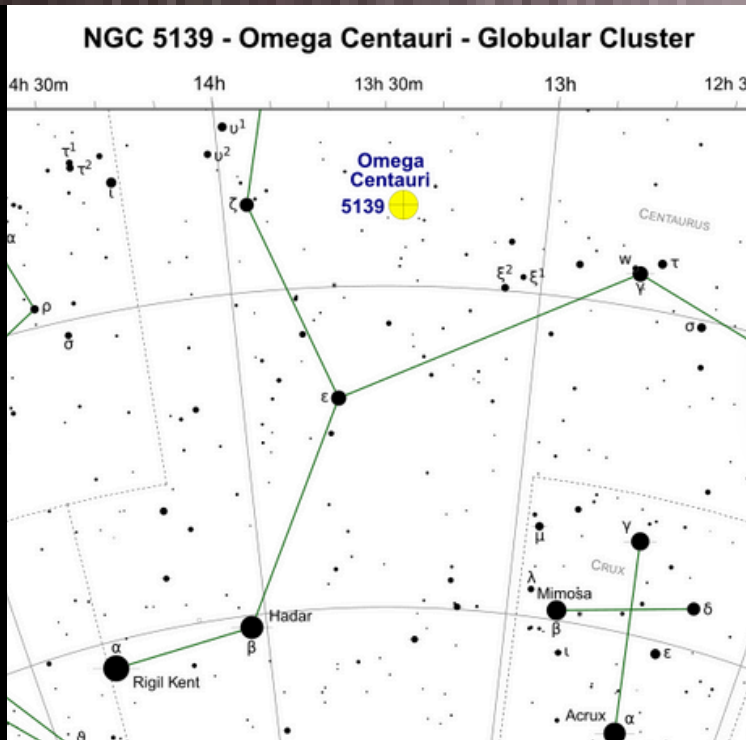




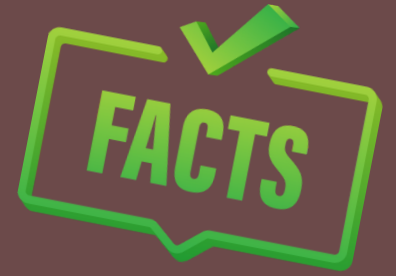
Liverpool John Moores University

UNVEILING THE HEART OF DARKNESS



MODELING THE CENTRAL KINEMATICS OF OMEGA CENTAURI AND ITS ELUSIVE BLACK HOLE

Presentation by **Renuka Pechetti**



OMEGA CENTAURI

- DENSEST CLUSTER OF MILKY-WAY
- SUGGESTED STRIPPED NUCLEUS OF GAIA-ENCELADUS/SAUSAGE GALAXY
- A POSSIBLE IMBH AT THE CENTER?

AN IMBH IN OMEGA CEN?

Central Dynamics of Globular Clusters: the Case for a Black Hole in ω Centauri

Eva Noyola¹, Karl Gebhardt² and Marcel Bergmann³

NEW LIMITS ON AN INTERMEDIATE-MASS BLACK HOLE IN OMEGA CENTAURI. II. DYNAMICAL MODELS*

ROELAND P. VAN DER MAREL AND JAY ANDERSON

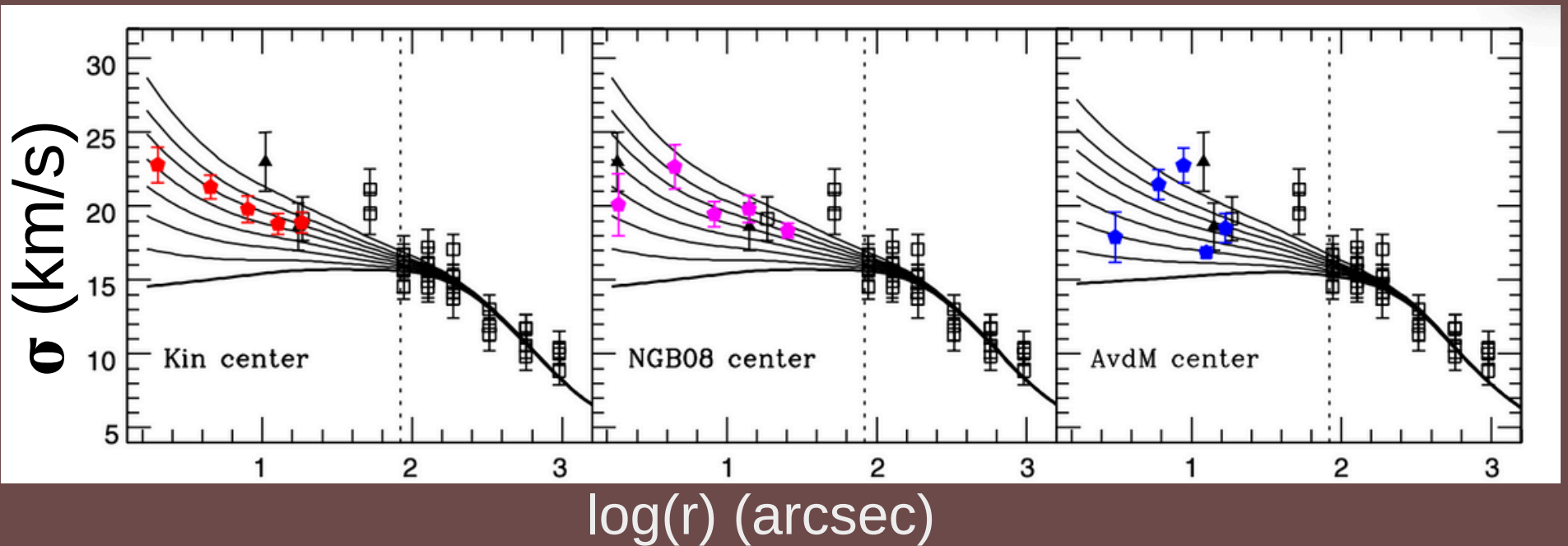
VERY LARGE TELESCOPE KINEMATICS FOR OMEGA CENTAURI: FURTHER SUPPORT FOR A CENTRAL BLACK HOLE*

EVA NOYOLA^{1,2}, KARL GEBHARDT³, MARKUS KISSLER-PATIG⁴, NORA LÜTZGENDORF⁴, BEHRANG JALALI⁴, P. TIM DE ZEEUW^{4,5}, AND HOLGER BAUMGARDT⁶

The effect of stellar-mass black holes on the central kinematics of ω Cen: a cautionary tale for IMBH interpretations

Alice Zocchi,^{1,2★} Mark Gieles³ and Vincent Hénault-Brunet^{4,5}

PREVIOUS MODELS



	Center RA	Center Dec	M_{BH} (M_{\odot})	σ_{LOS} (km/s)
NGB08	13:26:46.04	-47:28:44.8	$4.0^{+0.75}_{-1.0} \times 10^4$	23.0 ± 2.0
vdMA10	13:26:47.24	-47:28:46.5	$\leq 1.2 \times 10^4$	-
N10	13:26:47.11	-47:28:42.1	$4.7 \pm 1.0 \times 10^4$	22.8 ± 1.2

MOST RECENT PREDICTION

Article

Fast-moving stars around an intermediate-mass black hole in ω Centauri

<https://doi.org/10.1038/s41586-024-07511-z>

Received: 15 December 2023

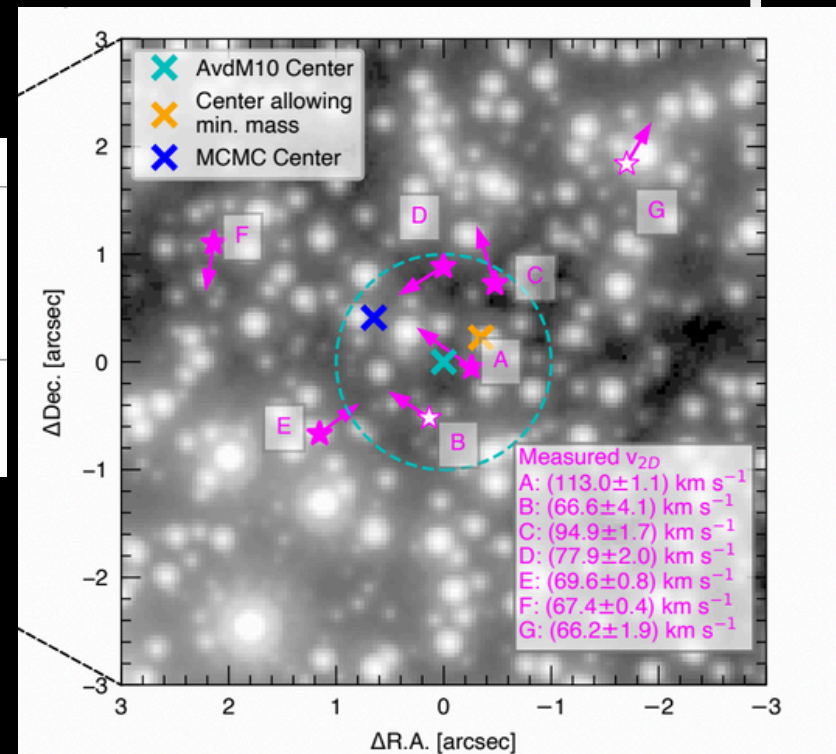
Accepted: 2 May 2024

Maximilian Häberle^{1,5}, Nadine Neumayer¹, Anil Seth², Andrea Bellini³, Mattia Libralato^{4,5}, Holger Baumgardt⁶, Matthew Whitaker², Antoine Dumont¹, Mayte Alfaro Cuello^{3,7}, Jay Anderson⁸, Callie Clontz^{1,2}, Nikolay Kacharov⁹, Sebastian Kamann⁹, Anja Feldmeier-Krause¹⁰, Antonino Milone¹¹, Maria Selina Nitschai¹, Renuka Pechetti⁹ & Glenn van de Ven¹⁰

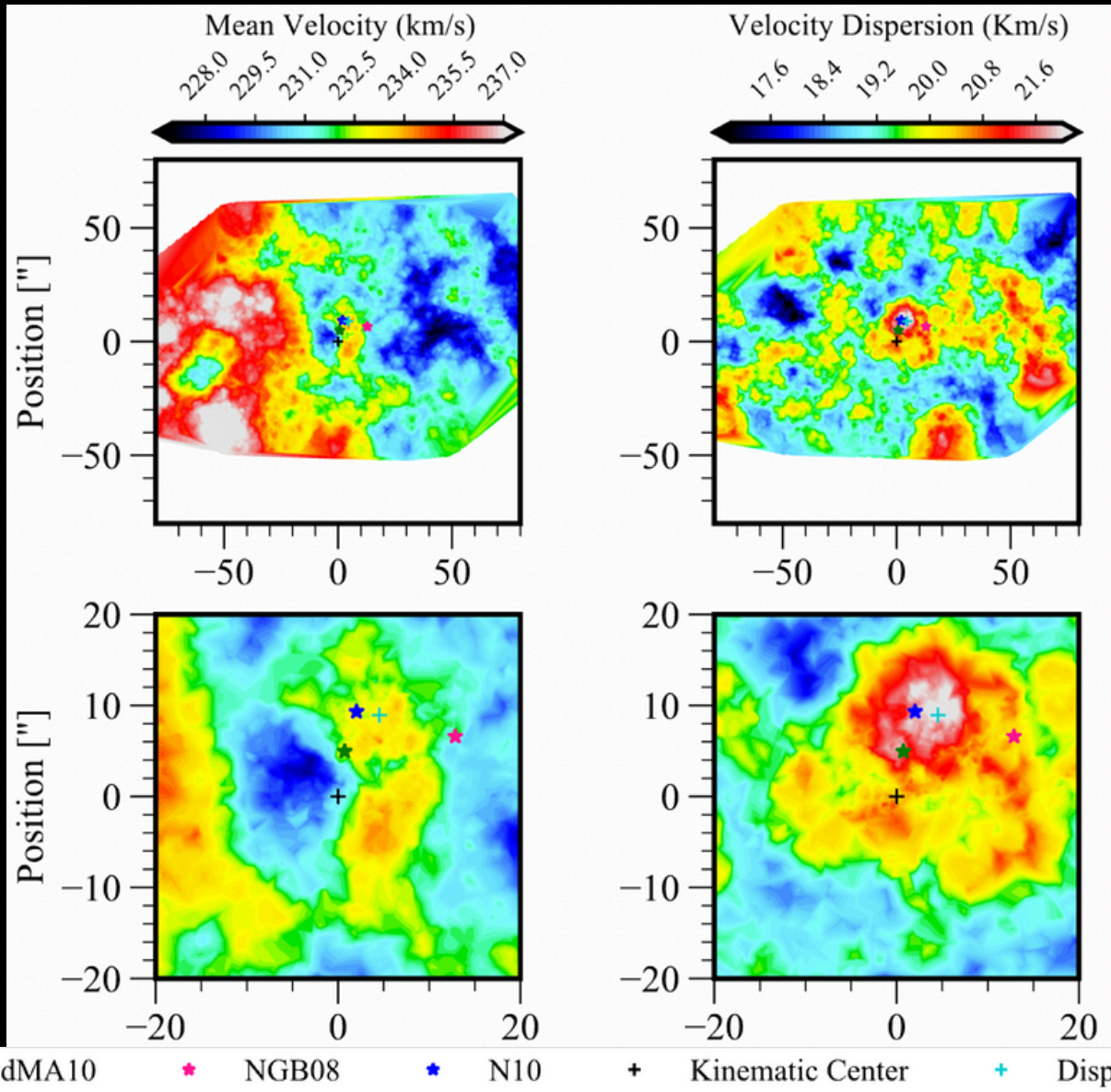
LOWER LIMIT: 8200 M_{\odot}

HÄBERLE + 2024

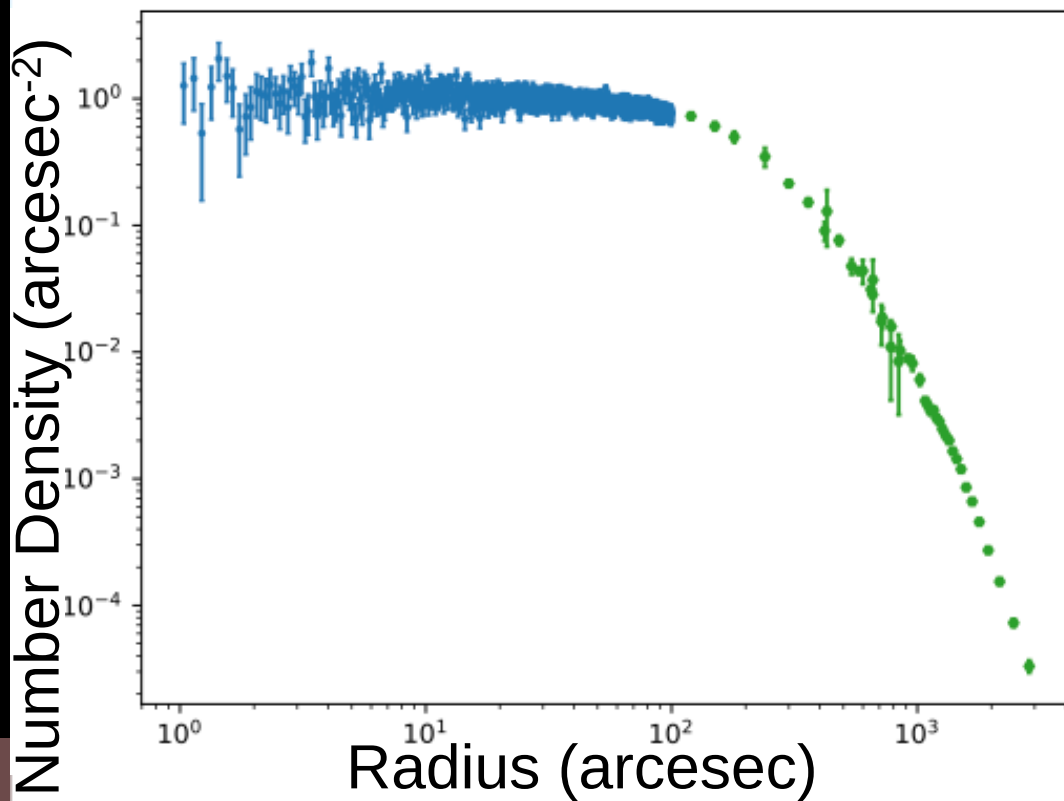
See Max's talk on Friday!



MUSE WFM/NFM DATA



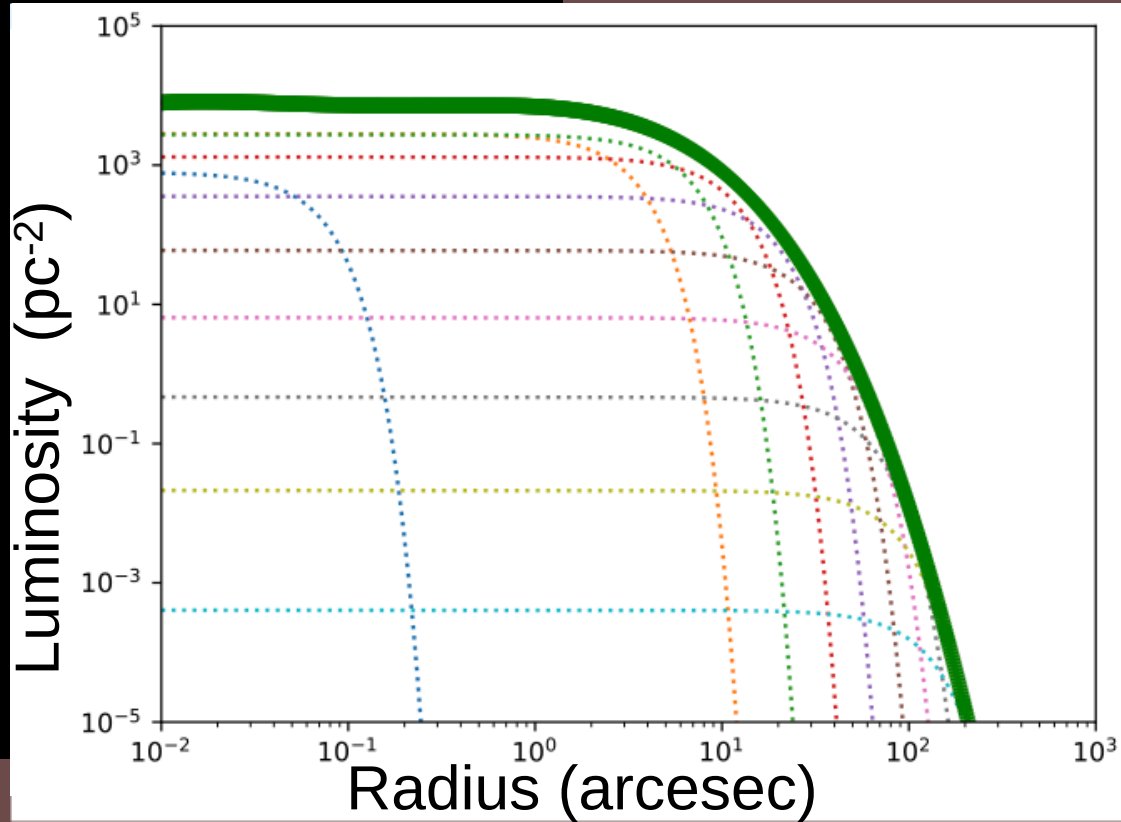
Pechetti
+
2024



MULTI - GAUSSIAN EXPANSION

Surface brightness profile

Bellini 2017 Catalogue
+
Gaia Densities (de Boer
2019)



MULTI - GAUSSIAN EXPANSION

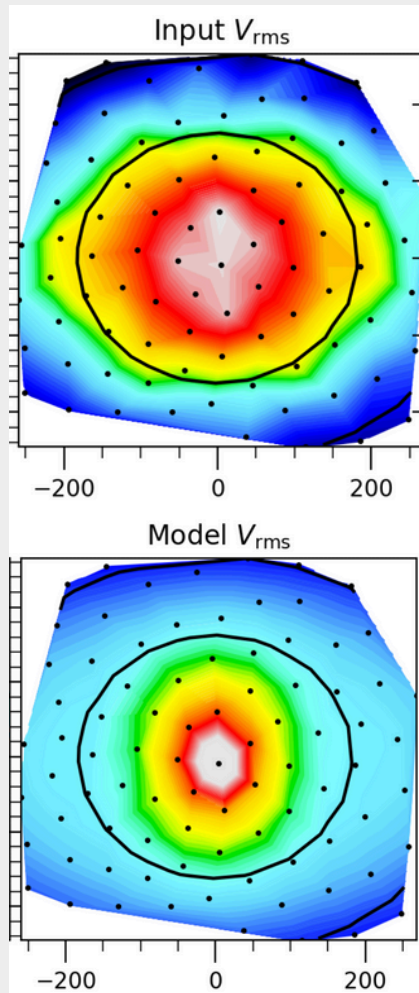
Surface brightness profile

Bellini 2017 Catalogue
+
Gaia Densities (de Boer
2019)

DYNAMICAL MODELING

LUMINOSITY MODELS

KINEMATIC DATA



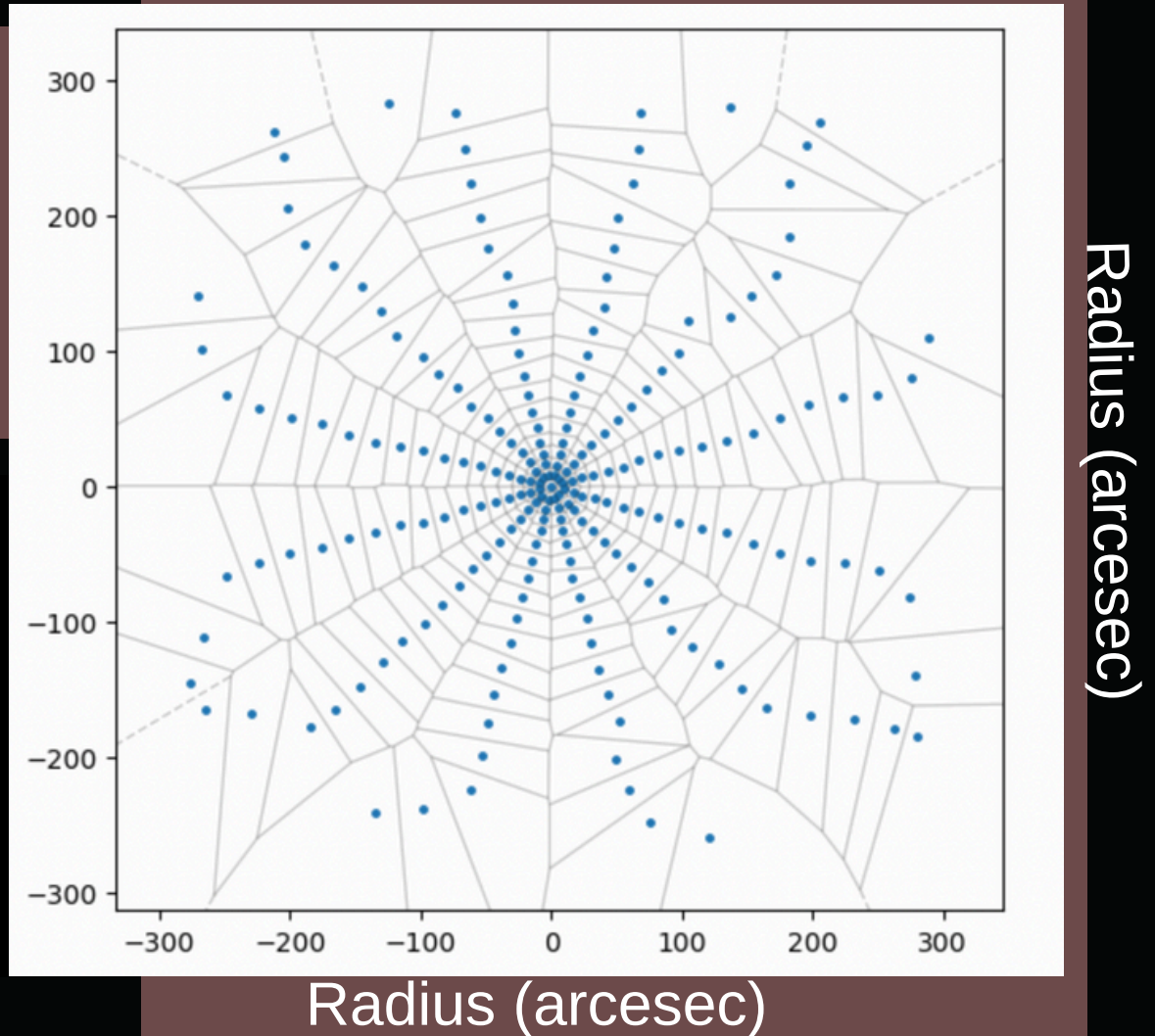
- THE LUMINOSITY MODELS PREDICT THE 3-D COMPONENTS OF VELOCITIES USING JEANS' ANISOTROPIC MODELING
- THIS IS COMPARED TO THE KINEMATIC DATA TO ESTIMATE THE BEST-FIT PARAMETERS

3-D VELOCITIES

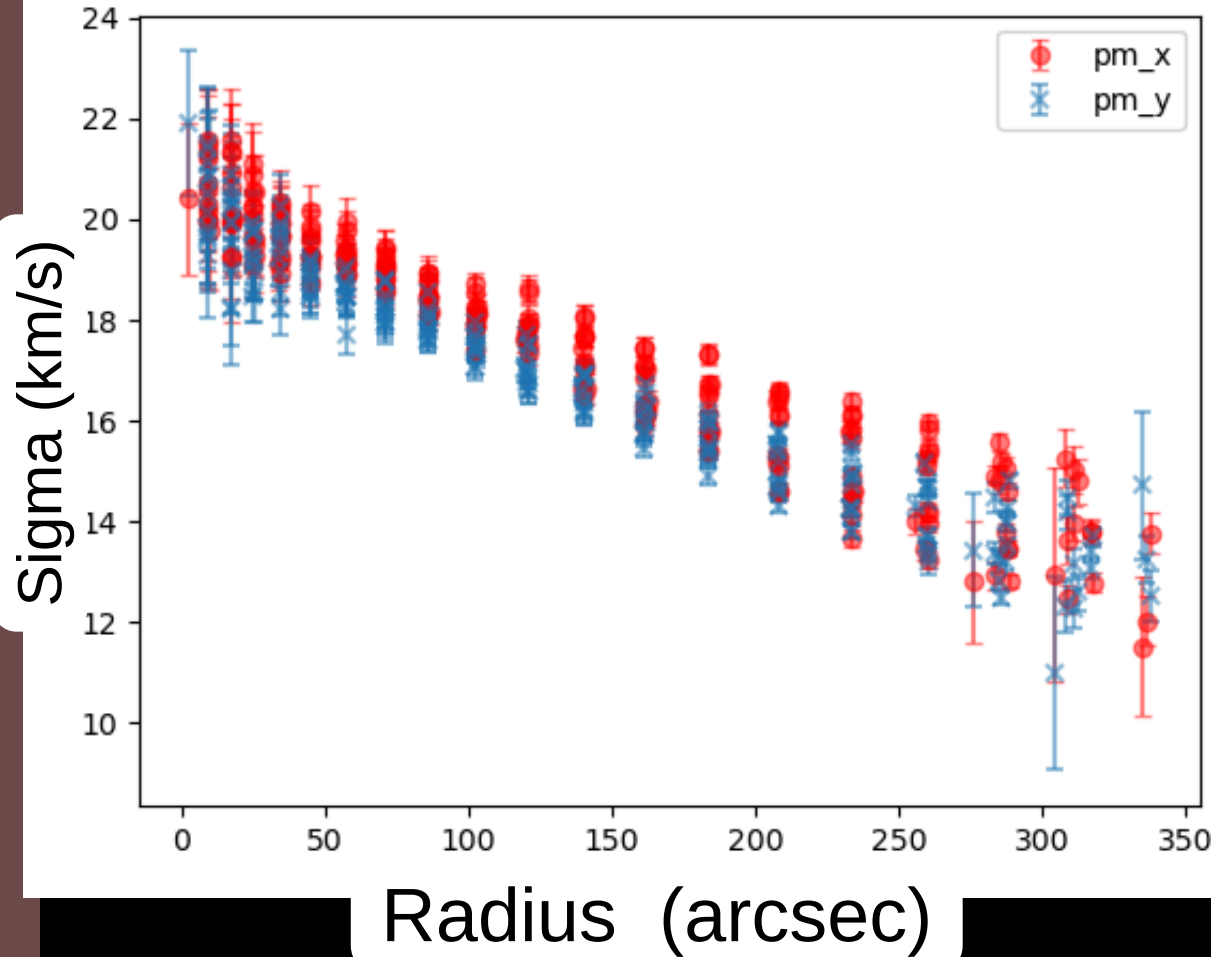
COMBINING THE PROPER MOTIONS FROM HST CATALOGUE WITH THE LINE OF SIGHT VELOCITIES FROM MUSE GTO/GO DATA (HÄBERLE + 2024)

> 1 MILLION STARS CONTAINING THE VELOCITIES

WE USE A HIGH SELECTION QUALITY CRITERIA FOR PROPER MOTIONS ~ 640,000 STARS



VELOCITY DISPERSION OF PROPER MOTIONS



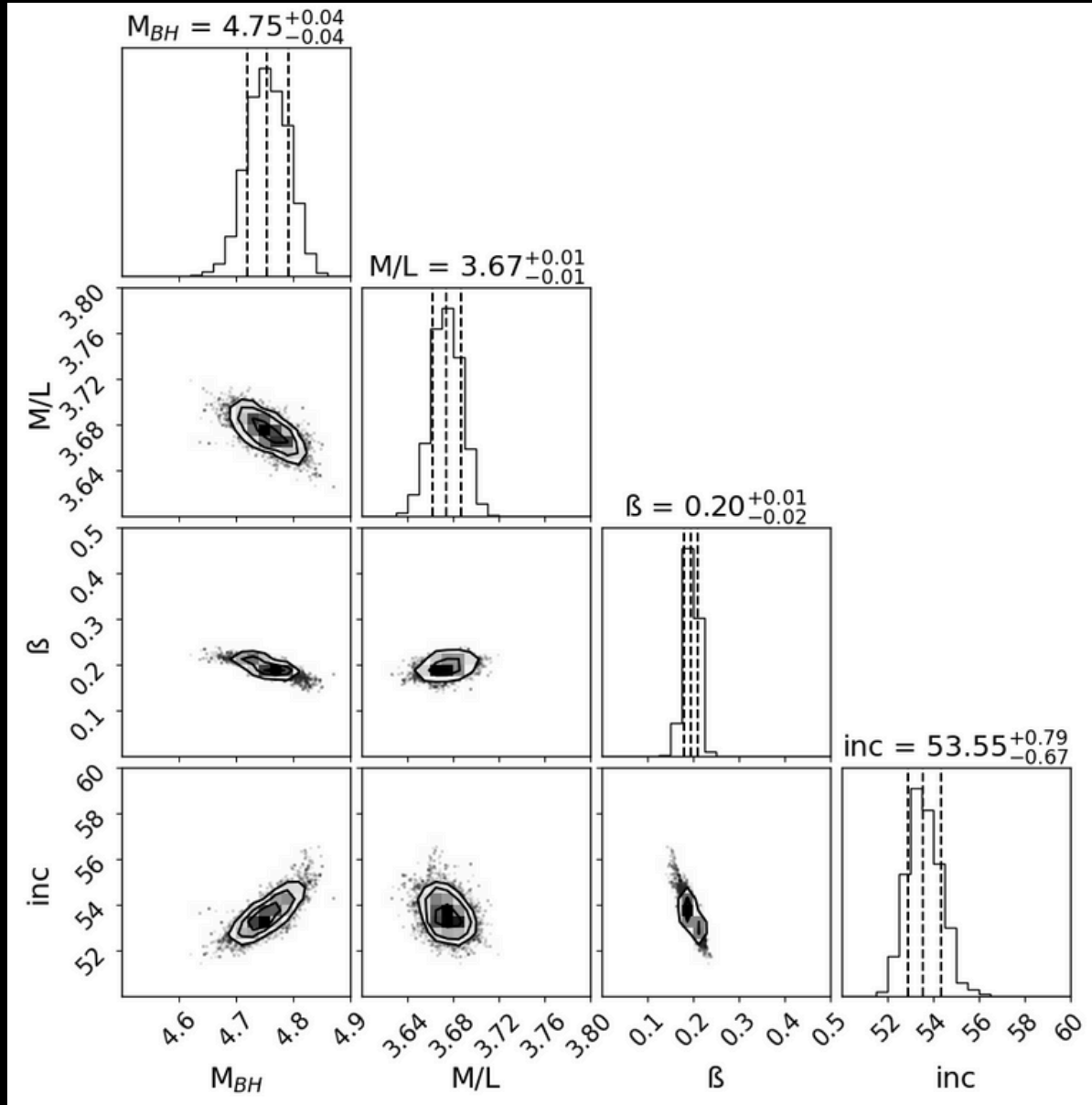
Velocity Dispersion (km/s)

- THE STARS ARE BINNED HERE WITH ATLEAST STARS PER BIN
- A LIKELIHOOD FUNCTION IS RUN TO ESTIMATE DISPERSION ALONG X AND Y COMPONENT

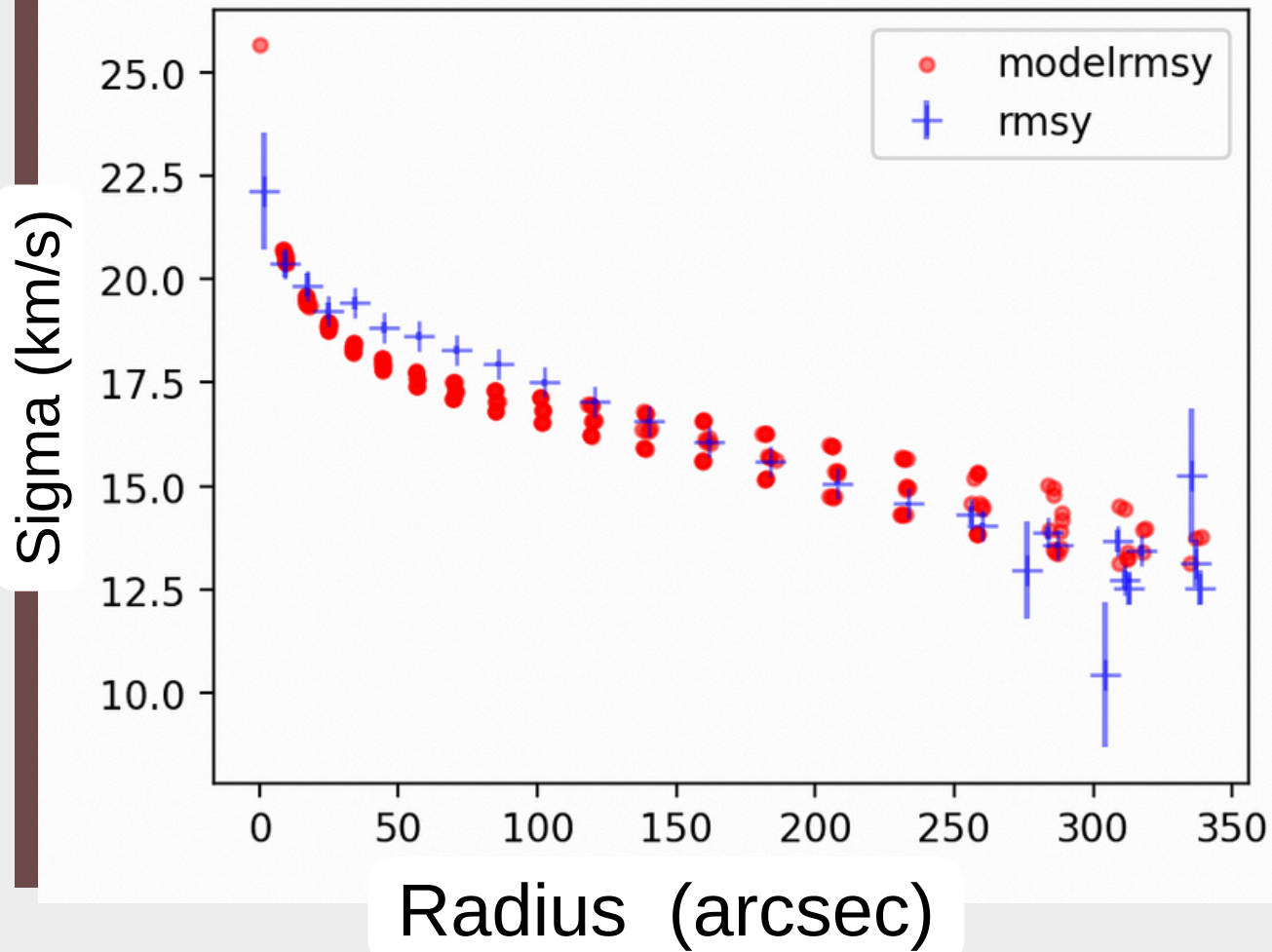
A SIMPLE IMBH MODEL

FREE PARAMETERS

- BH MASS
- M/L RATIO
- ANISOTROPY
- INCLINATION



RMS PROFILE

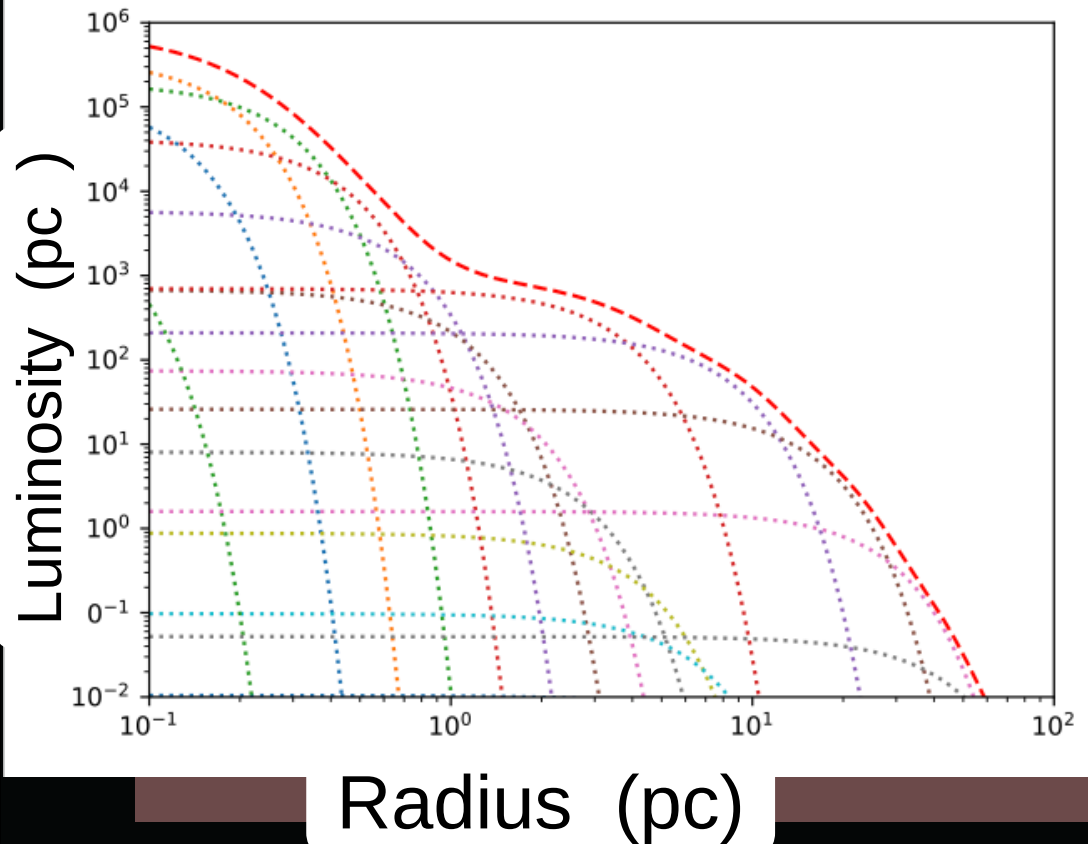


The central velocity dispersion was always too high!

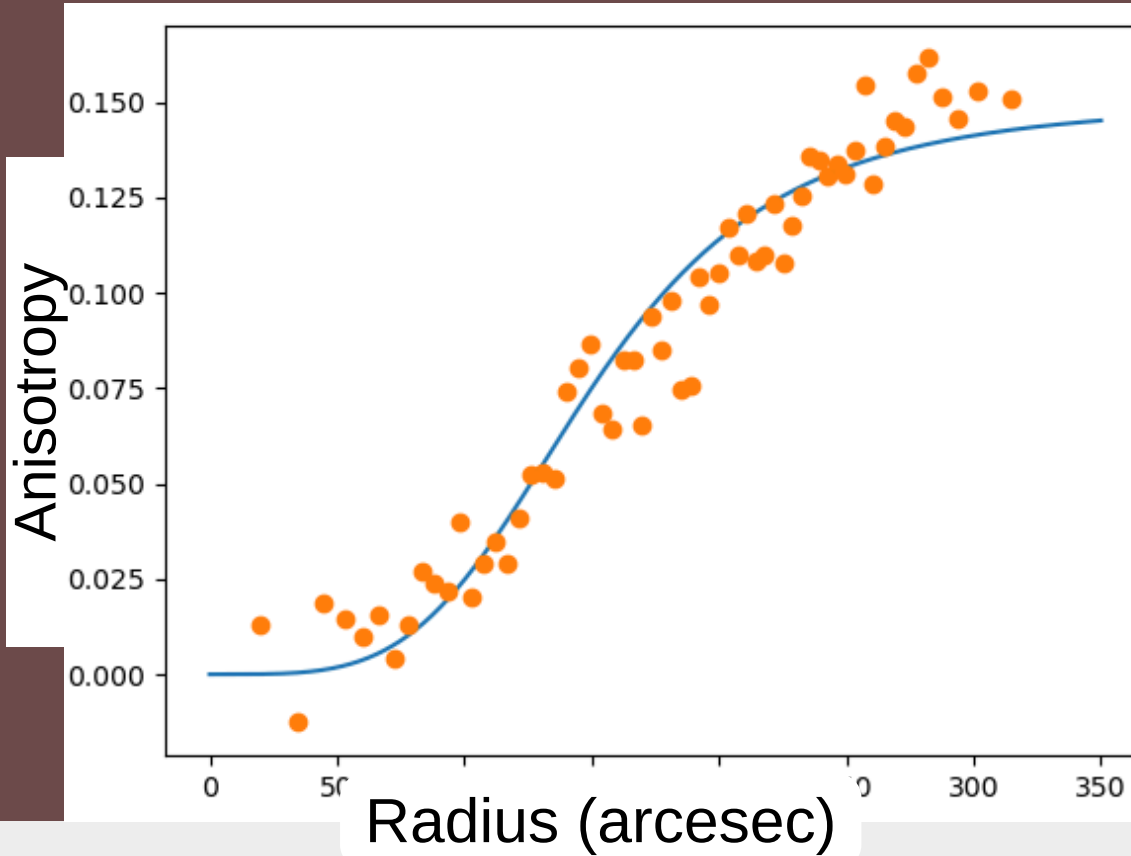
ADDITIONAL PARAMETERS: AN EXTENDED MASS

Adding an additional
profile to the original MGE

Using an extended mass
(Gaussian/Plummer)
 $\log M$ and $\log R$ as an
indicator of stellar mass
black holes



ANISOTROPY PROFILE



Observations from proper motions constrain anisotropy and inclination

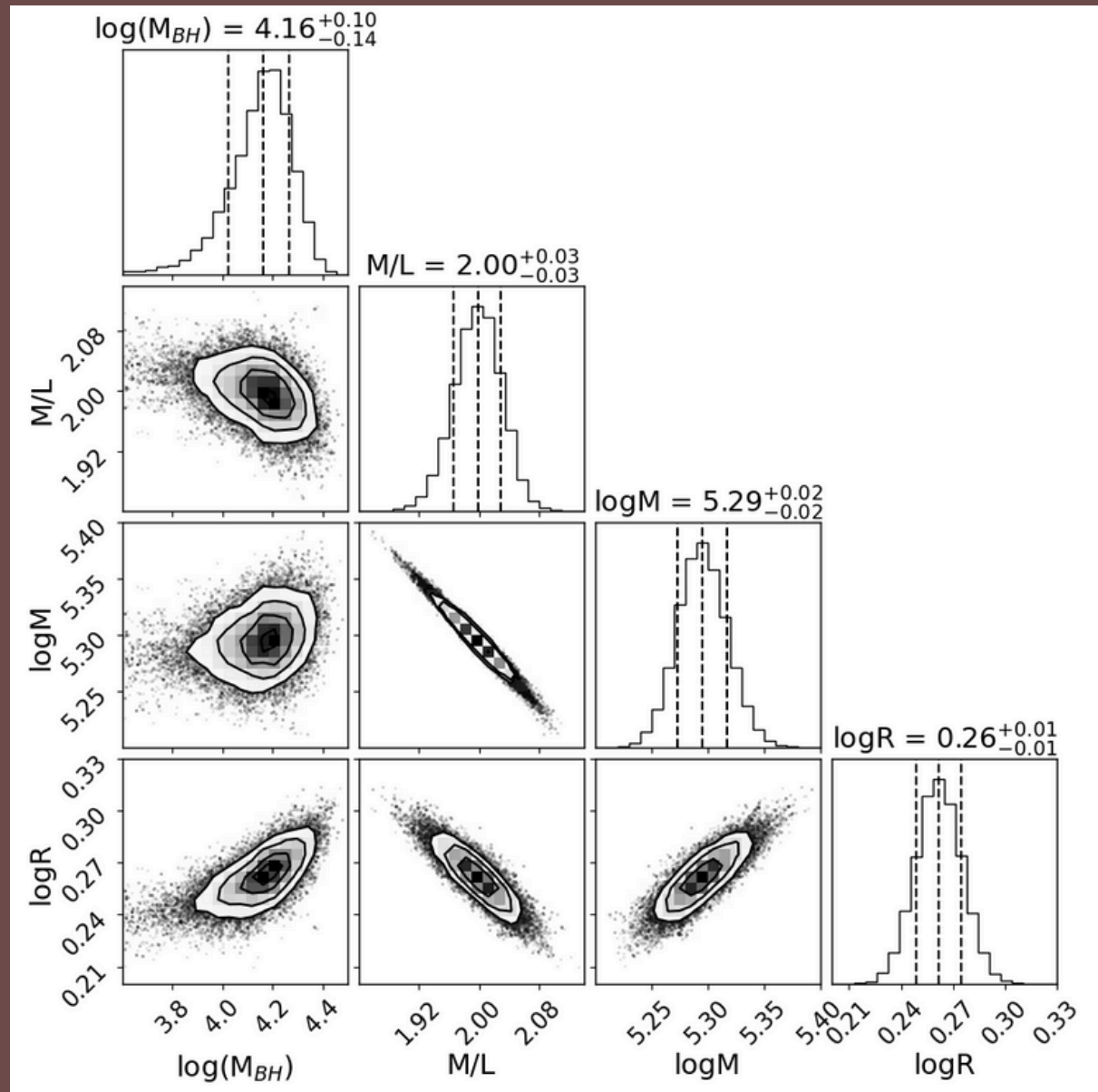
EXTENDED DARK MASS: GAUSSIAN PROFILE

FREE PARAMETERS

- DARK MASS
- RADIUS
- M/L RATIO
- IMBH mass

FIXED PARAMETERS

- ANISOTROPY
- INCLINATION



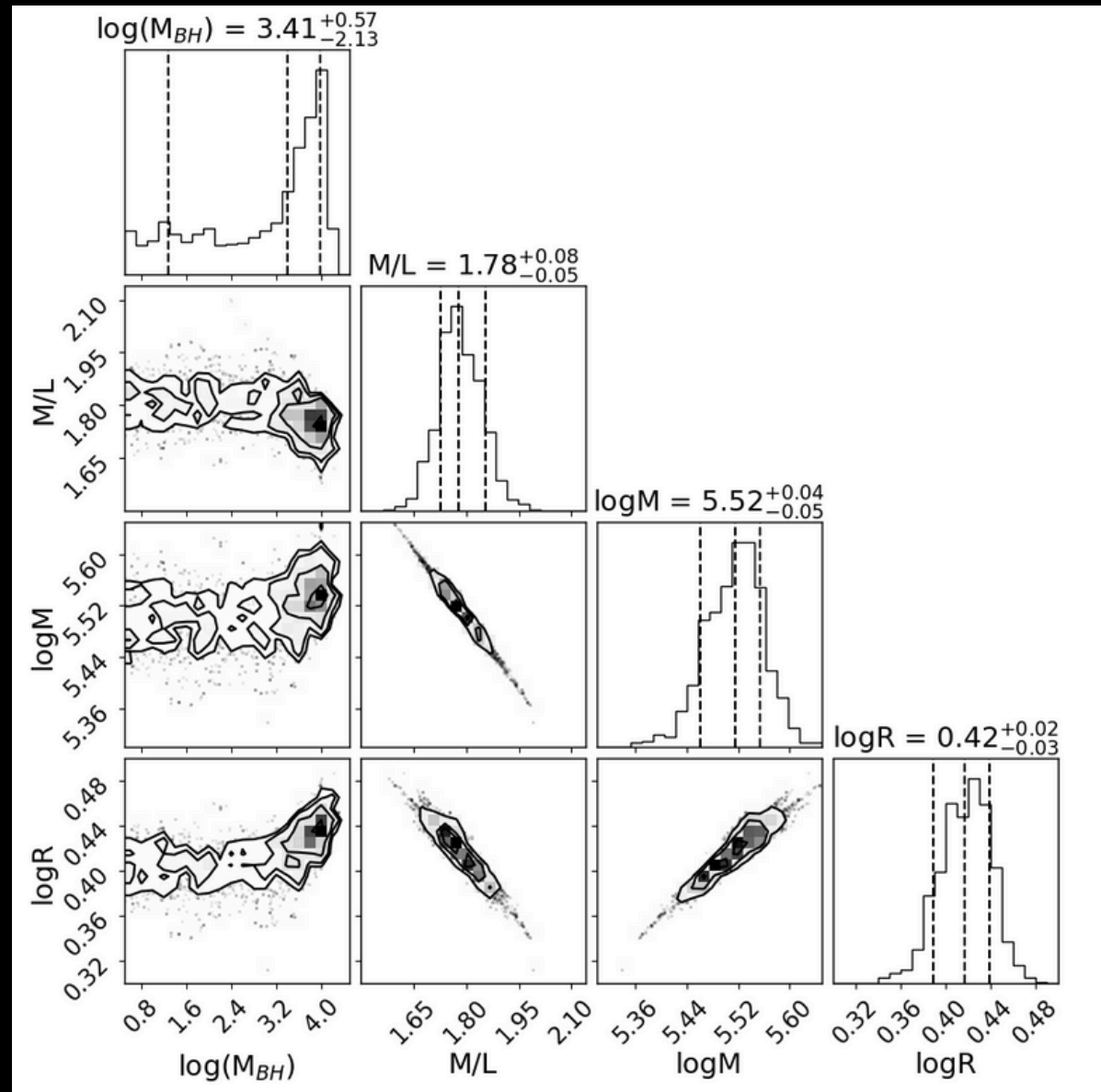
EXTENDED DARK MASS: PLUMMER PROFILE

FREE PARAMETERS

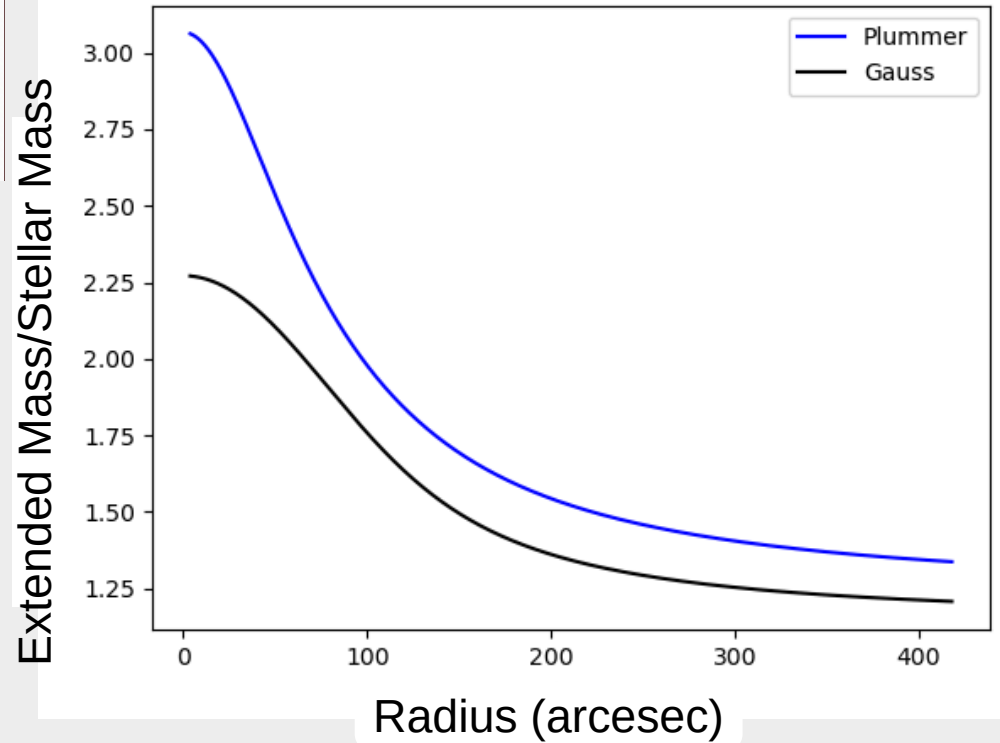
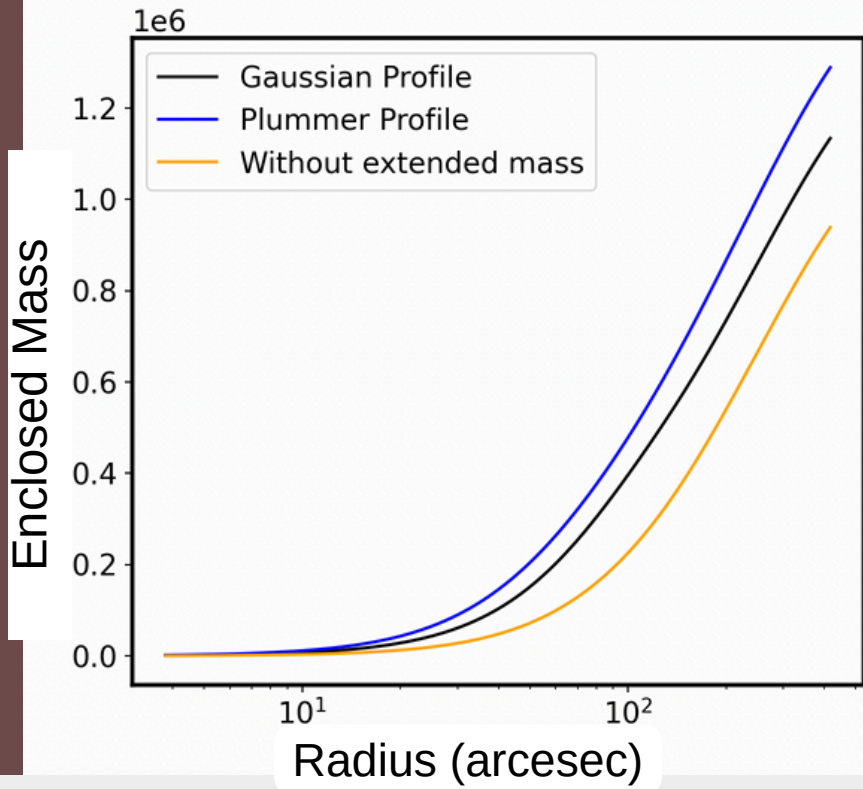
- DARK MASS
- RADIUS
- M/L RATIO
- IMBH mass

FIXED PARAMETERS

- ANISOTROPY
- INCLINATION

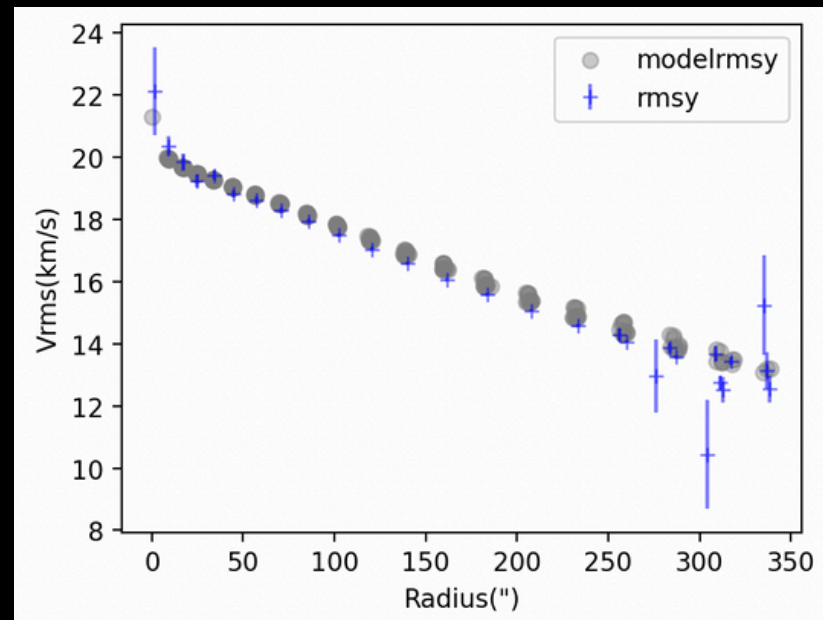
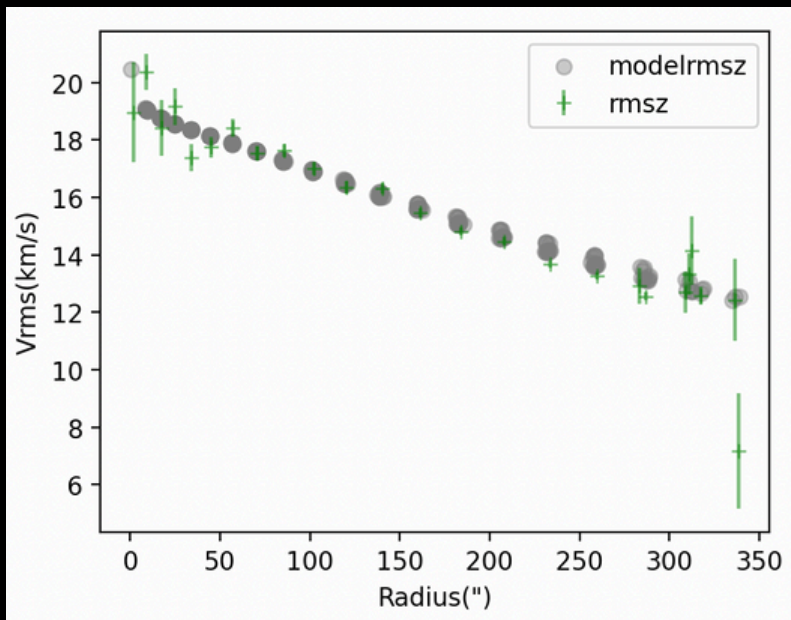
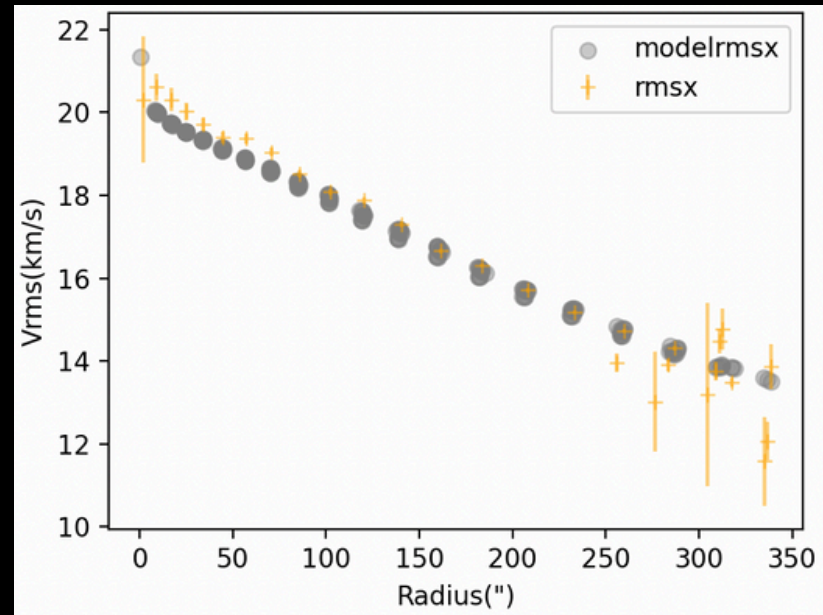


ENCLOSED MASS



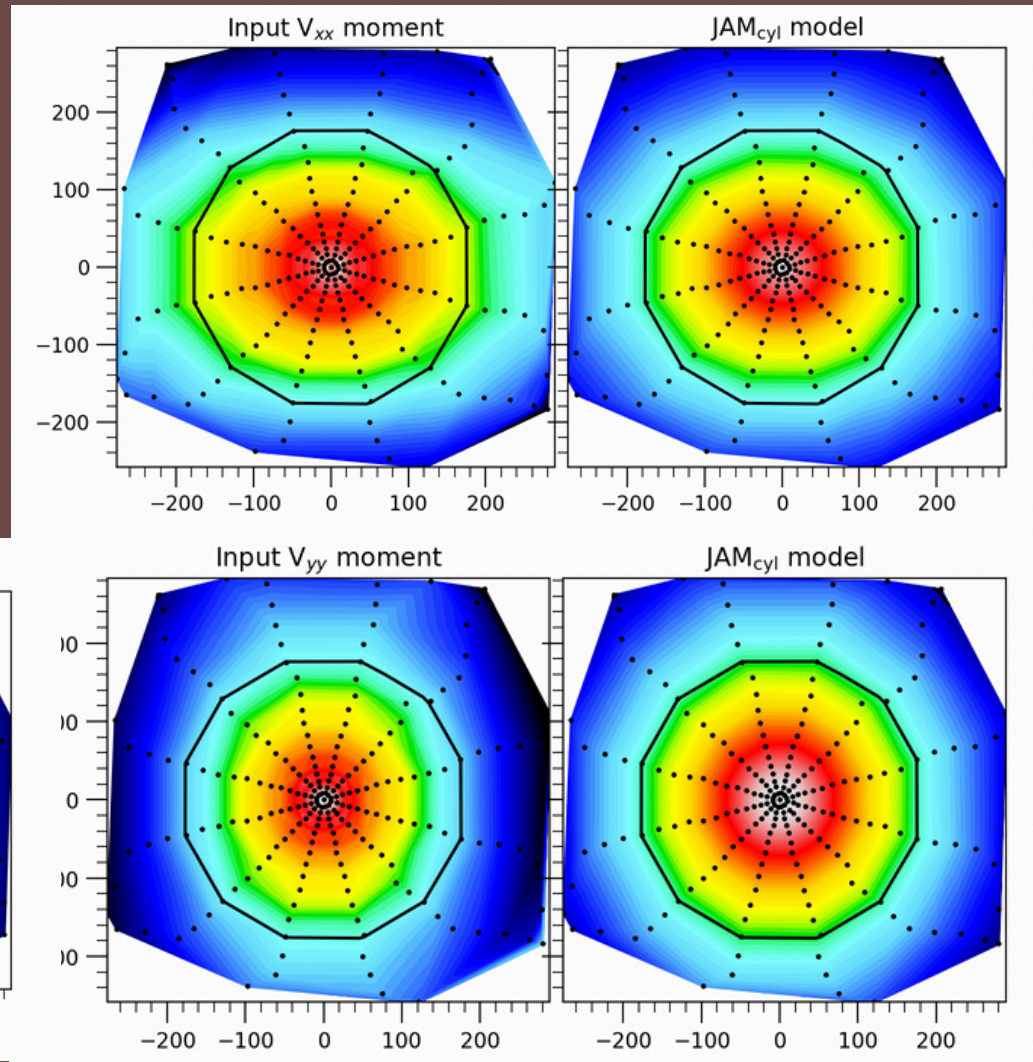
VELOCITY DISPERSION COMPARISON

- 'XX' MOMENTS
- 'YY' MOMENTS
- 'ZZ' MOMENTS



VELOCITY FIELD COMPARISON

- 'XX' MOMENTS
- 'YY' MOMENTS
- 'ZZ' MOMENTS



WORK IN PROGRESS!

Adding an extended mass profile from simulations or testing other density profiles

Adding rotation parameter

Free parameters for anisotropy

Pechetti et al. 2024 (*in prep.*)



Presentation by **Renuka Pechetti**