Krakow STT front-end electronics meeting 2013-02-28

Simple measurements for a better understanding of the performance of STT electronics

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in collaboration with many people from Jülich and Krakow involved in the STT project

A few point-like investigations of various aspects only with a digital oscilloscope, a pulse generator, radioactive sources and cosmics particles

Why ? Results of in-beam test often too complex for an unambiguos interpretation

Studies of
- the behaviour of the ASIC
- very fast wire-chamber signals
- the effect of long transmission cables
- electromagnetic interference (EMI) in straws and electronics

Open questions (briefly and often only implicitly) touched by these investigations

Choice of the Read-out system

Timing and Time-over-threshold with the Krakow ASIC
Fast amplifiers or shaping amplifiers with fast QDCs

Performance of the ASIC

ToT
Limitations for the timing resolution

Signal shapes, Noise level and timing resolution

Wire-chamber signals recorded with very fast amplifiers

Placement of electronics
HV transfer to the straws

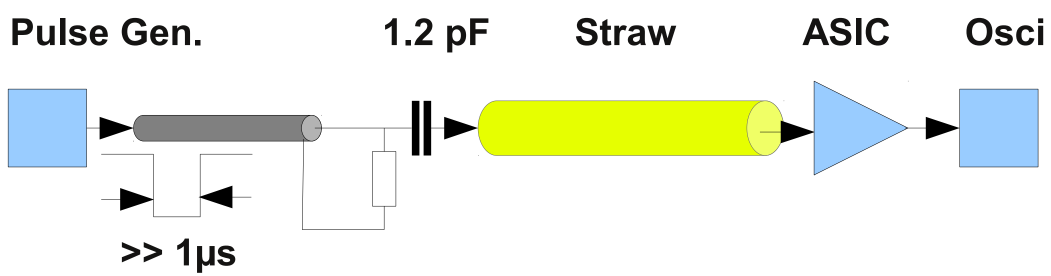
Preamplifiers inside the STT	transfer cables for <u>analog</u> signals
ASIC inside	transfer cables for <u>logical</u> signals
Nothing inside	signals and HV through common cables

Individual HV cables for groups of straws (How many are affordable ?)
HV transfer via signal cables

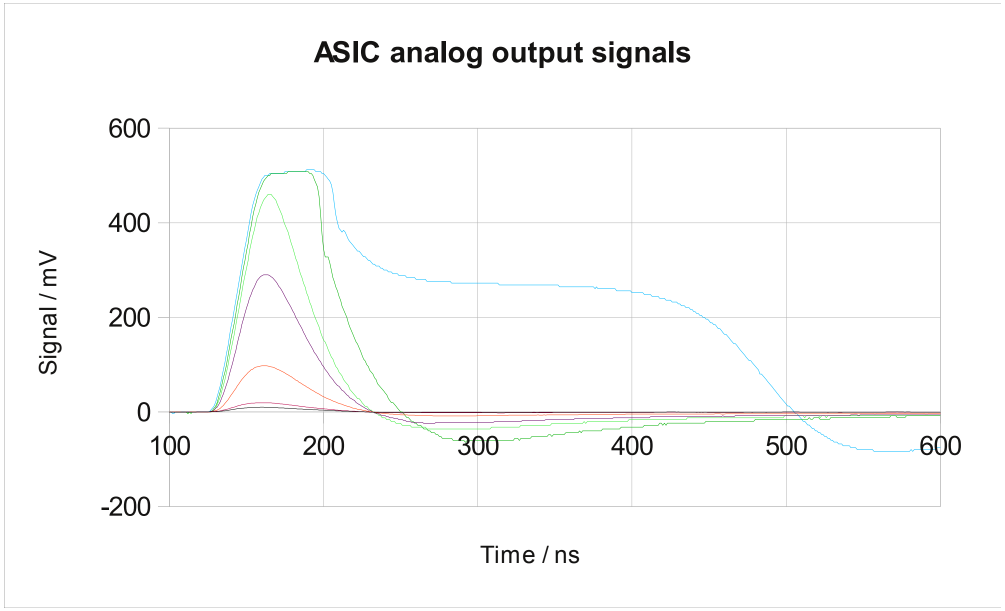
Protection against parasitic signals from external sources (EMI)

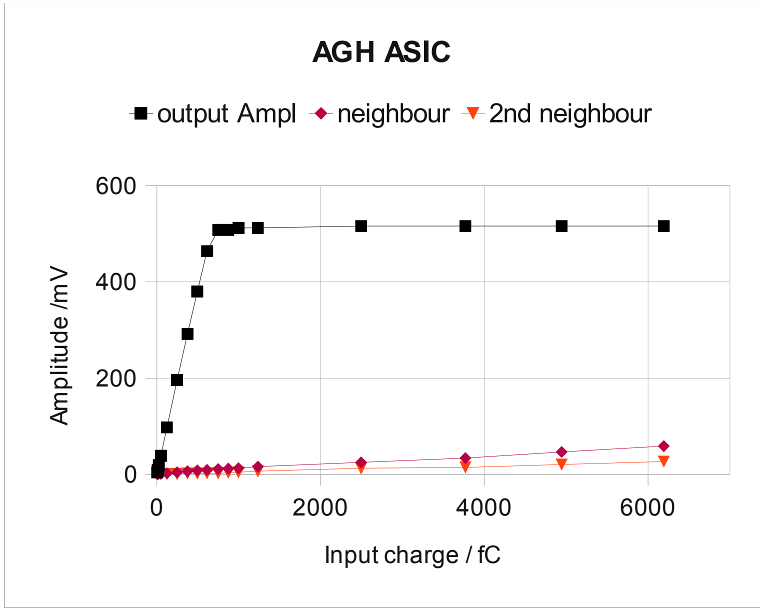
Solution for a problem usually seen in every detector

ASIC input signals simulated by a pulse generator



Pulse rise time = 2.5 ns
Charge = 1.2 pC/V
Amplitudes from noise to saturation





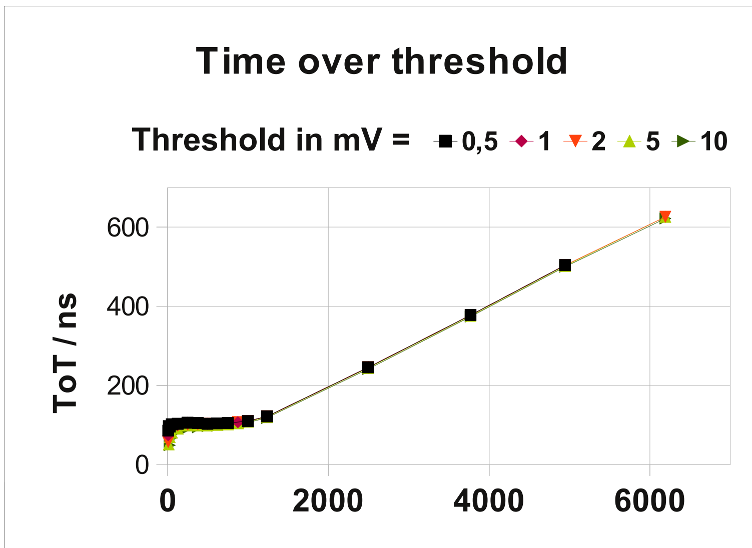
Saturation at q_{in} = 750 fC

Crosstalk ~ 2 % peak-to-peak in the neighbouring channel, rises linearly with pulse amplitude

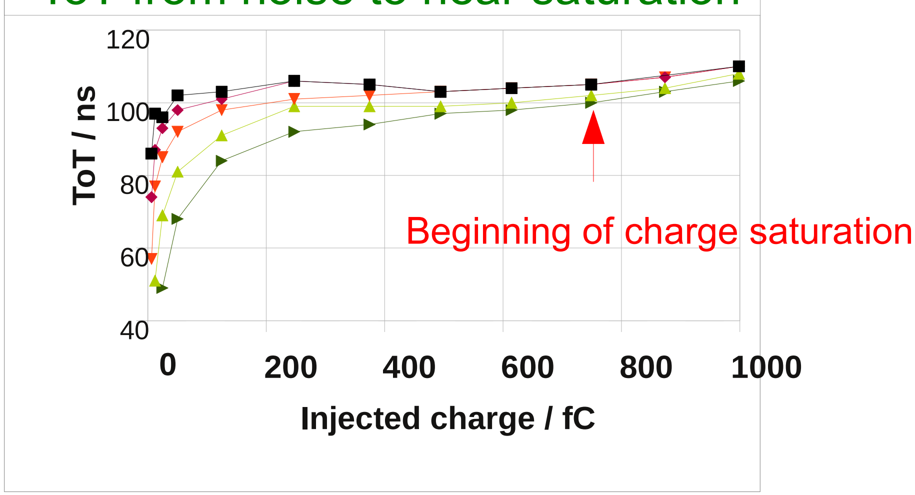
Gain = 0.78 mV / fC

Time over Threshold derived from pulser signals

ToT from noise far into the saturation region



ToT from noise to near saturation



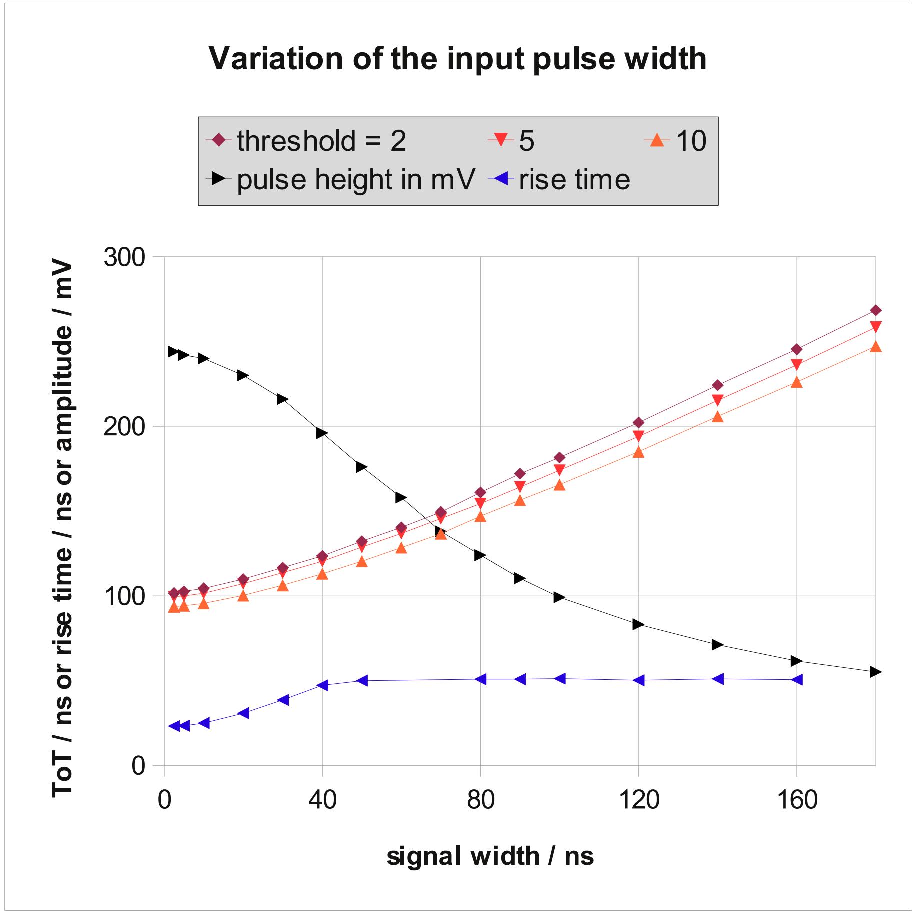
Results should be generalized only with care.
They belong only to a particular ASIC setting.

- Useful range of input charges is approx. 1/3 of the dynamical charge range
- The dynamical range increases with increasing threshold.

For rejection of the Landau tail:

The truncated-mean technique requires good resolution also for large signals

Time over threshold over a wide range of signal widths



Input signal charge = 300 fC
Pulse width from 2.5 ns to 180 ns
(Max drift time = 200 ns)

Variation of ToT with signal width
can exceed the effect of the input charge

Loss of amplitude with signal width might
be tolerable

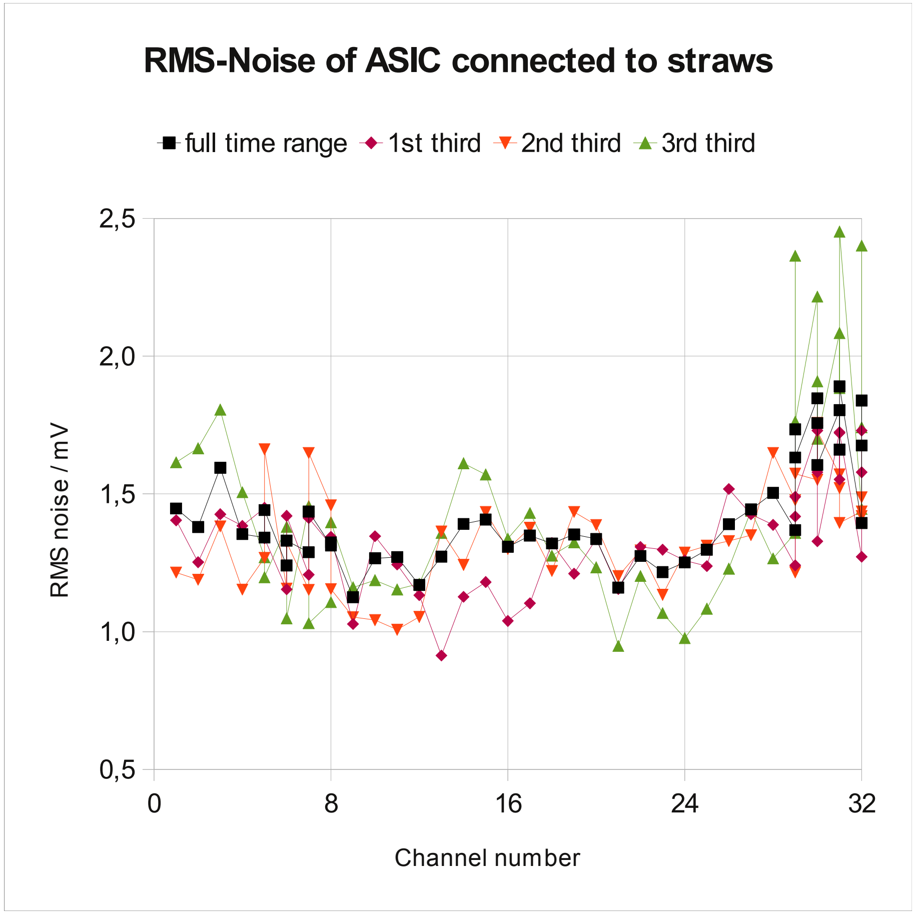
Signal rise time from 23 ns to 50 ns

Is a reasonable compromise for the shaping time feasible ?

Do we have to double the number of ASIC channels ?

Fast channels for timing
Slow channels for ToT

RMS Noise voltage over 32 straw & ASIC channels



Noise level of 1.3 mV corresponds to Equivalent Noise Charge of 1.7 fC or 11 000 e

For gas amplification of $5*10^4$ single electrons visible at 4 sigma level

Noise contribution to the timing resolution (linearly rising signal assumed):

$$\sigma_t = \sigma_V / dV/dt$$

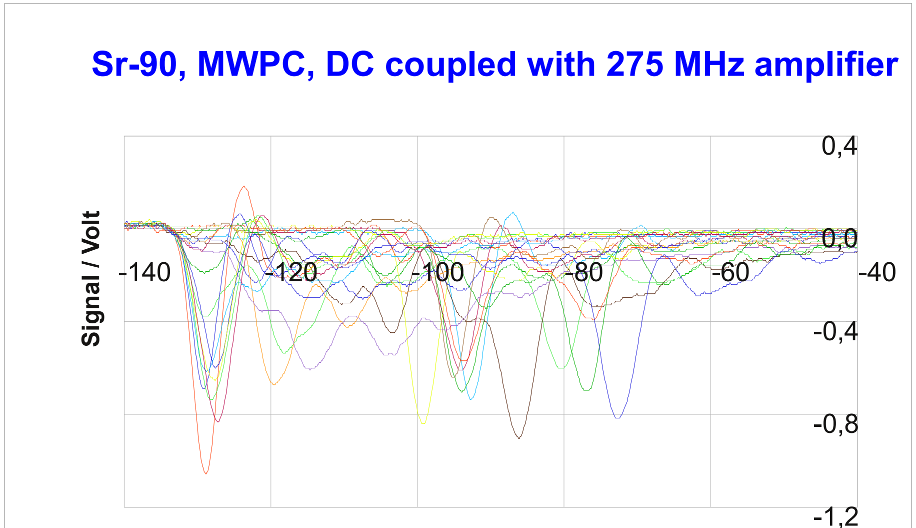
rms noise voltage = 1.3 mV
Output amplitude = 250 mV
Risetime = 23 ns

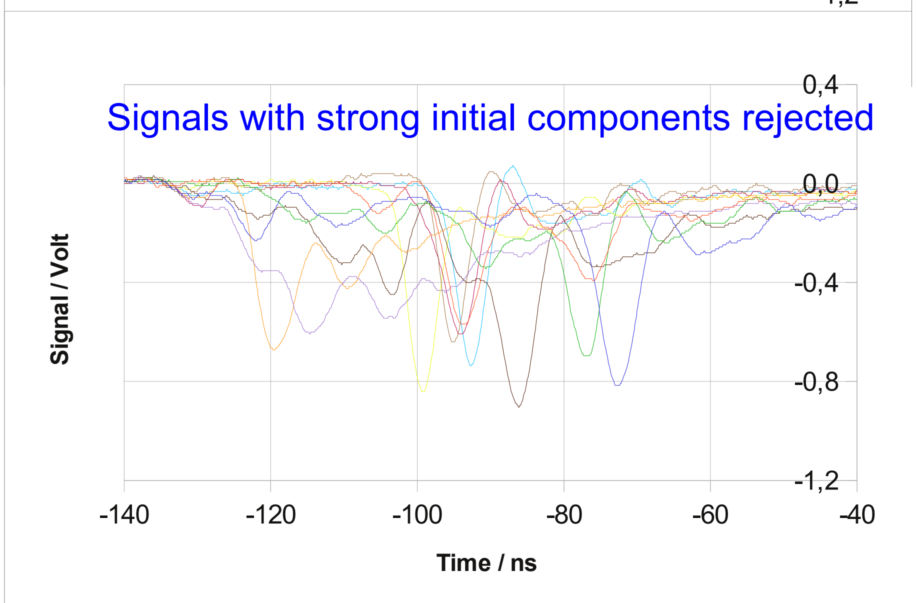
$$\sigma_t = 0.12 \text{ ns}$$

Time walk (slewing) is more dominant:
Same signals
threshold = 5 * σ_V = 6.5 mV

Δt = 0.6 ns

What do initial anode signals of a proportional chamber look like ?
Is the applied shaping adequate ?





MWPC with DC coupling to a 275 MHz amplifier
70% Ar, 30% CO_2, 1 bar abs.
Max drift time ~ 100 ns
Sr-90 source at the far end of the anode wire

Signal rise time ~ 3.5 ns
Signals with cluster groups over ~ 100 ns range
Onset of signal is sometimes hard to detect

- Uniform pulser signal is too a simple approximation
- The above measurements on the ASIC should be repeated with realistic particle signals using a fast trigger
- The same should be done with FQDC read out

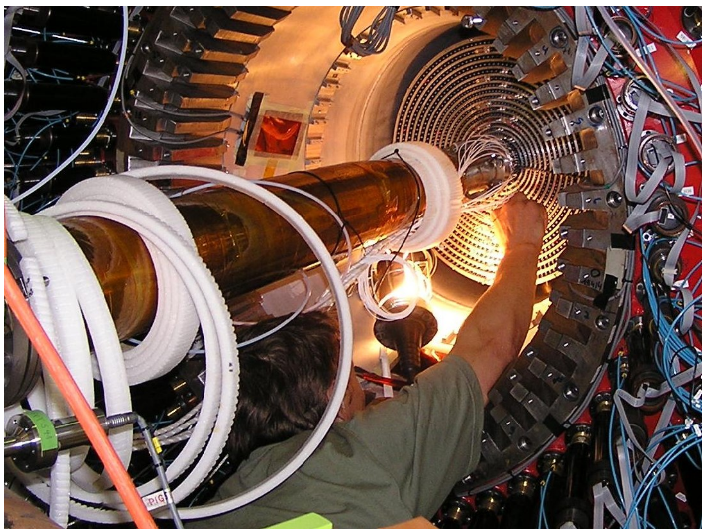
Ar we able
to detect the first cluster arriving at the anode ?

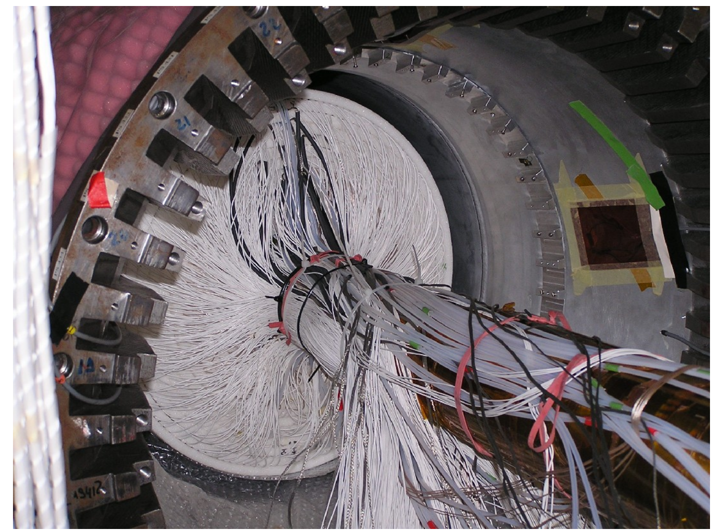
Where and how to place electronics and cables ?

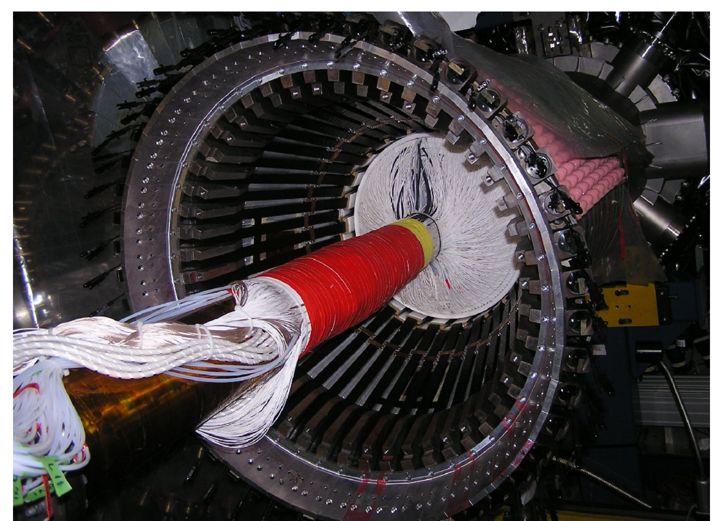
Inside	Signals to be transmitted	Outside	Comments
ASIC + HV decoupling board	Logical signals	TDC	**Enough space for boards and cables ?** **Quality of transmission less critical**
Preamplifier + HV decoupling board	Analog signals	Flash ADC	**Quality of transmission cables more important**
NO Electronics + HV decoupling board	Analog signals	ASIC + TDC or Preamp + FQDC	**Less Space needed**
			For all solutions above: **No decoupling** **of individual broken straws possible**
NO electronics	Analog signals + HV	Everything, ASIC or Flash ADC	**HV-safe signal cables needed, Volume ?** **No low-voltage cable,** **No separate HV cables** **No heat dissipation** **Easy access for trouble shooting** **We have enough space at the STT !**

Mounting of signal & HV cables at the WASA central tracker

Cable-by-cable mounting in the final detector position	took > 2 weeks
No cable support	several connections are lost
No loop-free ground connections	increased sensitivity for EMI



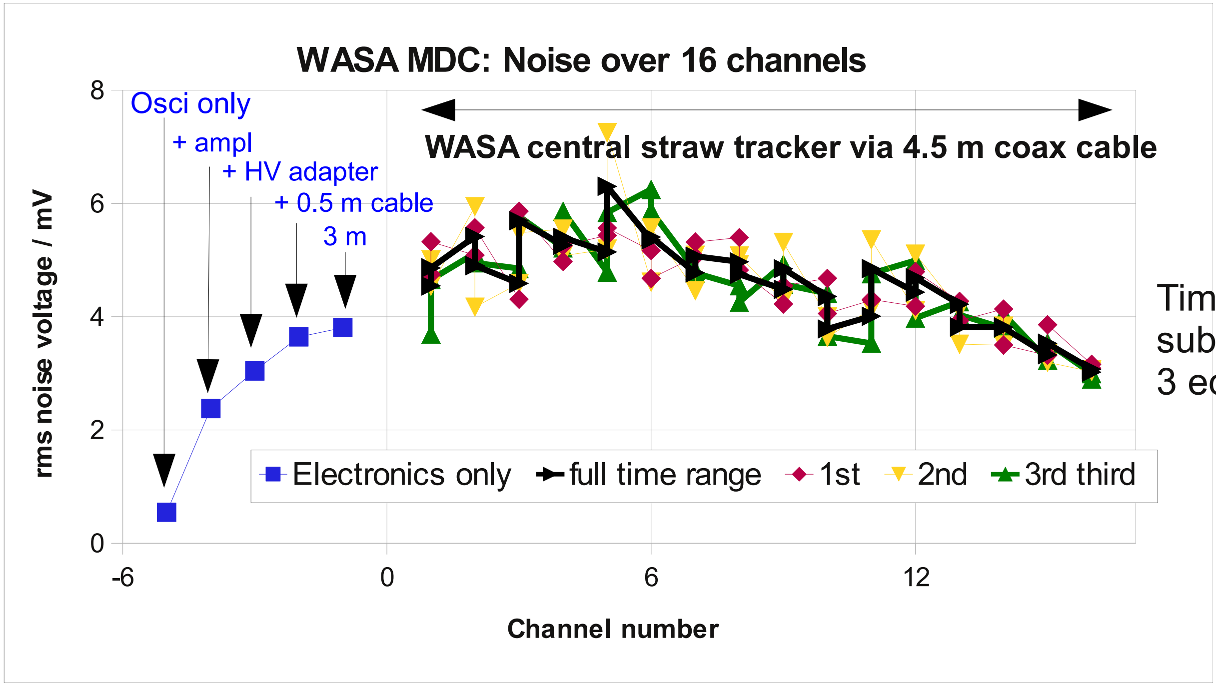




Are there any consequences of long cable connections for the noise level ?

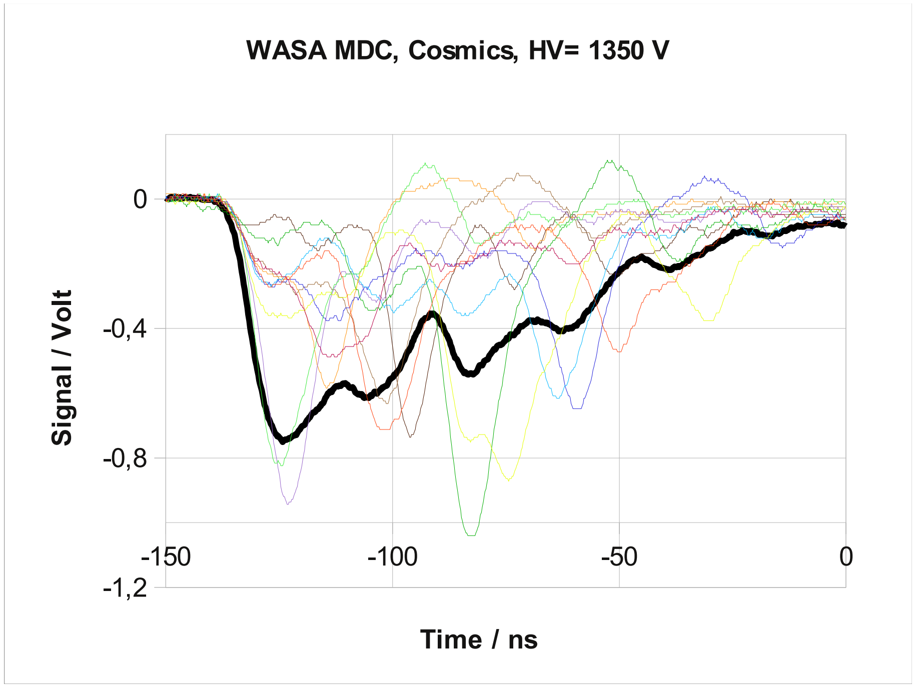
Laboratory tests:
Length of cables
has small effect
on the (thermal) noise

WASA central tracker:
Noise level shows variation over series of straws
Some channels show weak oscillations (EMI)
Channels free of induced signals are as good as in the lab



Time range
subdivided into
3 equal regions

Analog signals from the WASA central tracker recorded with a 60 MHz bandwidth amplifier



Signal rise time approx 8 ns
(4 * faster than ASIC)

RMS noise approx. 4 * higher

Similar conclusions for noise contribution to timing resolution

Electromagnetic interference in radiation detectors

Large detectors suffer more strongly from parasitic signals
Keep them small for a low discriminator threshold

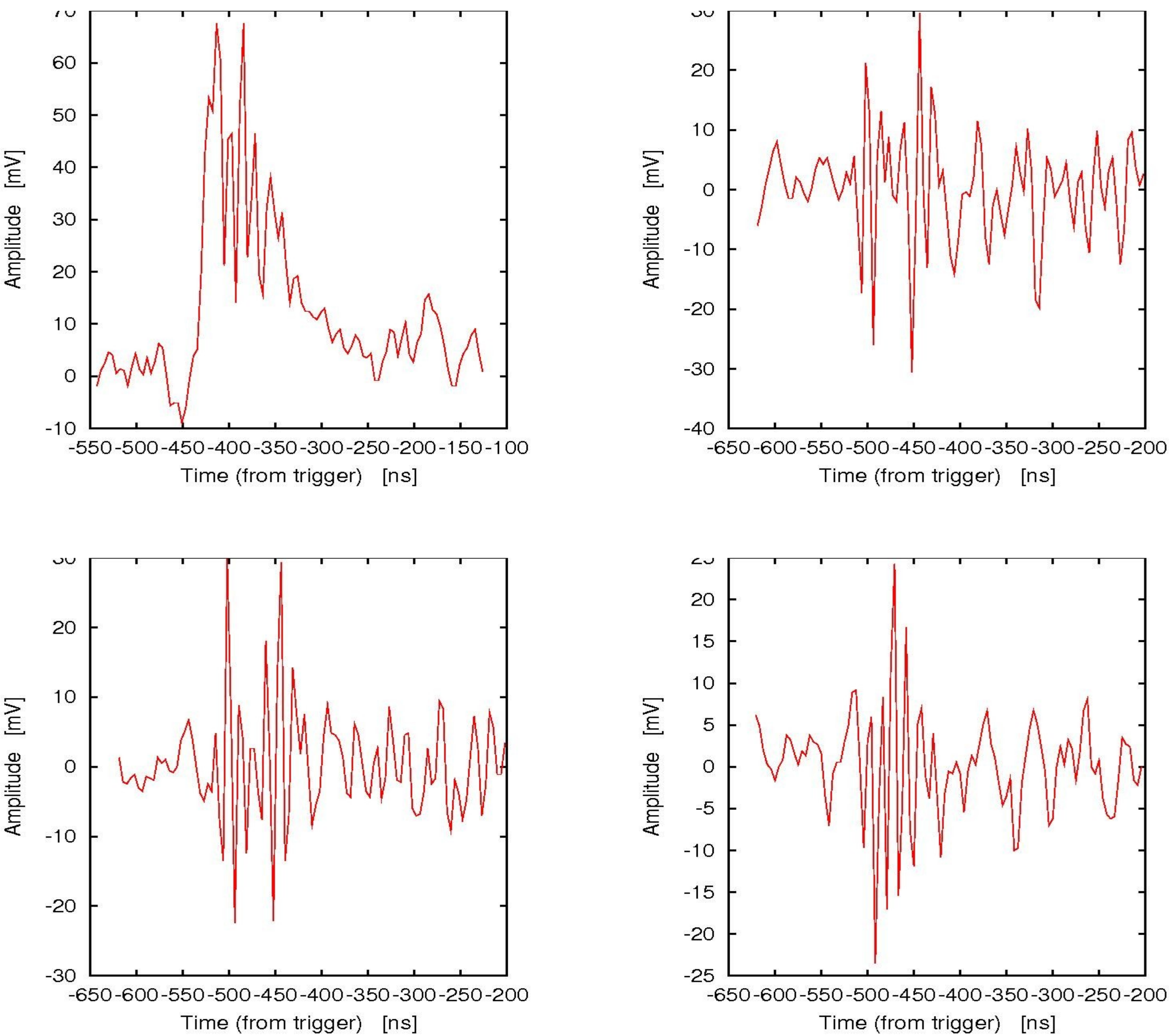
Critical points:

- ground connection between detector and amplifier are more difficult for straws than for more massive detectors
- the straws themselves

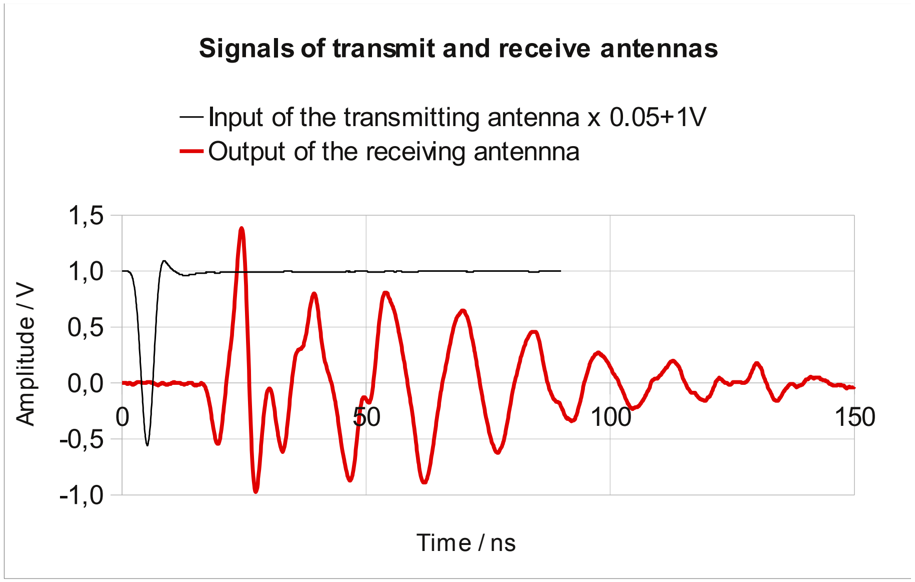
Sources:

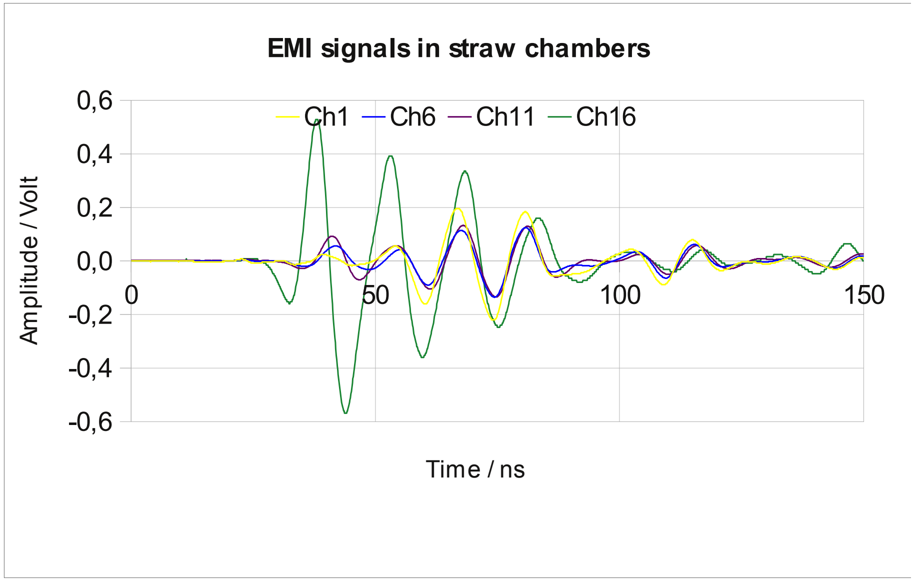
- Often unknow
- All powerful electrical devices
- Signal cables with logical signals (twisted pair and also coax)
- Worst case: coincident parasitic signals, e.g from photomultipliers

STT in-beam signals spoiled by induced parasitic signals



Generation of RF signals for systematical studies





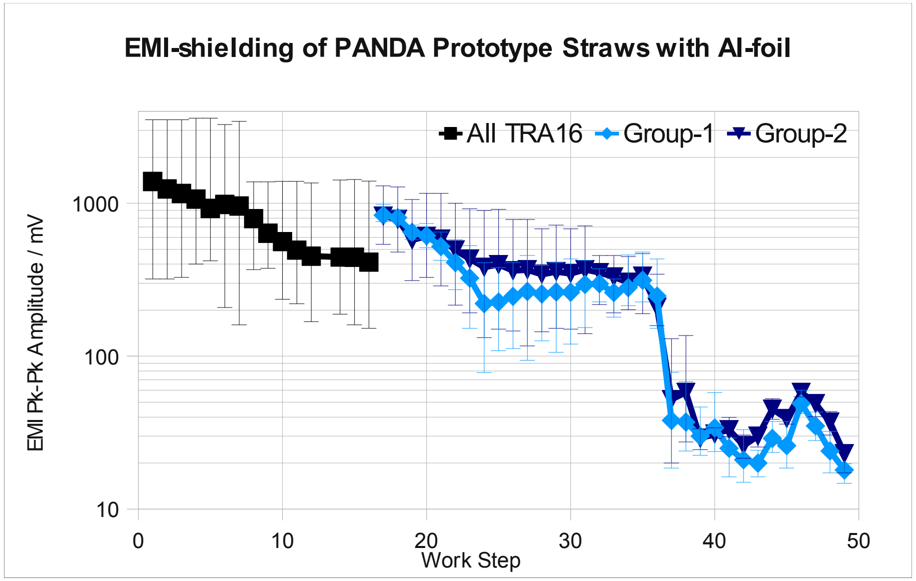
Application of counter measures:

Ground connection via 20 µm Cu foils
Shielding of straws with 6 µm Al-foil
(12 µm Mylar + 100 nm Al is equally good)

Improvement via many individual steps:

Shielding and grounding of coax signal cables
Tight wrapping of the straw detector with Al-foil
Low resistance ground connection straw → amplifier
Shielding of cables behind the amplifier

Significant improvement
happens only when the last hole is closed



Conclusions and recommendations

ASIC

- ToT vs. charge highly nonlinear
- ToT saturates already in 1/3 of the dynamical range of the ASIC
  Is truncated mean applicable ?
- Shape dependence of ToT comparable with amplitude dependence
- Two ASIC channels per straw, fast and slow ?

Placement of electronics, selection of cables

- The „WASA-solution“ saves space and simplifies electronics layout

Electromagnetic interference:

- How much disturbance do we expect from other subdetectors of Panda ?
- Tight Faraday cage with very thin foil is needed
- Continued EMI tests have to be done during the assembling phase

Final decision about electronics and cabling ? It is too early.

More systematical one-parameter tests needed
In-beam tests are often too complex for the question to be answered

ASIC	Pre amp gain	Pre amp T	Rp	Cp	Tp	Tail canc.	RT1	CT1	RT2	CT2
A	1	100	10	10	11	on	19	13.5	11	1.65
B	1	100	10	10	11	on	19	13.5	11	1.65
C	1	100	10	10	11	on	19	13.5	11	1.65
D	1	100	10	10	11	on	19	13.5	11	1.65
E	1	100	10	10	11	on	19	13.5	11	1.65
F	1	100	10	10	11	on	19	13.5	11	1.65
G	2	200	10	10	11	on	27	7.5	11	1.65
H	4	400	10	10	11	on	11	13.5	14	1.65