DE LA RECHERCHE À L'INDUSTRIE

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Experiment E143

Search for the nuclear two-photon decay in swift fully-stripped heavy ions

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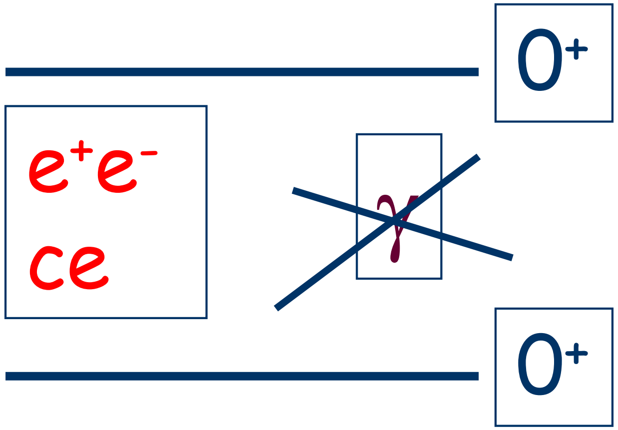
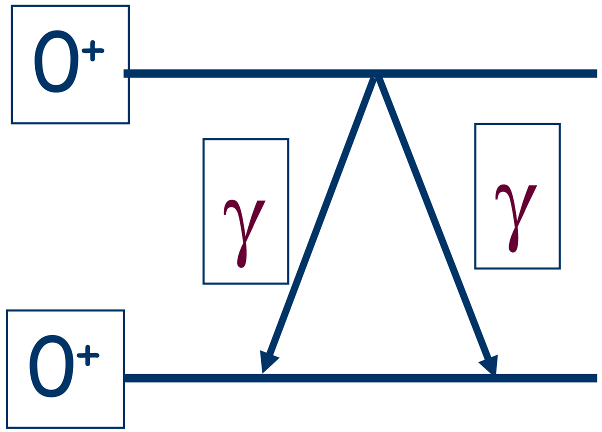
Nuclear two-photon or double-gamma decay

Rare decay mode whereby two gamma rays are simultaneously emitted

- Second order quantum mechanical process proceeds through virtual excitation of (higher-lying) intermediate states
- Observable only when first order decays are hindered
  ex. $0^+ \rightarrow 0^+$ E0 decay : single γ-ray emission is forbidden





- $E_x(0^+) < 2\ m_e c^2$ ➔ no e^+e^- decay
- fully stripped ions ➔ no ce decay

$E_{\gamma 1} + E_{\gamma 2} = \omega = E_x(0^+)$

$\Gamma_{\gamma\gamma} \propto \omega^7 [\alpha^2(E1) + \chi^2(M1) + \omega^4 \alpha^2(E1)/4752]$

First clear observation in 1985 using the HD-DA Crystal Ball (NaI array)

Proposed two-gamma decay experiment

Novel technique to search for the 2γ decay at low excitation energies
➔ no competing decay modes in bare nuclei
➔ unique to access low-lying 0^+ isomers in nuclei far from stability

- **Experimental challenge : short lifetimes as compared to cooling times**
➔ **Isochronous Schottky Mass Spectrometry (ISMS)**

- Measurement of 0^+ isomer decay in ^{72}Ge and isomer search in ^{70}Se
- Possible through unique capabilities of the SIS+ESR facility
- Very promising new development for **isomer searches at FAIR**

Beam time allocation:
460 MeV/u ^{78}**Kr** ~10^9 p/spill
6 shifts for **commissioning ISMS** at the ESR
3+3 shifts for **data taking** on ^{72}**Ge** & ^{70}**Se**

The proposed SIS + ESR experiment

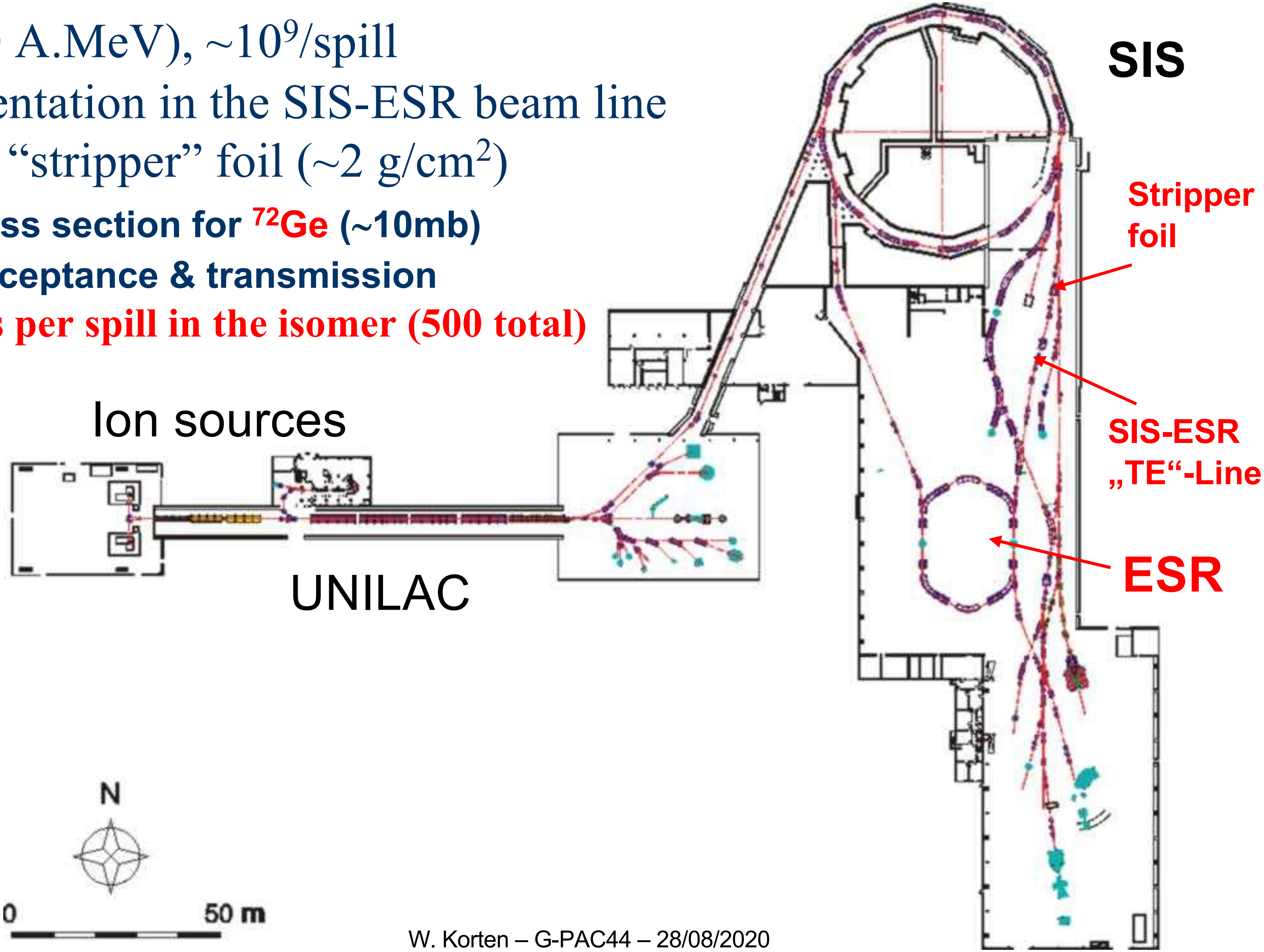
^{78}**Kr** (460 A.MeV), ~10^9/spill

➢ Fragmentation in the SIS-ESR beam line in a Be "stripper" foil (~2 g/cm^2)

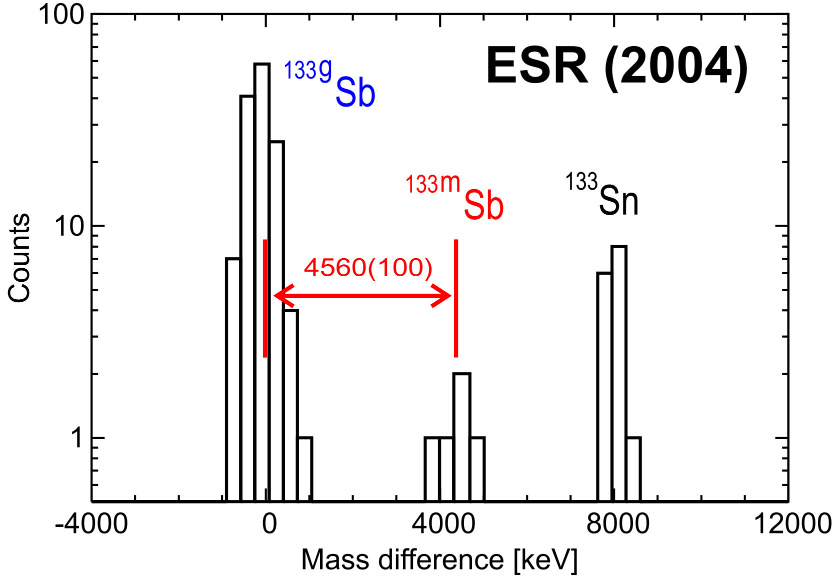
✚ **high cross section for ^{72}Ge (~10mb)**

large acceptance & transmission

➔ **~20 ions per spill in the isomer (500 total)**

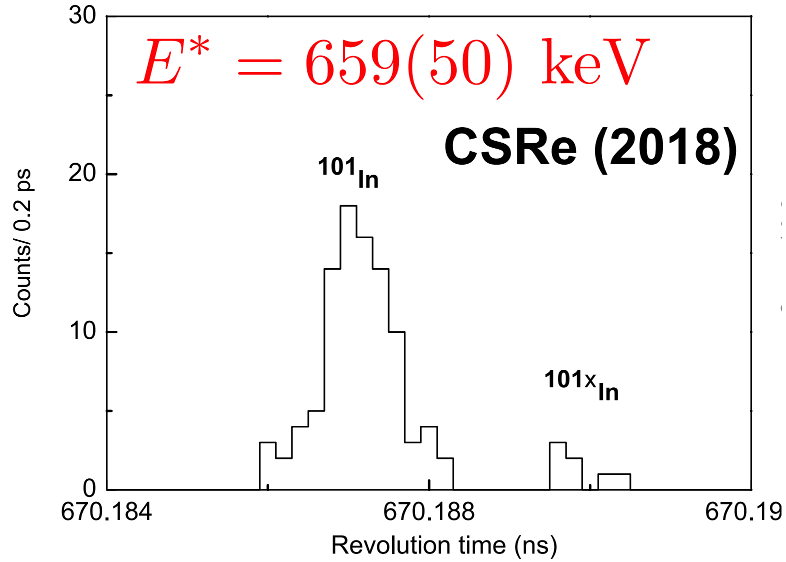


Isomer detection with Isochronous Mass Spectrometry at storage rings



B. H. Sun et al., Phys. Lett. B688 (2010) 294

$$\frac{m}{\Delta m} \approx 200'000$$



X. Xu et al., Phys. Rev. C100 (2019) 051303(R)

$$\frac{m}{\Delta m} \approx 320'000$$

Required Mass Resolving Power for A=72 & E*=691 keV

$$\frac{A}{E^*} = 97'100$$

^{72}Ge isomer will be well separated with the new Schottky detector
Lifetime will be determined by the disappearance of the isomer peak

Requirements and challenges of the experiment

Optimise injection of fragments from TE target into ESR
➔ Beam diagnosis (Profilgitter and Leuchttarget)
➔ Control momentum distribution on injection (scrapers)

Isochronous mode of the ESR needs to be fully (re)established
➔ Schottky detectors allow keeping isochronicity for many turns
➔ Required mass resolving power **$m/\Delta m > 200000$** should be achievable
➔ Single ion mode if isomeric ratio is (too) unfavourable

No changes in ESR needed before and after E143

E143 Collaboration

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