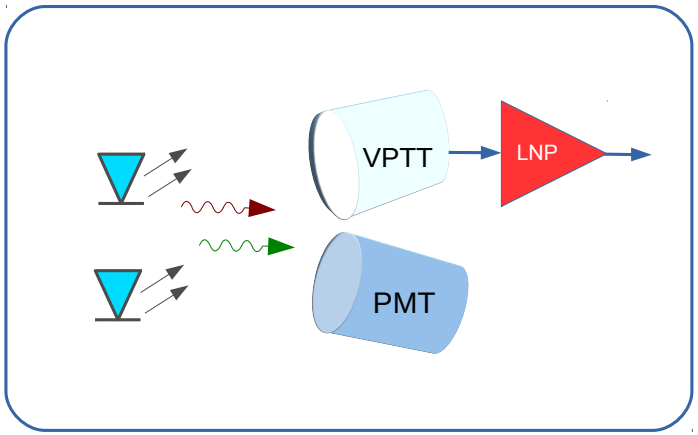
Amplitude Linearity

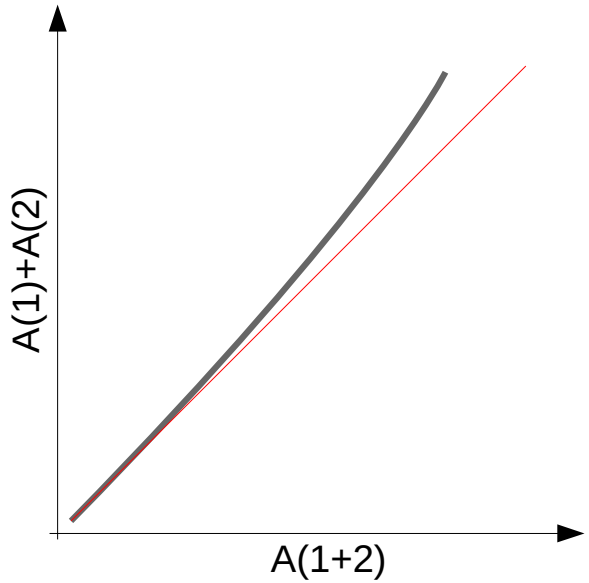




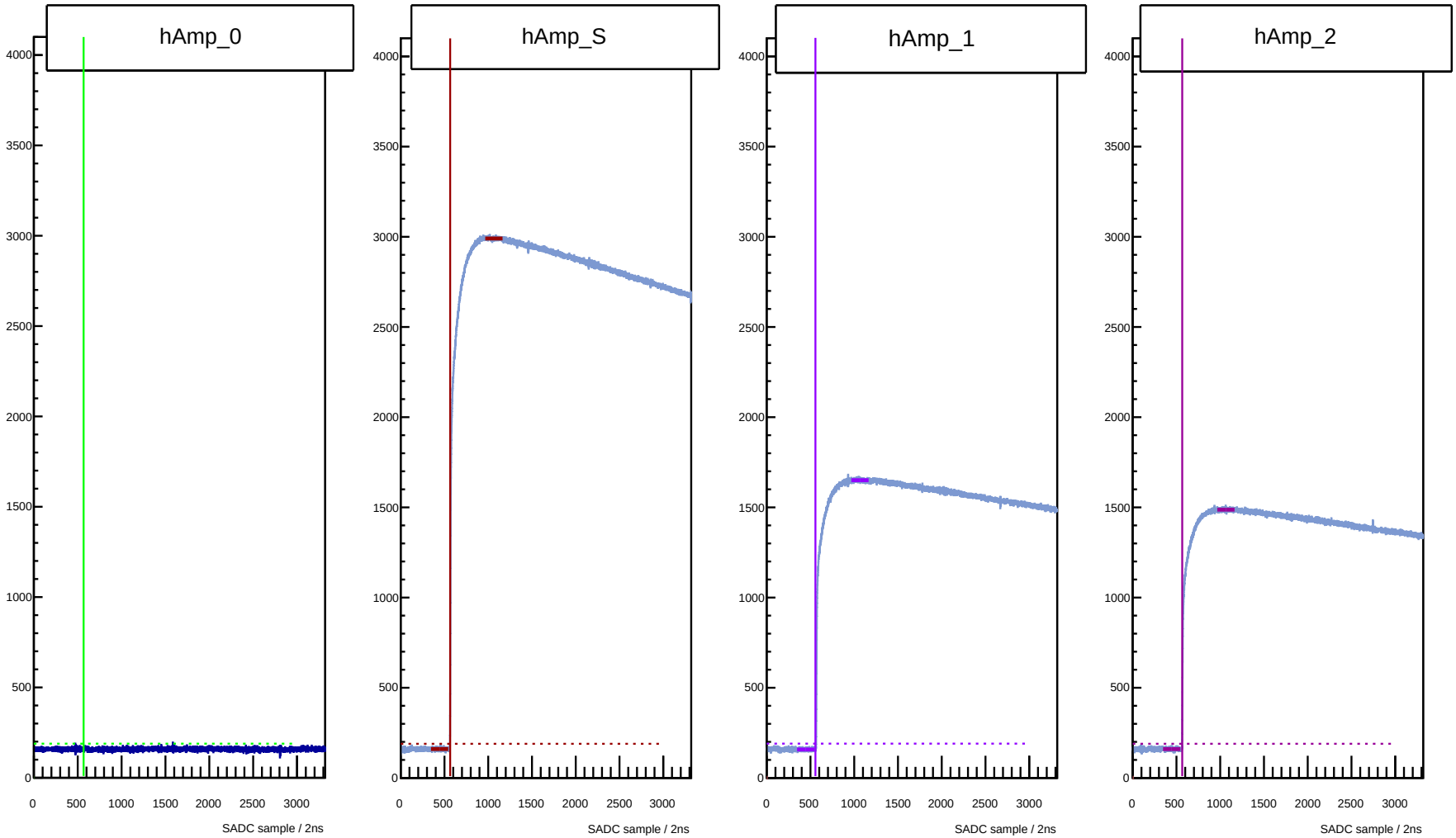
Method for Amplitude Linearity Test



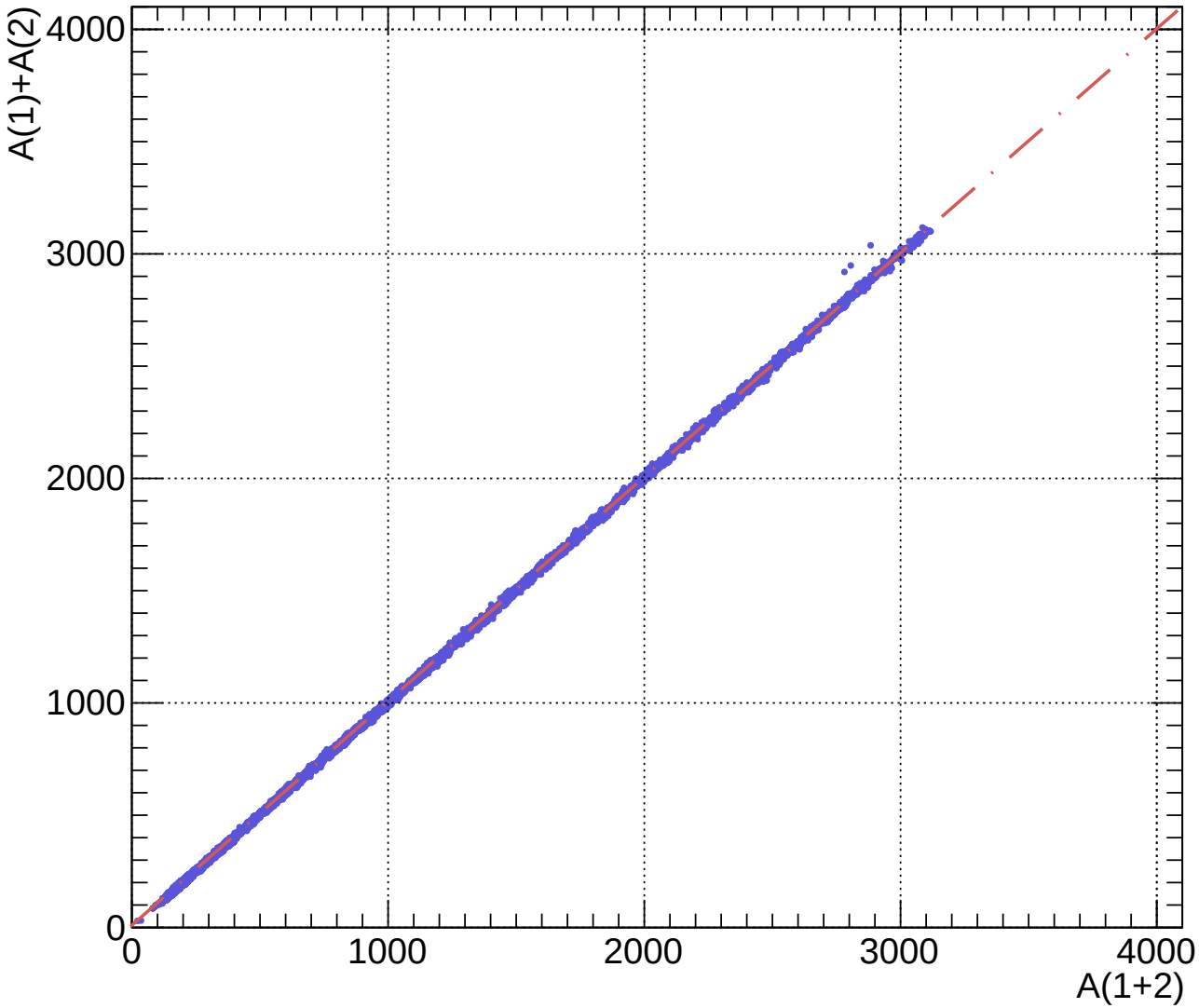




Amplitude Linearity Signal Extraction using VPTT



Amplitude Linearity Test using VPTT



Radiation Hardness - ^{60}Co source

JUSTUS-LIEBIG-
UNIVERSITÄT
GIESSEN

FACHBEREICH 07
Mathematik
und Informatik,
Physik, Geographie

II. Physikalisches Institut • Heinrich-Buff-Ring 16 • D-35392 Gießen

Universität Basel
z.Hd. Werner Erni

II. Physikalisches Institut

Till Kuske
Heinrich-Buff-Ring 16
D-35392 Gießen
Tel.: 0641 / 99 – 3 32 72
Fax.: 0641 / 99 – 3 32 09
Email: till.kuske@exp2.physik.uni-giessen.de
Az.:

25.02.2014

Rücksendung der bestrahlten Elektronik

Hallo Werner,

wie gefordert haben wir die Elektronik im Strahlenzentrum mit Cobalt Quellen bestrahlt.

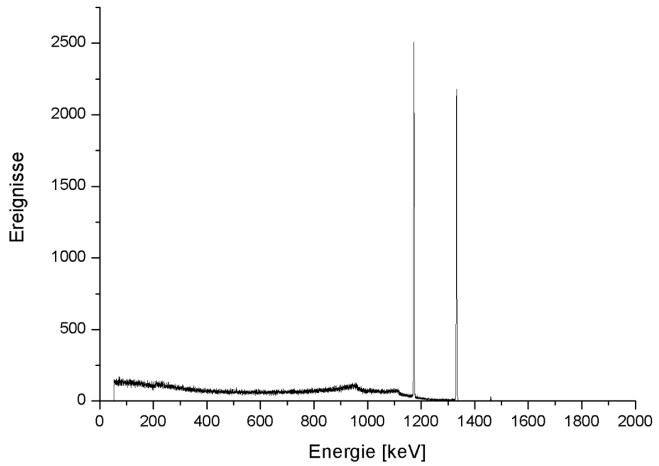
Das aktive Bauteil hat eine Strahlungsdosis äquivalent zu 30kGy abbekommen (verglichen mit unserer Bestrahlung von PWO-II) und lief die ganze Zeit ohne Anstieg des Stroms oder der Temperatur.

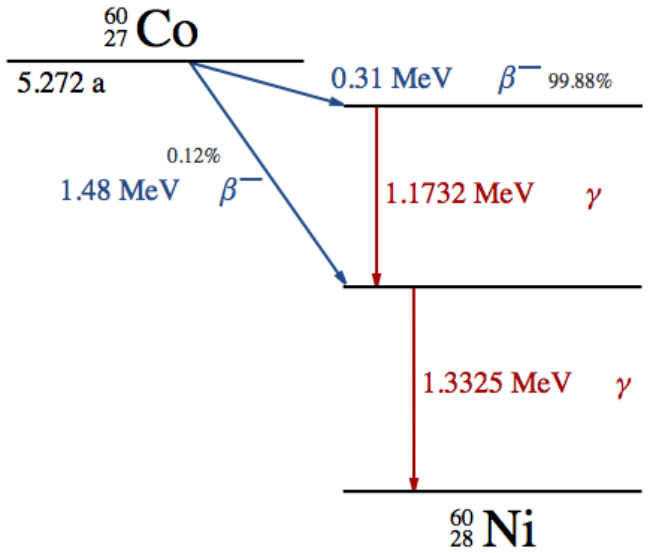
Die nicht aktive Elektronik hat eine Gesamtdosis von 8kGy abbekommen (verglichen mit unserer Bestrahlung von PWO-II).

Die Dosisangaben beziehen sich immer auf das, was PWO absorbiert hätte. Die Elektronik absorbiert natürlich deutlich weniger und so ist die Dosisangabe immer auf die Umgebung zu beziehen.

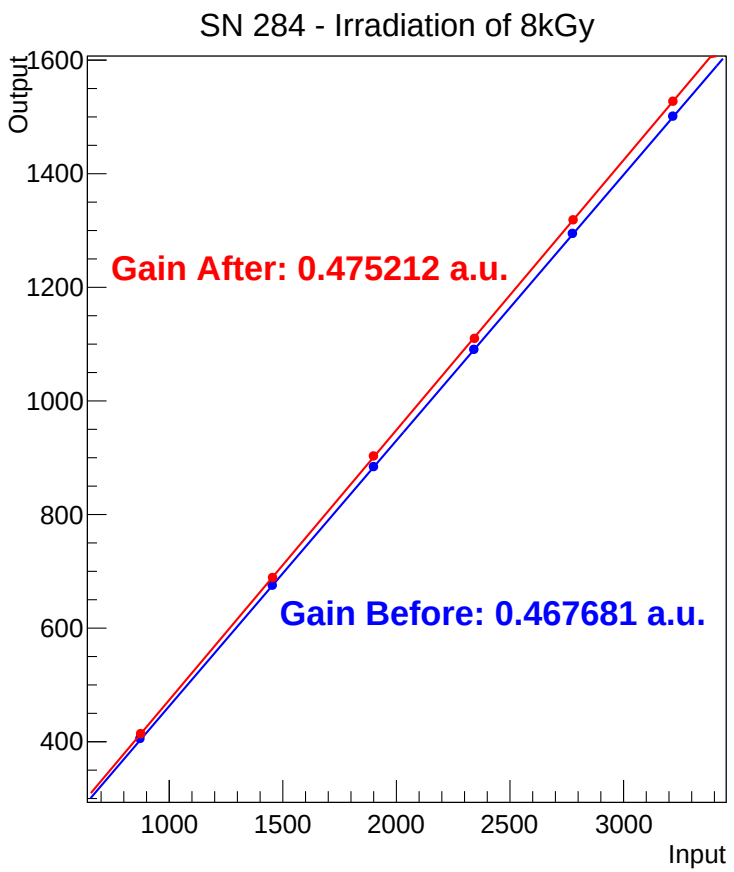
Mit freundlichen Grüßen,

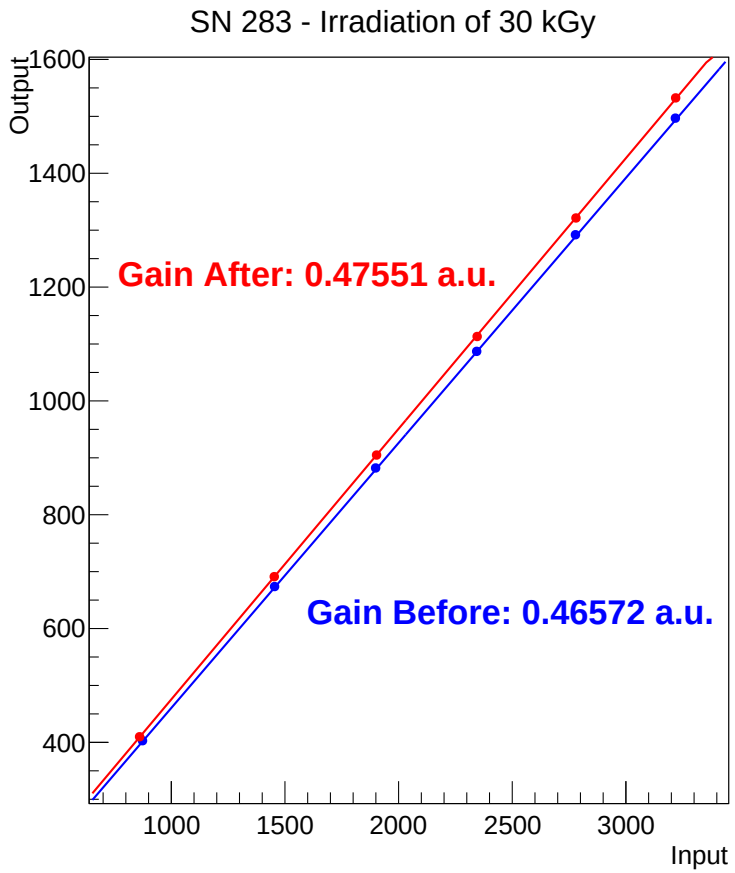
Till Kuske





Gain Change: 1.6% for 8 kGy and 2.1% for 30 kGy





Summary

- Pile-Up Effect $\sim$ 1 %

Summary

- Pile-Up Effect $\sim$ 1 %
- Amplitude Linearity $\sim$ 1 %

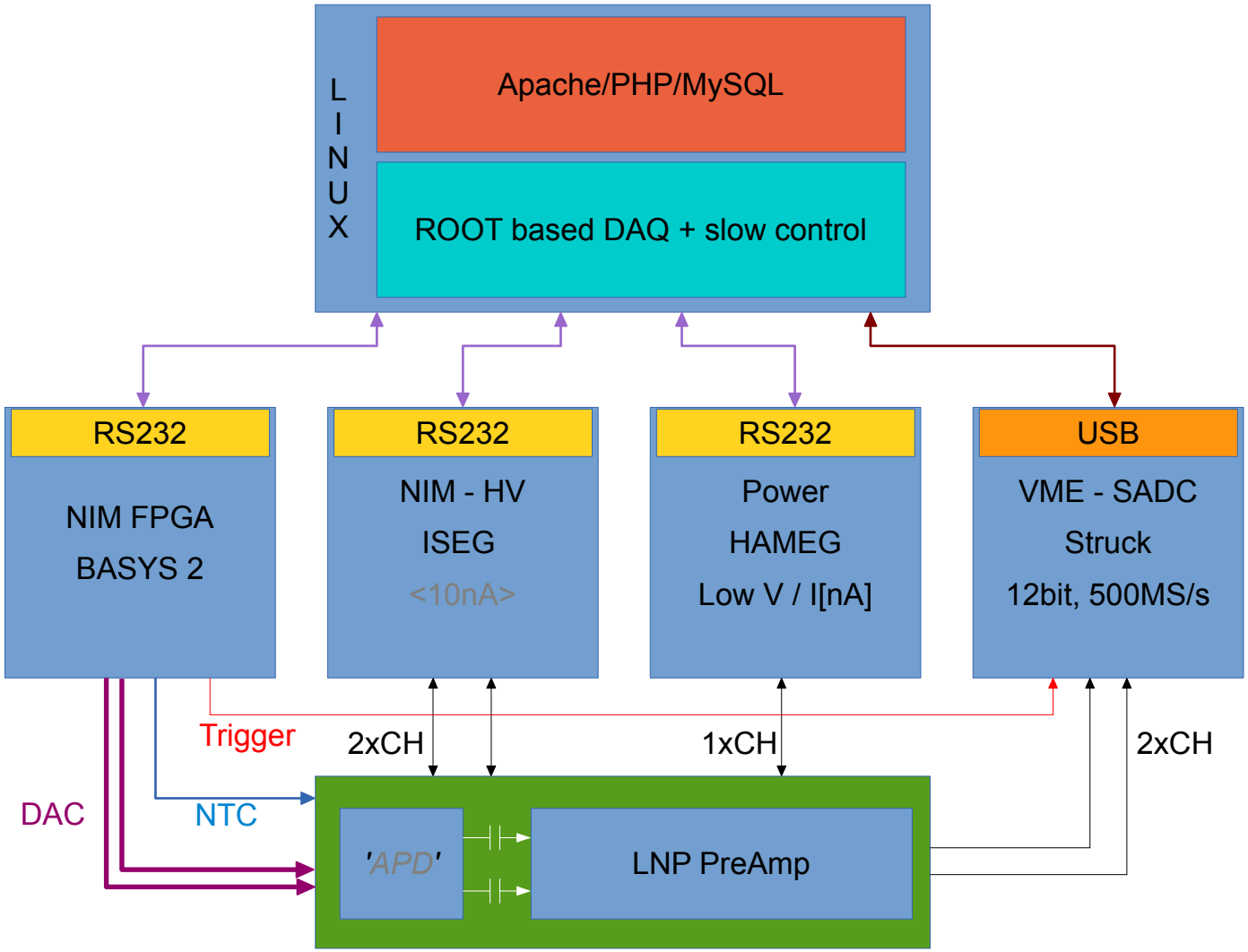
Summary

- Pile-Up Effect $\sim$ 1 %
- Amplitude Linearity $\sim$ 1 %
- Radiation Hardness $\sim$ 2 % for 30kGy

Summary

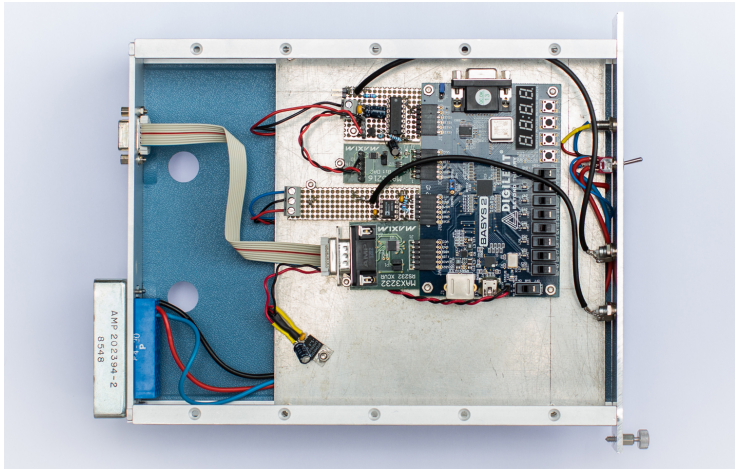
- Pile-Up Effect $\sim$ 1 %
- Amplitude Linearity $\sim$ 1 %
- Radiation Hardness $\sim$ 2 % for 30kGy
- Time Resolution / Signal Transition Time is $\ll$ 1ns
- Temperature Stability (-30^{o}C and +30^{o}C) $<$ 1%
- Noise level allows High Dynamic Range $\sim$ 10'000

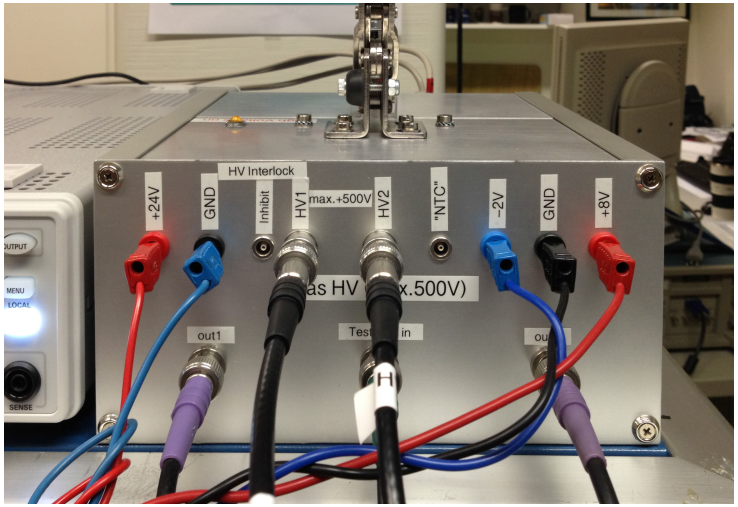
Concept of Serial Test Setup

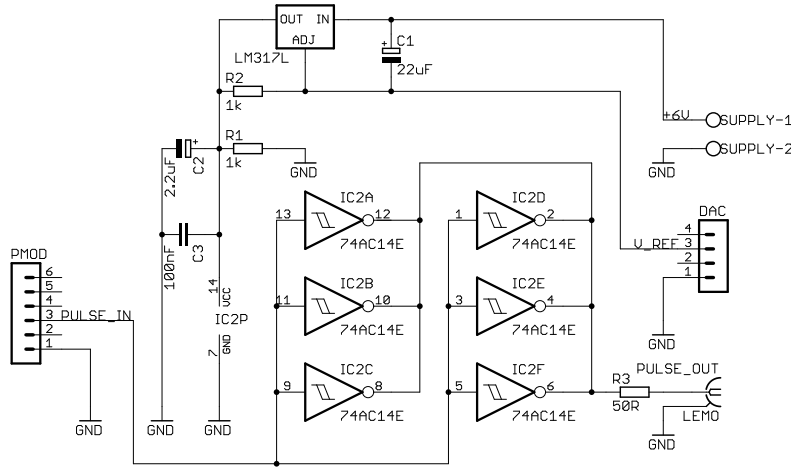


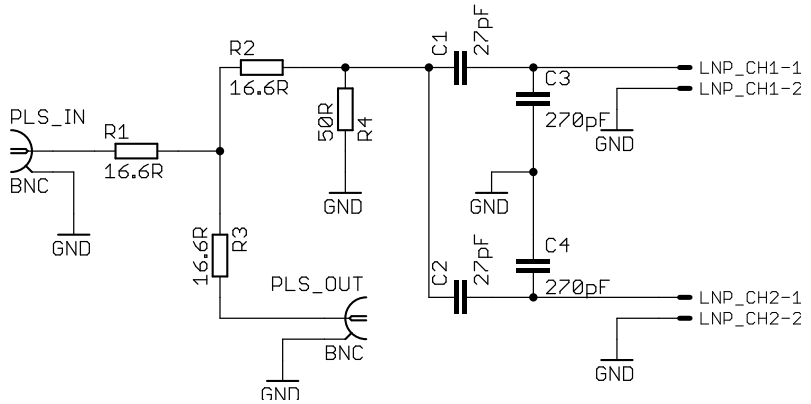
Test Laboratory

FPGA Pulser Generator and Test Box

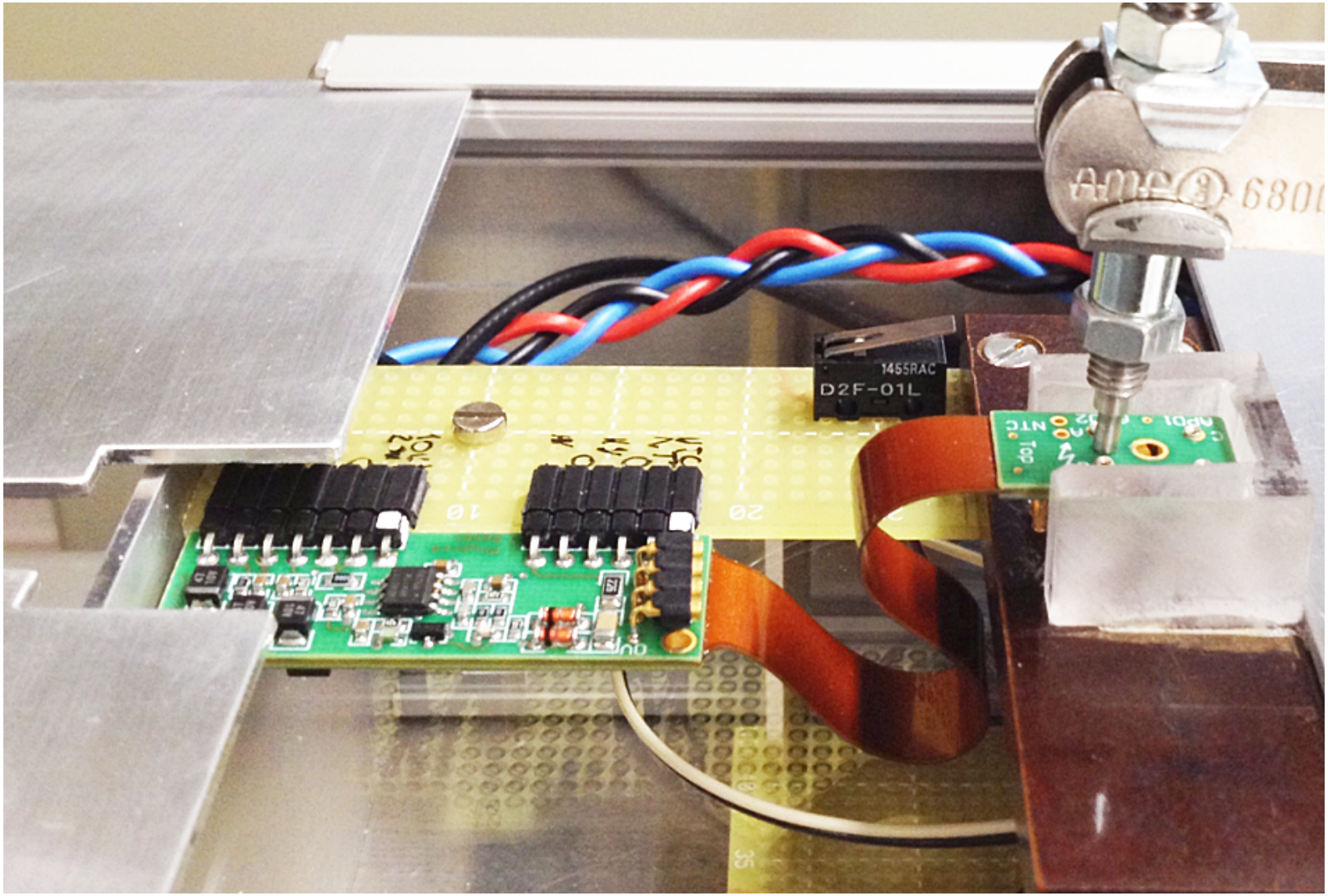




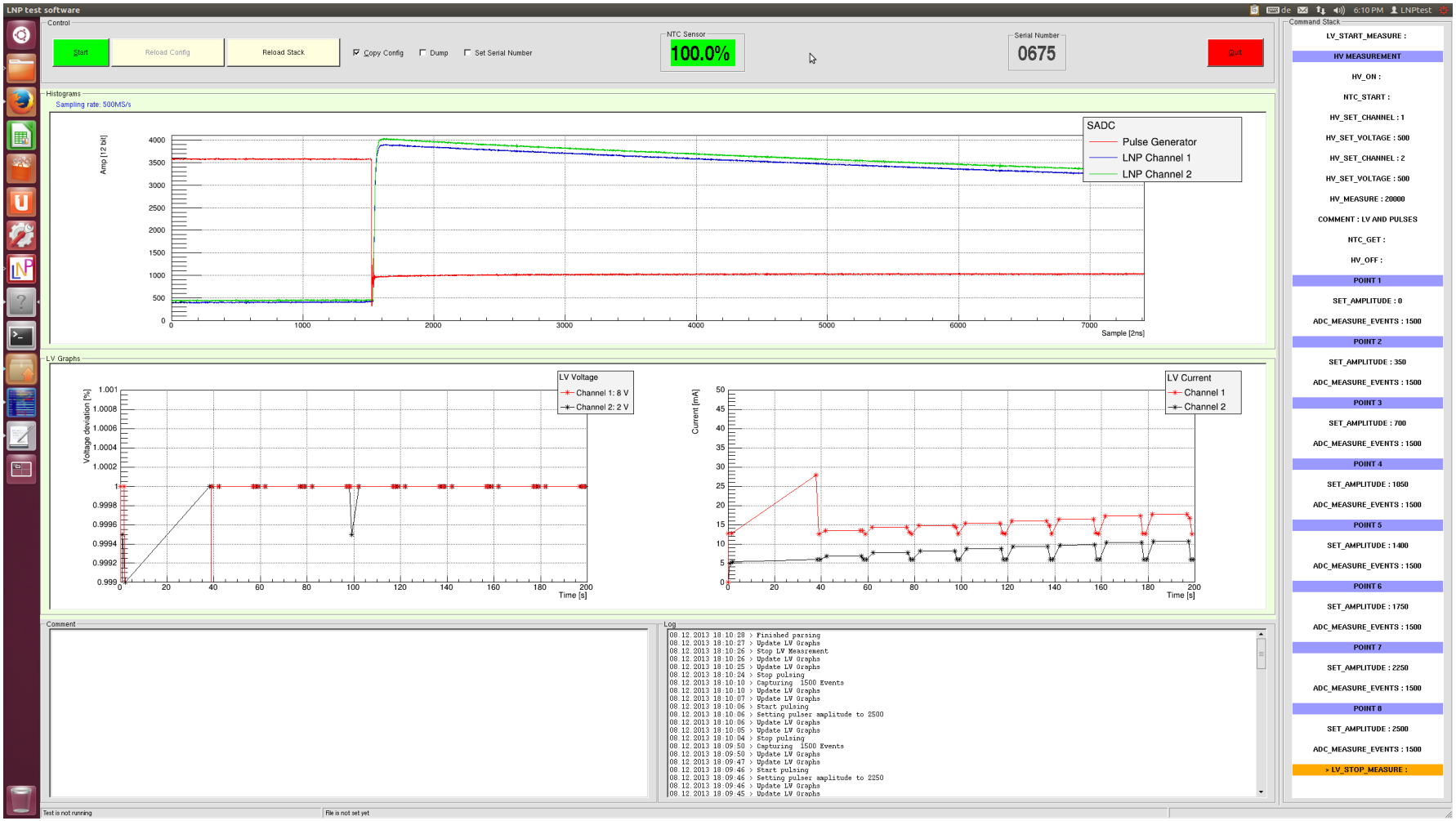




Flat Cable Banding



Test Software



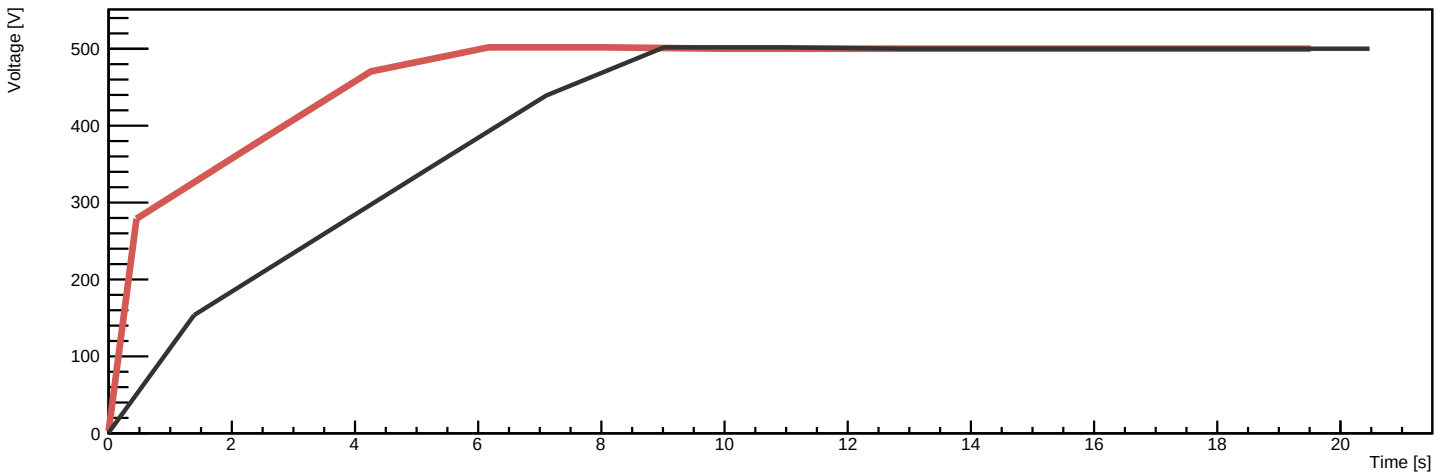
Summary

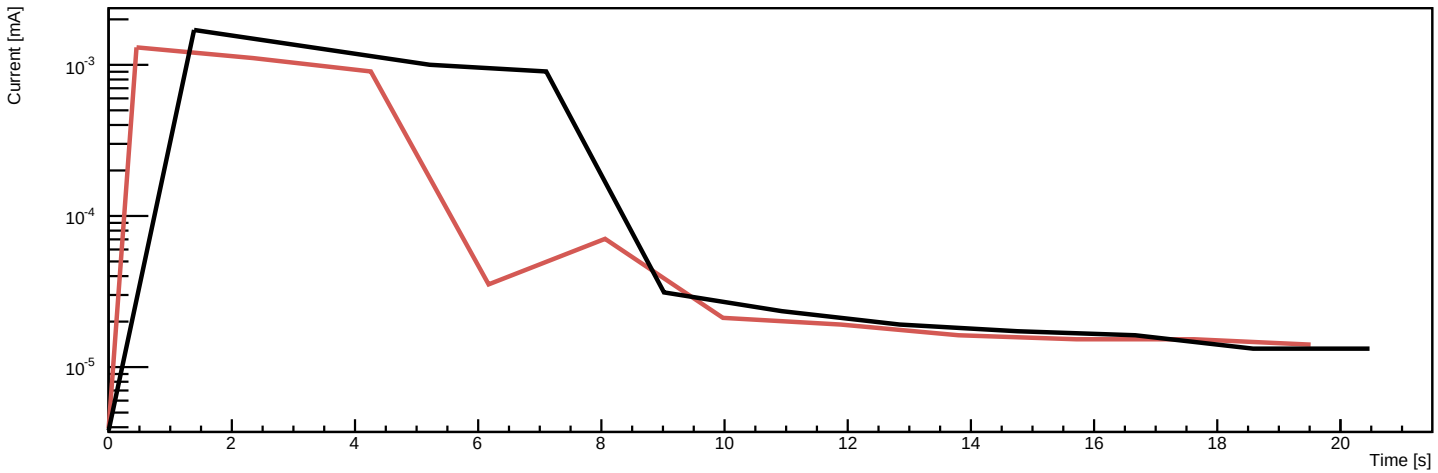
- Hardware - Modular and Computer Controlled

Summary

- Hardware - Modular and Computer Controlled
- Software - Easily Customisable

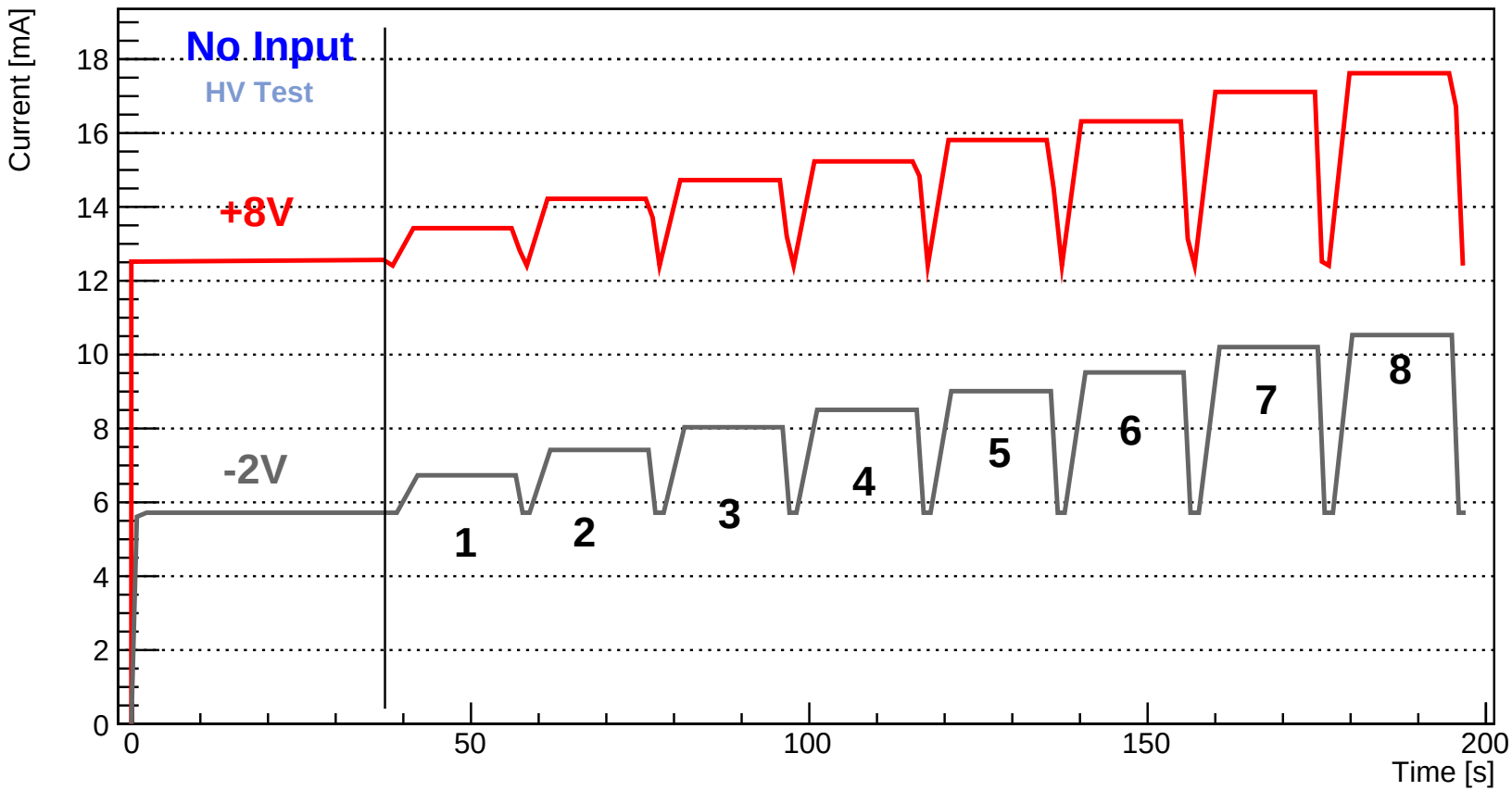
Typical HV Measurement



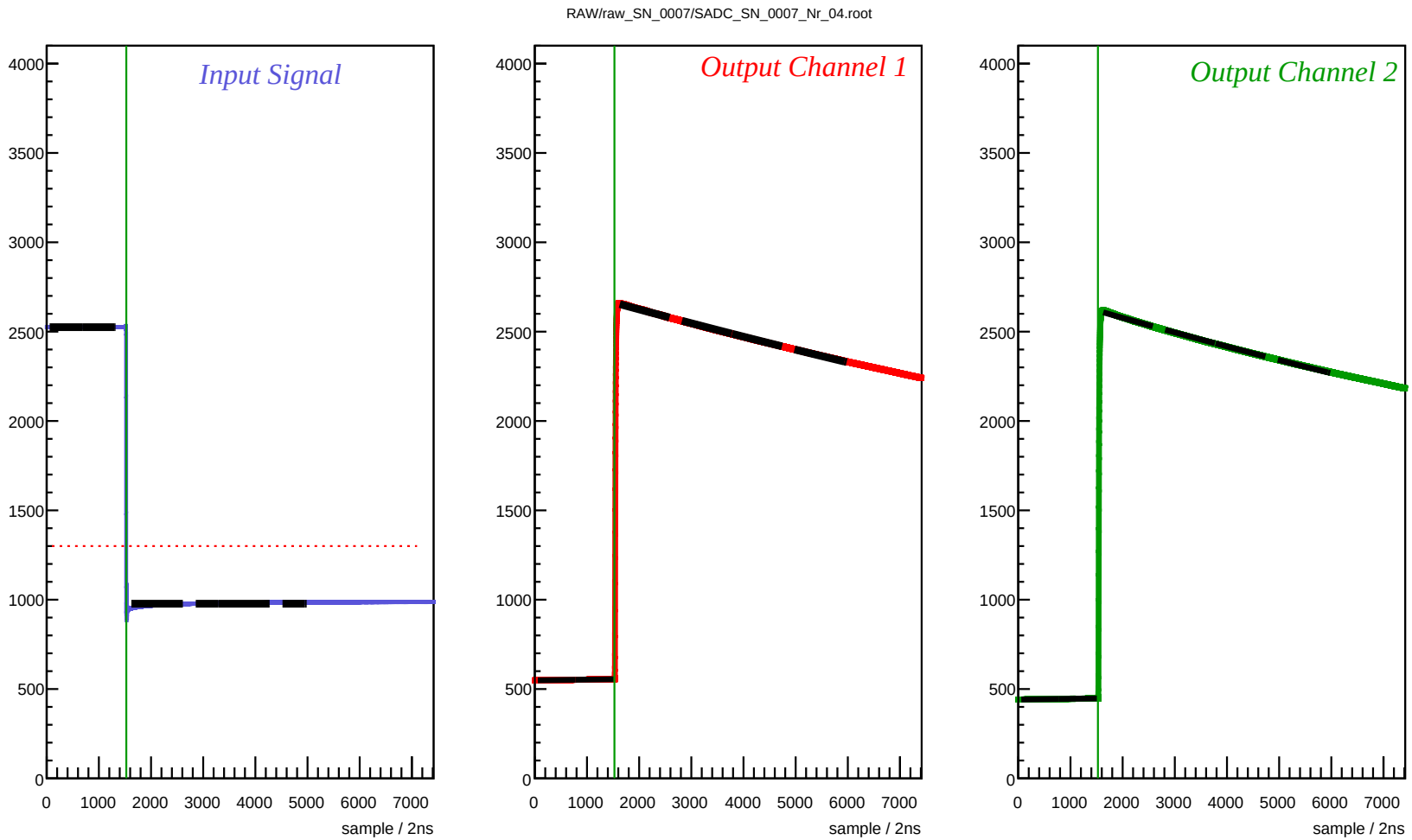


Typical Current Measurement

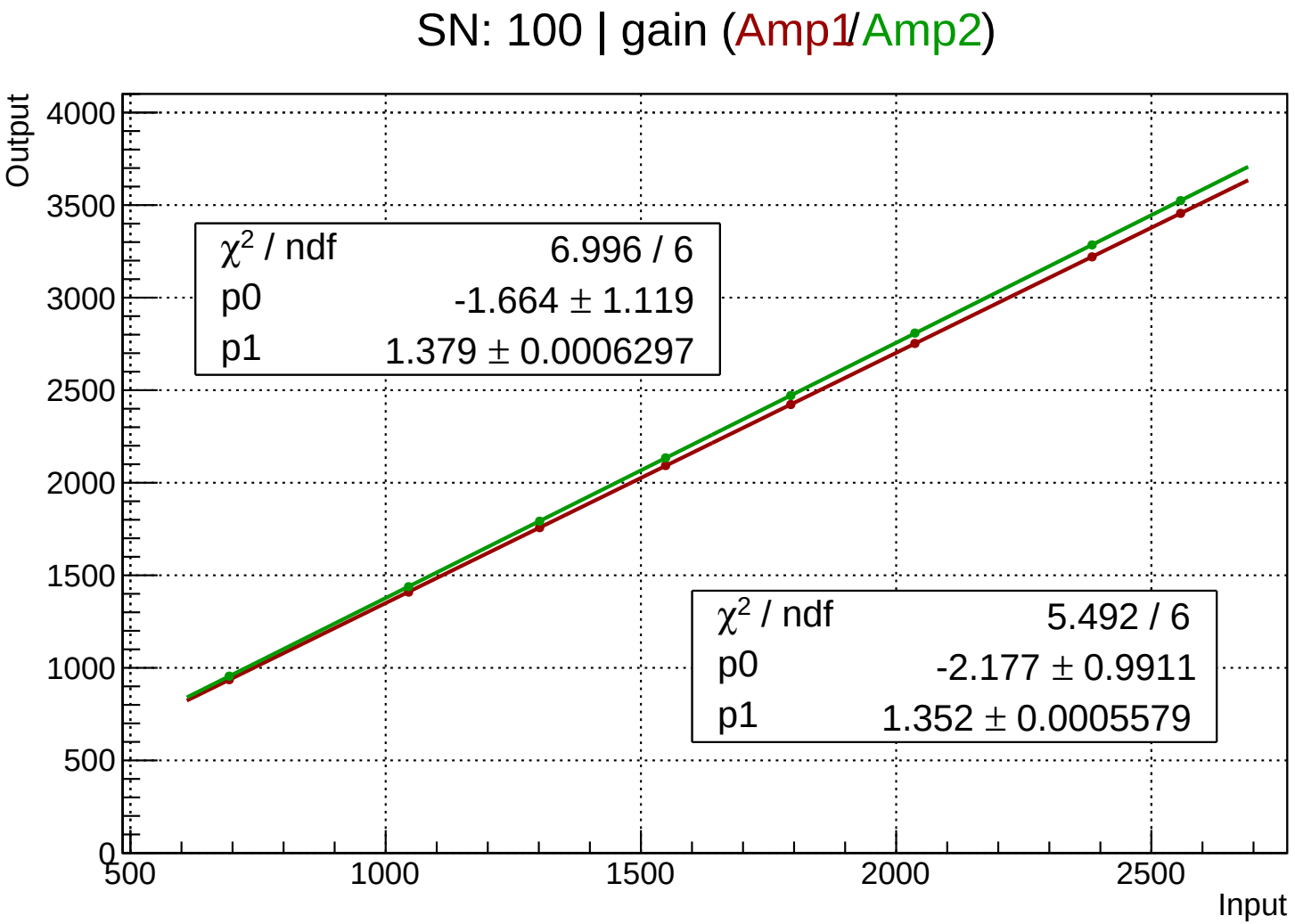
8 different amplitudes between min. $\rightarrow$ max., 10kHz countrate



Typical Signals Processing

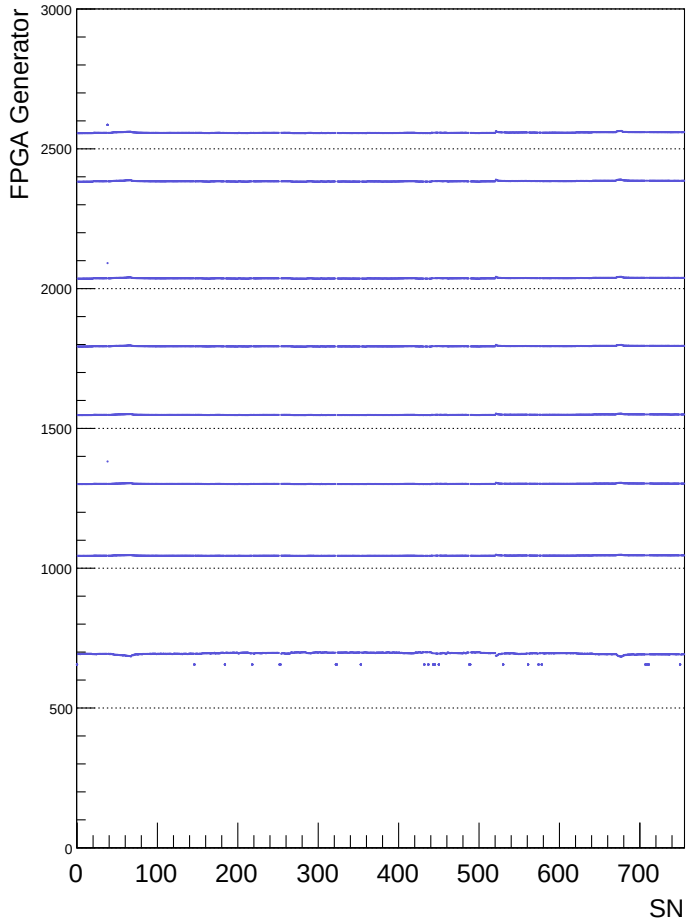


Amplitude Linearity Measurement

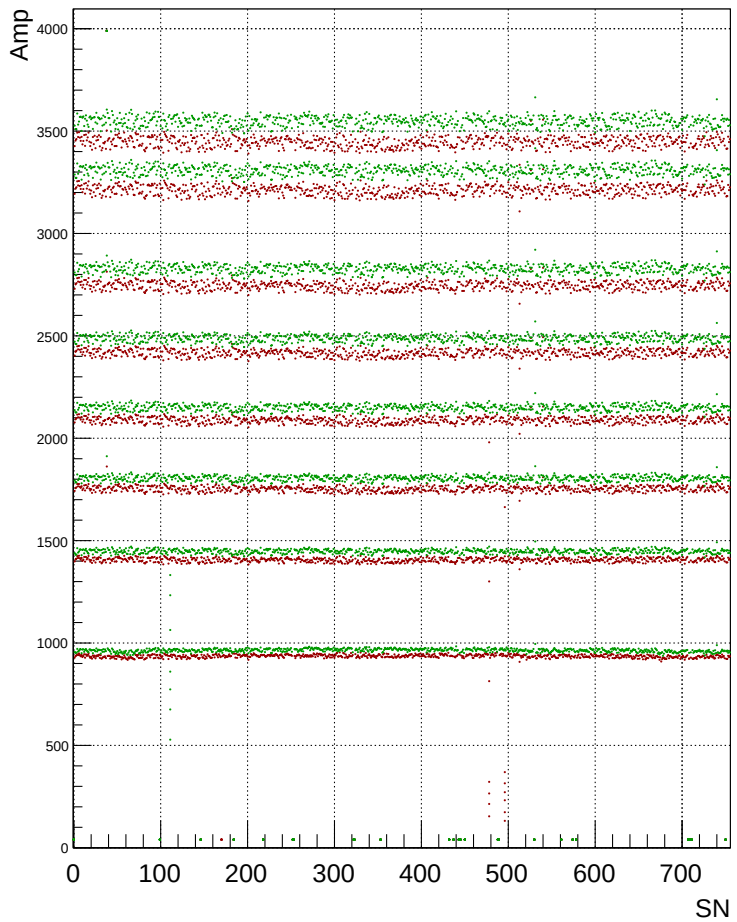


Input and Output Signals Vs SN

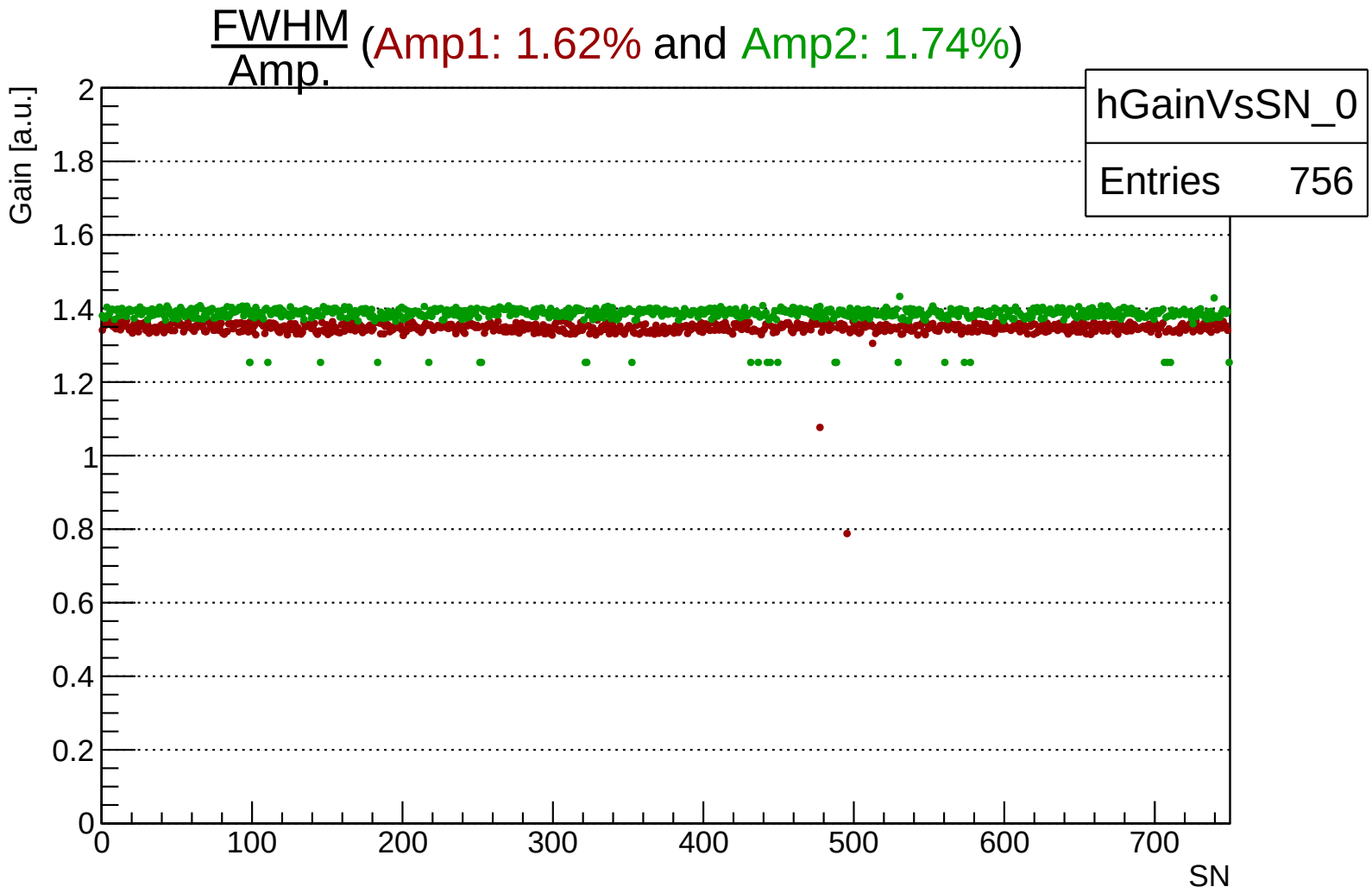
8 different input amplitudes Vs SN



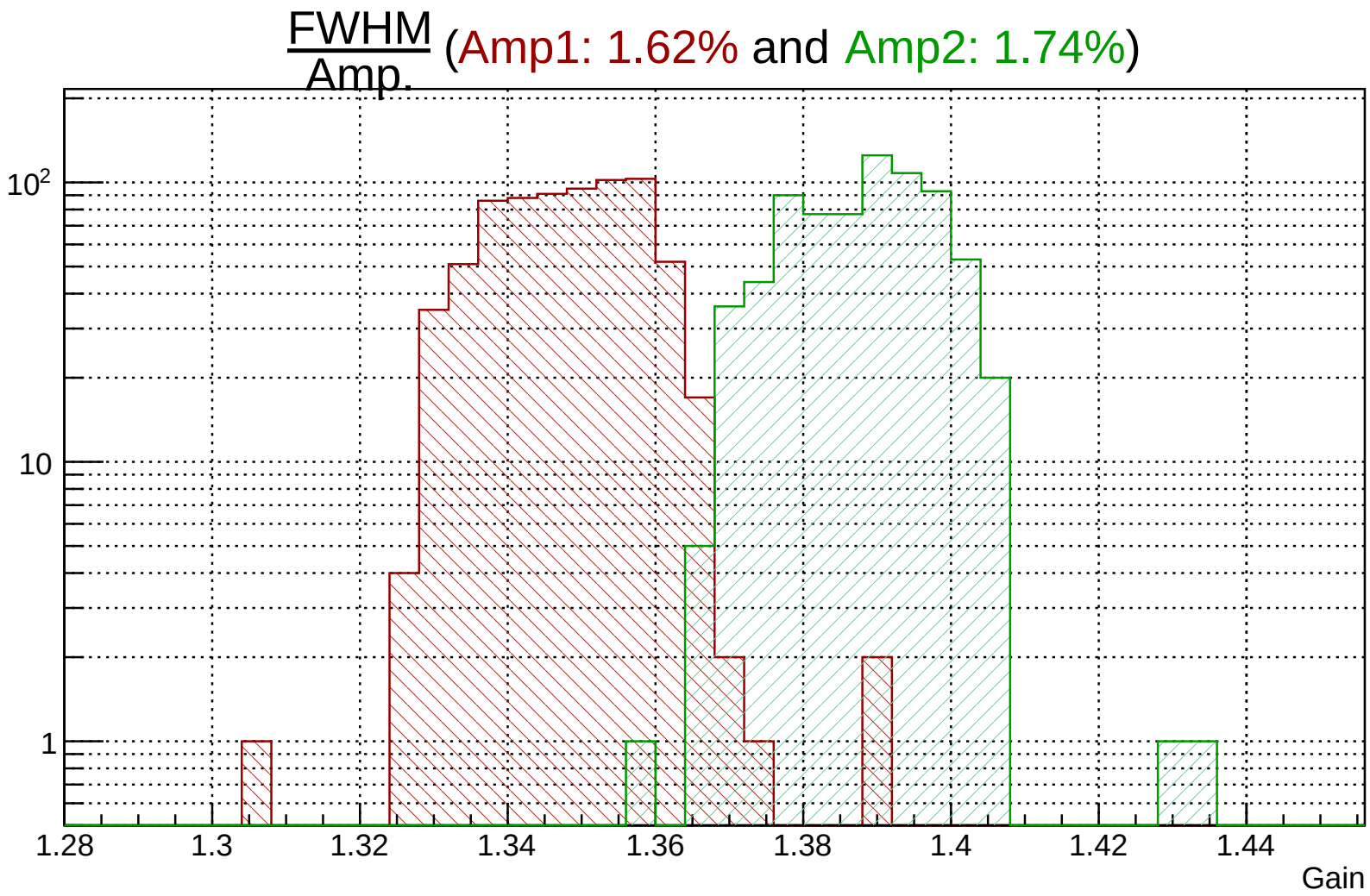
Amp1 and Amp2 Vs SN



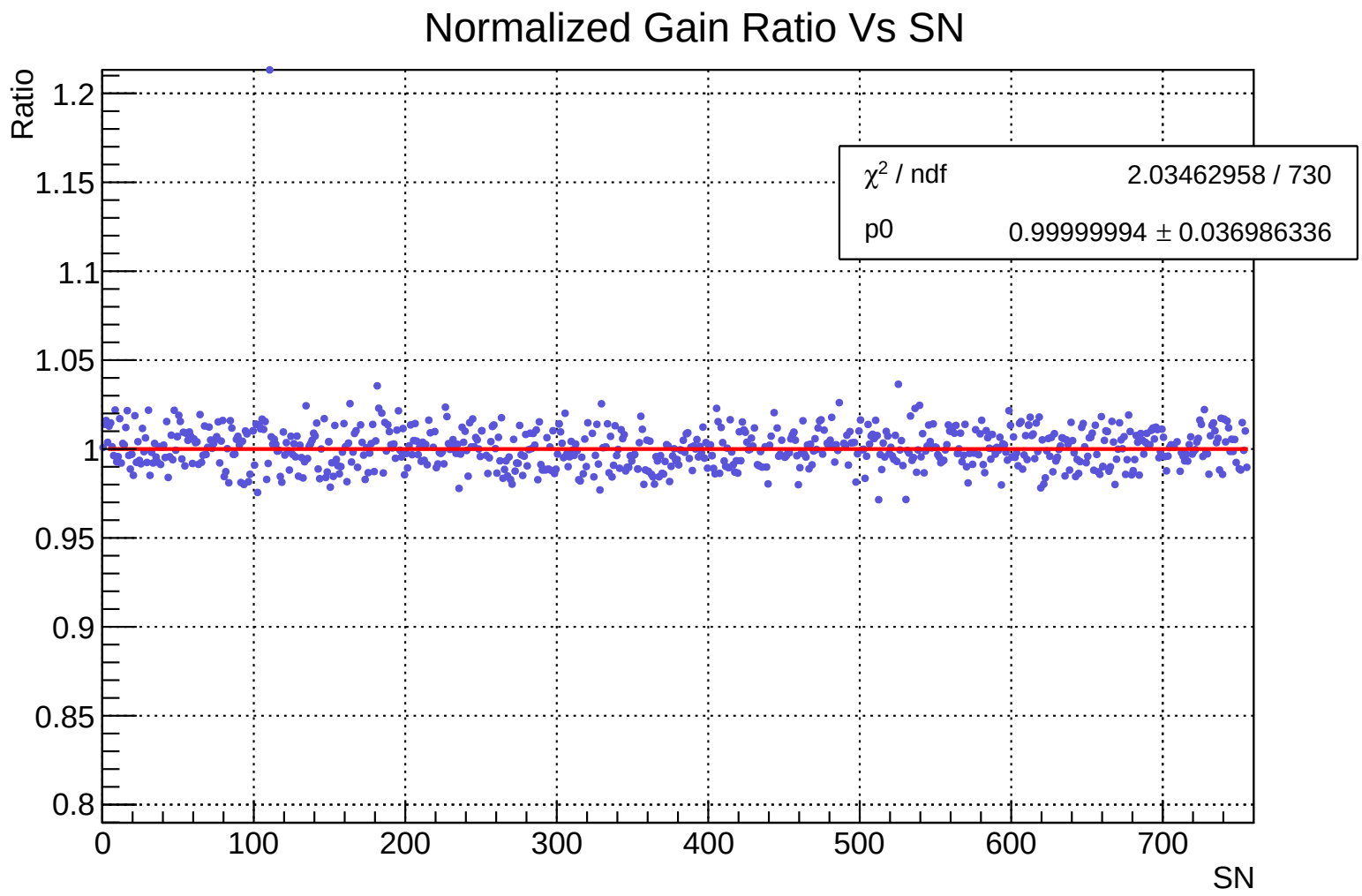
Gain Vs SN


FWHM/Amp. (Amp1: 1.62% and Amp2: 1.74%)
hGainVsSN_0
Entries 756
Gain [a.u.]
SN
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
100
200
300
400
500
600
700

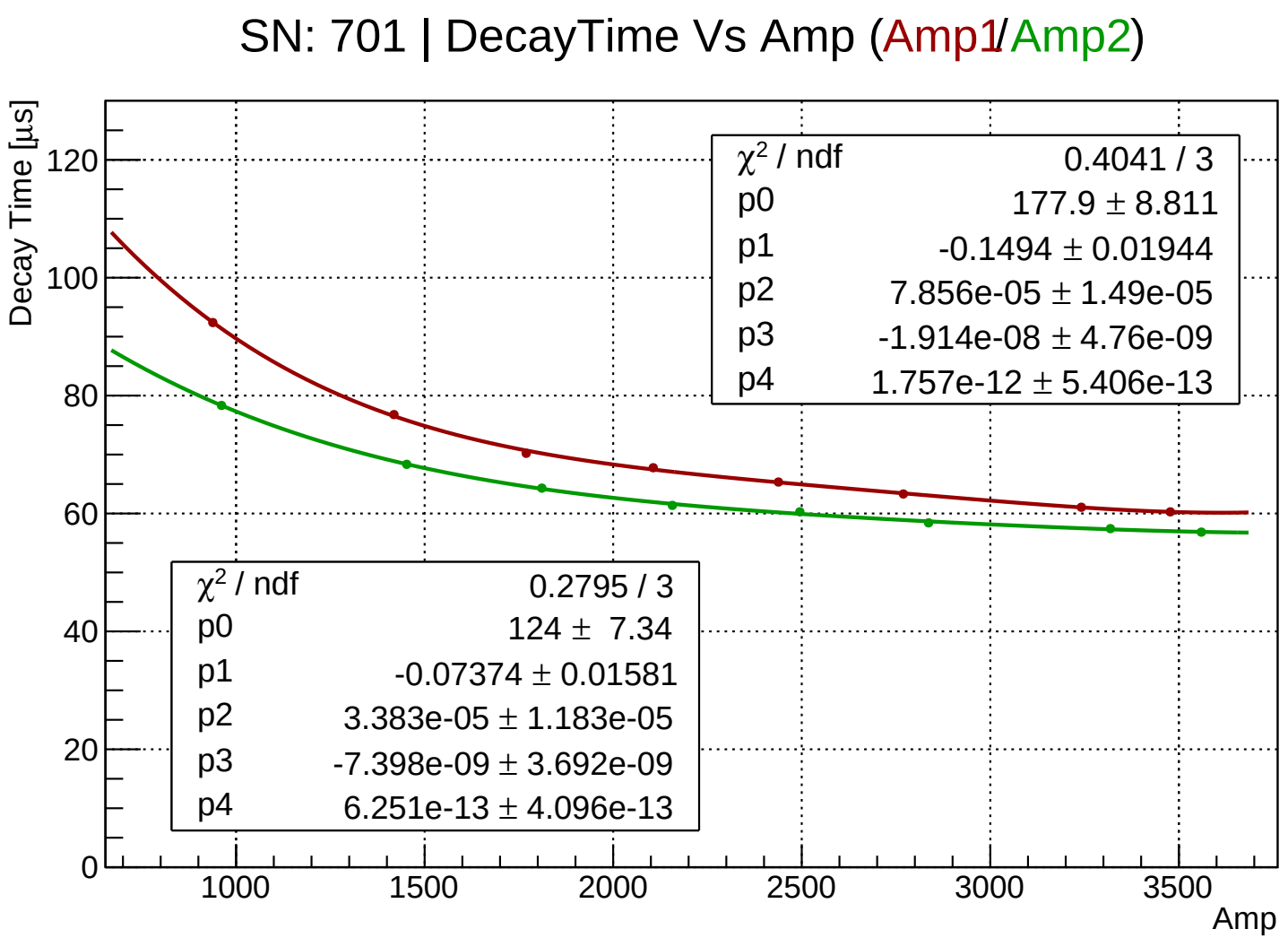
Gain Distribution / Log Y



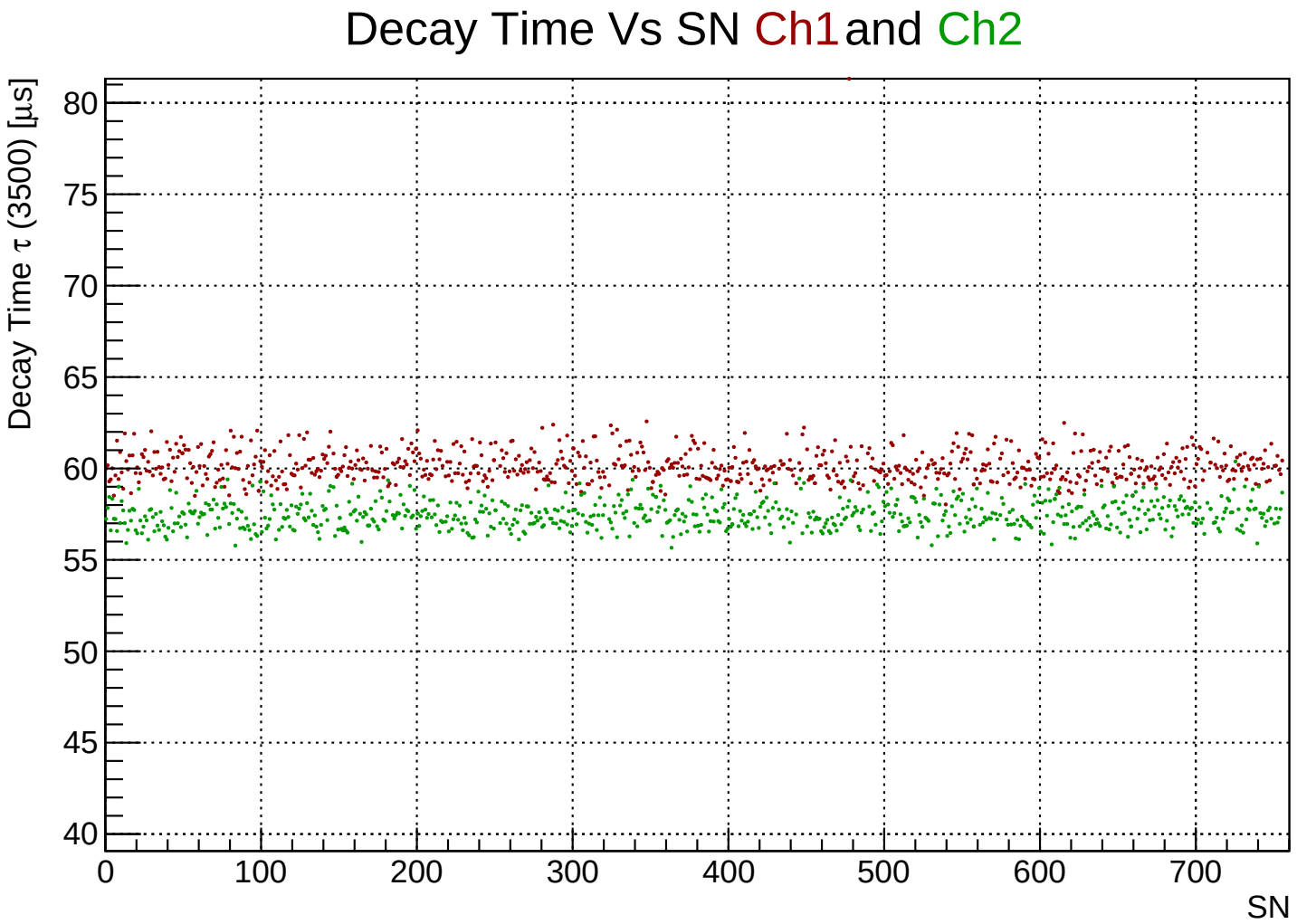
Normalized Gain Ratio - Gain1 / Gain 2



Gain Vs SN


SN: 701 | DecayTime Vs Amp (Amp1/Amp2)
Decay Time [µs]
Amp
0
20
40
60
80
100
120
1000
1500
2000
2500
3000
3500
χ² / ndf 0.4041 / 3
p0 177.9 ± 8.811
p1 -0.1494 ± 0.01944
p2 7.856e-05 ± 1.49e-05
p3 -1.914e-08 ± 4.76e-09
p4 1.757e-12 ± 5.406e-13
χ² / ndf 0.2795 / 3
p0 124 ± 7.34
p1 -0.07374 ± 0.01581
p2 3.383e-05 ± 1.183e-05
p3 -7.398e-09 ± 3.692e-09
p4 6.251e-13 ± 4.096e-13

Decay Time Vs SN



Summary

- First serial test of large # of LNP's - DONE!

Summary

- First serial test of large # of LNP's - DONE!
- Till now, there was no PreAmps damaged after beam test

Summary

- First serial test of large # of LNP's - DONE!
- Till now, there was no PreAmps damaged after beam test
- High stability and ... proves conceptual design

Thank's for your attention!

Fabian Müller, Timo Gasser, Daniel Regenass,

Rony Blum, Faizal Zeeshan,

Werner Erni, Michael Steinacher,

Group of Prof. B. Krusche

This work is supported by: Swiss National Fund (SNF)

and Deutsche Forschungsgemeinschaft (DFG)