STUDY OF ^{31,33}Ar β-decay@ISOLDE

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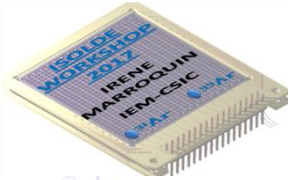
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

CSIC Consejo Superior de Investigaciones Científicas

ISOLDE Decay Station

ISOLDE

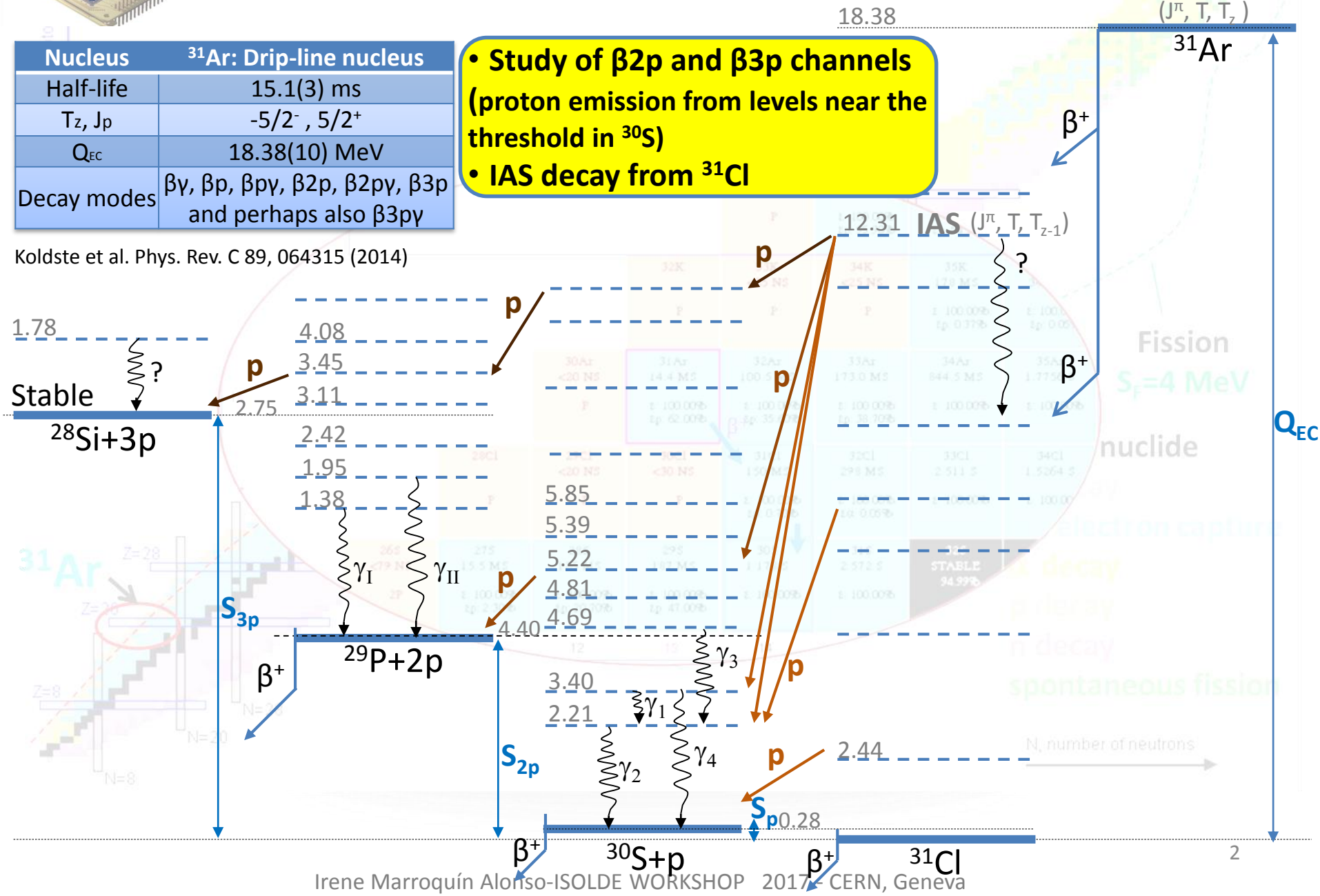


MOTIVATION: IS577 experiment @ ISOLDE Decay Station

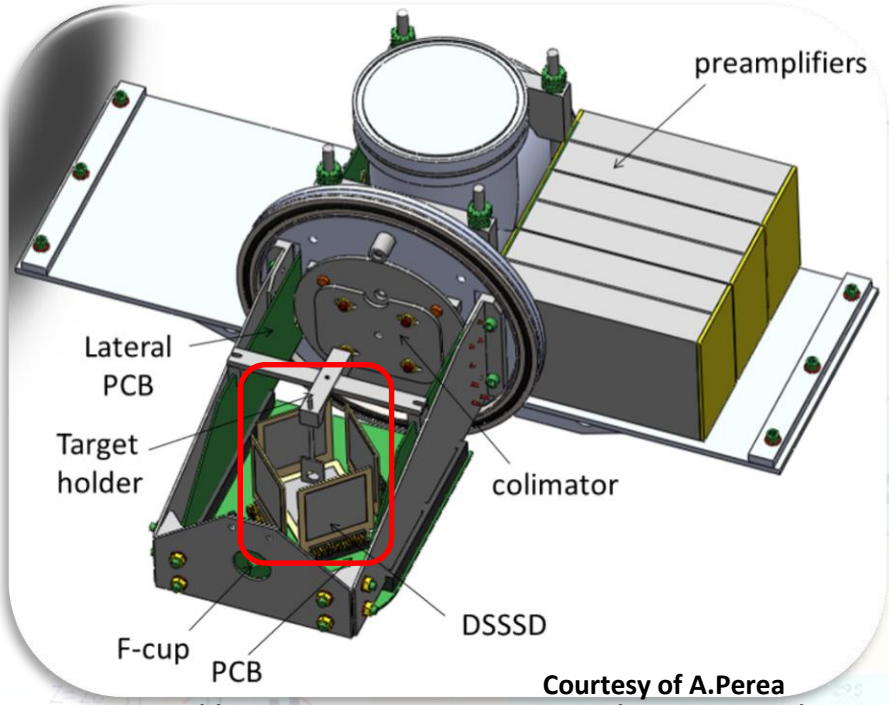
Nucleus	^{31}Ar: Drip-line nucleus
Half-life	15.1(3) ms
T_z, J_p	-5/2$^-$, 5/2$^+$
Q_{EC}	18.38(10) MeV
Decay modes	βγ, βp, βpγ, β2p, β2pγ, β3p and perhaps also β3pγ

- **Study of β2p and β3p channels (proton emission from levels near the threshold in ^{30}S)**
- **IAS decay from ^{31}Cl**

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

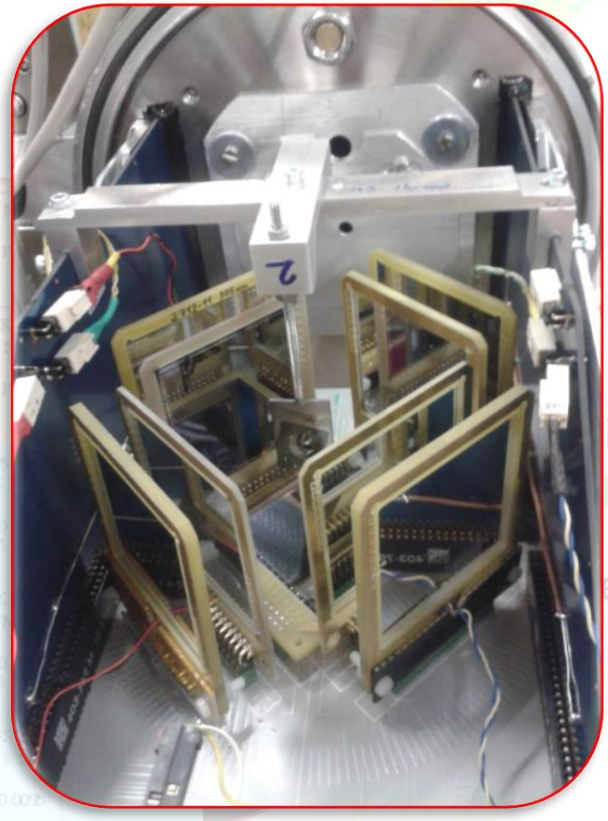


SET-UP: MAGISOL Si plug-in chamber @



Courtesy of A.Perea

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

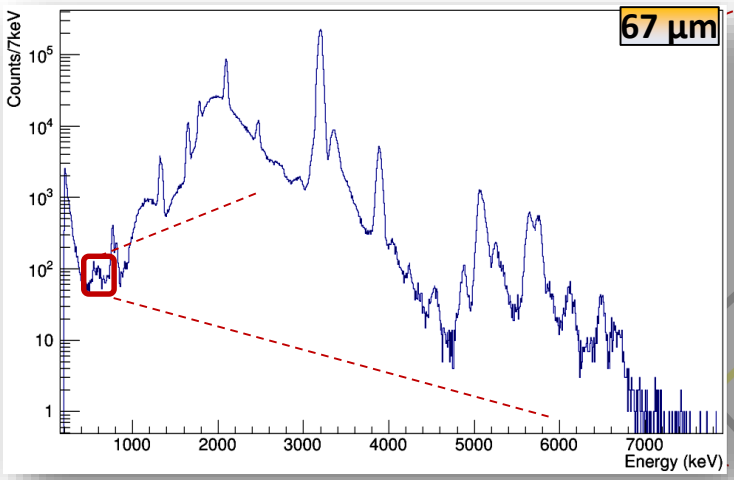


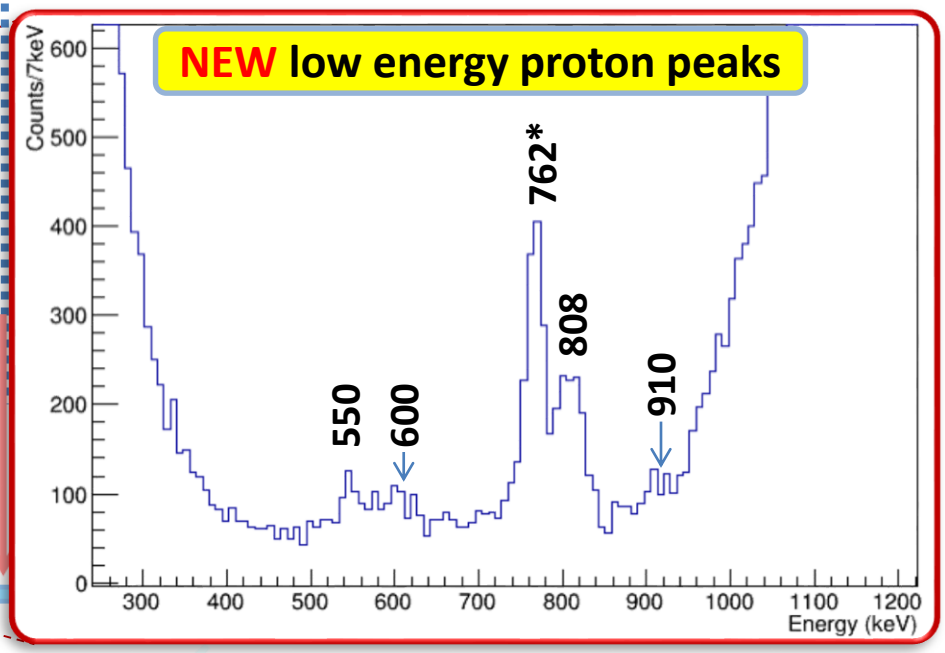
- Array of **Double Sided Si Strip Detectors** (DSSSD) and **PADs** in ΔE-E/telescope configuration located inside the new ***MAGISOL Si-Plugin Chamber***
- **Different thickness of DSSSDs** for **different proton energies**

- **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**

RESULTS: ^{33}Ar p-spectra…beyond calibration….

THIN TELESCOPES





P4: 505 µm
U4: 67 µm
U5: 1000µm
U6: 65 µm
P6: 500 µm
U2: 524 µm
P3: 1473 µm

- **Low energy thresholds for protons**
- **Very good energy resolution in all energy range**

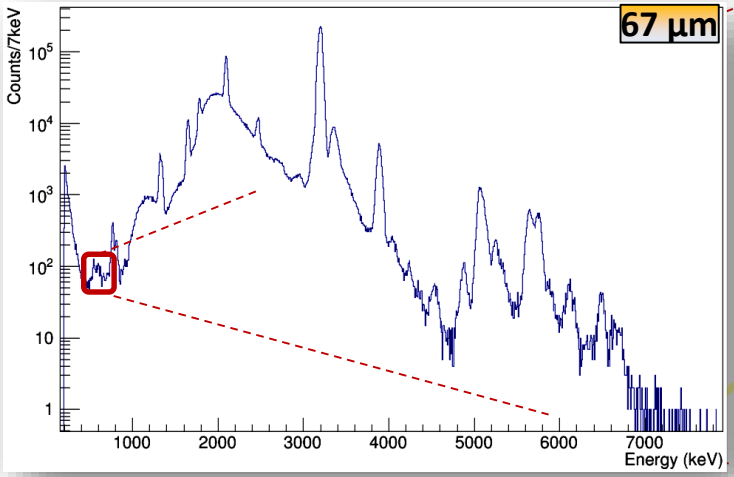
***762 keV peak is known**

N. Adimi et al. Phys. Rev. C81, 024311(2010)

DETECTOR	THICKNESS (um)	SOLID ANGLE (%)	ENERGY THRESHOLDS for protons (keV)	ANALYSIS CONDITIONS
U1	300	7.4	350	·|Ef-Eb|<50keV·
U2	524	11.72	350	·mul > 6 excluded·
U4	67	10.43	200	·Ef,Eb>80keV·
U5	1000	9.6	-	·TPROTON: 519 ms·
U6	65	8.28	200	

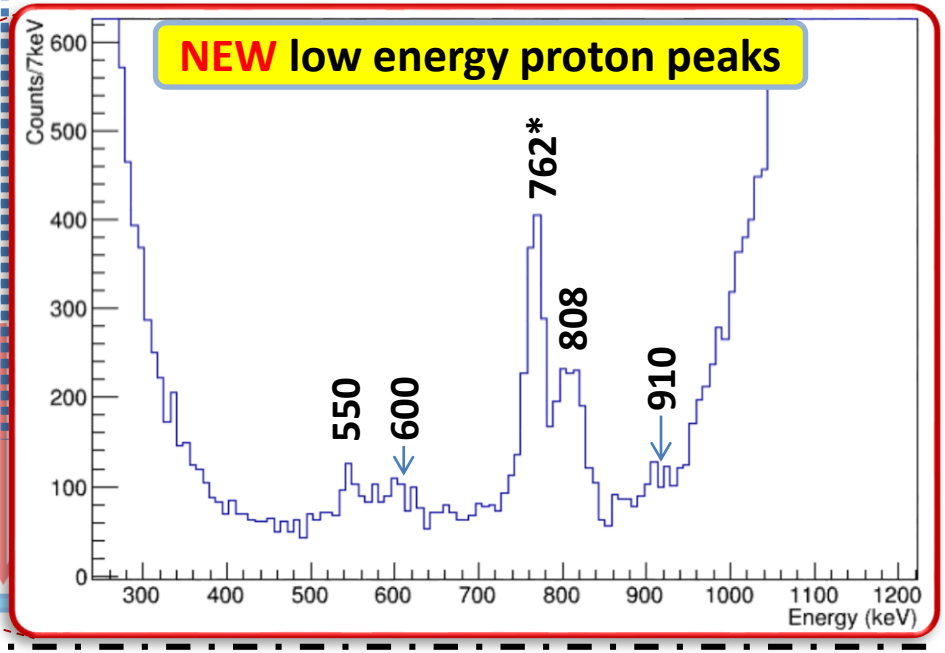
RESULTS: ^{33}Ar p-spectra…beyond calibration….

THIN TELESCOPES

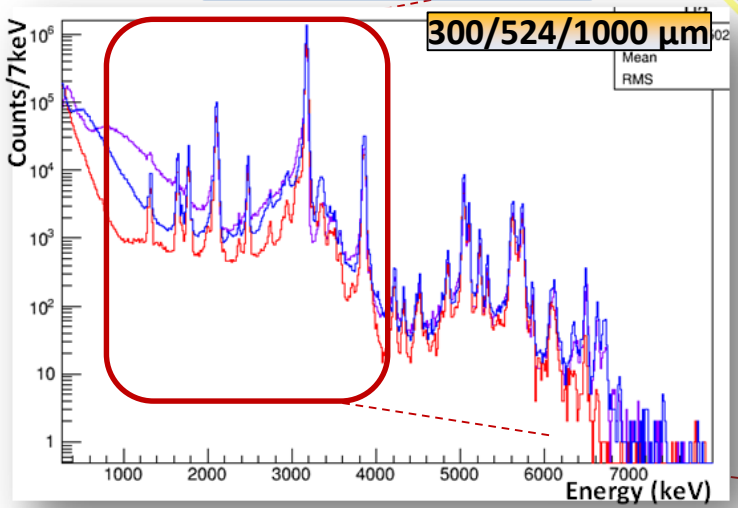


P4: 505 µm

U4: 67 µm



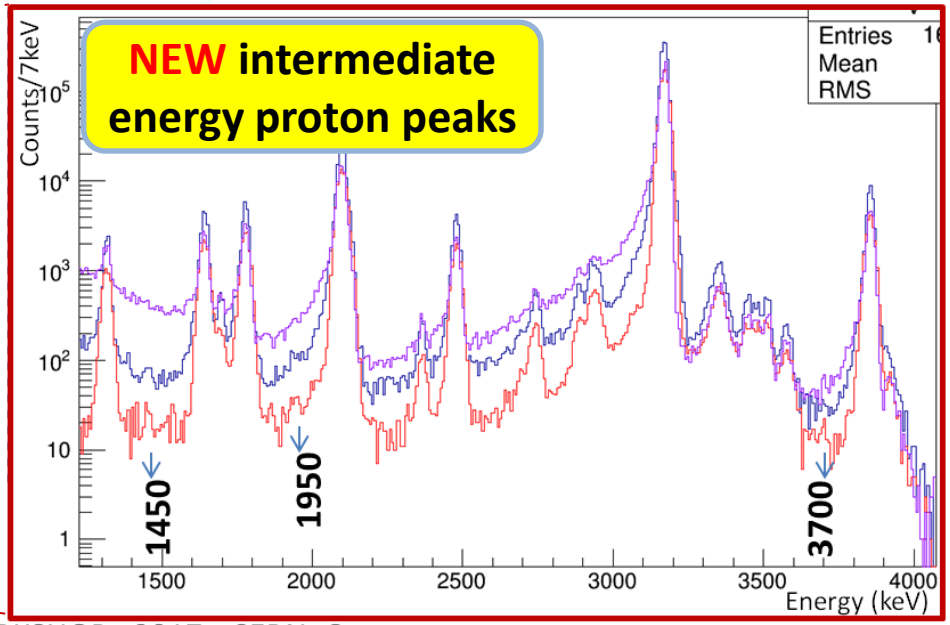
THICK TELESCOPES



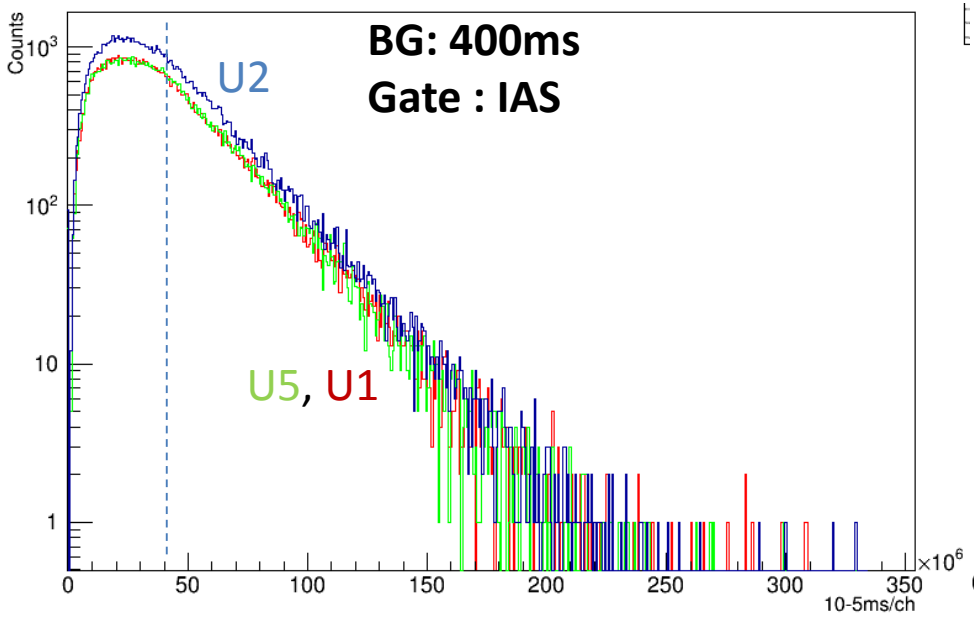
U5: 1000µm

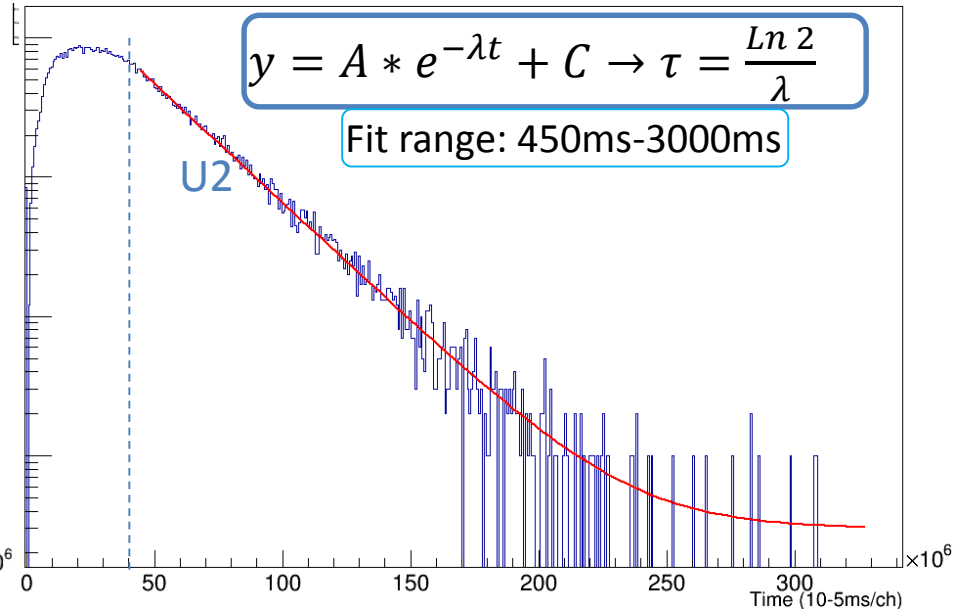
U6: 65 µm

P6: 500 µm



RESULTS: ^{33}Ar half-life





Beam gate	U1: 295 um	U2:524 um	U5:1000 um	Weighted Average	Reference value*
400 ms	173.4±1.8	171.8±1.4	175.9±1.4	174.0±0.8	173.9±0.9

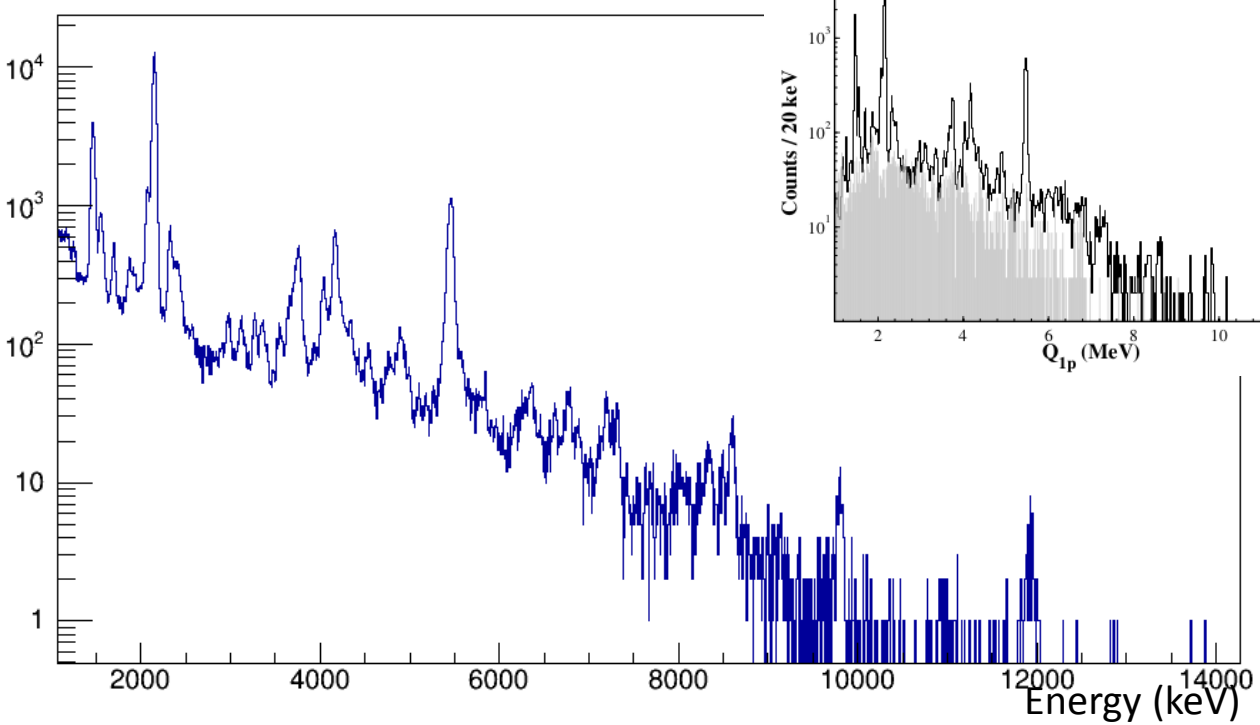
*N. Adimi et al. Phys. Rev. C81, 024311(2010)

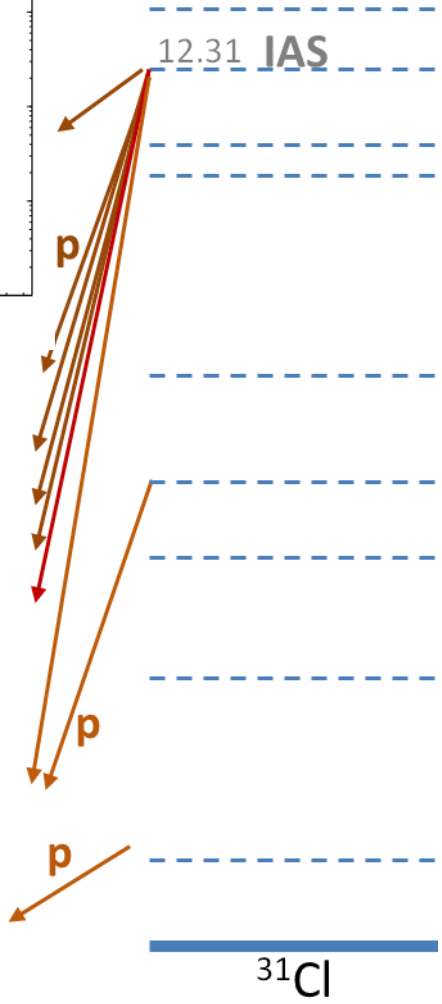
PRELIMINARY

^{33}Ar Half-life value in good agreement with the literature value

^{31}Ar-Q_{1p} value

Do we see states in ^{31}Cl at high energy ??





Present work has higher statistics and higher resolution than previous ones.

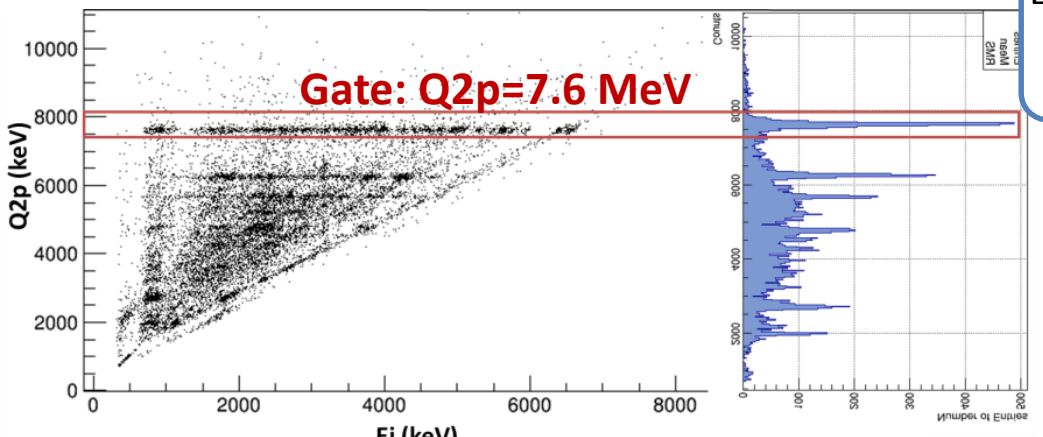
Koldste G.T. (2015) *Deciphering drip-line decays-the case of ^{31}Ar* (Doctoral dissertation)
Koldste G.T. et al. Physics Letters B Volume 737, 7 October 2014, Pages 383-387

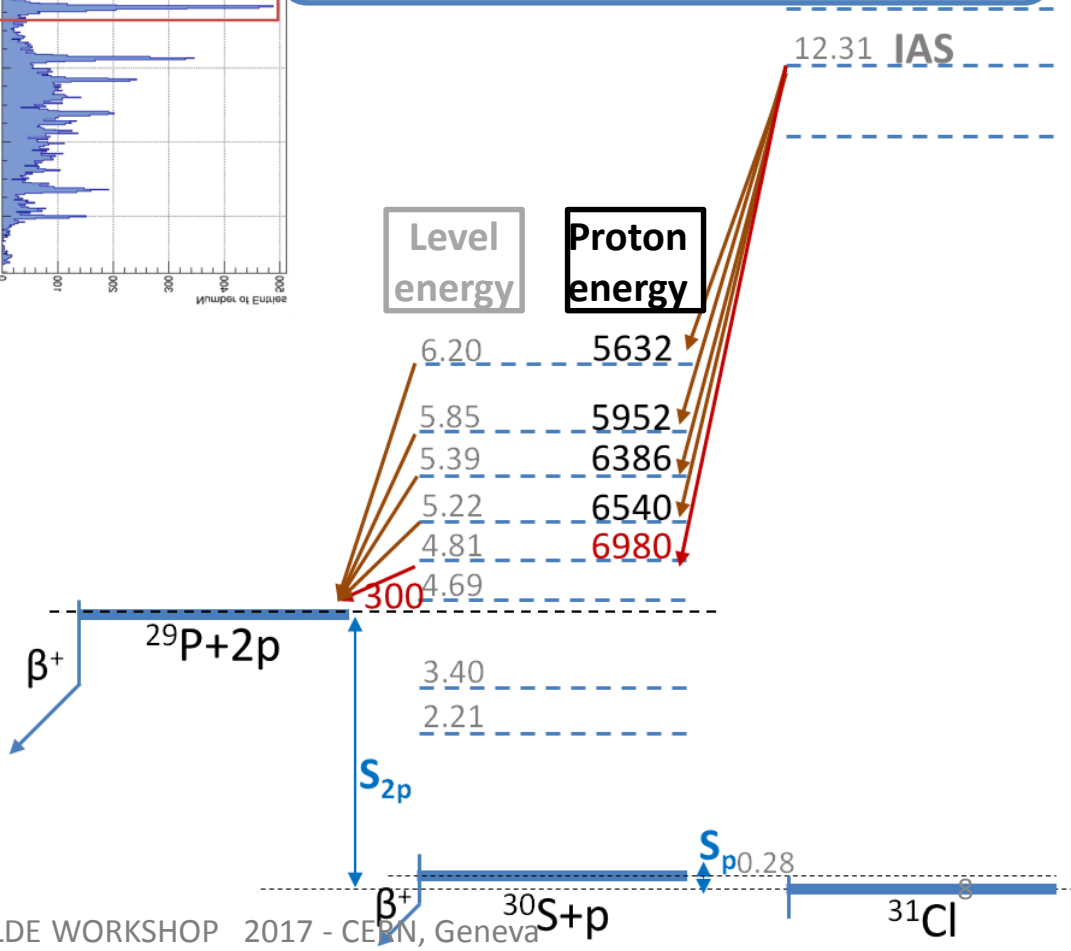
$$Q_{1p} = \frac{m_{30_S}}{m_{30_S} + m_p}(E_{31_{Cl}} - S_p)$$

RESULTS: ^{31}Ar: Q_{2p} value

Do we see low energy protons from states of ^{30}S near the threshold??

Excited levels in ^{30}S near the particle threshold determine the ^{29}P(pig) reaction rate which influences the solar Si abundances

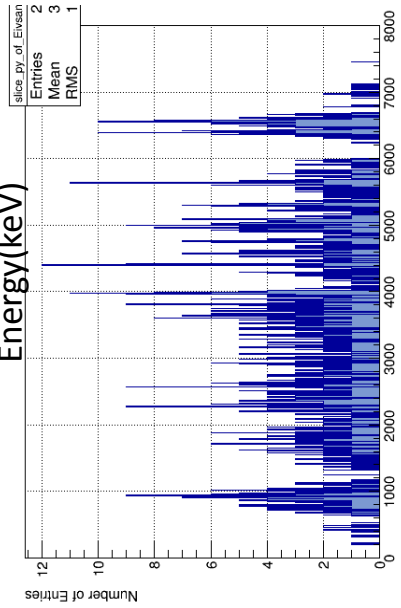


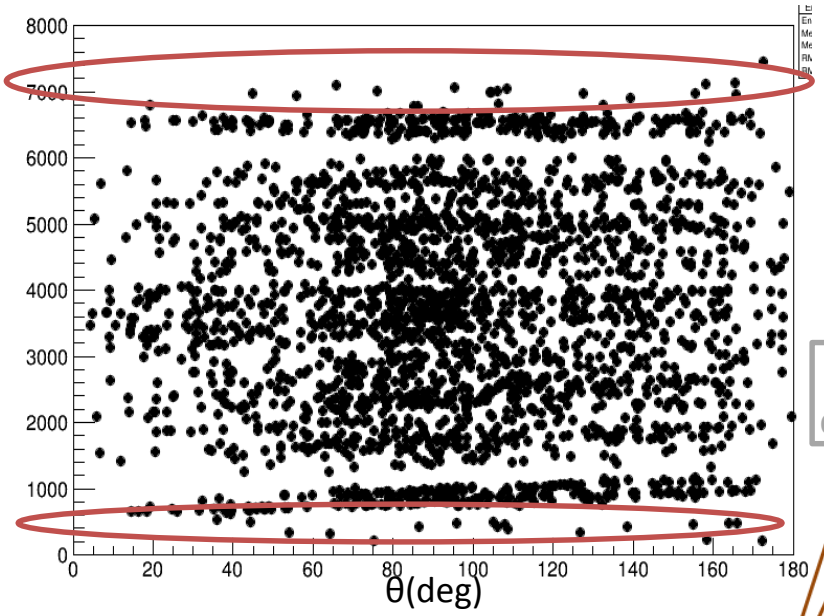


$$Q_{2p} = E_1 + E_2 + \frac{m_p}{m_{29_P}}(E_1 + E_2 + 2\sqrt{E_1 E_2}\cos\theta_{2p})$$

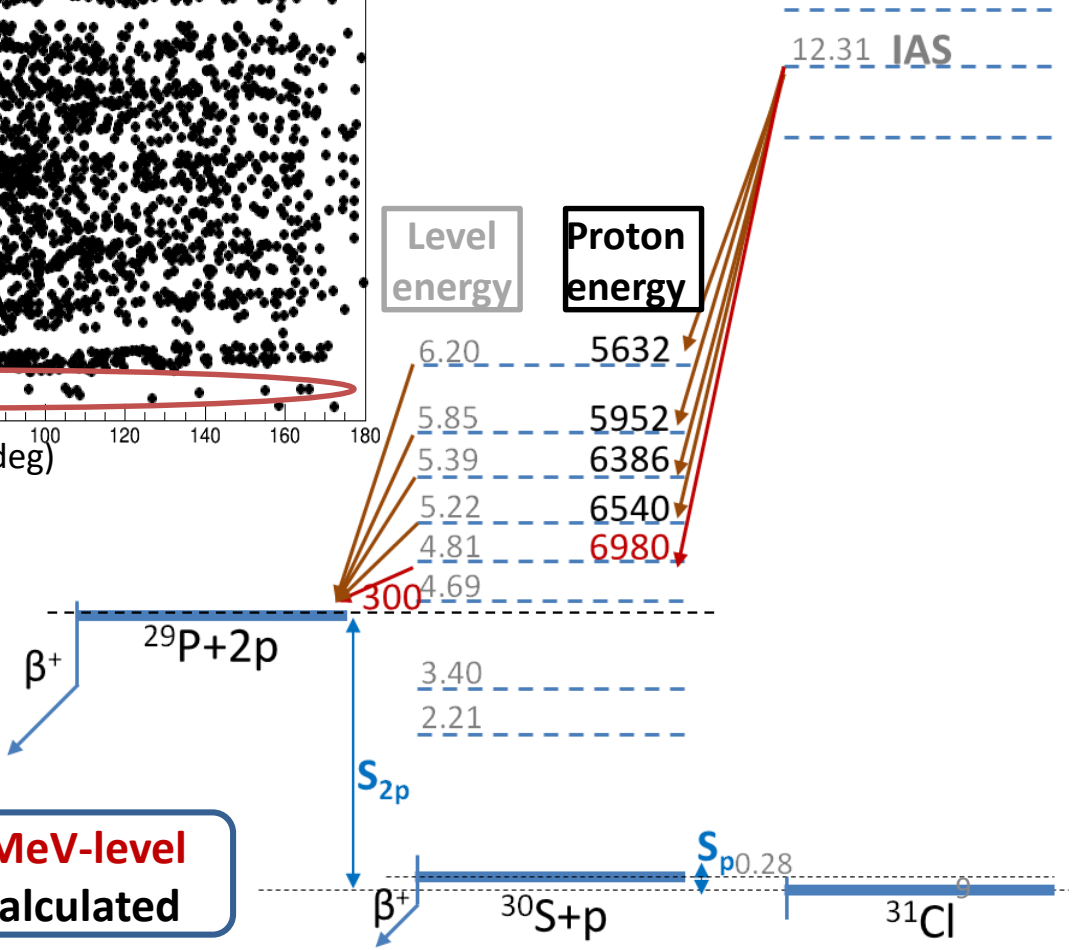
RESULTS: ^{31}Ar: Q_{2p} value

Do we see low energy protons from states of ^{30}S near the threshold??





OUI!!



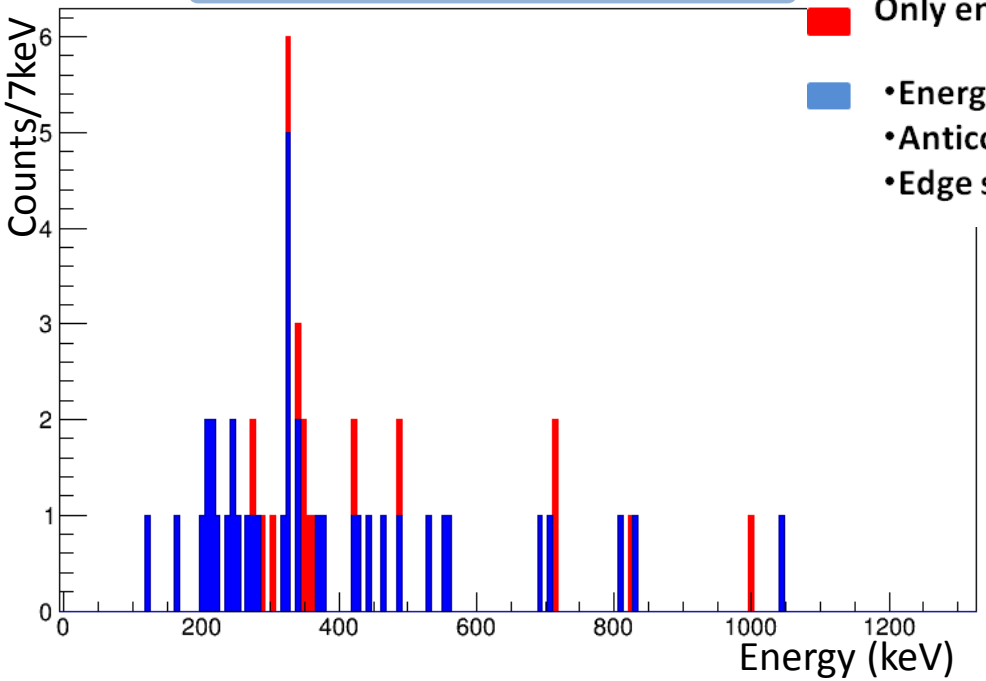
$$Q_{2p} = E_1 + E_2 + \frac{m_p}{m_{29_P}}(E_1 + E_2 + 2\sqrt{E_1 E_2}\cos\theta_{2p})$$

6.98MeV-300 keV proton pair from 4.81 MeV-level is seen when angle between p-p pairs is calculated

RESULTS: ^{31}Ar p-p coincidences

Do we see low energy protons from states of ^{30}S near the threshold??

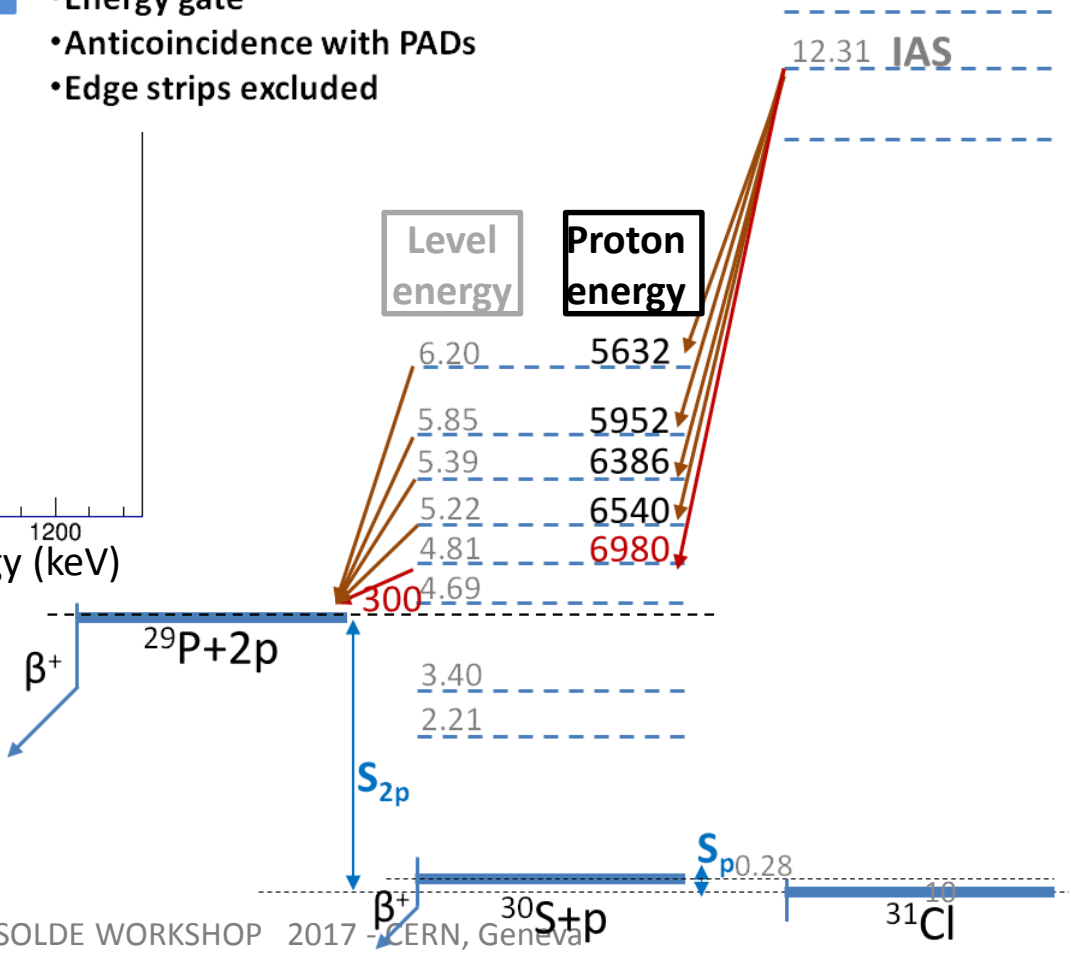
6.98 MeV-p-gated p-spectrum



Only energy gate on 6.98 MeV

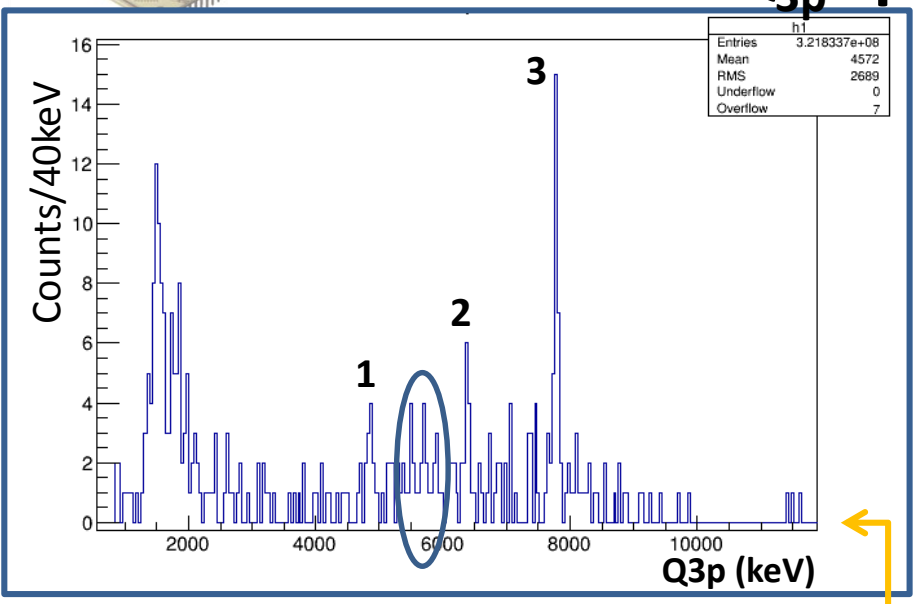
- Energy gate
- Anticoincidence with PADs
- Edge strips excluded

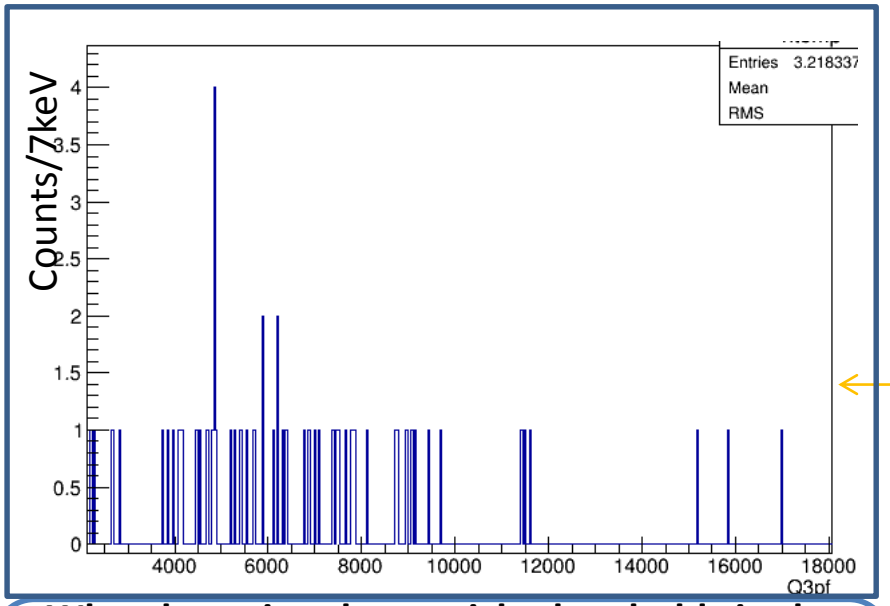
OUI!!

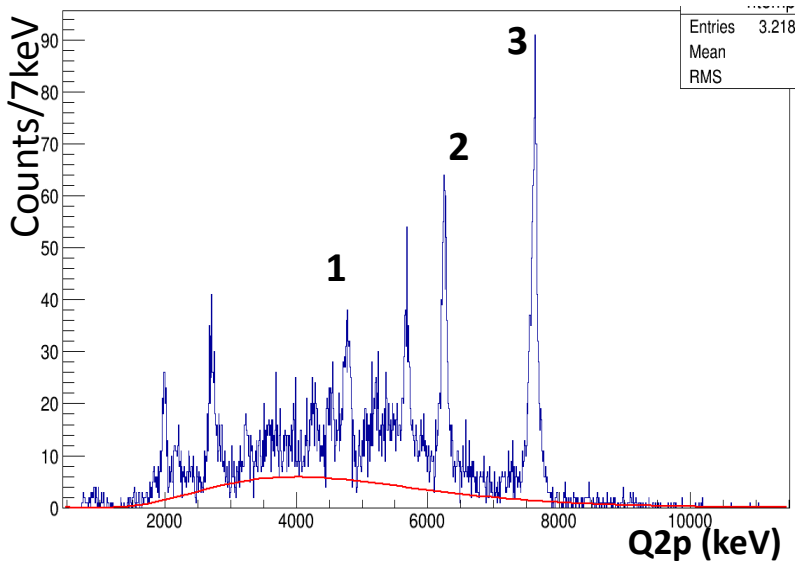


In p-p coincidence we also see the 300 keV proton from 4.81 MeV-level

RESULTS: ^{31}Ar: Q_{3p} spectrum

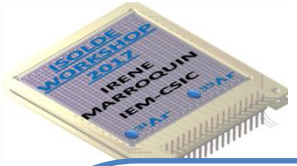






When lowering the particle thresholds in the detectors , spectrum above is obtained.
-Work in progress-
Expected to be able to clean the spectrum by applying the time condition

DETECTOR	THICKNESS (um)	SOLID ANGLE (%)	ENERGY THRESHOLDS (keV) (1)	ENERGY THRESHOLDS (keV) (2)	ANALYSIS CONDITIONS
U1	300	7.4	350	1000	·|Ef-Eb|<50keV·
U2	524	11.72	400	1000	·mul > 6 excluded·
U4	67	10.43	200	400	·Ef,Eb>80keV·
U5	1000	9.6	800	2000	·Energy per telescope·
U6	65	8.28	200	400	



CONCLUSIONS - ^{31}Ar, ^{33}Ar

SUMMARY

- ^{33}Ar used for calibration due to the **high resolution and low energy thresholds** of the detectors
- **New proton transitions have been identified,** its placement in the level scheme is on-going.
- Half-life of ^{33}Ar is determined **in agreement** with previous results.
- Study of β2p and β3p channels of ^{31}Ar:
  - Proton emission from level near the proton threshold in ^{30}S is identified (4.81 MeV-level), relevant for nuclear astrophysics.
  - ^{31}Ar-Q3p high energy contributions to the 3p branch identified, contributions from low energy protons is on progress.

FUTURE WORK

- Calculate Γ_p/Γ_γ in particular for levels near the threshold in ^{30}S: 4.69, 4.81 and 5.22 MeV levels
- Spin assigment to the states in ^{30}S.

THANKS FOR YOUR ATTENTION

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  GFN-UCM, Madrid, Spain

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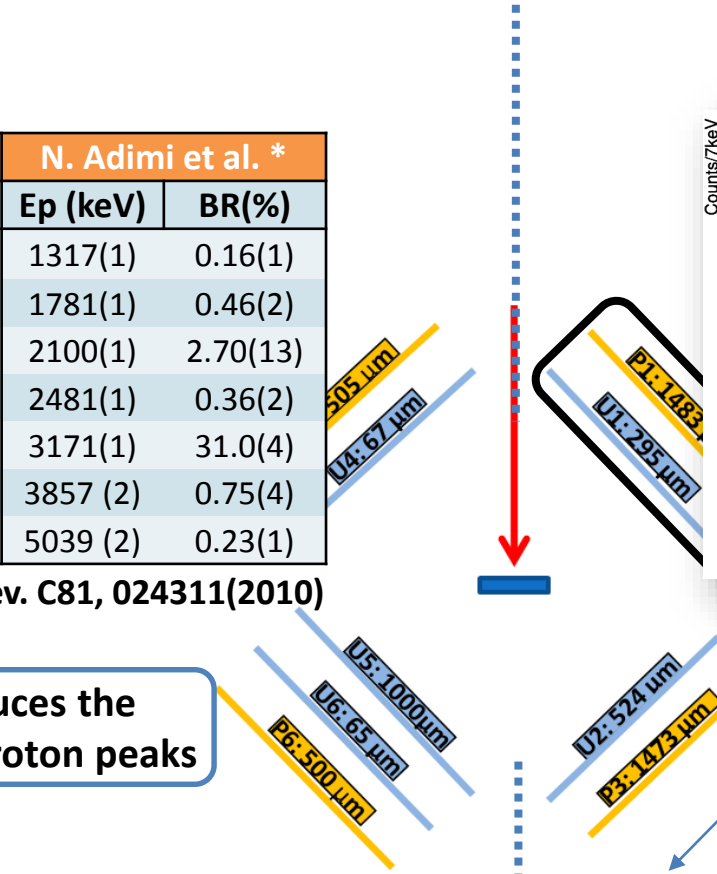
  IFIN-HHBucharest - Magurele, ROMANIA

BACKUP SLIDES

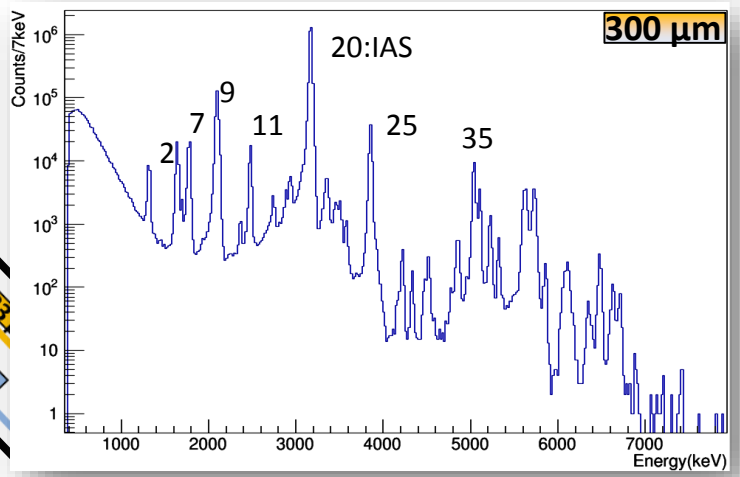
RESULTS: ^{33}Ar p-spectra…beyond calibration….

	U1: 295 um			N. Adimi et al. *	
	Ep (keV)	δ	BR (%)	Ep (keV)	BR(%)
2	1316	13.8	0.18	1317(1)	0.16(1)
7	1779	14.4	0.46	1781(1)	0.46(2)
9	2099	16.3	2.67	2100(1)	2.70(13)
11	2480	14.4	0.35	2481(1)	0.36(2)
20	3171	14.7	31.0	3171(1)	31.0(4)
25	3854	15.5	0.71	3857 (2)	0.75(4)
35	5038	14.5	0.19	5039 (2)	0.23(1)

*N. Adimi et al. Phys. Rev. C81, 024311(2010)



THICK TELESCOPES



Present work reproduces the previous intensities of proton peaks

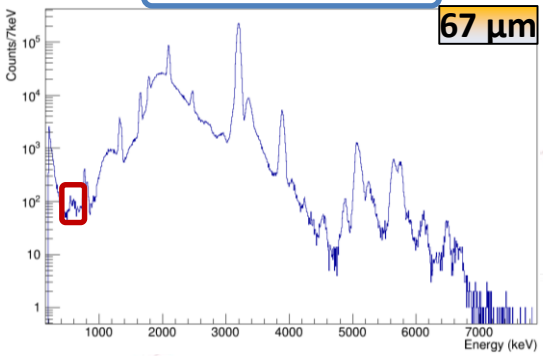
Low energy thresholds for protons. IMPORTANT FOR LOW PROTON ENERGIES.

DETECTOR	THICKNESS (um)	SOLID ANGLE (%)	ENERGY THRESHOLDS for protons (keV)	ANALYSIS CONDITIONS
U1	300	7.4	350	·|Ef-Eb|<50keV·
U2	524	11.72	350	·mul > 6 excluded·
U4	67	10.43	200	·Ef,Eb>80keV·
U5	1000	9.6	-	·TPROTON: 519 ms·
U6	65	8.28	200	

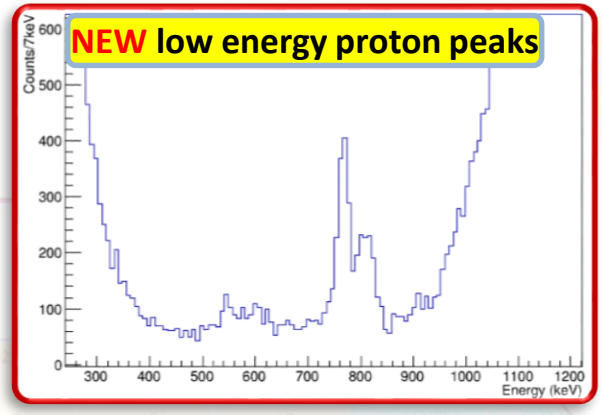
RESULTS: ^{33}Ar p-spectra…beyond calibration….

THIN TELESCOPES

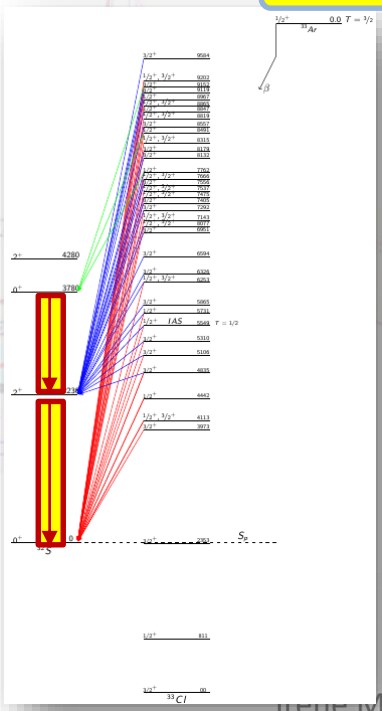
67 µm



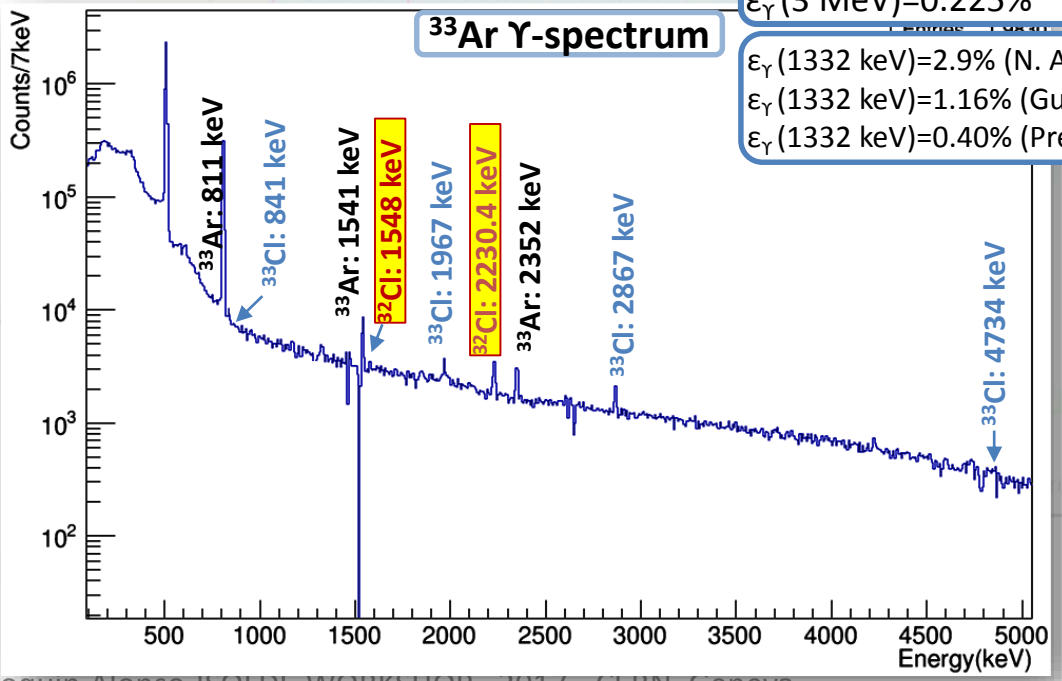
NEW low energy proton peaks



Level identification: p-ϒ coincidences



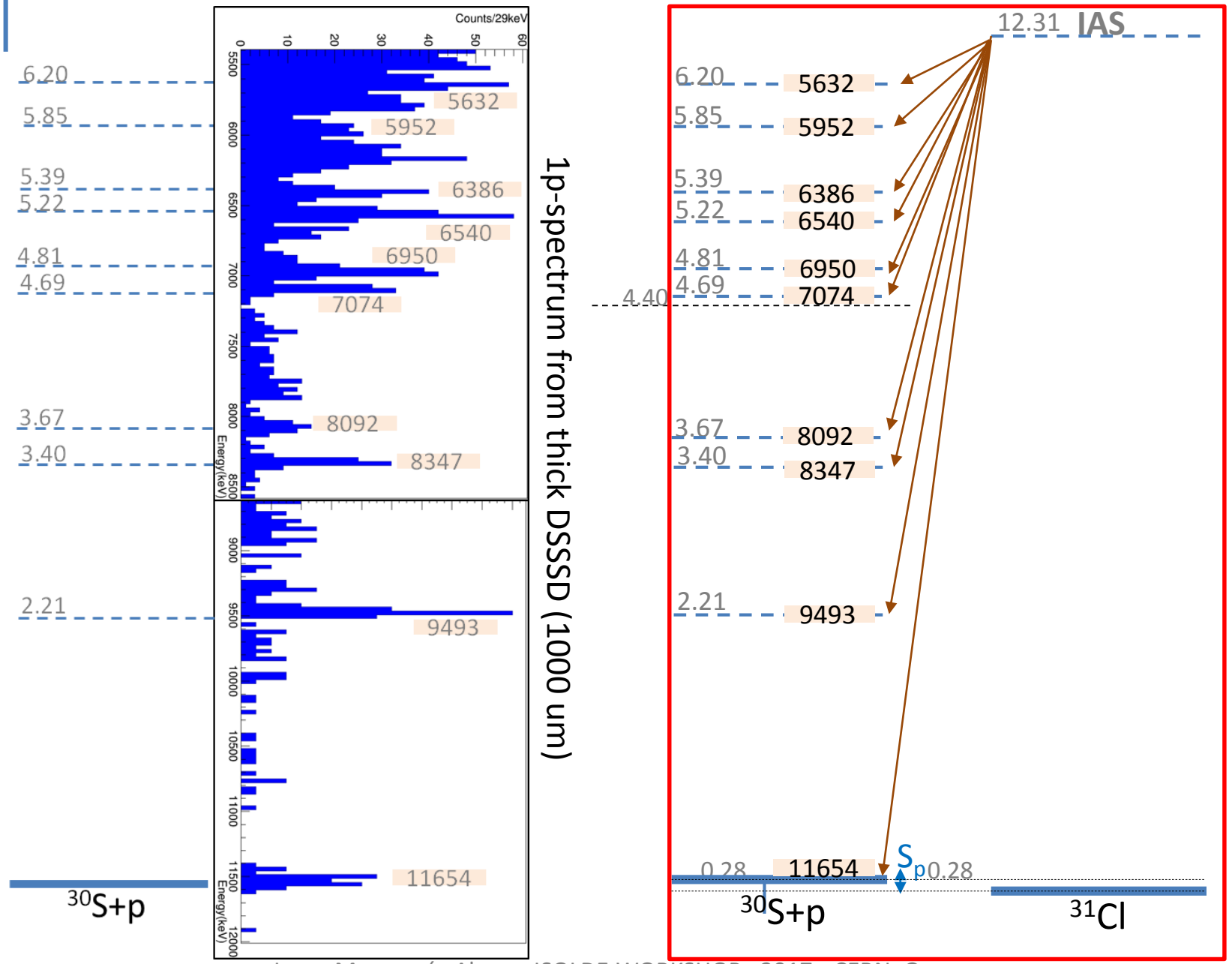
^{33}Ar ϒ-spectrum



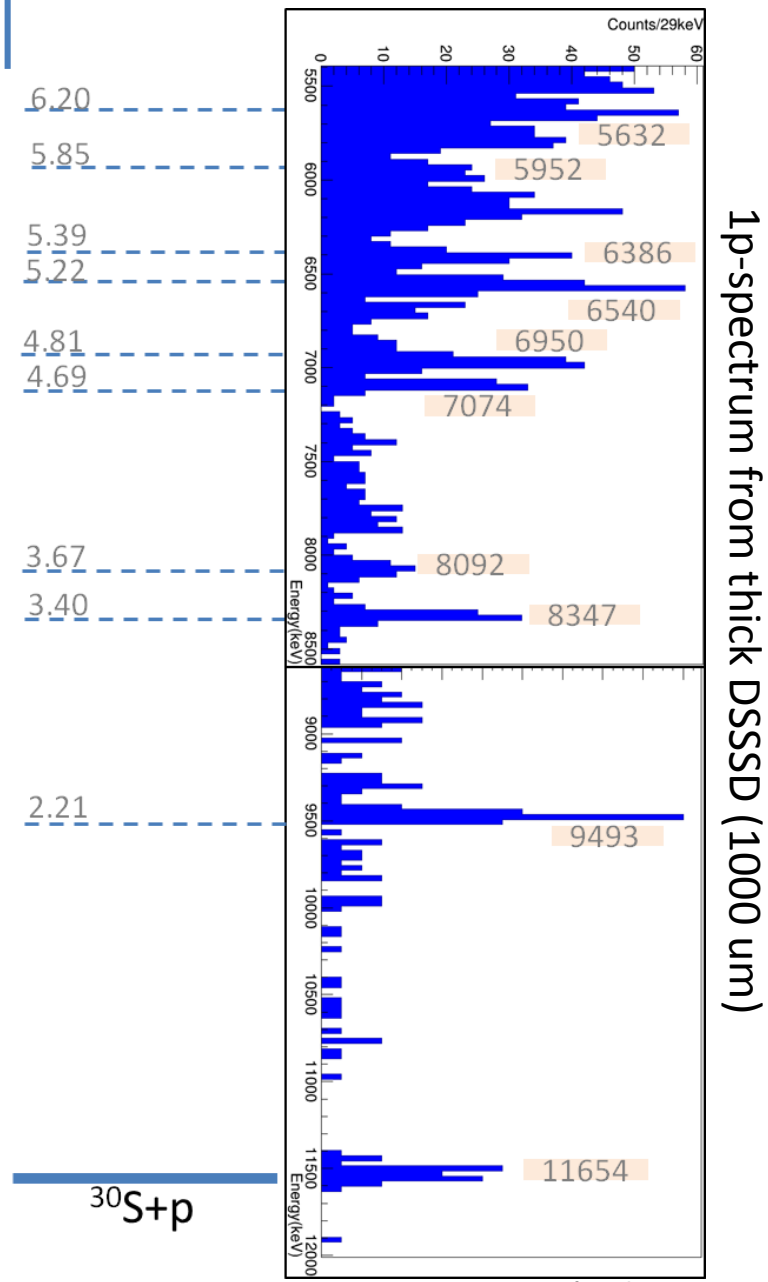
ε_γ (2 MeV)=0.325%
ε_γ (3 MeV)=0.225%

ε_γ (1332 keV)=2.9% (N. Adimi et al.)
ε_γ (1332 keV)=1.16% (Gunvor et al..)
ε_γ (1332 keV)=0.40% (Present work)

RESULTS: proton peak identification



RESULTS: proton peak identification



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)

IS577 experiment @ ISOLDE Decay Station

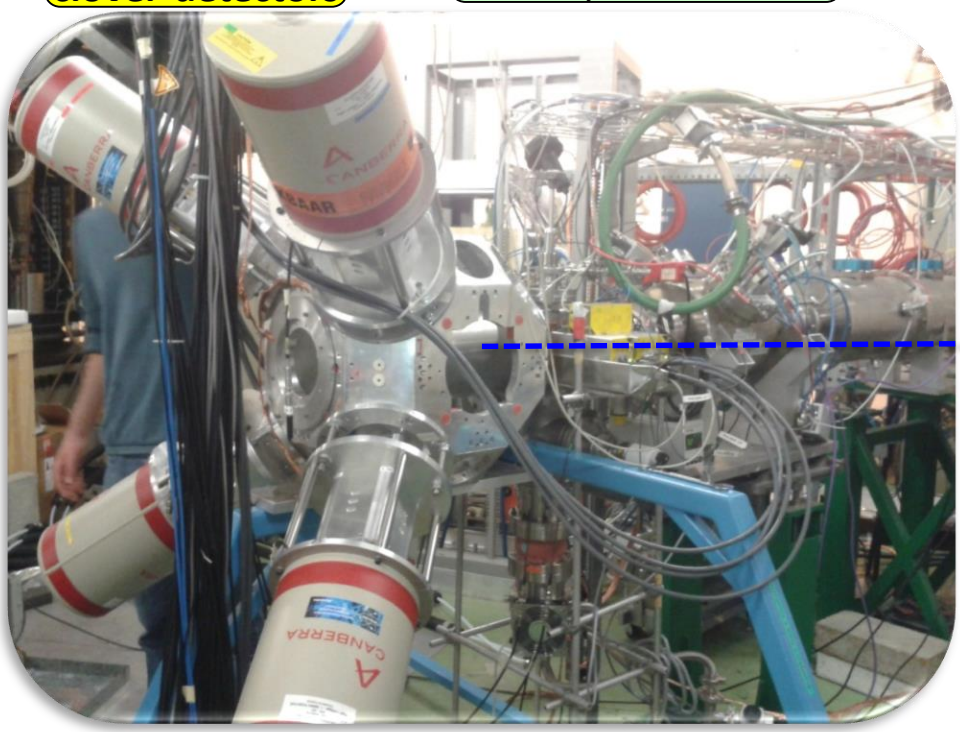
http://isolde-ids.web.cern.ch/isolde-ids/

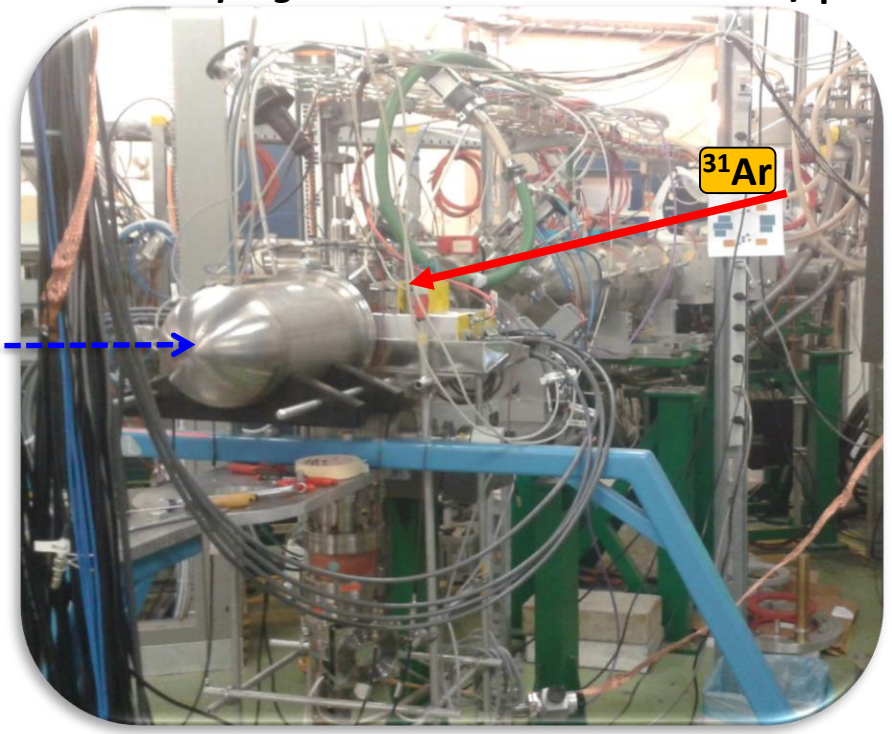
4x HPGe clover-detectors

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**…)