Neutron Unbound Single-Particle States in ^{133}Sn from the Beta Decay of ^{133}In

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UTK

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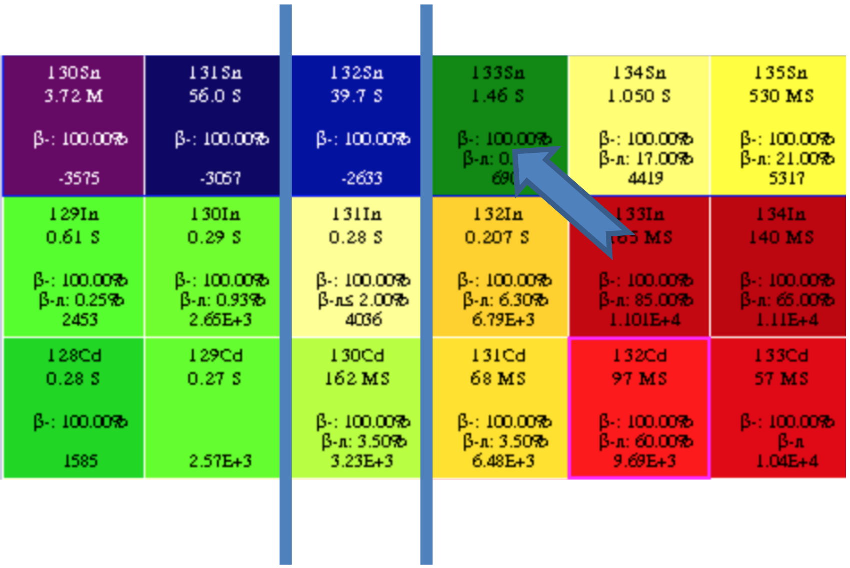
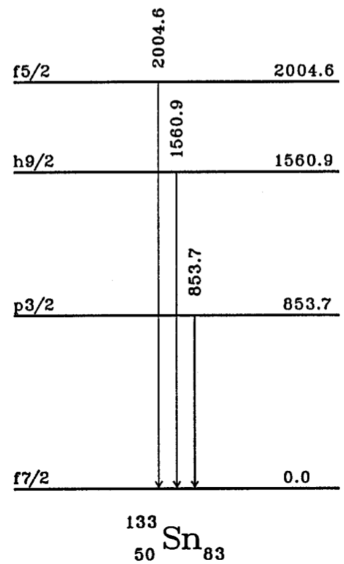
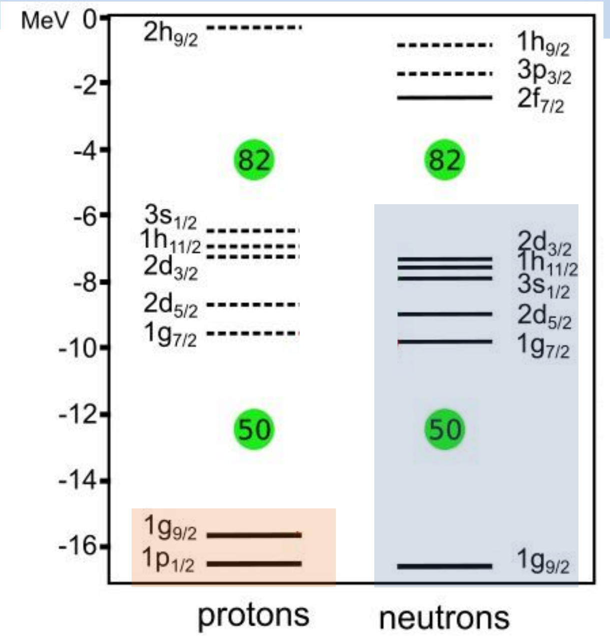
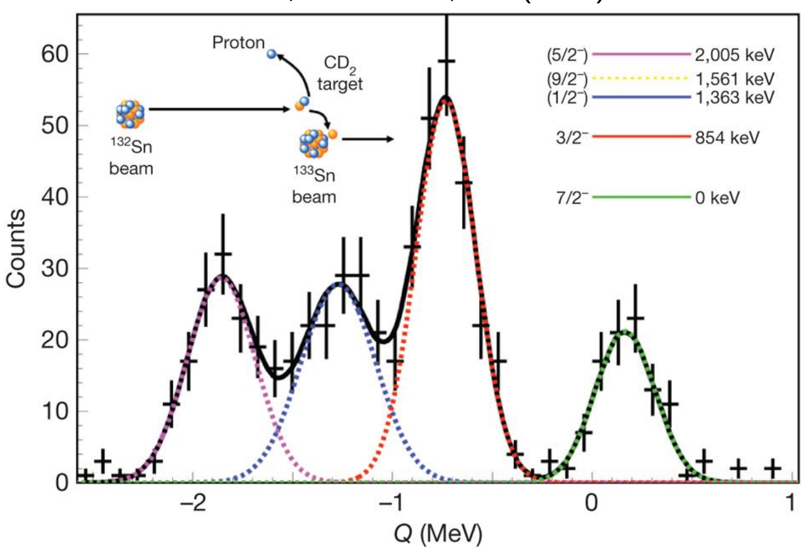
Neutron single particle states in ^{133}Sn







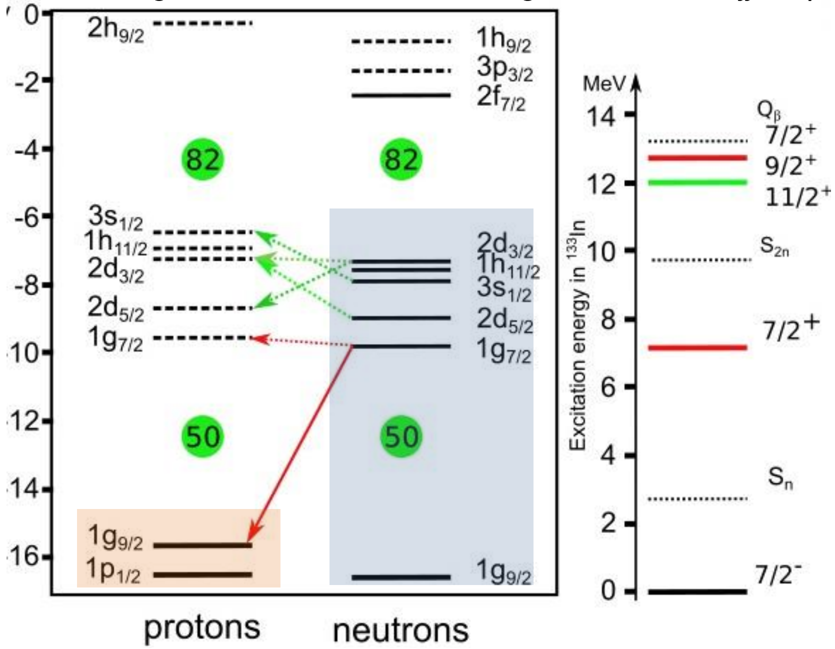
K.L. Jones et al., Nature **465**, 454 (2010).



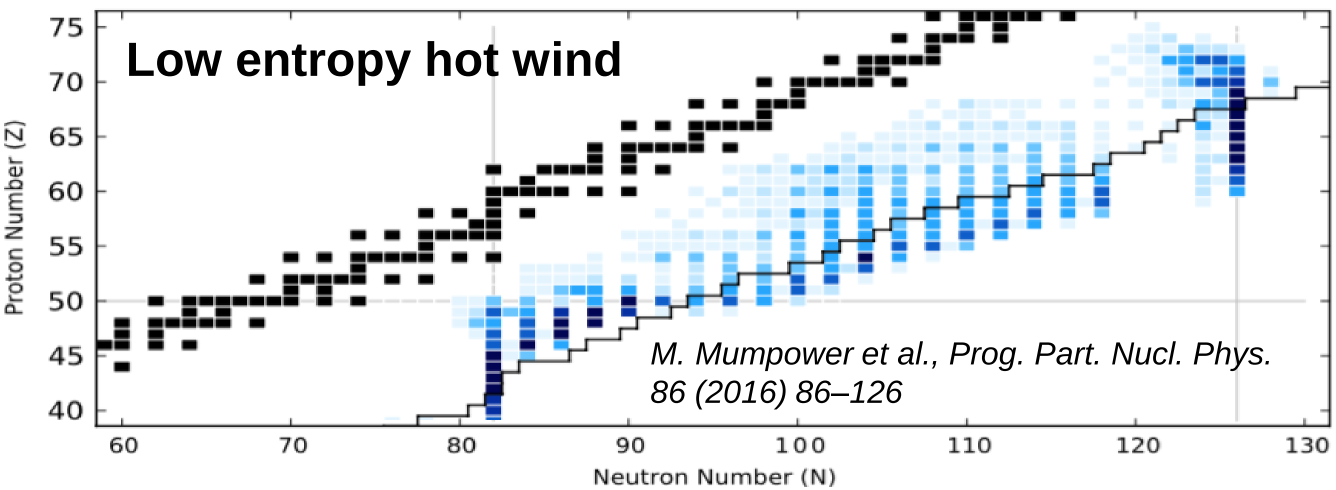
- ^{132}Sn quintessential closed core → pure single particle excited states in ^{133}Sn
- First observed in beta-decay of ^{133}In at ISOLDE P. Hoff et al., Phys. Rev. Lett. **77**, 1020 (1996).
- Magic shell closure confirmed in (d,p) at ORNL
- But that is not the entire beta-decay picture…

Beta decay of ^{133}In: Gamow-Teller transitions

Excitation energies from shell model using ^{78}Ni core and *jj99apn* interaction

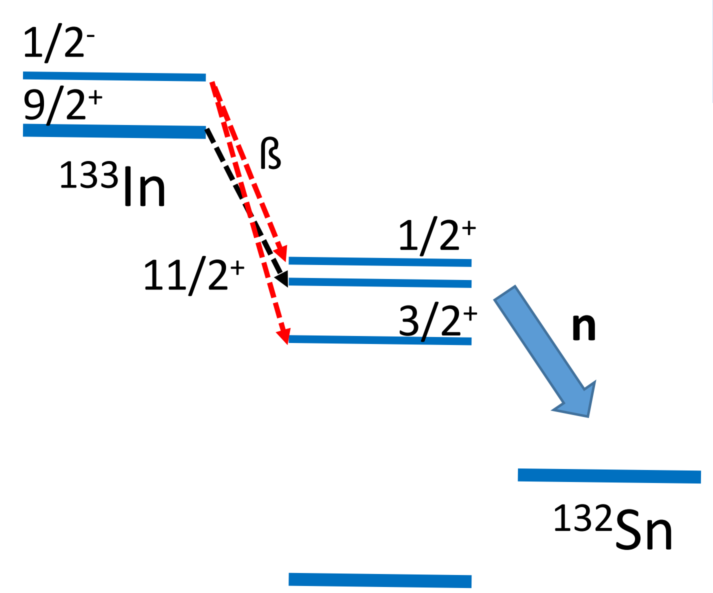


- Can only occur between neutron hole states in the ^{132}Sn core
- Decay half-life dominated by the $\nu g_{7/2} \rightarrow \pi g_{9/2}$ transition
  - No mixing! pure beta-decay matrix element
- The $\nu g_{7/2} \rightarrow \pi g_{9/2}$ transition determines half-lives of *all* *r*-process waiting points of Z<50

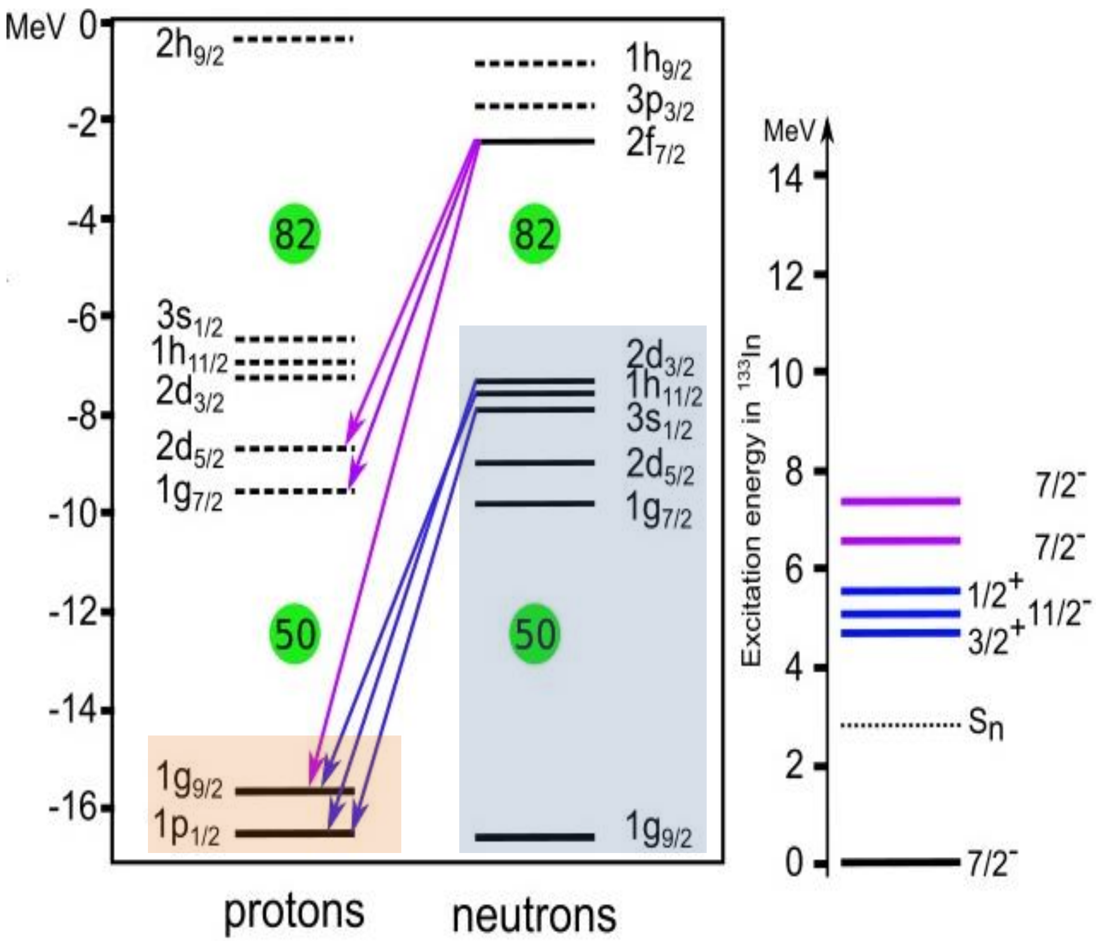


M. Mumpower et al., Prog. Part. Nucl. Phys. 86 (2016) 86–126

Beta decay of ^{133}In: forbidden transitions



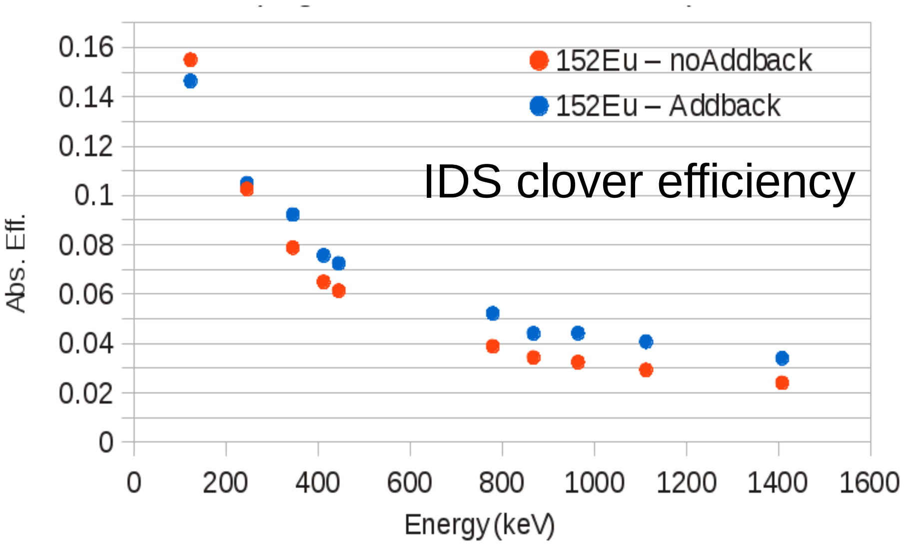
Excitation energies from shell model using ^{78}Ni core and *jj99apn* interaction

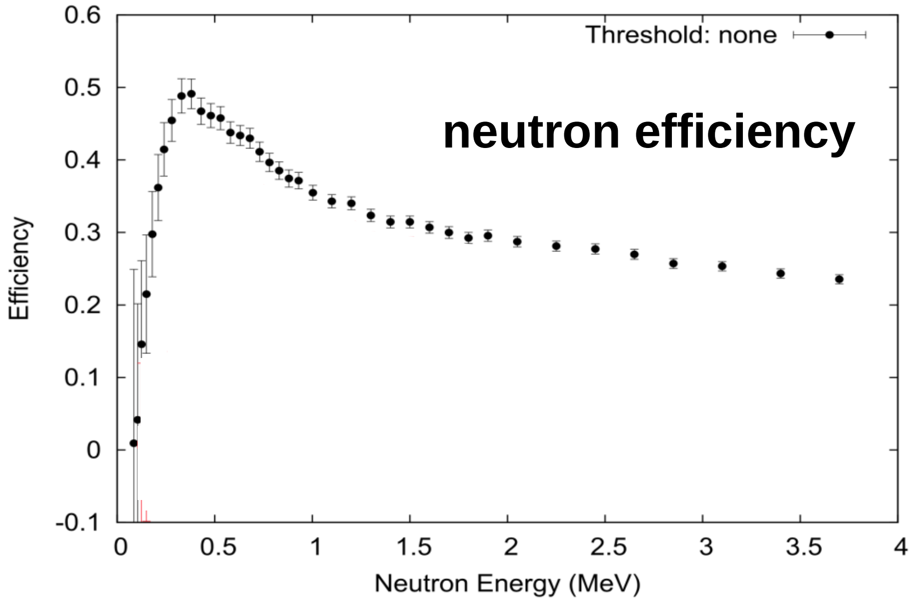


- beta-decay transitions with $\Delta L=1, \Delta\pi=0,1$
- N<82 neutron single hole states
  - single particle structure of the ^{132}Sn core
- Z>50 proton excited states

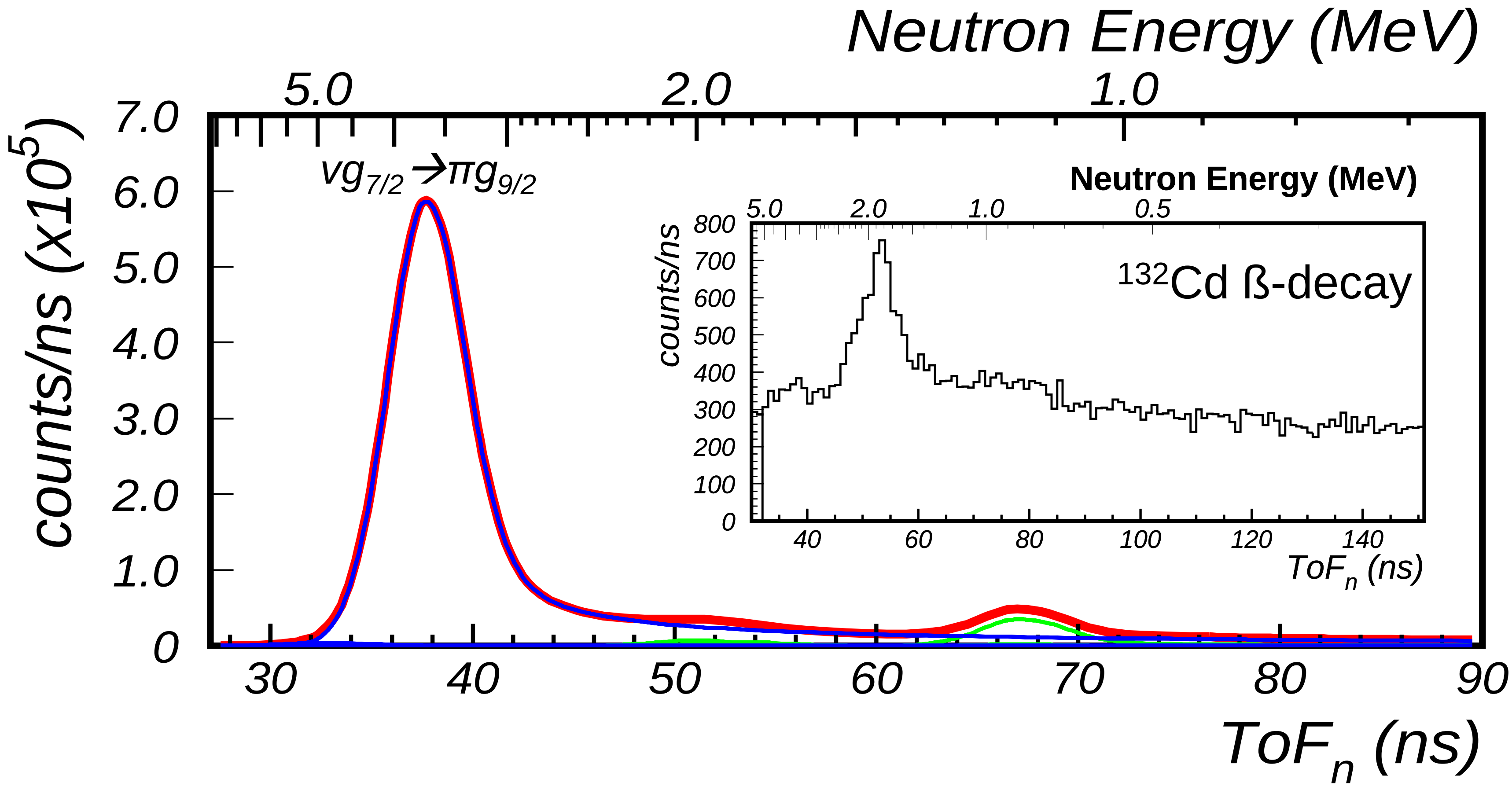
Neutron spectroscopy @ CERN

- 4 clovers, 4% efficient @ 1MeV
- 26 x 120 cm IDSND bars
  - 40% efficiency/bar @ 1MeV
  - Ω = 14.9% of 4π
  - 90% β-trigger efficiency
  - <u>5% total efficiency @ 1MeV</u>



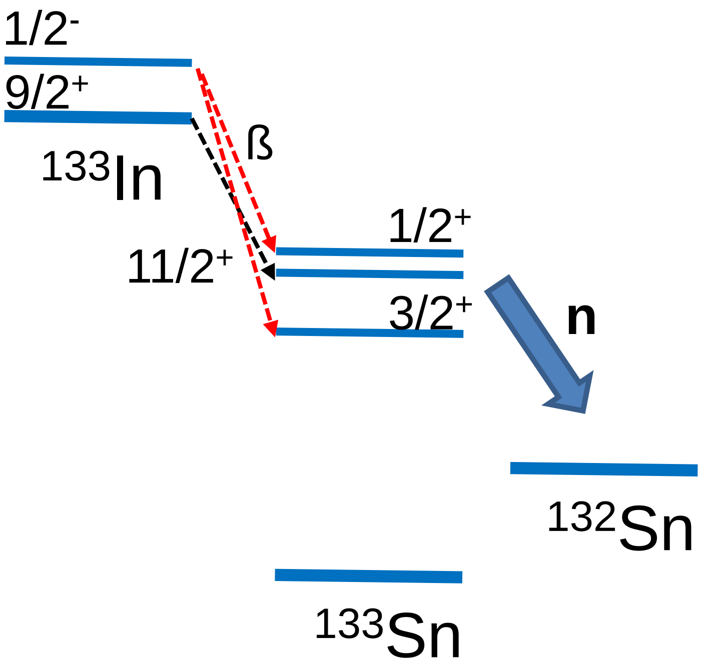


$^{133}In(9/2^+)$ Time-of-Flight spectrum



- Single GT transition dominates: $\nu g_{7/2}^{-1} f_{7/2} \rightarrow \pi g_{9/2}$ (^{132}Cd example)
- Smaller FF transitions at lower energies

Isomer selectivity for orbital identification



- Single particle energies for N=82-84 isotones
- isomer selective identification of:
  - $\nu d_{3/2}^{-1} f_{7/2}^{+2}$ → $3/2^+$
  - $\nu h_{11/2}^{-1} f_{7/2}^{+2}$ → $11/2^+$
  - $\nu s_{1/2}^{-1} f_{7/2}^{+2}$ → $1/2^+$

Summary of requested shifts

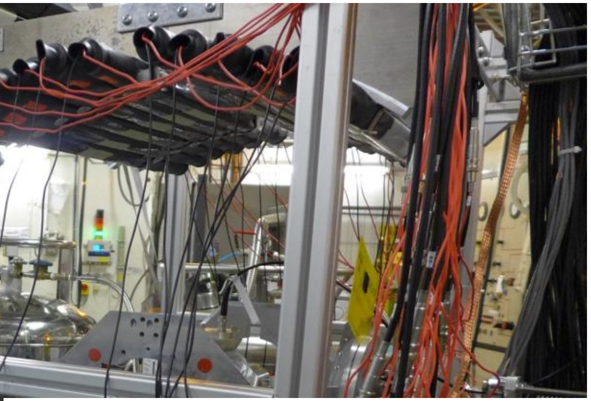
UC_x Target + neutron converter + Hot Ta cavity + RILIS

IDS run (summer 2016): Yields @ IDS and isomeric selectivity demonstrated
T. Goodacre, private communication (2016)

Calibration run can be replaced with ^{49}K using UC_X target

	P_n (%)	Yield (ion/µC)	IDSND Eff	Neutrons (1/h)	Shifts	Target	Source
^{133}In (9/2$^+$)	80	800	0.04	1.5 10^5	6	UC_X	Hot Ta line and cavity + RILIS
^{133}In (1/2$^-$)	4.75*	100	0.04	1.0$10^3$	6	UC_X	Hot Ta line and cavity + RILIS
^{17}N	95.1	100	0.04	1.8 10^4	1	CaO	Hot Ta line and cavity
^{49}K	86	2.7 10^5	0.04	22 10^6	1	UC_X	Hot Ta line and cavity

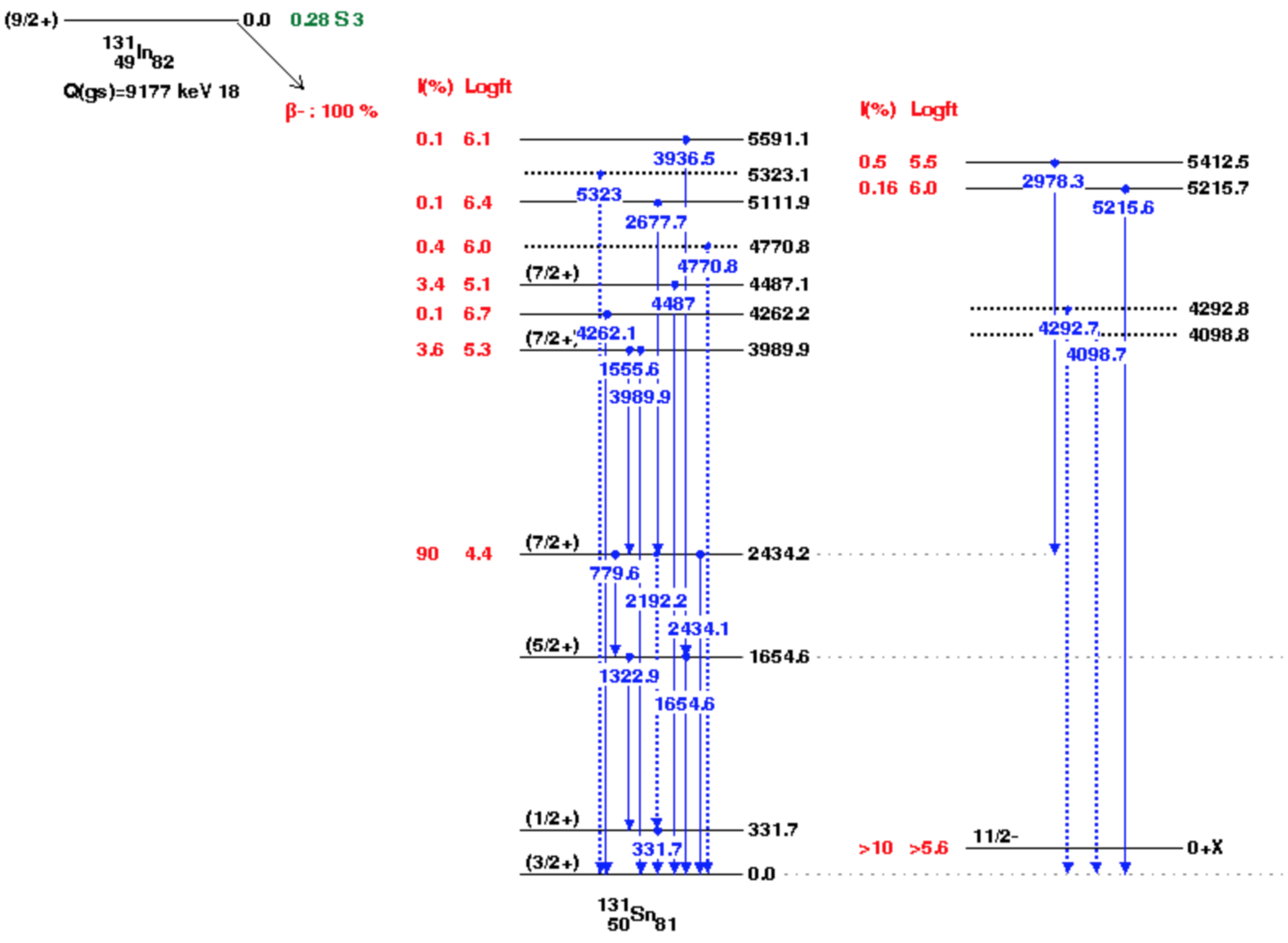
Summary



- Goal: Systematic study of unbound single-particle states in ^{133}Sn
  - Direct measurement of the $vg_{7/2} \rightarrow \pi g_{9/2}$ ß-decay matrix element
  - Location of the Fermi-level single particle states of the ^{132}Sn core
- Beam request: 13 shifts (collect ~10^6 n)
  - 6 x ^{133}In $9/2^+$, 6 x ^{133}In $1/2^-$, 1 x ^{17}N/^{49}K

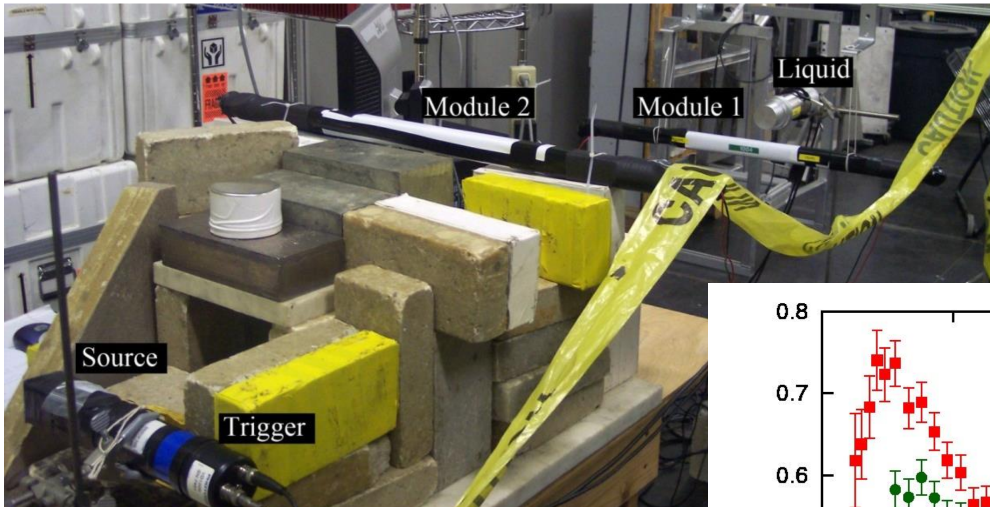
BACK UP SLIDES

Beta decay of ^{131}In

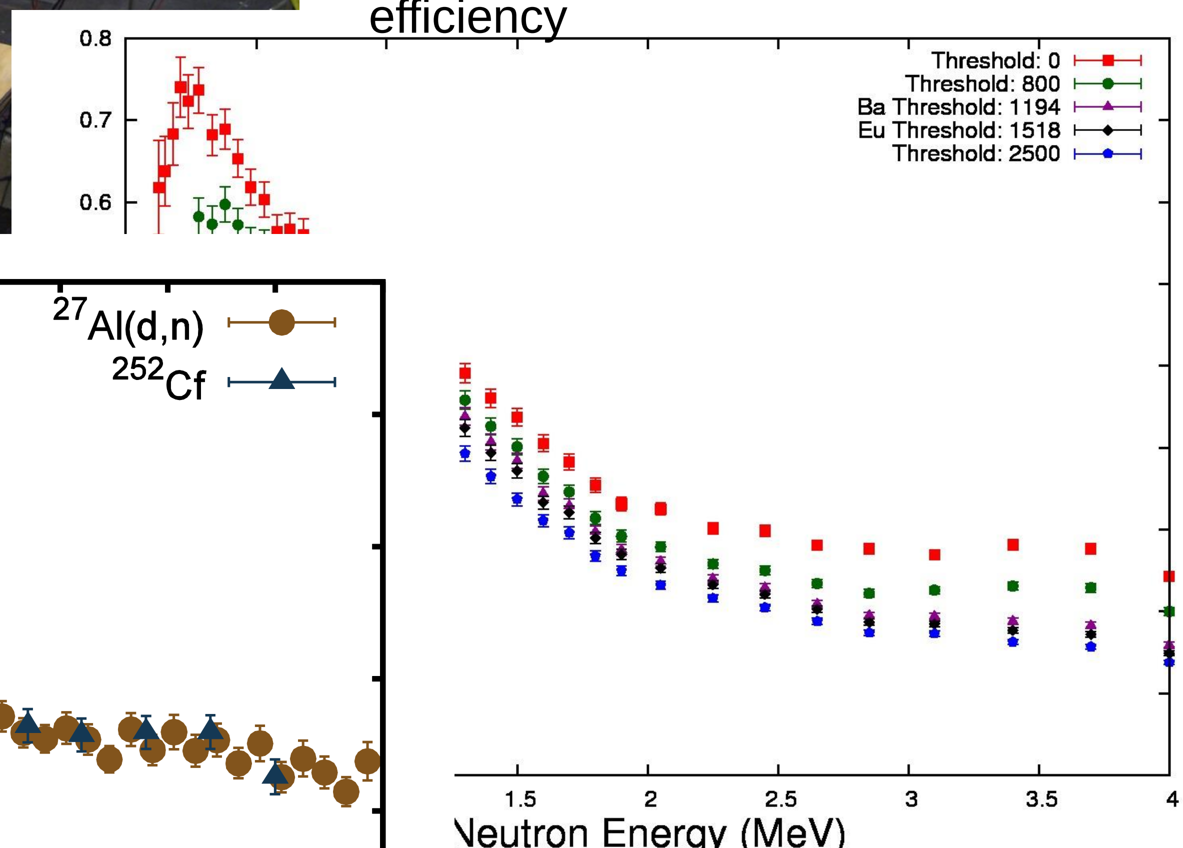


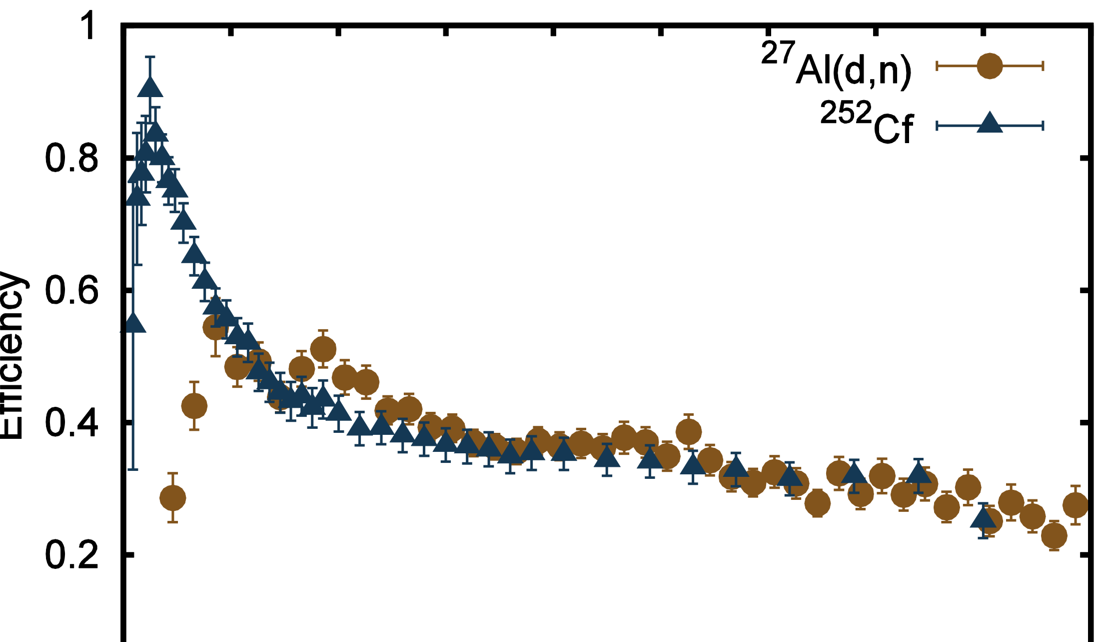
VANDLE efficiency @ ORNL

W.A. Peters & I. Spassova

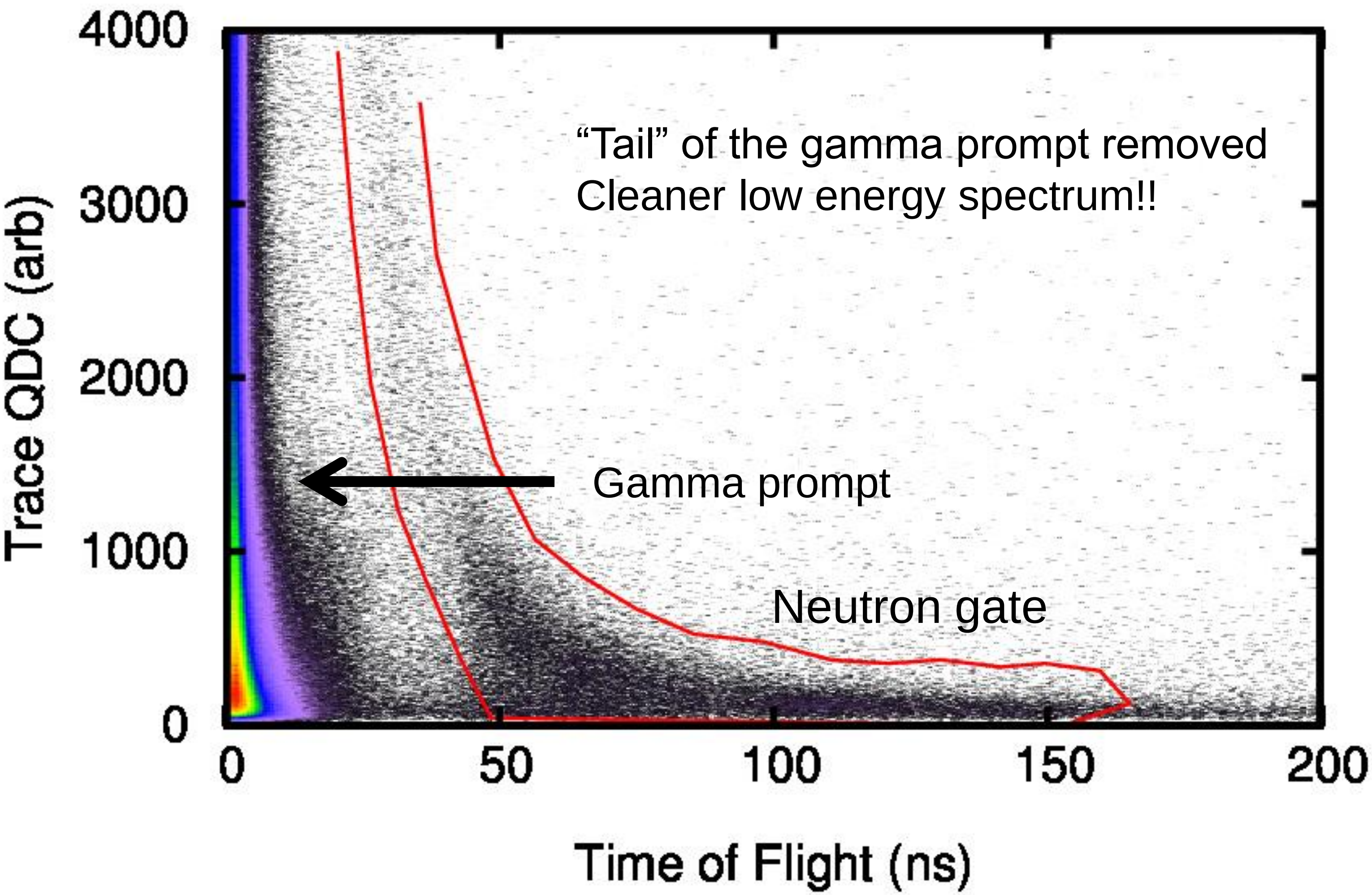


- Collimated ^{252}Cf source
- "shadowbar" measurement for scattered neutrons background
- Liquid scintillator normalized efficiency



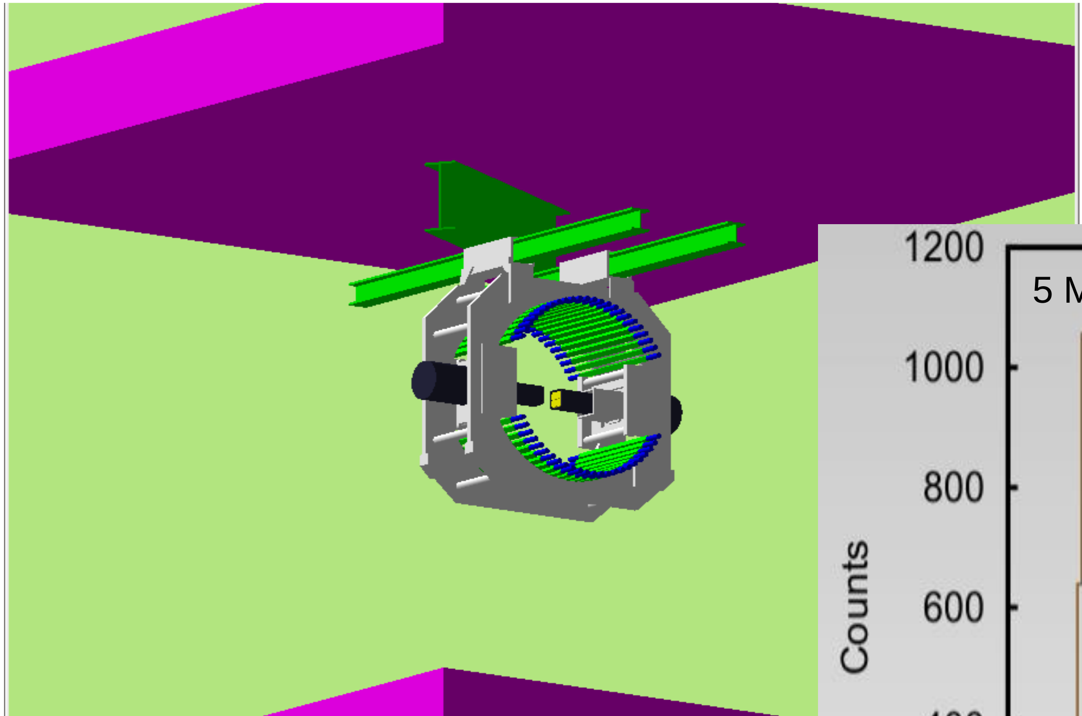


Light output vs Time of Flight: Neutron gate



Monte Carlo simulation of LeRIBSS setup

S. Ilyushkin



Isotropic, mono-energetic neutron source