



DRM Update

Joe Liske



Spectroscopic ETC

Infrared Exposure Time Calculator - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dmdlinc.hq.eso.org:8080/observing/etc/bin/gen/form?INS.NA Google



ELT Exposure Time Calculator

[HOME](#) [INDEX](#) [SEARCH](#) [HELP](#) [NEWS](#)

[Infrared Mode](#) [Version 3.2.1](#) [Description.](#) [F.A.Q](#) [Performance](#)

Target Input Flux Distribution

[Spectral Type \(Pickles Model\):](#) A0V (Pickles) (9480 K) (only U-K bands)

MARCS Model: Model type: standard [Fe/H]: -1.00 Teff: 5750 K log(g): +0.5
Geometry: spherical Microturbulence: 2 km/s
Mass: 1.0 M(Sun)

[Target Magnitude:](#) V = 10.00

Magnitudes are given per square arcsec for extended sources.

[Spatial Distribution:](#) [Point Source](#) [Extended Source](#)

Telescope Setup

[Observatory Site:](#) Paranal (2635 m)

[Telescope Diameter:](#) 42 m



Spectroscopic ETC

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ELT Exposure Time Calculator

[HOME](#) [INDEX](#) [SEARCH](#) [HELP](#) [NEWS](#)

[Infrared Mode](#) [Version 3.2.1](#) [Description.](#) [F.A.Q](#) [Performance](#)

Target Input Flux Distribution

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MARCS Model: Model type: standard [Fe/H]: -1.00 Teff: 5750 K log(g): +0.5
Geometry: spherical Microturbulence: 2 km/s
Mass: 1.0 M(Sun) [check availability](#)

[Target Magnitude:](#) V = 10.00

Magnitudes are given per square arcsec for extended sources.

[Spatial Distribution:](#) [Point Source](#) [Extended Source](#)

Telescope Setup

[Observatory Site:](#) Paranal (2635 m)

[Telescope Diameter:](#) Paranal (2635 m)
High and Dry (5000 m)

Parameters	T	PWV
Paranal-like	271 K	2.0 mm
High and Dry (U.S. Standard Atmosphere)	256 K	0.6 mm



Spectroscopic ETC

- Background = continuum + OH lines + $(1-tr) \cdot BB(T_{\text{atm}}) + \epsilon_{\text{Tel}} \cdot BB(T_{\text{Tel}})$

- Continuum in NIR???

Cuby, Lidman & Moutou, 2000, Messenger, 101, 2:

J: 1200 photons/s/m²/μm/arcsec² = 18.0 mag/arcsec²

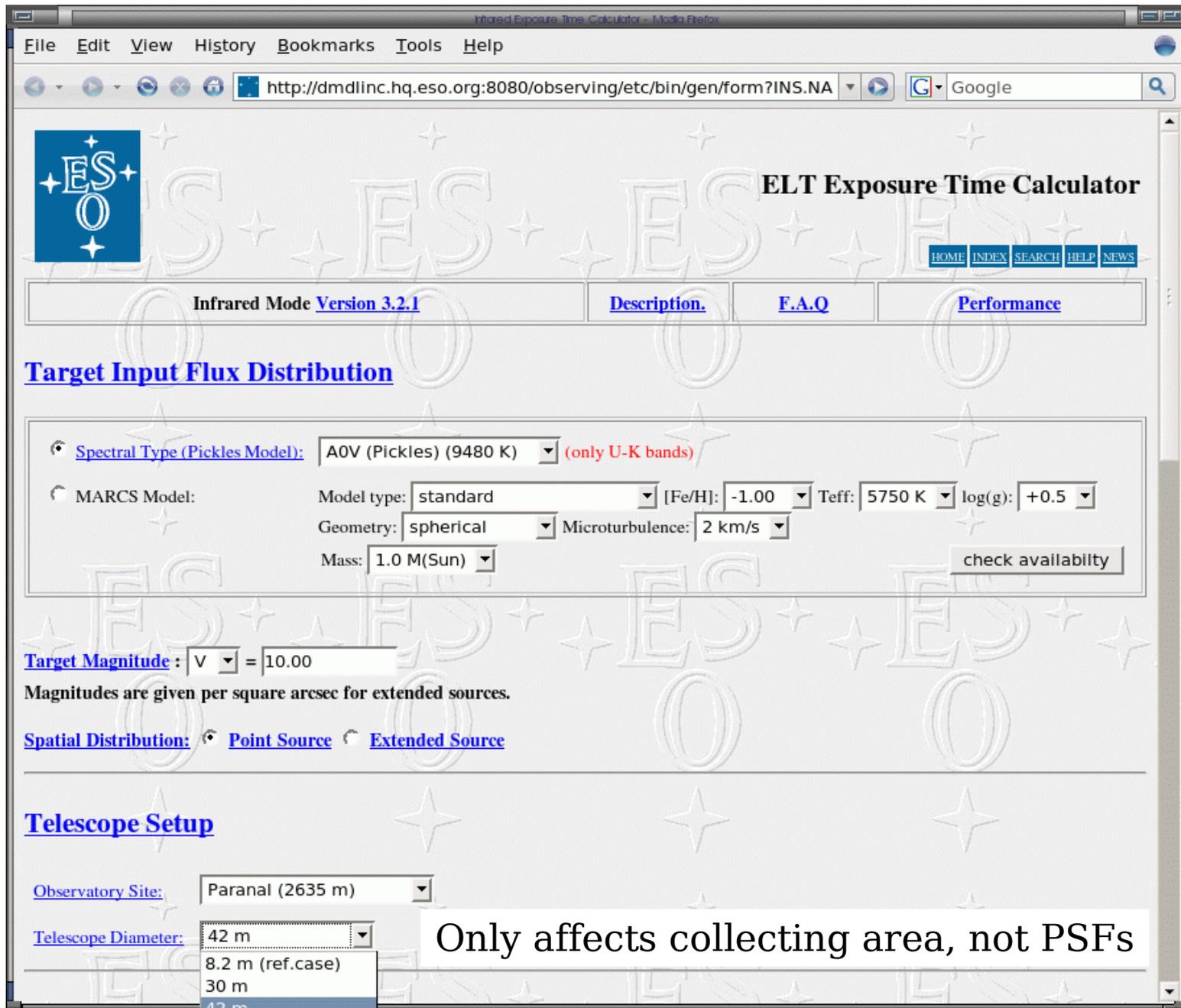
H: 2300 = 16.5 mag/arcsec²

Gemini ETC: continuum = zodiacal light = $tr \cdot BB(T=5800 \text{ K})$

- Atmospheric transmission = $tr(T_{\text{atm}}, \text{PWV}, \text{ZD})$

from HITRAN, provided by A. Smette

Spectroscopic ETC



The screenshot shows the 'ELT Exposure Time Calculator' web interface. The browser address bar shows the URL: <http://dmdlinc.hq.eso.org:8080/observing/etc/bin/gen/form?INS.NA>. The page title is 'Infrared Mode Version 3.2.1'. The main heading is 'ELT Exposure Time Calculator'. Navigation links include HOME, INDEX, SEARCH, HELP, and NEWS. A menu bar contains 'Infrared Mode Version 3.2.1', 'Description.', 'F.A.Q', and 'Performance'. The 'Target Input Flux Distribution' section has two radio buttons: 'Spectral Type (Pickles Model):' and 'MARCS Model:'. The 'Spectral Type (Pickles Model):' is selected, with a dropdown menu showing 'A0V (Pickles) (9480 K)' and a note '(only U-K bands)'. The 'MARCS Model:' section has several dropdown menus: 'Model type: standard', '[Fe/H]: -1.00', 'Teff: 5750 K', 'log(g): +0.5', 'Geometry: spherical', 'Microturbulence: 2 km/s', and 'Mass: 1.0 M(Sun)'. A 'check availability' button is located to the right of the 'Mass' dropdown. Below this, the 'Target Magnitude:' is set to 'V = 10.00'. A note states 'Magnitudes are given per square arcsec for extended sources.' The 'Spatial Distribution:' section has two radio buttons: 'Point Source' (selected) and 'Extended Source'. The 'Telescope Setup' section has a dropdown for 'Observatory Site:' set to 'Paranal (2635 m)'. The 'Telescope Diameter:' dropdown is open, showing options: '42 m', '8.2 m (ref.case)', '30 m', and '42 m'. A white text box at the bottom right of the screenshot contains the text: 'Only affects collecting area, not PSFs'.

Spectroscopic ETC

Infrared Exposure Time Calculator - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dmdlinc.hq.eso.org:8080/observing/etc/bin/gen/form?INS.NA Google

Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

AO Mode: Seeing Limited (FWHM=0".8)

Radius of circular S/N ref. area: 3.3 (DLC in V) mas (on the sky). DLC=1.22 λ /D is the radius of the diffraction limited PSF core for a D=42m telescope.
i.e. over which the S/N is calculated

Number of spectra on the detector:
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band: V

Results

<input checked="" type="radio"/> S/N ratio:	S/N = <input type="text" value="10.000"/>	DIT = <input type="text" value="30.000"/> sec
<input checked="" type="radio"/> Exposure Time:	NDIT = <input type="text" value="1"/>	

The total exposure time is the product of DIT (Detector Integration Time) by NDIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

On submission the model can generate the following graphs:
(input parameters are replicated in the output page)

Spectroscopic ETC

Infrared Exposure Time Calculator - Mozilla Firefox

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http://dmdlinc.hq.eso.org:8080/observing/etc/bin/gen/form?INS.NA Google

Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

1.00 (ZD=0 deg)

1.15 (ZD=30 deg)

2.00 (ZD=60 deg)

Instrument Setup

AO Mode: Seeing Limited (FWHM=0".8)

Radius of circular S/N ref. area: 3.3 (DLC in V) mas (on the sky). DLC=1.22 λ /D is the radius of the diffraction limited PSF core for a D=42m telescope.
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Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

AO Mode: Seeing Limited (FWHM=0".8)

Radius of circular S/N ref. area:
i.e. over which the S/N is calculated

Number of spectra on the detector:
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band: V

Seeing Limited (FWHM=0".8)
Ground-Layer AO
Laser-Tomography AO

(sky). $DLC = 1.22 \lambda/D$ is the radius of the diffraction limited PSF core for a D=42m telescope.

Results

<input checked="" type="radio"/> S/N ratio:	S/N = 10.000	DIT = 30.000 sec
<input checked="" type="radio"/> Exposure Time:	NDIT = 1	

The total exposure time is the product of DIT (Detector Integration Time) by NDIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

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Spectroscopic ETC

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Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

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Radius of circular S/N ref. area:
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3.3 (DLC in V) mas (on the sky). DLC=1.22 λ /D is the radius of the diffraction limited PSF core for a D=42m telescope.

Number of spectra on the detector:
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band:

Determines 'aperture loss' and number of sky photons

Determines RO noise and dark current

Results

S/N ratio:	S/N = 10.000	DIT = 30.000 sec
Exposure Time:	NDIT = 1	

The total exposure time is the product of DIT (Detector Integration Time) by NDIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

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Spectroscopic ETC

Some examples for choices of R_{ref} and N_{spec} :

- **IFU, point source:**
Choose $R_{\text{ref}} = \text{DLC}$ in the band you're observing in
 $N_{\text{spec}} = \text{number of spaxel in DLC (determined by choice of instrument)}$
- **IFU, extended source, S/N in a single spectrum:**
 $R_{\text{ref}} = \text{spaxel size}$
 $N_{\text{spec}} = 1$
- **IFU, extended source, total object S/N:**
 $R_{\text{ref}} = \text{size of object}$
 $N_{\text{spec}} = \text{number of spaxel in object (determined by choice of instrument)}$
- **CODEX, point source:**
 $R_{\text{ref}} = \text{size of entrance aperture (or something very large so that flux loss = small)}$
 $N_{\text{spec}} = 1$
- **Classical long-slit spectrograph, point source:**
 $R_{\text{ref}} = \text{such that EE is what you want}$
 $N_{\text{spec}} = \text{determined by pixel size in spatial direction}$

Spectroscopic ETC

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Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

AO Mode: Seeing Limited (FWHM=0".8)

Radius of circular S/N ref. area:
i.e. over which the S/N is calculated

Number of spectra on the detector:
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band:

3.3 (DLC in V) mas (on the sky). DLC=1.22 λ /D is the radius of the diffraction limited PSF core for a D=42m telescope.

2.2 (DLC in U)

2.6 (DLC in B)

3.3 (DLC in V)

4.2 (DLC in R)

5.0

5.4 (DLC in I)

7.5 (DLC in J)

9.9 (DLC in H)

10.0

13.0 (DLC in K)

15.0

20.0

21.0 (DLC in L)

29.0 (DLC in M)

50.0

63.0 (DLC in N)

100.0

120.0 (DLC in Q)

150.0

200.0

Results

S/N ratio: S/N = 10.00

Exposure Time: NDIT = 1

The total exposure time is the product of DIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

sec

On submission the model can generate the following graphs:
(input parameters are replicated in the output page)

Spectroscopic ETC

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Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

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i.e. over which the S/N is calculated

Number of spectra on the detector: 10.0
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band:

Results

S/N ratio: S/N = 10.00

Exposure Time: NDIT = 1

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Sky Conditions

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Instrument Setup

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i.e. over which the S/N is calculated

Number of spectra on the detector:
i.e. number of spatial elements (spaxel) in the S/N ref. area

Observation band:

Results

S/N ratio: S/N = 10.0

Exposure Time: NDIT = 1

DIT = 30.000 sec

The total exposure time is the product of DIT (Detector Integration Time) by NDIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

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Sky Conditions

Seeing: 0.8 arcsecs (FWHM in V band)

Airmass: 1.15 (ZD=30 deg)

Instrument Setup

AO Mode:

Radius of circular S...
i.e. over which the S/N is...

Number of spectra c...
i.e. number of spatial ele...
in the S/N ref. area

Observation band:

**Will be publicly available next week
(including documentation).**

Results

S/N ratio: S/N = 10.00

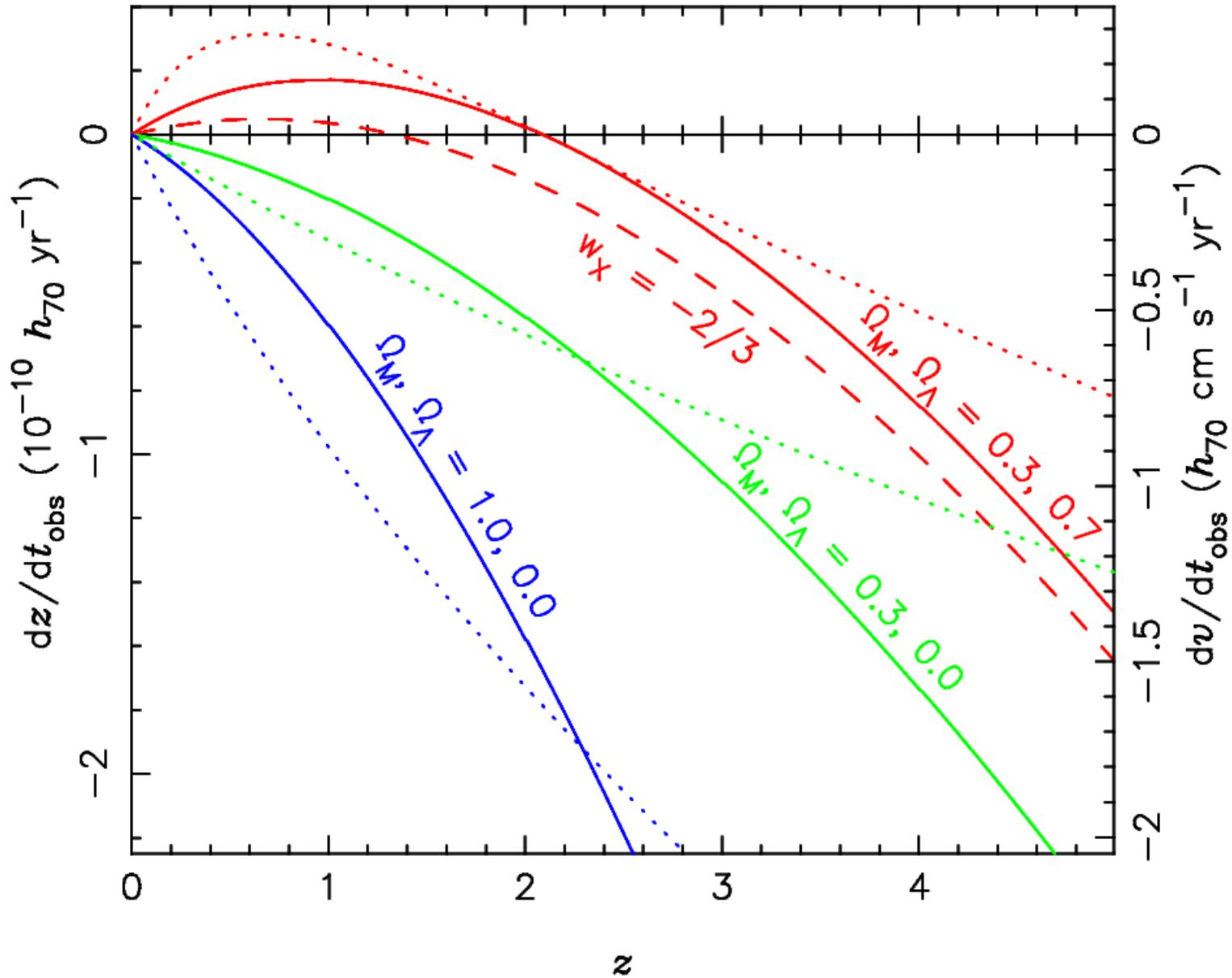
Exposure Time: NDIT = 1

DIT = 30.000 sec

The total exposure time is the product of DIT (Detector Integration Time) by NDIT (number of DITs). This exposure time does not take into account instrument and telescope overheads.

On submission the model can generate the following graphs:
(input parameters are replicated in the output page)

Cosmic Dynamics





DRM Goals

- Key issue: accuracy to which one can determine radial velocity shifts.
- In principle this depends only on the number of available spectral features, their shape and on the S/N at which they are recorded.
- In photon noise limit: S/N depends only on brightness of source(s), size of telescope, total efficiency, and integration time.
- Goal is to investigate this parameter space to clarify what can be achieved.
- Selected targets: high-z QSO absorption lines.

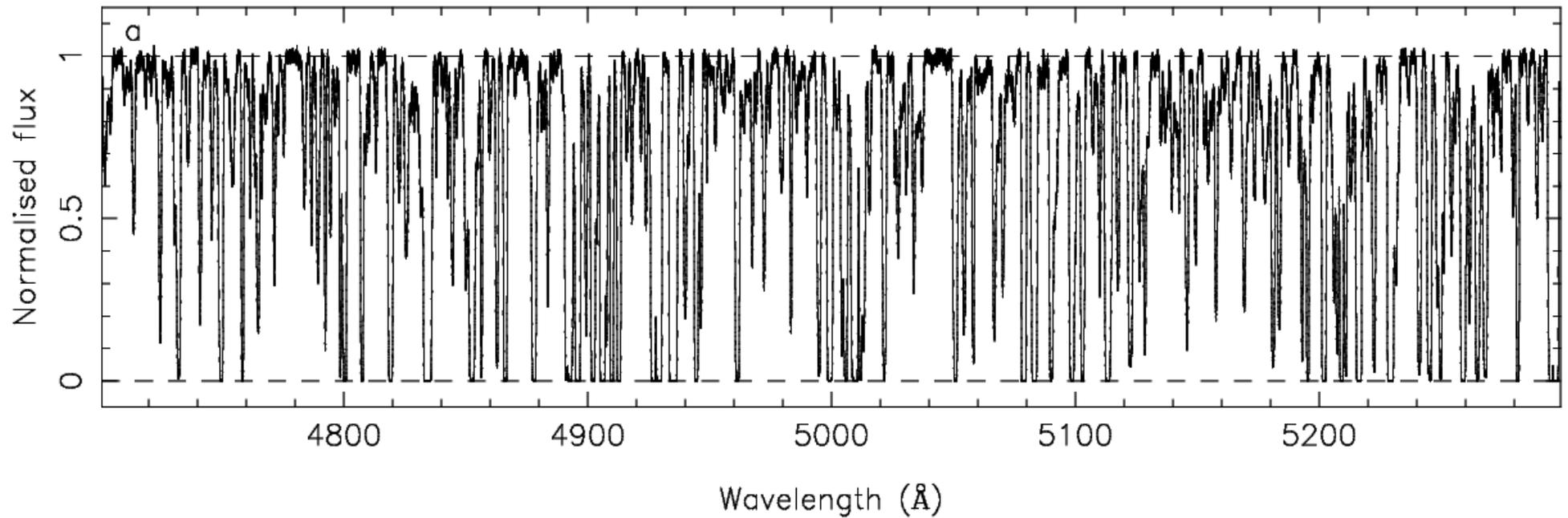


Ly α Forest Simulations

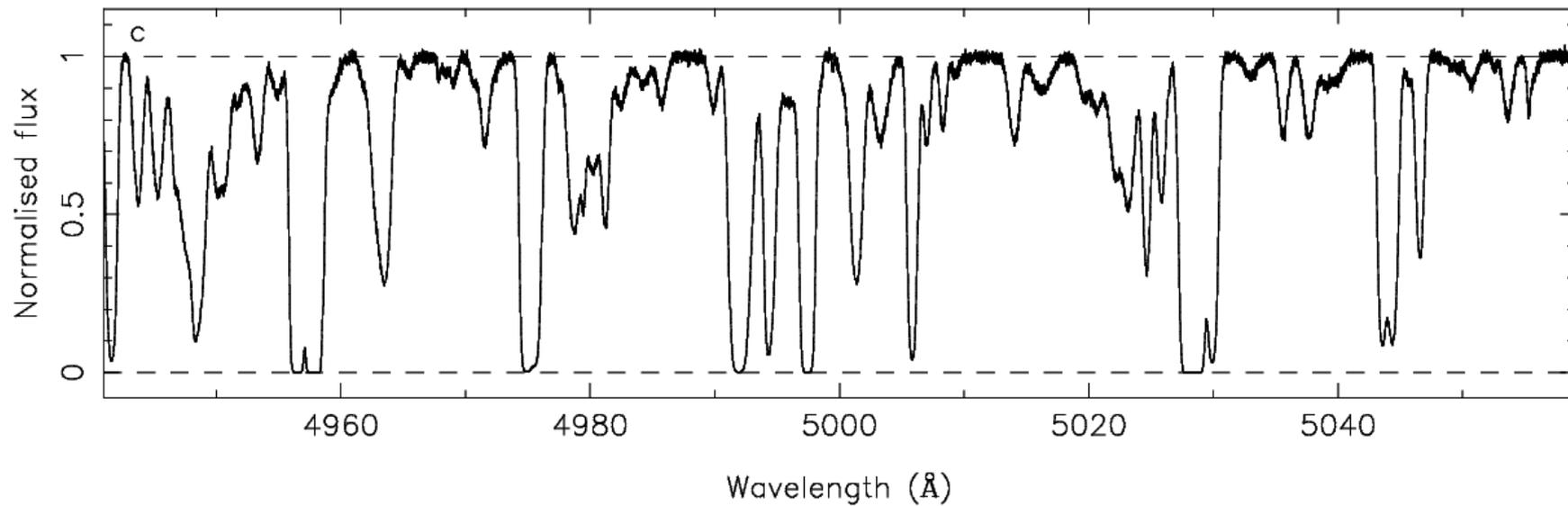
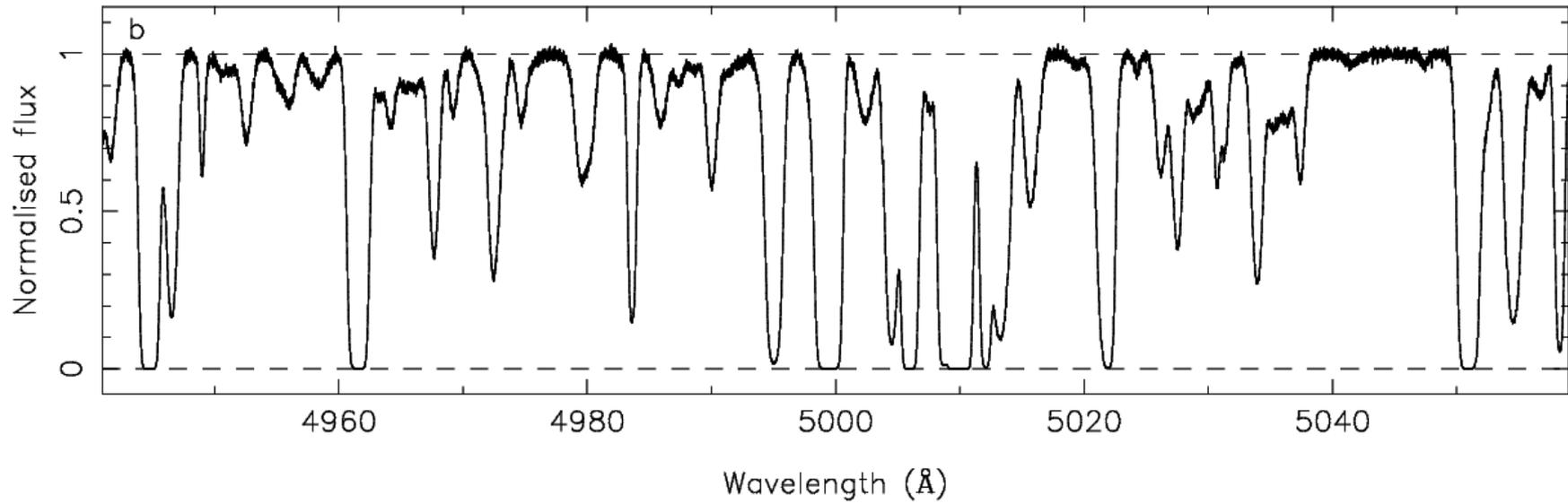
- In principle this depends only on the number of available spectral features, their shape and on the S/N at which they are recorded.
- Number of Ly α forest lines depends on redshift \rightarrow need a quantitative relation between the accuracy with which a velocity shift can be measured, and S/N and redshift \rightarrow simulations.
- Generate normalised Ly α forest spectra from lists of absorption lines (assumed to be Voigt profiles).
- I use Monte Carlo lists (line parameters randomly drawn from their known distributions) as well as real line lists derived from individual high-resolution spectra (from UVES and HIRES).



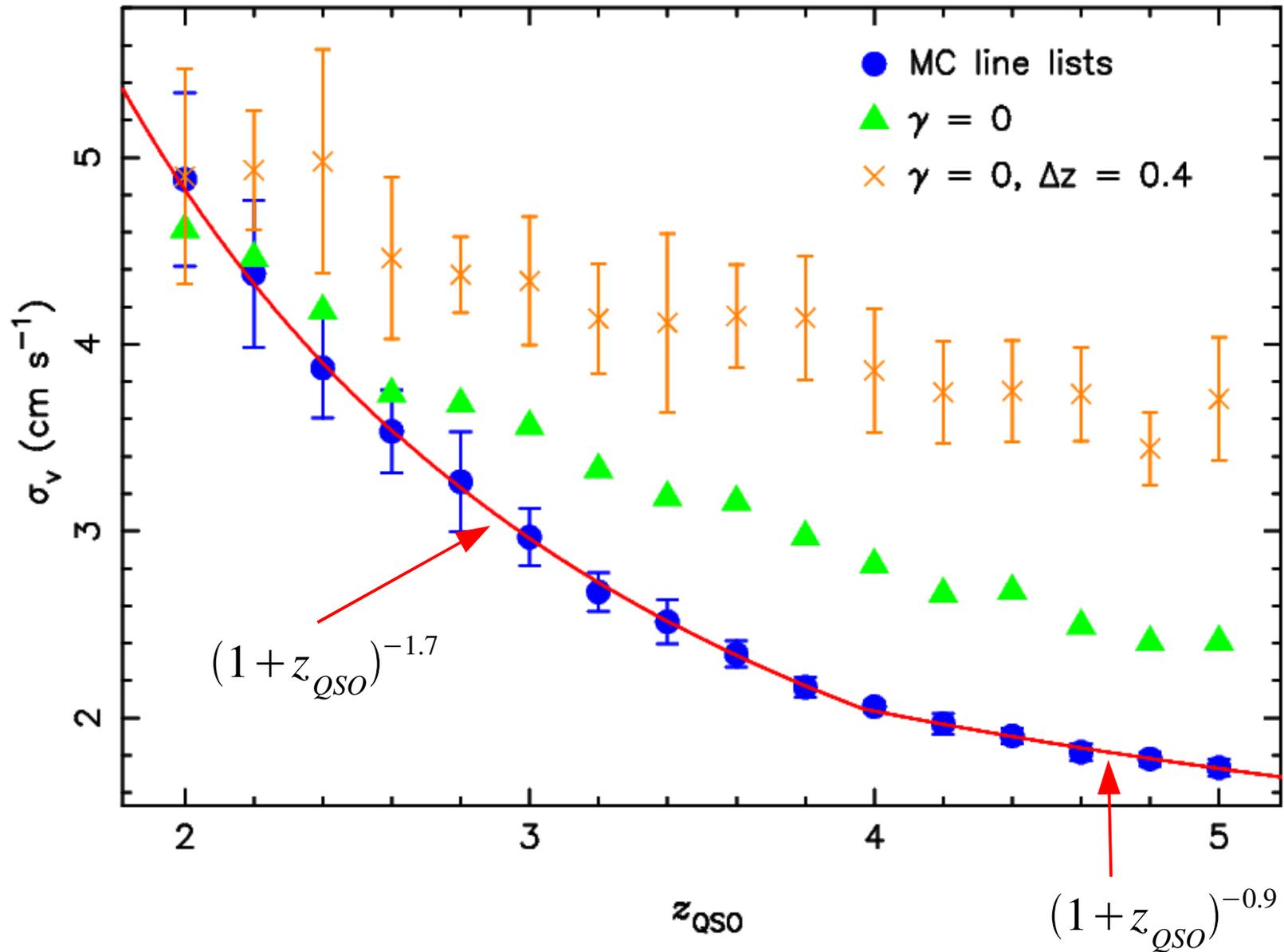
Ly α Forest Simulations



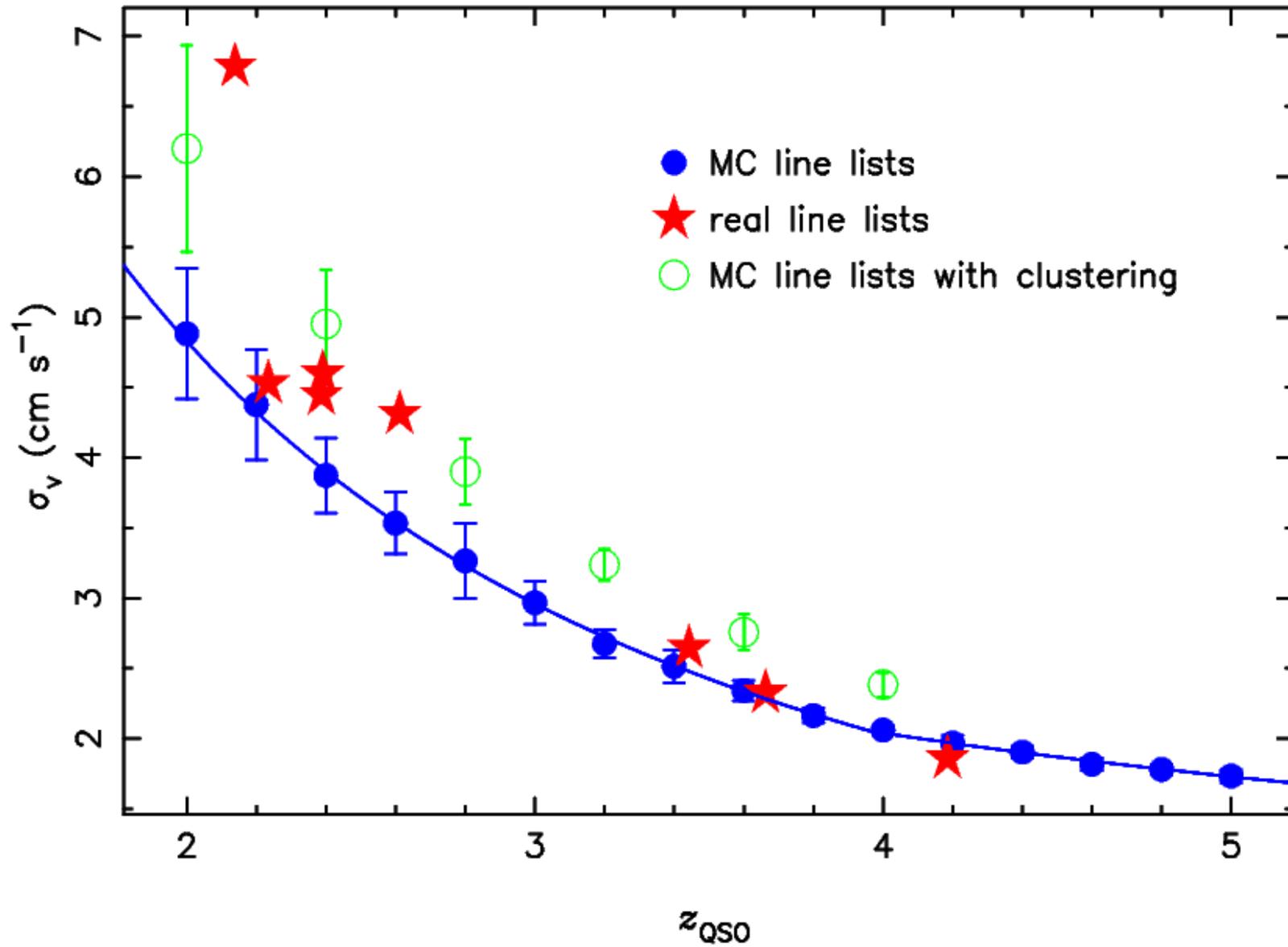
Ly α Forest Simulations



Simulation Results

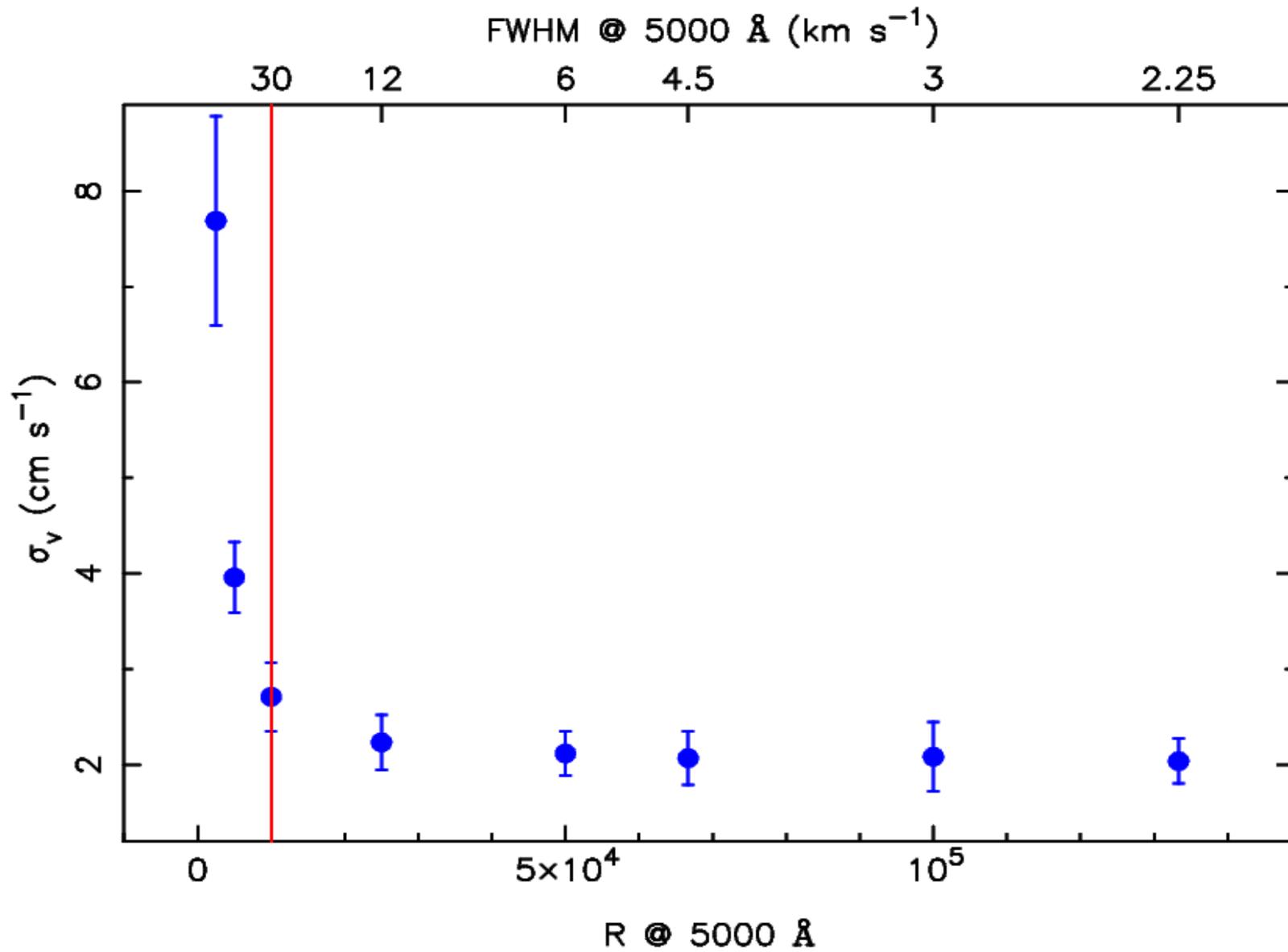


Simulation Results





Simulation Results





Simulation Results

$$\sigma_v = 1.35 \left(\frac{S/N}{3350} \right)^{-1} \left(\frac{N_{QSO}}{30} \right)^{-1/2} \left(\frac{1+z_{QSO}}{5} \right)^{-1.7} g(N_e) \text{ cm/s}$$

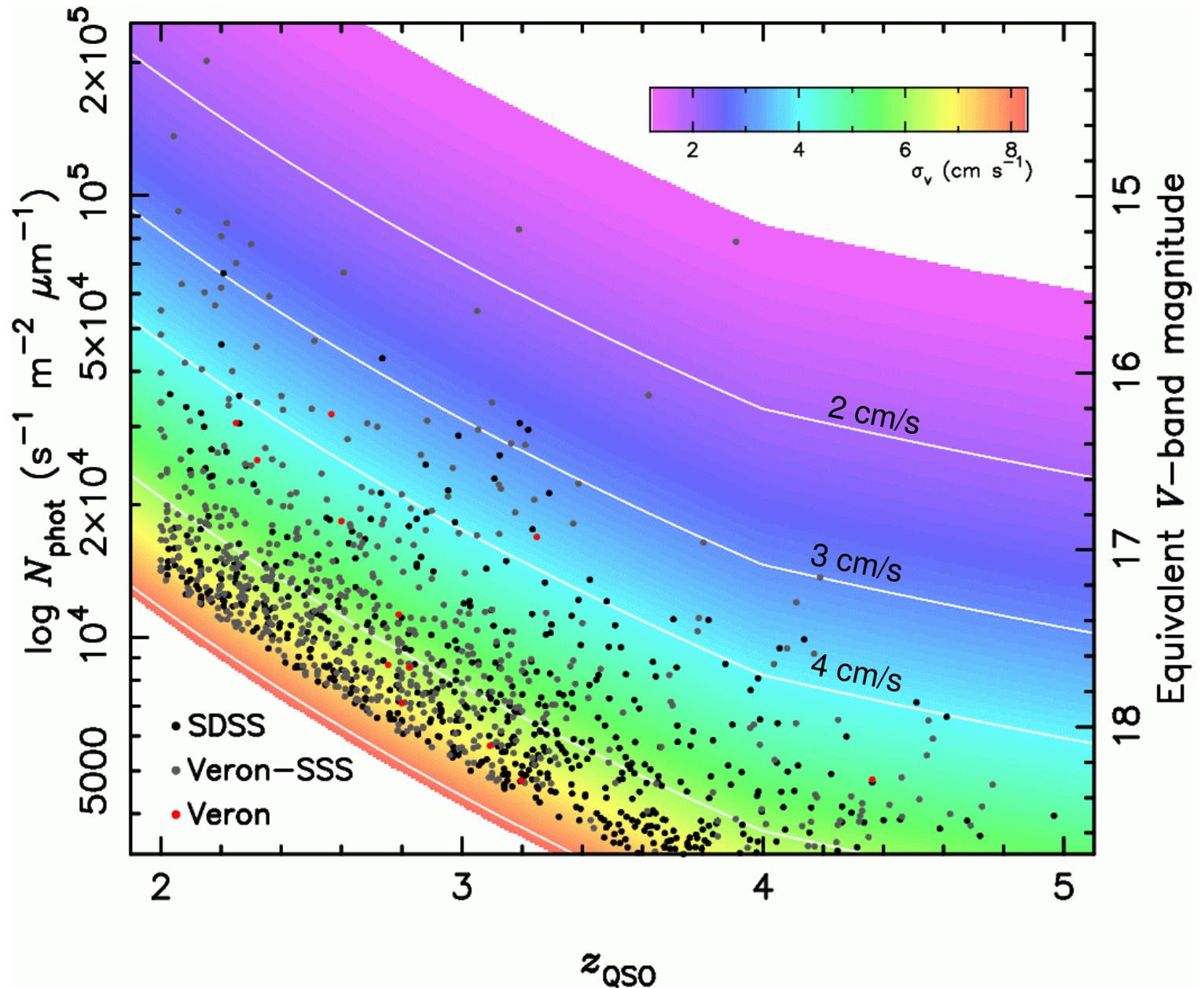
S/N = total, accumulated S/N per 0.0125 Å pixel per object

g = 'form factor', depends on the distribution of the observing time over the duration of the experiment $\approx 1.1 - 1.7$

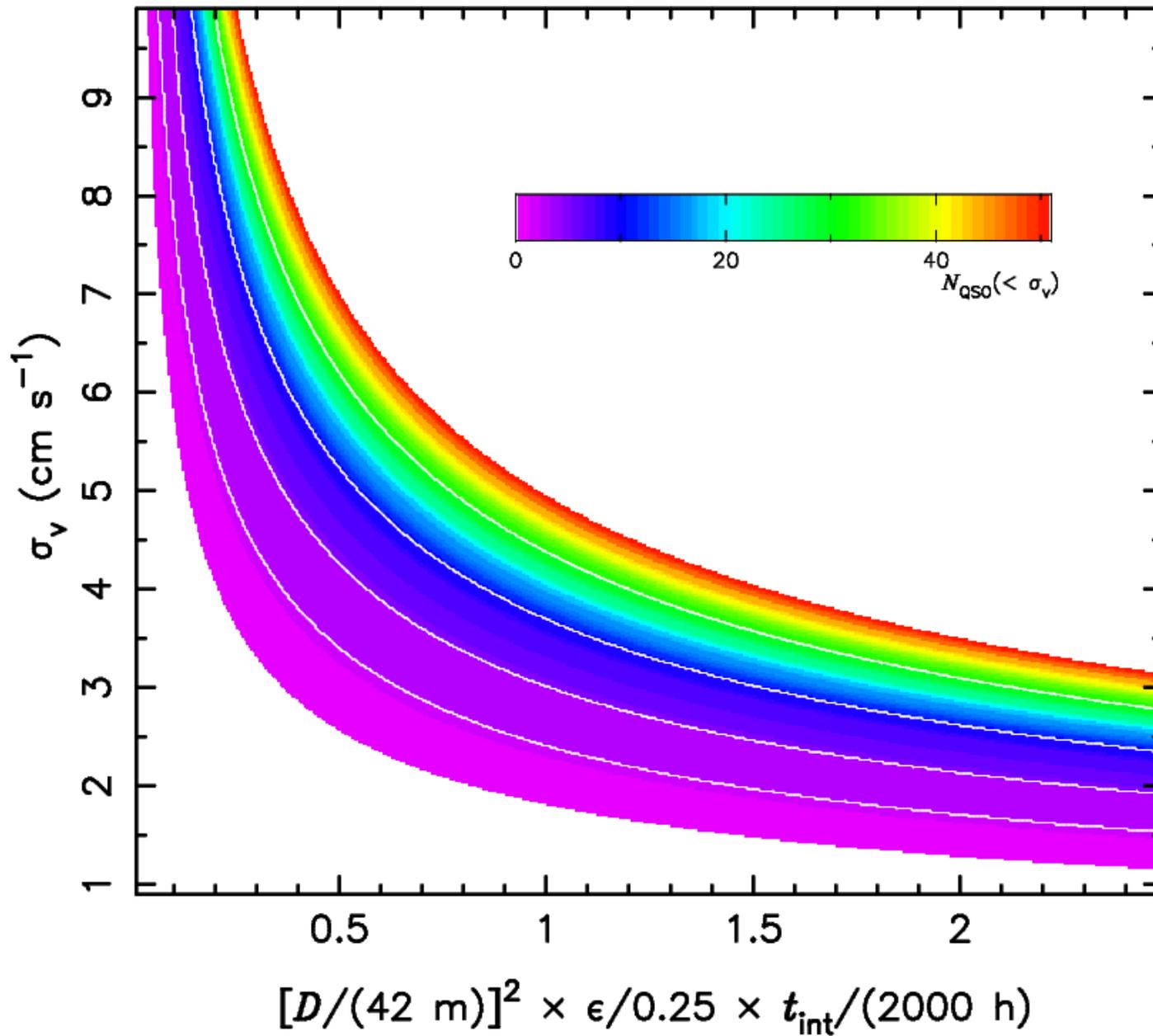
Are there enough photons?

$D = 42 \text{ m}$
 $\text{eff} = 25\%$
 $t_{\text{int}} = 4000 \text{ h}$

22 known QSOs
 with $2 < z < 5$ are
 bright enough to
 achieve 3 cm/s.



Are there enough photons?





Target Selection

- Target selection criterion depends on precise goal of the experiment.
- Possible goals:
 - Most precise measurement.
 - Most significant detection of redshift drift.
 - Best constraints on cosmological parameters.
- Also need to decide how many objects to include in the experiment and how to distribute the total available observing time among them.

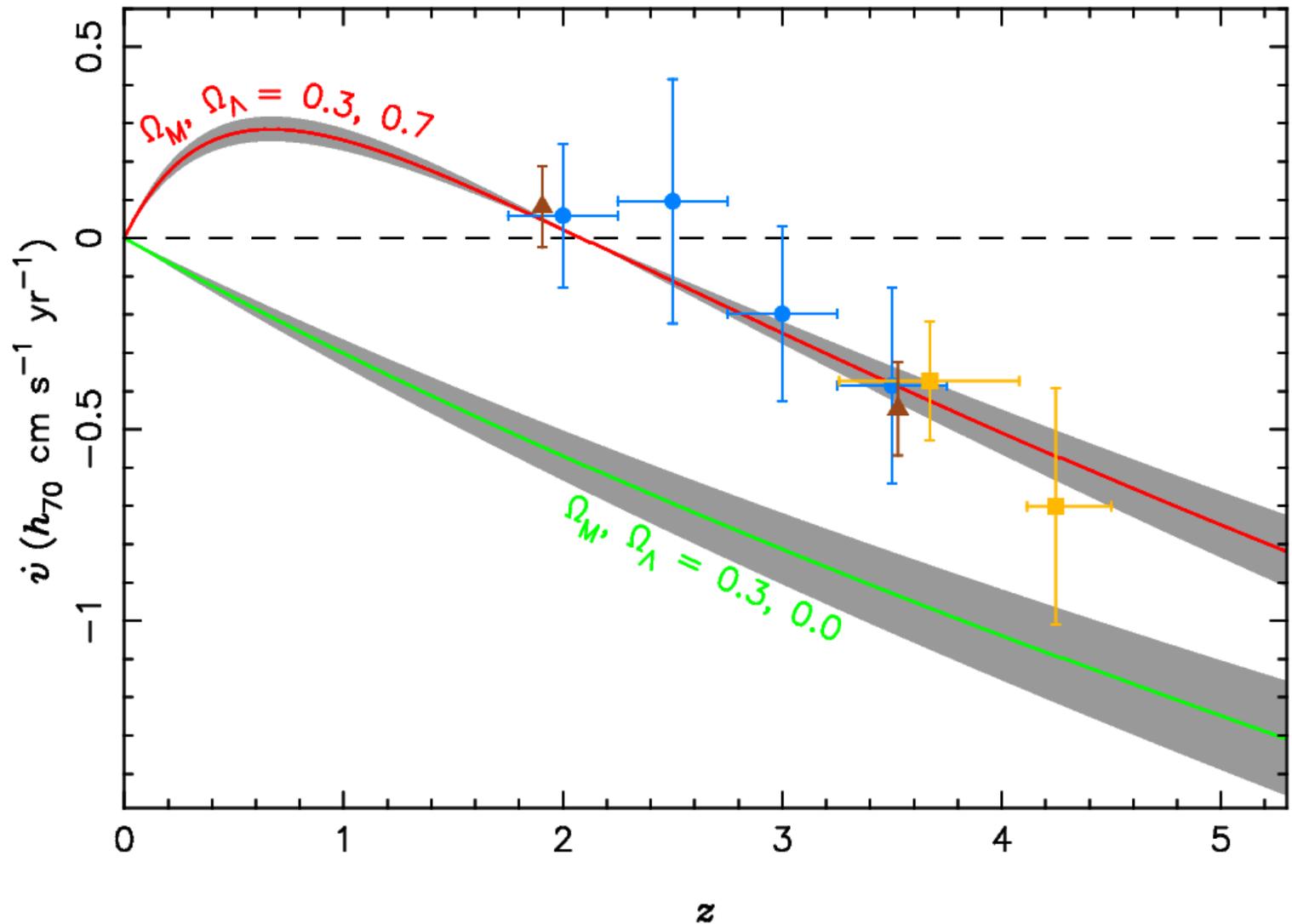
Simulated measurements

$D = 42 \text{ m}$
 $\text{eff} = 25\%$
 $t_{\text{int}} = 4000 \text{ h}$
 $\Delta t = 20 \text{ yr}$
 achieves any **one** of these sets of points.

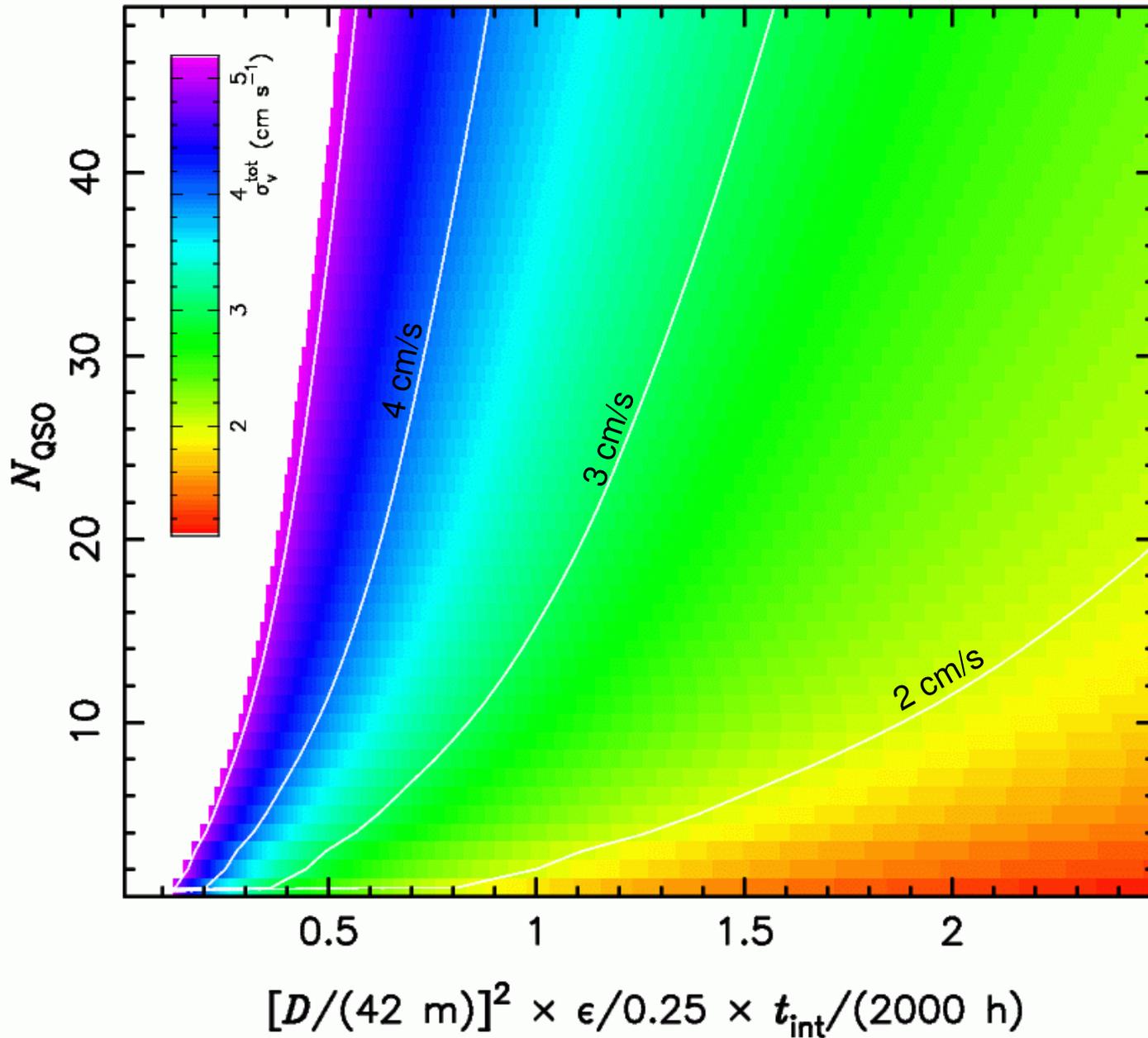
Blue: $N_{\text{QSO}} = 20$
 selection by σ_v

Yellow: $N_{\text{QSO}} = 10$
 selection by significance

Brown: $N_{\text{QSO}} = 2$
 selection by best constraint on Λ



Overall achievable accuracy

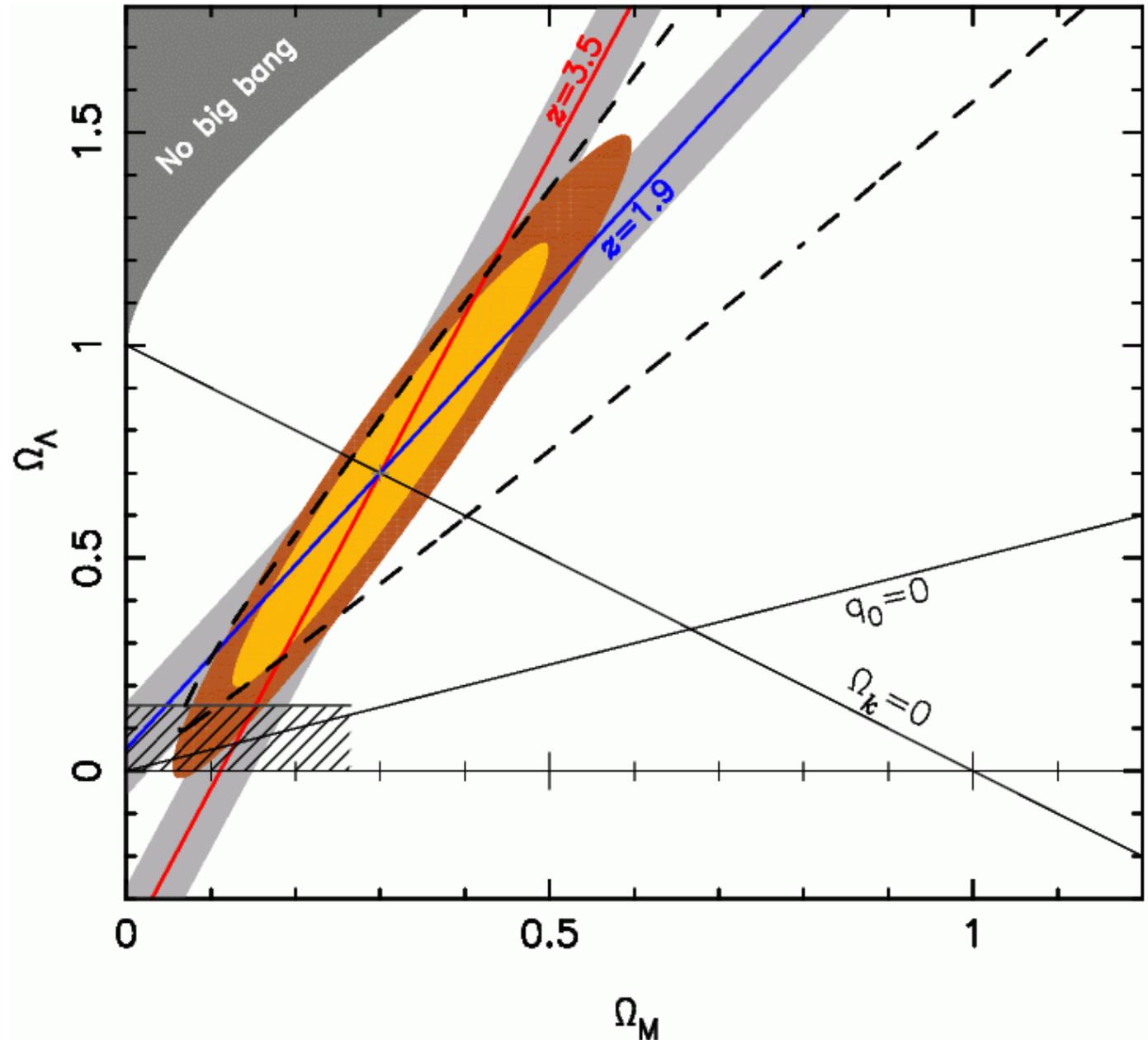


Cosmological Constraints

$D = 42 \text{ m}$
 $\text{eff} = 25\%$
 $t_{\text{int}} = 4000 \text{ h}$
 $\Delta t = 20 \text{ yr}$

$\Omega_{\Lambda} > 0.16$ at 2σ

Exclude $\Omega_{\Lambda} = 0$ at
98.2% confidence.



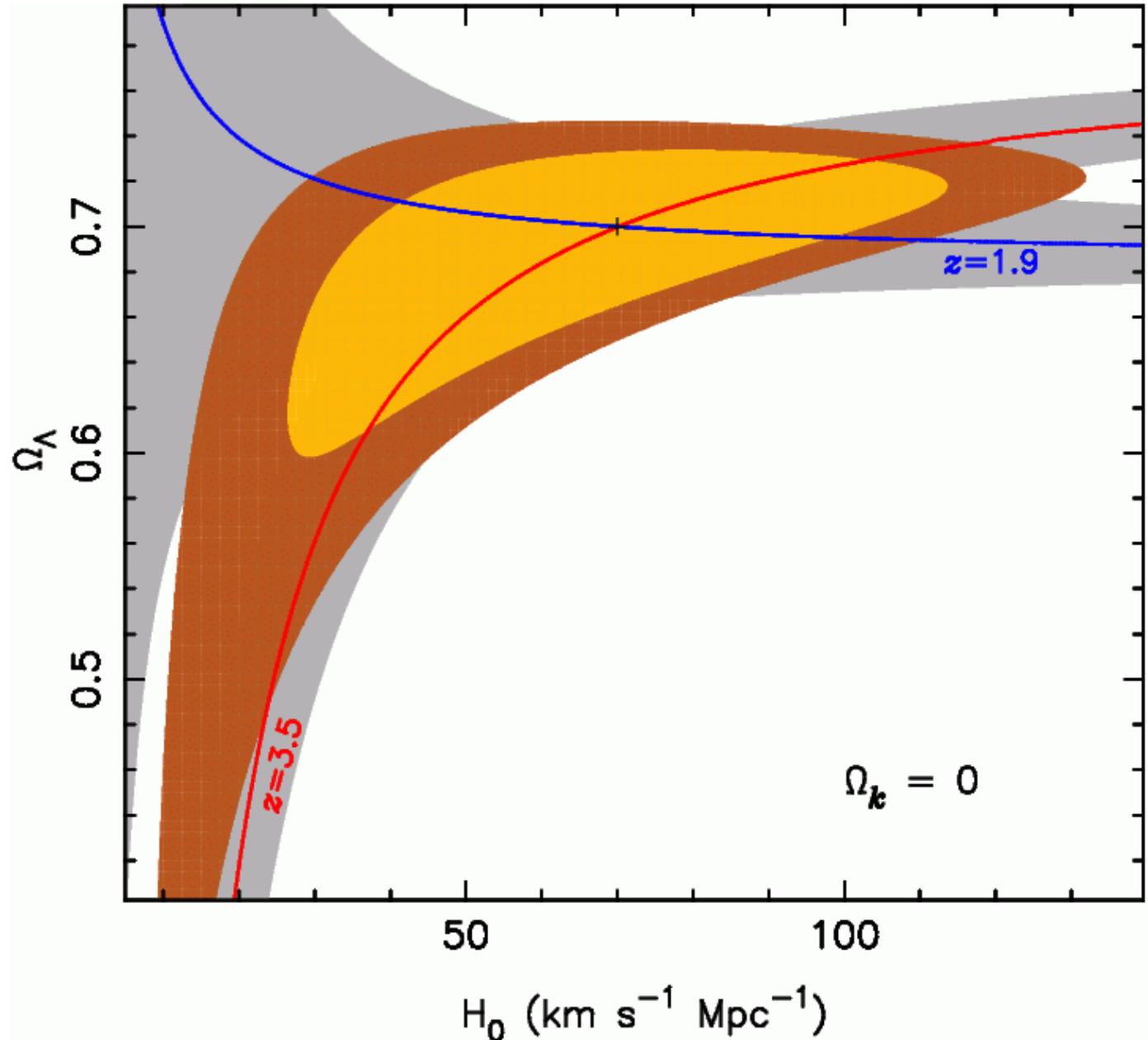
Cosmological Constraints

$D = 42 \text{ m}$
 $\text{eff} = 25\%$
 $t_{\text{int}} = 4000 \text{ h}$
 $\Delta t = 20 \text{ yr}$

Assuming flatness:

$0.42 < \Omega_{\Lambda} < 0.74$ at 2σ

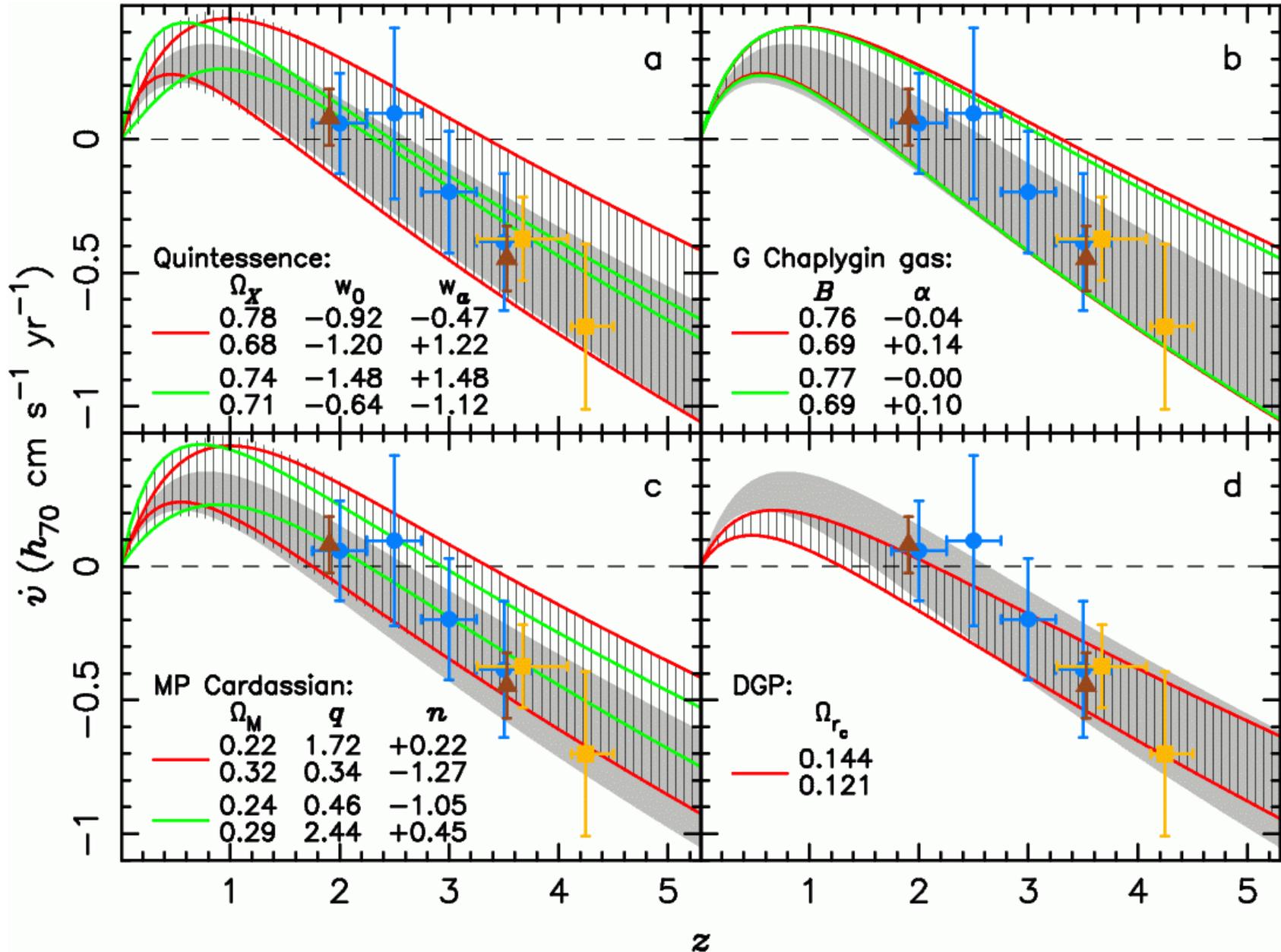
No useful constraint
on H_0



Constraints on alternative models

$D = 42 \text{ m}$
 $\text{eff} = 25\%$
 $t_{\text{int}} = 4000 \text{ h}$
 $\Delta t = 20 \text{ yr}$

Assuming
 flatness and
 a fixed H_0





Conclusions

- It is possible to unambiguously detect the redshift drift with a 42-m telescope in a ~ 20 yr long experiment using ~ 4000 h.
- Moreover, it is possible to unambiguously detect the acceleration and hence to independently confirm the need for dark energy.
- Most alternative cosmological models have too many free parameters, but redshift drift measurements definitely help.
- Signal extraction method is not yet optimal. σ_v only measures the accuracy to which an overall shift can be determined but ignores changes in the shape of the spectrum. Requires further work.



Requirements

- Photons, photons, photons.
 - $D > 40$ m
 - $\text{eff} > 20\%$
includes telescope, aperture losses, instrument, detector
- Photon noise must dominate.
 - Random errors from wavelength calibration, bias, flat-fielding, scattered light, etc, must not exceed photon noise.
- Systematics must be limited to < 1 cm/s.
 - Additional error from long-term systematic drifts in wavelength calibration, flat-fielding, bias, flat-fielding, scattered light must not exceed photon-noise limit.
 - Details depend on signal extraction method.