Gas Monitor Detector Electronics

from charged particles to digital value

Fini Jastrow, TTF/VUV-FEL meeting, 21. Mar 06

The Detector

Ion Current Measurement

Electron Pulse Measurement

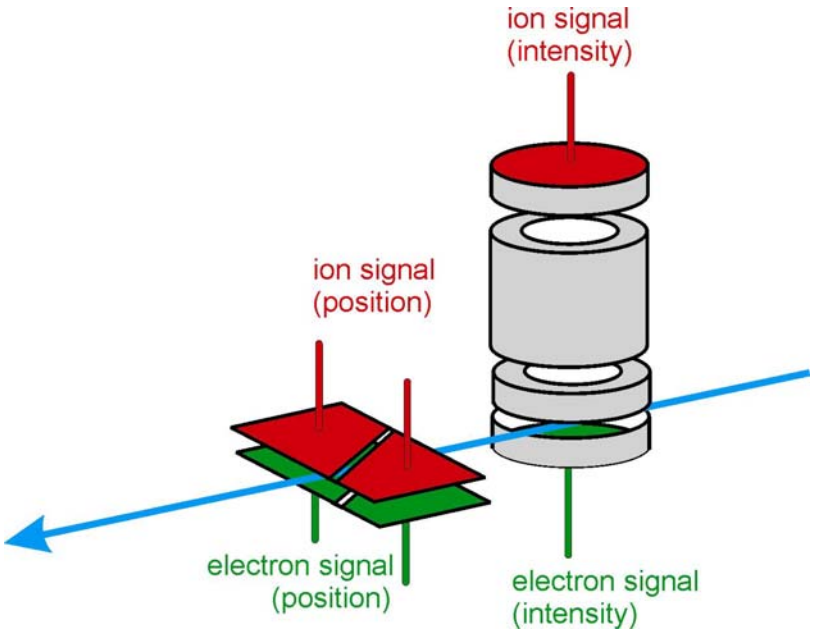
Measured Data

The MCP Signal Path

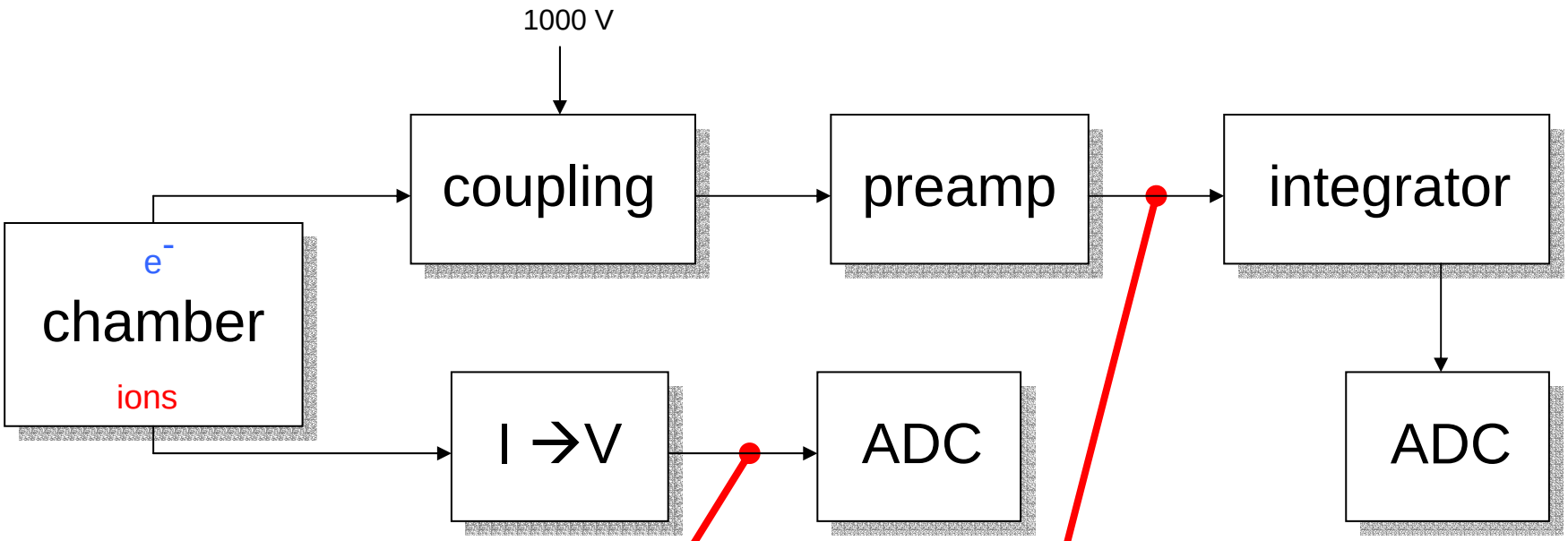
The Extended GMD

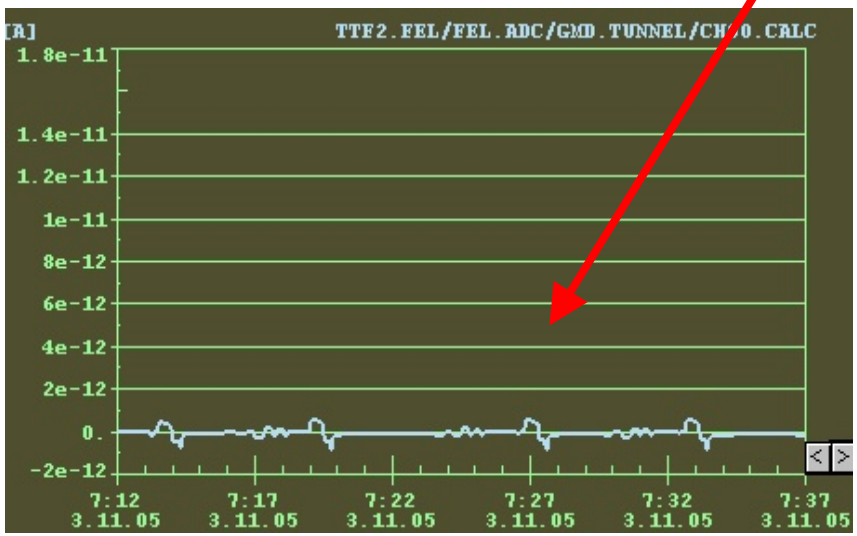
The Detector

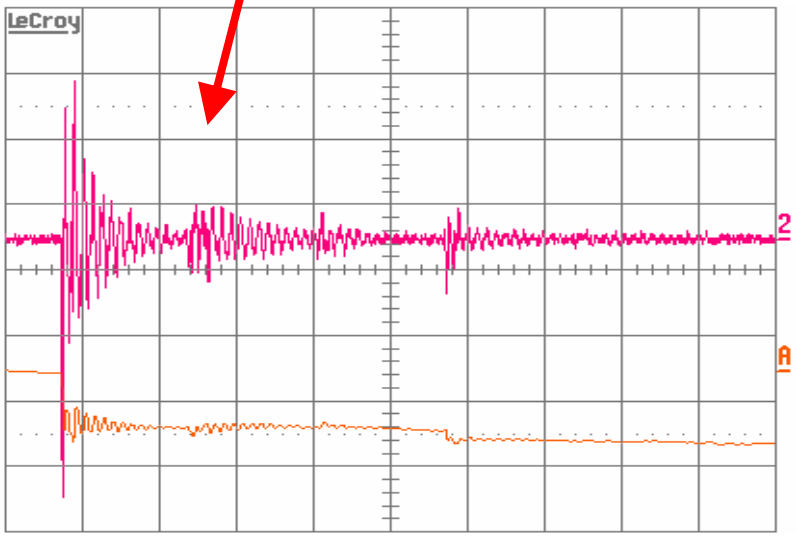
- Ionisation Chamber
- Detection of ions and electrons
- Ions calibrated with CW beam (slow)
- Electrons fast but susceptible to secondary electrons and magnetic fields



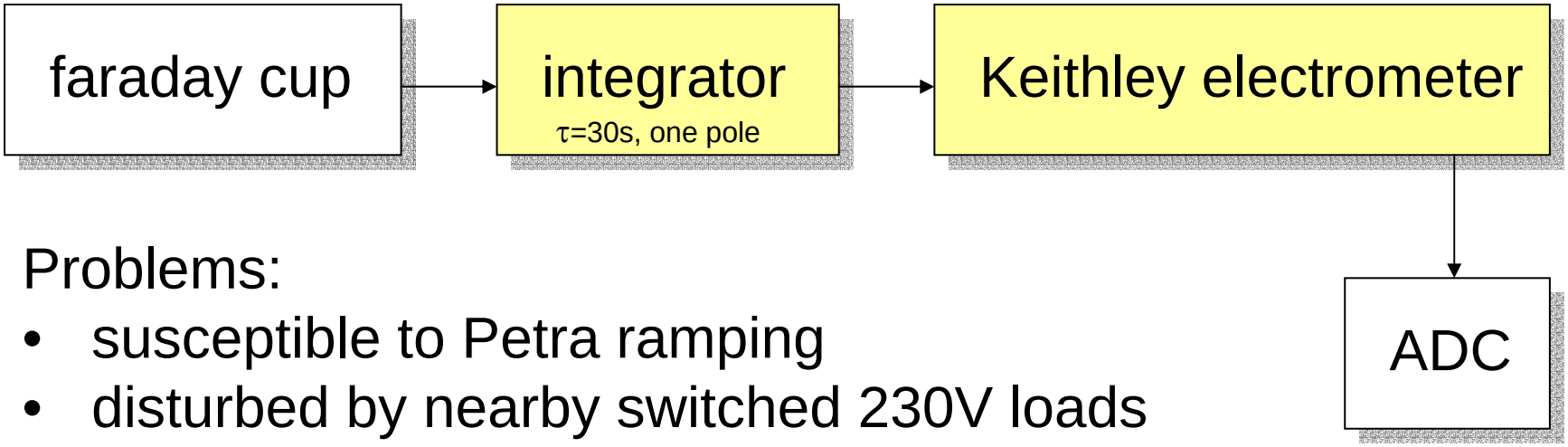
The Detector







Ion Current Measurement



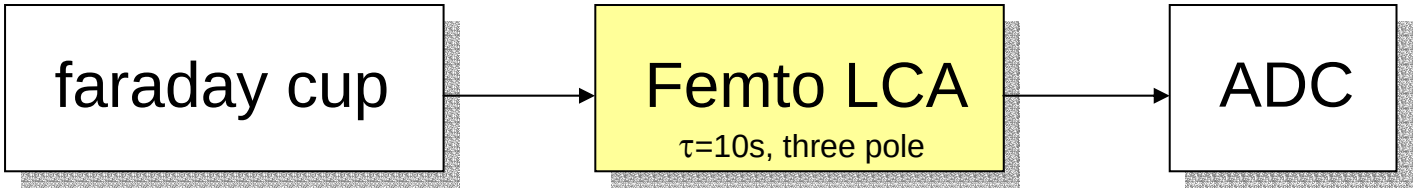
Problems:

- susceptible to Petra ramping
- disturbed by nearby switched 230V loads
- tendence to self resonance at 0.2 Hz

Solutions:

- ferromagnetic plate under Keithley
- 230V separation transformer
- ferrite beads and software damping

Ion Current Measurement

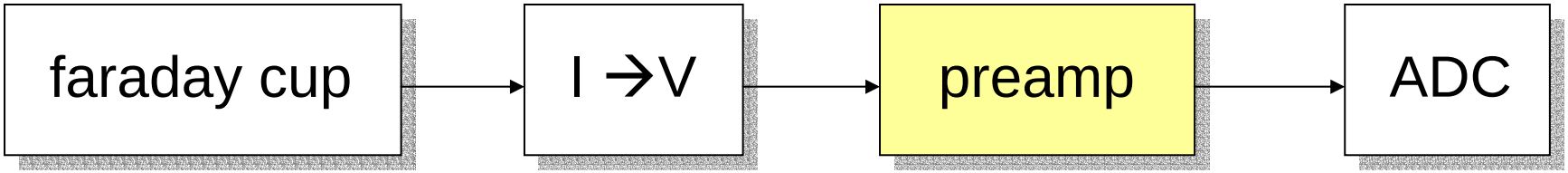


- 3 pole filter for faster response
- true active integrator
- independent on incoming charge pulse shape
- no problems with Petra or nearby loads

drawback: only two conversion factors available

available Mai 2006

Ion Current Measurement



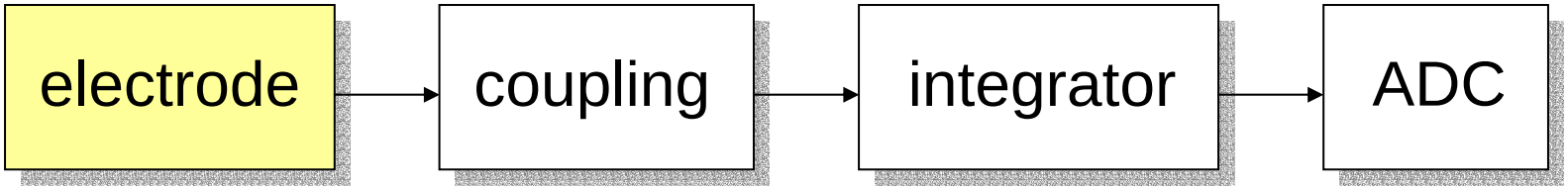
differential amplifier

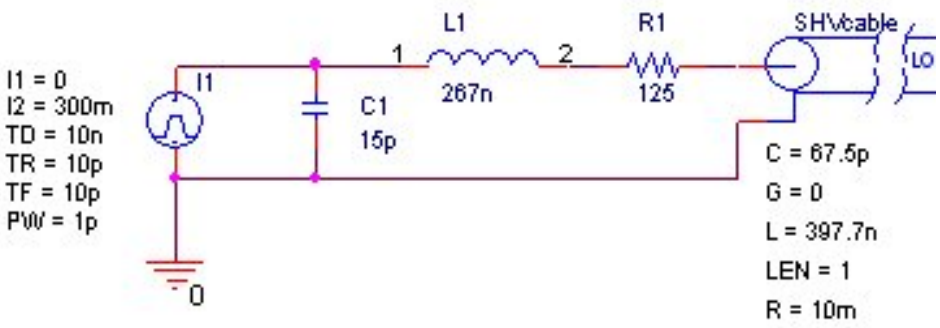
- high input impedance
- output impedance matched to ADC input

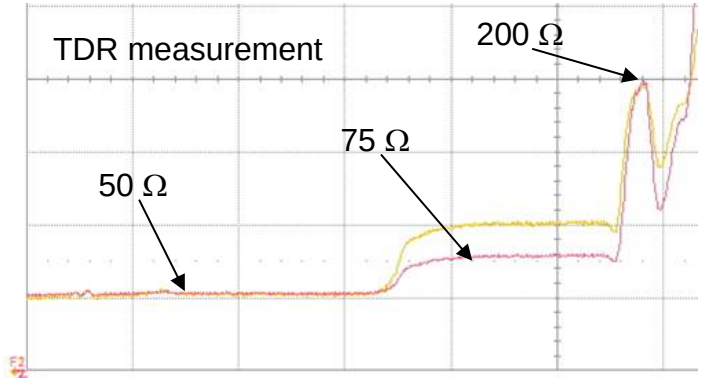
preventing ground loop noise

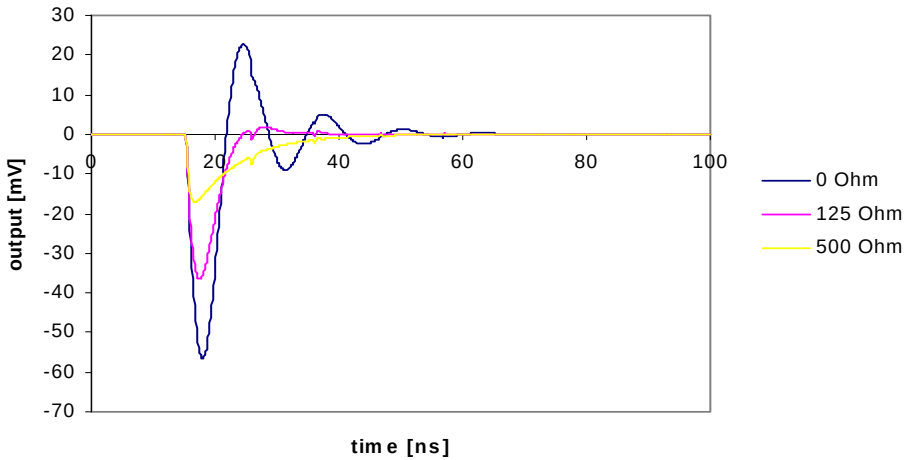
- high impedance to ground at LF (shield and signal conductor)
- no gain at HF (impedance to ground rather low)

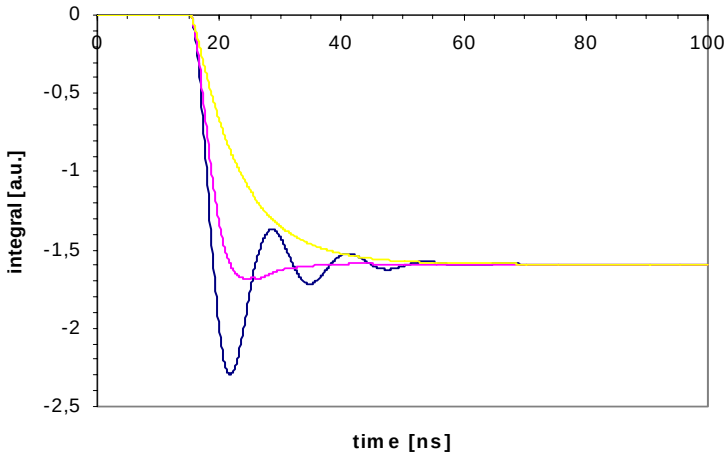
Electron Pulse Measurement









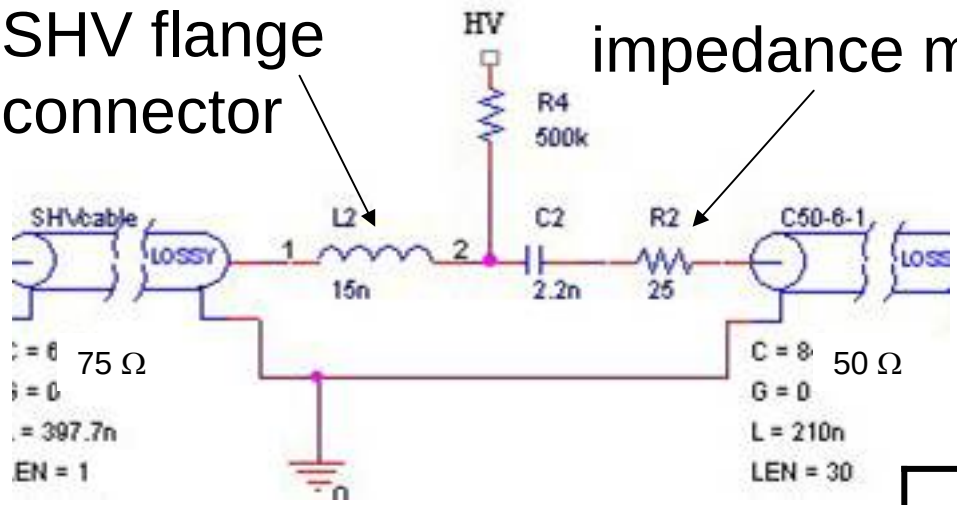


Electron Pulse Measurement

electrode → coupling → integrator → ADC

SHV flange connector

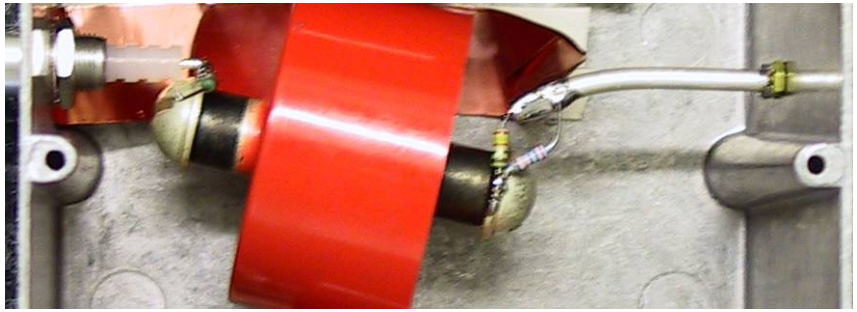
impedance match



measured:

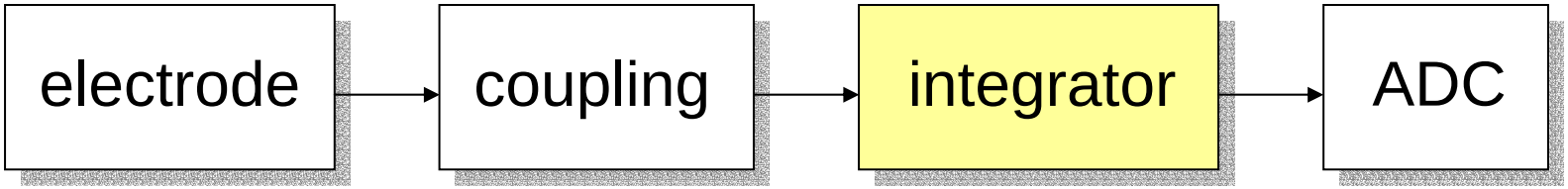
Γ_{LR} 0.045

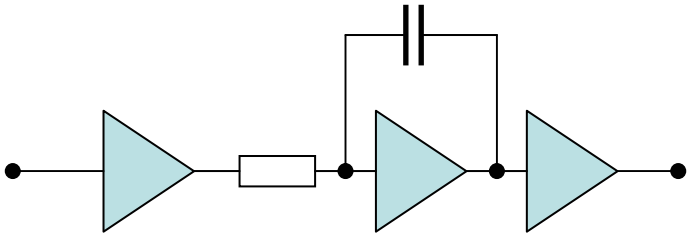
Γ_{RL} 0.76



	none	one way	both ways
Γ_{LR}	-0.2	0	0
Γ_{RL}	0.2	0.33	0
g_{LR}	0.8	0.67	0.42

Electron Pulse Measurement

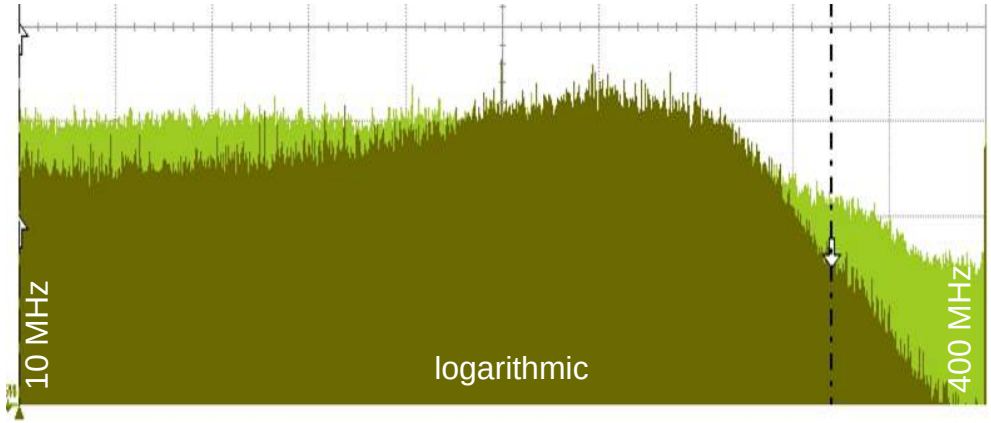




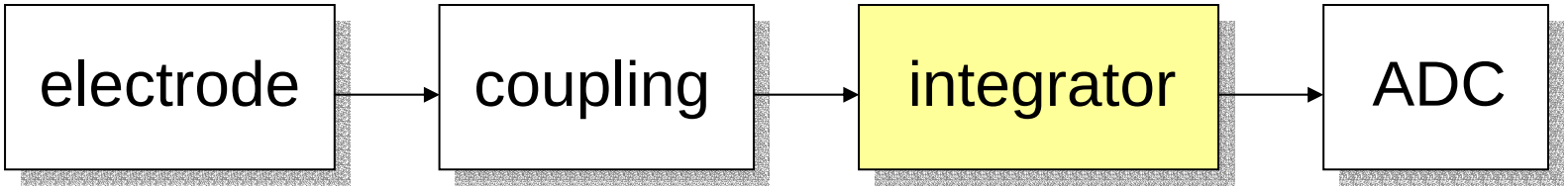
measured values:

- bandwidth 280 MHz (g = 2)
- frequency response unlinear
- gain dependent on charge
- charge error 420 ppm/°C
- timing jitter 20 ps/°C
- slew rate 1400V/µs
- risetime 0.56 ns
- input $\Gamma = 0.29$

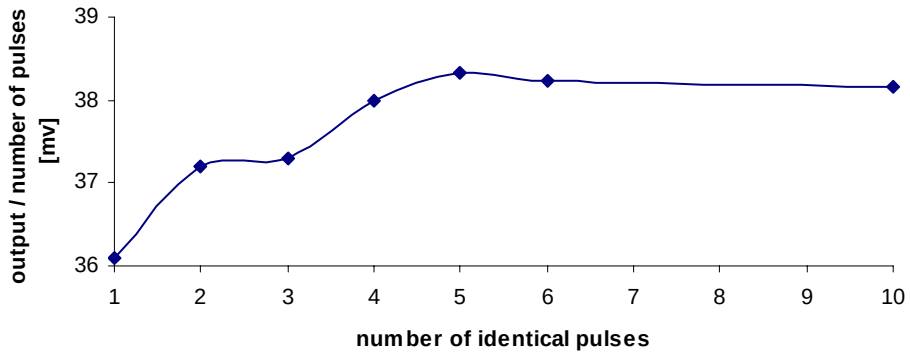
preamp frequency response

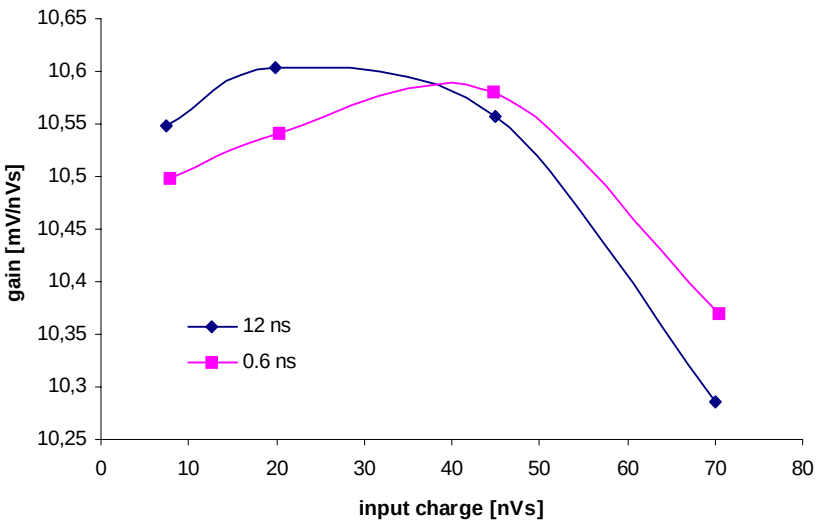


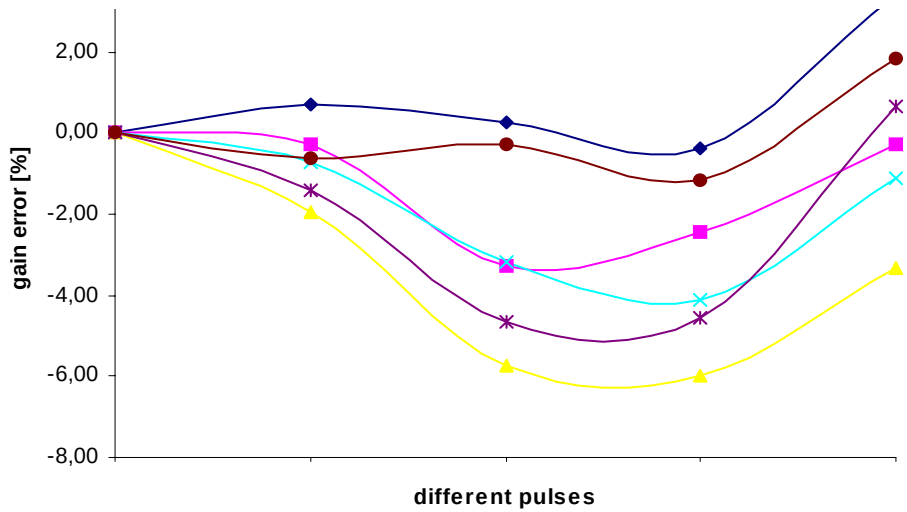
Electron Pulse Measurement



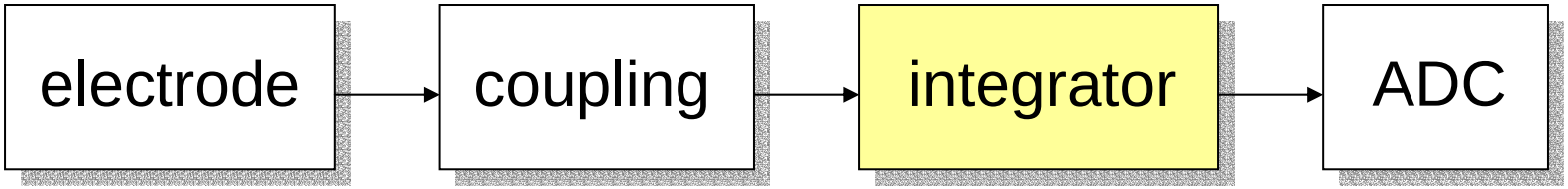
different kinds of observed gain errors







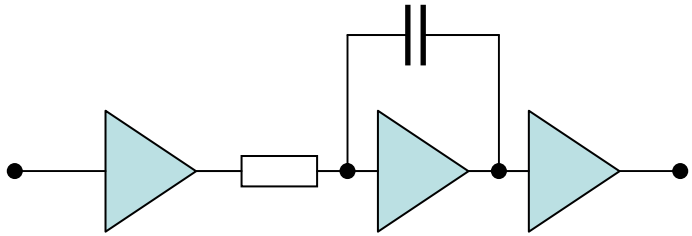
Electron Pulse Measurement



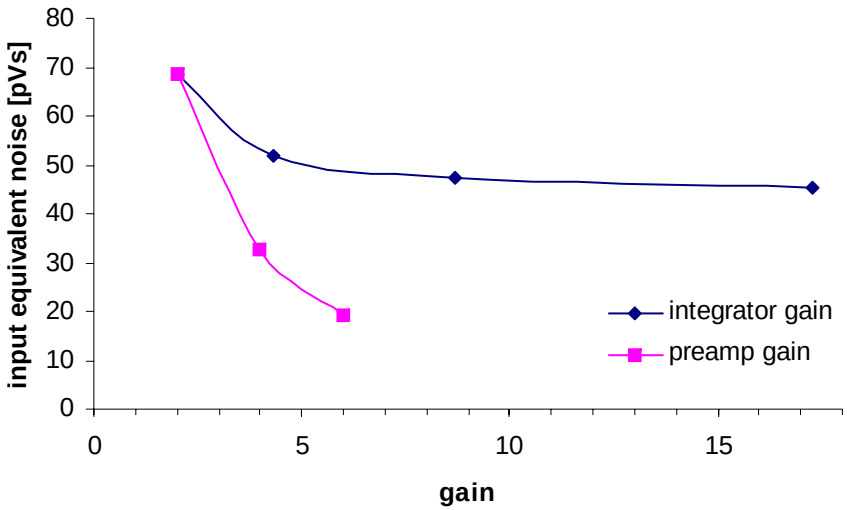
two gain setting possibilities:

- preamp gain
- integrator time constant

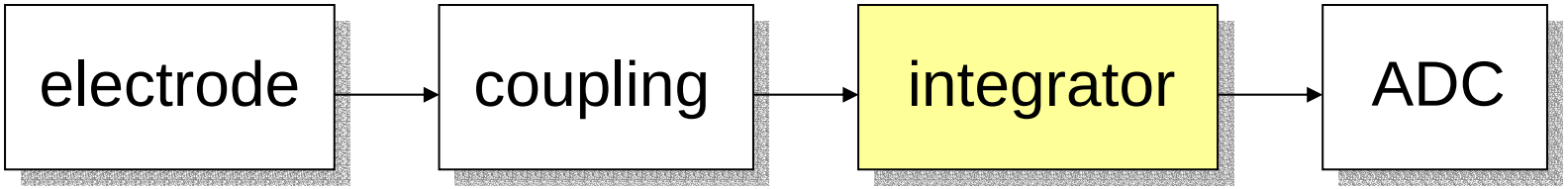
combined a factor of 50



preamp gains is prefered because it reduces the noise

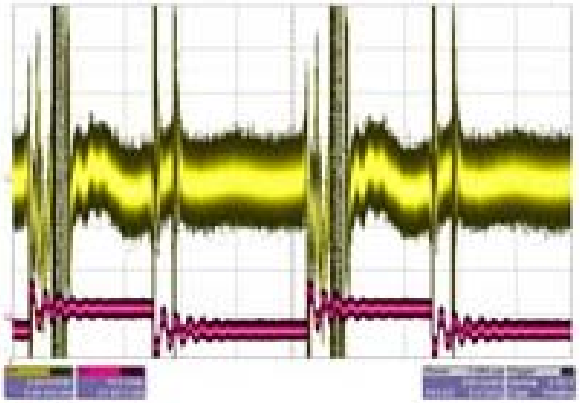


Electron Pulse Measurement

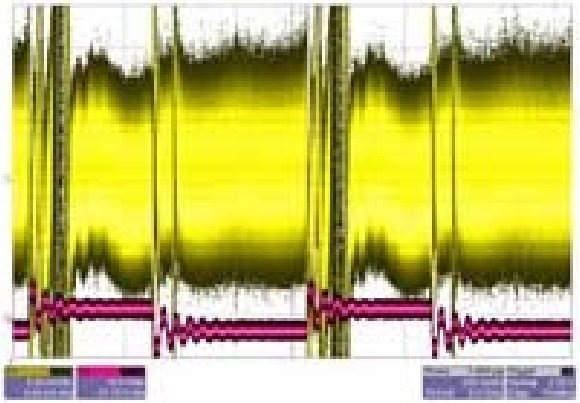


The VME crate induces noise of about 3 nVs $_{pp}$
An aluminum foild shield reduces this to 1 nVs $_{pp}$

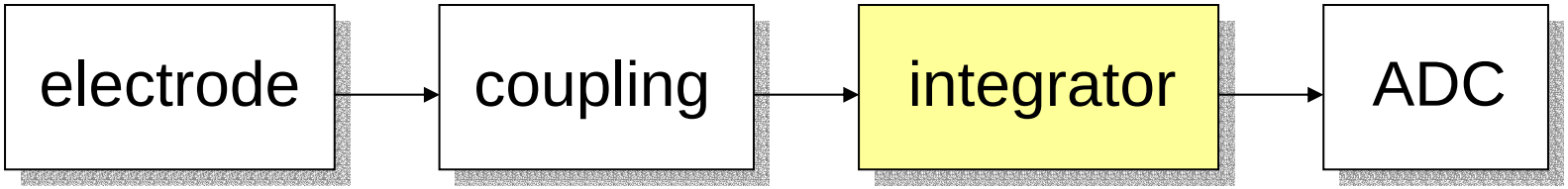
outside



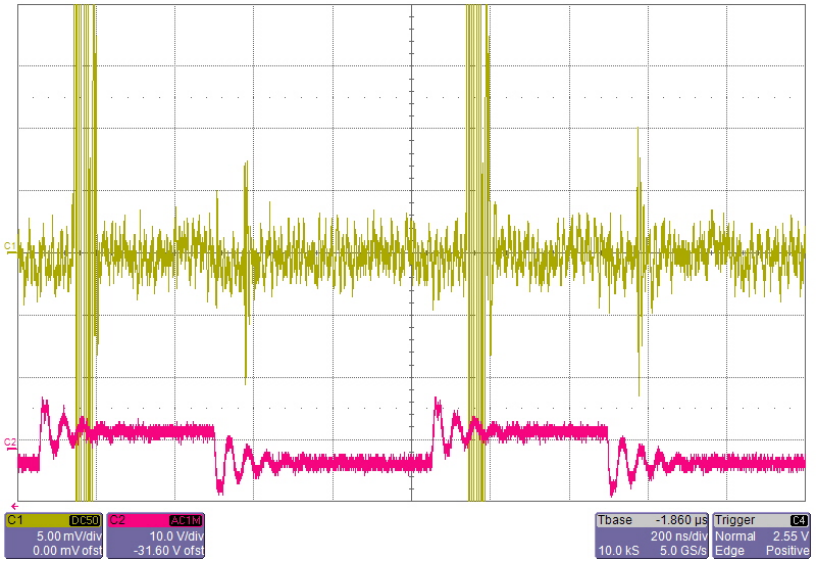
inside

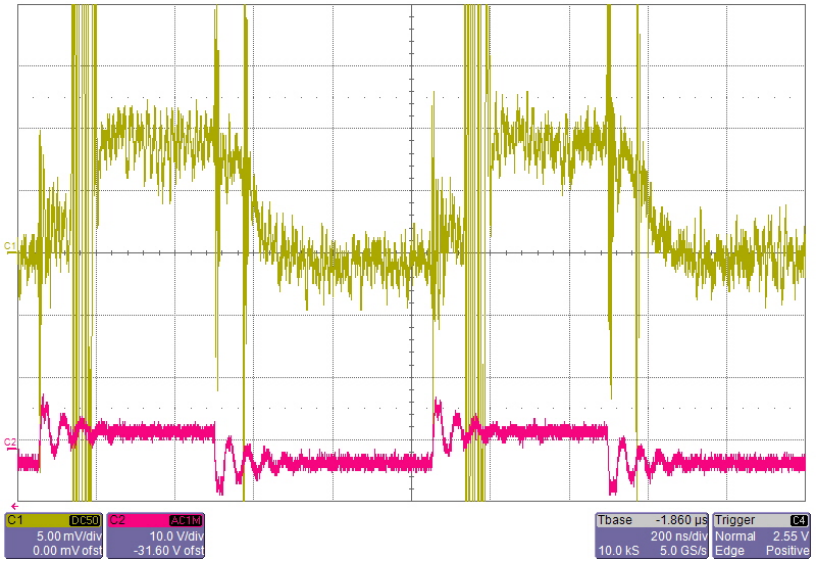


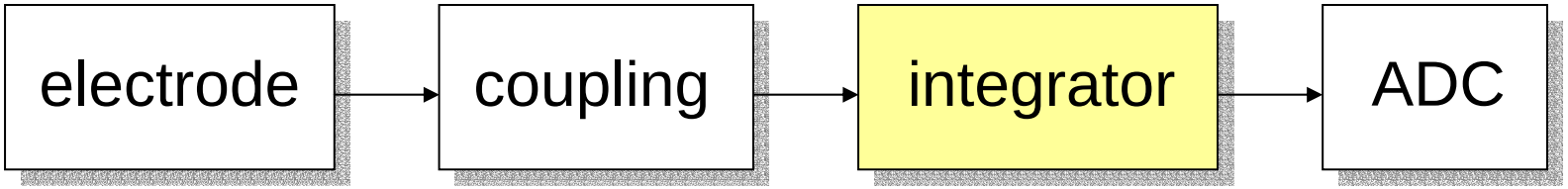
inside, shielded



All channels pick up noise from the card's own digital timing part – some are better, some are worse – but the pickup level for each channel is the same in all cards.



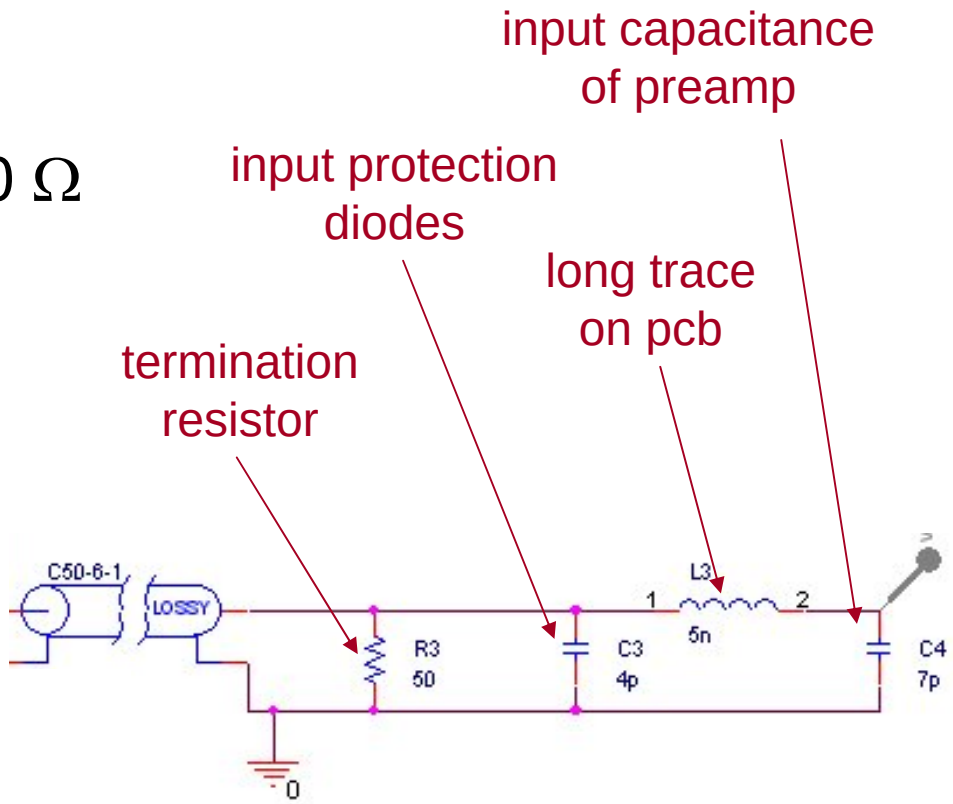


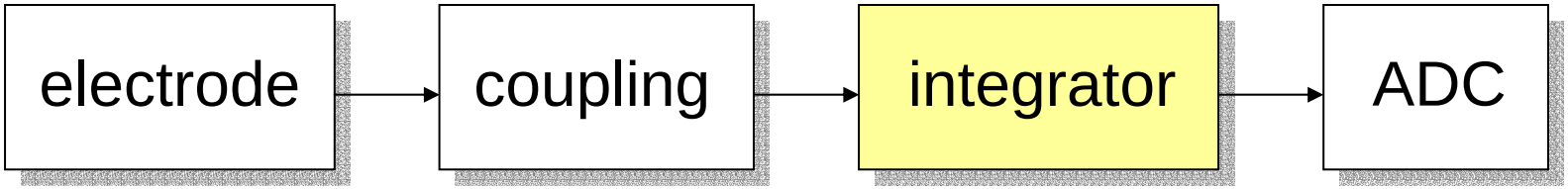


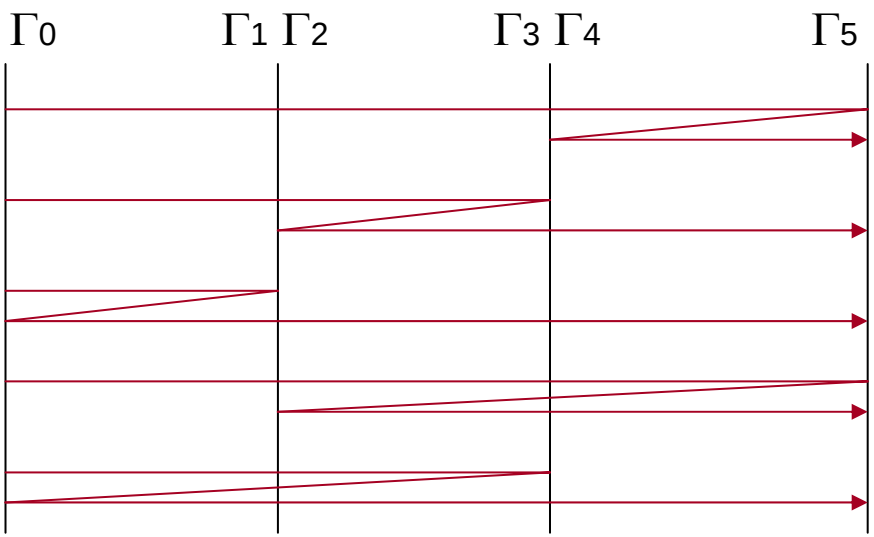
poor Γ of input: 0.29

pcb design weaknesses:

- impedance of trace not 50 Ω
- distance termination to amplifier too long
- cheap diodes in input
- amplifier capacitance not compensated
- jumper in signal path







$\Gamma_5\Gamma_4 = 0.023$ (300 ns)

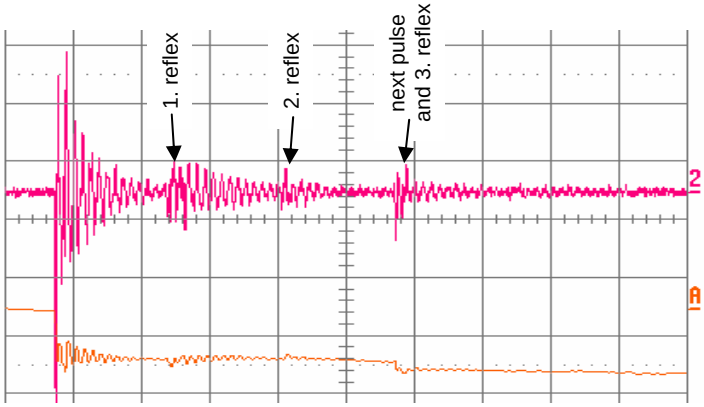
$\Gamma_3\Gamma_2 = 0.028$ (10 ns)

$\Gamma_1 = 0$ (2 ns)

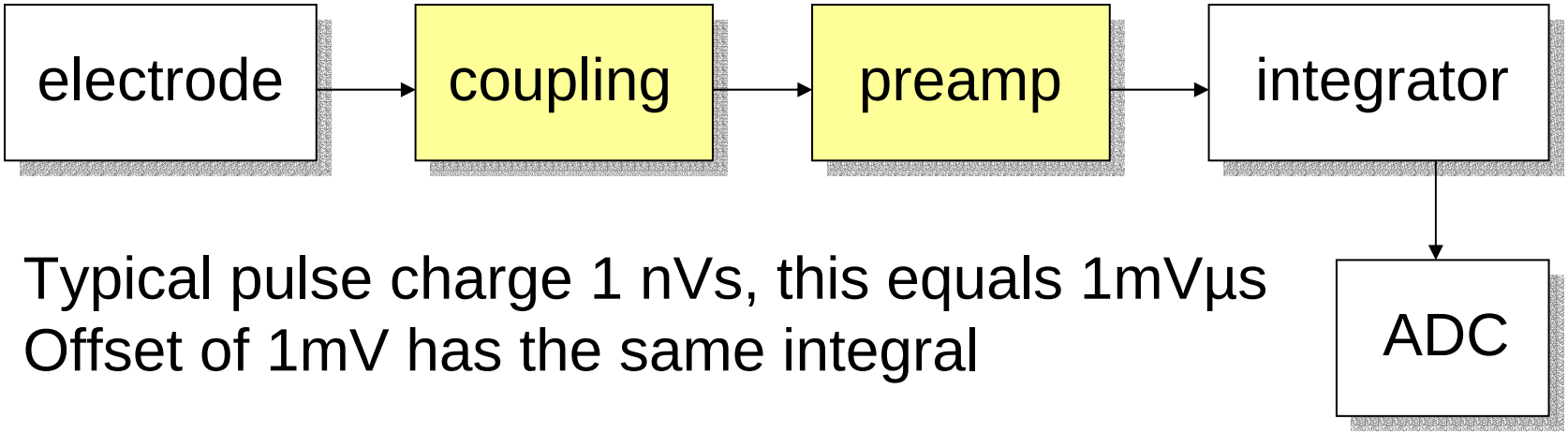
$\Gamma_5\Gamma_2 = 0.020$ (310 ns)

$\Gamma_3 = 0.040$ (12 ns)

Reflection has a long round trip time and might fall into the next's pulse integration window.

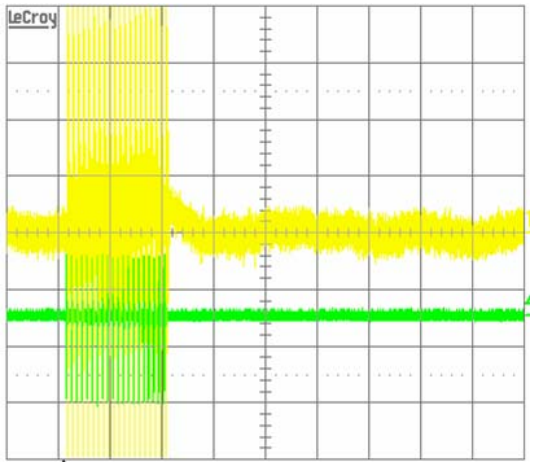


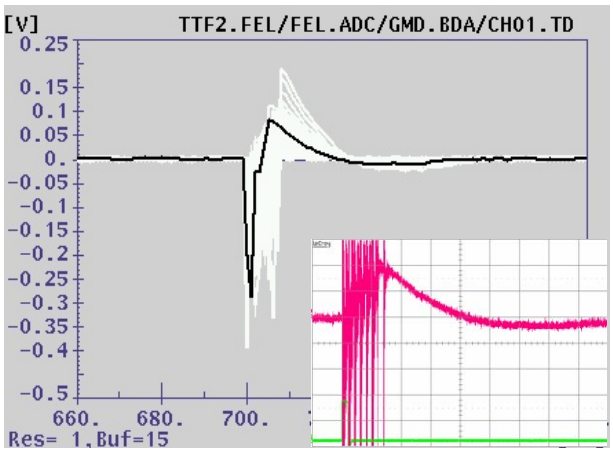
Electron Pulse Measurement

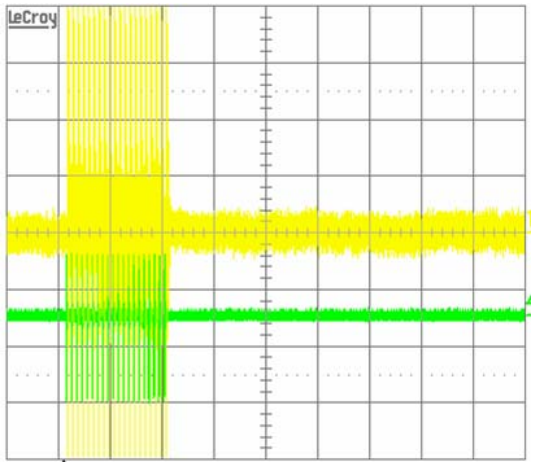


Typical pulse charge 1 nVs, this equals 1mVµs
Offset of 1mV has the same integral

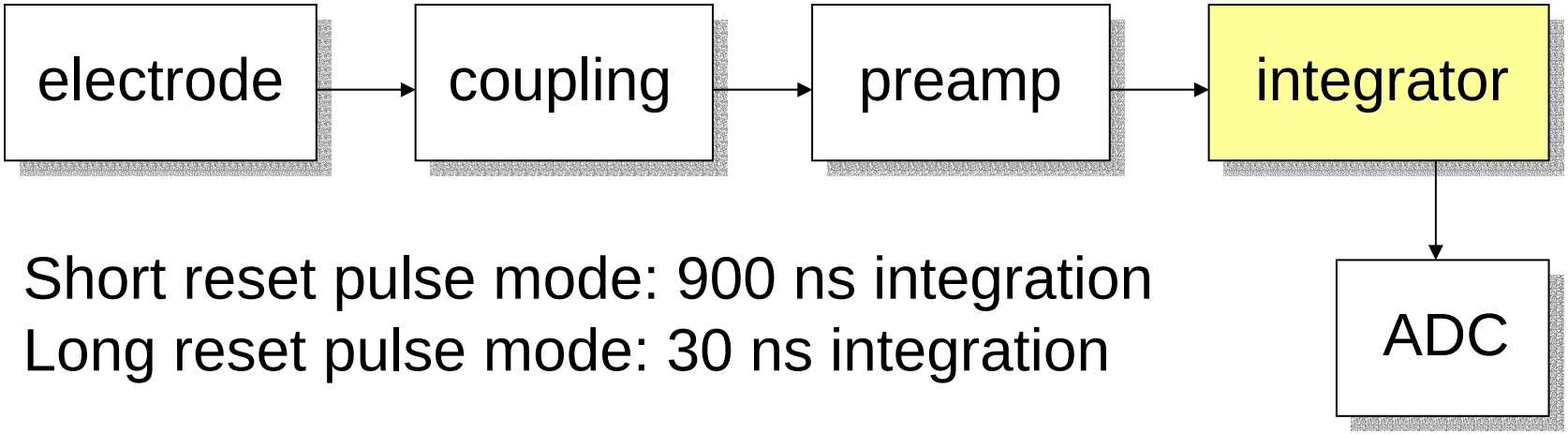
- DC coupled signal path
- integration window width as small as possible





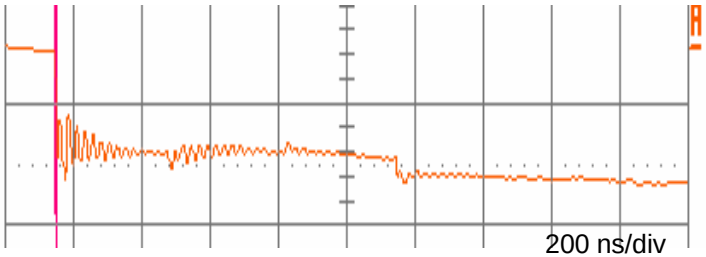


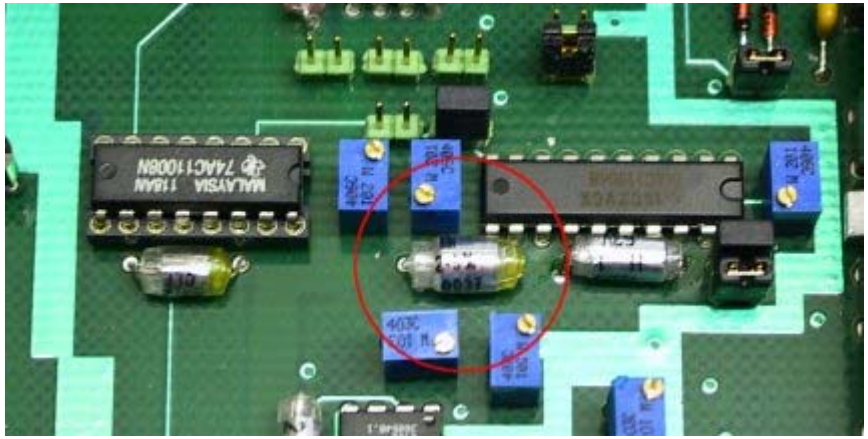
Electron Pulse Measurement

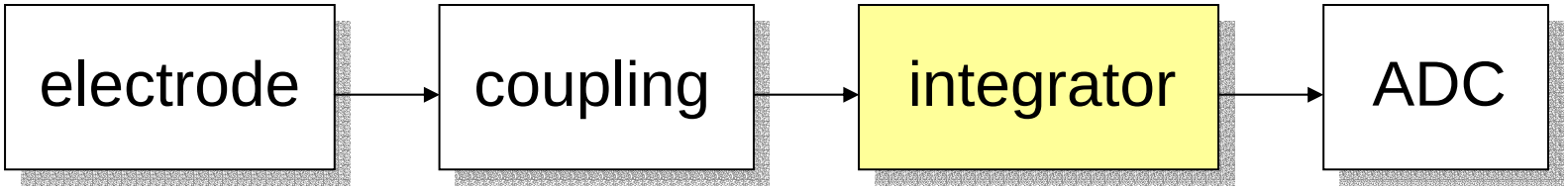


Short reset pulse mode: 900 ns integration
Long reset pulse mode: 30 ns integration

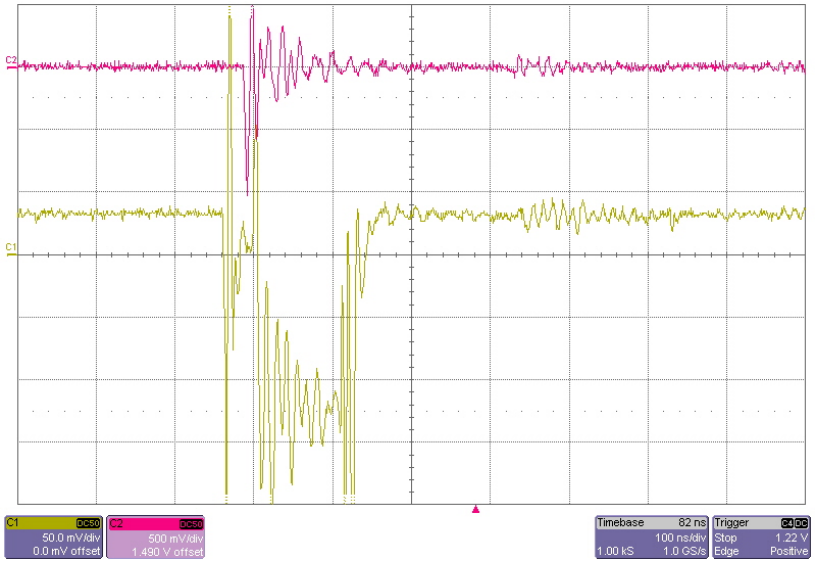
Changing the timing circuitry to allow 160 ns integration:
Based on LRP mode (needs other IC) with bigger capacitor

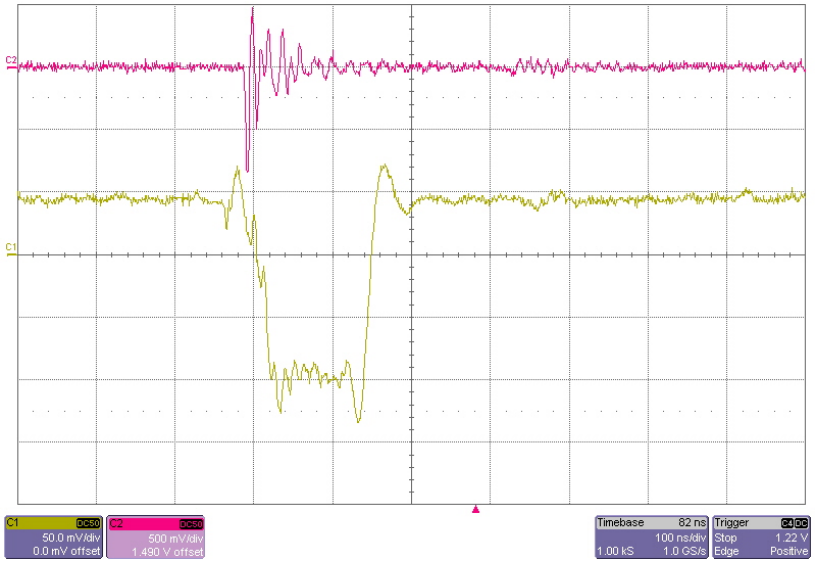


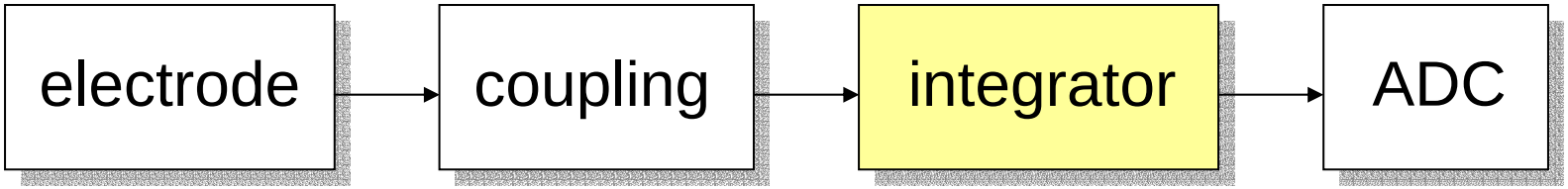




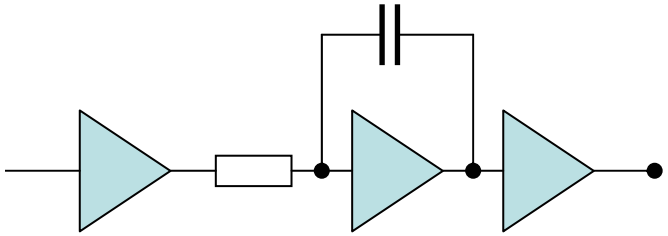
The signal's ringing prevents successful ADC, so we introduced a low pass filter after the integrator to get rid of the ringing on the integrator's output signal.

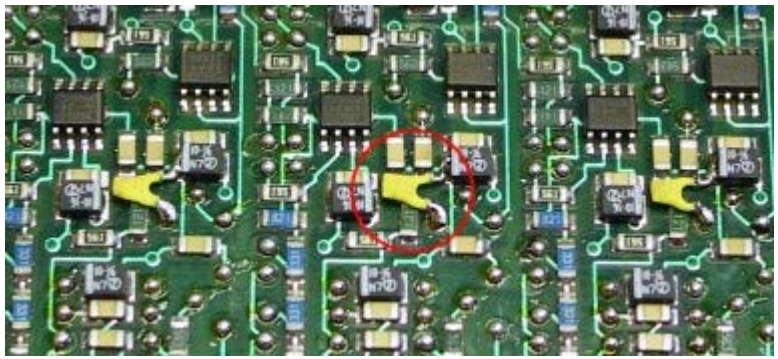


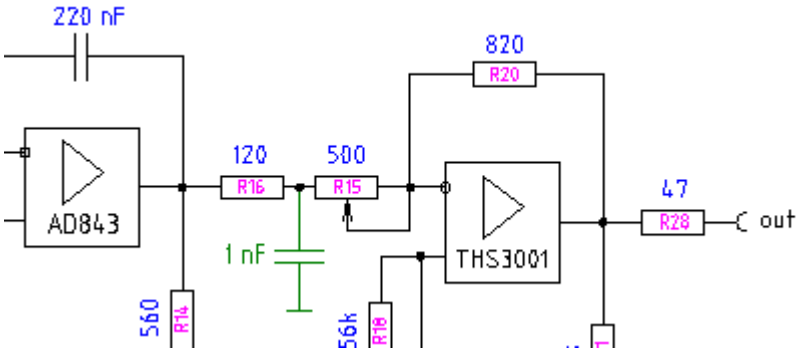


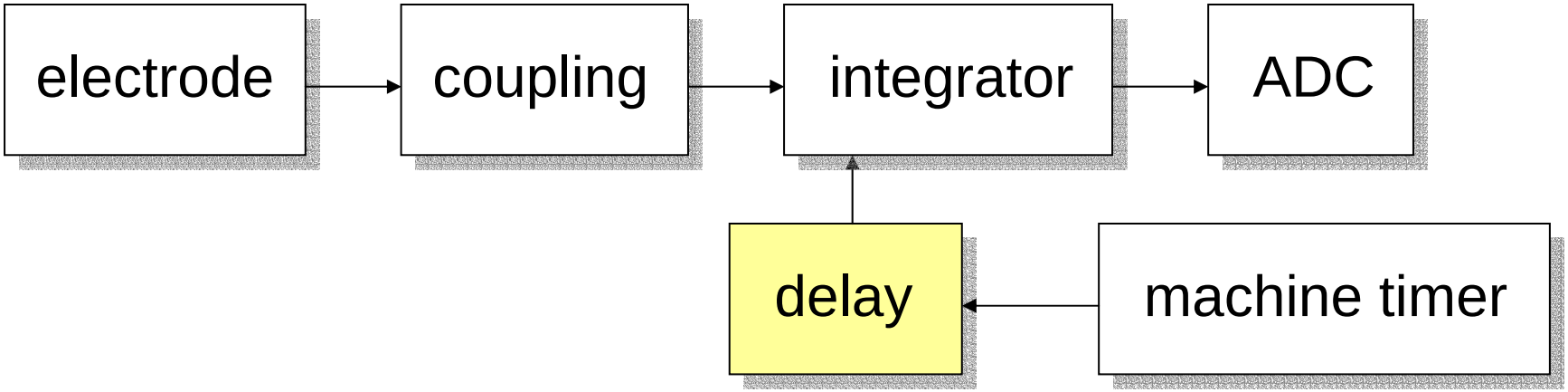


Placement and schematics of the damping capacitor









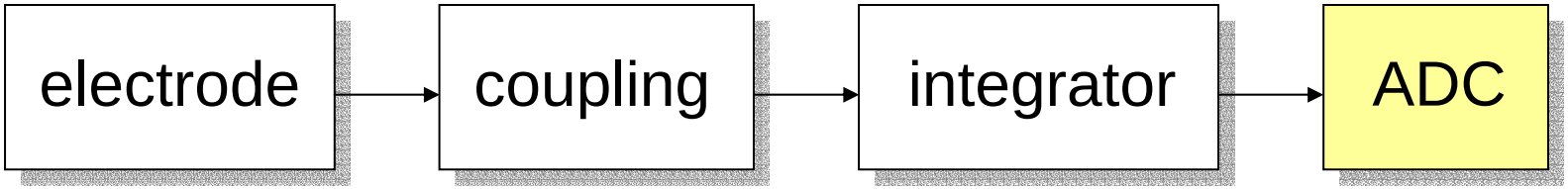
timing jitter extent

- 2.5 ps relative to input
- 2 ps for each daisy chain
- 0.46 ps for each ns of delay
- 160 ps pulse width
- 160 ps pulse distance

Jitter adds: for a 1 µs delayed pulse ~ 0.66 ns

→ *No problem for integrator usage*

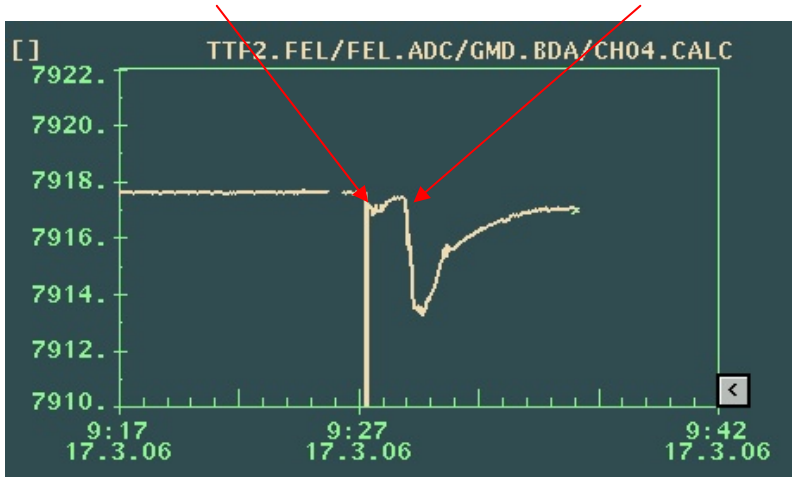
Electron Pulse Measurement



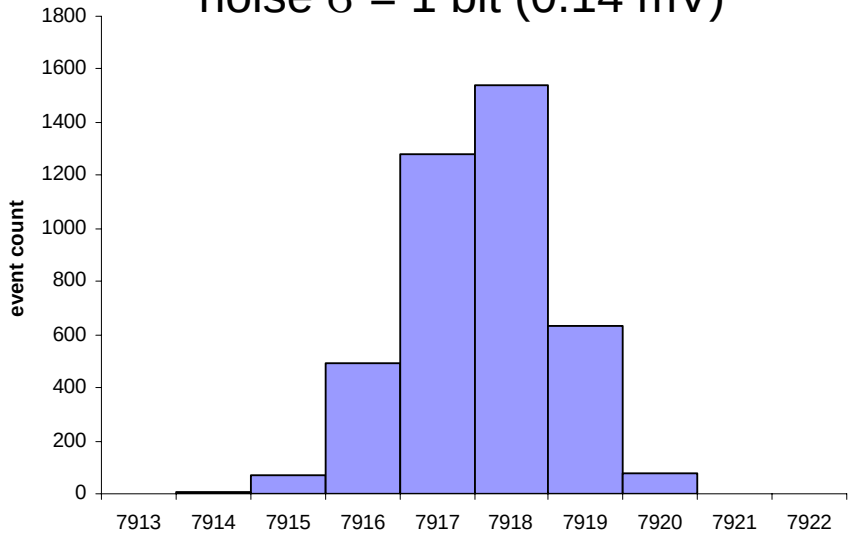
characteristics (1V range):

- resolution 14 bit → ENOB 12.2 bit → 12 bit measured
- 0.43 bit / °C
- acquisition time 45 ns typ (20 ns sample and hold)

next card removed ADC heated

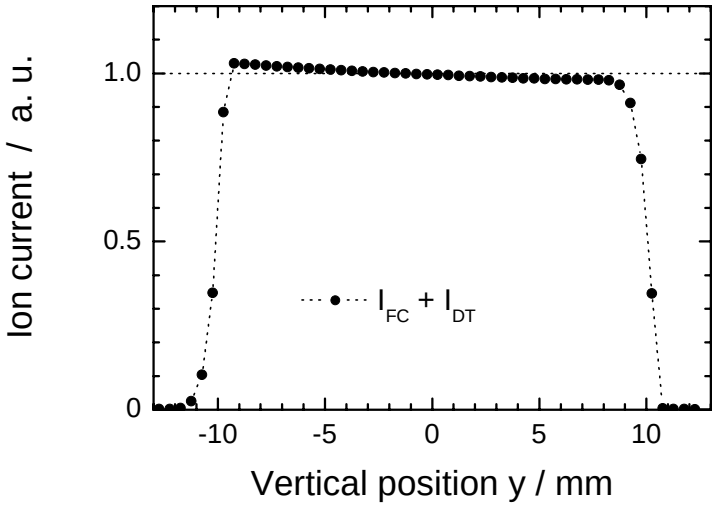


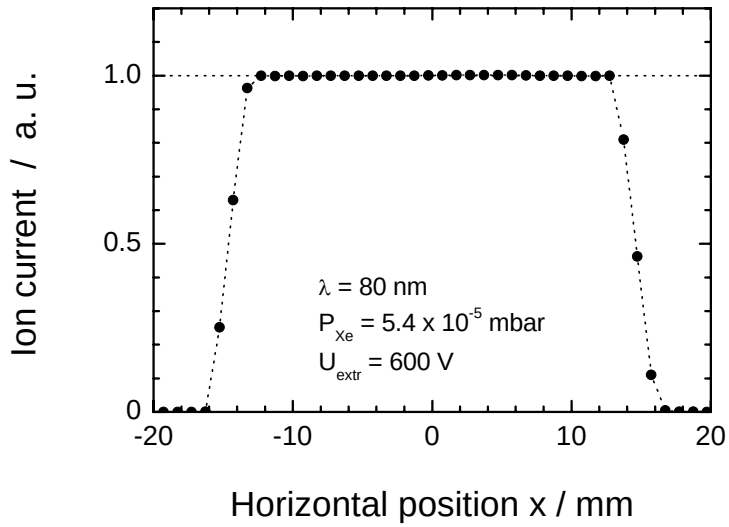
noise σ = 1 bit (0.14 mV)



Homogeneity of the intensity signal measured by PTB at Bessy

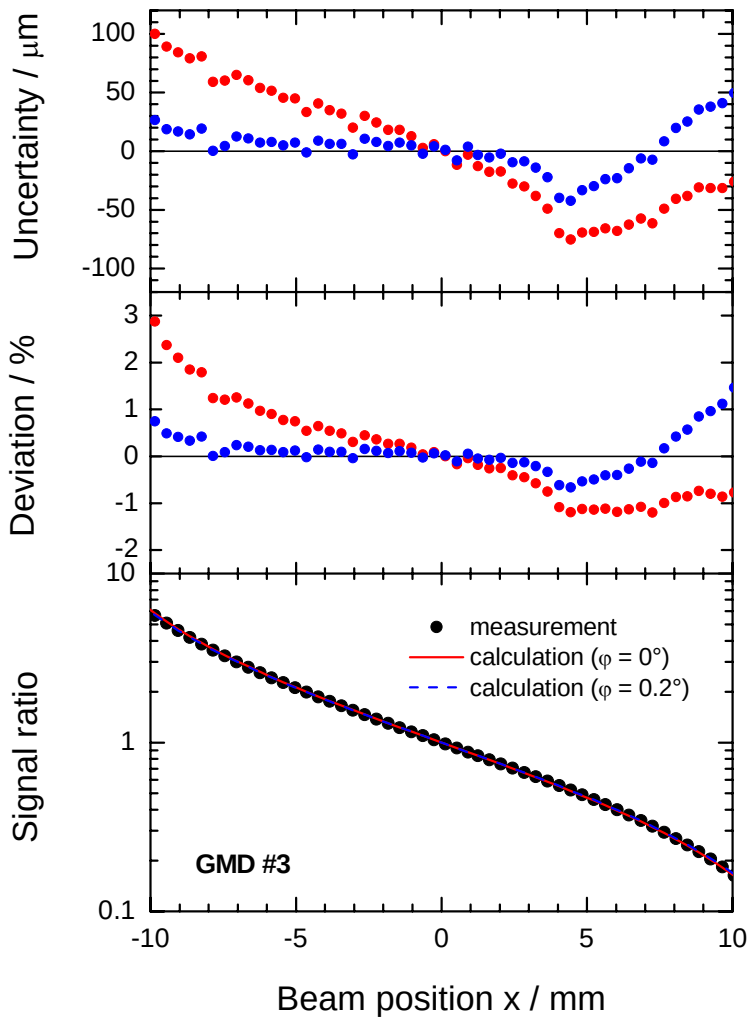
- ion current independent of horizontal and mostly of vertikal position of the beam
- sharp signal decrease if it leaves the measuring apertue
- ion current measurement unsusceptible to secondary electrons



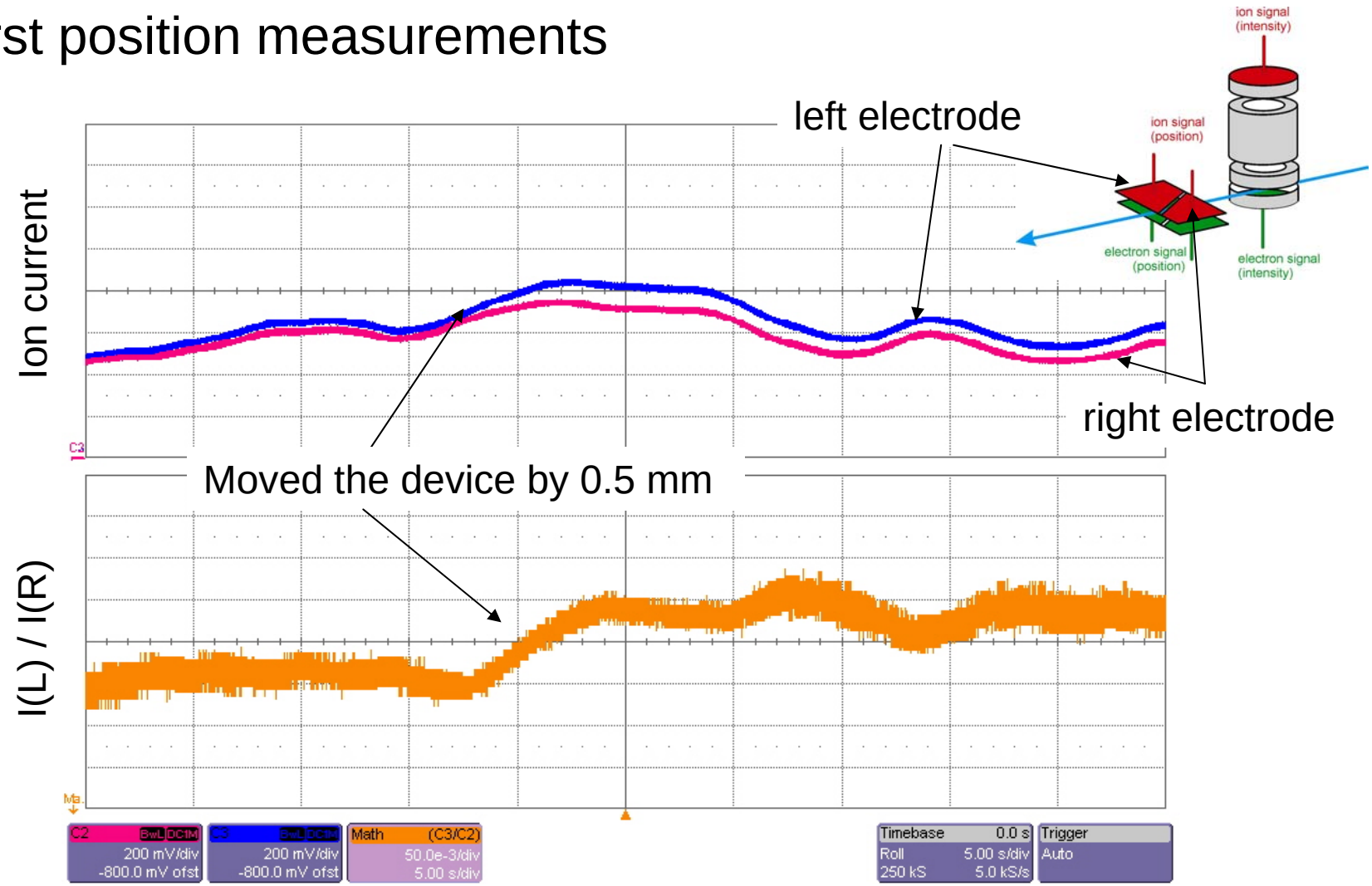


Calibration of the beam position monitor by PTB at Bessy

- measures the center of the beam
- position signal independent on intensity



First position measurements



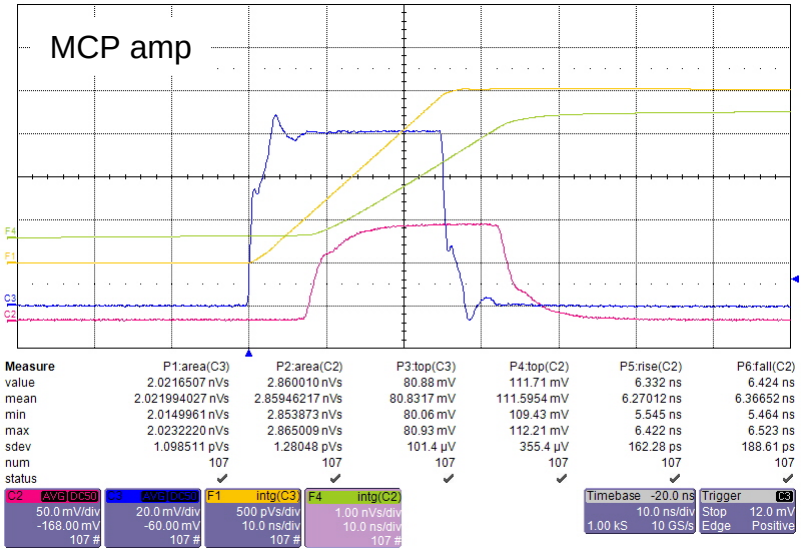
The MCP Signal Path

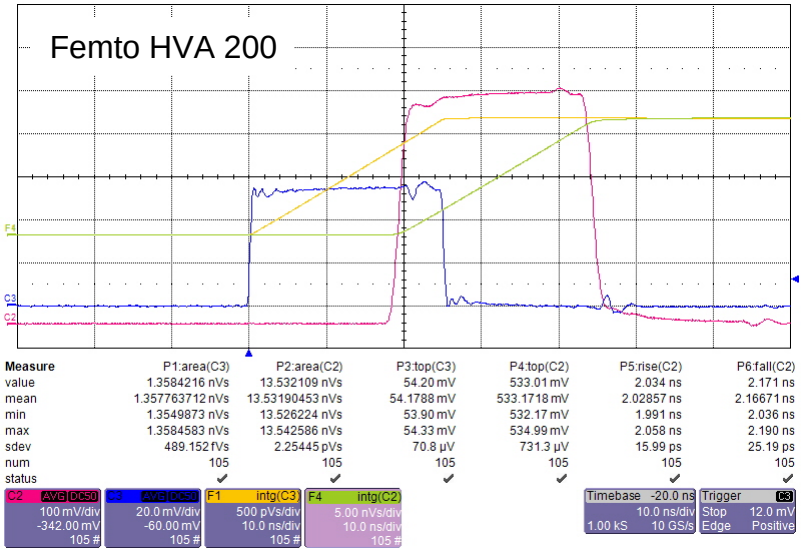
The MCP preamp

measured values:

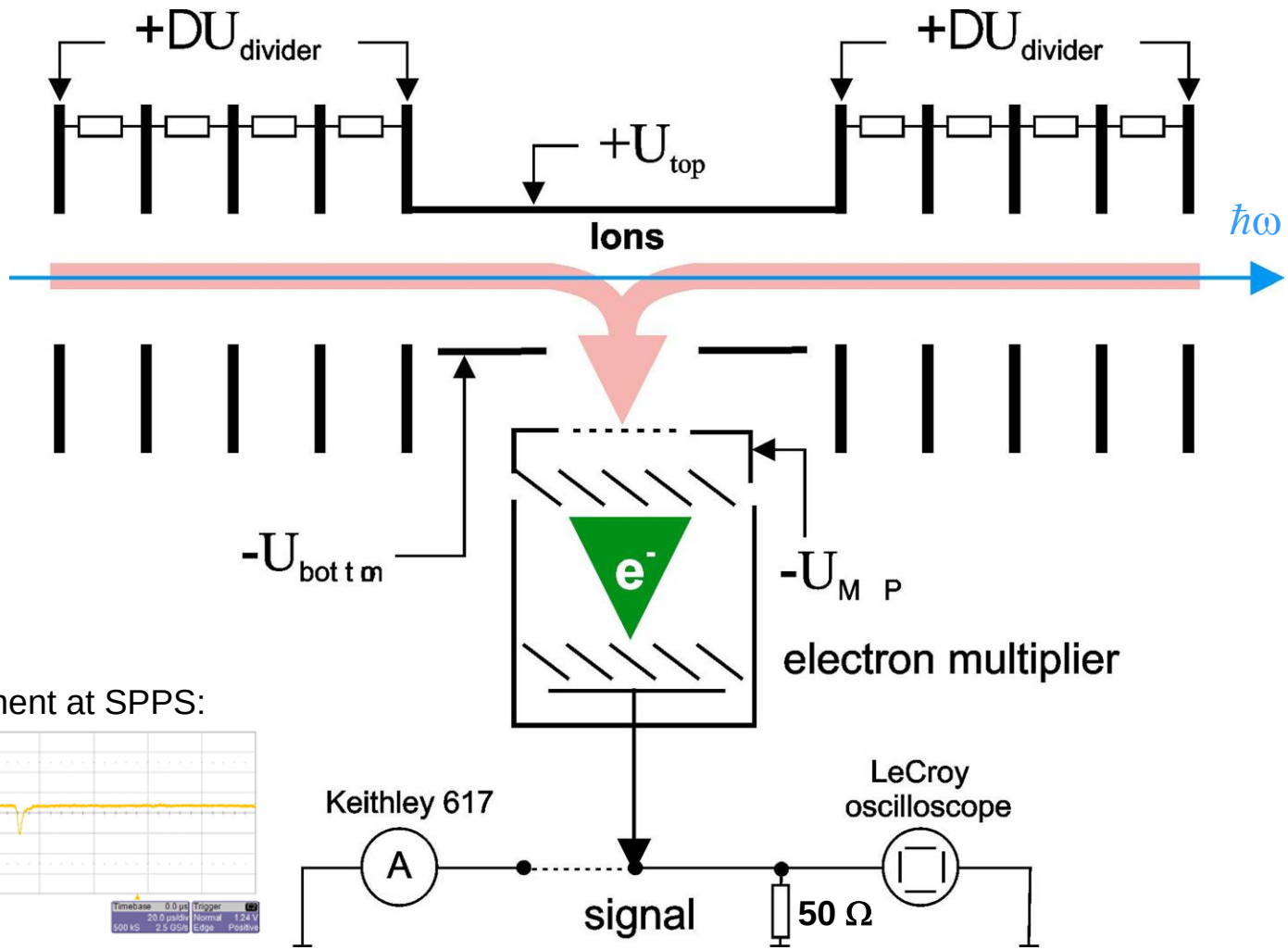
- rise time 6.3 ns
- bandwidth ~80 MHz
- gain 1.4
- no impedance match to 75 Ω SHV cable

Extreme ringing expected. Signal seems to be smooth due to the low pass characteristic of the amplifier.





Extended GMD Version for Ultra-short X-ray Pulses



Measurement at SPPS: