Rolfs & Rodney

General reaction rate:

$$\langle \sigma v \rangle = \left(\frac{8}{\pi\mu}\right)^{1/2} \frac{1}{(kT)^{3/2}} \int_0^\infty \sigma(E)\, E \exp\left(-\frac{E}{kT}\right) dE$$

Cross-section:

$$\sigma(E) = \sigma_R \frac{E_R}{E} \frac{\Gamma_p(E)}{\Gamma_p(E_R)} \frac{\Gamma_\gamma(E)}{\Gamma_\gamma(E_R)} \frac{(\Gamma_R/2)^2}{(E-E_R)^2 + [\Gamma(E)/2]^2}$$

where:

$$\sigma_R = 4\pi \lambda_R^2 \omega \frac{\Gamma_p \Gamma_\gamma}{\Gamma_R^2}$$

or:

$$\sigma_R = 4\pi \lambda_R^2 \times \frac{\omega\gamma_R}{\Gamma_R}$$

$\omega\gamma_R$ ← measured by DRAGON

Γ_R ← measured by DRAGON for broad resonances

Energy-dependent partial widths

charged particle:

$$\Gamma_p(E) = \frac{3\hbar}{r}\left(\frac{2E}{\mu}\right)^{1/2} P_\ell(E,r)\, \theta_\ell^2$$

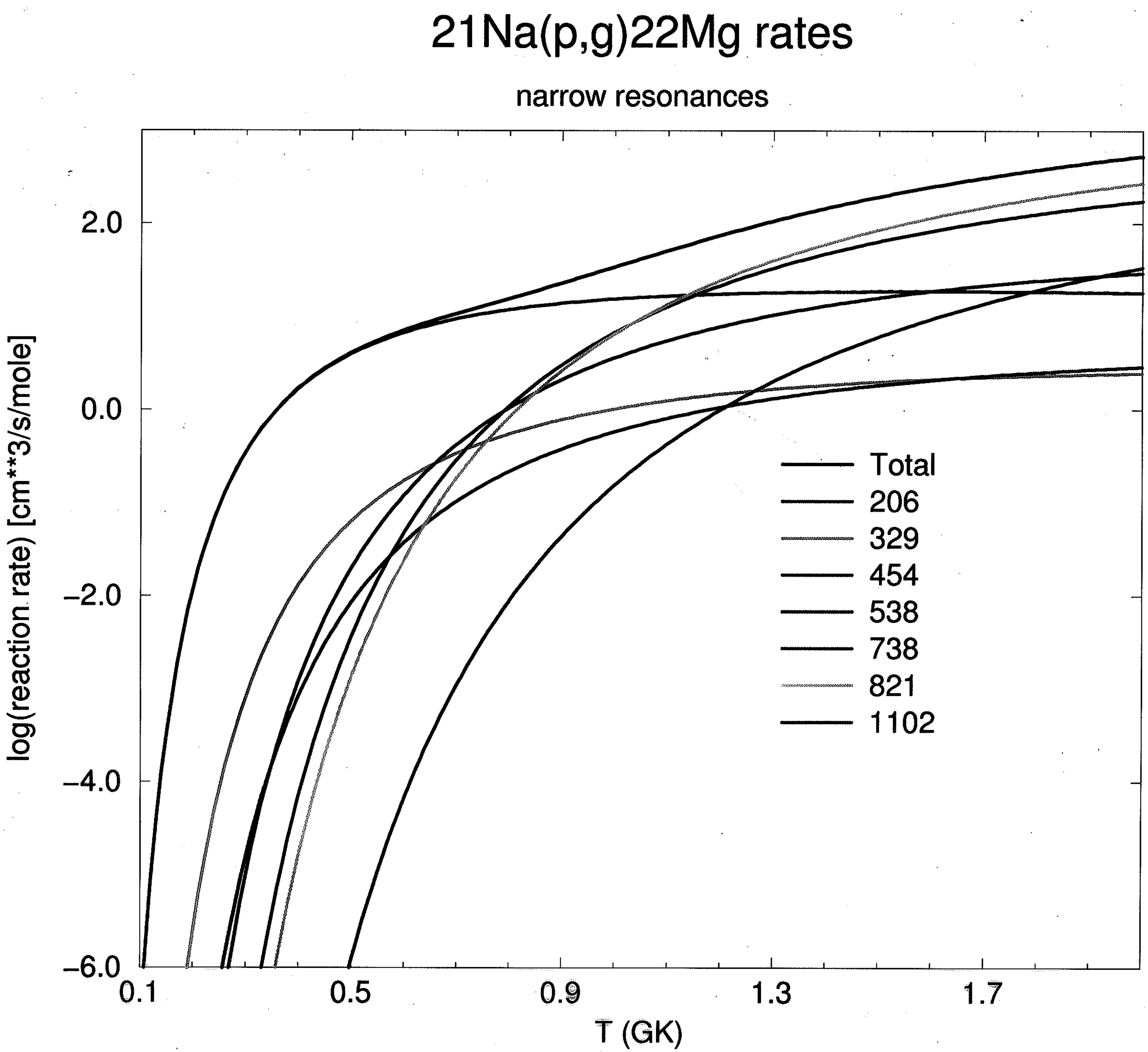
so setting $\Gamma_p(E_R) = \frac{3\hbar}{r}\left(\frac{2E_R}{\mu}\right)^{1/2} P_\ell(E_R,r)\, \theta_\ell^2$

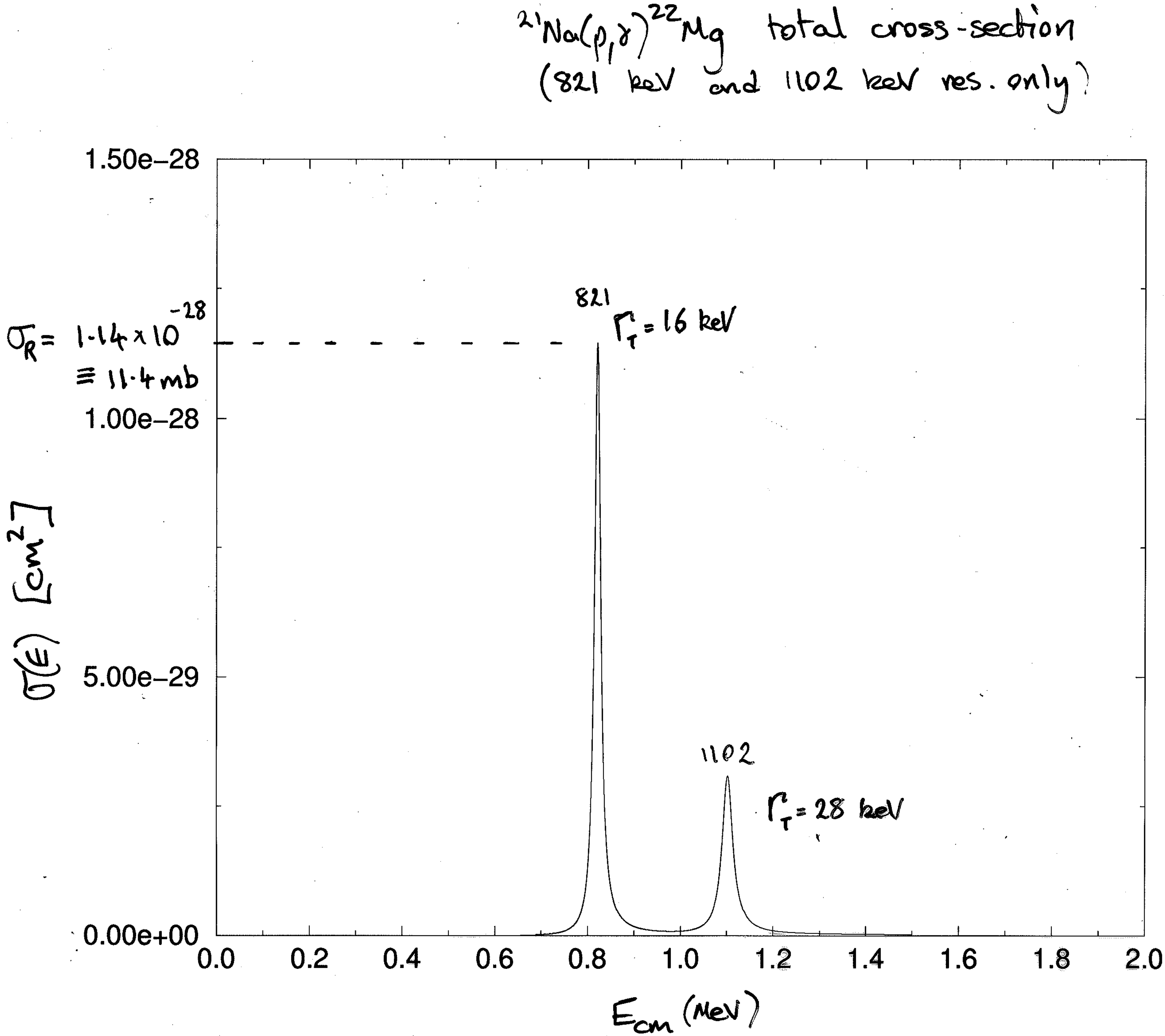
gives

$$\Gamma_p(E) = \Gamma_p(E_R) \sqrt{\frac{E}{E_R}} \frac{P_\ell(E,r)}{P_\ell(E_R,r)}$$

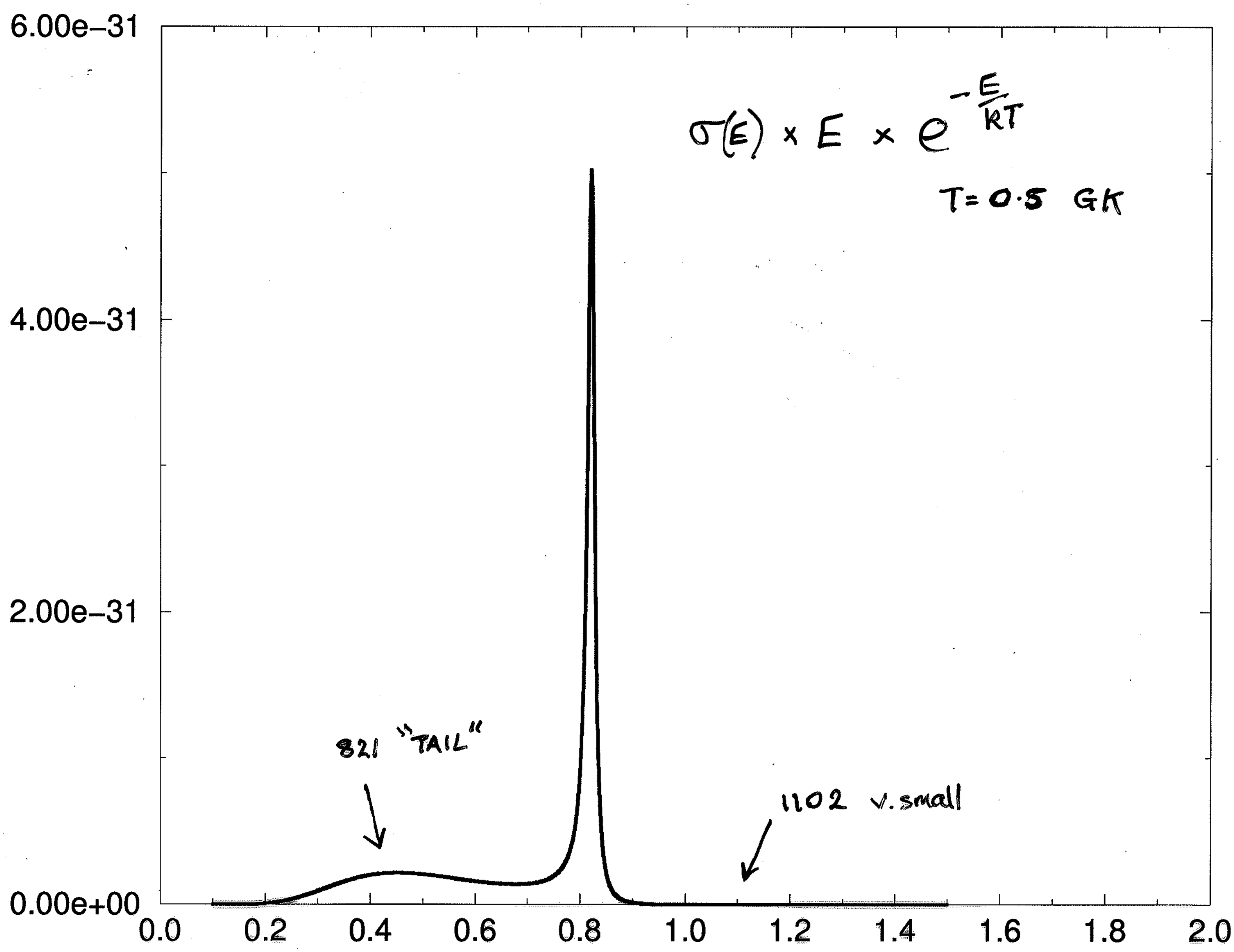
γ-: $\Gamma_\gamma^{M1}(E) \propto E_\gamma^3$

from ^{22}Ne 1^+ 6854 keV $\Gamma_\gamma \sim 1.7$ eV

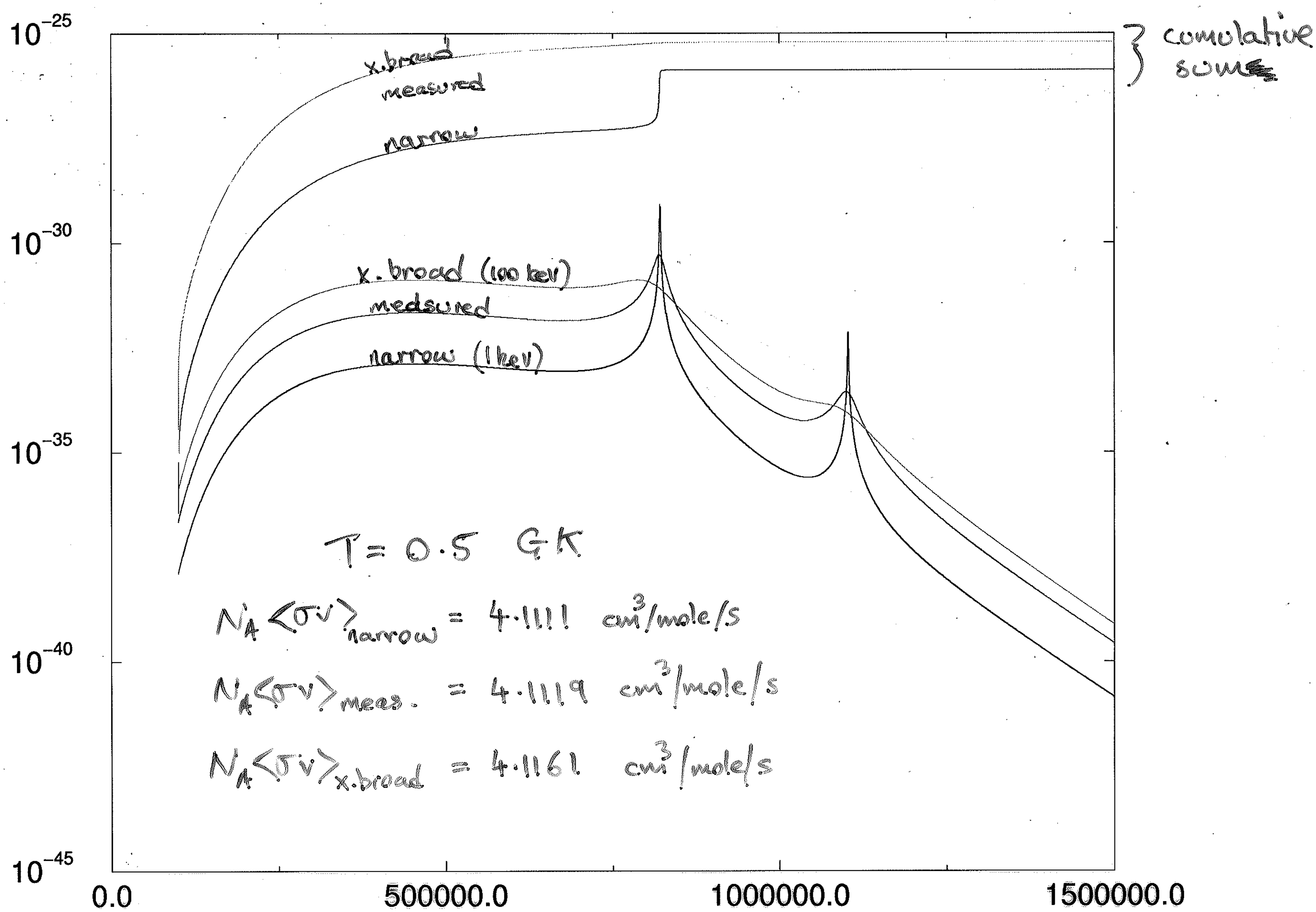

21Na(p,g)22Mg rates
narrow resonances
log(reaction rate) [cm**3/s/mole]
2.0
0.0
−2.0
−4.0
−6.0
0.1
0.5
0.9
1.3
1.7
T (GK)
Total
206
329
454
538
738
821
1102



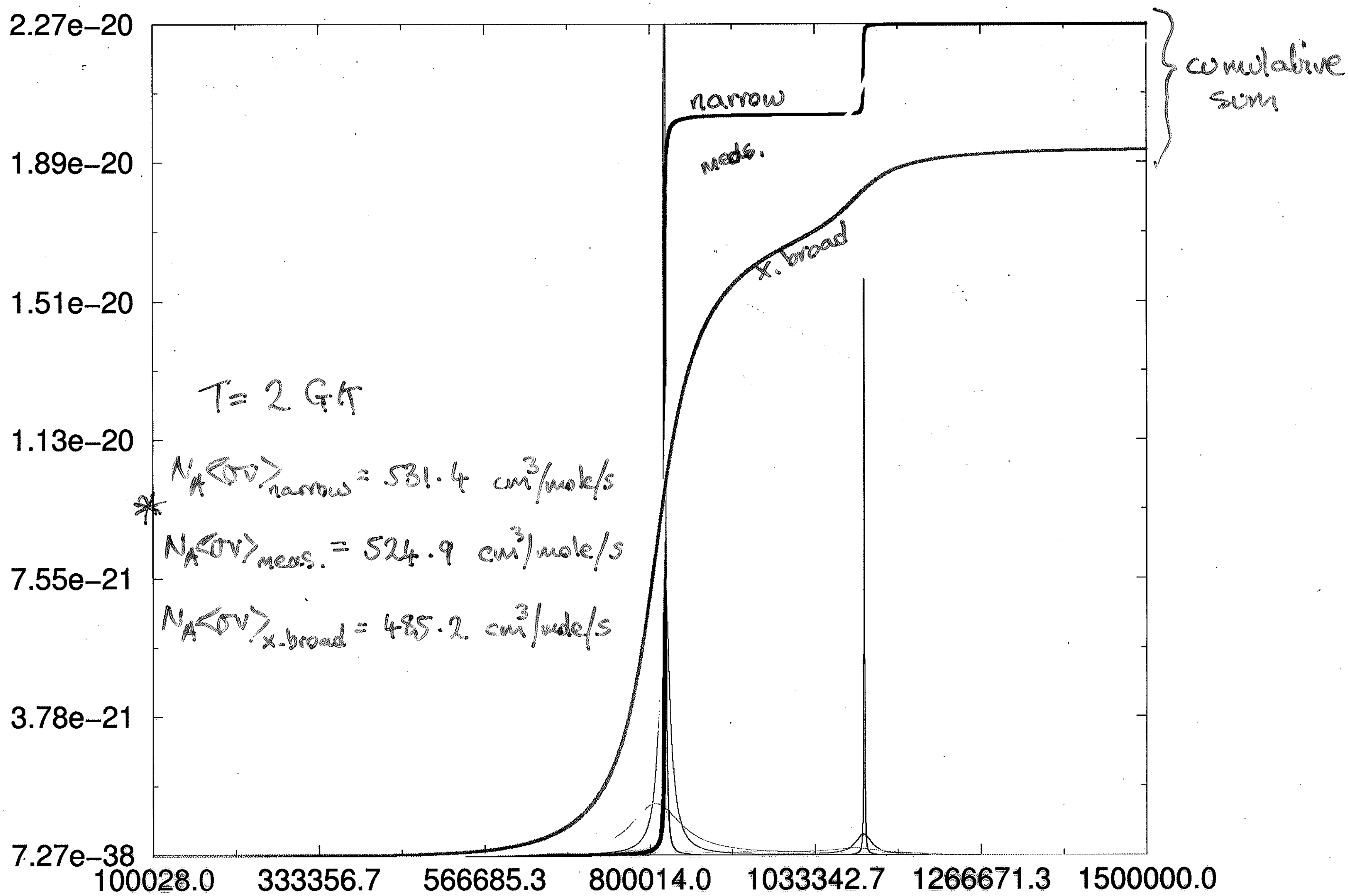
²¹Na(p,γ)²²Mg total cross-section
(821 keV and 1102 keV res. only)
1.50e−28
σ_R = 1.14 × 10^−28
≡ 11.4 mb
1.00e−28
5.00e−29
0.00e+00
σ(E) [cm²]
821
Γ_T = 16 keV
1102
Γ_T = 28 keV
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
E_cm (MeV)



6.00e−31
4.00e−31
2.00e−31
0.00e+00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
σ(E) × E × e^(−E/kT)
T = 0.5 GK
821 "TAIL"
1102 v.small



10^{-25}
10^{-30}
10^{-35}
10^{-40}
10^{-45}
0.0
500000.0
1000000.0
1500000.0
x.broad
measured
narrow
cumulative sum
x. broad (100 keV)
measured
narrow (1 keV)
T = 0.5 GK
$N_A\langle\sigma v\rangle_{narrow}$ = 4.1111 cm^3/mole/s
$N_A\langle\sigma v\rangle_{meas.}$ = 4.1119 cm^3/mole/s
$N_A\langle\sigma v\rangle_{x.broad}$ = 4.1161 cm^3/mole/s



2.27e−20
1.89e−20
1.51e−20
1.13e−20
7.55e−21
3.78e−21
7.27e−38
100028.0
333356.7
566685.3
800014.0
1033342.7
1266671.3
1500000.0
narrow
meas.
x. broad
cumulative sum
T= 2 GK
$N_A\langle\sigma v\rangle_{narrow}$ = 531.4 cm³/mole/s *
$N_A\langle\sigma v\rangle_{meas.}$ = 524.9 cm³/mole/s
$N_A\langle\sigma v\rangle_{x\text{-}broad}$ = 485.2 cm³/mole/s

* 1.2 % change

$^{21}Na(p,\gamma)^{22}Mg$ total reaction rate