Formation of the Sun in a dense collected shell
Implications for prebiotic chemistry

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In what kind of astrophysical environment did the Sun (and planets) form ?
Cluster size
Genealogy
Relationship with massive stars

A unique way to travel back in time

Short-lived radionuclides (SRs)

Chondrites contained short-lived radionuclides whose half-life (< 100 Myr) is shorter than the age of the Solar System

They have entirely decayed: they are now extinct

e.g. $^{26}Al \rightarrow {}^{26}Mg + e^{+} + \nu_e (+ \gamma)$

(β^{+}, $T_{1/2}$ = 0.74 Myr)

A stellar origin for ^{26}Al

Which star(s) ?

Incorporation in what phase ?

Timing ?

Will tell us about the astrophysical context of our Sun's birth

The classical single supernova model

The classical model is the injection by a single SN in a dense core (Cameron & Truran 1977; Boss et al. 2010; Gritschneder et al. 2012) or in a disk (Hester et al. 2004; Ouellette et al. 2007)

The Supernova Trigger for Formation of the Solar System

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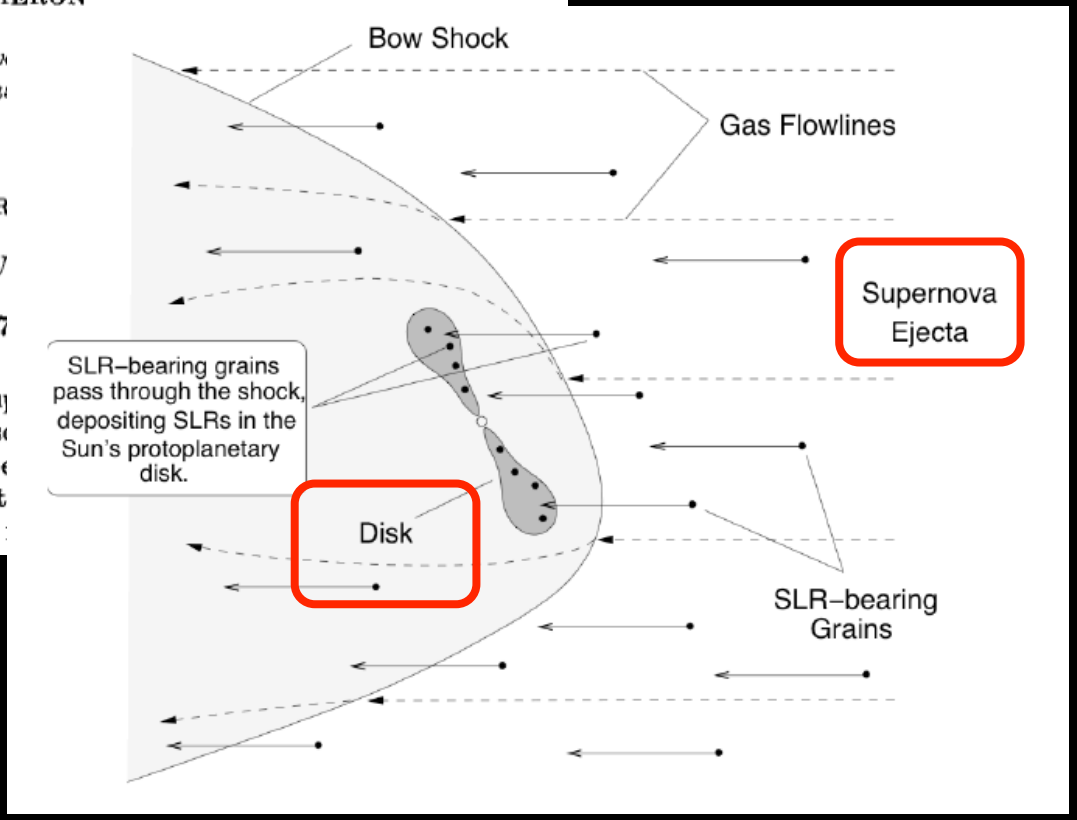
Received July 27

It is suggested that the explosion of a Type II su
interstellar cloud and led to the formation of the s
resulting from nuclear processing of the supernova
that nucleosynthesis in this single supernova event
and traces of extinct radioactivities in solar system



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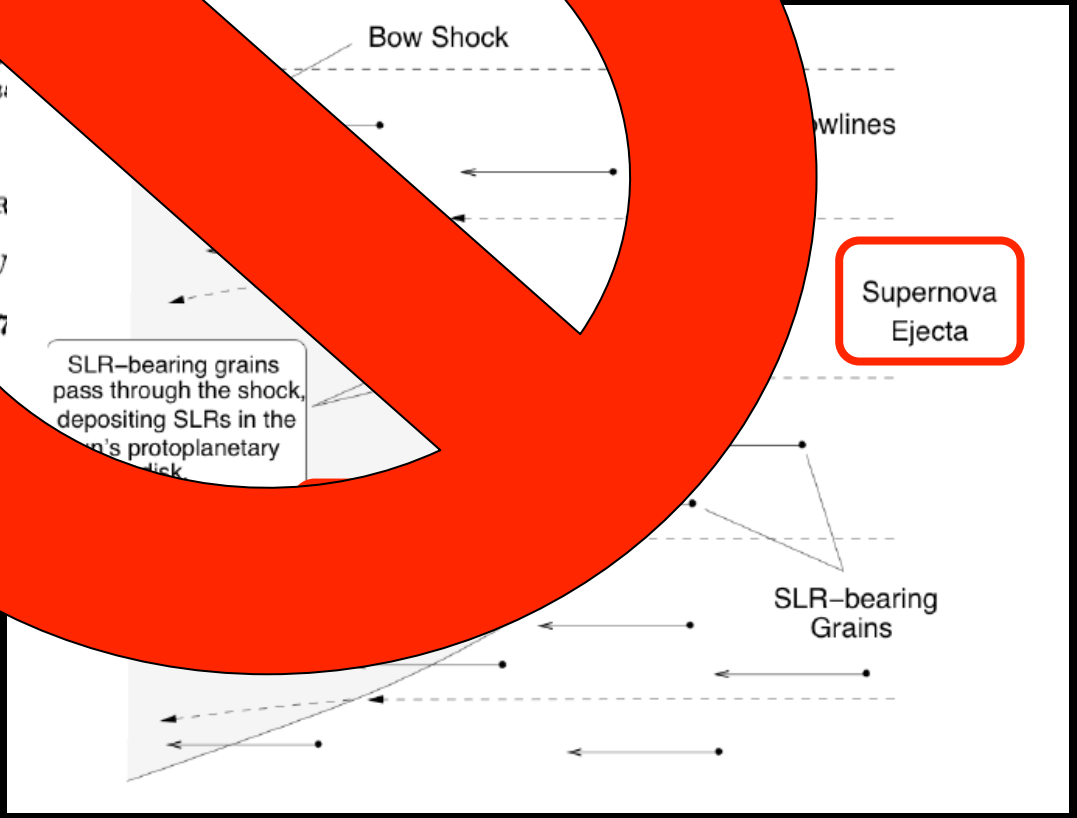
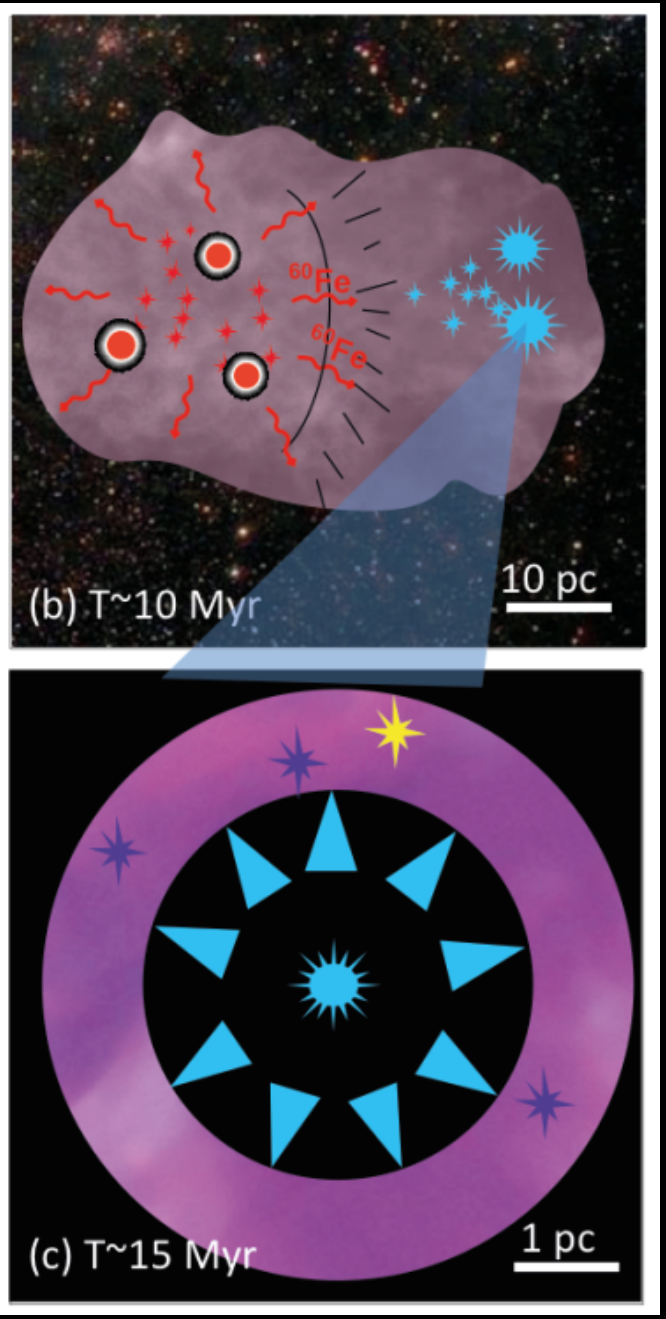
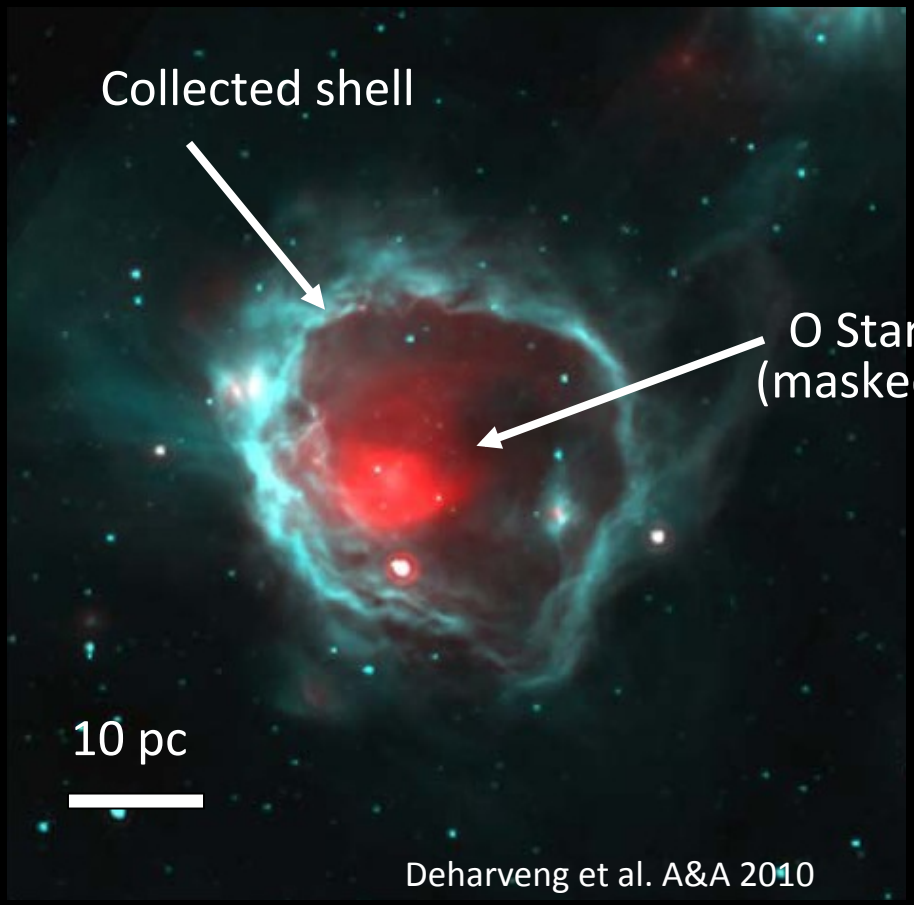


^{26}Al in a collected shell





^{26}Al from the wind of ONE massive star delivered into a collected shell which collapses after a few Myr

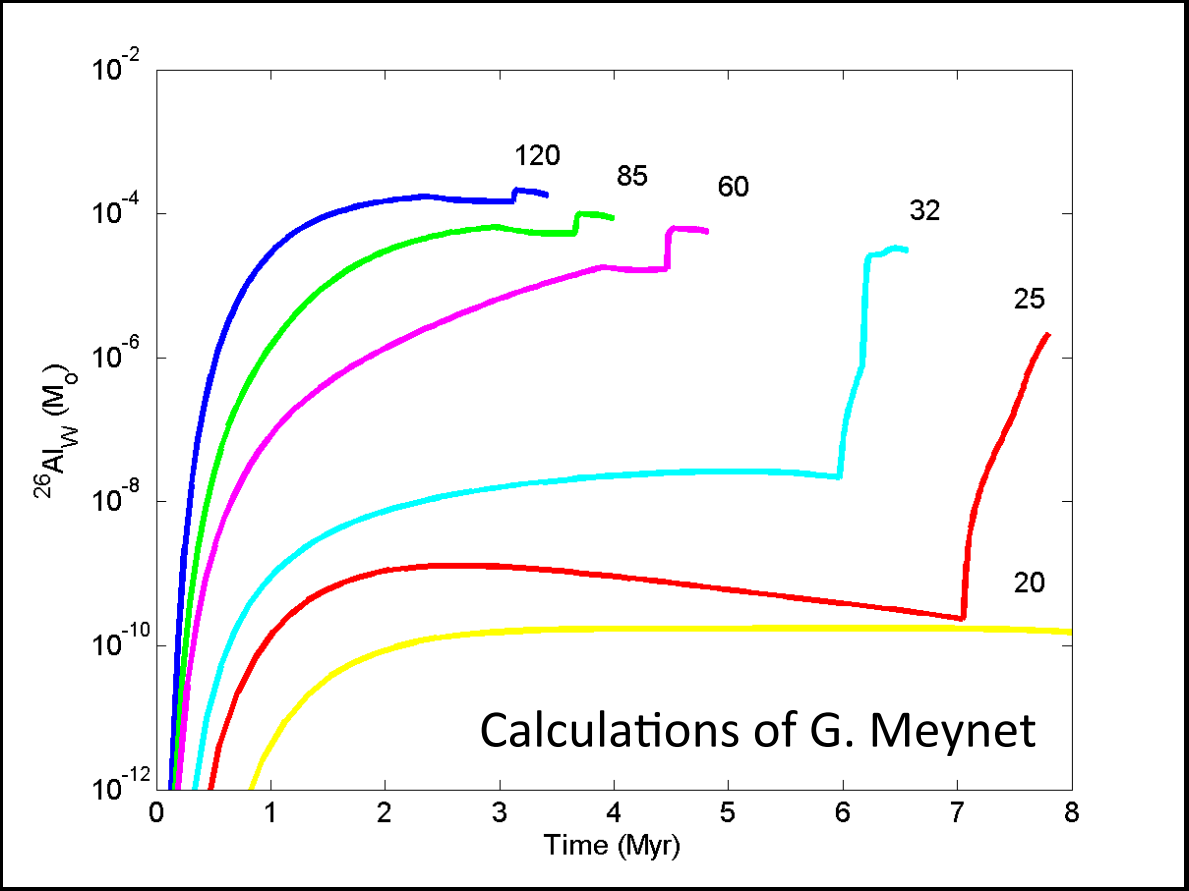
The Sun formed in that shell

Gounelle & Meynet, A&A 2012

^{26}Al yields of rotating massive stars

Calculations for a suite of stellar masses (Z = 0.014)

- ★ Rotation taken into account
- ★ Improved mass loss rate
- ★ Based on new solar abundances (Asplund et al. 2009)



Constraints on the cluster size 1

★ To deliver enough ^{26}Al, the central massive star needs to be massive enough ($M > 32\ M_{\odot}$)

The generation #2 cluster should be large enough to contain at least one star more massive than 32 $M_{\odot}$

Constraints on the cluster size 2

★ If too many second massive stars, an open superbubble forms and ^{26}Al is likely to leak out (Güdel et al. 2008)

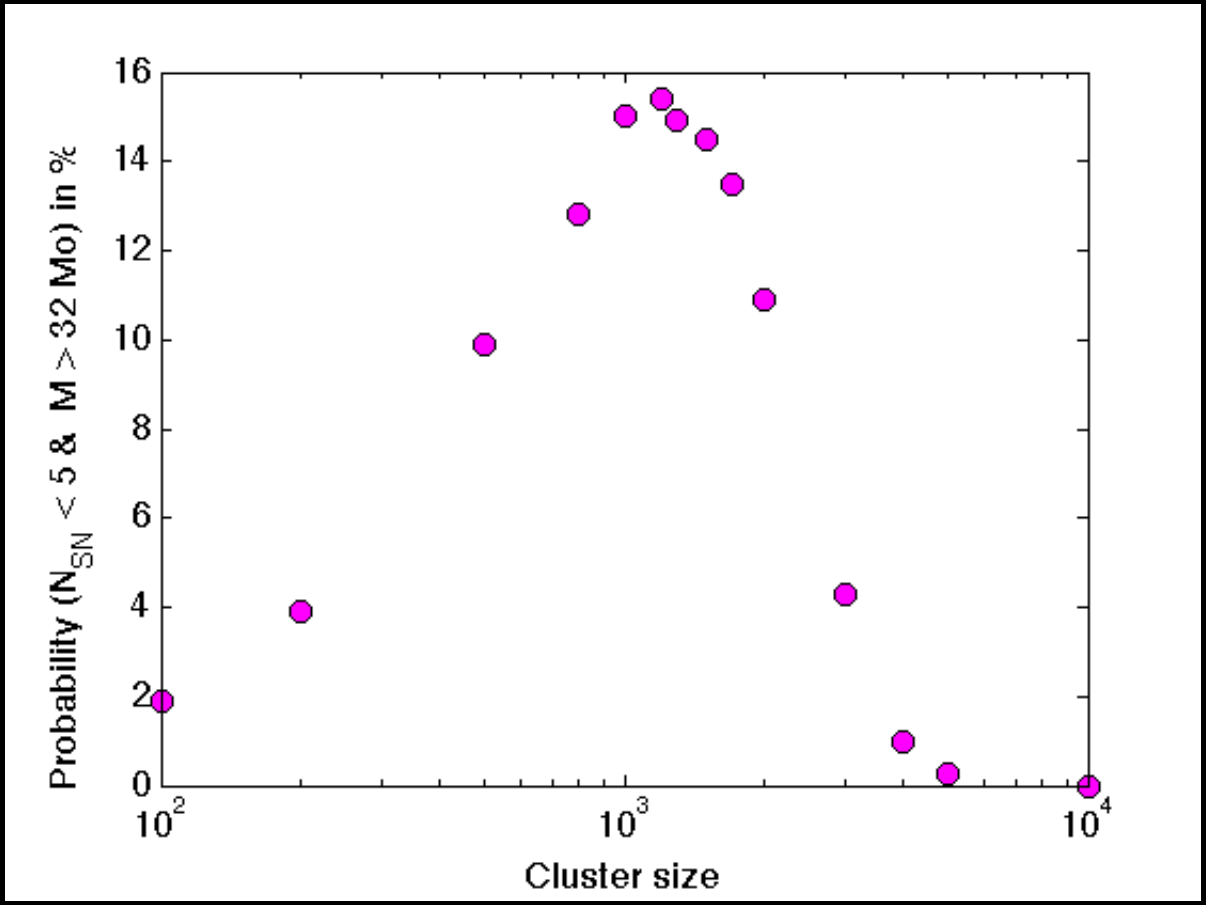
★ Superbubbles occur when the number of massive stars is larger than 5 (Higdon & Lingenfelter 2005)

The generation #2 cluster should be small enough
so that the total number of massive stars is below 5

Constraints on the cluster size

$P[N(M > 8\ M_{\odot}) < 5\ \&\ M > 32\ M_{\odot}]$

Sampling the IMF 10000 times for each point



Most likely cluster source ~ 1200 stars

The Sun formation environment

- ★ The Sun was born in a collected shell with 600 fellow stars
- ★ It was 5-10 pc from a massive O star
- ★ The massive star was born with 1200 other stars
- ★ The forming solar system was therefore exposed to a flux of UV from the massive star

Gounelle & Meynet, A&A 2012

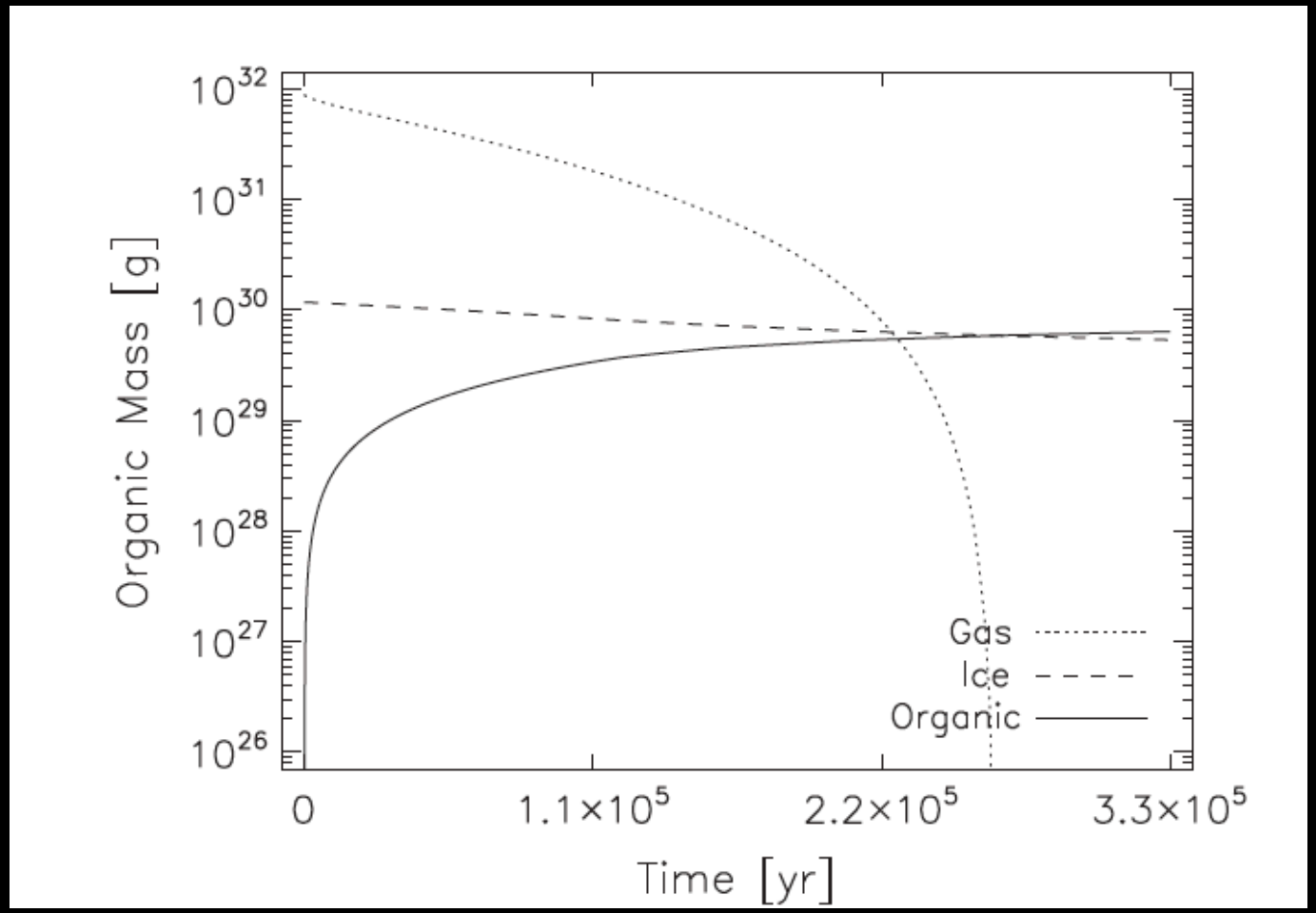
Implications

Synthesis of organic matter (Throop 2011)

Generation of enantomieric excesses (Fukue et al. 2010)

Change of the dust/gas ratio of the disk

Synthesis of organic matter



Throop 2011

Conclusions

- ★ The Sun formation environment is known
- ★ It was nearby (5-10 pc) a massive star
- ★ This has important implications that should be investigated

Gounelle & Meynet, A&A 2012