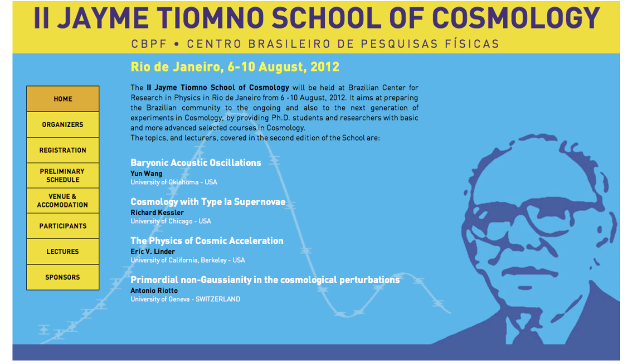

Lectures on Cosmology with Type Ia Supernovae: **SALT-II Spectral Training**

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Rio de Janeiro, Brazil

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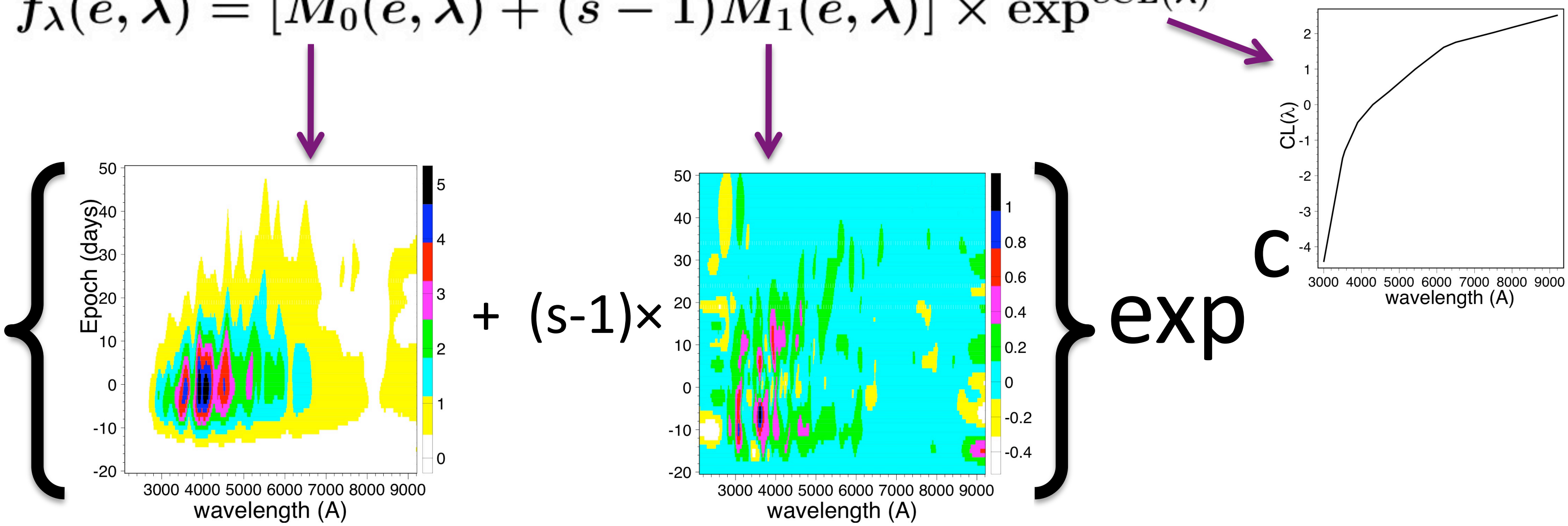
Review SALT-II Model

$$F_{e,f} = x_0(1+z)\int d\lambda\,[\lambda f_\lambda(e,\lambda)T_f(\lambda(1+z))]\ .$$

The SALT-II model (Guy 2007, 2010) is described by a spectral time-series,

$$f_\lambda(e,\lambda) = [M_0(e,\lambda) + (s-1)M_1(e,\lambda)] \times \exp^{c\mathrm{CL}(\lambda)}$$



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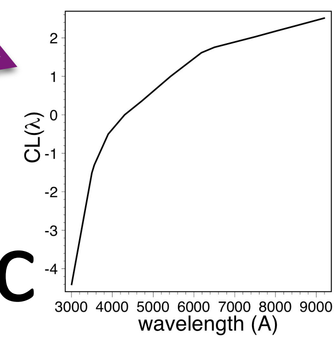

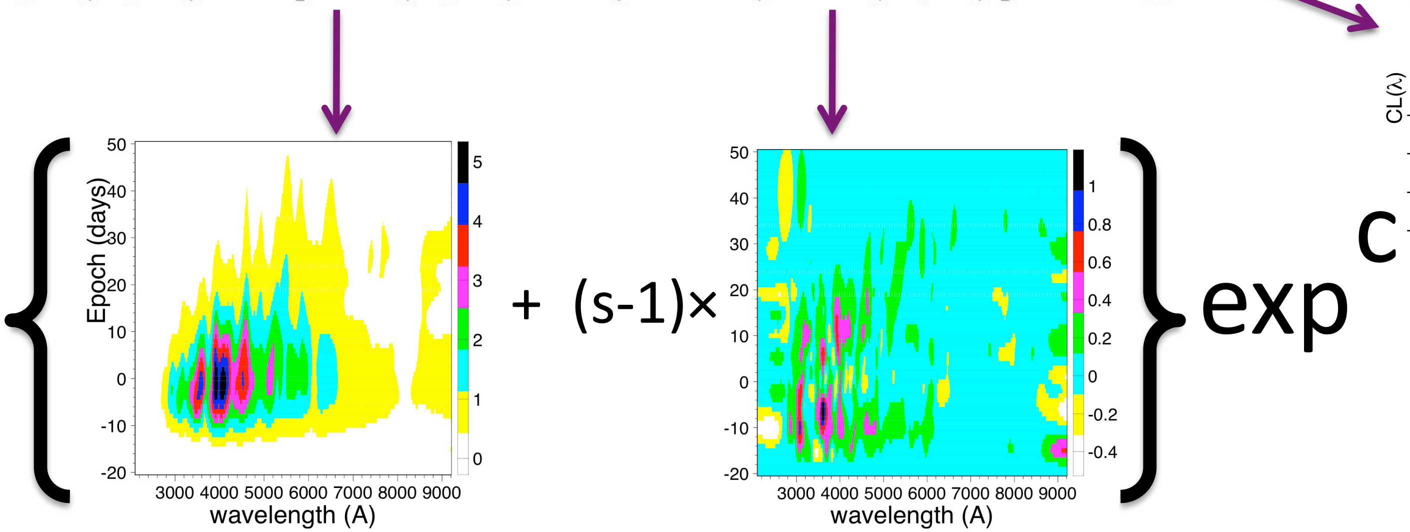

"***Training***" determines the fixed parameters for M_0, M_1 and CL(λ). Used in LCFIT to get shape (s) and color (c) for each SN.

Training the SALT2-II Model

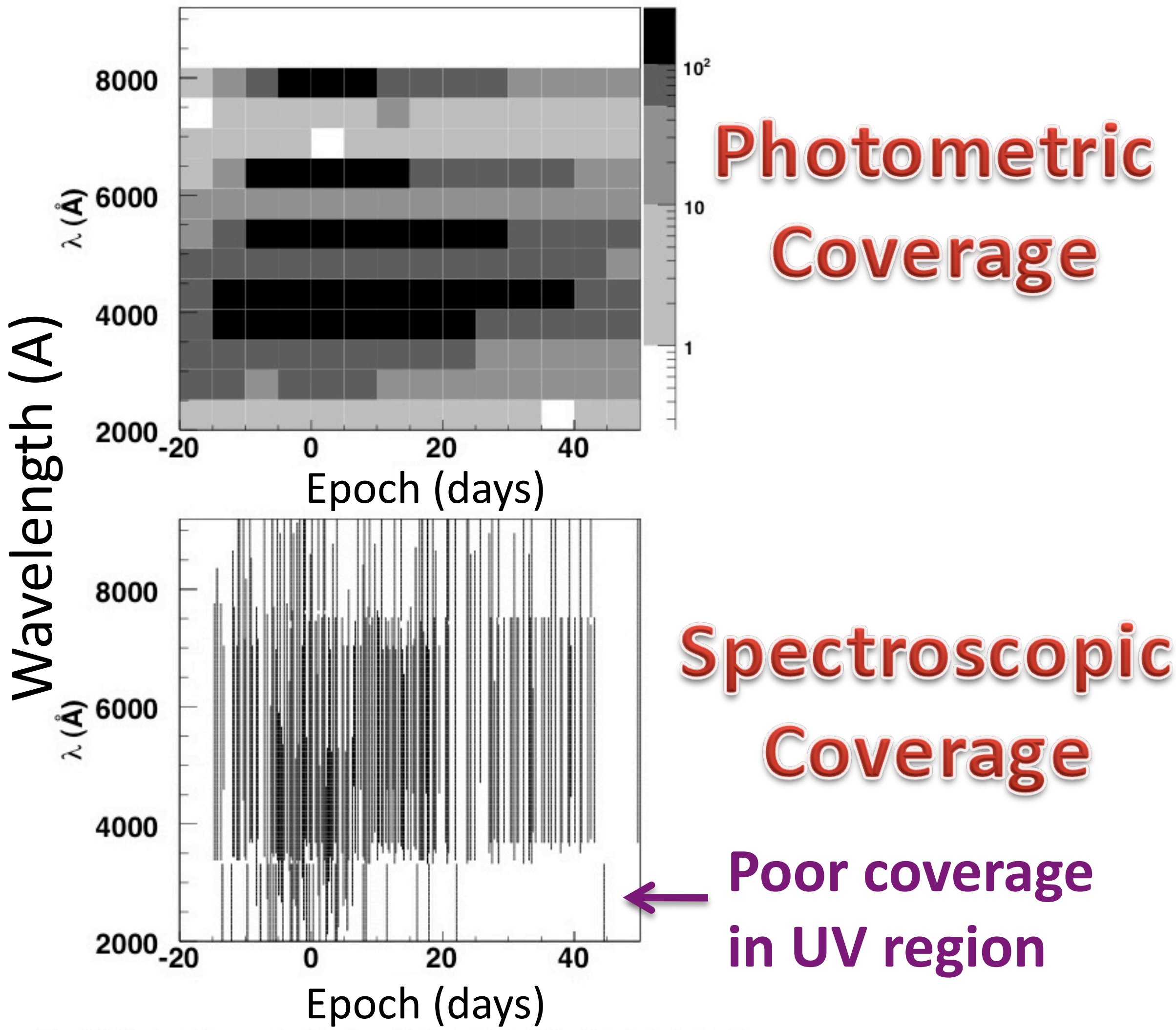

Fig. 1 Phase-space mapping by photometric data (top) and spectra (bottom). For photometric observations, the rest-frame central wavelength of the filter is considered.

Training the SALT2-II Model

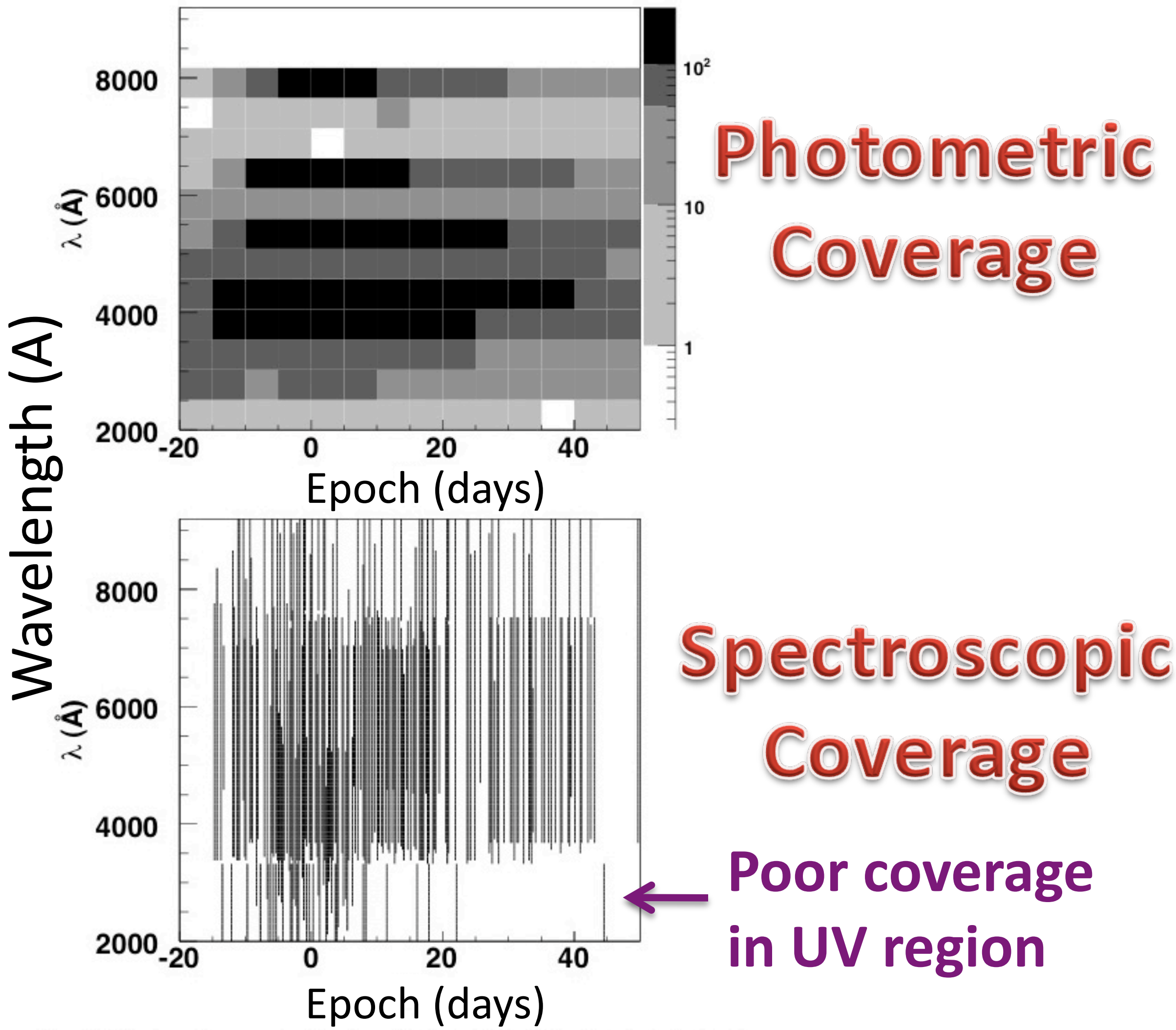

Fig. 1 Phase-space mapping by photometric data (top) and spectra (bottom). For photometric observations, the rest-frame central wavelength of the filter is considered.

Training: fit data with splines to create spectral sequences $M_0(e,\lambda)$ and $M_1(e,\lambda)$

Challenges:

- Gaps in data, mainly in UV
- Distinguishing spectral noise from real features
- Poor spectral calibration (~10%)

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Challenges:

- Gaps in data, mainly in UV
- Distinguishing spectral noise from real features
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Interpolate with splines (ideal: add more data !!!)

“Regularization” to avoid high frequency noise: major issues under study by SDSS+SNLS collab.

Warp spectra so that synthetic mags match photometry.

Training the SALT2-II Model: Regularization

$$\chi^2 = \sum_{e,\lambda} [\boldsymbol{F}_{\mathrm{data}(t,\lambda)} - \boldsymbol{F}_{\mathrm{model}(t,\lambda)}]^t C_D^{-1} [\boldsymbol{F}_{\mathrm{data}(t,\lambda)} - \boldsymbol{F}_{\mathrm{model}(t,\lambda)}]$$

$$+ \chi^2_{\mathrm{reg}}$$

→ **Penalty for spectral changes that are too rapid**

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$$\chi^2_{\mathrm{reg}} = (W_{\mathrm{reg}}/N_{\mathrm{bin}}) \sum_{e,\lambda} (\Delta F_{\mathrm{model}(t,\lambda)}/\Delta\lambda)^2$$

or

$$\chi^2_{\mathrm{reg}} = (W_{\mathrm{reg}}/N_{\mathrm{bin}}) \sum_{e,\lambda} (\Delta F_{\mathrm{model}(t,\lambda)}/\Delta t)^2$$

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$$\chi^2_{\mathrm{reg}} = (W_{\mathrm{reg}}/N_{\mathrm{bin}}) \sum_{e,\lambda} \sum_{l,k} (\Delta_{l,k} F_{\mathrm{model}(t,\lambda)}/\Delta_l\lambda\Delta_k t)^2$$

Multiple scales for λ and t

W_{reg} weight is arbitrary: no clear optimization algorithm

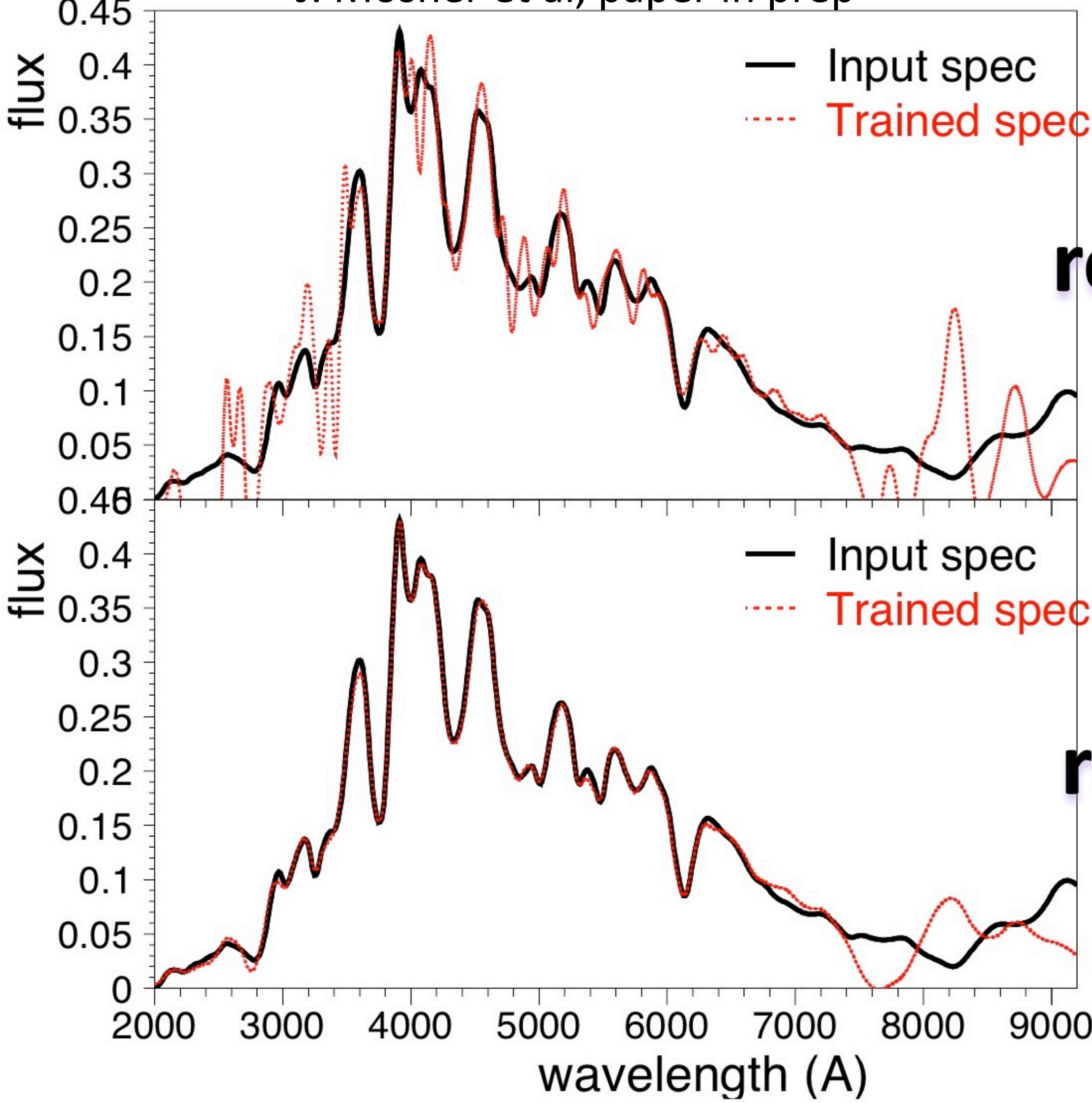
SALT-II Trainings Tests on **Simulations**
(part of SDSS+SNLS collaboration)

Train on **REALISTIC** data-like samples (photometry + spectra) including nearby, SDSS, SNLS

Evaluate biases from training.

SALT-II Training Test on **Simulations**: No spectra within ±3 days

J. Mosher et al, paper in prep



no regularization

with regularization

SALT-II Trainings Tests on Simulations: Hubble Bias

Train on **REALISTIC** data-like sample (photometry + spectra)

Use trained model to fit **IDEAL** SNLS3 sample: x10,000 exposure time --> no Malmquist bias

➔ Hubble bias from training only.

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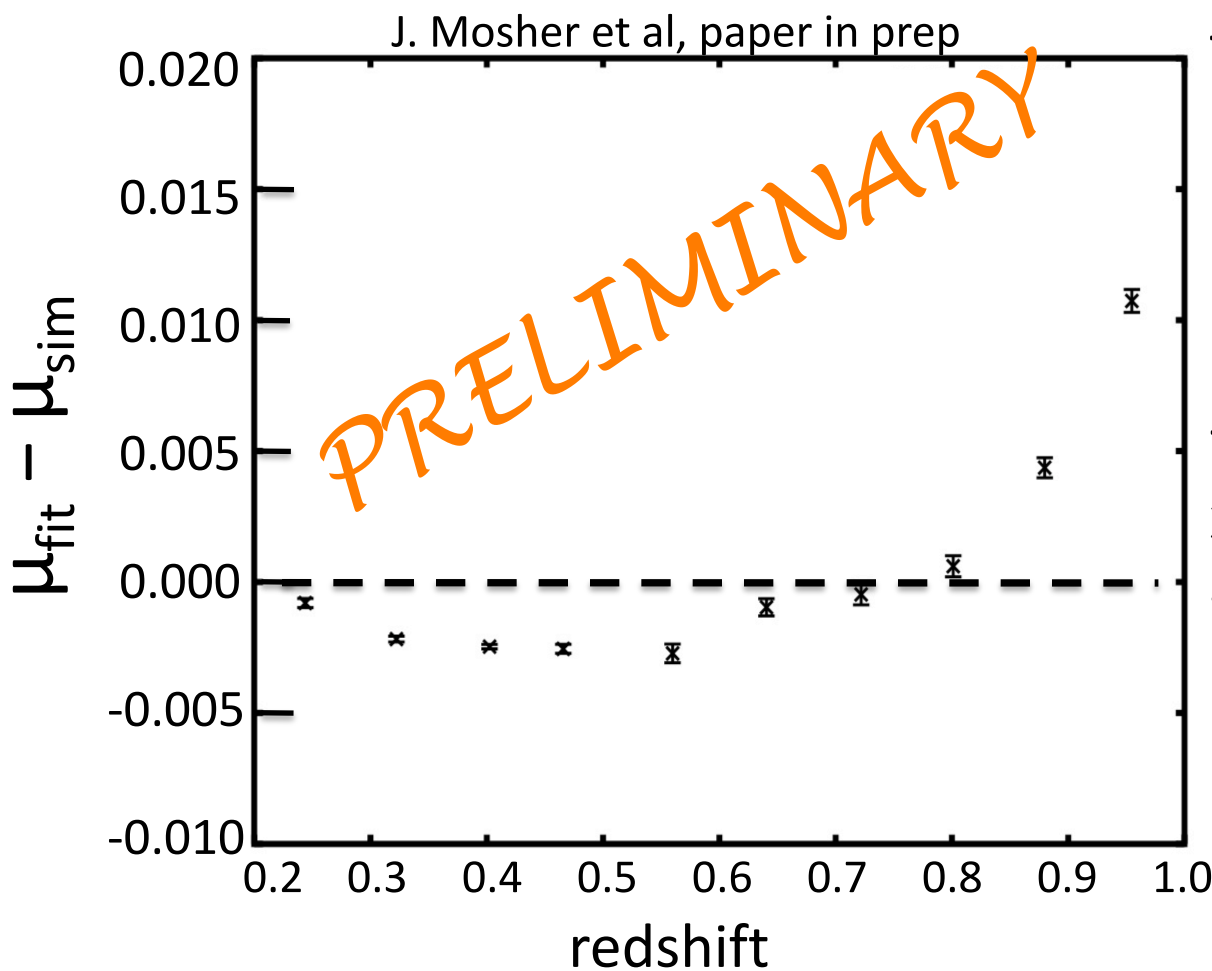

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