Simulations of back-scatter regions beyond 1 AU

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Reference: Agueda N., Vainio R., Lario D. & Sanahuja B., 12th Solar Wind. AIP Conference Proceedings, 2010.

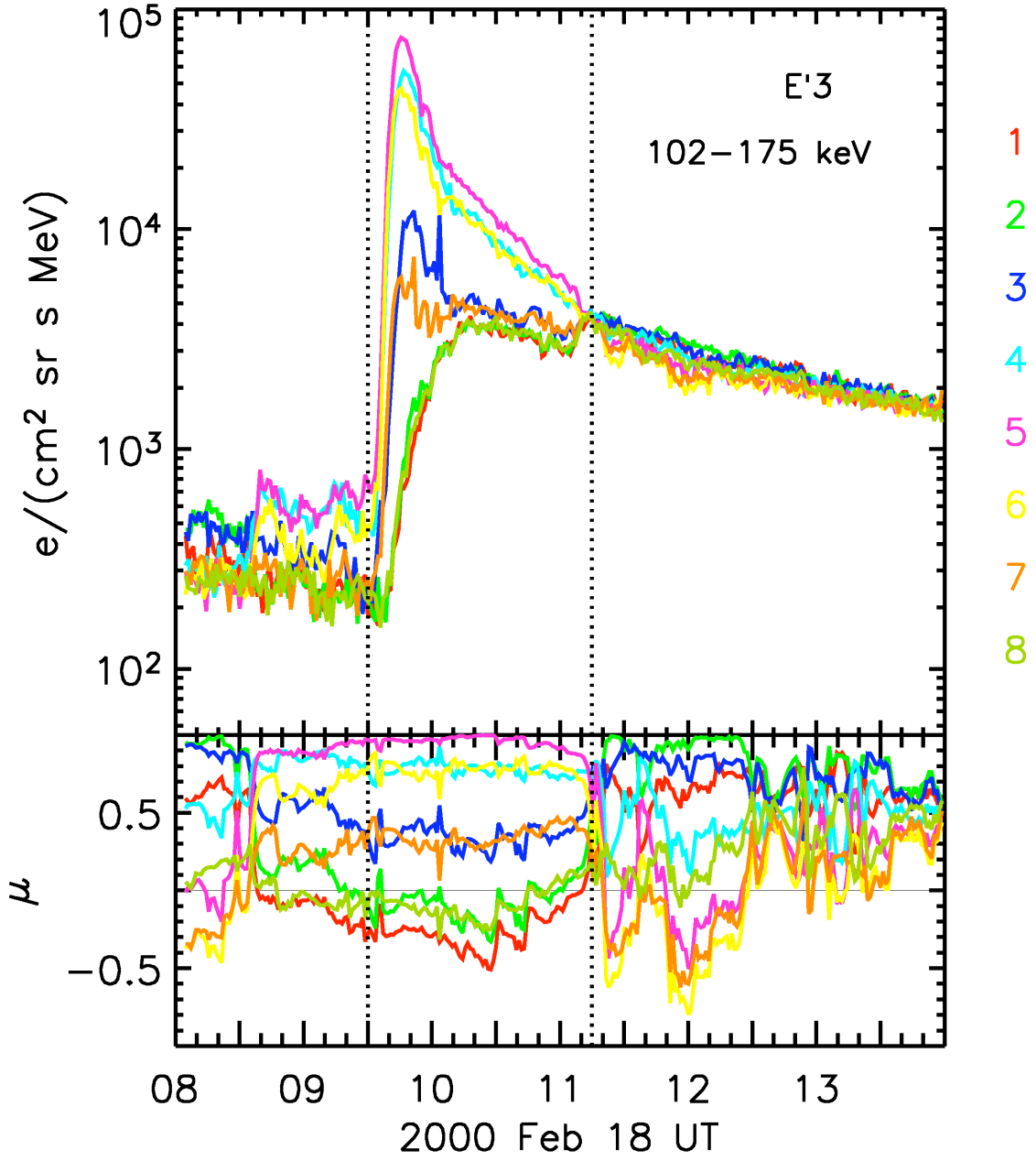
Back-scatter regions beyond 1 AU

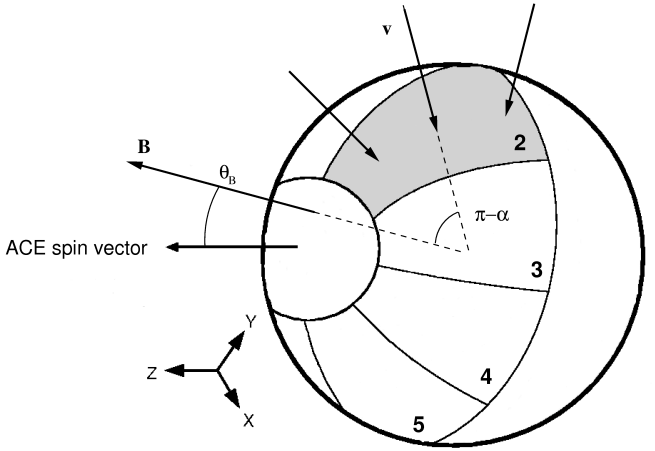
- Previous studies have provided evidence of the presence of discrete solar wind-IMF structures beyond 1 AU, which are able to reflect SEPs back to the inner heliosphere.

  (e.g. Anderson et al. 1995, Roelof et al. 1992, Bieber et al. 2002, Tan et al. 2009)

- The evolving global configuration of the helisophere, as it is disturbed by the transit of ICMEs, can shape the characteristics of the SEP events observed at 1 AU.

2000 Feb 18 NR electron event





- Onset at 09:32 UT in the E'4 (175-312 keV) channel.
- Highly anisotropic PADs at the onset (Haggerty & Roelof 2002, Simnett et al. 2002).
- Stable IMF
- <μ-co> = 82 %

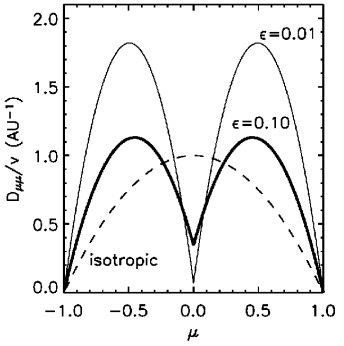
Simulation of the event

- Monte Carlo IP transport model

  (e.g. Kocharov et al. 1998, Vainio et al. 2000, Agueda et al. 2009)

  - particle streaming along the magnetic field lines
  - pitch-angle focusing by the diverging IMF
  - pitch-angle scattering by magnetic fluctuations

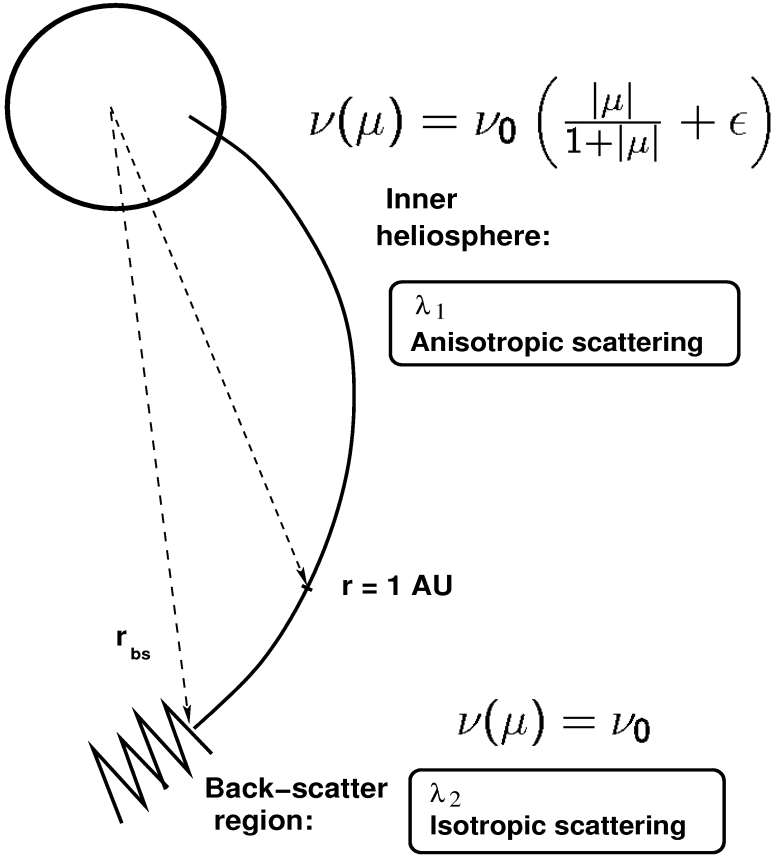
$$D_{\mu\mu} = \frac{\nu(\mu)}{2}(1-\mu^2)$$



  - adiabatic deceleration

- Assumptions:

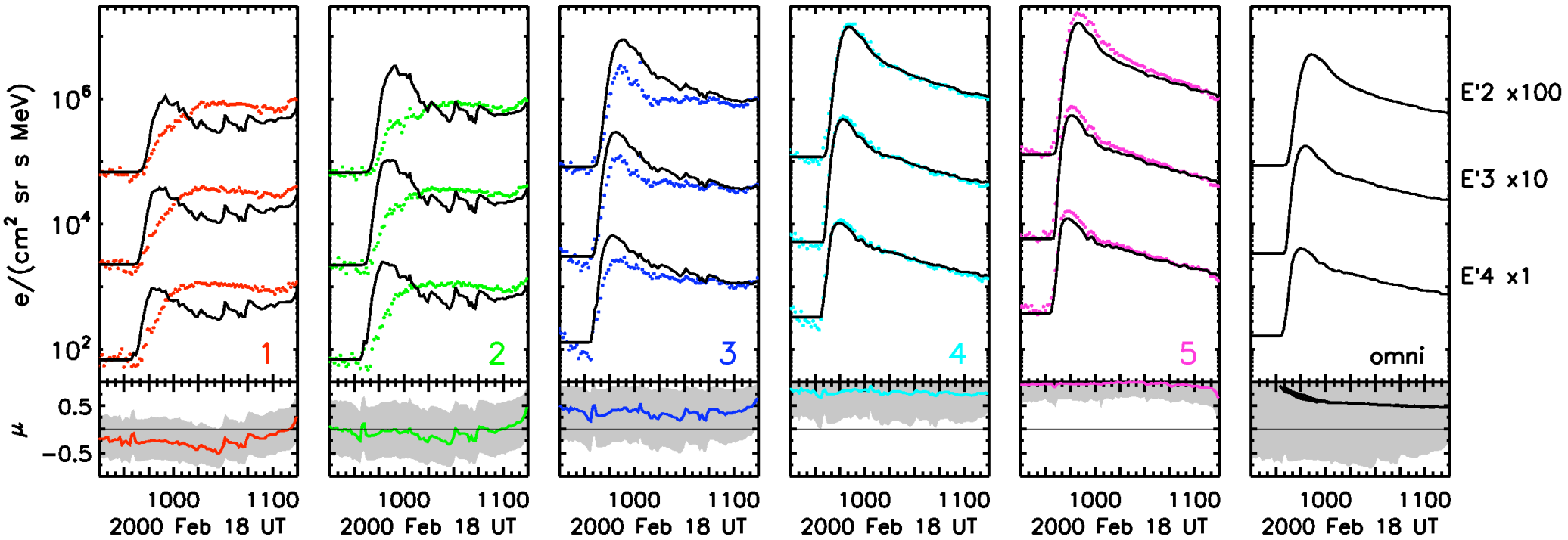
  - Parker spiral u=380 km s^{-1} (W63)
  - Source at $2R_\odot$
  - Instantaneous injection (Green's functions)



Scenario	λ_1 (AU)	r_{bs} (AU)	λ_2 (AU)
A	[0.5, 1.5]	∞	—
B	∞	[1.1, 1.6]	[0.01, 0.5]
C	[2.2, 4.2]	[1.1, 1.6]	[0.01, 0.5]

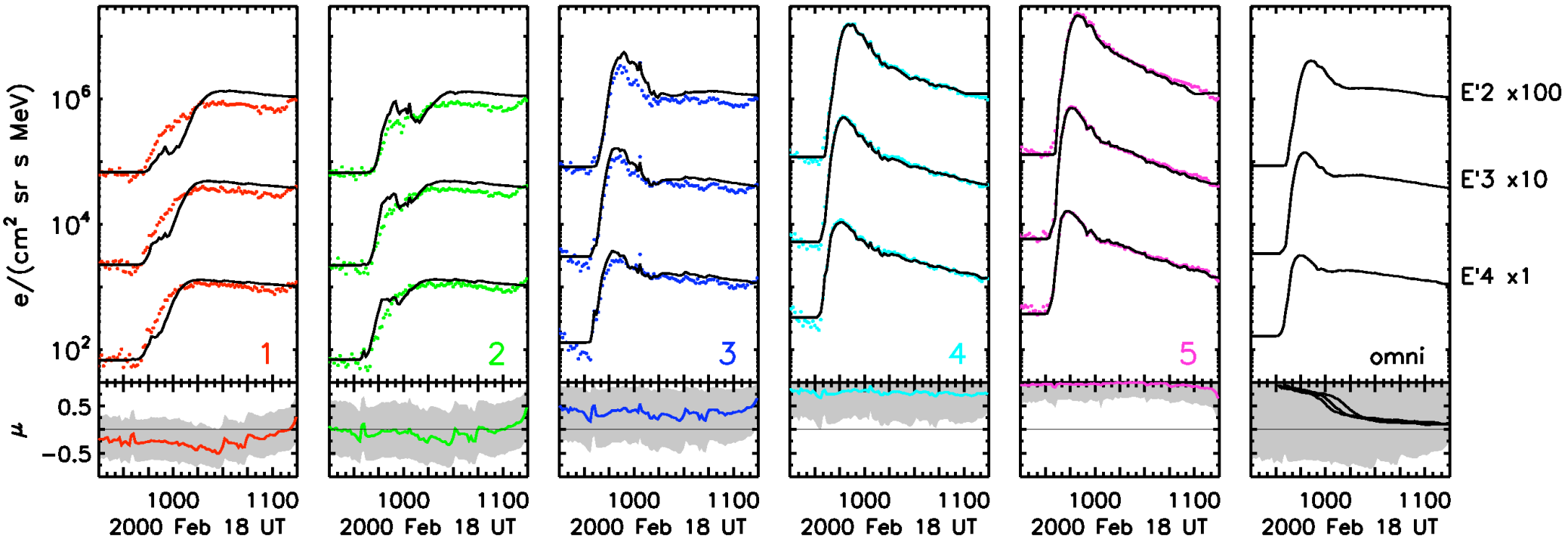
Scenario A

$r_{bs} = \infty$ (no back-scatter region)

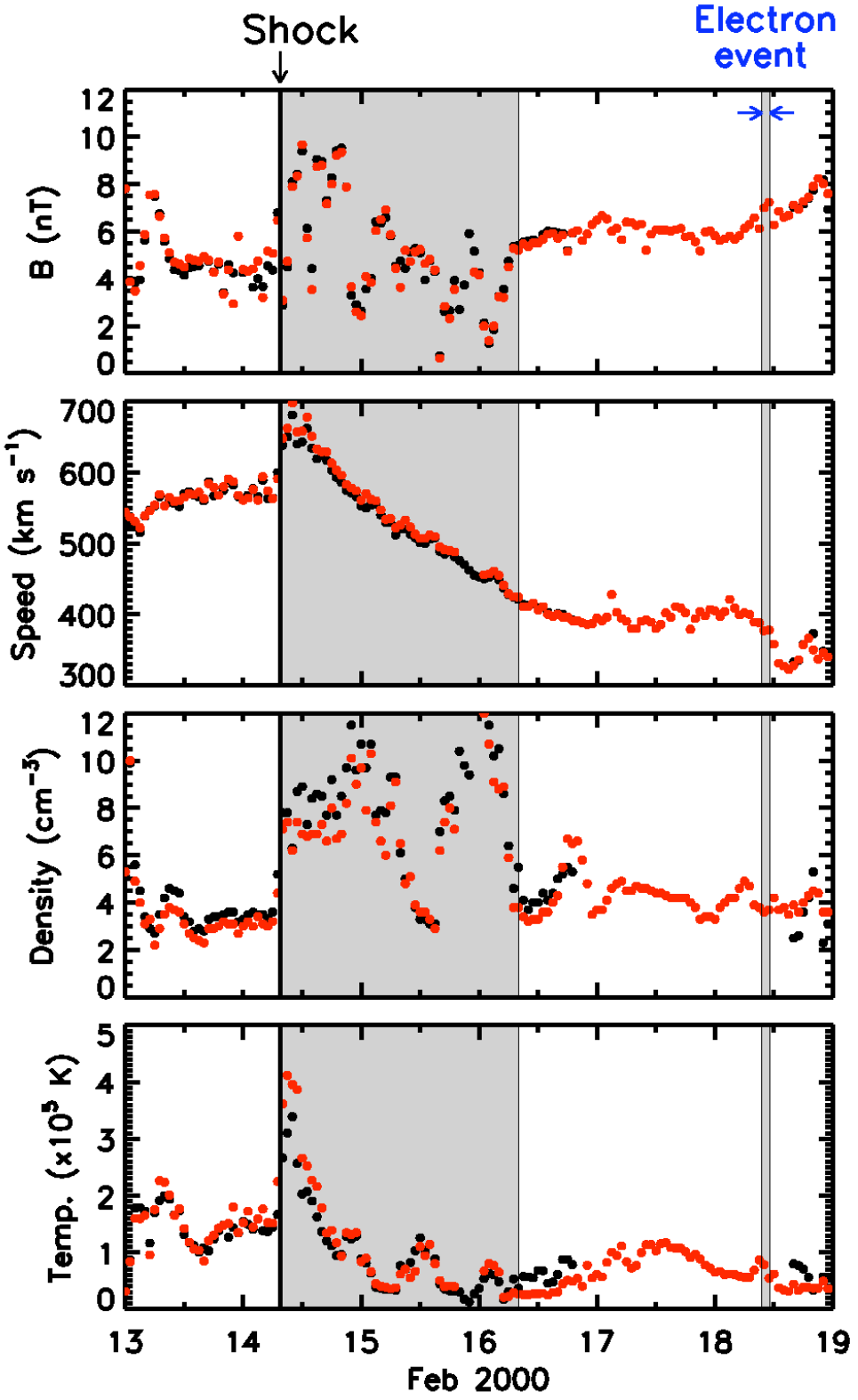


Best-fit parameters $\lambda_1 = 1.0$ AU

Scenario C



Best-fit parameters $\lambda_1 = 3.2$ AU; $\lambda_2 = 0.2$ AU; $r_{bs} = 1.2$ AU



Cane & Richardson (2003):

- IP shock on Feb 14 at 07:31 UT
- ICME from Feb 14/12:00 UT to Feb 16/08:00 UT
- Boundaries “ill-defined”

- At 380 km s^{-1}, the trailing edge of the ICME would have been convected to a radial distance of about 0.4 AU beyond 1 AU.