Performance of diamond detectors used for timing applications in HADES

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for the HADES Collaboration

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Acknowledgements

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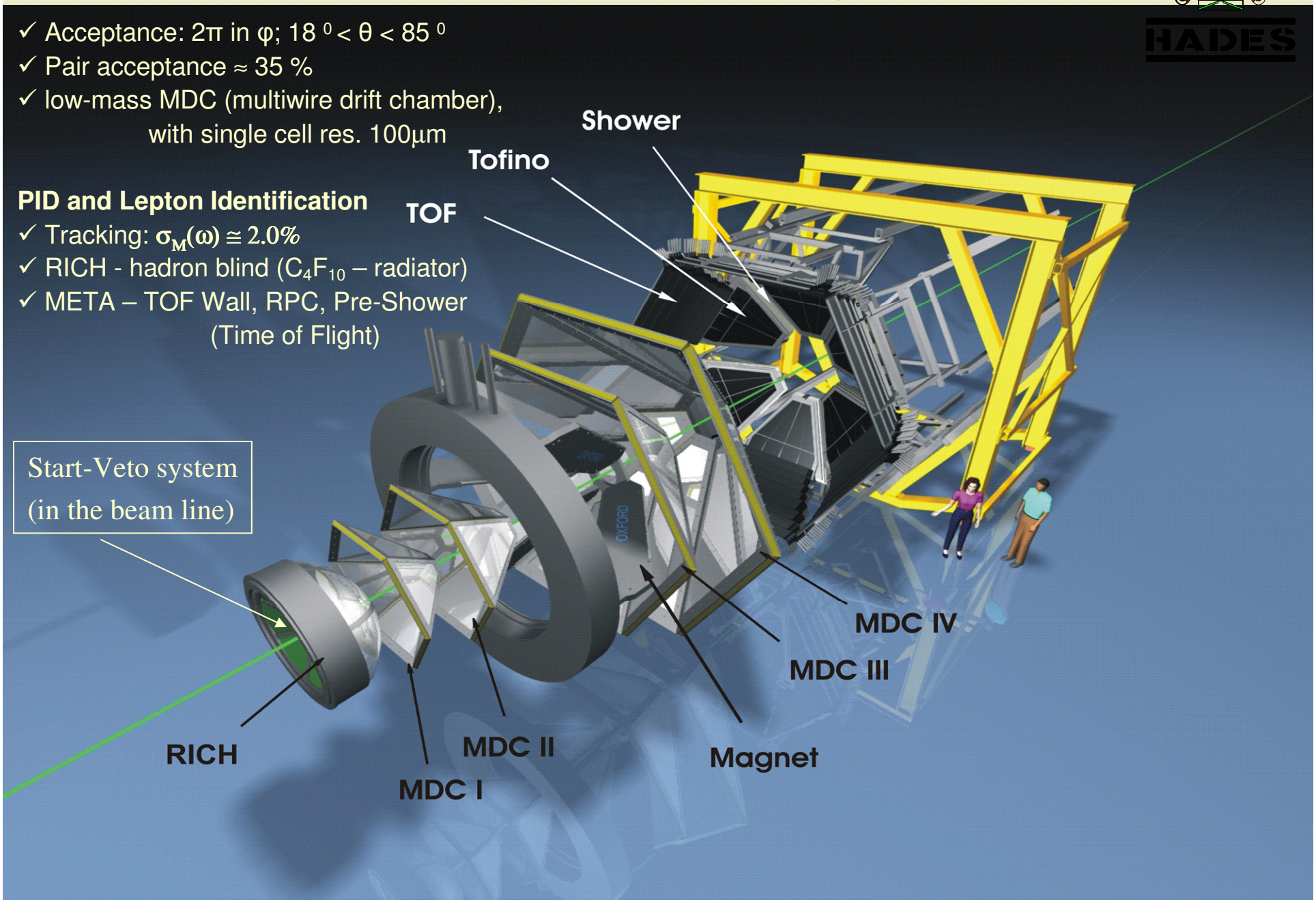
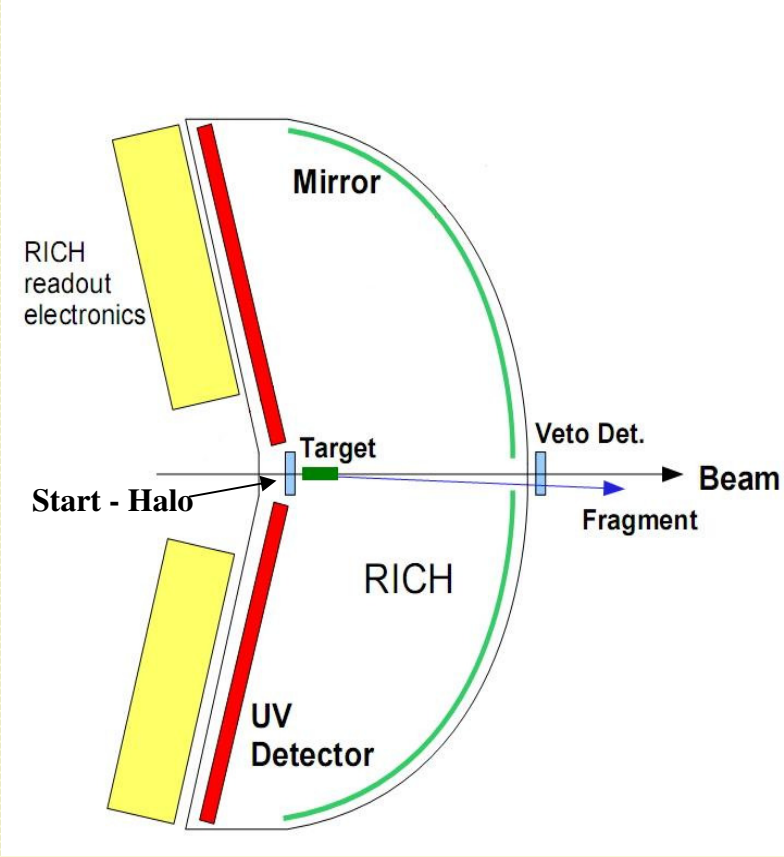
HADES Start-Veto system

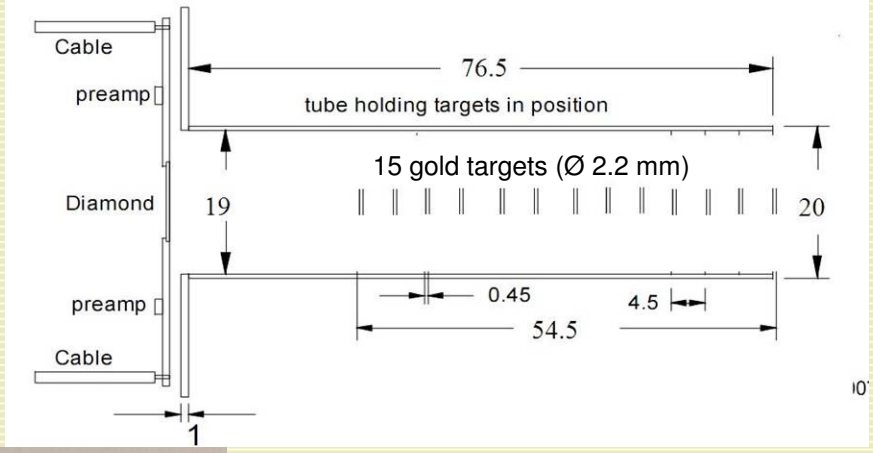


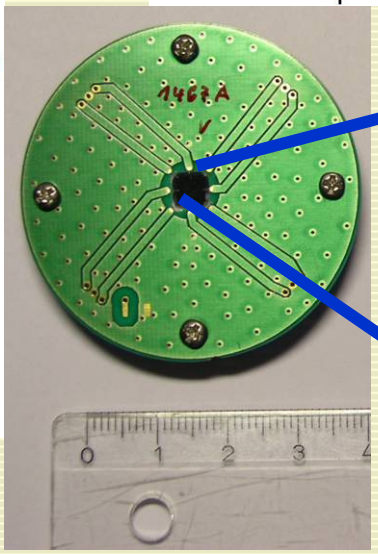
HADES Start-Veto system (Au+Au)

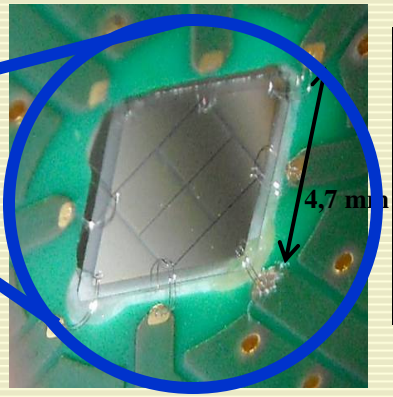
Issues:

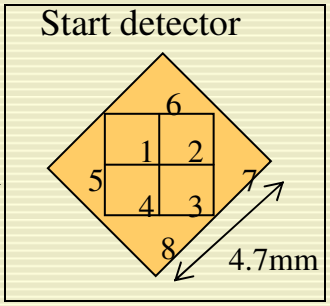
- ✓ Low interaction probability, low Z, good time resolution, below 50 ps
- ✓ In vacuum operation, located directly in front of the target in order to reduce load on the RICH
  - → Start det.: monocrystalline diamond, 50 µm thickness, 4.7mm x 4.7mm
  - →Veto det.: polycrystalline diamond, 100 µm thickness, behind the RICH Detector.



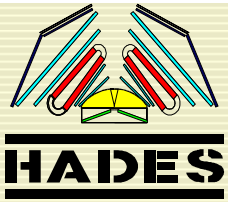








Beam detector requirements
(driven by physics program)



Heavy ion program Au +Au @ 1.25 AGeV

Elementary and pion induced reactions – short summary

(NIMA 618 (2010) 121-123)

Beam detector requirements/tasks:

- Beam position monitoring (beam spot: 1mm^2)
- Start signal for Time-of-Flight measurement.
- Fast trigger signal for Data Acquisition System.
- High rate capability - **particle intensity about 10^6/s Au ions/ channel**.
  → Position sensitive, fast detector, directly in front of the target.
  → Included in the LVL1 trigger. Selecting beam particles which hit the target.
  → **Time resolution: below 50 ps.**
  → Efficiency: close to 100 %.
  → Fast readout electronics

Start-Veto system readout electronics

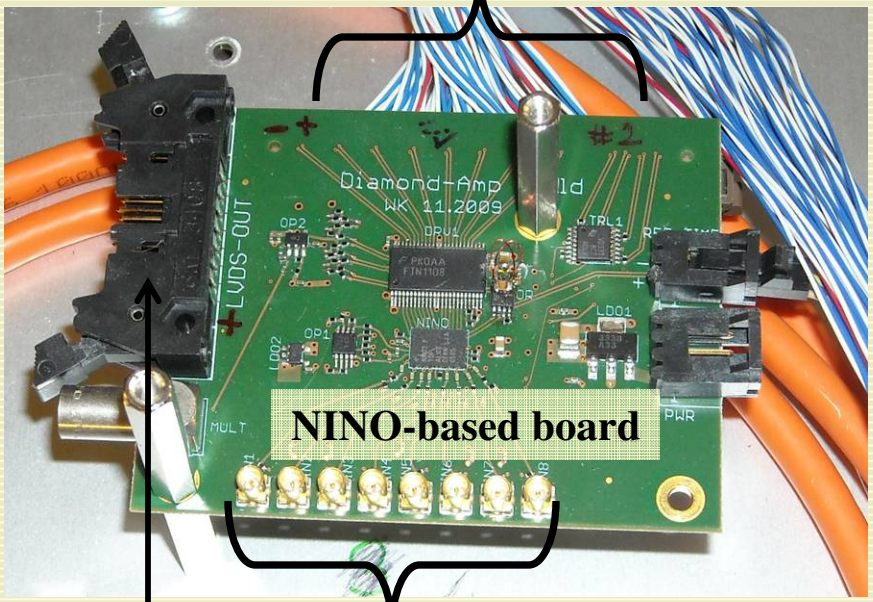
Issues:

- ✓ High rate, up to 10^7/s per channel.
- ✓ Fast signals, analog signal from diamond – 200 ps rise time, base width < 1ns.

Our approach:

- ✓ Dedicated NINO based discriminator board with trigger functionality.
- ✓ Time measurement performed by HADES TRB board – based on HPTDC.

8 x LVDS timing output signals



8 x input signals

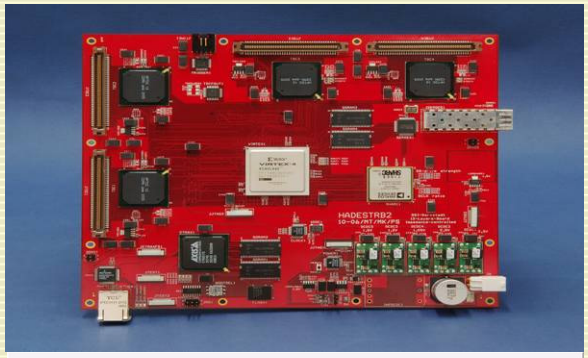
8 x scaler/trigger output signals

NINO chip: Developed for Time-of-flight measurements in the ALICE experiment

Key features:

- ✓ Adjustable discriminator thresholds.
- ✓ Front end time jitter <10ps.
- ✓ Sustains very high rate (>>10MHz)
- ✓ Peaking time: 1ns.
- ✓ Input signal range: 30fC - 2pC.
- ✓ Noise: <2500 e-.
- ✓ Discriminator threshold: 10fC - 100fC.
- ✓ Timing precision: <10ps jitter.
- ✓ Output: LVDS.

The Multipurpose Trigger Readout Board TRB



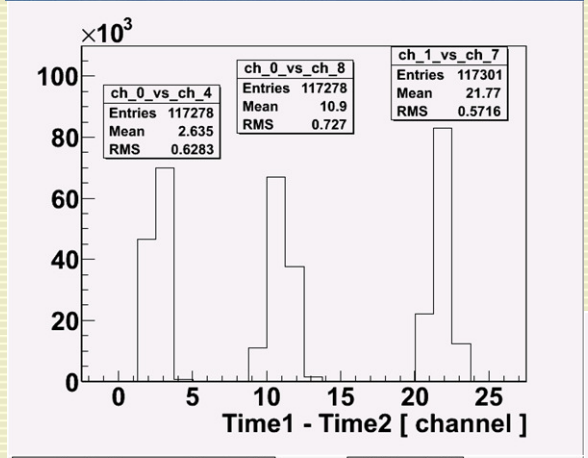
TRB Board:

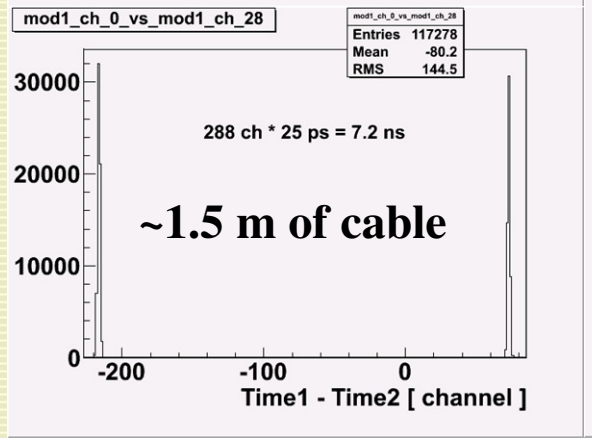
4 TDC – 128 channels (HPTDC), 4x512Mb SDRAM, FPGA – Virtex4LX40, ETRAX, FS – 4 processors, 100Mb/s,TCP/IP, 2,5 Gb/s optical link, DSP TigerSharc, DC/DC converters, AddOn connector

→ Time, ToT, 96ps/bin - 128 channels

→ Time, ToT, 25ps/bin - 32 channels

→ Rate capability: up to 3 MHz per channel

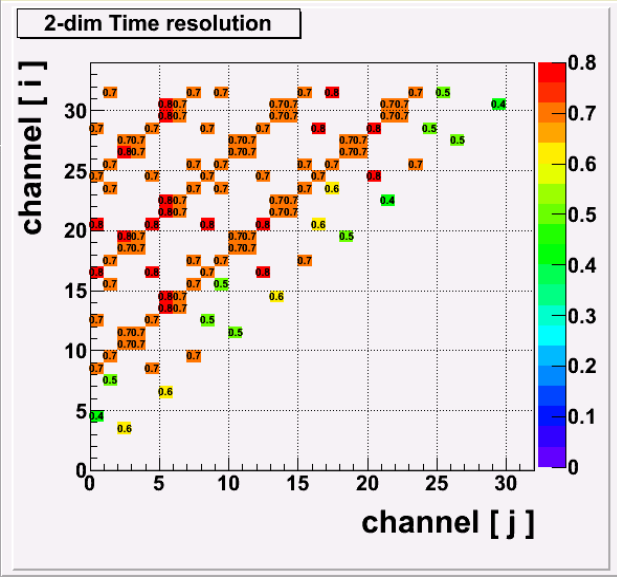


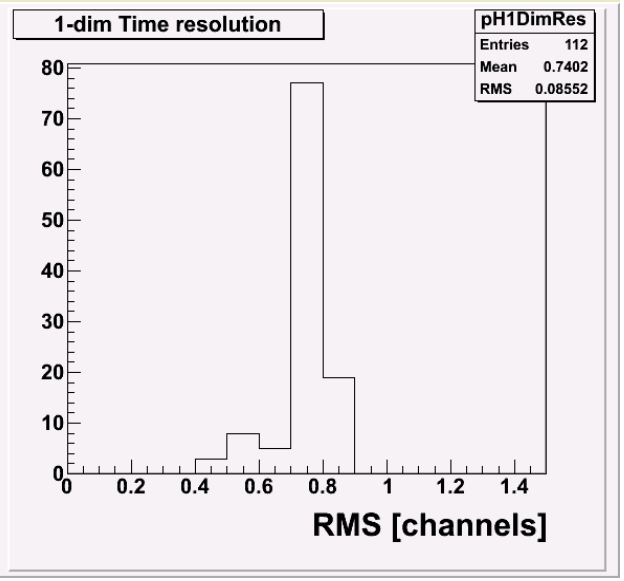


Pulser test signal sent to 8 channels.

✓ Individual INL corrections for each channel

→ **All 32 channels show RMS below 25ps/1.4 = 17.8 ps**

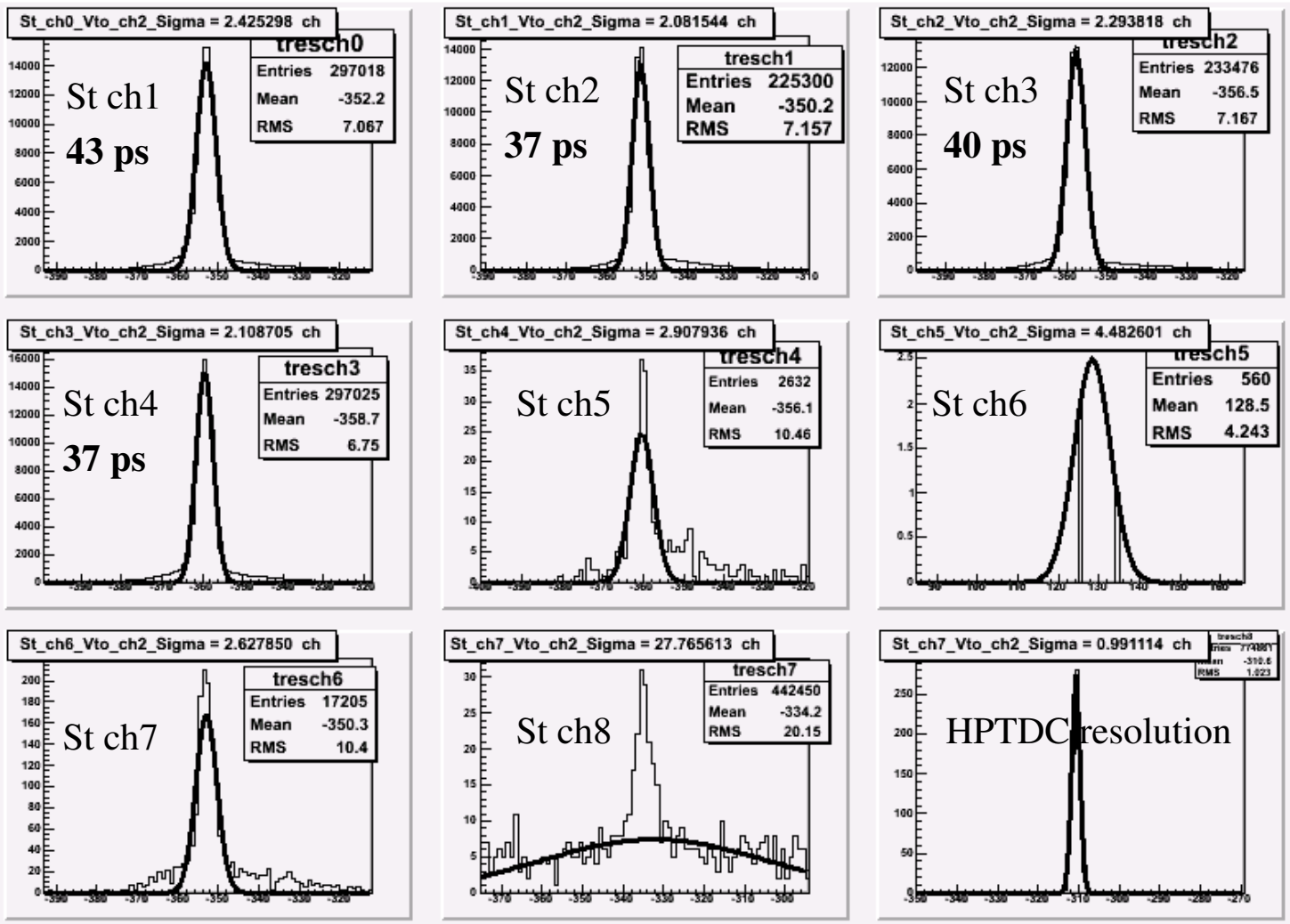


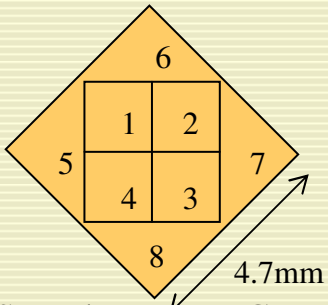


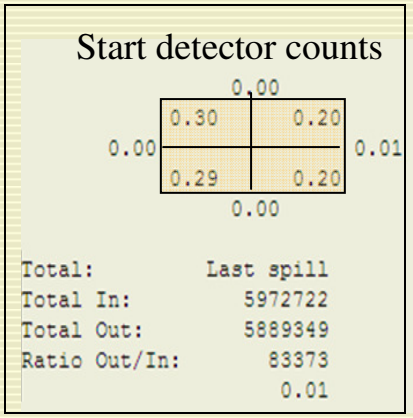
Start-Veto system – test with Au beam, time res

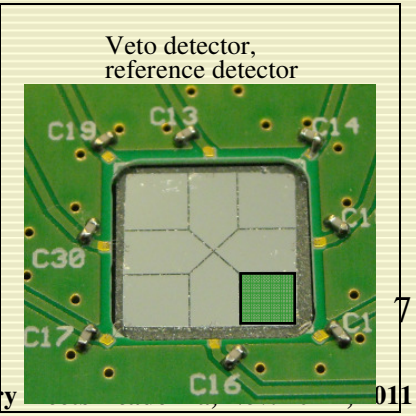
Setup and conditions:

- ✓ Start det.: monocrystalline diamond, 50 μm thickness, HV set to 200 V
- ✓ Veto det.: polycrystalline diamond, 100 μm thickness, HV set to 200 V.
- ✓ Beam particles intensity: 10^6/s per channel.









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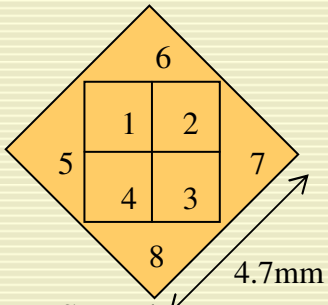
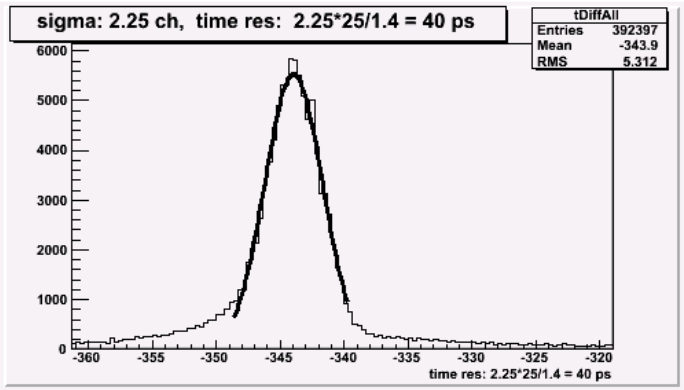
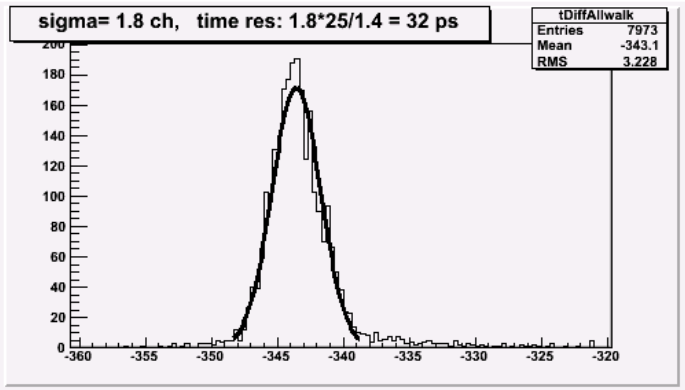
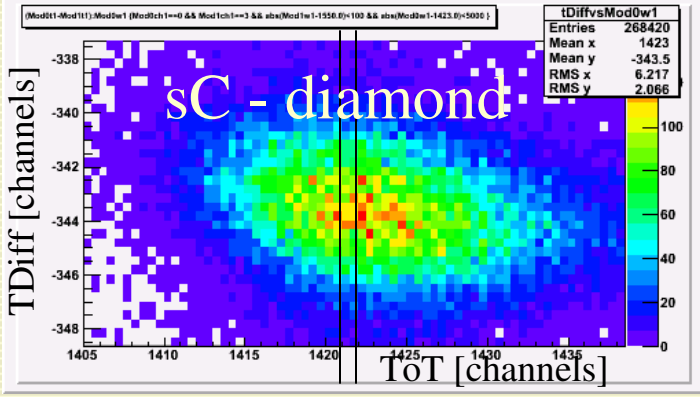


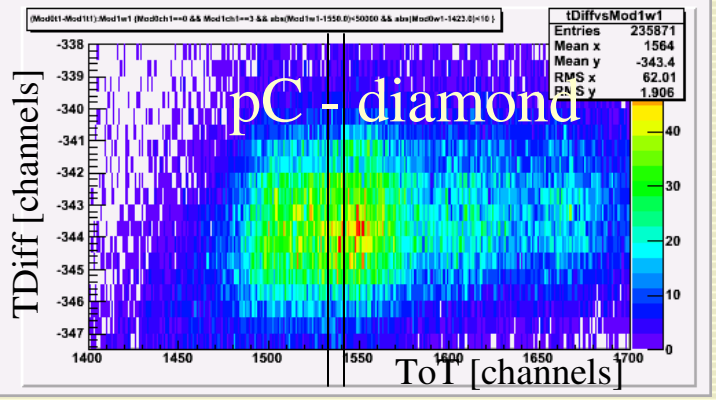
Start detector

One channel with "walk" correction – 32 ps

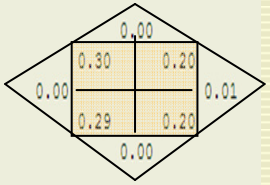






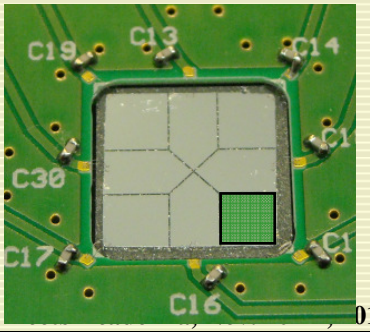


Start detector counts



	Total:	Last spill
Total In:	5972722	
Total Out:	5889349	
Ratio Out/In:	83373	
	0.01	

Veto detector, reference detector

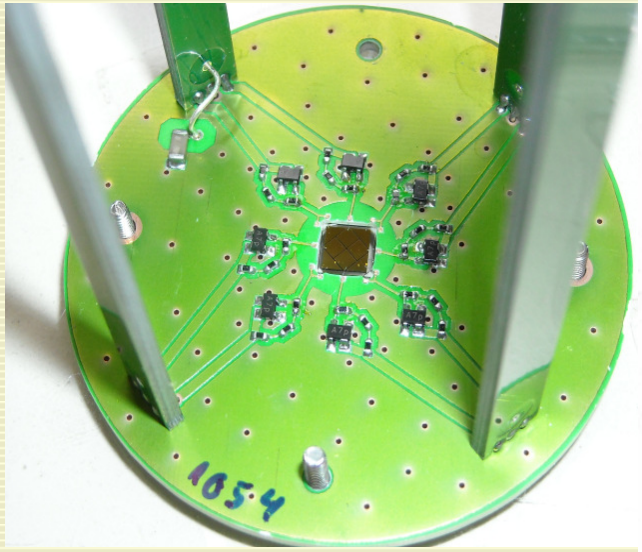


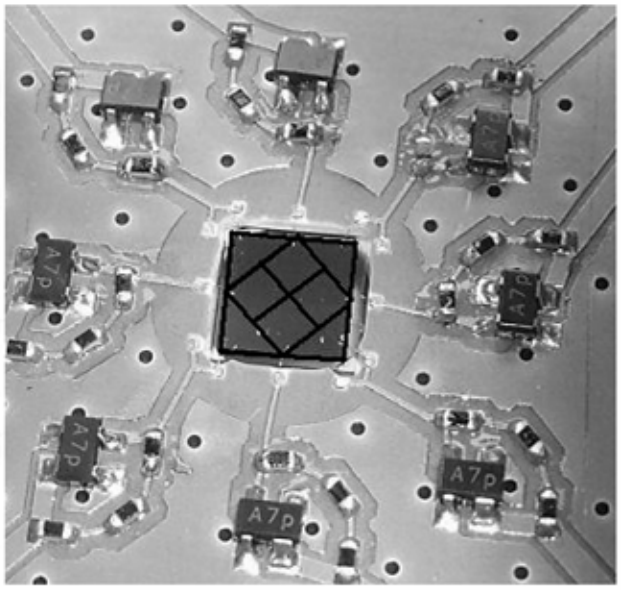
Start-Veto system for HADES pion/proton experiment (MIPs)

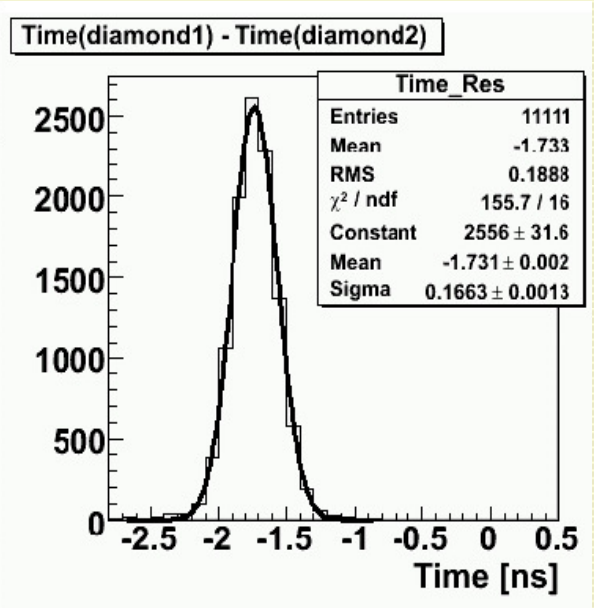
Experimental conditions and requirements for HADES pion experiment:

- ✓ **Secondary pion beam, mom.=1GeV/c (MIPs) → scCVD**
- ✓ Demanding beam particles intensity $>10^6$ pions/sec
- ✓ **Secondary beam. Beam spot diameter 1-2 cm → Large area moncrystaline diamond**
- ✓ **Timing signal for Tof measurement and for trigger - 50 ps time resolution**

Prototype: 4.7 mm x 4.7 mm, monocrystalline: used for proton induced reactions



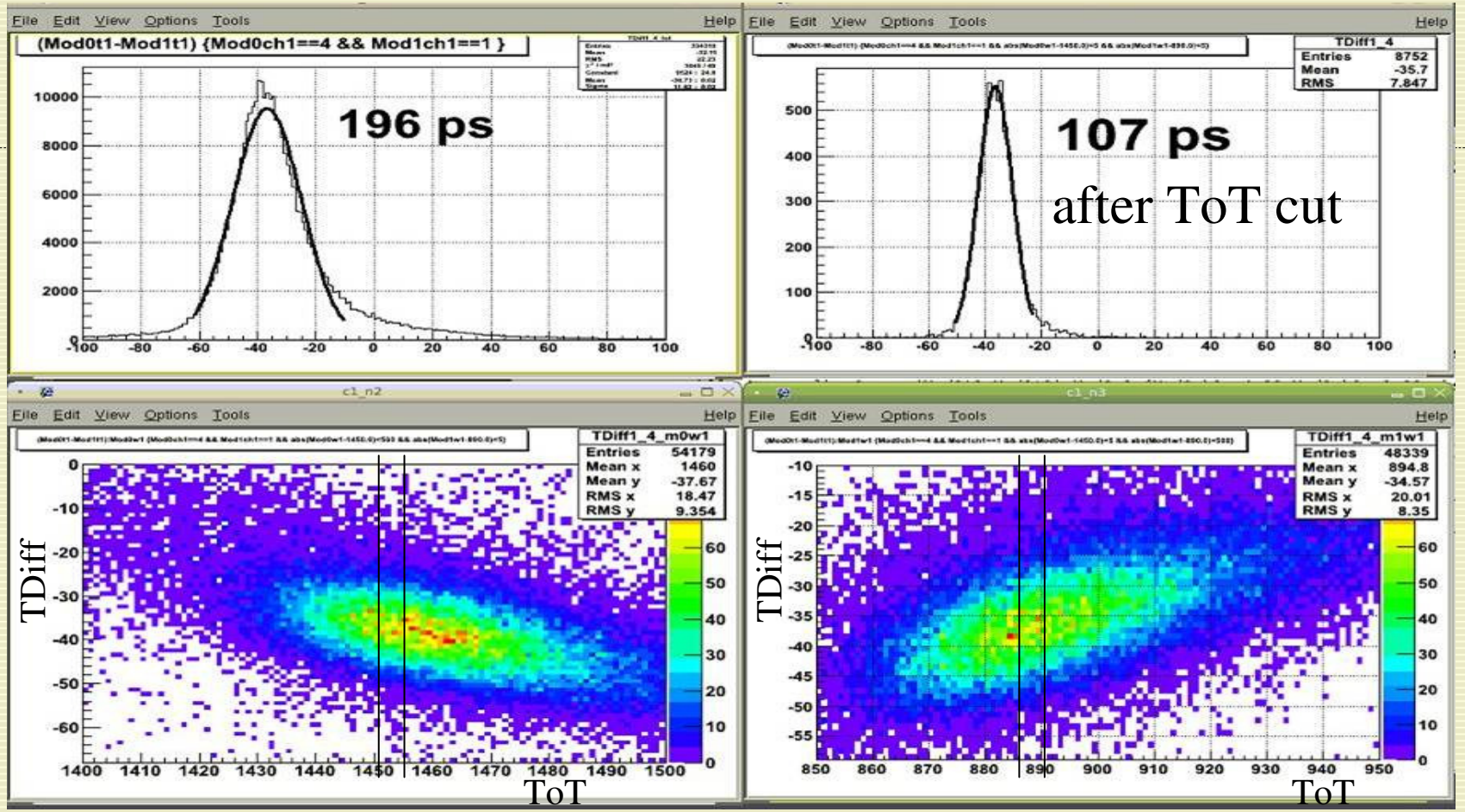




Start-detector for MIPs – test with p beam

Juelich proton beam, 2.95 GeV:

- ✓ Two Start det.: monocrystalline diamond, 500 µm thickness, 4.7mm x 4.7mm, with halo functionality, 50nm Cr/150nm Au metallization.
- ✓ Stable operation at intensities > 10^6 protons/ s/channel, BEST TIME RES = 100 ps, expected 50ps



Summary and outlook

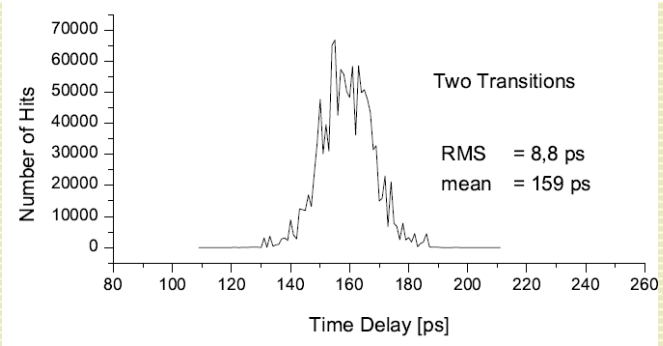
- ✓ Segmented diamond based sensors for HI and MIPs beam available.
- ✓ Single particle detection at beam intensities above $10^6/mm^2/s$ with time resolution < 50ps (HI)
- ✓ Stable operation for MIPs at intensities > 10^6 protons/ s/channel, measured time res. 100 ps, expected 50ps !!!!

In preparation:

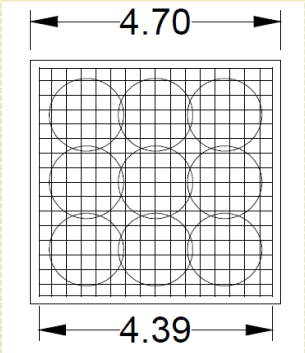
- ✓ Double-sided multi-strip diamond based sensor for HI (16 channels on each side)
- ✓ New generation of TDC will be available soon (TDC in FPGA)

A High-Resolution (< 10 ps RMS) Multi-Channel Time-to-Digital Converter (TDC) Implemented in a Field Programmable Gate Array (FPGA)

Eugen Bayer and Michael Traxler



diamond sensor, 16 stripes on each side



backup slides

backup slides