Beam detectors for HADES

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for the HADES Collaboration

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Beam detector requirements
(driven by physics program)

Heavy ion program Au +Au @ 1.25 AGeV - topic of my talk

Reaction: Au +Au @ 1.25 AGeV, 4-5 weeks.

Beam intensity about 10^6/s Au ions.

Beam detector tasks:

Beam position monitoring

Start signal for Time-of-Flight measurement.

Fast trigger signal for Data Acquisition System.

→ 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

Elementary and pion induced reactions

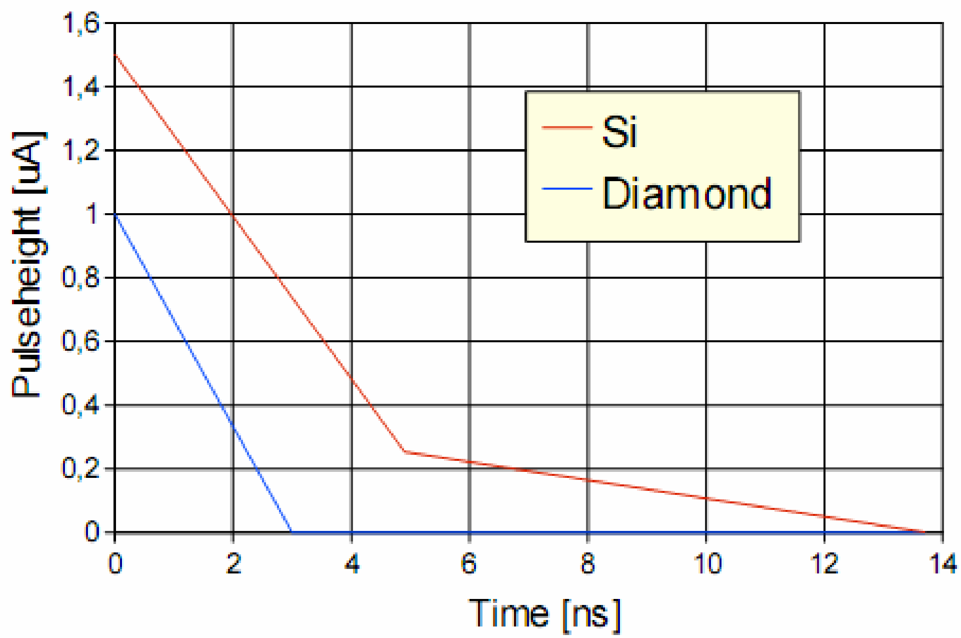
→ Reported during previous CARAT 2009 by W. Koenig,

(NIMA 618 (2010) 121-123)

Start-Veto system for HADES – diamond based

Diamond is radiation hard

	Diamond	Si detector
L_{rad}	12 cm	9.4 cm
ε	5.7	11.9
E_{eh}	13 eV	3.6 eV



Primary current signal from a 300 μm detector
Field: **1 kV / mm** , **2kV / mm**

short timing signals:
Si advantage of a factor 3.6 more e-h pairs is nearly compensated by higher charge mobility, smaller capacitance (**ε**) and longer radiation length L_{rad}

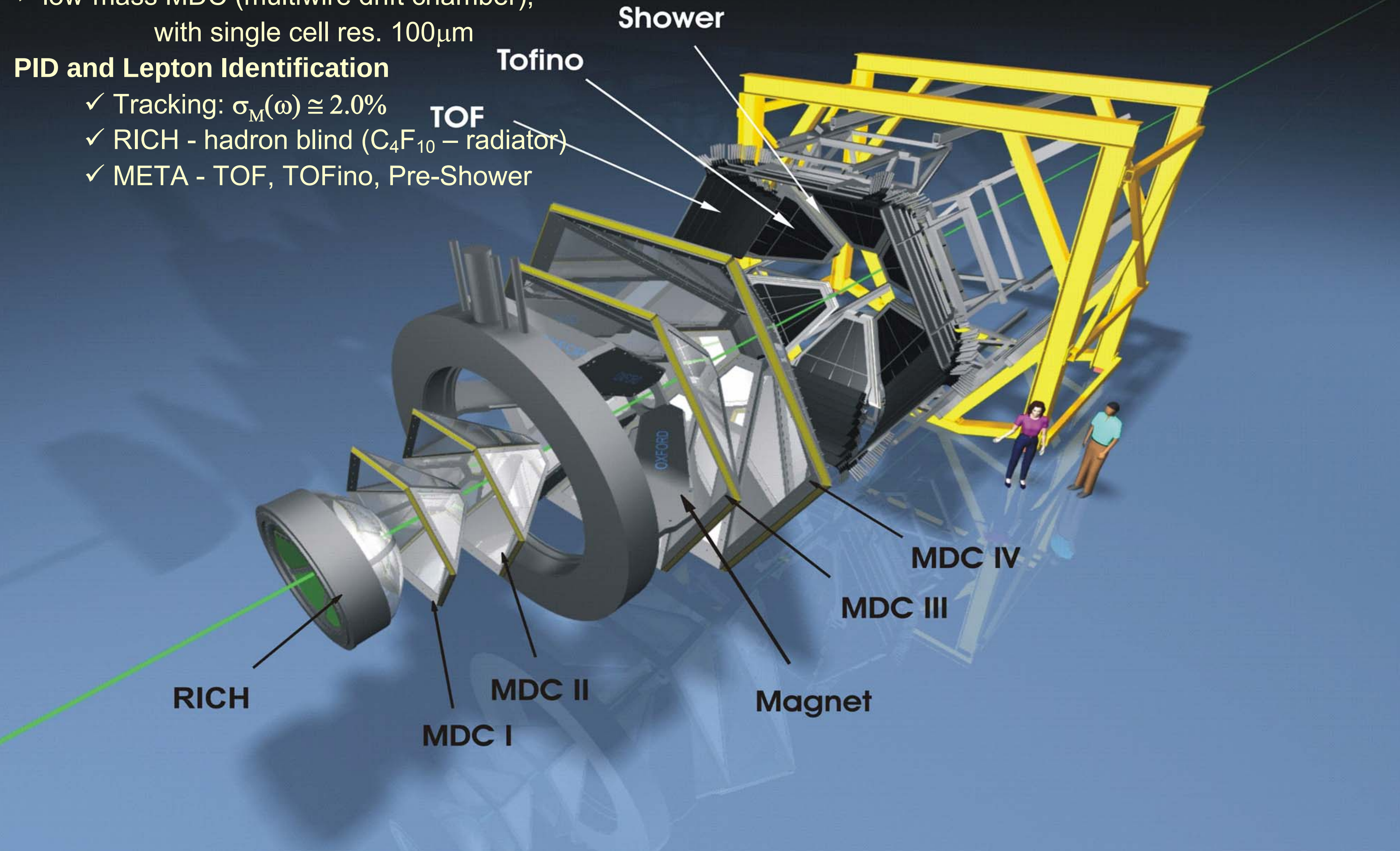
Problem: 8000 e-h pairs for a 300 μm diamond is small

HADES Start-Veto system for Au+Au experiment

- ✓ Acceptance: 2π in φ; $18^0 < \theta < 85^0$
- ✓ Pair acceptance $\approx$ 35 %
- ✓ low-mass MDC (multiwire drift chamber), with single cell res. 100μm

PID and Lepton Identification

- ✓ Tracking: $\sigma_M(\omega) \cong 2.0\%$
- ✓ RICH - hadron blind (C_4F_{10} – radiator)
- ✓ META - TOF, TOFino, Pre-Shower



HADES Start-Veto system for Au+Au experiment

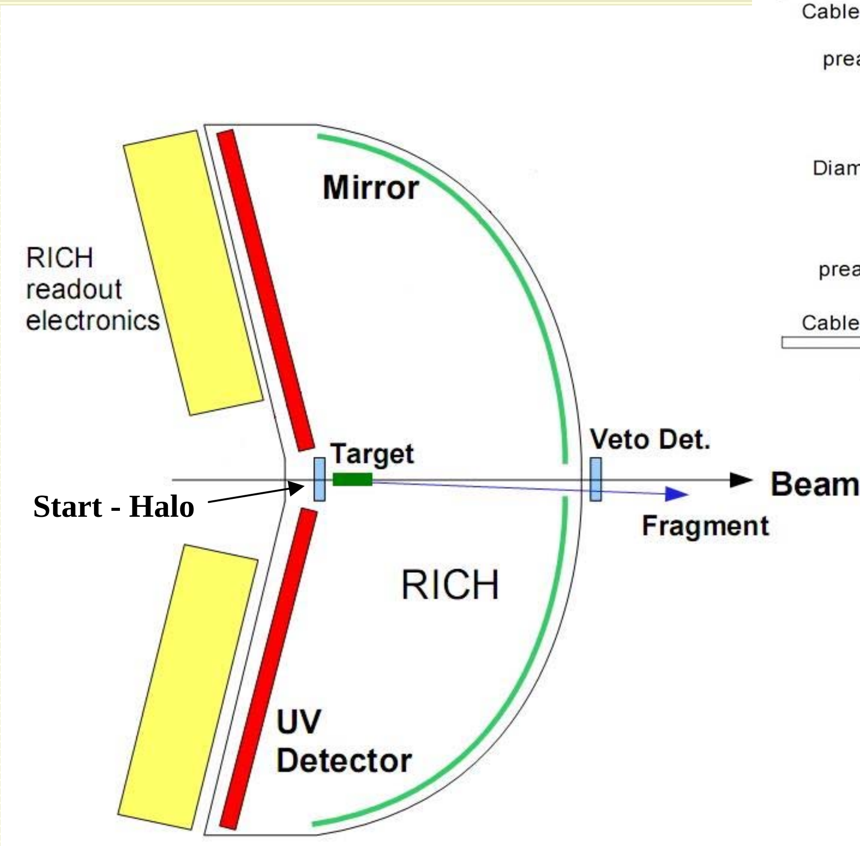
Issues:

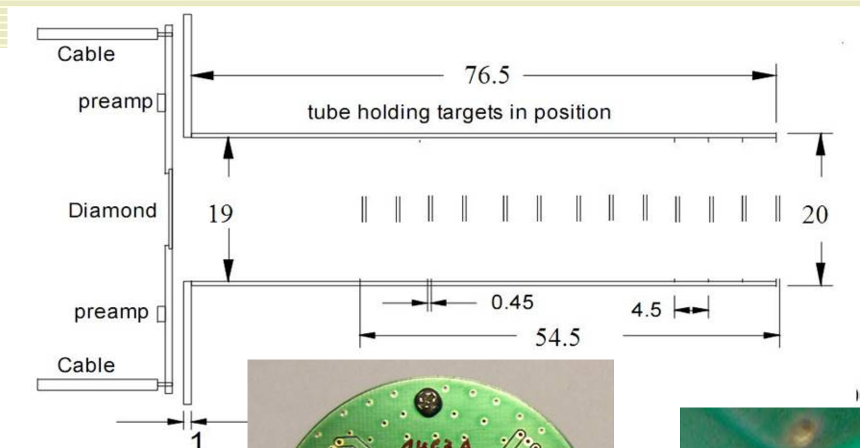
- ✓ Low interaction probability, low Z, good time resolution, below 50 ps
- ✓ In vacuum operation, located directly in front of the target in order to reduce load on the RICH

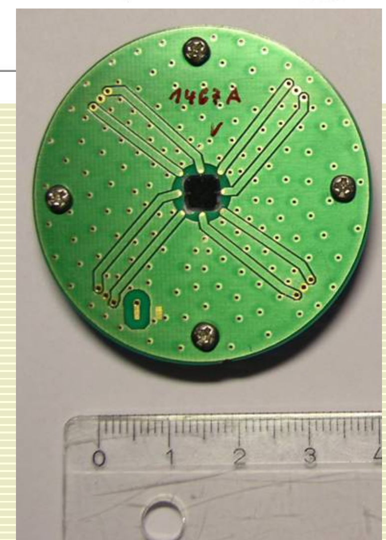
→ **diamond detector**

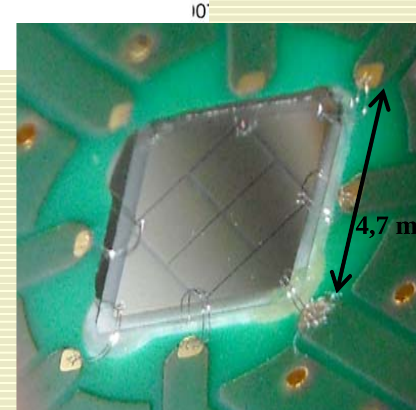
Configuration:

- ✓ Start det.: monocrystalline diamond, 50 μm thickness, 4.7mm x 4.7mm, with halo functionality
- ✓ Veto det.: polycrystalline diamond, 100 μm thickness, behind the RICH Detector.





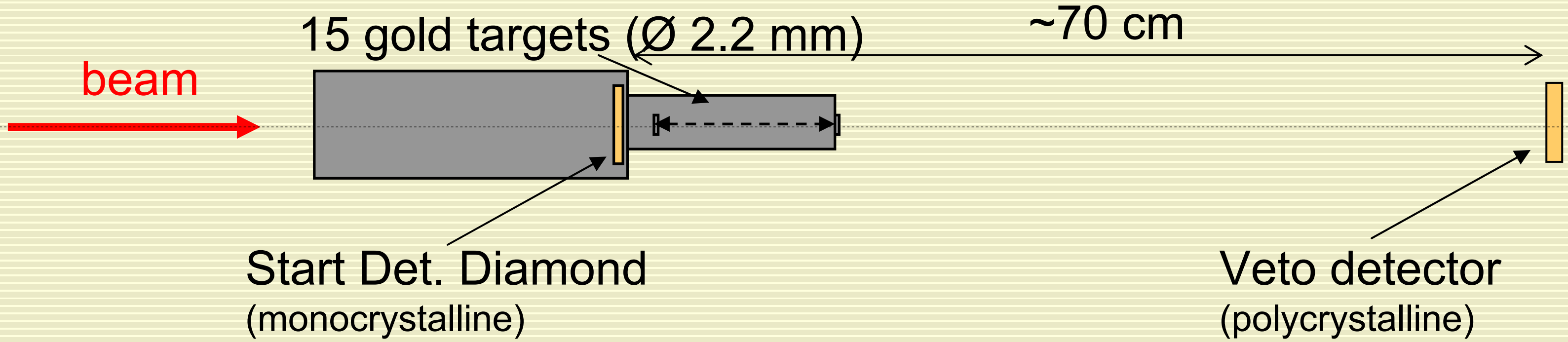


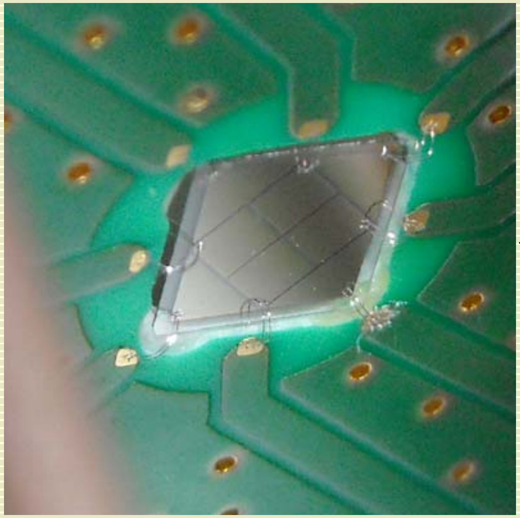


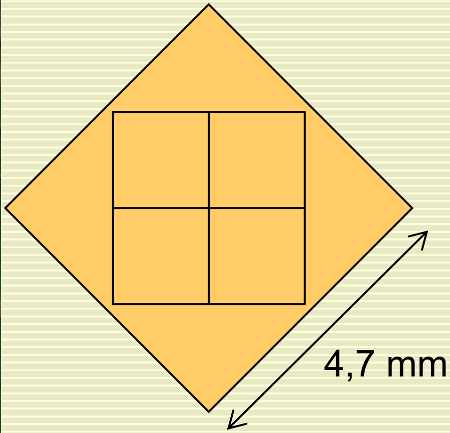
Start-Veto system – test with Au beam

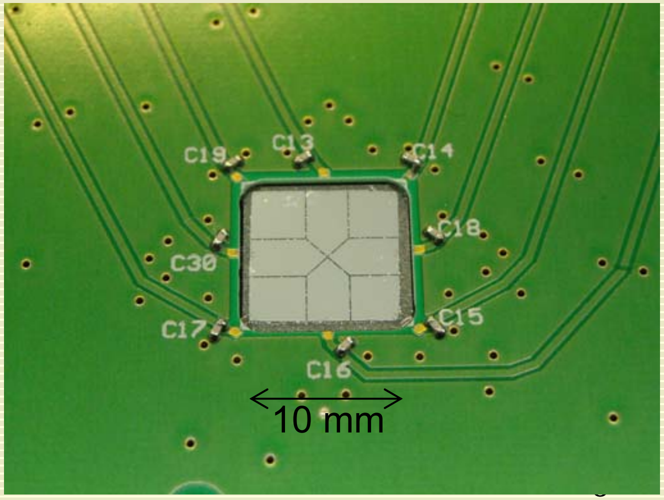
Setup and conditions:

- ✓ Start det.: monocrystalline diamond, 50 μm thickness, 4.7mm x 4.7mm, with halo functionality, 50nm Cr/150nm Au metallization.
- ✓ Veto det.: polycrystalline diamond, 100 μm thickness, behind the RICH Detector. Al metallization.
- ✓ Beam particles intensity: 10^6/s per channel.









Start-Veto system readout electronics (W.Koenig)

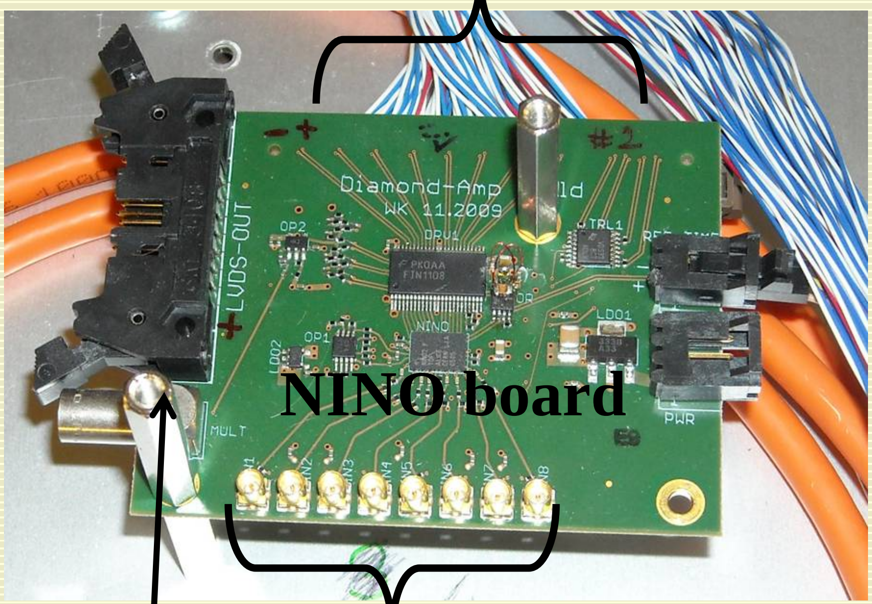
Issues:

- ✓ High rate, up to 10^6/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

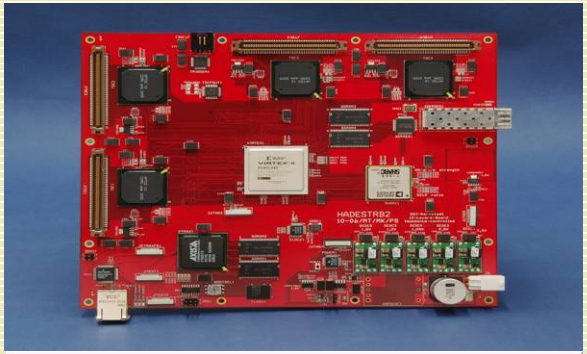
8 x scaler/trigger output signals

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



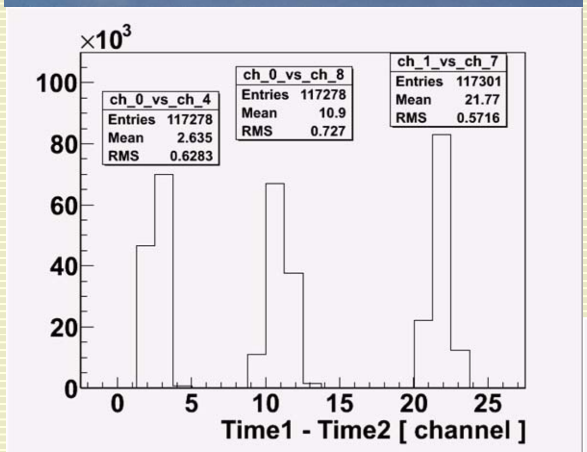
TRB Board:

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

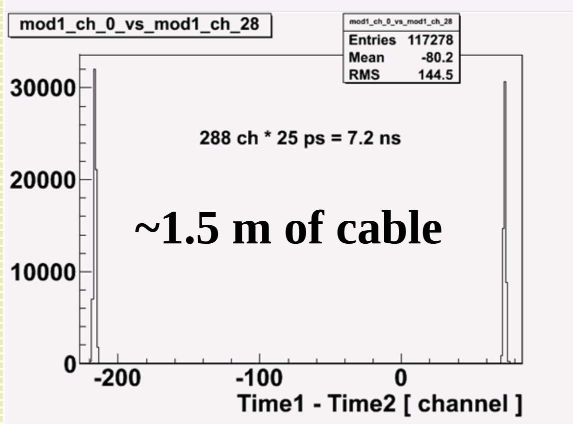
→ Rate capability: up to 3 MHz per channel

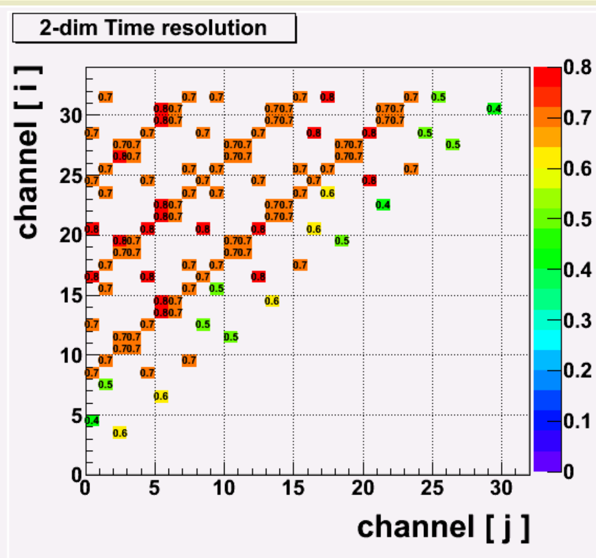


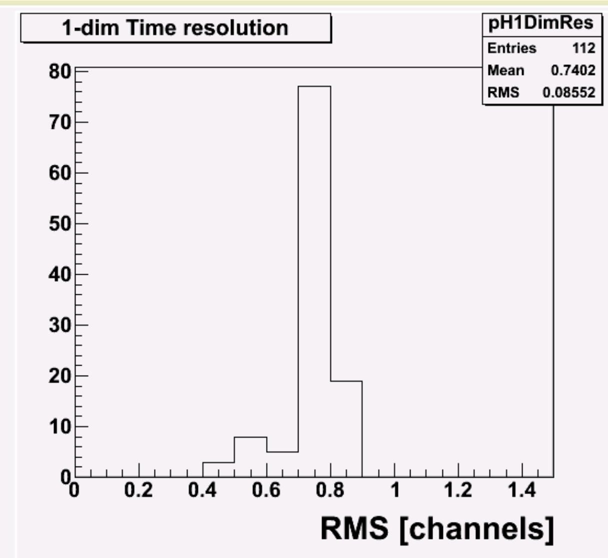
Pulser test signal sent to 8 channels.

✓ Individual INL corrections for each channel

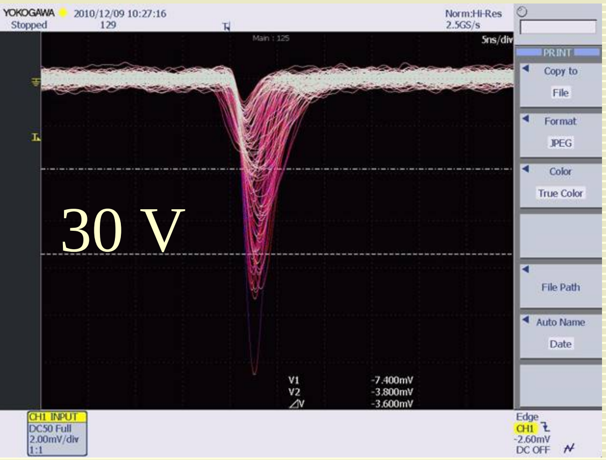
→ **All 32 channels show RMS below 25ps/1.4 = 17.8 ps**

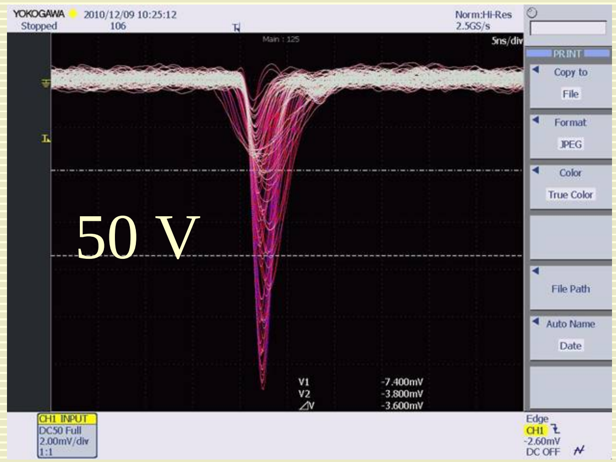


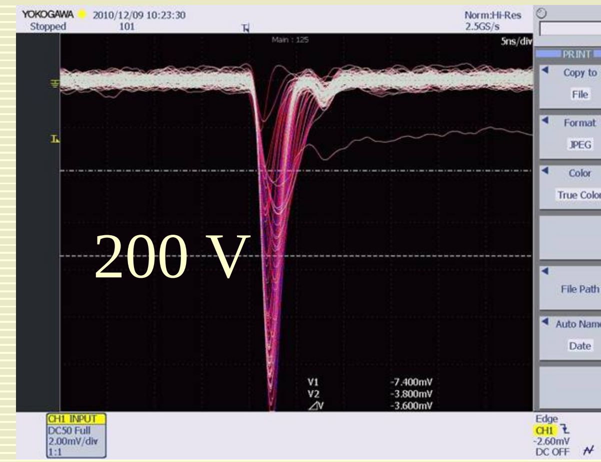


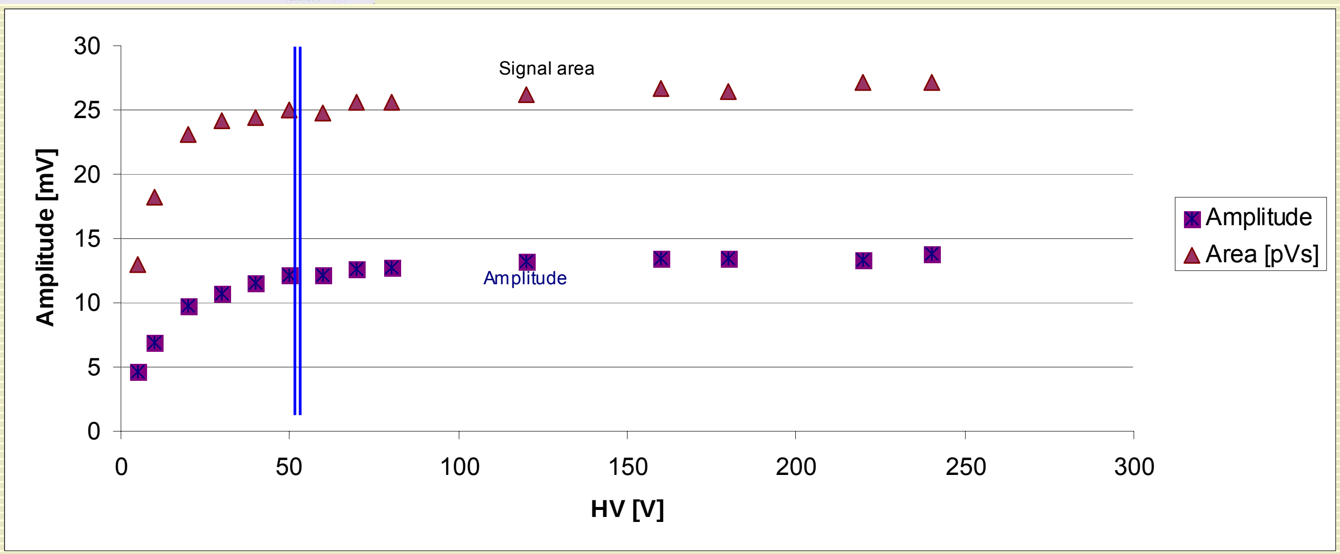


Start-Veto system – test with Au beam, working point determination with Alpha source





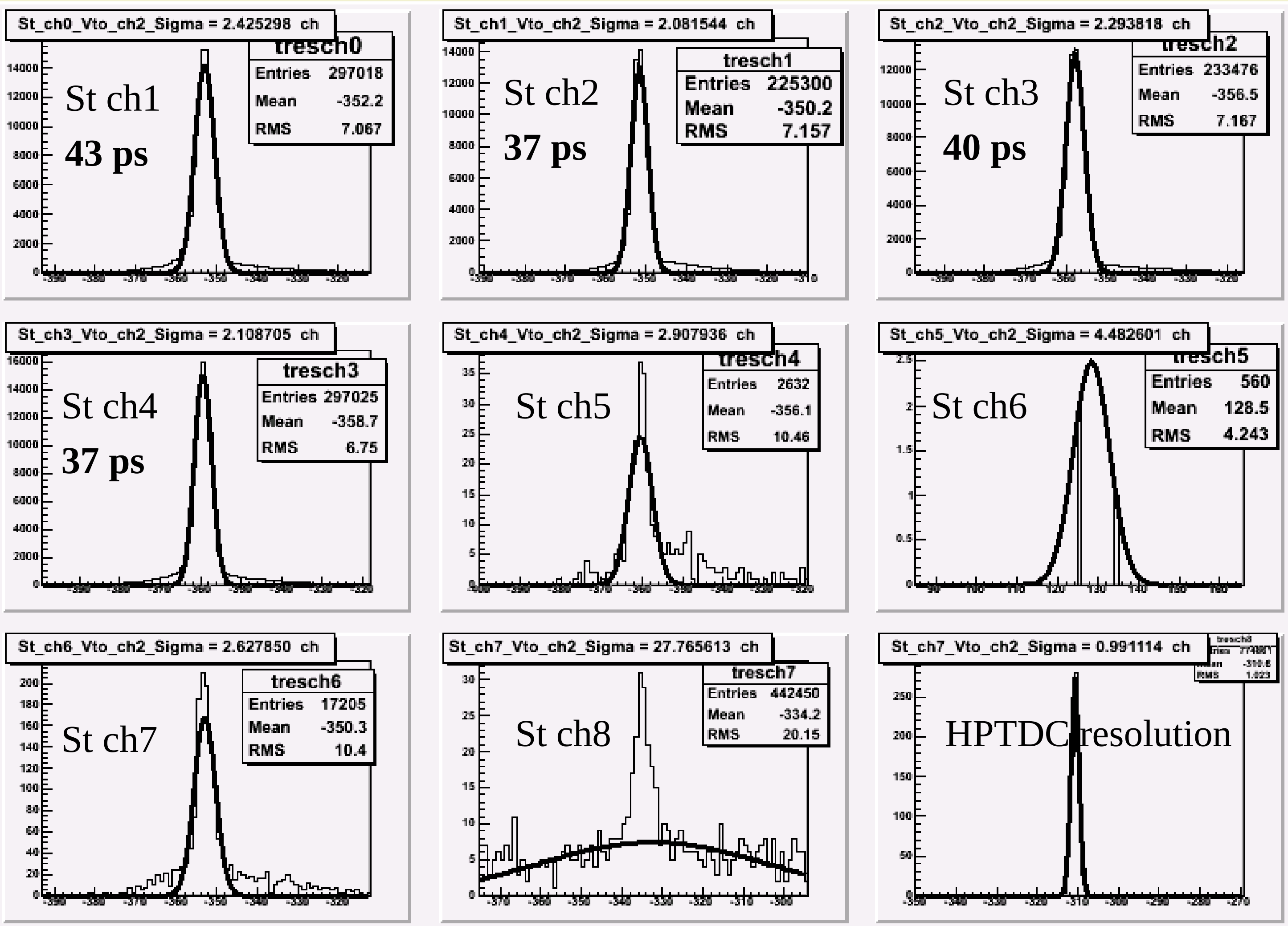


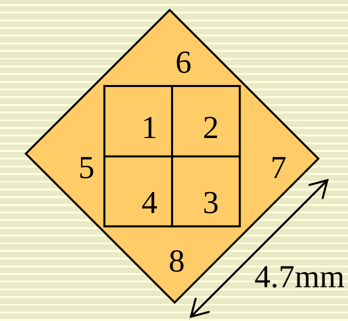


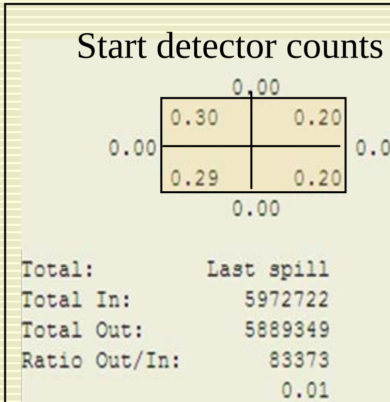
Start-Veto system – test with Au beam, time res.

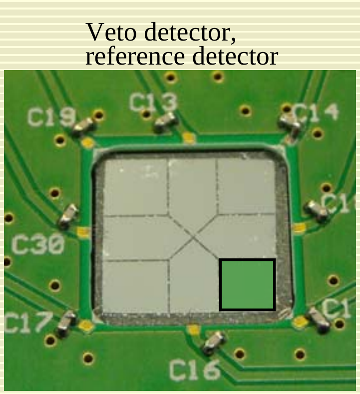
Setup and conditions:

- ✓ 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.









Start-Veto system – test with Au beam, problems !!

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.

Long term stability problem - raising current

- ✓ Effect clearly visible after 2-3 hours of continues Au beam with intensity 10^6/s
- ✓ Visible for Start and Veto (mono and poli-crystalline material)

Time	Start current in spill	Start current off spill	Veto current in spill	Veto current off spill
10:00	2.5 μA	0.00 μA	2.6 μA	0.00 μA
11:39	2.5 μA	0.09 μA	2.6 μA	0.04 μA
12:01	1.4 μA	0.88 μA	1.8 μA	0.20 μA
12:41	2.2 μA	0.88 μA	2.4 μA	0.40 μA
. . .				

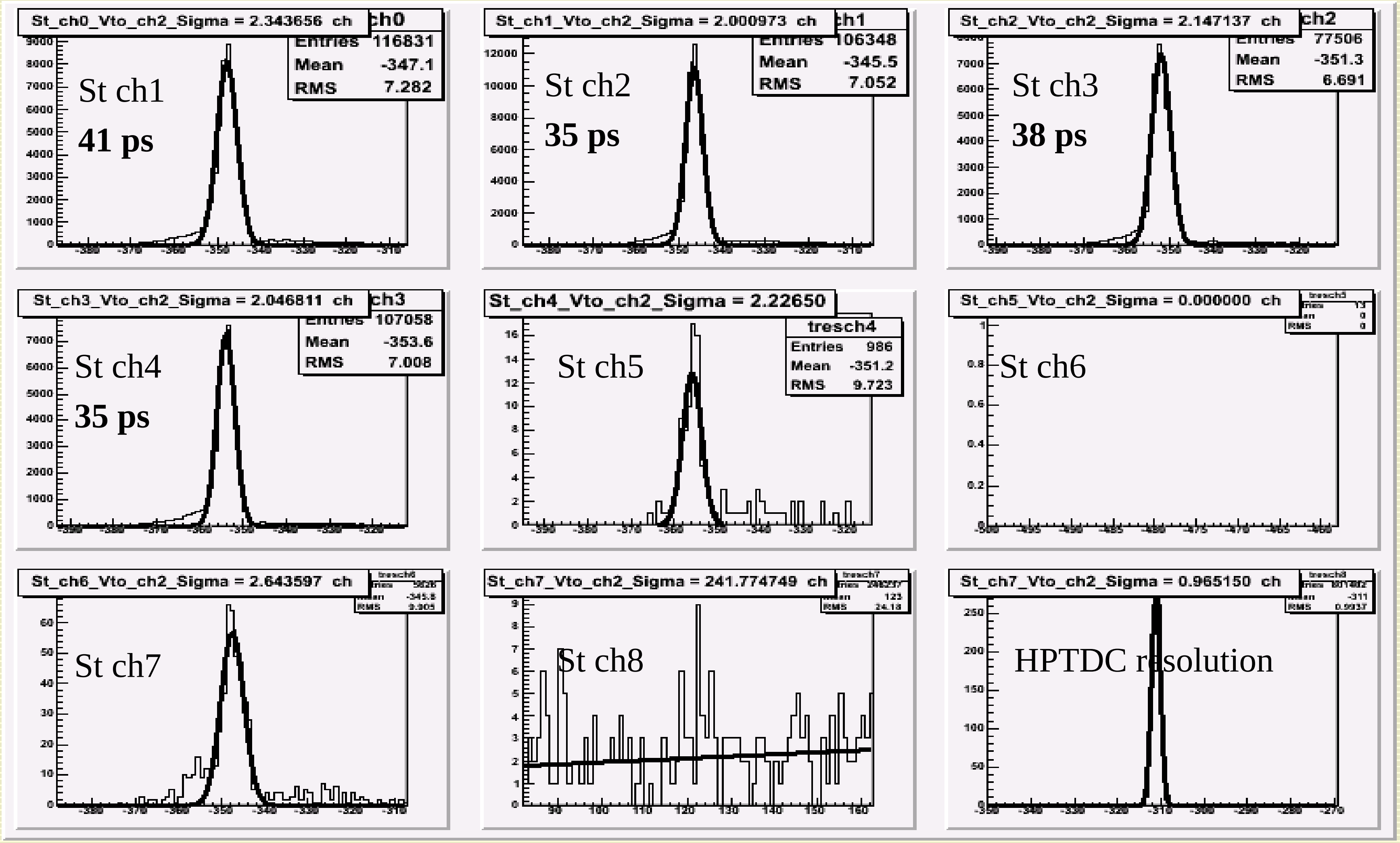
→ strong dependence on the HV observed: example: 200 V – 0.25 μA

150 V – 0.08 μA

4-5 weeks of Au+Au production run in HADES !!!!

Will diamond be operational ?

Start-Veto system – test with Au beam, time resolution at 1V/ μm (HV = 50 V)



HV reduced by a factor of 4 (200 V → 50 V) - the time resolution below 50 ps

→ expected stable long term operation during high intensity HI run !

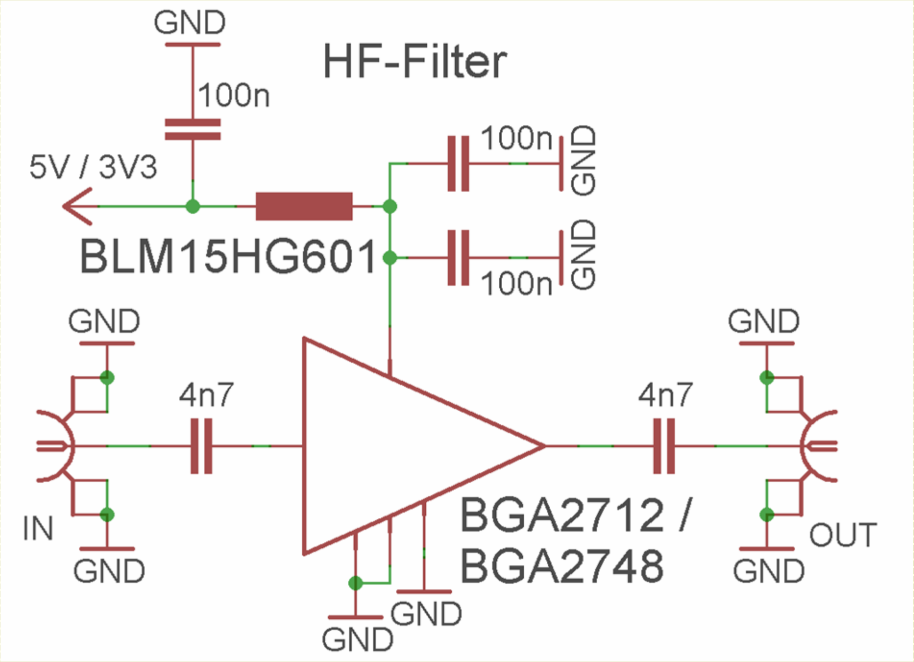
HADES Start-Veto system – summary

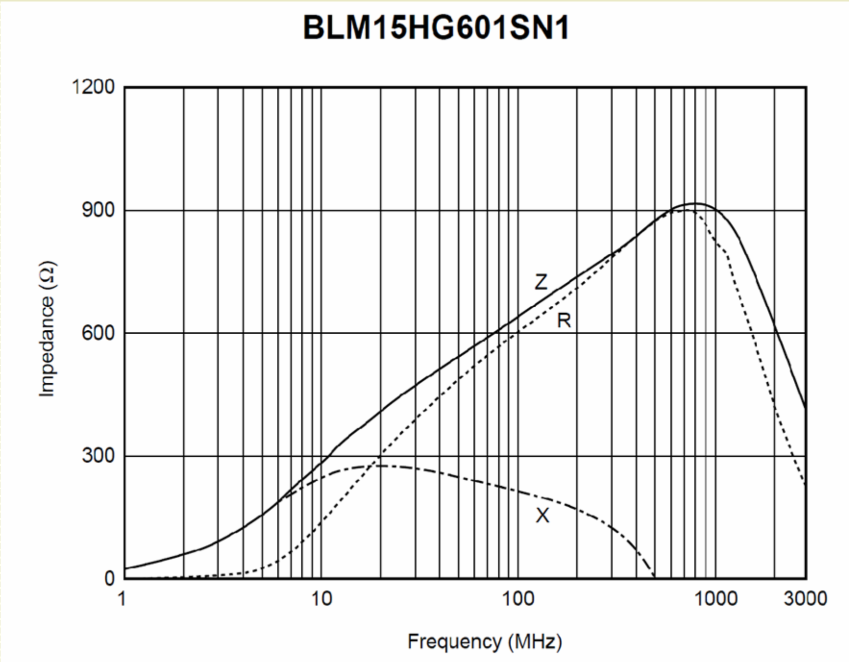
- ✓ Monocrystalline diamond detector available for high intensity Au + Au run
- ✓ Spare detector has to be prepared.
- ✓ Time resolution below 50 ps and can be further improved
- ✓ Fast, stable analog electronics tested
- ✓ 32 channel TRB board (based on HPTDC) with intrinsic time res. below 17 ps available

HADES Start-Veto system – outlook

Next steps in electronics improvement (W. Koenig) –

improvement in HF filtering → reduce oscillations





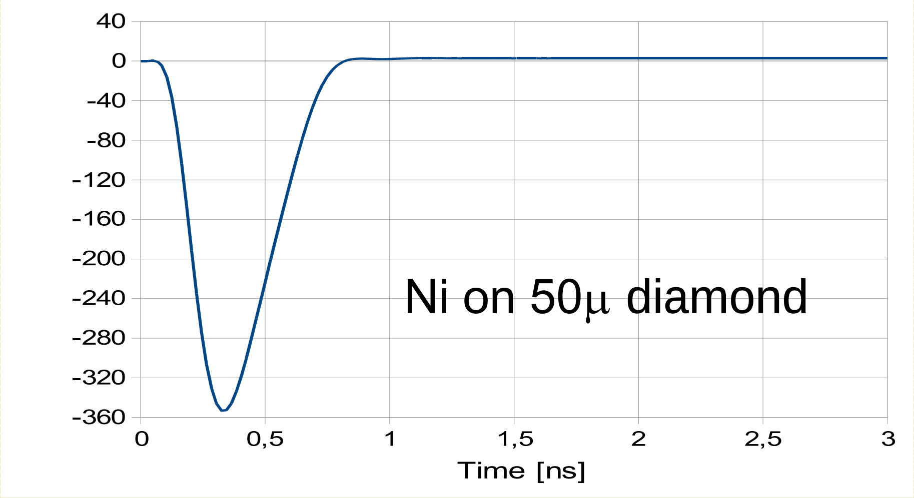
HADES Start-Veto system – outlook

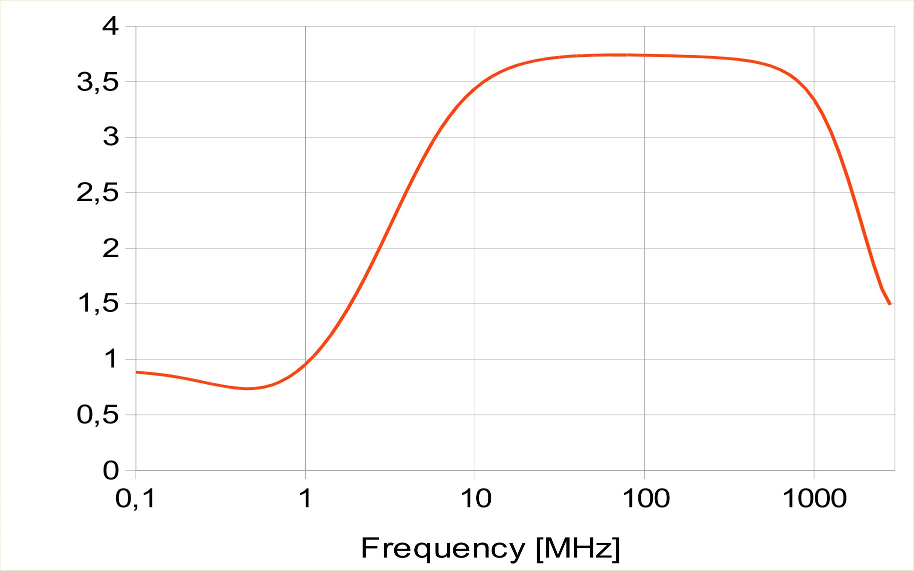
Next steps in electronics improvement (W. Koenig) – State of the art transistor

- Monocrystalline Diamond
- 50 μ thickness, 1pF segments
- Ni beam

- Transistor: SiGe:C
- BFR720 Infineon
- Noise Figure: 0.5 dB@1.8GHz

•Rise time(10%-90%):	150ps
•Base Width:	< 0.8ns
•Integrated noise:	0.15mV rms
•Signal/Noise (Ni):	2280
•Signal/Noise(p):	2.9 (50μ)
•Voltage Gain:	11





Acknowledgements

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Thank you