

# A study of an alternative readout electronics for a LC TPC with Time-to-Digital Converter.



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## Why TDC ?

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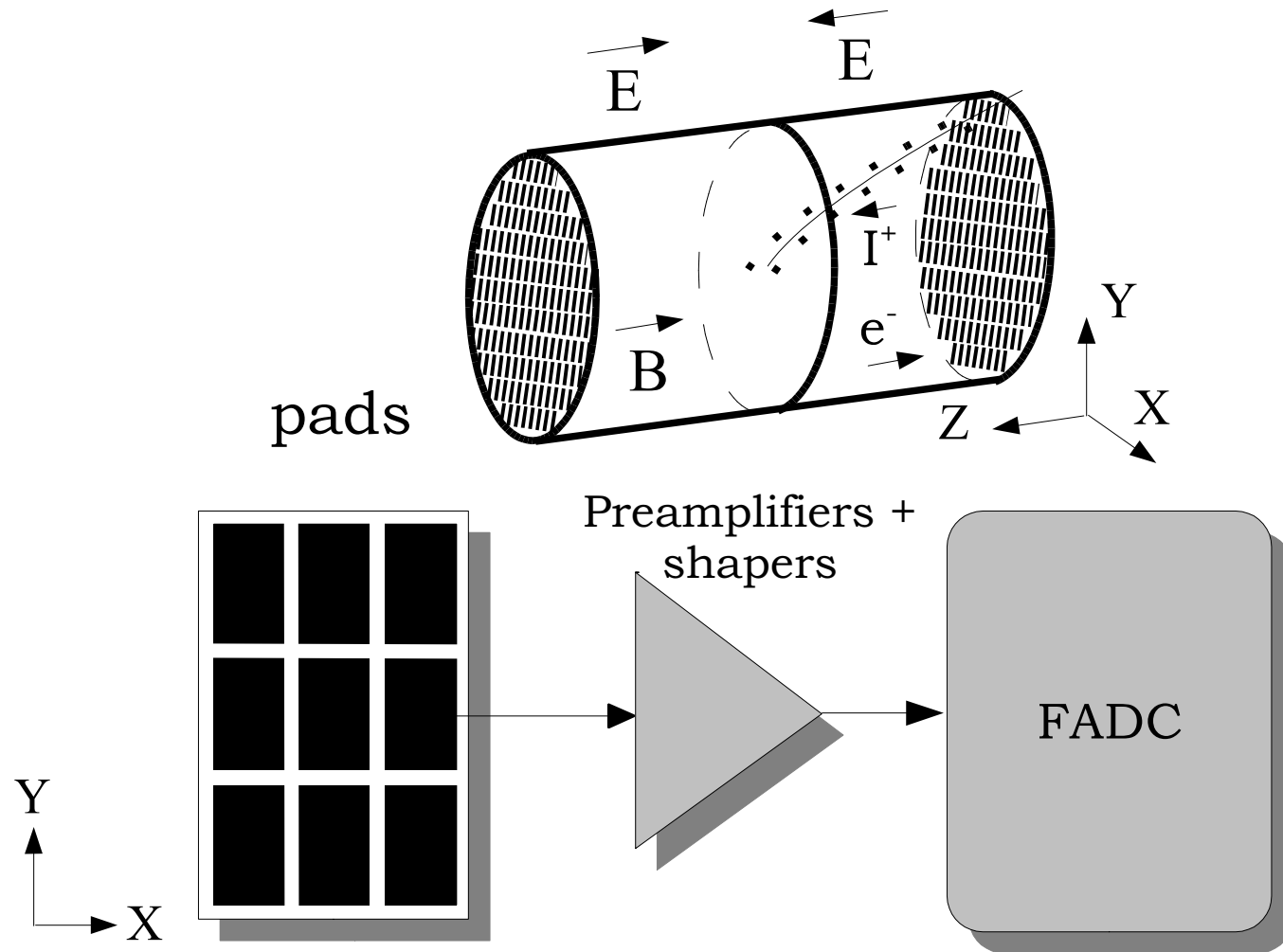
- TDCs are cheaper than FADCs

When the number of readout channels is large ( $\sim 1\,200\,000$ ), TDC might be the more attractive solution than FADC

- Expect that it may have the same functionality as a FADC
- Reduced data flow rate and simple data representation format, because one needs to measure only two numbers for each track segment:
  - a) drift time  $\rightarrow$  z coordinate
  - b) charge of the signal  $\rightarrow$   $dE/dx$
- Reduced power consumption
- Development of a digital ASIC (TDC) is cheaper and easier, as compared with development of an analog ASIC (FADC)

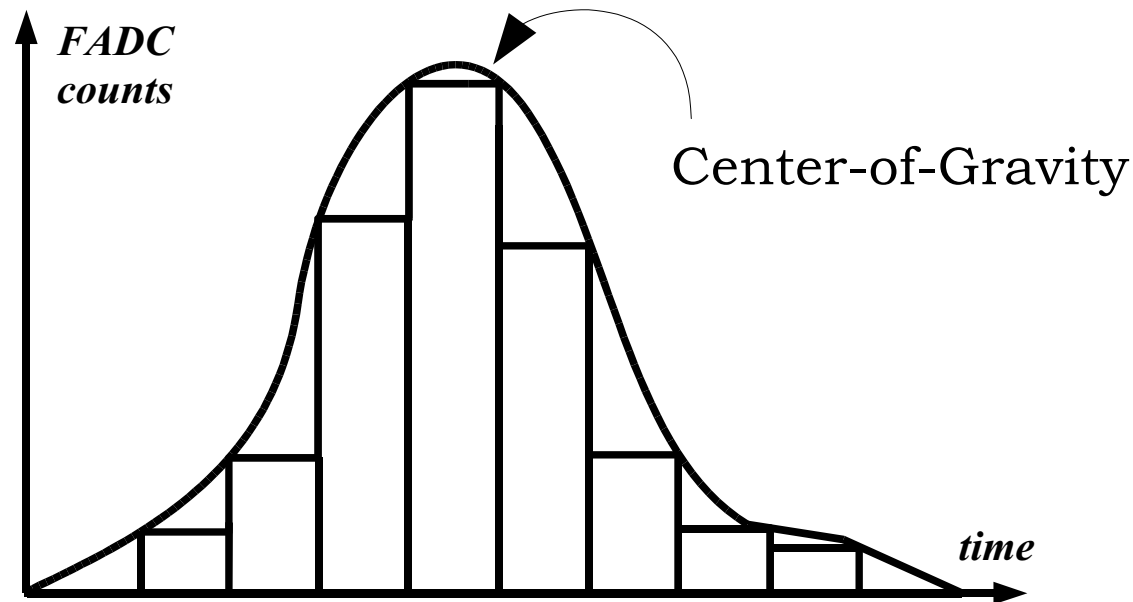
## Typical readout electronics for TPC with Flash-ADC

The main goals of Time Projection Chamber are tracking and particle ID



## Data acquisition with Flash-ADC

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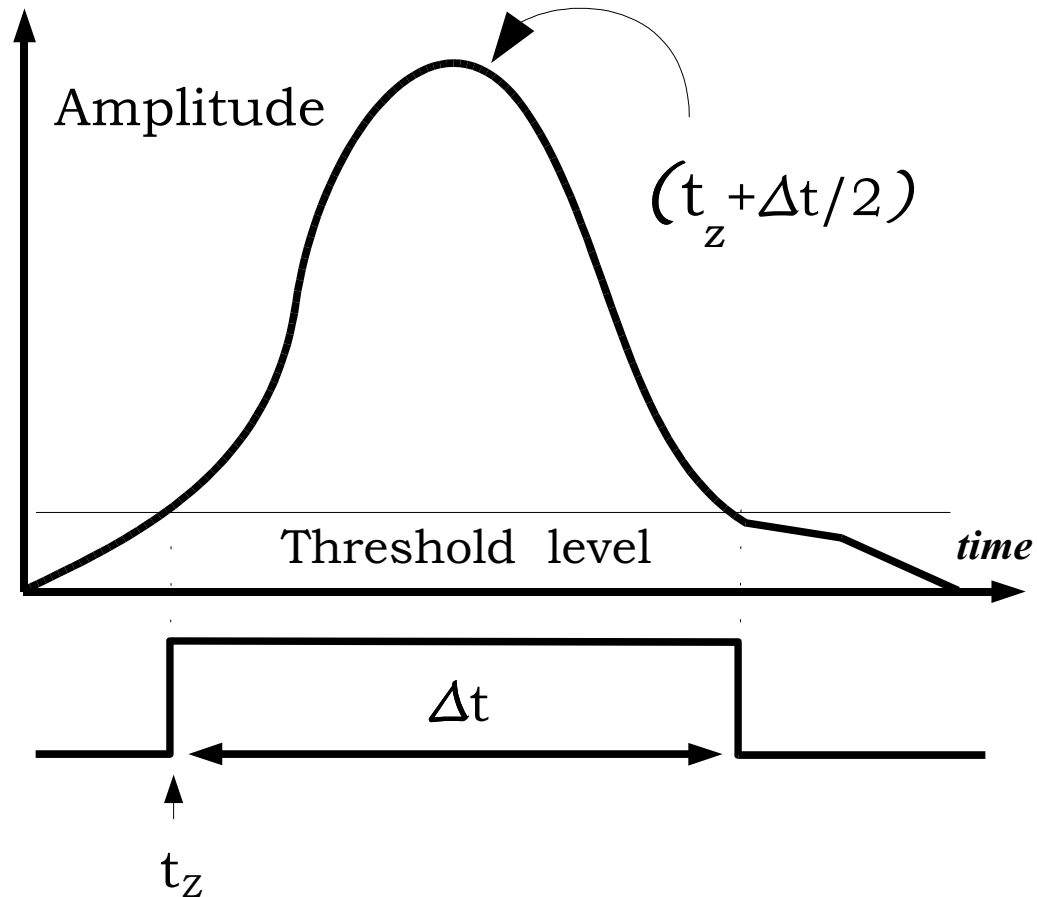
- $X$  and  $Y$  information is given from the pads
- Center-of-Gravity (CoG) of the signal defines the  $Z$ -coordinate of the track segment
- Charge – area under the waveform
- Waveform data is used only to derive CoG of the signal and charge
- Charge over many points of the track should be proportional to  $dE/dx$

ALEPH TPC  $dE/dx$  resolution was 4,5 % [M.Gruvé] (8-bit ALEPH FADC)

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## Data acquisition with TDC

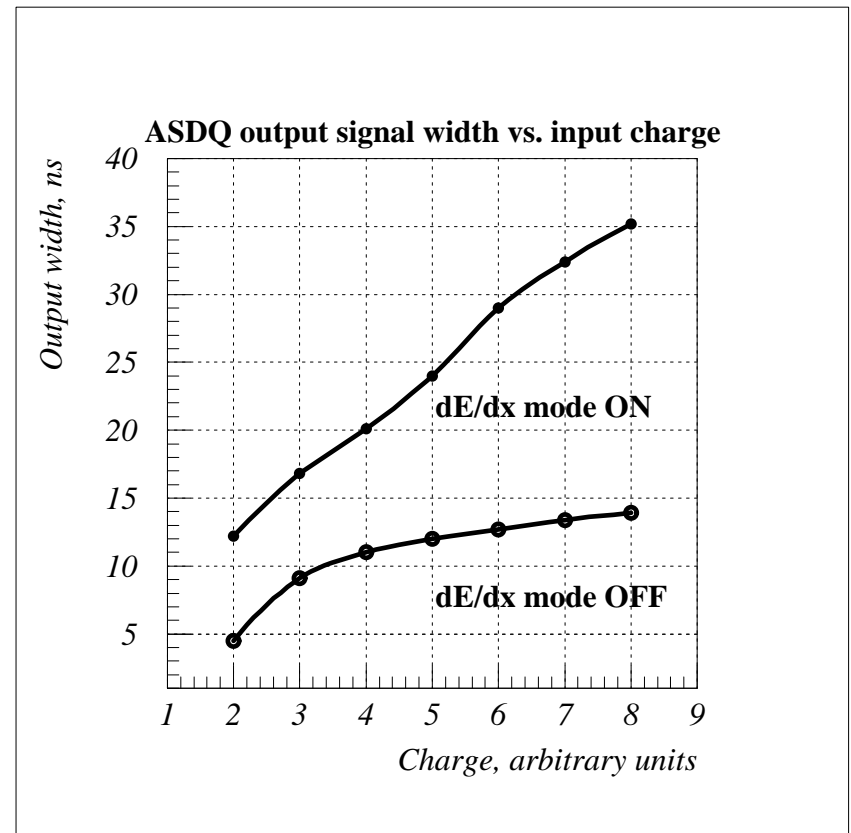
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One need to measure only two numbers:  $t_z$  and  $\Delta t$   
 $(t_z + \Delta t/2)$  of the signal defines the z-coordinate of the track segment  
 $\Delta t \sim$  charge of the signal (with appropriate amplifier)

## Charge measurement with TDC

- Example of preamplifier, which uses charge-to-time conversion is ASDQ preamplifier for Central Outer Tracker in CDF
- Measured output signal width of ASDQ shows linear dependence on input signal charge
- Charge-to-time conversion technique allows us to use a TDC for  $dE/dx$  measurement

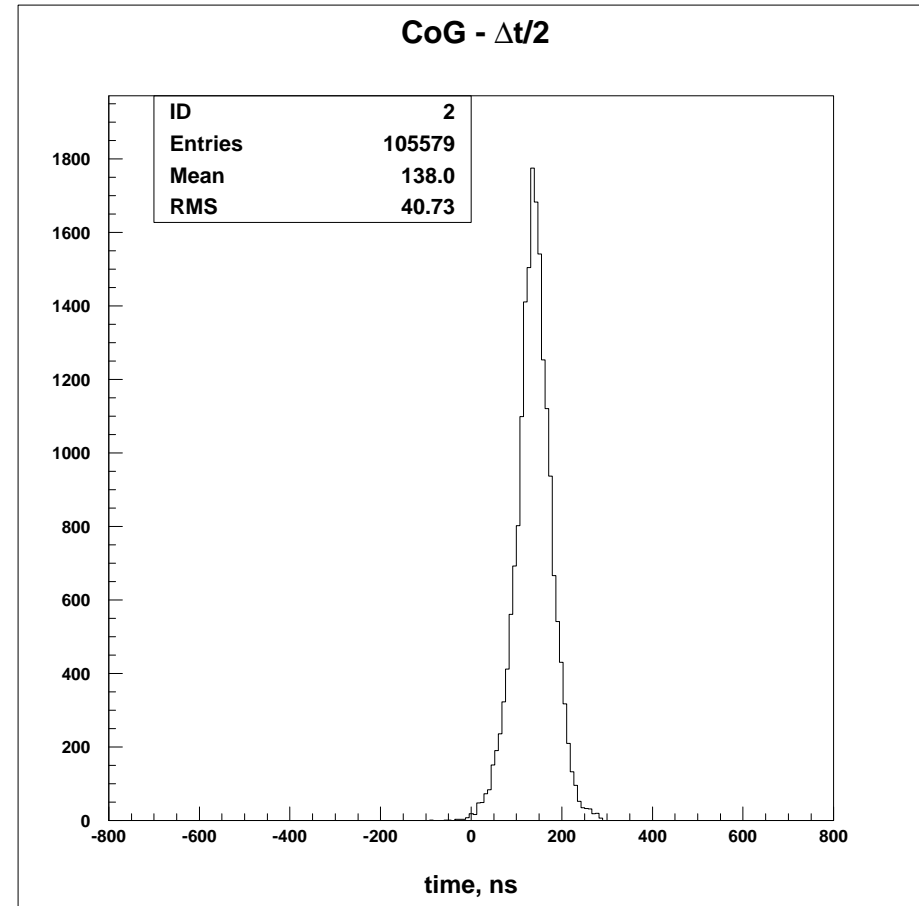


Test with pulse generator

## Track segment position with TDC

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- FADC data (TPC prototype at DESY) was used, to compare Center-of-Gravity of the signal and  $\Delta t/2$
- RMS  $\sim 1.8$  mm
- Longitudinal diffusion for 1 meter drift path is  $\sim 3$  mm



## Open questions

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- Front-End preamplifier (type, shaping time,...)
- Charge measurement ( $\Delta t$  or ASDQ-like)
- Occupancy in r,z directions ( multi-hit resolution of the TDC)
- Trigger, the “common stop” signal for the TDC
- TDC architecture
- DAQ interface

## Summary

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### New TDC development:

Being based on already implemented designs of the TDC (HERA-B, OPERA), we study the possibility of a TDC-based readout for a LC TPC.

TDC architecture might accommodate both designs of TDC:

- TDC for HERA-B experiment (0.5ns bin size - for charge measurement)
- TDC for OPERA experiment (large dynamic range for time measurement). OPERA TDC measures two times per signal. This allows, beside the time measurement for tracking, to determine the width of the signal, which is a measure of the collected charge. Price for 8-channel OPERA TDC chip is about 30 Euro.

### Plans for the near future :

- Tests of different preamplifiers with TPC prototype (DESY)
- Adaptation of HERA-B TDC to build prototype of readout electronics with ASDQ preamplifiers.