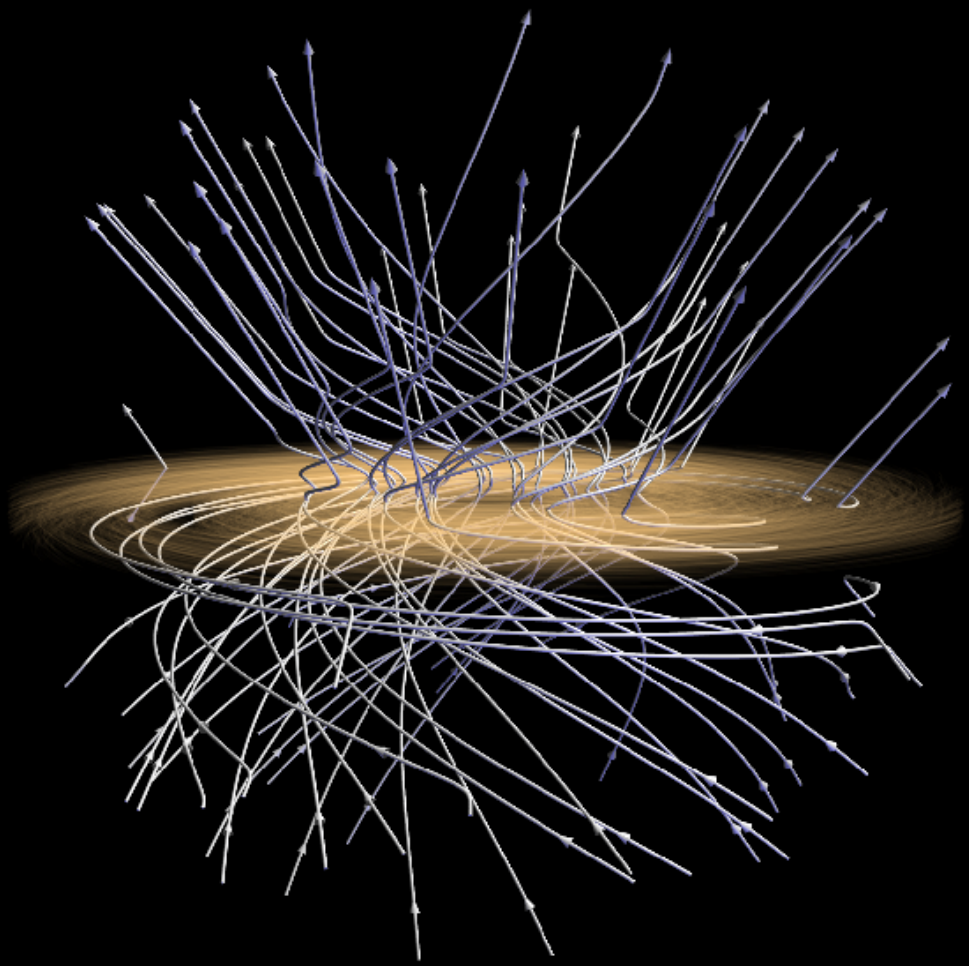
# Uncertainties of Models of the Galactic Magnetic Field

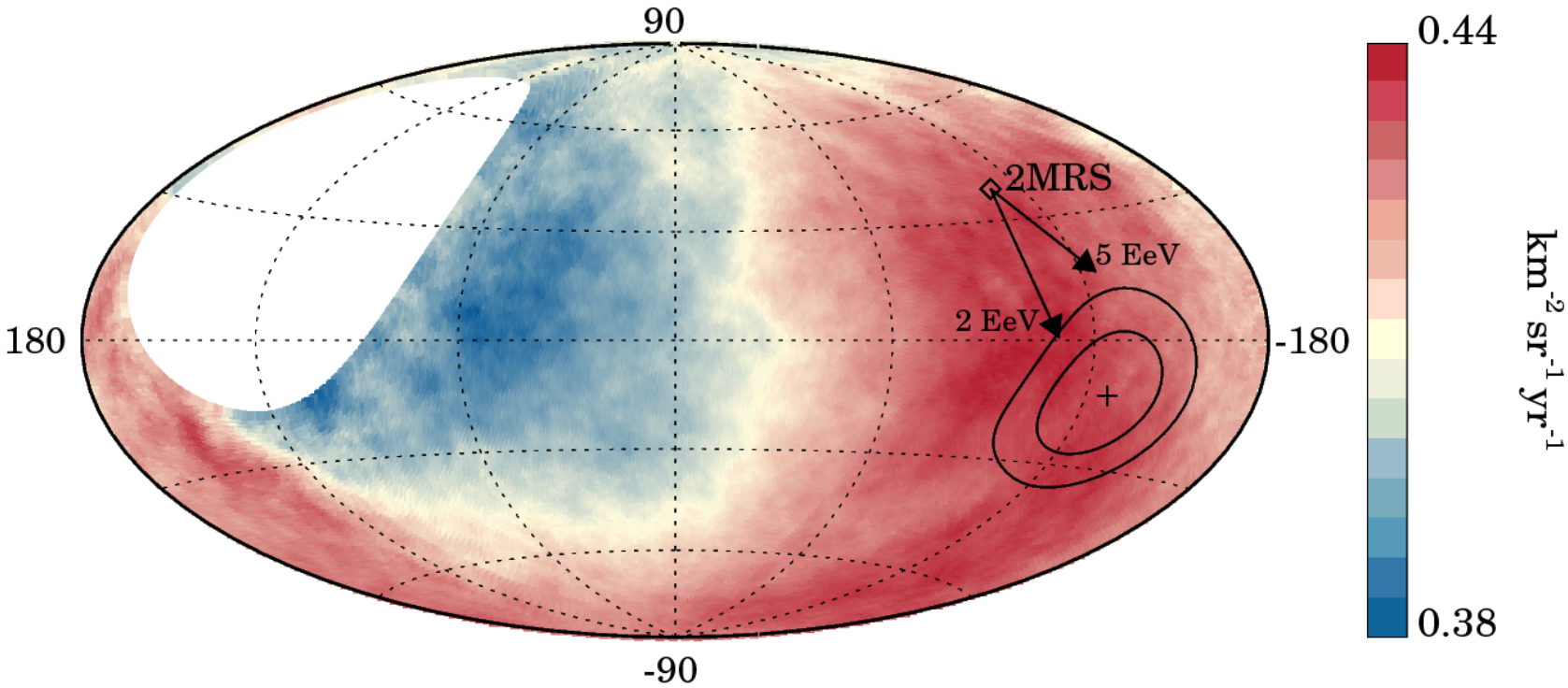
M. Unger & G.R. Farrar



JF12 visualization by Farrar & Sandstrom

# Motivation

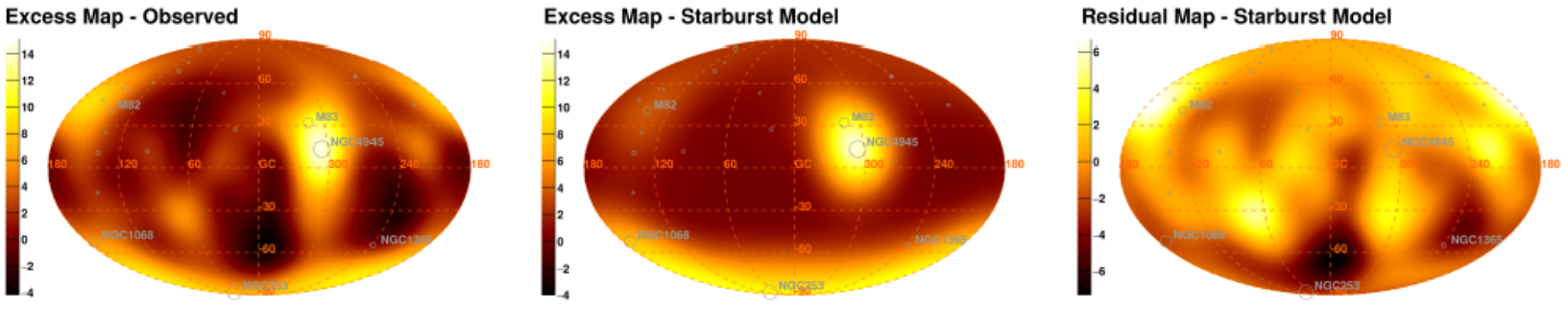
Dipole paper:




"...arrows show the deflections expected for a particular model of the Galactic magnetic field for $E/Z = 5$ EeV or $2$ EeV."

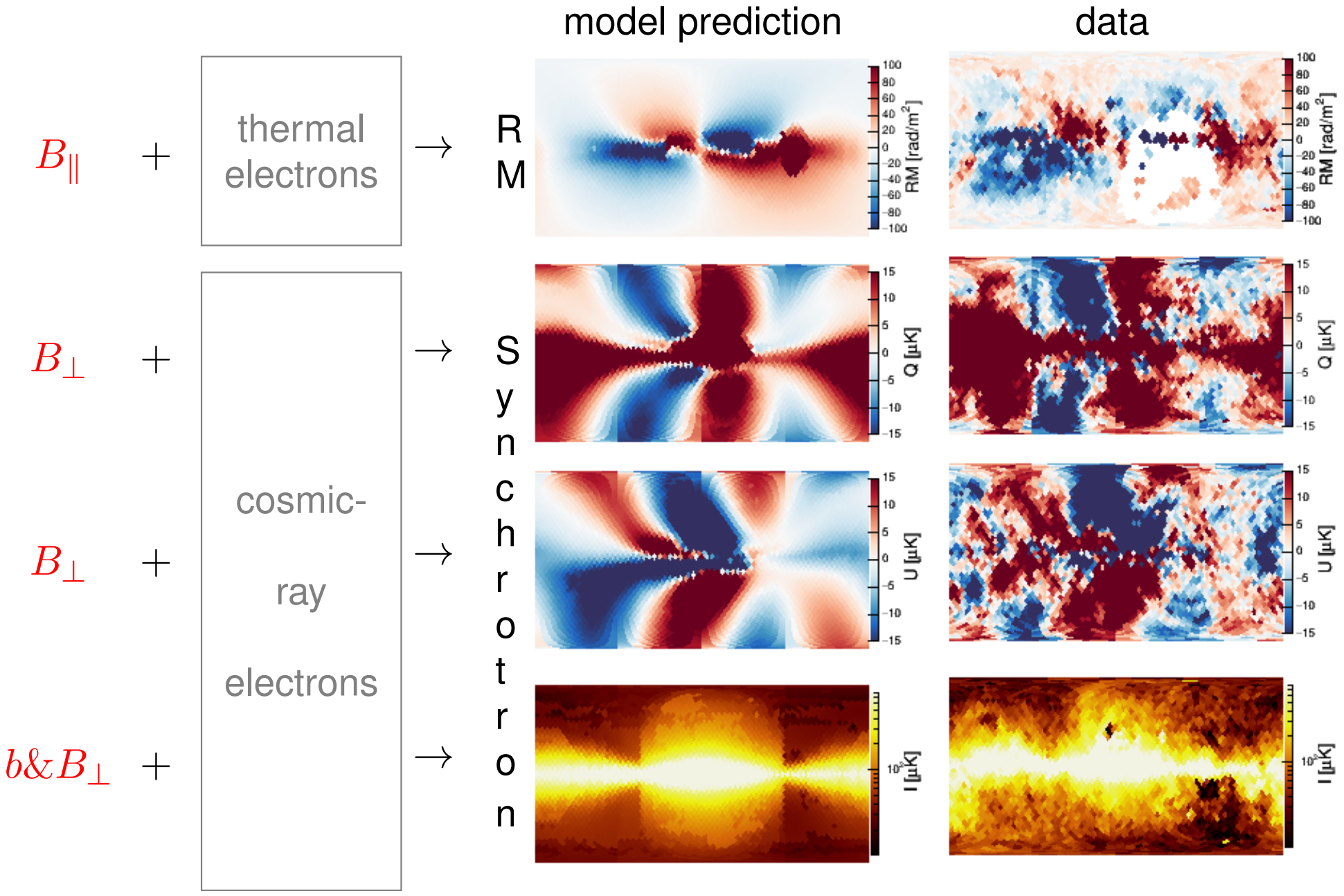
# Motivation

Jonathan& Olivier (AD phone meeting Feb. 22):



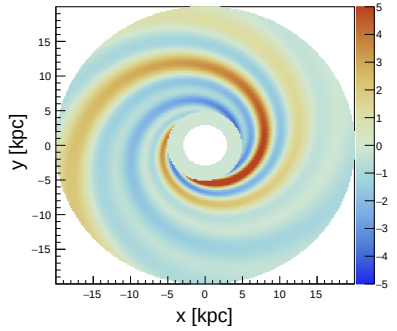

"Anisotropy consistent with magnetic blurring for CNO nuclei."

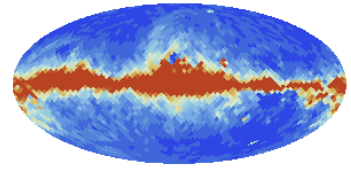
# Fitting GMF Models

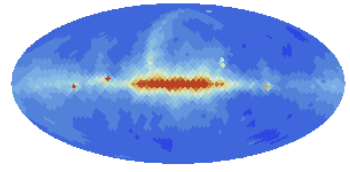


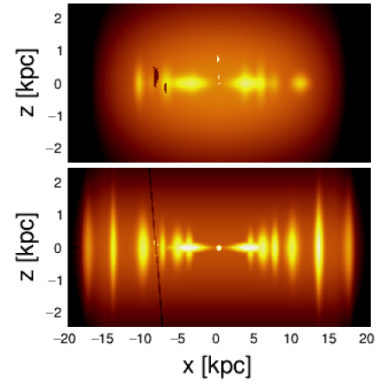
# Fit Variations

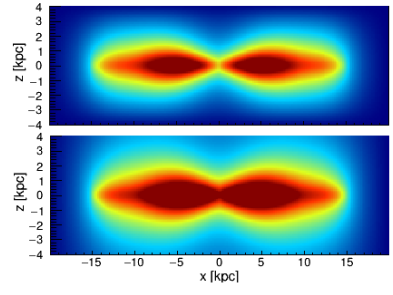
| id | disk | toroidal | poloidal | NE | ncre | QU | misc | $\chi^2$/ndf |
|---|---|---|---|---|---|---|---|---|
| **Parametric models** | | | | | | | | |
| a | JF | JF | JF | 01 | GP_JF | W7 | - | 1.10 |
| b | JF | JF | FTC | 01 | GP_JF | W7 | - | 1.09 |
| c | JF | JFsym | FTC | 01 | GP_JF | W7 | - | 1.11 |
| d | JF | JFsym | FTC | 01 | GP_JF | W7 | warp | 1.11 |
| e | m4 | JFsym | FTC | 01 | GP_JF | W7 | - | 1.09 |
| f | m4 | twisted FTC | | 01 | GP_JF | W7 | - | 1.14 |
| g | m4 | twisted FTC, $r_{\rm cut}$ | | 01 | GP_JF | W7 | - | 1.09 |
| **Synchrotron products** | | | | | | | | |
| h | JF | JFsym | FTC | 01 | GP_JF | W9base | - | 1.22 |
| i | JF | JFsym | FTC | 01 | GP_JF | W9sdc | - | 1.24 |
| j | JF | JFsym | FTC | 01 | GP_JF | W9fs | - | 1.11 |
| k | JF | JFsym | FTC | 01 | GP_JF | W9fss | - | 1.22 |
| l | JF | JFsym | FTC | 01 | GP_JF | P15 | - | 0.78 |
| **Thermal electrons** | | | | | | | | |
| m | JF | JFsym | FTC | 16 | GP_JF | W7 | - | 1.21 |
| n | m4 | JFsym | FTC | 16 | GP_JF | W7 | - | 1.14 |
| o | JF | JF | FTC | 01 | GP_JF | W7 | $\kappa = -1$ | 1.05 |
| p | JF | JF | FTC | 01 | GP_JF | W7 | $\kappa = +1$ | 1.05 |
| q | JF | JFsym | FTC | 01 | GP_JF | W7 | HIM | 1.12 |
| **Cosmic-ray electrons** | | | | | | | | |
| r | JF | JFsym | FTC | 01 | O13a | W7 | - | 1.13 |
| s | JF | JFsym | FTC | 01 | O13b | W7 | - | 1.12 |
| t | JF | JFsym | FTC | 01 | S10 | W7 | - | 1.13 |



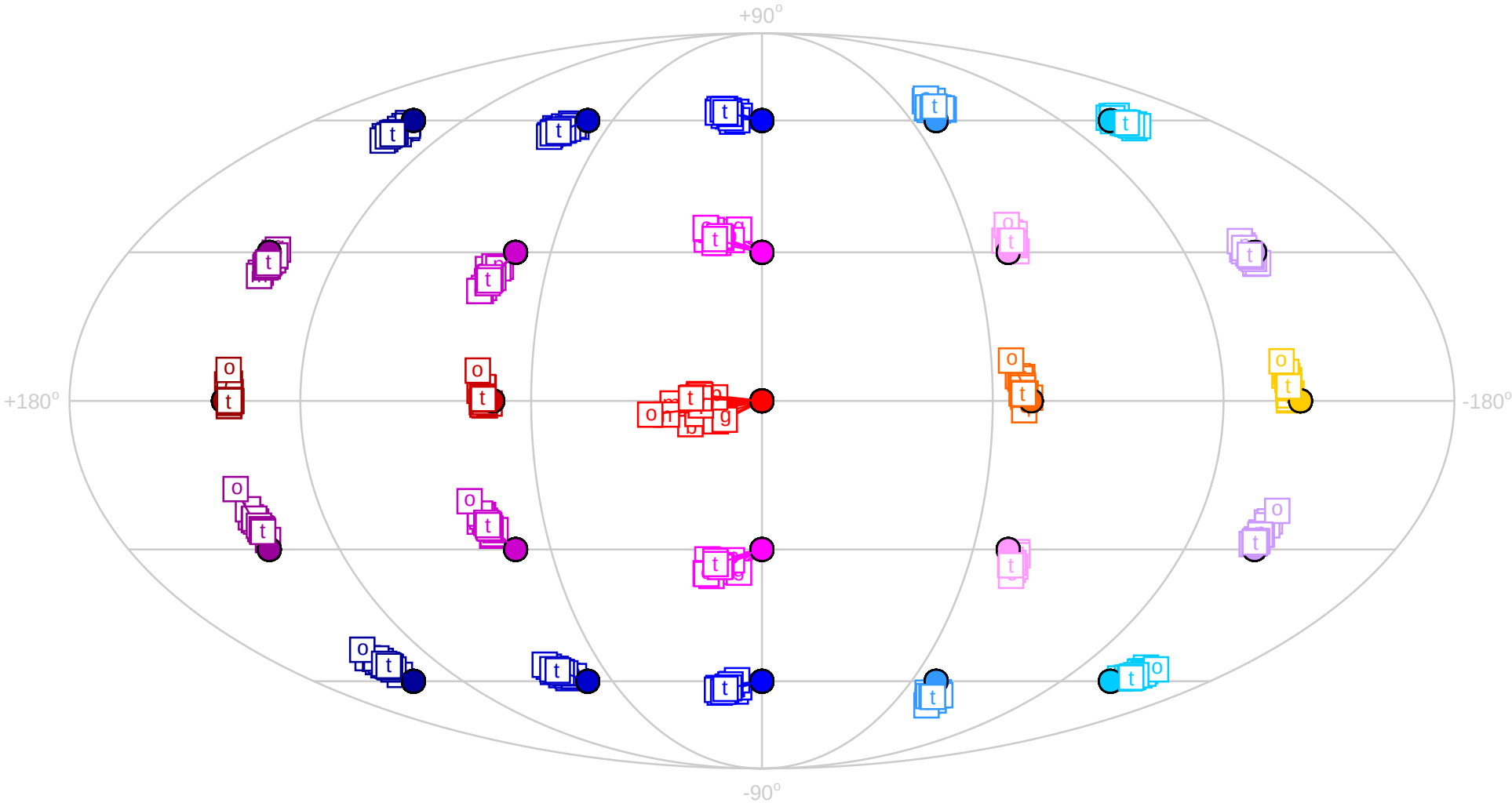





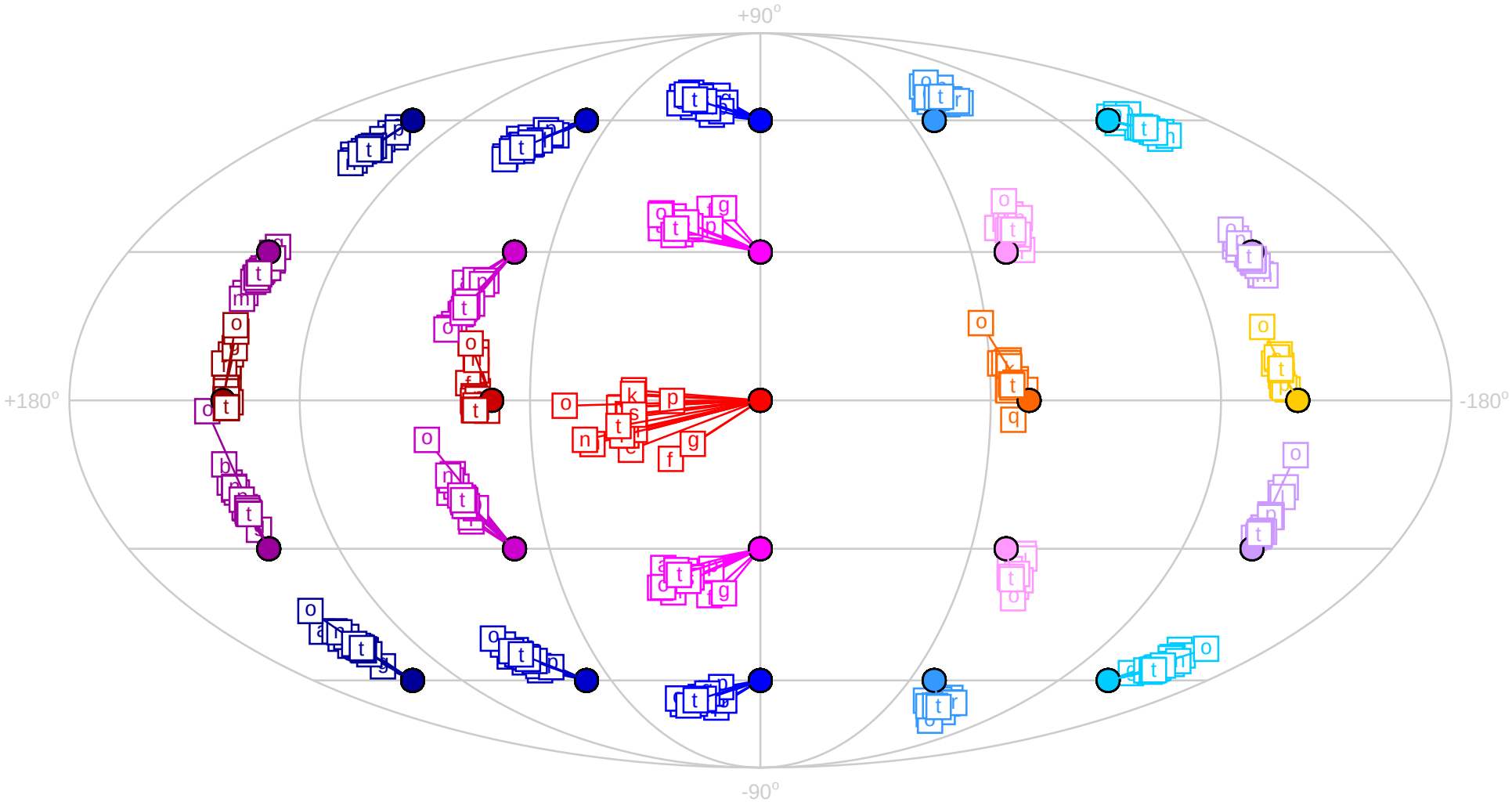


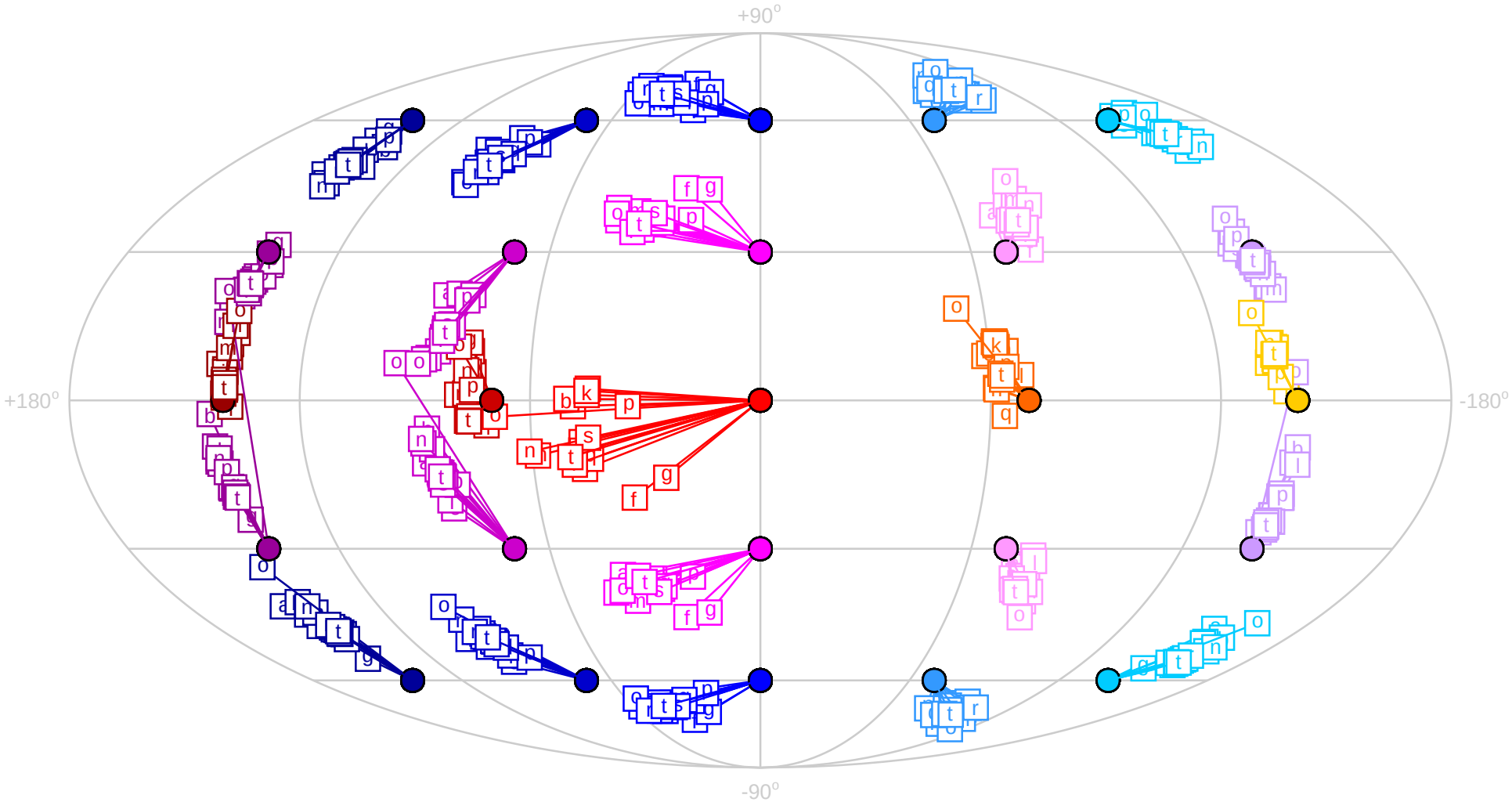
# Back-tracking, $\mathbf{R = 60}$ EV



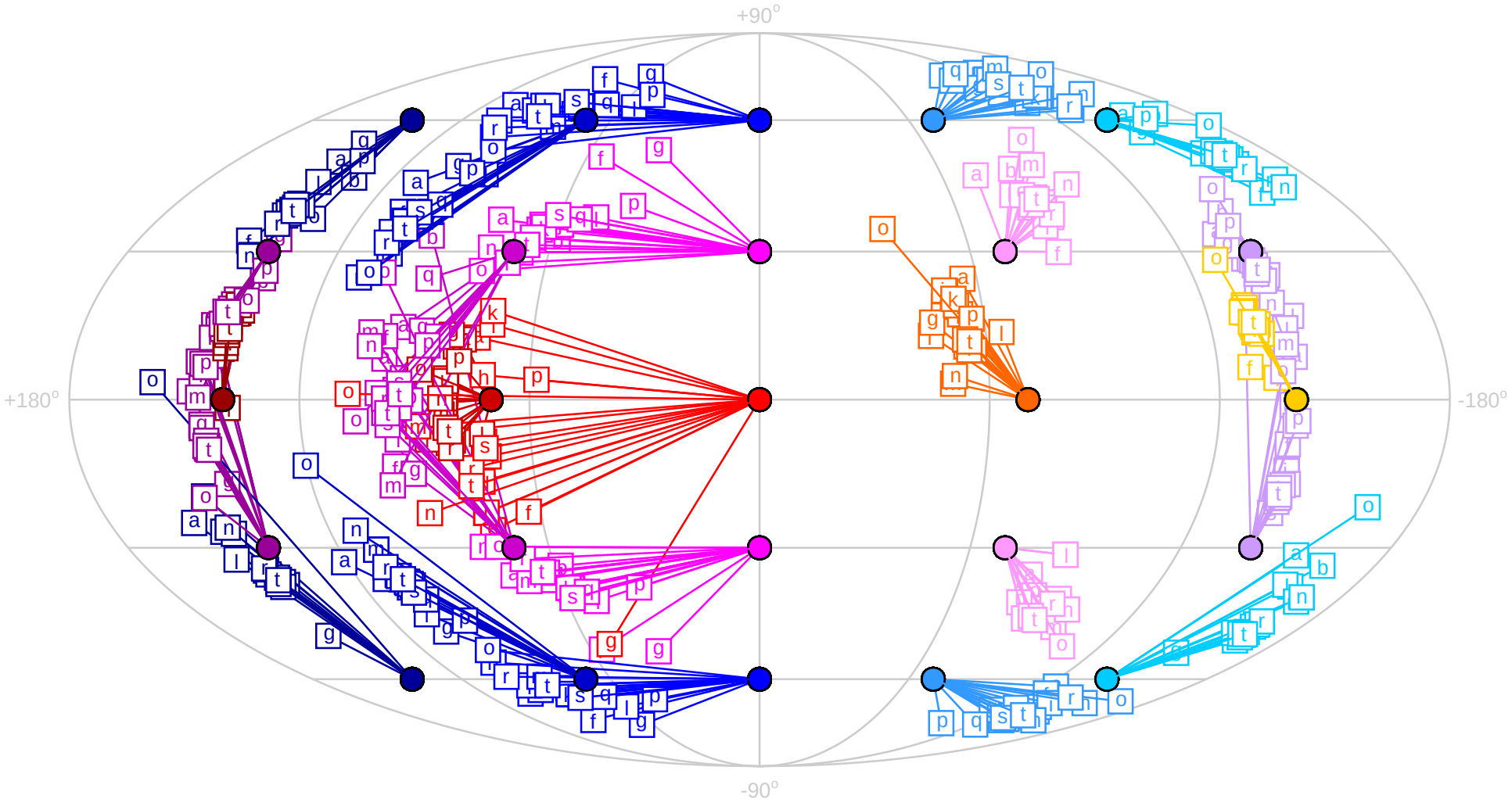
# Back-tracking, $\mathbf{R = 30}$ EV



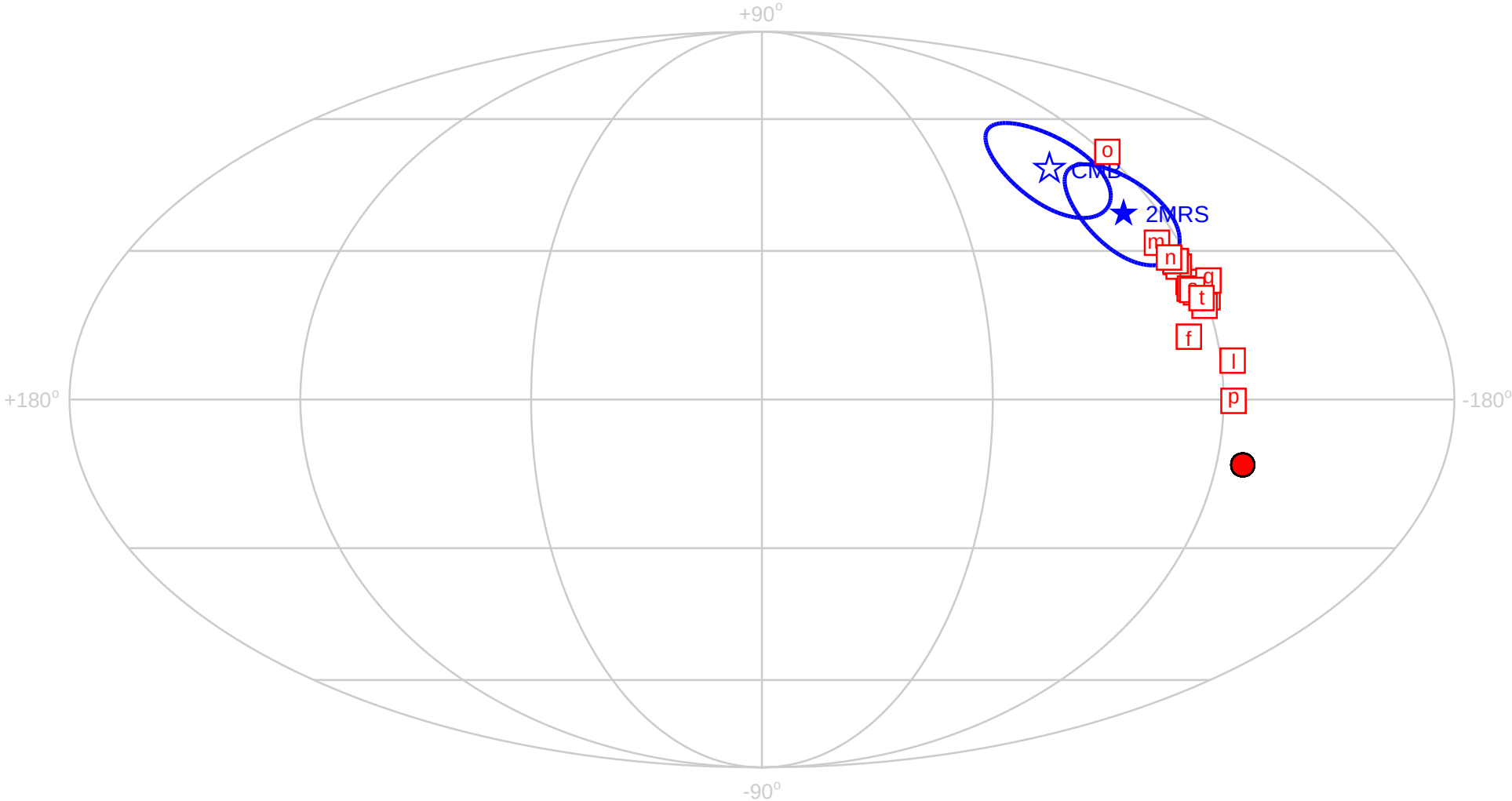
# Back-tracking, $\mathbf{R = 20}$ EV



# Back-tracking, $\mathbf{R = 10}$ EV

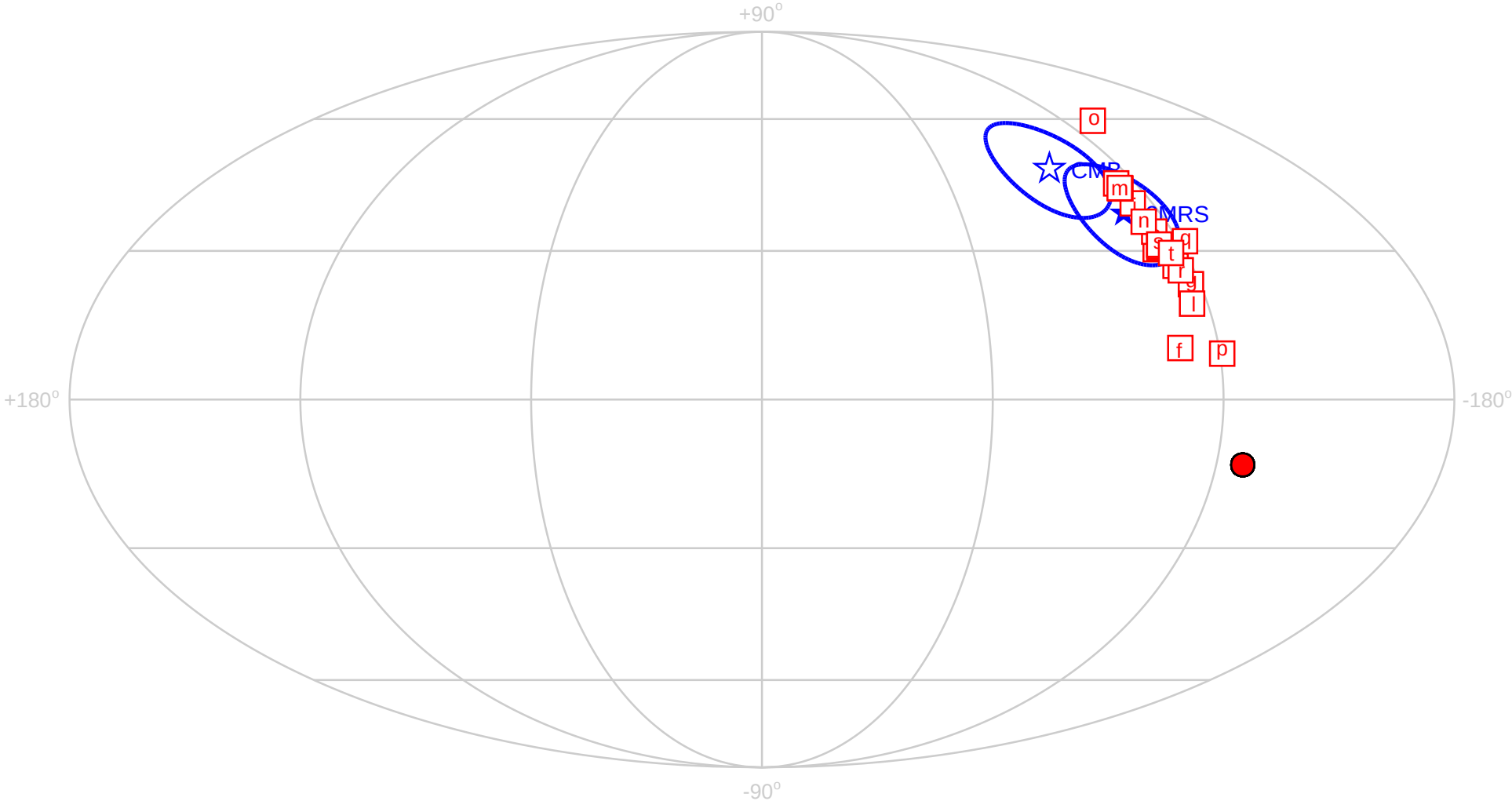


# Back-tracking of Dipole, $\mathbf{R = 6}$ EV ($\sim$ 10 EeV, $\langle Z \rangle = 1.7$)



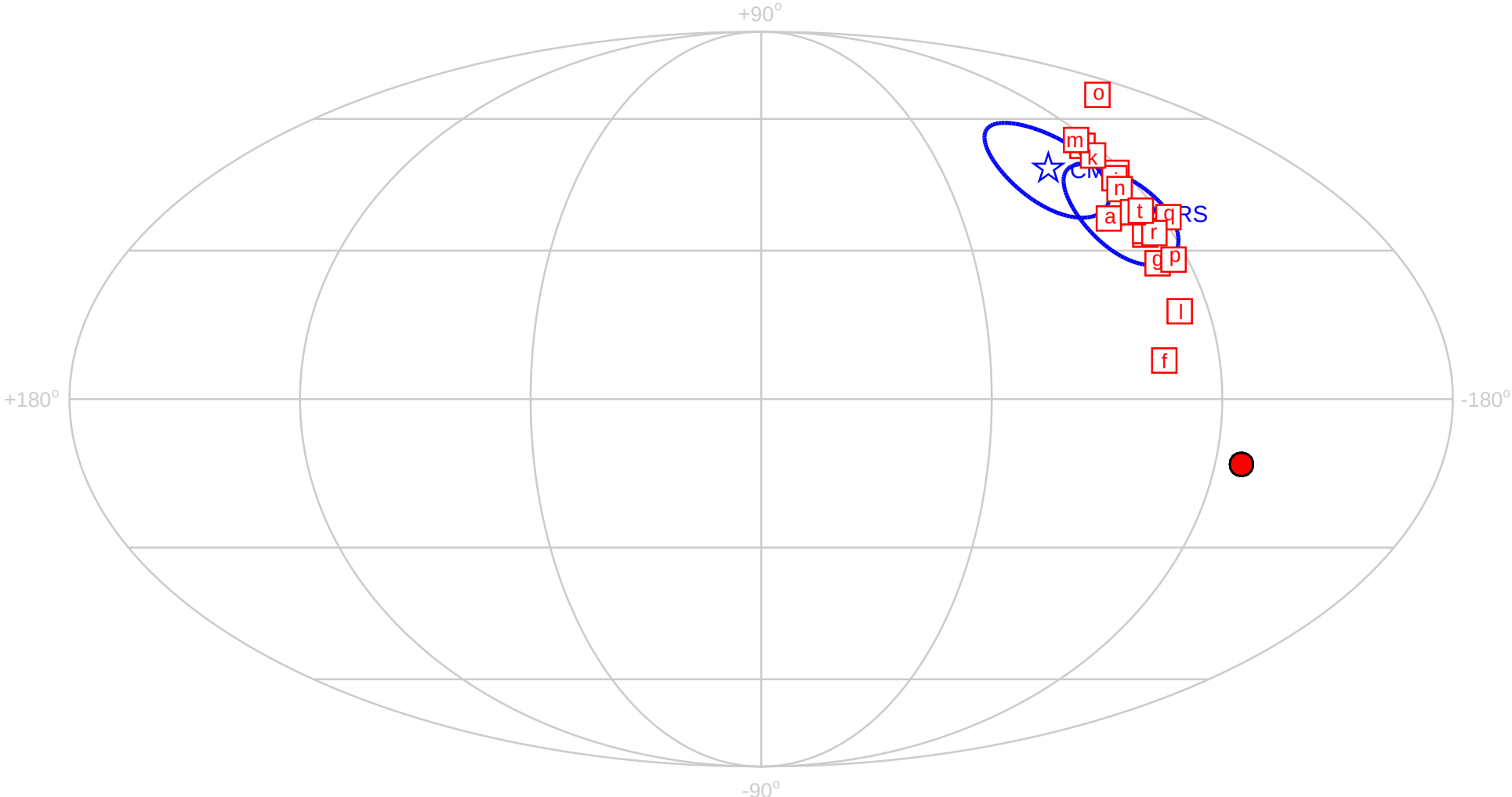

circles: uncertainty of CR dipole direction ($\sim 11^\circ$)

# Back-tracking of Dipole, $\mathbf{R = 5}$ EV ($\sim$ 10 EeV, $\langle Z \rangle = 2$)



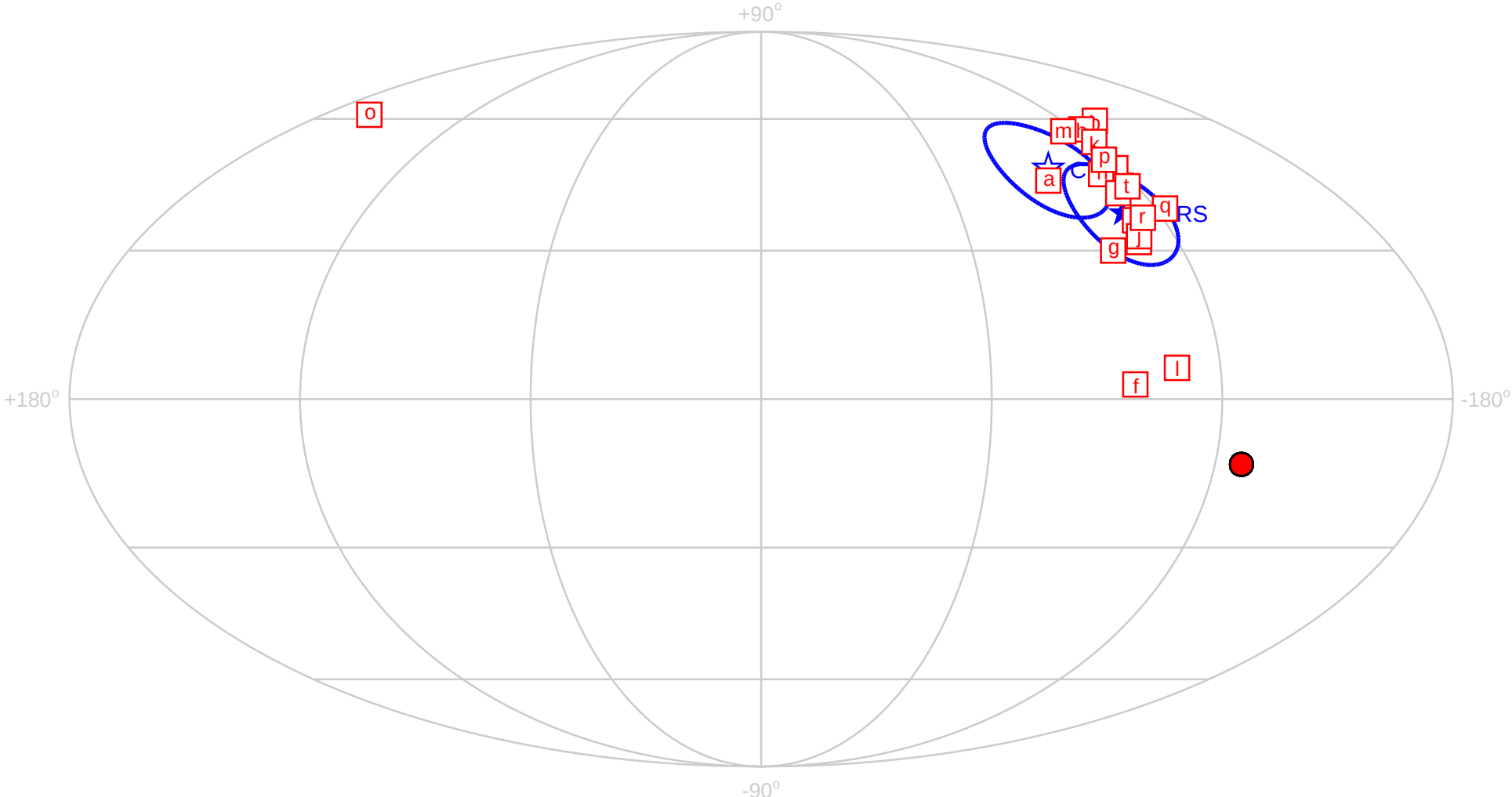

circles: uncertainty of CR dipole direction ($\sim 11^\circ$)

# Back-tracking of Dipole, $\mathbf{R} = 4$ EV ($\sim$ 10 EeV, $\langle Z \rangle = 2.5$)



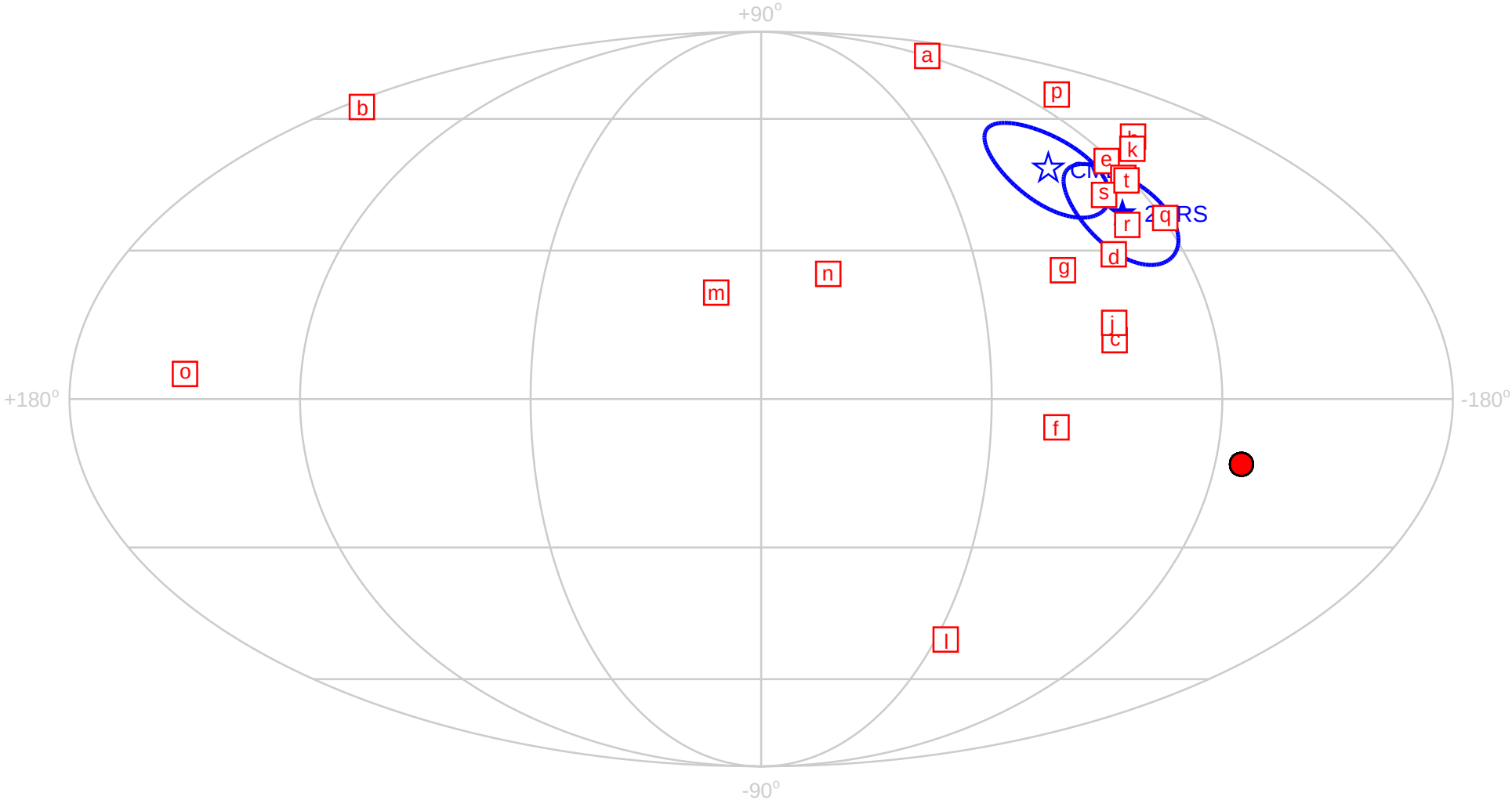

circles: uncertainty of CR dipole direction ($\sim 11^\circ$)

# Back-tracking of Dipole, $\mathbf{R} = \mathbf{3}$ EV ($\sim$ 10 EeV, $\langle Z \rangle = 3.3$)



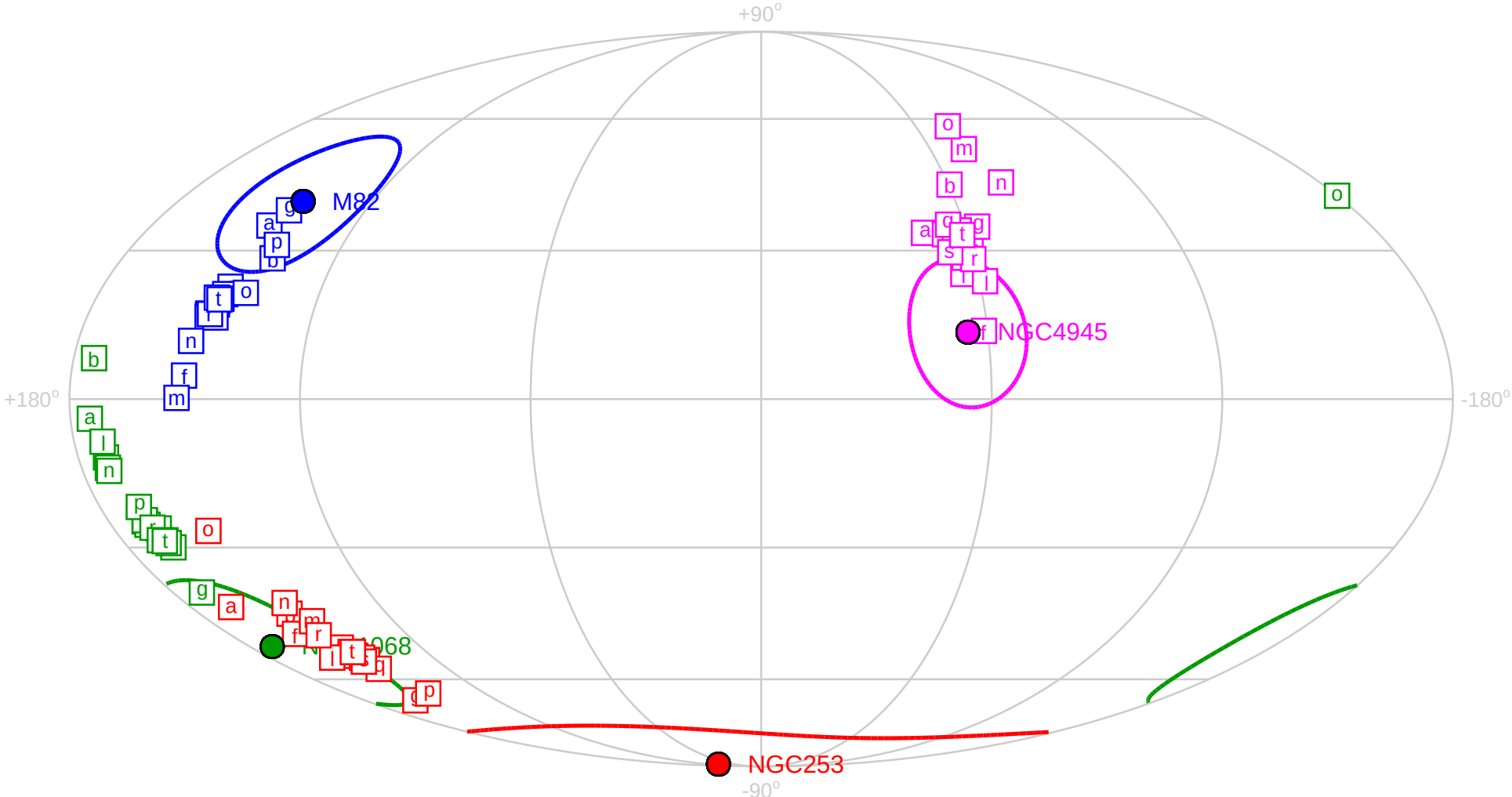

circles: uncertainty of CR dipole direction ($\sim 11^\circ$)

# Back-tracking of Dipole, $\mathbf{R} = \mathbf{2}$ EV ($\sim$ 10 EeV, $\langle Z \rangle = 5$)



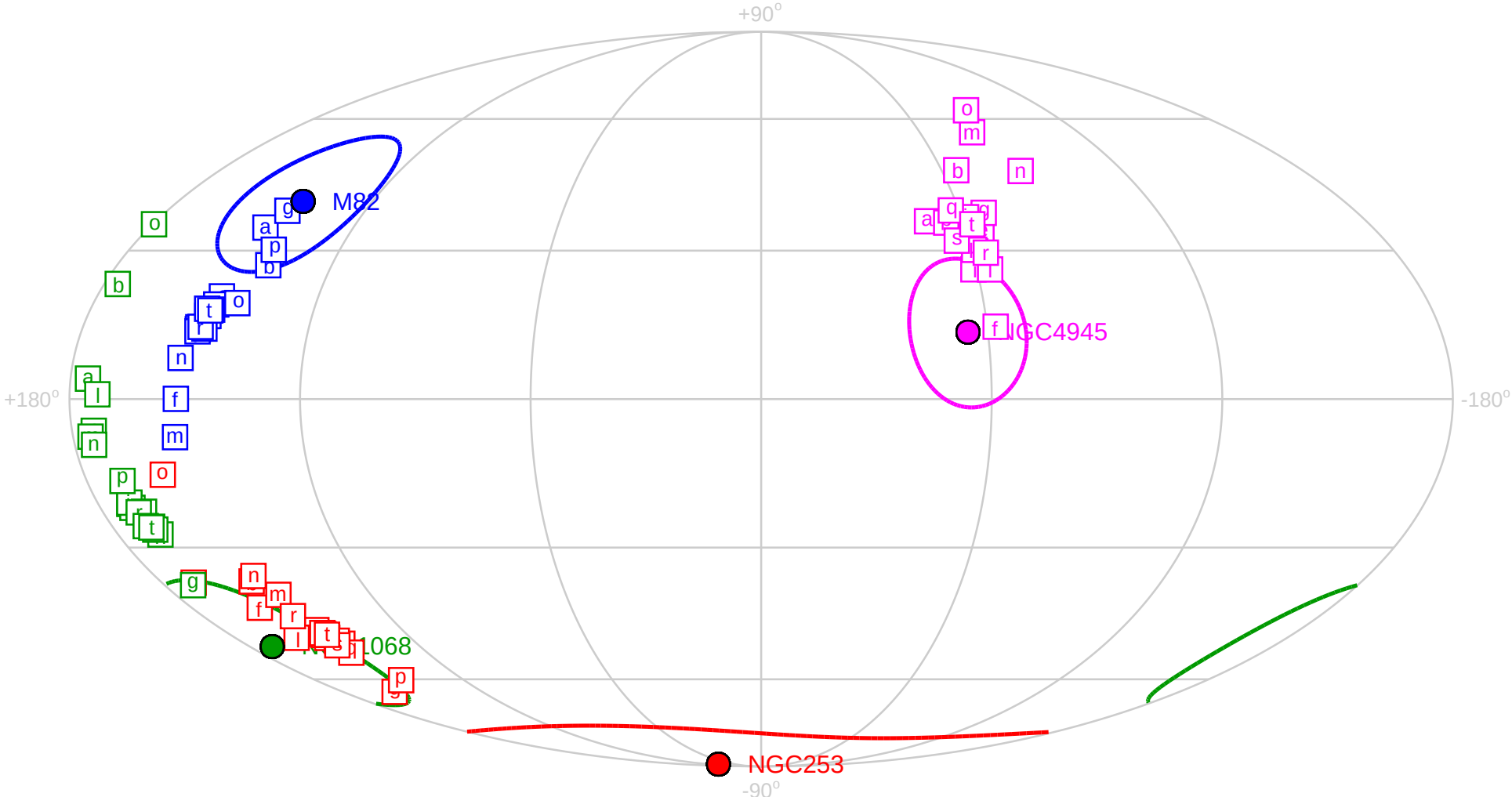

circles: uncertainty of CR dipole direction ($\sim 11^\circ$)

# Back-tracking in Direction of Starburst Galaxies , $\mathbf{R} = 8$ EV ($\sim$50 EeV C)



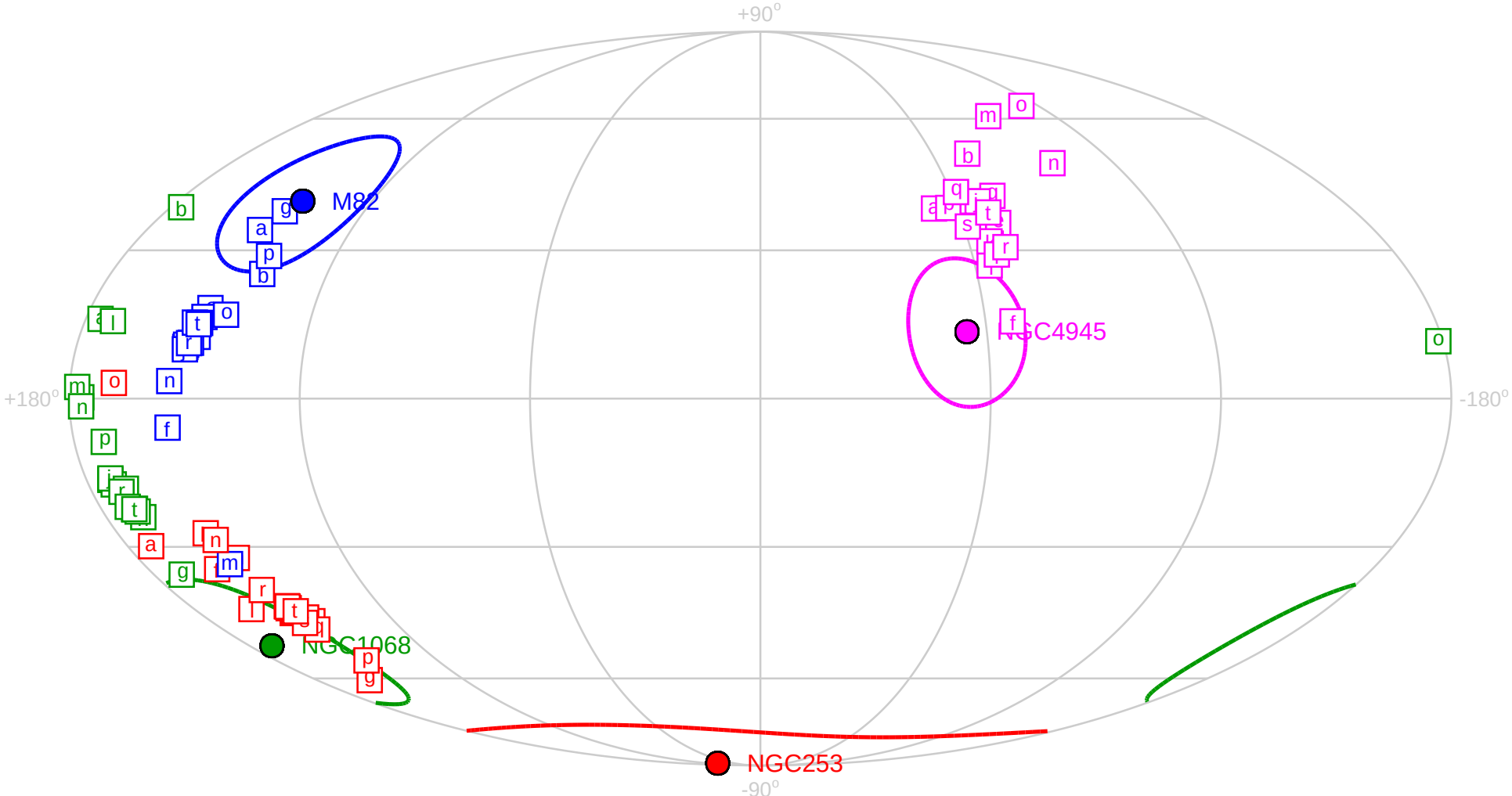

circles: starburst model “RMS deflection” ($15^\circ$)

# Back-tracking in Direction of Starburst Galaxies , $\mathbf{R = 7}$ EV ($\sim$50 EeV N)



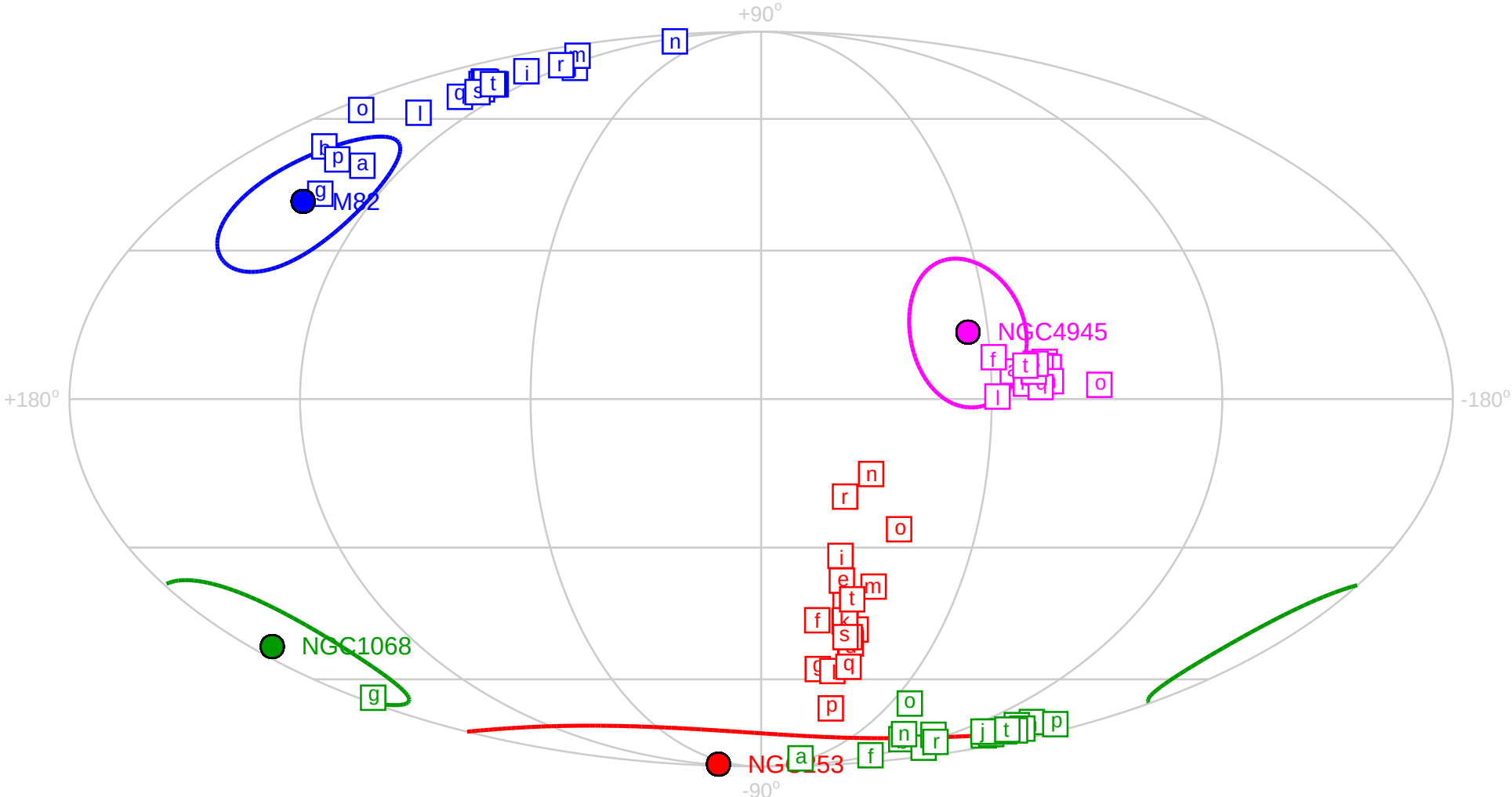

circles: starburst model “RMS deflection” ($15^\circ$)

# Back-tracking in Direction of Starburst Galaxies , $\mathbf{R = 6}$ EV ($\sim$50 EeV O)



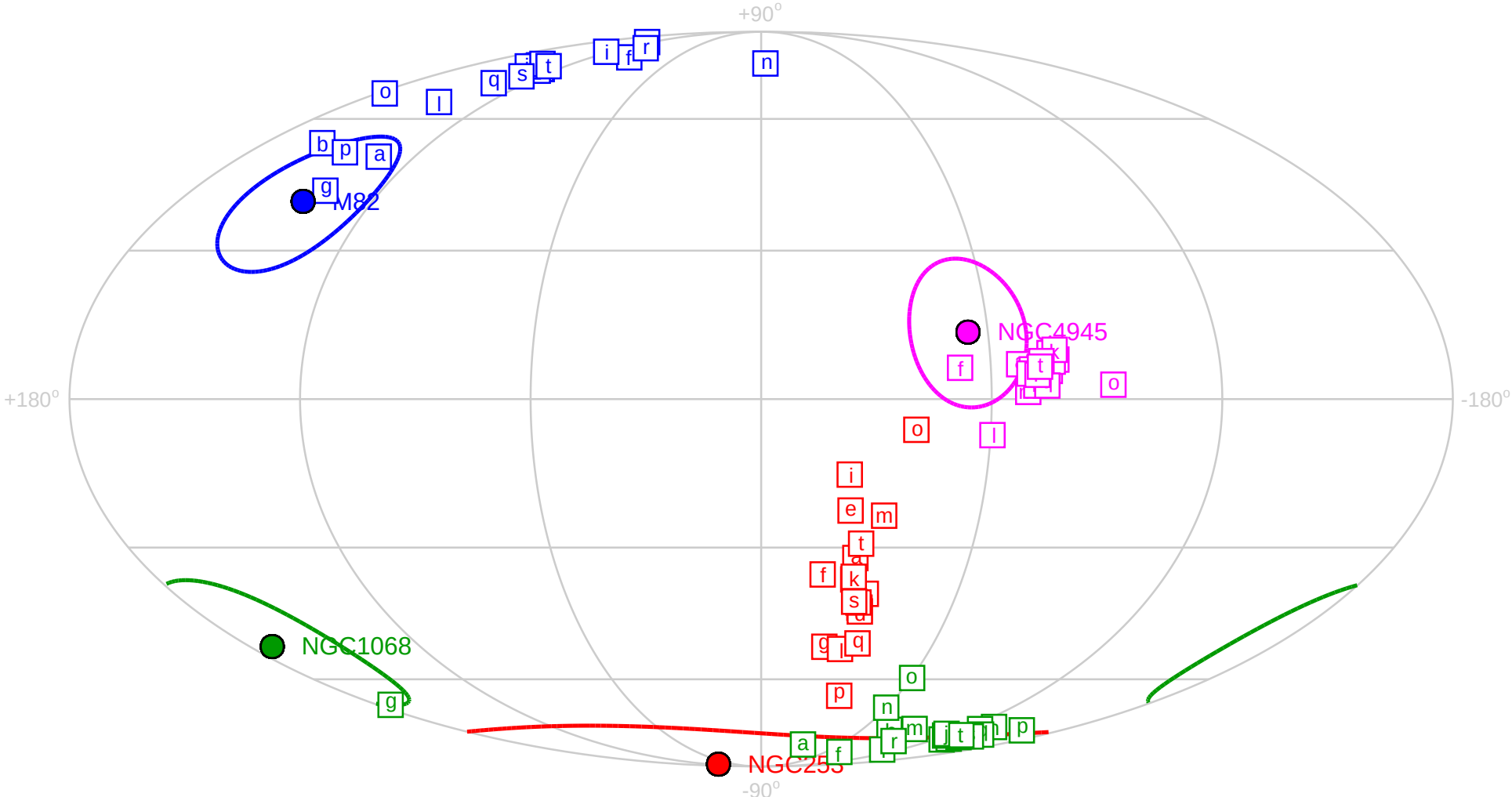

circles: starburst model “RMS deflection” ($15^\circ$)

# Forward-tracking from Starburst Galaxies , $\mathbf{R = 8}$ EV ($\sim$50 EeV C)




circles: starburst model "RMS deflection" ($15^\circ$)

# Forward-tracking from Starburst Galaxies , $\mathbf{R = 7}$ EV ($\sim$50 EeV N)

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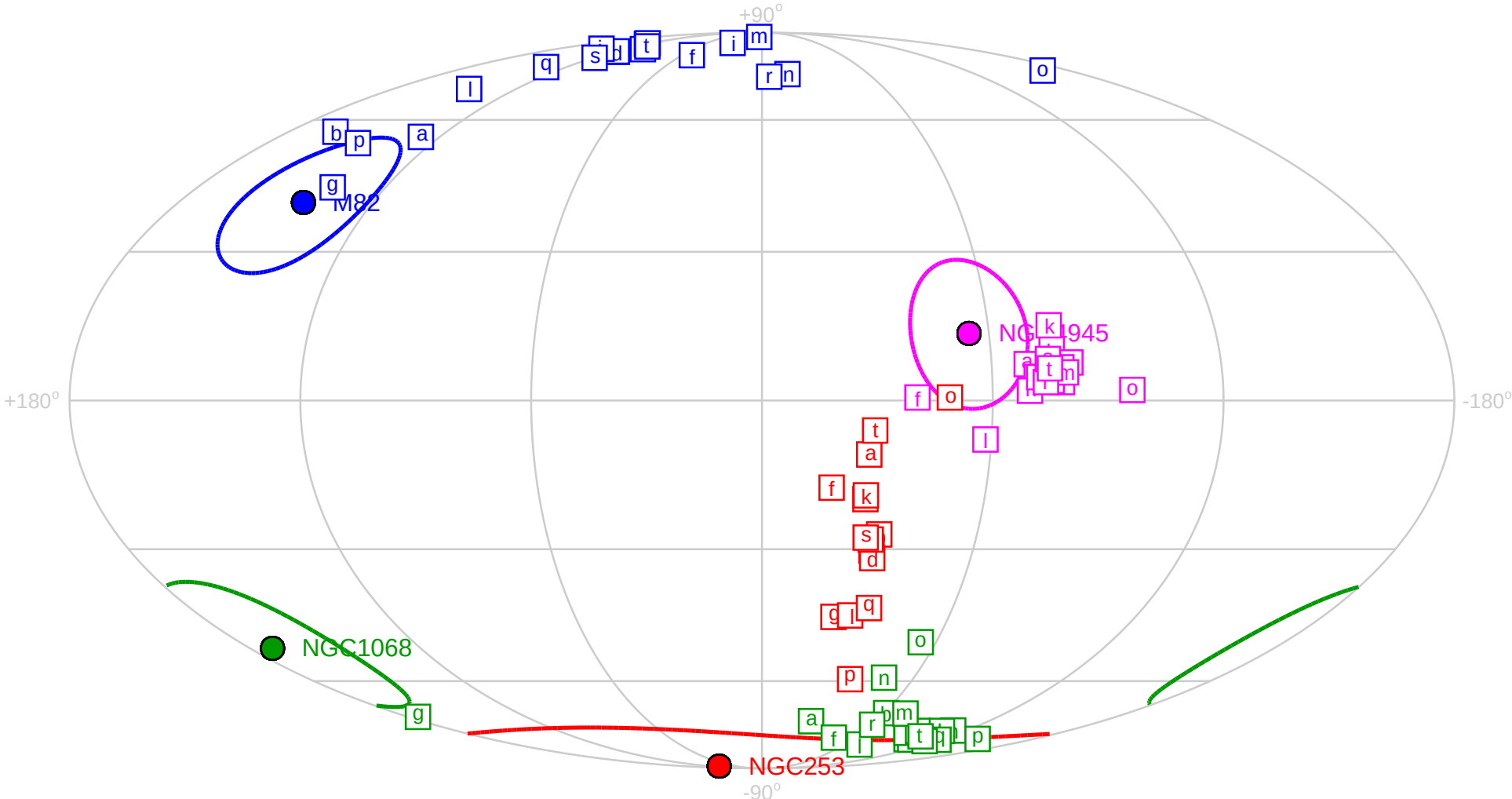
# Forward-tracking from Starburst Galaxies , $\mathbf{R = 6}$ EV ($\sim$50 EeV O)




circles: starburst model "RMS deflection" ($15^\circ$)

# Summary

- lower limit on GMF model uncertainties by variation of underlying model assumptions
- ultimate goal: provide deflection-pdf for anisotropy studies
- 2MRS dipole compatible with CR dipole within model uncertainties
- large deflections for nuclei in direction of hot/warm spots $\rightarrow$ compatible with starburst scenario?