# Misaligned Fuelling and the Unified Scheme

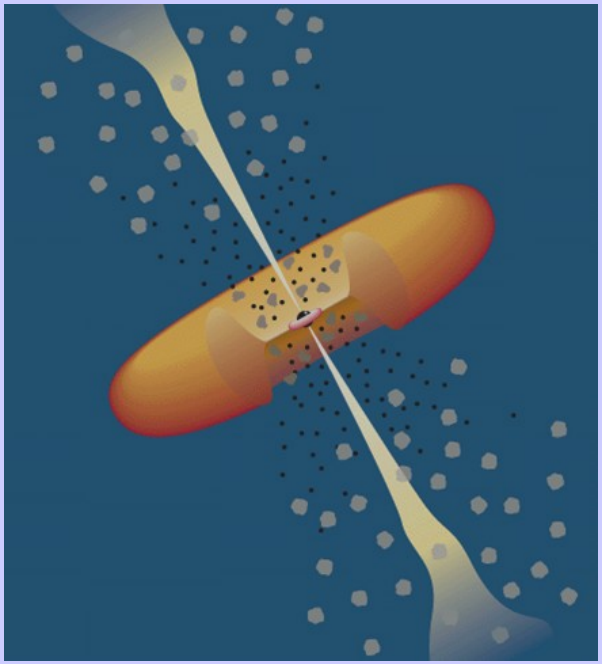
- Introduction
- Gathering facts
- Misaligned discs



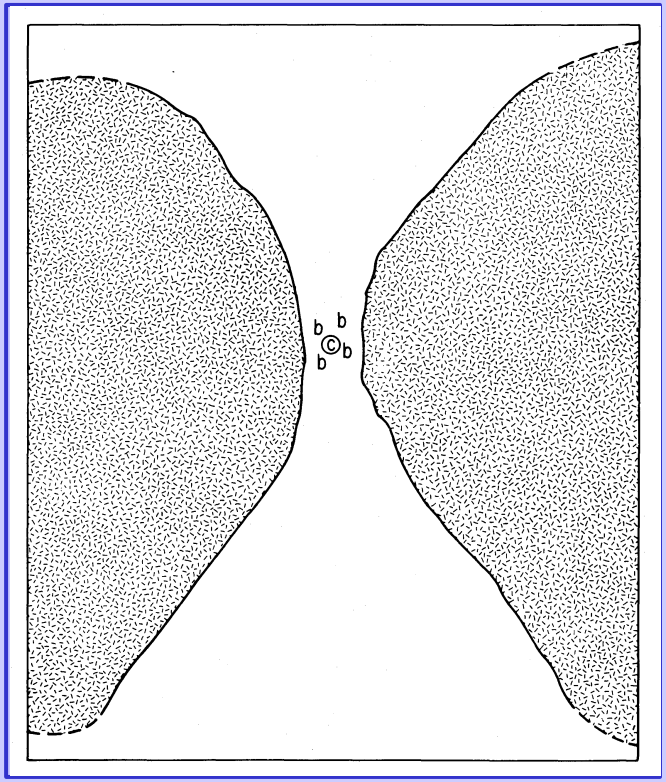
ROYAL OBSERVATORY EDINBURGH

# Introduction

## Torus Dreams



## Donut Nightmare



Antonucci and Miller 1985

***Issues :***

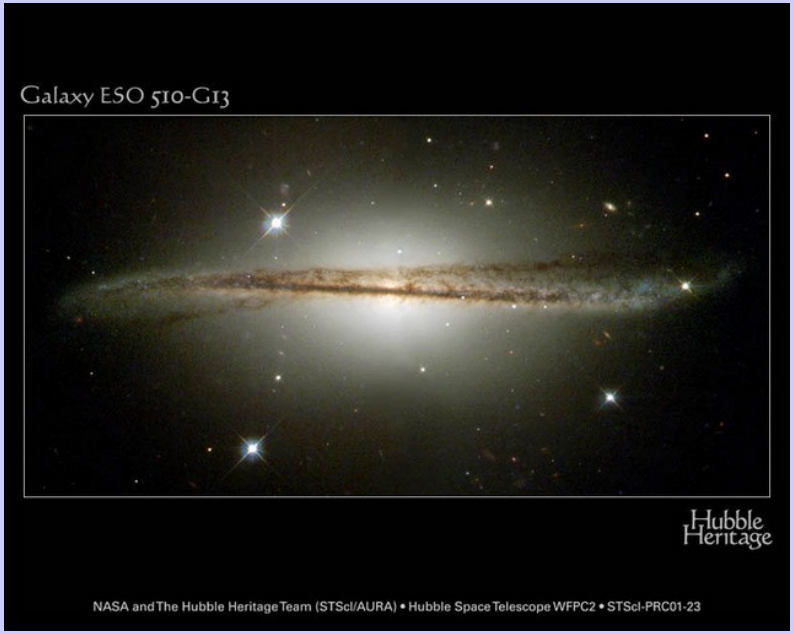
**- physically implausible**

**- properties arbitrary**

# Other ways to make a geometrically thick structure

- radial outflow with dust formation
  - Elvis 2000, Elvis Marengo and Karovska 2002
- settling warp
  - Phinney 1989, Sanders et al 1989
- driven warp
  - Pringle 1996, Pringle et al 1997

***look at this one***

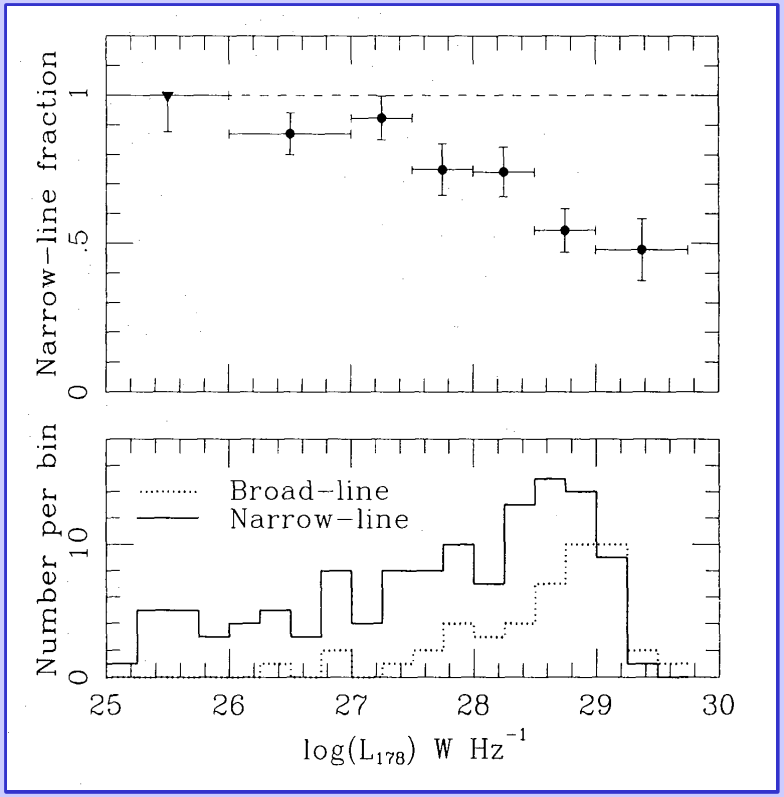



**warped discs common on kpc scales**
**- parsec scales ?**
**- severe warps ?**

# Quasar fraction : radio

- $f_Q \propto L$ ?
- due to low-excitn gals at low L
  - Laing *et al* 1994, Willott *et al* 2000, Grimes *et al* 2004
  - switched off quasars ? (Willott *et al* 2000)
  - different mode of accretion ?
- Willott *et al* 2000 : 3C/6C/7C remove FRI and low-excitn

  $f_Q = 0.40 \pm 0.03$ constant




**Lawrence 1991**

# Gathering facts

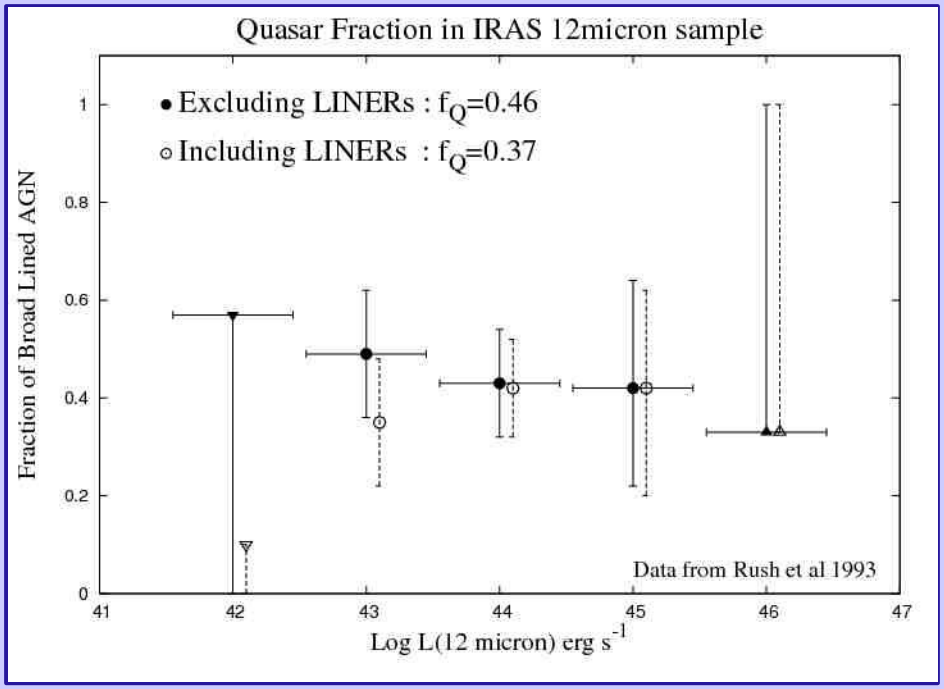
# Quasar fraction : MIR

- Spitzer 24μm : $f_Q \sim 0.5$
  - Lacy *et al* 2005
  - Stern this meeting Spitzer 8μm $f_Q \sim 0.3$ ?

- IRAS 12μm : Rush *et al* 1993 re-analysis of data

  LINERs take off at low L
  if remove these, then :

  $f_Q = 0.46 \pm 0.08$



# Quasar fraction : nearby galaxies

- Ho Fillipenko and Sargent 1997
- again, depends on LINERs...

- Sy1/(Sy1+Sy2) : $f_Q = 0.41 \pm 0.11$
- (Sy1+LINER-1)/(all) : $f_Q = 0.22 \pm 0.04$

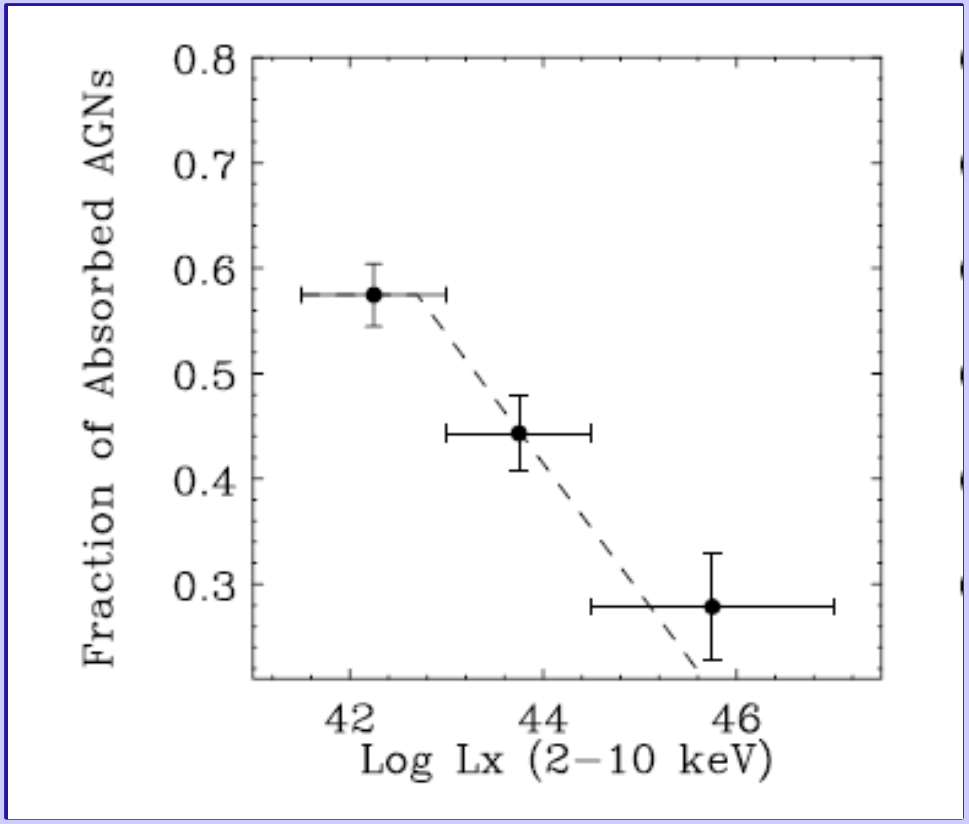
- Maiolino and Rieke 1995 RSA galaxies
  claim Sy2/Sy1 = 4.0 ==> $f_Q = 0.2$
  but their "Sy2" includes Sy 1.8 and 1.9...
  grouping these with Sy1 ==> $f_Q = 0.4$

# Quasar fraction : X-rays

- Absorbed fraction
  ~0.25 at high-L
  ~0.55 at low-L

- corrections
  - 15% abs. objects are Sy1
  - $N_{thick} = 1.7 \times N_{thin}$
    (Risaliti et al 1999)

- Net $f_Q \sim 0.29$ low-L
  $f_Q \sim 0.58$ high-L



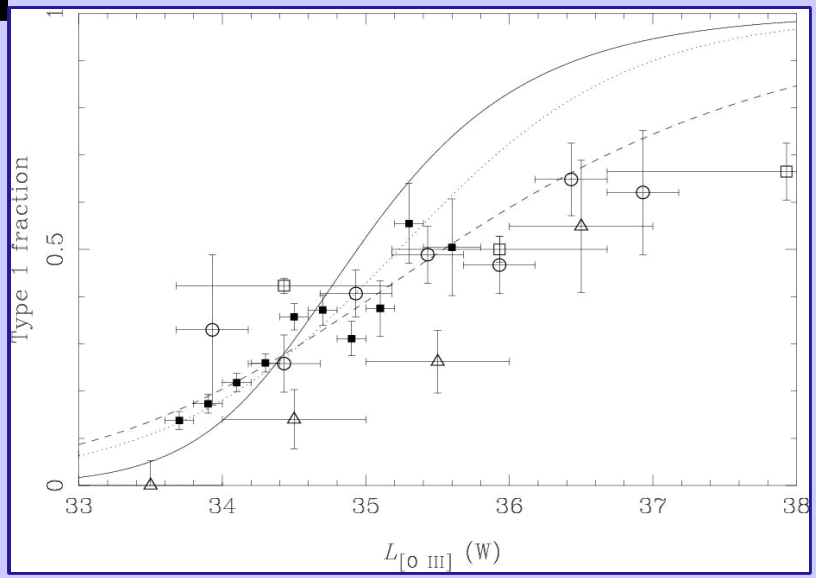

**Ueda et al 2003**

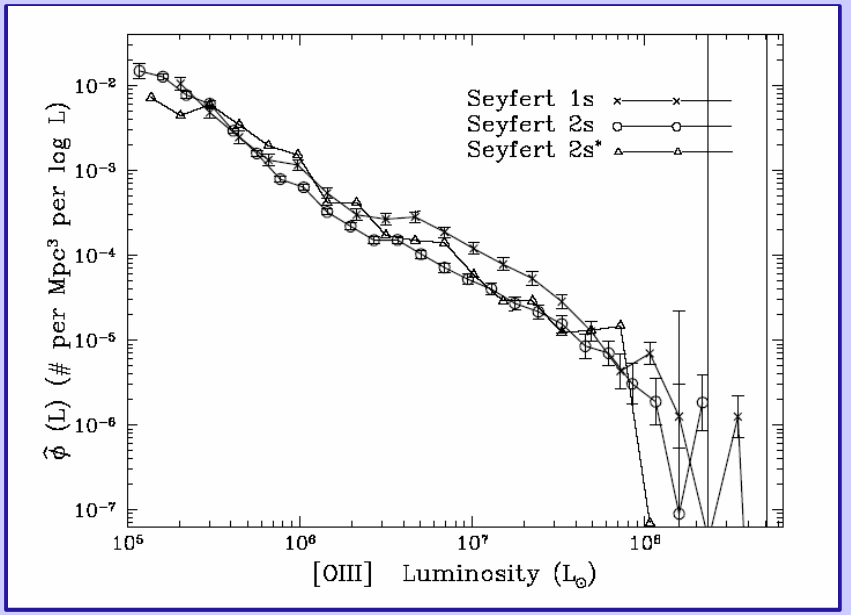
- Lots of uncertainties
- Need IR spectra to find reddened Sy1s
- LINERs ?

# Quasar fraction : OIII

- SDSS samples : discrepancy
- | | High-L | Low-L |
  |---|---|---|
  | Simpson | $f_Q \sim 0.6$ | $f_Q \sim 0.2$ |
  | Hao | $f_Q \sim 0.8$ | $f_Q \sim 0.5$ |
- what are the low-L objects ?

**Simpson 2005**

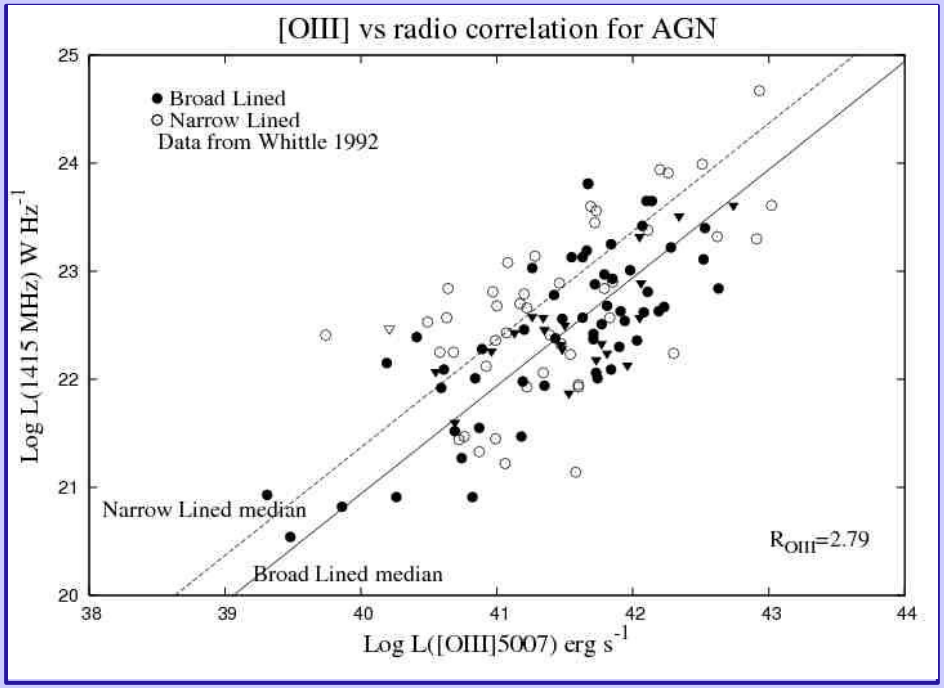



**Hao et al 2005**

# Range of covering factors

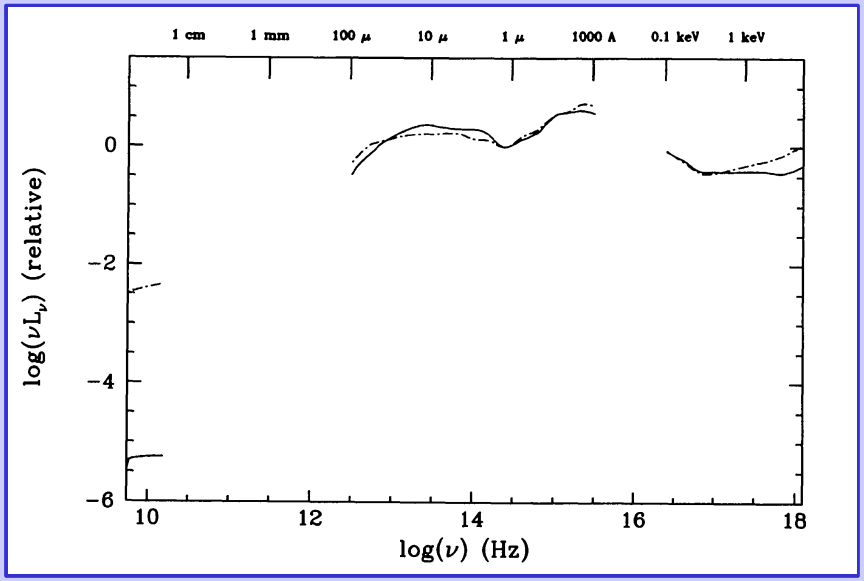
- OIII/radio : BL > NL
  - Whittle 1985; Jackson&Browne 1990; Lawrence 1991; Grimes et al 2005
- $R_{OIII}$ = ratio of relative OIII
- Radio gals : $R_{OIII} \sim 4$
  - Grimes et al 2005
- Seyfert gals : $R_{OIII} = 2.8$
  - re-analysis of Whittle 1992 data




- requires range of covering factors
  - radio : pre-obscured power
  - OIII : uncovered fraction

# Reprocessing

- SED peaks at 10μm
  - Sanders et al 1989, Elvis et al 1994
- T ~ 400K
  - but broad : 20-1500K
- $D_{reproc}$ ~1-10pc (Sy-Q)
  - but broad : 0.1pc to kpc
- Reprocessed fraction $f_{reproc}$ ~ 0.3
  - from L(IR)/L(UV)
  - Sanders et al 1989, Elvis et al 1994
- $f_{reproc} \neq f_Q$
  ==> distbn of covering factors




**Mean quasar - Elvis et al 1994**

**Note : D ~1-10pc is boundary of "sphere of influence" of black hole (Krolik and Begelman 1988)**

**Also dust "spherisation radius" ?**

# Requirements

- Natural way of
  - obscuring much of sky
  - producing range of covering factors
  - producing broad range of temps
- Predicting values of
  - $f_Q \sim 0.4$
  - $R_{OIII} \sim 3$
  - $f_{reproc} \sim 0.3$
  - $D_{reproc} \sim$ 1-10 pc

# Interlude


**Chris Simpson breaking the world speed record for public speaking**

# Misaligned discs

# misaligned incoming disc

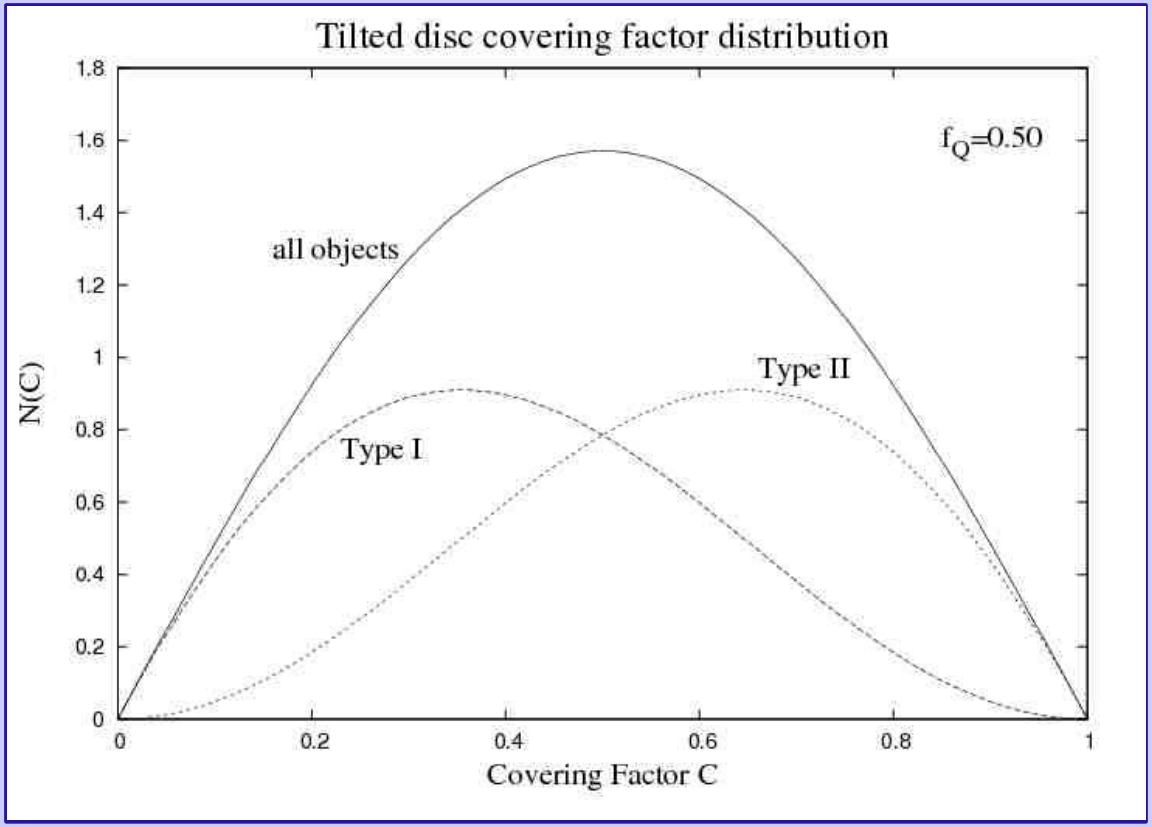
- Incoming disc and nuclear disc unconnected
  - axis difference θ random
  - dP = sin θ dθ
  - natural range of covering factors C(θ)
- Re-aligns over a range of radii
- Covering factor depends on degree of twist :

| | | |
|---|---|---|
| Tilt only : | C = θ/π/ | one sided |
| Fully precessed : | C = sin θ | full equatorial wall |

- $N_{II}(C)=C*N(C)$ $N_I(C)=(1-C)*N(C)$
- $f_Q$ given by $\Sigma(N_I(C))$
- typical $f_{reproc}$ given by peak of $N_I(C)$
- $R_{OIII}$ given by mean $N_{II}(C)$/mean $N_I(C)$

# M1 : Random, tilt only

- $f_Q = 0.50$
- $f_{reproc} \sim 0.35$
- $R_{OIII} \sim 2$

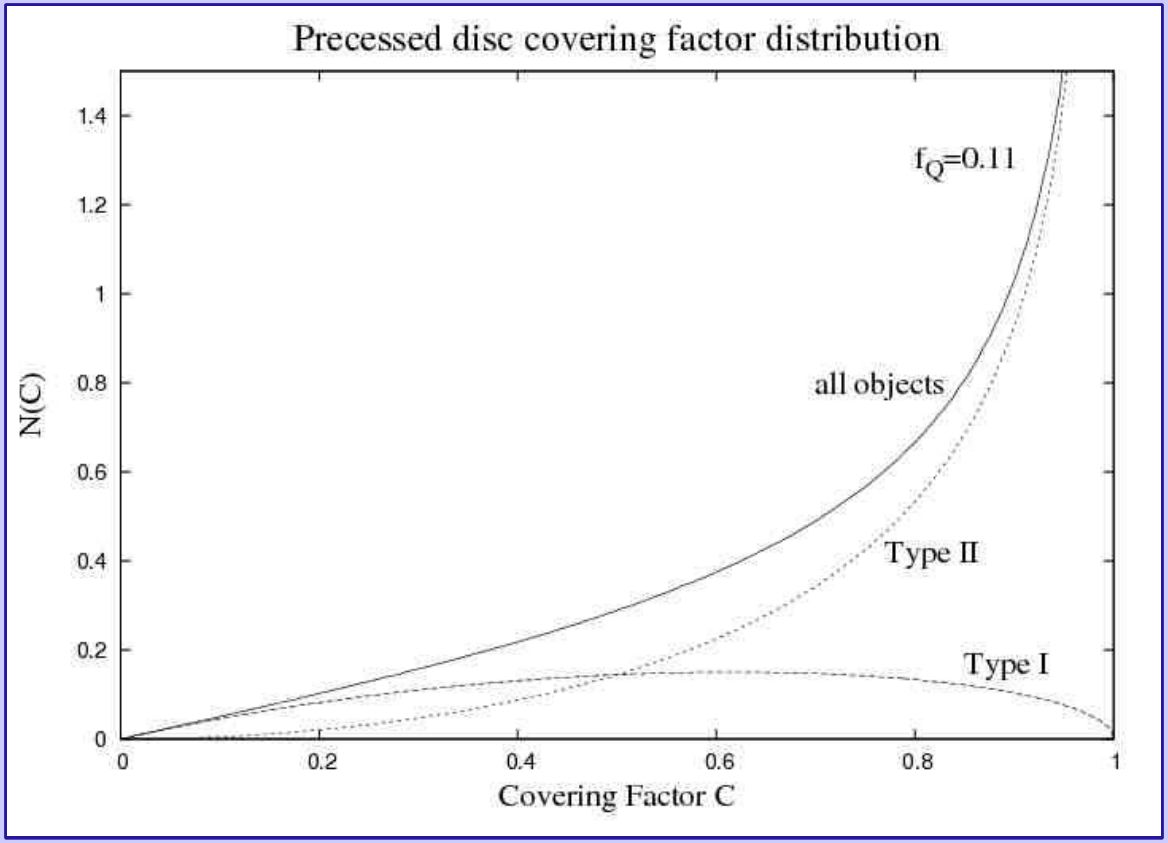



- BUT

- makes asymmetric "cones"
- jets and cones misaligned
- jets often run into disc
  - note incoming disc can be counter rotating

# M2 : Random, twisted

- $f_Q = 0.11$
- $f_{reproc} \sim 0.6$
- $R_{OIII} \sim ?$

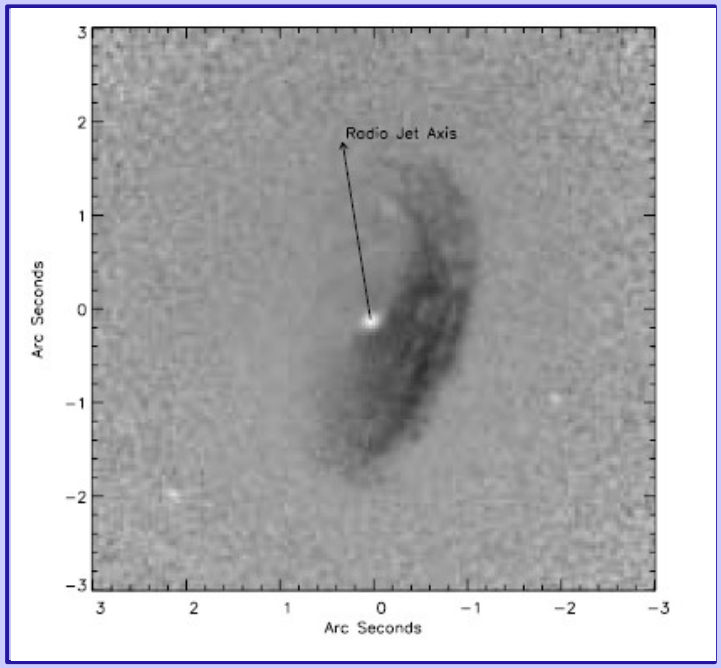



- includes 50% completely obscured objects
  - from counter rotating incoming discs
  - $f_Q = 0.22$ even if exclude these
- OIII/rad distbn wrong shape

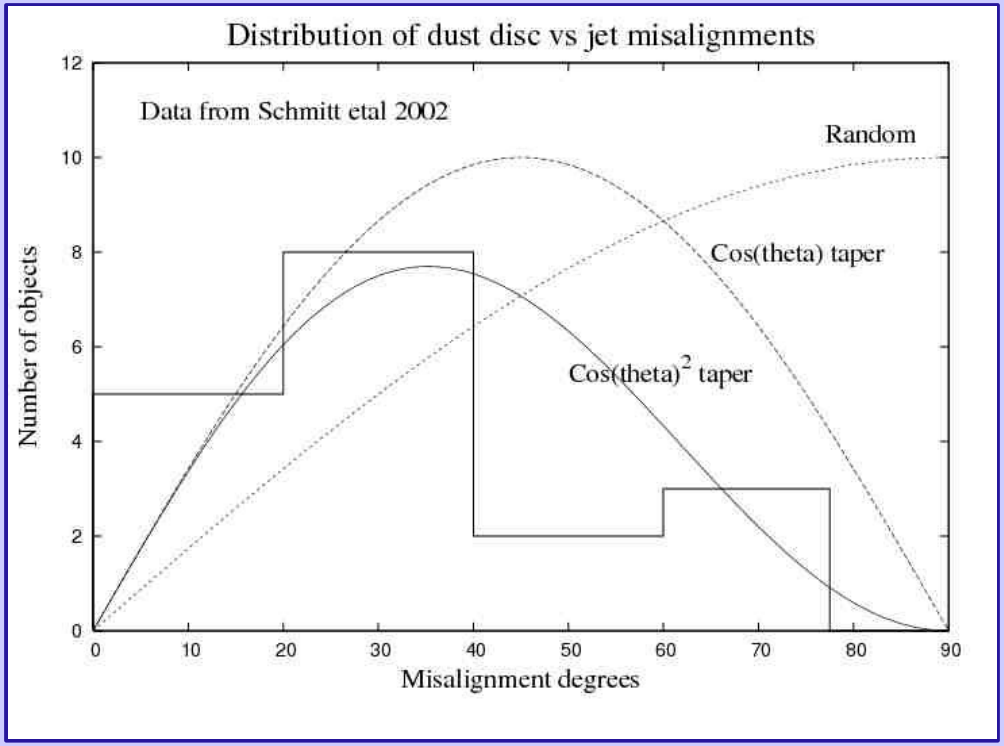
# observed misalignment of kpc-scale discs

- jet axis vs host galaxy : random
  - Ulvestad and Wilson 1984; Clarke et al 1998; several others

- jet axis vs kpc-scale disc : looks like tapered distribution
  - Schmitt et al 2002




**3C449 HST : Tremblay et al 2006**

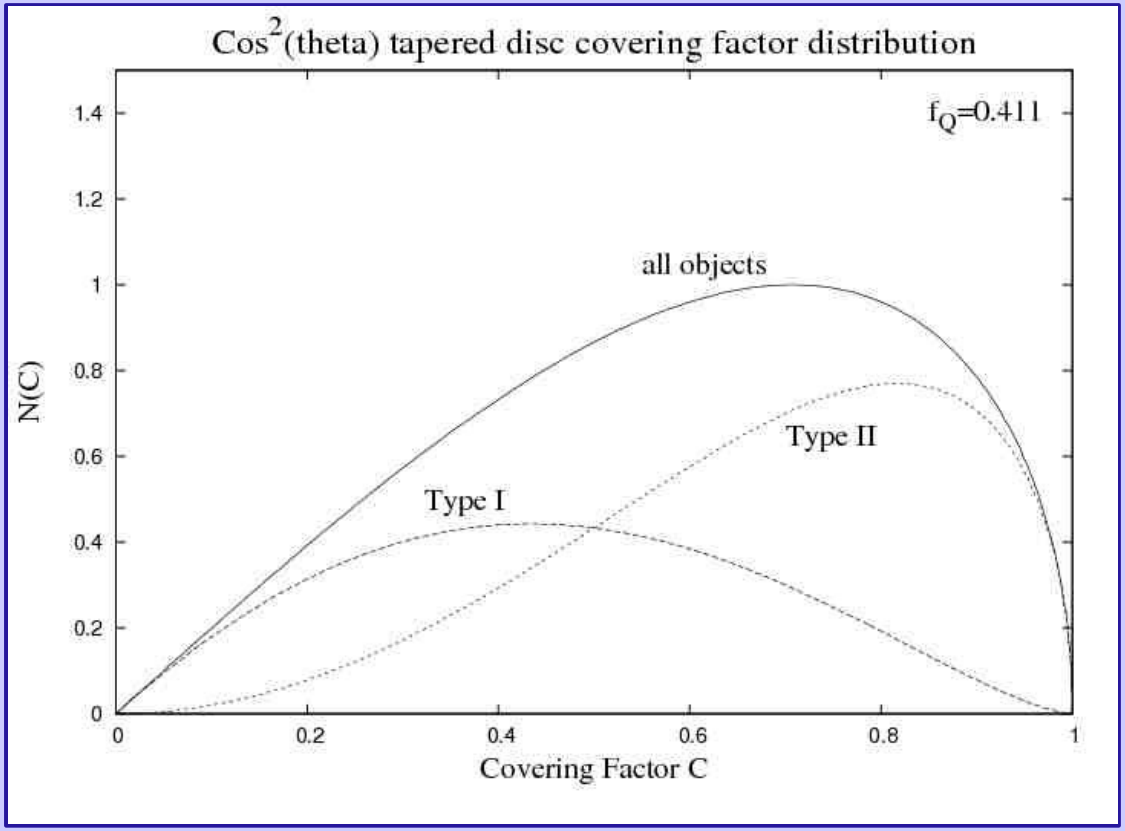


# M3 : Tapered, twisted

- Using $P(\theta) \propto \cos^2(\theta)$

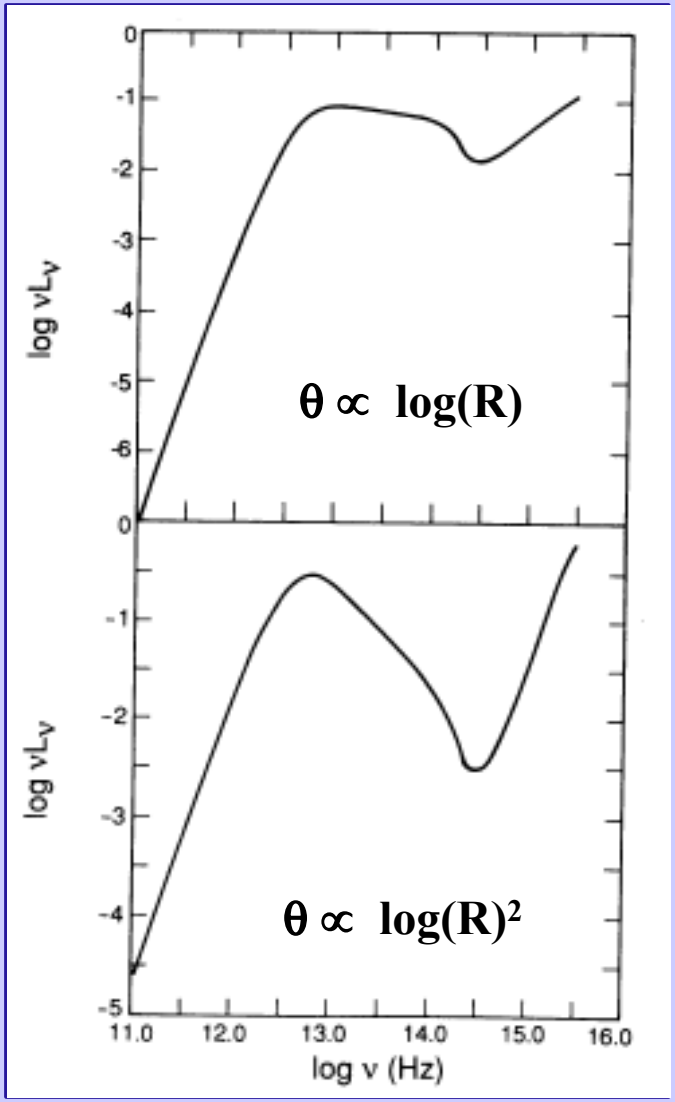
- $f_Q = 0.41$
- $f_{reproc} \sim 0.4$
- $R_{OIII} \sim 2$

- fairly good fit all round



# IR spectrum

- Already calculated by Sterle Phinney
- SED depends on tilt vs radius
- $\theta_{tilt} \propto \log(R)$ gives fairly good fit
- Still a bit cool




**Sanders et al 1989**

# Questions

- Cause of re-alignment
  - flattened central star cluster ?
  - large scale magnetic field ?
  - need a prediction for $\theta(R)$
- Cause of $P(\theta)$ taper
  - discrete fuelling events from bulge ?
  - need a proper model

# Cosmic Evolution

- Mechanism same at all epochs
- But fuelling source may not be ...

- Early times : mergers
  - directions random
  - 90% obscured
- Late times : bulge stars / clouds
  - source partially aligned
  - 60% obscured

**FIN**