

Lightning Interferometry

NRAO Synthesis Imaging Workshop – 2014

Michael Stock



Jacob Trueblood

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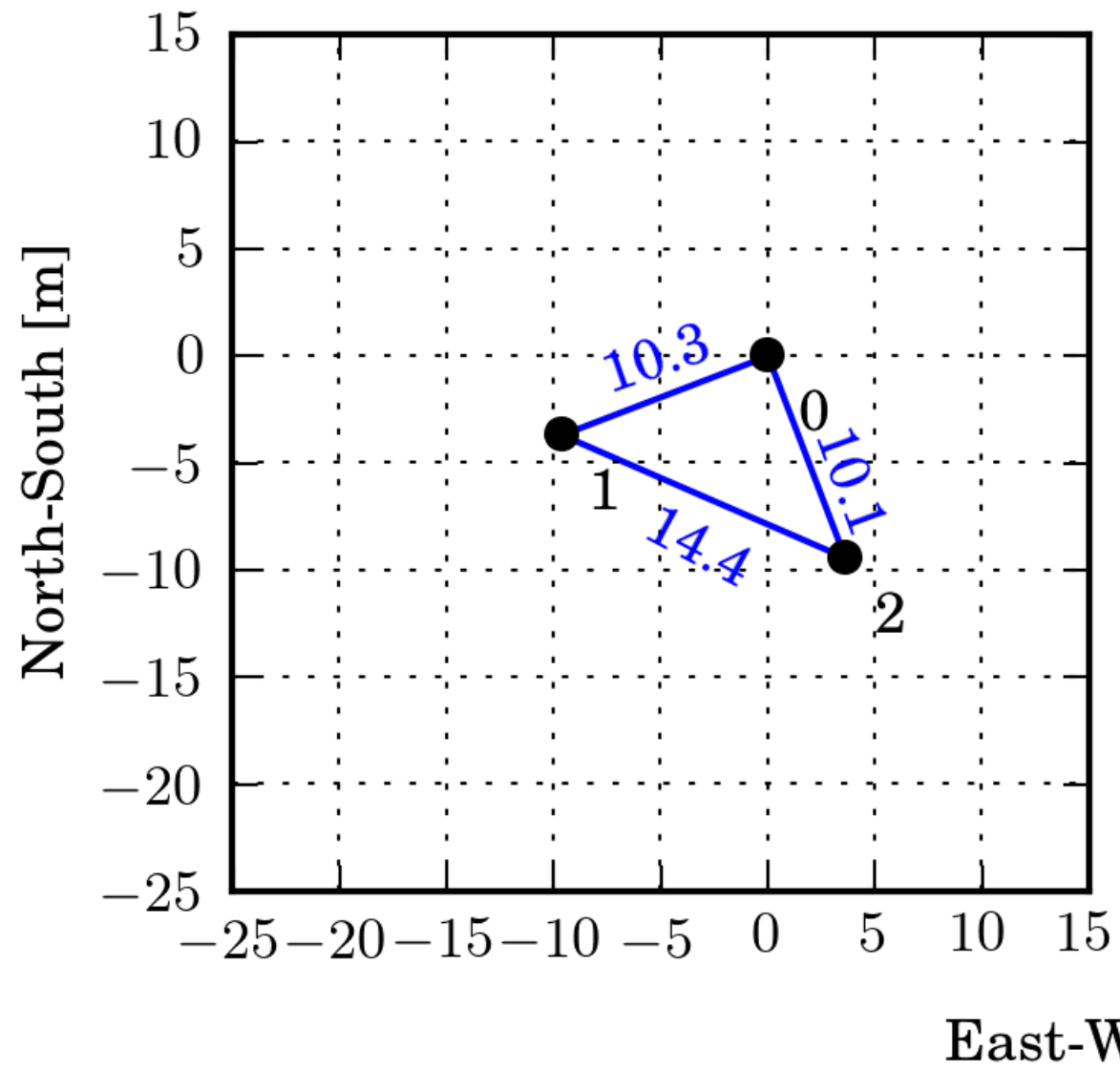
Langmuir

1

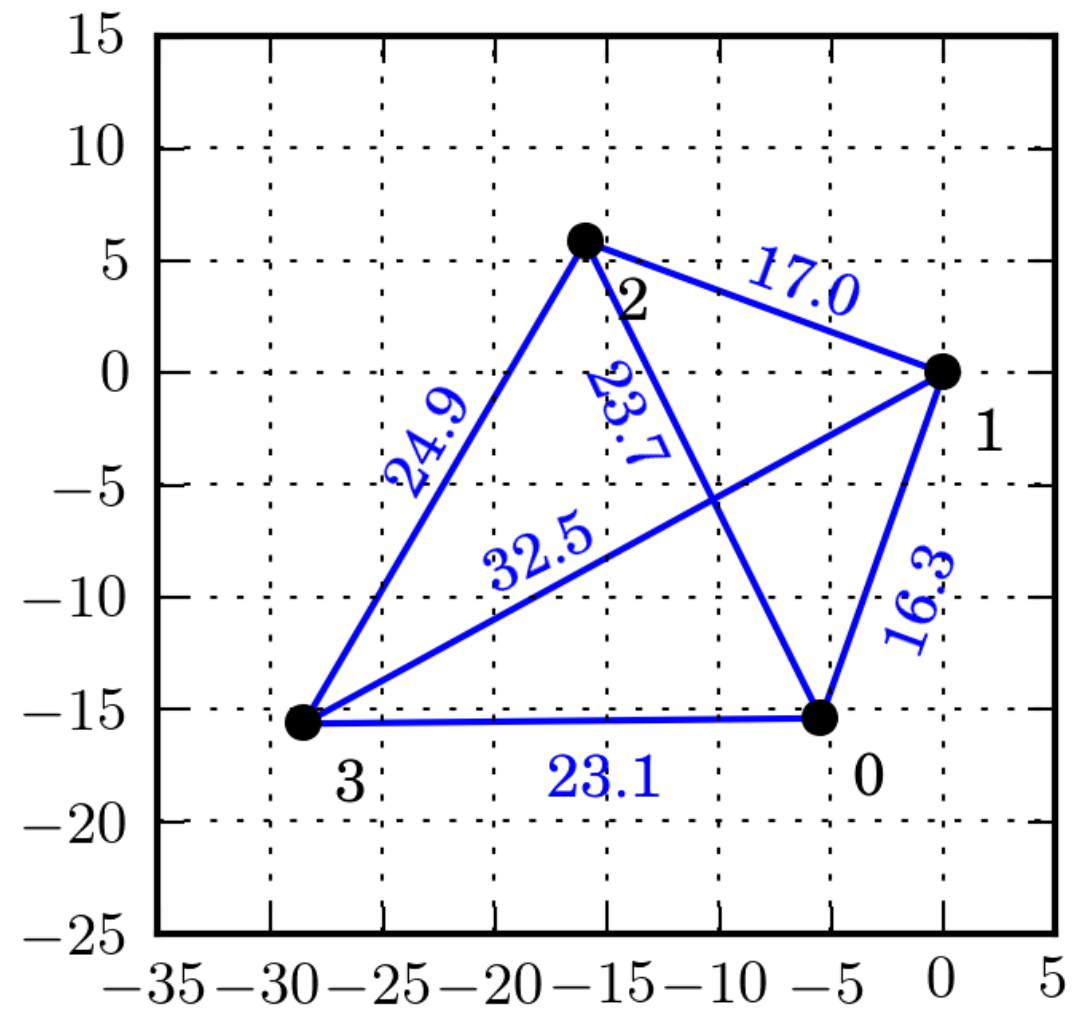
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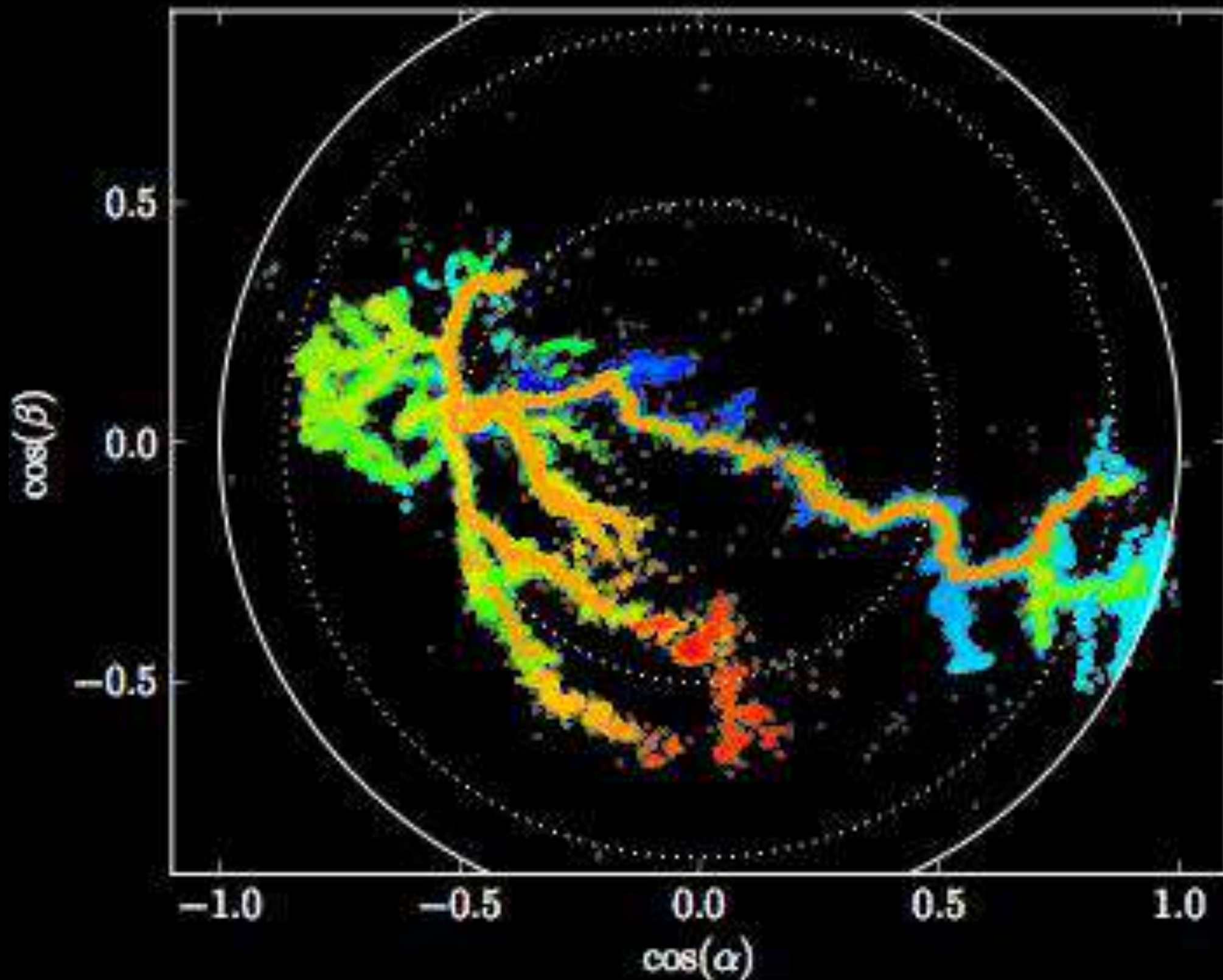
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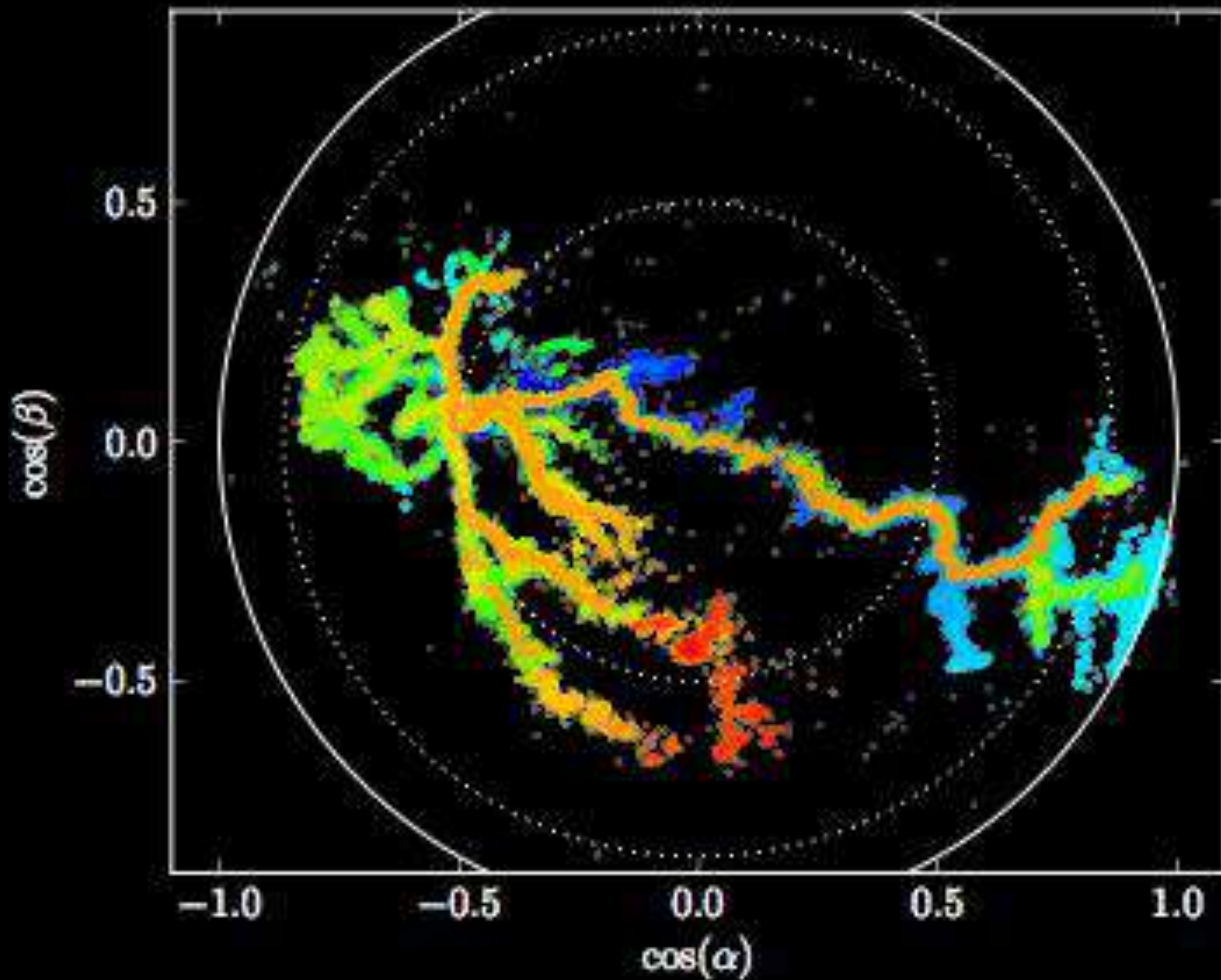
2012

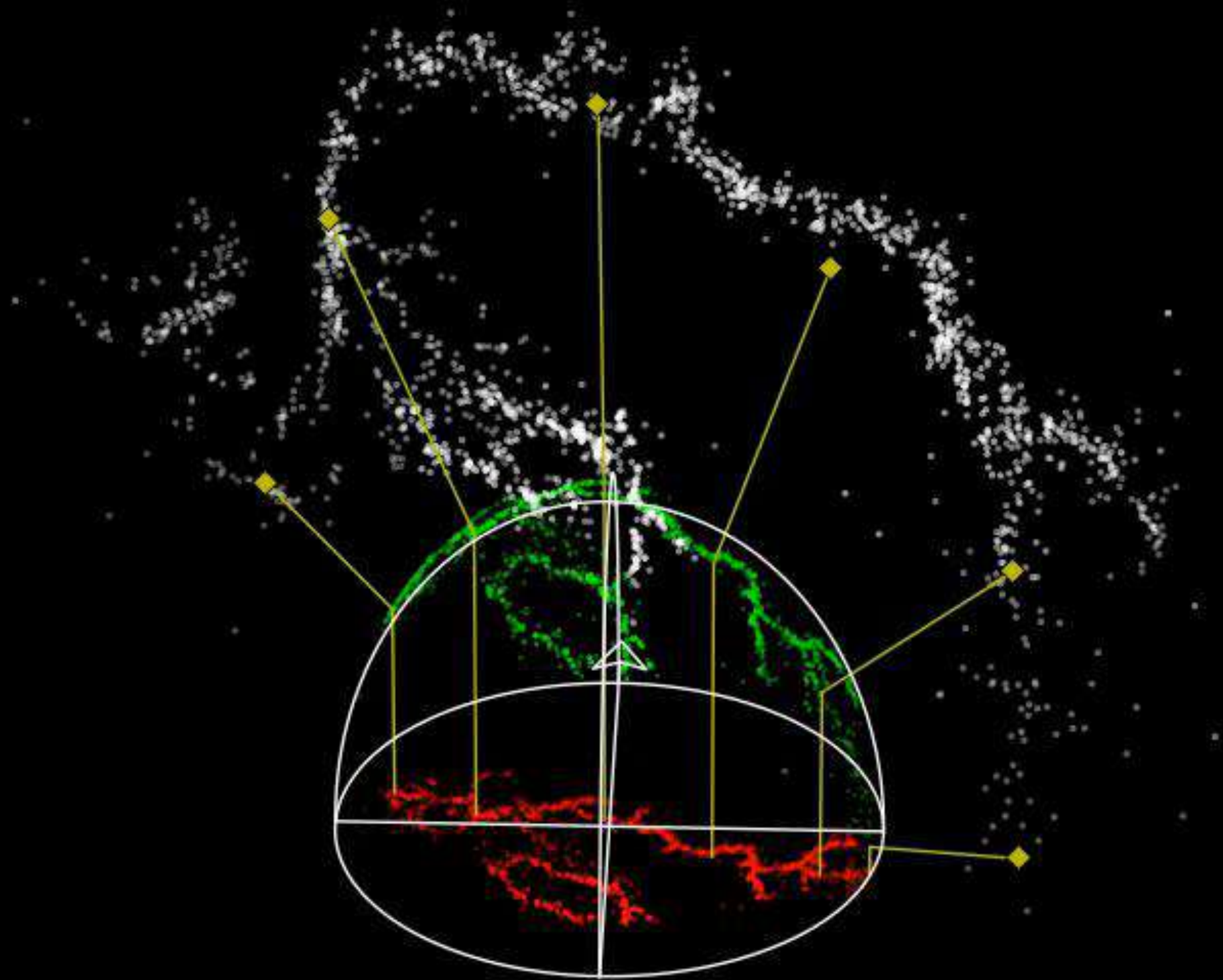


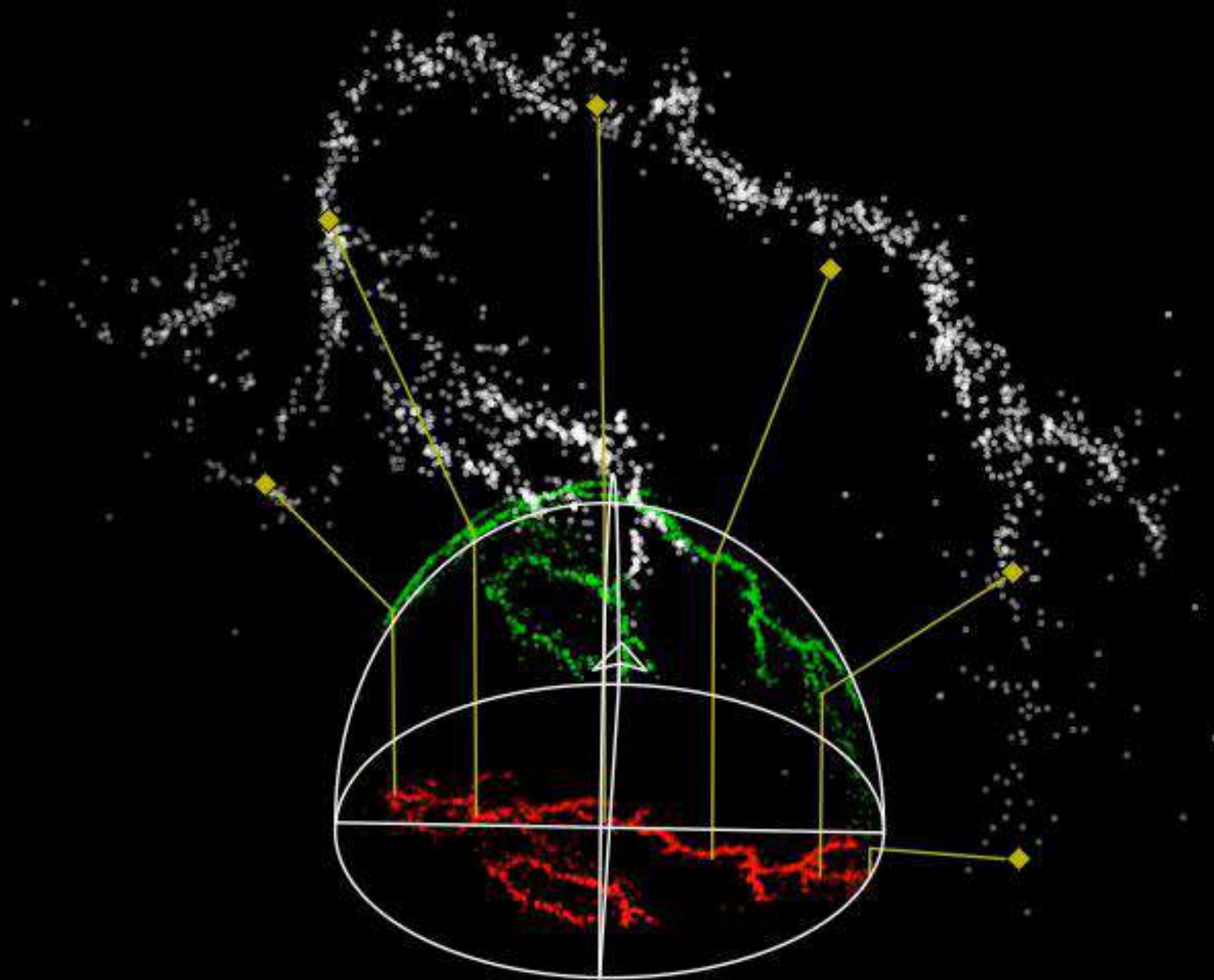
2013

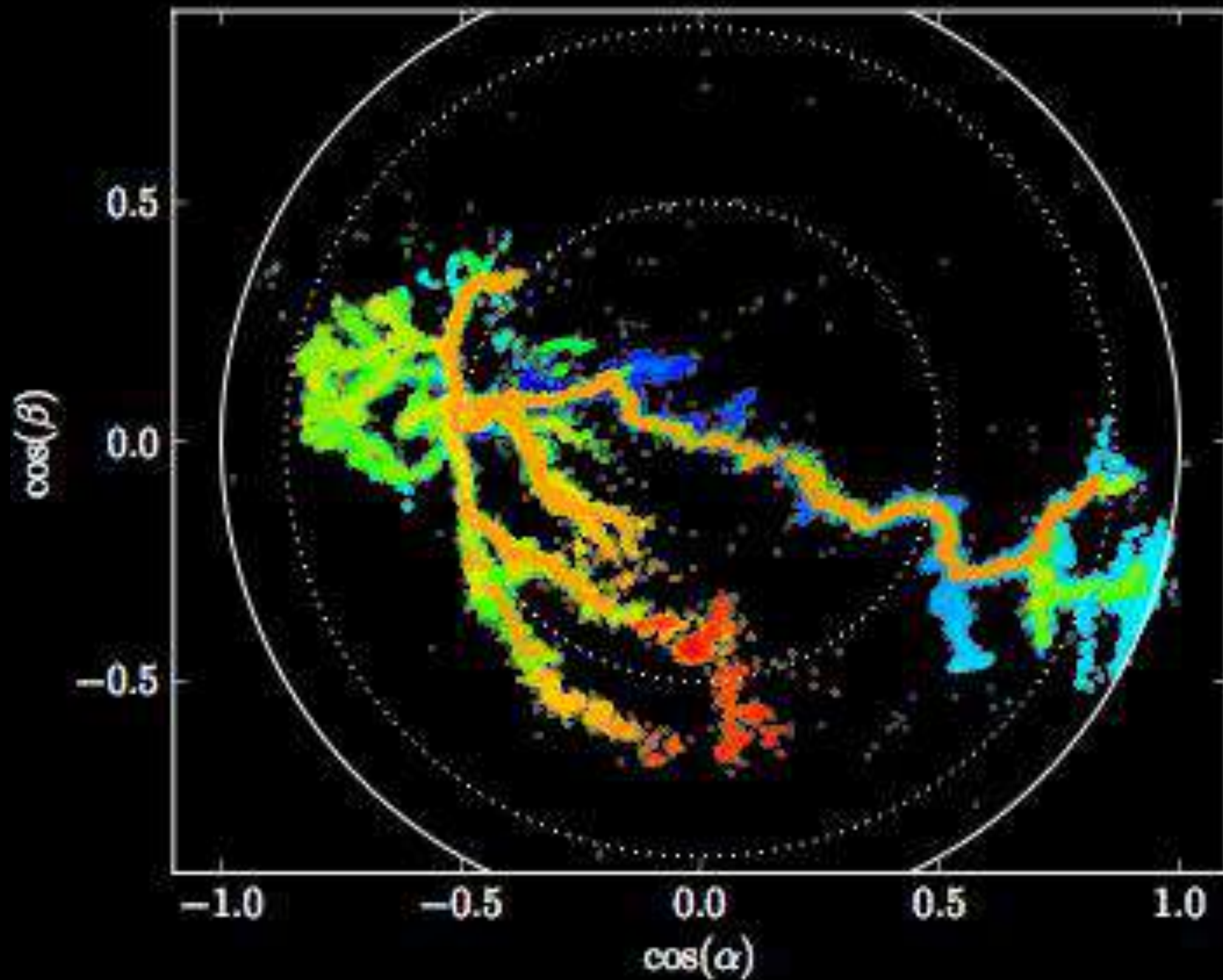


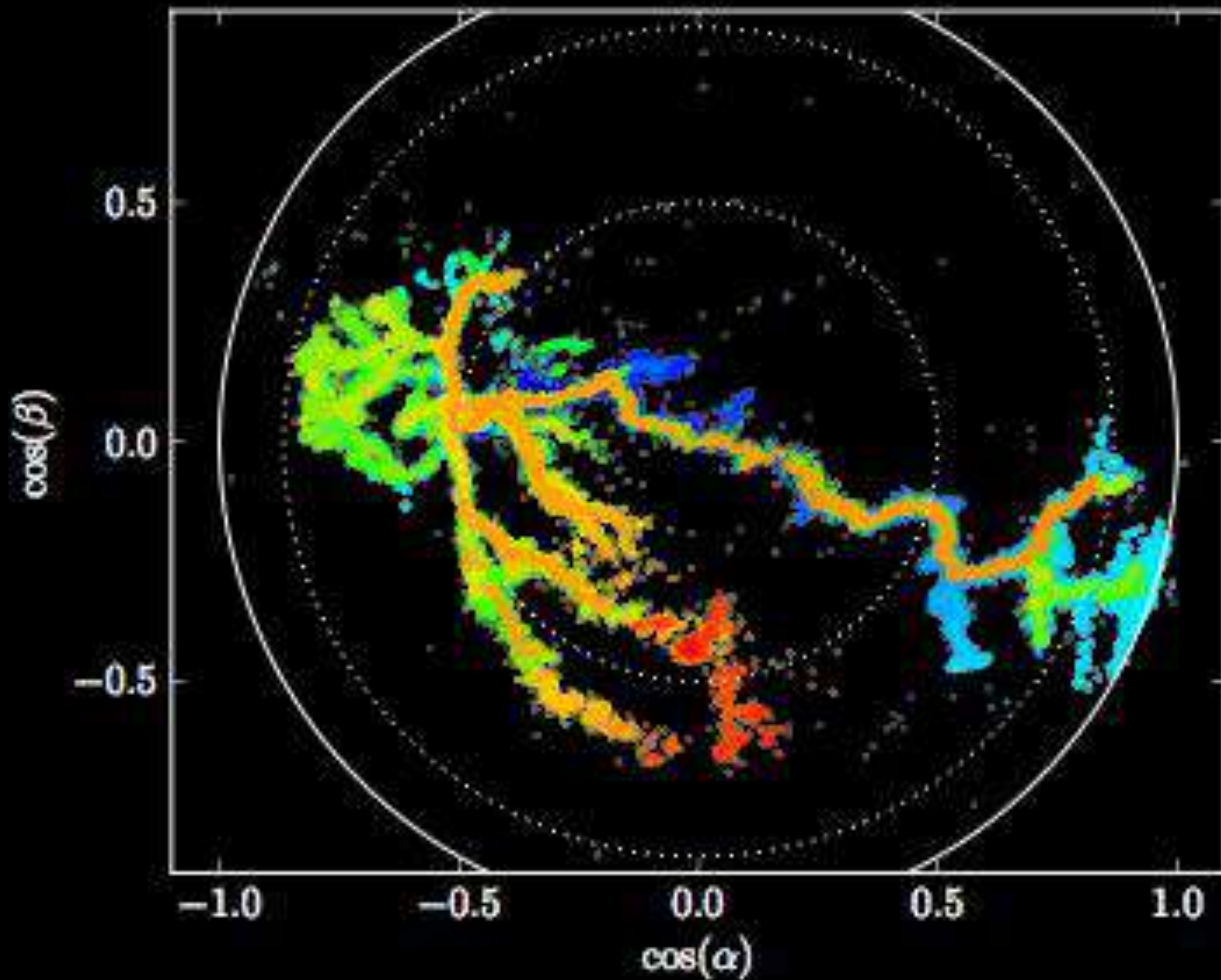


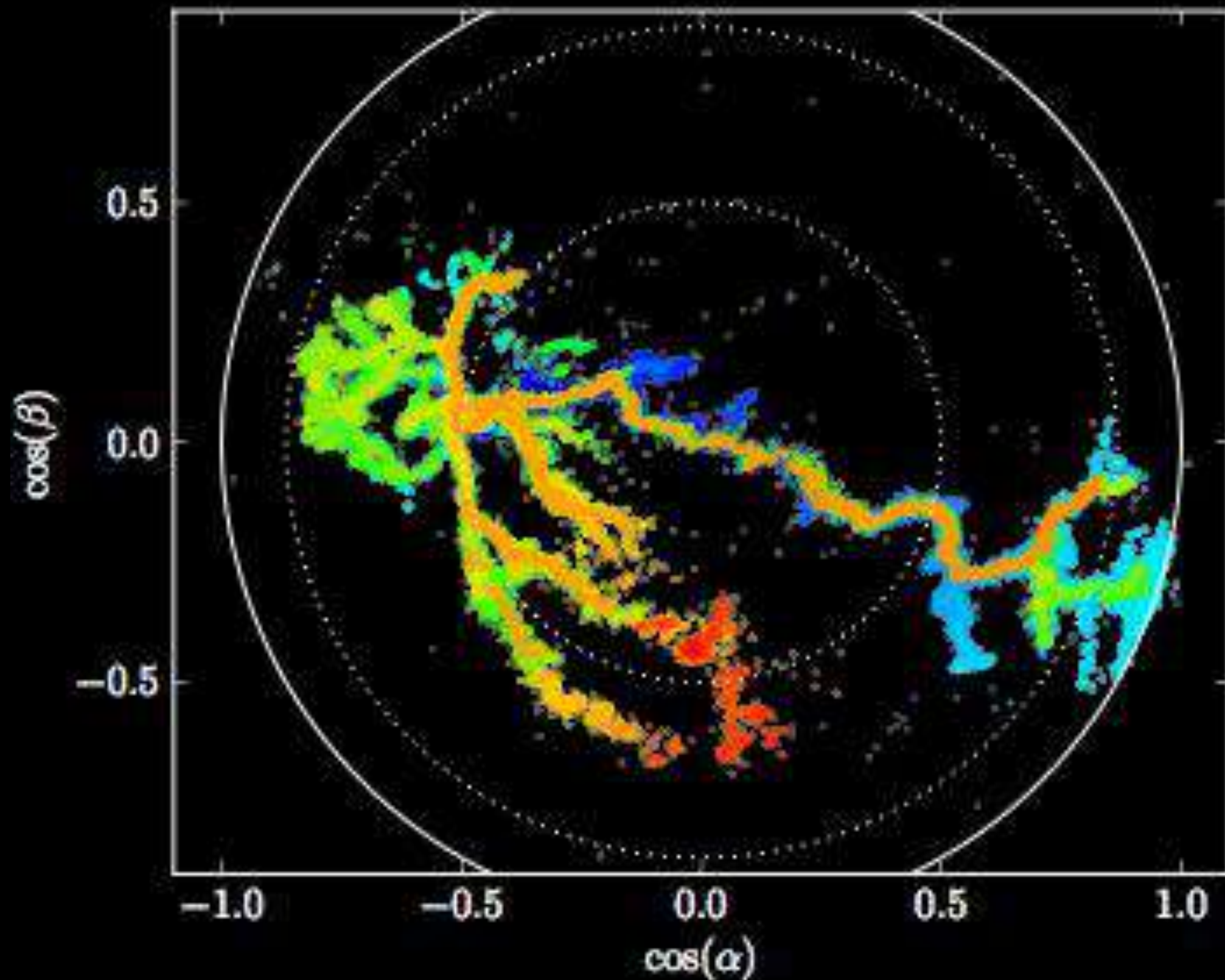




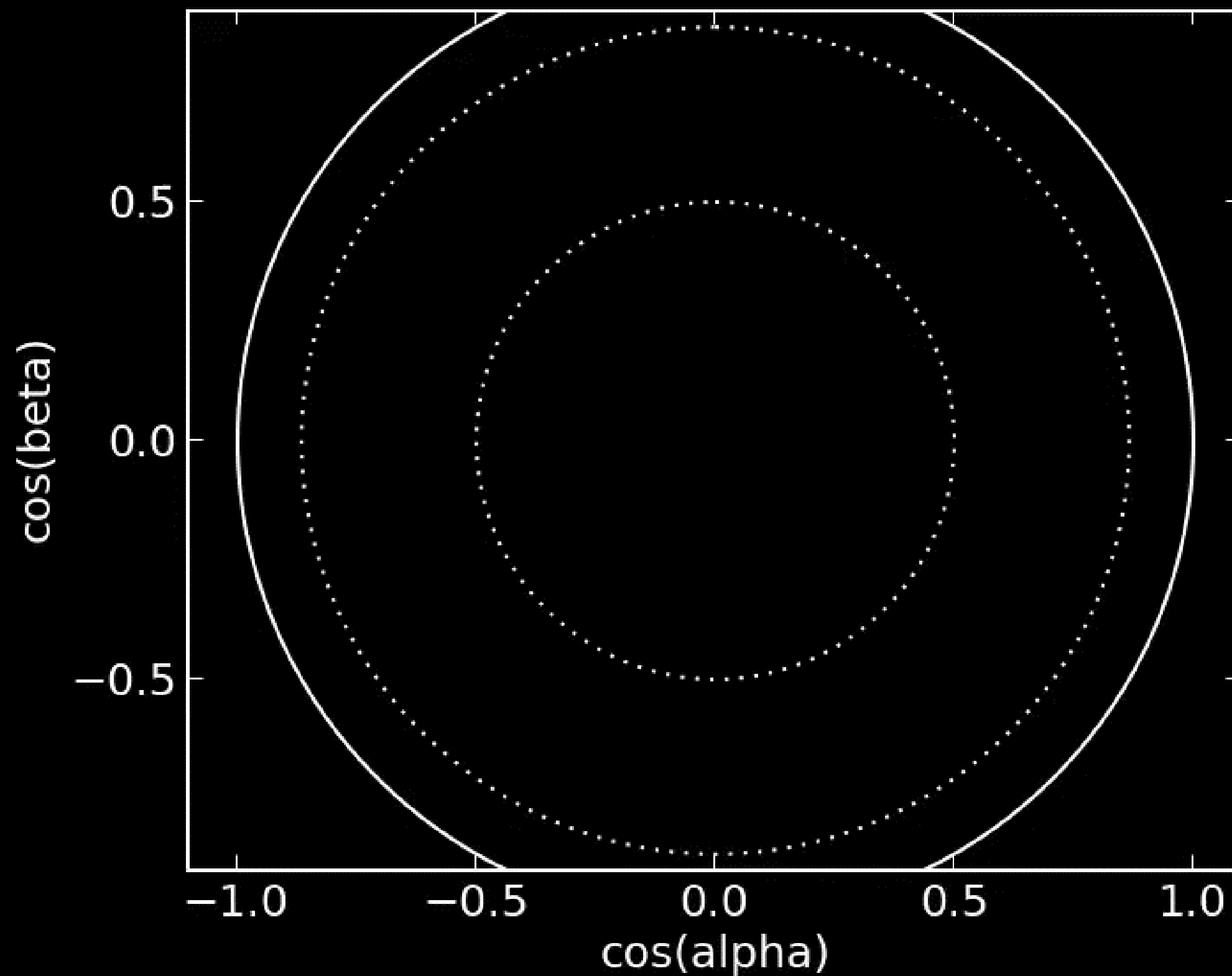




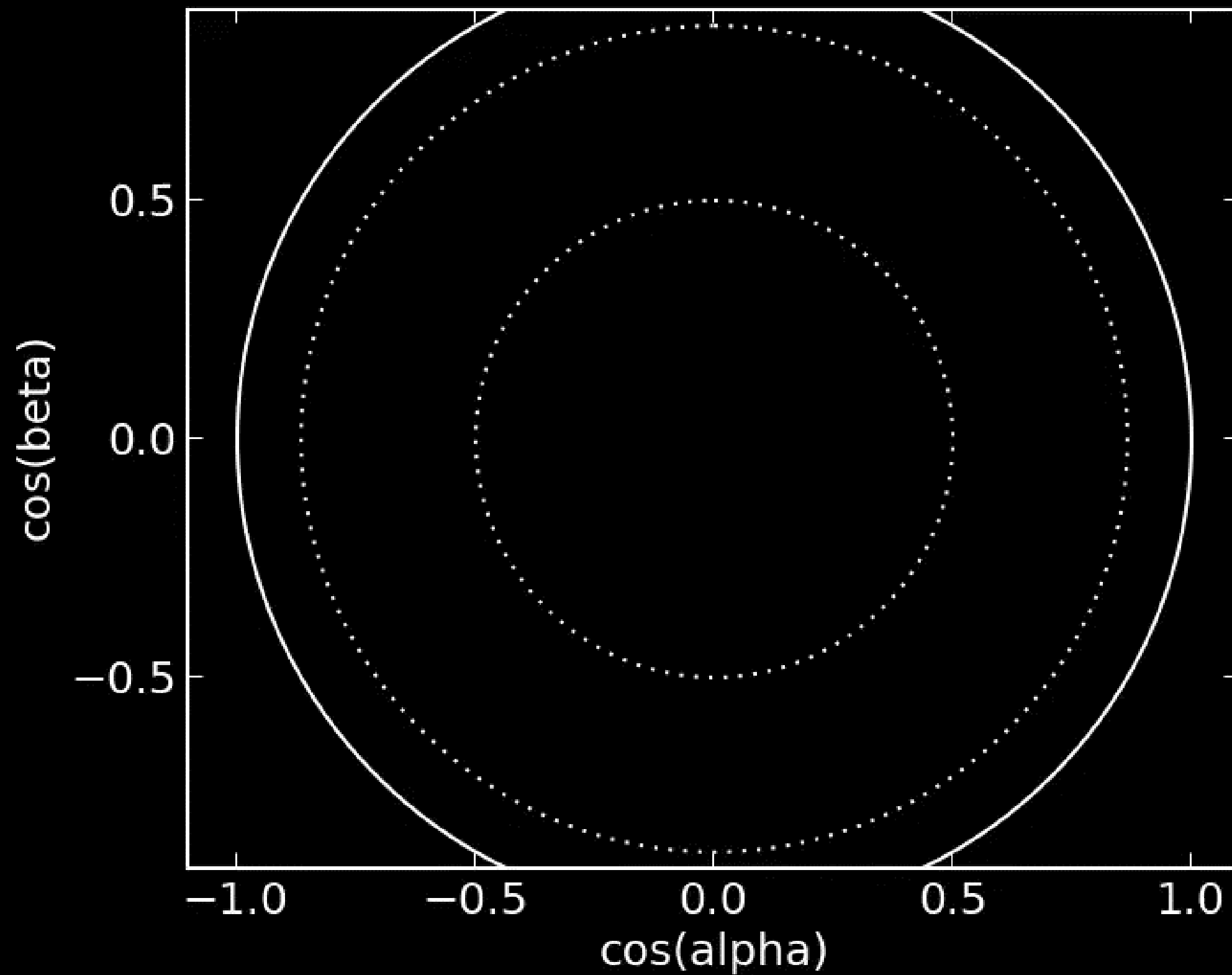


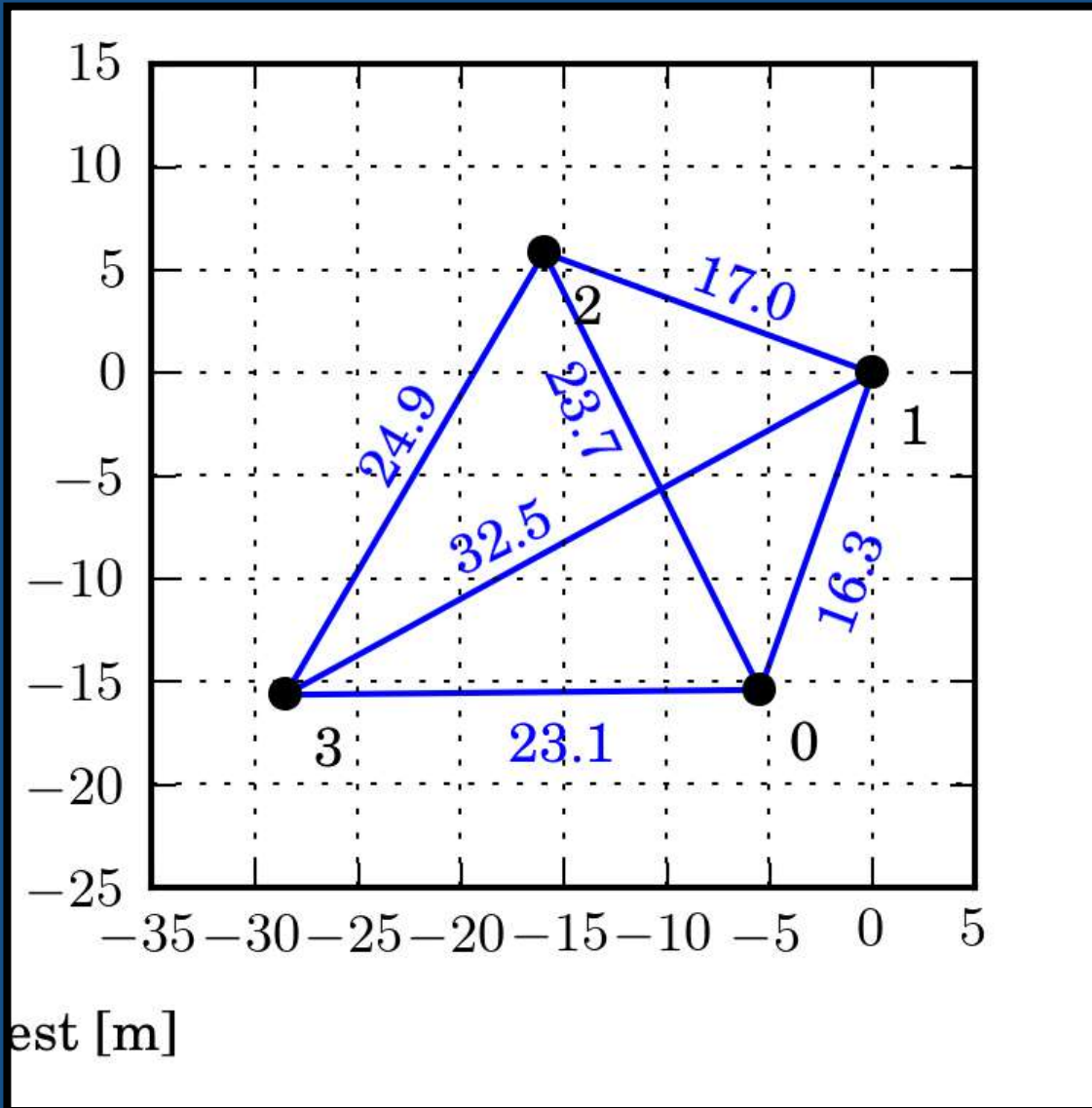


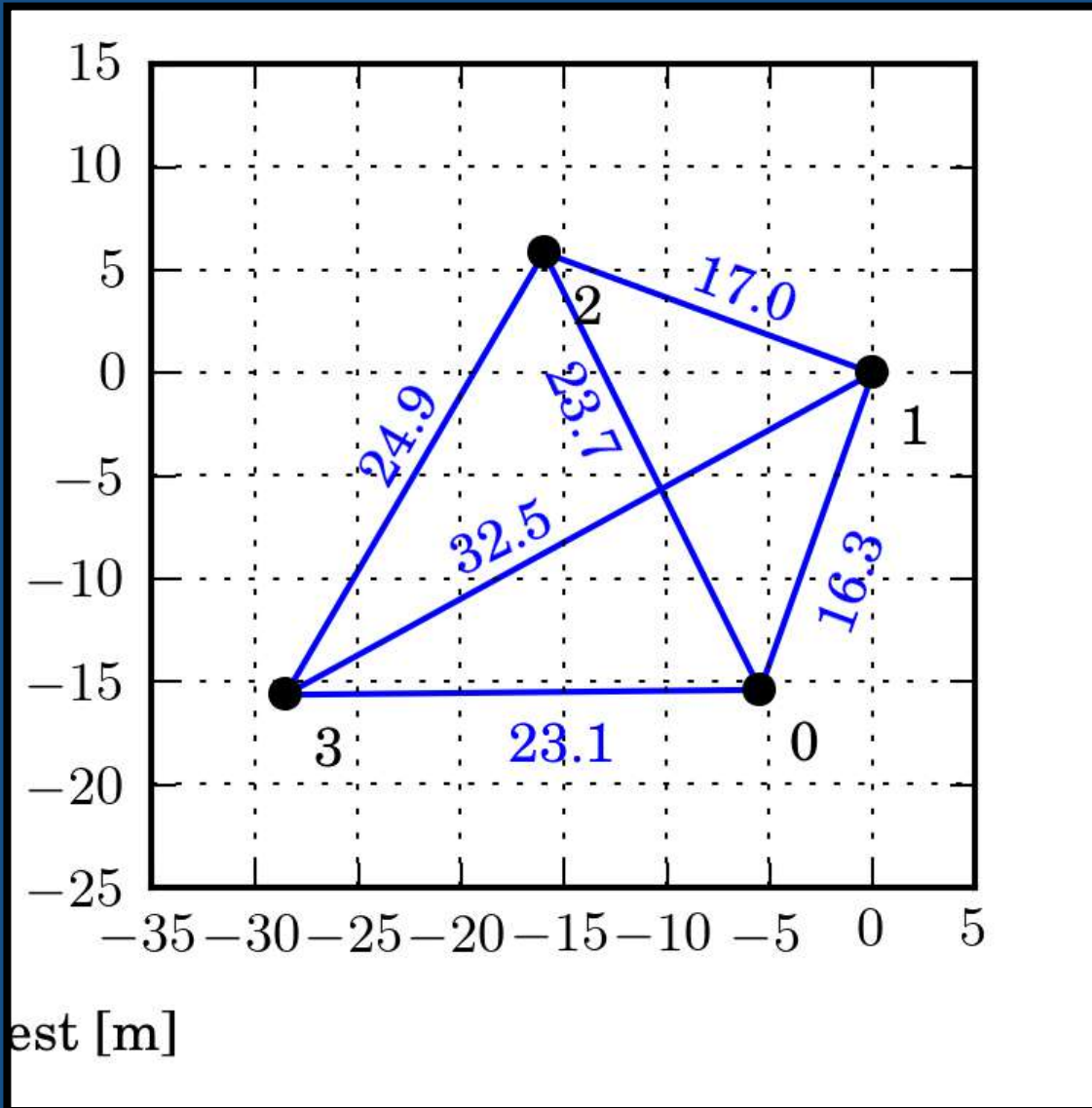
Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
43.300



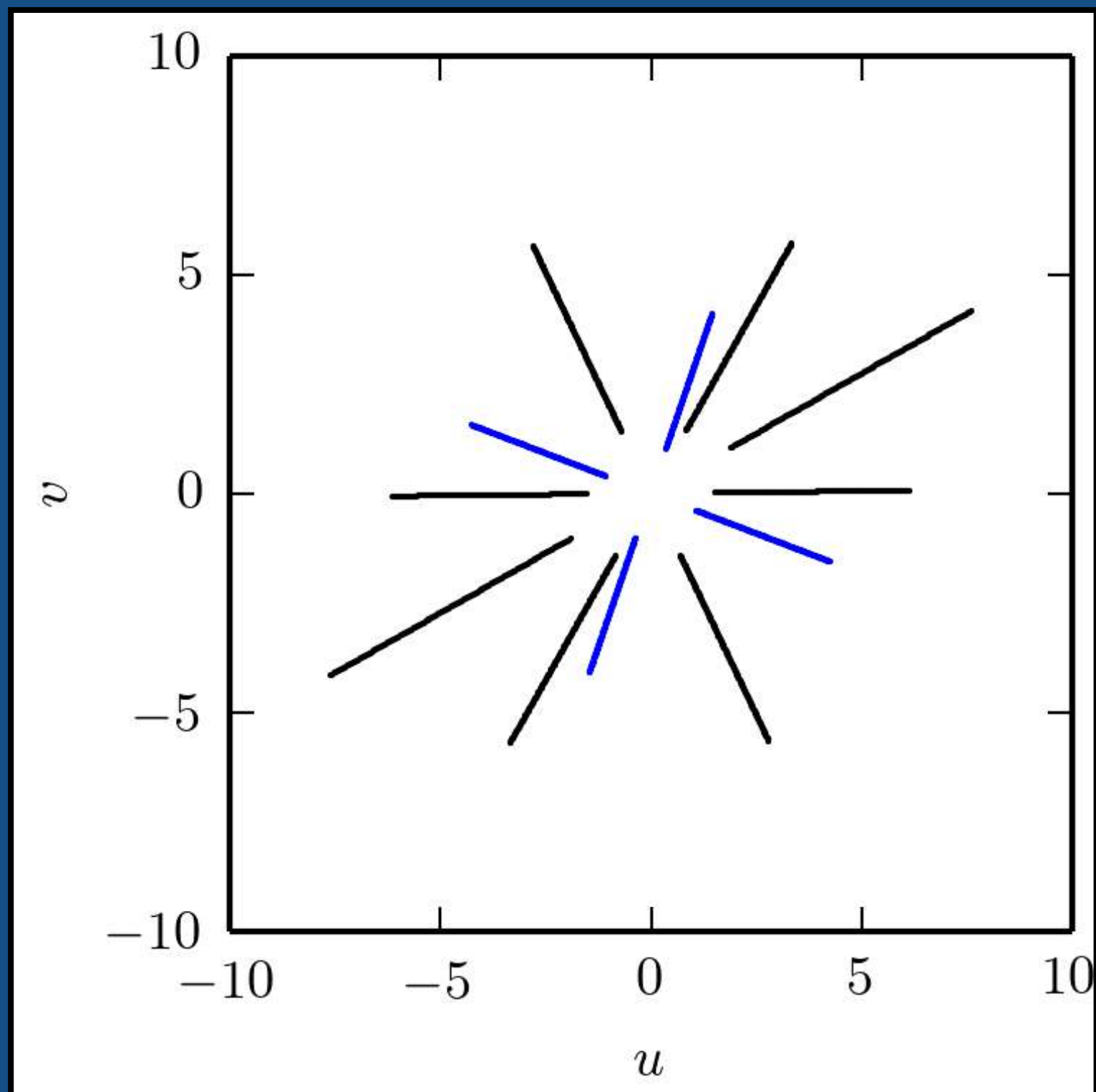
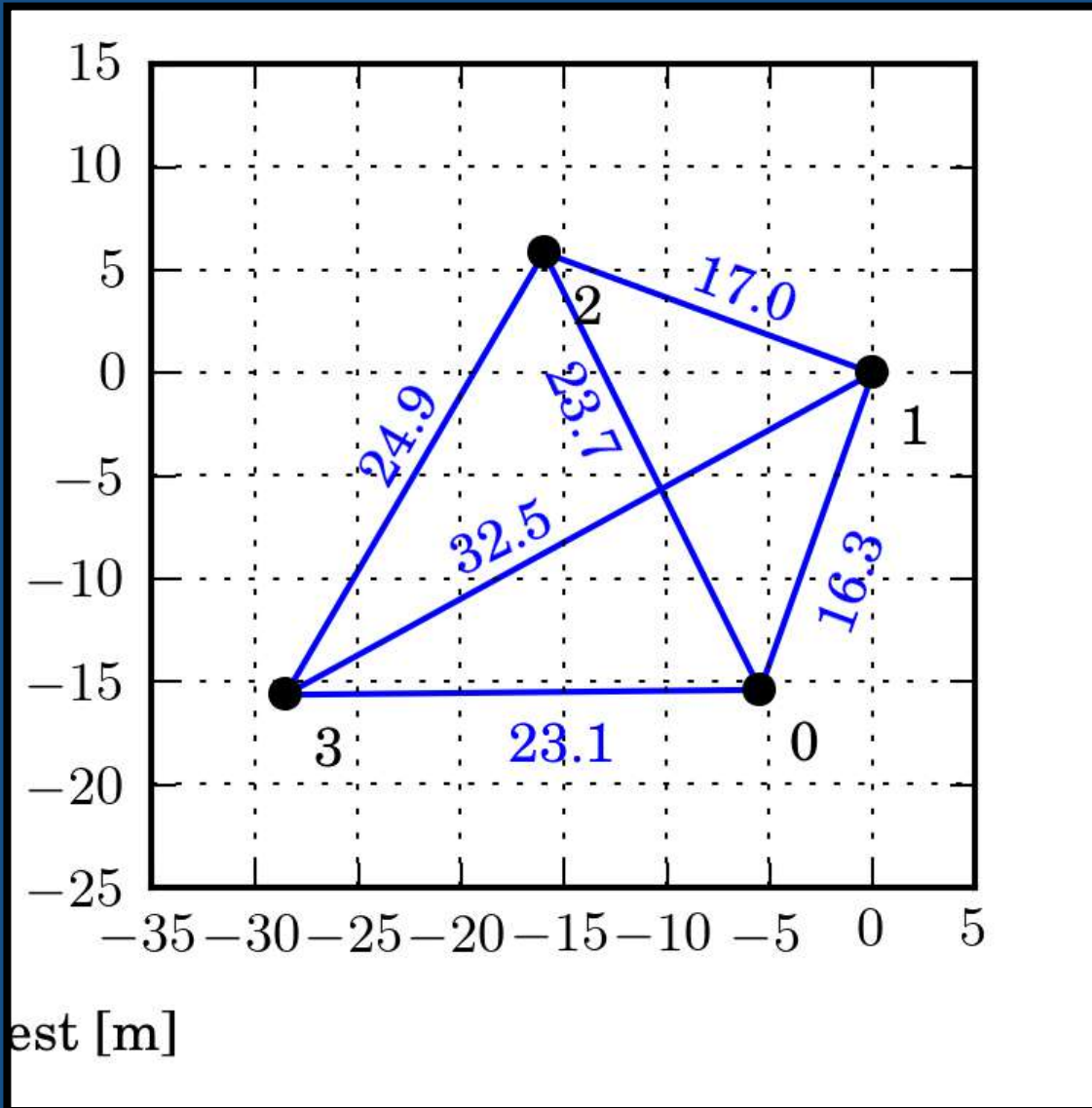
Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
43.300





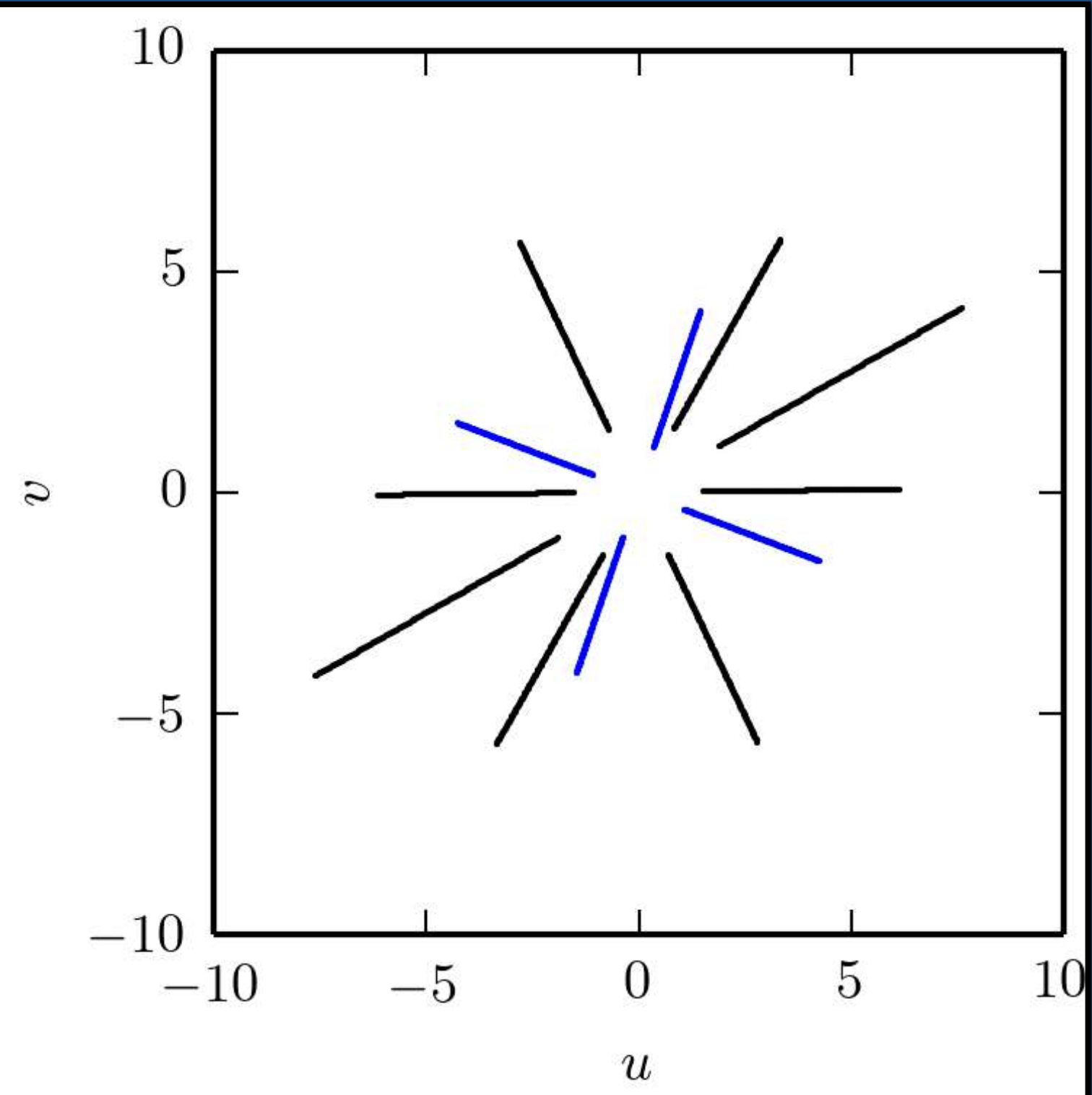
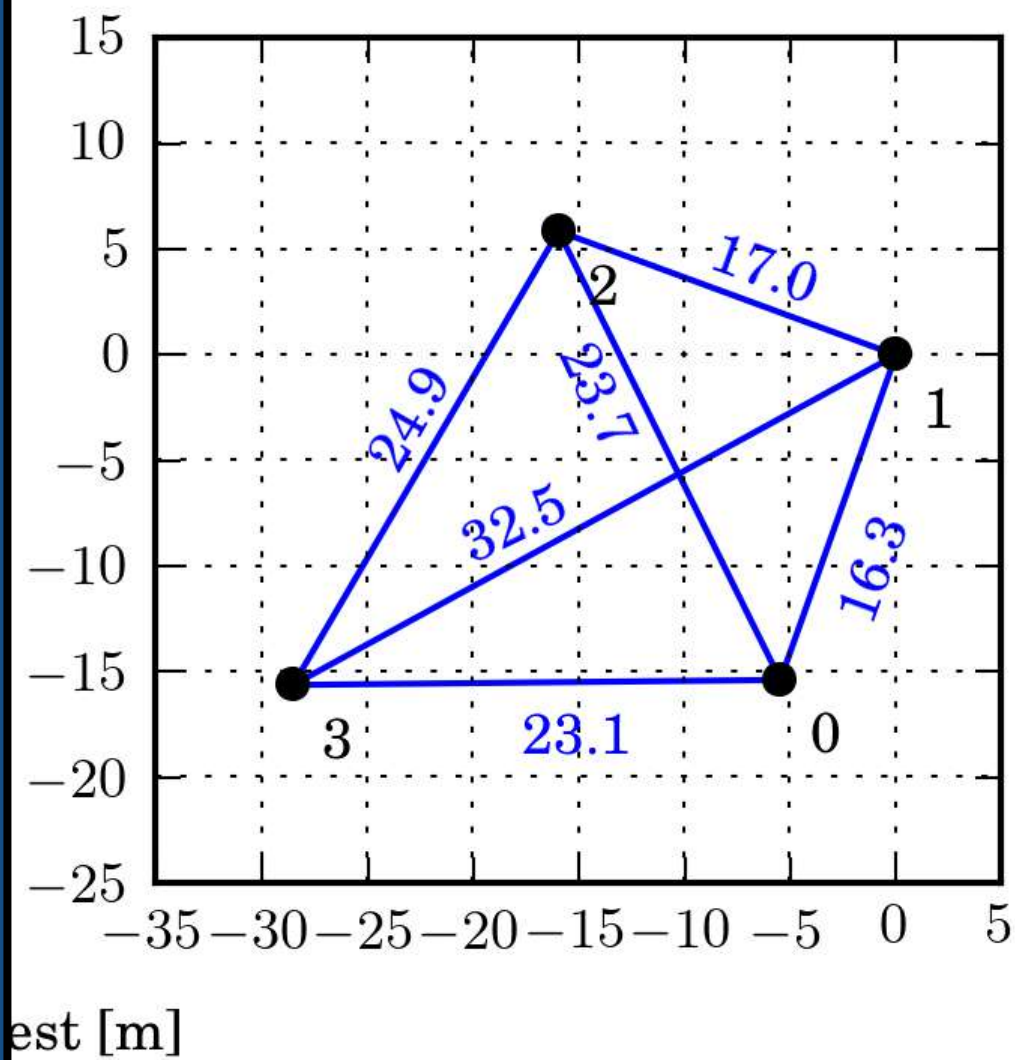


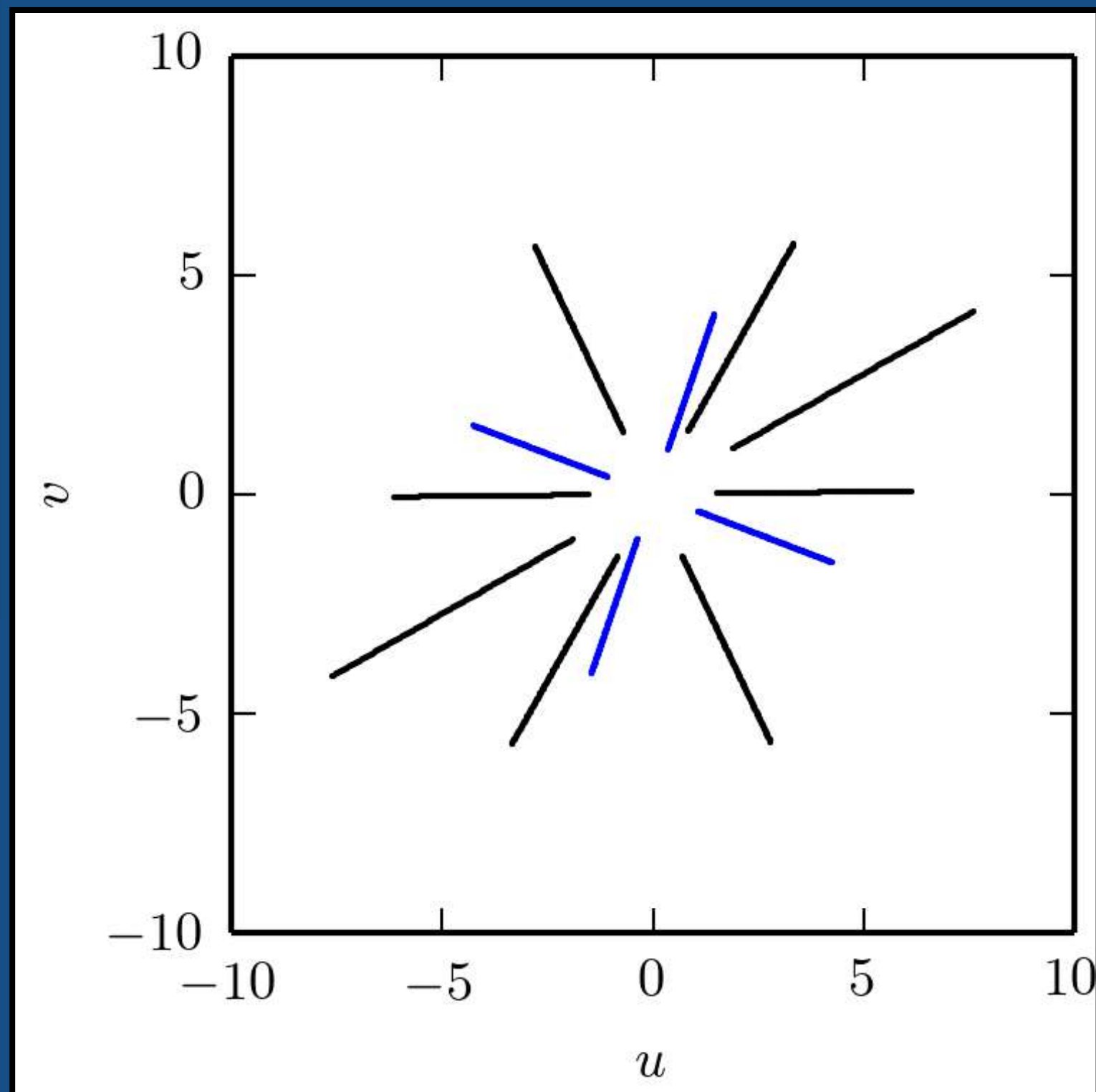
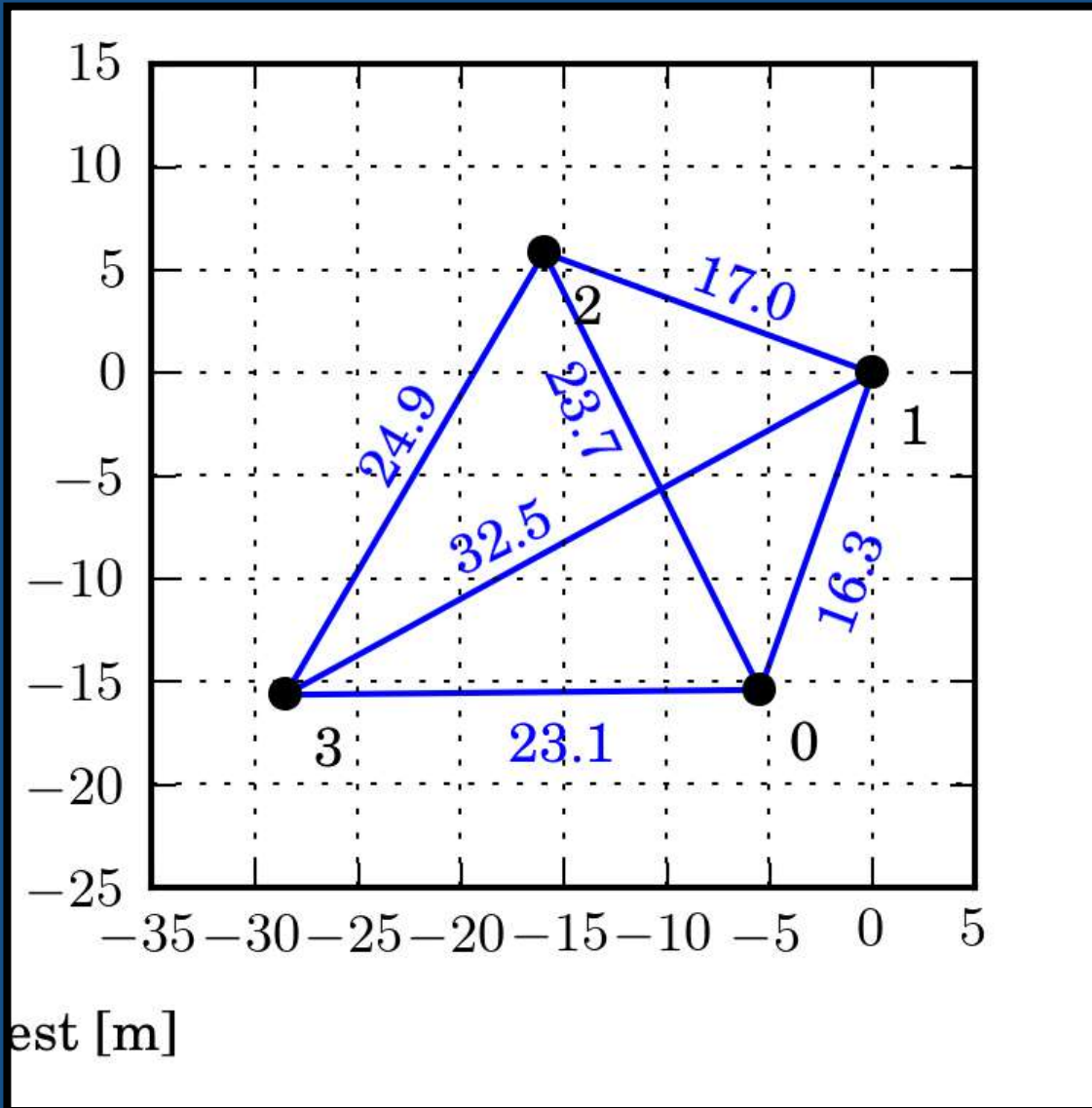
Bandwidth: 20-80 MHz

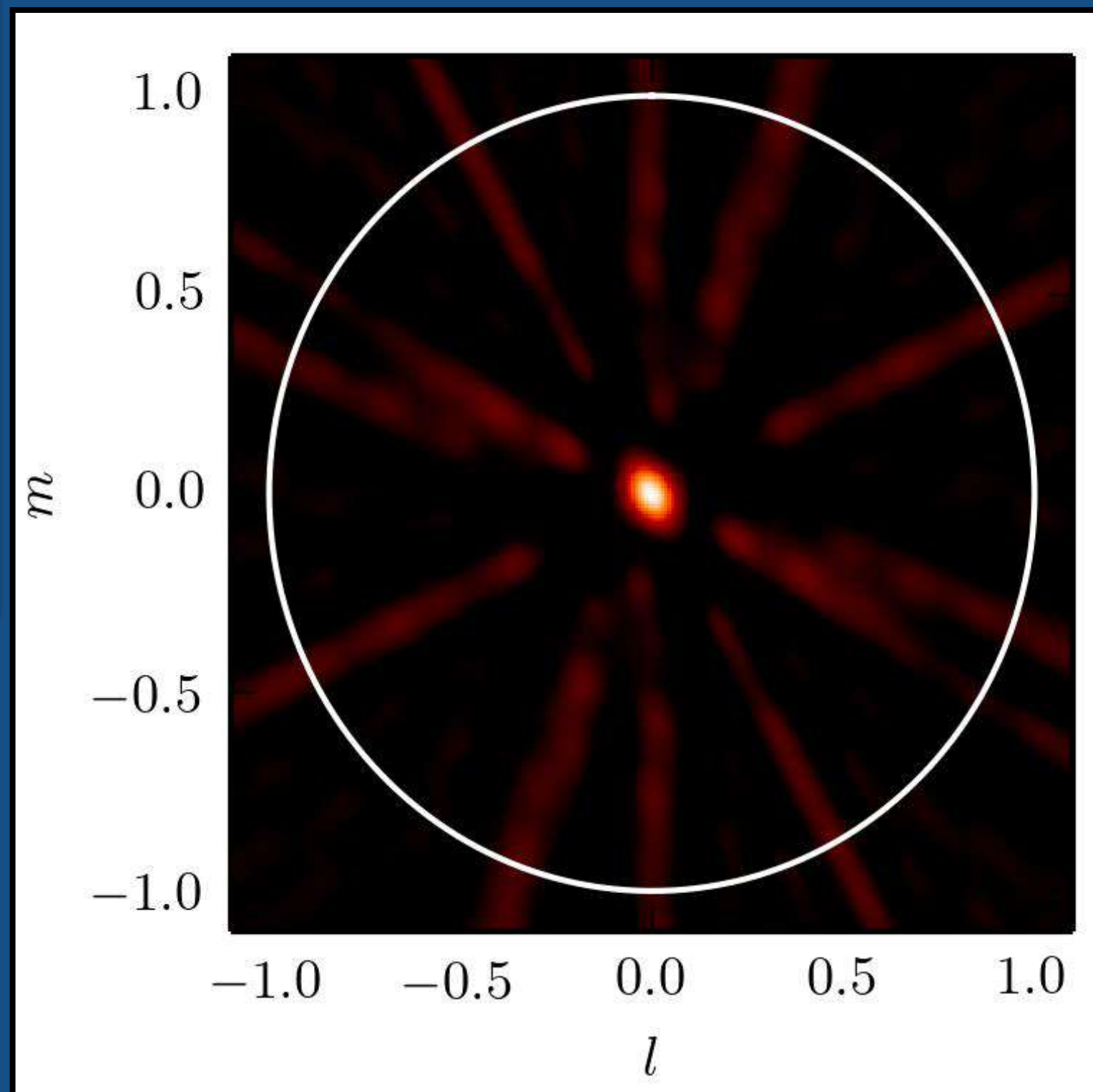
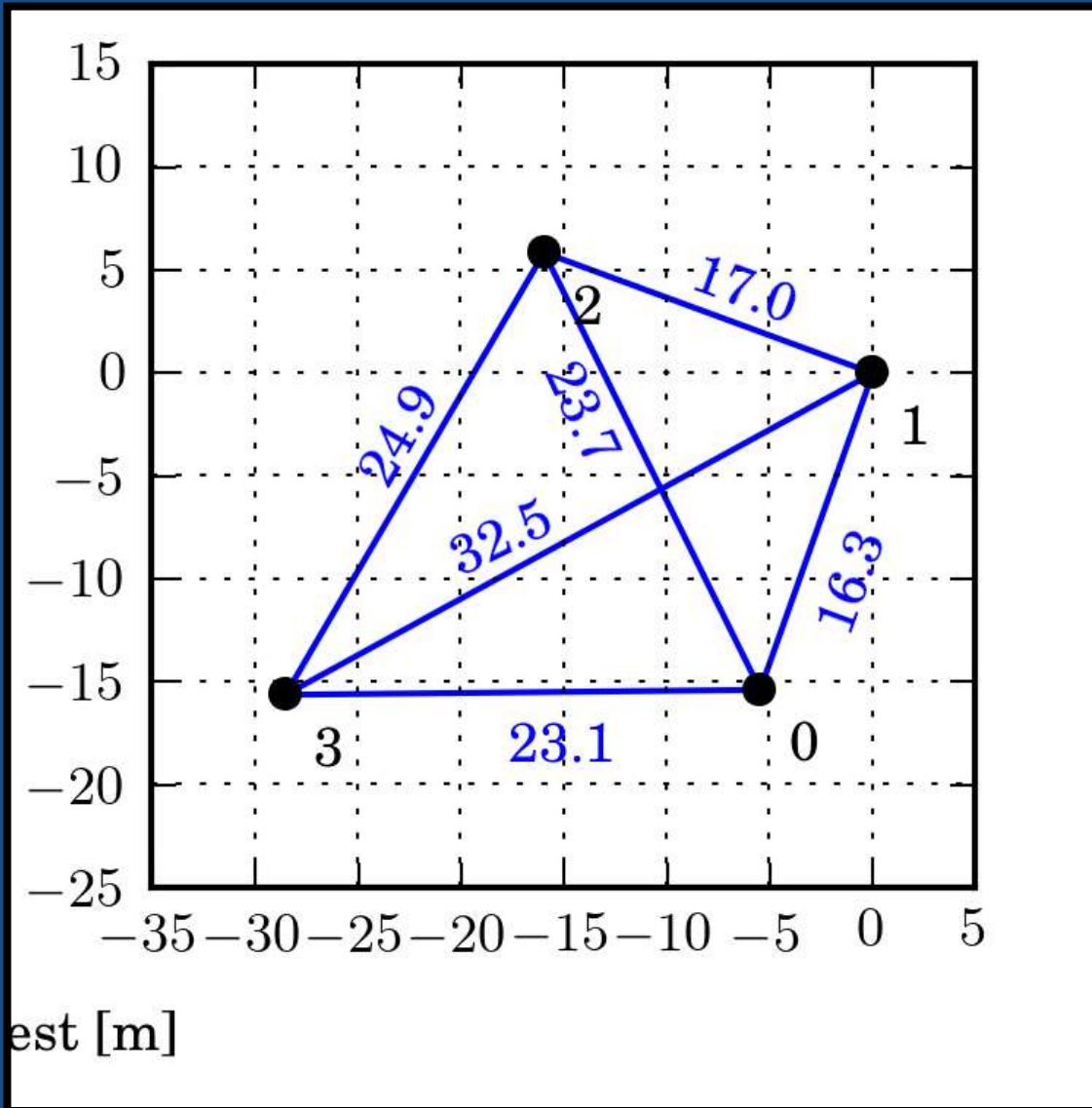


Bandwidth: 20-80 MHz

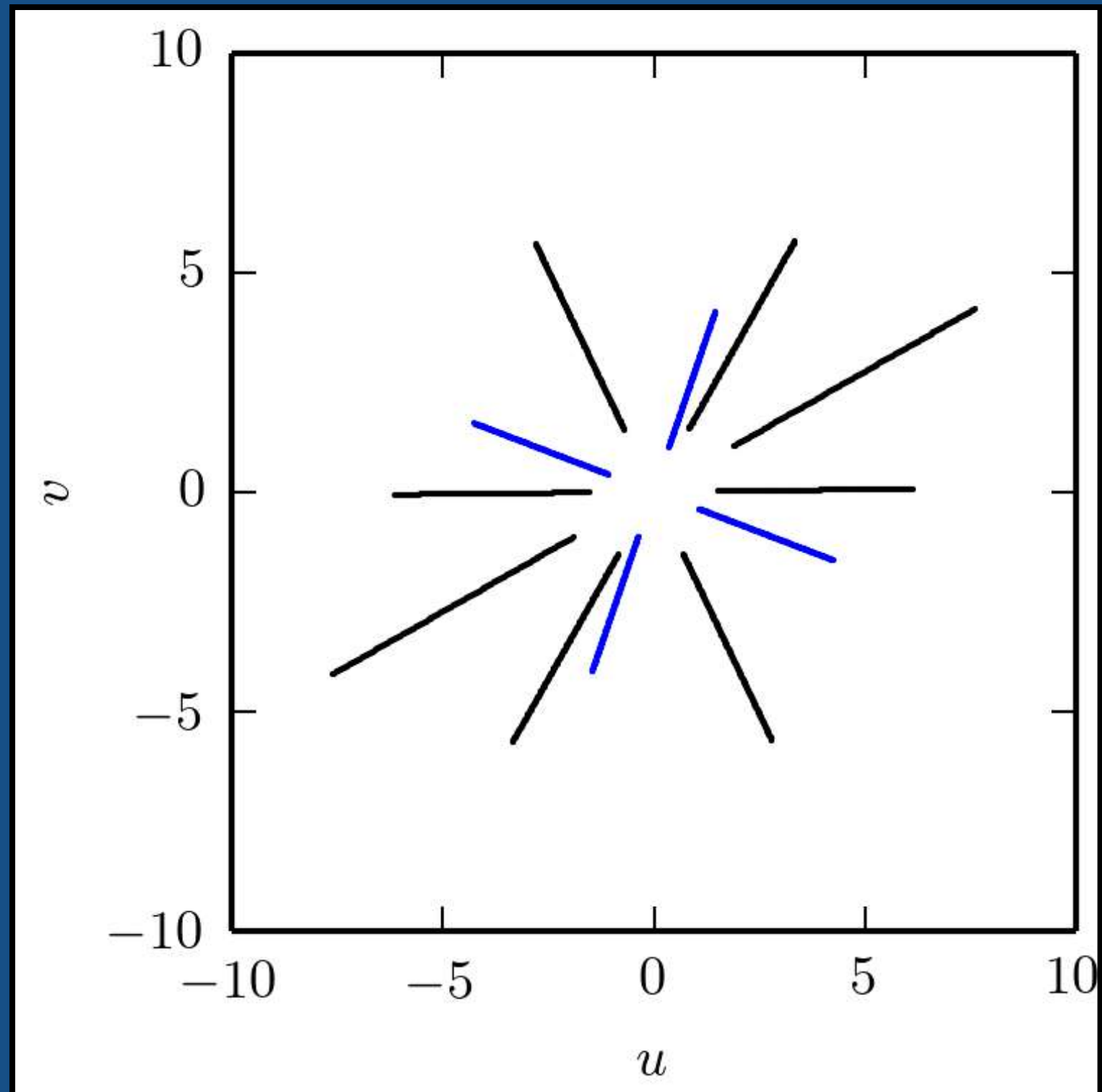
Very Short Baseline Array



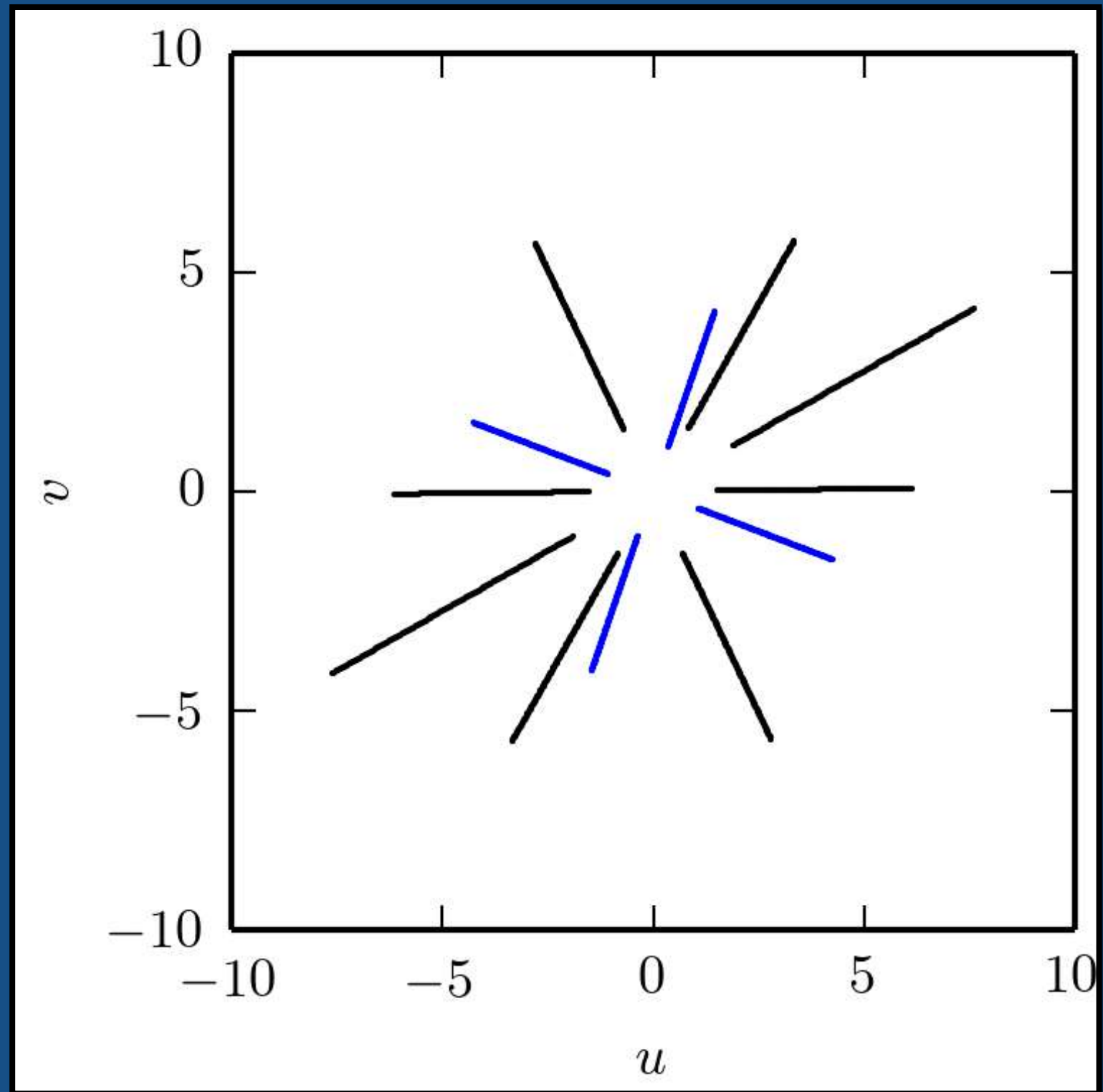




$$I(l, m) = \sum_u \sum_v V(u, v) e^{2\pi i(ul + vm)}$$



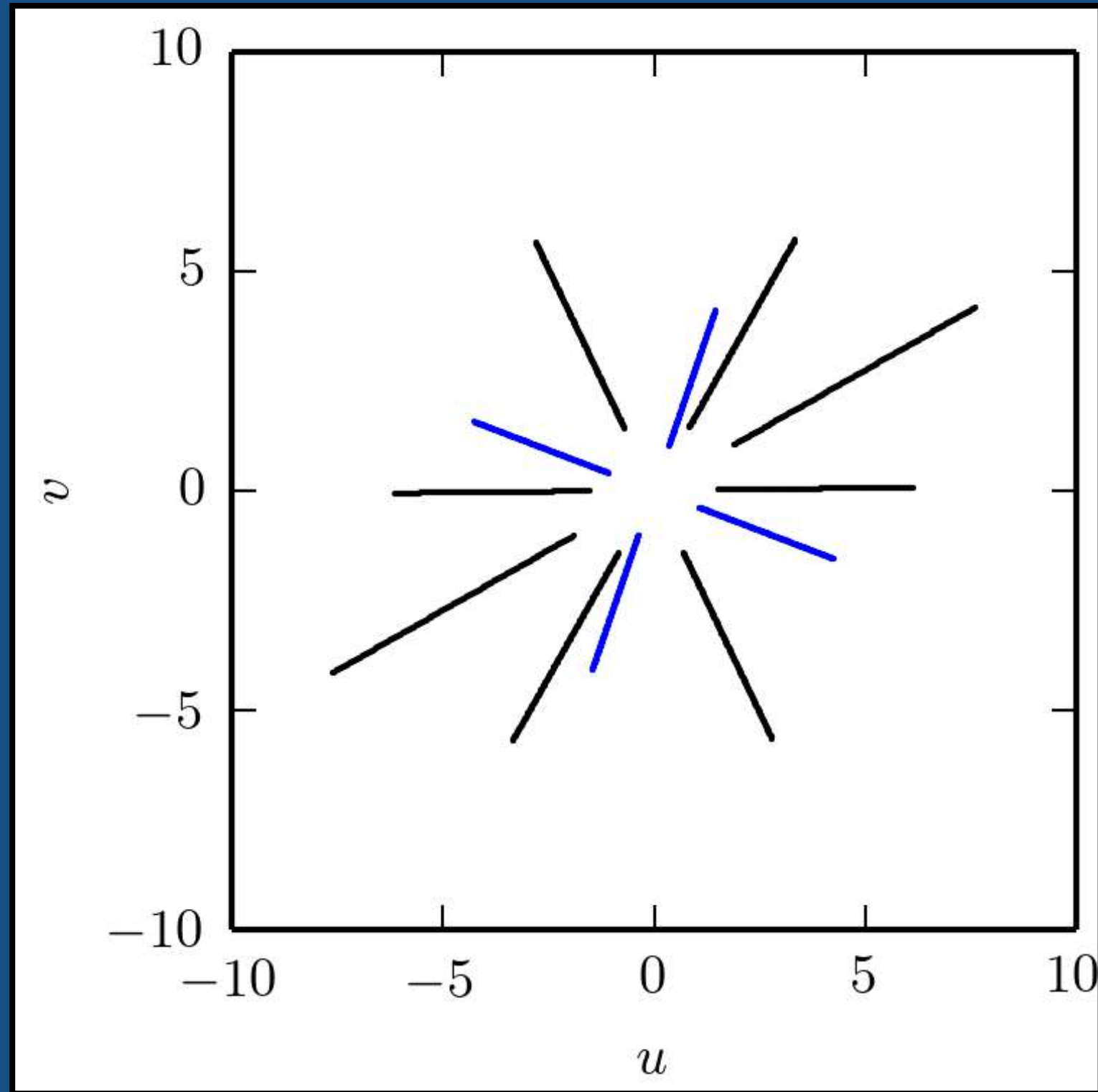
$$I(l, m) = \sum_u \sum_v V(u, v) e^{2\pi i(ul + vm)}$$



$$I(l, m) = \sum_B \sum_f V(f) e^{2\pi i(u_f l + v_f m)}$$

$$u_f = \frac{B_x}{c} f$$

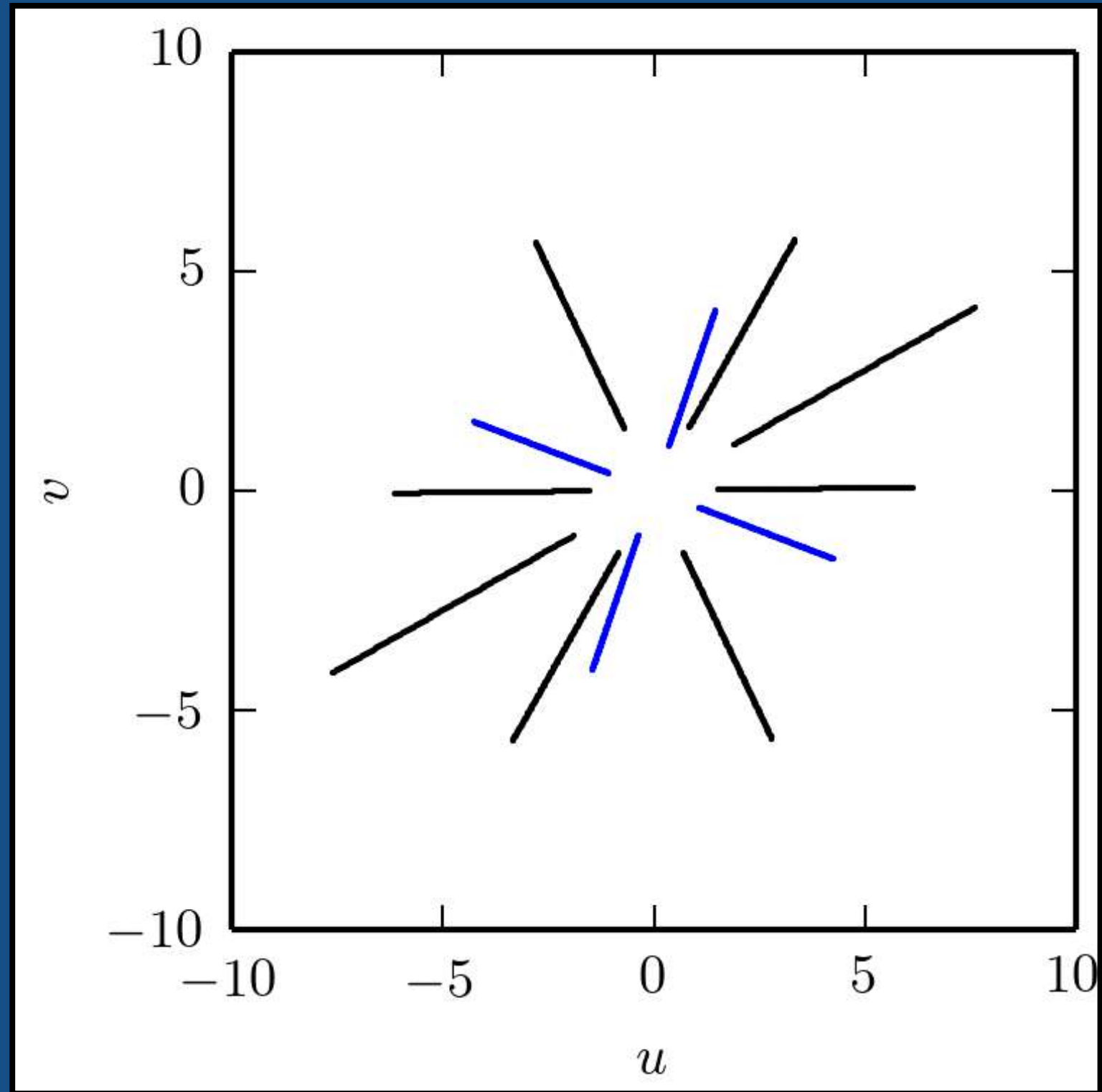
$$v_f = \frac{B_y}{c} f$$



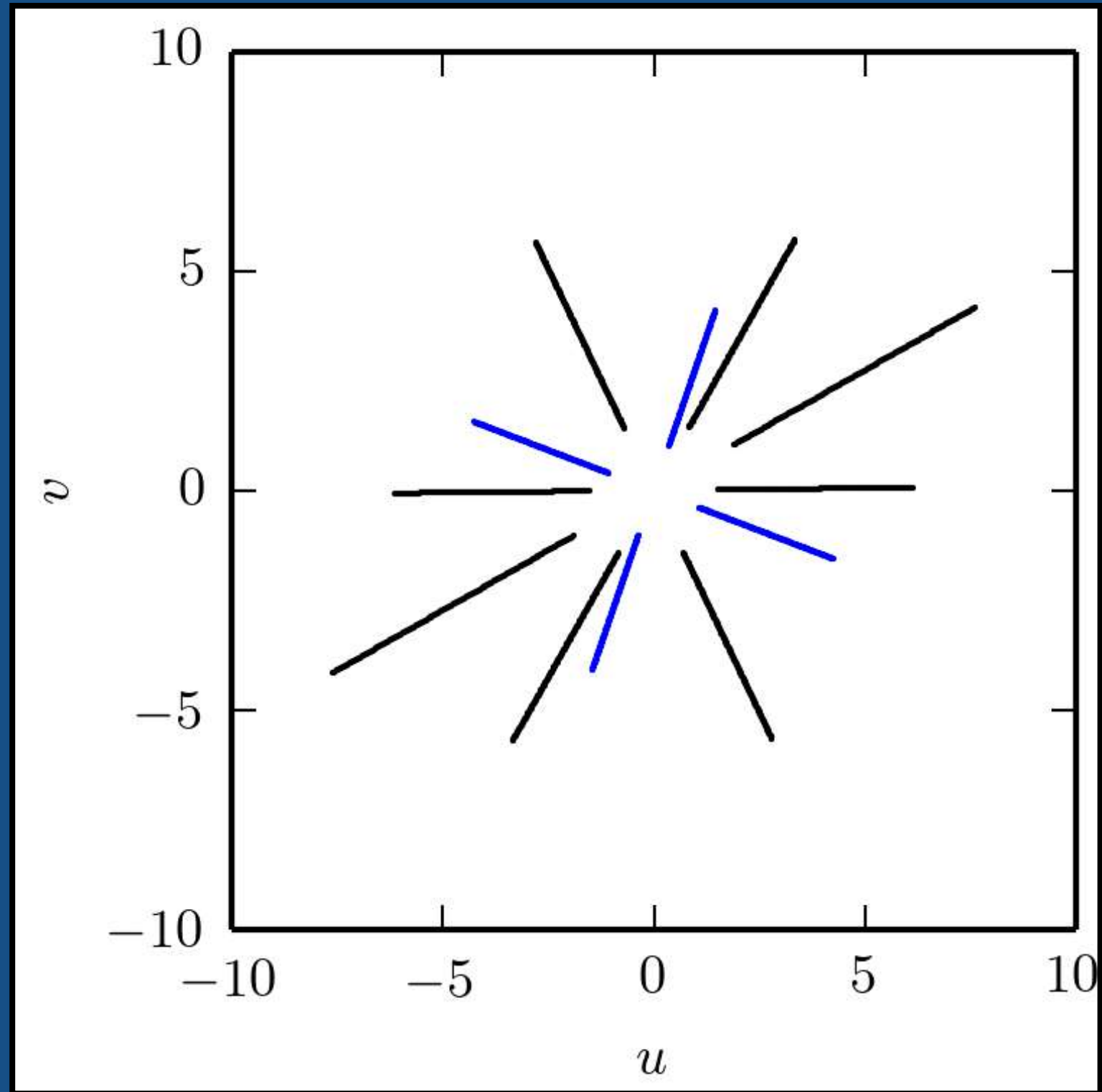
$$I(l, m) = \sum_B \sum_f V(f) e^{2\pi i(u_f l + v_f m)}$$

$$u_f = \frac{B_x}{c} f$$

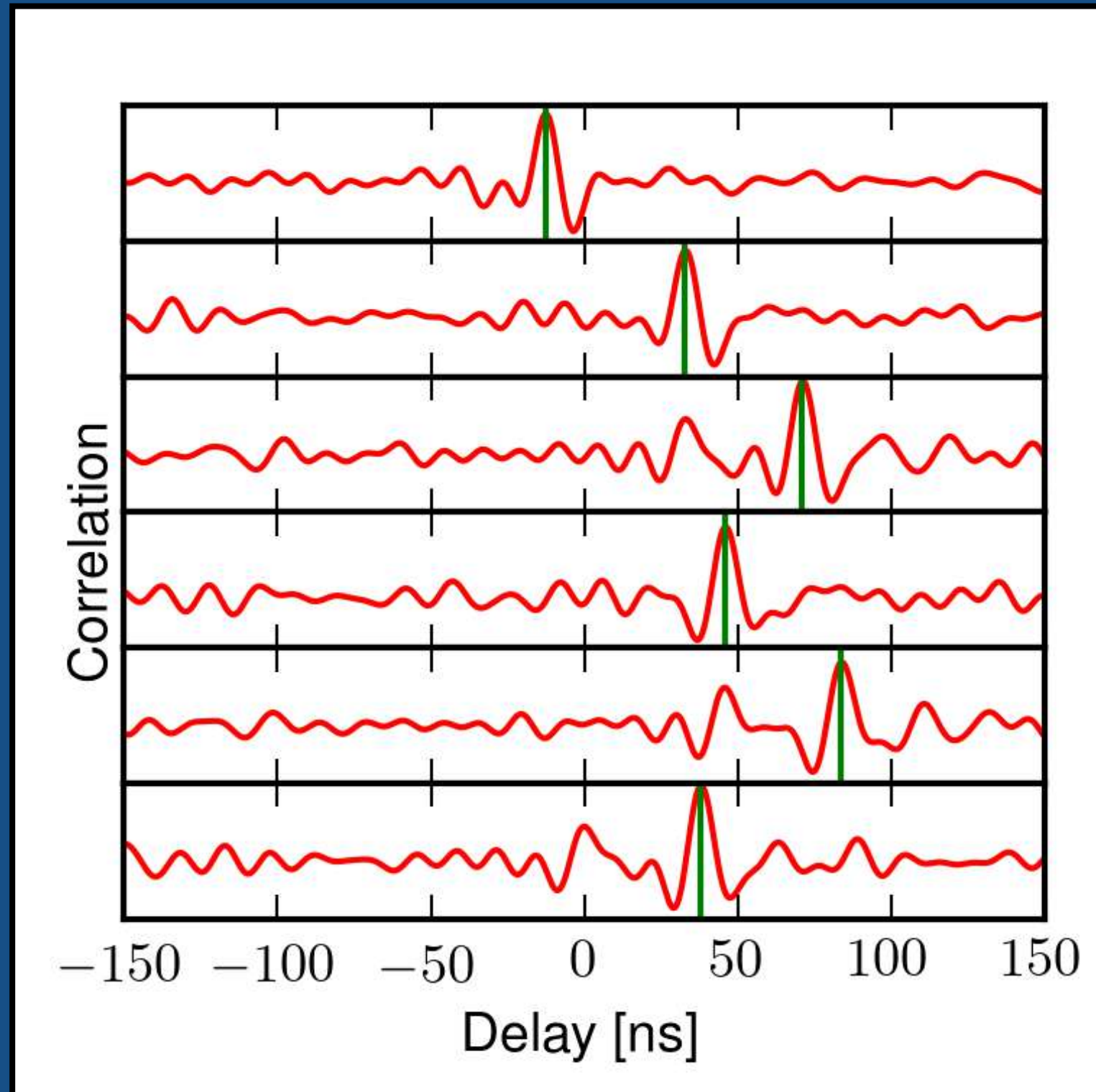
$$v_f = \frac{B_y}{c} f$$



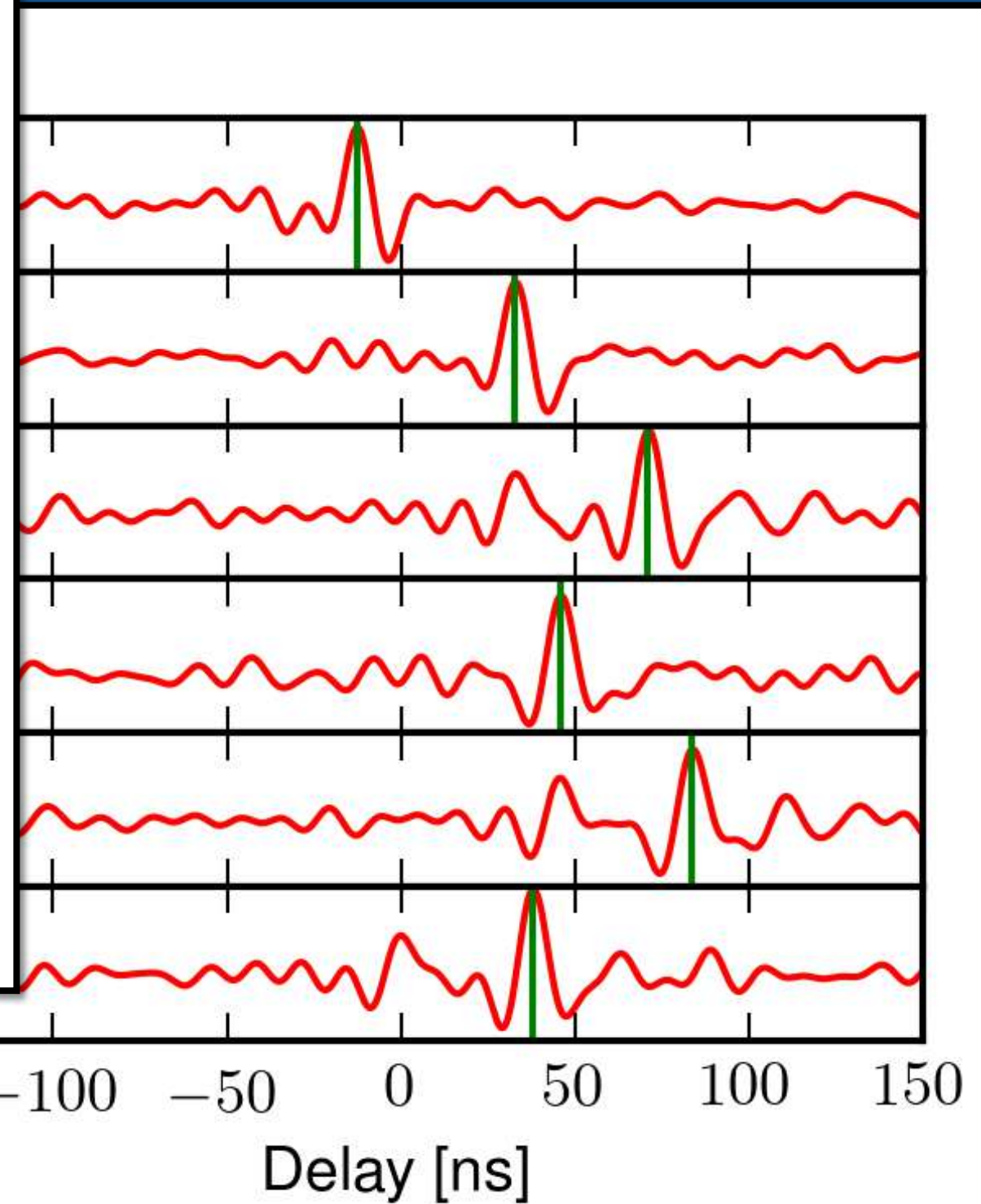
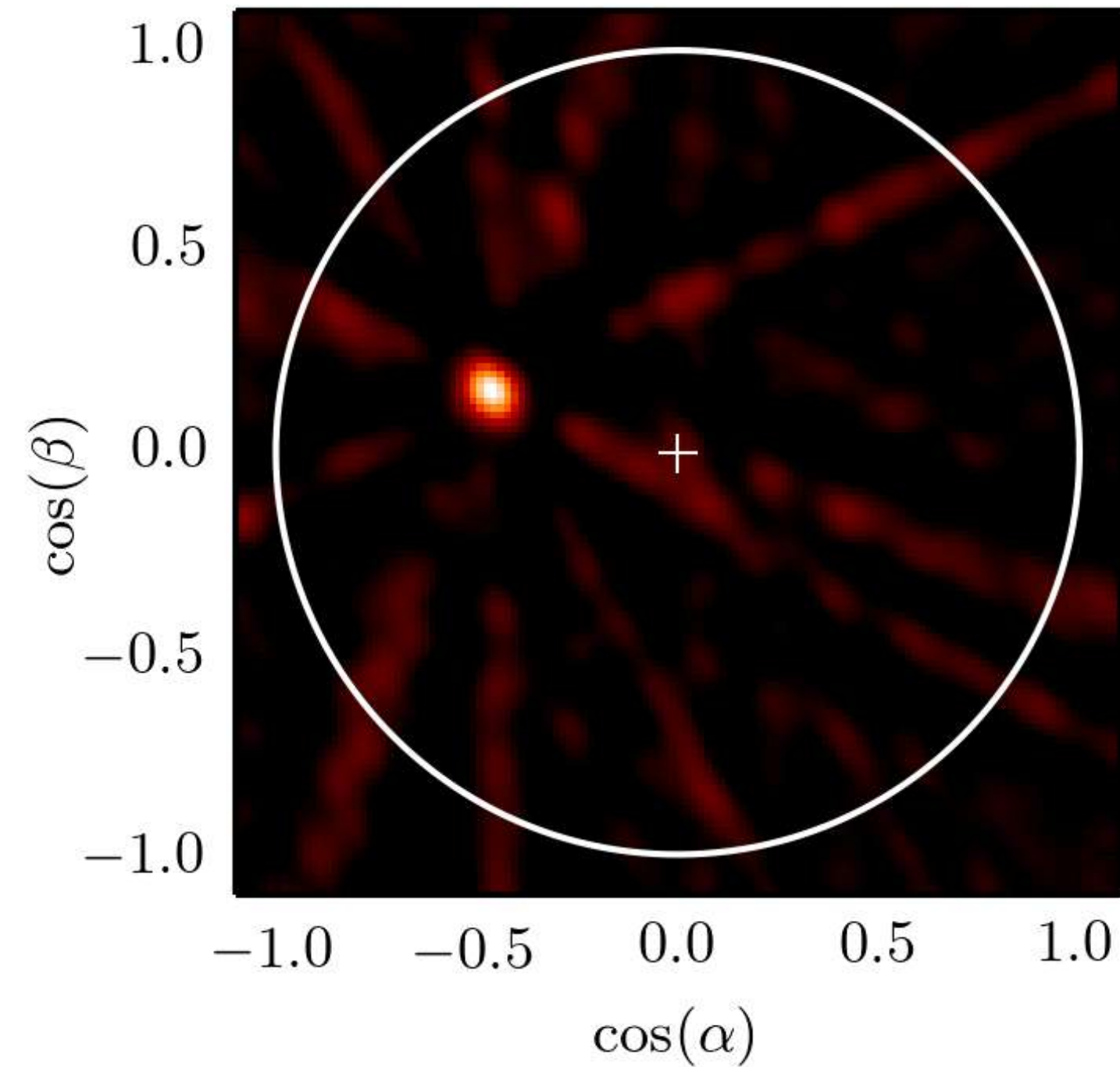
$$I(l, m) = \sum_B X_B(\tau_B)$$



$$I(l, m) = \sum_B X_B(\tau_B)$$



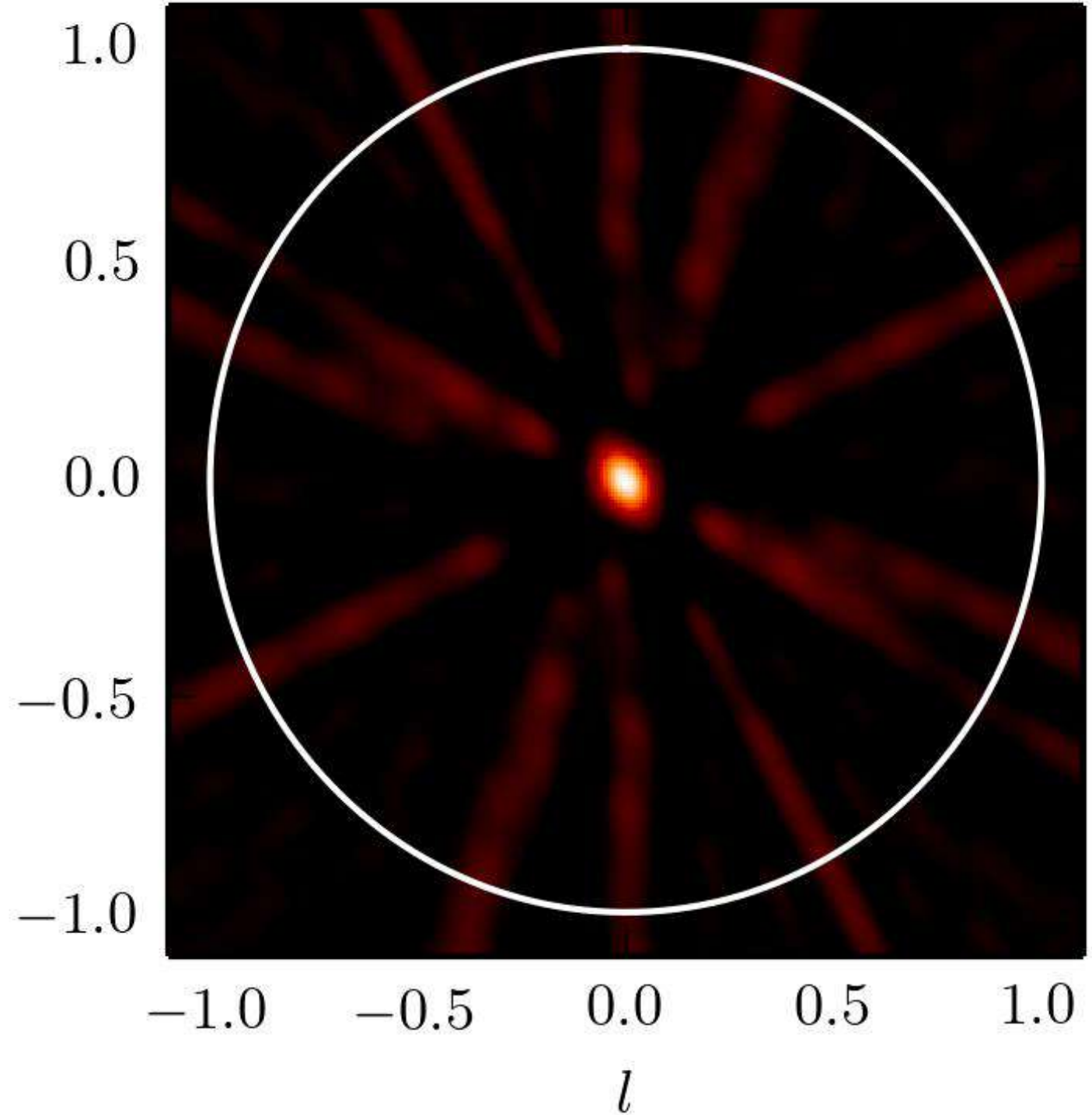
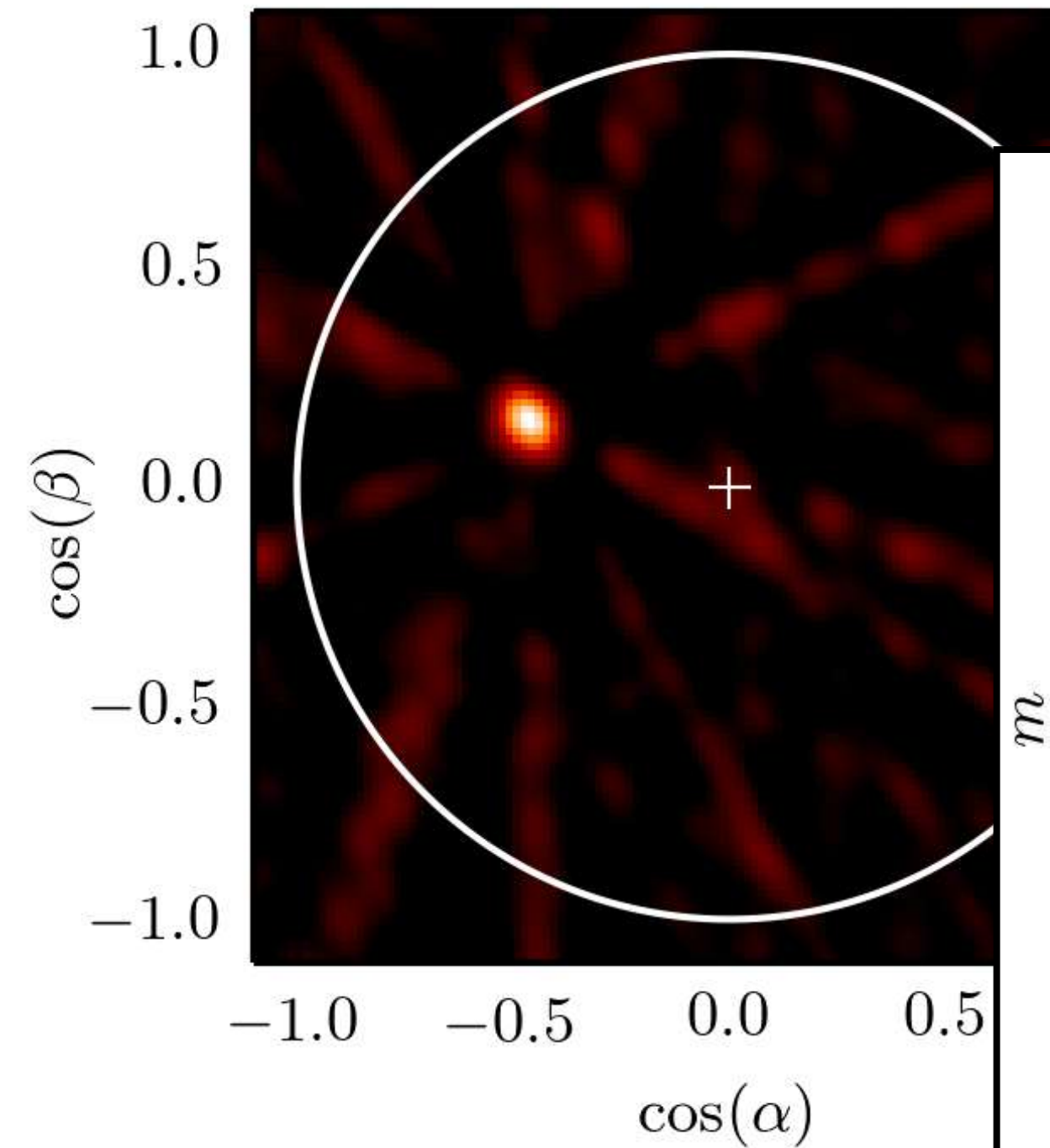
-3755.418 ms



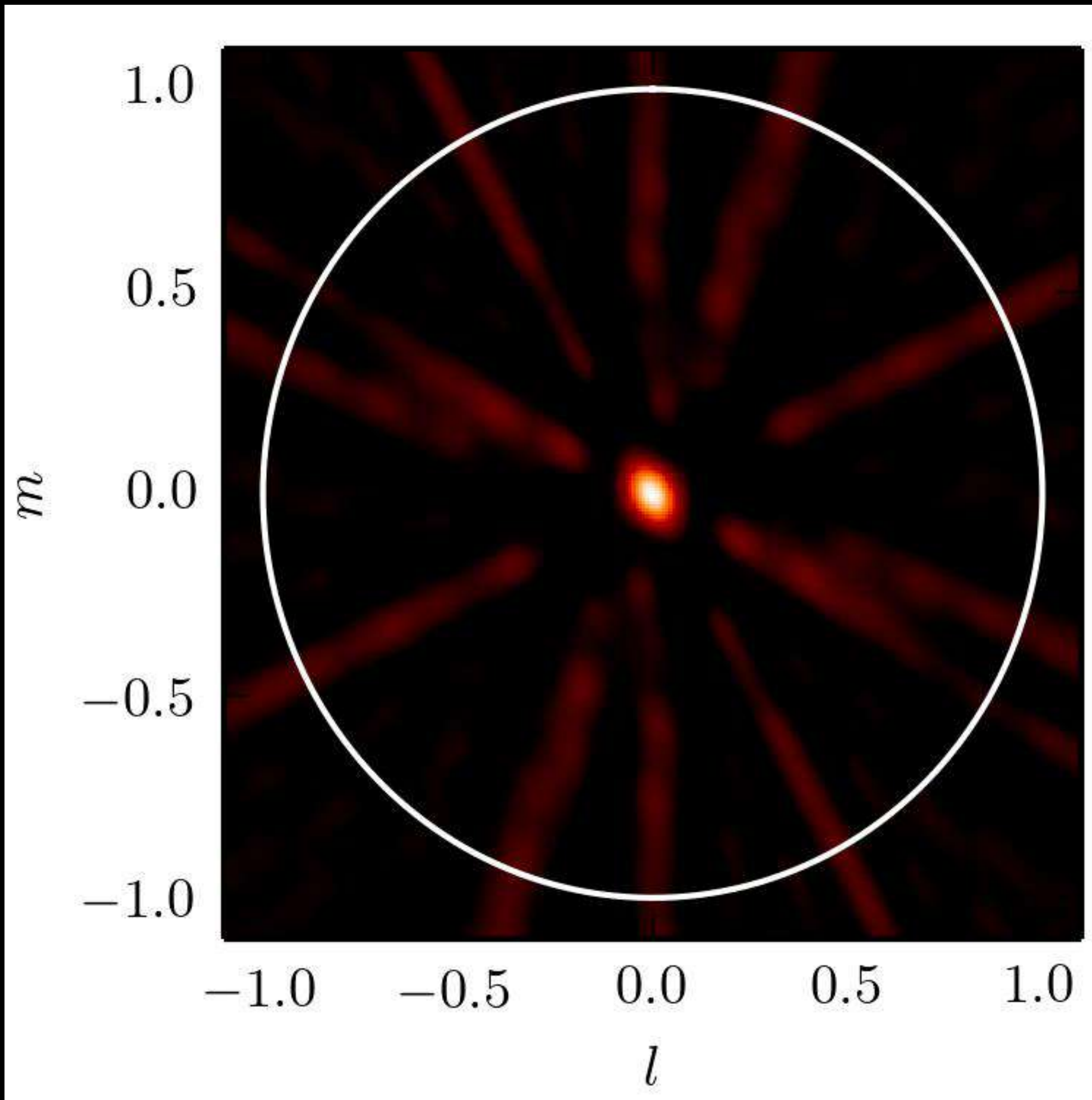
Bright Source

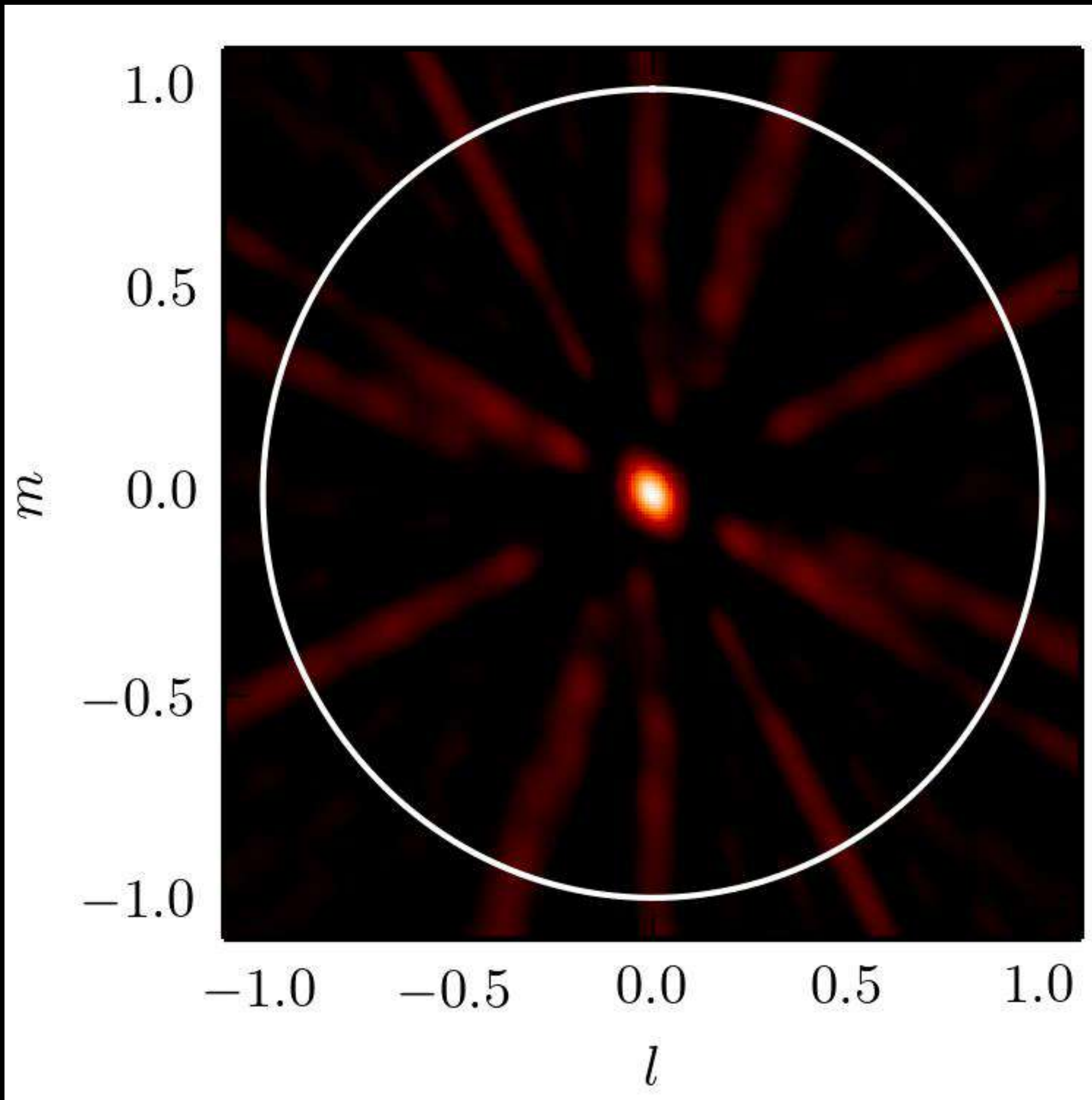
-3755.418 ms

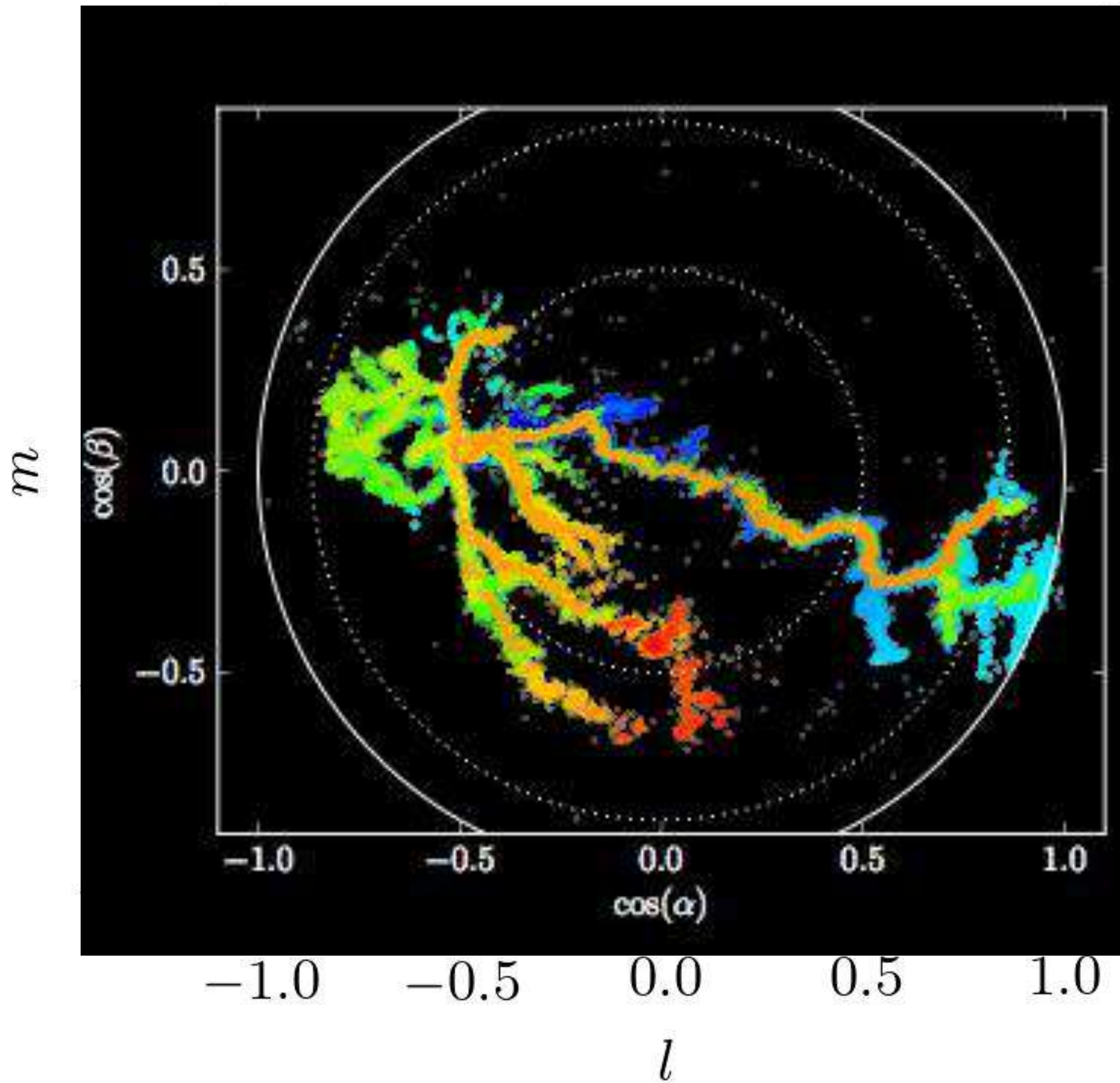
Point Spread



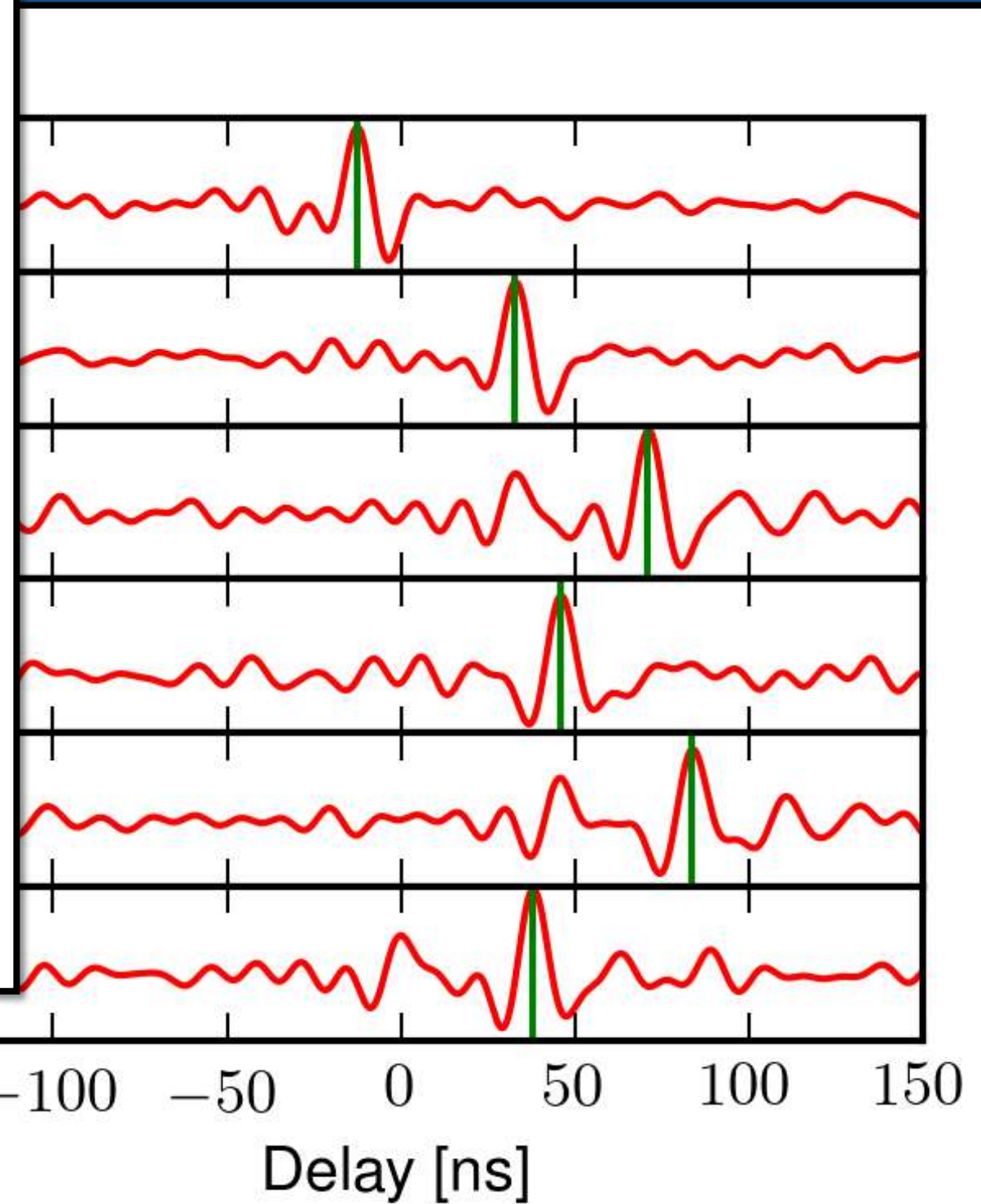
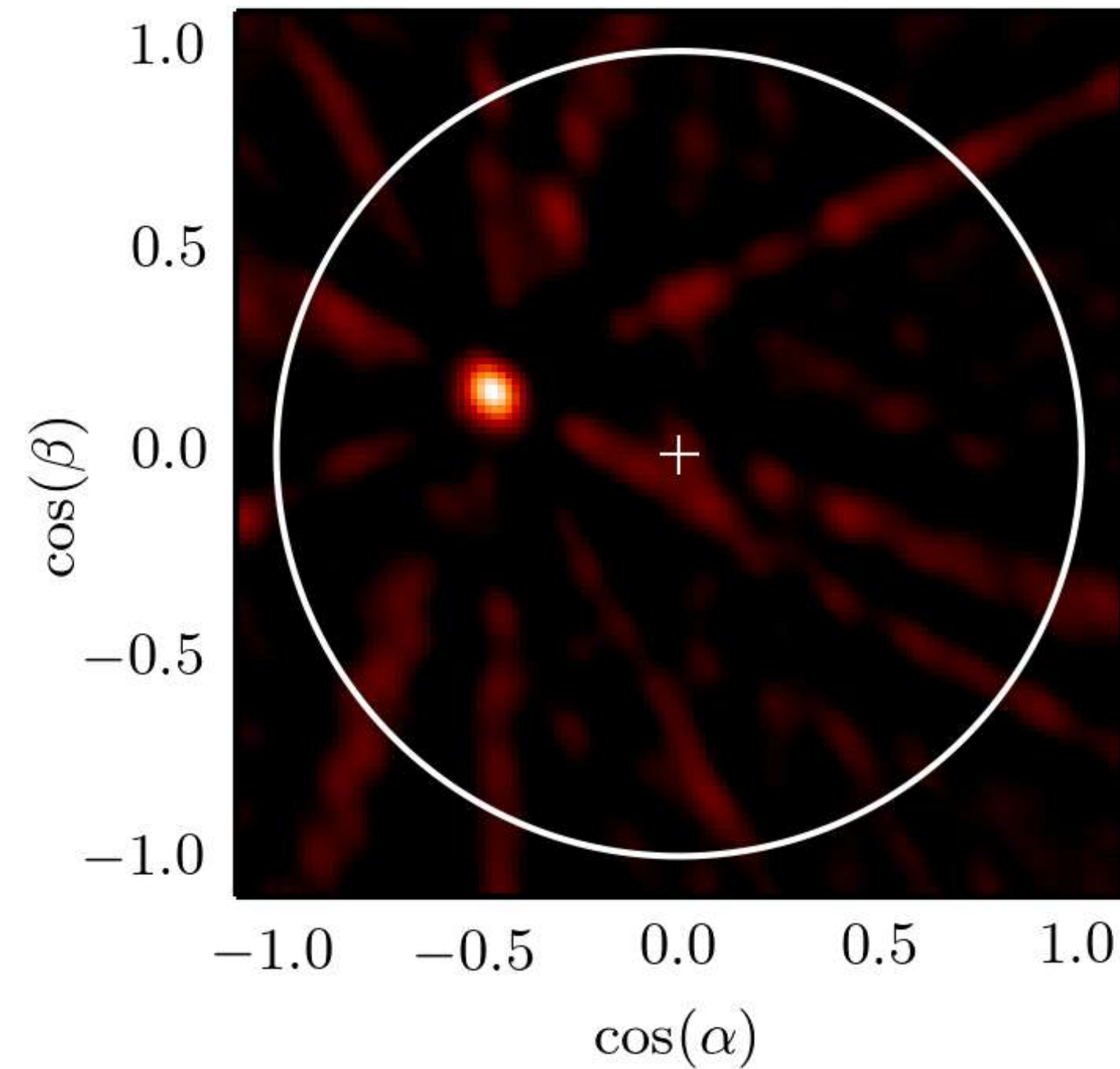
Bright Source





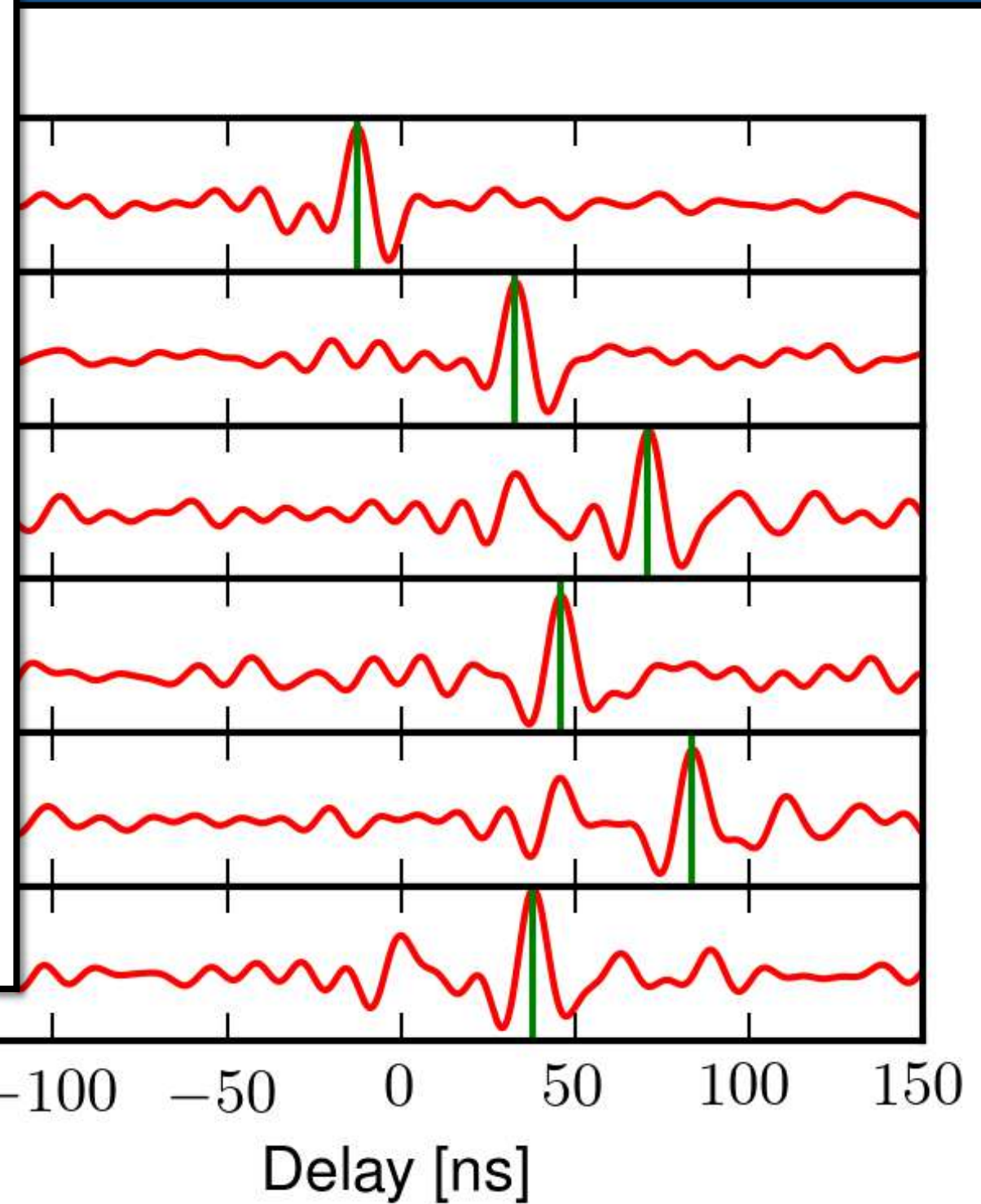
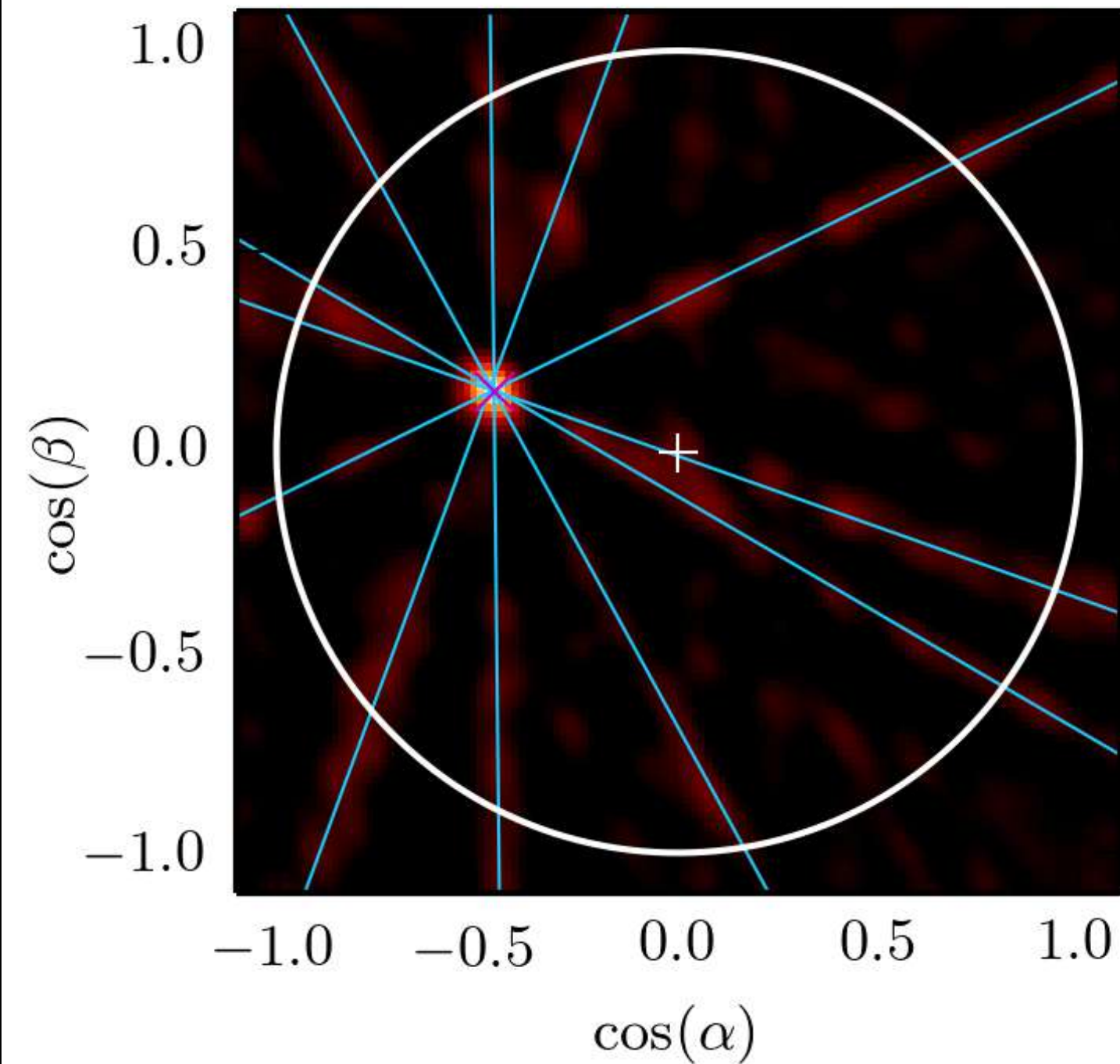


-3755.418 ms



Bright Source

-3755.418 ms

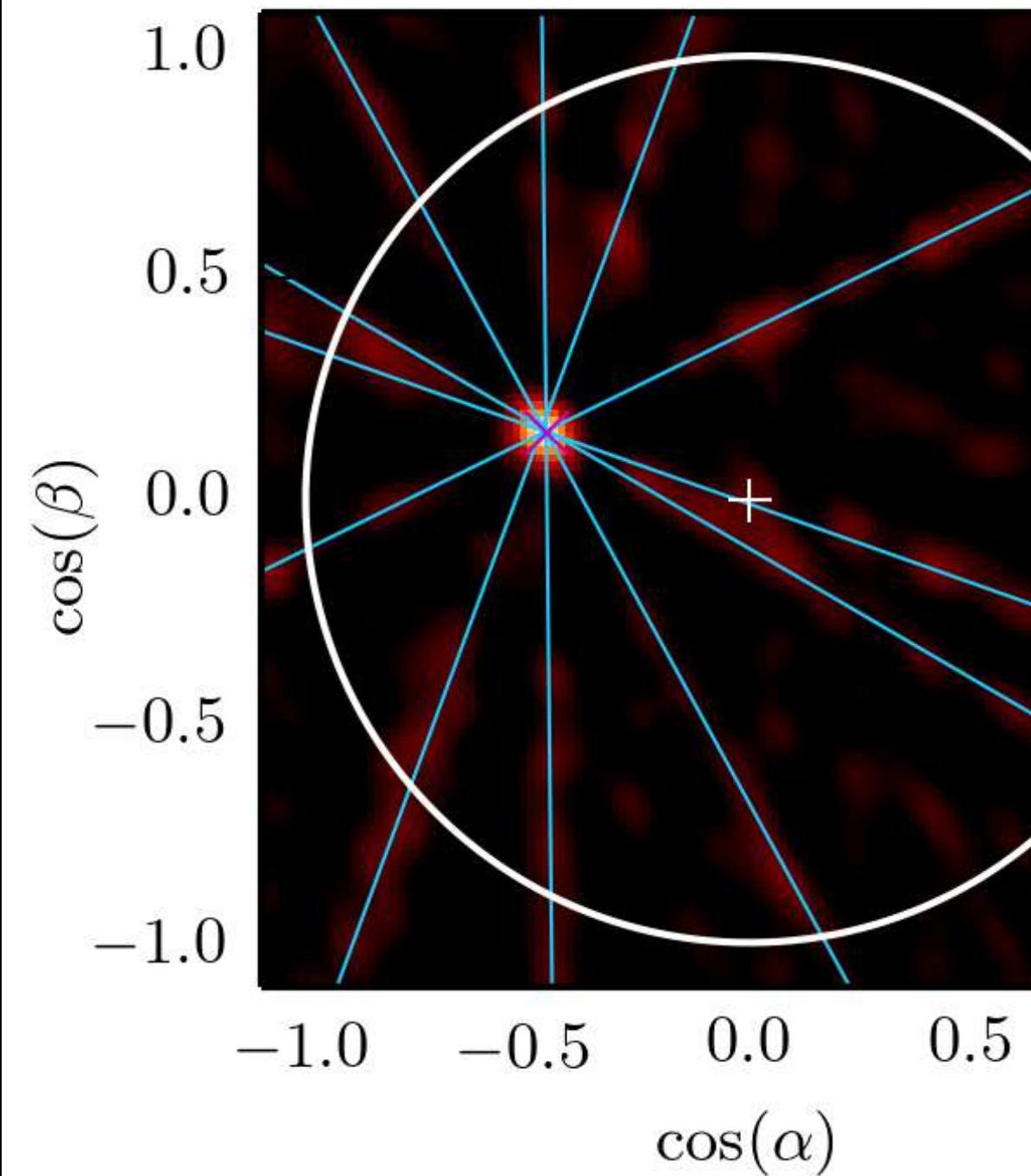


Bright Source

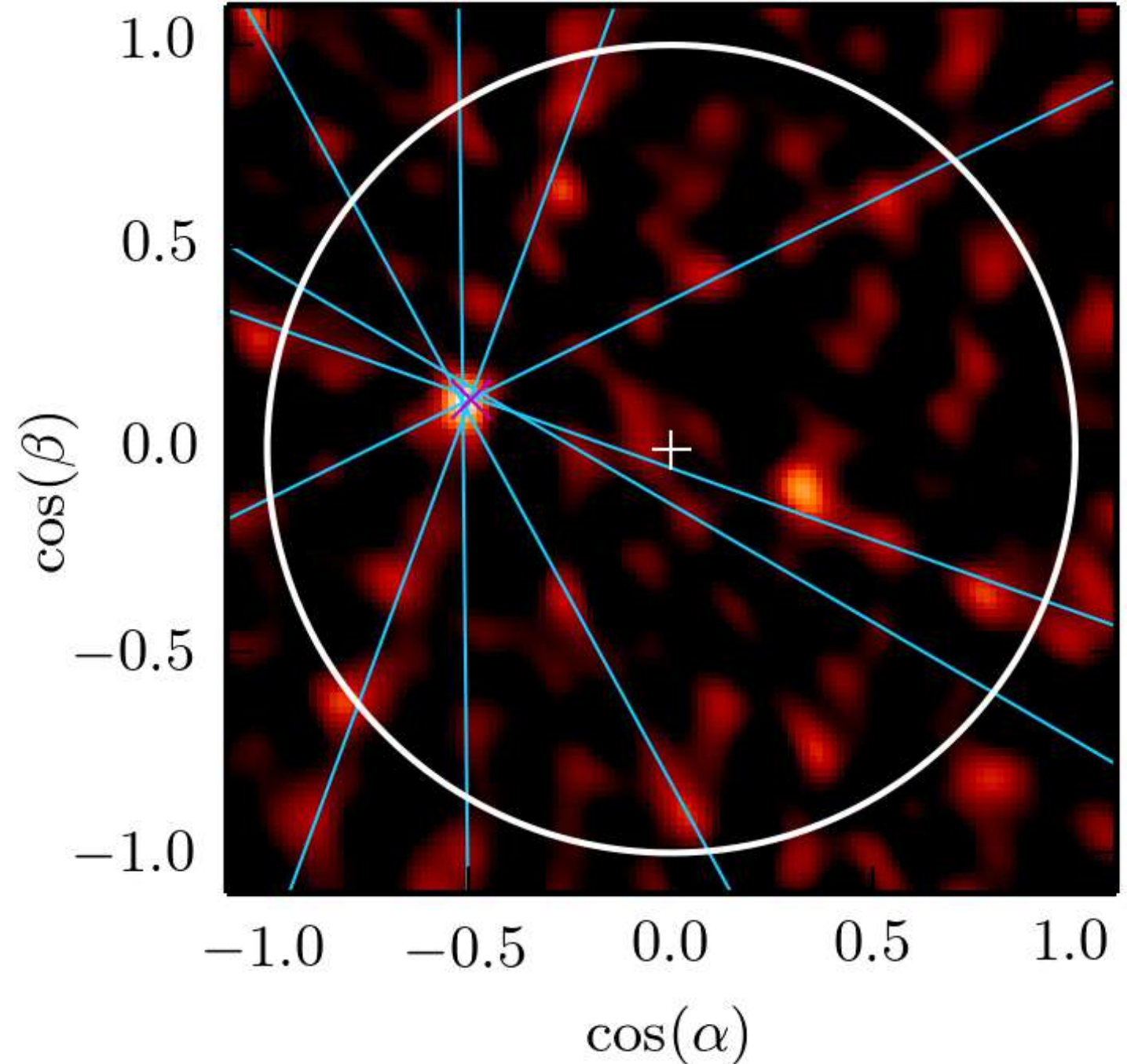
Interferometric Mapping

-3755.418 ms

Faint Source

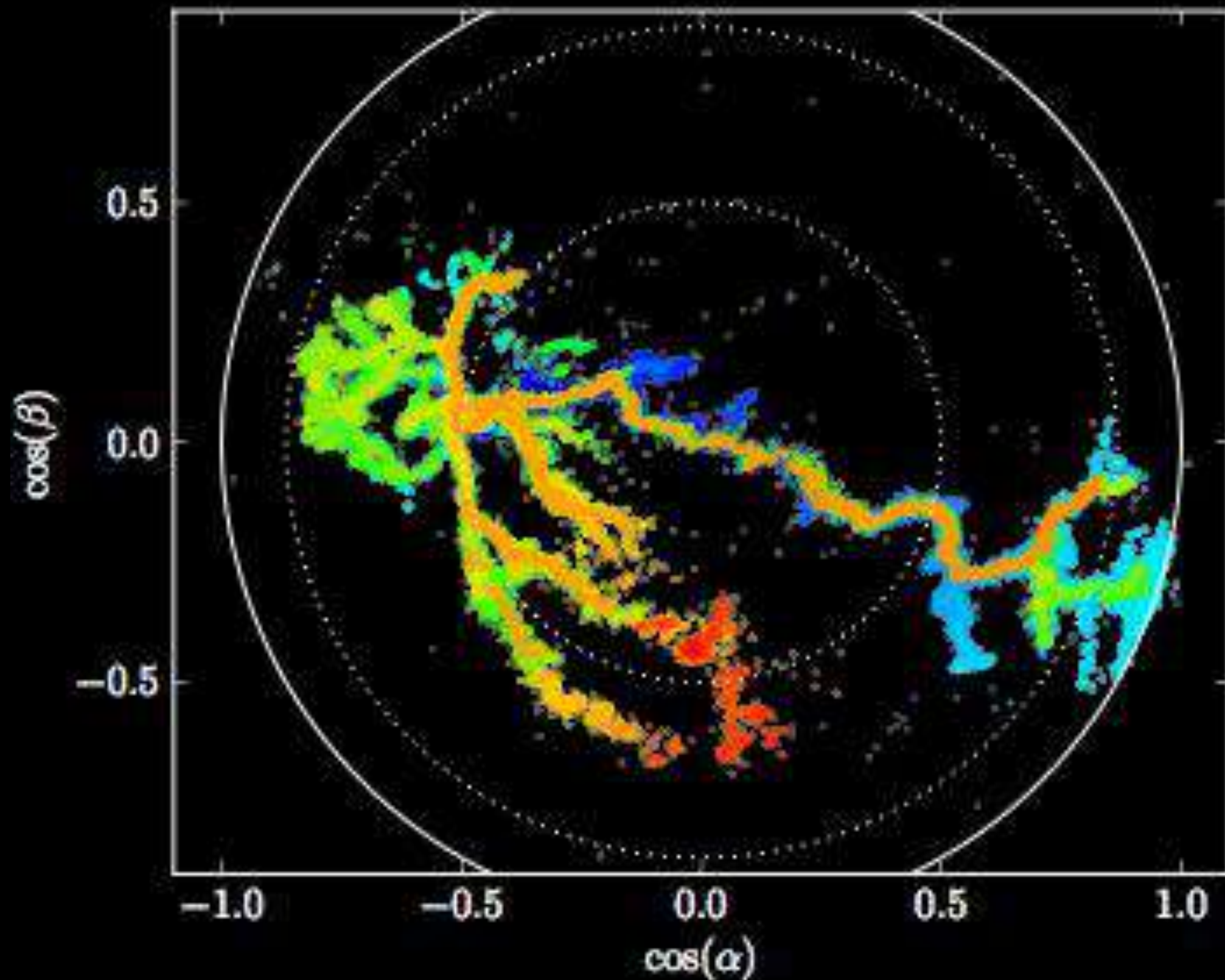


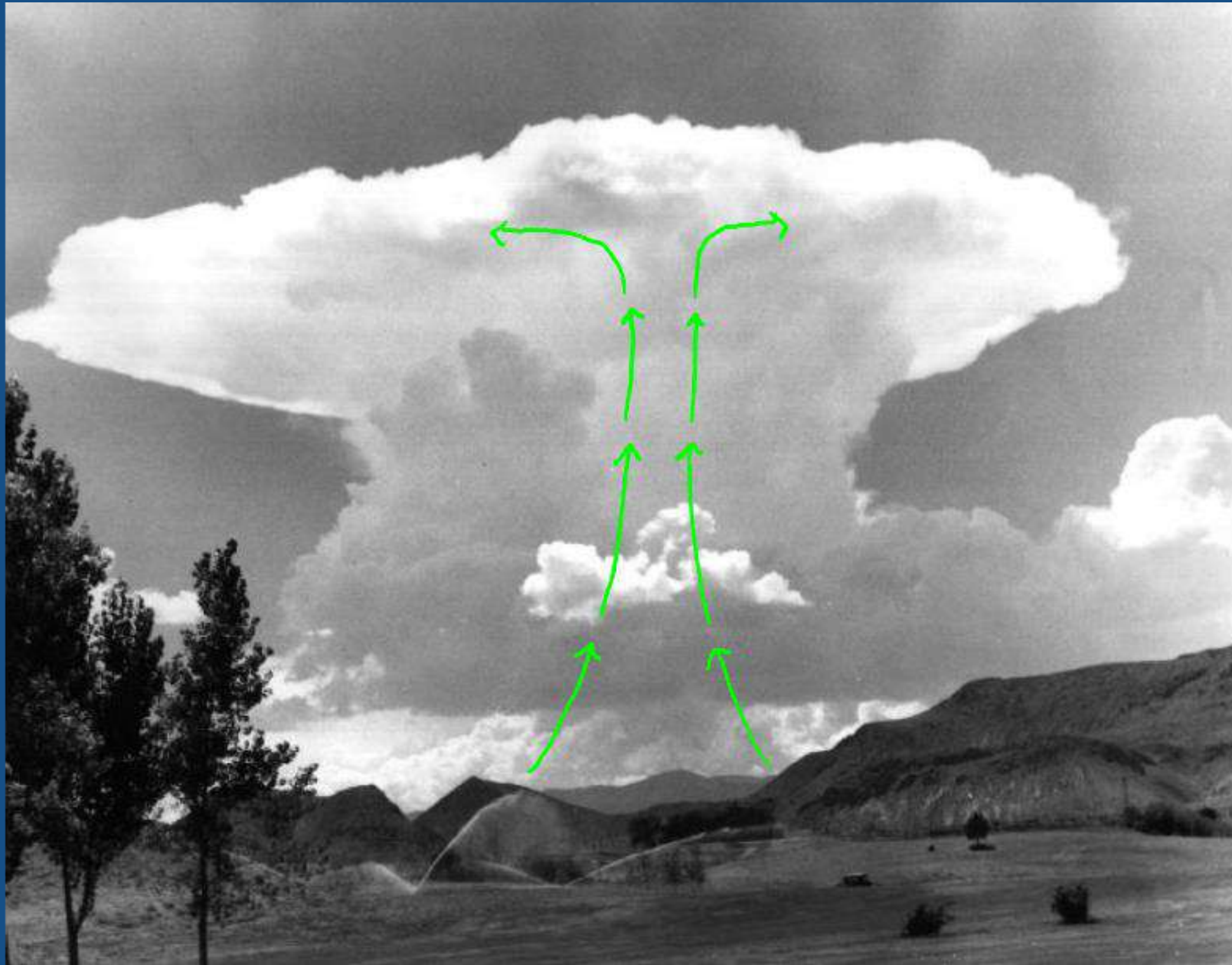
-3755.643 ms

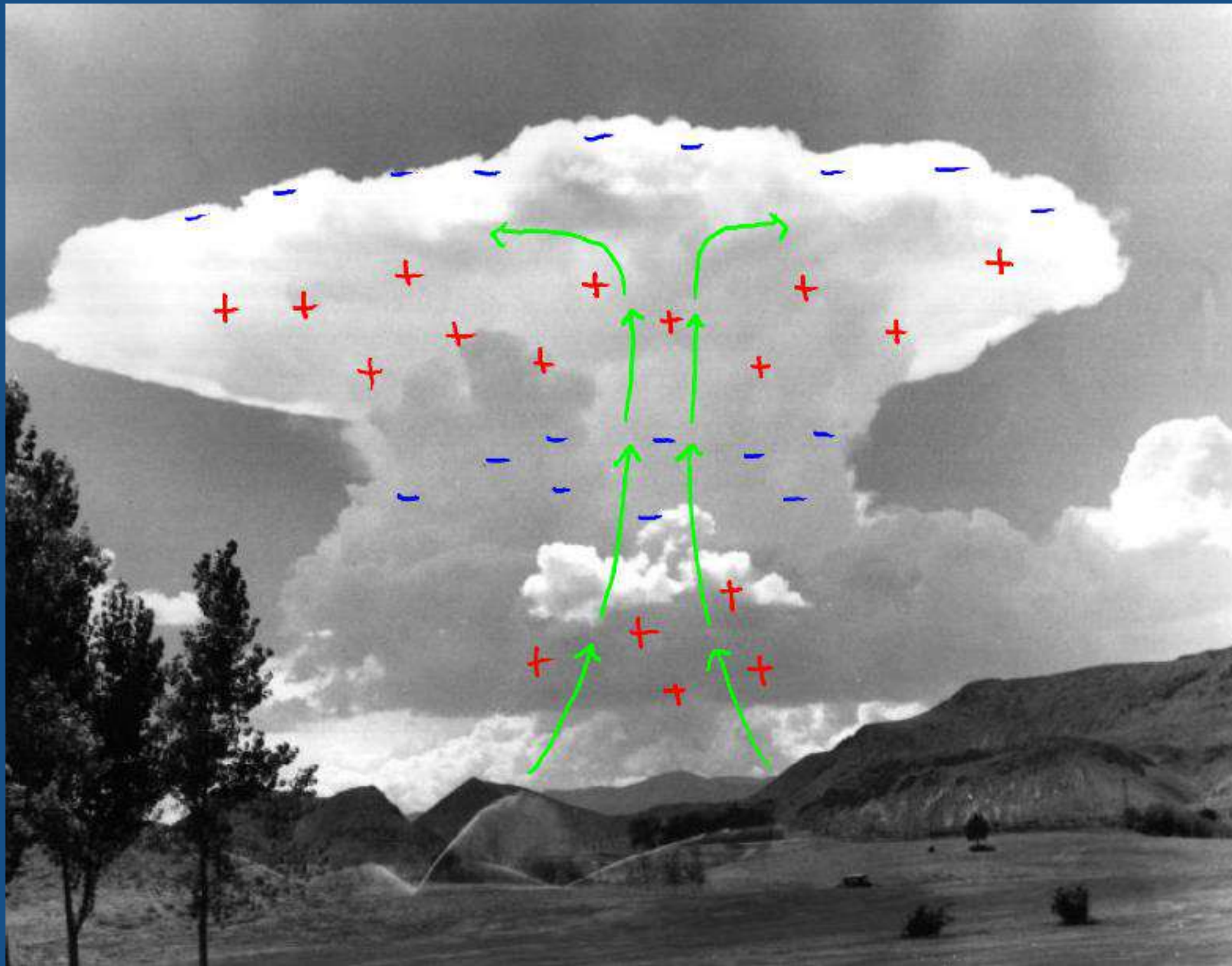


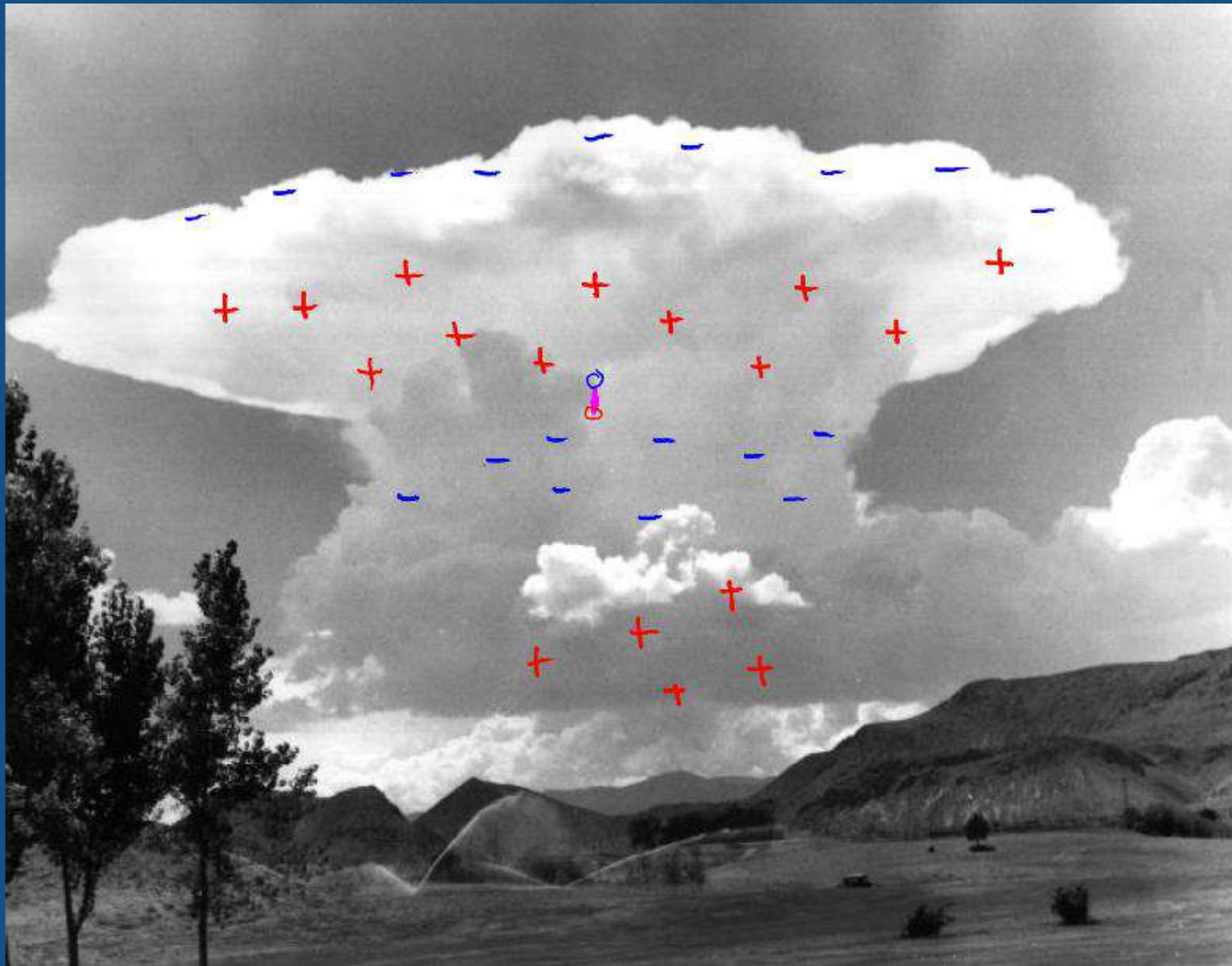
Bright Source

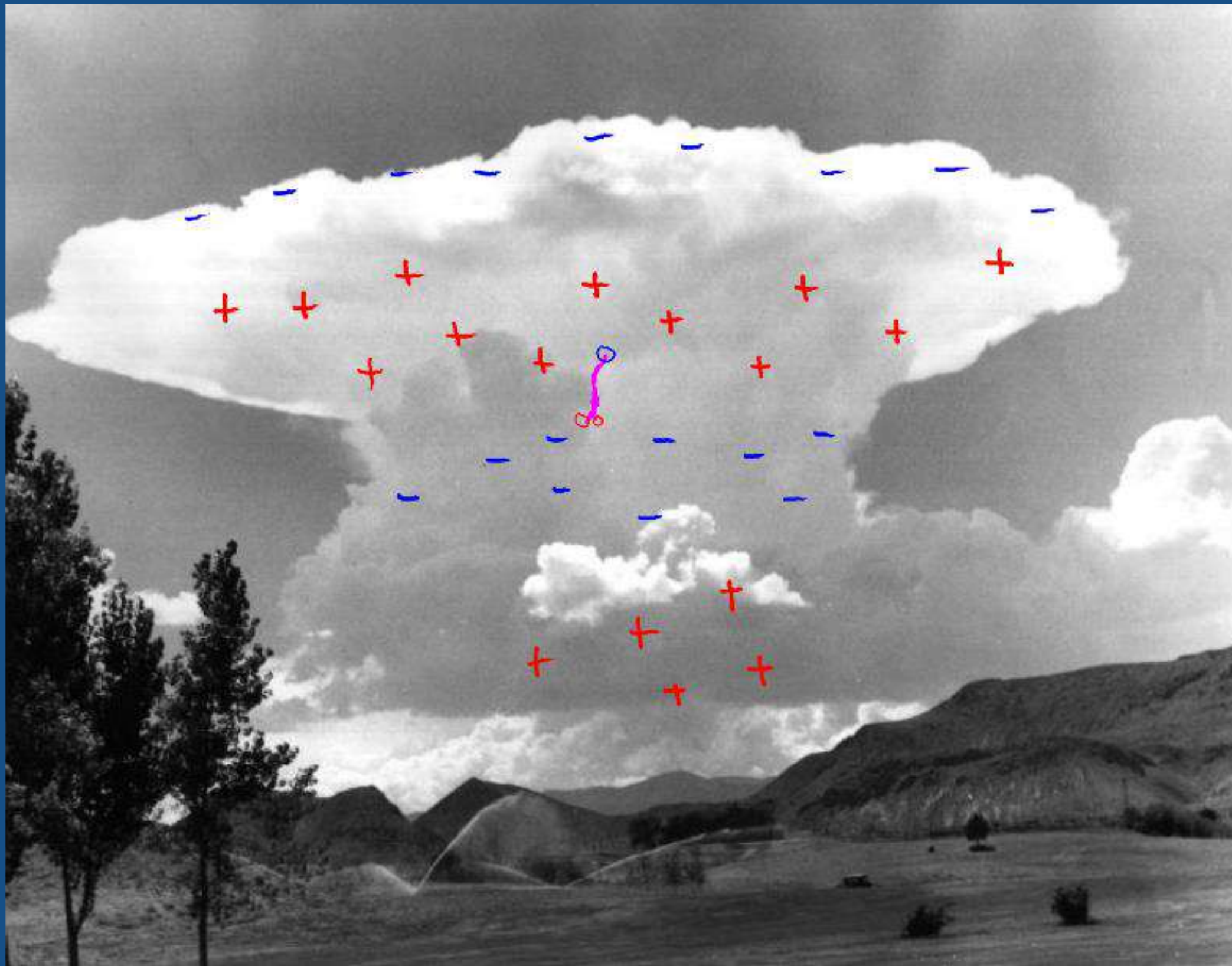
Interferometric Mapping

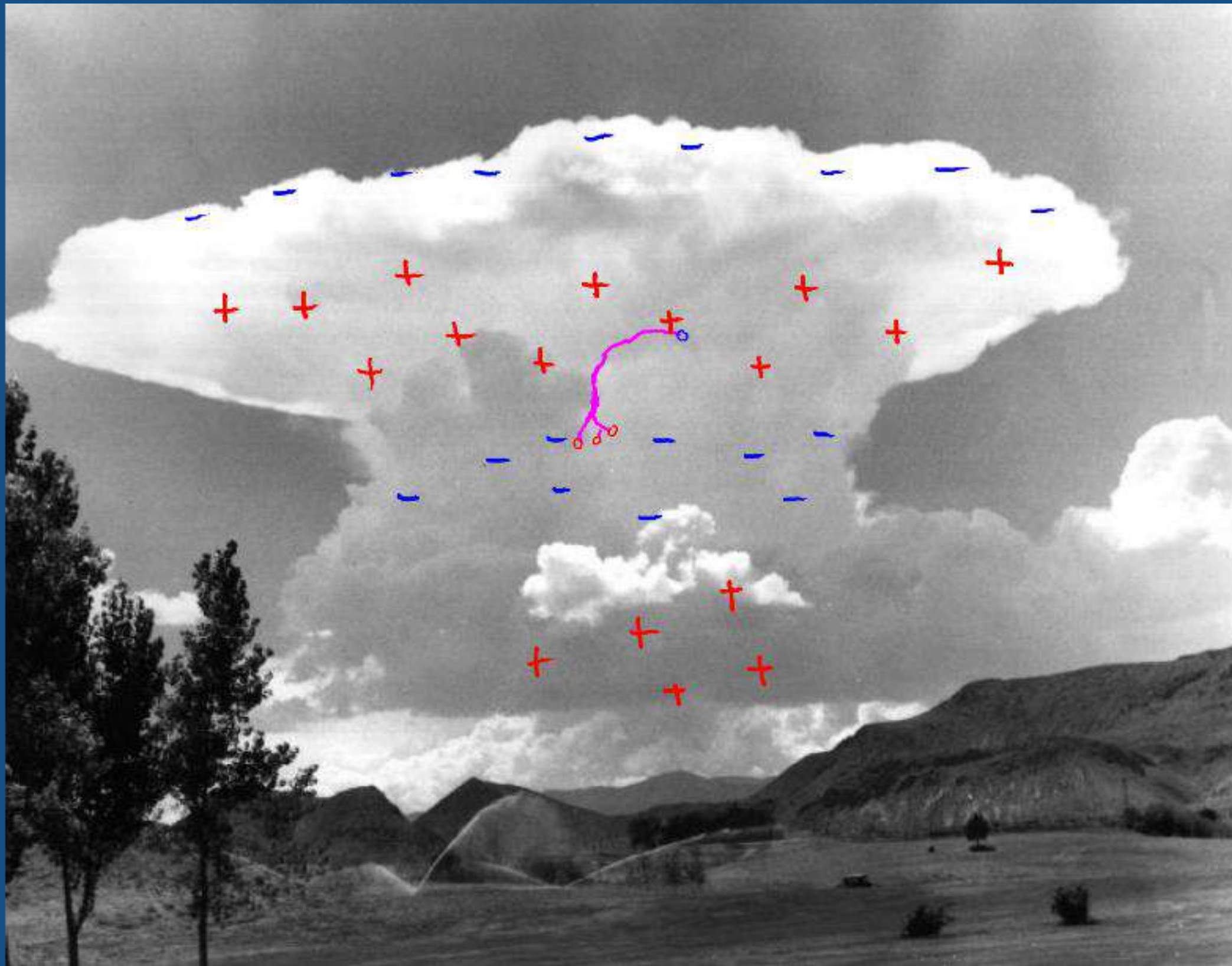


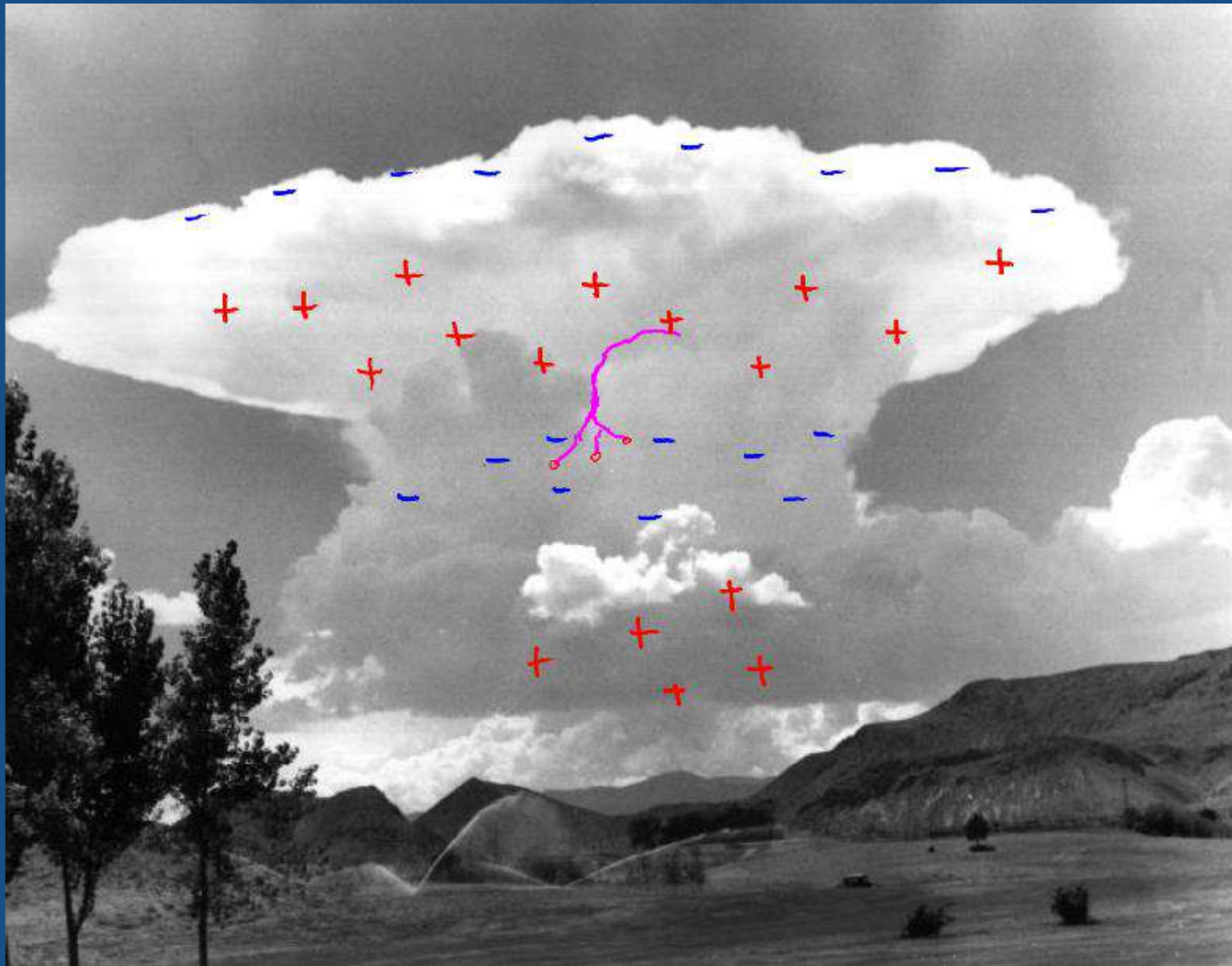


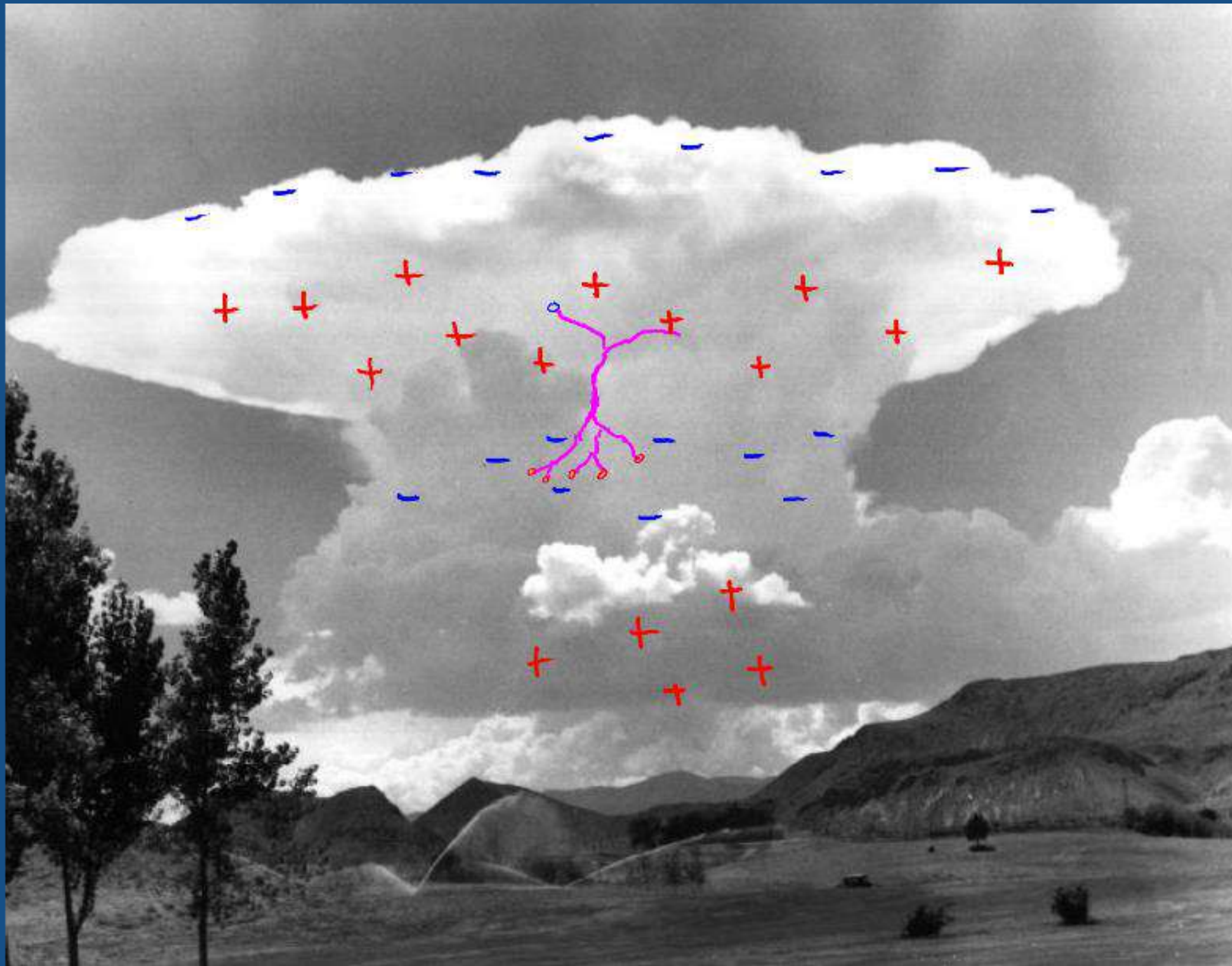


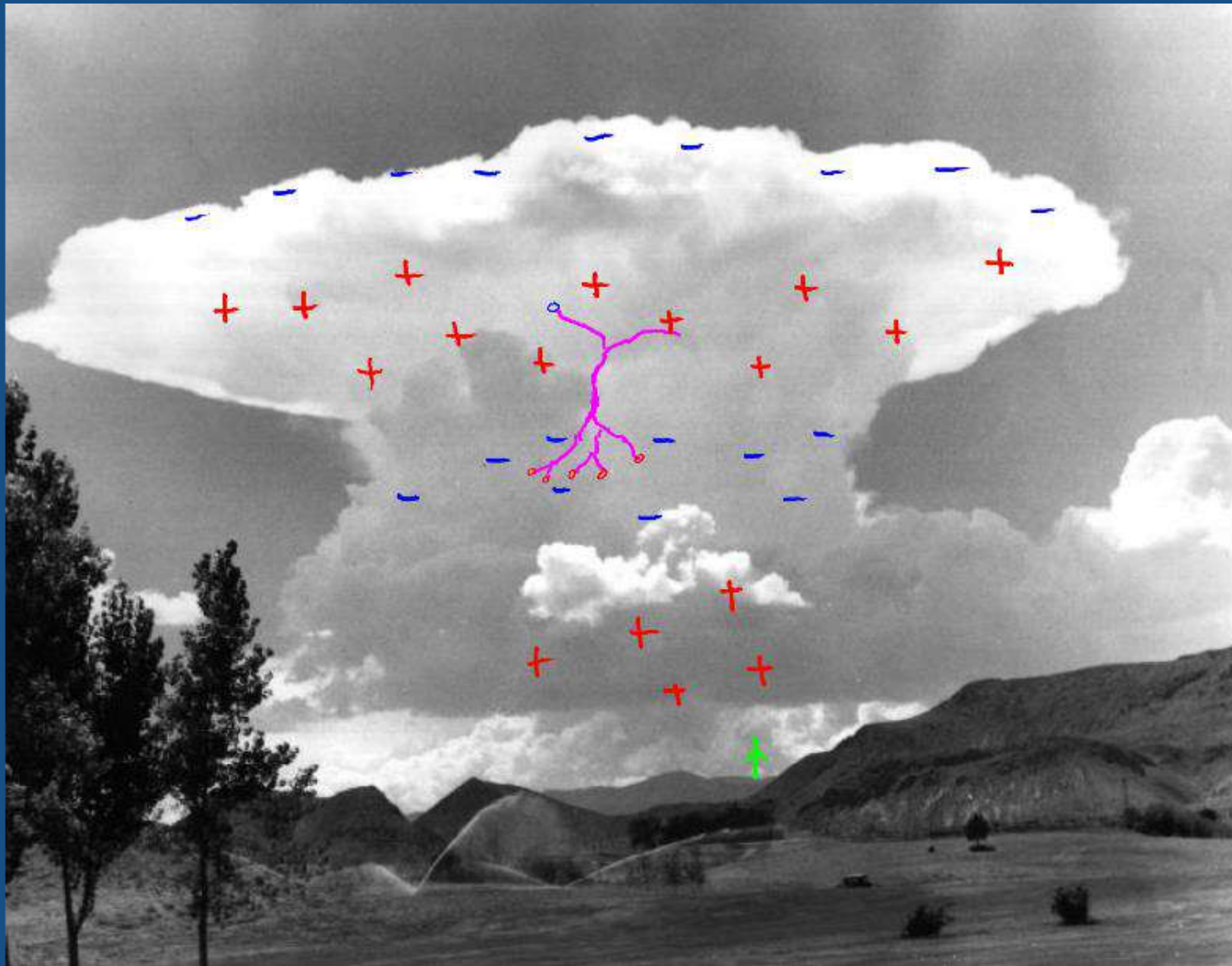


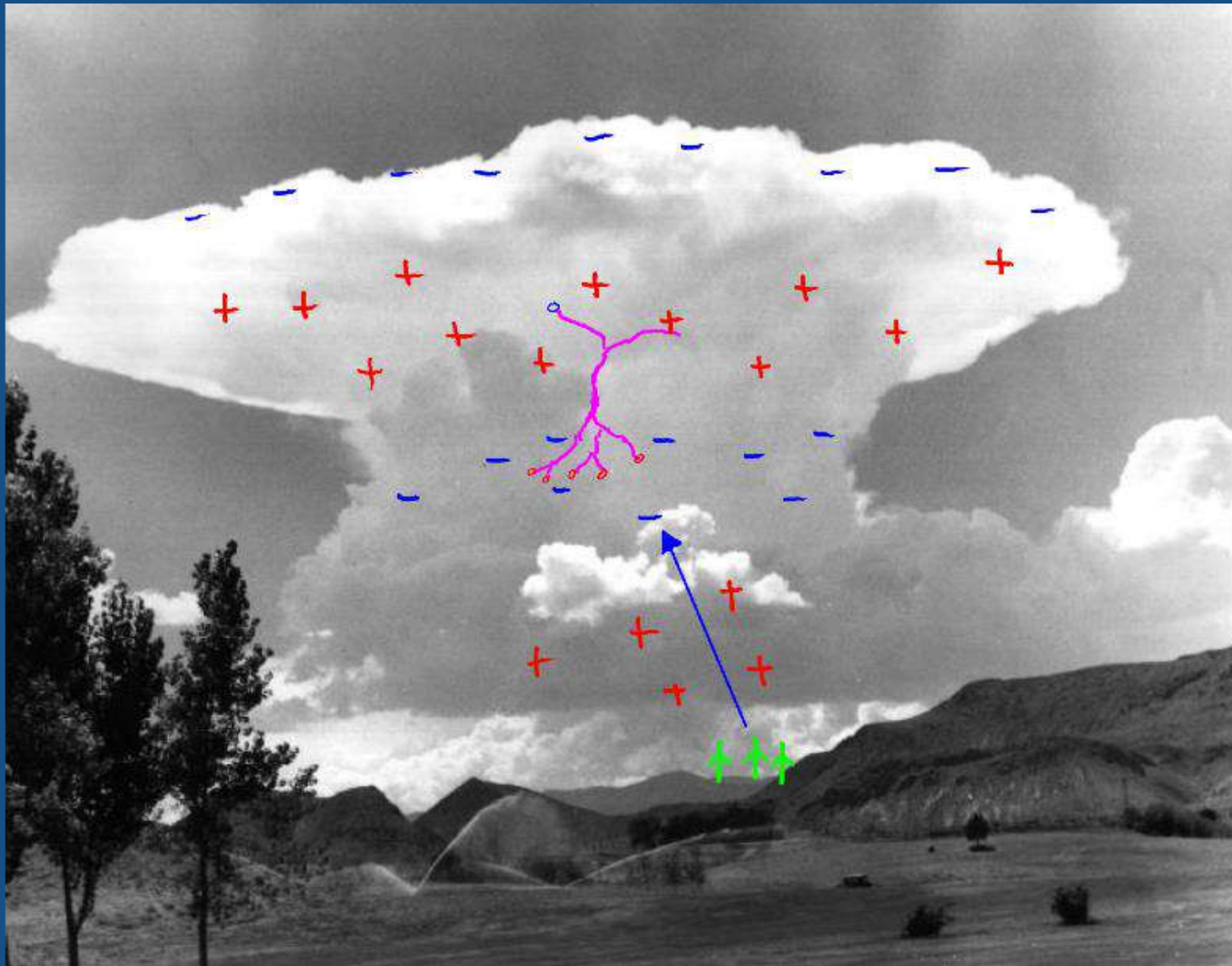




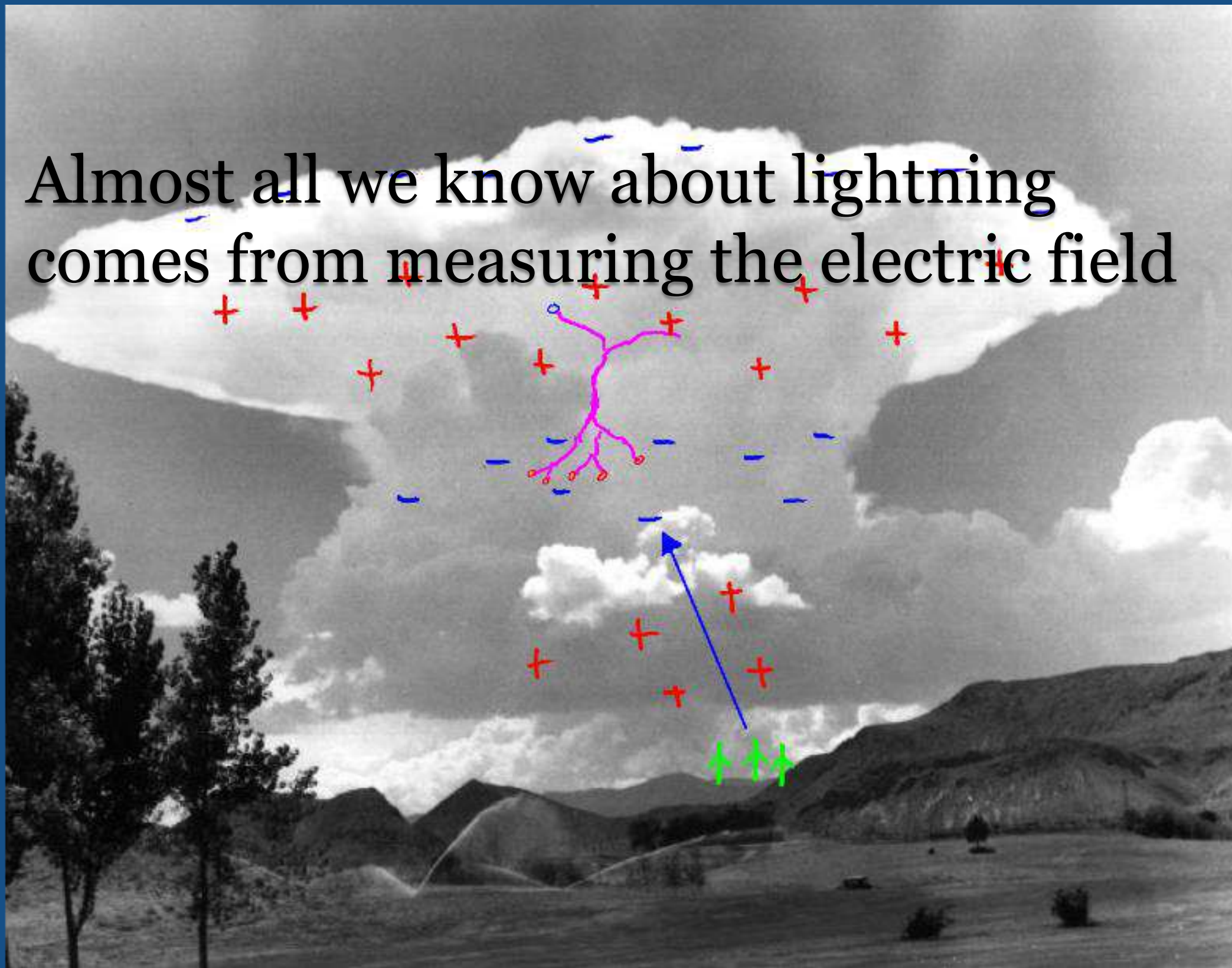


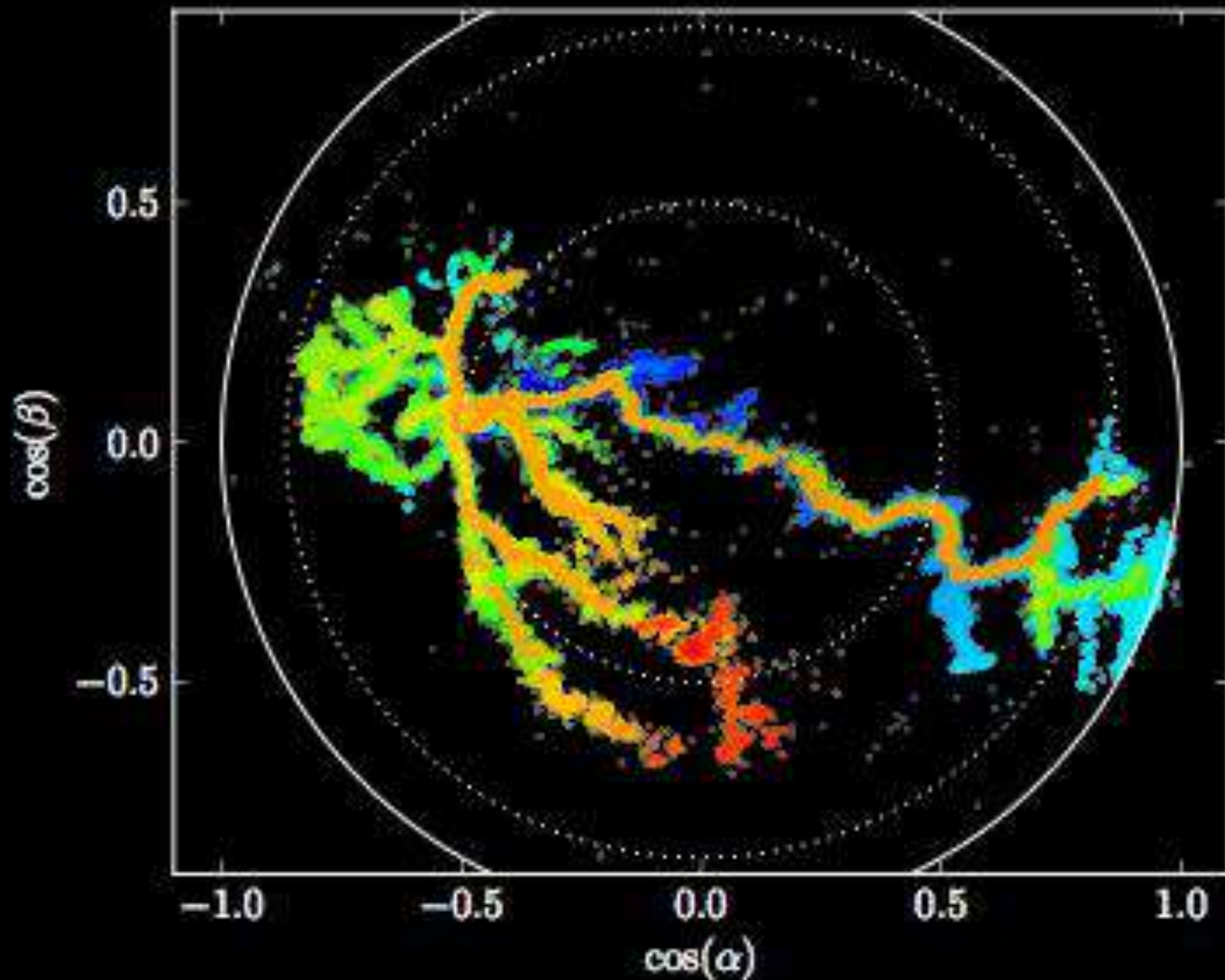






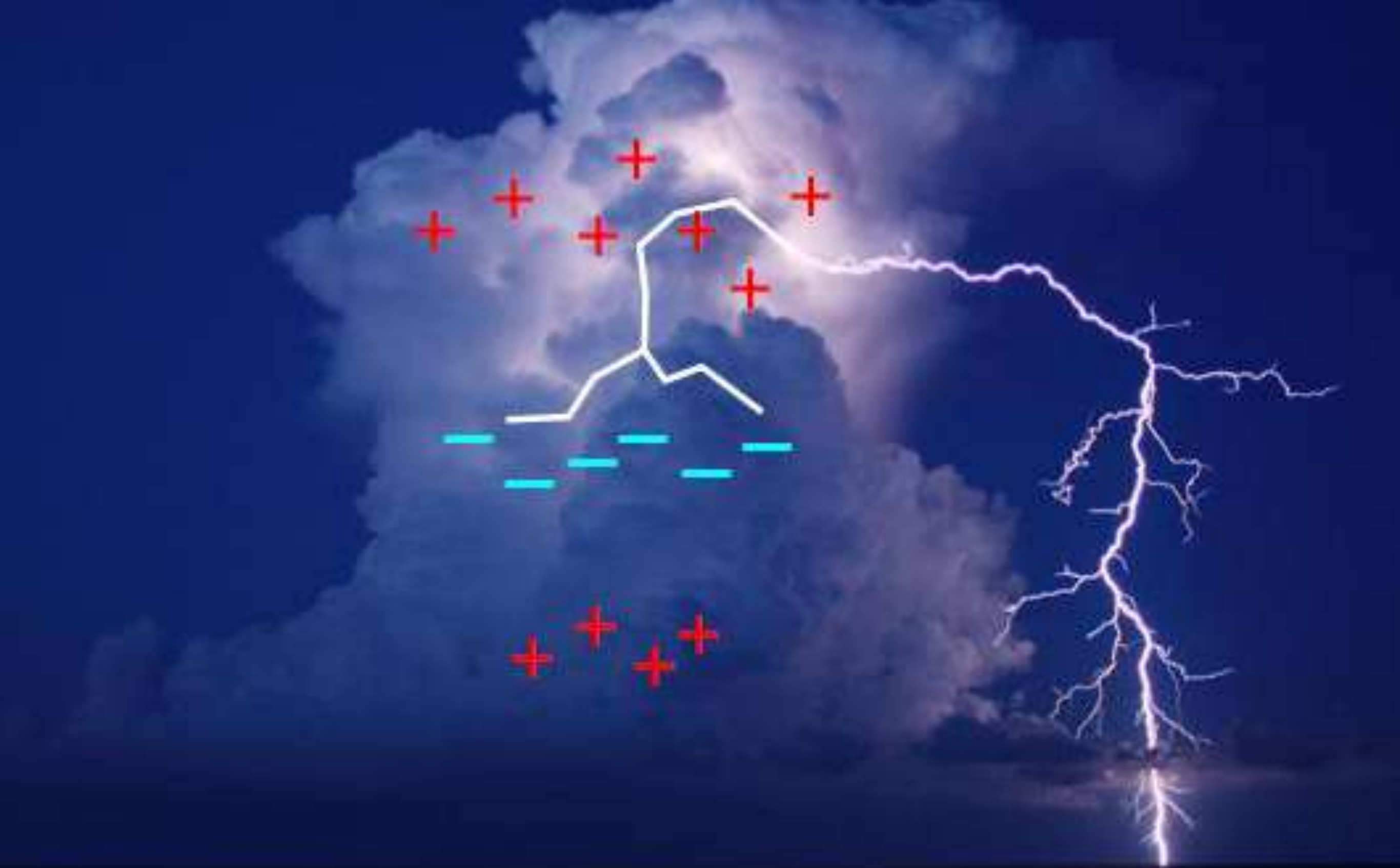
Almost all we know about lightning comes from measuring the electric field



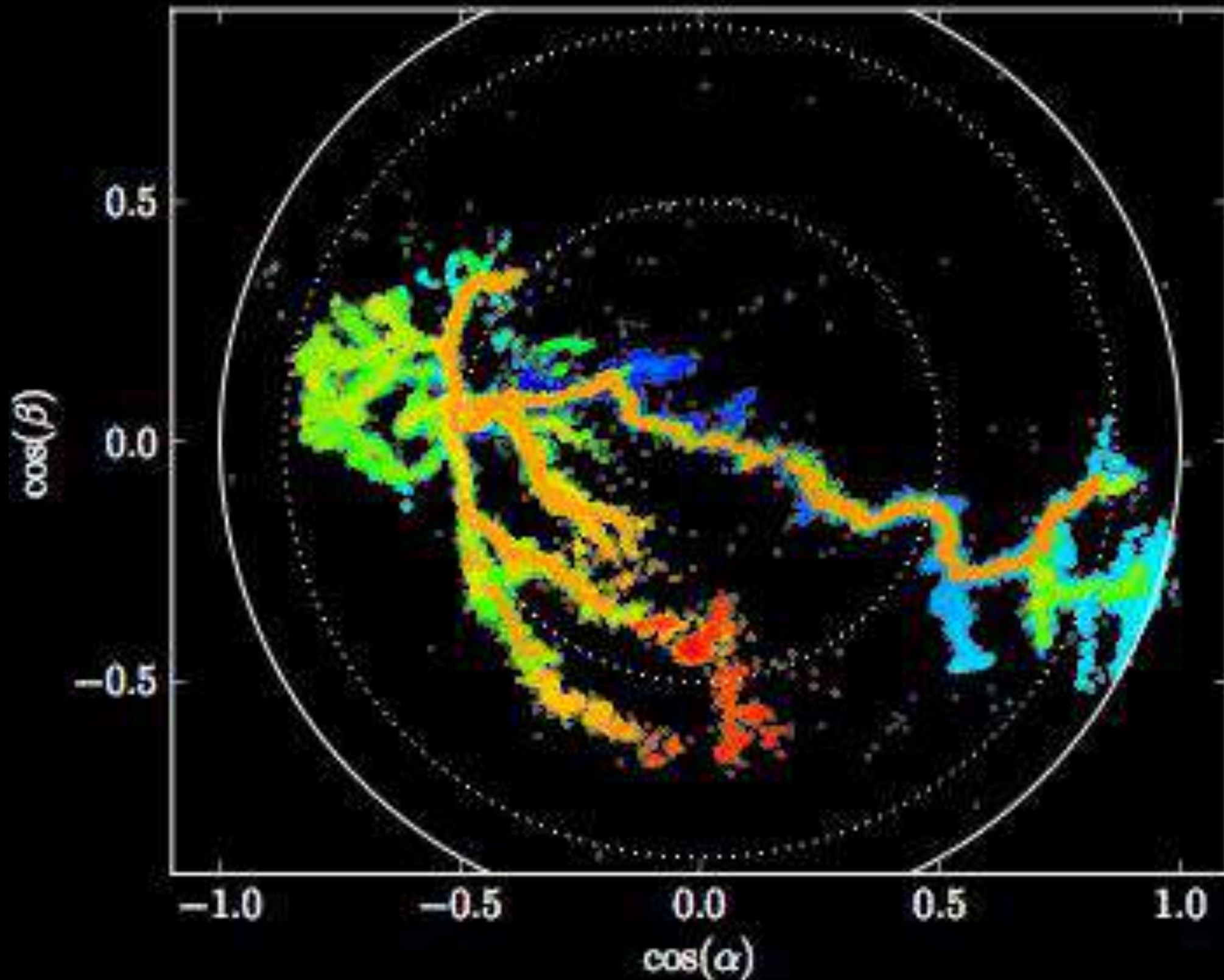


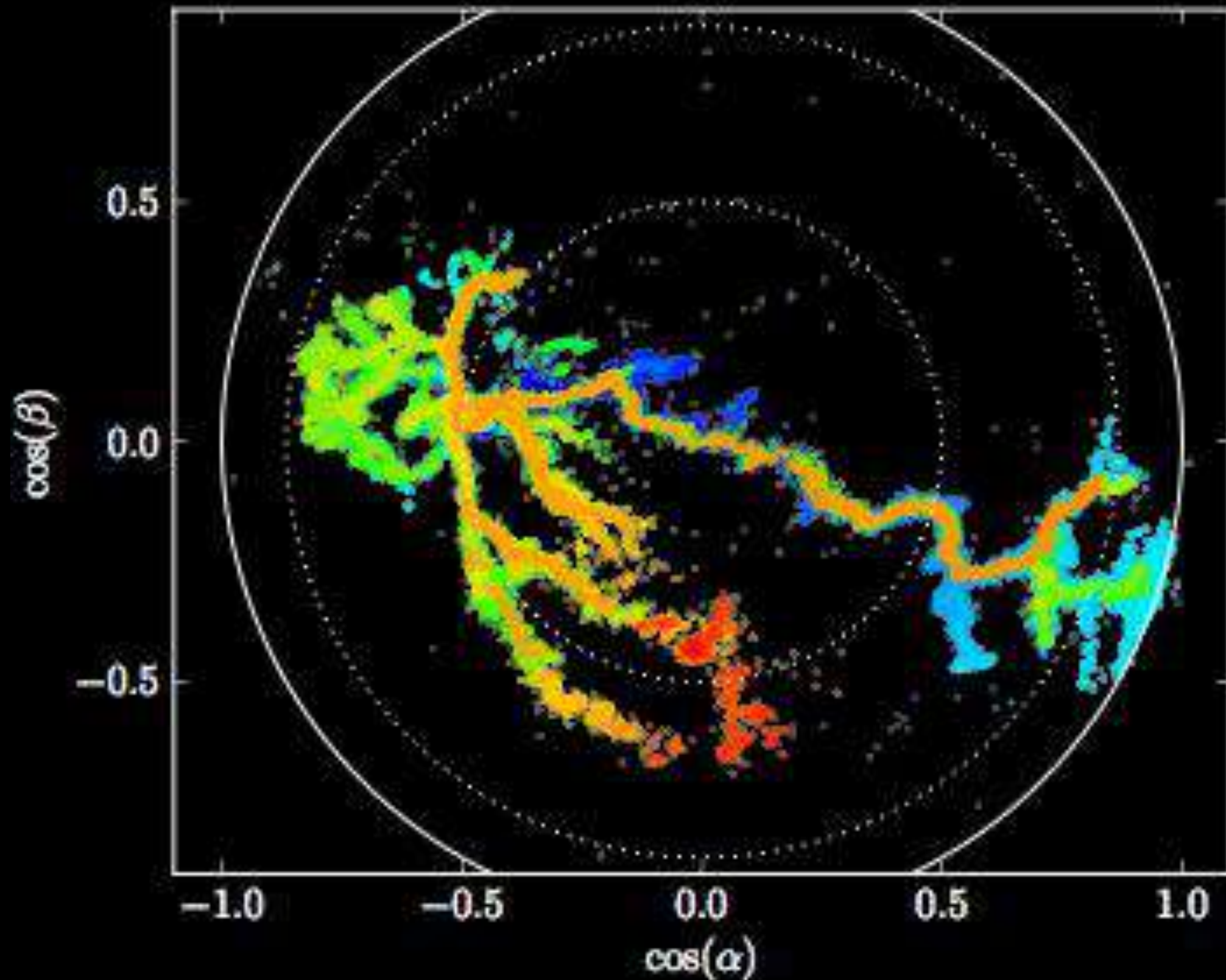


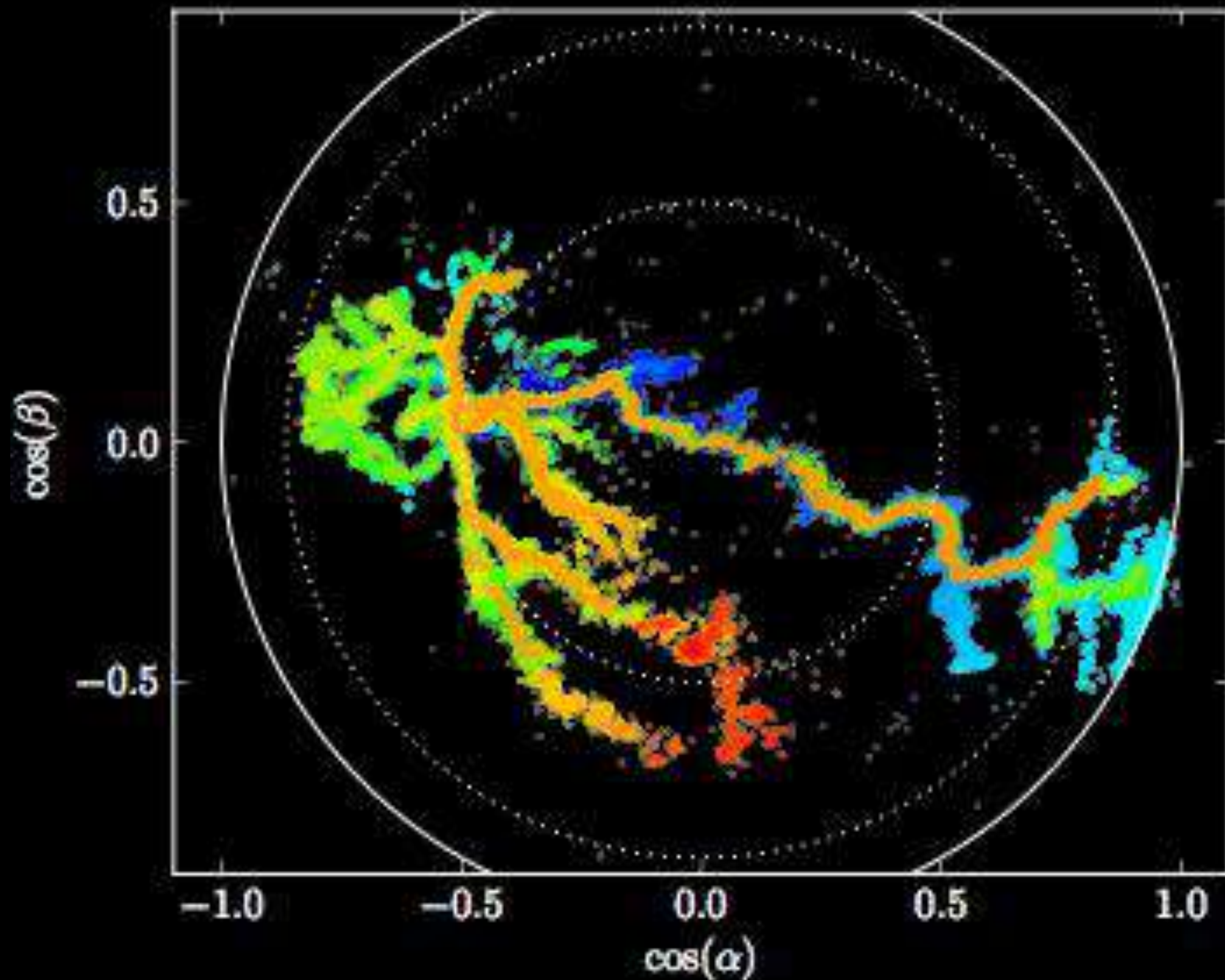
Photograph by Kara Swanson

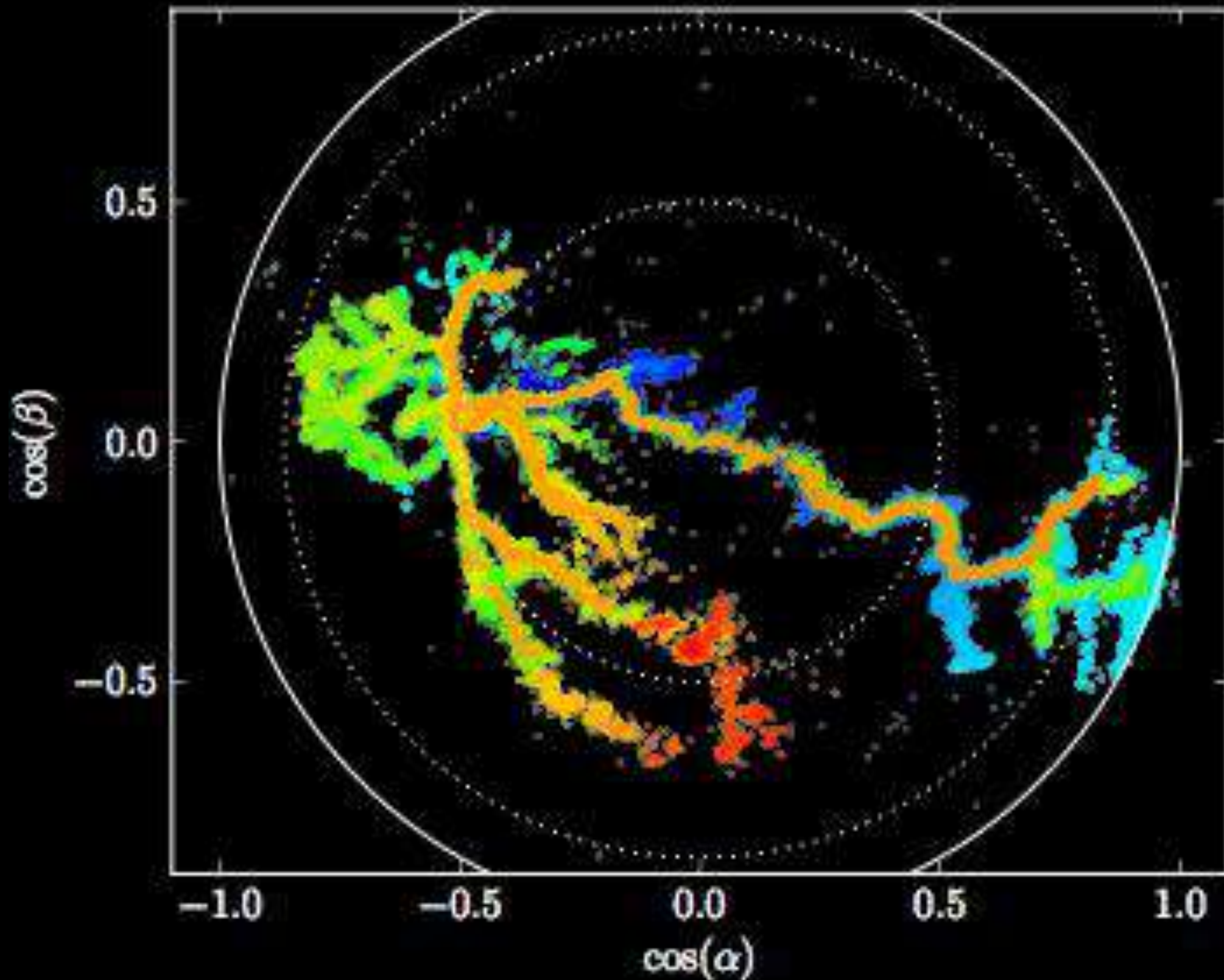


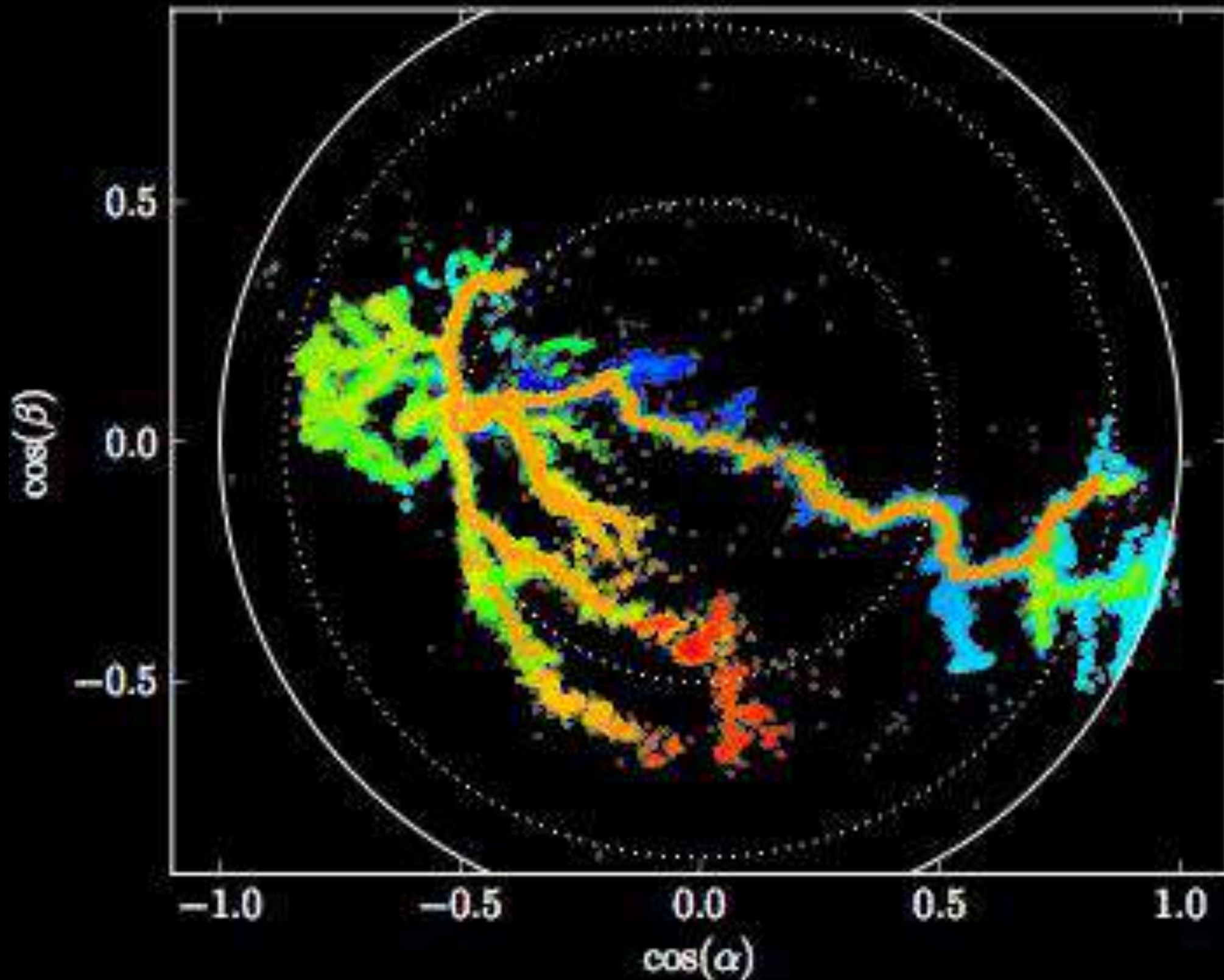
Photograph by Kara Swanson



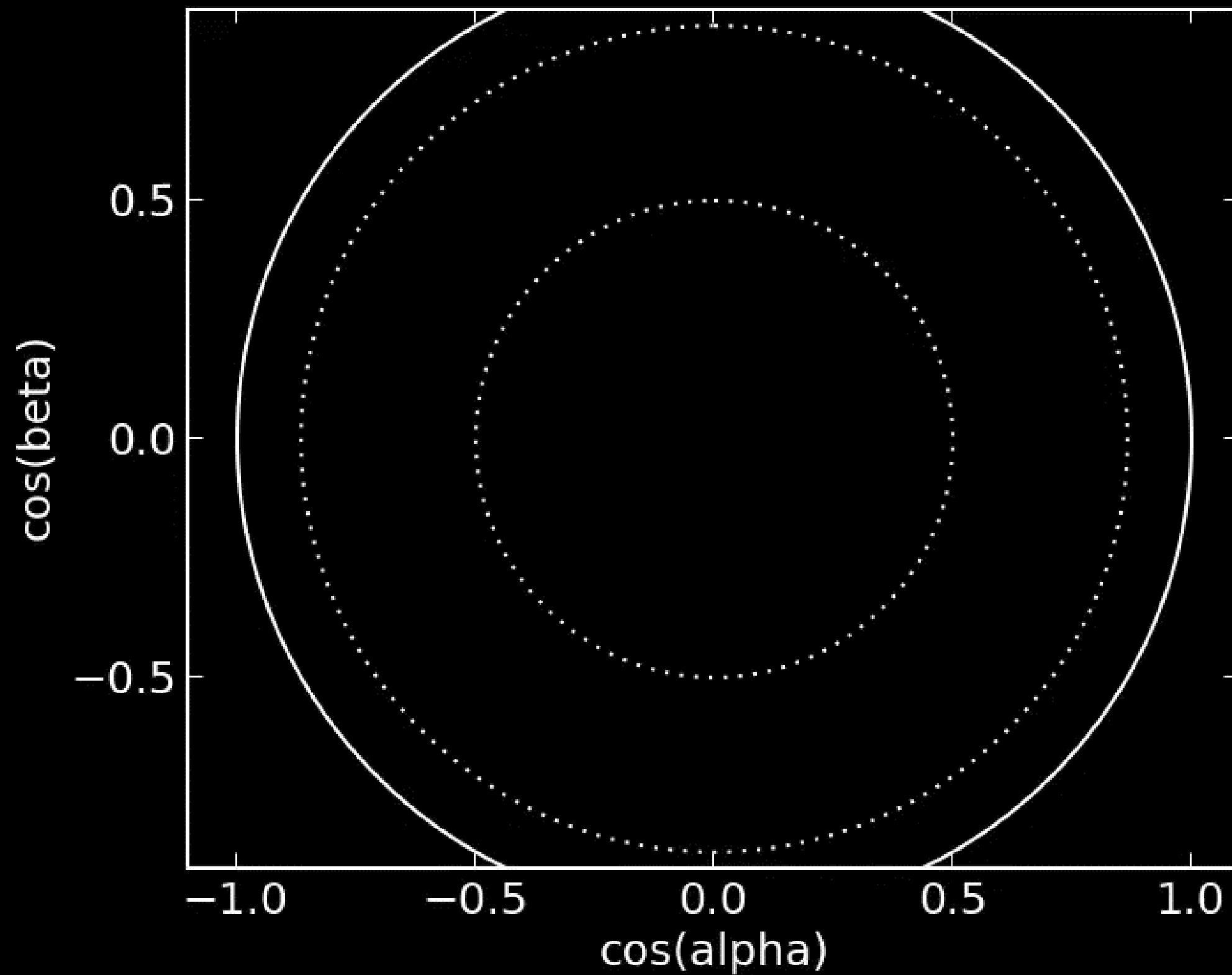




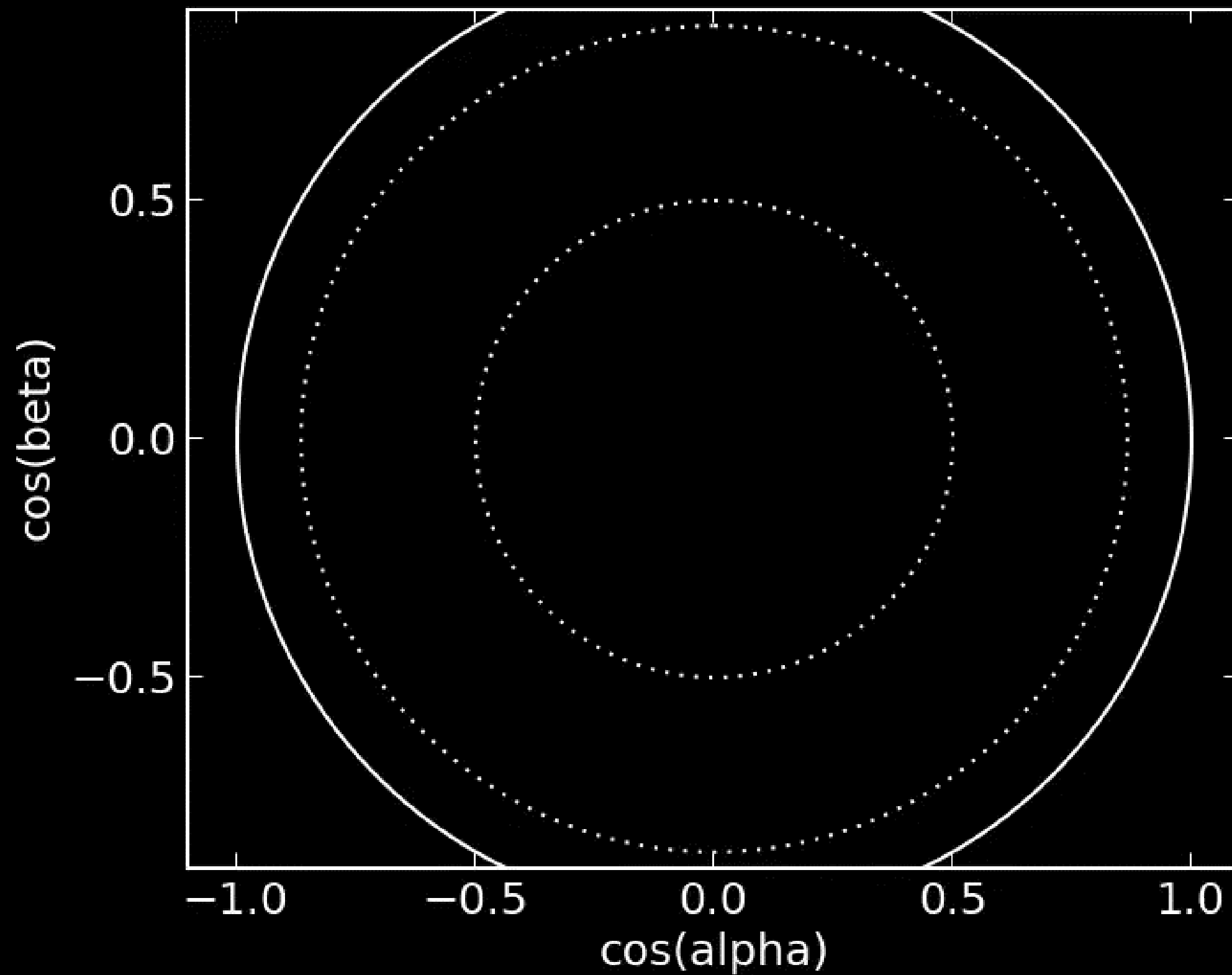


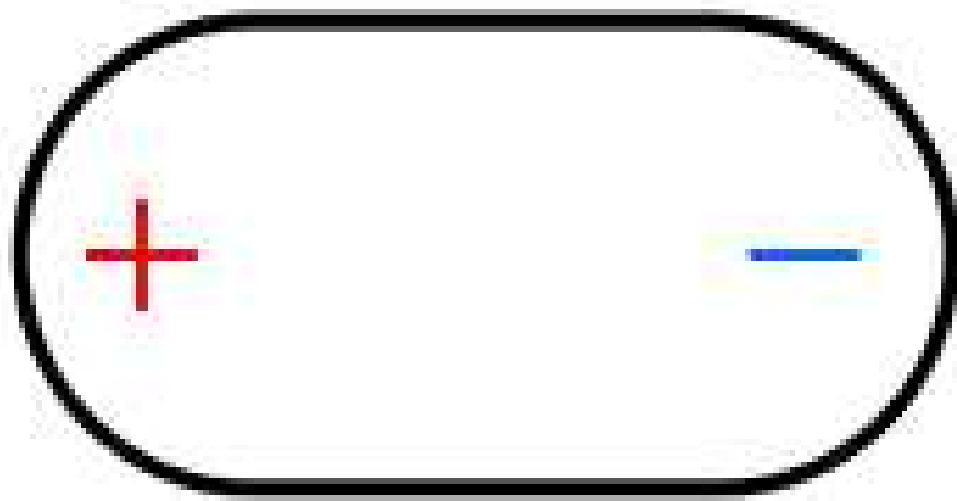


Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
43.300

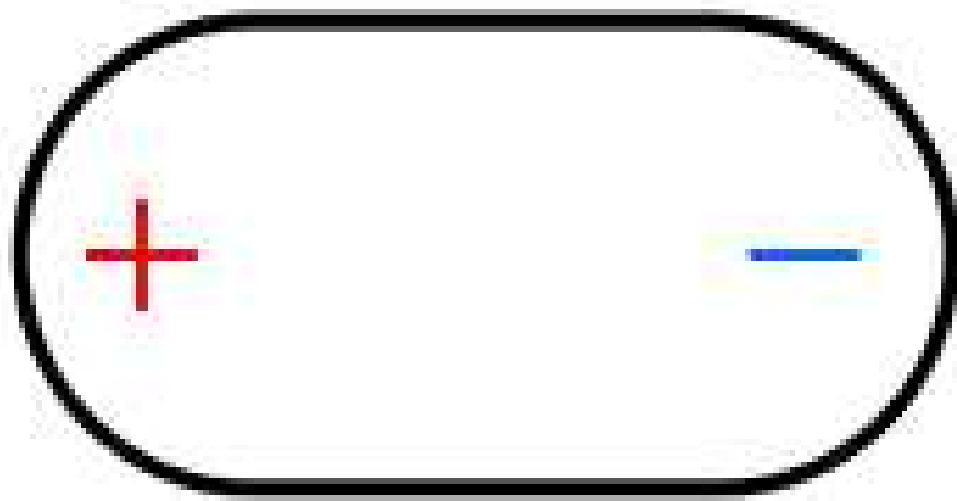


Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
43.300

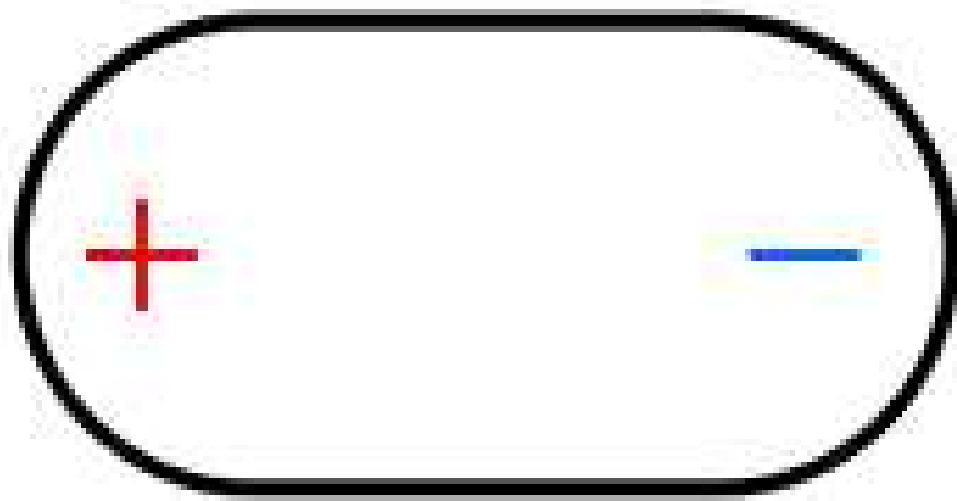








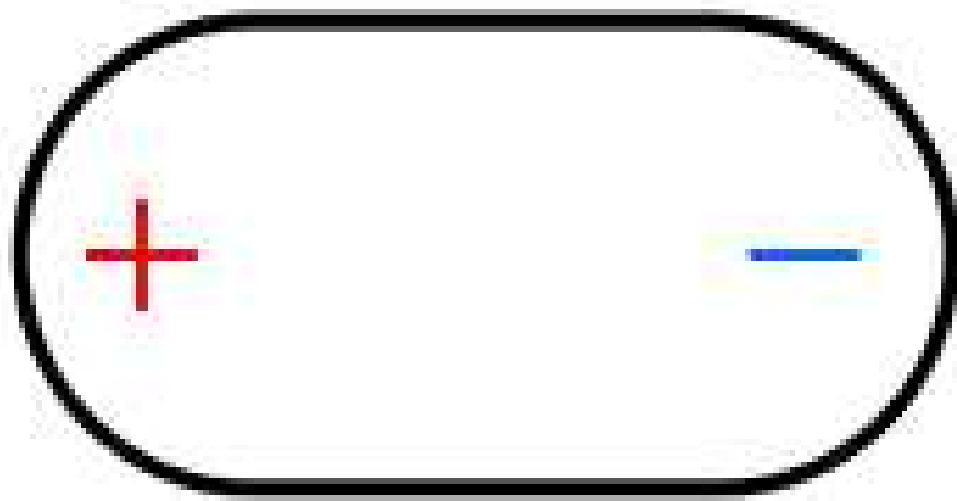




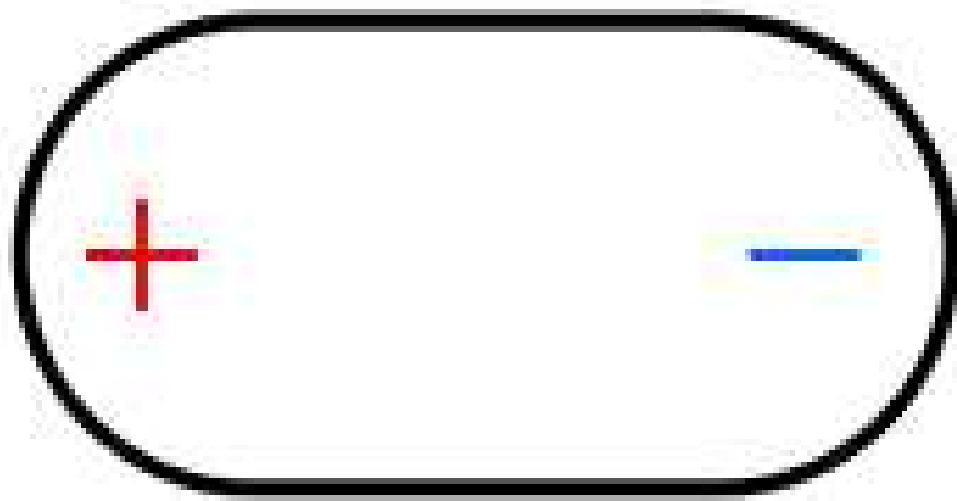
Leader (10,000 K)



Streamer (< 1500 K)



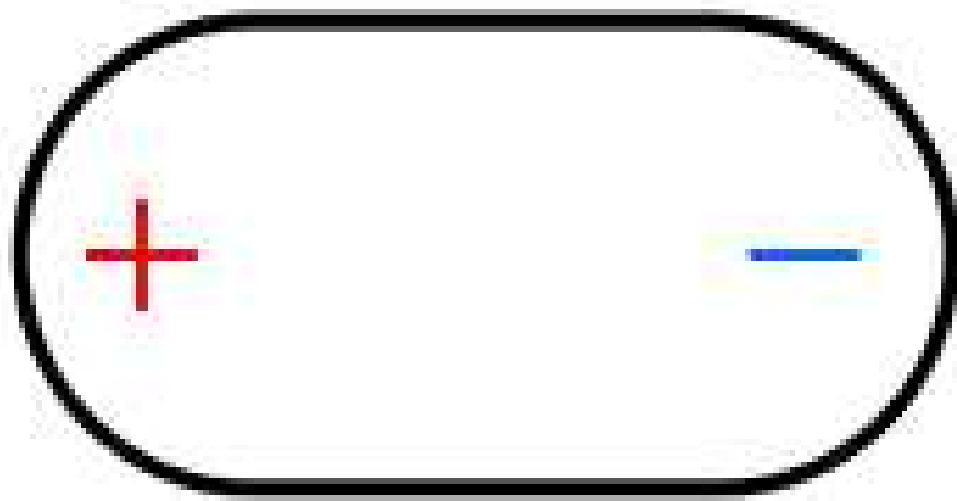












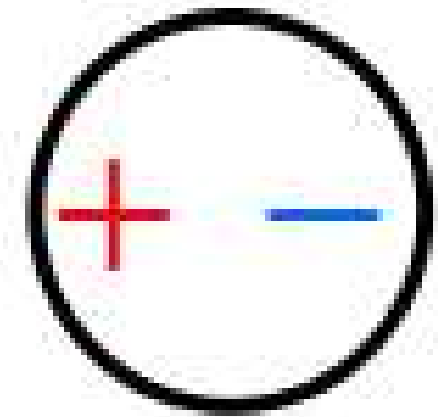




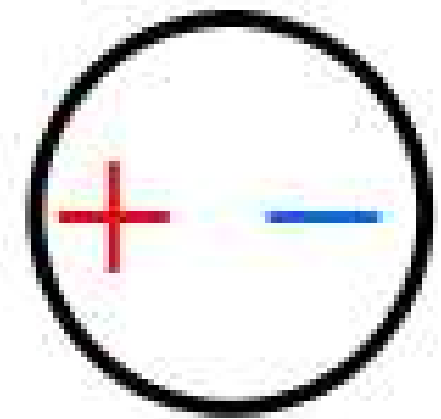


Faint

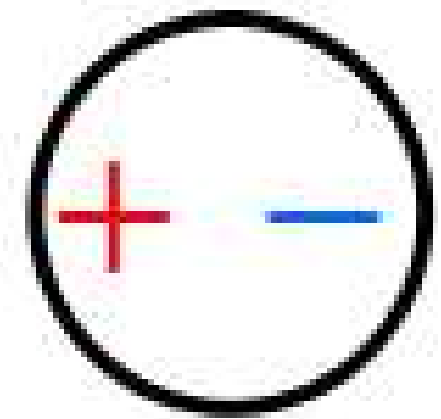
Space Stem



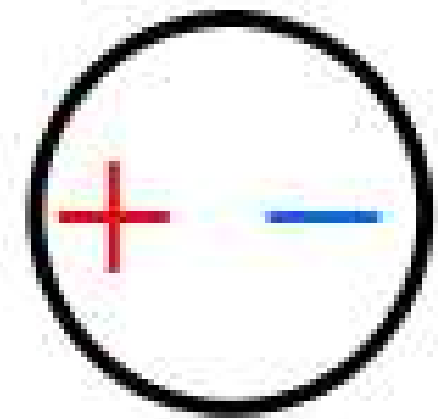
Faint



Faint



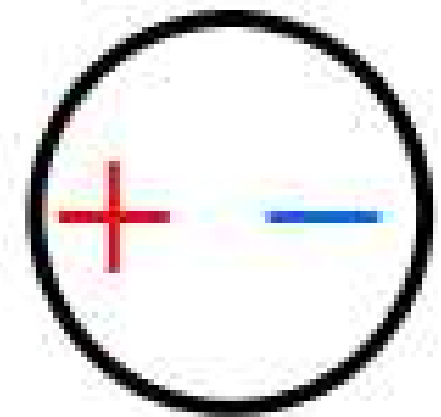
Faint



Faint

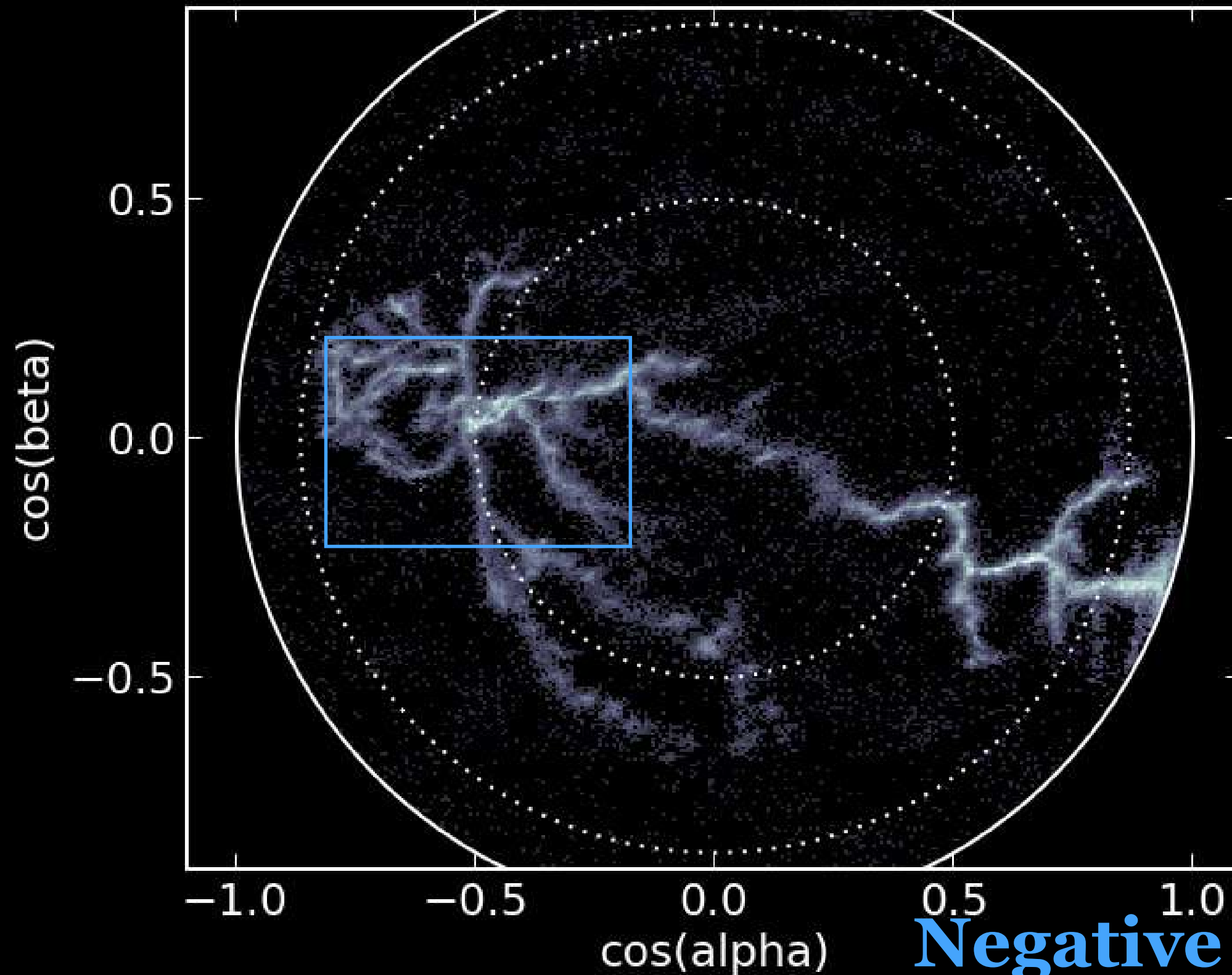


Bright



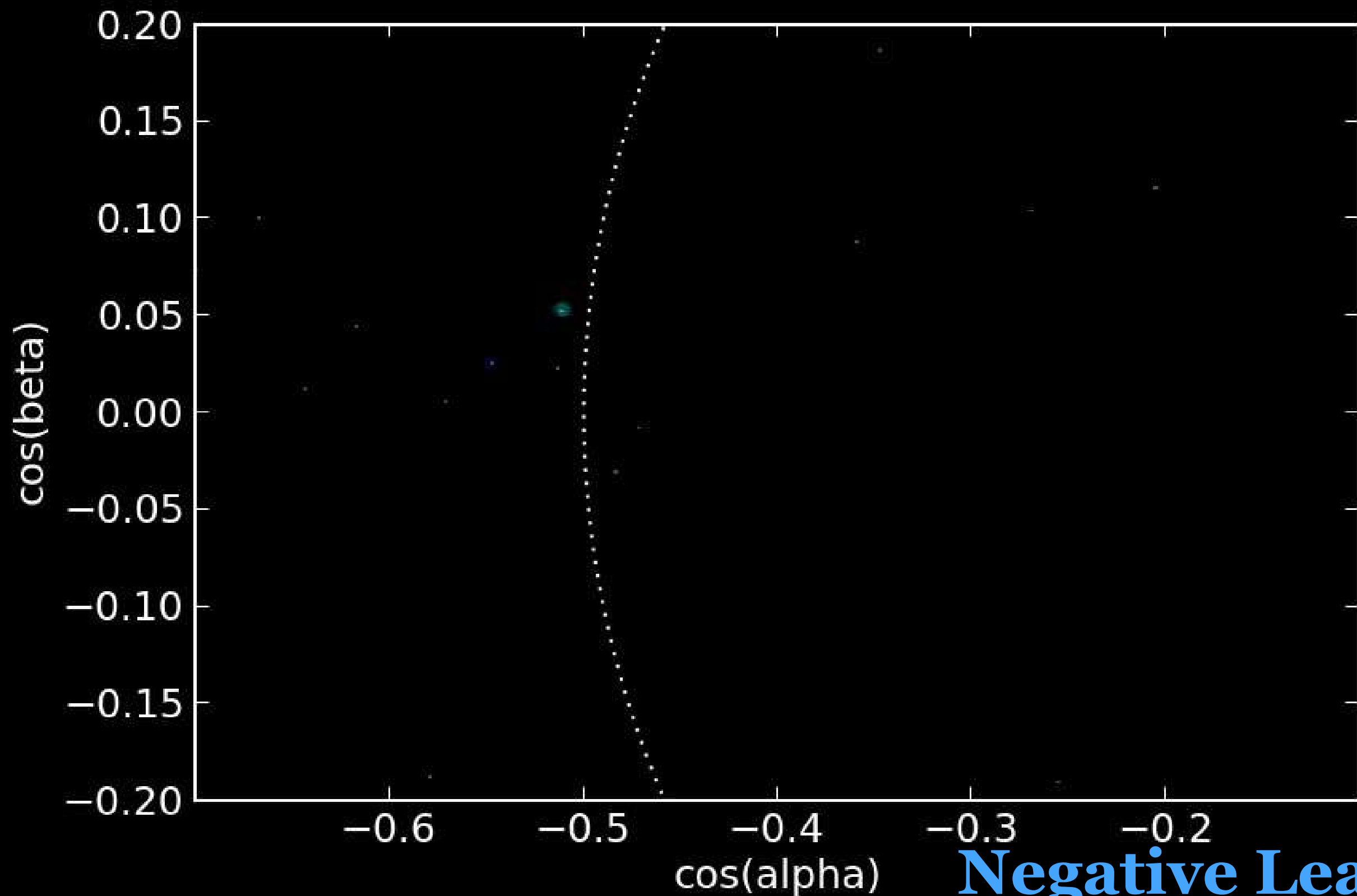
Faint

Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
406.800

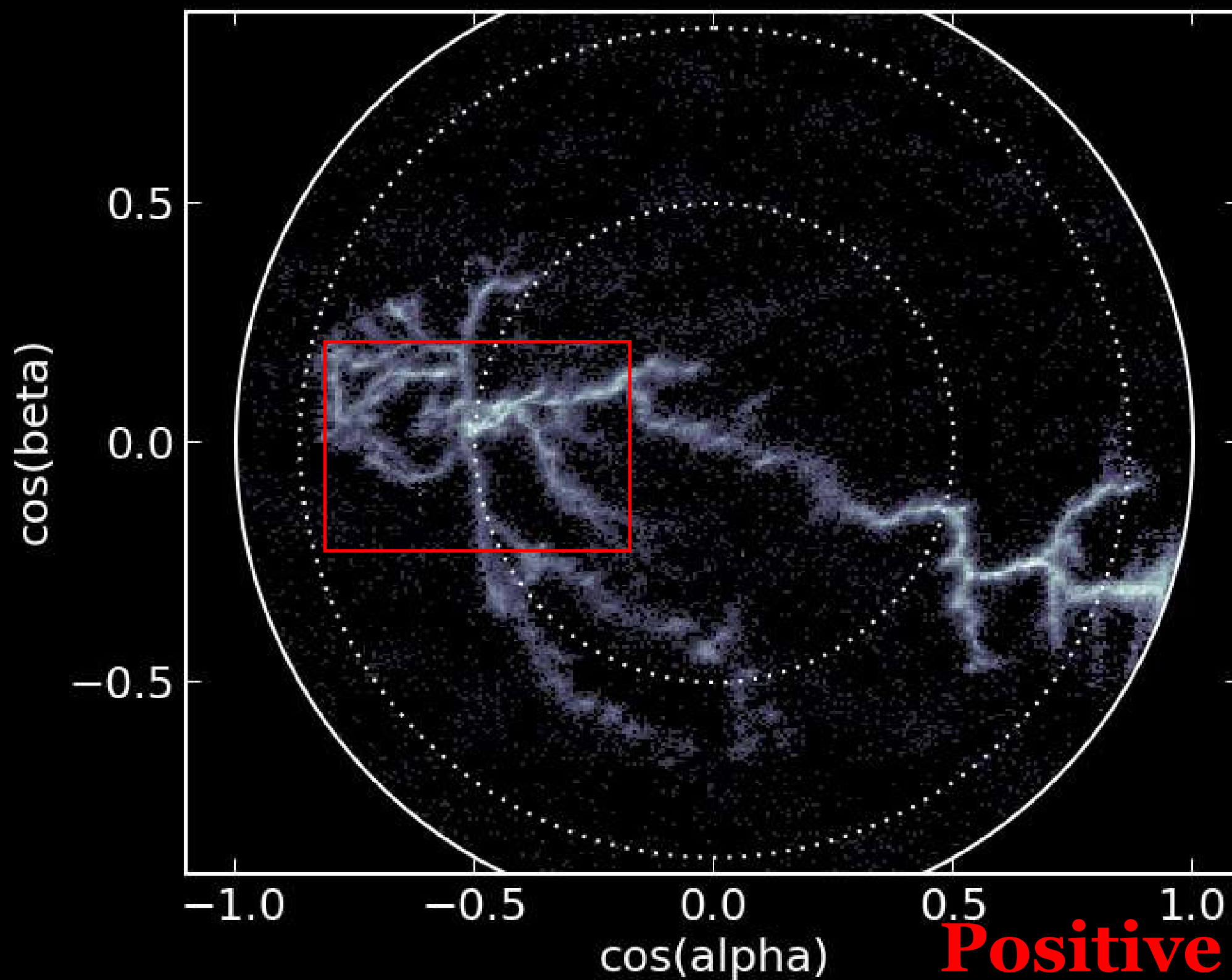


Negative Leader

Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 40000 fps
54.000

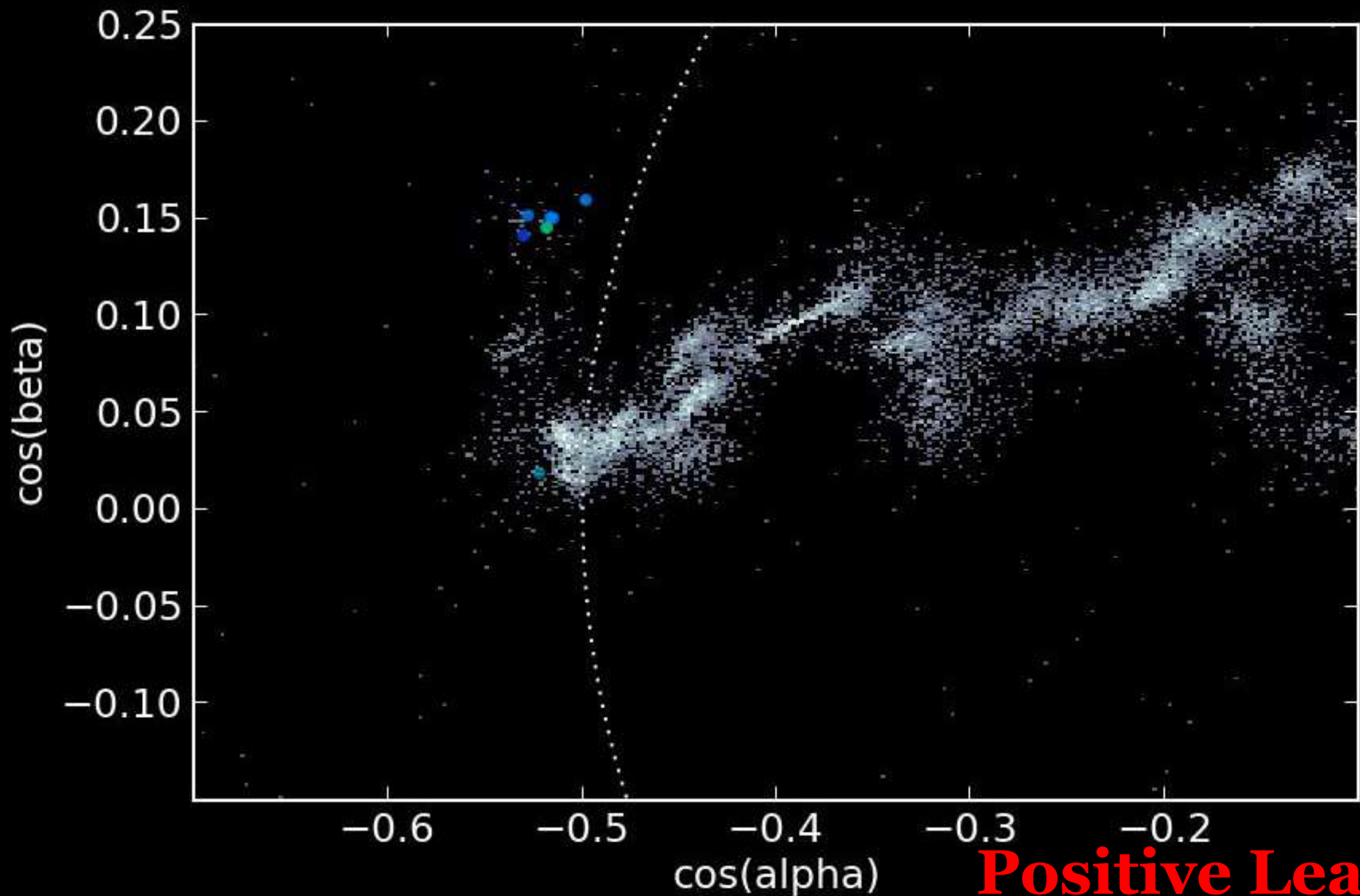


Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 4000 fps
406.800



Positive Leader

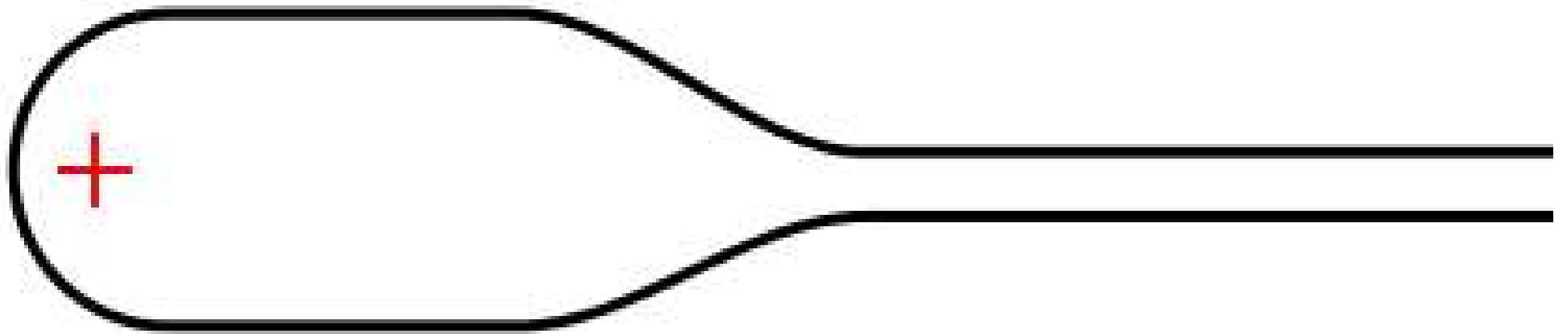
Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 20000 fps
100.000

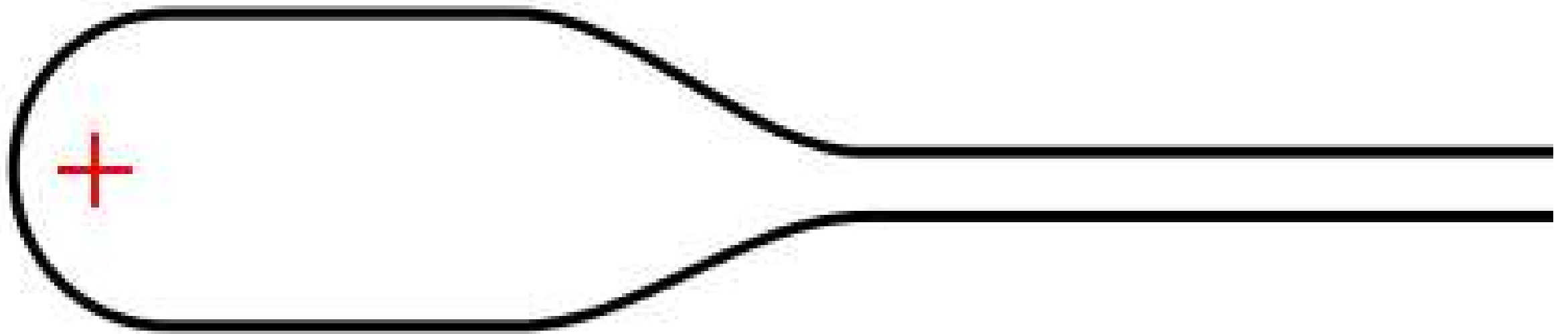


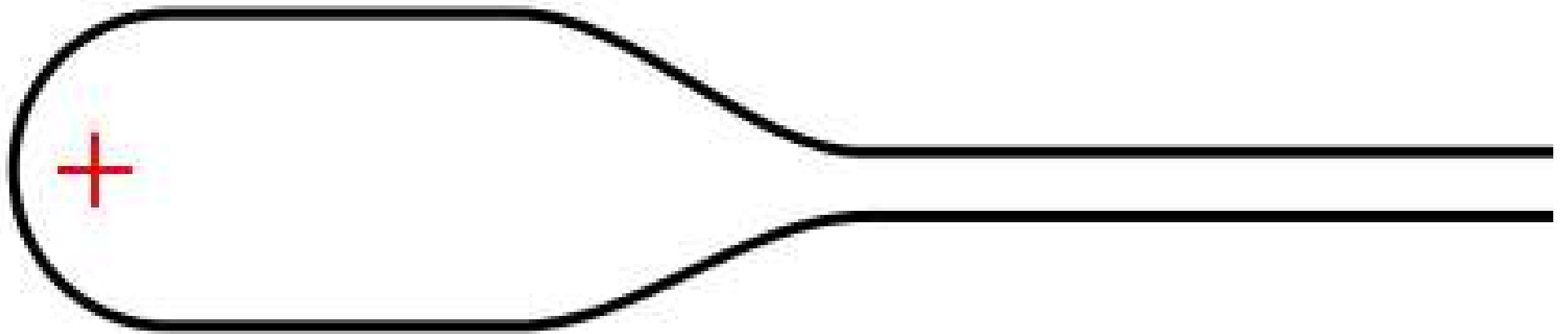
Positive Leader

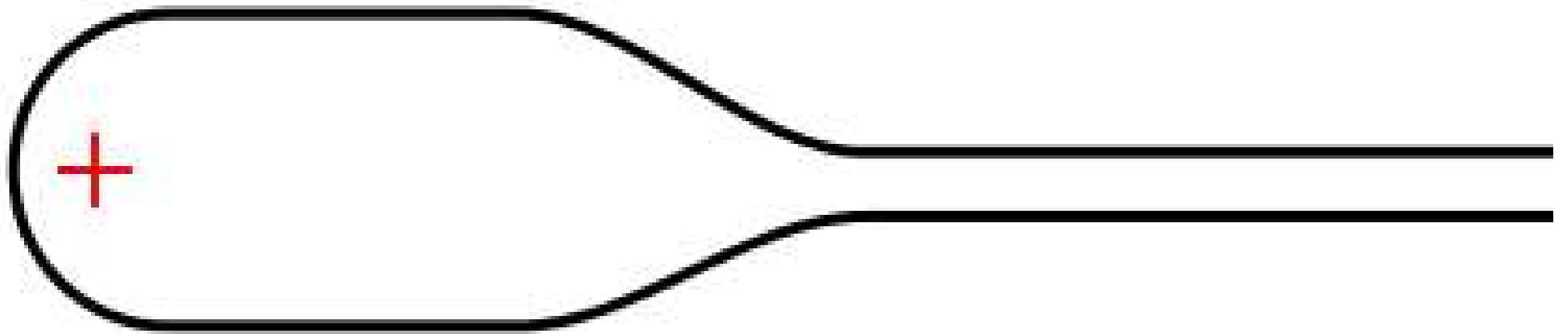
Recoil Leader?

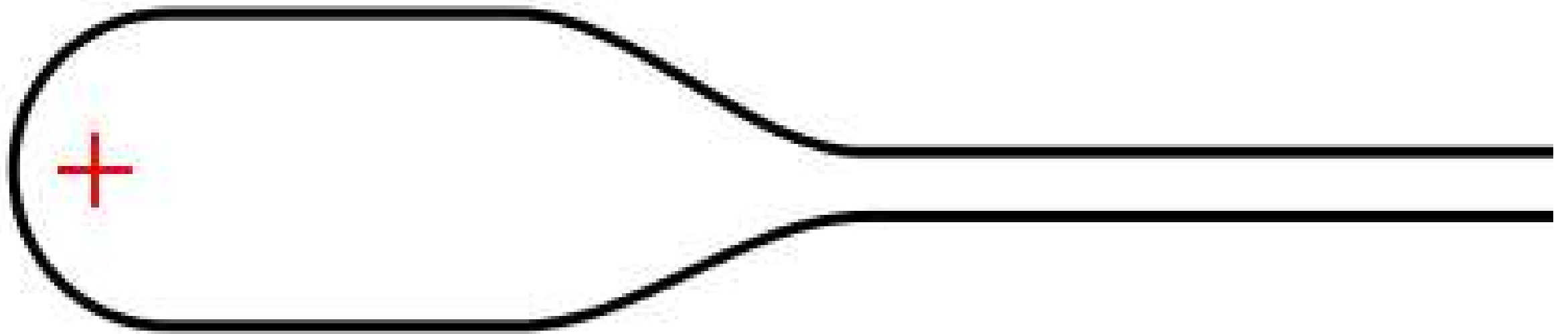


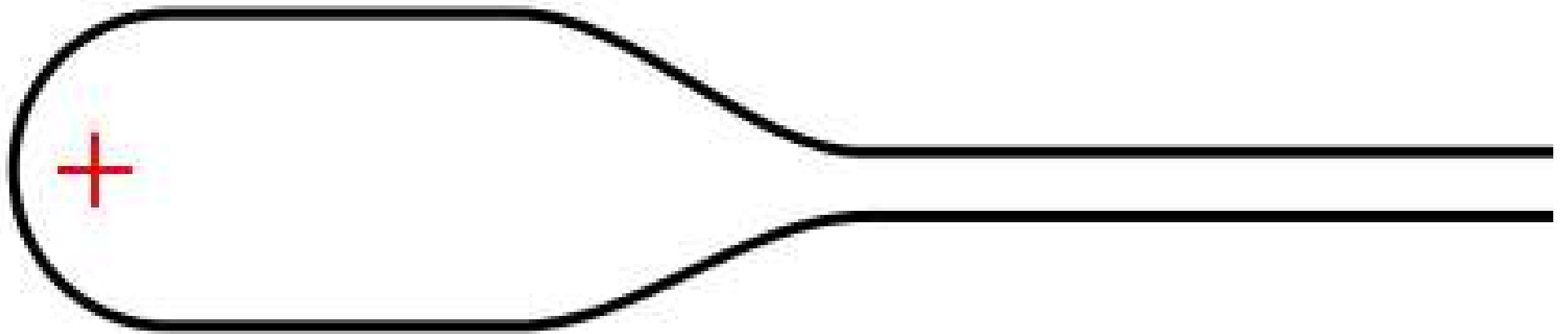


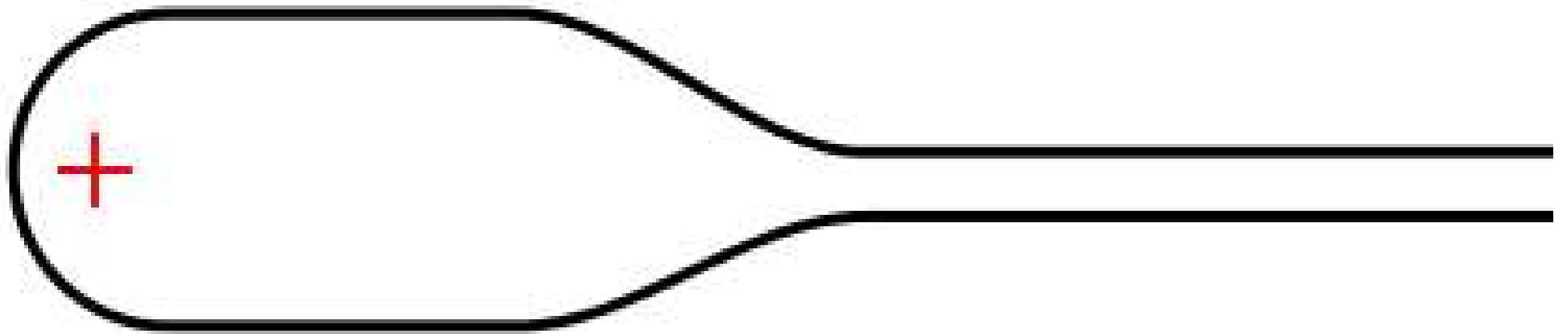


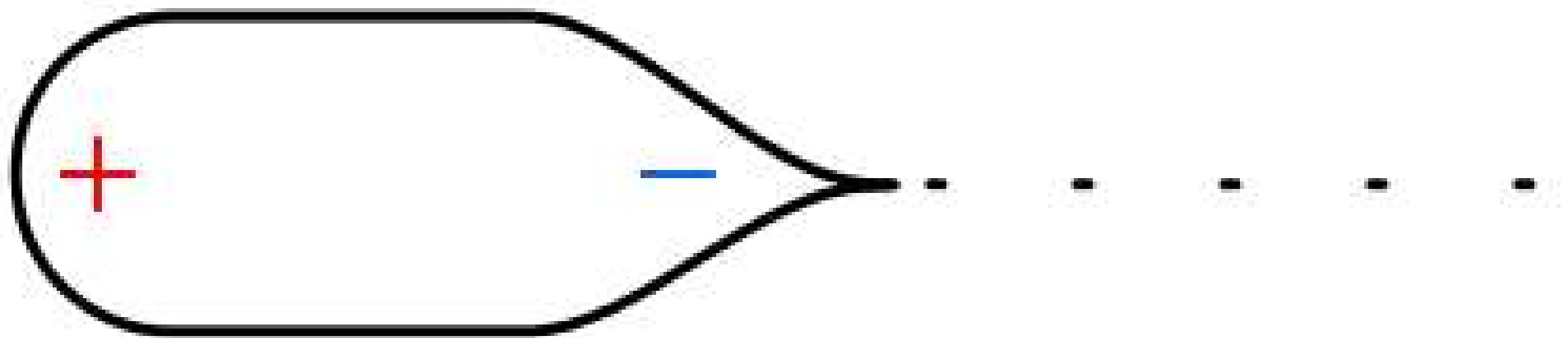


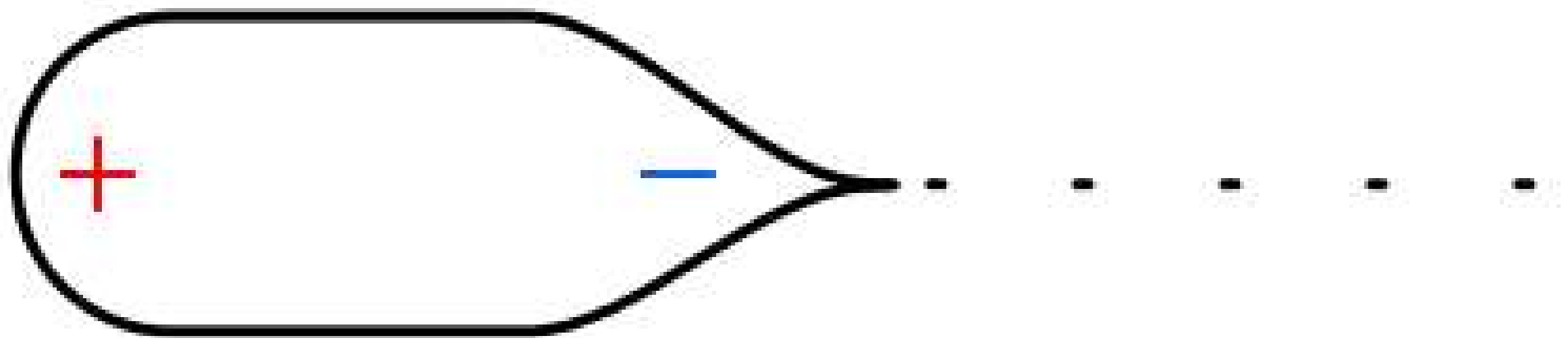


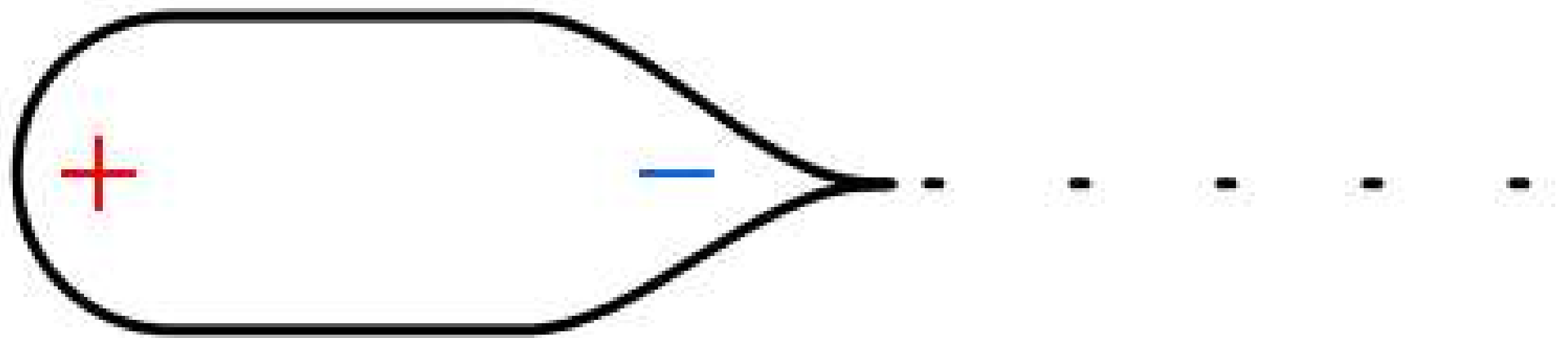


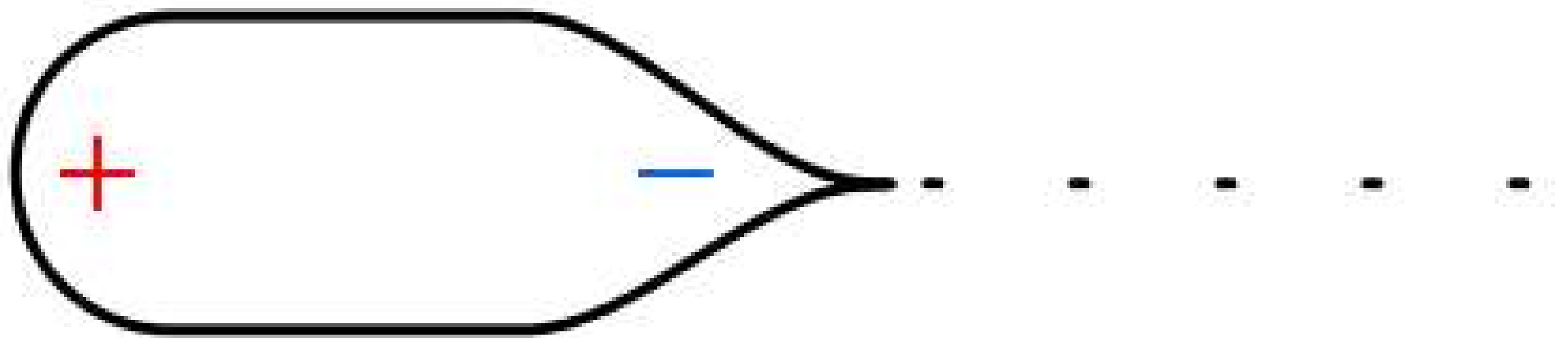




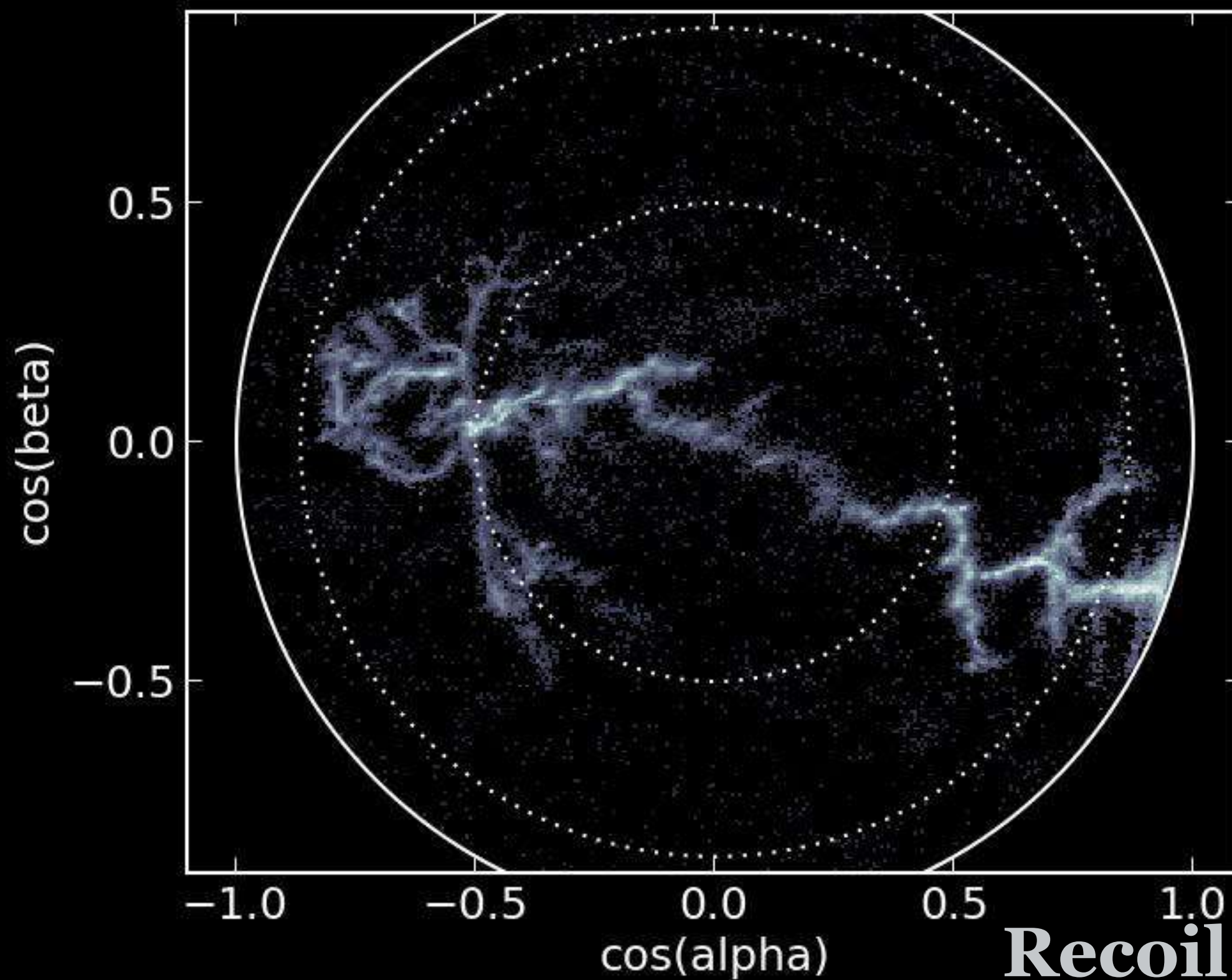






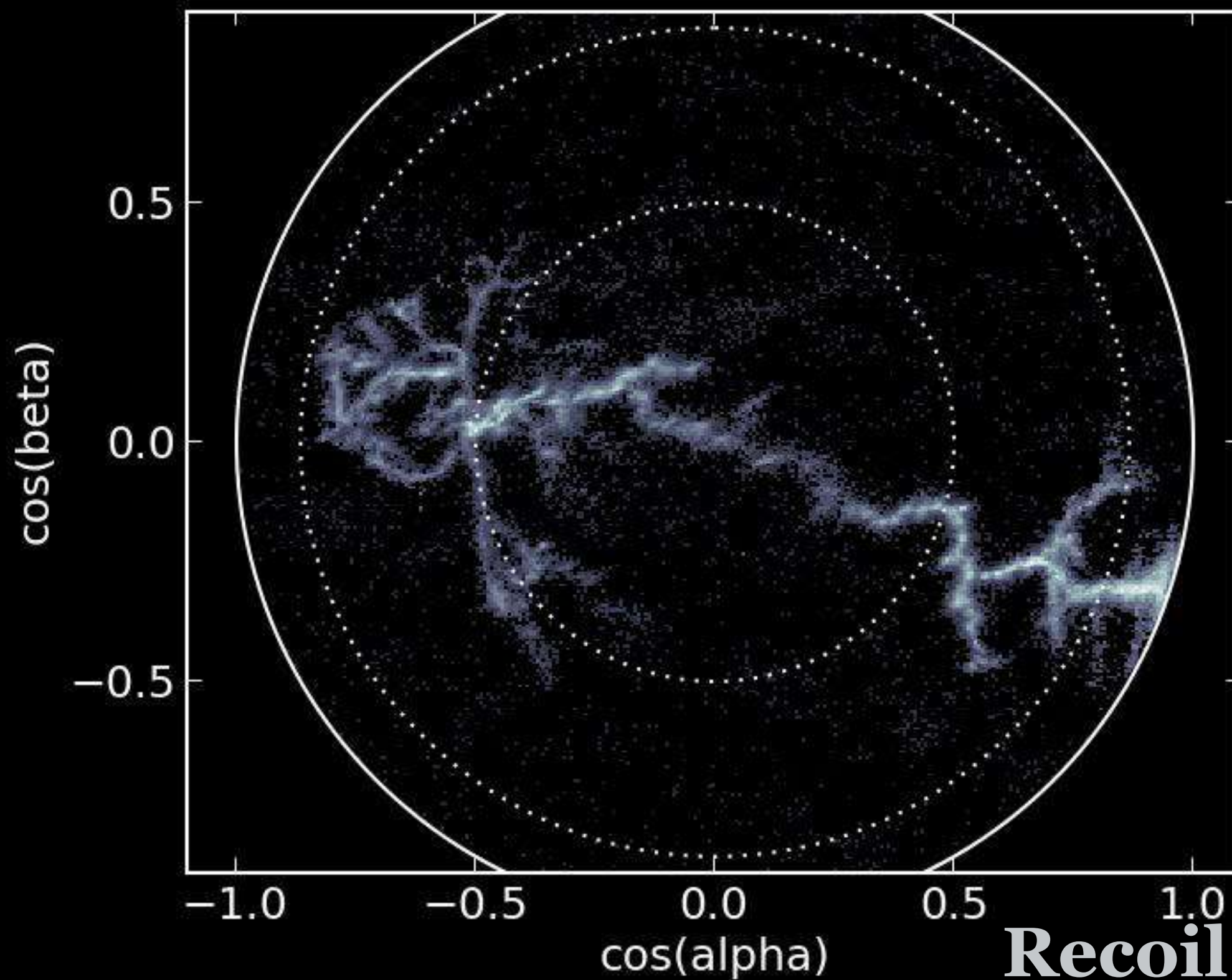


Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 200000 fps
262.400



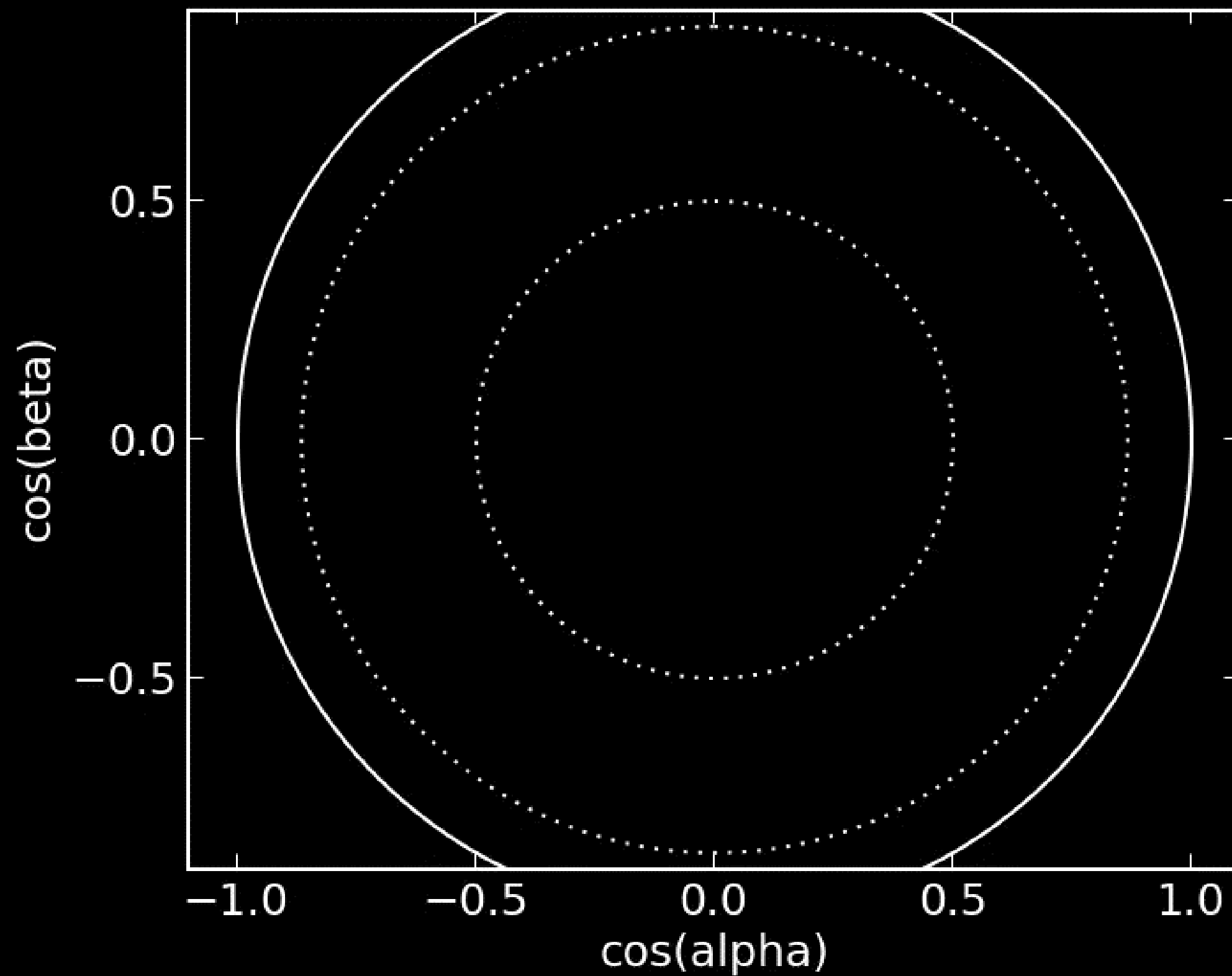
Recoil Leader

Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 200000 fps
262.400



Recoil Leader

Flash at 2013/07/08 20:09:01.143378 UT
Frame Rate: 6250 fps
43.300

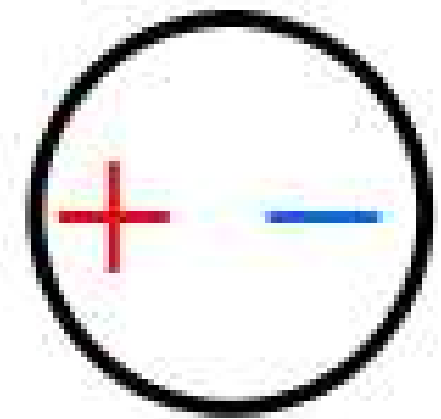




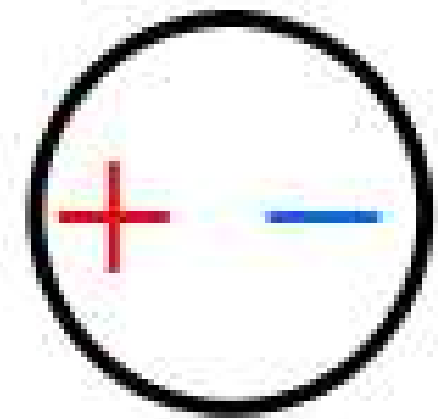






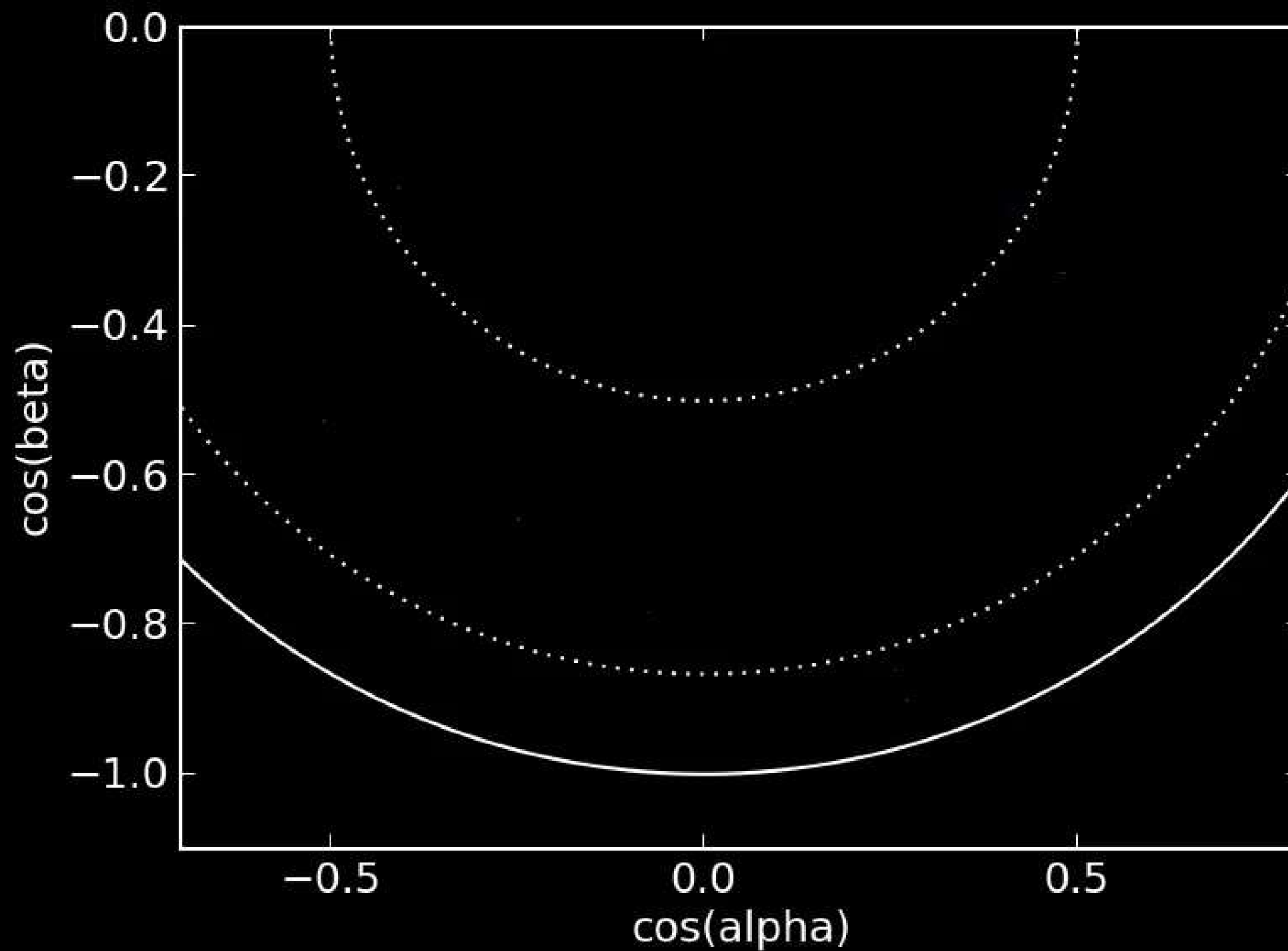


Faint



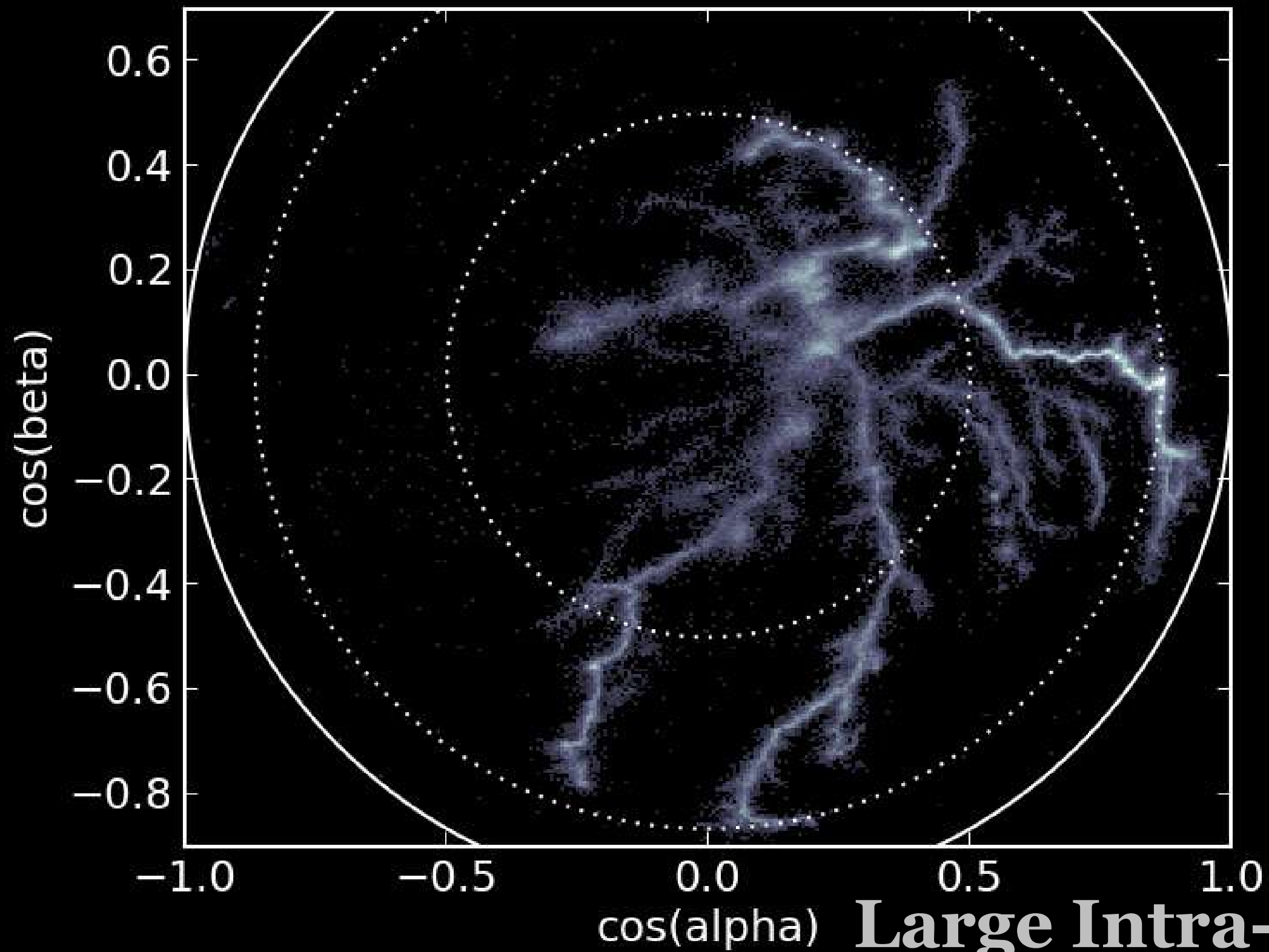
Faint

Flash at 2013/07/24 21:32:07.881056 UT
Frame Rate: 6250 fps
190.000



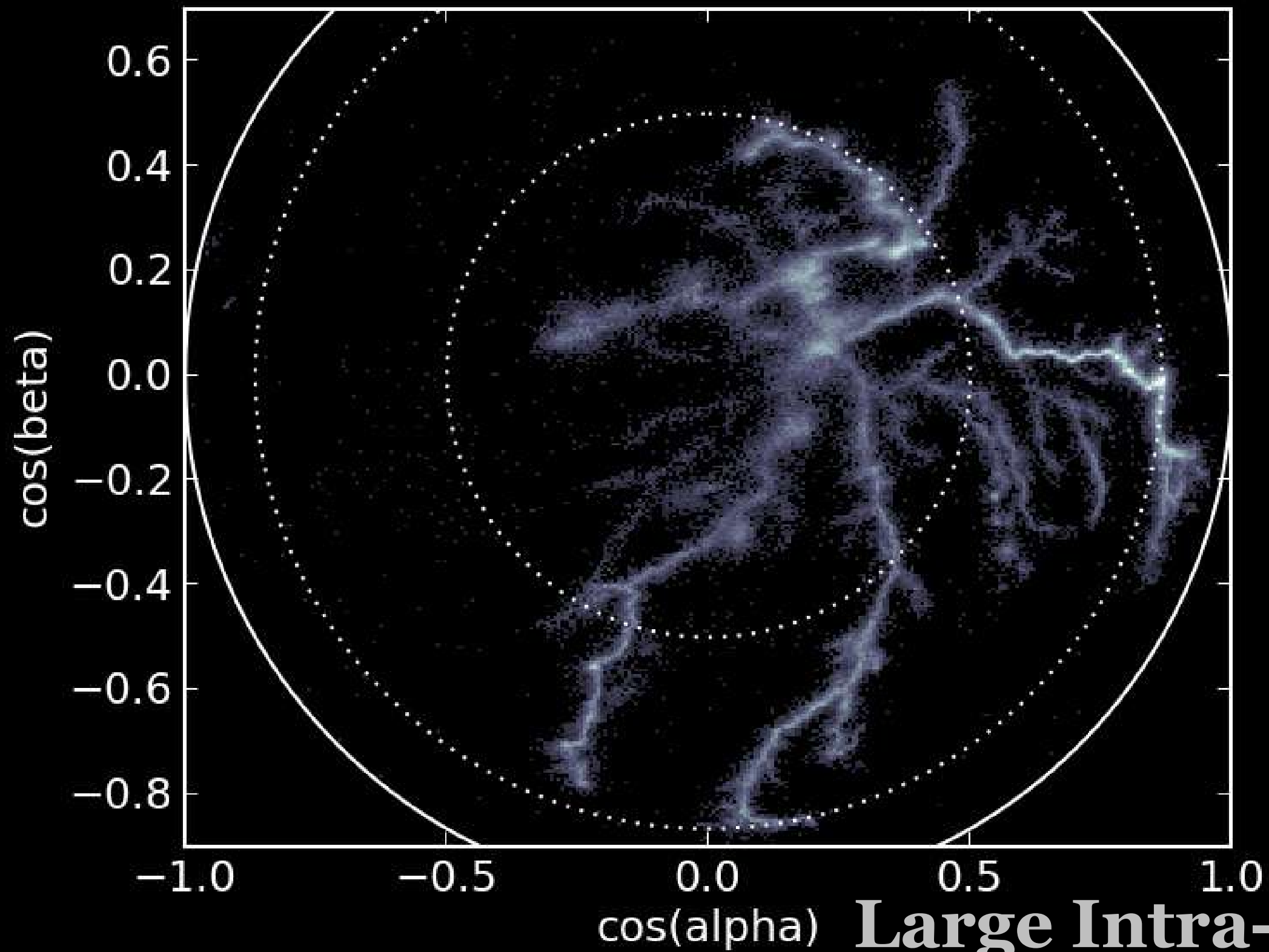


Flash at 2013/08/06 03:11:53.125666 UT
Frame Rate: 6250 fps
1009.880



Large Intra-cloud

Flash at 2013/08/06 03:11:53.125666 UT
Frame Rate: 6250 fps
1009.880



Flash at 2013/08/06 03:11:53.125666 UT
Frame Rate: 6250 fps
155.000

