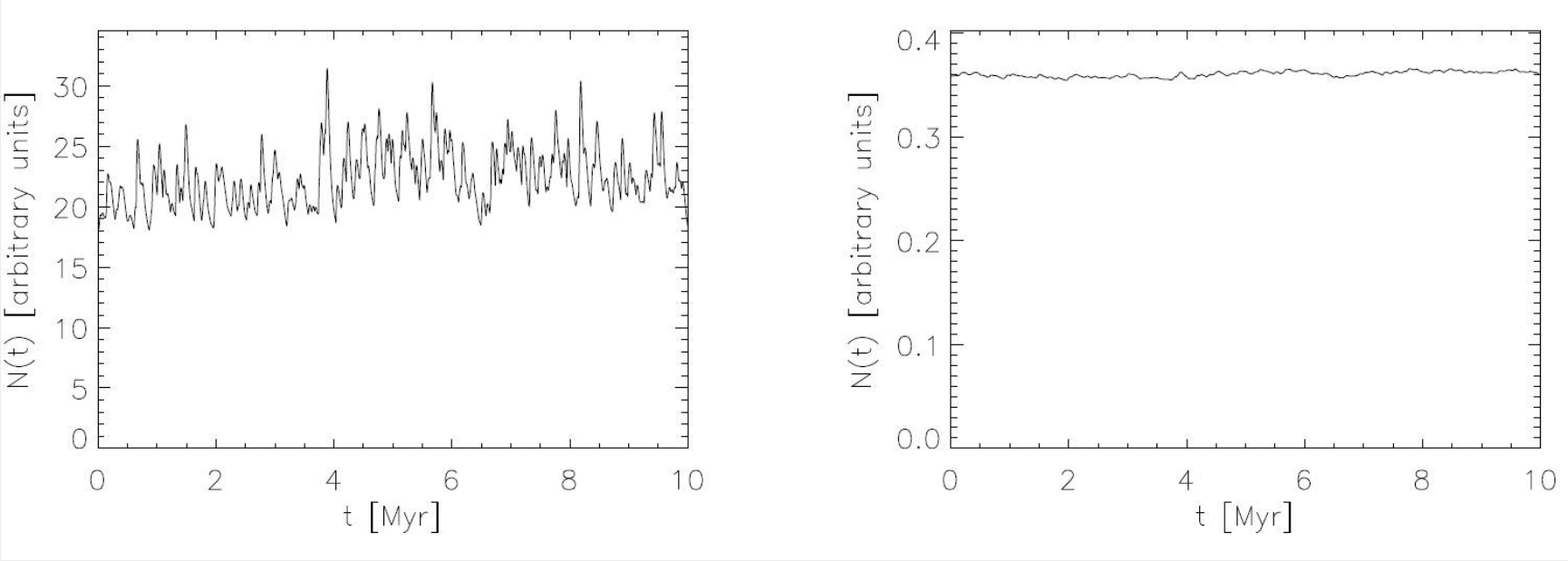
Searching for signatures of nearby sources of Cosmic rays in their local chemical composition

I. Büsching
D. Bisschoff and M.S. Potgieter

Cosmic Rays and the Heliospheric Plasma Environment
September 12th 2011

Motivation

Results from 3D, time depended diffusion calculations:



Primary 12 C (left) and secondary 11 B (right) @10 GeV/nuc (see e.g. Büsching et al. 2005)

Motivation cont.

If CRs are accelerated at point-like sources (SN + SNR)

- CR Primary flux - depends on local source history
- CR Secondary flux - depends not on local source history
- 2D propagation models can’t include local source history but should describe CR secondaries well

- Fitting secondary CR fluxes with a 2D steady state model should result in a good fit

- 2D steady state models cannot describe transient point sources, primary data should not be fitted that well

Parameter Study

Idea: separate parameter studies for

- Secondary data (secondary fraction > 70%)
- Primary data (secondary fraction <30%)
- Mixed data (30% < secondary fraction <70%)

as only secondary data may be described adequately by 2D steady state diffusion models

Parameter Study

- GALPROP 2D steady state plain diffusion model
- MPI-wrapper for comprehensive parameter studies
- Modulation treated with Force Field model with the force filed parameter depending on the time of measurement in the solar cycle
- Data is divided into three groups:
  mainly primary, mainly secondary, mixed

Parameter Study

- Parameter space k_0, δ, α
- Plain diffusion model

Parameter	Min	Max	Units
k_0	0.5	5.0	$10^{28}\,\mathrm{cm}^2\mathrm{s}^{-1}$
δ	0.1	1.0	
α	1.50	3.50	

- 3 CR component groups
- Pri, Mix, Sec CRs

Component	% Secondary CR fraction
Primary	< 30 %
Mixed	> 30 %, < 70 %
Secondary	> 70 %

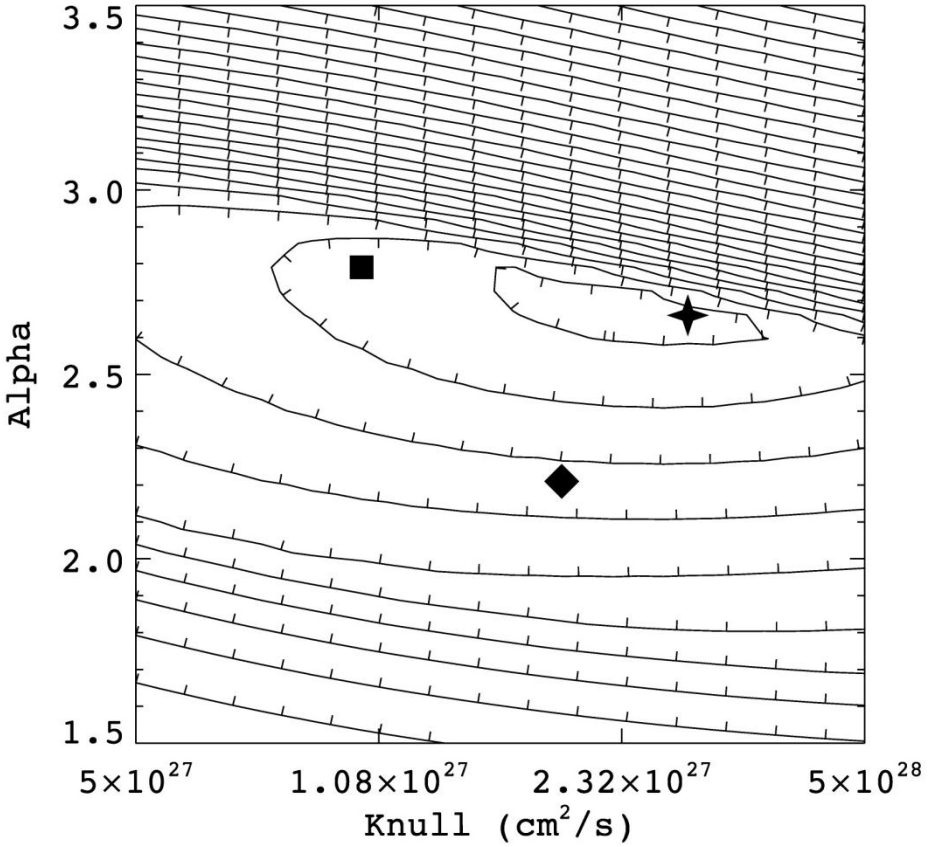
- χ^2 test comparing models to data above 4 GeV
- Database maintained by Strong & Moskalenko
  - » http://www.mpe.mpg.de/~aws/propagate.html

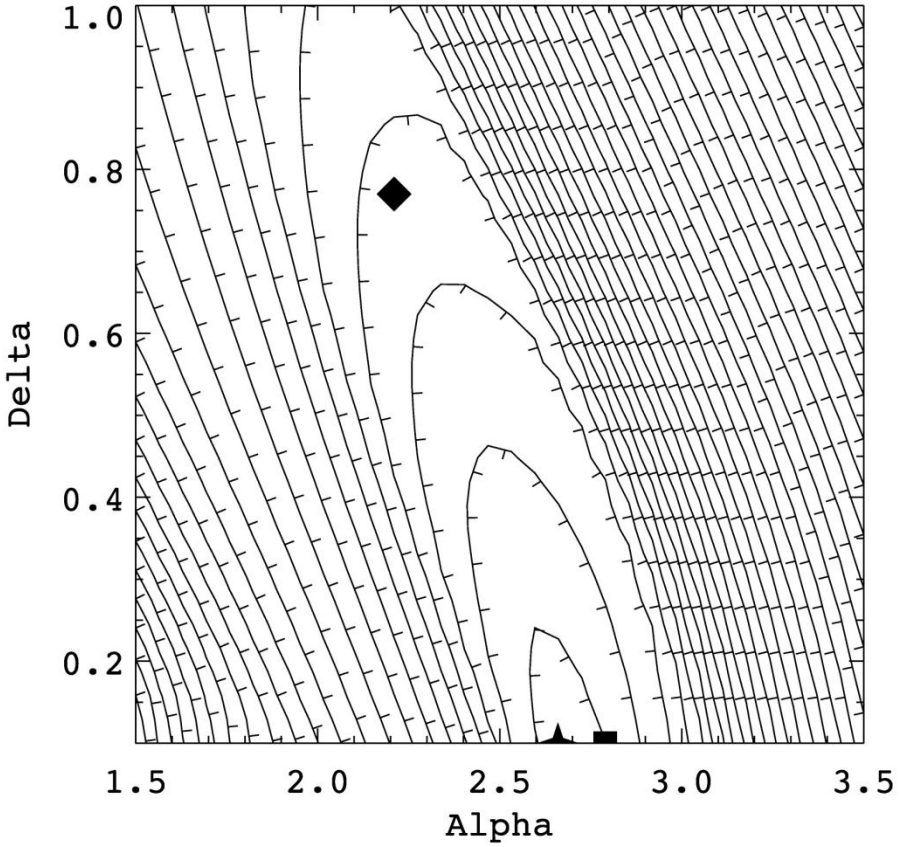
Results

- Best fit models and parameter values found:

Parameter	Primary	Mixed	Secondary	Units
k_0	2.868	1.022	1.928	$10^{28}\,\mathrm{cm}^2\mathrm{s}^{-1}$
δ	0.100	0.100	0.767	
α	2.661	2.661	2.210	

- Contours of minimum χ^2 also differ between Primaries and Secondaries





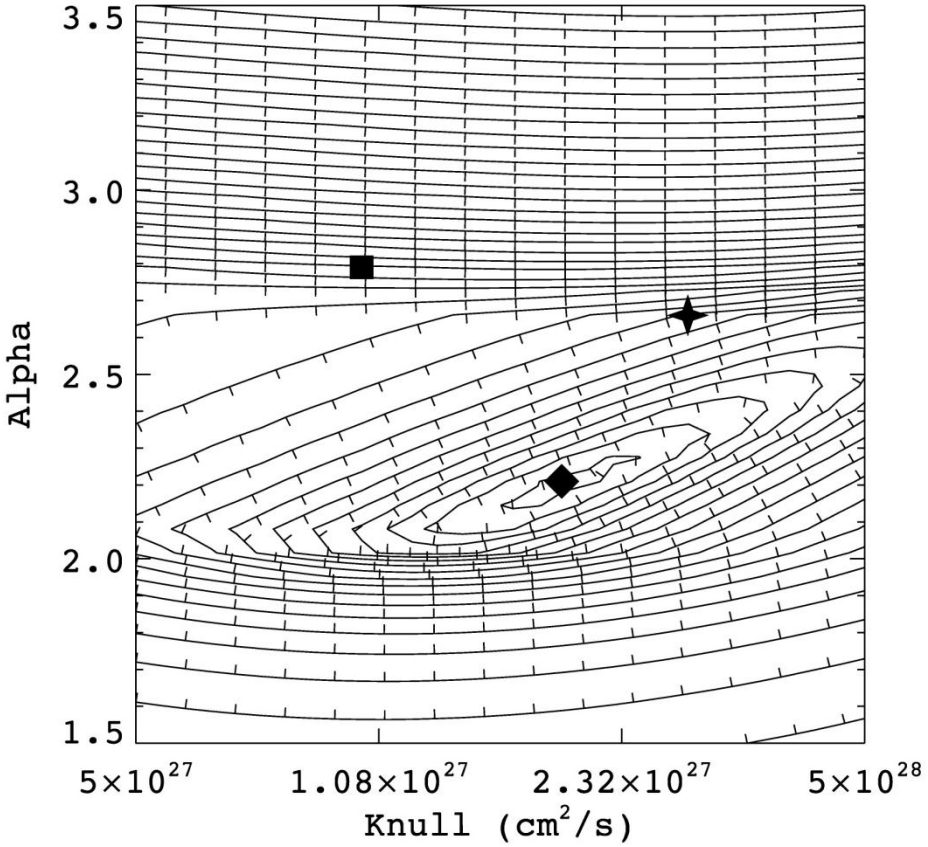
Minimum χ^2 values in the $\alpha - k_0$ and $\delta - \alpha$ planes for

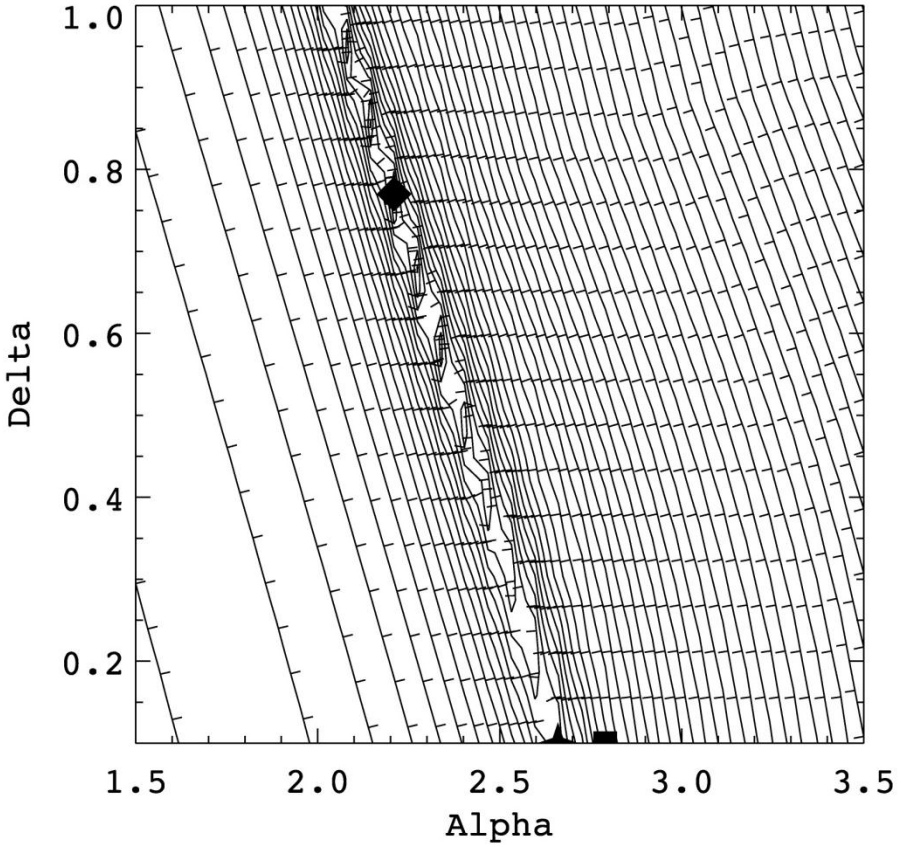
CR Primaries

✦: Primaries best fit model

■: Mixed best fit model

◆: Secondaries best fit model





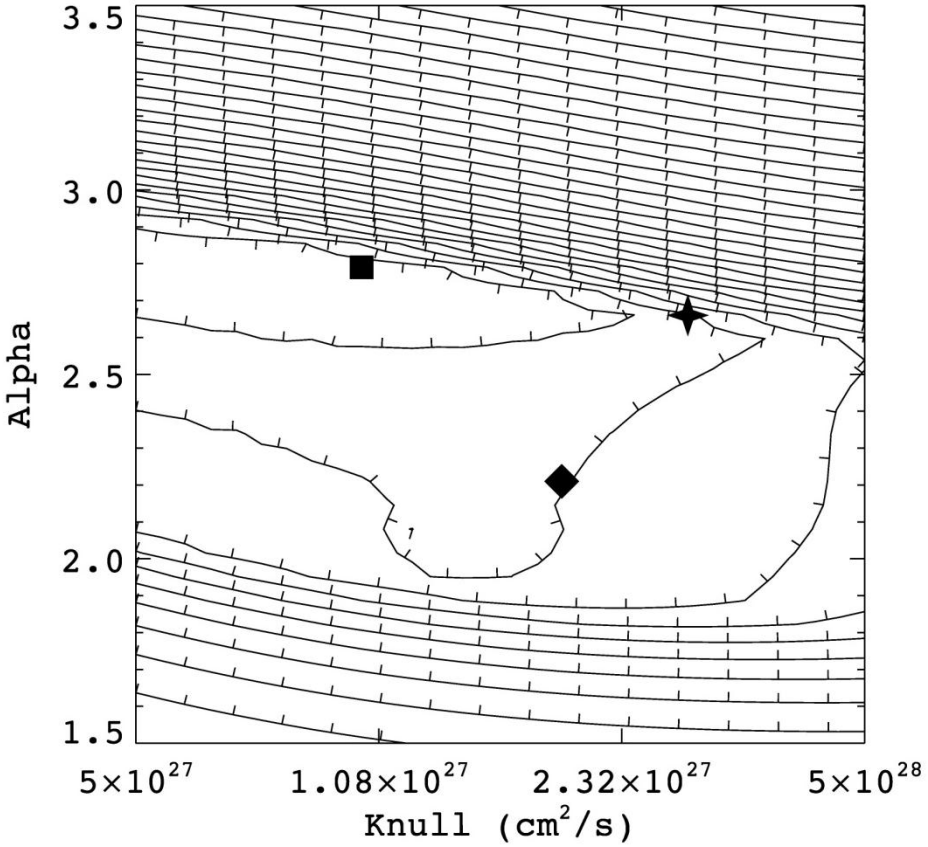
Minimum χ^2 values in the $\alpha - k_0$ and $\delta - \alpha$ planes for

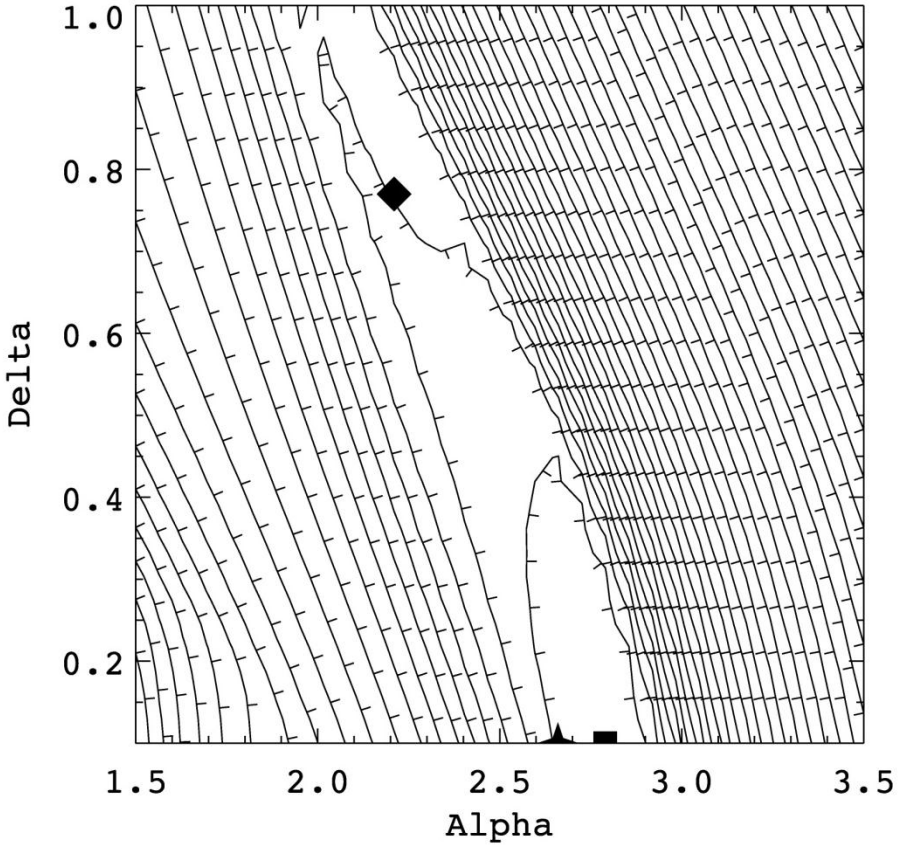
CR Secondaries

✦: Primaries best fit model

■: Mixed best fit model

◆: Secondaries best fit model





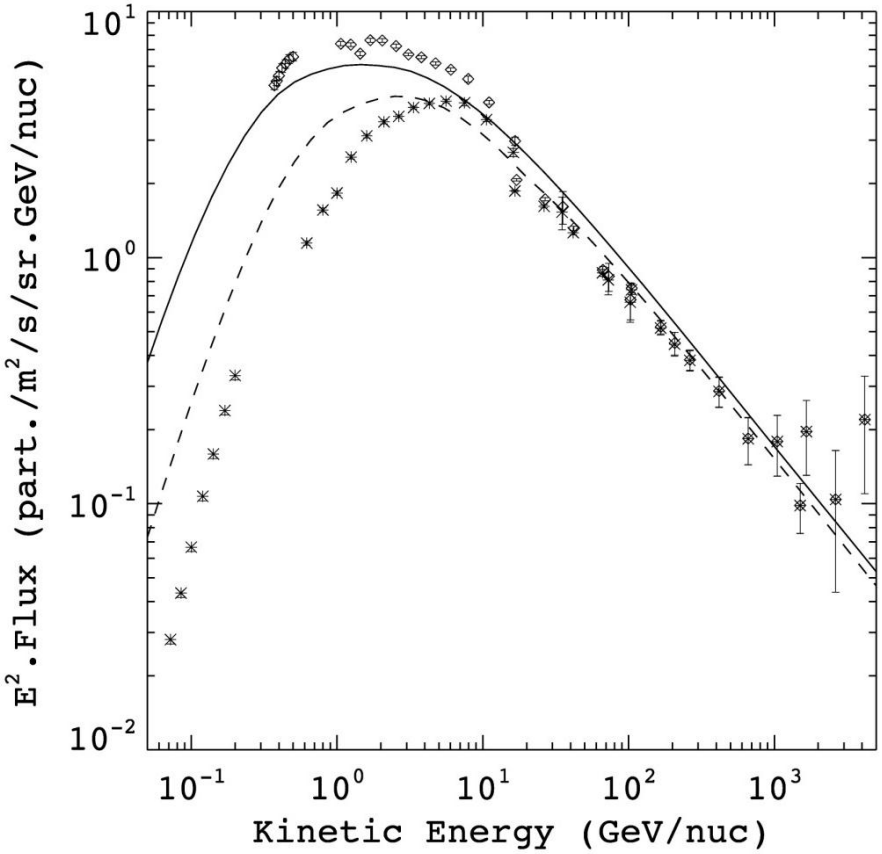
Minimum χ^2 values in the $\alpha - k_0$ and $\delta - \alpha$ planes for

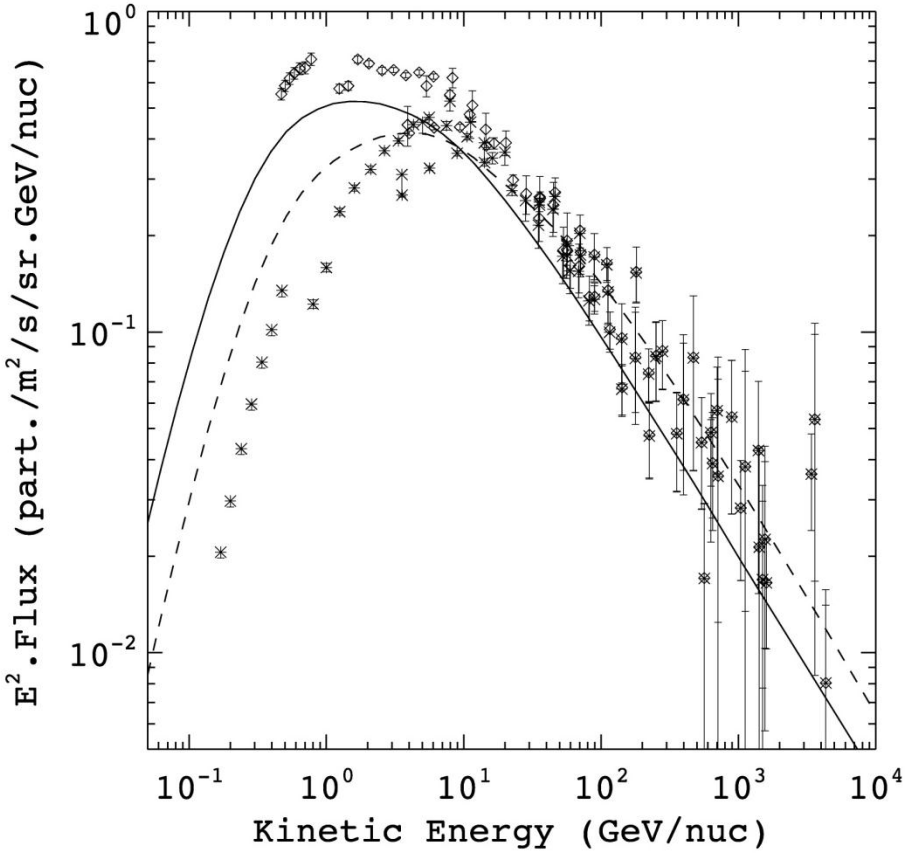
Mixed CRs

✦: Primaries best fit model

■: Mixed best fit model

◆: Secondaries best fit model





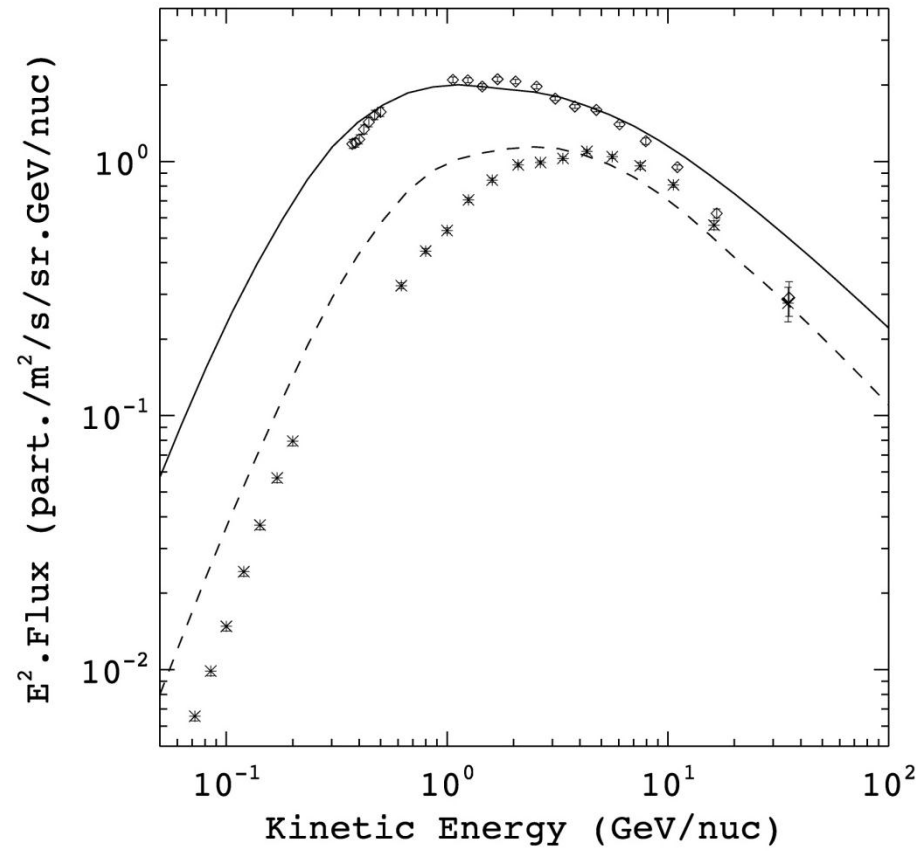
Spectra for CR Primaries:

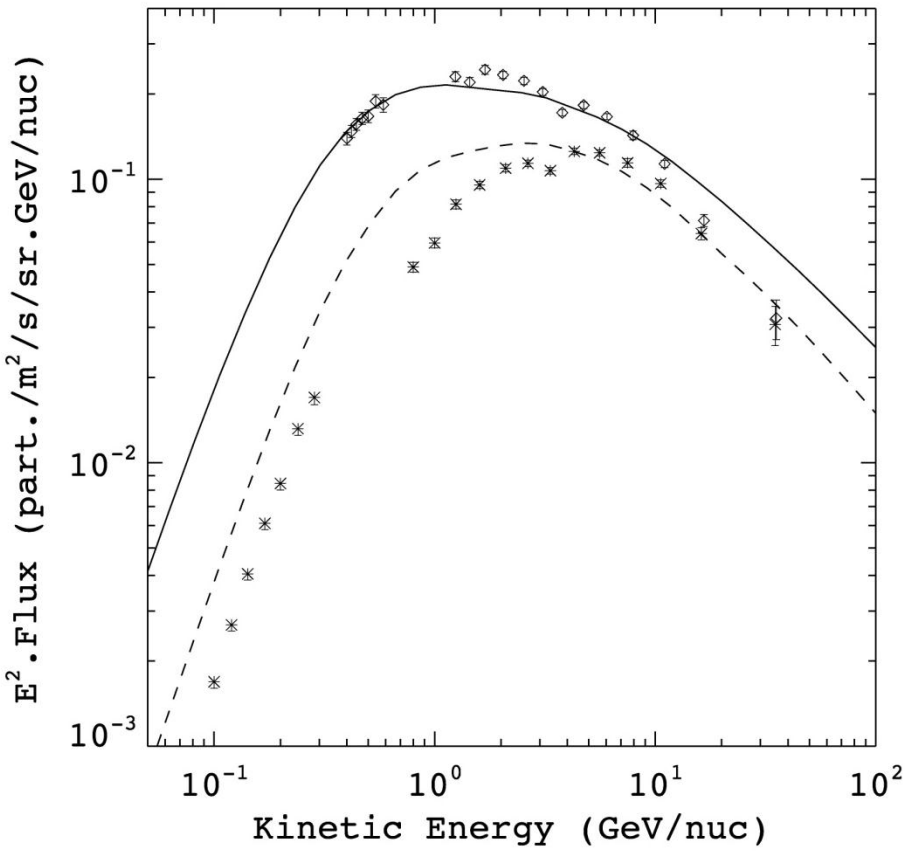
Carbon (left) and Iron (right)

(stars) Modulated data,

(diamonds) LIS

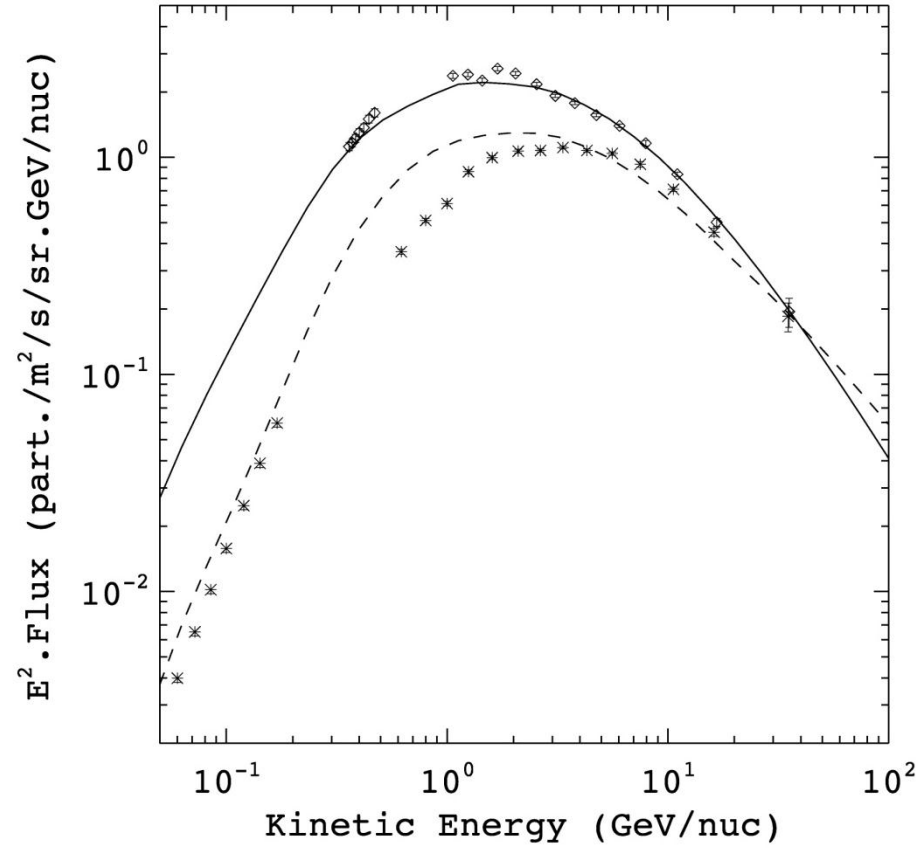
Solid line: fit, dashed line: GALPROP standard fit

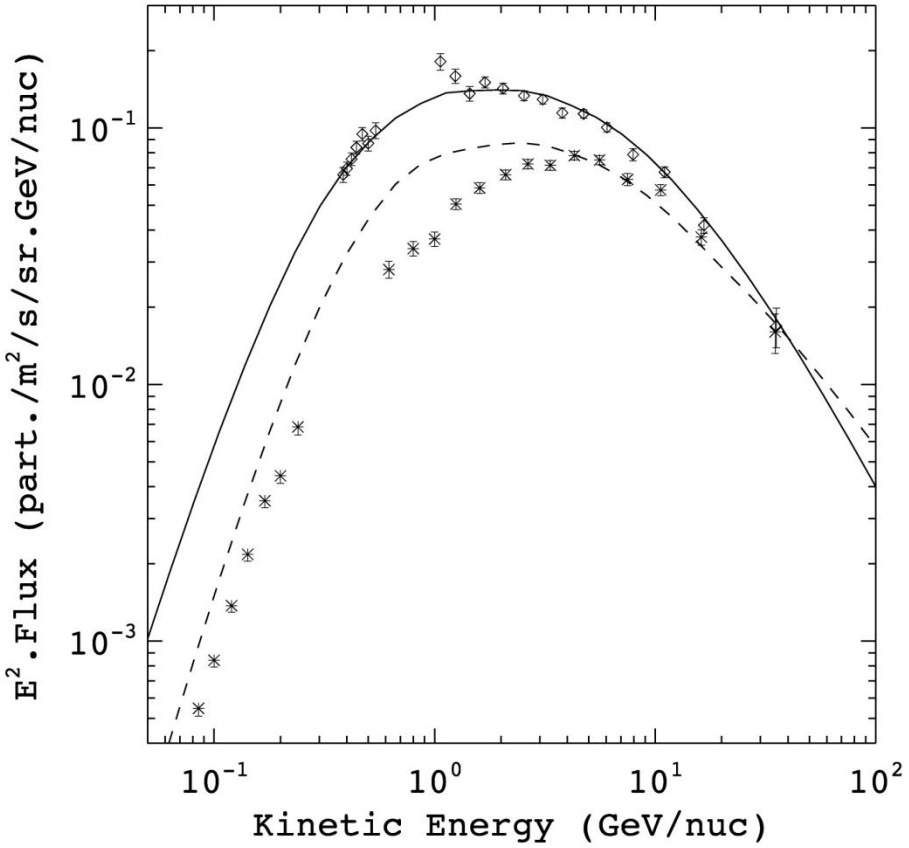




Spectra for Mixed CRs:

Nitrogen (left) and Sodium (right)





Spectra for CR Secondaries:

Boron (left) and Fluorine (right)

Conclusions

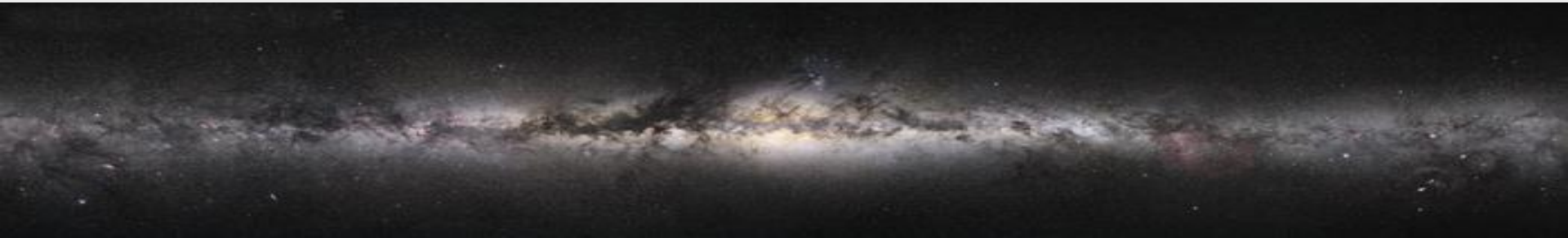
Separately modelling primary, secondary and mixed

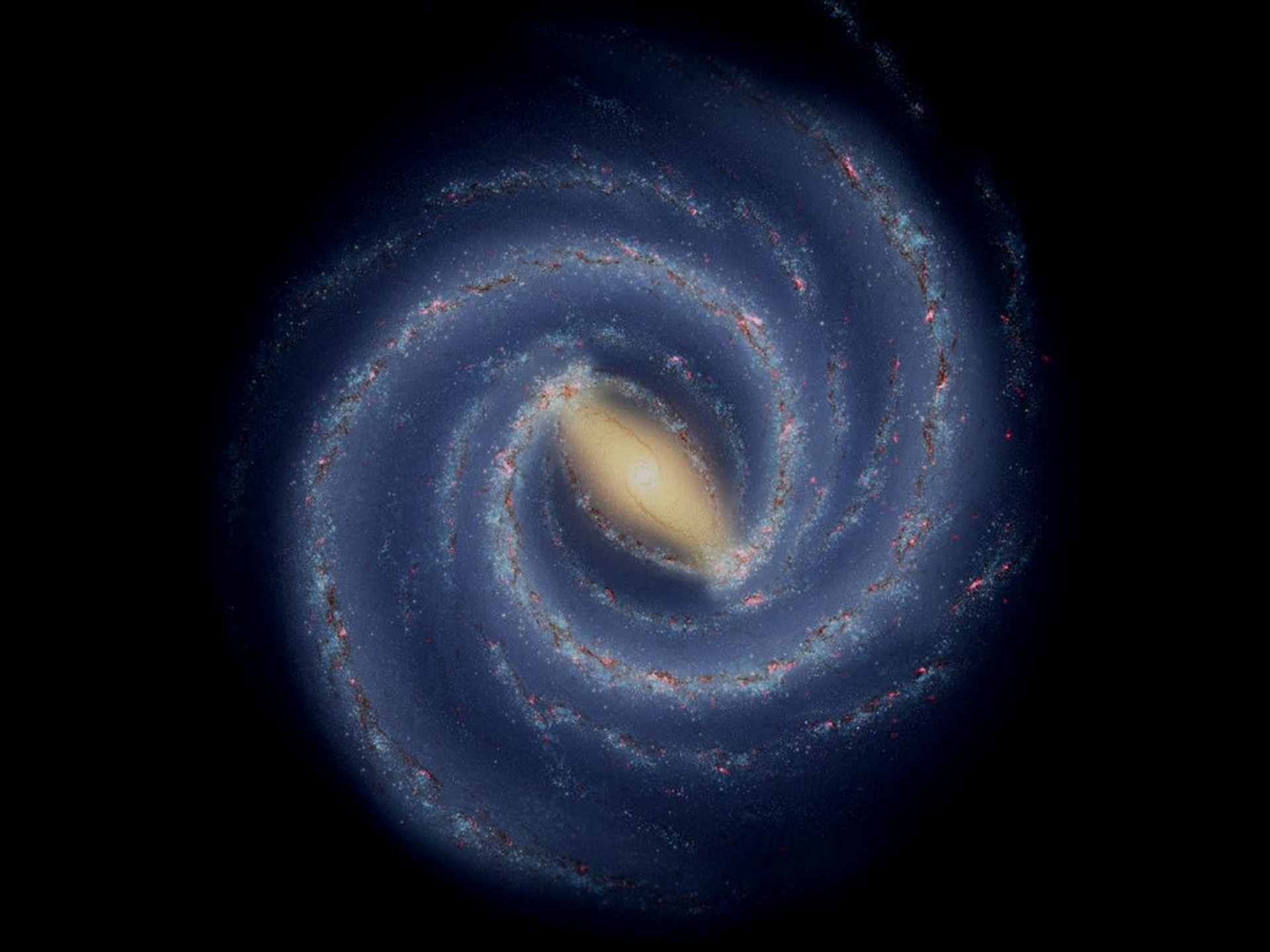
- Components favour different best fit values
- Different sensitivities to model parameters
- Secondaries show in total better fits to the data

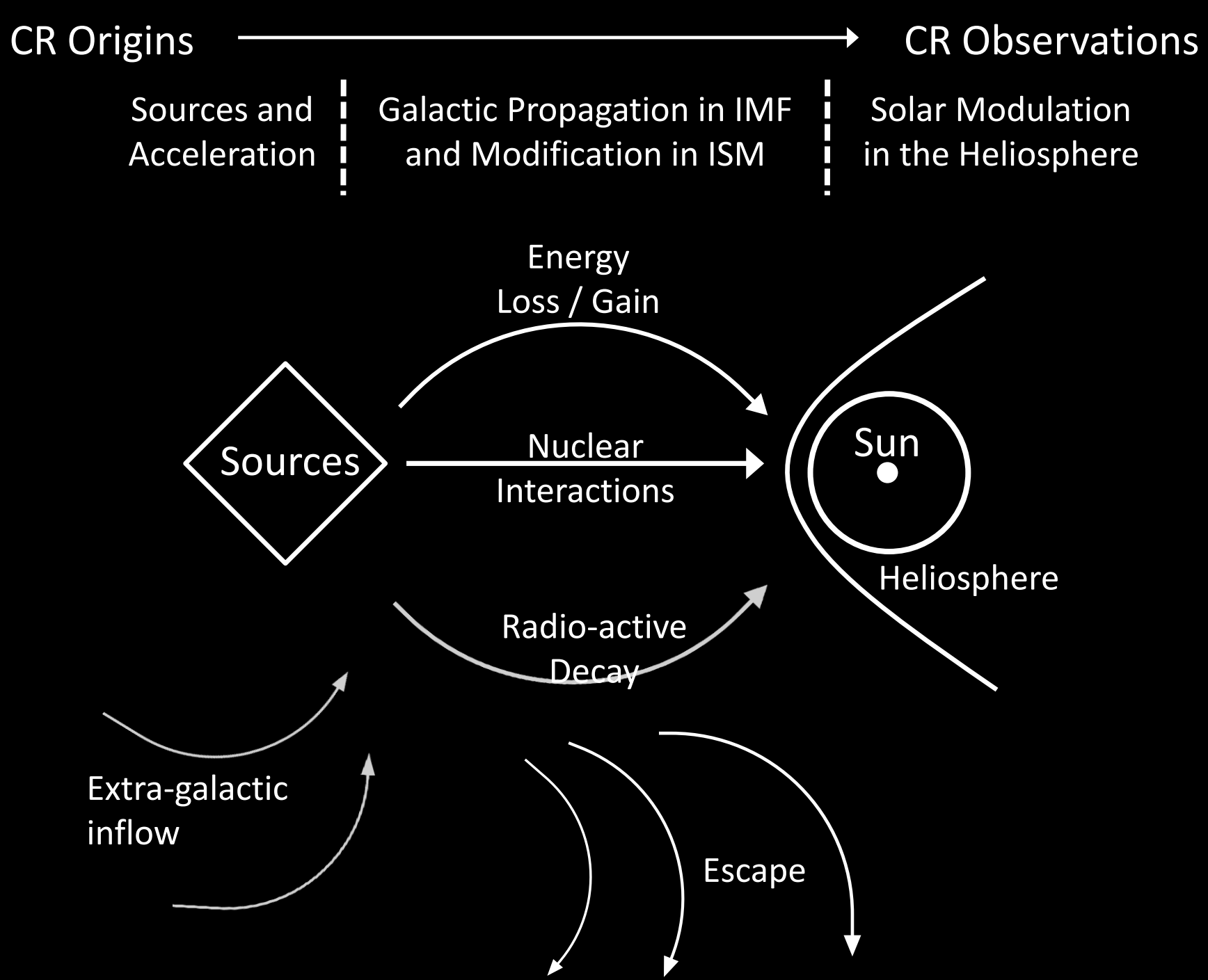
This may be an indication that the Primary CR flux indeed depends on the local source history and is thus not adequately described in a 2D steady state model.

Overview

- Search for signatures of local sources of CRs by numerical modelling separately Primaries and Secondaries, and comparing to observational data
- GALPROP model used to include the Galactic propagation processes
- Parameter study in 3 parameter space, splitting Primaries and Secondaries
- Resulting in best fit models for the 3 components showing differences in how each is effected by the parameters






CR Origins
CR Observations
Sources and Acceleration
Galactic Propagation in IMF and Modification in ISM
Solar Modulation in the Heliosphere
Energy Loss / Gain
Sources
Nuclear Interactions
Sun
Heliosphere
Radio-active Decay
Extra-galactic inflow
Escape