E-ELT

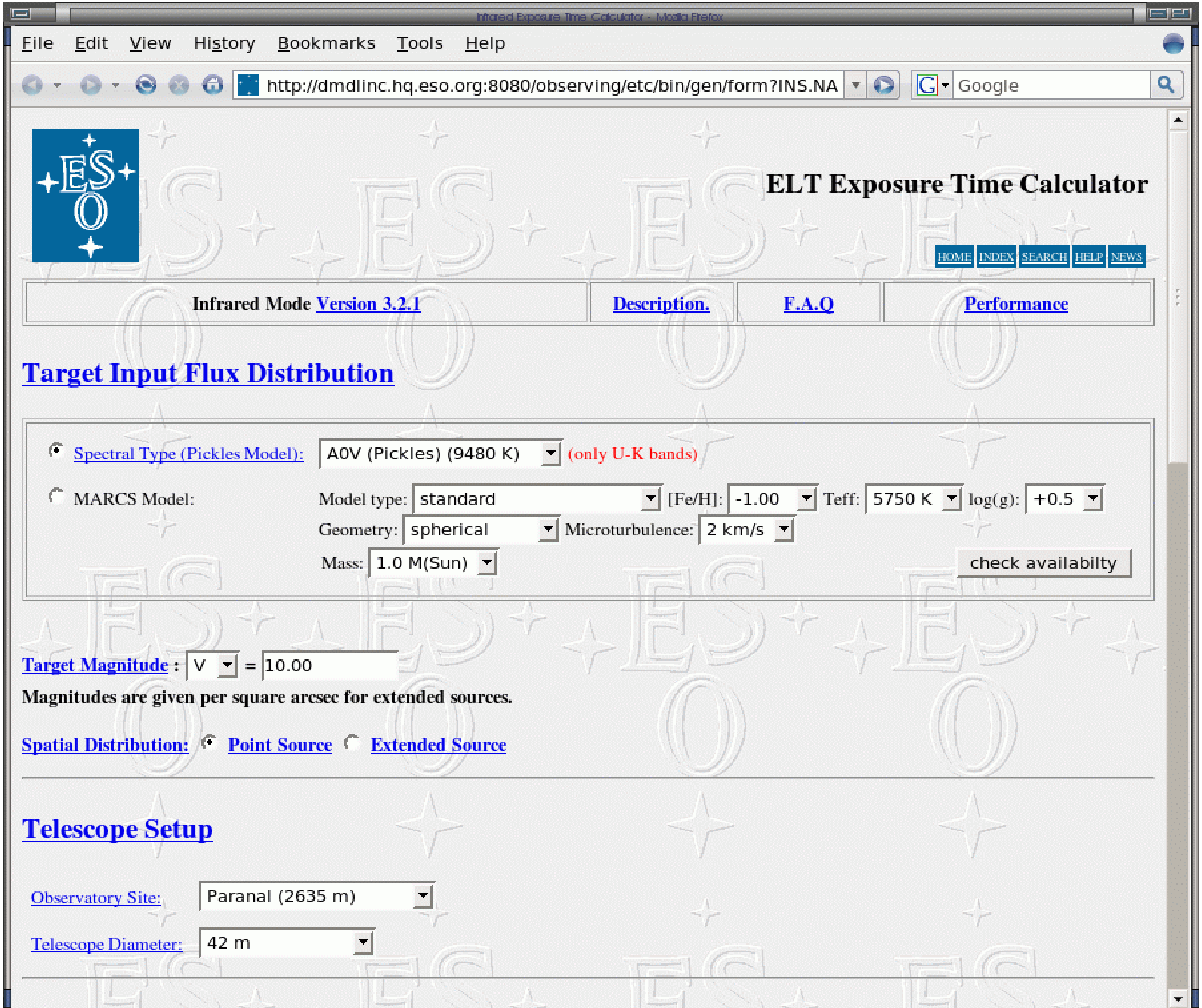
DRM Update

Joe Liske

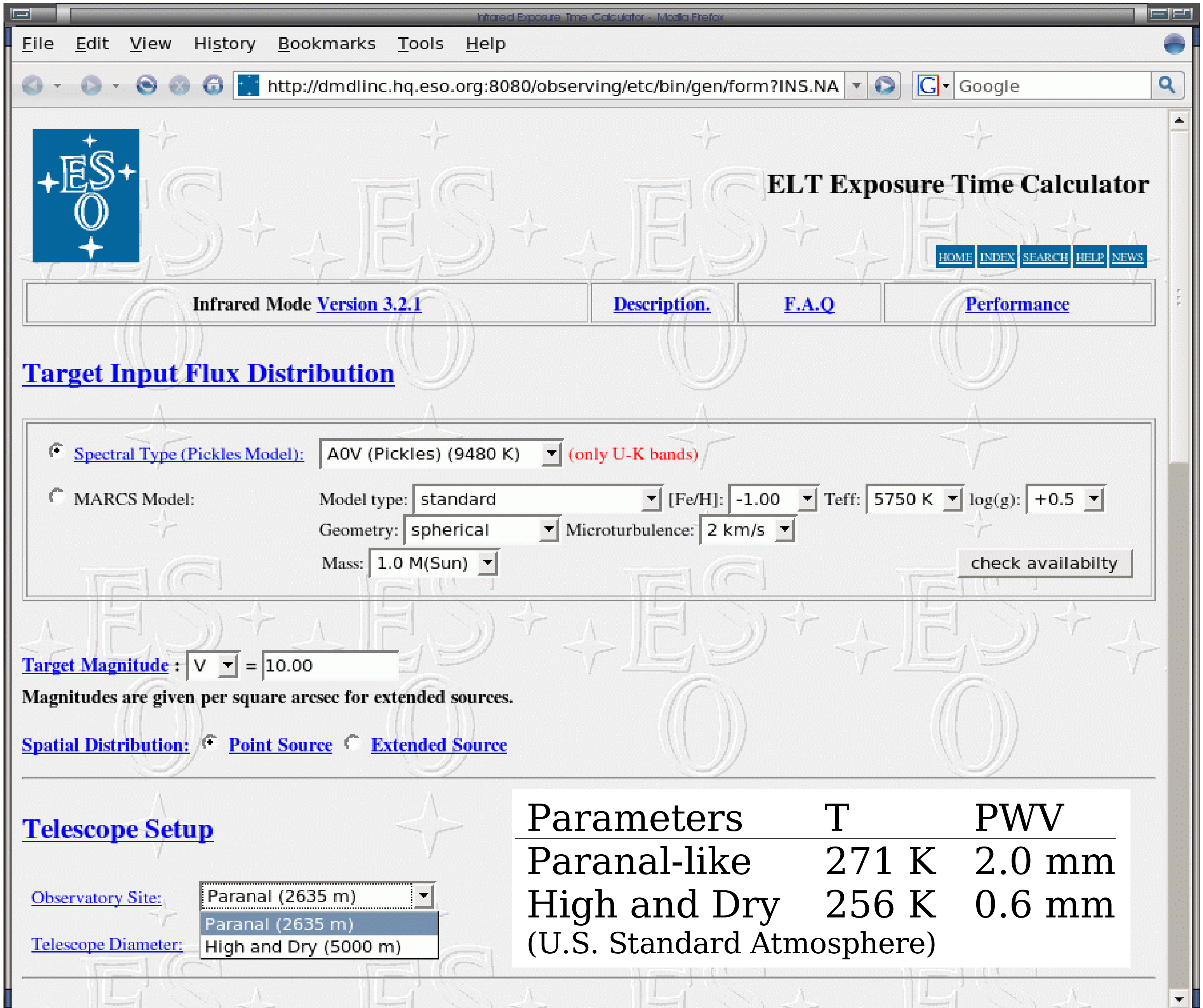
ESO

E-ELT

Spectroscopic ETC



Spectroscopic ETC



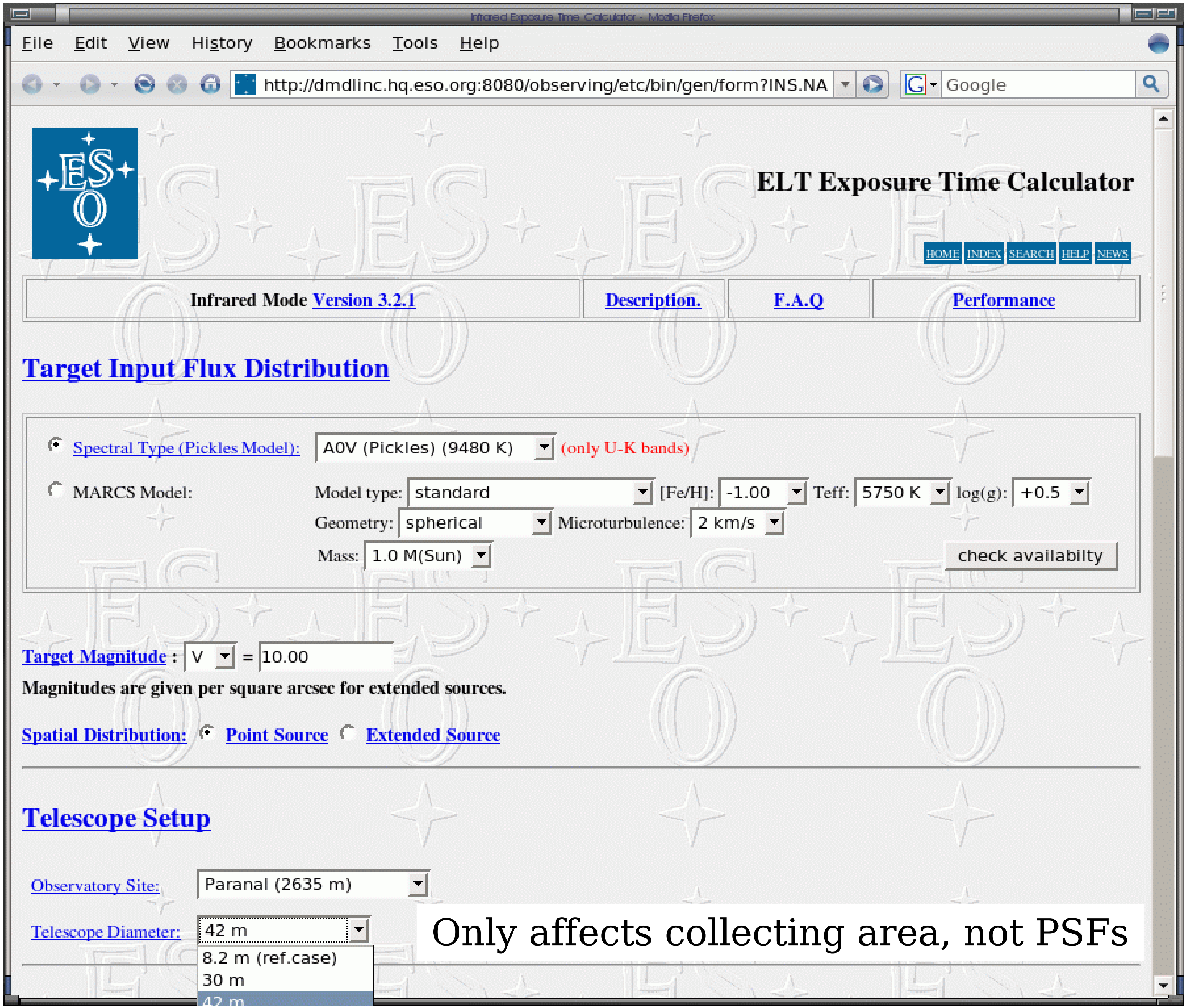
Parameters	T	PWV
Paranal-like	271 K	2.0 mm
High and Dry	256 K	0.6 mm
(U.S. Standard Atmosphere)		

Spectroscopic ETC

- Background = continuum + OH lines + (1-tr) • BB(T_{atm}) + ε_{Tel} • BB(T_{Tel})
- Continuum in NIR???
  Cuby, Lidman & Moutou, 2000, Messenger, 101, 2:
  J: 1200 photons/s/m^2/μm/$arcsec^2$ = 18.0 mag/$arcsec^2$
  H: 2300 = 16.5 mag/$arcsec^2$

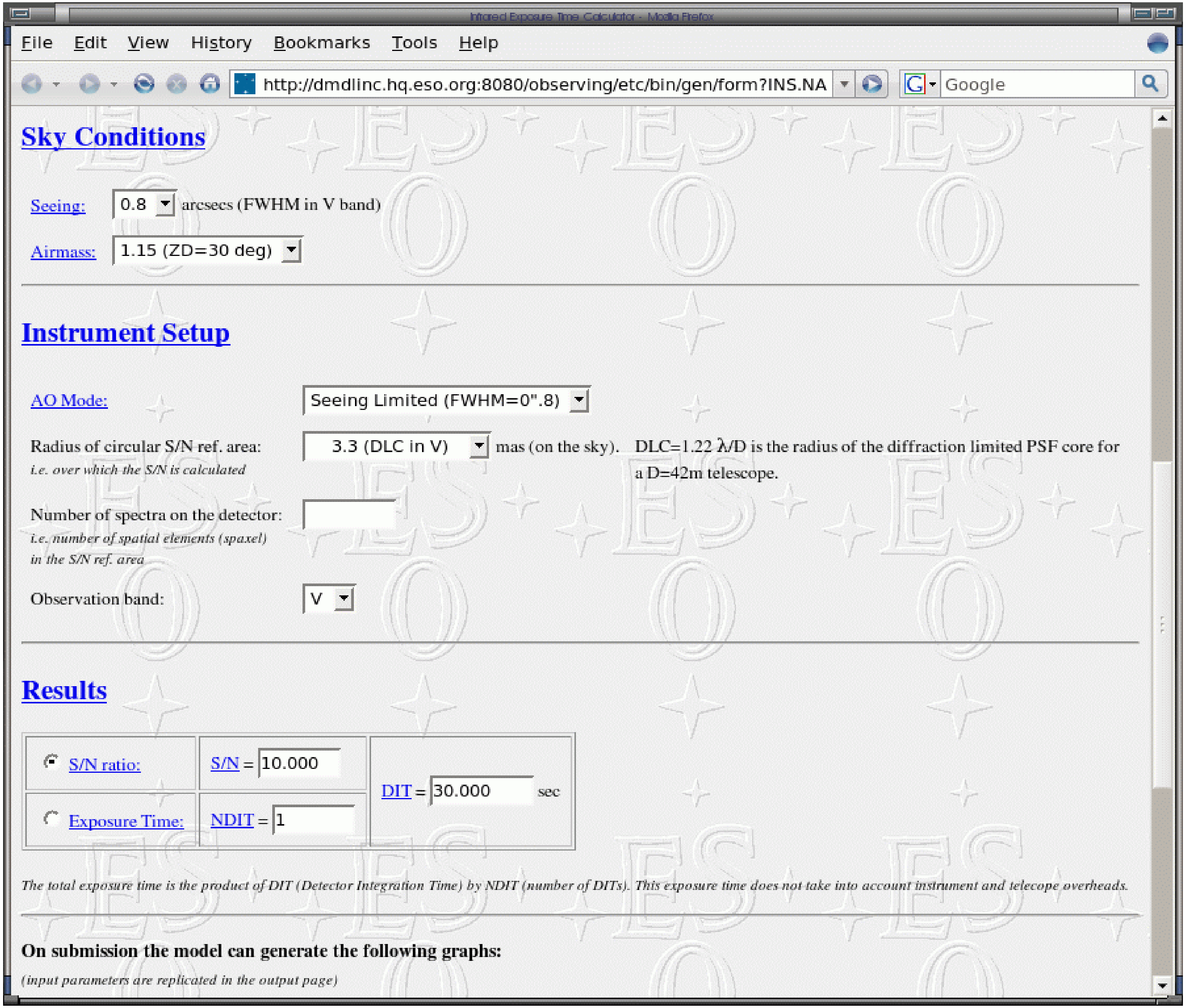
  Gemini ETC: continuum = zodiacal light = tr • BB(T=5800 K)
- Atmospheric transmission = tr(T_{atm}, PWV, ZD)
  from HITRAN, provided by A. Smette

Spectroscopic ETC

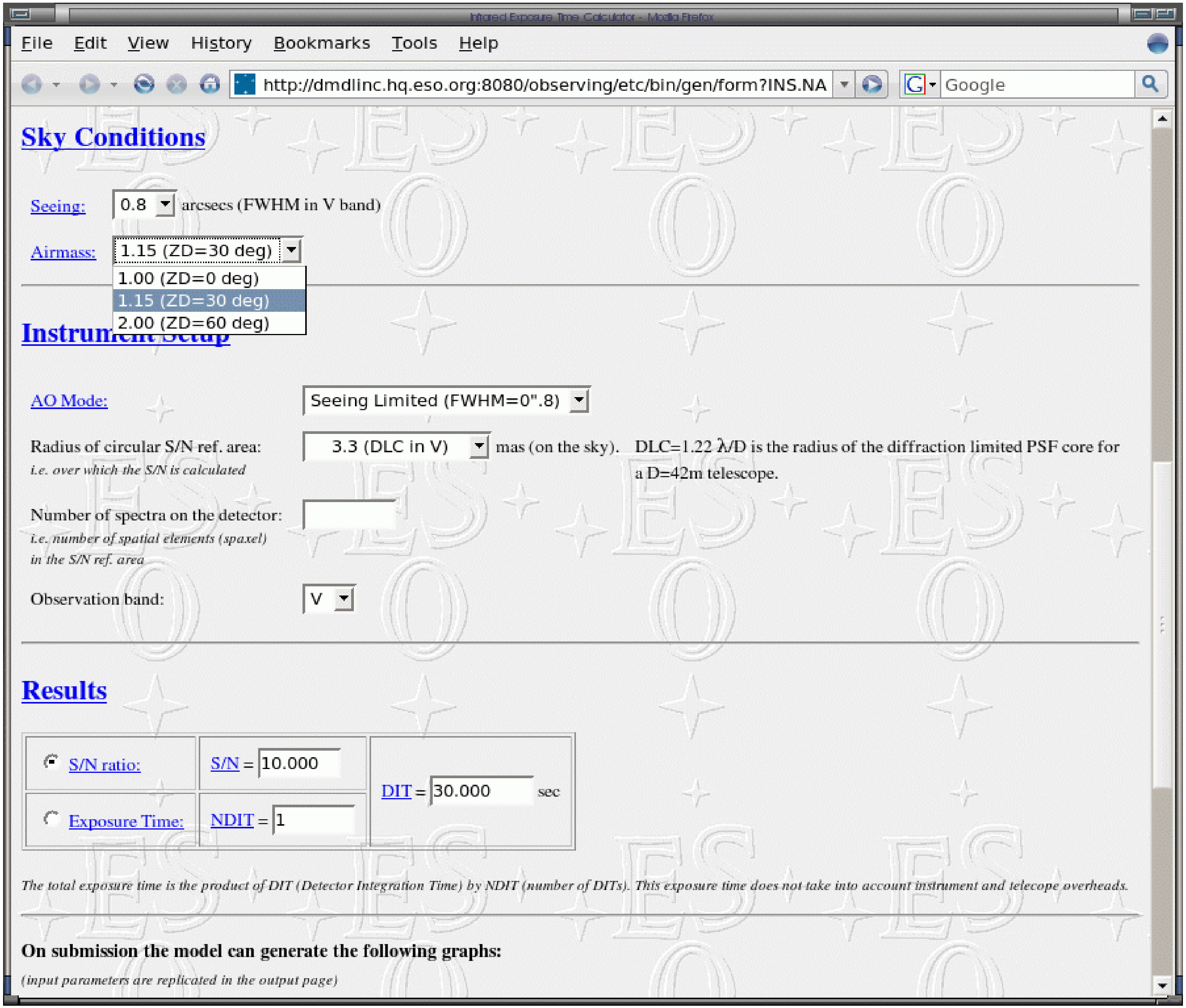


Only affects collecting area, not PSFs

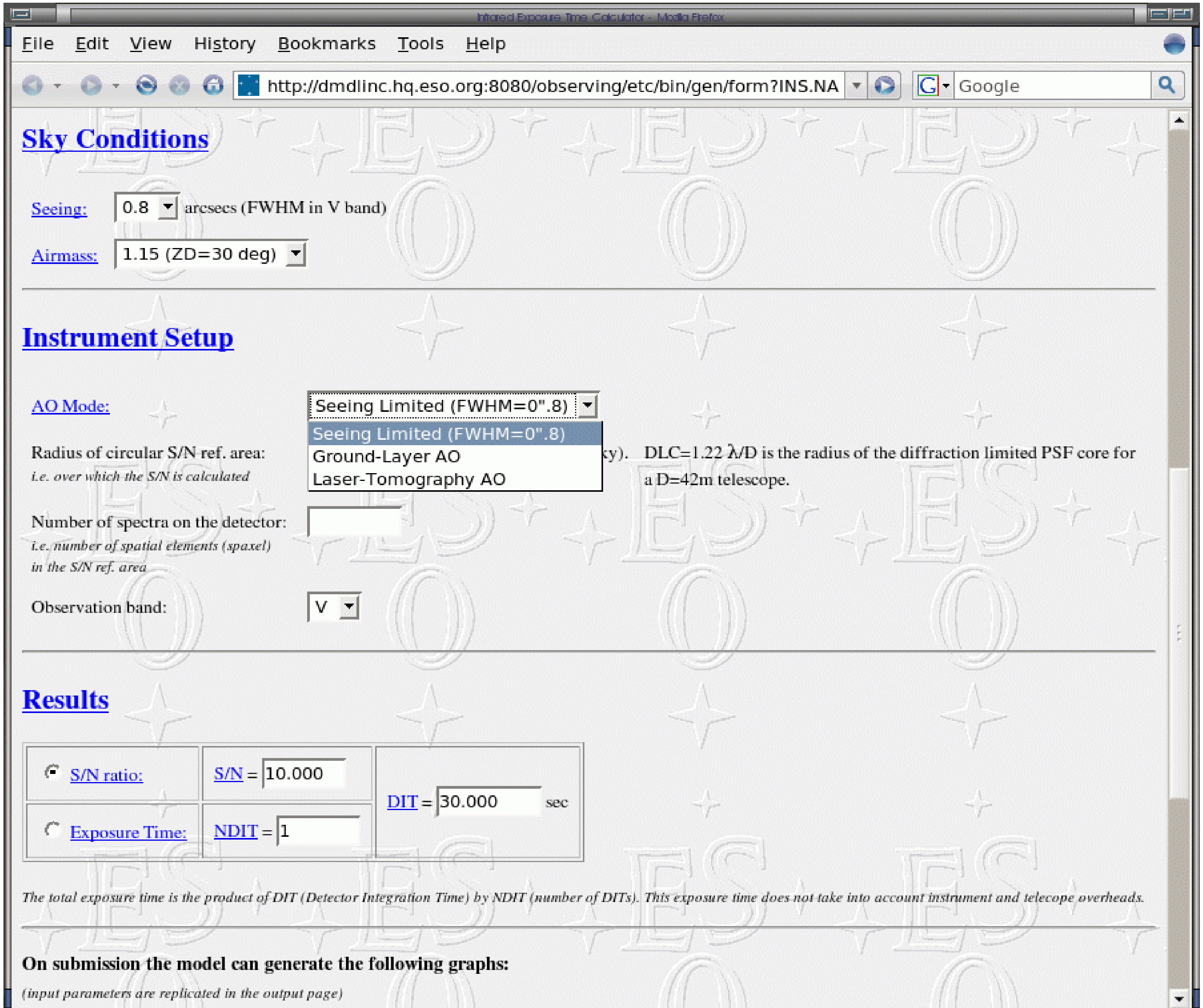
Spectroscopic ETC



Spectroscopic ETC

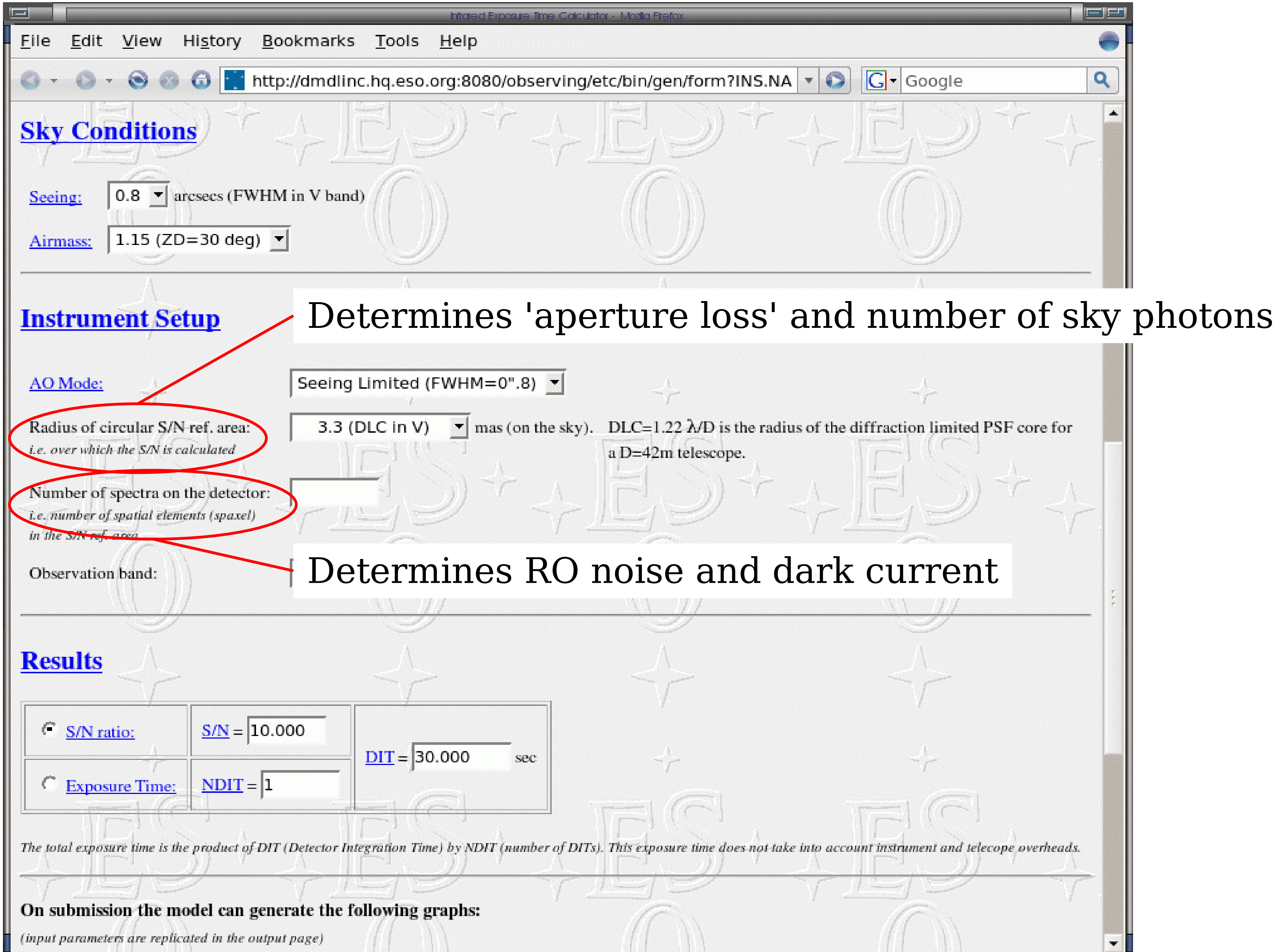


Spectroscopic ETC



E-ELT

Spectroscopic ETC



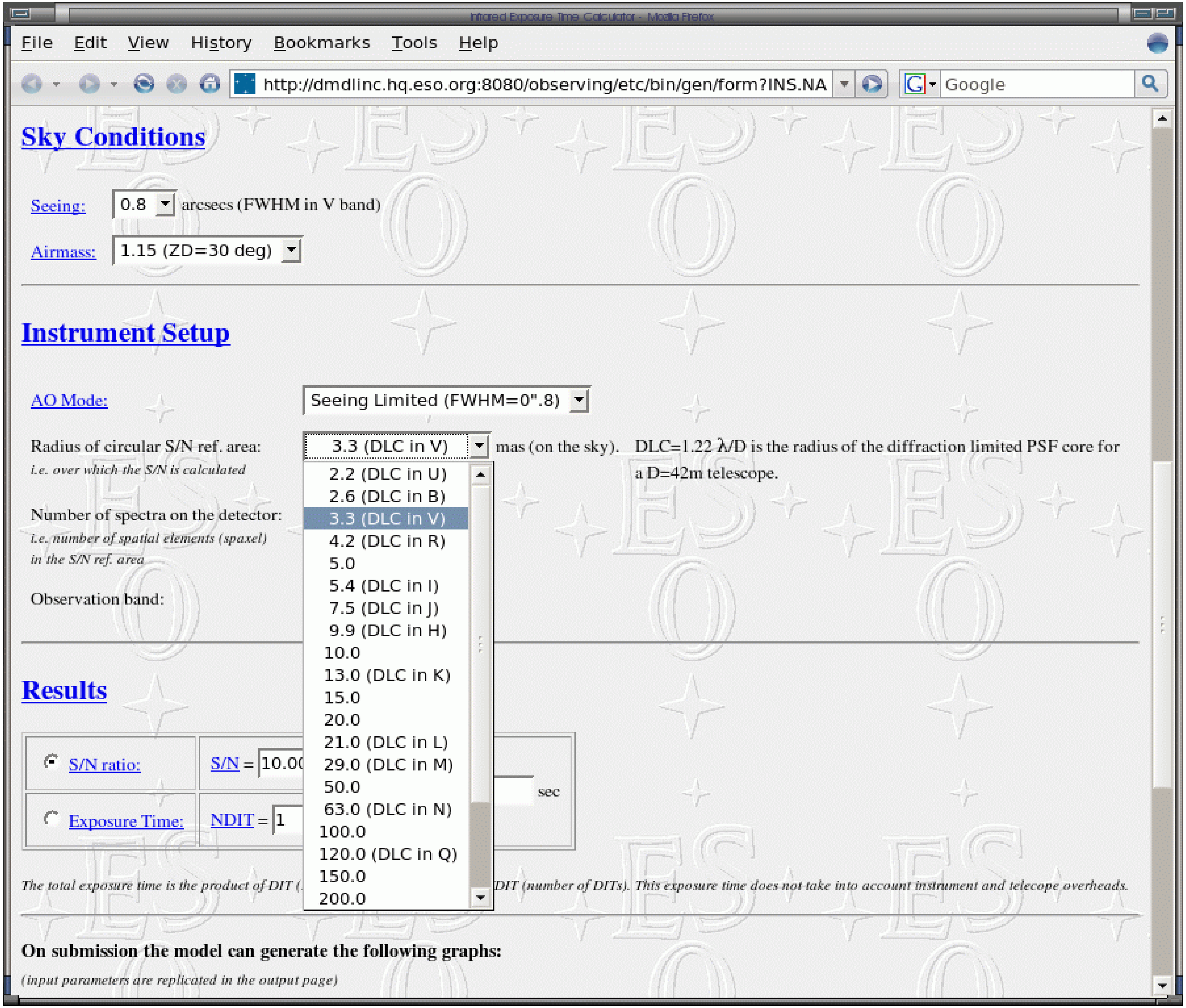
Spectroscopic ETC

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

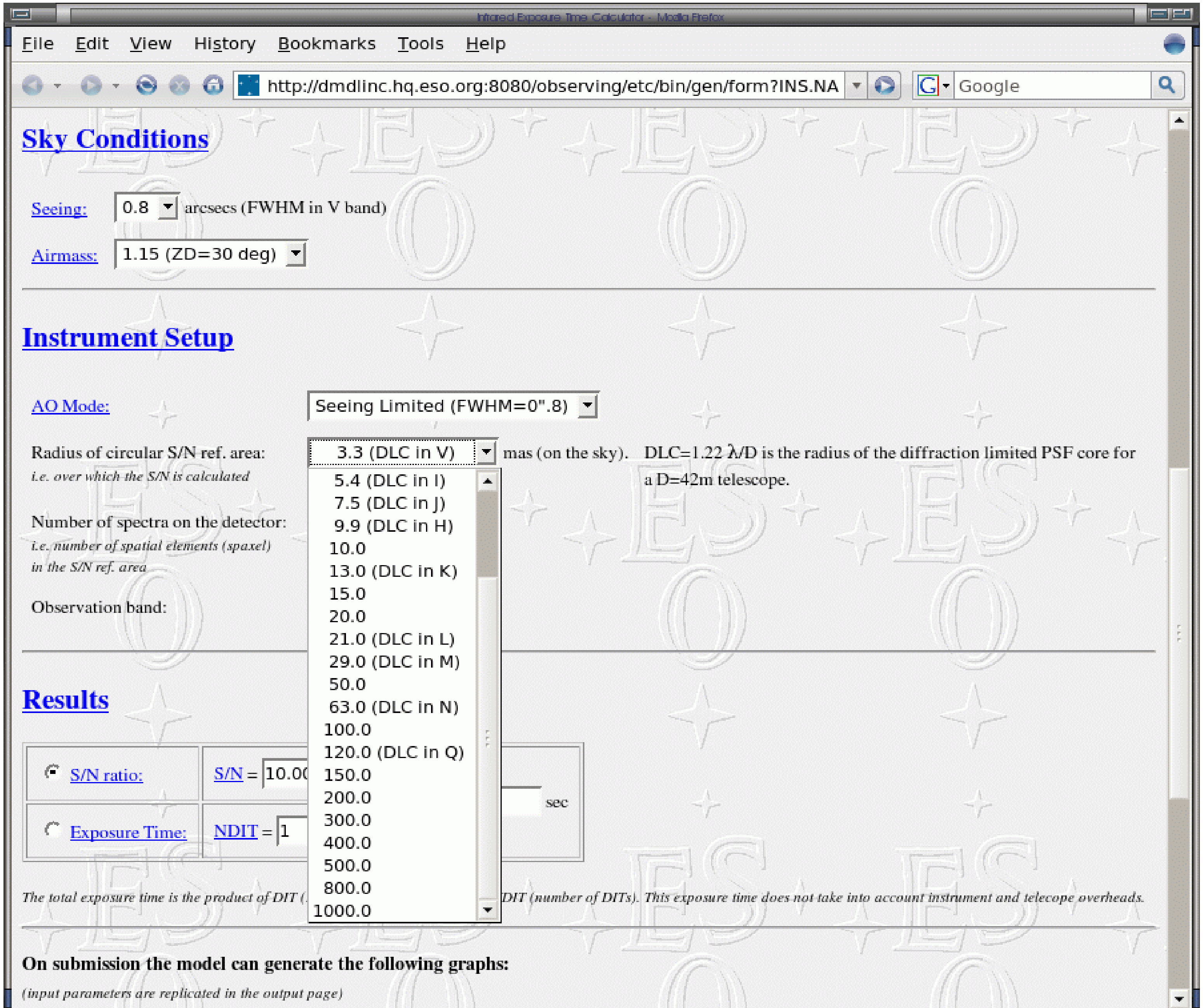
- IFU, point source:
  Choose R_{ref} = DLC in the band you're observing in
  N_{spec} = number of spaxel in DLC (determined by choice of instrument)
- IFU, extended source, S/N in a single spectrum:
  R_{ref} = spaxel size
  N_{spec} = 1
- IFU, extended source, total object S/N:
  R_{ref} = size of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

E-ELT

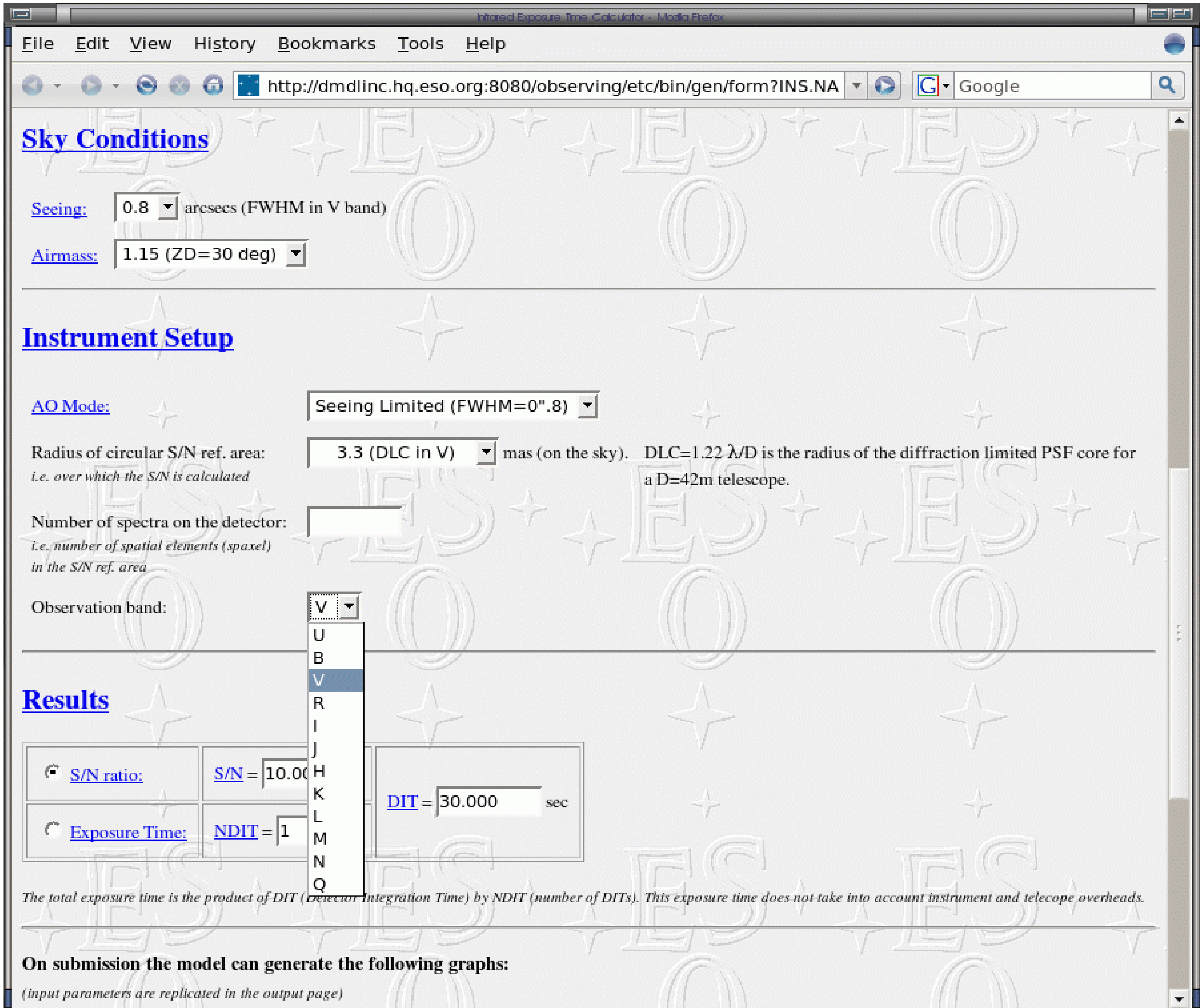
Spectroscopic ETC



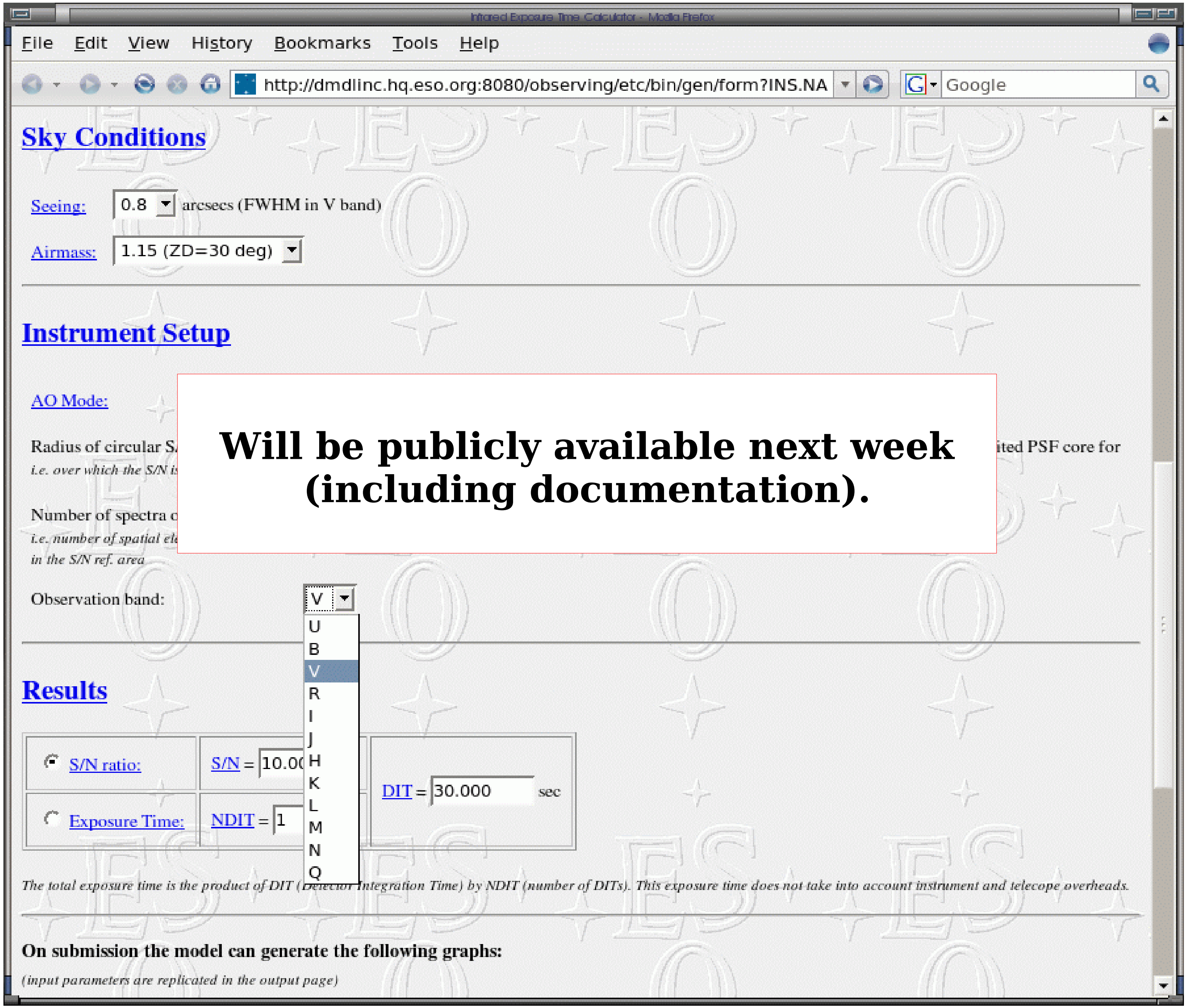
Spectroscopic ETC



Spectroscopic ETC

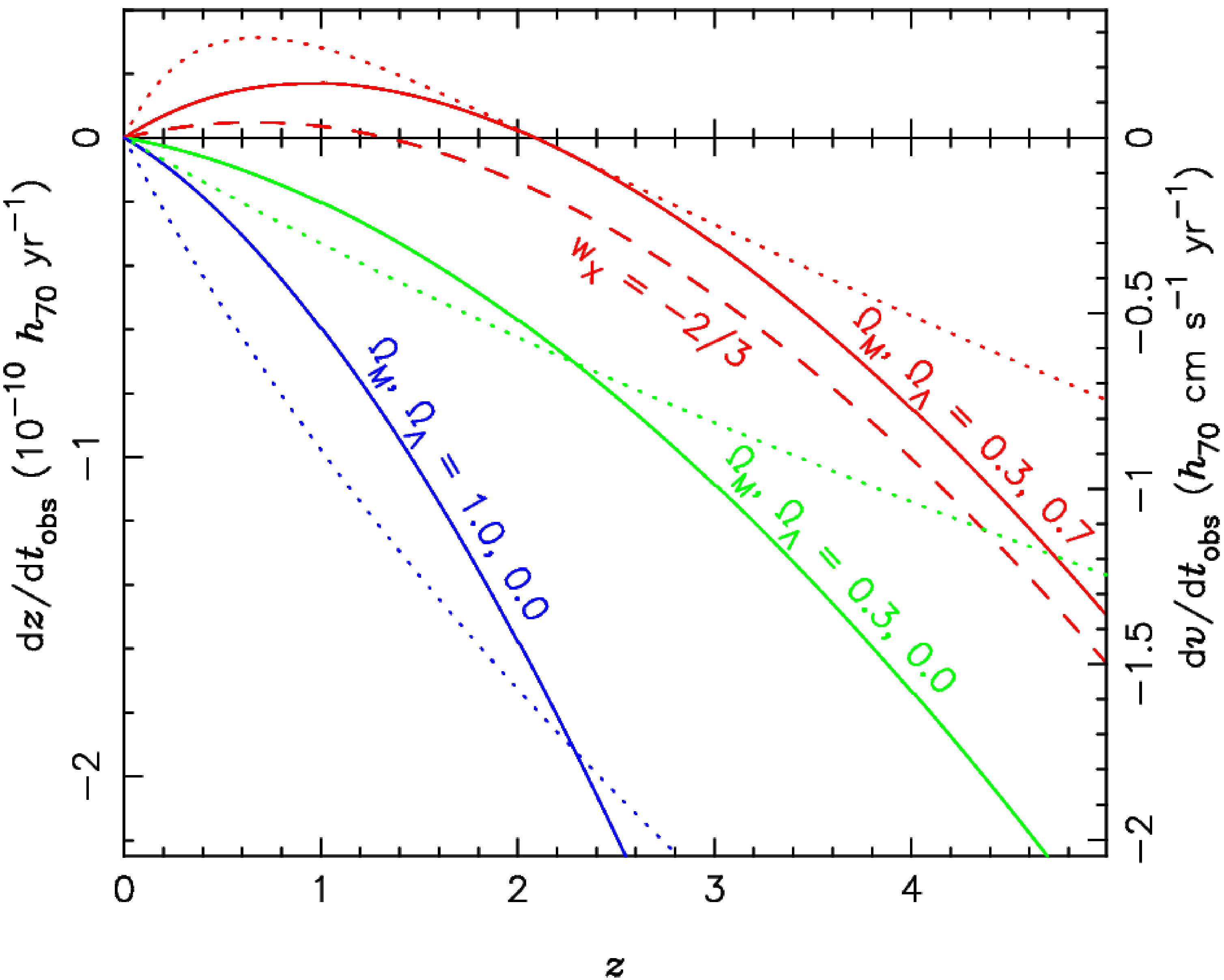


Spectroscopic ETC



Will be publicly available next week (including documentation).

Cosmic Dynamics



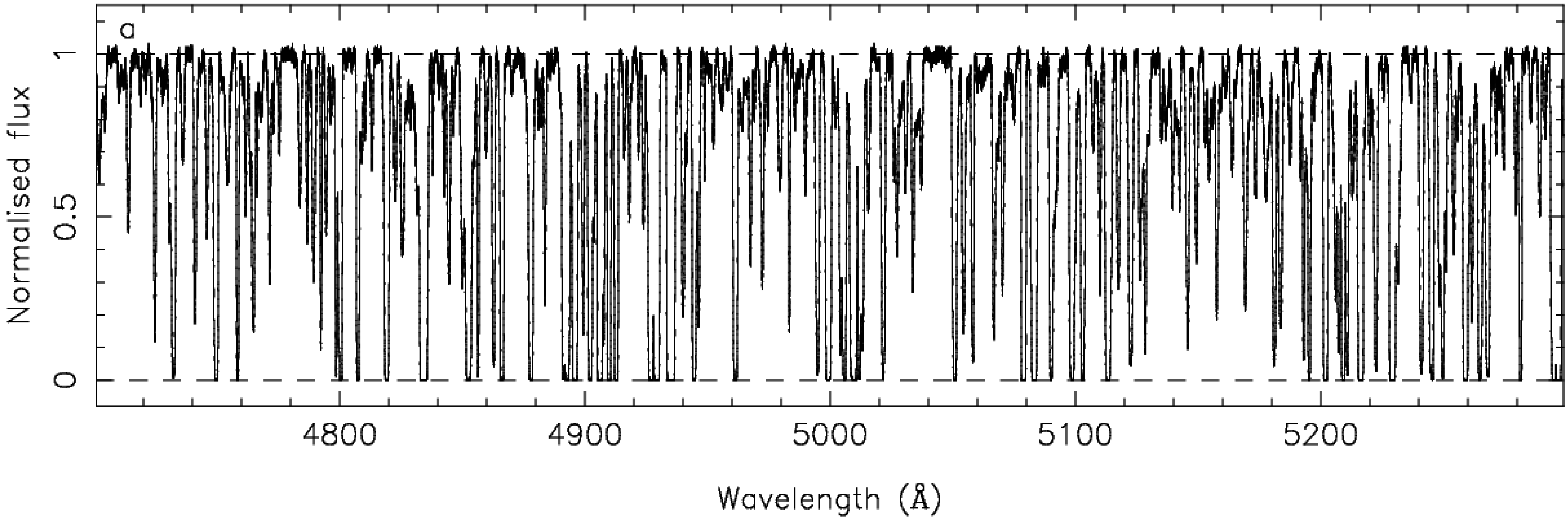
DRM Goals

- 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.

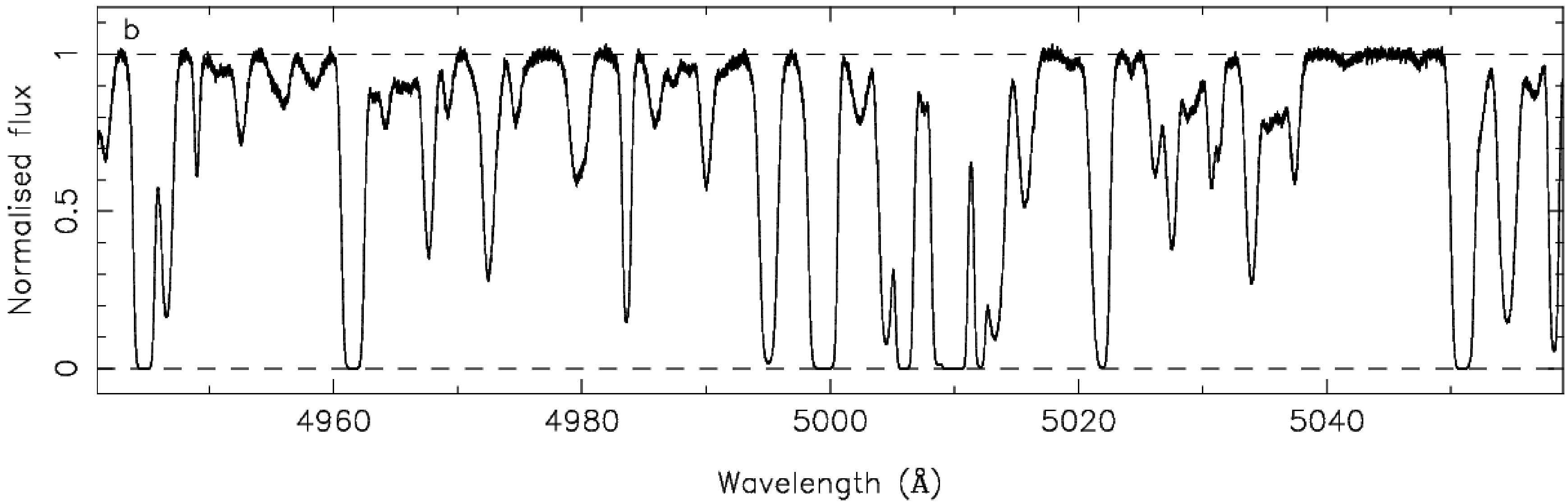
Lyα Forest Simulations

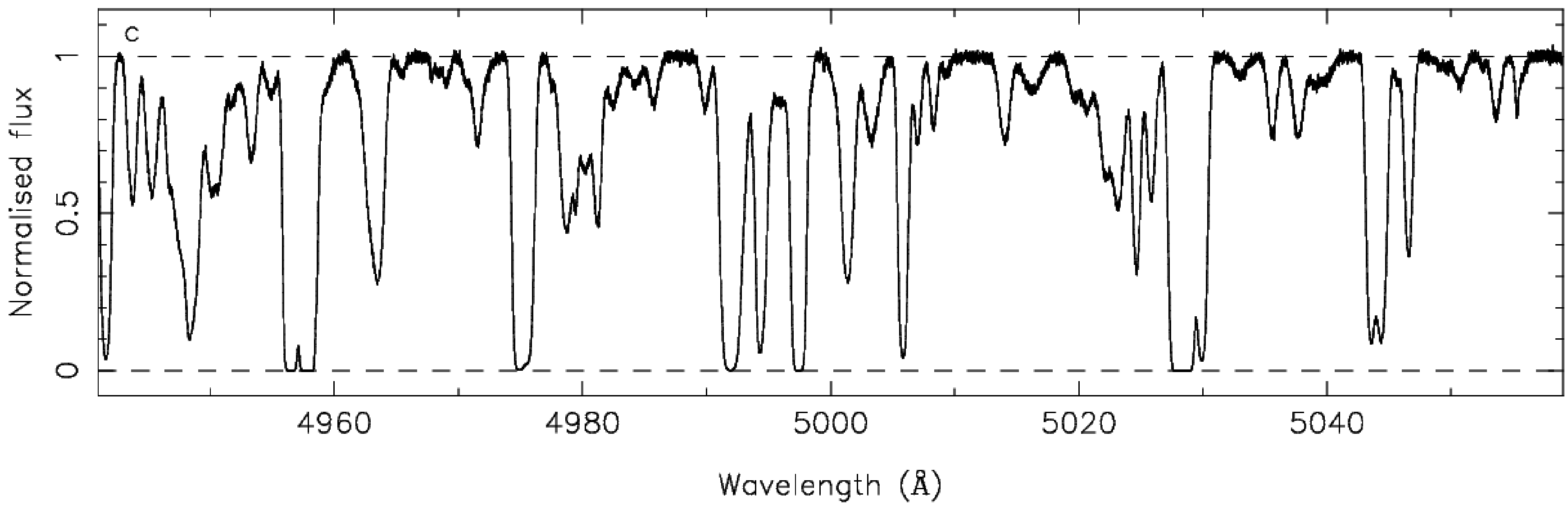
- In principle this depends only on the number of available spectral features, their shape and on the S/N at which they are recorded.
- Number of Lyα forest lines depends on redshift → need a quantitative relation between the accuracy with which a velocity shift can be measured, and S/N and redshift → simulations.
- Generate normalised Lyα 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).

Lyα Forest Simulations

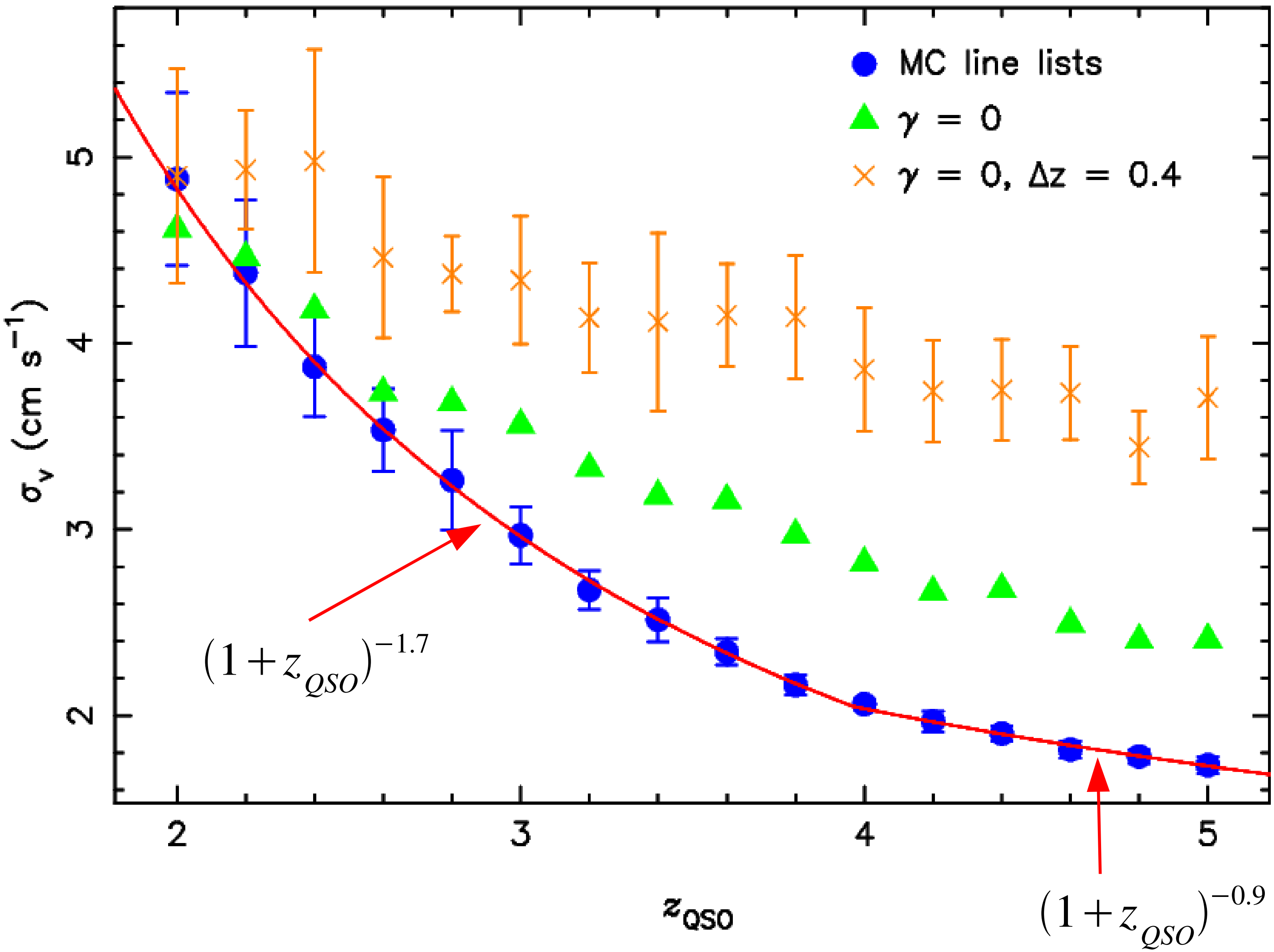


Lyα Forest Simulations

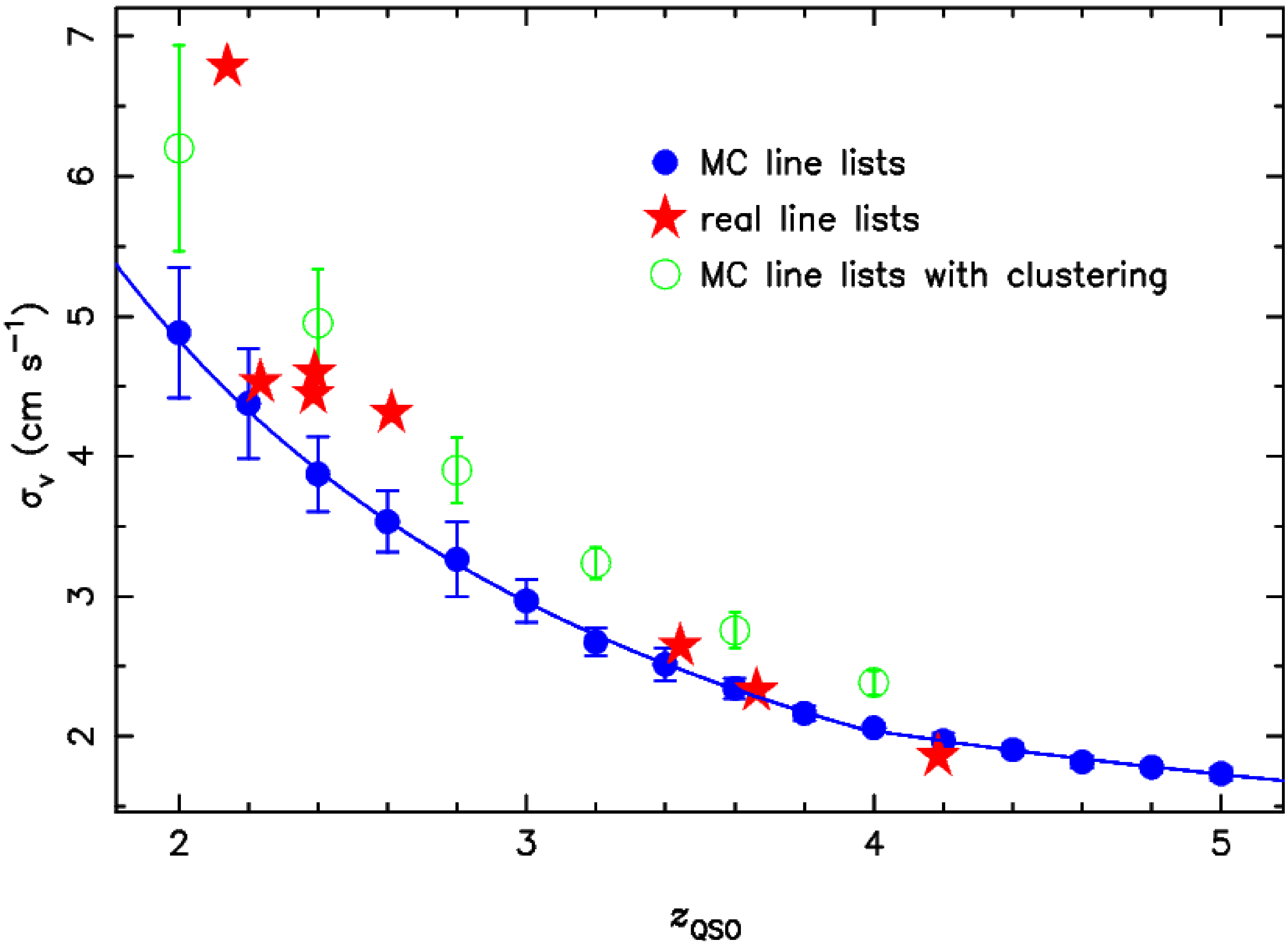




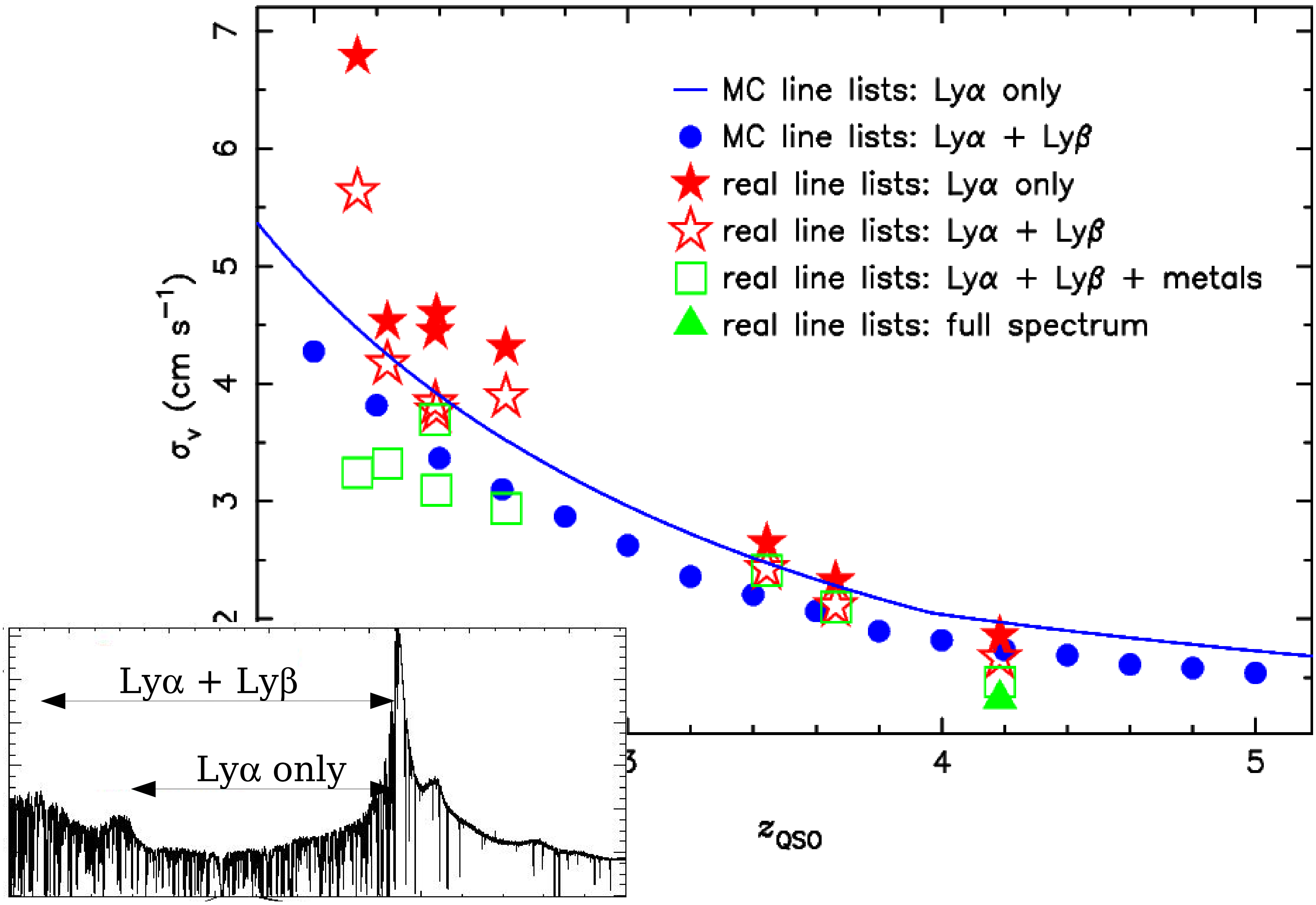
Simulation Results



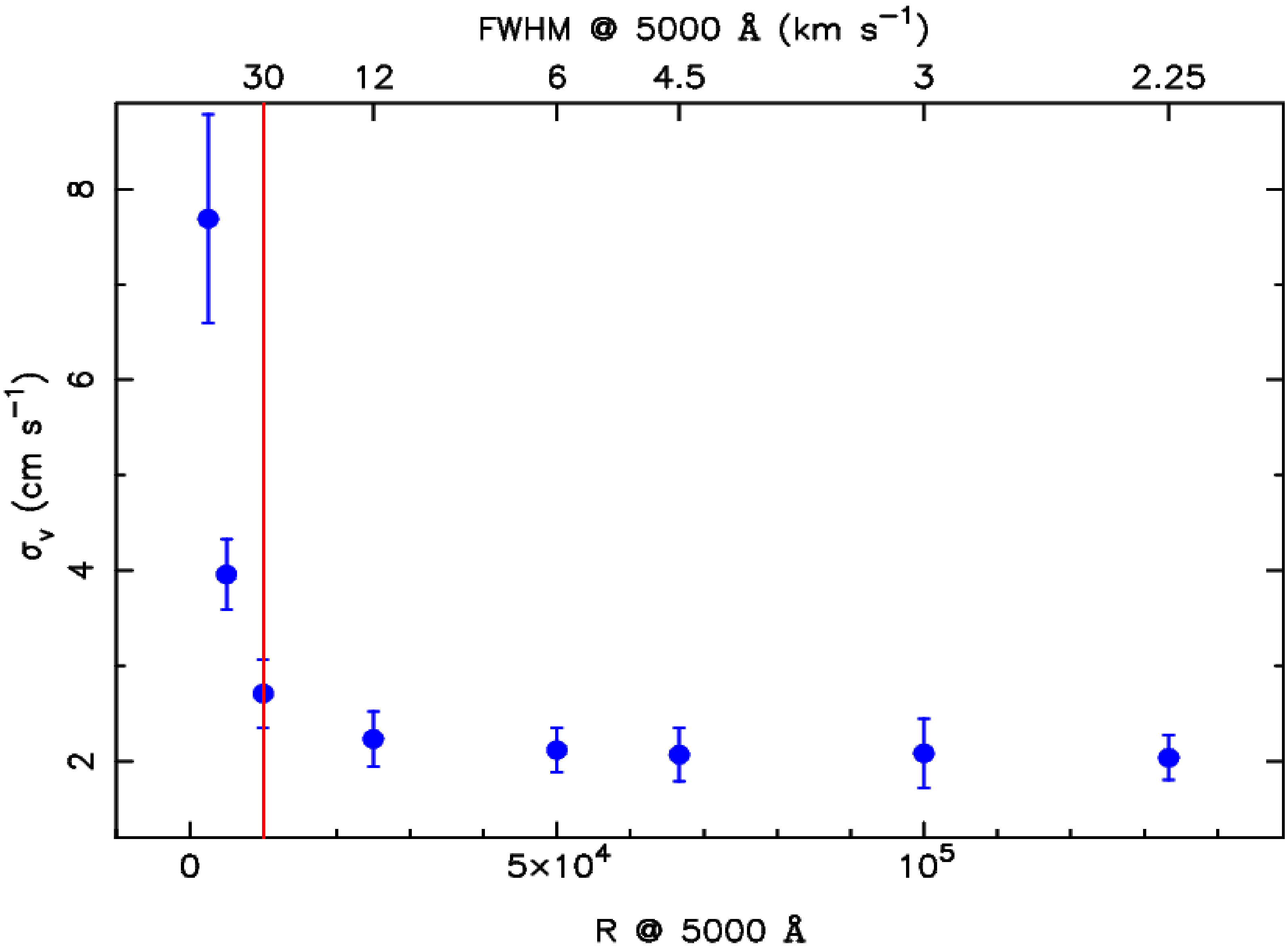
Simulation Results



Simulation Results



Simulation Results



Simulation Results

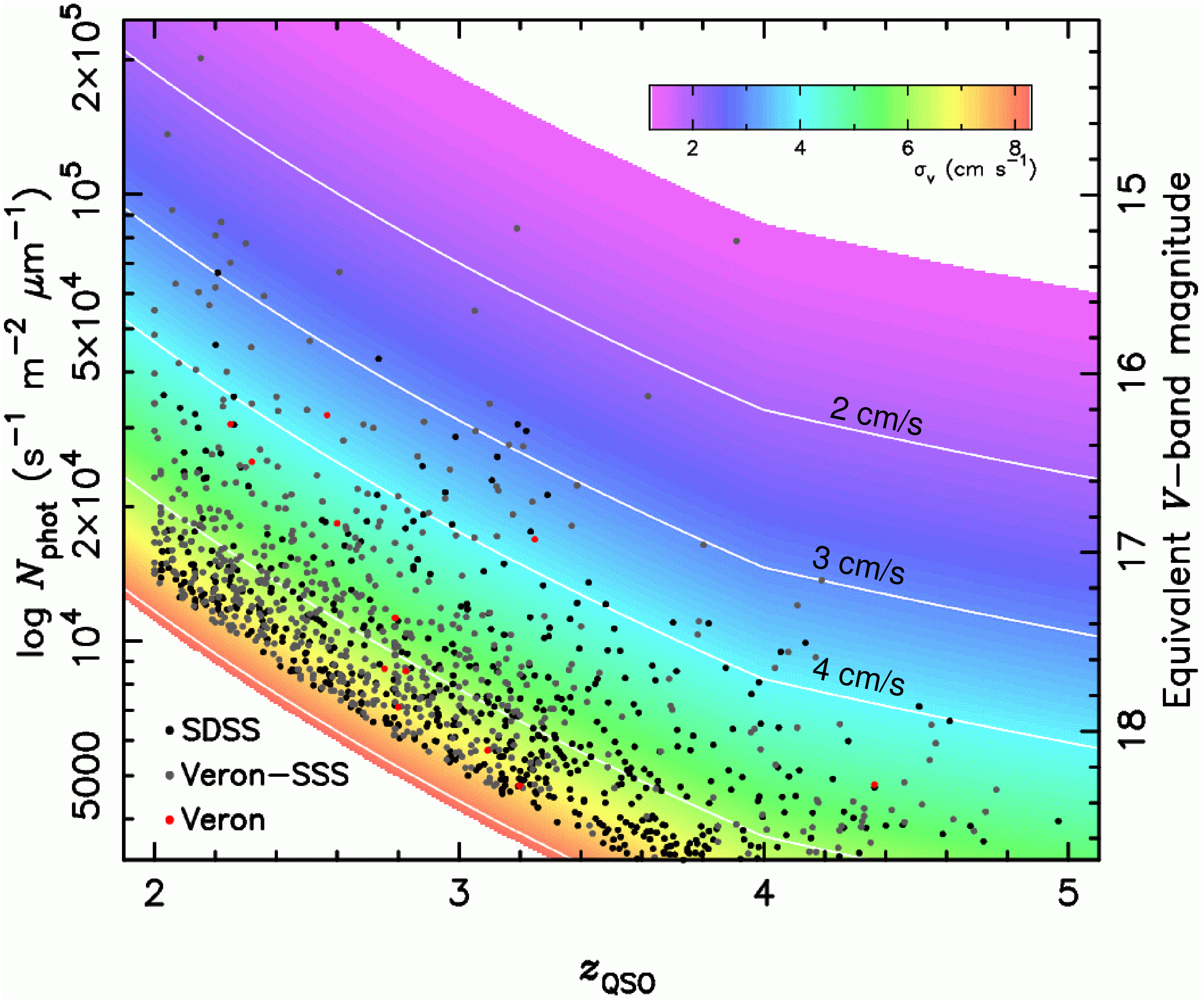
$$\sigma_v = 1.35 \left(\frac{S/N}{3350}\right)^{-1} \left(\frac{N_{QSO}}{30}\right)^{-1/2} \left(\frac{1+z_{QSO}}{5}\right)^{-1.7} g(N_e) \quad cm/s$$

S/N = total, accumulated S/N per 0.0125 A pixel per object
g = 'form factor', depends on the distribution of the observing time over the duration of the experiment ≈ 1.1 - 1.7

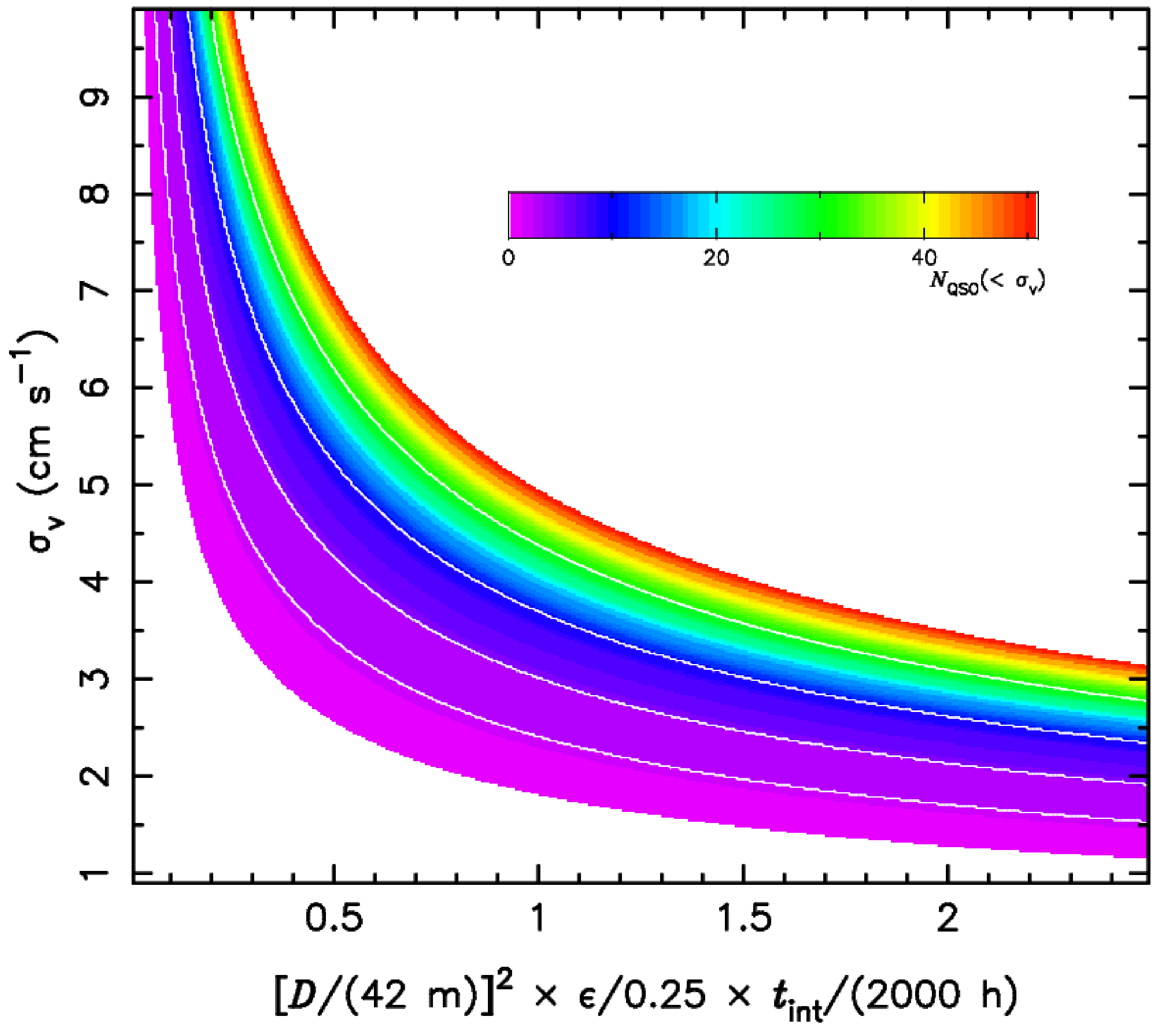
Are there enough photons?

D = 42 m
eff = 25%
t_{int} = 4000 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.

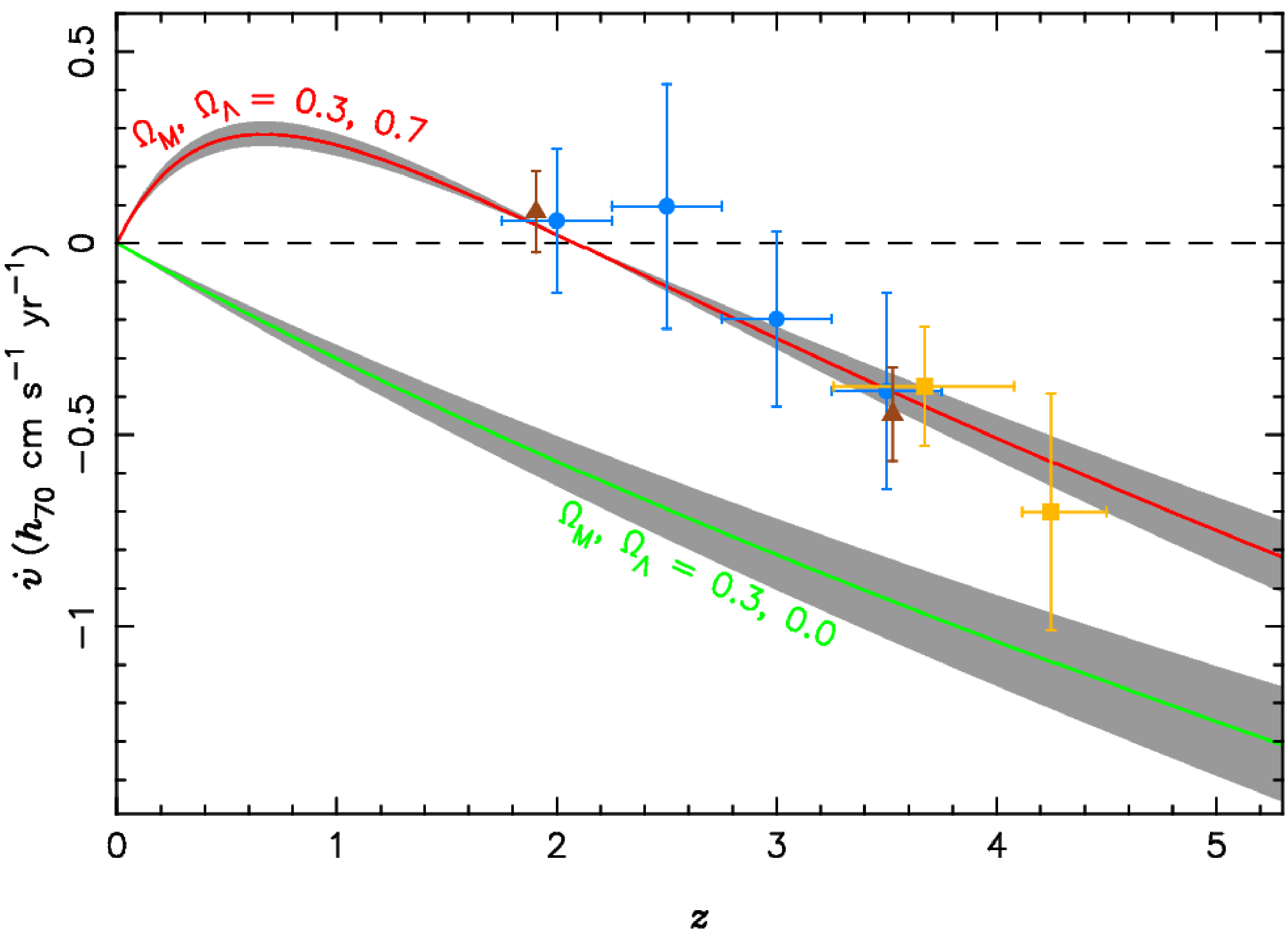
Simulated measurements

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

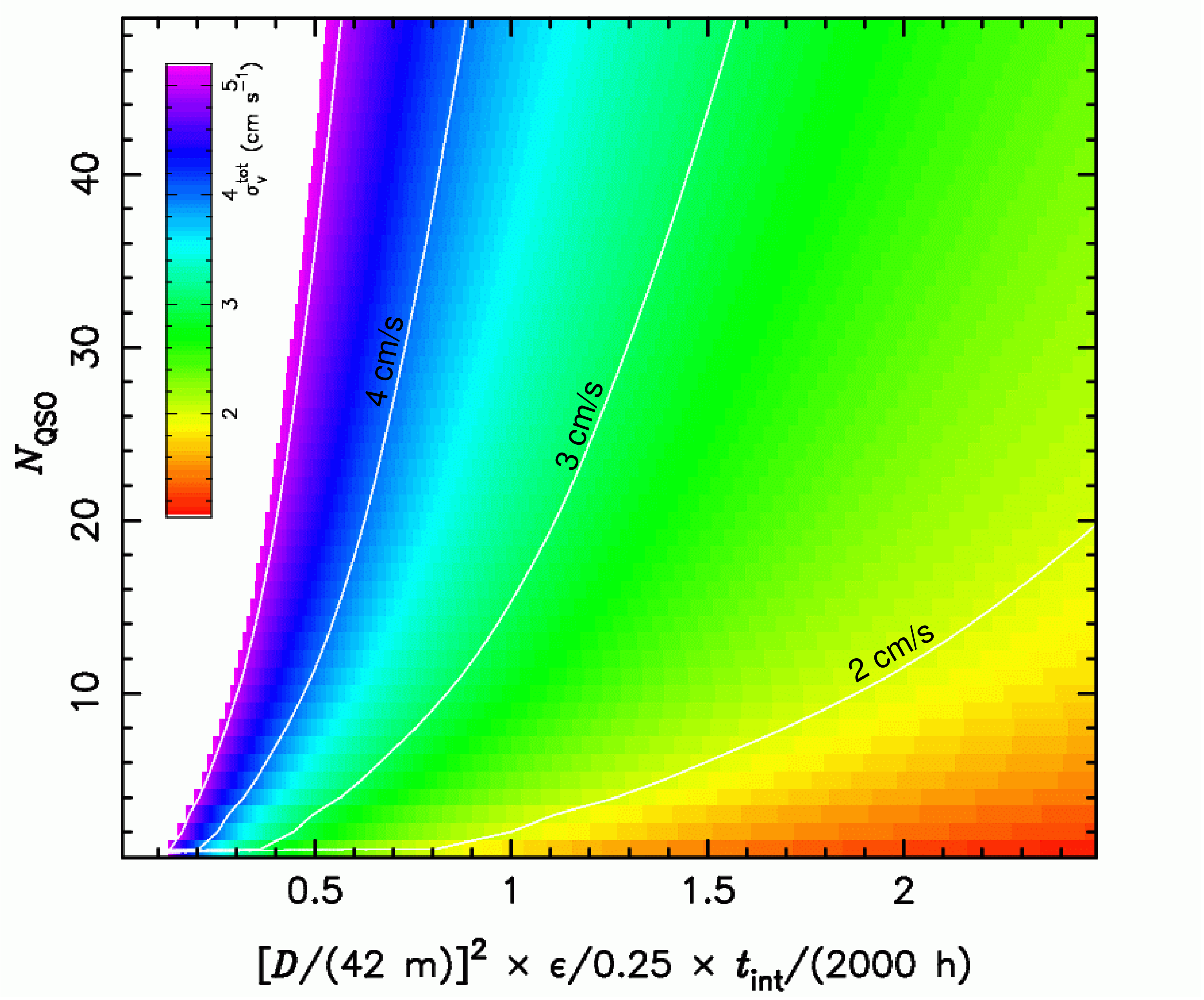
Blue: N_{QSO}= 20 selection by σ_v

Yellow: N_{QSO}= 10 selection by significance

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



Overall achievable accuracy

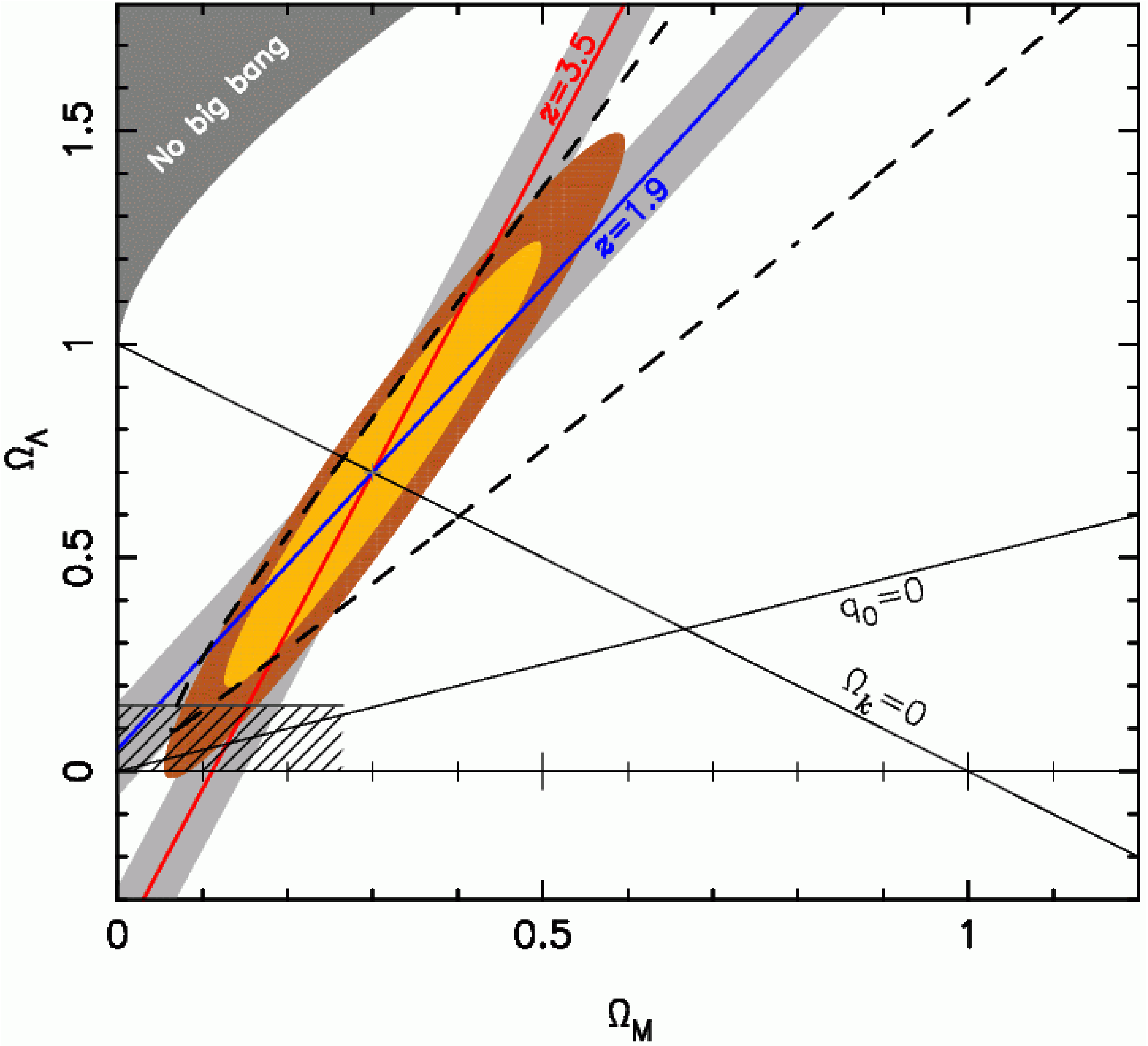


Cosmological Constraints

D = 42 m
eff = 25%
t_{int} = 4000 h
Δt = 20 yr

$\Omega_\Lambda > 0.16$ at 2σ

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



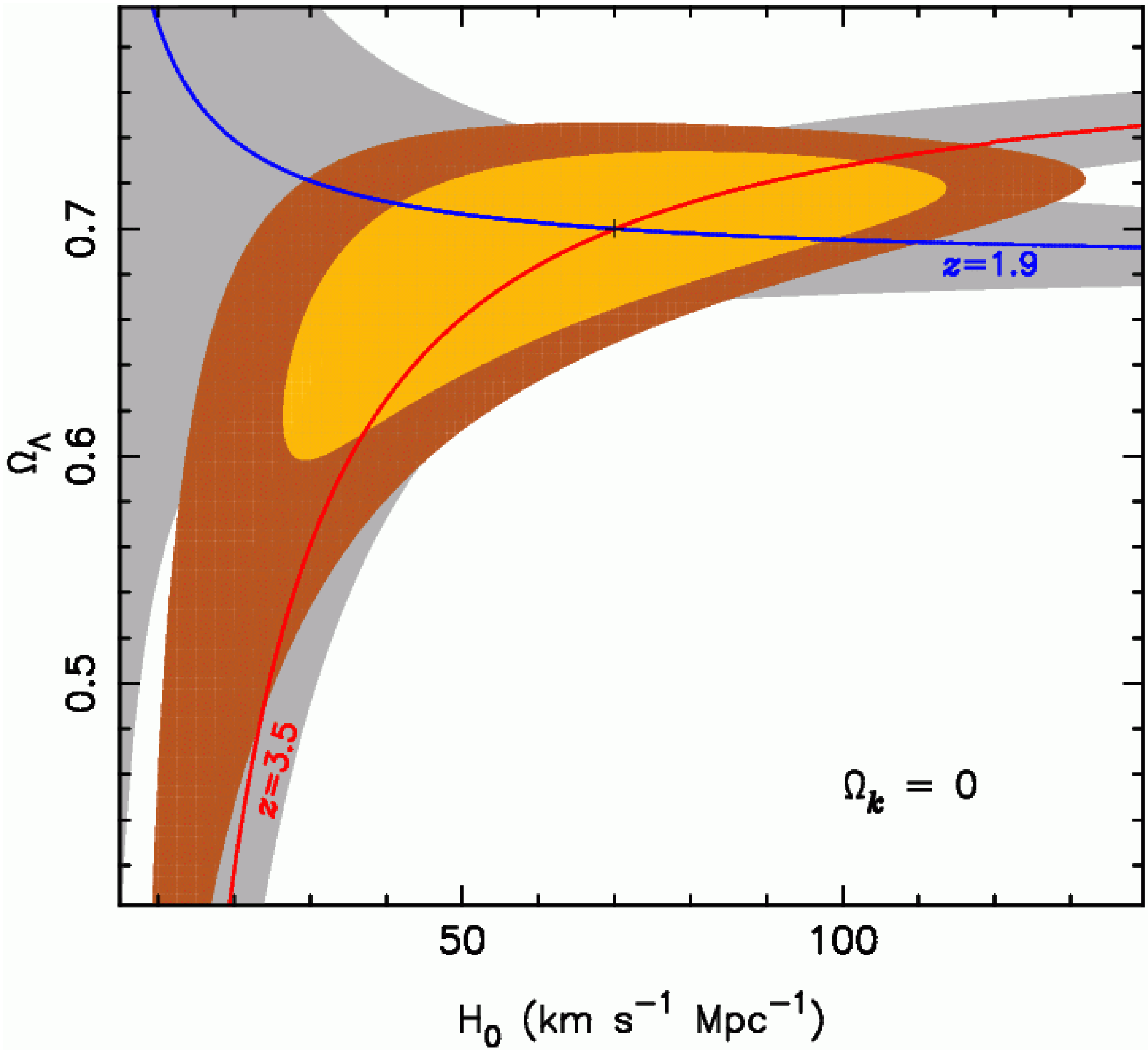
Cosmological Constraints

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

Assuming flatness:

$0.42 < \Omega_\Lambda < 0.74$ at 2σ

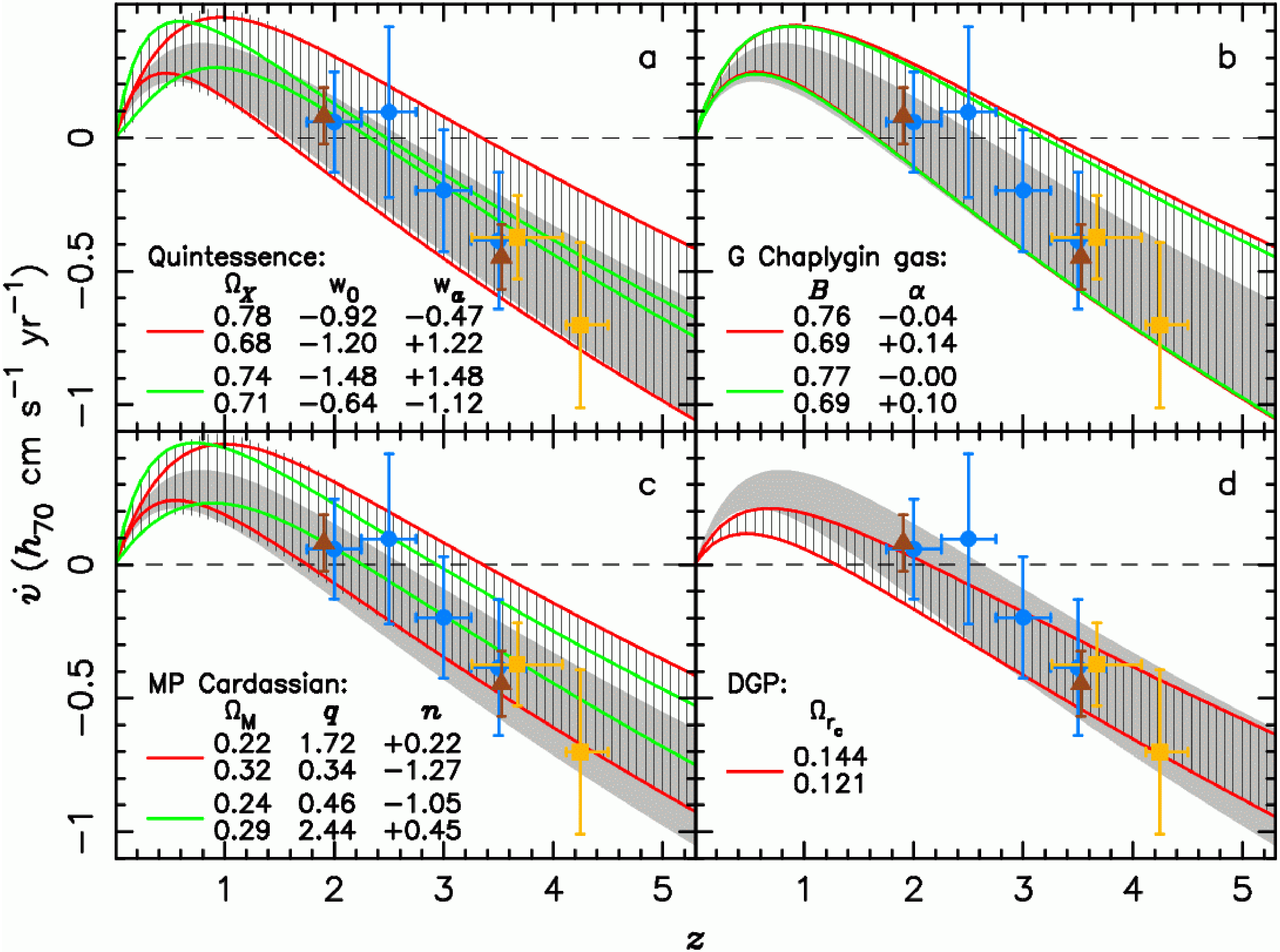
No useful constraint on H_0



Constraints on alternative models

D = 42 m
eff = 25%
t_{int} = 4000 h
Δt = 20 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
  - 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.