Some experience with $LaBr_3$ detectors

(in-beam)
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Stefan Lalkovski (Uni. Sofia)
Dimiter Balabanski (INRNE)

(source tests)
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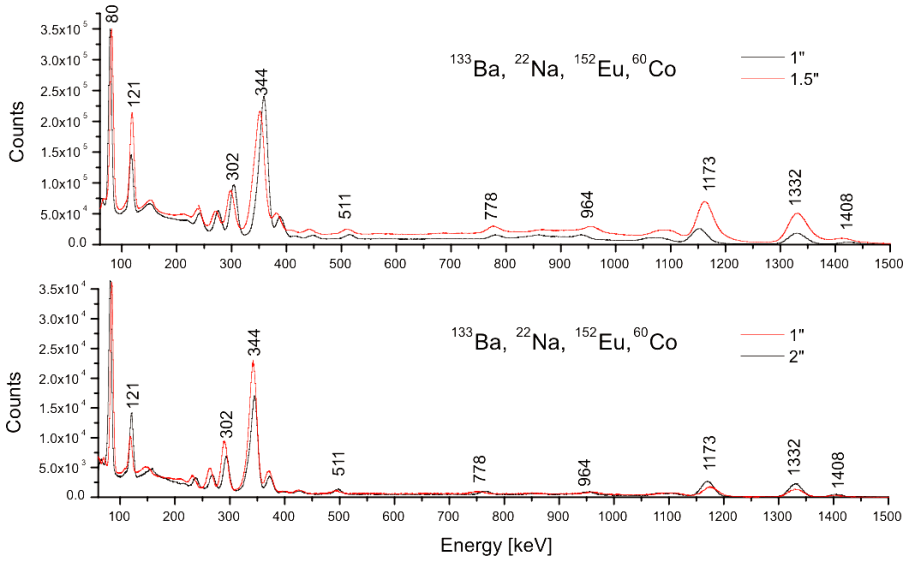
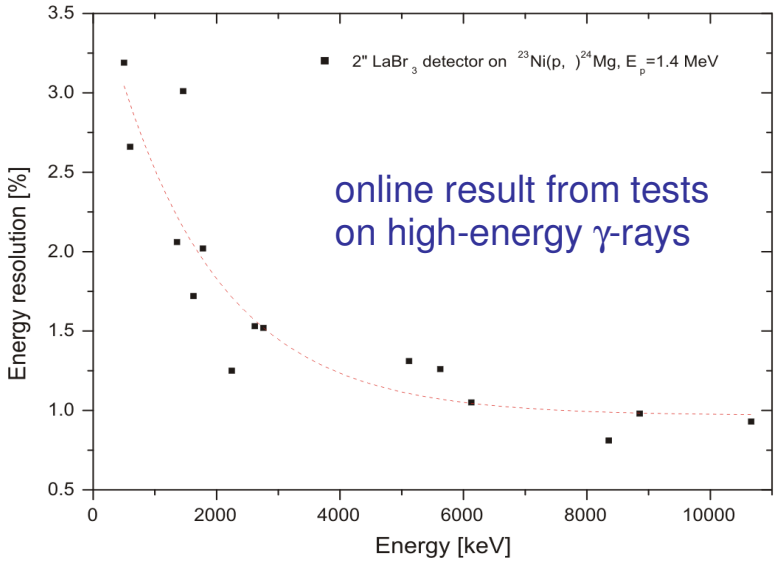
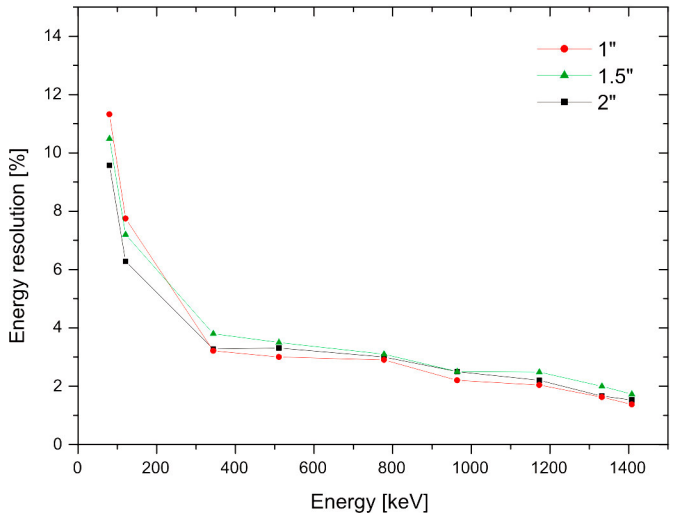
(CSNSM)

Tests of 1“, 1.5“ and 2“ $LaBr_3$:Ce detectors with sources – energy resolution







Energy [keV]	δE[%] 1“	δE[%] 1.5“	δE[%] 2“
121	7.7(28)	7.2(26)	6.3(25)
344	3.2(17)	3.8(19)	3.2(18)
511	3.0(16)	3.5(18)	3.3(18)
1173	2.0(14)	2.4(15)	2.2(14)
1408	1.4(11)	1.7(13)	1.5(12)

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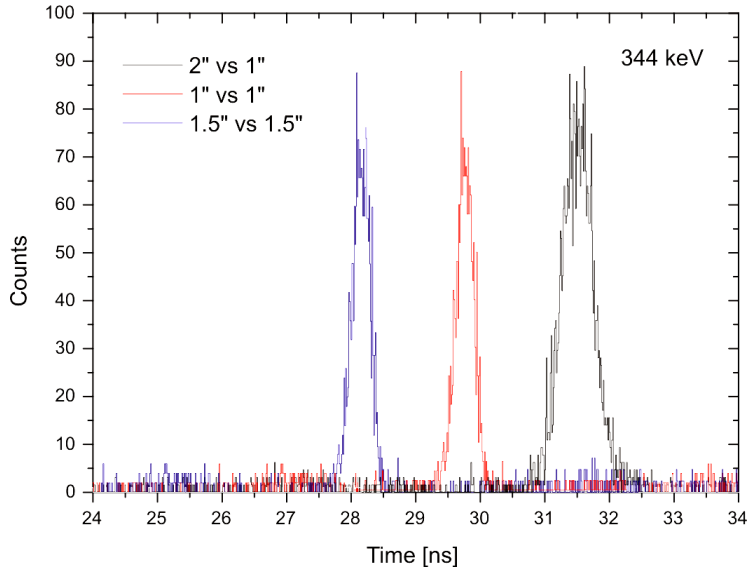
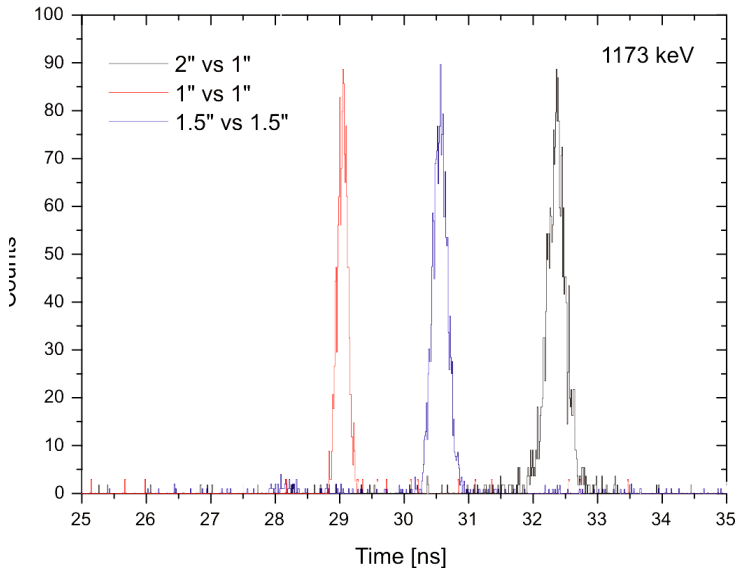
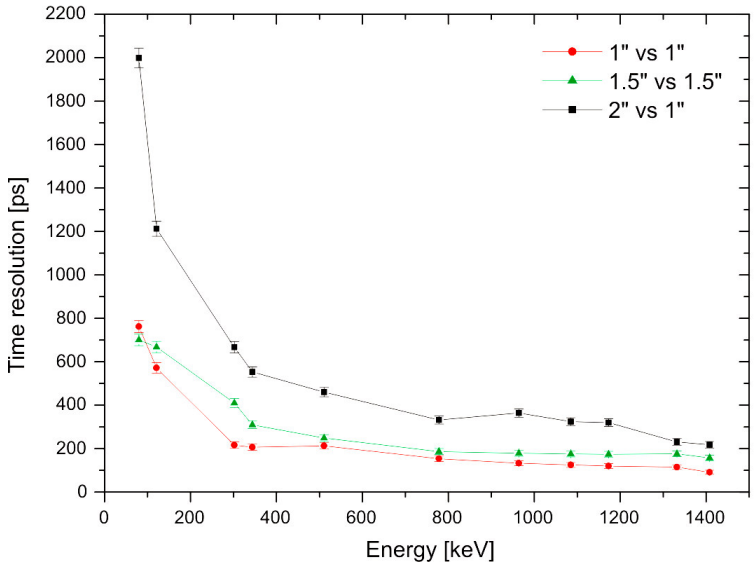
Tests of 1“, 1.5“ and 2“ $LaBr_3$:Ce detectors with sources – time resolution





^{133}Ba
^{22}Na
^{152}Eu
^{60}Co



Energy [keV]	δT[ps] 1“ vs 1“	δT[ps] 1.5“ vs 1.5“	δT[ps] 2“ vs 1“
121	572(24)	668(26)	1212(35)
344	212(15)	309(18)	553(24)
511	206(14)	248(16)	460(21)
1173	120(11)	174(13)	320(18)
1408	100(10)	158(13)	218(15)

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Experiments at IFIN-HH, Bucharest

TANDEM Laboratory at IFIN-HH Bucharest :

- 9 MV TANDEM accelerator
- Duoplasmatron alpha particles source
- Sputtering source

Ions from protons to Si can be accelerated at energies above the Coulomb barrier

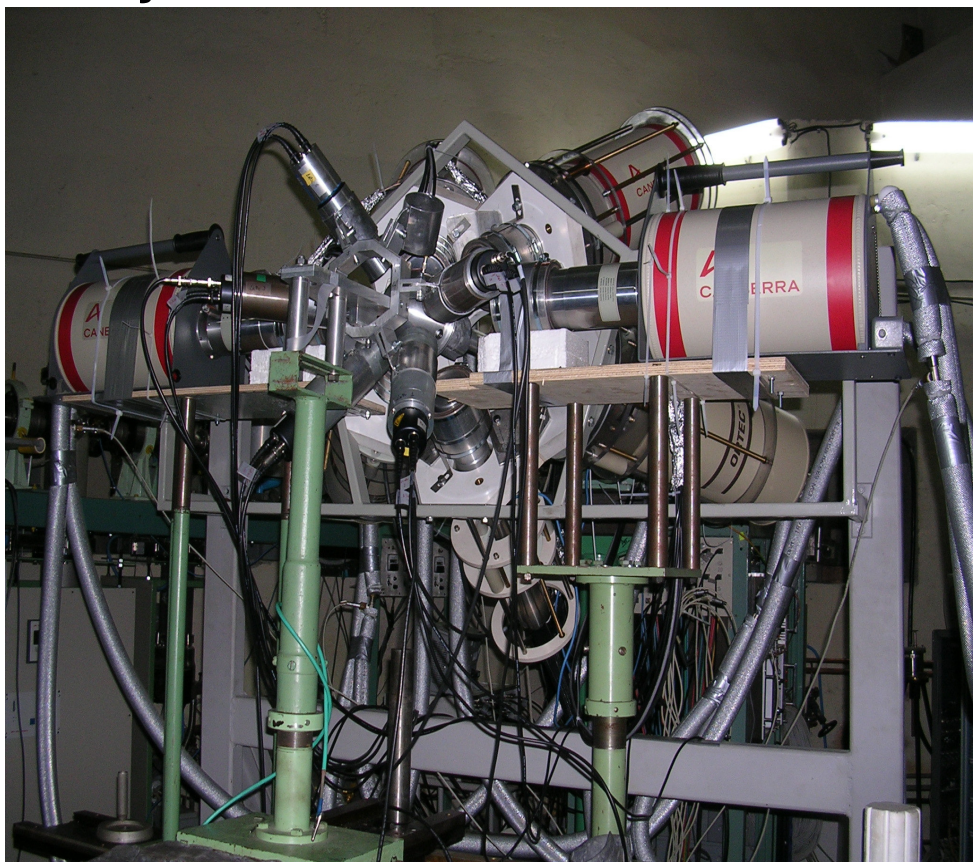
Some aspects of the reactions with light projectiles

- Reactions like (p,γ), (p,n), (α,n) are rather non-selective in angular momentum
  - **give access to non-yrast states**
- Reactions with heavier projectiles start to be selective along the yrast line
  - **with projectiles up to Carbon one have a small number of reaction channels and large (hundreds of milibarns) cross-sections**

Gamma detection system

Consistent investments in the last years

- 18 HPGe detectors with 55% efficiency
- two clover detectors with anti-Compton shields
- scintillation detectors ($LaBr_3$:Ce, BGO anti-Compton) to be delivered during 2009



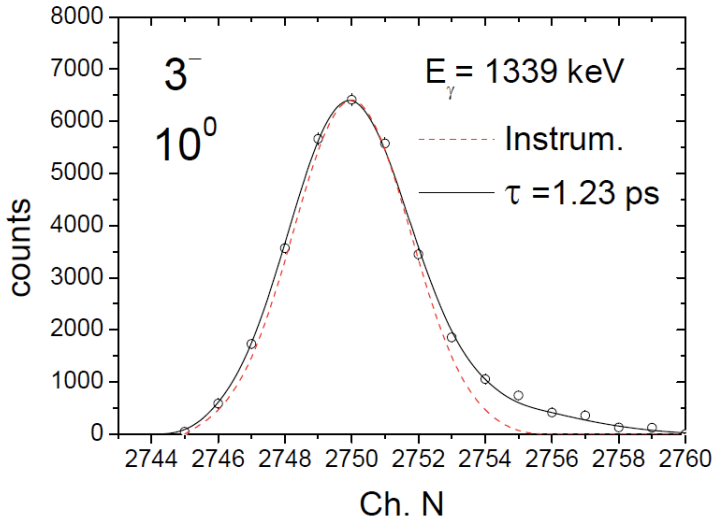
Permanent gamma detection array

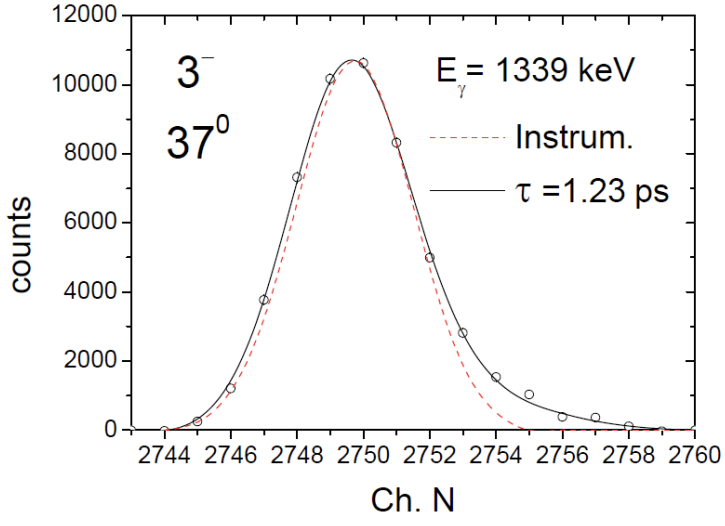
7-8 55% HPGe detectors

5 $LaBr_3$:Ce detectors from Sofia and CSNSM

DSAM at low recoil energy

- Non-yrast states in Te isotopes populated in Sn(α,n) reactions at 15 MeV incident energy
- Recoil energy of ~ 500 keV ➔ one need very good energy resolution and stability of the detection system





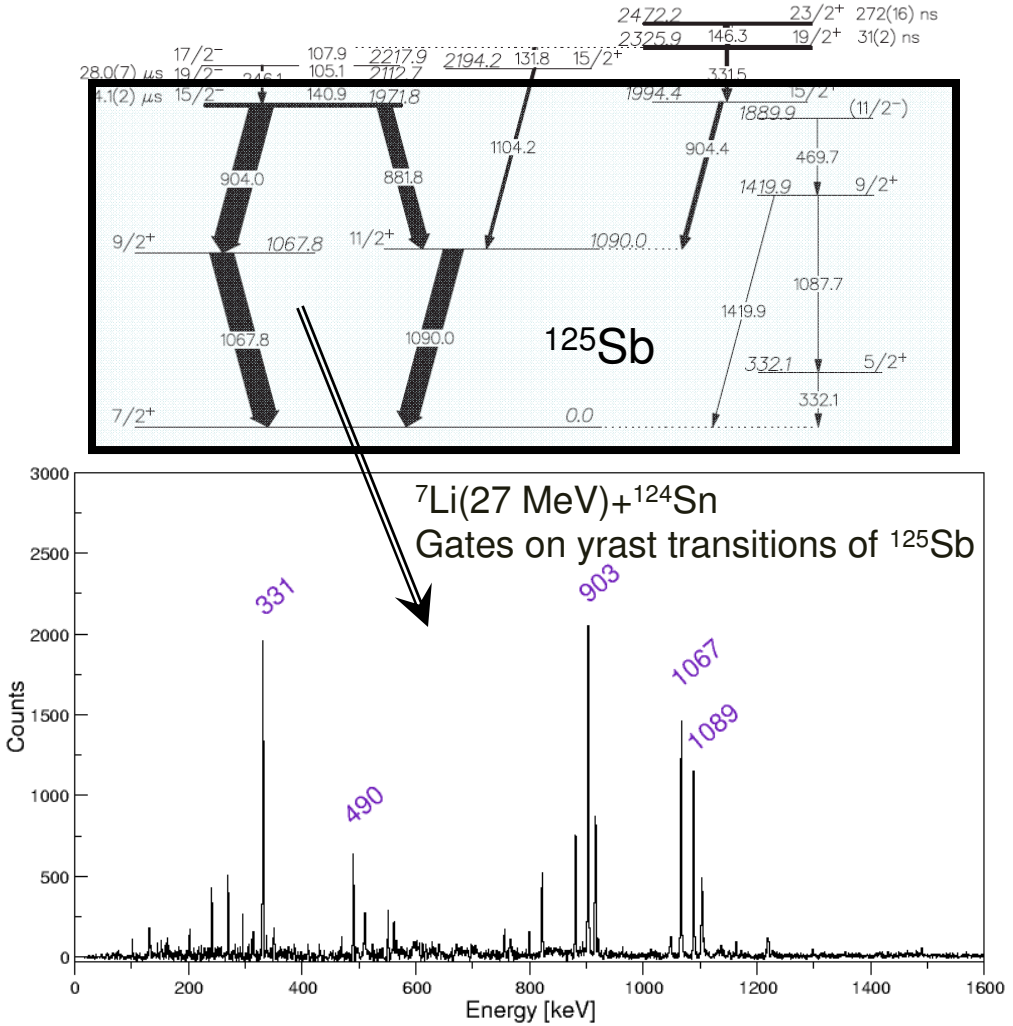
“Transfer” reactions with ^{7}Li

In the reaction ^{7}Li(23-27 MeV) + ^{124}Sn nuclei like ^{125,126}Sb were populated with cross-sections with **orders of magnitude higher** respect of what we expect from compound-nucleus reactions

The same phenomenon was observed in reaction studies without gamma detection systems and was interpreted as transfer processes followed by breakup of the remaining fragment of the projectile

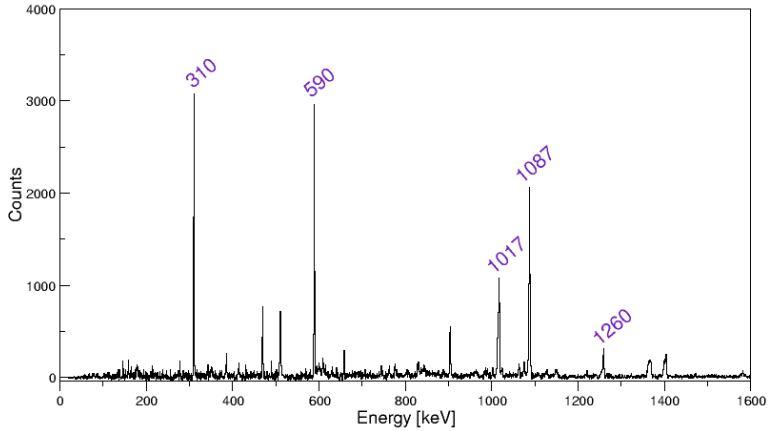
A. Shristava et al. Phys. Letters B 633 (2006) 463

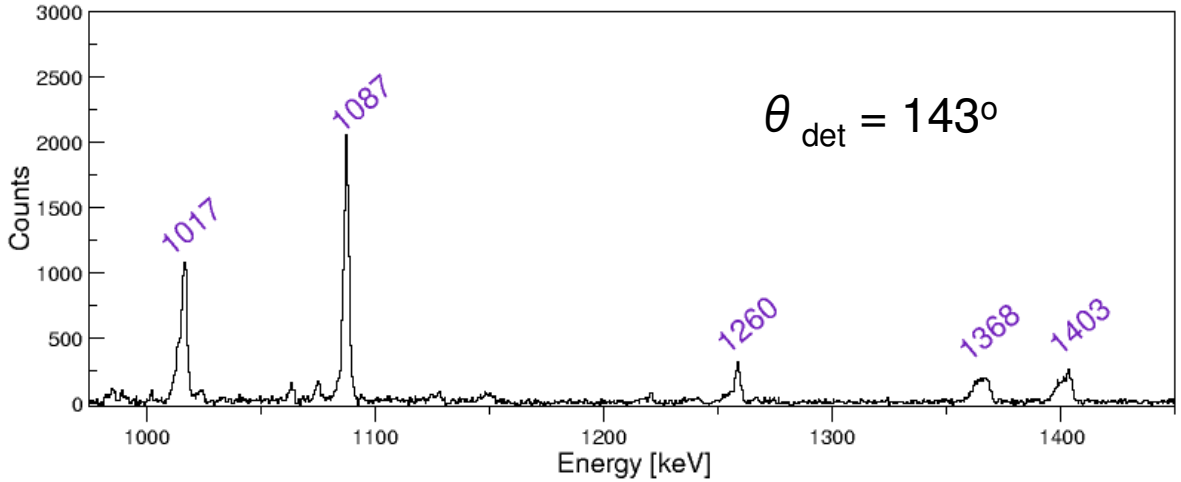
These reactions might be used to produce nuclei otherwise difficult to reach in heavy-ion reactions



Non-yrast states populated in reactions with ^{7}Li

- All non-yrast states up to 3 MeV excitation energy were observed in the reaction
- From γ - γ coincidences we deduced that most of the levels are **directly populated**
- Significant Doppler lineshapes for many γ lines



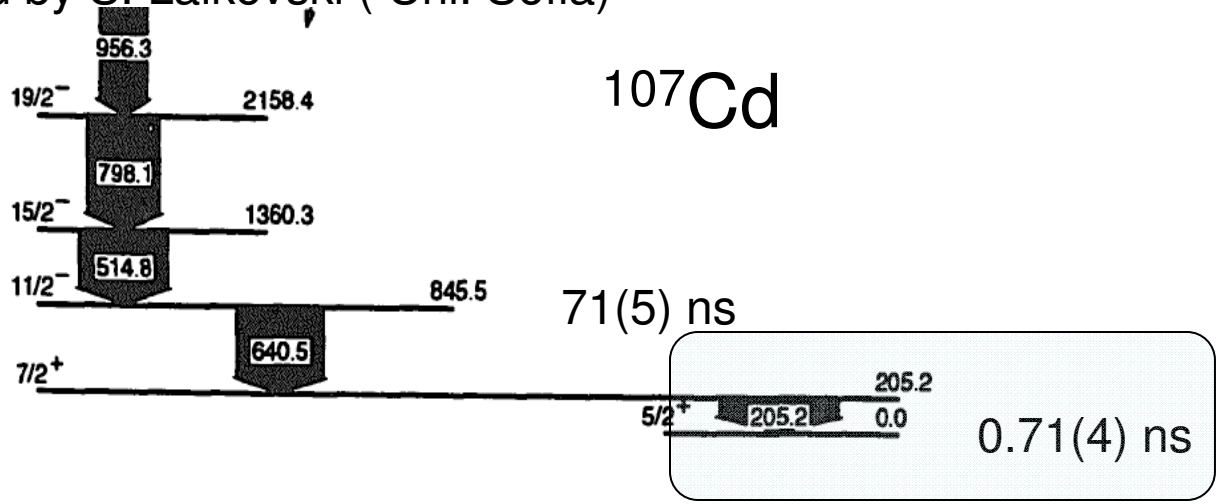


DSAM method may be applied in α - γ coincidence experiments without significant feeding problems

In-beam Fast-Timing : test experiment

Experiment proposed by S. Lalkovski (Uni. Sofia)

$^{98}Mo(^{12}C,3n)^{107}Cd$
50 MeV incident energy

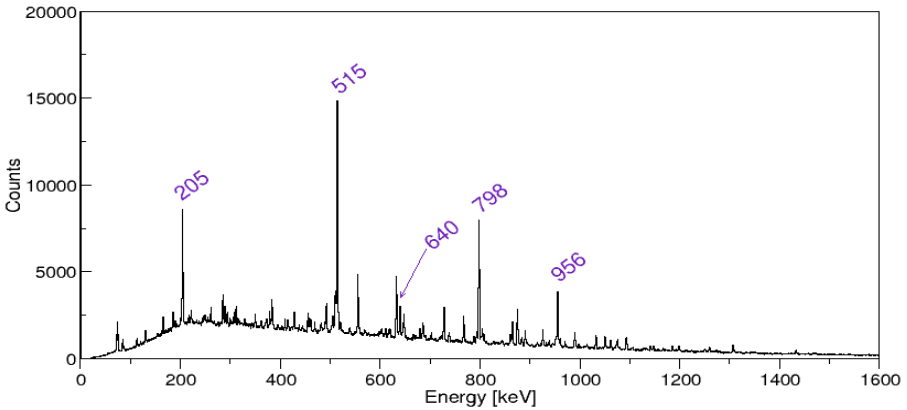


^{107}Cd

71(5) ns

0.71(4) ns

- 5 $LaBr_3$:Ce detectors (Sofia)
- 7 HPGe detectors (Bucharest)



72 hours experiment, January 2009

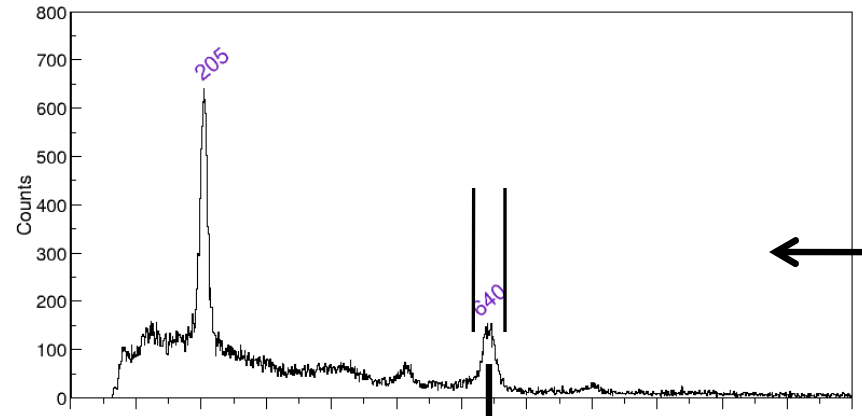
Trigger condition
Ge ≥ 1 AND $LaBr_3$:Ce ≥ 2

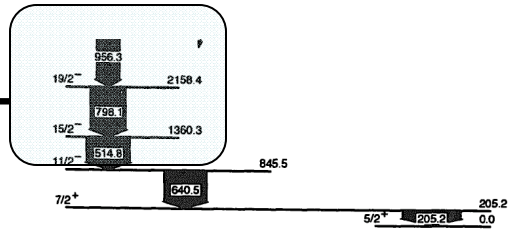
In-beam Fast-Timing : ^{107}Cd test case

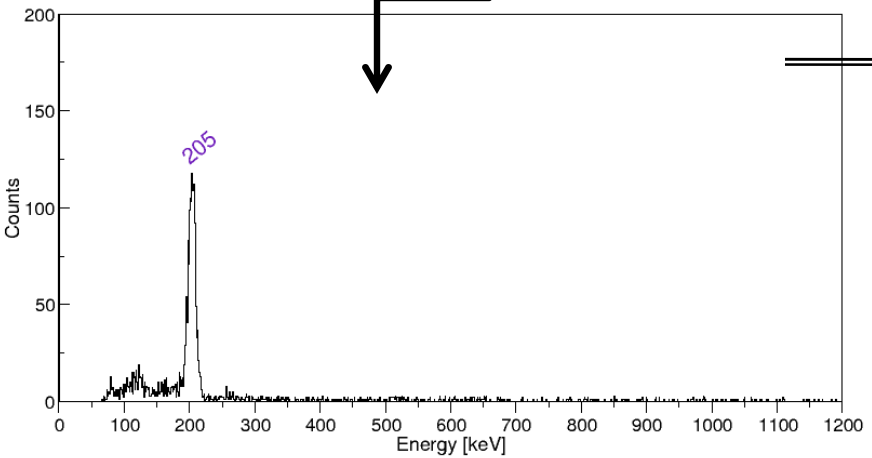
640-205 coincidence in $LaBr_3$:Ce detectors

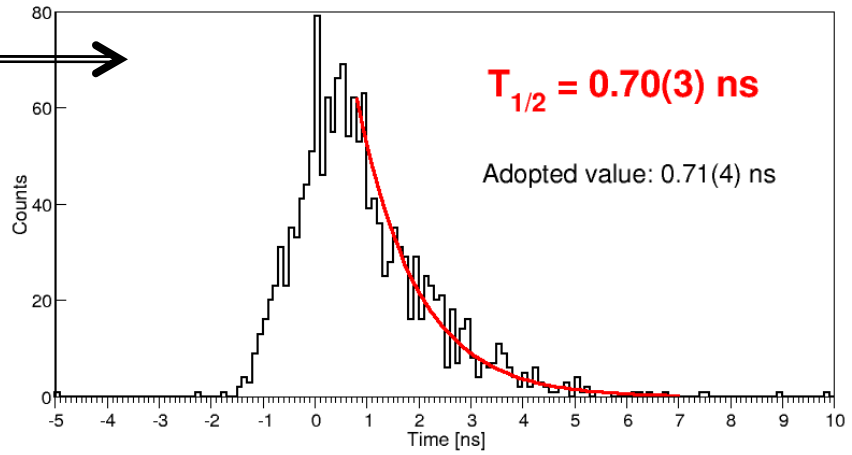
selected gating with HPGe detectors

on yrast transitions of ^{107}Cd





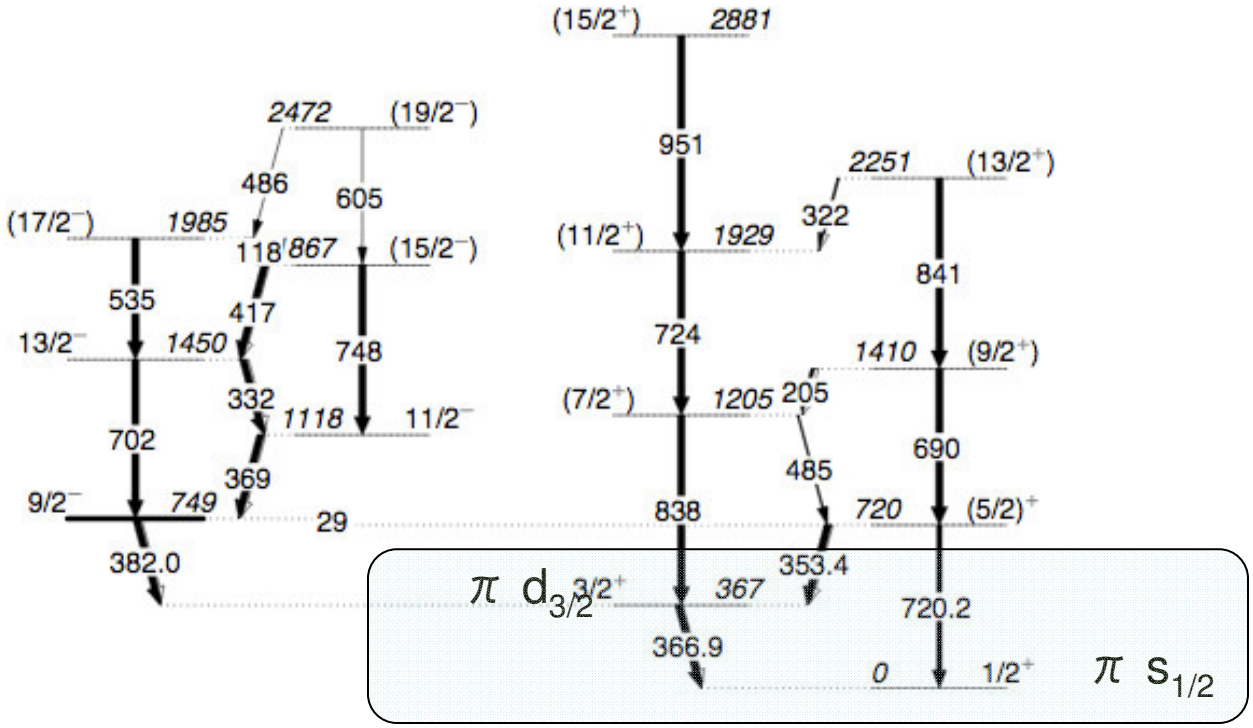




Spectroscopy of ^{199}Tl

- ^{197}Au(α,2n)^{199}Tl at 24 MeV beam energy

  8 HPGe and 5 $LaBr_3$:Ce detectors

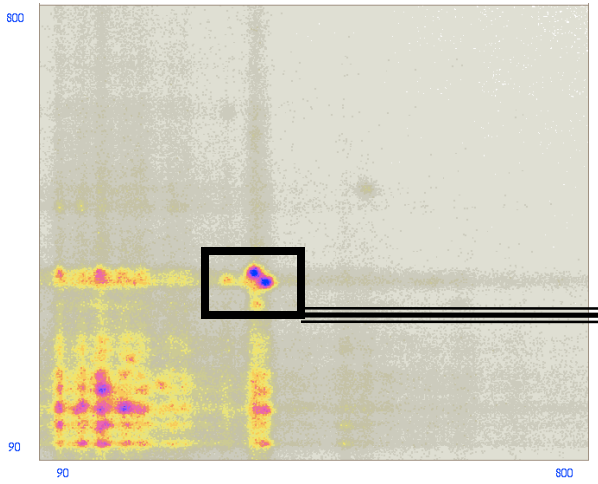


$T_{1/2}$=28.4(2) ms

If these states have pure single-particle configurations, one expects lifetime of several hundreds of picoseconds for the 367 keV level

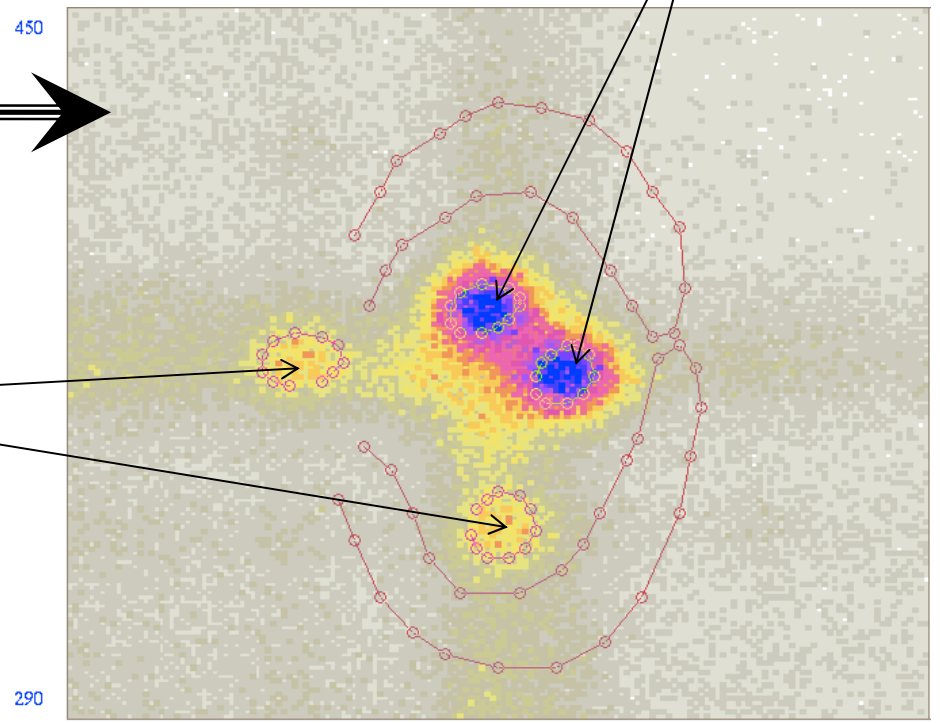
Lifetime of the 367 keV level

γ - γ - Δt cube with $LaBr_3$:Ce detectors



381 keV – 367 keV coincidence

332 keV – 369 keV coincidence

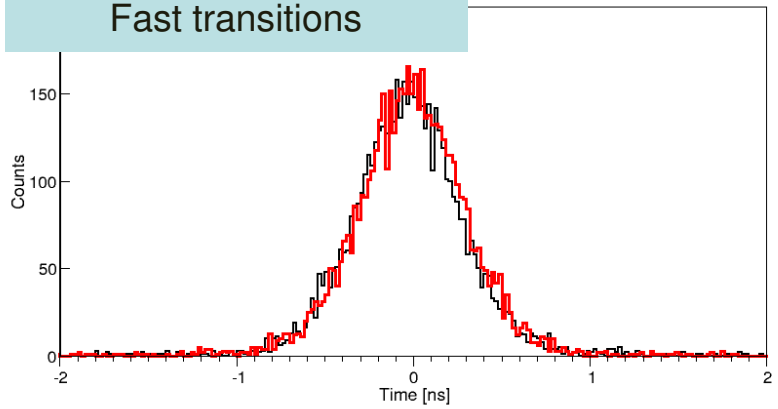


E_γ start

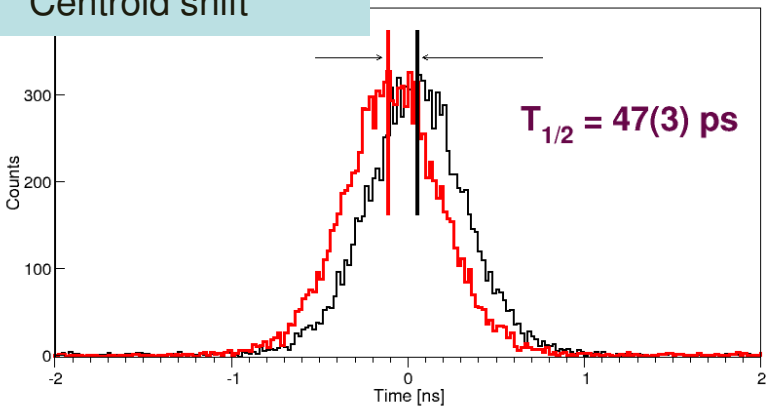
E_γ stop

Lifetime of the 367 keV level

332-369 keV coincidence
Fast transitions



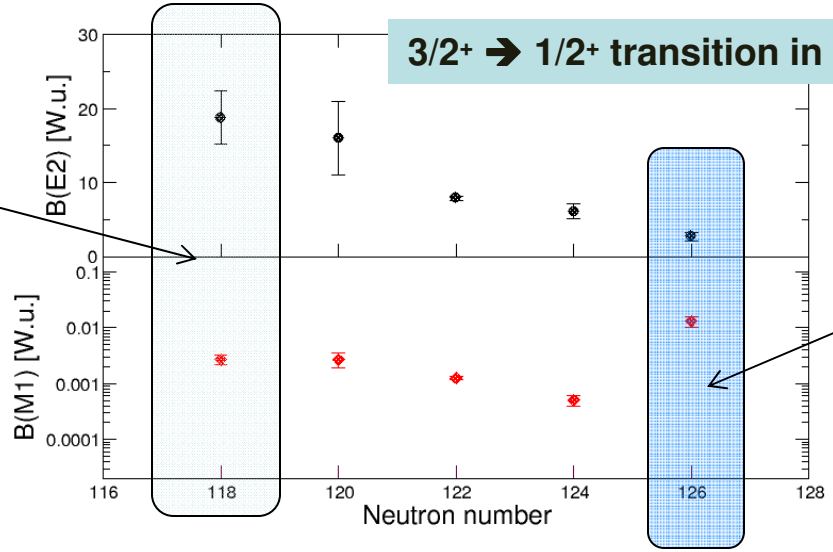
367-381 keV coincidence
Centroid shift



3/2⁺ ➔ 1/2⁺ transition in odd-A Tl isotopes

Present data

Increased collectivity
of the two states

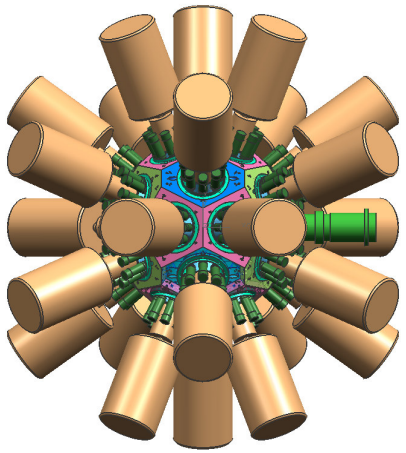


One hole in doubly-magic ^{208}Pb
Single-particle states

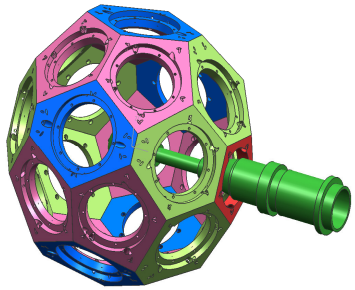
Forthcoming developments

Array of 25 HPGe 55% detectors

with BGO anti-Compton shields



- Increase granularity
- Increase P/T ratio
- Increase detection efficiency



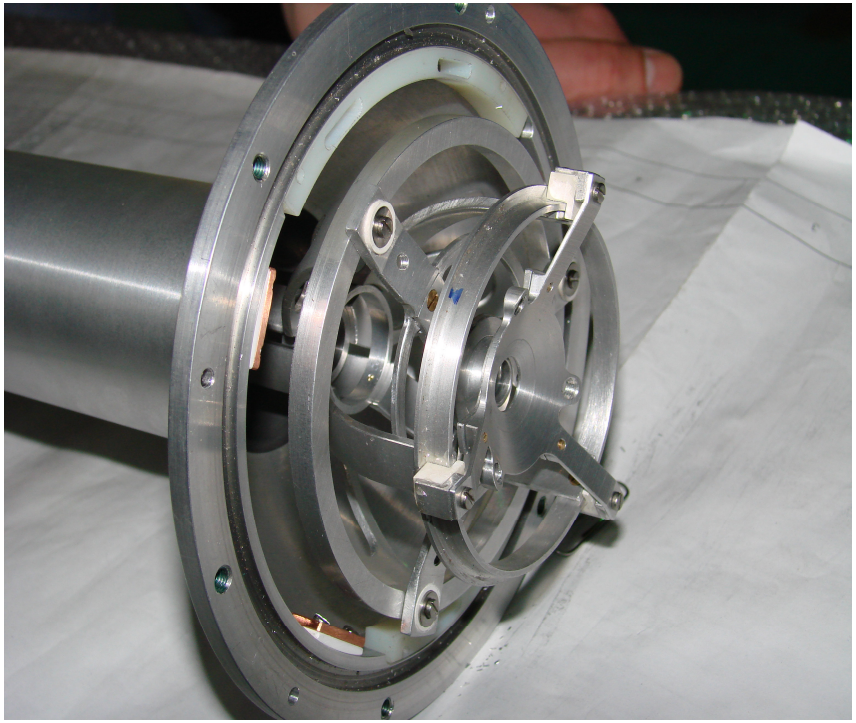
Absolute detection efficiency ~ 1%

Expected commissioning : 2010-2011

Mechanical project of R. Dima (IFIN-HH)

Forthcoming developments

- 6 $LaBr_3$:Ce will be delivered to IFIN-HH in April 2009
- Stable fast-timing setup with 6-10 $LaBr_3$:Ce in coincidence with Ge detectors
- Nanosecond pulsing system, to be installed and commissioned in May 2009 at IFIN-HH Tandem accelerator
- Plunger device under construction in collaboration with IKP Köln (A. Dewald)



Acknowledgements

IFIN-HH Bucharest

D. Bucurescu

N.V. Zamfir

D. Filipescu

C. Mihai

T. Glodariu

L. Stroe

R. Marginean

Al. Negret

G. Suliman

R. Dima

Gh. Cata-Danil

S. Pascu

D. Deleanu

M. Ivascu

I. Cata-Danil

INRNE-BAS Sofia

D. Balabanski

S. Lalkovski

P. Dentisov

D. Radulov