β3p spectroscopy and proton-γ width determination in the decay of ^{31}Ar

Presented by

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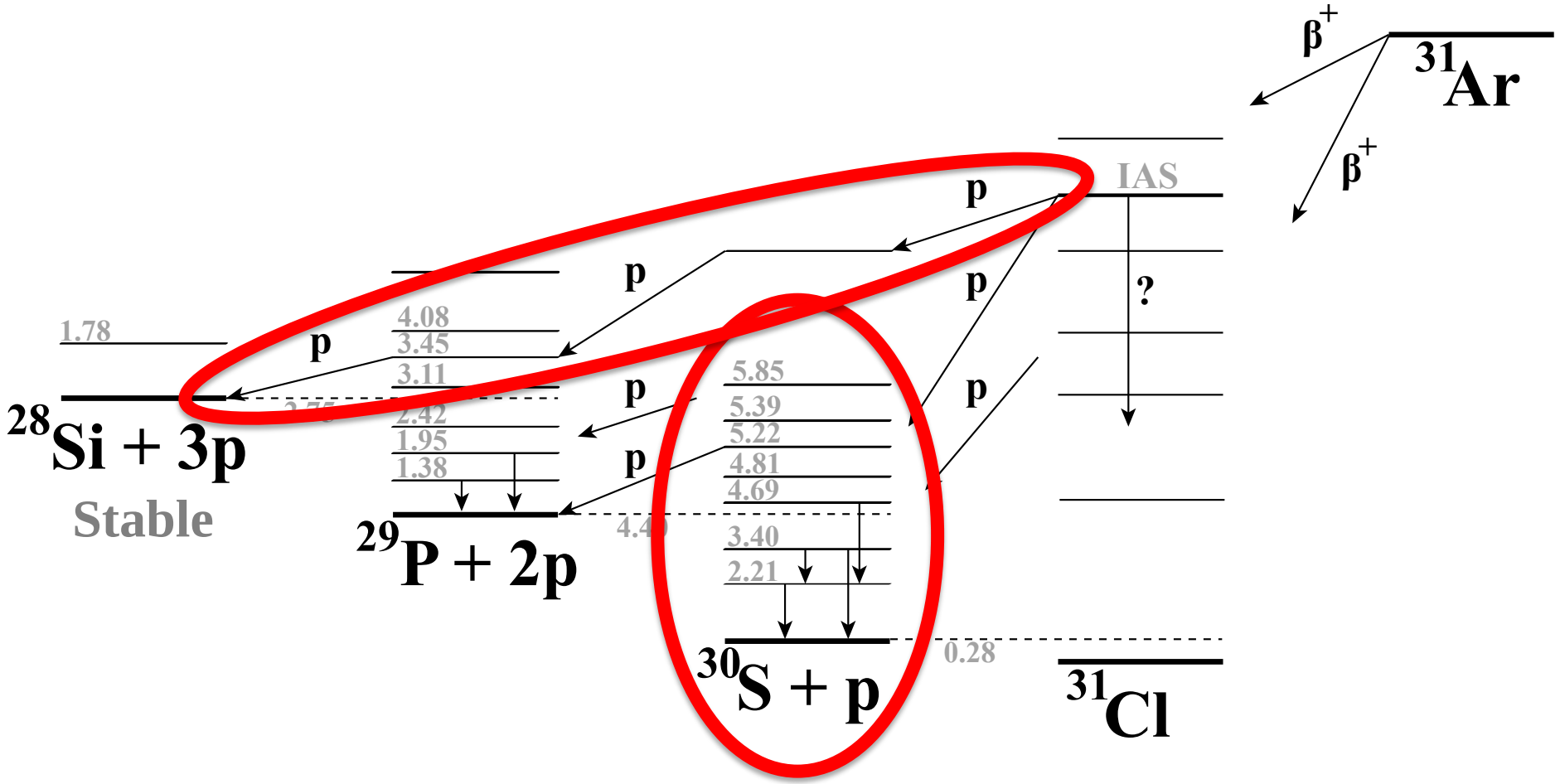
The decay of ^{31}Ar



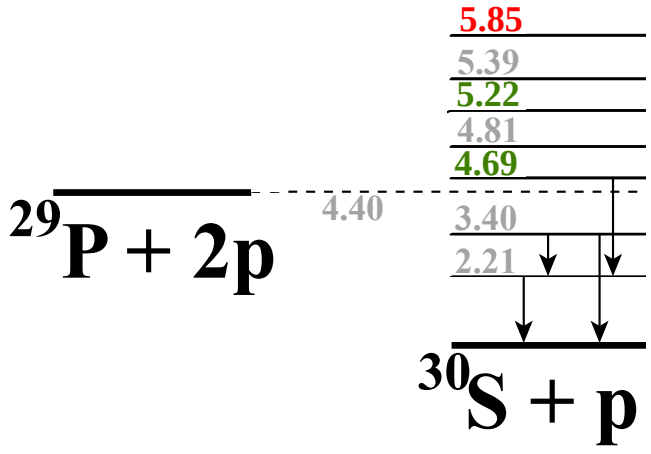
Levels of ^{30}S important for astrophysics

IS476 in 2009:

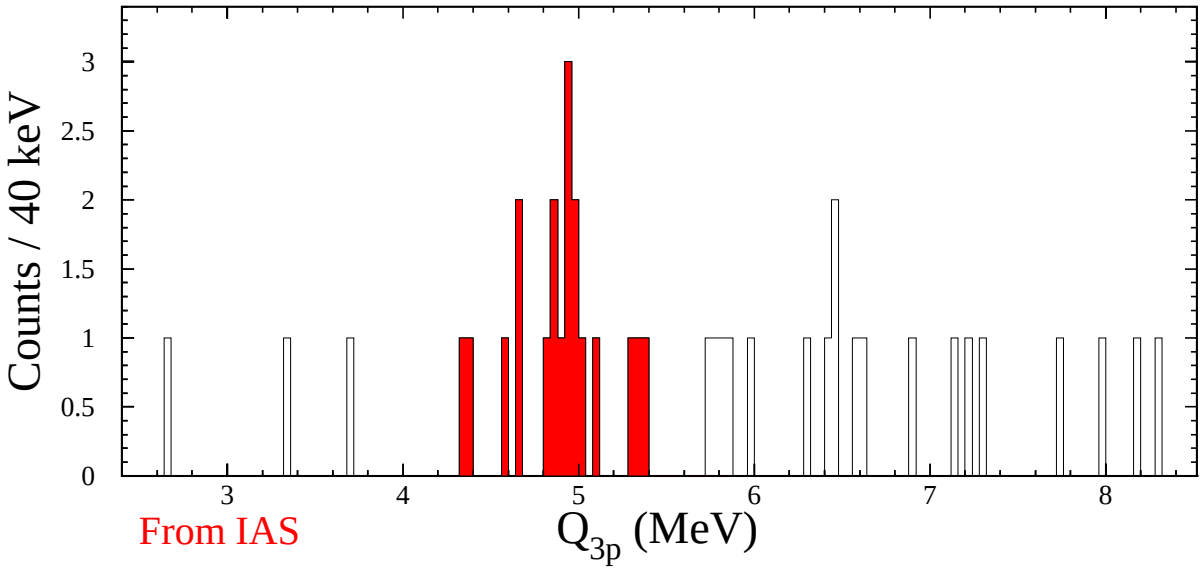
- Limits on the Γ_p/Γ_γ ratio for 3 levels
  - 1 contradict theory
  - 2 two orders of magnitude higher
- Phys. Rev. C 87 (2013) 055808
- Spin from p-p correlations
- Statistics limited…

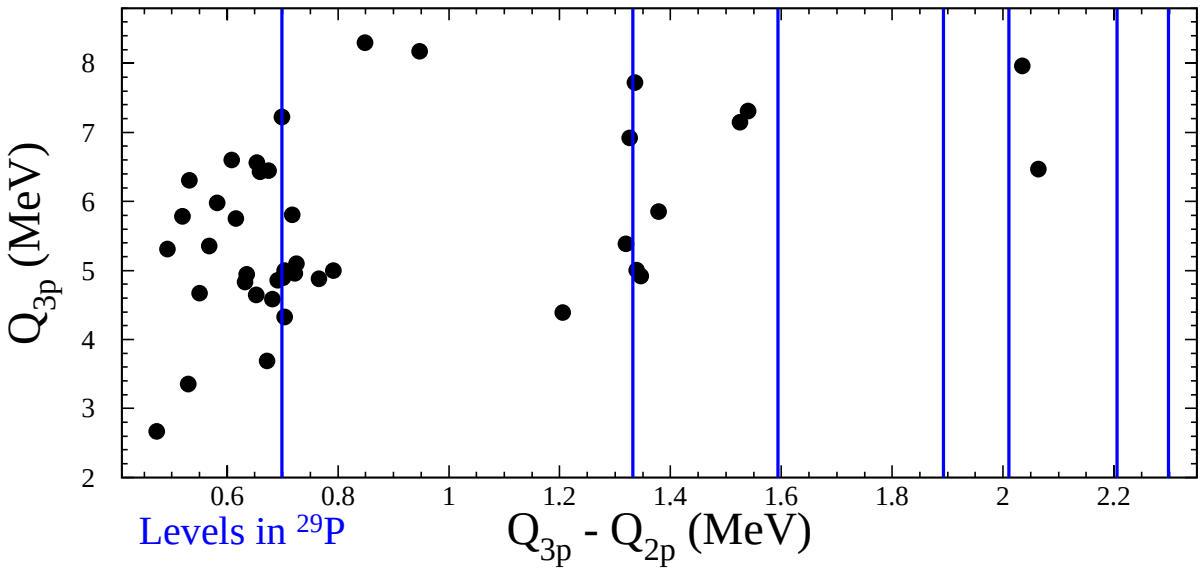
This proposal:

- Γ_p/Γ_γ ratios:
  - 40 protons from 4.69 MeV
  - 4 γ's from 5.22 MeV
  - γ's and protons from 4.81 MeV
- Spin assignment of 5.22 MeV



β3p-decay





IS476 in 2009:

- Approx. 30 3p-events
- Identified β3p-decay
  - From IAS
  - Higher lying levels
- (partly) sequential
- Populate higher lying levels in ^{29}P
- Publication in preparation

This proposal:

- Approx. 500 3p-events
- Precise B.R. for IAS
  - both 3p and 2pγ
- Thorough investigation of decay mode

Setup

IS476 in 2009:

- 42 % of 4π particle detection
  - 6 DSSSD's
    4x300 μm, 1x69 μm, 1x500 μm
  - Only backing on 4
- Approx. 6 % of 4π γ detection
  - 2 Miniball detectors
- CaO target
  - Yield: approx. 1 ^{31}Ar per sec.
  - ^{16,17}N contamination (N_2)
- 25 shifts used of 27

This proposal:

- 70 % of 4π particle detection
  - Compact setup of 6 DSSSD's with backing
- Approx. 25 % of 4π γ detection
  - **ISOLDE Decay Station**
- CaO nano-structured target:
  - Yield: 10 ^{31}Ar per sec.
  - Less contamination
- 24 shifts in total

Summary

24 shifts: CaO nano-structured target

^{30}S:

- Γ_p/Γ_γ ratios:
  - 40 protons from 4.69 MeV
  - 4 γ's from 5.22 MeV
  - γ's and protons from 4.81 MeV
- Spin assignment of 5.22 MeV

β3p:

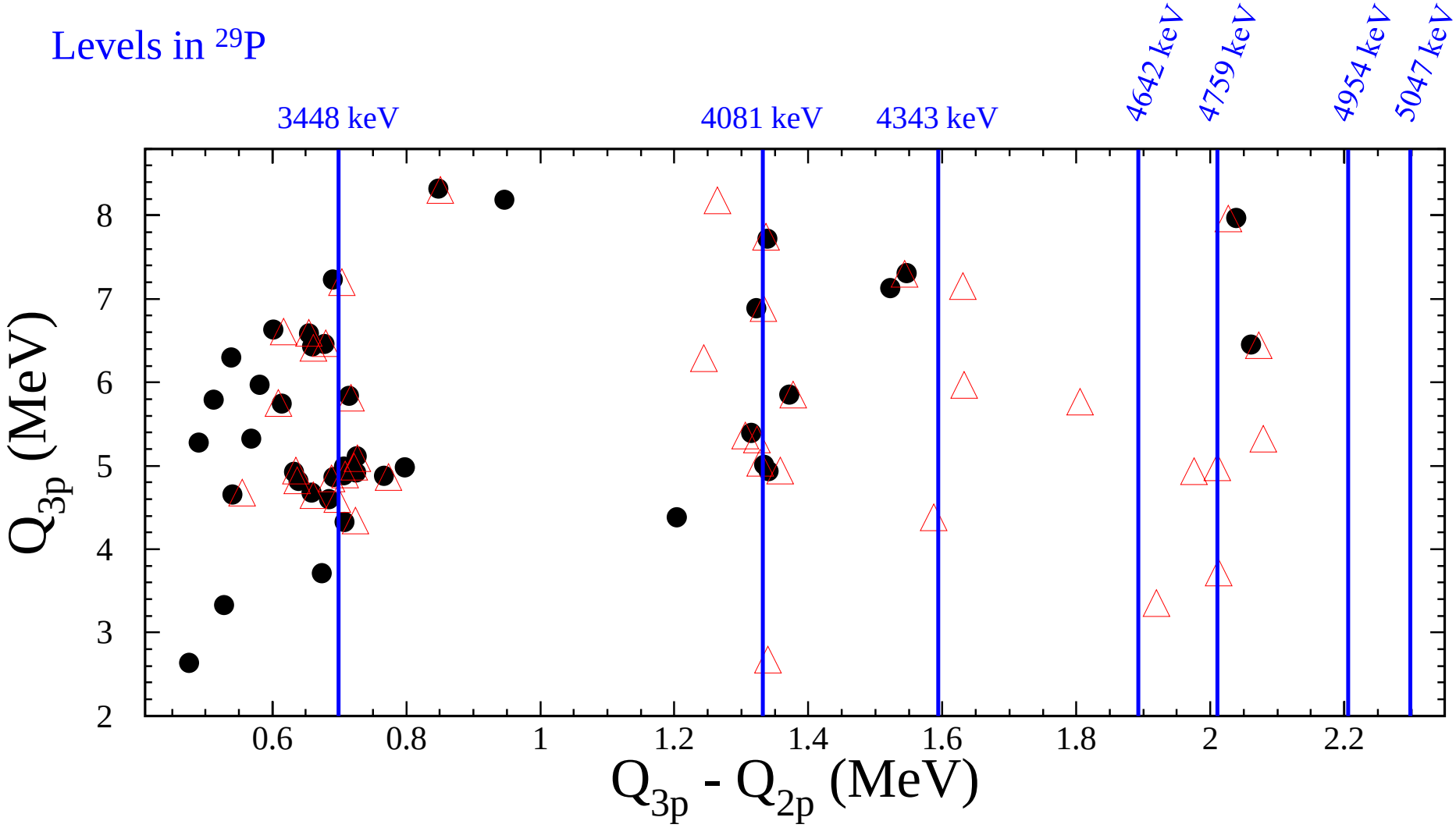
- Approx. 500 3p-events
- Thorough investigation of decay mode
- Which states in ^{31}Cl

β-strength:

- Fermi strength
  - IAS 1p-, 2p-, 3p, γ-decay
- Gamow-Teller strength
  - Correctly assigned above IAS

Bonus slides

β3p-decay



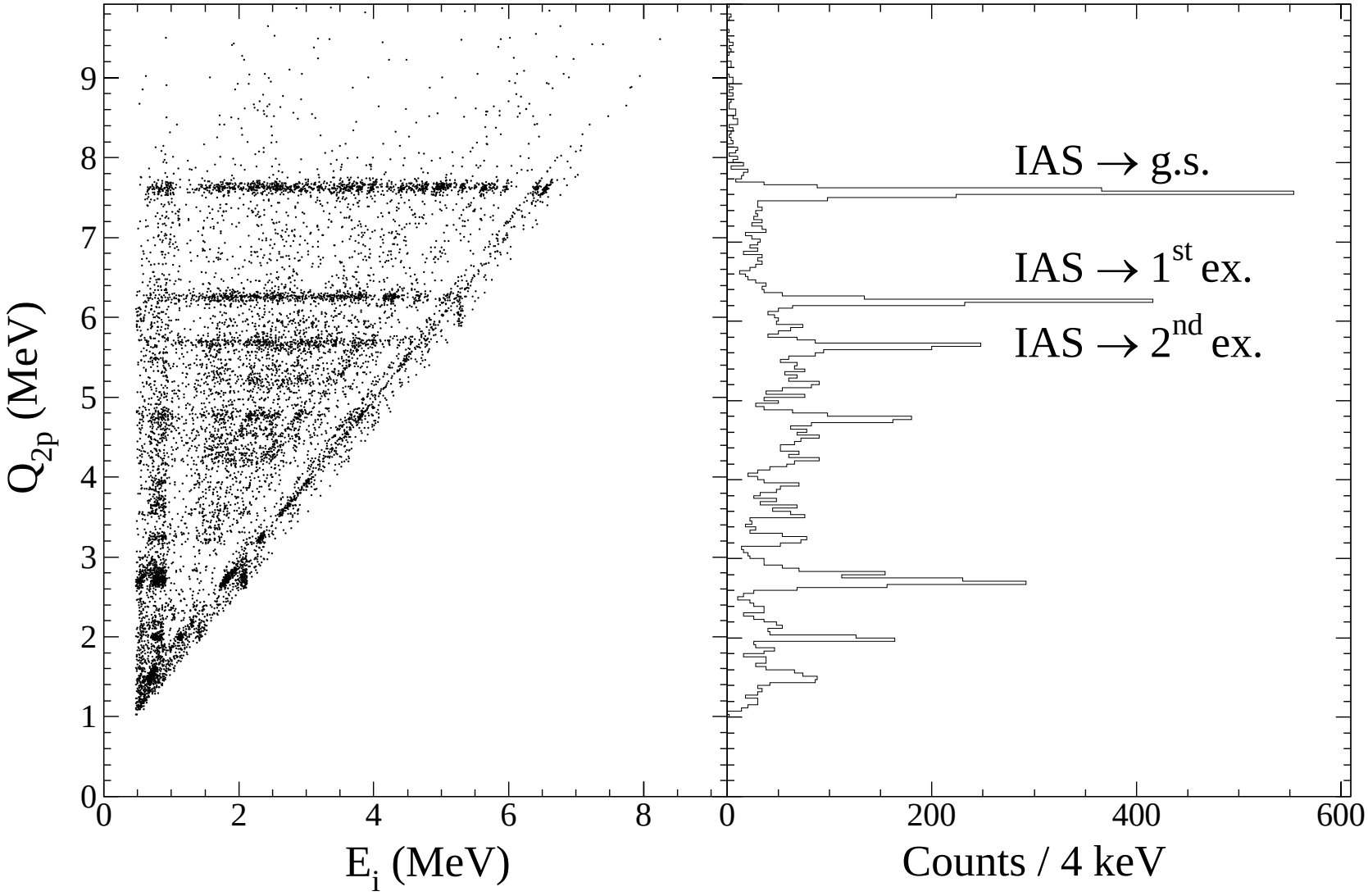
Spin determination from proton-proton angular correlations

$$W(\cos\theta) = \sum_{\nu=0}^{\nu_{\max}} A_\nu P_\nu(\cos\theta)$$

^{31}Cl	A_2	$\Delta\chi^2$
7.7	0.42(16)	6.52
7.0	0.11(22)	0.15
IAS	0.5(3)	2.95

^{30}S \ ^{31}Cl	$\frac{3}{2}^+$	$\frac{5}{2}^+$	$\frac{7}{2}^+$
0^+	0	0	0
1^+	0	0	0
2^+	0	0	$[-0.7; -0.25]$
3^+	$[0.15; 0.87]$	0	0
4^+	$[0.76; 1.00]$	$[0.13; 0.95]$	0
0^-	0	0	0
1^-	$[-0.80; -0.64]$	$[-0.60; -0.75]$	$[-0.67; -0.53]$

β2p-events



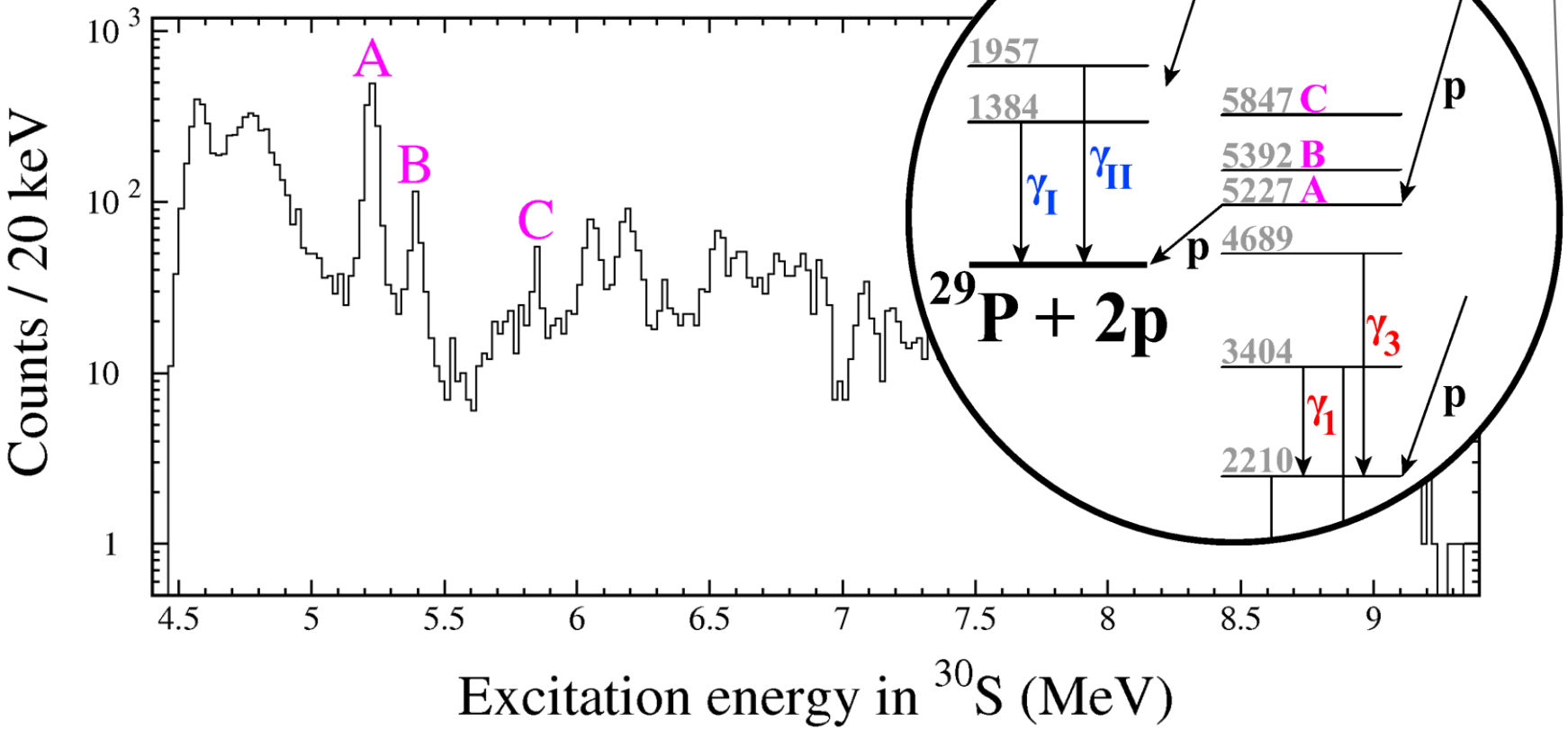
B.R. for the decay of IAS

TABLE I. Total theoretical branching ratio is 4.17(10) %.

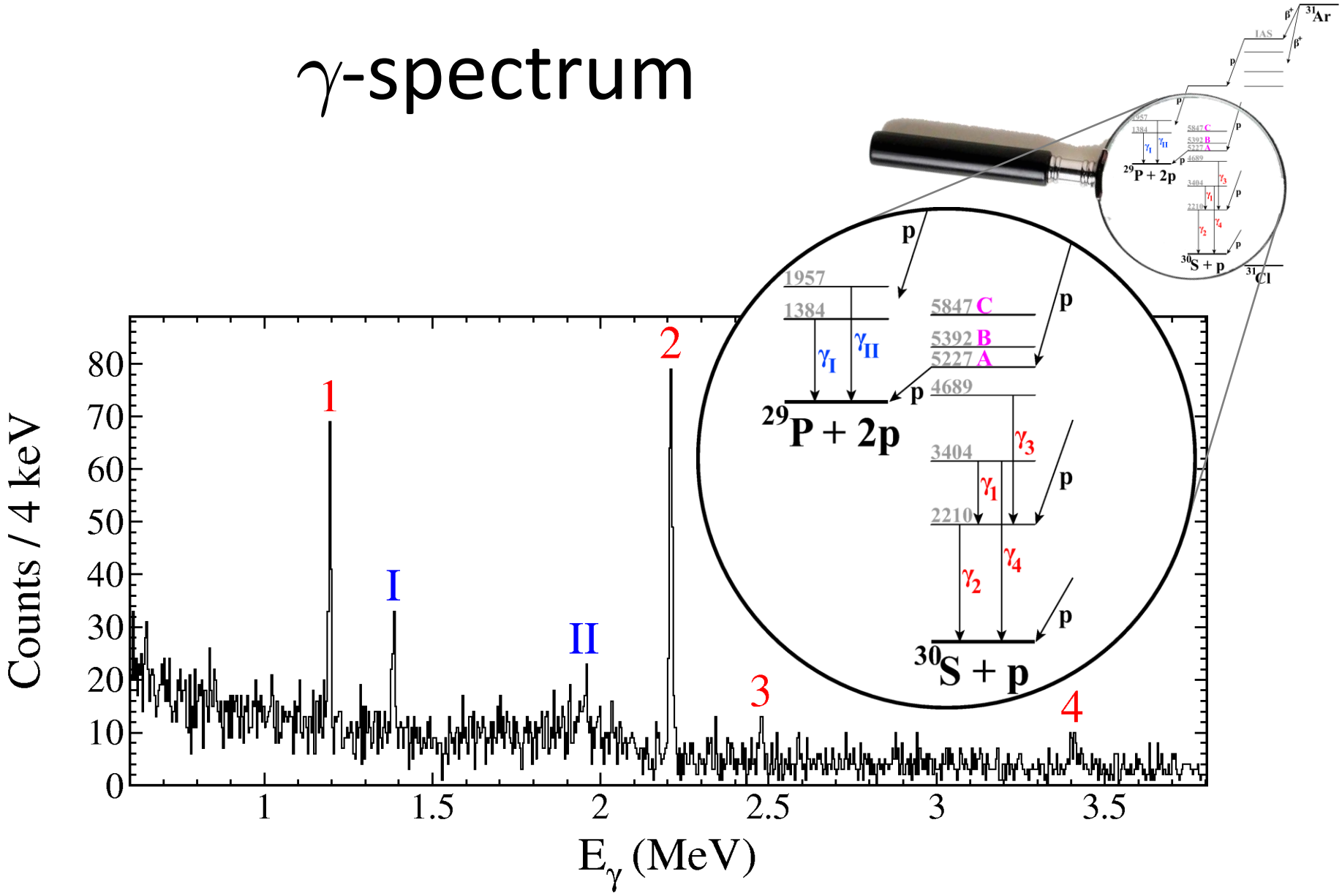
Three-proton branch				
Final state in ^{28}Si (keV)	J^π	Q_{3p} (MeV)	E_{IAS} (MeV)	B.R. (%)
0	0^+	4.89(29)	12.32(29)	0.04(2)
Two-proton branch				
Final state in ^{29}P (keV)	J^π	Q_{2p} (MeV)	E_{IAS} (MeV)	B.R. (%)
0	$\frac{1}{2}^+$	7.633(4)	12.311(6)	1.47(28)
1383.55(7)	$\frac{3}{2}^+$	6.251(4)	12.313(6)	0.88(18)
1953.91(17)	$\frac{5}{2}^+$	5.688(6)	12.320(8)	0.40(11)
2422.7(3)	$\frac{3}{2}^+$	5.22(8)	12.32(8)	0.07(5)
One-proton branch				
Final state in ^{30}S (keV)	J^π	E_p (MeV)	E_{IAS} (MeV)	B.R. (%)
0	0^+	11.57(8)	12.24(8)	0.049(12)
2210.2(1)	2^+	9.46(8)	12.27(8)	0.104(21)
3404.1(1)	2^+	8.33(8)	12.30(8)	0.108(21)
3667.7(3)	0^+	8.08(8)	12.30(8)	0.101(24)
Total			12.313(4)	3.22(36)

^{30}S spectrum

$$E(^{30}\mathrm{S}) = Q_{2p} + E(^{29}\mathrm{P}) - \frac{M(^{30}\mathrm{S}) + m_p}{M(^{30}\mathrm{S})} E_1 + S_{p2}$$



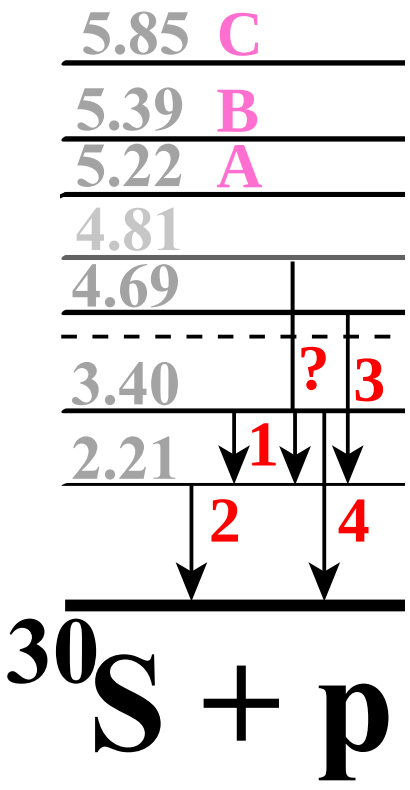
γ-spectrum



Levels of ^{30}S important for astrophysics

Ritcher & Brown 2013			IS476	
E_x (keV)	J^π	Γ_γ/Γ_p	E_x (keV)	Γ_γ/Γ_p
4688	3^+	372	4689.2(24)	> 3.8
4809	2^+	2.2		
5130*	4^+	3.5×10^{-2}		
5218	0^+	9.3×10^{-4}		
5219	3^+	4.0×10^{-3}	5227(3)	< 0.5
5312	3^-	5.2×10^{-3}		
5382	2^+	7.6×10^{-3}		
5836*	4^+	16	5847(4)	< 9

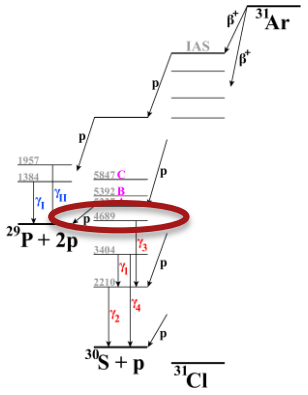
*From Almaraz-Calderon *et al.* 2012

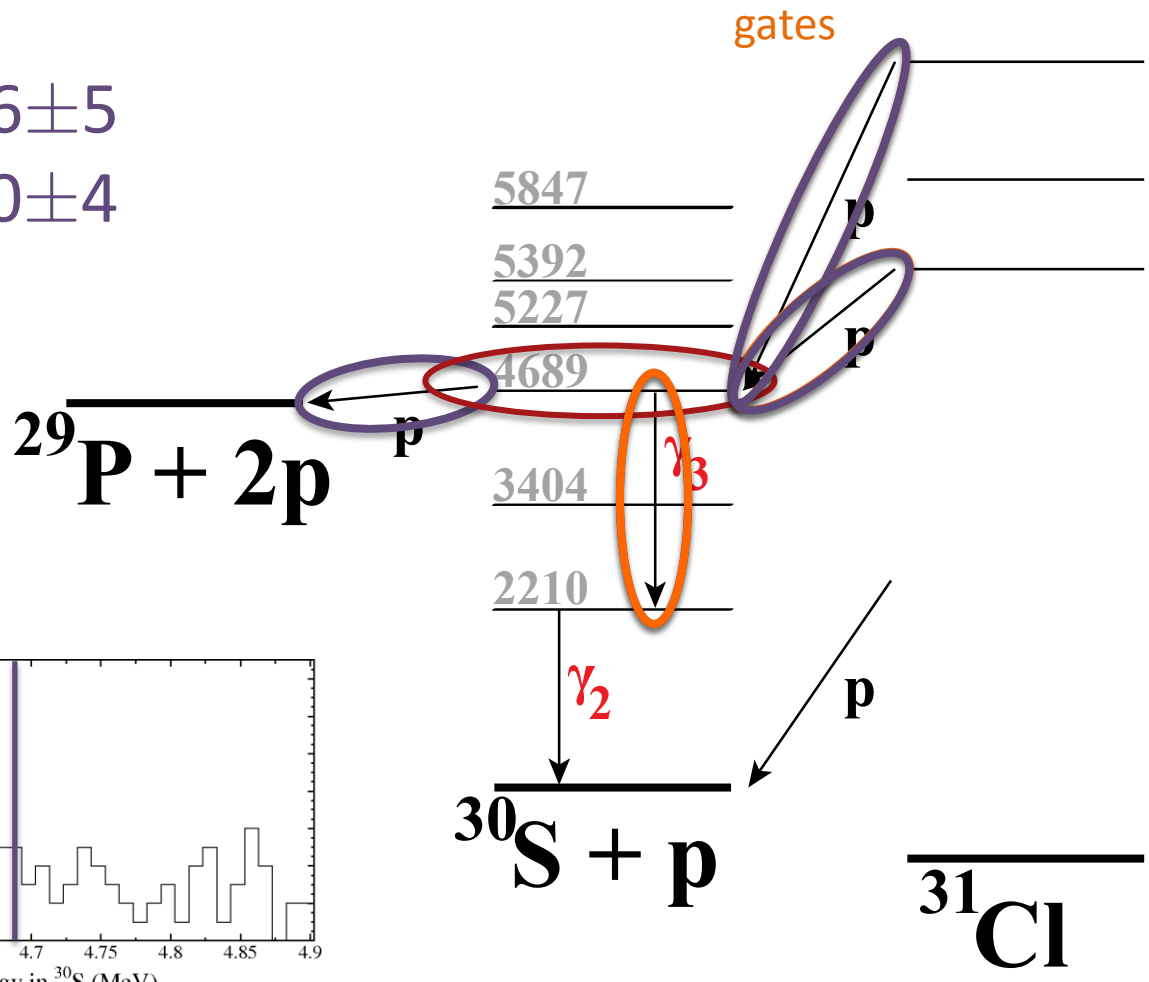


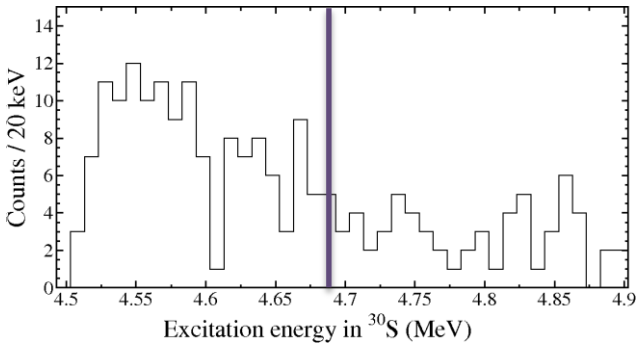
Γ_p/Γ_γ for the 4689 keV level

#p < 16±5

#γ = 10±4







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