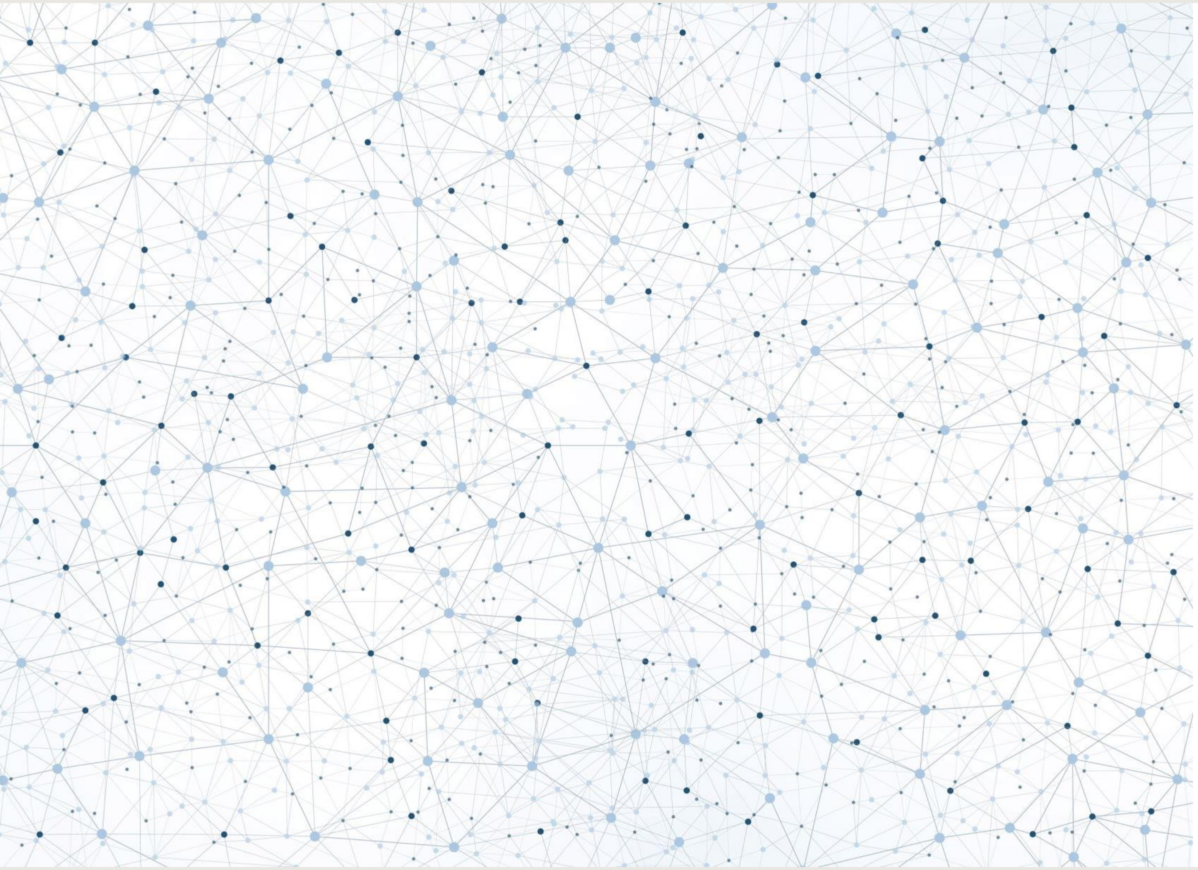
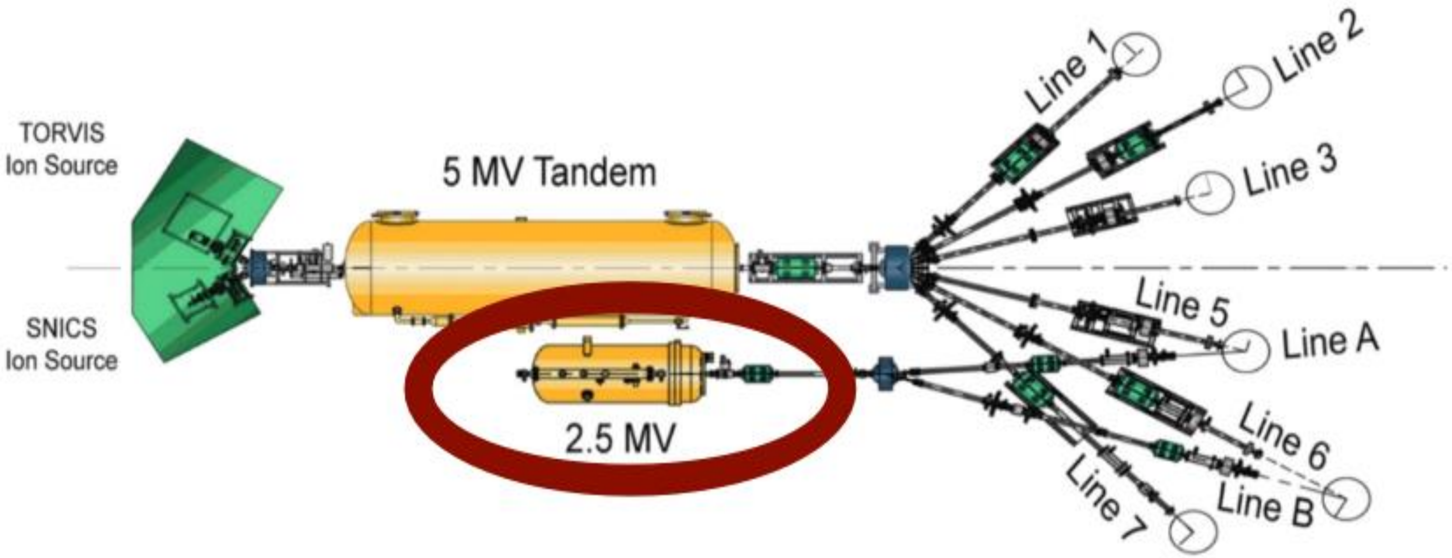


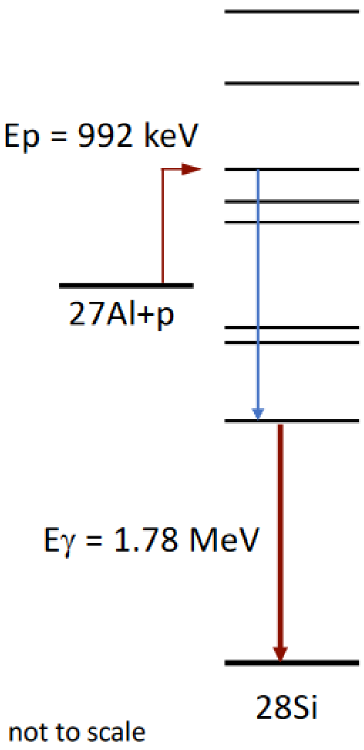
Energy calibration at Dalton Cumbria Facility

ENERGY CALIBRATION OF A 2.5MV PELLETRON AT DCF



- Energy calibration of the 2.5 MV pelletron
- Yield measurement of resonance strengths in $^{27}Al(p,\gamma)^{28}Si$ due to the well-known strength values
- Proton beam onto a ^{27}Al target and a NaI γ -ray detector

Resonances in $^{27}Al(p, \gamma)^{28}Si$

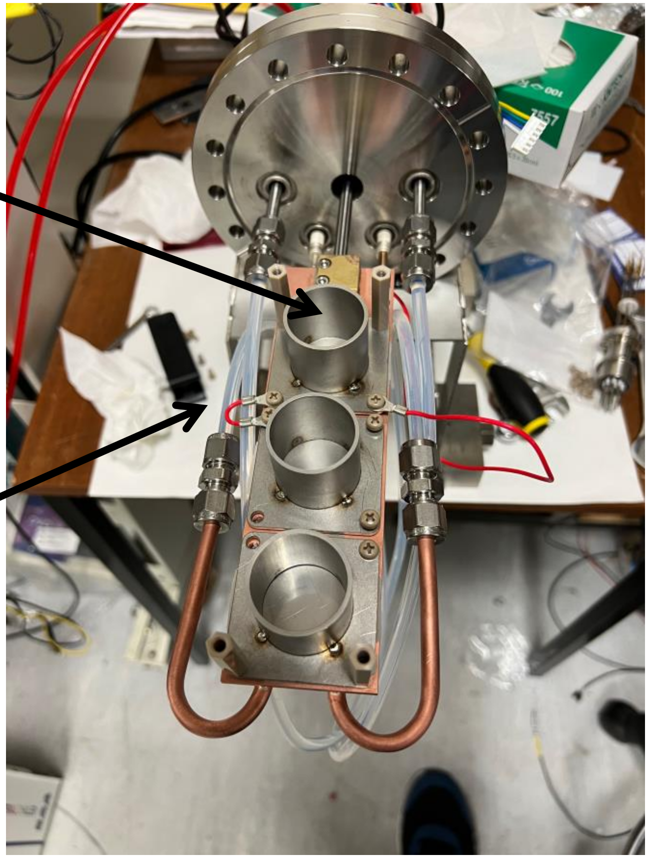


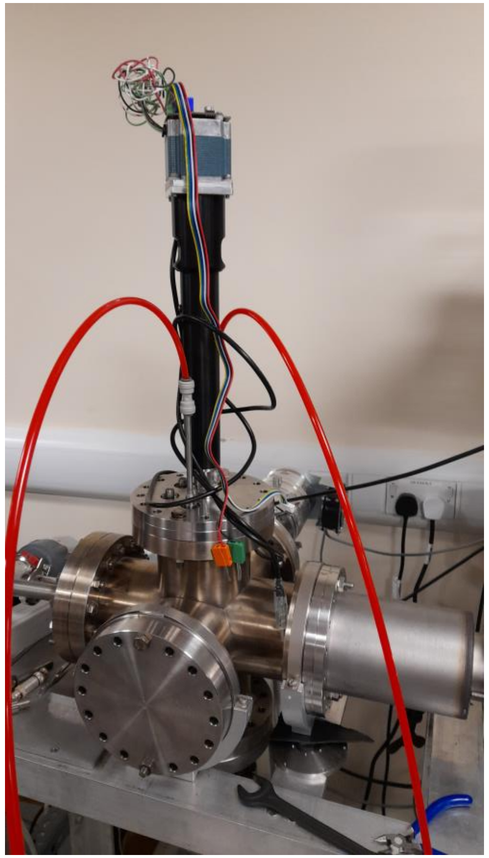
E_p	Γ
632.23 ± 0.04 keV	6.7 ± 0.5 eV
991.86 ± 0.017 keV	70 ± 10 eV
1213.08 ± 0.06 keV	< 100 eV
1587.49 ± 0.08 keV	< 200 eV
1799.75 ± 0.09 keV	450 ± 60 eV

Experimental set up

Aluminium target

Water cooling





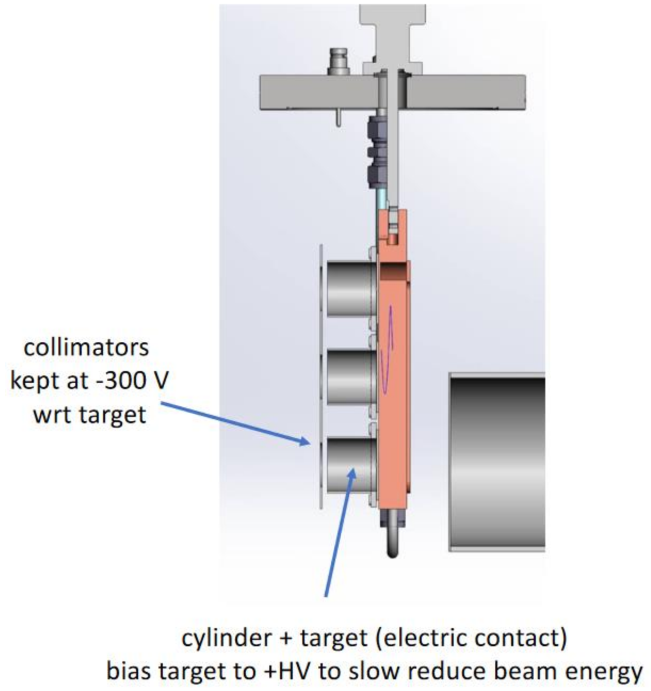
Actuator

NaI detector

Experimental method

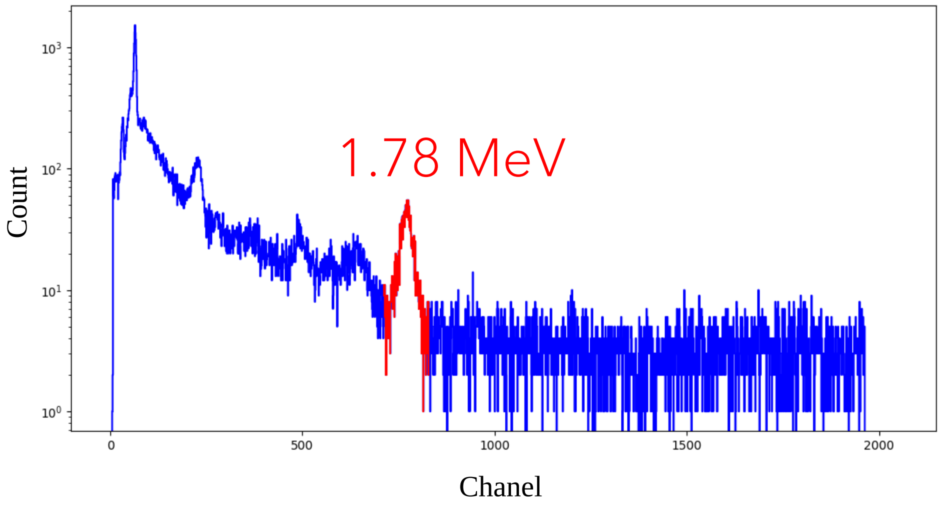
Instead of changing the proton beam parameters a bias voltage was applied to scan through the resonance range.

- Initiate the beam with nominal energy
- Set up a bias between the target and collimator by 300 V for electron suppression
- Beam on target to collect a spectrum with a NaI detector
- Save and reset spectrum measurement
- Change the target bias voltage to continue the resonance scan



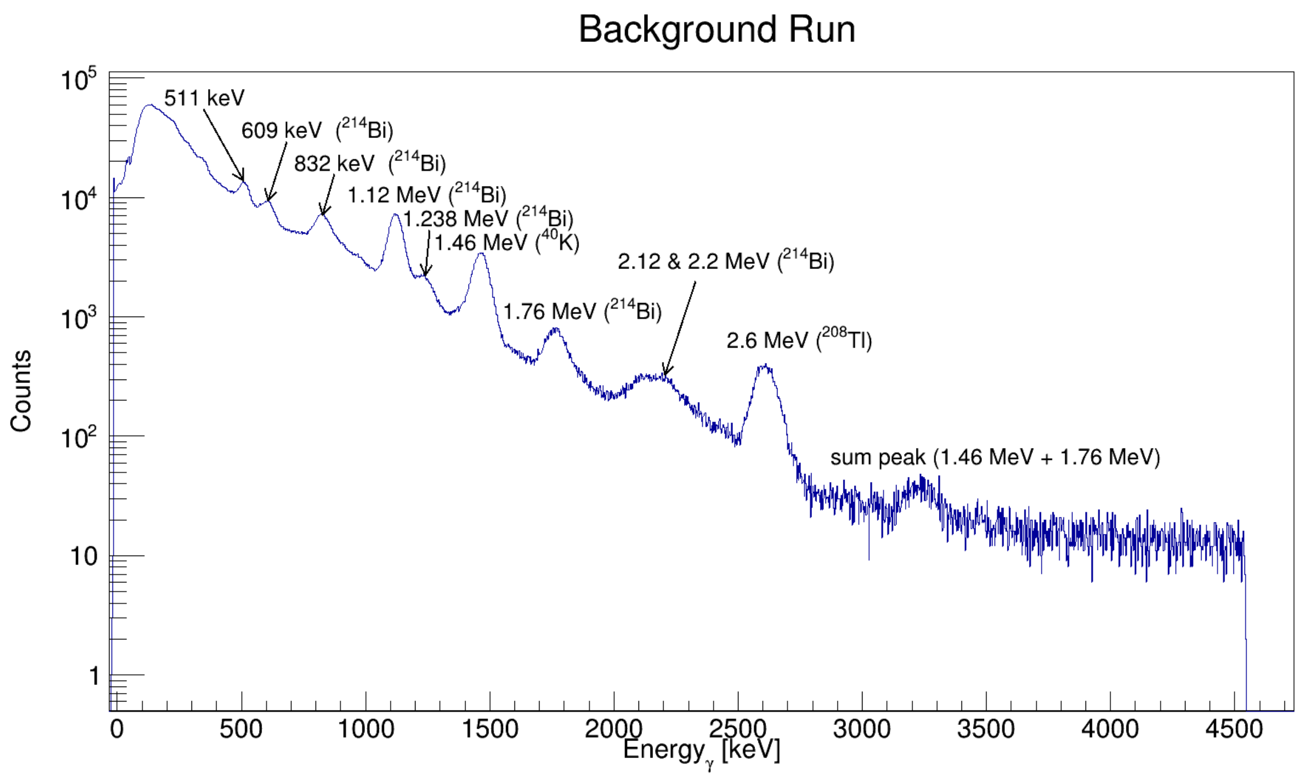
Data fitting

- From the $^{27}Al(p, \gamma)^{28}Si$ reaction we want to measure gamma emission of about 1.78 MeV so an appropriate region of interest has been selected.
- The spectra are saved with the use of Ortec MAESTRO in an ASCII format to allow analysis on raw data.

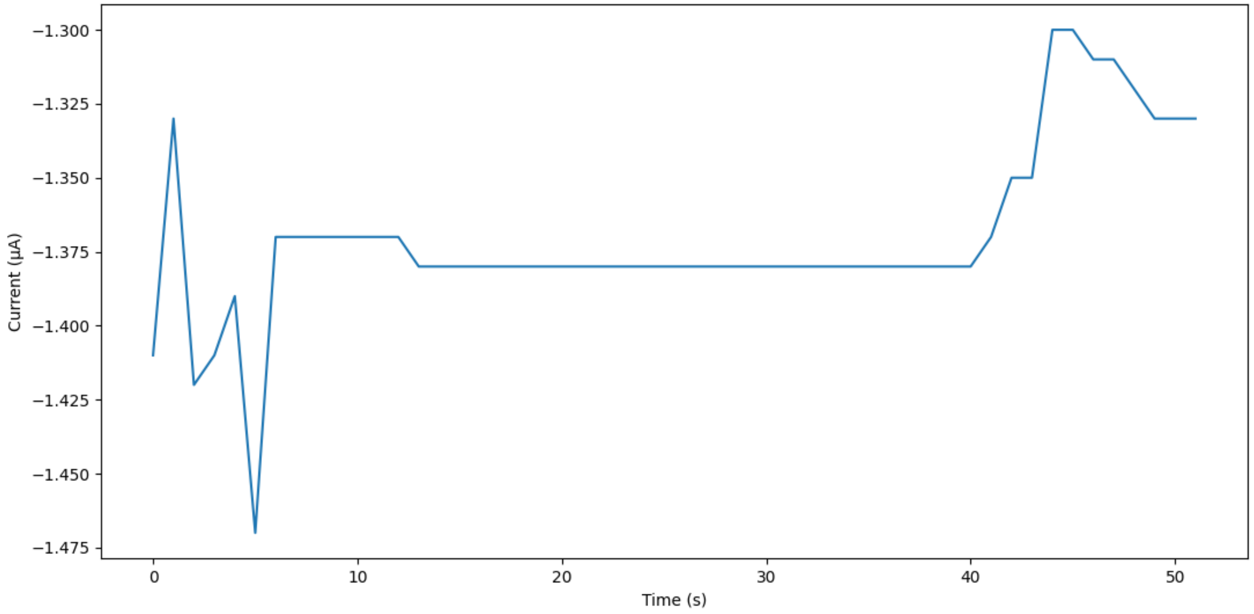


Detector calibration

- The NaI detector was calibrated by correlating common background radiation peaks with the gamma energy.
- Calibration has been performed at DCF before the first experimental run.



Yield calculation



- Due to unstable current output the current values have been integrated.

- A Gaussian and a first-degree polynomial is used to find the area under the emission peak.

Fitting functions

Gaussian function

- Straggling fit function

$$Y = \mathrm{k} \int dE_i \int_{E_p - \Delta E}^{E_p} F(E_i, E, \sigma_{\mathrm{tot}}) \sigma_{\mathrm{BW}}(E, E_{\mathrm{res}}, \Gamma) dE$$

Breit-Wigner cross section

- Step function fit

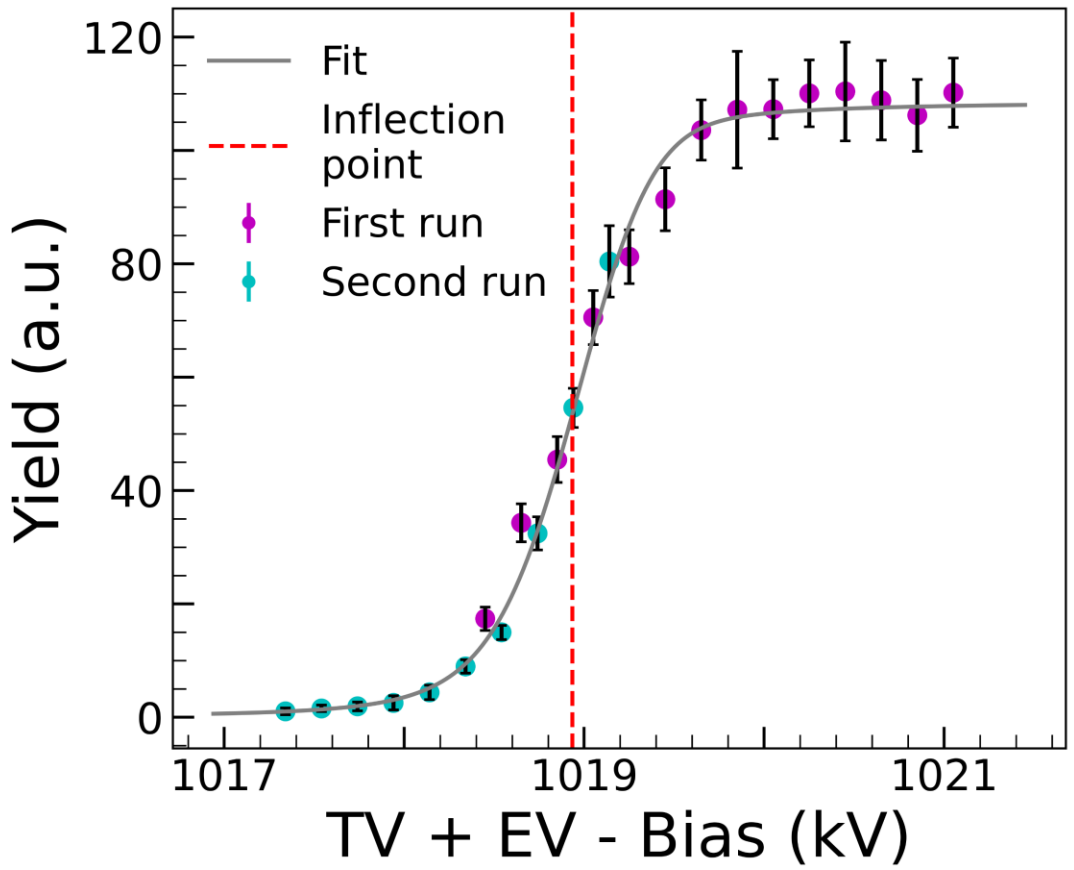
$$Y = S \tan^{-1}(\mathrm{W}(\mathrm{E} + \mathrm{C})) + \mathrm{D}$$

Vertical scale

Width scale

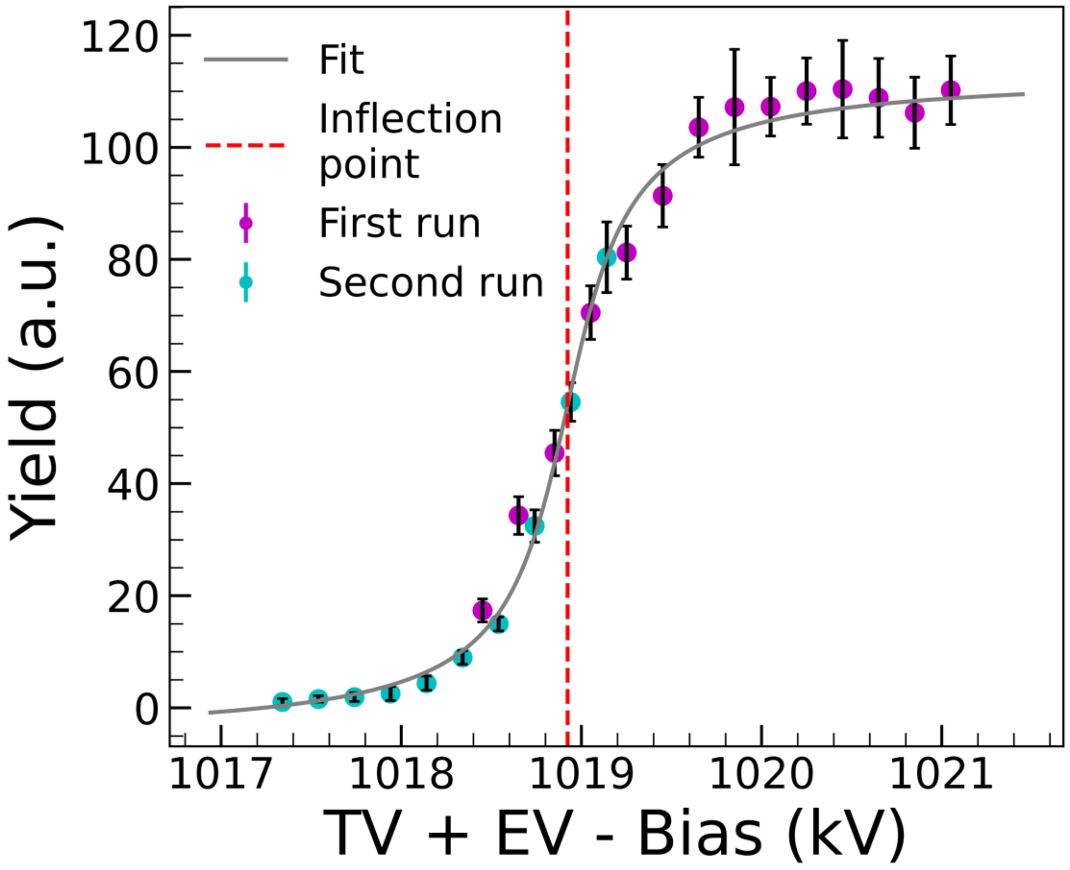
$^{27}Al(p, \gamma)$ at 992 keV

Straggling fit



Unscaled $X^2/N = 8.1$
Scaled by 2.7 $X^2/N = 1.1$

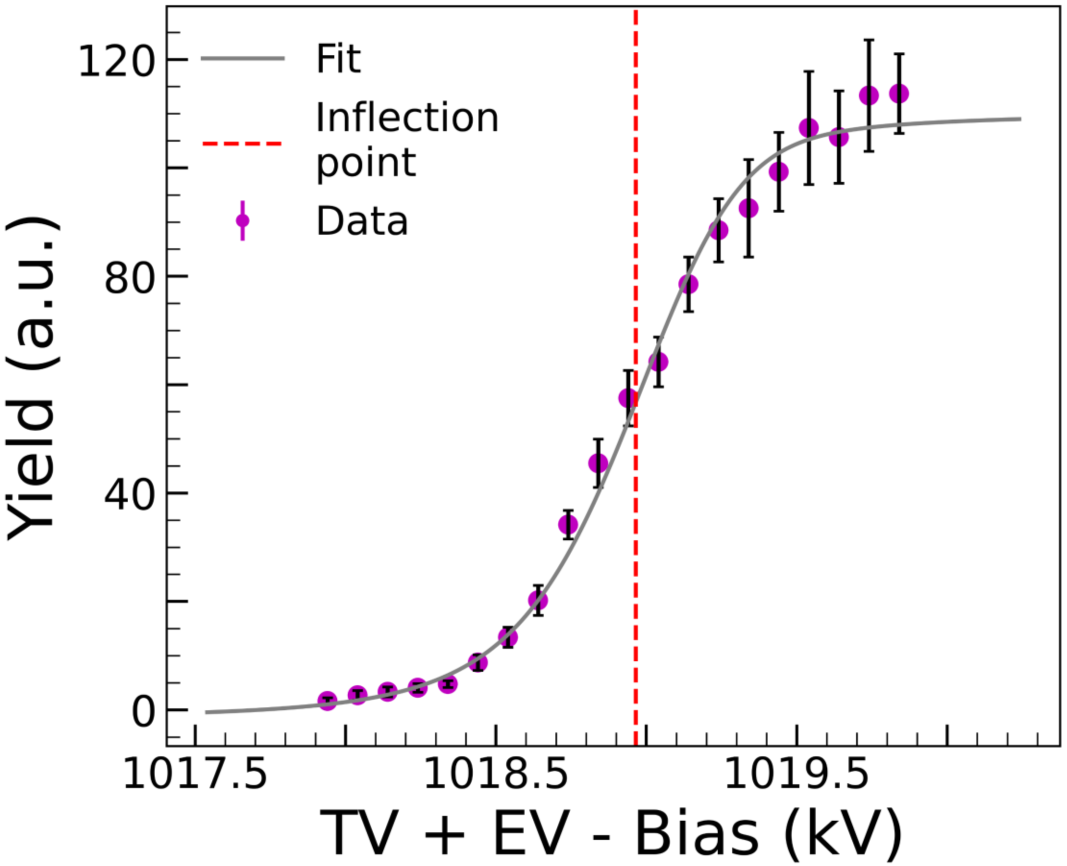
Step function fit



Unscaled $X^2/N = 8.9$
Scaled by 2.7 $X^2/N = 1.2$

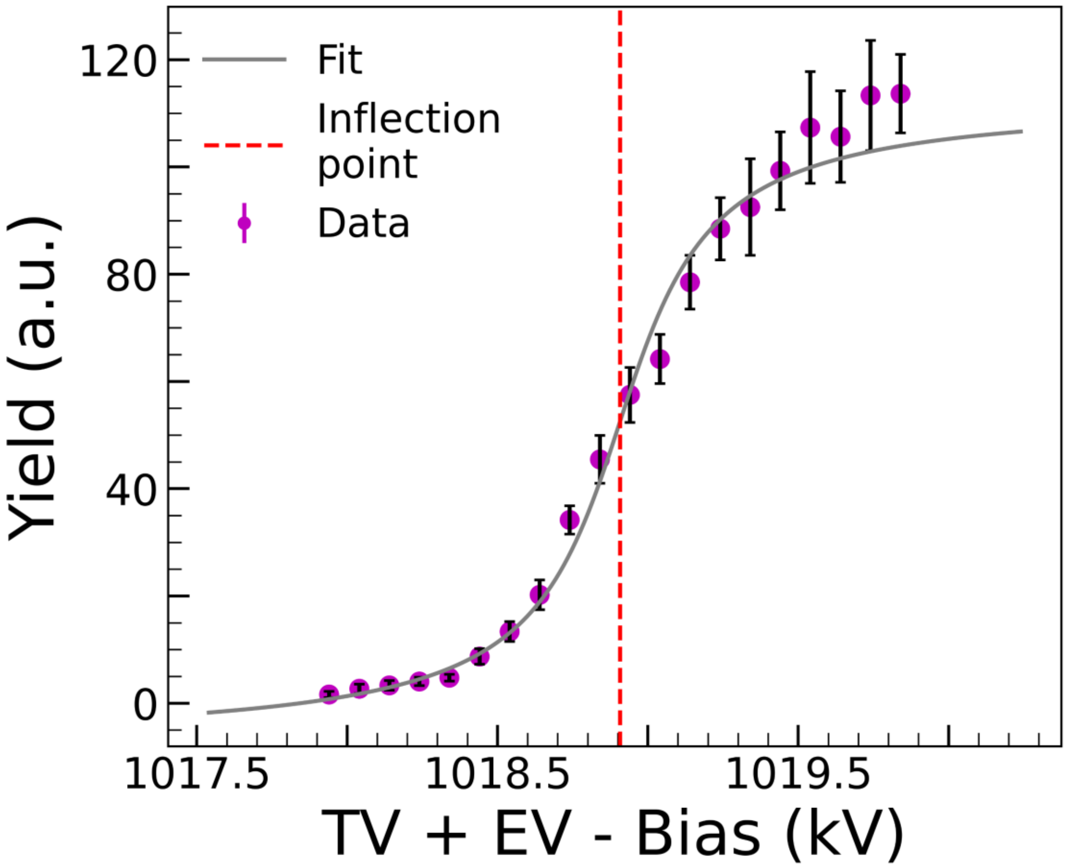
Second measurement at 992 keV

Straggling fit



Unscaled $X^2/N = 8.3$
Scaled by 2.7 $X^2/N = 1.1$

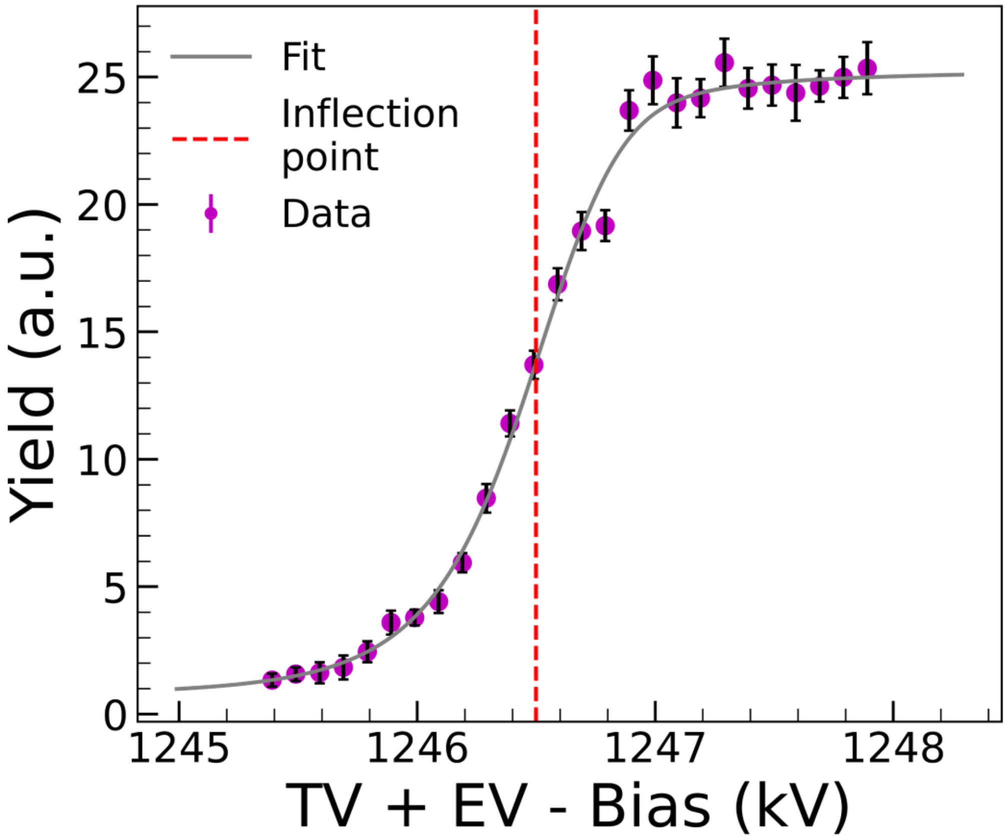
Step function fit



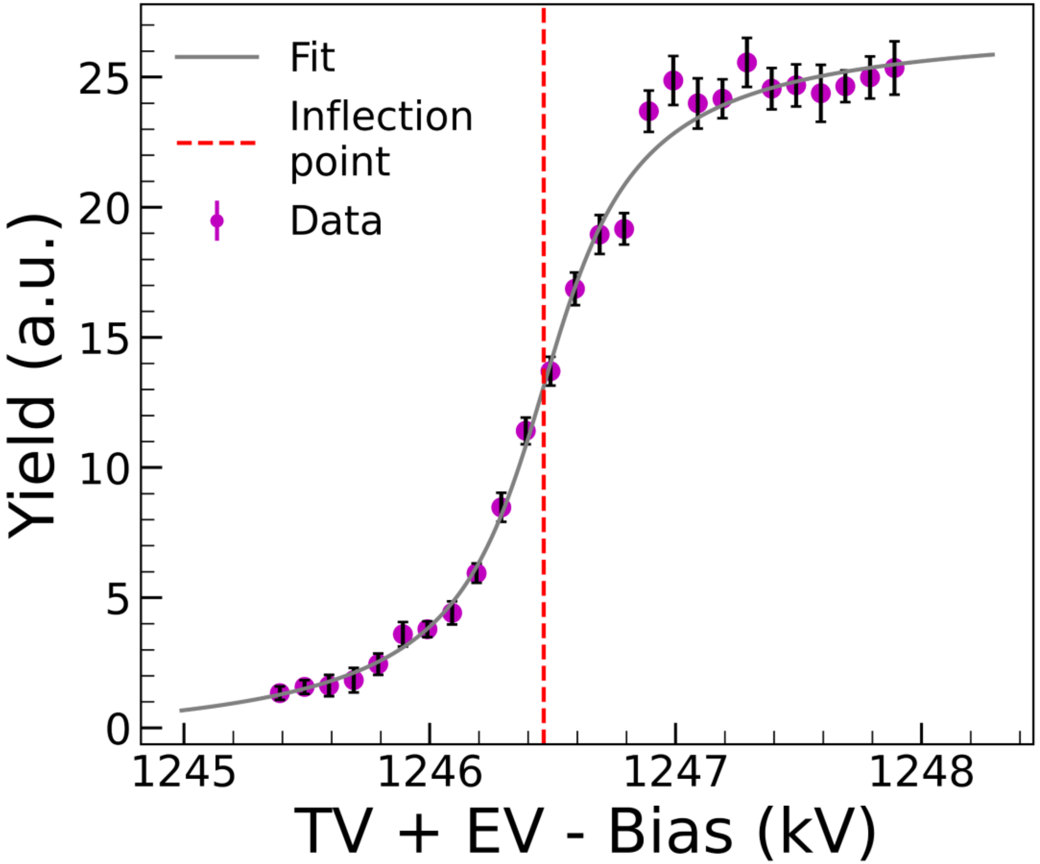
Unscaled $X^2/N = 9.8$
Scaled by 2.7 $X^2/N = 1.3$

$^{27}Al(p, \gamma)$ at 1213 keV

Straggling fit



Step function fit

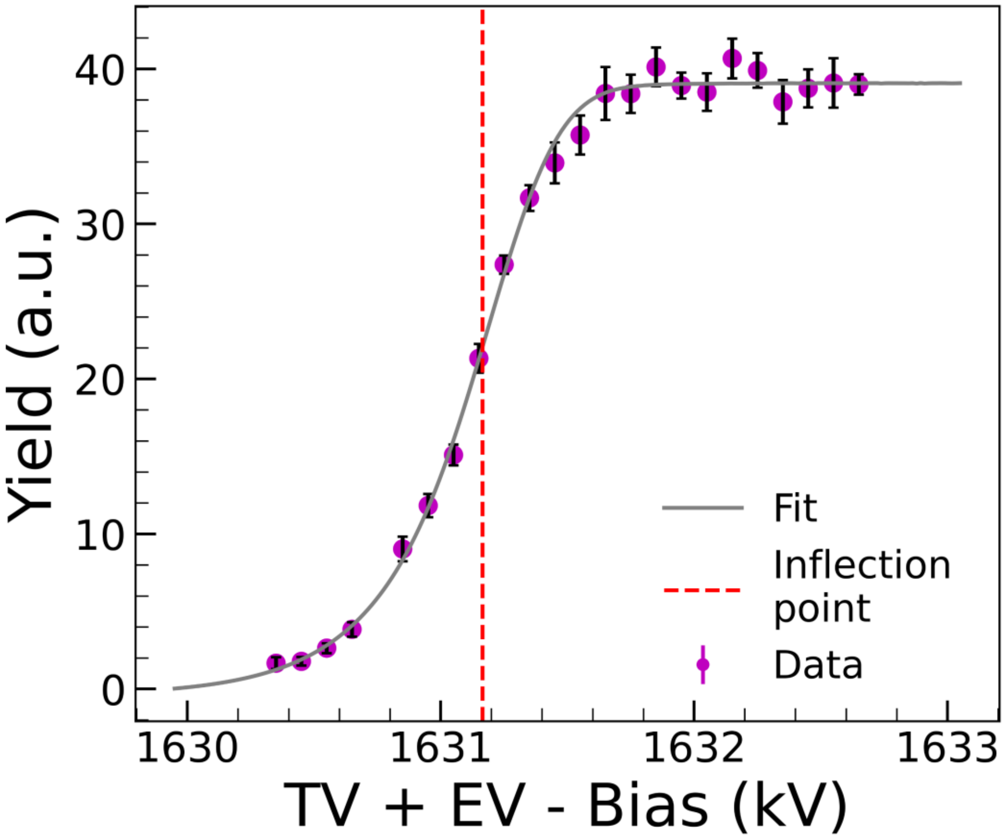


Unscaled $X^2/N = 2.0$
Scaled by 1.4 $X^2/N = 1.0$

Unscaled $X^2/N = 1.9$
Scaled by 1.4 $X^2/N = 1.0$

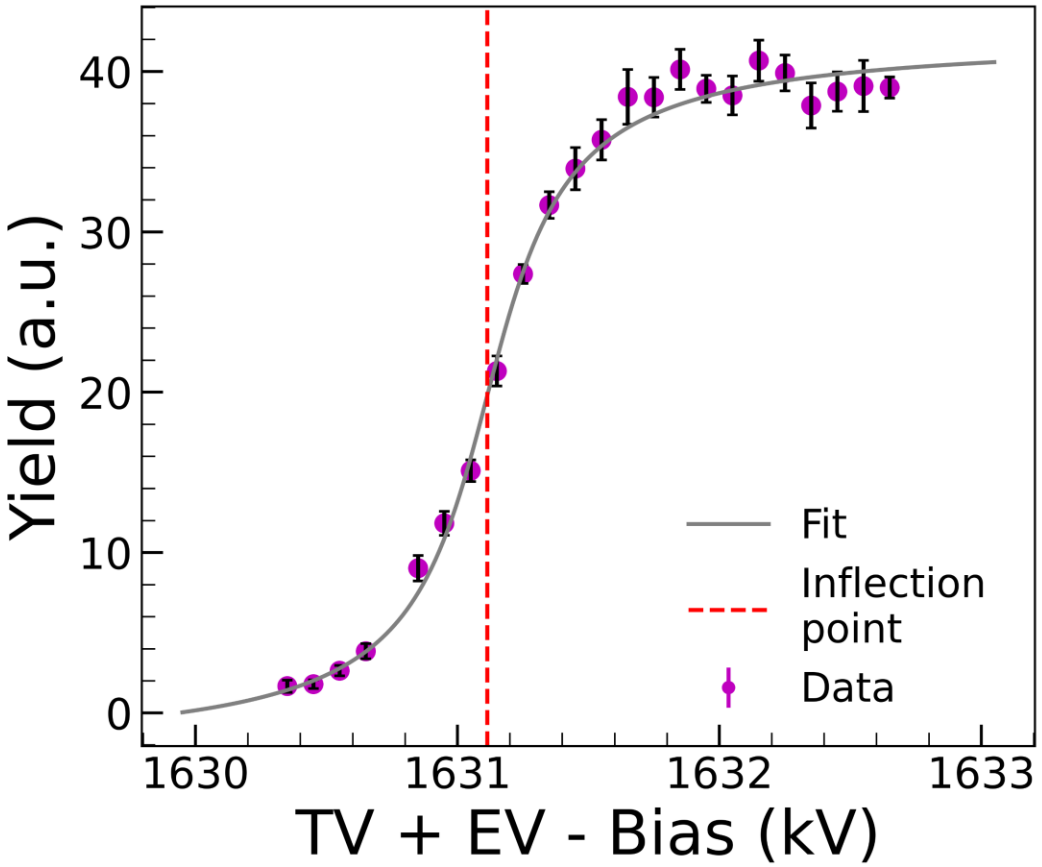
$^{27}Al(p, \gamma)$ at 1587 keV

Straggling fit



Unscaled $X^2/N = 0.7$
Scaled by 1.0 $X^2/N = 0.7$

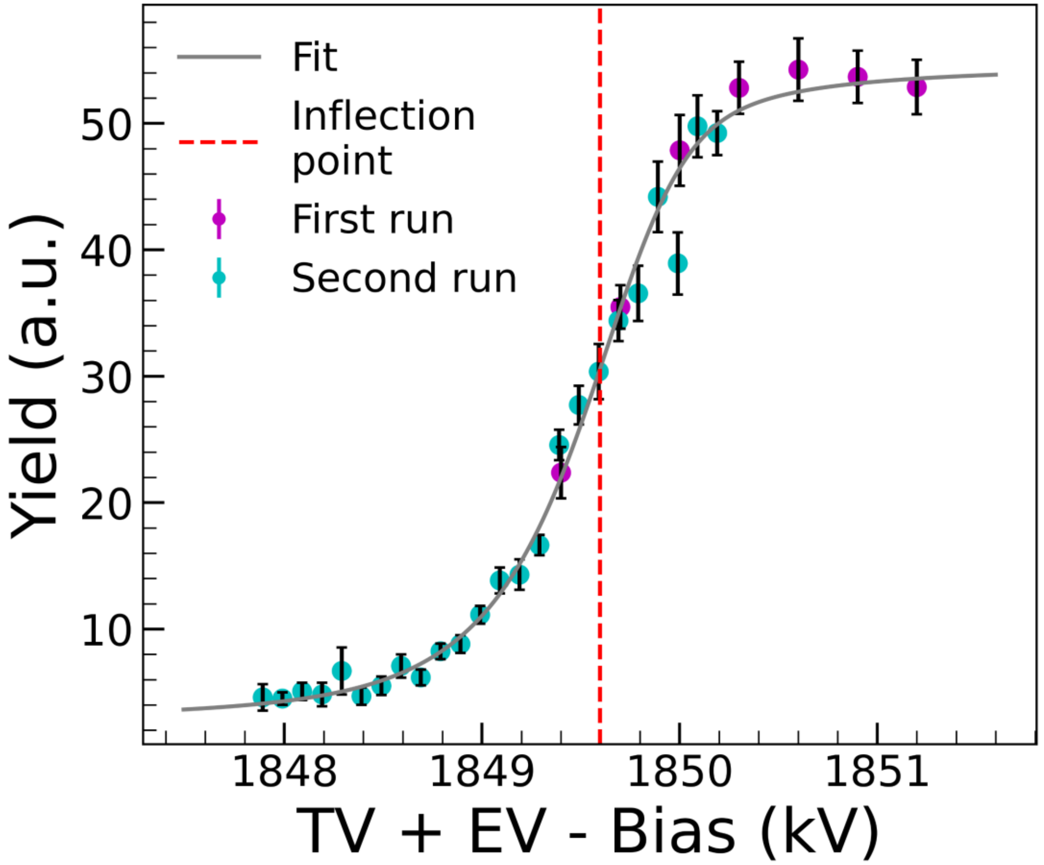
Step function fit



Unscaled $X^2/N = 0.9$
Scaled by 1.0 $X^2/N = 0.9$

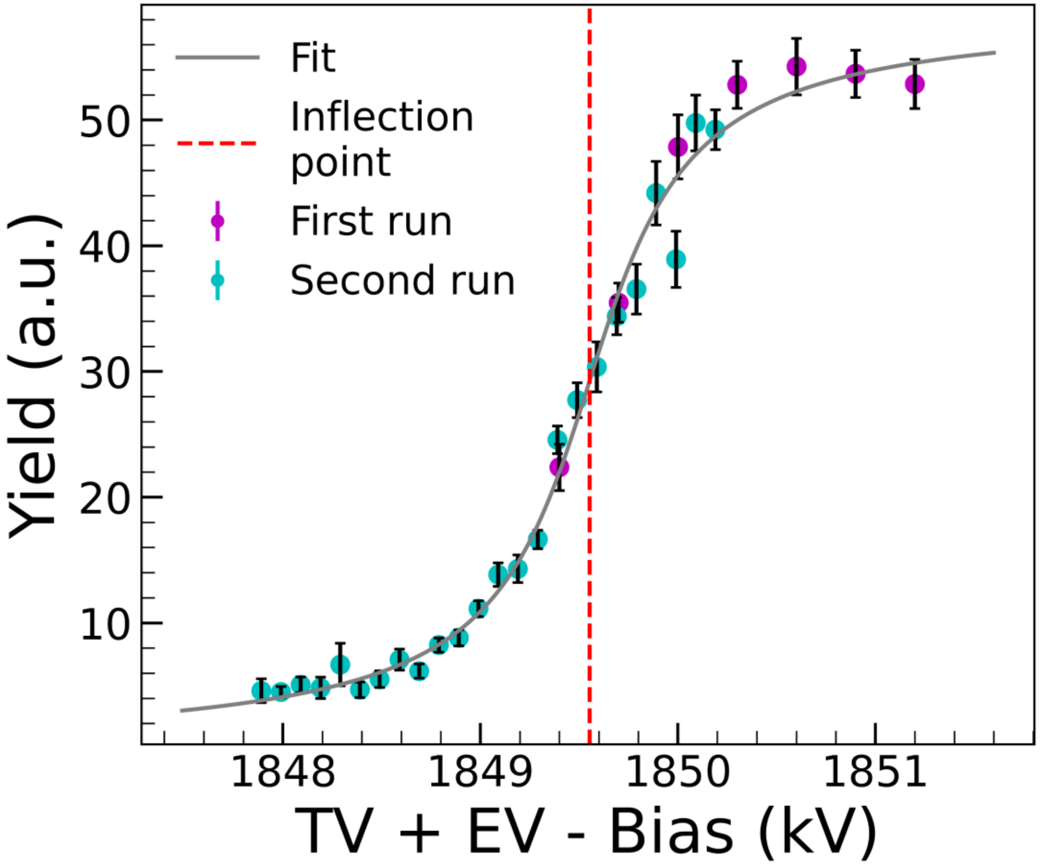
$^{27}Al(p, \gamma)$ at 1799 keV

Straggling fit



Unscaled $X^2/N = 1.5$
Scaled by 1.2 $X^2/N = 1.0$

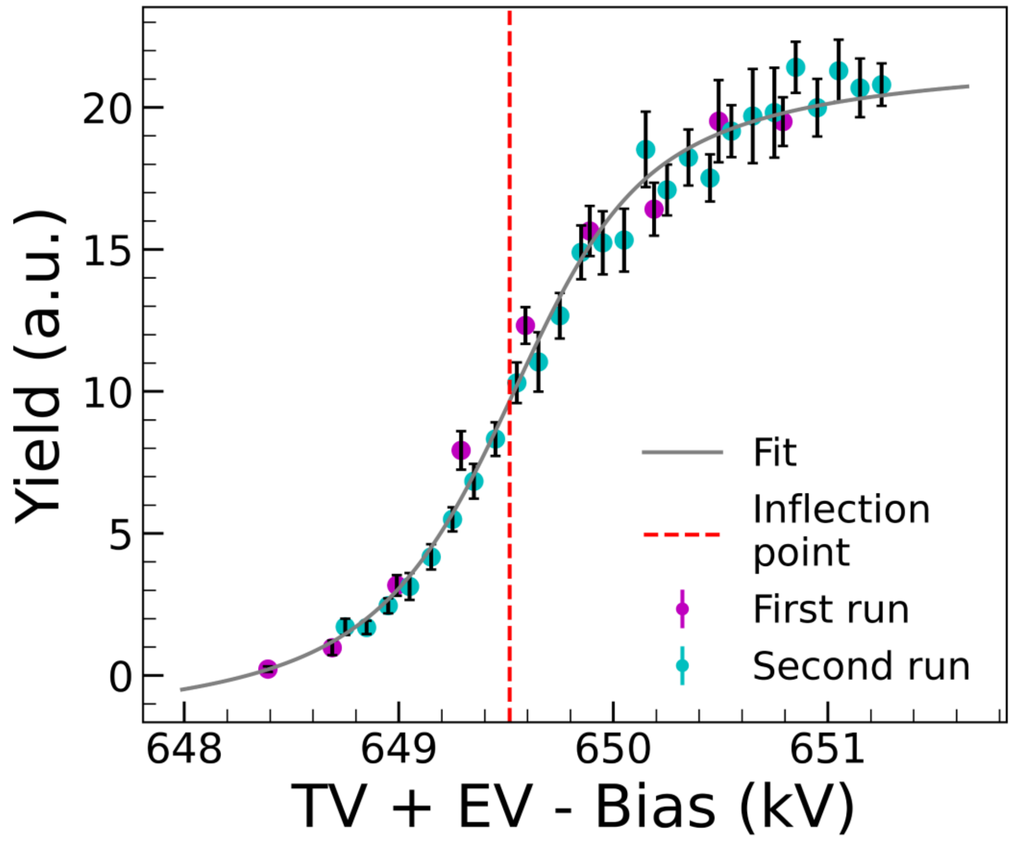
Step function fit



Unscaled $X^2/N = 1.4$
Scaled by 1.2 $X^2/N = 1.0$

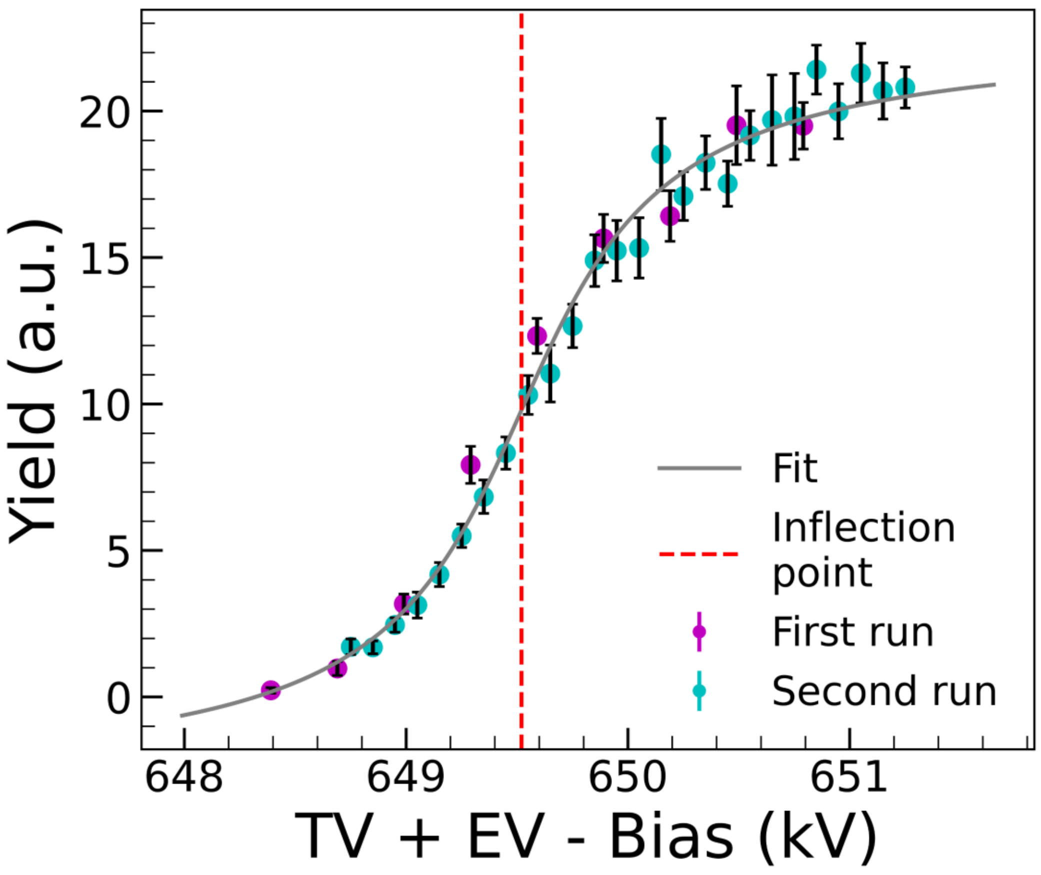
$^{27}Al(p, \gamma)$ at 632 keV

Straggling fit



Unscaled $X^2/N = 2.0$
Scaled by 1.3 $X^2/N = 1.2$

Step function fit



Unscaled $X^2/N = 1.7$
Scaled by 1.3 $X^2/N = 1.0$

Calibration stragg fit

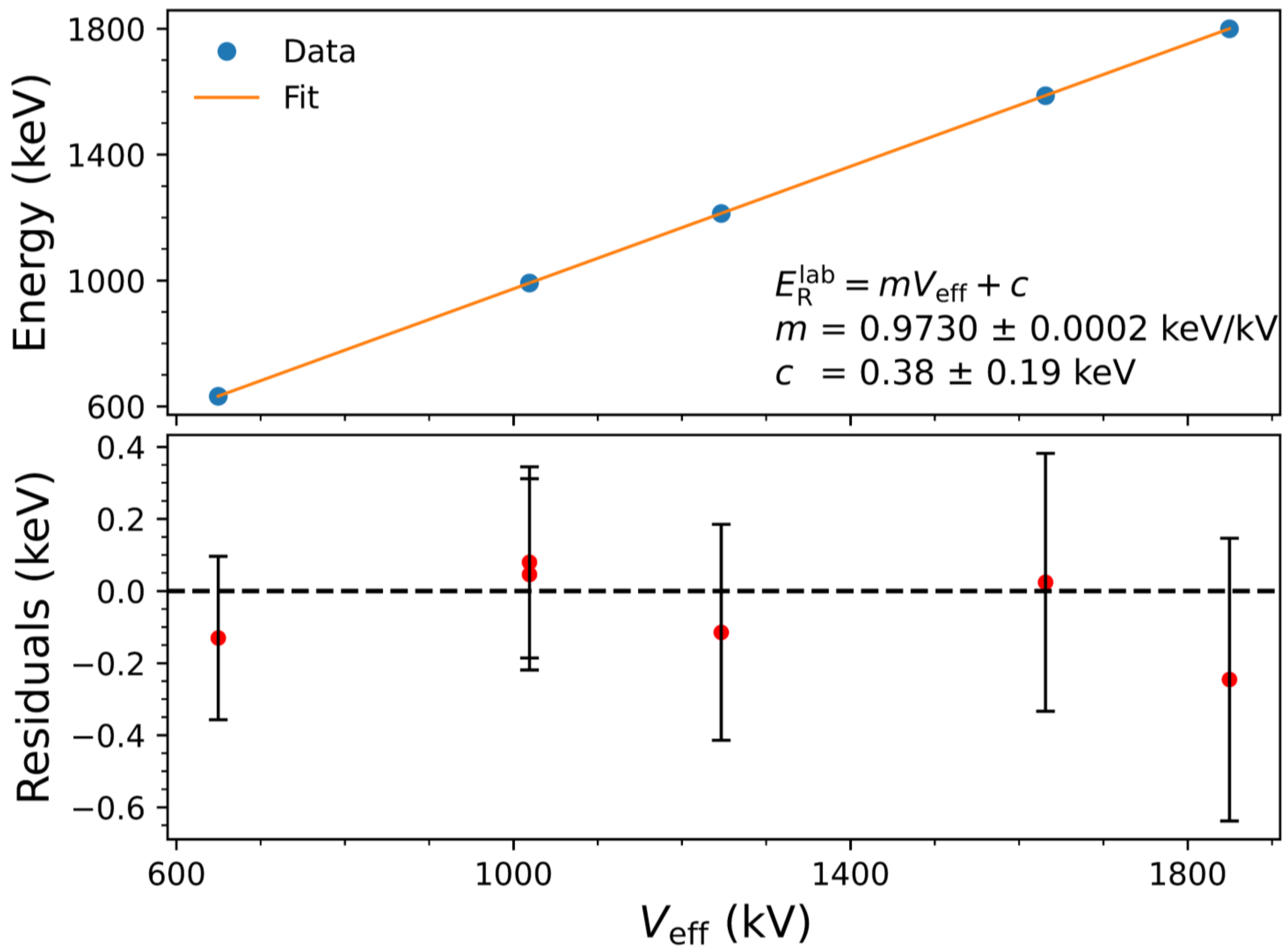
$E = m\,(TV\,[kV] + EV\,[kV]) + c\,[keV]$

TV: Terminal Voltage

EV: Extraction Voltage

$m = 0.9730\ \pm 0.0002\ keV/kV$

$c = 0.38\ \pm 0.19\ keV$



Residual (r)

$r = (Ep - E)\ keV$

Calibration arctan fit

$E = m\,(TV\,[kV] + EV\,[kV]) + c\,[keV]$

TV: Terminal Voltage

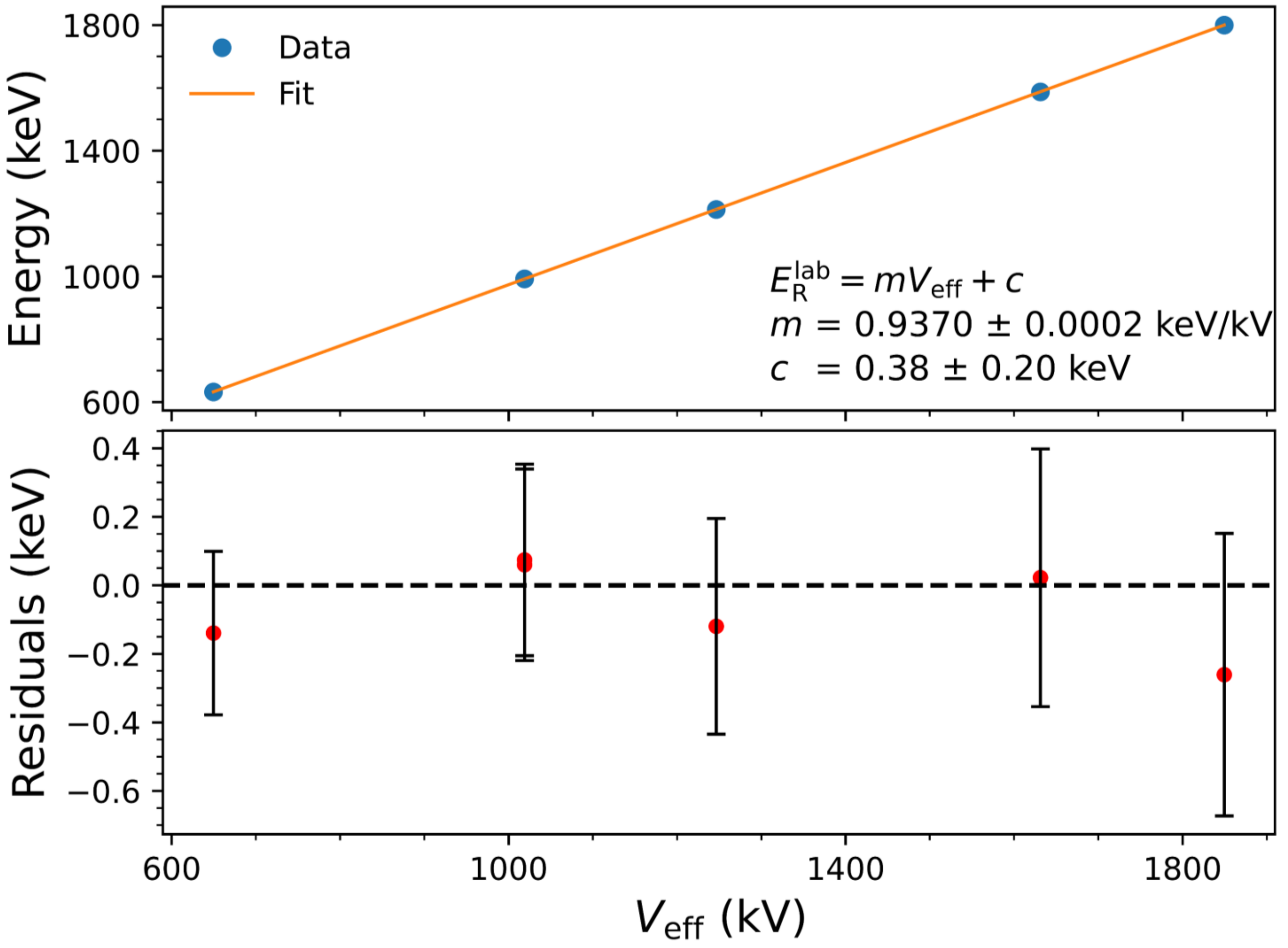
EV: Extraction Voltage

$m = 0.9730 \pm 0.0002$ keV/kV

$c = 0.38 \pm 0.20$ keV

Residual (r)

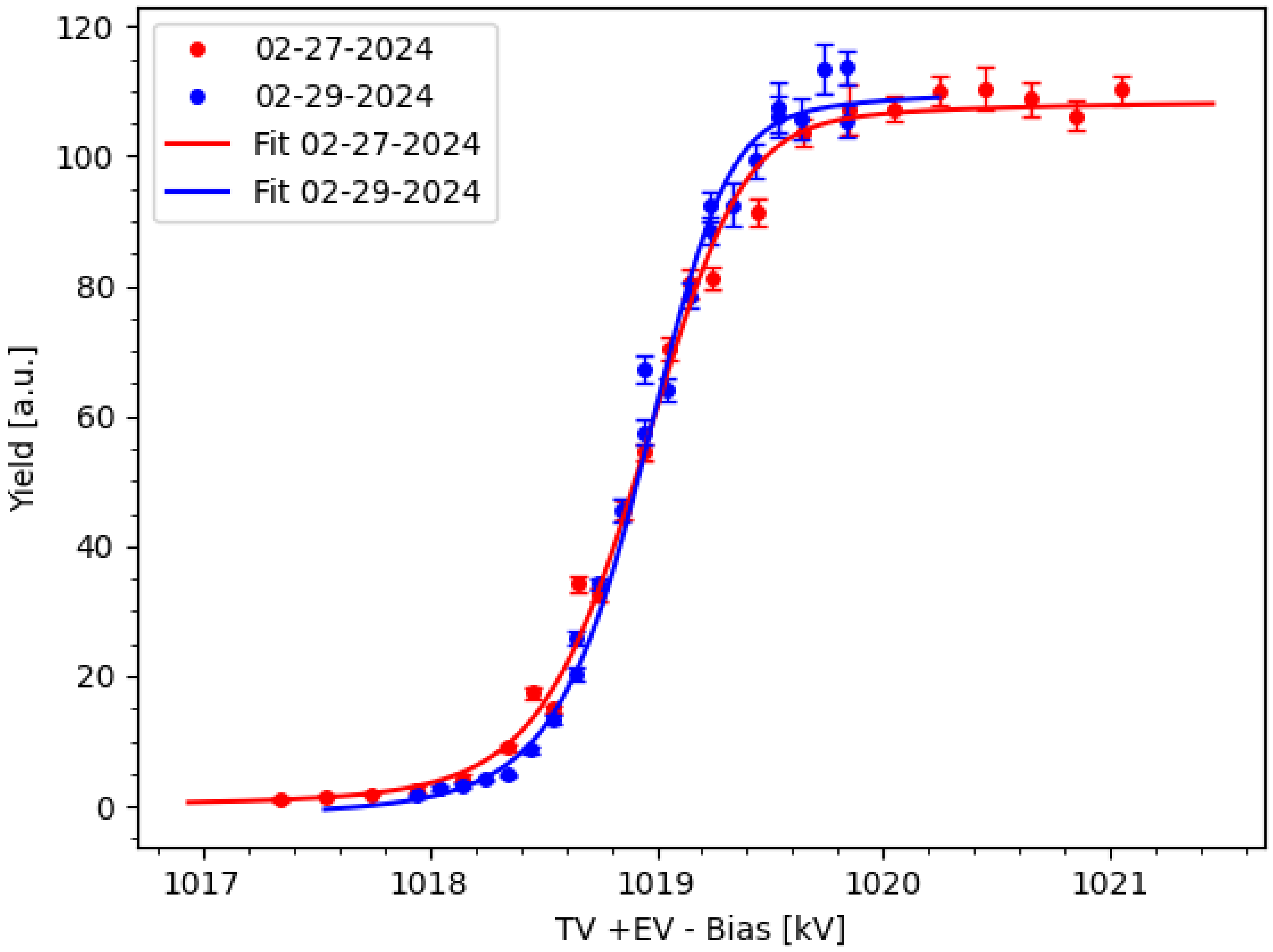
$r = (Ep - E)$ keV



Inflection points for both methods

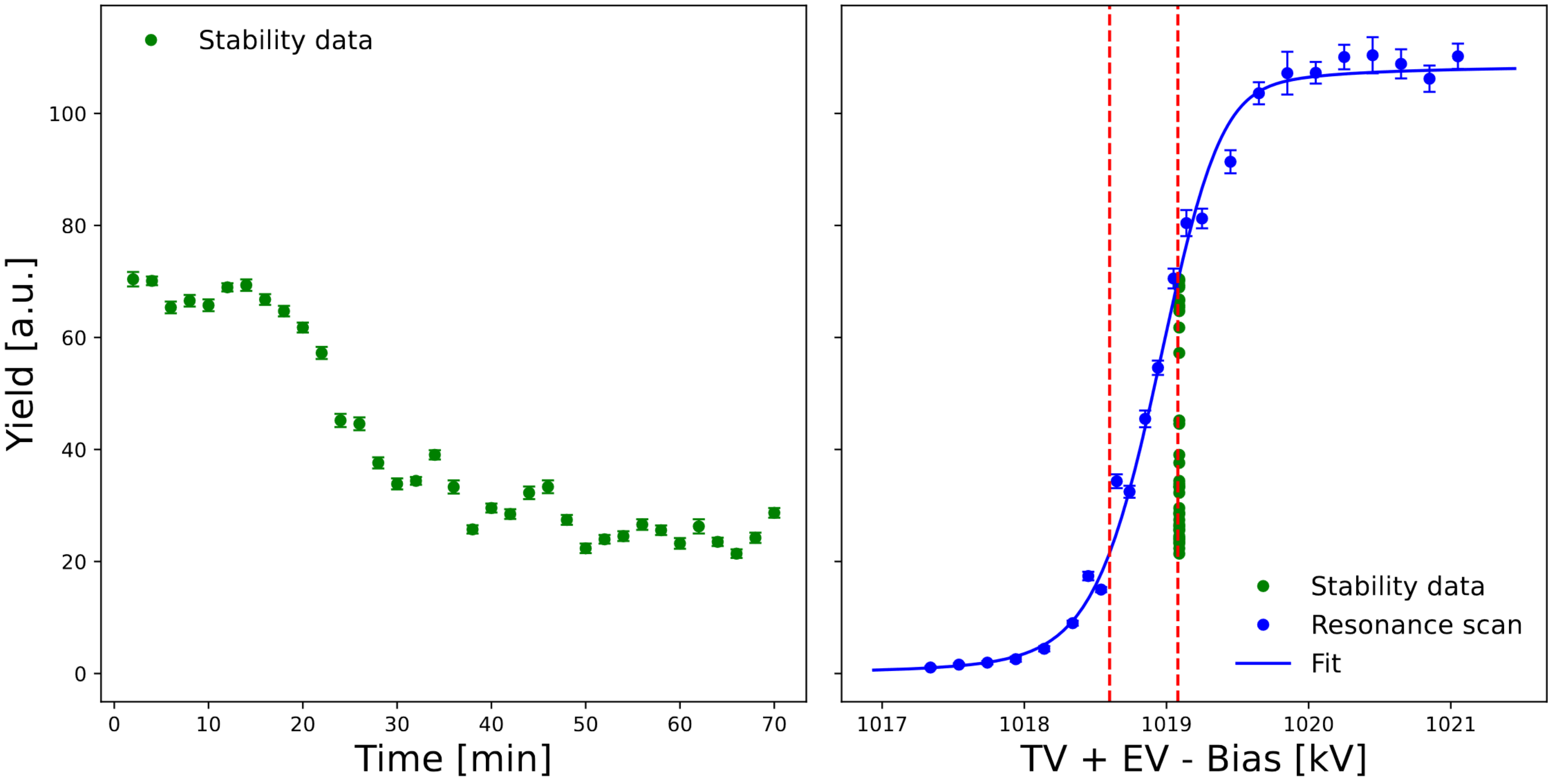
Inflection stragg (kV)	Inflection arctan (kV)	Difference (kV)
649.544	649.520	0.024
1018.952	1018.922	0.030
1018.986	1018.907	0.079
1246.519	1246.463	0.056
1631.190	1631.114	0.076
1849.626	1849.552	0.074

Reproducibility



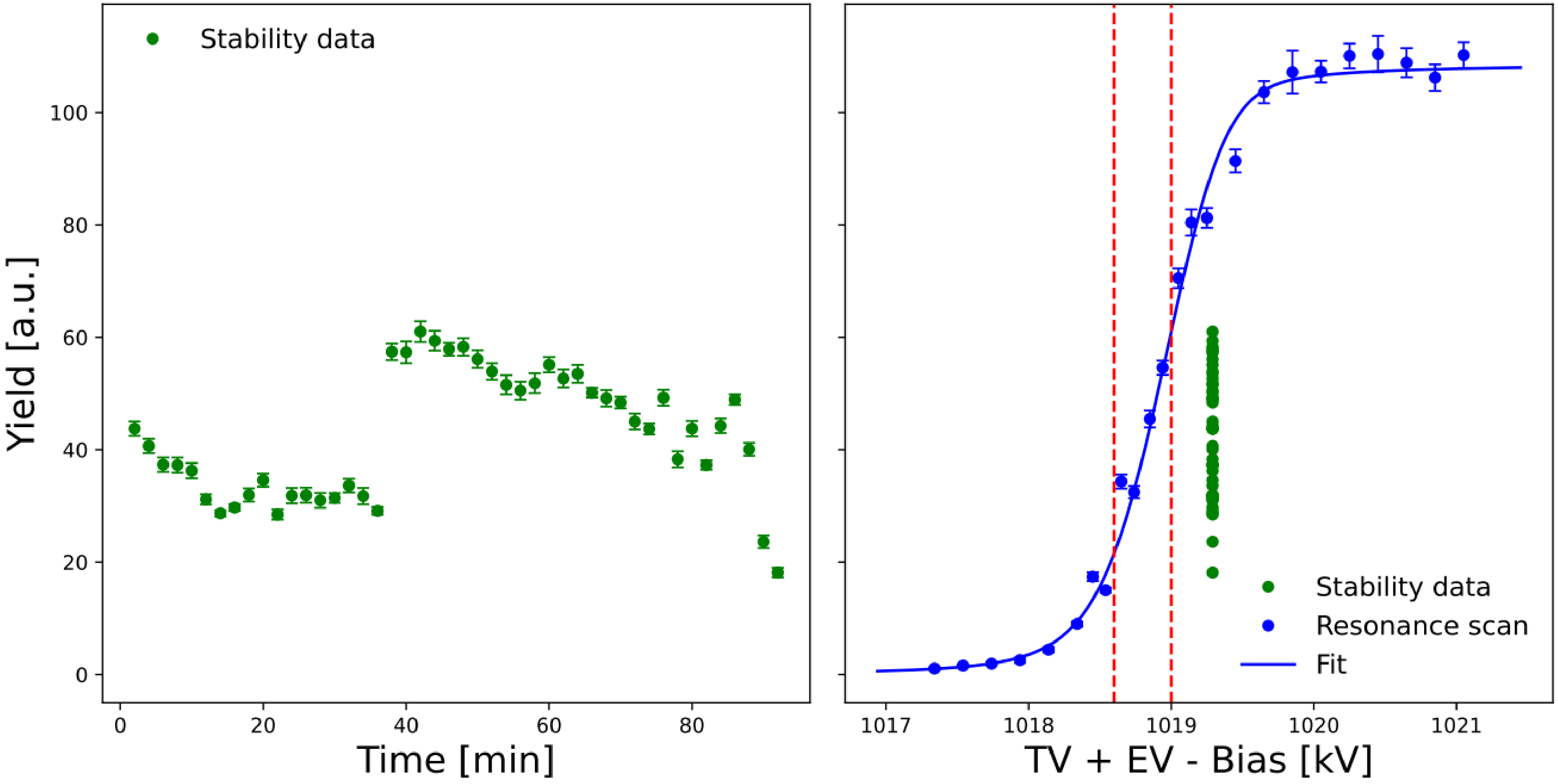
- Two 991 keV measurements have been performed to check for reproducibility.
- Both the data and fits are close to each other which suggests good reproducibility

Stability



Voltage drift of 480 V during the measurement

Second stability run



Voltage drift of 400 V during the measurement