Electron pair emission: Insights on the electron correlation strength

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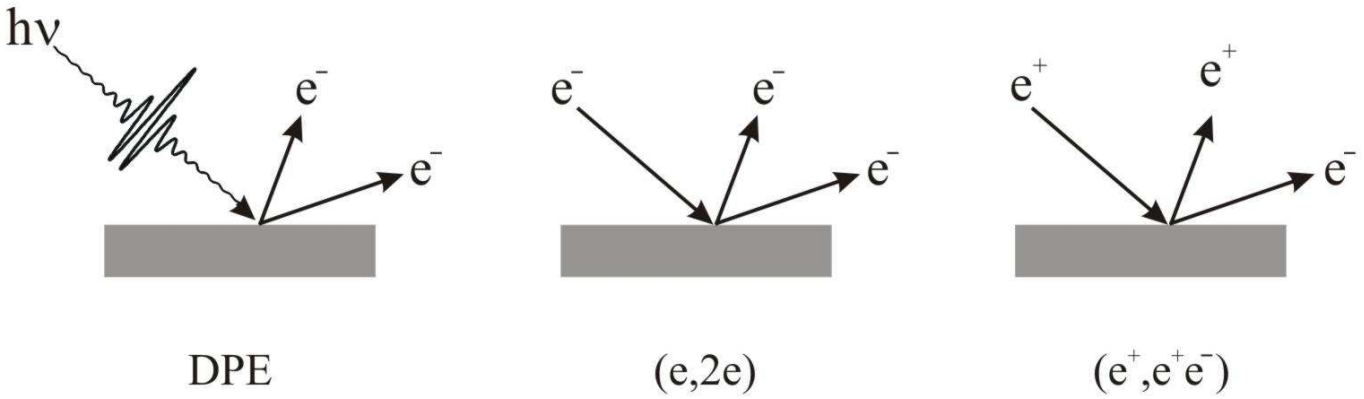
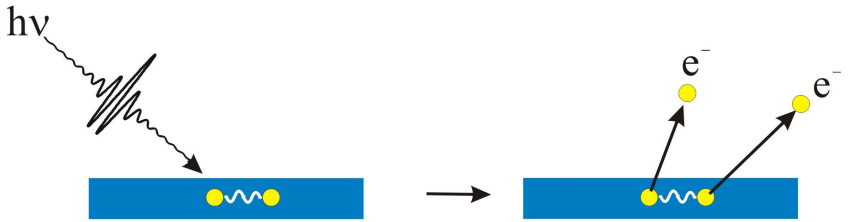
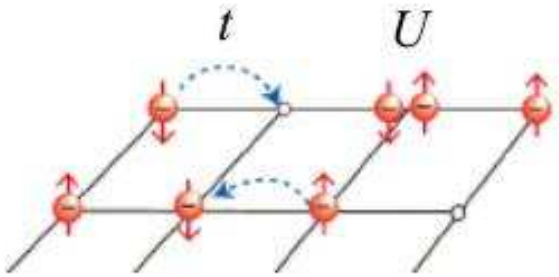


F.O. Schumann et al., PRB 86, 035131 (2012)
F.O. Schumann et al., JPCM 25, 094002 (2012)

Motivation



DPE requires finite electron-electron interaction.



Theory predicts: DPE intensity ~ U^2 U-Hubbard parameter

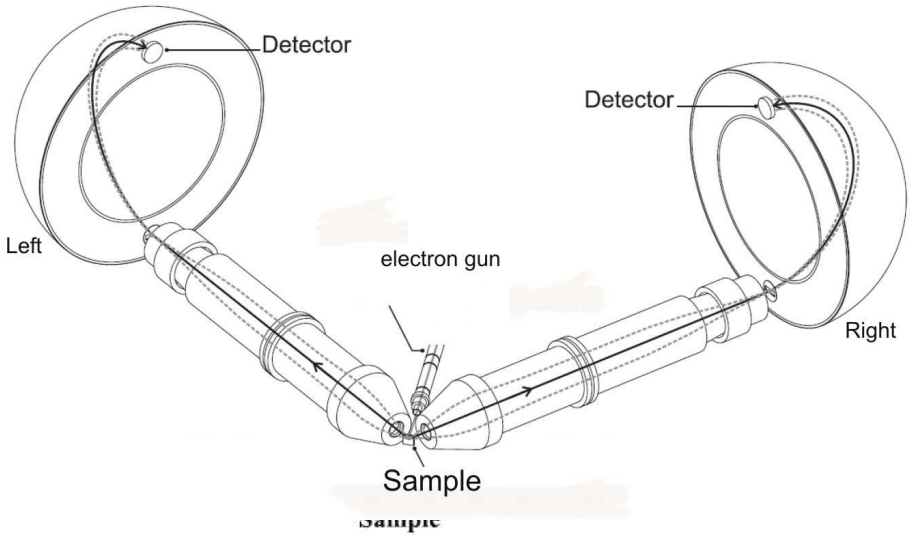
Similar dependence expected for (e,2e)

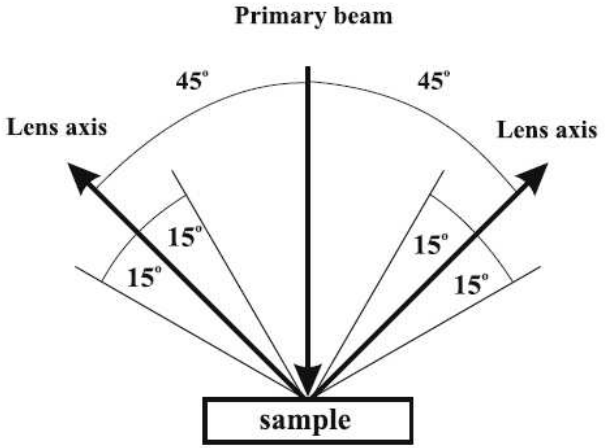
- NiO "highly correlated" description via LDA+U → U=6 eV
- Ag description via LDA → U≈0

Is the pair intensity strongly material dependent, e.g. NiO vs Ag?

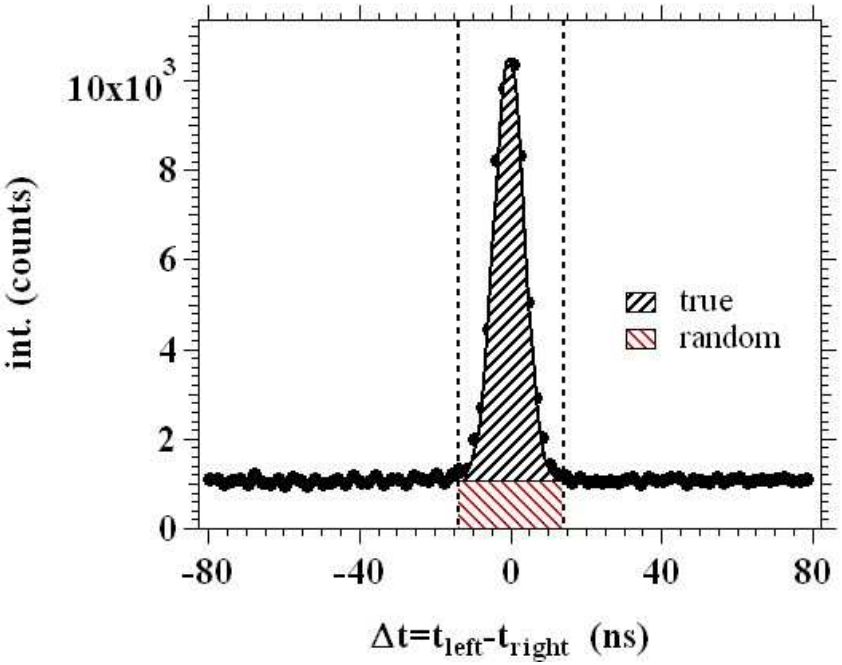
B.D. Napitu and J. Berakdar, PRB **81**, 195108 (2010).

Energy-dispersive coincidence set-up

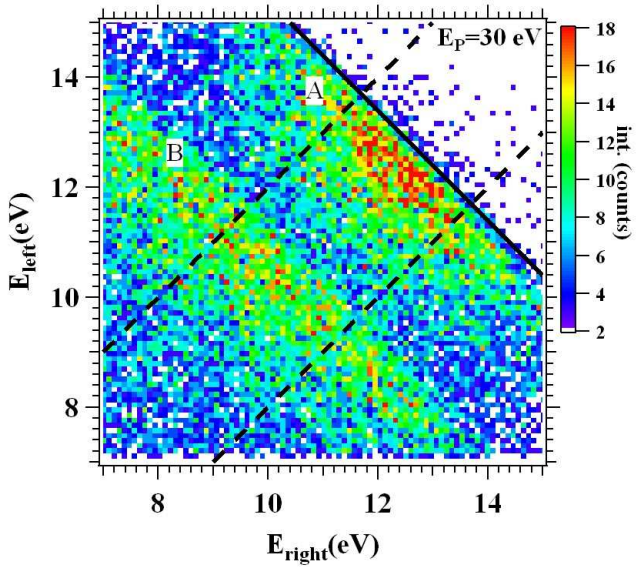


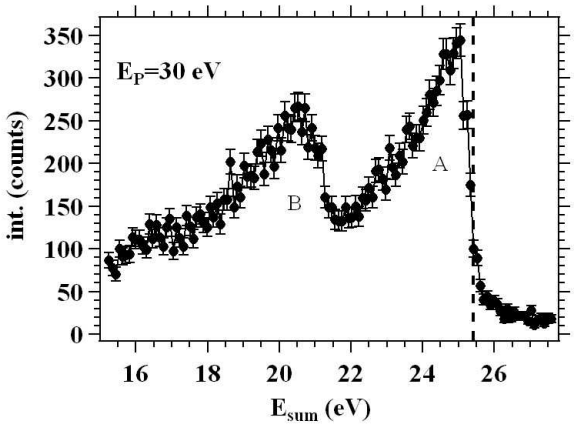


- operation at 100 eV pass energy/no scanning
- detection within 9 eV energy window
- primary flux control
- E_p=31.6 eV



Energy distributions Ag(100)





Energy conservation:

$$E_p + E_{VB} = E_{left} + E_{right} + \phi = E_{sum} + \phi$$

$$E_{sum} = E_{left} + E_{right}$$

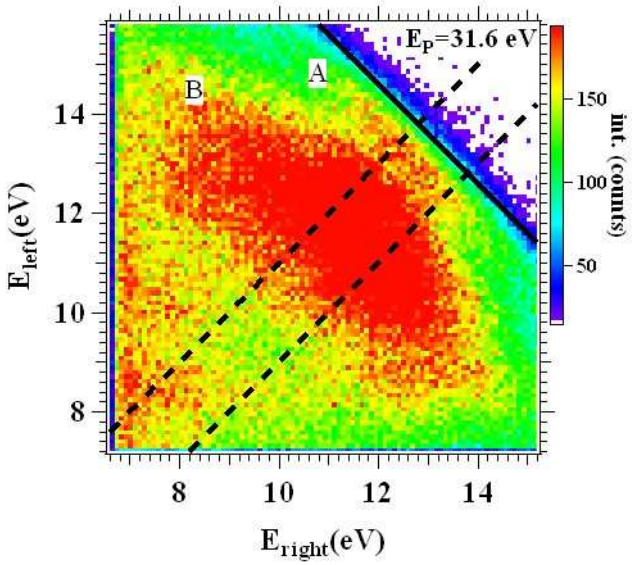
$$\Rightarrow E_{sum}^{\max} = E_p - \phi$$

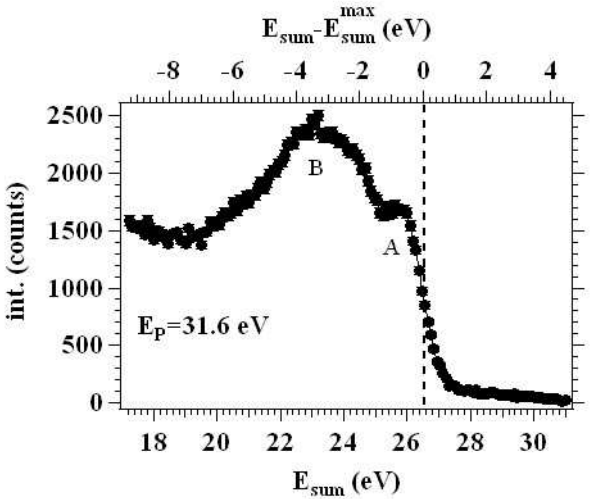
Observation of diagonal intensity bands:
$\Longrightarrow$ emission of pairs with well-defined E_{sum}
$\Longrightarrow$ valence state with well-defined E_{VB}

Plot intensity versus E_{sum} under contraint: $\left|E_{left} - E_{right}\right| \leq 3\text{eV}$

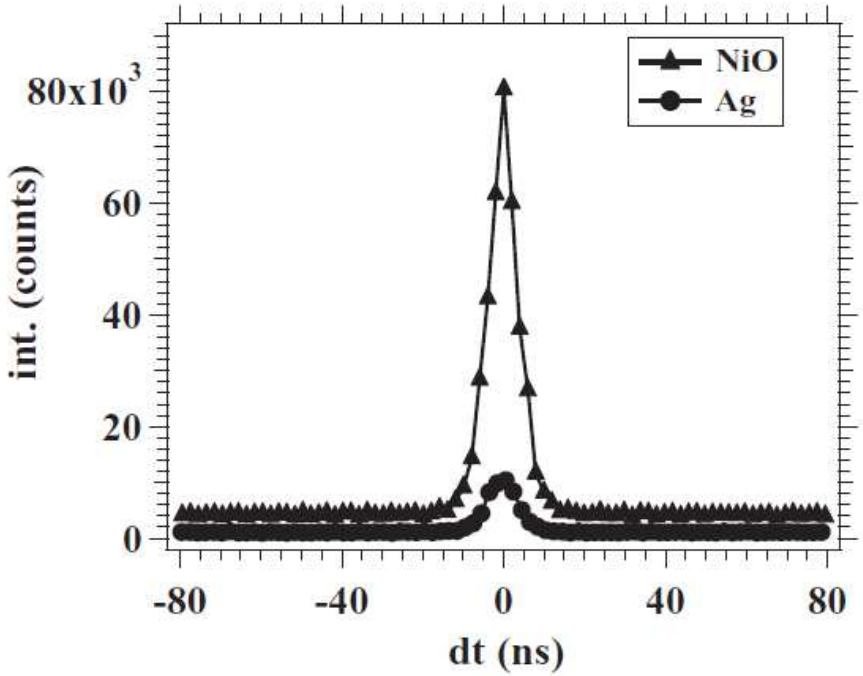
Energy distributions of 15 ML NiO/Ag(100)

15 ML NiO





increased intensity from NiO

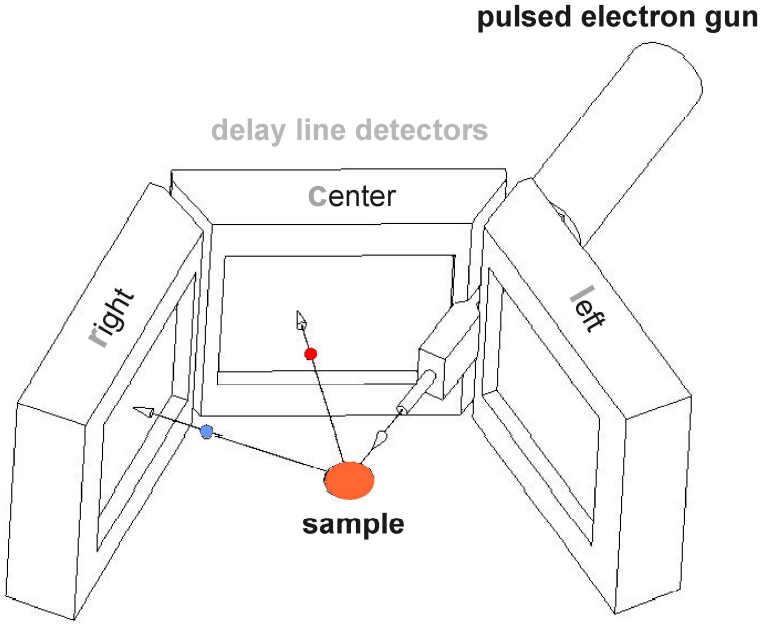


Intrinsic effect or due to:

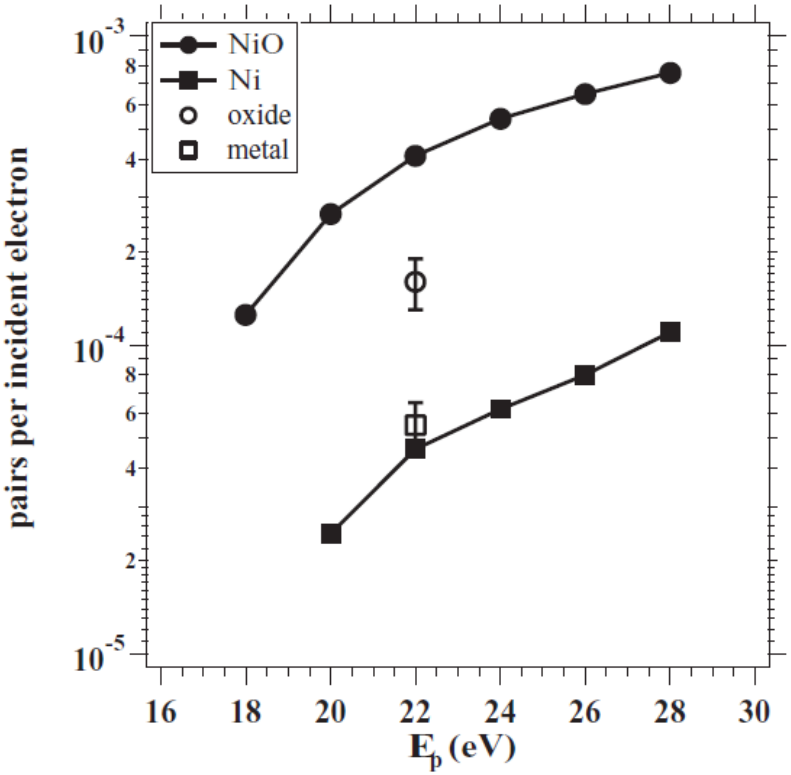
(i) angular variations

(ii) mean free path variations

Large angular acceptance

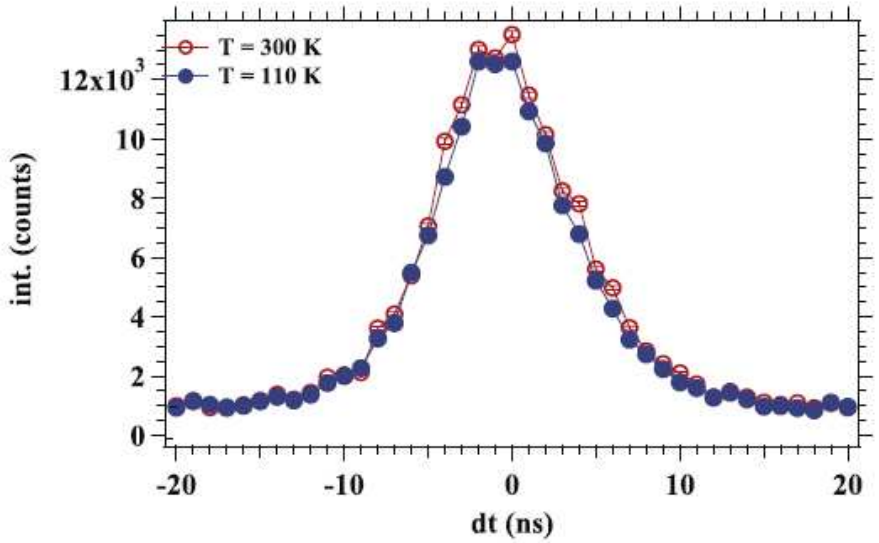


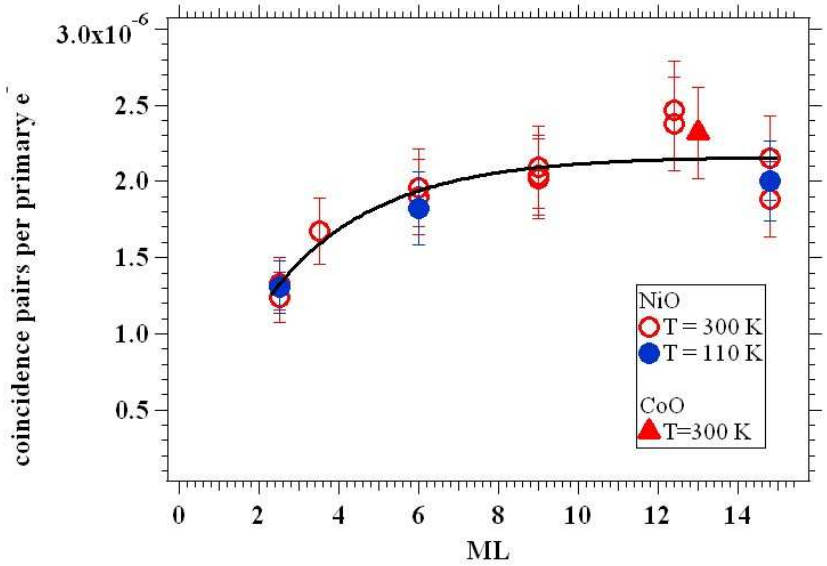
Time-of-flight coincidence set-up



- enhanced coincidence rate intrinsic
- general trend of enhanced intensity for metal oxides

Temperature dependence

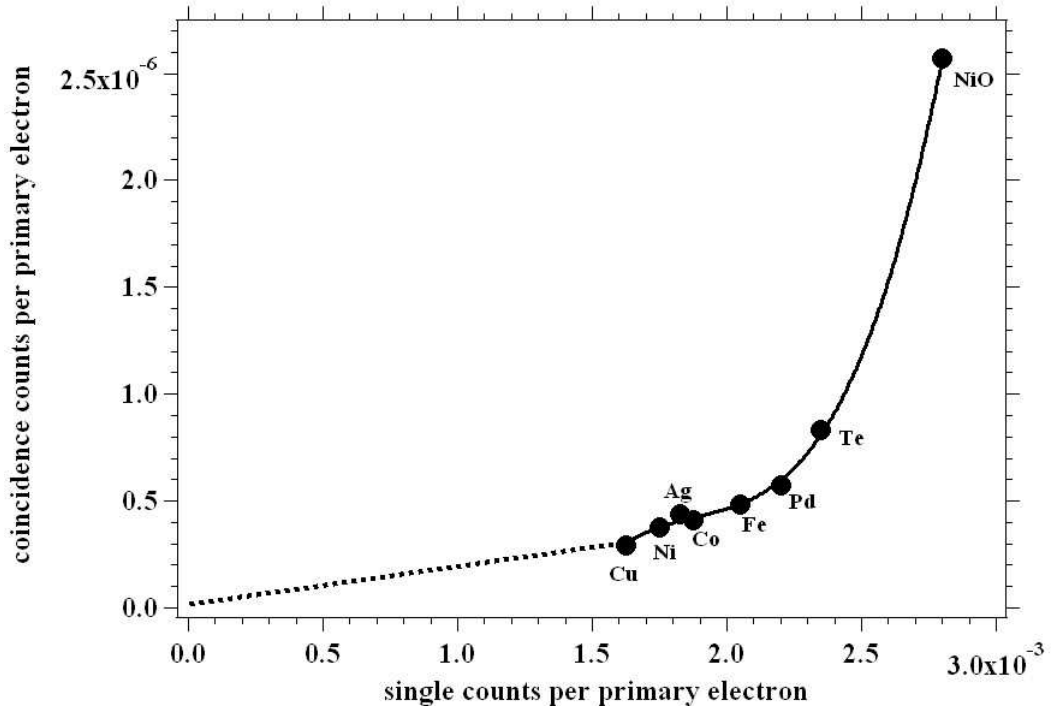




- 2.5 ML NiO almost “bulk” like
- no T-dependence of intensity
- probing local correlation
- different from AR-APECS

EPL **94**, 37008 (2011)
PRL **107**, 217602 (2011).

Relation singles-coincidence rate

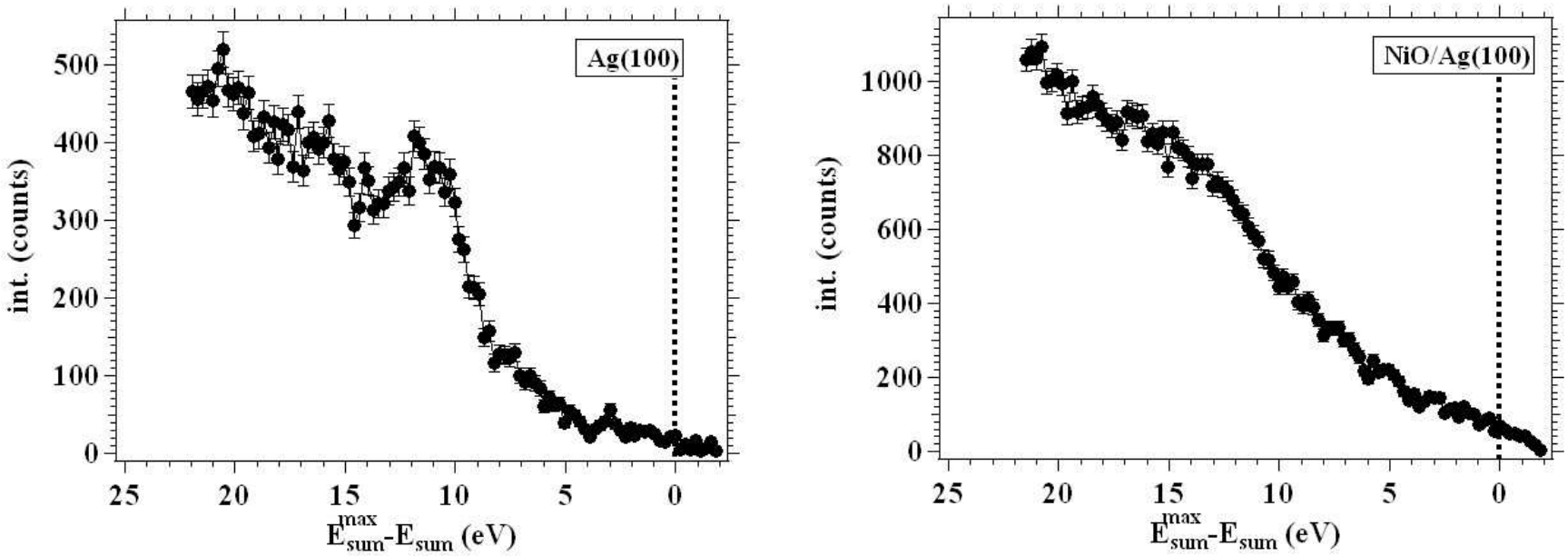


• polycrystalline metal films

• ordered Ag(100),CoO(100) and NiO(100) samples

high singles rate ⇒ high coincidence rate

Double photoemission



hv=60 eV same coincidences rates for Ag and NiO

hv=30 eV evidence of 5 times higher coincidence rate for NiO

Summary

- (e,2e) intensity of oxides higher than for metals
- monotonic relation between coincidence and singles rate
- high intensity ⇒ “strong” correlation ?
- up to 10% of electron emission is via pairs

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