

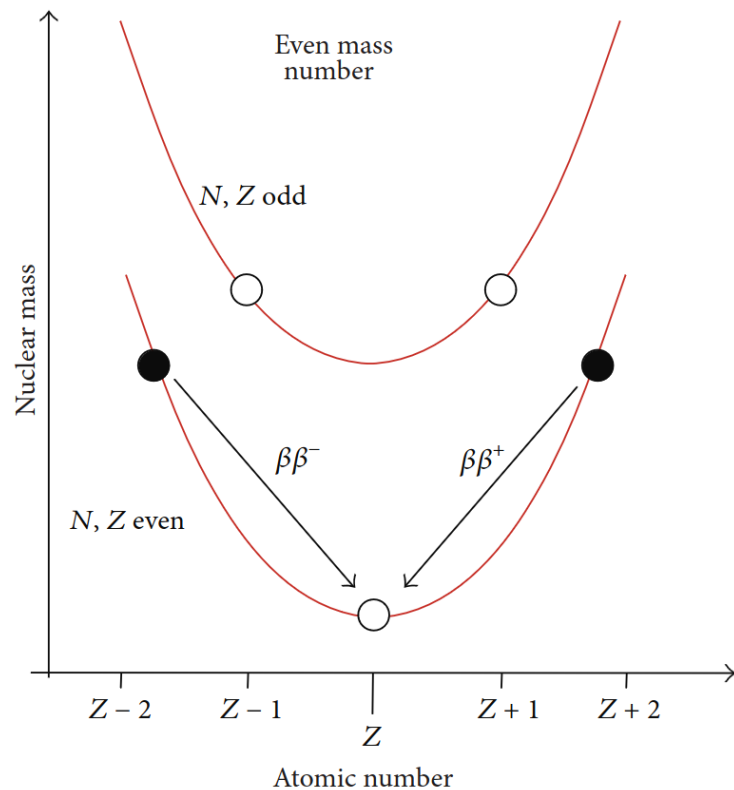
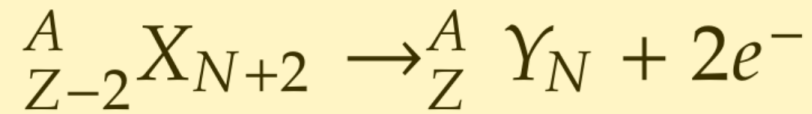
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DEGLI STUDI
DI PADOVA

Gamma decay study of the Double Isobaric Analog State in ^{48}Ti

Damiano Stramaccioni – August 28th 2026

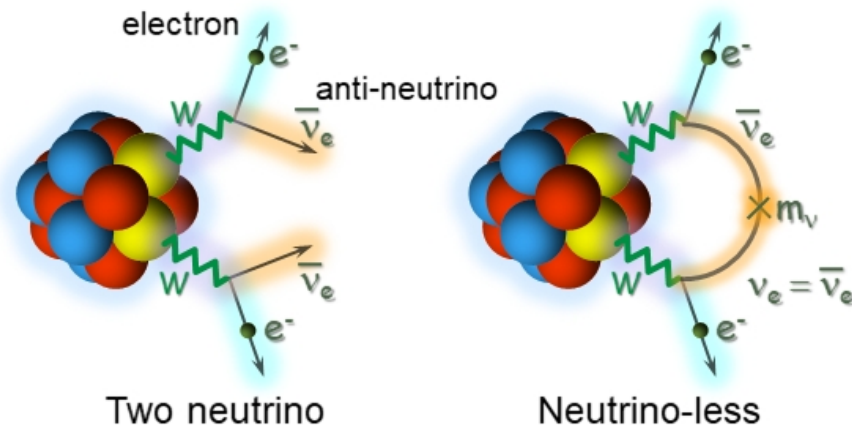
$0\nu\beta\beta$ decay and the role of Nuclear Physics

$0\nu\beta\beta$ decay suggested by theories BSM: promising process to observe **L-violation** in laboratory, ν a **Majorana** particle, ν mass...



Candidates are **even-even** nuclei which, due to pairing force, are lighter than the odd-odd (A,Z-1) nucleus:

${}^{48}\text{Ca}$, ${}^{76}\text{Ge}$, ${}^{82}\text{Se}$, ${}^{96}\text{Zr}$, ${}^{100}\text{Mo}$,
 ${}^{116}\text{Cd}$, ${}^{130}\text{Te}$, ${}^{136}\text{Xe}$, ${}^{150}\text{Nd}$



$0\nu\beta\beta$ decay and the role of Nuclear Physics



Generically,

$$[T_{1/2}^{0\nu}]^{-1} = G_{0\nu}(Q, Z) |M^{0\nu}|^2 m_{\beta\beta}^2$$

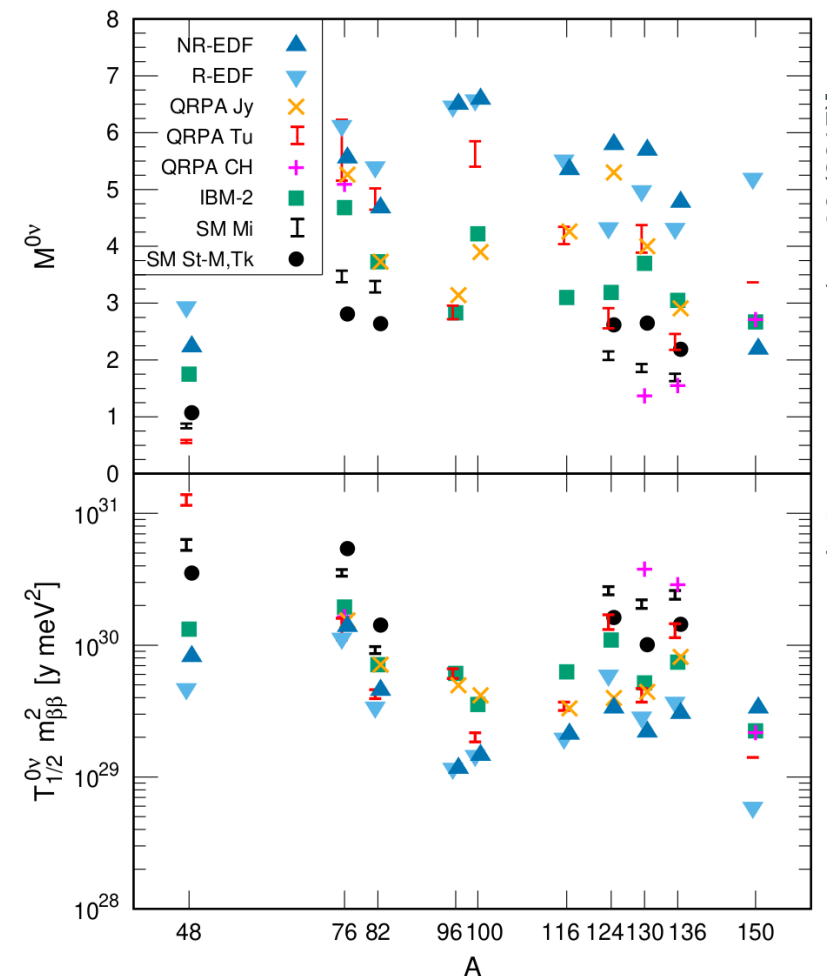
$G_{0\nu}(Q, Z)$ Phase space Factor

$m_{\beta\beta}^2$ New Physics parameter

$|M^{0\nu}|^2$ Nuclear Matrix Element (NME)
brings **large uncertainties** in
DBD half-lives

Can we reduce them studying observables
that are linked to $0\nu\beta\beta$, even not mediated
by same interaction?

→ **Double-gamma decay!**



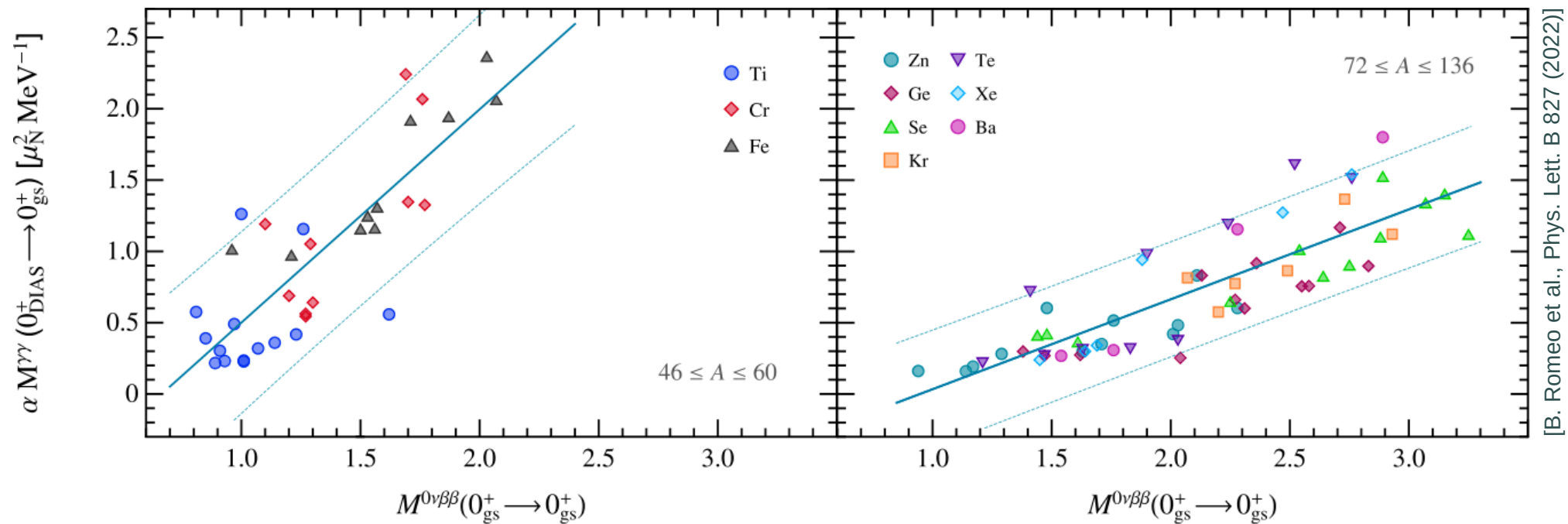
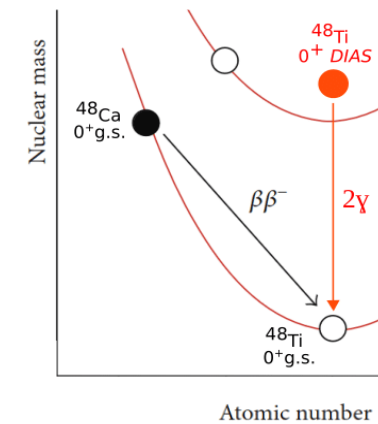
[J. Engel and J. Menéndez, Rept. Prog. Phys. 80 (2017)]

Correlation with $0\nu\beta\beta$ decay



In 2022, a strong correlation between **NMEs of 2γ -decays** from DIAS to g.s. and **$0\nu\beta\beta$** decays found.

➔ The correlation holds if we consider **M1M1 decays** with **equal-energy gammas**.



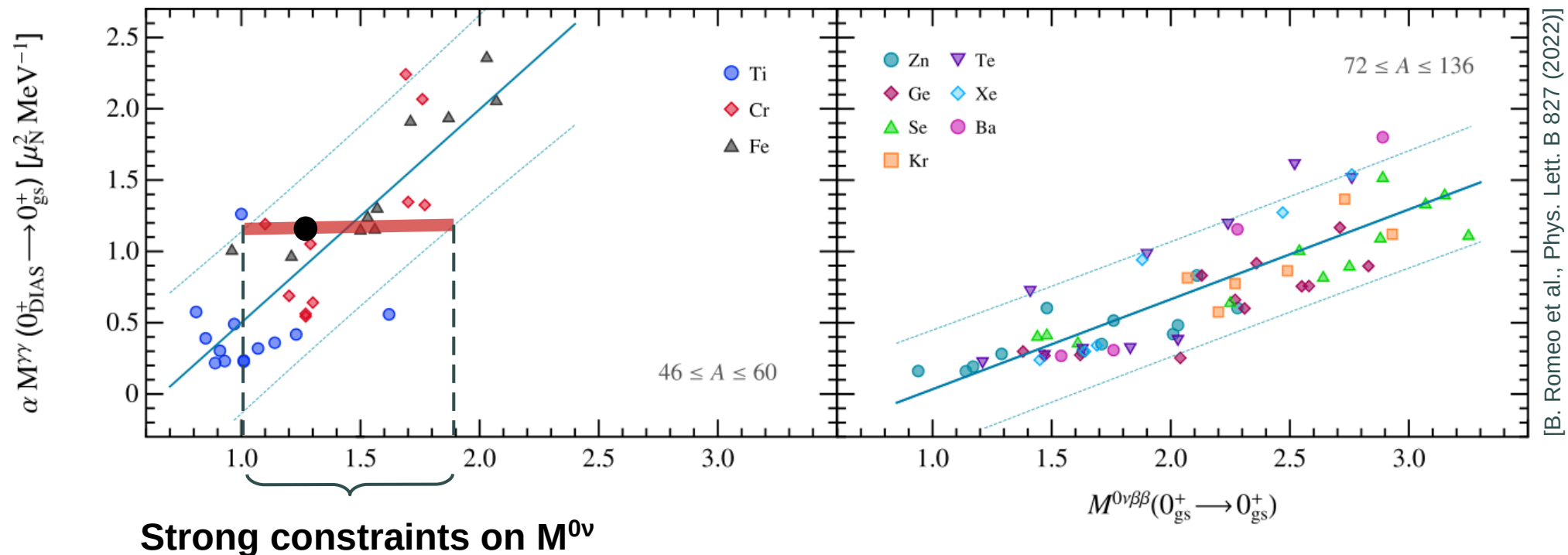
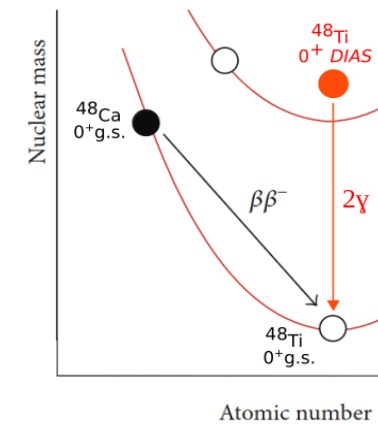
[B. Romeo et al., Phys. Lett. B 827 (2022)]

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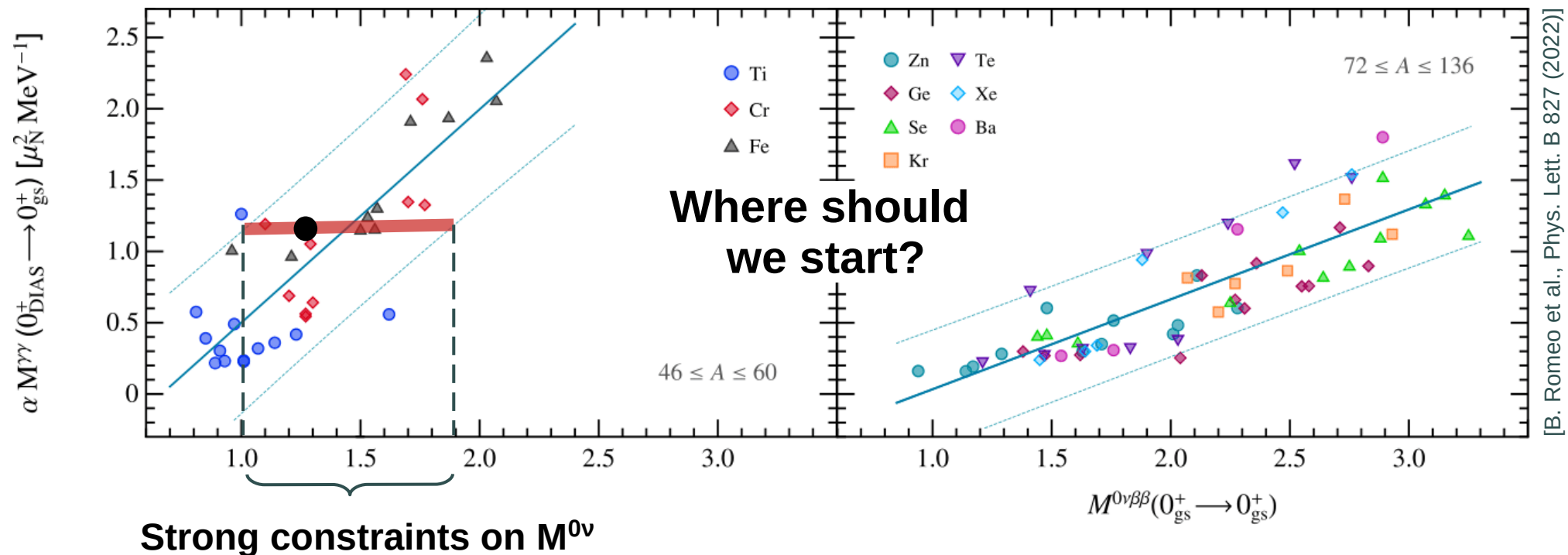
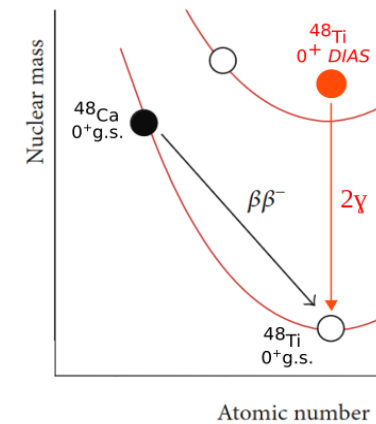


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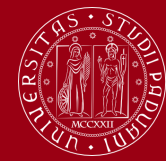


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Double-gamma decay candidates



Best candidate: $^{48}\text{Ti} \rightarrow$ mimic $0\nu\beta\beta$ ^{48}Ca decay

- PROS**
- 1) The 17 MeV 0^+ **DIAS** is known
 - 2) Particle unbound, but **particle decay is highly suppressed** (isospin forbidden).

- CONS**
- 1) **Difficult to populate** (high energy 0^+)
 - 2) Extremely small double-gamma decay width:
 $\Gamma_{\gamma\gamma} / \Gamma_{\text{tot}} \approx 10^{-8}$

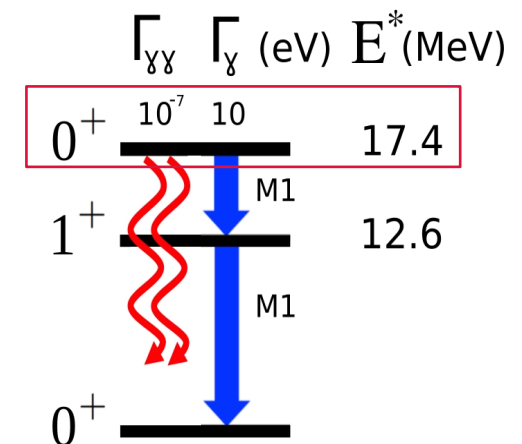
- How to populate the 17 MeV 0^+ DIAS?



→ isospin conserving and very selective (light particles)

- How strong are the competing channels?

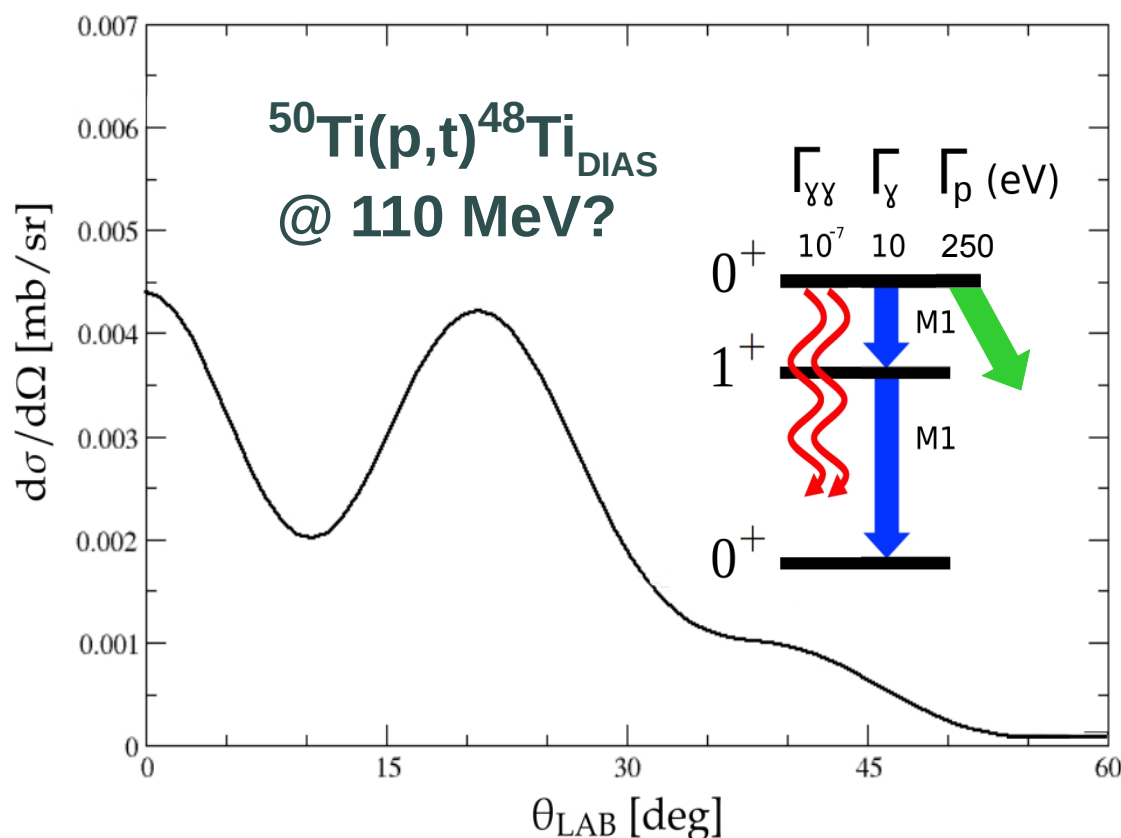
^{48}Ti STABLE 73.72%	^{47}Ti STABLE 5.11%	^{46}Ti STABLE 5.18%
^{47}Sc 3.3492 d $\beta^- = 100.00\%$	^{48}Sc 43.67 h $\beta^- = 100.00\%$	^{49}Sc 57.18 min $\beta^- = 100.00\%$
^{46}Ca > 0.28E+16 y 0.004% $2\beta^-$	^{47}Ca 4.536 d $\beta^- = 100.00\%$	^{48}Ca > 5.8E22 y 0.187% $2\beta^- = 75.00\%$



➔ Preparatory experiment needed to assess these points

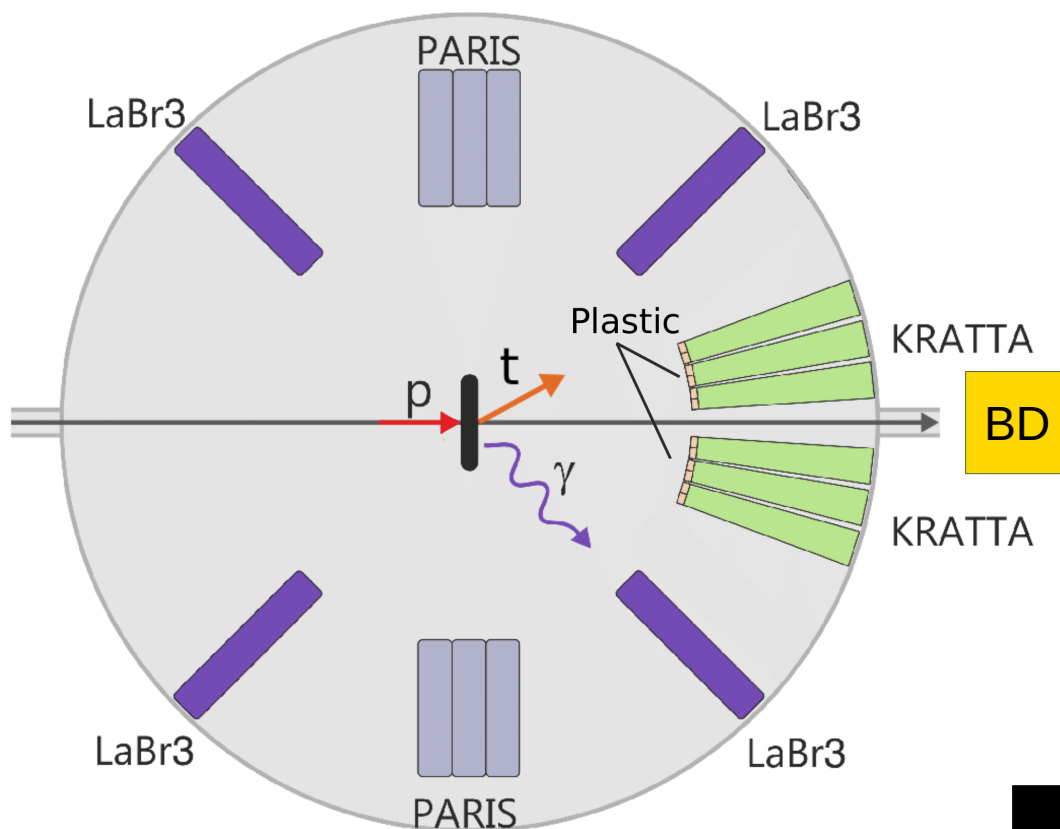
Gamma decay study of the Double Isobaric Analog State in ^{48}Ti .

Spokepersons: D. Stramaccioni, M. Balogh, J.J. Valiente-Dobón



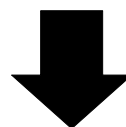
Main intermediate goals:

- 1) determine the **cross section** to populate the DIAS σ_{DIAS}
- 2) measure the **decay branching** between the dominant competing processes
→ **single gamma decay BR**



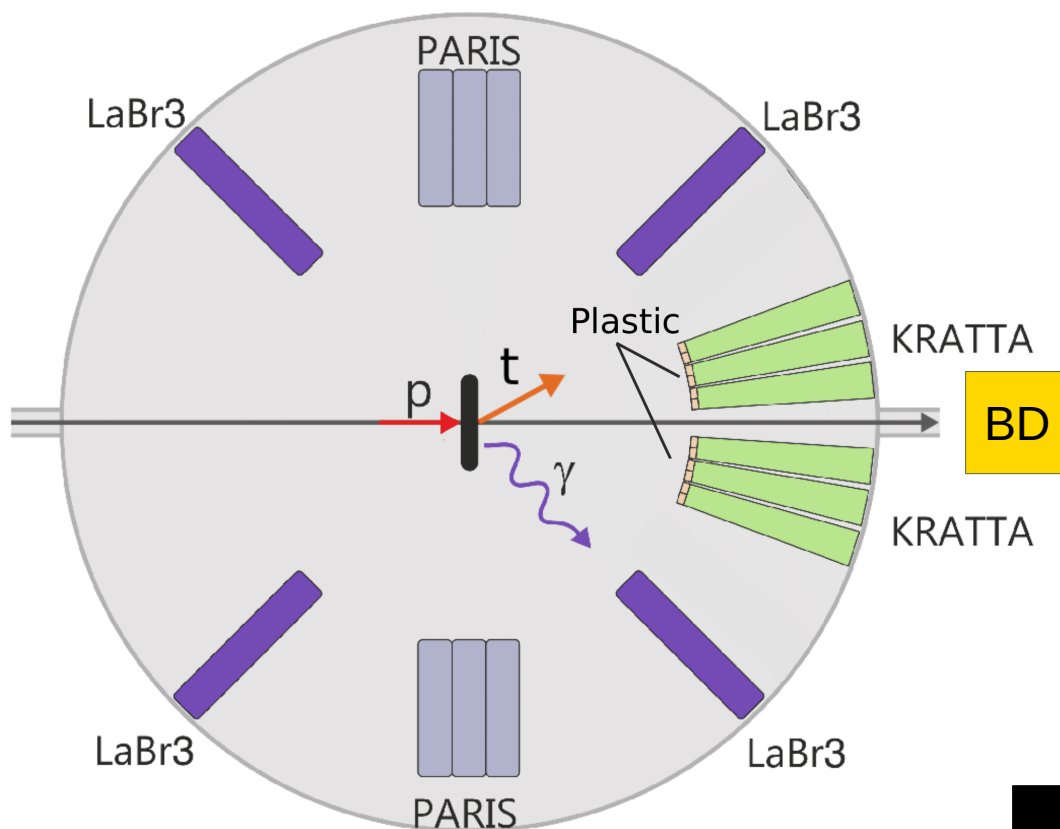
$^{50}\text{Ti}(p,t)^{48}\text{Ti}_{\text{DIAS}}$ @ 110 MeV

- Energetic proton beam ($Q = -27$ MeV)
- 32 **KRATTA triple telescopes** (segmented plastic scintillator in front) to measure the **scattered tritons**
- 4 large volume **LaBr₃** detectors & 2 **PARIS** clusters for the measurement of **γ rays**



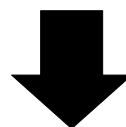
1) σ_{DIAS} determination

→ **PID** via ΔE -E **PD0 vs PD1** (non-standard) → Reconstruction of **excitation energy**
→ **Beam Dump** current / **elastic** scattering for normalization



$^{50}\text{Ti}(p,t)^{48}\text{Ti}_{\text{DIAS}}$ @ 110 MeV

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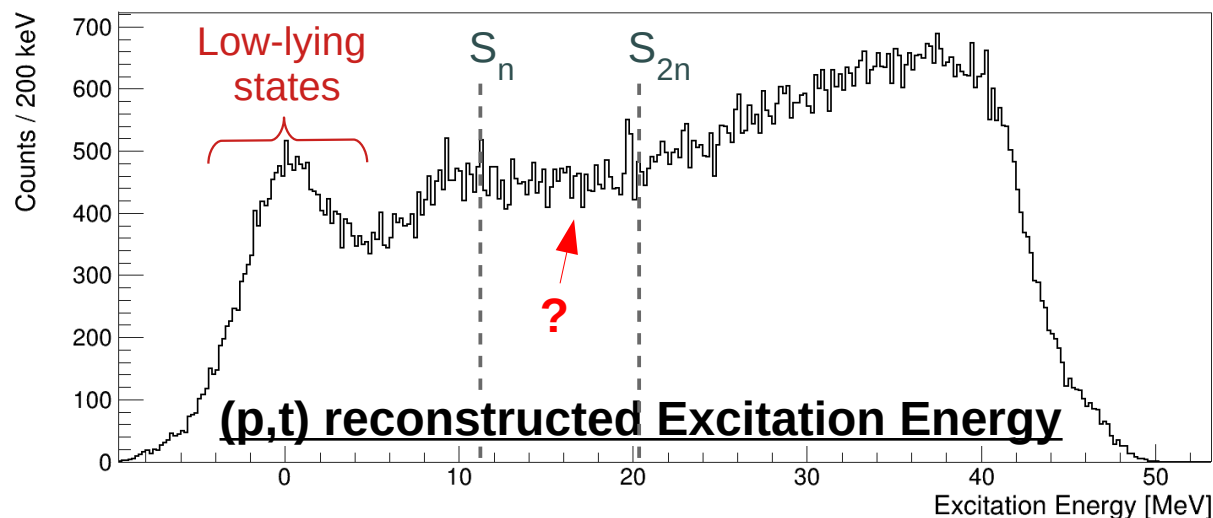
2) **γ-decay BR** estimate

- **Gamma spectrum** in coincidence with the **tritons** populating the **DIAS**
- Count **number of gammas** going to the **lower-lying** states in ^{48}Ti

Preliminary results (25% beam time so far)



Preliminary E_x - γ coincidence analysis looks promising!



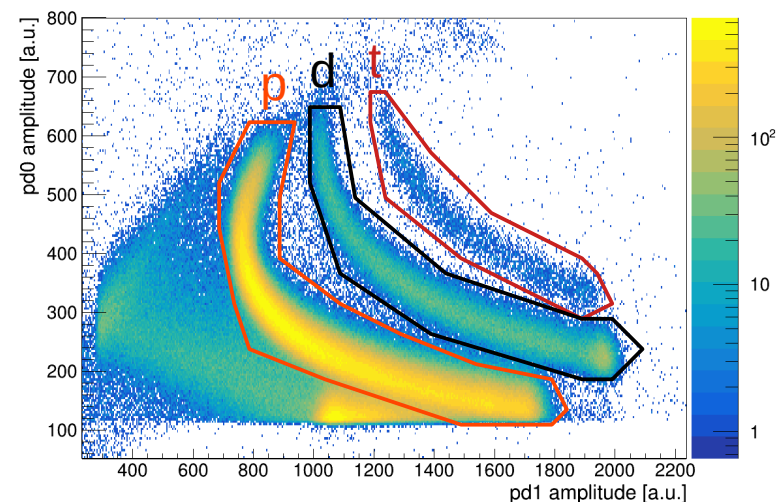
Poor energy resolution (about 4 MeV FWHM),

No clear sign of a structure around 17 MeV..



One needs to clean up with γ coincidences!

Gate on **tritons** (ΔE -E)



We see ^{48}Ti gamma lines requiring $E_x < S_n$!

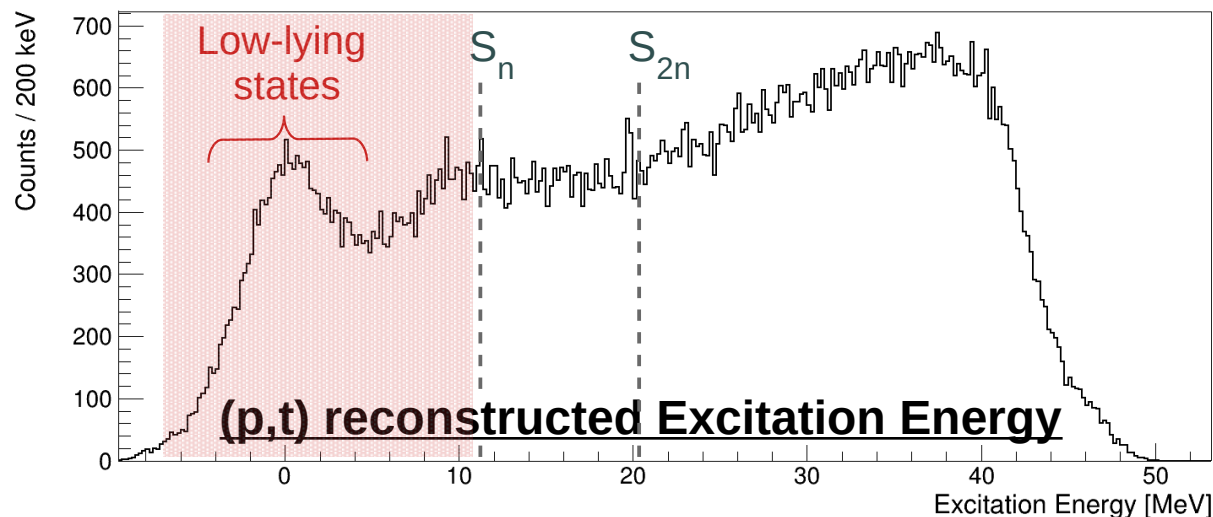
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Arrows point from 48V to 48Ti (labeled 't') and from 50V to 50Ti (labeled 'p').

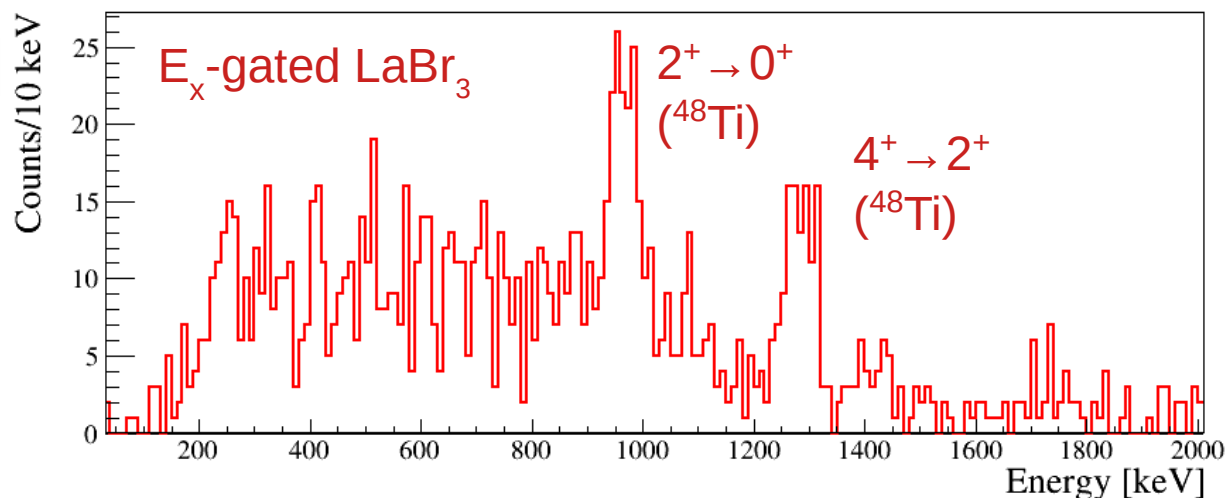
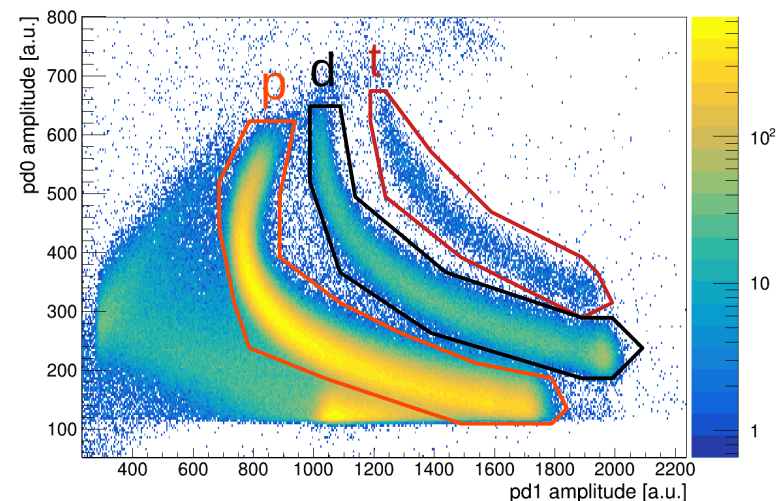
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We see ⁴⁸Ti gamma lines
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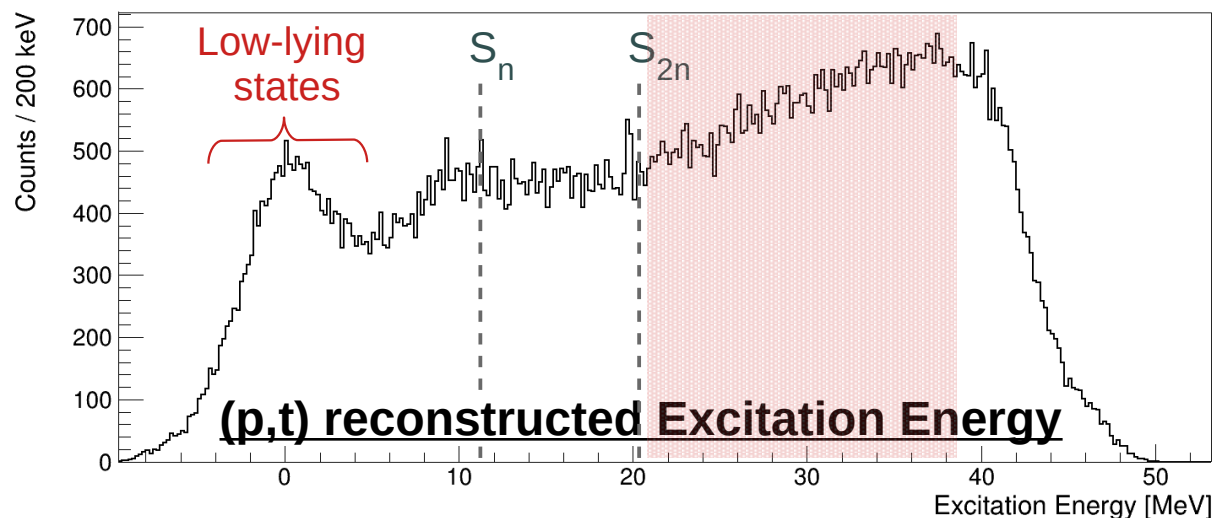
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Arrows point from 48Ti to 49Ti (labeled 't') and from 49Ti to 50Ti (labeled 'p').

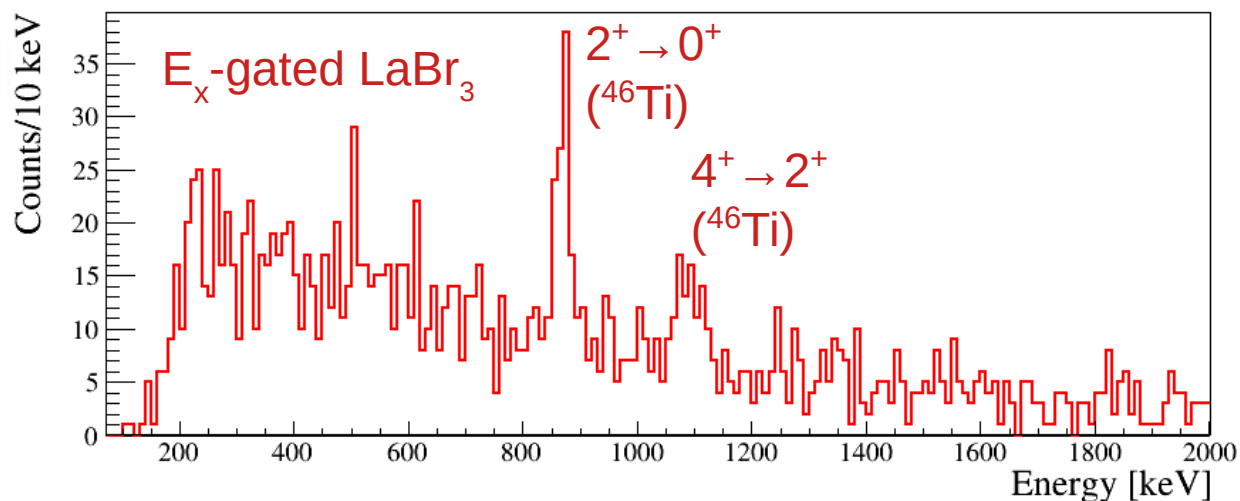
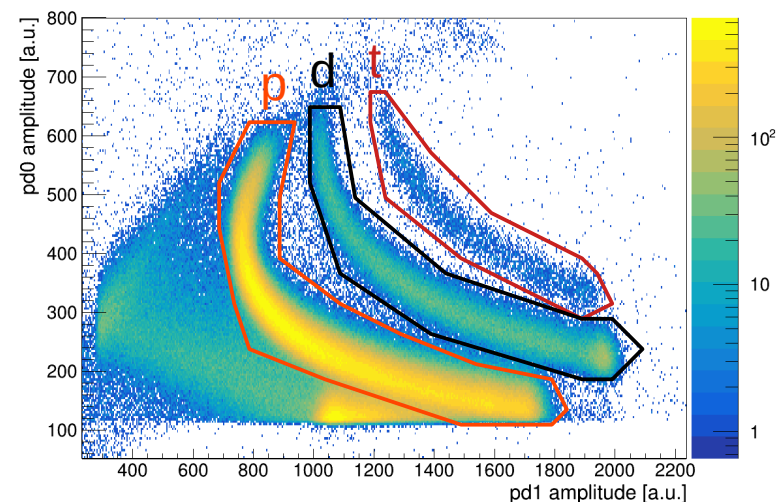
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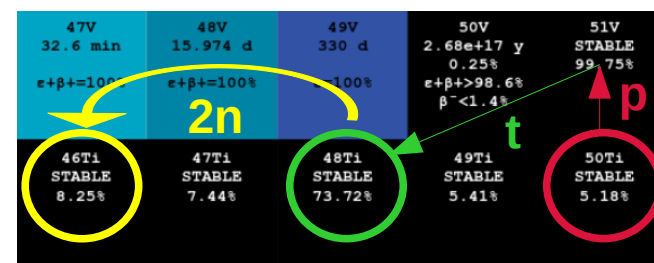
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Gate on **tritons** (ΔE - E)



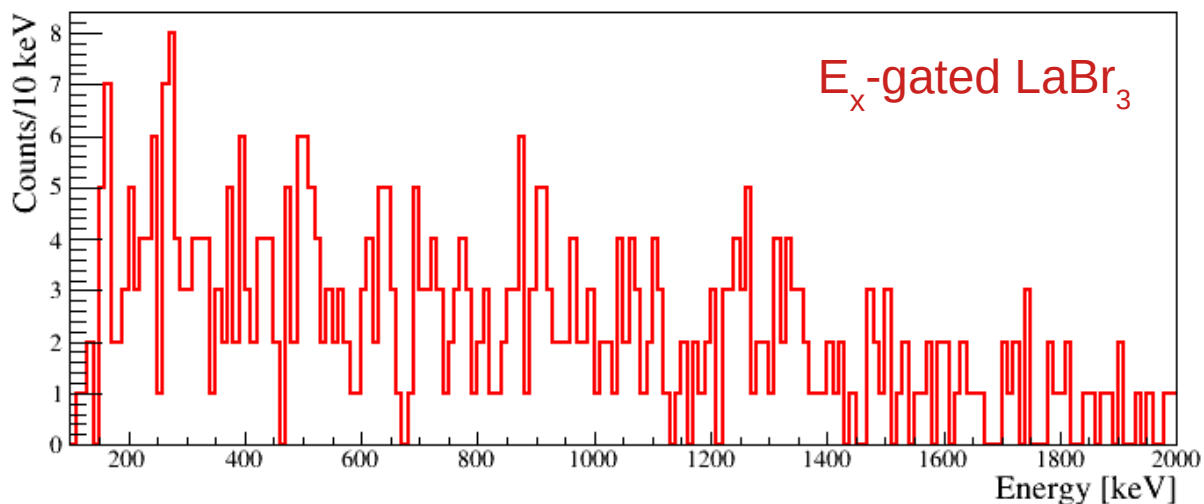
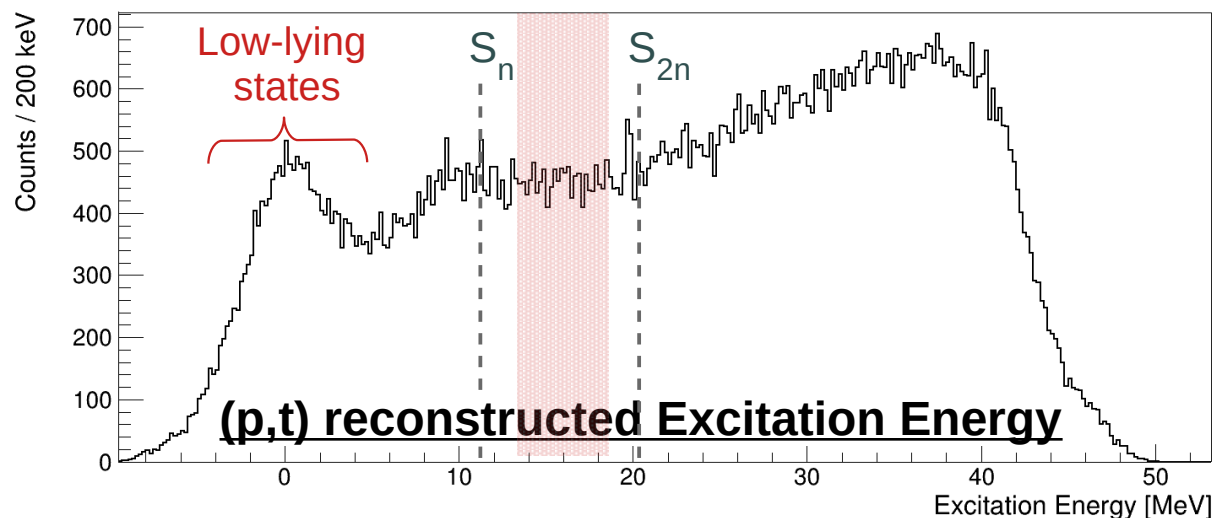
We see ^{46}Ti gamma lines
requiring $E_x > S_{2n}$!



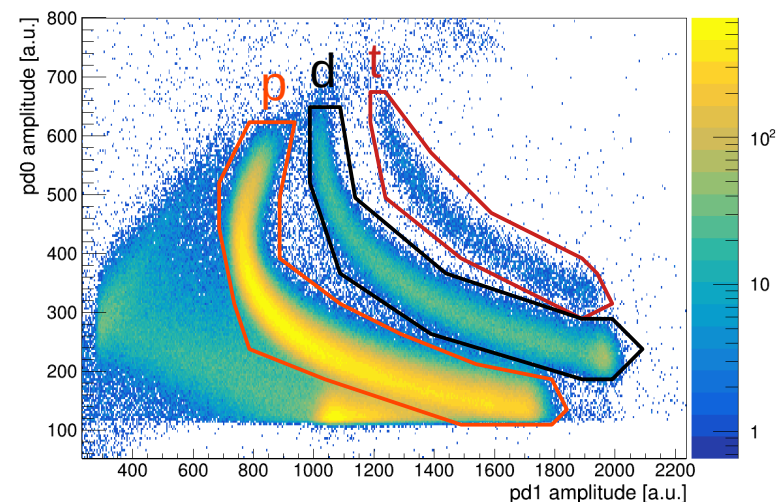
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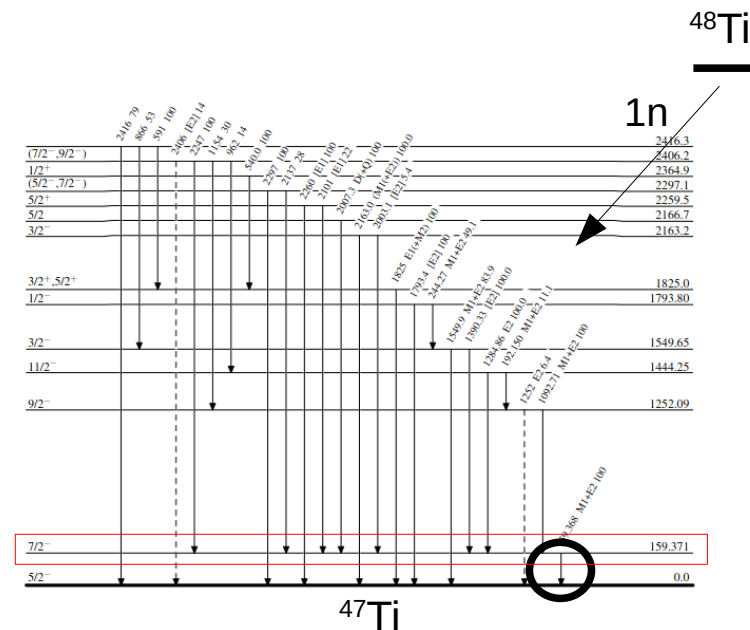
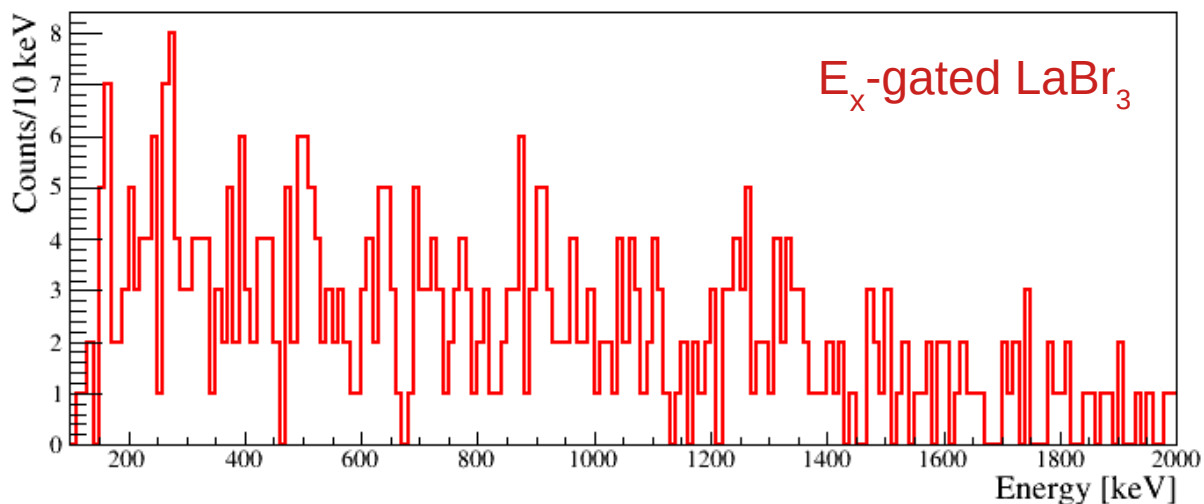
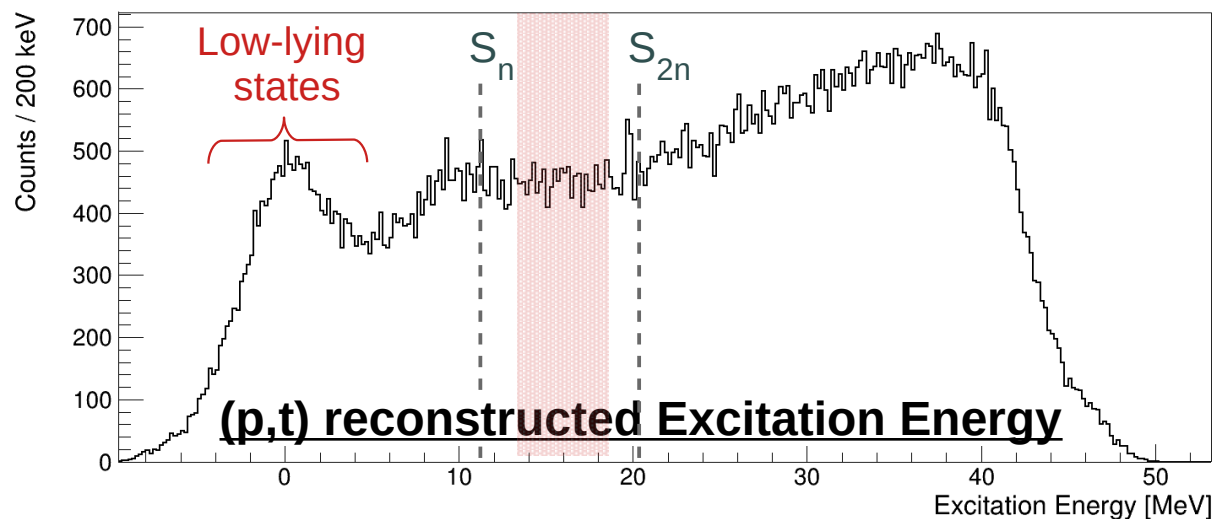
Lowest-lying γ rays of the **-1n**
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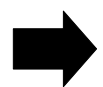
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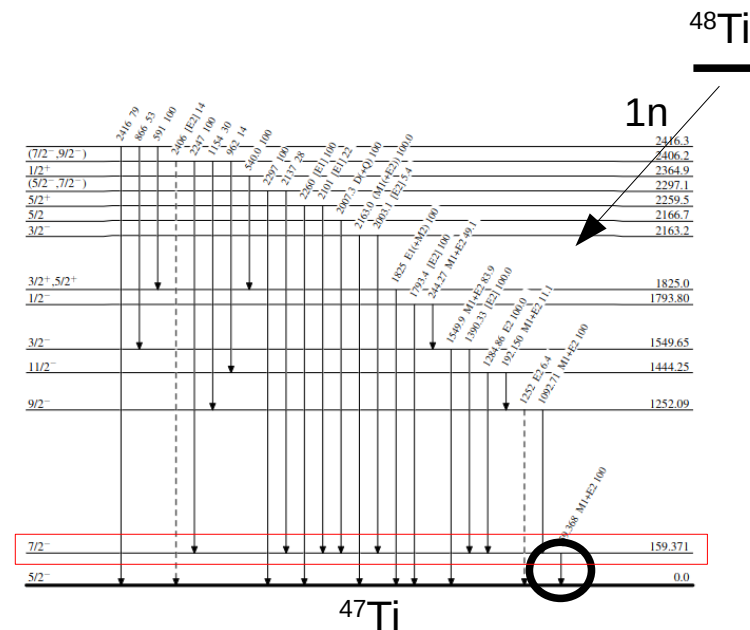
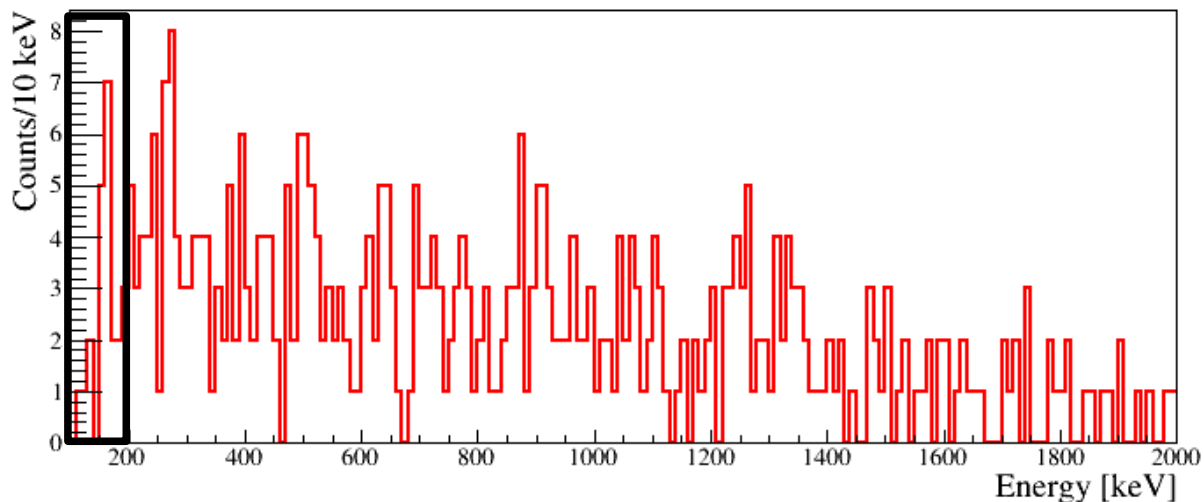
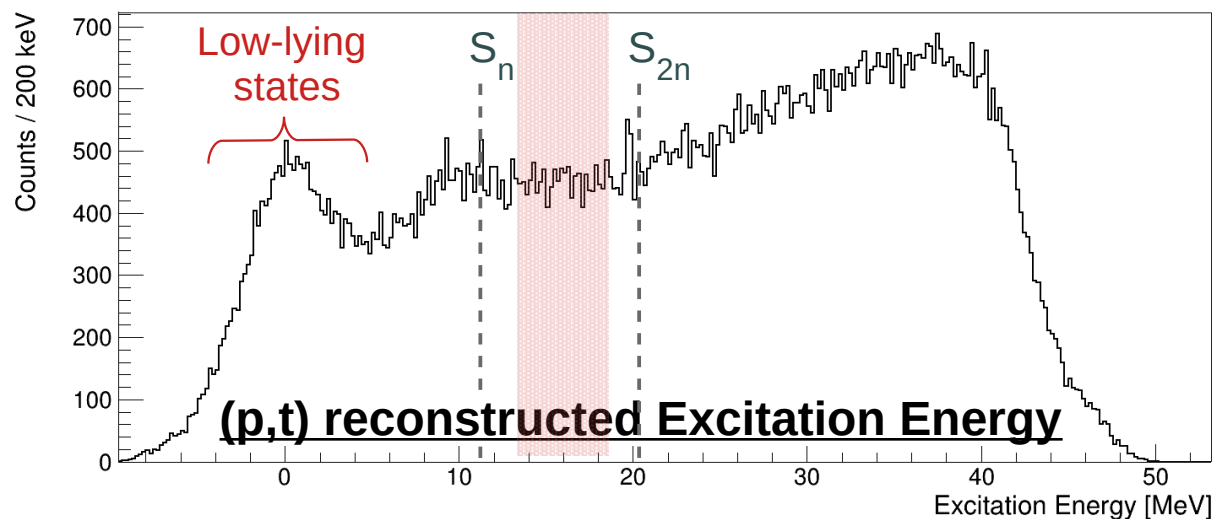
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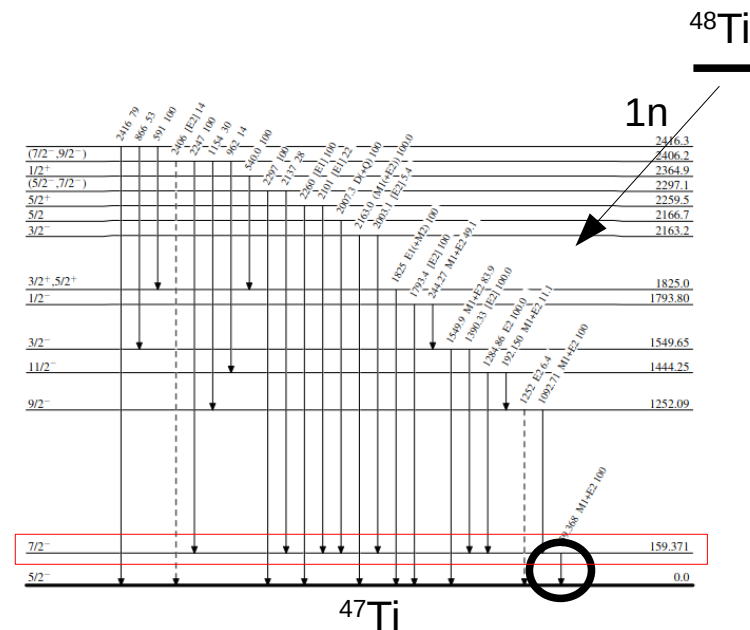
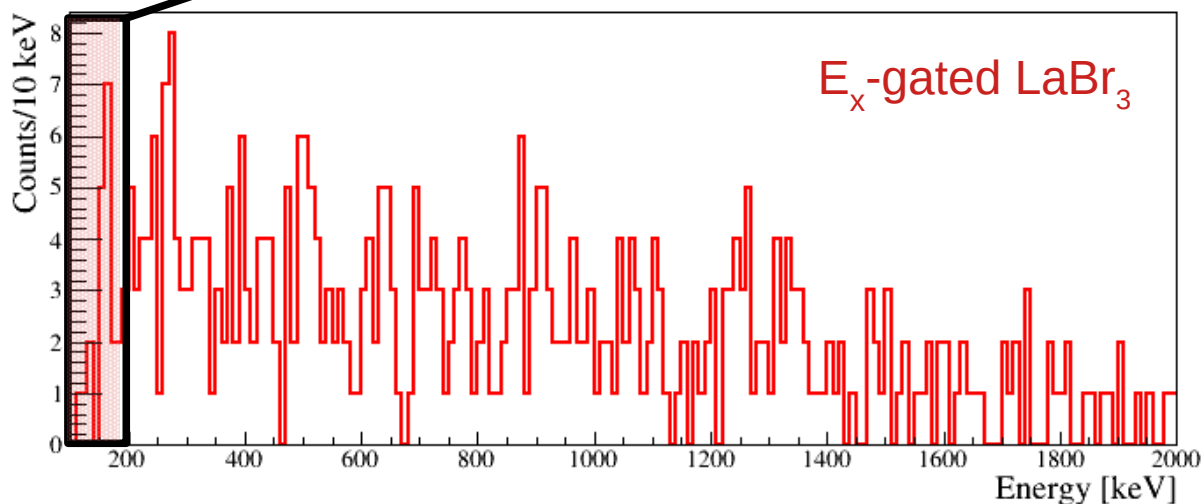
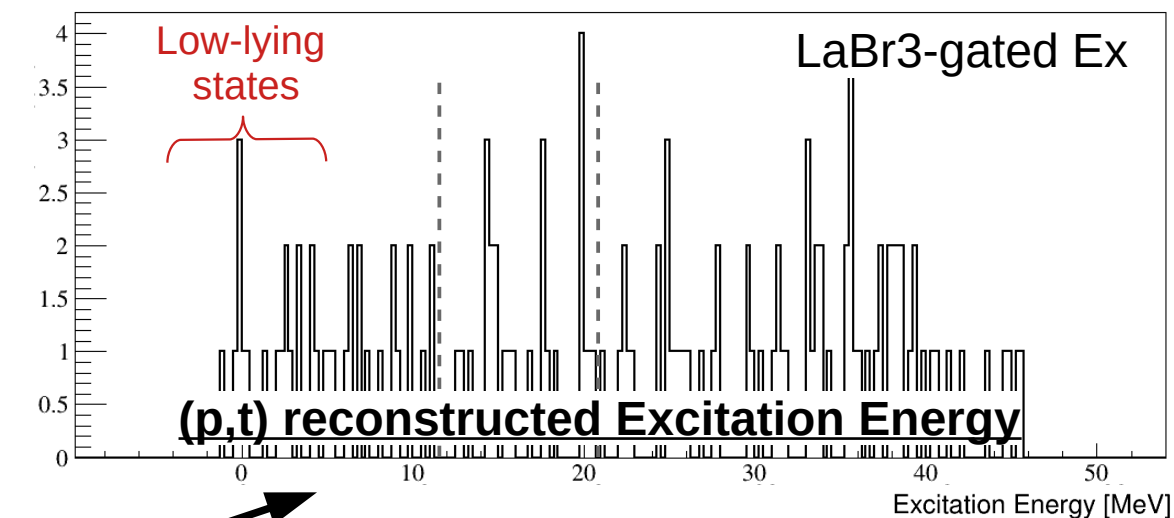
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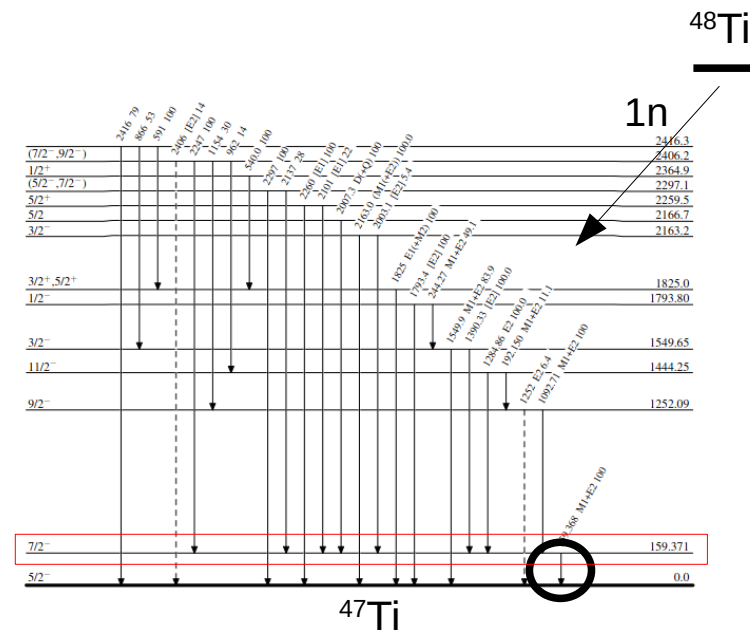
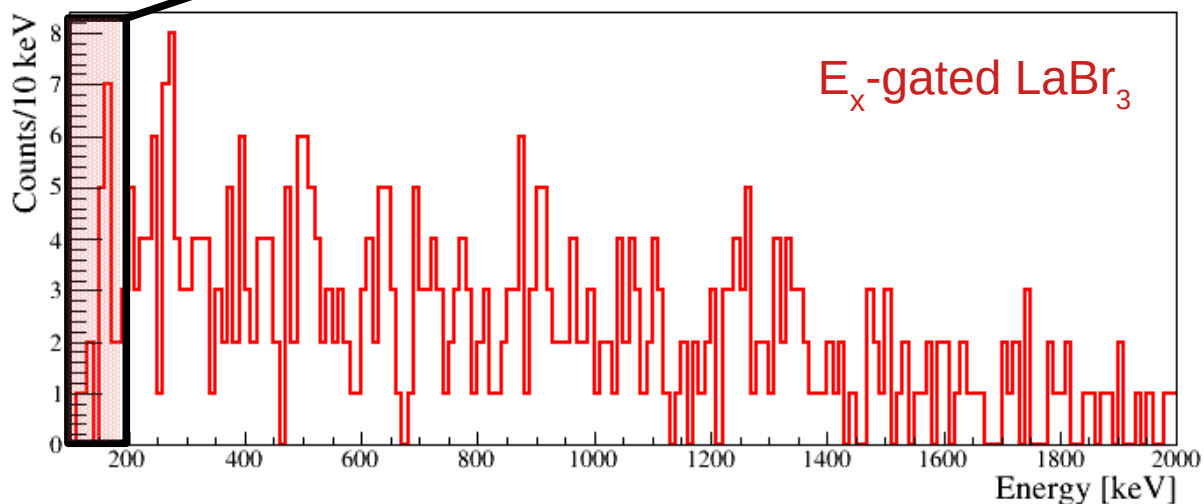
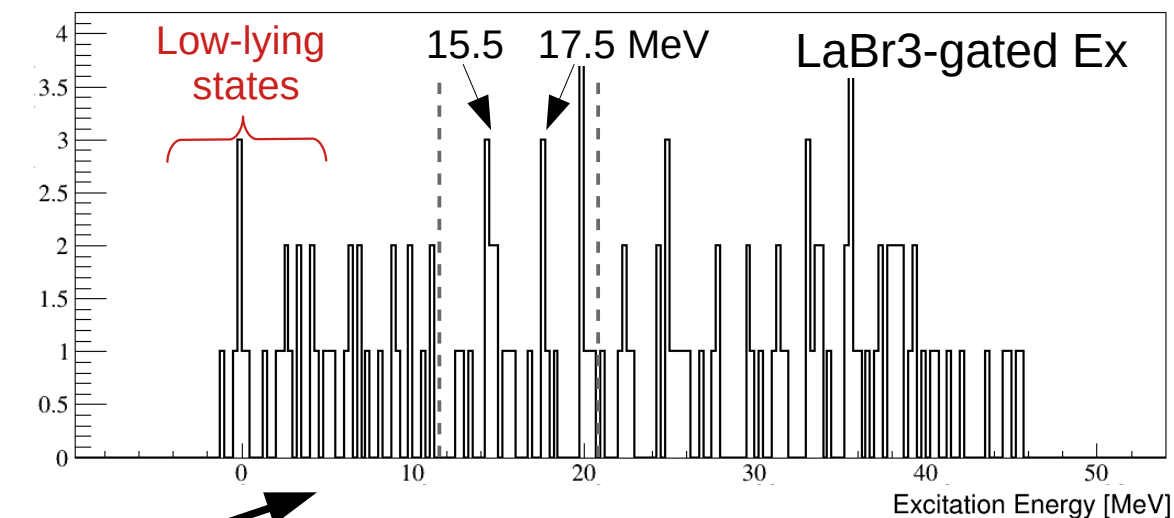
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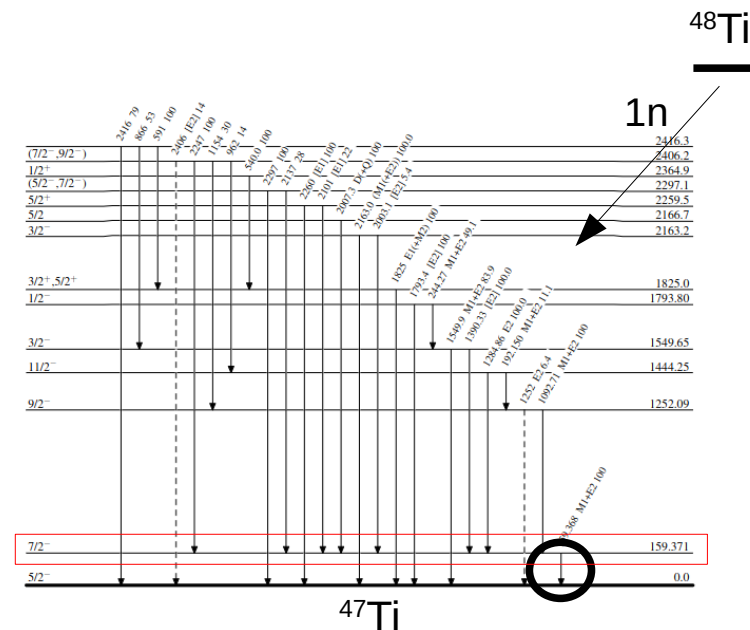
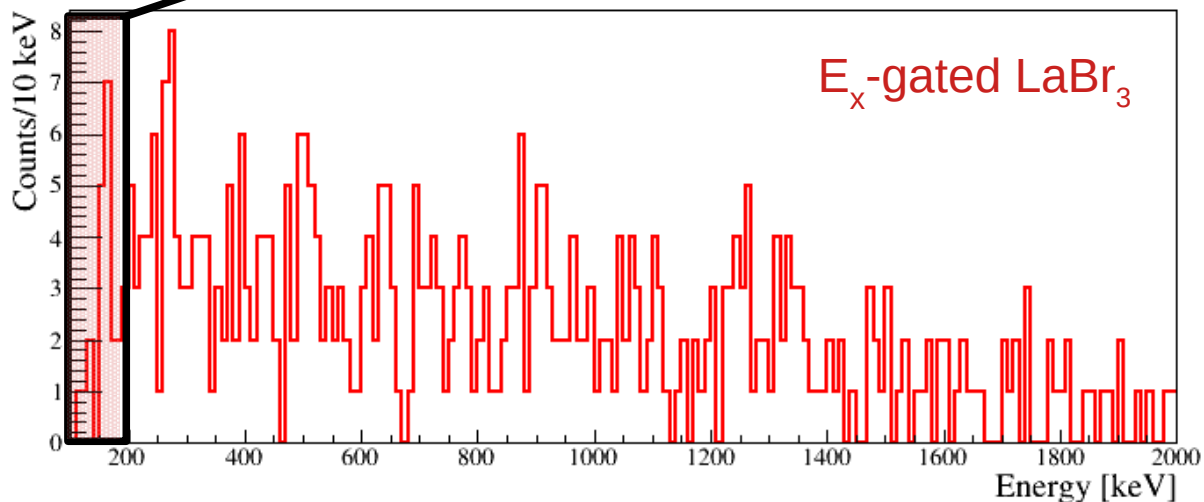
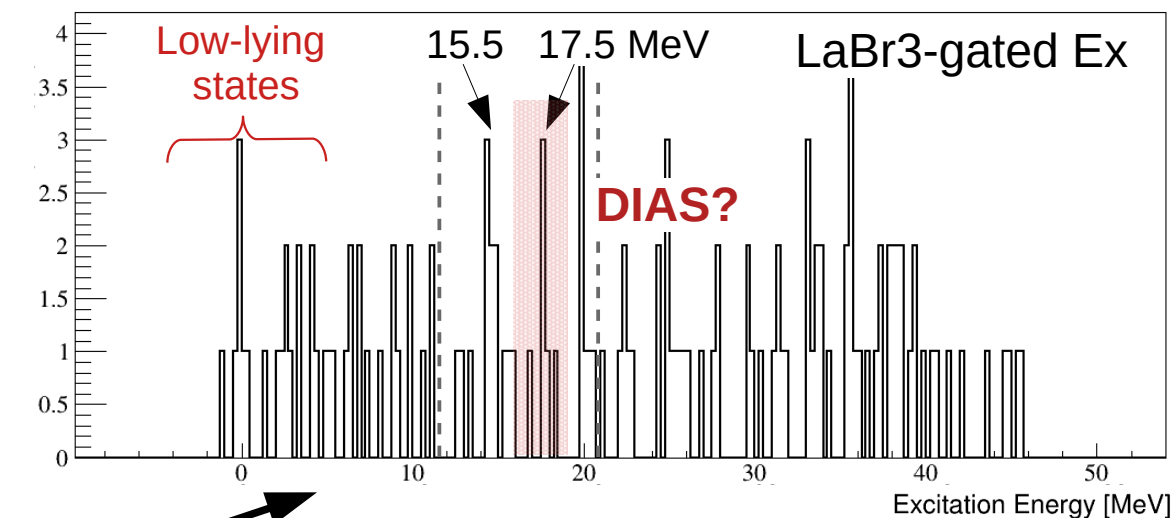
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Main **issues** we encountered:

- High LaBr **thresholds** for most of the time (above 200 keV)
 - γ rays were **excluded from the trigger** (high dead time)
 - **low KRATTA energy resolution** (3 MeV FWHM)
- ➡ Easily solvable! (x8 gain)
- ➡ Need another setup :(

Without a **much better resolution** (< 1 MeV FWHM), we cannot do better!

Realistic goals for the next future:

- 1) σ to populate the **DIAS**?
 - **not feasible** (DIAS peak too small)
- 2) γ **decay** branching ratio from **DIAS**?
 - only **relative**, not **absolute** (poor E_x resolution)
 - + contribution from **nearby states**



- Beam energy = **110 MeV**
- ^1H beam intensity $\approx$ **0.1 nA**
- Target $\approx$ **30 mg/cm²**
- Trigger $\approx$ **PARPLAKRA**

In **4 more days** (12 BTU) we can increase the statistics by **x8** and **try to measure** the relative **γ branching from DIAS** and nearby states!

Thanks a lot for the attention!
Any question is clearly welcome!