Investigation for ISGDR of ^{58}Ni with (α,α'-*p*) coincidence measurement

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Collaborators

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Giant resonances and nuclear incompressibility

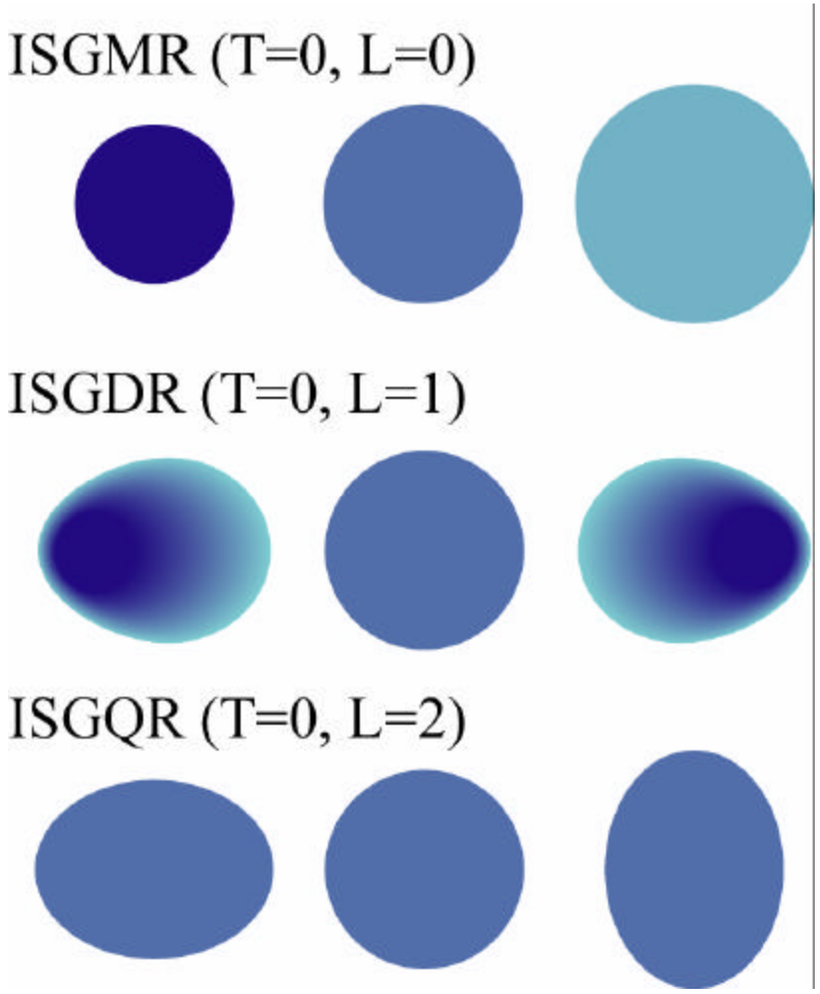
- **Giant Resonances**

  Collective excitation modes that nucleons vibrate coherently in nucleus

- Compressive giant resonances relate directly to the nuclear incompressibility (K_A) because of the density oscillation

$$E_{ISGMR} \approx \sqrt{\frac{K_A}{m < r^2 >}}$$

$$E_{ISGDR} \approx \sqrt{\frac{3}{7}\frac{K_A + (27/25)e_F}{m < r^2 >}}$$

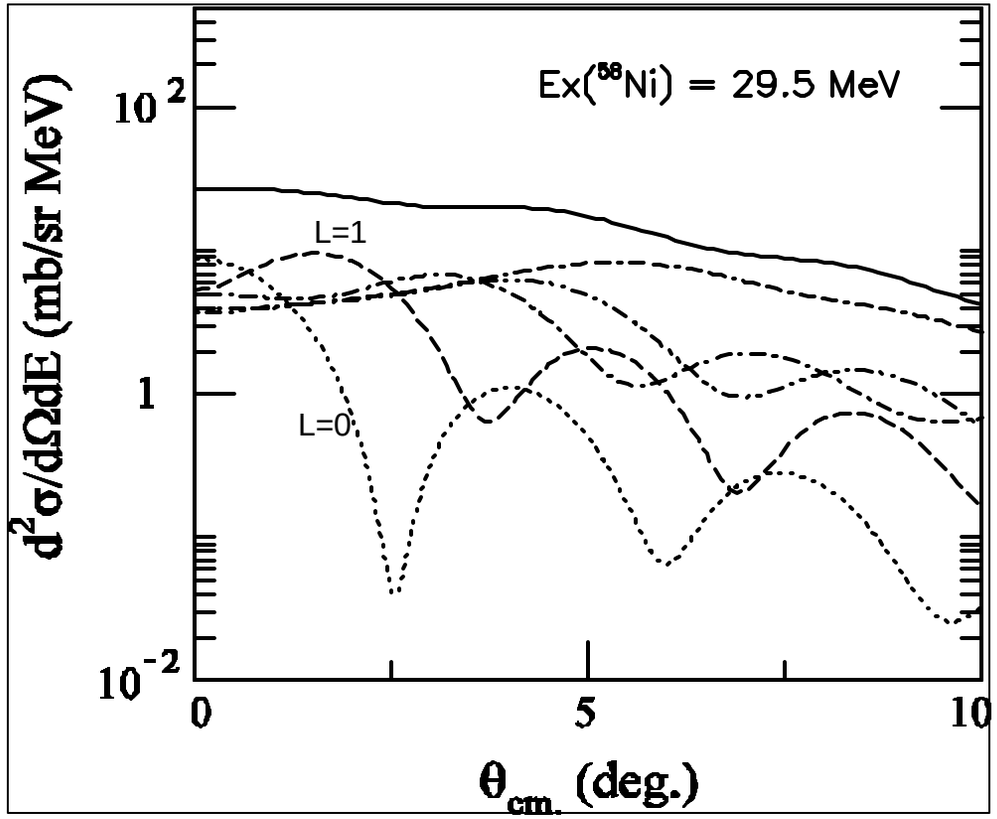


Inelastic a scattering and Isoscalar resonances

- a particle
  Isospin (T) = 0 ? Responsible only for isoscalar excitations in hadronic interaction
  Spin (S) = 0

- Isoscalar giant resonance
  ? T = 0
  ? S = 0

- The cross-section distributions at forward angles for L=0 and 1 are different from the others



Expriment

- Ring cyclotron facility

  (Research Center for Nuclear Physics, Osaka univ.)

- Spectrometer

  "Grand Raiden"

  (*p/? p* = 37,000)

- Incident beam

  ^{4}He, E = 400 MeV

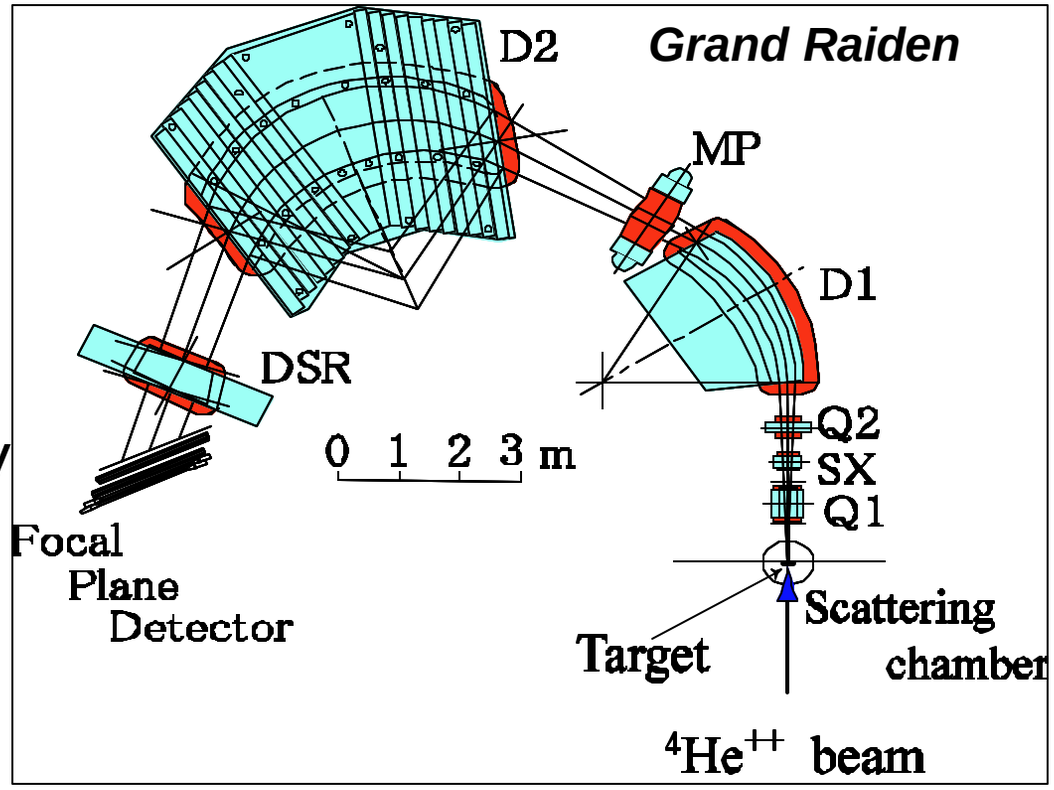
  E_{FWHM} = 200 keV

- Reaction target

  ^{58}Ni foil : 4.0 mg/cm^{2}

- (a ,a ') at 2.5 °

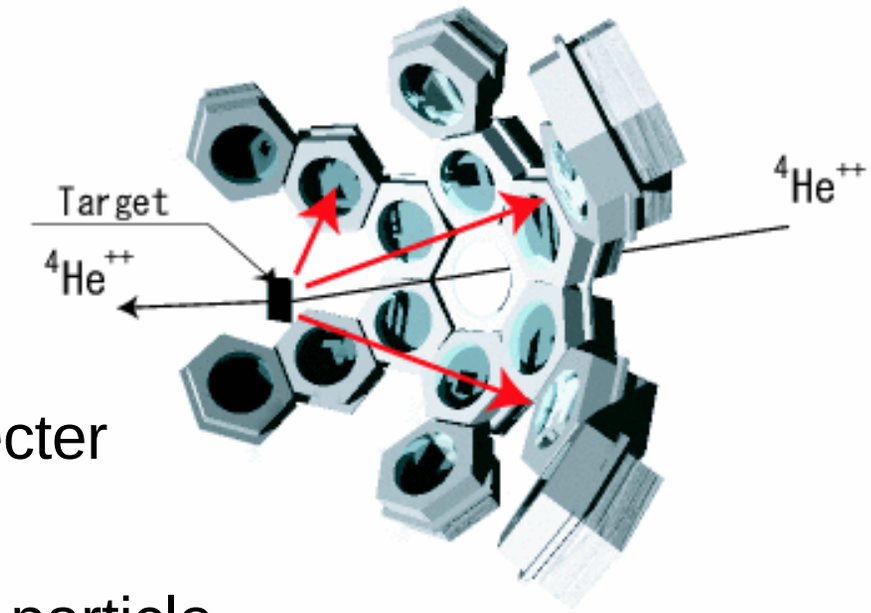
  Excitation energy range : 19 – 43 MeV



Coincidence measurement

- Lithium drifted silicon detecter
- ➢ Active depth : 5 mm (E_p ?30 MeV)
- ➢ Effective area : 405 mm^2×16 (total solid angle : 4%)
- ➢ E_{FWHM} ? 70 keV
- ➢ $?_{SSD}$ = 100 ° – 160 ° at intervals of 10°

? elimination of quasi-free/pick-up/ break-up

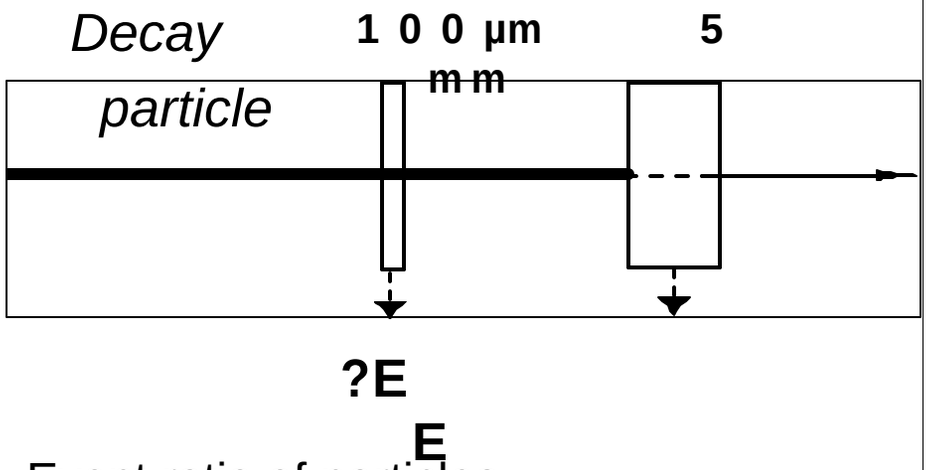


? : decay particle

- Surface barrier type silicon detecter
- ➢ active depth : 100 µm
- ➢ Three sets of ?E-E counters for particle identification

Identification for decay particles

? E-E counter



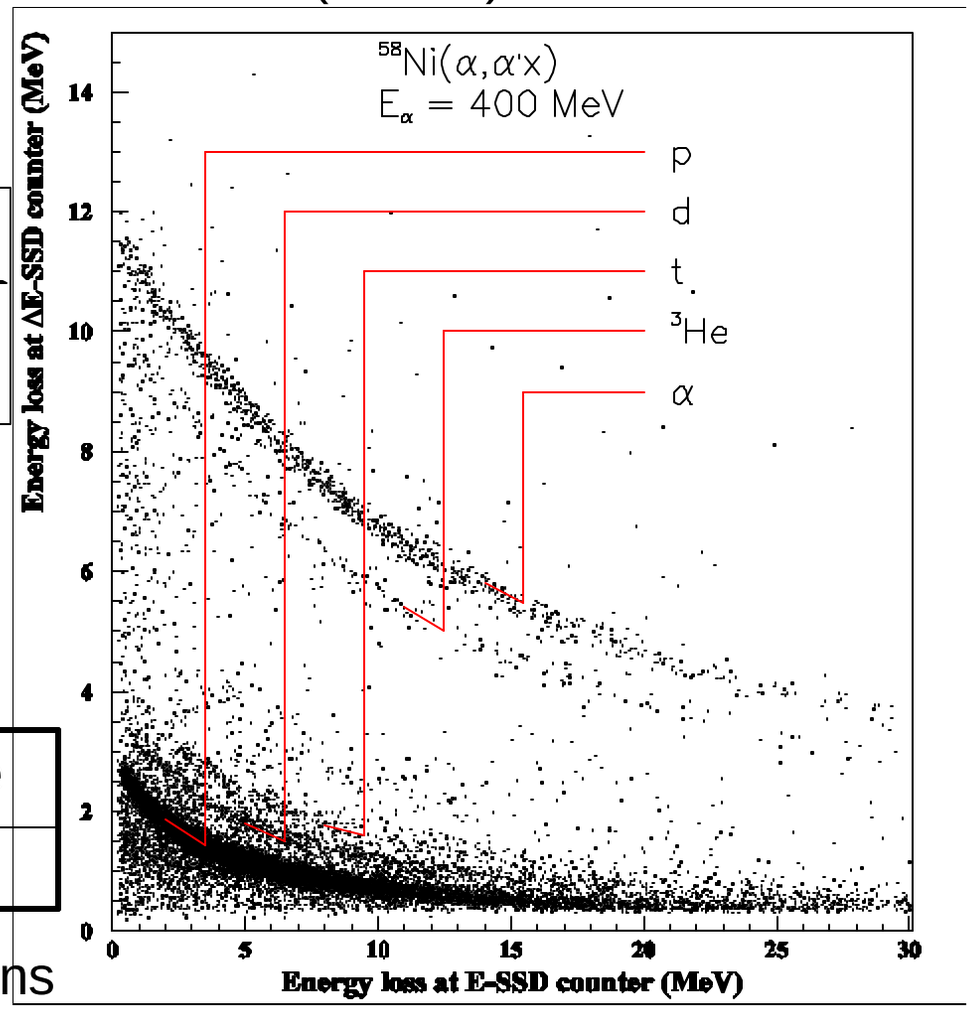
Event ratio of particles

(Y_{proton} = 100nn, E(5mm) ? 13 MeV)

p	d	t	^{3}He	^{4}He
100	3	0.7	0.4	1.7

- Good particle identification for protons with E_p ? 13 MeV

$^{5\ 8}$Ni(a,a'-x) reaction



Scatter plot of proton decay

^{58}Ni(a ,a '-*p*)^{58}Ni ? ^{57}Co+*p*

$$E_p = Ex - Ex_{fin} - Q_p$$

E_p : Energy of decay proton

Ex : Energy of excited states in ^{58}Ni

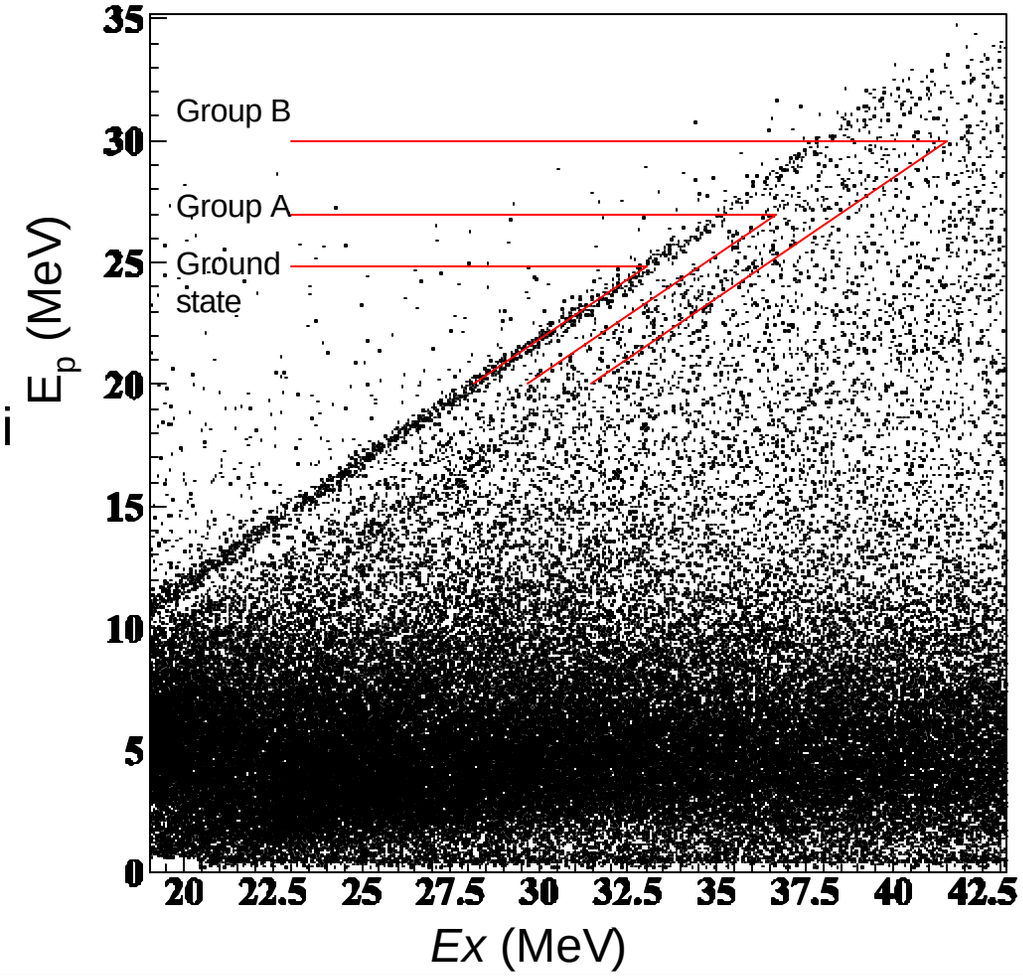
Ex_{fin} : Energy of final states in ^{57}Co

Q_p : decay threshold of proton

8.17 MeV

cf. Q_n : decay threshold of neutron

12.22 MeV



Scatter plot of decay-energy vs. the excitation energy in ^{58}Ni.

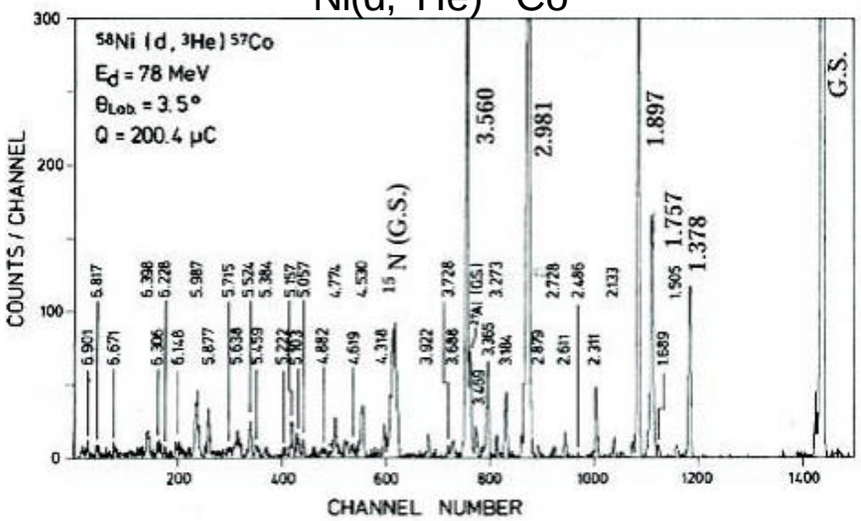
The loci correspond to the final states in ^{57}Co.

Final states in ^{57}Co

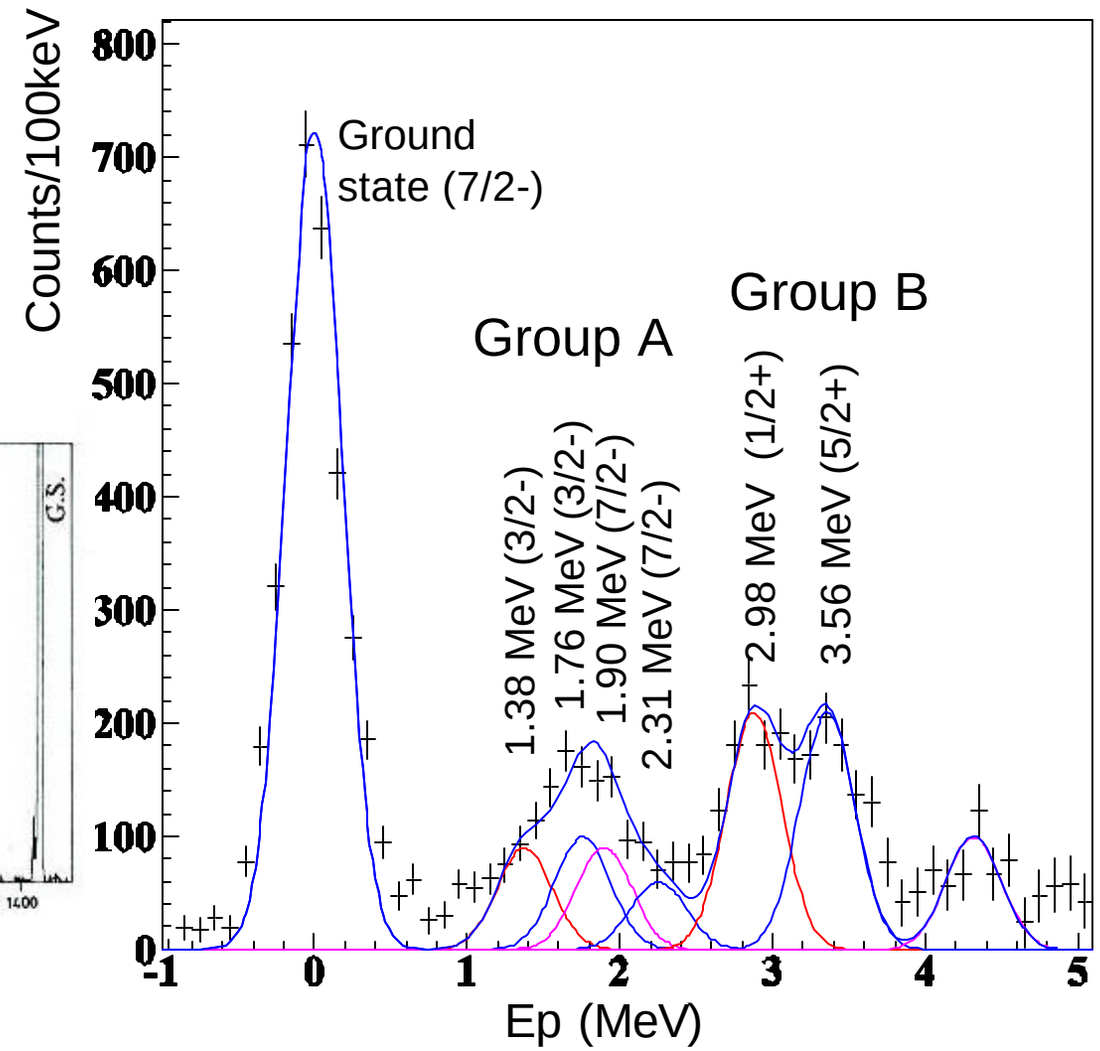
- Final states of the low-lying proton hole states
- Gaussian fitting

  resolution(FWHM)= 180 keV

^{58}Ni(d,^{3}He)^{57}Co



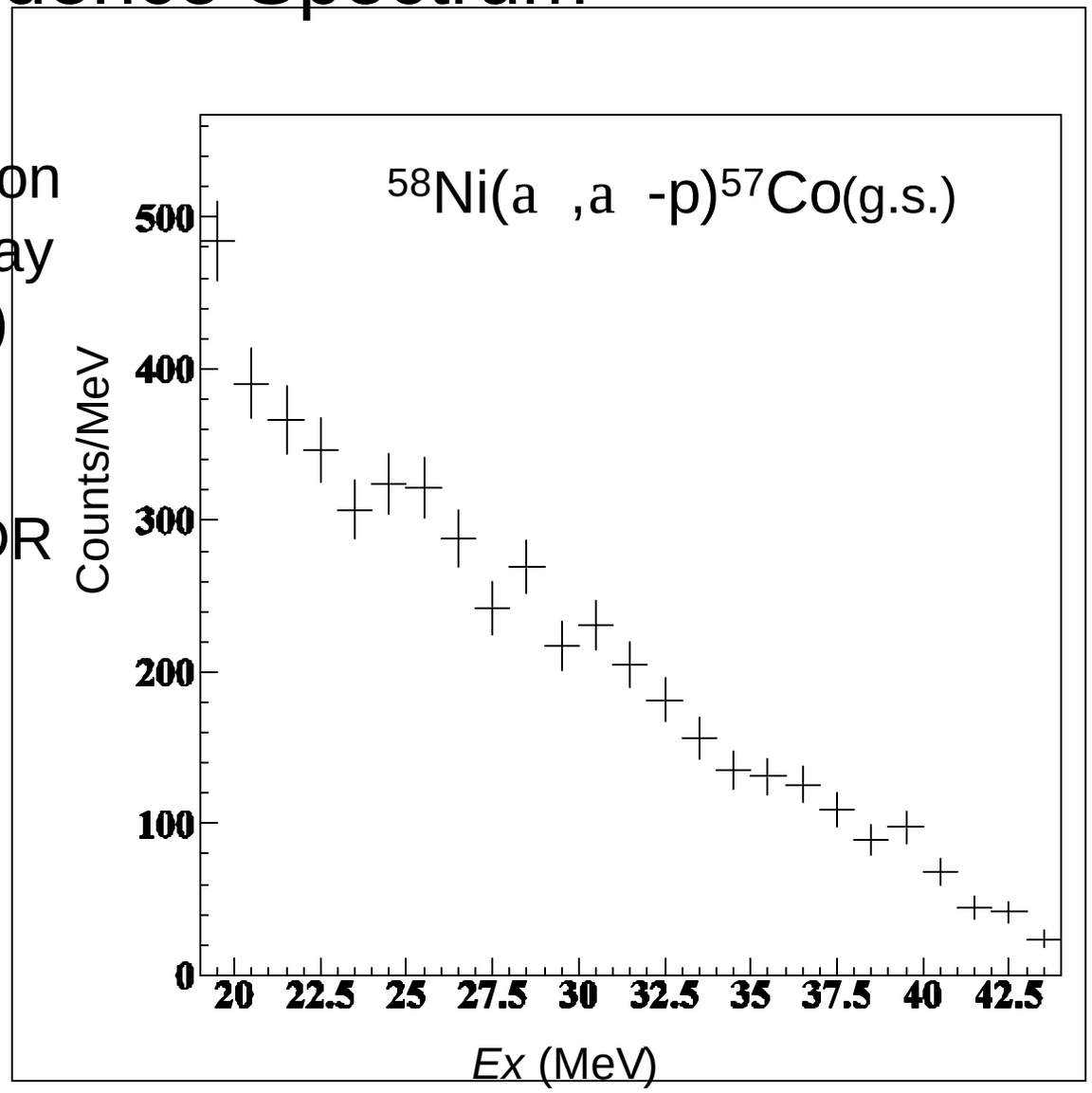
ref. Nucl. Phys. A438 (1985)



Coincidence Spectrum

- Spectrum of ^{58}Ni gated on the events of proton decay to the ^{57}Co(ground state)

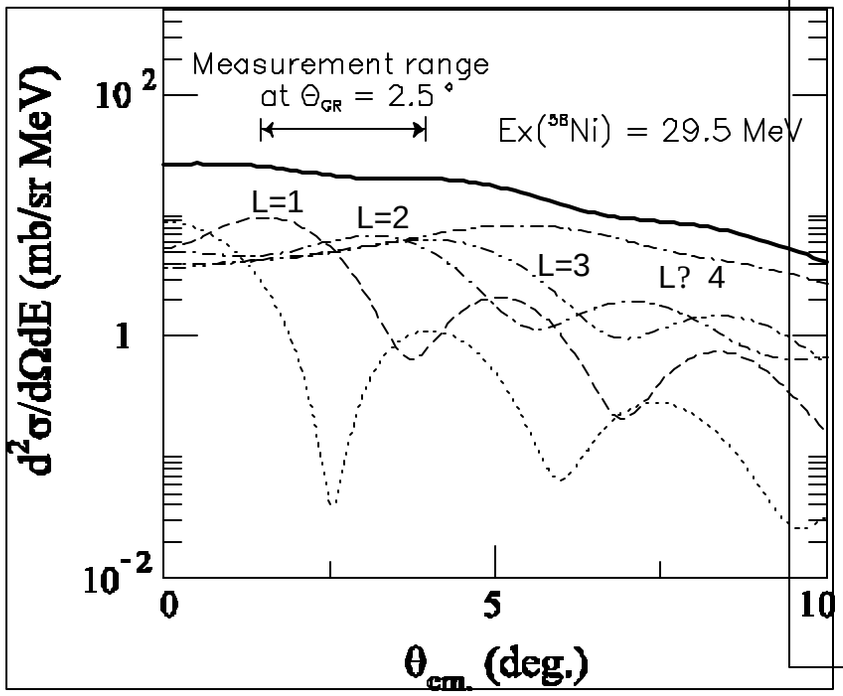
- No clear bump for ISGDR

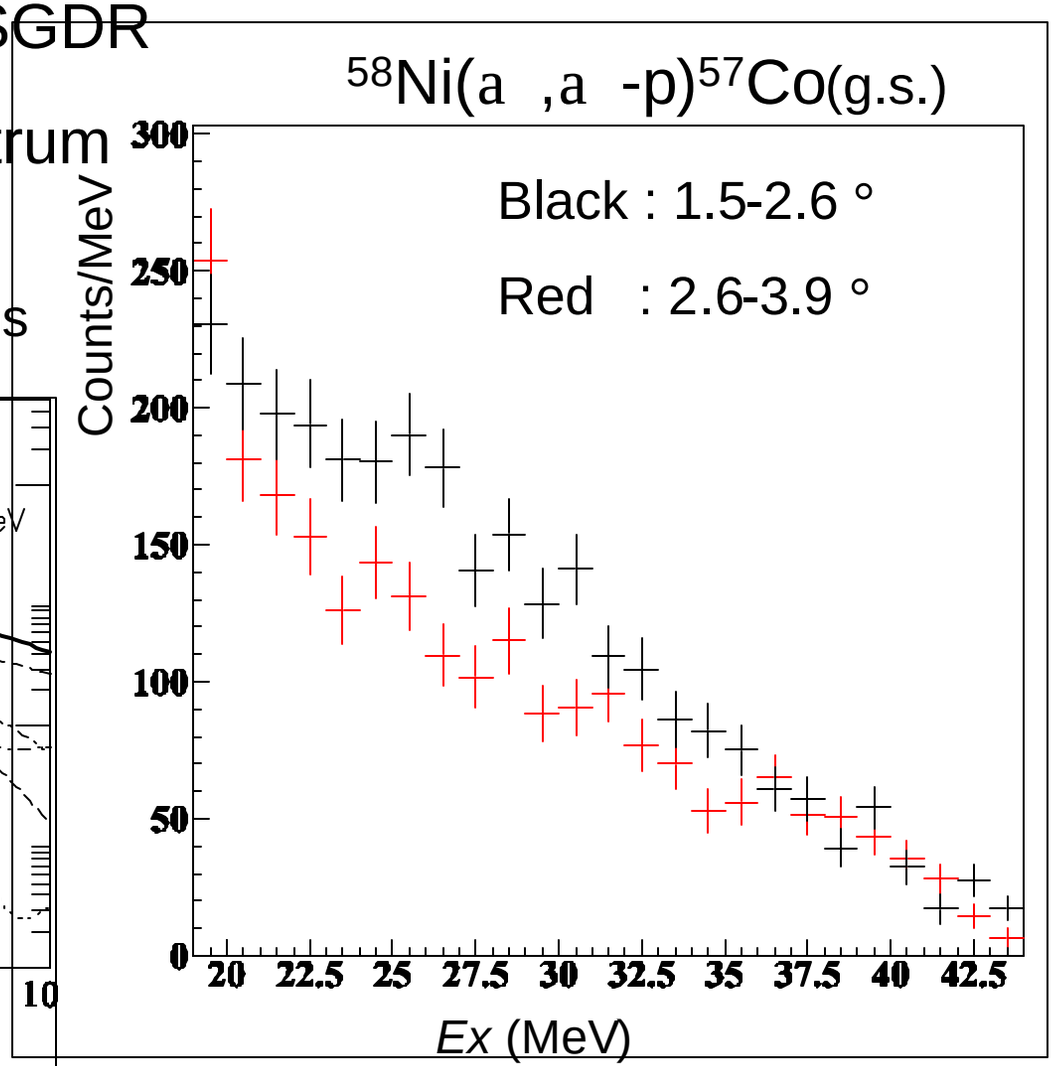


Difference-of-spectra method

- Angular distribution of ISGDR
- Subtraction of one spectrum from the other spectrum

? cancel of L ? 2 contributions



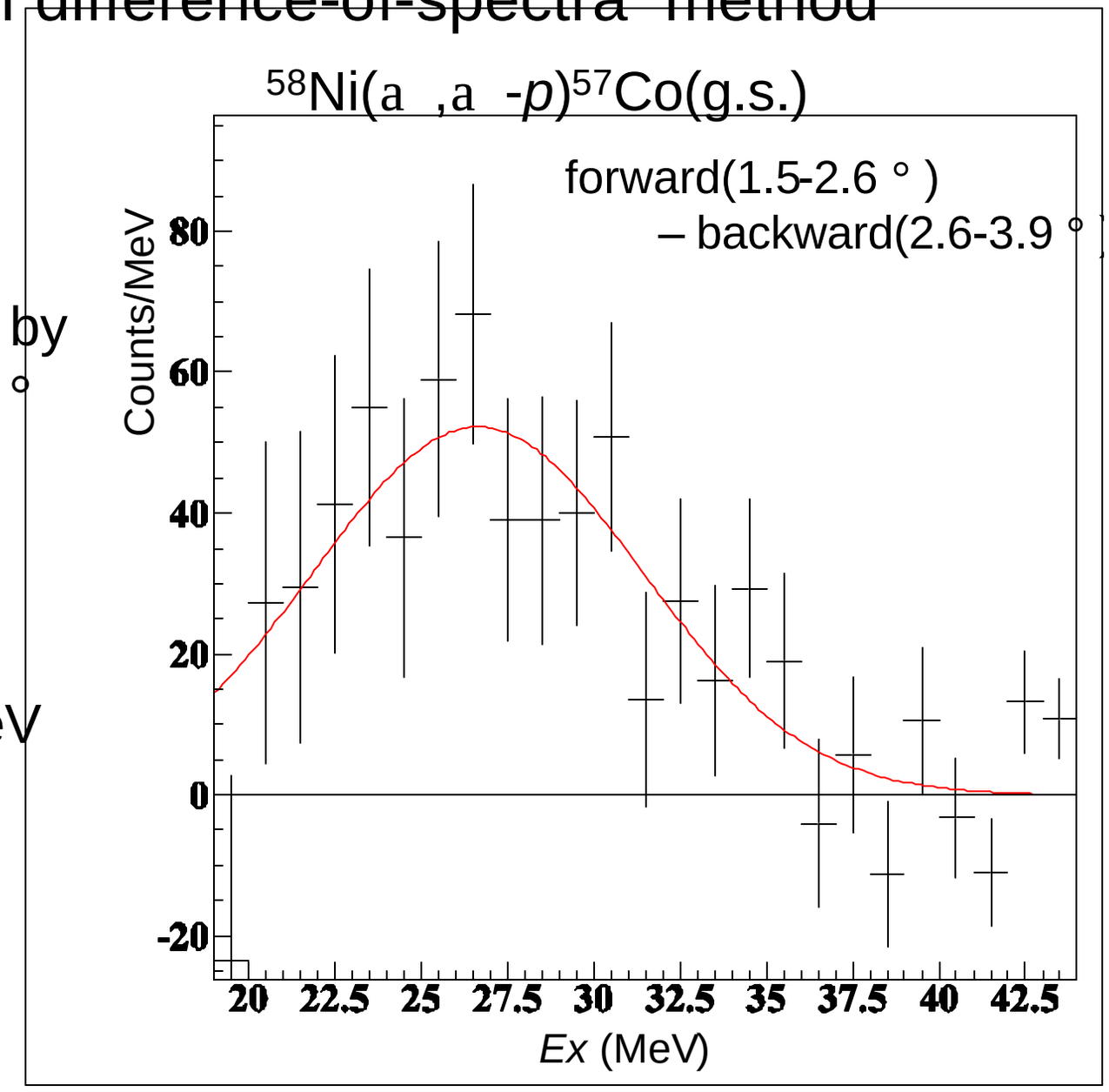


Spectrum of difference-of-spectra method

Spectrum obtained by subtraction 2.6-3.9 ° from 1.5-2.6 °

E_{peak} = 26.6 ± 0.9 MeV

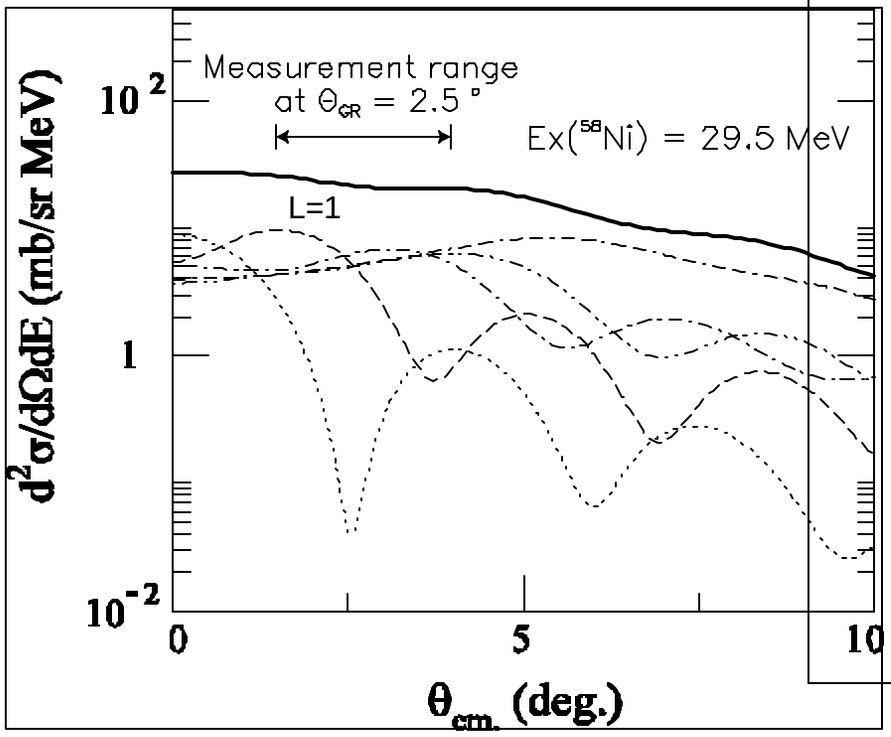
G = 9.5 ± 1.6 MeV

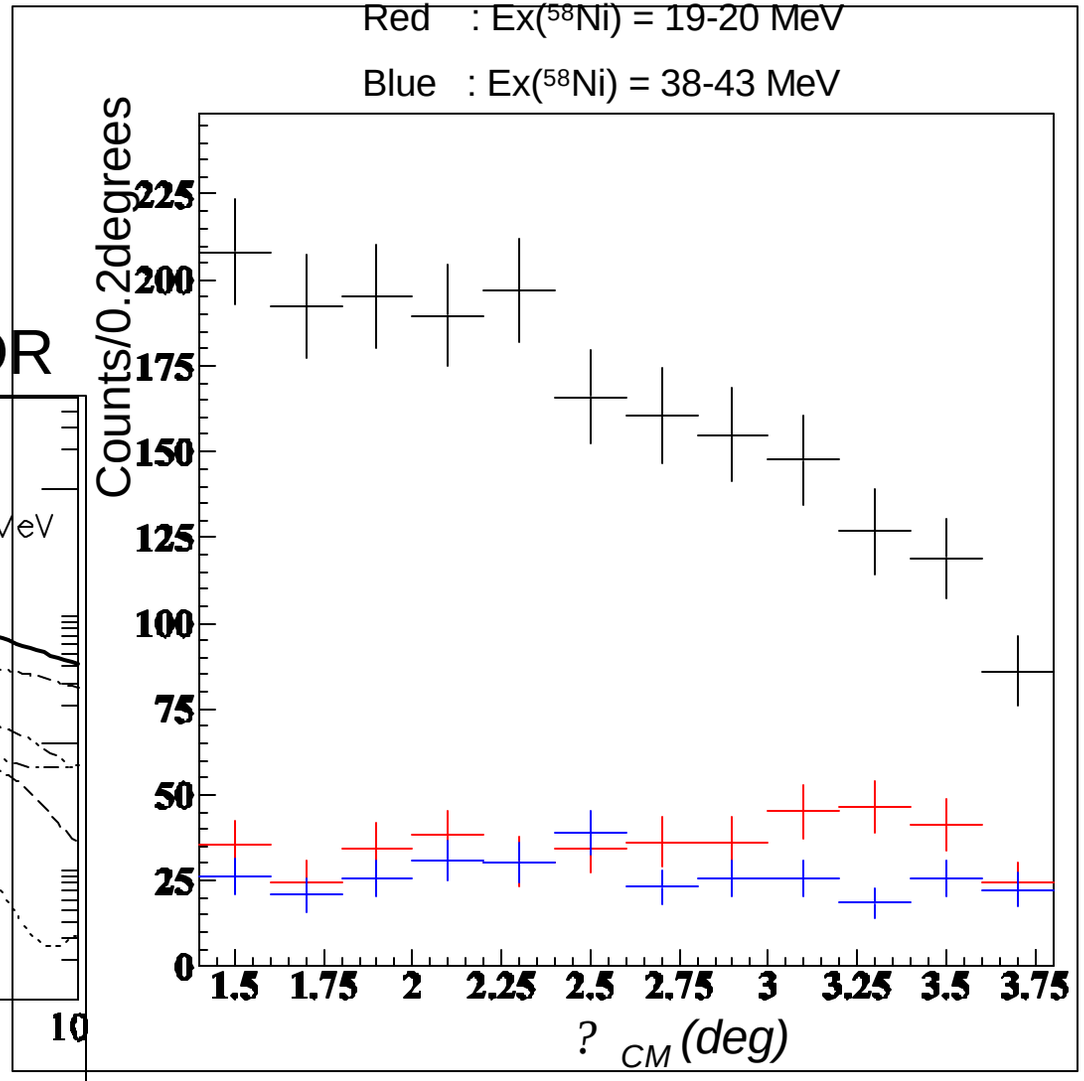


Angular distributions

The distribution gated on Ex(^{58}Ni) = 23-31 MeV decreases with increasing the scattering angle from 1.4 ° to 3.7 °

This is the feature of ISGDR





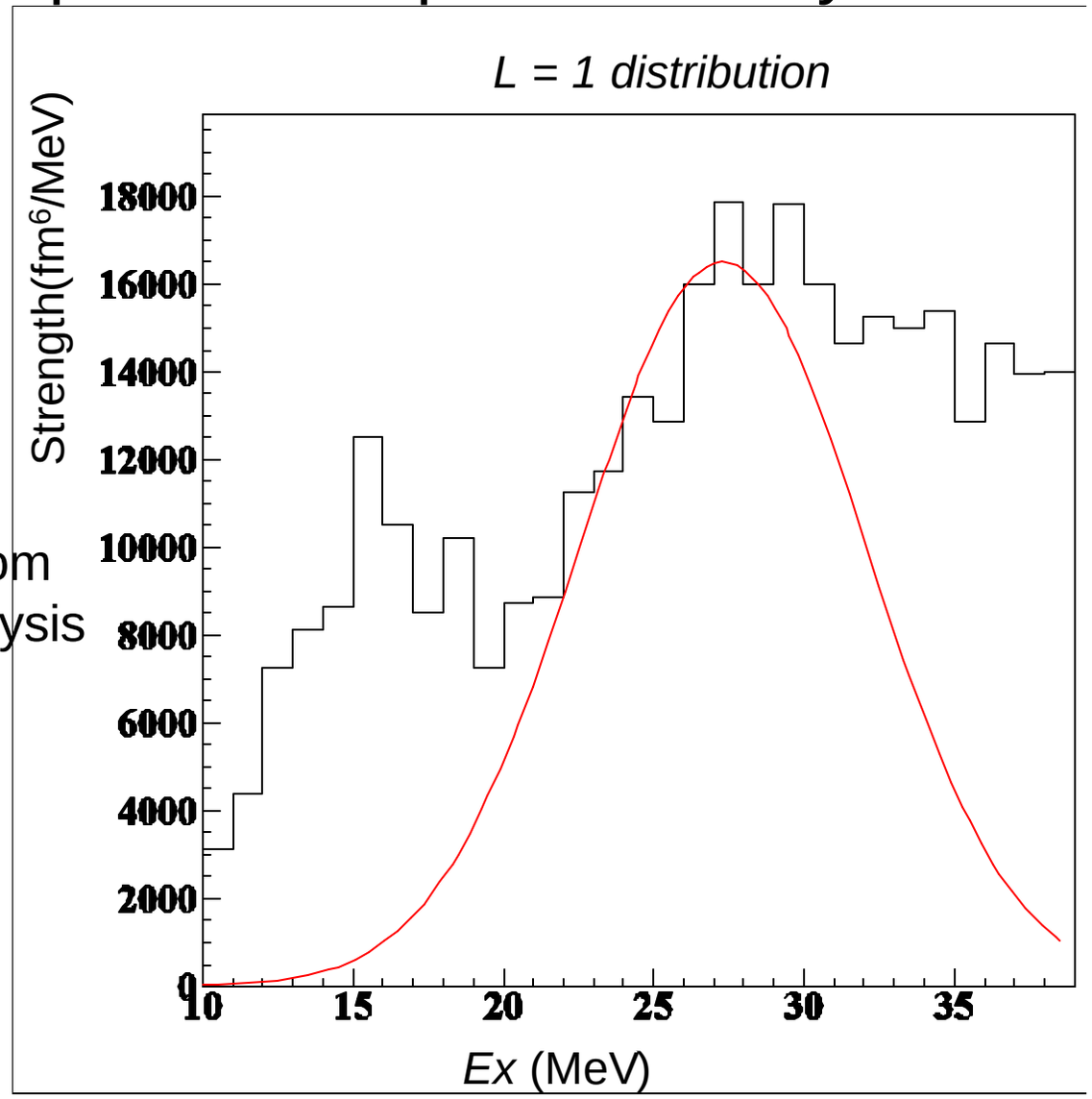
Comparision to multipole decomposition analysis

- Difference-of-spectra at coincidence measurement

  E_{peak} = 26.6 ± 0.9 MeV

  G ? = 9.5 ± 1.6 MeV

- Fitting to preliminary result from multipole decomposition analysis at single measurement



Summary

- Measurement of decay particles from excited states via the ^{58}Ni(α,α') reaction
- Identification of proton hole states
- Identification of ISGDR in ^{58}Ni

Hole states of ^{57}Co gated on the excitation energy in ^{58}Ni