

SiPM and diamond front-end electronics made in LPSC

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- LPSC and Grenoble-Alpes University, Grenoble
- CPPM and Aix-Marseille University, Marseille
- Centre Antoine Lacassagne, Nice
- Arronax, Nante

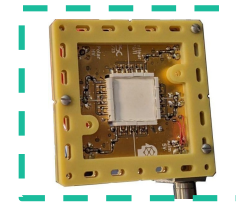
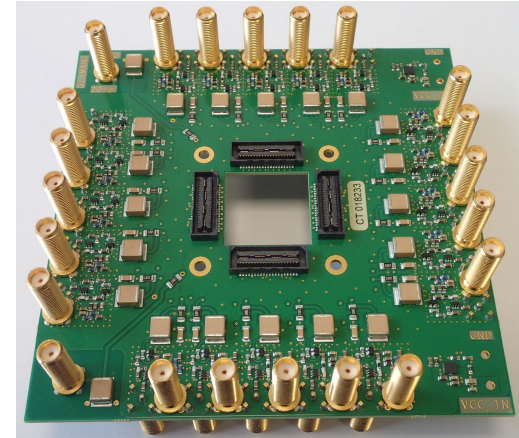
Proton therapy

- **Beam Monitoring**

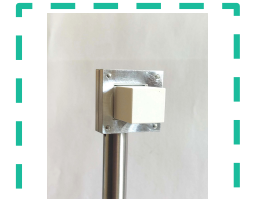
- Master project Diamant
- Projet Hodoscope
- Diamants $2 \times 2 \text{ cm}^2$, 40 strips for sub-mm spatial imaging

- **Prompt Gamma Time Imaging**

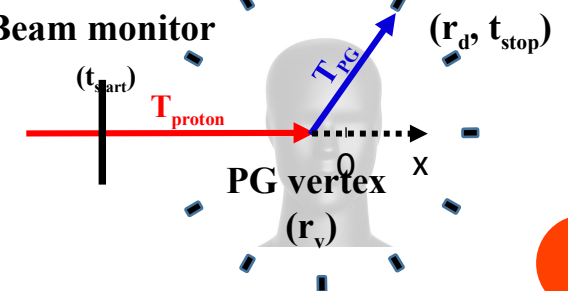
- ERC Starting Grant by Sara Marcatili 2022-2027
- CPPM $\rightarrow$ modelisation and algorithm
- CAL $\rightarrow$ medical expertise and facilities
- Real-Time dose monitoring
- Proton beam monitor : T_{START}
- Gamma prompt detector : T_{STOP}
- Time-of-flight = $T_{\text{START}} - T_{\text{STOP}} \rightarrow$ **Reconstruction**



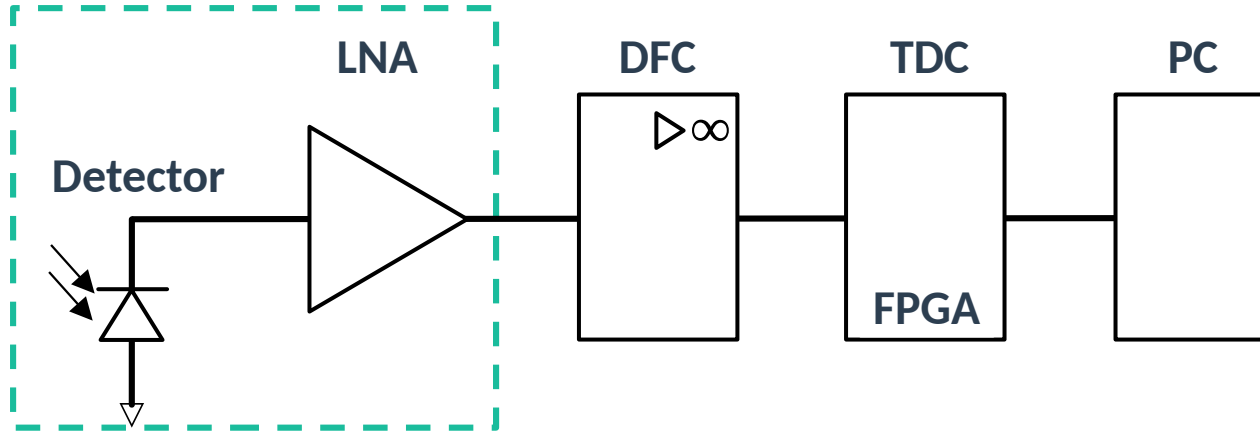
Beam monitor



TIARA module



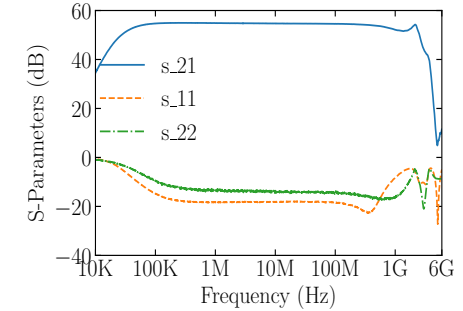
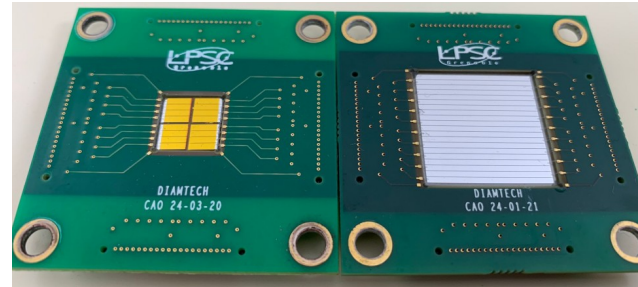
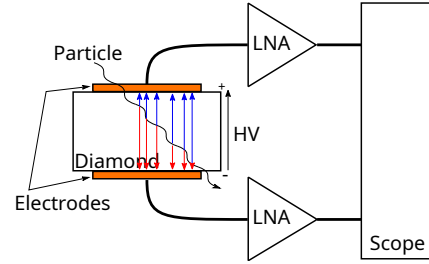
SiPM and diamond front-end electronics



Detector : Hodoscope beam monitor

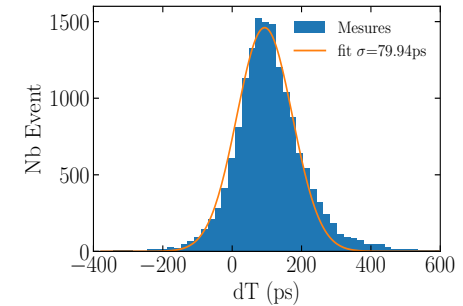
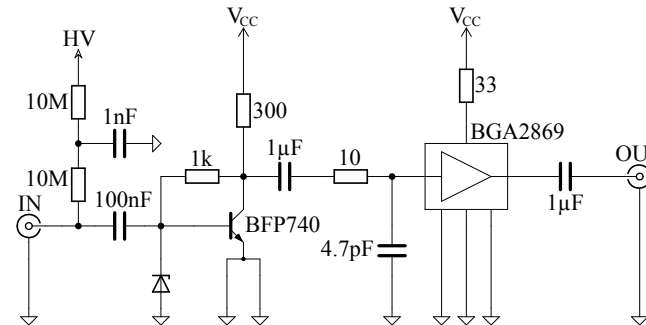
• Diamond

- poly- or monocristal
- 20 & 20 strips
- $1 \times 1 \text{ cm}^2$ or $2 \times 2 \text{ cm}^2$
- single or 4 assembled



• Amplifier

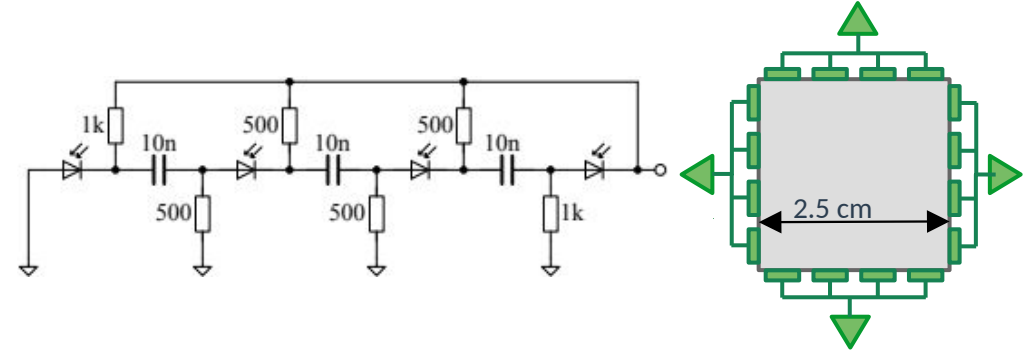
- Hetero junction bipolar transistor
- High gain (55 dB)
- Low noise ($< 150 \text{ } \mu\text{V rms}$)
- Coincidence $\sigma < 100 \text{ ps}$
- Low power $\sim 20 \text{ mW}$ / channel



Detector : SiPM beam monitor and γ -detector

- **Beam monitor with plastic scintillator**

- Plastic scintillator (EJ-204) 1x25x25 mm³
- Read-out by 16 SiPM Hamamatsu 3x3 mm²

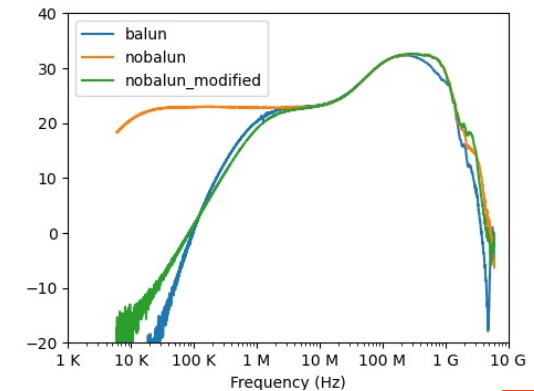
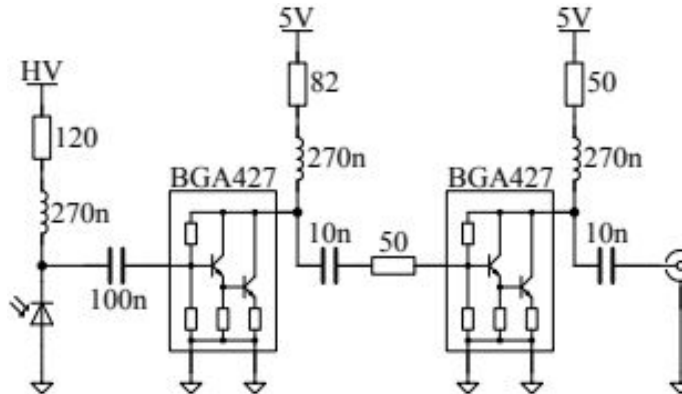


- **γ -detector**

- Cherenkov radiator 20x20 mm²
- 4 SiPM Hamamatsu

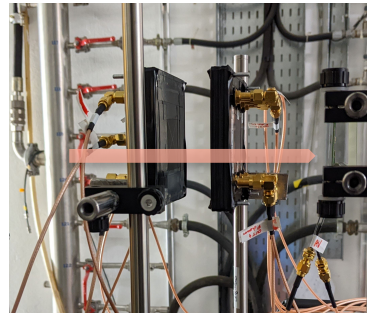
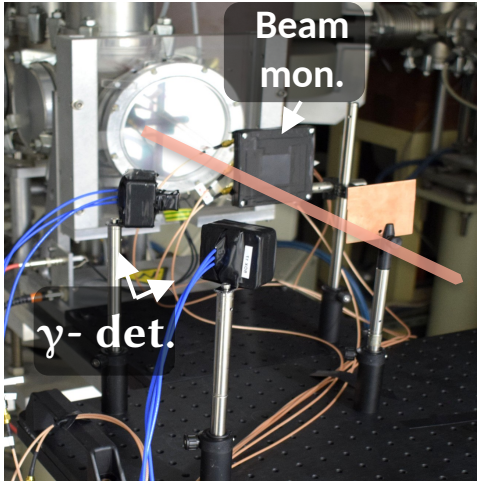
- **Amplifier :**

- 2 Stages with BGA427
- ~33 dB
- ~ 100 MHz - 1GHz



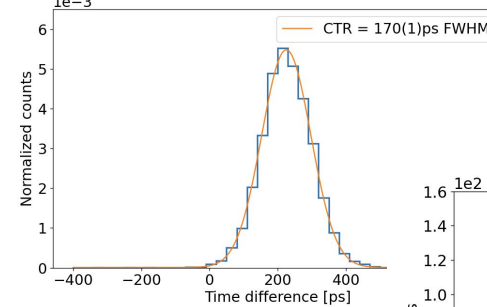
Detector : SiPM beam monitor and γ -detector

- **monitor-monitor**
 - 170 ps FWHM
 - Spatial resolution = 1.8 mm σ / proton @ 63 MeV
- **monitor- γ**
 - <220 ps FWHM

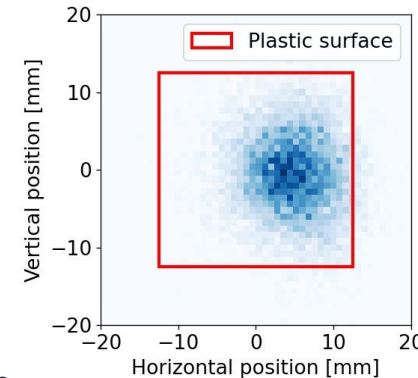
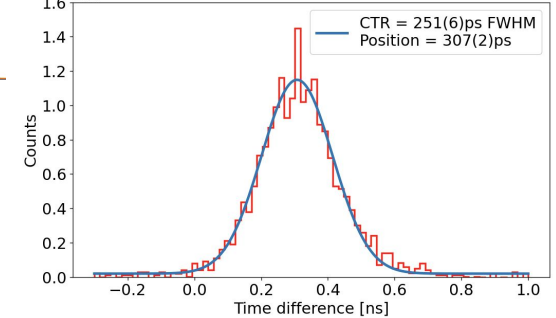


Read-out: Wavecatcher II CLAB

Coincidence: monitor-monitor



Coincidence : monitor- γ

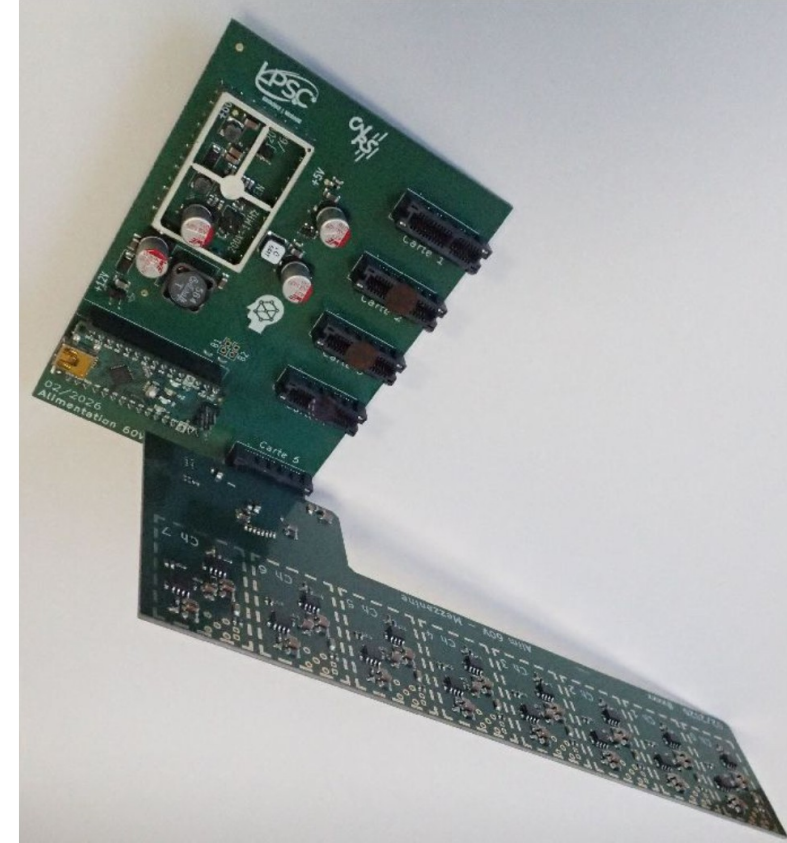
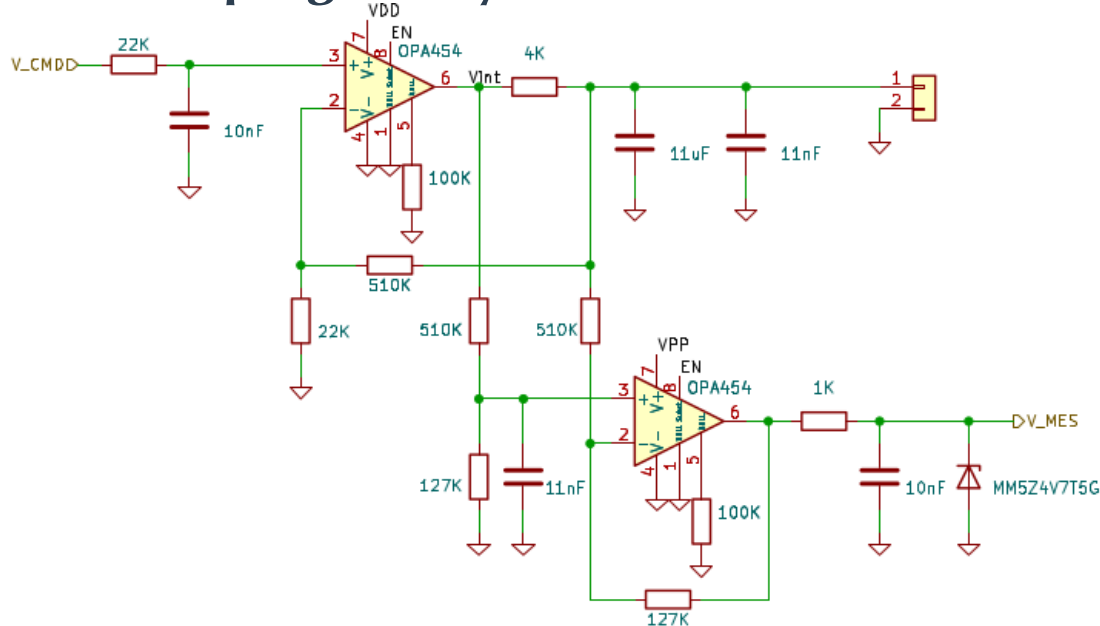


60V Voltage source for SiPM

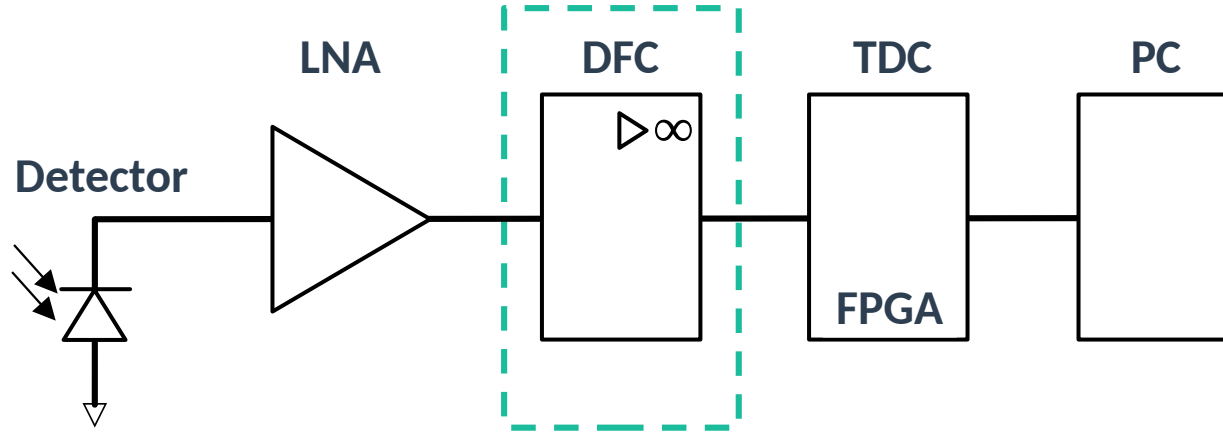
- Controlled voltage source

- 40 channels 60 V, 1 mA
- USB control and pyQT gui

Work in progress by Mahéva Lehmann-Chaudot

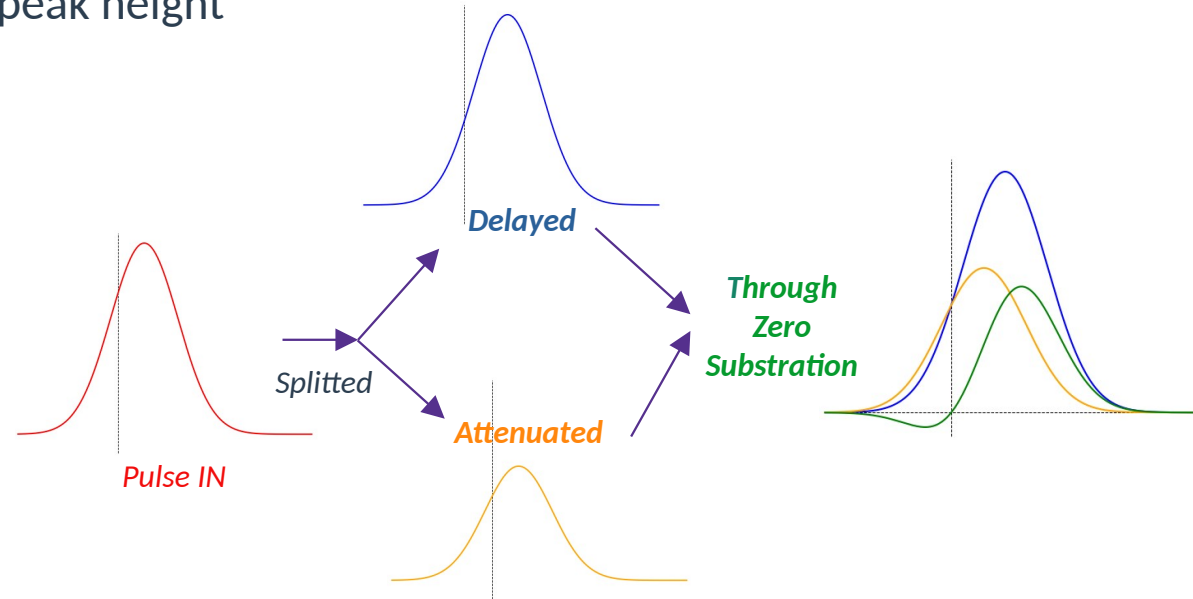
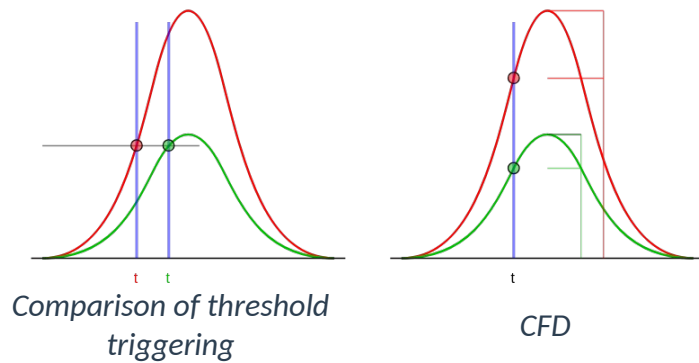


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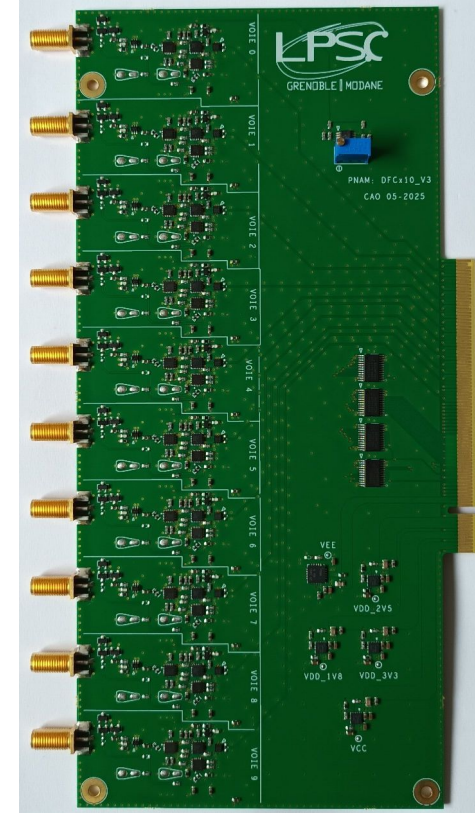
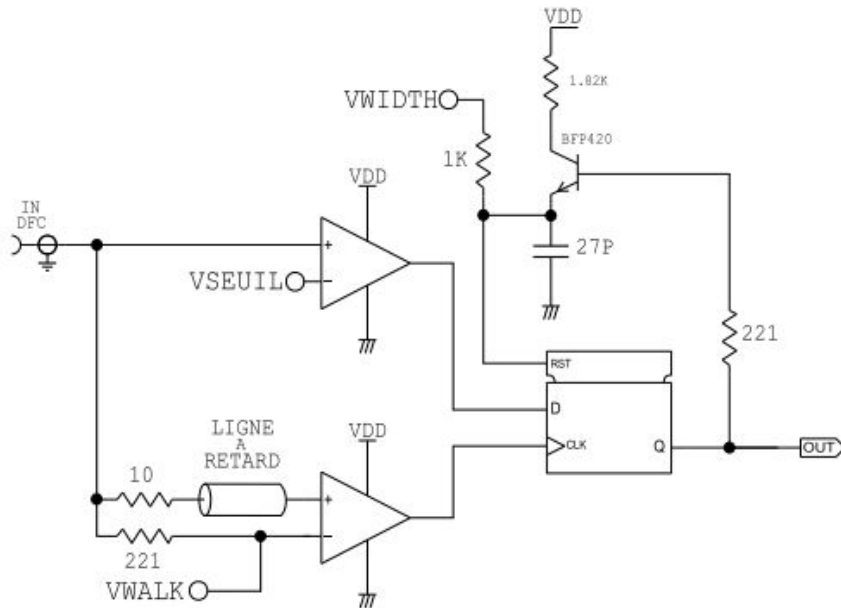


Constant Fraction Discriminator (CFD)

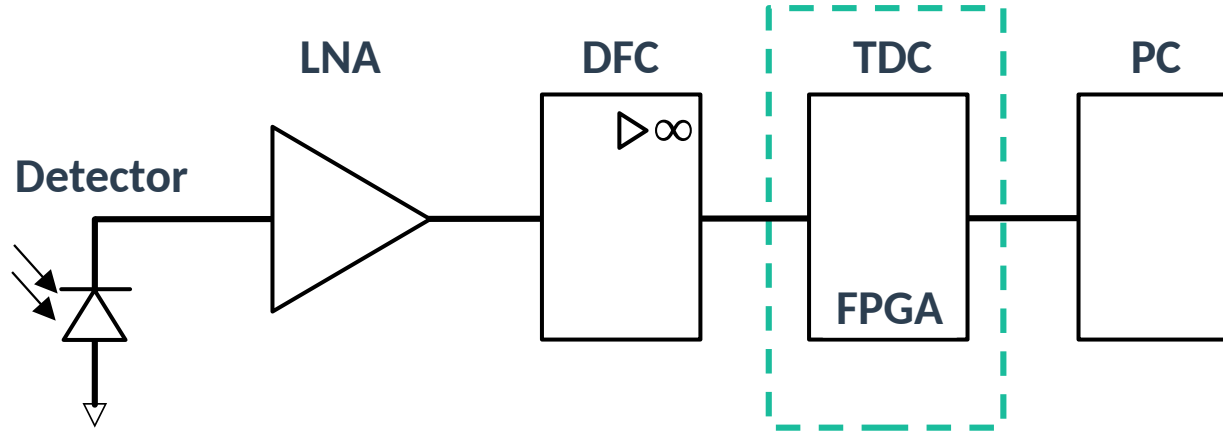
- An electronic signal shaping to find a constant relative level in a slope
- Trigger times are independent of peak height
- but in practice with a walk time



- DAC controled threshold and walk
- Global width (monostable effect)
- delay and attenuation imposed with components

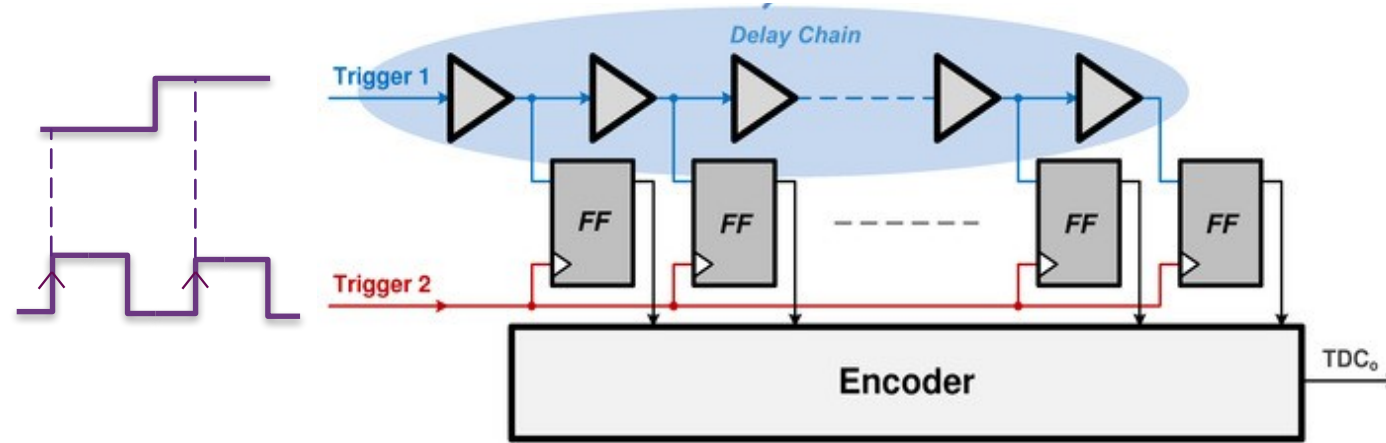


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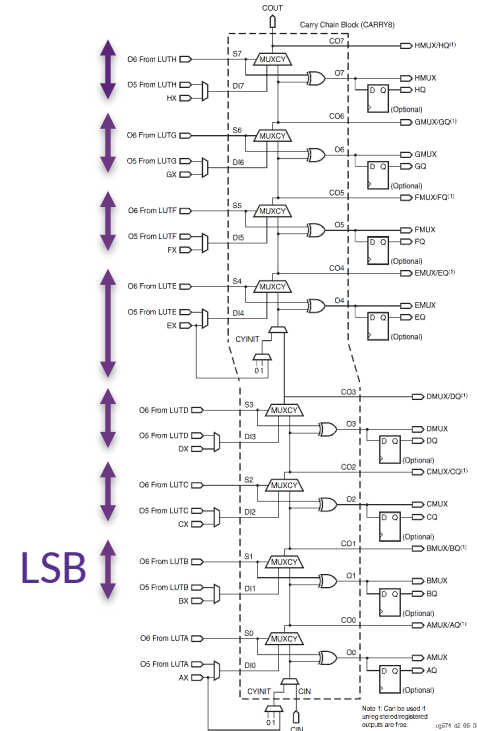


Time to digital converter with tapped delay line

- Delay is created by cascading carry blocks
- Delay Line > Clock period (3ns)



« Time Resolution Improvement using a Dual Delay Lines
for FPGA-based TDC with Real-Time Calibration ¶ »



« Exploring Linearity and Temperature
Stability in Time-to-Digital Converters ¶ »

Conclusion

Questions ?