S1240: Precision mass cartography of the island of inversion

TITAN mass measurement of $^{30-34}$Mg, $^{29-31}$Na, ^{29,32}Al

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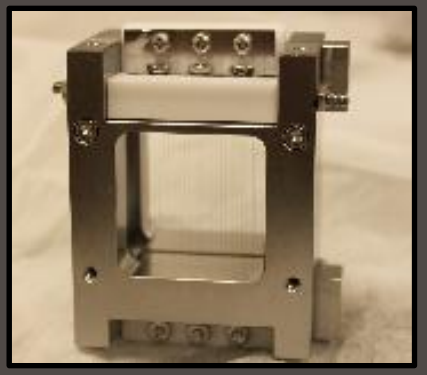
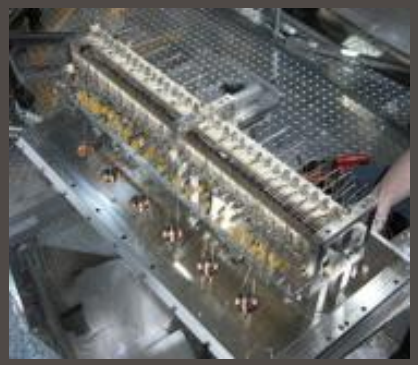
for the TITAN collaboration

ISAC Science Forum, January 18, 2012

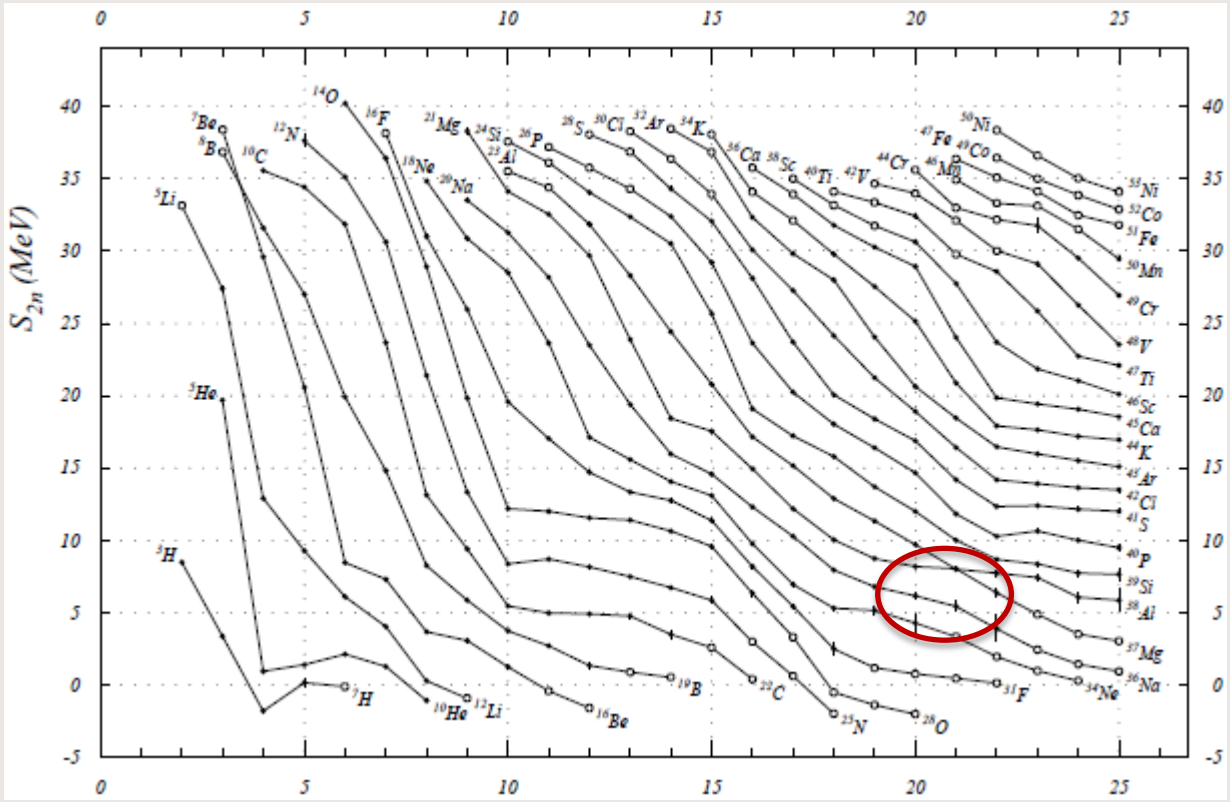




Motivation for S1240

View on the island of inversion through S_{2n}:

Vanishing of a shell closure at N=20

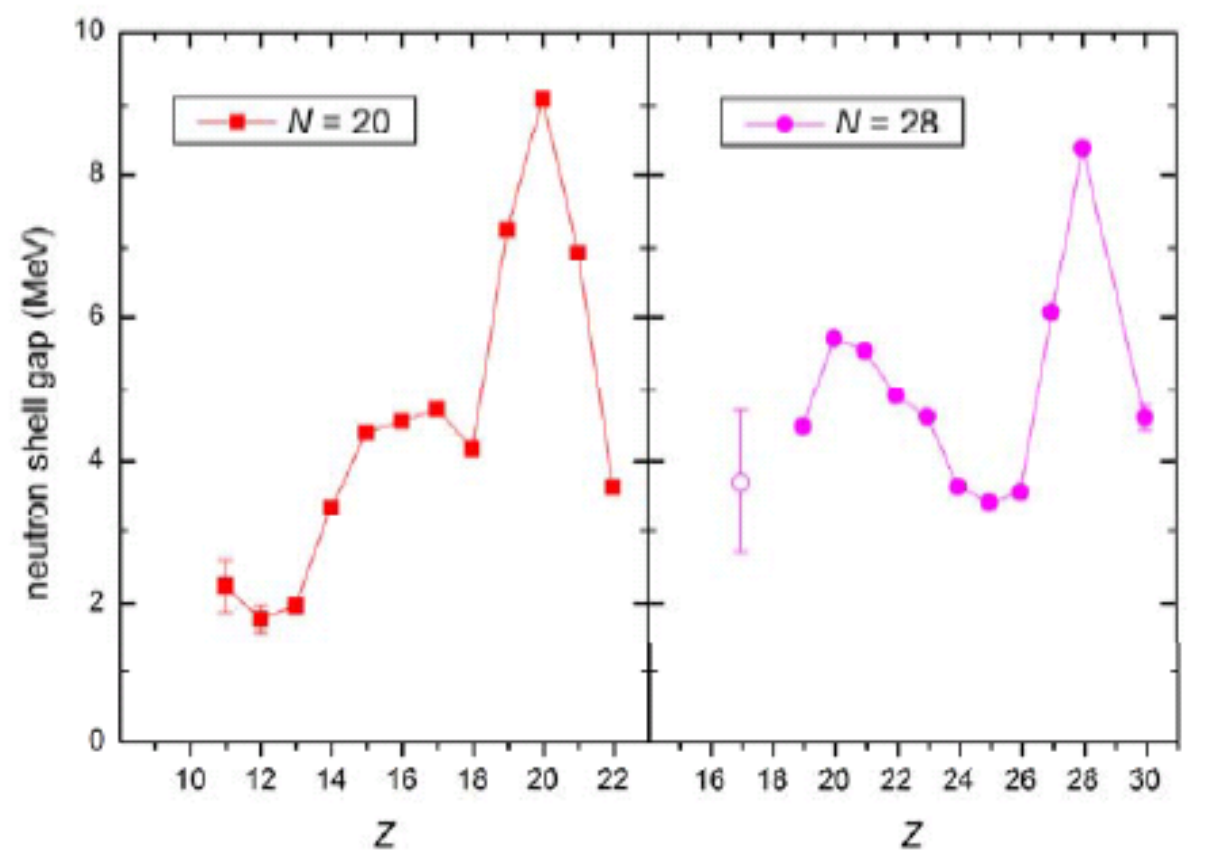


S_{2n}=BE(Z,N)-BE(Z,N-2)
=-M(Z,N)+M(Z,N-2)+2m_n

G. Audi et al., Nucl. Phys. A 729 (2003) 337

Motivation for S1240

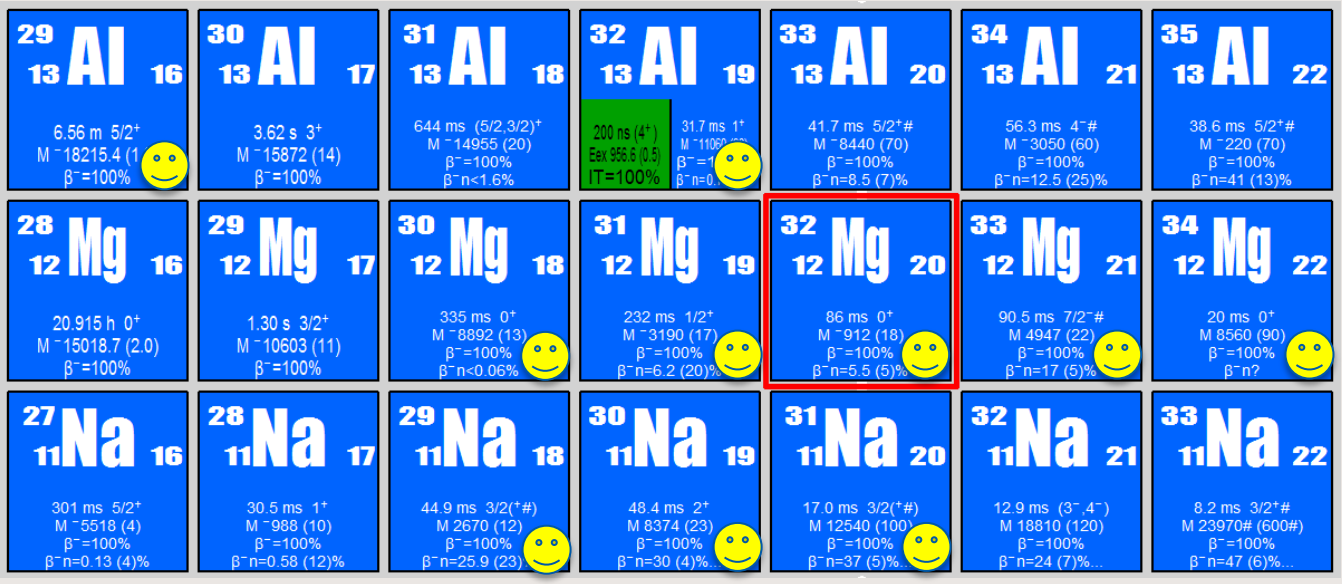
The shell gap illustrates the magic number disappearance for N=20



Neutron shell gap=
$S_{2n}(Z,N)-S_{2n}(Z,N+2)$

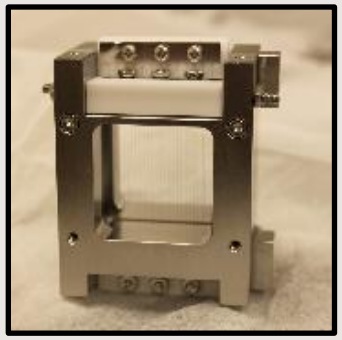
Figure courtesy:
EEC proposal S1240

TITAN measurement for S1240

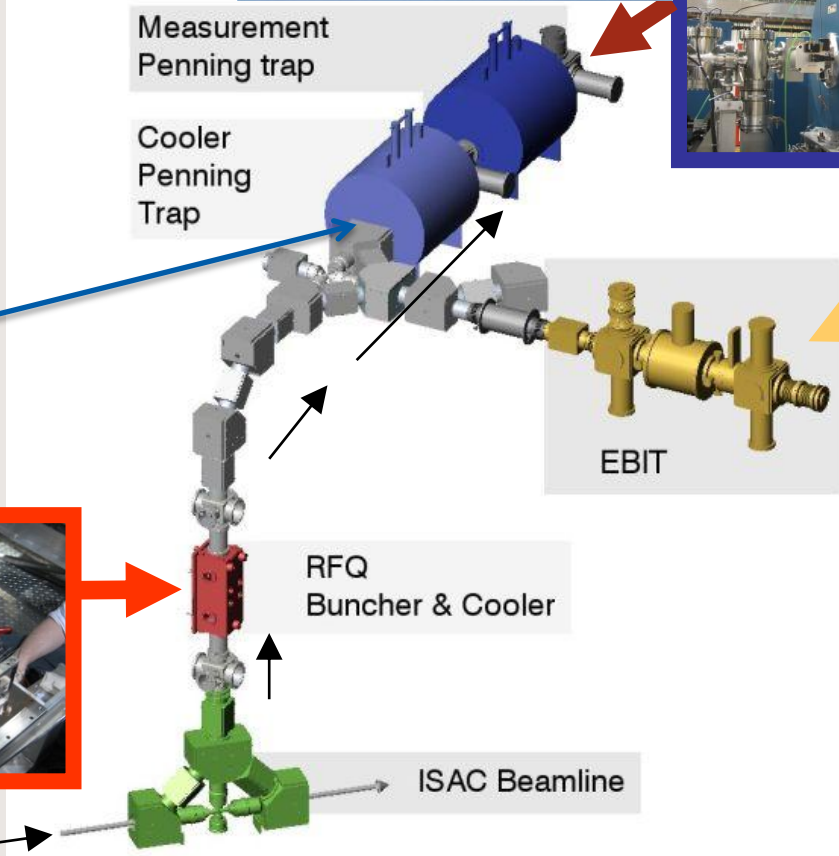


Isotopes	$T_{1/2}$
^{30}Mg	335 ms
^{31}Mg	232 ms
^{32}Mg	86 ms
^{33}Mg	90.5 ms
^{34}Mg	20 ms
^{29}Na	44.9 ms
^{30}Na	48.4 ms
^{31}Na	17 ms
^{29}Al	6.56 min
^{32}Al	31.7 ms

TITAN set-up

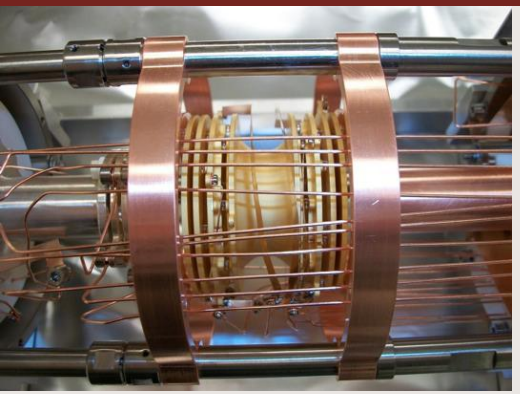


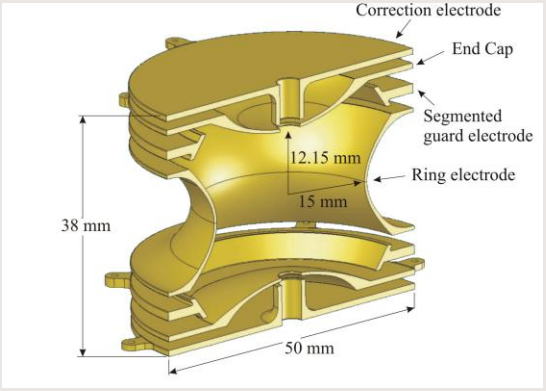
Bradbury–Nielsen Gate

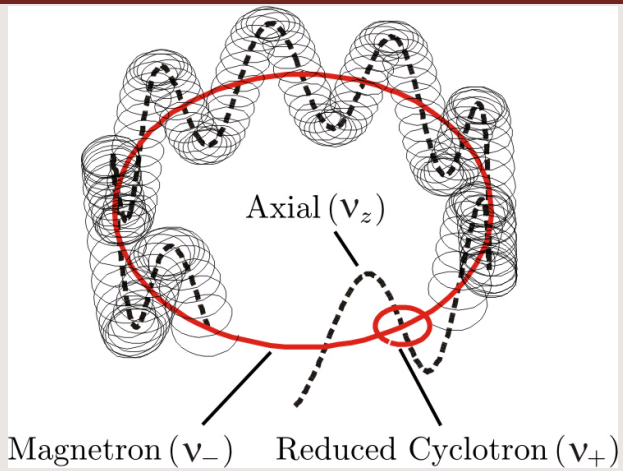


Radio-active ion

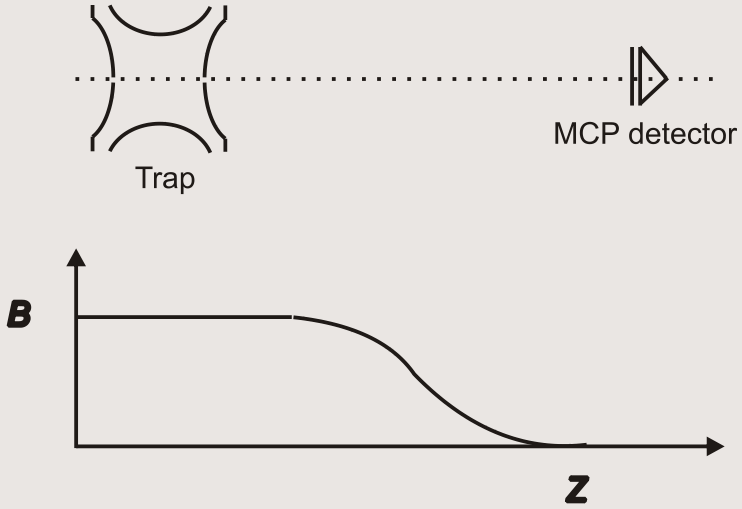
Penning trap mass spectrometry

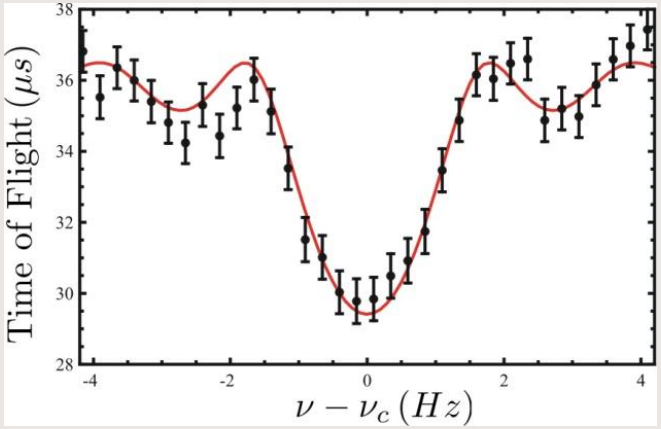






$$\nu_c = \nu_+ + \nu_- = \frac{1}{2\pi}\frac{q}{m}B$$





Penning trap mass spectrometry

Determine mass via cyclotron frequency measurement

$$\nu_C = \frac{1}{2\pi}\frac{qB}{m_{ion}}$$

Magnetic field calibration

$$\nu_{c,ref} = \frac{1}{2\pi}\frac{q_{ref}B}{m_{ion,ref}}$$

$$\frac{m_{ion}}{m_{ion,ref}} = \left(\frac{\nu_{c,ref}}{\nu_c}\right)\left(\frac{q}{q_{ref}}\right)$$

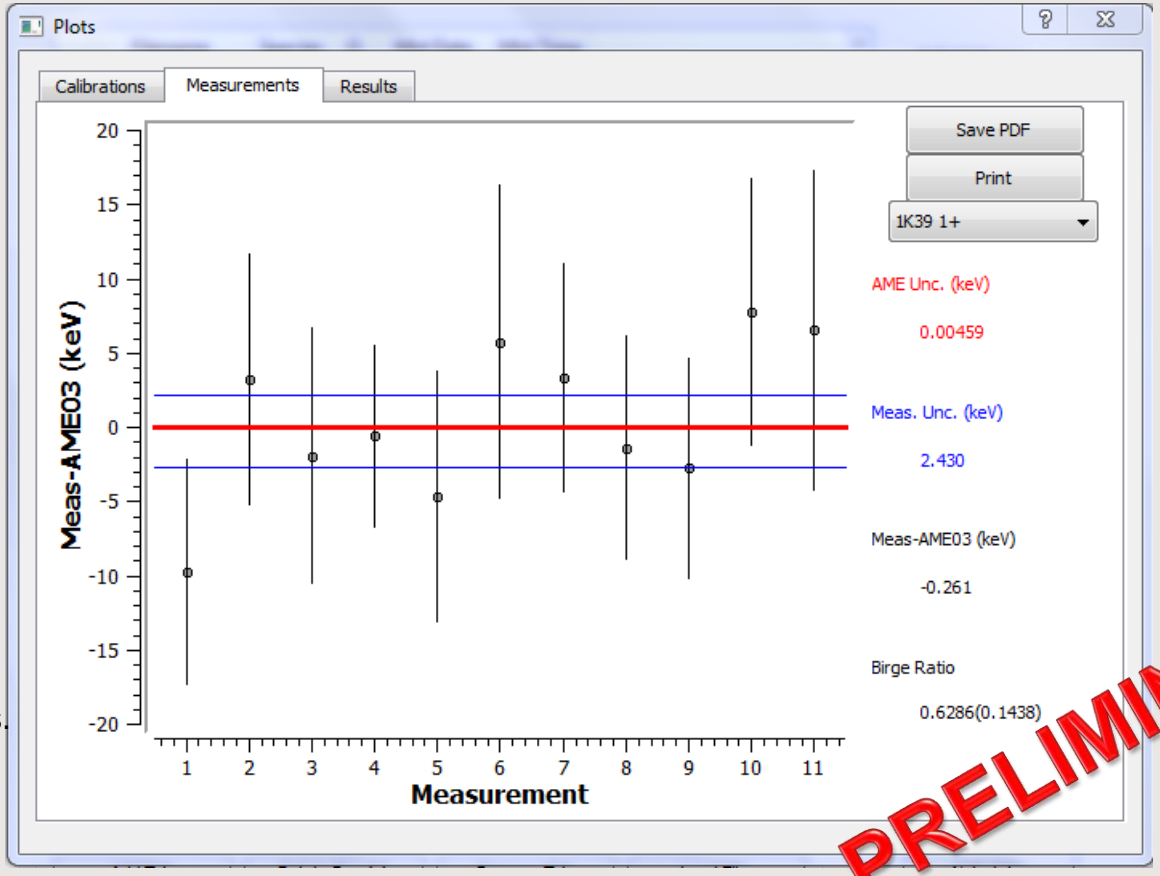
$\Rightarrow$ **atomic mass**

$$m = r\left(m_{ref} - m_e\right) + m_e$$

$$r = \frac{\nu_{c,ref}}{\nu_c}$$

Accuracy check

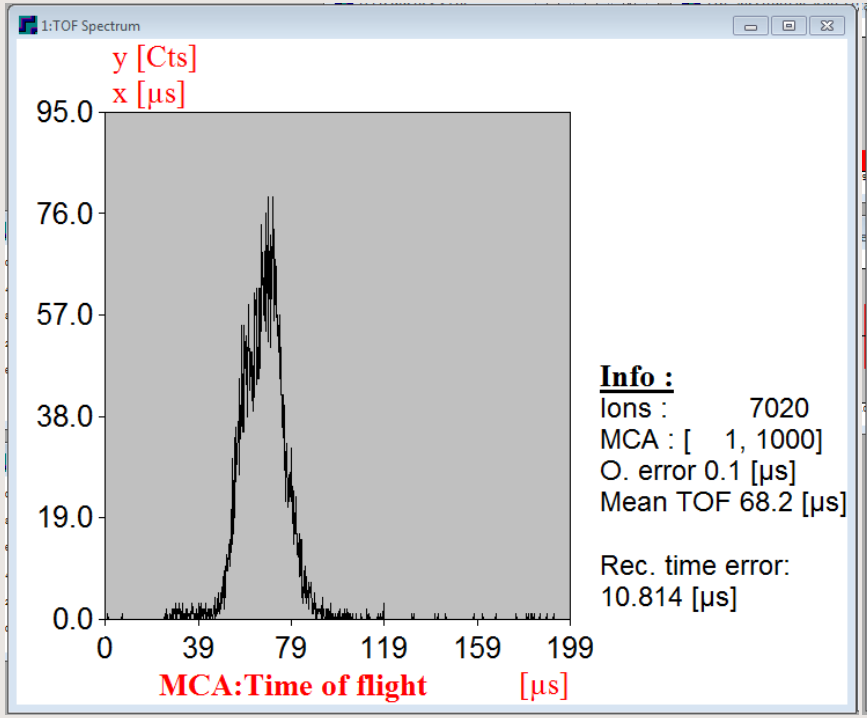
- ^{39}K (from TITAN surface ion source) measurement at 10 Hz measurement cycle
- Reference: $^{16}O_2$ from OLIS
- $^{16}O_2$ from OLIS was used for optimizing trapping parameters and scaling thereafter.

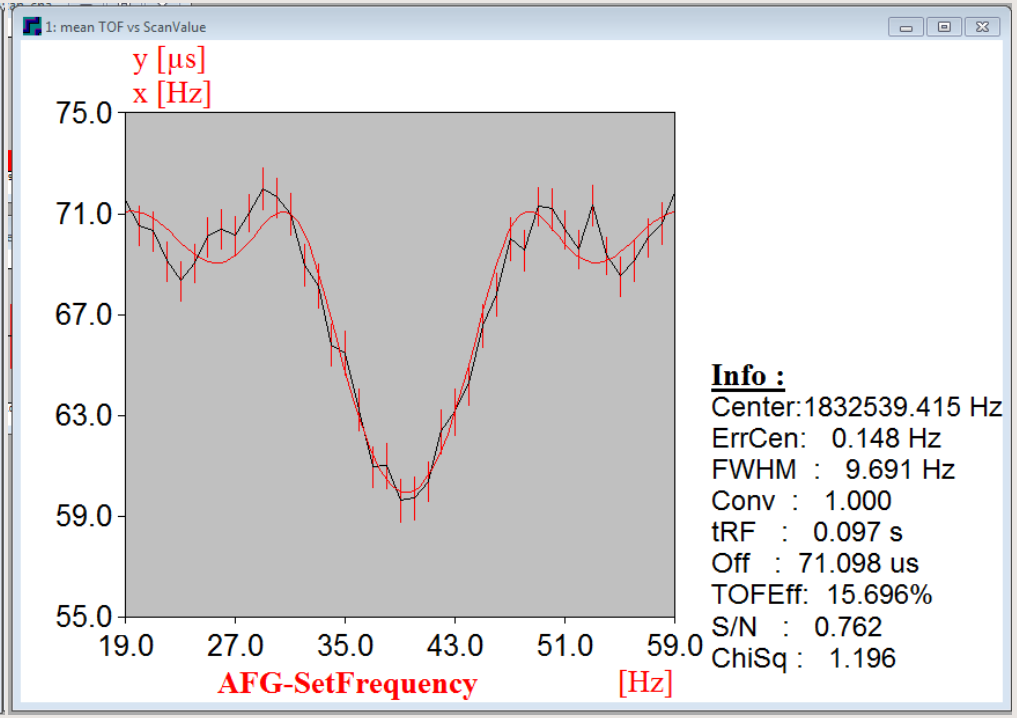


AME03:
G. Audi et al., Nucl. Phys. A 729 (2003) 337

$^{30\text{-}34}$Mg

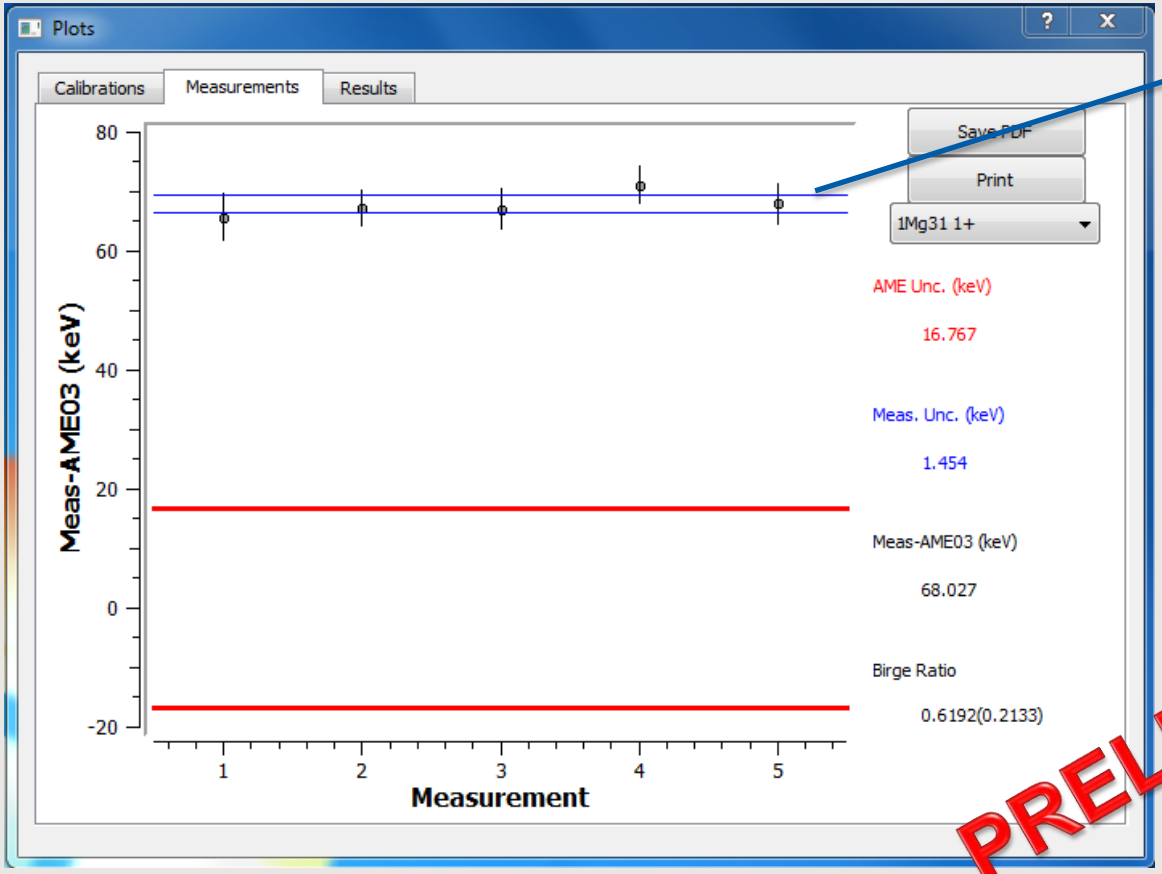
- Example I: ^{31}Mg ($T_{1/2}$=232 ms, yield 1X10^5 pps)





$^{30\text{-}34}$Mg

- Example I: ^{31}Mg
- Reference ion: $^{16}O_2$ from OLIS
- Measurement cycle : 10Hz



Statistical Uncertainty

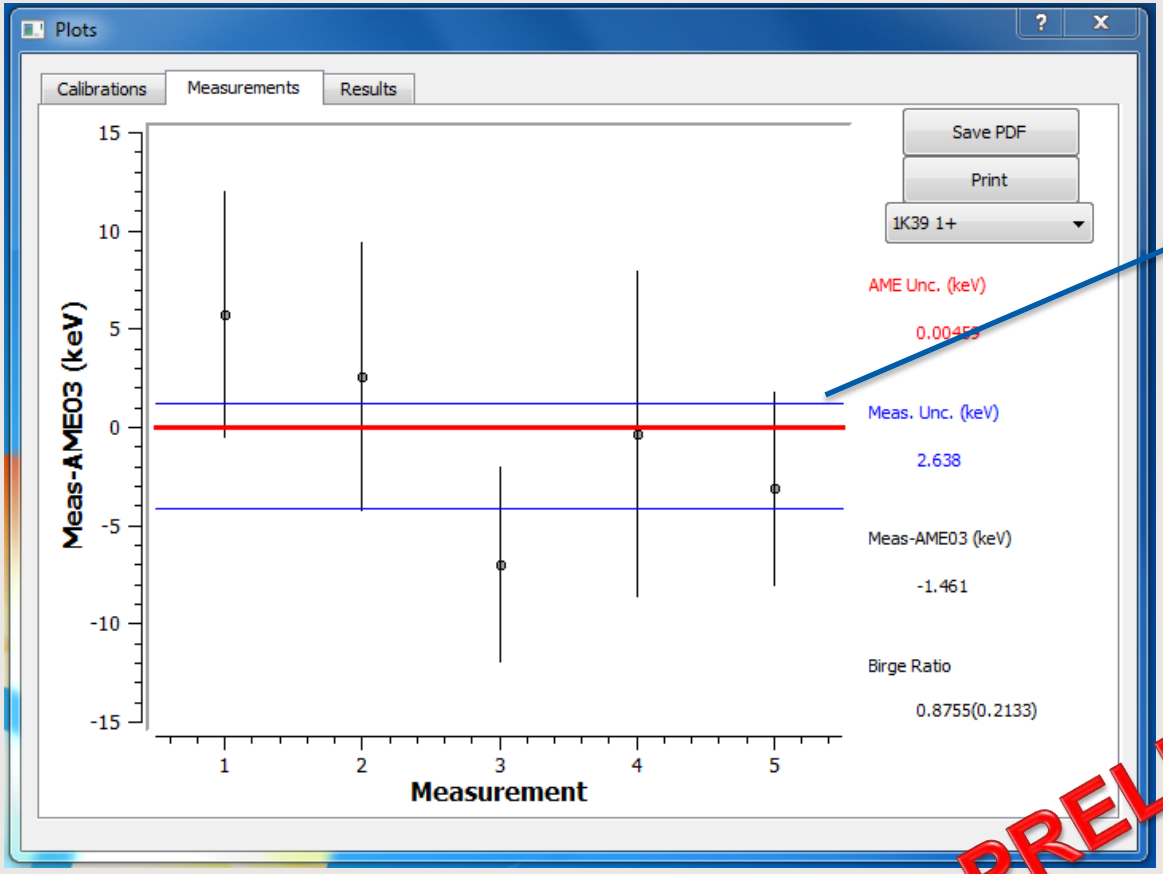
PRELIMINARY

$^{30-34}$Mg

Measurement of ^{39}K (from TITAN Ion Source)

Reference: $^{16}O_2$

Measurement cycle: 10 Hz

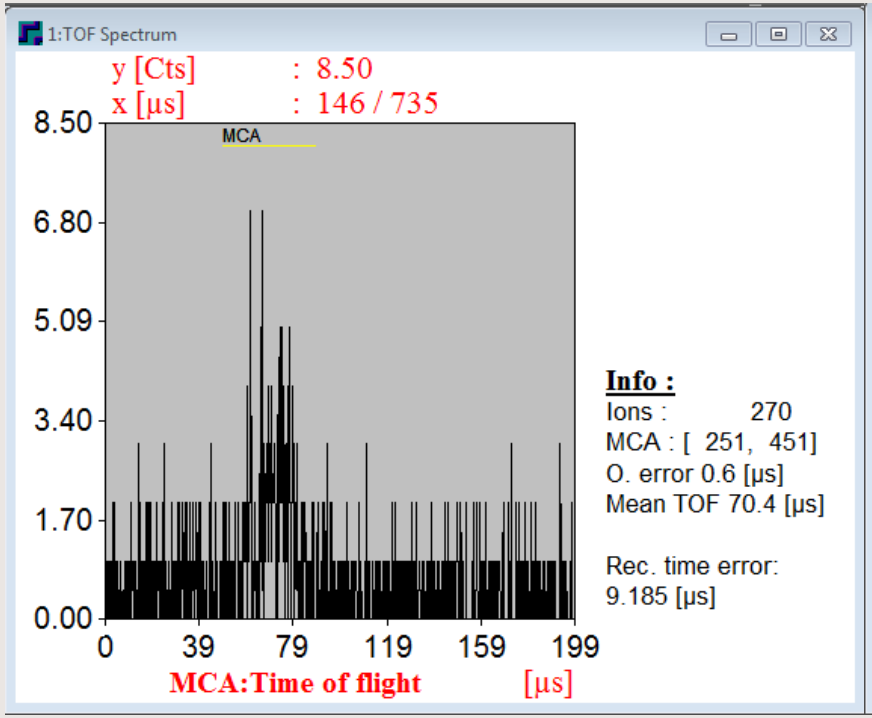


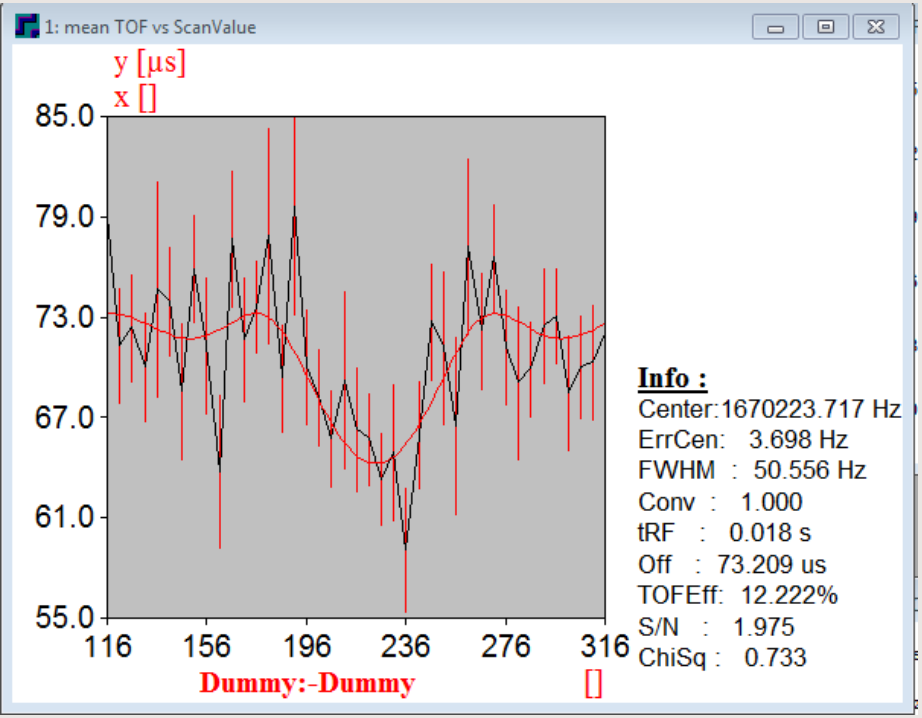
Statistical Uncertainty

PRELIMINARY

$^{30\text{-}34}$Mg

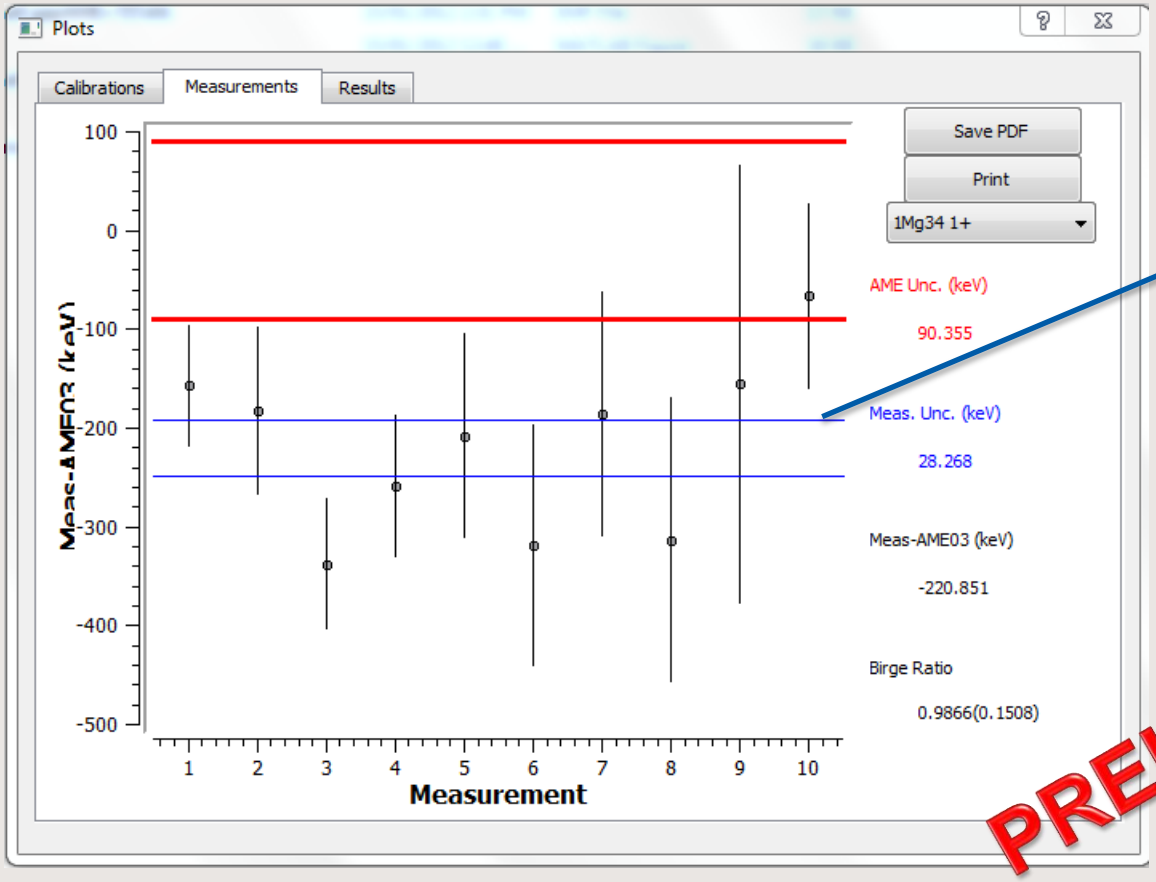
- Example II: ^{34}Mg ($T_{1/2}$=20 ms, yield 1X10^3 pps)





$^{30\text{-}34}$Mg

- Example II: ^{34}Mg
- Reference ion: $^{16}O_2$ from OLIS
- Measurement cycle : 50Hz

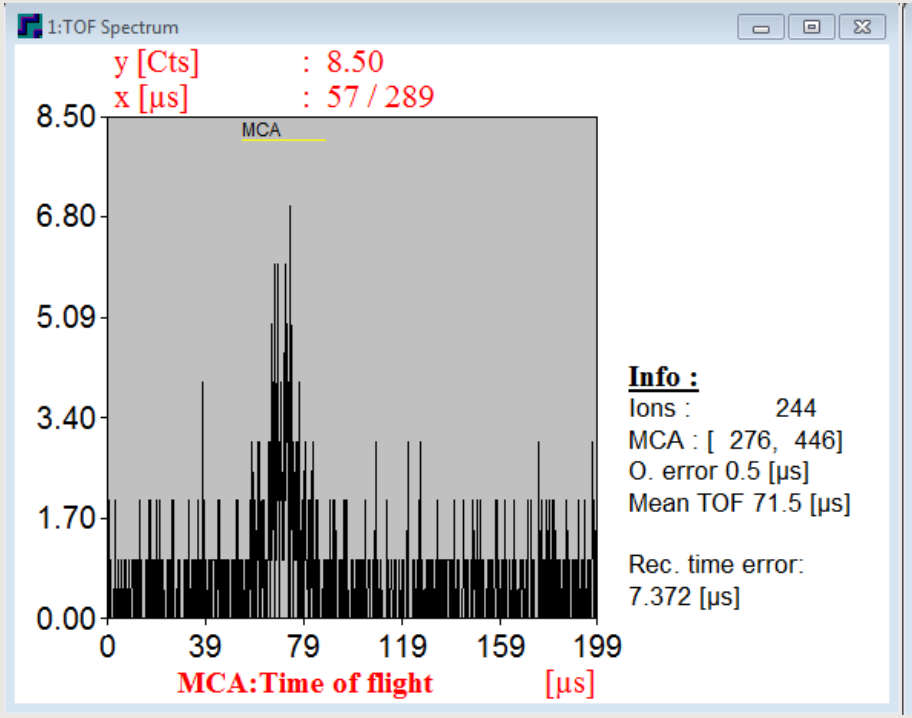


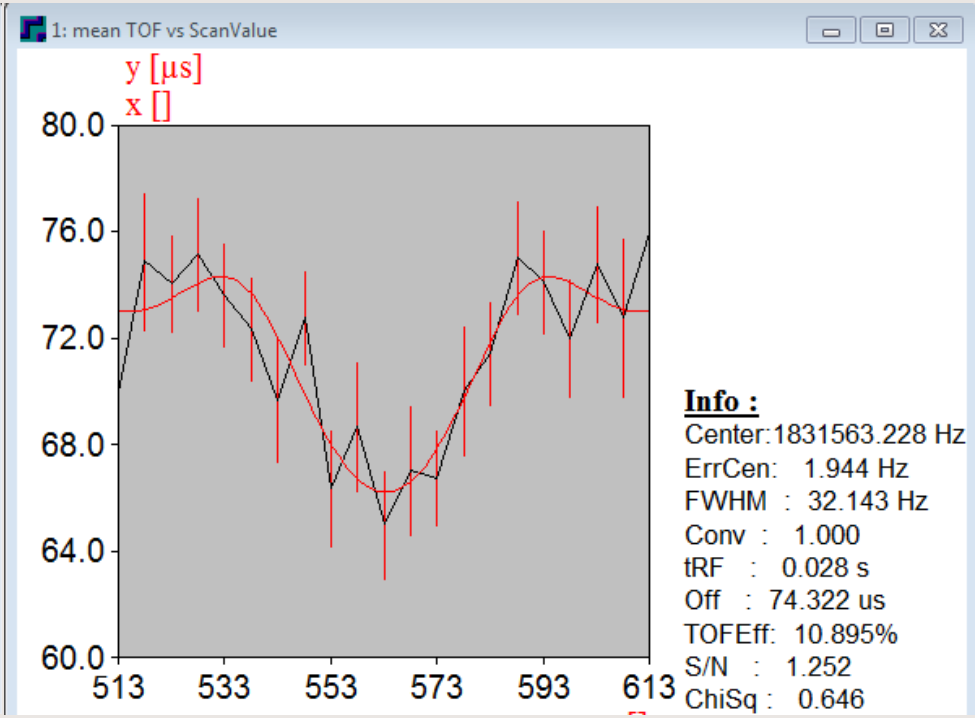
Statistical Uncertainty

PRELIMINARY

$^{29-31}$Na

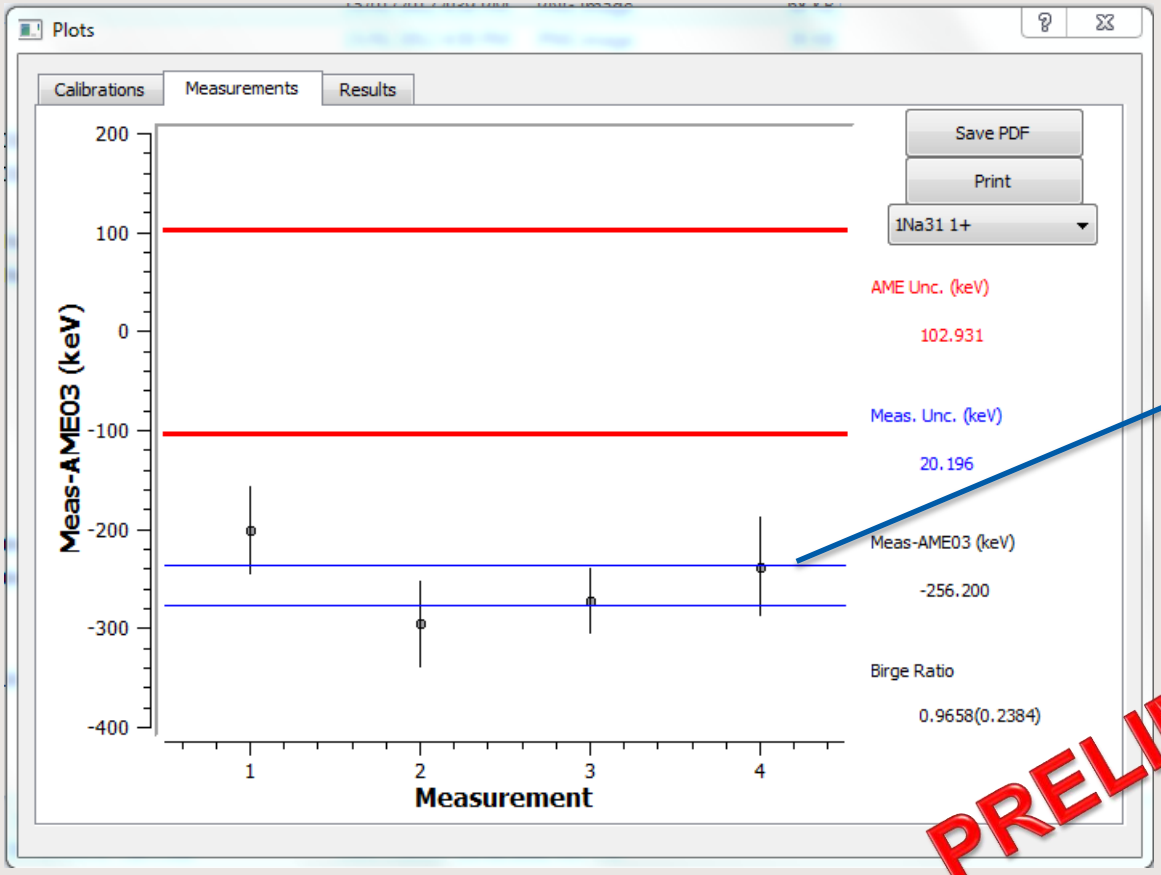
- Example III: ^{31}Na ($T_{1/2}$=17 ms)





$^{29-31}$Na

- Example III: ^{31}Na
- Reference ion: ^{39}K from TITAN Ion Source
- Measurement cycle : 20Hz

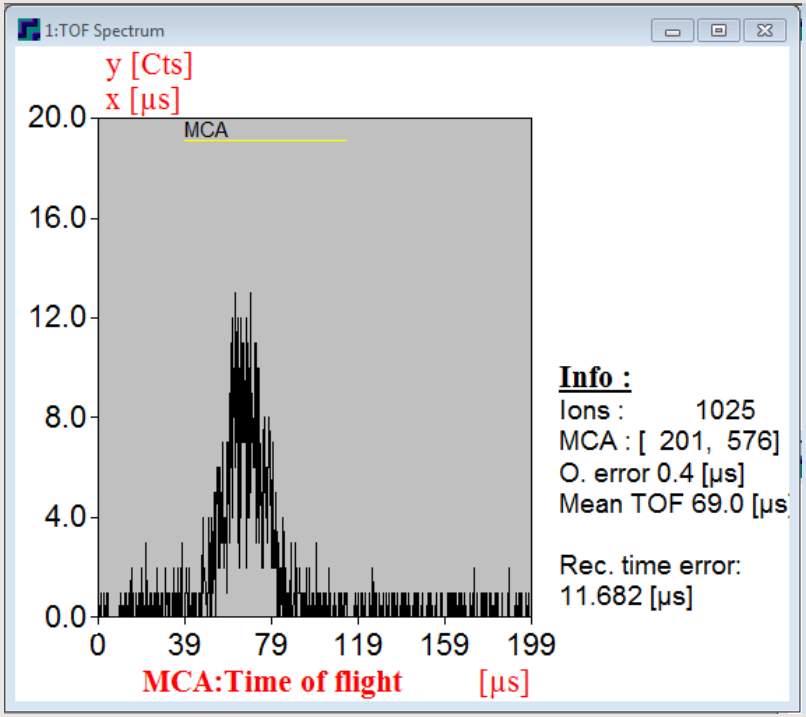


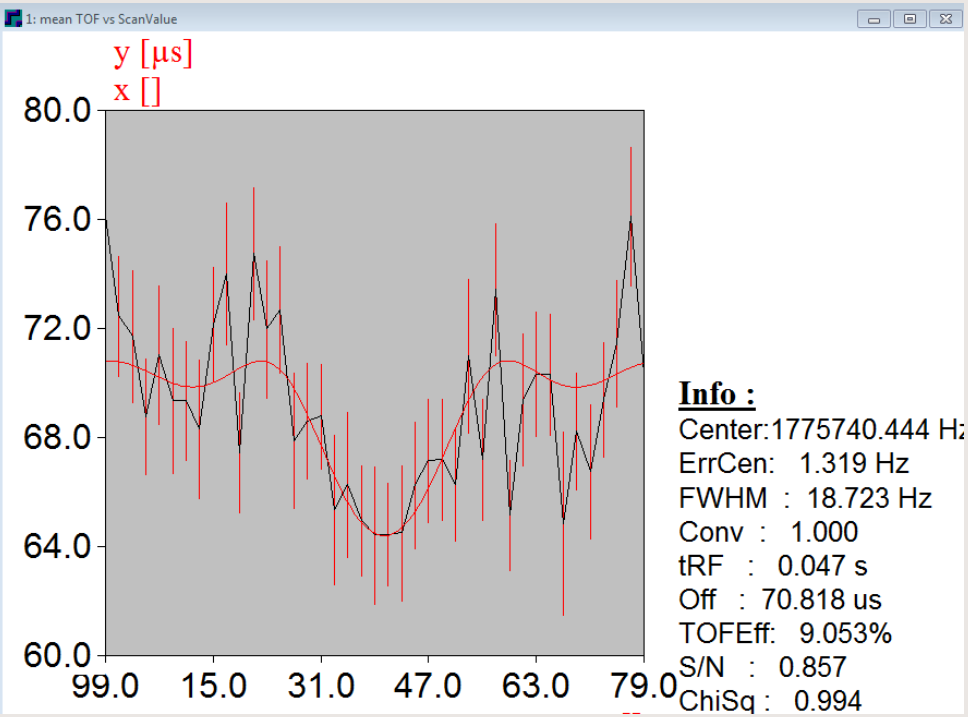
Statistical Uncertainty

PRELIMINARY

^{29,32}Al

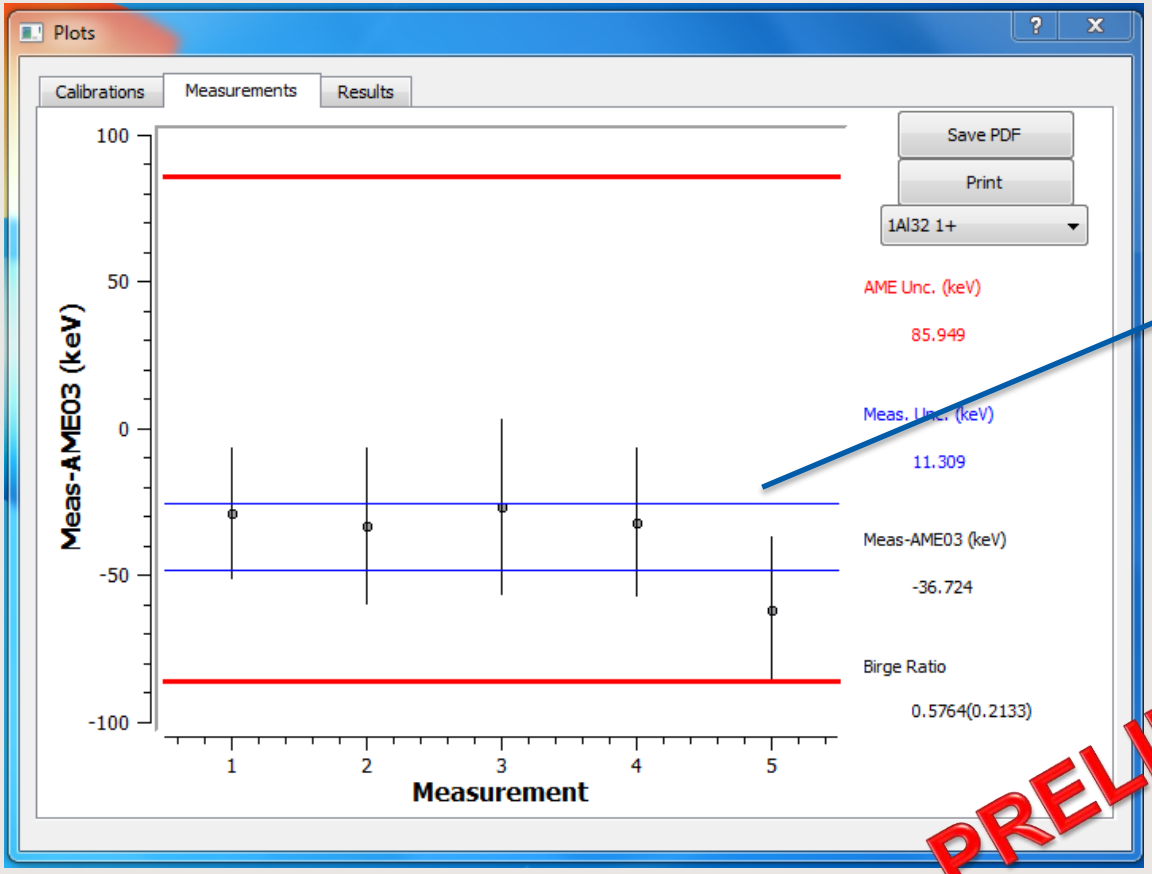
- Example IV: ^{32}Al ($T_{1/2}$=31.7 ms, yield 3 X10^{3} pps)





^{29,32}Al

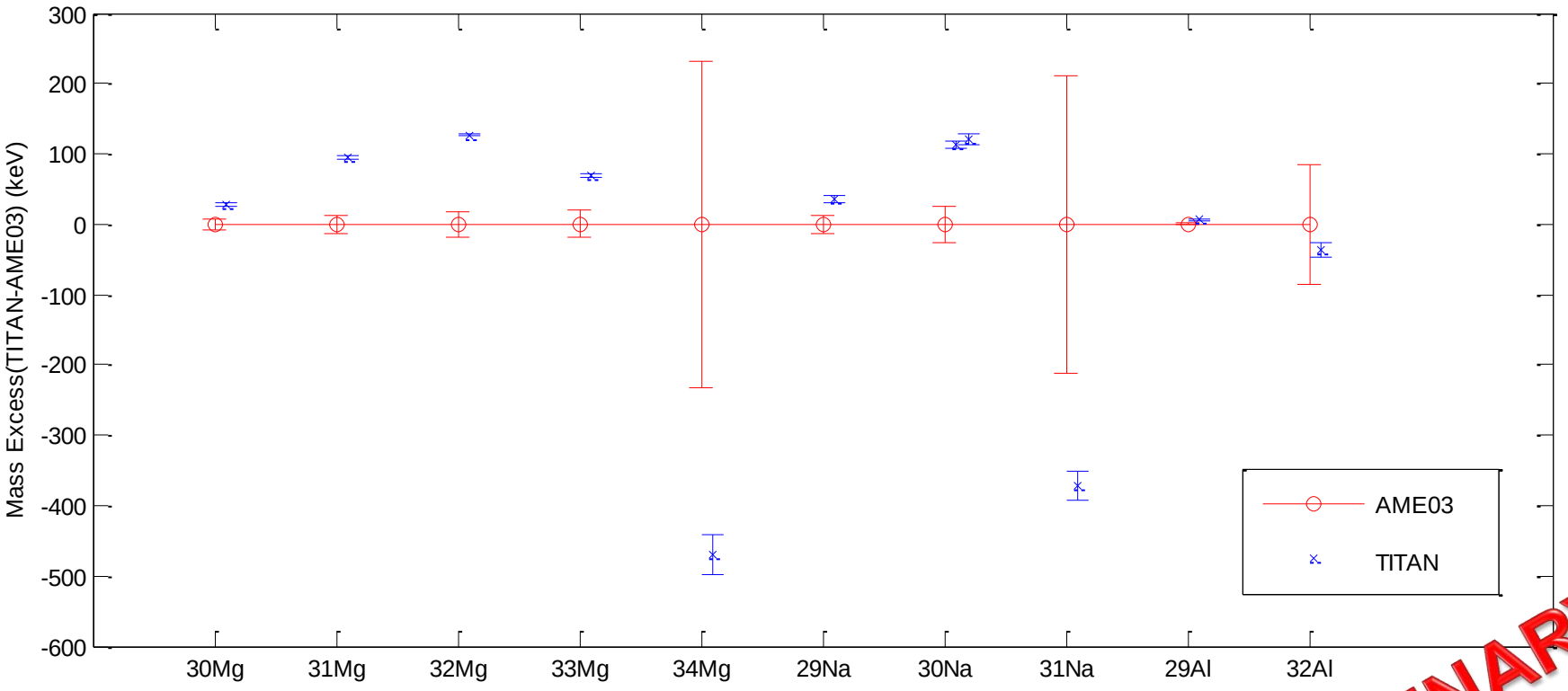
- Example II: ^{32}Al
- Reference ion: $^{16}O_2$ from OLIS
- Measurement cycle : 20Hz



Statistical Uncertainty

PRELIMINARY

Preliminary Results

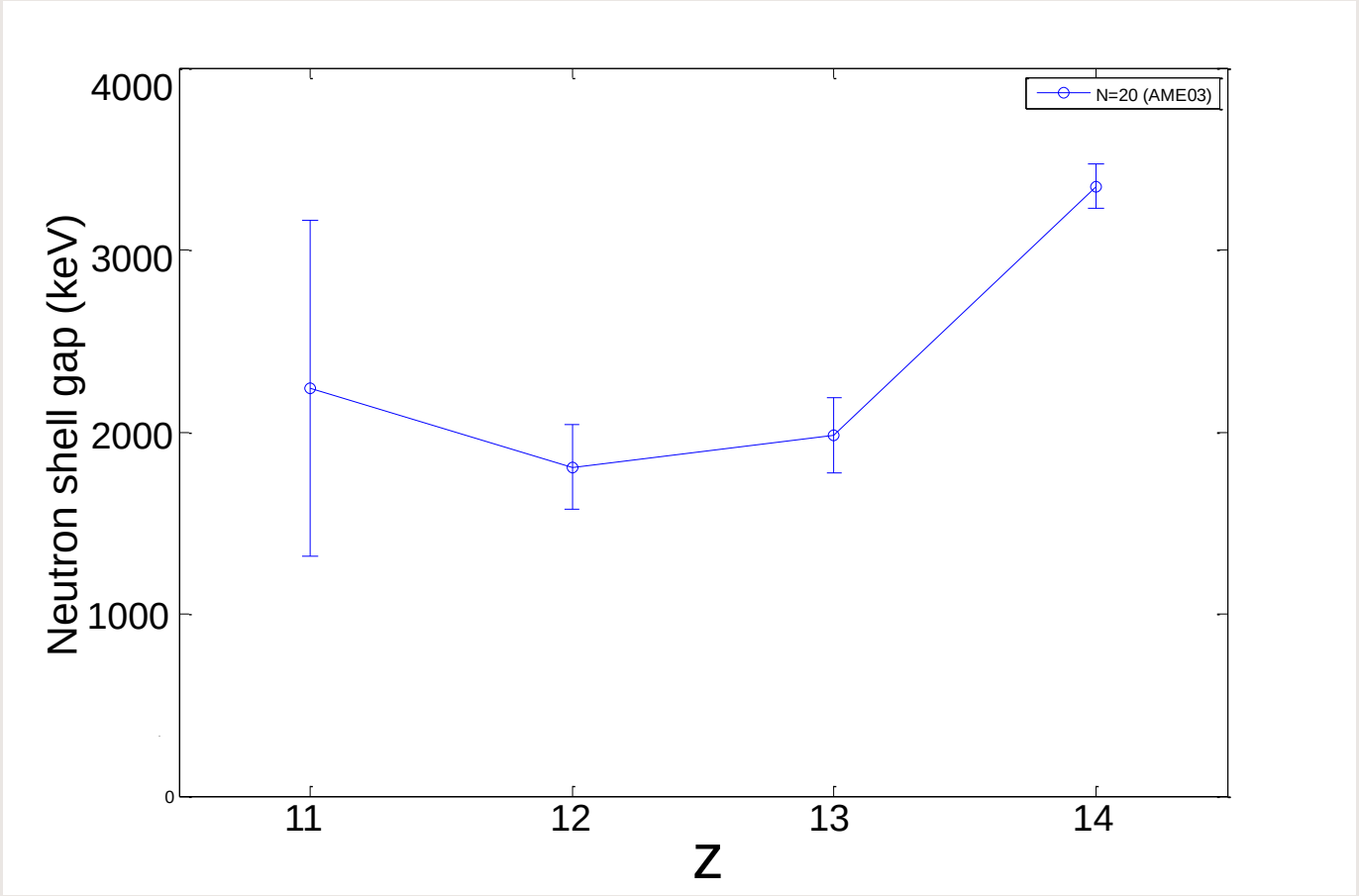


* TITAN measurement shows only statistical uncertainty

AME03: G. Audi et al., Nucl. Phys. A 729 (2003) 337

Neutron shell gap

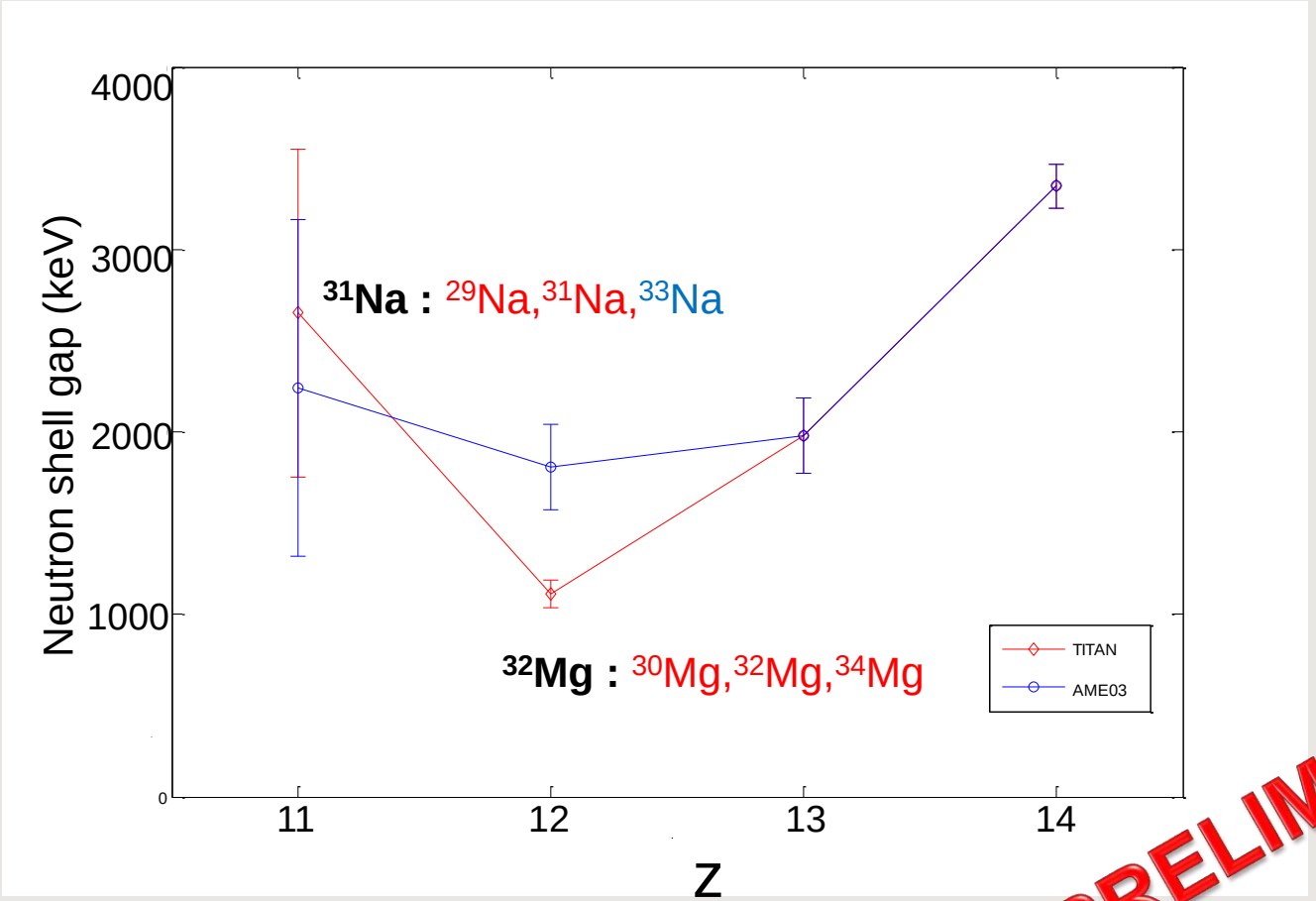
Neutron shell gap $\Delta=S_{2n}(Z,N)-S_{2n}(Z,N+2)$ for N=20



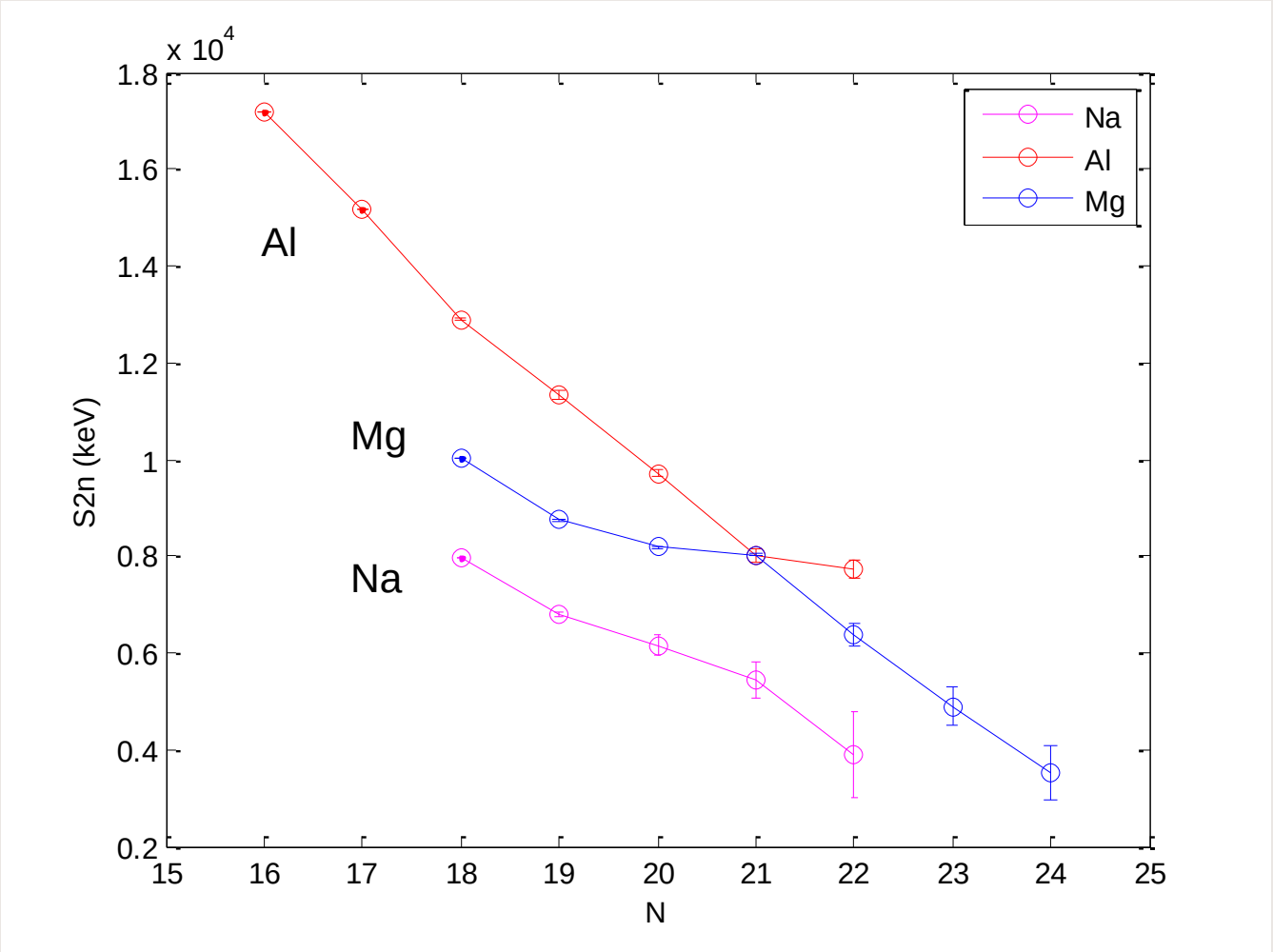
AME2003: G. Audi et al., Nucl. Phys. A 729 (2003) 337

Neutron shell gap

Neutron shell gap $\Delta=S_{2n}(Z,N)-S_{2n}(Z,N+2)$ for N=20

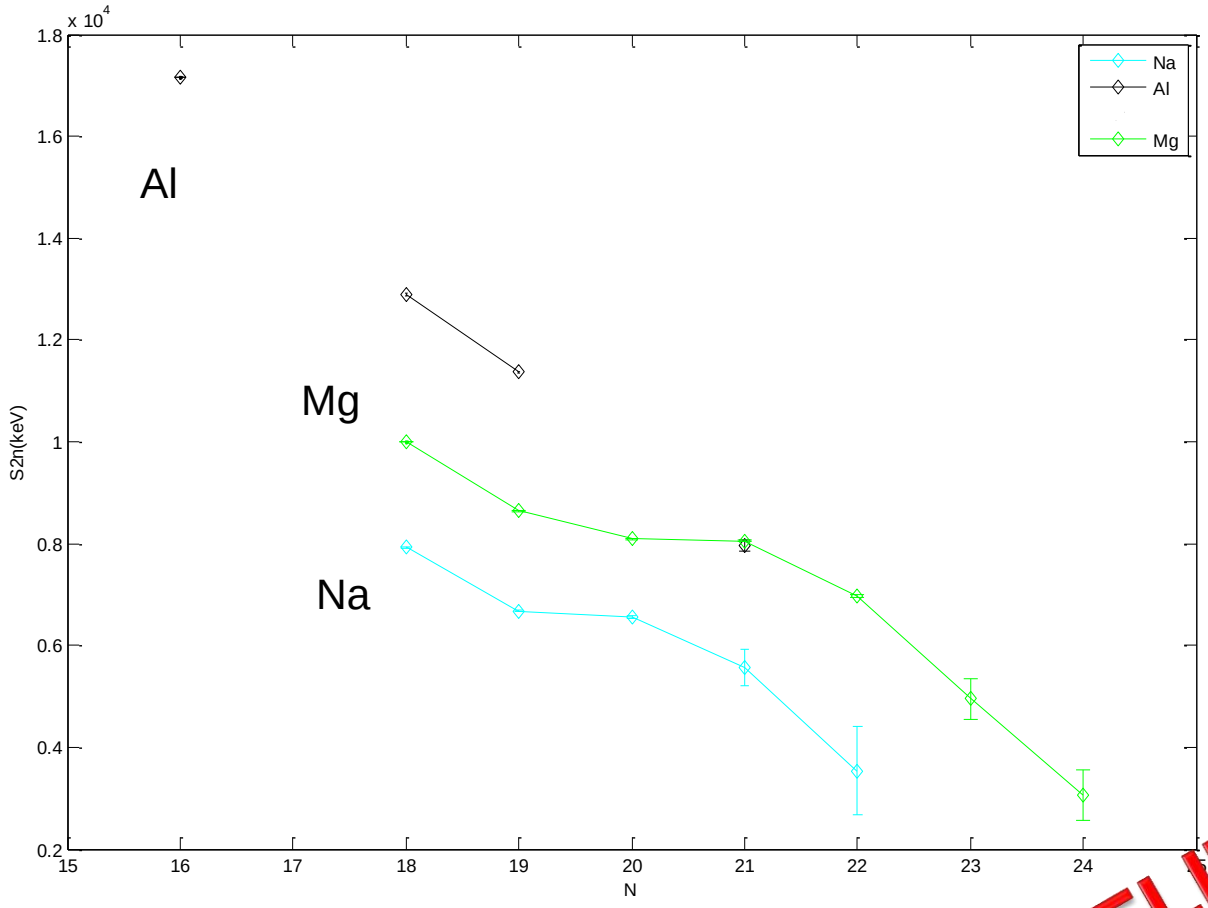


Two neutron separation energy



AME2003

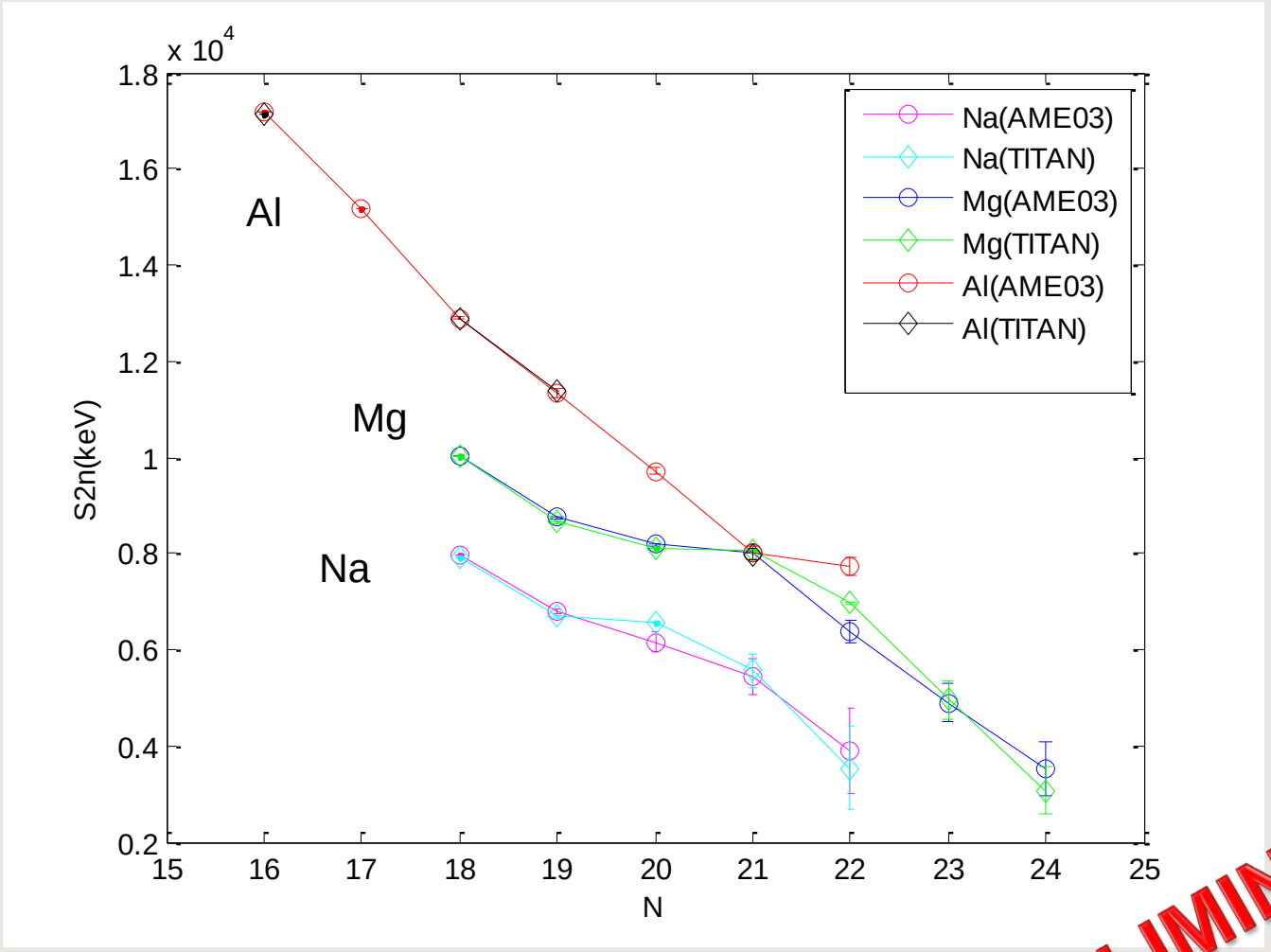
Two neutron separation energy



PRELIMINARY

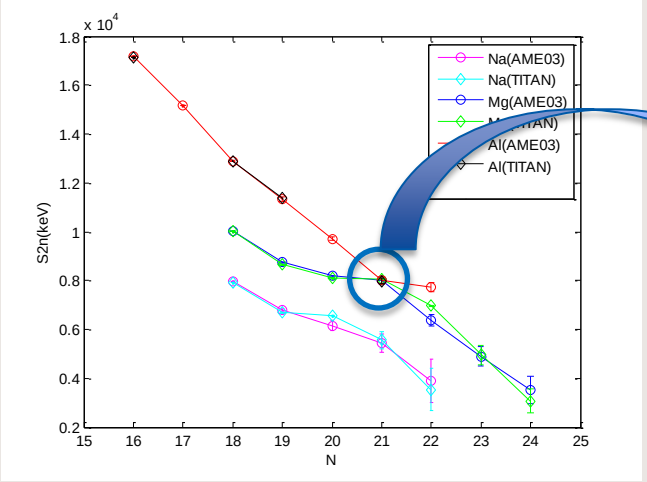
TITAN

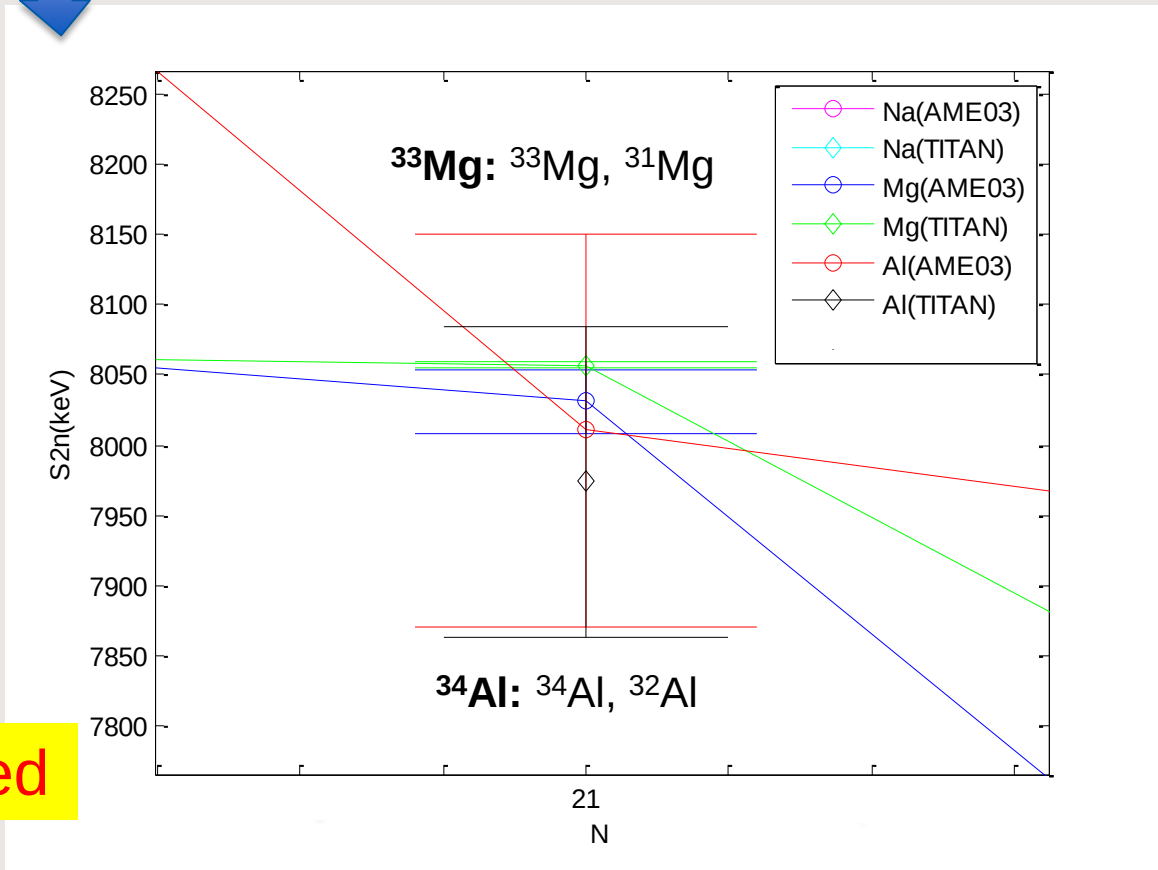
Two neutron separation energy



PRELIMINARY

Two neutron separation energy

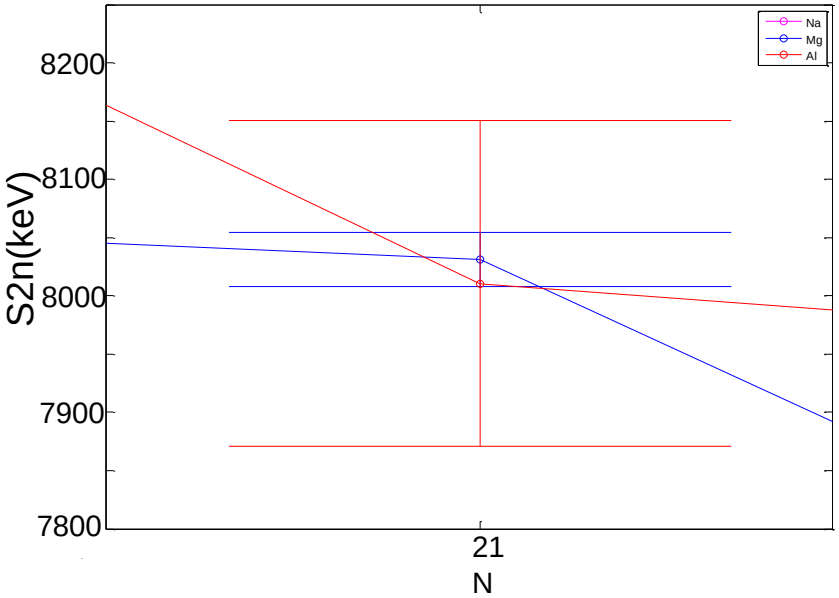




^{34}Al needs to be measured

Two neutron separation energy

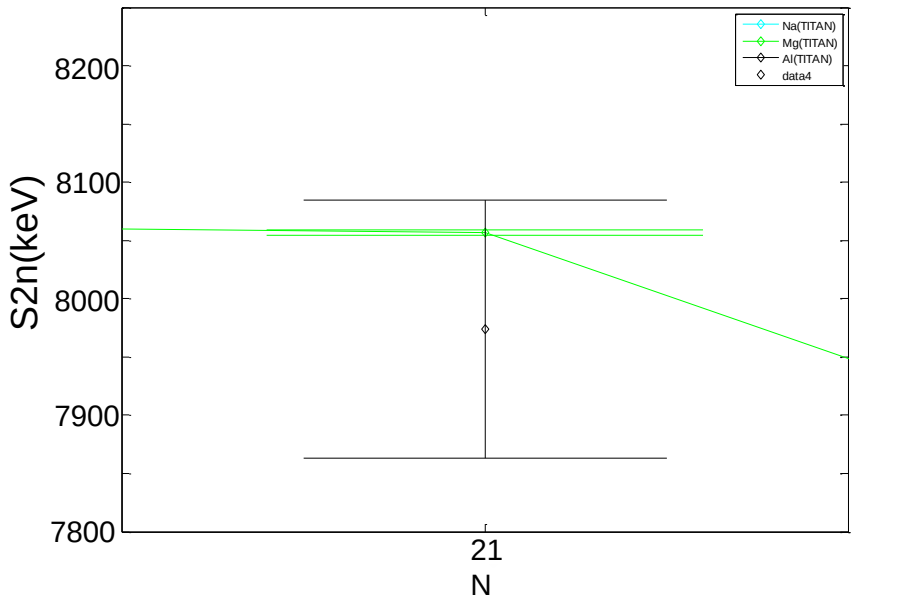
AME2003



^{33}Mg: ^{33}Mg, ^{31}Mg

^{34}Al: ^{34}Al, ^{32}Al

TITAN

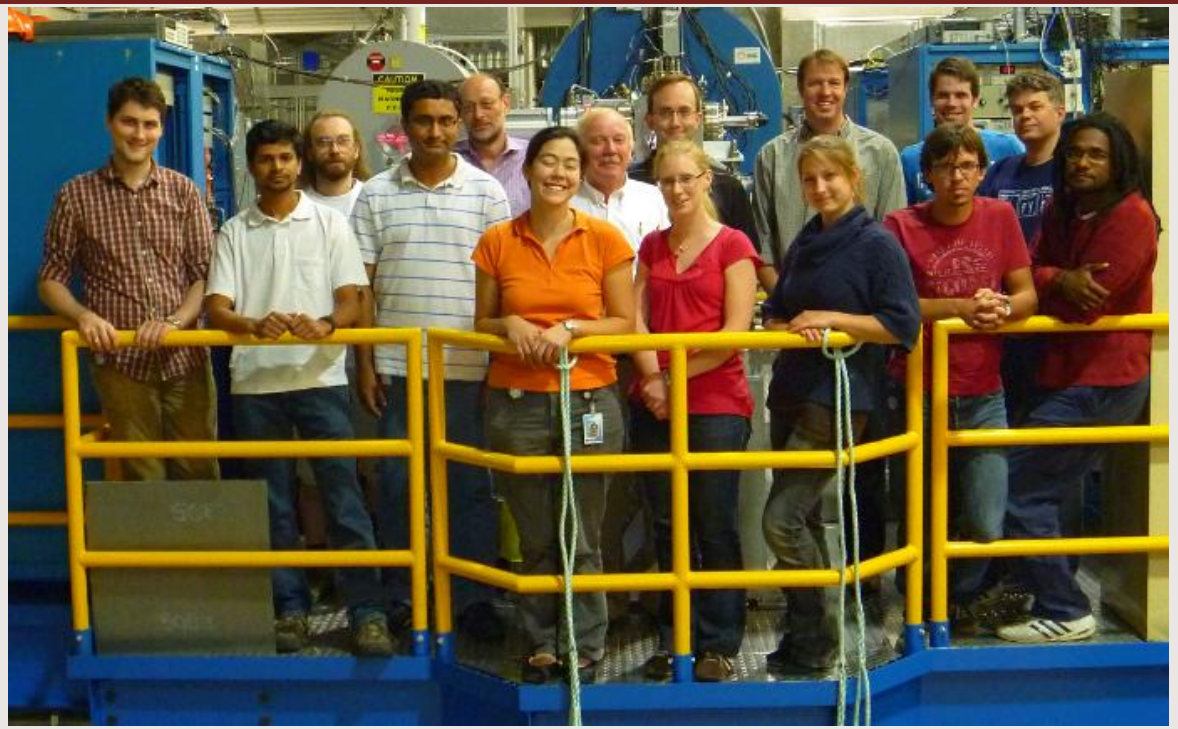


^{33}Mg: ^{33}Mg, ^{31}Mg

^{34}Al: ^{34}Al, ^{32}Al

Summary

- Masses of ten short-lived nuclei in the region of island of inversion were measured using TITAN facility. Those are $^{29-31}$Na, $^{30-34}$Mg and ^{29,32}Al.
- Uncertainty of TITAN measurement ~ 10-30 keV depending on the half-life of the isotope.
- Preliminary analysis confirms the disappearance of magic number at N=20 around Z=12.
- ^{34}Al needs to be measured to confirm the overlapping of S_{2n} for the aluminum and magnesium isotope at N=21.



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•This measurement was done with the 10μA UCx target.

•We thank the UCx -team, the yield measurement team, and the TRILIS team.

•Special thanks to J. Lassen and the TRILIS group for their special efforts to change the tune to Al in short notice.

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Thank you!
Merci

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