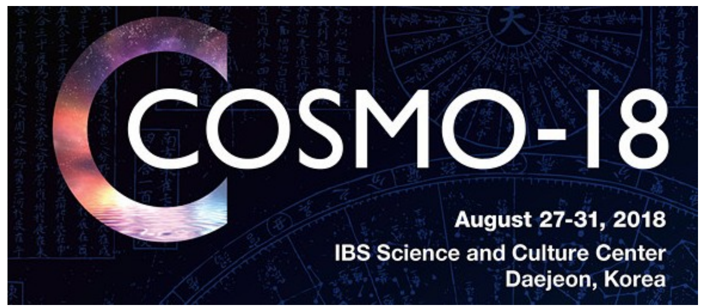
Cosmological constraints using BAO

From spectroscopic to photometric catalogues



Srivatsan Sridhar

Postdoctoral researcher @ KASI

Korea Astronomy and Space Science Institute

Cosmology Group at Korea Astronomy and Space Science Institute

Himalayas, Taj Mahal, Darjeeling, tea estates, Namaste, Naan with panneer butter masala

i.e. where most foreigners travel to and their image of India

Mamallapuram, Athirapally waterfalls, Coorg, Vanakkam, Idly & Dosa with sambhar and a lot more!

6th largest country in terms of GDP, has 29 states and

just the 5 South Indian states contribute 35% of India's GDP!!

i.e. where most foreigners have to travel to !

I am from Madras (now Chennai), located in the state of Tamilnadu

Mamallapuram / Mahabalipuram – 58kms from Chennai, Tamilnadu

Bustling seaport during 1st century CE, Temple constructed 7th century CE
Some **temples and rathas were cut from single piece of rock!**

Marina beach, Chennai

World's second longest Urban coastline !

Ellora caves - Maharashtra

More than 100 caves, but the famous Kailasha temple is the largest monolithic rock excavation in the world!

200,000 tonnes of stone removed in just 20 years = **approx 26 tonnes each day!** Not possible even with modern technology :)

Athirapilly waterfalls - Kerala

55 kms from Kochi, nicknamed as the “Niagara of India”.

Diverse wildlife and only location where all 4 types of hornbills are found living together !

That’s enough advertisement,
let’s get back to Science

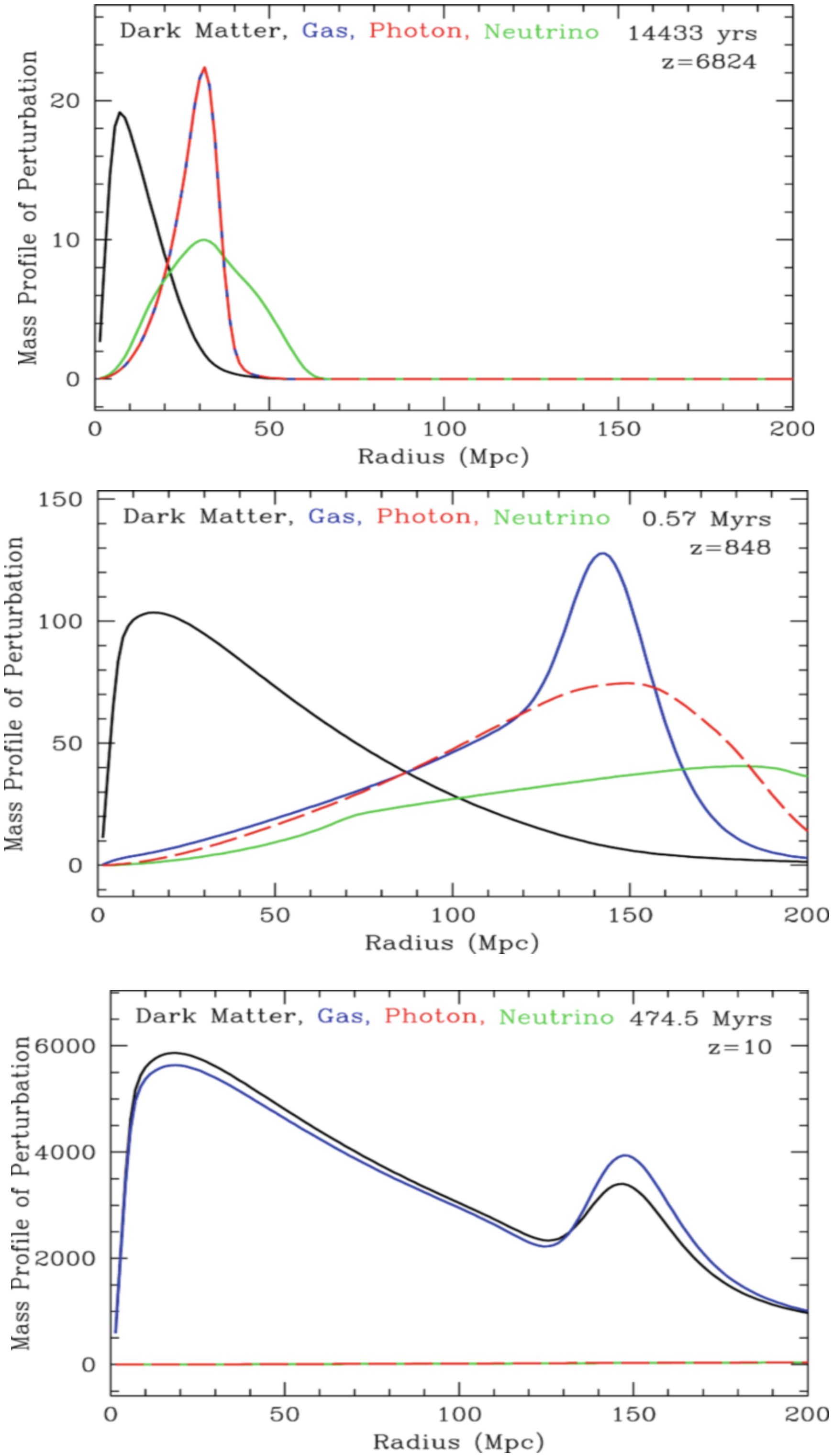
Questions addressed

* The BAO feature is clearly measured in spectroscopic redshift space. What happens in photometric redshift space ?

* If the BAO feature is not clearly measured in the angle averaged monopole correlation function from photo-z's, are there ways to get BAO information from photo-z's ?

* If at all we recover the BAO feature from another method, to what accuracy do we recover it ?

* Even if we recover it with a given accuracy, can we use it to get cosmic distance measures comparable to what we get from spectro-z's ?



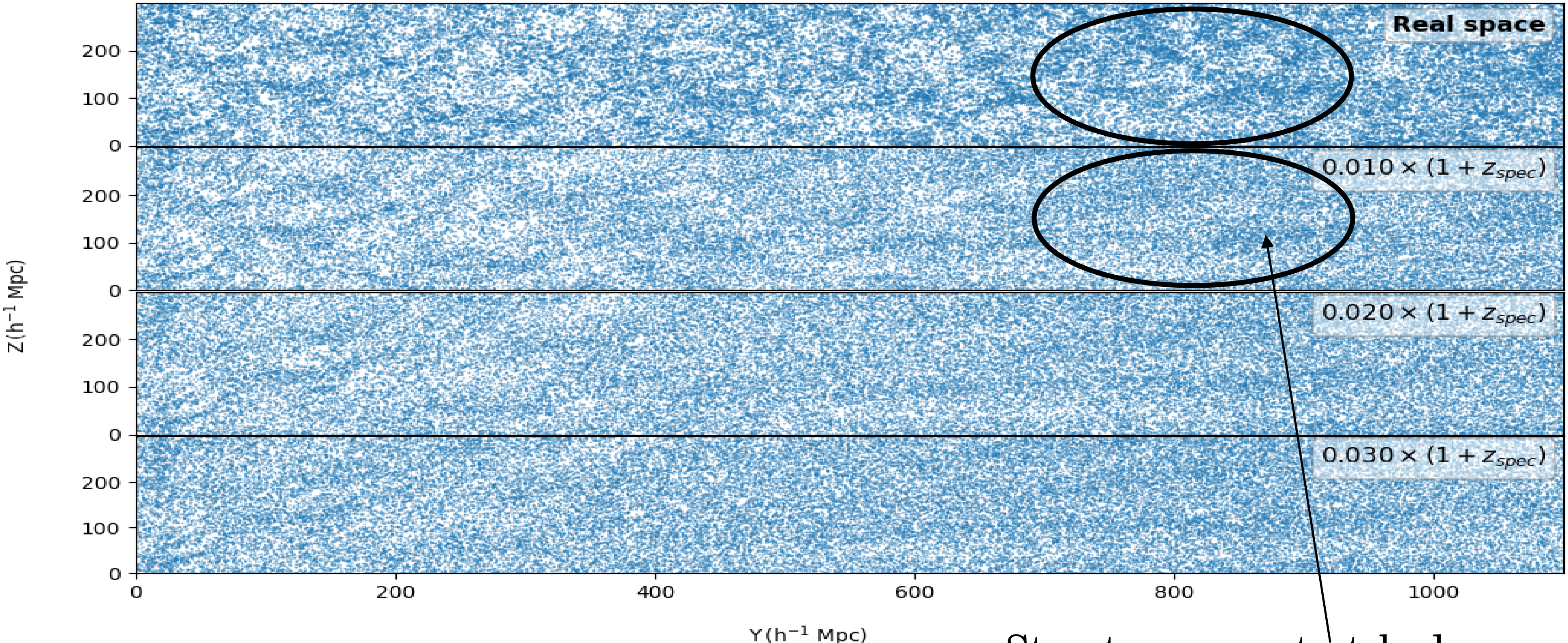
Credits: D.J. Eisenstein et al. 2007

Photons and baryons strongly coupled before recombination

After recombination, the photons are no longer coupled to the baryons and freely stream away. The sound speed of the baryons drops to zero.

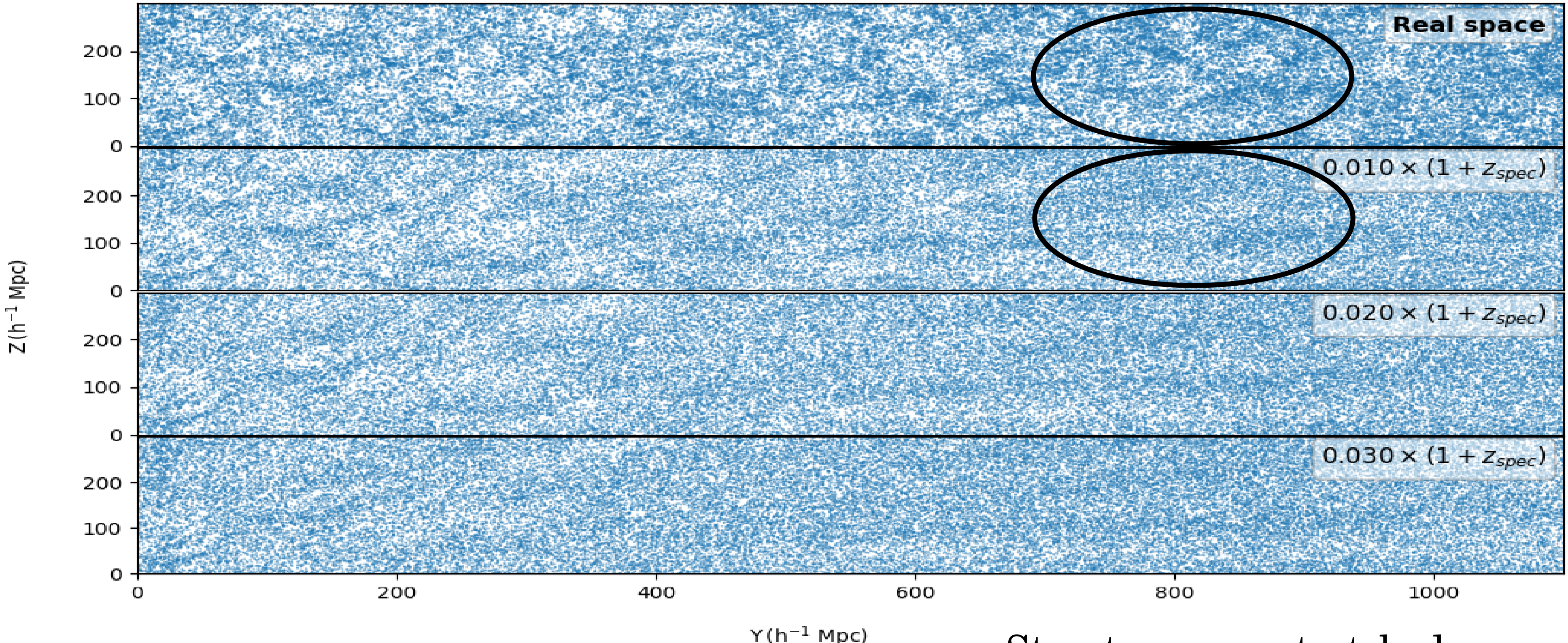
At late times, the distributions of baryons and dark matter become similar. The secondary peak has a well defined separation.

Sridhar & Song (in prep)



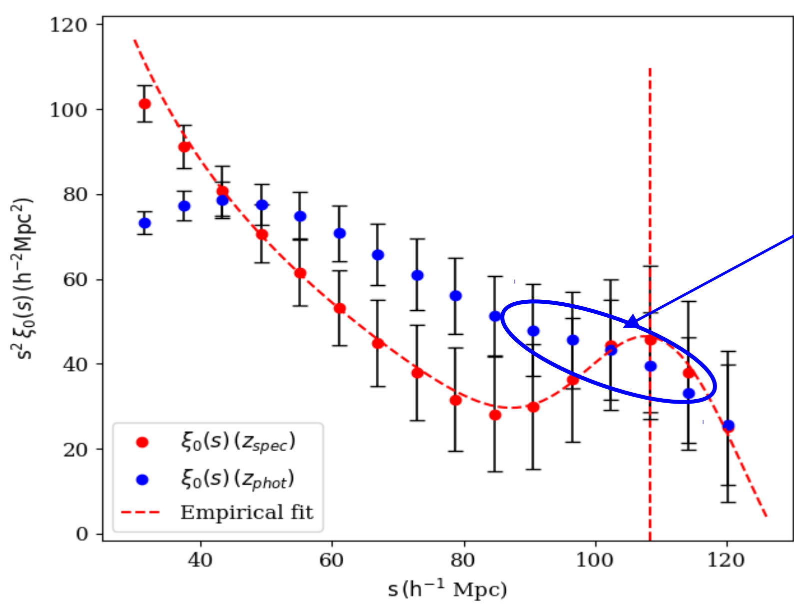
Structures are stretched
in photometric redshift space

Sridhar & Song (in prep)



Structures are stretched
in photometric redshift space

BAO peak smeared out in photo-z space



Correlation function (Landy & Szalay)

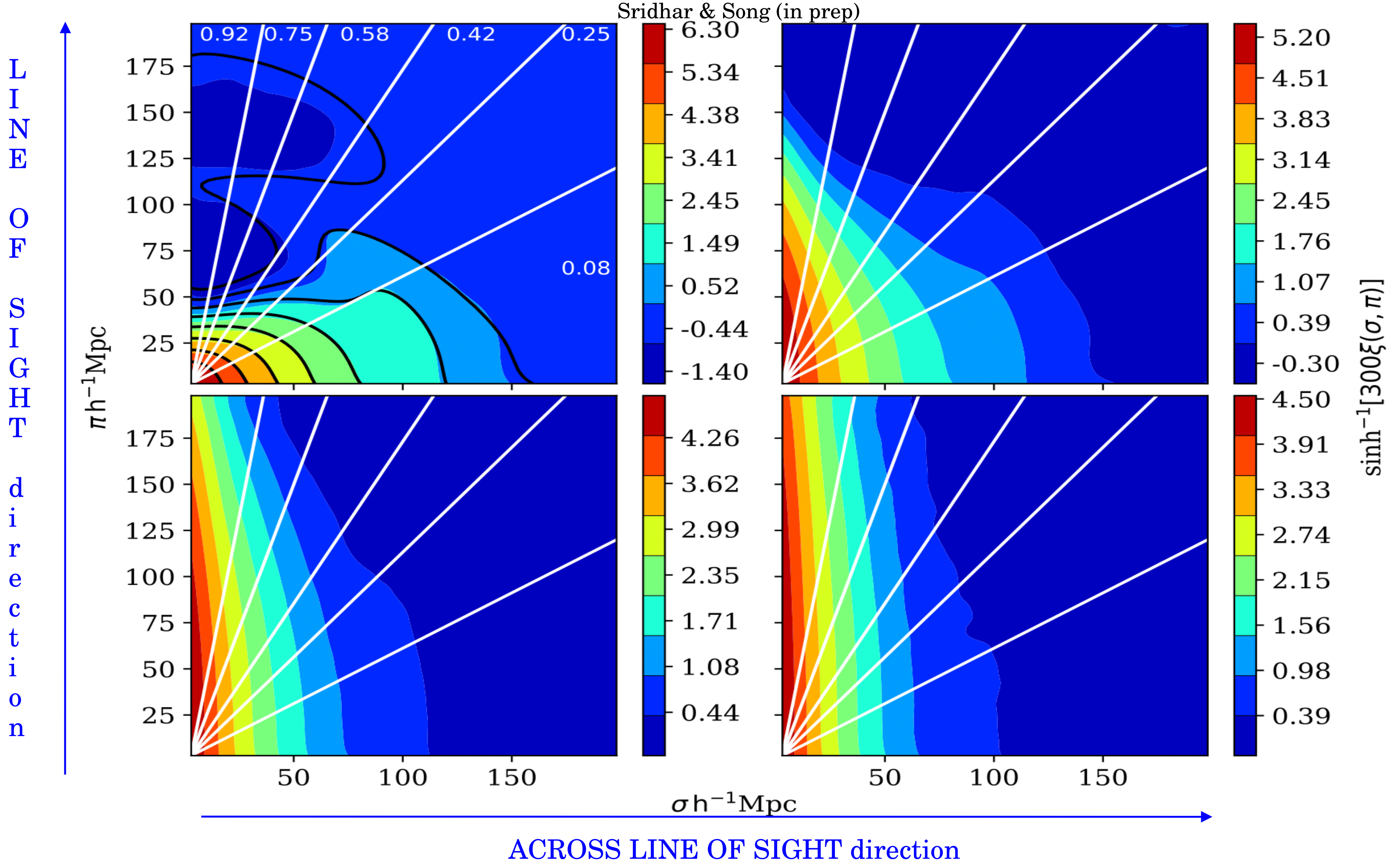
$$\xi(r) = \frac{DD(r) - 2DR(r) + RR(r)}{RR(r)}$$

If spectro-z's are already perfect,
why care about photo-z's ?

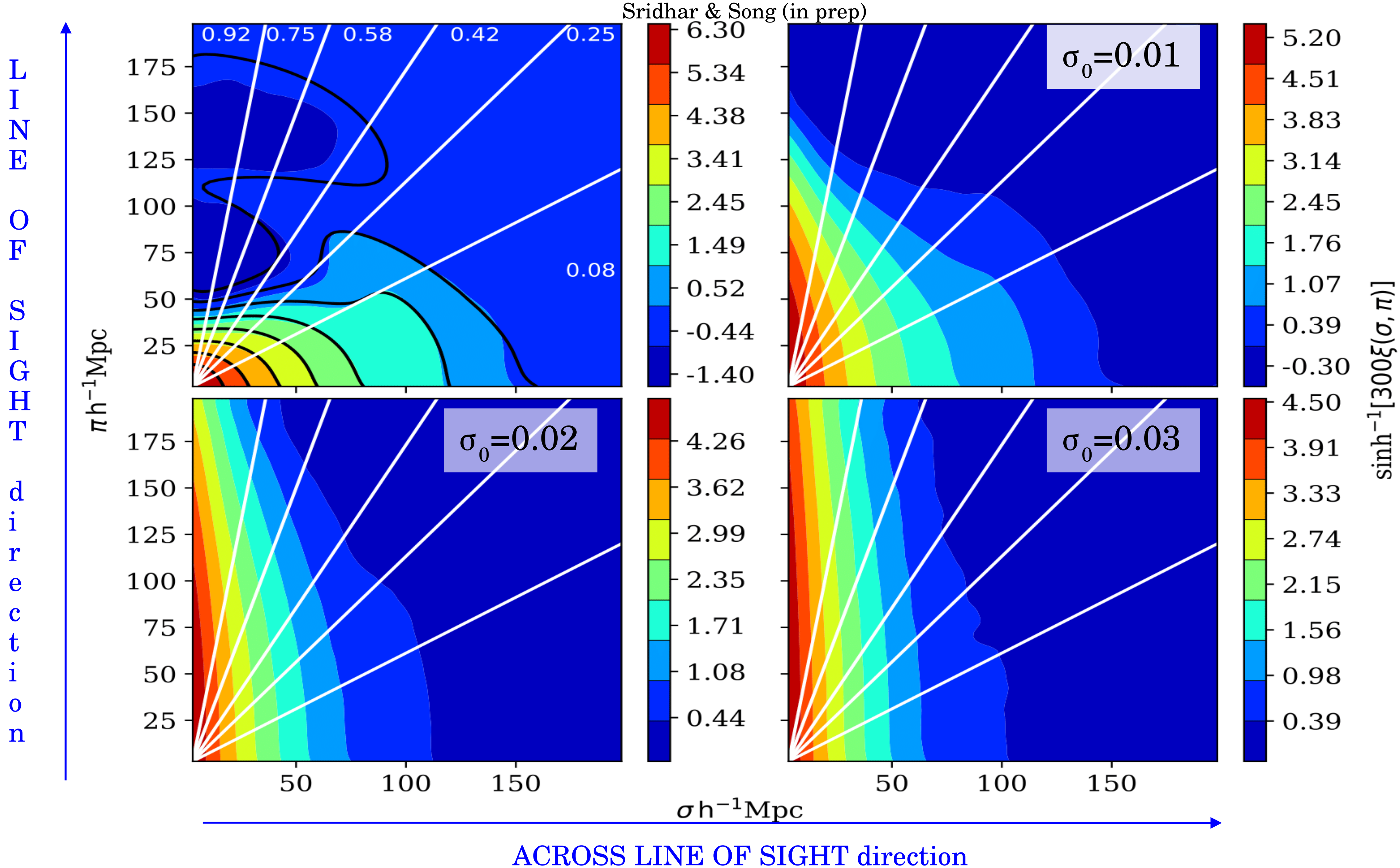
* Only 15-20% of galaxies from a survey will have spectroscopic redshifts !

* For galaxies beyond $z \gtrsim 1.0$, getting spectro-z is an extremely challenging task (as these objects are very faint).

The wedge approach towards calculating the correlation function

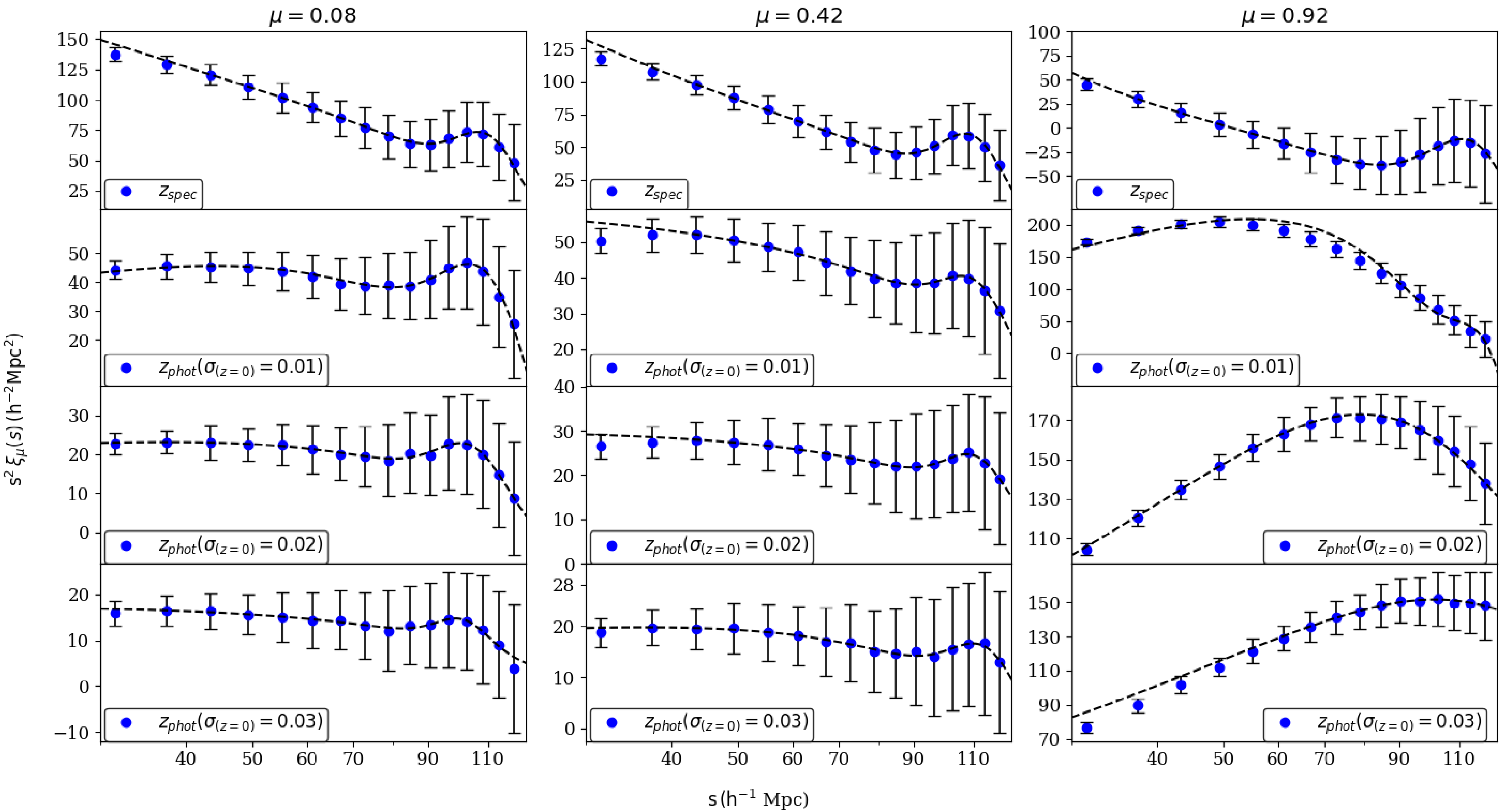


The wedge approach towards calculating the correlation function



Photometric redshifts –> random extraction from a Gaussian distribution with mean = galaxy z_{spec} and standard deviation = photometric redshift error

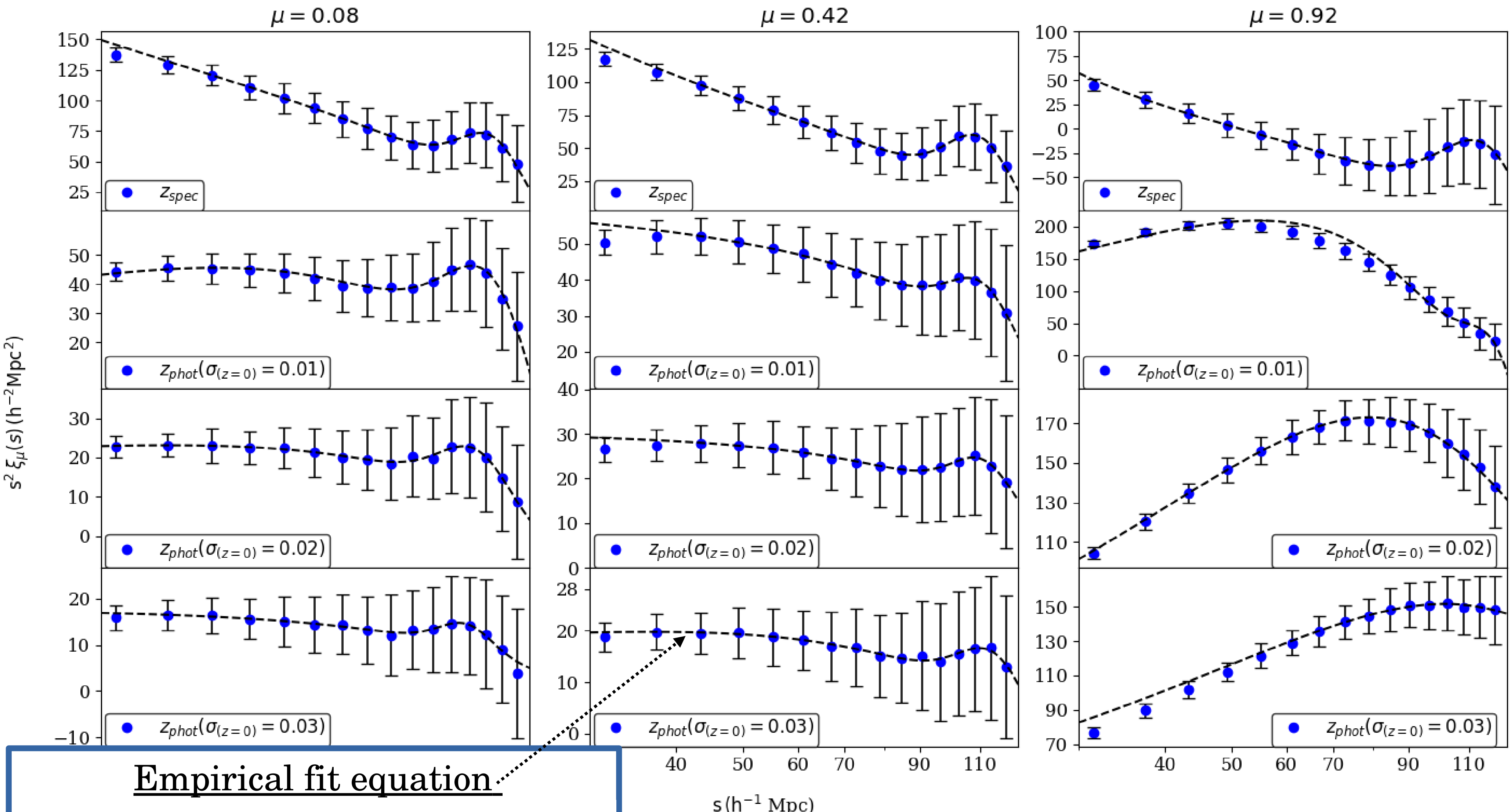
Correlation function stretched along LOS, smearing of peak with photo-z (increases with error)



Sridhar & Song (in prep)

$$\xi(s,\mu) = \frac{DD(s,\mu) - 2DR(s,\mu) + RR(s,\mu)}{RR(s,\mu)}$$

$$\xi_i(s,\mu_i) = \int_{\mu_i^{\rm min}}^{1} d\mu W(\mu : \mu_{\rm cut} = \mu_i^{\rm max})\xi(s,\mu)\,,$$



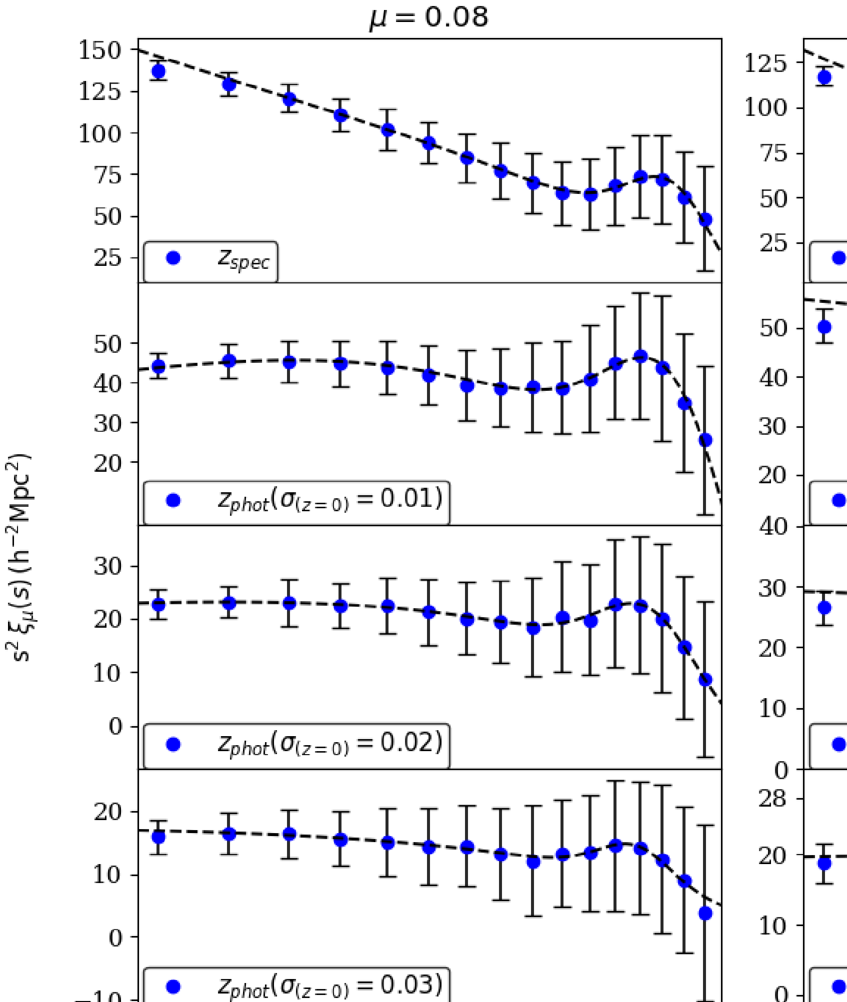
Sridhar & Song (in prep)

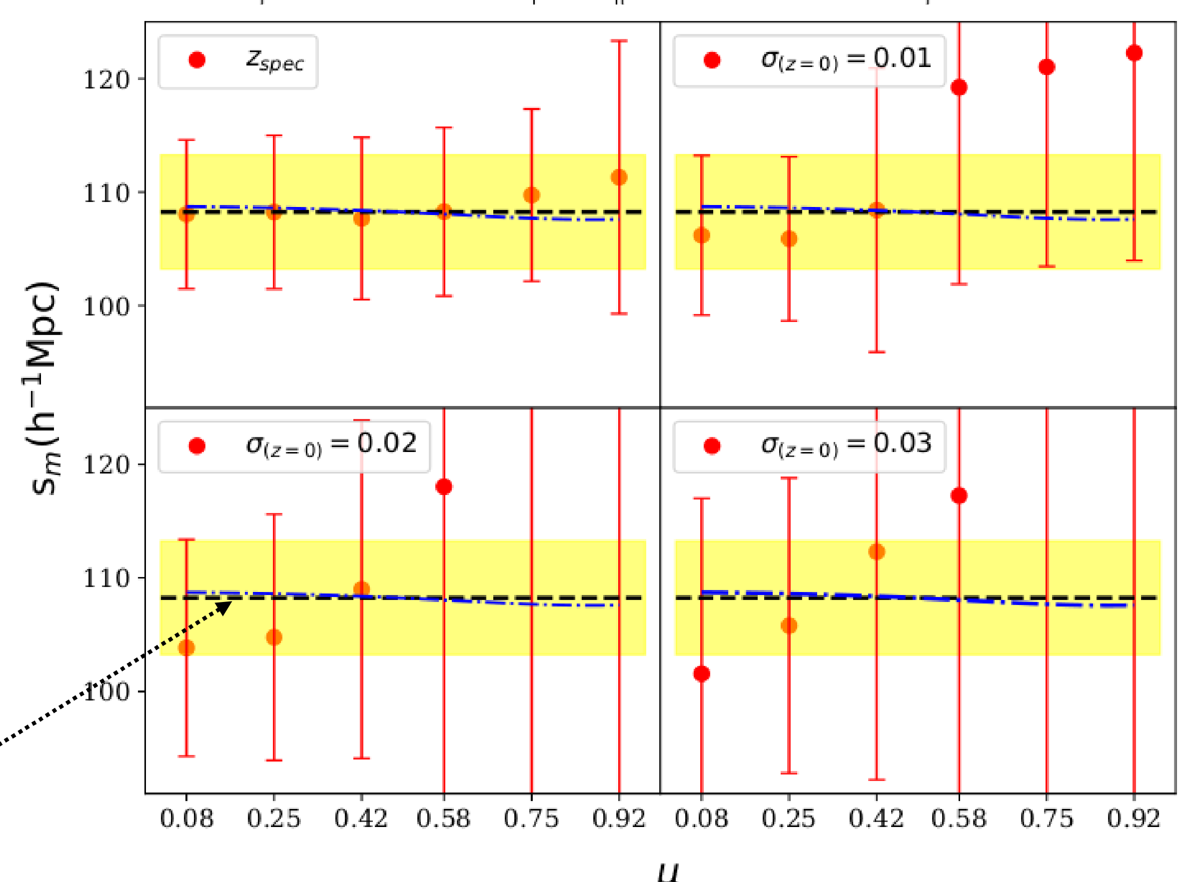
Empirical fit equation

$$\xi(s) = B + \left(\frac{s}{s_0}\right)^{-\gamma} + \frac{N}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{(s-s_m)^2}{2\sigma^2}\right)$$

$$\xi(s,\mu) = \frac{DD(s,\mu) - 2DR(s,\mu) + RR(s,\mu)}{RR(s,\mu)}$$

$$\xi_i(s,\mu_i) = \int_{\mu_i^{\rm min}}^{1} d\mu W(\mu : \mu_{\rm cut} = \mu_i^{\rm max})\xi(s,\mu)\,,$$





Sridhar & Song (in prep)

Empirical fit equation

$$\xi(s) = B + \left(\frac{s}{s_0}\right)^{-\gamma} + \frac{N}{\sqrt{2\pi\sigma^2}}\exp\left(-\frac{(s-s_m)^2}{2\sigma^2}\right)$$

s_m (monopole) –> Black dashed line

–> $s_m \pm 1\sigma$ (monopole corr)

Cosmic distances measured using the BAO peak

$$D_V(z) = \left[(1+z)^2 D_A(z)^2 \frac{cz}{H(z)}\right]^{1/3}$$

Isotropic volume distance

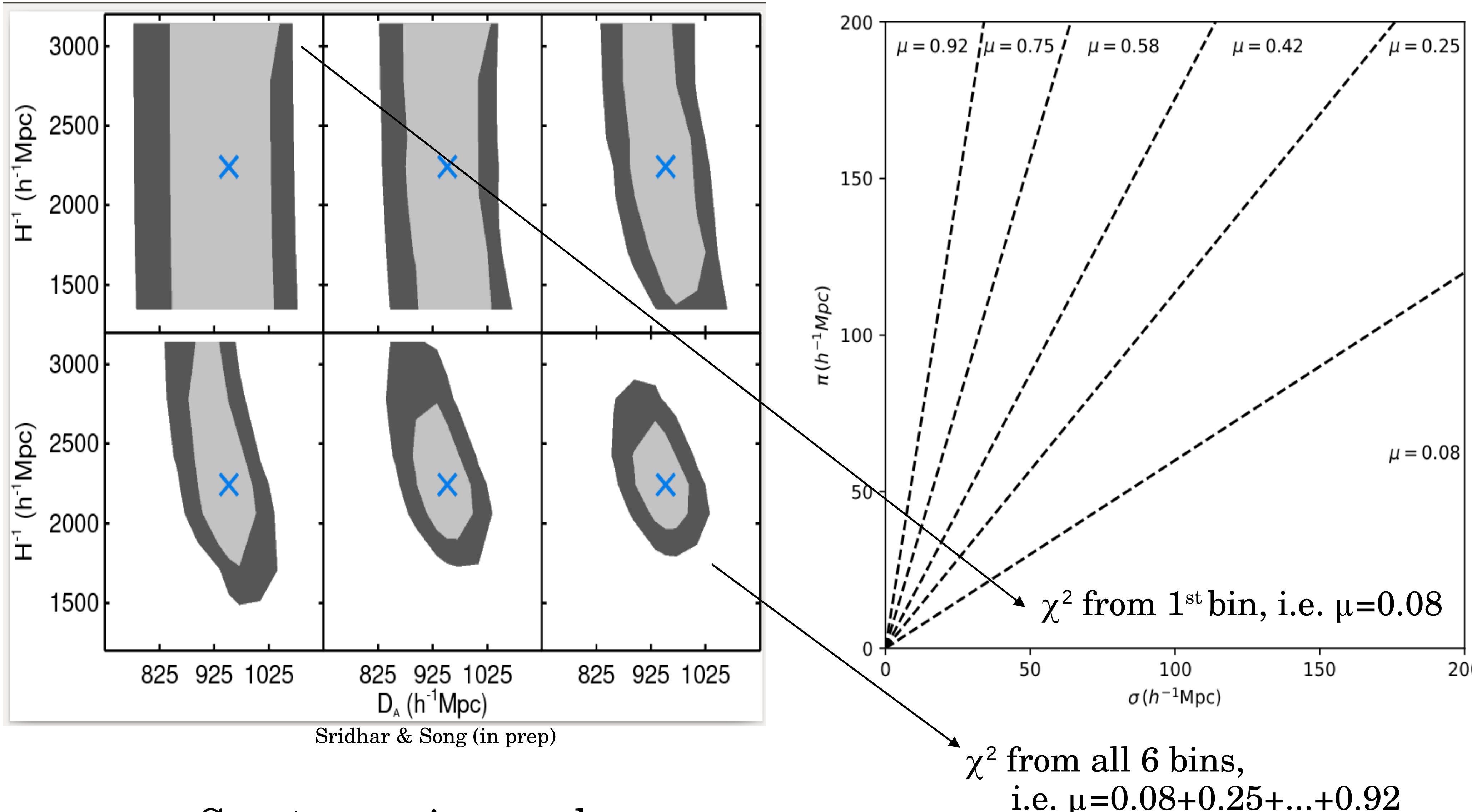
Given in terms of D_A and H^{-1}

Angular diameter distance

Across LOS direction

Hubble parameter

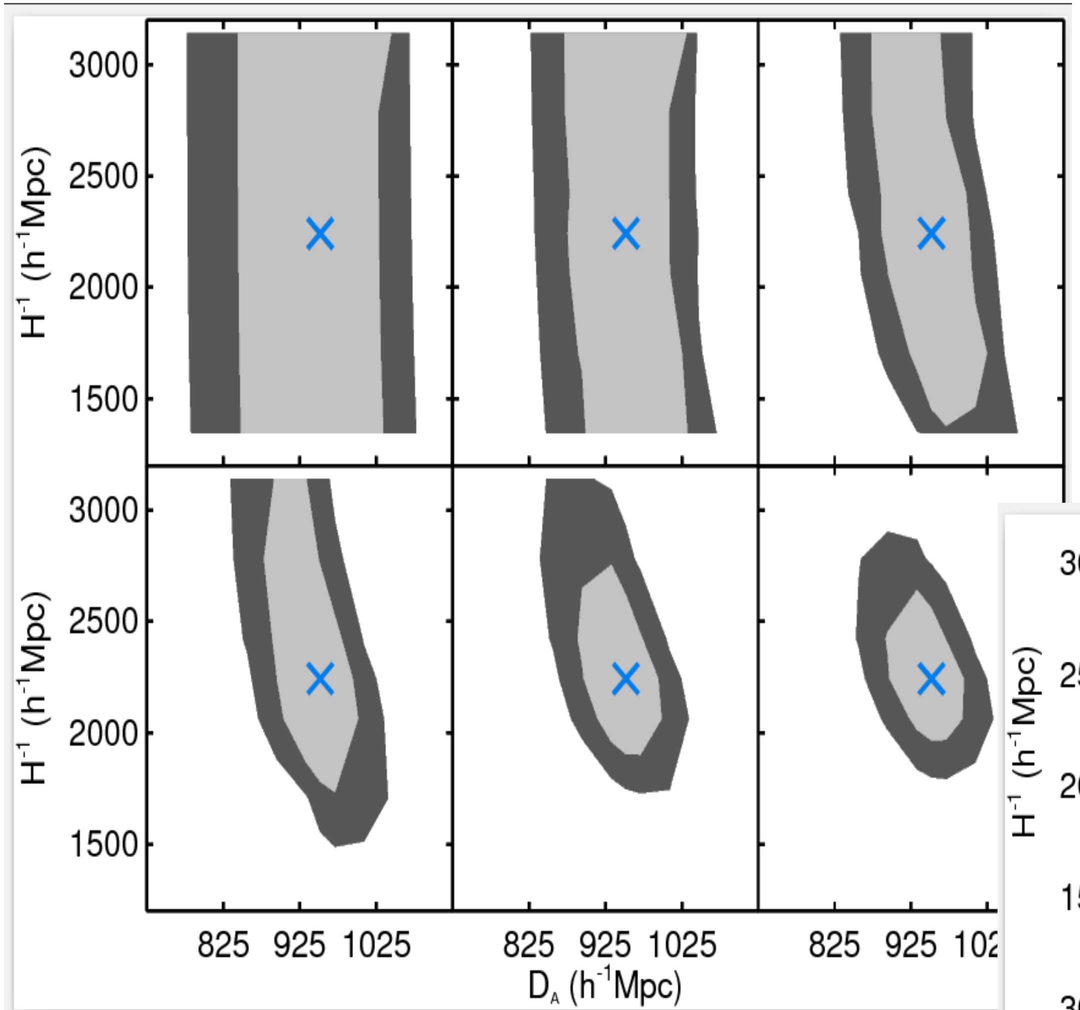
LOS direction



Sridhar & Song (in prep)

Spectroscopic sample

D_A –> 5% precision
H^{-1} –> 12% precision

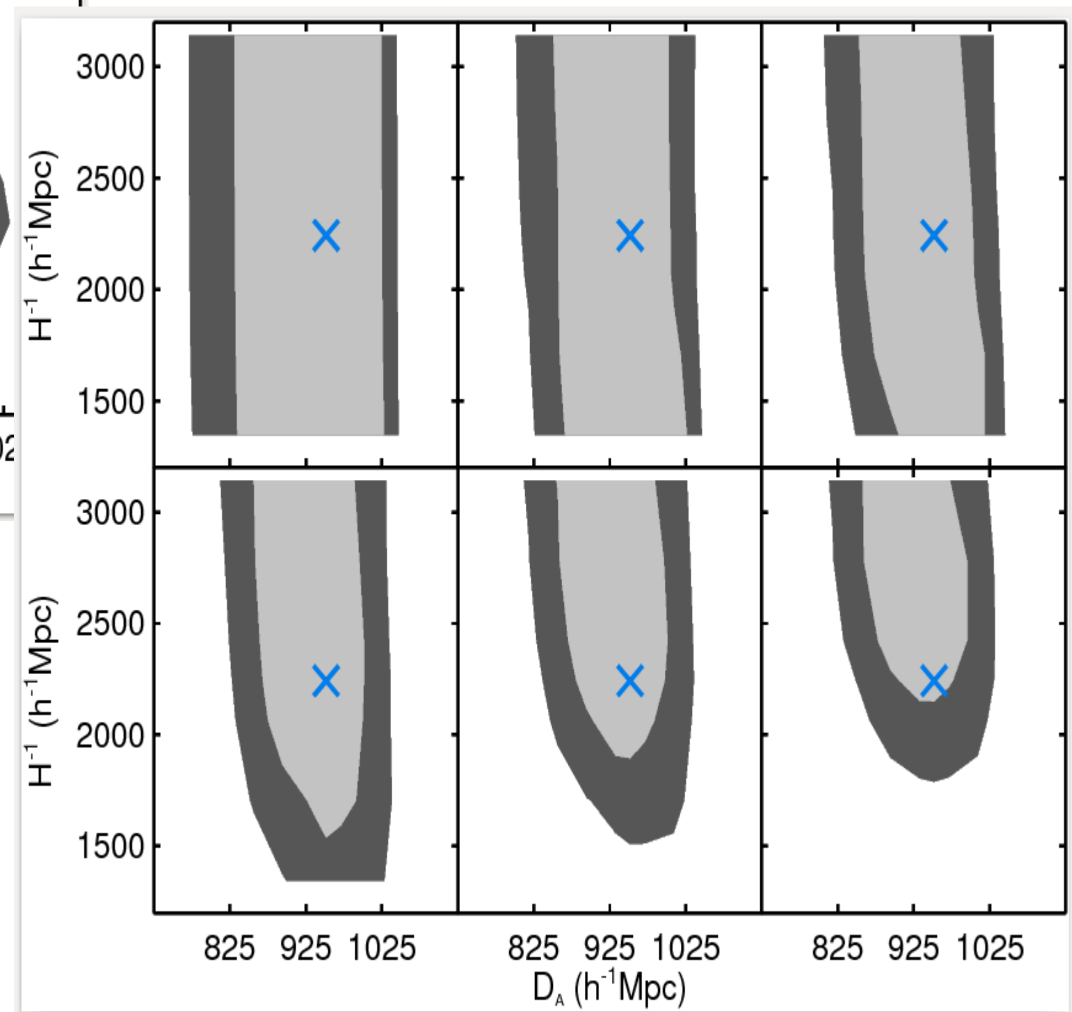


Sridhar & Song (in prep)

Spectroscopic sample

D_A –> 5% precision
H^{-1} –> 12% precision

σ_0= 0.01 photometric sample
D_A –> 6% precision
No tight constraints on H^{-1}



* The BAO feature is clearly measured in spectroscopic redshift space. What happens in photometric redshift space ?

  BAO is smeared out because of anisotropies, stretched along LOS

* If the BAO feature is not clearly measured in the angle averaged monopole correlation function from photo-z's, are there ways to get BAO information from photo-z's ?

  The wedge approach works well with photo-z samples, BAO feature recovered

* If at all we recover the BAO feature from another method, to what accuracy do we recover it ?

  For the first 3 μ bins, recovered with 3% precision

* Even if we recover it with a given accuracy, can we use it to get cosmic distance measures comparable to what we get from spectro-z's ?

  D_A recovered with 6%, no tight constraints on H^{-1}

நன்றி (Nandri) – Thank you