# Компактный цифровой спектрометр возмущенных угловых гамма-гамма корреляций (ВУК)

## Compact digital time differential perturbed angular gamma-gamma correlation (TDPAC)-spectrometer

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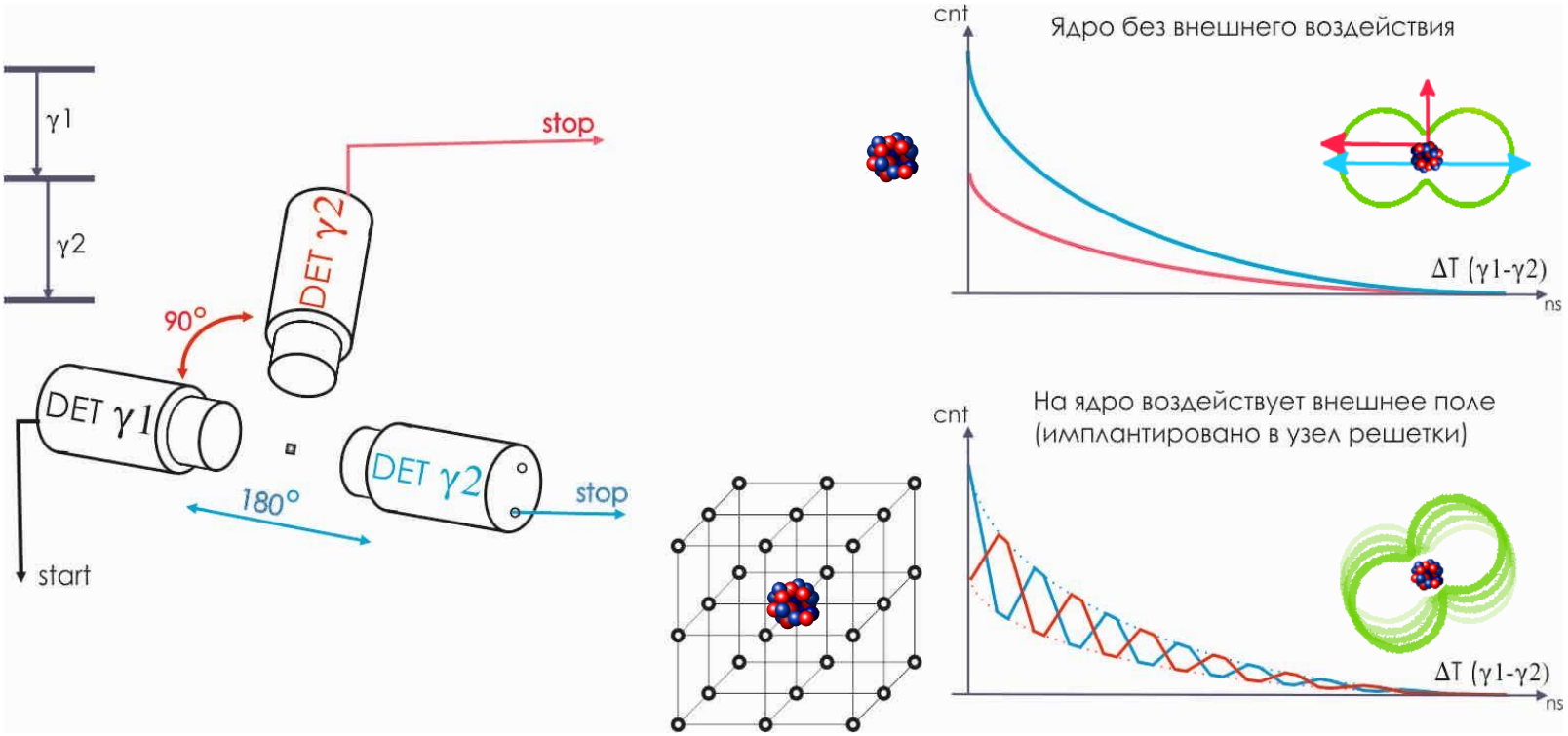
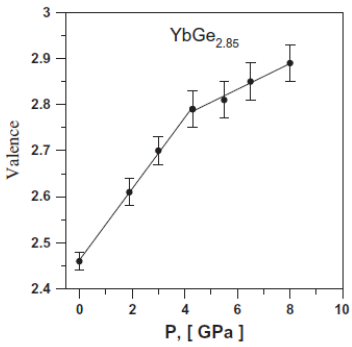
# Time differential perturbed angular gamma-gamma correlation (TDPAC) method

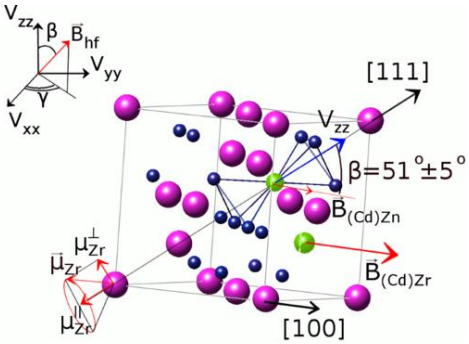


# The applications of TDPAC



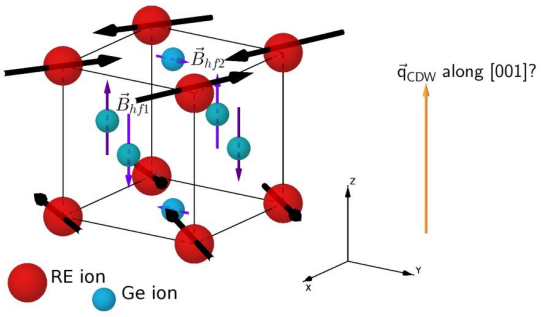

**$^{111}$Cd-TDPAC study of pressure effect on the valence of Yb in the $YbGe_{2.85}$ cubic phase**
*A.V. Tsvyashchenko et al. JALCOM (2013)*

doi: 10.1016/j.jallcom.2012.10.02




**Hyperfine field assessment of the magnetic structure of $ZrZn_2$**
*A.V. Tsvyashchenko et al. PRB (2015)*

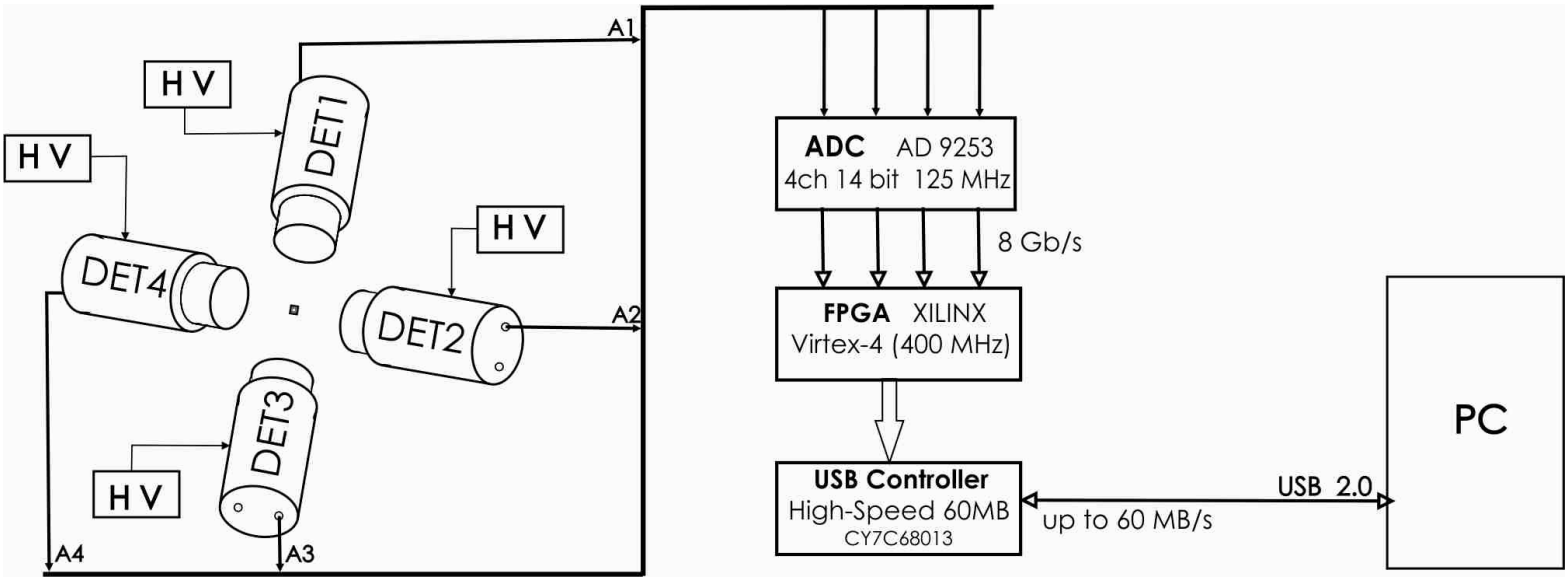
doi: 10.1103/PhysRevB.91.104423




**Incommensurate antiferromagnetism induced by a charge density wave in the cubic phase of $TbGe_{2.85}$**
*A.V. Tsvyashchenko et al. PRB (2015)*

doi: 10.1103/PhysRevB.92.104426

# The block-scheme of the setup

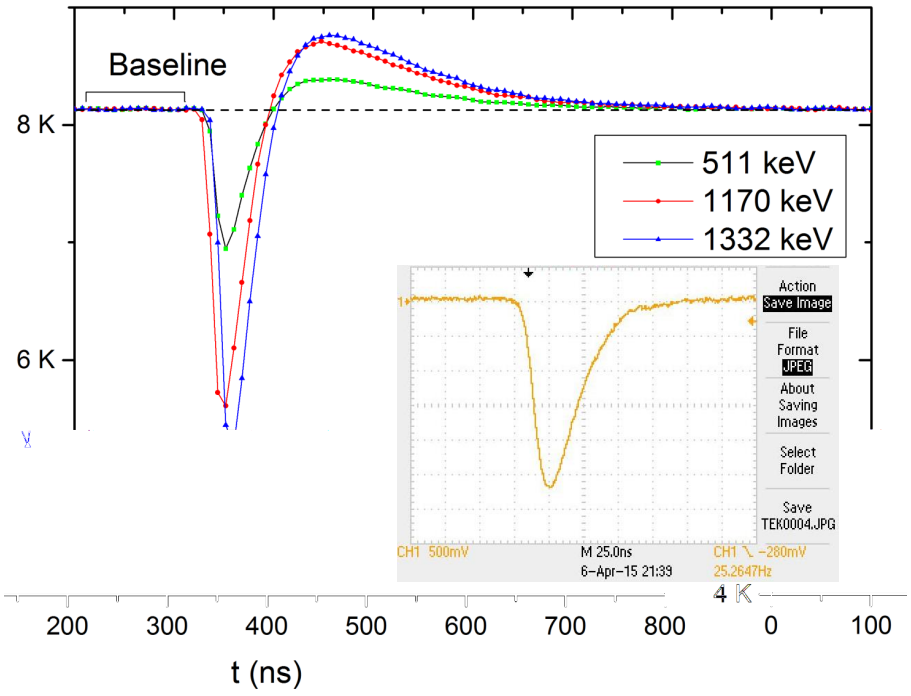


# $LaBr_3$ detectors

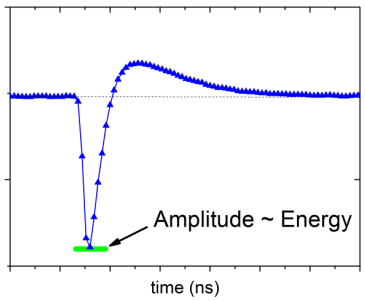
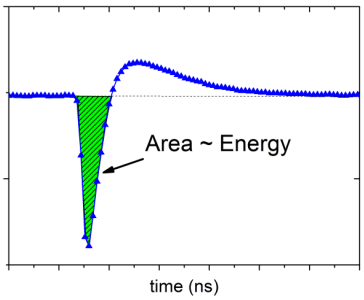
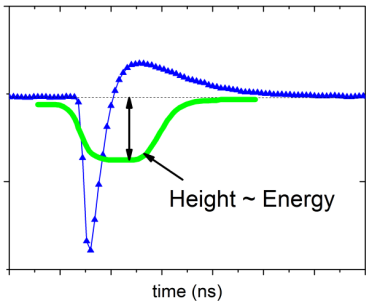
| | Energy resolution @ $^{137}Cs$ | Time resolution @ 511-511 keV, ps | Density, $g/cm^3$ | Light yield, photons/ keV | Decay time, ns |
|---|---|---|---|---|---|
| $LaBr_3$:Ce (BrilLanCe 380) | 3 % | 250 | 5.1 | 65 | 16 |
| $BaF_2$ | 10 % | 150 | 4.9 | 2/10 | 0.7/630 |
| NaI:Tl | 7 % | > 1000 | 3.7 | 39 | 250 |

**PMT:** Hamamatsu R6231-100, risetime = 8 ns

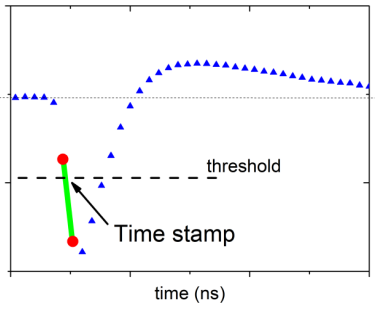
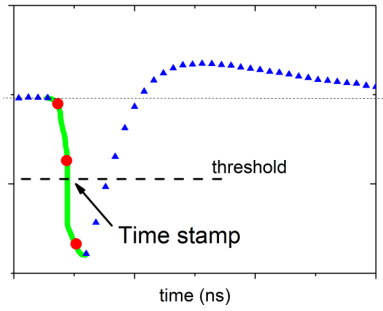
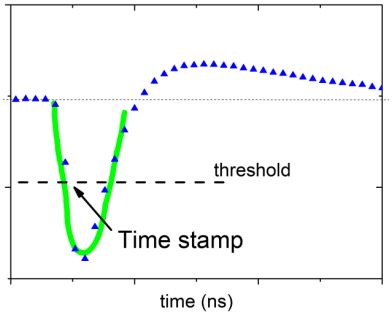
# The signals from the detector



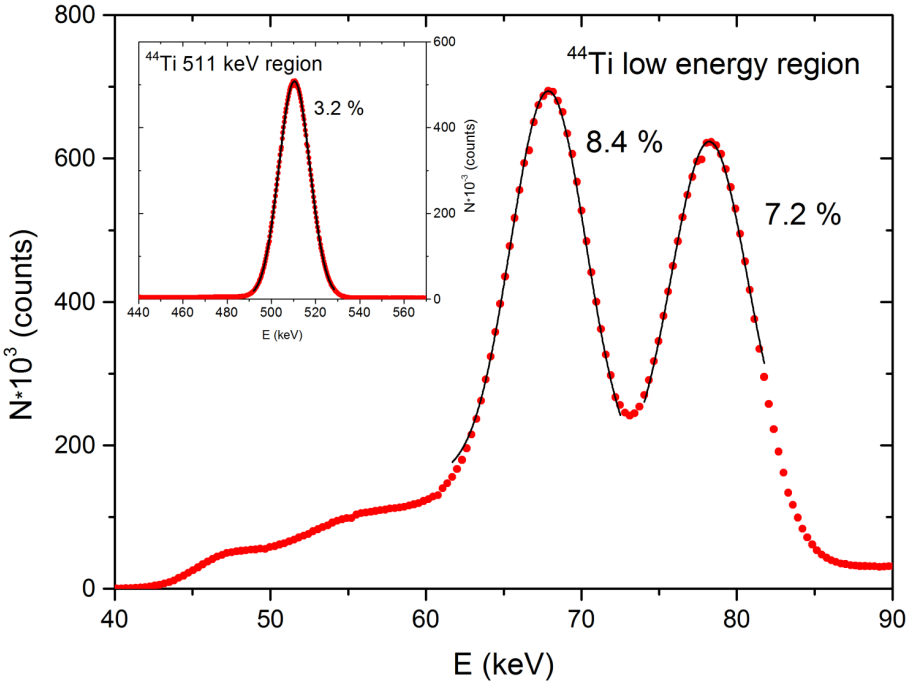
# Energy algorithms

| | Amplitude of the signal | Integration of the signal (QDC) | Trapezoidal pulse shaping filter |
|---|---|---|---|
| Average resolution at 511 keV | 8.0 % | 4.0 % | 3.2 % |
| Algorithm implementation |  |  |  |

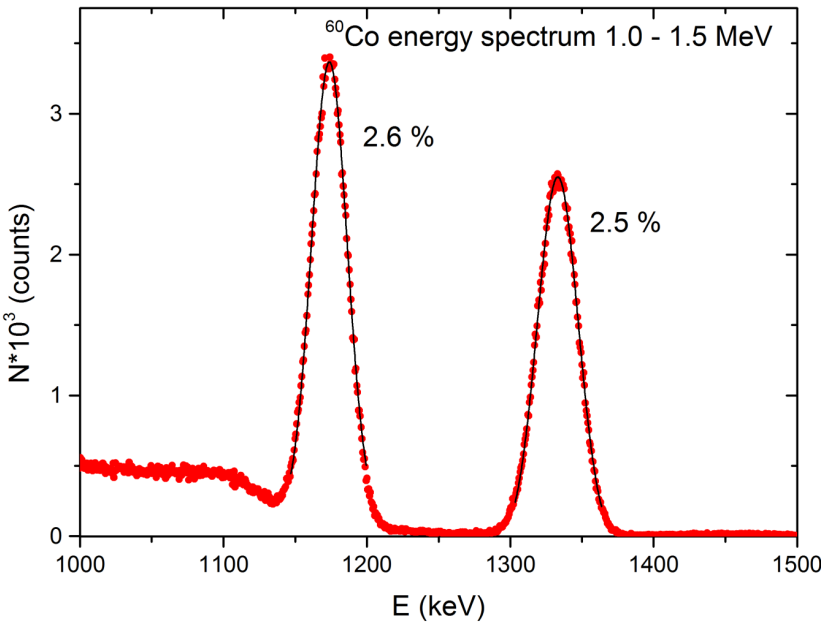
# Time algorithms

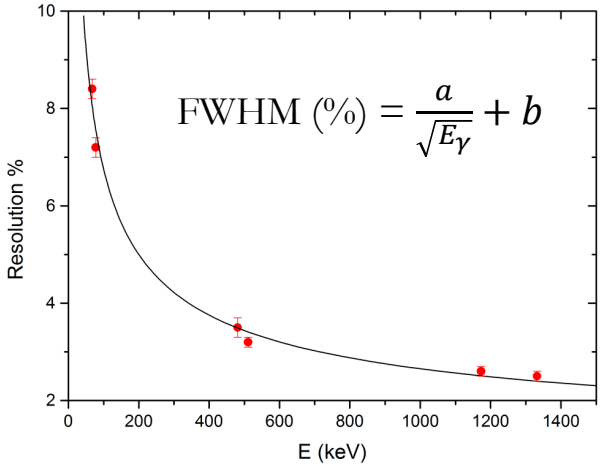
| | Digital CFD line interpolation | Digital CFD cubic interpolation | Gaussian approximation |
|---|---|---|---|
| Average resolution at 1173 - 1333 Kev @ $^{60}$Co | 425 ps | 400 ps | 400 ps |
| Algorithm implementation |  |  |  |

# Tests: energy resolution (1)

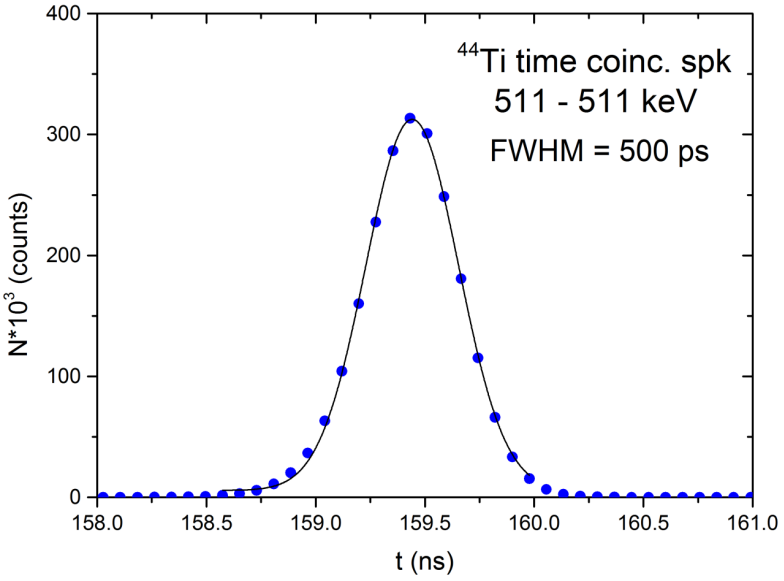


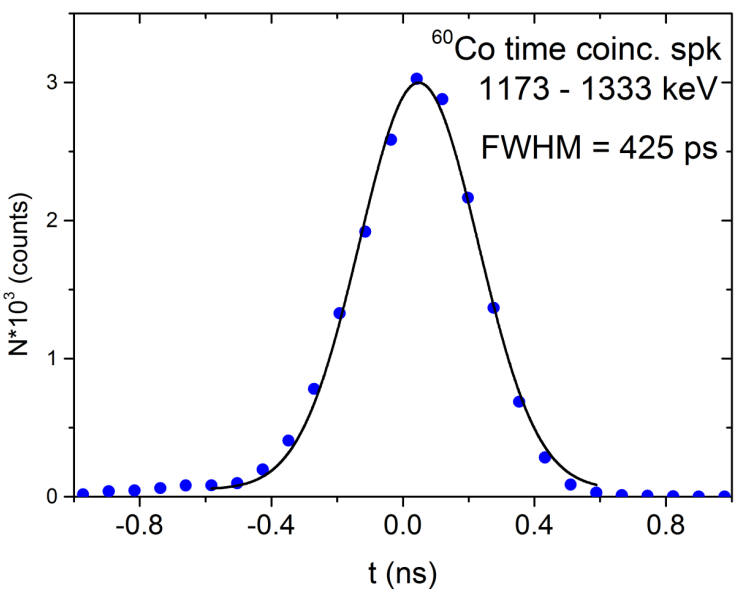
# Tests: energy resolution (2)



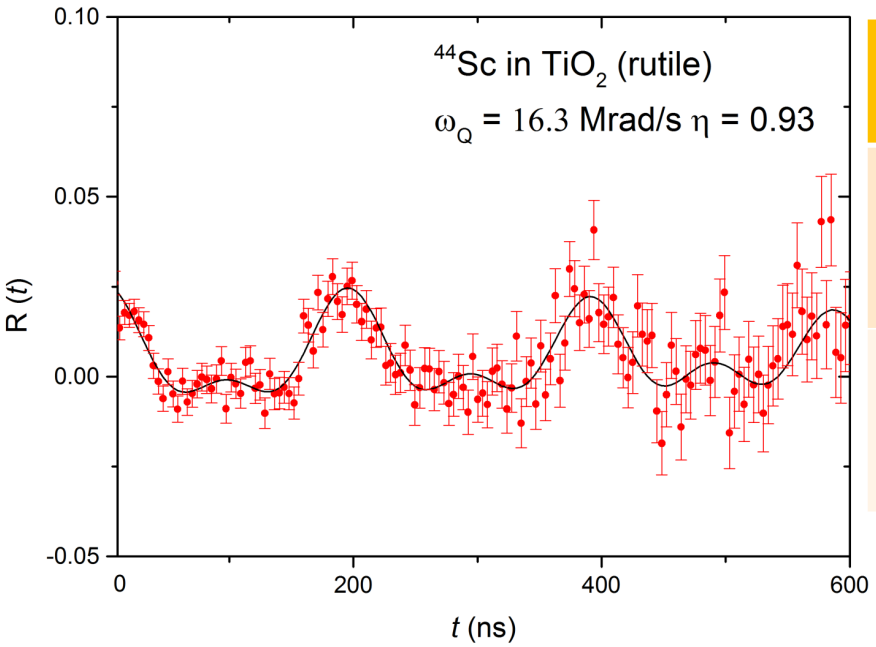



# Tests: time resolution



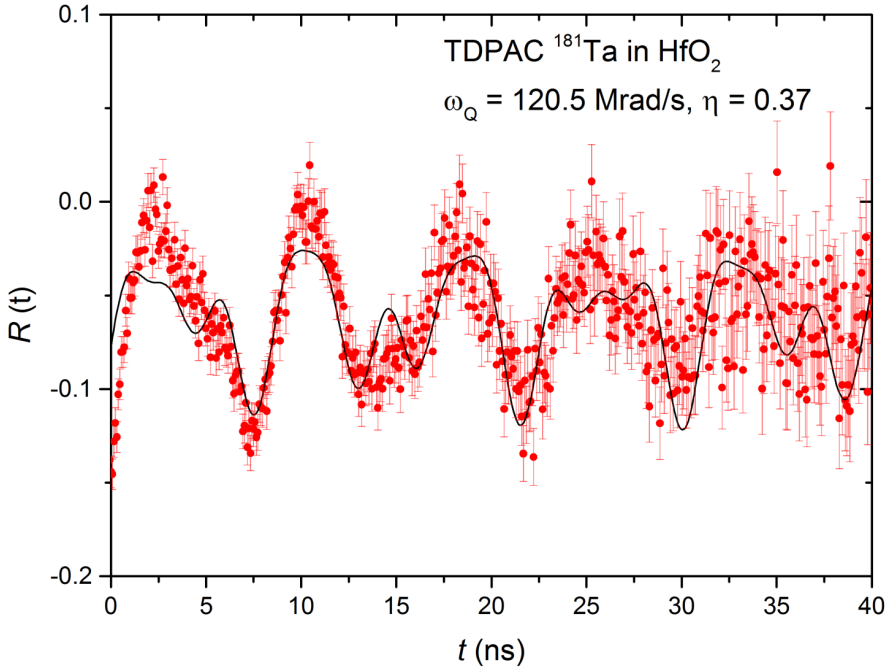



# Tests: TDPAC for $^{44}Ti$ in $TiO_2$ (rutile phase)




| $\omega_Q$ (Mrad/s) | $\eta$ | Ref. |
|---|---|---|
| 16.1 | 0.94 | T. Butz et al. PRB (2008) \| $LaBr_3$ |
| 16.4 | 0.93 | Старая установка (2016) \| NaI |

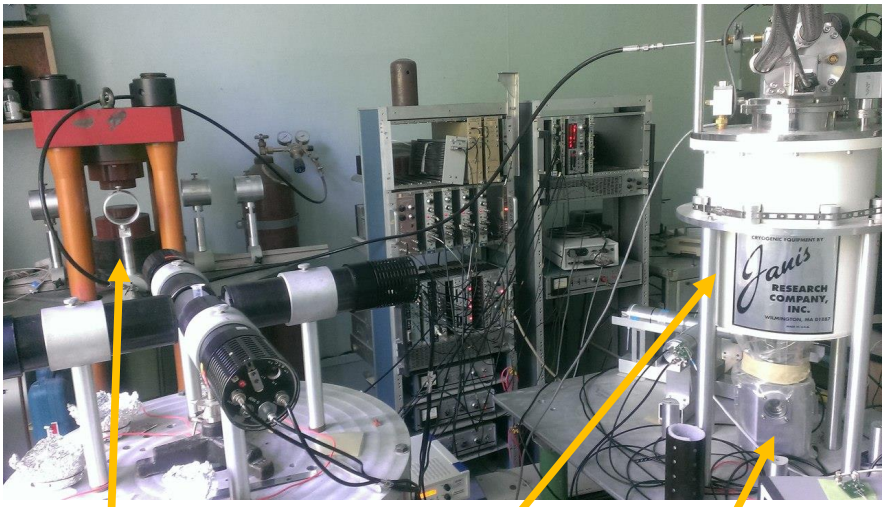
# Tests: TDPAC for $^{181}Ta$ in $HfO_2$ (monoclinic phase)




| $\omega_Q$ (Mrad/s) | $\eta$ | Ref. |
|---|---|---|
| 126.0 | 0.36 | Baudry et al. HI (1983) \| $BaF_2$ |
| 123.0 | 0.34 | A. Ayala et al. PRB (1994) \| CsI |
| 119.0 | 0.32 | Старая установка (2002) \| $BaF_2$ |

# Old setup vs the modern one

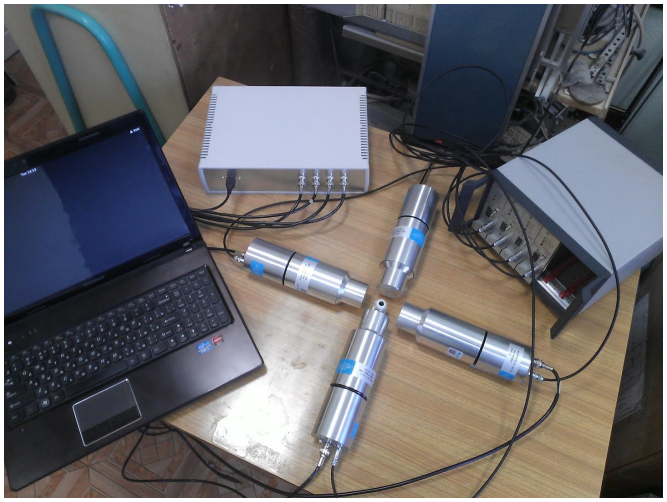
35 electronic modules
~55 cables




Helium cryostat

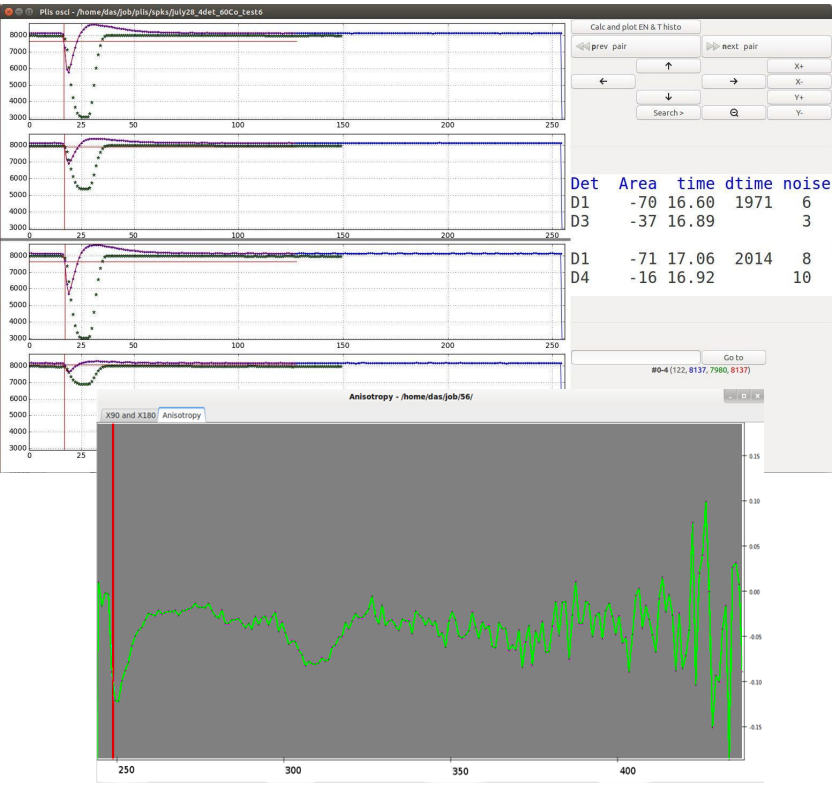
Toroid high-pressure cell:
$P < 8$ GPa, $T = 300$ K

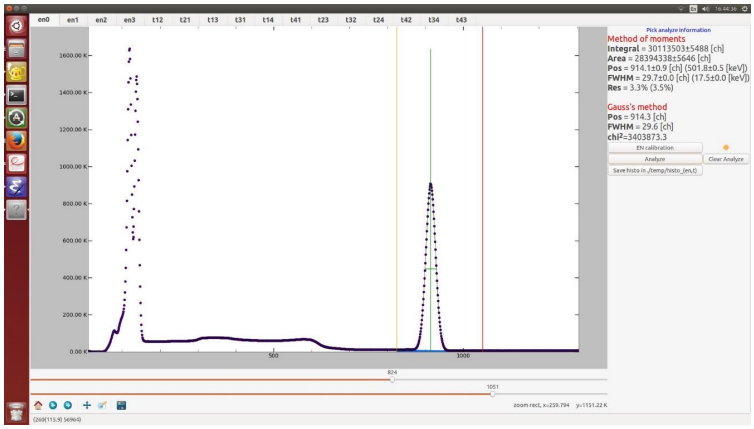
Piston-cylinder ($P < 2$ GPa, $T > 4$ K) and diamond anvil ($P < 20$ GPa, $T > 4$ K) high-pressure cells

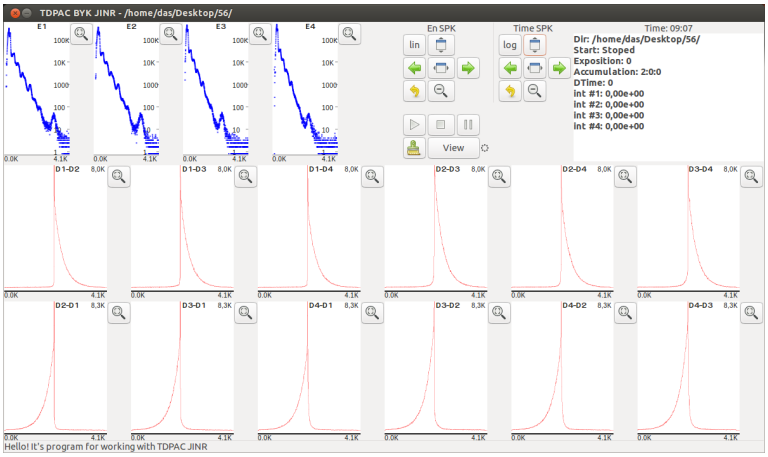


5 electronic modules
9 cables

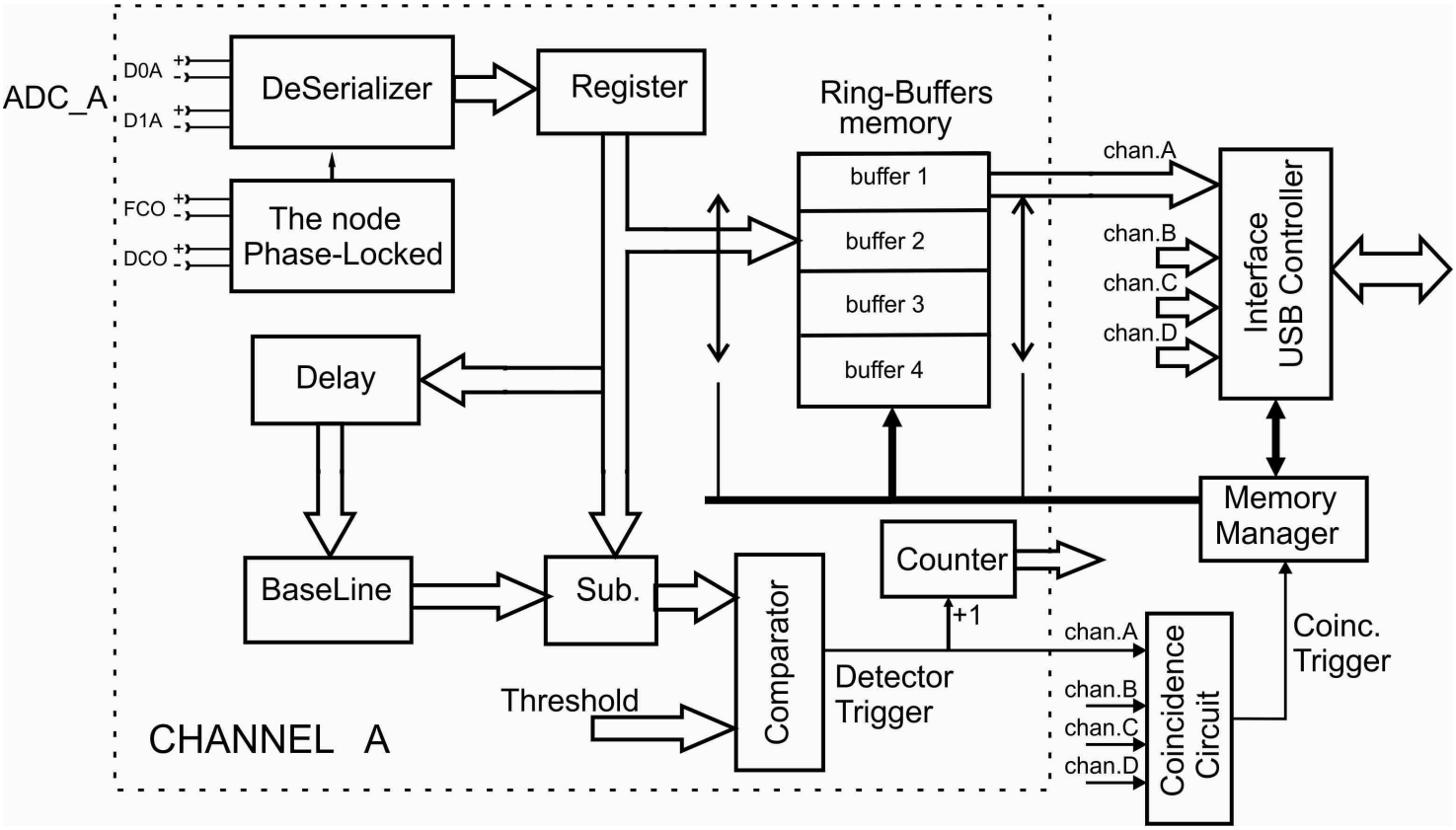
# Spectrometer software



*Thank you for you attention!*


ADC_A
D0A
D1A
FCO
DCO
DeSerializer
Register
The node
Phase-Locked
Ring-Buffers
memory
buffer 1
buffer 2
buffer 3
buffer 4
chan.A
chan.B
chan.C
chan.D
Interface
USB Controller
Delay
Memory
Manager
BaseLine
Sub.
Comparator
Counter
+1
Threshold
Detector
Trigger
chan.A
chan.B
chan.C
chan.D
Coincidence
Circuit
Coinc.
Trigger
CHANNEL A