Title: Crescent Black Hole Images

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URL: http://pirsa.org/14110108

Abstract: Maximizing the science return on the Event Horizon Telescope project requires fitting models for spatially resolved black hole images to the data. These images can be calculated from accretion and jet theory, but theoretical uncertainties lead to systematic errors in the predicted images. In many cases, however, the images are dominated by the combined effects of Doppler beaming and light bending, leading to a characteristic â€œcrescentâ€• shape. I will discuss a geometric crescent model for black hole images based on these effects. The crescent outperforms other simple geometric shapes in the description of current data, can be used to simulate future EHT observations, and has implications for detecting a black hole shadow.

Crescent Black Hole Images

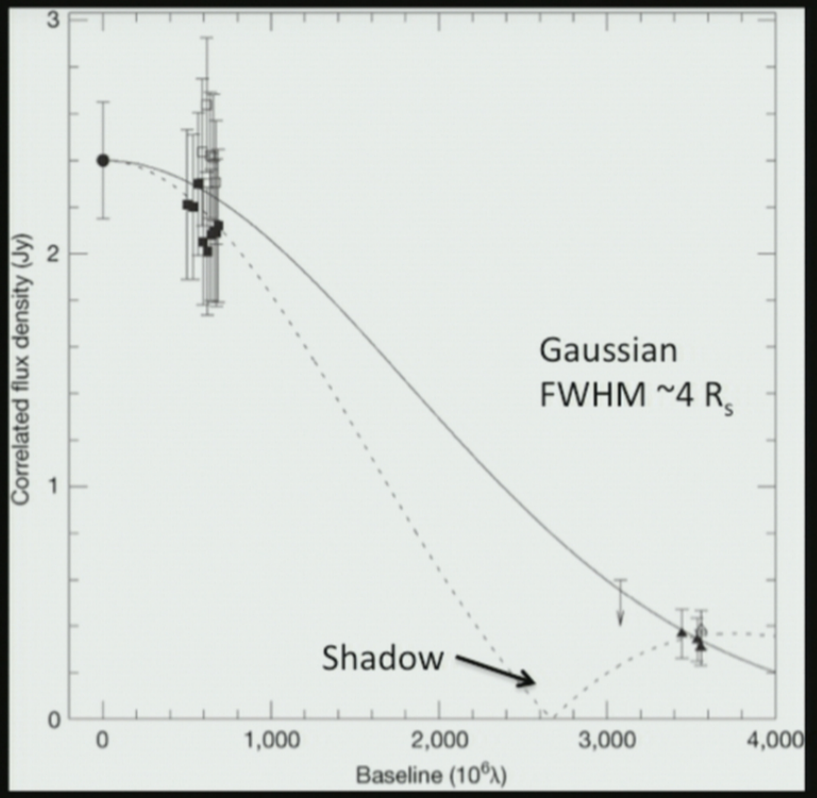
Jason Dexter
MPE Garching

With Eric Agol, Chris Fragile, Jonathan McKinney,
Ayman Bin Kamruddin, Angelo Ricarte, Alwin Mao

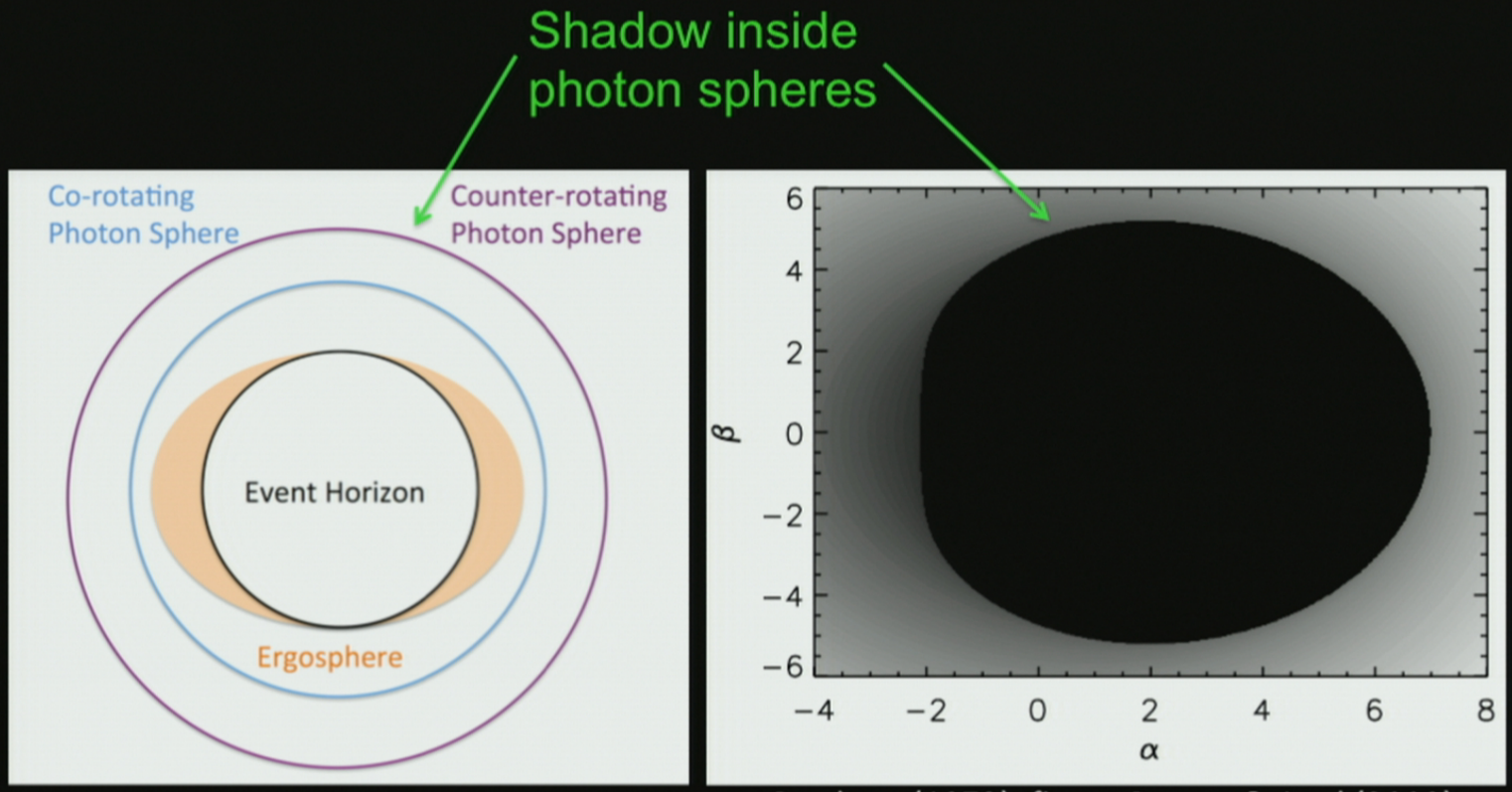
Interpreting EHT Data

- EHT science requires modeling
  - Pre-imaging: no choice
  - Later: quantitative comparisons
- What do we expect?

Doeleman et al. (2008)



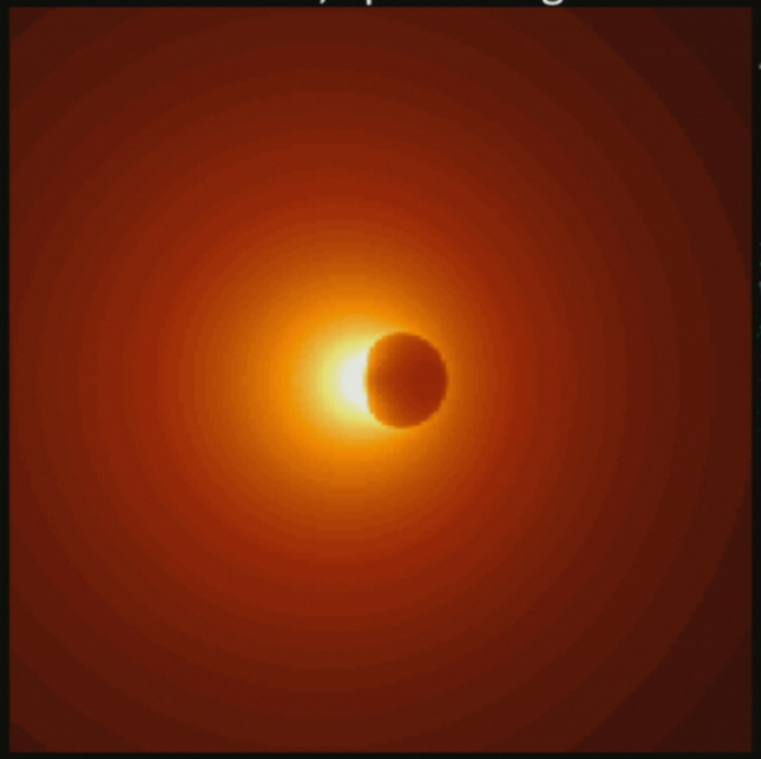
Black Hole Shadow



Bardeen (1973); figure Dexter & Agol (2009)

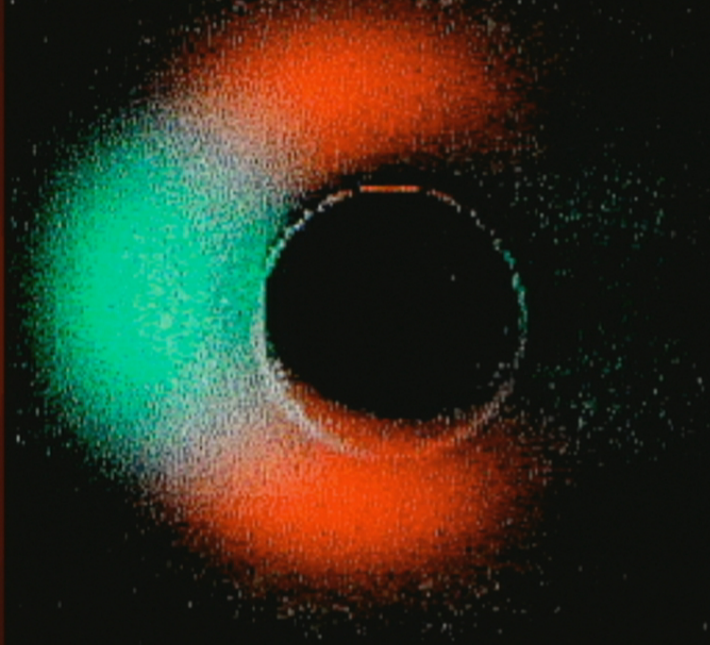
Black Hole Images

Orbital motion, spherical gas dist.



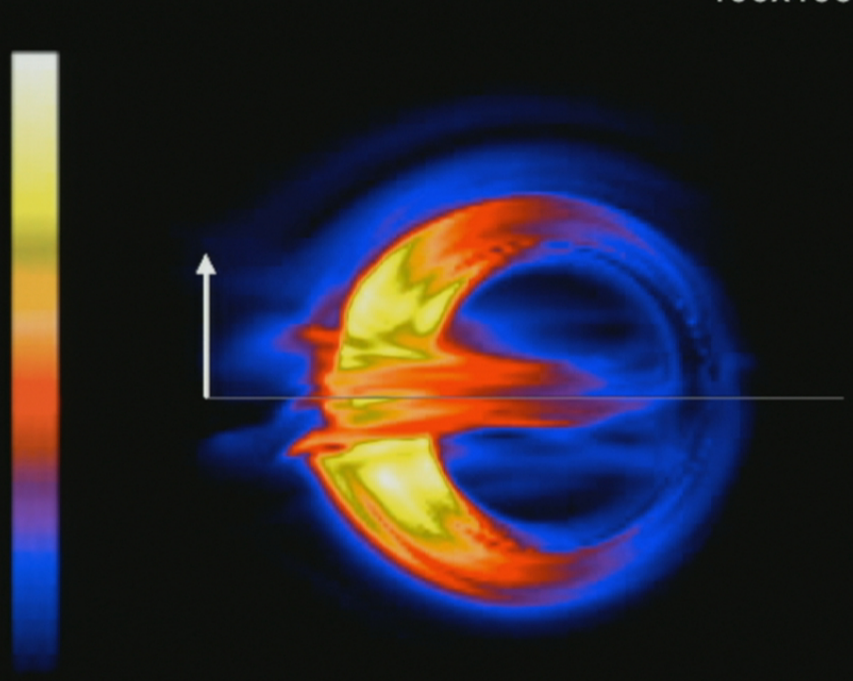
Falcke, Melia & Agol (2000)

Orbital motion, gas torus, inclined to observer



Bromley, Melia & Liu (2001)

Sagittarius A* Disk Images

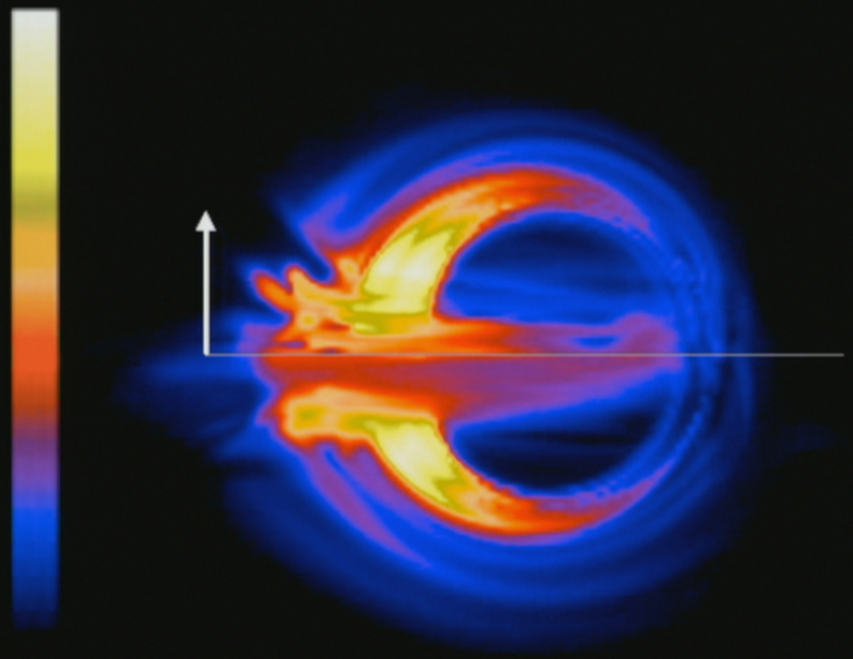


Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

Sagittarius A* Disk Images

100x100 μas



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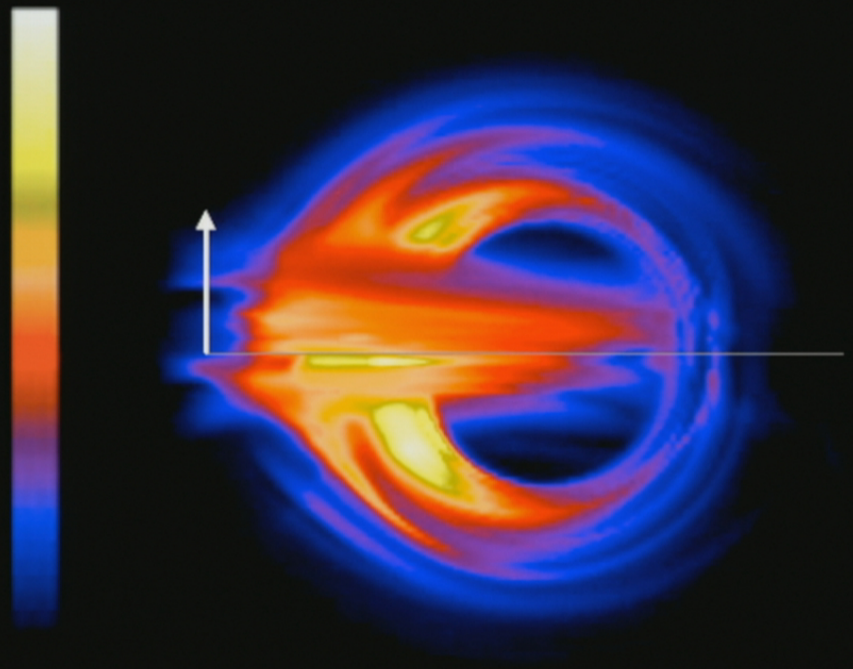
100x100 μas



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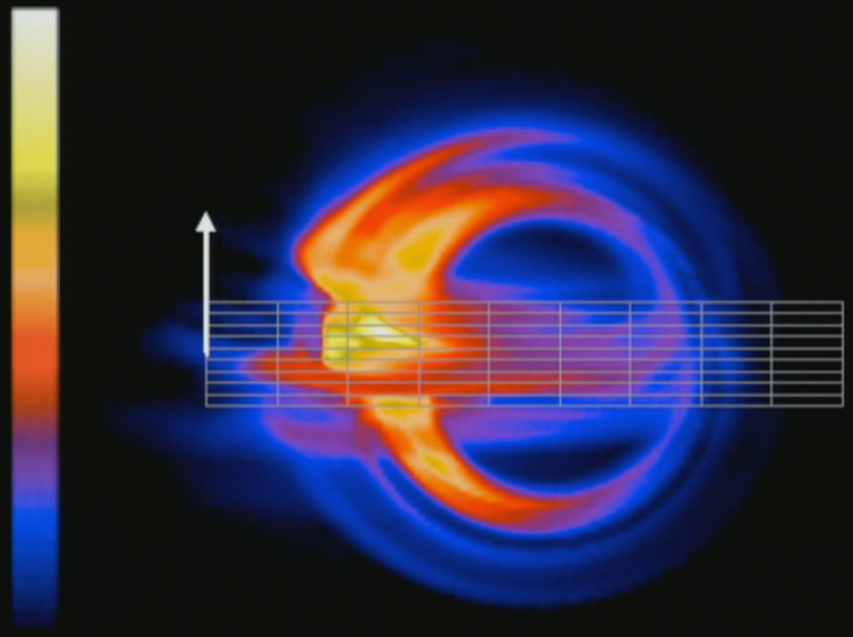
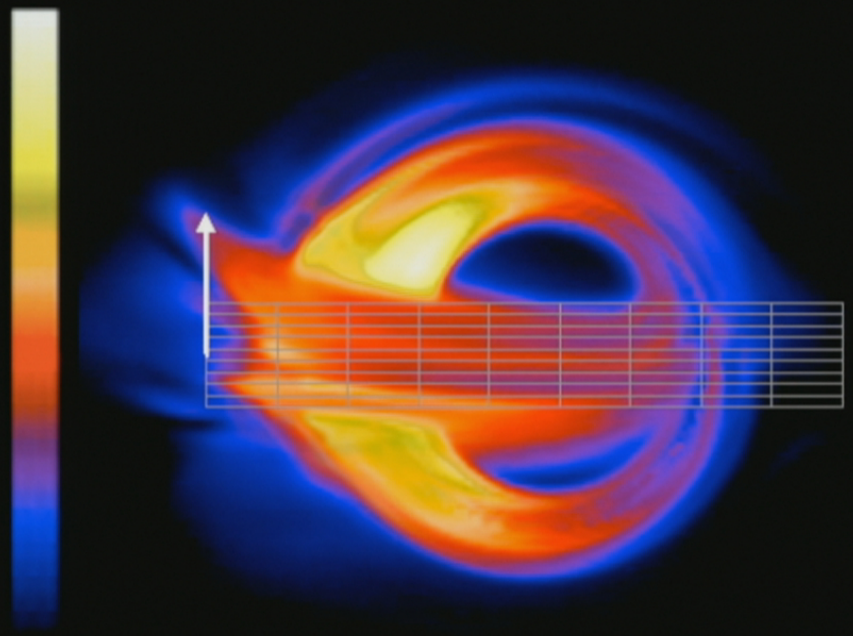


Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

Sagittarius A* Disk Images

100x100 μas



Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

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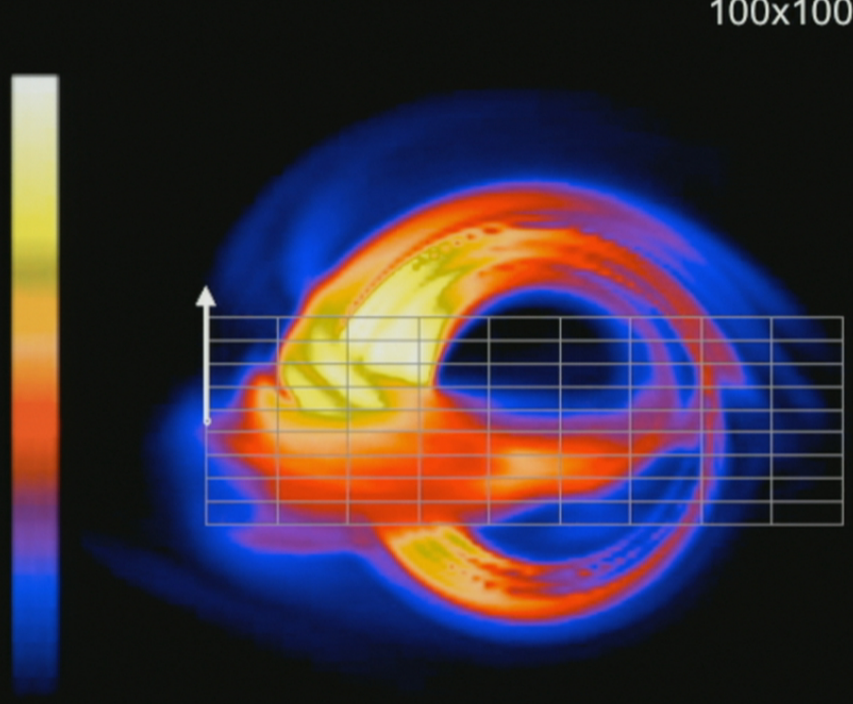
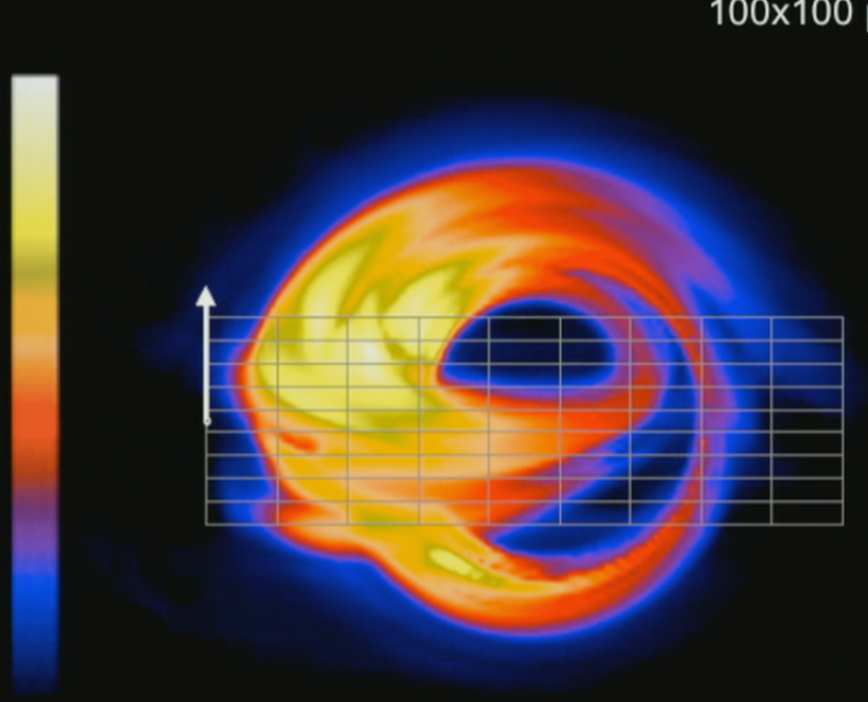


Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

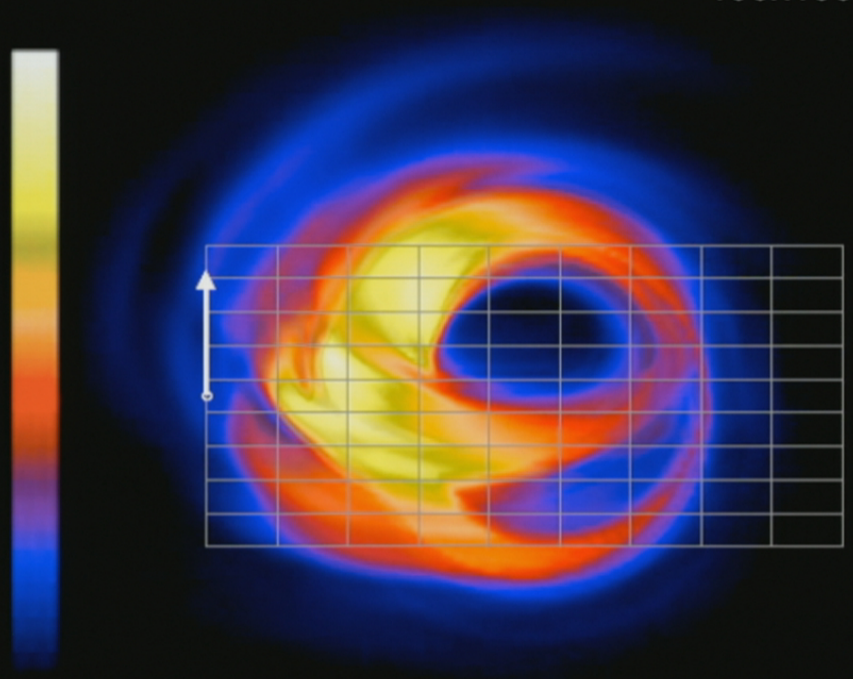
Sagittarius A* Disk Images



Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

Sagittarius A* Disk Images



Dexter et al. (2009, 2010)

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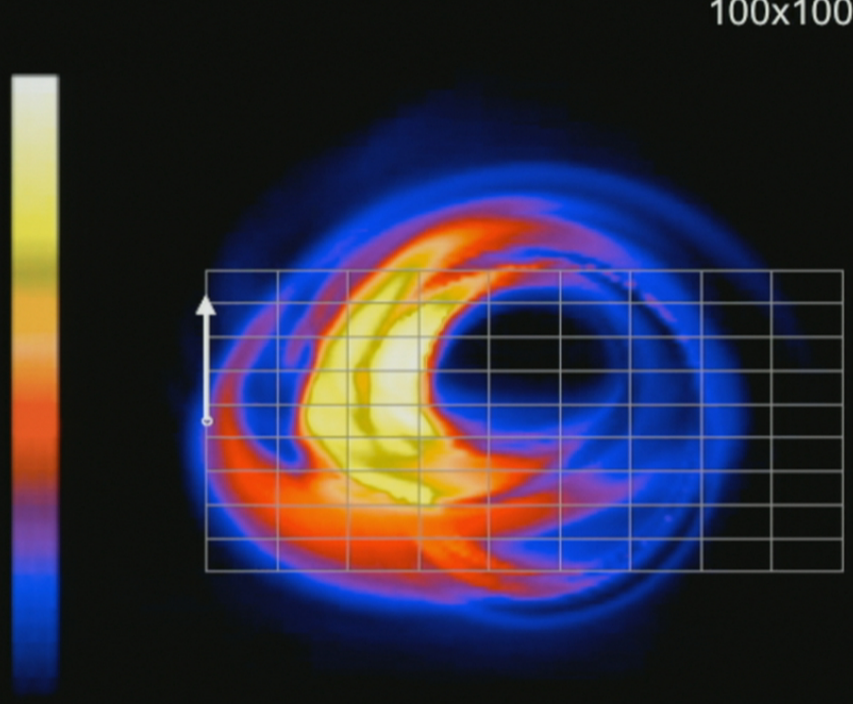
Sagittarius A* Disk Images



Dexter et al. (2009, 2010)

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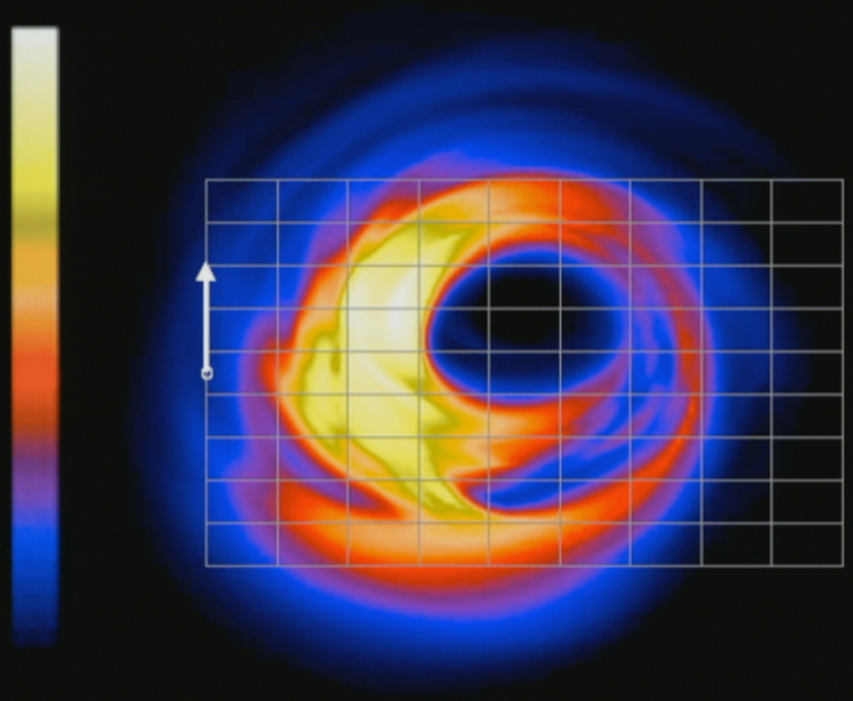

Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

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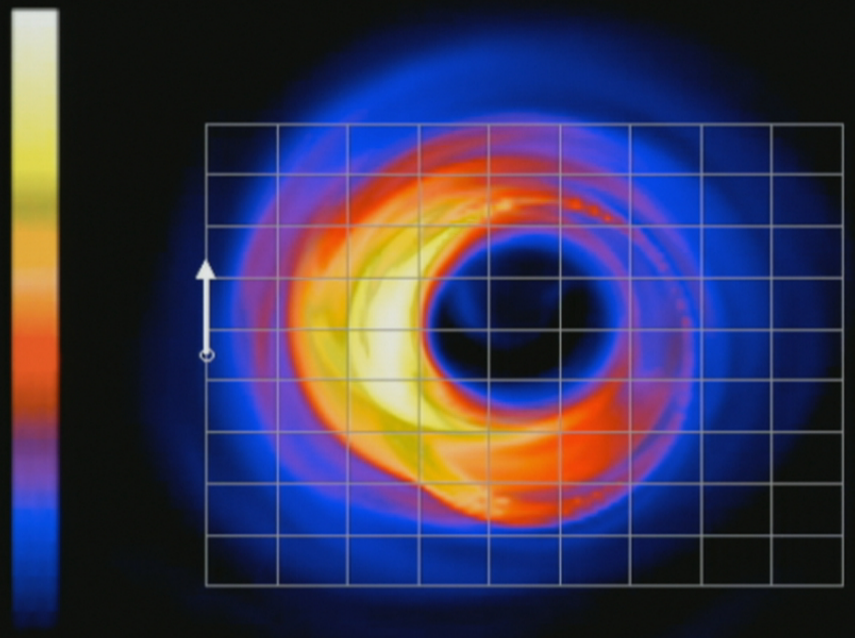

Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

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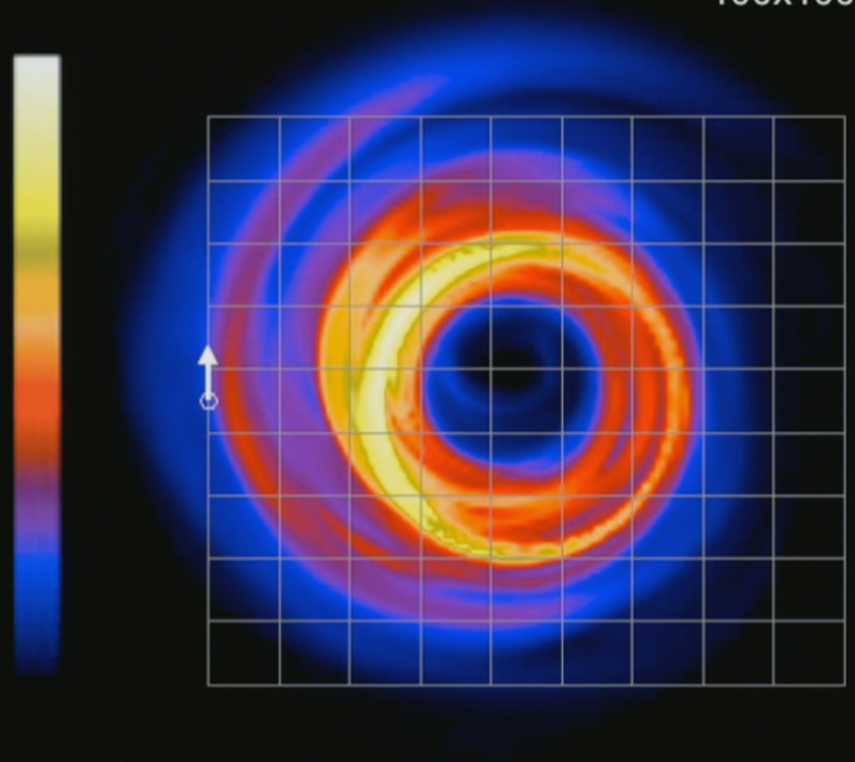

Dexter et al. (2009, 2010)

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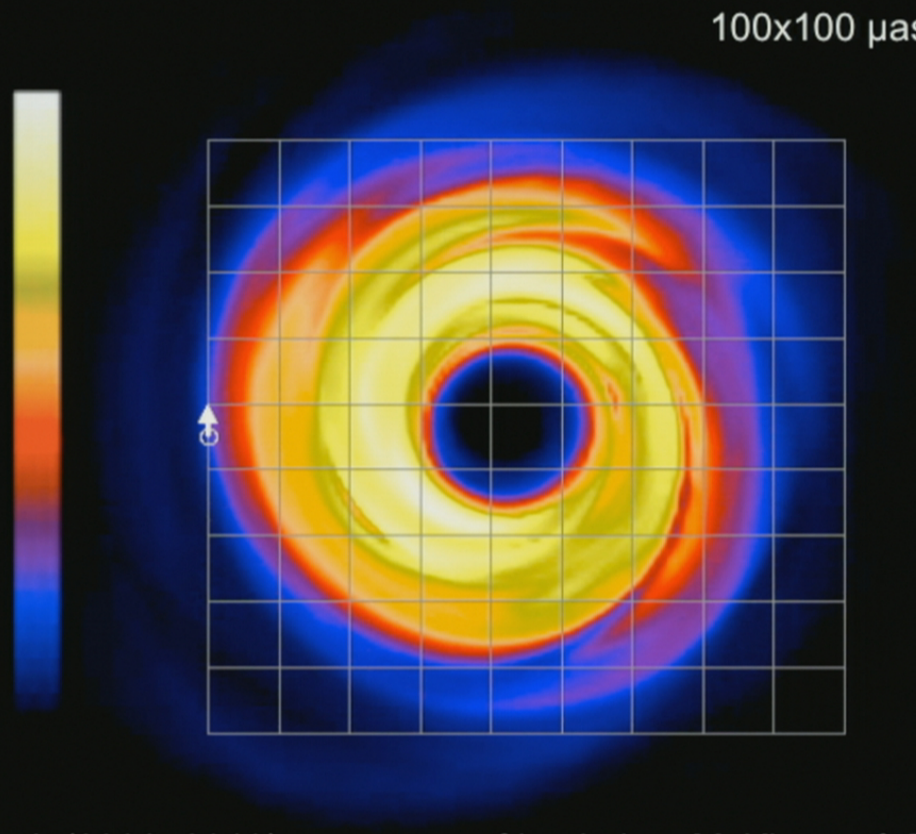
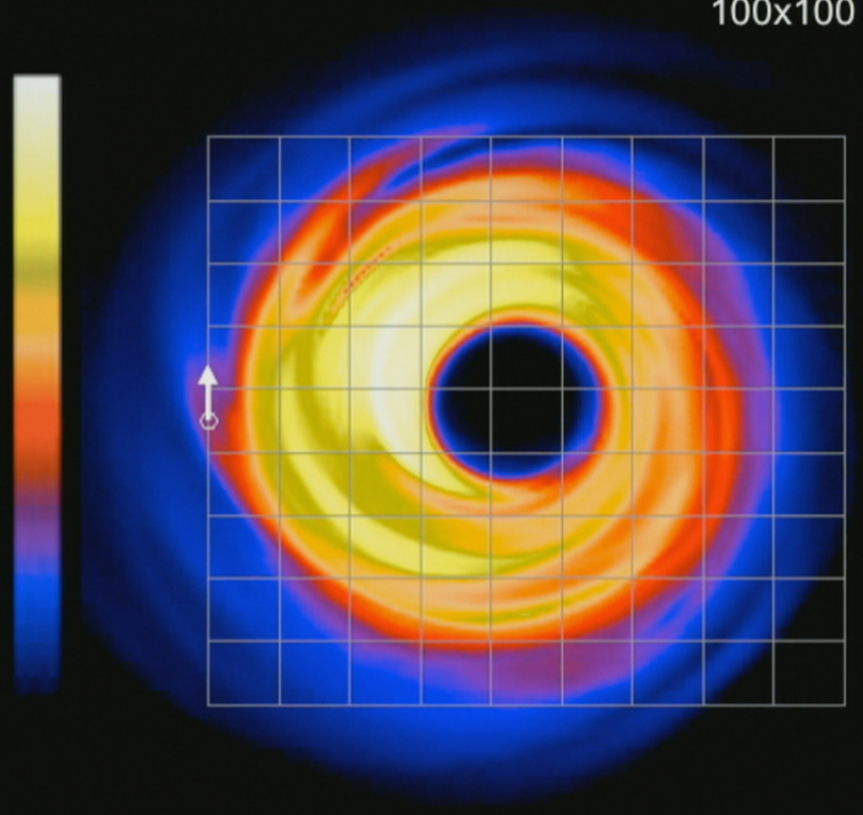


Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

Sagittarius A* Disk Images



Dexter et al. (2009, 2010)

Simulation: McKinney & Blandford (2009)

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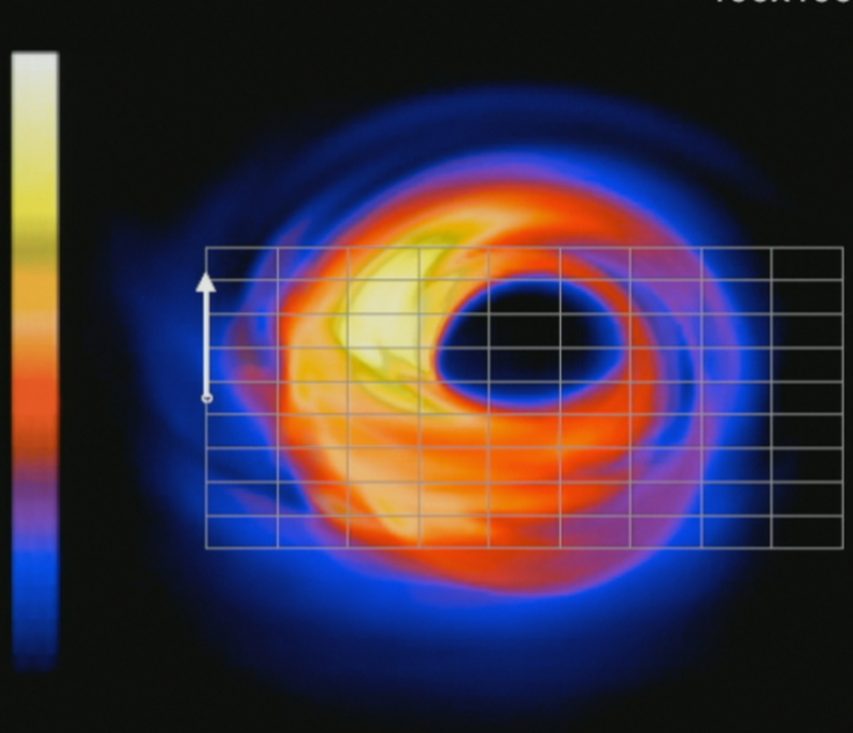
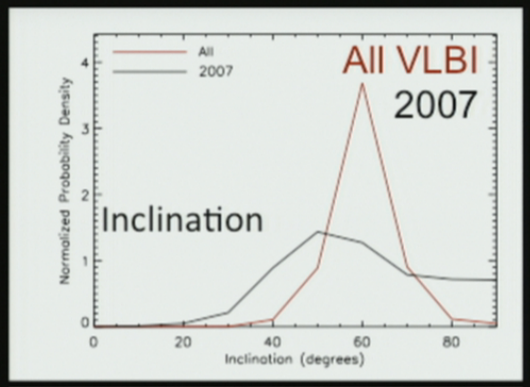
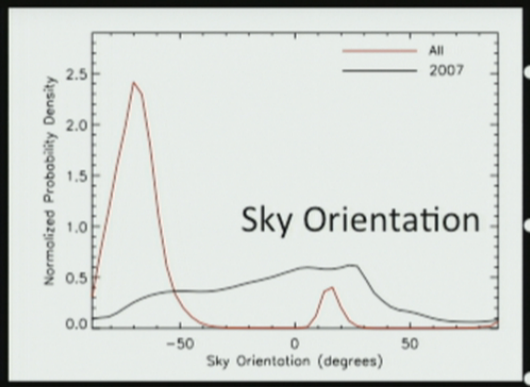


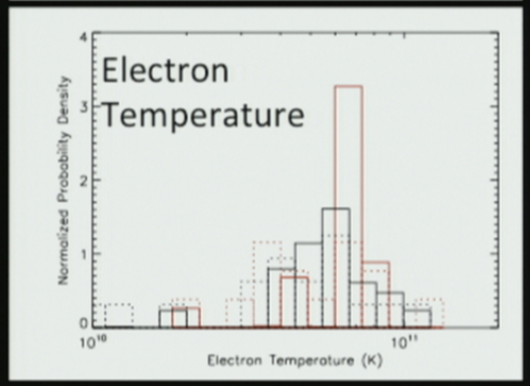
Dexter et al. (2009, 2010)

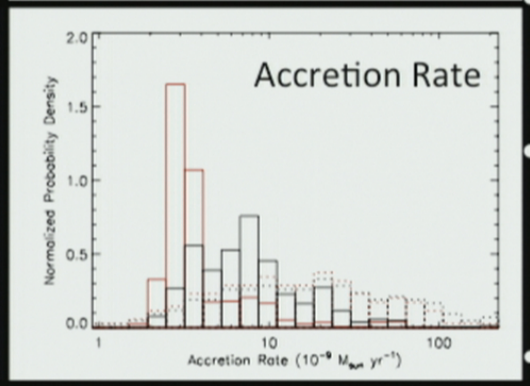
Simulation: McKinney & Blandford (2009)

Parameter Estimates







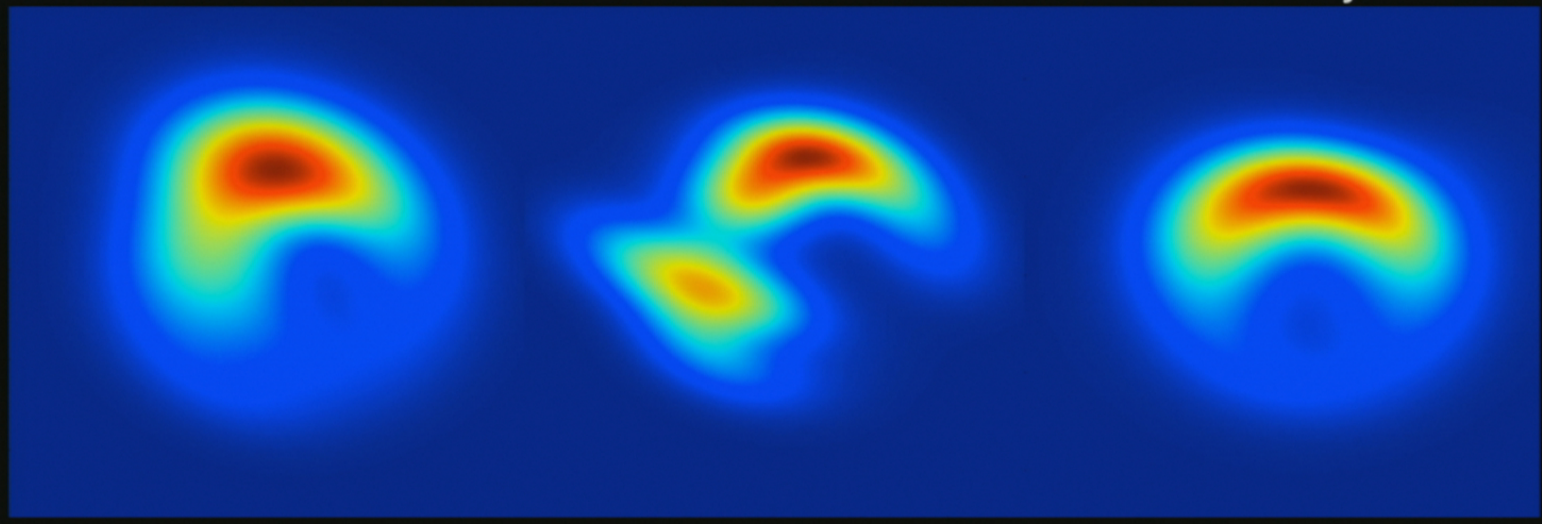


- $i = 60^{+15}_{-15}$ degrees
- $\xi = -70^{+86}_{-15}$ degrees
- $T_e/10^{10}\ K = 6 \pm 2$
- $dM/dt = 3^{+7}_{-1} \times 10^{-9}$ $M_{sun}\ yr^{-1}$
- All to 90% confidence

Dexter et al. (2010)

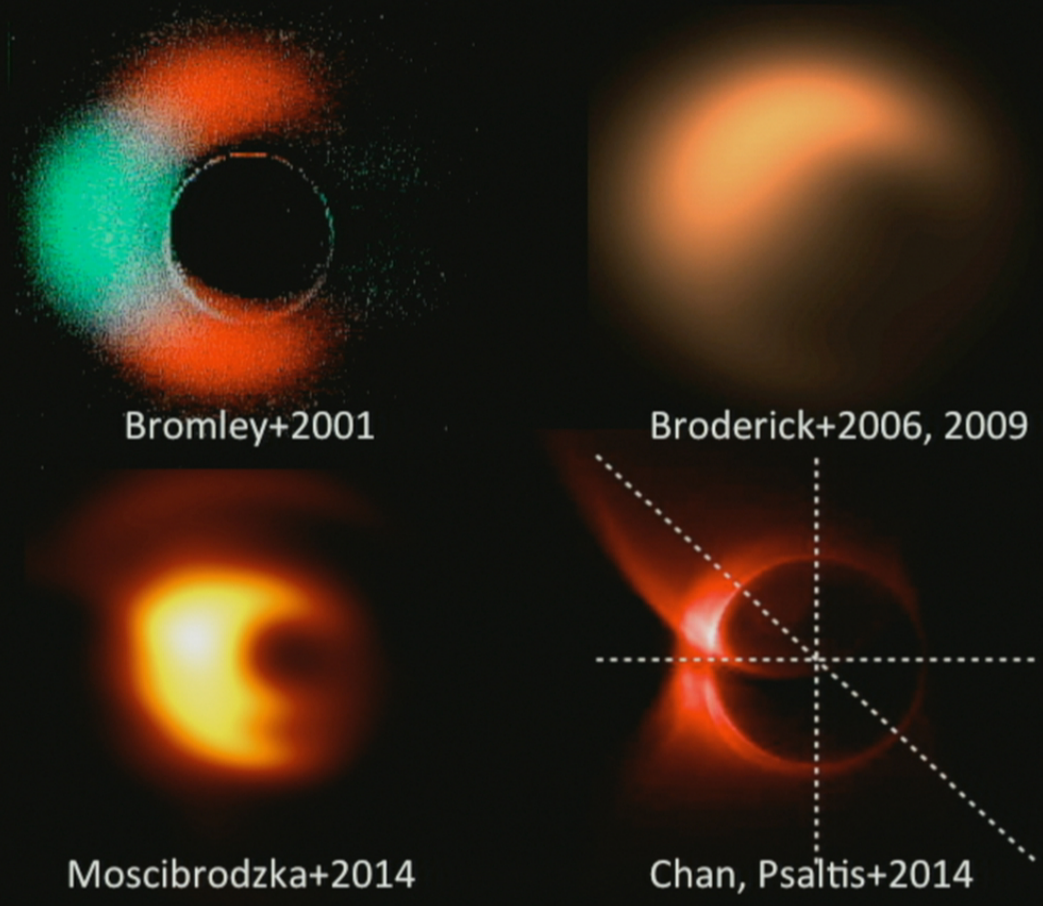
Crescent Images

Disk | Tilted disk | Counter-jet



Dexter+2010, 2012; Dexter & Fragile 2013

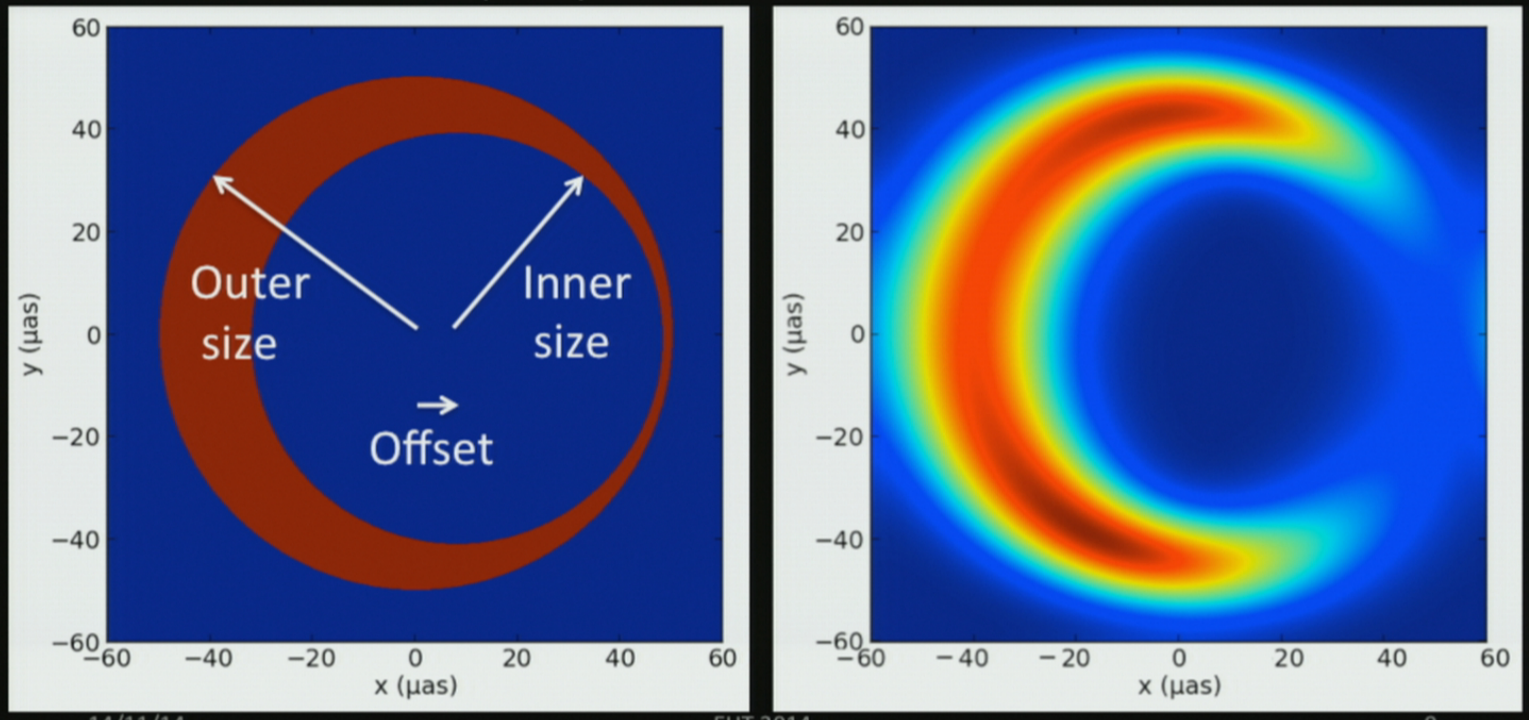
Crescent Images



Geometric Crescent Model

- Difference between two disks, 5 parameters

Kamruddin & Dexter (2013)



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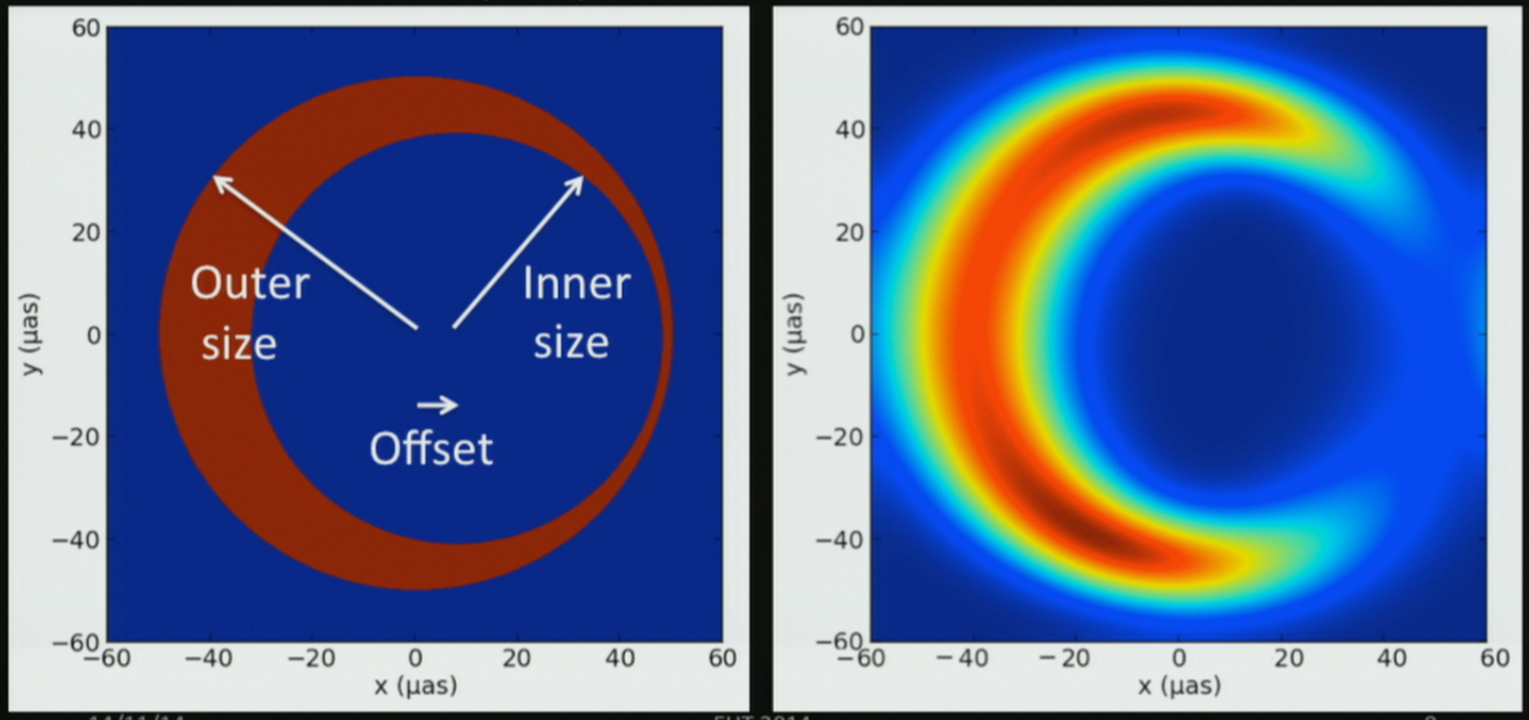
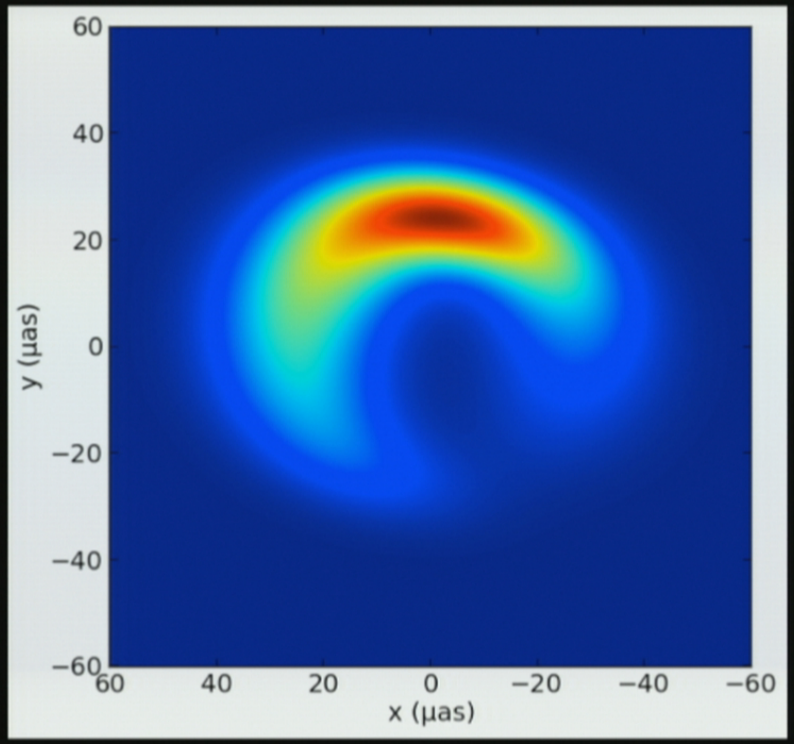


Sgr A* Crescent

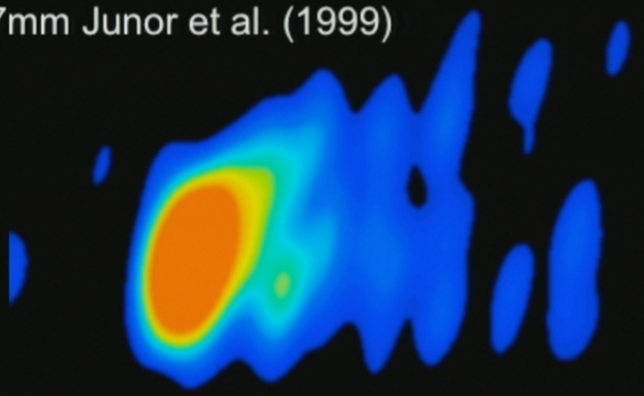
- Better fit to data than rings, Gaussians
  (Kamruddin & Dexter 2013, also Broderick+2011)



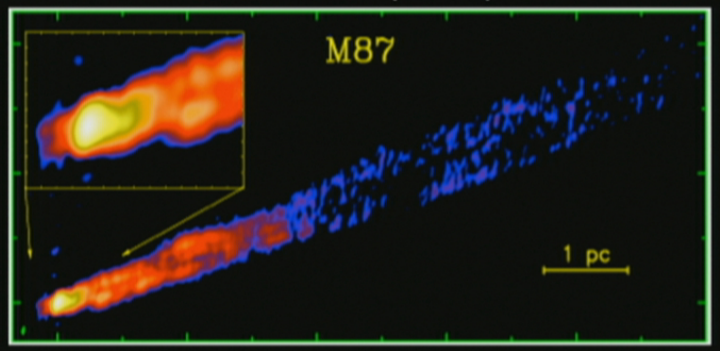
M87

- Known viewing geometry?

7mm Junor et al. (1999)



2cm Kovalev et al. (2007)



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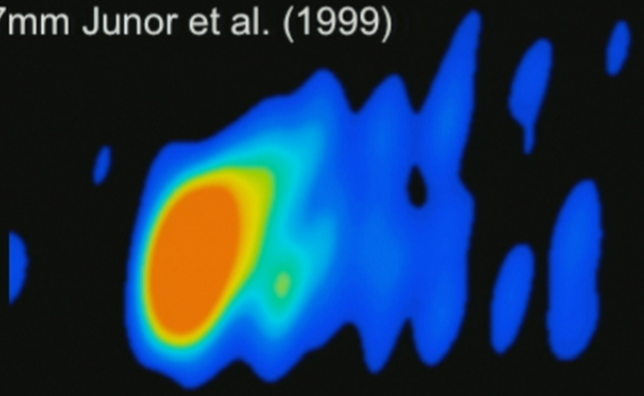

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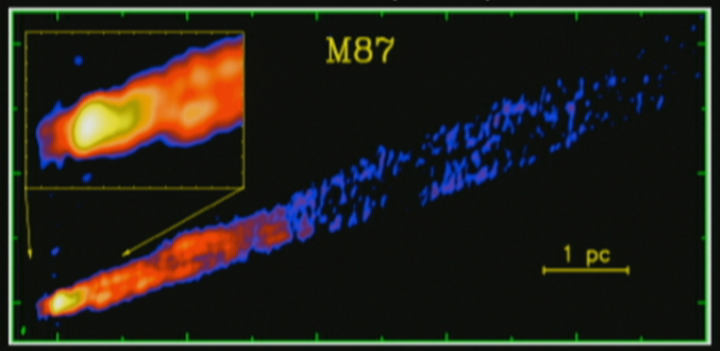
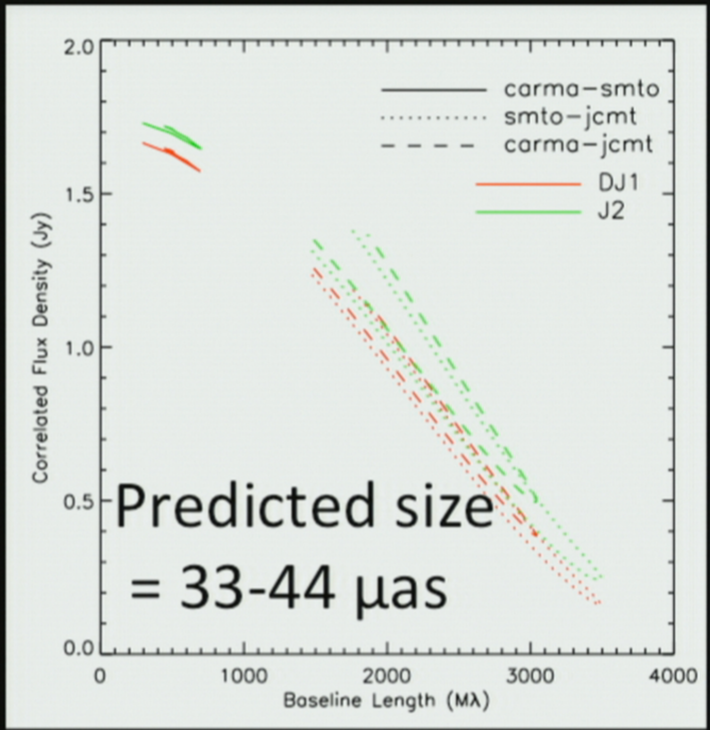
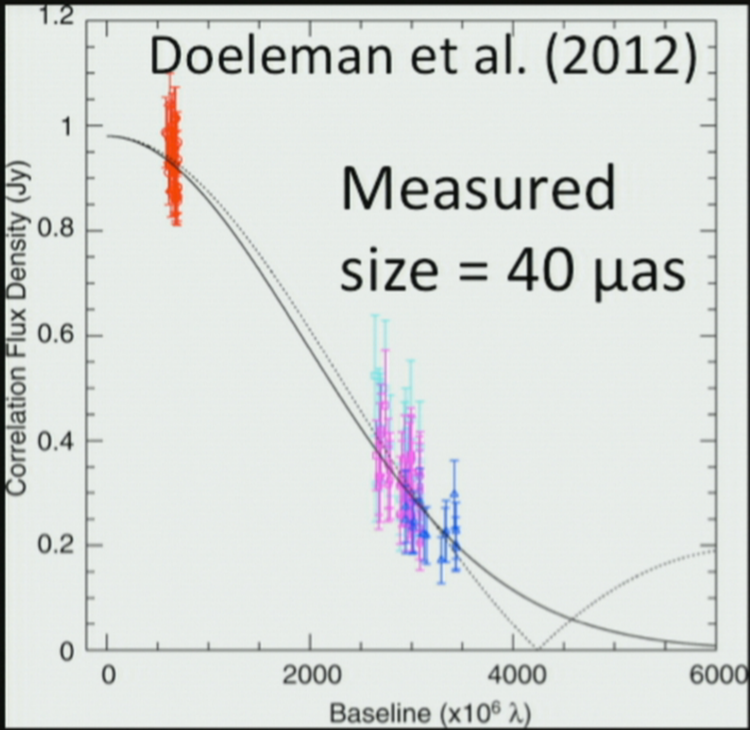


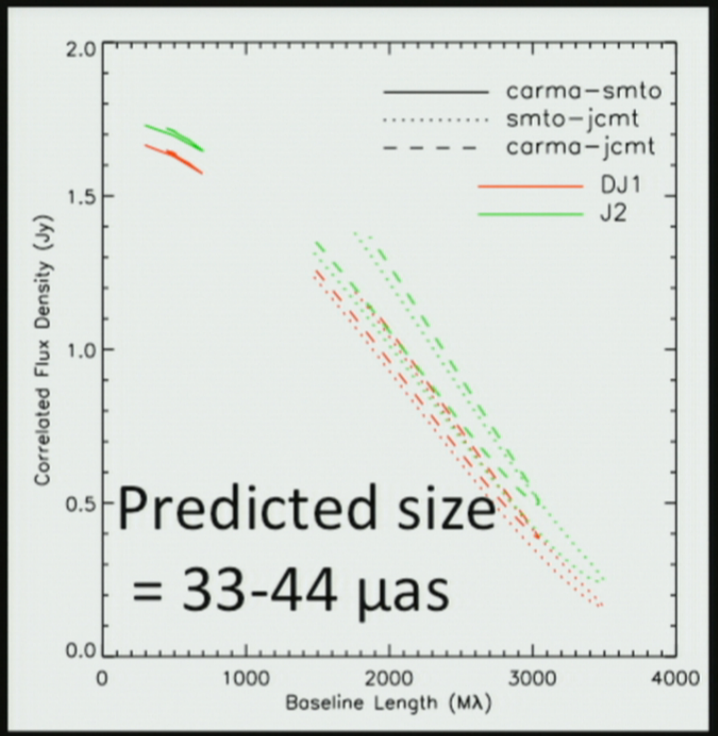
The Size of M87

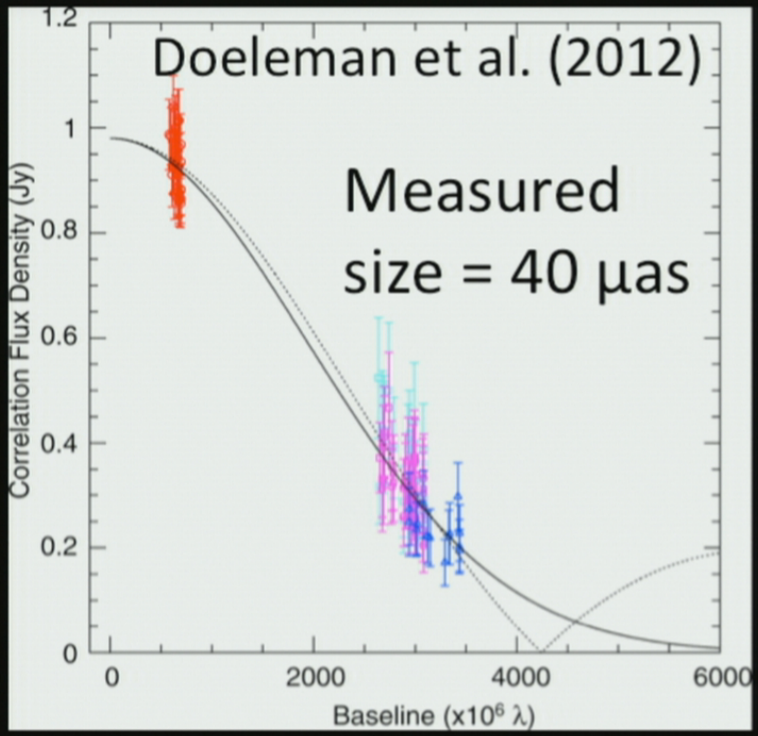




Dexter et al. (2012)

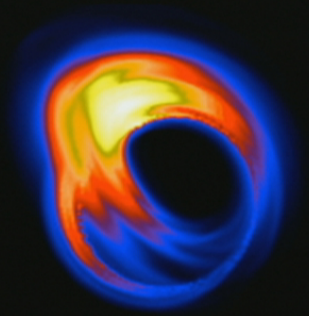
The Size of M87

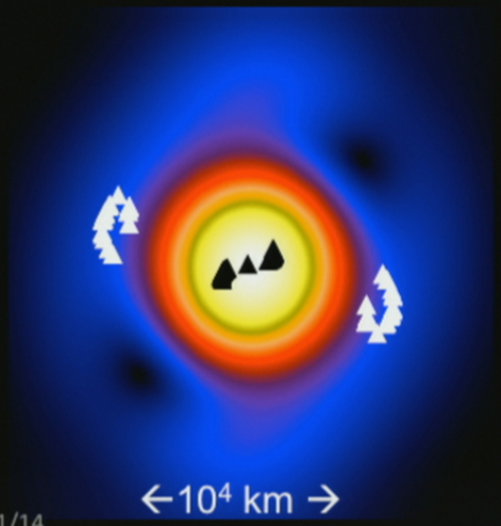


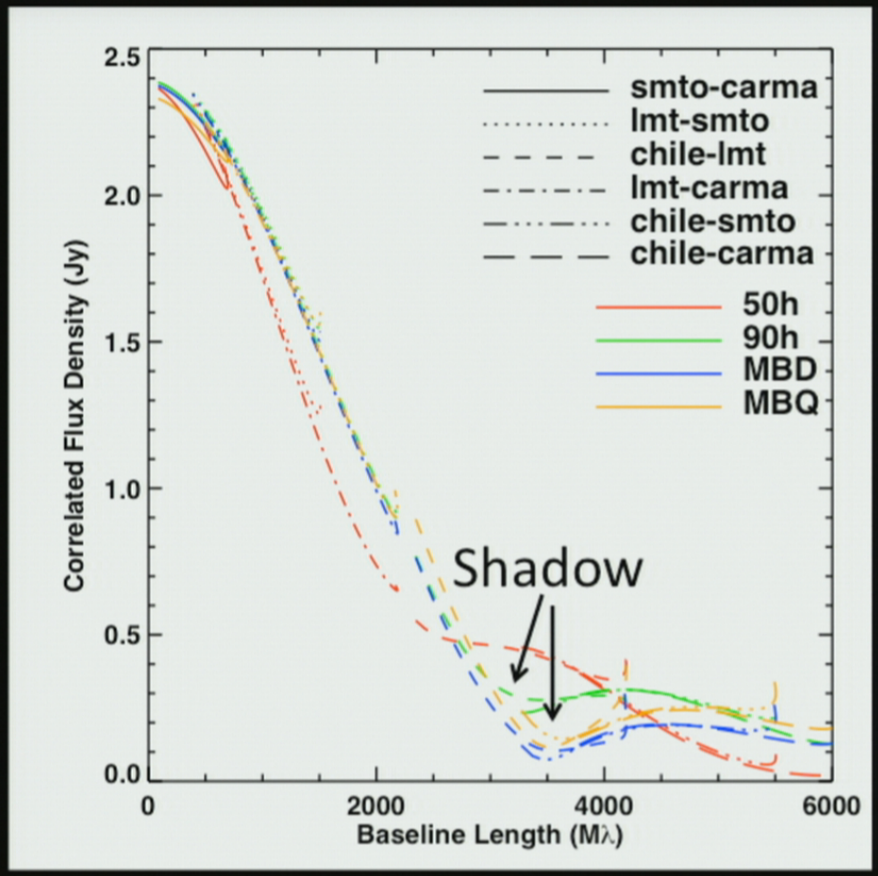


Dexter et al. (2012)

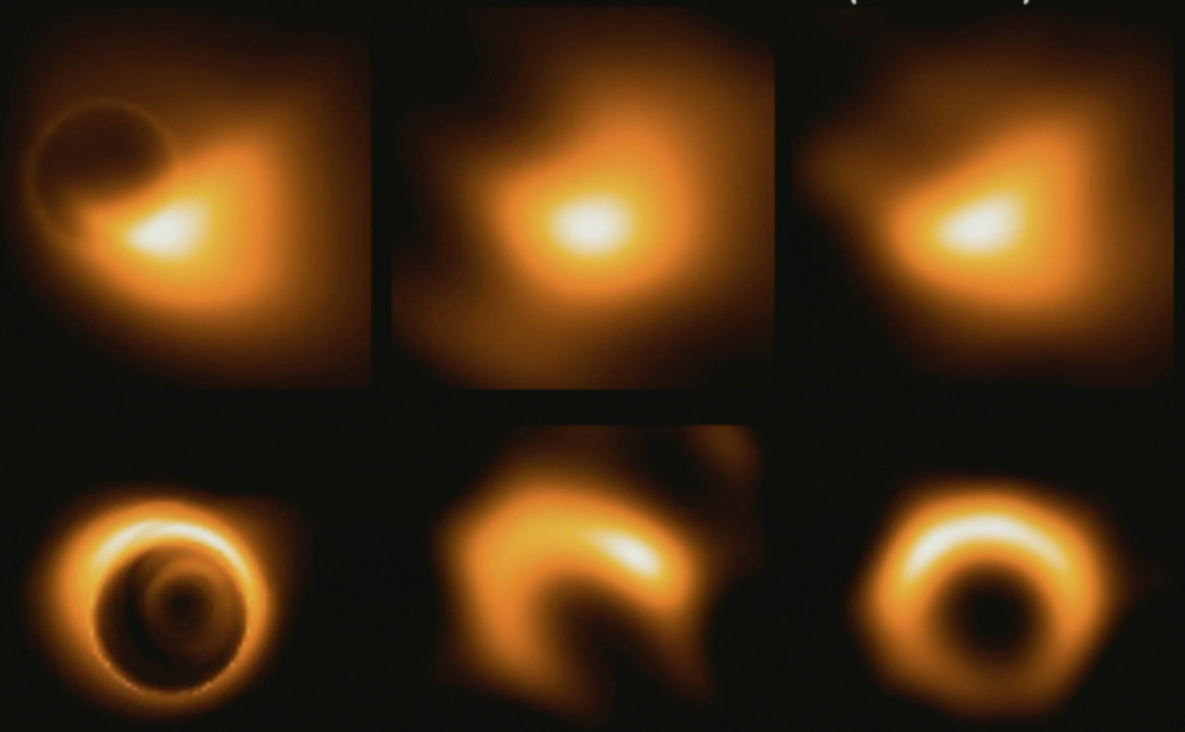
Crescent BH Shadows



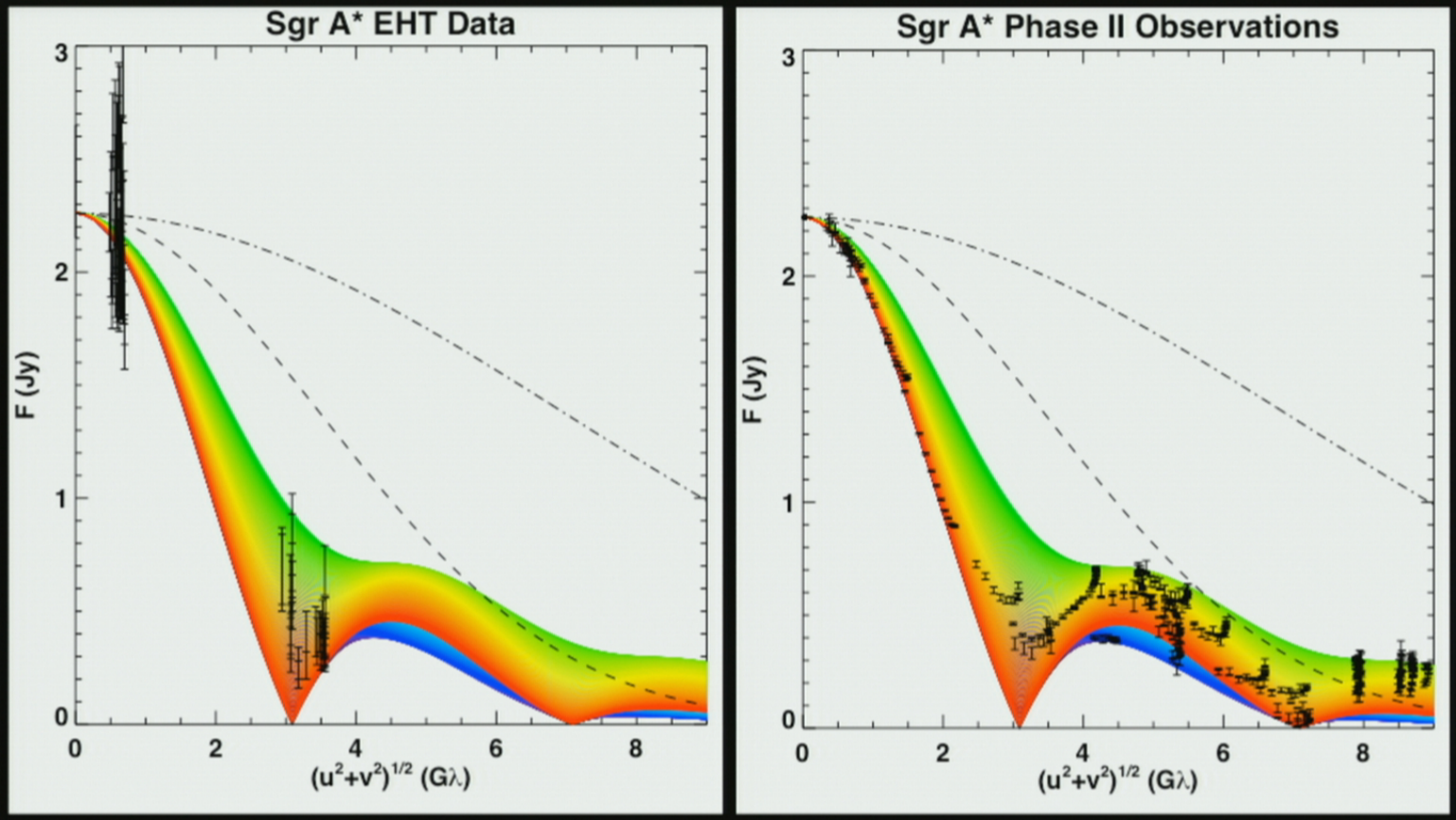




M87 Imaging


Baron & Monnier
(U. Mich)
Broderick
et al.
Dexter et al.
(2012)
Original
4 stations
7 stations

Simulated Future EHT Data

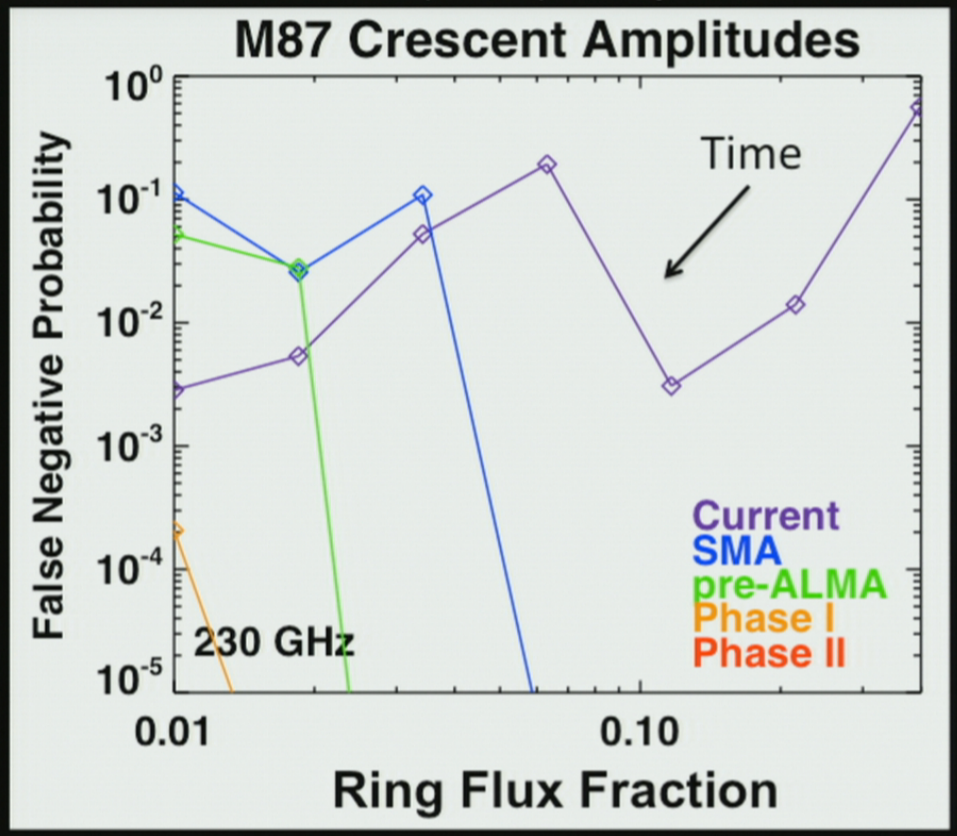


Ricarte & Dexter (2014)

When can the EHT…

- Test models? Now-ALMA.
- Detect photon ring? ALMA or beyond.

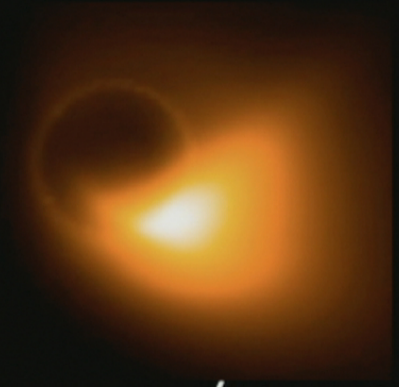
Ricarte & Dexter (2014) and poster!



Non-crescent Images

- Away from BH or compact (weak light bending)

Broderick
et al.



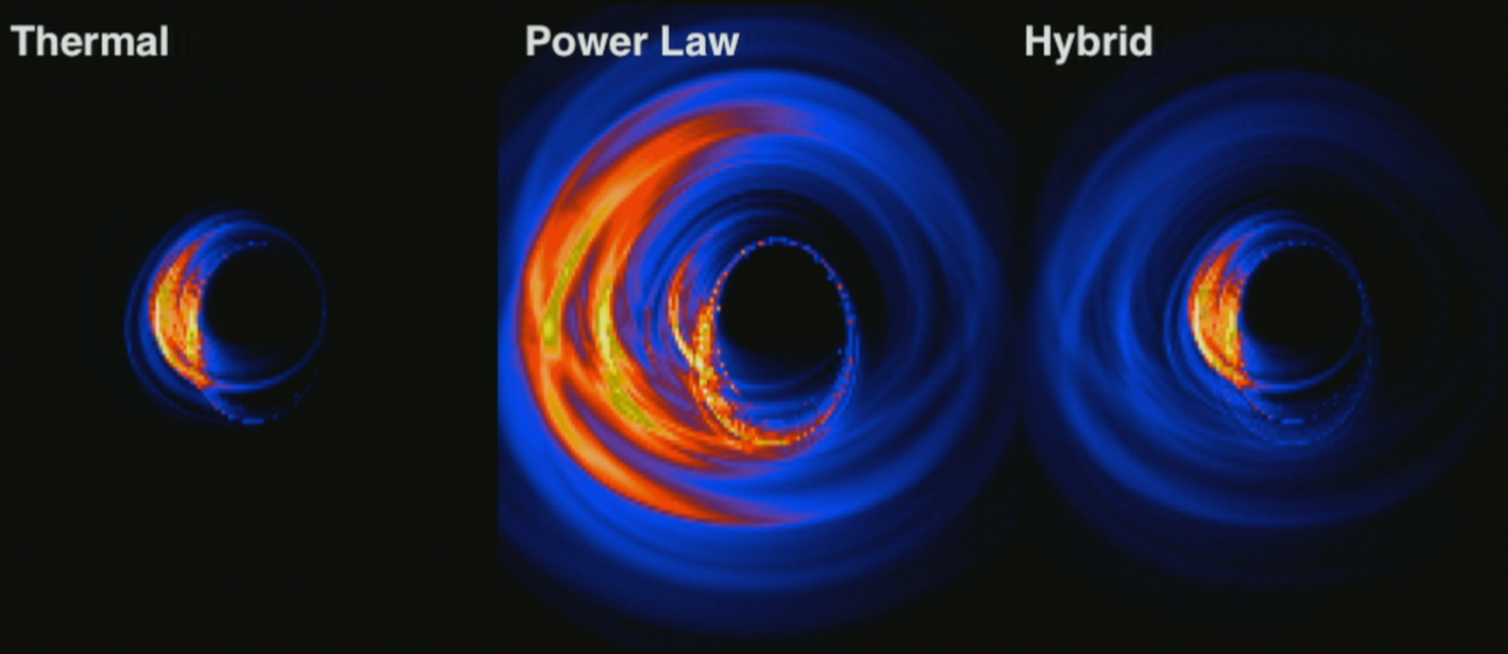
- Multiple components (structural var.)

Dexter &
Fragile (2013)

Non-crescent Images

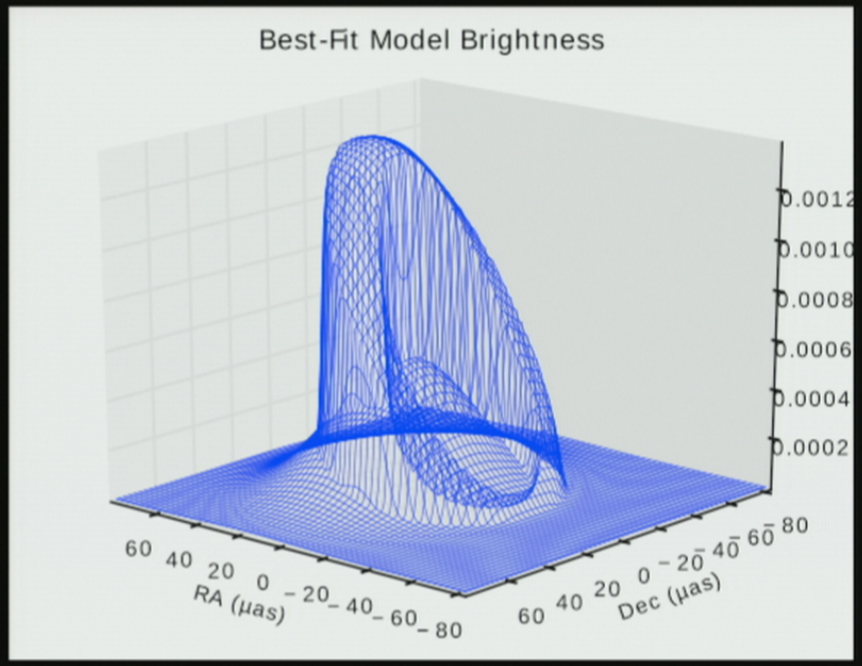
- Non-thermal electrons

Alwin Mao

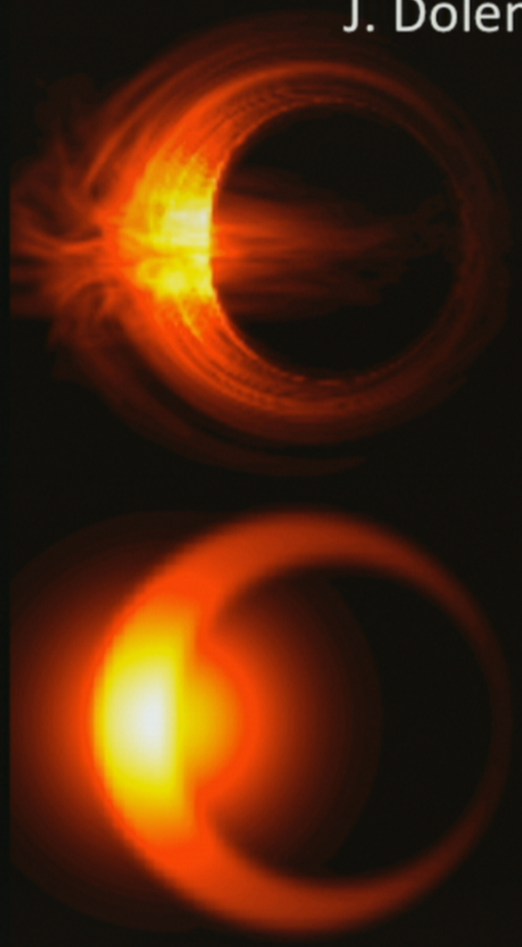


Extensions

- 9 parameters, analytic (Leo Benkevitch)



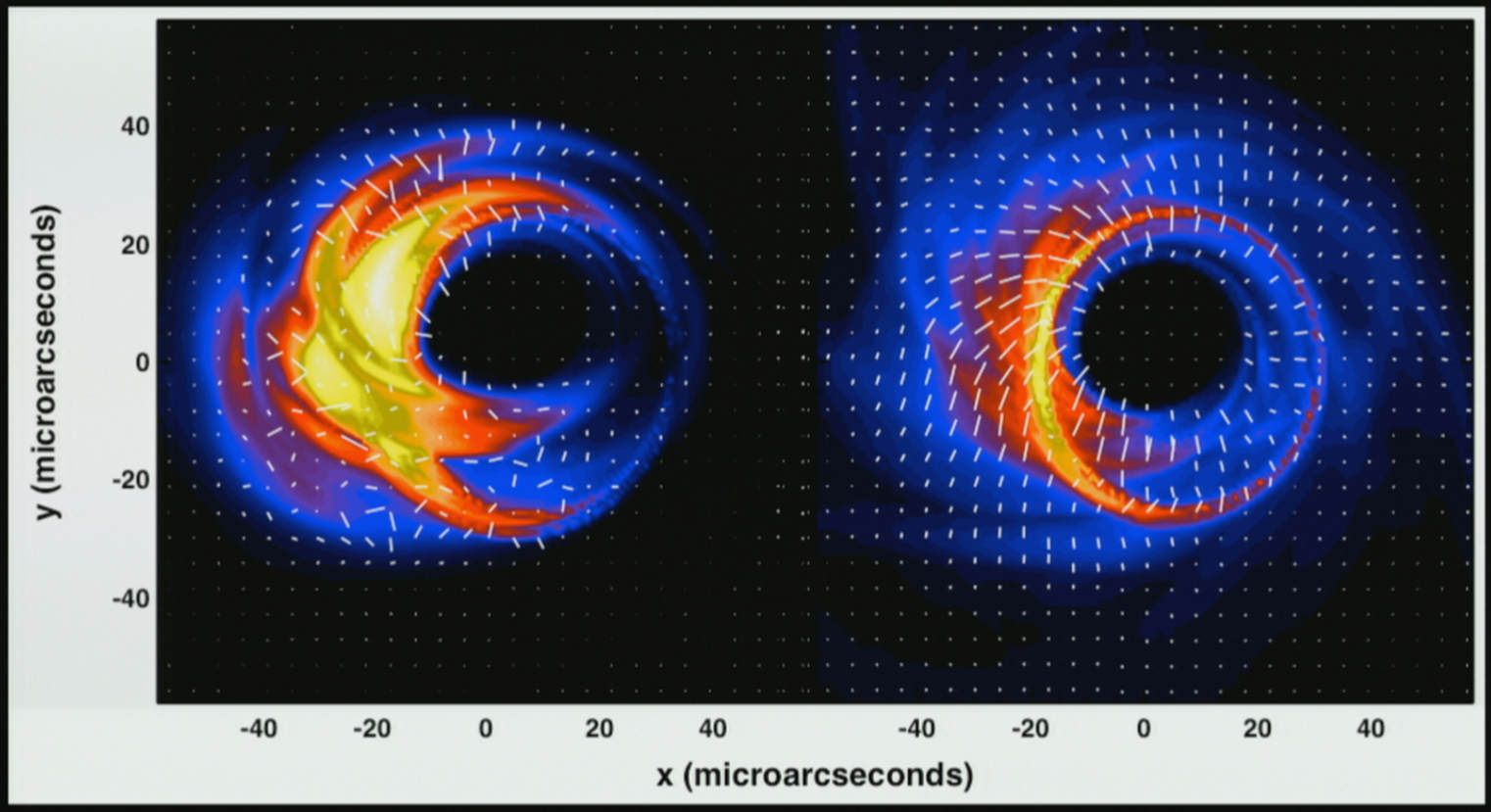
J. Dolence



14/11/14

EHT 2014

What About Polarization?



Summary

- Crescents are a physically-motivated shape for black hole images
- Better description of Sgr A* data than other shapes

- Applications: shadow signatures and simulated observations (A. Ricarte poster!)

Open Positions at MPE

- PhD through IMPRS program
- Postdoctoral fellowship

- http://mpe.mpg.de/~jdexter