Comenius University Bratislava

50 years from the foundation of Department of Nuclear Physics

Study of charge - exchange reactions at RCNP Osaka

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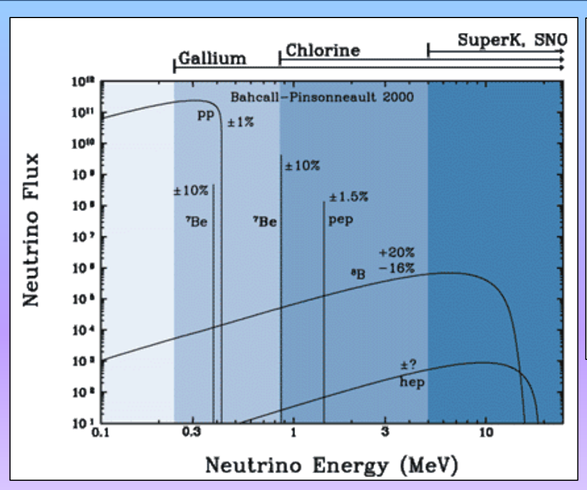
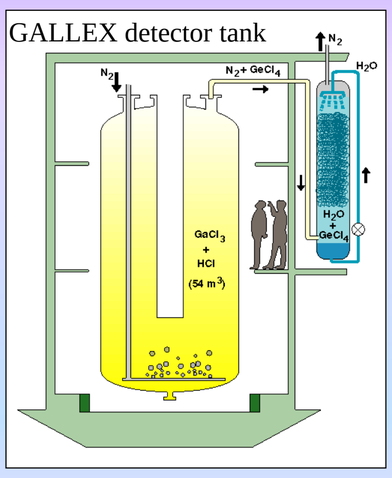
The objective of the charge-exchange experiment was to extract with high precision the Gamov-Teller (GT) transition strength in the reaction ^{71}Ga(^{3}He,t)^{71}Ge for the three lowest-lying transitions to ^{71}Ge at 0 MeV (1/2$^-$), 0.175 MeV (5/2$^-$) and 0.5 MeV (3/2$^-$) [1]. These are the relevant states, which can be populated via a charged-current reaction induced by solar neutrinos from the pp-cycle. A precise knowledge of the GT transition rates provides an independent calibration to the SAGE [2] and GALLEX [3] solar neutrino data obtained some years ago.

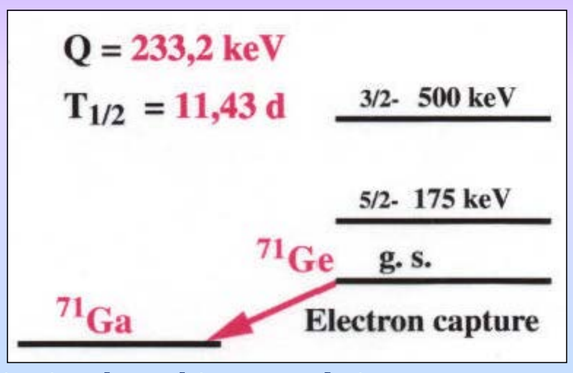
Solar Neutrino Problem



- Measurement the low energy solar neutrino flux.
- Different experiments are sensitive to different solar processes.
- Experiments based on:

$$\nu_e^{solar} + {}^{71}Ga \rightarrow {}^{71}Ge + e^-$$

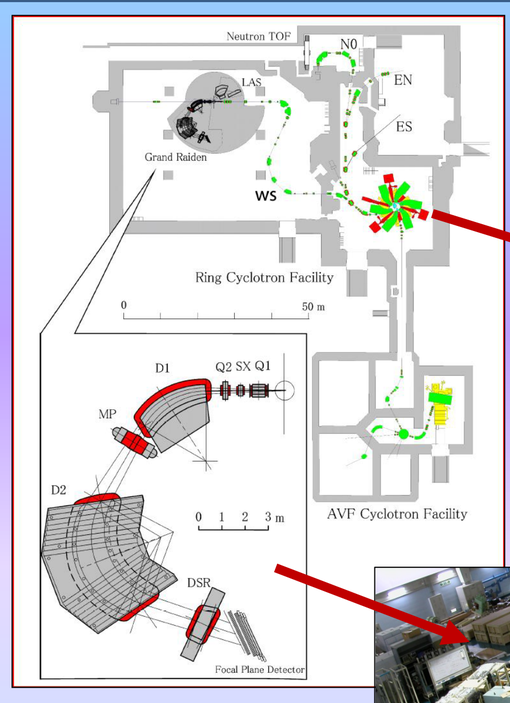




http://ewi.npl.washington.edu/sage
http://www.mpi-hd.mpg.de/lin/research_history.en.html#gallex

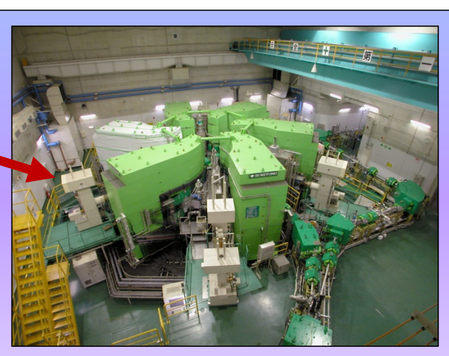
GALLEX (Gran Sasso, Italy)– $GaCl_3$+HCl (30 tons of Ga)[2]
SAGE (Baksan, Russia)– Liquid Ga metal (50 tons of Ga) [3]

RCNP facility at Osaka University

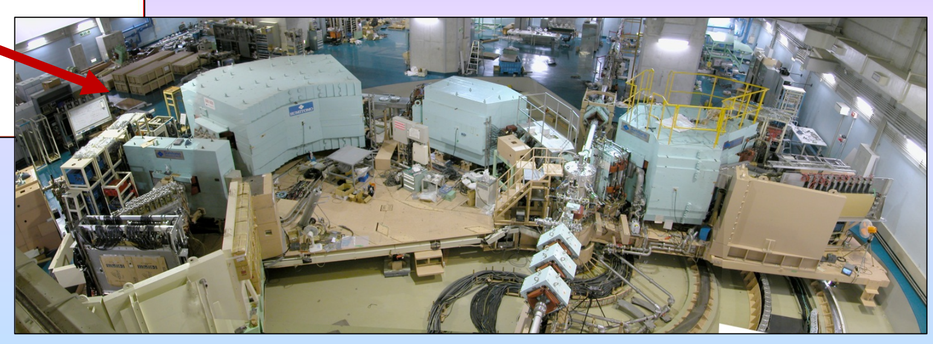


The RCNP cyclotron facility

Research **C**enter for **N**uclear **P**hysics → founded in 1971



Ring cyclotron



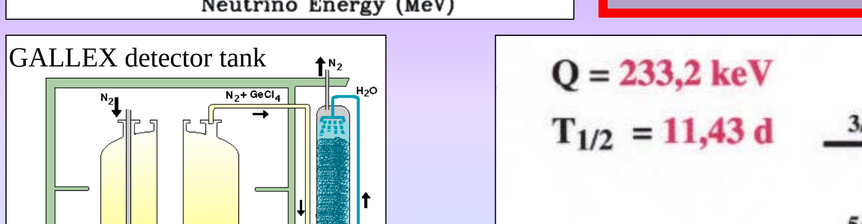
Spectrometer Grand Raiden

- Dispersion matching technique
- High resolution - **30 keV**
- High intensities ~ **10 nA**

http://www.rcnp.osaka-u.ac.jp

Physical applications

→ **Measurement of GT strengths via charge-exchange reactions relevant for double β-decay nuclear matrix elements and astronuclear processess**



Beam requirements:

- Type of particle: **^{3}He**
- Beam energy: **420 MeV**
- Beam intensity: **10 nA**
- Energy resolution: **$\Delta E \leq 100$ keV**

Target:

^{69,71,nat}Ga

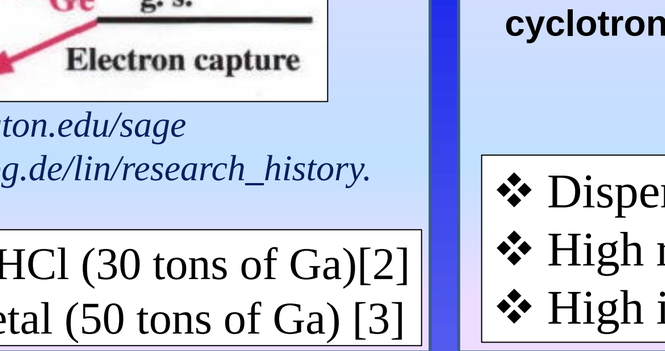
Measurement **B(GT$^+$)/B(GT$^-$)** through **(n,p)/(p,n)** - type reaction, respectively.

GT nuclear matrix element

$$M(GT) = \left\langle 1^+ \left\| \sigma\tau^+ \right\| 0^i_{g.s.} \right\rangle$$

GT transition strengths

$$B(GT^{\pm}) = \frac{1}{2J_i + 1} \left| M(GT^{\pm}) \right|^2$$



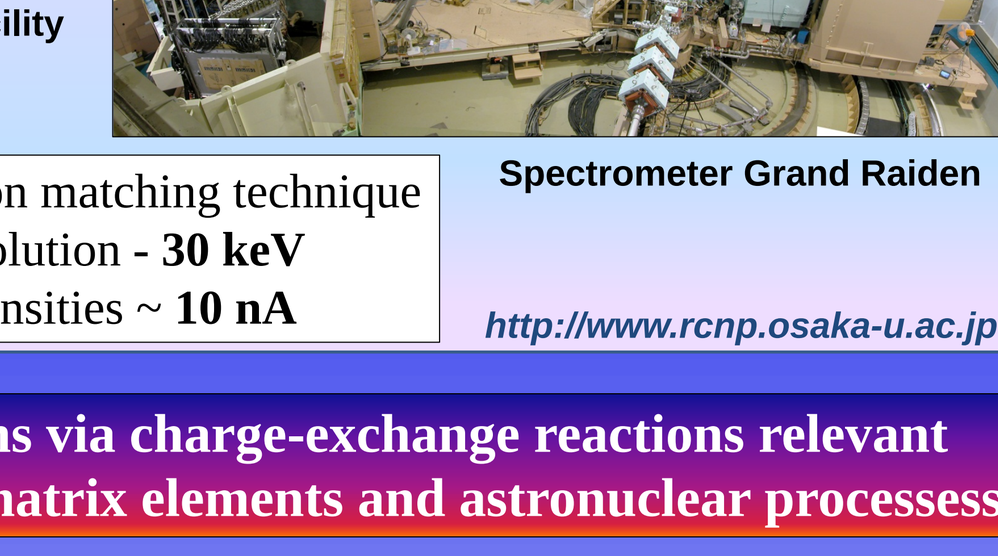
GT strength extraction

Distortion factor

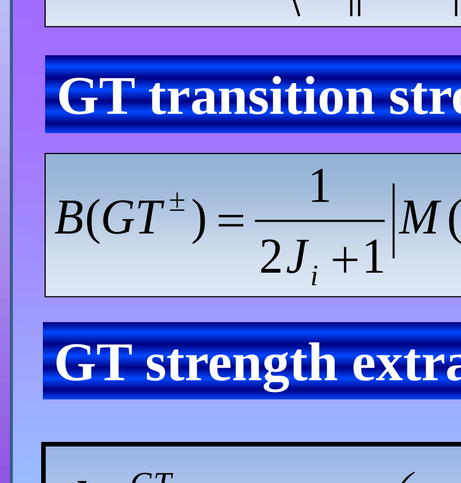
$$\frac{d\sigma^{GT}}{d\Omega}(q=0) = \left(\frac{\mu}{\pi\hbar^2}\right)^2 \frac{k_f}{k_i} N_D^{\sigma\tau} \left| J_{\sigma\tau} \right|^2 B(GT)$$

Volume integral of the effective nucleon - nucleon interaction

B(GT) relates to the GT part of the cross section at forward angles, i.e. **zero momentum transfer** (q = 0) and ΔL = 0.



Excitation-energy spectrum of the ^{71}Ga(^{3}He,t)^{71}Ge reaction at 420 MeV [1].



References

[1] D. Frekers et al. (R. Hodák, P. Povinec, F. Šimkovic), Phys. Lett. B706, (2011) 134
[2] J.N. Abdurashitov, et al., Phys. Rev. C59, (1999) 2246
[3] W. Hampel et al., Phys. Lett. B420, (1998) 114

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