The background of the slide is a composite image of a galaxy. It features a bright, glowing yellow and orange core, likely representing a quasar or an active galactic nucleus. From this core, several blue, filamentary structures extend outwards, possibly representing jets or filaments of ionized gas. The overall appearance is that of a complex, multi-colored galactic structure.

Kvasarer: Supertunge sorte
huller i galakserne
- hvad er nu det?

Marianne Vestergaard

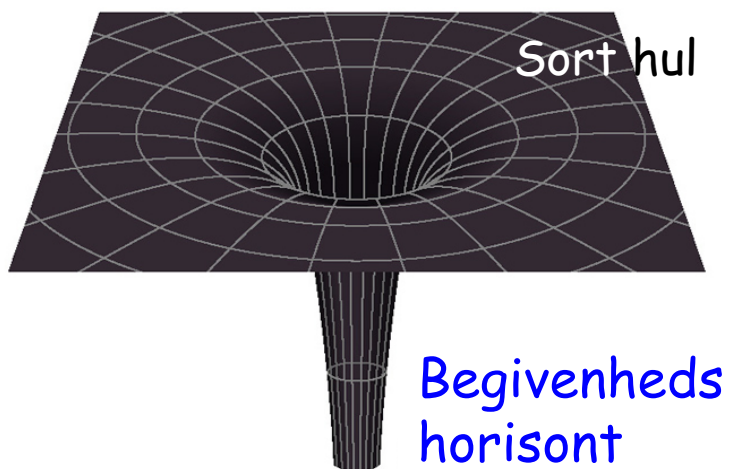
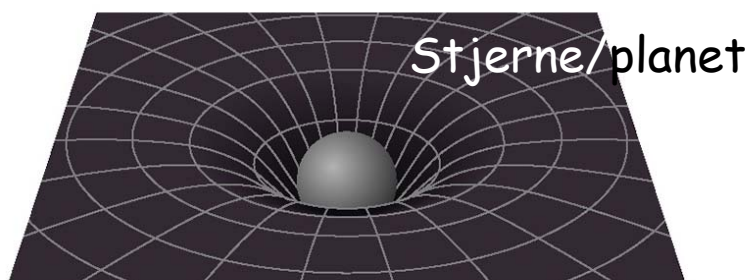
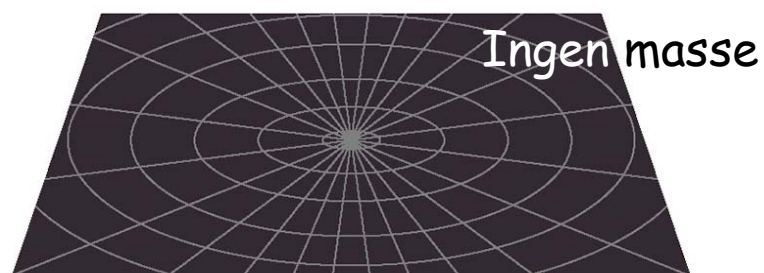
Freja Fellow

Dark Cosmology Centre

NBI Kickoff, 24 Januar 2011

Hvad er et sort hul?

Objekter så kompakte at selv lys ikke undslipper!



Schwarzschild radius

$$R_S = 2GM/c^2$$
$$= 3 \times 10^{13} M_{BH}/10^8 M_{\odot} \text{ cm}$$

Solen: $R_S = 3 \text{ km}$

Jorden: $R_S = 9 \text{ mm}$

Mælkevej [$4 \times 10^6 M_{\odot}$]: $1.2 \times 10^7 \text{ km} = 0.08 \text{ AU}$

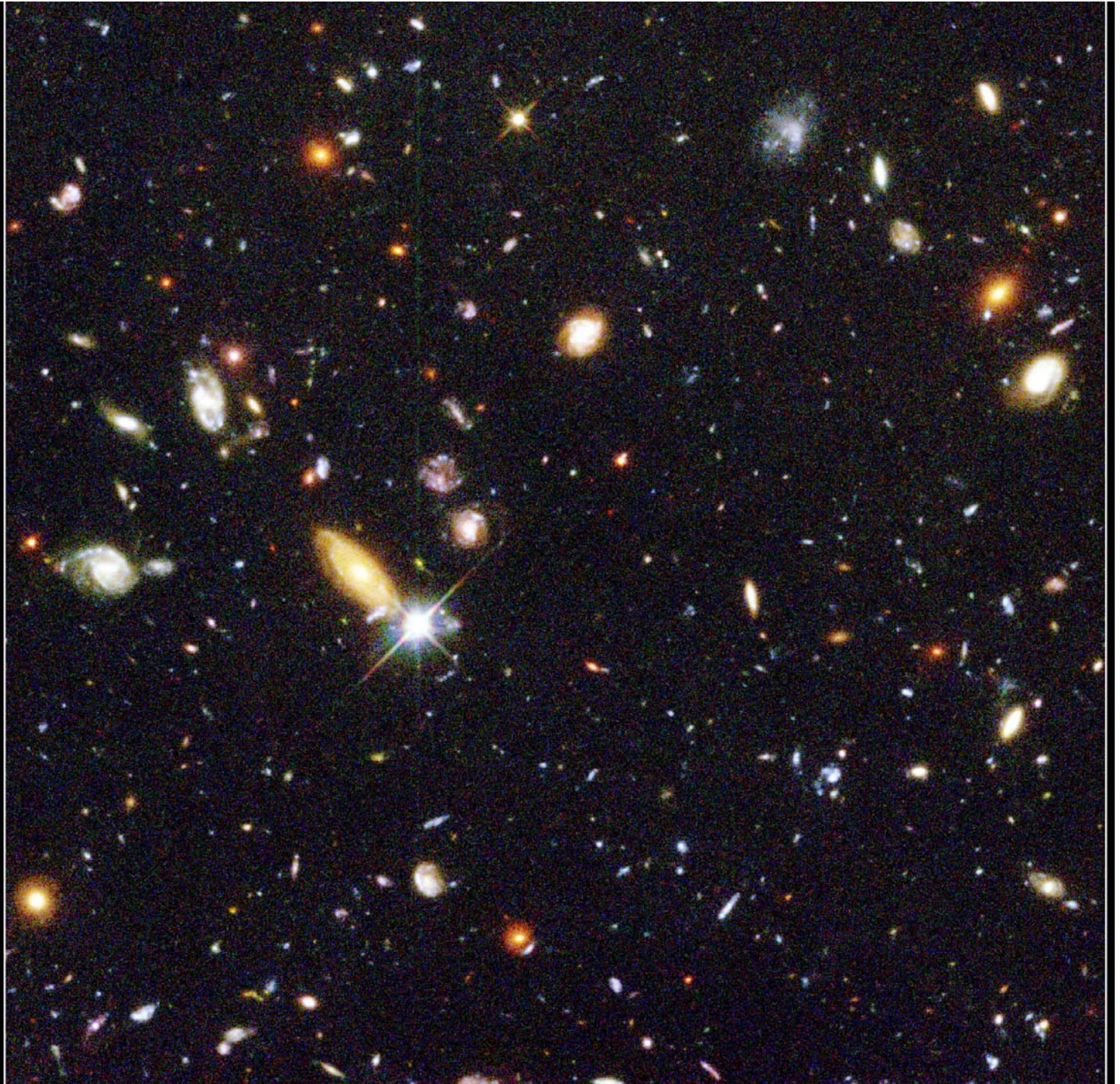
Kvasar [$10^9 M_{\odot}$]: $3 \times 10^9 \text{ km} = 20 \text{ AU}$

Et sort hul's masse forvrænger kraftigt rum og tid i nærheden af begivenhedshorizonten

Hubble Deep Field

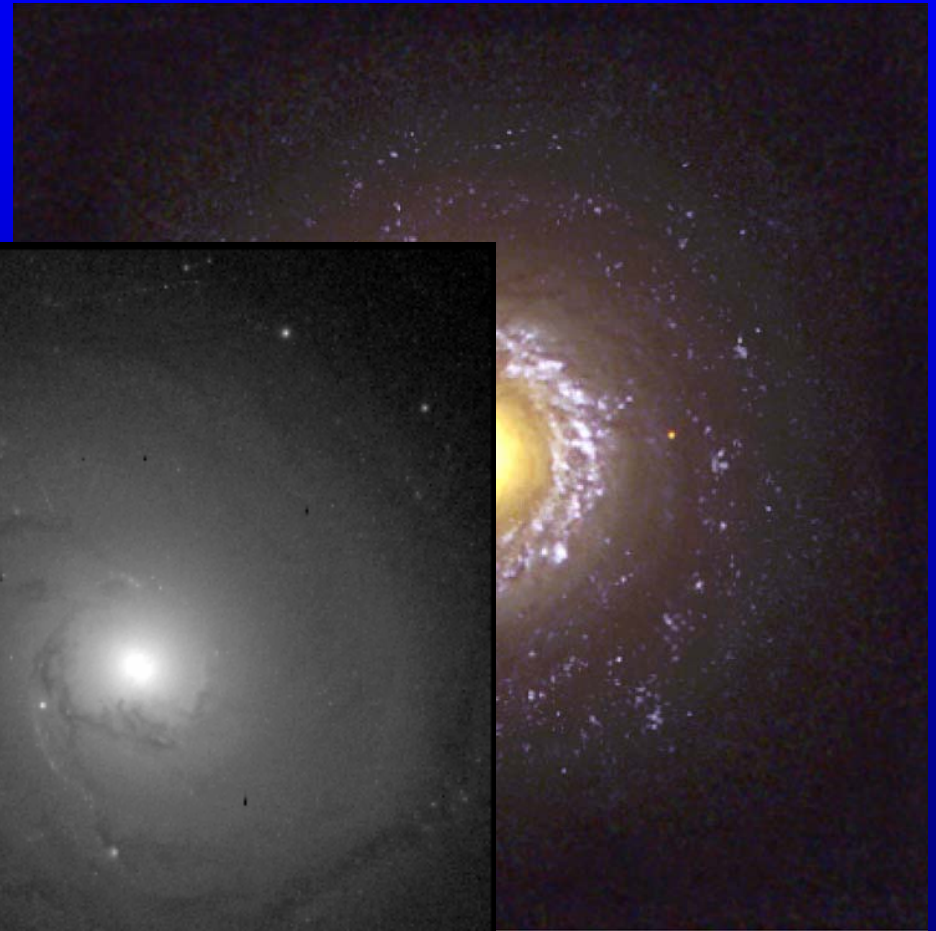
Alle objekter
i dette billede
(pånær et)
er galakser

WFPC2
1996



Aktive Galaksekerner

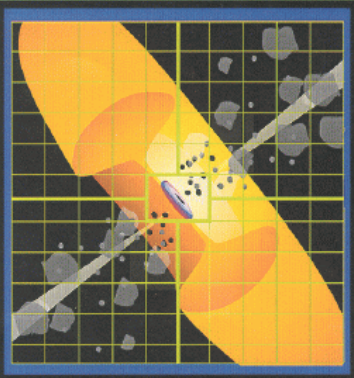
- Lysklare galakser med en punktkilde af **ikke-stellar aktivitet** i kernen - drevet af et sort hul i vækst



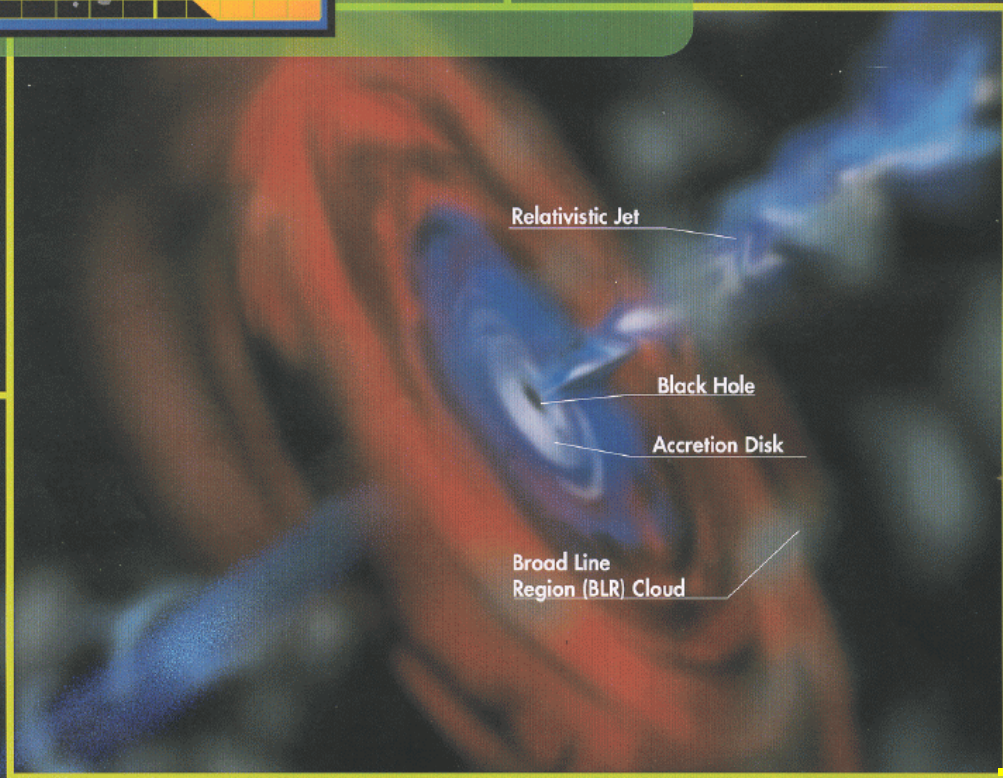
Aktive Galaksekerner

- Lysklare galakser med en punktkilde af **ikke-stellar aktivitet** i kernen - drevet af et sort hul i vækst
- De er sjældne - udgør kun få % af **lysklare** galakser
- De mest kraftfulde og lysklare kaldes kvasarer
- Kvasar-kerner lyser kraftigere end deres værtsgalakser

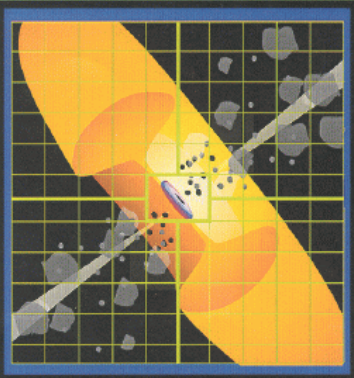




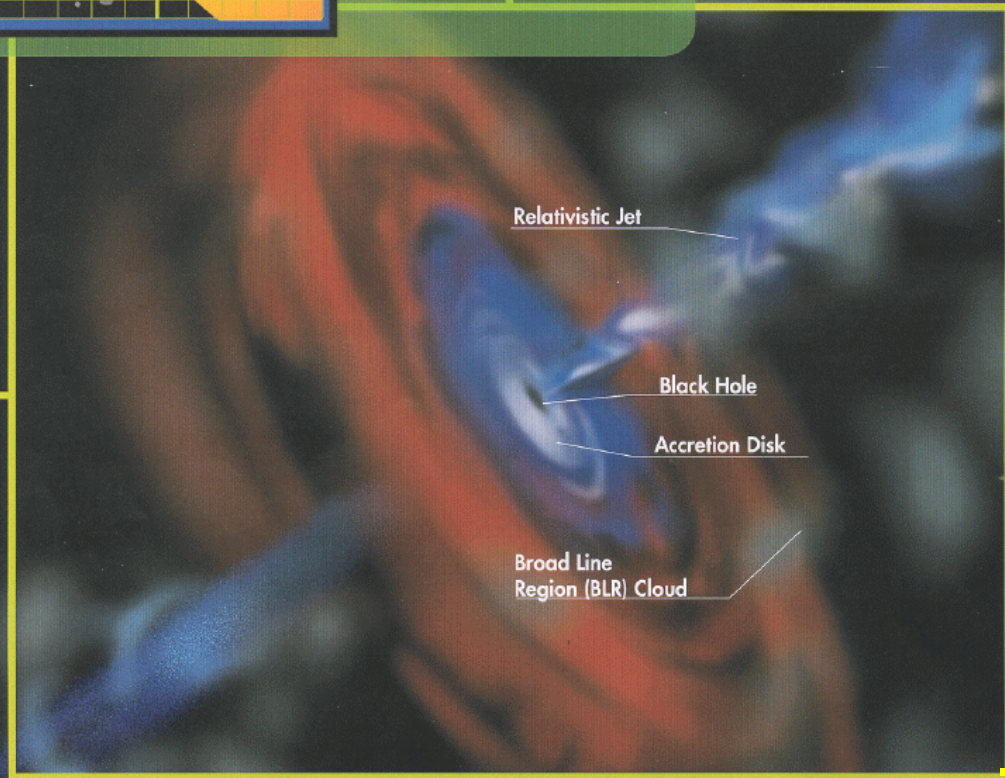
A schematic view
of the center of an
Active Galactic
Nucleus (AGN)



$\sim 10^{17}$ cm -- ca størrelsen
af vores sol system



A schematic view
of the center of an
Active Galactic
Nucleus (AGN)

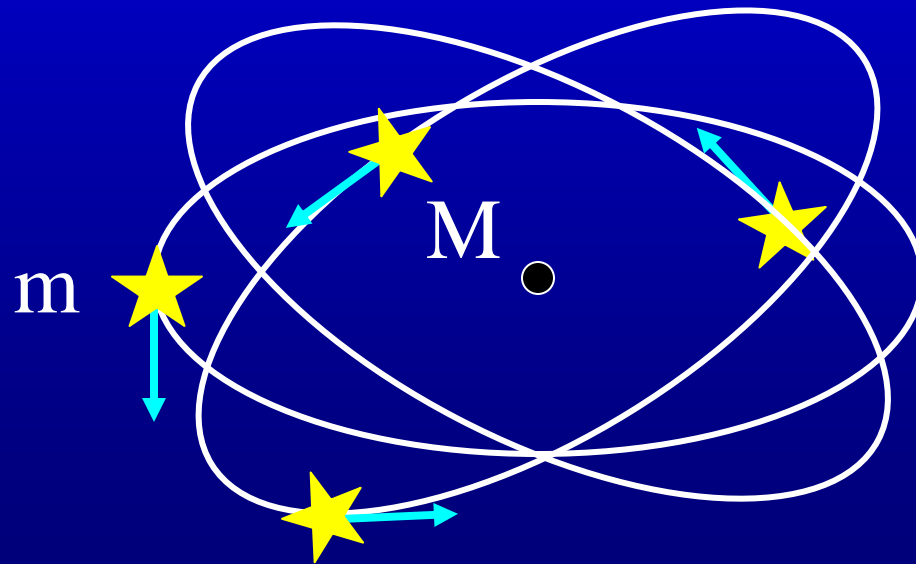


Roterende
centralt gas
(giver brede
emissionslinier)

Gas hastigheder:
2,000 - 10,000 km/s
= 7.2 mill. - 36 mill. km/t

Hvordan bestemmer astronomer masser?

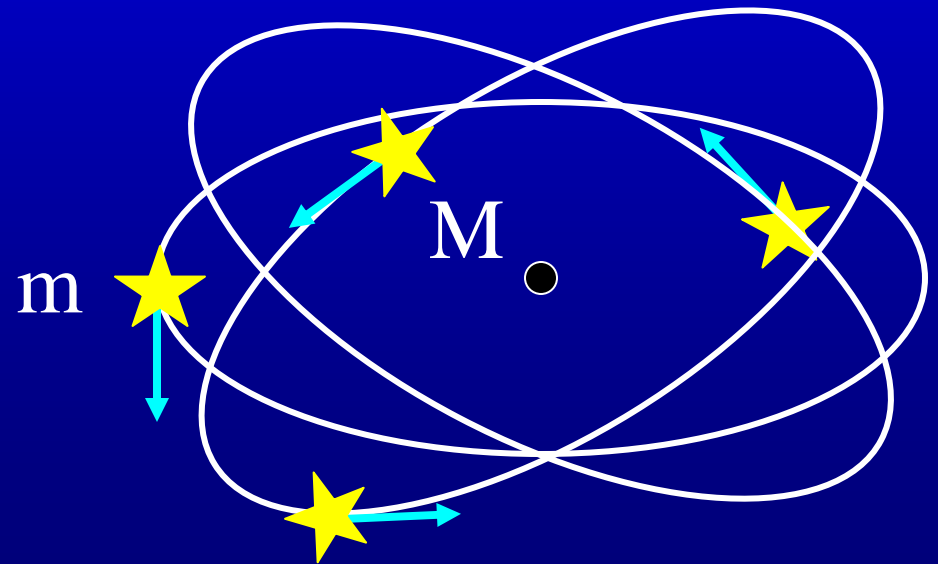
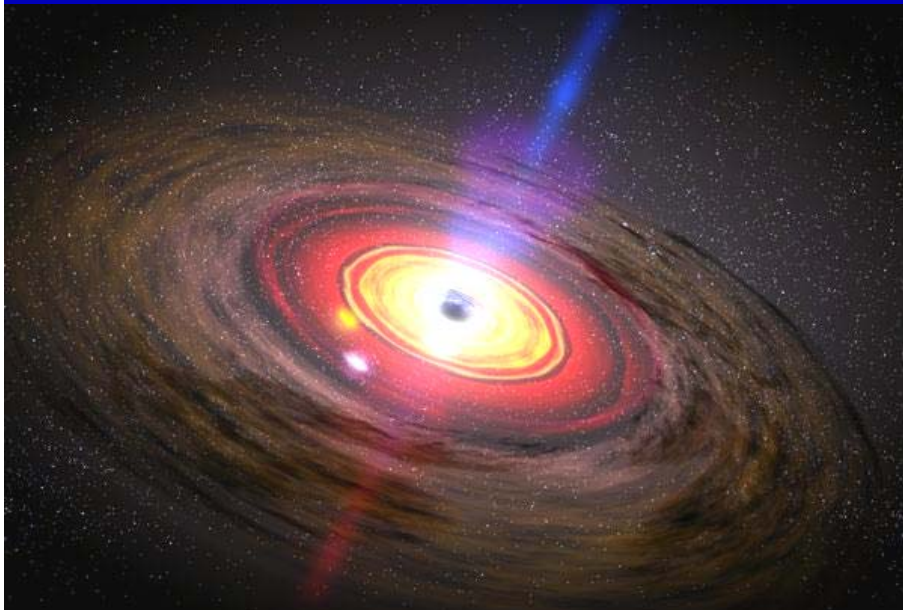
- Kepler's love: Elliptiske banebevægelser
- Virial teoremet (systemer i E-ligevægt):
Bevægelsesenergi = gravitationel pot.
energi



V.h.j.a.
tyngde-kraften!

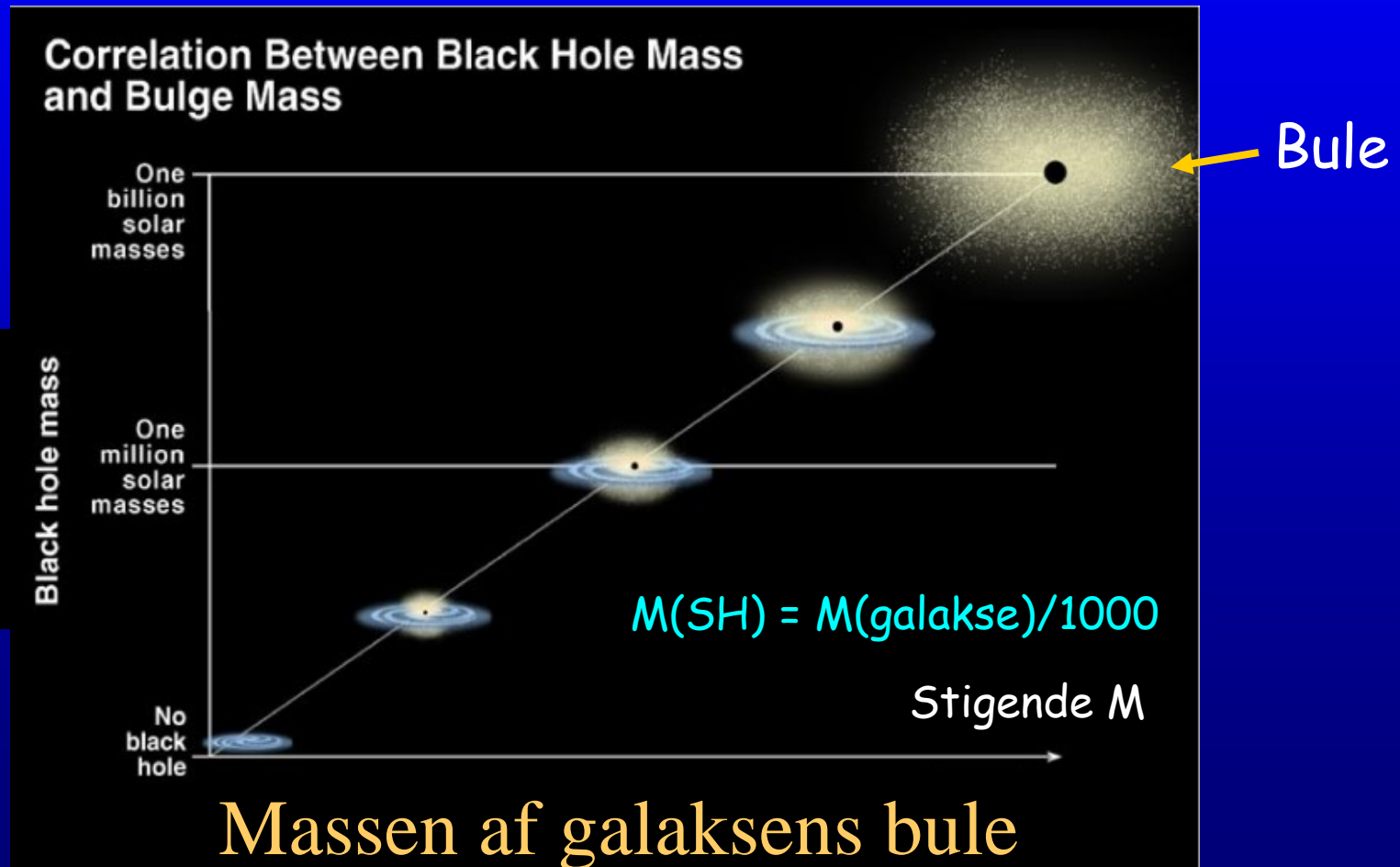
Hvordan bestemmer
astronomer masser?

$$M_{\text{BH}} = v^2 R / G$$



Hvorfor er astronomer interessede i sorte huller?

- Markant forbindelse mellem massen af det sorte hul og massen af den centrale kugleformede komponent i lokale galakser



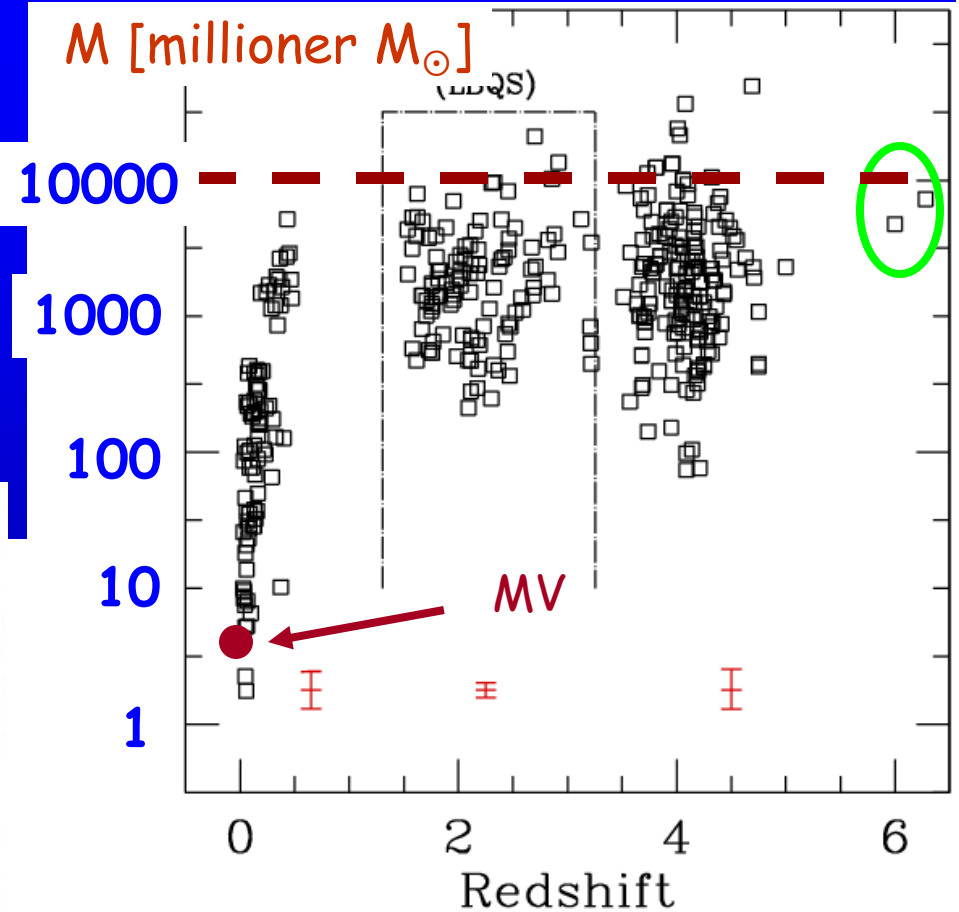
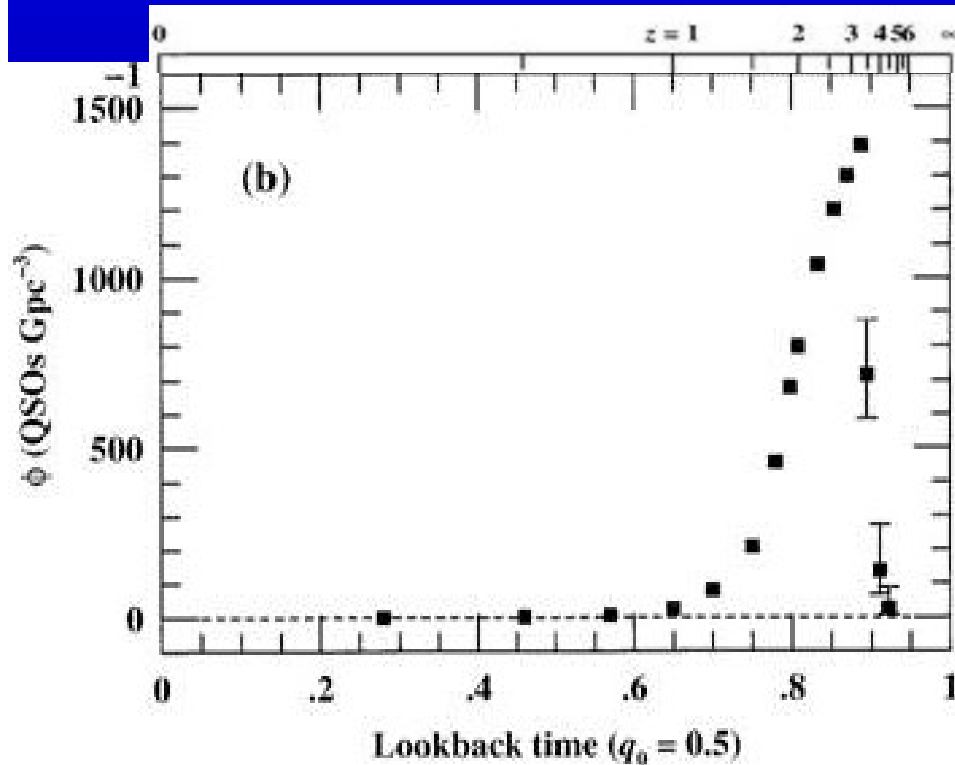
Massen af fjerne kvasarer

Fjerne aktive sorte huller er meget tunge:

$$M_{\text{BH}}: 10^8 - 10^{10} M_{\odot}$$

og meget lysstærke:

$$L_{\text{BOL}}: 10^{38} - 10^{41} \text{ W}$$

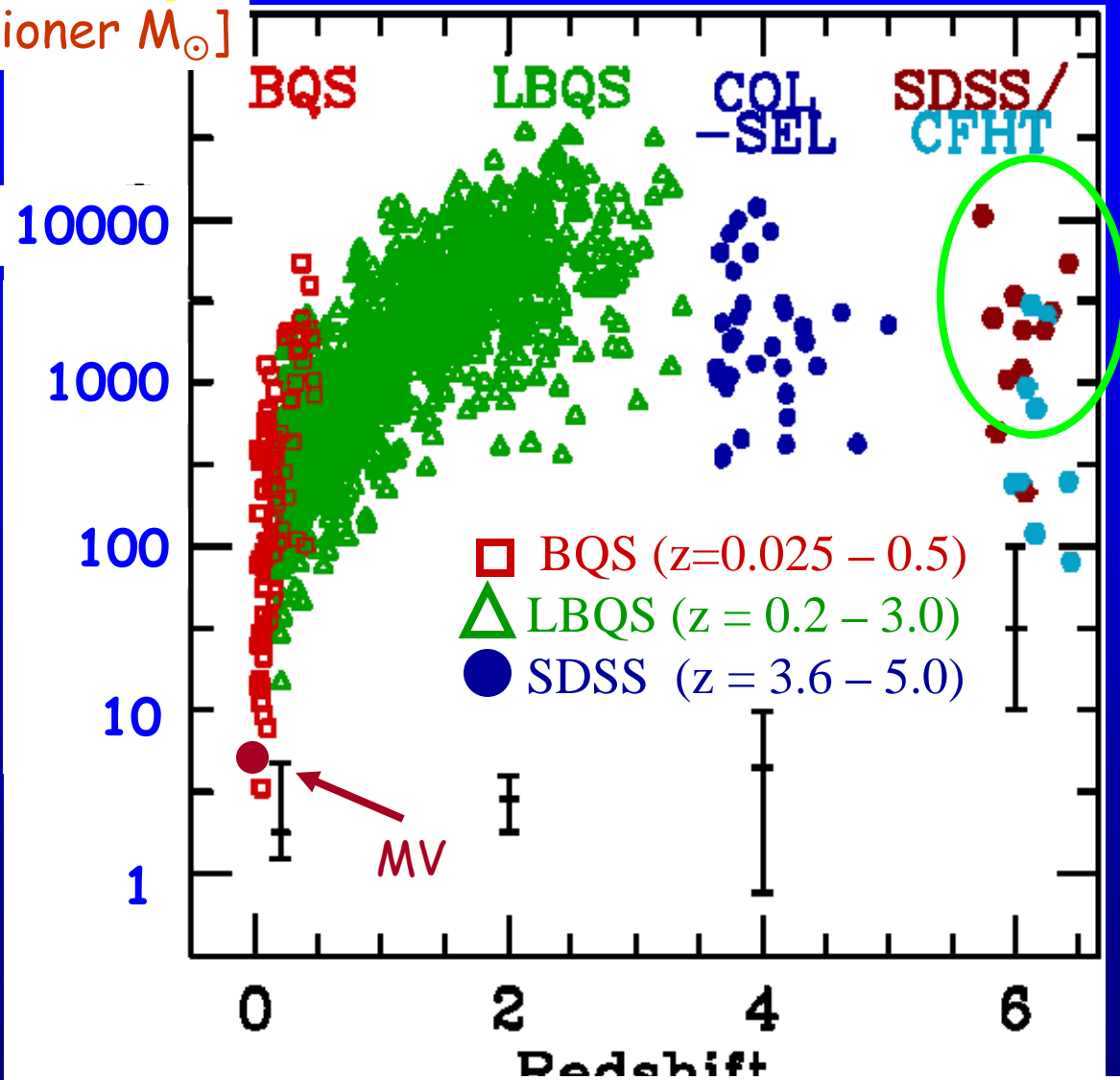


Alder: 13.8 8.8 3.4 2.2 1.6 1.2 1
(i milliarder år)

Massen af fjerne kvasarer

- Loft ved
 $M_{\text{BH}} \approx 10^{10} M_{\odot}$
 $L_{\text{BOL}} < 10^{48}$
 ergs/s
- $M_{\text{BH}} \approx 10^9 M_{\odot}$
 - selv ved $z \geq 3$
 hvor volumentætheden er drastisk reduceret

M [millioner M_{\odot}]



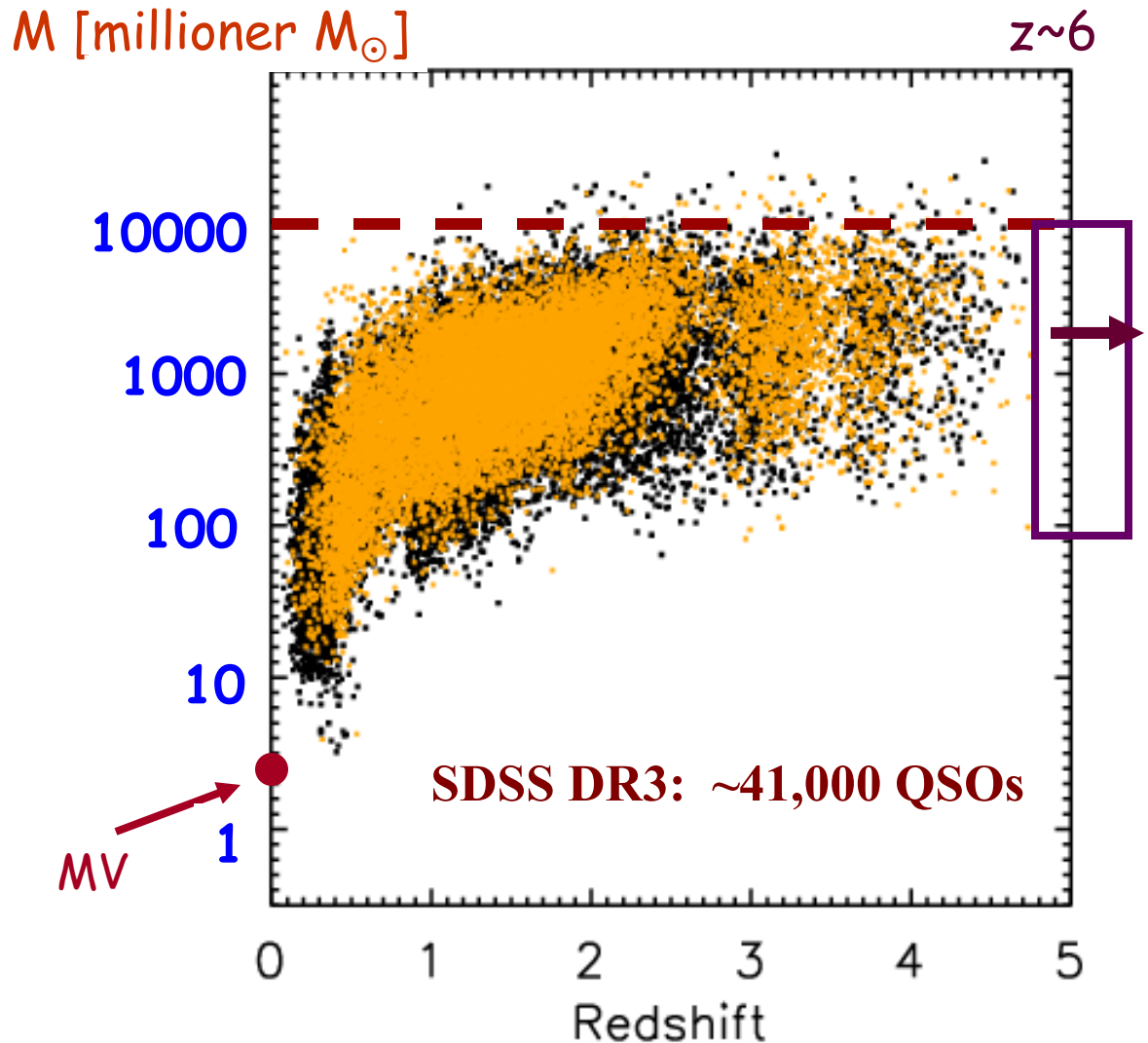
Alder: 13.8 8.8 3.4 2.2 1.6 1.2 1
 (i milliarder år)

Massen af fjerne kvasarer

- Loft ved
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 $L_{\text{BOL}} < 10^{48}$
ergs/s

- $M_{\text{BH}} \approx 10^9 M_{\odot}$
- selv ved $z \geq 3$
hvor volumentætheden er drastisk reduceret

(DR3 Qcat: Schneider+ 2005)

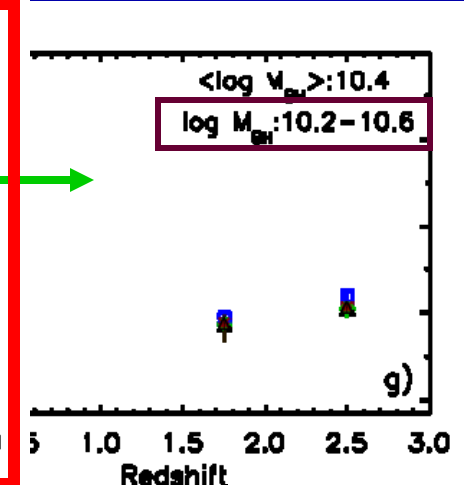
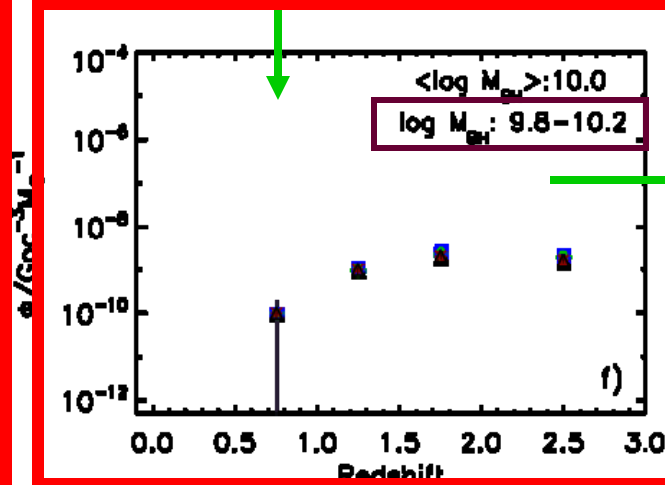
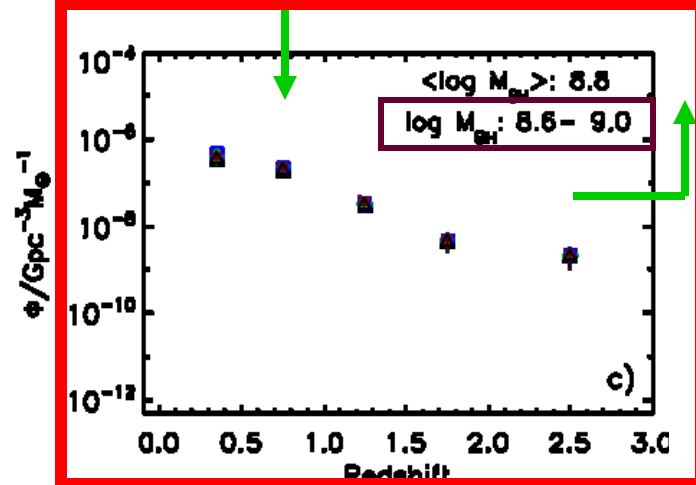
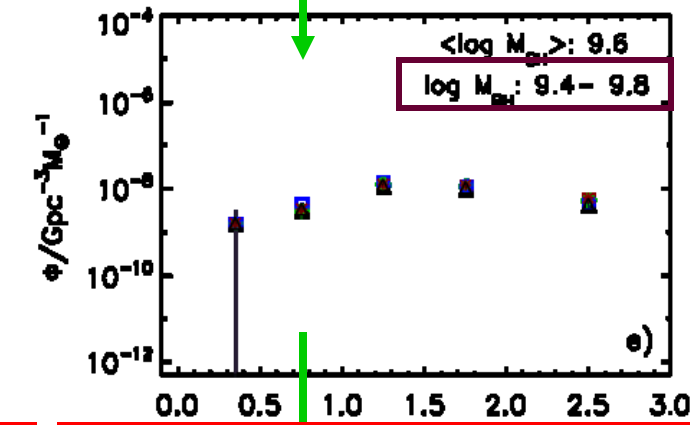
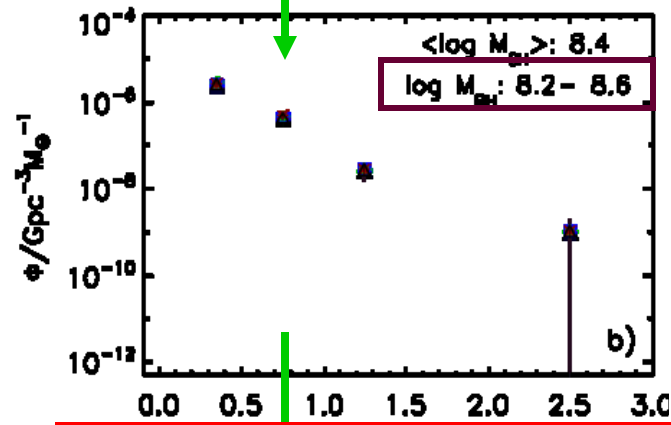
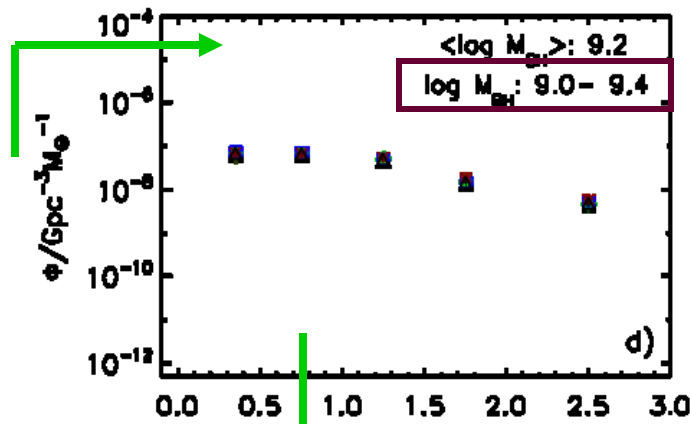
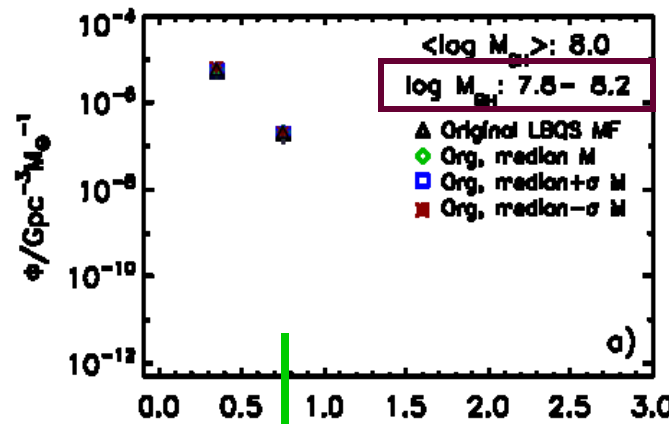


Alder: 13.8 8.8 3.4 2.2 1.6 1.2
(i milliarder år)

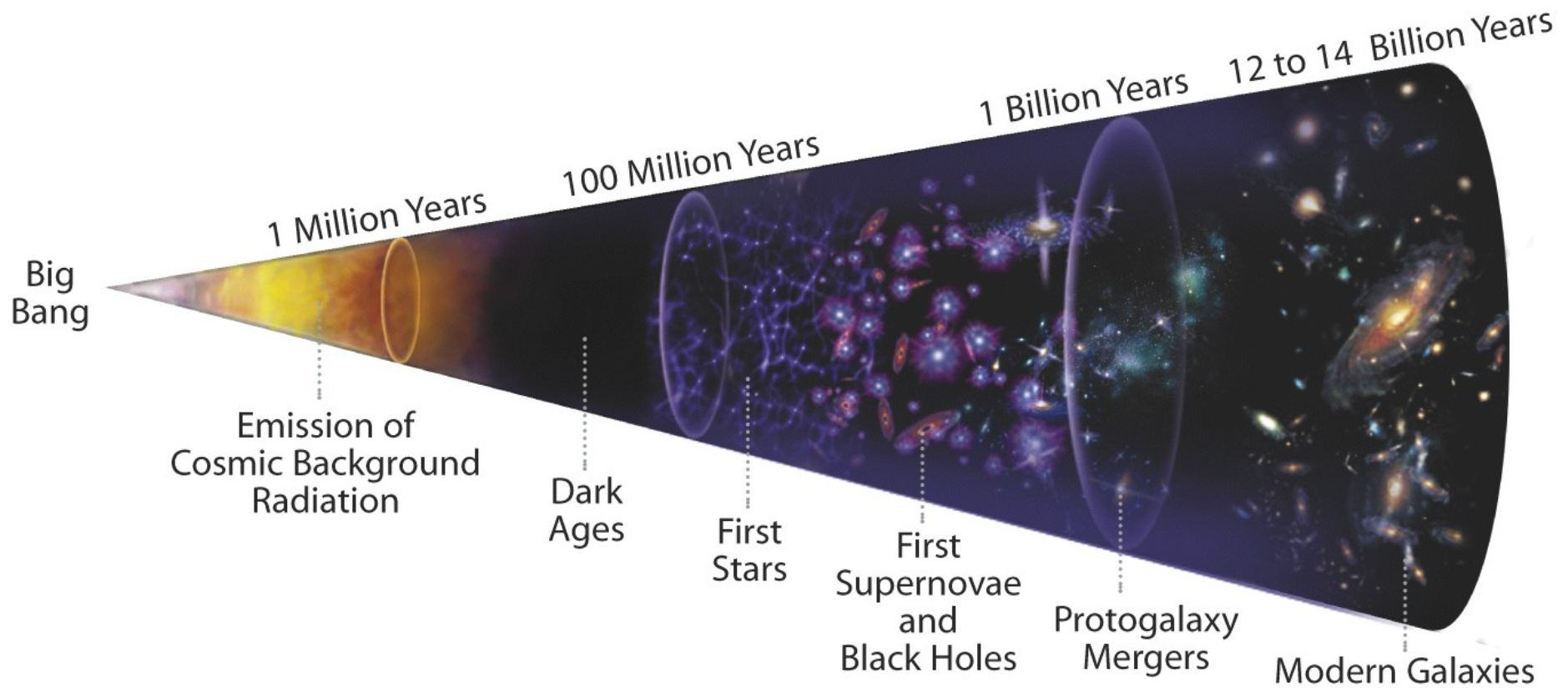
LBQS MF(z|M)

Evidence of
'downsizing'

(MV & Osmer
2009)

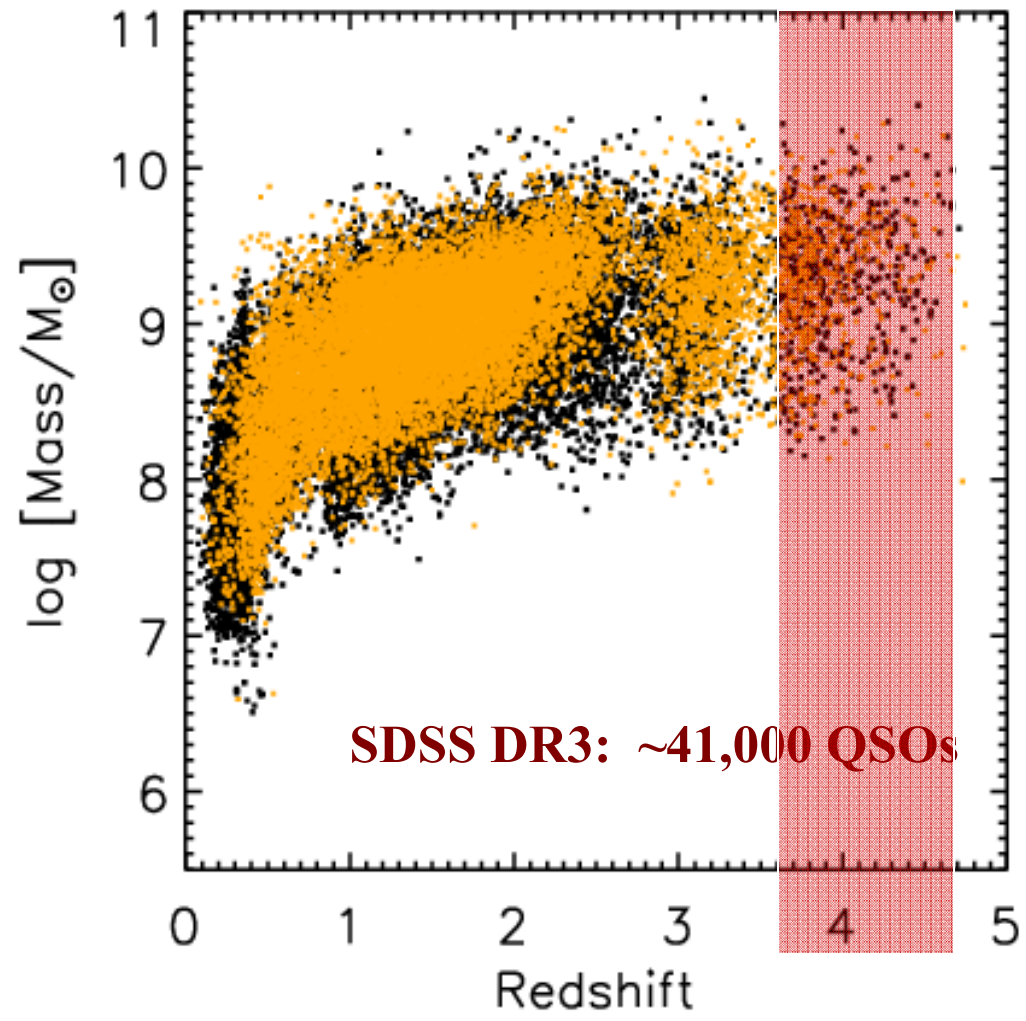


Fra Big Bang til nutiden

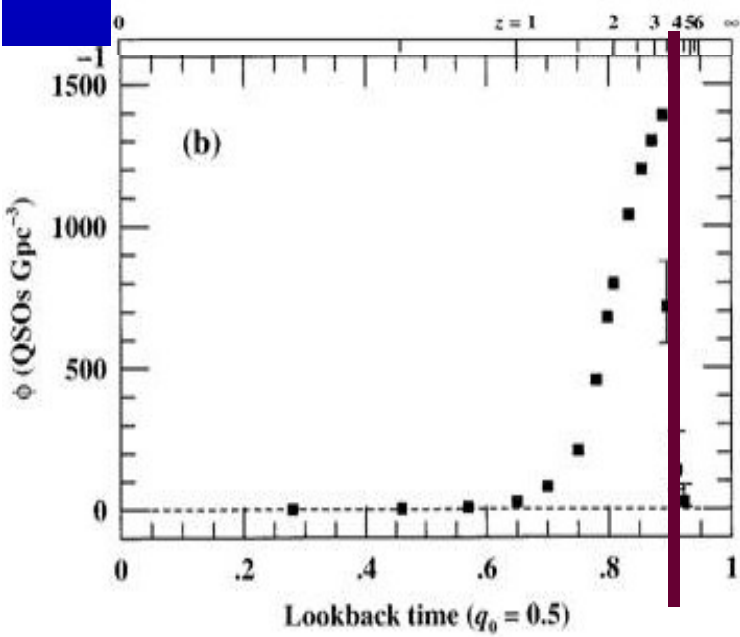


Store sorte huller i fjerne kvasarer

Er galakserne med de mest tunge sorte huller fuldt 'udvoksede' og med 'modne' stjernepopulationer?

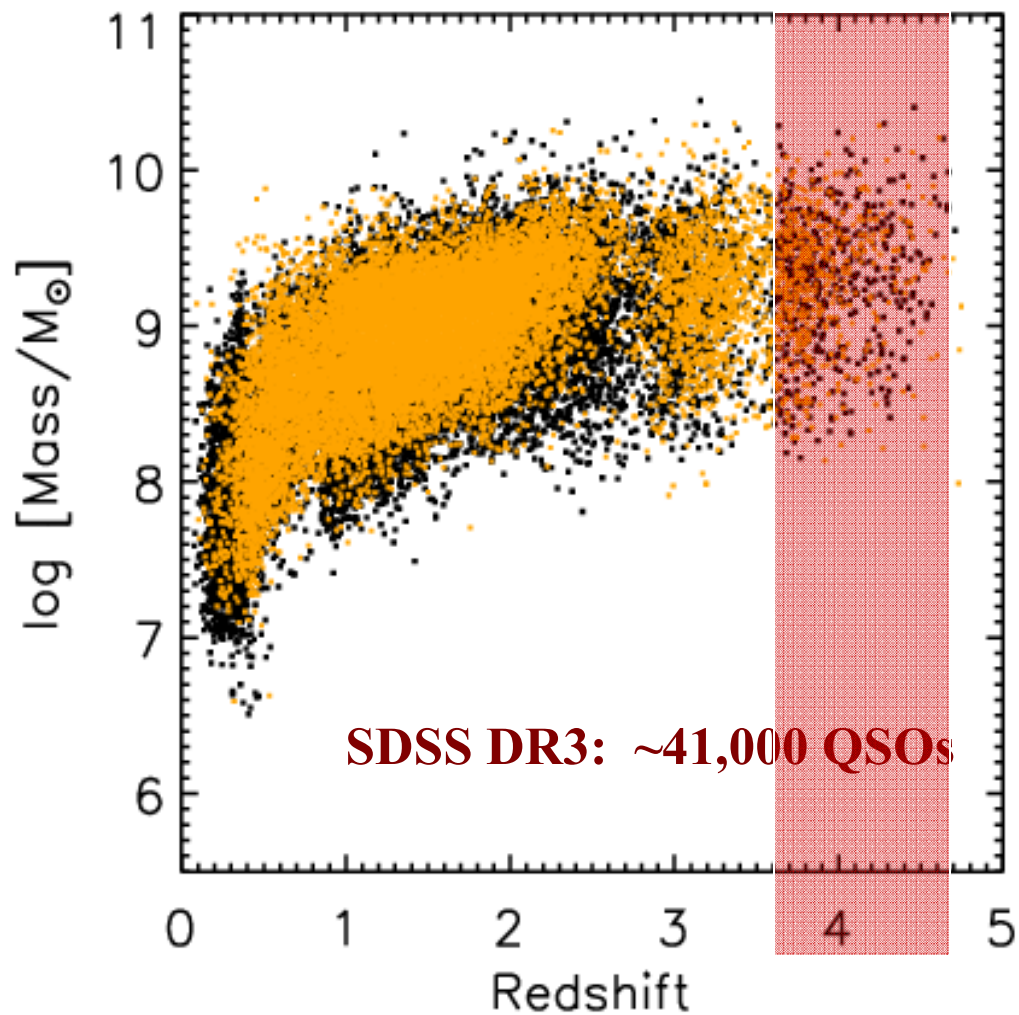


Alder: 13.8 8.8 3.4 2.2 1.6 1.2
(i milliarder år)



Store sorte huller i fjerne kvasarer

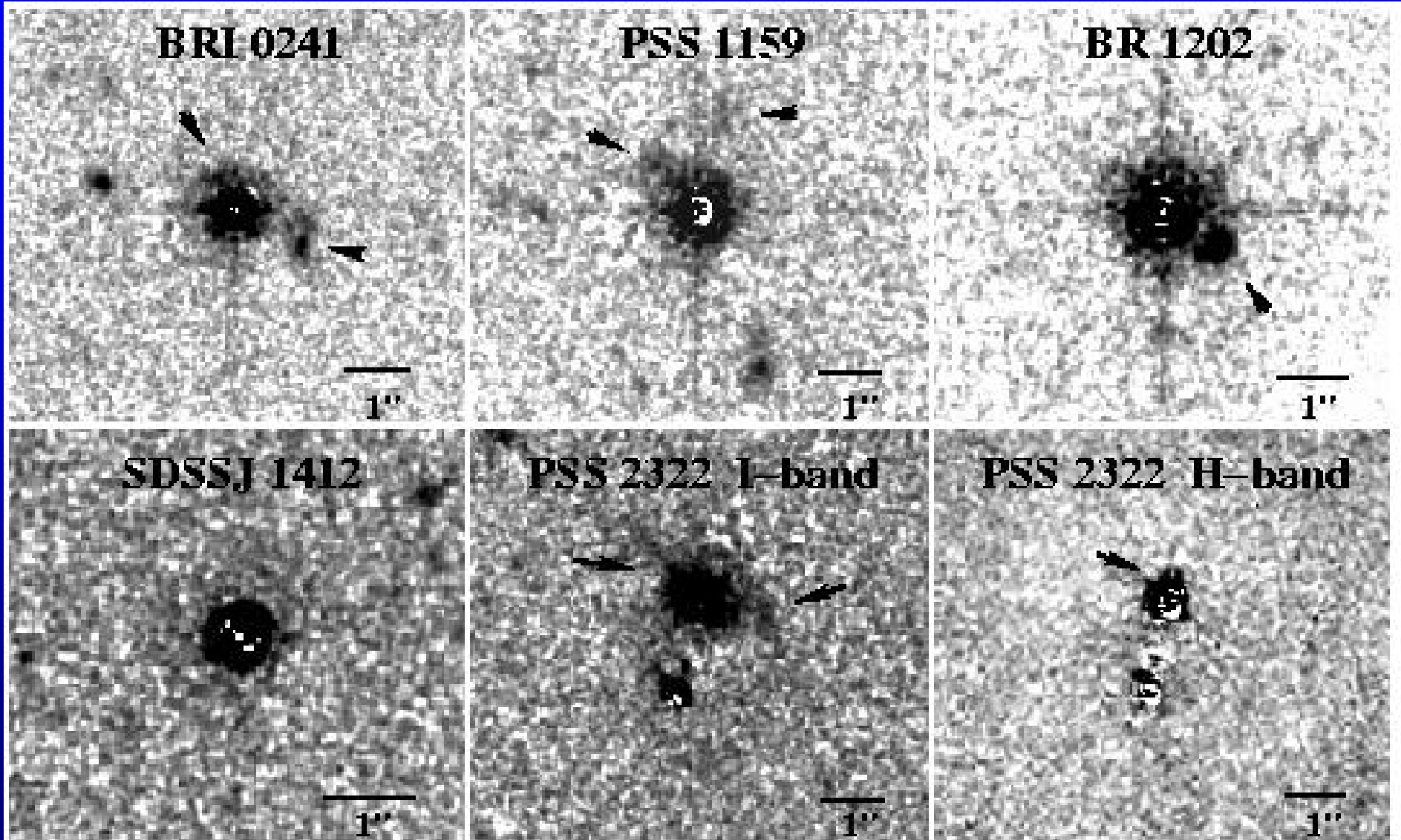
Er galakserne med de mest tunge sorte huller fuldt 'udvoksede' og med 'modne' stjernepopulationer?



Alder: 13.8 8.8 3.4 2.2 1.6 1.2
(i milliarder år)



Værtsgalakser i fjerne kvasarer



Universet er ca 1.2 milliarder år gammel

Værtsgalakser i fjerne kvasarer

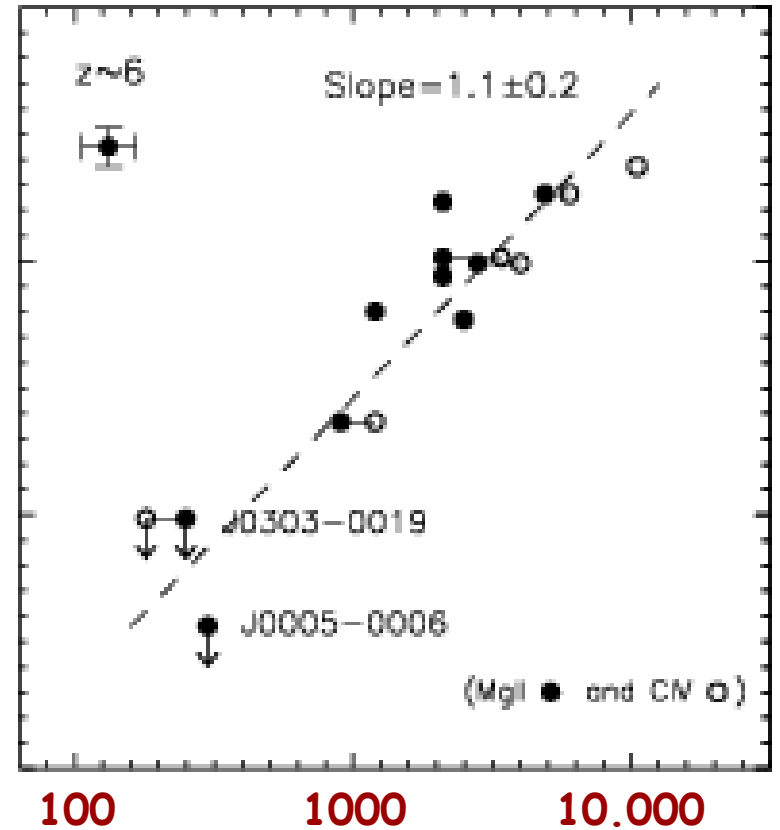


Universet er ca 1.2 milliarder år gammel

Opbygning af støv og det sorte hul før Universet er 1 milliard år gammel



Mængden af varmt støv ved kernen



Sorte Huls Masse i Millioner solmasser

(Jiang et al. 2010, nature)

Sammenfatning

- Bestemmer massen og demografi af de aktive supertunge sorte huller i fjerne univers
- Søger forbedringer til massebestemmelserne
- Undersøger beskaffenheden af værtsgalakserne til kvasarer i tidlige univers: hvad kom først, SH eller galaksen?