

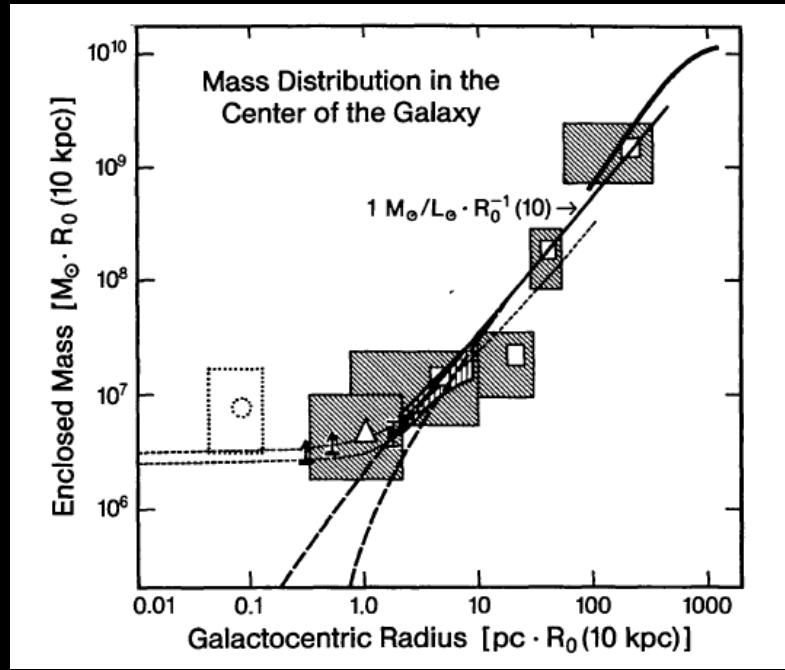
The Quest for the Galactic Center Massive Black Hole

and why Charlie knew it all along.

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Townes group evidence for a central mass concentration in 1985

motivated by black hole paradigm for QSOs (Lynden-Bell & Rees 1971)



→ but: concerns about gas tracing the gravitational potential

Wollman et al. 1977, Lacy et al. 1980, 1982, Serabyn & Lacy 1985, Crawford et al. 1985, Serabyn et al. 1987, Geballe et al. 1987, Genzel & Townes 1987

high resolution stellar NIR imaging/spectroscopy

adaptive optics @ the ESO/VLT and Keck



astrometric precision: 20 mas (1993) → 300μarcsec (2008)



**NACO
(NIRC2)**



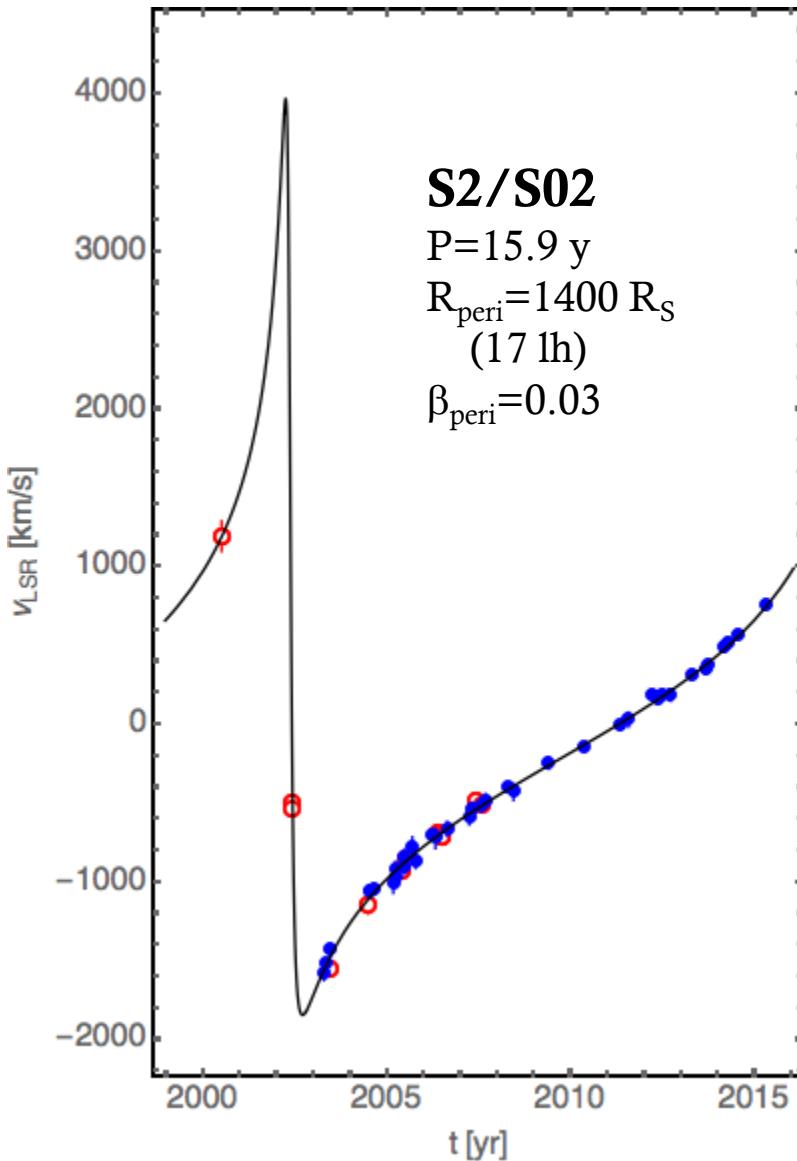
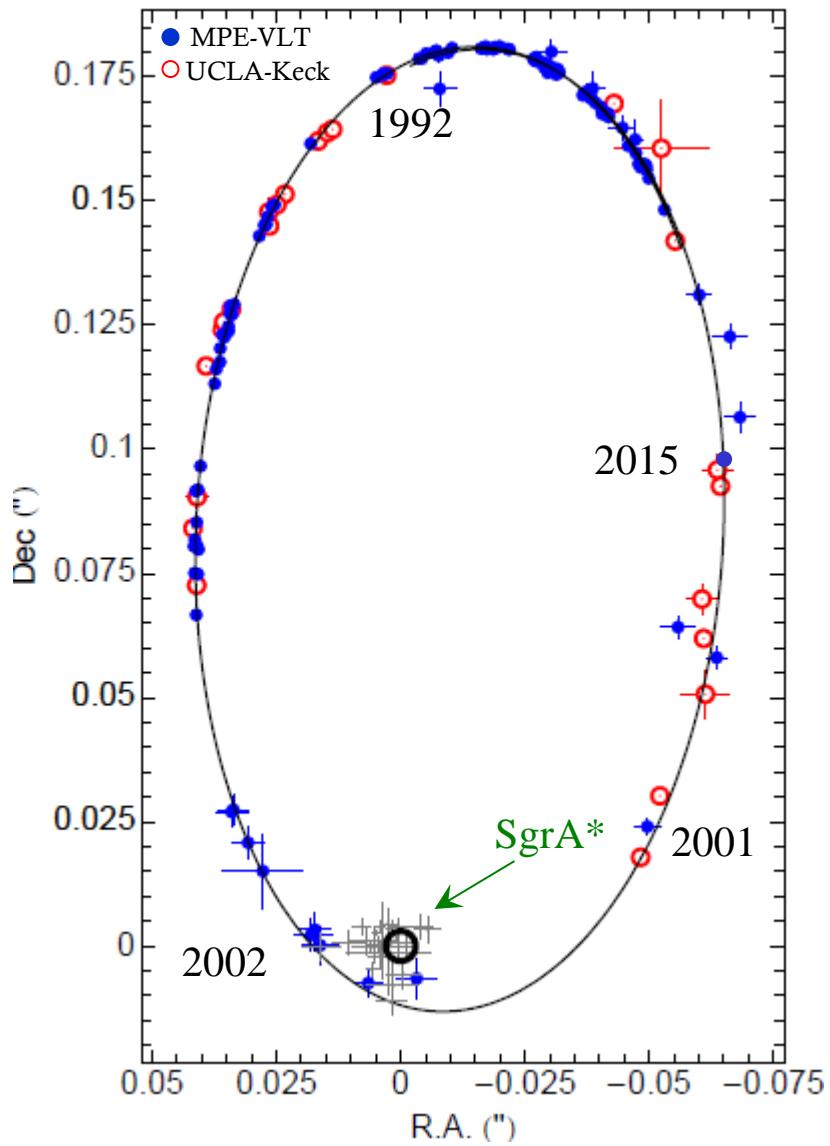
**SINFONI
(OSIRIS)**



**PARSEC
(LGSF)**

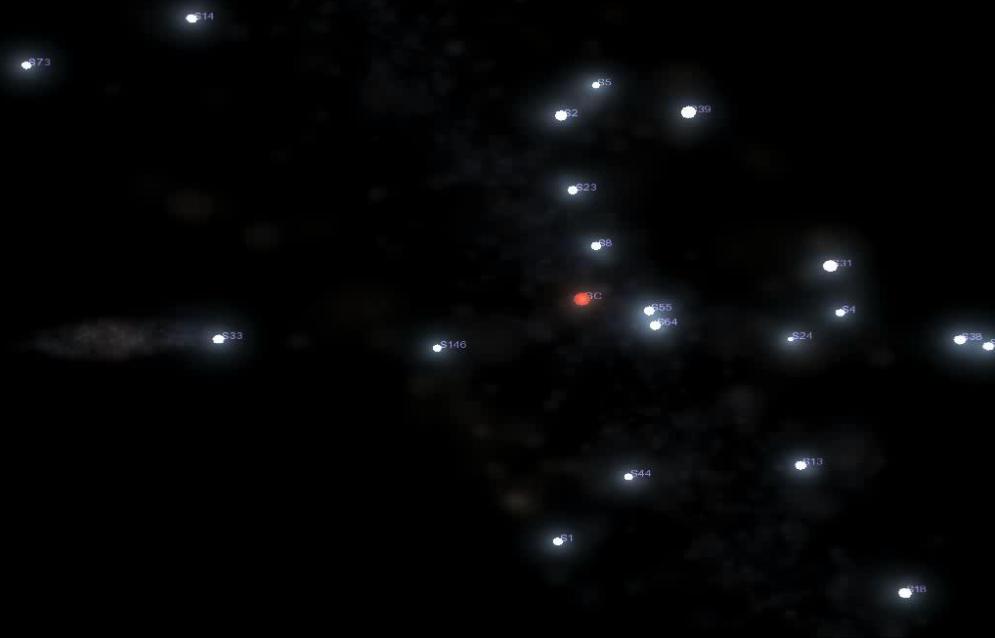


Stellar Orbits 1992-2015: S2/S02



Schödel et al. 2002, Ghez et al. 2003, 2008, Gillessen et al. 2009a,b

stellar orbits testing the potential



$$M_{\bullet} = 4.26(\pm 0.14)_{\text{stat}}(\pm 0.2)_{\text{sys}} \times 10^6 M_{\odot}$$

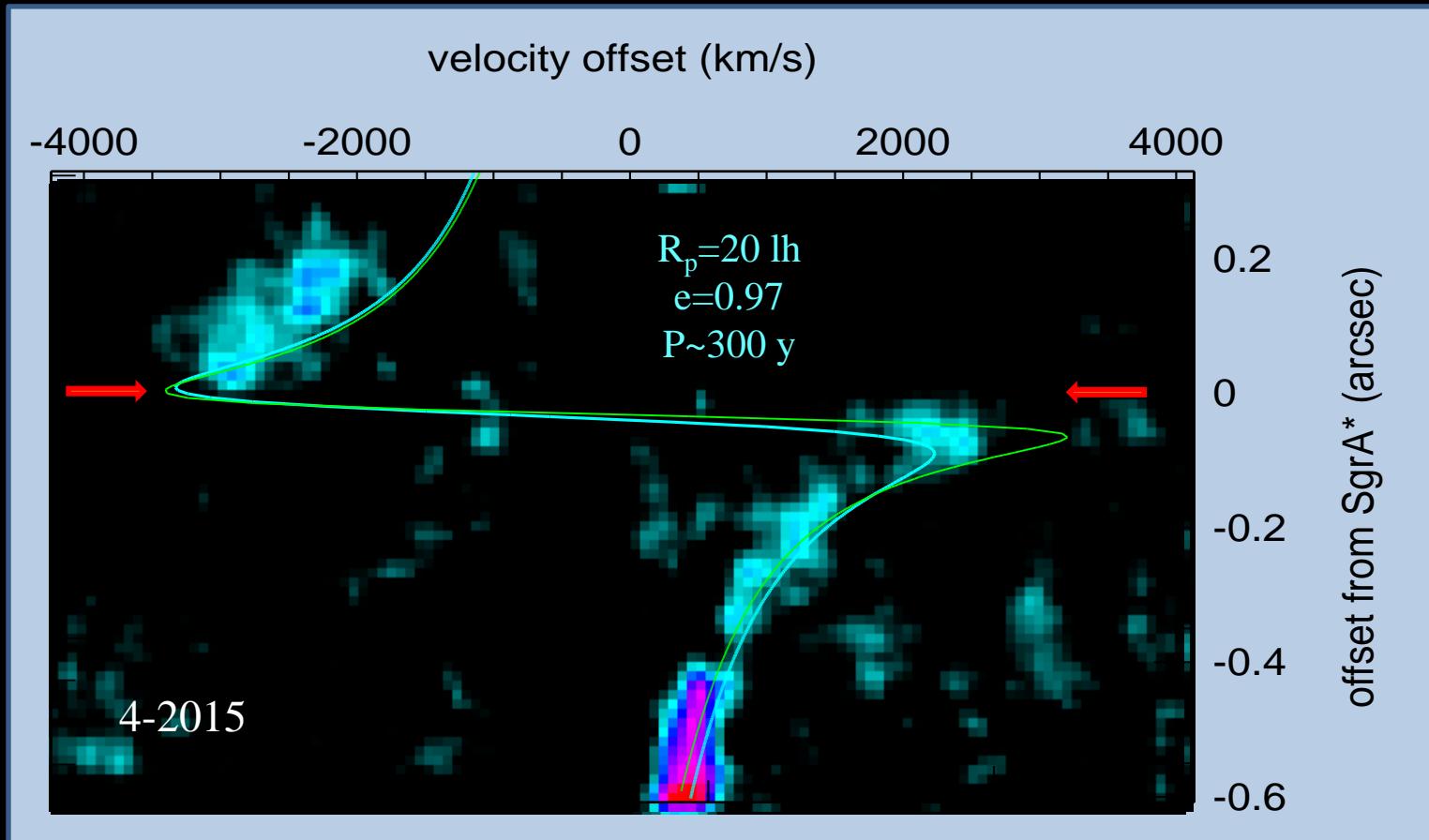
$$R_0 = 8.36 (\pm 0.1)_{\text{stat}}(\pm 0.15)_{\text{sys}} \text{ kpc}$$

$$\rho_{\bullet} > 10^{16..19.5} M_{\odot} \text{ pc}^{-3}$$

$$M_{\text{extended}}/M_{\bullet} < \text{a few } 10^{-2}$$

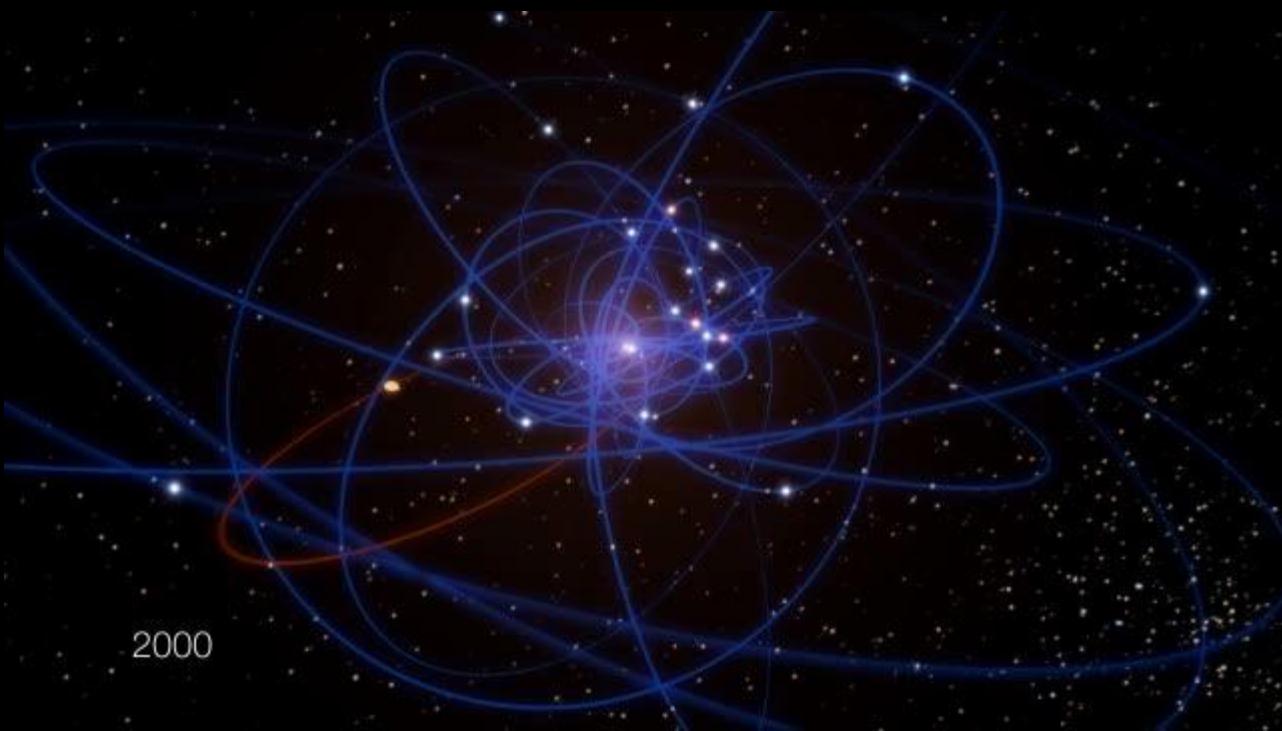
Schödel et al. 2002, 2003, Ghez et al. 2003, 2008, Gillessen et al. 2009a,b, Meyer et al. 2012, Chatzopoulos et al. 2015, Fritz et al. 2015, Plewa et al. 2015

Lacy et al. 1982: tidal disruption of stars



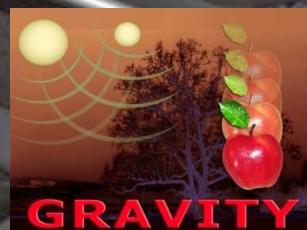
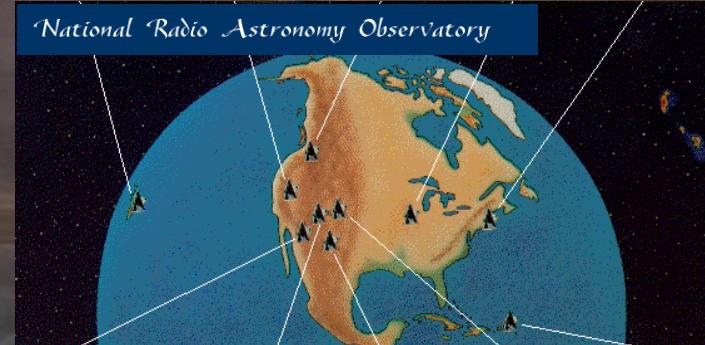
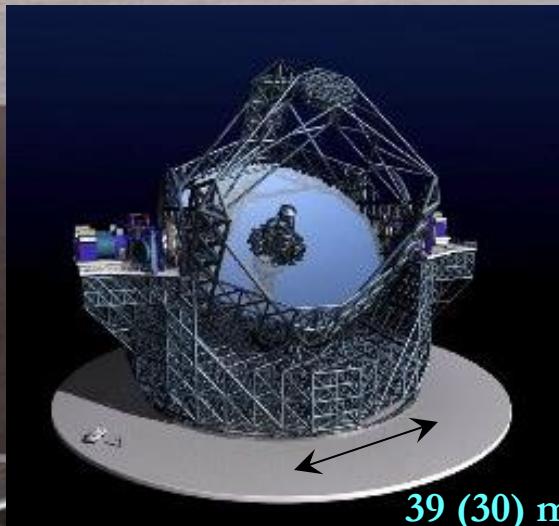
Evolution of pv structure of Br γ -emission in G2 2004-2015
with SINFONI & AO: Gillessen et al. 2012, 2013a,b, Pfuhl et al. 2014

Probing the accretion zone : disruption of a gas cloud



Gillessen et al. 2012, 2013, 2014, Pipher et al. 2014, Pfuhl et al. 2014, Witzel et al. 2014 theory: Burkert et al. 2012, Schartmann et al. 2012, Murray-Clay & Loeb 2012, Miralda-Escude 2012, Meyer & Meyer-Hofmeister 2012, Moscibrodzka et al. 2012, Scoville et al. 2013

The next step: using the GC-BH to test GR

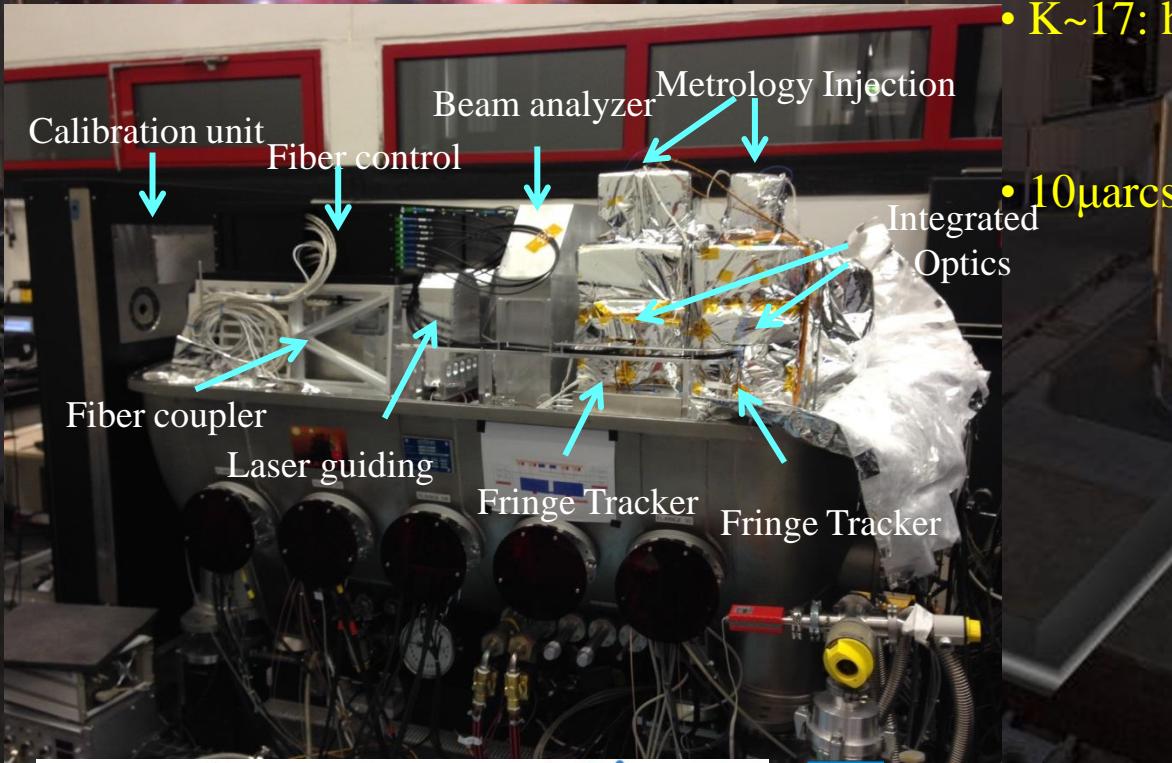
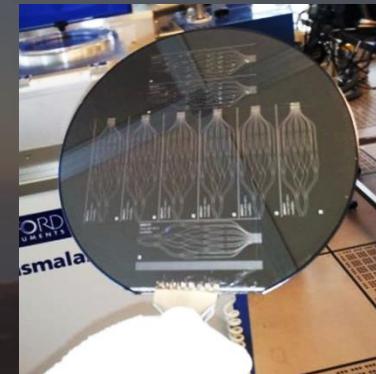
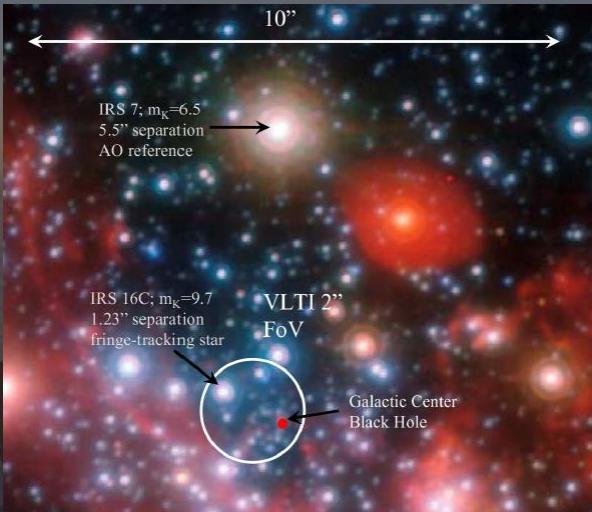


'GRAVITY' Experiment

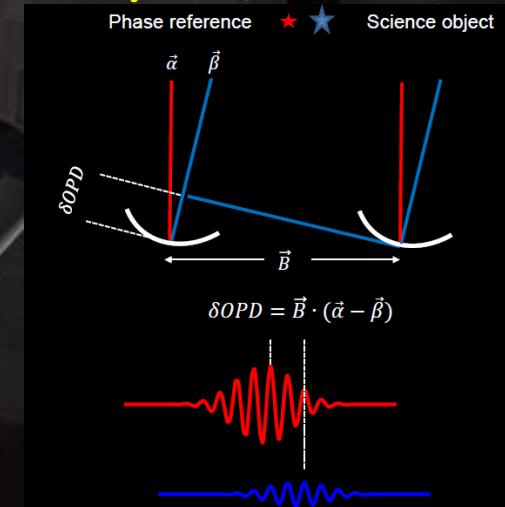
'shadow' of a massive
black hole

ESO-VLTI

GRAVITY concept

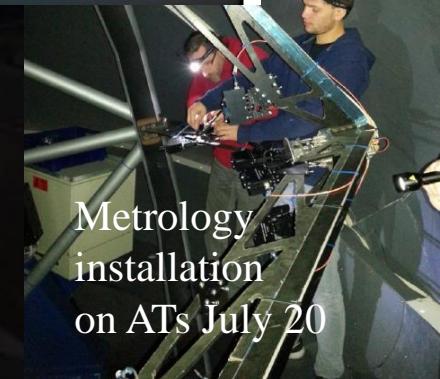


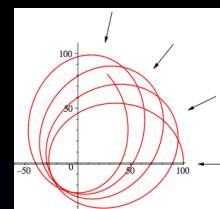
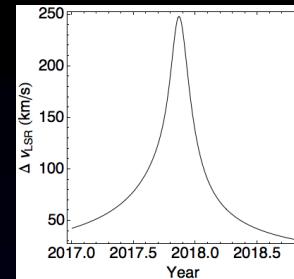
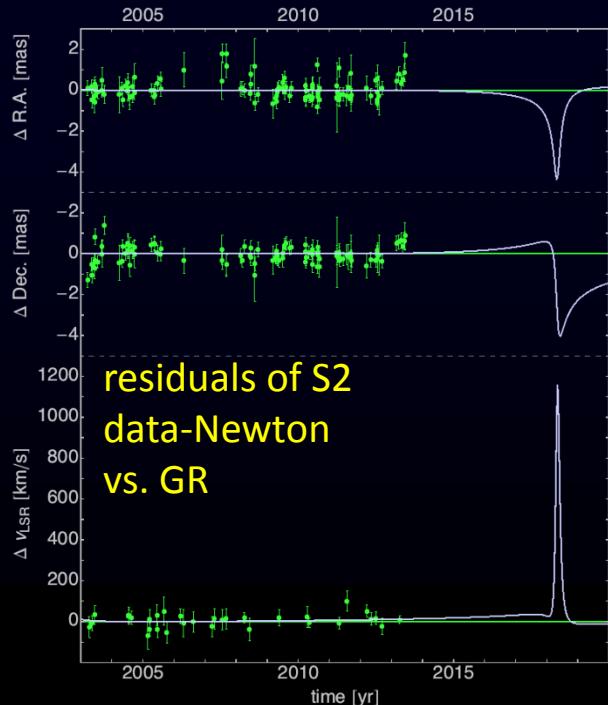
- dual beam astrometric interferometric imager
- K~17: high throughput optics on 4 UTs, efficient IR wave front sensing, active laser metrology
- 10μarcsec astrometry: phase/fringe tracking on nearby star (< 5nm rms)





First fringes July 21





2

more challenging

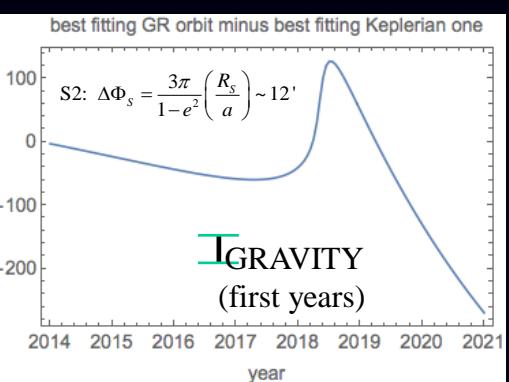
1

3

Lense-
Thirring
precession

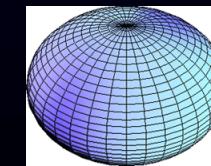
4

black hole
spin from
flares



Inward bound

IR & radio instruments



Quadrupole moment of
metric, no hair &
quantum effects

