Soft Dipole Mode in Ca & Ni Regions

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1-1. Motivation

* Giant Dipole Resonance

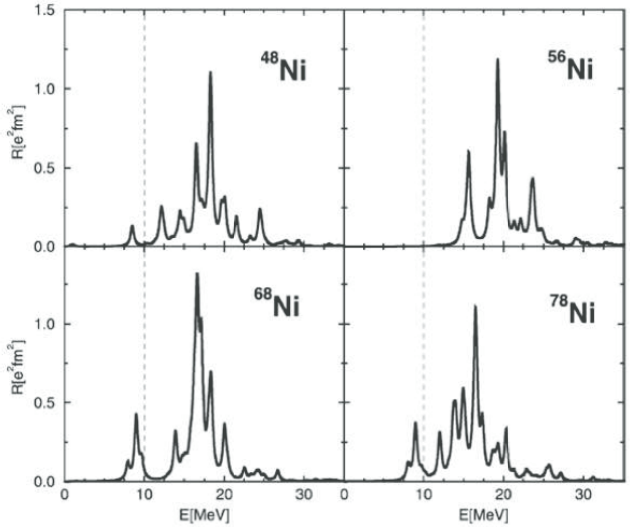
  * Collective excitation : ~ oscillation of neutrons against protons

* Soft Dipole (Pygmy) Mode

  for nuclei with isospin asymmetry, with extra neutrons

  response at energy below GDR

  ~ oscillation of extra neutrons against the core

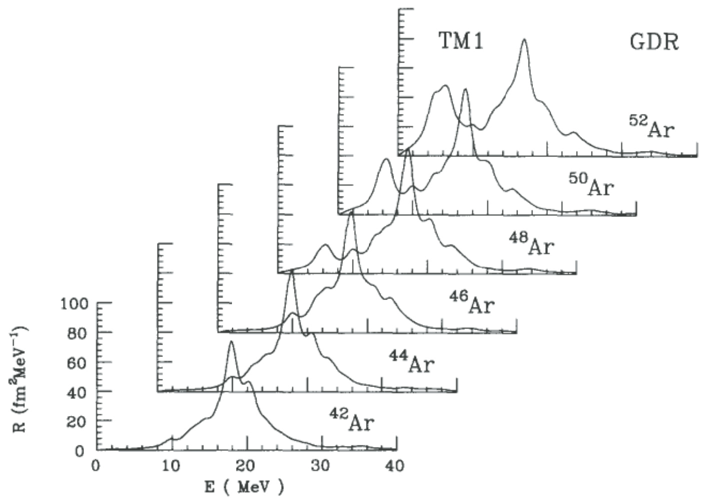


* Light halo nuclei : ^{11}Li, ^{11}Be, ^{14}Be, ^{19}C...

  single-particle nature via electromagnetic excitation

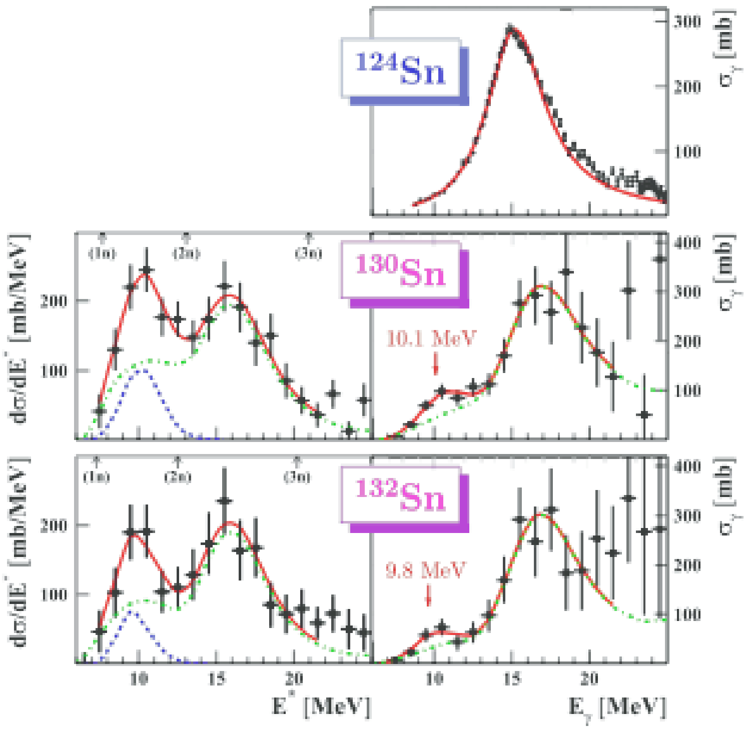
* Heavier neutron-rich nuclei

  collective excitation via EM excitation



1-2. Soft Dipole Mode in Sn Region

* EM excitation exp. at LAND/GSI (2005), $^{129-132}$Sn @500MeV/A



* Low-lying strength

  i.e. soft (Pygmy) dipole mode

  observed

  at Ex ~ 10MeV

  few % of TRK sum rule

* strength related to

  evolution of neutron skin

  symmetry energy

followup exp's @GSI

^{68}Ni / RISING : published

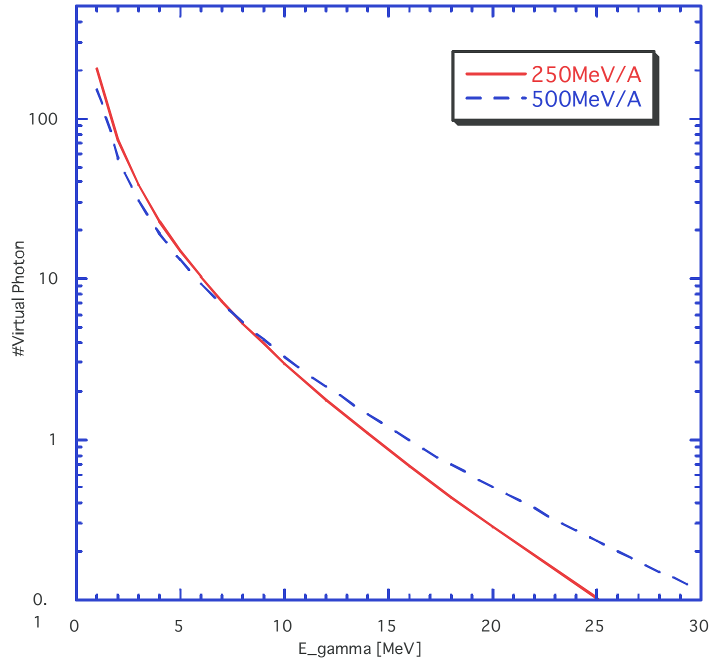
-^{72}Ni / LAND : under analysis

2-1. Electro Magnetic Excitation of Soft Dipole Modes at RIBF

* Purposes :
  * collective excitation of soft dipole mode in Ni & Ca regions
  * performance of the spectrometer system up to A~80 (z~28)
    * Rigidity resolution ~0.1%
    * Total energy resolution ~0.1%

* Experimental design follows

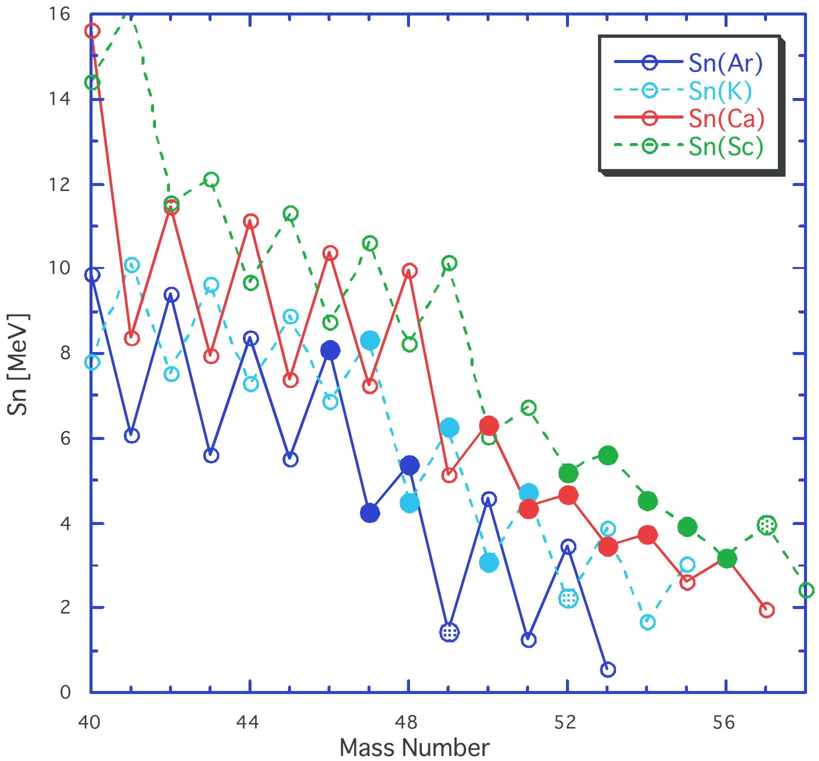
virtual photon



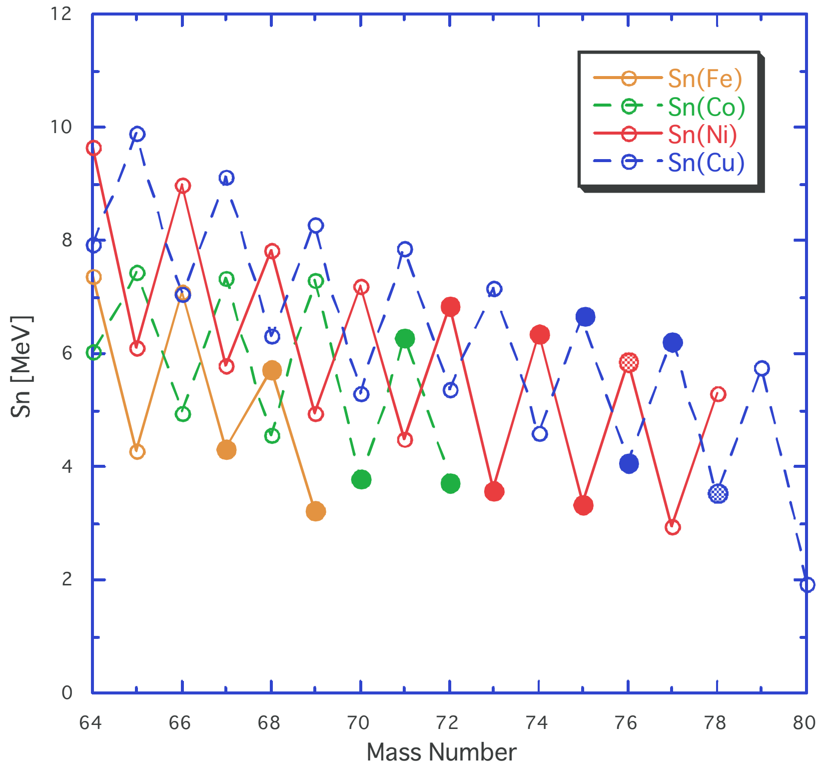
2-2. Mass Range

＊ using "mixed" beam

$^{50-54}Ca$ from ^{82}Se

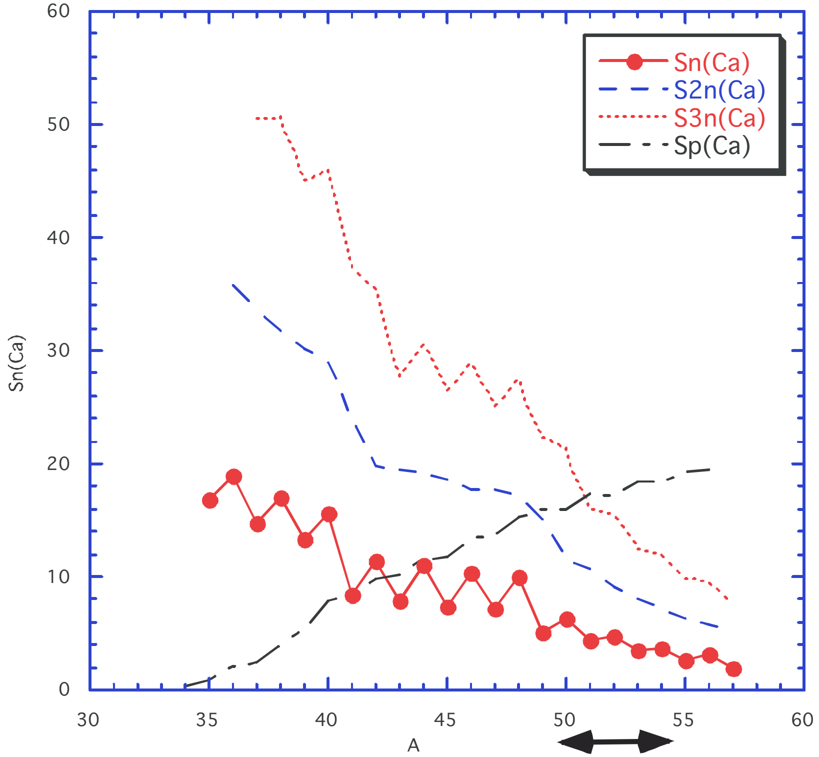


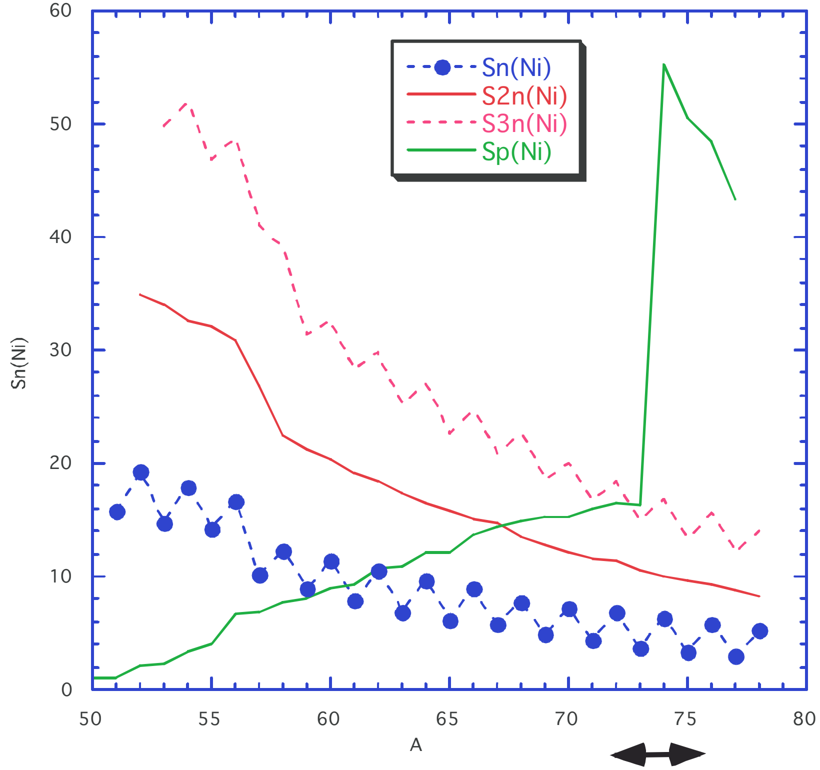
$^{72-76}Ni$ from ^{86}Kr



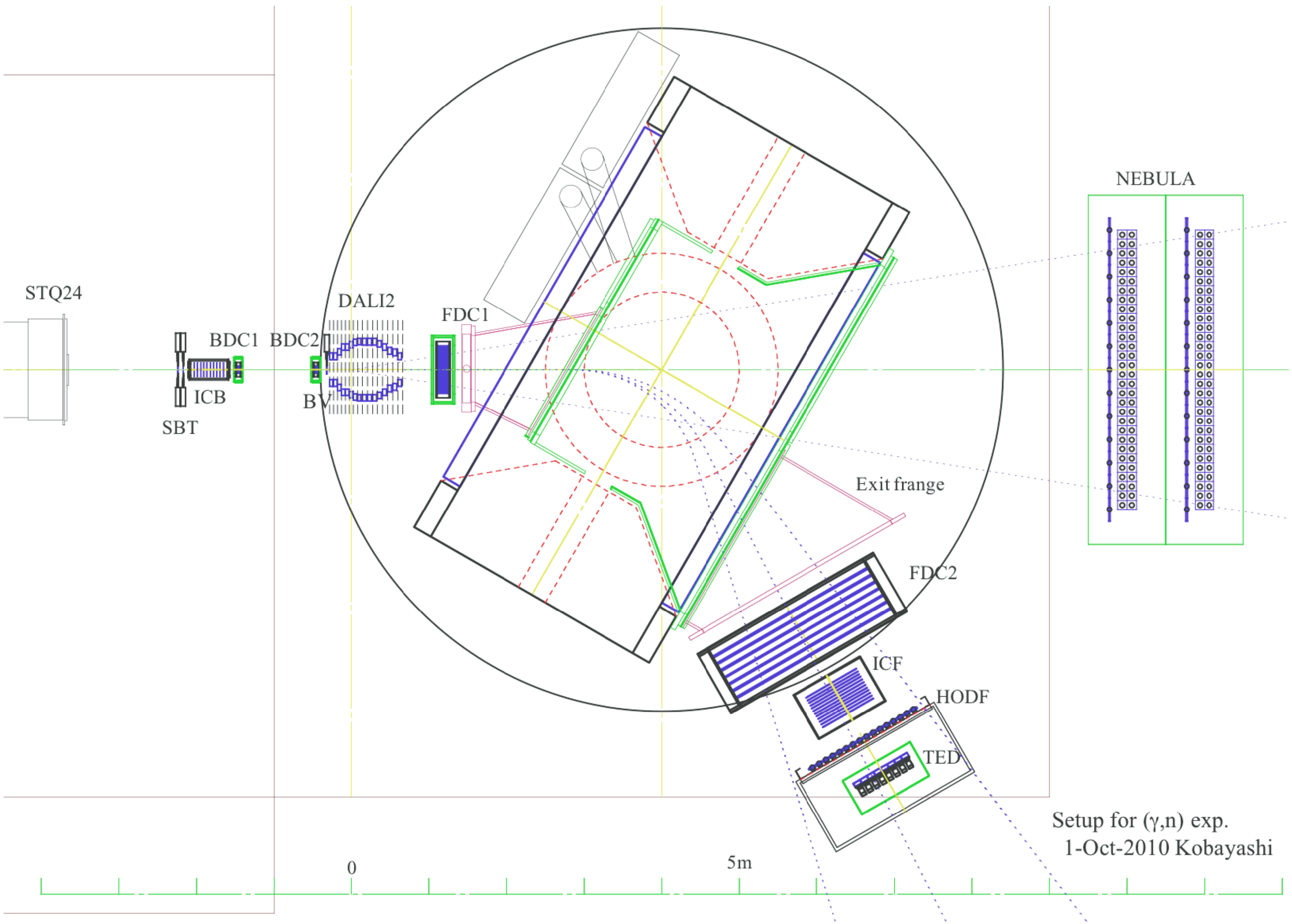
2-3. Excitation Energy Range

* Sn < Ex < S3n by detecting 1n & 2n





3-1. Experimental Setup @ spring 2012



3-2. Secondary Beams

* detector debugging for z~20

  * ^{46}Ar (>1MHz), ^{48}Ar (~0.1KHz), ^{50}Ca (~1kHz) <-- ^{48}Ca @350MeV/A(200pnA)

* data taking, @250MeV/A

production target: Be 2.0 g/cm^2, degrader: 3mm

45Ar	46Ar	47Ar	48Ar	49Ar	50Ar
20	110	110	40	9	1

<-- 350MeV/A ^{82}Se (30pnA)

50Ca	51Ca	52Ca	53Ca	54Ca	55Ca
350	1070	730	180	30	3

72Ni	73Ni	74Ni	75Ni	76Ni	77Ni
46	123	66	21	4.3	0.5

<-- 350MeV/A ^{86}Kr (30pnA)

mixed mode :

total rate <~10kHz

also important for stability monitor of CsI

3-3 : Yield Estimate

* Soft dipole mode (assumption)
  * strength : 5% of TRK sum rule
  * excitation energy : Ex ~6 MeV (Ca), ~9 MeV (Ni)
* Excitation cross section : ~0.5 b (Ca), 0.2b (Ni)
* Neutron detection eff. : ~40 % (Ca), ~36% (Ni)
* Target : Pb : 1 g/cm^2 (θ_{MCS} ~4 mrad)、 C : 2 g/cm^2
* Yield : ~84/h (^{48}Ar), ~50/h (^{74}Ni)
* Total=5K events : 2.5 days (Ar/Ca), 4.2 days (Ni)

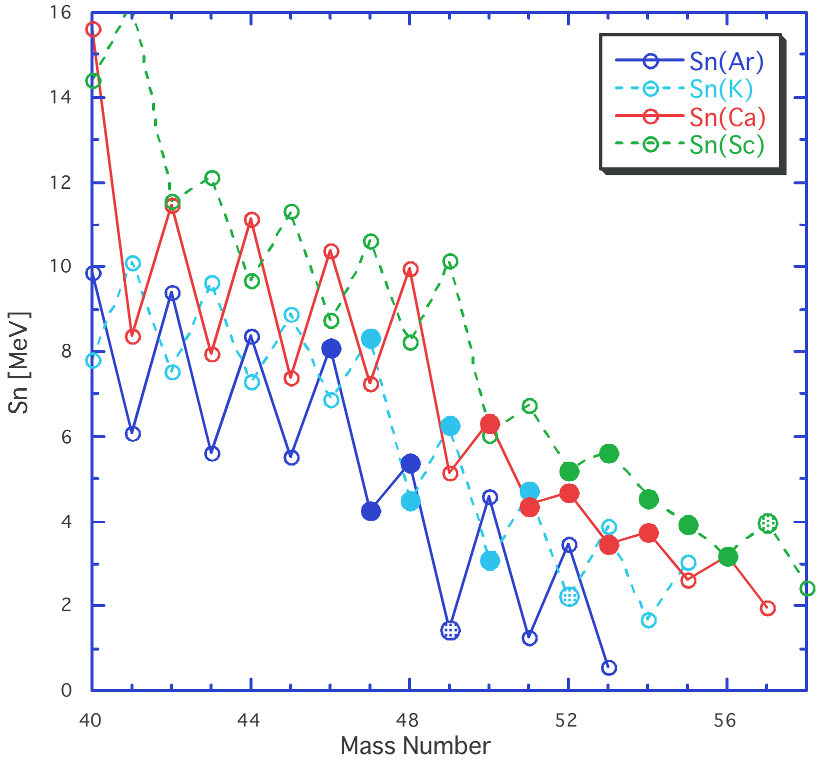
  1.1 Kevt (^{49}Ar), 0.3 Kevt (^{76}Ni)
* (+ part of normal GDR)
* + C & empty (estimation not final) :

  ~ 5-6 days (Ca/Ar), ~ 8-9 days (Ni)

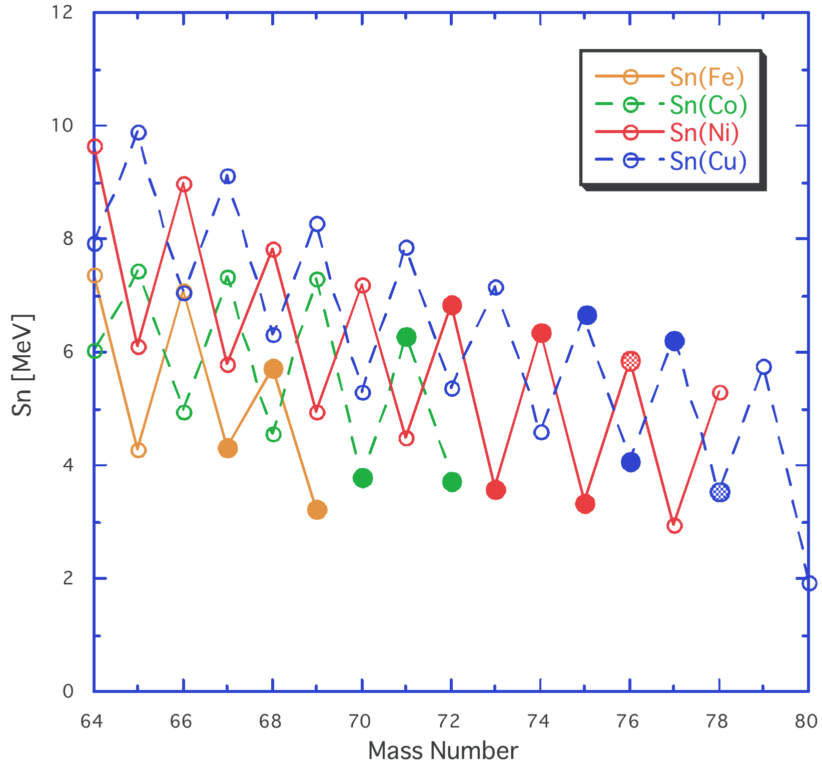
3-4. Measurable Mass Range

* "Mixed" beam   closed circles : can be measured in one setting

$^{50-54}$Ca from ^{82}Se



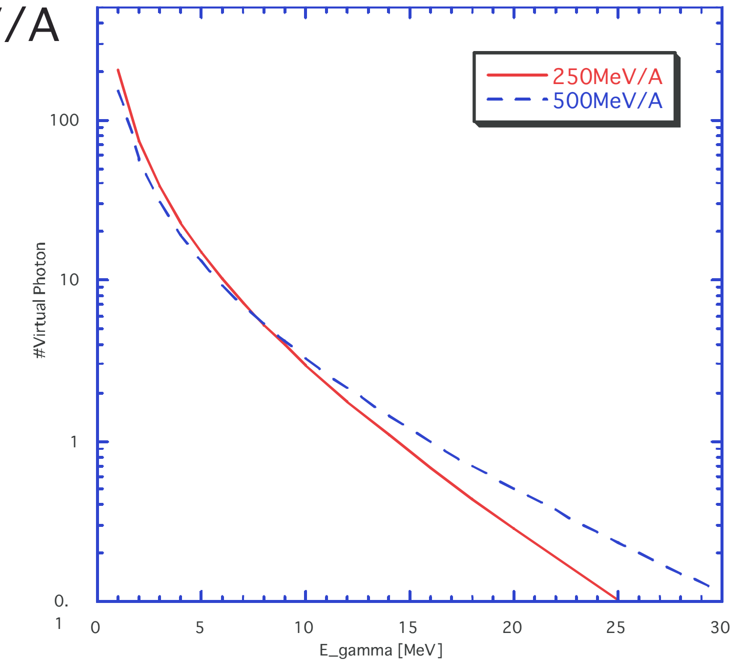
$^{72-76}$Ni from ^{86}Kr



* interaction cross section measurement :   possible with the same setup

3-5. Comparison (with LAND/GSI)

	RIBF		LAND/GSI
* Beam Energy :	250 MeV/A	.vs.	>500 MeV/A
* Virtual Photon:			
* $Eff_{neutron}$:	~40%		~100%
* Beam intensity:	"factory"	.	
need more primary beams : ^{82}Se, ^{86}Kr			
* PID:	probably better		
* target thickness:			thicker
* γ detectors	(DALI2)		CsI-array



4. Summary

* Electromagnetic excitation/breakup for soft dipole mode in Ca & Ni regions

  experimental conditions : estimated

  "mixed" beam experiment

  like to have more beams

    ^{82}Se: or better primary for Ca regions

    more intensity for ^{86}Kr

  range : $^{50-54(55)}$Ca, $^{72-75(76)}$Ni

* better with other information

  interaction cross section measurement : possible with the same setup

* Extraction of information

  symmetry energy ?