

**Positive Parity States
in $208Pb$
Observed in the Proton Decay
of the $j15/2$ (Intruder)
Isobaric Analog Resonance in $209Bi$**

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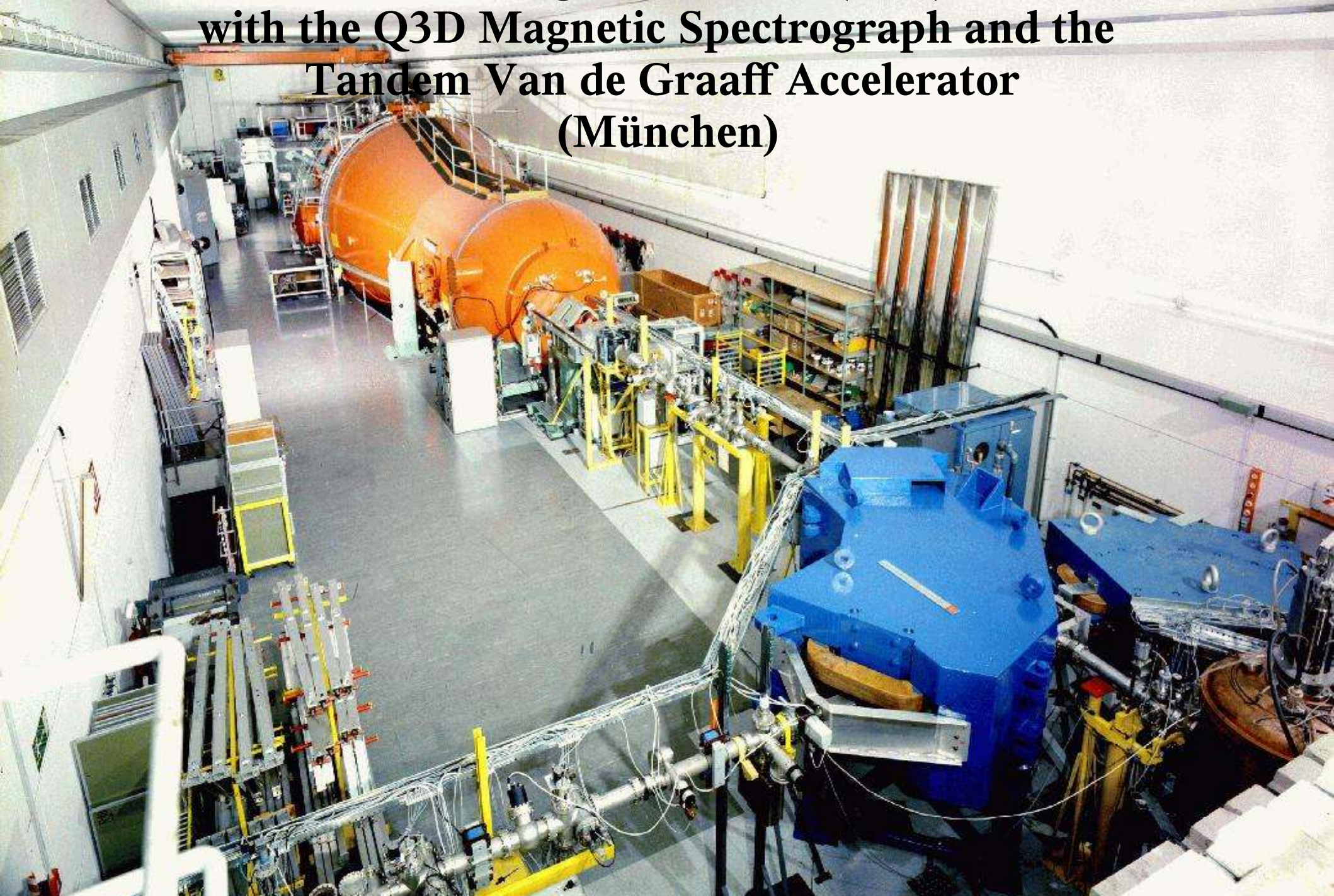
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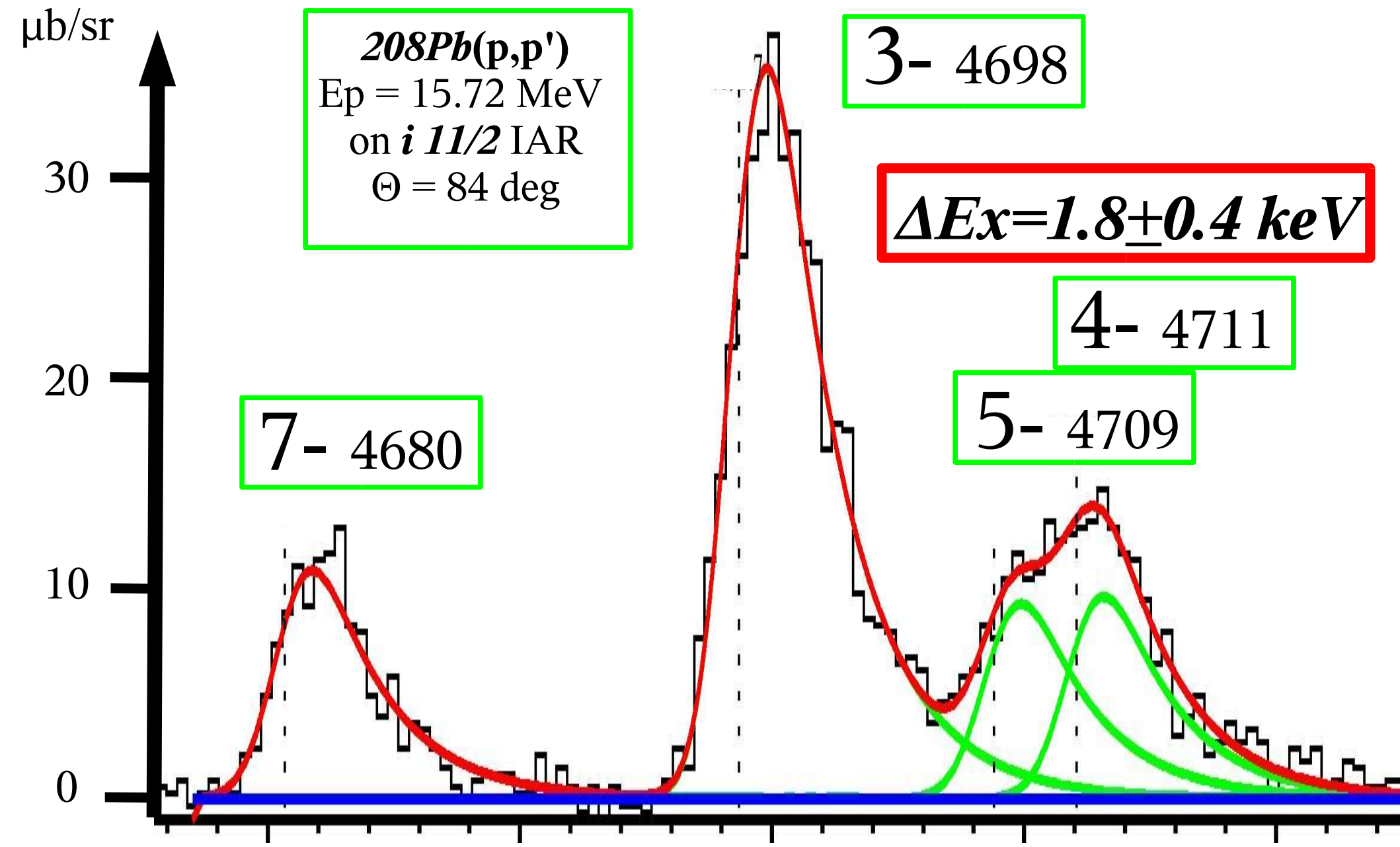
Wright Nuclear Structure Laboratory, **Yale**, USA

**High Resolution Measurements of $^{208}\text{Pb}(p,p')$
via Isobaric Analog Resonances (IAR) in ^{209}Bi
with the Q3D Magnetic Spectrograph and the
Tandem Van de Graaff Accelerator
(München)**



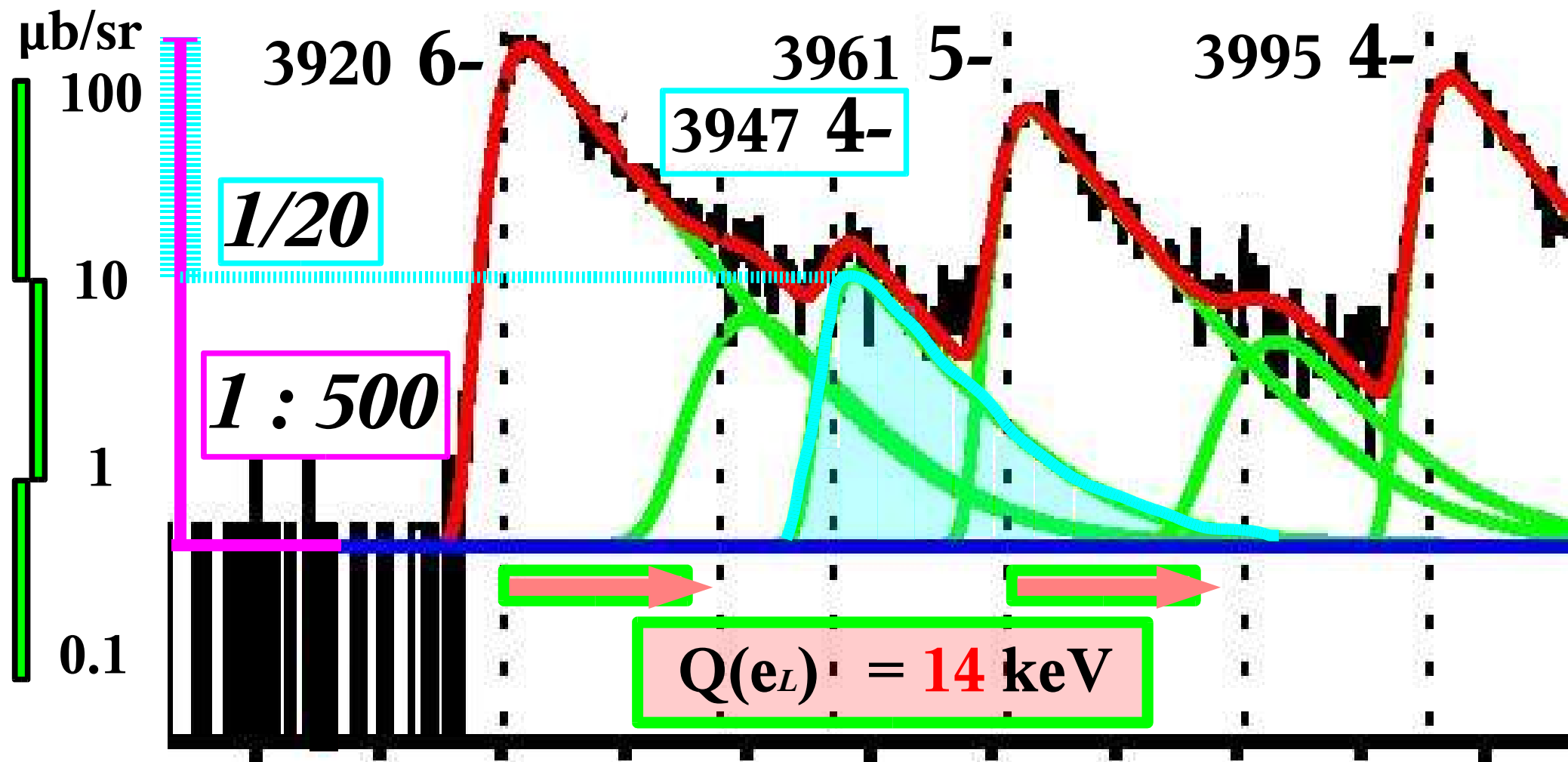
Q3D magnetic spectrograph

* High Resolution with Gaussian Width ~ 3 keV ($E_{p'} \sim 10$ MeV)



Q3D magnetic spectrograph

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- * Sensitive Line Shape Allows to Discriminate Lines of $^{208}\text{Pb}(p,p')$ from $^{208}\text{Pb}(p,pn')$ and $^{12}\text{C}(p,p')$, $^{14}\text{N}(p,p')$ etc.
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- * Together with Low Background up to 1:500, ~ 10 keV Doublets with Cross Sections Differing by a Factor ~ 20 can be Resolved
- * Large Solid Angle 10 msr Covers 10% of Spectrum (~ 1 MeV)
- * Data-Taking Rates up to 100 kHz are Supported

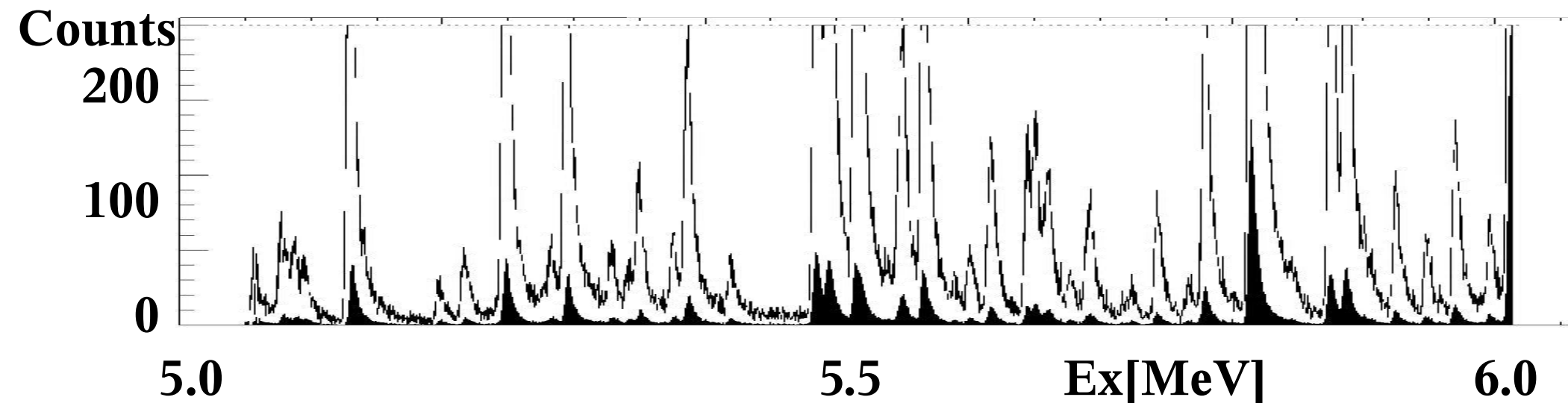
Tandem Van De Graaff Accelerator

- * Energy Stability better than 1 keV ($E_p \sim 15-18$ MeV)
- * Stable Stern-Gerlach Hydrogen Source with Several μA

Fast Measurements of Highly Linear Proton Spectra
with Low Background
and Good Resolution

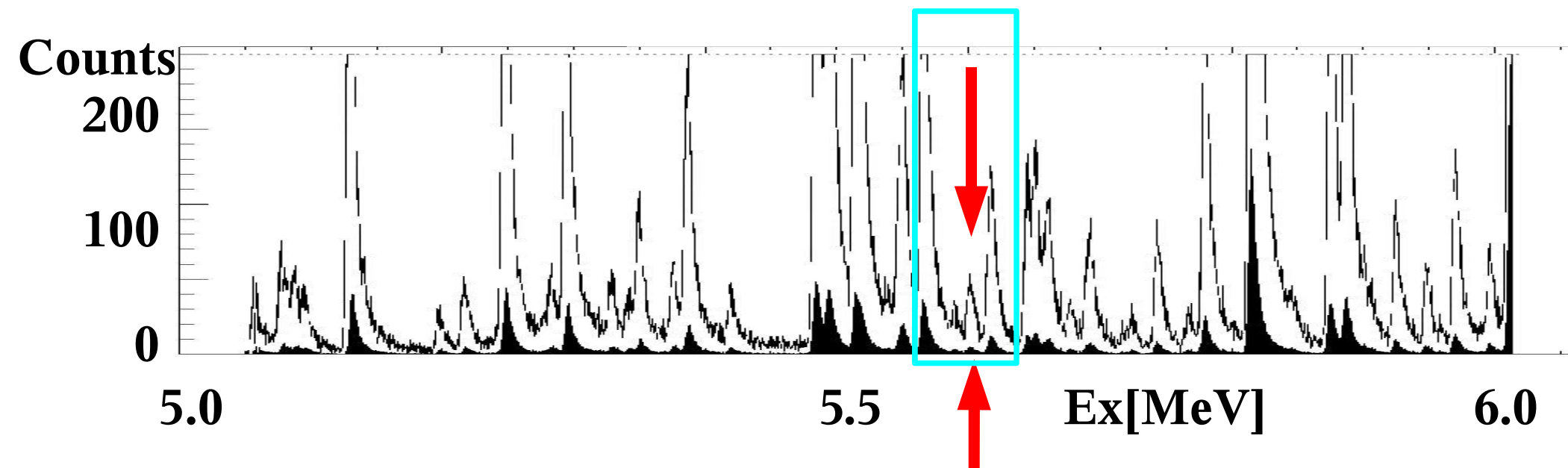
New Data for $^{208}\text{Pb}(p, p')$ with the Q3D Magnetic Spectrograph (München)

- * Proton Energy $E_p = 14.92 - 17.72$ MeV,
all seven IAR in ^{209}Bi covered (g $_{9/2}$, i $_{11/2}$, j $_{15/2}$, d $_{5/2}$, s $_{1/2}$, d $_{3/2}$, g $_{7/2}$)
- * ~ 200 Spectra with ~1 MeV Length and up to 100 Peaks

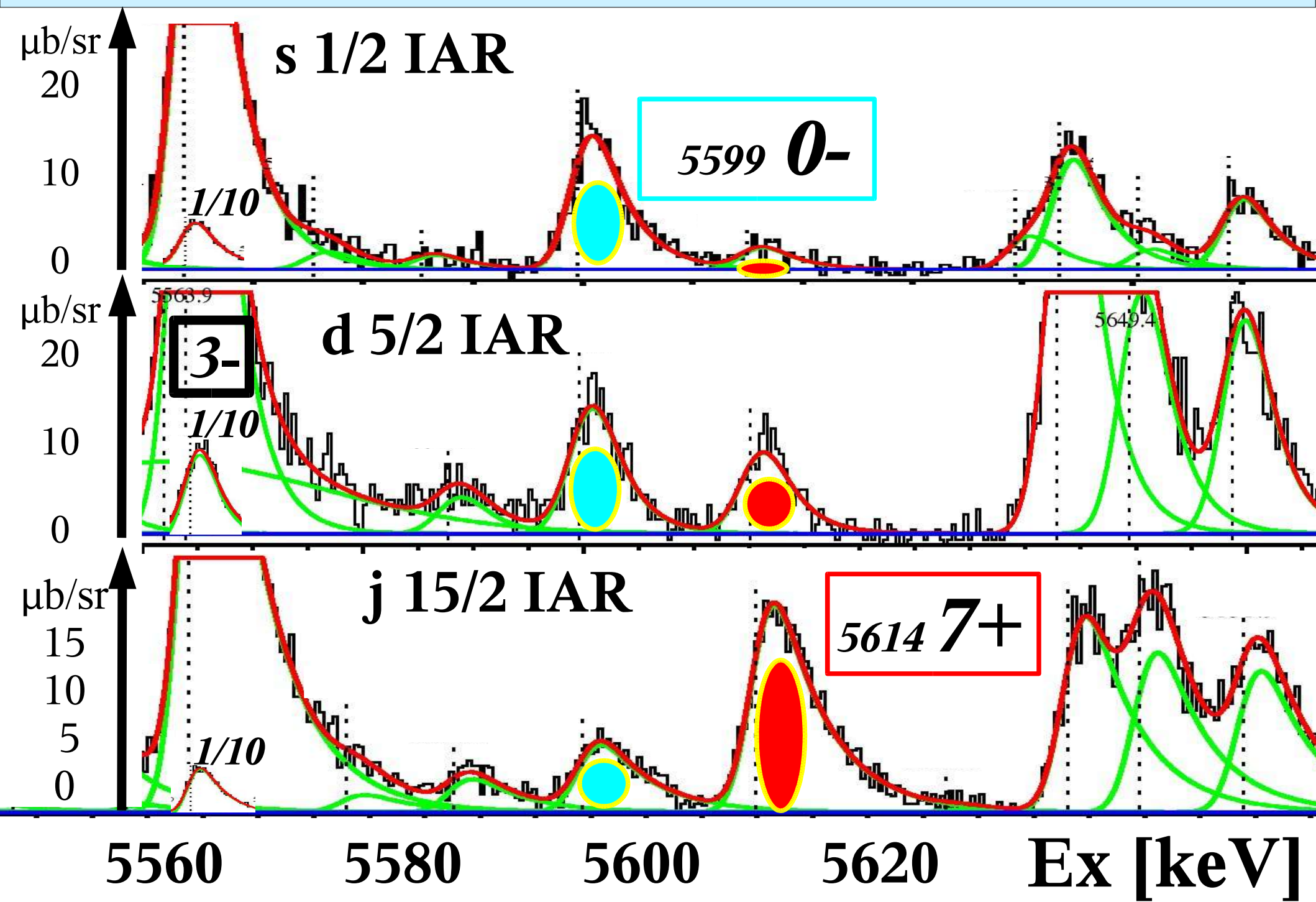


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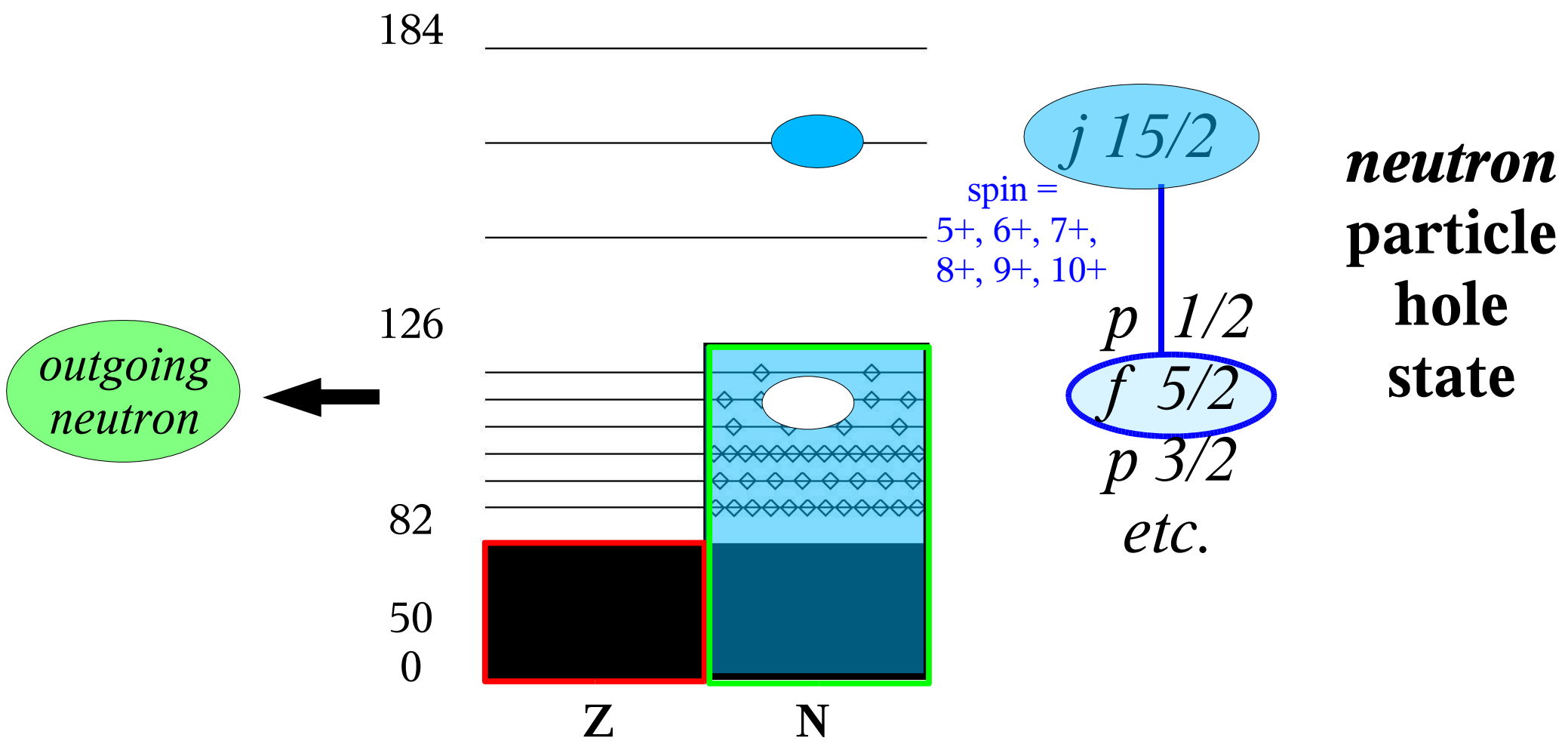
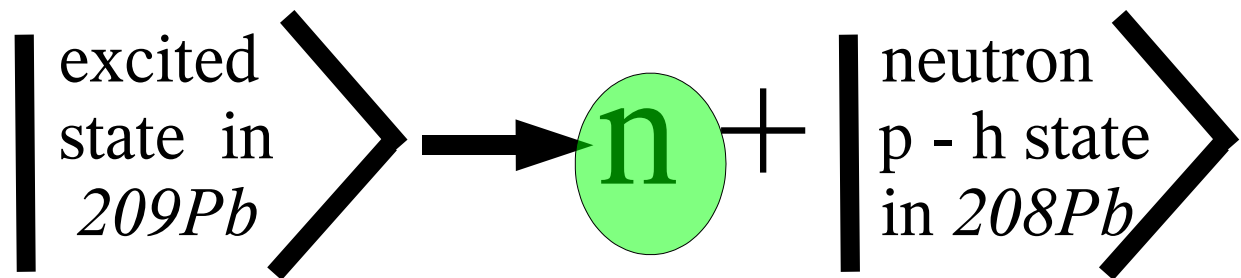
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- * ~ 200 Spectra with ~1 MeV Length and up to 100 Peaks
- * ~ 150 States for $E_x < 6.1$ MeV,
> 400 States for $E_x < 7.8$ MeV in ^{208}Pb identified
- * Absolute Energy Calibration Error up to $\delta E_x \sim 100$ eV
- * Cross Sections of 0.1 - 500 $\mu\text{b}/\text{sr}$



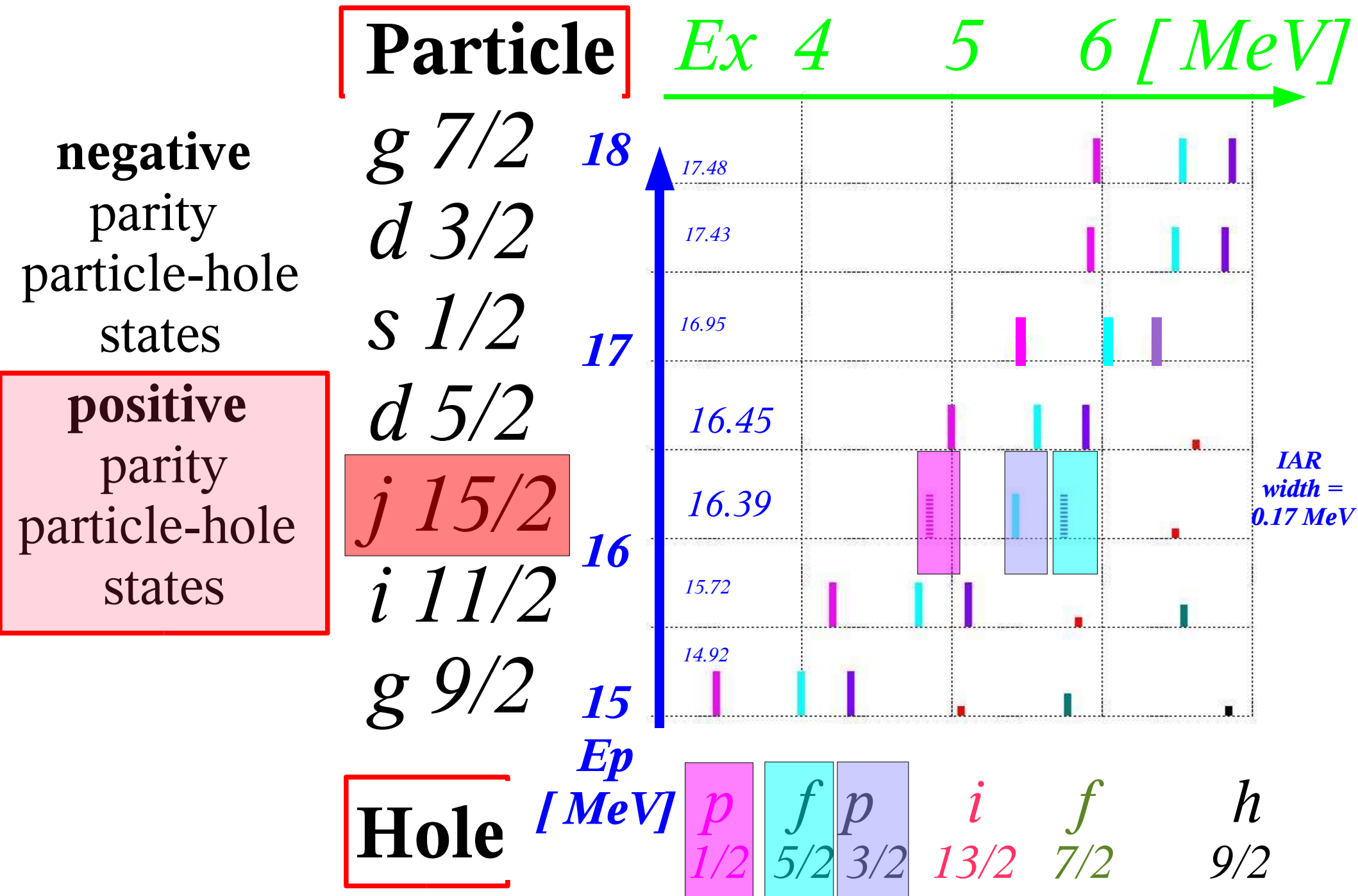
^{208}Pb (p,p') via Isobaric Analog Resonances (IAR) in ^{209}Bi



$^{208}\text{Pb}(p,p')$ via IAR is *equivalent* to a neutron pickup reaction on an excited state in ^{209}Pb

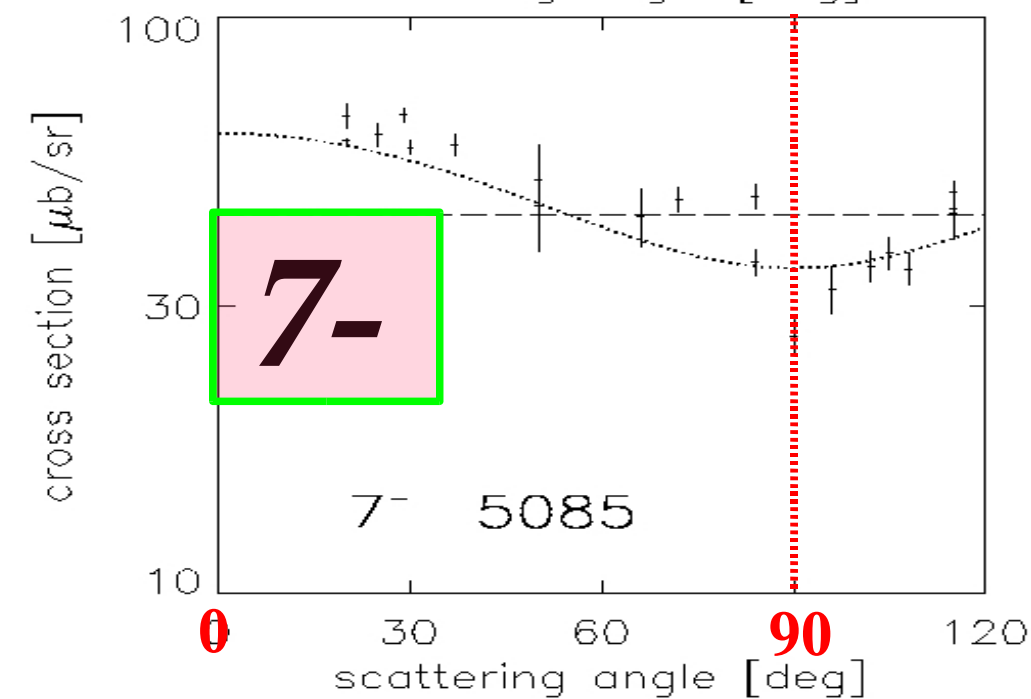
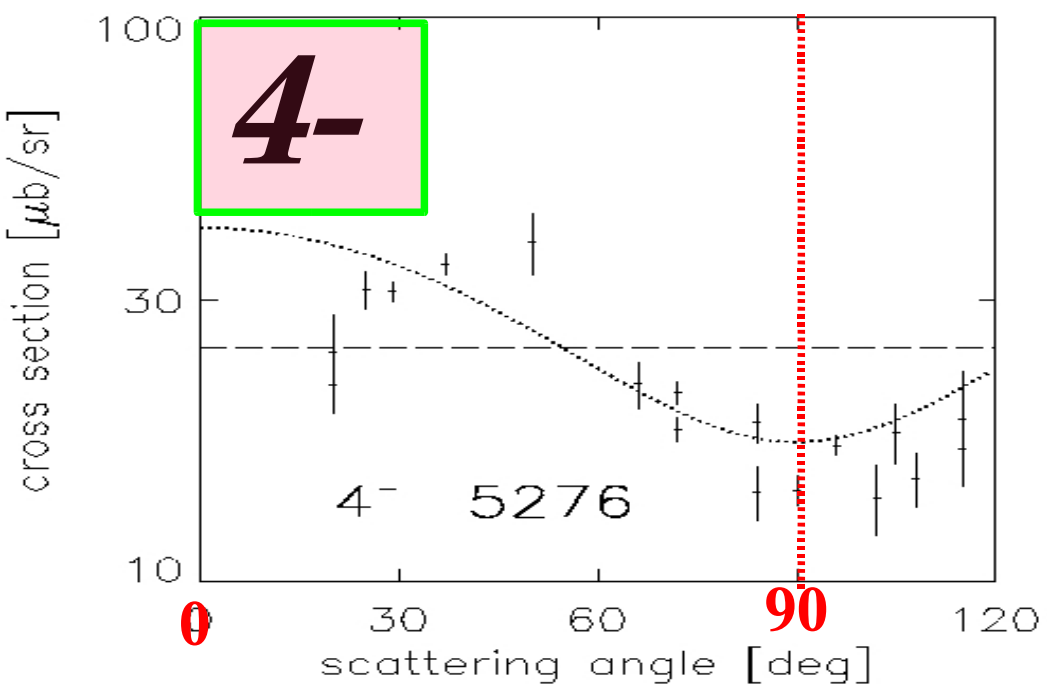
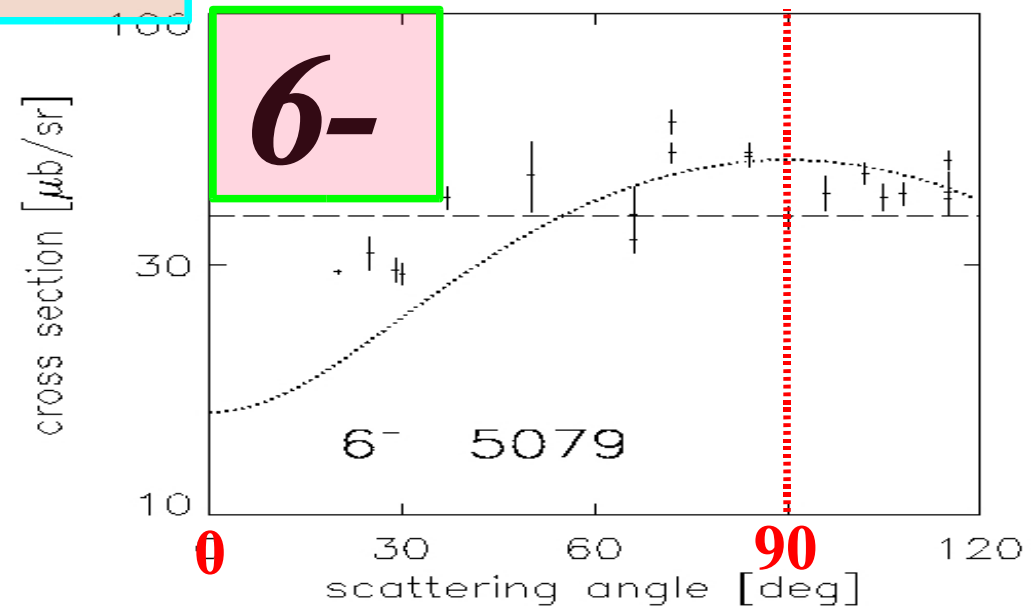
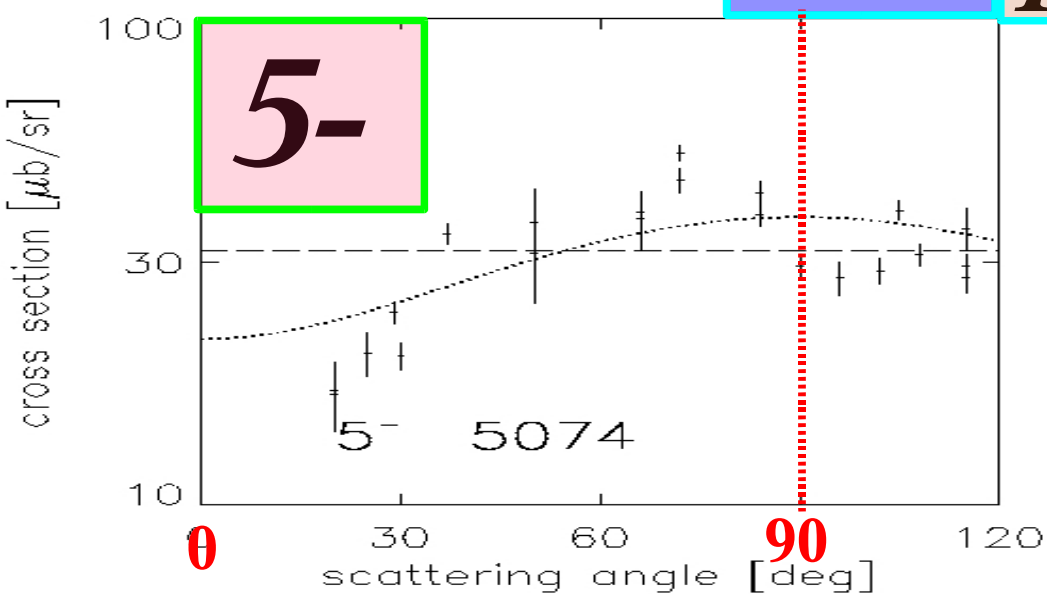


Neutron Particle-Hole States in ^{208}Pb



Determination of Spin and Major Neutron p-h Configuration from the Angular Distribution of $^{208}\text{Pb}(p, p')$ via $i11/2$ IAR

$i11/2$ $p3/2$



Partial Strength of
 p-h States in ^{208}Pb with $j15/2$ Particle
 determined from
 $^{208}\text{Pb}(p,p')$ via $j15/2$ IAR

$p\ 1/2$

$f\ 5/2$

$p\ 3/2$

$\pi\ h9/2\ h11/2$

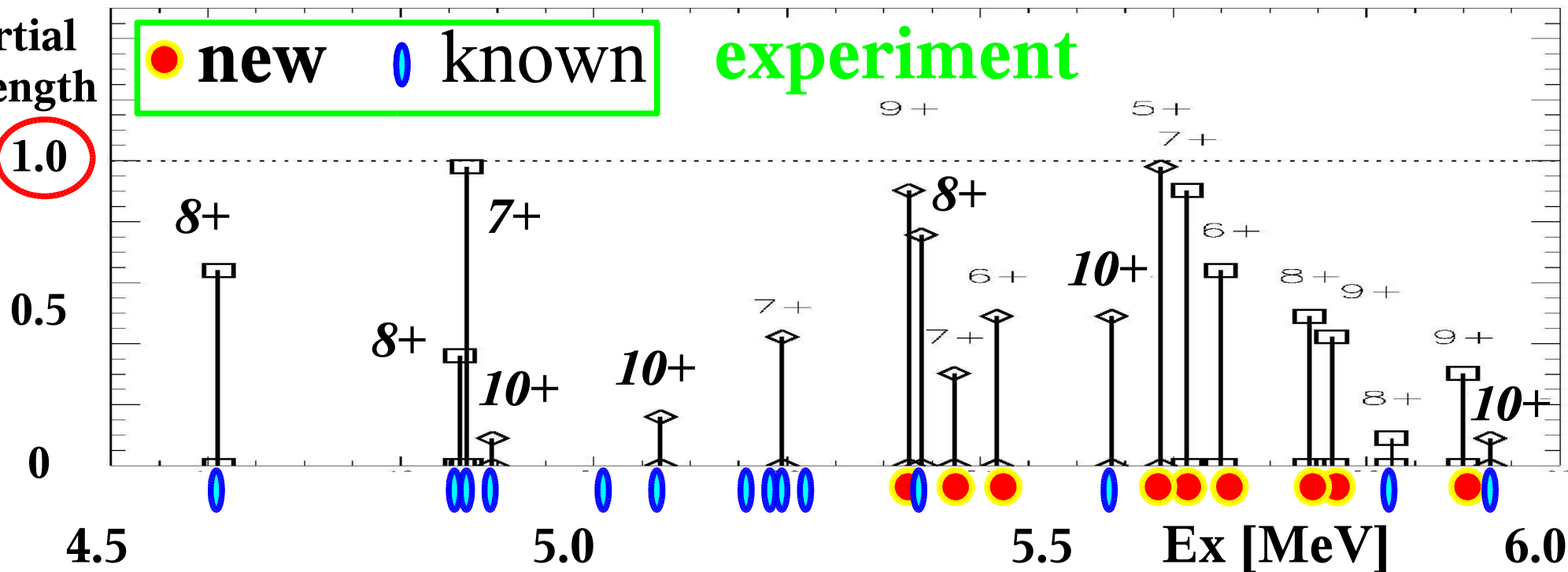
partial
 strength

● new

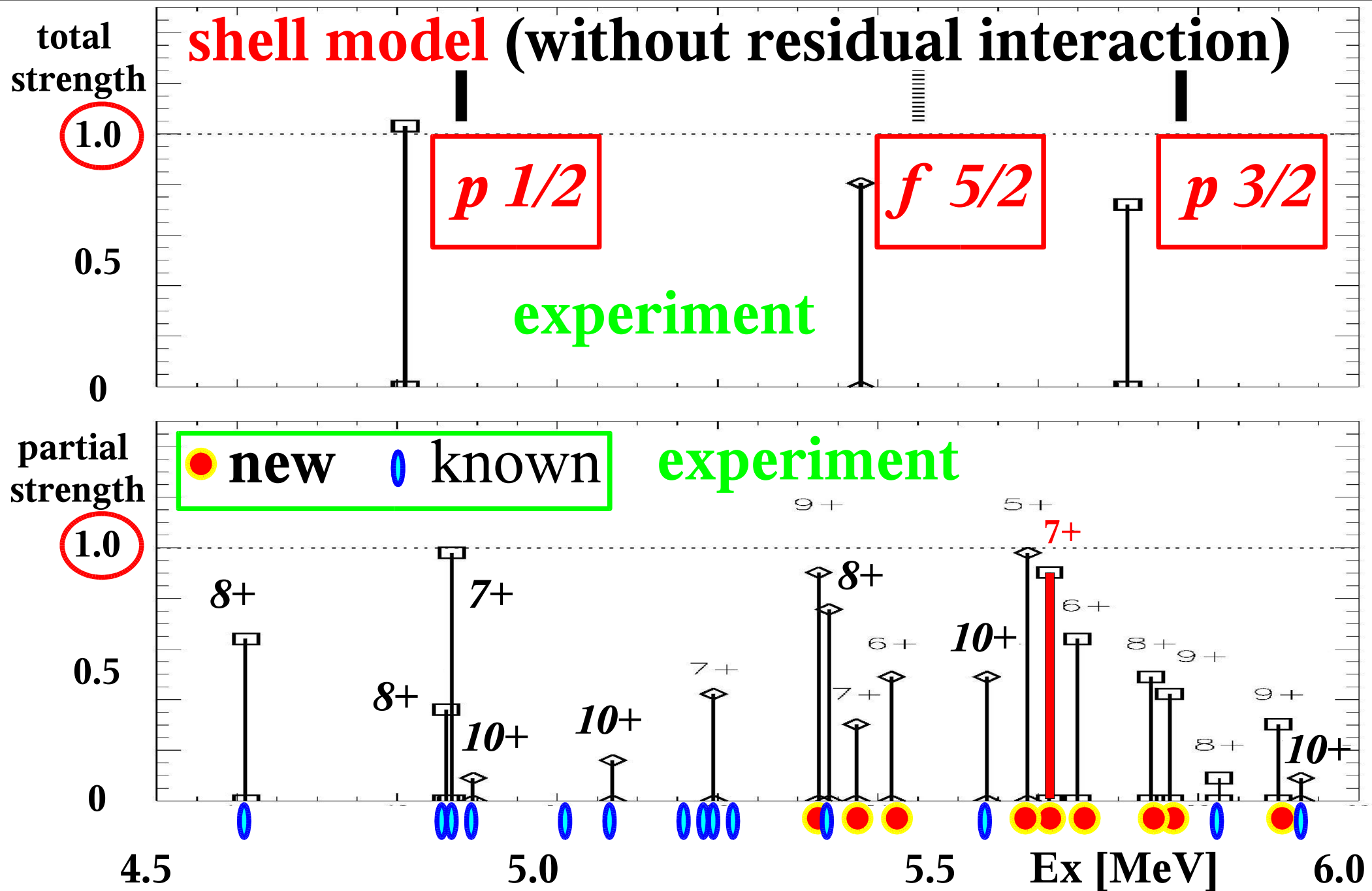
● known

experiment

1.0



Total Strength and Centroid Energy of p-h States in ^{208}Pb with $j15/2$ Particle



Mixing of 1p-1h and 2p-2h configurations in ^{208}Pb

Structure of $5614\ 7+$ state in ^{208}Pb

$$|^{208}\text{Pb}(5614\ 7+) \rangle \sim |^{209}\text{Pb}(15/2-) \rangle \times p_{3/2} \rangle$$

Mixing of 1p-1h and 2p-2h configurations in ^{208}Pb

Structure of $5614\ 7+$ state in ^{208}Pb

$$|^{208}\text{Pb}(5614\ 7+) \rangle \sim |^{209}\text{Pb}(15/2-) \rangle \times p_{3/2} \rangle$$

$$= 0.85 |^{208}\text{Pb}(\text{g.s.}) \rangle \times j_{15/2} \rangle \times p_{3/2} \rangle$$

$$+ 0.52 |^{208}\text{Pb}(2614\ 3-) \rangle \times g_{9/2} \rangle \times p_{3/2} \rangle$$

(Bohr&Mottelson II)

Mixing of 1p-1h and 2p-2h configurations in $208Pb$

Structure of $2614\ 3^-$ state in $208Pb$

$$|208Pb(2614\ 3^-) \rangle = \sum |208Pb(g.s.) \times 1p \times 1h \rangle$$

Structure of $5614\ 7^+$ state in $208Pb$

$$|208Pb(5614\ 7^+) \rangle \sim |209Pb(15/2^-) \rangle \times p_{3/2} \rangle$$

$$= 0.85 |208Pb(g.s.) \rangle \times j_{15/2} \rangle \times p_{3/2} \rangle \\ + 0.52 |208Pb(2614\ 3^-) \rangle \times g_{9/2} \rangle \times p_{3/2} \rangle$$

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$$|208Pb(5614\ 7^+) \rangle \\ = 0.85 |208Pb(g.s.) \times 1p \times 1h \rangle \\ + \sum |208Pb(g.s.) \times 2p \times 2h \rangle$$

Summary

High Resolution Measurements of $^{208}\text{Pb}(p,p')$ via IAR in ^{209}Bi with the Q3D Magnetic Spectrograph for $E_x < 6.1 \text{ MeV}$

- Proton spectra of $^{208}\text{Pb}(p,p')$ via all seven isobaric analog resonances in ^{209}Bi with a resolution of $dE_x = 3 \text{ keV}$
- 150 states in ^{208}Pb identified

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36 states predicted by the shell model
- 30 (12 new) states identified by the Q3D measurements

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- **150 states** in ^{208}Pb identified
- **Positive parity states with spin $5+ \dots 10+$:**
36 states predicted by the shell model
- **30 (12 new)** states identified by the Q3D measurements
- First experimental evidence for the **mixing** of **1p-1h** and **2p-2h** configurations in ^{208}Pb
- Realistic calculations needed