AMS measurement of the reaction $^{35}Cl(n,\gamma)^{36}Cl$ and its relevance to astrophysics and nuclear technology

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- **Aims:** 1.) measurement of the MACS of ^{35}Cl
  2.) production of a $^{36}Cl/^{35}Cl$ standard for AMS measurements
- **Methods:** neutron-irradiations
  activity measurements
  AMS-measurements
- **Motivation:** nucleosynthesis in stars
  production of ^{36}Cl in nuclear facilities

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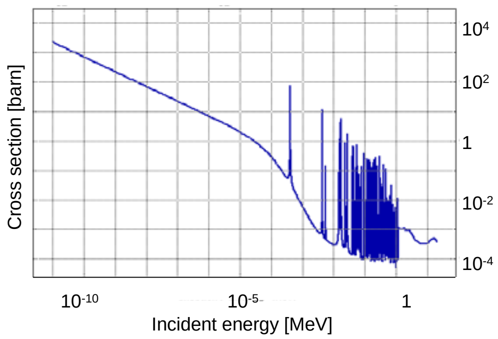
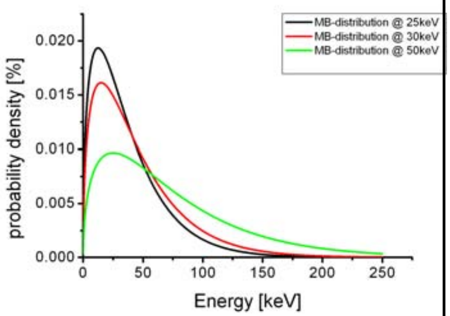
Cross section and MACS

$^{36}Cl = {}^{35}Cl \Phi_n \sigma$

$\sigma \propto 1/v$



Energy dependent cross section of neutron capture on ^{35}Cl
http://www-nds.iaea.org/exfor/servlet/E4sMakeE4



Maxwell-Boltzmann distributions at different energies

Experimental Procedures

- Irradiation of NaCl-pellets at different facilities, Au-foils and Au-powder used as fluence-monitor
- Activity measurements on the Au-foils and the pellets, calculation of the neutron flux during the irradiation
- Calculation of the $^{36}Cl/^{35}Cl$ ratio via $^{36}Cl/^{35}Cl=\Phi_n\sigma$ for the designated standards
- Chemical and mechanical pretreatment of the samples
- AMS measurements of the samples
- Determination of the MACS of ^{35}Cl using the AMS-data

Irradiations at ATI and BRR

ATI Vienna:

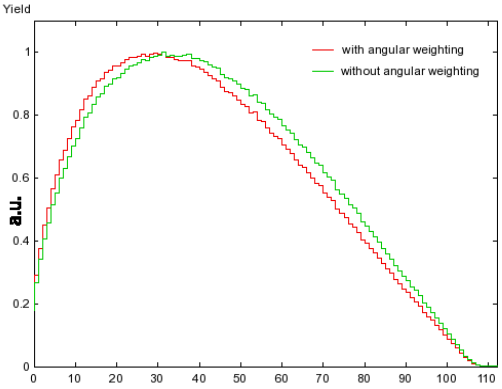
- Two samples
- High flux ($>10^9 cm^{-2}s^{-1}$) => irradiation time for wanted $^{36}Cl/^{35}Cl$ ratio is very short (30 s)
- Thermal neutrons and significant high epithermal neutrons-background which altars the $^{36}Cl/^{35}Cl$ ratio

BRR:

- Three samples
- Low flux ($10^7 cm^{-2}s^{-1}$) => irradiation time ~1h
- Sharp, quasi monoenergetic neutrons (~5 meV, cold neutrons)

Irradiation at KIT

- Irradiation with brought quasi Maxwellian neutron energy spectrum of 25 keV
- Neutrons production via $^{7}Li(p,n)^{7}Be$ with 1912 keV proton-beam
- n-flux 1-3*10^{9} cm^{-2} s^{-1}
- Irradiation time 5 days for FZK ^{35}Cla and 10 days for FZK ^{35}Clb



Neutron spectrum of the irradiation at KIT generated with the Monte Carlo simulation PINO http://141.2.245.217/pino/

Activity measurements

The activities of Au foils and the Au powder in pellets were measured with a high purity Ge-Detector.

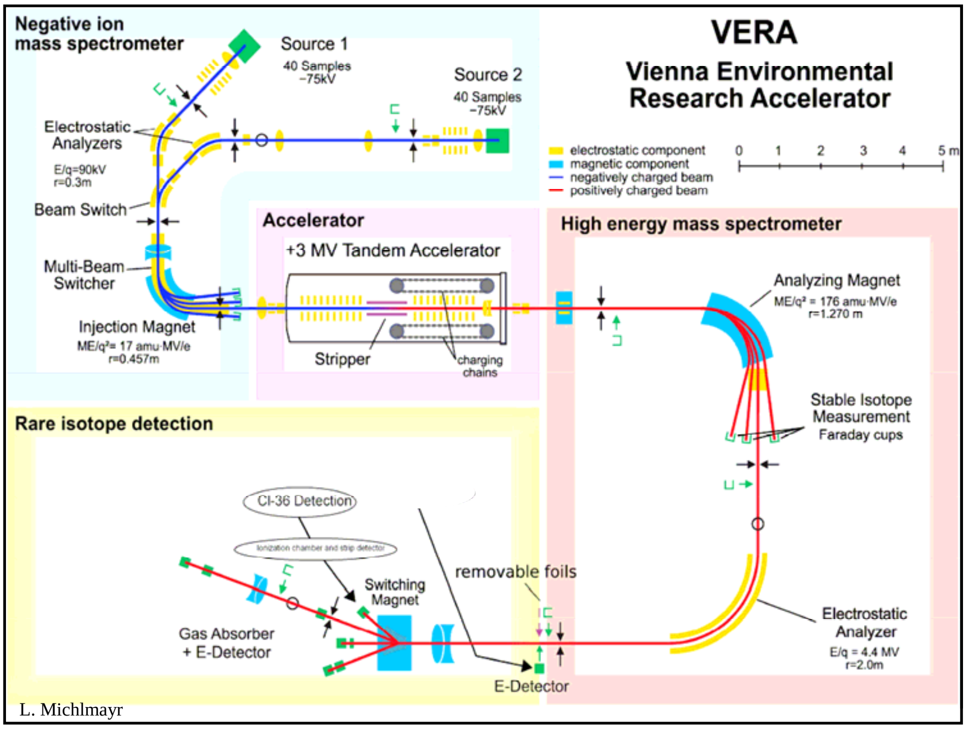
The thermal cross section of $^{197}Au(n,\gamma)^{198}Au$ and the decay constant of ^{198}Au are well known. The n-fluence was calculated:

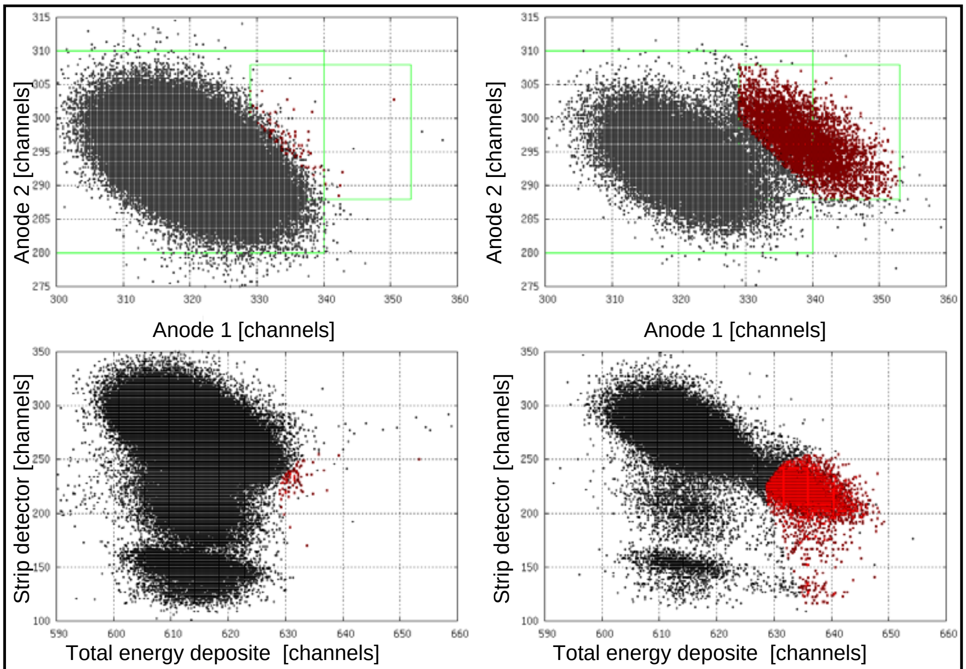
$$\Phi = K_{\mu} \frac{A(^{198}Au)}{\lambda} \frac{1}{N(^{197}Au)} \frac{1}{\sigma_{Au}}$$

Calculation of the $^{36}Cl/^{35}Cl$ ratio of the BRR and ATI samples with the fluence values and the known thermal cross section of $^{35}Cl(n,\gamma)^{36}Cl$.

$$\frac{^{36}Cl}{^{35}Cl} = \Phi \sigma_{Cl}$$

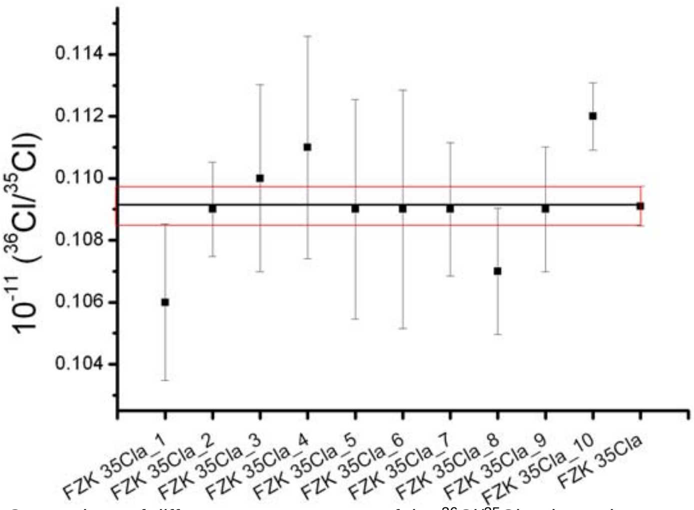
These values for the $^{36}Cl/^{35}Cl$ ratio are independent of the AMS measurements and so can be used as standards for AMS.





Two dimensional energy spectra of blank material (left) and a standard (right). The red dots were counted as ^{36}Cl, all other registered events are marked by black dots.

Results I



Comparison of different measurements of the $^{36}Cl/^{35}Cl$ ratio on the same sample.

Results II

	$^{36}Cl/^{35}Cl$ [10^{-12}] from Au activity measurements	Err [10^{-12}]
BUD1	7.82	0.10
BUD2	10.54	0.13
BUD3	9.57	0.12
ATI2	5.25	0.08
ATI3	5.47	0.08

Tab.1: Results for the $^{36}Cl/^{35}Cl$ ratios from the activity measurements of the Au-foils.

	σ_{MACS} [mb]	Err [mb]
FZK ^{35}Cla	10.6	0.6
FZK ^{35}Clb	8.8	0.5
Guber et al	11.0	0.3
Bao et al	11.7	-

Tab.2: Measured MACS and reference values.

Conclusions

• An independent standard for AMS measurements was produced.

• Discrepancy of 20% between the MACS measured on the two FZK samples. To clarify this discrepancy more AMS measurements on samples irradiated at KIT will be performed.

• The MACS measured on sample FZK ^{35}Clb is 25% smaller than the other values. This would decrease the estimated stellar production of ^{36}Cl by 25%.

Thank you for your attention!