

# Beam detectors for HADES

Jerzy Pietraszko<sup>a</sup>, W. Koenig<sup>b</sup>, M. Weber<sup>c</sup>

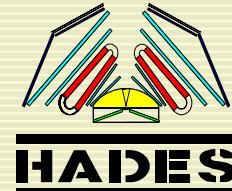
for the HADES Collaboration

<sup>a</sup> Institut für Kernphysik, Goethe-Universität, Max von Laue Strasse 1, D-60438 Frankfurt, Germany

<sup>b</sup> GSI Helmholtz Centre for Heavy Ion Research GmbH Planckstrasse 1, D-64291 Darmstadt, GERMANY

<sup>c</sup> Physik Department E12, Technische Universität München James Franck Str. D-85748 Garching, Germany.

# 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

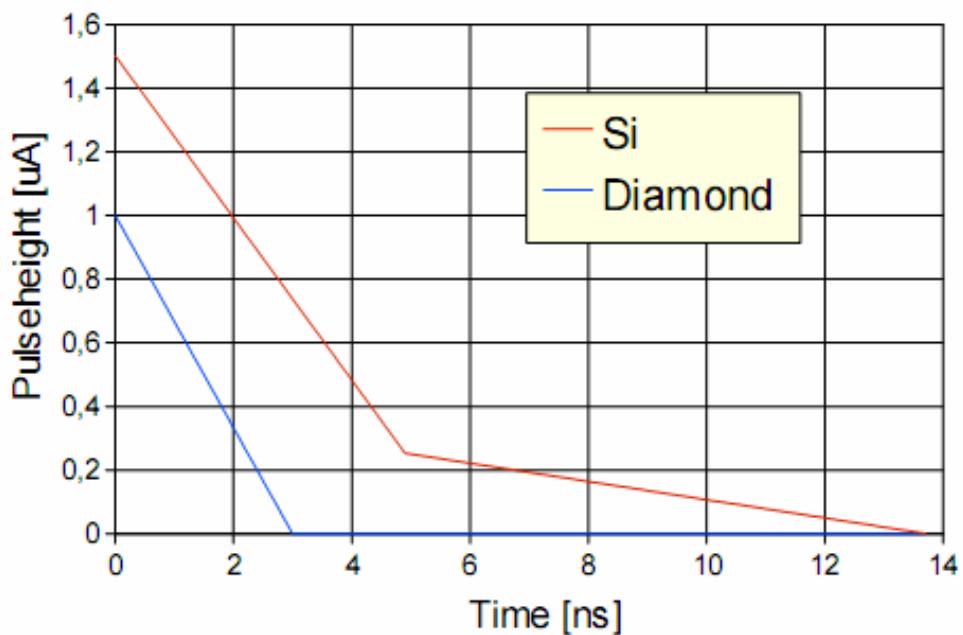
- Reported during previous CARAT 2009 by W. Koenig,

(NIMA 618 (2010) 121-123)

# Start-Veto system for HADES – diamond based

Diamond is radiation hard

	Diamond	Si detector
$L_{\text{rad}}$	12 cm	9.4 cm
$\epsilon$	5.7	11.9
$E_{\text{eh}}$	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 ( $\epsilon$ ) and longer radiation length  $L_{\text{rad}}$

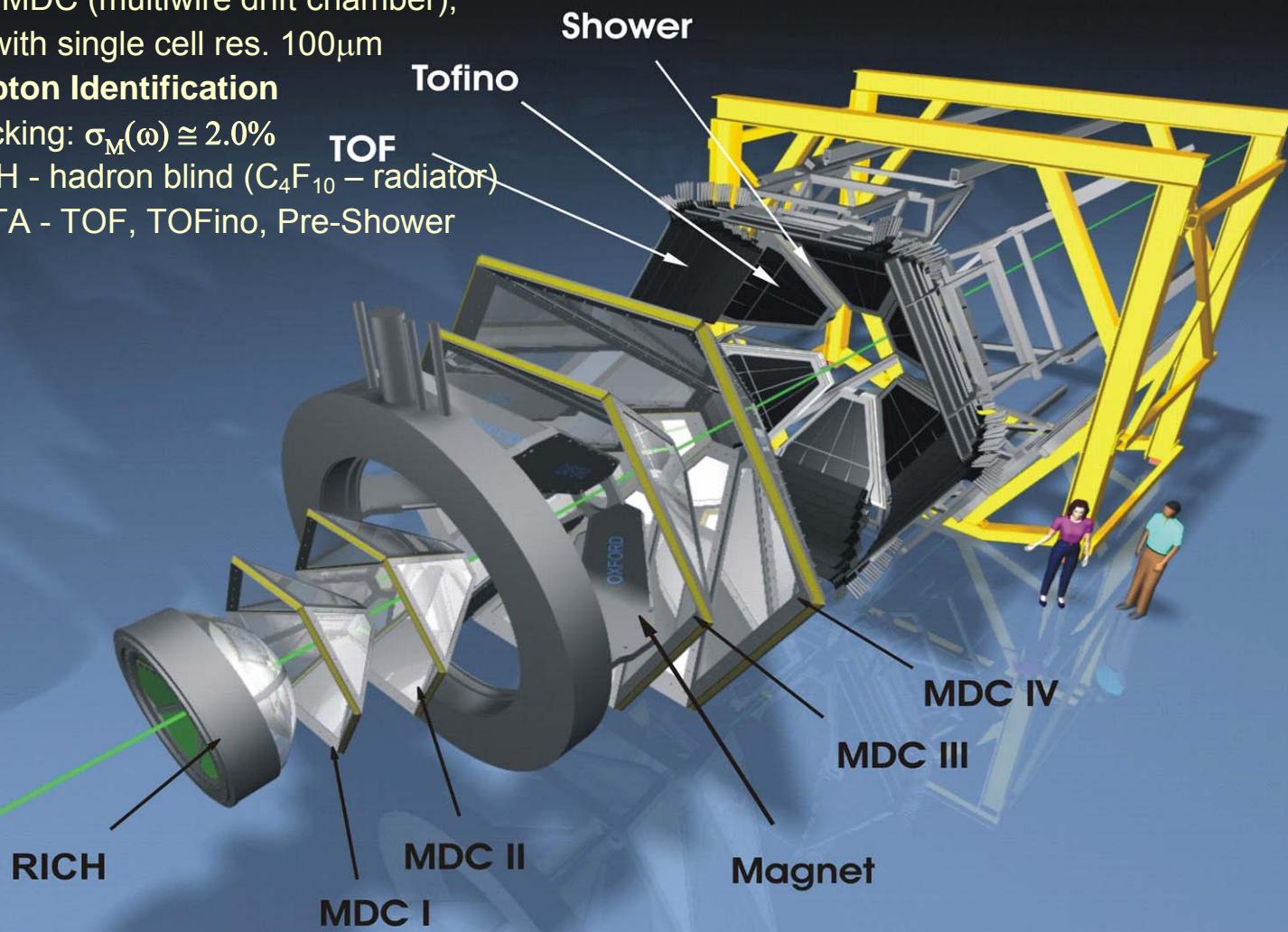
**Problem:** 8000 e-h pairs for a 300 μm diamond is small

# HADES Start-Veto system for Au+Au experiment

- ✓ Acceptance:  $2\pi$  in  $\varphi$ ;  $18^\circ < \theta < 85^\circ$
- ✓ Pair acceptance  $\approx 35\%$
- ✓ low-mass MDC (multiwire drift chamber),  
with single cell res.  $100\mu\text{m}$

## PID and Lepton Identification

- ✓ Tracking:  $\sigma_M(\omega) \cong 2.0\%$
- ✓ RICH - hadron blind ( $\text{C}_4\text{F}_{10}$  – radiator)
- ✓ META - TOF, TOFino, Pre-Shower



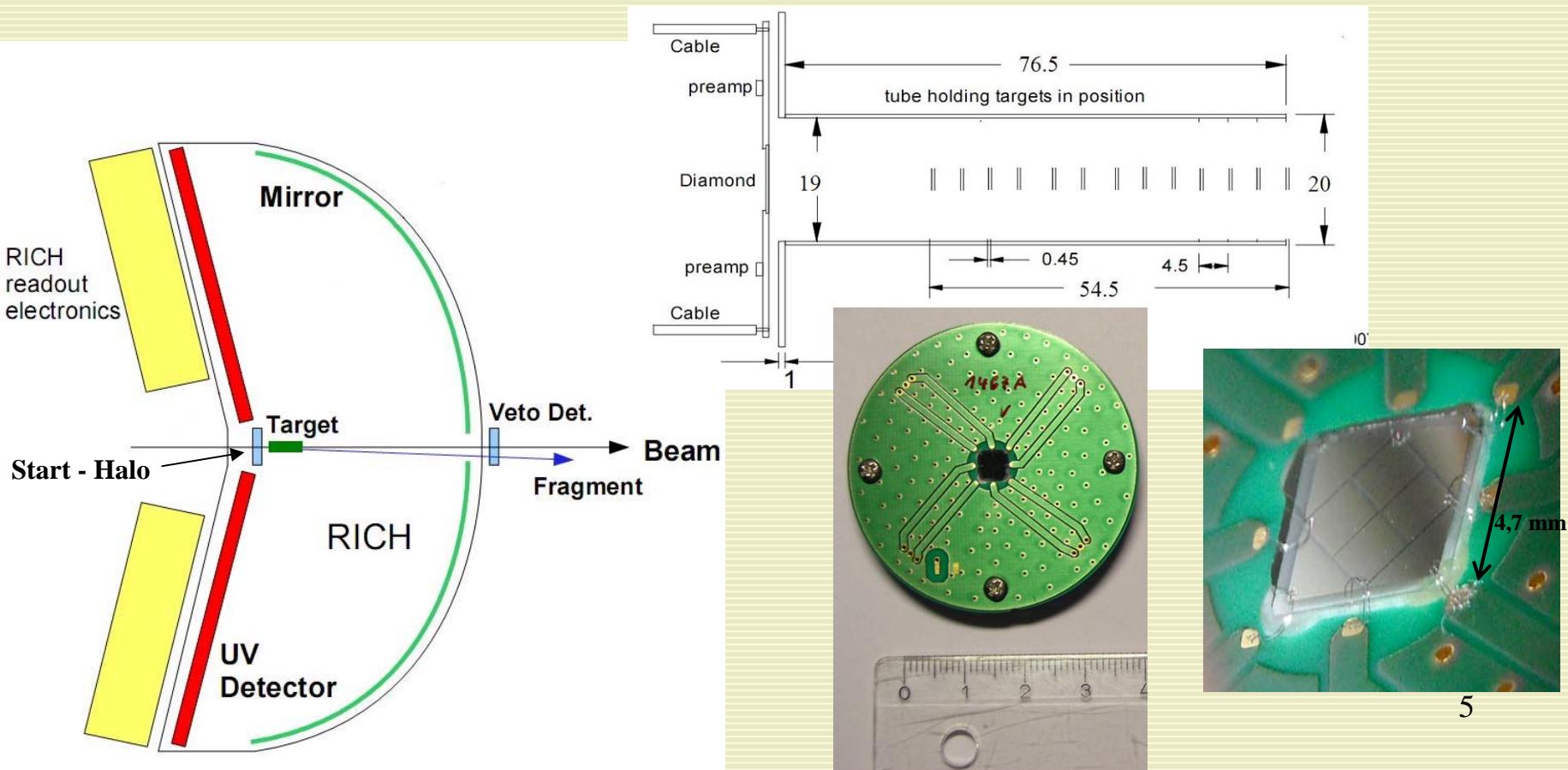
# HADES Start-Veto system for Au+Au experiment

## 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:

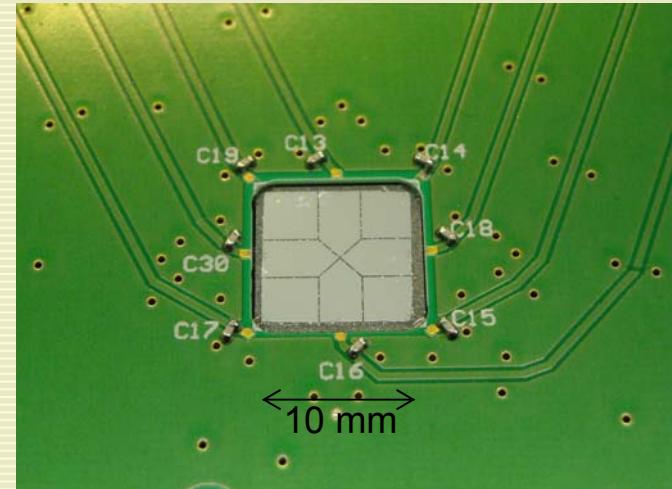
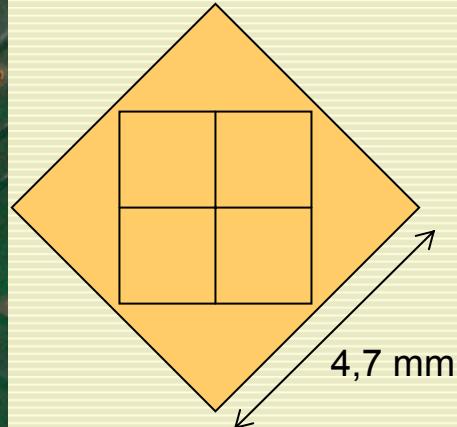
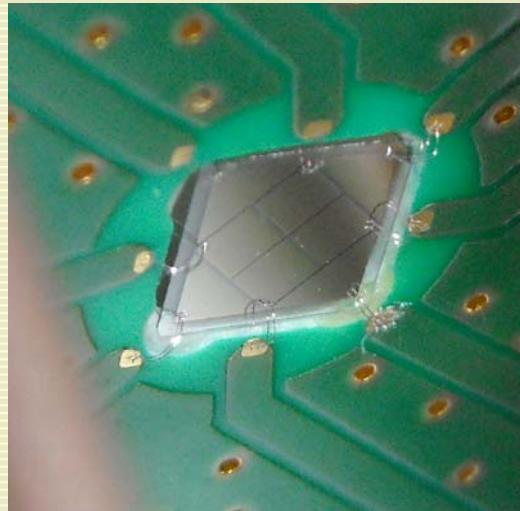
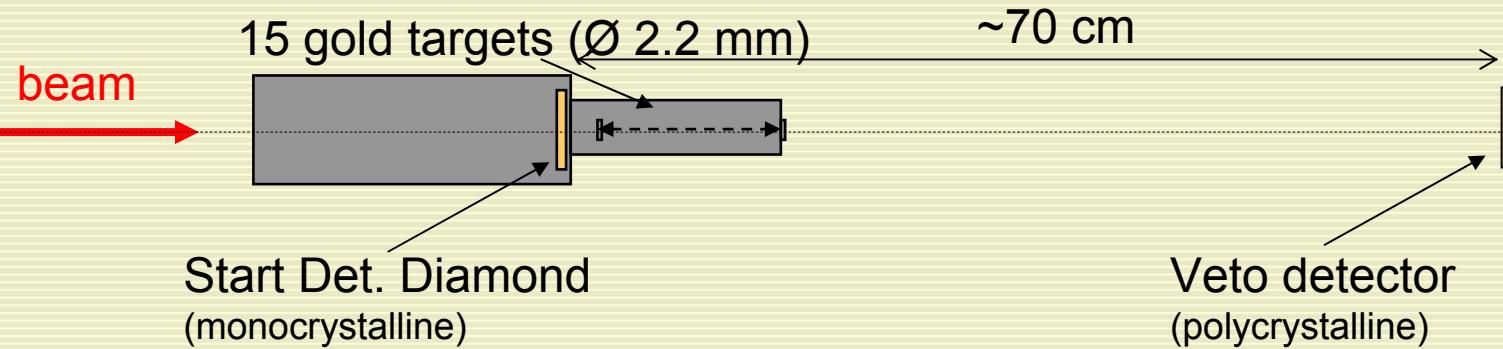
- ✓ Start det.: monocrystalline diamond, 50 µm thickness, 4.7mm x 4.7mm, with halo functionality
- ✓ Veto det.: polycrystalline diamond, 100 µm thickness, behind the RICH Detector.



# 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)

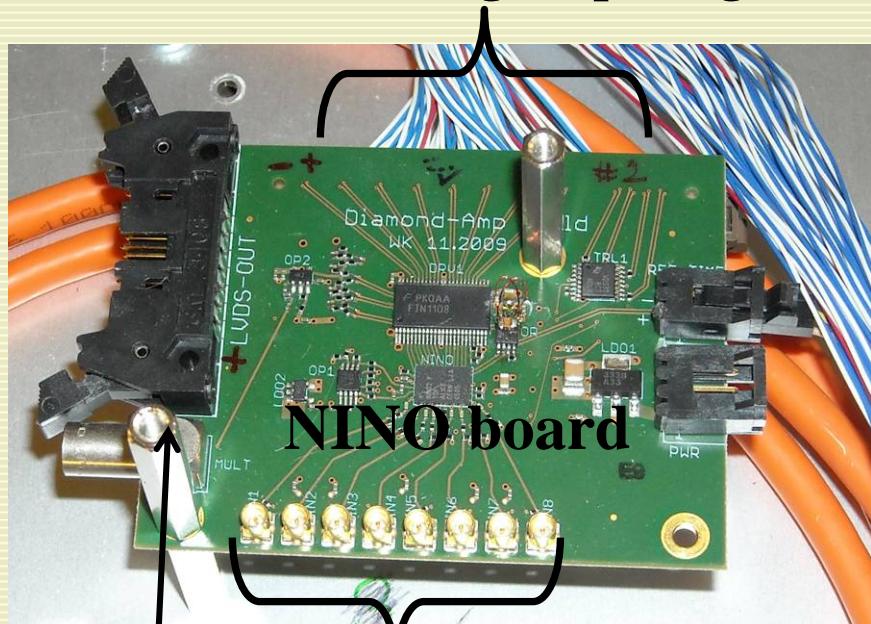
## Issues:

- ✓ 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

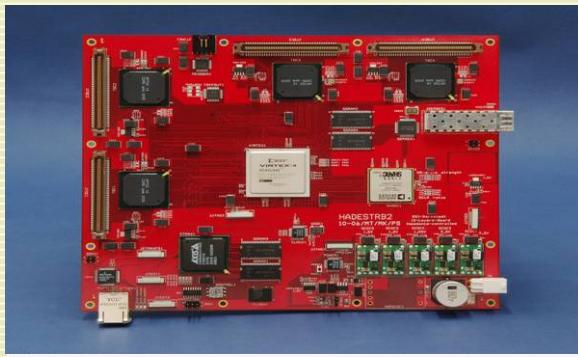
8 x scaler/trigger output signals

**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.

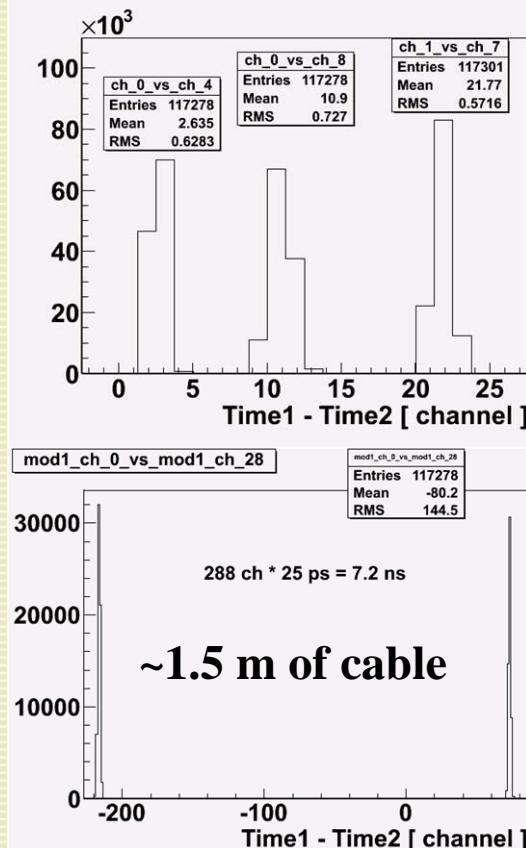
# The Multipurpose Trigger Readout Board TRB



## TRB Board:

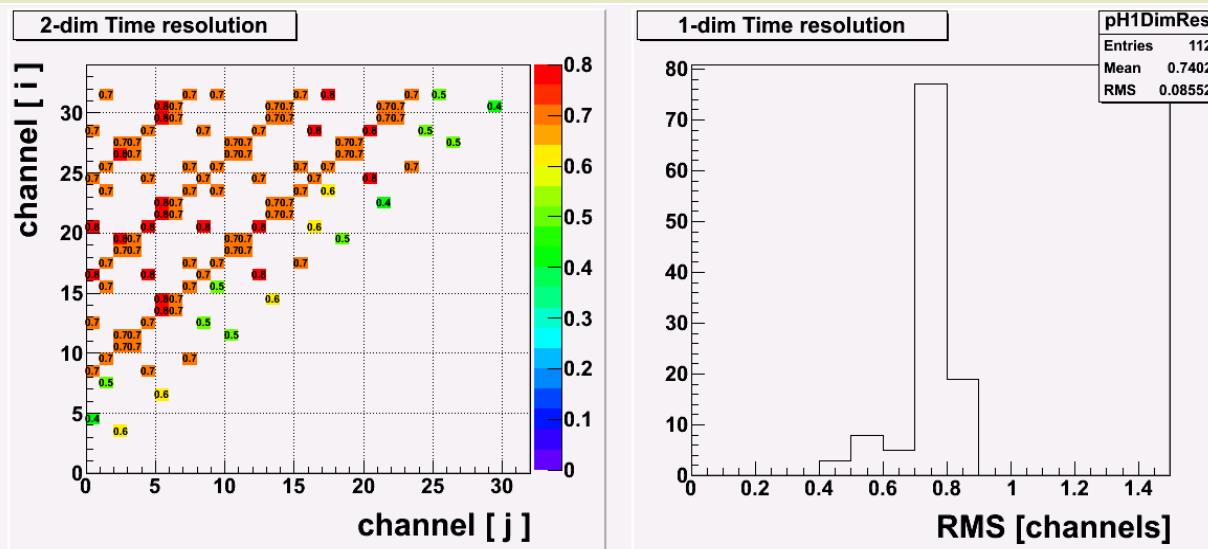
4 TDC – 128 channels (HPTDC), 4x512Mb SDRAM, FPGA – Virtex4LX40, ETRAX, FS – 4 processors, 100Mb/s,TCP/IP, 2.5 Gb/s optical link, DSP TigerSharc, DC/DC converters, AddOn connector

- Time, ToT, 96ps/bin - 128 channels
- Time, ToT, 25ps/bin - 32 channels
- Rate capability: up to 3 MHz per channel

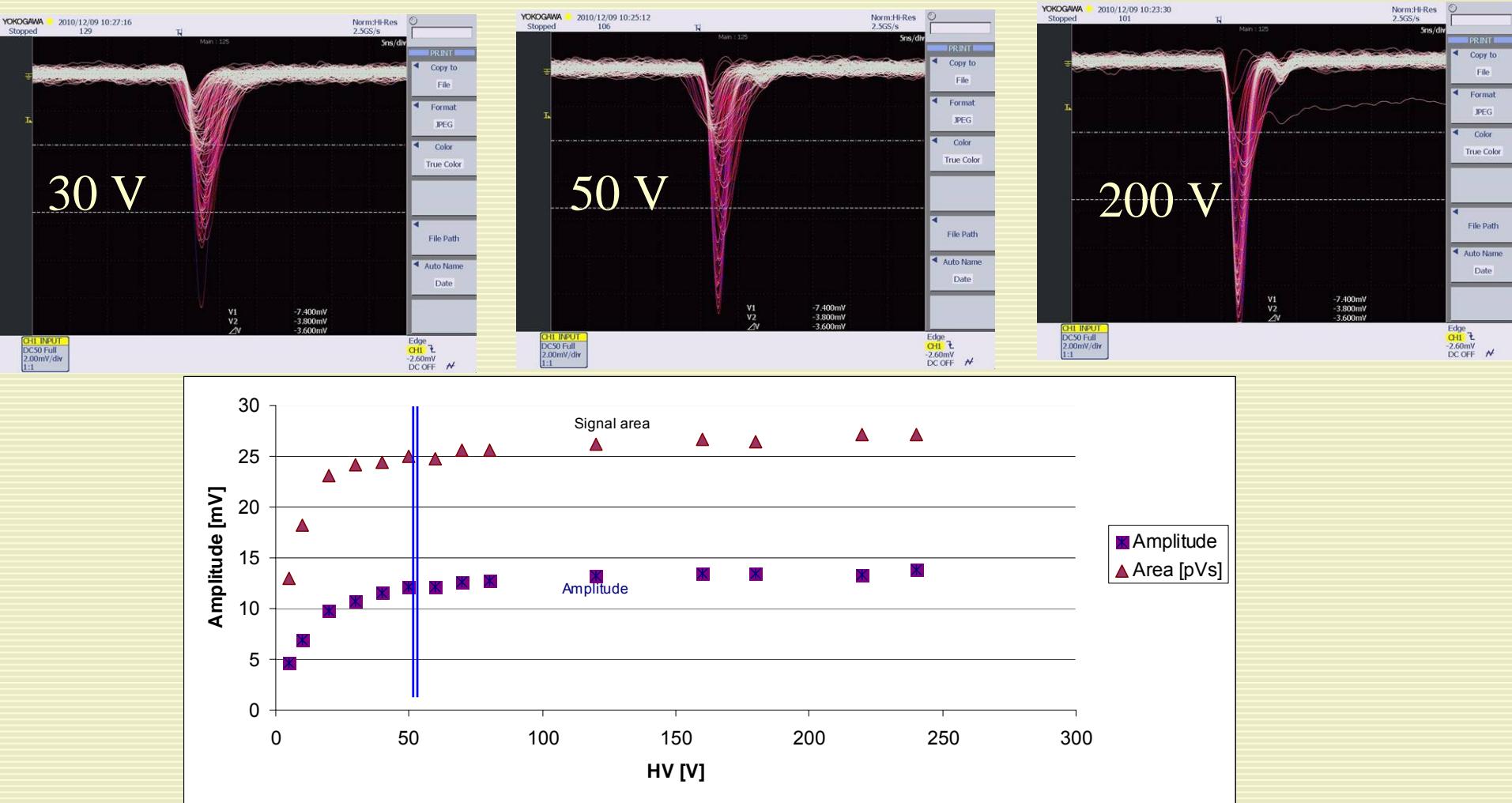


## Pulser test signal sent to 8 channels.

- ✓ Individual INL corrections for each channel
- All 32 channels show RMS below  $25\text{ps}/1.4 = 17.8 \text{ ps}$



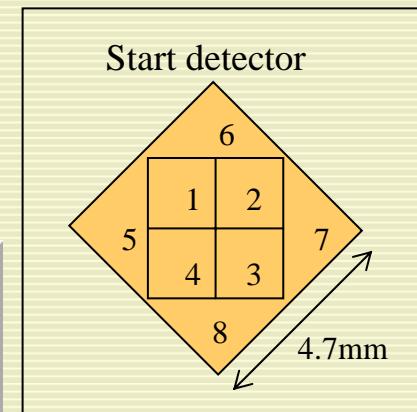
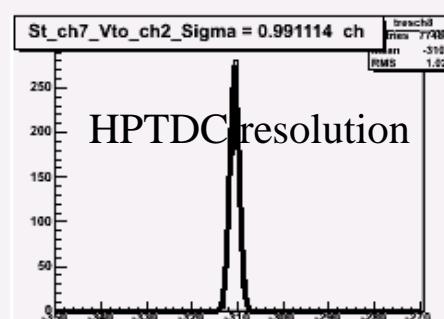
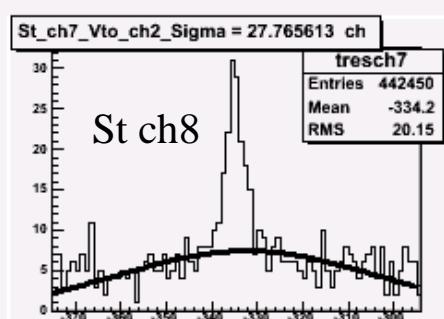
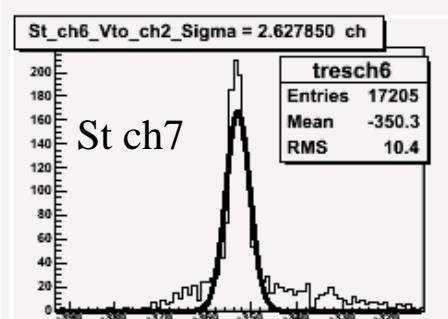
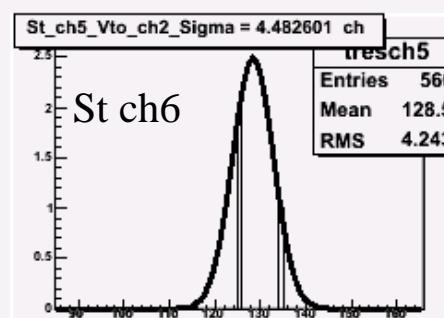
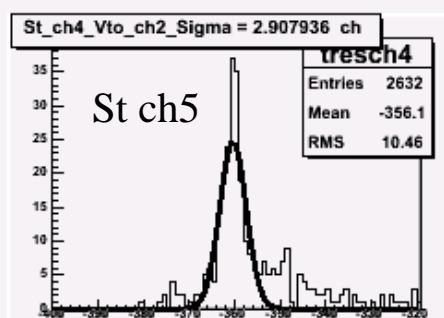
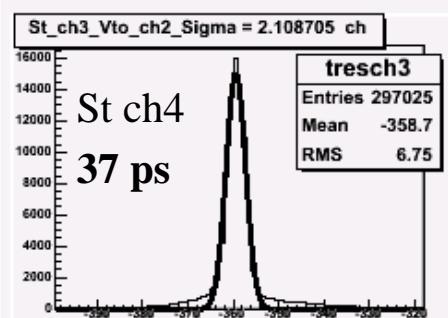
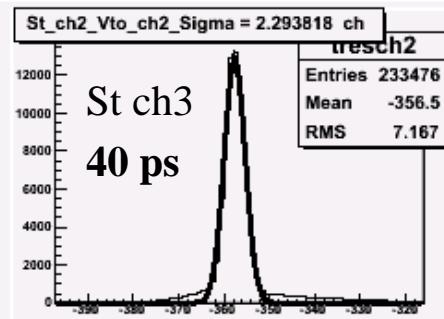
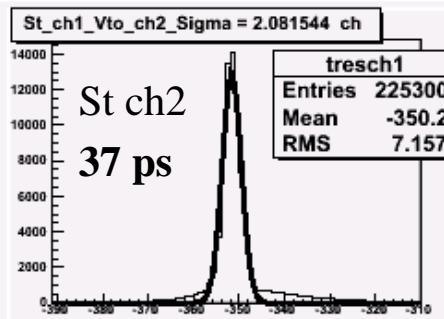
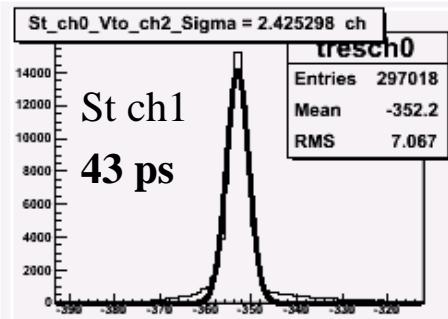
# Start-Veto system – test with Au beam, working point determination with Alpha source



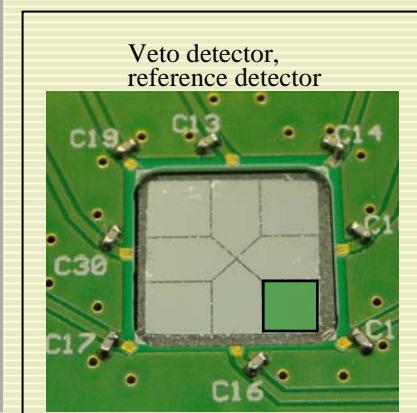
# Start-Veto system – test with Au beam, time res.

## 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 detector counts			
0.00	0.30	0.20	0.01
0.00	0.29	0.20	0.00
Total:	Last spill		
Total In:	5972722		
Total Out:	5889349		
Ratio Out/In:	0.83373		
	0.01		



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

## Setup and conditions:

- ✓ Start det.: monocrystalline diamond, 50  $\mu\text{m}$  thickness, **HV set to 200 V.**
- ✓ Veto det.: polycrystalline diamond, 100  $\mu\text{m}$  thickness, **HV set to 200 V.**
- ✓ Beam particles intensity:  $10^6/\text{s}$  per channel.

## Long term stability problem - raising current

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

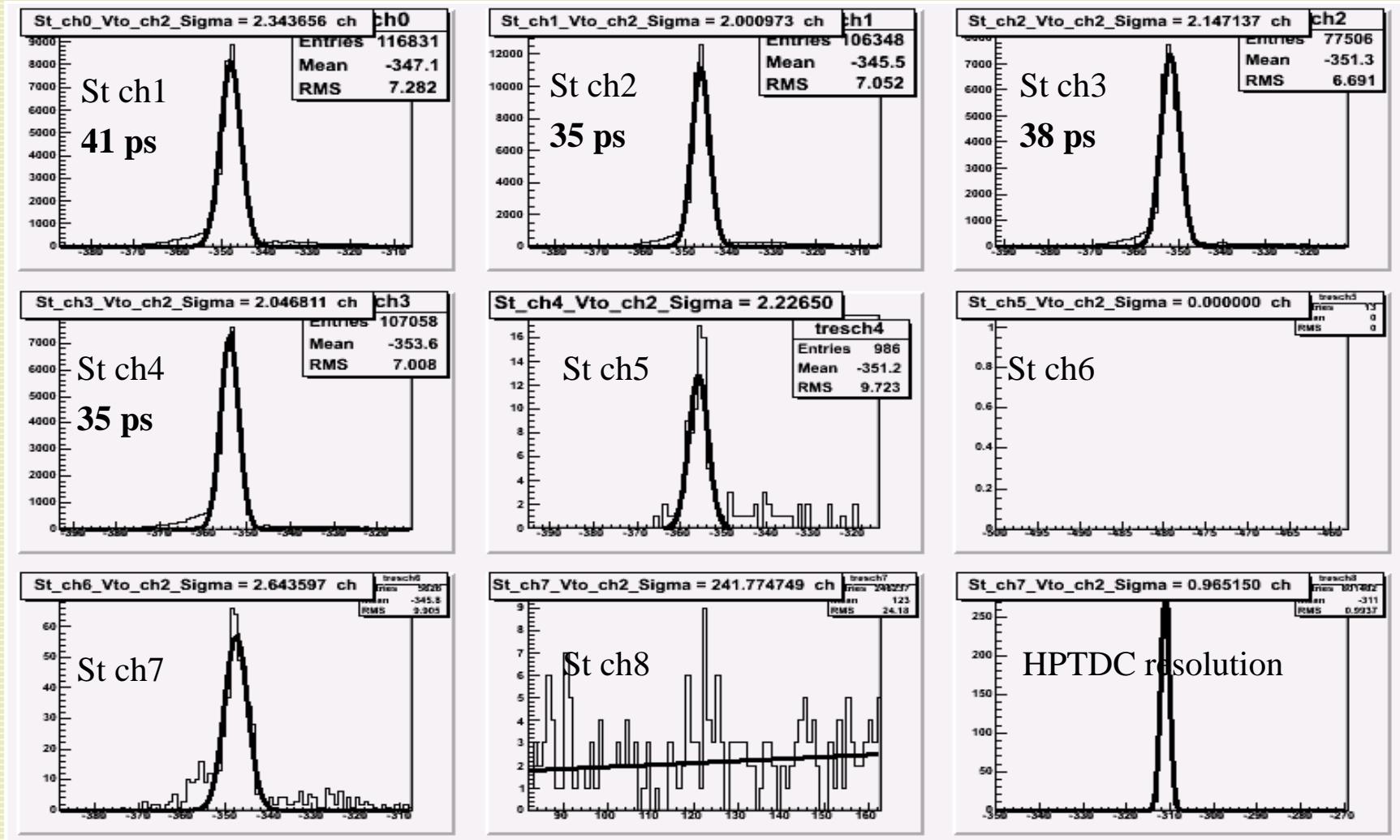
Time	Start current in spill	Start current off spill	Veto current in spill	Veto current off spill
10:00	2.5 $\mu\text{A}$	0.00 $\mu\text{A}$	2.6 $\mu\text{A}$	0.00 $\mu\text{A}$
11:39	2.5 $\mu\text{A}$	0.09 $\mu\text{A}$	2.6 $\mu\text{A}$	0.04 $\mu\text{A}$
12:01	1.4 $\mu\text{A}$	0.88 $\mu\text{A}$	1.8 $\mu\text{A}$	0.20 $\mu\text{A}$
12:41	2.2 $\mu\text{A}$	0.88 $\mu\text{A}$	2.4 $\mu\text{A}$	0.40 $\mu\text{A}$
...				

→ strong dependence on the HV observed: example: 200 V – 0.25  $\mu\text{A}$   
150 V – 0.08  $\mu\text{A}$

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/ $\mu$ m (HV = 50 V)



HV reduced by a factor of 4 (200 V  $\rightarrow$  50 V) - the time resolution below 50 ps<sub>12</sub>  
 → expected stable long term operation during high intensity HI run !

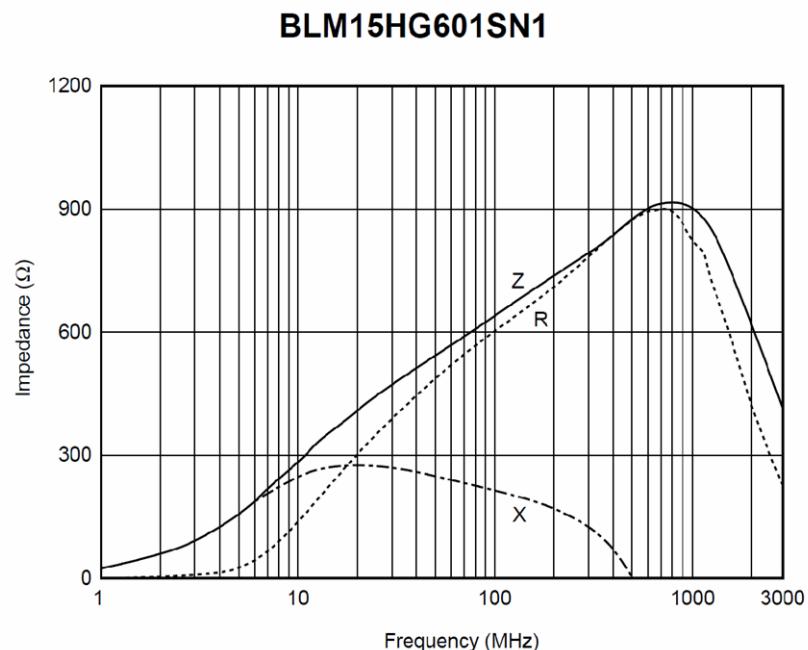
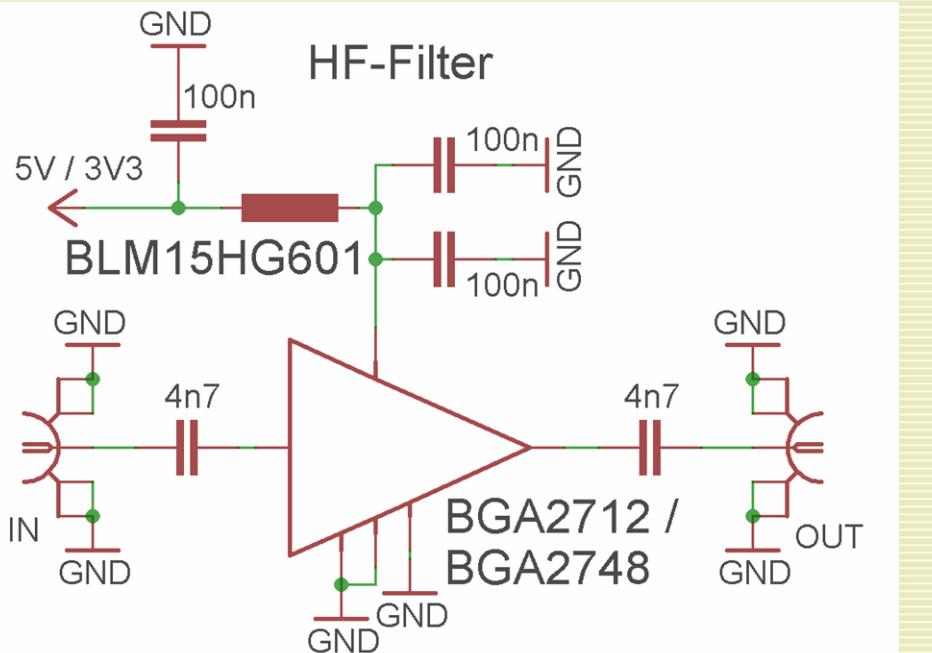
# HADES Start-Veto system – summary

- ✓ 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) –

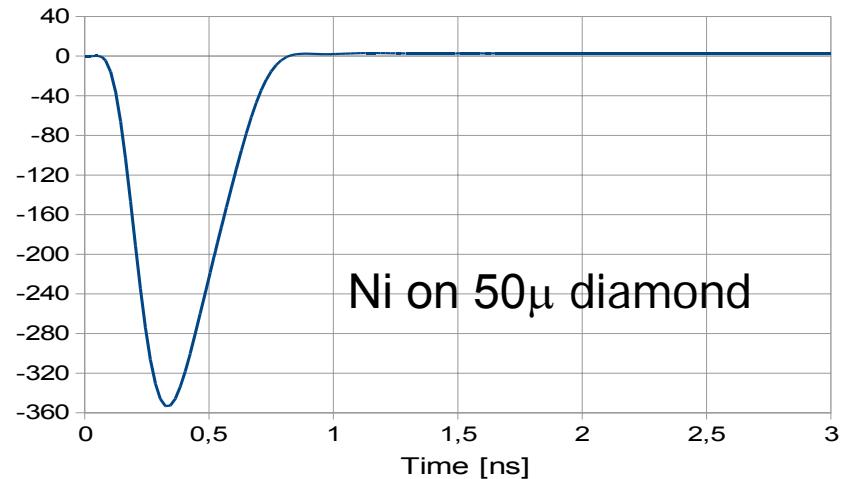
improvement in HF filtering → reduce oscillations



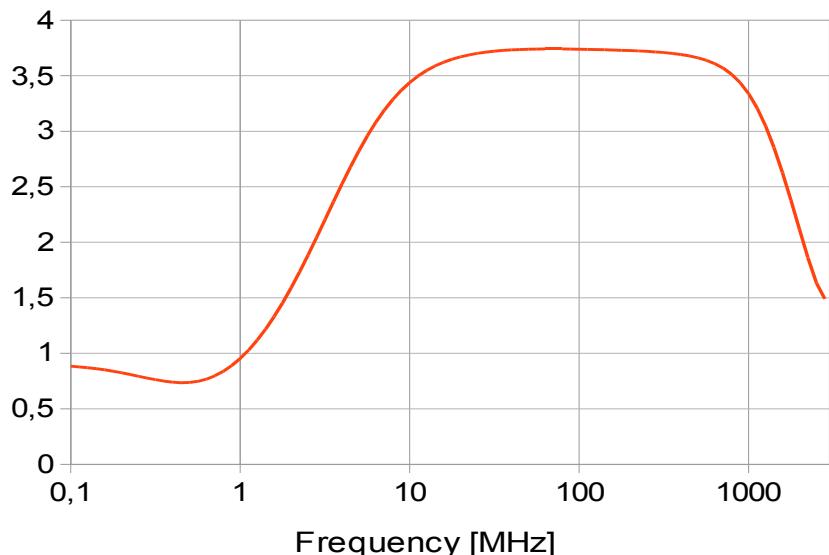
# HADES Start-Veto system – outlook

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

- Monocrystalline Diamond
- 50  $\mu$  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 (50 $\mu$ )
- Voltage Gain: 11



## Acknowledgements

For the preparation of the detectors, metallization and bonding of the diamonds we highly appreciate the support of E. Berdemann, M. Träger et al., GSI Detector Laboratory and A. Hübner et al., GSI Target Laboratory.

Thank you