# Remote Electronics and HV for the PANDA STT
# Component- and Prototype Studies

PANDA CM, December 9, 2014


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# Component and Prototype Studies

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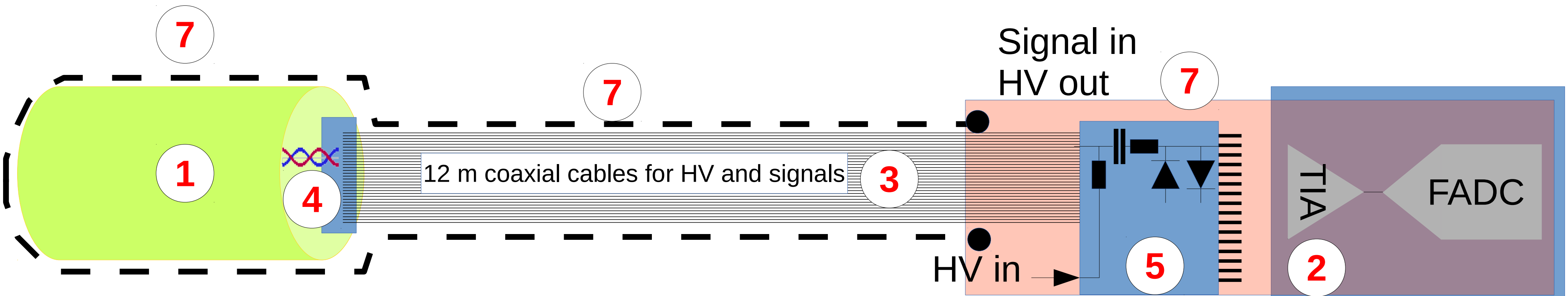
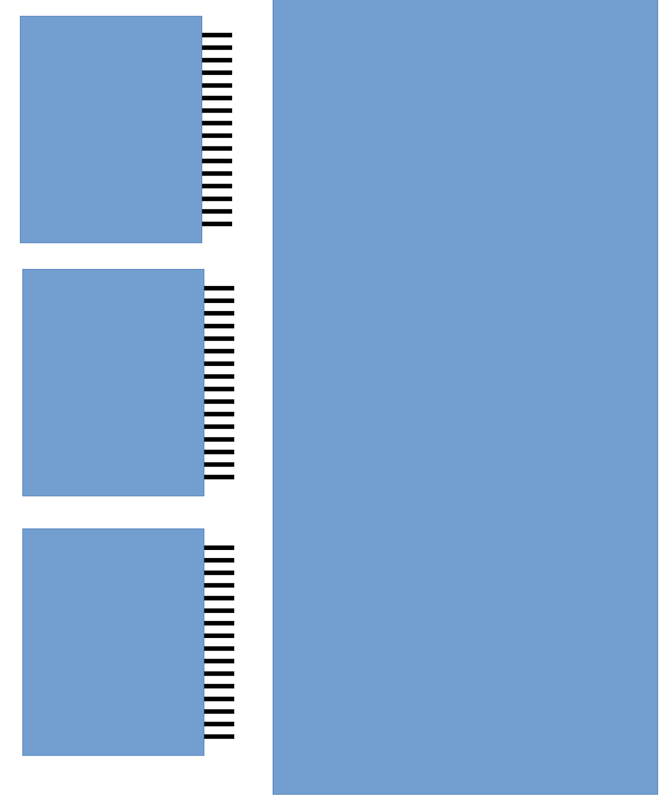


1 STT (currently: Prototype, 16x8 tubes)

2 Transimpedance amplifier

3 Coaxial cables for signals and HV, 1.1 mm Ø

4 STT-side: Coupling of cables

5 Amplifier side: Signal / HV decoupling Connector

6 HV stability of cables and capacitors

7 Electromagnetic interference: shielding and grounding

8 Time-resolution estimates

# Remote Electronics and HV for the PANDA STT

## Advantages expected:

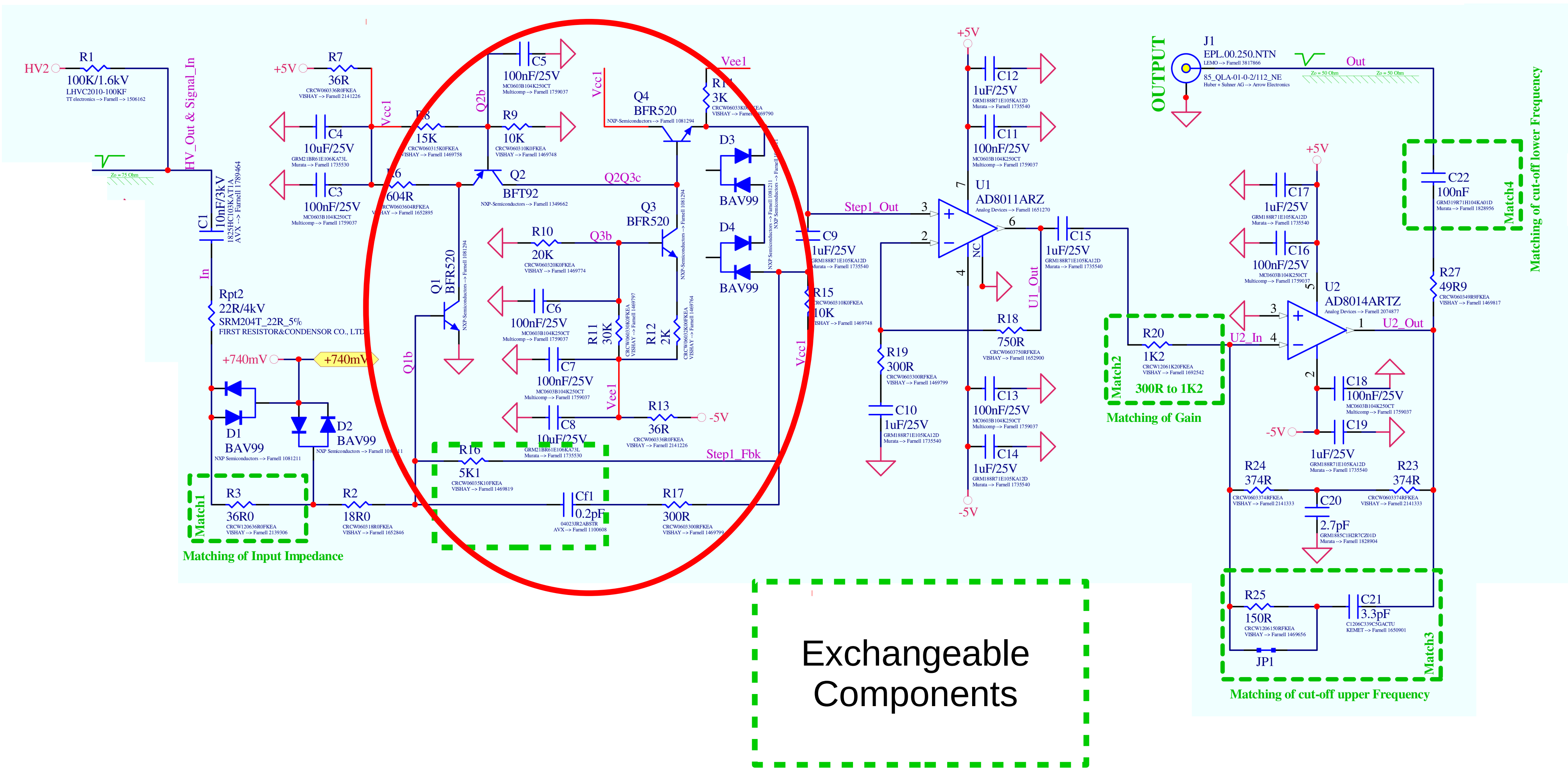
- No space problem
- No heat release
- No additional cables for HV and LV needed
- No radiation damage
- All components possibly subject to failure are accessible outside the detector
- Broken tubes in the STT can be decoupled individually from HV

## To be demonstrated:

- HV Stability
- Protection against induced parasitic signals ("EMI")
- Still good time resolution
- Technical solutions exist

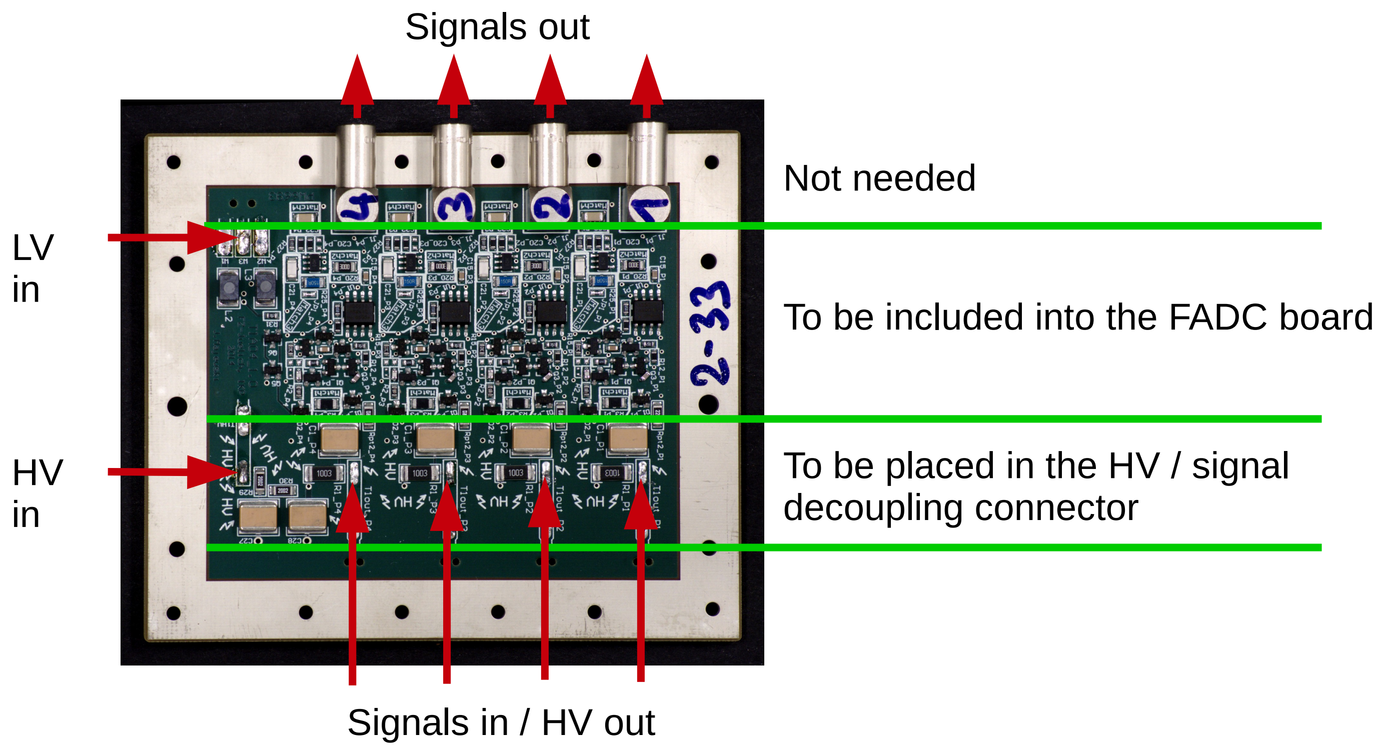
# Low-Noise Transimpedance Amplifier

- To be included into the FADC board
- New design needed
- Low-noise input stage with discrete components
- Components controlling input impedance, gain and shaping easily exchangeable



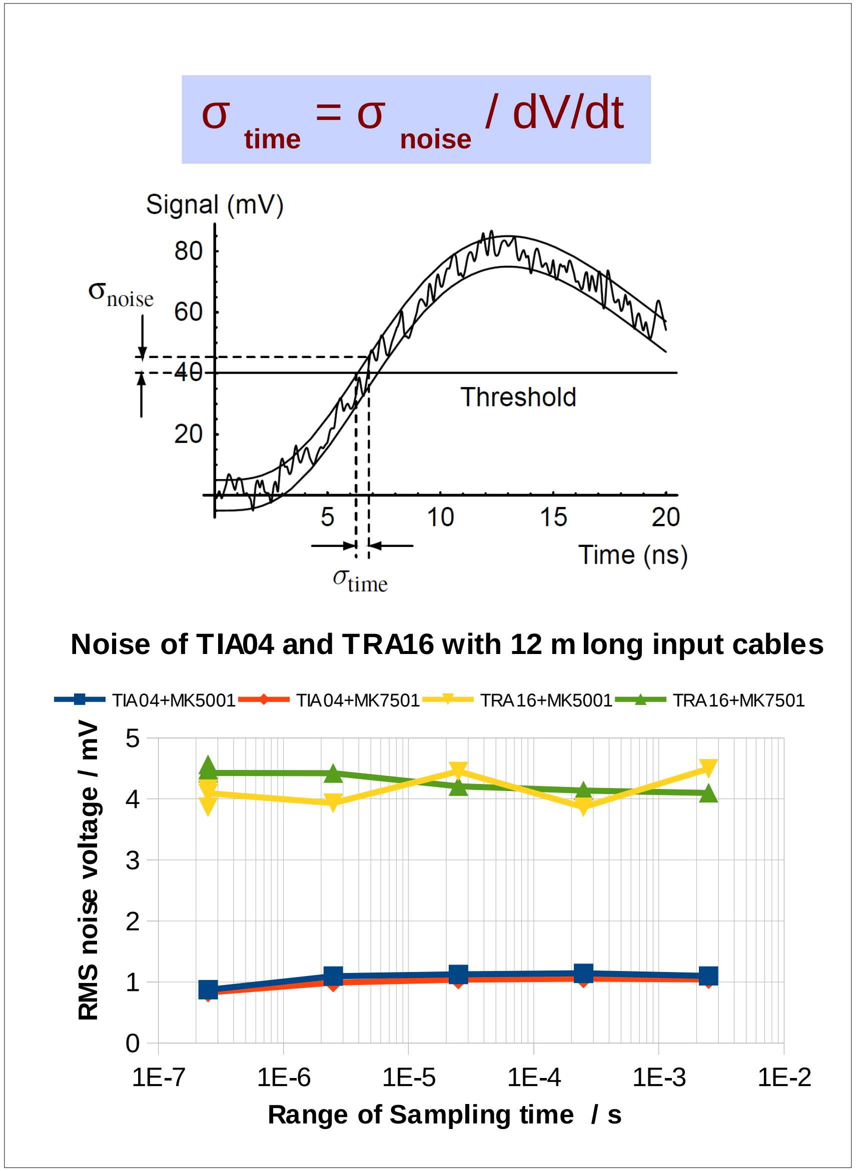
# Low-Noise Transimpedance Amplifier

- Successfully used for STT read-out in recent beamtimes

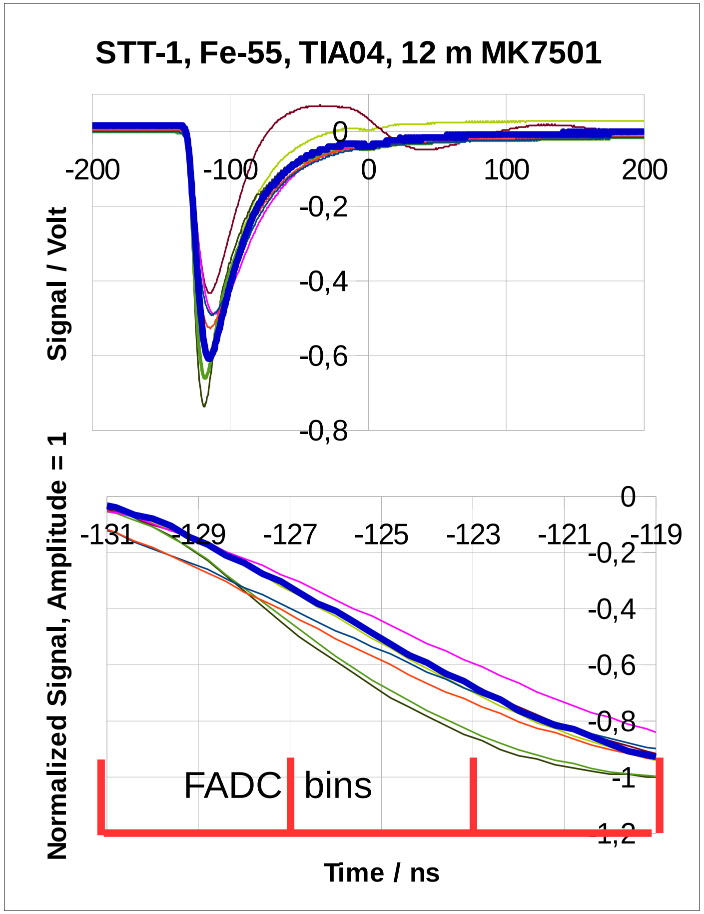


# Performance of Transimpedance Amplifiers

Improvement of the time resolution
with a low-noise amplifier



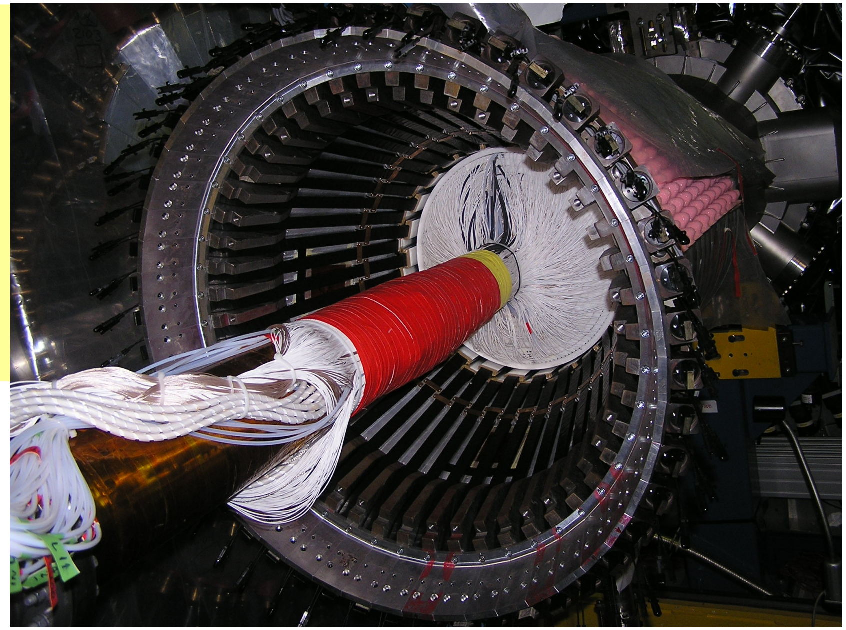

Signal shapes optimized
for analysis with the FADC



# Common Cables for Signals & HV

**WASA@COSY:**

Filotex 75 Ω
1.2 mm Ø
5 m long
operating voltage
1400 V over 8 years

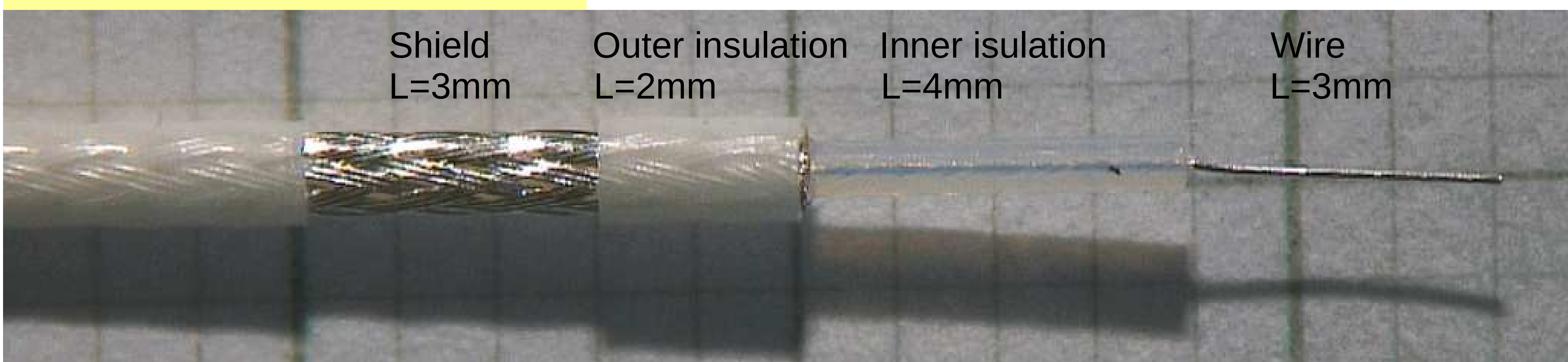


**PANDA STT Demonstrator:**

MK7501
1.1 mm
12 m long
HV test at factory: 1000 V
routinely operated at 1900 V
Lab tests: stable at 4 kV

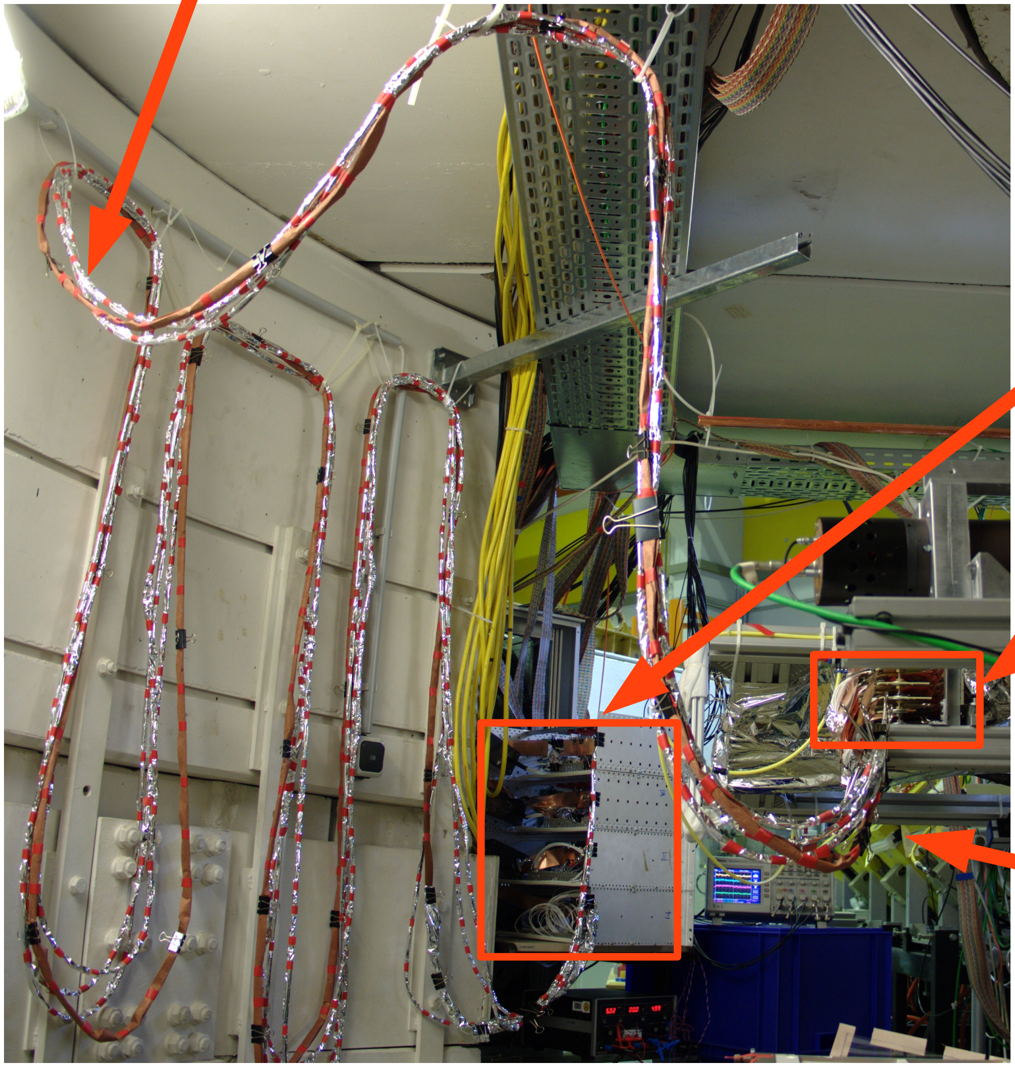
**Don't be a slave of ratings:**

3M Twisted Pair Flat Cable
Voltage Rating:
USA: 300V Canada: 150V EU: <50V
tested up to 7 000 Volts !



# Cable Connection between the STT and the amplifiers during in-beam tests

Bunches with 32
coaxial cables
Shielding: 12 µm
Mylar + 2x50 nm Al



Crates with preamplifiers

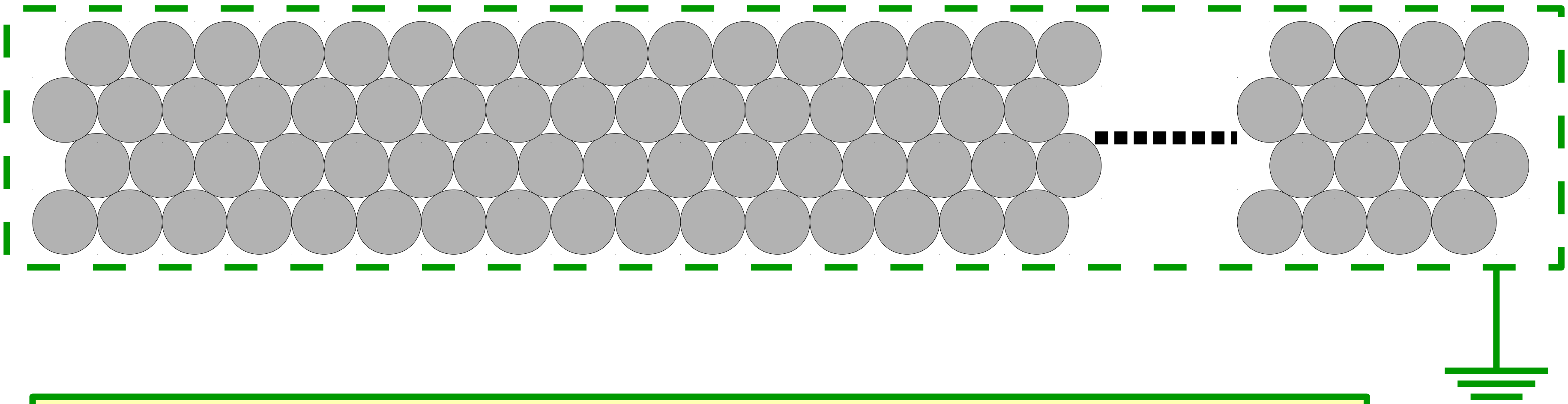
Connector end of the
**STT prototype**

Beamline

# Packing of Signal / HV Cables

**4500 cables MK7501**
**Total Cross section = 4720 mm²**
**for dense packing**

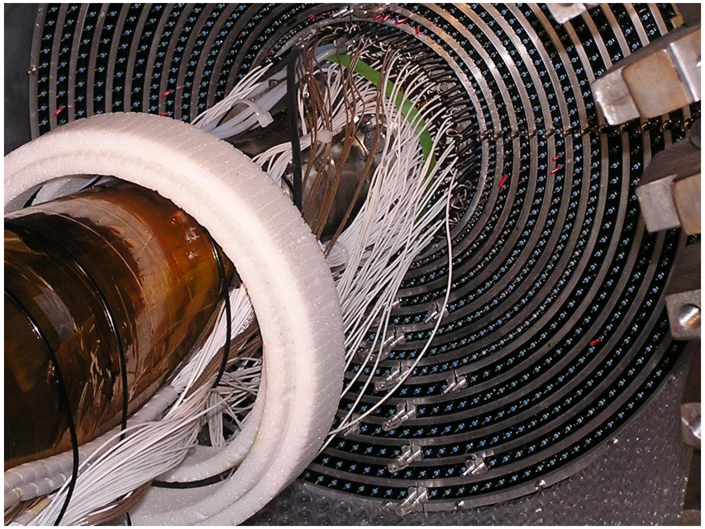
Shielding material
e.g.
12 µm Mylar
+ 2 * 50 nm Al



The shielding around all cables has to extend
from the STT to the remote preamplifier
without any weak contact in between

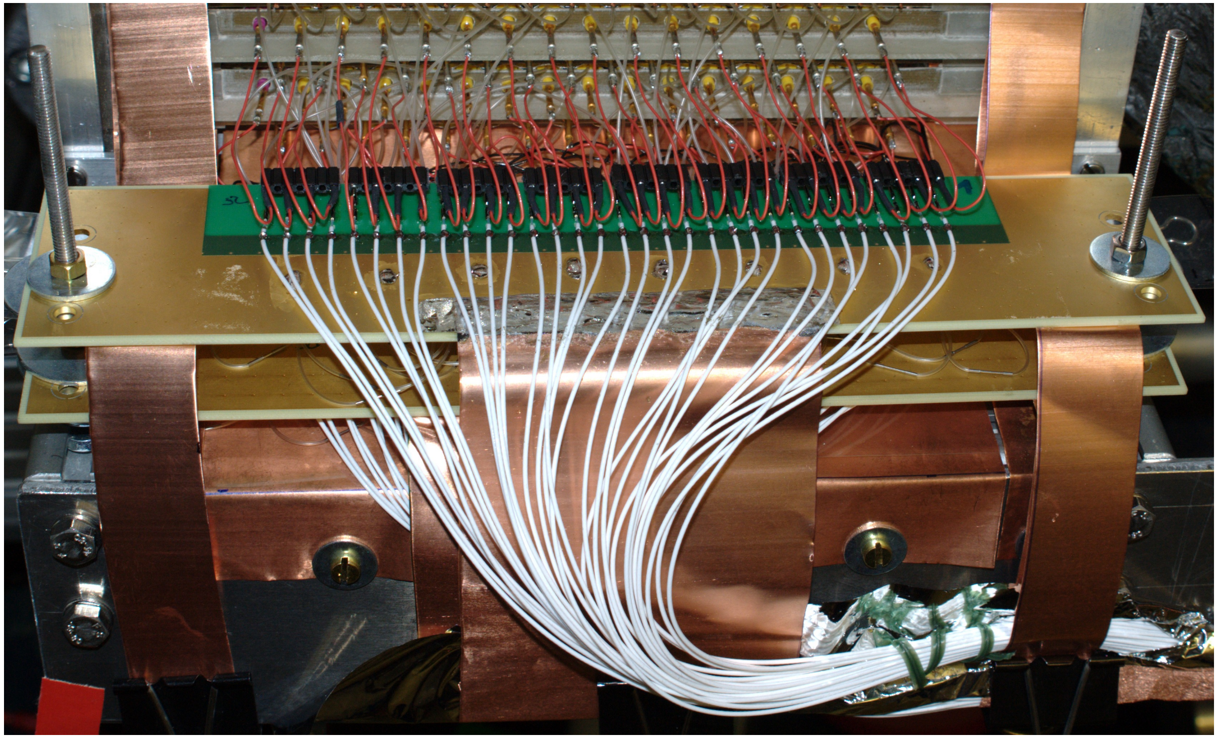
It has to ensure that
RF voltage differences
between the detector and the preamplifier ground
are < 10 µV

# Cable Connection to Straw Detectors



**WASA@COSY**

Coaxial cables are individually plugged onto the central straw detector



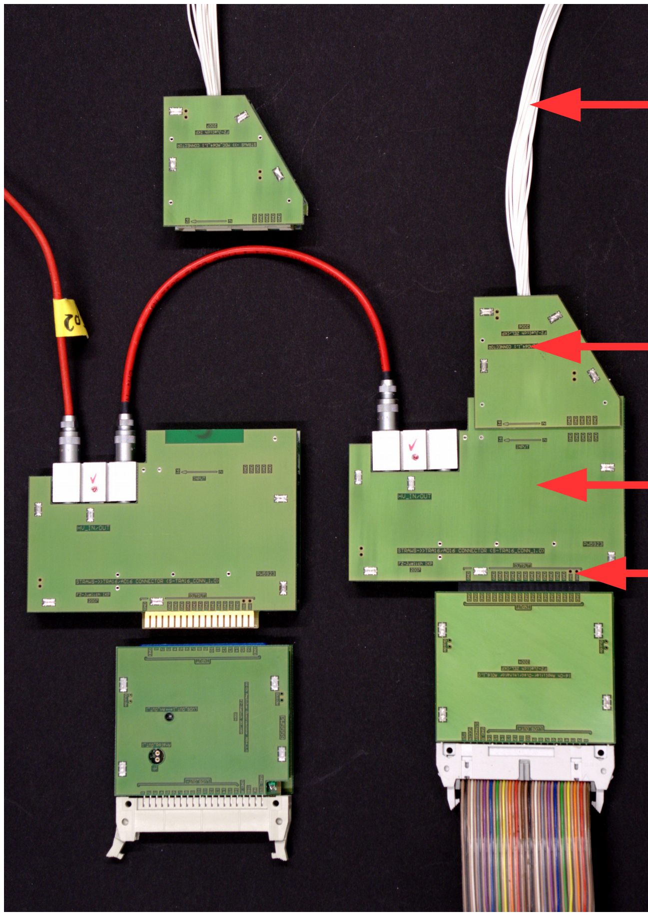
**Prototype for PANDA @COSY**

- 32 Coaxial cables are held by a PCB
- Short cables from the straws with multiple connector
- Ground connection with the body of the detector via Cu strips

To be changed:
- Short connecting cable will be twisted pair or coax
- Everything can become smaller

# Signal and HV / (De-)coupling in Front of the Amplifier / Flash-ADC

## WASA@COSY (and ANKE@COSY):



Cables coming
from the straws

Connector: HV in
and Signal out

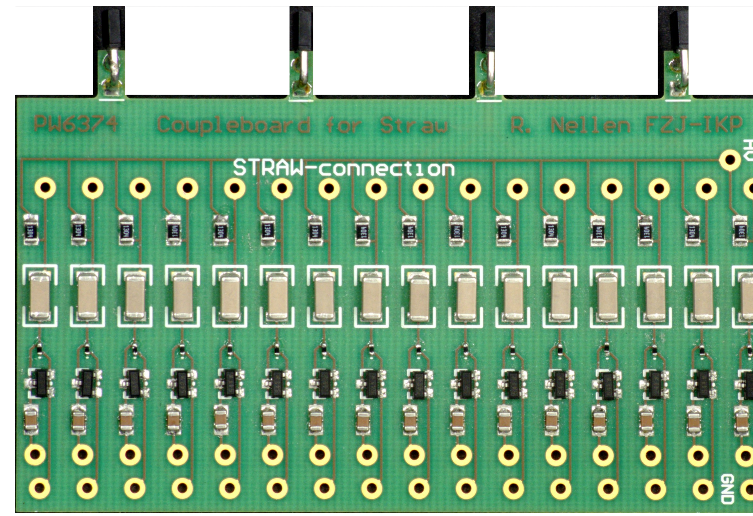
Both modules
to be unified

This end to be tailored
to the FADC input

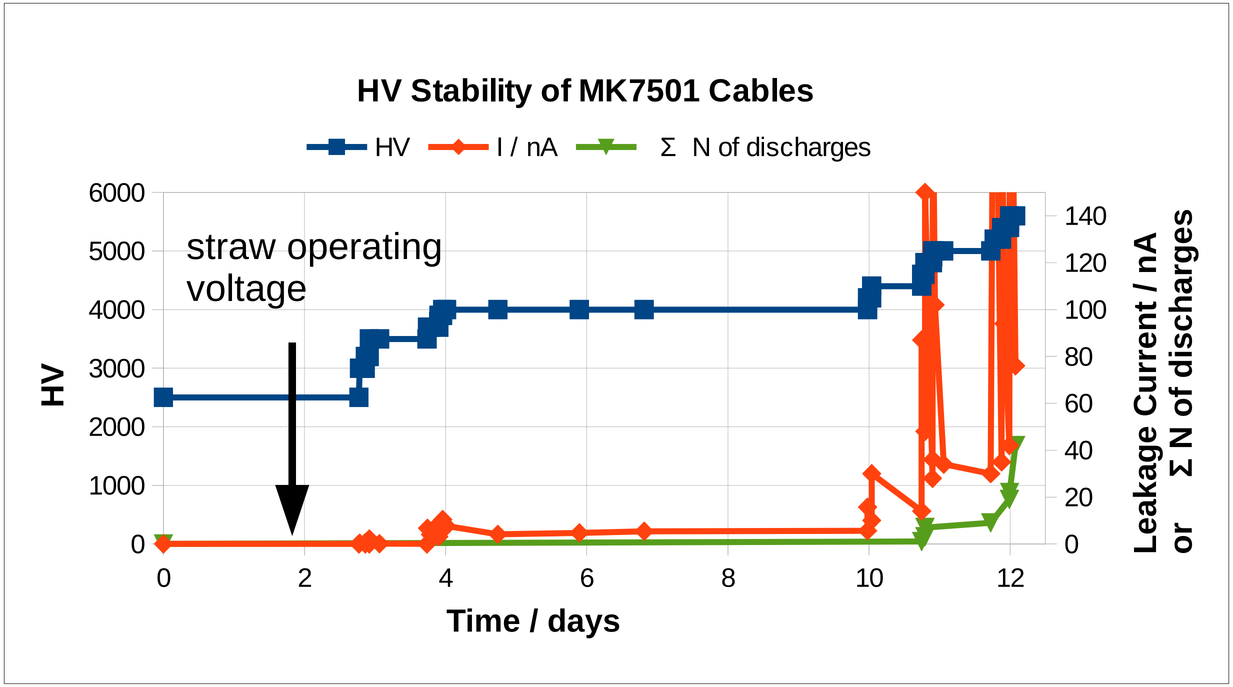
Amplifier / Discriminator

## Prototype for the STT

To be built into the
Signal / HV connector



# HV Stability of Cables and Capacitors

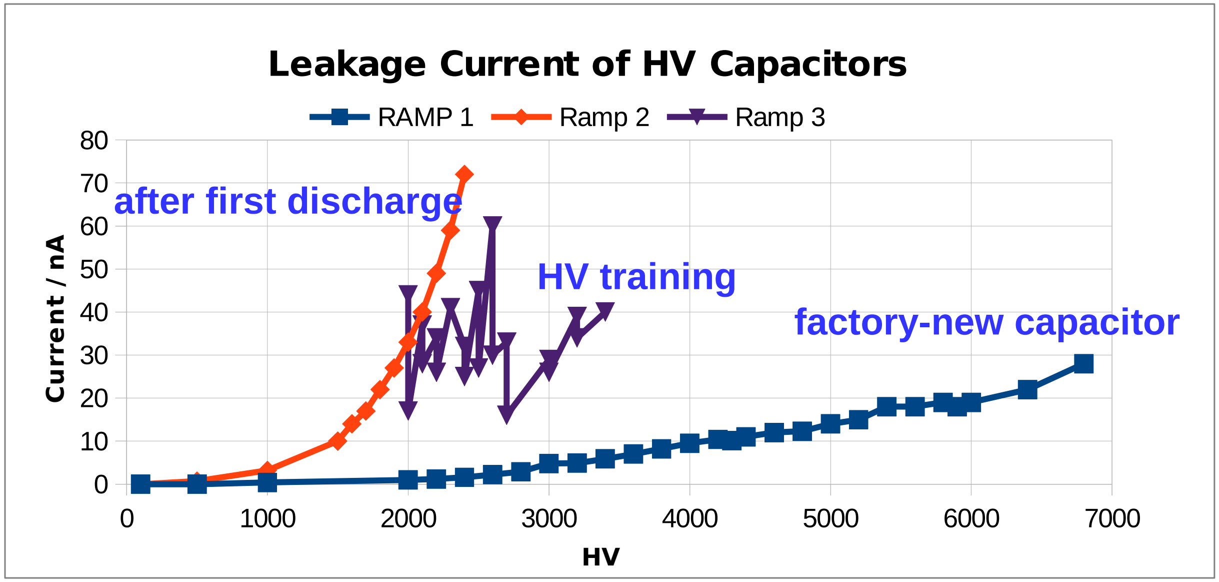


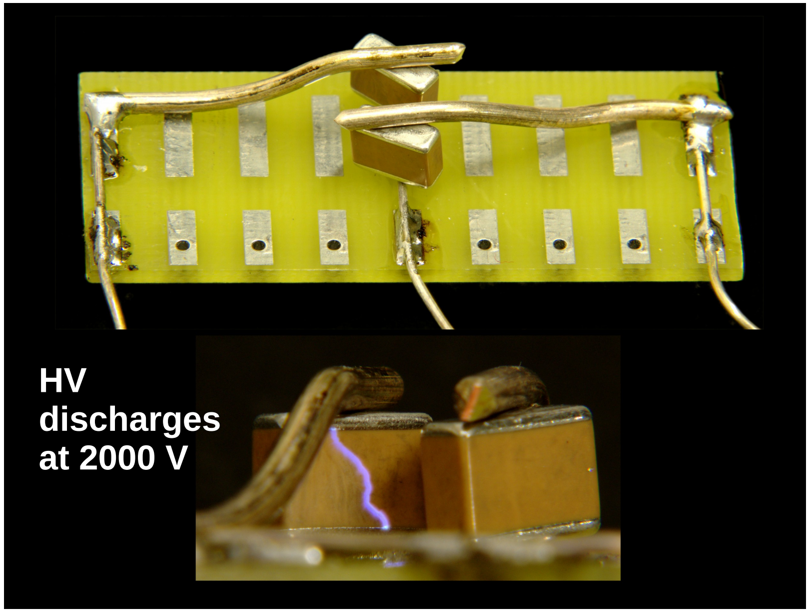

## How close are we to the limit of HV stabilty ?

**Are components destroyed at overvoltage ?**
**Is the effect of discharges reversible ?**

**Cables:**
- **Robust also beyond limiting voltage**

**Capacitors:**
- **Sparking sometimes 1000 V below limit**
- **Depends on surface cleanness**
- **Partial recovery after HV training**



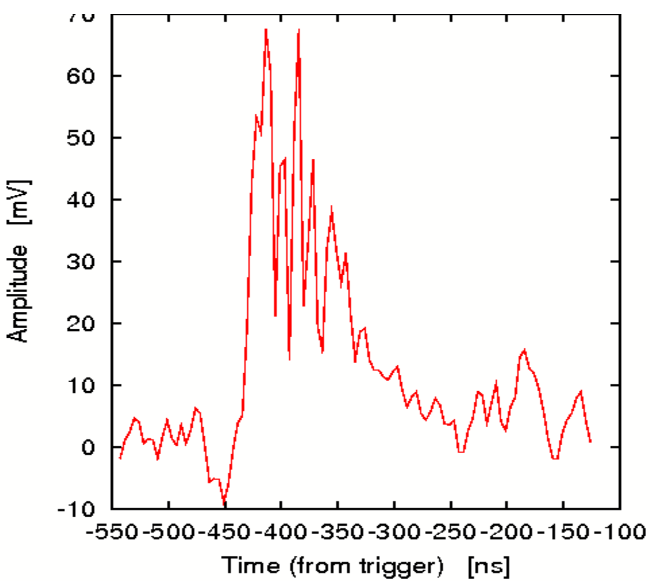



# Electromagnetic interference:
# Parasitic signals in straw chambers and application of countermeasures

## EMI inside and near PANDA ?

Usual sources:
PMs, signal cables, clock signals, HV oscillators ...

**EMI in a straw chamber during a beam time**

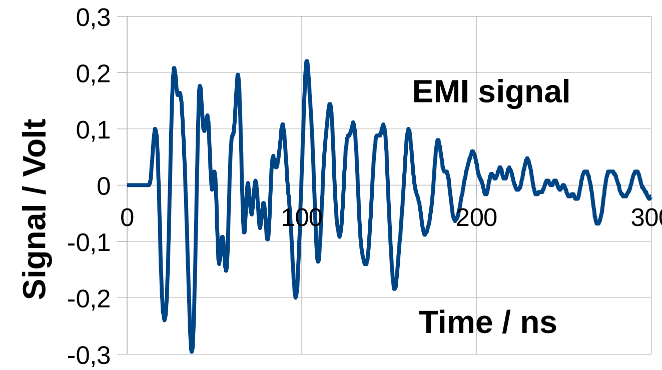


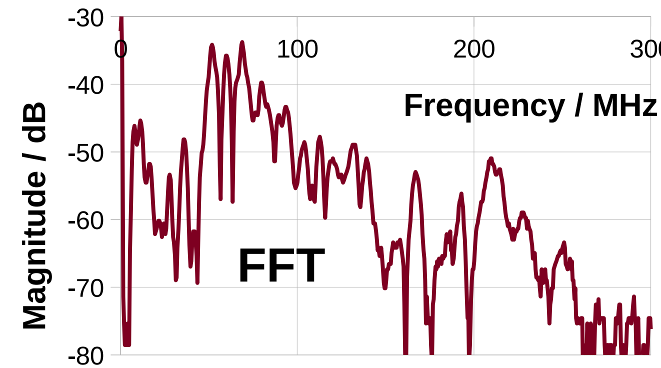

## EMI countermeasures

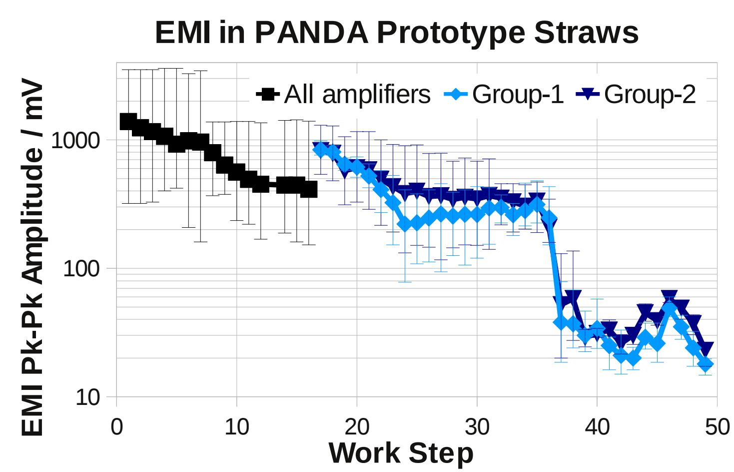
**in the presence of a reproducible RF field**

**Shielding of**
- **STT**
- **Cables**
- **Amplifiers**

**with 6 µm Al foil**

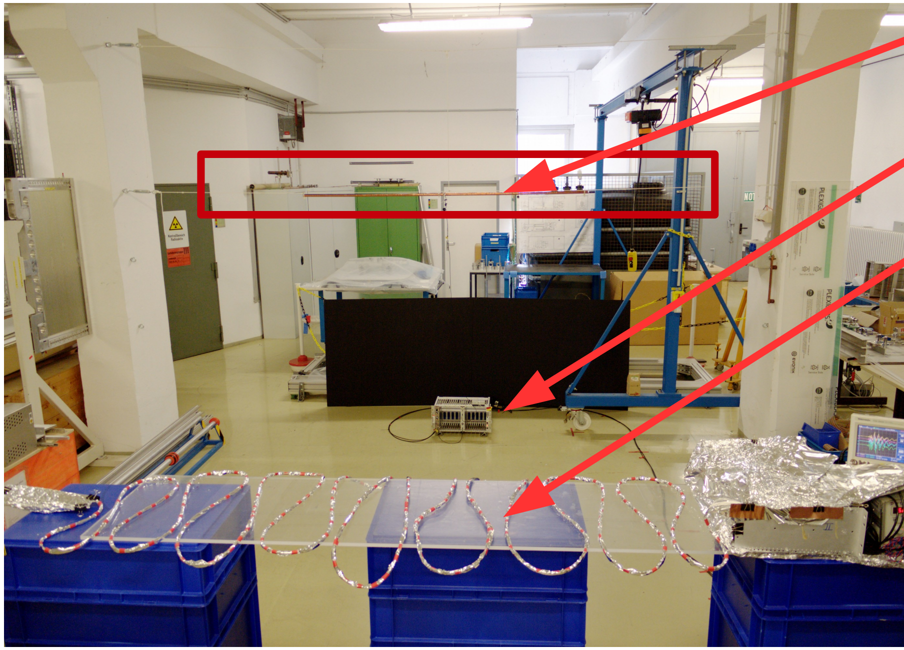


# Electromagnetic Interference in Straw Detectors

## EMI test area for detectors and electronical components

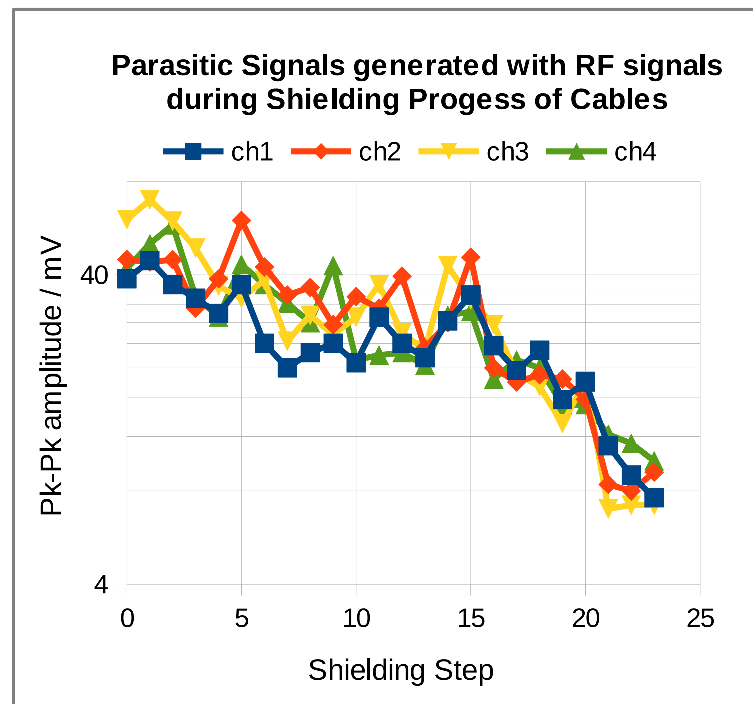


Transmitter dipole

Pulse generator

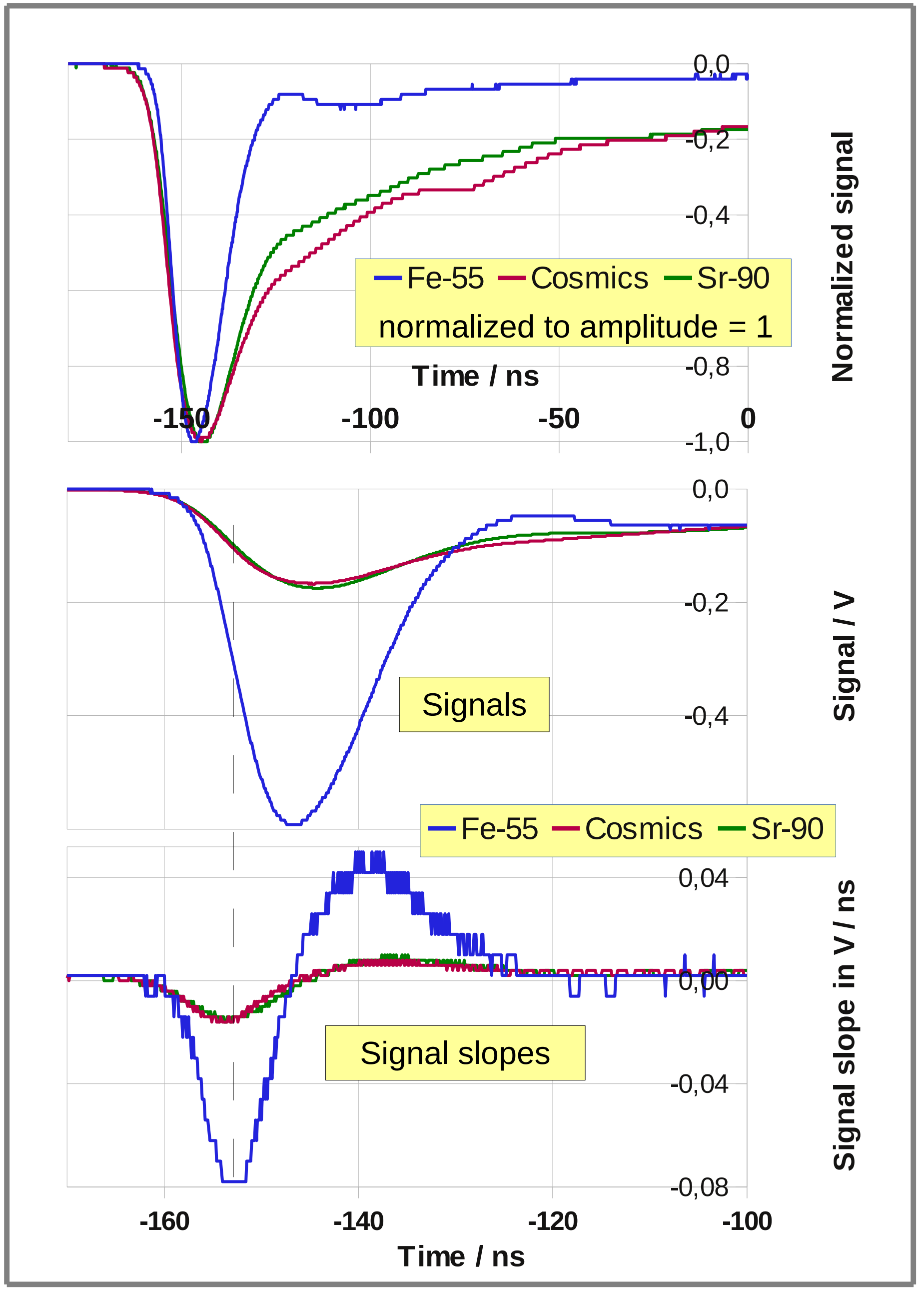
Object under test

## Reduction of induced signals during shielding progress



# Fe-55 signals as a model for average pulse parameters of track signals

Fe-55, Sr-90 and Cosmics Signals averaged over 128 events

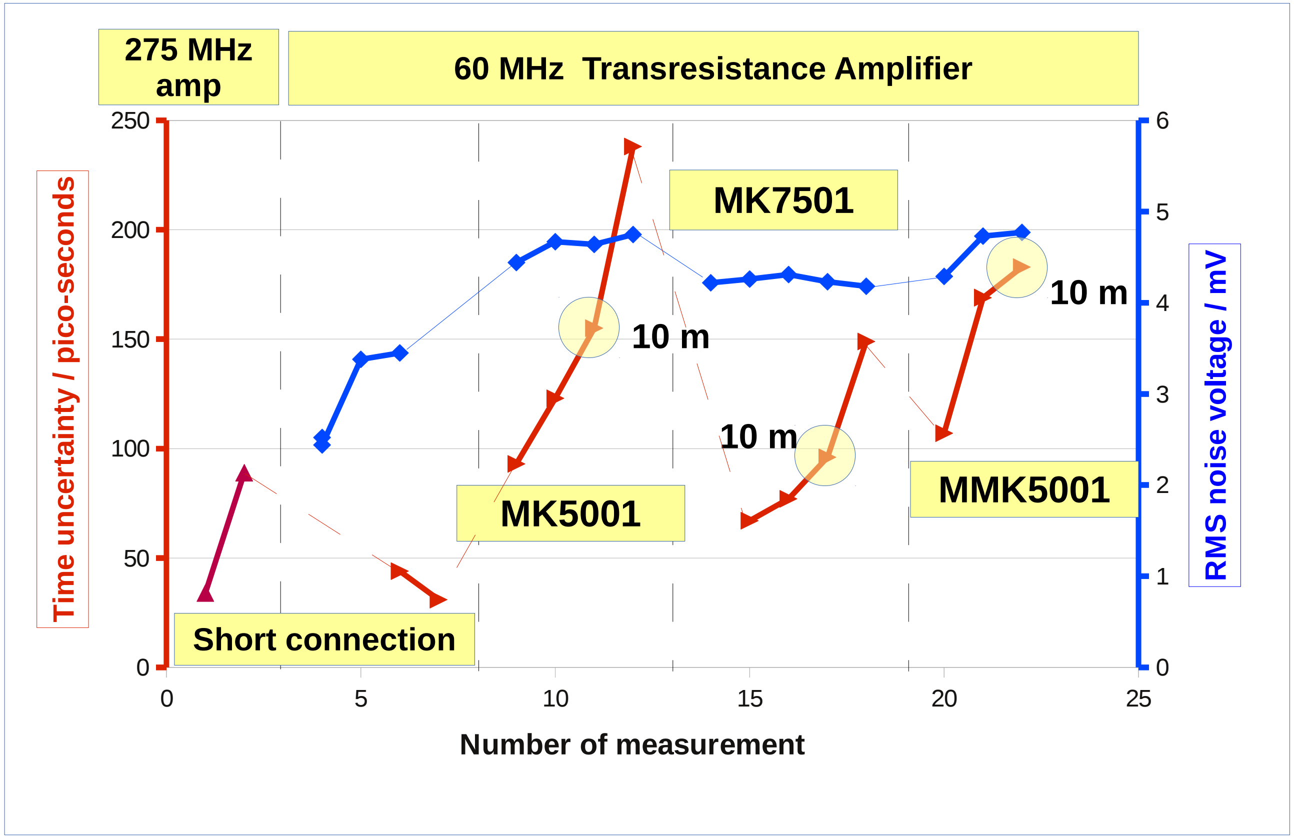



Time resolution

| | Amplit. [mV] | Slope [mV / ns] | Time uncertainty [ns] |
|---|---|---|---|
| RMS noise | 3.5 | | |
| Fe-55 | 590 | 80 | 0.044 |
| Cosmics | 168 | 18 | 0.19 |
| Sr-90 | 176 | 18 | 0.19 |

# Estimated electronical time uncertainty

(previous amplifier, no active timing, close (50 cm) to straw chambers or with 5 / 10 / 20 m cable)



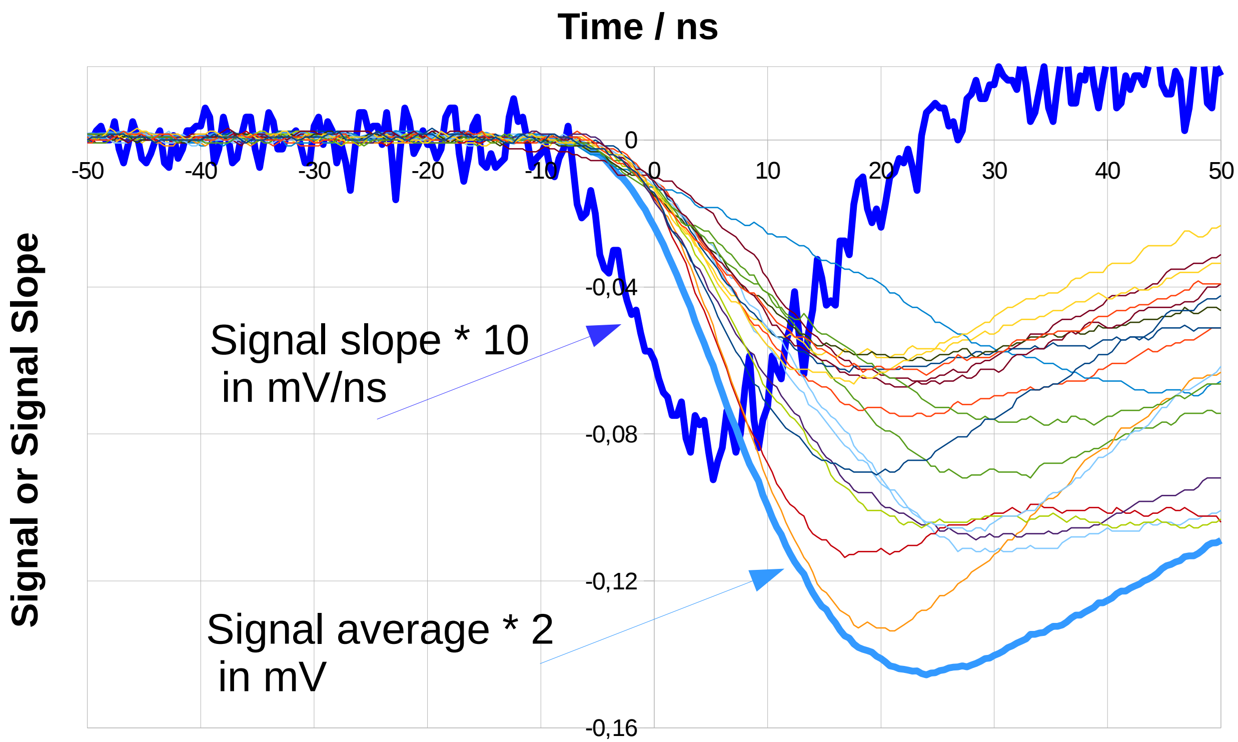

Assumption: timing is derived from the steepest slope, there is no walk

| | | |
|---|---|---|
| Fe-55 | short connection | 44 ps |
| Sr-90 or cosmics | Normalization: * 4.4 | 190 ps |
| Reduction of gas amplification | $8*10^4 \rightarrow 5*10^4$ | 300 ps |
| Sr-90 or cosmics | thin cable, 10 m long | 680 ps (≙ 23 µm) |

# Signals with proton beam

**COSY beamtime October 2014:**

**Protons, 1.0 GeV/c, Ar/CO2=90/10, 1800 V,**
**Remote low-noise amplifier**




**Estimated time resolution**
**including all contributions in the analog chain**
**= 100 ps** (≙ 3 µm)

# Summary & Outlook

**The STT operated with remote electronics fulfills TDR specifications !**

- **128 channels with low-noise amplifier successfully tested under beam conditions**
- **Shaping optimized for STT signals**
- **1.1 mm Ø cables are safe under HV**
- **Efficient protection against Electromagnetic Interference**
- **Spatial resolution near 150 µm achieved**

**Next steps:**

- **Design, production and tests of the HV / Signal decoupling connector**
- **Test of this with the current electronics**
- **Prototype of the new FADC including the low-noise amplifier**
- **Measurements at the STT demonstrator at COSY**
- **Operation at PANDA**