The Infrared K-band Identification of the DSO/G2 Source from VLT and Keck Data

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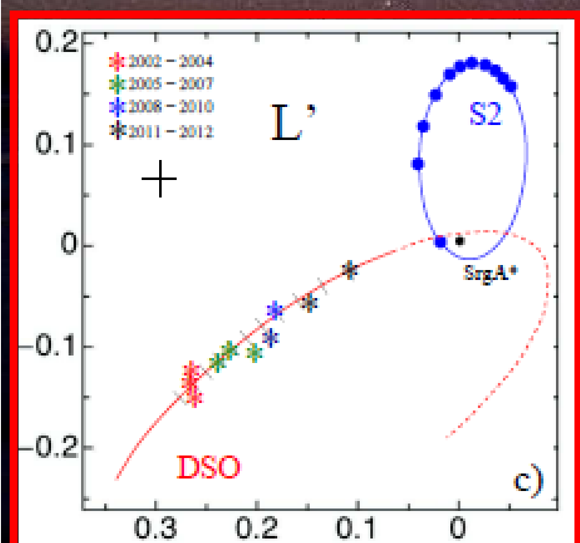
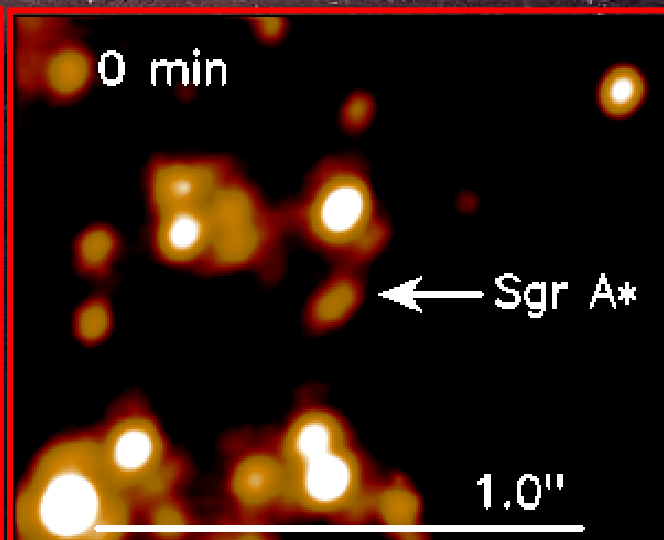
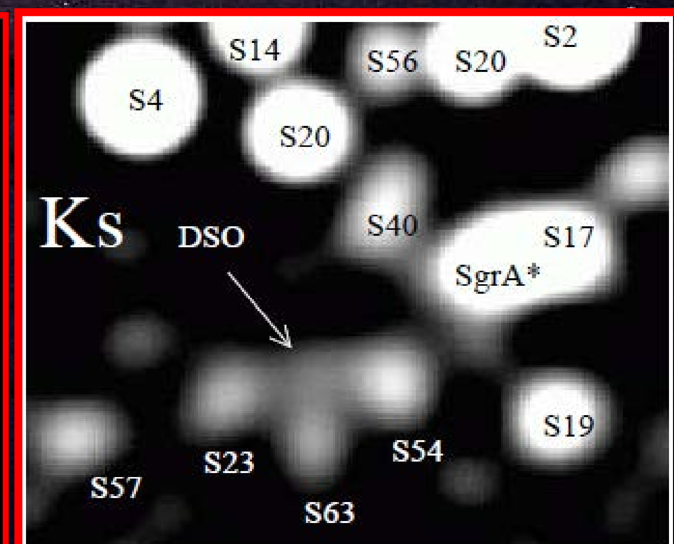






Talk Banafsheh Shahzamanian (University of Cologne, MPIfR) et al.
NIR Polarized Observations of Sagittarius A*

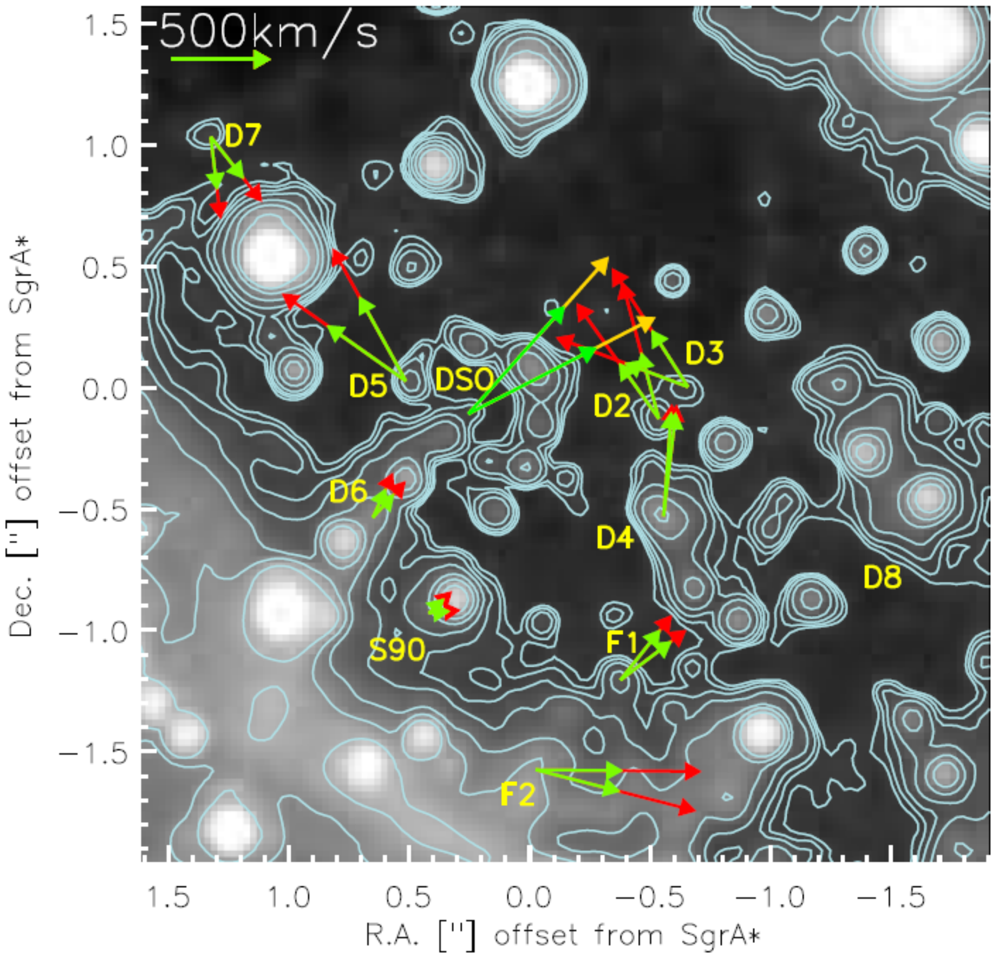
P29 Jihane Moultaka (IRAP - OMP, Toulouse, France) et al.
3D Mid-infrared View of the Central Parsec

P26. Behrang Jalali (University of Cologne) et al.
Star Formation in the Vicinity of Sgr A*

P33 Nadeen Sabha (University of Cologne / MPIfR)
Faint Point Sources and a Bowshock in the Central Parsec

P6. Lydia Moser (University of Cologne)
Sgr A West in the Light of Molecules, Ionized Gas and Dust

Proper Motions of Dusty Sources within 2” of SgrA*



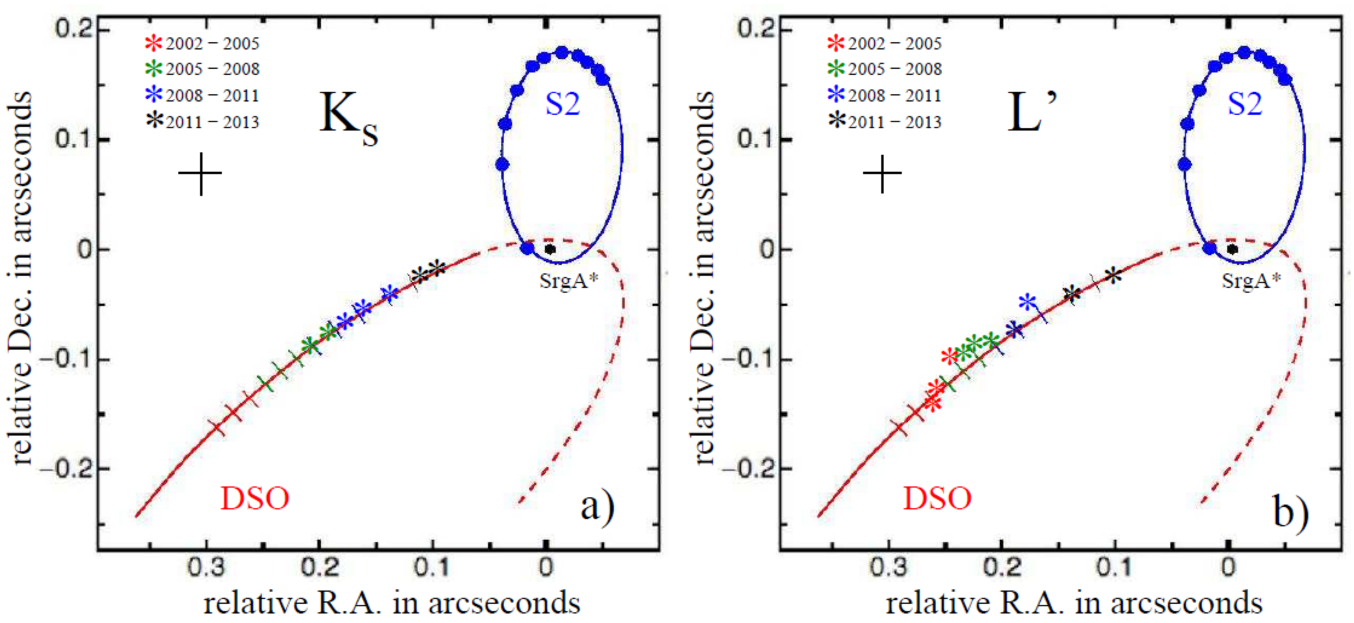
A&A 551, 18, 2013a - A. Eckart, K. Mužić, S. Yazici, N. Sabha, B. Shahzamanian, G. Witzel, L. Moser, M. Garcia-Marin, M. Valencia-S., B. Jalali, M. Bremer, C. Straubmeier, C. Rauch, R. Buchholz, D. Kunneriath, J. Moultaka and (2013b) S. Britzen, M. Horrobin, M. Zamaninasab, M. Bursa, G. Karssen, V. Karas, S. Smajic, K. Markakis, A. Borkar, A. Zensus

Cologne, Bonn, Prague, Toulouse & ESO

A Dusty S-cluster Object is approaching SgrA*

A dusty object that can be identified with a star or a pure dust cloud
Is approaching the Black Hole SgrA* at the
Center of the Milky Way (Gillessen et al. 2012, 2013, Eckart et al. 2013ab).
Periapse will probably be reached in ***September 2013 to May 2014***.

An enhanced accretion activity is expected. Brighter flares may also help to gain information of the particel acceleration processes.

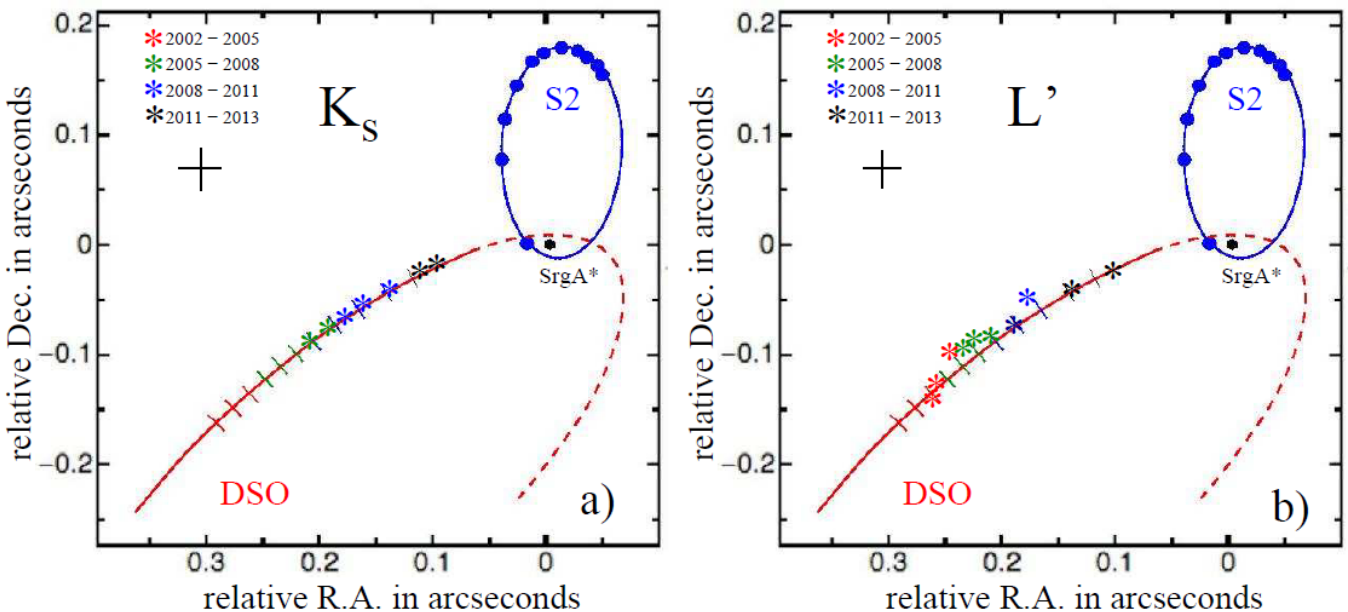


Gillessen+, Burkert+,
Murray-Clay & Loeb,
Eckart+
and others

Eckart et al. 2013a

A Dusty S-cluster Object is approaching SgrA*

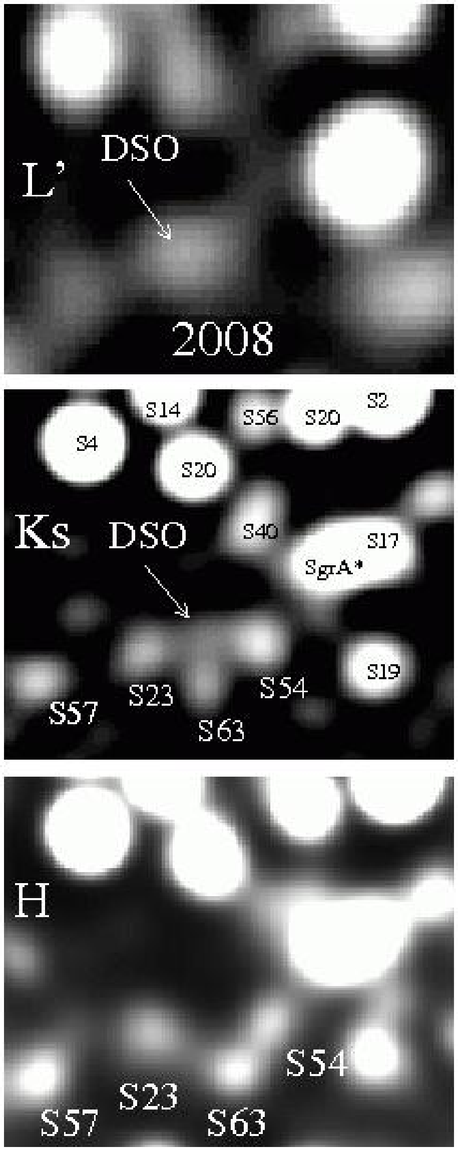
The K-band detection of the DSO/G2 source is important to explain expected accretion phenomena and related flux density variations of SgrA*.
It may also give a hint at what the nature of the DSO may be and how it originated.



Gillessen+, Burkert+, Murray-Clay & Loeb, Eckart+
und andere

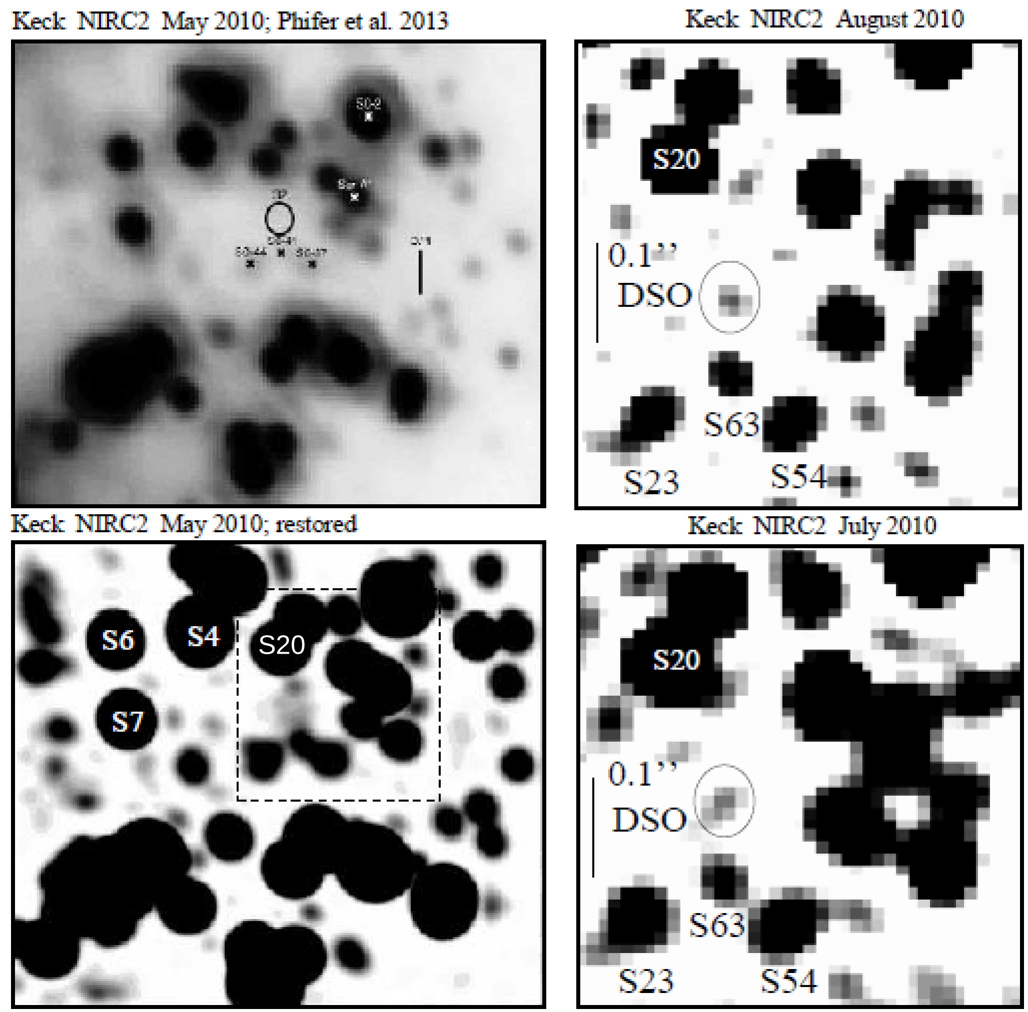
Eckart et al. 2013a

Keck and VLT data confirm a K-band



0.1'' = 4 mpc

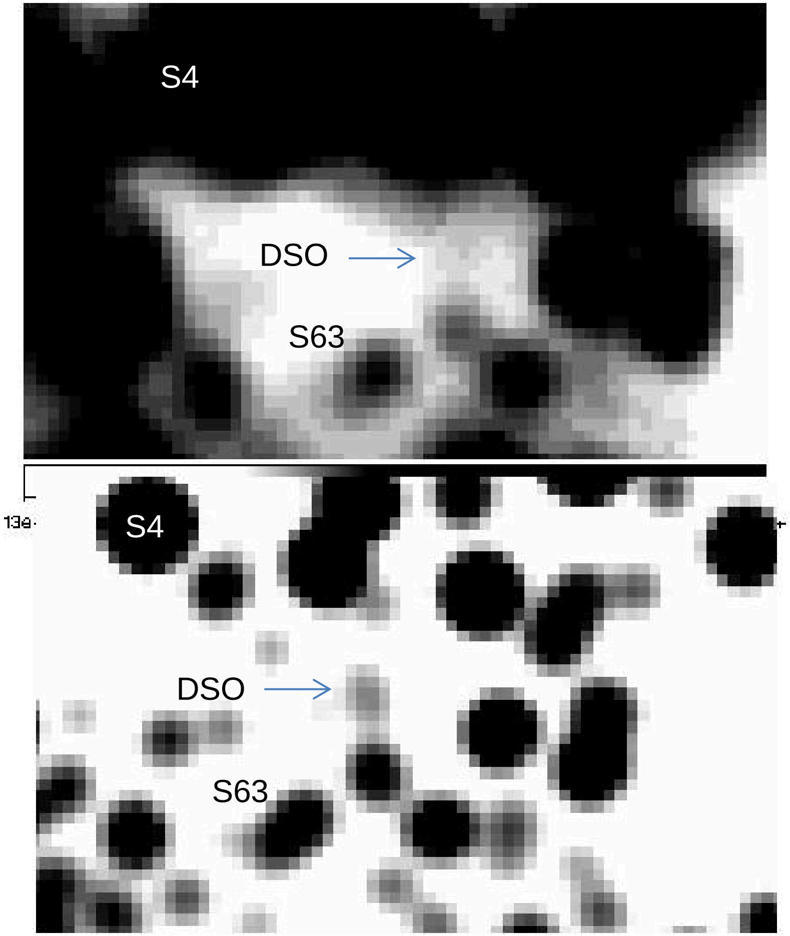
Keck NIRC2; P.I.: Lu, Morris & Soifer



ESO NACO Eckart et al. 2013a

No confusion with S63 since 2008

DSO identified in public Keck data



Example:
August 2010 data – the K-band counterpart of the DSO can be seen in the raw adaptive optics data

Lucy deconvolved and reconvolved with a Gaussian to an angular resolution that Is close to the one observationally achieved.

P.I.: J. Lu, M.R. Morris, T. Soifer

W. M. Keck Observatory and the NASA Exoplanet Science Institute (NExScI), under contract with the National Aeronautics and Space Administration.

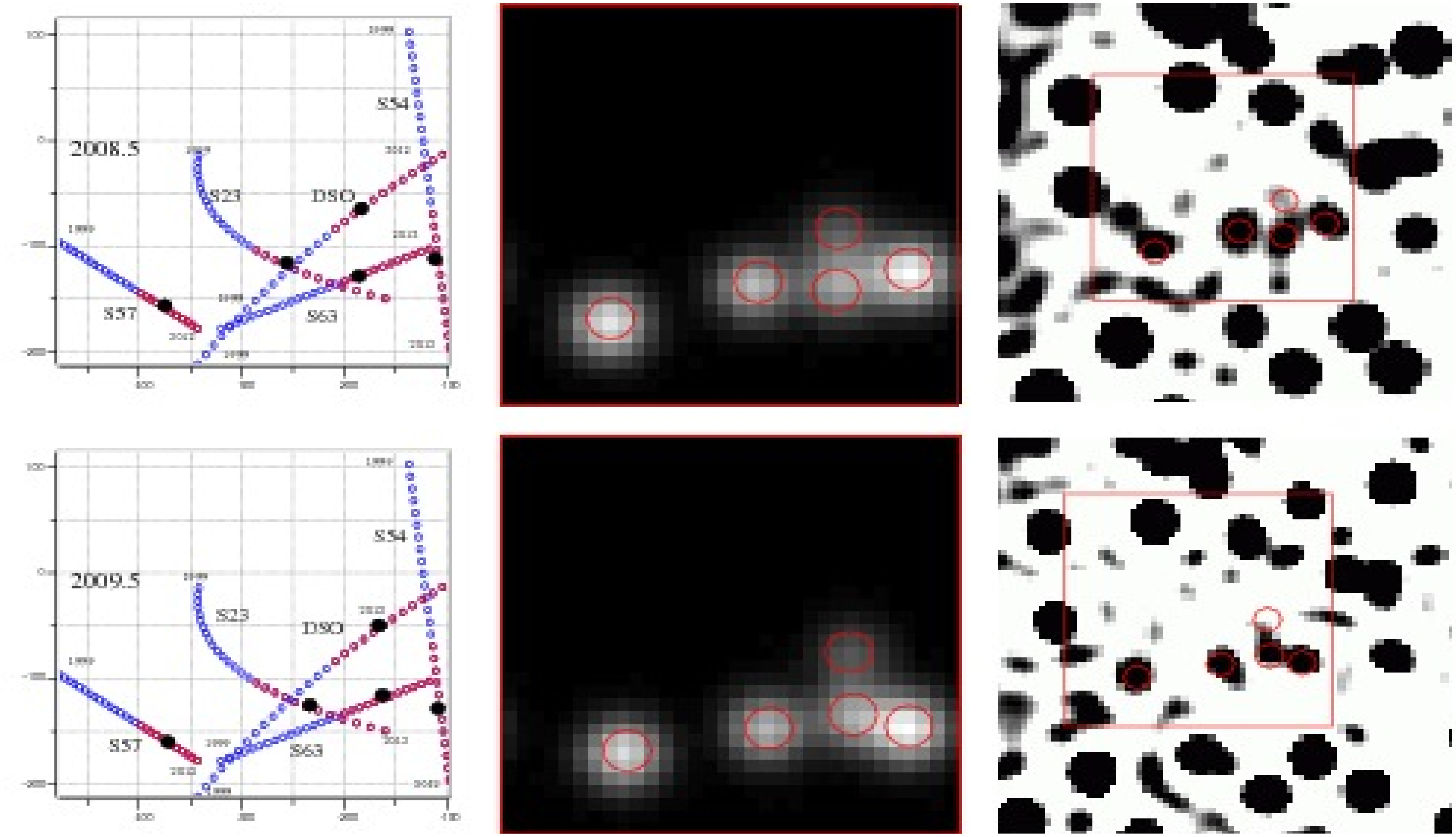
DSO identified in public Keck data

~0.3“x0.35“ field

α–δ trajectories | modelled emission | NIRC2 K‘-band Keck

2008

2009



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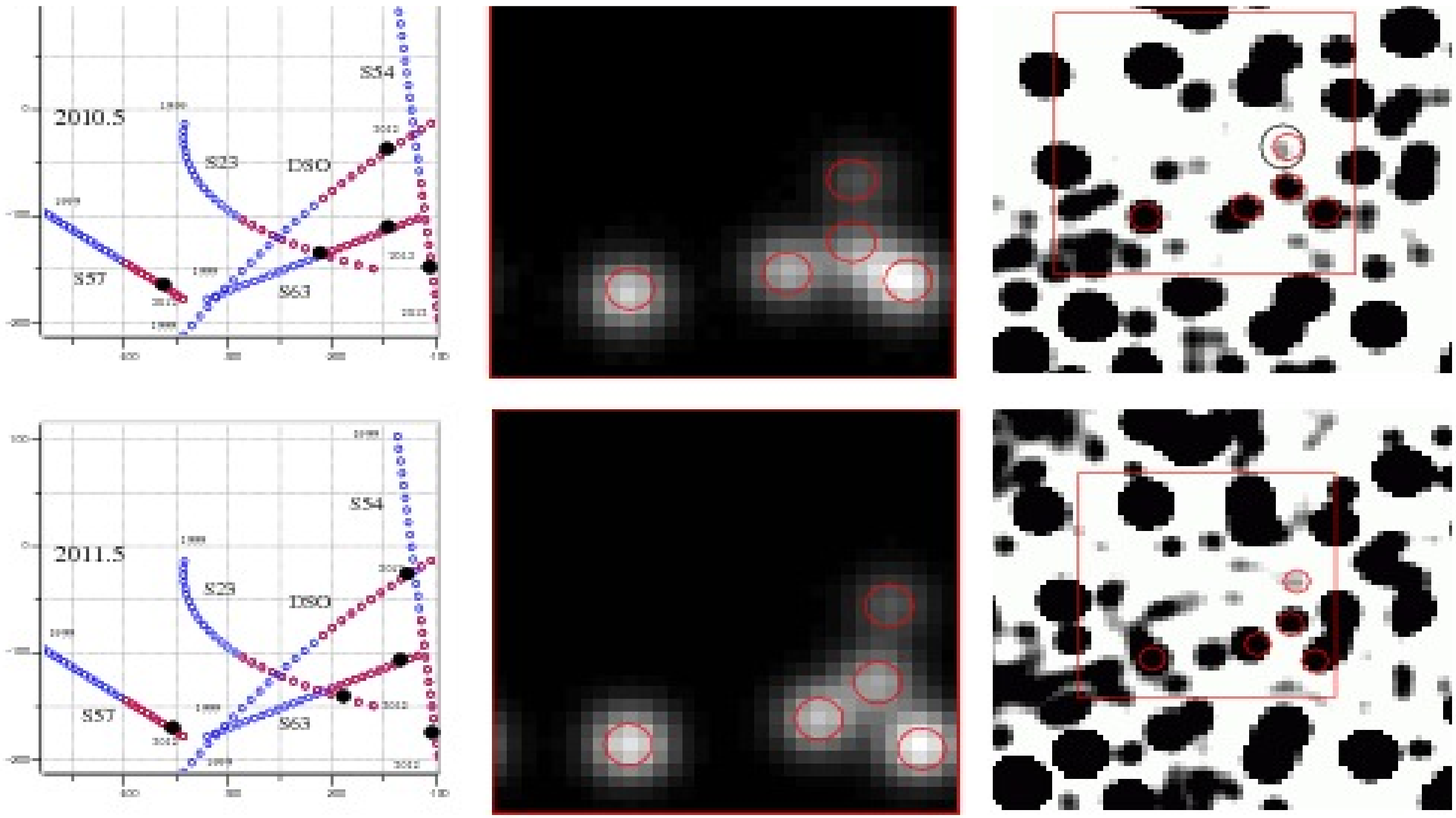
DSO identified in public Keck data

α–δ trajectories | modelled emission | NIRC2 K'-band Keck

2010

2011



at least 2 epochs in 2010

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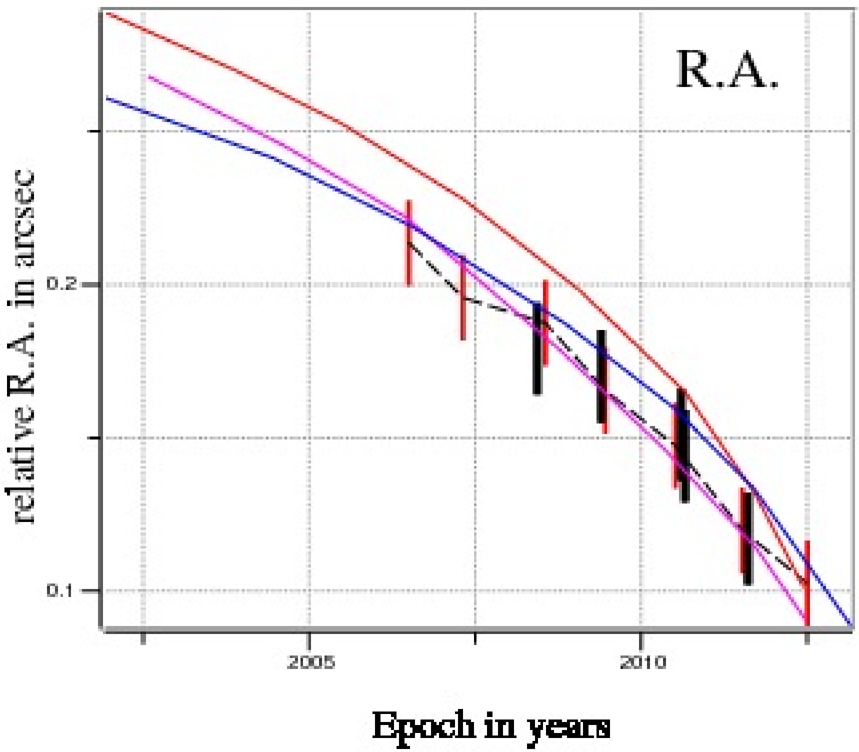
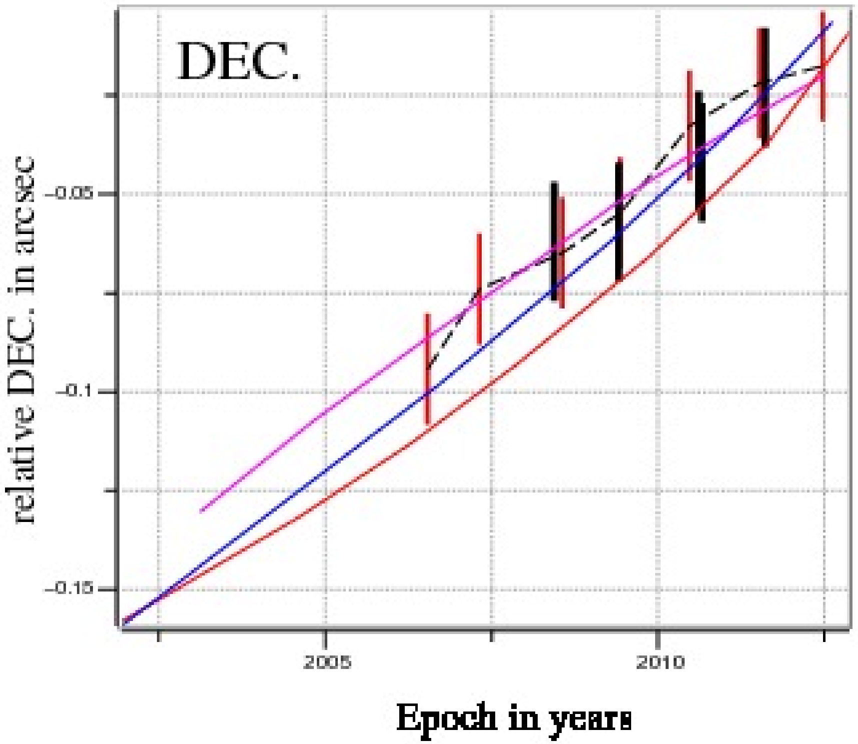
Comparison of trajectories published for DSO/G2





A comparison between the L'-band tracks of the DSO used by Gillessen et al. (2013) (magenta line; L'-band), Phifer et al. (2013) (blue (K'-band Brγ) and red (L'-band) lines). We also show the coordinates obtained from the Ks-band identification by Eckart et al. (2013a) using VLT NACO data (data points with red error bars connected by a black dashed line).

Data point with thick red and black error bars represent the K'-band identification based on NACO and Keck NIRC2 data.

VLT/Keck indentification of the DSO/G2 source

What is the K-band flux due to?

Could it be hot dust?

In the case of the dusty IRS13N sources
we have H-band identifications as well
which support photospheric emission
from stars rather than emission from hot dust.

VLT/Keck indentification of the DSO/G2 source

In the case of the DSO there are to possibilities:

1) *The DSO is an externally heated cloud:*

We would then expect the hot dust emission
to be rather extended, similar to the Brγ emission
which is reported to be extended over up to 0.2“
(Gillessen et al. 2012).
Not observed
Temperature gradients that may point at an external
heating excess due to hot stars near gas and dust
filaments etc. are not seen throughout the mini-spiral
and other dusty sources close to the center.
The dust is mostly at 200 K (except IRS3 and IRS7
which are hotter and contain a star).

VLT/Keck indentification of the DSO/G2 source

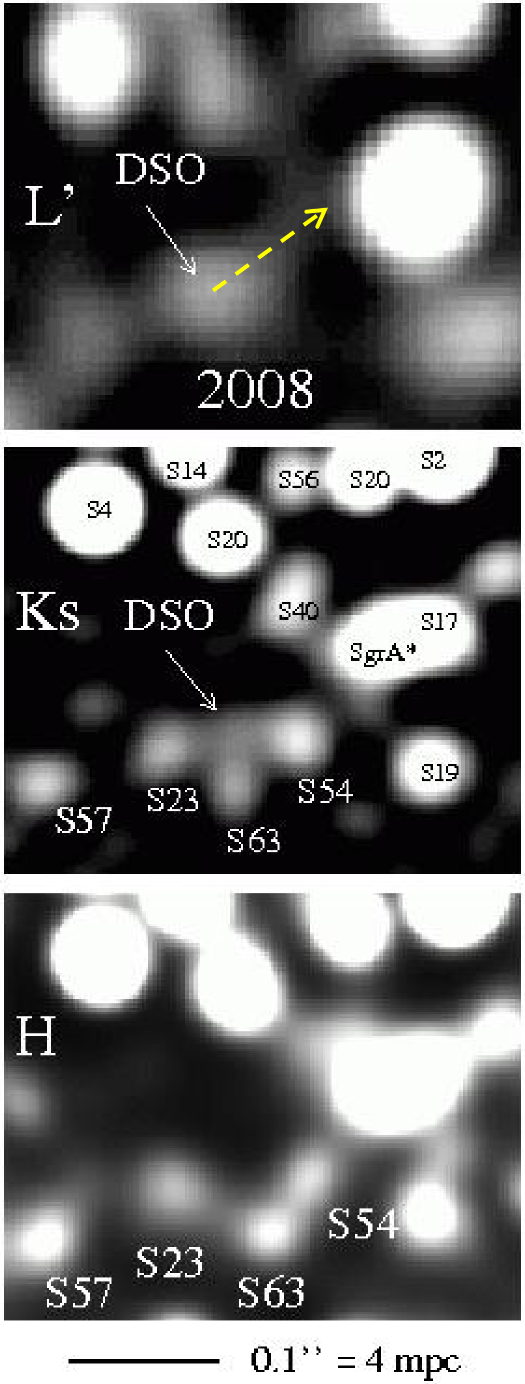
2) ***The DSO could be an internally heated cloud:***

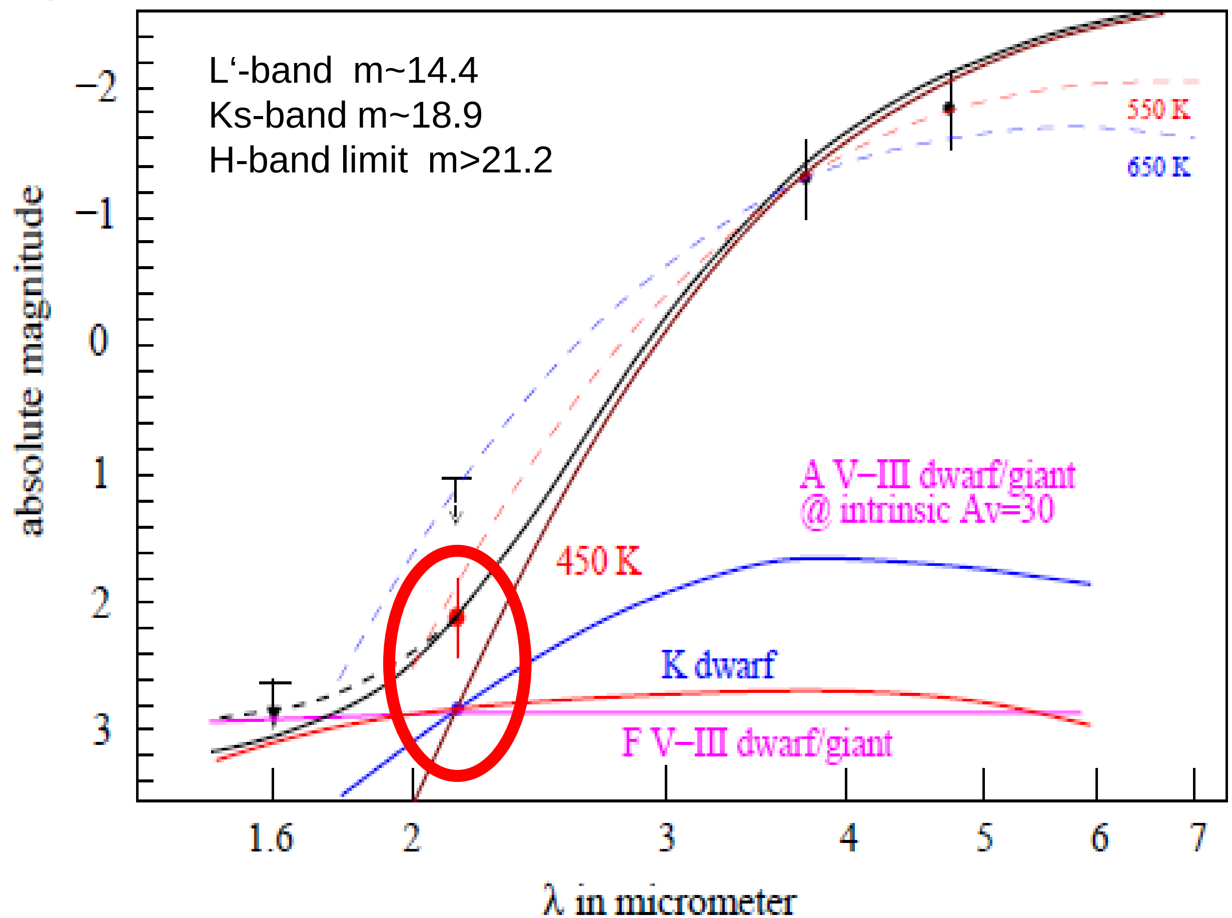
Here we expect compact K-band emission as observed
… but now we need an internal heating source.

This points at the presence of an embedded star ....

… and leads us in fact to the interpretation that the K-band flux is *photospheric emission* from an embedded star (with possible contributions from hot dust).

K-band identification of the DSO

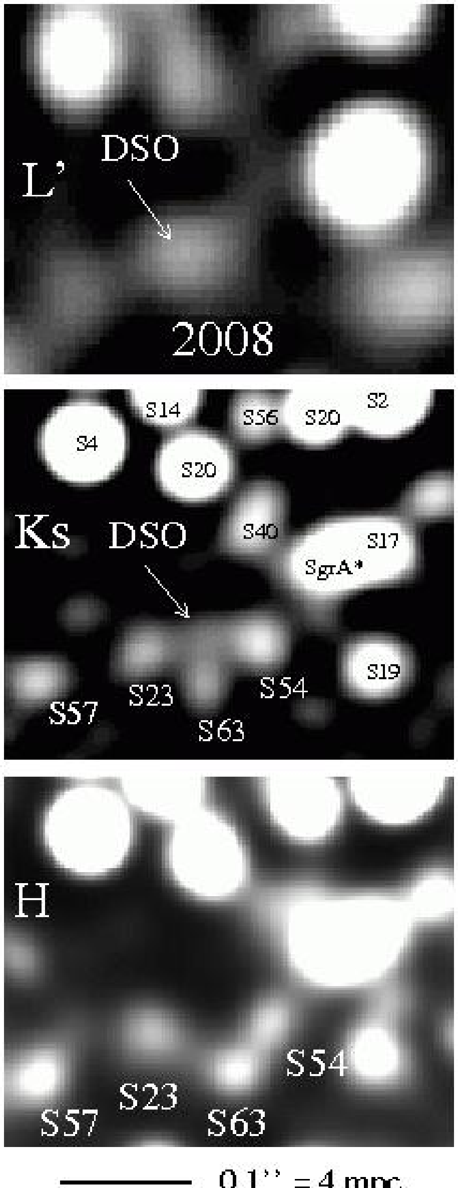




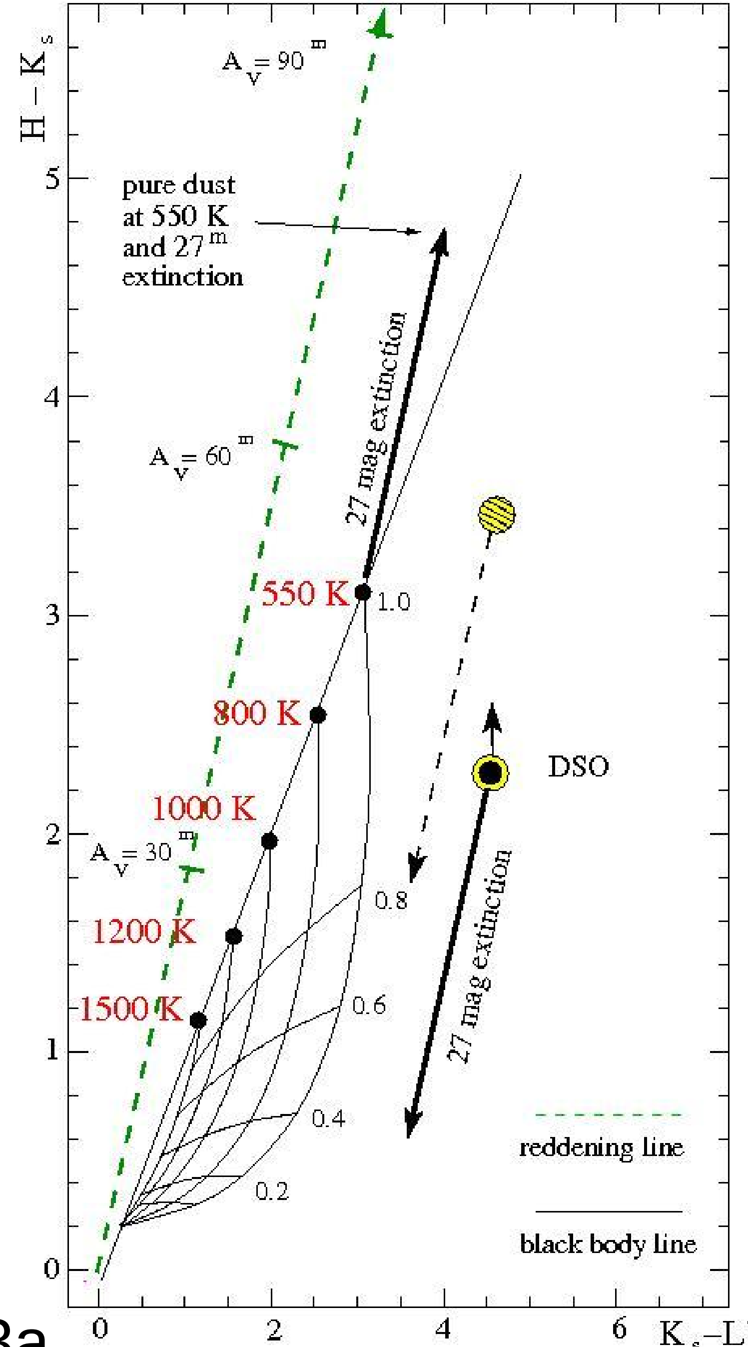
Eckart et al. 2013a

Black body luminosities and the detection of photospheric emission imply possible stellar luminosities of up to 30 Lsol ; i.e. masses of 10-20 Msol are possible

NIR Colors of the DSO



L'-band m~14.4
Ks-band m~18.9
H-band limit m>21.2



Eckart et al. 2013a

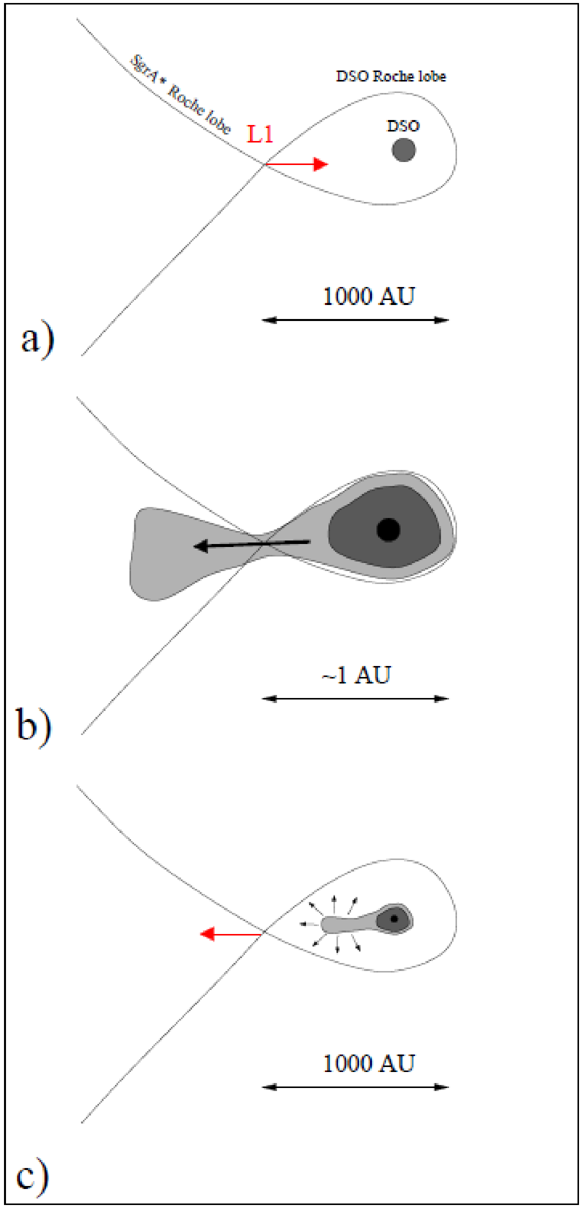


Fig. 16. Sketch of the relative position and motion of the Lagrange point L1 and the DSO.

Eckart et al. 2013a

DSO Accretion in 2013/14 ?

The presence of a star may have a influence on the accretion activity. *(20-30 Msol gives L1 distance ~1 AU)*

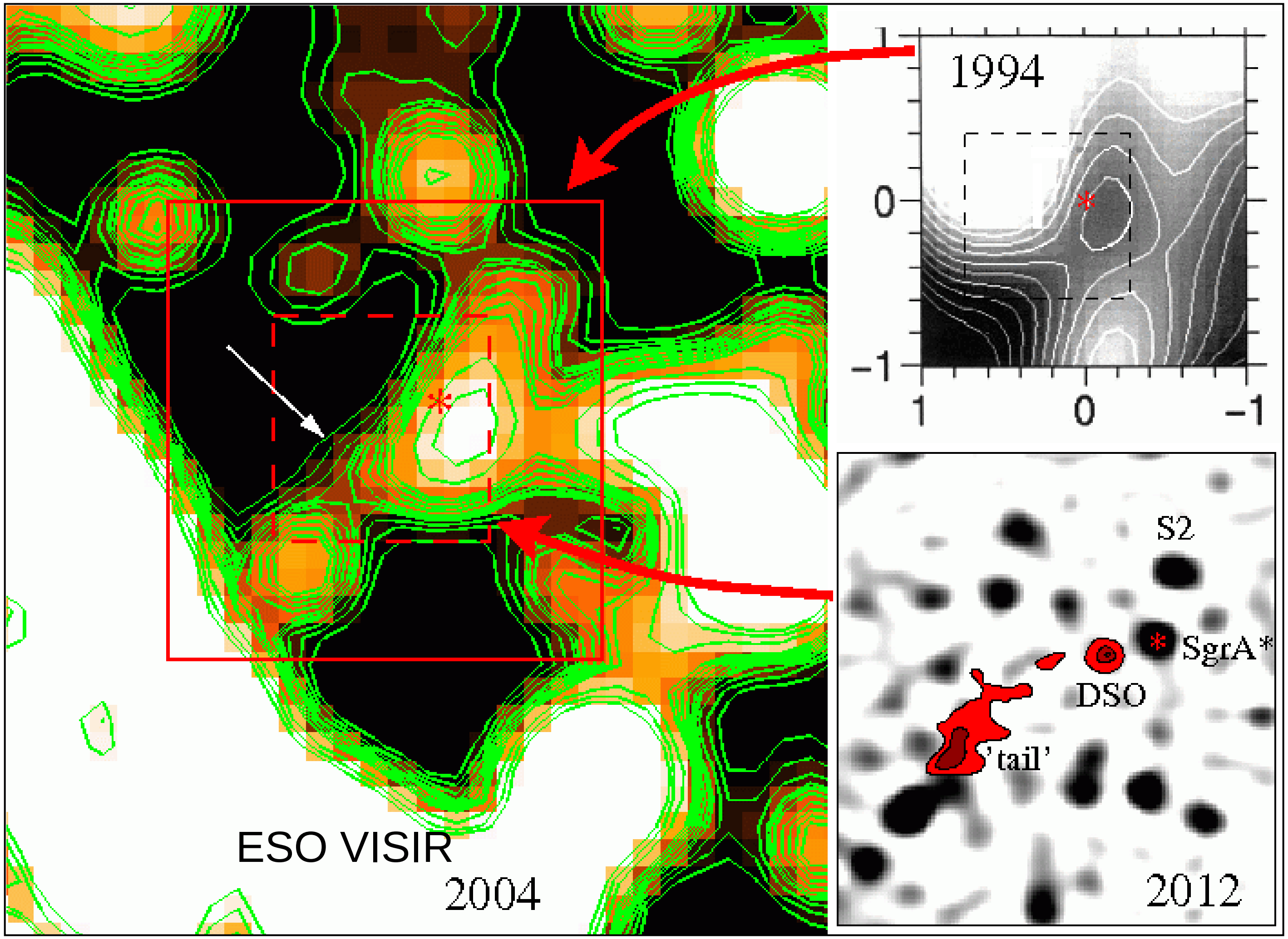
Simulations by Schartmann + 2012; Burkert + 2012 and others.

The NIR/MIR continuum emission is due to a compact object (<80mas), while the Brγ line flux is extended over 0.2"(Gillessen + 2012)

Dust source at the GC and variability

But …. !

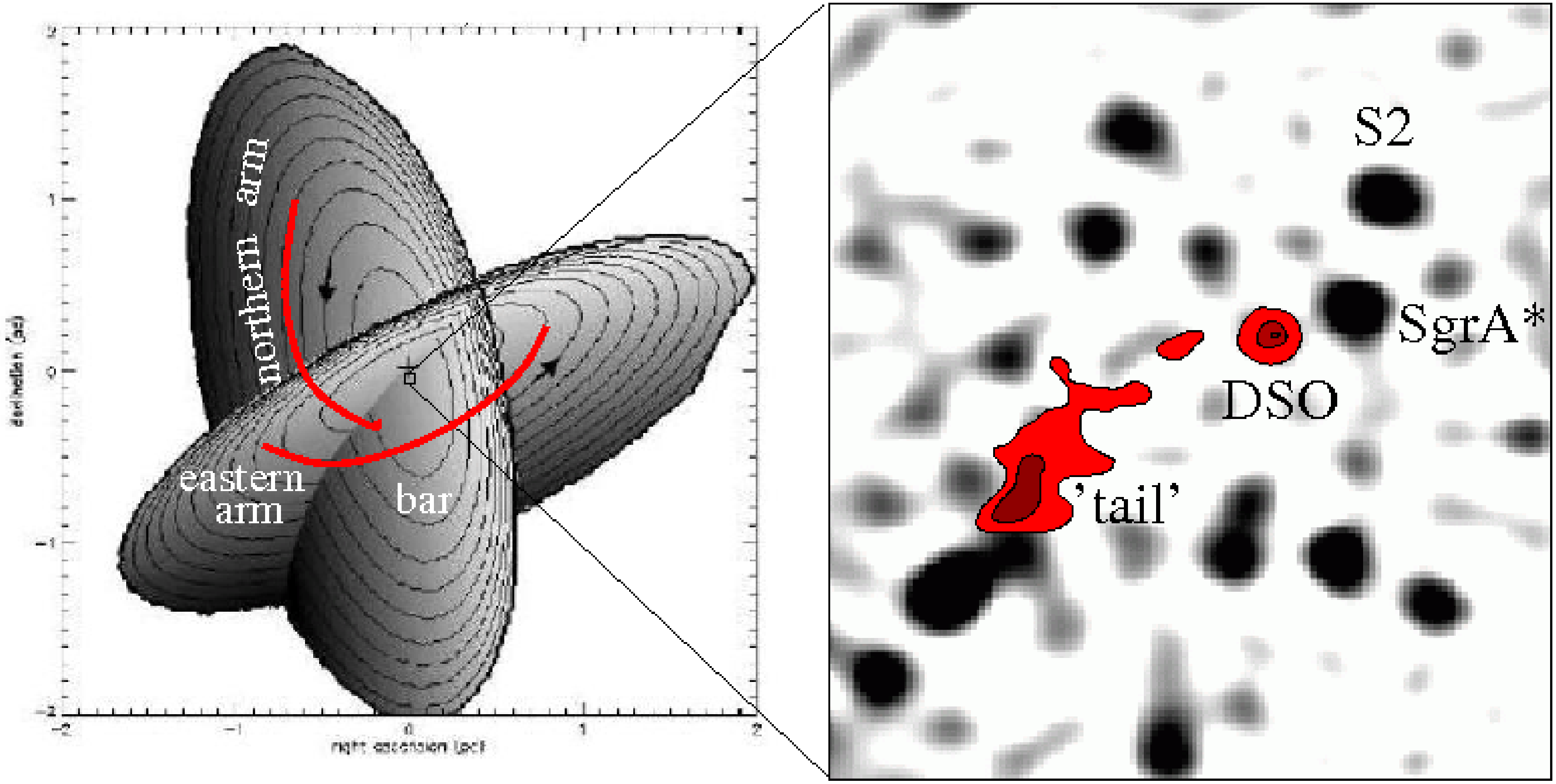
Gas and dust in the direction of Sagittarius A*



8.6 μm Palomar
Stolovy 1996

Eckart et al. 2013b
Gillessen et al. 2013

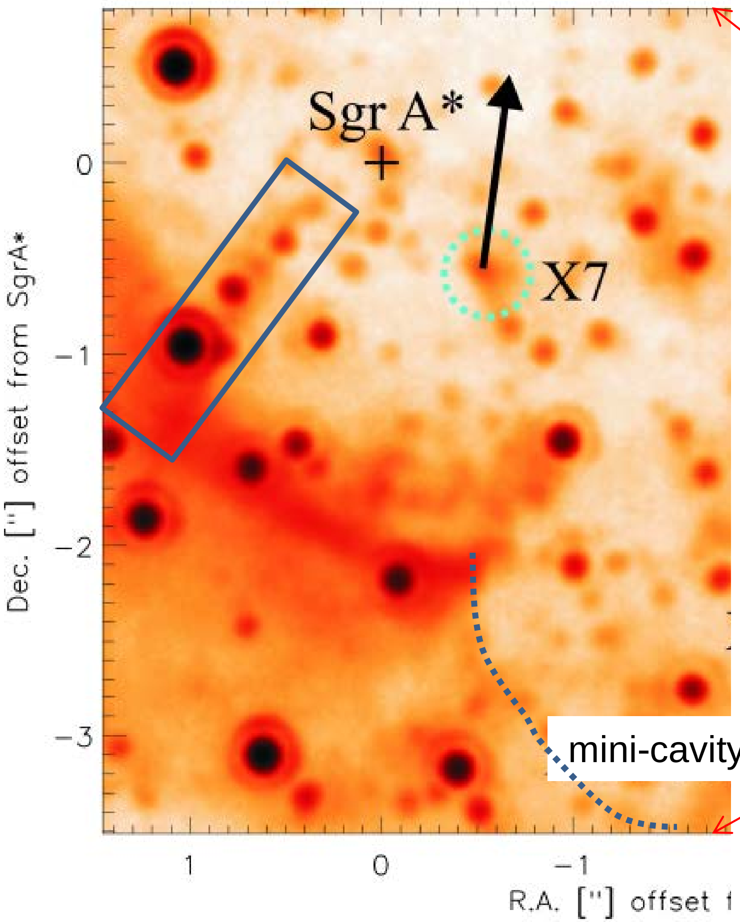
The ‘tail‘ may be part of the disk interaction zone



Vollmer & Duschl 2000

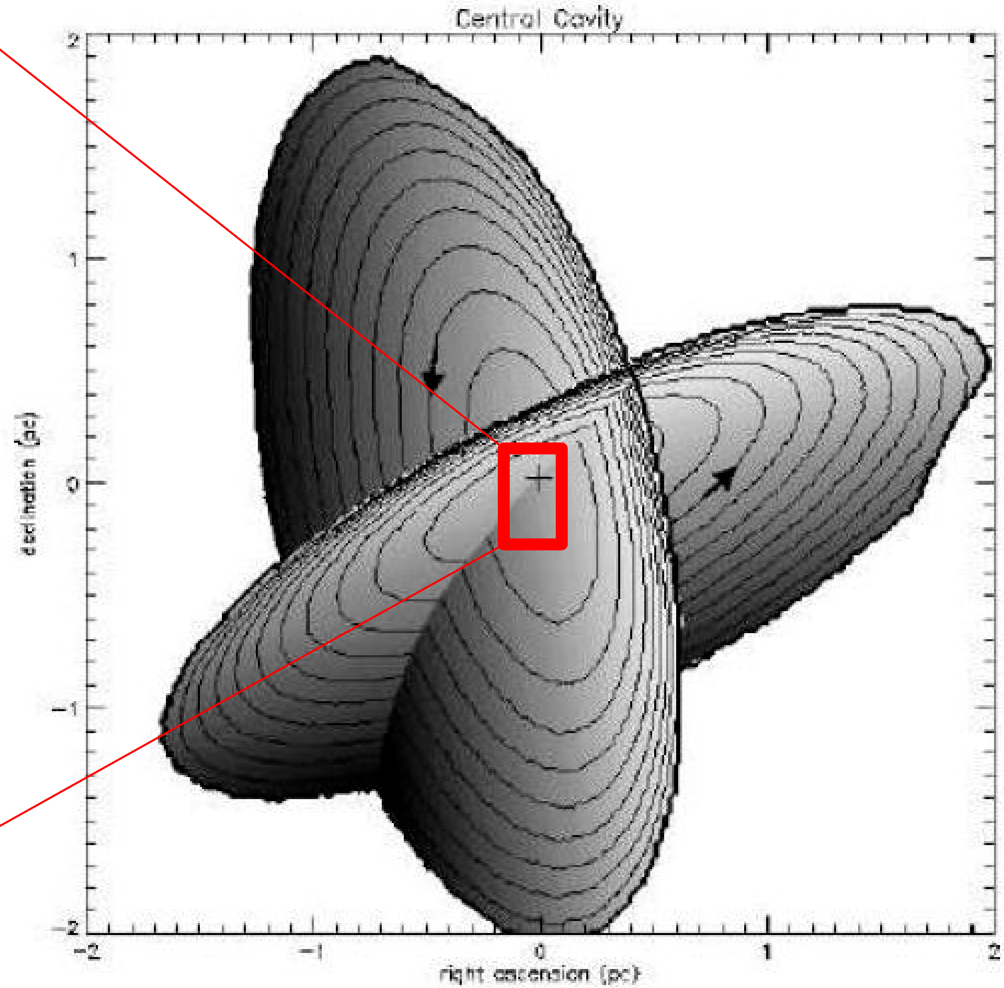
Eckart et al. 2013b
Gillessen et al. 2013

The 'tail' may be part of the disk interaction zone



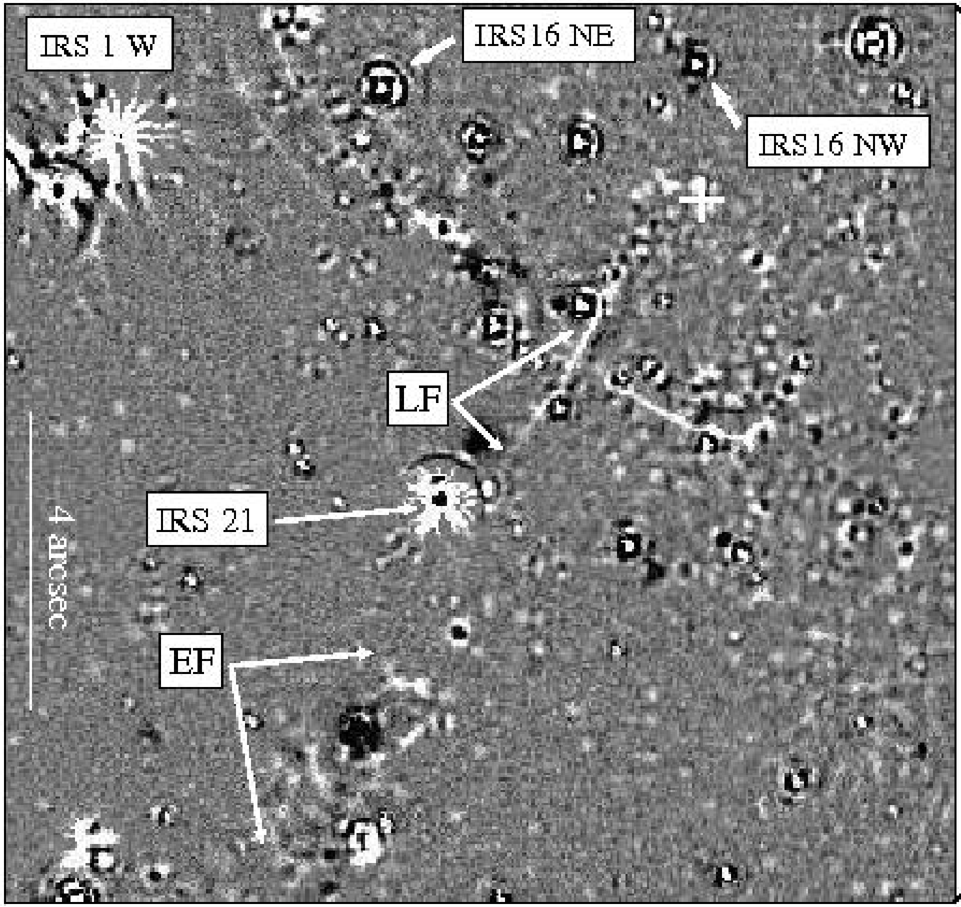
L-band image of the GC

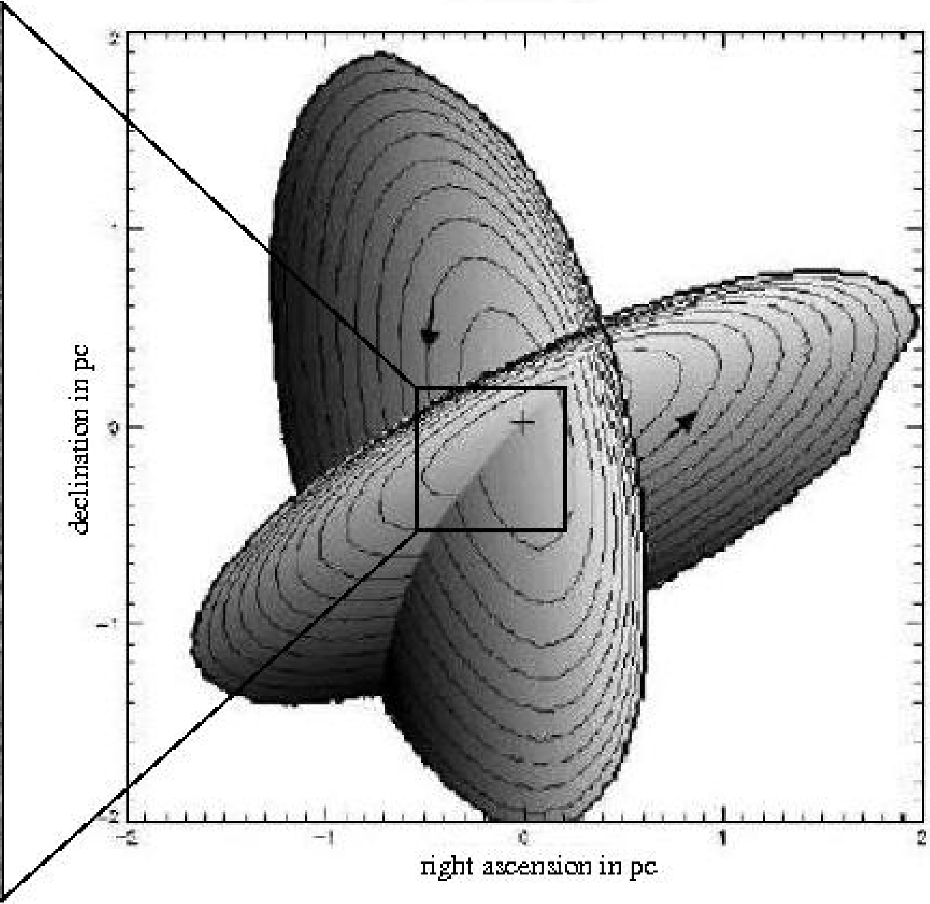
Muzic, Eckart, Schödel et al. 2007, 2010



Vollmer & Duschl 2000

The ‘tail‘ and ‚linear feature‘ may be part of the disk interaction zone



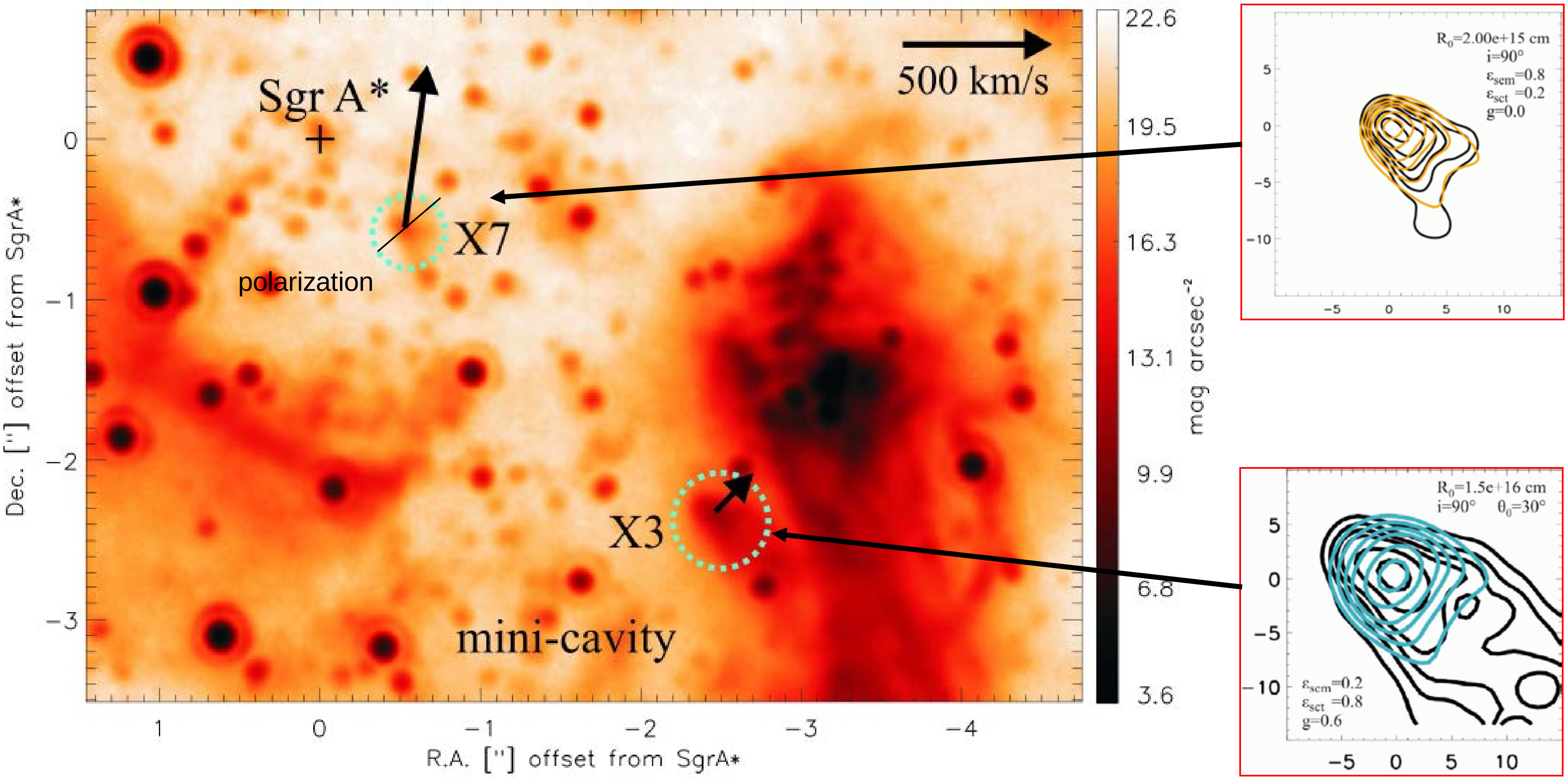


High-pass filtered L-band image
Eckart et al. 2006

Vollmer & Duschl 2000

with the linear feature LF crossing the northern arm
and the extended feature EF associated with the eastern arm

Cometary Sources: Shaped by a wind from SgrA*?



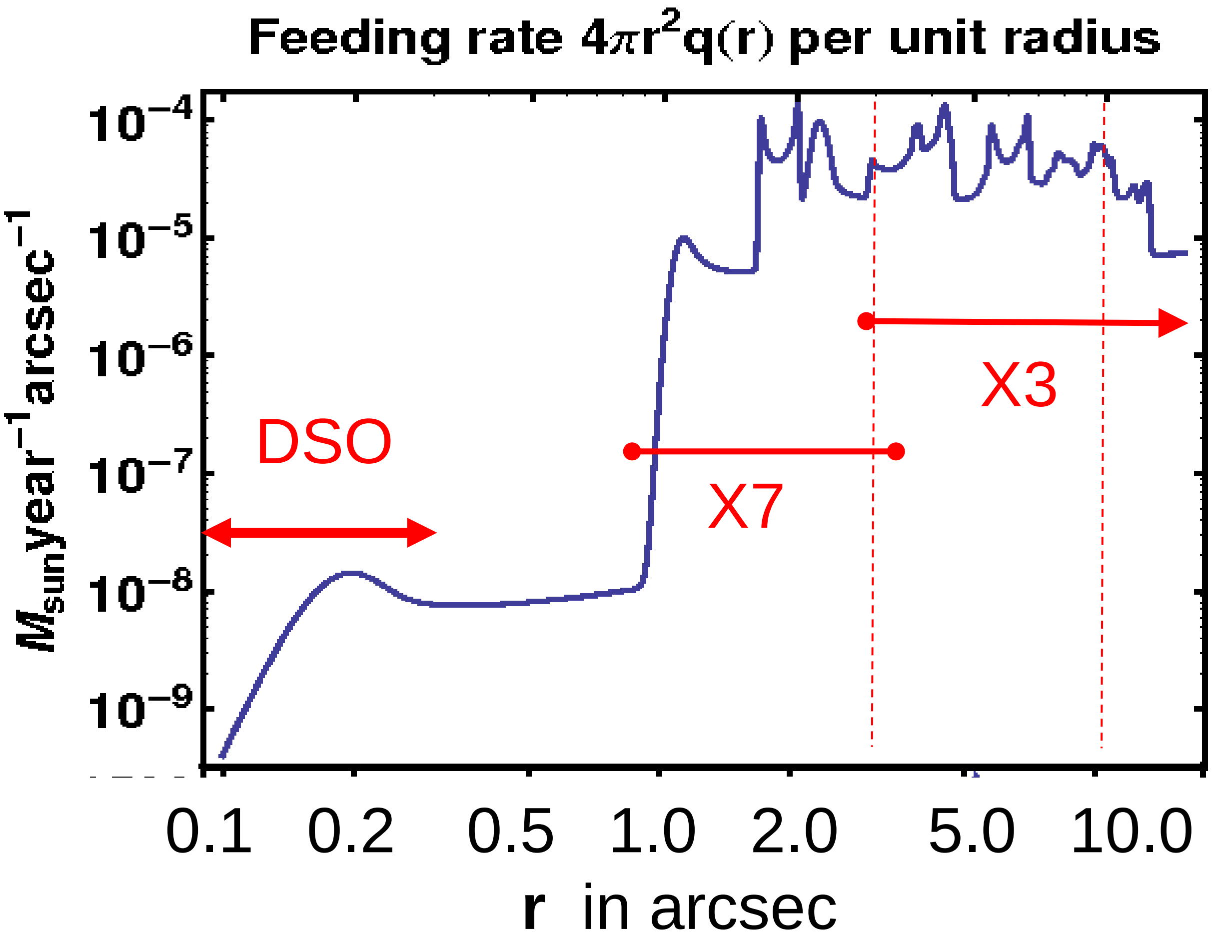
X7 polarized with 30% at PA -34+-10
Mie → bow-shock symmetry along PA 56+-10
includes direction towards SgrA*

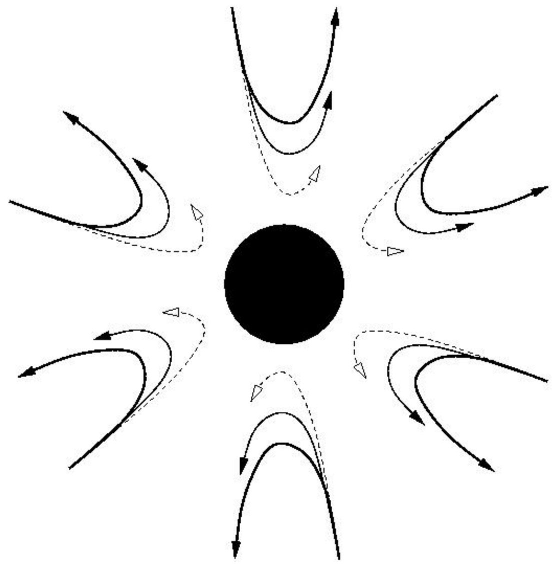
see also P33 Nadeen Sabha

Besides the mini-cavity – X3 and X7 are the strongest indication for a fast wind from SgrA*!

Muzic, Eckart, Schödel et al. 2007, 2010

Accretion onto SgrA*





radius dependent accretion

Mass input into the feeding region around the BH. Using square averaged wind velocities feeding is averaged over stellar orbits. Each wiggle represents a turning point of a single orbit. Only a few stars may feed matter within 0.8".

Shcherbakov & Baganoff ApJ, 2010

How can the DSO and other dusty source potentially also young dust enshrouded stars form in the central stellar cluster environment?

*P26. Star Formation in the Vicinity of Sgr A**

Behrang Jalali

I. Pelupessy, A. Eckart, S. Portegies Zwart, N. Sabha, A. Borkar, J. Moultaka

Modeling Approach

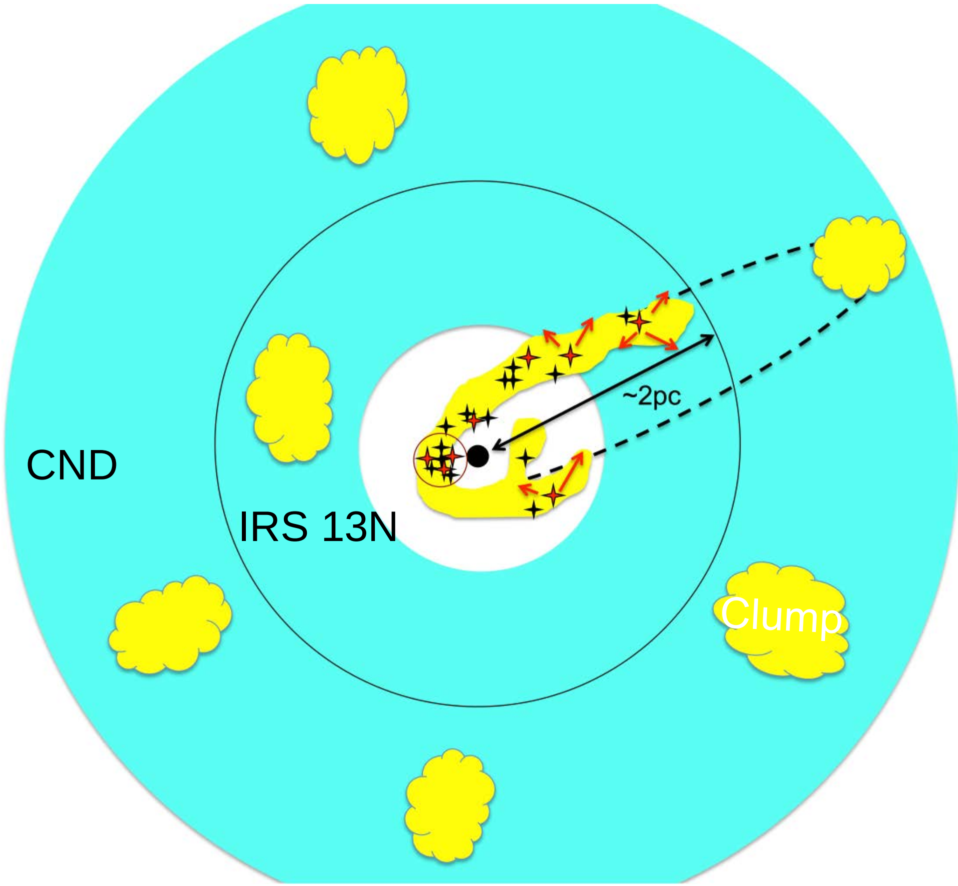
100 Msun molecular clump,
0.2 pc radius,

Test with 10 & 50 Kelvin,
isothermal gas

Timescales:
clump free fall time ~ 10^5 yr
CND orbital period ~ 10^5 yr

Semi-major axis=1.8 pc →
orbital period ~10^5 yr,

two Orbits:
peri-center~0.1 pc → ecc.= 0.95
peri-center~0.9 pc → ecc.= 0.5



See also P6 Lydia Moser

Behrang Jalali, I. Pelupessy, A. Eckart, S. Portegies Zwart, N. Sabha, A. Borkar, J. Moultaka, 2013 in prep.

Please watch

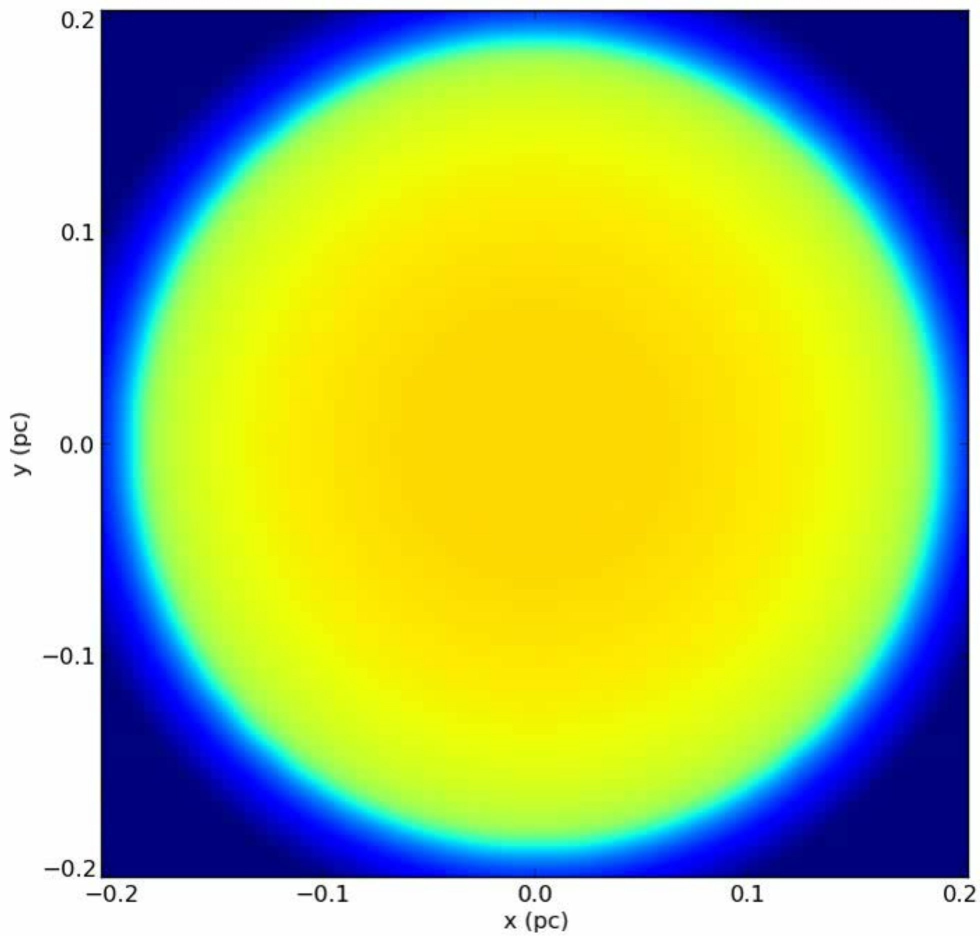
1) Notice the two cores forming at about 1 free fall time, proto-stars start forming there, and they keep accreting gas afterward in a filamentary structure.

2) Color code for stars with different mass:
red: **1- 5 Msun** (IRS 13N possible sources in orbiting models)
yellow: **0.5 - 1 Msun**,
green: **0.1 – 0.5 Msun**, low-mass stars (but also there are Brown Dwarfs & extremely massive giant planets)

3) AMUSU SPH simulations – half a million particles at

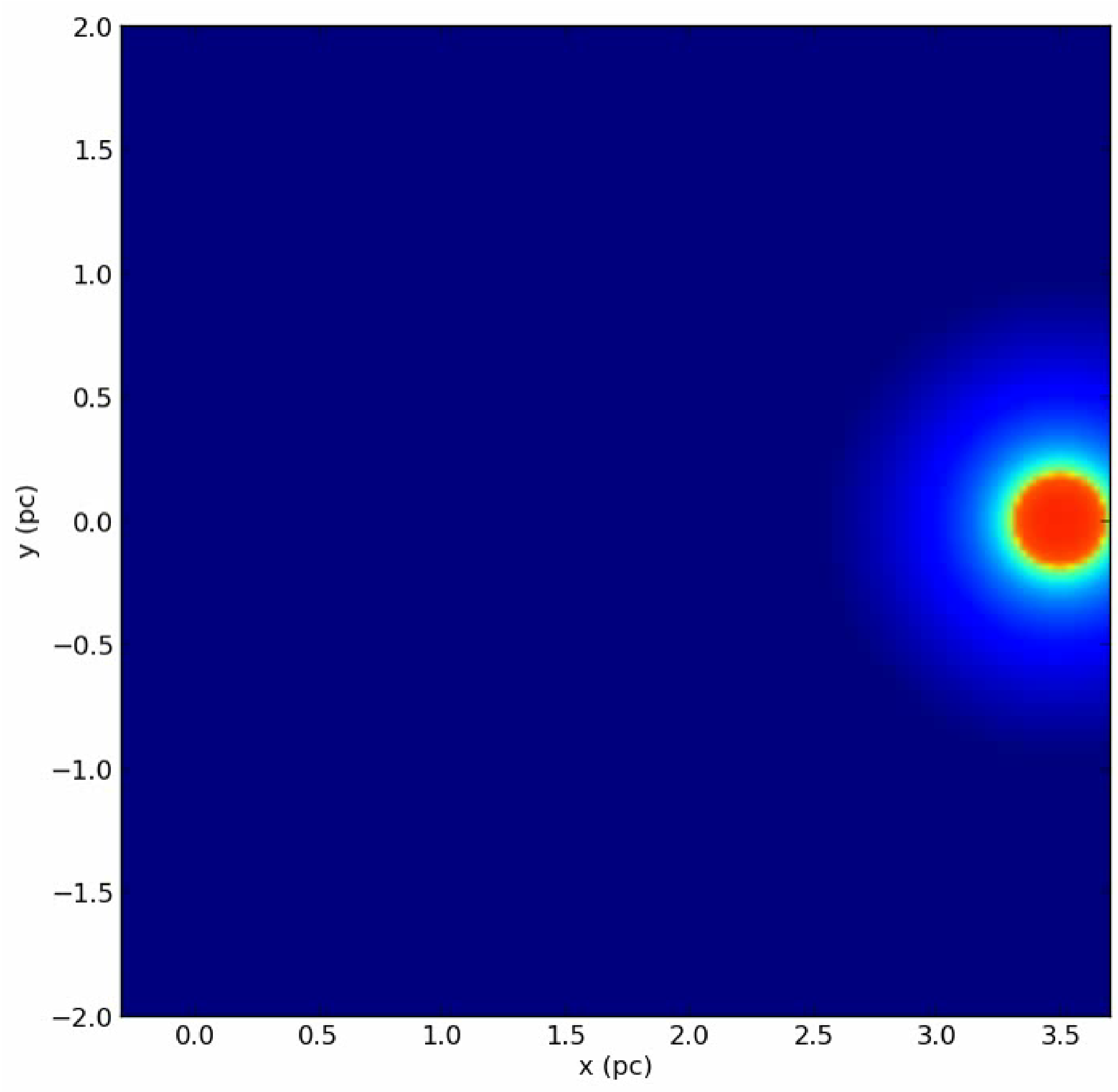
10K and 50K. Threshold density for sinks around 10**11 amu/cm**-3, threshold mass for a star at 20 MJup.

Isolated 10 Kelvin clump, column density movie



blue to red, column densities cover 10^{17}-10^{24} range in (atomic mass unit/cm^2)

orbiting 50 Kelvin clump with e=0.94



Results

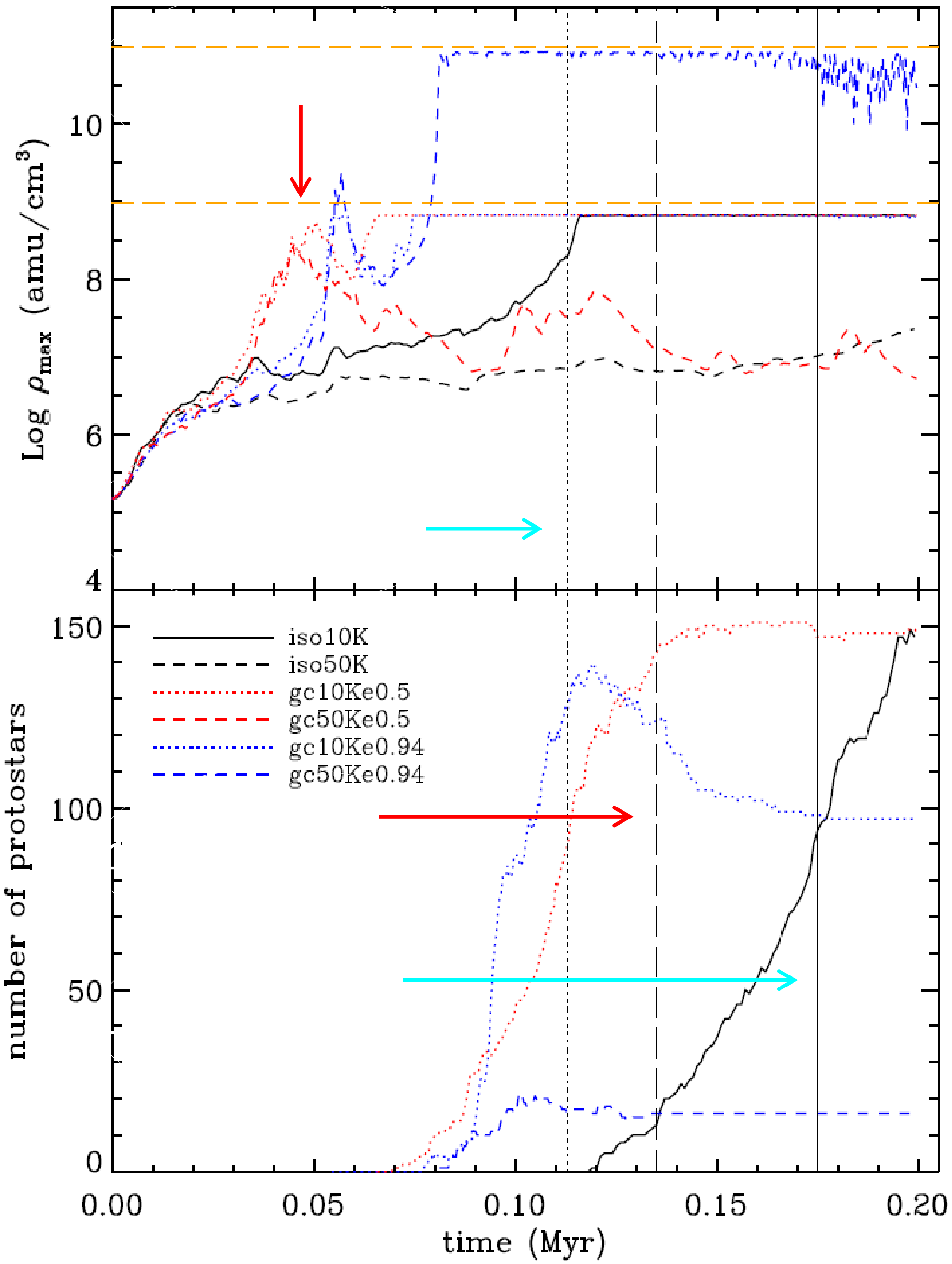
Critical density increase and formation of stars with 0.1 Myrs!

In agreement with the Herbig Ae/Be colors and luminosities of the IRS13N stars

For orbiting models
GC10Ke0.944,
GC50Ke0.944 &
GC10Ke0.5,
protostars start forming after first peri-passage (period/2),
as SMBH tidally compress
the clumps perpendicular to the orbit!

Note that minimum Jeans mass for 10 & 50K models are 1 and 10 Msun!

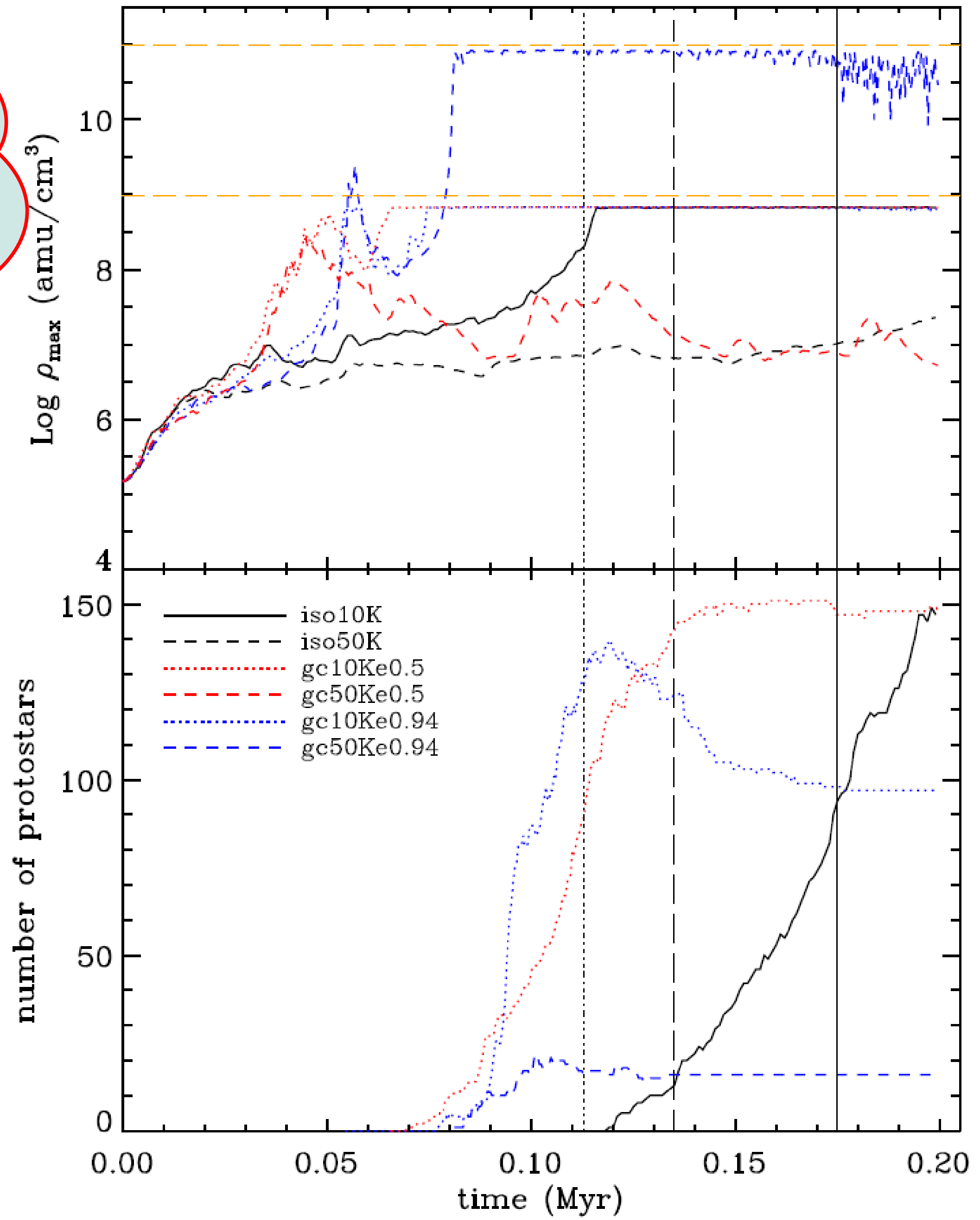
No stars formed in
isolated50K & GC50Ke0.5 models



SMBH helps SF!

This process may explain the presence of

- DSO type objects
- Stellar associations like IRS13, IRS13N, IRS16
- matter and stars getting close to SgrA*
- Ongoing star formation at the Galactic Center



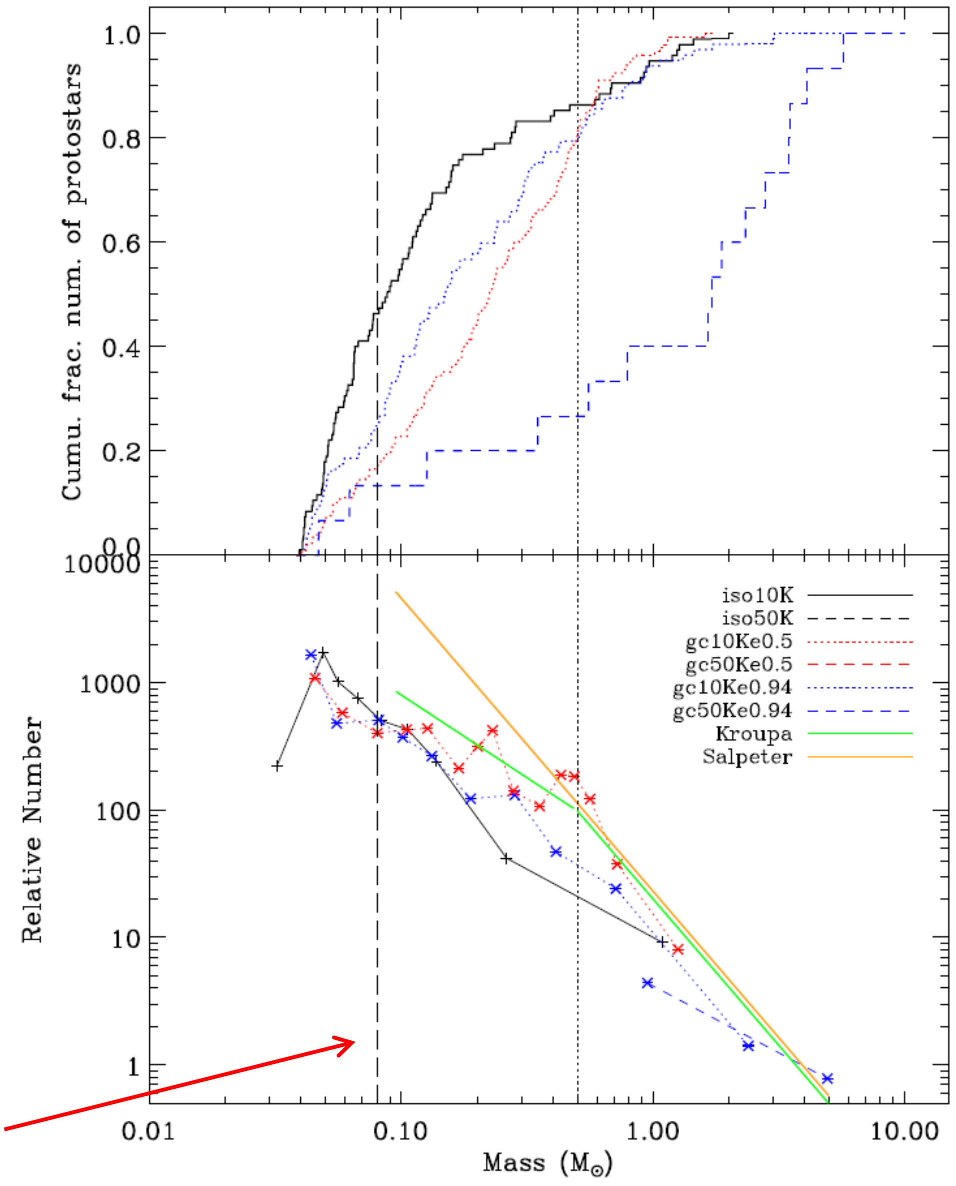
Results: Mass distributions

Notice the shallower slope for gc50Ke0.944 (due to higher Jeans mass)

IMF seems consistent with Kroupa & Salpeter slopes

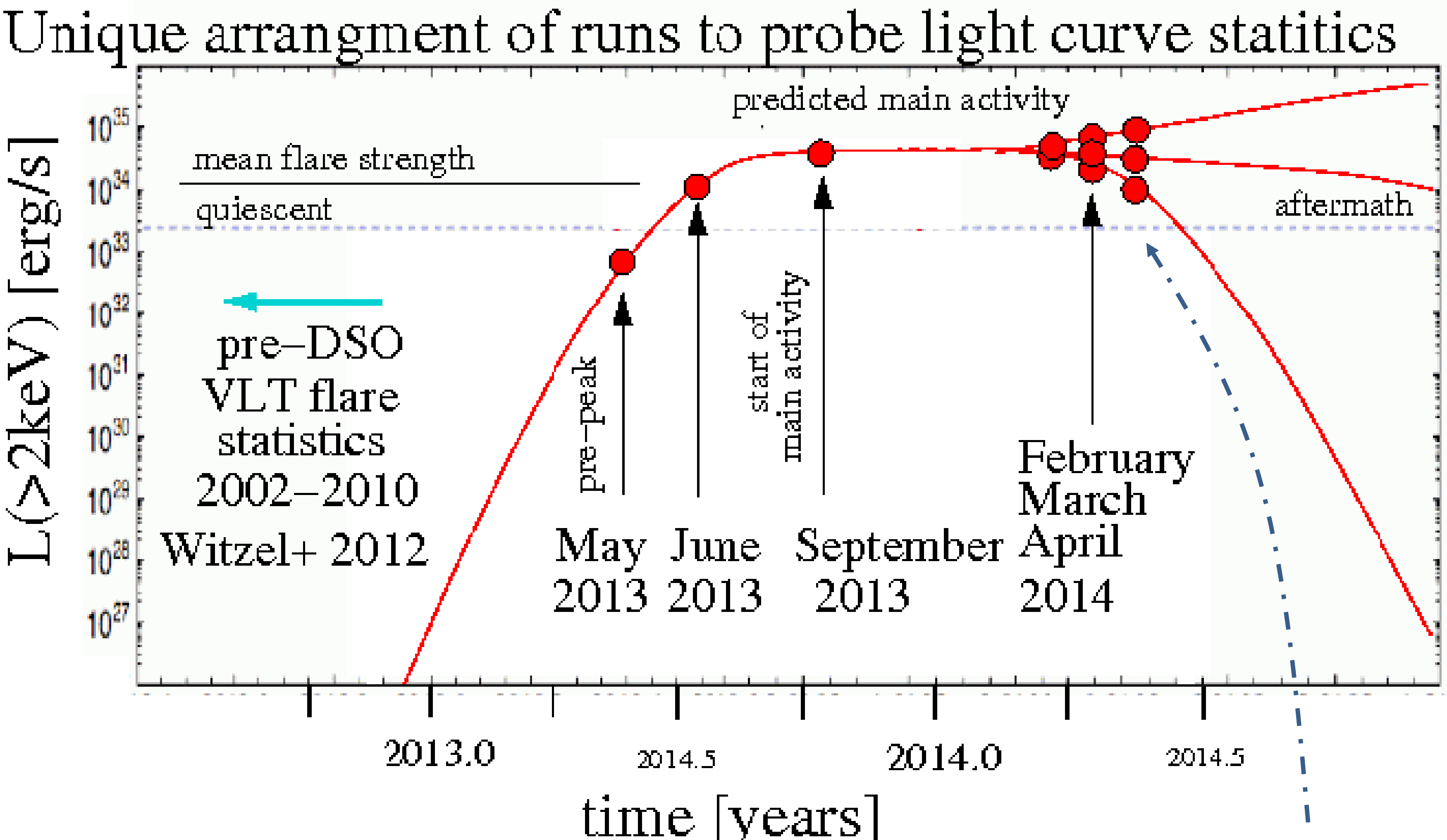
gc50Ke0.944 shows top-heavy trend: 6-10 Msol stars are formed

Isolated10K results are consistent with Bate2009 SF models.



BDs limit

Observing the DSO Flyby 2013/2014

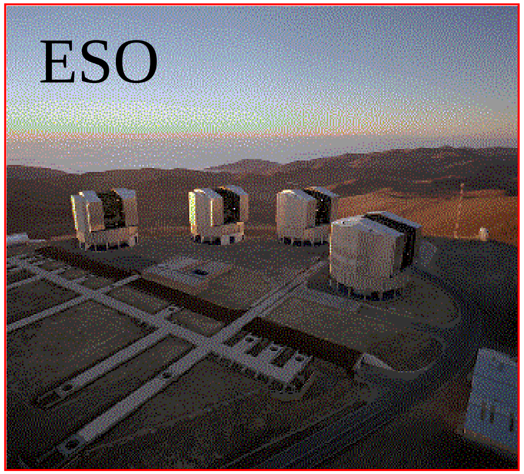


2013/14 NIR sub-mm multi-wavelength run (Eckart+)

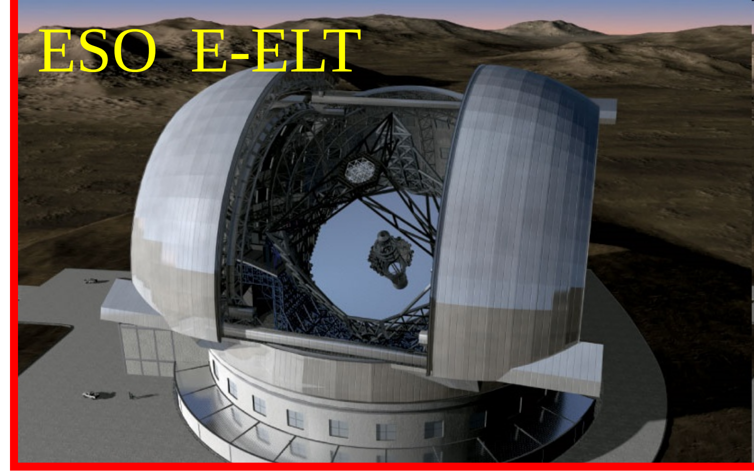
predictions: Gillessen+ Phifer+ 13

$$L = \frac{GM\dot{M}}{2r} = 2\pi r^2 \sigma T^4$$

XMM
N. Grosso,
D. Porquet et al.

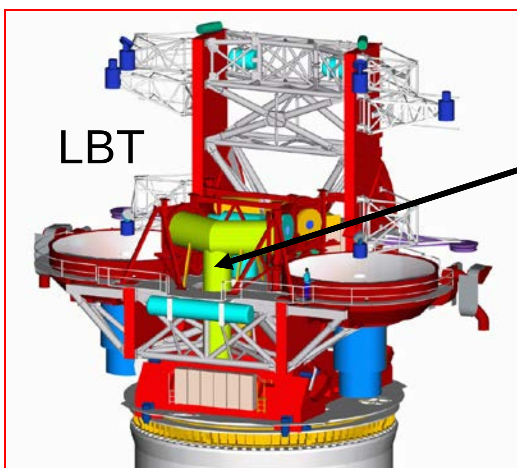


NL leads Euro-Team
University of Cologne
studies for
METIS @ E-ELT



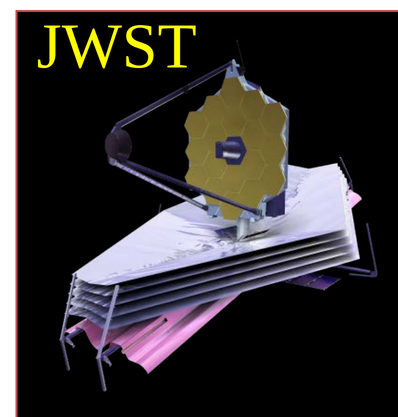
MPE, MPIA, Paris, SIM
University of Cologne
participation
GRAVITY @ VLTI

The Galactic Center is a unique laboratory in which one can study signatures of strong gravity with GRAVITY



NIR Beam Combiner:
University of Cologne
MPIA, Heidelberg
Osservatorio Astrofisico di Arcetri
MPIfR Bonn

Cologne
contribution to
MIRI on JWST



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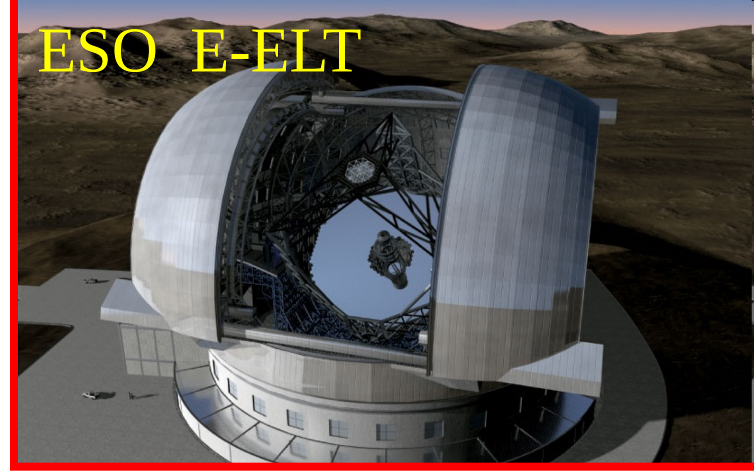

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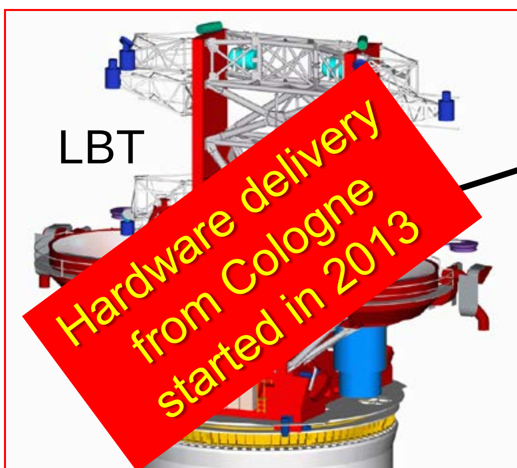

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Cologne
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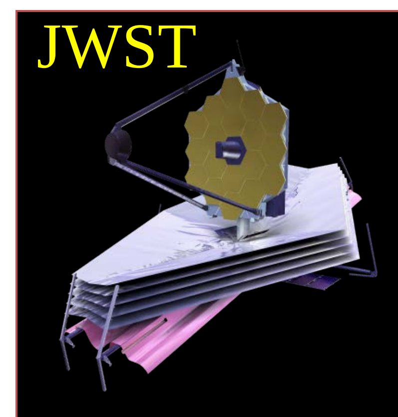
MIRI on JWST



The GC2013 COST conference in Granada, Spain 19-22, November 2013

http://www.astro.uni-koeln.de/gc2013

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GC2013

The Galactic Center Black Hole Laboratory

November 19 - 22, 2013

Granada, Spain

END