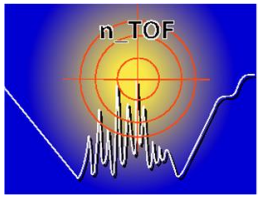
Destruction of the cosmic γ ray emitter ^{26}Al by neutron induced reactions

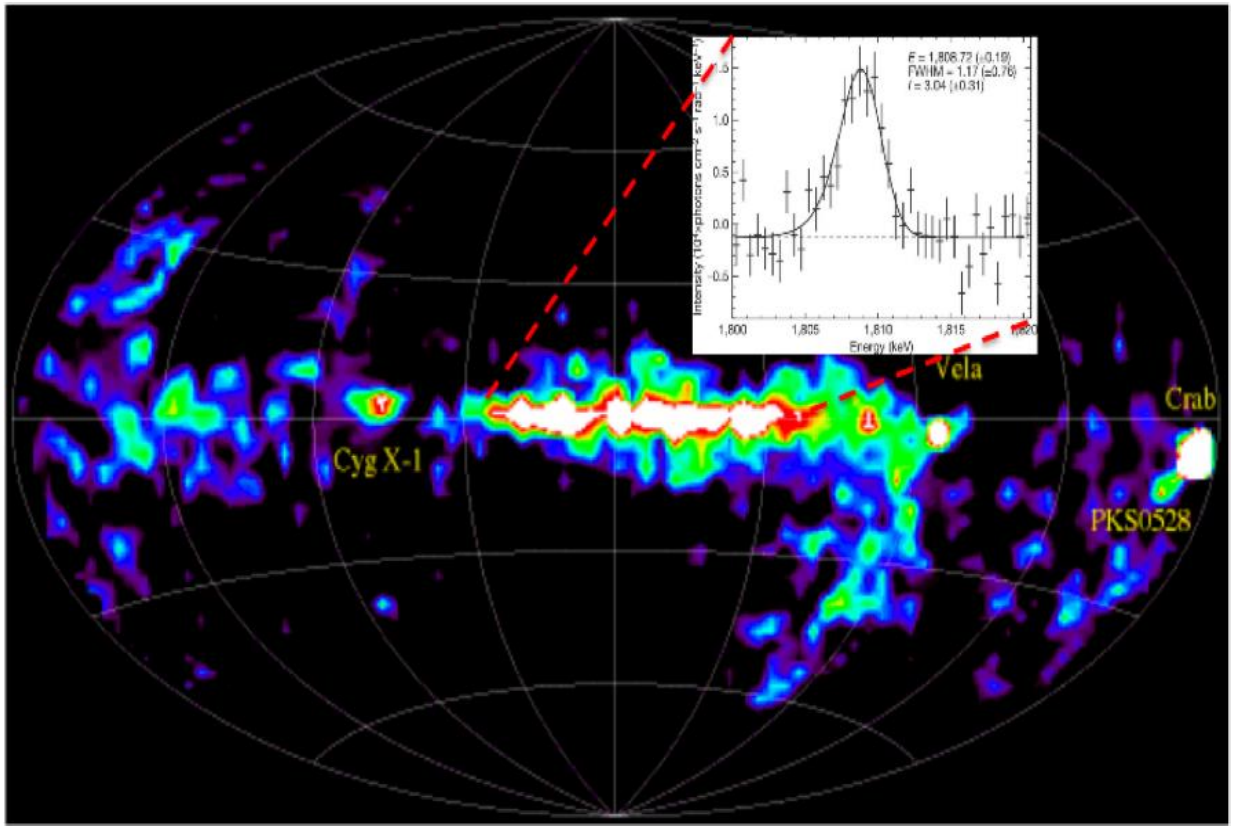
Claudia Lederer
Goethe University Frankfurt/
University of Edinburgh

PJ Woods, C Lederer, F Käppeler, E Berthoumieux, E Chiaveri, N Colonna, T Davinson, A Estrade, C Guerrero, F Gunsing, J Heyse, C Massimi, W Mondelaers, R Reifarth, P Schillebeeckxs, G Tagliente, C Wagemans, A Wallner, C Weiss



Galactic abundance distribution of the cosmic γ-ray emitter ^{26}Al

INTEGRAL Measured abundance 2.8(8) Solar Masses
[R. Diehl, *Nature* ***439***, *45(2006)*]



Main Origin of ^{26}Al in massive stars

3 Mechanisms:

- convective hydrogen burning in Wolf-Rayet stars followed by ejection by stellar wind
- convective Carbon shell burning followed by ejection from core collapse supernova
- explosive Ne/C burning in core collapse phase of supernova

C Illiadis et al., Ast. J. Supp. 193, 16 (2011)
Sensitivity study of ^{26}Al abundance in Massive stars

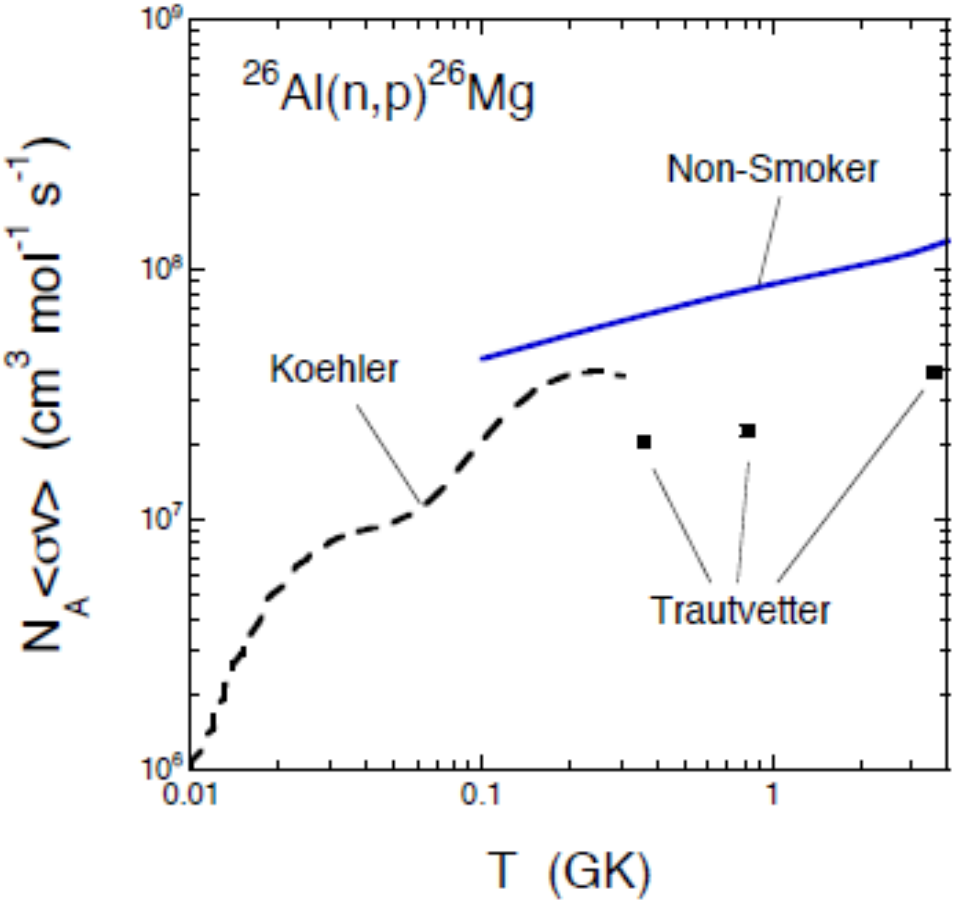
FACTOR CHANGES OF FINAL ^{26}Al^{g} ABUNDANCE RESULTING FROM REACTION RATE VARIATIONS FOR CONVECTIVE SHELL C/Ne BURNING[a] , ASSUMING FIVE SPECIES OF ^{26}Al

Reaction[b]	Rate multiplied by						Source[c]	Uncertainty[d]
	100	10	2	0.5	0.1	0.01		
^{26}Al^{g}(n,p)^{26}Mg	0.017	0.16	0.63	1.3	1.9	2.0	present	
^{25}Mg(p,γ)^{26}Al^{g}	2.9	5.4	1.5	0.63	0.35	0.29	il10	5%
^{25}Mg(p,γ)^{26}Al^{m}	6.7	3.0	...	...	0.75	0.71	il10	6%
^{26}Al^{g}(n,α)^{23}Na	0.12	0.54	...	...	...	...	present	
^{26}Al^{m}(n,p)^{26}Mg	0.58	...	...	...	...	...	present	

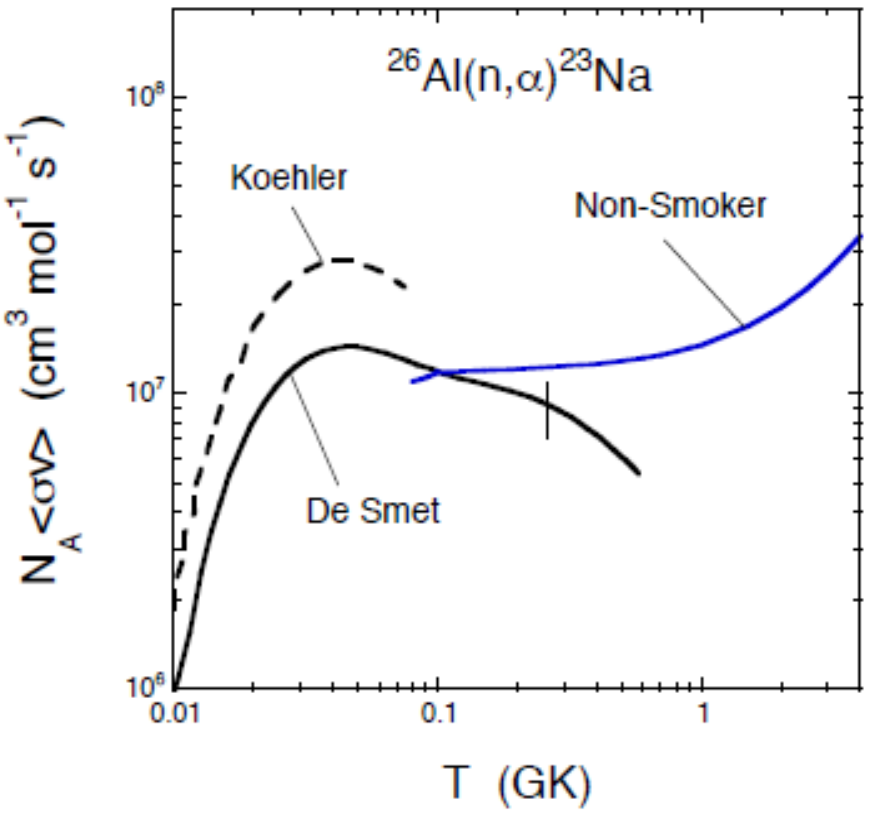
→ ^{26}Al(n,p) and ^{26}Al(n,α) reaction rates represent critical uncertainties for ^{26}Al material processed by explosive and convective burning in massive stars and ejected into the ISM by core collapse supernovae

Discrepancies in cross-sections for ^{26}Al(n,p) reaction

→ Illiadis et al. emphasise need for new measurement particularly at high energies/T relevant for CCSN



Discrepancies between Koehler et al. PRC 56, 1138 (1997) and GELINA measurements of $^{26}Al(n,\alpha)^{23}Na$, L de Smet et al., PRC 76, 045804 (2007)



• Successful test run at n_TOF EAR-1 using double-sided silicon strip detector investigating the $^{6}Li + n \rightarrow \alpha + t$ reaction

• Successful test run at n_TOF EAR-1 using double-sided silicon strip detector investigating the $^{6}Li + n \rightarrow \alpha + t$ reaction

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

Destruction of the cosmic γ-ray emitter ^{26}Al by neutron induced reactions

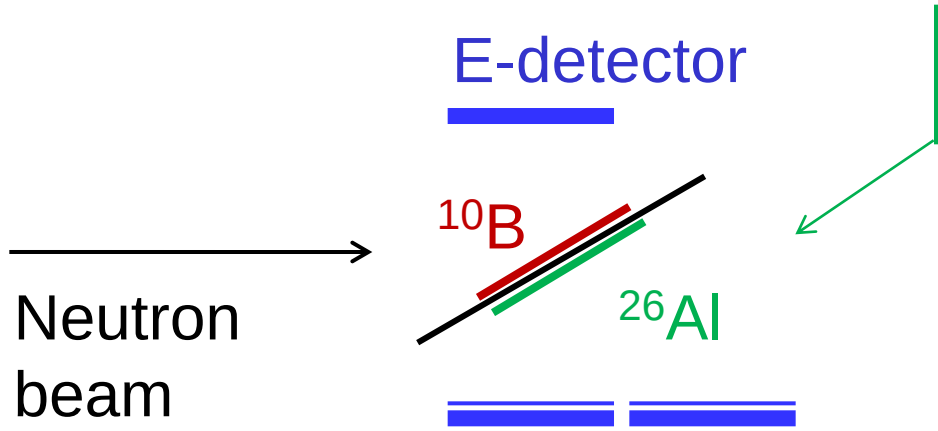
P.J. Woods[1] , C. Lederer[2] , F.Käppeler[3], E. Berthoumieux[4] , E. Chiaveri[4] , N. Colonna[5] , T. Davinson[1], C. Guerrero[4] , F. Gunsing[6] , J. Heyse[7] , G. Lotay[1] , C. Massimi[8] , W. Mondelaers[7] , R. Reifarth[9] , P. Schillebeeckx[7] , G. Tagliente[5] , C. Wagemans[10] , A. Wallner[3,11] , C. Weiss[4] , and the n TOF Collaboration

• Letter of intent to measure $^{26}Al(n,p)/(n,\alpha)$ at EAR-1 during 1 year parasitically (1.6E19 protons) – ACCEPTED by INTC

• **included in science case for EAR-2**

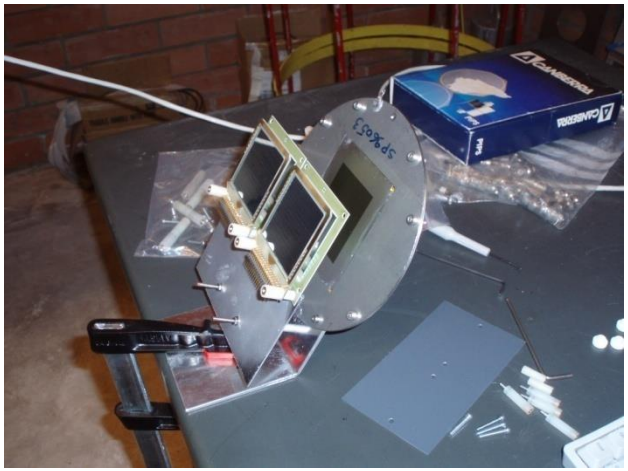
Edinburgh DSSD Setup at GELINA (8 m station)

T. Davinson, A. Estrade, J. Heyse, C. Lederer, P. Schillebeeckxs, P.J. Woods



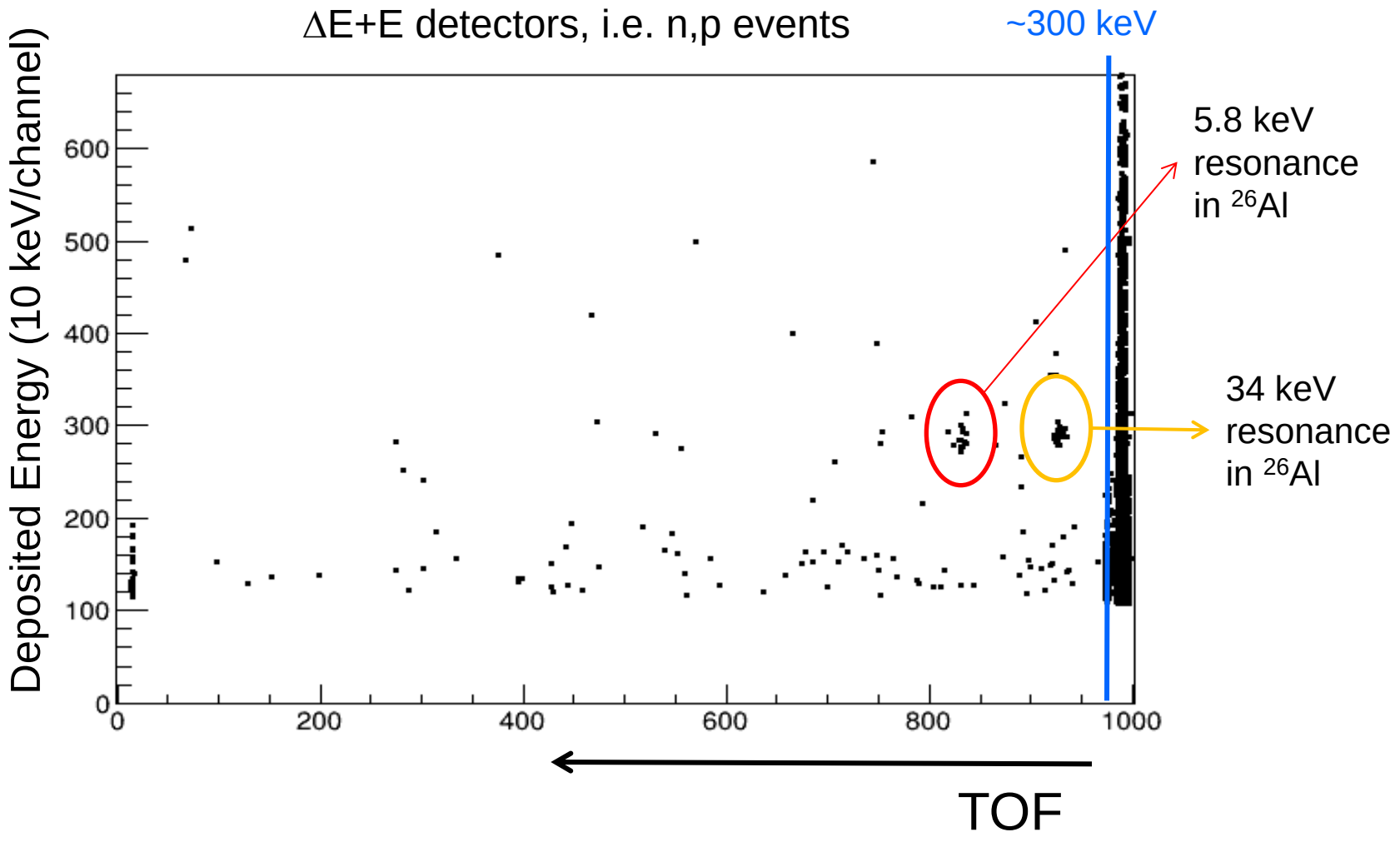
Worlds most enriched ^{26}Al target owned by IRMM

ΔE: 20μm,
E: 400 μm
5x5 cm area



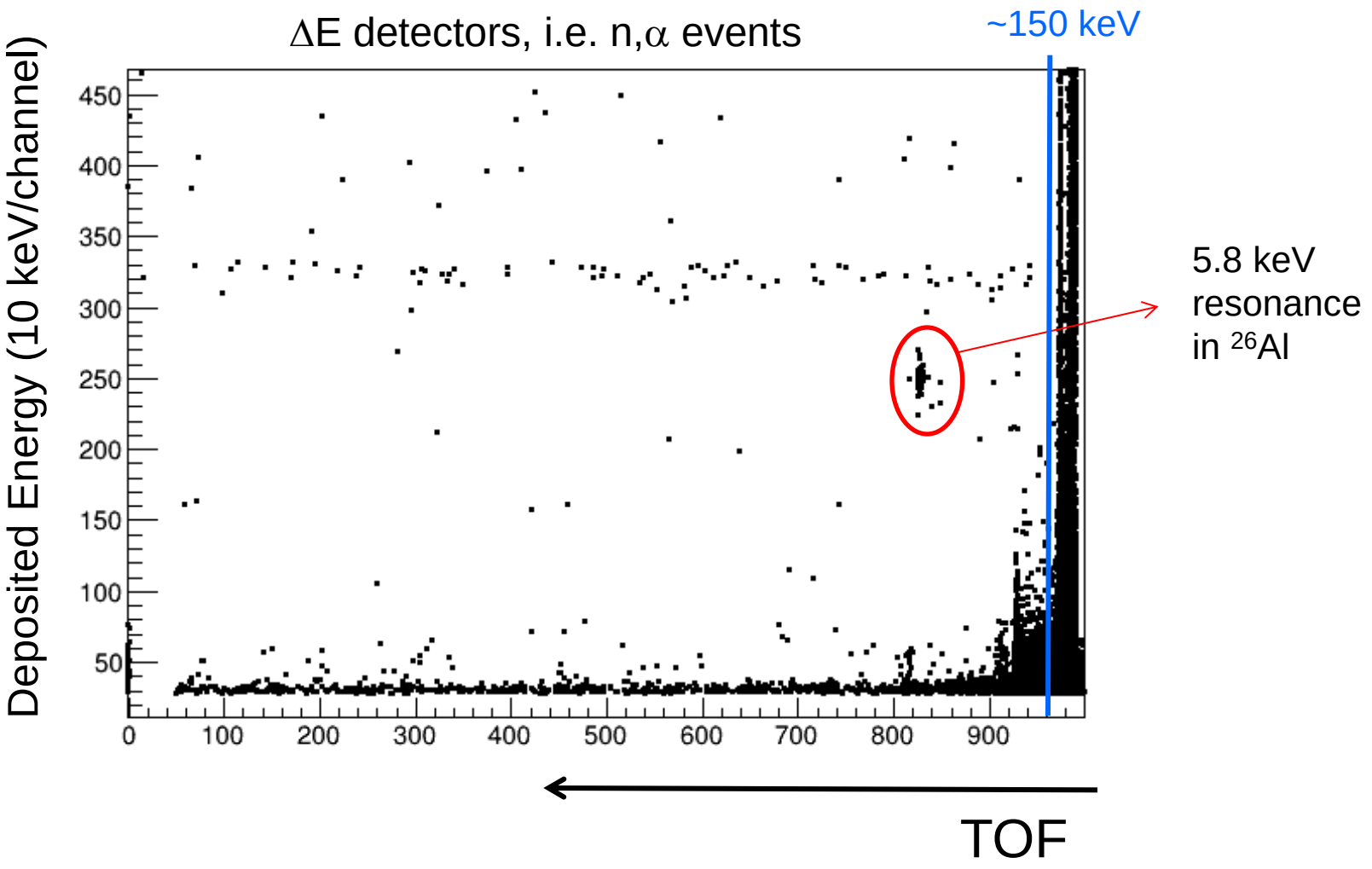
Detector performance

- Data from ^{26}Al run at GELINA/IRMM @ 8 m (15 May-7 June)

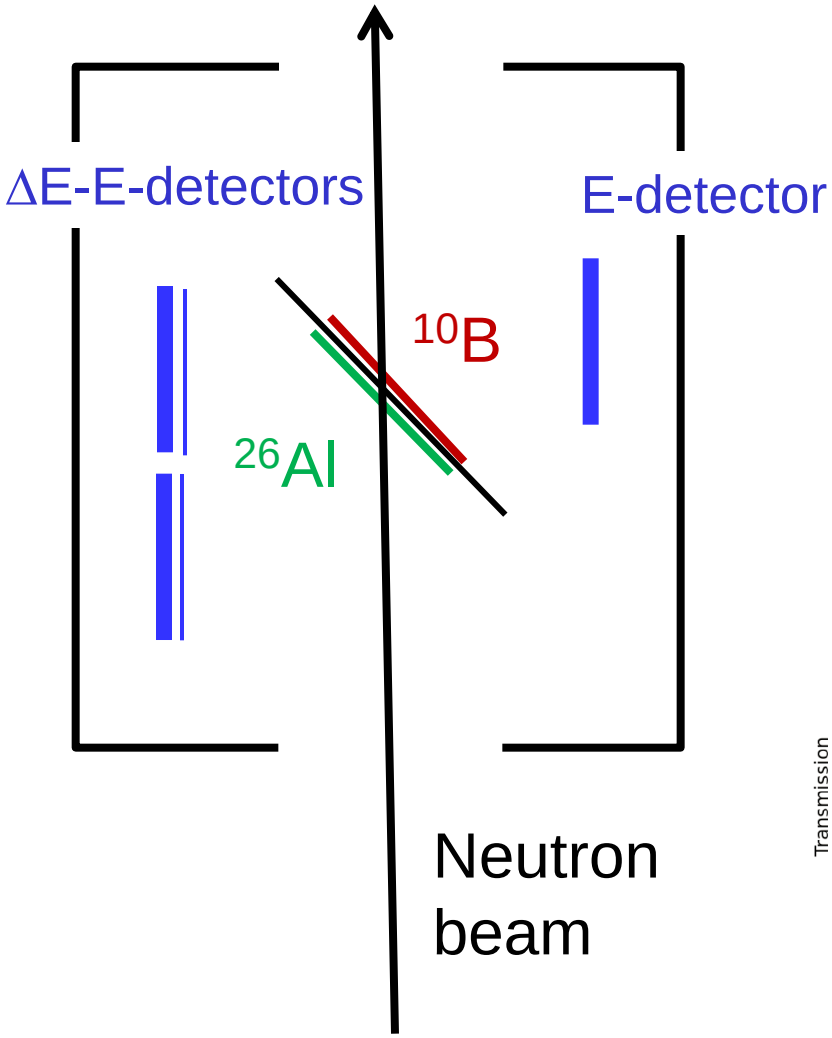


Detector performance

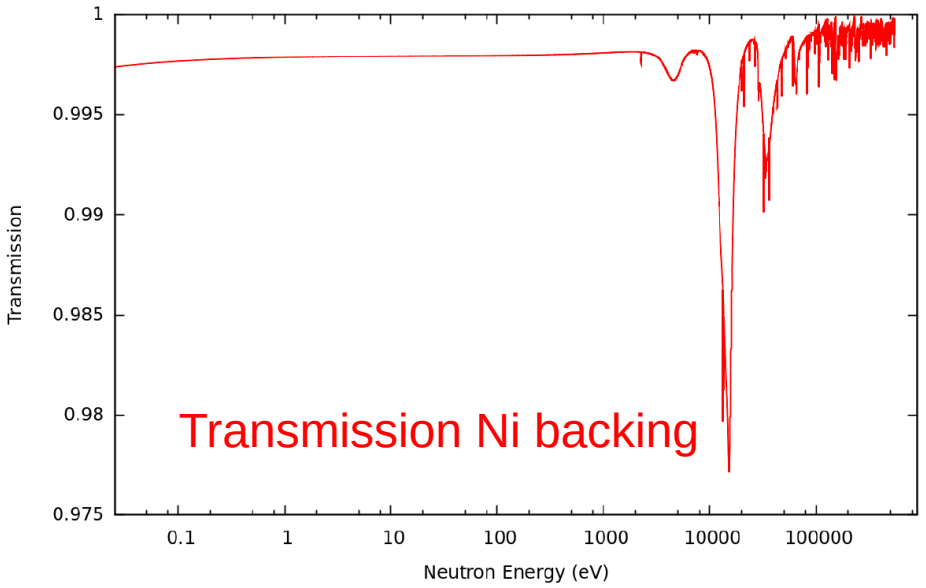
- Data from ^{26}Al run at GELINA/IRMM @ 8 m (15 May-7 June)



Proposed Experimental Setup for EAR-2



- construction of a vertical chamber
- particle identification via ΔE-E telescope
- neutron monitor ^{10}B or ^{7}Li
- normalization of cross section rel. to standard cross section (e.g. ^{10}B)
- possible to run in parallel with other measurements (e.g fission)



Count rate estimations

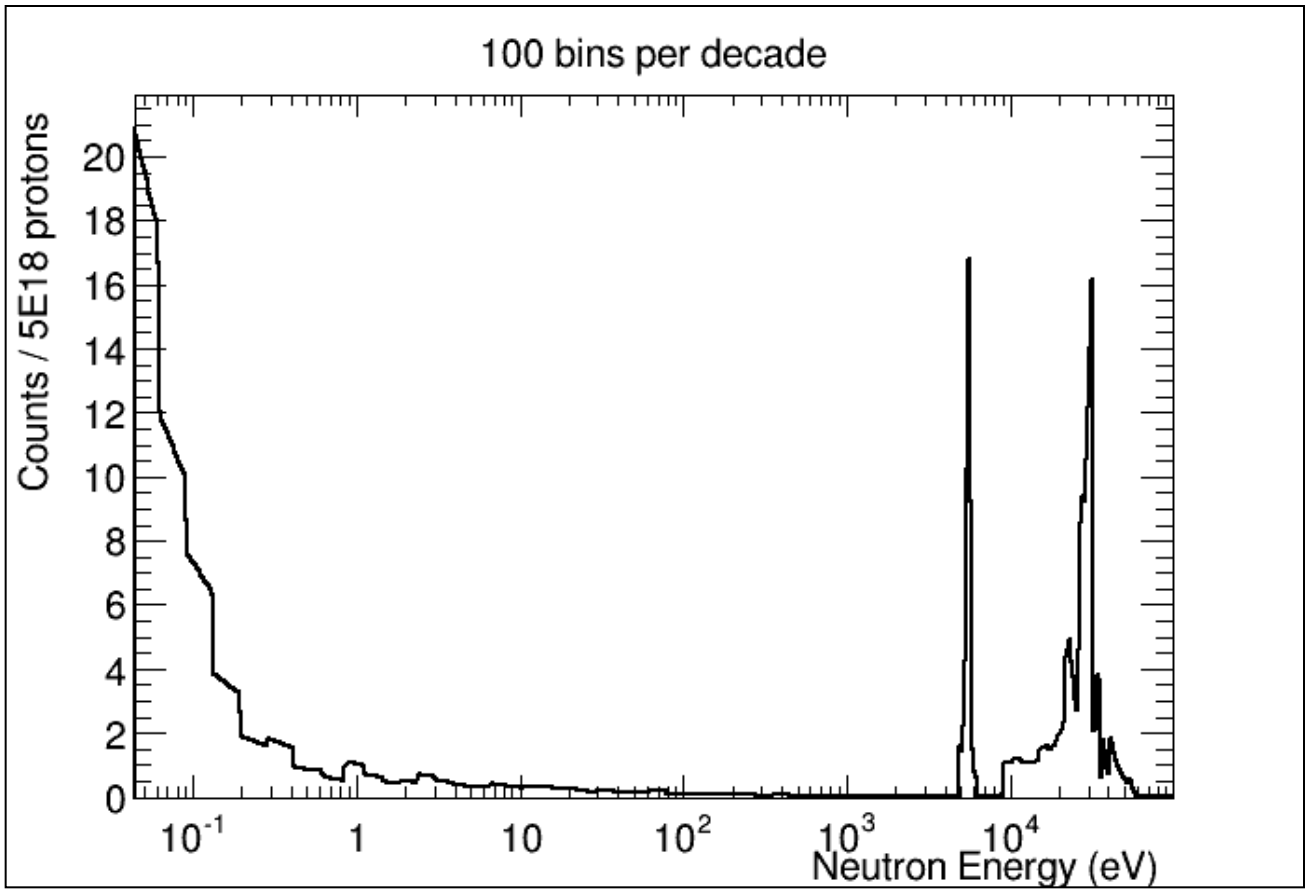
Assumptions:

- ^{26}Al target (IRMM/Geel): 2.6E17 atoms
- size: 5x6 cm2
- target tilted by 40 degrees: areal density increases by 1.3
- simulated flux EAR-2 covers whole sample
- solid angle coverage 20%

Counts in resonance per 5E18 protons:

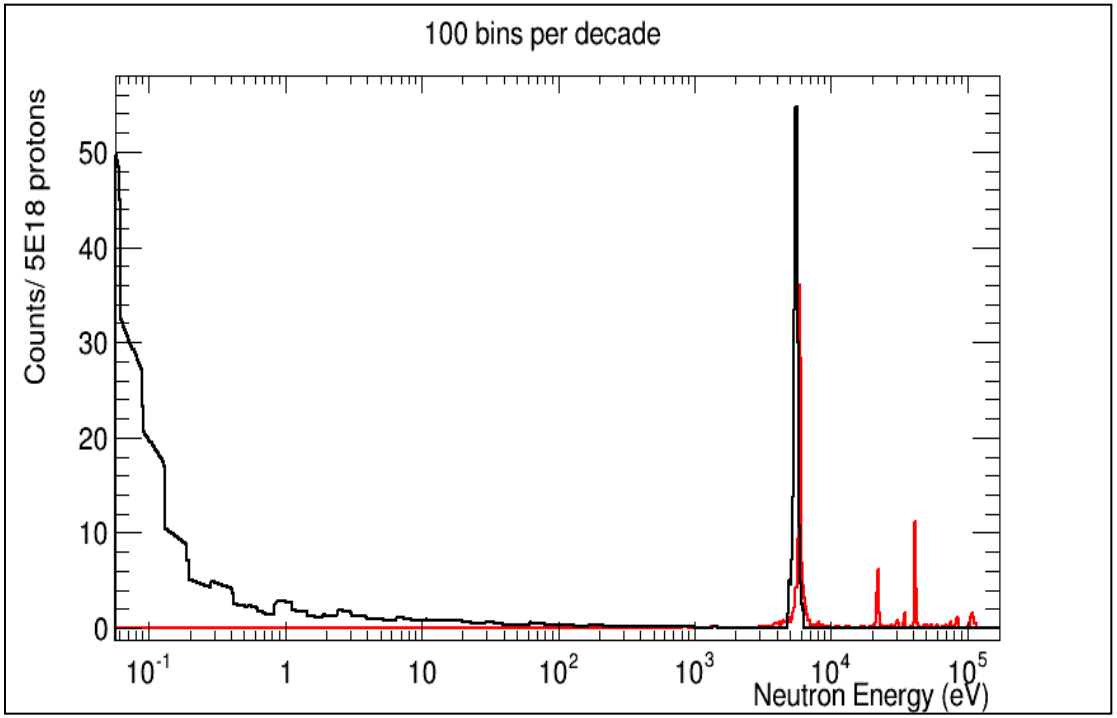
(n,p) channel: ~50 counts at 5.8 keV (EAR-1: ~5 counts)
~70 counts at 34 keV (EAR-1: ~12 counts)

Data from:
Koehler et al



Counts in resonance per 5E18 protons:

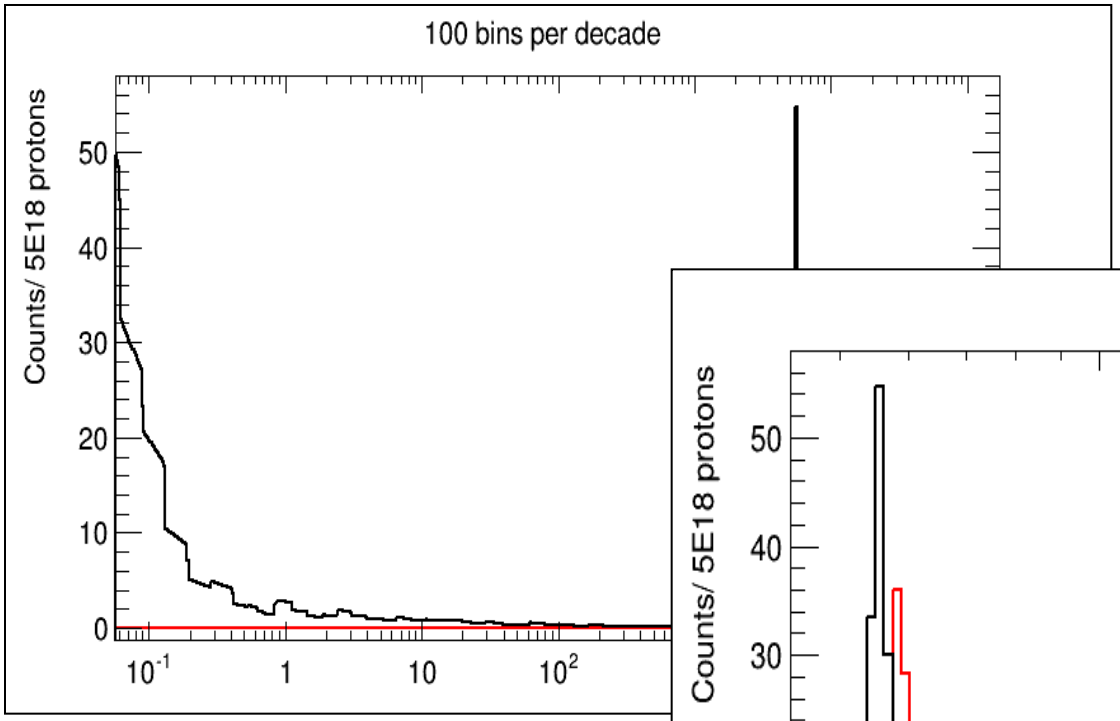
(n,a) channel: ~110 counts at 5.8 keV (EAR-1: ~16 counts)
~7 counts at 34 keV (EAR-1: ~0 counts)



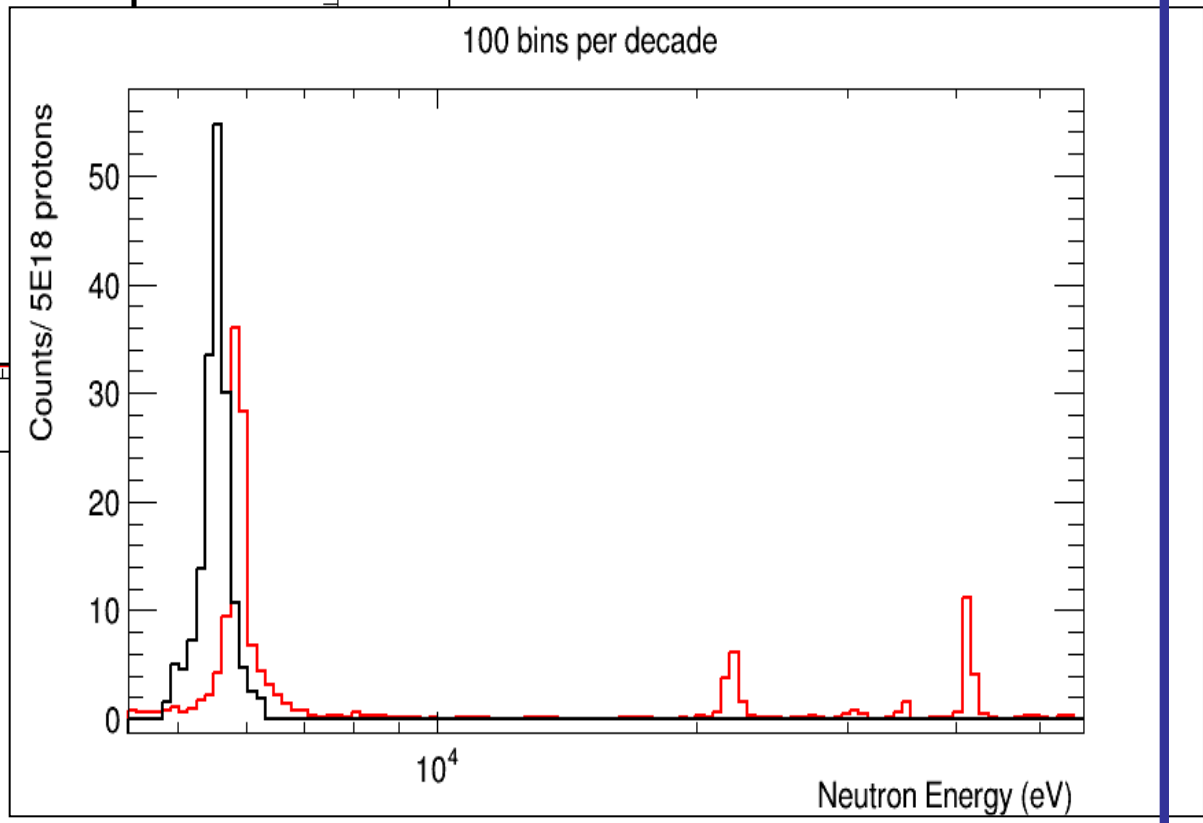
Data from:
Koehler et al
De Smet et al

Counts in resonance per 5E18 protons:

(n,a) channel: ~110 counts at 5.8 keV (EAR-1: ~16 counts)
~7 counts at 34 keV (EAR-1: ~0 counts)



Data from:
Koehler et al
De Smet et al



Summary

- neutron induced reaction rates on ^{26}Al represent critical uncertainty for ^{26}Al abundances in the interstellar medium
- planned to make new measurements of (n,p) and (n,α) reaction cross sections
- propose construction of a vertical chamber and DSSD setup for EAR-2 – based on successful system implemented at Geel
- system will be designed to run in parallel with other measurements since samples are very thin
- setup could be used for other (n,cp) measurements at n_TOF, e.g. ^{7}Be(n,p)
- proposal will be submitted to INTC for February 2014 meeting