GRAN SASSO
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Heavy Galactic Cosmic Rays: The Iron Problem

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March 02, 2021

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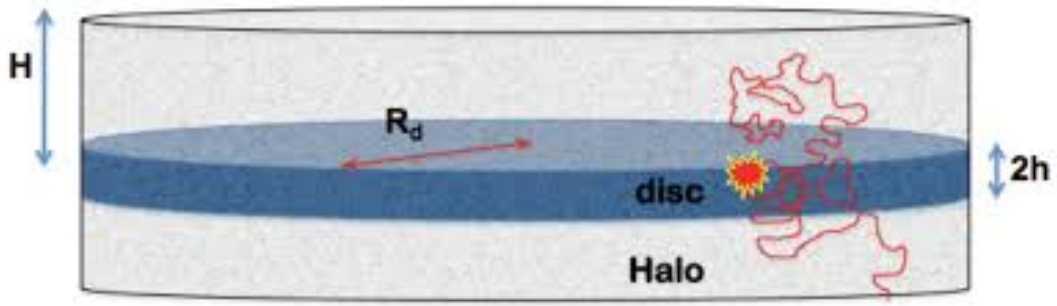
Content

Introduction

Goal of the talk

- give you an idea of the typical work of a theorist in our group
- illustrate this with a recent example of my work: The Iron Problem
- mention when appropriate open problems and illustrate the bigger picture

Standard Picture of CR Transport



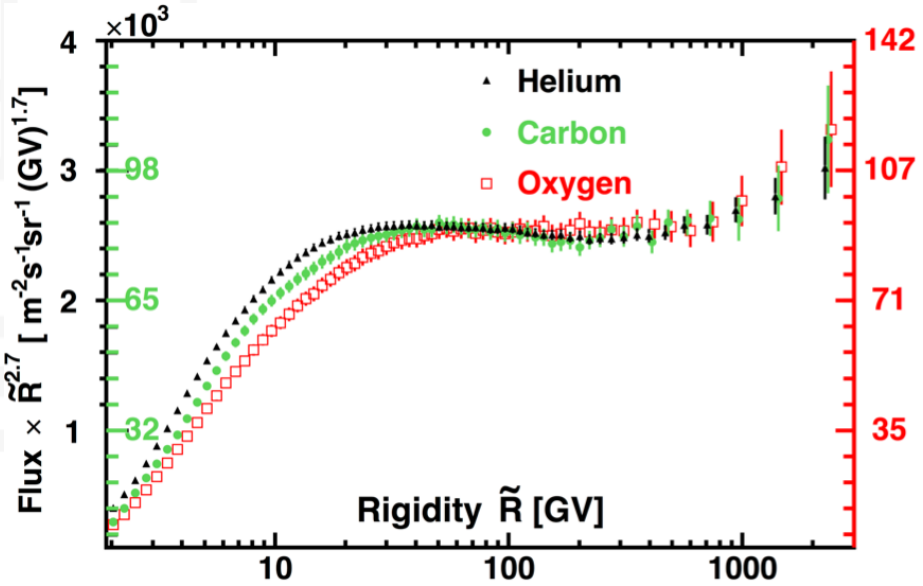
$$-\frac{\partial}{\partial z}\left[D_a\frac{\partial f_a}{\partial z}\right]+v_A\frac{\partial f_a}{\partial z}-\frac{dv_A}{dz}\frac{p}{3}\frac{\partial f_a}{\partial p}$$

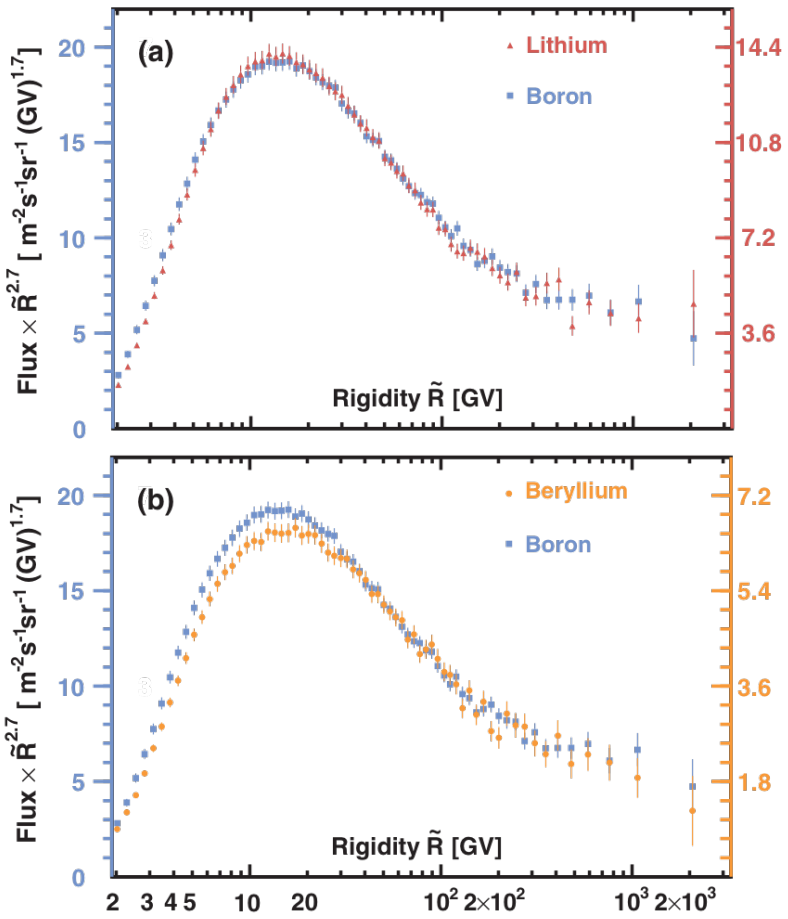
$$+\frac{1}{p^2}\frac{\partial}{\partial p}\left[p^2\left(\frac{dp}{dt}\right)_{a,\mathrm{ion}}f_a\right]+\frac{\mu v(p)\sigma_a}{m}\delta(z)f_a+\frac{f_a}{\hat{\tau}_{d,a}}$$

$$=2h_d q_{0,a}(p)\delta(z)+\sum_{a'>a}\frac{\mu\, v(p)\sigma_{a'\to a}}{m}\delta(z)f_{a'}+\sum_{a'>a}\frac{f_{a'}}{\hat{\tau}_{d,a'}}$$

The story so far

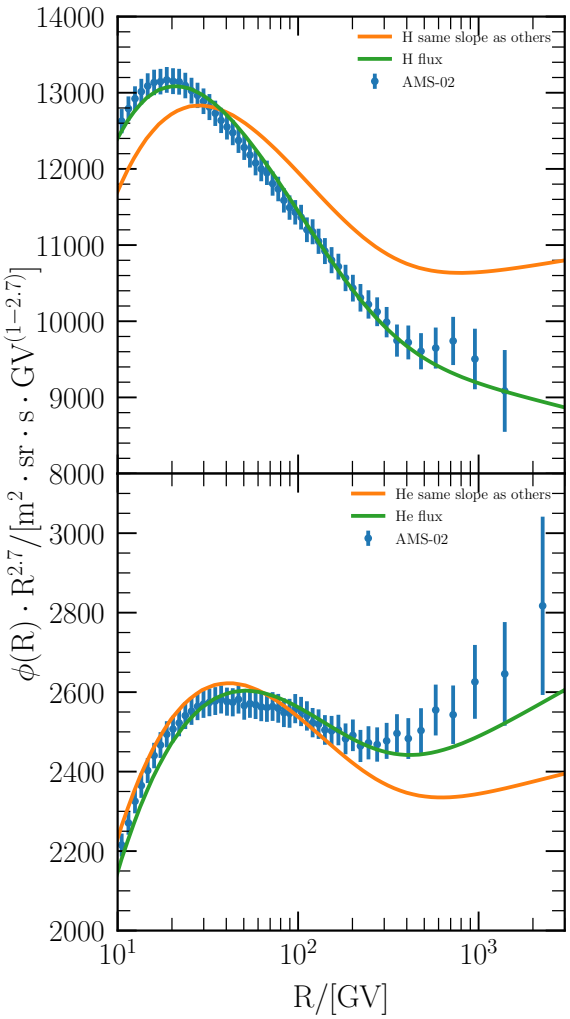
Brief History

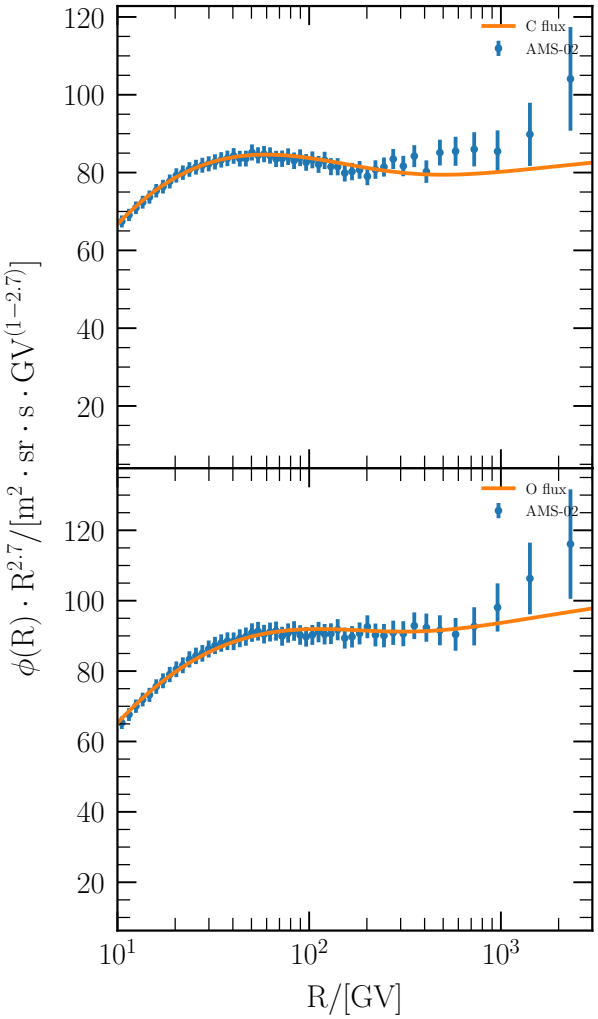




- High precision data of many different nuclei has lead to increasingly complete picture of CR transport
- Detected anomalies lead in the past to many new interesting challenges e.g. the spectral break around 300 GV

Puzzling observation

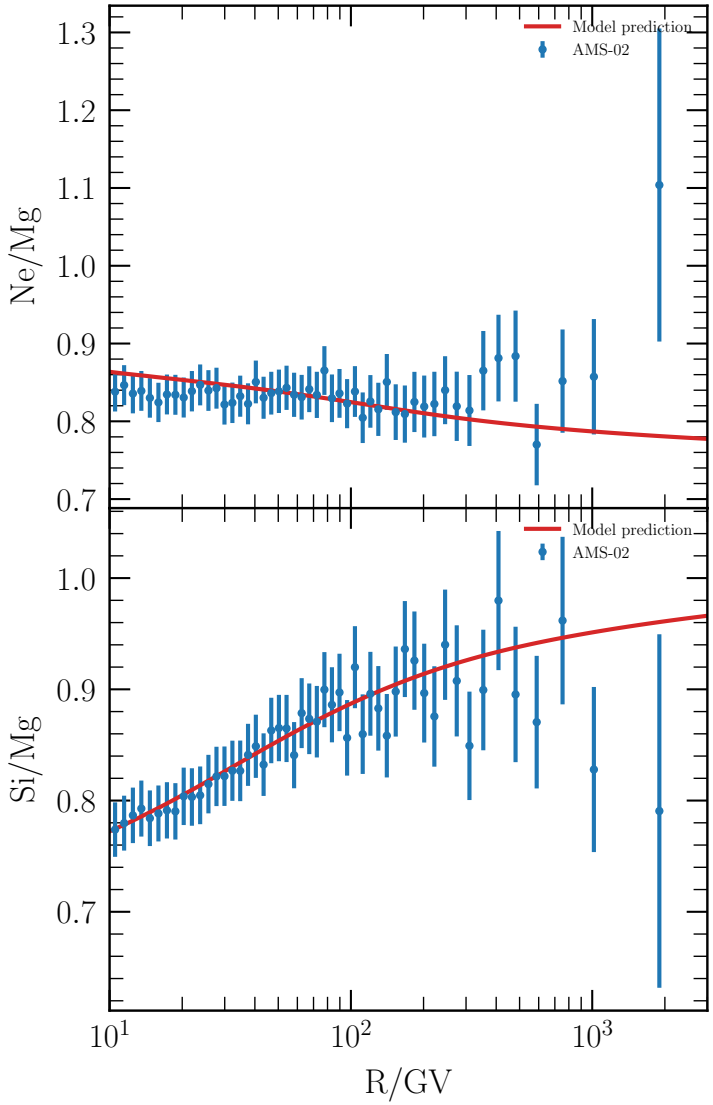




- Need different injection slope for H and He compared to other nuclei and each other

Heavy nuclei

Results



- Difference in slope is due to contribution from spallation rather than different injection slope
- Non trivial consistency check for underlying model that all spectra are reproduced with the same transport parameters which contain all the information about the microphysics

Moment to Appreciate

- Explaining 9 different fluxes and their ratios with very high precision using a simple well motivated model

The Iron Measurement

- Don't draw the conclusions too early
- Hidden problem: The Iron Measurement

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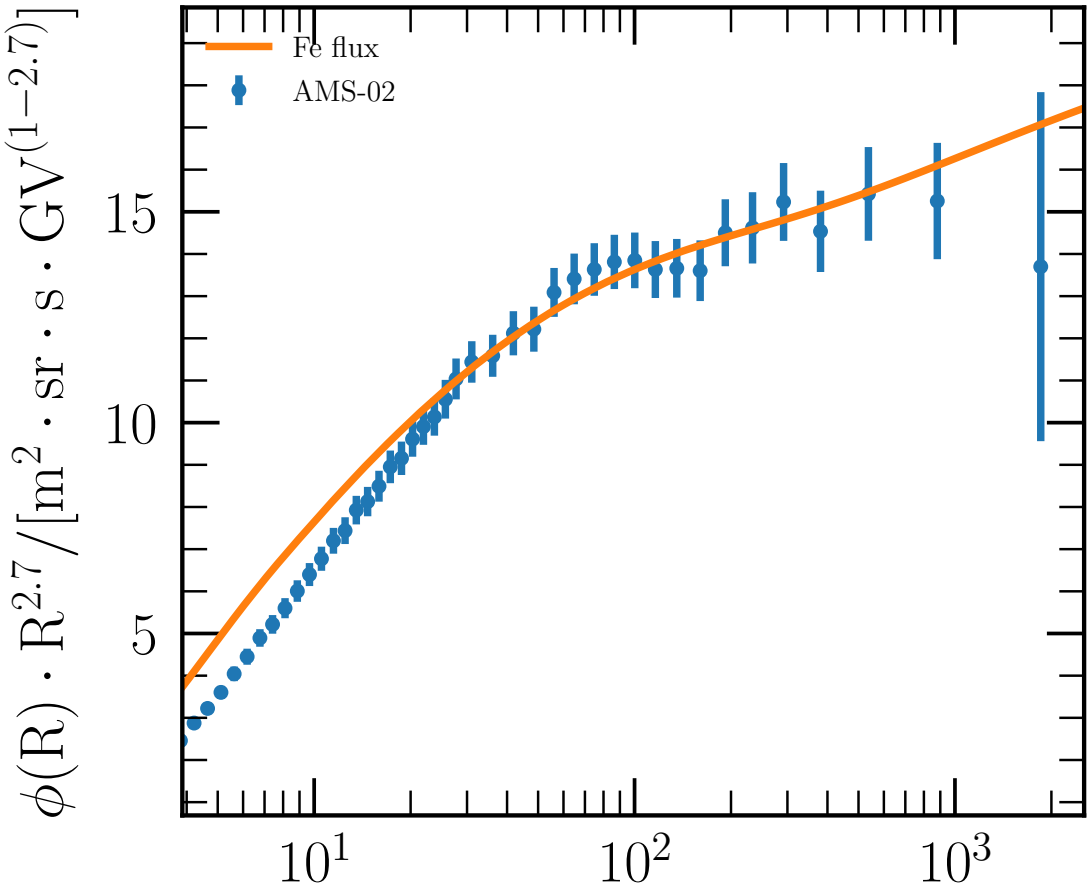
- Low energy trend is completely different than what is expected



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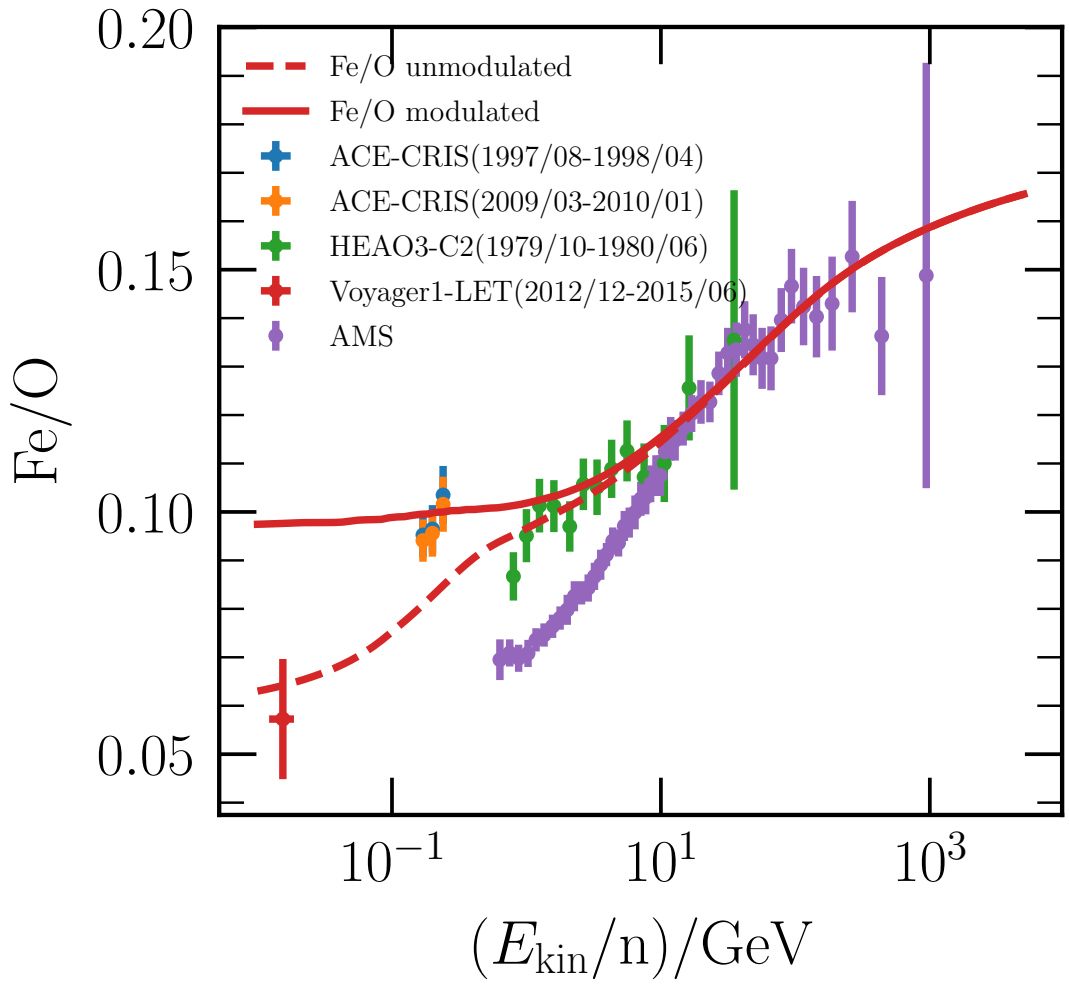
- ~~maybe Iron has another injection slope like H and He~~ Does not give a satisfying fit either

Not all hope is lost:

Disagreement of AMS-02 with other experiments

- Even more puzzling: perfect agreement of our spectrum with other experiments



Take away message from this talk

As a theorist:

- Start from a problem/equation
- Solve it as far as possible on a piece of paper, make reasonable assumptions
- Compare predictions to available data and try to fit your model
- If problems arise, reasses your assumptions and come up with possible solutions

Open questions

- different injection slopes of different particles (also e^- w.r.t. protons) $\Rightarrow$ connected to release of particles into ISM $\rightarrow$ source environment is important
- with gradually better data effects like halo grammage soon will become important and need proper treatment
- need self-consistent model of self generated diffusion inside the Galaxy
- once particles escape the Galaxy not well understood what happens