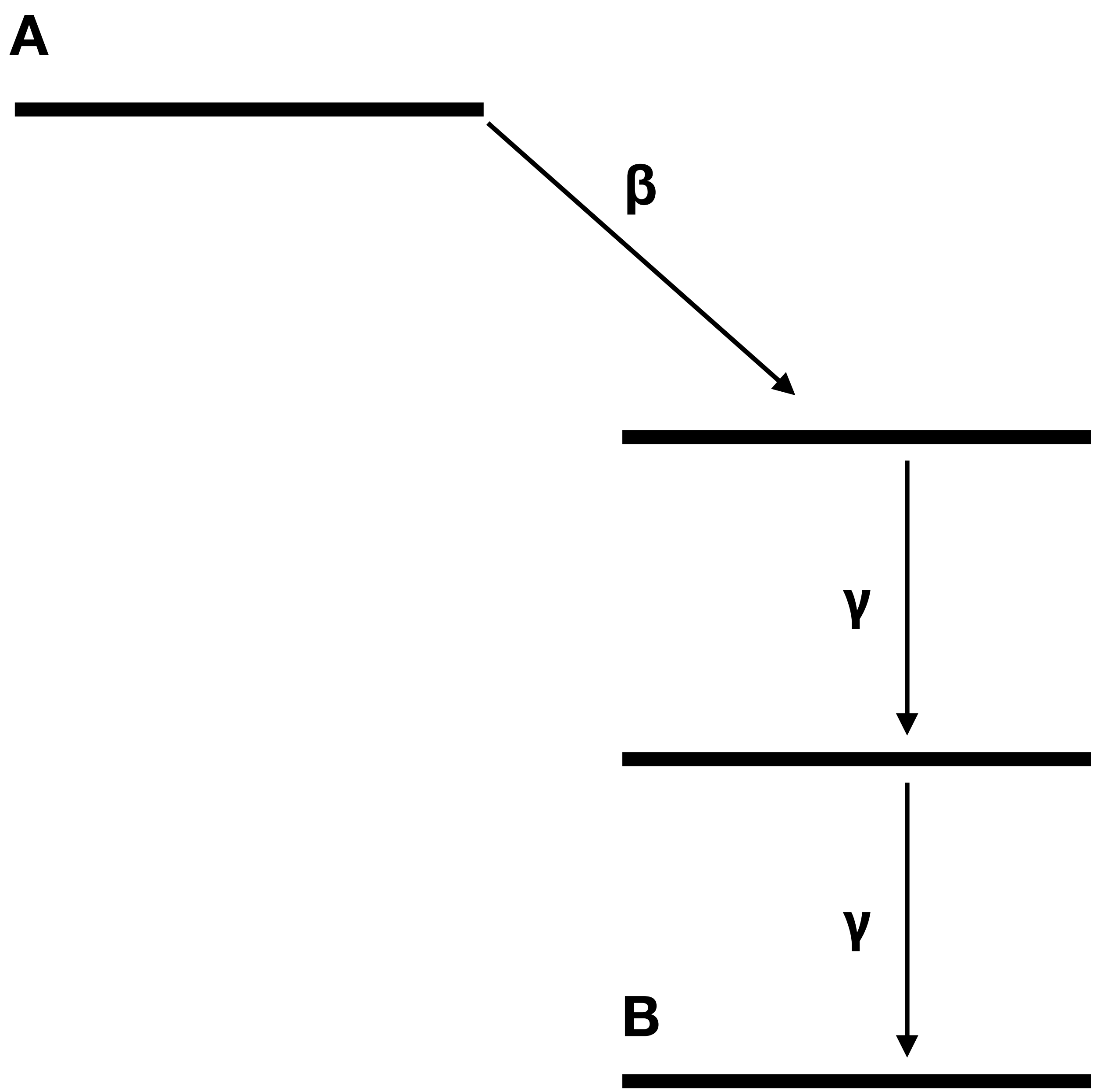
GAmma Nuclear Decays Hiding from Investigators Experiment (GANDHI)

Surjeet Rajendran
with

Giovanni Benato, Alexey Drobizhev and Hari Ramani

Proof of Concept:
Rupak Mahapatra (TAMU)

Missing Energy in Gamma Cascades



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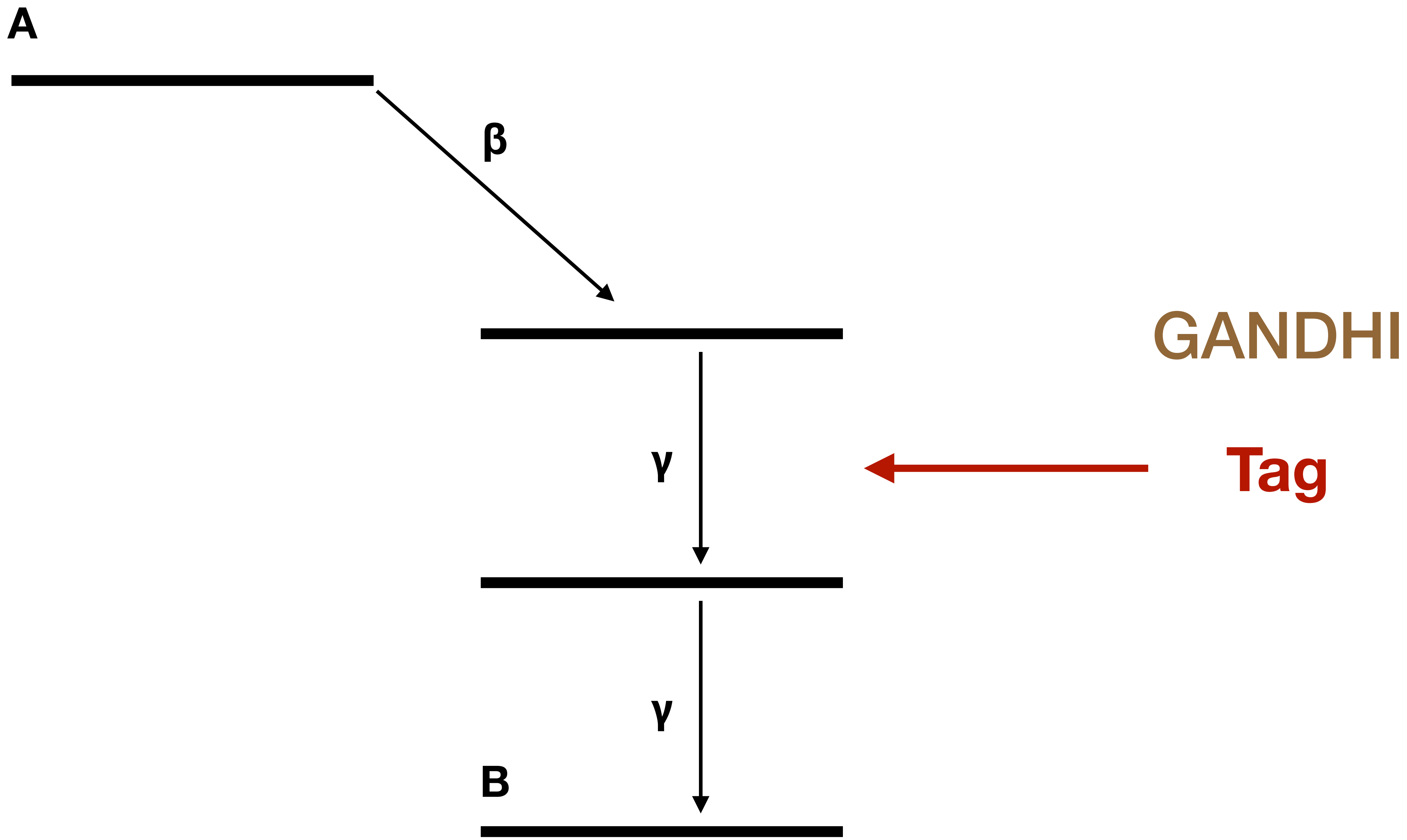

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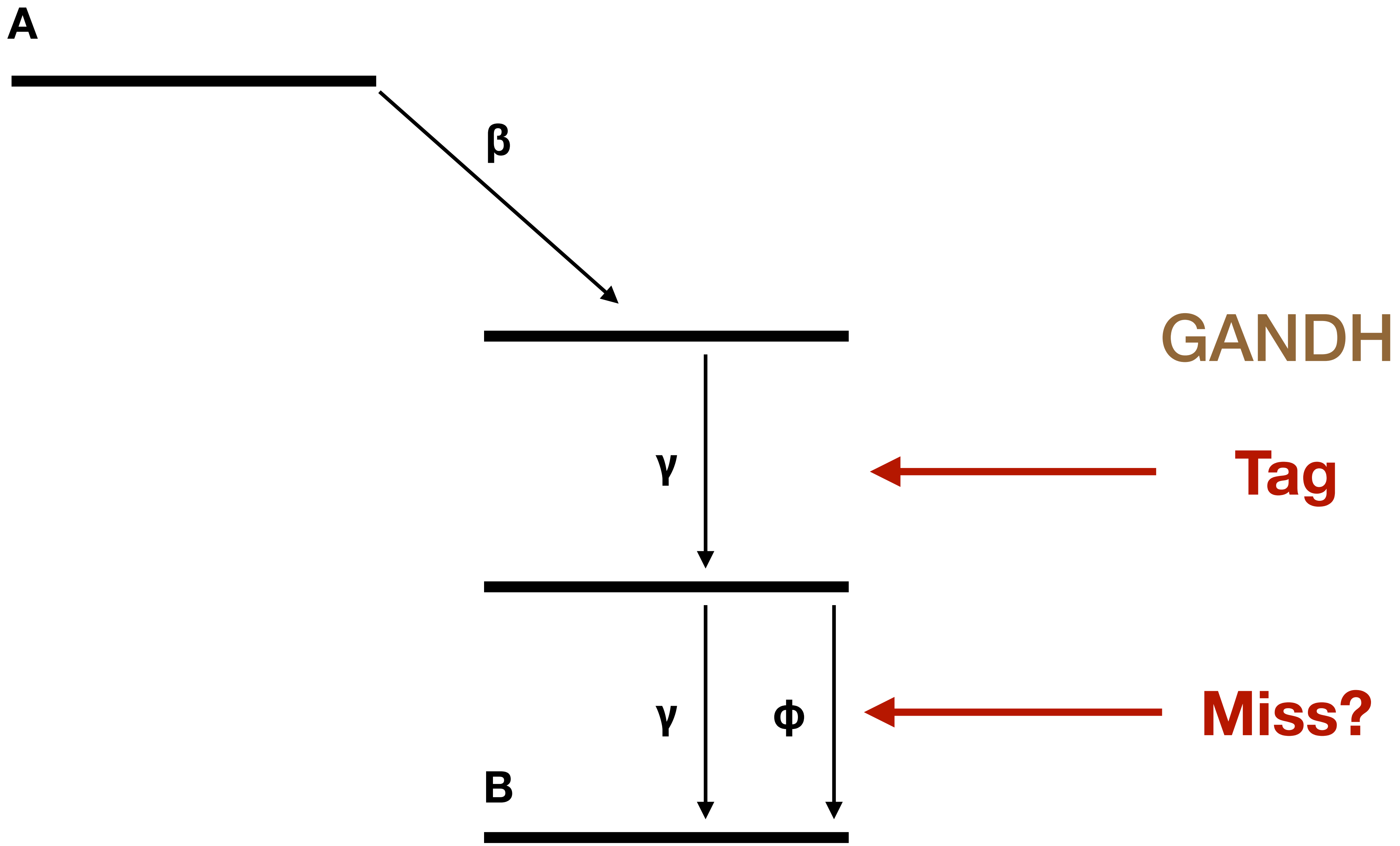

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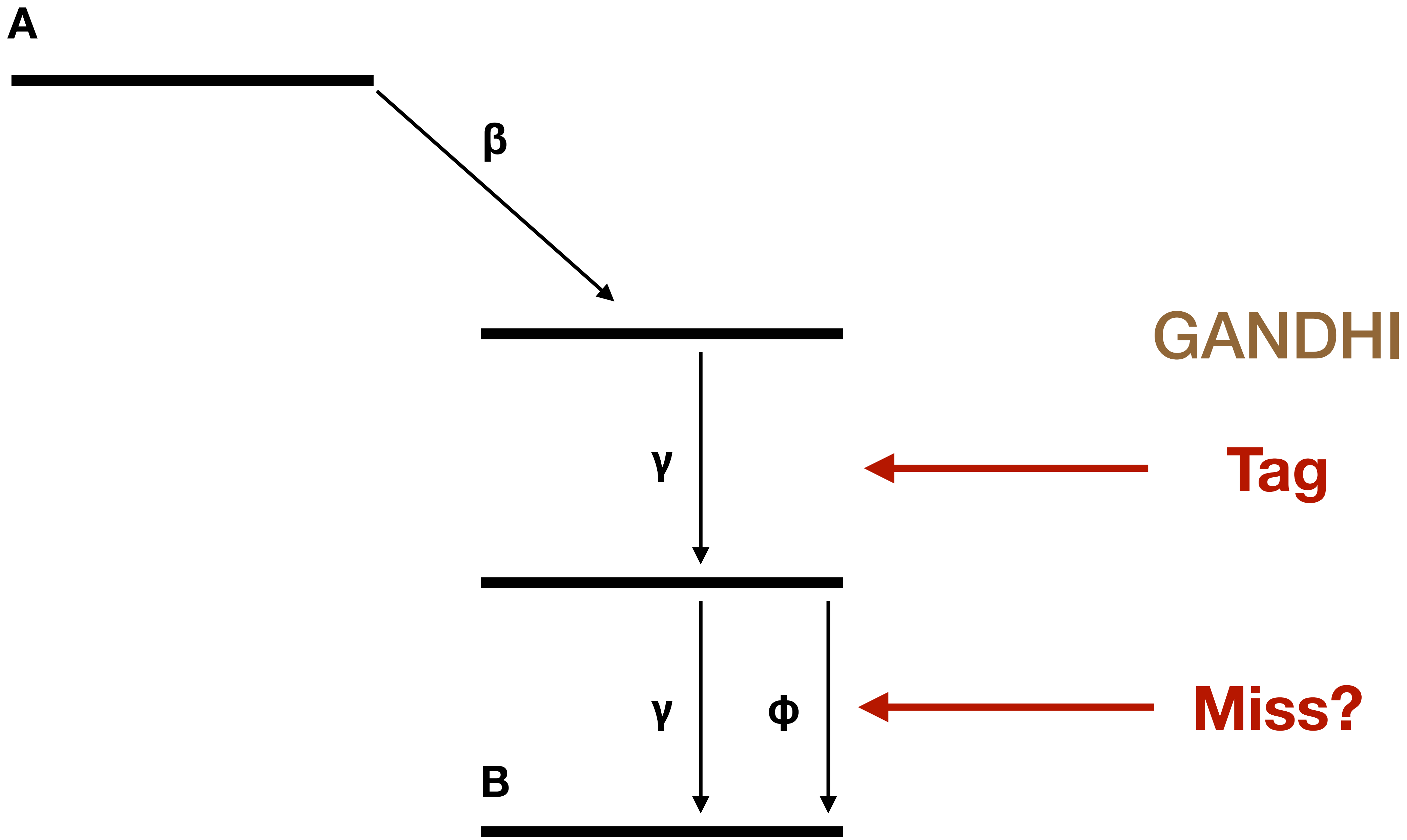

Aim: Single Event for Discovery

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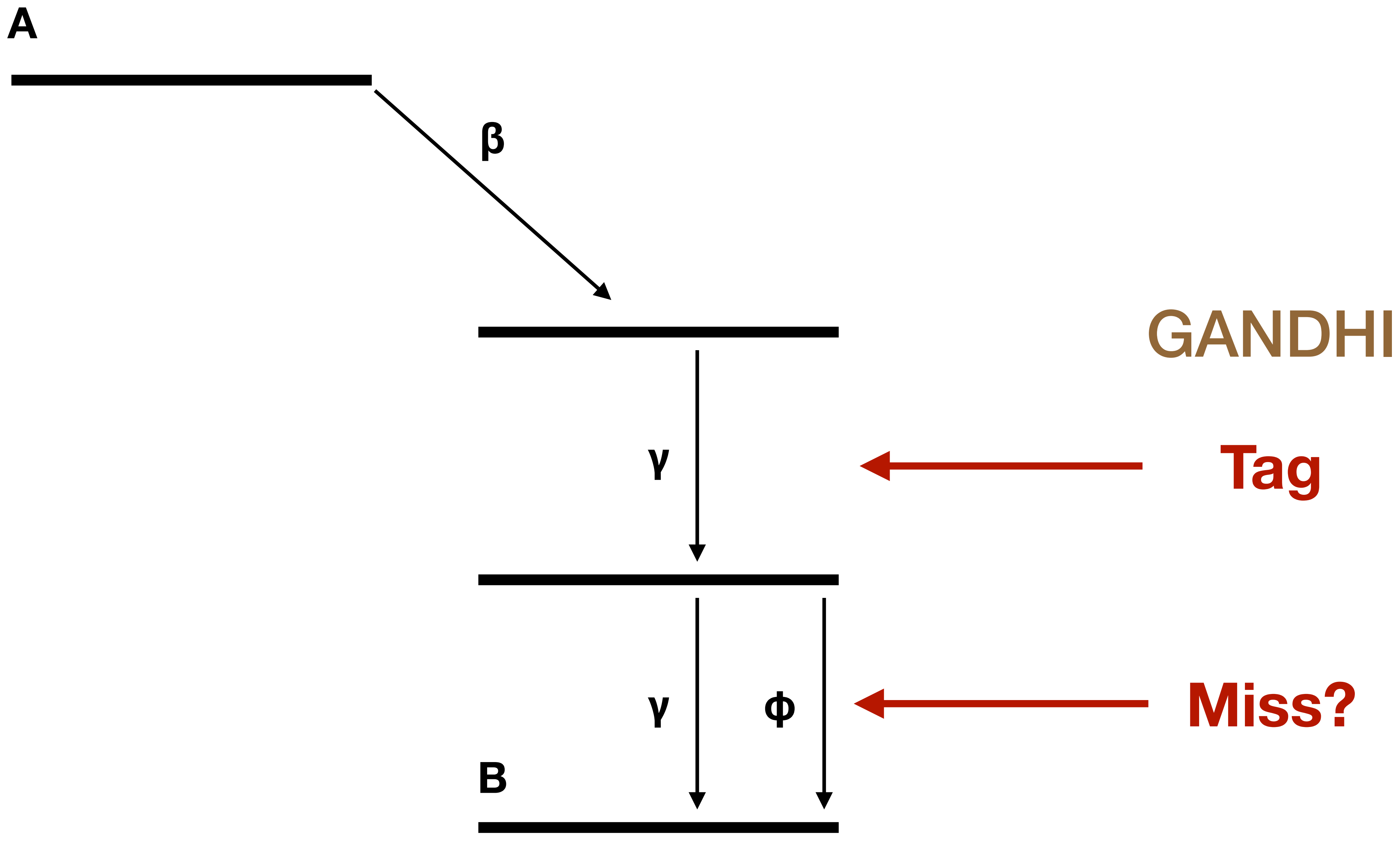

Aim: Single Event for Discovery

How well can we do?

Baryonically coupled ϕ, mass <~ MeV

Outline

1. Nuclei

2. Setup

3. Theory/Reach

4. Conclusions

Nuclei

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Lifetime, Cascade Efficiency, Availability

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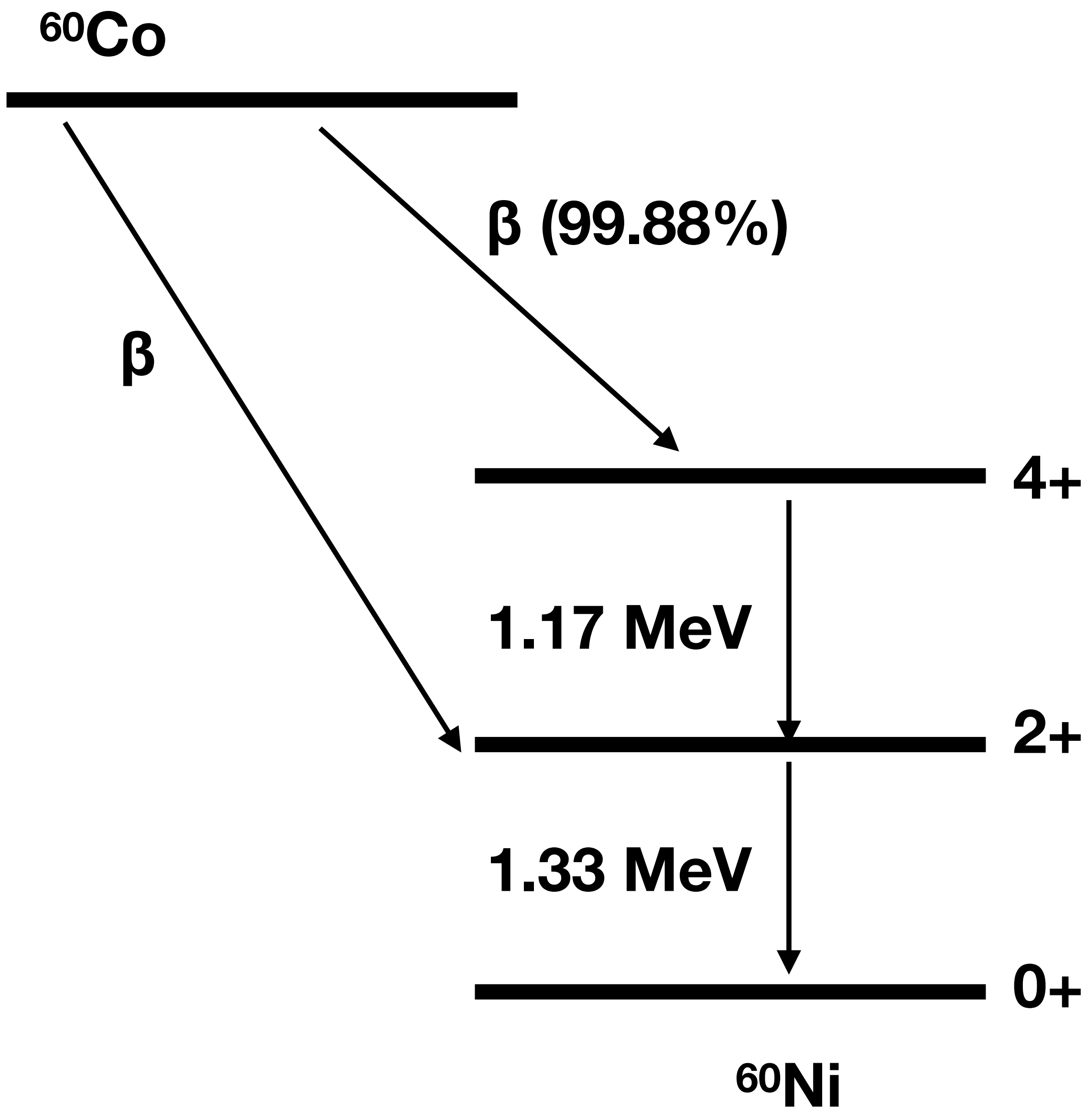

$t_{1/2}$ ~ 5 years

Similar energy Gammas

Nuclei

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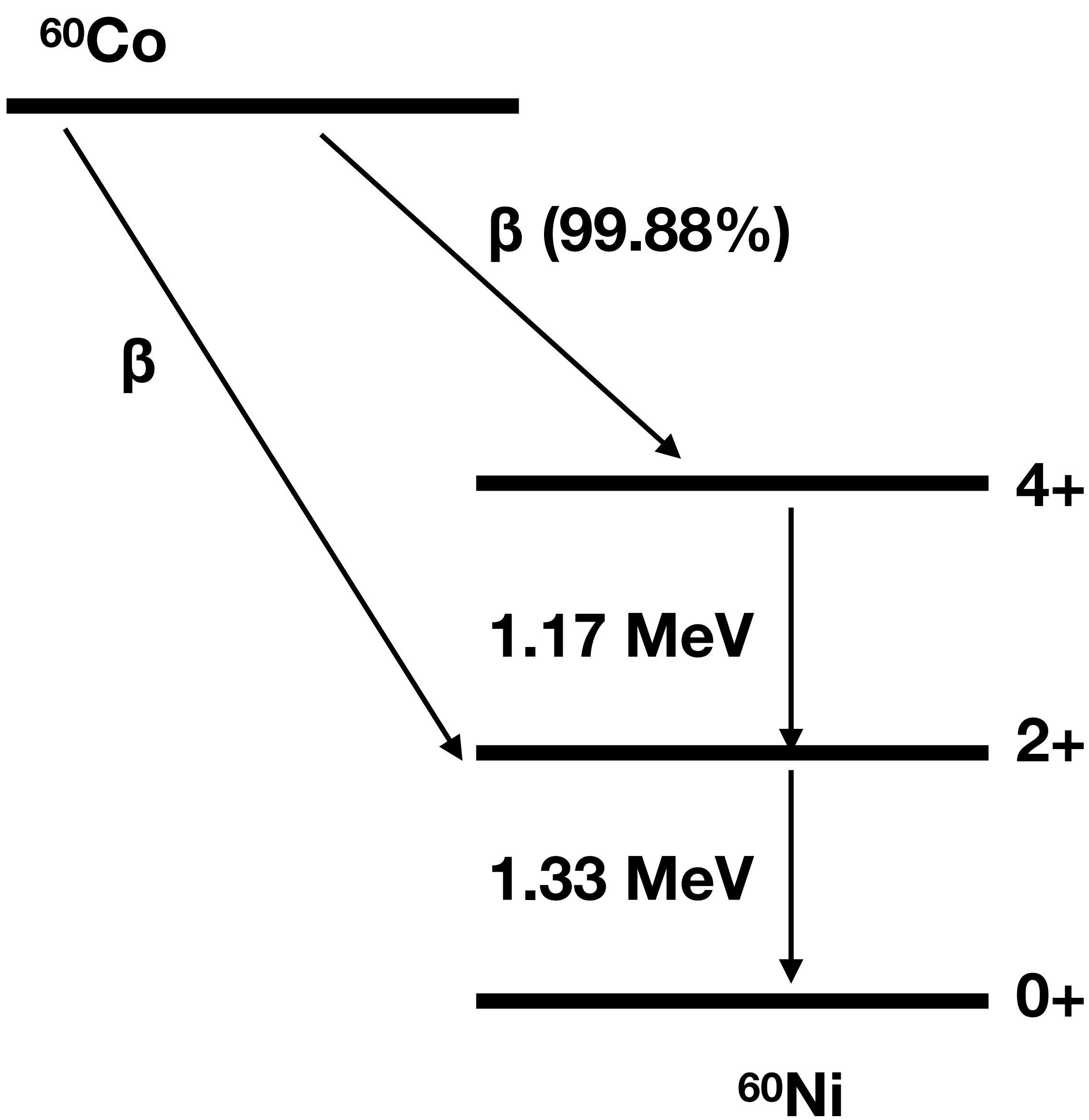

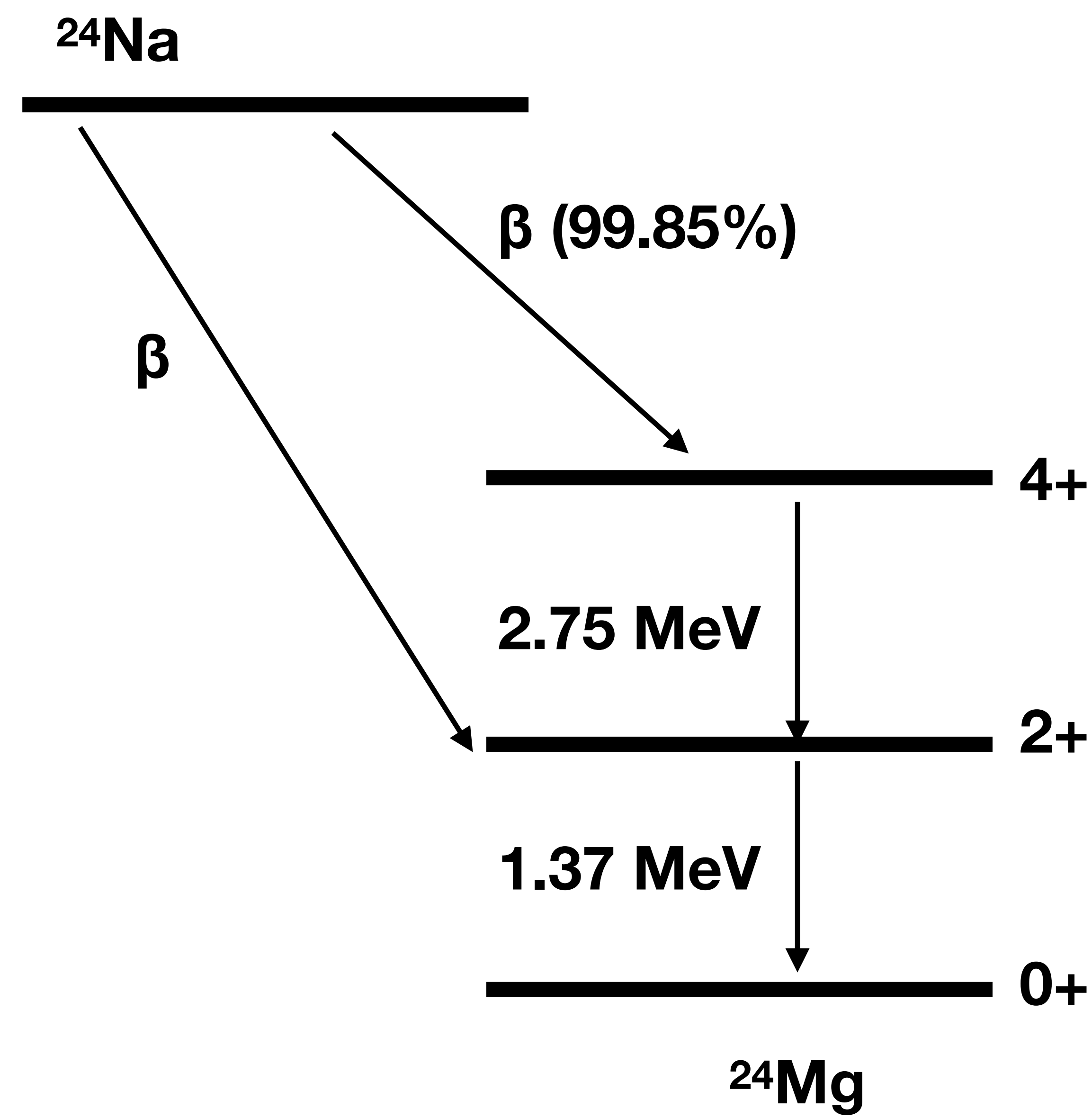

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$t_{1/2}$ ~ 15 hr

Medical Isotope

Nuclei

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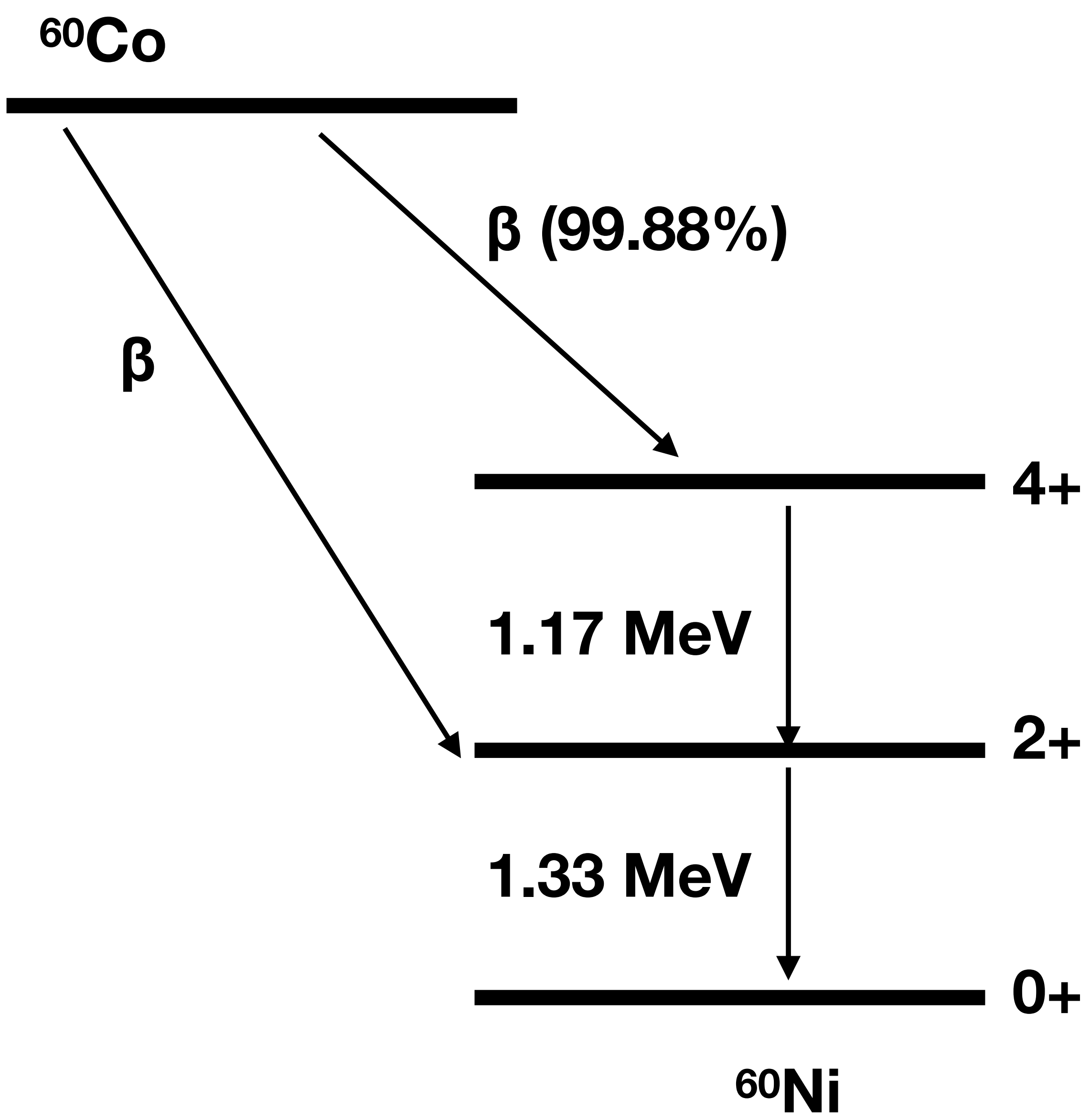

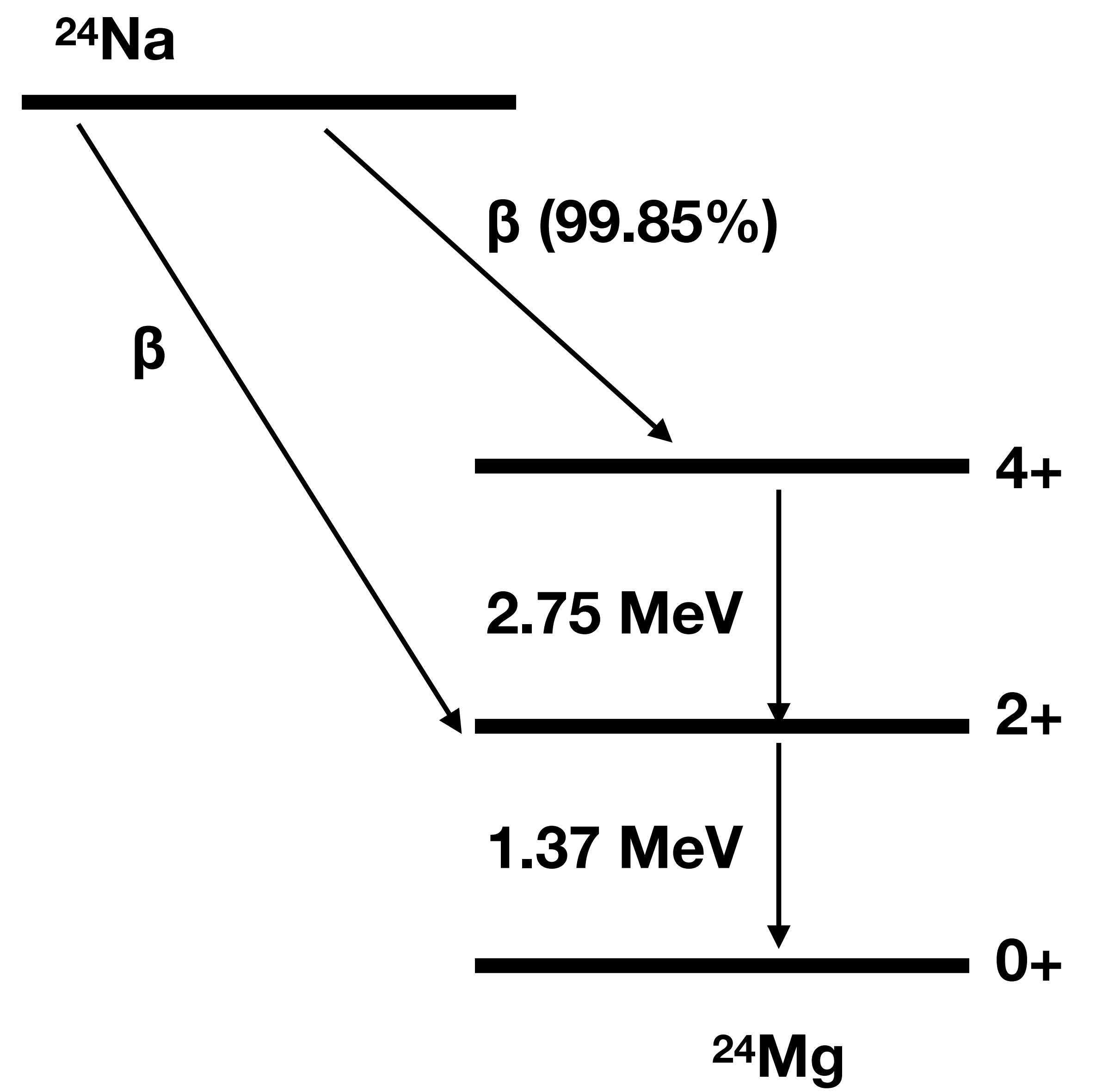

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Medical Isotope

Parity of States -> scalars and vectors

Setup

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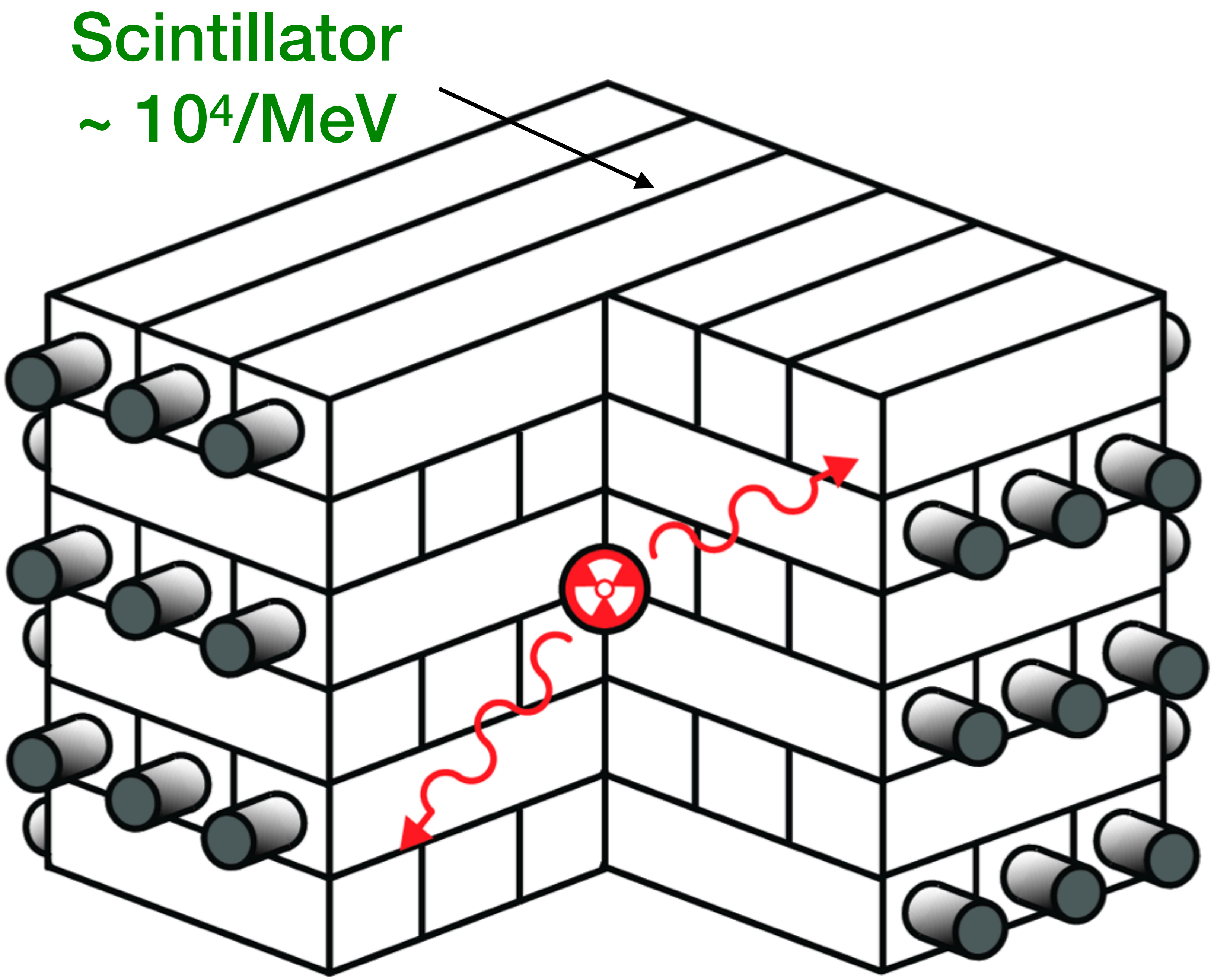

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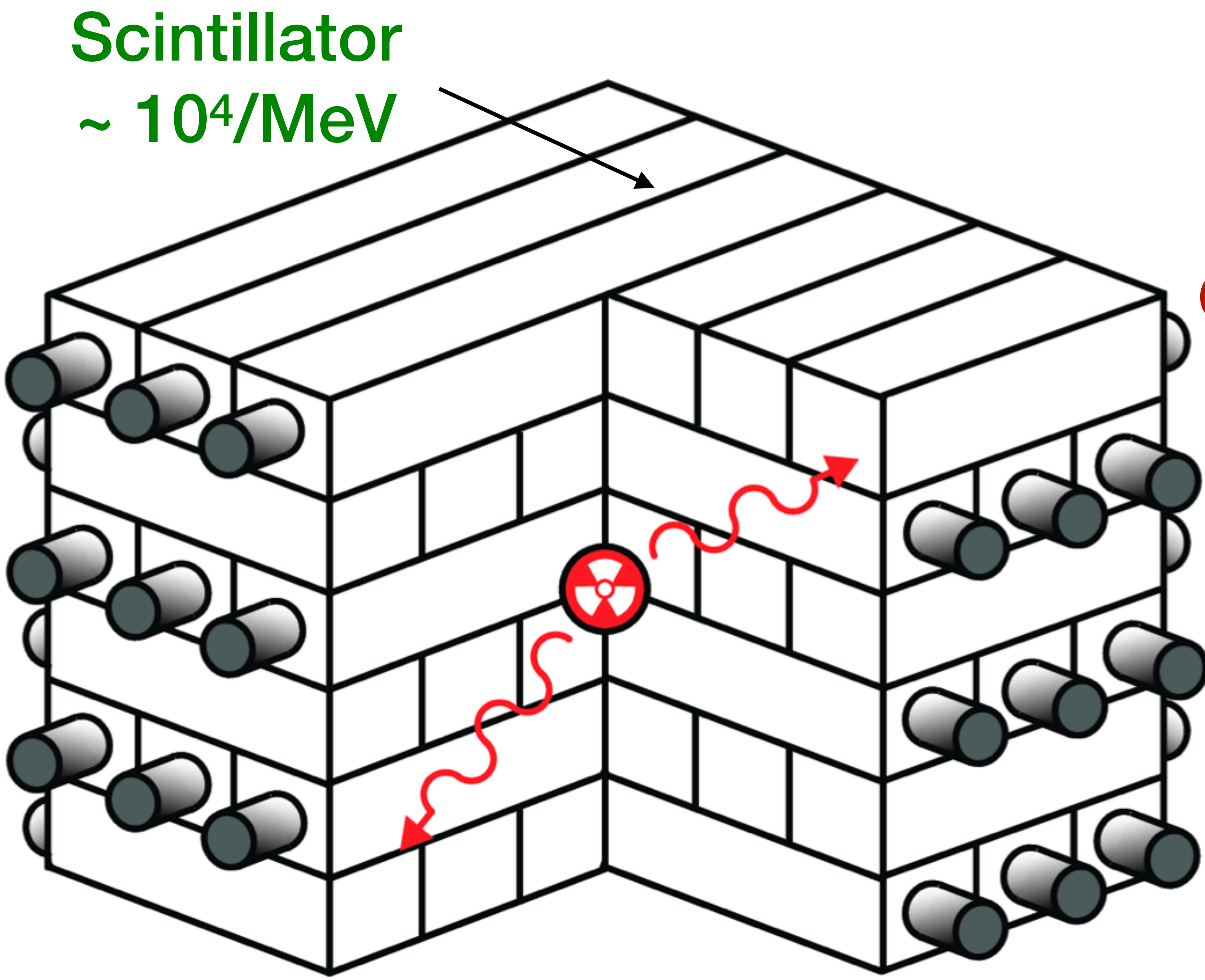


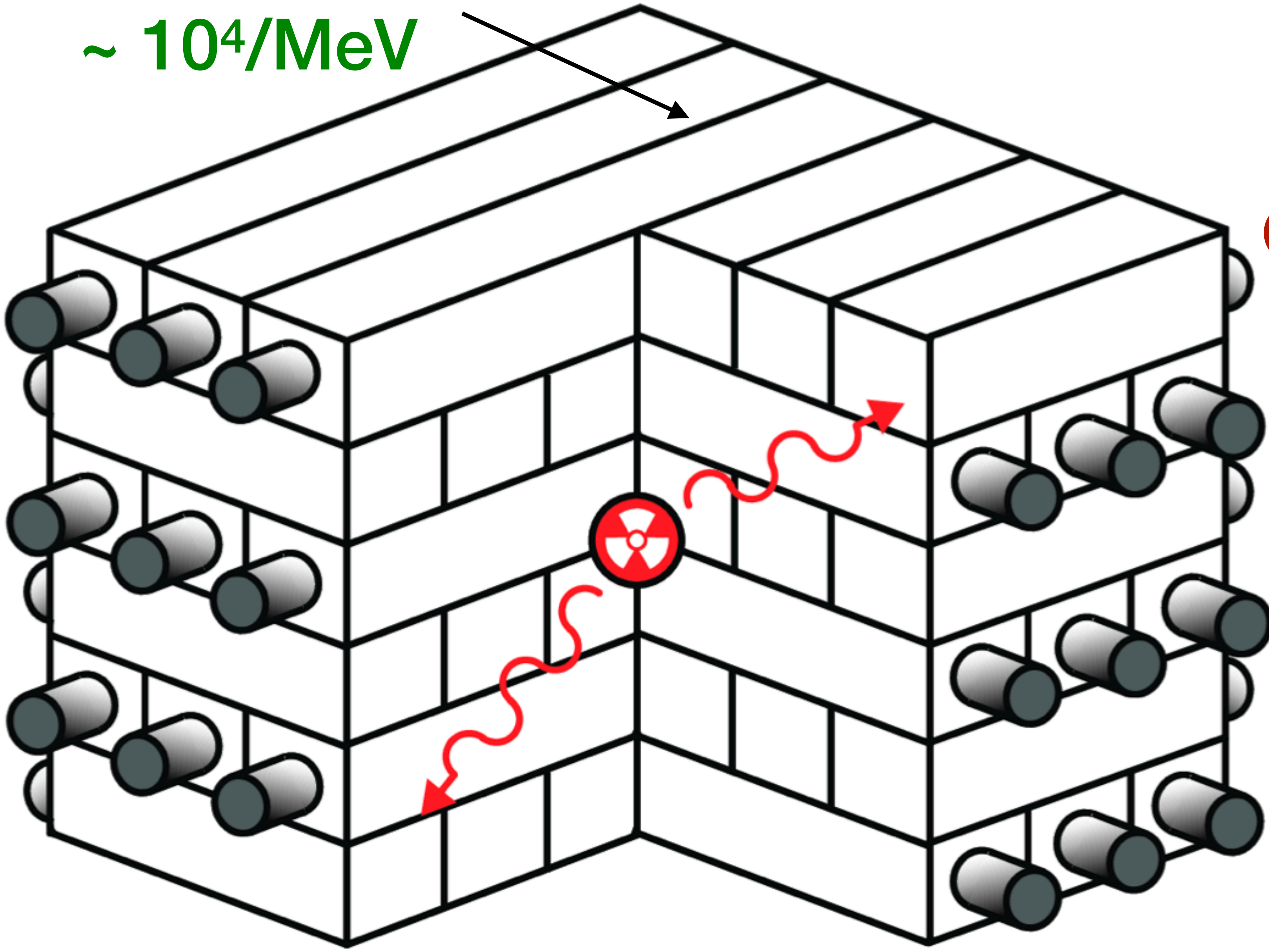
Initial Goal: 10^{-11}
Eventual Goal: 10^{-14}

Observe Individual Event
No pile up

High Event Rate
Fast Scintillator

Plastics or Crystals
~ ns response

Setup



Scintillator

~ 10^4/MeV

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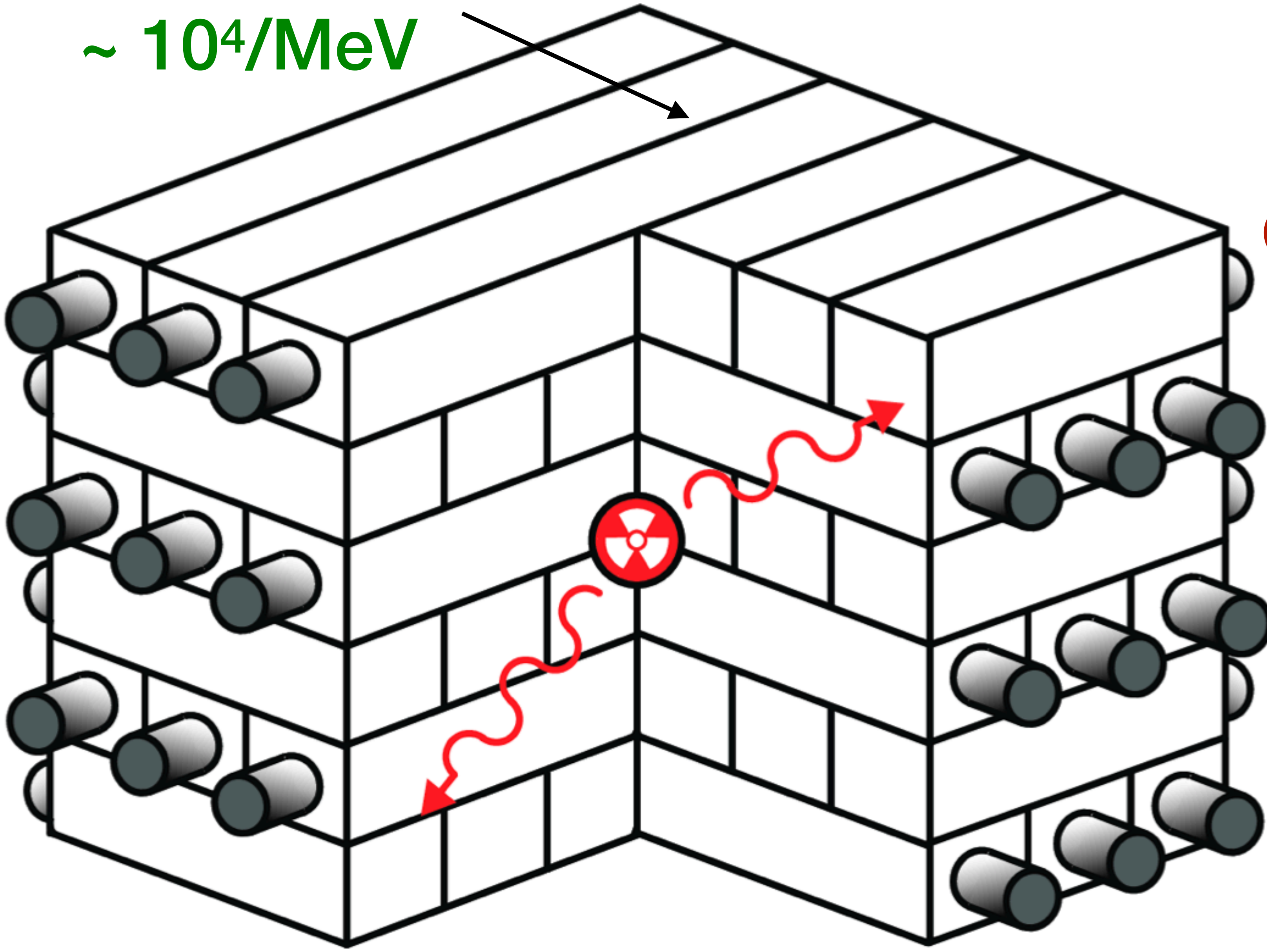

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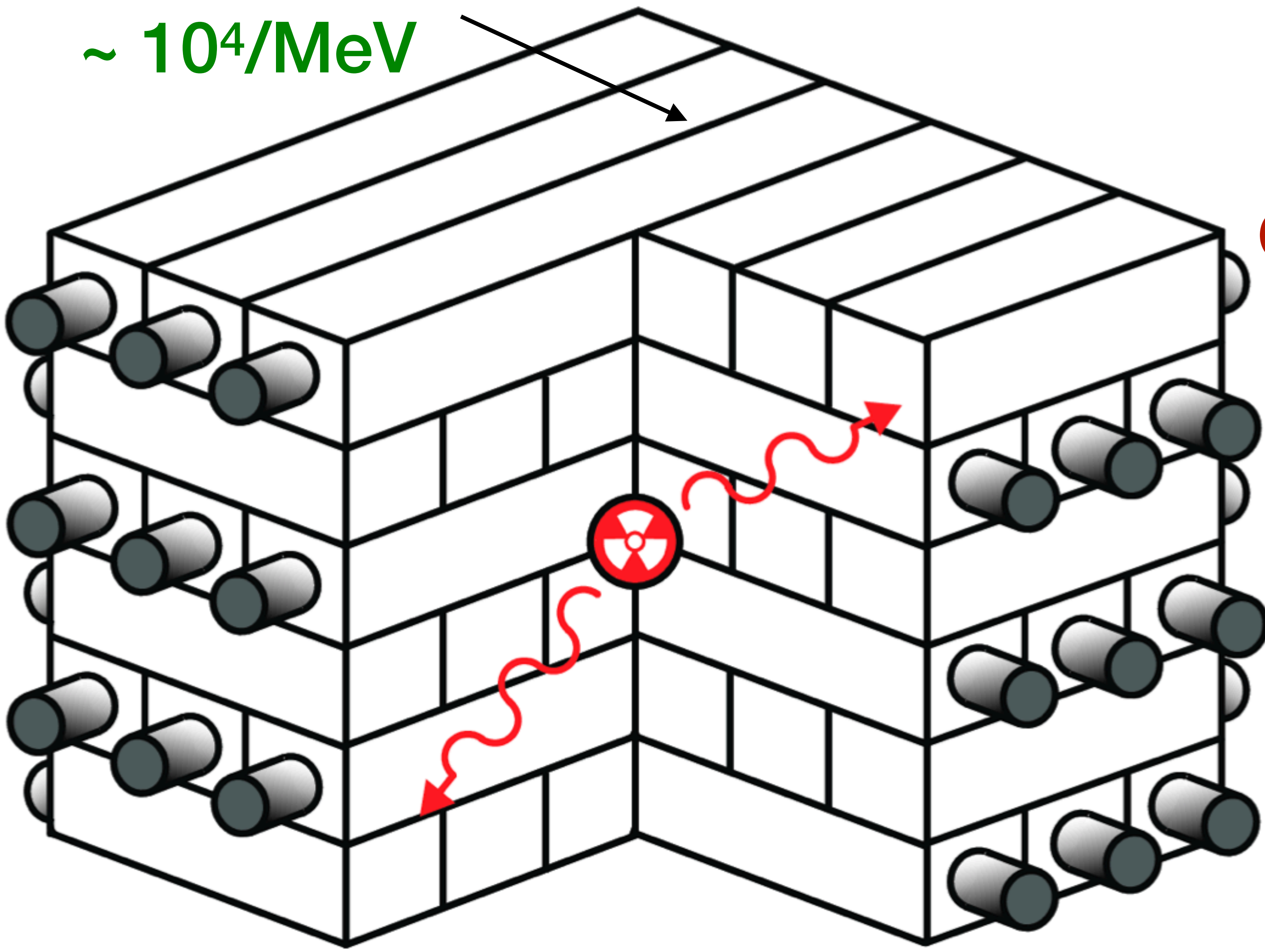

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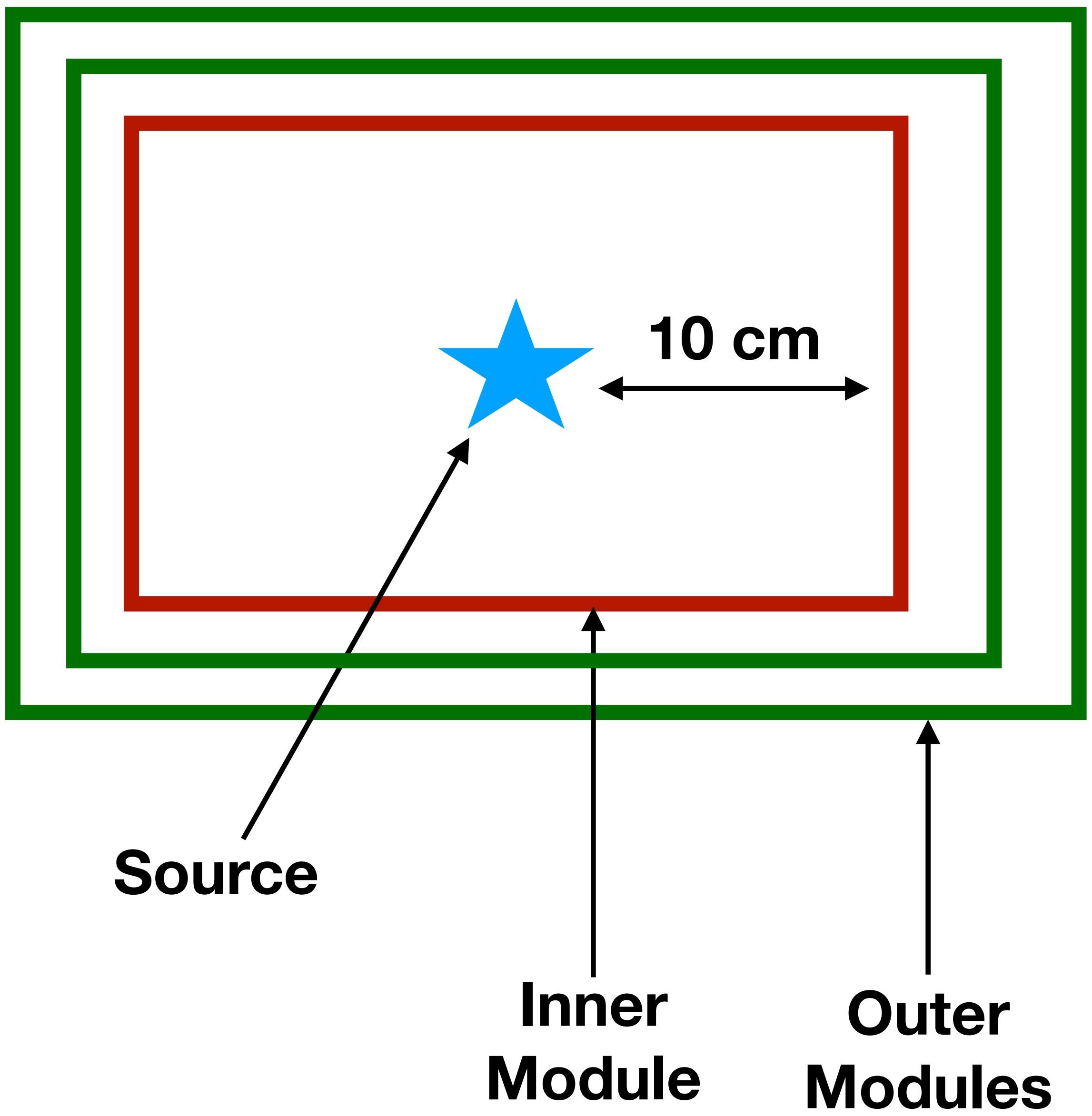
Crystals: ~ 2 m, harder to grow. CMS E-cal

Protocol



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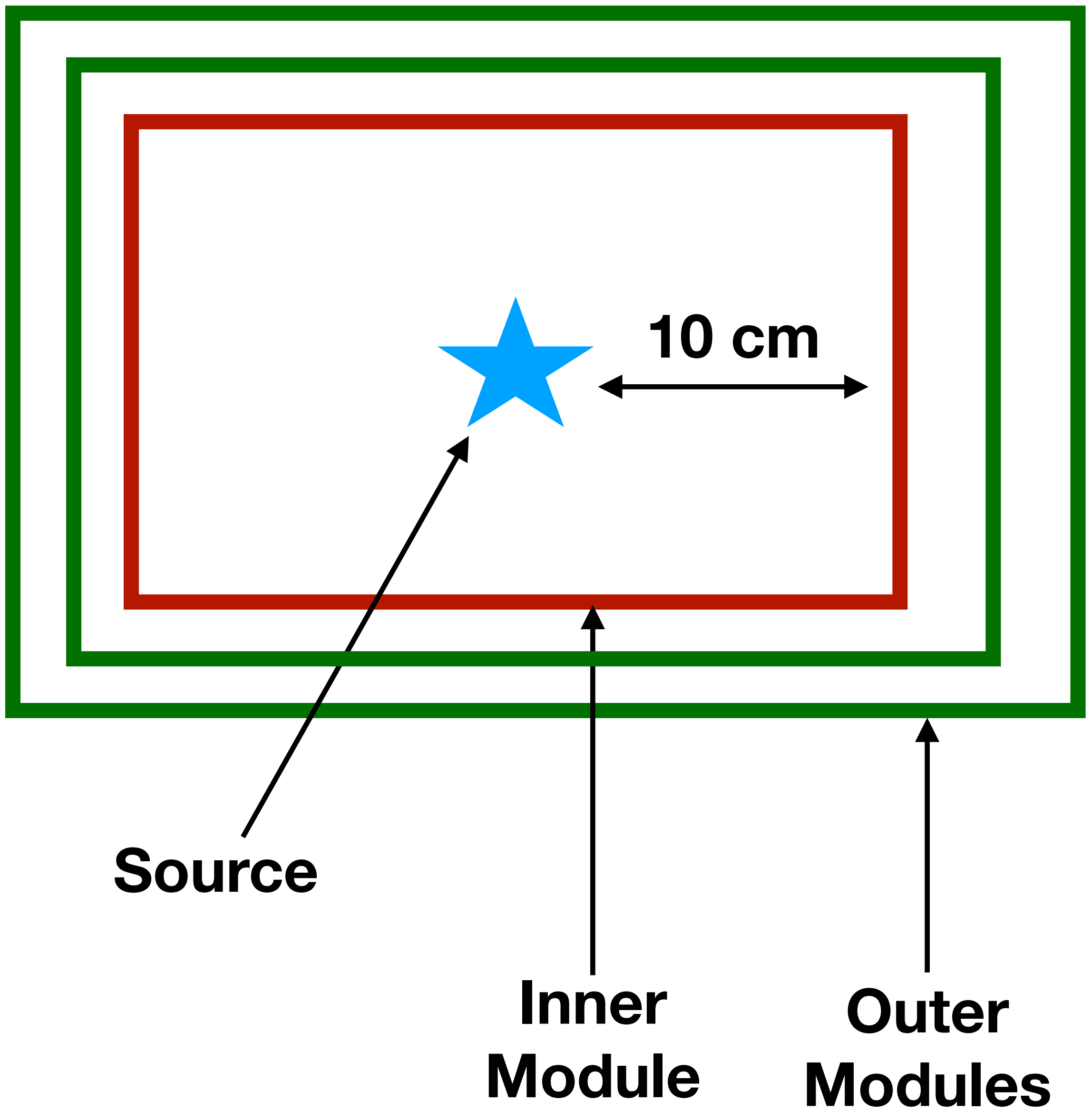

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1. Observe β activity consistent with initial decay

2. Within ~ ns, observe 1st γ in inner module

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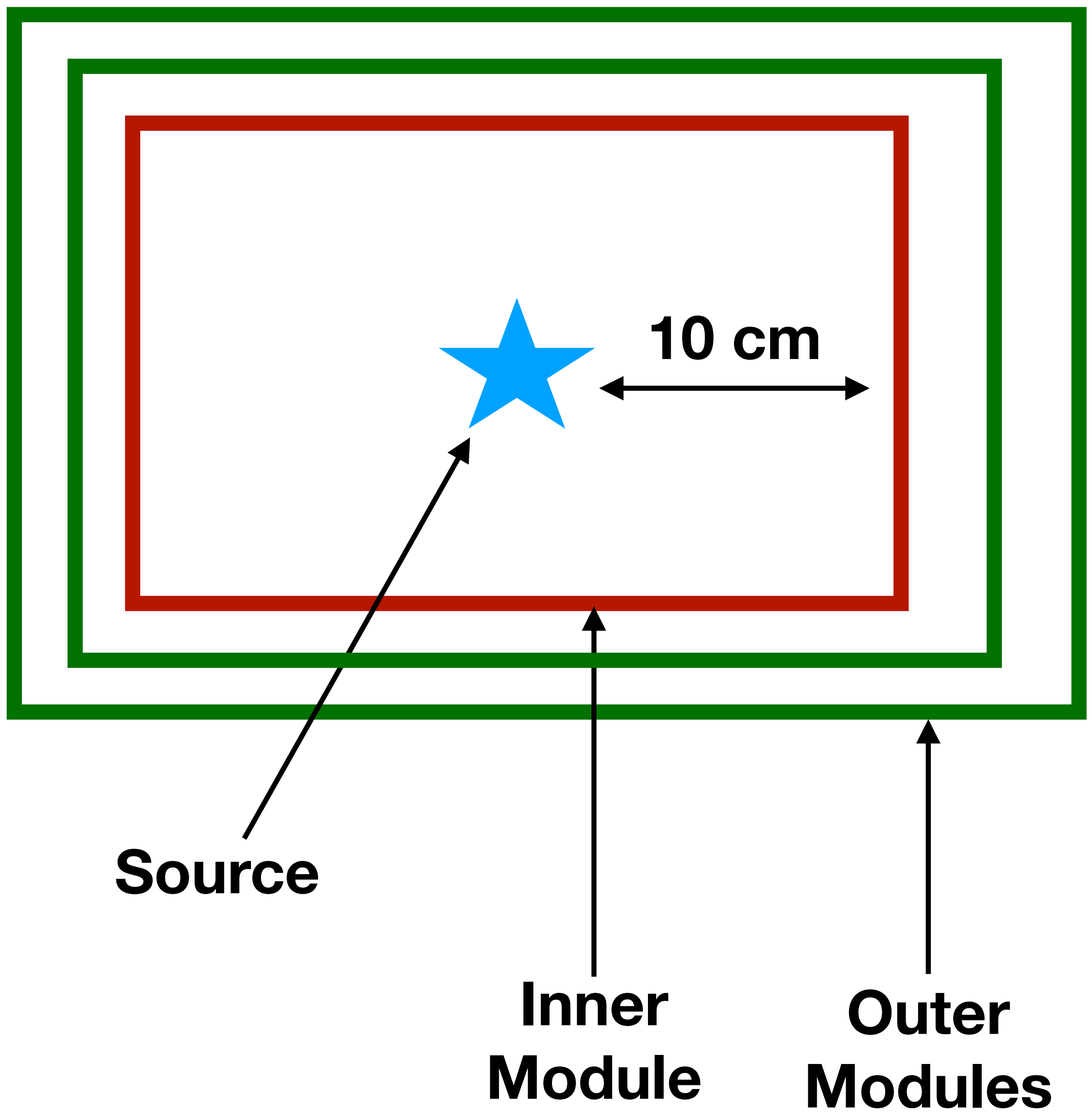

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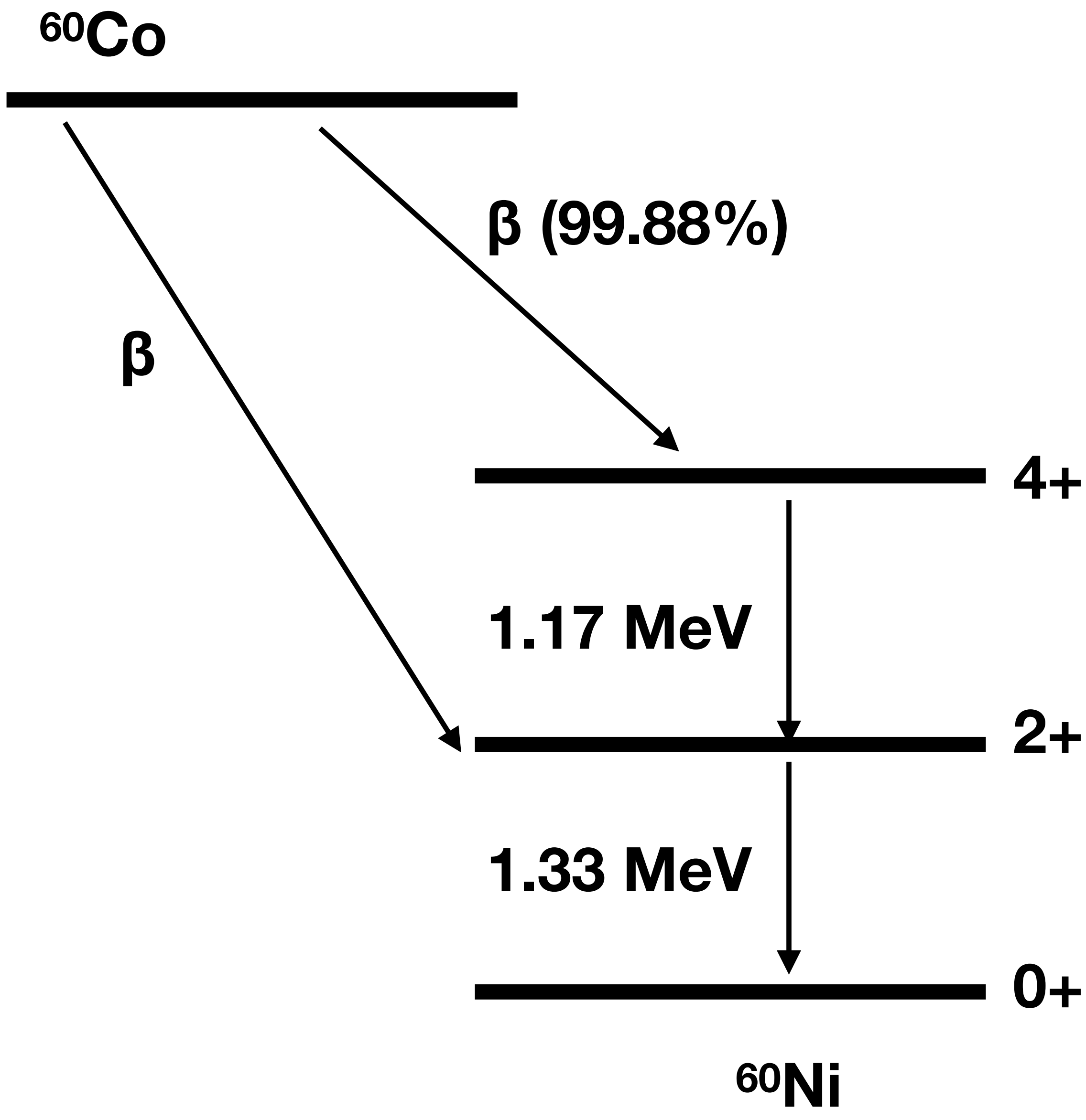
Backgrounds?

Intrinsic Background for ^{60}Co

Can 2nd γ fake 1st?



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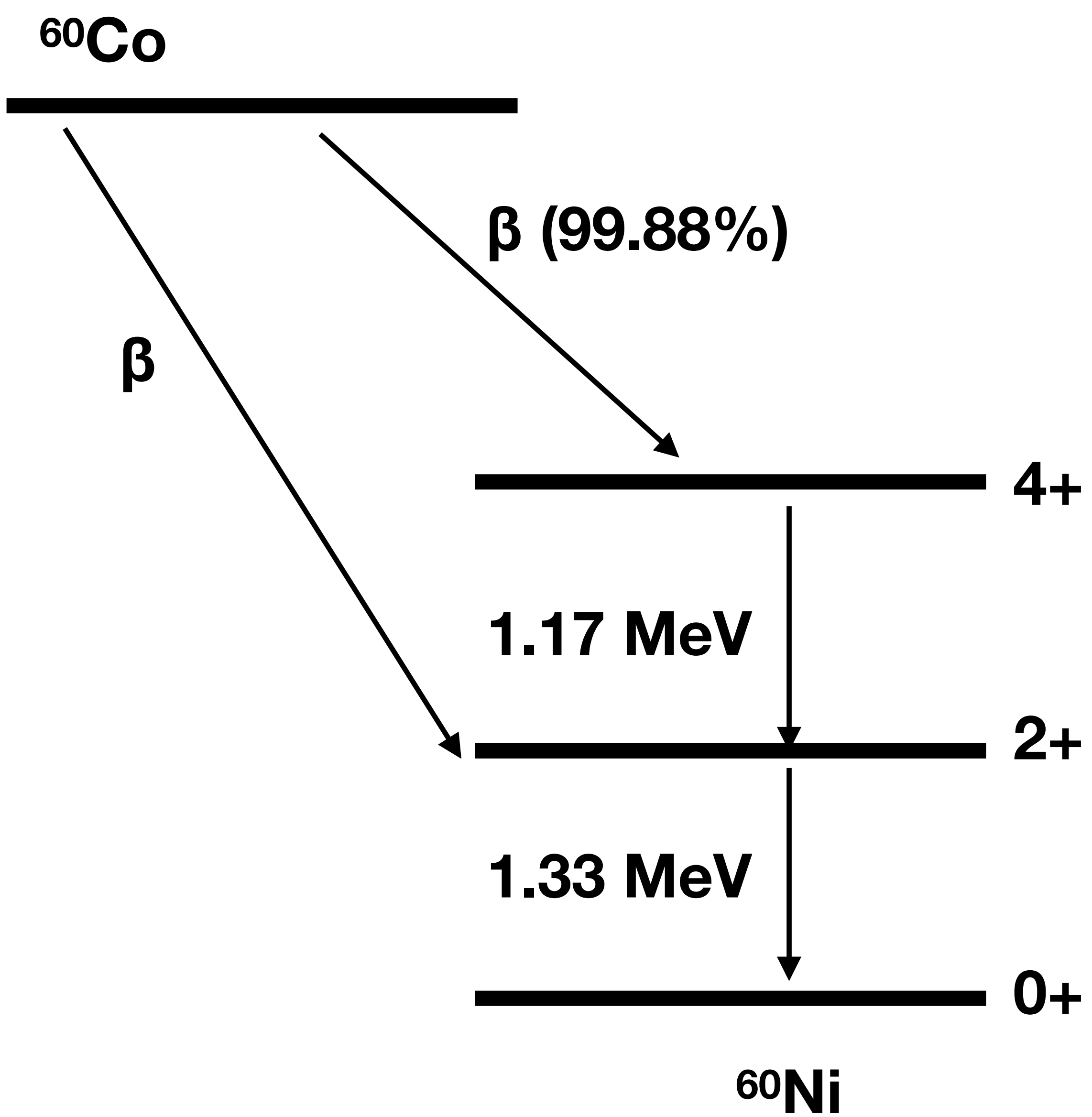

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Produce both. Confuse 1.33 MeV γ for 1.17 MeV γ

Requiring single γ only eliminates background

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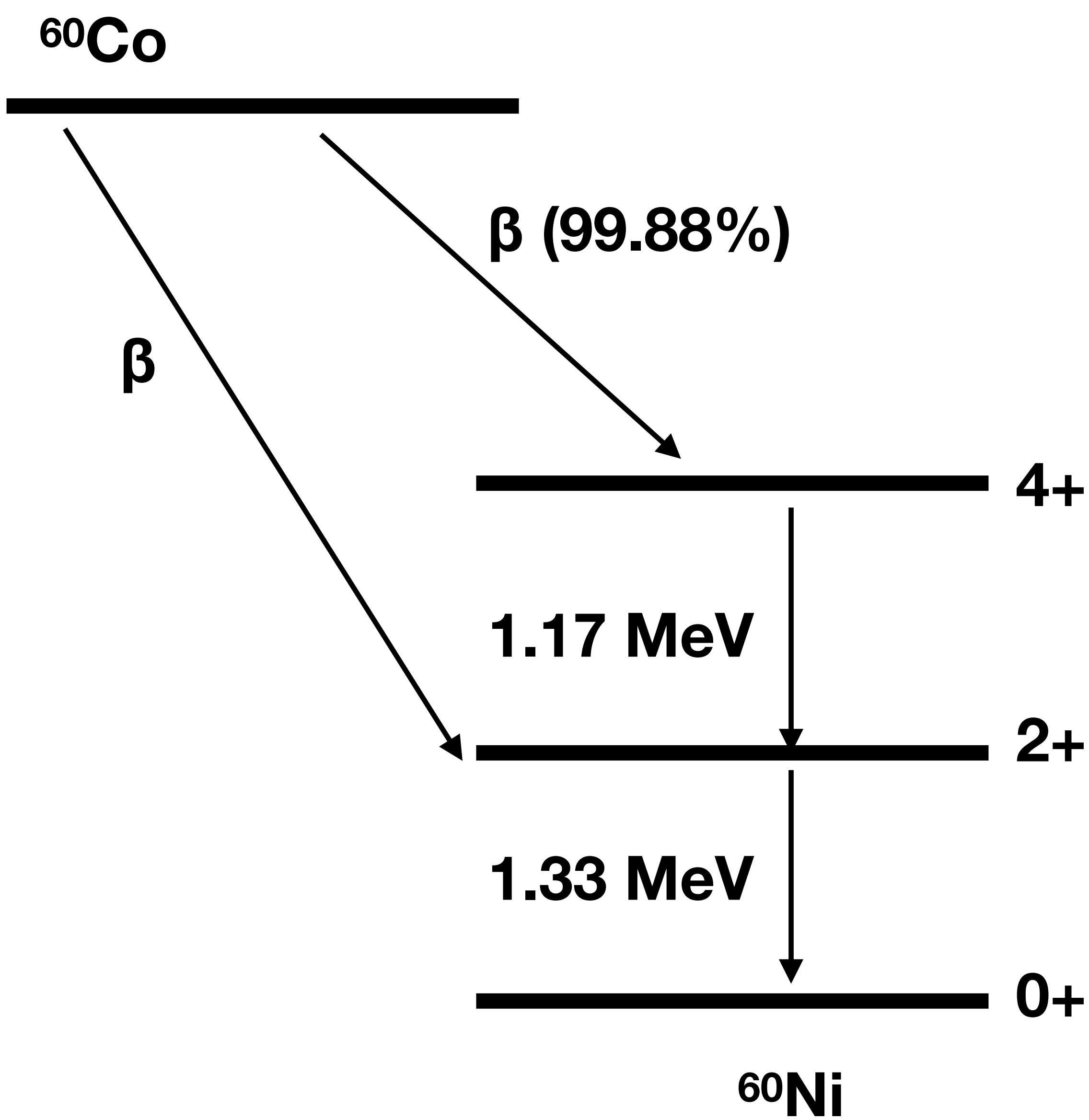

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Soft β to 2+ and Soft Compton γ

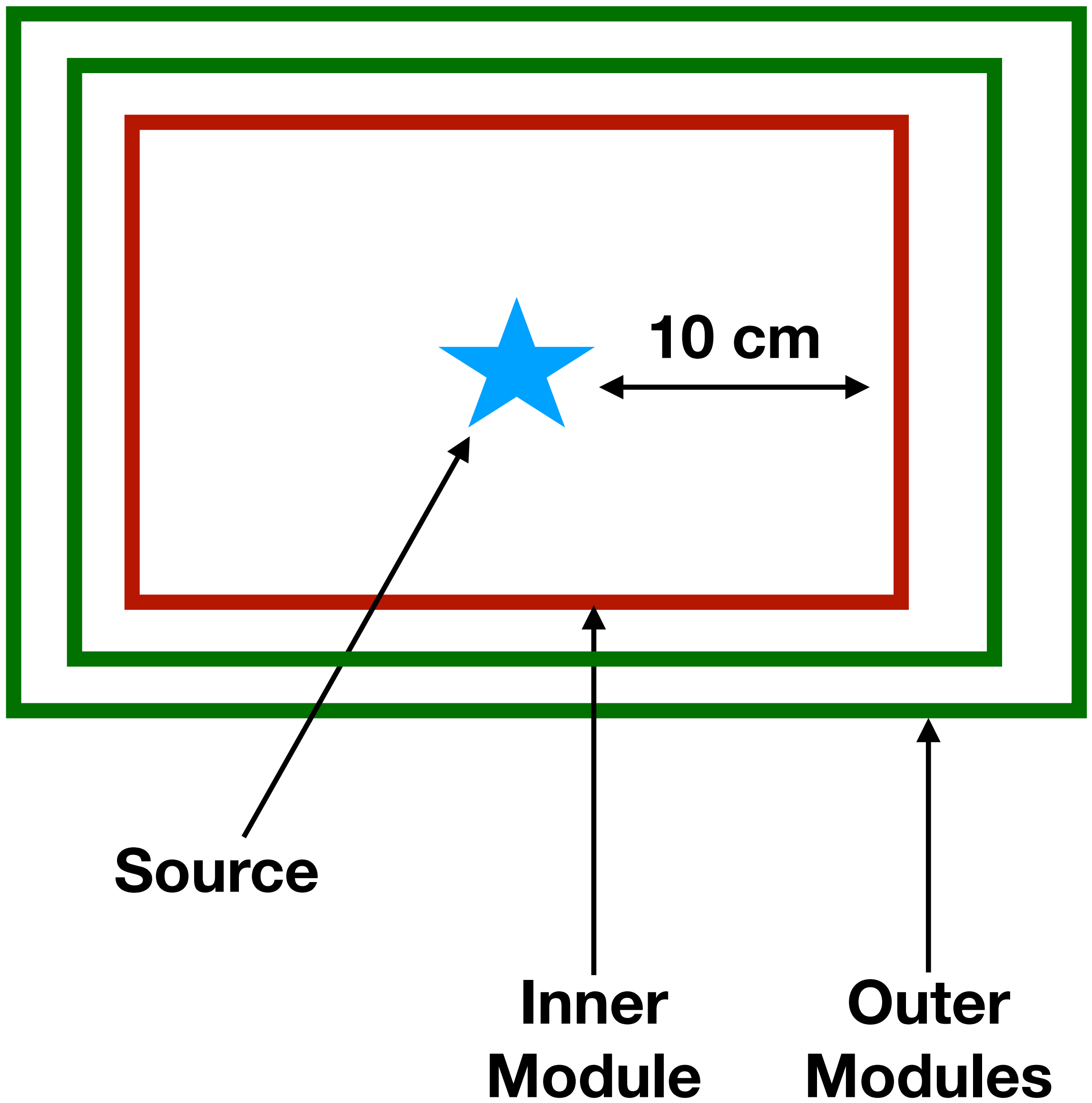
Populate 2+ @ 10^{-3}.

Soft β + Soft 1.33 MeV = β to 4+ and 1.17 γ?

Soft β + Energy Resolution of 1.33 MeV?

Geometry

Soft β to 2+ and Soft Compton γ



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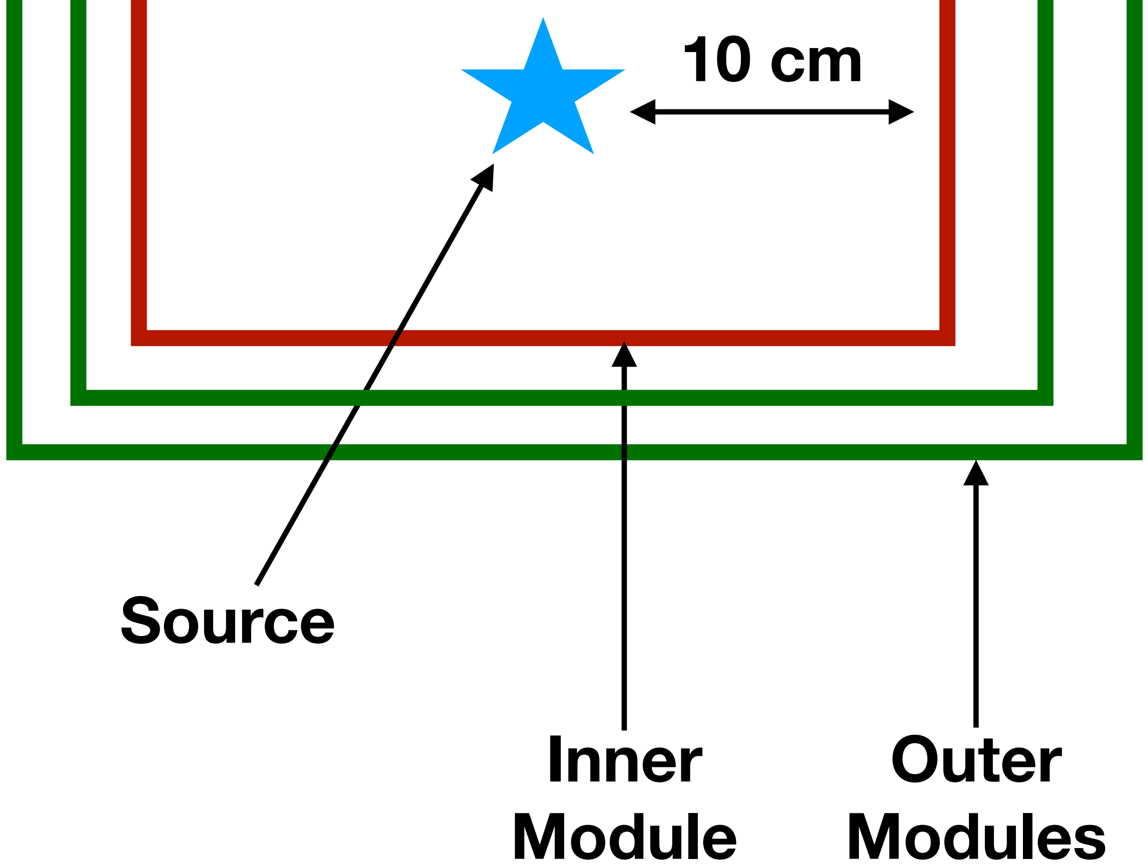

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Confusion only if both hit same scintillator (~ cm)

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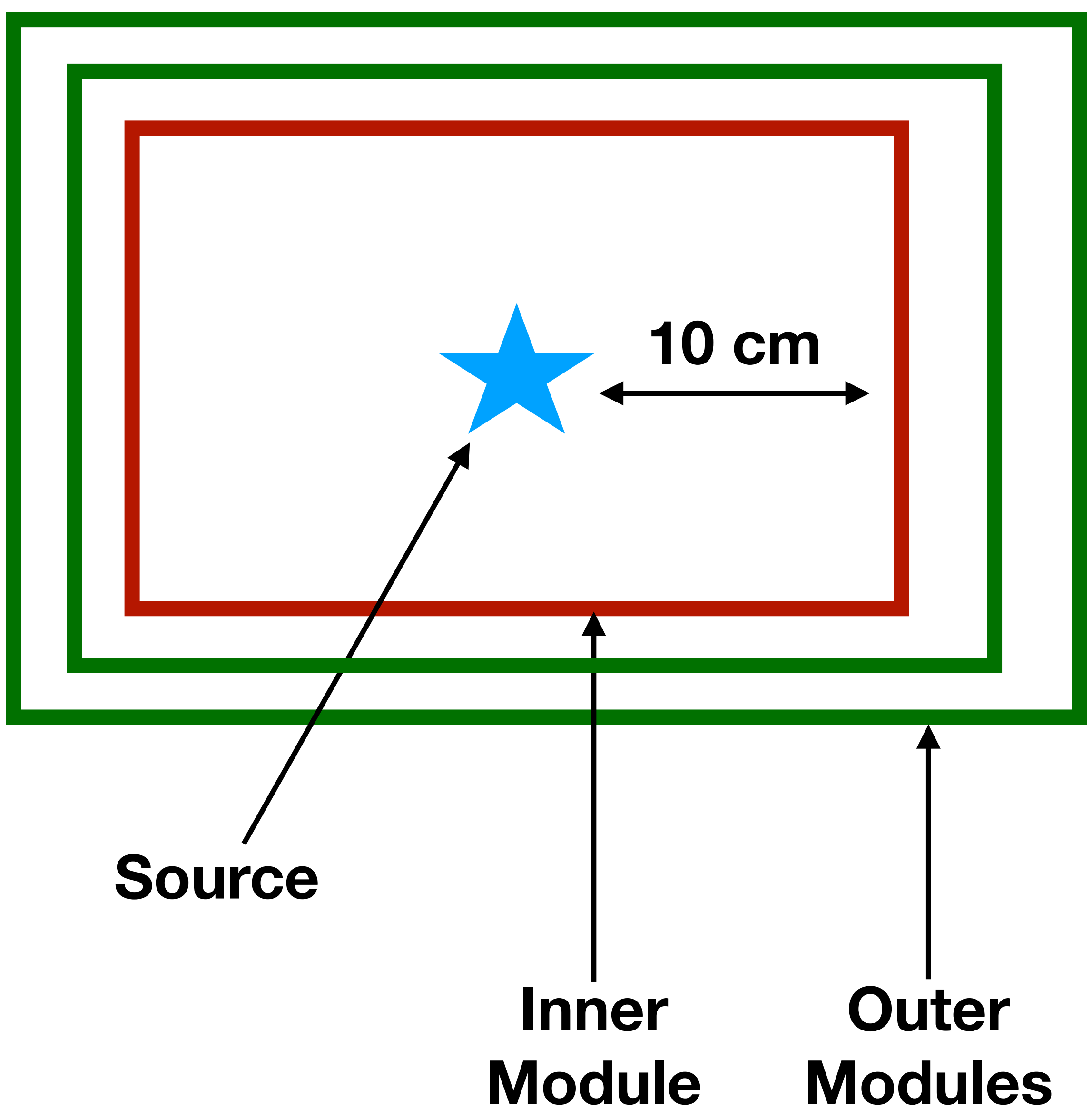

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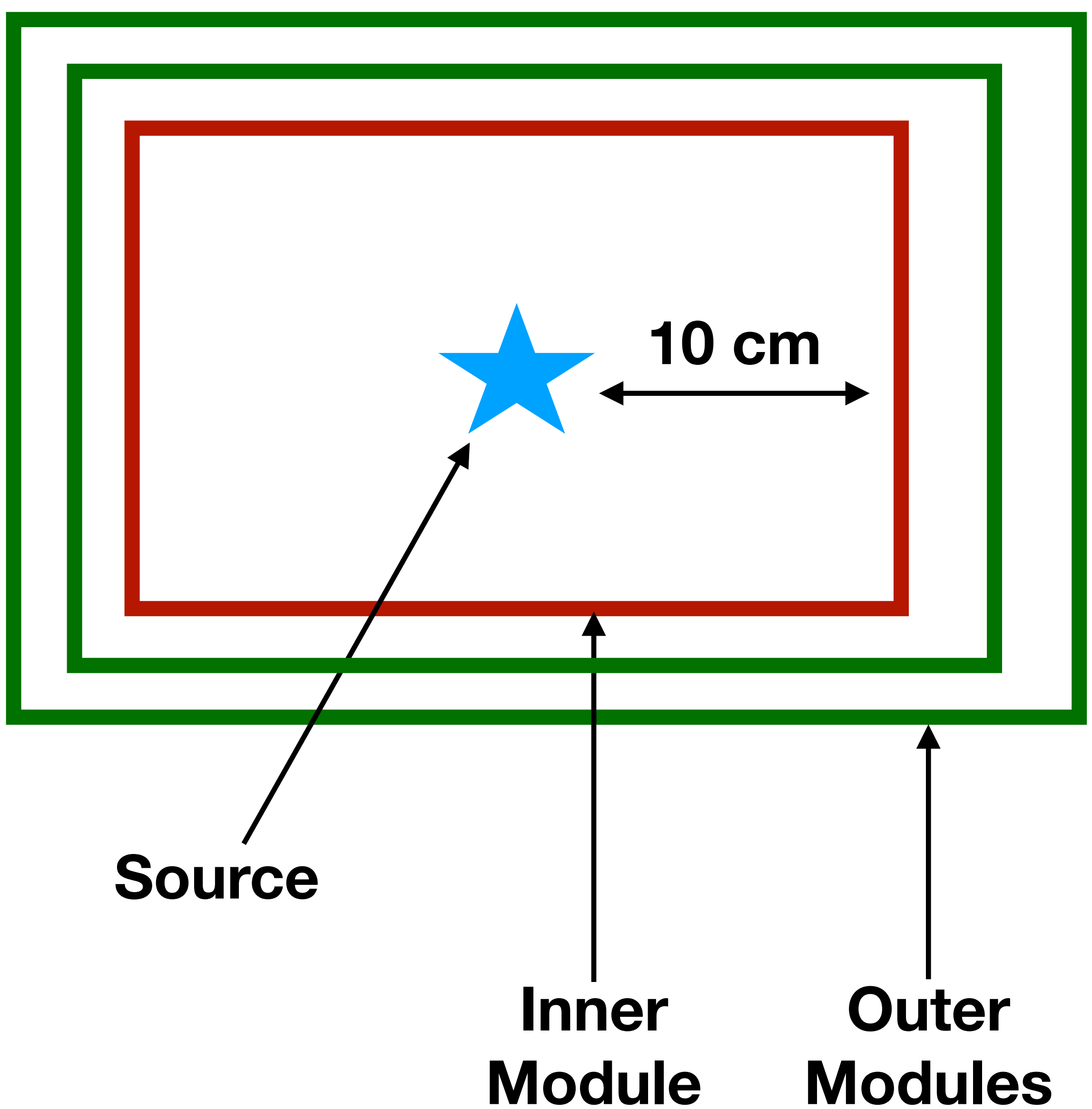

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Absent in ^{24}Na where $E_1 >> E_2$

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Measure energy from light yield (LY)

Light yield set by quantum efficiency of photodetector (Q)

Plastic Scintillators: LY ~ 10000/MeV

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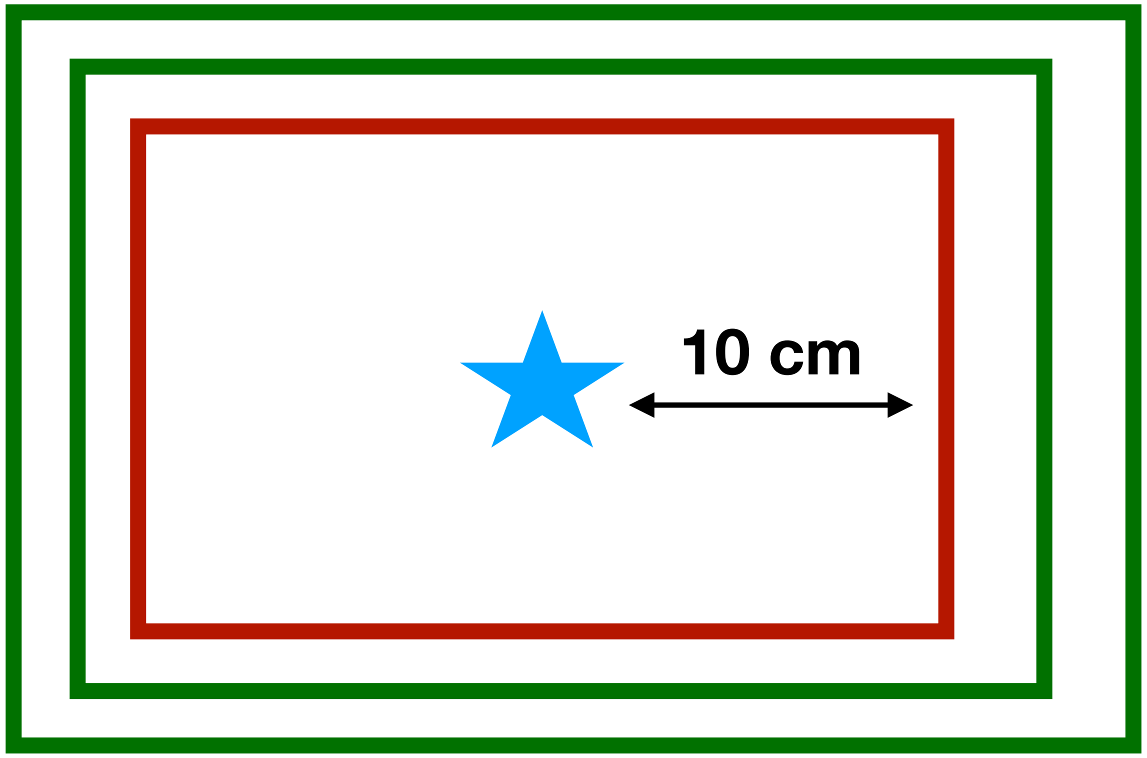

Detector Dead Volumes?

Well calibrated inner modules

Radiation Damage < 10^4 Grays

Further limit through separation

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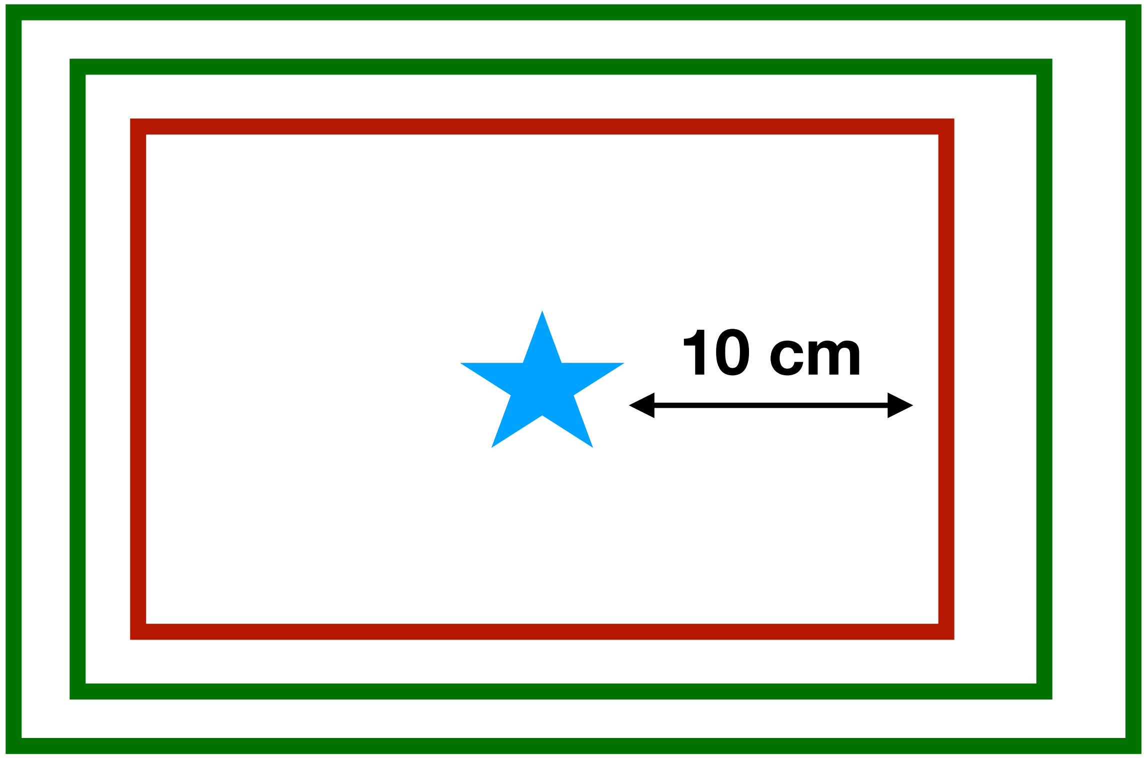

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Radioactive Contaminants

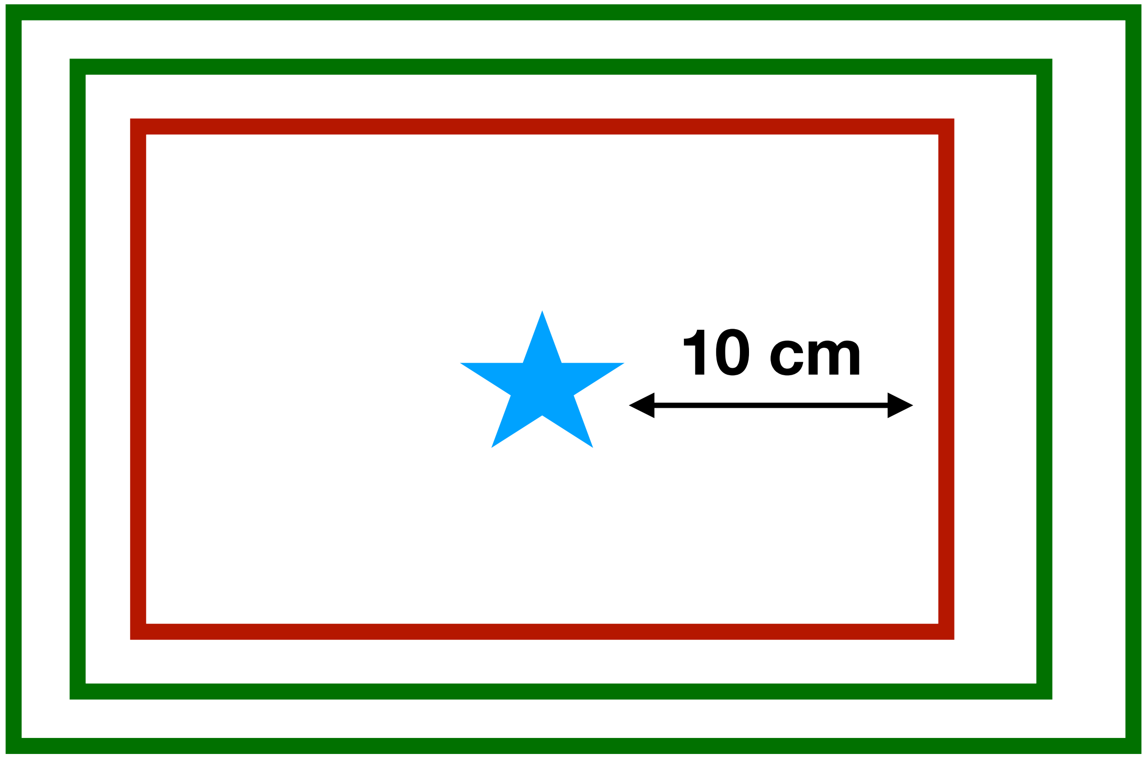
Long lived β at right energy?

None for ^{24}Na.

^{40}K for ^{60}Co - mBq/gm in some plastics.

Demand well separated β and γ in central module, ns timing

Triggers



Cosmic Rays

Veto event with energy outside inner module

Require well separated β and γ in inner modules within ~ ns

Many radiation lengths separate inner module from environment

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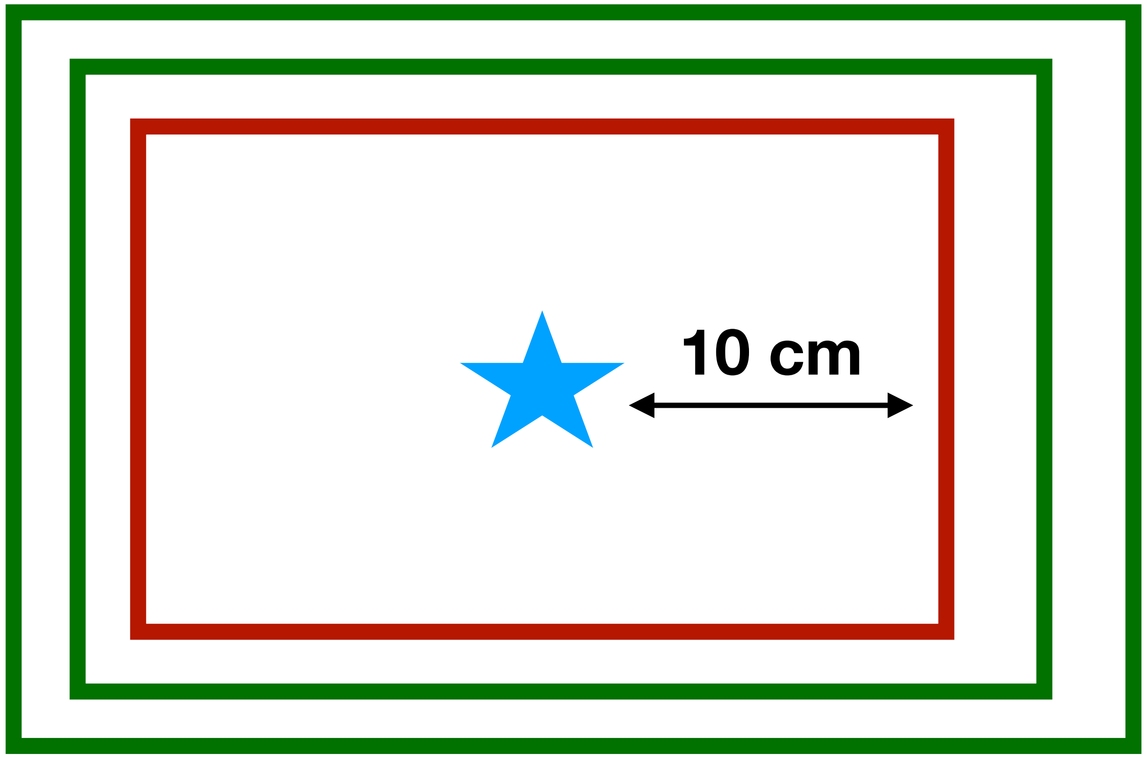

Trigger

@ 10^{-11}, not as hard as LHC

@ 10^{-14}, comparable to LDMX

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Theory/Reach

Model

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Need Branching fraction in E2 transitions.

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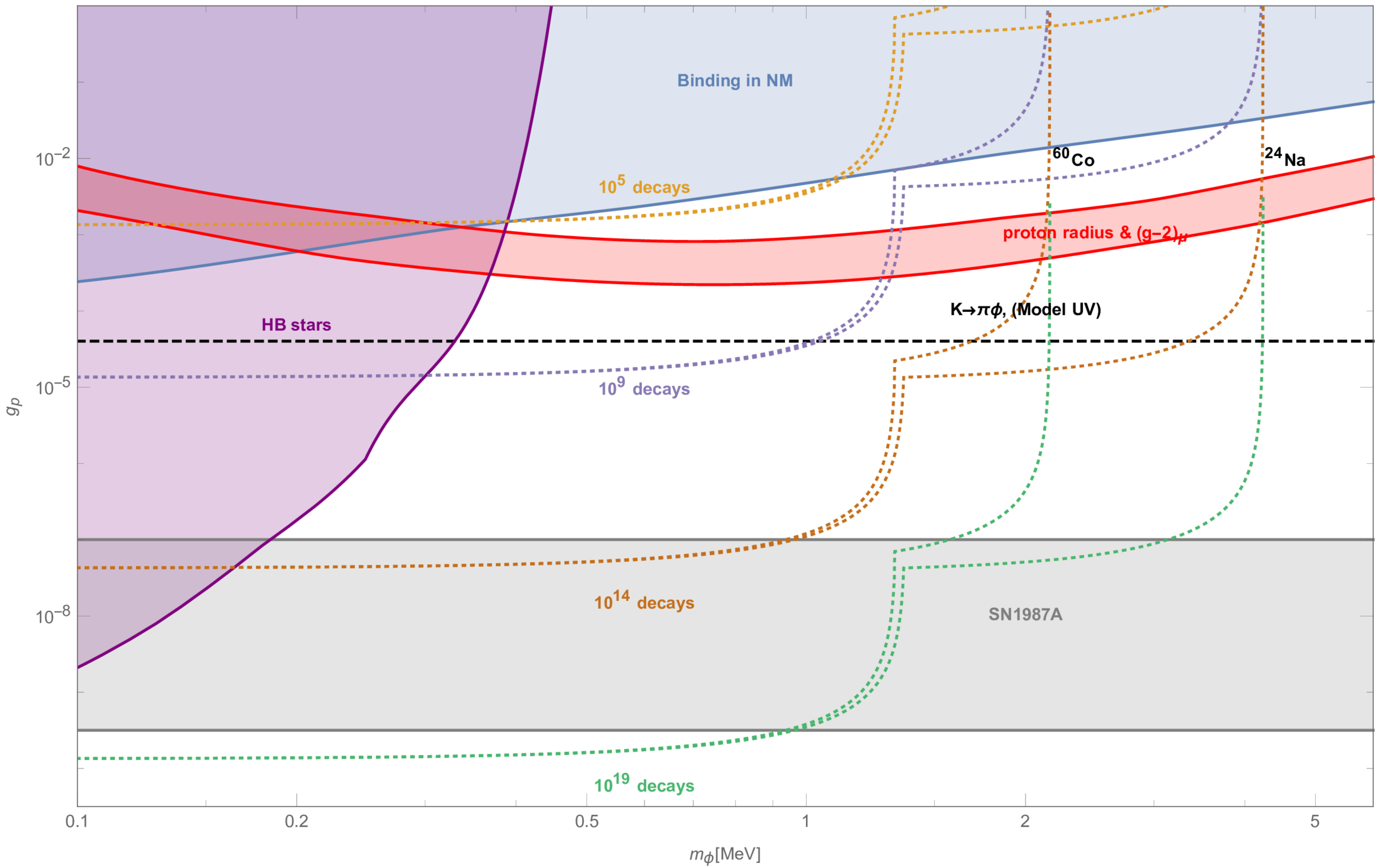
Poor constraints on baryonic forces > 100 keV

Relevant for light dark matter experiments

Potentially cause Type 2 Supernova

Constraints



Conclusions

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(> 10^{12}/s)

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Axions: M1 transitions - ^{65}Cu -> ^{65}Ni?