Study of ^{31}Ar @ ISOLDE

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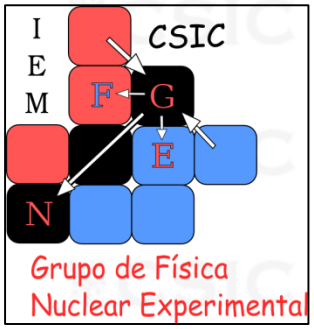
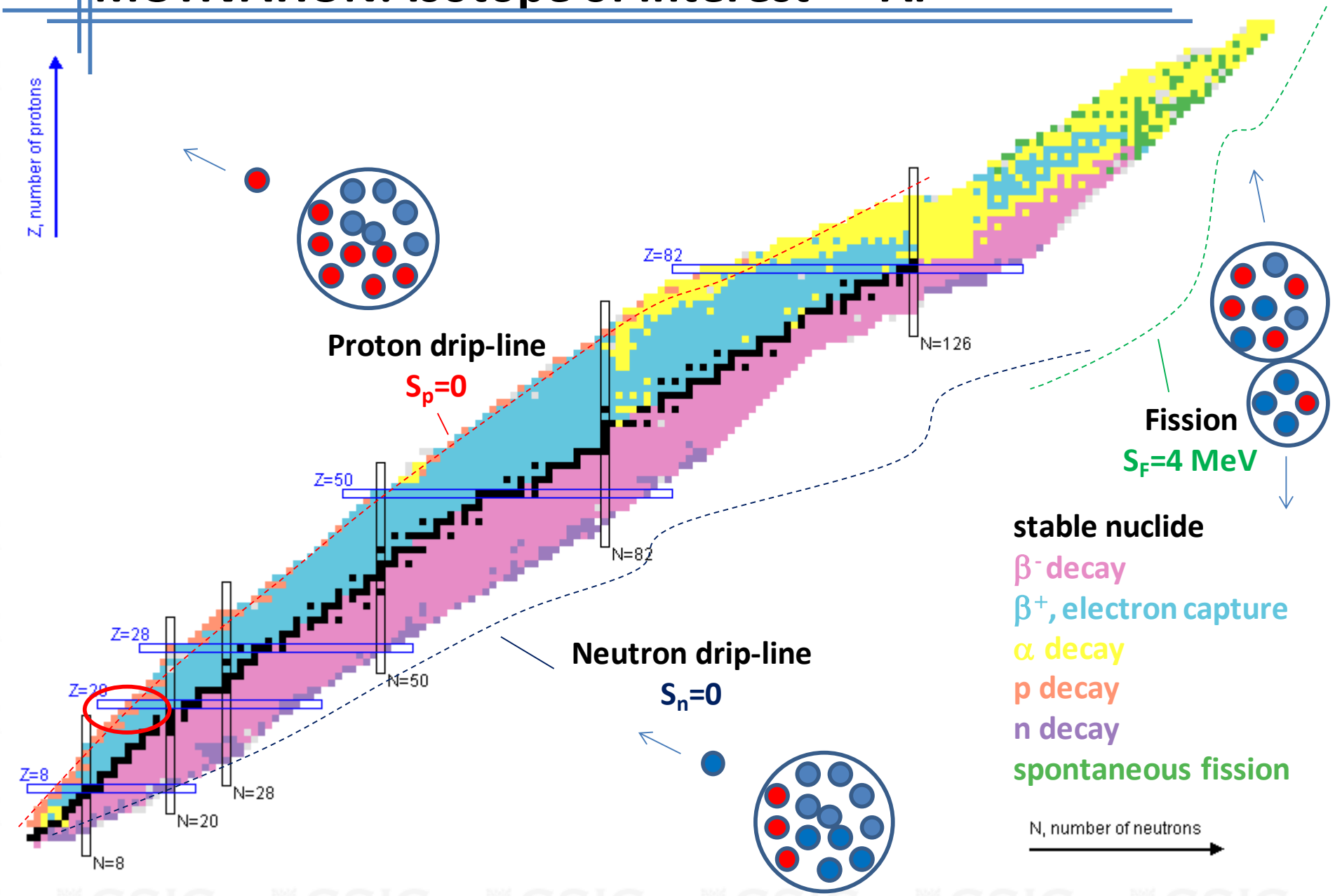
IEM - CSIC

ISOLDE Workshop and Users Meeting 2016 - CERN, Geneva

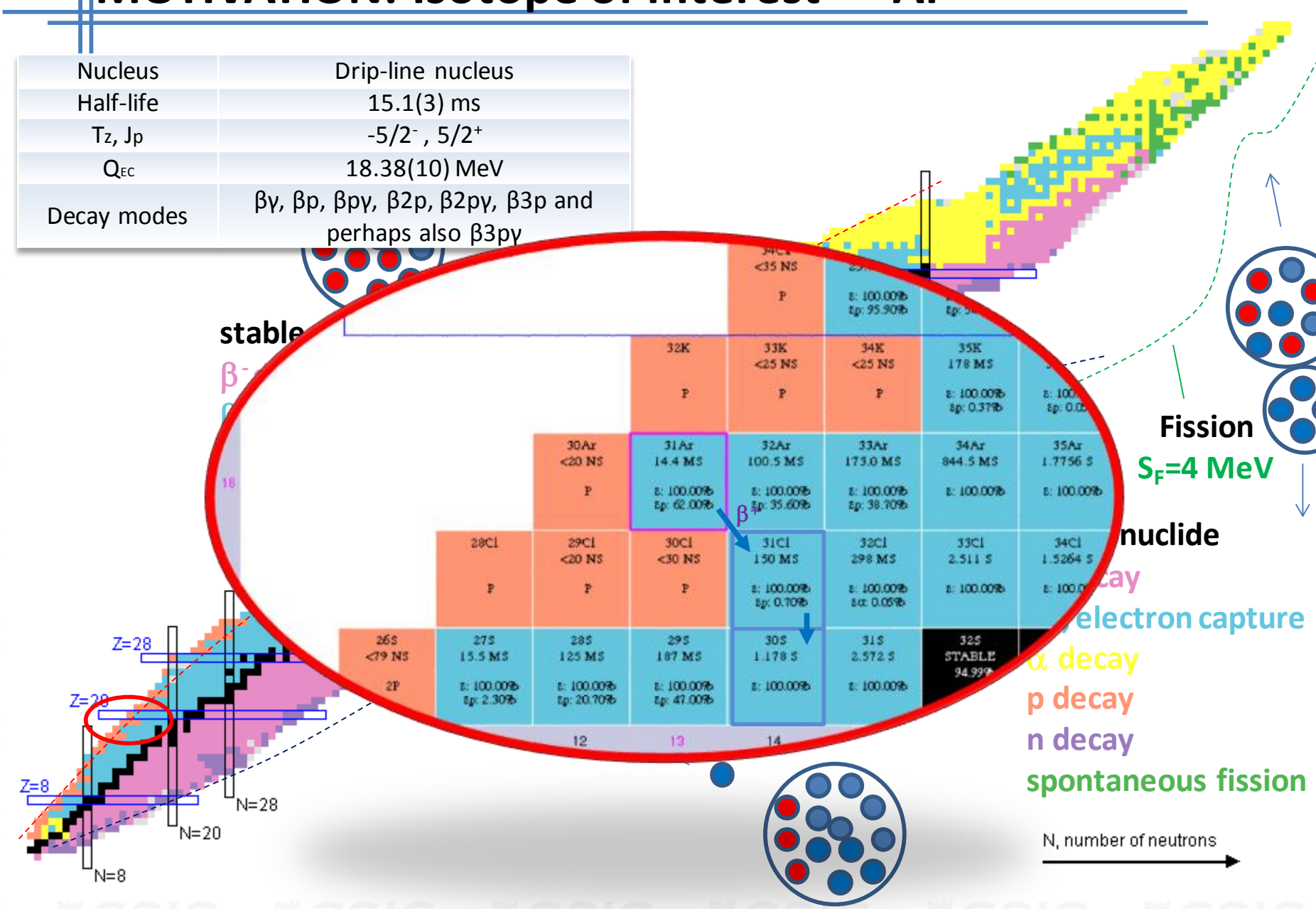


MOTIVATION: Isotope of interest - ^{31}Ar



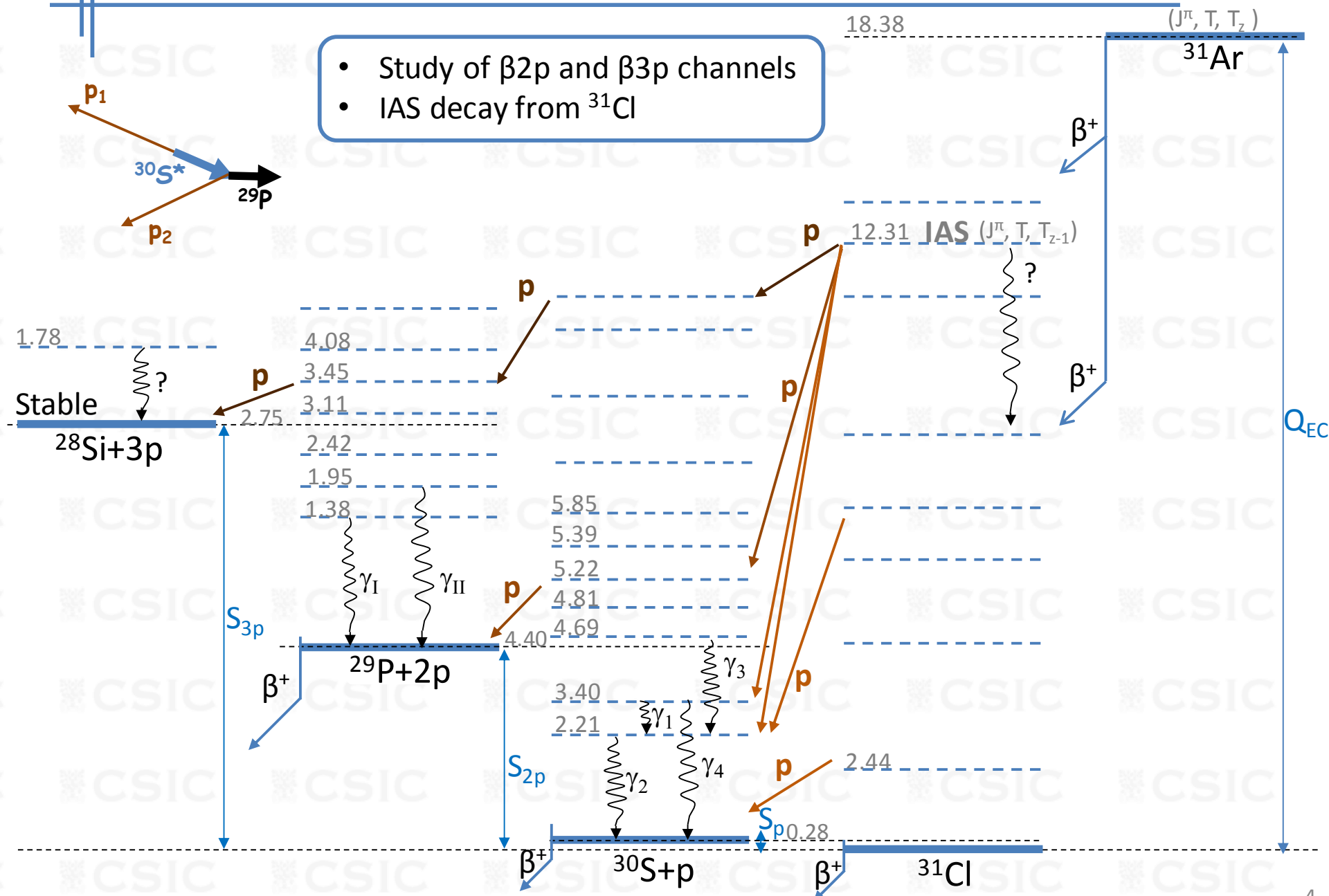
MOTIVATION: Isotope of interest - ^{31}Ar

Nucleus	Drip-line nucleus
Half-life	15.1(3) ms
Tz, Jp	$-5/2^-$, $5/2^+$
Q_{EC}	18.38(10) MeV
Decay modes	βγ, βp, βpγ, β2p, β2pγ, β3p and perhaps also β3pγ



MOTIVATION: Isotope of interest - ^{31}Ar

- Study of β2p and β3p channels
- IAS decay from ^{31}Cl



IS577 experiment @ ISOLDE Decay Station

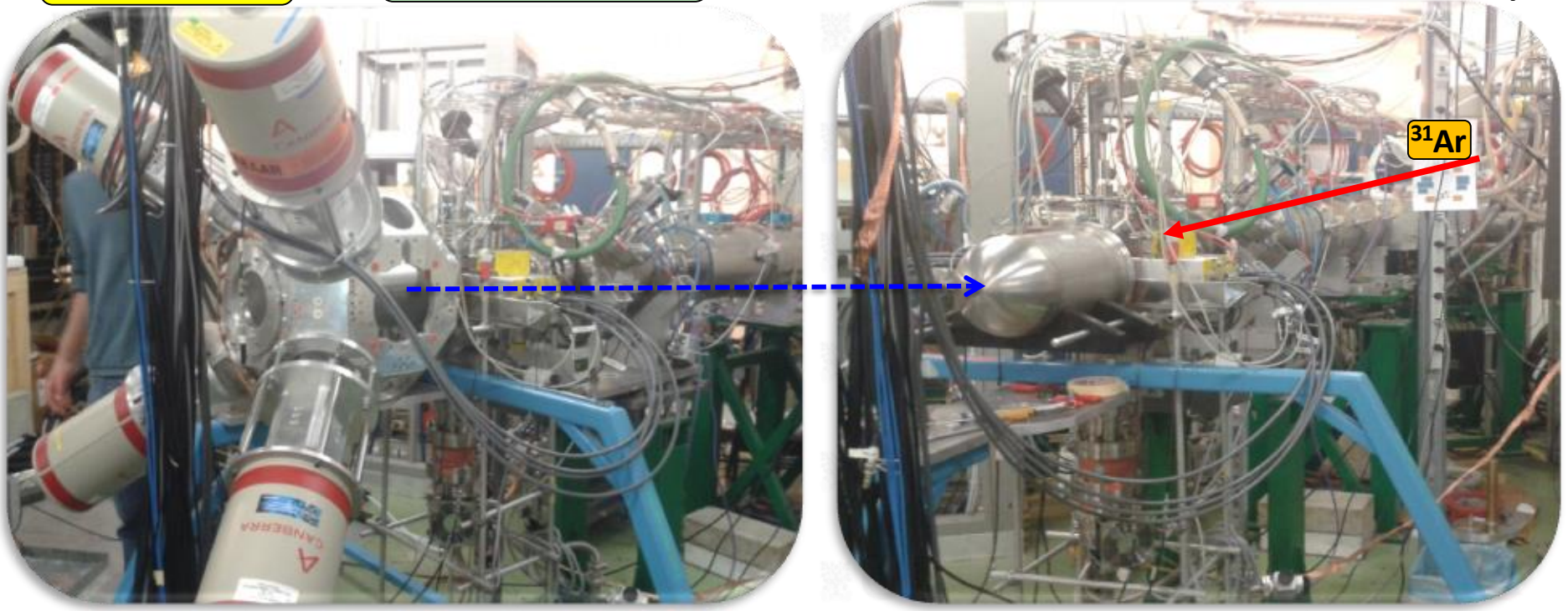
http://isolde-ids.web.cern.ch/isolde-ids/

4x HPGe clover-detectors

1 Clover → 4 crystals
→16 crystals in total

MAGISOL Si plug-in chamber

^{31}Ar 1^{+} @ 50 keV
Yield: 1-2 ^{31}Ar/ µC

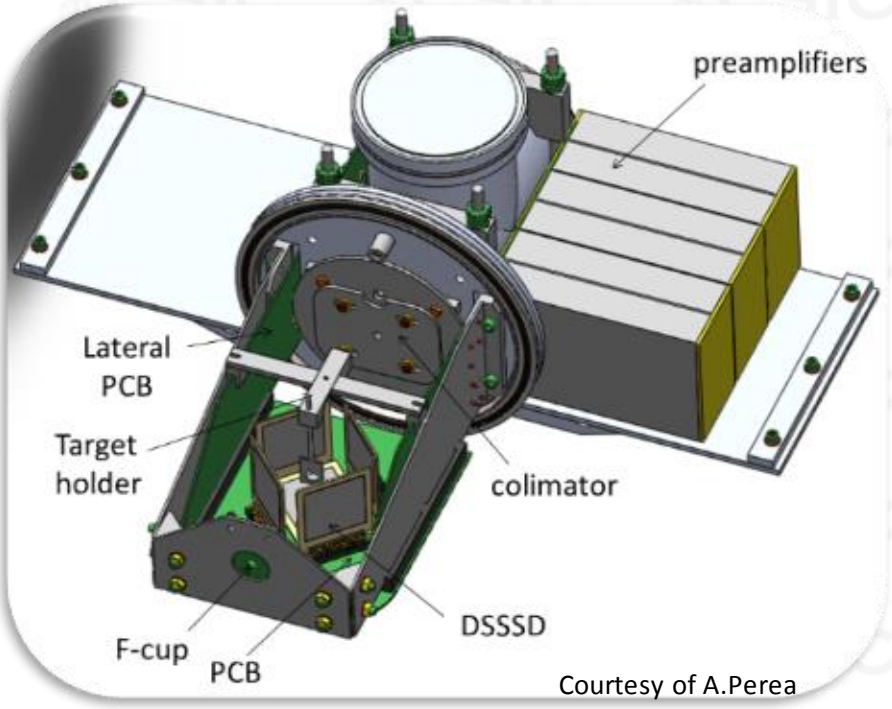


•New permament station devoted to β-decay measurements:

➢**4 HPGe clover-detectors** surrounding the ***experimental chamber*** for high gamma ray detection efficiency

➢ ***Modular experimental chamber*** (fast timing, neutron time-of-flight, beta and **charge particle emission**…)

SET-UP: MAGISOL Si plug-in chamber

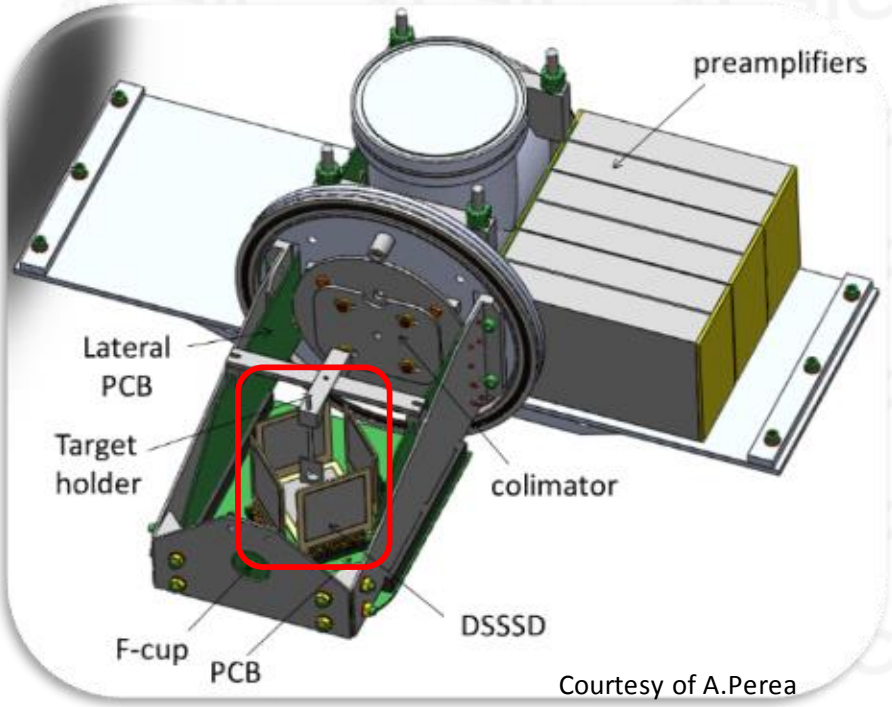


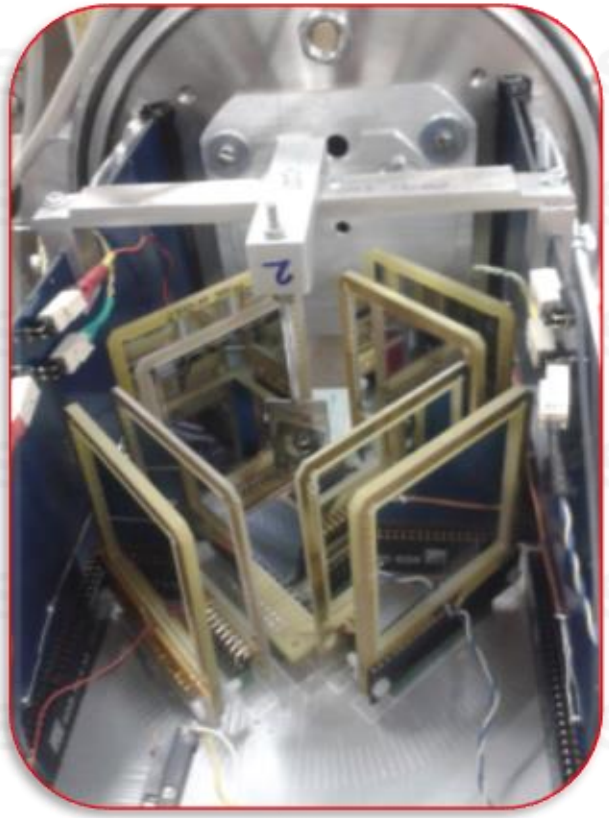
➢Array of **Double Sided Si Strip Detectors** (DSSSD) and **PADs** in ΔE-E/telescope configuration located inside the new ***MAGISOL Si-Plugin Chamber***

➢**Different thickness** for **different proton energies**

- **high efficiency** for multi-particle emission detection → **Solid angle: 5x 9% of 4π**
- **low cut-off energy (150 keV).**
- **Energy and Angular resolution: 25 KeV, 3º**

SET-UP: MAGISOL Si plug-in chamber





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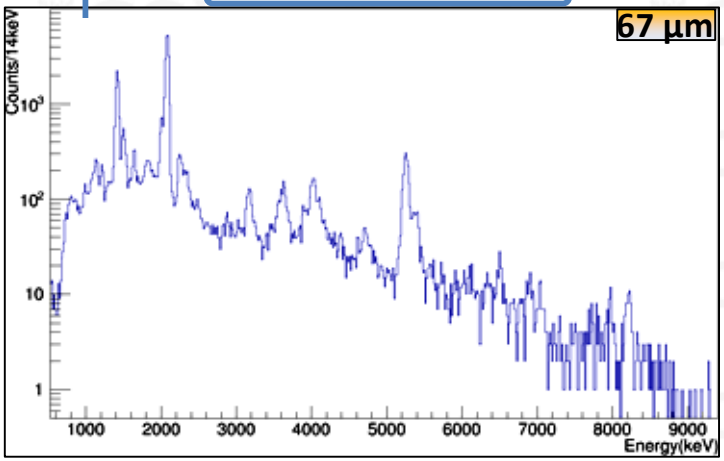
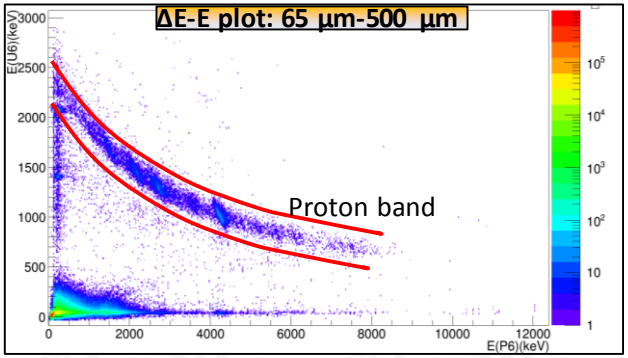
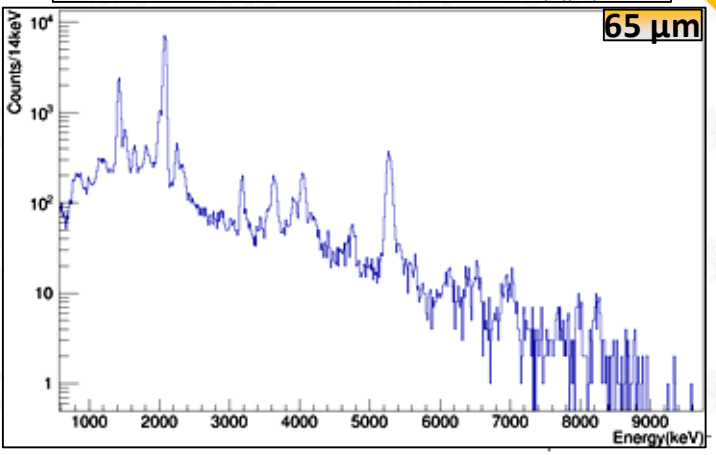
RESULTS: 1-p spectra from telescopes

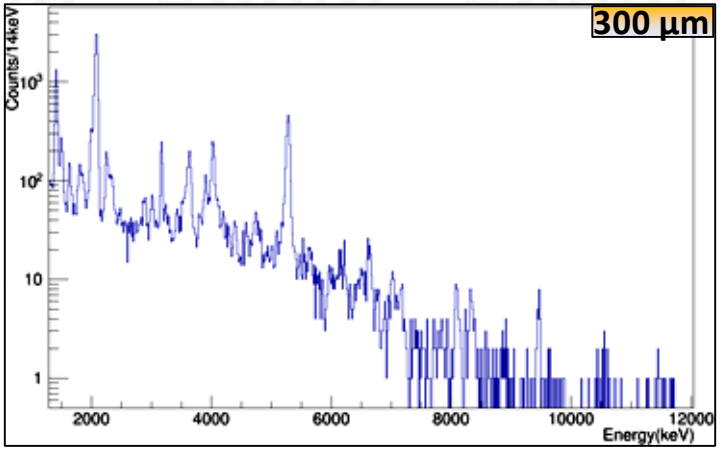
THIN TELESCOPES

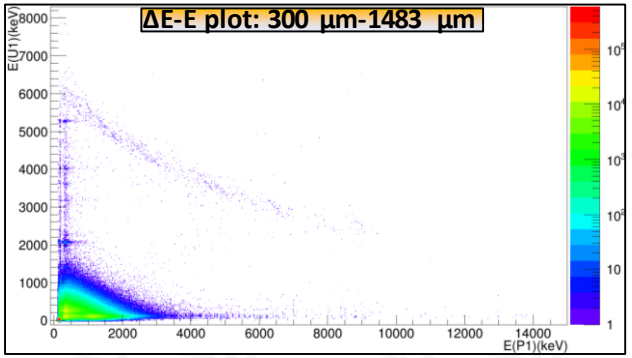


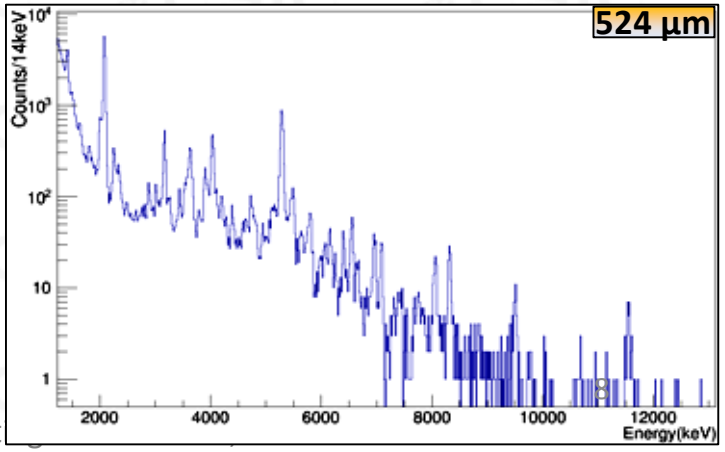


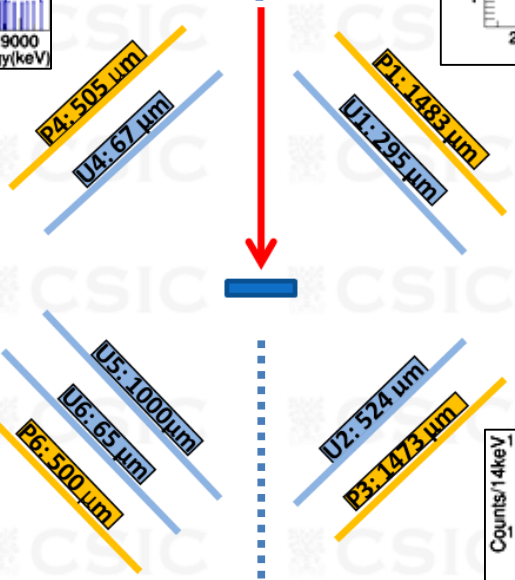


THICK TELESCOPES









RESULTS: 1-p spectra from telescopes

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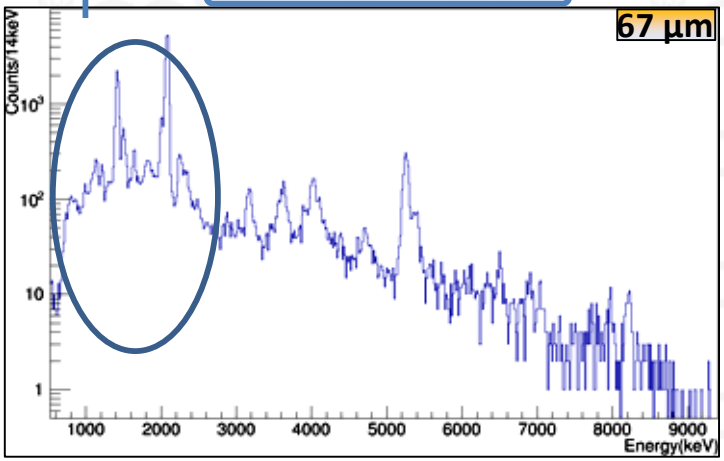

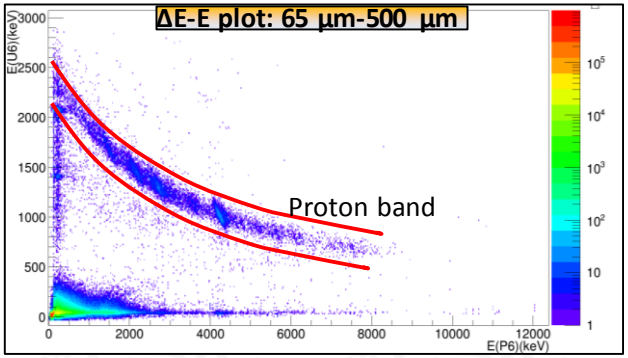

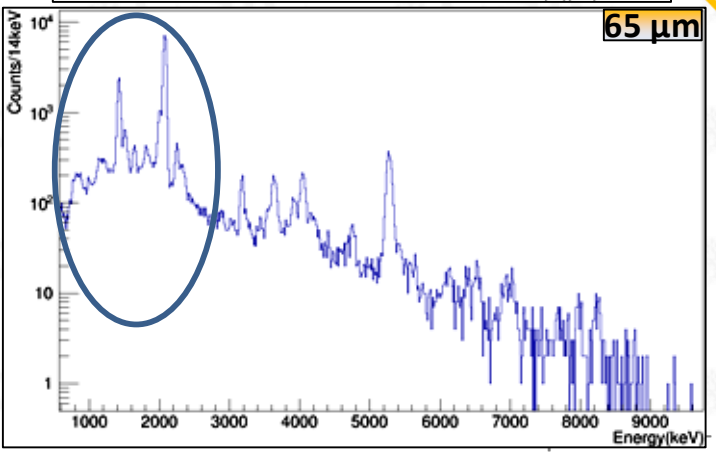

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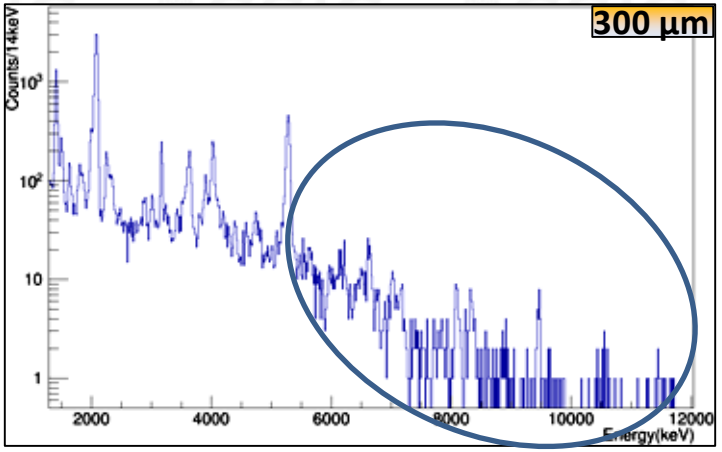
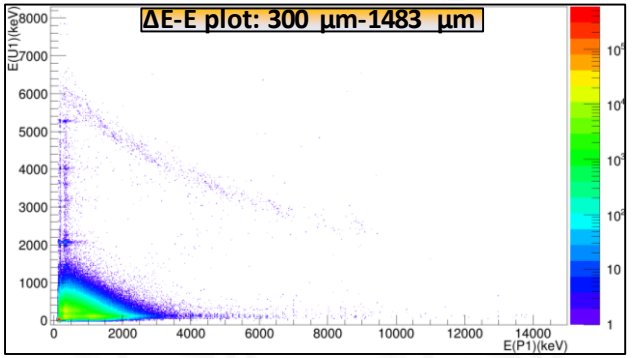
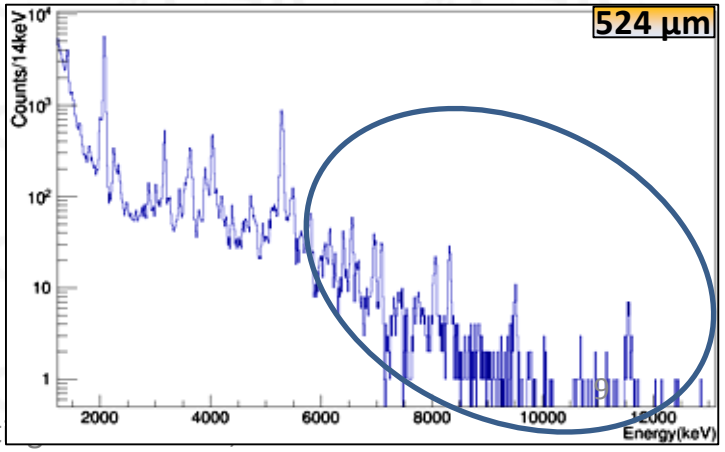
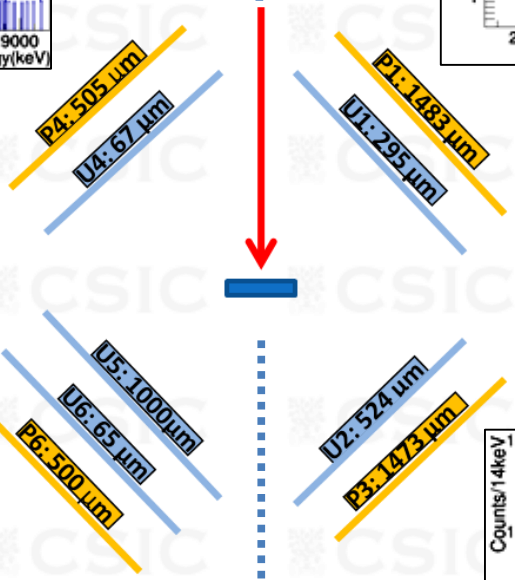
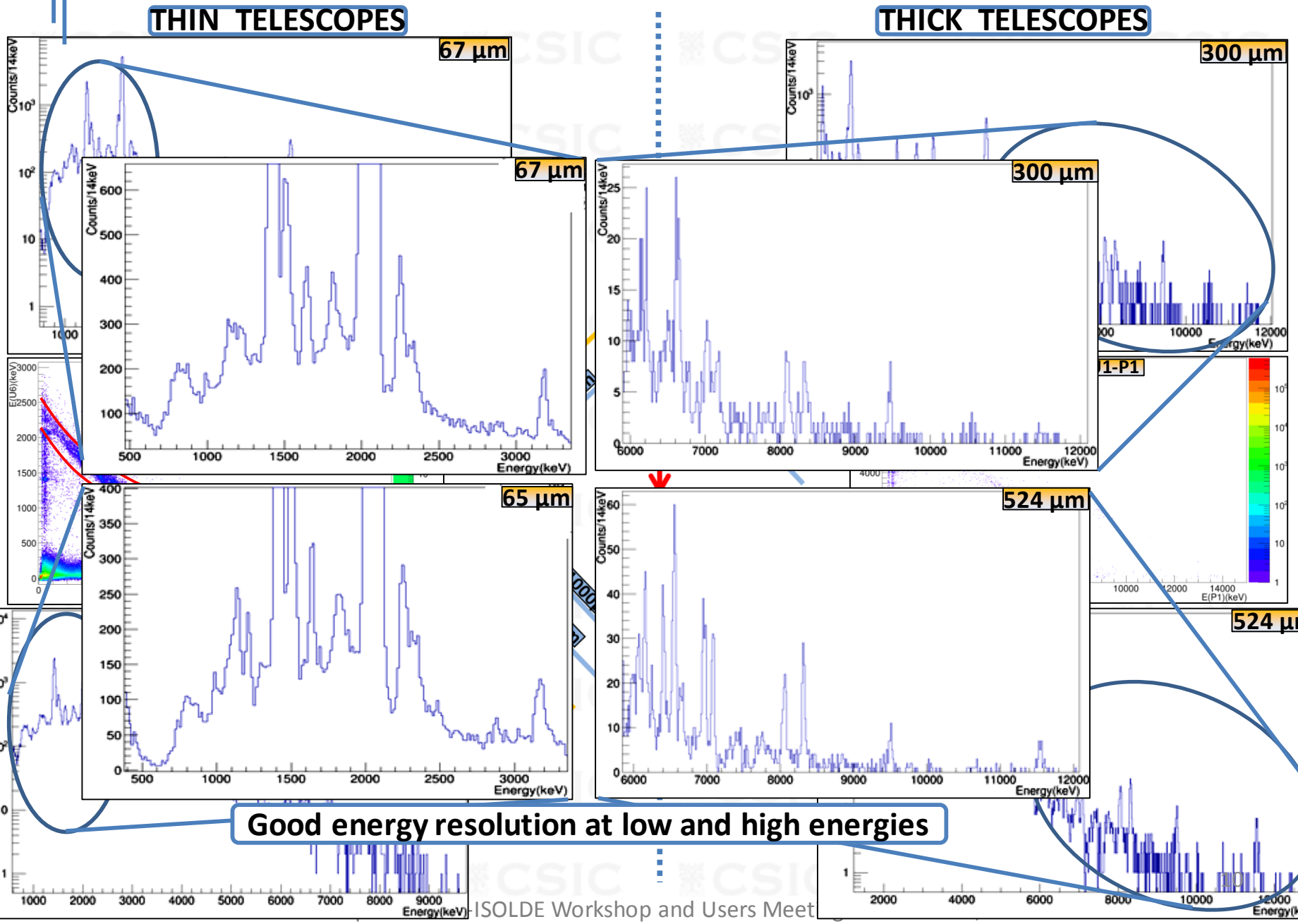






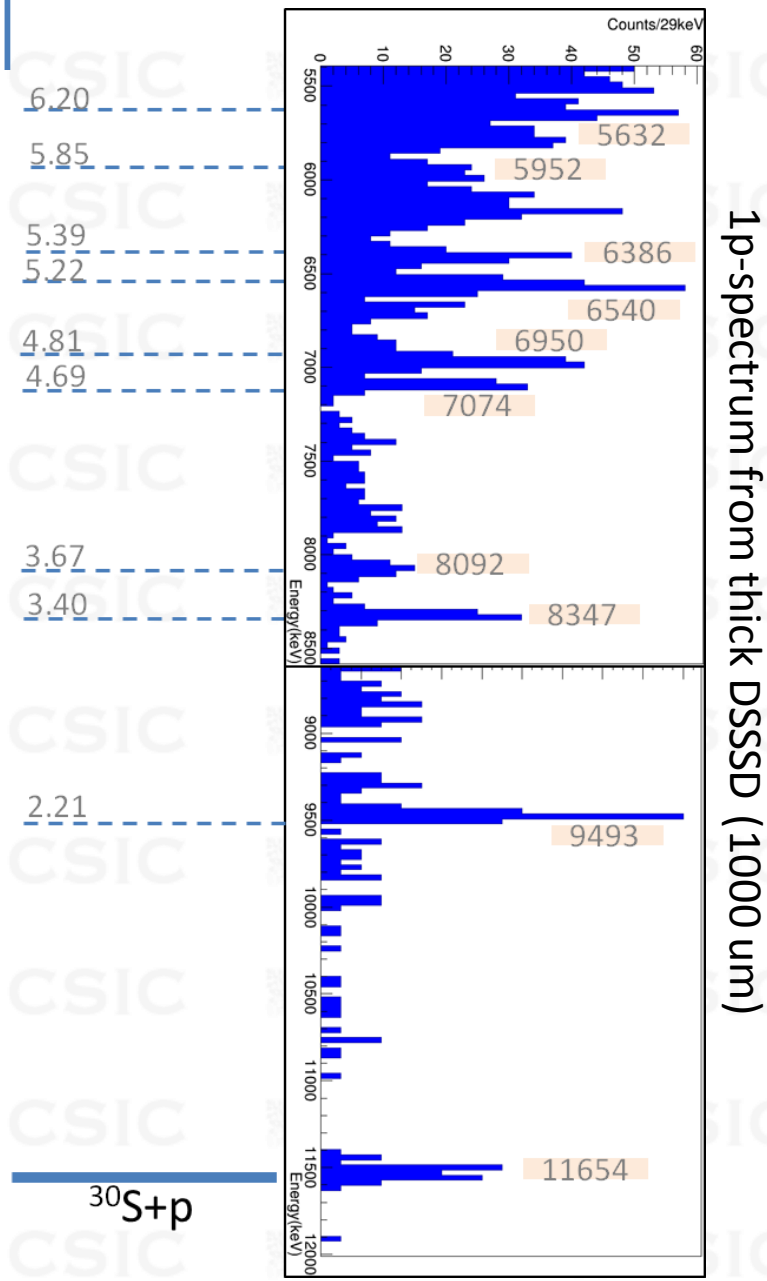


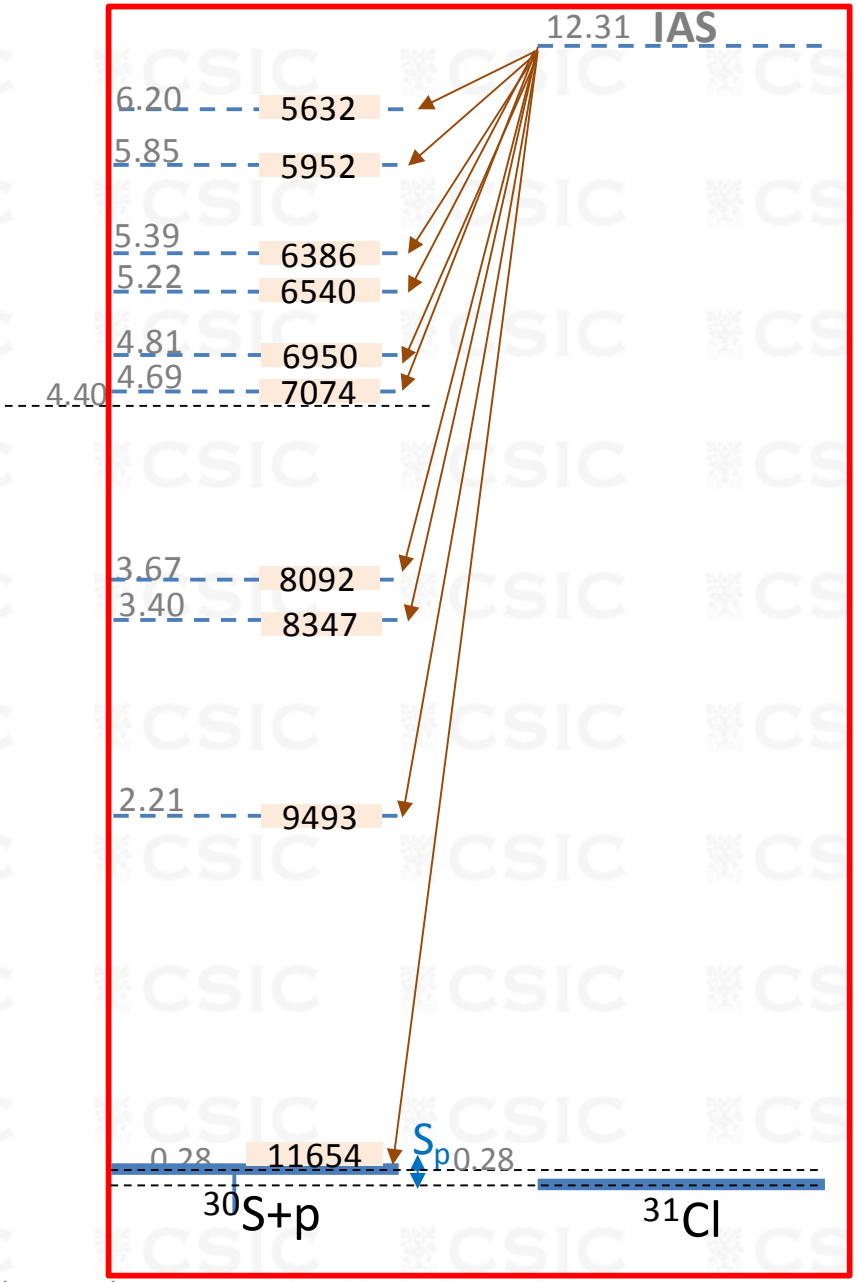
RESULTS: 1-p spectra from telescopes



Good energy resolution at low and high energies

RESULTS: proton peak identification





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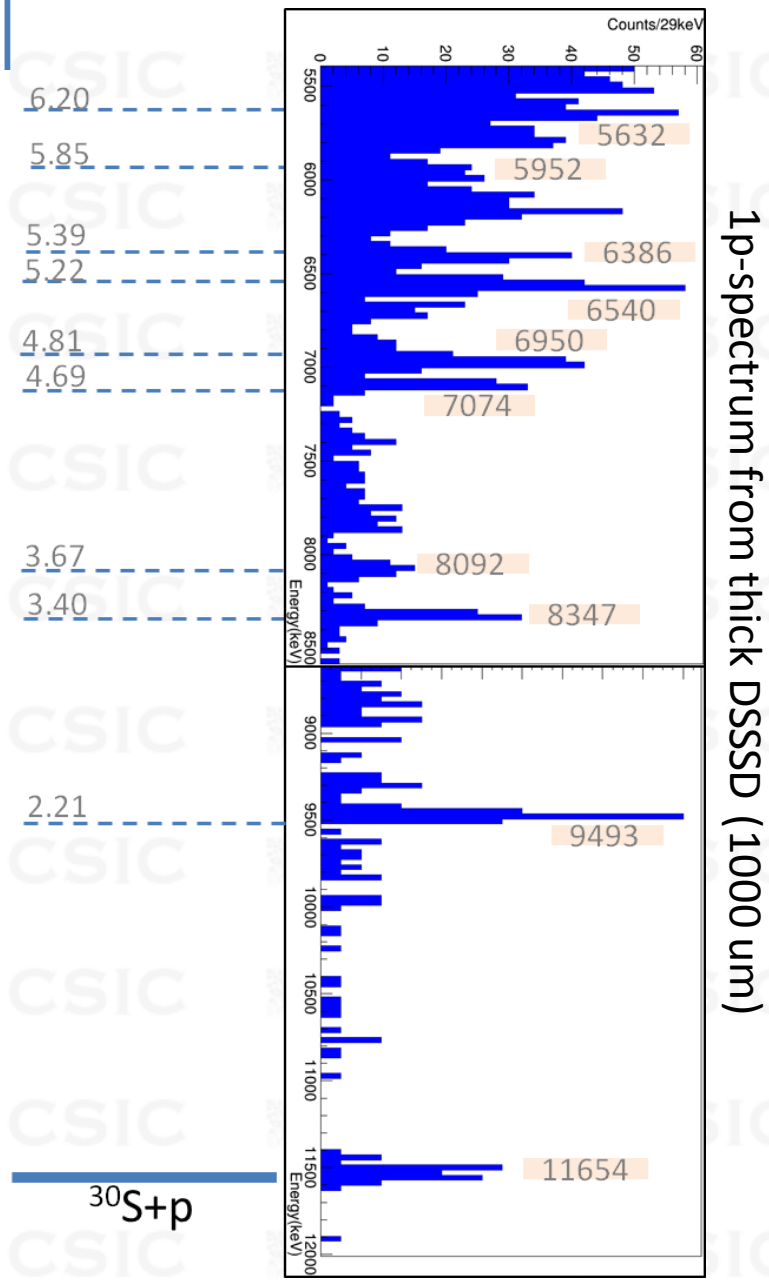
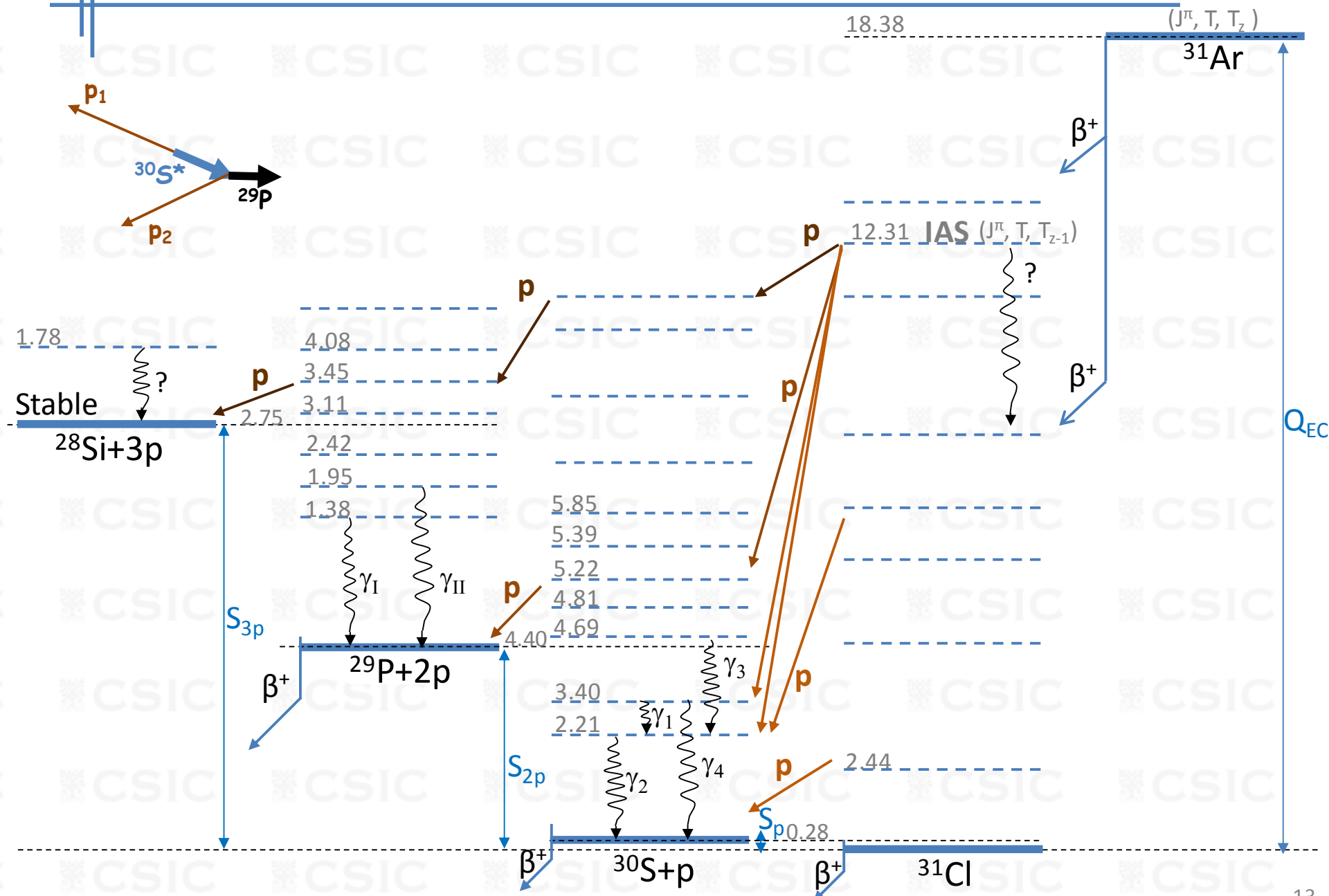


Intense peaks at high energies come from IAS: IAS decay to all levels in ^{30}S

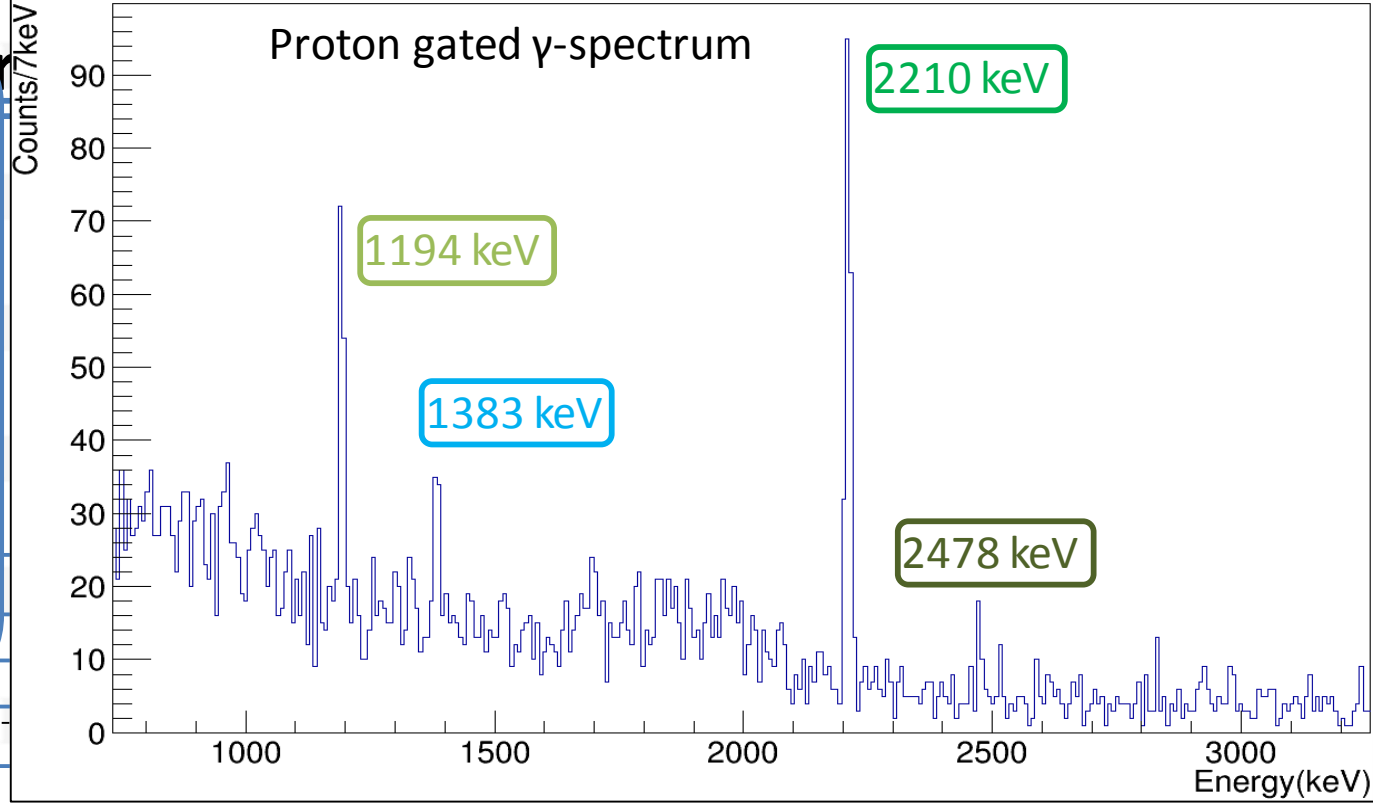
Koldste G.T. (2015) *Deciphering drip-line decays-the case of ^{31}Ar* (Doctoral dissertation)

Good resolution at high energies: better demonstration than in previous measurements (IS476, IS339)

RESULTS: ^{31}Ar Coincidences γ-1p and γ-2p

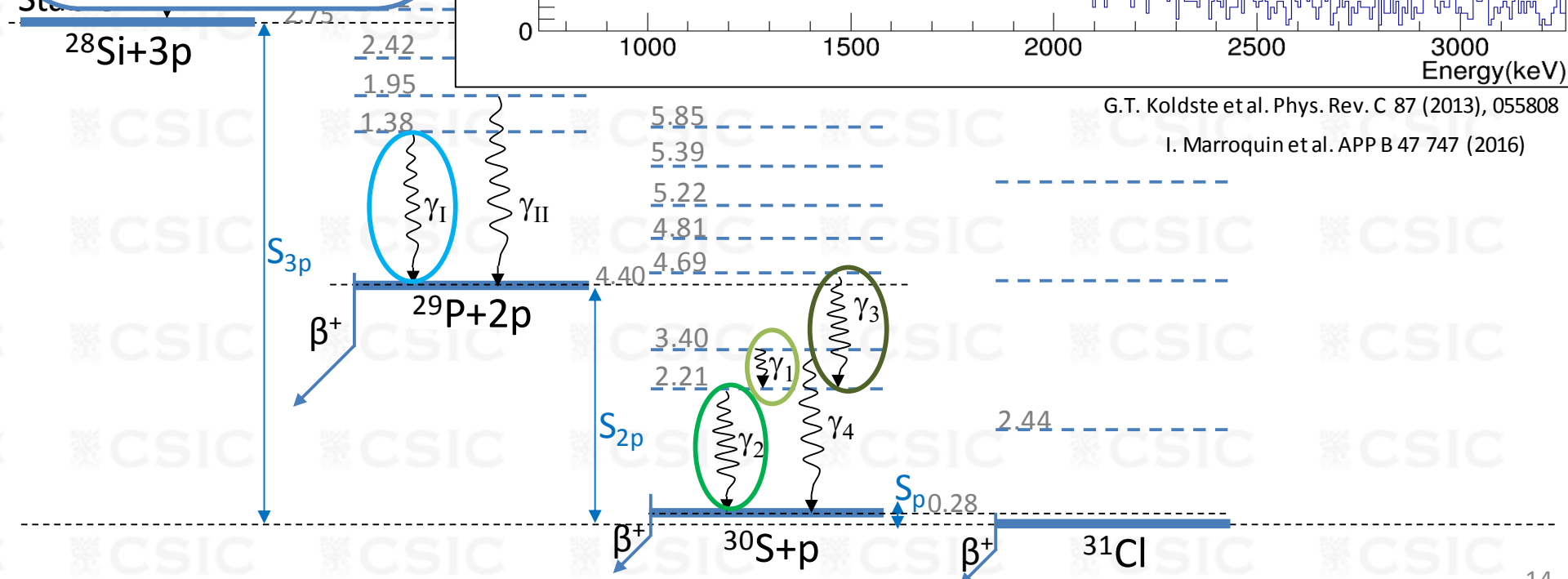


- Coincidences between any clover and any DSSD → **^{30}S and ^{29}P states**
- Setup optimized for maximizing proton detection efficiency (not for γ efficiency):
  - -Proton efficiency: 45% of 4π
  - -γ efficiency: 0.235% at 2 MeV

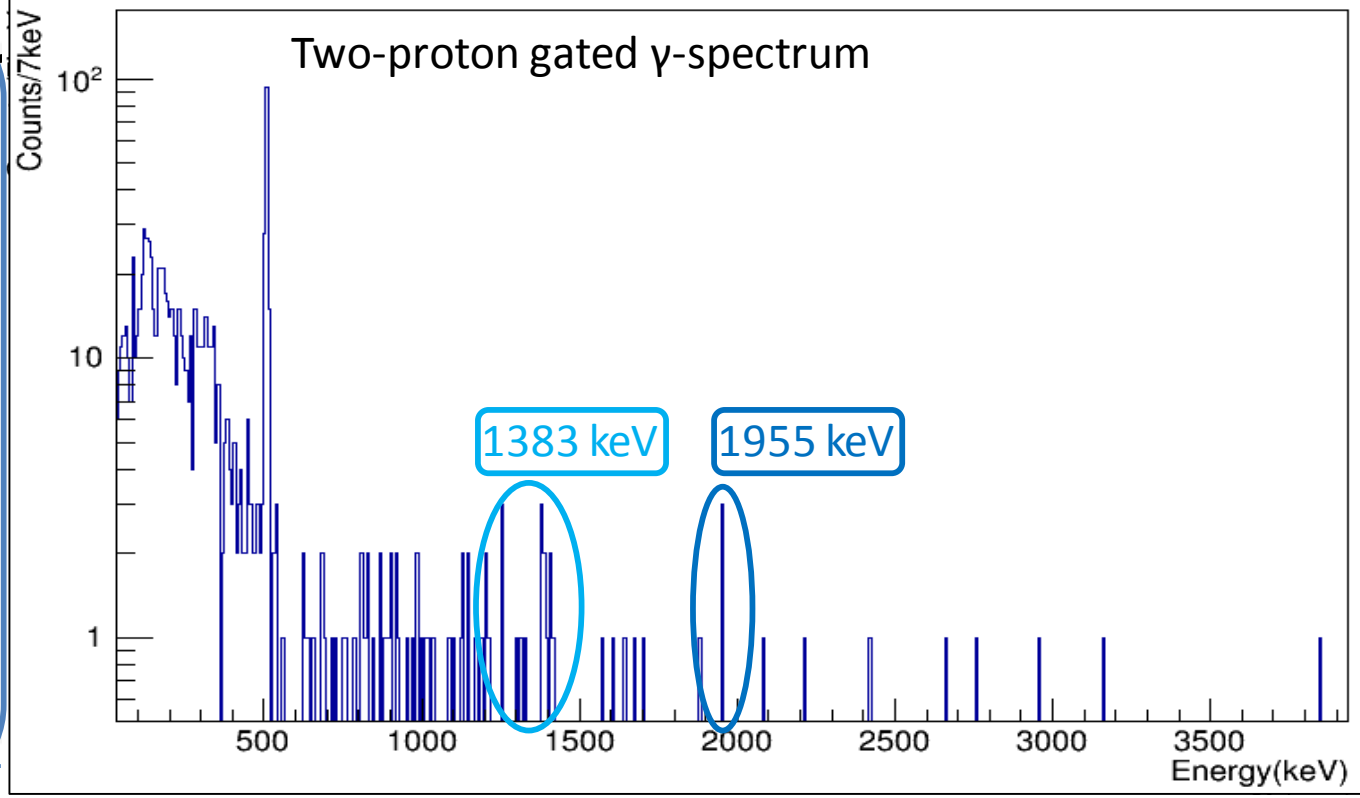


G.T. Koldste et al. Phys. Rev. C 87 (2013), 055808

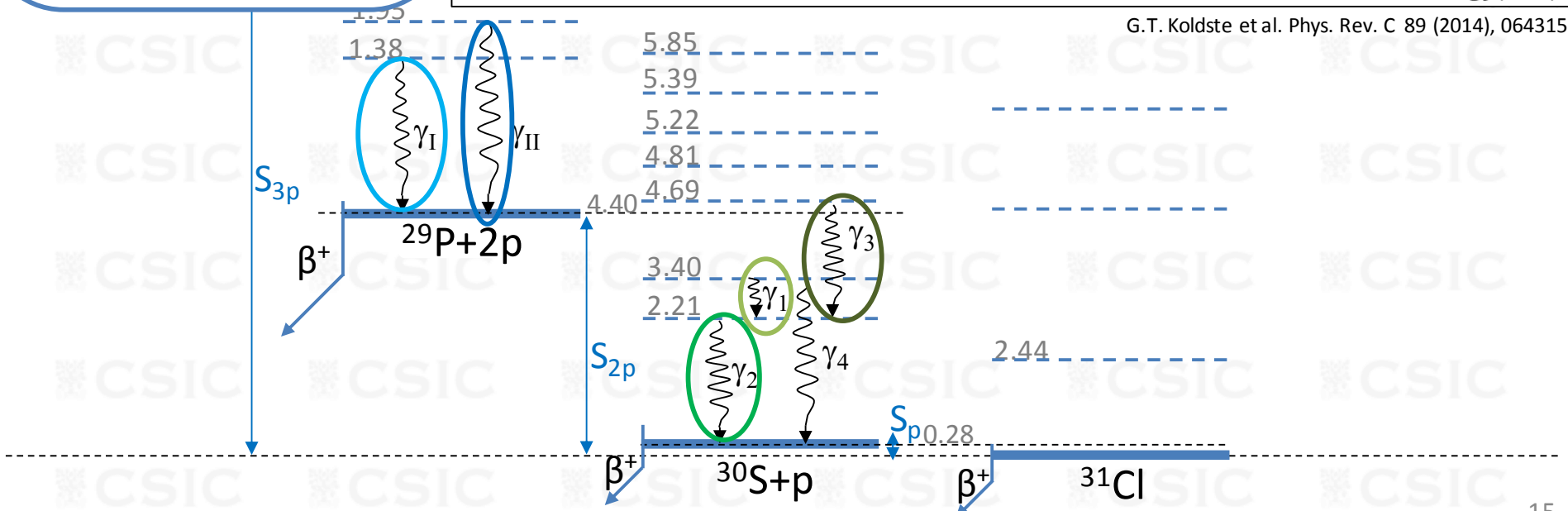
I. Marroquin et al. APP B 47 747 (2016)



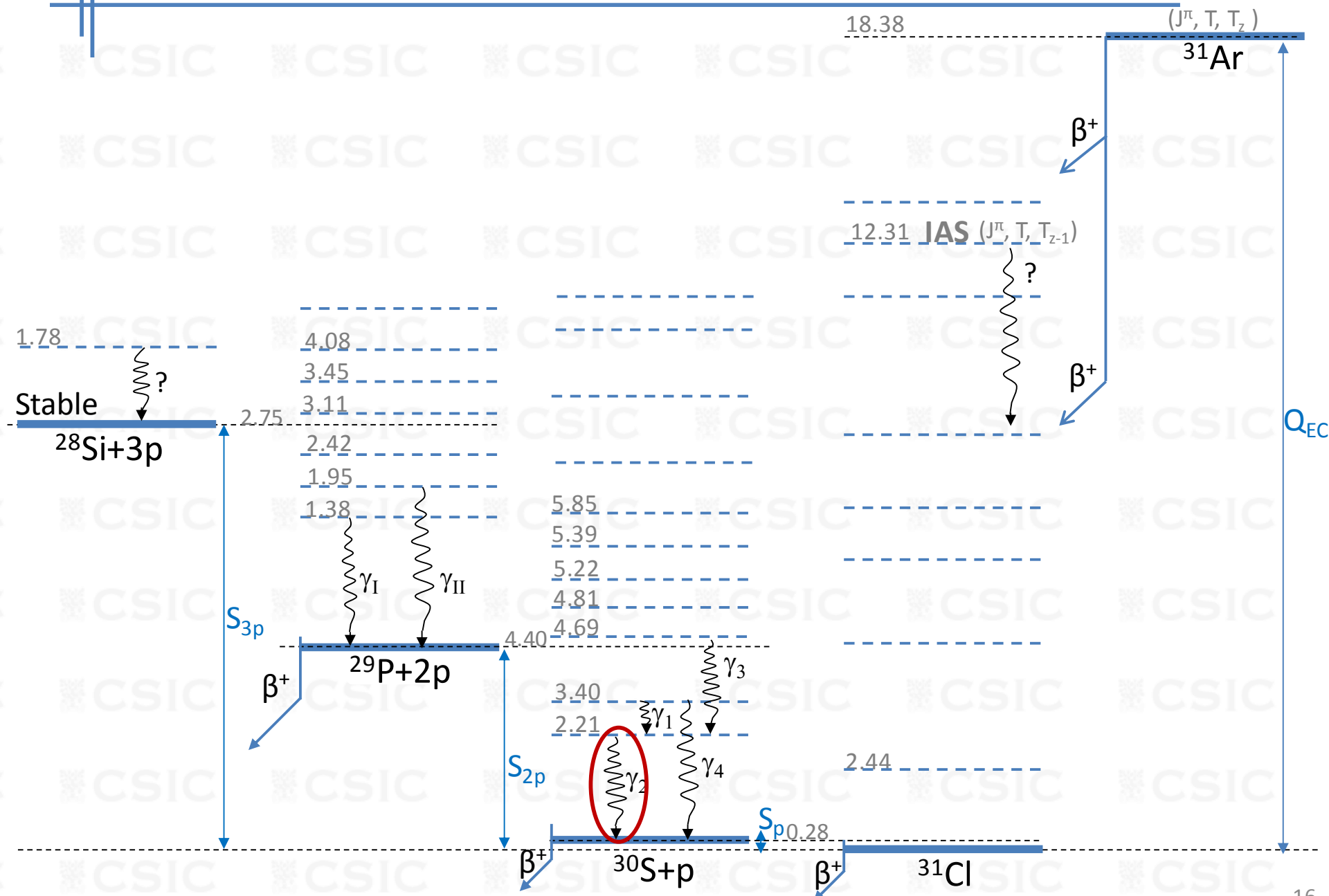
- Coincidences between any clover and any pair of DSSSD → **^{29}P states**
- γ_I is seen in γ-1p and γ-2p
- γ_{II} is seen only in γ-2p coincidences
- γ-2p coincidences complete the information from γ-1p about ^{29}P states
- **Clear evidence of γ-2p coincidences**



G.T. Koldste et al. Phys. Rev. C 89 (2014), 064315



RESULTS: ^{31}Ar Coincidences 1p-γ → ^{30}S states



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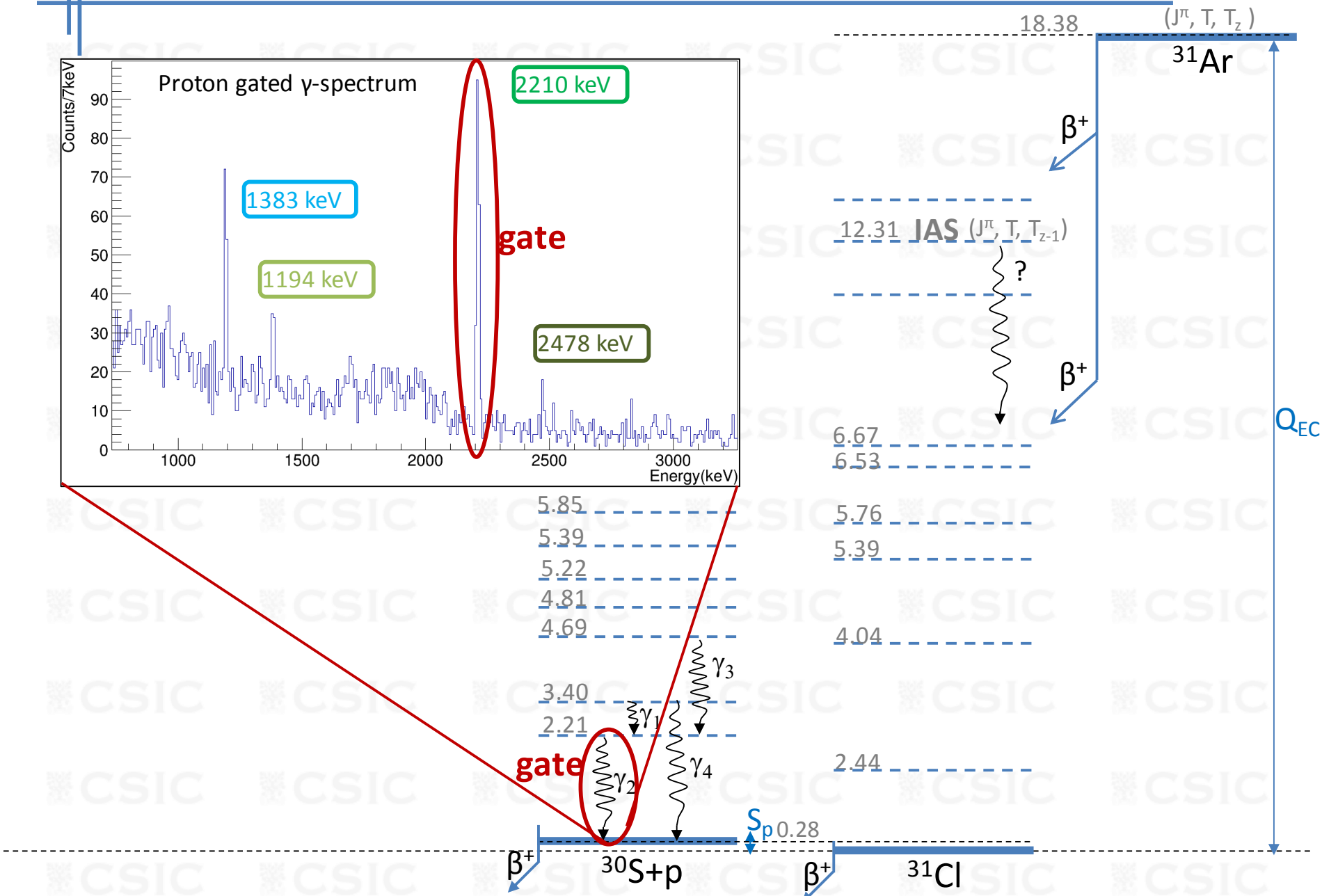

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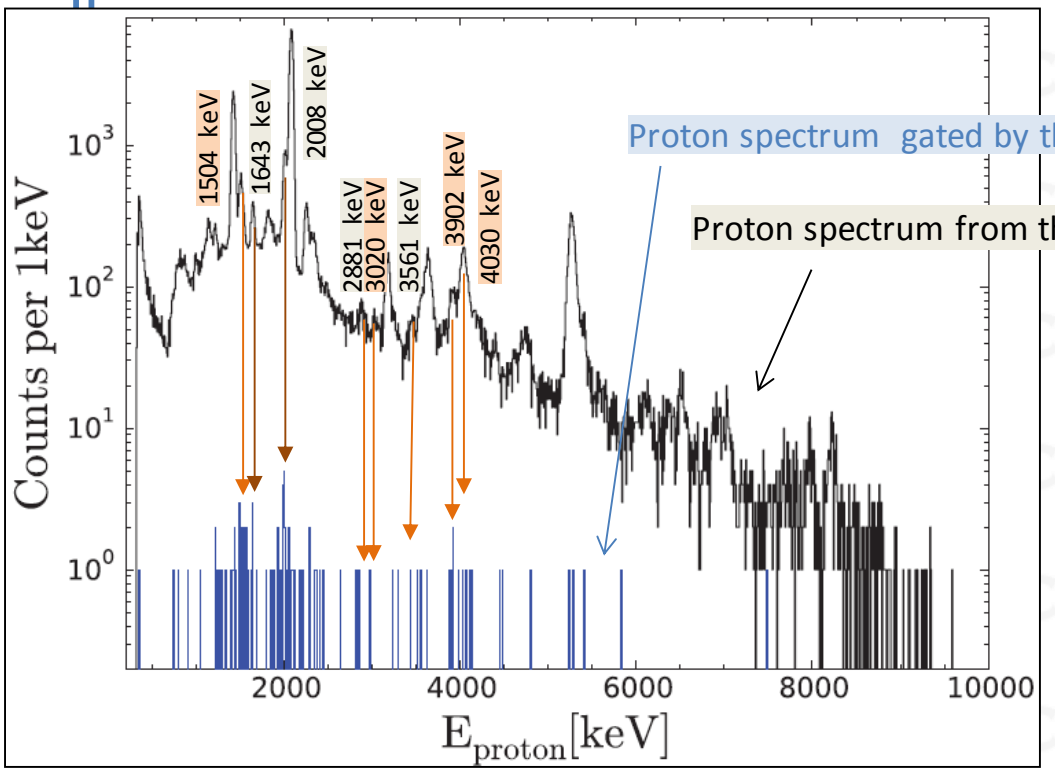
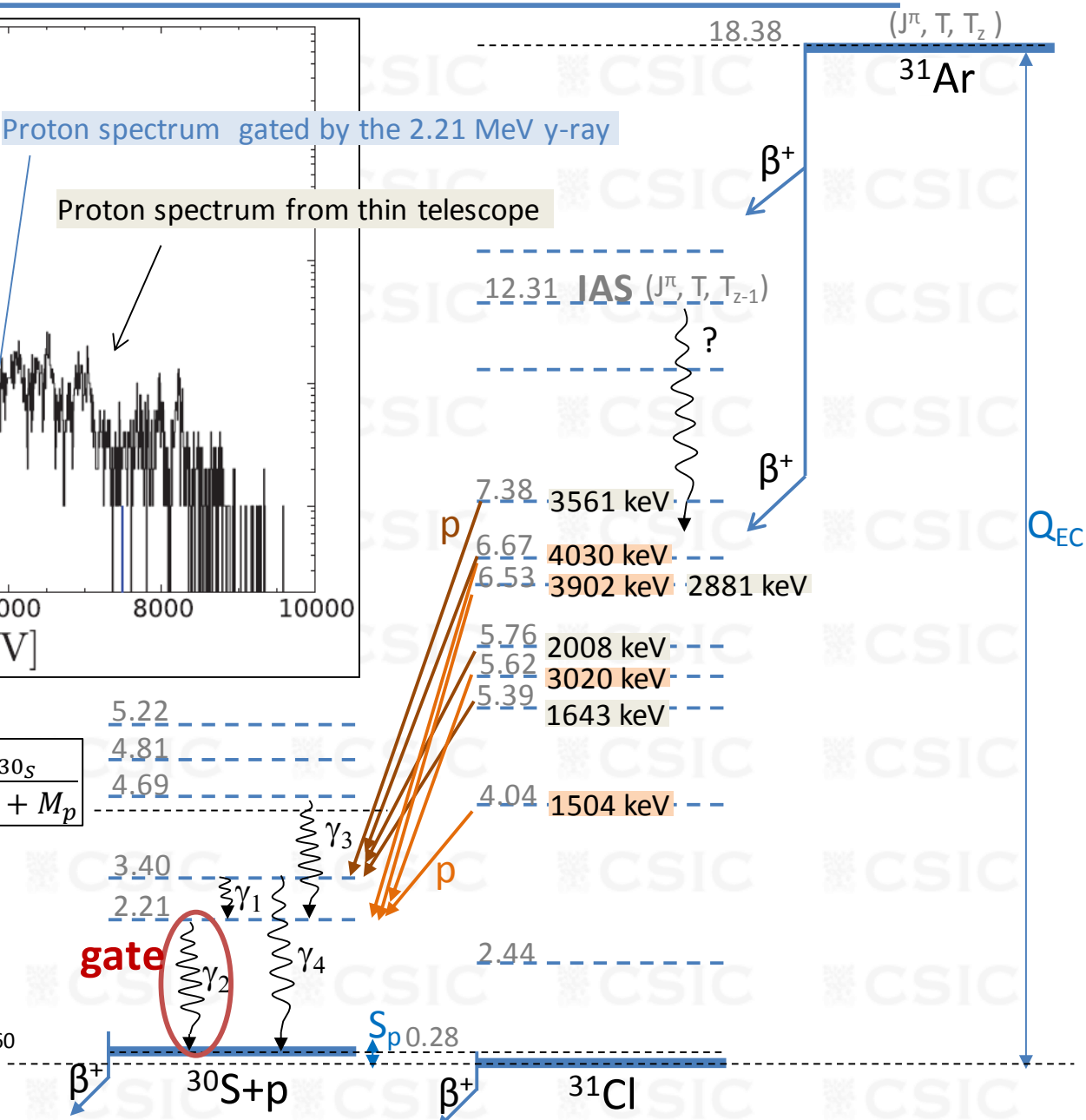
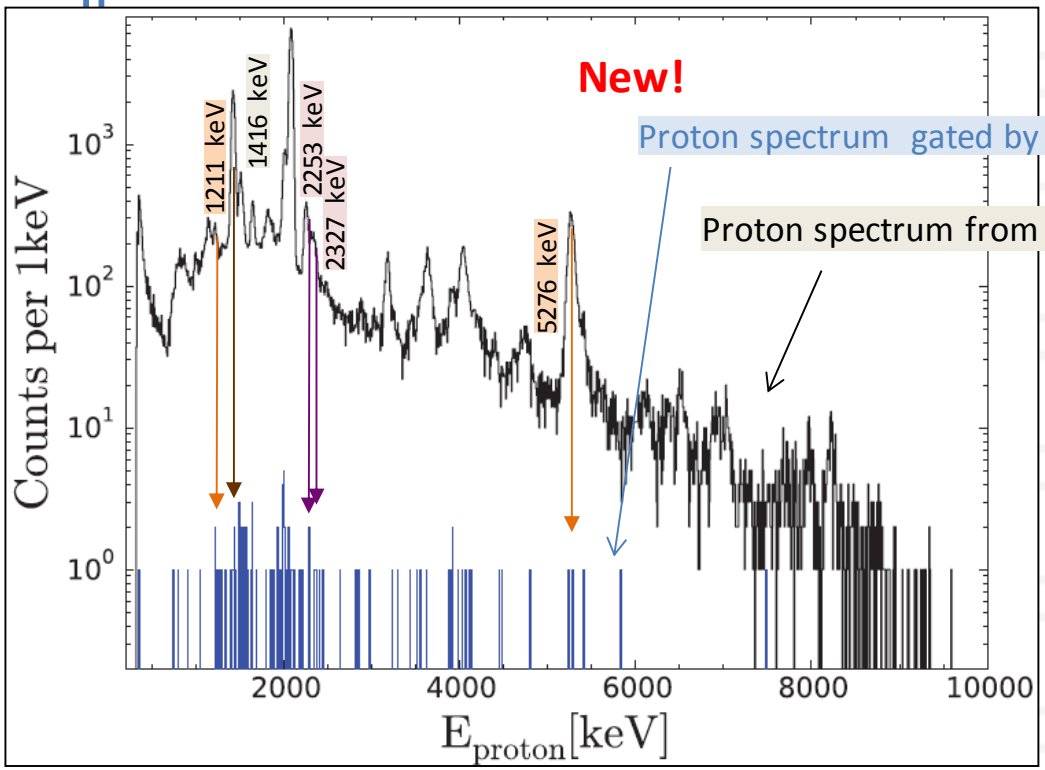


$$E_p = \left(E_{level31_{Cl}} - S_p - E_{level30_S}\right)\frac{M_{30_S}}{M_{30_S} + M_p}$$



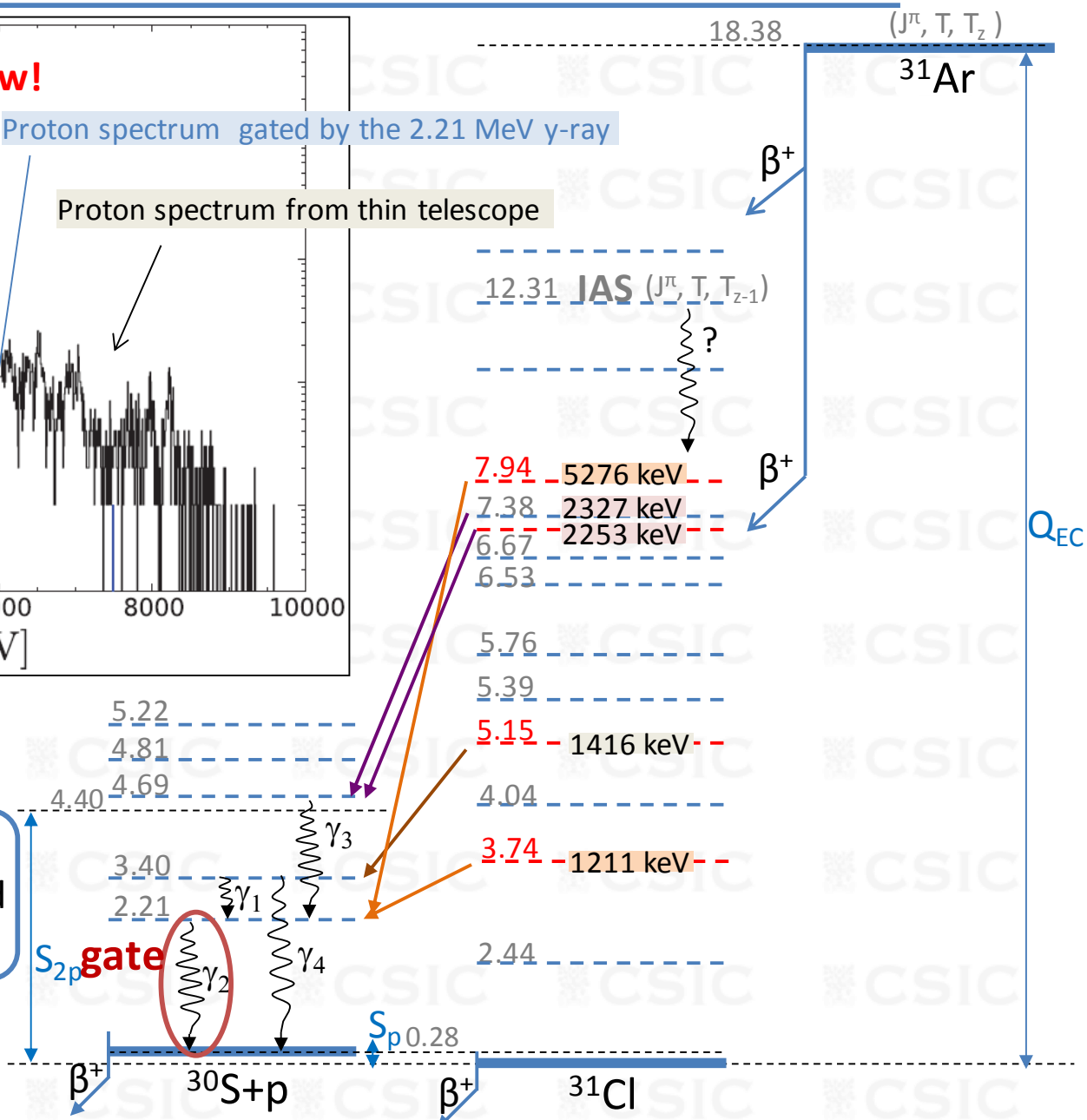
H.O.U. Fynbo et al. Nuclear Physics A 677 (2000) 38-60

RESULTS: ^{31}Ar Coincidences 1p-γ → ^{30}S states



preliminary

Proton peaks wrongly identified before, found to decay in excited states in ^{30}S



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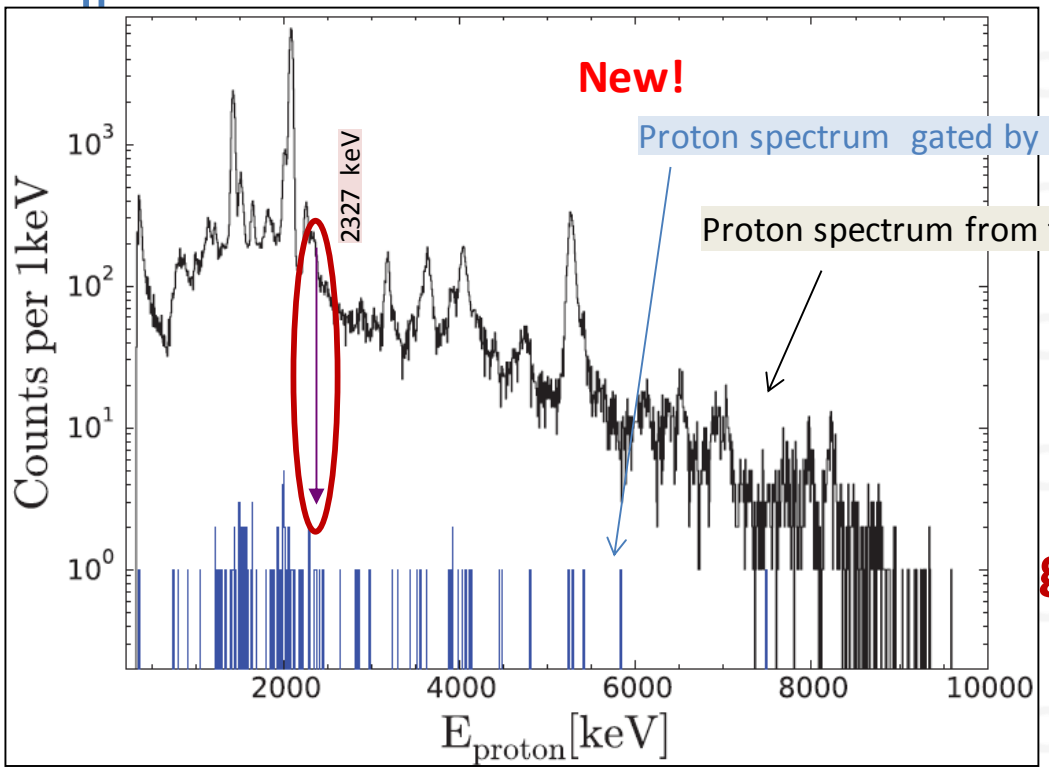
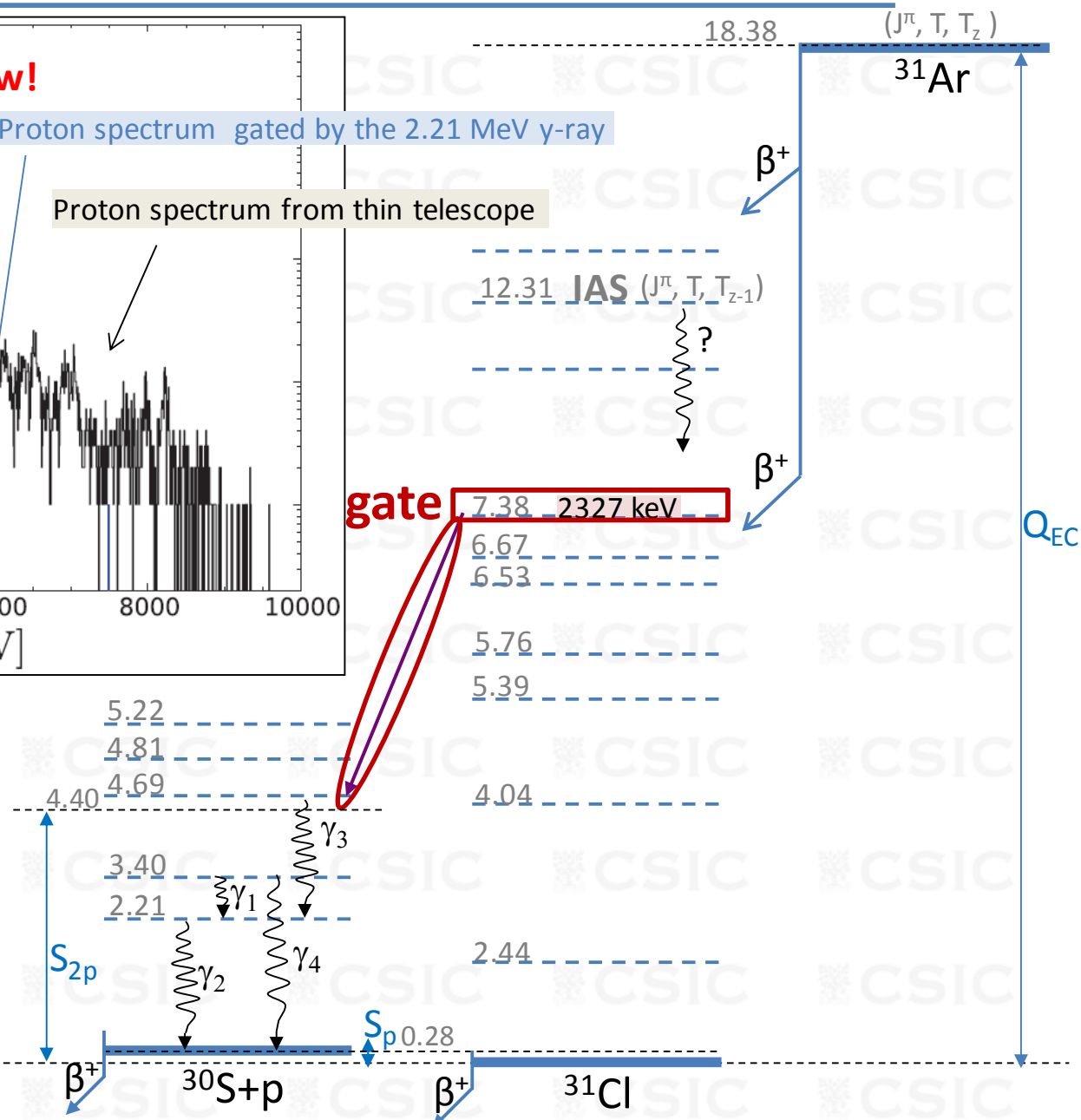
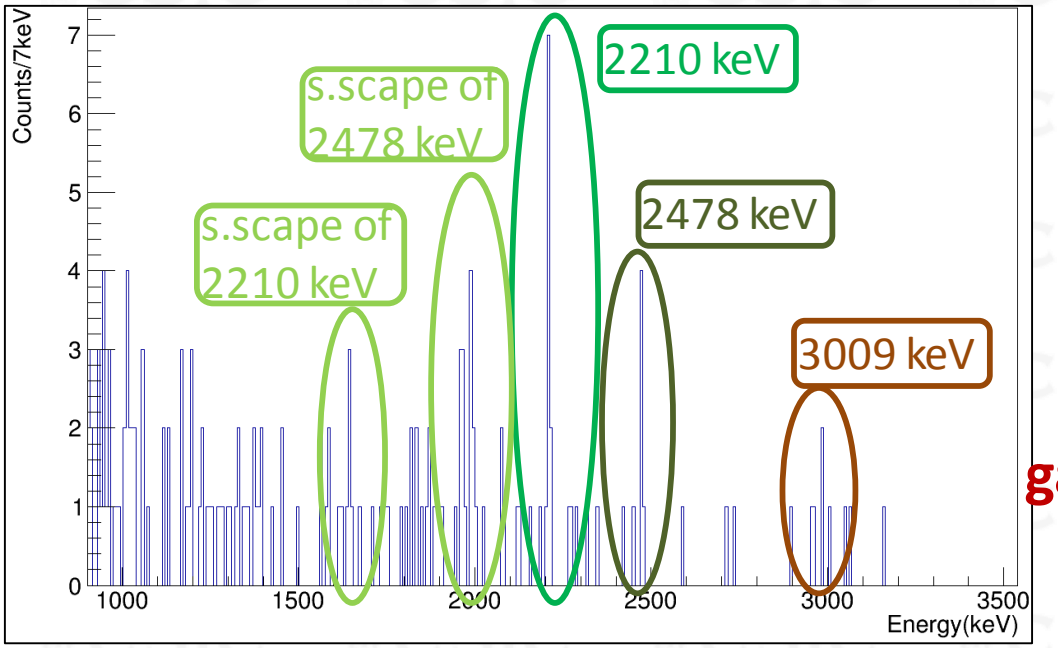




Gate on 2327-keV-proton peak to see the gammas in coincidence

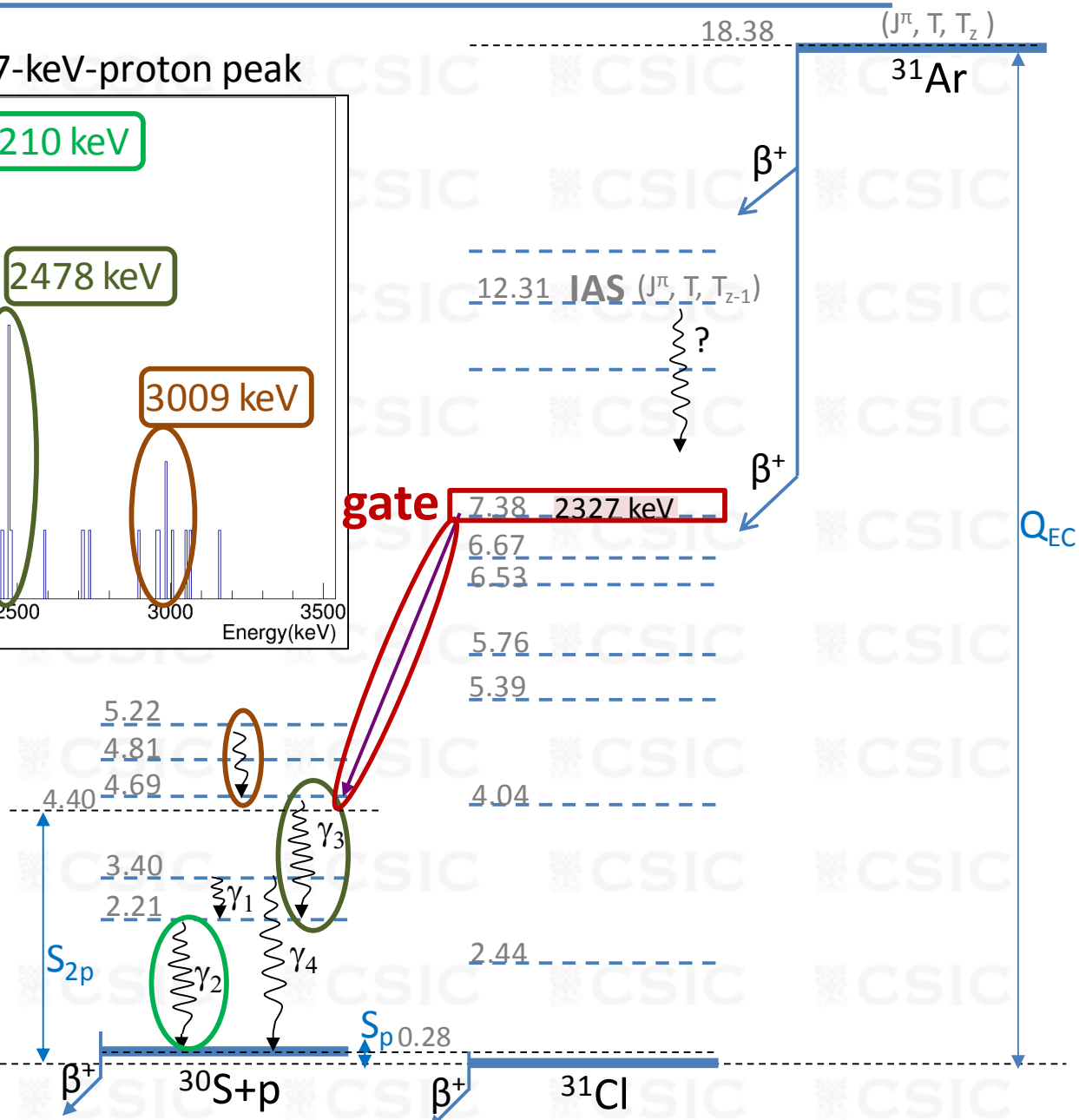
RESULTS: ^{31}Ar Coincidences 1p-γ → ^{30}S states

γ-spectrum gated on 2327-keV-proton peak

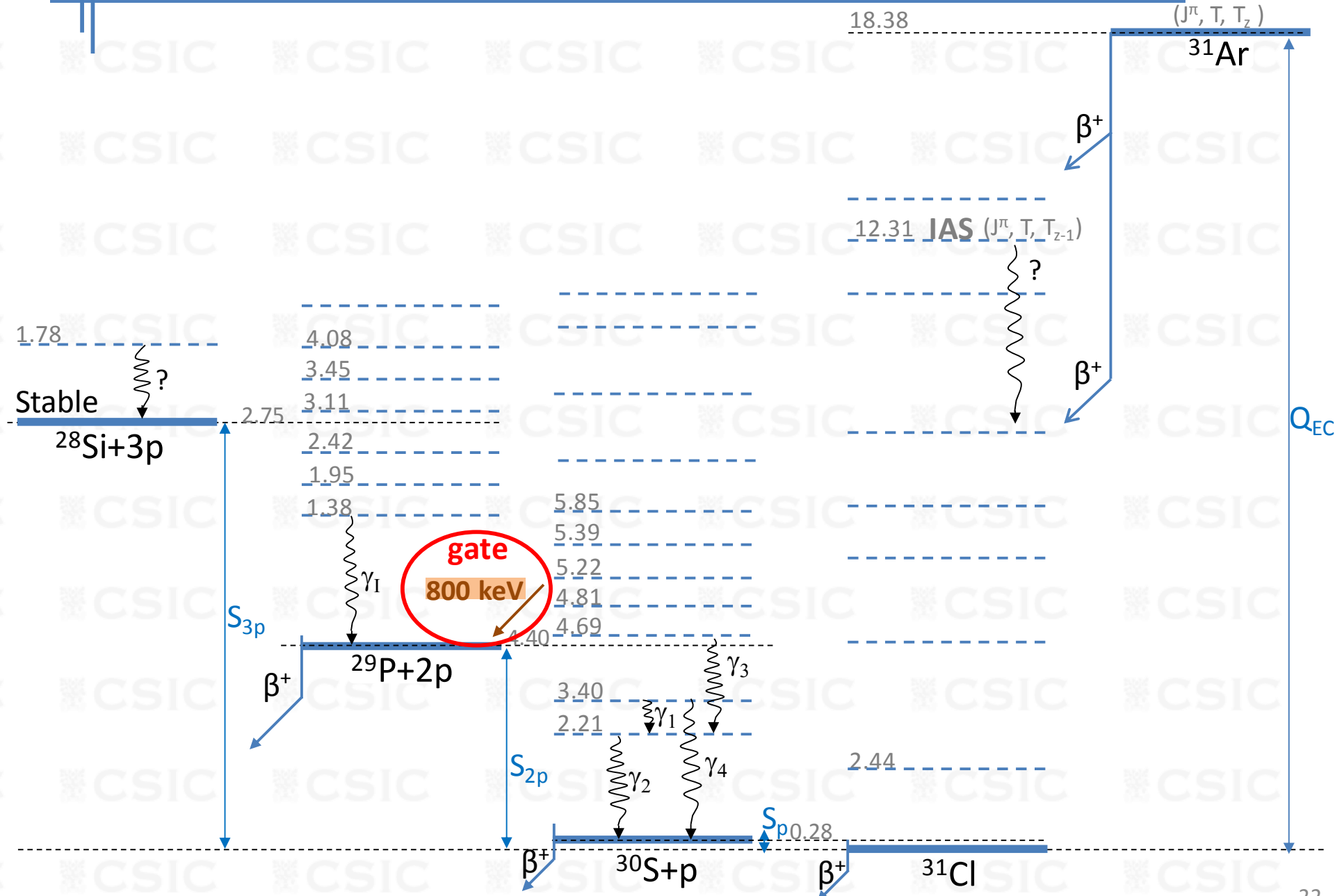


preliminary

Main component corresponds to the decay from the 7.37-MeV level to the 4.69-MeV level in ^{30}S



RESULTS: ^{31}Ar Coincidences p-p → ^{29}P+2p



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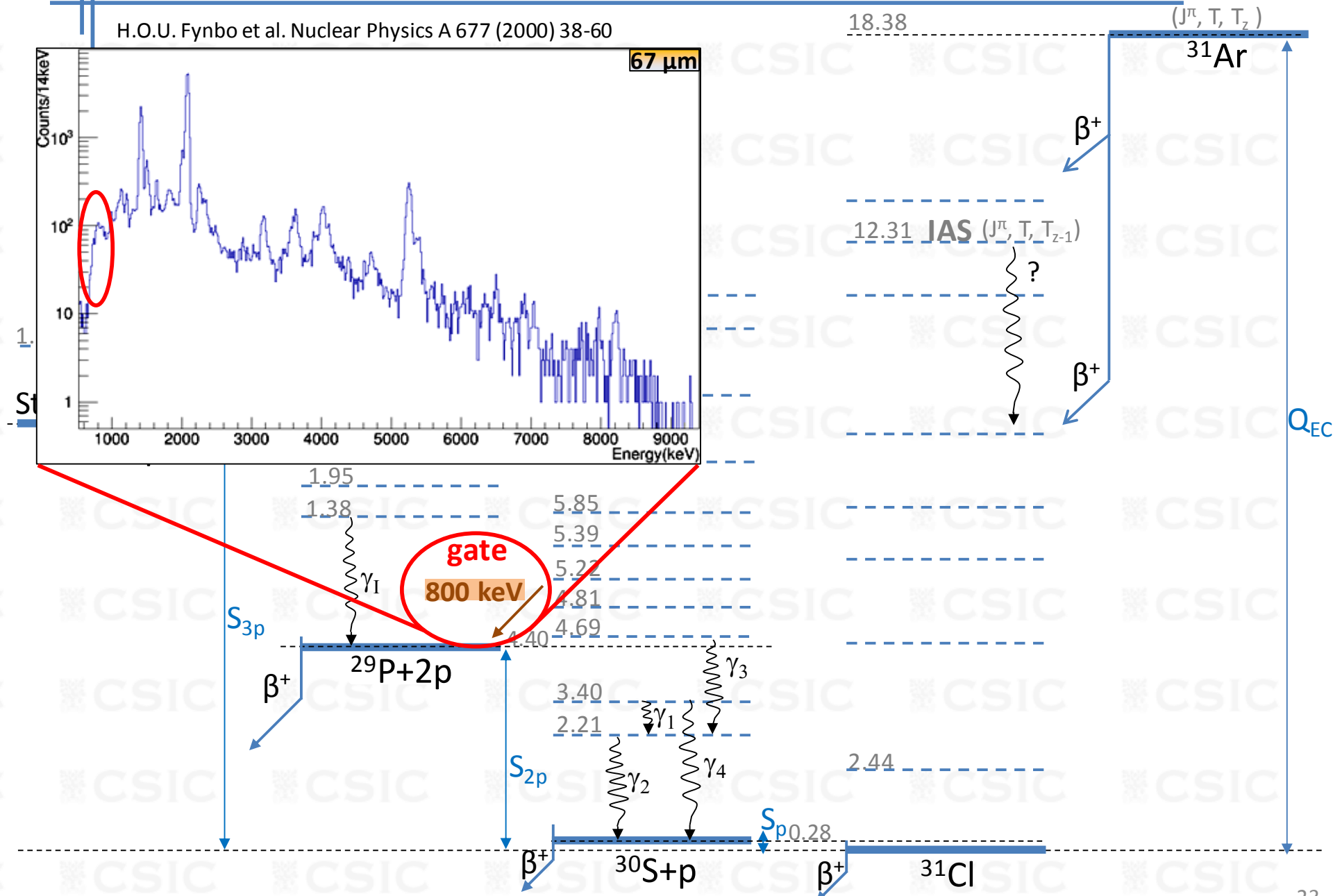

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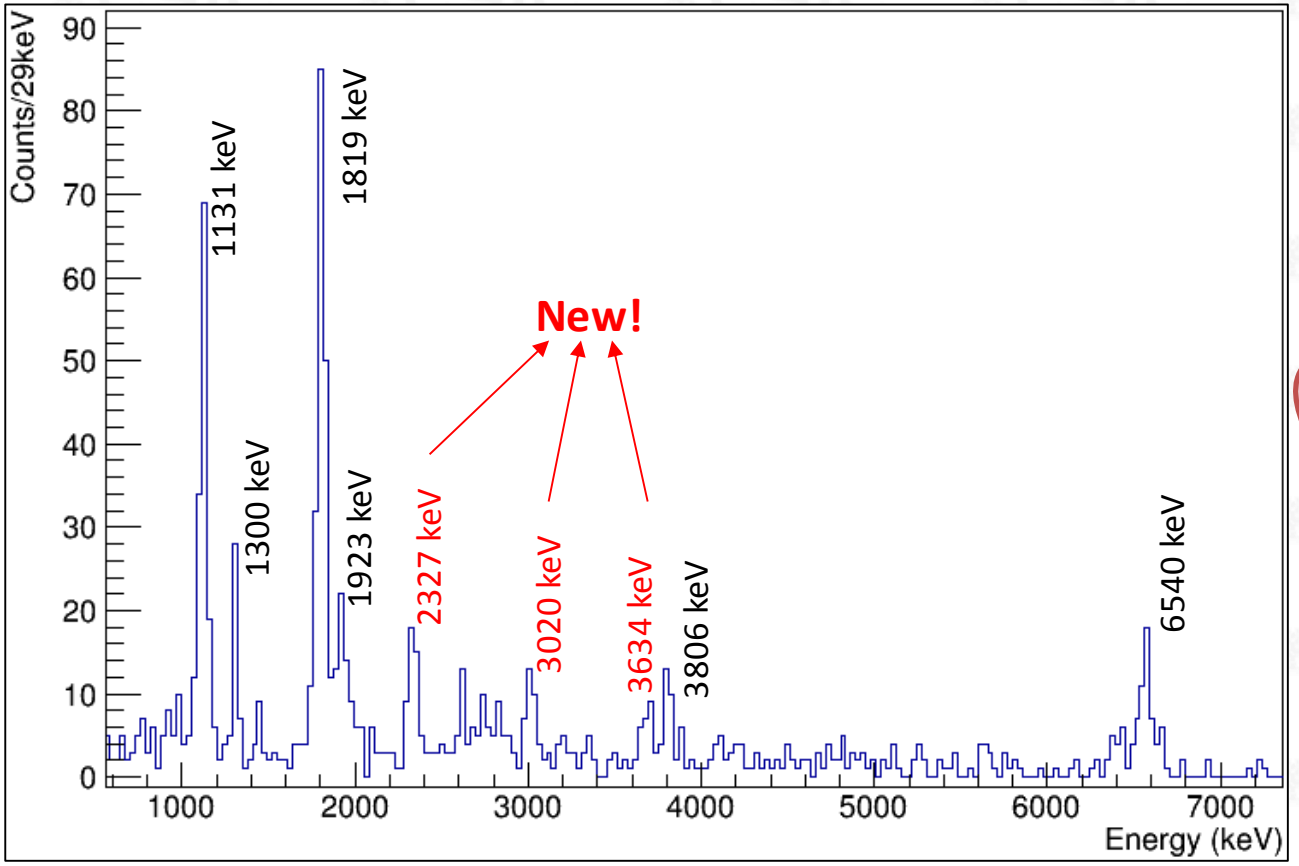
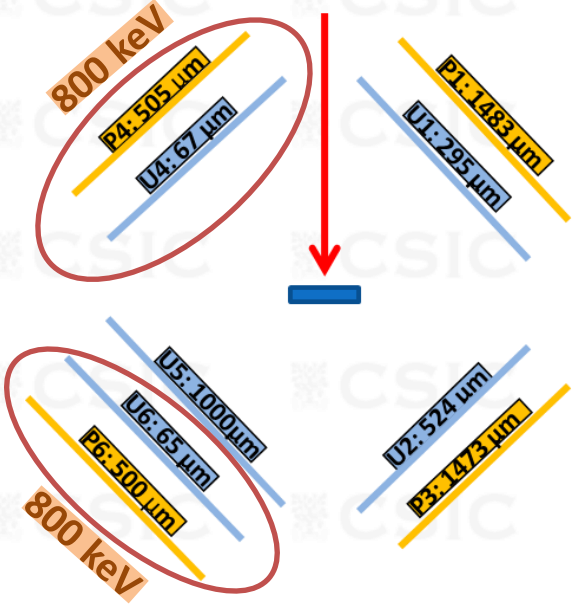
p-spectrum gated by 800 keV p-peak





preliminary

- 800 keV is the second emitted proton → energy of the first emitted proton larger than the energy of the second one
- Three proton peaks identified before as 1-p emission are found to be 2-p emission.

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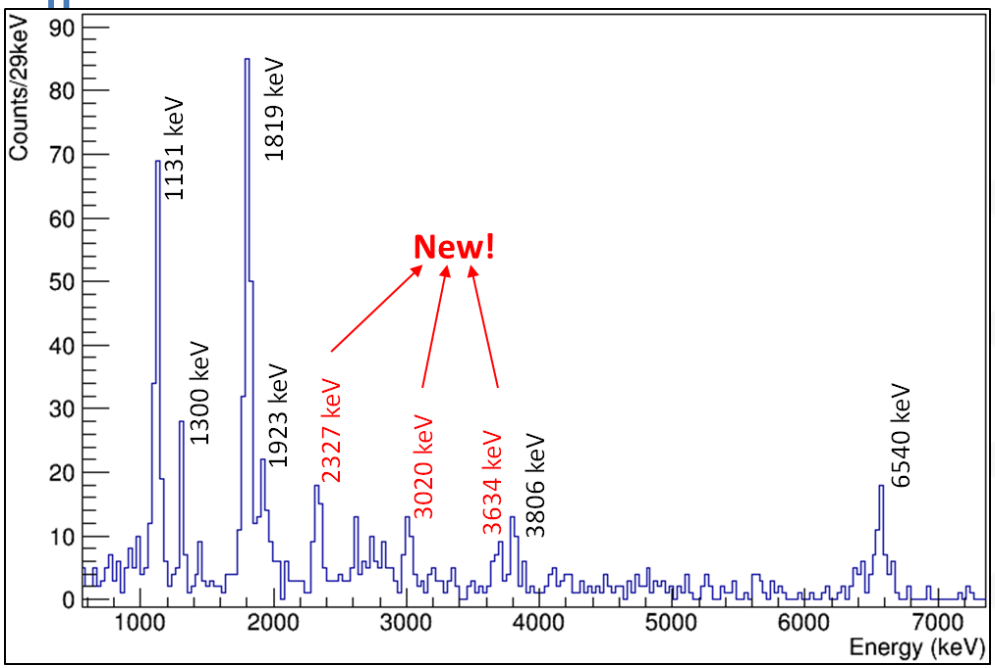
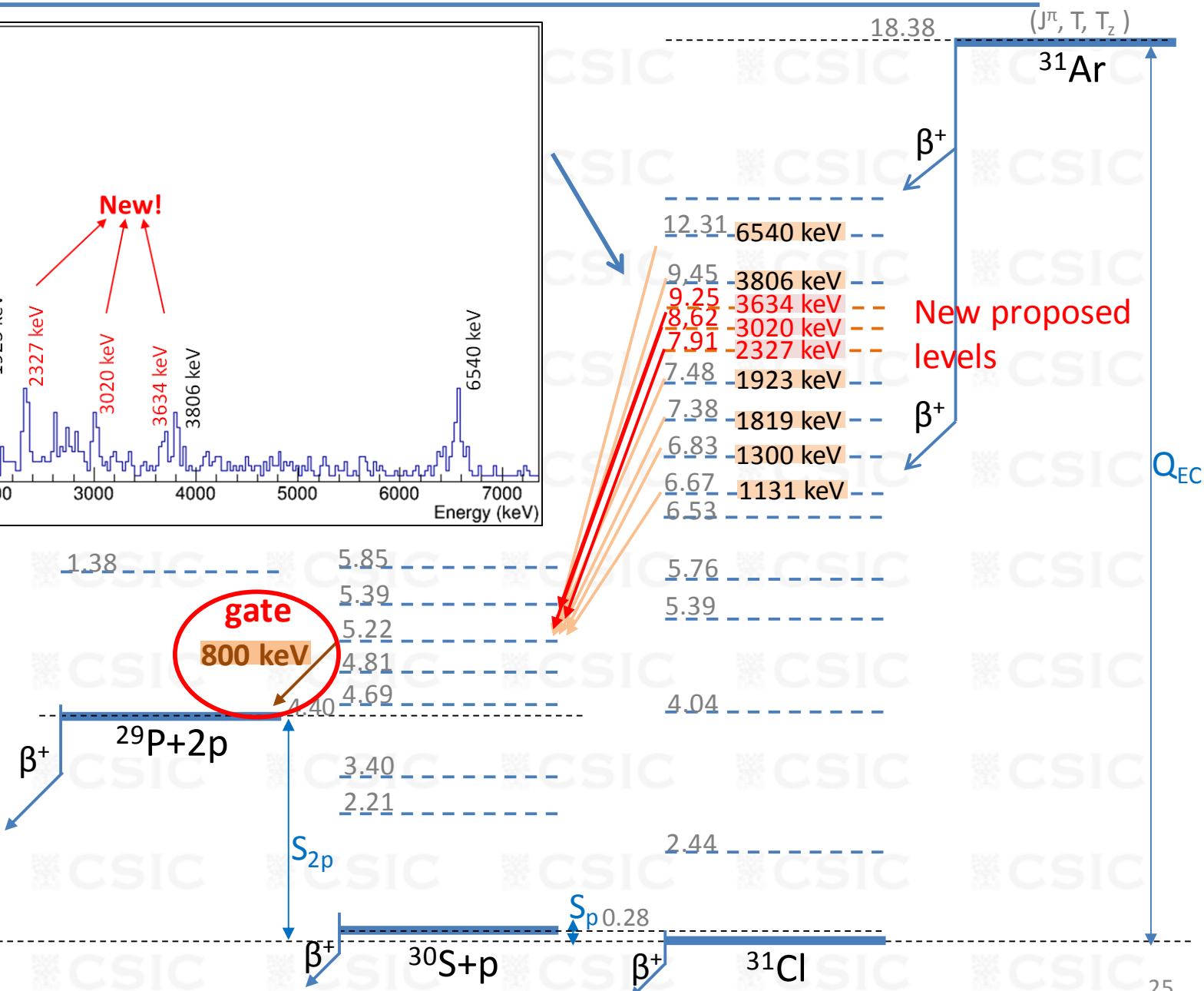


preliminary



CONCLUSIONS - ^{31}Ar

- Multi-particle emission experiment performed successfully at the **IDS** **for the first time**.

- Set-up optimized for multi-particle emission (1p,2p,3p) with high efficiency, good energy (25 keV) and angular (3º) resolution.

- Levels of proton daughters of ^{31}Ar, ^{30}S and ^{29}P studied:
  - **Good resolution** at low and high energies in telescopes:

    ✓ High fragmentation in the IAS decay, which populates all levels in ^{30}S
    ✓ Clear identification of 2p-γ coincidences
    ✓ **Clear identification of the 5.22-MeV and 4.69-MeV levels: with the last one, near the threshold, we can calculate the proton and gamma partial width**

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