Joint CNA/JINA-CEE Winter School on Nuclear Astrophysics

Charge and frequency resolved isochronous mass spectrometry: the mass of ^{51}Co and isospin-nonconserving forces

Dr. Peng SHUAI

Institute of Modern Physics

Outline

- **Introduction:**

  Isospin symmetry and Isospin non-conserving forces

- **Charge and frequency resolved isochronous mass spectrometry:**

  Pulse height analysis for the particle identification of $^{34}Ar^{18+}$ and $^{51}Co^{27+}$ ions and the mass of ^{51}Co

- **Coulomb displacement energy:**

  Isospin non-conserving forces for the mirror nuclei with T=3/2 in fp-shell

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Isospin symmetry

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- 1932, Heisenberg, “Isospin”:

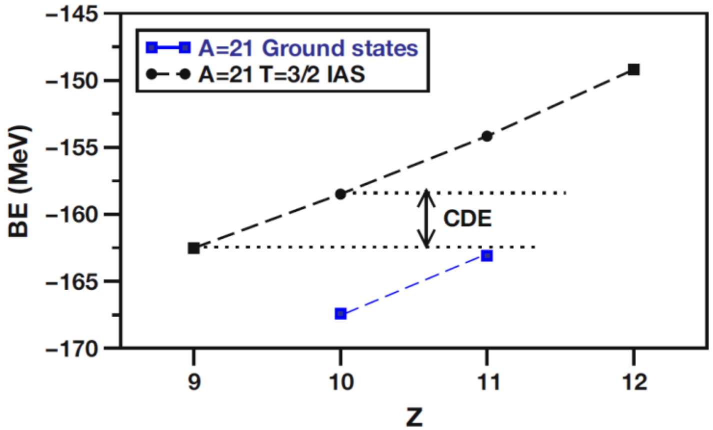
$$V_{pp} = V_{nn}$$ $$V_{pp} + V_{nn} = 2V_{pn}$$

the concepts of charge-symmetry and independence can result in identical behavior of proton and neutron.

$$T_z(p) = -1/2, \qquad T_z(n) = 1/2$$

- 1937, Wigner, “Isobaric Analog State (IAS)” :

$$A, \quad T, \quad J^\pi,$$
$$T_z = -T, -T+1, \ldots, T-1, T$$



Coulomb displacement energy

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❖ Coulomb displacement energy

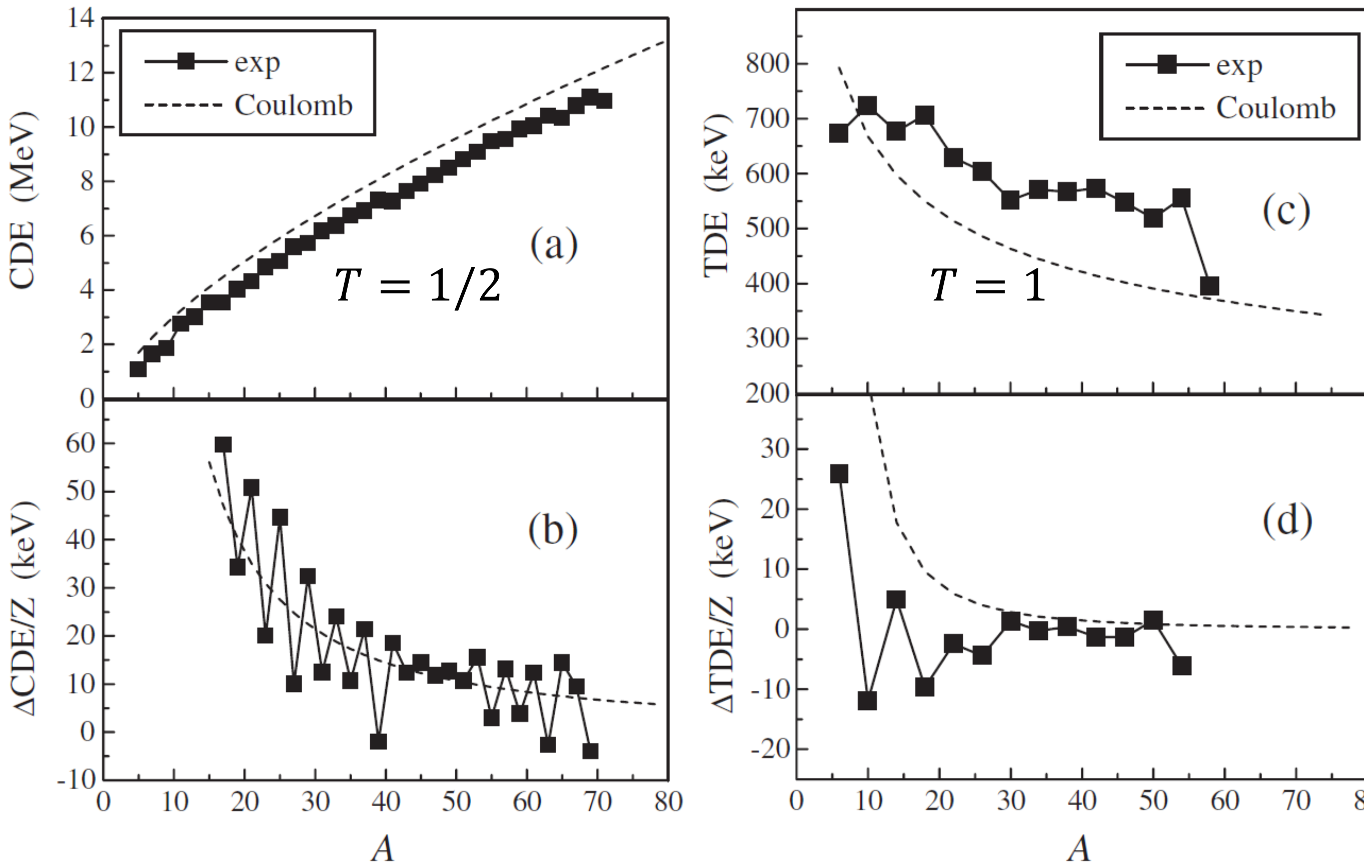
$$CDE(A,T,T_z) = M_{T,T_z} - M_{T,T_z+p} + p\Delta_{nH}$$

❖ Odd-even stag

$$\Delta CDE(A,T,T_z)$$

❖ Triplet displac

$$TDE(A,T=1)$$



Isovector and Isotensor

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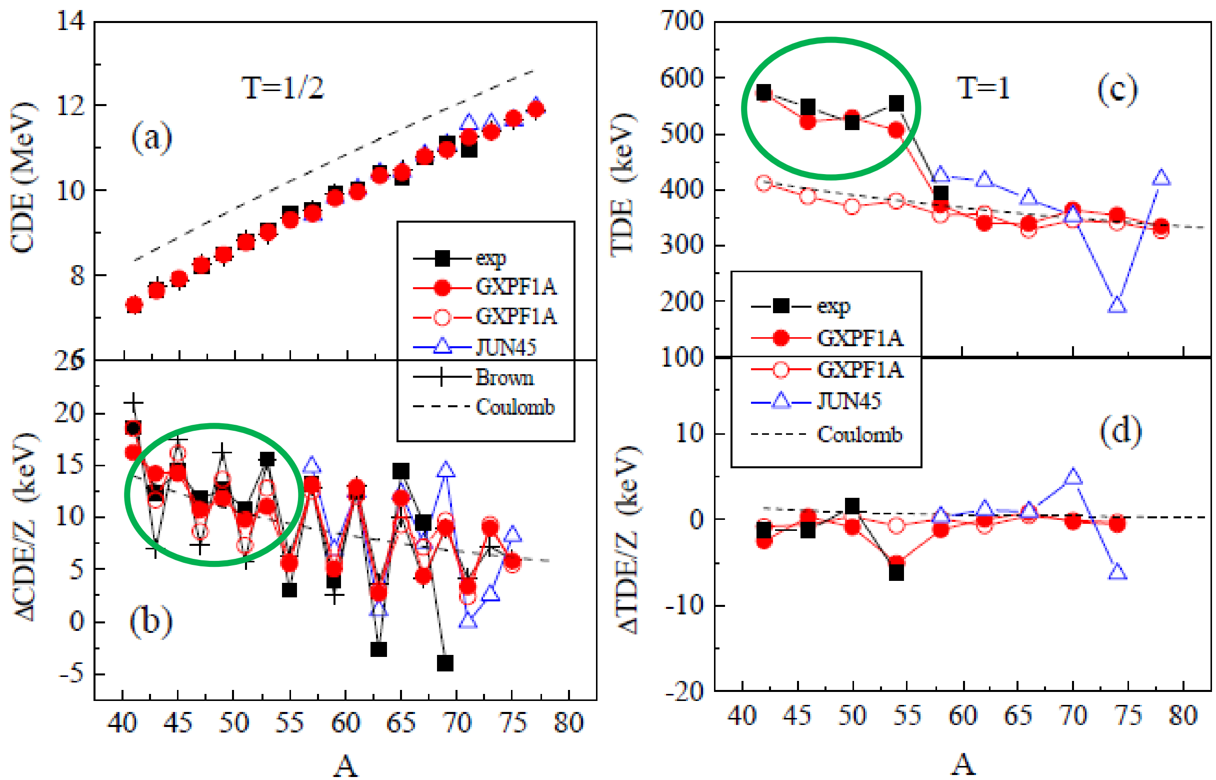
Isovector *Isotensor*

$$V^{(1)}_{INC} = V_{pp} - V_{nn}, \quad V^{(2)}_{INC} = V_{pp} + V_{nn} - 2V_{pn}$$



Kaneko, Sun, Mizusaki, Tazaki, Phys. Rev. Lett. 110 (2013) 172505

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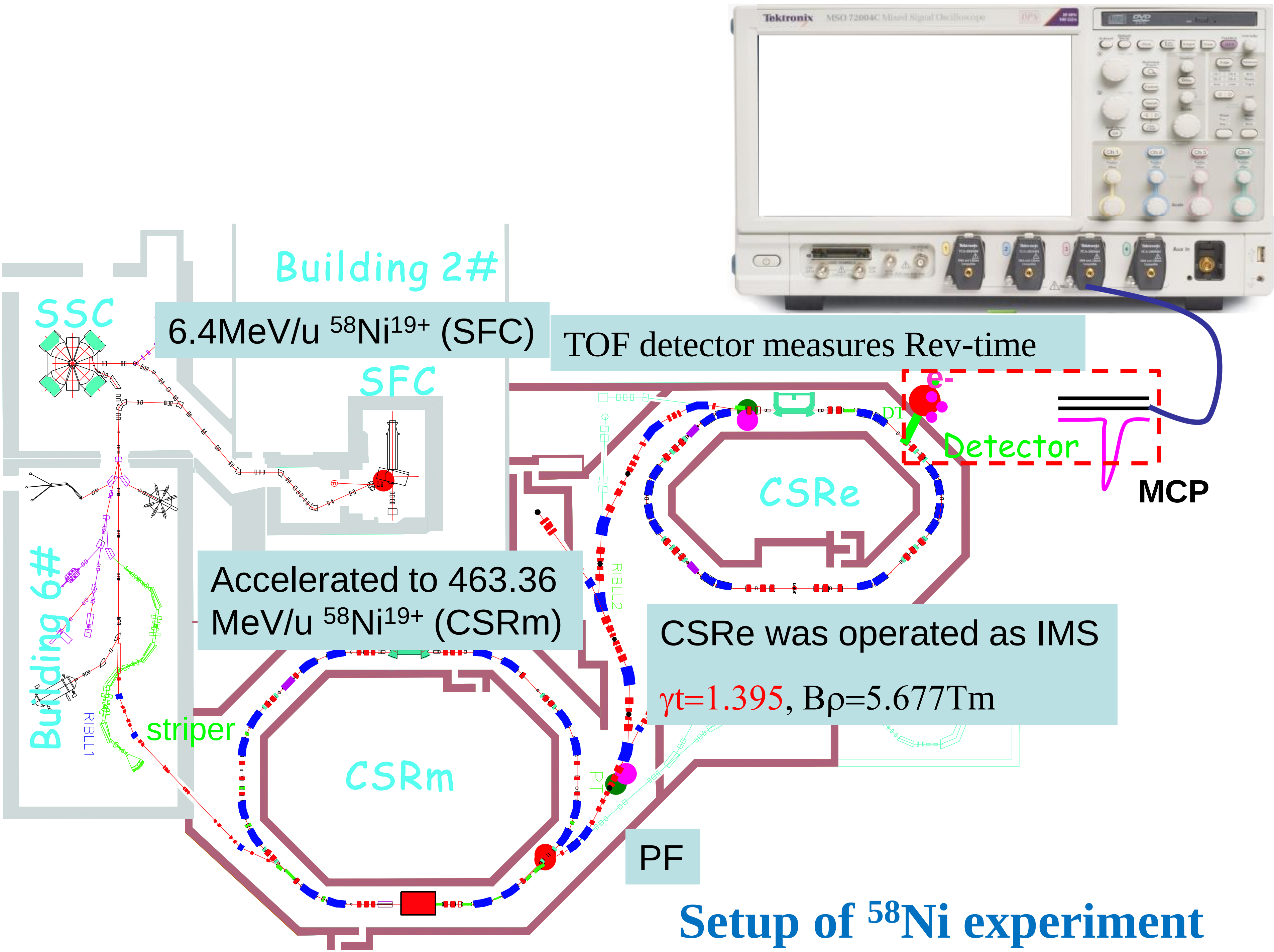
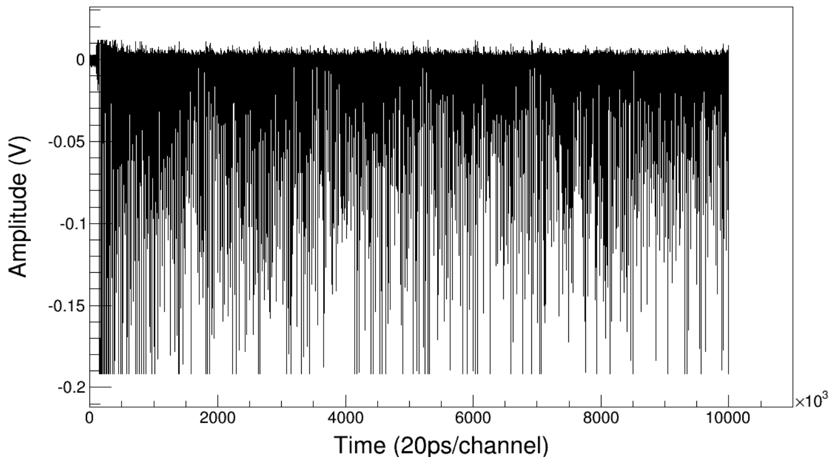
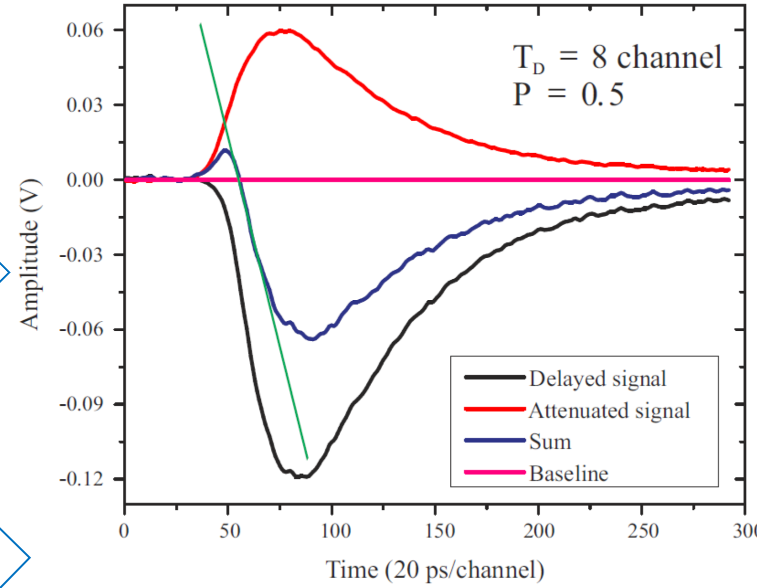
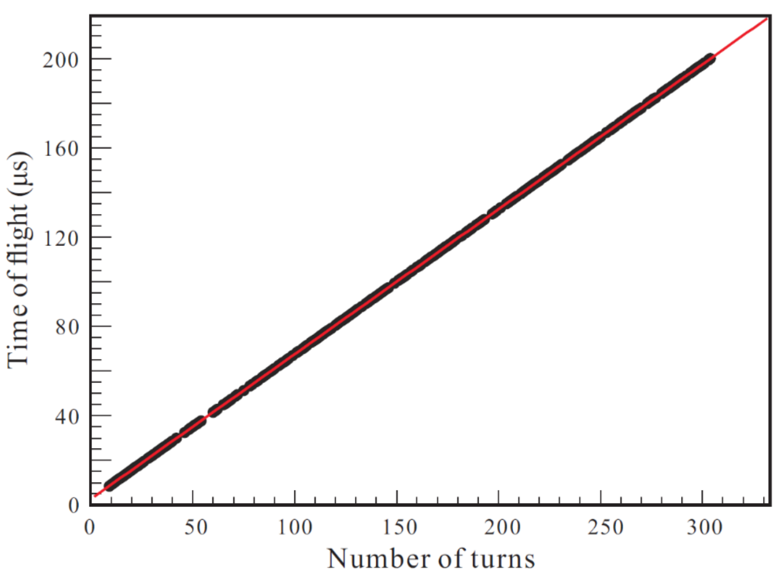


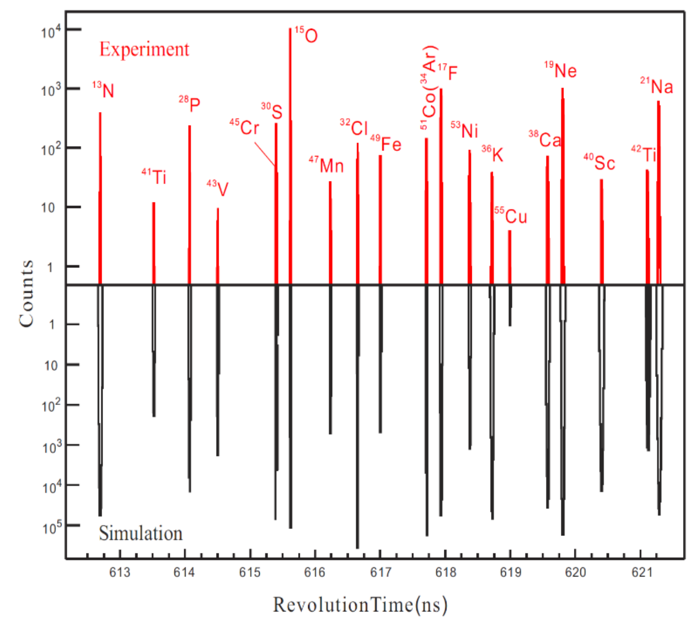
Setup of ^{58}Ni experiment

Data analysis of IMS

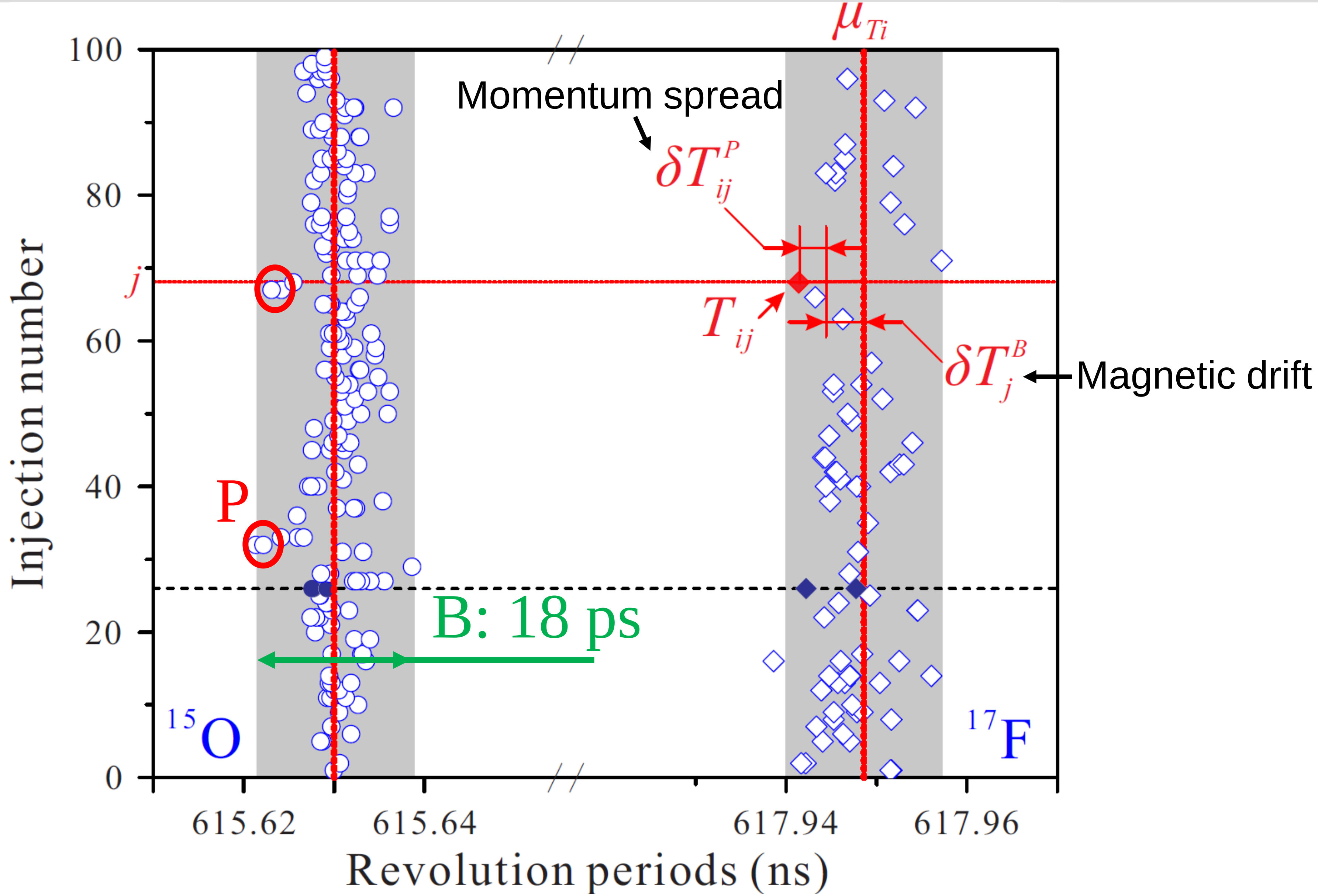






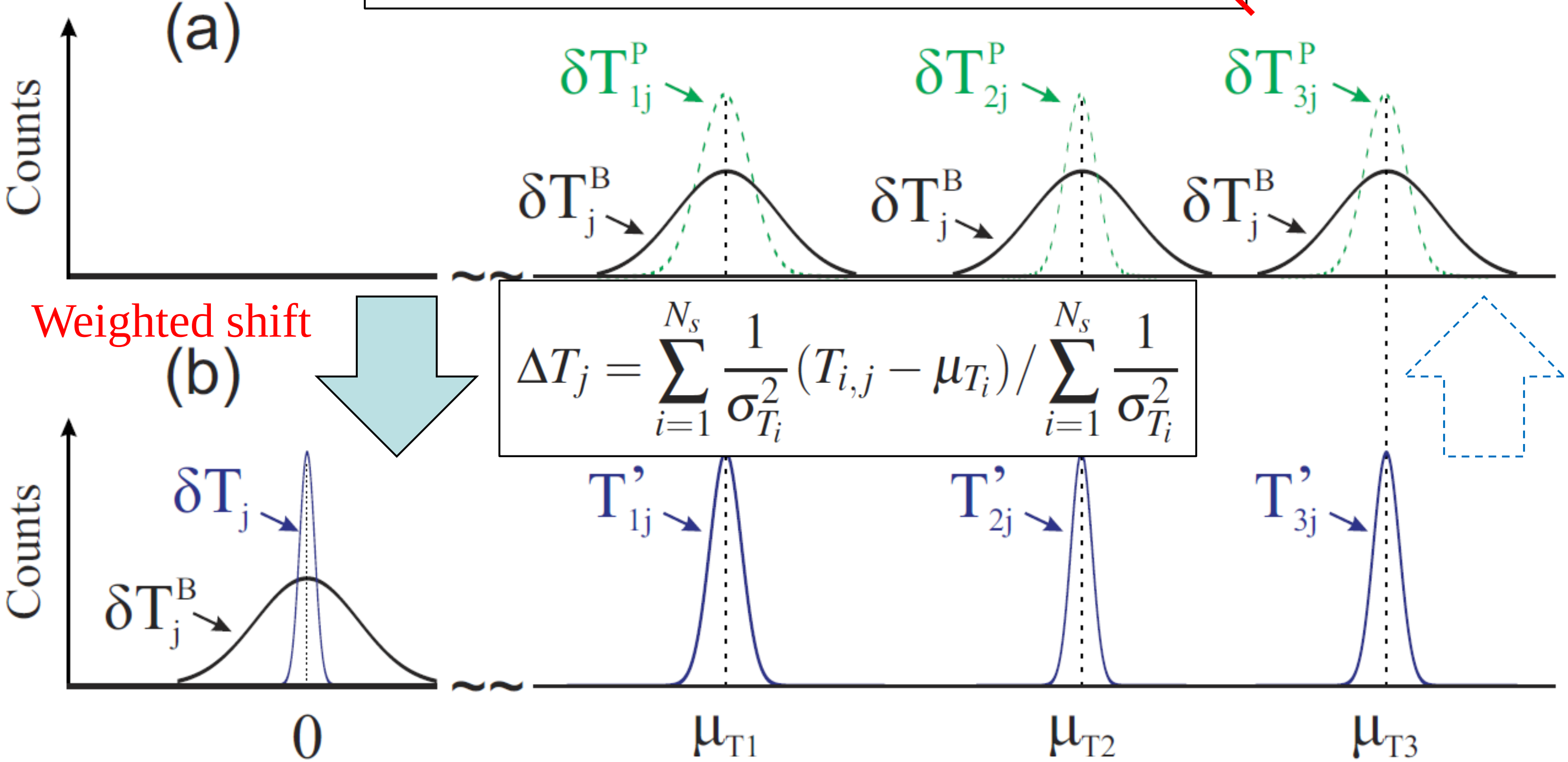


Influence of magnetic drift



Weighted shift correction

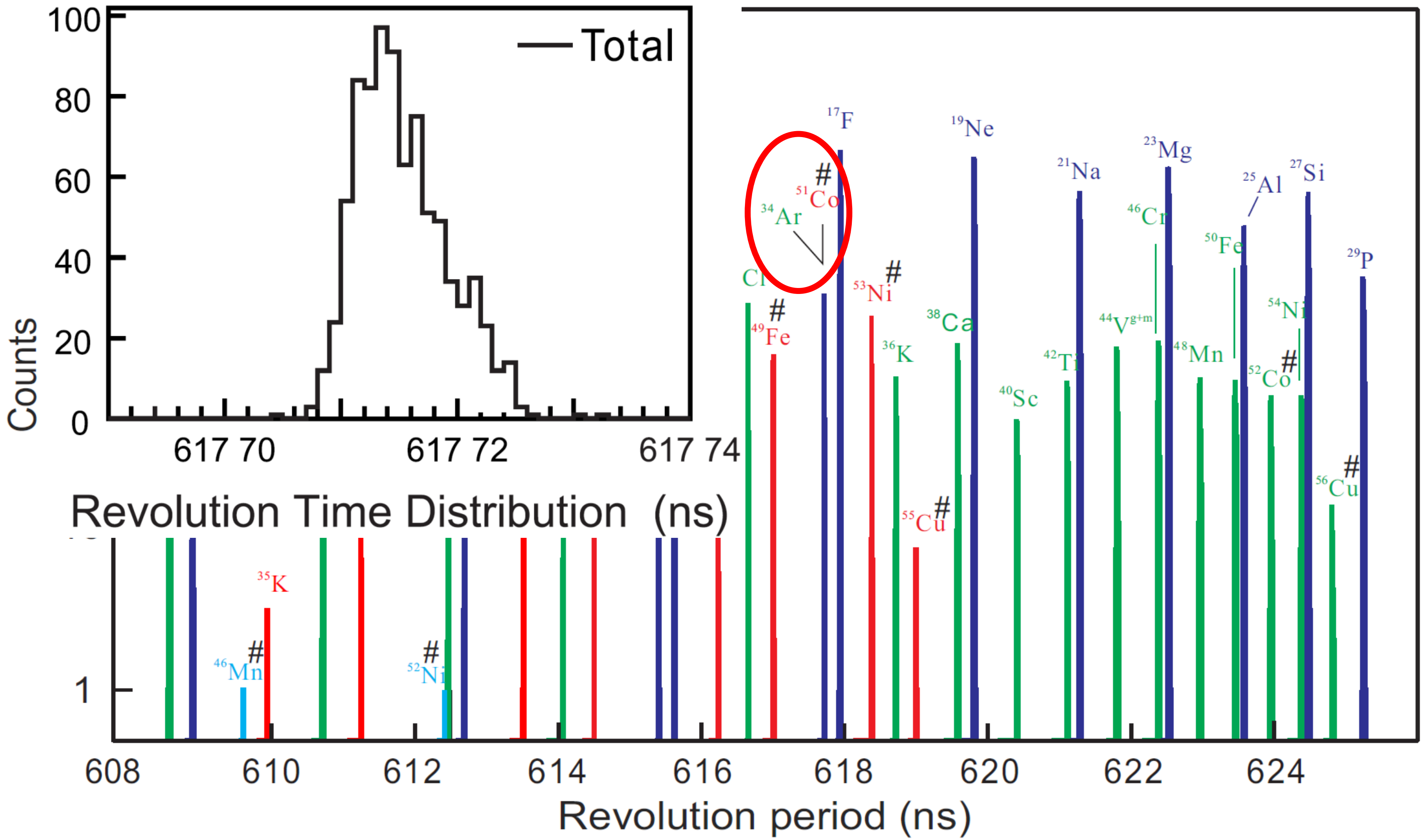
$$T_{i,j} = \mu_{T_i} + \delta T^{P}_{i,j} + \delta T^{B}_{j}$$



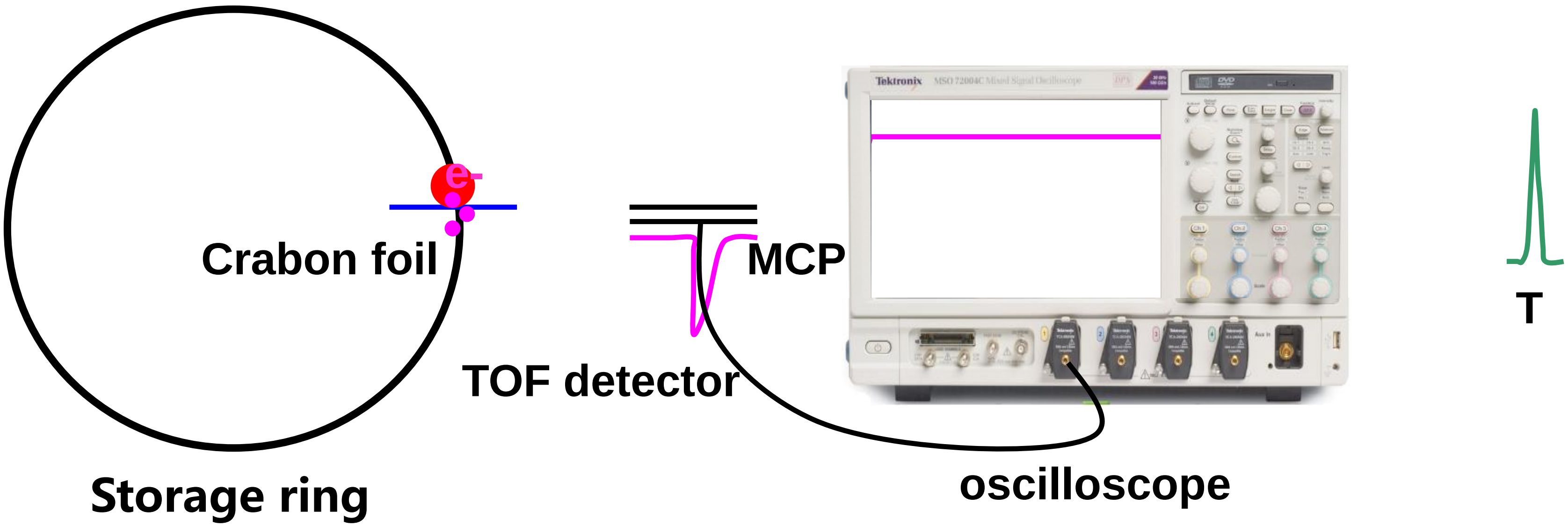
$$\Delta T_j = \sum_{i=1}^{N_s} \frac{1}{\sigma^2_{T_i}} (T_{i,j} - \mu_{T_i}) / \sum_{i=1}^{N_s} \frac{1}{\sigma^2_{T_i}}$$

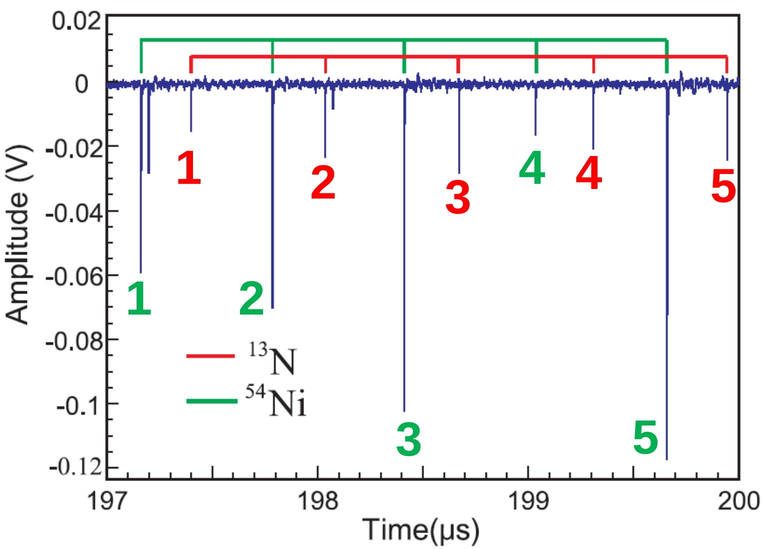
$$\sigma^2_{T_i} = s^2_{T'_i} + \frac{1}{\frac{1}{\sigma^2_{T_1}} + \frac{1}{\sigma^2_{T_2}} + \cdots + \frac{1}{\sigma^2_{T_{N_s}}}}$$

Revolution time Spectrum



Mean pulse height





Mean pulse height ⇔ Secondary electrons ⇔ Energy loss ⇔ Z^2

PID of ^{34}Ar and ^{51}Co

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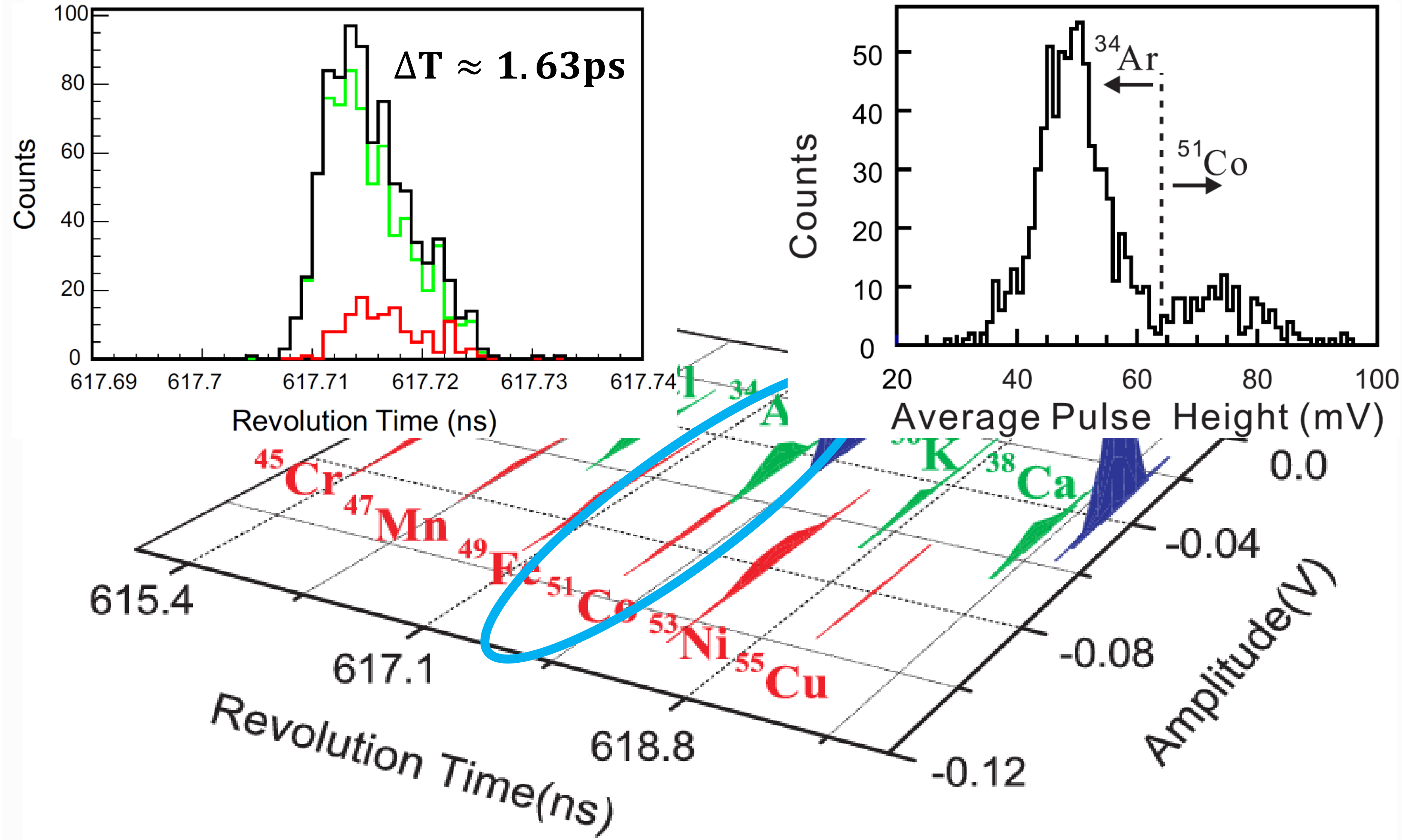

The mass of ^{51}Co

The experimental masses of ^{51}Co and ^{34}Ar

- ME(^{51}Co) = -27342(48) keV
- ME(^{34}Ar) = -18379(15) keV

The masses of ^{51}Co and ^{34}Ar in AME

- ME(^{51}Co) = -27274#(149#) keV
- ME(^{34}Ar) = -18377.387(335) keV

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Mirror nuclei with T=3/2

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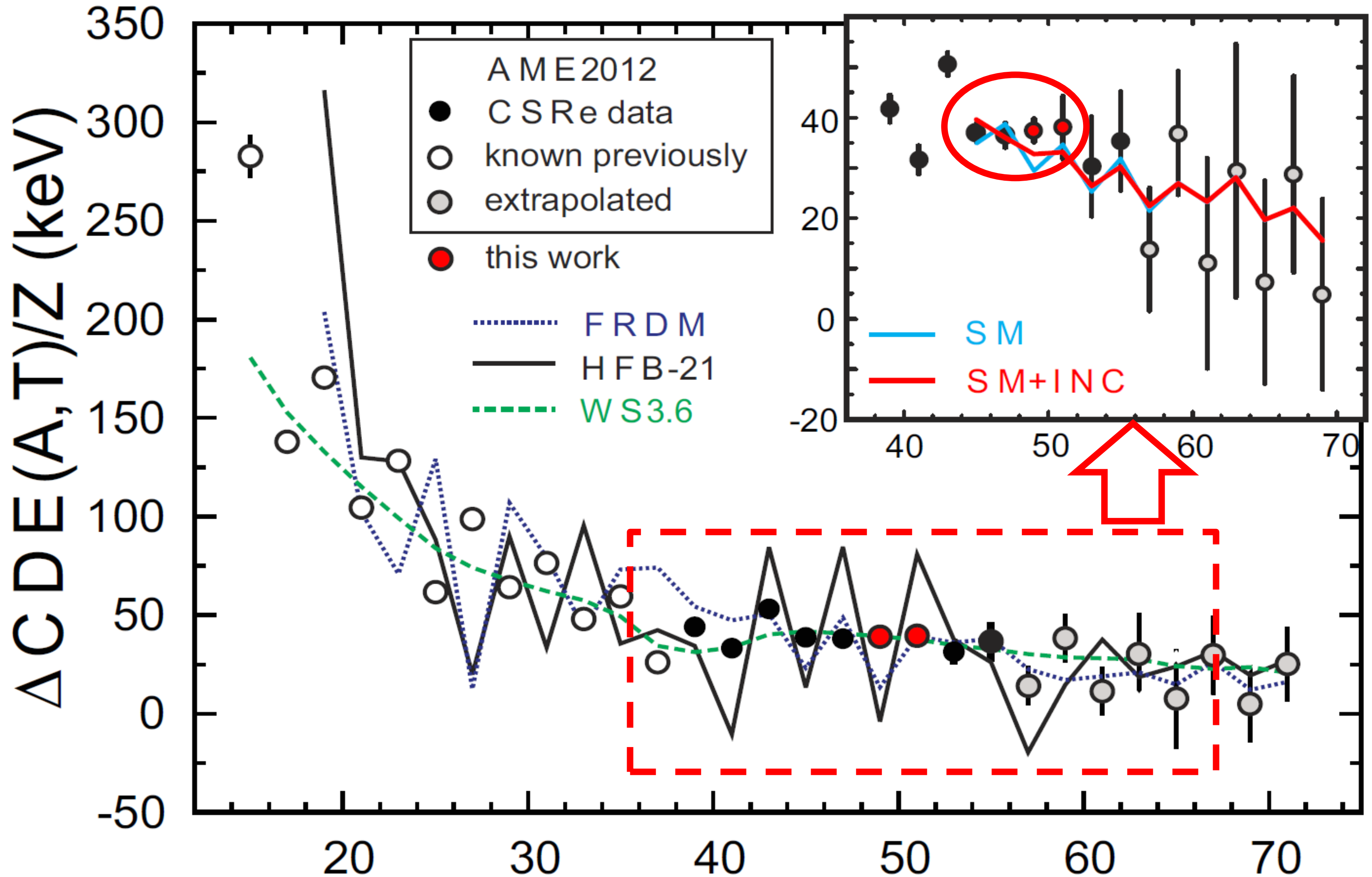
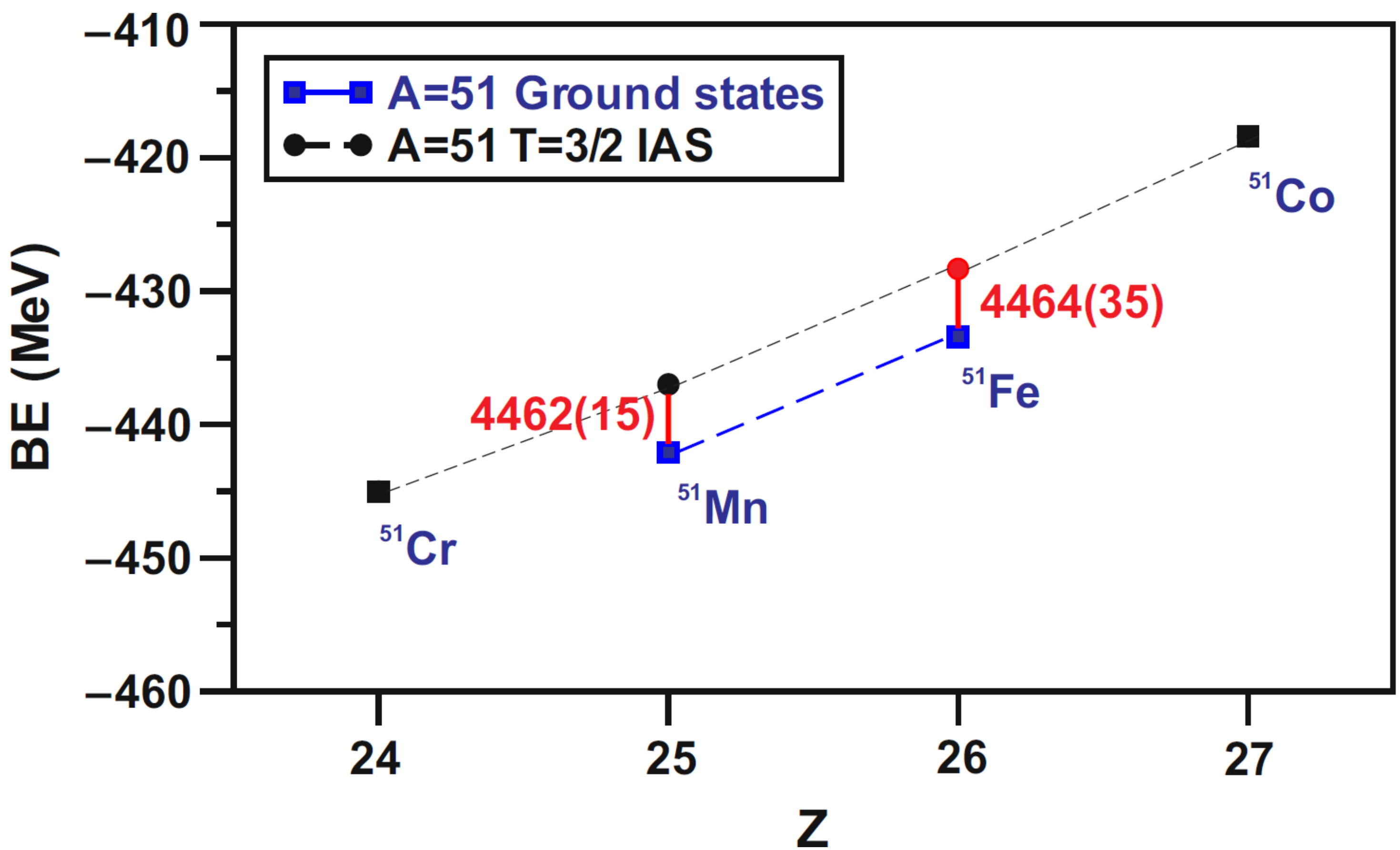


P.Shuai, et al. Physics Letters B 735 (2014) 327–331

The Ex of the IAS of ^{51}Fe

$$\mathrm{ME}(A,T,T_z) = a(A,T) + b(A,T)T_z + c(A,T)T_z^2$$



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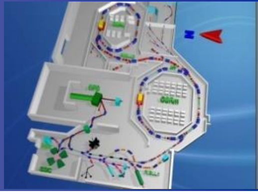
- We developed the charge and frequency resolved isochronous mass spectrometry for ions very close m/q.

- I developed a new method to correct the magnetic shift in IMS experiments. The new method is the key improvement of IMS for mass measurements of isomers.

- We have measured many new masses near the proton-dripline. The investigation of coulomb displacement energy indicates the isospin nonconserving forces should be considered in the shell model calculation of fp-shell.

Thank you for your attention



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