FATIMA: a versatile tool for nuclear physics studies

S. Pascu

Design of the FATIMA detectors

FATIMA = FAst TIMing Array

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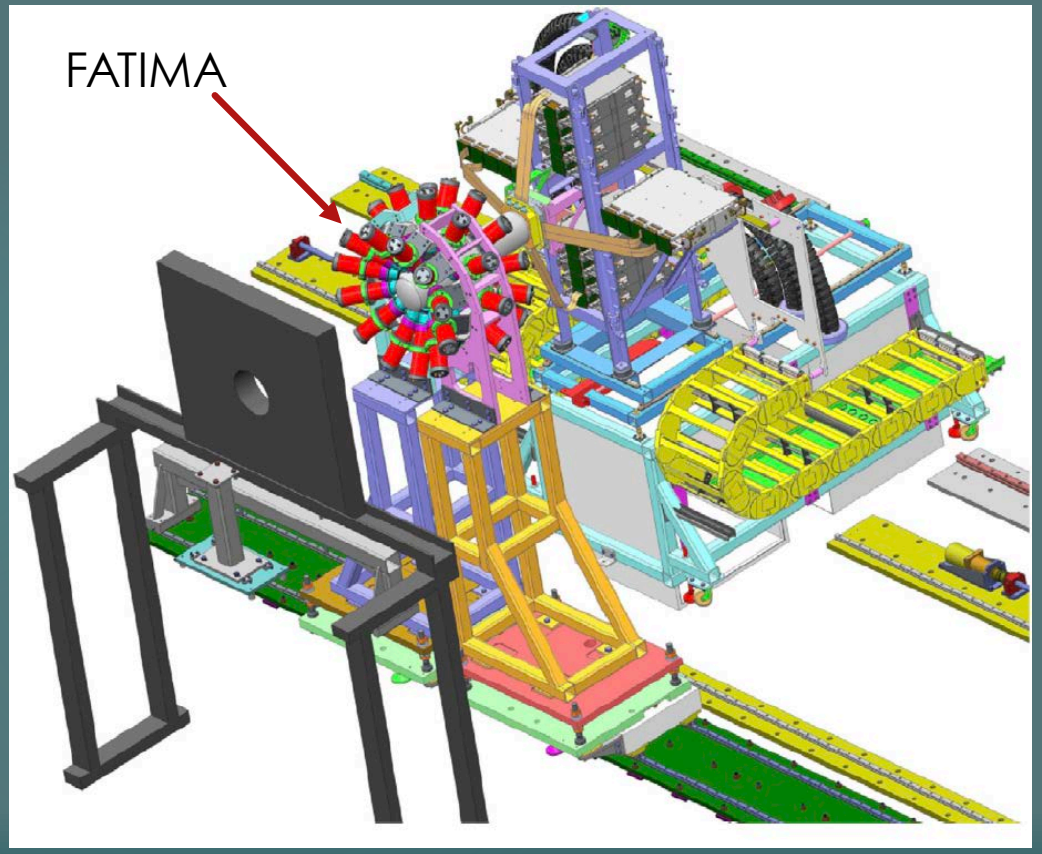
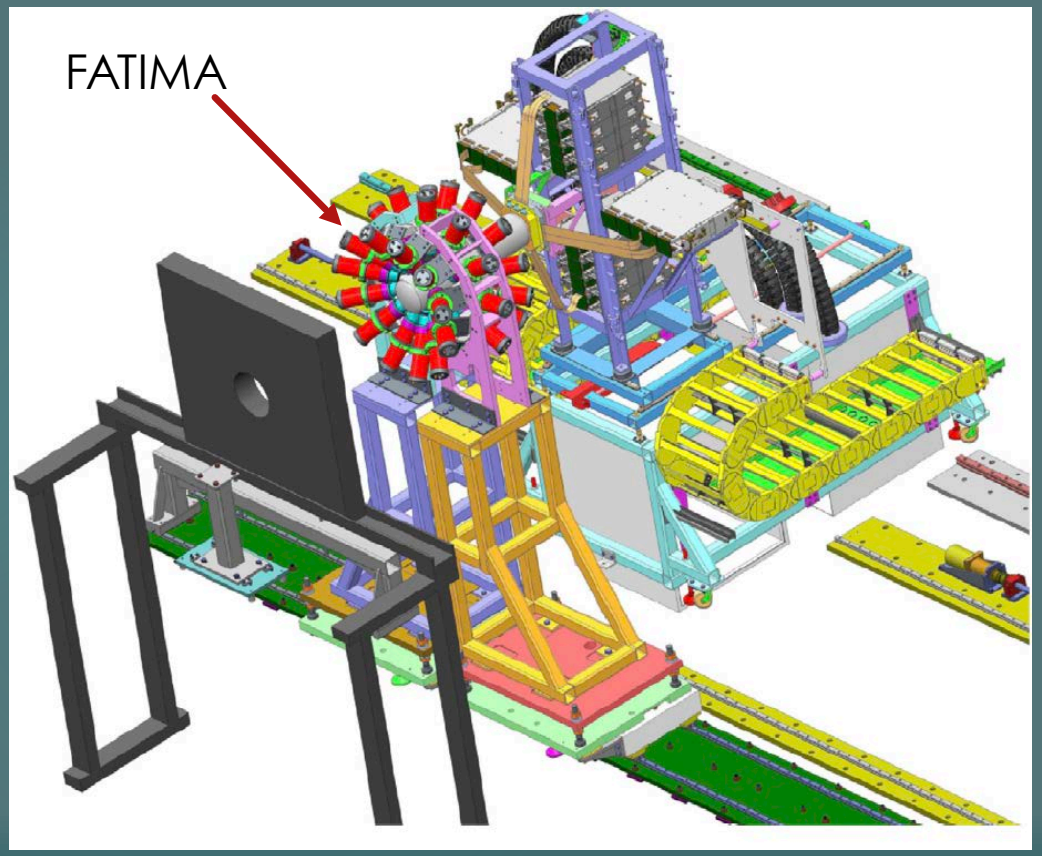


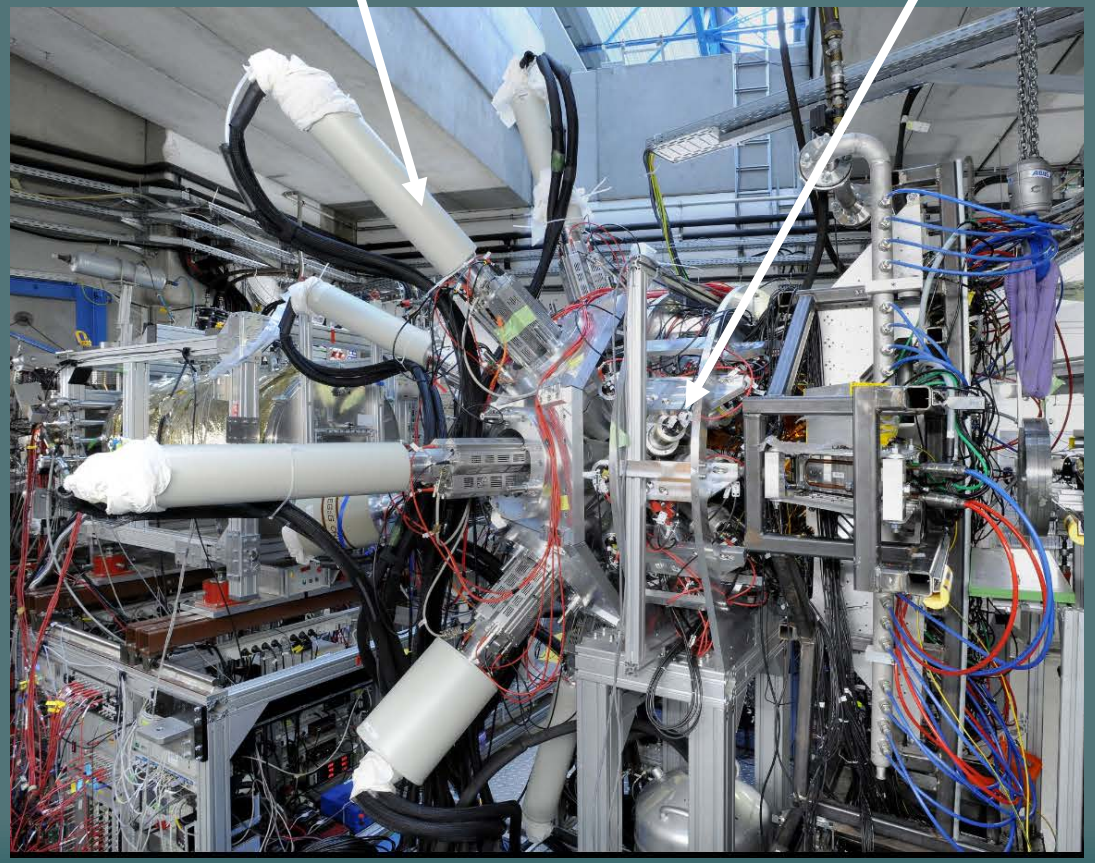
DESPEC@FAIR

Design of the FATIMA detectors

FATIMA = FAst TIMing Array

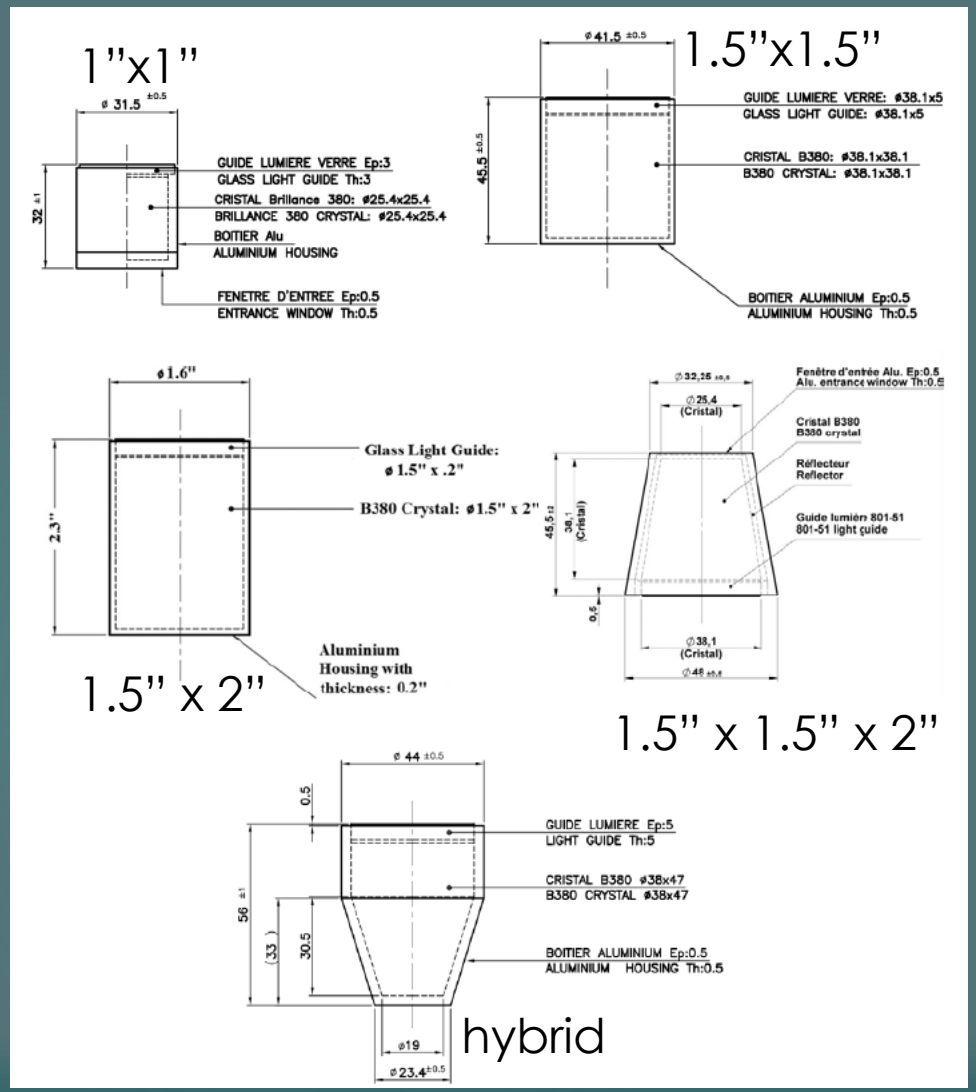


DESPEC@FAIR



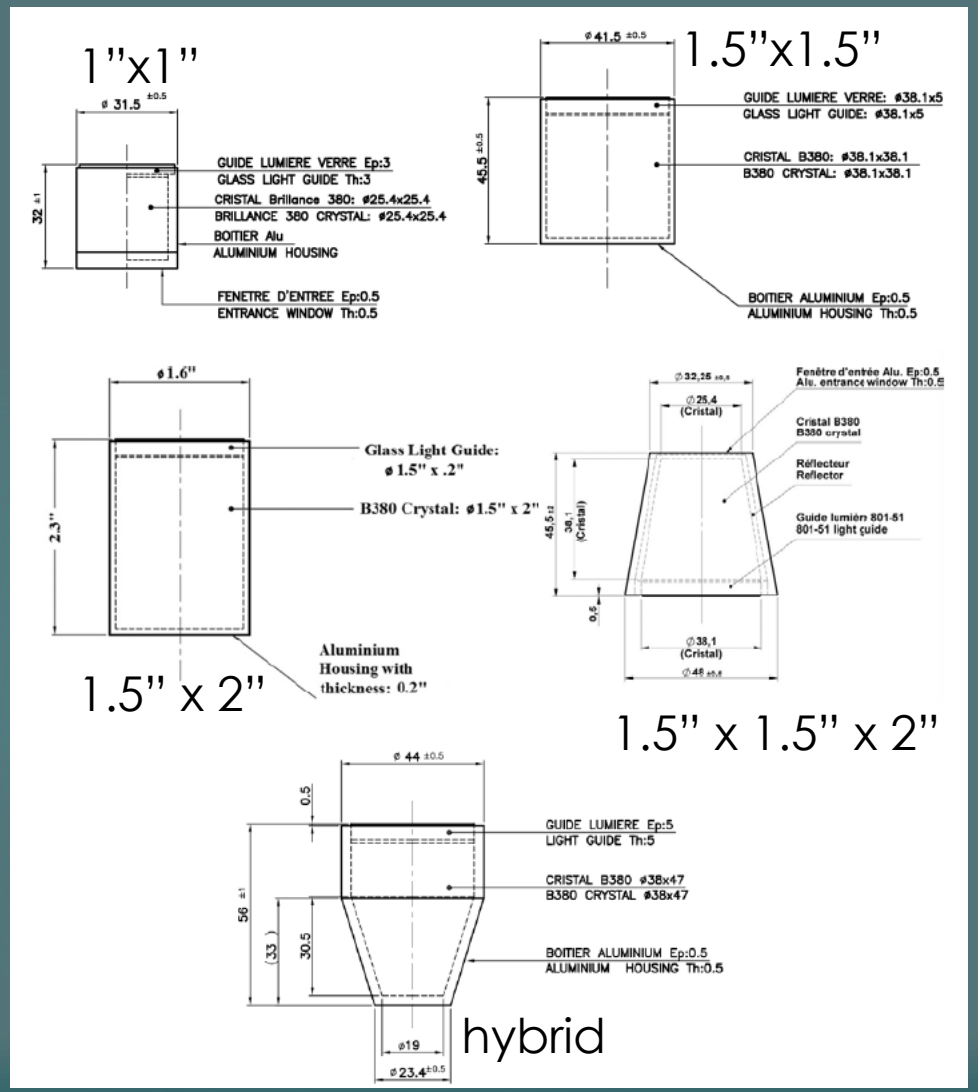
DESPEC@FAIR

Design of the FATIMA detectors



L.M. Fraile et al., FATIMA TDR (2015)

Design of the FATIMA detectors



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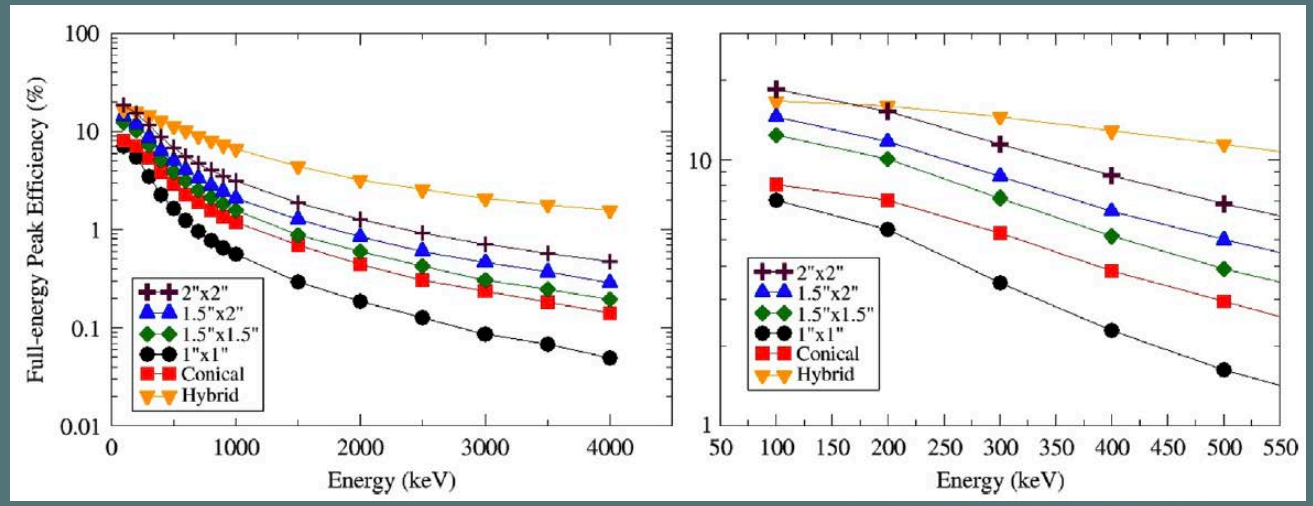
Energy performances



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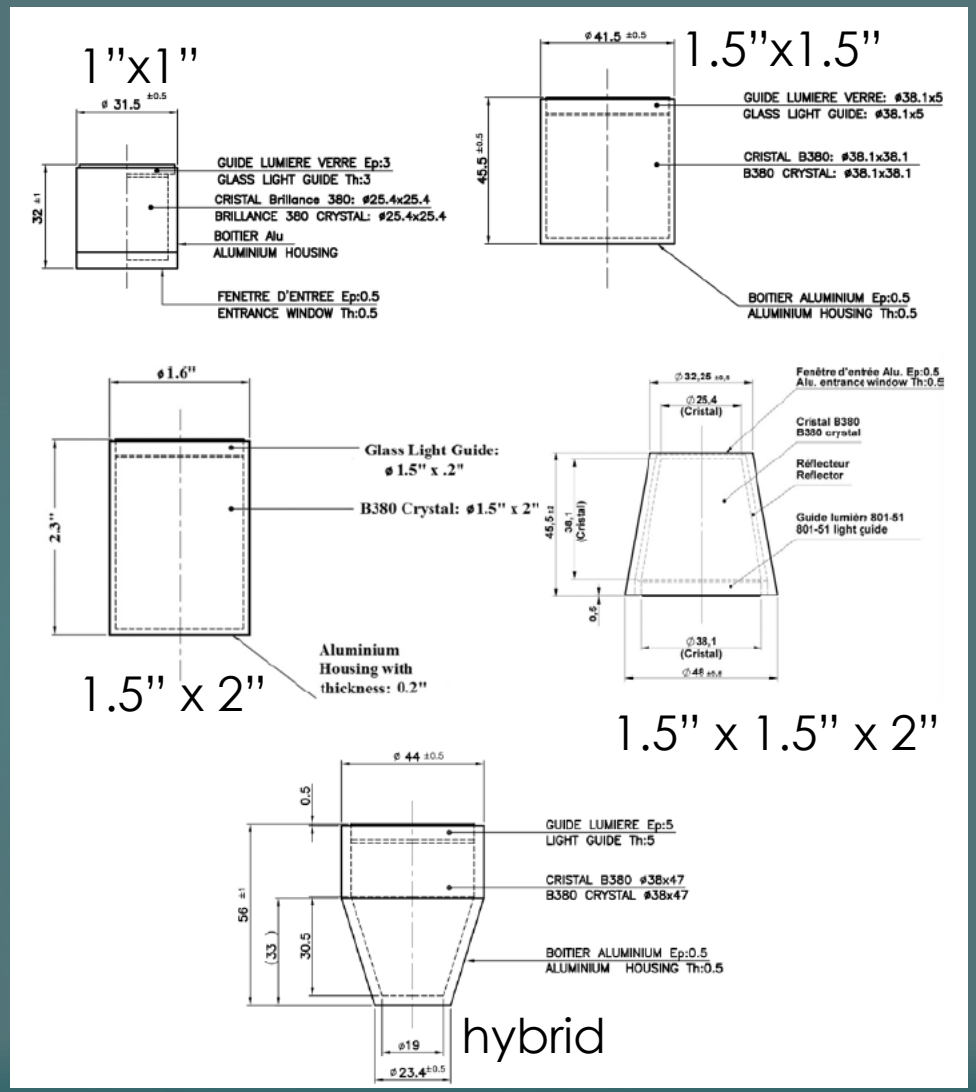

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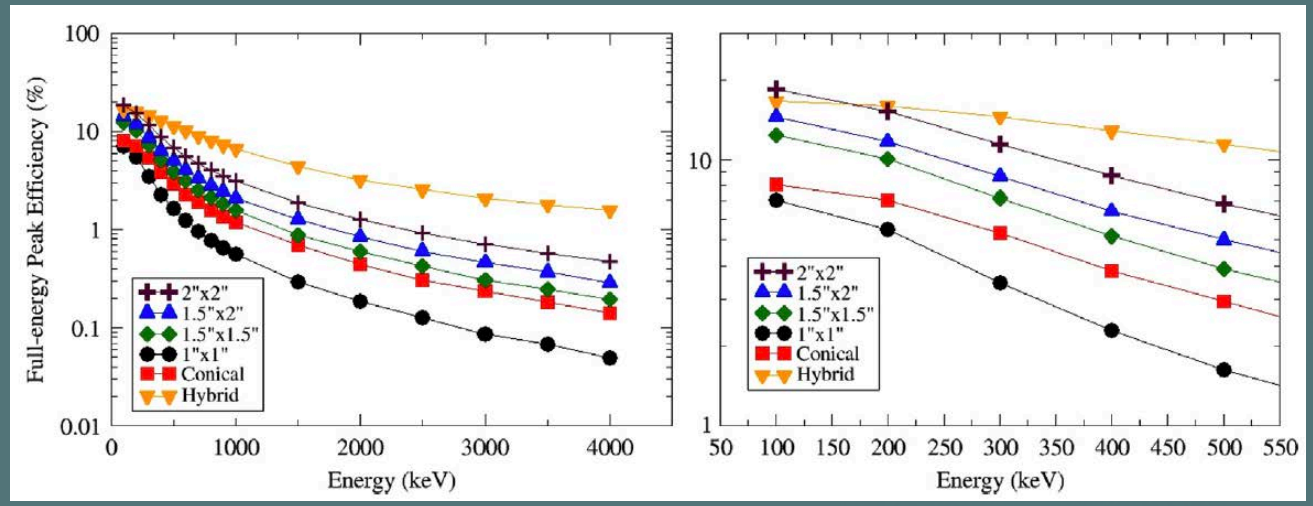


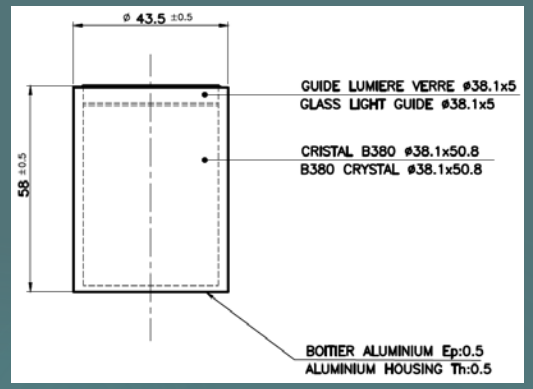
Timing performances

#	Dimensions	Geometry	T_{FWHM} at 511 keV	T_{FWHM} at 1332 keV
8	⌀2 in. × 2 in.	Cylindrical	450 [39]	300 [16]
10	⌀1.5 in. × 2 in.	Cylindrical	400	210
10	⌀1.5 in. × 1.5 in.	Cylindrical	360 [39]	180 [16]
13	⌀1 in. × 1 in.	Cylindrical	200 [29]	150 [16,35,40]
13	⌀1 in. × 1.5 in. × ⌀1.5 in.	Conical	–	160 [40]
13	⌀0.75 in. × 1.85* in. × ⌀1.5 in.	Hybrid	–	–

O.J. Roberts et al., NIM A 748, 91 (2014)

Design of the FATIMA detectors

1.5"x 2" $LaBr_3(Ce)$ crystals



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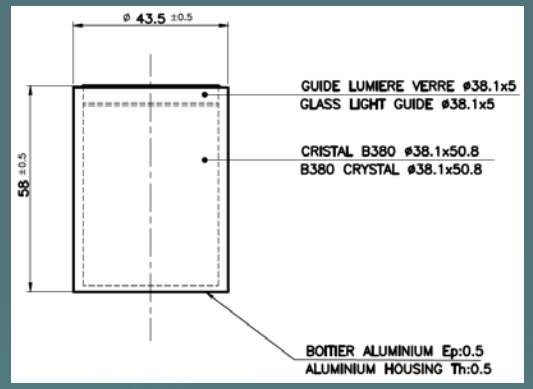
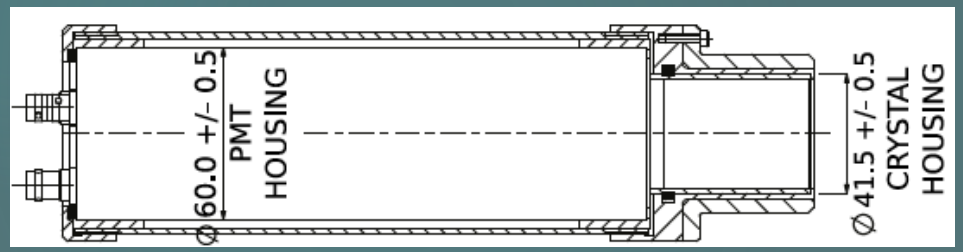
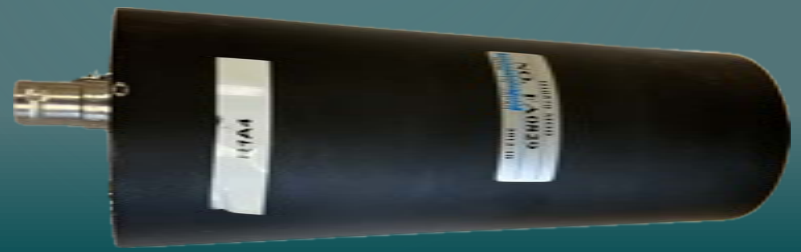


R9779 PMTs





Design of the FATIMA detectors

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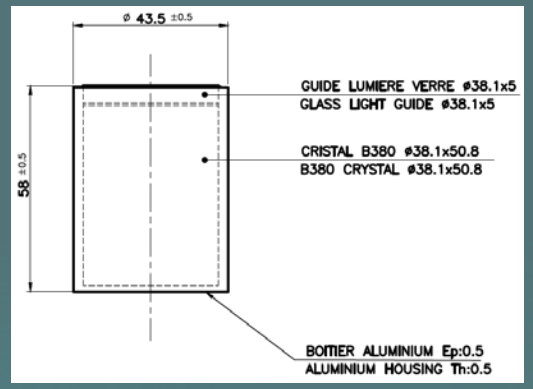
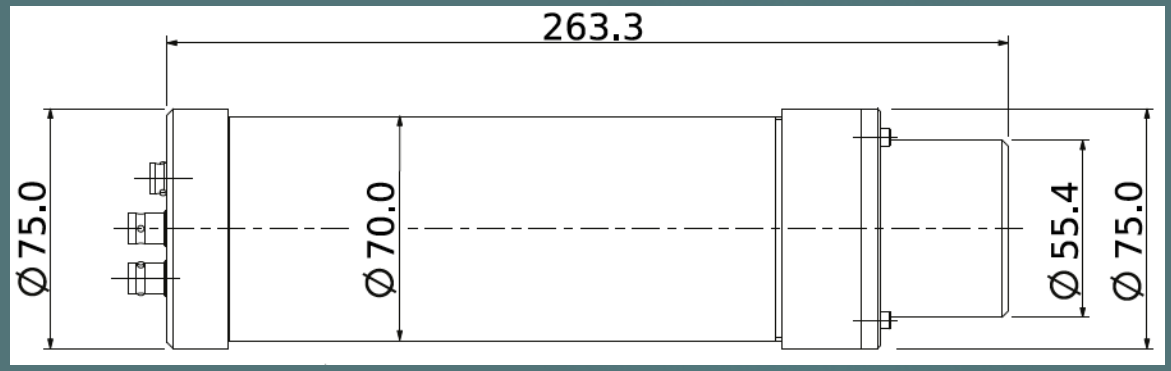


FATIMA = 36 detectors



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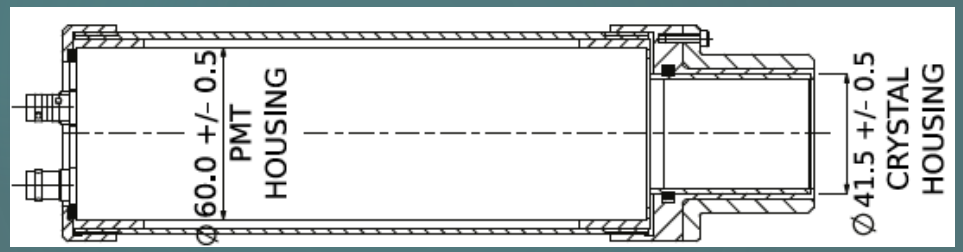
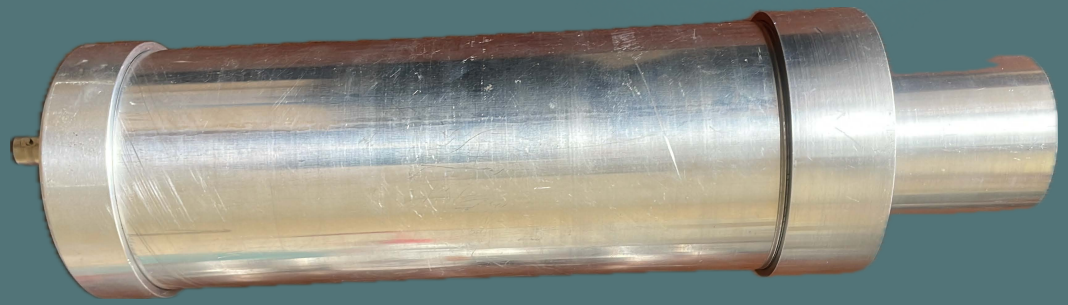
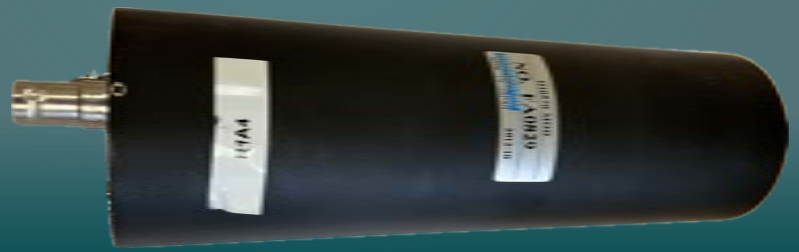


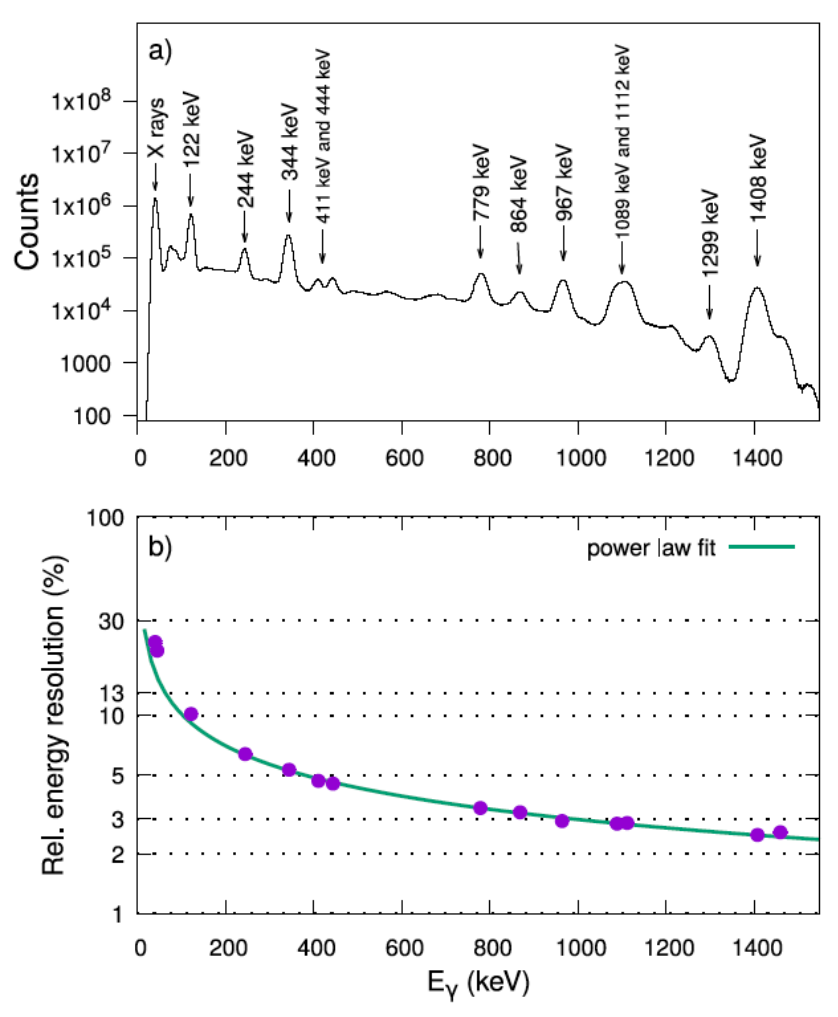




Characteristics of FATIMA detectors

Characteristics of FATIMA detectors

Energy performances



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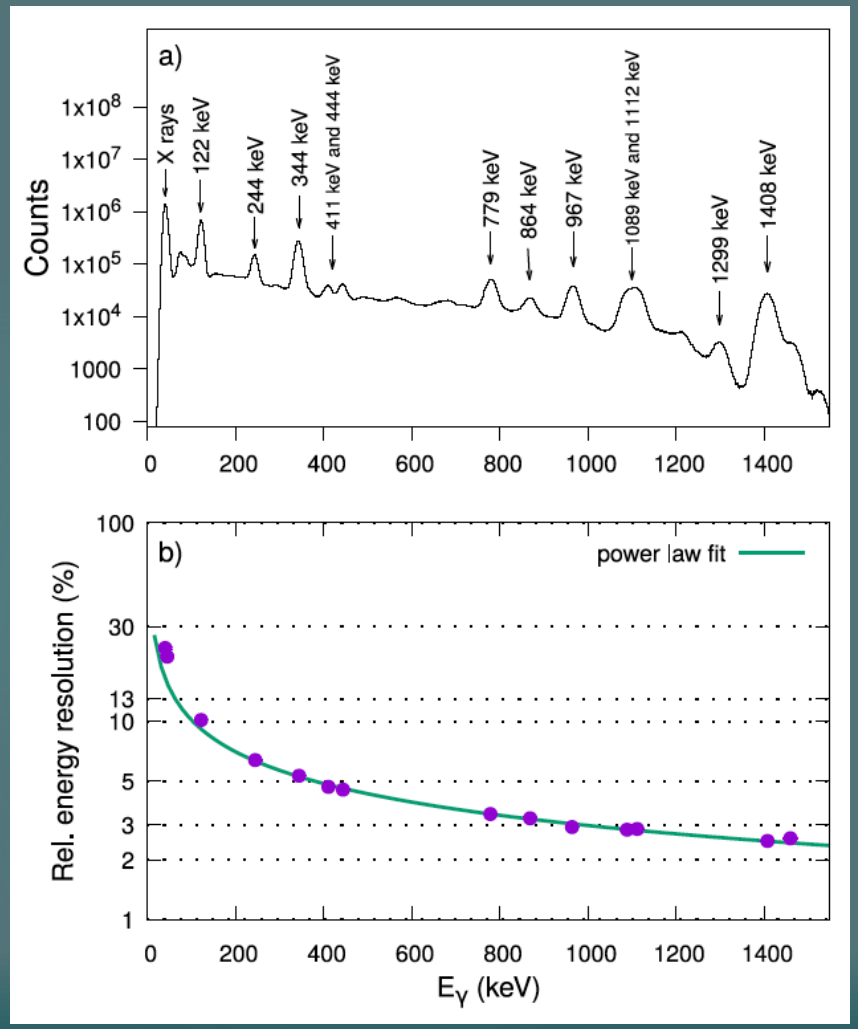
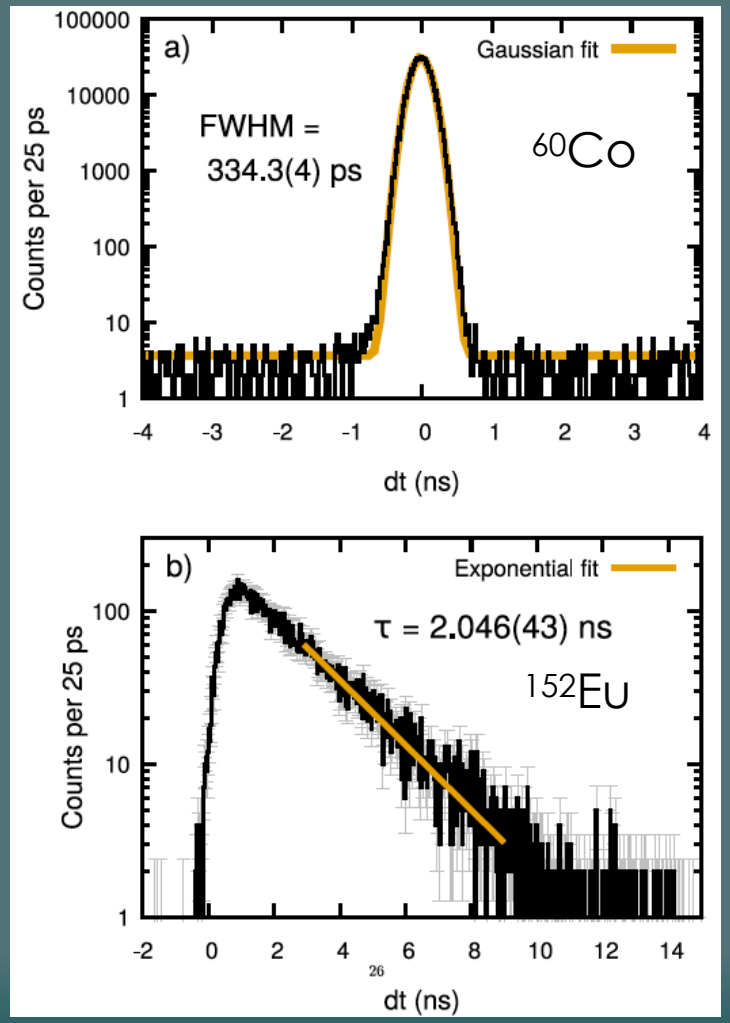


Timing performances



M. Rudigier et al., NIM A 969, 163967 (2020)

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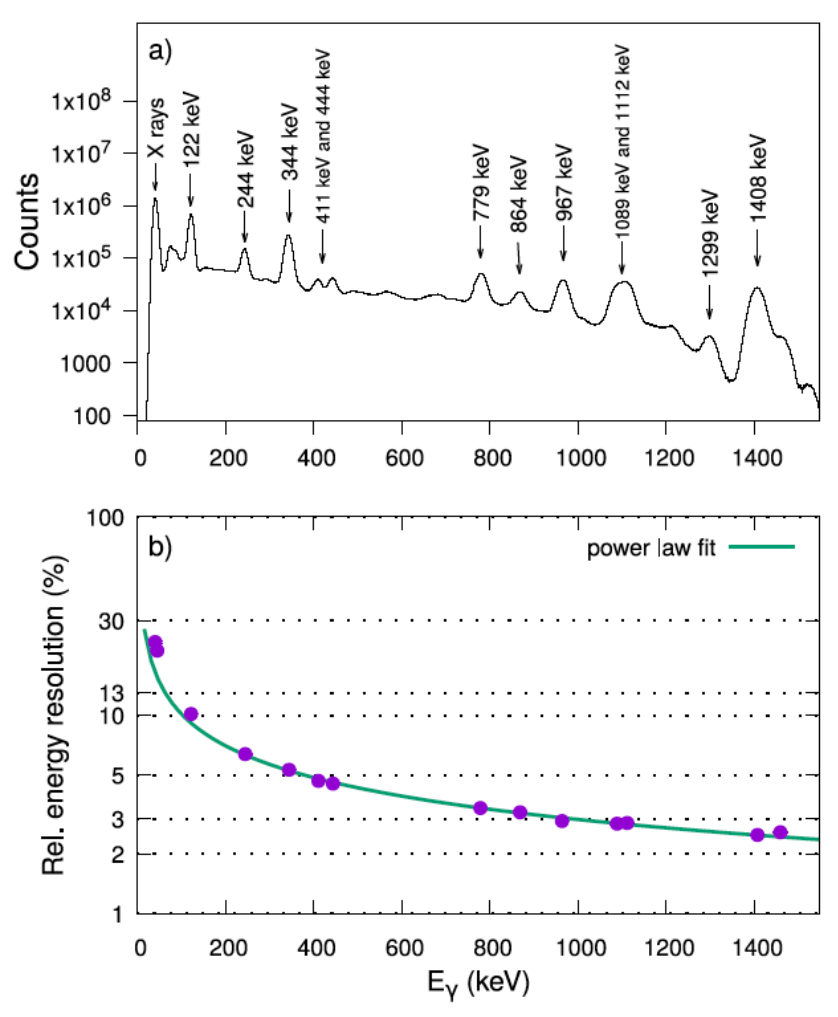

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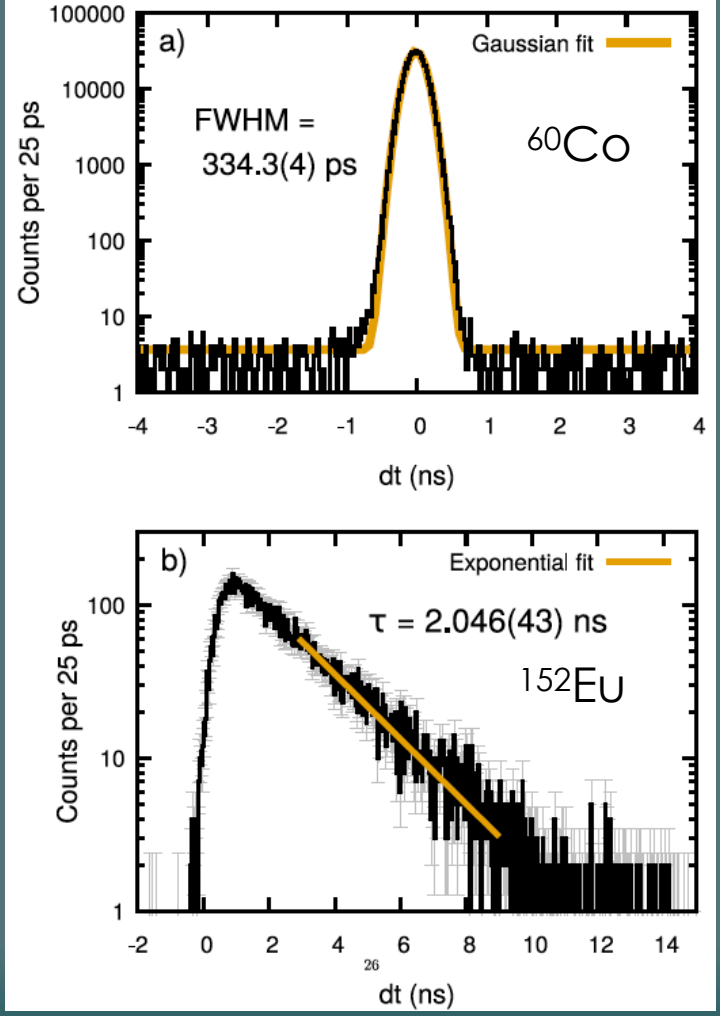
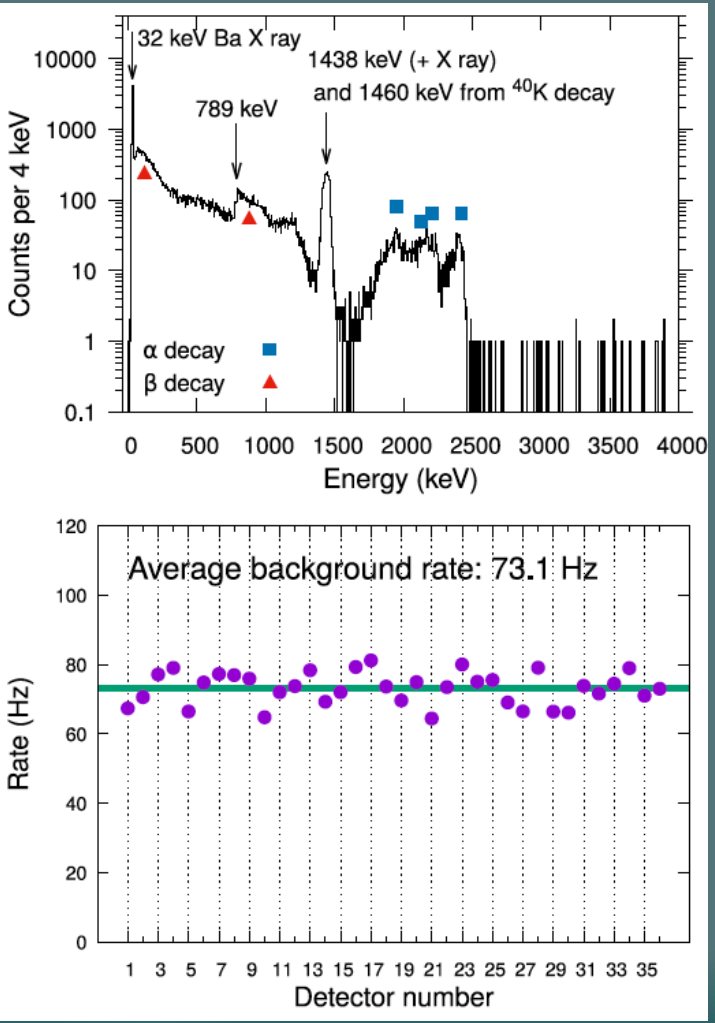
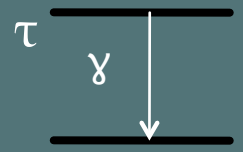


Internal radioactivity



M. Rudigier et al., NIM A 969, 163967 (2020)

FATIMA: a tool for Fast-timing measurements



$N=N_0e^{-t/\tau}$

$$\lambda_{if}(\sigma L) = \frac{8\pi(L+1)}{\hbar L((2L+1)!!)^2}\left(\frac{E_\gamma}{\hbar c}\right)^{2L+1} B(\sigma L; J_i^\pi \rightarrow J_f^\pi),$$

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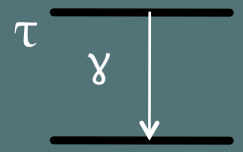

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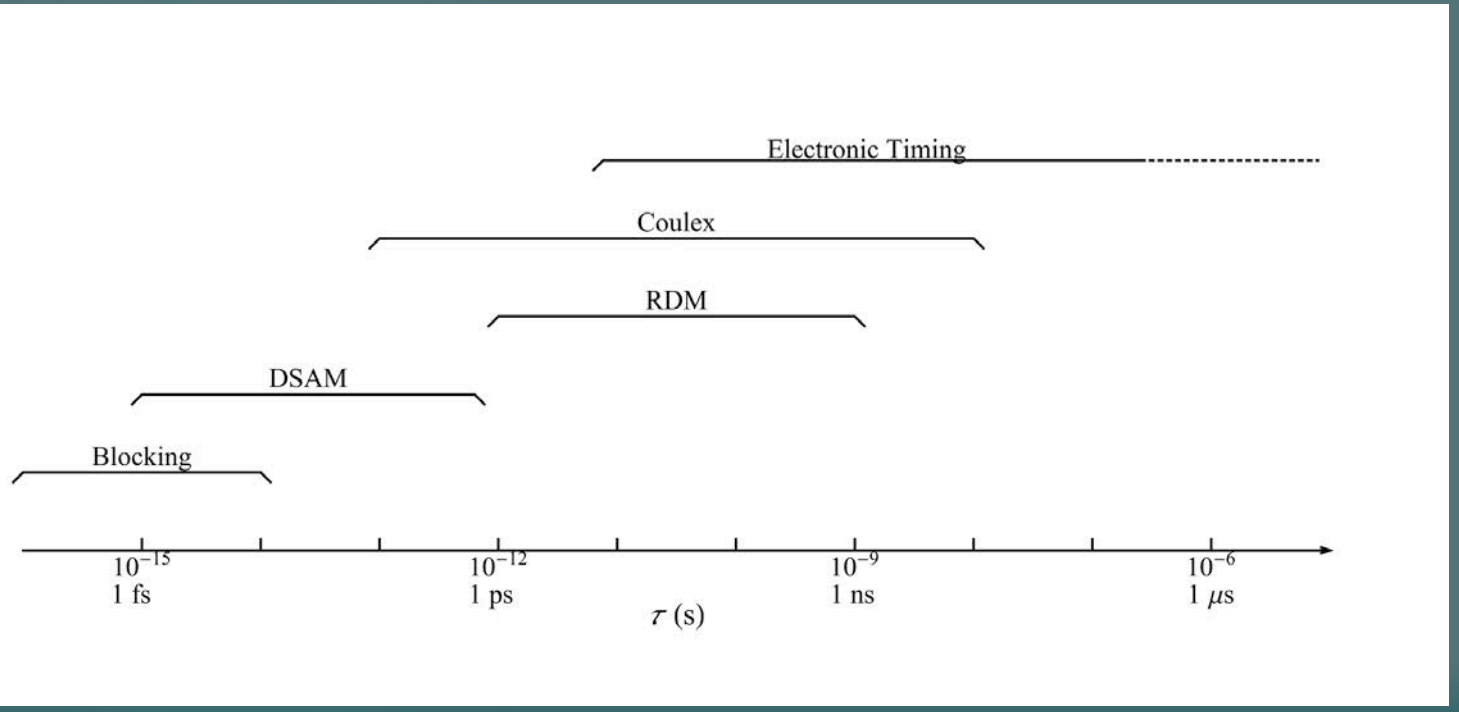

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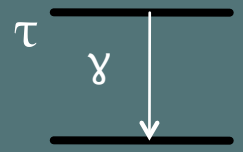

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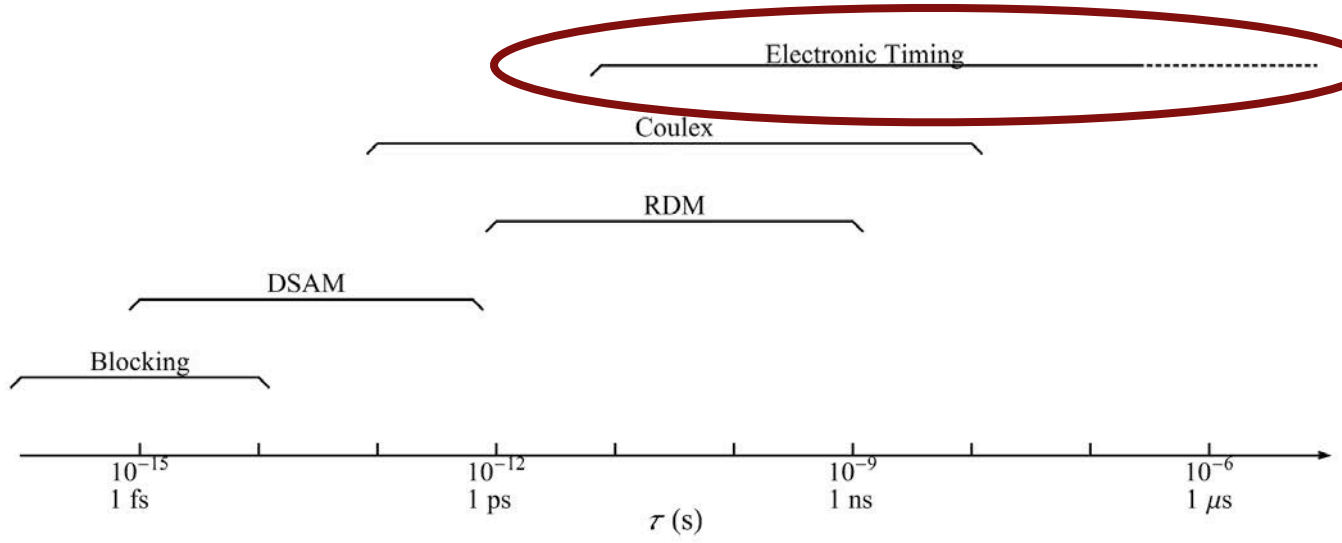

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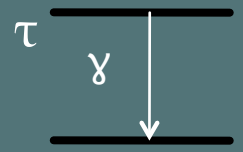

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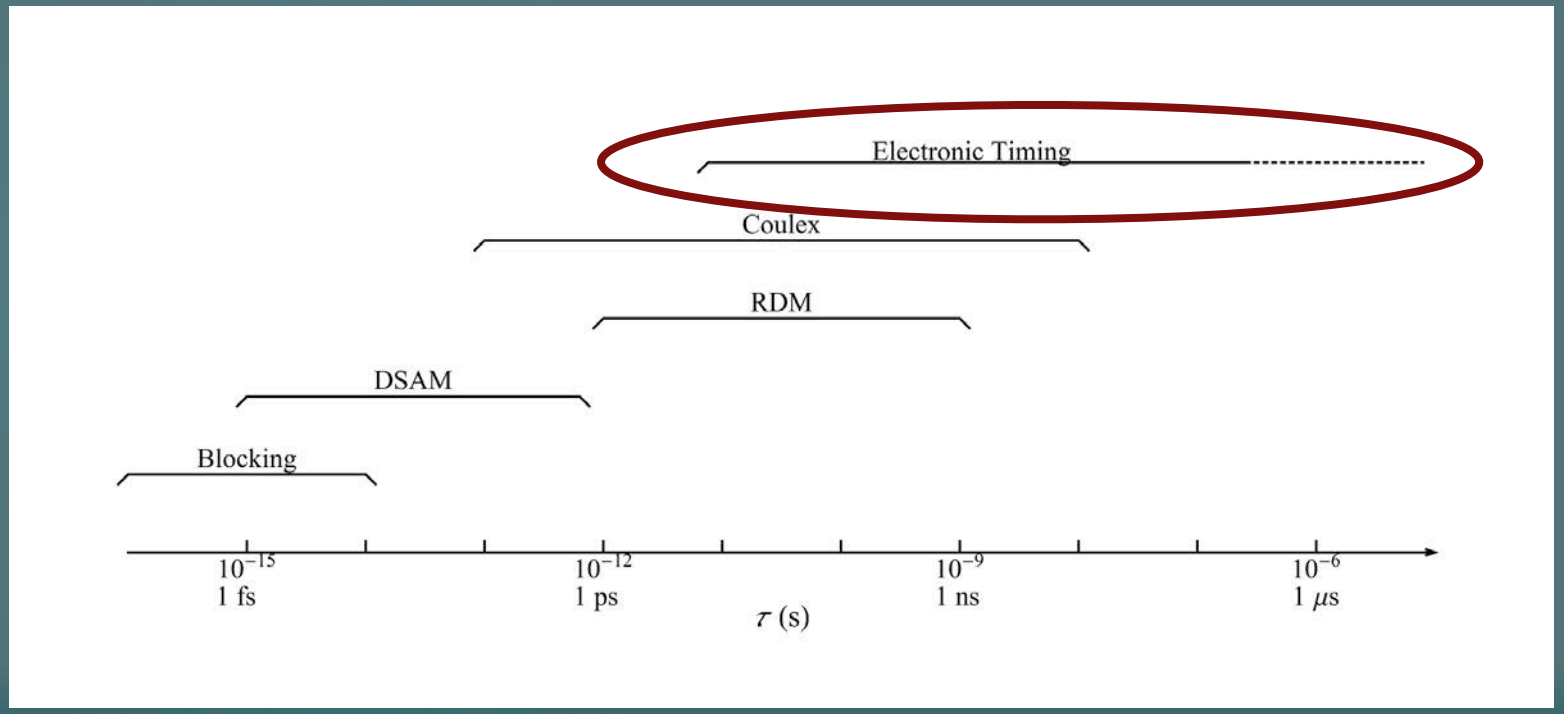
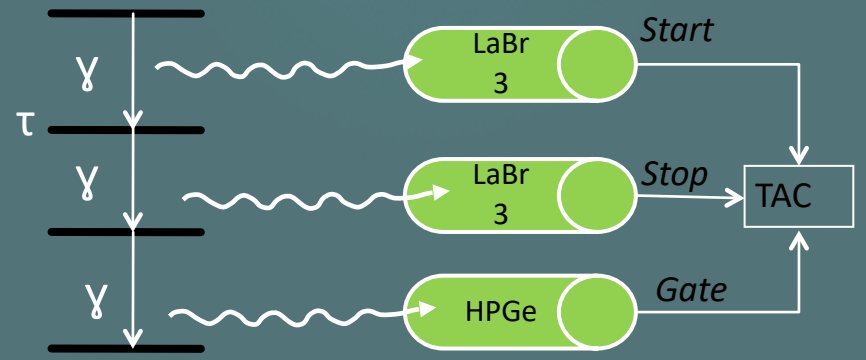
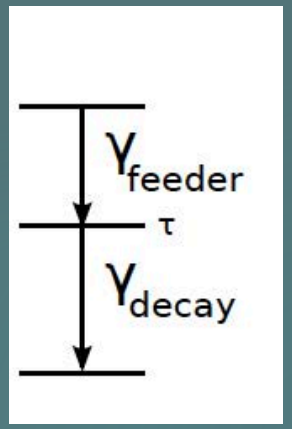
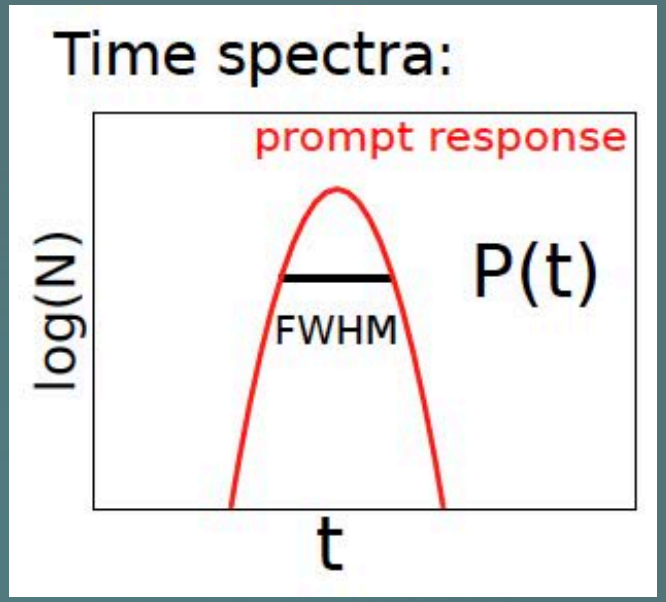




FATIMA: a tool for Fast-timing measurements

Prompt



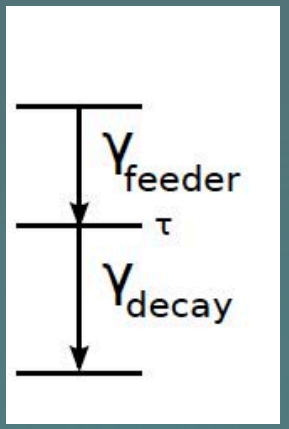


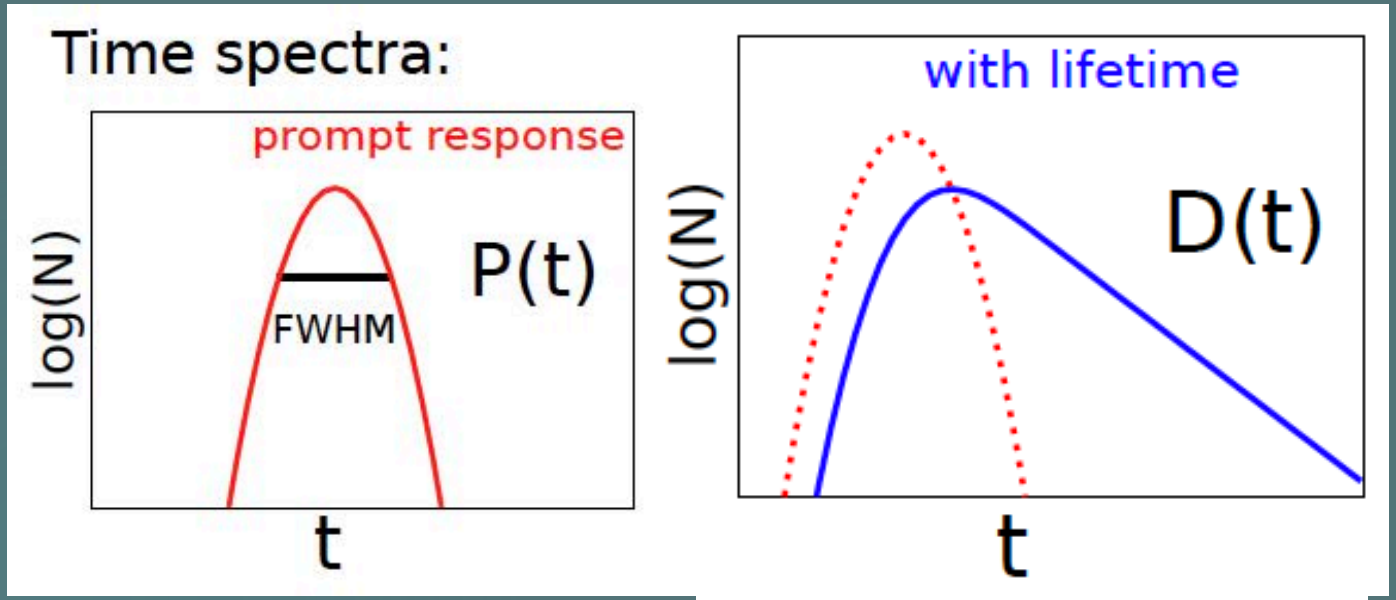
Gaussian

FATIMA: a tool for Fast-timing measurements

Prompt

Deconvolution





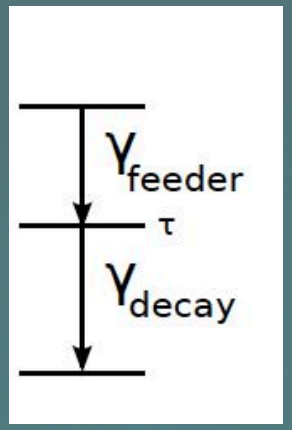
Gaussian

$$D(t) = \lambda N_0 \int_{-\infty}^{t} P(t') e^{-\lambda(t-t')} dt'$$

$$D(t) = \frac{N_0}{2\tau} e^{\frac{\sigma^2}{2\tau^2} - \frac{t-t_0}{\tau}} \operatorname{erfc}\left(\frac{\sigma}{\sqrt{2}\tau} - \frac{t-t_0}{\sqrt{2}\tau}\right)$$

M. Rudigier, private communication

FATIMA: a tool for Fast-timing measurements



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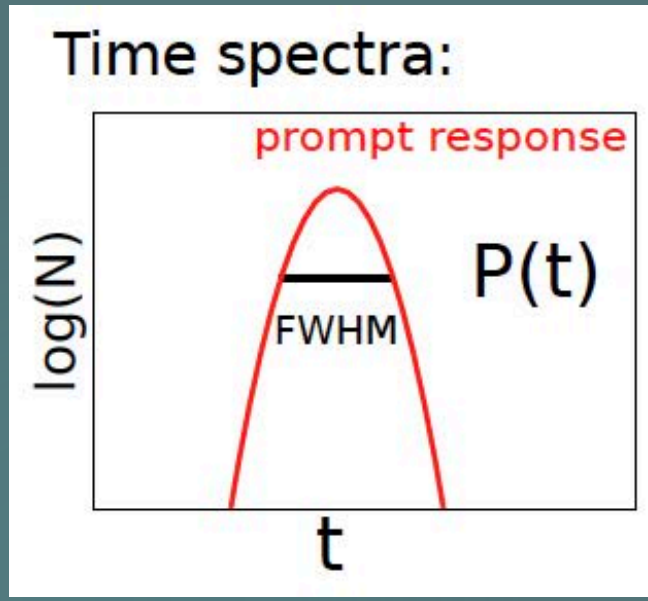

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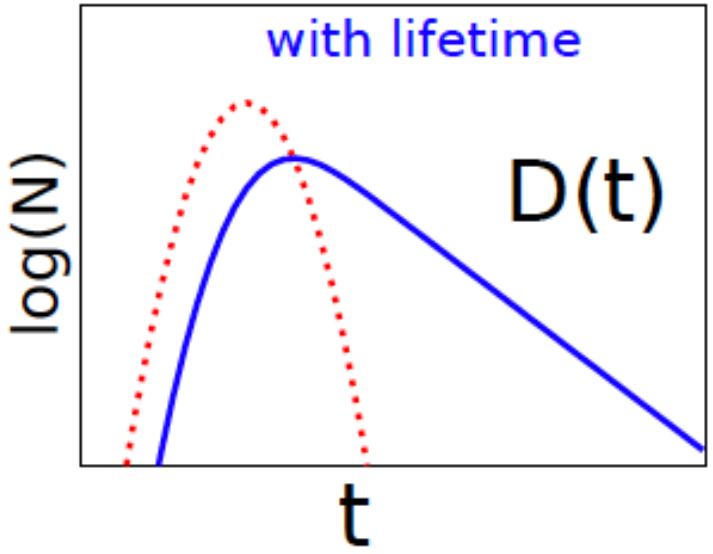

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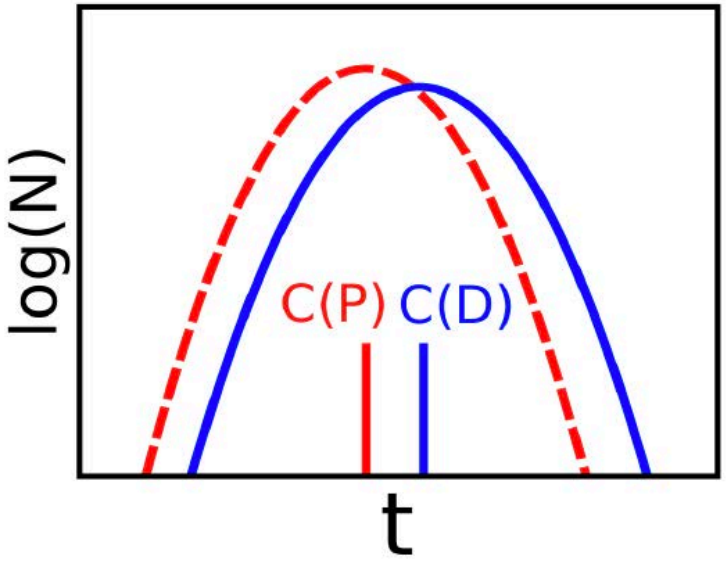
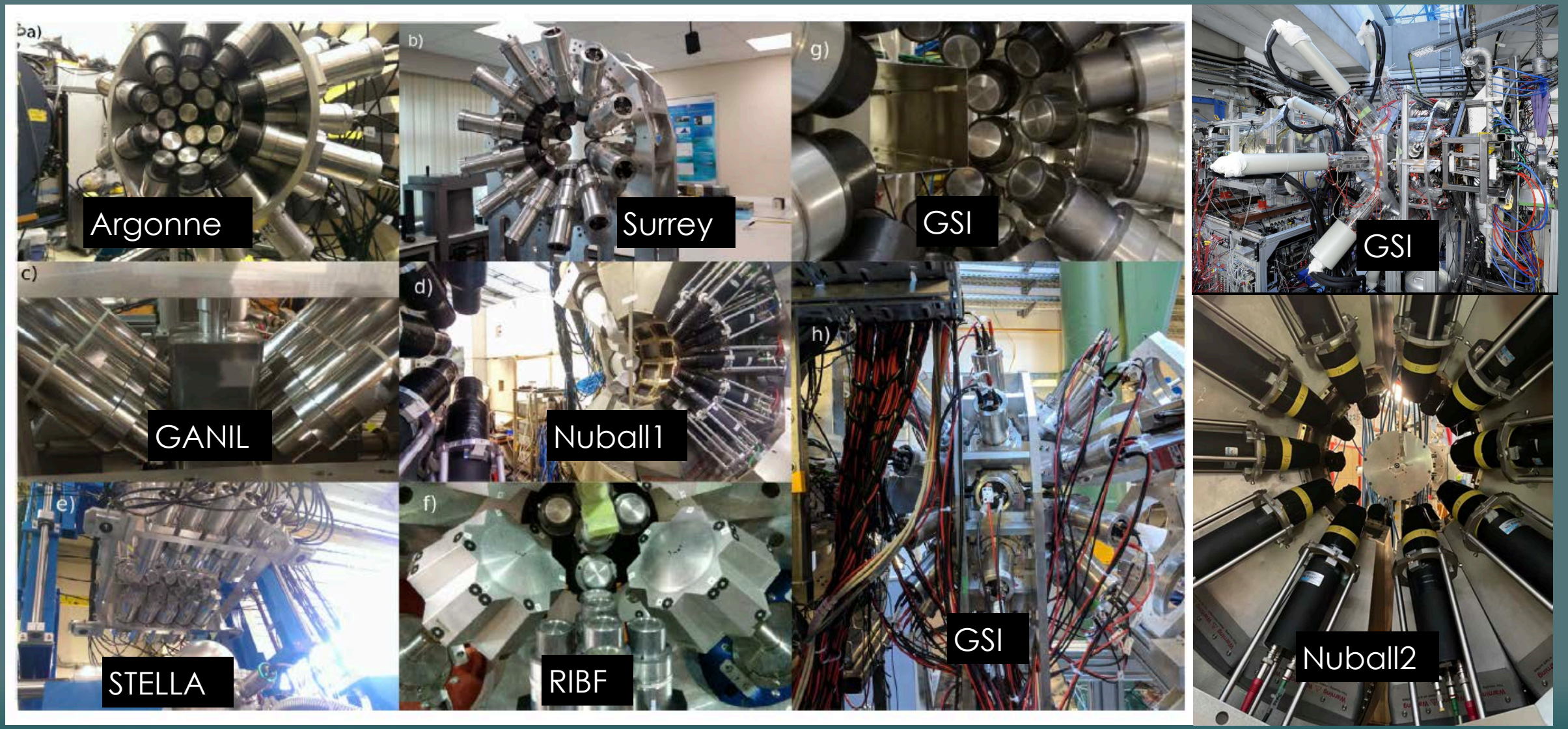
M. Rudigier, private communication

Centroid shift method



$$\tau = C(D) - C(P)$$

FATIMA on the road



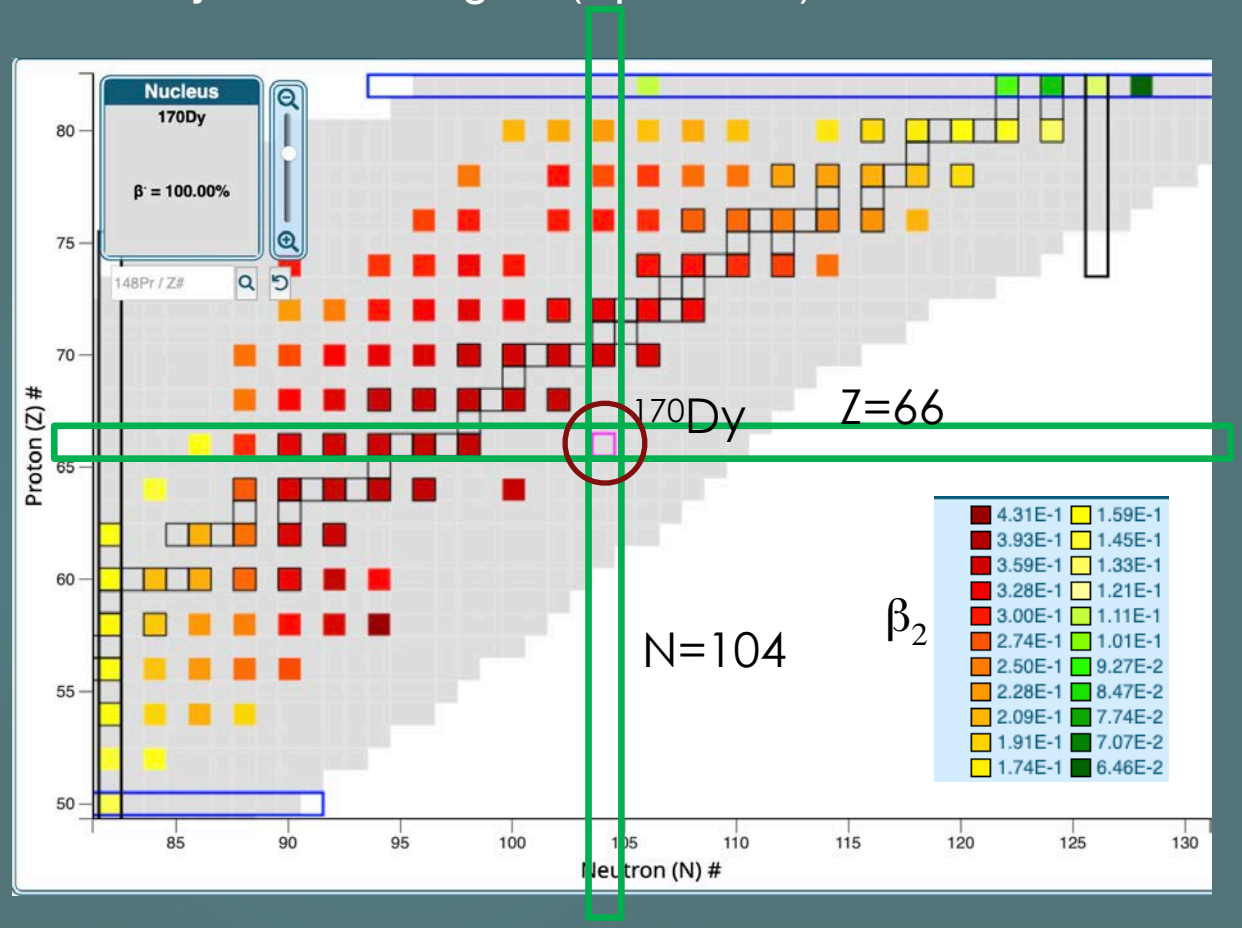
M. Rudigier et al., NIM A 969, 163967 (2020)

FATIMA @ GSI

Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (April 2024)

FATIMA @ GSI

Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (April 2024)



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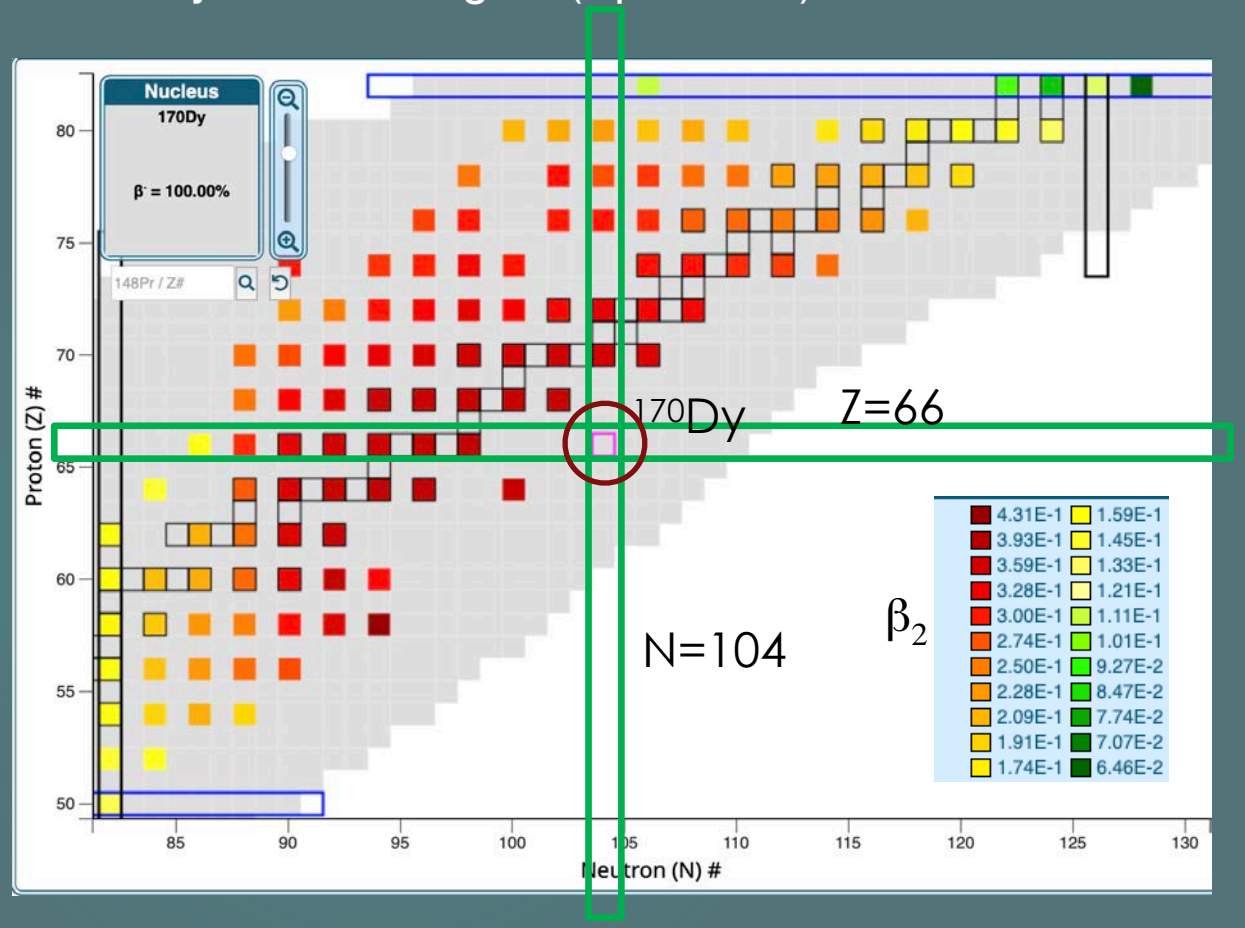
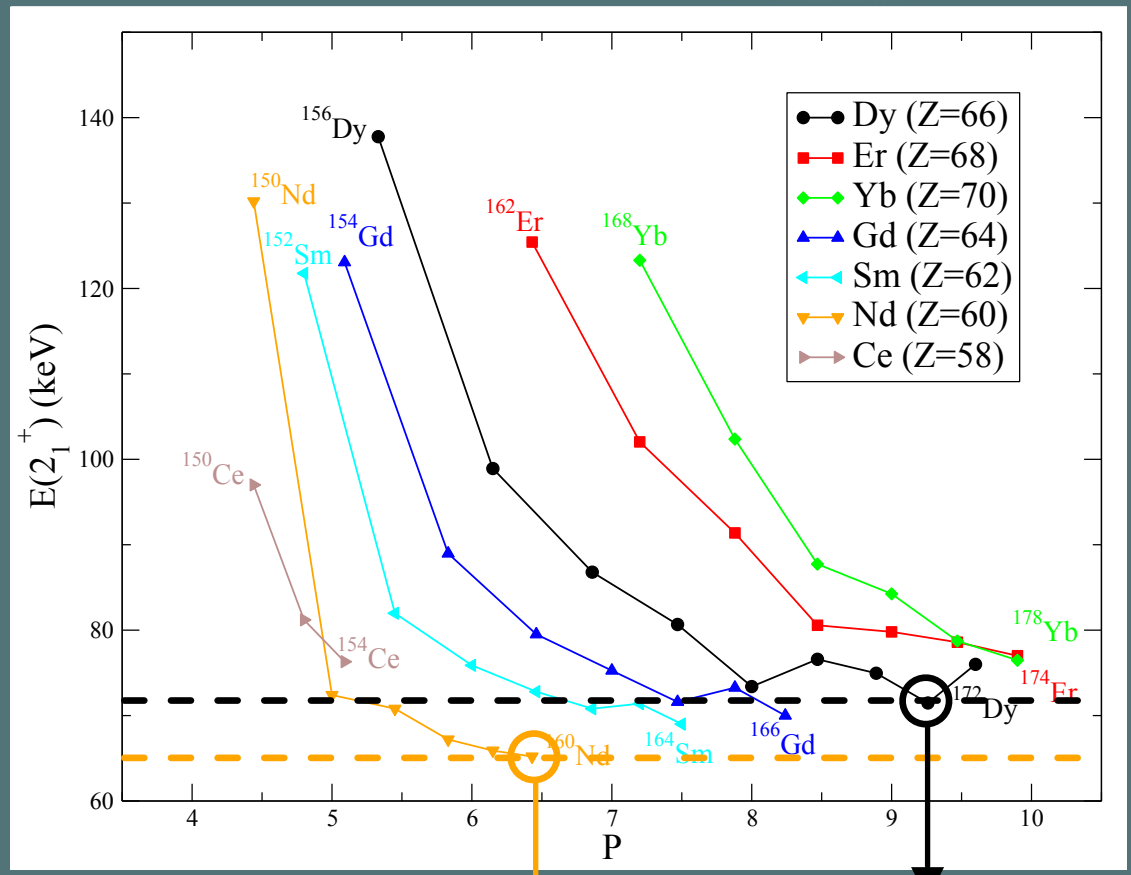
Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (April 2024)





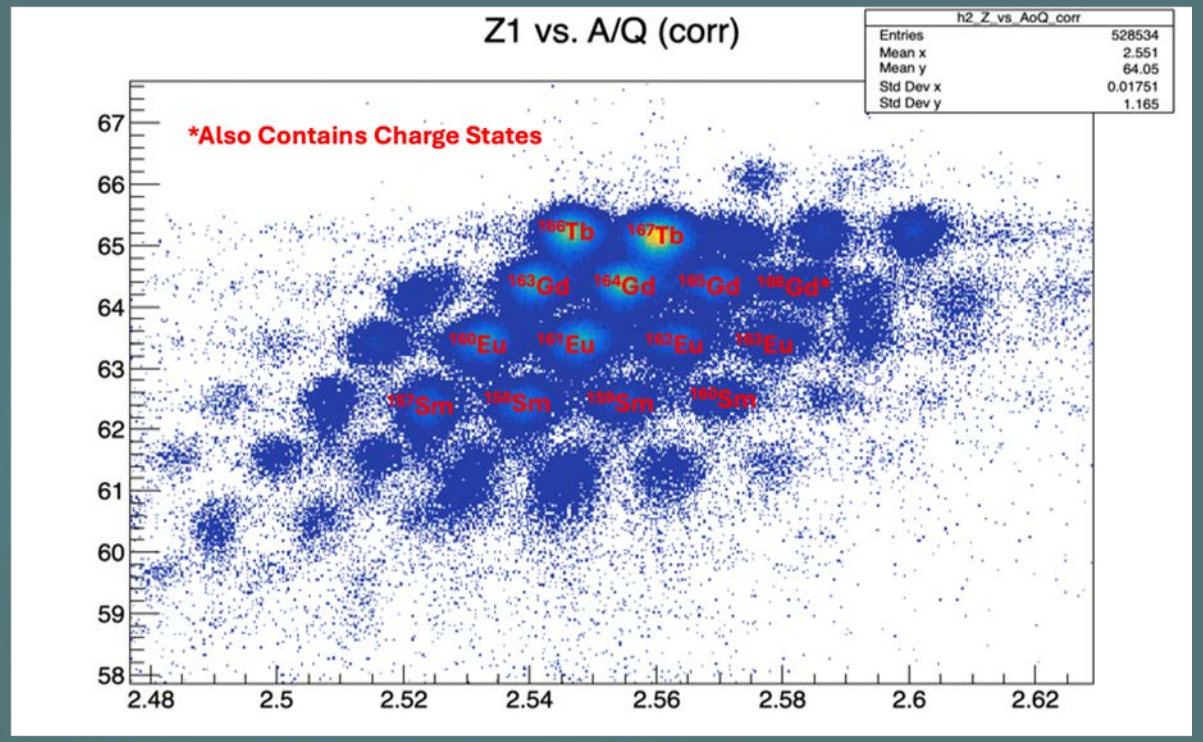
160Nd

170Dy

FATIMA @ GSI

Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (April 2024)

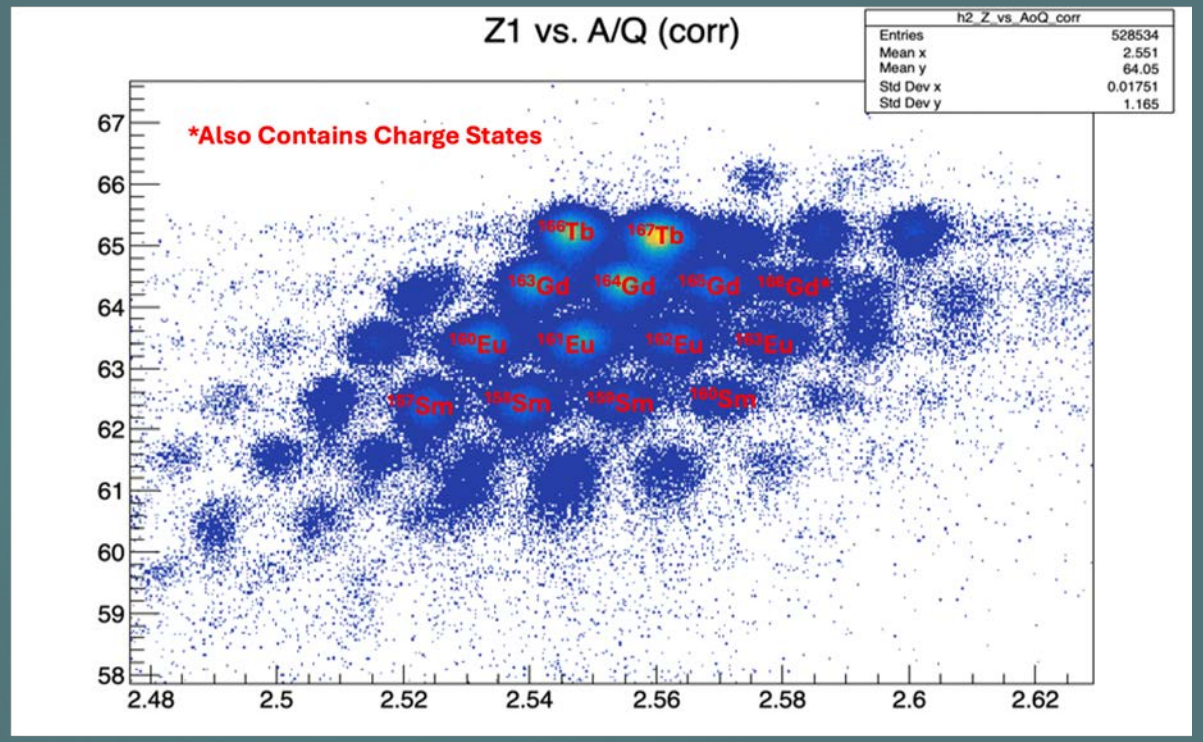
Fragmentation of the new ^{170}Er beam



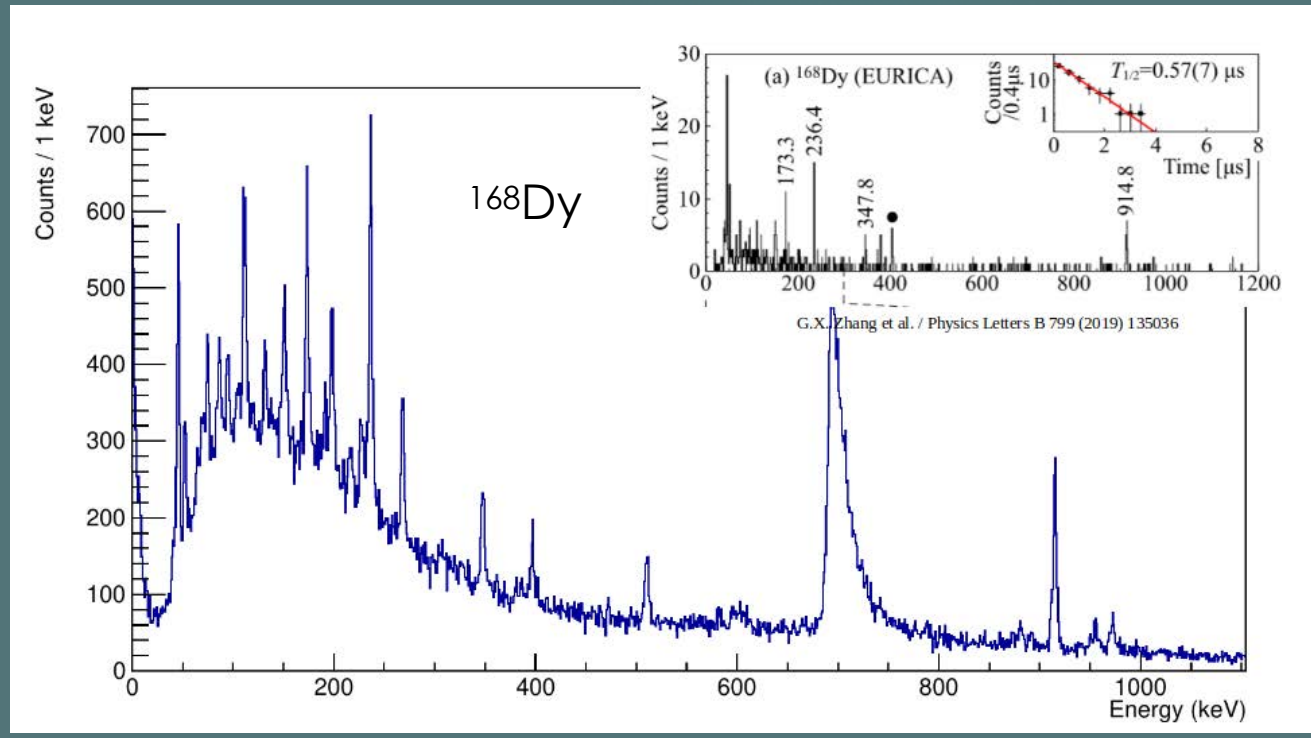
FATIMA @ GSI

Structure evolution in highly-deformed rare-earth nuclei in the A~170 doubly-midshell region (April 2024)

Fragmentation of the new ^{170}Er beam



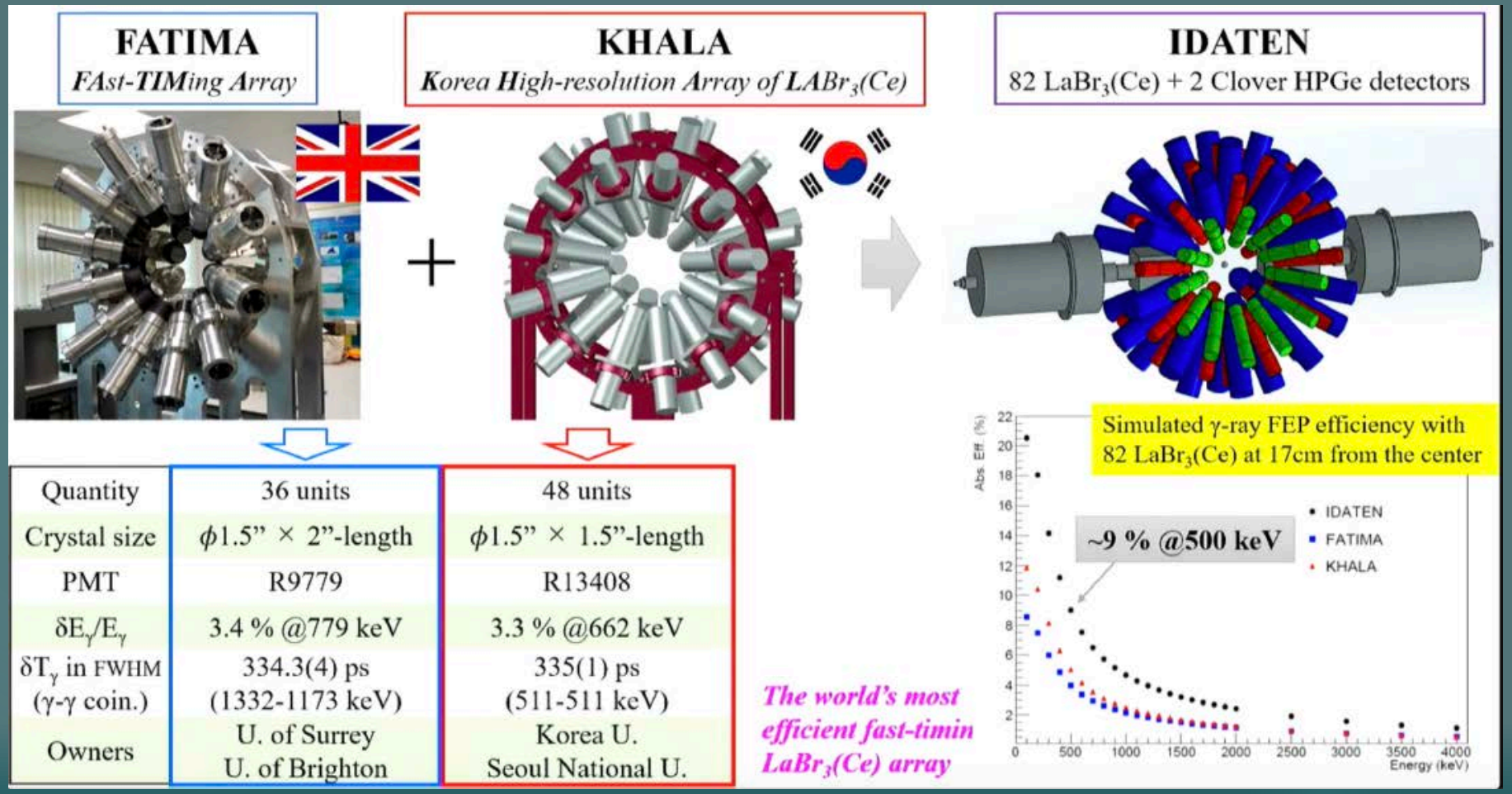
Subset of online data, DEGAS HPGe spectrum



Courtesy of H. Albers

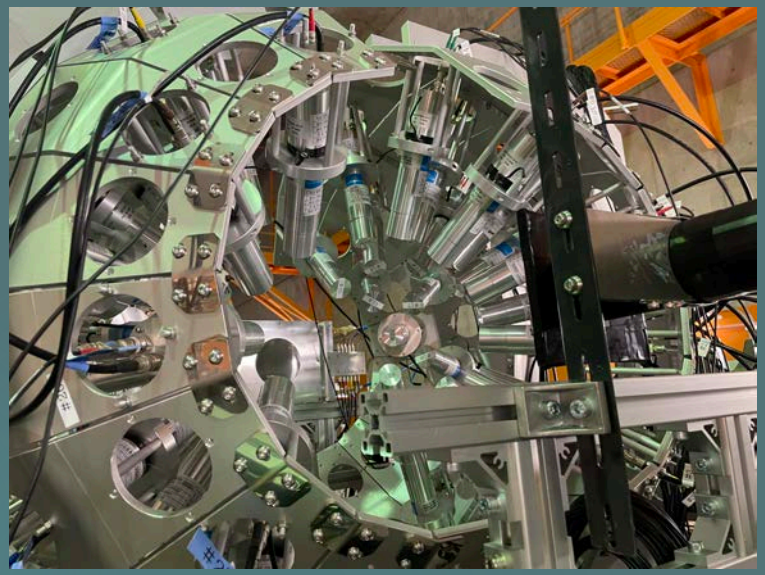
FATIMA @ RIBF

New lifetimes measurement campaign @ RIBF
IDATEN: International Detector Assembly for fast-Timing measurements of Exotic Nuclei



FATIMA @ RIBF

Current frame at F11



FATIMA @ RIBF

Current frame at F11

Total rate at F11: 155 cps

^{96}Cd 1.33e-4 0.008%	^{97}Cd 1.92e-1 0.529%	^{98}Cd 1.89e-4 2.2e-5%	^{99}Cd
^{95}Ag 1.93e-4 1.7e-4%	^{96}Ag 7.69e+0 0.253%	^{97}Ag 5.03e-1 9.1e-4%	^{98}Ag
^{94}Pd 9.24e-7 1.1e-8%	^{95}Pd 3e+1 0.024%	^{96}Pd 2.48e+1 0.002%	^{97}Pd
^{93}Rh	^{94}Rh 4.6e+0 2e-4%	^{95}Rh 6.01e+1 2.4e-4%	^{96}Rh
^{92}Ru	^{93}Ru 3.24e-1 9.9e-7%	^{94}Ru 2.43e+1 2.4e-5%	^{95}Ru 2.46e-6 7.9e-13%

FATIMA @ RIBF

Current frame at F11

Total rate at F11: 155 cps

^{96}Cd 1.33e-4 0.008%	^{97}Cd 1.92e-1 0.529%	^{98}Cd 1.89e-4 2.2e-5%	^{99}Cd
^{95}Ag 1.93e-4 1.7e-4%	^{96}Ag 7.69e+0 0.253%	^{97}Ag 5.03e-1 9.1e-4%	^{98}Ag
^{94}Pd 9.24e-7 1.1e-8%	^{95}Pd 3e+1 0.024%	^{96}Pd 2.48e+1 0.002%	^{97}Pd
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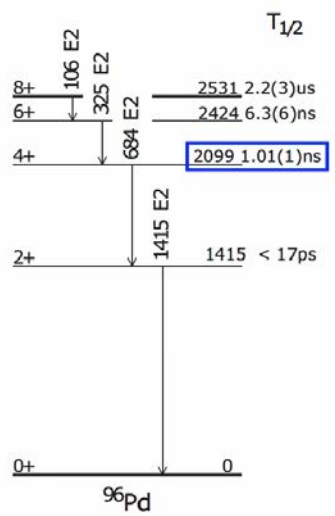
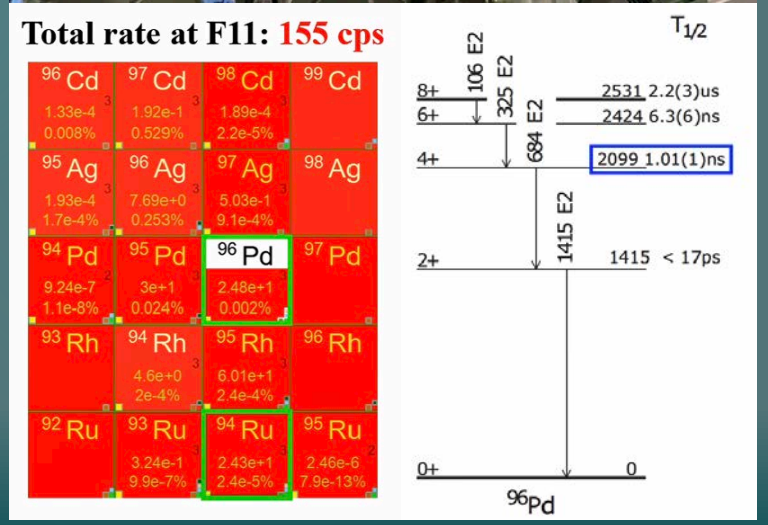
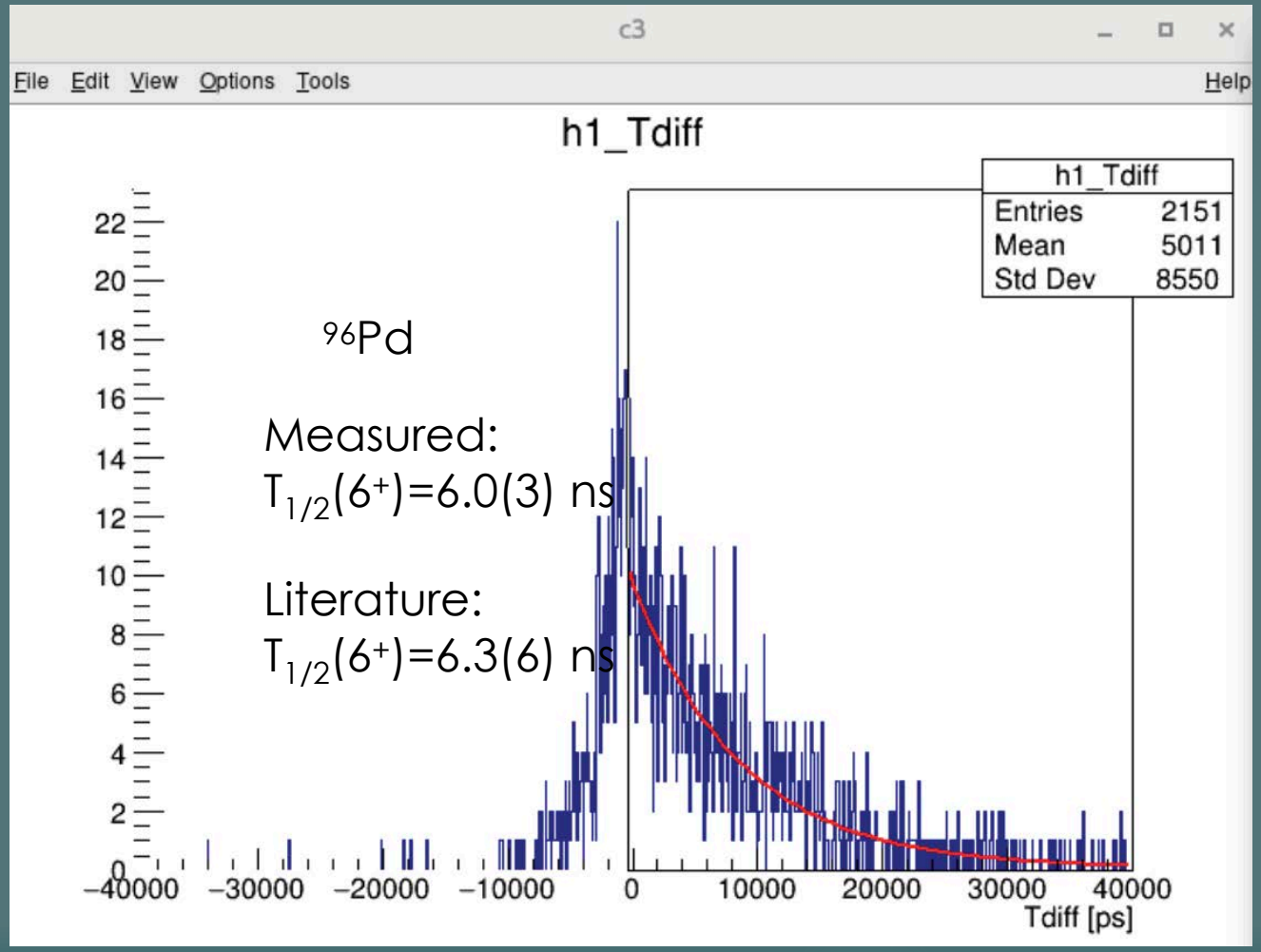


FATIMA @ RIBF

Current frame at F11



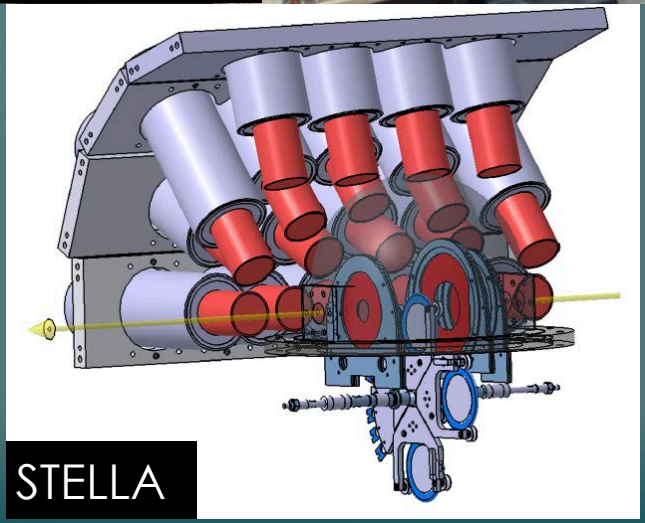
Preliminary results



J. Lee

FATIMA @ STELLA

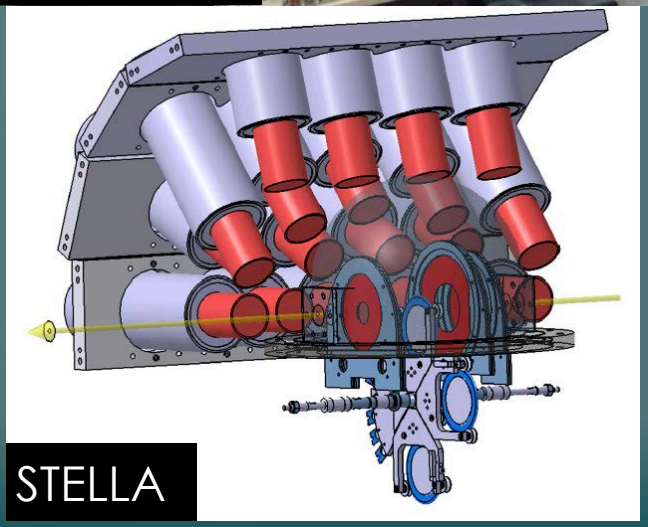
ANDROMEDE



STELLA

FATIMA @ STELLA

ANDROMEDE

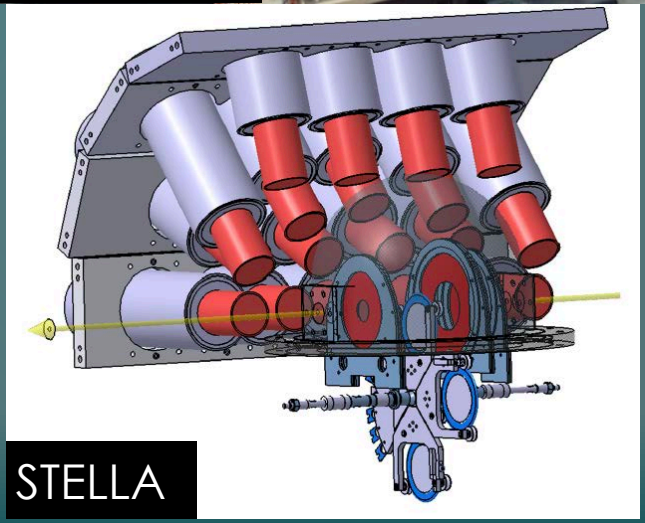


STELLA

- $^{12}C+^{12}C$ at $I = 1..1.5$ pμA
- resonances in excitation function:
  - $E_{\mathrm{rel}} = 4..4.8$ MeV
  - $E_{\mathrm{rel}} = 2..2.9$ MeV
- UK-FATIMA in STELLA DAQ
- particle detector at steep angles:
  - BB10: granularity
  - SuperX3: timing
- refurbishment target rotation

FATIMA @ STELLA

ANDROMEDE



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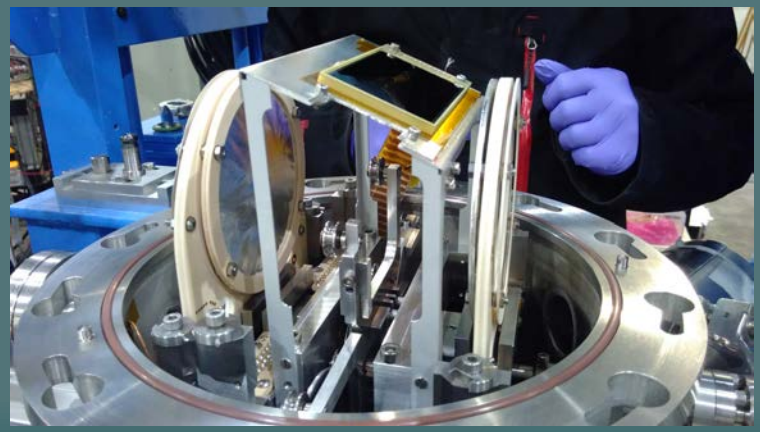
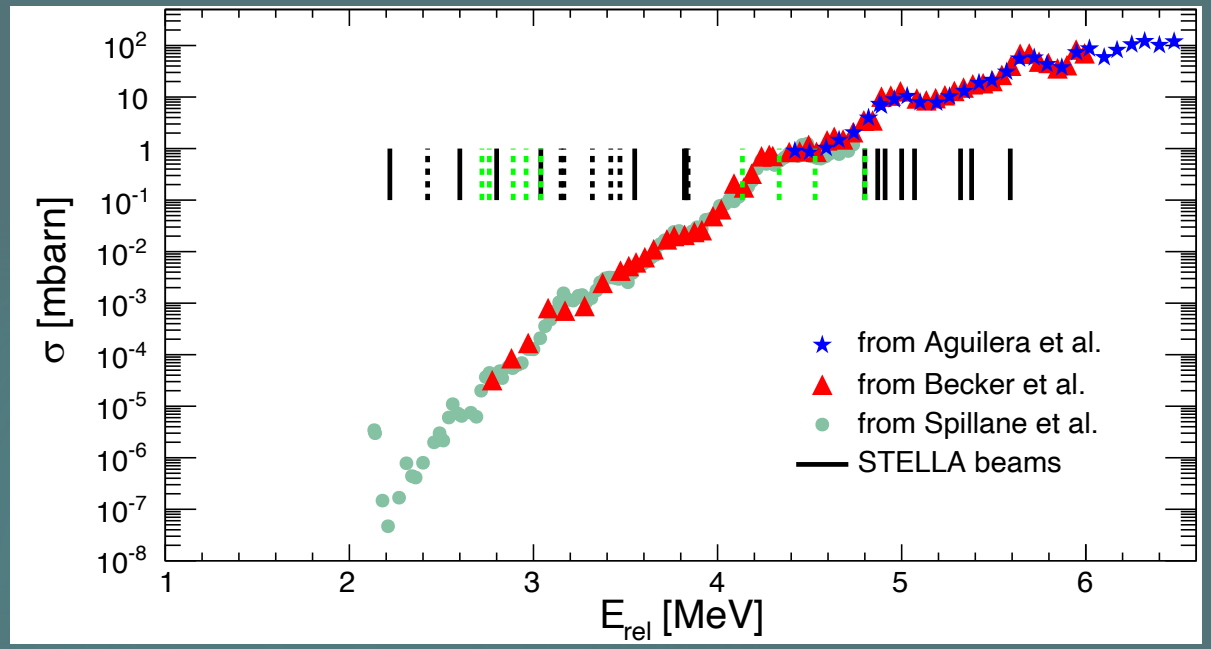
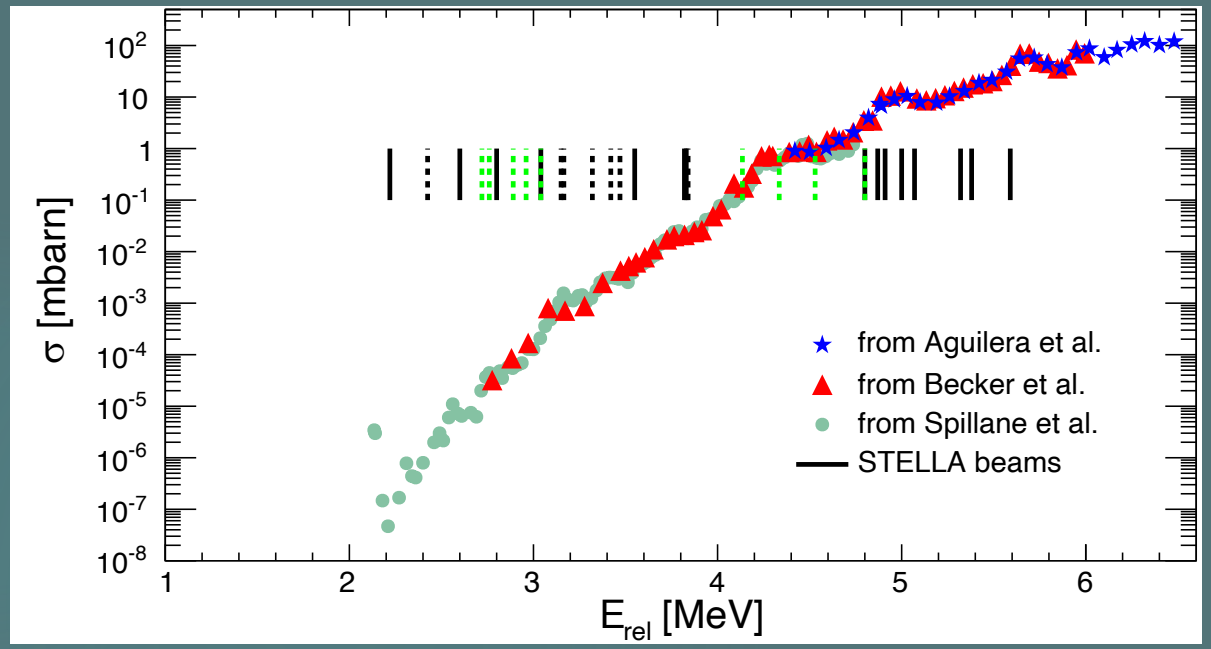


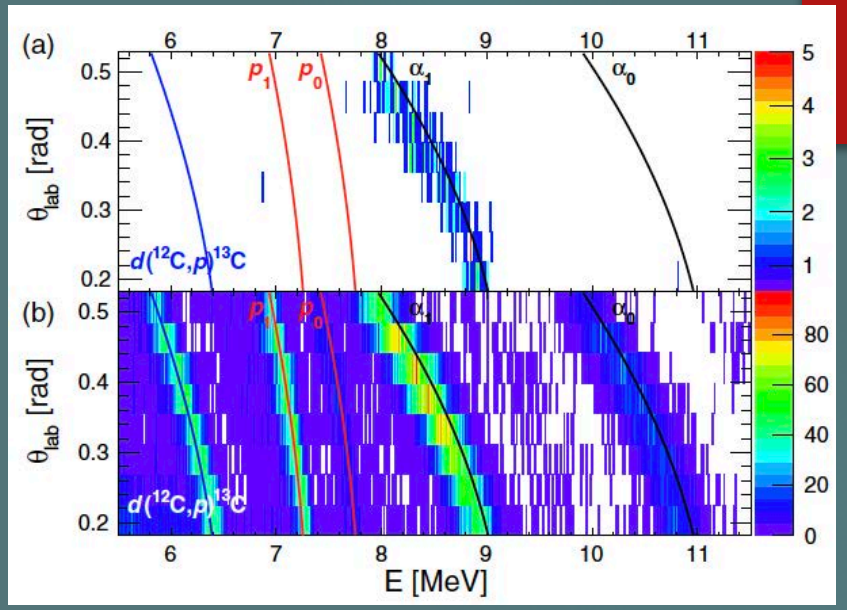
Courtesy of M. Heine, IPHC/CNRS

FATIMA @ STELLA

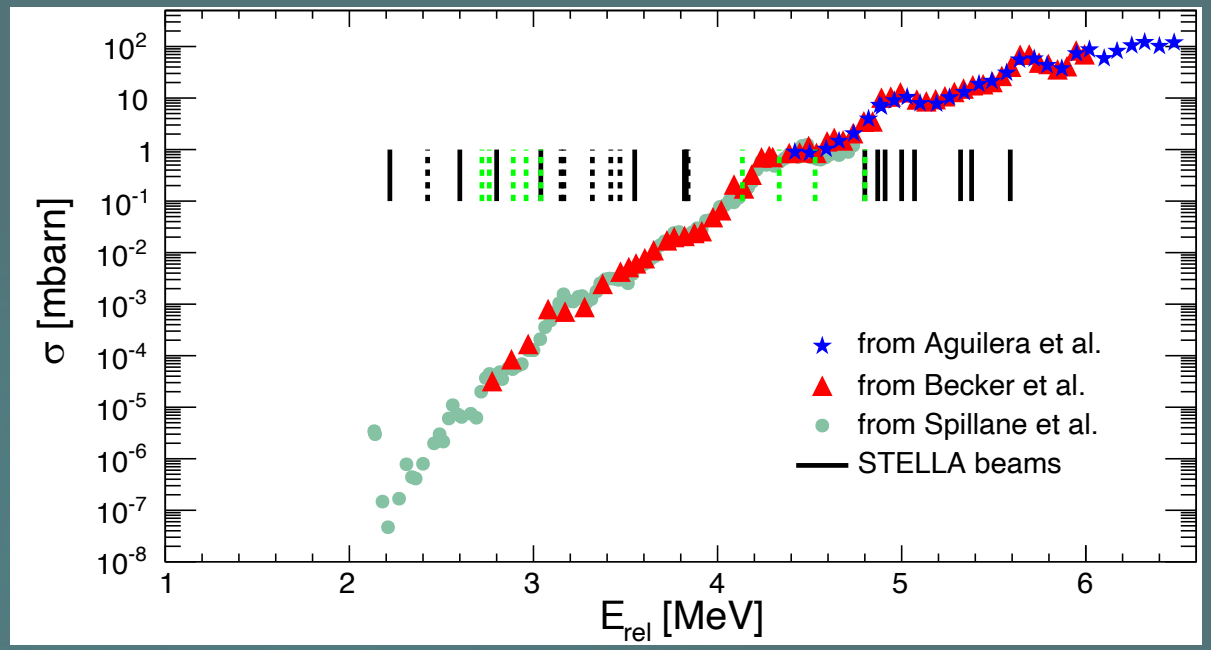


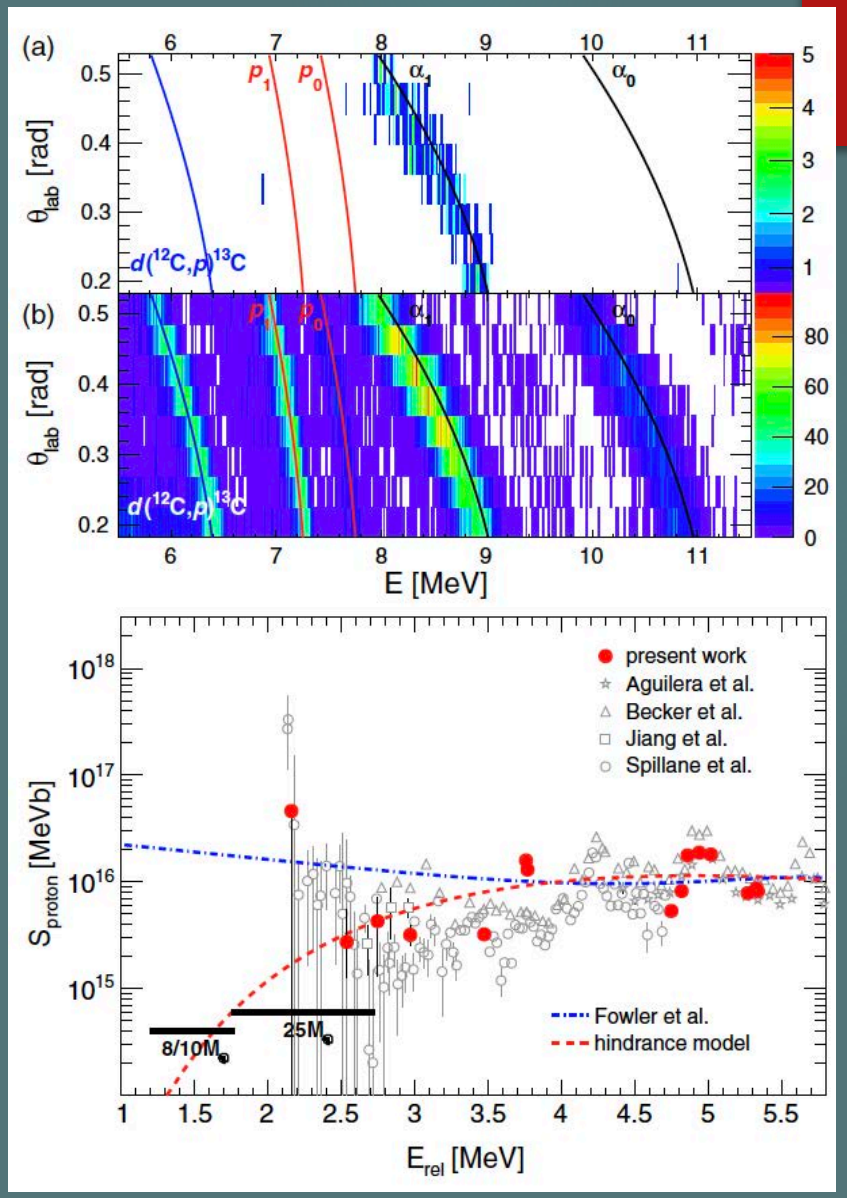
FATIMA @ STELLA





FATIMA @ STELLA





G. Fruet et al., PRL 124, 192701 (2020)

FATIMA upgrades

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- +5 new crystals: 41 in total

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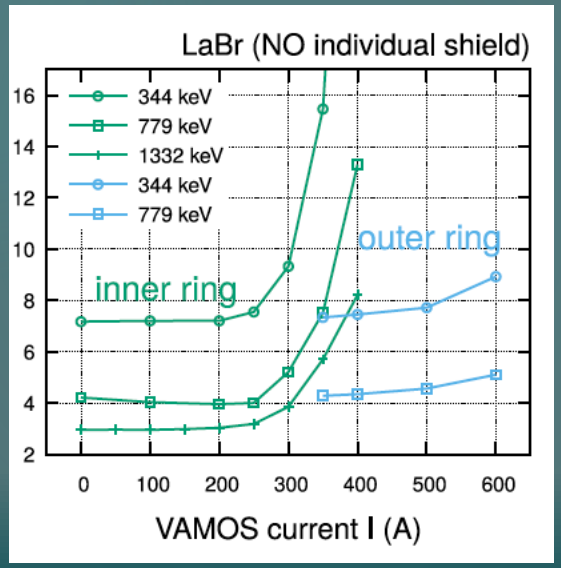

M. Rudigier et al., NIM A 969, 163967 (2020)

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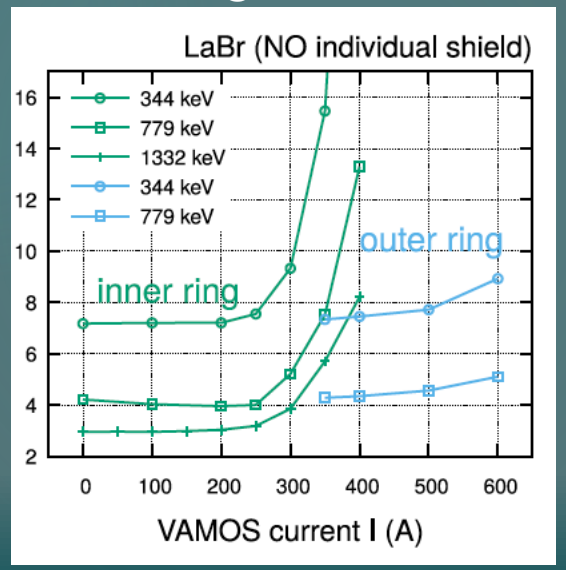
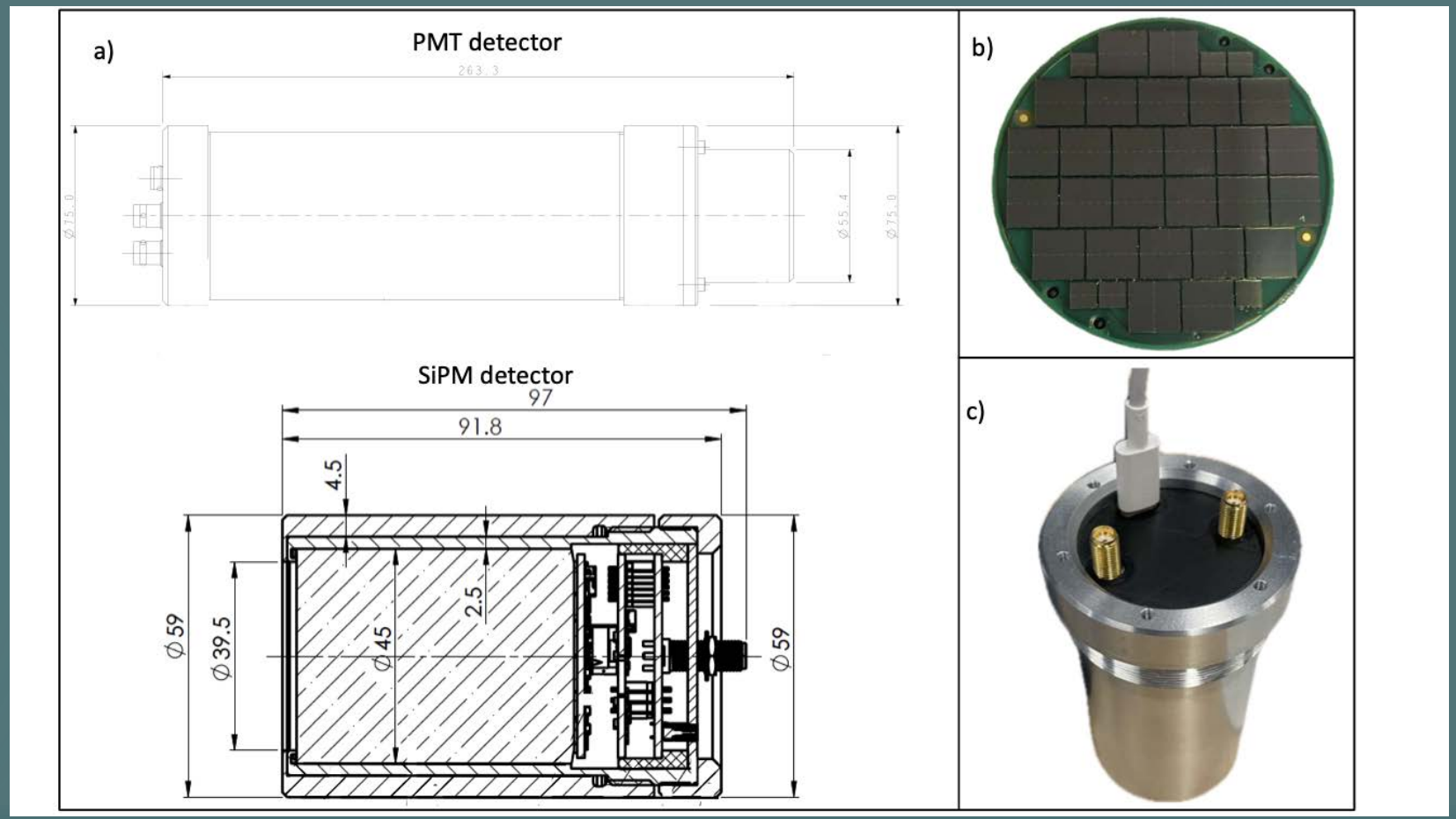


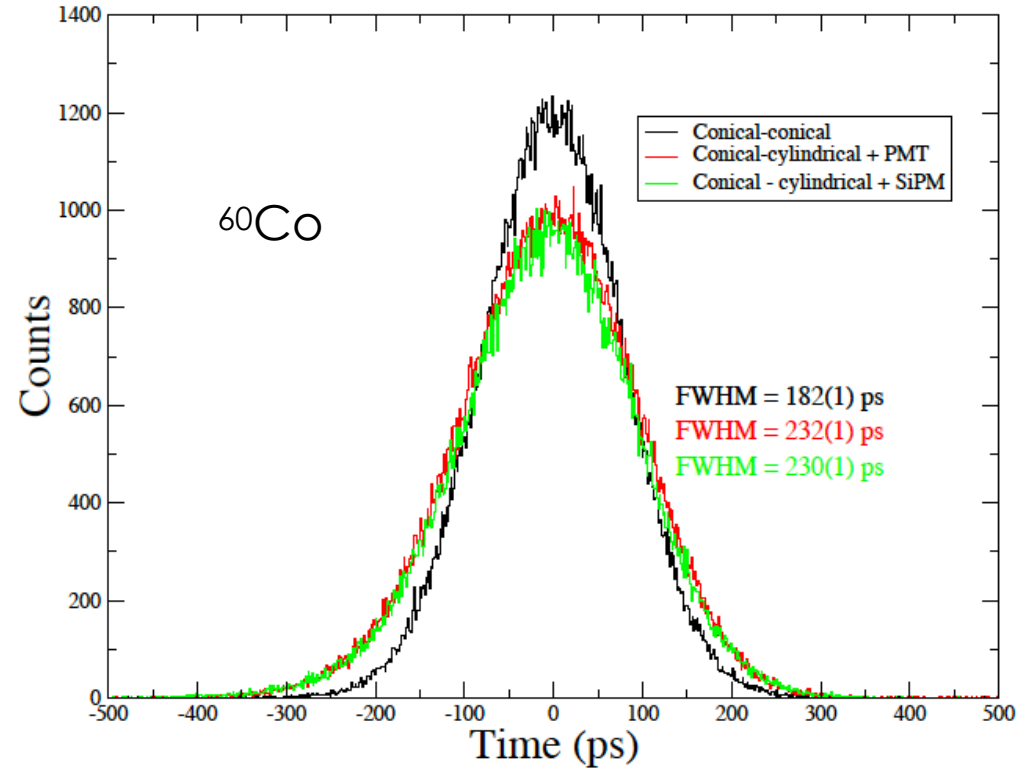
M. Rudigier et al., NIM A 969, 163967 (2020)

New readout system based on SiPM



FATIMA upgrades

Timing performances



FATIMA upgrades

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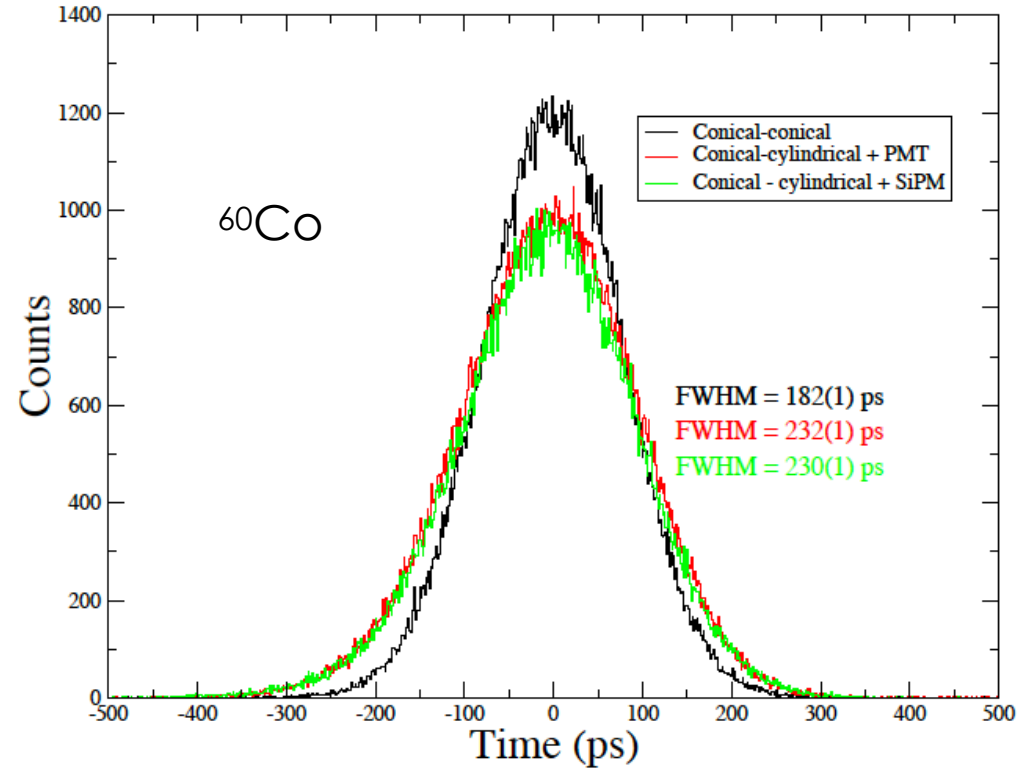
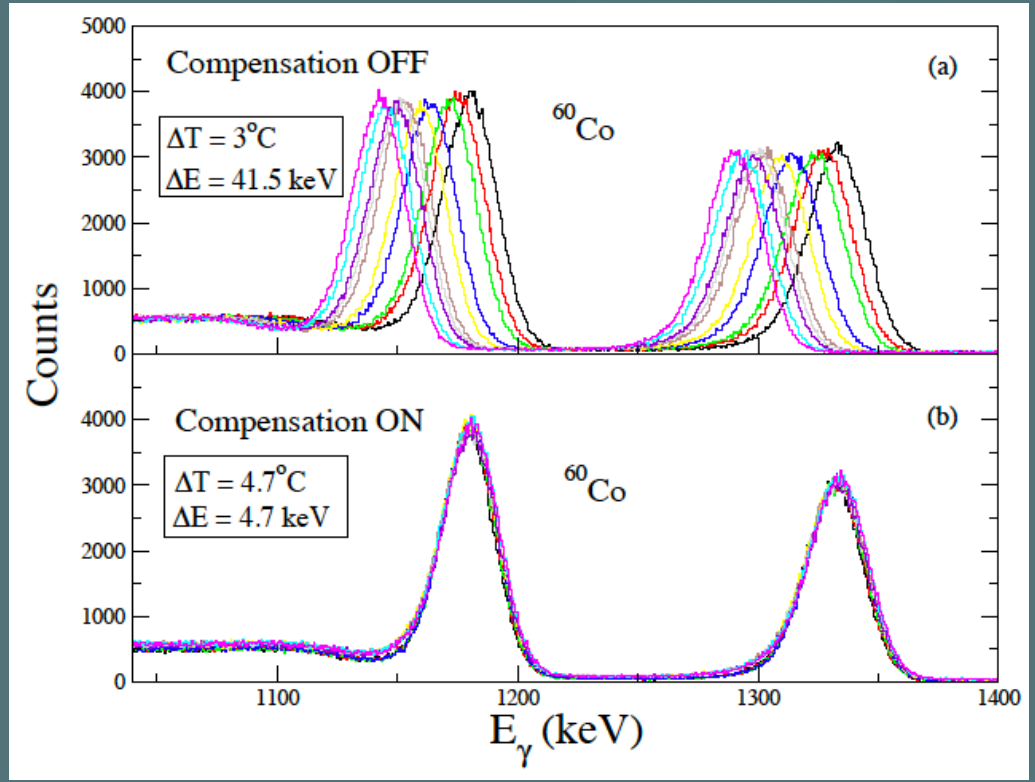


Temperature compensation



Conclusions

- FATIMA: state-of-the-art array for nuclear spectroscopy
- Fast-timing measurements
- Cross-sections measurements
- FATIMA on the road
- Upgrade of FATIMA: new readout method