PAUL SCHERRER INSTITUT

NMI3 - Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy

NMI3 Meeting 26.-29.9.05
JRA8 MUON-S

WP1: Positron detection at high rates – revival of the integral analogue detection technique

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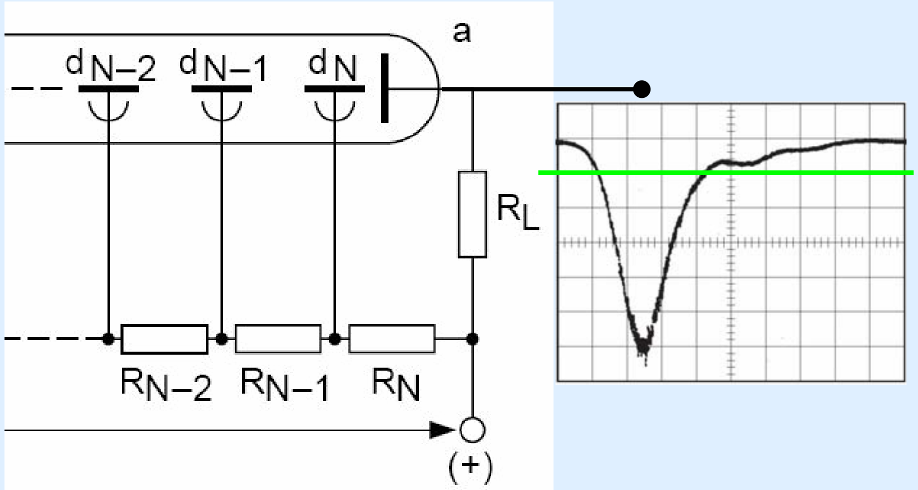
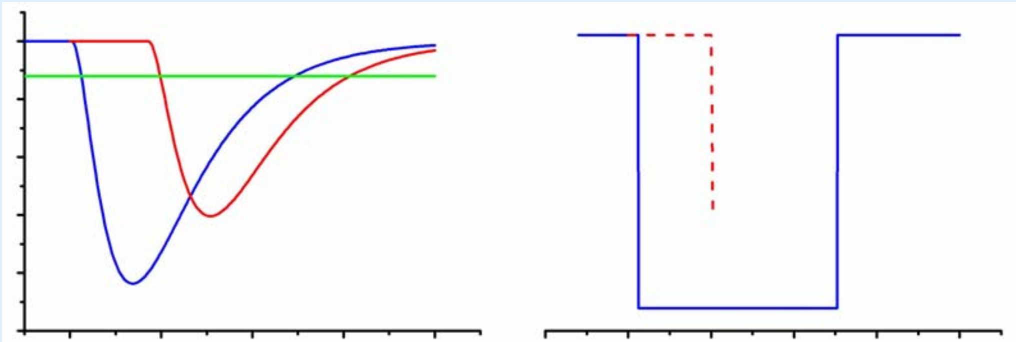
‘Digital’ counting

Pulse forming at anode output



signal above threshold
‘standard’ pulse formed
by discriminator

2 consecutive pulses
within pulse width ⇒ pile-up



(count loss at short times)
avoid this by
multi-segment detectors

'Analogue' counting

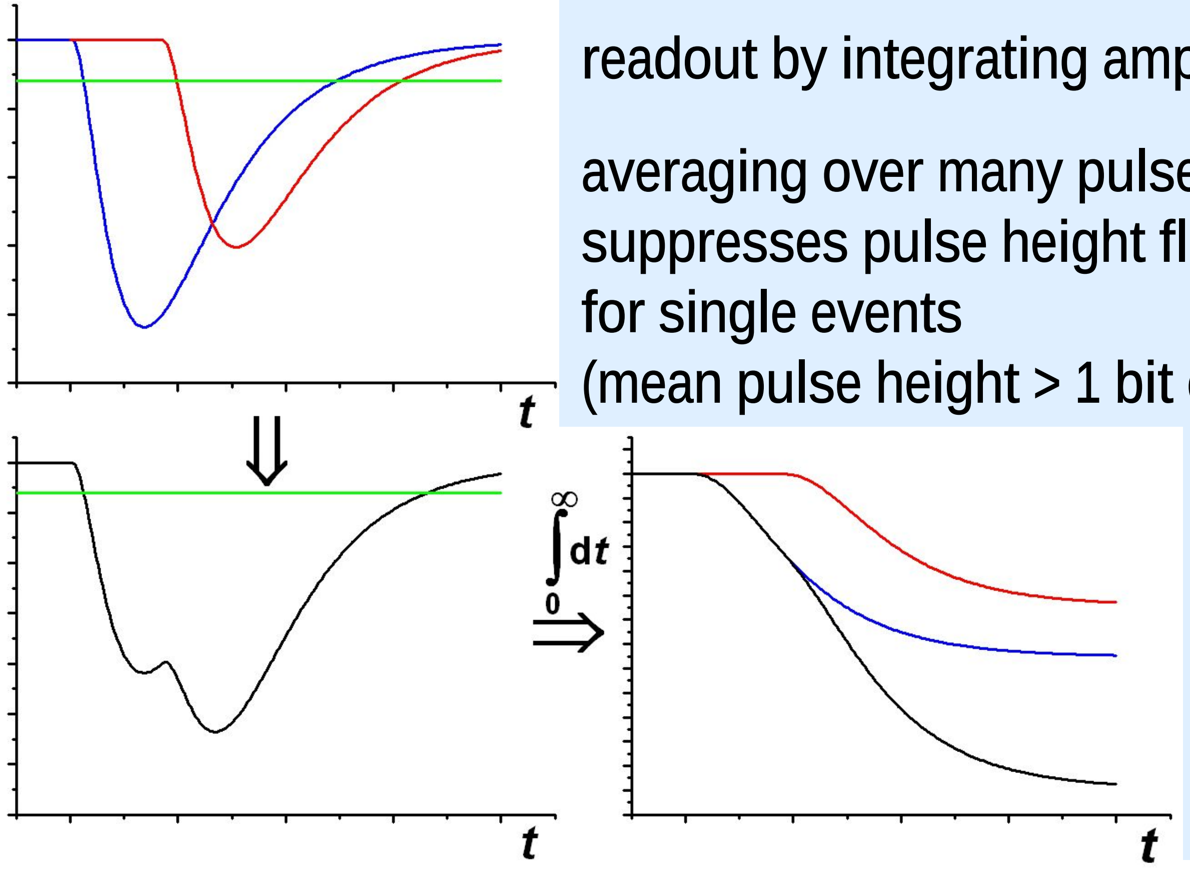
1) True waveform digitizing,
waveform analysis

2) Integration of anode current:
charge collection

(remove anode resistor from PMT base)

readout by integrating amplifier,

averaging over many pulses (~10^4) suppresses pulse height fluctuations for single events
(mean pulse height > 1 bit of digitizer !)



Analog Integration Detector Technique for RFμSR at Pulsed Muon Beams

1990-1996: Technical Development by

M. Hampele, K. Maier, J. Major, Th. Pfiz, R. Scheuermann, J. Schmidl

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&

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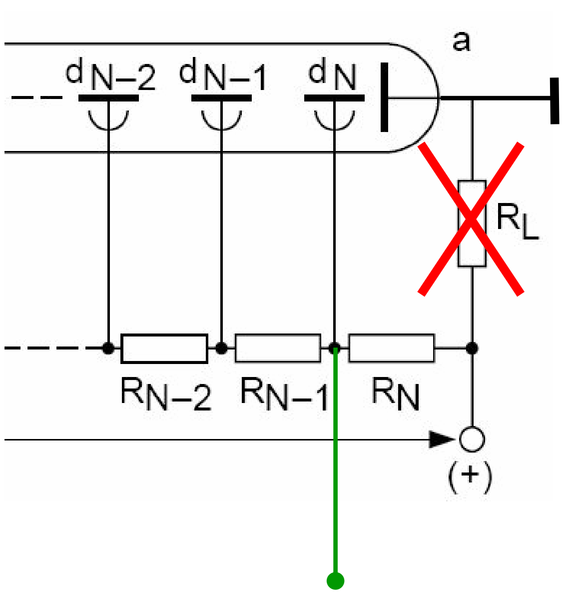
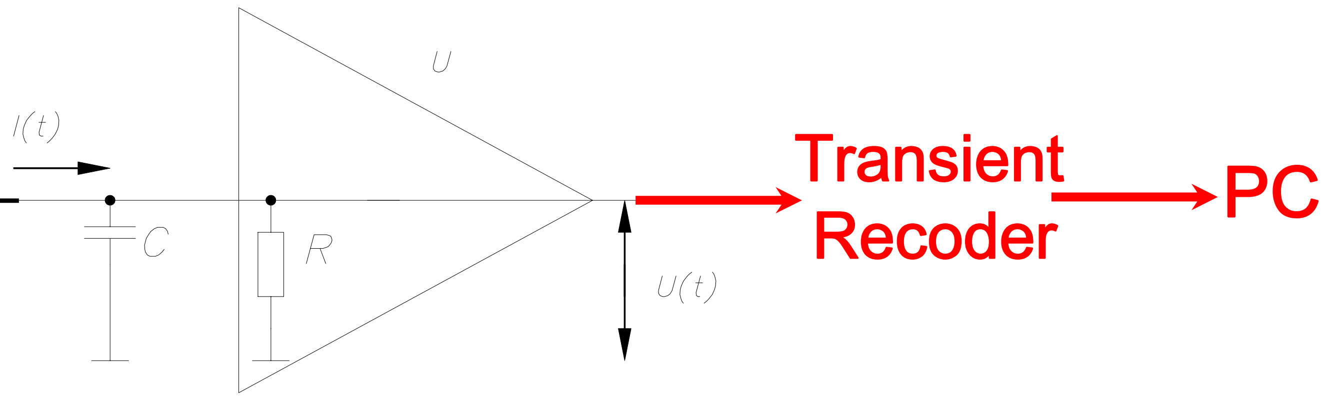
- M. Hampele *et al.,* Hyperfine Interactions 87 (1994), 1043
- R. Scheuermann *et al.,* Applied Magnetic Resonance 13 (1997), 195
- R. Scheuermann, Diploma Thesis, Universität Stuttgart (1993)
- R. Scheuermann, Dr. rer. nat. Thesis, Universität Stuttgart (1997)
- J. Schmidl, Dr. rer. nat. Thesis, Universität Stuttgart (1997)

Integrator circuit: RC – self discharge!

$$I(t) = C\dot{U}(t) + \frac{U(t)}{R}$$





$$I(t) = I_0 e^{\frac{-t}{\tau_\mu}} \left(1 + a \cdot e^{-\lambda t} \cdot \cos(\omega_1 t + \phi)\right)$$ **Linearity!**

dynode signal:
'digital' counting

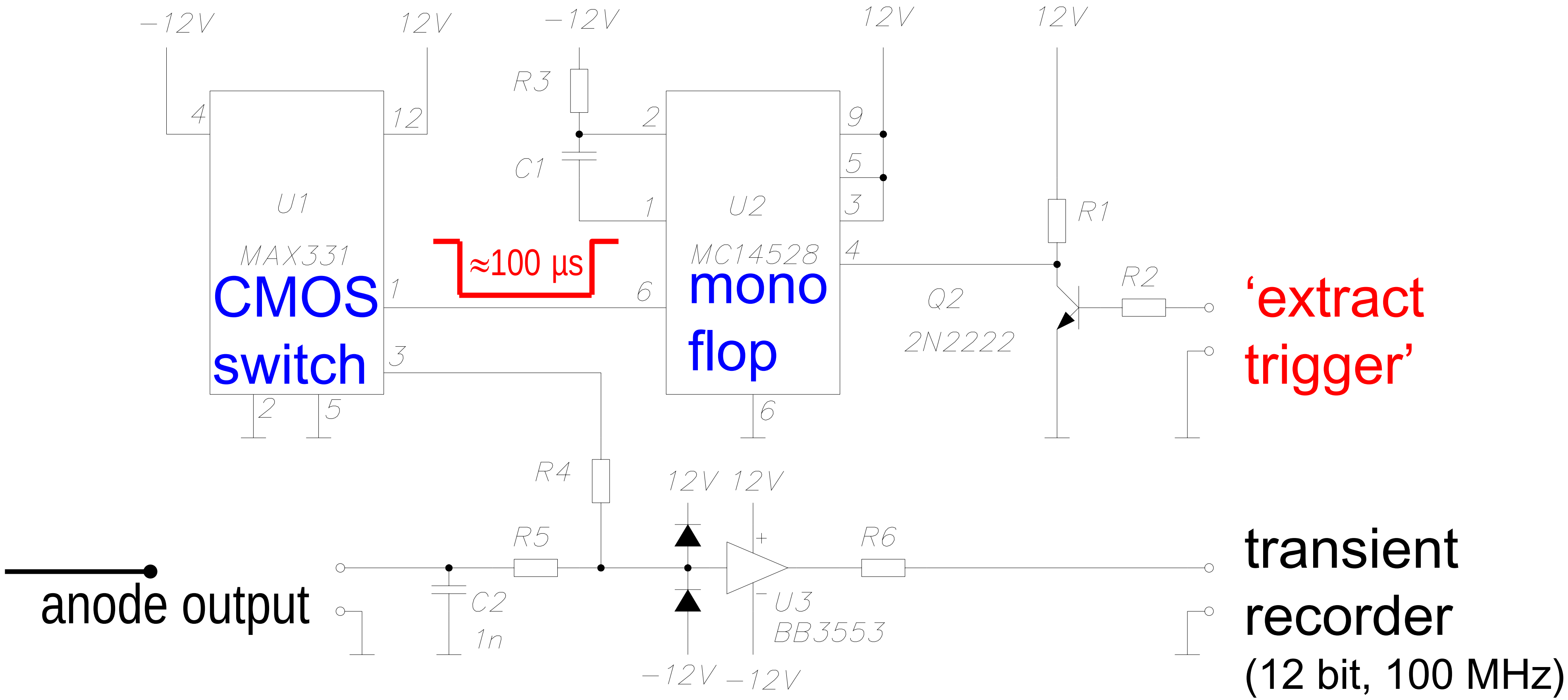
correction for self discharge at long times:
fit of the numerically differentiated signal d*U(t)*/dt
in order to correct *U(t)*

$$\dot{U}(t) = \frac{I_0}{C(RC - \tau_\mu)} \left(RC \cdot e^{\frac{-t}{\tau_\mu}} \cdot \left(1 + a \cdot e^{-\lambda t} \cdot \cos(\omega_1 t + \phi)\right) - \tau_\mu \cdot e^{\frac{-t}{RC}} \right)$$

integating circuit kept discharged between muon pulses (U1 ‘closed’)

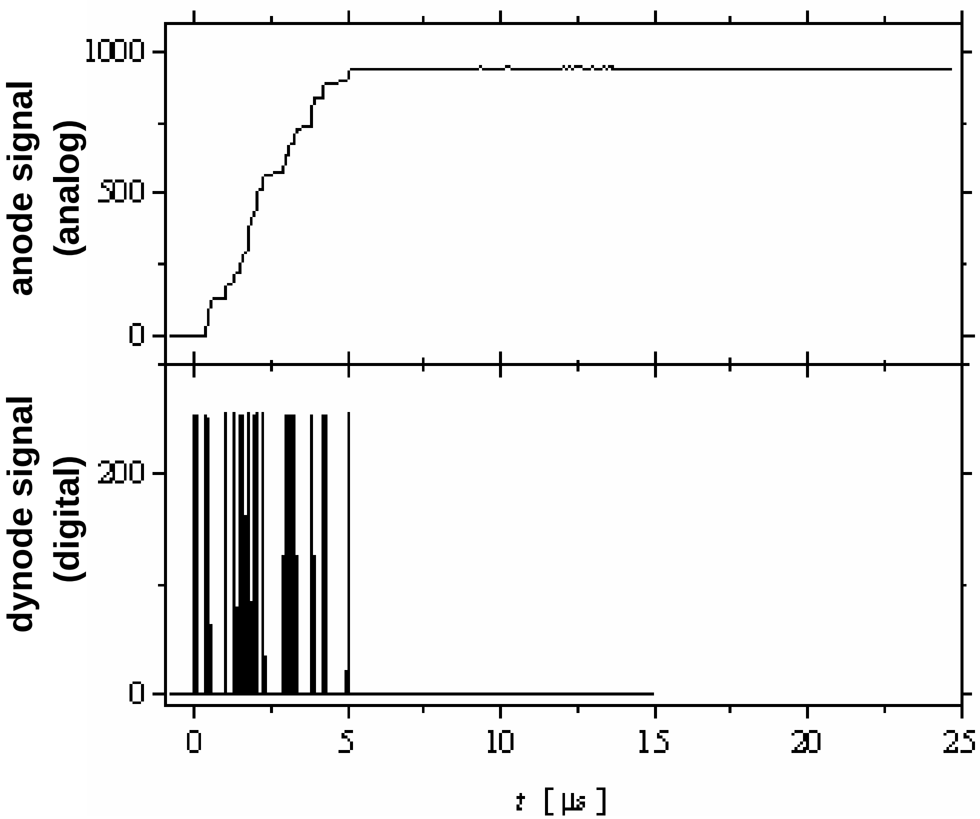
CMOS switch U1 opened by ‘extract trigger’ a few µs before muon pulse

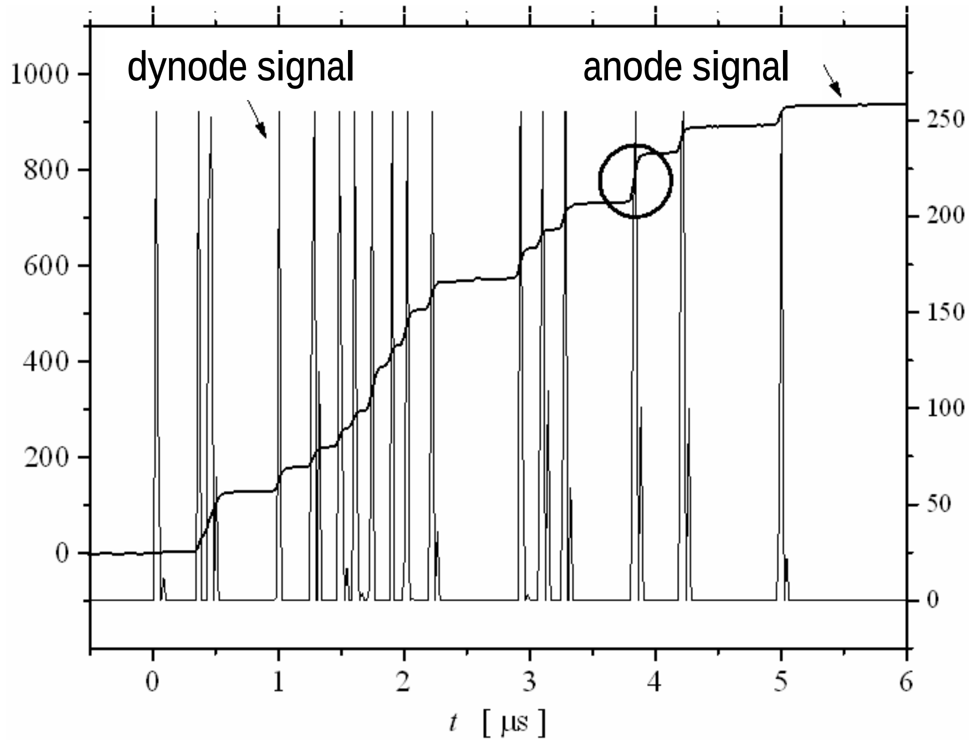
DAQ gate 100 µs (R3C1)



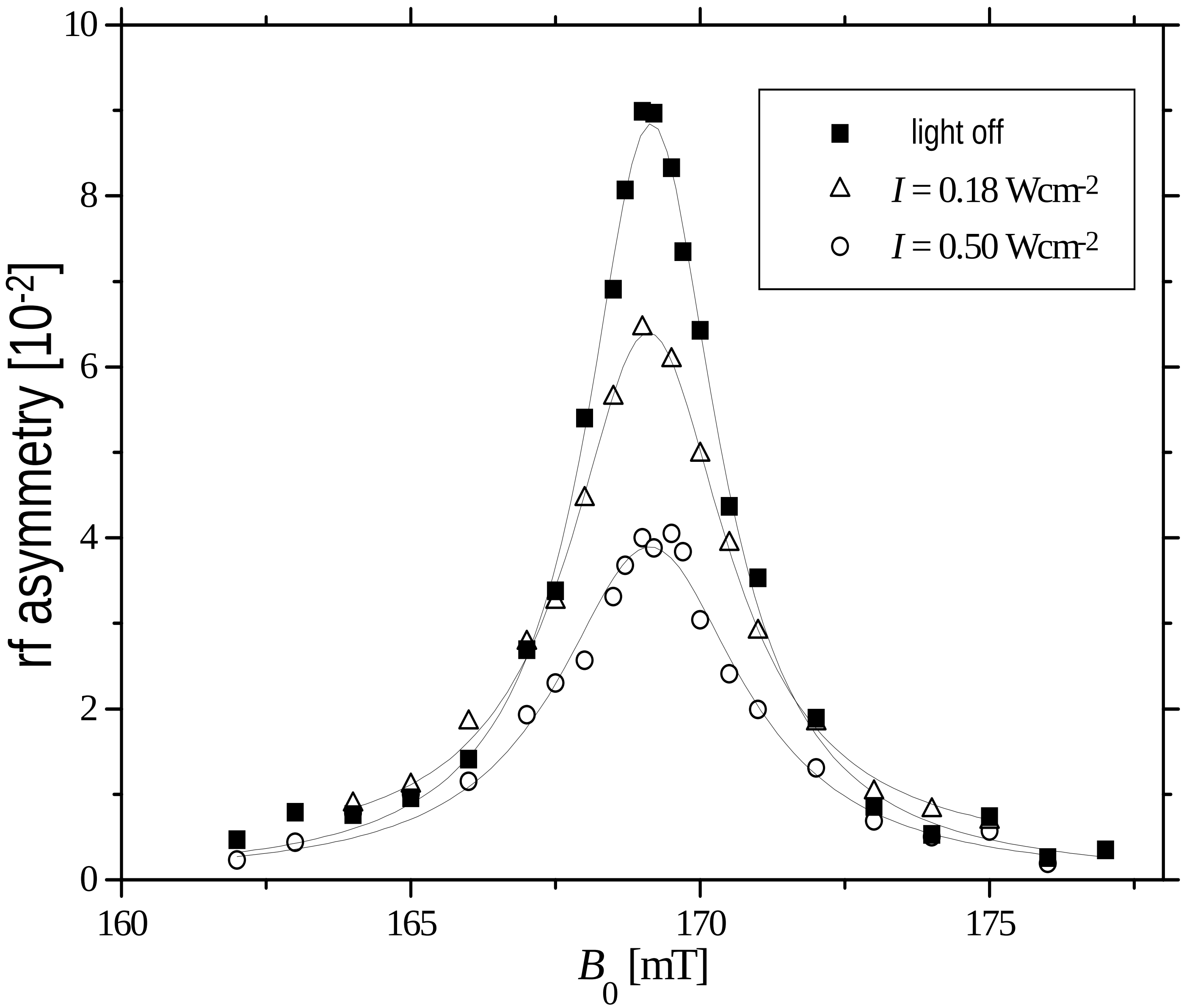
integrated signal from anode,

‘digital signal’ from dynode

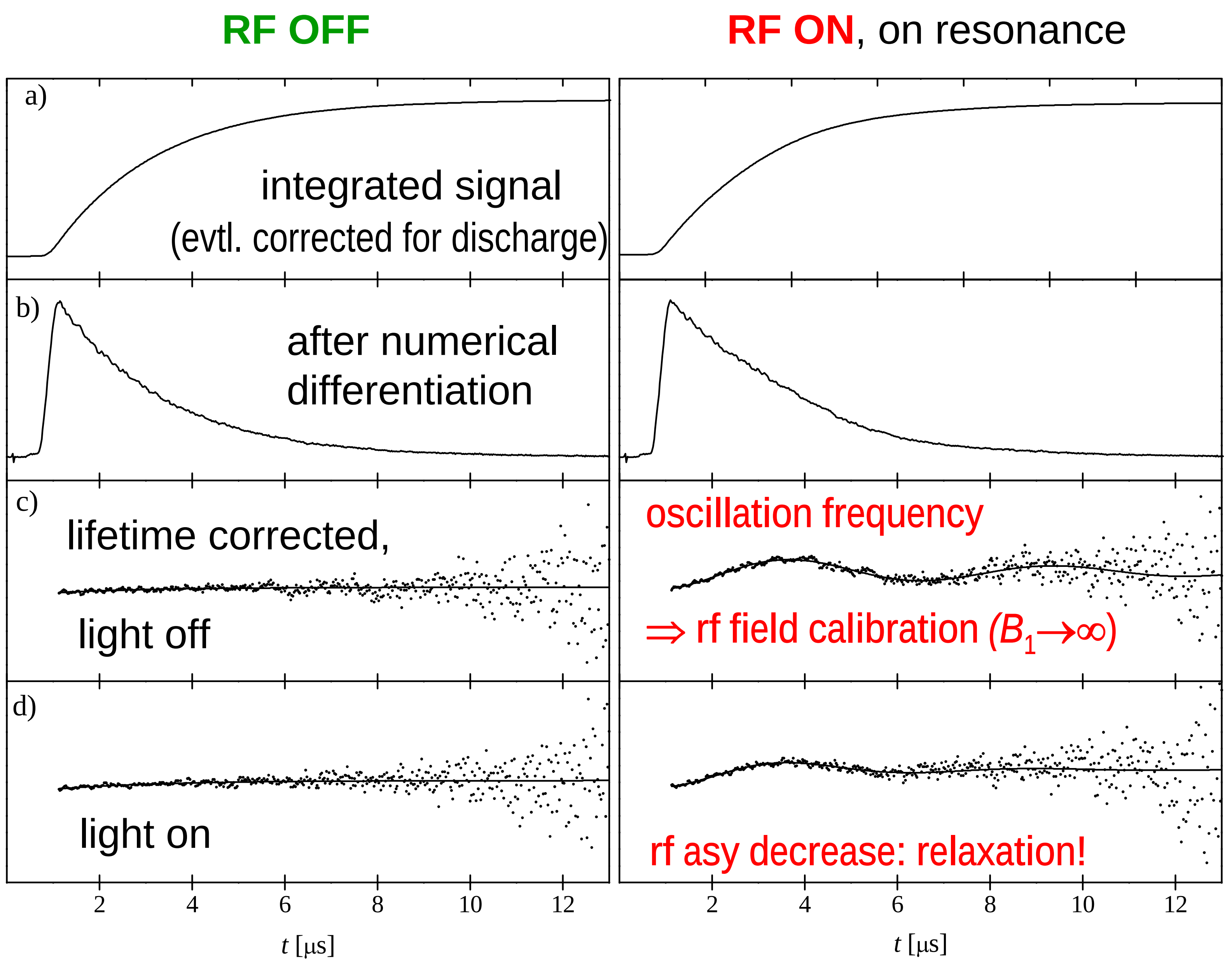




Example: RFµSR on Si:B under illumination



decrease of rf asymmetry under illumination:
diamagnetic fraction
or
relaxation?


RF OFF
RF ON, on resonance
a)
integrated signal
(evtl. corrected for discharge)
b)
after numerical
differentiation
c)
lifetime corrected,
light off
oscillation frequency
⇒ rf field calibration (B_1→∞)
d)
light on
rf asy decrease: relaxation!
2
4
6
8
10
12
t [μs]
t [μs]

Advantage:

- multi-segmentation not necessary!
- especially suited for TI techniques (RFμSR) at pulsed beams

Problems:

- discharge integration circuit: very small relaxaxion rates difficult to observe
- sensitive to pick-up distortions
- fit of multi-component signal (TD) ‘difficult’…

to be further developed! ⇒ JRA MUON-S (ISIS-PSI-Oxford-Parma)

- voltage divider for PMT (linearity at high rates),
- shielding, stabilisation
- integrator optimisation (DAQ gate – RC discharge)