Probing the isotropy of cosmic acceleration

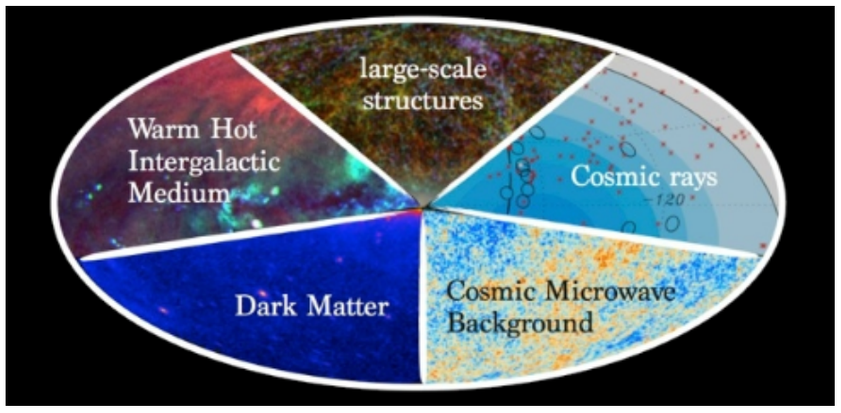
Behnam Javanmardi

Collaborators: C. Porciani, P. Kroupa & J. Pflamm-Altenburg

Argelander-Institut für Astronomie

universitätbonn

arXiv:1507.07560



2nd Anisotropic Universe Workshop
Amsterdam

IMPRS astronomy & astrophysics Bonn and Cologne

Max-Planck-Institut für Radioastronomie

The Cosmological Principle

Homogeneity & Isotropy

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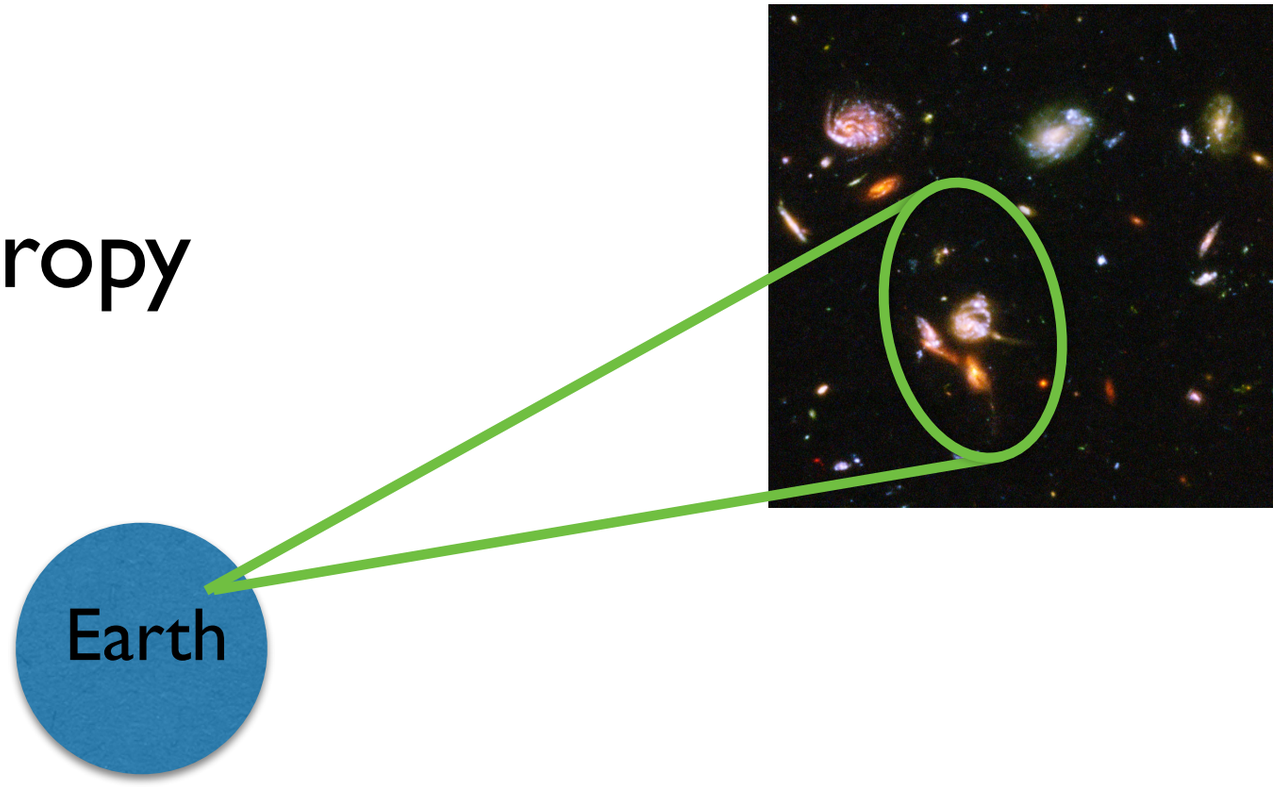
Homogeneity & Isotropy



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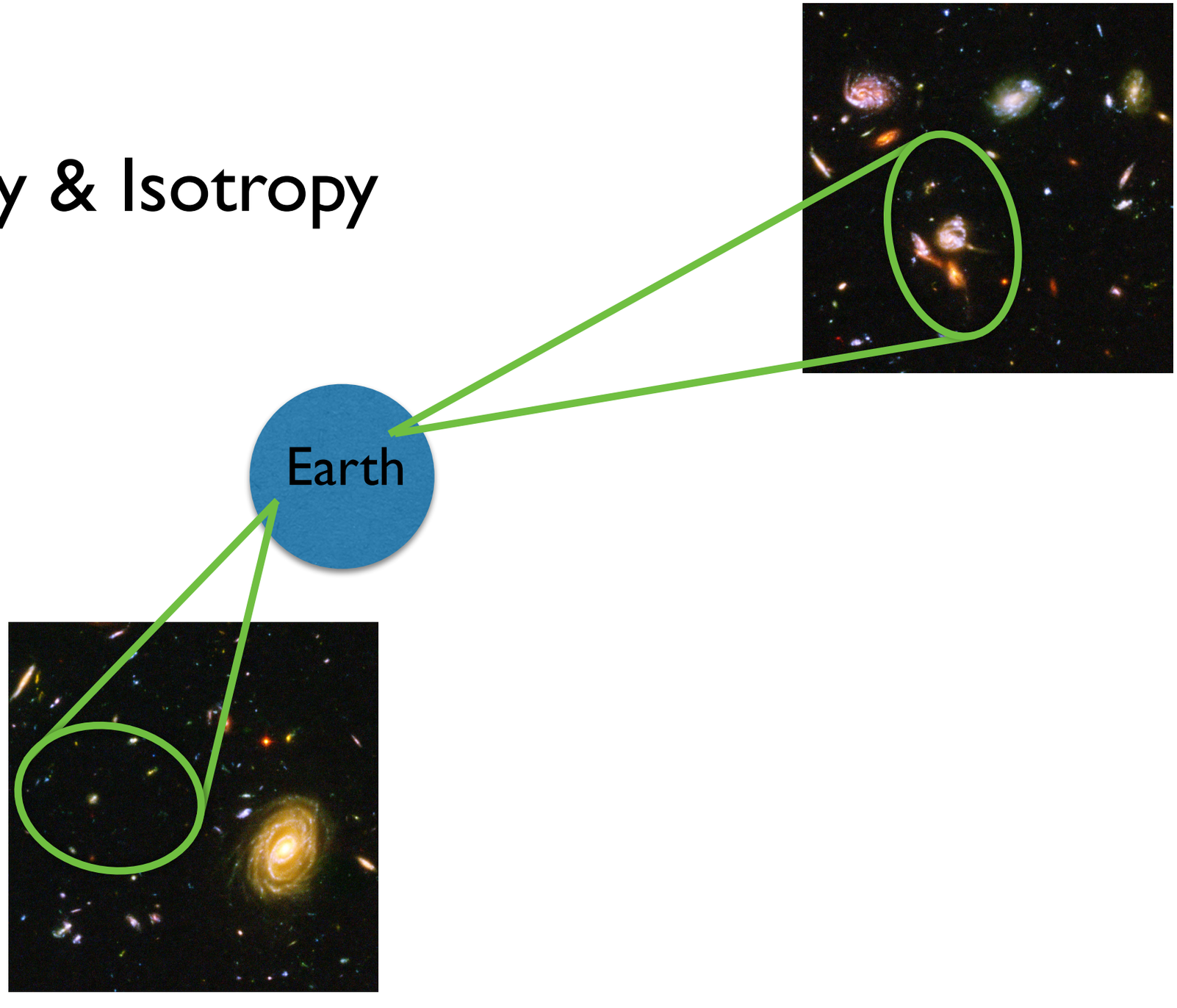
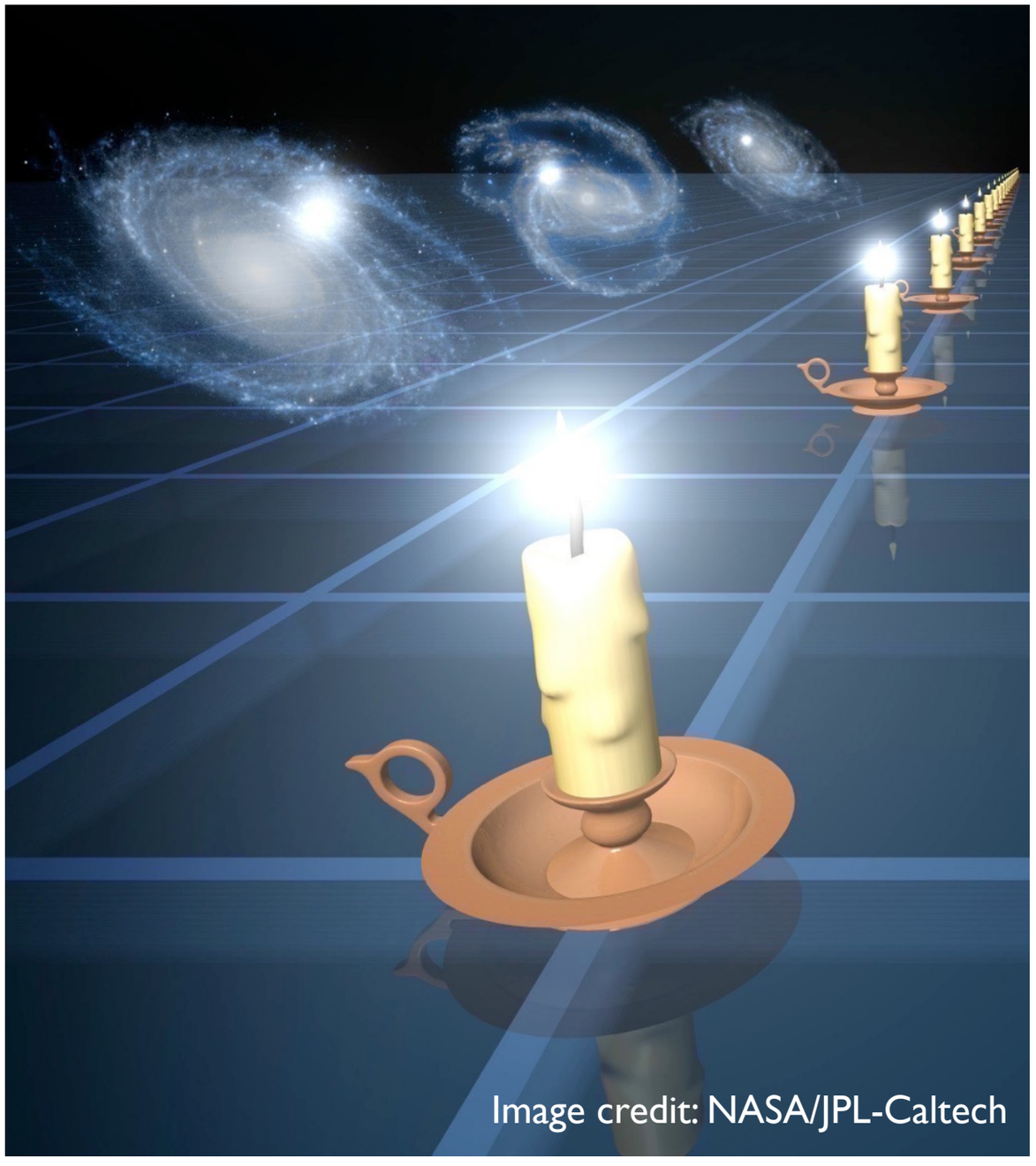


SNe Ia as standard candles: acceleration of the expansion



Previous works

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  Studying bulk motion in the Local Universe

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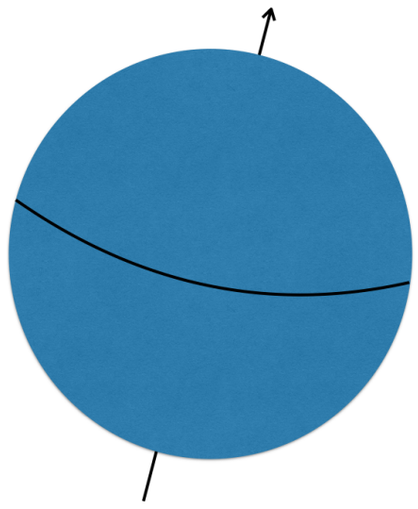

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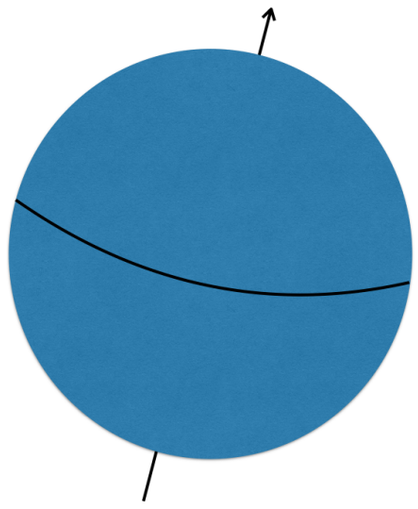
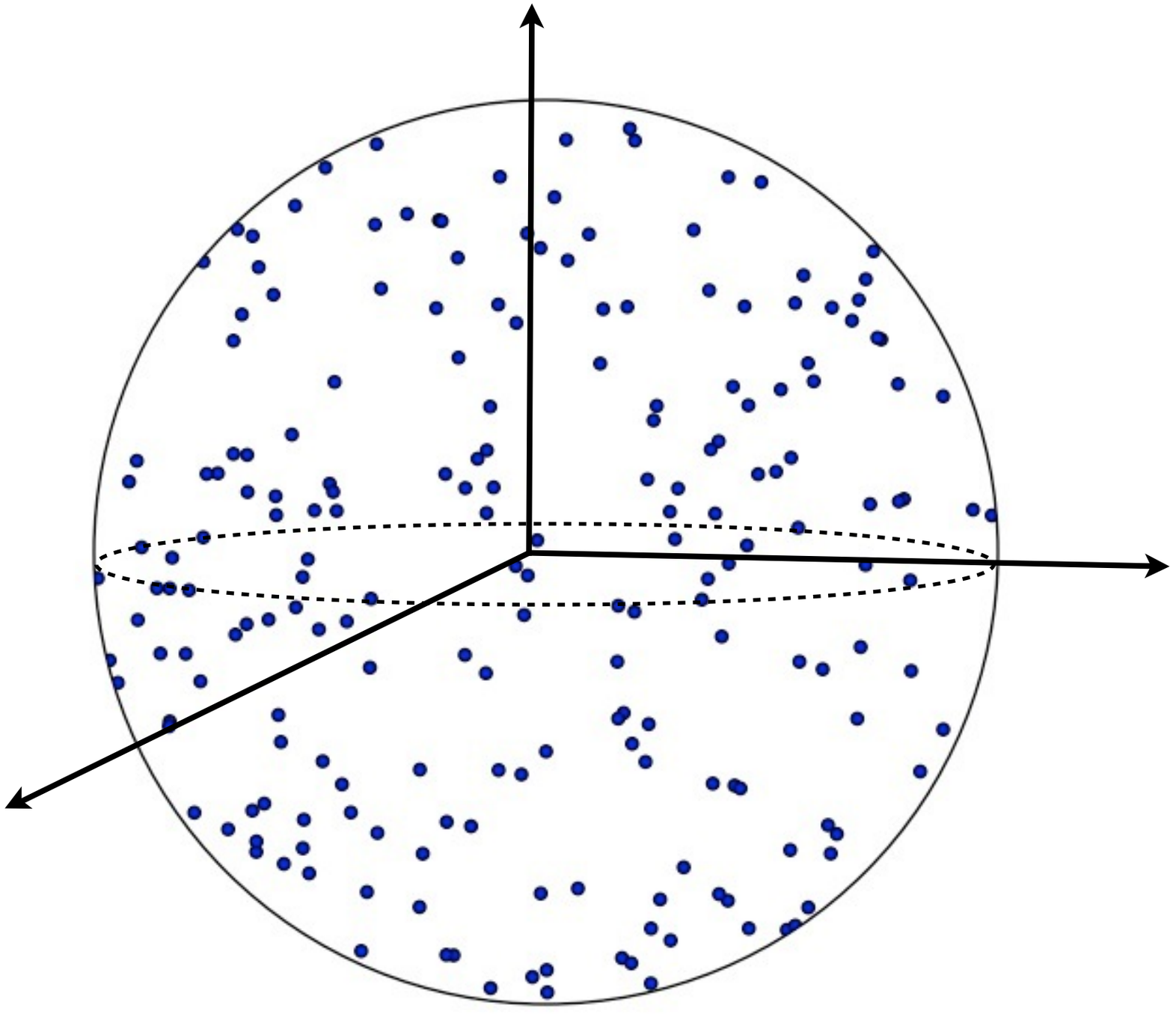
Anisotropic Cosmological Model
e.g. Campanelli et al. (2011)



Our Method: *Cone Analysis*



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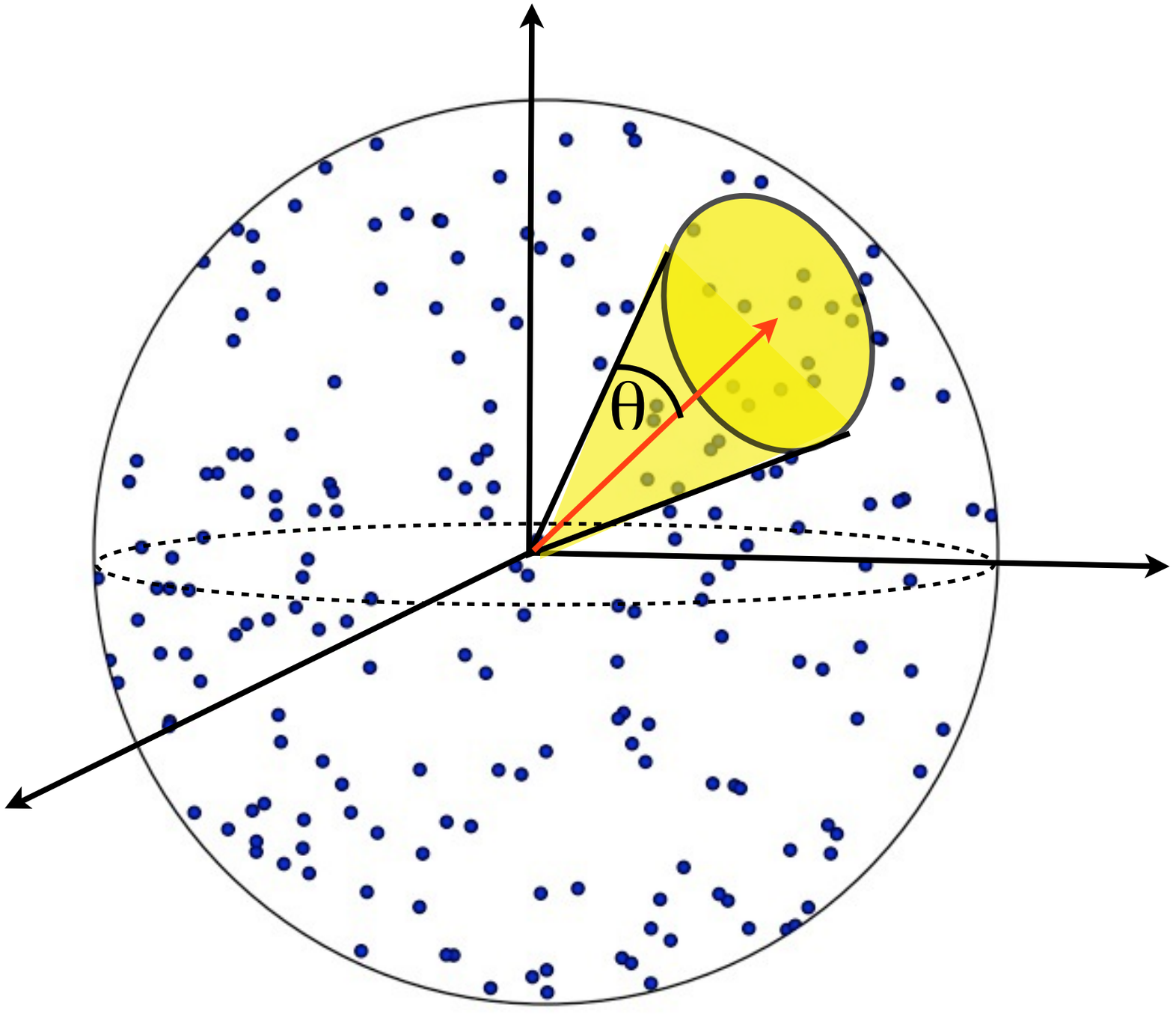

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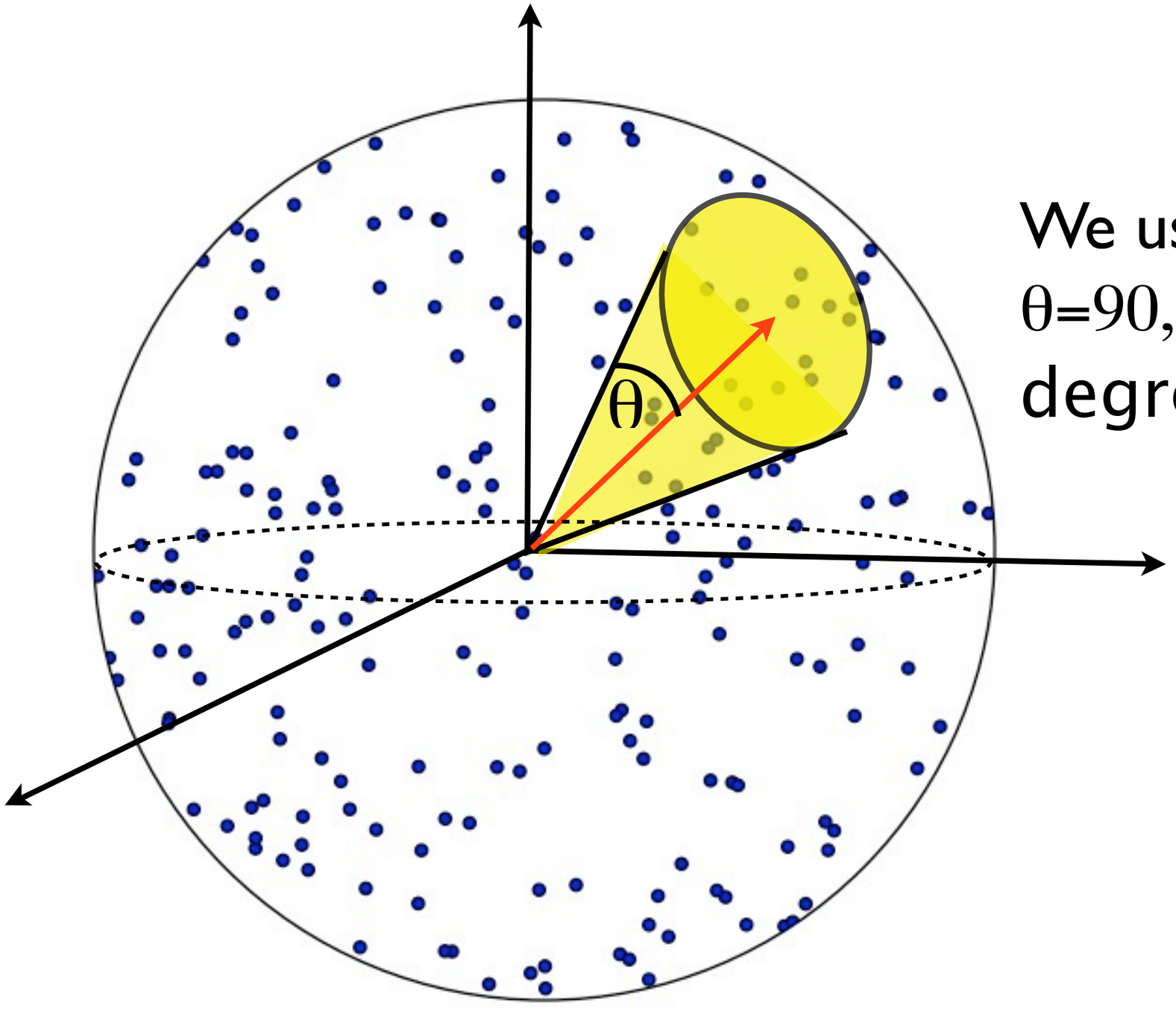

We use Cone Angle θ=90, 60 and 30 degrees

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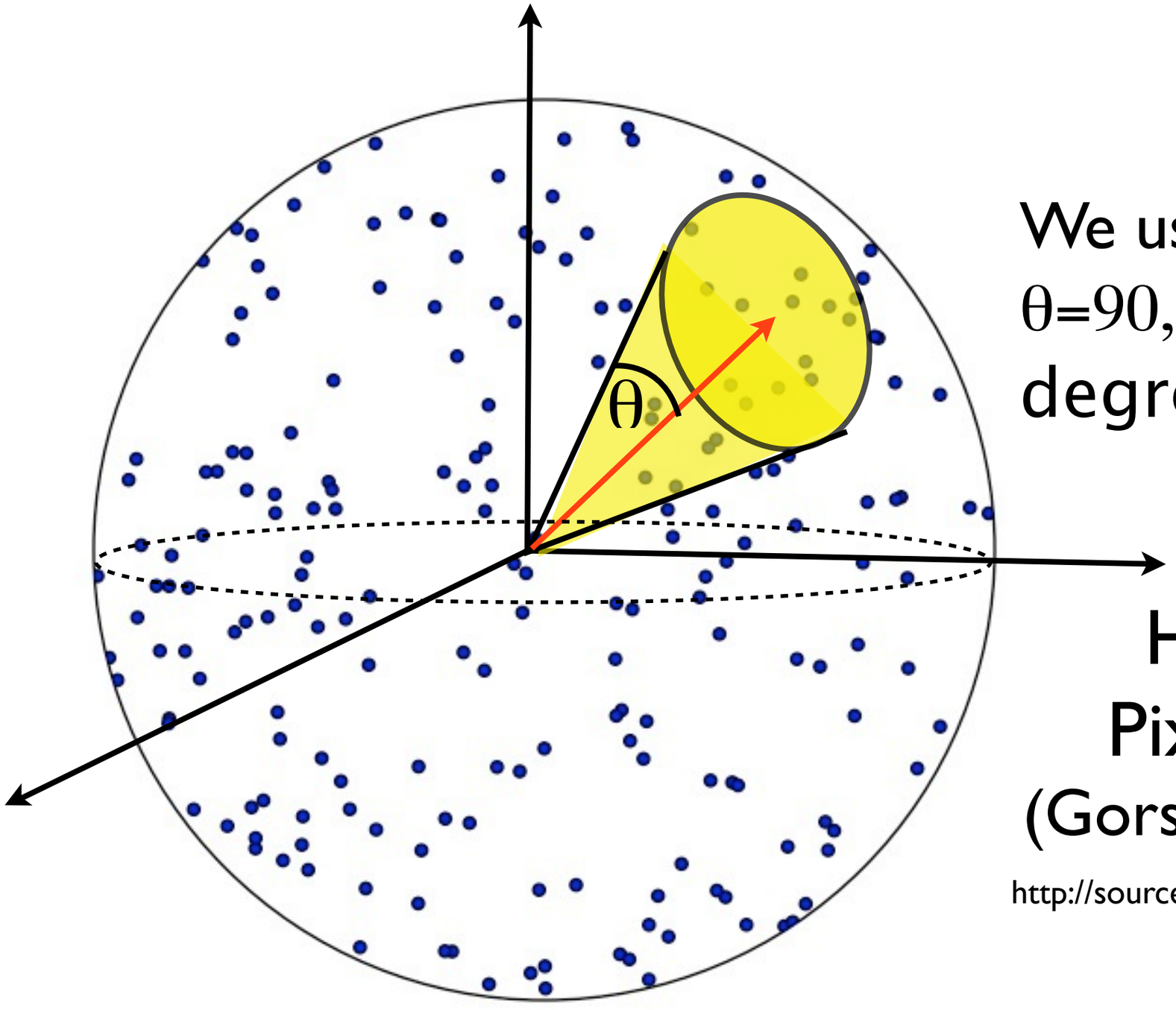

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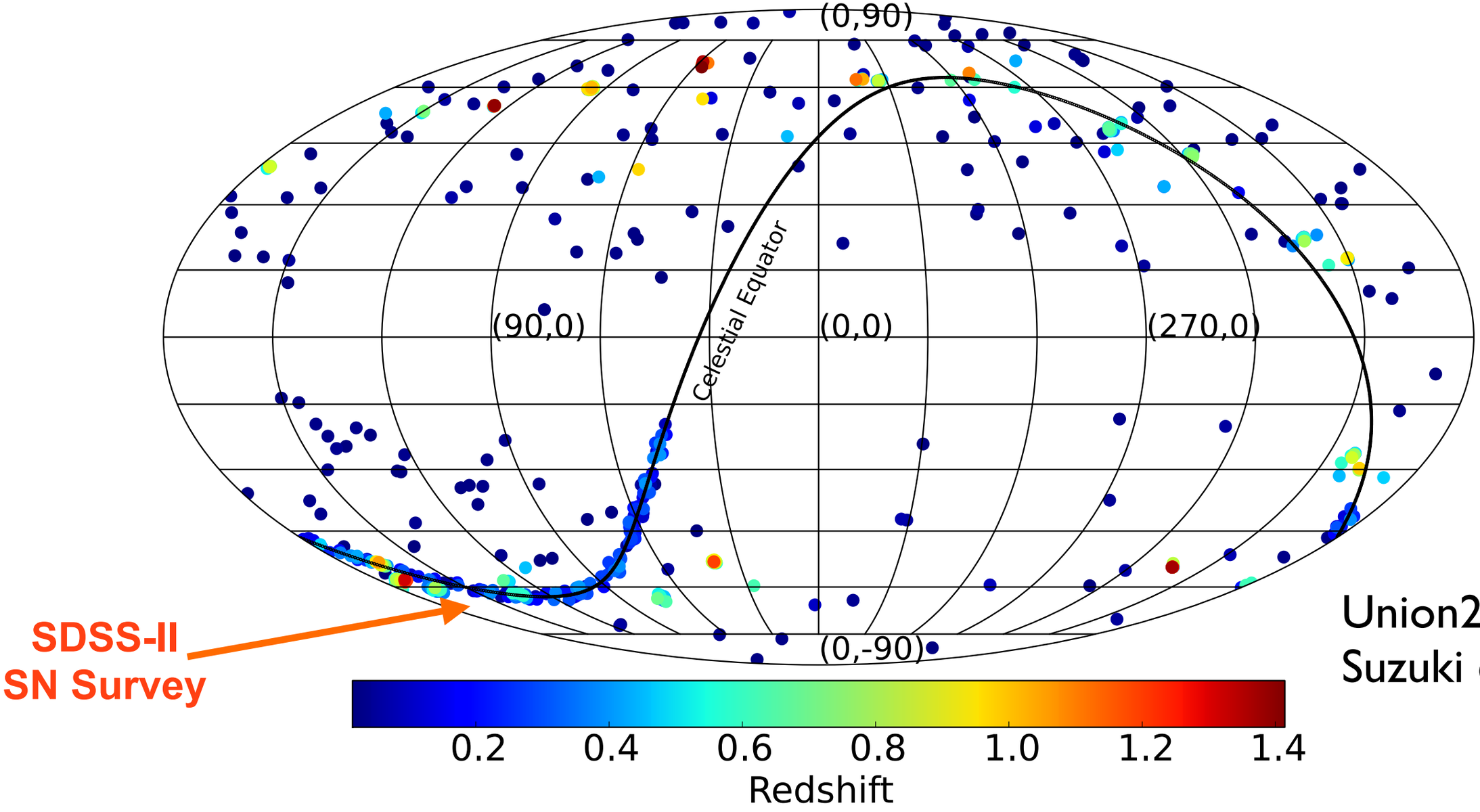
HEALPix Pixelization (Gorski et al. 2004)

http://sourceforge.net/projects/healpix/

Distribution of SN Ia in Galactic Coordinate System



SDSS-II SN Survey

Union2.1 Data
Suzuki et al. 2012

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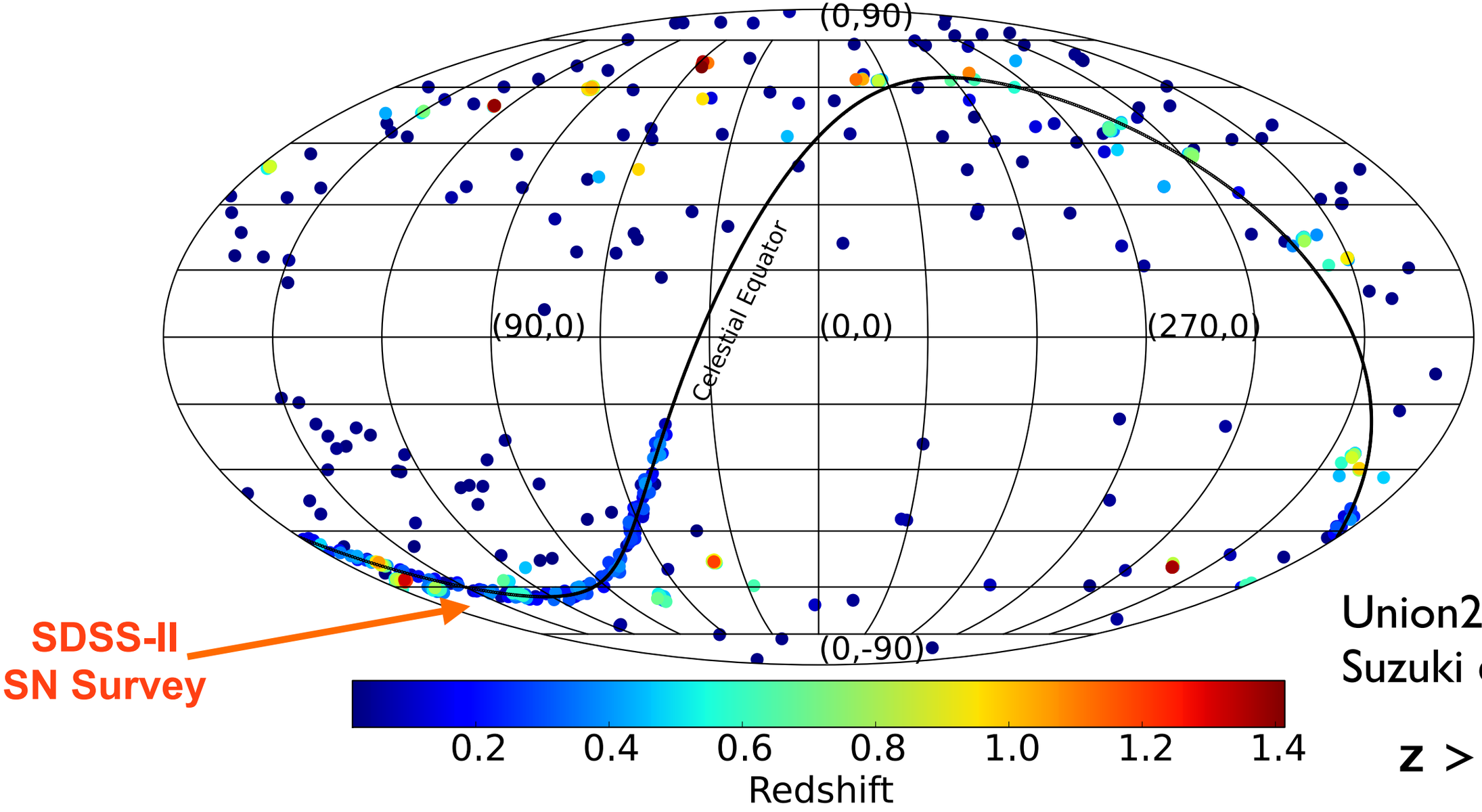

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z > 0.2

Formulation

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$$\chi^2 = V^T C^{-1} V$$

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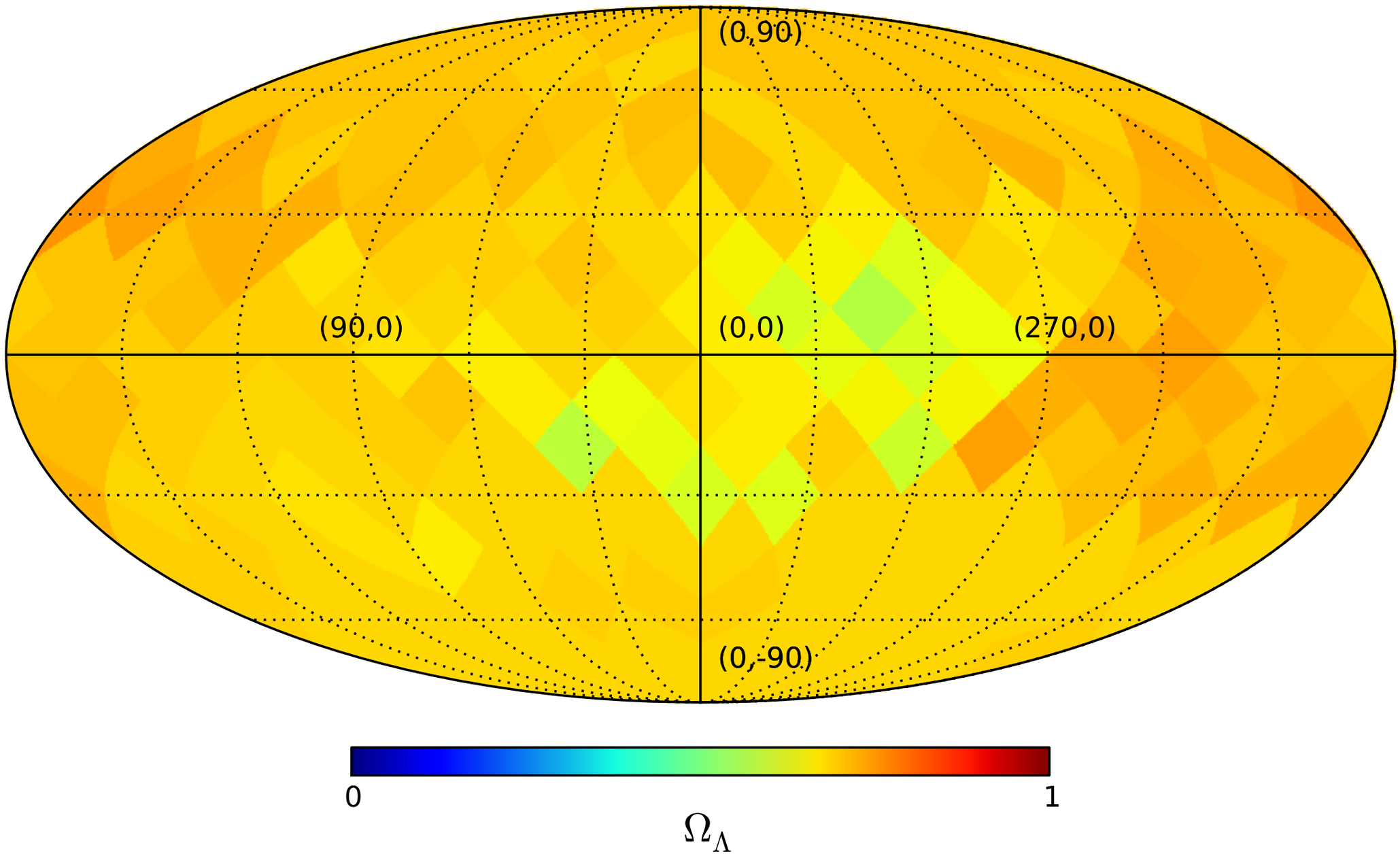
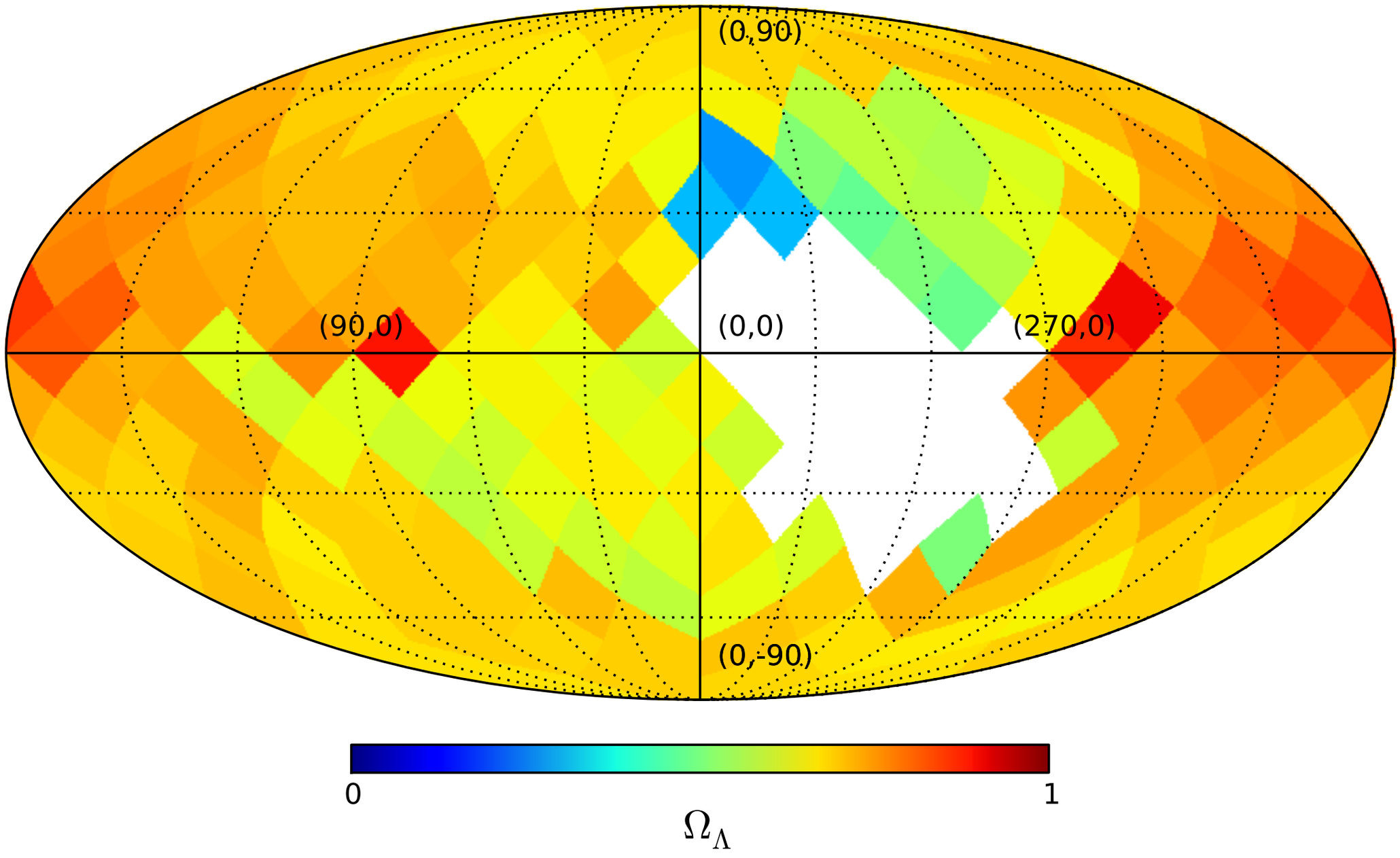
$$\Omega_\Lambda = 0.705^{+0.040}_{-0.043}$$

Suzuki et al. 2012

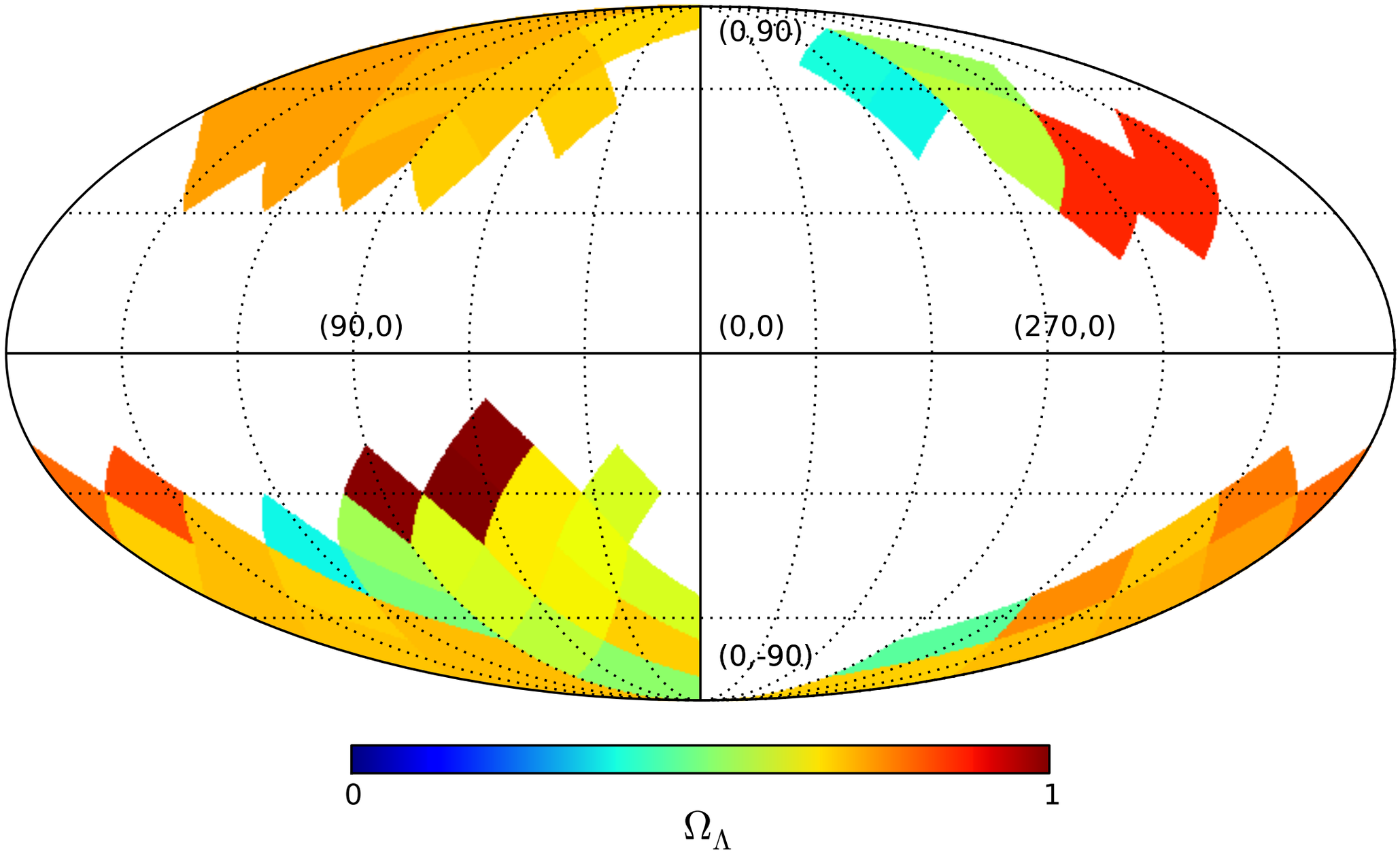
Result for Cone Angle $\theta=90^\circ$



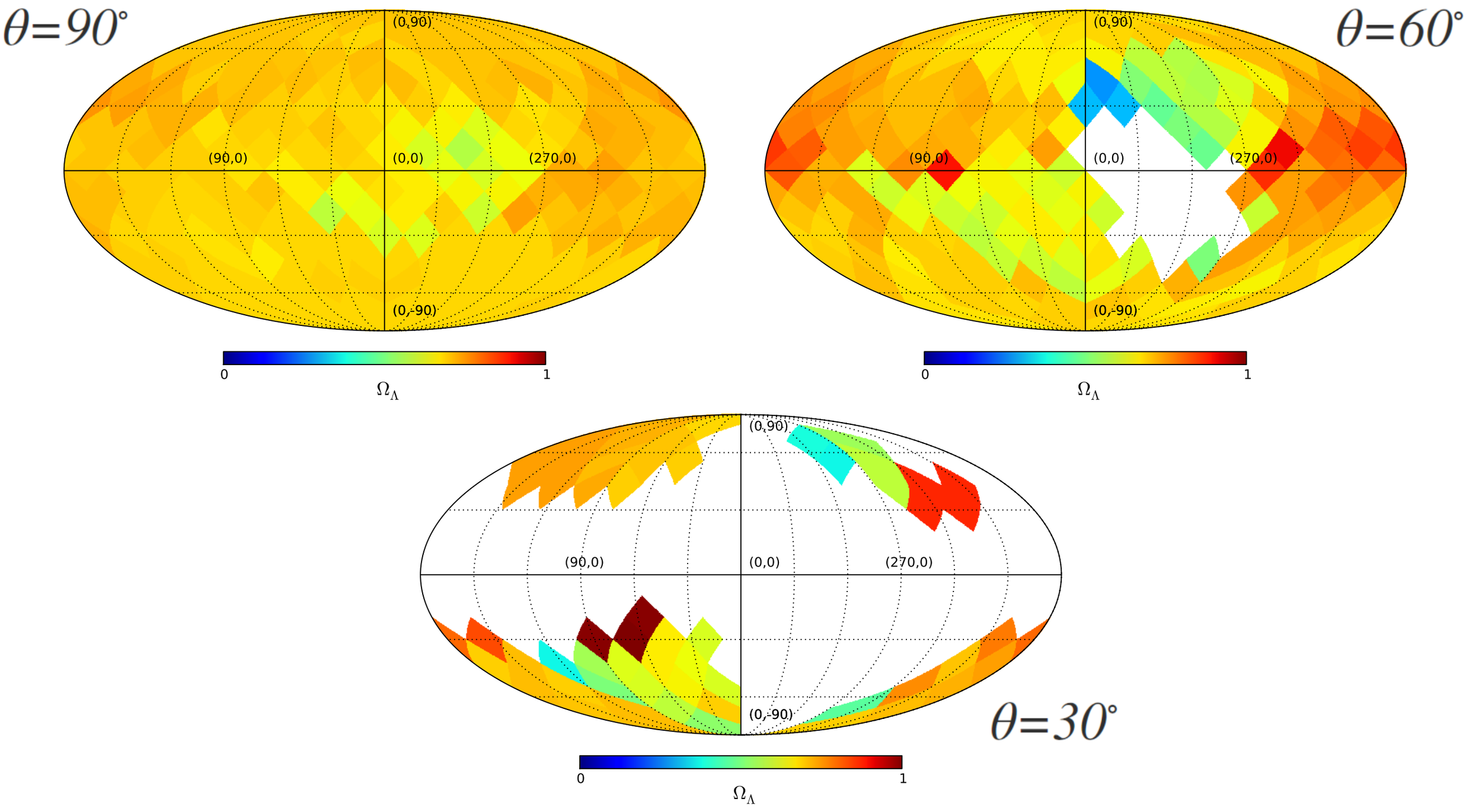
Result for Cone Angle $\theta=60^\circ$



Result for Cone Angle $\theta=30^{\circ}$



Result of *Cone Analysis*: Ω_Λ Maps



Finding The Most Discrepant Direction

Null hypothesis:
Universe accelerates equally in all directions

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Chi-Square Probability

P

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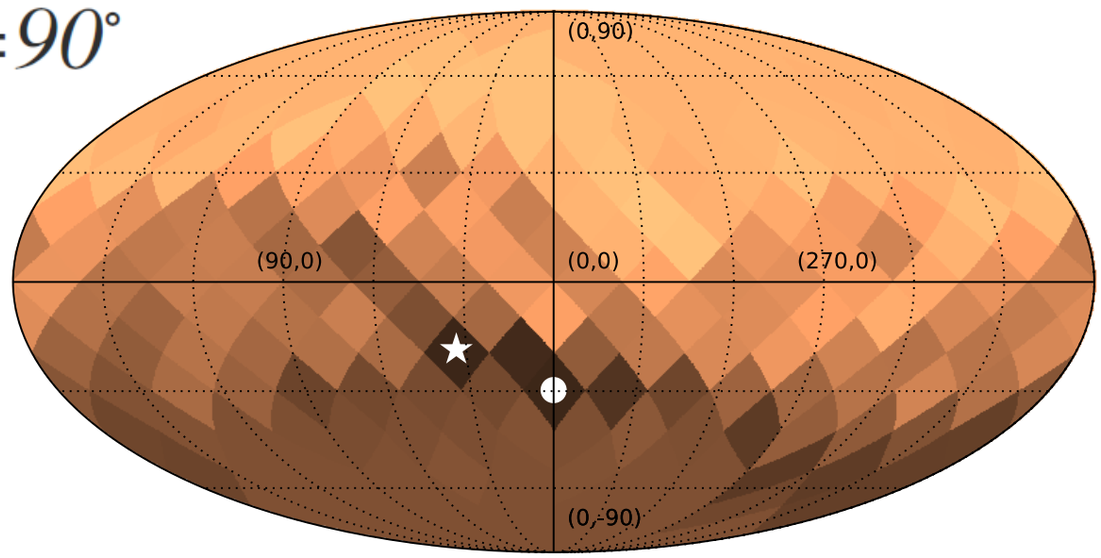
Most discrepant direction = Direction with the smallest P

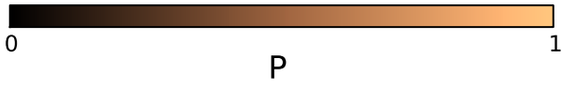
Result of *Cone Analysis*: P Maps

$\theta=90^\circ$

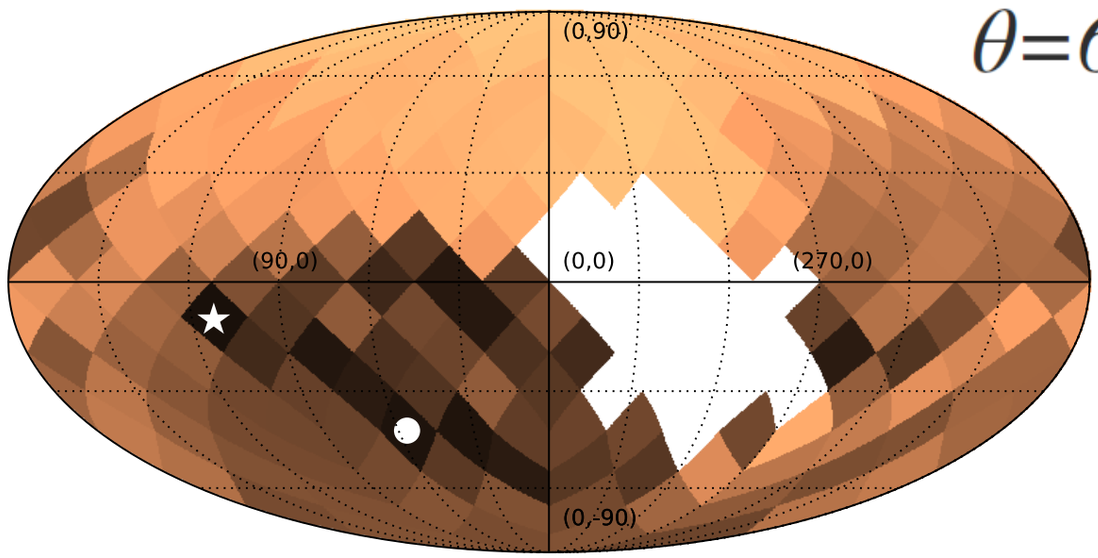


$P_\bigstar$ =0.192

$P_\bullet$ =0.197

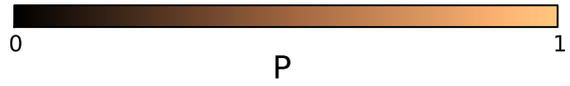


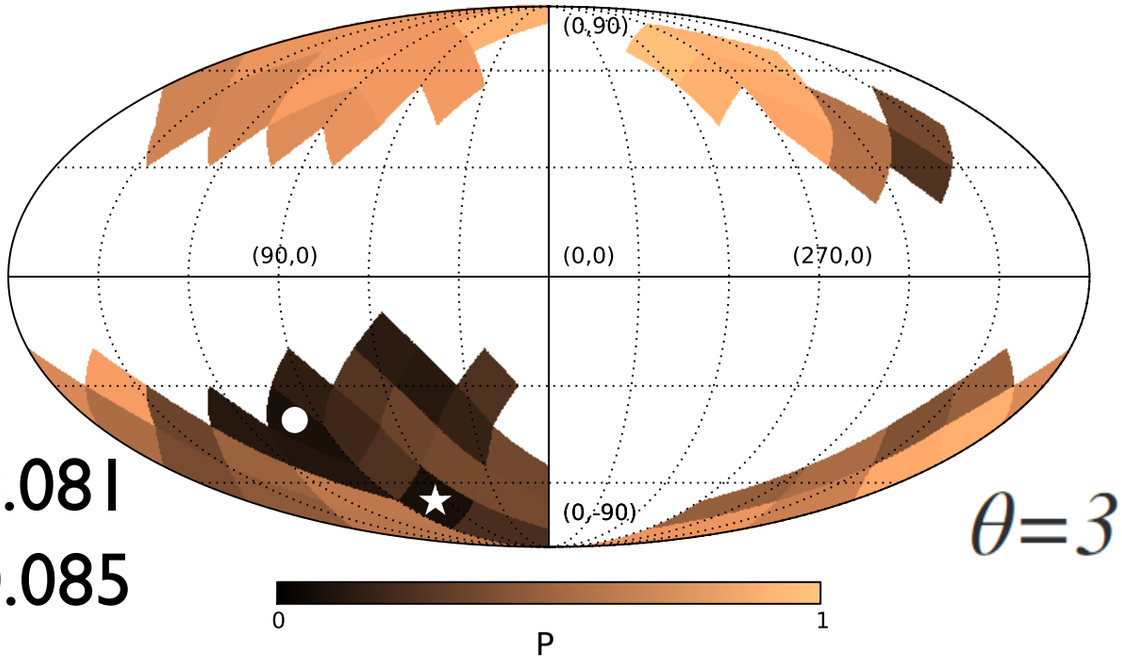
$\theta=60^\circ$



$P_\bigstar$ =0.086

$P_\bullet$ =0.101





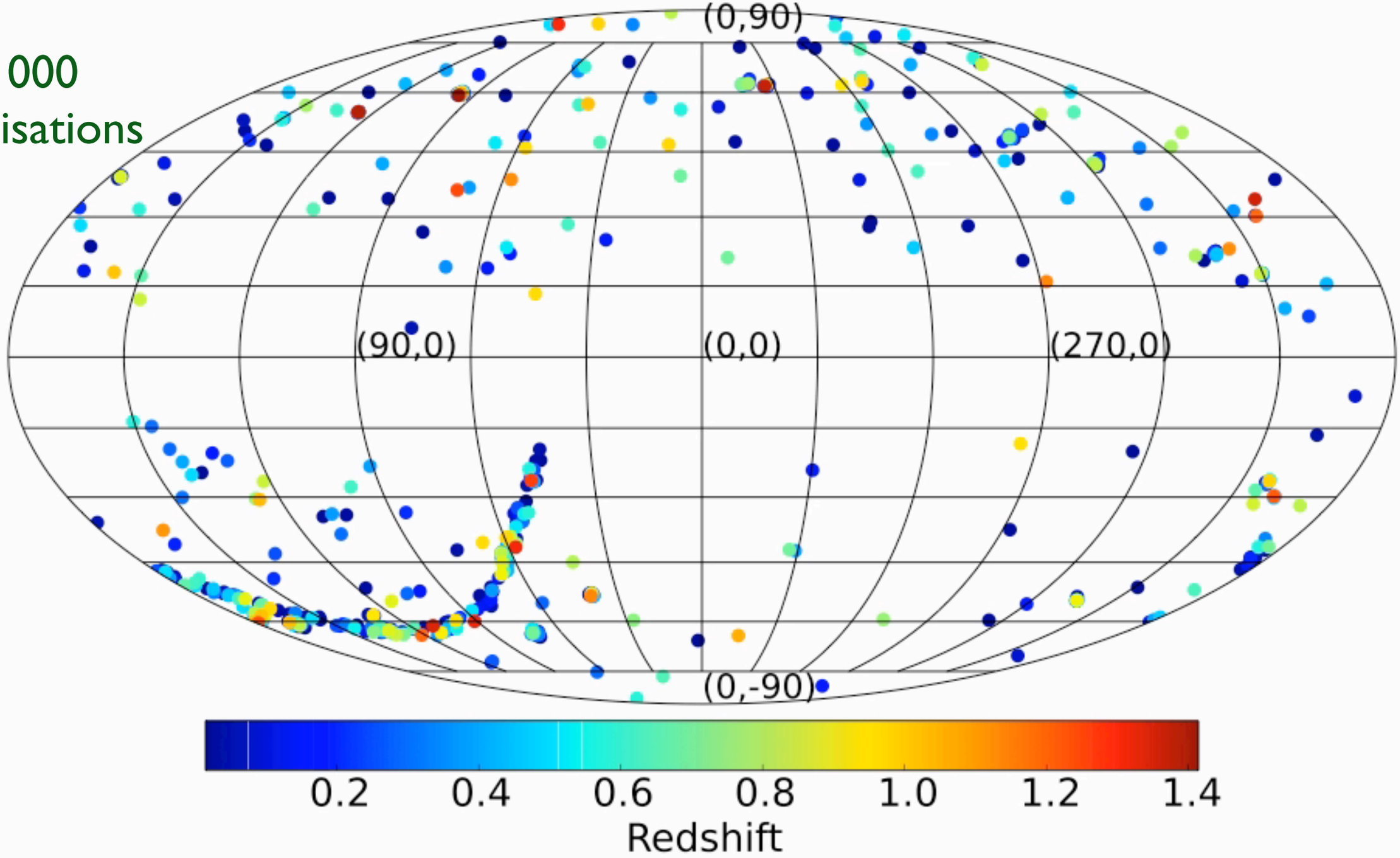
$P_\bigstar$ =0.081

$P_\bullet$ =0.085

$\theta=30^\circ$

Shuffling Union2.1 while keeping angular distribution constant

1000 Realisations



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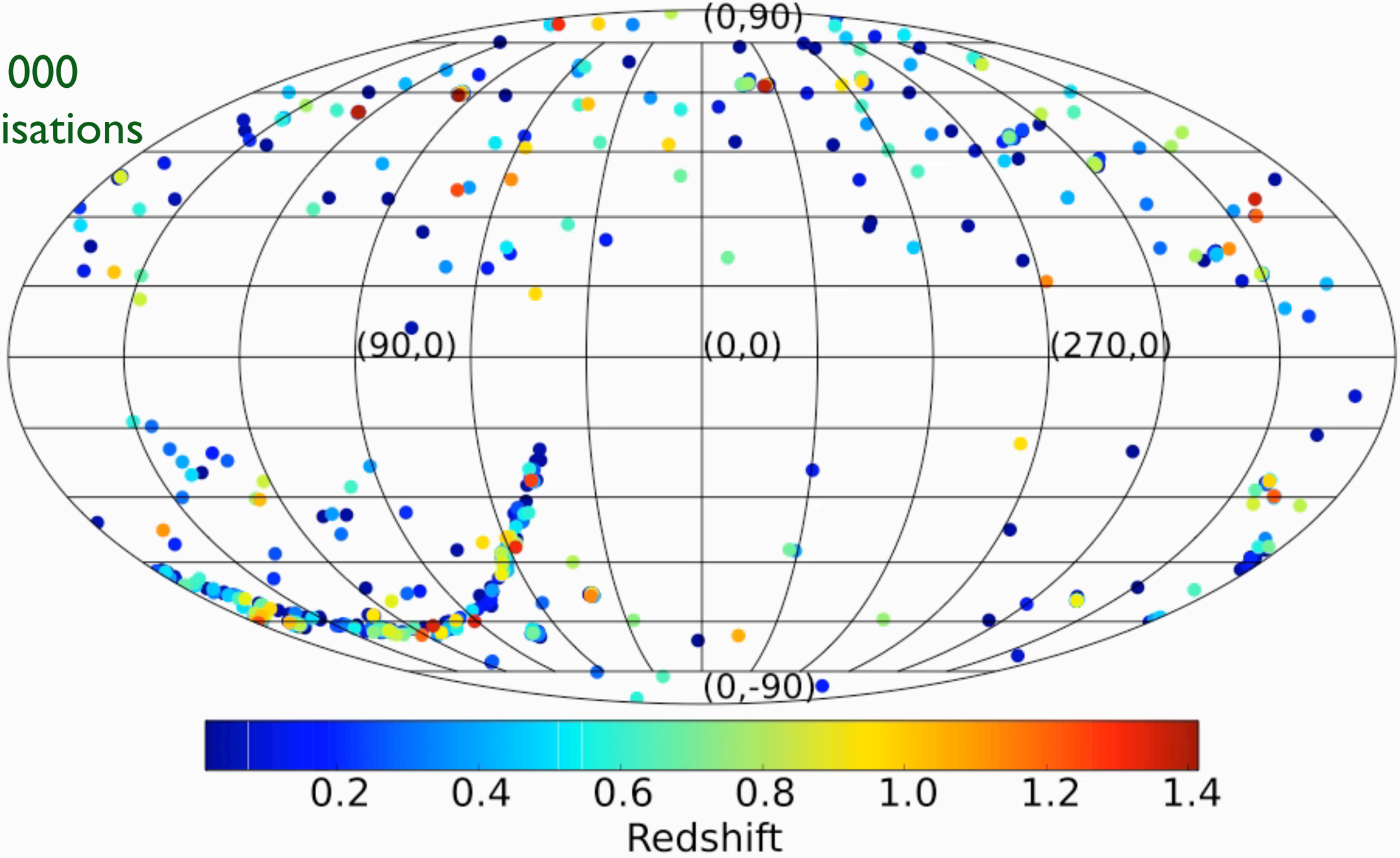

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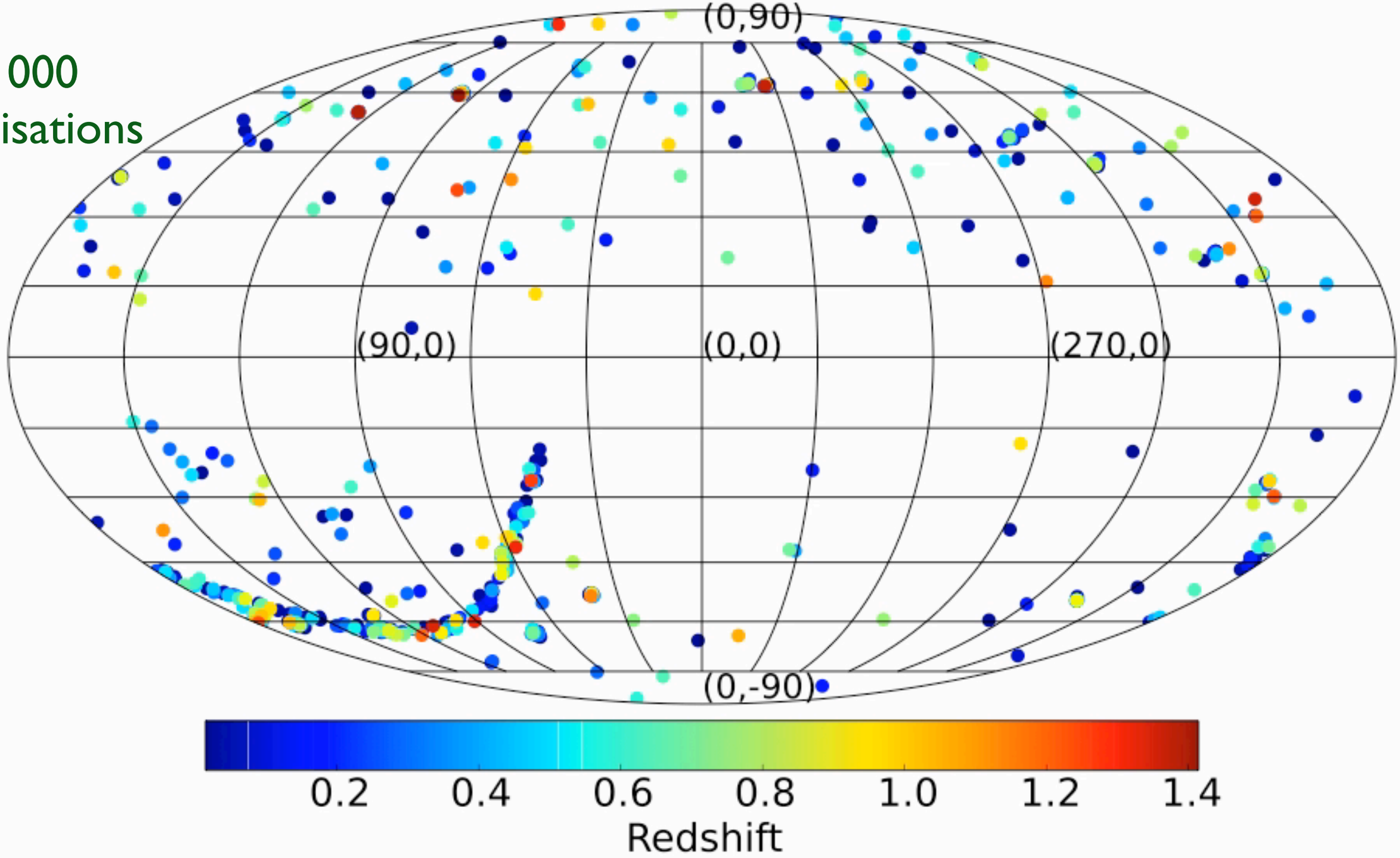
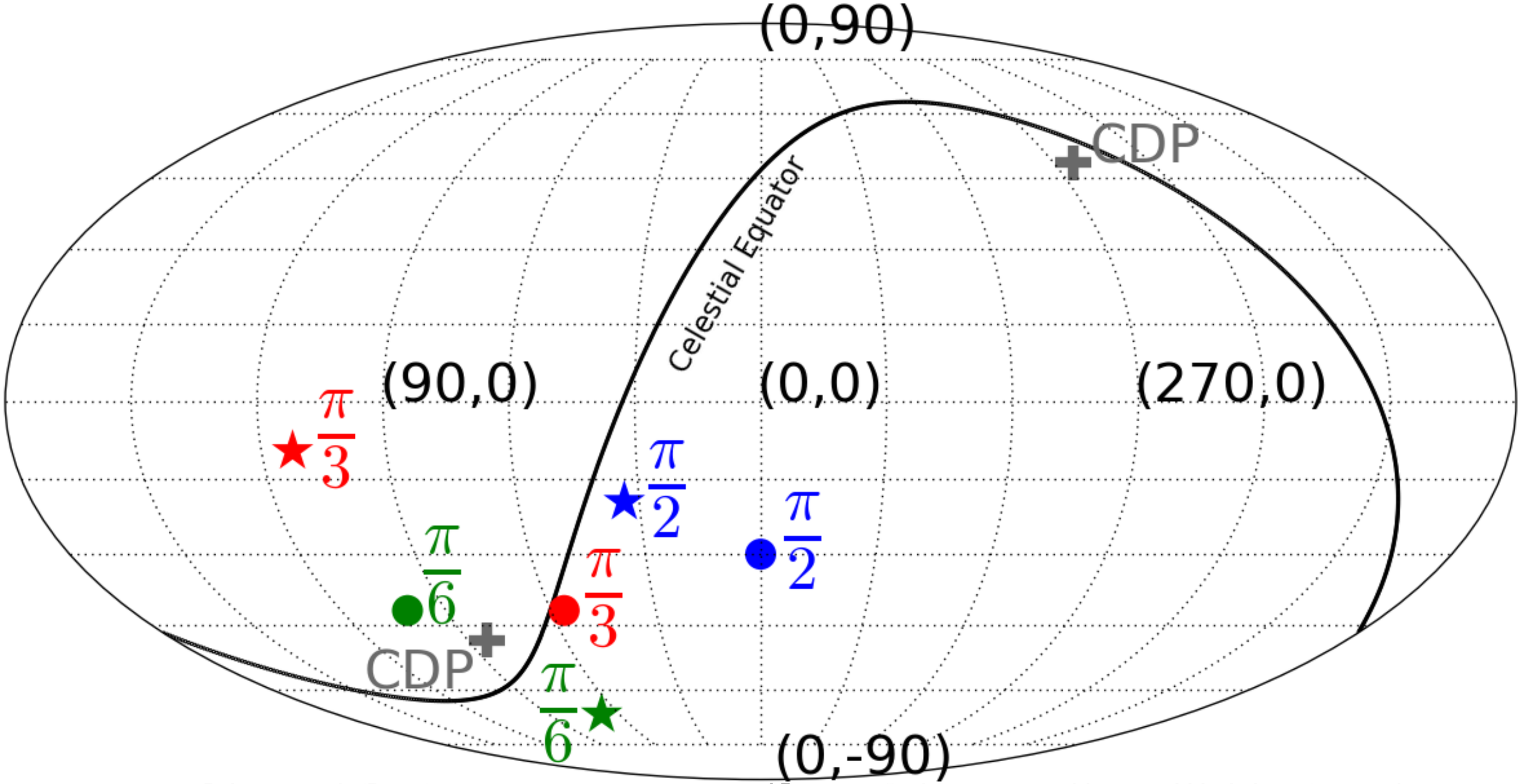


Monte Carlo result: the discrepancy is not significant

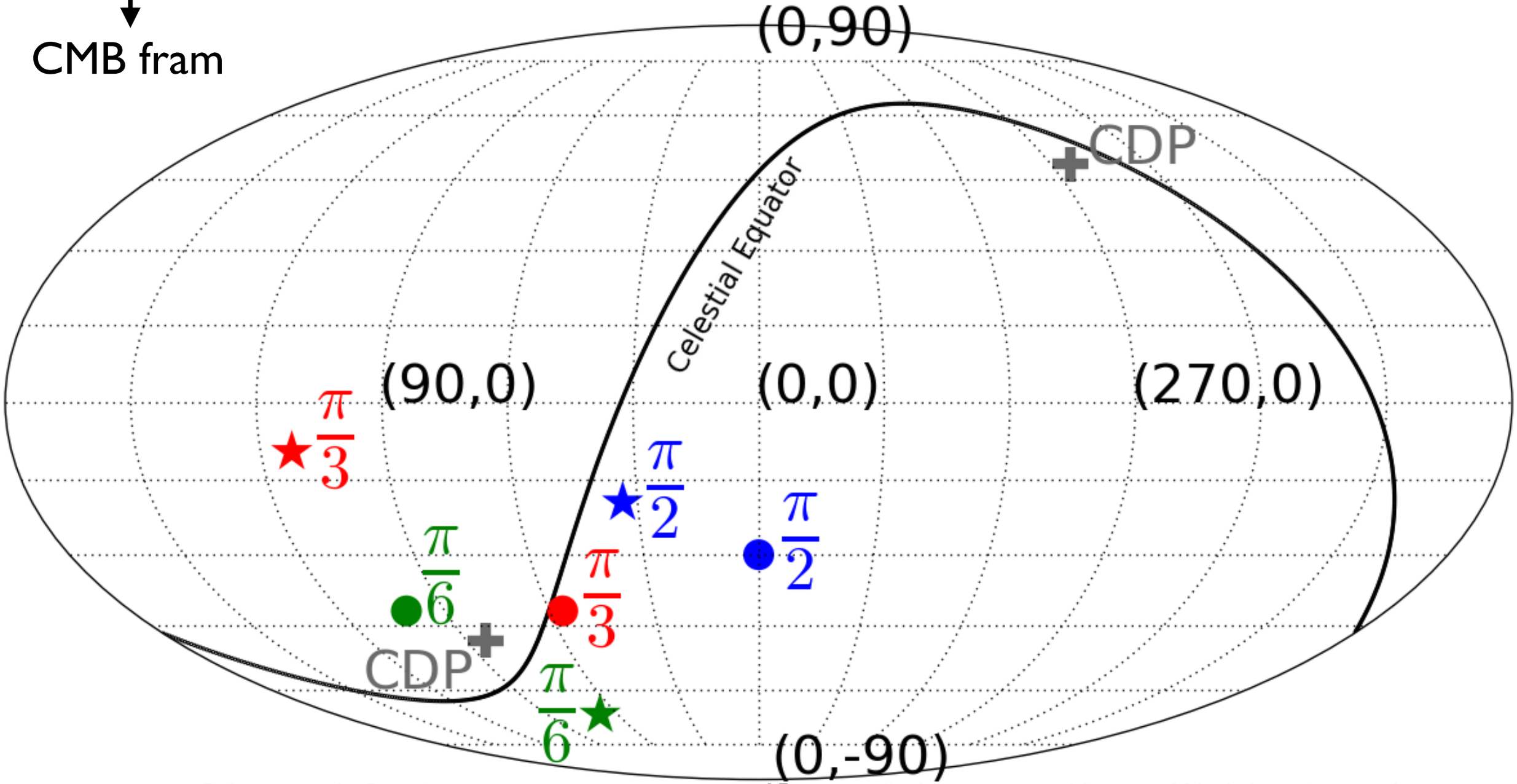
Anisotropy Directions



Anisotropy Directions

SNe redshifts

CMB fram



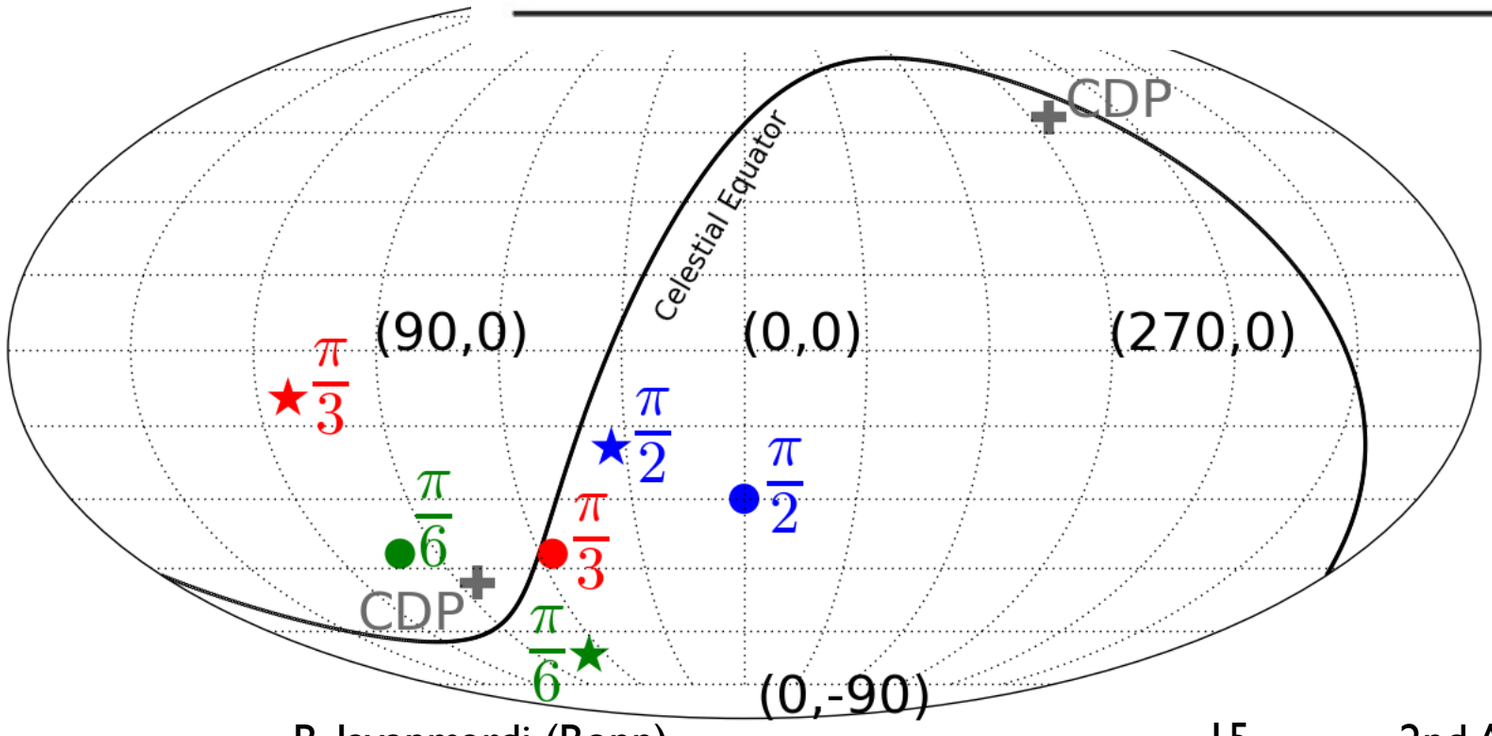
Anisotropy Directions

SNe redshifts

↓

CMB fram

θ	α	f_1	f_2
$\star\ \pi/2$	49°.4	0.085	0.027
$\bullet\ \pi/2$	64°.3	0.152	0.052
$\star\ \pi/3$	45°.5	0.045	0.021
$\bullet\ \pi/3$	20°.5	0.008	0.002
$\star\ \pi/6$	20°.1	0.064	0.045
$\bullet\ \pi/6$	13°.7	0.010	0.006



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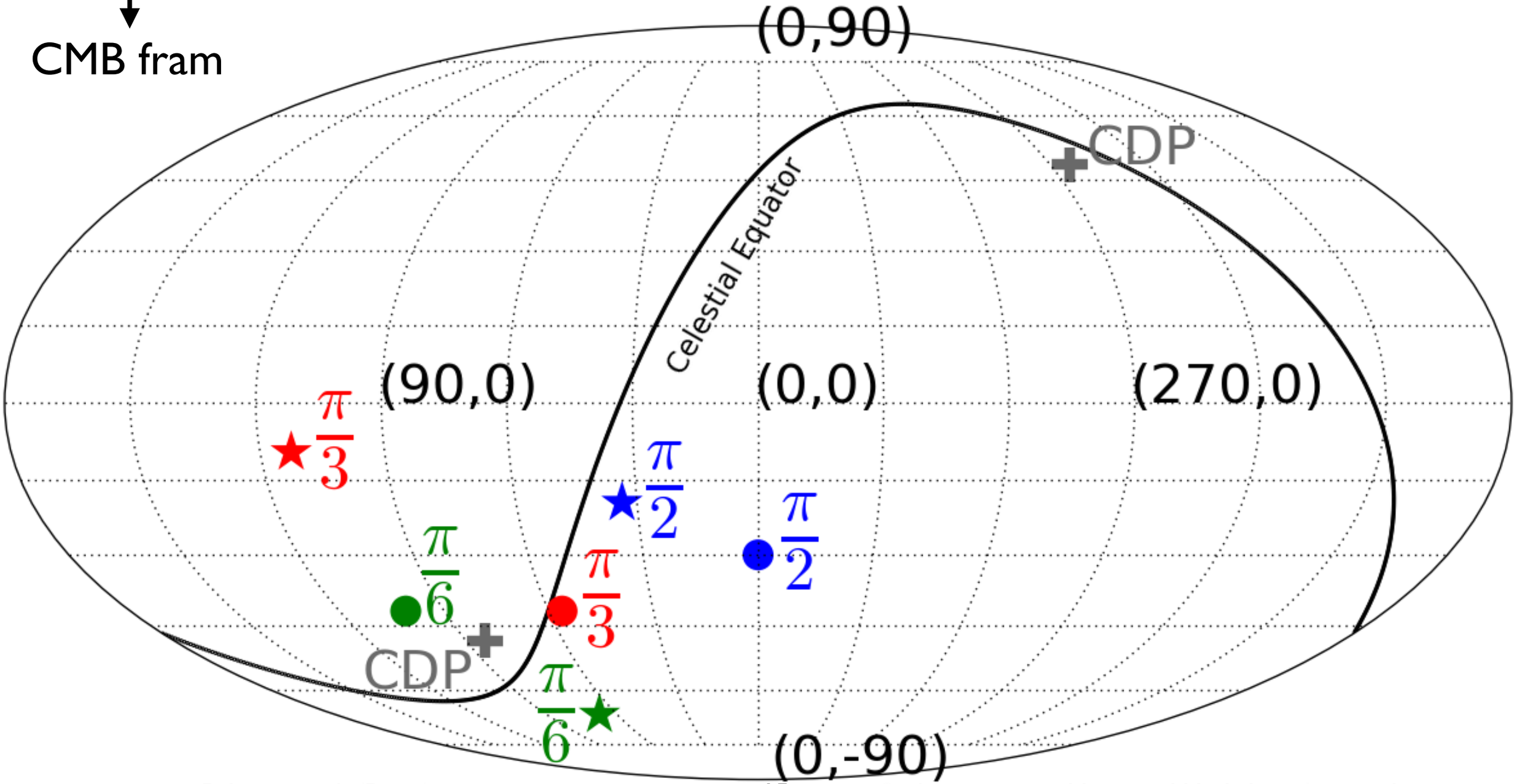
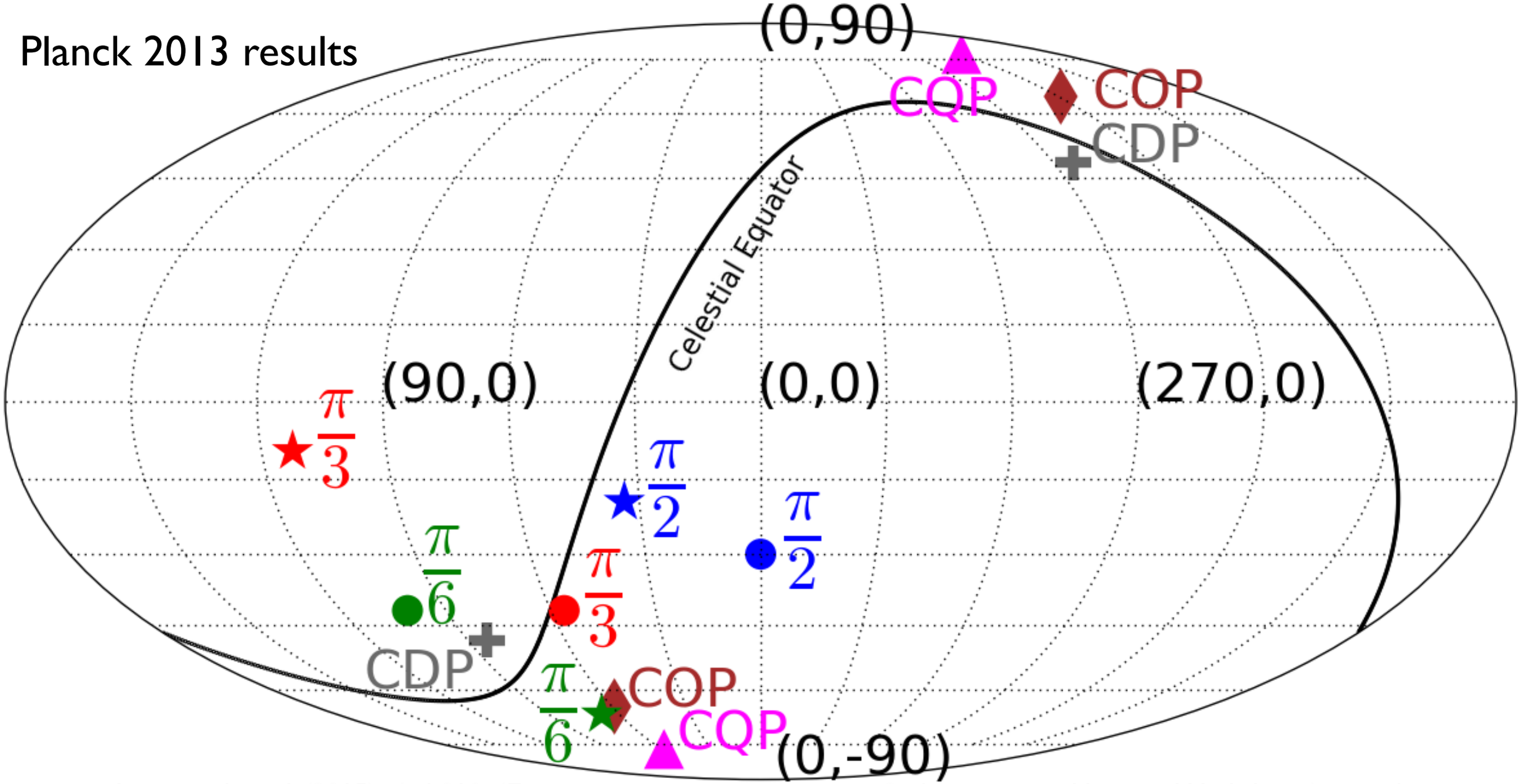
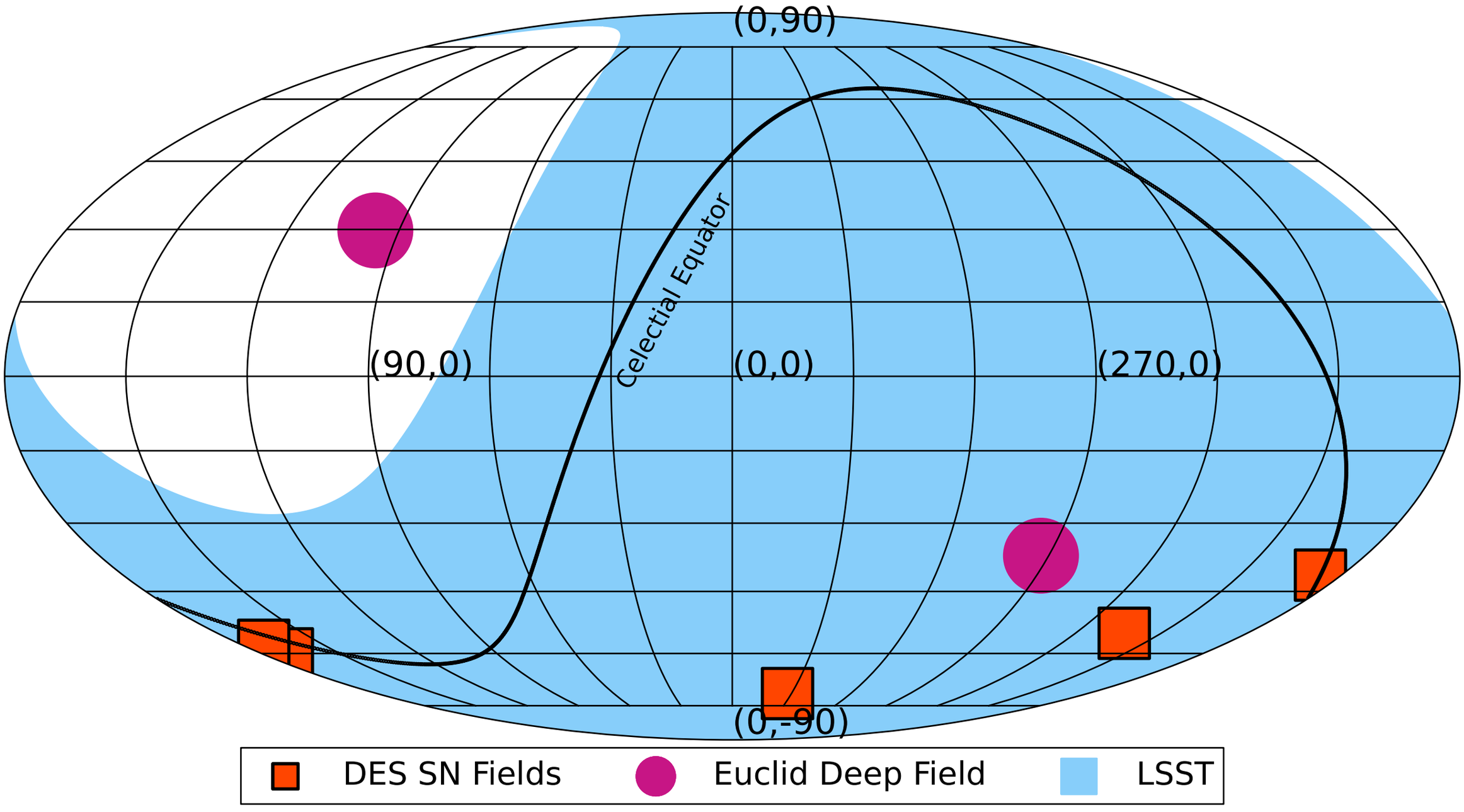


Anisotropy Directions & CMB quadrupole-octopole alignment

Planck 2013 results



Fields of future surveys



Summary

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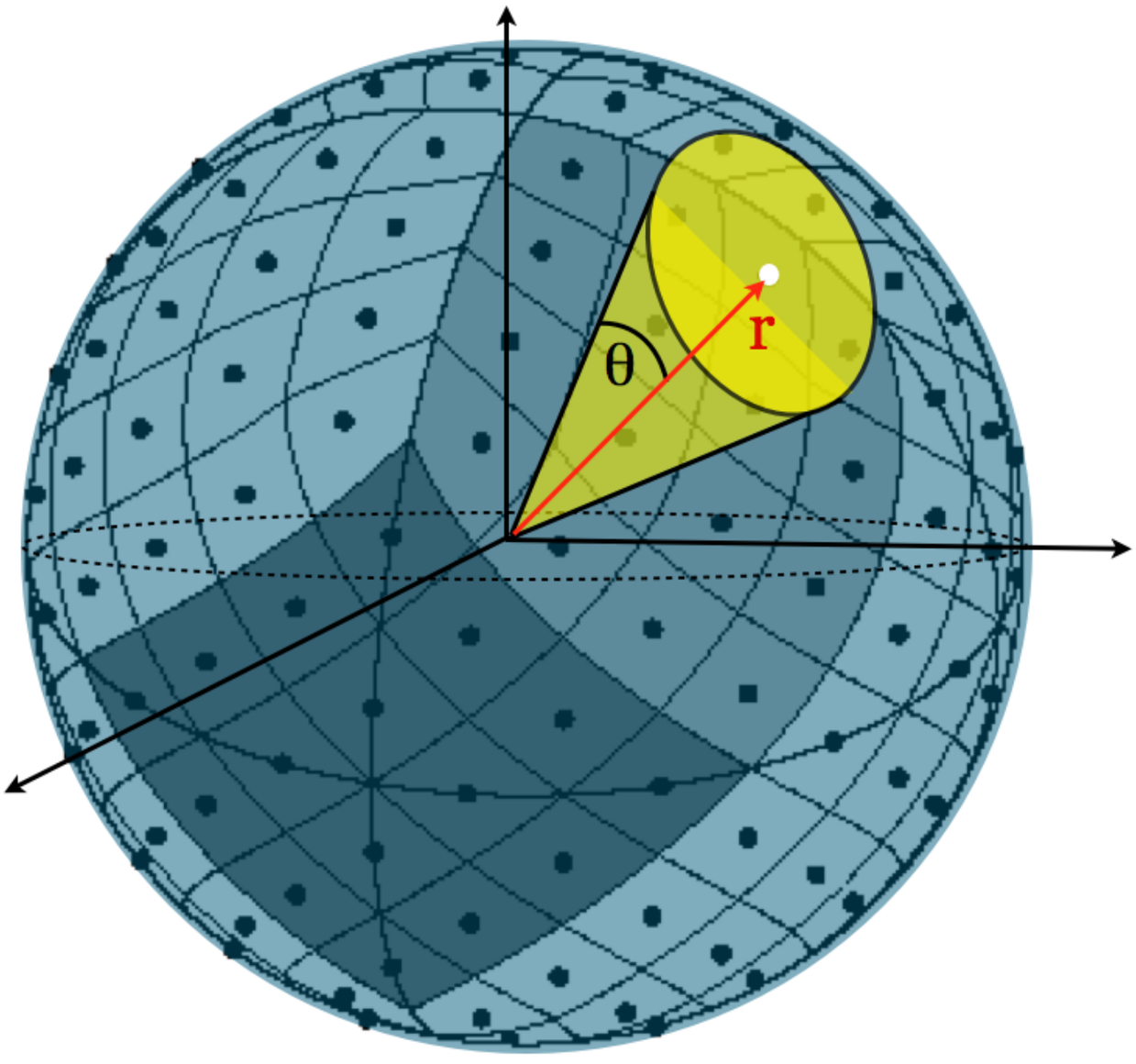

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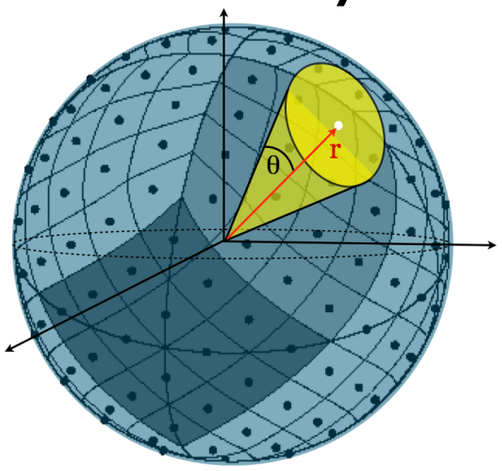
Cone Analysis



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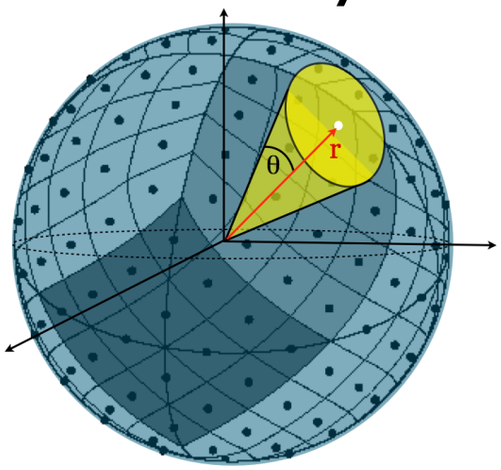

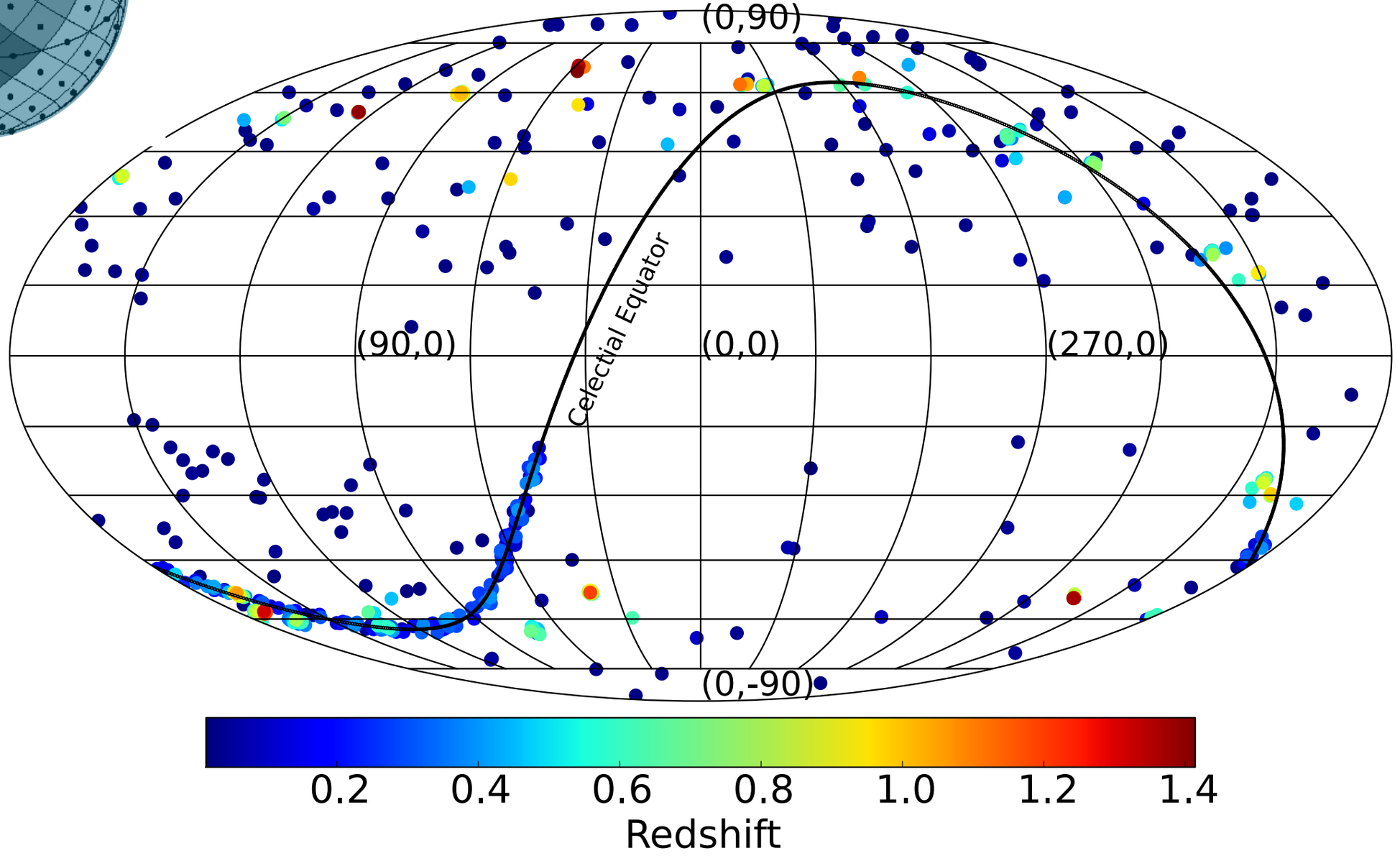

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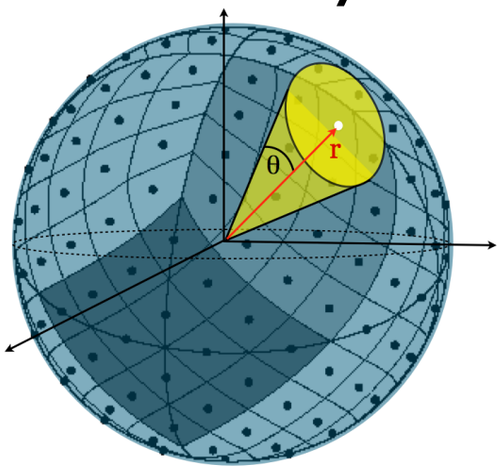
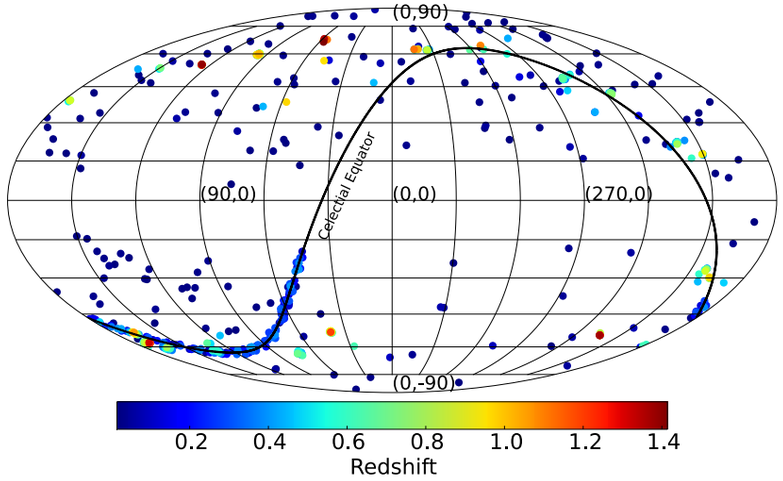


Union2.1 SN data



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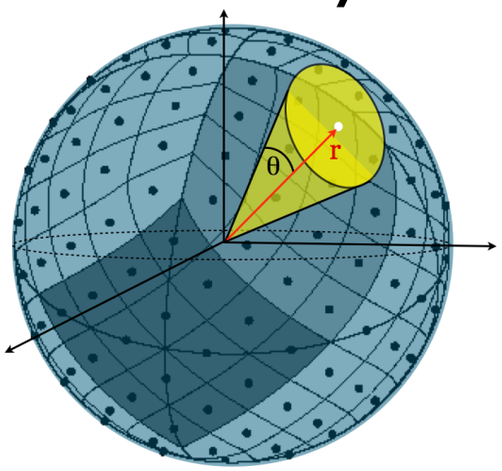

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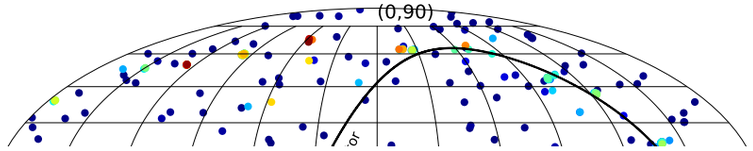

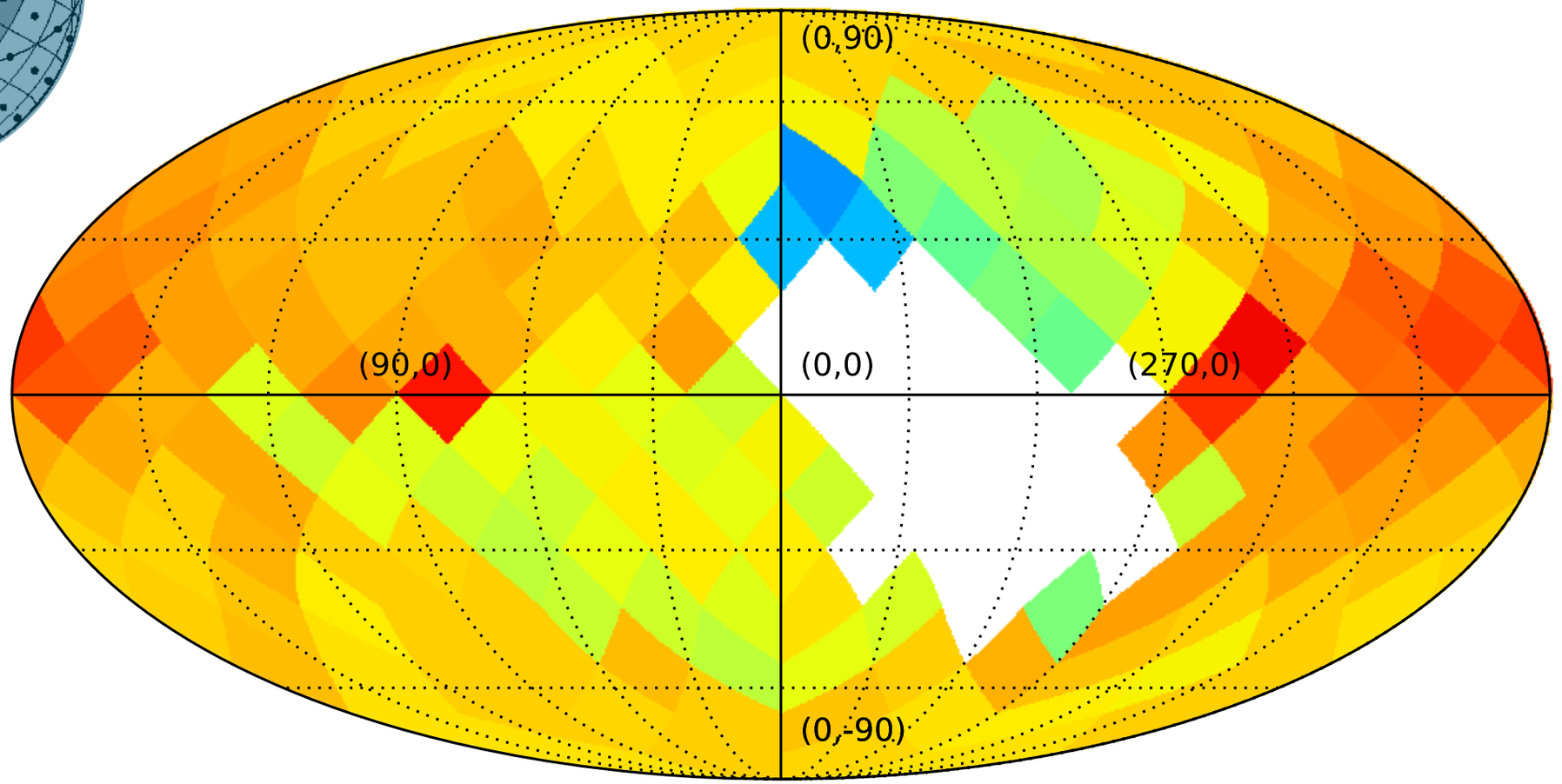

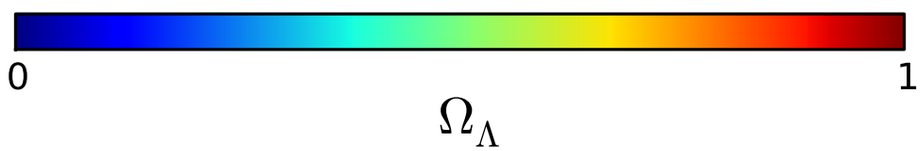

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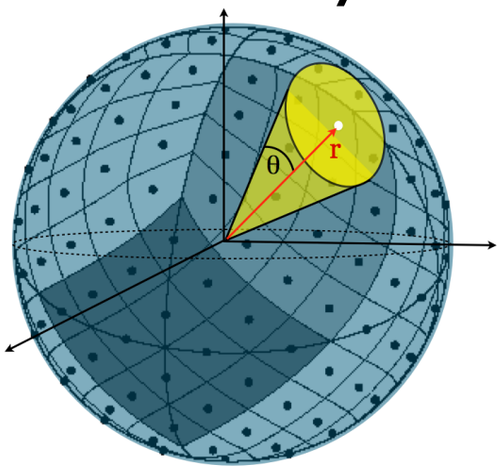

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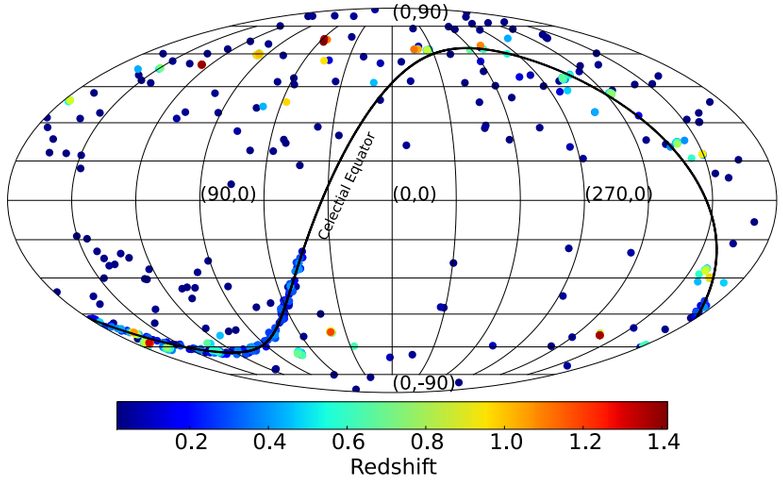
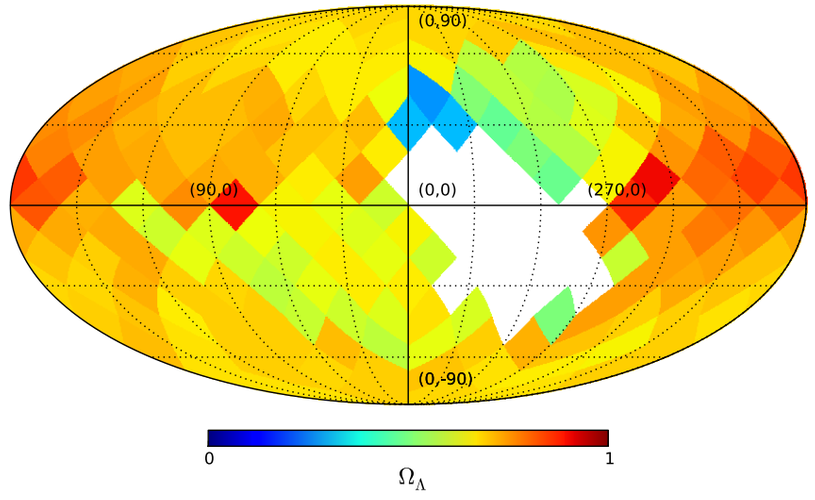


Ω_Λ Maps



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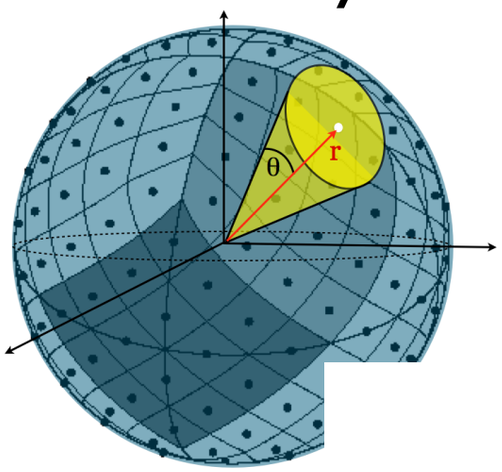

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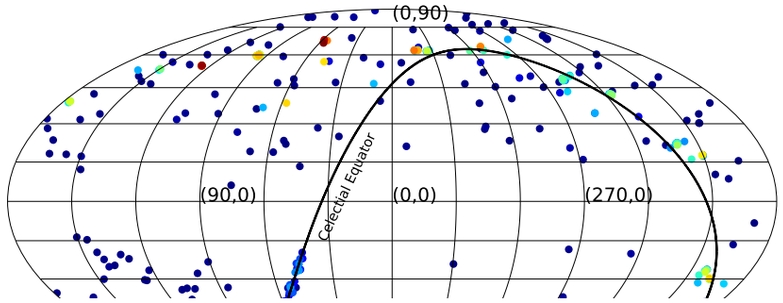

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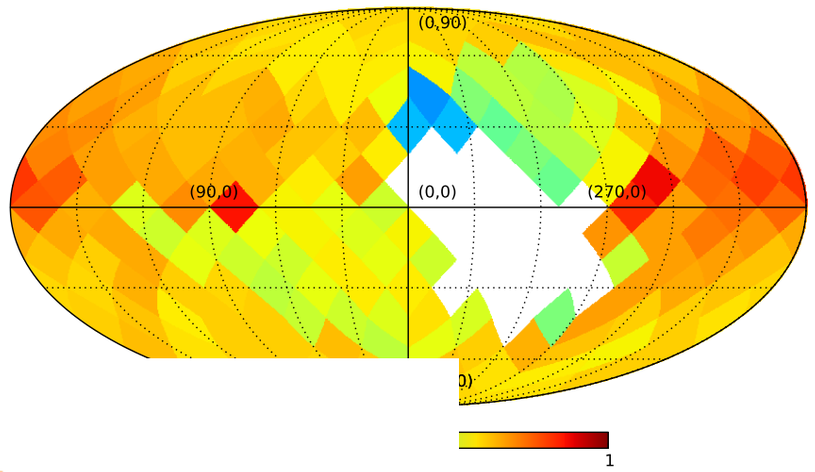

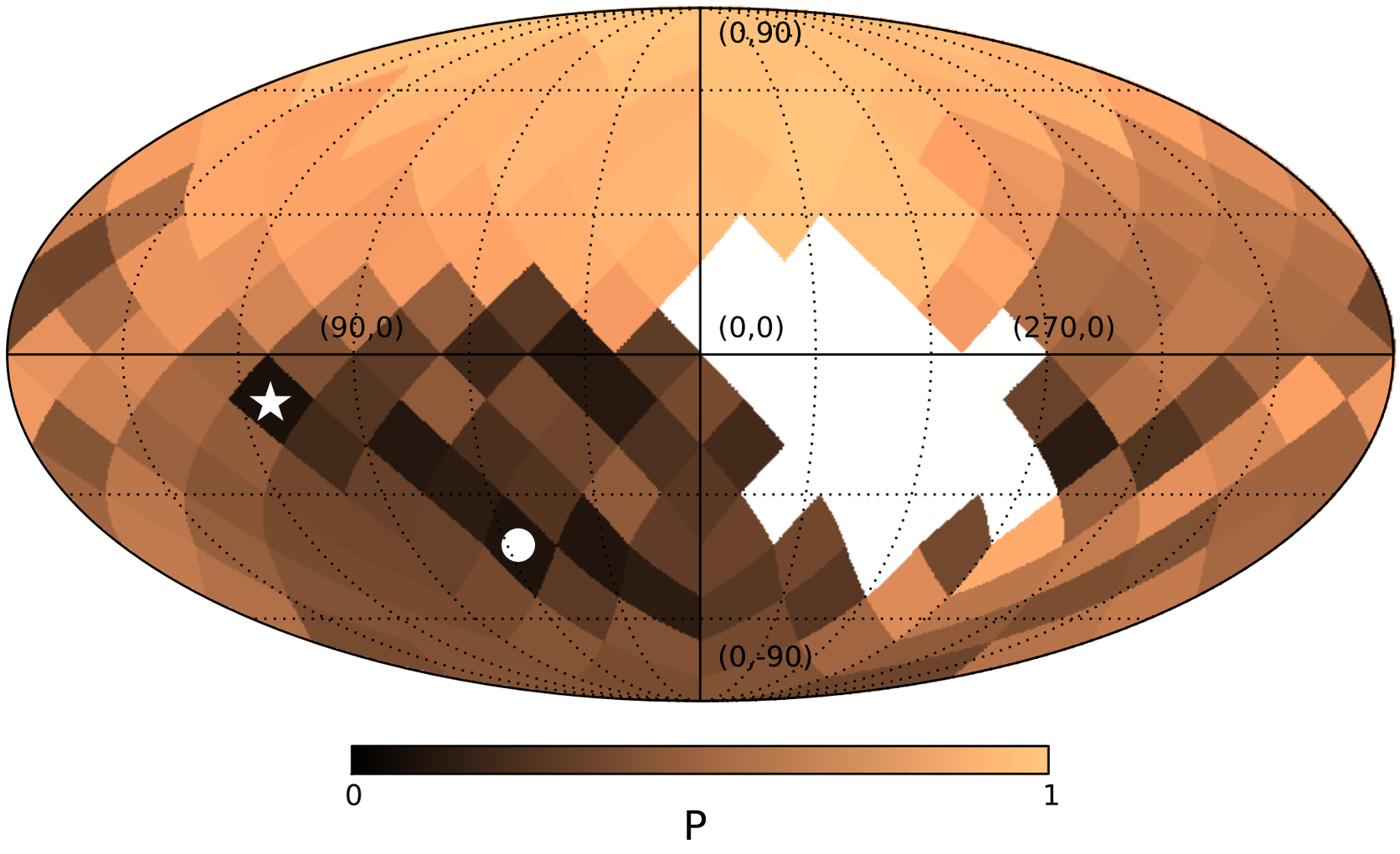

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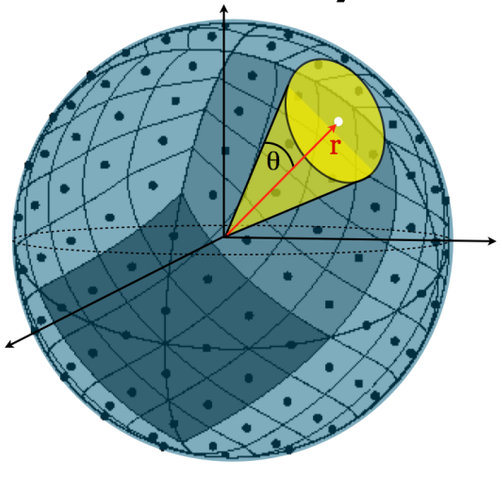

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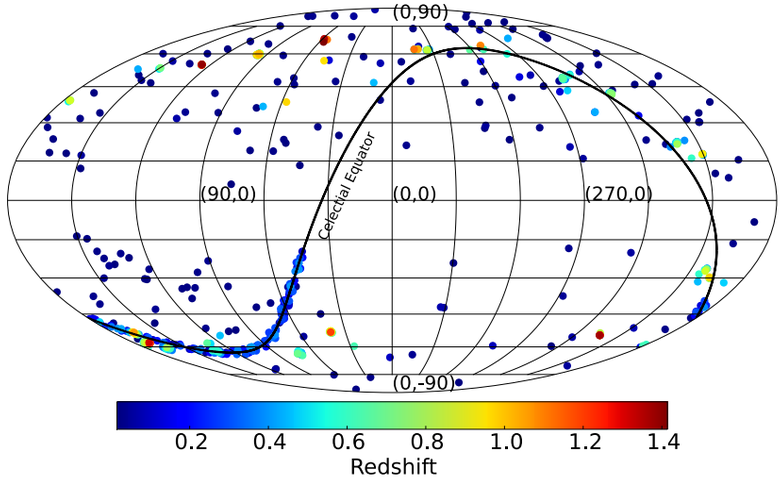

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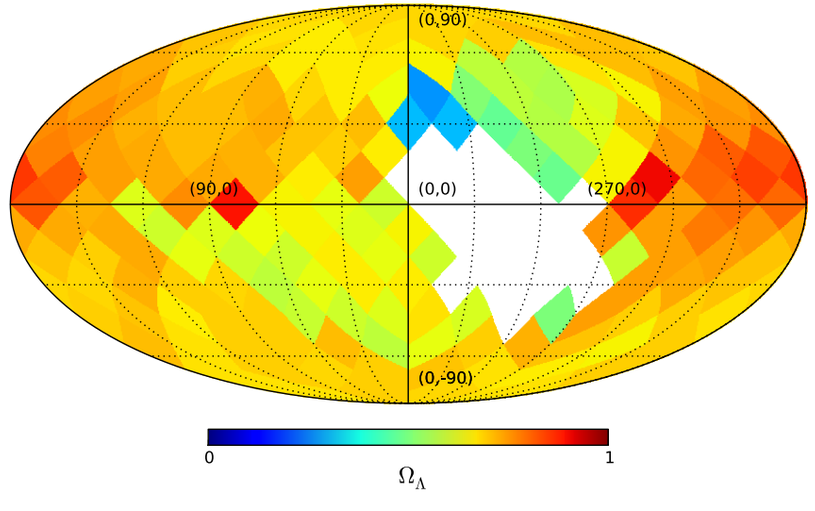
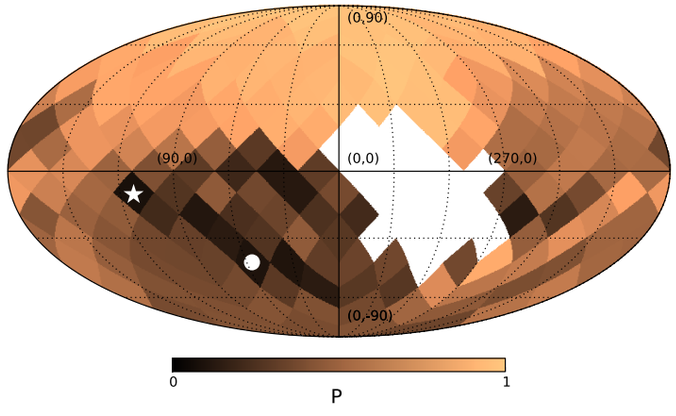
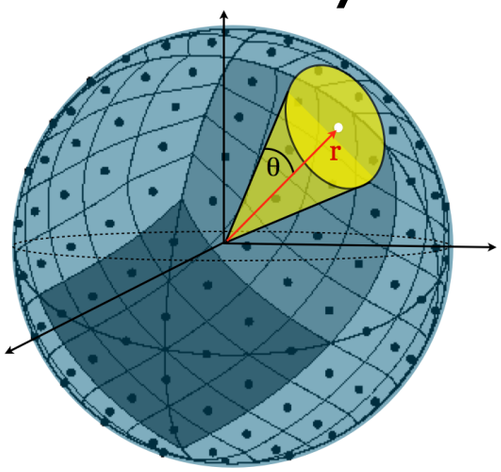


P-value Maps

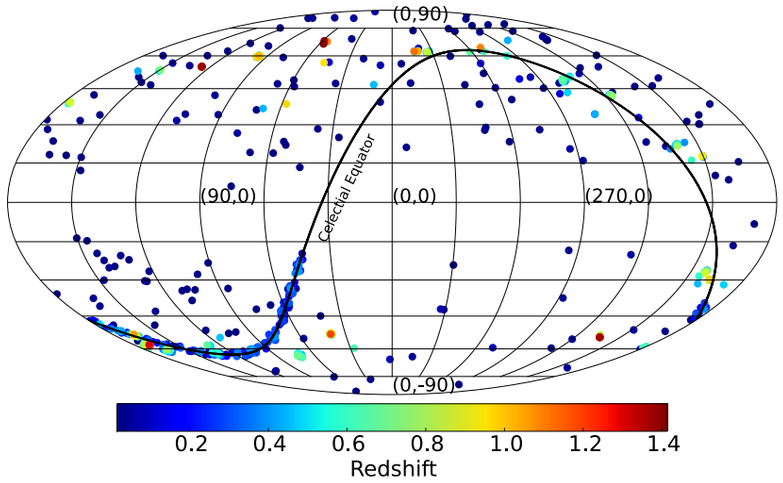


Summary

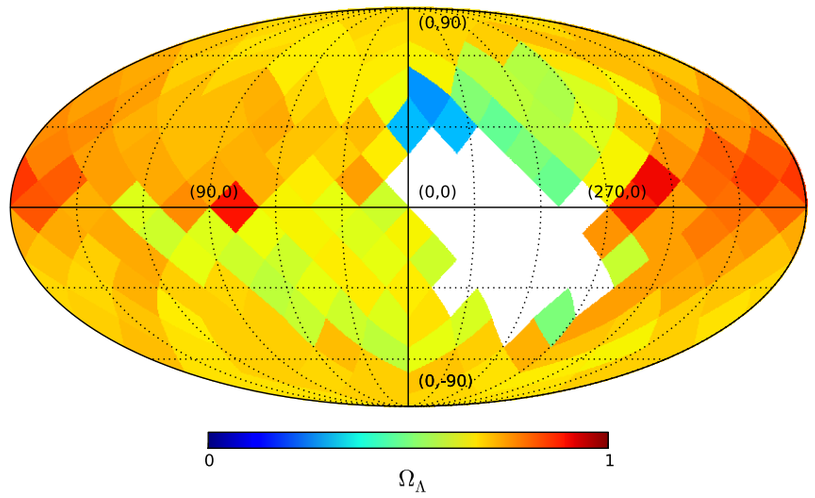
Cone Analysis



Union2.1 SN data



Ω_Λ Maps



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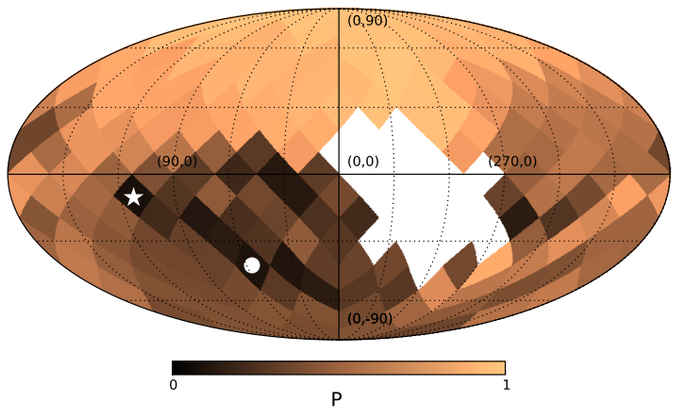

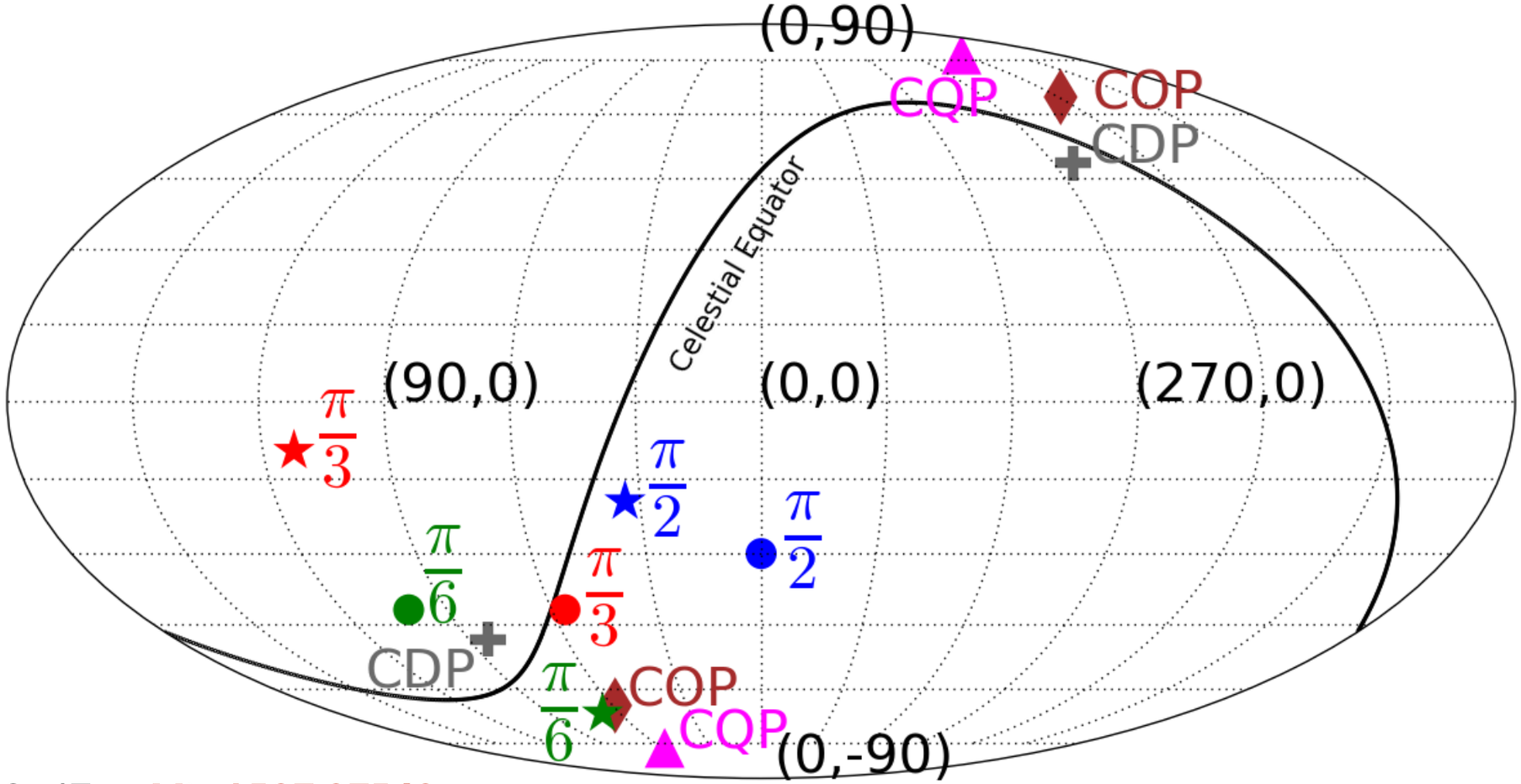

Javanmardi et al. (2015), ApJ 810, 47, arXiv:1507.07560