



Green Flash in La Silla Observatory (2005-10-25)
Canon EOS Digital Rebel -- 1/160s, f/18, 190mm + focal doubler, ISO 800.



Ceci n'est pas une pipe.

The nice story of the distance of GRO J1655-40

Cédric Foellmi

(in collaboration with T. Dall, E. Depagne & F. Mirabel)

ESO Vitacura, 1 February 2006

"Science is an essentially anarchistic enterprise..."

Paul K. Feyerabend, in

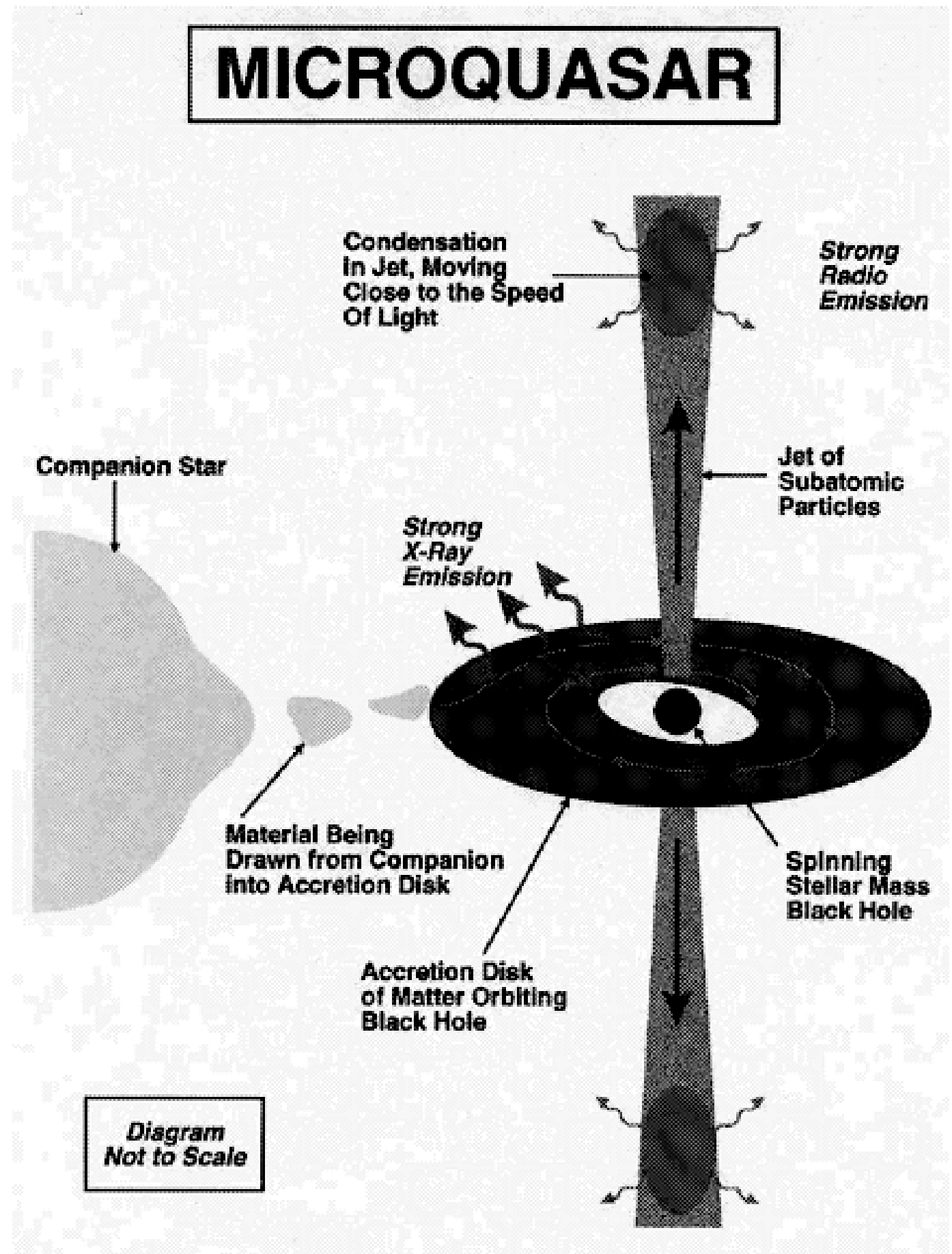
Against the method — Outline of an anarchist theory of knowledge

What is GRO J1655-40?

- Discovered by BATSE in 1994
- **Runaway black-hole** in our Galaxy.
- Also called Soft X-ray Transient and microquasar.
- It is supposed to be a **super-luminal source**.
- Since its discovery 10 years ago, everybody uses a distance of **3.2 kpc**.

You said microquasar?

Mirabel, 2004,
ESA SP-552: 5th INTEGRAL Workshop
on the INTEGRAL Universe



Yes but no.

Bailyn et al. (1995b)
Greiner et al. (1995)
Orosz & Bailyn (1997)
Bianchini et al. (1997)
van der Hooft et al. (1998)
Hynes et al. (1998)
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Kuulkers et al. (2000)
Green et al. (2001)
Beer & Podsiadlowski (2002)
Brocksopp et al. (2005)
etc...

quote *Hjellming & Rupen (1995)*
they quote

Kinematic model of the jets
(VLA observations) : **3.2 kpc**

McKay & Kesteven (1994)
Tingay et al. (1995)
~~Harmen et al. (1995)~~

della Valle (1994) IAU Circ. 6052
“optical spectrum looks red”

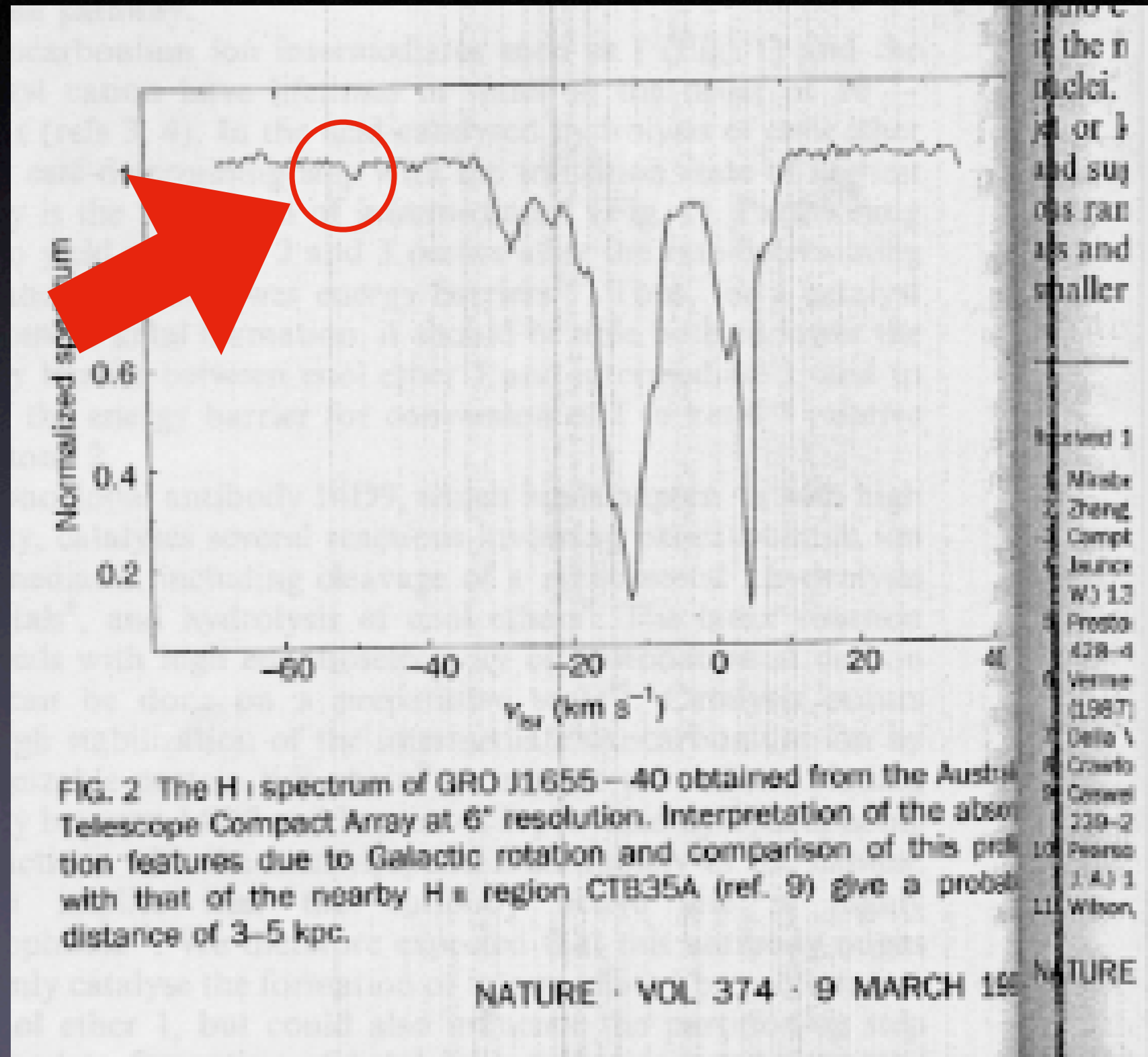
VLBI + ATCA obs.
HI and HII clouds along
mean Galactic curve
Estimate **3-5 kpc**

IAU Circ. 6062 (radio data)
“probability” of **3.5 kpc**.

You said **an H I spectrum?**

Tingay et al. (1995, Nature, 374, 141)

Feature at -50 km/s,
if due to Galactic
rotation, implies
 $D > 4.2$ kpc



Yes but no.

EW of NaI-D
use SNI relation EW-E(B-V)
obtain 3.0 kpc

Model of ROSAT halo
Get the Dust, then N_H
Mean abs. of Allen(1973)

quote

Robinson et al. (1996) ApJ,
inexistent

and

Horne et al. (1996) (HST data)
but IAU Circ. 6406

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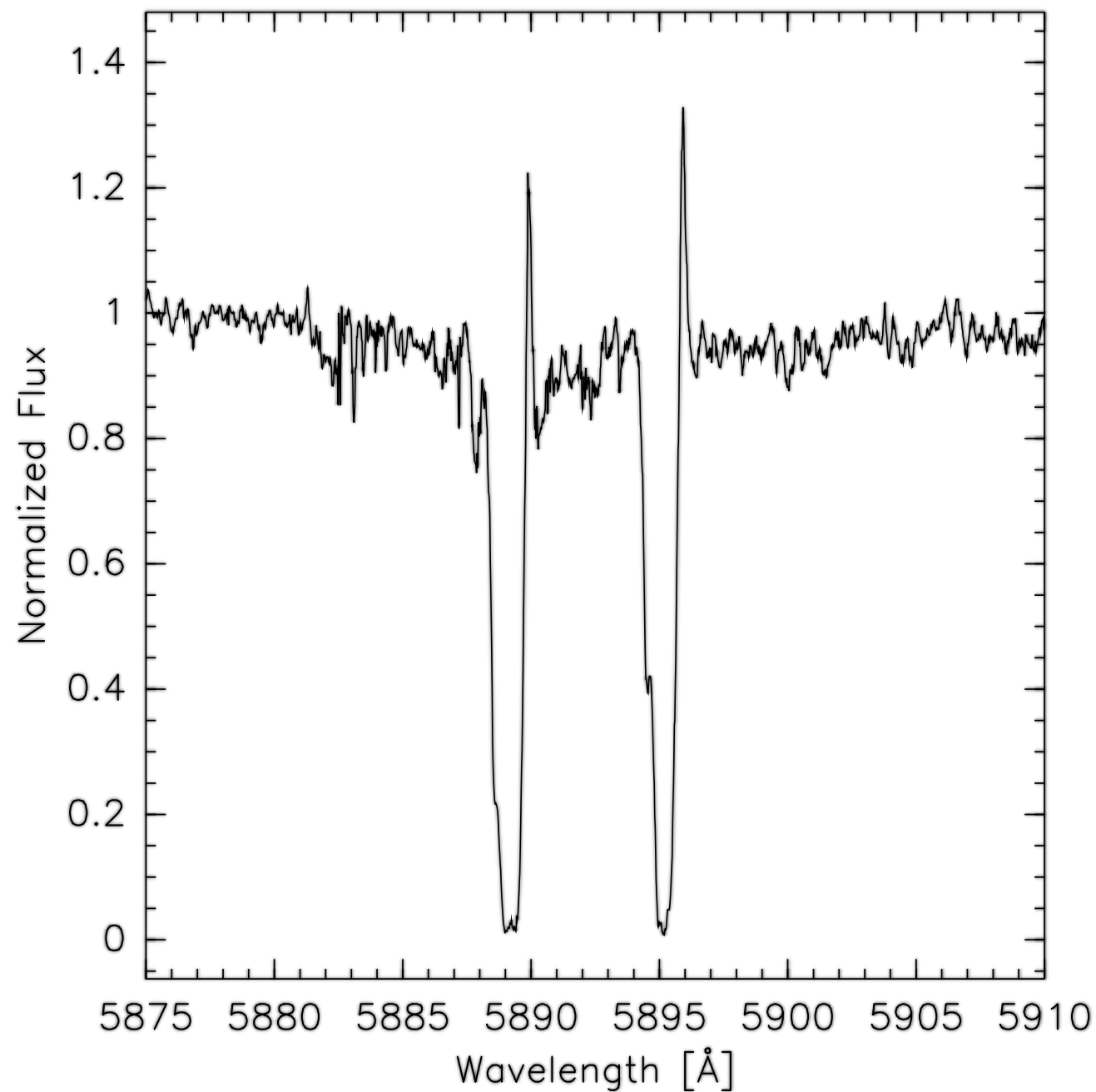
della Valle (1994) IAU Circ. 6052
“optical spectrum looks red”

VLBI + ATCA obs.
HI and HII clouds along
mean Galactic curve

Estimate **3-5 kpc**

You said

EW of (saturated) Na lines?



UVES spectrum

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Compute $M = 0.7$ (?)
Correct m to 17.12
Adopt 3.2 kpc

Assume mean Reddening law. “optical spectrum looks red”
Obtain $E(B-V) = 1.2$

della Valle (1994) IAU Circ. 6052

VLBI + ATCA obs.
HI and HII clouds along
mean Galactic curve
Estimate 3-5 kpc

HST, AAT, RXTE, CGRO data.
assume mean Galactic ext. curve.

Inoue et al. (1994) IAU Circ. 6063
Nagase et al. (1995) IAU Circ. 6094
Inoue et al. (1995) IAU Circ. 6210

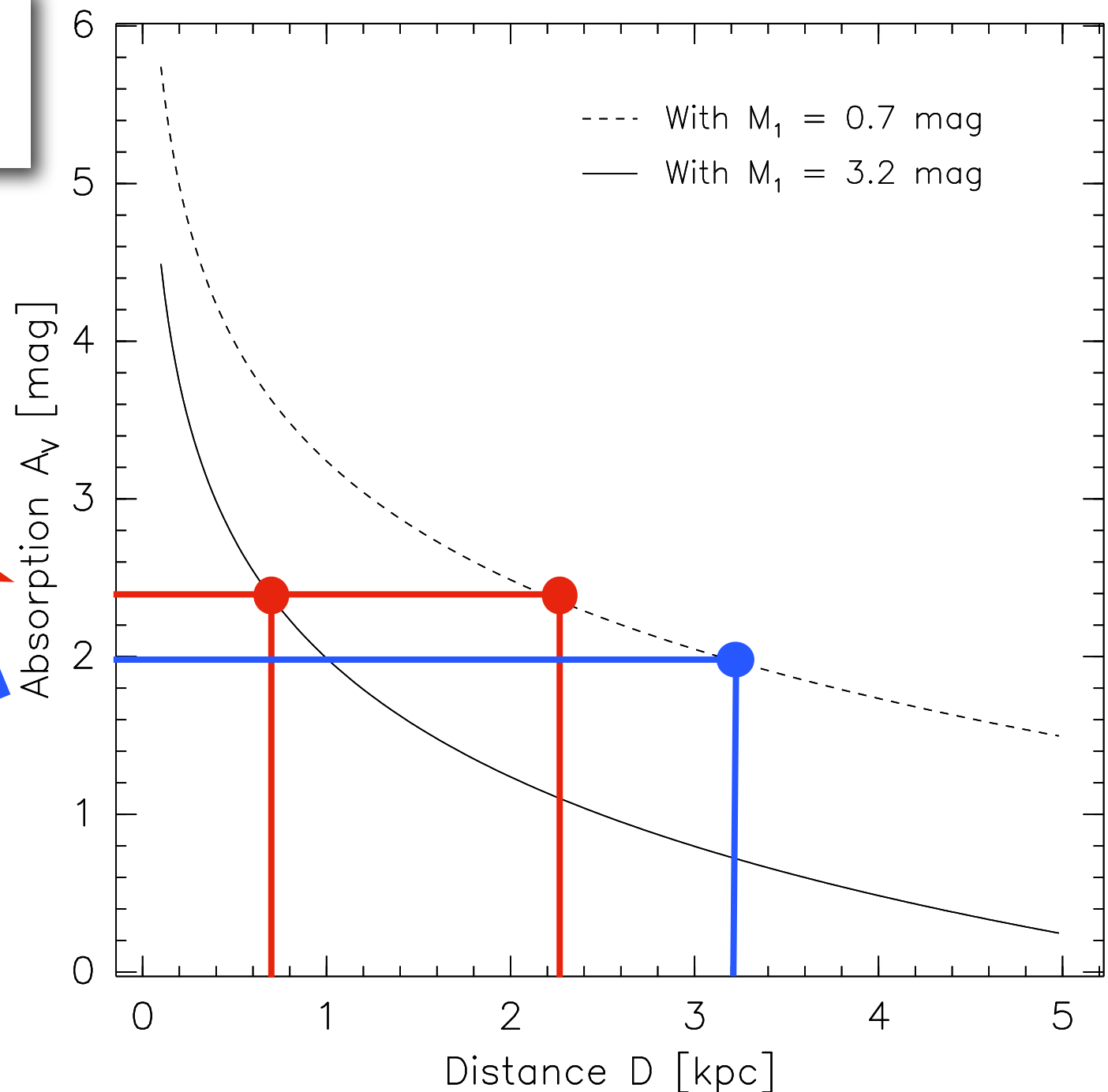
obtain inconsistent results.

You said **inconsistency**?

$$A_V = \frac{1}{2} (17.12 + 5 - 5 \log D - M_1)$$

$E(B-V) = 1.25$,
(Hynes et al. 1998)

$E(B-V) \sim 0.55$



EW of NaI-D
use SNI relation EW-E(B-V)
obtain 3.0 kpc

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VLBI + ATCA obs.
HI and HII clouds along
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Estimate 3-5 kpc

- Model of disk - lightcurve fit
- Reject one model *because* $D \ll 3$ kpc
- If $E(B-V)$ was incorrect, fit compensate for D , Temp. and $E(B-V)$
- *Since* $E(B-V) \sim$ mean galactic, thus D is correct...

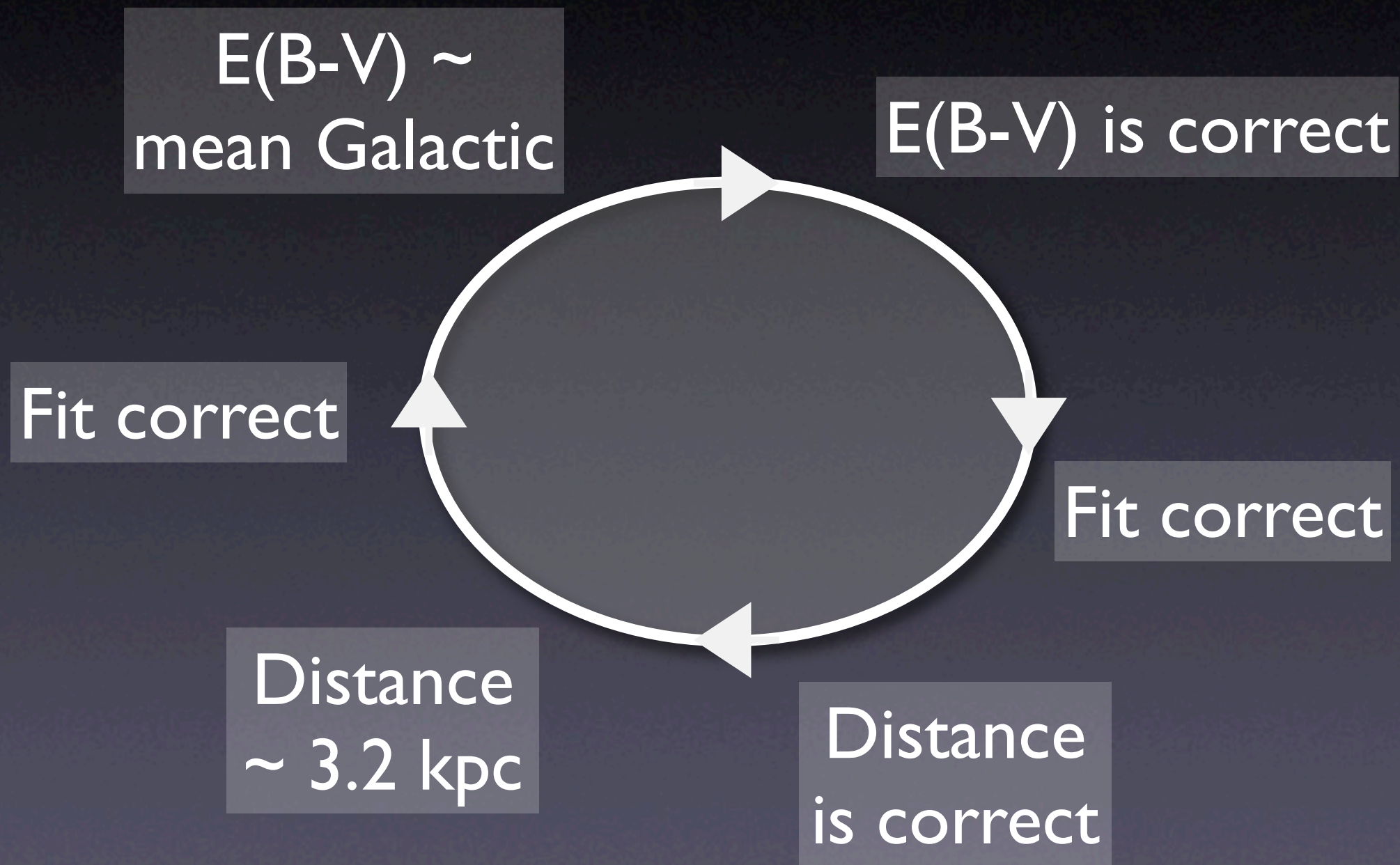
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Green et al. (2001)
Beer & Podsiadlowski (2002)
Brocksopp et al. (2005)
etc...

You said **circular argumentation**?

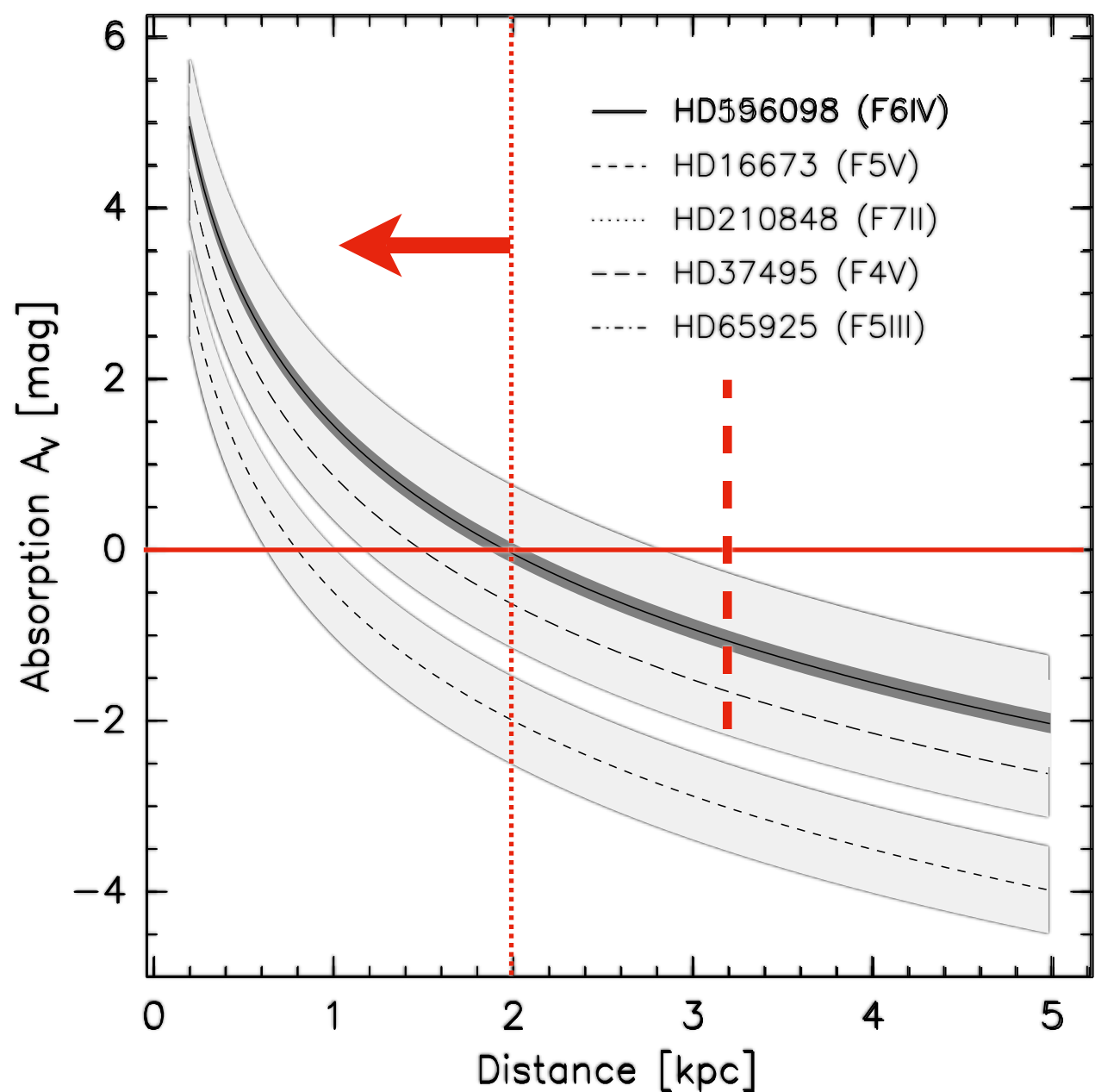


Anything to propose?...

With flux-calibrated VLT-UVES data (found freely inside ESO archive...)

- Data obtained during quiescence
- Companion F6IV
- Comparison with known stars of similar spectral type.
- Distance < 2.0 kpc

$$A_V = 5 \log \left(\frac{D_2}{D_1} \frac{1}{\sqrt{f}} \right) + M_2 - M_1$$



Even better...

NGC 6242
at **1.0 kpc**
from the Sun

Mirabel et al. (2002),
A&A, 395, 595

598

I. F. Mirabel et al.: The runaway black hole GRO J1655-40

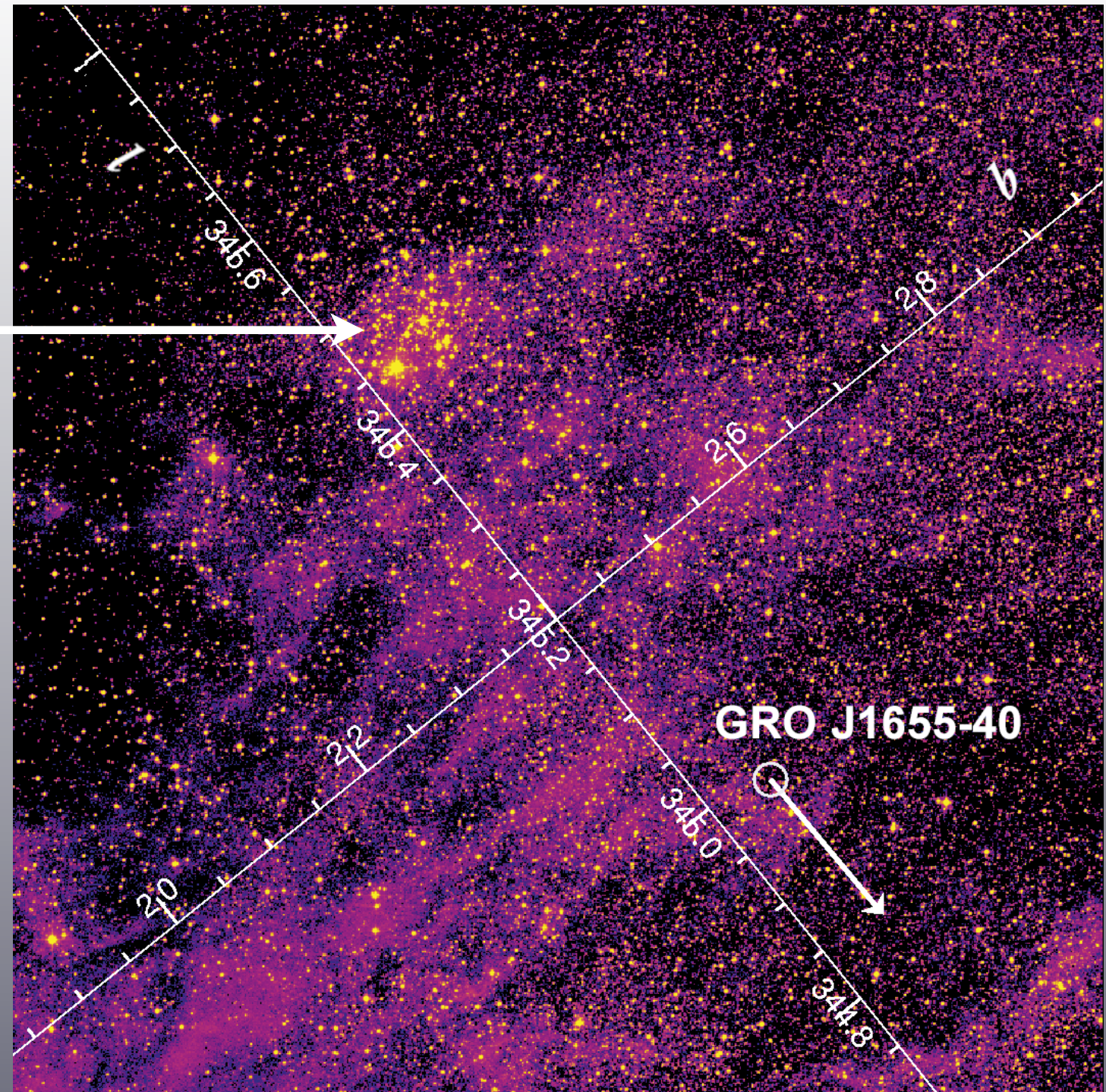


Fig. 1. Position of GRO J1655-40 on a *R* band image from the Digitized Palomar Observatory Sky Survey II (POSS II), in Galactic coordinates. The arrow shows the direction of the motion at a rate of $5.2 \pm 0.5 \text{ mas yr}^{-1}$ measured with the Hubble Space Telescope. Most of the stars around $l = 345.44^\circ$, $b = +2.43^\circ$ belong to the open cluster NGC 6242 which is at a distance of $1 \pm 0.1 \text{ kpc}$ from the sun. Because of the uncertainty in the distance to GRO J1655-40 the association with the cluster cannot be assessed.

Conclusions?

assuming GRO J1655-40 is correctly originating from NGC6242...

- The jets of this source are **not superluminal** anymore.
- The BH is born ~300 000 years ago probably from a ~7+ M_{\odot} progenitor through a 2-steps SN explosion with fallback.

The distance values
and the associated models
of the following *papers*
(at least):

Bailyn et al. (1995a)
Bailyn et al. (1995b)
Greiner et al. (1995)
Orosz & Bailyn (1997)
Bianchini et al. (1997)
van der Hooft et al. (1998)
Hynes et al. (1998)
Shabbaz et al. (1999)
Kuulkers et al. (2000)
Combi et al. (2001)
Green et al. (2001)
Beer & Podsiadlowski (2002)
Podsiadlowski et al (2002)
Jonker & Nieuwe (2004)
Brocksopp et al. (2005)
Willems et al. (2005)
... and counting...

...

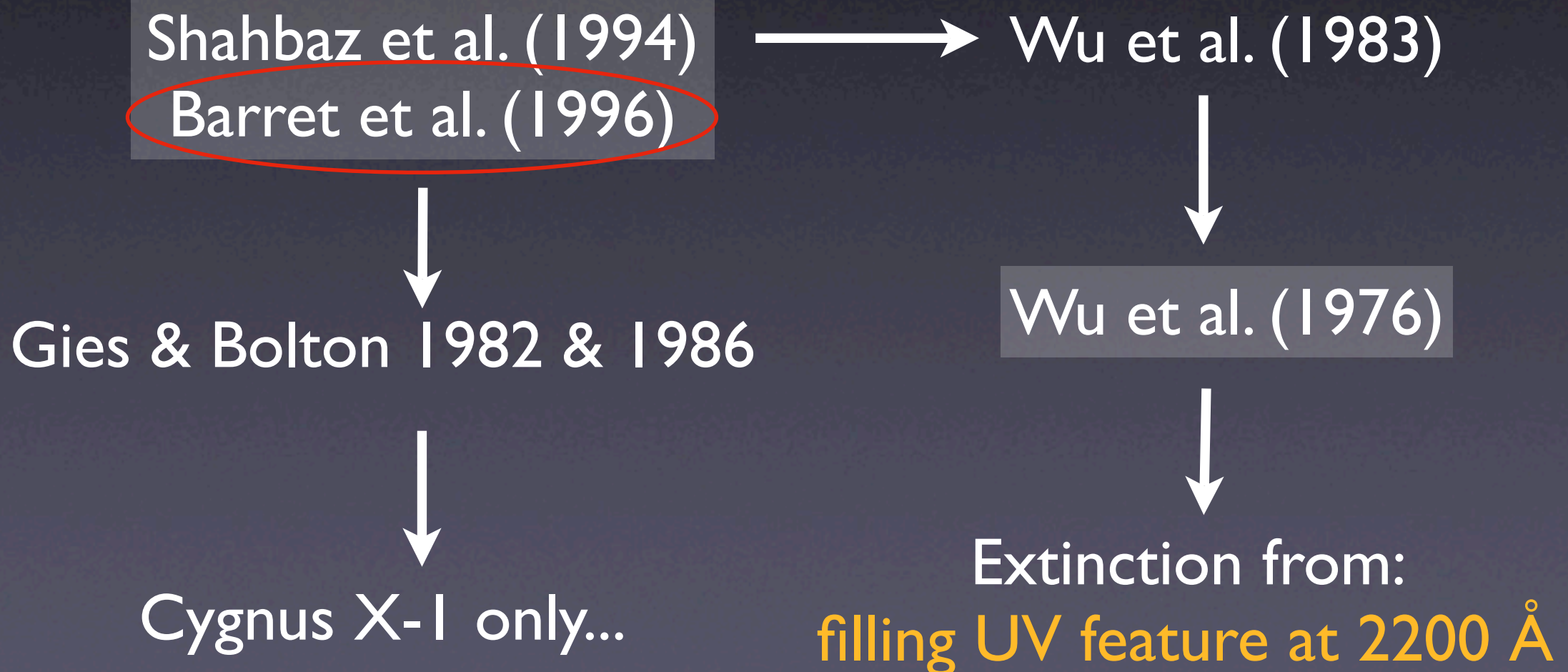
should be revised.

On the distance of GRO J1655-40
Foellmi, Depagne, Dall, Mirabel, A&A **submitted**.

Is GRO J1655-40 the **closest** black hole?

The record (1.0-1.2 kpc) is held by **IA 0620-00**

Jonker & Nielemans (2004) cite:



You said
check
your
damn
sources?

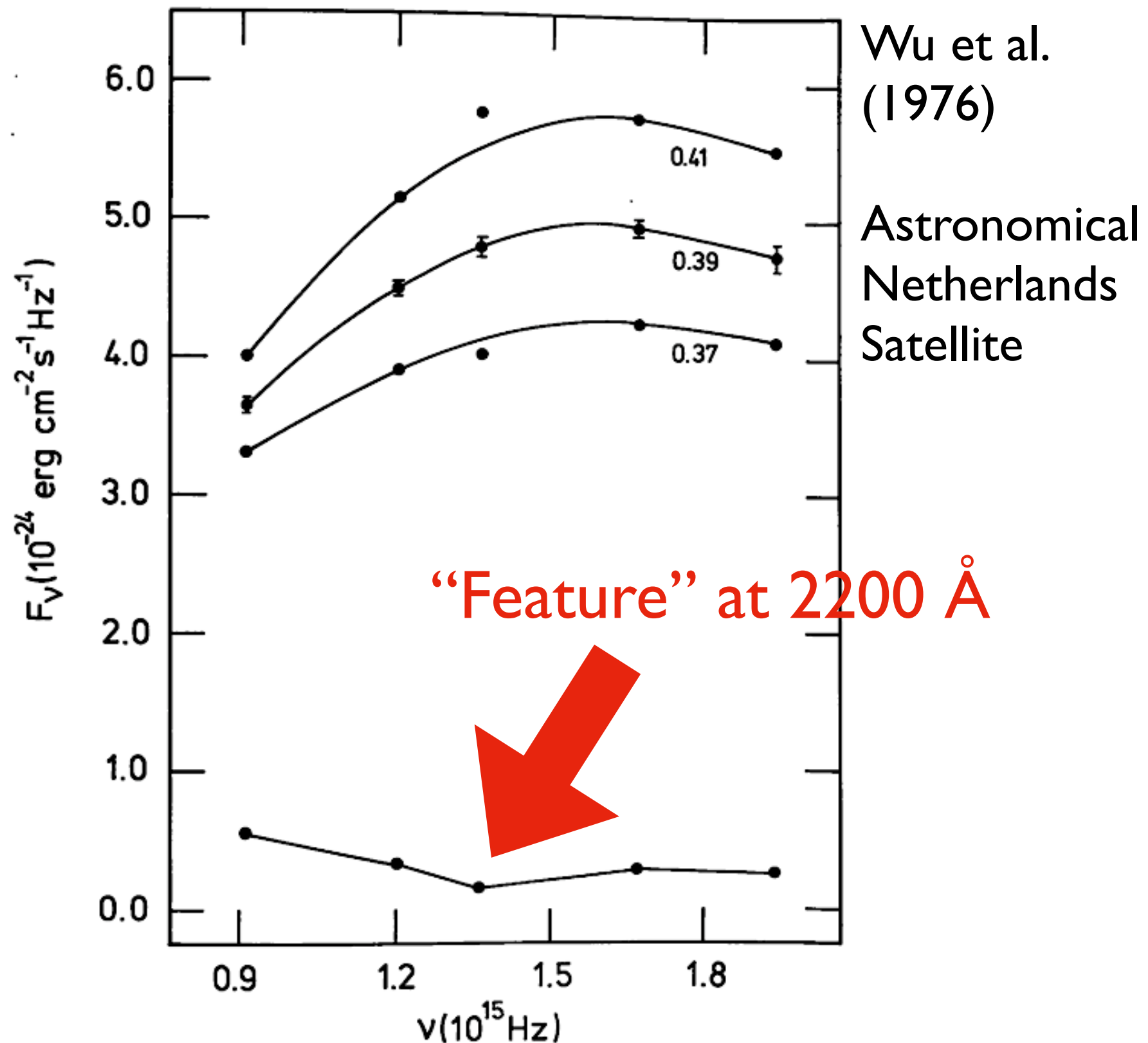


Fig. 1. The interstellar extinction of A0620-00. The observed spectrum is shown at the bottom. The three curves at the top are the dereddened spectra labelled by the $E(B-V)$ used. $E(B-V)=0.39 \pm 0.02$ is the best estimate

On the distance of I A 0620-00

Foellmi, Dall, Depagne, (Mirabel?), A&A **in prep.**

Yet another conclusion?

"Science is an essentially anarchistic enterprise.

Theoretical anarchism is more humanitarian and more likely to encourage progress than its law-and-order alternatives..."

Paul K. Feyerabend, in

Against the method — Outline of an anarchist theory of knowledge.



Green Flash in La Silla Observatory (2006-01-15)
Canon EOS Digital Rebel -- 1/400s, f/7, 200mm + focal doubler, ISO 800.