^{79}Kr, ^{80}Brのカイラルペアバンドの探索

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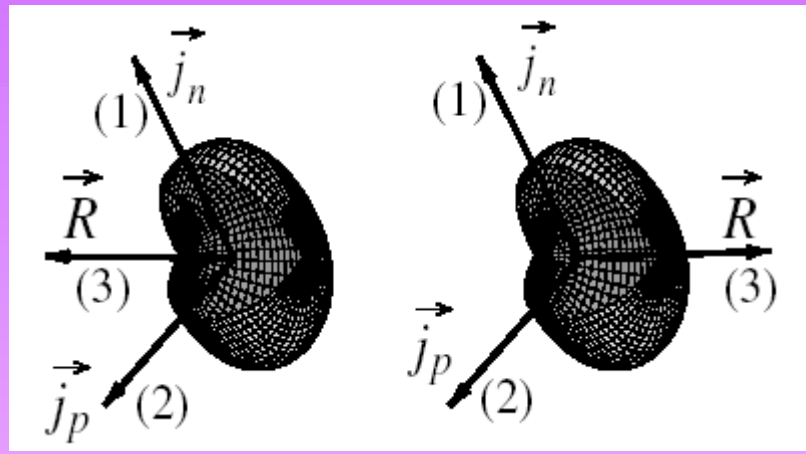
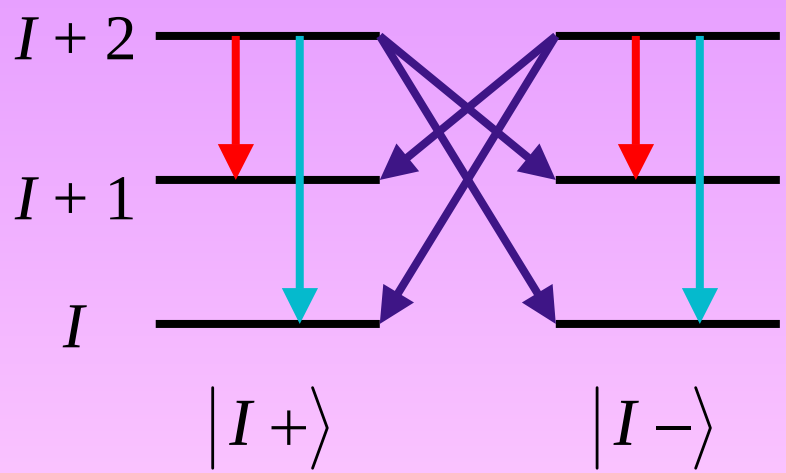
Nuclear Chirality

- For Mass 80 region $\left(\pi g_{9/2} \otimes \nu g_{9/2}^{-1}\right)$
  - (1) 1-axis : longest axis of the triaxial shape
    - j_n; neutron-hole in a high-j_n shell
  - (2) 2-axis : shortest axis
    - j_p; proton-particle in a high-j_p shell
  - (3) 3-axis : intermediate axis of the triaxial shape
    - R; core rotation
- Three perpendicular angular momentum can be formed into two systems of handedness, the right-handed or the left-handed system

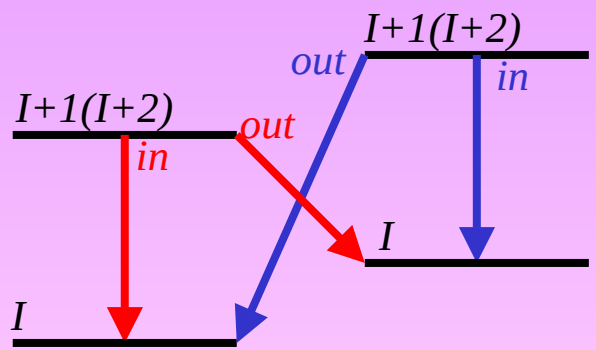
$$E = \begin{cases} |I+\rangle = \frac{1}{\sqrt{2}}\left(|IR\rangle + |IL\rangle\right) \\ |I-\rangle = \frac{i}{\sqrt{2}}\left(|IR\rangle - |IL\rangle\right) \end{cases}$$





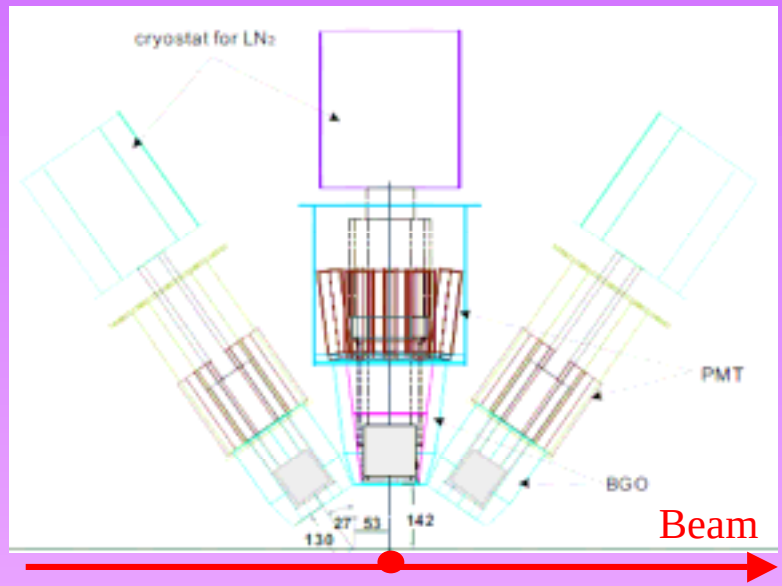
Criteria for Nuclear Chirality

- Nearly degenerate $\Delta I = 1$ twin bands with the same parity
  - observed in some odd-odd and odd-A nuclei in A~130 region
    - proton $h_{11/2}$ particle and neutron $h_{11/2}$ hole configuration
      - ^{124,126,128,130,132}Cs, ^{130,132,134}La, ^{132,134}Pr, ^{136}Pm, ^{138,140}Eu, ^{135}Nd, ^{135}Ce
  - observed in some odd-odd and odd-A nuclei in A~105 region
    - proton $g_{9/2}$ hole and neutron $h_{11/2}$ particle configuration
      - ^{106,107}Ag, ^{102,103,104,105,106}Rh, ^{100}Tc
- $B(E2; I \rightarrow I-2)_{in,out}$ and $B(M1; I \rightarrow I-2)_{in,out}$ values are the same between both bands.
  - lifetime measurements are required.
    - measured in ^{134}Pr, ^{132}La, and ^{128}Cs
    - GS plus plunger experiment done for ^{103,104}Rh (RDDS; Recoil Distance Doppler shit Method)



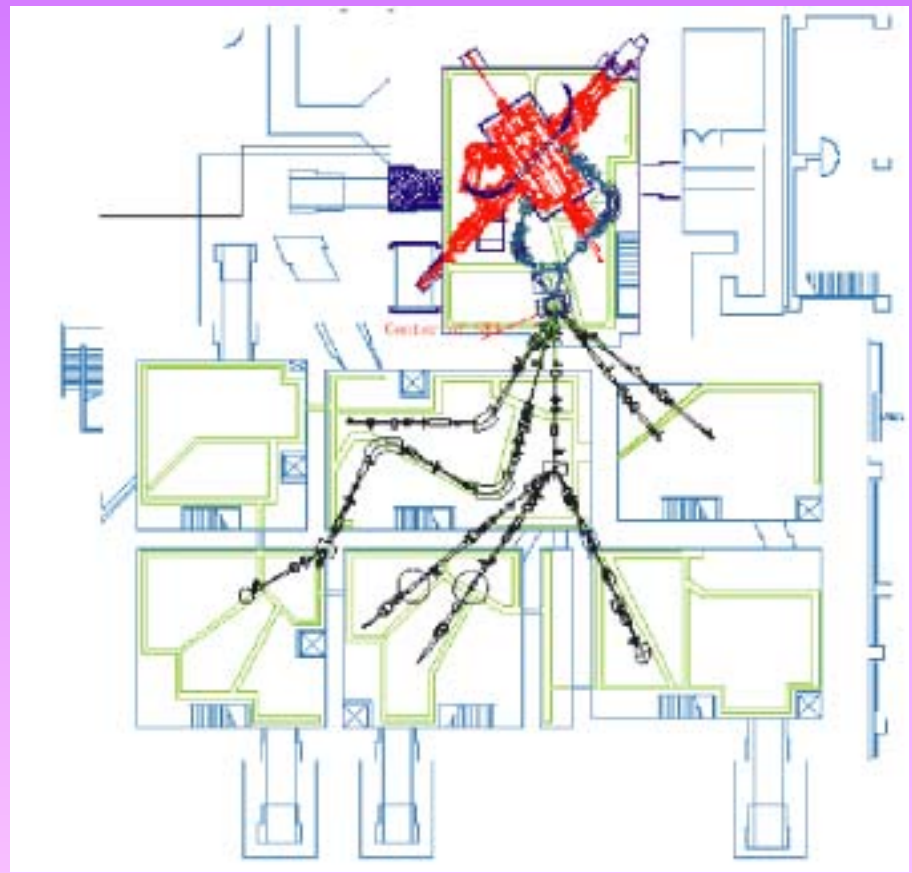
In-beam experiments with Hyperball-2

- Total of 20 detectors
  - Photo peak efficiency ~4% at 1MeV
    - Eurisys Coaxial Ge + BGO
      - r.e. 60% x 4
    - Ortec Coaxial Ge +BGO
      - r.e. 60% x10
    - Eurisys Clover type Ge (+BGO) x 6
      - r.e 20%x4, 125% with add-back
  - Transistor-reset type pre-amplifier
- Advantages
  - Large total photo peak efficiency (γ-γ-γ coincidence measurement)
  - Possible to use with high intensity (~10pnA) beam (high counting rate).
- Disadvantages
  - Few angles
    - Detectors placed mostly around 90deg. (lower angular correlation sensitivity)
  - Detectors in upper and lower ring point off center



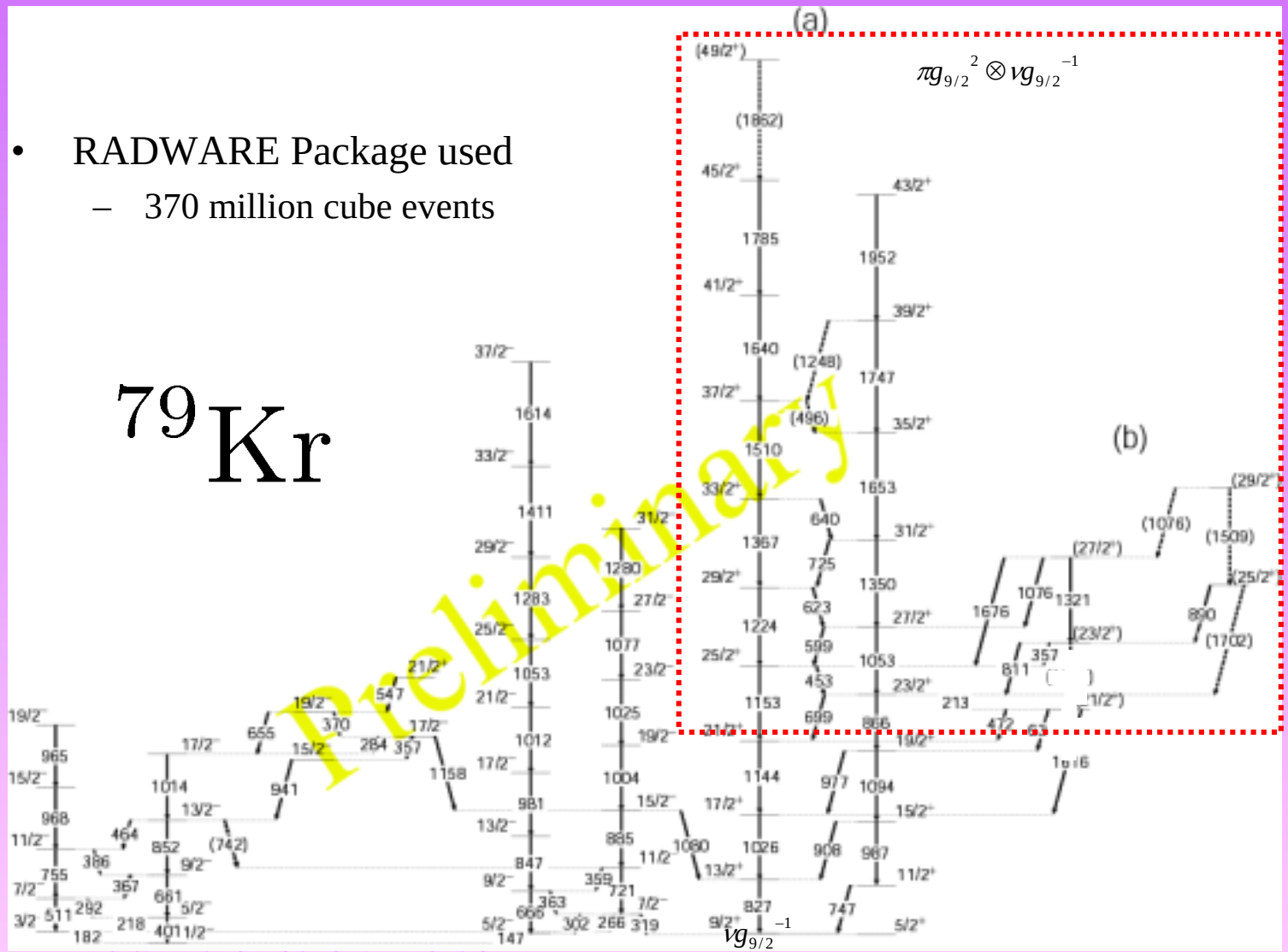
Experiments

- Course 33 at CYRIC, Tohoku University
- Reaction and target
  - $^{70}Zn(^{13}C,4n)^{79}Kr$
    - Beam: $^{13}C^{3+}$ @ 65MeV from 930 cyclotron
    - Target: 500μg/cm^2 70% enriched ^{70}Zn (self-supporting, stacked)
  - $^{70}Zn(^{13}C,p2n)^{80}Br$
    - Beam: $^{13}C^{3+}$ @ 53MeV from 930 cyclotron
    - Target: 1 mg/cm^2 70% enriched ^{70}Zn (Pb backing, 10mg/cm^2)
- HPGe array: Hyperball-2 for γ ray detection
- trigger: γ–γ–γ (triple coincidence)

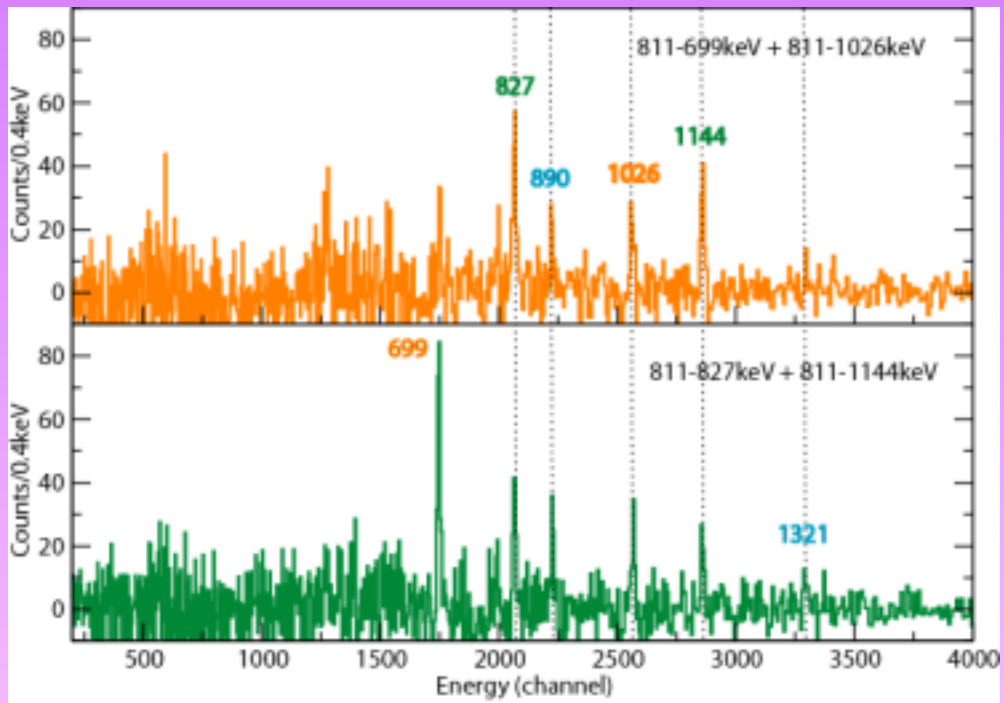


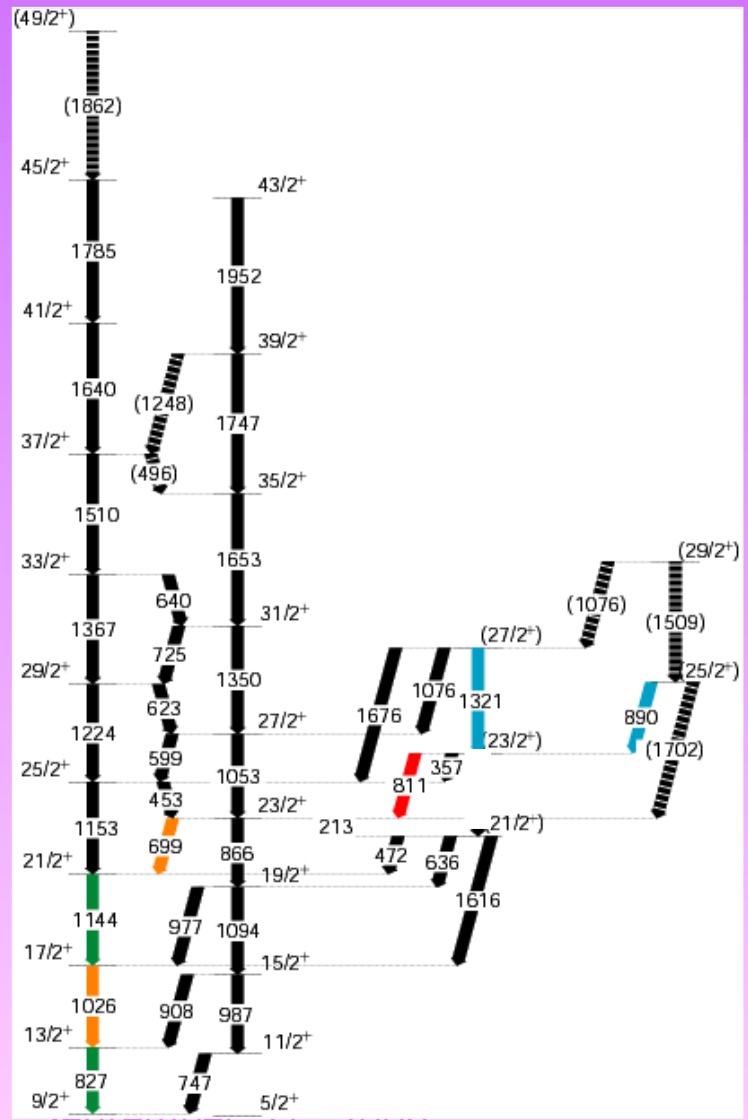
Deduced Level Scheme

- RADWARE Package used
  - 370 million cube events



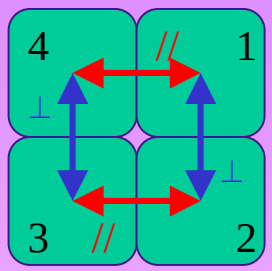
γ–γ–γ spectra


811-699keV + 811-1026keV
827
890
1026
1144
699
811-827keV + 811-1144keV
1321
Counts/0.4keV
Energy (channel)

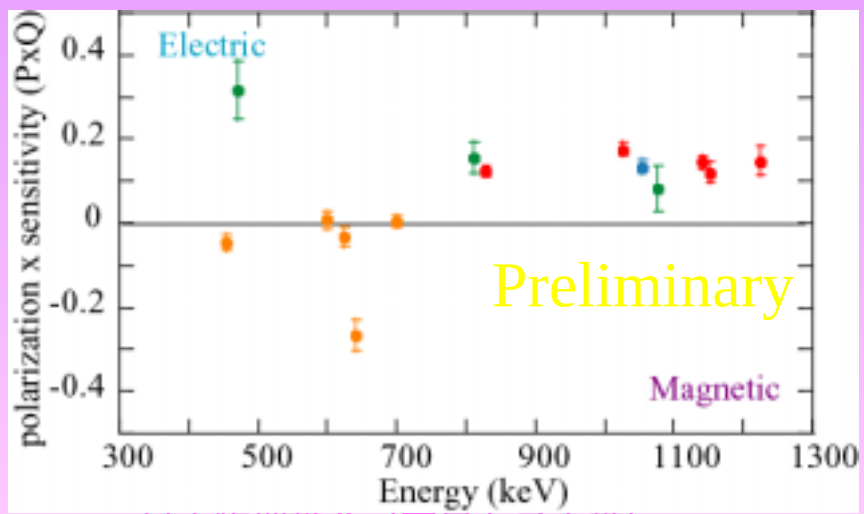

(49/2+)
(1862)
45/2+
43/2+
1785
1952
41/2+
39/2+
1640
(1248)
1747
37/2+
(496)
35/2+
1510
1653
33/2+
31/2+
640
(1076)
(29/2+)
1367
(27/2+)
(1509)
725
1350
29/2+
1076
1321
25/2+
623
1676
27/2+
890
1224
(23/2+)
(1702)
599
1053
357
25/2+
811
453
23/2+
213
21/2+
1153
699
866
472
636
21/2+
19/2+
1616
1144
977
1094
17/2+
15/2+
1026
908
987
13/2+
11/2+
827
747
9/2+
5/2+

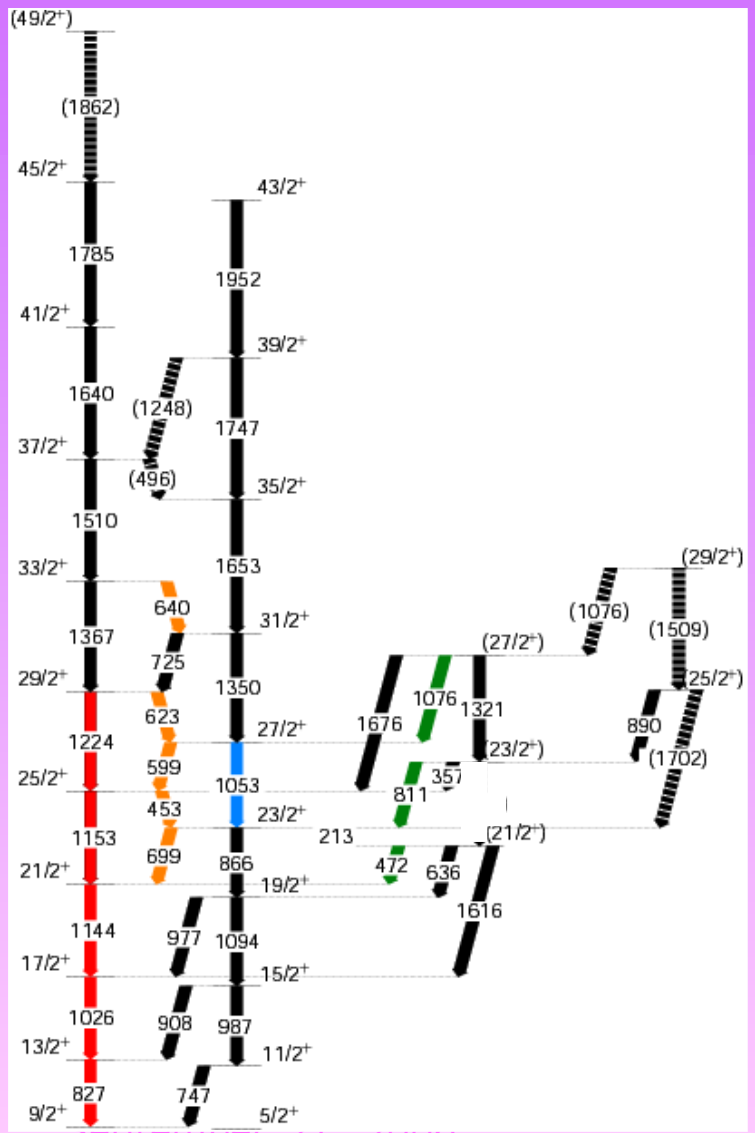
Relative Spin-Parity assignment

- Linear polarization can be extracted with clover detectors to infer relative spin and parity.
  - Sign of *P* can be known without knowing sensitivity *Q(E)*.

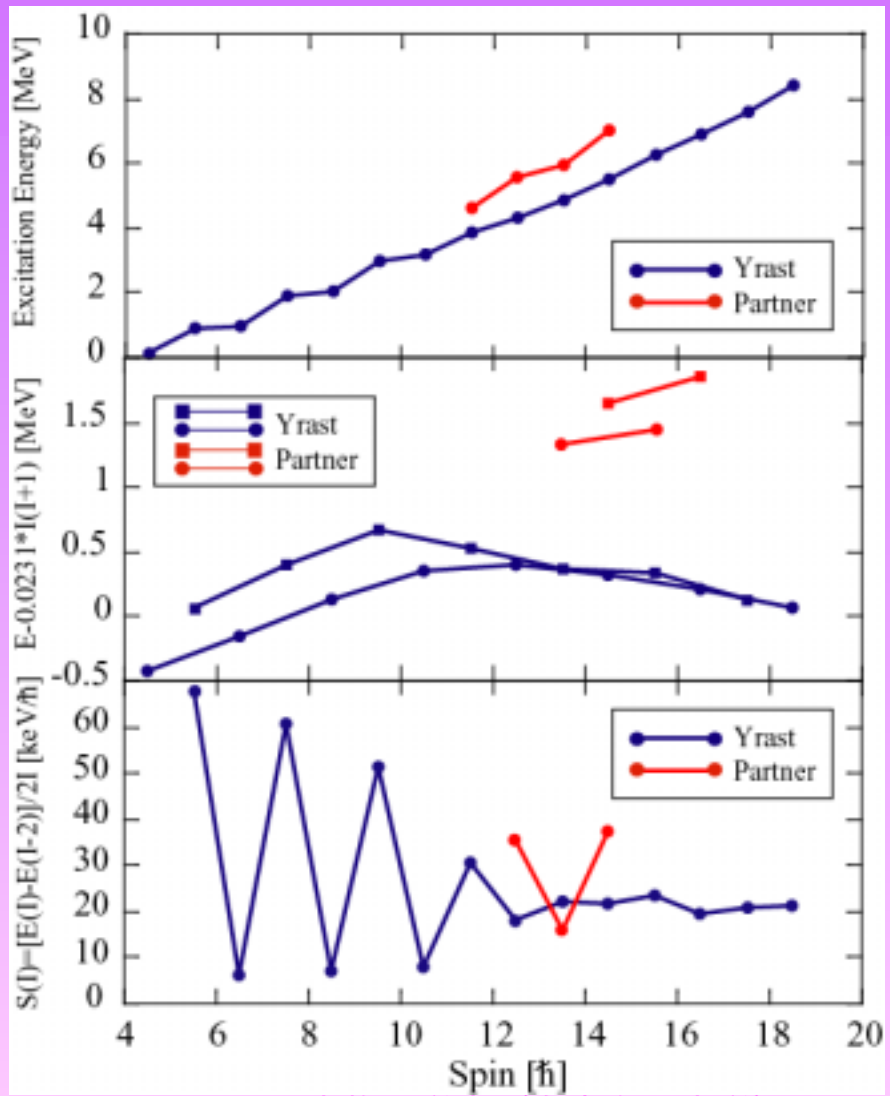


$$P = \frac{1}{Q}\frac{N_{\perp} - N_{//}}{N_{\perp} + N_{//}}$$





Discussion of results: ^{79}Kr

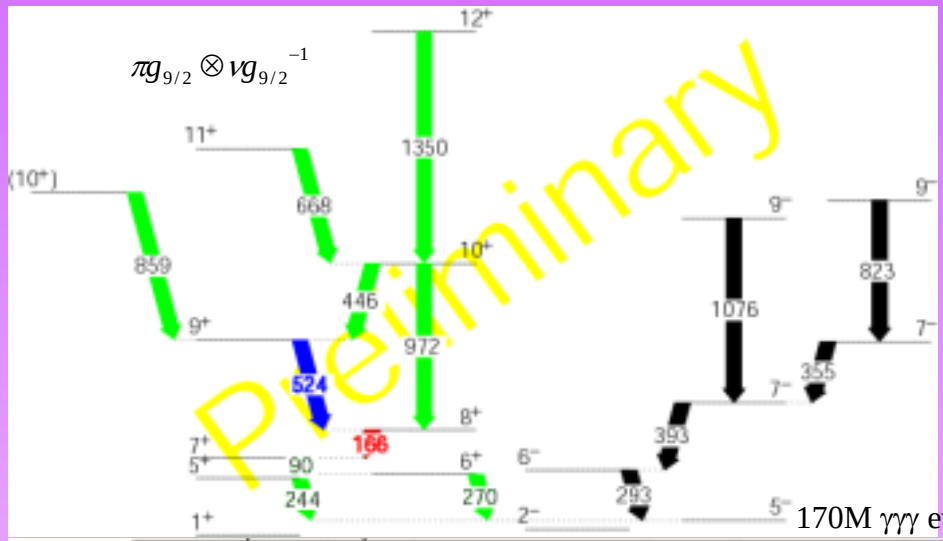


I	27/2	29/2	31/2	33/2
$E(I)_P$-$E(I)_Y$ in keV	811	1247	1079	1532

- If two bands are chiral partners…
  - Nearly degenerate between two bands.
  - single particle states should be the same.
  - $S(I) = [E(I)-E(I-2)]/2I$ should be smoothly varying.
- Further experiment on ^{79}Kr is proposed to GAMMASPHERE
  - γ–γ–γ–γ → building to higher spin states.
  - DCO measurement → determination of multipolarity
  - Doppler Shift Attenuation Method (DSAM) → life time measurement

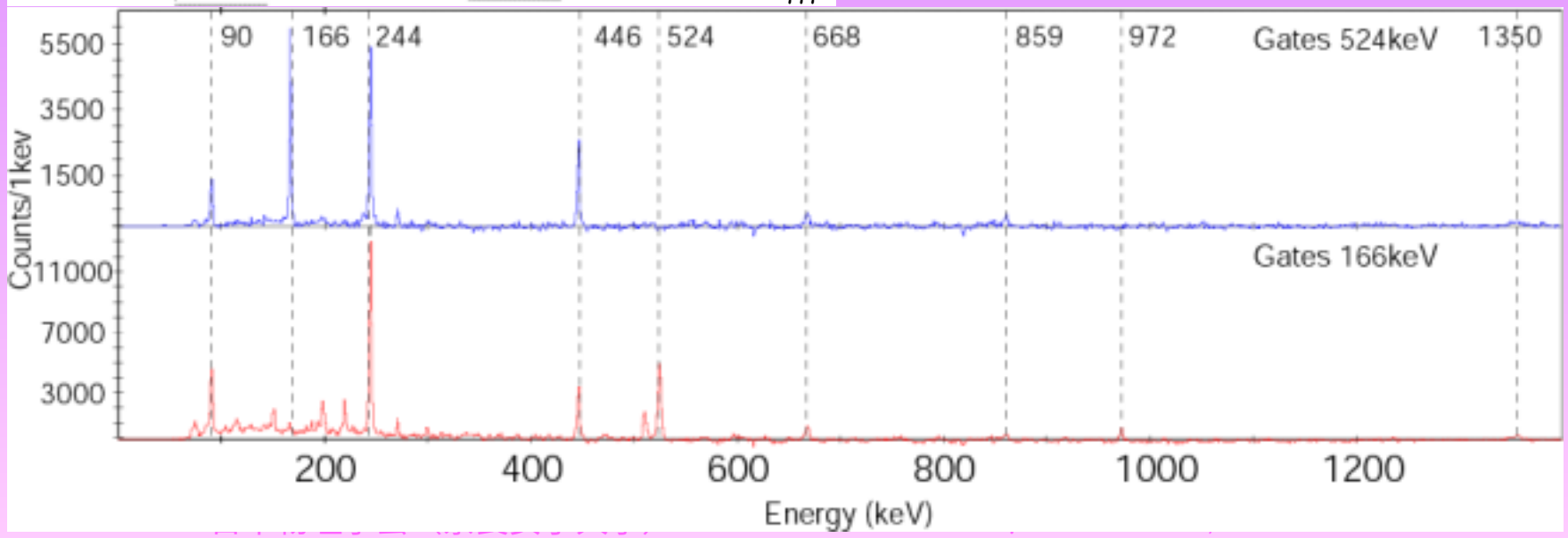
Complete spectroscopy of ^{79}Kr

^{80}Br; ^{70}Zn(^{13}C,p2n)@54MeV



- Jul 4-8, 2006 (12shifts)
  - Excitation function measurement
  - Charged particle detector
  - BGO Multiplicity-filter

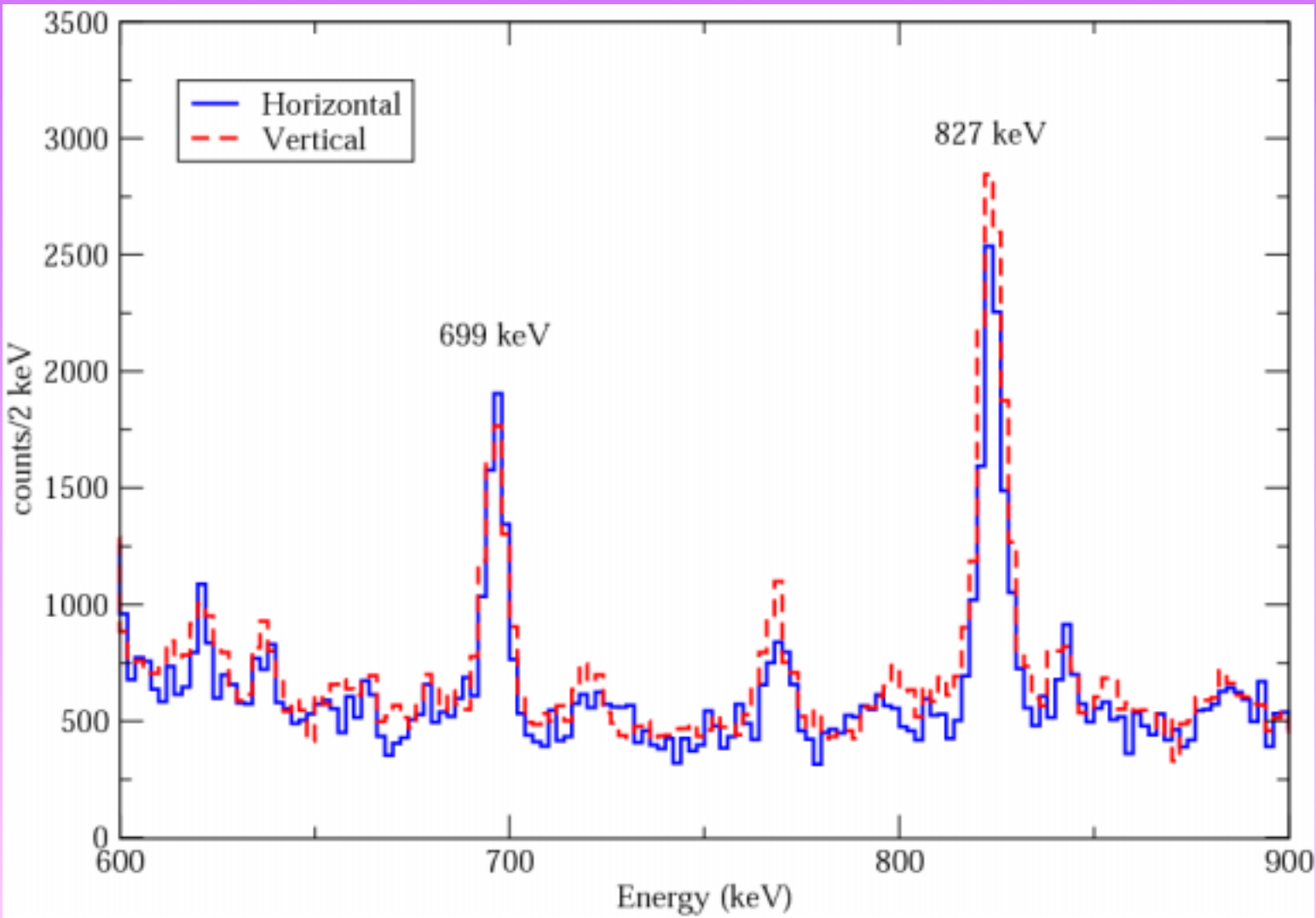
170M γγγ events



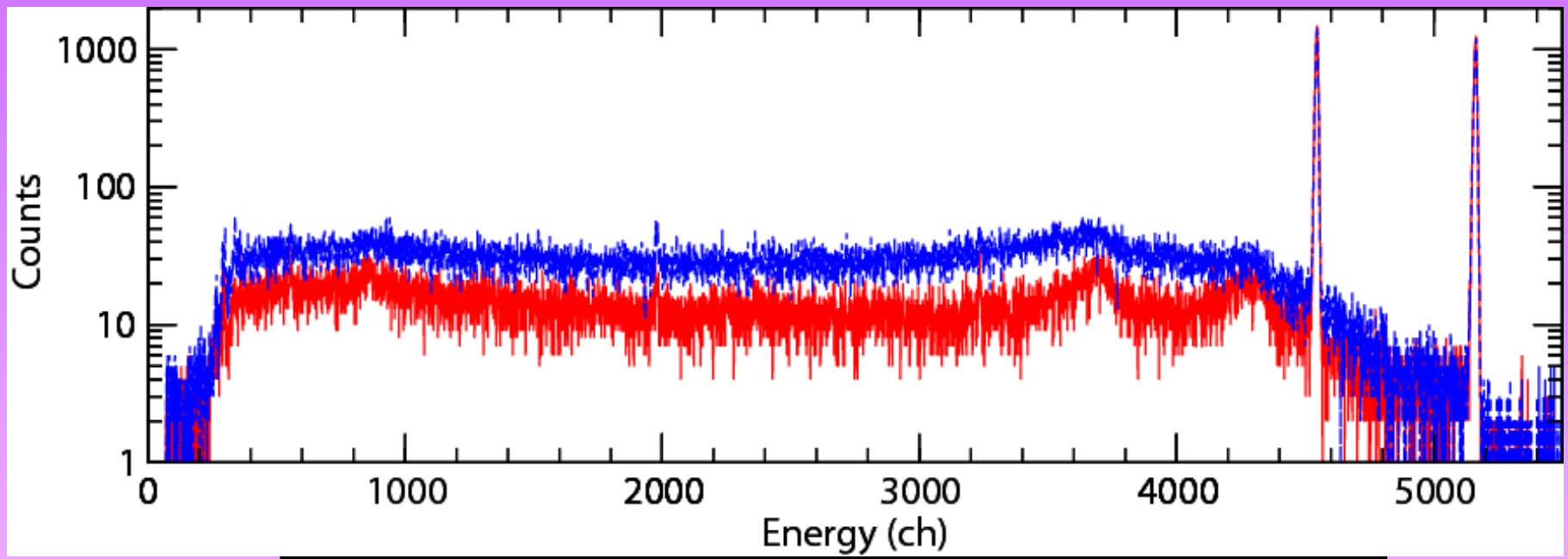
Summary

- ^{79}Kr and ^{80}Br were studied via the ^{70}Zn(^{13}C,4n)^{79}Kr and ^{70}Zn(^{13}C,p2n)^{80}Br reaction, respectively, in search for chiral doublet structures in the mass ~80 region.
- Preliminary analysis has identified new band structure in ^{79}Kr.
- Tentative spin and parity assigned based on linear polarization measurement.
- Experiments for ^{80}Br will be improved with excitation function measurement, addition of charged particle detector of BGO multiplicity filters *etc*..

Linear Polarization



BGO suppression

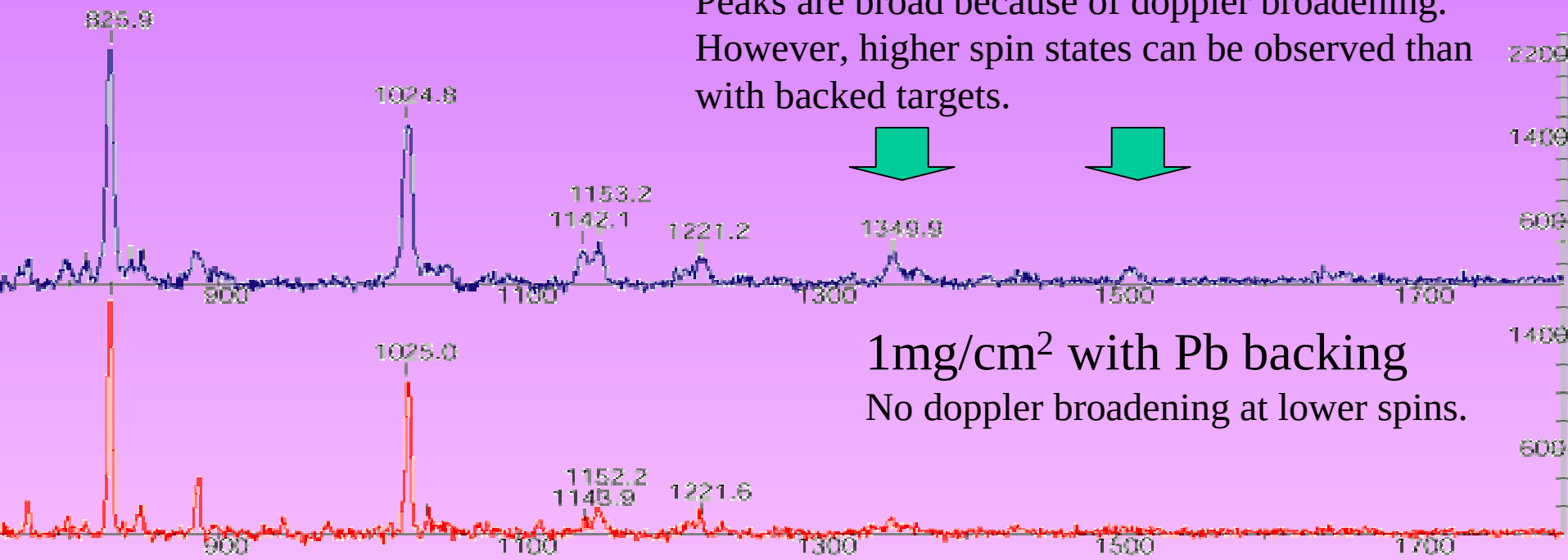


Peak/Total	BGO OFF	BGO ON
Single Crystal	~ 18%	~ 32%
Clover(individual)	~ 10%	~ 15%
Clover(Add-back)	~ 20%	~ 30%

Choice of targets

1mg/cm^2 without backing

Peaks are broad because of doppler broadening. However, higher spin states can be observed than with backed targets.



1mg/cm^2 with Pb backing

No doppler broadening at lower spins.

In March experiments, 520+560μg/cm^2 self-supporting target is used.