Images of hairy black holes at Sgr A*

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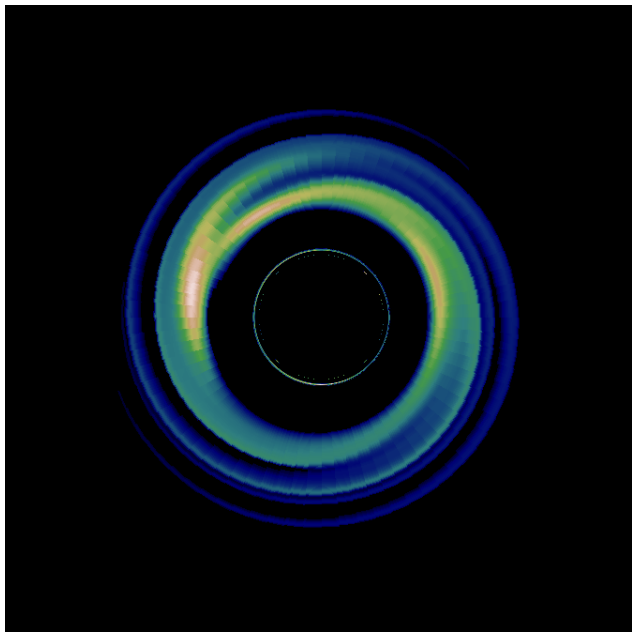
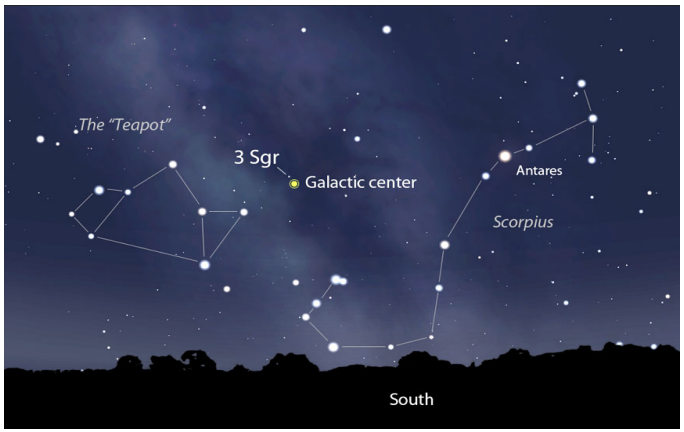
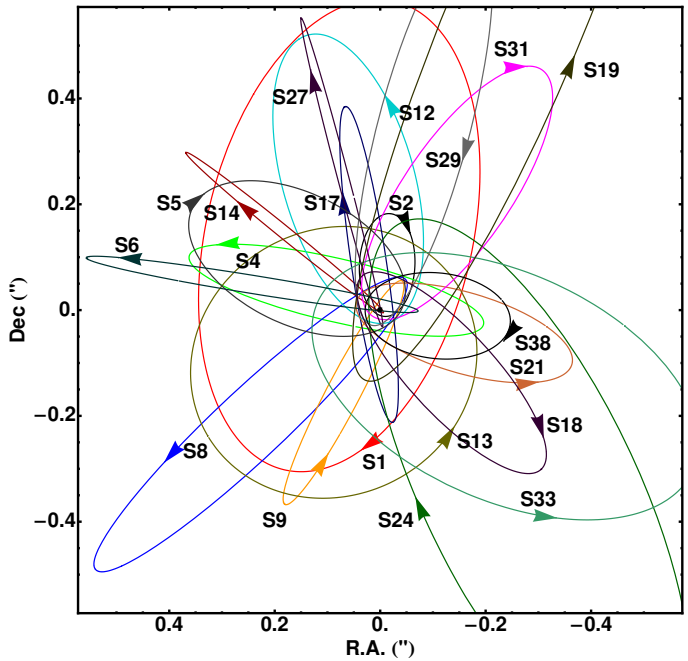




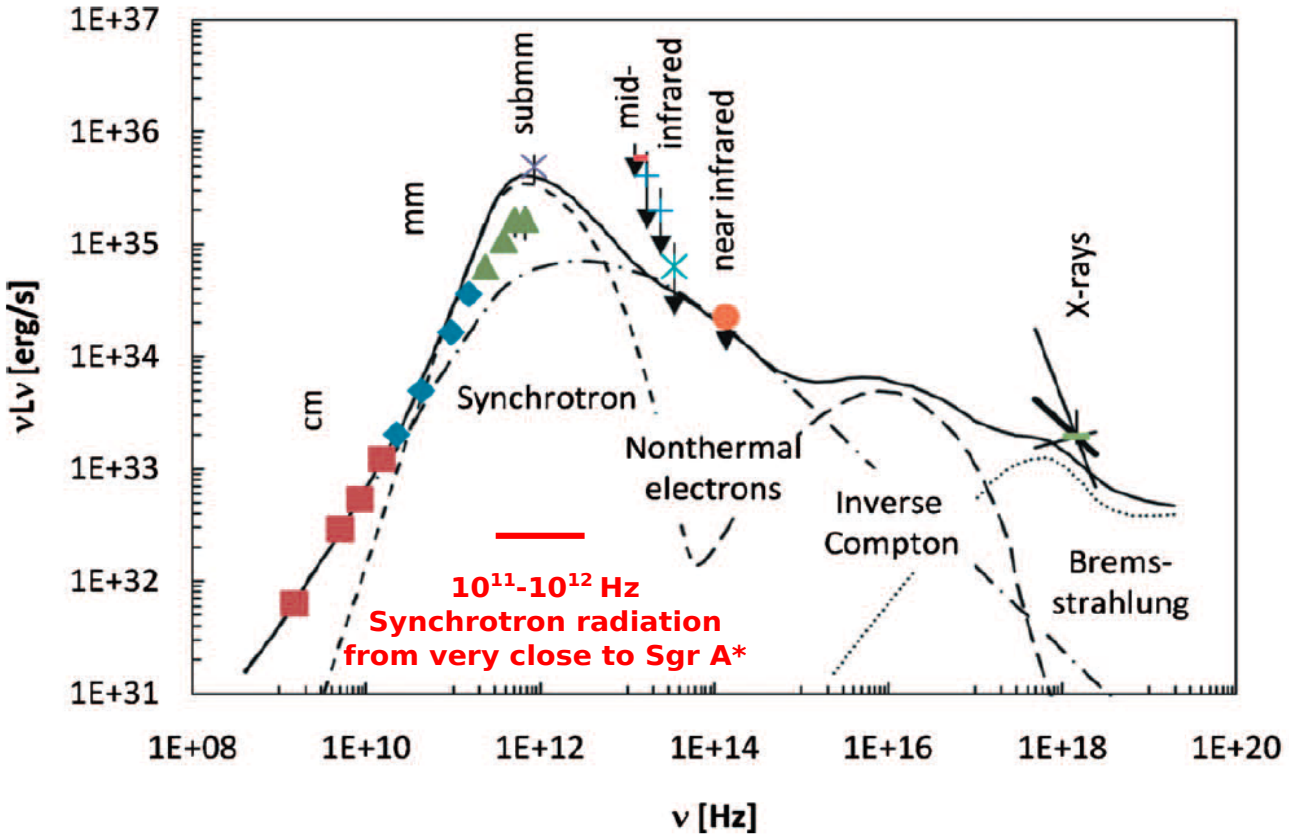
Credit : Stellarium, Bob King



S-stars cluster (Gillessen+09): size = **1" ≈ 0.05 pc**

Sgr A*: big mass in small region, SMBH

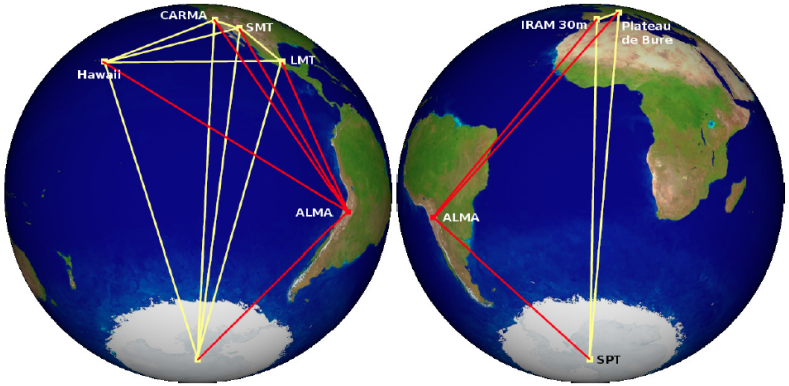
- Astrometric measurements of close stars → central mass
- Sgr A* mass is **$4.3\,10^6 M_\odot$**,
  S2 at perimelanophrear at **100 AU** from Sgr A*,
  $\theta_{\mathrm{app,Sch}} \approx$ **50 μas**

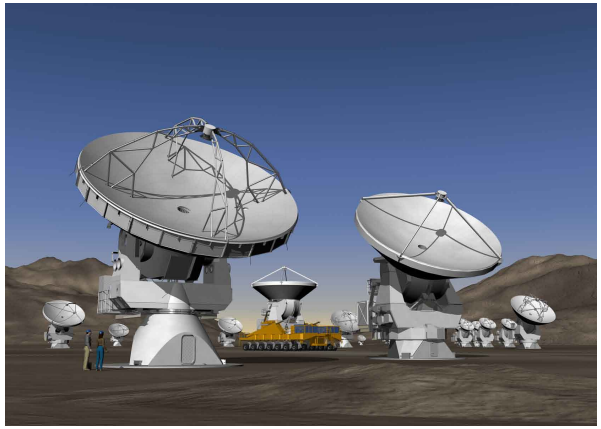


Genzel+10

Sgr A* spectrum

- Different $\nu \rightarrow$ different r
- **Innermost accretion flow** at few 100 GHz
- **Thermal synchrotron** emission dominates there





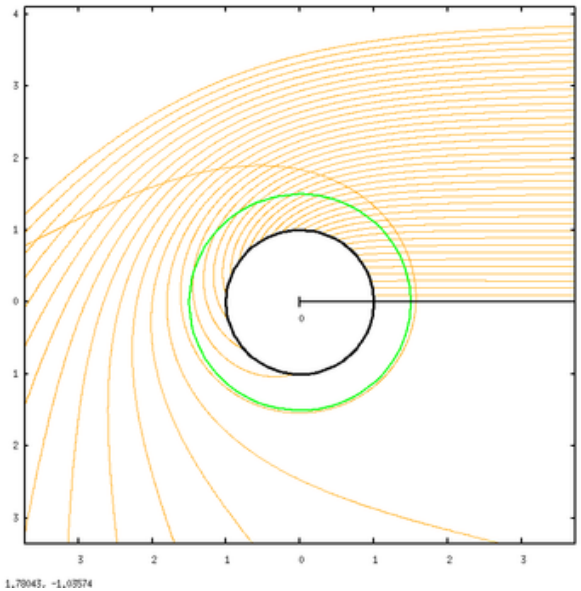
Event Horizon Telescope (2008-2020)

Quiescent state imaging

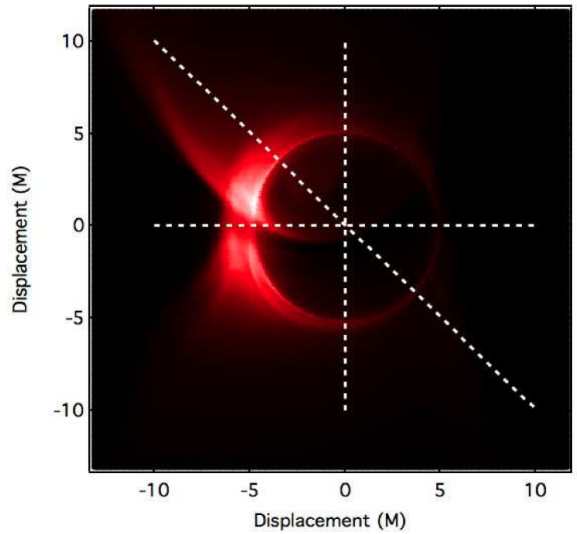
- EHT: **15 μas** resolution (mm; 230 and 345 GHz)

$\rightarrow$ Doeleman+08, *Nature, 455, 78*; Doeleman+09, *Astro2010 White Paper*

$\rightarrow$ What will it see?



Credit: R. Antonelli



Chan+14

EHT Goal

- Detect the **shadow/photon ring**
- Recent performance analysis: **10%** angular size precision (Psaltis+15)

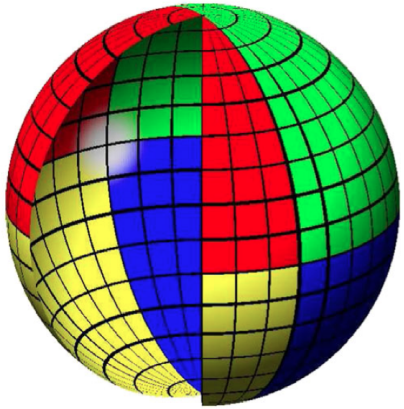
Our question

- Differentiate Kerr black hole / hairy black hole?

Hairy black holes + accretion torus

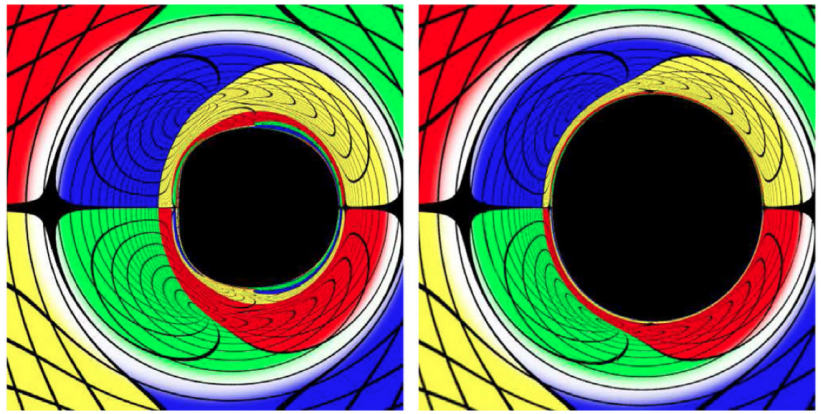
- Solution of Einstein-Klein-Gordon equations (standard GR), for a complex, massive, free scalar field
  $S = \int \mathrm{d}^4x\sqrt{-g}\left[R - \frac{1}{2}g^{\alpha\beta}\left(\Phi^*_{,\alpha}\Phi_{,\beta} + \Phi^*_{,\beta}\Phi_{,\alpha}\right) - m^2|\Phi|^2\right]$
  $\rightarrow$ Herdeiro & Radu, CQG, 32, 14, 144001 (2015)

- Toroidal accretion structure, emitting synchrotron in the EHT band
  $\rightarrow$ Vincent et al., A&A, 574, A48 (2015)



Painted celestial sphere

Rather non-Kerr hairy BH

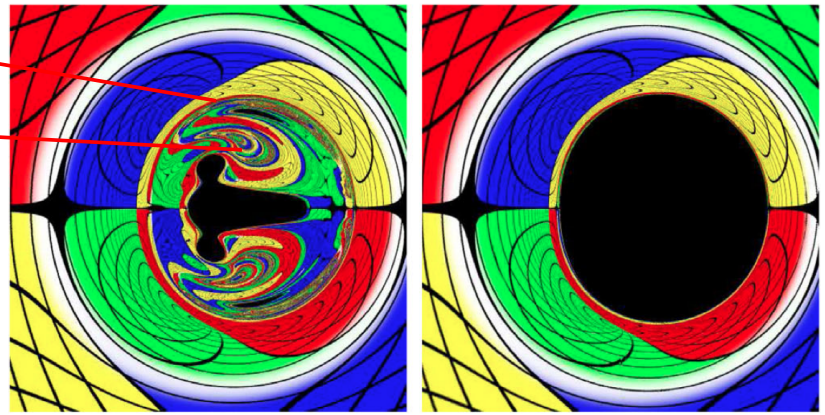


Comparable Kerr BH

Lensing ring

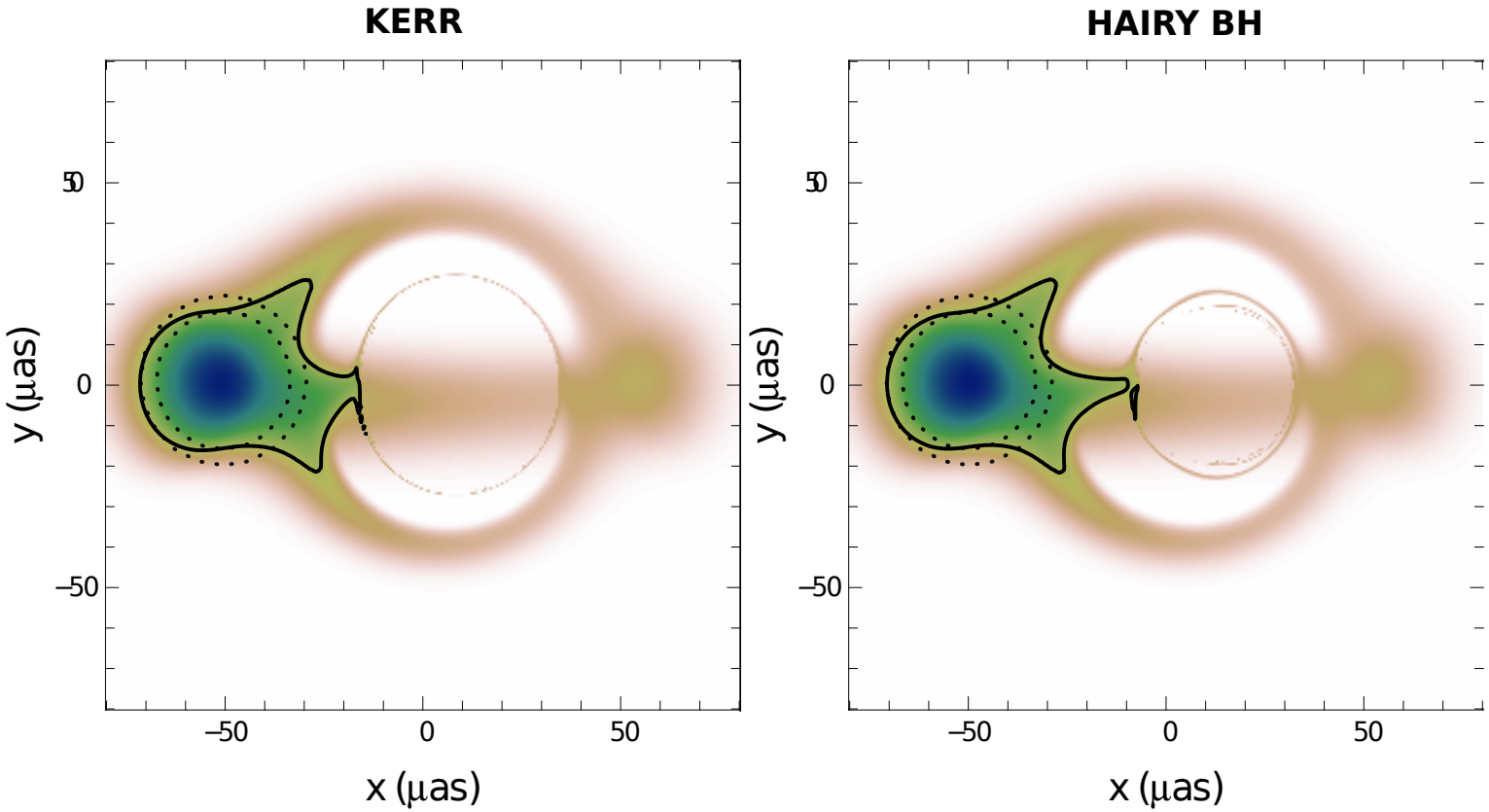
Hyper-lensed region

Very non-Kerr hairy BH



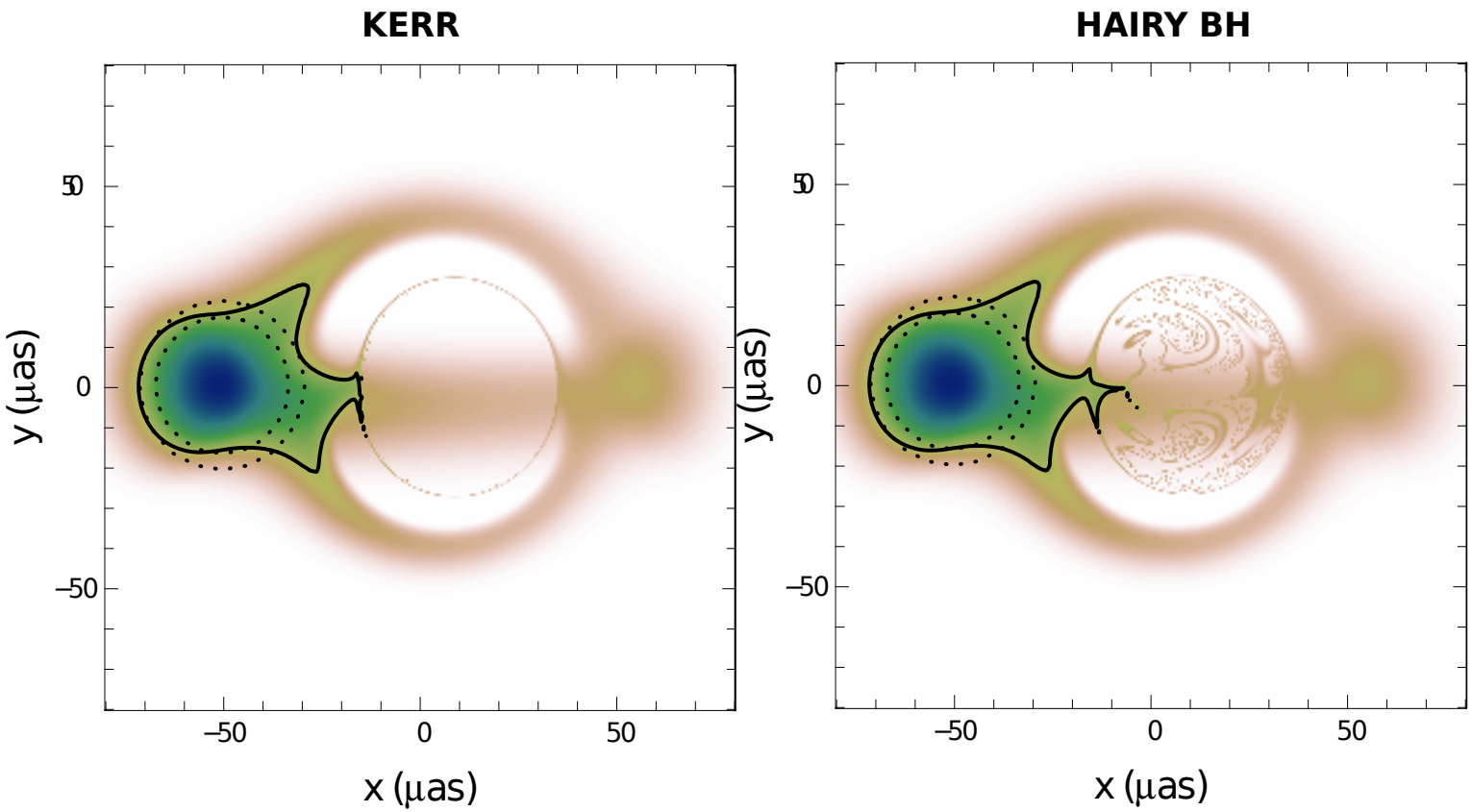
Comparable Kerr BH

Cunha+15



Rather non-Kerr hairy BH

- Lensing ring size 20% smaller than Kerr: **detectable**
- Size difference not degenerate with Kerr of different spin



Rather non-Kerr hairy BH

- No shadow-like region
- Kerr-designed algorithm would not converge: **detectable**

Conclusion

- Images of Kerr / sufficiently non-Kerr hairy BH differ
- Size of the photon/lensing ring
- Existence of a ring-like structure
- If sufficiently non-Kerr hairy BH exist, EHT can detect them