A Custom Discrete Amplifier-Shaper-Discriminator Circuit for the Drift Chambers of the R3B Experiment at GSI

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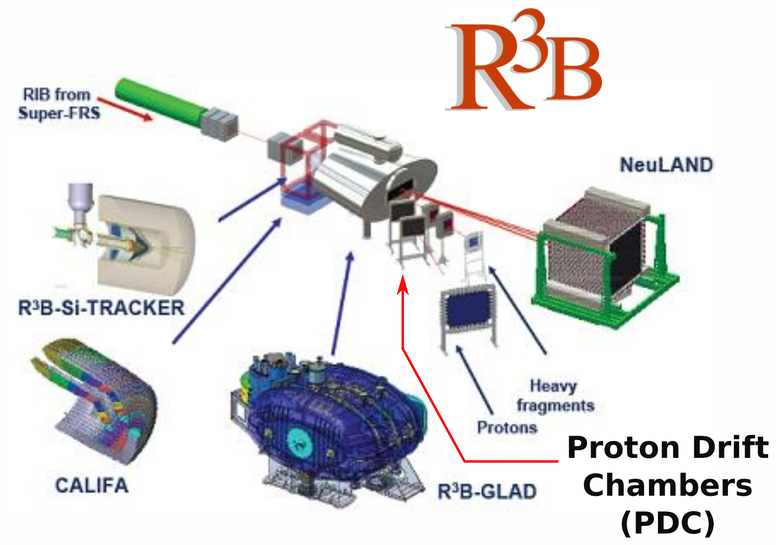
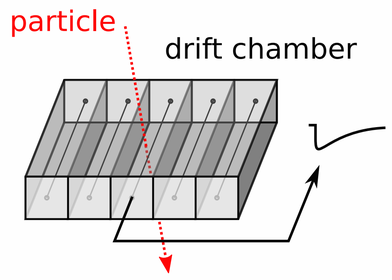
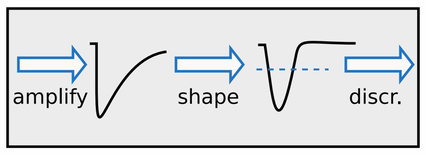


Proton Drift Chambers (PDC)

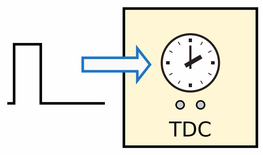
R³B Drift Chambers + Electronics

In the R³B experiment at GSI Darmstadt, two identical **drift chambers** allow for detection and **tracking** of light fragments like protons. Reconstructing their track yields the deflection in the separator magnet, and thus their **momentum**. In addition, the drift chambers contribute to **particle identification** by measuring the specific **energy loss**. Each chamber has an active area of 100x80 cm² and a total number of 256 read-out channels in perpendicular x and y planes. The drift cell is 14 mm wide with a sensing wire in its center. Each channel is equipped with an **amplifier + analog pulse shaper + discriminator + TDC**.





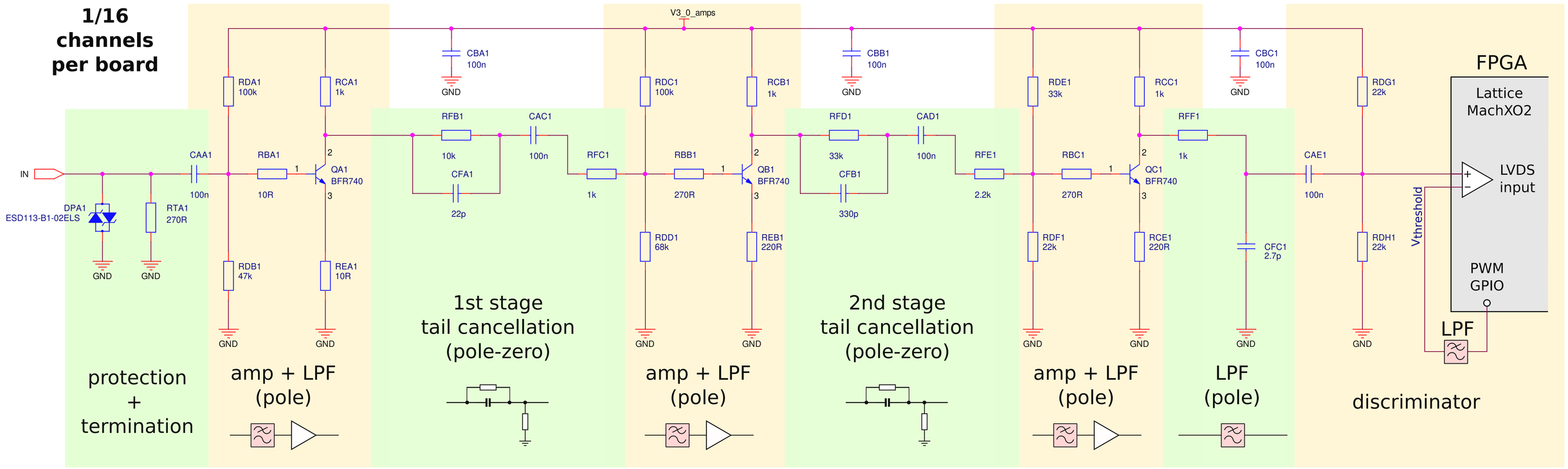
analog read-out circuit

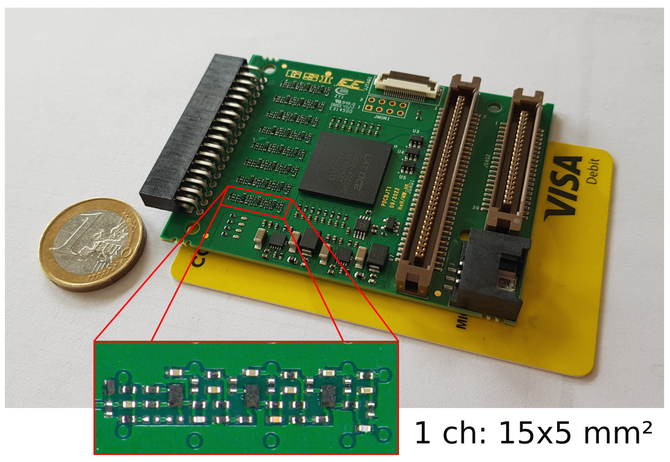


time to digital

TDC data:
- leading edge → drift time → **track position**
- pulse width → charge → **dE/dx**

New Development: Discrete Analog Front-End Electronics





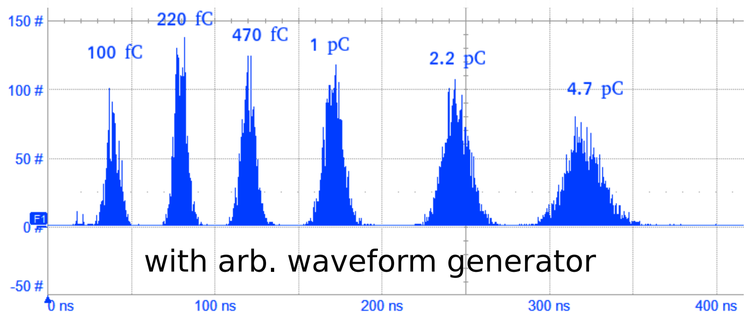
1 ch: 15x5 mm²

Specs:
- 16 channels on credit card sized board
- function inspired by ASD8 ASIC
- <40mW / channel
- high channel density due to 0201 SMD technology
- gain: 3.5 mV/fC
- peaking time: 14 ns
- SPI interface for slow control
- LVDS outputs to TDC
- Z_{in} = 270 Ω (customizable)
- sensitivity: ~20 fC up to ~10 pC

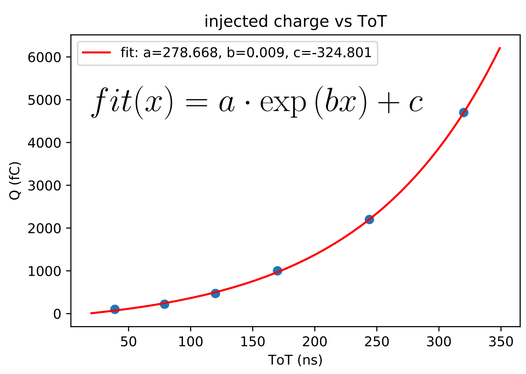
Pros:
- commonly available components
- customizable through placement variants
- good noise performance / high detection efficiency
- analog design without feedback → no problems with self-oscillation (observed so far)
- little variation between channels
- individual threshold for each channel
- input impedance matched to source

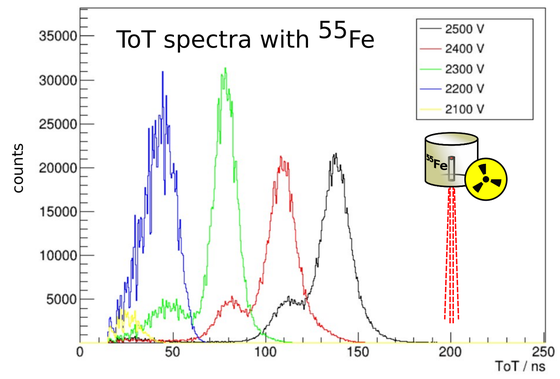
Limitations:
- suited for ~kHz rather than ~MHz hit rates, lacks active baseline restorer
- shaper / gain not adjustable via slow control
- single ended input only

Shaper Test with Pulser and Source

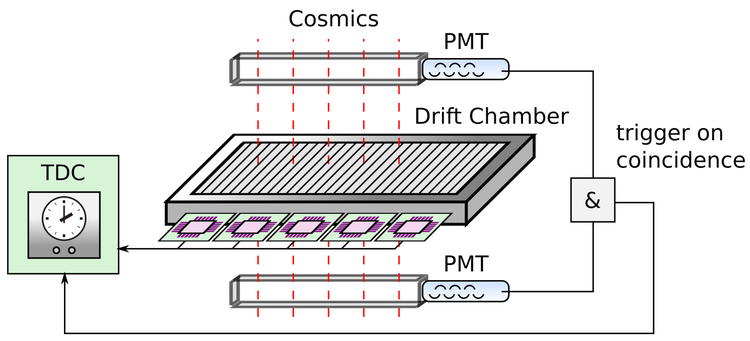


- Time over Threshold (ToT) measured with realistic ion tail pulse sample
- denoted charge includes ballistic deficit
- ToT increases logarithmically with charge
- intrinsic Q precision: 8-15% (RMS)



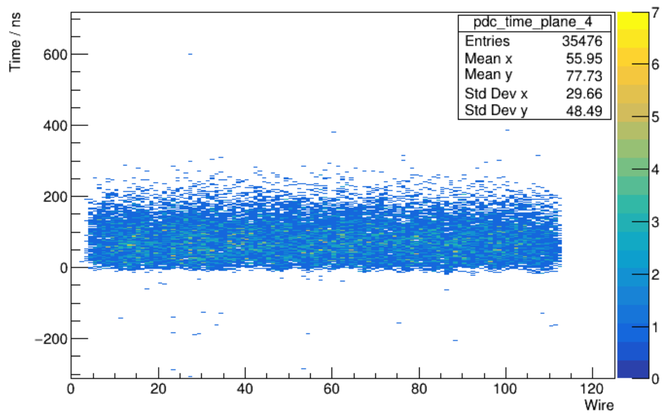


System Test with Cosmics



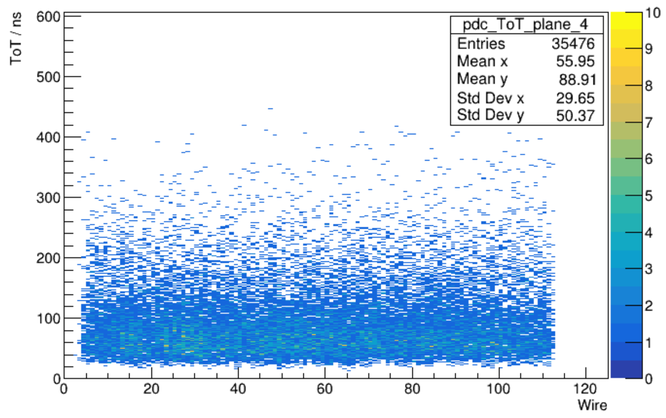
- detection efficiency ≥ 99%

Drift Time vs Scintillator Trigger



- no dead channels

Time over Threshold



- uniform behaviour across channels