Feeding of low-energy structures in ^{188}Pt of different deformations by the GDR decay

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Proposal

„Feeding of low-energy structures of different deformations by the GDR decay: the nu-Ball array coupled to PARIS"

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IFJ PAN Kraków, Poland;

F.C.L. Crespi, A. Bracco, F. Camera, S. Leoni et al. *INFN Milano and Milano University, Italy;*

J. Wilson, I. Matea, et al. *IPN Orsay, France;*

P. Napiorkowski, M. Kicińska-Habior et al., *Warsaw University, Poland;*

O. Dorvaux, Ch. Schmitt, J. Dudek et al. *IPHC Strasbourg, France;*

D. Jenkins et al. *University of York, UK;*

I. Mazumdar, V. Nanal et al, *TIFR Mumbai, India;*

And the PARIS Collaboration

Spokesperson: M. Kmiecik (IFJ PAN Krakow)

Co-spokeperson: F.C. L. Crespi (Milano)

Local liaison: J. Wilson (IPN Orsay)

Objective

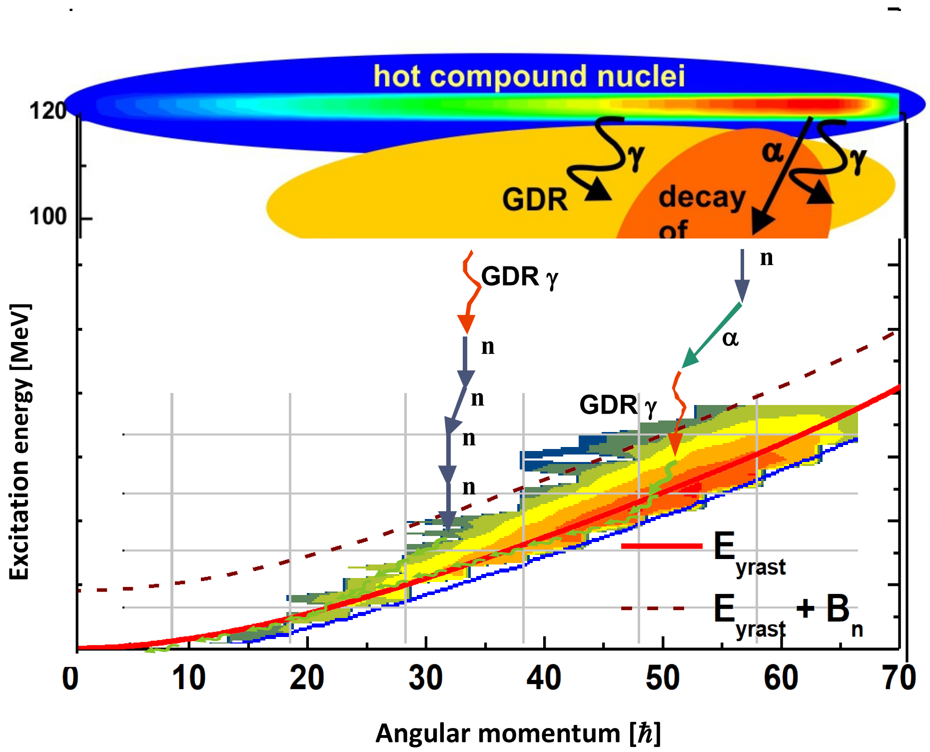
to study:

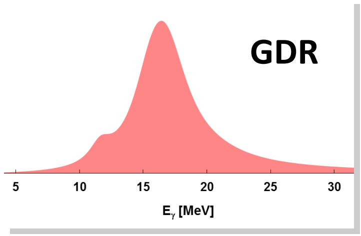
- *link between deformation of hot compound nucleus and different deformation of the final state of the residue*
- *population of states of different deformation by high-energy γ–rays from GDR decay*

***By measurement** of high-energy gamma GDR decay from ^{192}Pt compound nucleus associated with the 4n decay channel leading to ^{188}Pt evaporation residue*

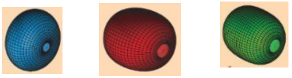
Motivation

link between deformation of hot compound nucleus and deformation of cold evaporation residue

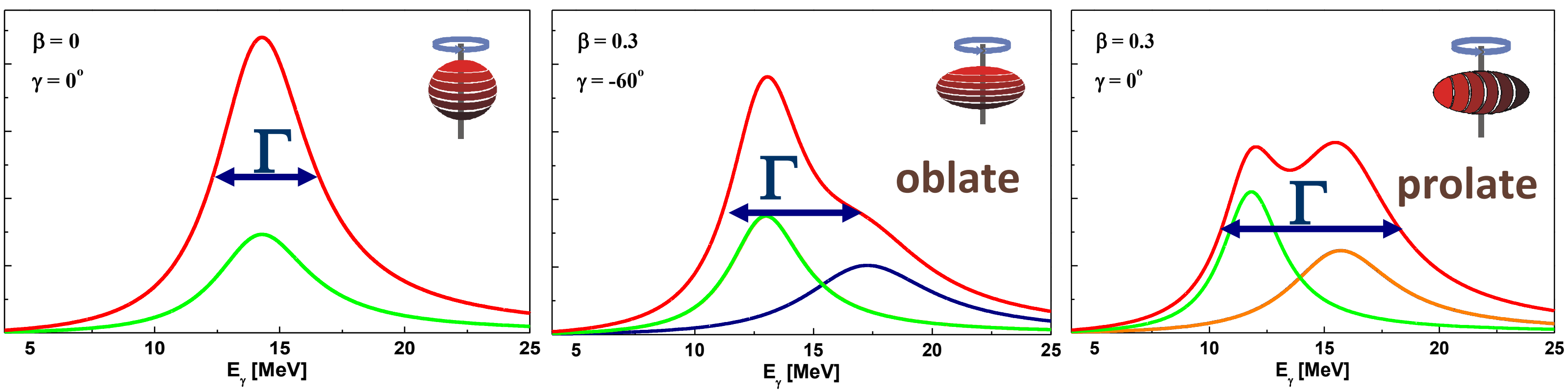




- ❑ GDR high energy gamma rays
  - hot nucleus shape
- ❑ low energy transitions
  - deformation of excited residue

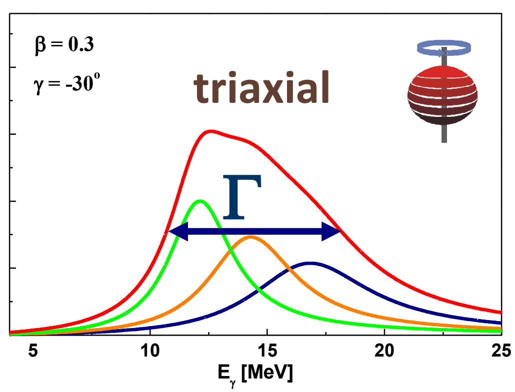


GDR - probe for nuclear shape studies



$$E_k = E_0 \exp\left[-\sqrt{\frac{5}{4\pi}}\beta\cos\left(\gamma - \frac{2\pi k}{3}\right)\right]$$

$$E_0 = 18A^{-\frac{1}{3}} + 25A^{-\frac{1}{6}}$$



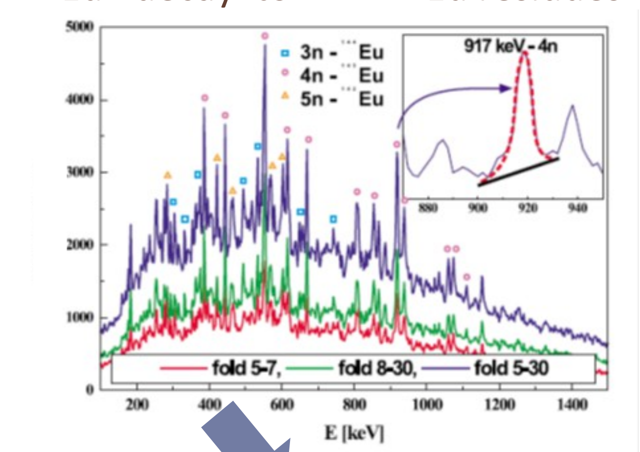
$$Y(E_\gamma) = Y_1(E_\gamma) + Y_2(E_\gamma) + Y_3(E_\gamma)$$

$$Y_k(E_\gamma) = \frac{S_k \Gamma_k E_\gamma^2}{\left(E_\gamma^2 - E_{GDR\,k}^2\right) + \Gamma_k^2 E_\gamma^2}$$

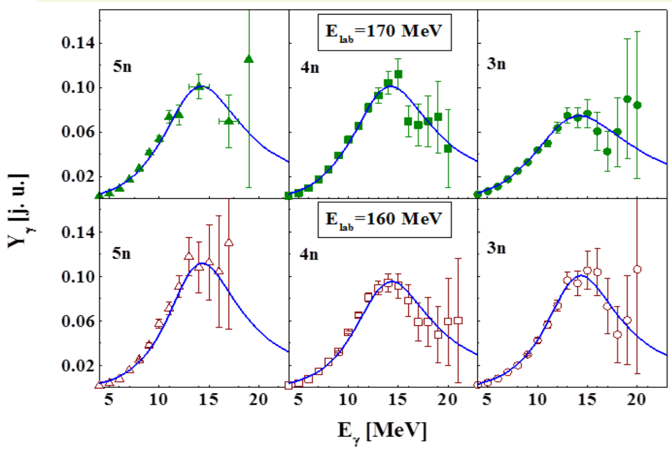
$$\Gamma_k = \Gamma_{GDR}\left(\frac{E_k}{E_{GDR}}\right)^\delta$$

Previous studies - coincidence measurement of high-energy and low-energy γ-rays

^{147}Eu* decay to ^{144,143,142}Eu residues



low energy gated GDR strength functions



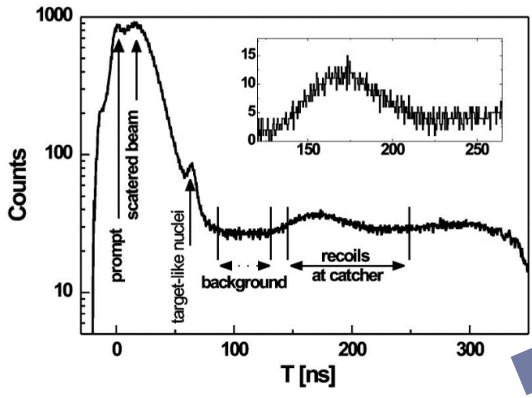
result:
GDR width → deformation

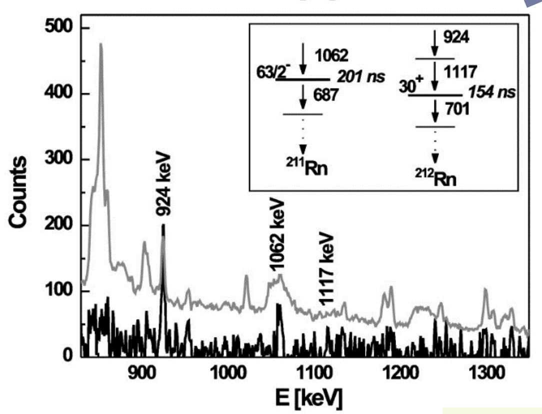
M. Kmiecik et al., Nucl. Phys. A 674, 29 (2000);
M. Kmiecik et al., Eur. Phys. J. A 12, 5 (2001);

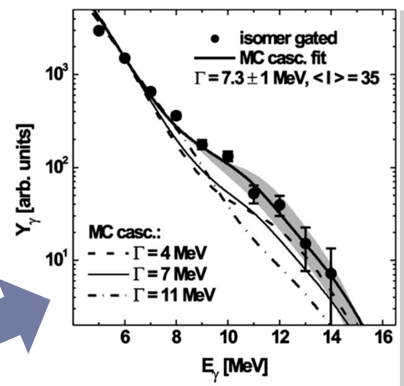
Previous studies – isomer gated GDR

gate on time and discrete transitions

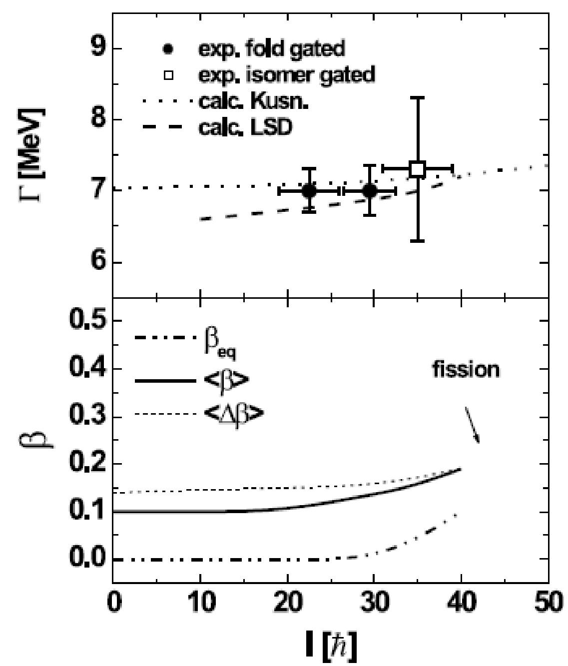
^{216}Rn* decay to ^{211,212}Rn residues







result:
GDR width → deformation



small increase of deformation for highest spin - nucleus remains almost spherical up to the fission limit

M. Kmiecik et al. PRC 70, 064317 (2004)

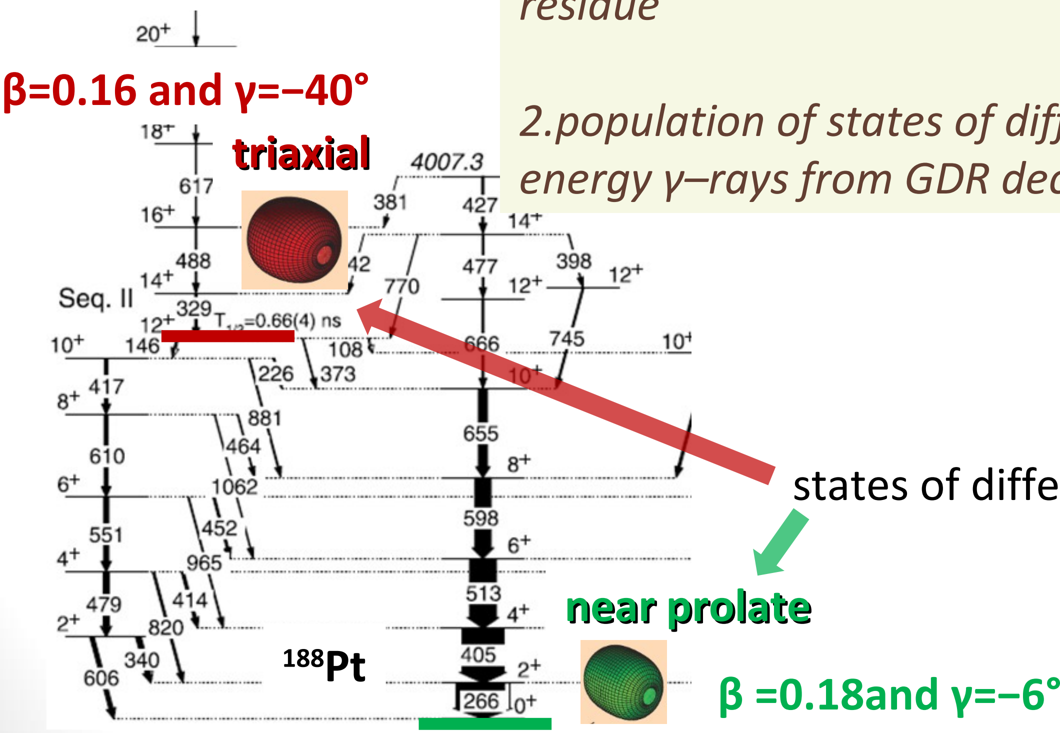
Proposed investigation

GDR emission from $^{192}Pt^*$ CN decay leading to ^{188}Pt

To study:

1.the relation between deformation of ^{192}Pt compound nucleus and deformation of the final state of the ^{188}Pt residue

2.population of states of different deformation by high-energy γ–rays from GDR decay

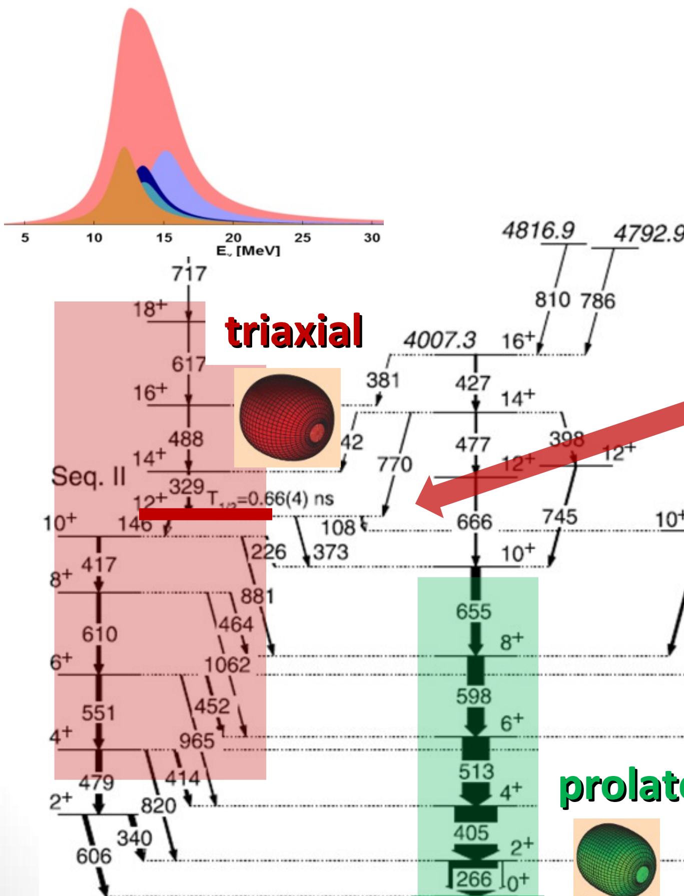


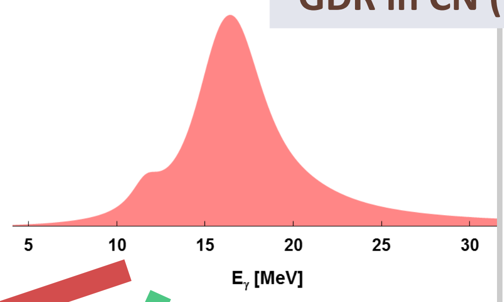
S. Mukhopadhyay et al., Phys. Lett. B 739, 462 (2014)

Method

1. the relation between deformation of ^{192}Pt compound nucleus and deformation of the final state of the ^{188}Pt residue

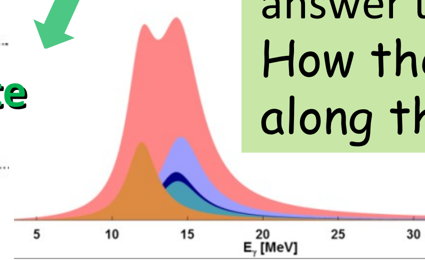
MEASURED: high energy gamma-rays from GDR decay in coincidence with low energy transitions from bands of different deformation





obtained: GDR strength functions for CN decaying to particular states of ^{188}Pt

answer the question:
How the deformation changes along the decay path?

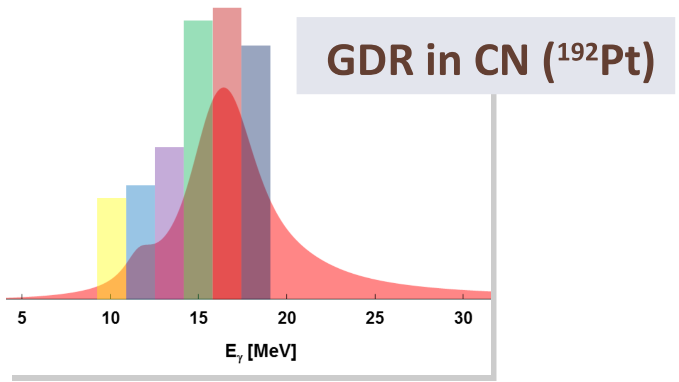


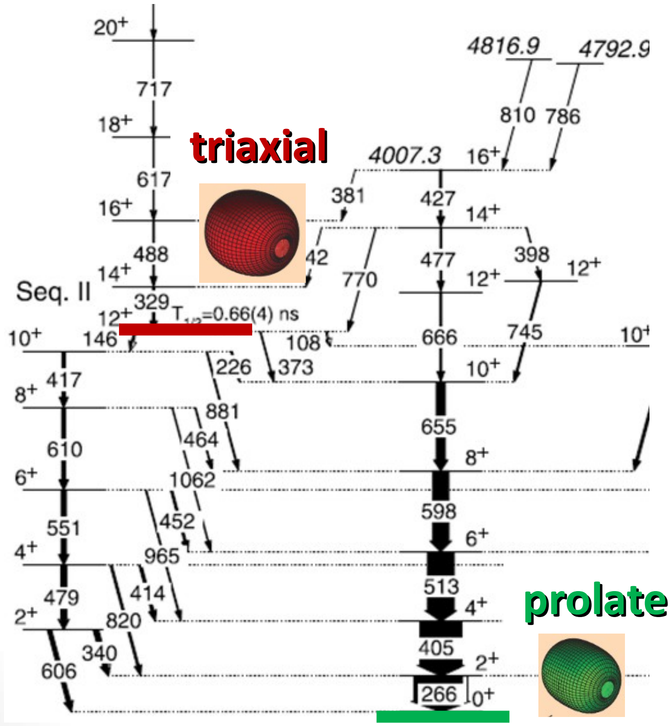
S. Mukhopadhyay et al., Phys. Lett. B 739, 462 (2014)

Method

2. *population of states of different deformation by high-energy γ–rays from GDR decay*

MEASURED: intensity of low energy transitions from bands of different deformation gated on GDR energy



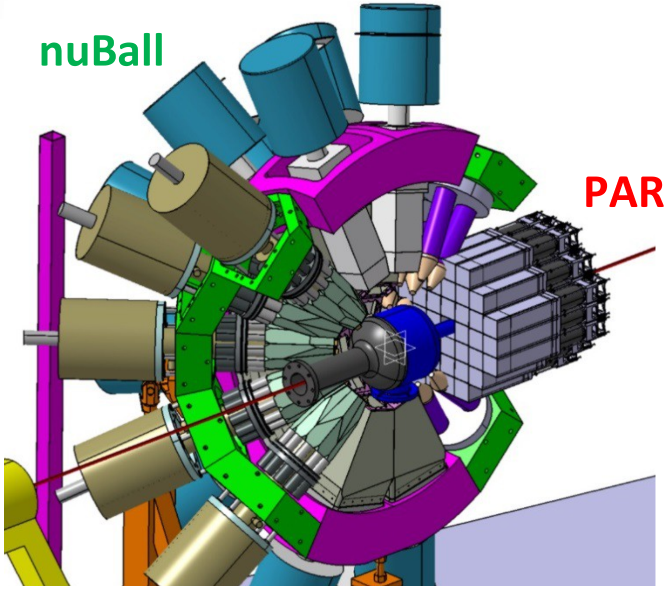


S. Mukhopadhyay et al., Phys. Lett. B 739, 462 (2014)

obtained:
transitions yield as a function of GDR energy

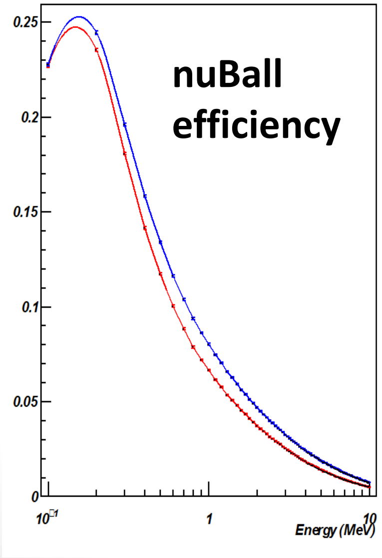
answer the question:
How the GDR feeds low energy structures?

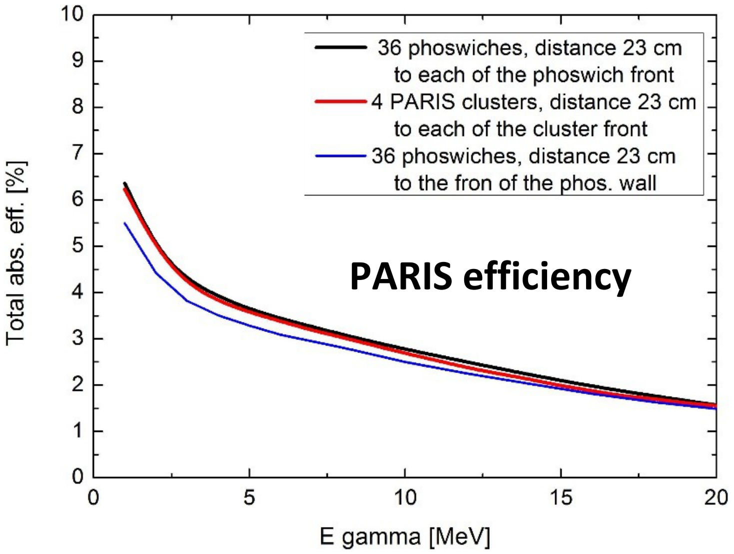
Experimental setup

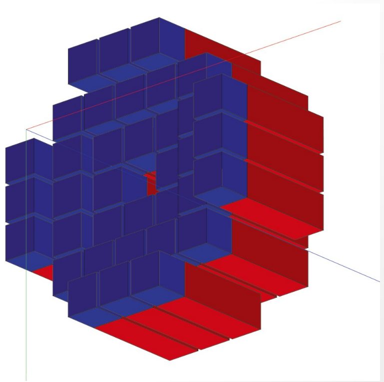


- ***nuBall*** (24 clover HPGe detectors, 10 coaxial Ge detectors)
- ***4 PARIS clusters*** (36 phoswich $LaBr_3/CaBr_3$+NaI detectors
  - „wall" configuration
  at backward angles at 23 cm

- *high energy resolution*
- *very good efficiency*







Reaction

^{18}O @ 82MeV on ^{174}Yb

Injected Ion species	Injected Intensity (nA)	charge	Terminal voltage (MV)	Energy (MeV)	I analysed électrique (nA)	I analysed max. Possible	Frequency pulsation (ns)
$^{18}O^-$	600	6^+	12,84	82	280	420	400 ns

d_{174Yb} = 4.8 mg/cm²

$E_{1/2}$ = 77.5

Bombarding energy (MeV)	77.5
Center of Mass energy (MeV)	70.234
Compound nucleus Excitation energy	48.8
Q-value of reaction (MeV)	-21.43
Compound nucleus recoil energy	7.266
Compound nucleus recoil velocity	2.70E-01
Compound nucleus recoil velocity/c	9.01E-03
Beam velocity (cm/ns)	2.88E+00
Beam velocity/c	9.62E-02
diffuseness	2
Fusion cross section (mb)	2.36E+02
Bass L	19.69
L0	19.46
Bass cross section	244.8

Residue	Percent	x-section (mb)
187Pt	20.40%	48.16
189Pt	1.90%	4.58
188Pt	**77.10%**	**181.99**

d_{174Yb} = 1.5 mg/cm²

$E_{1/2}$ = 80.5

Bombarding energy (MeV)	80.5
Center of Mass energy (MeV)	72.953
Compound nucleus Excitation energy	51.52
Q-value of reaction (MeV)	-21.43
Compound nucleus recoil energy	7.547
Compound nucleus recoil velocity	2.76E-01
Compound nucleus recoil velocity/c	9.19E-03
Beam velocity (cm/ns)	2.94E+00
Beam velocity/c	9.80E-02
diffuseness	2
Fusion cross section (mb)	3.74E+02
Bass L	25.49
L0	25.29
Bass cross section	386.65

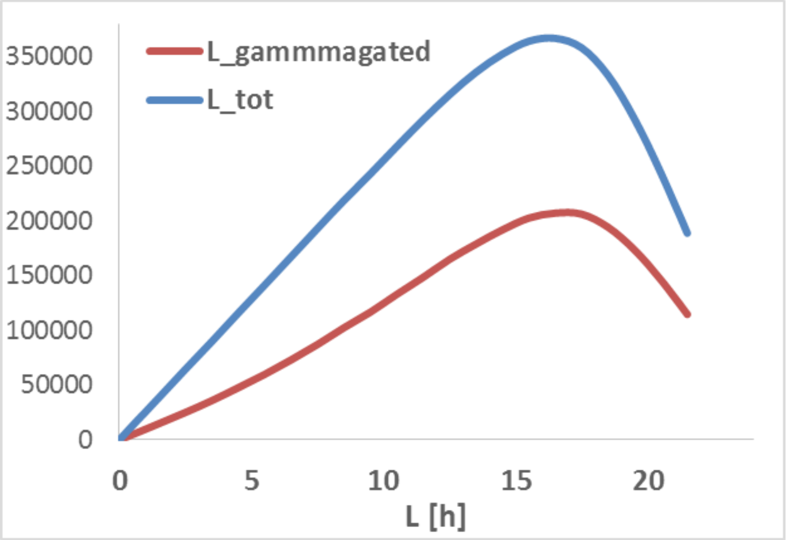
Residue	Percent	x-section (mb)
187Pt	38.10%	142.76
189Pt	0.70%	2.65
188Pt	**60.70%**	**227.18**

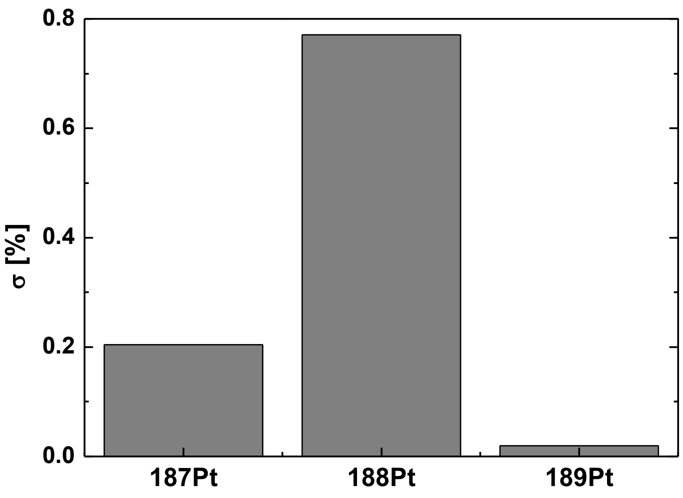
GEMINI calculations

Reaction

82 MeV ^{18}O + ^{174}Yb → ^{192}Pt (E*= 48.8 MeV, L_{max} = 20 ħ)

4.8 mg/cm^2 thick target





Beam time estimation

Reaction parameters:

fusion evaporation cross section = 236 mb

^{188}Pt cross section = 182 mb

target thickness = 4.8 mg/cm^2

I_{beam} = 280 nA

We will require simultaneously:

- low energy gamma measured by nuBall
- high energy gamma measured by PARIS

assuming

nuBall efficiency @ 500 keV = 10%

PARIS efficiency @15 MeV = 2%

Estimated: **~500 events per shift (8 hours)** for coincidence of GDR with low intensity gammas from the side band

In the proposal we asked for 21 shifts (7 days) of beam (based on estimation of **120 events / 8 h** for target thickness of **1.2 mg/cm2**)

Recommended by PAC: 21 UBT **(7 days)**

summary

*We propose to measure **high-energy gamma GDR decay from ^{192}Pt** compound nucleus associated with the 4n decay channel **leading to ^{188}Pt** evaporation residue in order to study:*

- *relation between deformation of hot compound nucleus and different deformation of the residue final state*
- *population of states of different deformation by high-energy γ–rays from GDR decay*

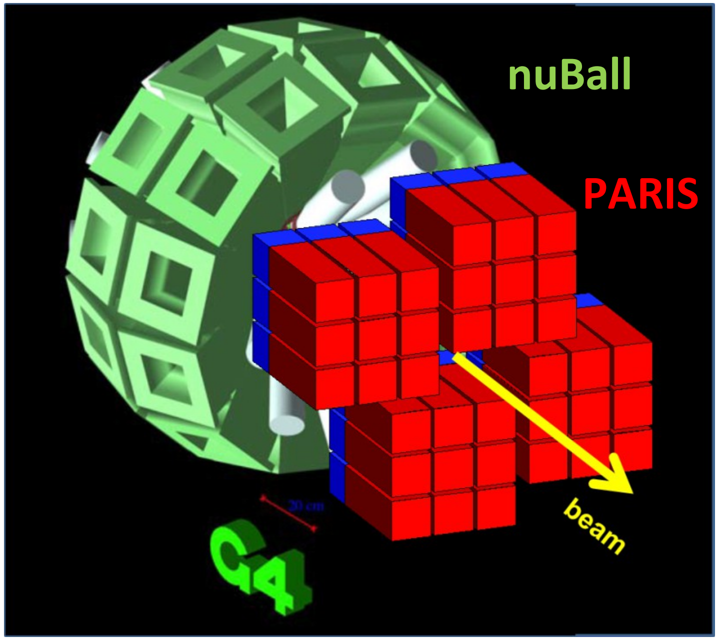
The experimental setup will consists of:

- *nuBall*
- *4 PARIS clusters' detectors*

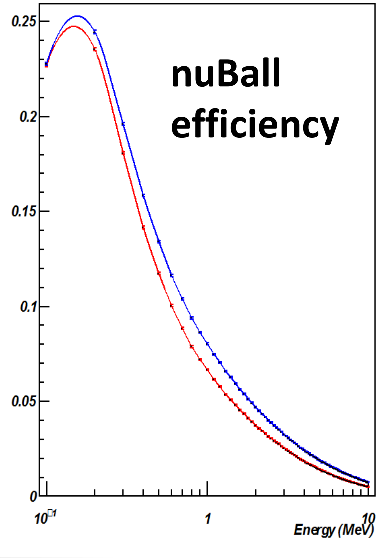
*Approved beam time is **21 shifts***

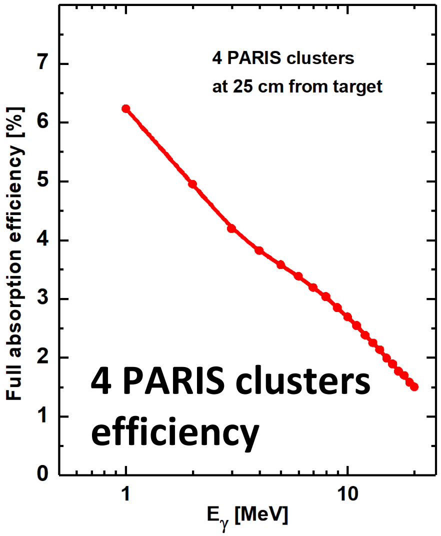
Experiment is planned to be done in June 2018

Experimental setup - proposed



- ***nuBall*** (24 clover HPGe detectors, 10 coaxial Ge detectors and 10 1.5”×2” $LaBr_3$:Ce detectors from FATIMA)
- ***4 PARIS clusters*** (4 x 9 phoswich $LaBr_3$/$CaBr_3$+NaI detectors) at backward angles at 25 cm distance for neutron discrimination



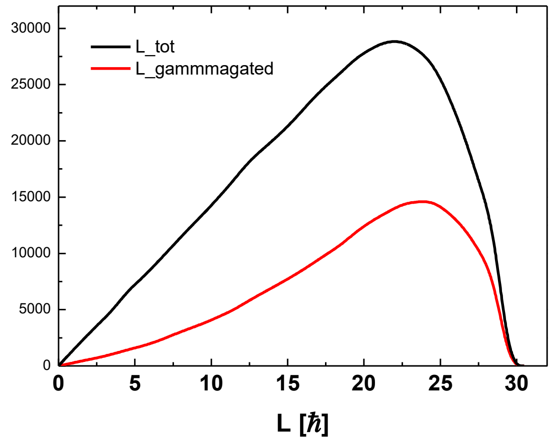


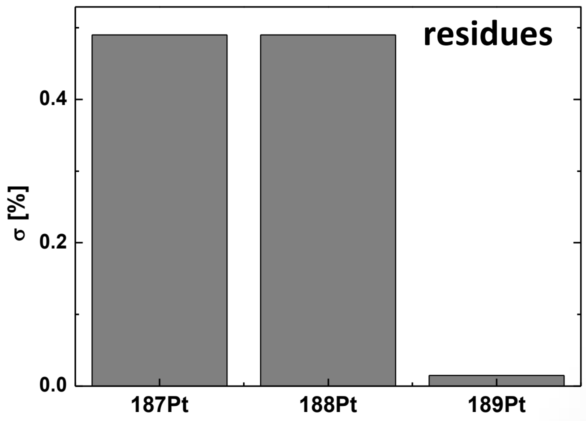
Reaction – from proposal

^{18}O @ 82MeV on ^{174}Yb 1.2 mg/cm^2 thick target

Injected Ion species	Injected Intensity (nA)	charge	Terminal voltage (MV)	Energy (MeV)	I analysed électrique (nA)	I analysed max. Possible	Frequency pulsation (ns)
$^{18}O^-$	600	6^+	12,84	82	280	420	400 ns

$^{18}O + {}^{174}Yb \rightarrow {}^{192}Pt$ (E*= 52 MeV, L_{max} = 26 ħ)





beam time estimation

Reaction parameters:

fusion evaporation cross section = 363 mb

^{188}Pt cross section = 176 mb

target thickness = 1.2 mg/cm^2

I_{beam} = 280 nA

We will require simultanously:
- low energy gamma measured by nuBall
- high energy gamma measured by PARIS

nuBall efficiency @ 500 keV = 10%

PARIS efficiency @15 MeV = 2%

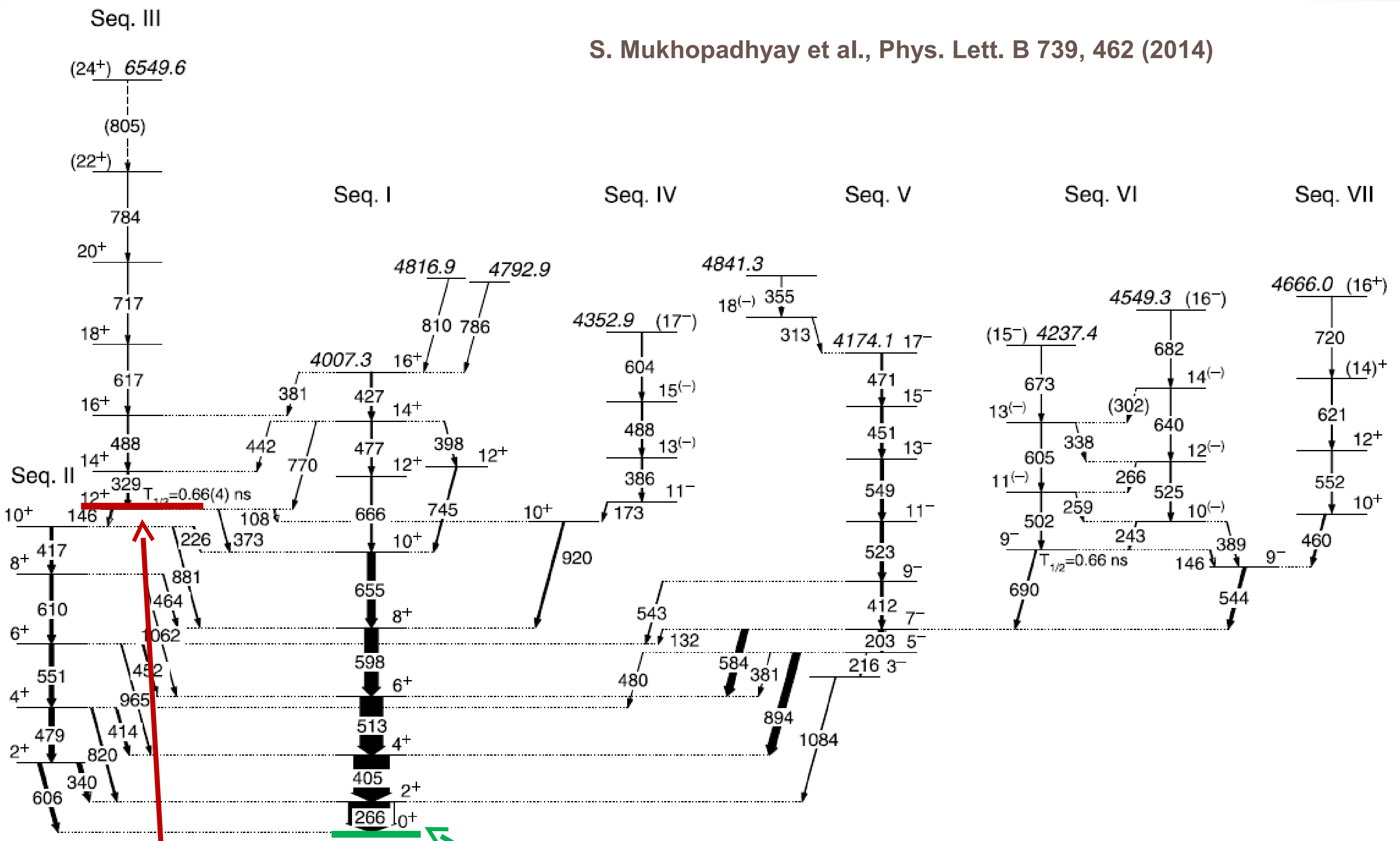
Estimated: **~120 events per shift (8 hours)** for coincidence of GDR with low intenstity gammas from the side band

Minimum for GDR line shape is ~ 2500 counts → **21 shifts**

Based on this estimation **we ask for 21 shifts (7 days) of beam** and **2 additional shifts** for setting up detectors and calibration

^{188}Pt

S. Mukhopadhyay et al., Phys. Lett. B 739, 462 (2014)



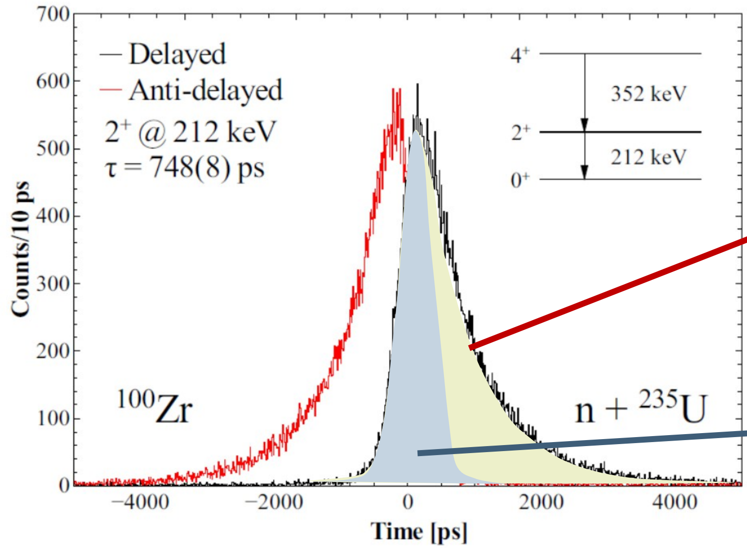
triaxial

near prolate

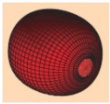
β =0.18and γ=−6°

β=0.16 and γ=−40°

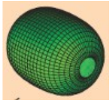
gating on time



gate on triaxial deformation



gate on (mostly) prolate deformation



result: GDR strength function delivering information on shape of hot nuclei decaying to given final deformation