Spectroscopy of n-rich Cd isotopes via (*d,p*) reactions

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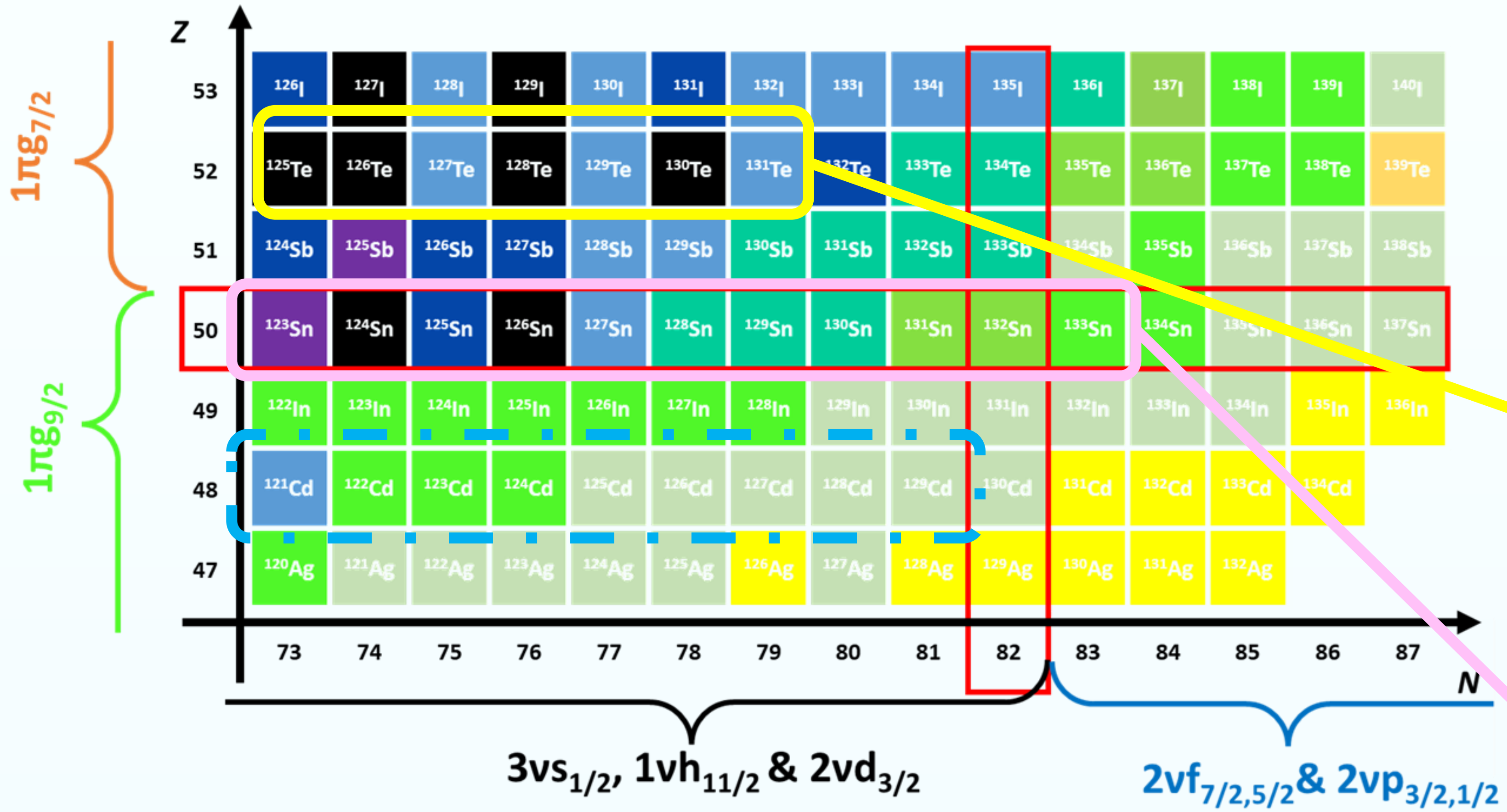
Motivation: Study of single-particle properties



Transfer reactions are ideal probe of SP properties.

- Single particle energies
- Angular momentum of the states.
- Spectroscopic factors.

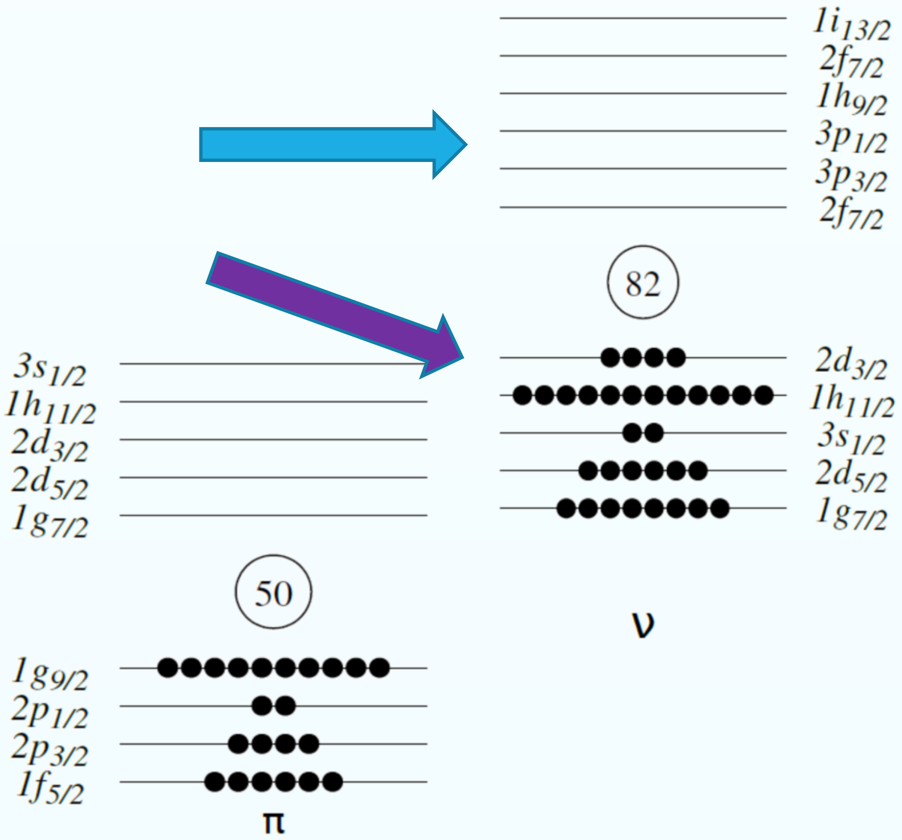
(*d*,*p*) studies in direct kinematics has been performed all over the Te isotopic chain.

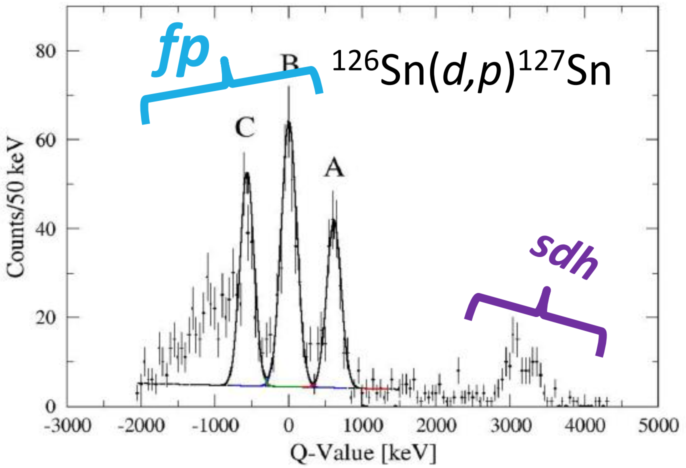
The Sn chain has been studied (*d*,*p*) studies using inverse kinematics.

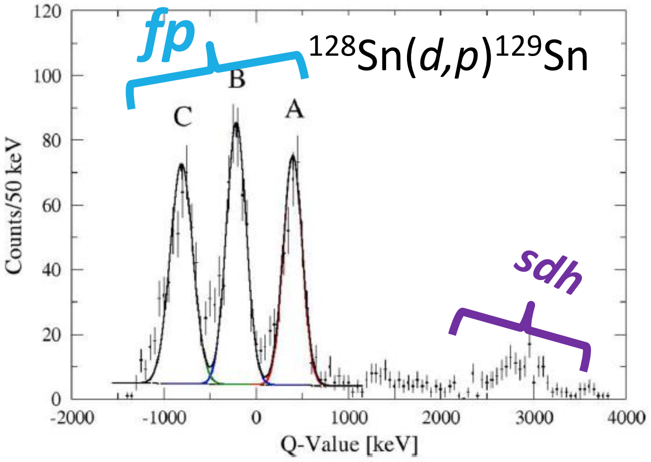
Information from transfer reactions in Cd isotopes is still missing.
ISOLDE-ISS can complete this information.

(*d,p*) reactions studies in the tin chain

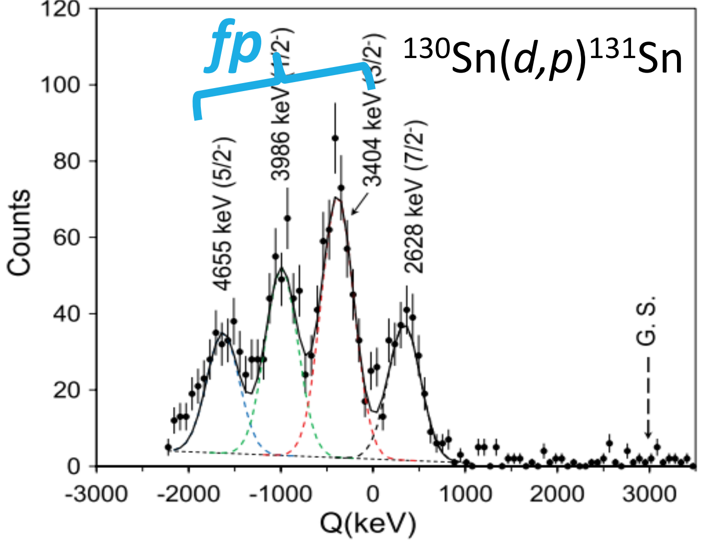
- (d,p) reactions studies show an strong contribution of the fp Shell above N=82.
- Neutron orbitals below N=82 become availbe for lower masses.

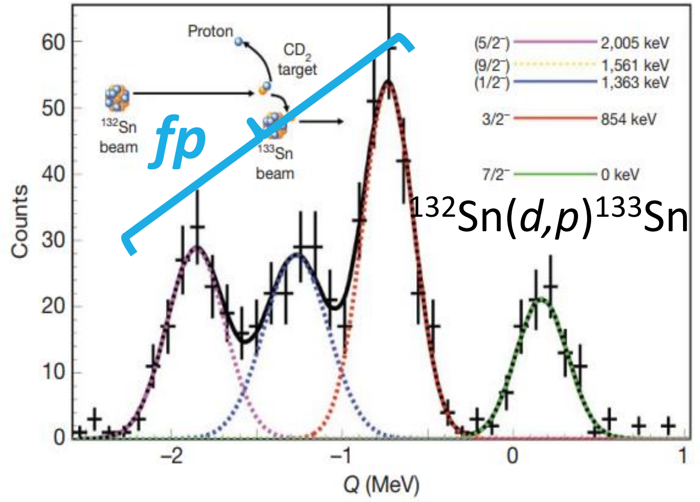






B. Manning et al. Phys. Rev. C, 99:041302, 2019





R. L. Kozub et al. Phys. Rev. Lett., 109:172501, (2012.)

K. L. Jones et al.. Nature, 465(7297):454–457, May 2010.

(*d,p*) reactions studies in the telurium chain

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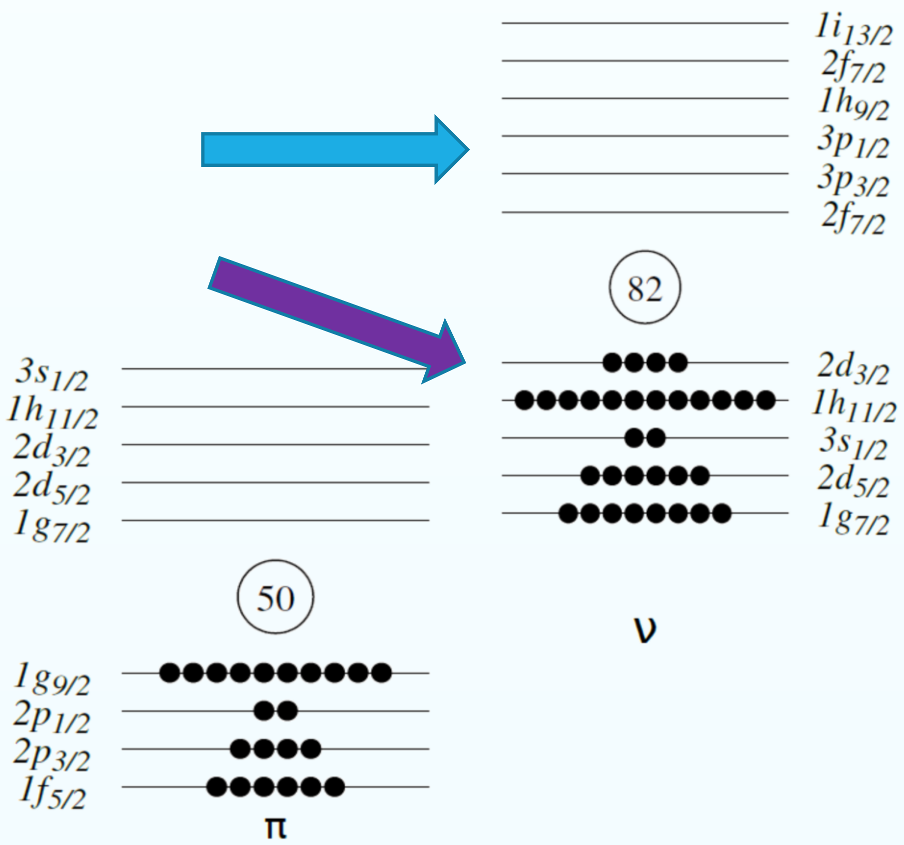
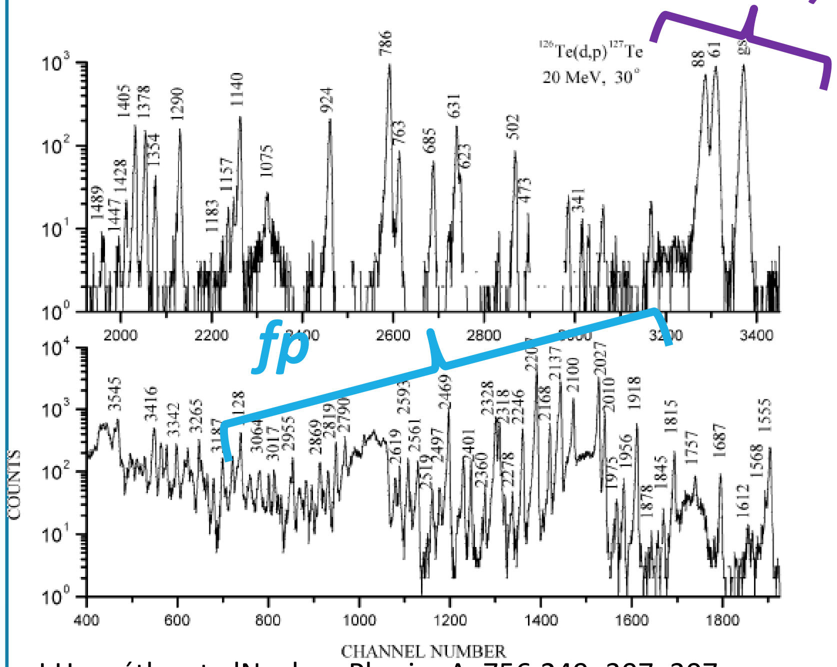
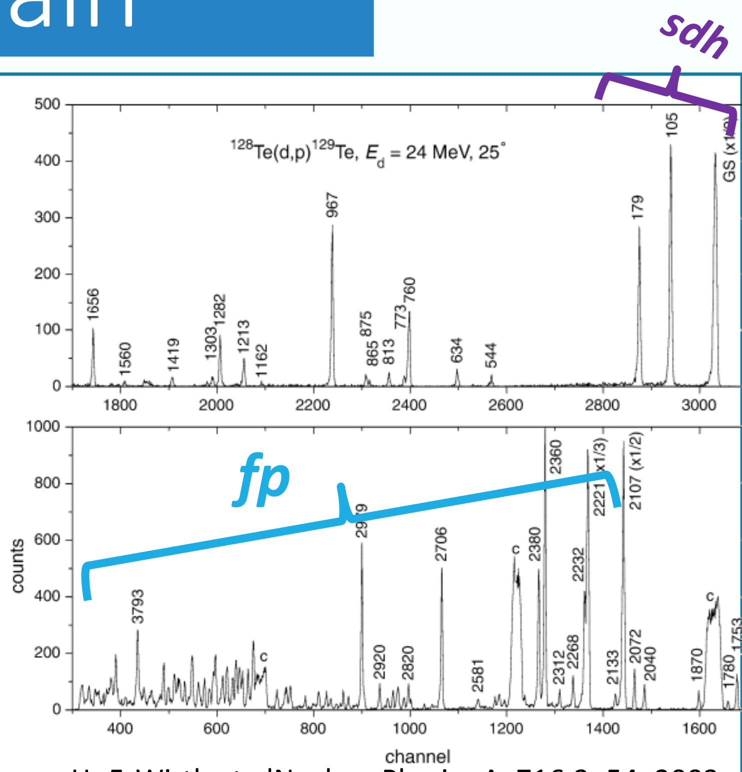
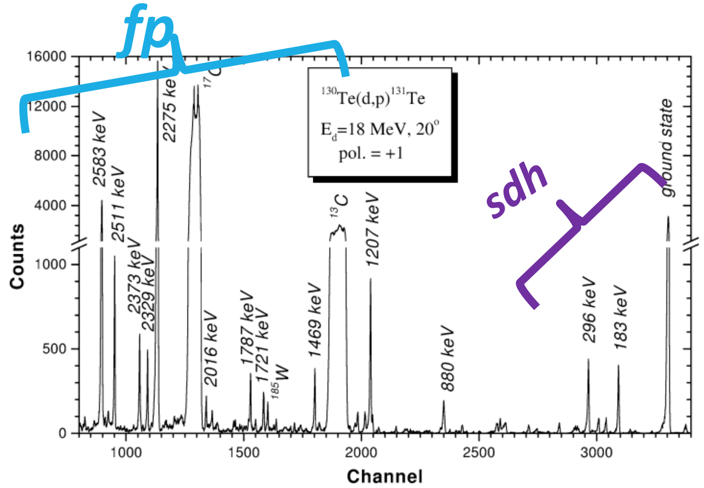




J.Honzátko et alNuclear Physics A, 756:249–307, 307



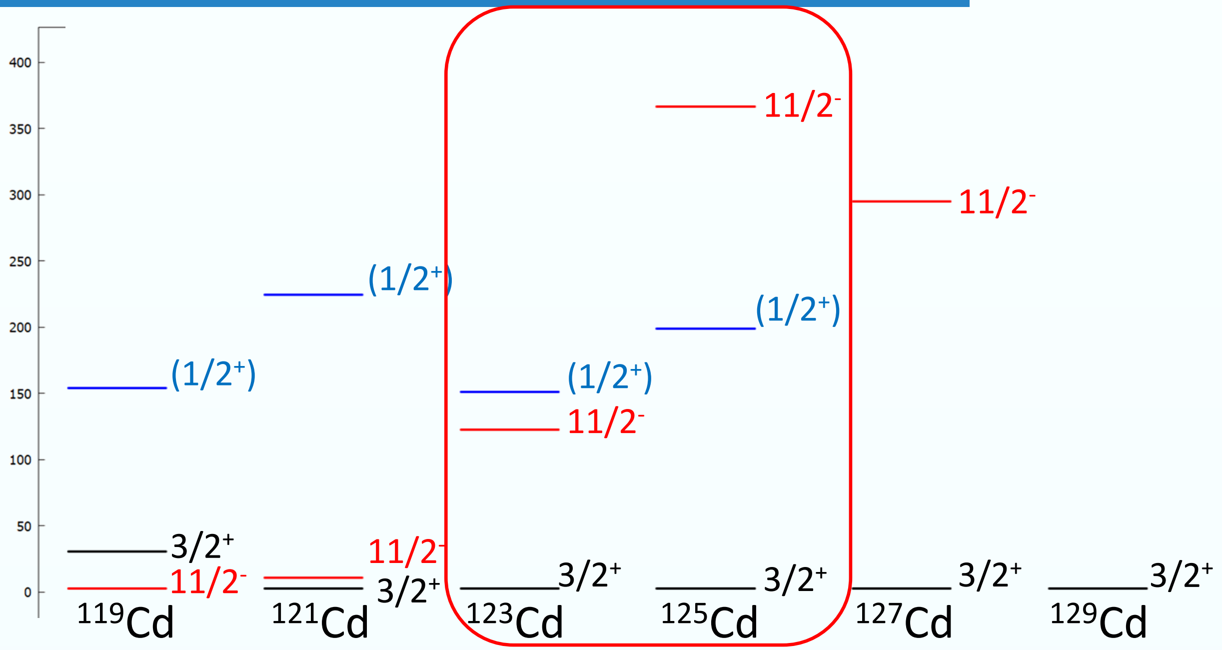
H.-F. Wirth et alNuclear Physics A, 716:3–54, 2003

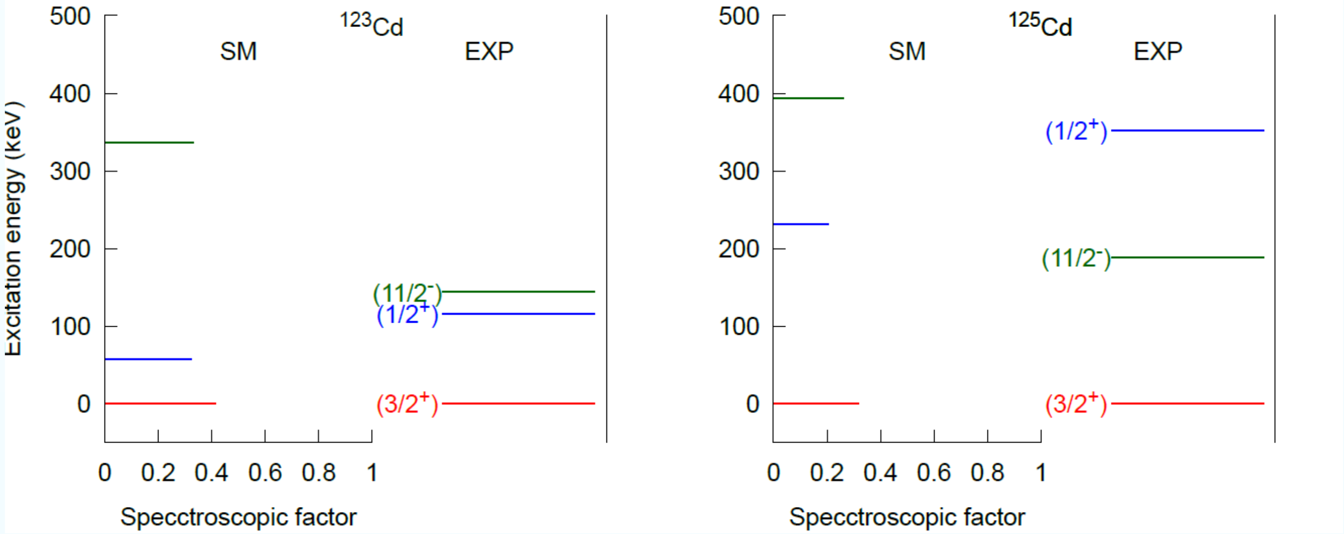


I. Tomandl et al..Nuclear Physics A, 717(3):149–198, 2003

Systematics of Cd isotopes

- Experimental information in this region is mostly extracted from fission experiments and beta-decay meassurements up to A=125.
- No experimental information of ***fp*** configurations above N=82.
- Shell model calculations predict three low-lying states corresponding to the **3v$s_{1/2}$, 1v$h_{11/2}$ & 2v$d_{3/2}$** configurations.

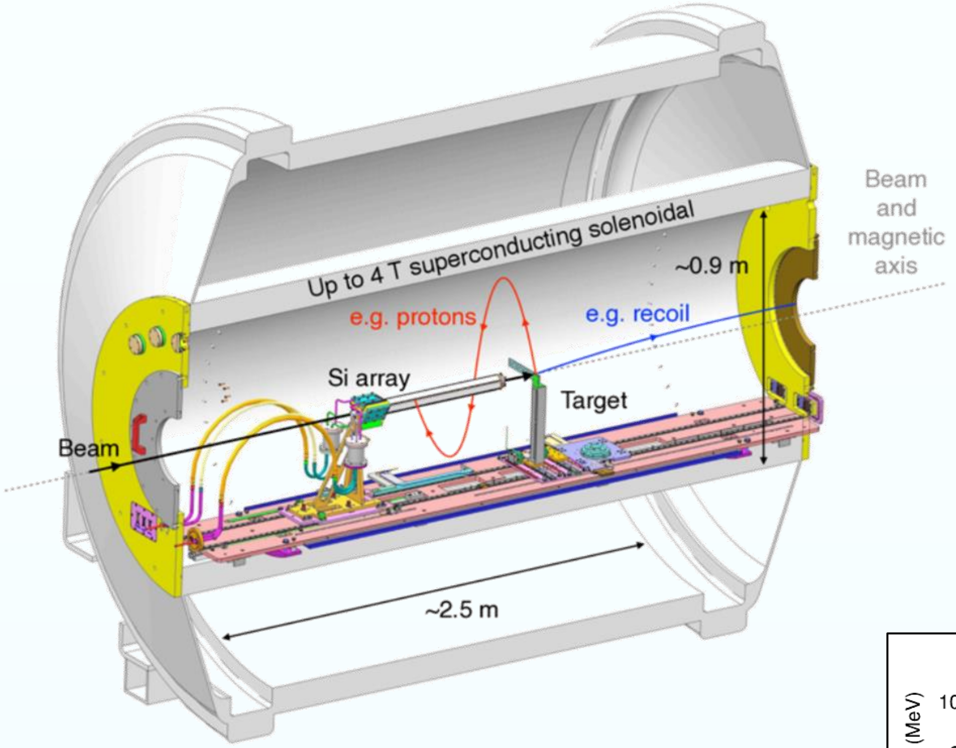




GOALS of this proposal

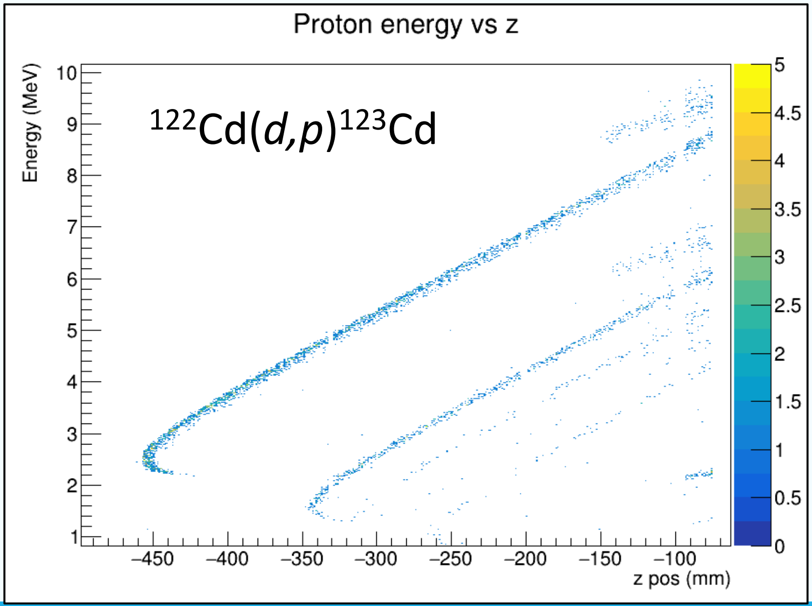
- Meassurement of ^{122}Cd(*d,p*) and ^{124}Cd(*d,p*)
- Fragmentation of single particle strenght.
- Transfered angular momentun
- Spectroscopic factors
- First identification of the *fp* strength in Cd.

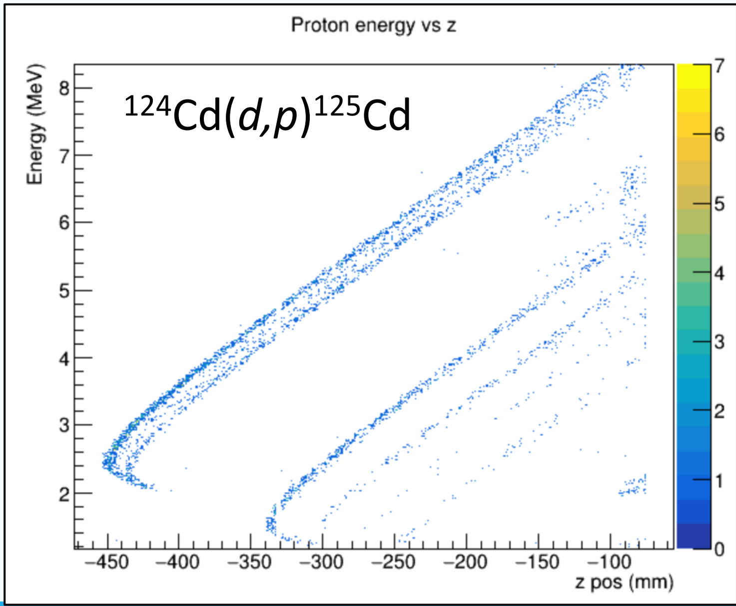
ISOLDE Solenoidal Spectrometer set up



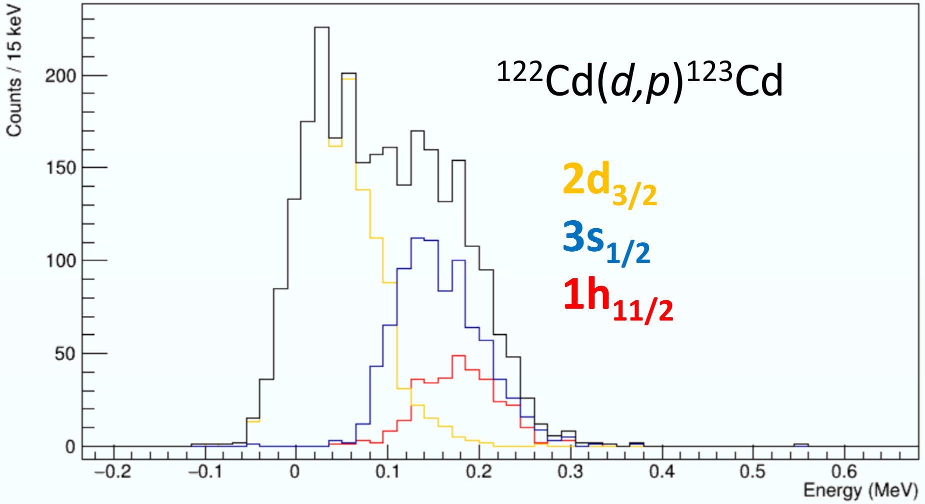
- Use of the standard setup with a Si array detector
- 2 T Magnetic field
- Array-to-target distance of 7.5 cm
- 100 $\mu g/cm^2$ CD_2 target.
- Silicon detector at forward position for elastic scattered deuterons.
- Beam energy of 7.5 MeV/u.

- Angular coverage from 10 to 45 degrees.
- Energy range from 0 to 5 MeV.
- Energy resolution ~140 keV

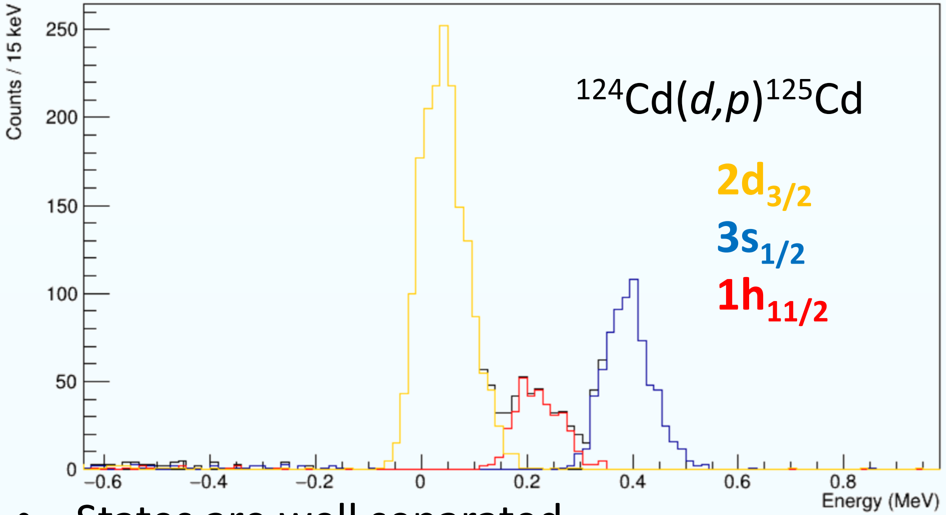




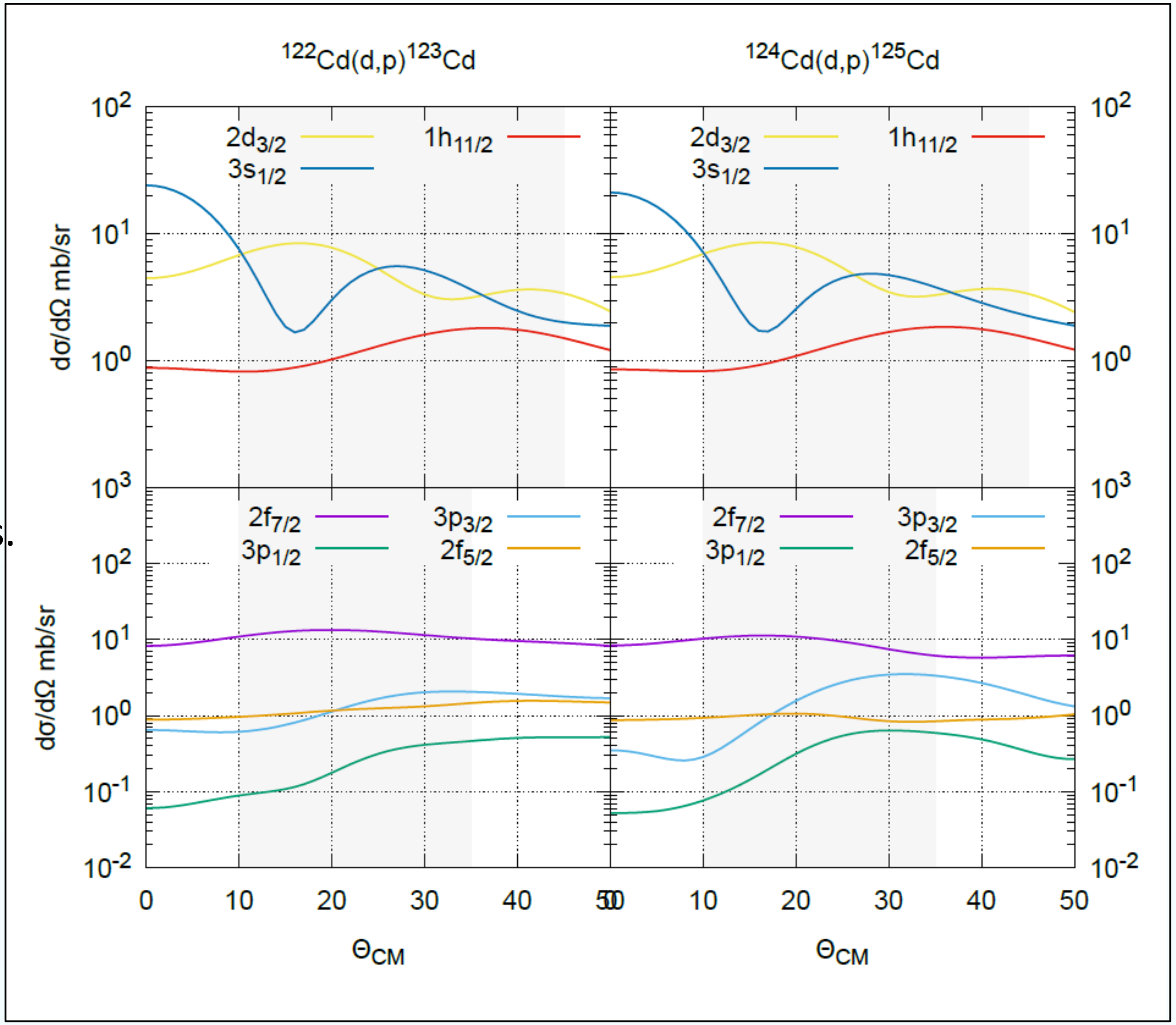
Realistic simulations and DWBA calculations



- Overlapping between the three states.
- $3S_{1/2}$ and $2d_{3/2}$ can be separated from convoluted analysis.



- States are well separated.
- Spectroscopic factors can be extracted for the three states.



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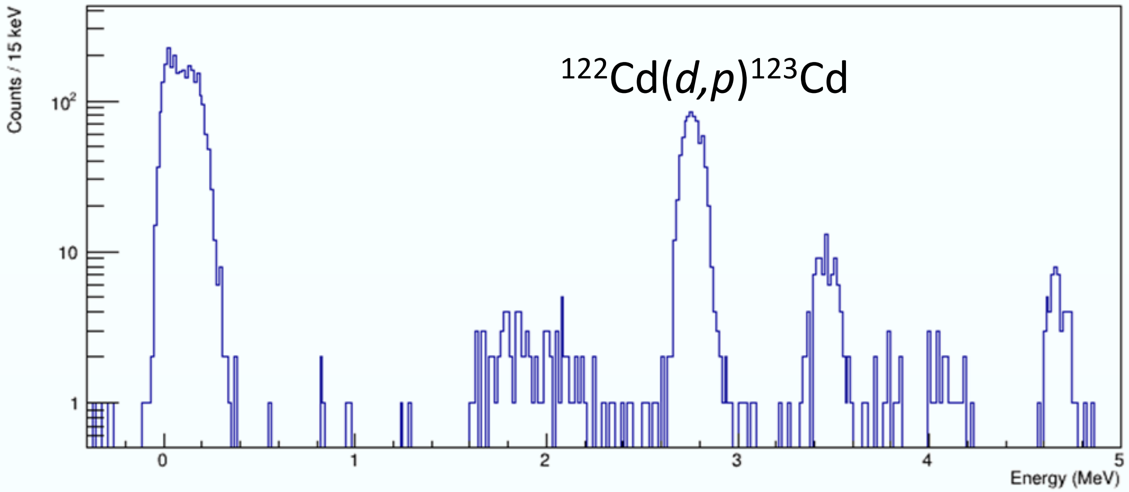

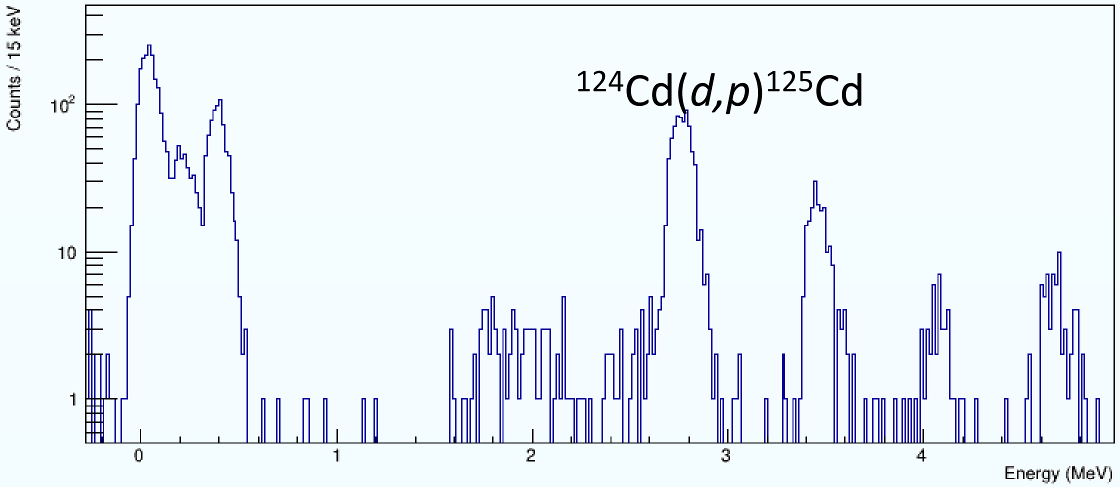

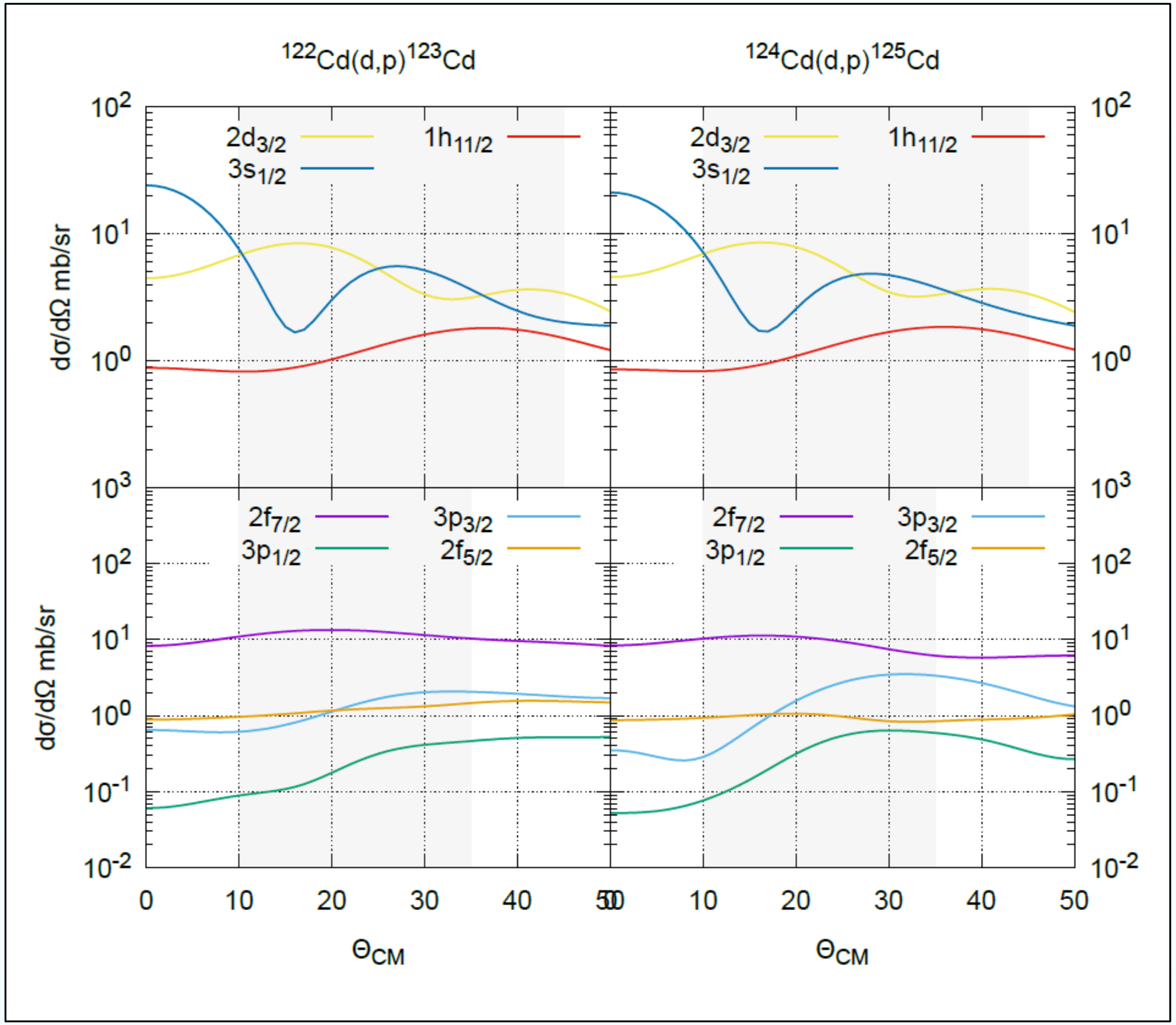

Expected yields and beam time request

Reaction/ target	Intensity at ISS (pps)	Config.	J^π	Energy (MeV)	S	Δl	σ (mb)	Proton counts per shift	Total number of events
^{122}Cd$(d,p)^{123}$Cd at 7.5 MeV/u on 100 μg/cm^2 **3 shifts**	1.0x10^6	$2d_{3/2}$	$3/2^+$	0	0.4	2	3.2	700	2060
		$3s_{1/2}$	$1/2^+$	0.116[2]	0.25	0	1.8	392	1176
		$1h_{11/2}$	$11/2^-$	0.144[19]	0.25	5	0.8	170	504
		$2f_{7/2}$	$7/2^-$	~2.6	0.1	3	1.3	270	810
		$3p_{3/2}$	$3/2^-$	~3.4	0.1	1	0.17	36	107
		$3p_{1/2}$	$1/2^-$	~3.9	0.1	1	0.03	7	21
		$2f_{5/2}$	$5/2^-$	~4.5	0.1	3	0.13	28	84
^{124}Cd$(d,p)^{125}$Cd at 7.5 MeV/u on 100 μg/cm^2 **18 shifts**	2.3x10^5	$2d_{3/2}$	$3/2^+$	0	0.35	2	2.8	140	2502
		$3s_{1/2}$	$1/2^-$	0.353 [3]	0.2	0	1.2	60	1073
		$1h_{11/2}$	$11/2^-$	0.188 [3]	0.2	5	0.6	31	558
		$2f_{7/2}$	$7/2^-$	~2.6	0.1	3	0.9	46	834
		$3p_{3/2}$	$3/2^-$	~3.4	0.1	1	0.3	13	275
		$3p_{1/2}$	$1/2^-$	~3.9	0.1	1	0.05	2	52
		$2f_{5/2}$	$5/2^-$	~4.5	0.1	3	0.1	5	102

- ❑ **UC_2/graphite target**
- ❑ **Neutron converter (To remove the proton-rich contaminants)**
- ❑ **Quartz transfer line (Removal of In and Cs contamination)**
- ❑ **RILIS**

TAC feedback and response

"The TAC notes that the yields in the proposal have been over estimated. Is the experiment still feasible? 124Cd in particular may not be considering these rates"

Reaction/ target	Intensity at ISS (pps)	Config.	J^π	Energy (MeV)	S	Δl	σ (mb)	Proton counts per shift	Total number of events
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3 shifts									810
									107
									21
									84
^{124}Cd[...] at 7[...] on 1[...]									2502
									1073
									558
									834
18 shifts		$3p_{3/2}$	$3/2^-$	~3.4	0.1	1	0.3	13	275
		$3p_{1/2}$	$1/2^-$	~3.9	0.1	1	0.05	2	52
		$2f_{5/2}$	$5/2^-$	~4.5	0.1	3	0.1	5	102

		Proposal	TAC prediction	Estimation from IS685
^{122}Cd	**Yields (uC^{-1})**	1.7E+07	2.3E+06	1.2E+07
	ISS (pps)	9.90E+05	1.00E+05	5.00E+05
^{124}Cd	**Yields (uC^{-1})**	4.0E+06	2.5E+05	1.0E+06
	ISS (pps)	2.30E+05	9.00E+03	4.00E+04

Recent measurement IS685 experiment.
Higher yields achieved using the same configurations.
(Private communication from L.M. Fraile)

- **UC$_2$/graphite target**
- **Neutron converter (To remove the proton-rich contaminants)**
- **Quartz transfer line (Removal of In and Cs contamination)**
- **RILIS**

- Removing the neutron converter will increase notably the yields.
- Cs contamination removed by quartz line.

Thank you!

Spectroscopy of neutron-rich ^{122,124}Cd isotopes via d,p reactions

May 11, 2022

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