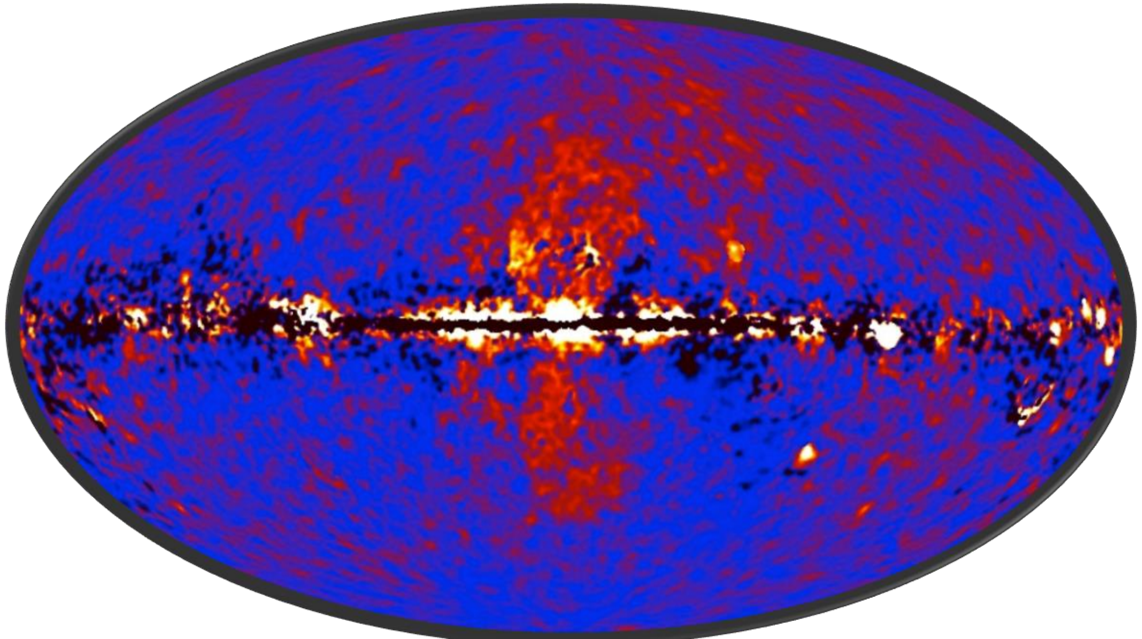
Contribution of a central source

0. Energy budget

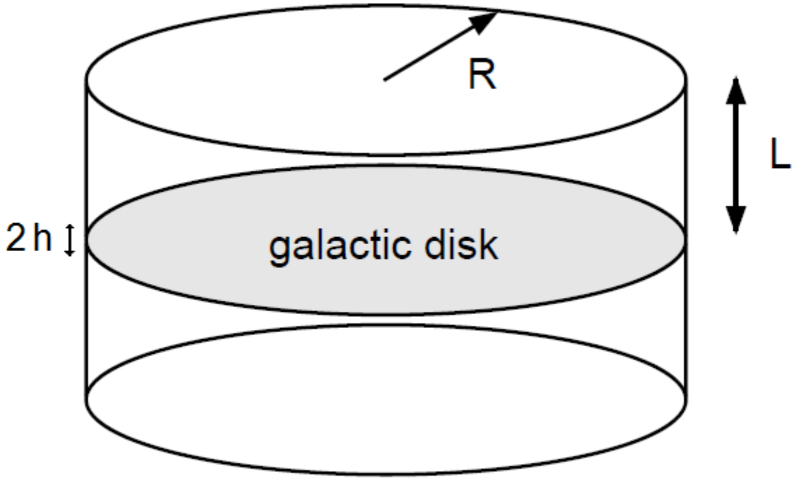
Power from SNa (standard model) : 10^{41} erg/s

Fermi Bubbles : F. Guo & W. Mathews, APJ 756(2): 181, 2012

Total emitted power : 10^{41} - 10^{43} erg/s



1. Model Description

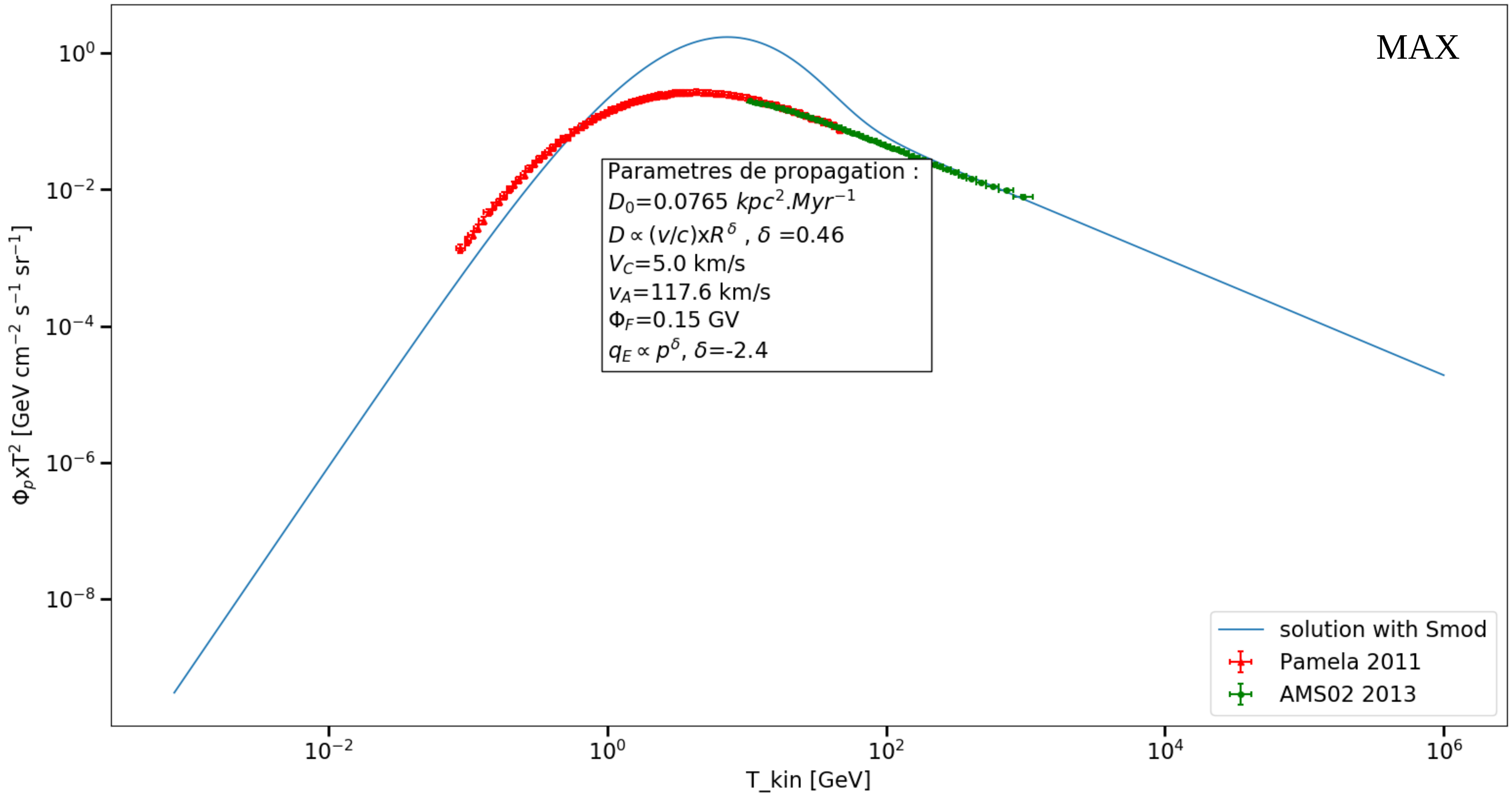


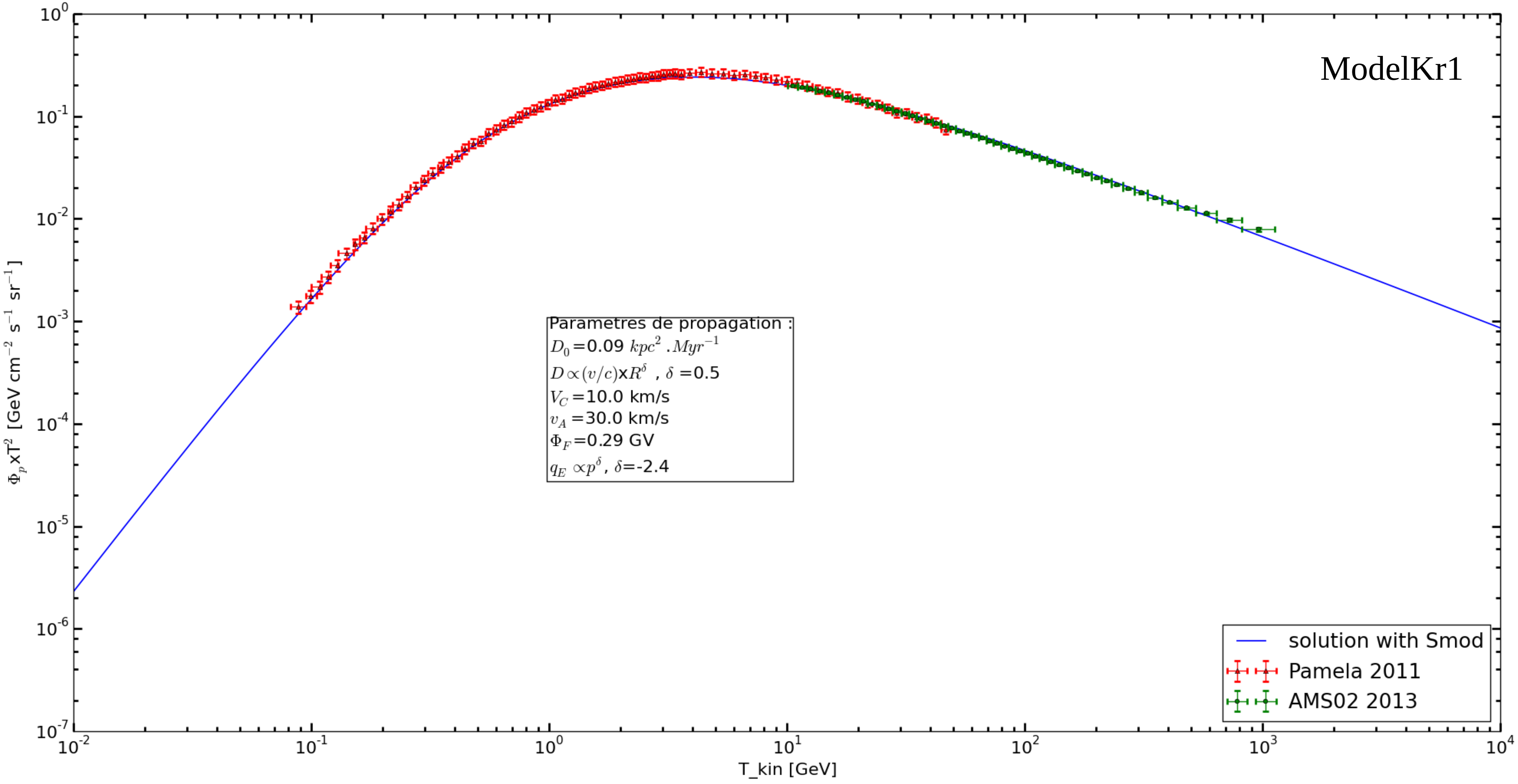
$$\mathcal{L}_{Diff}\,\Psi + \partial_z \left\{V_C \Psi\right\} + \partial_T \left\{b^{loss}(T)\Psi - D_{EE}(T)\partial_T \Psi\right\} = Q(\vec{r}, t, T)$$

$$b^{loss}\,\Psi(r, z, t, T) = b^{loss}(T)\,\Psi(r, z=0, t, T) \times 2h\,\delta(z)$$

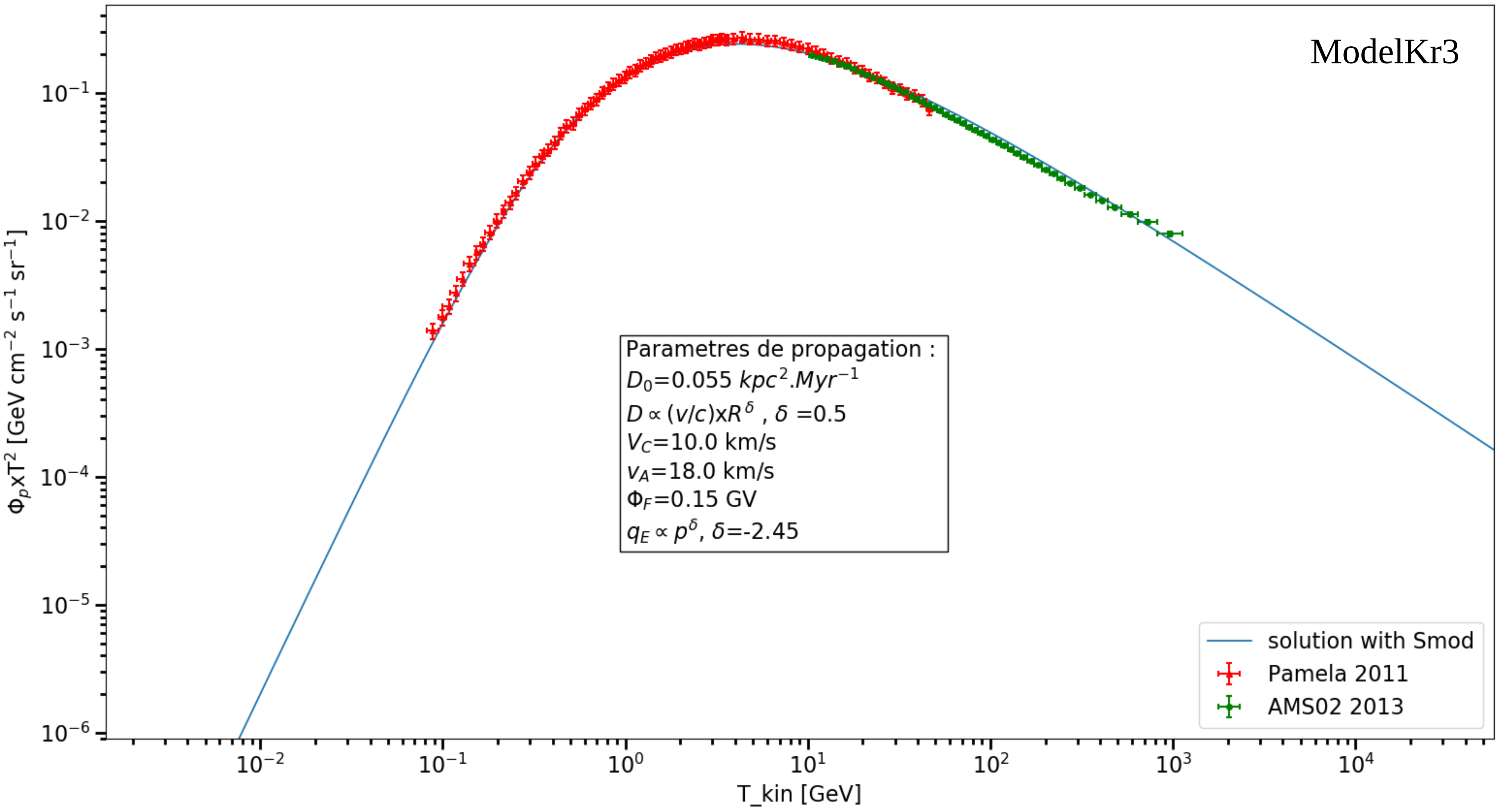
$$\Psi(r, z, t, T) = \sum_{i=1}^{+\infty} P_i(z, t, T) \times J_0(u_i \frac{r}{R})$$

2. Energy Spectrum of Primary CRs

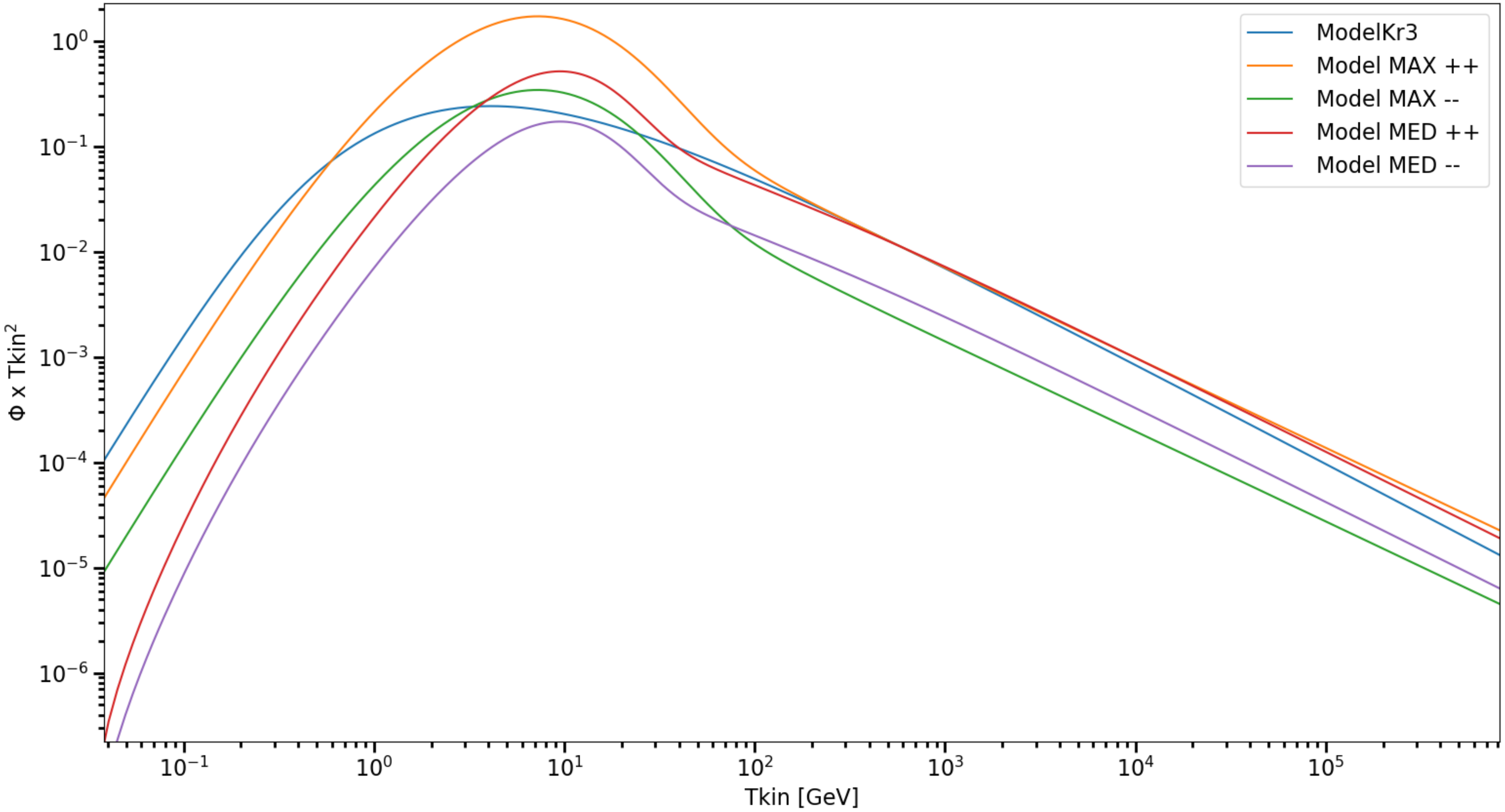




ModelKr1
Parametres de propagation :
D_0=0.09 $kpc^2.Myr^{-1}$
$D \propto (v/c)$xR^δ , δ =0.5
V_C =10.0 km/s
v_A =30.0 km/s
Φ_F=0.29 GV
$q_E \propto p^\delta$, δ=-2.4
solution with Smod
Pamela 2011
AMS02 2013
Φ_p xT^2 [GeV cm^{-2} s^{-1} sr^{-1}]
T_kin [GeV]

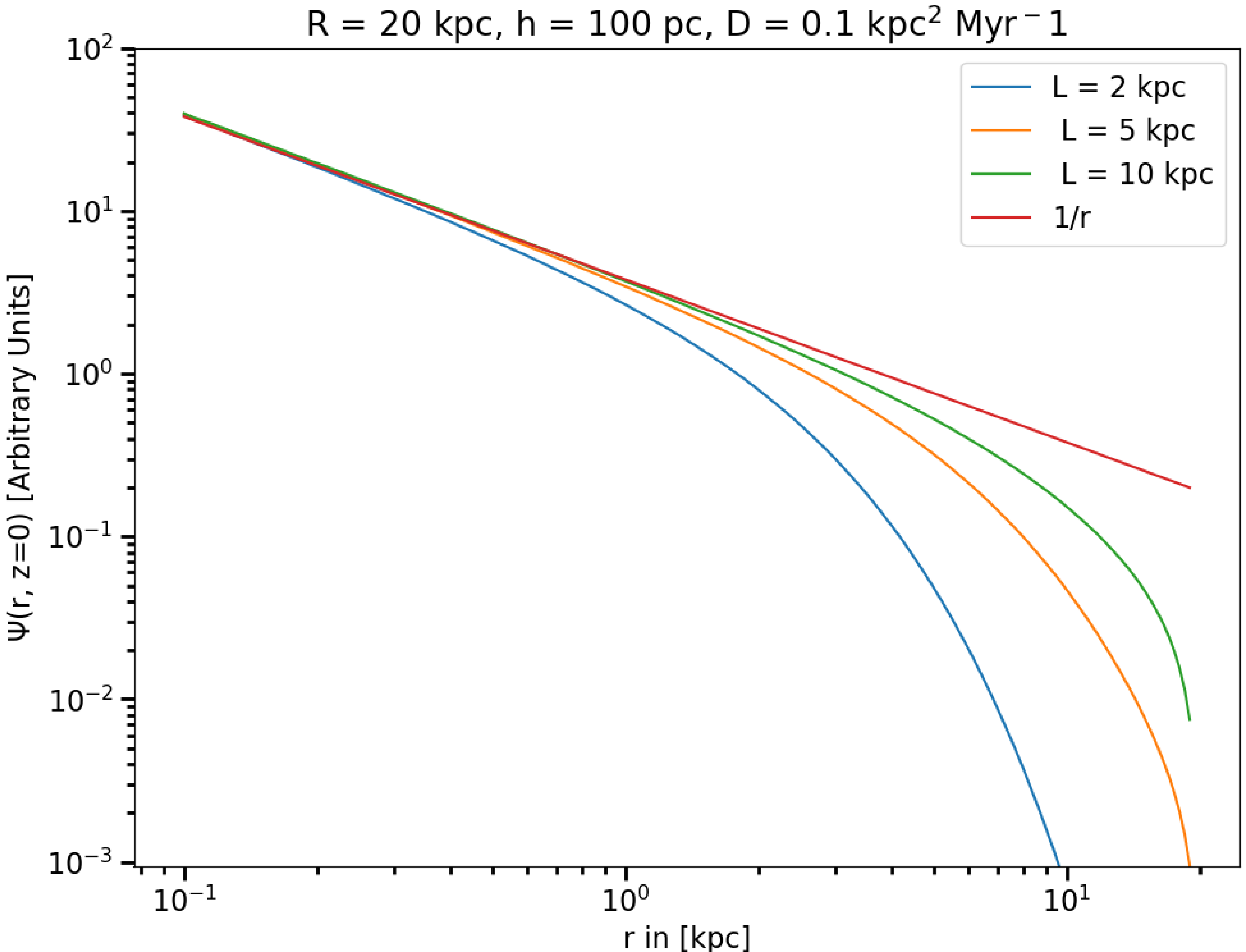


ModelKr3
Parametres de propagation :
D_0=0.055 $kpc^2.Myr^{-1}$
$D \propto (v/c)xR^{\delta}$, δ =0.5
V_C=10.0 km/s
v_A=18.0 km/s
Φ_F=0.15 GV
$q_E \propto p^{\delta}$, δ=-2.45
solution with Smod
Pamela 2011
AMS02 2013
$\Phi_p x T^2$ [GeV cm^{-2} s^{-1} sr^{-1}]
T_kin [GeV]

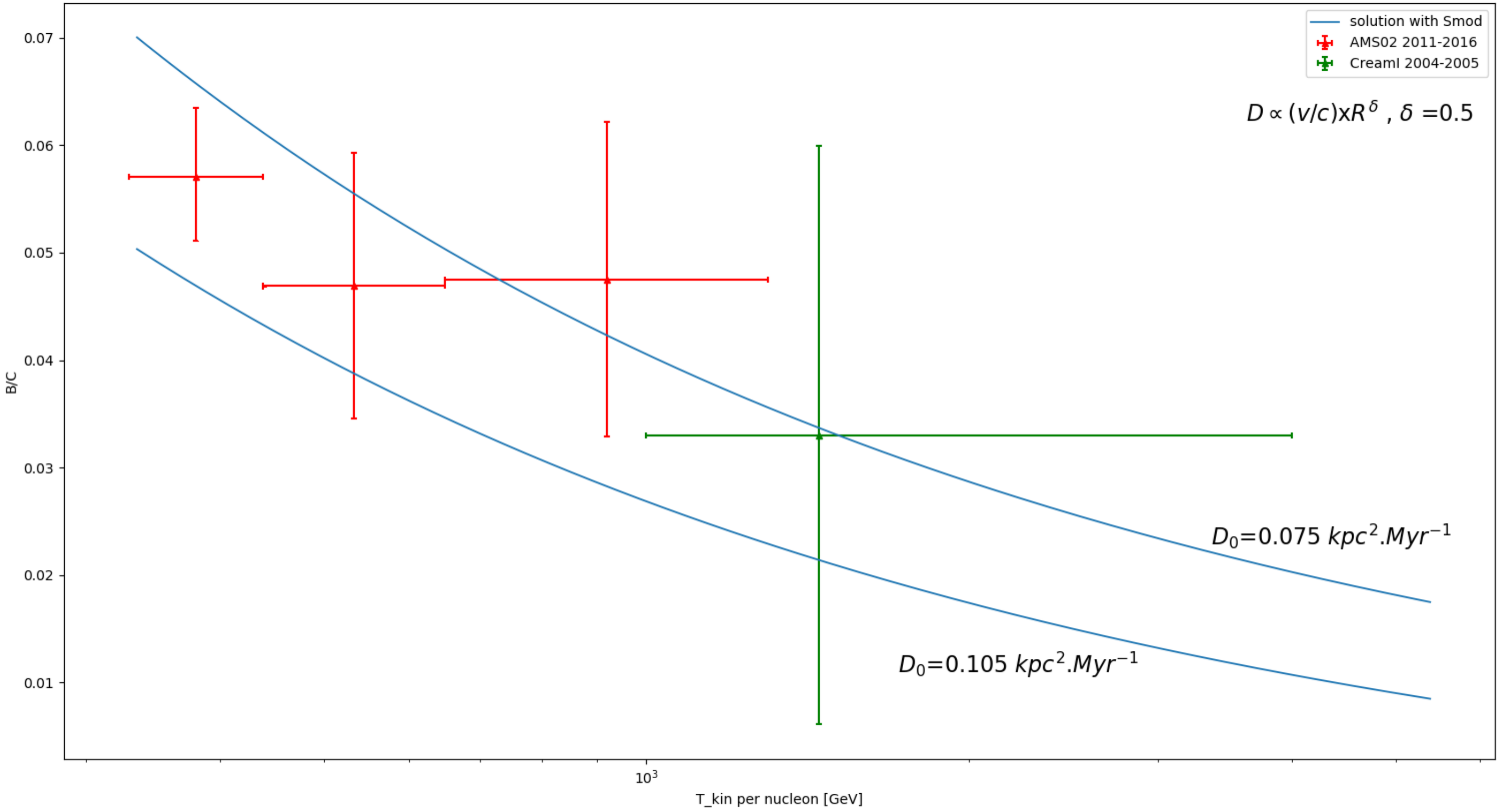


Model	δ	D_0 [kpc^2/Myr]	V_C [km/s]	L [kpc]	v_A [km/s]	$\mathcal{P}$ [erg/s]
MED	0.70	0.012	12	4	52.9	$1.8 - 5.5\,10^{41}$
MAX	0.46	0.0765	5	15	117.6	$4.2 - 21\,10^{40}$
ModelKr1	0.5	0.09	10	10	30	$2.1\,10^{41}$
ModelKr2	0.5	0.09	10	5	30	$5.4\,10^{41}$
ModelKr3	0.5	0.055	10	10	18	$3.3\,10^{41}$
ModelKo1	1/3	0.09	10	10	20	$9.7\,10^{40}$

Influence of L

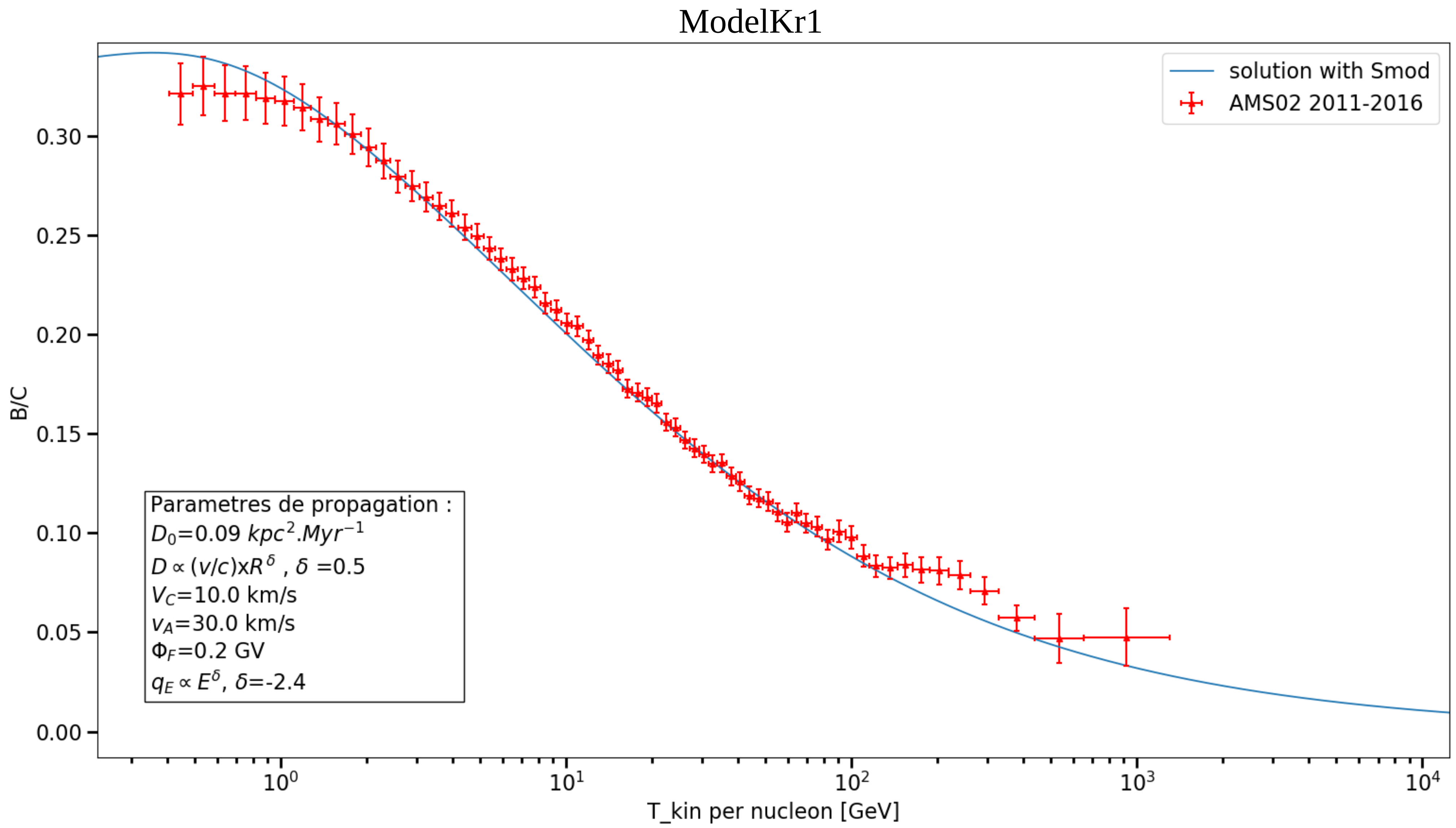


3. Secondary CRs fluxes



$$Q_{i,\,spallation} = - < \sigma > \, n_{ISM} \, \beta \, P_i(0,T); \qquad \text{for primary CR}$$

$$Q_{i,\,spallation} = + \sigma_{I,\,II} \, n_{ISM} \, \beta \, P_{i,\,I}(0,T); \qquad \text{for secondary CR}$$



ModelKr1
solution with Smod
AMS02 2011-2016
B/C
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Parametres de propagation :
D_0=0.09 $kpc^2.Myr^{-1}$
$D \propto (v/c)xR^{\delta}$, δ =0.5
V_C=10.0 km/s
v_A=30.0 km/s
Φ_F=0.2 GV
$q_E \propto E^{\delta}$, δ=-2.4
10^0
10^1
10^2
10^3
10^4
T_kin per nucleon [GeV]

4 .Discussion regarding the stationnary scenario

$$\mathcal{L}_{Diff}\,\Psi_H + \partial_z\left\{V_C\Psi_H\right\} = -2h\,\delta(z)\,\Gamma_{ISM}\,\Psi_H(r, z=0, t)$$

$$\Psi_H = \sum_{j\geq 1} P_{H,j}(t,\,z)\,J_0(u_j\frac{r}{R})$$

$$\partial_t P_{H,j} = i\omega_j P_{H,j}$$

$$\mathcal{R}e(\omega_j^{(k)}) = 0\ ,\ \mathcal{I}m(\omega_j^{(k)}) = D\left\{\left(\frac{u_j}{R}\right)^2 + \left(\frac{b_j^{(k)}}{L}\right)^2\right\} + \frac{V_C^2}{4D} = \gamma_j^{(k)}$$

$b^{(k)} > 0$ is the k^{th} positive zero of $b \times \frac{-D}{L(V_C/2+h\Gamma_{ISM})} = \tan(b)$

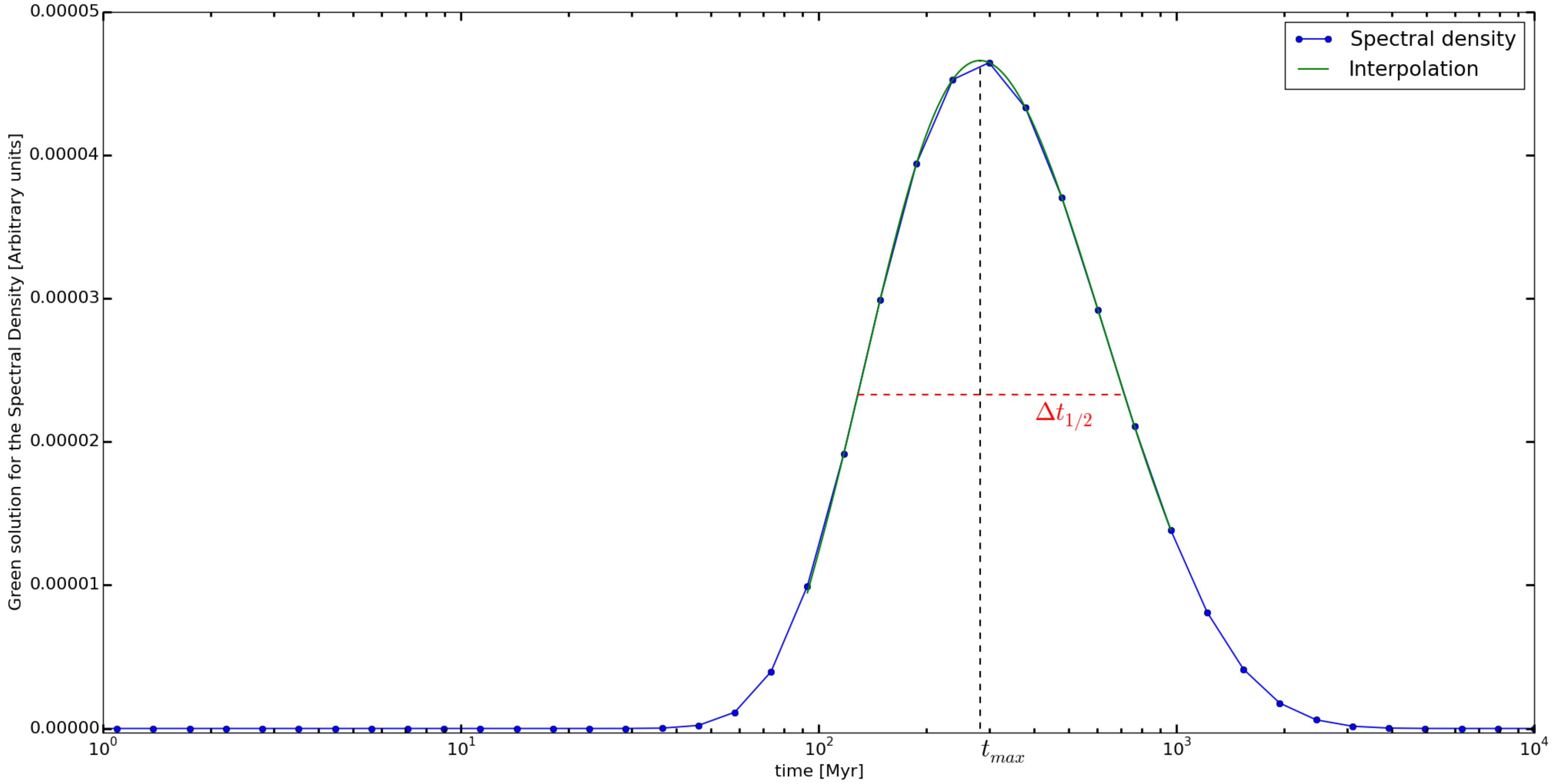
Green's solution

$$\Psi_G(r,z,t) = \Theta(t) \times \Psi_H(r,z,t)$$

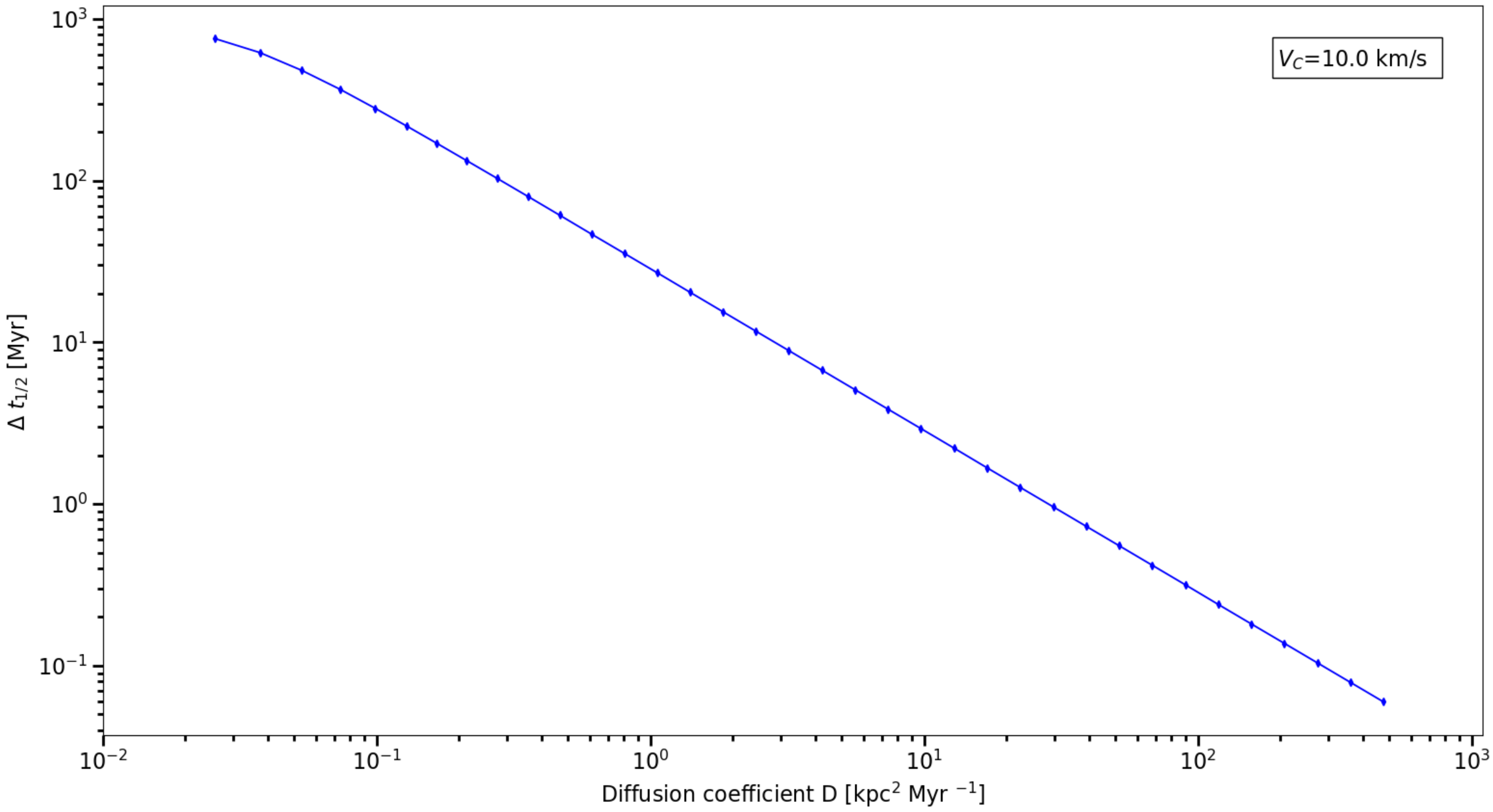
$$\Psi_H(r,z,t) = \sum_{j\geq 1}\left(\sum_{k\geq 1} P_j^{(k)}(z)\exp\left\{-\gamma_j^{(k)}t\right\}\right) J_0(u_j\frac{r}{R})$$

$$\sum_{k\geq 1} P_j^{(k)}(z) = Q_j\delta(z)\ ,\ Q_j = \frac{1}{\pi R^2 J_1(u_j)^2}$$

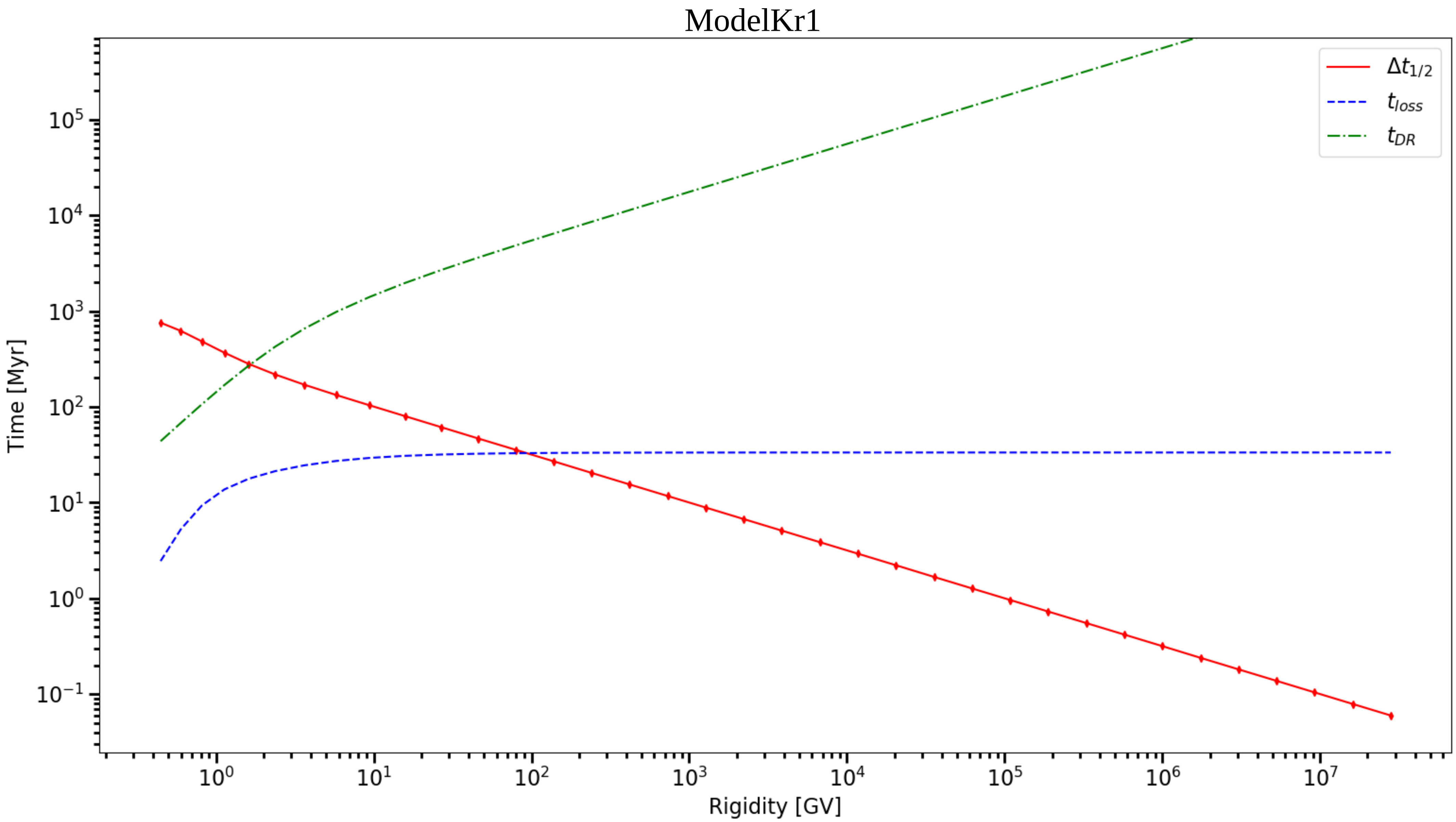
$$P_j^{(k)}(z) = A_j^{(k)} \times \exp\left\{\frac{V_C}{2D}z\right\}\sin\left(\frac{b^{(k)}}{L}(L-z)\right) = Q_j \times A^{(k)} \times P^{(k)}(z)$$



Spectral density
Interpolation
0.00005
0.00004
0.00003
0.00002
0.00001
0.00000
Green solution for the Spectral Density [Arbitrary units]
$\Delta t_{1/2}$
10^0
10^1
10^2
t_{max}
10^3
10^4
time [Myr]



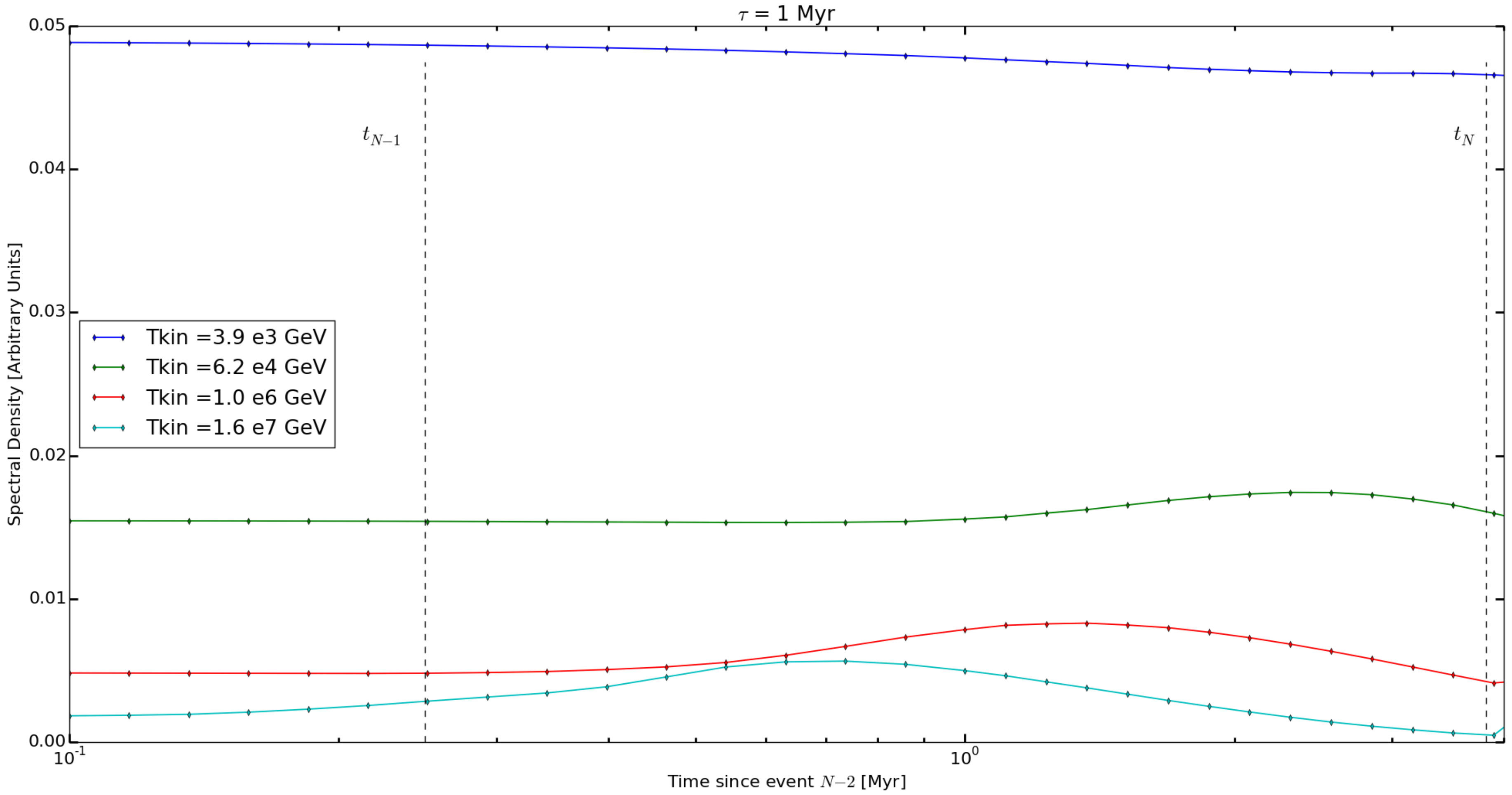
V_C=10.0 km/s
$\Delta\ t_{1/2}$ [Myr]
Diffusion coefficient D [kpc^2 Myr $^{-1}$]
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}

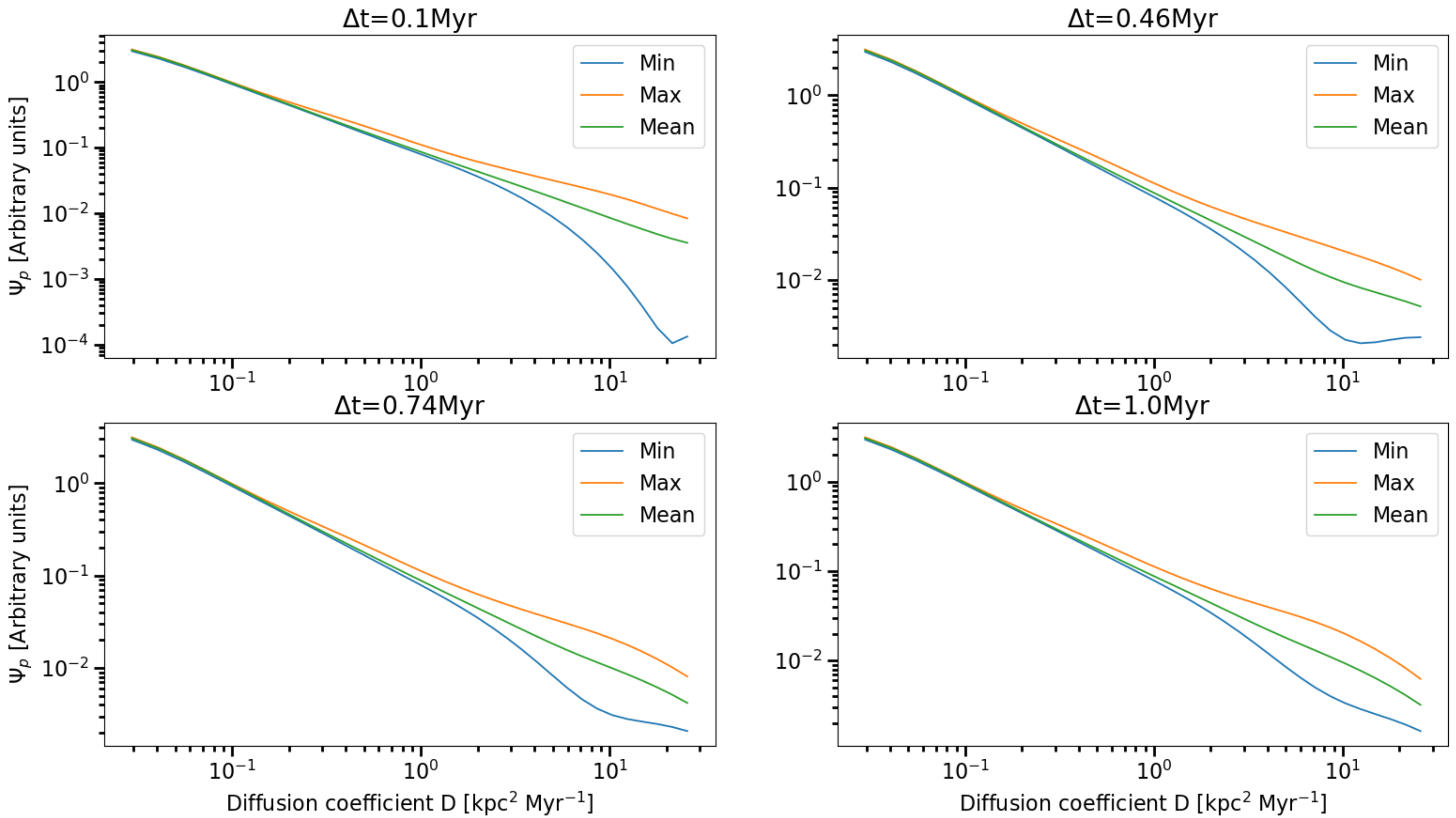


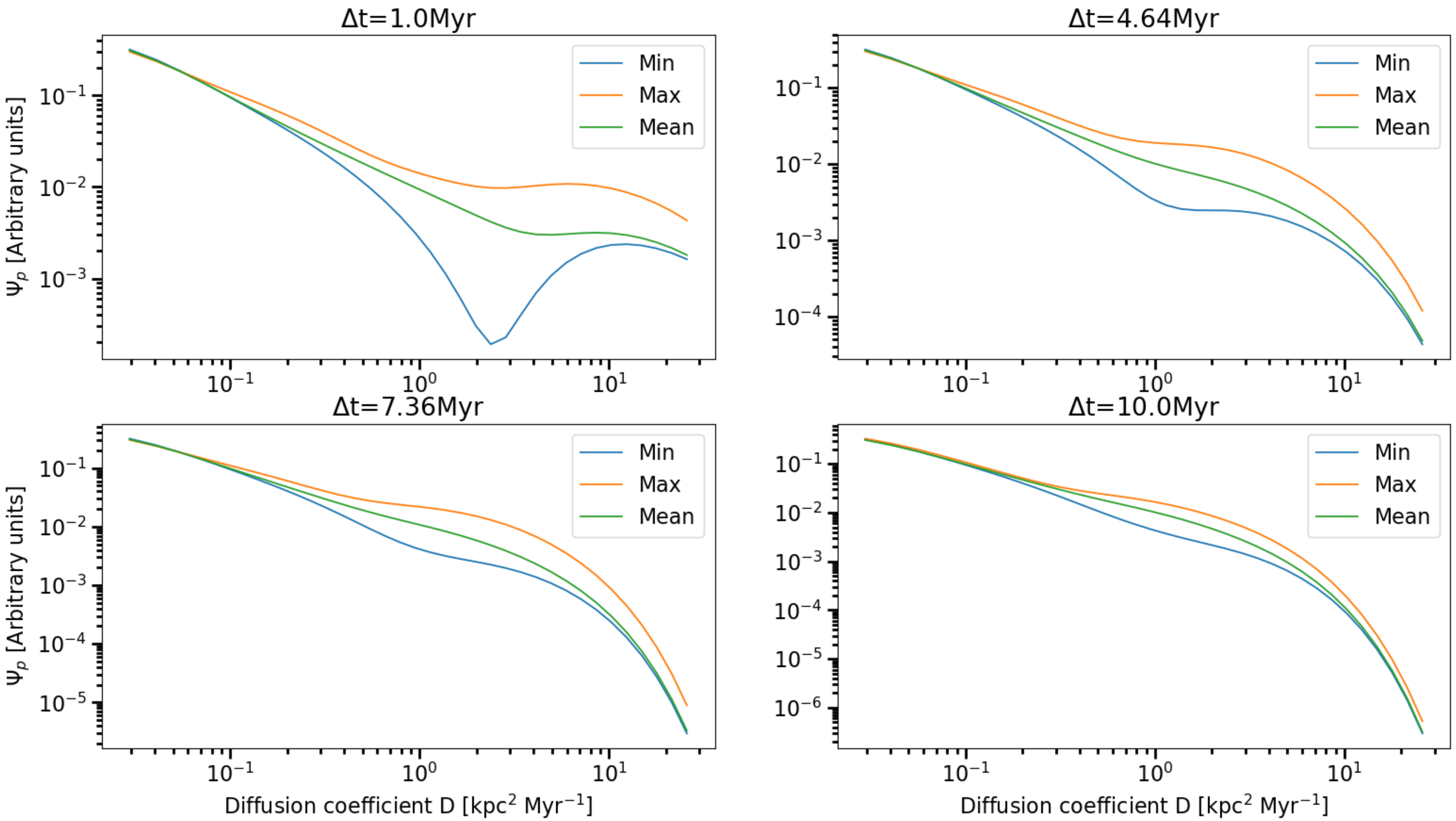
ModelKr1
$\Delta t_{1/2}$
t_{loss}
t_{DR}
Time [Myr]
Rigidity [GV]
10^{-1}
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7

Repeated emission

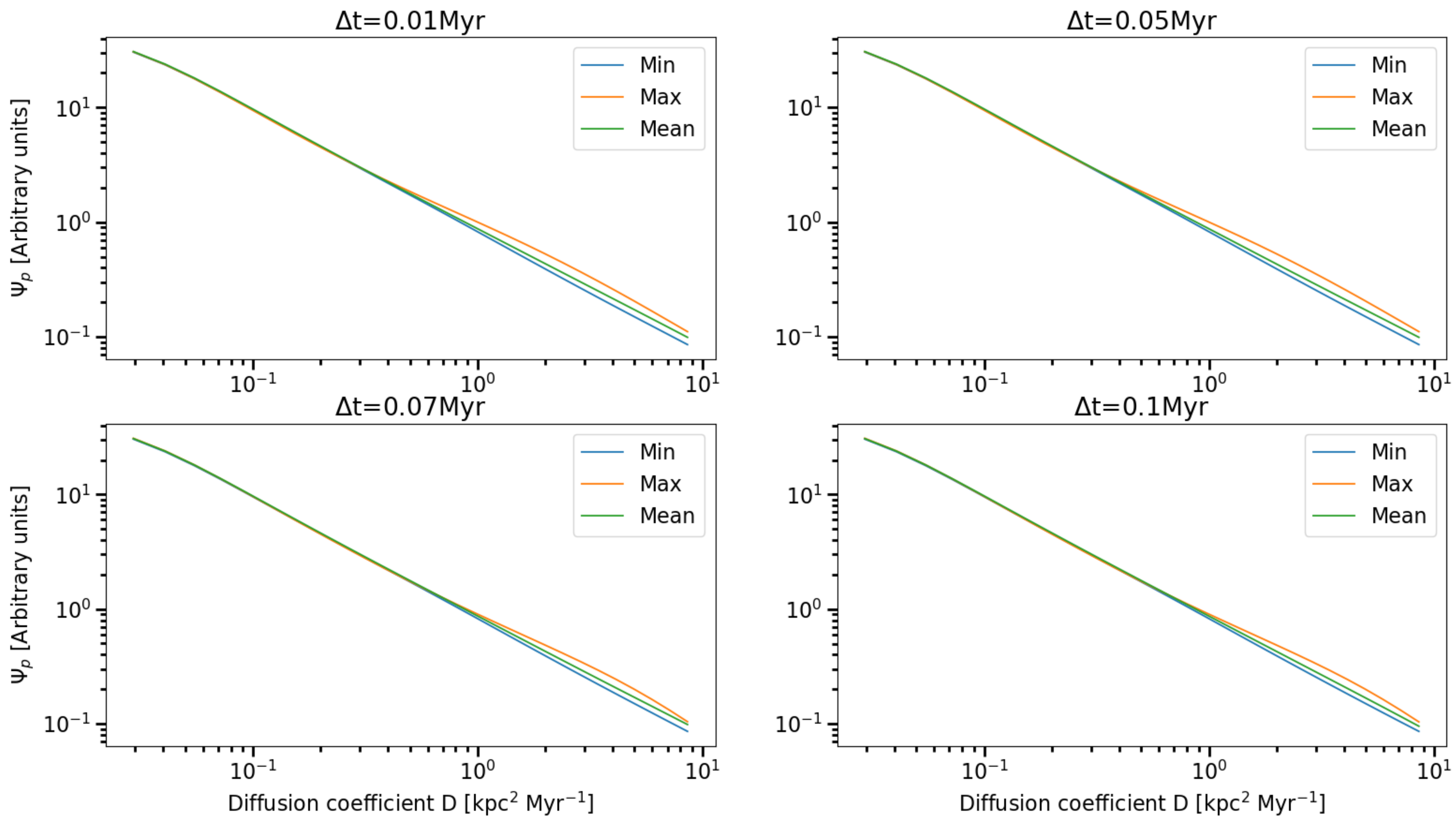
$$\Psi(r = r_\odot, z = 0, t, T) = \sum_{n=0}^{N} \Psi_G(r = r_\odot, z = 0, t - t_N, T)$$



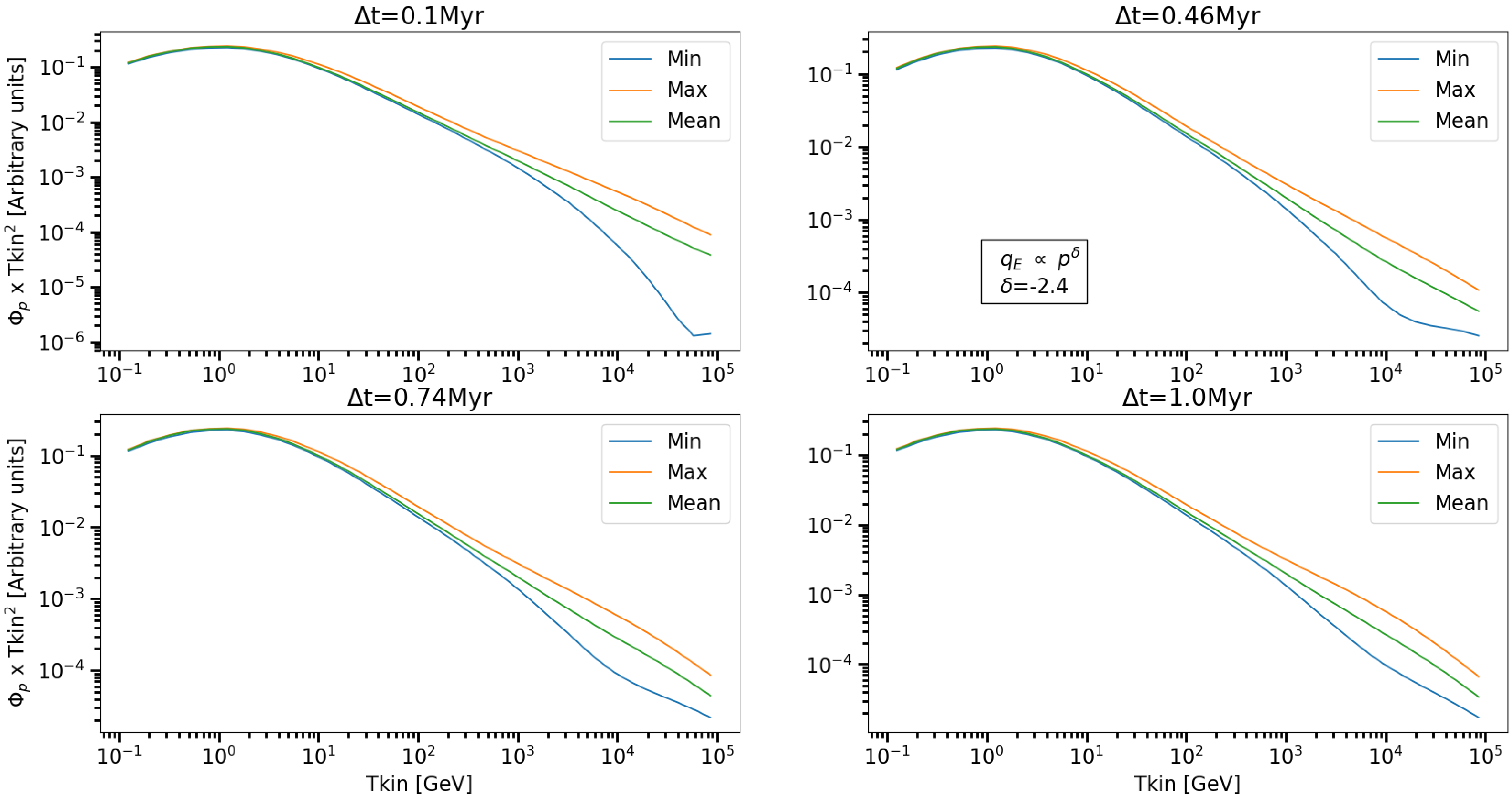

Δt=0.1Myr
Δt=0.46Myr
Δt=0.74Myr
Δt=1.0Myr
Min
Max
Mean
Ψ_p [Arbitrary units]
Diffusion coefficient D [kpc^2 Myr^{-1}]

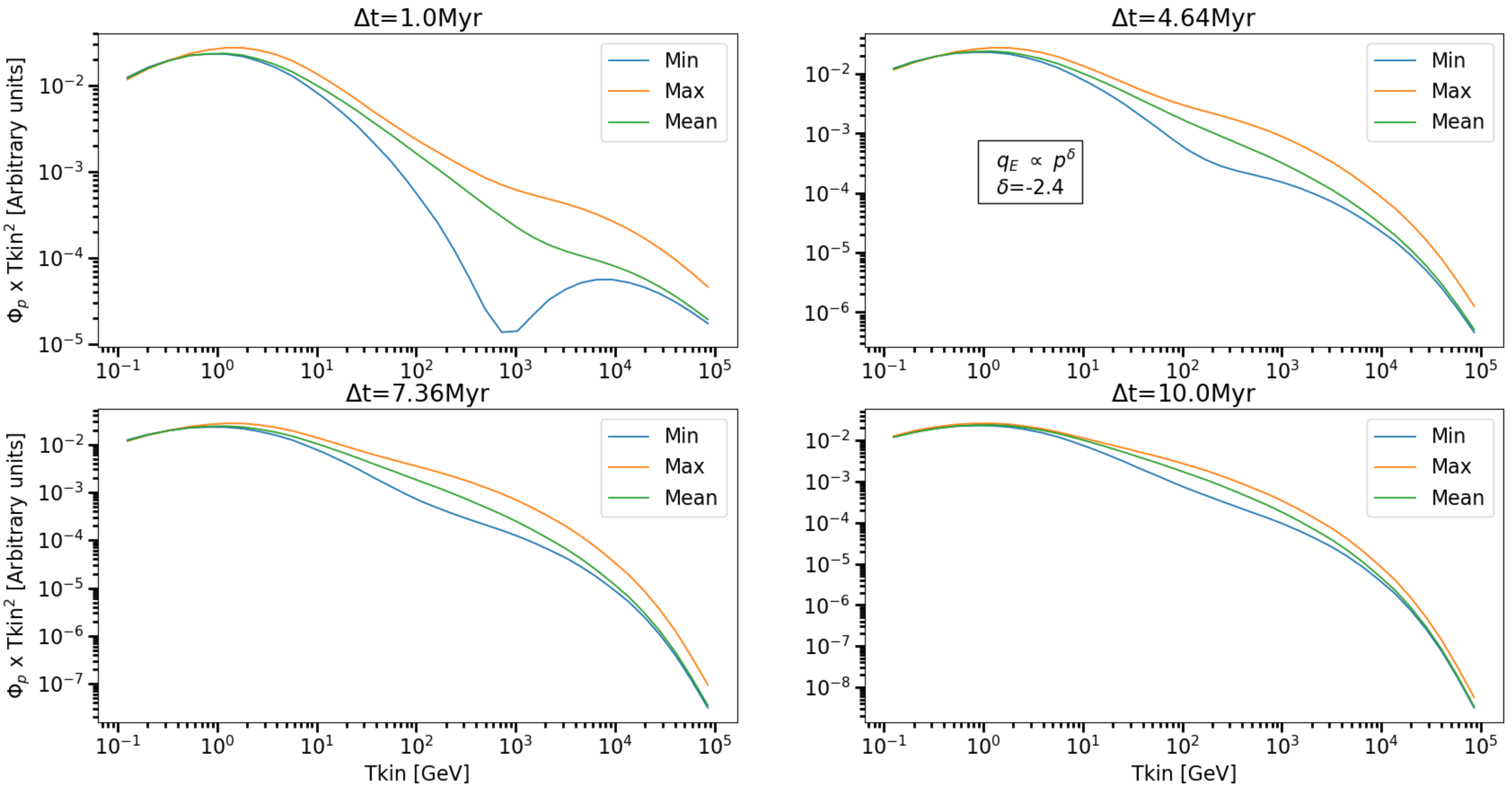


Δt=1.0Myr
Δt=4.64Myr
Δt=7.36Myr
Δt=10.0Myr
Min
Max
Mean
Ψ_p [Arbitrary units]
Diffusion coefficient D [kpc^2 Myr^{-1}]

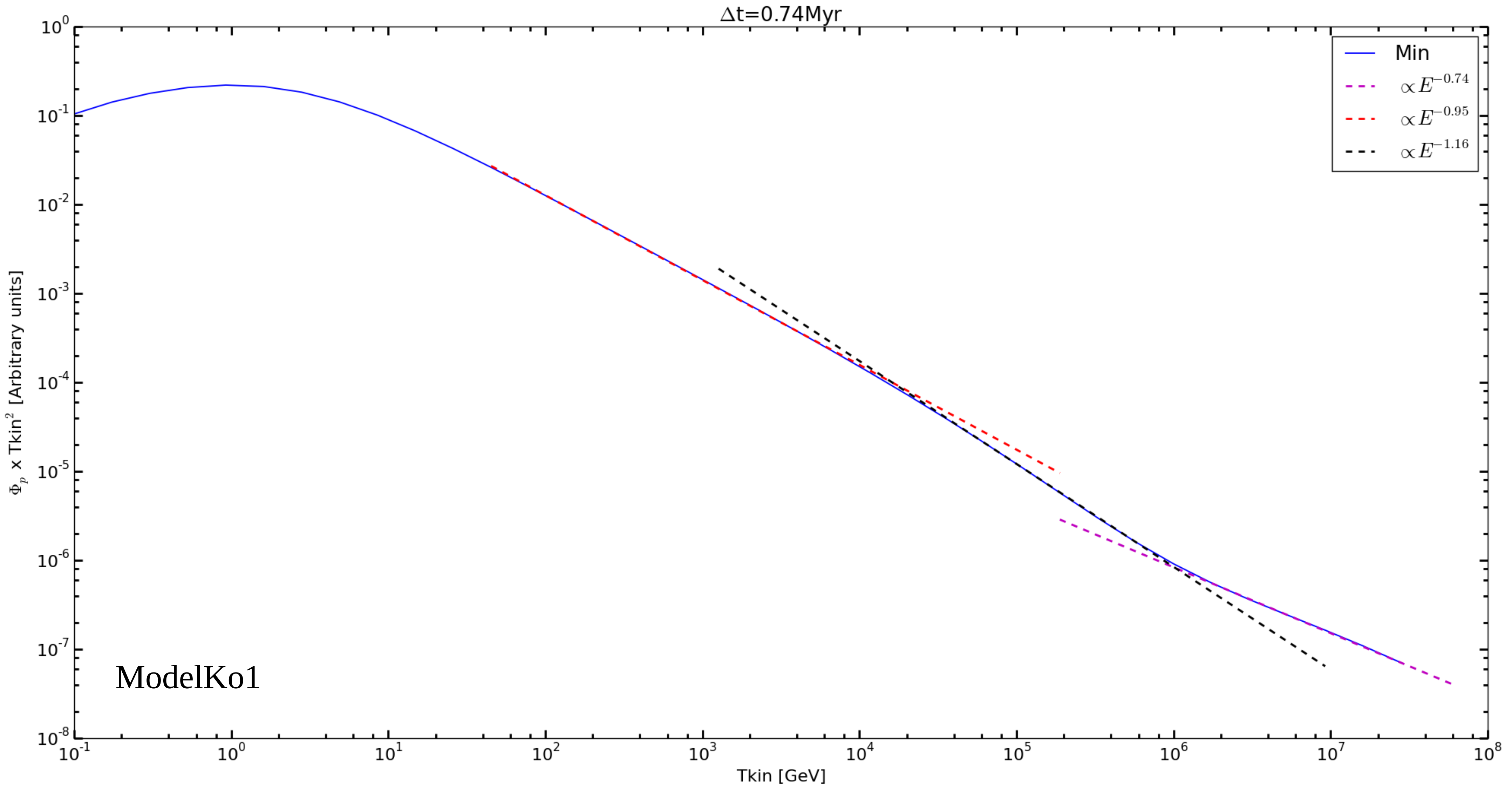


Δt=0.01Myr
Δt=0.05Myr
Δt=0.07Myr
Δt=0.1Myr
Min
Max
Mean
Ψ_p [Arbitrary units]
Diffusion coefficient D [kpc^2 Myr^{-1}]
10^{1}
10^{0}
10^{-1}

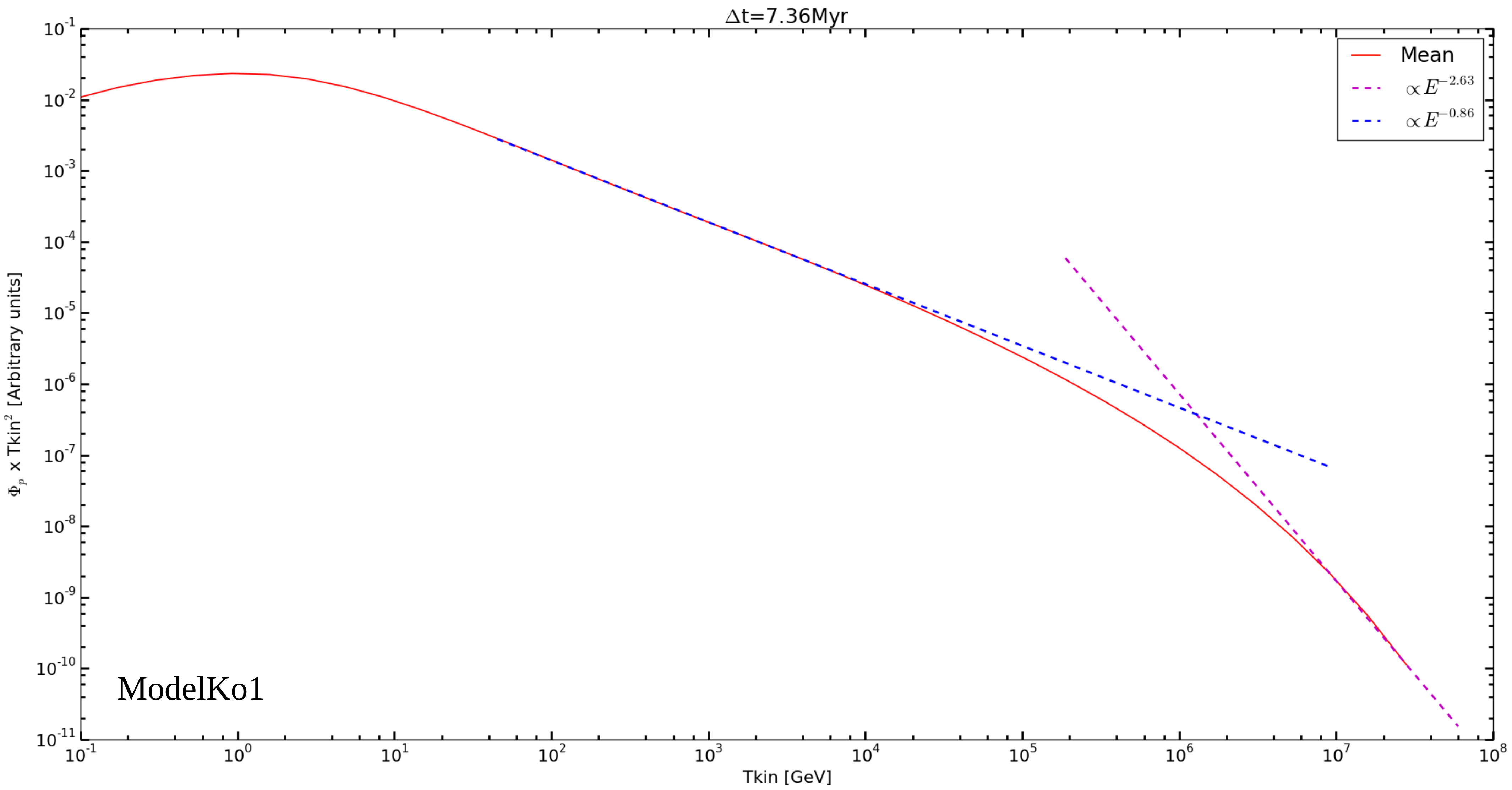

Δt=0.1Myr
Δt=0.46Myr
Δt=0.74Myr
Δt=1.0Myr
Min
Max
Mean
$q_E \propto p^\delta$
δ=-2.4
Φ_p x Tkin^2 [Arbitrary units]
Tkin [GeV]



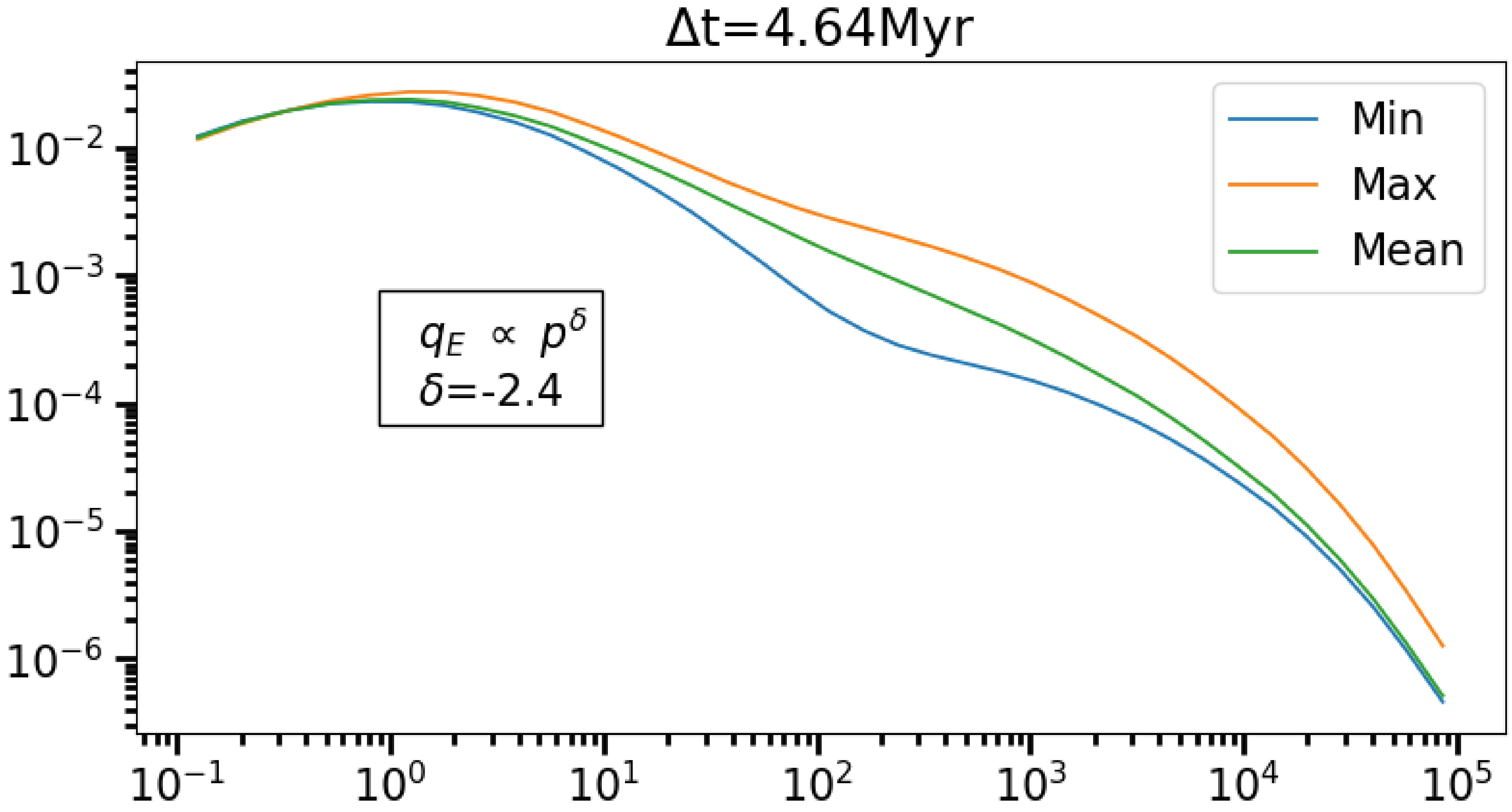
Δt=1.0Myr
Δt=4.64Myr
Δt=7.36Myr
Δt=10.0Myr
Min
Max
Mean
$q_E \propto p^\delta$
δ=-2.4
Φ_p x Tkin^2 [Arbitrary units]
Tkin [GeV]



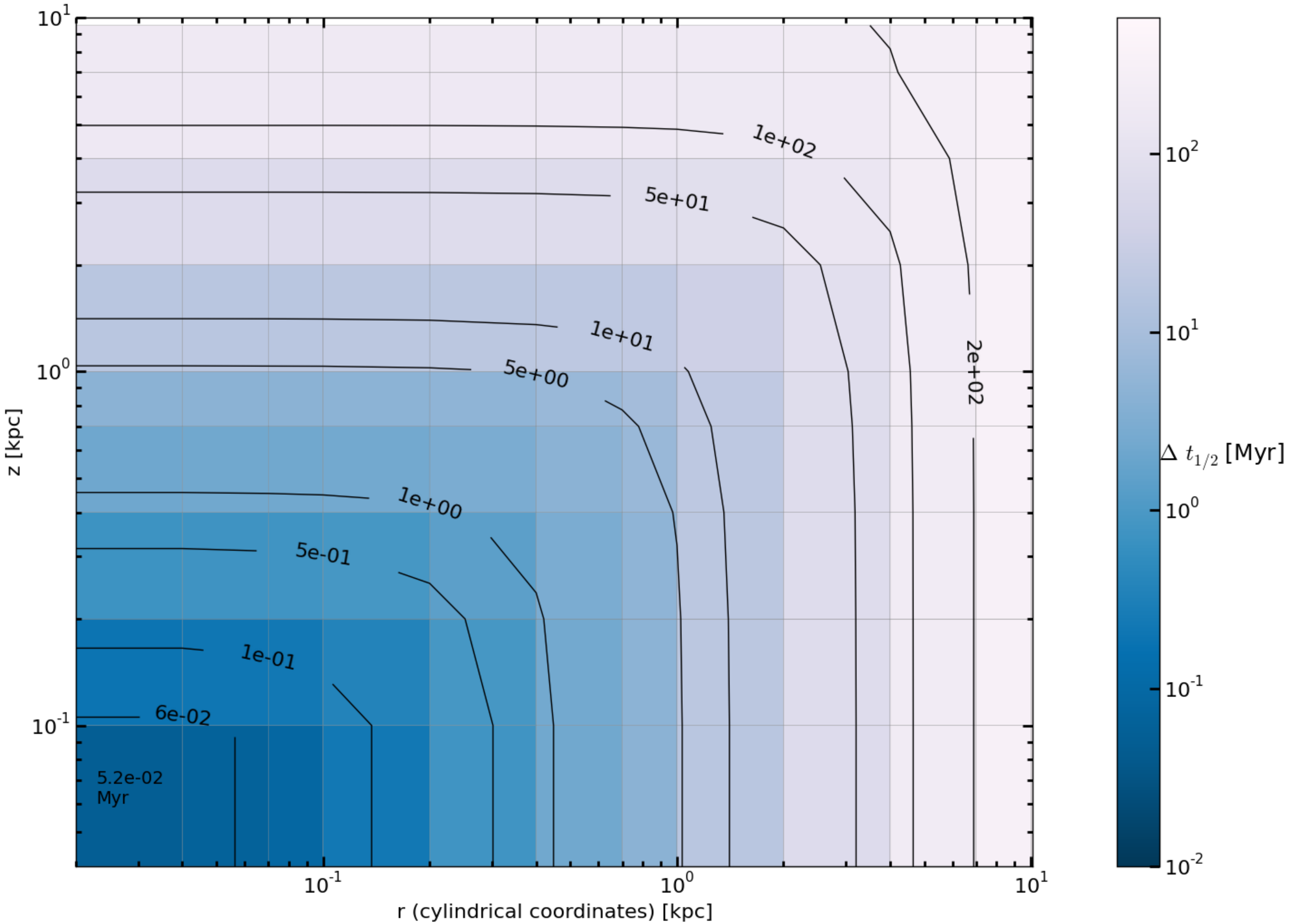
Δt=0.74Myr
Min
$\propto E^{-0.74}$
$\propto E^{-0.95}$
$\propto E^{-1.16}$
ModelKo1
Φ_p x Tkin^2 [Arbitrary units]
Tkin [GeV]
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}



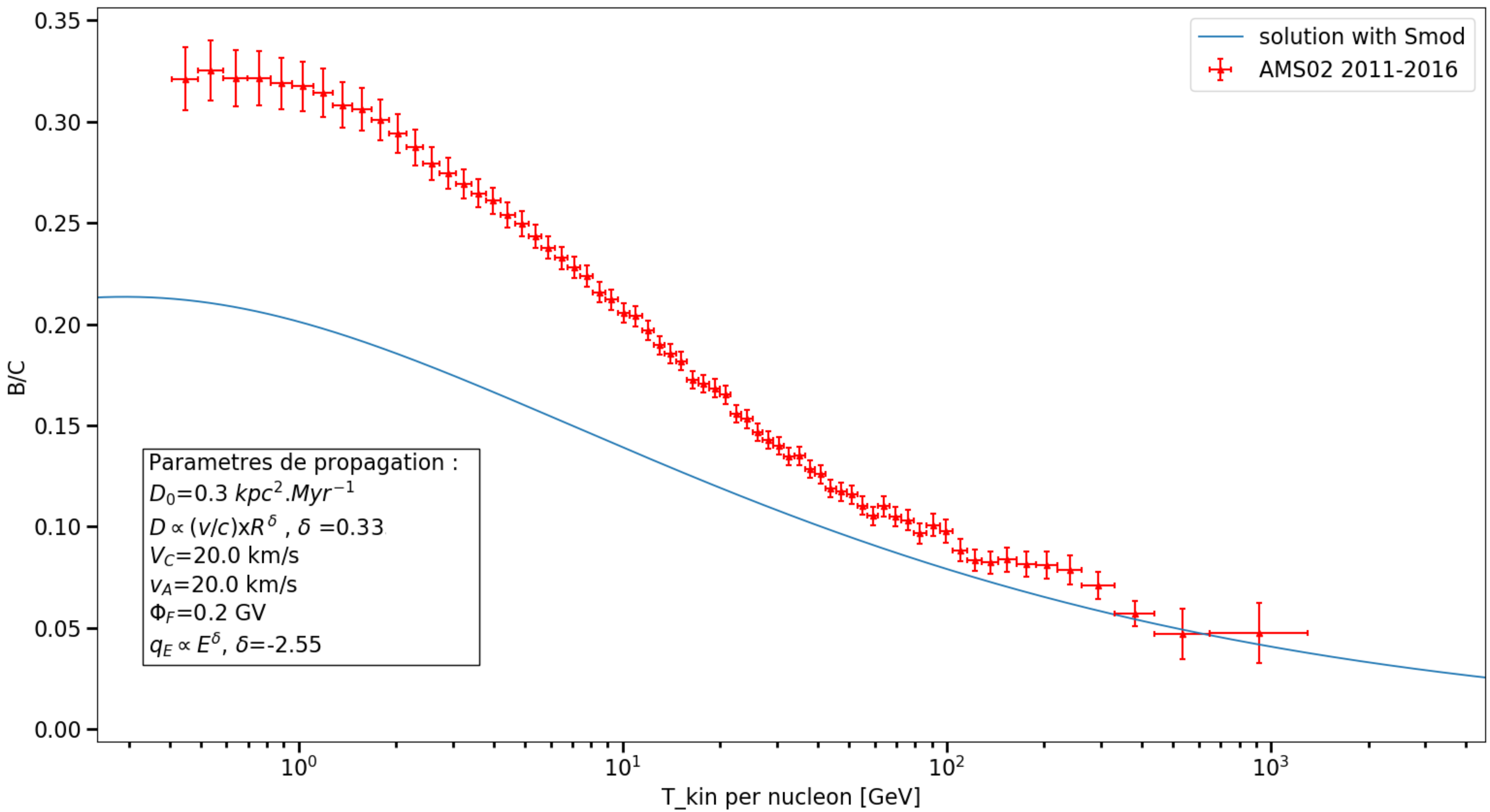
Δt=7.36Myr
Mean
$\propto E^{-2.63}$
$\propto E^{-0.86}$
Φ_p x Tkin^2 [Arbitrary units]
Tkin [GeV]
ModelKo1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}



Δt=4.64Myr
Min
Max
Mean
$q_E \propto p^\delta$
δ=-2.4
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}



1e+02
5e+01
1e+01
5e+00
1e+00
5e-01
1e-01
6e-02
2e+02
5.2e-02
Myr
z [kpc]
r (cylindrical coordinates) [kpc]
$\Delta\ t_{1/2}$ [Myr]



solution with Smod
AMS02 2011-2016
Parametres de propagation :
D_0=0.3 $kpc^2.Myr^{-1}$
$D \propto (v/c)xR^{\delta}$, δ =0.33
V_C=20.0 km/s
v_A=20.0 km/s
Φ_F=0.2 GV
$q_E \propto E^{\delta}$, δ=-2.55
B/C
T_kin per nucleon [GeV]
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10^0
10^1
10^2
10^3