Large Collectivity in ^{60,62}Cr studied by proton inelastic scattering

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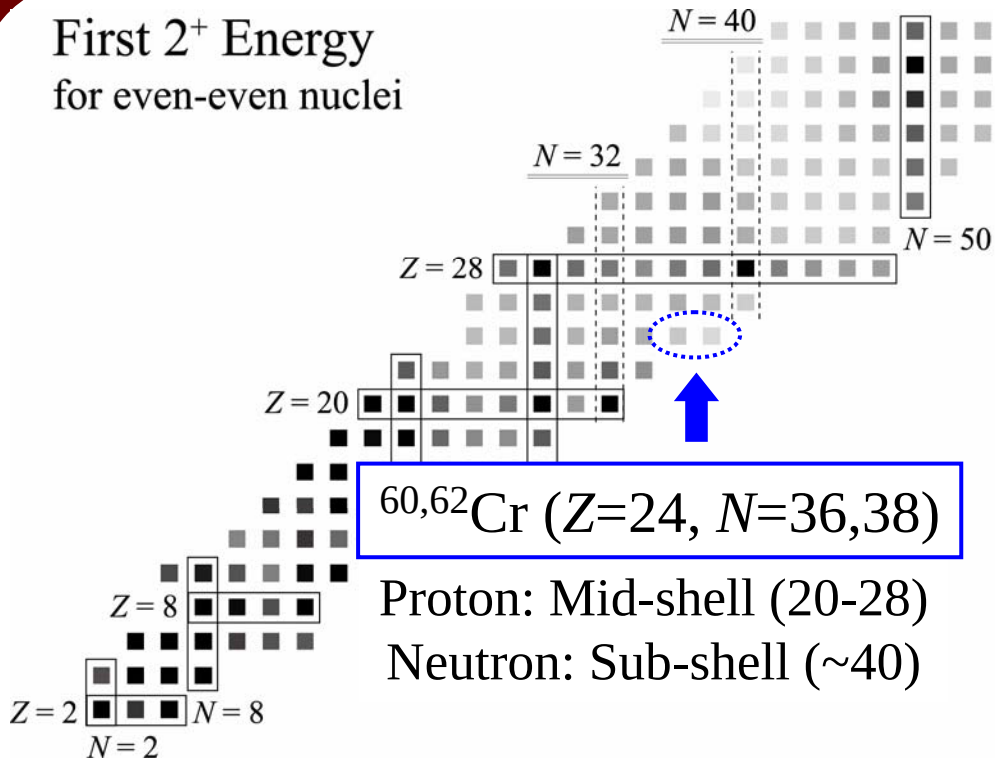
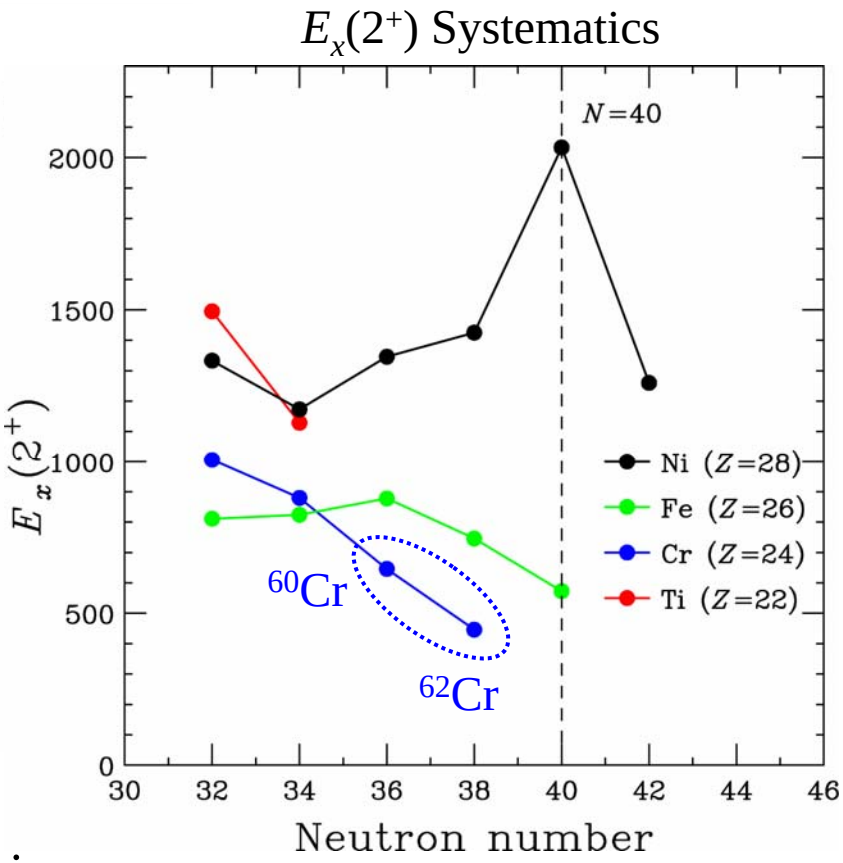
Neutron-rich Cr isotopes around N=40





$E_x(2^+)$ of ^{60,62}Cr are lower than neighbor nuclei.

^{60}Cr 646keV, ^{62}Cr 446keV

The large collectivity in ^{60,62}Cr ??

($\beta-\gamma$, O. Sorlin *et al.*, EPJA **16** (2003) 55.)

Reference:
[^{68}Ni] R. Broda *et al.*, Phys. Rev. Lett. **74** (1995) 868.
[^{70}Ni] R. Grzywacz *et al.*, Phys. Rev. Lett. **81** (1998) 766.
[^{60,62}Fe] A.N. Wilson *et al.*, Eur. Phys. J. A **9** (2000) 183.
[^{64,66}Fe] M. Hannawald *et al.*, Phys. Rev. Lett. **82** (1999) 1391.
[^{58}Cr] J.I. Prisciandaro *et al.*, Nucl. Phys. A **682** (2001) 200c.
[^{54,56}Ti] B. Fornal *et al.*, Phys. Rev. C **70** (2004) 064304.

Proton inelastic scattering on ^{60}Cr and ^{62}Cr

Study of collectivity in ^{60,62}Cr ← 2_1^+ states

(p,p') in inverse kinematics

γ-ray spectroscopy

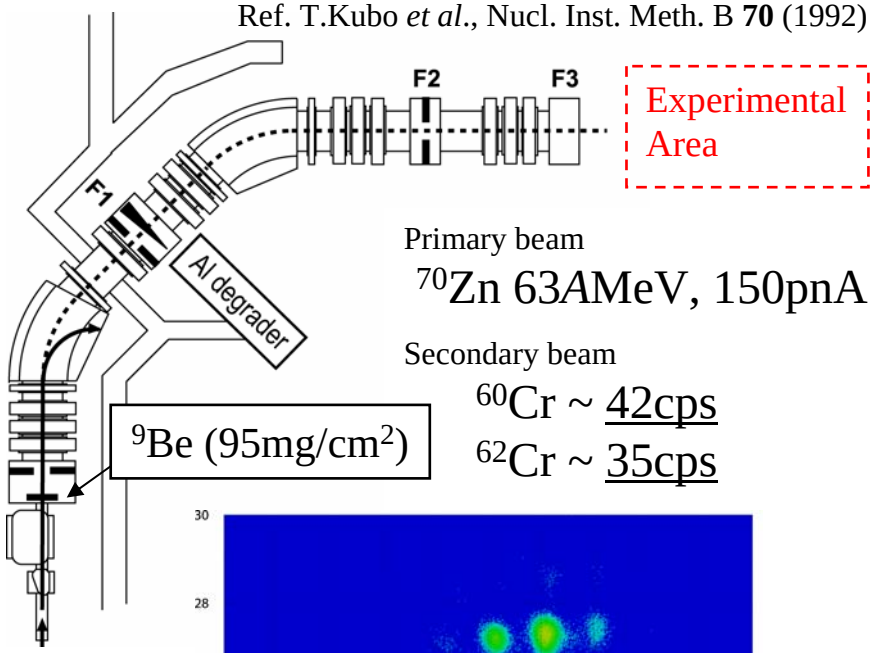
- Angle-integrated cross section $\sigma_{pp'}(2^+)$

- deformation parameter $\beta_{pp'}$

Experimental Setup

RIPS(RIKEN projectile-fragment separator)

Ref. T.Kubo *et al.*, Nucl. Inst. Meth. B **70** (1992) 309.



Experimental Area

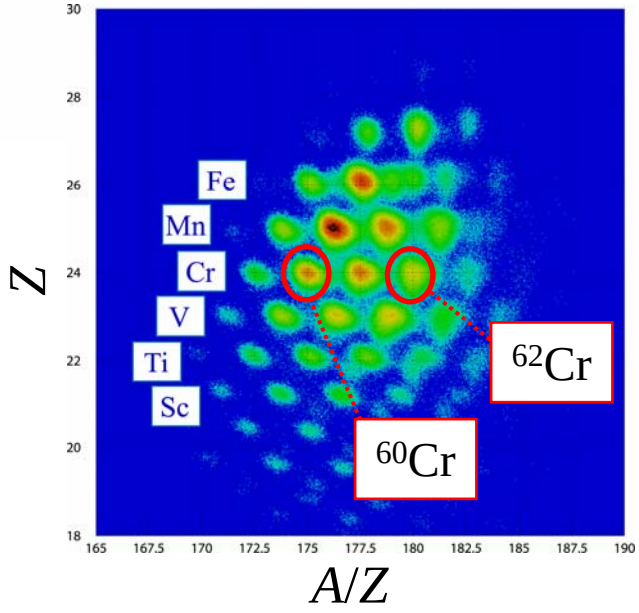
Primary beam

^{70}Zn 63*A*MeV, 150pnA

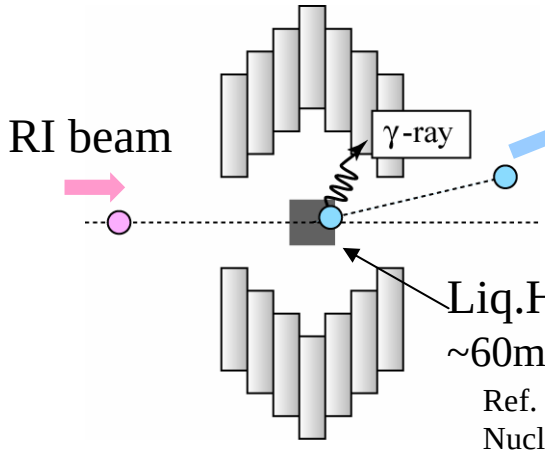
Secondary beam

^{60}Cr ~ 42cps

^{62}Cr ~ 35cps



Inelastic proton scattering



Ref. H.Ryuto *et al.*, Nucl. Inst. Meth A **555**(2005)1.

$$N_\gamma \rightarrow \sigma_{pp},(2^+)$$

NaI(Tl) array **DALI2**

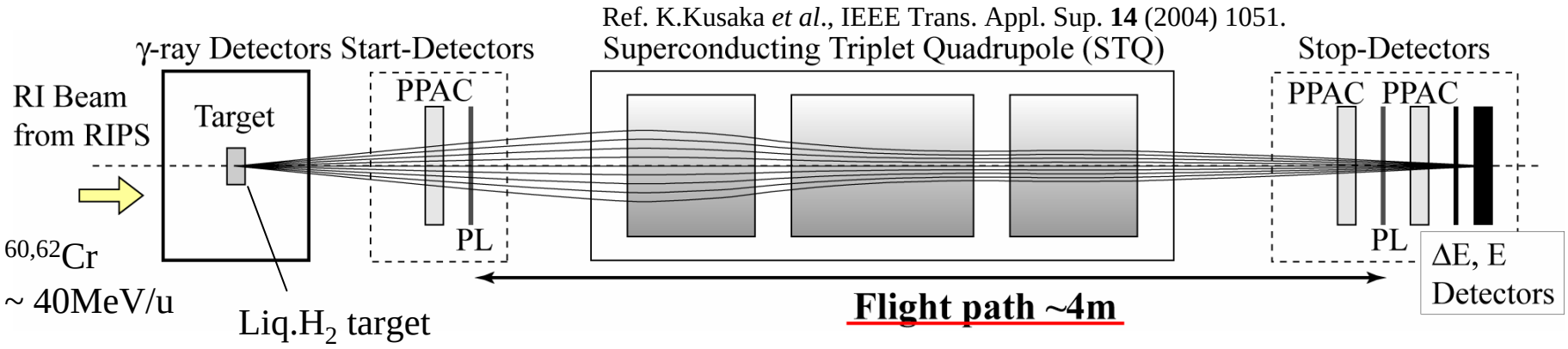
Ref. S.Takeuchi *et al.*, RIKEN Accel. Prog. Rep. **36**(2003)148

Efficiency : 26% @ 0.7MeV

Energy resolution : 10% @ 0.7MeV (FWHM)

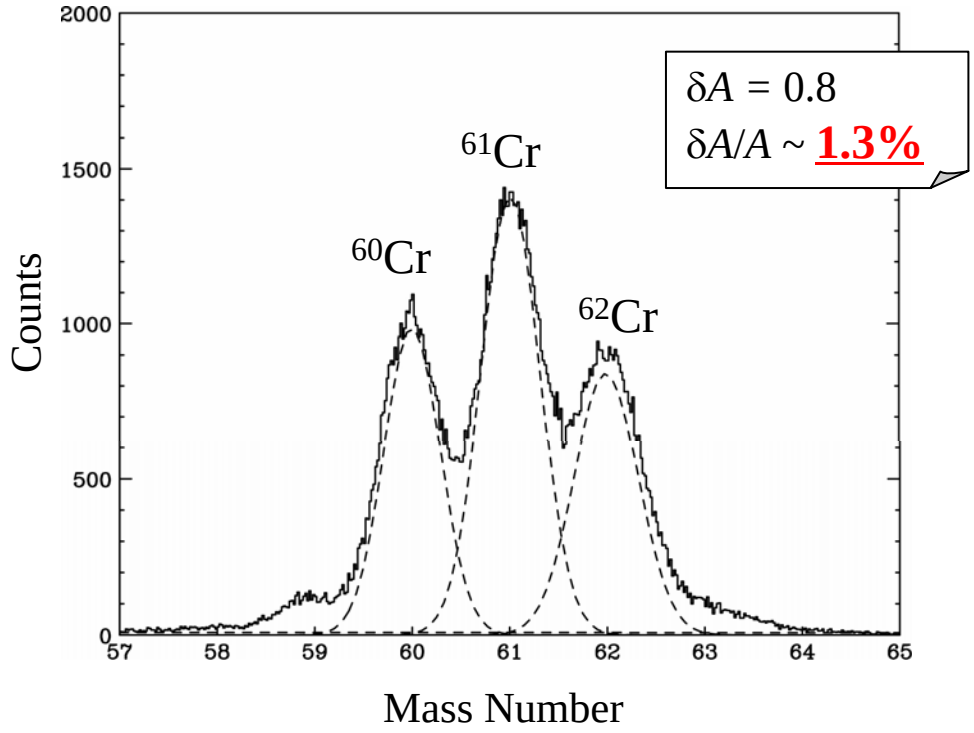
(β ~0.3)

PID by TOF Spectrometer



- TOF : Plastic scintillators (0.1mm)
  δTOF/TOF ~ 140ps/40ns = 0.4%
- *ΔE* : Si detectors (100μm)
  δ*ΔE*/*ΔE* ~ 1.6%
- *E* : Si detectors (320μm)
  δ*E*/*E* ~ 1.3%

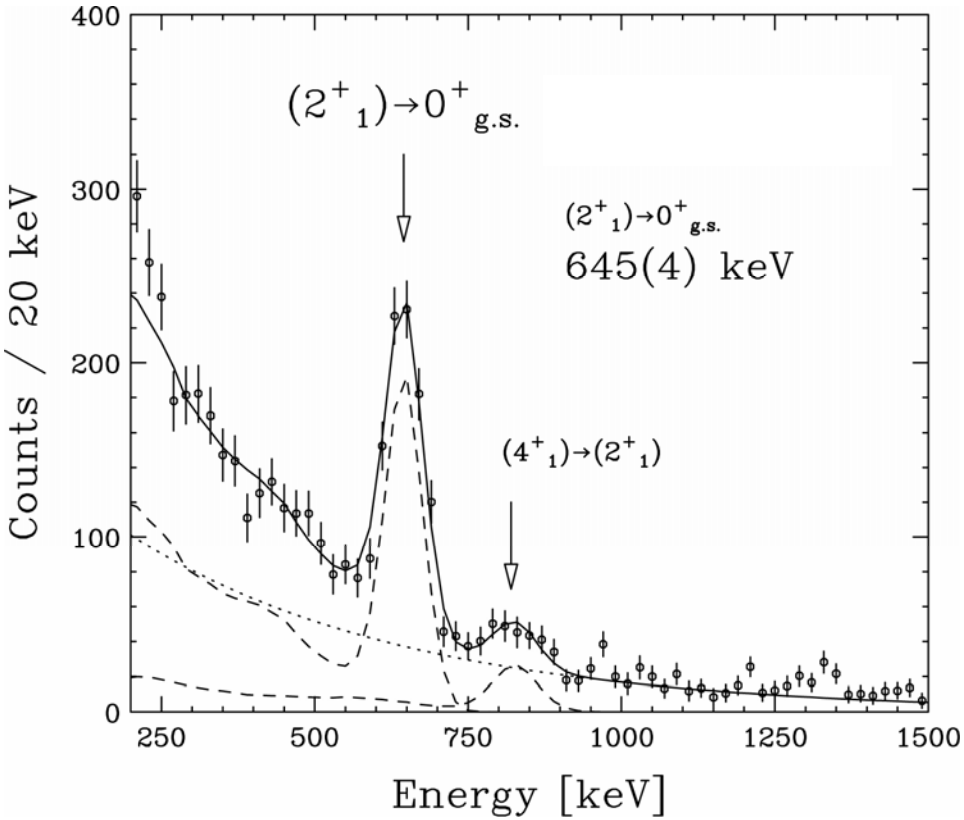
$$Z \propto \sqrt{\Delta E} \;/\; TOF$$
$$A \propto E \times (TOF)^2$$



Results of ^{60,62}Cr(p,p')

γ-ray spectrum ^{60}Cr(p,p')

H(^{60}Cr,^{60}Cr)

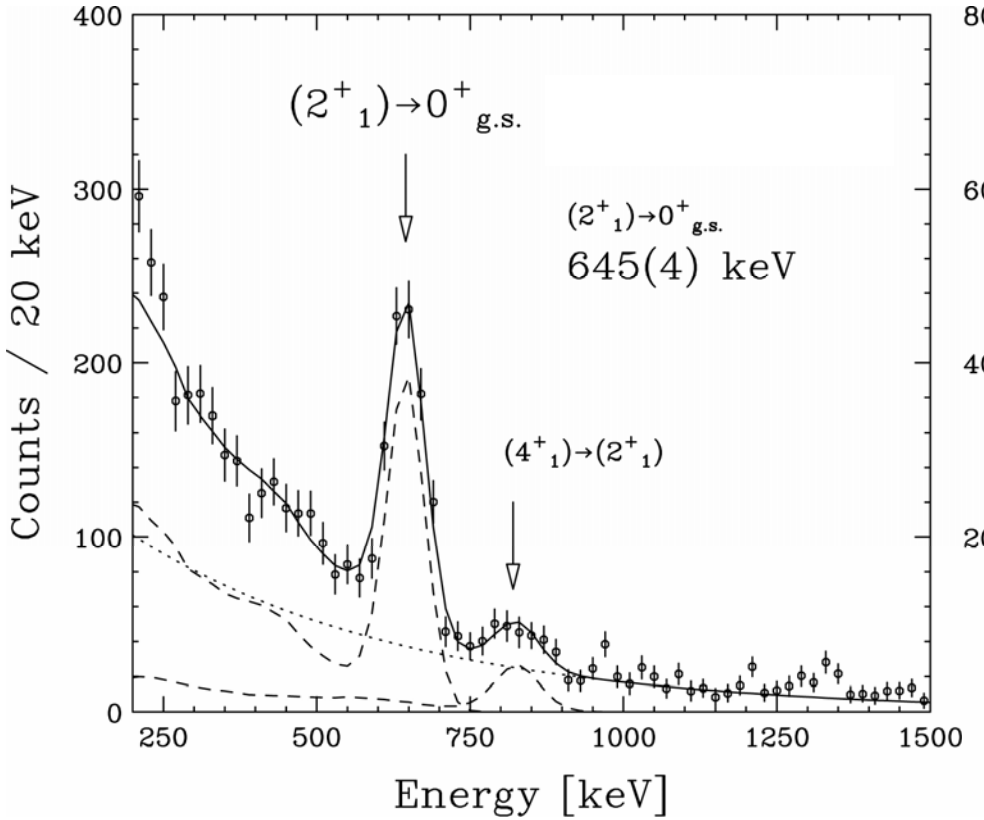


645 keV $(2^+) \rightarrow 0^+_{g.s.}$
817 keV $(4^+) \rightarrow (2^+)$

N. Marginean *et al.*, PLB **633** (06) 696.

γ-ray spectra ^{60}Cr(p,p') and ^{62}Cr(p,p')

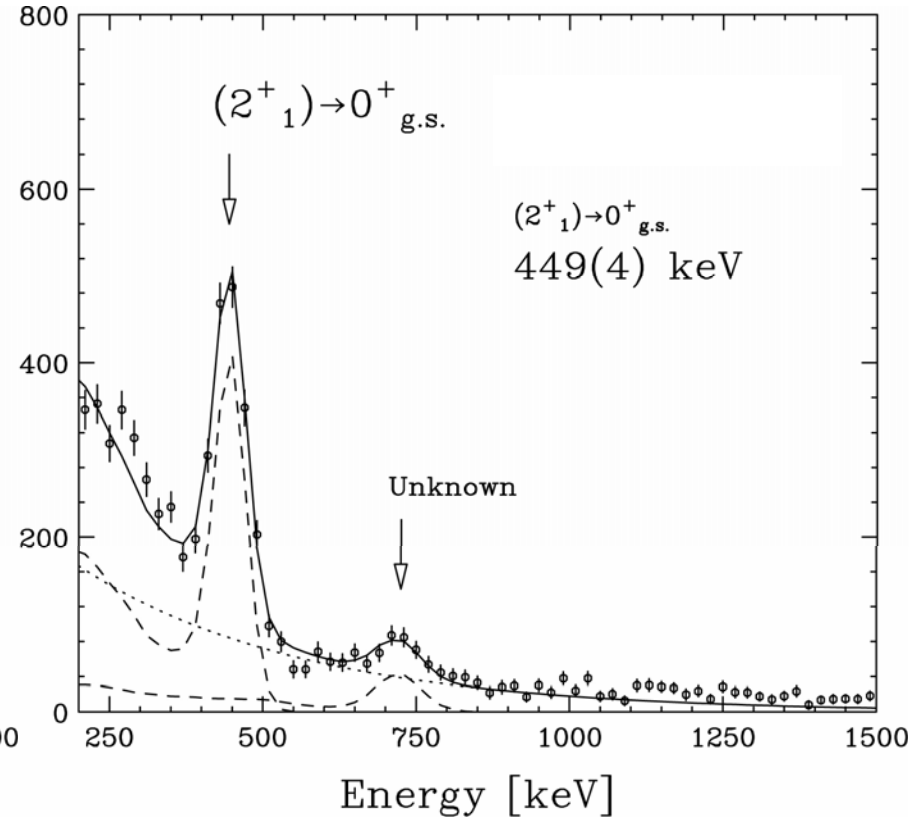
H(^{60}Cr,^{60}Cr)



645 keV $(2^+) \rightarrow 0^+_{g.s.}$
817 keV $(4^+) \rightarrow (2^+)$

N. Marginean *et al.*, PLB **633** (06) 696.

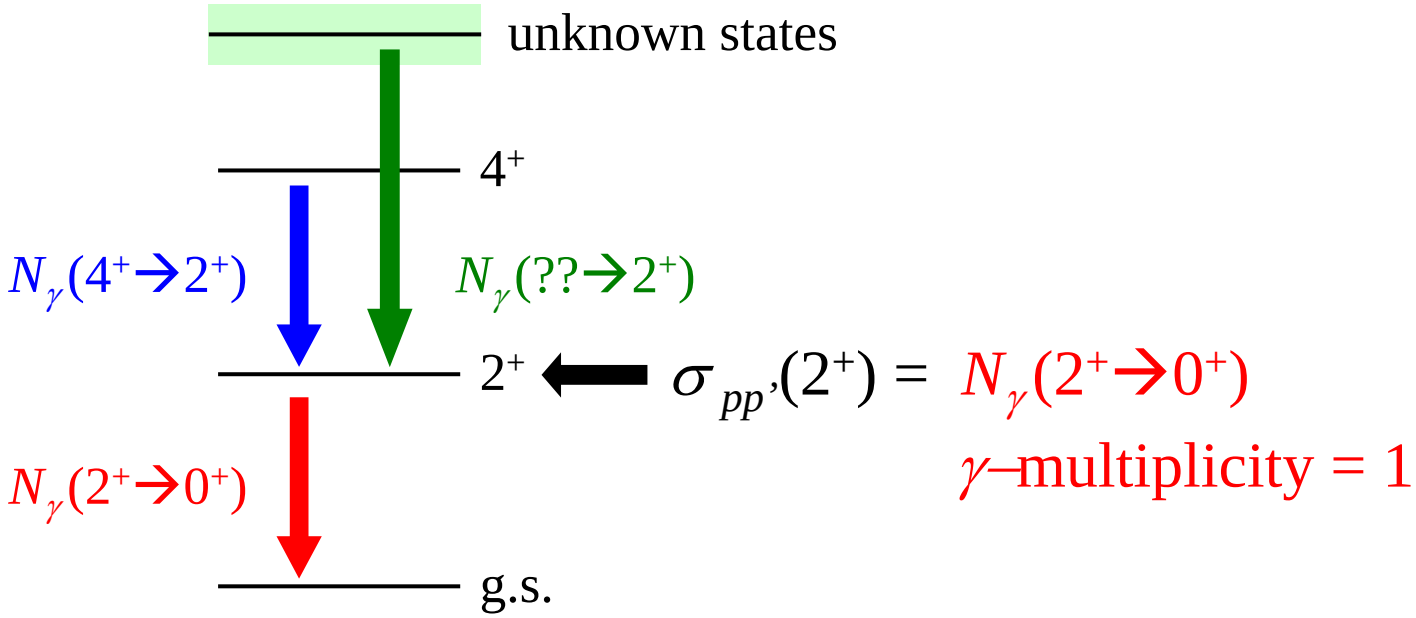
H(^{62}Cr,^{62}Cr)



446 keV $(2^+) \rightarrow 0^+_{g.s.}$

O. Sorlin *et al.*, EPJA **16** (2003) 55

Cross section $\sigma(2^+)$



- Angle integrated cross section $\sigma_{pp'}(2^+)$

^{60}Cr : **26(7) [mb]**

^{62}Cr : **38(6) [mb]**

Cross section $\sigma(2^+)$ → deformation parameter $\beta_{pp'}$

- $\beta_{pp'}$ was deduced by the DWBA calculation from the cross section.

^{60}Cr : $\beta_{pp'}$ = 0.28 (4)
^{62}Cr : $\beta_{pp'}$ = 0.31 (2)

- Optical potential

  Global optical potential

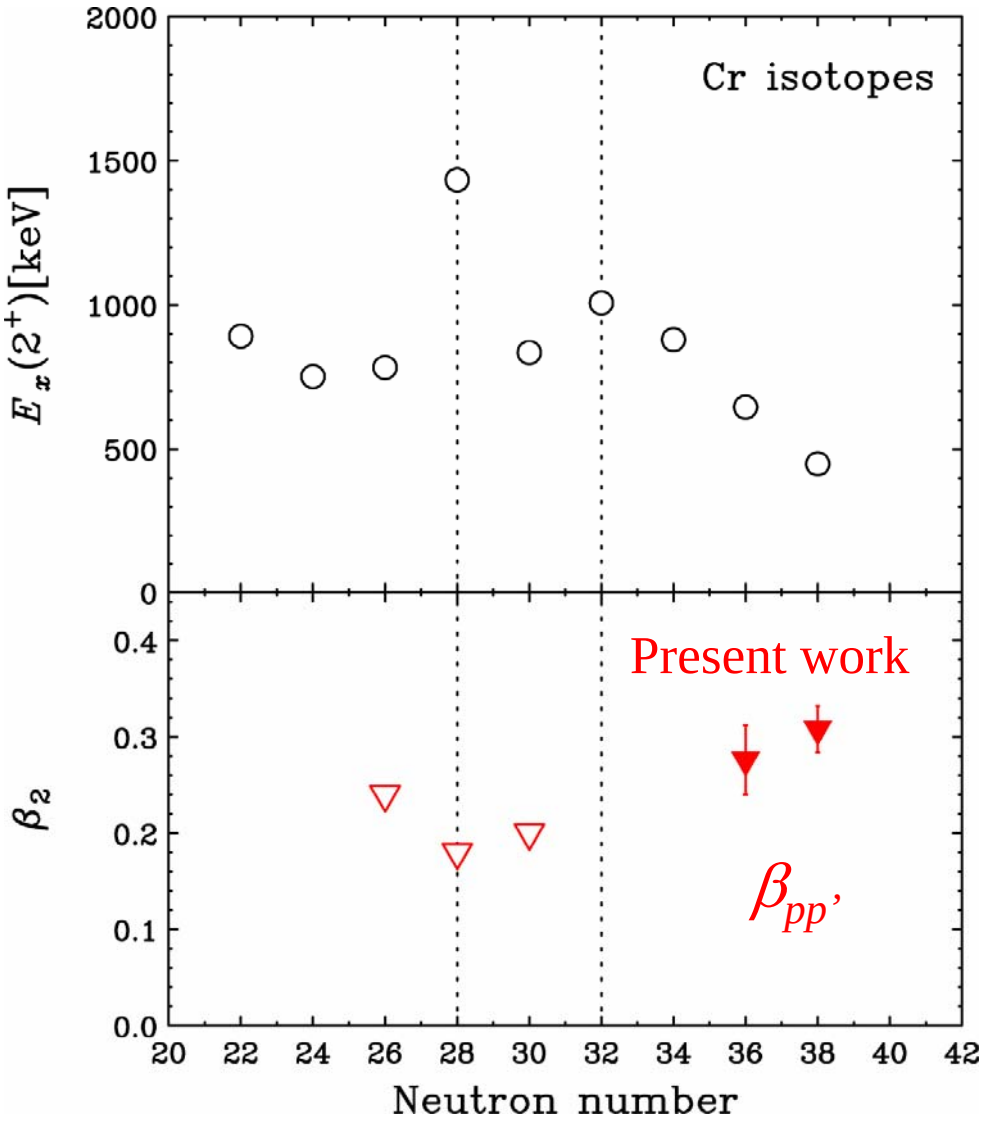
  - R.L. Varner *et al.*, Phys. Rep. **201** (1991) 57.
  - A.J. Koning *et al.*, Nucl. Phys. A **713** (2003) 231.
  - F.D. Becchetti *et al.*, Phys. Rev. **182** (1969) 1190.

  Elastic proton scattering of ^{50,52,54}Cr

  - E.Fabrici *et al.*, Phys. Rev. C **21** (1980) 844.

  Difference from the optical potential → ~10%

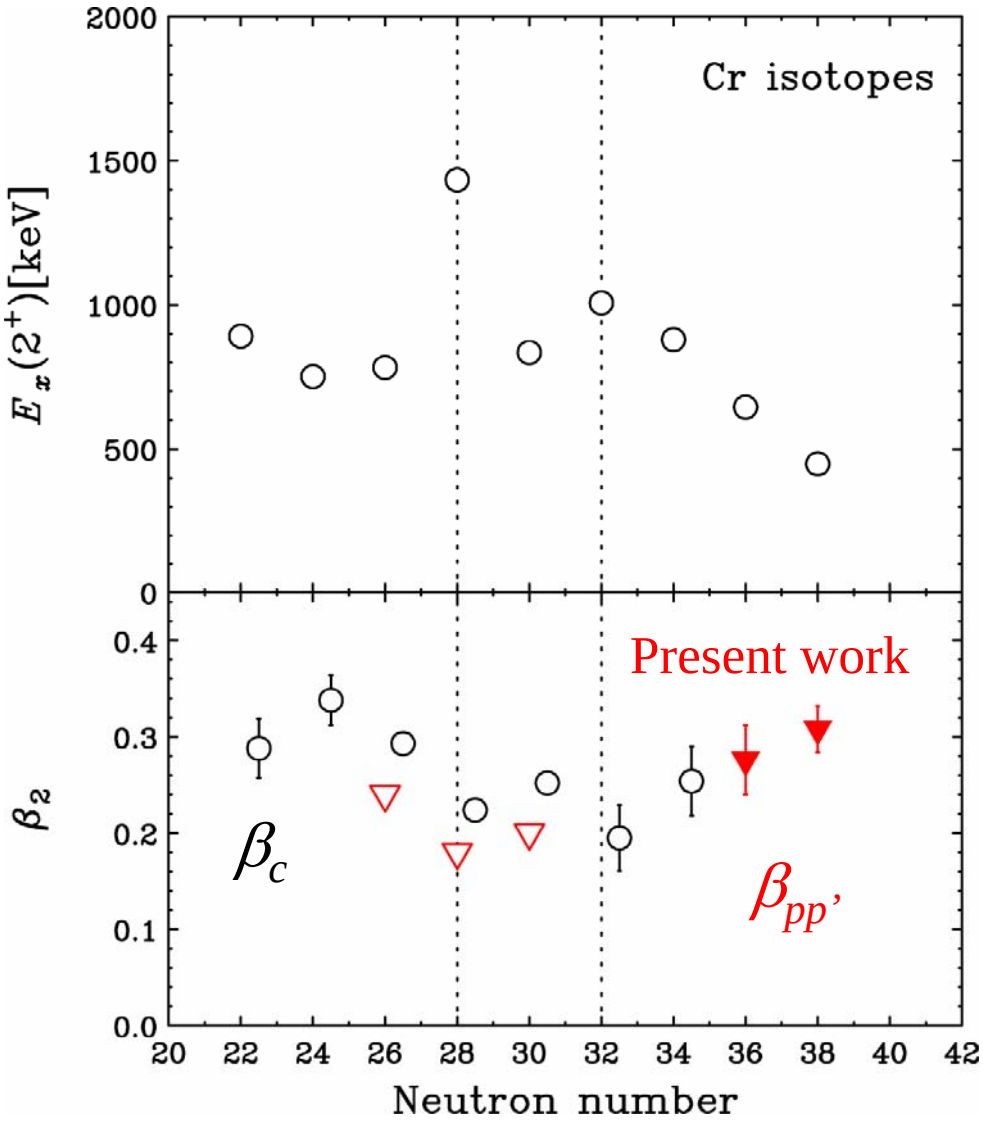
Systematics of $E_x(2^+)$, β_2 (β_c, β_{pp},)



- $E_x(2^+)$ decreases toward $N = 40$.
- Deformation parameter β_{pp}, of ^{60,62}Cr are very large!

F.D. Becchetti *et al.*, PLC **21** (80) 844.

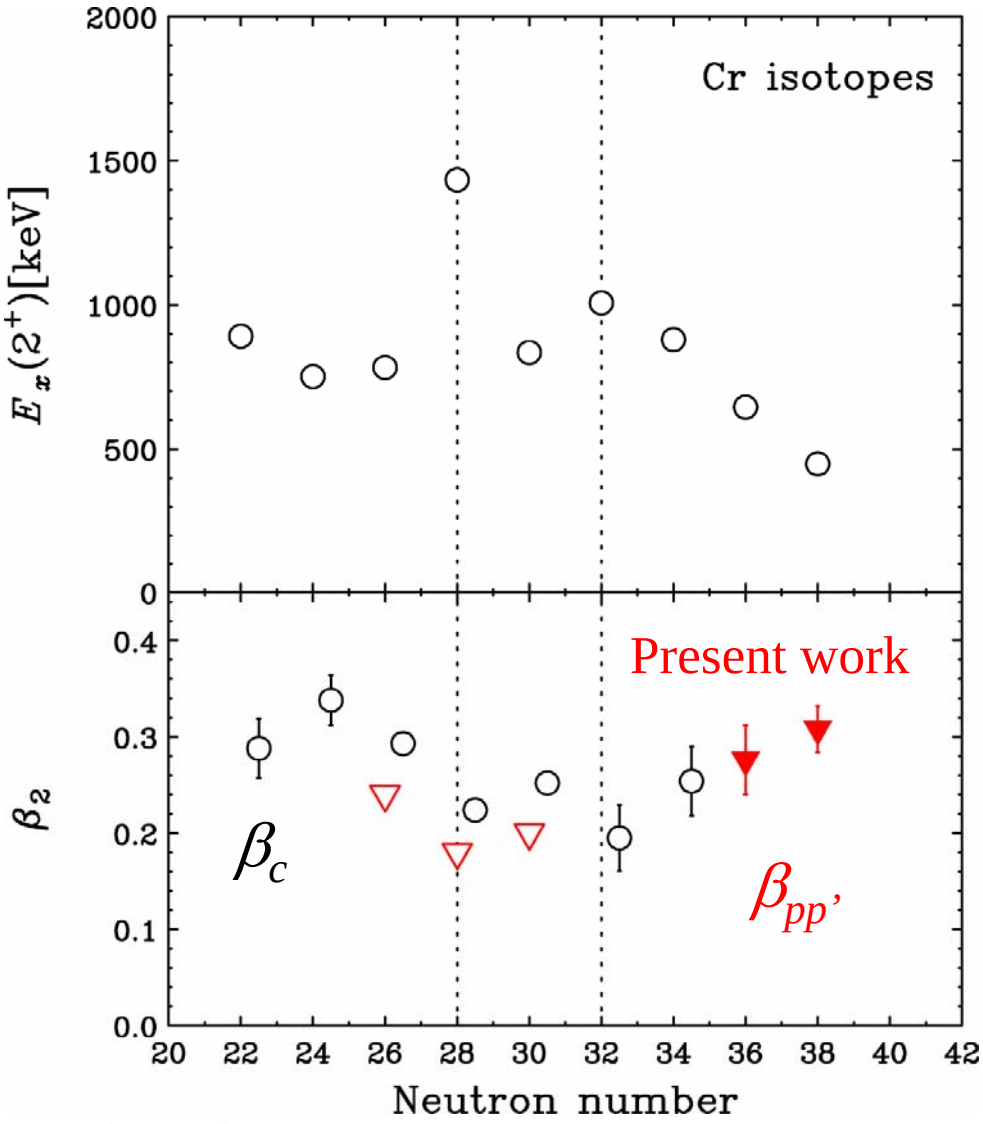
Systematics of $E_x(2^+)$, β_2 (β_c, $\beta_{pp'}$)



- $E_x(2^+)$ are smaller toward $N = 40$.
- Deformation parameter $\beta_{pp'}$ of ^{60,62}Cr are very large!
- Many data by coulex B(E2) → β_c

F.D. Becchetti *et al.*, PLC **21** (80) 844.
M. Burger *et al.*, PLB **622** (05) 20.

Systematics of $E_x(2^+)$, β_2 (β_c, $\beta_{pp'}$)



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Mn/Mp (SM-*pf*, GXPF1A)

M. Honma *et al.*, private communication

β_c

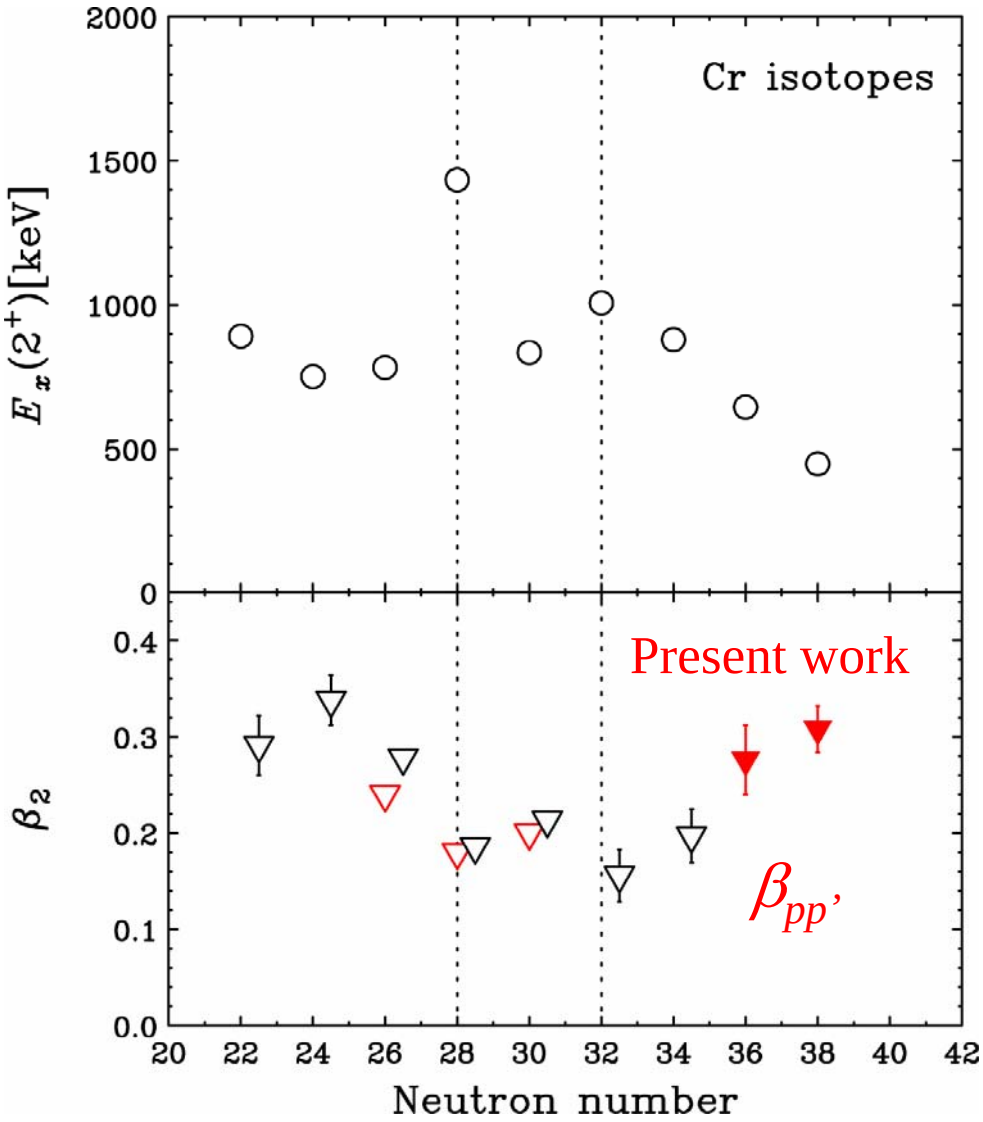
Bernstein

A. M. Bernstein *et al.*,
Comments Nucl. Part. Phys. **11** (83) 203.

$\beta_{pp'}$

F.D. Becchetti *et al.*, PLC **21** (80) 844.
M. Burger *et al.*, PLB **622** (05) 20.

Systematics of $E_x(2^+)$, β_2 (β_c, β_{pp},)



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M. Honma *et al.*, private communication

β_c

Bernstein

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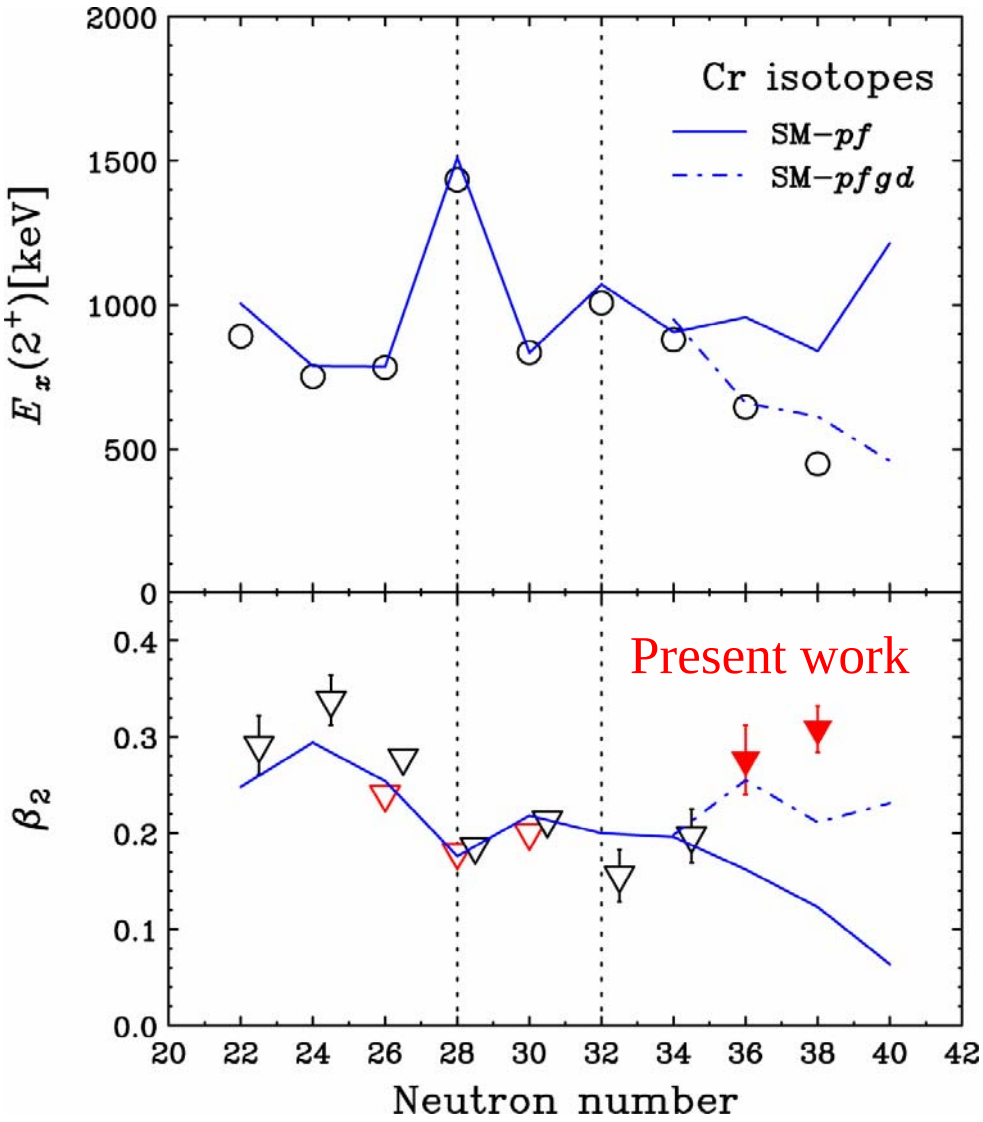
Comments Nucl. Part. Phys. **11** (83) 203.

β_{pp},

F.D. Becchetti *et al.*, PLC **21** (80) 844.
M. Burger *et al.*, PLB **622** (05) 20.

Systematics of $E_x(2^+)$, β_2 (β_c, β_{pp},)



- $E_x(2^+)$ are smaller toward $N = 40$.
- Deformation parameter β_{pp}, of ^{60,62}Cr are very large!
- SM-*pf* GXPF1A ^{60,62}Cr ☹
- SM-*pfgd* ^{60}Cr ☺
  ^{62}Cr ☹

M. Honma *et al.*,
PLC **69** (04) 034335
and private communication

Large collectivity in the Cr isotopes

F.D. Becchetti *et al.*, PLC **21** (80) 844.
M. Burger *et al.*, PLB **622** (05) 20.

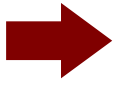
Summary

- Angle integrated inelastic cross sections of ^{60,62}Cr were determined for the first time.

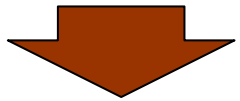
^{60}Cr : $\sigma_{pp'}(2^+)$ = **26(7) [mb]**
^{62}Cr : $\sigma_{pp'}(2^+)$ = **38(6) [mb]**

- From these cross sections,
  $\beta_{pp'}$ was deduced using DWBA calculation.

^{60}Cr : $\beta_{pp'}$ = 0.28 (4)
^{62}Cr : $\beta_{pp'}$ = 0.31 (2)



very large !



Large collectivity in the Cr isotopes !!