Reminder on radioactive nuclei and geometry parameters

D. Maurin

A. Secondary radioactive species and L

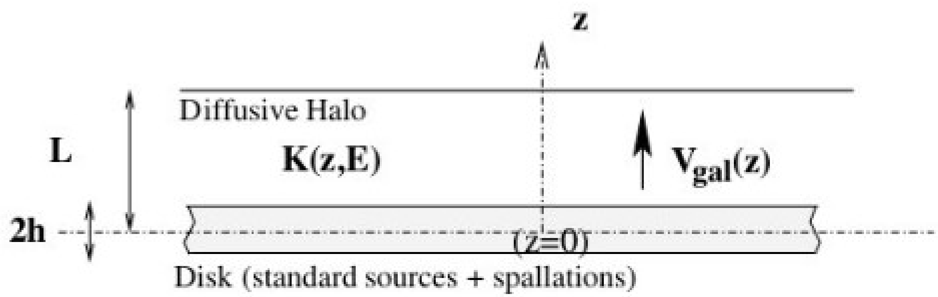
B Possible ratios to explore with ^{10}Be

C. Secondary radioactive species and LISM

D. Previous analyses

PHENOD meeting
05/07/2019

A. Secondary radioactive species and L



$$\boxed{-K\triangle_{\vec{r}}N^r + \frac{N^r}{\gamma\tau_0} = Q(r)}$$

$$N^r(r) = \int d^3r\, G(|r-r'|)\frac{Q(r)}{K} = \int d^3r\, Q(r)\frac{e^{-\lambda r}}{4\pi K r}$$

$$\lambda = 1/\sqrt{K\gamma\tau_0}$$

$$\boxed{\frac{N^r(0)}{N^p(0)} = h n_{\rm ISM} v \sigma^{p\to r}\sqrt{\frac{\gamma\tau_0}{K}}}$$

→ *Secondary radioactive species (^{10}Be, ^{26}Al, ^{36}Cl) depend on K only*

→ *Secondary stable species (e.g., B/C) depend on K/L only*

→ **Secondary rad / secondary stable (e.g., ^{10}Be/^{9}Be) fixes L!**

Contribution of ^{10}Be to ^{10}B, hence to B!

$$N^j(z) = \left\{ \varpi \cdot \frac{\sinh(S^j(L-z)/2)}{\sinh(S^jL/2)} - \nu\Theta\Lambda \cdot \frac{\cosh(S^jz/2)}{\cosh(S^jL/2)} \right\} \times \exp^{(V_c z/2K^j)}$$
$$+\Theta\left\{ \lambda \sinh\left(\frac{S^r}{2}(L-z)\right) + \Lambda \cosh\left(\frac{S^r}{2}(L-z)\right)\right\} \times \exp^{(V_c z/2K^r)},$$

where

$$\Theta \equiv -\frac{\Gamma^{k\to j}_{\rm rad}}{K^j(\lambda^2-\Lambda^2)}\,\frac{N^r(0)}{\sinh(S^rL/2)}$$

and

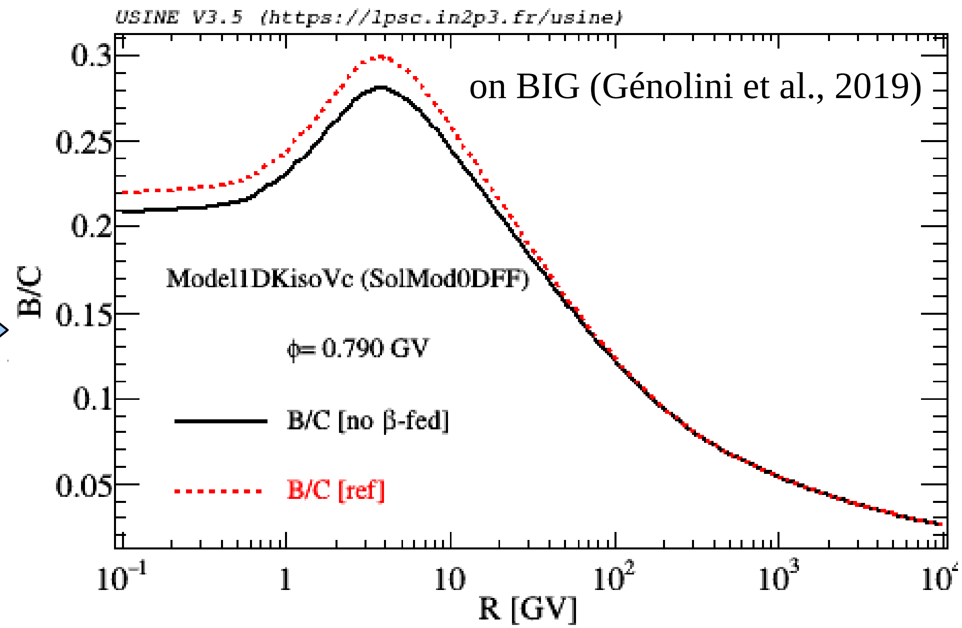
$$\varpi \equiv \frac{2hQ^j_{\rm disc}}{A^j} + \frac{\Theta}{A^j} \times \left\{ \frac{\nu a_i}{\cosh(S^jL/2)}\left[V_c + 2h\Gamma^j\right] - \sinh(S^rL/2)\left[a\left(V_c\left(2-\frac{K^j}{K^r}\right)+2h\Gamma^j\right)+a_iK^jS^r\right] - \cosh(S^rL/2)\left[a_i\left(V_c\left(2-\frac{K^j}{K^r}\right)+2h\Gamma^j\right)+aK^jS^r\right]\right\}$$

where

$$\kappa \equiv 1/K^r - 1/K^j$$

$$\nu \equiv e^{\kappa V_c L/2} \quad \Lambda \equiv \kappa\frac{S^rV_c}{2} \quad \lambda \equiv \frac{\kappa V_c^2}{2K^r} + \frac{\Gamma^r_{\rm rad}}{K^r} - \frac{\Gamma^j_{\rm rad}}{K^j}.$$

`./bin/usine -e ... (with suboption E2)`



~5% effect

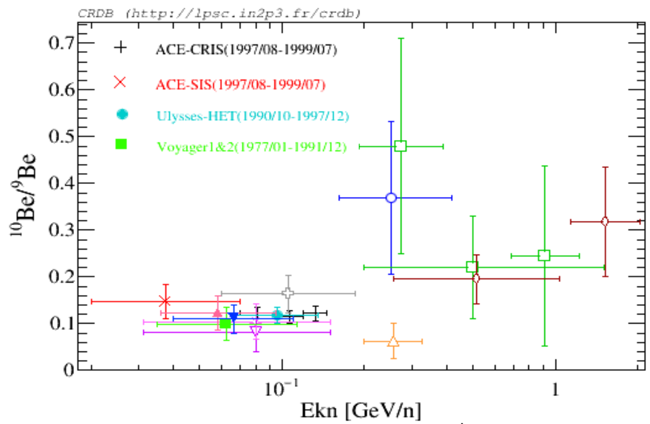
→ not sufficient to constrain L

→ degenerate with other transport parameters?

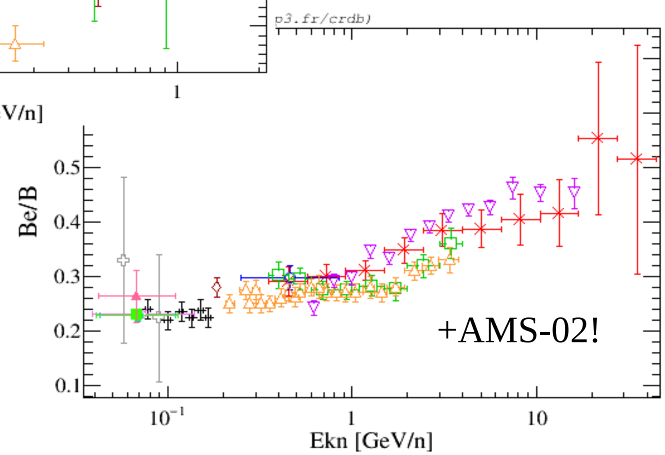
B. Possible ratios to explore with ^{10}Be

From most to least optimal secondary ratios

^{10}Be/^{10}B progenitor/daughter isotopes no data



^{10}Be/^{9}Be ’same’ production



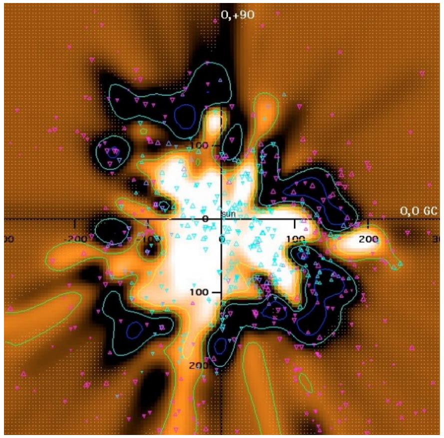
Be/B progenitor/daughter elements
[Ptuskin & Soutoul, A&A 337, 859 (1998)]

B/C … see previous slide

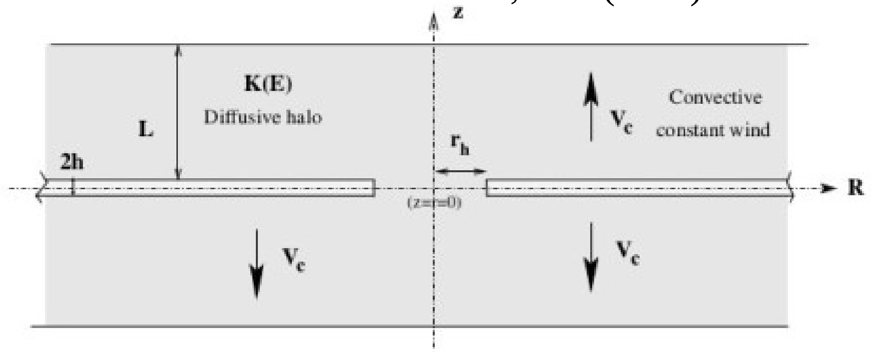
→ See Gilles’ slides for quantitative assessment
→ See Nathanael’s slides for preliminary fits on data

C. Secondary radioactive species and LISM

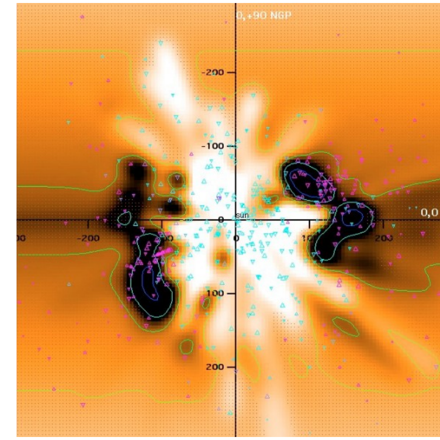
Welsh et al., A&A 510, A54 (2010)



Donato et al., A&A 381, 539 (2002)
Putze et al. A&A 516, A66 (2010)



Welsh et al., A&A 510, A54 (2010)



See also
Capitanio et al., A&A 606, A65 (2017)

$$N^r(r) = \int d^3r\, G(|r - r'|)\frac{Q(r)}{K} = \int d^3r\, Q(r)\frac{e^{-\lambda r}}{4\pi K r}$$

$$\boxed{\kappa \equiv \frac{N_{r_h}}{N_{r_h=0}} = \exp\left(\frac{-r_h}{\sqrt{K\gamma\tau_0}}\right)}$$

	τ_0 (Myr)	$l_{\rm rad}$ (pc)	κ
^{10}Be	2,17	351	0,57
^{26}Al	1,31	273	0,48
^{36}Cl	0,443	159	0,28
^{54}Mn	2,9	406	0,61

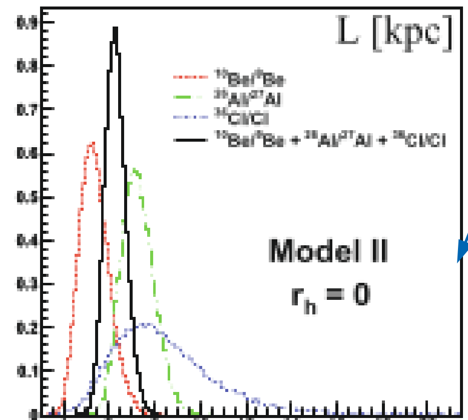
→ Exponential attenuation of fluxes w.r.t. ‘no hole’ (i.e. no LISM)

→ New degeneracy between K and r_h

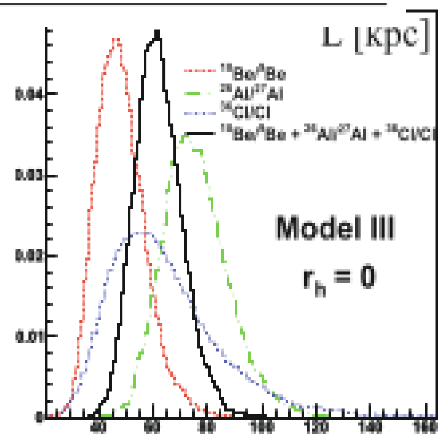
D. Previous analyses

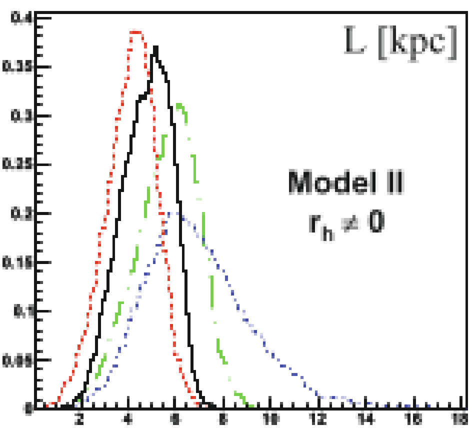
Putze et al. A&A 516, A66 (2010)

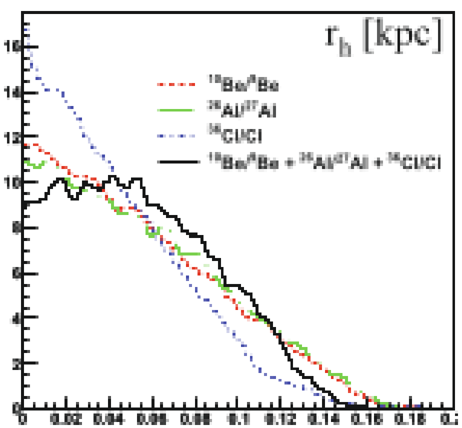
Model Data	$K_0^{\rm best} \times 10^2$ (kpc^2 Myr^{-1})	$\delta^{\rm best}$	R_0 (GV)	$V_a^{\rm best}$ (km s^{-1})	χ^2/d.o.f.
II-F	5.26	0.38	…	65.1	1.78
III-F	4.19	0.43	2.94	53.9	1.56

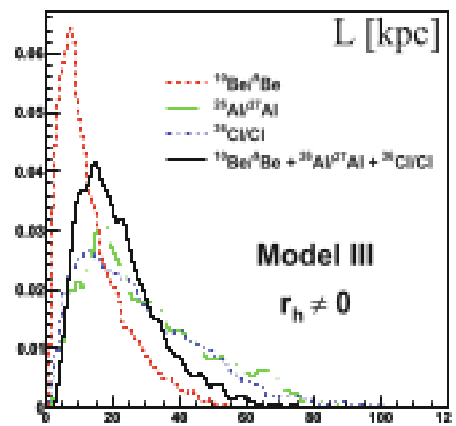


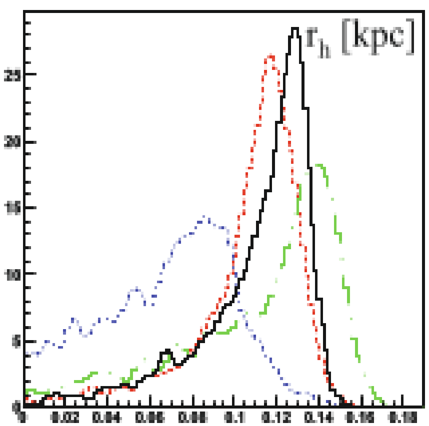
vs











→ Constraints strongly depends on models

→ **To repeat with BIG/SLIM/QUAINT (other ideas/improvements?)**