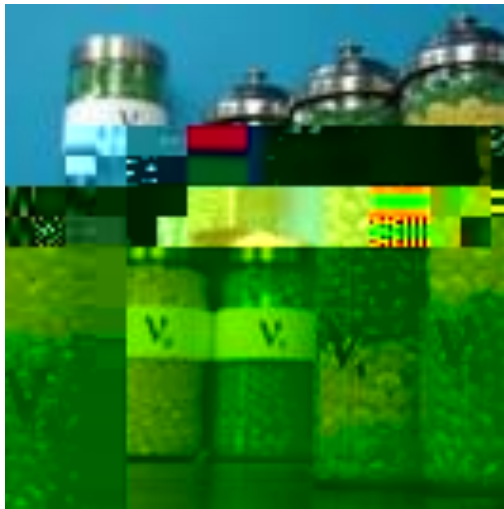


! " # \$ % & ' ( ) \* + , , ) - % ( \* )  
· ( , \* ( / ( 0 & . + / ) , # % 1 " 2 , )



6 < = > 9 (! / + \$) ( % 2 " " \$) + / : " -- " :

3 - "% ) 4 + 5 + 1 ) 6 7 8 4 9





@5 ")A&0)! " # \$ % & ' ( ) B # " , \$ & ( ' ,

- ◆ C5+\$)&, )\$5"))+D, (/#\$"), # \* )(-)' " # \$ % & ' ( ) \* + , , E  
F#GG"%)/&\* &\$) (-)+D (#\$)=;<)"H)-%(\* )8( , \* (/ (02  
F / (I "%)/&\* &\$))=;=J)"H)-%(\* ) ( , . &/+\$&( ' ,
- ◆ C5+\$)&, )\$5")5&"%+% . 52)K ! (%\* +/) (%L' 1 "%\$ "ME))
- ◆ L, )! " \_ )N)O;=PQR)  
(%)/+%0""%)6S\$ "%&/' )' " # \$ % & ' ( ) TUM+%V)%+M&+\$&( ' W9E)
- ◆ L, )\$5")' " # \$ % & ' ( ) &\$ , )+ ' \$&FG+%\$& . /'" )6X+Y (%+ ' +9E)
- ◆ ! " # \$ % & ' ( ) G%(G "%\$&" , )-%(\* )8( , \* (/ (02Z  
+). % # . &+ / )\$ " , \$) (-) (#%)M+\$+)+ ' M) \* "\$5 (M (/ (02)

A%&" -) [ &, \$ (%2) (-)  
' [ (\$) \ + %V) X + \$\$ "' %'

\* ! " # \$ % & ' ( ) \* + , ) - . ' % / 0 . 123 ) ' - 345 ' 6 1 % % 370 ' . 08423 . ) % '  
9 : ; < = ' + > 0 ? , ) 7 3 / 5 @ 1 . / 1 A 0 %'

B ! " C \$ % & ' ' : ; < ' + @ 2 ) D ? 0 6 % ' - 345 ' % 428 / 4820 ' E ) 2 6 1 4 3 ) .

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B J \$ \$ \$ % & ' ' K 1 2 L ) . % ' 9 M H = ' I ' G ; < ' 9 J N H = ' I O 1 6 D , 1 ' 9 # \$ H = &'

K 8 4 ' . ) - ' - 0 ' A . ) - ' : ; < ' O F 3 % 4 % P '  
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( ' \* ) 5 2 .. \* ) , 2 . " )

A'R'A<sub>2</sub> S'\$T\$!C'96 U!'OV=!!U 6 !!U 5U < \* /

$h^2 = M_V / (93.0V)$



*Agarwal & Feldman 2010  
Cf. Krishna Naidoo's talk*

! " # \$ % & ' ( ) \* + , - . / + 0 1 % ! " #  
1 - . , 2 - , . ) % 4 5 1 6 ) 7 % 0 , - 8

$$]A+.V)(-)\$5'''' 1''/(G''^{\wedge})$$

$$6. -;)A (/ \$_ * + ' ' ), (/ 1''\%)8` XA9)$$

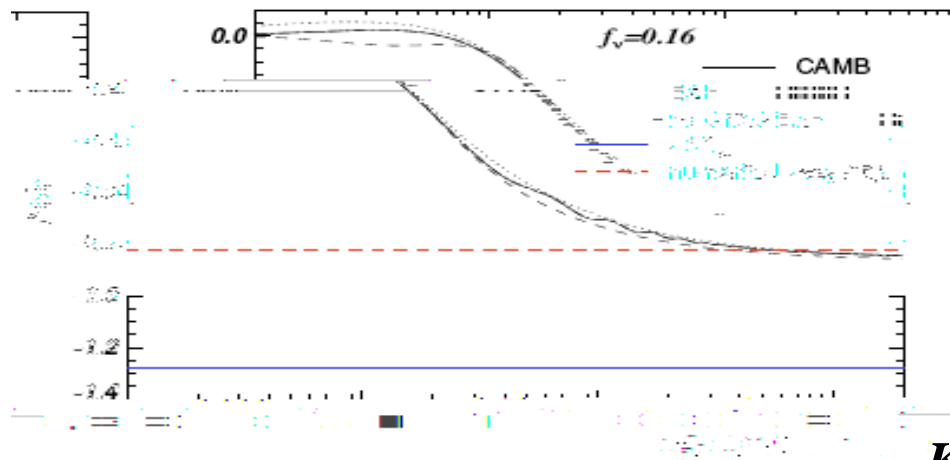
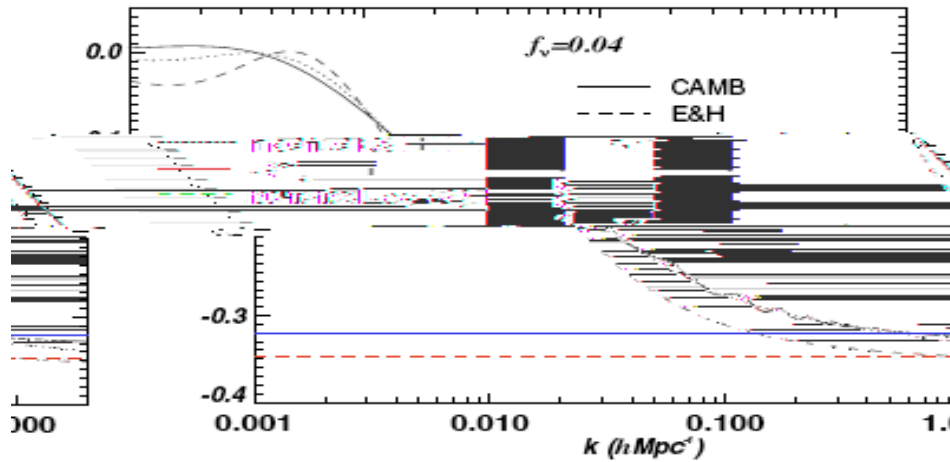
$$\ddot{\delta} + 2\frac{\dot{a}}{a}\dot{\delta} = 4\pi G\rho_0(1 - f_\nu)\delta.$$

$$E S'' / 6 \pi$$

$$P(k, f_\nu) - P(k, f_\nu = 0) \quad 6$$

$$S'+C' / 6 \pi$$

$$\frac{\Delta P(k)}{P(k; f=0)} = \frac{P(k; f) - P(k; f=0)}{P(k; f=0)}$$



@9A=U@9A='  
S'+C' / 6

91?45)8X5' .)4'  
71?3,') '8%0E8?'  
%/1?0%=

# C52)M ()I ''')' ''''M)D&00''%), #1''2, E

Y a%(%(')G(I ''%), G'' . \$%# \* )  
 (-)M''', &\$2)-/#. \$#+\$&(' ,

$$\Delta \epsilon^2 / P(k) \propto 1 / \sqrt{V_{eff}}$$

Y S#GG%'' , , &(')M#'' )\$( )  
 ' ''#\$%&' ( )-%''''), \$%'' + \* &' 0)

$$\Delta \epsilon^2 / P(k) \propto 1 / \sqrt{V_{eff}}$$

Y S() \* '' + , #%' \* '' '\$) (-)  
 ' ''#\$%&' ( ) \* + , , )&\* G%(1'' , )  
 + , )&' 1''%, '' )  $\sqrt{V_{eff}}$

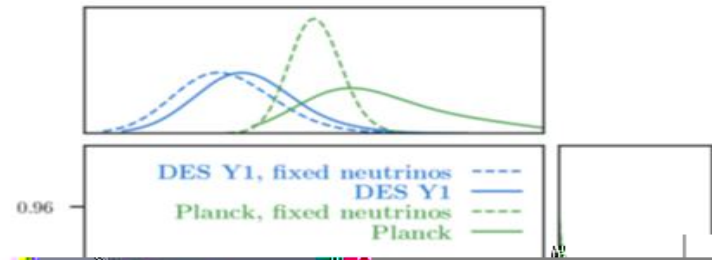
'';0;)<Mb)Z))=;<)6cG. T59d0  
 \aSZ)))<=))6cG. T59d0  
 S()+) - + . \$ (%>=)&\* G%(1'' \* '' '\$)  
 (')' ''#\$%&' ( ) \* + , , )

<F, &O \* +)! "#\$%&' ()\* +, ,)#GG"%)/&\* &\$, )  
 -%(\* )"e&,\$&' 0)M+\$+

Data	Authors	M = 6 <sub>3</sub>
2dFGRS	Elgaroy, OL et al. (2002)	< 1.8 eV
MegaZ-LRG + WMAP	Thomas et al. (2010)	< 0.28 eV
Planck13+robust surveys	Leistedt et al. (2014)	< 0.3 eV
Planck15++	Planck collaboration 2015	< 0.23 eV
BOSS Ly-alpha + Planck15	Palanque-Delabrouille et al. (2015)	< 0.12 eV
DES Y1 + Planck15+JLA+BAO	DES collaboration (2017)	< 0.26 eV



! "#\$%&'()\*+,,)-%(\* )\aS)f>  
. /# , \$ "%&' 0g)I " +V)/"" , &' 0)60e<G\$9



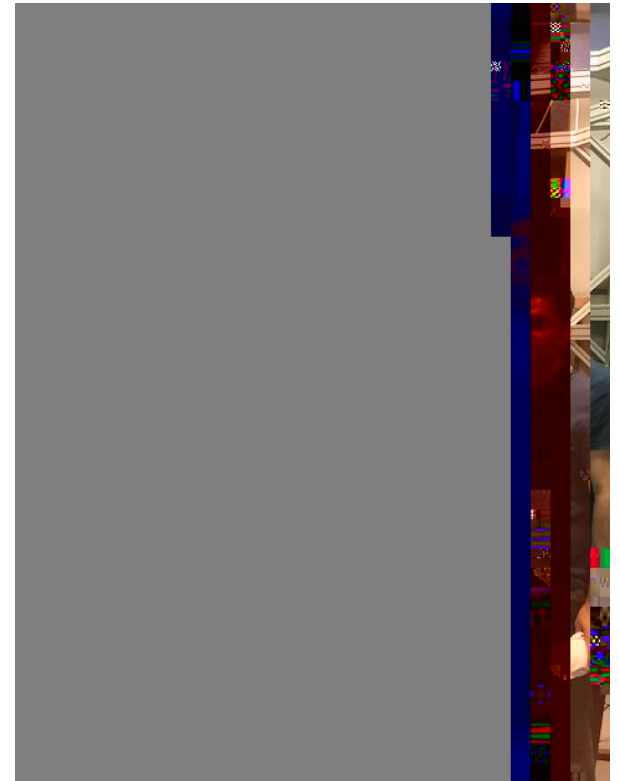
<F, &O \* +) "%% (%,) (' )! "#\$%&' ()\* +, ,)K  
- (% " . +, \$)- (%)-#\$\$#%" ), #%1 "2,



\aSL)8 (%%" . \$ (%)3G\$&. +/). (%%" . \$ (%)  
Y# , \$). ( \* G/"\$ "M)+\$)784

Y S&e)5#0")/"" , " , )6(' "F\* "\$"%). /+ , , 9)+%"")%"h#&%"M)  
-(%)\$5")\aSL). (%%" . \$ (%)

Y Ni)SG" . \$%+)(-00QX)0+ /+e&" , )j )BS3,



Rotation of ADC1 wrt ADC2

X"\$5 (M (/ (02Z)5" +/\$5)I +% ' &' 0,

Y ` ' +/2, &, )&, )M (' ")I &\$5&' )\$5") F8\X), . "" +%&(R)  
, #DY" . \$)\$ ()G%&(%, ;

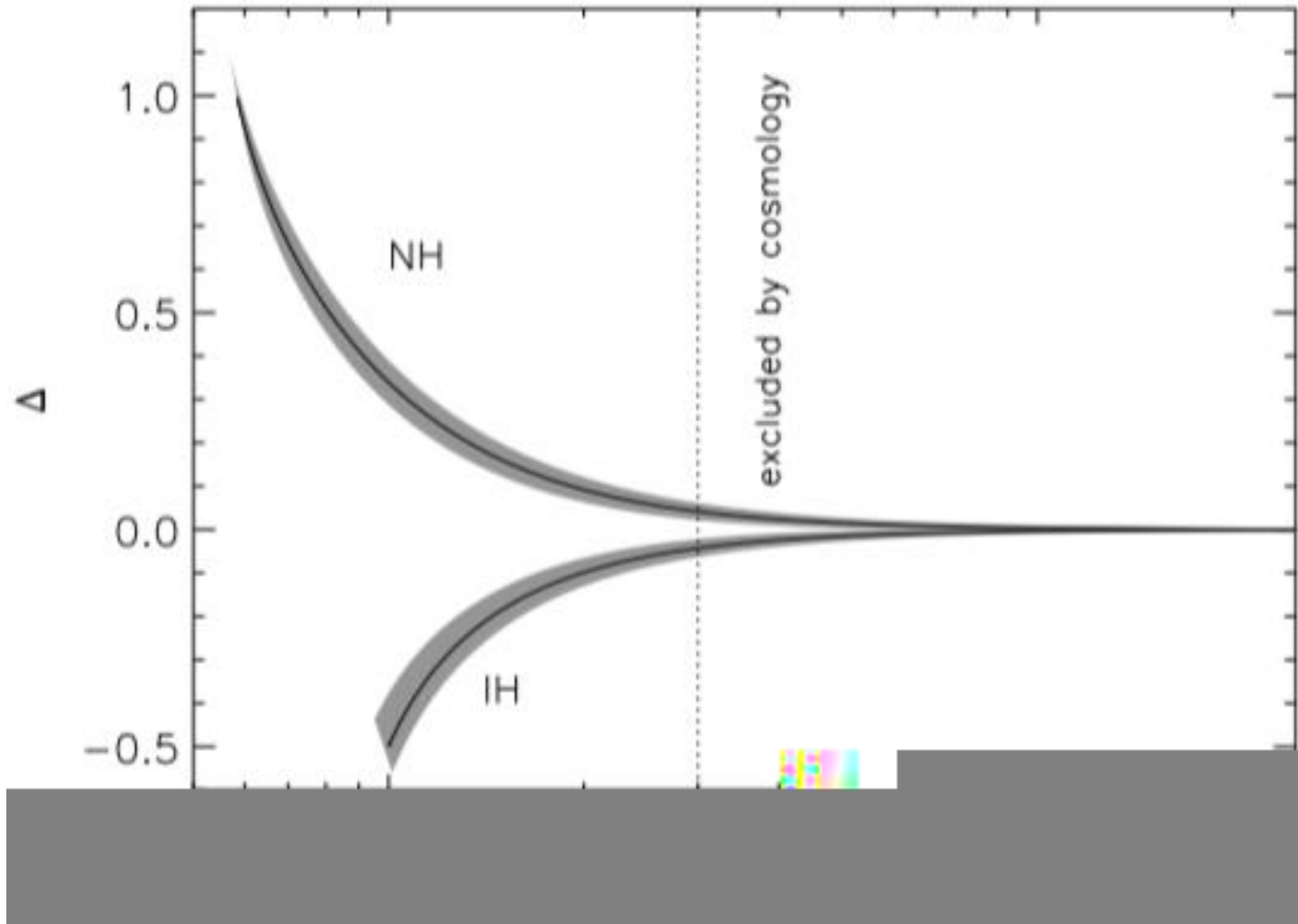
Y S (\* ")G%(D" , )+%"), "" , &\$&1")\$ ()\$5")' "#\$%&' ()\* +, , )  
M&%". \$/2)6";0;) \$5"), 5+G") (-)\$5")G (I "%, G". \$%#\* 9;

Y 3\$5"%G%(D" , )Y#, \$). (' , \$%+&' )D"\$\$\$"%)\$5") (\$5"%)! F>)  
G+%+ \* "\$"% , )&' )\$5"). ( , \* (/ (0&. +/)\* (M"/)6"0 S! )L+R)  
A` 39;

Y @5"), "/". \$&(' )(-)]D" , \$)M+\$+), "\$, ^)&, , (\* "I 5+\$)  
, #DY". \$&1";

Y X&, \* +\$. 5) (-)M+\$+), "\$, ). (#/M)/" +M)\$ (), G#%&(#, , )  
]' "I )k52, &. , ^;

$\Delta = (M - m)/M$  for normal hierarchy



$\Delta = (M - m)/M$  for normal hierarchy

$\Delta = (M - m)/M$  for inverted hierarchy

~ )0/(D+/)A+2" , &+ ' )+ ' +/2, &, )

(-)' "#\$%&' ()\* +, ,

-%( \* )\ (#D/" )A"\$ \$+ )\ ". +2R))3, . &/+\$&( ' , )

j )8 ( , \* (/ (02

8-;) [ ( , \$R)34))"\$ \$)+/)

6<==m9) ( ' )

k/+ ' . Vgo+\$%&'

8+/MI " /)"\$)+/;R)+%l &1Z>m=Q;=>nPQ

8-;))` 0( , \$&' & "\$)+/;)+%l &1Z>m=Q;=<nnJ

S# \* \* +%2

Y 8#%%" \$)#GG"%)/&\* &\$,)( ' ),#\* )' "#\$%&' ()\* +,,)

p))=;<)"H))6<F,&0\* +9

Y b#\$#%"),#%1"2,)I &/)&\* G%(1"&\$)D2)-+.\$(%QR)%"+.5&' 0)\$5")