Progress Report of Precision Internal Electron Conversion Coefficient Measurement with transition in ^{103m}Rh

TEXAS A&M PROGRAM TO MEASURE ICC
N. NICA

Internal Conversion Coefficients (ICC):

- **Big impact on quality of nuclear science**
- **Central for USNDP and other nuclear data programs**
- **Intensely studied by theory and experiment**
- **Important result: hole calculation now standard**
- ***Is the series of measurements complete?***
- ***Are there other critical cases to measure?***

2002RA45 survey ICC's theories and measurements

- **Theory: RHFS and RDF comparison**

  Exchange interaction, Finite size of nucleus, ***Hole treatment***

- **Experiment:**

  100 *E2*, *M3*, *E3*, *M4*, *E5* ICC values, 0.5%-6% precision,

  very few <1% precision!

- **Conclusions, Δ(exp:theory)%:**

No hole*: +0.19(26)% *BEST!

(bound and continuum states - SCF of neutral atom)

***Hole-SCF*: -0.94(24)%**

(continuum - SCF of ion + hole (full relaxation of ion orbitals))

***Hole-FO*: -1.18(24)%**

(continuum - ion field from bound wave functions of neutral atom

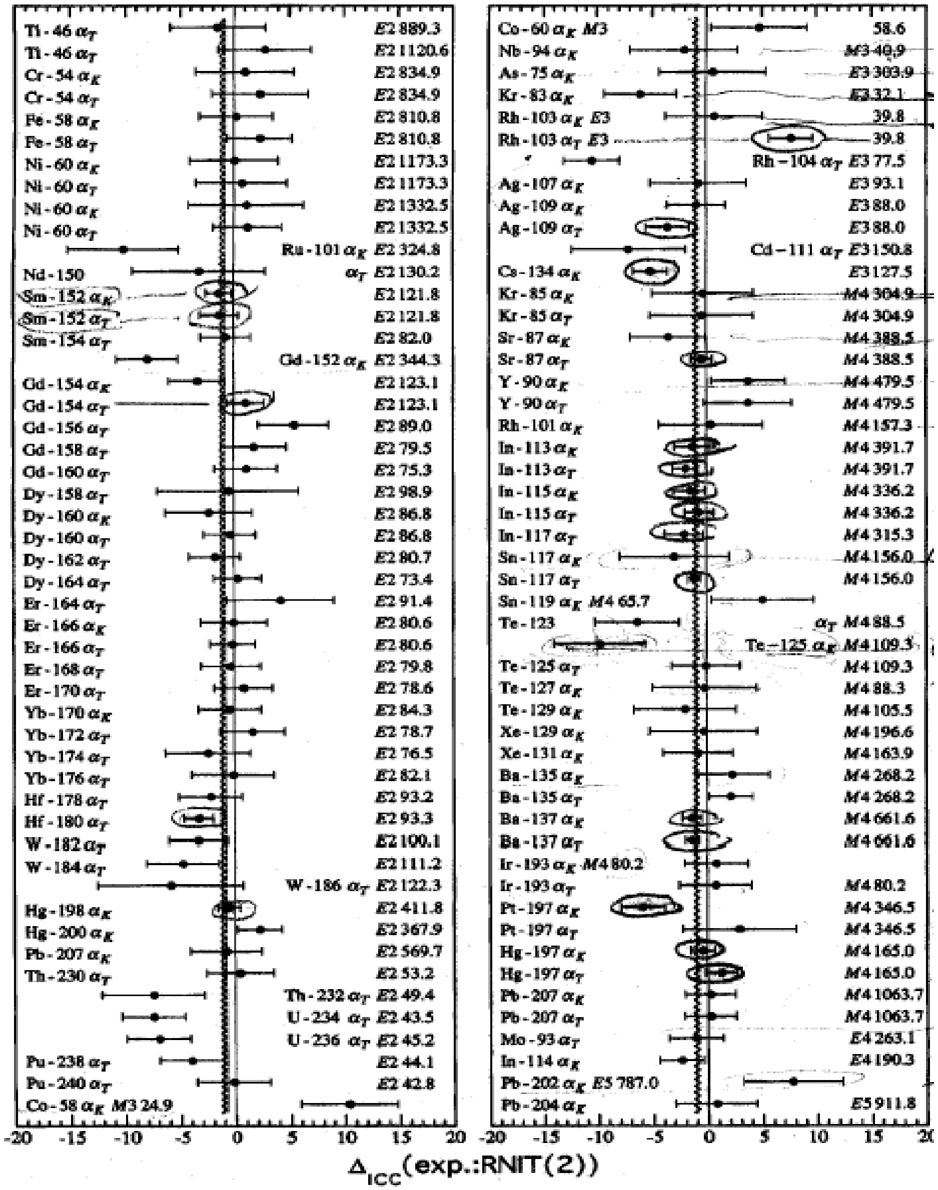
(no relaxation of ion orbitals))

PHYSICAL ARGUMENT

K-shell filling time vs. time to leave atom

$\sim 10^{-15} - 10^{-17}$ s » $\sim 10^{-18}$ s

2002Ra45: 100 α_K(exp) cases compared with 'hole FO' calculations



Texas A&M precision ICC measurements:

- **KX to γ rays ratio method**

$$\alpha_K \omega_K = \frac{N_K}{N_\gamma} \cdot \frac{\varepsilon_\gamma}{\varepsilon_K}$$

  - N_K, N_γ **measured from *only one K-shell converted transition***
  - ω_K **from 1999SCZX (**compilation and fit**)**

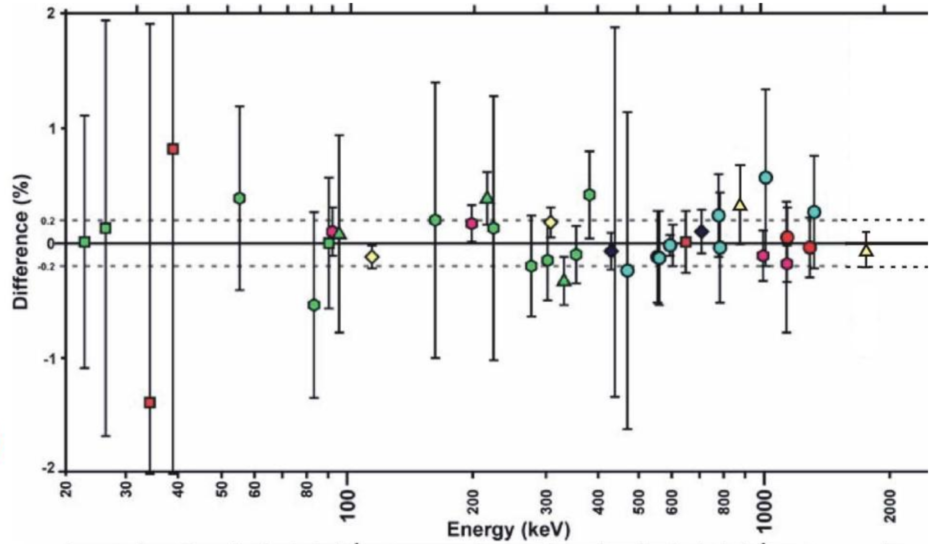
- **Very precise detection efficiency for ORTEC γ-X 280-cm^3 coaxial HPGe at standard distance of 151 mm:**
  - **0.2% , 50-1400 keV (2002HA61, 2003HE28)**
  - **0.4% , 1.4-3.5 MeV (2004HE34)**
  - **1% , 10-50 keV (KX rays domain)**

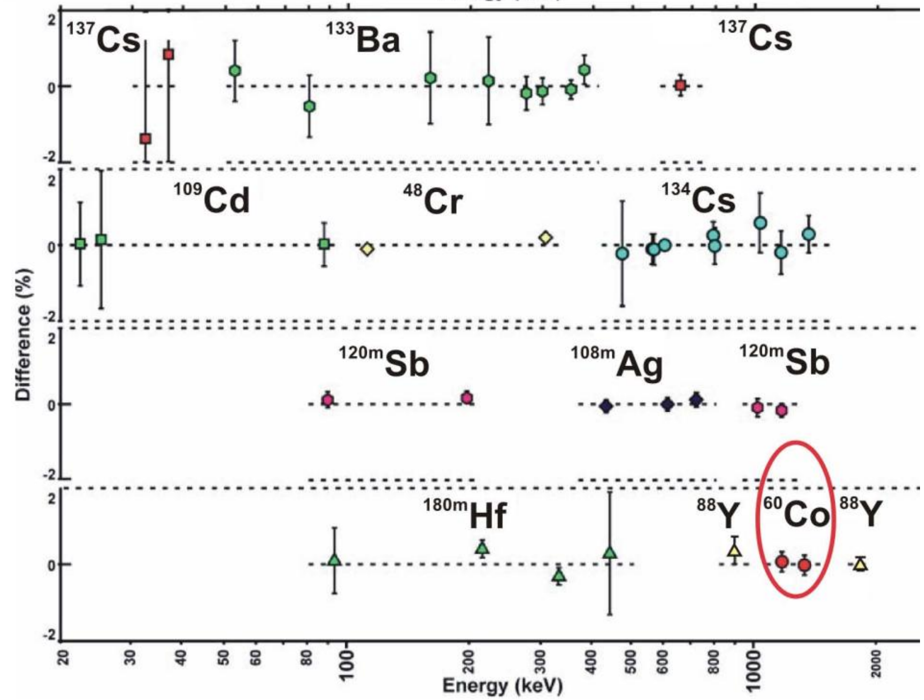
DETECTOR EFFICIENCY
50 keV < E_γ < 1.4 MeV

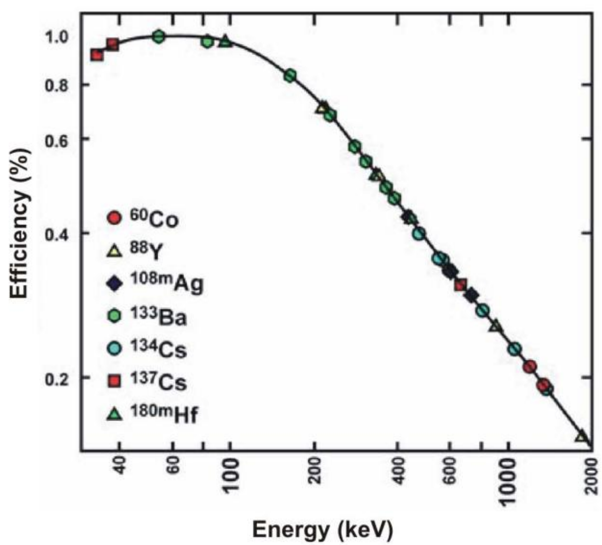
Coaxial 280-cc n-type Ge detector:

- Measured absolute efficiency (^{60}Co source from PTB with activity known to + 0.1%)
- Measured relative efficiency (9 sources)
- Calculated efficiencies with Monte Carlo (Integrated Tiger Series - CYLTRAN code)

0.2% uncertainty for the interval 50-1400 keV





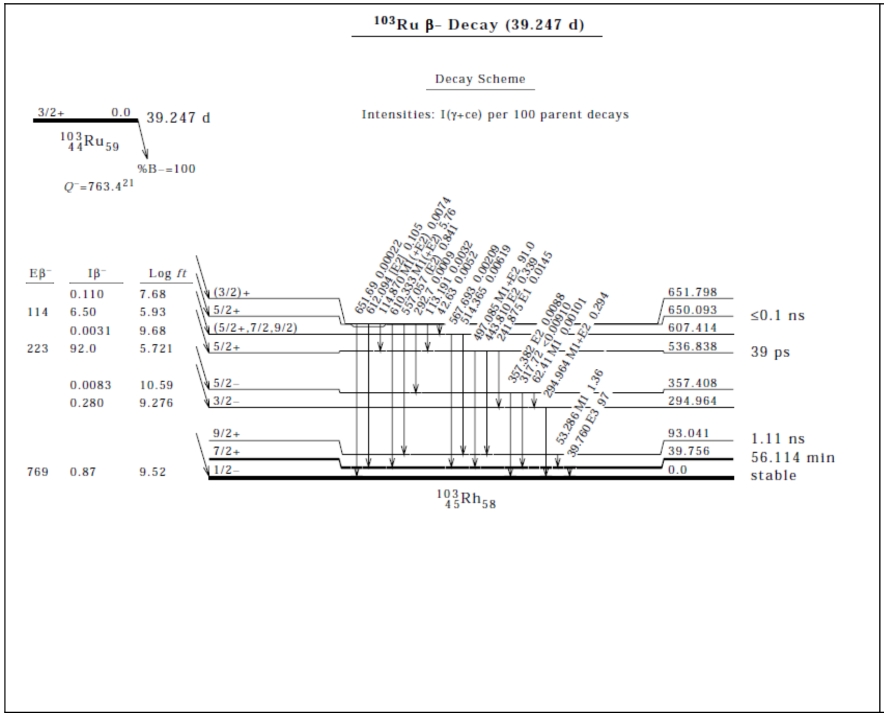


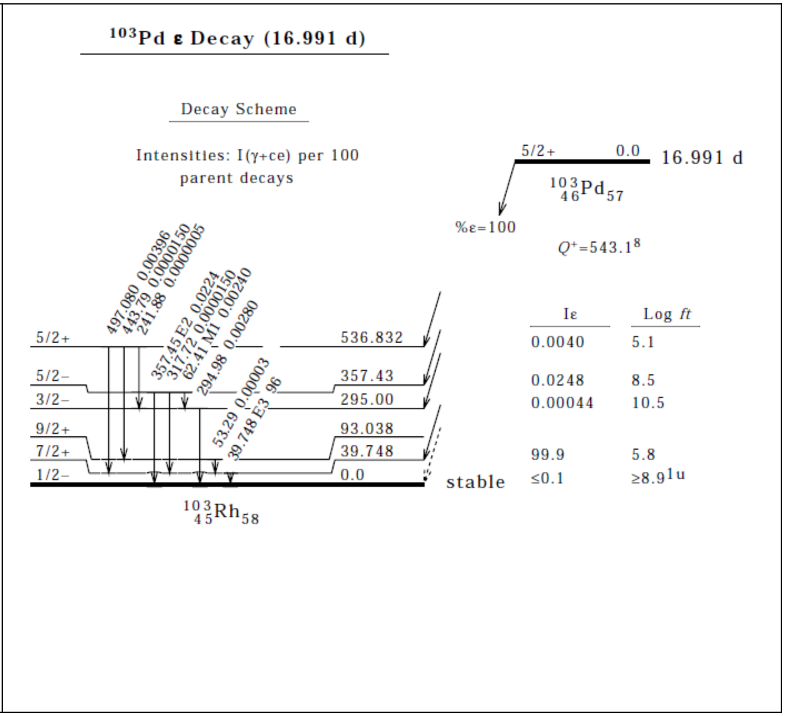
KX to γ rays ratio method

- **Sources for n_{th} activation**
  - **Small selfabsorption (< 0.1%)**
  - **Dead time (< 5%)**
  - **Statistics (> 10^6 for γ or x**
  - **High spectrum purity**
  - **Minimize activation time (0.5 h)**
- **Impurity analysis - *essentially based on ENSDF***
  - **Trace and correct impurity to 0.01% level**
  - **Use decay-curve analysis**
  - **Especially important for the K X-ray region**
- **Voigt-shape (Lorentzian) correction for X-rays**
  - **Done by simulation spectra, analyzed as the real spectra**
- **Coincidence summing correction**

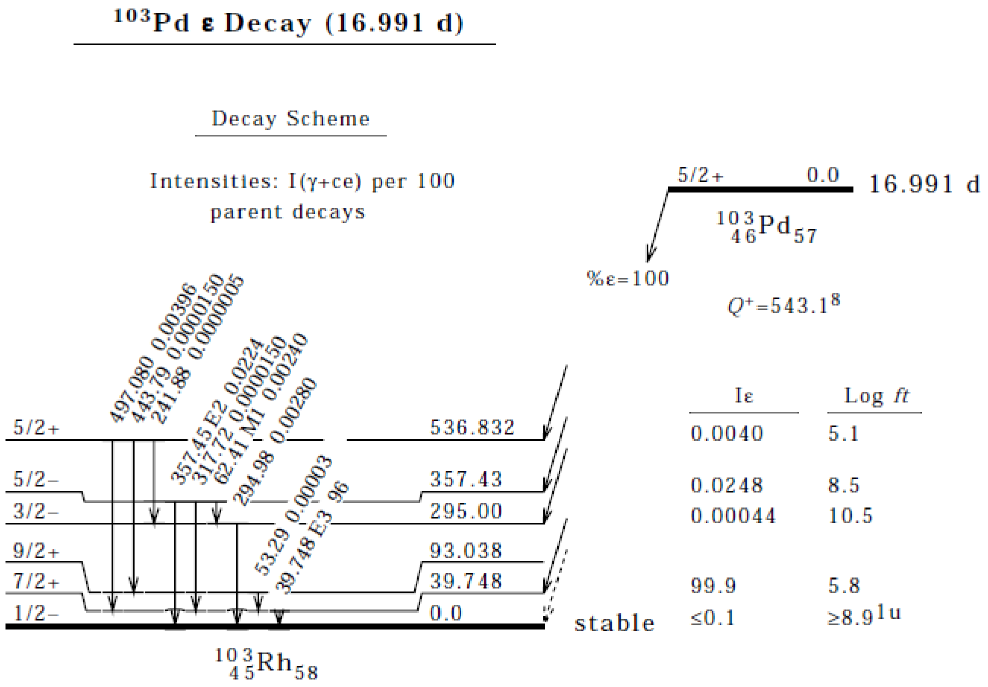
^{103m}Rh 39.748 keV, E3 transition

- α(K)exp = 138 *5* (1970NiZV), %unc=3.6
- α(K)exp = 127 *6* (1975Cz03), %unc=4.7
- $\alpha(K)_{hole\_FO}$ = 135.2(19), $\alpha(K)_{no\_hole}$ = 127.4(18)

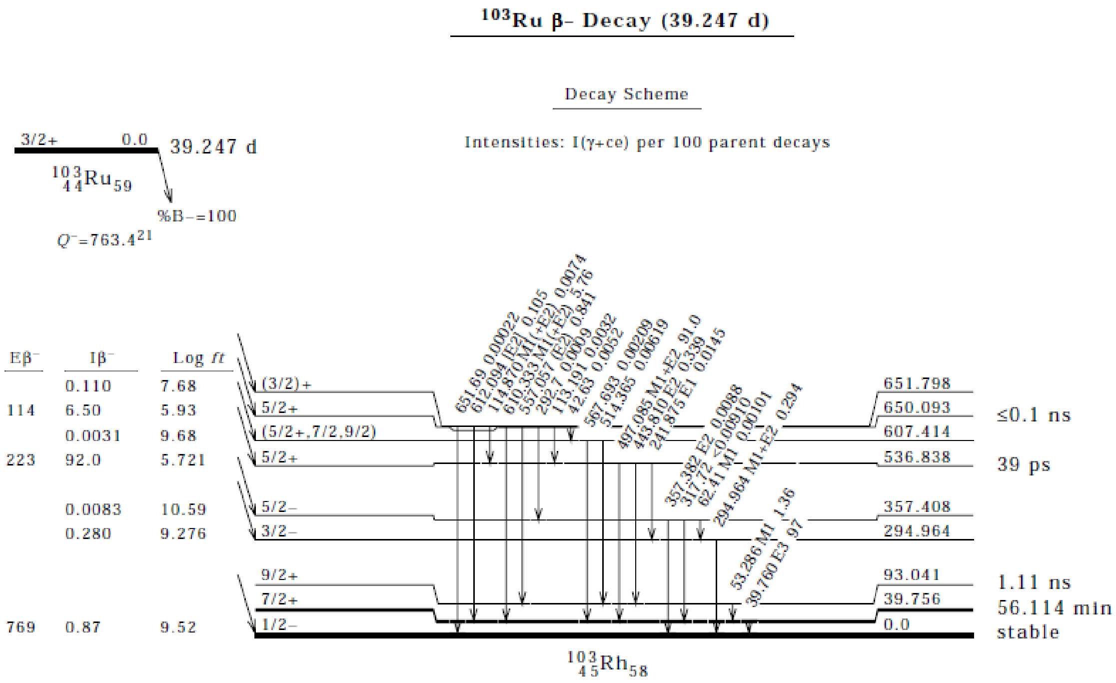




^{103}Pd ε Decay



^{103}Ru β^- Decay



^{103m}Pd -> ^{103m}Rh 39.748 keV, E3 transition

- 25 mm × 25 mm × 4 μm ^{nat}Pd foil
  - $\Phi = 7.5 \times 10^{12}$ n/(cm^{2}s)
  - $\alpha_{th} = 3.4(3)$ b
  - Sample activated 10 h, then cooled down for 15 days
  - Measured for several weeks

^{103m}Ru -> ^{103m}Rh 39.748 keV, E3 transition

1. **Sample I: 1.06(5) mg of Ru_2O, 0.66(3) μm thick, on 25 μm thick Al backing**
   - Activated for 20 h at 7.5×10^{12} n/(cm^{2}s) at NSC reactor (TAMU)
   - $\sigma_{th}(^{102}Ru) = 1.21(7)$ b
   - Measured after 30 days
2. **Sample II: 0.7 mg of Ru metal, 0.9 μm thick**
   - Activated for 20 h at 7.5×10^{12} n/(cm^{2}s) at NSC reactor (TAMU)
   - *To be measured after 30 days*

Results for ^{103m}Rh 39.748 keV, E3 transition

Very preliminary!!!

^{103m}Ru β^- decay

Experimental: $\alpha_K = 135(3)$

Vacancy FO : $\alpha_K = 135.2(19)$

No Vacancy : $\alpha_K = 127.4(18)$

^{103m}Pd ε decay

Experimental: $\alpha_T = 1432(44)$

Vacancy FO : $\alpha_T = 1404(20)$

No Vacancy : $\alpha_T = 1389(20)$