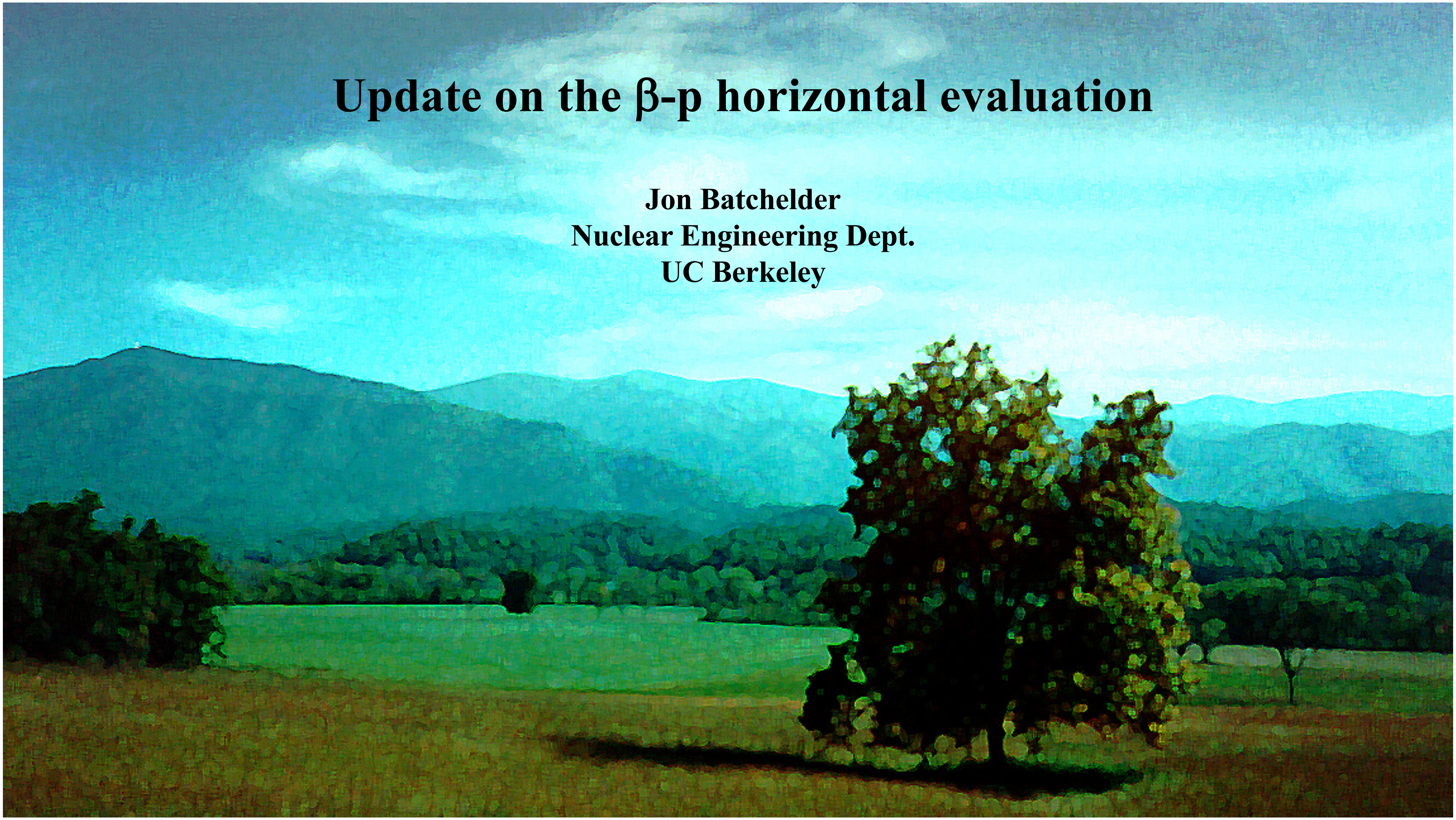


Update on the β-p horizontal evaluation

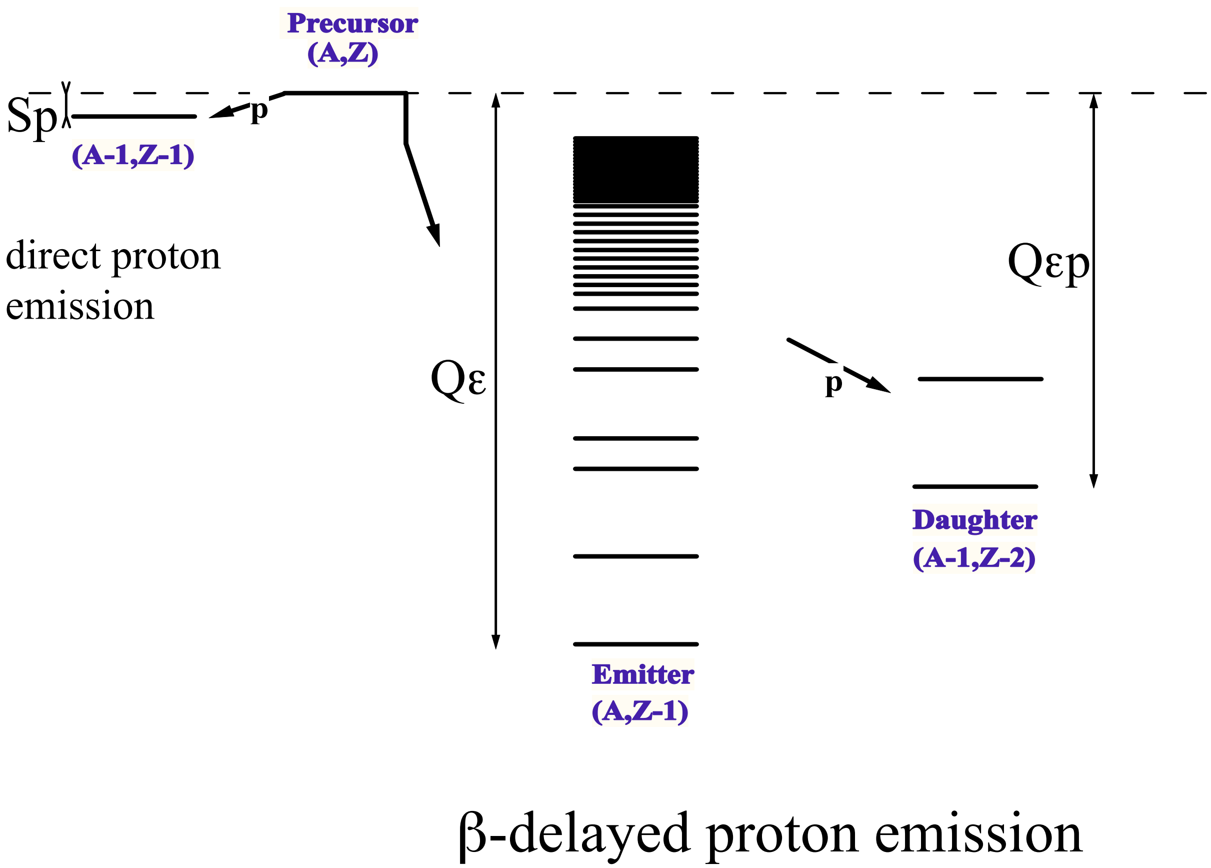
Jon Batchelder
Nuclear Engineering Dept.
UC Berkeley

Talk Outline

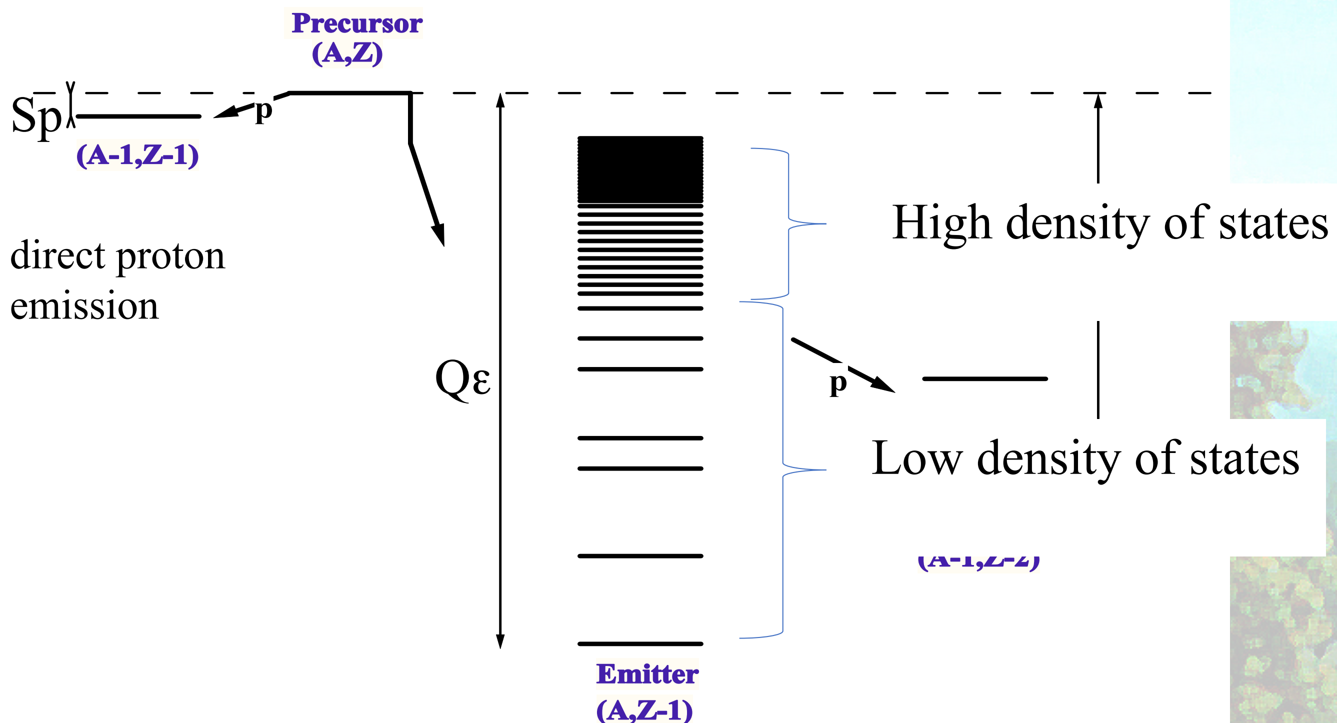
1. β-p basics (What can be learned?)
2. Purpose of Evaluation (who benefits from this work)
3. Past Beta –p evaluations
4. Contents of current version
5. Status of current evaluation

β-p basics

Schematic of a proton-rich nucleus that is energetically open to direct and β_+-delayed proton emission.



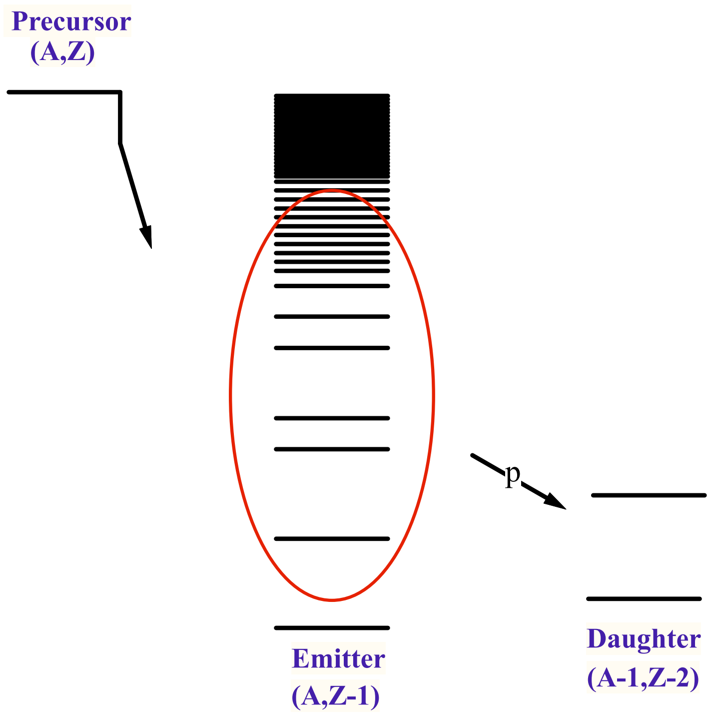
β-p basics



β-delayed proton emission

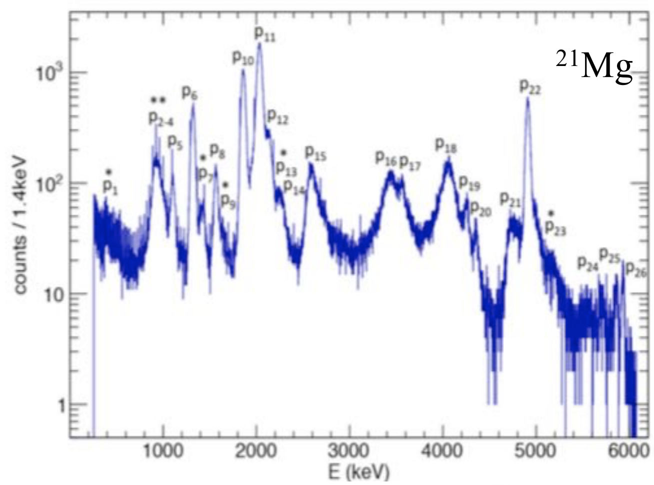
"Strong" βp emitters

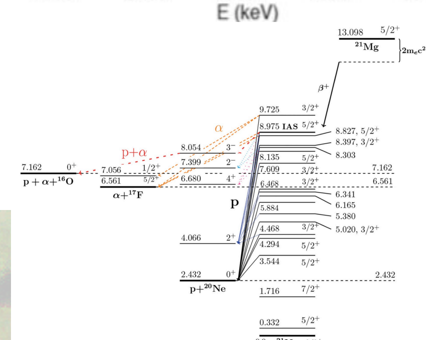
Large $Q_{\varepsilon p}$



Example:

M. V. Lund,*et al.*, Eur. Phys. J. A **51**, 113 (2015)





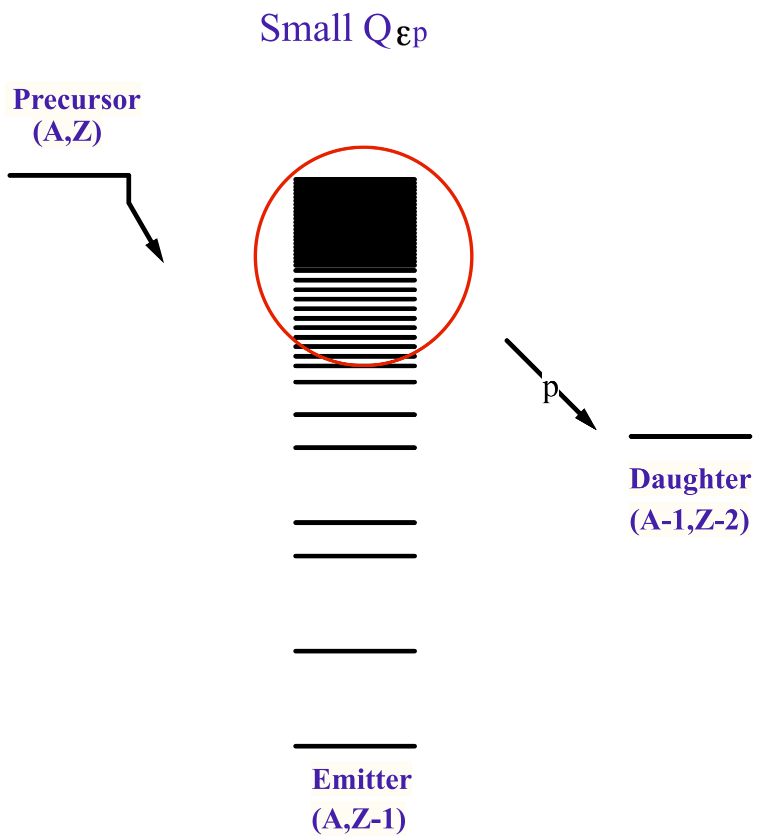
large value of $Q\varepsilon p$ compared to $Q\varepsilon$

Many low-lying states (often including IAS) are unbound to proton emission.

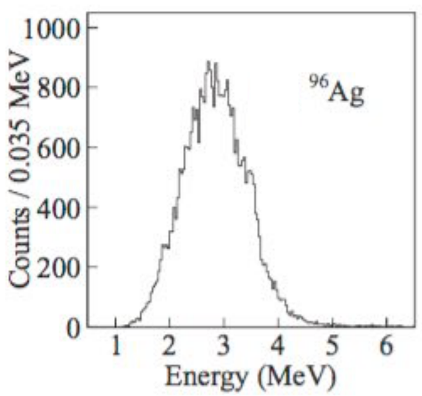
These states can only be measured via β-delayed protons

Proton spectrum consists of well defined peaks

"Weak" βp emitters



Example:



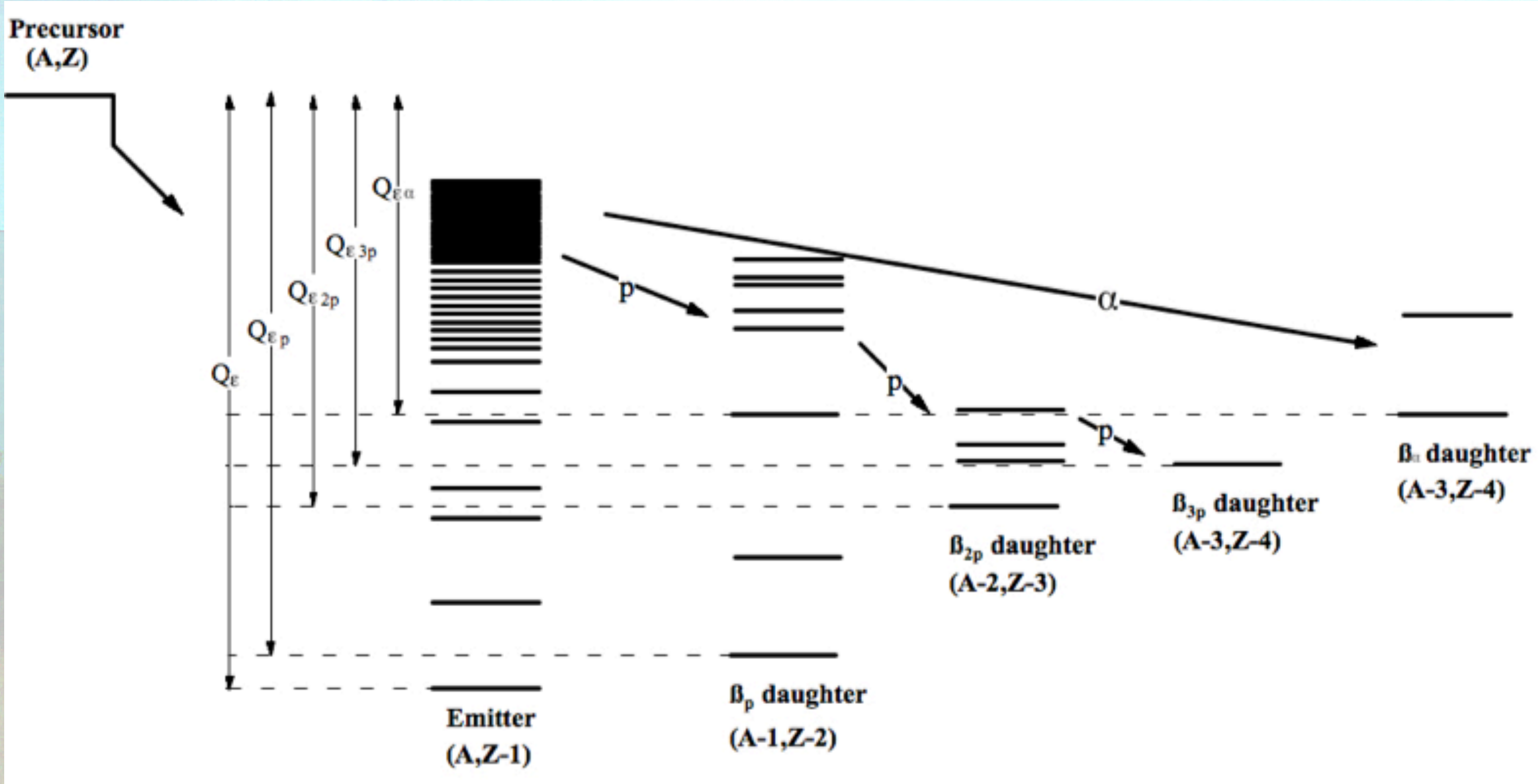
G. Lorusso, *et al.*, Phys. Rev. C **86**, 014313 (2012).

small value of $Q_{\varepsilon p}$ compared to Q_ε

Only high energy states are unbound to proton emission

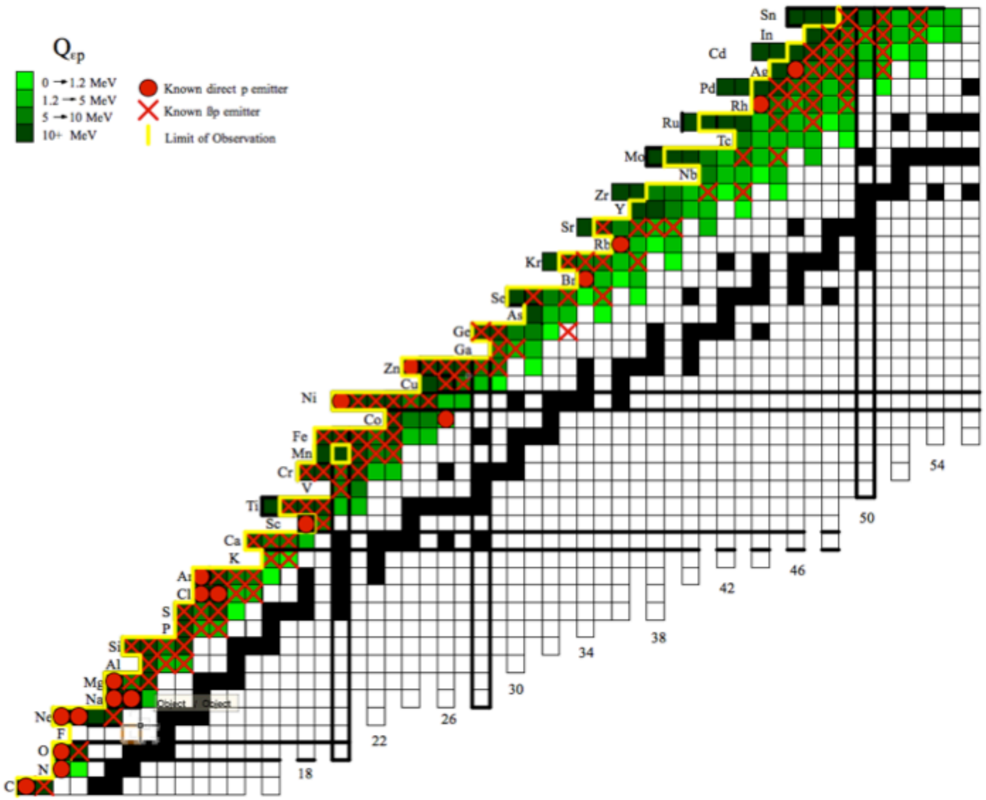
Proton spectrum is a broad continuum

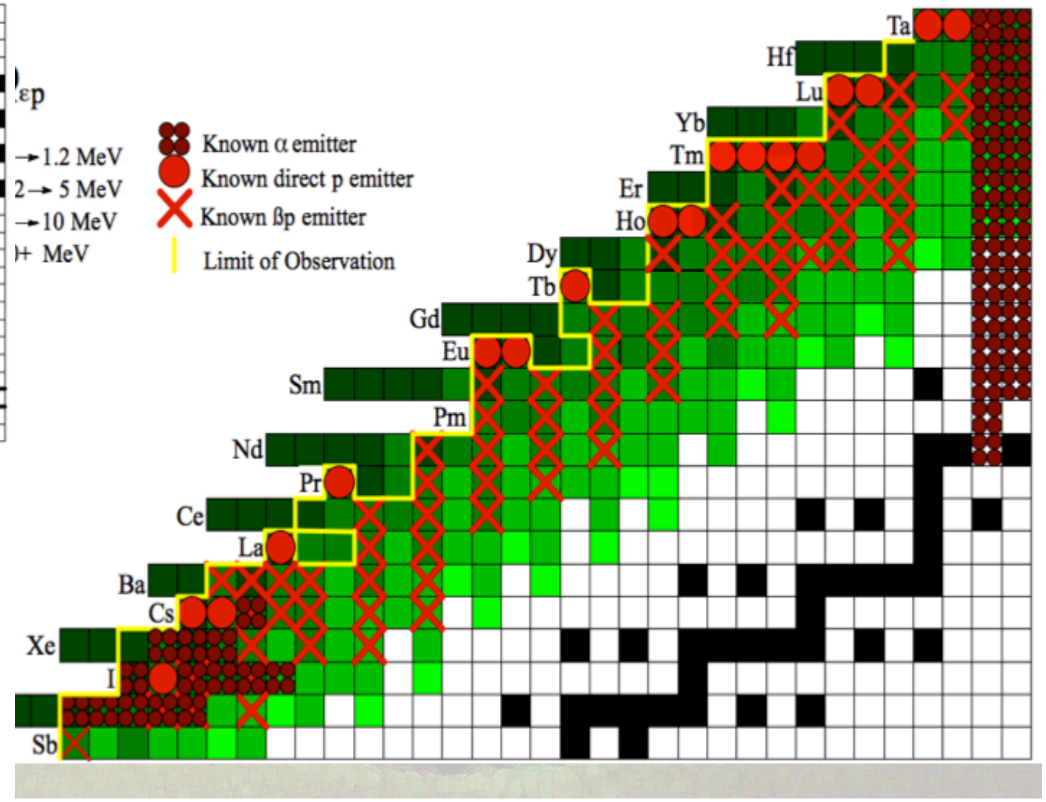
Emission of multiple particles if energy allows.



Currently known

195 ß-p emitters
13 ß-2p emitters
3 ß-3p emitters
28 ß-α emitters
from 200 nuclei (including isomers)





Purpose of Evaluation

For Experimenters:

Provide all of the evaluated information on the topic in one place in a consistent manner that allows one to see patterns in the available data. This can act as an aid in planning experiments.

This is similar to documents I've made for myself in the past when I did charged particle spectroscopy but on a much larger scale

For Evaluators:

Provide an updated evaluation on very proton rich nuclei across nearly the entire chart.

Past β–p evaluations

- The first review of β-delayed proton emitters was performed by V. I. Goldanskii in 1966
  (V. I. Goldanskii, Ann. Rev. Nuclear Sci. **16** (1966).
  10 β-p with $T_{1/2}$, Qβ, Ep, Ip, BR, refs.

- 2nd review - J. C. Hardy in 1972
  J. C. Hardy, Nucl. Data Tables **11**, 327 (1972).
  25 β-p with $T_{1/2}$, Q_{β}, Ep, Ip, BR, refs

- Updated version in 1977
  J. Cerny, J. C. Hardy, Ann. Rev. Nucl. Part. Sci**. 27,** 333 (1977).
  42 β-p with $T_{1/2}$, BR, refs organized by Tz

- Review in 1989
  J. C. Hardy, E. Hagberg, Particle Emission from Nuclei, Vol. 3, p. 99, CRC Press, Florida (1989).
  78 β-p with $T_{1/2}$, BR, refs organized by Tz

- The most recent review (which included direct proton emitters) in 2008
  B. Blank, M. J. G .Borge, Prog. Part. Nucl. Phys. **60**, 403 (2008)
  73 β-p emitters with negative Tz values, with $T_{1/2}$, Q_{ε}, BR, refs organized by Tz

- It should be noted that with the exception of the first two reviews by Goldanskii and Hardy, **none of the reviews attempt to provide a complete list of emitted proton energies, intensities and populated levels as this evaluation does.**

Current Evaluation

Table 1. - Delayed particle data for all the known precursors (including experimental upper limits).

nucleus ID	T_z	J^π	$T_{1/2}$	Decay mode	BR	$T_{1/2}$ reference	BR reference
^{8}B	-1	2^+	770(3) ms	β^+-α	100%	[1988Aj01]	[1988Aj01]
^{9}C	-3/2	(3/2-)	126.5(10) ms	β^+-p	61.1(17)%	[1972Es05]	[a]
				β^+-α	37.6(56)%		[a]
^{12}N	-1	1^+	11.000(16) ms	β^+-α	1.93(4)%	[1978Al01]	[2009Hy01][b]
^{13}O	-3/2	(3/2-)	8.55(5) ms	β^+-p	11.3(20)%	[1990As01]	[2005Kn02]
^{17}Ne	-3/2	1/2-	109.3(6) ms	β^+-p	94.4(29)%	[1988Bo39]	[2002Mo19]
				β^+-α	3.51(16)%		[2002Mo19]
				β^+-αp	0.014(4)%		[2002Mo19]
^{20}Na	-1	2^+	447.9(40) ms	β^+-α	20.05(22)%	[1998Ti06][c]	[1989Cl02]
^{20}Mg	-2	0^+	90.4(6) ms	β^+-p	30.0(12)%	[2016Lu13][d]	[e]
^{21}Mg	-3/2	5/2+	118.6(5) ms	β^+-p	20.9(13)%	[2015Lu12]	[2015Lu12]
				β^+-α	0.115(19)%		[2015Lu12]
				β^+-pα	0.016(3)%		[2015Lu12]
^{22}Al	-2	$(4)^+$	91.1(5) ms	β^+-p	54.5(25)%	[2006Ac04]	[2006Ac04]
				β^+-2p	1.10(11)%		[2006Ac04]
				β^+-α	0.038(17)%		[2006Ac04]
^{22}Si	-3	0^+	29(2) ms	β^+-p	32(4)%	[1996Bl11]	[1997Cz02]
				β^+-2p	0.7(3)%		[2017Xu01]
^{23}Al	-3/2	$5/2^+$	446(6) ms	β^+-p	1.22(5)%	[2006Ia03]	[2011Sa15]
^{23}Si	-5/2	$(5/2)^+$	42.3(4) ms	β^+-p	≈ 88%	[1997Bl04]	[1997Bl04]
				β^+-2p	3.6(4)%		[1997Bl04]
^{24}Al	-1	4^+	2.053(4) s	β^+-p	0.0012(3)%	[1985Ad10]	[1994Ba54]
				β^+-α	0.035(6)%		[1979Ho08]
^{24m}Al	-1	1^+	127(6) ms	β^+-α	0.028(6)%	[1979Ho08]	[1979Ho08]
^{24}Si	-2	0^+	141.4(15) ms	β^+-p	33.3(16)%	[f]	[2011Ic06]
^{25}Si	-3/2	5/2+	220(4) ms	β^+-p	35.0(20)%	[g]	[2004Th09]
^{26}P	-2	$(3)^+$	43.7(6) ms	β^+-p	35.2(20)%	[2004Th09]	[h]
				β^+-2p	2.16(24)%		[2017Ja05]
^{27}P	-3/2	$1/2^+$	260(80) ms	β^+-p	≈0.07%[i]	[1985Ay02]	[1996Og01]
^{27}S	-5/2	$(5/2)^+$	15.5(16) ms	β^+-p	61(3)%[j]	[2017Ja05]	[2017Ja05]
				β^+-2p	3.0(6)%		[2017Ja05]

Major properties of β–p emitters all in one table – organized by A

203 nuclei detailed over 6 pages with each footnote on same page References at end of document.

Current Evaluation

Table 2. - Q, S value table for all the (known or potential) β+-delayed particle decaying nuclides.

T_z	Parent ID	Q_ϵ	$Q_{\epsilon p}$	$Q_{\epsilon 2p}$	$Q_{\epsilon 3p}$	$Q_{\epsilon\alpha}$	S_p
-4	^{48}Ni	15.29(71)#	16.37(71)#	14.78(64)#	14.43(50)#	7.34(71)#	0.87(78)#
-7/2	^{45}Fe	19.01(57)#	19.83(50)#	17.10(40)#	17.00(40)#	11.02(45)#	0.56(64)#
	^{49}Ni	18.08(78)#	18.91(72)#	16.19(680)#	15.81(60)#	11.03(72)#	0.59(78)#
-3	^{22}Si	15.14(64)#	15.14(50)#	11.91(50)#	9.72(50)#	5.88(51)#	0.94(78)#
	^{26}S	16.11(63)#	15.96(60)#	12.55(60)#	10.69(60)#	6.46(72)#	-0.050(720)#
	^{30}Ar	16.49(28)#	16.80(21)	13.50(21)	11.45(21)#	7.54(29)#	-0.48(16)#
	^{34}Ca	15.07(36)#	15.95(30)#	12.60(30)#	11.03(30)#	6.99(36)#	0.48(36)#
	^{38}Ti	15.12(36)#	16.72(30)#	13.71(30)#	12.05(30)#	9.67(36)#	-0.06(42)#
	^{42}Cr	14.35(45)#	15.14(40)#	12.67(40)#	12.15(40)#	8.56(45)#	0.88(45)#
	^{46}Fe	13.48(64)#	13.14(50)#	10.13(53)#	8.04(50)#	8.25(64)#	
	^{50}Ni	13.51(64)#	13.34(50)#	10.60(50)#	8.58(50)#	6.03(64))#	
	^{54}Zn	15.14(57)#	16.07(40)#	13.51(56)#	12.07(40)#	9.09(81)#	0.29(64)#
-5/2	^{19}Mg	18.900(50)	19.220(50)	15.300(50)	14.700(50)	12.83(52)	
	^{23}Si	16.95(50)#	16.80(50)#	11.31(50)#	8.88(50)#	8.35(50)#	
	^{27}S	17.75(40)#	16.88(40)#	11.37(40)#	9.10(40)#	7.86(40)#	
	^{31}Ar	18.36(20)#	18.06(21)#	13.67(21)#	10.92(21)#	9.59(21)#	0.41(28)#
	^{35}Ca	15.96(20)#	15.88(20)	11.22(20)#	8.94(20)#	9.44(21)#	
	^{39}Ti	16.37(21)#	16.97(20)#	12.42(20)#	10.57(20)#	10.95(20)#	0.84(28)#
	^{43}Cr	15.95(40)#	15.52(40)#	11.6(10)#	11.01(40)#	9.78(40)#	
	^{47}Fe	15.70(50)#	14.59(50)#	10.44(50)#	8.81(50)#	8.63(50)#	
	^{51}Ni	15.44(50)#	14.26(80)#	11.14(80)#	9.06(80)#	8.25(80)#	
	^{55}Zn	17.07(43)#	17.01(70)#	13.51(40)#	11.89(40)#	10.35(40)#	0.45(57)#
	^{59}Ge	17.89(43)#	18.70(30)#	16.86(40)#	16.17(40)#	13.35(43)#	-0.38(50)#
-2	^{20}Mg	10.671(22)	8.437(2)	2.027(2)		4.373(8)	
	^{24}Si	10.794(19)	8.930(19)	1.349(19)		1.469(19)	
	^{28}S	11.22(16)	9.17(16)	1.702(160)		1.69(16)	
	^{32}Ar	11.1343(19)	9.553(2)	3.423(2)		2.523(2)	
	^{36}Ca	10.97(4)	9.31(4)	3.412(40)		4.46(4)	
	^{40}Ti	11.67(16)	11.14(16)	5.373(160)	0.231(160)	6.14(16)	
	^{44}Cr	10.76(35)#	8.67(30)#	4.18(30)	-0.09(30)	4.74(30)#	
	^{48}Fe	11.30(40)#	9.27(40)#	4.50(40)		3.70(44)#	
	^{52}Ni	12.03(40)#	10.58(40)#	5.72(40)	1.14(40)	4.54(40)#	
	^{56}Zn	13.25(40)#	12.66(40)#	8.04(40)	3.69(40)	6.55(40)#	
	^{60}Ge	12.50(36)#	12.84(30)#	10.00(30)	7.13(30)	9.13(30)#	0.62(35)#
	^{64}Se	12.83(54)#	12.93(50)#	10.71(50)	7.78(50)	10.47(54)#	0.49(54)#
	^{22}Al	18.60(40)#	13.10(40)#	10.66(40)#		10.46(40)#	-0.01(40)#
	^{26}P	18.11(20)#	12.60(20)#	10.33(20)#		8.95(20)#	0.14(20)#
	^{46}Mn	16.9040)#	11.63(40)#	10.40(40)#	1.75(40)#	10.11(40)#	0.34(40)#
	^{50}Co	16.85(40)#	12.57(60)#	10.61(40)#	2.51(40)#	9.42(40)#	0.70(64)#

Q_ε, $Q_{\varepsilon p}$, $Q_{\varepsilon 2p}$, $Q_{\varepsilon 3p}$, $Q_{\varepsilon\alpha}$, Sp - values of kno
predicted β-p emitters
– organized by Tz.

This allows one to see patterns
and outliers indicating something
interesting (or maybe just a data point
that needs to be remeasured).

Large negative Q-values
are not listed as these
decays are energetically forbidden.

223 nuclei detailed over 4 pages
with each footnote on same page

Current Evaluation

Table 3. - Individual β+-delayed particle emission transitions.

Nuclide	Decay	E_p(c.m.)	I_p(rel)%	I_p(abs)%[e]	$E_{emitter}$ (^{17}F)	$E_{daughter}$(^{16}O)[c]	coincident γ-rays[c]
^{17}Ne[a]	β^+-p	0.358	<0.10	<0.049	8.075	7.1169(1)	7.115
		0.47	0.066(59)	0.033(29)	10.655	9.585(11)	9.582, 6.916, 2.688
		0.48	3.06(24)	1.51(9)	8.197	7.1169(1)	7.115
		0.557	< 0.12	<0.058	8.074	6.9171(6)	6.916
		0.560	<0.0037	<0.0018	10.032	8.8719(5)	2.742, 6.129, 1.755, 7.115
		0.680	3.61(27)	1.78(13)	8.197	6.9171(6)	6.916
		0.719	1.28(6)	0.63(3)	8.436	7.1169(1)	7.115
		0.720	$< 2.8 \times^{-6}$	$< 1.4 \times^{-6}$	10.905	9.585(11)	9.582, 6.916, 2.688
		0.918	1.28(6)	0.63(3)	8.435	6.9171(6)	6.916
		1.002	0.029(8)	0.014(4)	11.187	9.585(11)	9.582, 6.916, 2.688
		1.108	2.53(10)	1.25(5)	8.825	7.1169(1)	7.115
		1.19	< 0.020	< 0.0		8.8719(5)	2.742, 6.129, 1.755, 7.115
		1.307	2.47(11)	1.22(5		6.9171(6)	6.916

+ many more bp

Nuclide	Decay	E_α	I_α (rel)%	I_α (abs)%	$E_{emitter}$ (^{17}F)	$E_{daughter}$(^{13}N)[c]	coincident γ-rays
^{17}Ne[a]	β^+-α	1.827	0.08(4)[d]	0.002(1)[d]	11.193	3.547(4)	3.547
		1.872			11.193	3.502(2)	3.502
		2.256	100(6)	2.7(2)	8.075	0	
		2.381	10.3(8)	0.28(2)	8.2	0	
		2.617	4.4(3)	0.12(1)	8.436	0	
		3.006	8.5(6)	0.23(2)	8.825	0	
		3.63	2.7(2)	0.074(5)	9.45	0	
		4.21	2.4(2)	0.065(5)	10.03	0	
		4.84	0.031(28)	0.00085(76)	10.66	0	
		5.09	0.55(7)	0.025(2)	10.91	0	
		5.374	0.12(3)	0.003(1)	11.193	0	

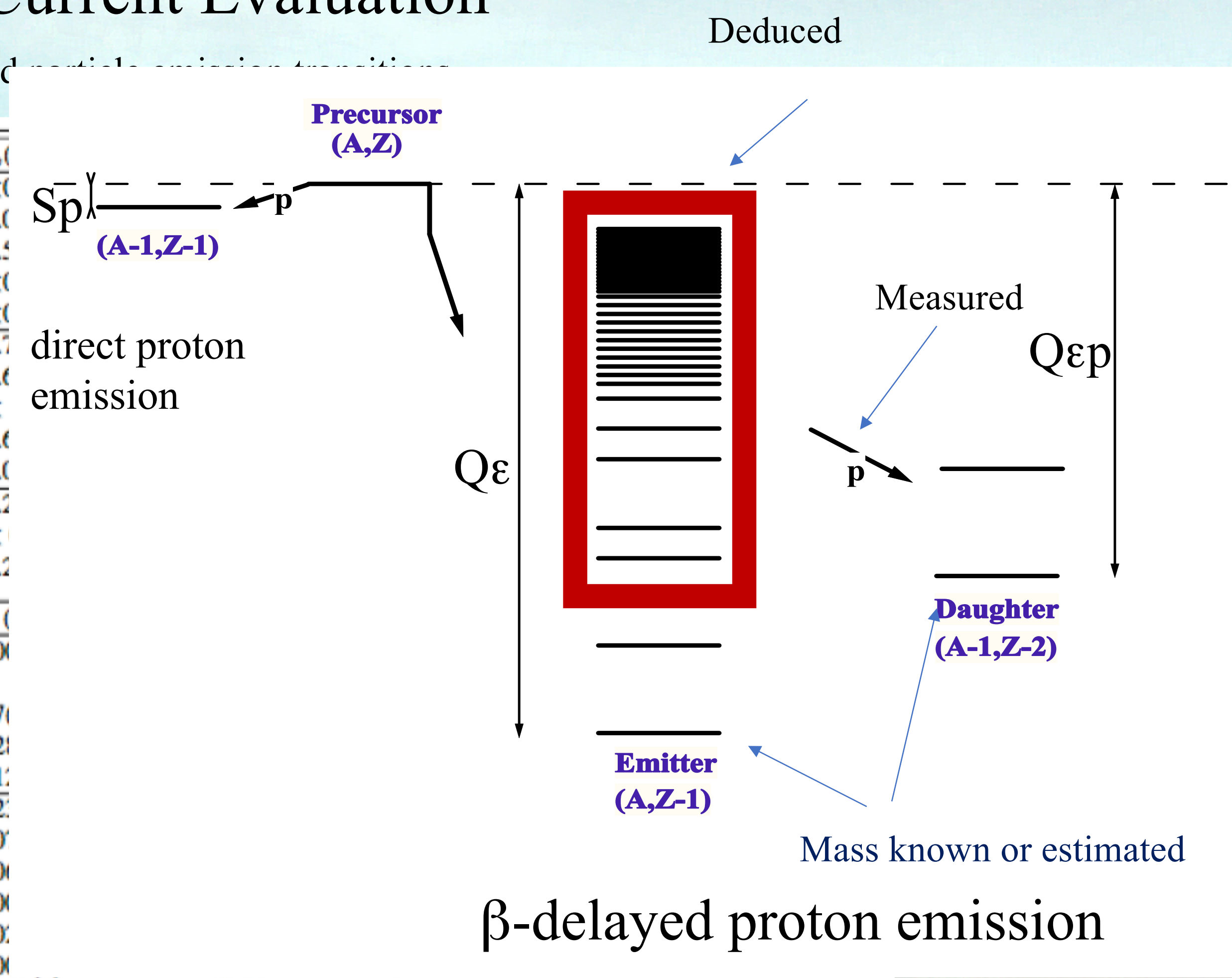
Nuclide Decay

Current Evaluation

Table 3. - Individual β+-delayed

Nuclide	Decay	E_p(c.m.)	I_p(rel)%	I_p(
^{17}Ne[a]	β^+-p	0.358	<0.10	<(
		0.47	0.066(59)	0.(
		0.48	3.06(24)	1.5
		0.557	< 0.12	<(
		0.560	<0.0037	<(
		0.680	3.61(27)	1.7
		0.719	1.28(6)	0.6
		0.720	$< 2.8 \times^{-6}$	<
		0.918	1.28(6)	0.6
		1.002	0.029(8)	0.(
		1.108	2.53(10)	1.2
		1.19	< 0.020	<
		1.307	2.47(11)	1.2

Nuclide	Decay	E_α	I_α (rel)%	I_α (
^{17}Ne[a]	β^+-α	1.827	0.08(4)[d]	0.0
		1.872		
		2.256	100(6)	2.7
		2.381	10.3(8)	0.2
		2.617	4.4(3)	0.1
		3.006	8.5(6)	0.2
		3.63	2.7(2)	0.0
		4.21	2.4(2)	0.0
		4.84	0.031(28)	0.0
		5.09	0.55(7)	0.0
		5.374	0.12(3)	0.0



Nuclide Decay E...

Current Evaluation

Table 3. - Individual β+-delayed particle emission transitions.

999 transitions from
56 precursor nuclei
detailed over 22 pages

Nuclide	Decay	E_p(c.m.)	I_p(rel)%	I_p(abs)%[e]	$E_{emitter}$ (^{17}F)	$E_{daughter}$(^{16}O)[c]	coincident γ-r
^{17}Ne[a]	β^+-p	0.358	<0.10	<0.049	8.075	7.1169(1)	7.115
		0.47	0.066(59)	0.033(29)	10.655	9.585(11)	9.582, 6.916, 2.688
		0.48	3.06(24)	1.51(9)	8.197	7.1169(1)	7.115
		0.557	< 0.12	<0.058	8.074	6.9171(6)	6.916
		0.560	<0.0037	<0.0018	10.032	8.8719(5)	2.742, 6.129, 1.755, 7.115
		0.680	3.61(27)	1.78(13)	8.197	6.9171(6)	6.916
		0.719	1.28(6)	0.63(3)	8.436	7.1169(1)	7.115
		0.720	$< 2.8 \times^{-6}$	$< 1.4 \times^{-6}$	10.905	9.585(11)	9.582, 6.916, 2.688
		0.918	1.28(6)	0.63(3)	8.435	6.9171(6)	6.916
		1.002	0.029(8)	0.014(4)	11.187	9.585(11)	9.582, 6.916, 2.688
		1.108	2.53(10)	1.25(5)	8.825	7.1169(1)	7.115
		1.19	< 0.020	< 0.0		8.8719(5)	2.742, 6.129, 1.755, 7.115
		1.307	2.47(11)	1.22(5		6.9171(6)	6.916

+ many more βp

Nuclide	Decay	E_α	I_α (rel)%	I_α (abs)%	$E_{emitter}$ (^{17}F)	$E_{daughter}$(^{13}N)[c]	coincident γ-rays
^{17}Ne[a]	β^+-α	1.827	0.08(4)[d]	0.002(1)[d]	11.193	3.547(4)	3.547
		1.872			11.193	3.502(2)	3.502
		2.256	100(6)	2.7(2)	8.075	0	
		2.381	10.3(8)	0.28(2)	8.2	0	
		2.617	4.4(3)	0.12(1)	8.436	0	
		3.006	8.5(6)	0.23(2)	8.825	0	
		3.63	2.7(2)	0.074(5)	9.45	0	
		4.21	2.4(2)	0.065(5)	10.03	0	
		4.84	0.031(28)	0.00085(76)	10.66	0	
		5.09	0.55(7)	0.025(2)	10.91	0	
		5.374	0.12(3)	0.003(1)	11.193	0	

Nuclide Decay E_α E (^{17}F) E E (^{13}N) E (^{12}C)

What's new?

195 ß-p emitters
13 ß-2p emitters
3 ß-3p emitters
28 ß-α emitters
from 200 nuclei (including isomers) in compilation/evaluation

16 nuclei - all new information on ß-p decay (no info on ß-p anywhere in ENSDF or XUNDL)

^{27}S(ß$_{3p}$)	^{45}Fe(ß$_{2p}$)	^{54}Zn	^{60}Ge	^{90m}Rh	^{91}Pd	^{92m}Rh	^{92}Pd	
^{96}Cd	^{96m}Cd	^{97m}Cd	^{97}In	^{98}In	^{98m}In	^{99}Sn	^{111}Te	^{121}Ba

27 nuclei ßp updated with new papers/evaluations

^{9}C	^{17}Ne	^{20}Mg	^{21}Mg	^{22}Si	^{24}Si	^{26}P	^{27}S	^{31}Cl	^{31}Ar	^{36}Ca	^{39}Ti
^{41}Ti	^{46}Fe	^{48}Fe	^{50}Ni	^{51}Ni	^{52}Ni	^{55}Cu	^{56}Zn	^{57}Zn	^{59}Zn	^{68}Kr	^{77}Sr
^{81}Zn	^{93}Pd	^{95}Pd	^{95m}Pd	^{95}Ag	^{95}Cd	^{96}Ag	^{96m}Ag	^{97}Cd	^{98}Ag	^{99}Cd	^{99}In
^{100}In	^{101}Sn	^{113}Xe	^{117}Ba	^{132}Pm	^{139}Dy	^{144}Dy	^{145}Dy	^{145m}Dy	^{145}Er		

53 nuclei (not listed above) with no ßp database in ENSDF or XUNDL - (some information available elsewhere in ENSDF)

^{8}B	^{12}N	^{24}Al	^{24m}Al	^{56}Cu	^{60}Ga	^{65}Ge	^{67}Se	^{71}Kr	^{73}Sr	^{83}Zr	
^{89}Ru	^{91m}Ru	^{94}Rh	^{102}In	^{108}Te	^{109}Te	^{110}I	^{112}I	^{114}Ba	^{115}Cs	^{115}Xe	^{115}Ba
^{116}Cs	^{116m}Cs	^{116}Ba	^{117}Xe	^{118}Cs	^{118m}Cs	^{119}Ba	^{120}La	^{120}Cs	^{122}La	^{124}Pr	^{126}Pr
^{127}Nd	^{128}Pm	^{128}Pr	^{129}Sm	^{129}Nd	^{130}Pm	^{134}Eu	^{137}Gd	^{139}Gd	^{142}Dy	^{142}Tb	^{144}Ho
^{146}Er	^{146}Ho	^{147}Dy	^{147m}Er	^{148}Er	^{148m}Ho						

10 nuclei (not listed above) with info only in XUNDL- decay dataset

^{22}Al	^{25}Si	^{48}Ni	^{65}Se	^{69}Kr	^{105}Sn	^{133}Sn	^{133m}Sm	^{143}Dy	^{145}Er

~ ½ are mostly unchanged.
There are many with small differences though.

Almost all of the Q values have changed in the most recent mass evaluation.

Nuclide	Decay	E_p(c.m.)	I_p(rel)%	I_p(abs)%	$E_{emitter}$ (^{22}Mg)	$E_{daughter}$(^{21}Na)[b]	coincident γ-rays[b]
^{22}Al[a]	β^+-p	0.475(8)	25.6(42)	4.73(63)	6.311(8)	0.3319(1)	0.332
		0.721(8)	40(7)	7.4(10)	6.225(8)	0	
		0.975(8)	1.4(3)	0.25(5)	6.479(8)	0	
		1.033(8)	16(2)	3.00(34)	6.869(8)	0.3319(1)	0.332
		1.223(8)	4.05(66)	0.75(10)	6.727(8)	0	
		1.299(8)	100(9)	18.51(174)	7.135(8)	0.3319(1)	0.332
		1.551(10)	4.38(96)	0.81(16)	7.055(10)	0	
		1.753(8)	2.4(5)	0.45(8)	7.257(8)	0	
		2.072(8)	2.59(45)	0.48(7)	7.576(8)	0	
		2.503(10)	3.46(77)	0.64(13)	8.007(10)	0	
		2.583(8)	26.4(28)	4.89(24)	8.419(8)	0.3319(1)	0.332
		2.838(8)	11.4(12)	2.11(9)	8.342(8)	0	
		3.088(8)	10.2(10)	1.89(7)	8.592(8)	0	
		3.484(8)	11.8(14)	2.18(15)	8.988(8)	0	
		4.017(8)	5.6(19)	1.04(33)	9.521([illegible])	0	
		4.224(9)	4.5(7)	0.84(11)	9.728(9)	0	
		4.464(8)	13.6(15)	2.52(14)	9.968(8)	0	
		4.912(10)	1.5(17)	0.27(32)	10.416(10)	0	
		5.177(13)	1.6(6)	0.29(11)	10.681(13)	0	
		5.667(8)	1.9(6)	0.35(11)	14.012(3)[c]	2.8291(7)	1.113, 1.384, 2.497, 0.332
		5.808(49)	1.0[d]	0.18[d]	11.312(49)	0	
		5.909(56)	1.1[d]	0.21[d]	11.413(56)	0	
		6.774(8)	2.2(7)	0.41(12)	14.012(3)[c]	1.7161(3)	1.384, 0.332
		7.517(11)	1.8(4)	0.33(7)	13.021(11)	0	

Nuclide	Decay	E_{2p}(c.m.)	I_{2p}(rel)%	I_{2p}(abs)%	$E_{emitter}$ (^{22}Mg)	$E_{daughter}$(^{20}Ne)[b]	coincident γ-rays[b]
^{22}Al[a]	β^+-2p	4.464(8)	100	0.69(8)	14.012(3)[c]	1.6337	1.634
		6.085(8)	59(12)	0.41(7)	14.012(3)[c]	0	

Nuclide	Decay	E_α(c.m.)	I_α(rel)%	I_α(abs)%	$E_{emitter}$ (^{22}Mg)	$E_{daughter}$(^{18}Ne)[b]	coincident γ-rays[b]
^{22}Al[a]	β^+-α	4.017(8)	100	0.038(17)	14.012(3)[c]	1.8873(2)	1.887

[a] All values taken from [2006Ac04], except where noted. Other experimental β^+-p and β^+-α references: [2018Wa24], [1997Bl03], [1984Ca29], [1983Ca01], [1982Ca1
[b] Values from adopted levels in ENSDF [2015Fi05], [1998Ti06], [1995Ti07].
[c] IAS, E_{level} from [2006Ac04].
[d] Upper limit.

New mass evaluation used.

^{22}Al εp decay:91.1 ms 2006Ac04

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	R. B. Firestone	NDS 127, 1 (2015)	15-Jan-2015

Parent: ^{22}Al: E=0; J^π=4$^+$; $T_{1/2}$=91.1 ms *5*; Q(εp)=13100 *SY*; %εp decay=54.5 *25*
^{22}Al-%εp decay: %εp=54.5 *25* (addition of all the observed proton branches).
^{22}Al isotope produced by fragmentation of 95 MeV/nucleon ^{36}Ar beam on a carbon target. Reaction products separated by LISE3 zero-degree achromatic recoil spectrometer.
Measured Eγ, Iγ, γγ, β, βγ coin, (delayed particles)γ coin, isotopic half-life. Detection system: two Si detectors, a Si(Li) detector and an EXOGAM Ge clover detector. Comparisons with shell-model calculations.
Other references: 1997Bl03,1982Ca16.

^{21}Na Levels

E(level)	J^π
0	3/2$^+$
332.0 *12*	5/2$^+$
1717.5 *18*	7/2$^+$
2830.4 *30*	9/2$^+$

γ(^{21}Na)

E_γ	I_γ[†‡]	E_i(level)	J^π_i	E_f	J^π_f
332.0 *12*	31.9 *15*	332.0	5/2$^+$	0	3/2$^+$
1112.9 *24*	0.35 *12*	2830.4	9/2$^+$	1717.5	7/2$^+$
1385.5 *13*	0.41 *12*	1717.5	7/2$^+$	332.0	5/2$^+$

[†] From β-delayed proton feeding intensity.
[‡] Absolute intensity per 100 decays.

Delayed Protons (^{21}Na)

E(p)[†]	E(^{21}Na)	I(p)[§]	E(^{22}Mg)	E(p)[†]	E(^{21}Na)	I(p)[§]	E(^{22}Mg)
475 *8*	332.0	4.7 *6*	6307	3088 *8*	0	1.89 *7*	8589
721 *8*	0	7.4 *10*	6221	3484 *8*	0	2.18 *15*	8985
975 *8*	0	0.25 *5*	6476	4017 *8*	0	1.04 *33*	9518
1033 *8*	332.0	3.0 *3*	6865	4224 *9*	0	0.84 *11*	9725
1223 *8*	0	0.75 *10*	6724	4464 *8*	0	2.52 *14*	9965
1299 *8*	332.0	18.5 *17*	7132	4912 *10*	0	0.27 *32*	10413
1551 *10*	0	0.81 *16*	7052	5177 *13*	0	0.29 *11*	10678
1753 *8*	0	0.45 *8*	7254	5667 *8*	2830.4	0.35 *11*	14012[‡]
2072 *8*	0	0.48 *7*	7573	5808 *49*	0	0.2 *6*	11309
2503 *10*	0	0.64 *13*	8004	5909 *56*	0	0.2 *6*	11410
2583 *8*	332.0	4.89 *24*	8416	6774 *8*	1717.5	0.41 *12*	14012[‡]
2838 *8*	0	2.11 *9*	8339	7517 *11*	0	0.33 *7*	13018

[†] In c.m. system.
[‡] 14012 *3* is the IAS of ^{22}Al$_{g.s.}$
[§] Absolute intensity per 100 decays.

What’s new ?

LOTS of new information – mainly from new papers (see previous slide)

New mass tables have changed nearly all of the Q values. This is reflected in this work.
Latest (2017) mass evaluation –
M. Wang, G. Audi, F. G. Kondev, W. J. Huang, S. Naimi, X. Xu, Chin. Phys. C 41, 030003 (2017).

Lab or C.M. for the emitters particles not consistent in ENSDF (sometimes not specified).
- All numbers in this document are in c.m. and MeV.

More complete listing of relevant references.

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Evaluation Status (current version)

4/13/18 - submission to ADNDT

5/7/18 - report received – major revisions required to presentation of the data reorganizations of the tables, etc.

7/16/18 - revised manuscript to ADNT

12/18/18 – report received

1/24/19 - revised version submitted

7/30/19 – report received

9/26/19 -revised version submitted

Conclusion

Process is nearing the end.

Should be published soon.

Thank you for your attention!

Recommended Values for β^+-Delayed Proton and α Emission

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Abstract

Beta$^+$-delayed proton (or α) emission is a typical decay mode of very neutron-deficient nuclei. Valuable information for the ground state in the precursor, such as half-life, spin, and parity, can be obtained by studying the β^+-p decay properties. The high efficiency and unique experimental signature for detecting protons allow one to study states in the β^+-decay daughter that are not accessible through other means. By measuring the properties of protons emitted to a known state in the daughter, information on the structure of the proton-unbound state can be obtained.

The known nuclei that exhibit this decay mode are evaluated to give the recommended values for the nuclear properties of these nuclei. This includes branching ratios, and half-lives. In addition for those nuclei with known resolved proton transitions, proton energies, intensities, and the energies of the proton-emitting states are compiled. A list of experimental references for each β^+-p precusor is also given.

All papers published prior to June 2019 have been considered in adopting the properties given in this work.