

15 December, 2015

Pascal Oesch  
Geneva Observatory  
51, Ch. des Maillettes  
Versoix, Switzerland 1290  
pascal.oesch@unige.ch

Brett Salmon  
Dept. of Physics & Astronomy  
Texas A&M University  
4242 TAMU  
College Station, TX USA 77843-4242  
bsalmon@physics.tamu.edu

Dear Prof. Pascal Oesch,

I would like to apply to the postdoctoral position at the Geneva Observatory as advertised on the AAS job register (JRID52448). I am finishing my PhD in the Department of Physics and Astronomy at Texas A&M University, under supervisor Prof. Casey Papovich.

My current research involves observational studies of distant galaxies, and how their physical properties evolve with time. In particular, I have experience in astro-statistics, nebular emission modeling, and galaxy spectral energy distribution (SED) modeling. As a junior scientist member of the CANDELS (Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey) team, I have contributed to several projects on high-redshift galaxy evolution. More recently, my research focuses on Bayesian approaches to infer the underlying dust absorption and scattering in high-redshift galaxies.

I am interested in working with you on better determinations of star formation rates (SFRs) at high redshift, new insights on the redshift evolution of dust properties and attenuation, and alternative approaches to the cosmic SFR function. I hope you find these project ideas well-suited for your position, as they will build the case for a *JWST* proposal and will benefit from your experience studying high-redshift galaxies. I look forward to discussing with you about the additional high- $z$  project ideas intended for the position.

My curriculum vitae and research statement are attached below, which provide more details on my research experience and potential future projects.

Thank you for your time and consideration. I hope to hear from you soon.

Sincerely,

A handwritten signature in black ink, appearing to read 'Brett Salmon', with a stylized, cursive script.

Brett Salmon

# Curriculum Vitae

## Brett Salmon

**Email:** [bsalmon@physics.tamu.edu](mailto:bsalmon@physics.tamu.edu)

|                                     |   |                 |
|-------------------------------------|---|-----------------|
| <b>Address</b>                      | <b>Website:</b> <a href="http://people.physics.tamu.edu/bsalmon">http://people.physics.tamu.edu/bsalmon</a> | <b>Phone</b>    |
| Texas A&M University                |   | 01-609-617-0510 |
| Department of Physics and Astronomy |   |                 |
| 4242 TAMU                           |   |                 |
| College Station, TX                 |   |                 |
| 77843-4242                          |   |                 |

### Research Interests

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Galaxy formation and evolution, high-redshift galaxies, star formation histories, SED fitting, Bayesian and other statistical techniques, Ly $\alpha$ /LyC emission, nebular emission, dust attenuation

### Education

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|                       |                  |
|-----------------------|------------------|
| <b>Ph.D., Physics</b> | <b>Aug. 2016</b> |
|-----------------------|------------------|

Texas A&M University  
Department of Physics and Astronomy  
4242 TAMU  
College Station, TX  
77843-4242  
Advisor: Casey Papovich  
Dissertation: “Bayesian Approaches to Infer the Physical  
Properties of Star-forming Galaxies at Cosmic Dawn”

|                      |             |
|----------------------|-------------|
| <b>M.S., Physics</b> | <b>2015</b> |
|----------------------|-------------|

(see above)  
Advisor: Casey Papovich

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|--|-------------|
| <b>B.S., Astronomy Magna Cum Laude</b> | <b>2010</b> |
|--|-------------|

Rutgers, The State University of New Jersey  
57 US Highway 1  
New Brunswick, NJ 0891-8554  
Advisors: Charles Keeton, Andrew Baker  
Senior Honors Thesis on Gravitational Lensing:  
“Exploration of the Quintuple Quasar PMN J0134-0931”

### Honors & Awards

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|   |           |
|---|-----------|
| APS TX Chapter Fall 2014 Presentation Award | 2014      |
| Richard J. Plano Summer Research Internship | 2009      |
| Harriet & Robert Druskin Scholar            | 2006-2010 |

## Conferences and Presentations

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|--|--------------------------|------------------|
| Talk: <i>AstroLunch Talk</i>   | University of Pittsburgh | Nov. 20, '15     |
| Talk: <i>Informal Seminar</i>  | Penn State University    | Nov. 19, '15     |
| Talk: <i>Large Scale Phenomena Seminar</i>   | CfA/Harvard              | Nov. 17, '15     |
| Talk: <i>Seminar</i>   | UMass Amherst            | Nov. 16, '15     |
| Talk: <i>Galaxy Journal Club</i>   | STScI                    | Nov. 13, '15     |
| Talk: <i>Astronomy Seminar</i>   | Columbia University      | Nov. 12, '15     |
| Talk: <i>Informal Seminar</i>  | New York University      | Nov. 11, '15     |
| Poster: <i>Bashfest Symposium</i>  | University of Texas      | Oct. 19–20, '15  |
| Talk: <i>South by High Redshift</i>  | University of Texas      | Apr. 1–3, '15    |
| Talk: <i>The SEDs of high redshift galaxies</i>                                    | Sesto, Italy             | Jan. 26–30, '15  |
| Talk: <i>Rutgers University</i>  | Rutgers University       | Nov. 25, '14     |
| Talk: <i>Galaxy Group Seminar</i>  | University of Texas      | Oct. 23, '14     |
| Talk: <i>APS TX Chapter Meeting</i>  | Texas A&M University     | Oct. 18, '14     |
| Talk: <i>Science in the ALMA Era: Mutli-Wavelength Studies of Galaxy Evolution</i> | Charlottesville, VA      | Aug. 4–7, '14    |
| Talk: <i>CANDELS Team Meeting</i>  | STScI                    | Jul. 28–31 '14   |
| Poster: <i>The Near-Field Deep-Field Connection</i>                                | UC Irvine                | Feb. 11–14, '14  |
| Poster: <i>Bashfest Symposium</i>  | University of Texas      | Oct. 6–8, '13    |
| Talk: <i>CANDELS Team Meeting</i>  | University of Kentucky   | Aug. 26–30, '13  |
| Poster: <i>GMT Science Meeting</i>   | University of Chicago    | Jun. 10–12, '13  |
| Talk: <i>CANDELS Team Meeting</i>  | University of Santa Cruz | Sept. 10–14, '12 |
| Poster: <i>Bashfest Symposium</i>  | University of Texas      | Oct. 9–11, '11   |
| Talk: <i>Texas A&amp;M Astronomy Symposium</i>                                     | Texas A&M University     | Aug. '11–'15     |

## Computational Expertise

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- Proficient in IDL programming and plotting, and currently learning Python and R.
- Have a fully customizable SED-fitting procedure built in a Bayesian framework.
- Regularly submit bundles of single-node computations to The Brazos Cluster, a major computing cluster.
- Redshift fitting with EAZY, source identification with SExtractor.
- Far-IR SED fitting.
- Basic scripts using CLOUDY photoionization code

## Observing Experience

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|--------------------------------|------------------------|-----------------|
| McDonald Observatory [VIRUS-P] | PI: Emily Freeland     | Jan 27–30, 2012 |
| McDonald Observatory [VIRUS-P] | PI: Steven Boada       | May 25–29, 2012 |
| Gemini-S [GMOS]                | PI: Vithal Tilvi       | Dec 17–18, 2012 |
|                                | Co-I: <b>B. Salmon</b> |                 |
| Gemini-N [GMOS]                | PI: Vithal Tilvi       | Feb 20–23, 2014 |
|                                | Co-I: <b>B. Salmon</b> |                 |

## Teaching

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|   |             |
|---|-------------|
| (PDP) REU Introduction Lesson: Distance Measures in Astronomy | Summer 2015 |
| Norton online lecture & assignment accuracy checking          | 2014–2015   |
| TA: Astronomy 101 Basic Astronomy                             | Spring 2014 |
| Lab: Astronomy 111 Overview of Modern Astronomy               | Fall 2013   |
| TA: Astronomy 101 Basic Astronomy                             | Spring 2013 |
| Lab: Astronomy 111 Overview of Modern Astronomy               | Fall 2012   |
| TA: Astronomy 314 Survey of Astronomy                         | Spring 2012 |
| Lab: Astronomy 111 Overview of Modern Astronomy               | Fall 2011   |
| TA: Astronomy 101 Basic Astronomy                             | Spring 2011 |
| Lab: Astronomy 111 Overview of Modern Astronomy               | Fall 2010   |

## Mentoring

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|  |             |
|--|-------------|
| REU: Shaquann Seedorf  | Summer 2015 |
| DEEP Mentor: Kate Elston, Aldo Galvan, Koki Hara, Joshua Stenzel, Fu-Anne Wang | 2014–15     |
| DEEP Mentor: Kate Elston, Madeline Hansalik, Ana Perez, Cole Williams          | 2013–14     |

## Outreach

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|  |               |
|--|---------------|
| CANDELS blog                               | 2015–present  |
| Mentoring Undergrad Researchers (training) | May 2013      |
| Public Star Parties                        | Fall 2012–14  |
| Prospective Grad Student Orientation       | May 2012–13   |
| Texas A&M Physics and Astronomy Festival   | April 2011–15 |

## Publications

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### First Author

- ★ 1. “*The Relation Between Star Formation Rate and Stellar Mass for Galaxies at  $3.5 < z < 6.5$  in CANDELS*” 2015 ApJ, 799, 183  
**Salmon, Brett**; Papovich, Casey; Finkelstein, Steven L.; Tilvi, Vithal; Finlator, Kristian; Behroozi, Peter; Dahlen, Tomas; Davé, Romeel; Dekel, Avishai; Dickinson, Mark; Ferguson, Henry C.; Giavalisco, Mauro; Long, James; Lu, Yu; Mobasher, Bahram; Reddy, Naveen; Somerville, Rachel S.; Wechsler, Risa H.
- 2. “*Breaking the Curve with CANDELS: A Bayesian Approach to Reveal the Non-Universality of the High-Redshift Dust-Attenuation Law*” ApJ (submitted)  
**Salmon, Brett**; Papovich, Casey; Long, James; Wilner, Steven; Finkelstein, Steven L.; Ferguson, Henry C.; Faber, Sandra; Newman, Jeffrey; Dickinson, Mark; Duncan, Kenneth; Pacifici, Camilla; Pérez-González, Pablo; Koekemoer, Anton; Kurczynski, Peter; Pforr, Janine

3. “*The Non-Universality of the Dust-Attenuation Law Since the First Billion Years*” (in prep.)  
**Salmon, Brett**; Papovich, Casey; Long, James; Finkelstein, Steven L.; Ferguson, Henry C.; Faber, Sandra; Dickinson, Mark; Duncan, Kenneth; Pacifici, Camilla;

**Co-Author**

1. “*An Increasing Stellar Baryon Fraction in Bright Galaxies at High Redshift*” 2015 ApJ 814, 95  
Finkelstein, S. L.; Song, M.; Behroozi, P.; & 12 coauthors including **Salmon, B.**
2. “*The SFR- $M^*$  Relation and Empirical Star-Formation Histories from ZFOURGE at  $0.5 < z < 4$* ” 2015 ApJ (accepted) arXiv:1510.06072  
Tomczak, Adam R.; Quadri, Ryan F.; Tran, Kim-Vy H.; Labbe, Ivo; & 18 coauthors including **Salmon, B.**
3. “*Probing the Physical Properties of  $Z = 4.5$  Lyman Alpha Emitters with Spitzer*” 2015 ApJ 813, 78  
Finkelstein, K. D.; Finkelstein S. L.; Tilvi, V.; Malhotra, Sangeeta; & 9 other coauthors including **Salmon, B.**
4. “*The Evolution of the Galaxy Rest-Frame Ultraviolet Luminosity Function Over the First Two Billion Years*” 2015 ApJ, 810, 71  
Finkelstein, S. L.; Ryan, R E., Jr.; Papovich, C.; Dickinson, M.; Song, M.; Somerville, R.; Ferguson, H. C.; **Salmon, B.**; & 21 coauthors
5. “*The Evolution of the Galaxy Stellar Mass Function at  $z = 4-8$ : A Steepening Low-mass-end Slope with Increasing Redshift*” 2015 ApJ (resubmitted) arXiv:1507.05636  
Song, M.; Finkelstein, S. L.; Ashby, M. L. N.; Grazian, A.; Lu, Y.; Papovich, C.; **Salmon, B.**; & 12 coauthors
6. *ZFOURGE/CANDELS: On the Evolution of  $M^*$  Galaxy Progenitors from  $z = 3$  to  $0.5$*  2015 ApJ, 803, 26  
Papovich, C.; Labbé, I.; Quadri, R.; Tilvi, V.; Behroozi, P.; Bell, E. F.; Glazebrook, K.; Spitler, L.; Straatman, C. M. S.; & 32 coauthors including **Salmon, B.**
7. “*The galaxy stellar mass function at  $3.5 < z < 7.5$  in the CANDELS/UDS, GOODS-South, and HUDF fields*” 2015 A& A, 575, 96  
Grazian, A.; Fontana, A.; Santini, P.; & 38 coauthors including **Salmon, B.**
8. “*The Distribution of Satellites around Massive Galaxies at  $1 < z < 3$  in ZFOURGE/CANDELS: Dependence on Star Formation Activity*” 2014 ApJ, 792, 103  
Kawinwanichakij, L.; Papovich, C.; & 24 coauthors including **Salmon, B.**
9. “*The HETDEX Pilot Survey. V. The Physical Origin of  $Ly\alpha$  Emitters Probed by Near-infrared Spectroscopy*” 2014 ApJ, 791, 3  
Song, M.; Finkelstein, S. L.; Gebhardt, K.; & 18 coauthors including **Salmon, B.**
10. “*Discovery of Lyman Break Galaxies at  $z \sim 7$  from the zFourGE Survey*” 2013 ApJ, 768, 56  
Tilvi, V.; Papovich, C.; Tran, K.-V. H.; & 22 coauthors including **Salmon, B.**

11. “*CANDELS: The Evolution of Galaxy Rest-frame Ultraviolet Colors from  $z = 8$  to 4*” 2012 ApJ, 756, 164  
Finkelstein, S. L.; Papovich, C.; **Salmon, B.**; Finlator, K.; Dickinson, M.; & 16 coauthors
12. “*Extreme Emission-line Galaxies in CANDELS: Broadband-selected, Starbursting Dwarf Galaxies at  $z > 1$* ” 2011 ApJ, 742, 111  
van der Wel, A.; Straughn, A. N.; Rix, H.-W.; & 29 coauthors including **Salmon, B.**

## References

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Dr. Casey Papovich  
Dept. of Physics & Astronomy  
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Dr. Steven Finkelstein  
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University of Texas  
01-512-471-1483  
[stevenf@astro.as.utexas.edu](mailto:stevenf@astro.as.utexas.edu)

Dr. Henry Ferguson  
Space Telescope  
Science Institute  
01-410-338-5098  
[ferguson@stsci.edu](mailto:ferguson@stsci.edu)

## Brett Salmon - Statement of Research

My research involves observational studies of distant galaxies, and how their physical properties evolve with time. Specifically, I am interested in how galaxies accrue stellar mass through star-formation, and both the processes that reveal and impede that understanding. I have worked with rest-frame ultra-violet through far-infrared data, as well as several nebular emission lines. In addition, my research identifies how absorption and scattering by dust and limitations involved with the modeling of spectral energy distributions (SEDs) affect our interpretation of galaxy properties.

**The Star-formation Rate and Stellar Mass Relation:** The relation between star-formation rate (SFR) and stellar mass is a measure of the current and past star-formation activity of galaxies. The scatter between the relation alludes to the stochasticity of galaxy SFRs and gas accretion histories. I have led a comprehensive study on this relation among high-redshift ( $z > 4$ ) galaxies which has become one of the key results of CANDELS (Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey). This study required facilitating communication between faculty and postdoctoral researchers from theory, observation, and statistics disciplines. Figure 1 shows the primary result, revealing little evolution in slope or scatter in the relation out to  $z \sim 6$ .

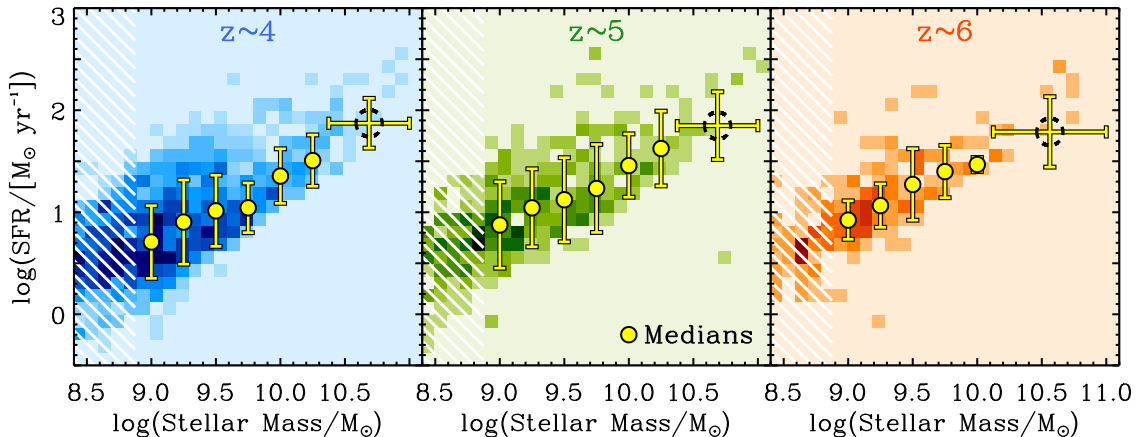


Figure 1: The relation between star formation rate (SFR) and stellar mass for star-forming galaxies in GOODS-S. The darker shaded regions indicate a higher number of galaxies in bins of stellar mass and SFR. Yellow circles and error bars represent the median and  $\sigma_{\text{NMAD}}$  scatter of SFR in bins of stellar mass, and the dashed black circle for a wider, high-mass bin. The white hatched regions mark the completeness limits. The slope or scatter of the relation evolves little from  $z \sim 6$  to 4.

Part of my thesis work involved constructing an SED-fitting procedure in a Bayesian framework, to improve constraints on SFRs and stellar masses. One of the strengths of Salmon et al. 2015 was the recovery of galaxy physical parameters from mock catalogs produced by semi-analytic models (Somerville et al. 2012 MNRAS 423 1992) of galaxies with complex star-formation histories. This proved fruitful on two counts: showcasing the improved SED-fitting methodology and enriching comparisons to cosmological models.

**Nebular Emission at High- $z$ :** Another aspect of my thesis involved the incorporation of nebular line emission to SED models of stellar populations. My public nebular emission procedure has already been used successfully in several studies (e.g., van der Wel et al. 2011 ApJ 742, 111; Tilvi et al. 2013 ApJ 768, 56; Finkelstein et al. 2012 ApJ 756, 164). Ionized gas near star-forming regions will produce strong nebular emission, which can significantly boost the broadband rest-optical flux of high- $z$  galaxies (Schaerer & de Barros 2009), causing the SED to mimic an older, more massive stellar population.

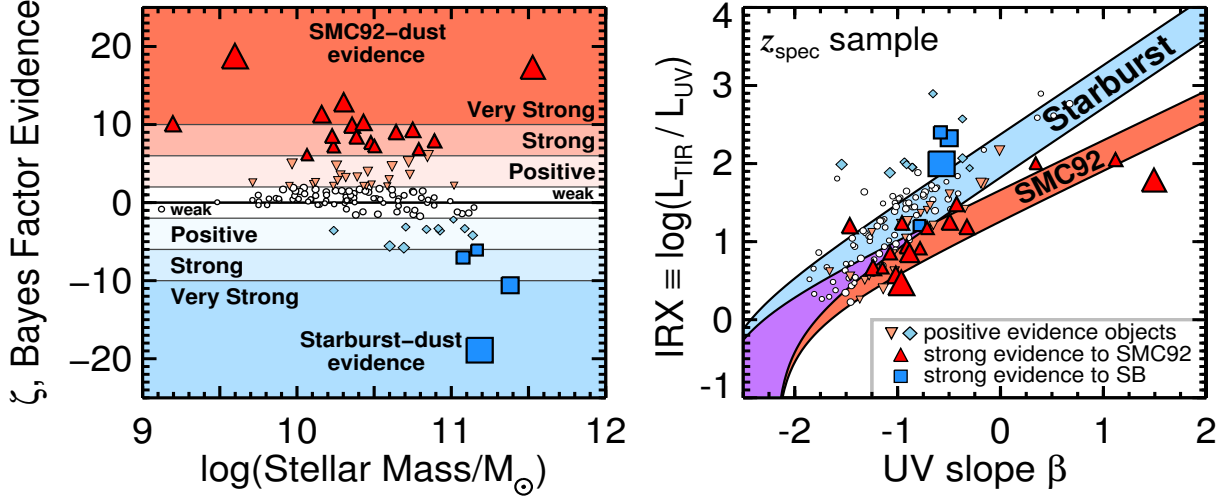


Figure 2: Left: The Bayes-factor evidence as a function of stellar mass for galaxies with spectroscopic redshifts  $1.5 \leq z \leq 2.5$  and  $24 \mu\text{m}$  detections. Darker regions indicate increasing levels of Bayes-factor evidence (Kass & Raftery '95) and are used to select galaxies with strong preference between SMC (Pei et al. 1992 ApJ 395, 130, **red triangles**) or Starburst (Calzetti et al. 2000, **blue squares**) dust laws. Right: UV slope vs. IR excess. Curves show predicted locations of galaxies from stellar population models. Galaxies selected by the strength of their Bayes-factor evidence tend to follow the  $IRX-\beta$  relation of their predicted dust law. This shows that although galaxies of a given  $\beta$  exhibit a range of attenuations, a Bayesian modeling of the rest-frame UV-to-near-IR SED can predict the appropriate shape and scale of their underlying dust law.

### Bayesian Approach to High- $z$ Dust:

Salmon et al. 2015b showcased the power of Bayesian statistics in studying dust in distant galaxies. Dust attenuation affects many aspects of galaxy evolution, including our interpretation of distant galaxy SFRs, and is parameterized by a wavelength-dependent dust-attenuation curve, or dust law. This dust law is usually assumed *a priori* when deriving physical properties of galaxies (Papovich et al. 2001 ApJ 559, 620).

With a sample of CANDELS galaxies at  $z_{\text{spec}} \sim 2$ , Salmon et al. 2015b demonstrates that we can distinguish between dust laws in individual galaxies using only broadband rest-frame UV-to-near-IR photometry, confirmed independently from IR measurements. The results are summarized in Figure 2. Galaxies with more attenuation (high IRX) have a flatter, grayer wavelength dependence to their dust law, and galaxies with low attenuation have steeper, SMC-like dust laws. This result has implications for dust corrections to high-redshift SFRs and potentially hints to radiative transfer predictions of dust production and grain size evolution (Gordon et al. 2001 ApJ 551, 269).

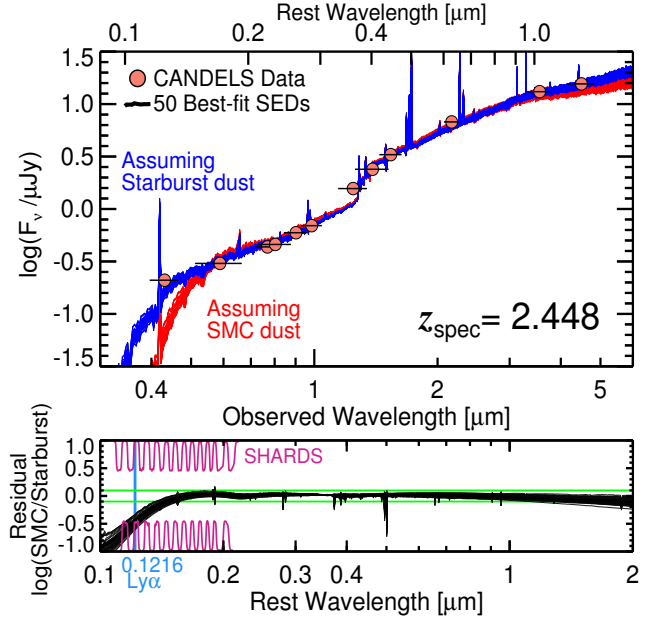


Figure 3: Example of fitting stellar populations to a galaxy SED under two assumptions of the dust law. For reddened galaxies, the color of the two bands in the rest-UV can help constrain the dust law. Bottom: residuals of the SEDs show that SHARDS medium bands can better sample the rest-UV at  $z \sim 3$ .



**Future Work - The High- $z$  Dust Law:** Figure 3 shows a galaxy from Salmon et al. 2015b with rest-UV colors indicative of a starburst (ie., Calzetti et al. 2000) dust law. When the UV-to-near-IR SED suggests heavy reddening, the UV colors constrain the wavelength-dependence of attenuation. Salmon et al. 2015b used this method to constrain the dust law with *HST* data, but the GTC/SHARDS medium bands provide an even finer sampling of the rest-UV. This data can better constrain the shape of the dust law and even produce evidence for the enigmatic 2175Å dust absorption feature, whose presence is poorly constrained in distant galaxies. The Bayesian methods required for this project have already been developed in Salmon et al. 2015b and the SHARDS data is provided through collaboration with CANDELS team members.

**Future Work - The SFRF:** The SFR function offers one of the most direct observations for cosmological models to constrain SF and feedback processes. The biggest challenge is to convolve the UVLF with dust attenuation; even a handful of dust-obscured star-forming galaxies would significantly change the bright end of the SFRF.

Figure 4 shows an example of different approaches to the SFRF. Calculating dust-corrections, and therefore SFRs, from individual galaxies accounts for higher SFRs than when assuming the UV luminosity correlates with  $\beta$ , which in turn correlates with (low levels of) UV attenuation. Smit et al. 2012 ApJ 756, 14 already alluded to the uncertainty at the high end of the SFRF from these massive, red galaxies, which also appear in early determination of  $z > 4$  stellar mass function (Grazian et al. 2015 A&A 575, 96). The uncertainty in dust corrections present two different interpretations of the distribution of SFRs, which leads to different constraints on cosmological models.

One promising resolution is to obtain followup observations from *ALMA* to observe dust continua of these candidate dust-obscured star-forming galaxies. In addition, the far-IR and sub-mm observations will build the science case for a future *JWST* NIRCам and MIRI proposal to obtain rest-frame UV-to-optical coverage of galaxy SEDs beyond  $z > 9$ , which will extend the search for the first significantly reddened galaxies and/or evolved stellar populations. At  $z > 9$ , NIRCам and MIRI provide analogous wavelength coverage to  $z \sim 2$  galaxies by *HST* and *Spitzer*.

I thank the committee for their consideration, and look forward to hearing back soon.

**Other References:** Calzetti et al. 2000 ApJ 533, 682; Salmon et al. 2015a ApJ 799, 183; Salmon et al. 2015b ApJ (submitted); Schaerer & de Barros 2009 A&A 502, 423

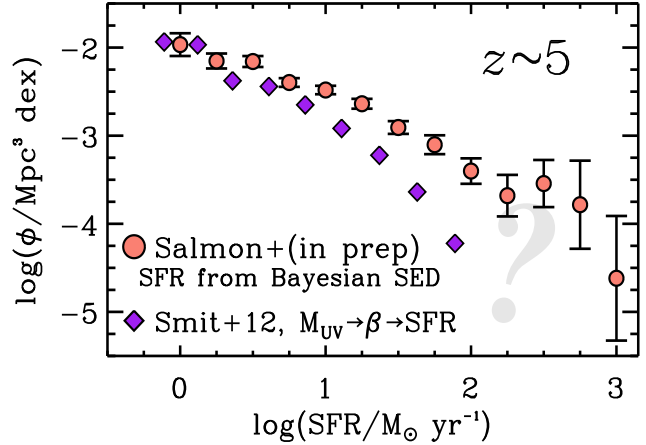


Figure 4: A preliminary look at the SFR function (SFRF) of galaxies in the CANDELS fields at  $z \sim 5$ . The salmon-colored points were derived using Bayesian dust corrections to the UV-based SFRs of individual galaxies. The purple diamonds are from Smit et al. 2012 who convert the luminosity function (LF) to a SFRF assuming smooth  $M_{UV} - \beta$  and  $\beta - A_{UV}$  relations. Similar SFR excess is seen at  $z > 5$ , suggesting the reddening in high-SFR galaxies is non-negligible. However, *ALMA* dust continua measurements are required to confirm such highly obscured SFR.