Texas A&M University
US Nuclear Data Program

TAMU NSDD CENTER
Report 2020

N. Nica
J.C. Hardy

Evaluation of Nuclear Structure and Decay Data OVERVIEW

- ***Scope:***
  - ***Promote and accomplish mass-chain nuclear structure data evaluation at Texas A&M University - Cyclotron Institute as regular activity and foresee future developments.***
  - ***Address gaps in data through targeted experiments***
- ***2005-2017: under contract with BNL/NNDC***
  - ***67% FTE Mass Chain Evaluation***
  - ***N. Nica (PI, evaluator), J.C. Hardy (scientific adviser)***
- ***2018-2020: NSDD Data Center***
  - ***FY18: 67% FTE Mass Chain Evaluation***
  - ***FY19-20: 100% FTE Mass Chain Evaluation***
  - ***N. Nica (PI, evaluator), J.C. Hardy (retiree, scientific adviser)***

Texas A&M - Cyclotron Institute Contributions

- ***Major Direct Contribution to USNDP/NSDD: Nuclear Data Evaluation***
  - ***16 major publications***
- ***Important Contribution to USNDP/NSDD: Precision ICC Measurements***
  - ***BrIcc adopted the "Frozen Orbitals" calculations***
  - ***^{93}Nb, ^{103}Rh, ^{125}Te, ^{127}Te, ^{111}Cd, ^{119}Sn, ^{134}Cs, ^{137}Ba, ^{191}Os, ^{193}Ir, ^{197}Pt***
  - ***17 major publications***
- ***Texas A&M Contribution to Precision Nuclear Data Production: Precision β-γ Measurements (Standard Model, CKM matrix)***
  - ***$T_{1/2}$, Branching Ratios, Efficiency calibration***
  - ***21 major publications***
- ***Texas A&M Medical Radioisotopes***
  - ***^{67}Cu, ^{99}Mo***
  - ***1 major publication***

Mass Chain Evaluation: *280 nuclei, 20 A-chains*

- 1. N.Nica, *Nuclear Data Sheets for A = 252*, Nucl.Data Sheets 106, 813 (2005)
  8 nuclei: ^{252}Cm, ^{252}Bk, ^{252}Cf, ^{252}Es, ^{252}Fm, ^{252}Md, ^{252}No, ^{252}Lr
- 2. N.Nica, *Nuclear Data Sheets for A = 140*, Nucl.Data Sheets 108, 1287 (2007)
  16 nuclei: ^{140}Te, ^{140}I, ^{140}Xe, ^{140}Cs, ^{140}Ba, ^{140}La, ^{140}Ce, ^{140}Pr, ^{140}Nd, ^{140}Pm, ^{140}Sm, ^{140}Eu, ^{140}Gd, ^{140}Tb, ^{140}Dy, ^{140}Ho
- 3. D.Abriola *et al.*, *Nuclear Data Sheets for A = 84*, Nucl.Data Sheets 110, 2815 (2009)
  1 nucleus: ^{84}Y
- 4. N.Nica, *Nuclear Data Sheets for A = 147*, Nucl.Data Sheets 110, 749 (2009)
  16 nuclei: ^{147}Xe, ^{147}Cs, ^{147}Ba, ^{147}La, ^{147}Ce, ^{147}Pr, ^{147}Nd, ^{147}Pm, ^{147}Sm, ^{147}Eu, ^{147}Gd, ^{147}Tb, ^{147}Dy, ^{147}Ho, ^{147}Er, ^{147}Tm
- 5. N.Nica, *Nuclear Data Sheets for A = 97*, Nucl.Data Sheets 111, 525 (2010)
  14 nuclei: ^{97}Br, ^{97}Kr, ^{97}Rb, ^{97}Sr, ^{97}Y, ^{97}Zr, ^{97}Nb, ^{97}Mo, ^{97}Tc, ^{97}Ru, ^{97}Rh, ^{97}Pd, ^{97}Ag, ^{97}Cd
- 6. J.Cameron, J.Chen, B.Singh, N.Nica, *Nuclear Data Sheets for A = 37*, Nucl.Data Sheets 113, 365 (2012)
  10 nuclei: ^{37}Na, ^{37}Mg, ^{37}Al, ^{37}Si, ^{37}P, ^{37}S, ^{37}Cl, ^{37}Ar, ^{37}K, ^{37}Ca
- 7. N.Nica, J.Cameron, B.Singh, *Nuclear Data Sheets for A = 36*, Nucl.Data Sheets 113, 1 (2012)
  10 nuclei: ^{36}Na, ^{36}Mg, ^{36}Al, ^{36}Si, ^{36}P, ^{36}S, ^{36}Cl, ^{36}Ar, ^{36}K, ^{36}Ca
- 8. N.Nica, B.Singh, *Nuclear Data Sheets for A = 34*, Nucl.Data Sheets 113, 1563 (2012)
  11 nuclei: ^{34}Ne, ^{34}Na, ^{34}Mg, ^{34}Al, ^{34}Si, ^{34}P, ^{34}S, ^{34}Cl, ^{34}Ar, ^{34}K, ^{34}Ca
- 9. B.Singh, N.Nica, *Nuclear Data Sheets for A = 77*, Nucl.Data Sheets 113, 1115 (2012)
  12 nuclei: ^{77}Ni, ^{77}Cu, ^{77}Zn, ^{77}Ga, ^{77}Ge, ^{77}As, ^{77}Se, ^{77}Br, ^{77}Kr, ^{77}Rb, ^{77}Sr, ^{77}Y
- 10. N.Nica, *Nuclear Data Sheets for A = 148*, Nucl.Data Sheets 117, 1 (2014)
  16 nuclei: ^{148}Xe, ^{148}Cs, ^{148}Ba, ^{148}La, ^{148}Ce, ^{148}Pr, ^{148}Nd, ^{148}Pm, ^{148}Sm, ^{148}Eu, ^{148}Gd, ^{148}Tb, ^{148}Dy, ^{148}Ho, ^{148}Er, ^{148}Tm
- 11. N.Nica, *Nuclear Data Sheets for A = 141*, Nucl.Data Sheets 122, 1 (2014)
  16 nuclei: ^{141}Te, ^{141}I, ^{141}Xe, ^{141}Cs, ^{141}Ba, ^{141}La, ^{141}Ce, ^{141}Pr, ^{141}Nd, ^{141}Pm, ^{141}Sm, ^{141}Eu, ^{141}Gd, ^{141}Tb, ^{141}Dy, ^{141}Ho
- 12. N.Nica, *Nuclear Data Sheets for A = 157*, Nucl.Data Sheets 132, 1 (2016)
  15 nuclei: ^{157}Nd, ^{157}Pm, ^{157}Sm, ^{157}Eu, ^{157}Gd, ^{157}Tb, ^{157}Dy, ^{157}Ho, ^{157}Er, ^{157}Tm, ^{157}Yb, ^{157}Lu, ^{157}Hf, ^{157}Ta, ^{157}W
- 13. N.Nica, *Nuclear Data Sheets for A = 158*, Nucl.Data Sheets 141, 1 (2017)
  15 nuclei: ^{158}Nd, ^{158}Pm, ^{158}Sm, ^{158}Eu, ^{158}Gd, ^{158}Tb, ^{158}Dy, ^{158}Ho, ^{158}Er, ^{158}Tm, ^{158}Yb, ^{158}Lu, ^{158}Hf, ^{158}Ta, ^{158}W
- 14. N.Nica, *Nuclear Data Sheets for A = 140*, Nucl.Data Sheets – Nucl.Data Sheets 154, 1 (2018)
  17 nuclei: ^{140}Sb, ^{140}Te, ^{140}I, ^{140}Xe, ^{140}Cs, ^{140}Ba, ^{140}La, ^{140}Ce, ^{140}Pr, ^{140}Nd, ^{140}Pm, ^{140}Sm, ^{140}Eu, ^{140}Gd, ^{140}Tb, ^{140}Dy, ^{140}Ho
- 15. N.Nica, A =155, *Nuclear Data Sheets for A = 155, Nucl.Data Sheets* 160, 1 (2019)
  16 nuclei: ^{155}Ce, ^{155}Pr, ^{155}Nd, ^{155}Pm, ^{155}Sm, ^{155}Eu, ^{155}Gd, ^{155}Tb, ^{155}Dy, ^{155}Ho, ^{155}Er, ^{155}Tm, ^{155}Yb, ^{155}Lu, ^{155}Hf, ^{155}Ta
- 16. N.Nica, A =160, *Nuclear Data Sheets for A = 160, Nucl.Data Sheets – in review (with evaluator)*
  17 nuclei: ^{160}Pr, ^{160}Nd, ^{160}Pm, ^{160}Sm, ^{160}Eu, ^{160}Gd, ^{160}Tb, ^{160}Dy, ^{160}Ho, ^{160}Er, ^{160}Tm, ^{160}Yb, ^{160}Lu, ^{160}Hf, ^{160}Ta, ^{160}W, ^{160}Re
- 17. N.Nica, A =153, *Nuclear Data Sheets for A = 153, Nucl.Data Sheets – in print* Nucl.Data Sheets, Dec (2020)
  16 nuclei: ^{153}La, ^{153}Ce, ^{153}Pr, ^{153}Nd, ^{153}Pm, ^{153}Sm, ^{153}Eu, ^{153}Gd, ^{153}Tb, ^{153}Dy, ^{153}Ho, ^{153}Er, ^{153}Tm, ^{153}Yb, ^{153}Lu, ^{153}Hf
- 18. N.Nica, *Nuclear Data Sheets for A = 147 – submitted to NNDC (FY19)*
  16 nuclei: ^{147}Xe, ^{147}Cs, ^{147}Ba, ^{147}La, ^{147}Ce, ^{147}Pr, ^{147}Nd, (*^{147}Pm Balraj Singh*), ^{147}Sm, ^{147}Eu, ^{147}Gd, ^{147}Tb, ^{147}Dy, ^{147}Ho, ^{147}Er, ^{147}Tm
- 19. N.Nica, *Nuclear Data Sheets for A = 141 – submitted to NNDC (FY20)*
  17 nuclei: : ^{141}Sb, ^{141}Te, ^{141}I, ^{141}Xe, ^{141}Cs, ^{141}Ba, ^{141}La, ^{141}Ce, ^{141}Pr, ^{141}Nd, ^{141}Pm, ^{141}Sm, ^{141}Eu, ^{141}Gd, ^{141}Tb, ^{141}Dy, ^{141}Ho

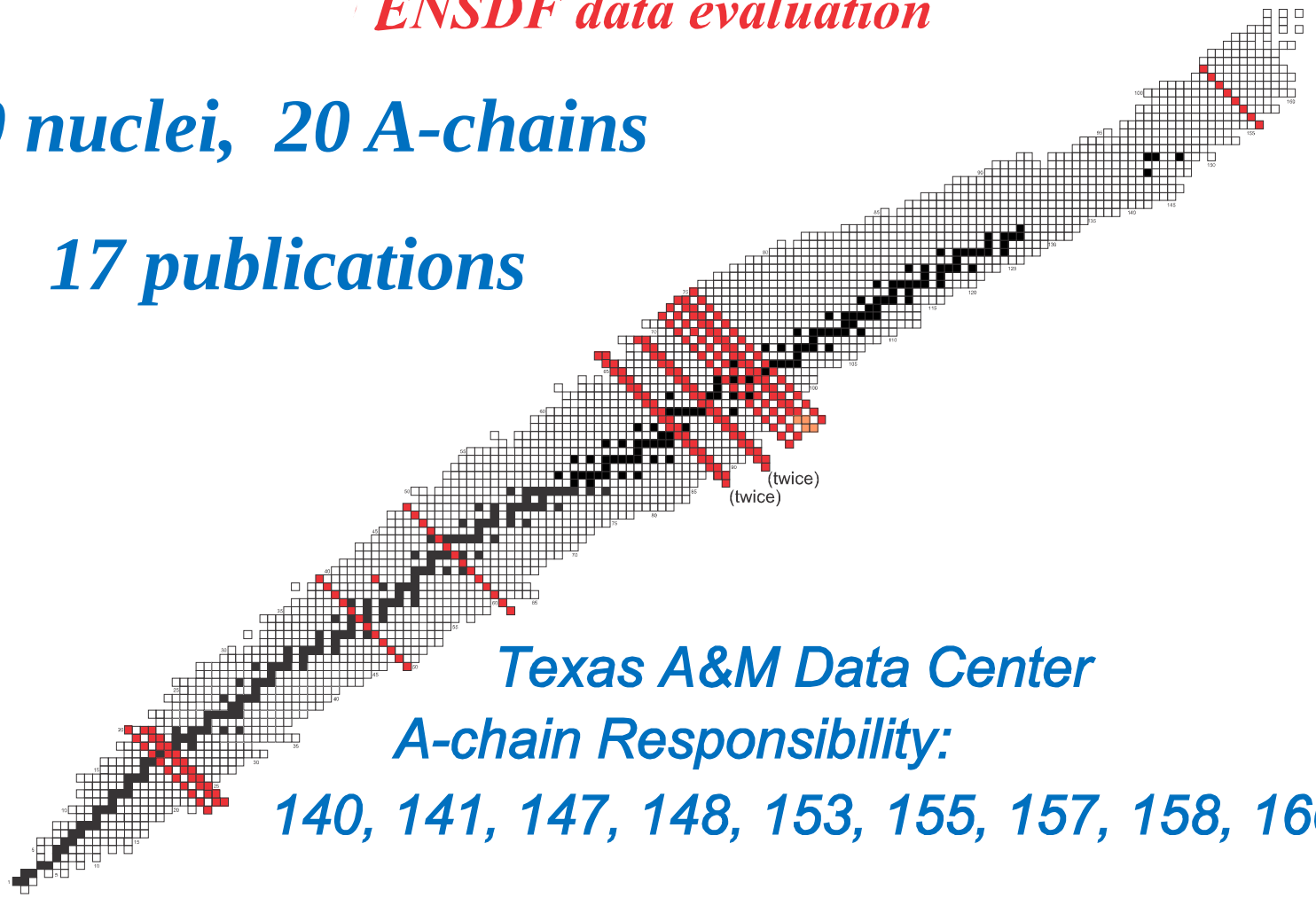
Mass Chain Evaluation: *280 nuclei, 20 A-chains*

- 16. N.Nica, A =160, *Nuclear Data Sheets for A = 160, Nucl.Data Sheets – in review (with evaluator)*
  17 nuclei: ^{160}Pr, ^{160}Nd, ^{160}Pm, ^{160}Sm, ^{160}Eu, ^{160}Gd, ^{160}Tb, ^{160}Dy, ^{160}Ho, ^{160}Er, ^{160}Tm, ^{160}Yb, ^{160}Lu, ^{160}Hf, ^{160}Ta, ^{160}W, ^{160}Re
- 18. N.Nica, *Nuclear Data Sheets for A = 147 – in review (with evaluator)*
  16 nuclei: ^{147}Xe, ^{147}Cs, ^{147}Ba, ^{147}La, ^{147}Ce, ^{147}Pr, ^{147}Nd, (^{147}*Pm Balraj Singh*), ^{147}Sm, ^{147}Eu, ^{147}Gd, ^{147}Tb, ^{147}Dy, ^{147}Ho, ^{147}Er, ^{147}Tm
- 19. N.Nica, *Nuclear Data Sheets for A = 141 – submitted to NNDC (FY20)*
  17 nuclei: ^{141}Sb, ^{141}Te, ^{141}I, ^{141}Xe, ^{141}Cs, ^{141}Ba, ^{141}La, ^{141}Ce, ^{141}Pr, ^{141}Nd, ^{141}Pm, ^{141}Sm, ^{141}Eu, ^{141}Gd, ^{141}Tb, ^{141}Dy, ^{141}Ho
- 20. N.Nica, *Nuclear Data Sheets for A = 162 – in progress (FY21)*
  17 nuclei: ^{162}Nd, ^{162}Pm, ^{162}Sm, ^{162}Eu, ^{162}Gd, ^{162}Tb, ^{162}Dy, ^{162}Ho, ^{162}Er, ^{162}Tm, ^{162}Yb, ^{162}Lu, ^{162}Hf, ^{162}Ta, ^{162}W, ^{162}Re, ^{162}Os,

V. Our accomplishments
ENSDF data evaluation

280 nuclei, 20 A-chains

17 publications



Texas A&M Data Center

A-chain Responsibility:

140, 141, 147, 148, 153, 155, 157, 158, 160

TEXAS A&M UNIVERSITY

Texas A&M - Cyclotron Institute

- ***ICC Precision Measurements***
  - ***Published ^{93m}Nb ICC (PRC)***
  - ***Last ICC measurement in the series of 10***

  - ***Completed 10 ICC measurements***

Hole FO calculations adopted by USNDP, NSDD, DDEP

Texas A&M - Cyclotron Institute

- ***β-γ Precision Measurements***
  - *New precise half-life measurement for the superallowed β^+ emitter ^{34}Ar, published in Phys.Rev. C 101, 015504 (2020)*
  - *Precise β branching-ratio measurement for the $0^+ \rightarrow 0^+$ superallowed decay of ^{34}Ar, published in Phys.Rev. C 101, 045501 (2020)*

- ***Medical Isotopes***
  - *K500 Cyclotron - MARS : ^{67}Cu published in Appl.Radiat.Isot. 149, 89 (2019)*
  - *K500 Cyclotron - MARS : ^{99}Mo test run analysis in progress*

Texas A&M - Cyclotron Institute, FY2020:

- 15. N.Nica, *Nuclear Data Sheets for A =153,* Nucl.Data Sheets (2020) (Dec) *FY2018*
  17 nuclei: ^{153}Ba, ^{153}La, ^{153}Ce, ^{153}Pr, ^{153}Nd, ^{153}Pm, ^{153}Sm, ^{153}Eu, ^{153}Gd, ^{153}Tb, ^{153}Dy, ^{153}Ho, ^{153}Er, ^{153}Tm, ^{153}Yb, ^{153}Lu, ^{153}Hf

- 19. N.Nica, A = 141 – *Submitted FY2020*
  17 nuclei: ^{141}Sb, ^{141}Te, ^{141}I, ^{141}Xe, ^{141}Cs, ^{141}Ba, ^{141}La, ^{141}Ce, ^{141}Pr, ^{141}Nd, ^{141}Pm, ^{141}Sm, ^{141}Eu, ^{141}Gd, ^{141}Tb, ^{141}Dy, ^{141}Ho

- Review: A = 212, Review of full mass chain evaluation
  12 nuclei: ^{212}Hg, ^{212}Tl, ^{212}Pb, ^{212}Bi, ^{212}Po, ^{212}At, ^{212}Rn, ^{212}Fr, ^{212}Ra, ^{212}Ac, ^{212}Th, ^{212}Pa

- 16. N.Nica, A =160 – *With evaluator, FY2017*
  17 nuclei: ^{160}Pr, ^{160}Nd, ^{160}Pm, ^{160}Sm, ^{160}Eu, ^{160}Gd, ^{160}Tb, ^{160}Dy, ^{160}Ho, ^{160}Er, ^{160}Tm, ^{160}Yb, ^{160}Lu, ^{160}Hf, ^{160}Ta, ^{160}W, ^{160}Re

- 18. N.Nica, A = 147 – *With evaluator, FY2019*
  16 nuclei: ^{147}I, ^{147}Xe, ^{147}Cs, ^{147}Ba, ^{147}La, ^{147}Ce, ^{147}Pr, ^{147}Nd, (^{147}Pm-NO), ^{147}Sm, ^{147}Eu, ^{147}Gd, ^{147}Tb, ^{147}Dy, ^{147}Ho, ^{147}Er, ^{147}Tm

Texas A&M - Cyclotron Institute, FY2019
Mass chain evaluations: Statistics

	A=160 Evaluation	A=147 Evaluation (-BS)	A=141 Evaluation	A=153 Evaluation Before review	A=153 Evaluation After review	A=162 Evaluation (before eval) (BNL)	A=148 Evaluation (before eval)	A=212 Review
Number of Adopted Levels	1216	1318	1069	1459	1532 (+5.0%)	1068	1219	344
Number of Adopted Gammas	2391	2168	1886	2507	2983 (+19.0%)	1675	1937	464
Number of nuclides	17	16	17	17	17	17	16	12
Number of datasets	78	81	97	94	95	77	92	49
Number of lines	21212	20510	17434	23808	26629 (+11.8%)	18023	17932	6864

Mass chains: Review, Updates & Editorial

Mass Chain A153: FY2018

.ens database file	Number of Publications	Increment	CUT Date
A153_old	460		31-Dec-2005
A153_new	485	+25	1-Mar-2017
A153_upd.arv	490	+5	16-Aug-2020, ***+2y10m***

Mass Chain A155: FY2016

.ens database file	Number of Publications	Increment	CUT Date
A155_old	339		1-Jan-2004
A155_new	368	+29	26-Jan-2016
A155_upd.arv	391	+23	21-Oct-2019, ***+3y9m***

Texas A&M - Cyclotron Institute, FY2020 Publications

Publications USNDP 2020 N. Nica TAMU

- **2020NIZZ** Nucl.Data Sheets *Dec (2020)*
  N.Nica
  Nuclear Data Sheets for A=153

- **2020HO10** Phys.Rev. C 102, 014310 (2020)
  V.Horvat, E.E.Tereshatov, J.C.Hardy, N.Nica, C.M.Folden, V.E.Iacob, M.B.Trzhaskovskaya
  K-shell internal conversion coefficient for M4 decay of the 30.8 keV isomer in ^{93}Nb

- **2020IA01** Phys.Rev. C 101, 015504 (2020)
  V.E.Iacob, J.C.Hardy, H.I.Park, M.Bencomo, L.Chen, V.Horvat, N.Nica, B.T.Roeder, A.Saastamoinen
  New precise half-life measurement for the superallowed β^+ emitter ^{34}Ar

- **2020IA02** Phys.Rev. C 101, 045501 (2020)
  V.E.Iacob, J.C.Hardy, H.I.Park, M.Bencomo, L.Chen, V.Horvat, N.Nica, B.T.Roeder, A.Saastamoinen, I.S.Towner
  Precise β branching-ratio measurement for the $0^+ \rightarrow 0^+$ superallowed decay of ^{34}Ar

- **2020DIZW** Proc.Intern.Conf.Nuclear Data for Science and Technology (ND2019), Beijing, China, May 19-24, 2019, Z.Ge, et al. Eds., p.15004 (2020);EPJ Web of Conf.Vol.239 (2020)
  P.Dimitriou, S.Basunia, L.Bernstein, J.Chen, Z.Elekes, X.Huang, A.Hurst, H.Iimura, A.K.Jain, J.Kelley, T.Kibedi, F.Kondev, S.Lalkovski, E.McCutchan, I.Mitropolsky, G.Mukherjee, A.Negret, C.Nesaraja, N.Nica, S.Pascu, A.Rodionov, B.Singh, S.Singh, M.Smith, A.Sonzogni, J.Timar, J.Tuli, M.Verpelli, D.Yang, V.Zerkin
  International network of nuclear structure and decay data evaluators

Texas A&M - Cyclotron Institute, FY2020 Conferences

Conferences USNDP 2020 N. Nica TAMU

- United States Nuclear Data Program Annual Meeting

  "Precise α_K and α_T Internal Conversion Coefficients Measurements of 30.77(6)-keV M4 Transition in ^{93m}Nb: Last Test of Internal Conversion Theory"

  Brookhaven National Laboratory, New York, Nov 7 – 8, 2019

- United States Nuclear Data Program Annual Meeting

  "Texas A&M University US Nuclear Data Program NSDD Center Report FY2019"

  Brookhaven National Laboratory, New York, Nov 7 – 8, 2019

Texas A&M - Cyclotron Institute
FY 2021

- *A-chain evaluation FTE: 100%*
- *A=162 full mass chain evaluation*
- *Review*
- *Xundl*
- *3 big A-chains in the publication pipe!*
  - *A=160 with evaluator*
  - *A=147 with evaluator*
  - *A=141 with reviwer*

A-Chain Evaluation Responsibility @Texas A&M University

- ***Responsibility:***

  140, 141, 147, 148, 153, 155, 157, 158, 160

- ***Status:***

✓ *153 (Aug 2020)*
✓ *155 (Oct-2019)*
✓ *140 (Nov 2018)*
✓ *158 (Feb 2017)*
✓ *157 (Dec 2015)*
➢ *147 (Nov-2018 – with evaluator)*
➢ *160 (Aug 2018 – with evaluator)*
➢ *141 (Sept 2020 – with reviewer)*
➢ *FY2021: 162 (Mar 2007 – in progress)*
➢ *FY2022: 154 (May 2008) or 148 (Oct 2013)*

OBS.: 162 and 154 are NOT TAMU RESPONSABILITY

Texas A&M Nuclear Data Program under DOE Grant and NSDD Data Center

Promoting Scientific Research Programs related to data evaluation:

- ***Possible Follow-up of ICC Measurements***
- ***Medial Isotopes Production Tests***
- ***Promoting original research ideas from reevaluating existing data !***

Texas A&M Evaluation Center
Strategic Priorities

- **Continuing ENSDF Mass Chain Evaluation (1 FTE)**

  First Strategic Priority according to the Mission Statement.

  All other priorities will be strictly subordinated to this purpose

- **Produce experimental nuclear data to aid data evaluation**

  Precision Internal Conversion Coefficients Measurements at Cyclotron Institute, Texas A&M University to give USDNP the best approach for ENSDF ICC-calculated values (concluding cases pending on conditions)

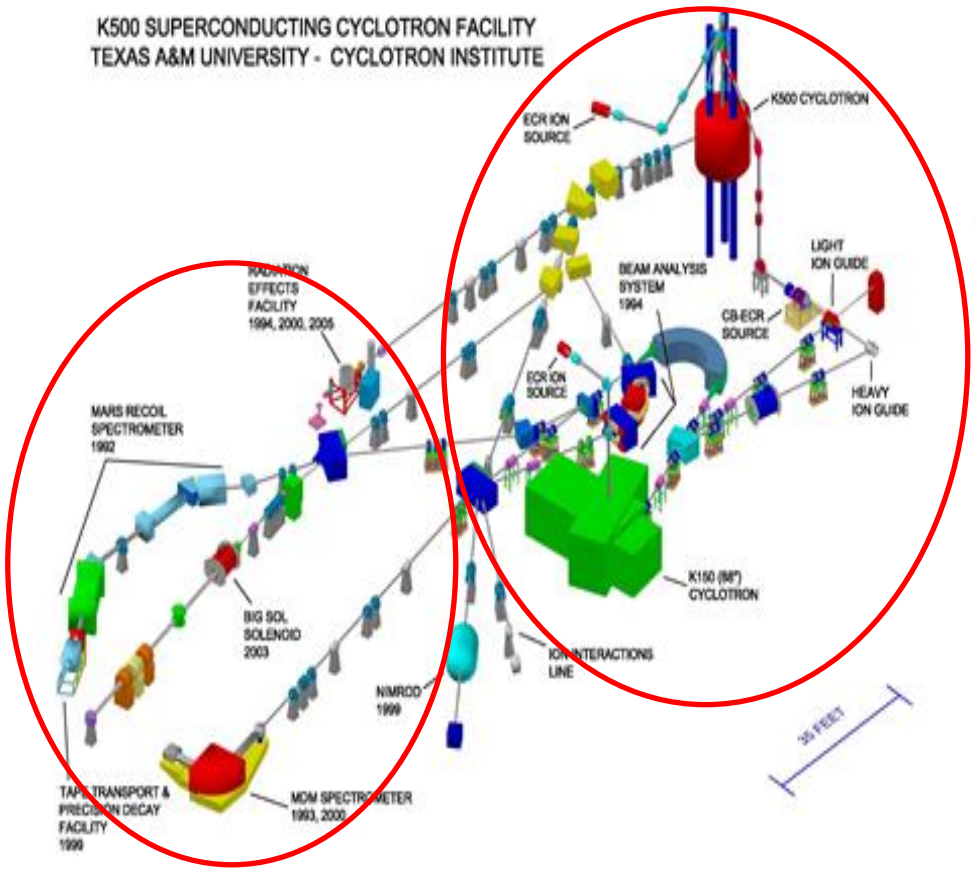
- **Experimental studies of Medical Isotopes**

  Invers kinematics methodology, Cyclotron Institute, Texas A&M University

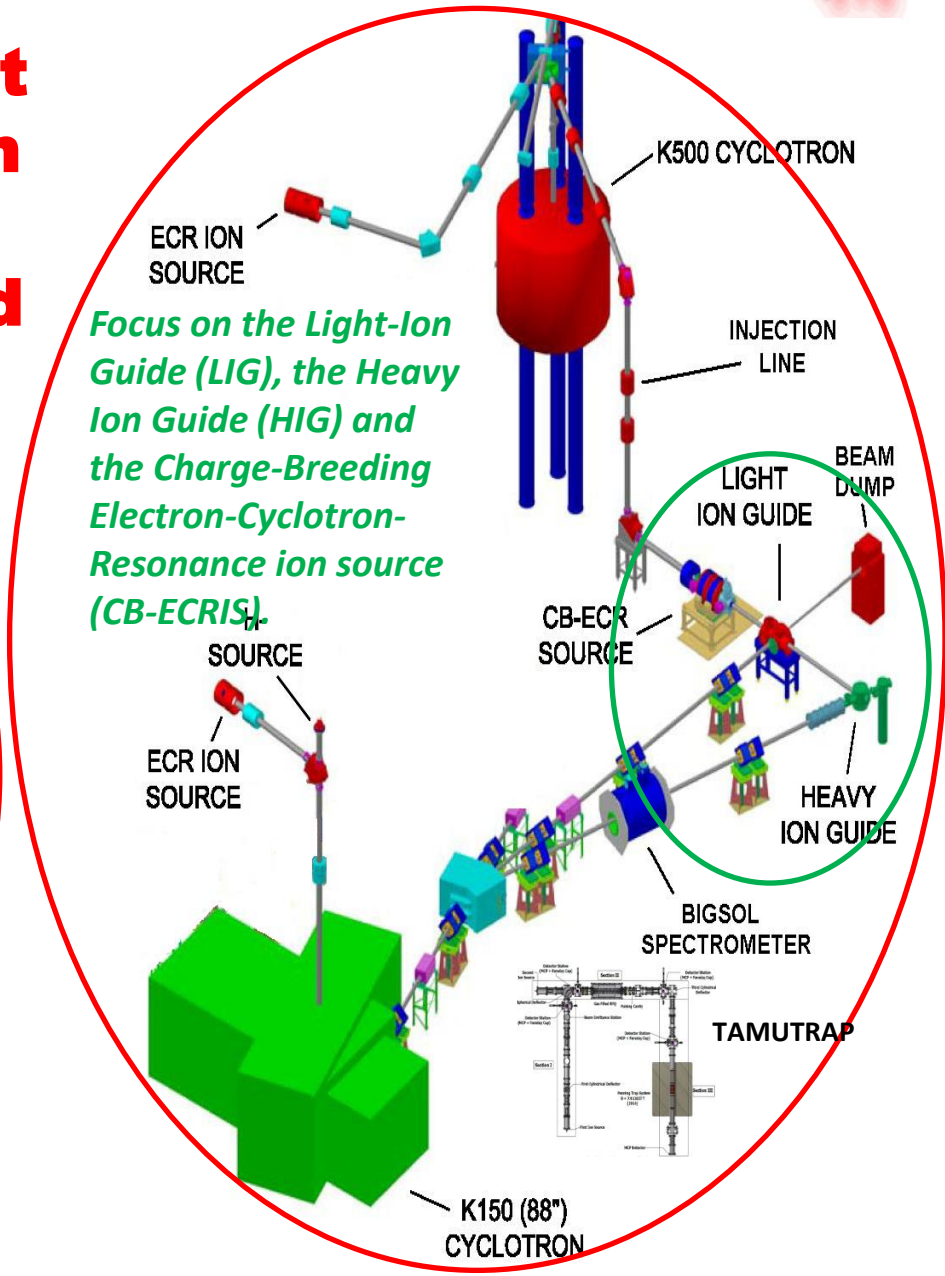
- **Reevaluation of data procedures for basic science**

Texas A&M Evaluation Center:

Data Evaluation Station at Cyclotron Radioactive Ion Beam Facility to assist experiments and



Focus on the Light-Ion Guide (LIG), the Heavy Ion Guide (HIG) and the Charge-Breeding Electron-Cyclotron-Resonance ion source (CB-ECRIS).

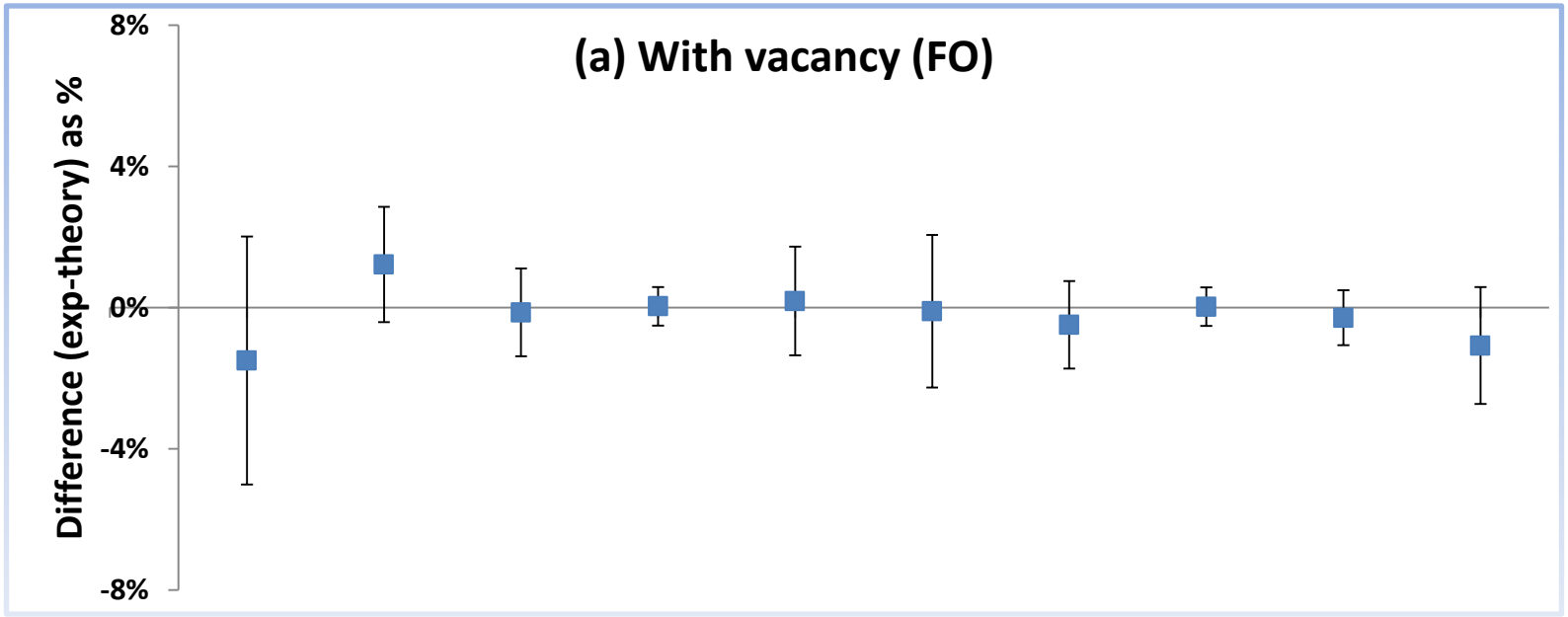


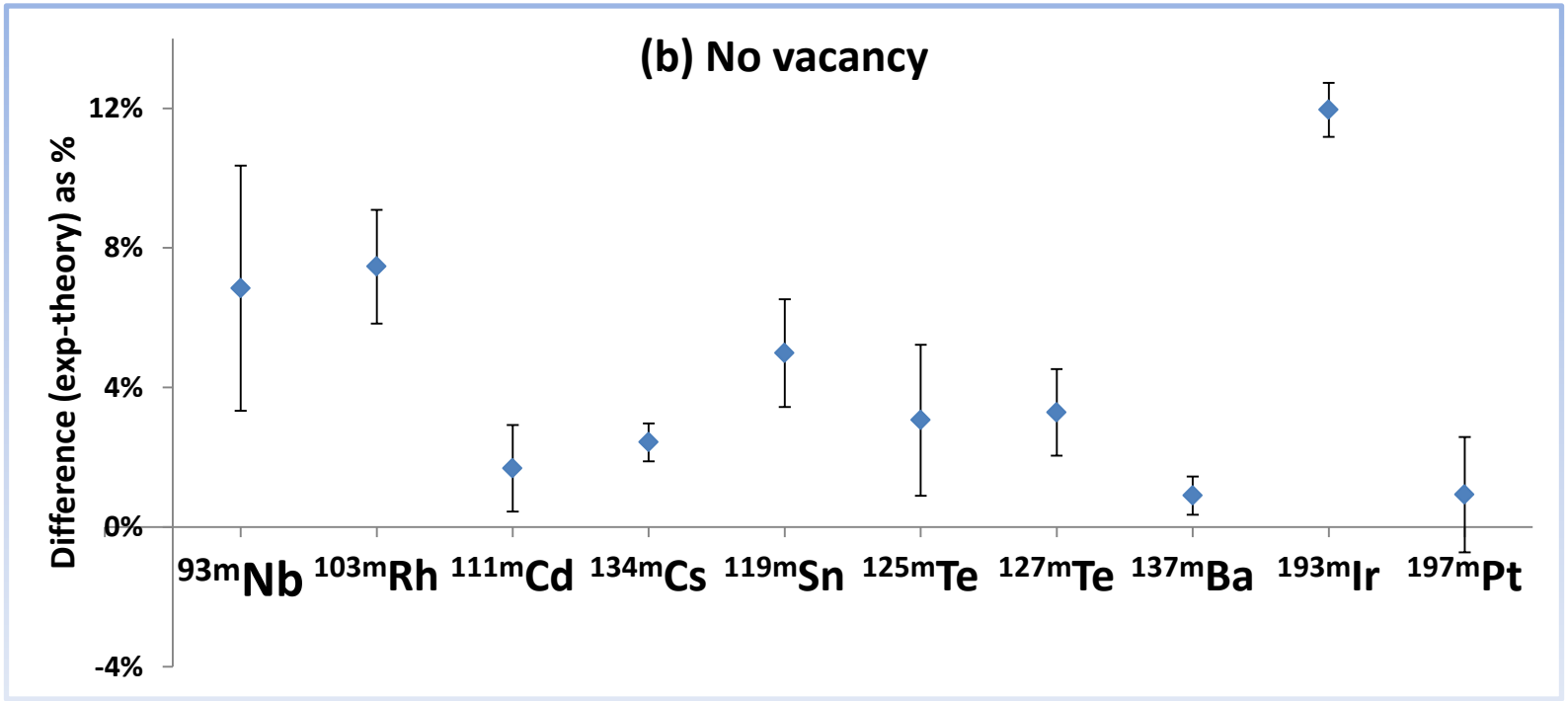
Texas A&M Evaluation Center: Expanded Involvement in Applied Measurements of Precision Internal Conversion Coefficients

Theme: Precision Measurements for USNDP

- **Texas A&M Center implied decisively by decade-long program of Internal Conversion Coefficient (ICC) Precision Measurements to guide USNDP for best appr ues**

					Calculated α_K values:		
	Parent		Transition	Measured	No	"Frozen	SCF
	State	Multipolarity	Energy (keV)	α_K	vacancy	Orbitals"	
1	^{93m}Nb	M4	30.760(5)	25600(900)	23960	25990	25440
2	^{103m}Rh	E3	39.752(6)	141.1(23)	131.3	139.4	137.2
3	^{111m}Cd	E3	150.825(15)	1.449(18)	1.425	1.451	1.446
4	^{119m}Sn	M4	65.660(10)	1621(25)	1544	1618	1603
	^{125m}Te	M4	109.276(15)	185.0(40)	179.5	185.2	184.2

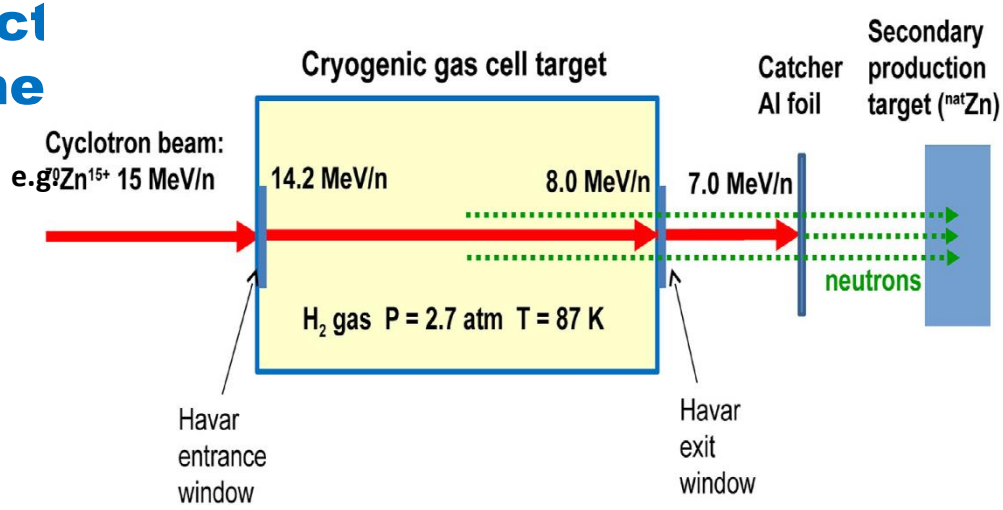

(a) With vacancy (FO)
Difference (exp-theory) as %
8%
4%
0%
-4%
-8%


(b) No vacancy
Difference (exp-theory) as %
12%
8%
4%
0%
-4%
93mNb
103mRh
111mCd
134mCs
119mSn
125mTe
127mTe
137mBa
193mIr
197mPt

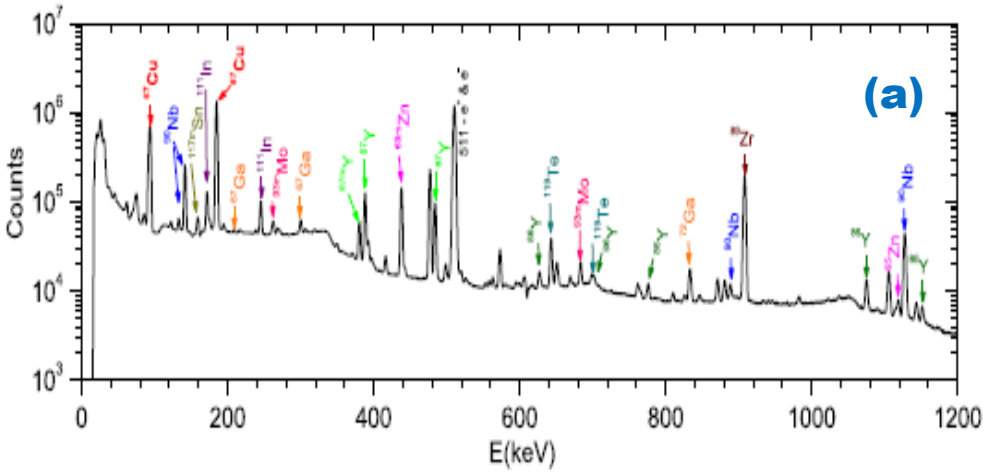
Texas A&M Evaluation Center
Expanded Involvement in Applied Measurements for Medical Isotopes Production by Inverse Kinematics

Theme: Research for Medical Isotopes Production by Inverse Kinematics

- **Innovative method for the production of important medical radioisotopes based on the nuclear reaction in inverse kinematics, by:**
  - **Directing a heavy ion beam of appropriate energy on a light target (e.g., H, d, He) and**
  - **Collect appropriate catche**



- **Case Studies (at this stage beyond the proof-of-principle):**
  - **^{67}Cu ($T_{1/2}$ = 62 h) via the reaction of ^{70}Zn beam of 15 MeV/nucleon with a cryogenic hydrogen gas target**
  - **^{99}Mo ($T_{1/2}$ = 66 h) via the reaction of ^{100}Mo of 12 MeV/nucleon with a cryogenic ^{4}He cryogenic gas target**
  - **Secondary neutrons from the primary reaction were used to irradiate a secondary target for further radioisotope production (to be further developed)**



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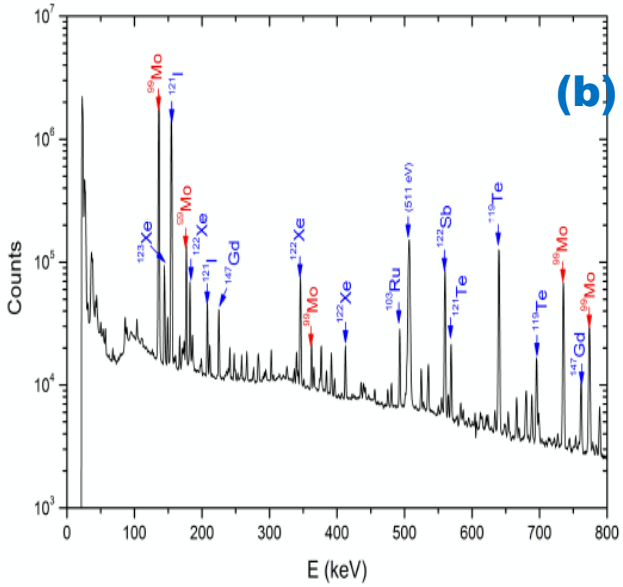


  - **Radioactive isotopes identified by γ-ray spectroscopy:**
    - **(a) ^{67}Cu run**
    - **(b) ^{99}Mo run**

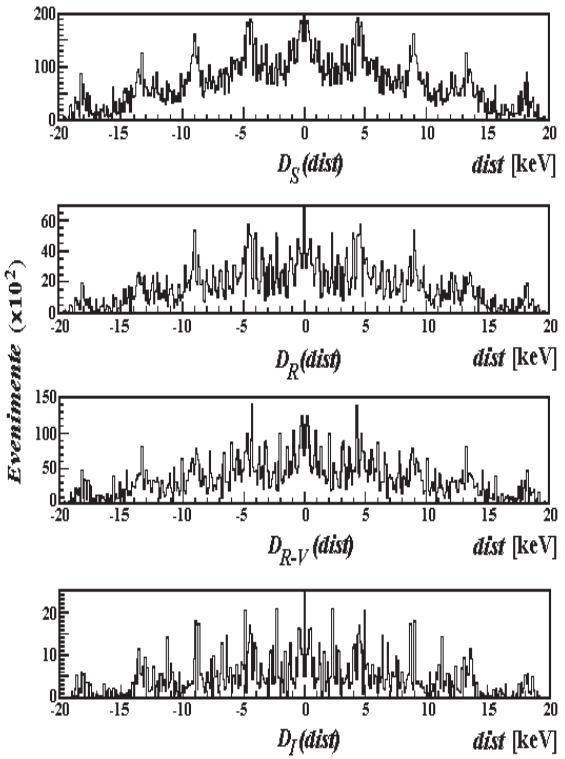
Texas A&M Evaluation Center
New Initiatives & Directions

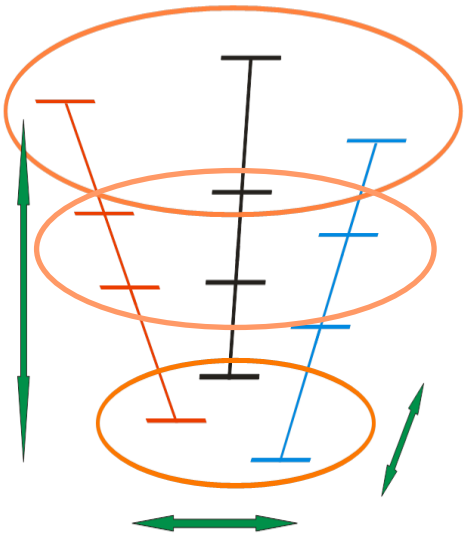
Theme: Data Evaluation for Basic Physics

- **Reevaluation of data procedures for basic science and data evaluation**

Level scheme re-concept based on

vly revealed experimental





Texas A&M Evaluation Center
Precision Internal Conversion Coefficients Measurements Follow-up

Theme: Precision Measurements for USNDP

- **Texas A&M Center implied decisively by decade-long program of Internal Conversion Coefficient (ICC) Precision Measurements to guide USNDP for best approach of theoretical ENSDF database ICC values**

					Calculated α_K values:		
	Parent		Transition	Measured	No	"Frozen	SCF
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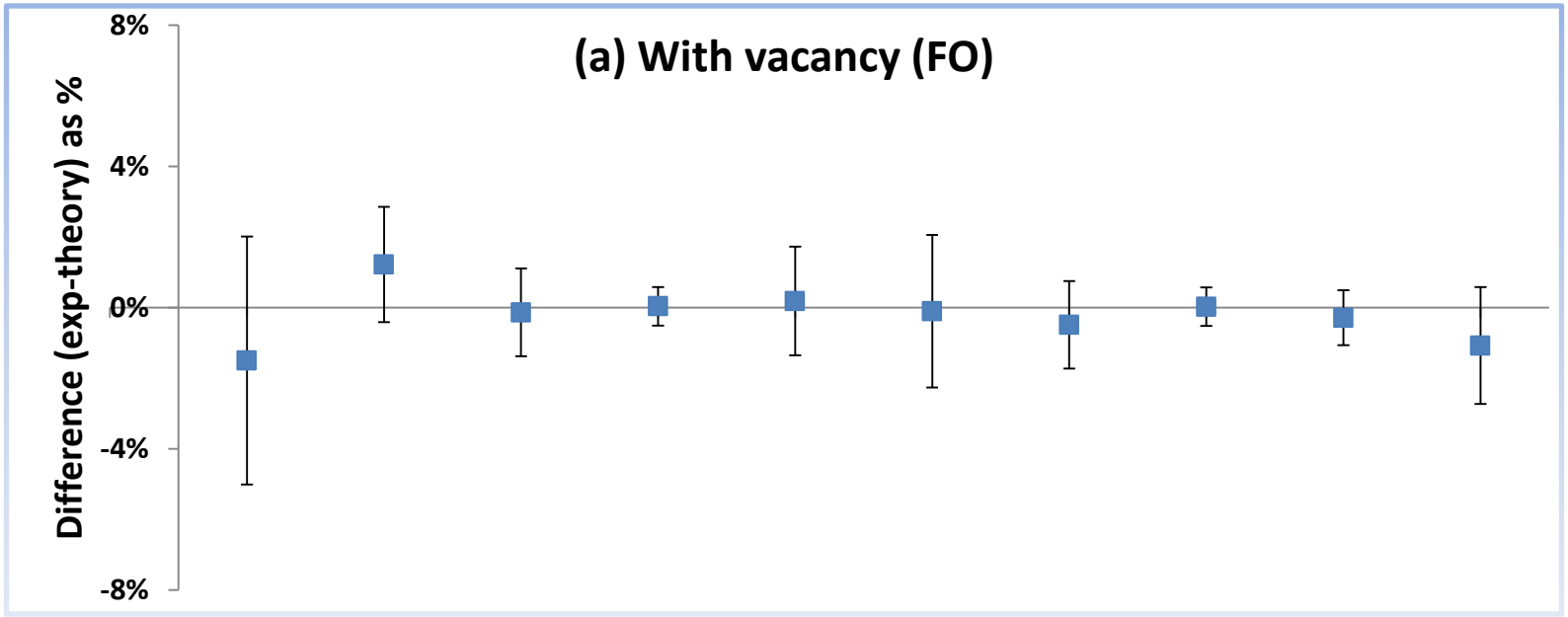
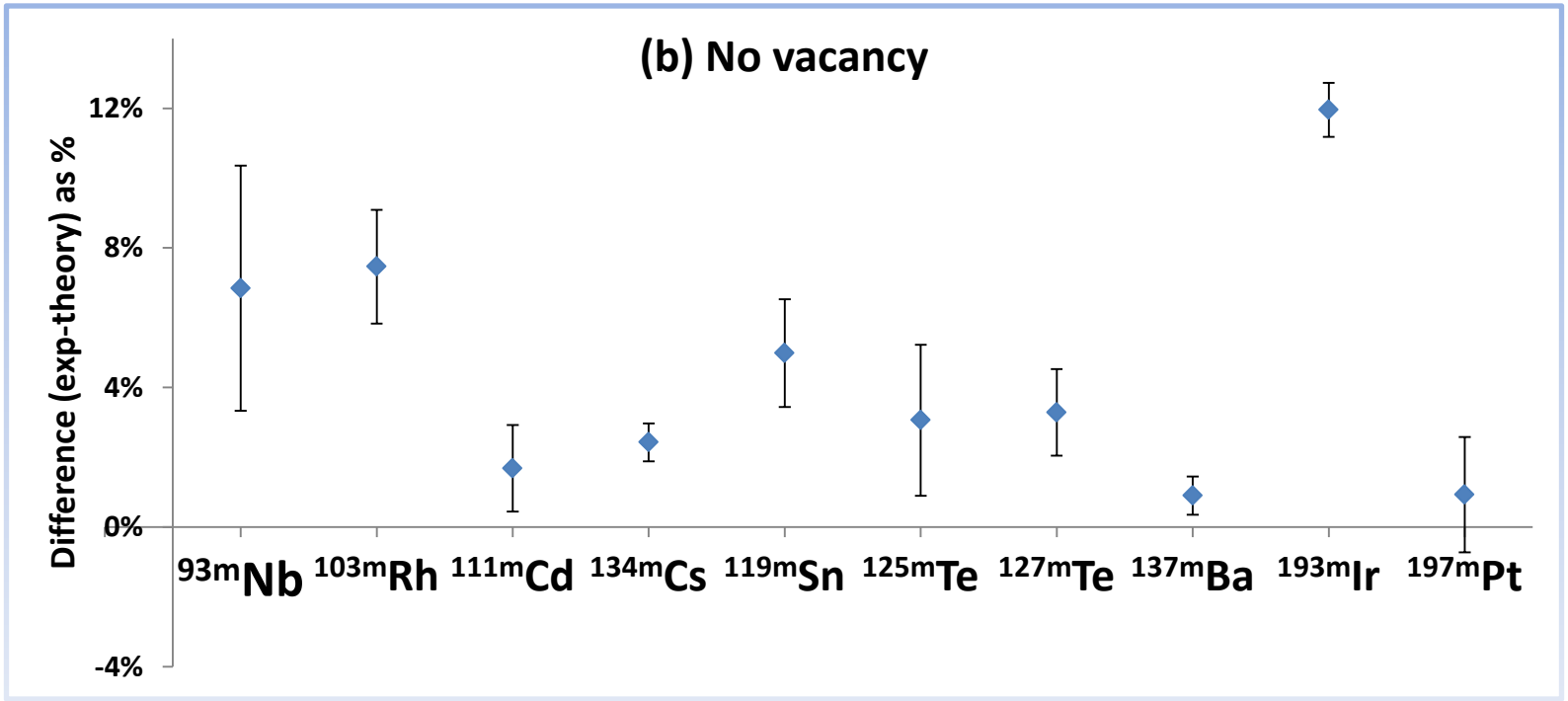
1	^{93m}Nb	M4	30.760(5)	25600(900)	23960	25990	25440
2	^{103m}Rh	E3	39.752(6)	141.1(23)	131.3	139.4	137.2
3	^{111m}Cd	E3	150.825(15)	1.449(18)	1.425	1.451	1.446
4	^{119m}Sn	M4	65.660(10)	1621(25)	1544	1618	1603
5	^{125m}Te	M4	109.276(15)	185.0(40)	179.5	185.2	184.2
6	^{127m}Te	M4	88.23(7)	484(6)	468.6	486.4	483.1
7	^{134m}Cs	E3	127.502(3)	2.742(15)	2.677	2.741	2.73
8	^{137m}Ba	M4	661.659(3)	0.0915(5)	0.09068	0.0915	0.091
9	^{193m}Ir	M4	80.22(2)	103.0(8)	92.0	103.3	99.7
10	^{197m}Pt	M4	346.5(2)	4.23(7)	4.191	4.276	4.265
				χ^2:	252	1.5	21.5


(a) With vacancy (FO)
Difference (exp-theory) as %
8%
4%
0%
-4%
-8%


(b) No vacancy
Difference (exp-theory) as %
12%
8%
4%
0%
-4%
93mNb
103mRh
111mCd
134mCs
119mSn
125mTe
127mTe
137mBa
193mIr
197mPt

Texas A&M Evaluation Center
Precision Internal Conversion Coefficients
Measurements Follow-up

- Covered the interval 93<A<197 of nuclear chart and concluded that the "frozen orbitals" hole calculations are best describing the results.
- However the calculation methodology is an approximate description of reality with no obvious reason, other than the empirical evidence, that it is universally valid.
- ***Game changer:*** the last studied case, ^{93m}Nb, was done with a Si(Li) detector that was painstakingly efficiency calibrated and it is now fit to explore for ICC measurements in the underrepresented region A<100.
- There are but two measurements close to A~200 limit and one can use the HPGe detector for more measurements in this region (and higher)

  - Conclusion: it is still possible to improve the ICC test by extending the A range

  - Possible candidates: ^{58m}Co, ^{198m}Au

$_{27}{}^{58m}Co$

$_{27}{}^{58m}Co$, Δ_K=4.7%, α_K(exp)=1860(100) (ENSDF), %unc=5.4% ; 2030(90) (2002RA45)

24.9-keV M4, single IT γ , $T_{1/2}$=9.1 h,

α_K(FO)=1840, α_K(NH)=1754

^{58}Co g.s. ε, $T_{1/2}$=70.9 d, (λ×I_{Kx})(g.s./m.s.)= 0.51(3)%

ONLY Si(Li) detector

ENSDF list of reactions:

a) There are many reactions used for *prompt* studies:

With γ measured: (α,nγ), (p,γ), (p,nγ), (n,2nγ), (d,nγ);

Only particles: (p,n), (p,d), (d,t), (d,n), (d,α), (^{3}He,d), (α,d)

that generally did not observed the 24.9γ, nor give relevant cross sections.

b) Most promising ^{58}Co IT decay dataset were considered:

1. ^{58}Ni(n,p)^{58}Co in n flux Φ=10^{14} n/cm^{2}s (1971Pl02)

- **"spectroscopically pure" NiO activated for 24 h;**
- **^{58m}Co was separated from NiO with anion-resin (Dowex-2, X-10, 200-400 mesh);**
- **Ni was washed out with 7N HCl solution => separation factor ~10^5**
- **The elude was dried and dissolved in *aqua destillata* from which it was electroplated on Pt foil**
- **99.9% enriched (from 68%) ^{58}Ni (metal, oxide) is available from Isoflex, Trace**

Texas A&M Nuclear Science Center reactor activation estimation

- **NSC fast neutron: Φ(integrated) ~ 5.1x10^{10} n/cm^{2}s (…)**
- **EXFOR V0002009: σ_{aver}(n,p,E_n)=1.1-14 MeV=478 mb (should be divided in between m.s. and g.s…)**
- **2 mg of ^{58}Ni activated for 1 h give about 1 μCi of ^{58}Co**

$^{198m}_{79}Au$

$^{198m}_{79}Au$, Δ_K=5.0%, α_K(exp)= , %unc= ;

115.2 -keV M4, multiple IT γ , $T_{1/2}$=2.3 d,

α_K(FO)=185, α_K(NH)=176

^{198m}Au IT vs. g.s.

811.715	(12-)	2.272 d 16	IT
0.0	2-	2.6941 d 2	ß-: 100 %

ONLY HPGe detector

ENSDF list of reactions to populate the IT state:

^{200}Hg(d,α) (1972Cu06), ^{197}Au(d,p) (1968Bo30,1973Pa08), ^{198}Hg(n,p) (1973Pa08),

^{196}Pt(α,pn)(1975Ma30),^{198}Pt(d,2n) (1975Ma30),

^{197}Au(n,γ) (1990Pi08).