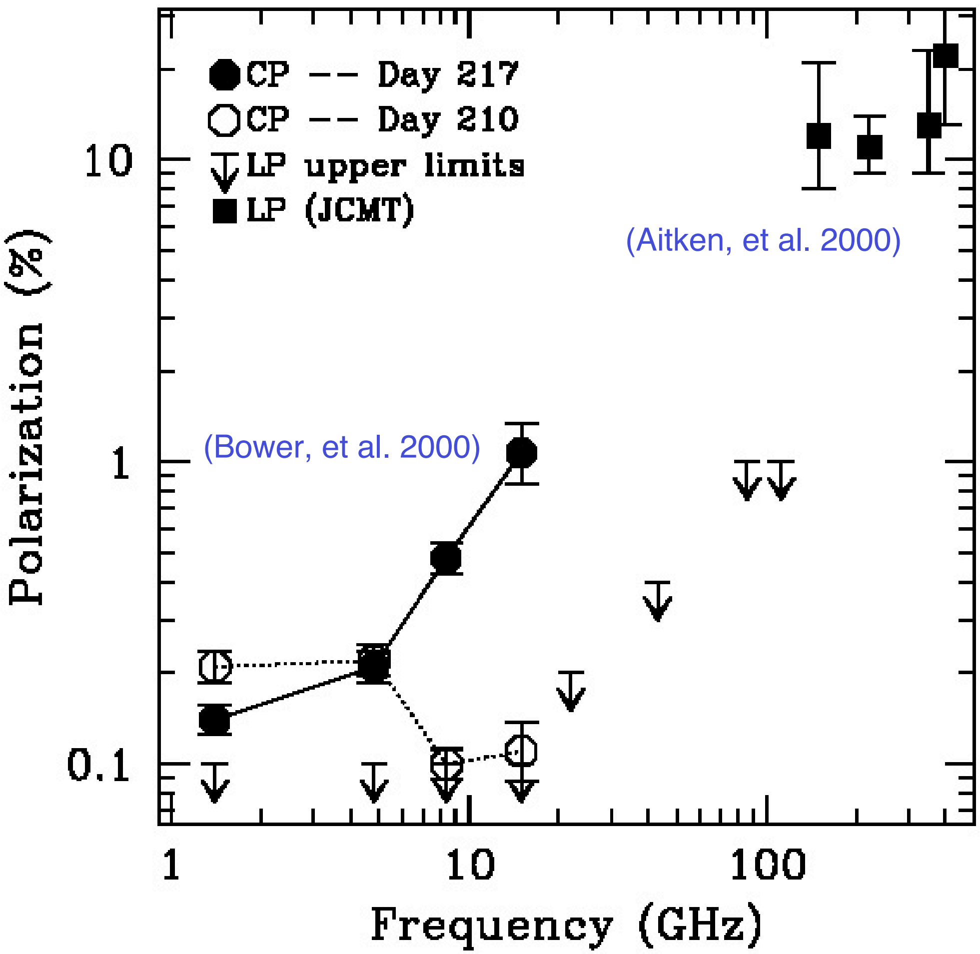
Two Important Predictions: [1]

REGION IS

US A*'S

RUM

ILITY

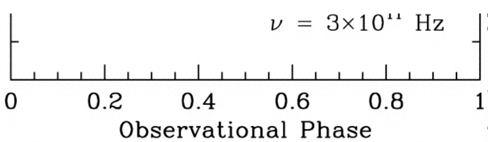


DIO EMISSION IN SAGITTARIUS A*

r 21; published 2001 October 10

at the Galactic center, as well as its polarization

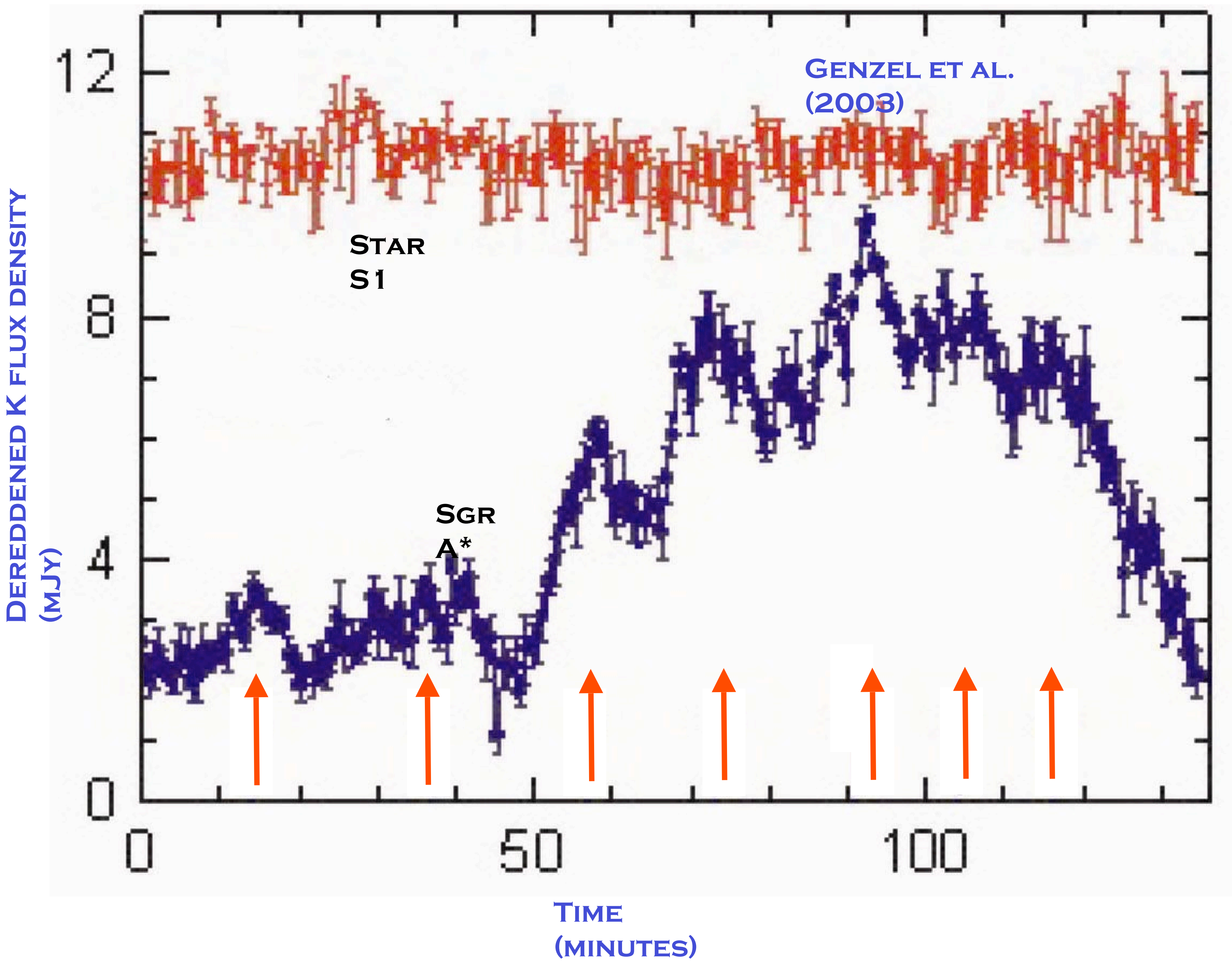
h significant convection (Narayan, Igu-
nowicz 2000). The approach followed by
a 1992) has been based on the idea that
eting a low specific angular momentum
l value of λ, the infalling gas does not
radius $\sim 2\lambda^2 r_S$, and depending on
etic field annihilation, or generation (see,
ie, & Balbus 1996), it may not become an
it falls to within tens of Schwarzschild
rizon. Recent radio polarization measure-
1999; Aitken et al. 2000) seem to support
expected for such a low angular mo-
lia et al. (2000, 2001), we demonstrated
an structure, with a magnetic field domi-
nated by its azimuthal component inferred from earlier mag-
netohydrodynamic simulations (Brandenburg, Nordlund, &
Stein 1995; Hawley et al. 1996), not only produces the mil-
limeter bump but also accounts for these polarization charac-
teristics, especially the ~90° flip of the polarization angle near



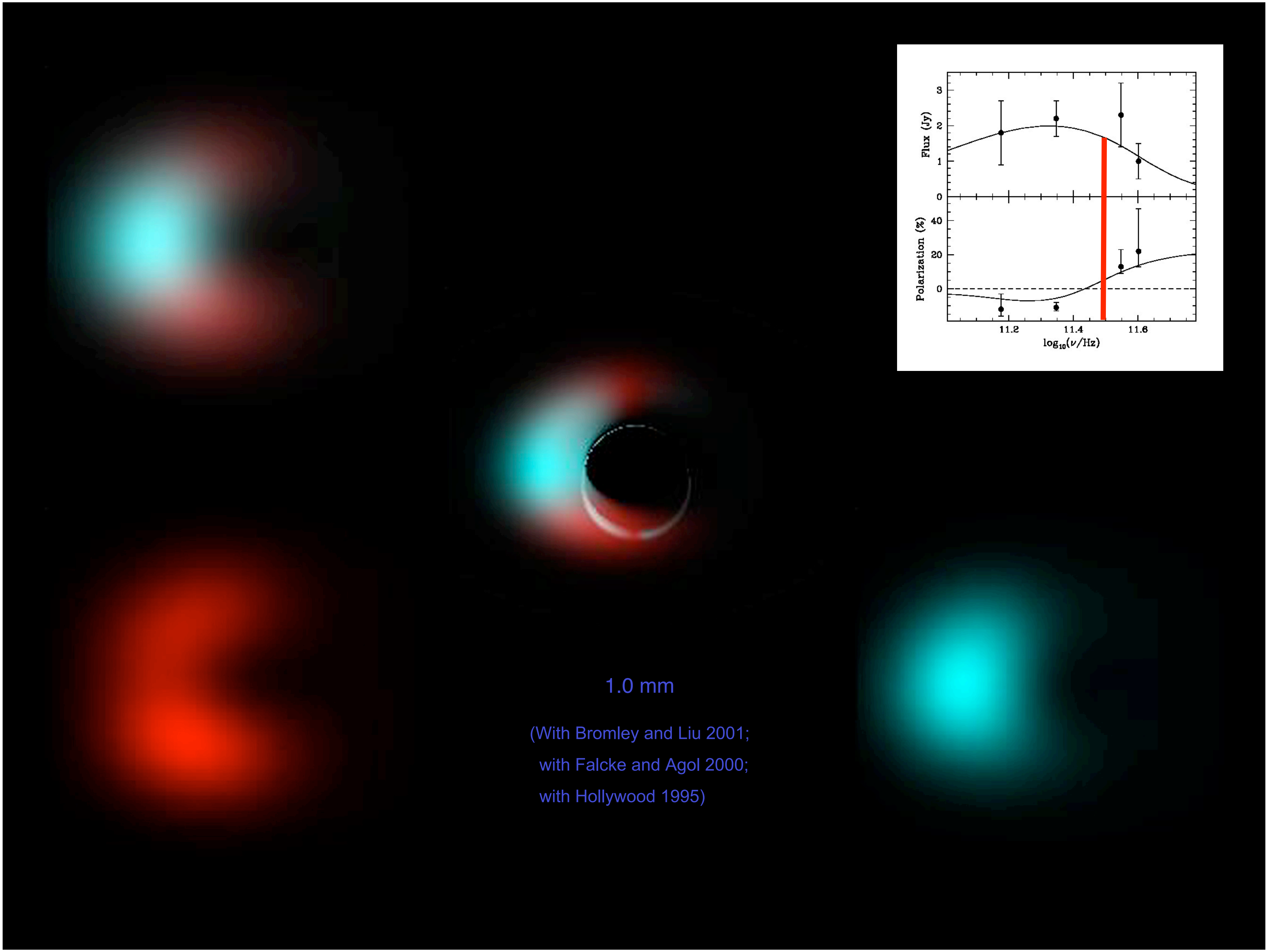
range.
Several di
& Falcke 20
from jet emis
large-scale a
a picture tha
sions, includ

[1] Department
son, AZ 85721.
[2] Steward Obs
Tucson, AZ 857
[3] Sir Thomas

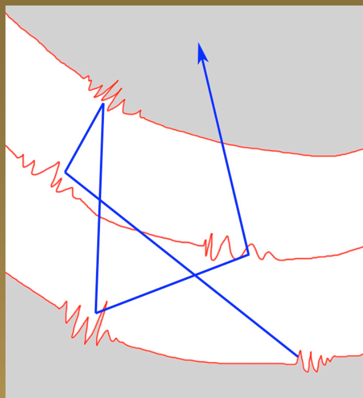
L77



Genzel et al.
(2003)
Star
S1
Sgr
A*
12
8
4
0
0
50
100
Dereddened K flux density
(mJy)
Time
(minutes)



Flux (Jy)
0
1
2
3
Polarization (%)
0
20
40
11.2
11.4
11.6
$\log_{10}(\nu/\mathrm{Hz})$
1.0 mm
(With Bromley and Liu 2001;
with Falcke and Agol 2000;
with Hollywood 1995)



The Particle Distribution

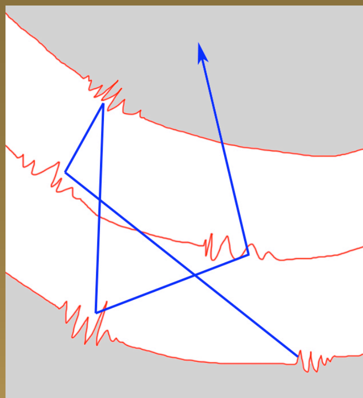
The mm, IR, and X-ray spectral components apparently arise in a partially self-absorbed, orbiting medium, produced either by a hot ($T \sim 10^{10} - 10^{11}$ K) MB plasma, or a modified MB plasma with non-thermal particles (Liu & Melia 2001; see also Mahadevan 1998).

But the lack of an obvious particle acceleration mechanism has led to diverse interpretations (Markoff et al. 2001; Nayakshin et al. 2003; Yuan et al 2003).

Given the suspected environment, an obvious process to consider is stochastic acceleration of particles interacting resonantly with plasma waves or turbulence generated via an MHD dissipation process (Liu, Petrosian & Melia 2004).

This may happen either locally via a coronal-type breakout, or globally via an enhancement in the accretion rate. *The emission spectra are different.*

Also, some electrons diffuse out to larger radii where they presumably produce the cm radio spectrum.



The Particle Distribution

Depends on:

- n, B, which govern cooling rate (mostly Coulomb and synchrotron);
- turbulent spectrum, which governs scattering & acceleration rates;
- spatial scale, which determines diffusion, and escape time T_{esc}
- injected spectrum, presumably MB (with kT)

Consider 3 cases:

A R = 2.5 R_s n ~ 1 x 10^7 cm^{-3} B = 9 G kT/mc^2 = 25 (Steady)

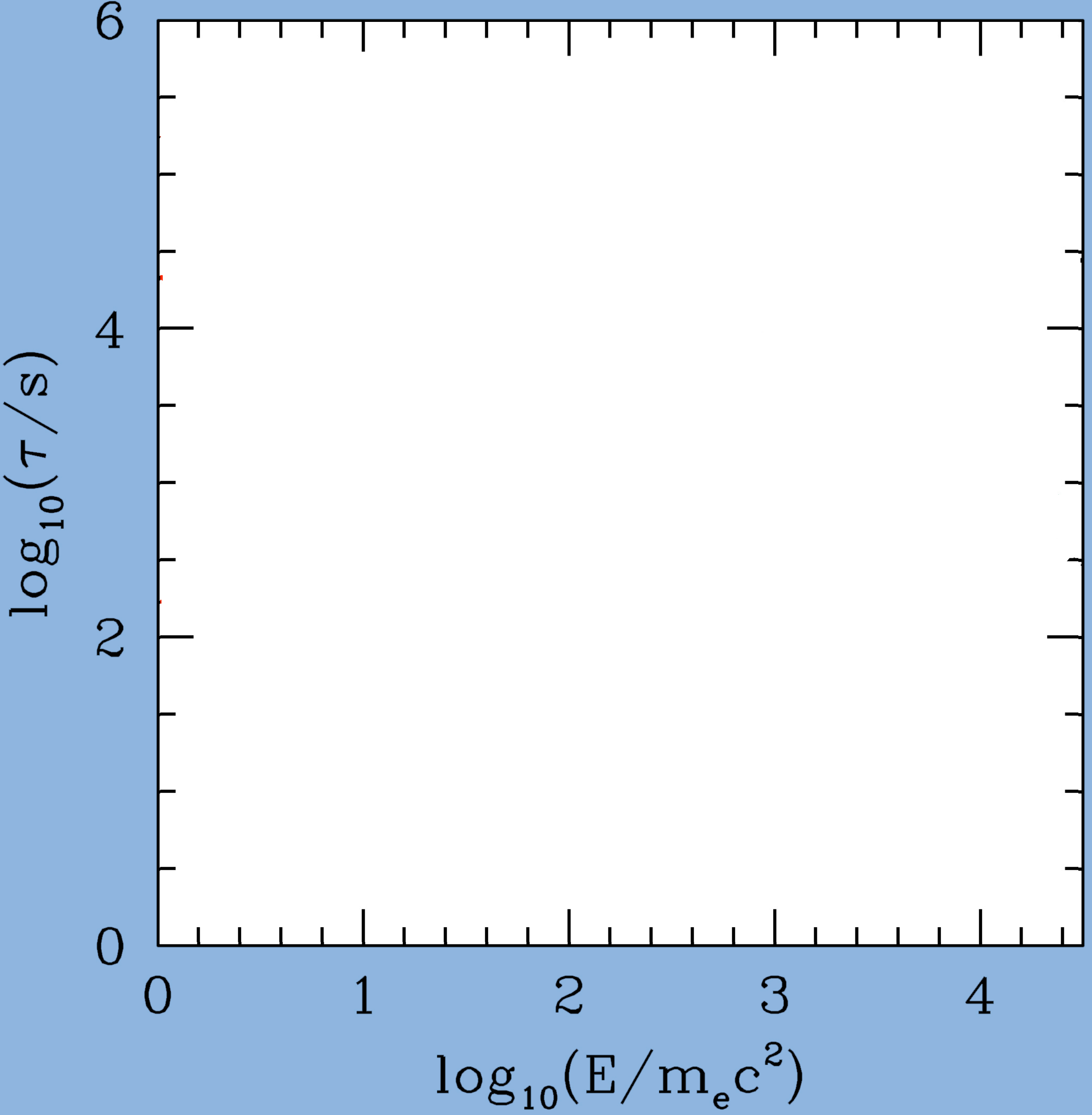
B R = 0.22 R_s n ~ 20 x 10^7 cm^{-3} B = 44 G kT/mc^2 = 34 (Chandra)

C R = 1.9 R_s n ~ 18 x 10^7 cm^{-3} B = 43 G kT/mc^2 = 10 (XMM)

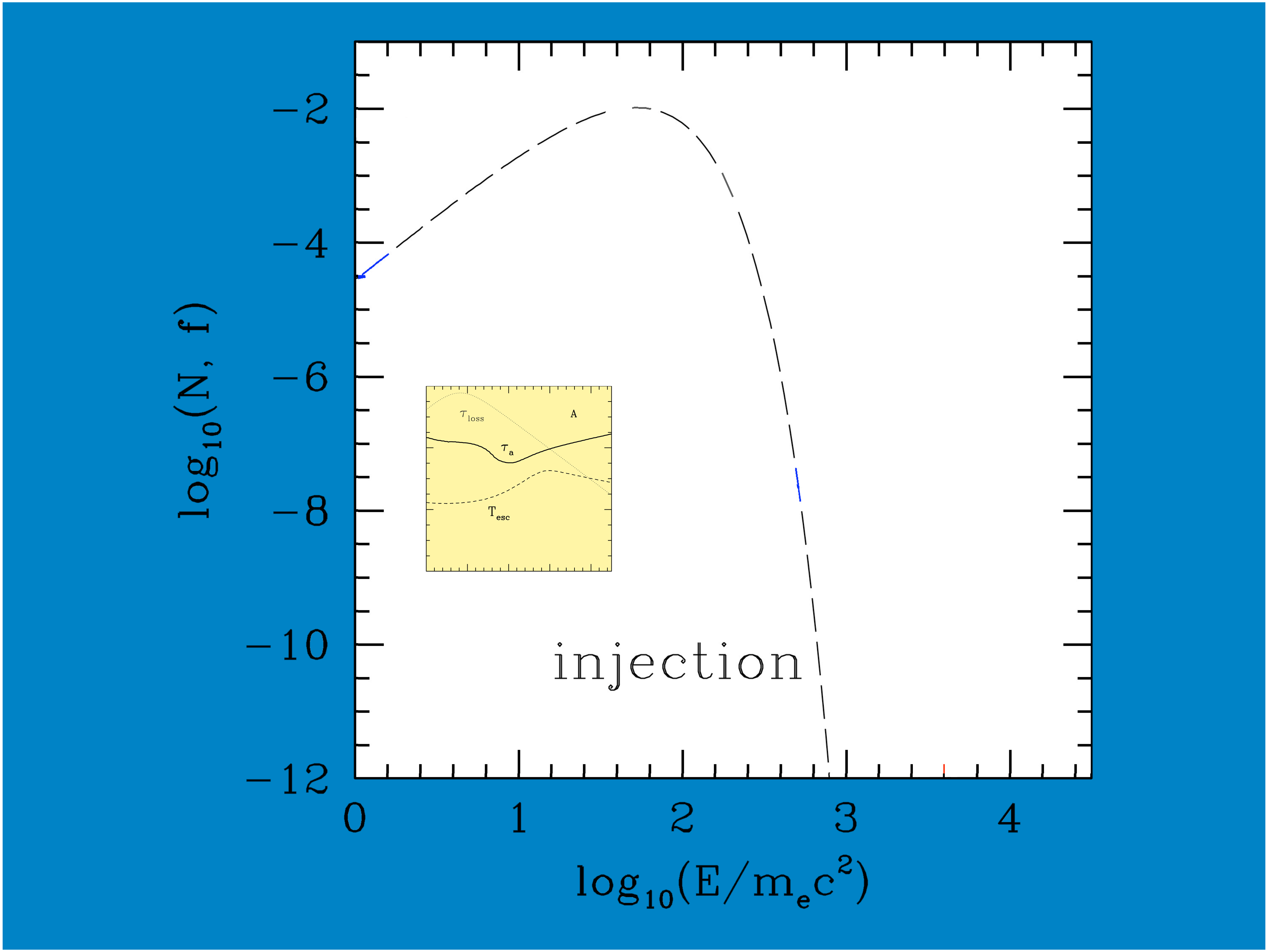
Particle Diffusion

A Steady particle luminosity: L(□>100) ~ 10^{37} ergs s^{-1} ~ 20% of accretion energy

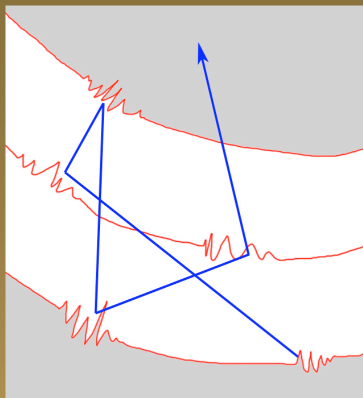
C L(□>100) ~ 10^{40} ergs s^{-1}, which sustains a 2-day radio flare like 2002-10-04



6
4
2
0
0
1
2
3
4
$\log_{10}(\tau/s)$
$\log_{10}(E/m_e c^2)$



−2
−4
−6
−8
−10
−12
0
1
2
3
4
log10(N, f)
log10(E/mec2)
injection
τloss
A
τa
Tesc



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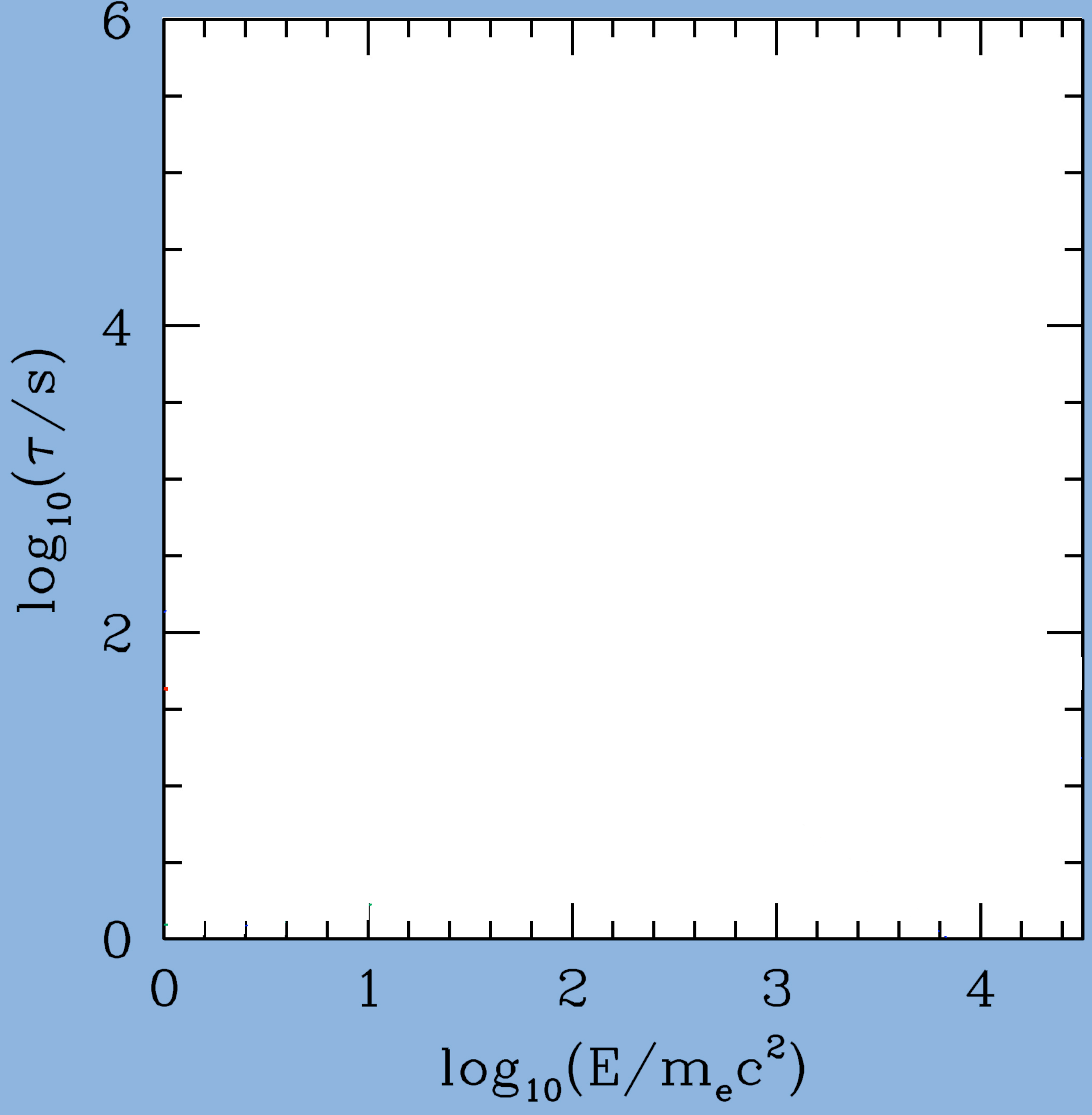
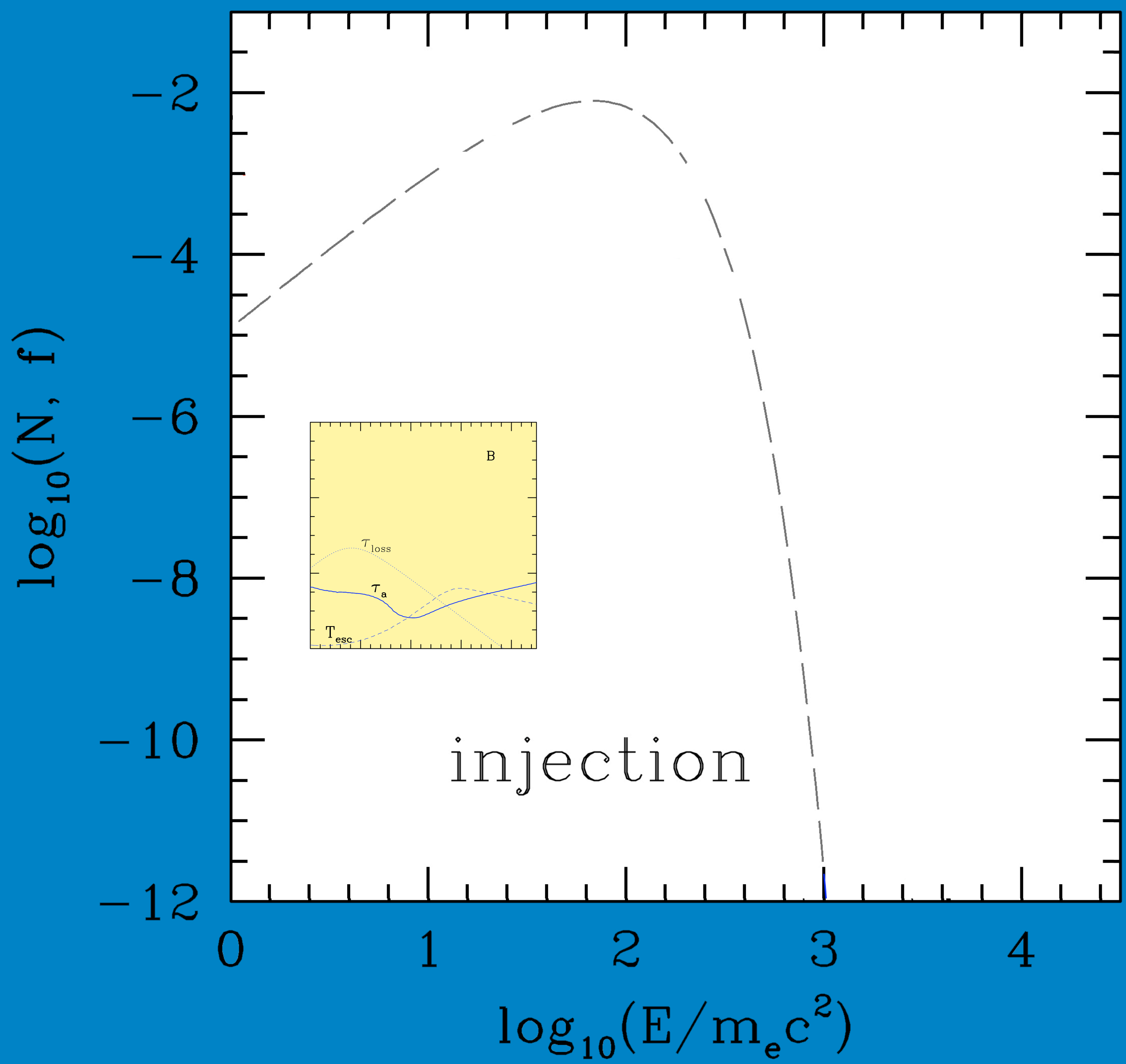
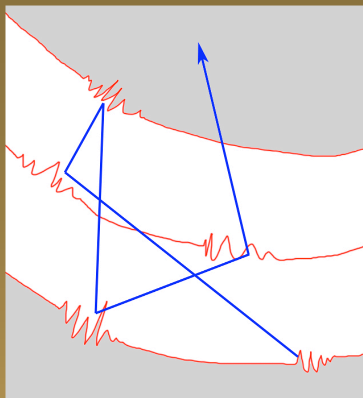


6
4
2
0
0
1
2
3
4
log10(τ/s)
log10(E/mec2)



−2
−4
−6
−8
−10
−12
0
1
2
3
4
$\log_{10}(N,\ f)$
$\log_{10}(E/m_ec^2)$
injection
B
τ_{loss}
τ_a
T_{esc}



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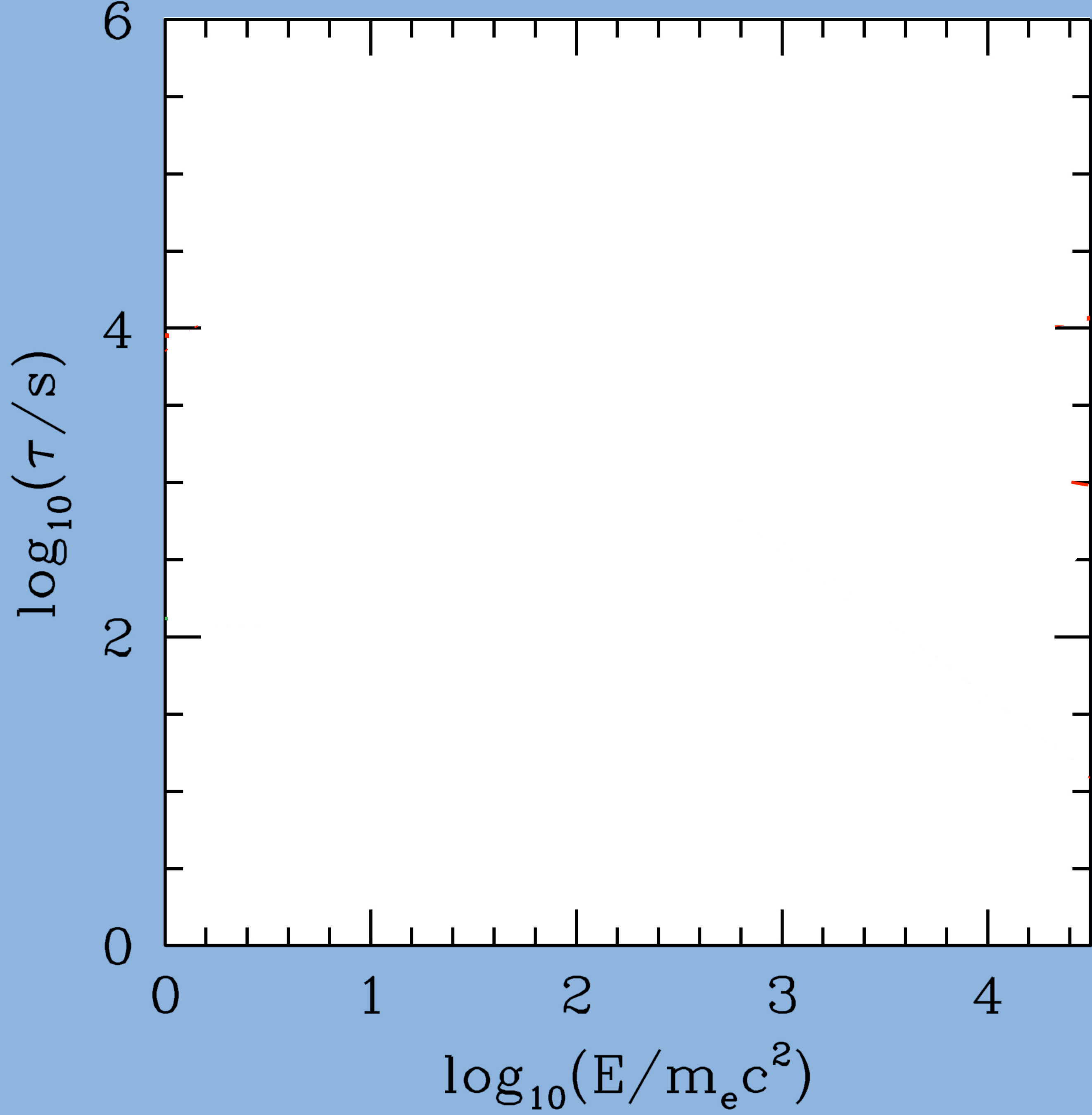
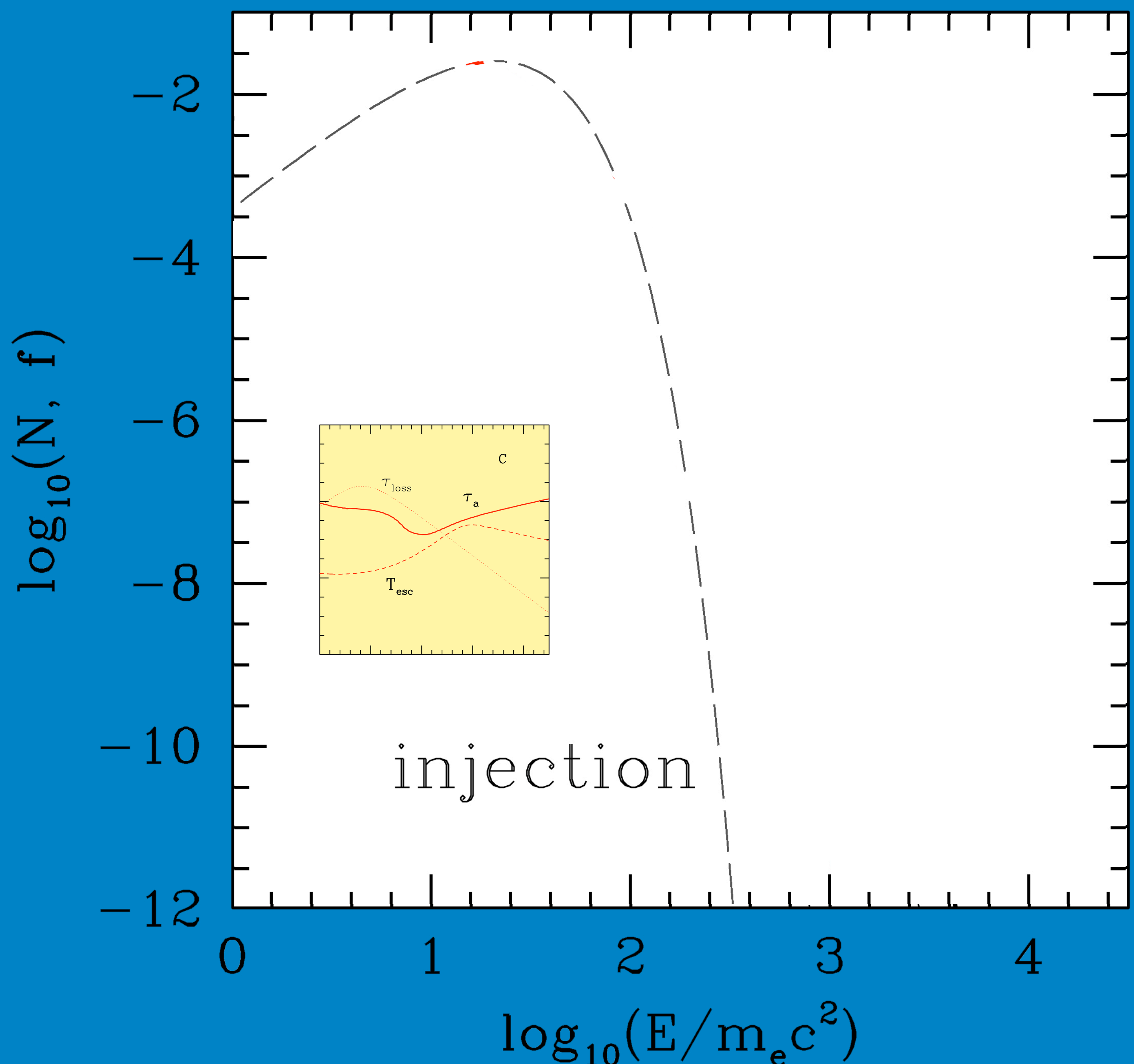
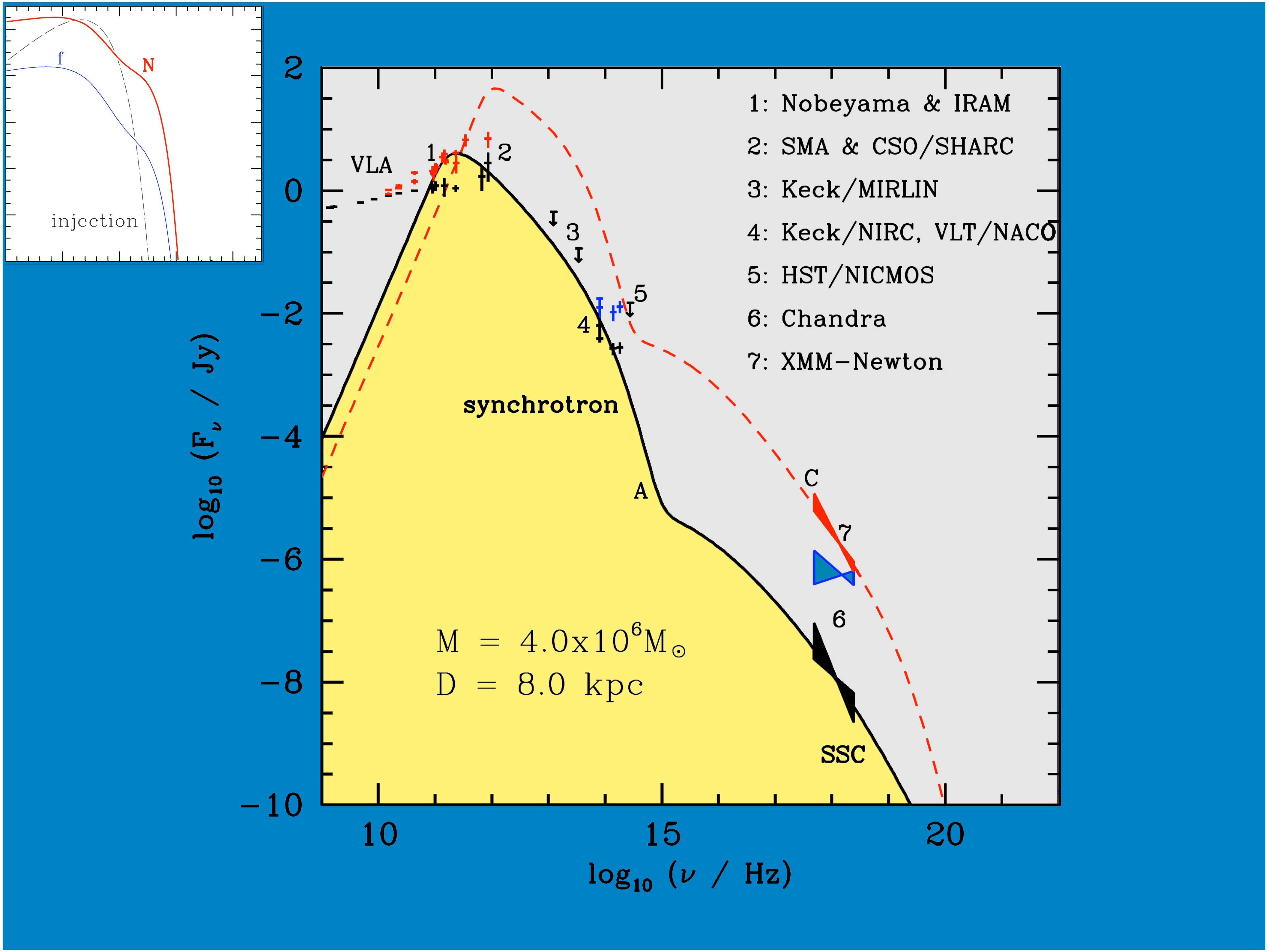


6
4
2
0
0
1
2
3
4
$\log_{10}(\tau/s)$
$\log_{10}(E/m_e c^2)$

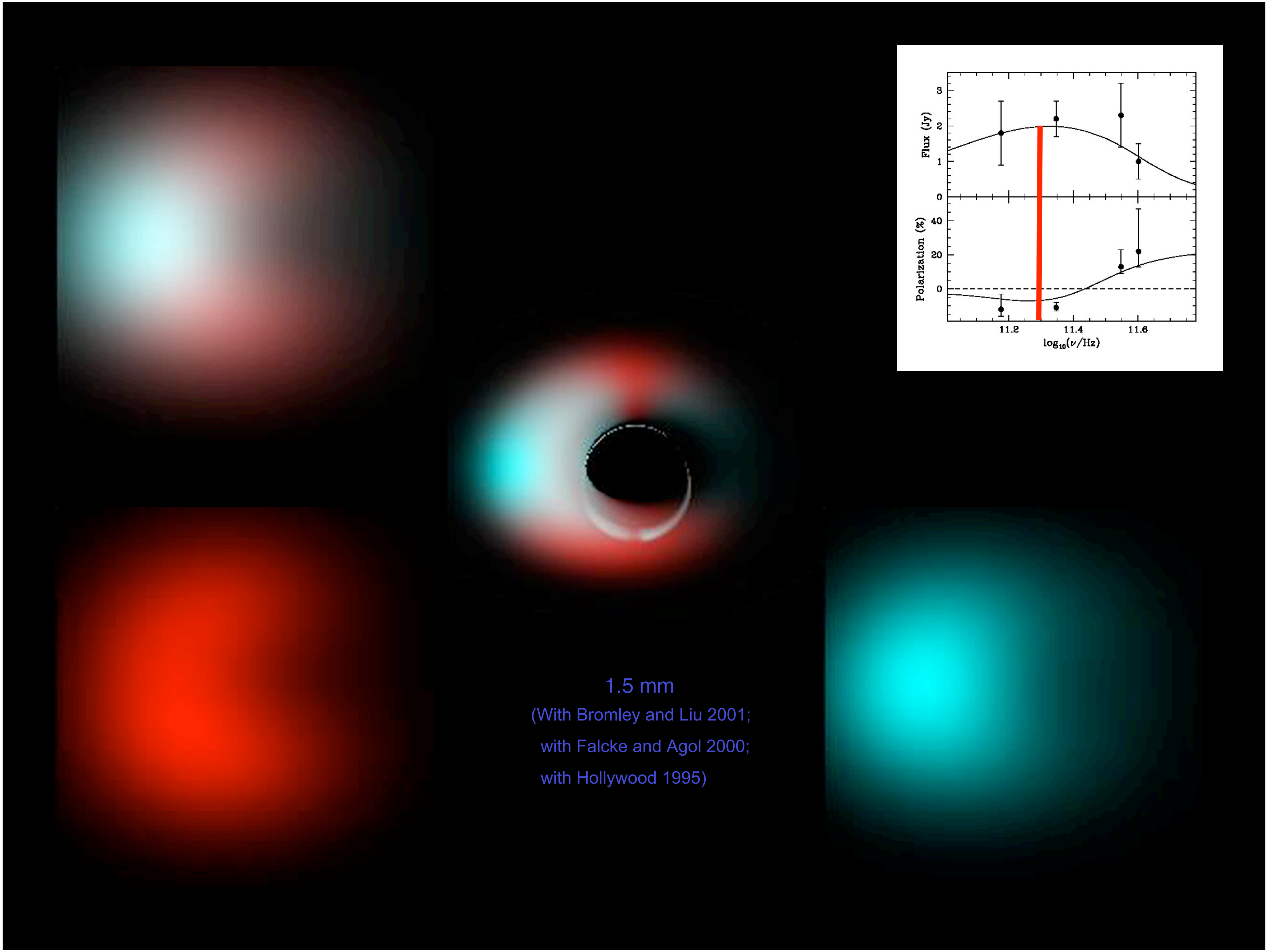


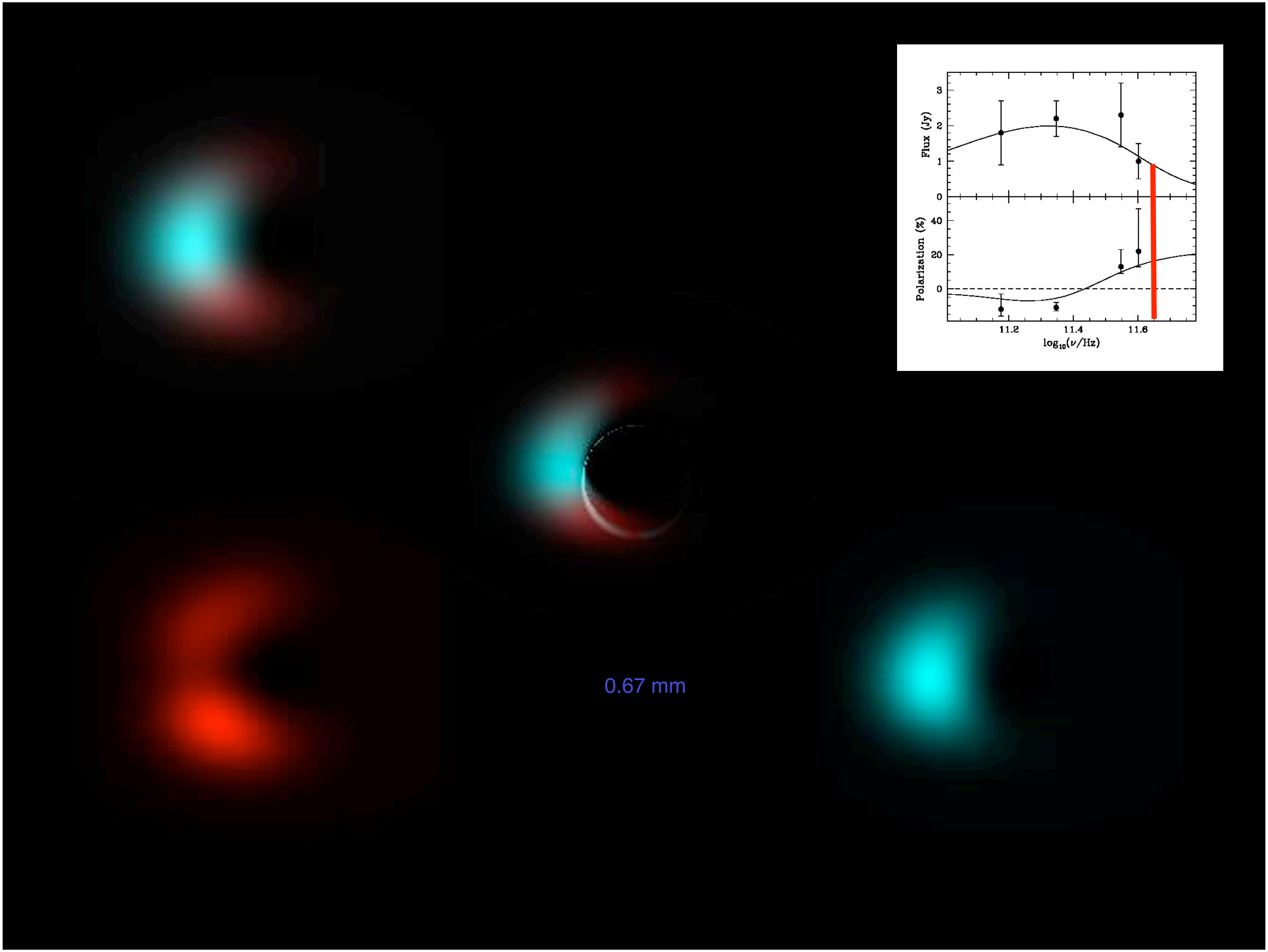
−2
−4
−6
−8
−10
−12
0
1
2
3
4
$\log_{10}(N, f)$
$\log_{10}(E/m_ec^2)$
injection
c
τ_{loss}
τ_a
T_{esc}



f
N
injection
1: Nobeyama & IRAM
2: SMA & CSO/SHARC
3: Keck/MIRLIN
4: Keck/NIRC, VLT/NACO
5: HST/NICMOS
6: Chandra
7: XMM−Newton
VLA
1
2
3
4
5
6
7
C
A
synchrotron
SSC
$M = 4.0 \times 10^{6} M_{\odot}$
$D = 8.0$ kpc
$\log_{10} (F_\nu$ / Jy)
$\log_{10} (\nu$ / Hz)
2
0
−2
−4
−6
−8
−10
10
15
20

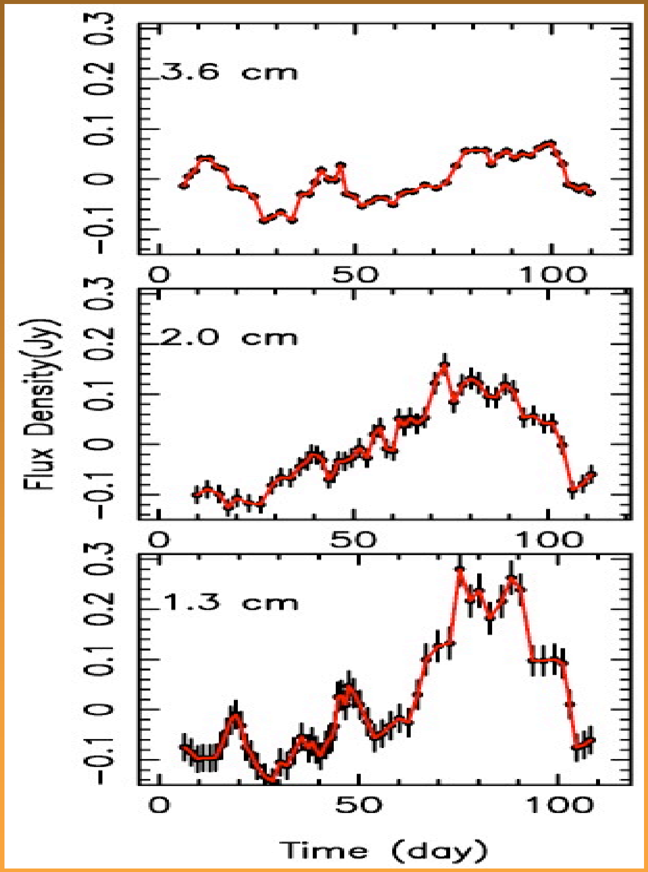
Look for coordinated multi-wavelength observations later this year


Flux (Jy)
Polarization (%)
log10(ν/Hz)
1.5 mm
(With Bromley and Liu 2001;
with Falcke and Agol 2000;
with Hollywood 1995)

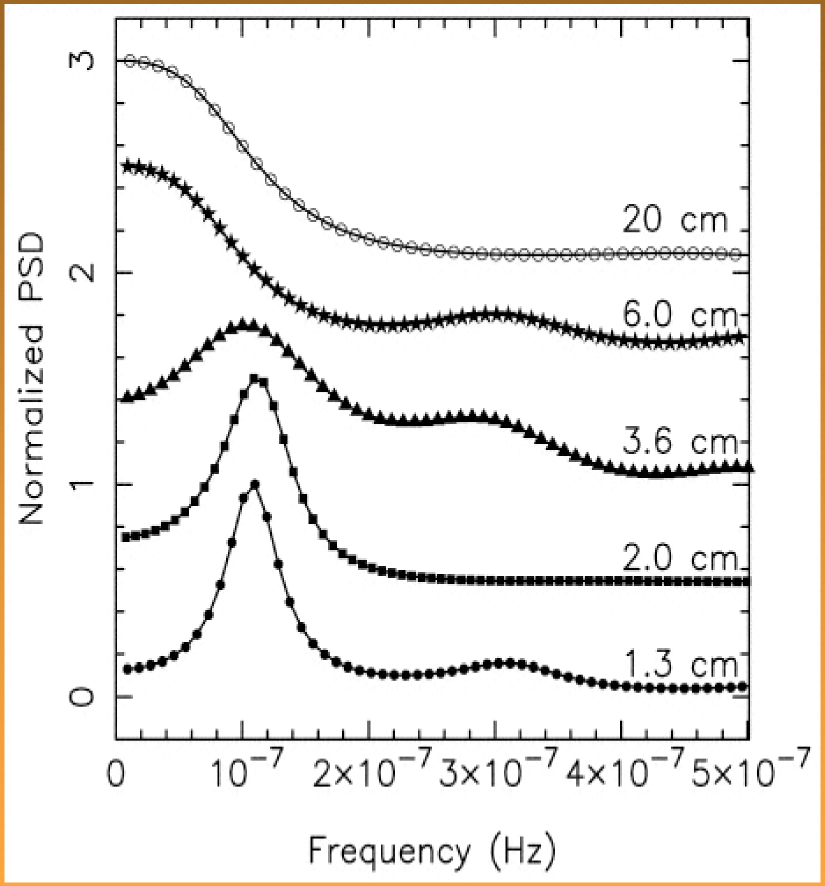

Flux (Jy)
Polarization (%)
$\log_{10}(\nu/\mathrm{Hz})$
11.2
11.4
11.6
0.67 mm

Long-Term Radio Periodicity

(Zhao et al. 2001)



Folded light curve



Power spectral distribution

Implications of the radio periodicity

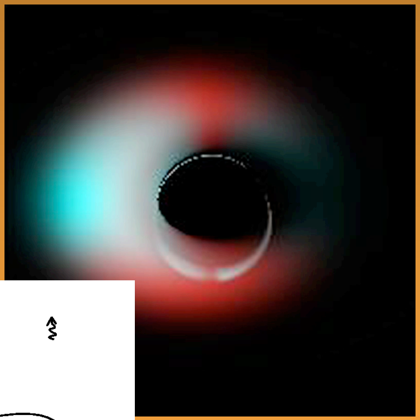
- This 106-day period is much longer than the dynamical time scale where the emission is produced.
- Strong internal coupling would require the disk to precess as a rigid body.
- It may be the signature of a **precessing** disk about a spinning black hole.

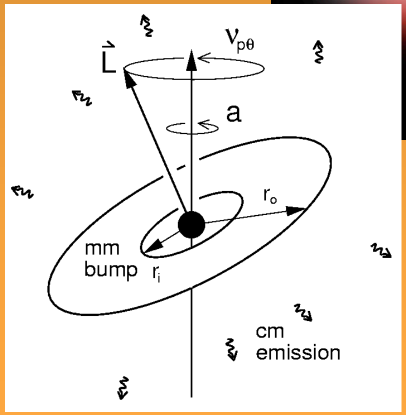
Precession Period:

$$P = \frac{\square\, r_o^{2.5}\, r_i^{0.5}[1-(r_i/r_o)^{2.5}]}{5\, a\, M\, [1-(r_i/r_o)^{0.5}]}$$

Black Hole Spin:

$a/M \sim \mathbf{0.1}\ (r_i/3r_S)^{0.5}(r_o/30r_S)^{2.5}$





Polarization