# Three-dimensional fluorophore orientation imaging with polarized multiview microscopy

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**Abstract:** We show that polarized fluorescence microscopes collect data in the angular frequency domain. We use this result to propose and demonstrate efficient algorithms for reconstructing three-dimensional fluorophore orientations from polarized multiview microscope data.

**OCIS codes:** 180.2520 Fluorescence microscopy, 260.5430 Polarization

**1. Introduction**

**2. Theory**

**3. Results**

*3.1. Typographical Style*

*3.2. Author Names and Affiliations*

*3.3. Abstract*

*3.4. OCIS Subject Classification*

*3.5. Notation*

3.5.1. General Notation

Margins and type size will be set by the OSA LaTeX commands for title, author names and addresses, abstract, references, captions, and so on. The `osameet2.sty` package references `mathptmx.sty` for Times text and math fonts. Authors who require Computer Modern font may modify the style file or, preferably, invoke the package `ae.sty` or similar for optimum output with Computer Modern.

Author names should be given in full with first initials spelled out to assist with indexing. Affiliations should follow the format division, organization, and address—and complete postal information should be given. Abbreviations should not be used. United States addresses should end with ", USA."

The abstract should be limited to no more than words. It should be an explicit summary of the paper that states the problem, the methods used, and the major results and conclusions. If another publication author is referenced in the abstract, abbreviated information (e.g., journal, volume number, first page, year) must be given in the abstract itself, without a reference number. (The item referenced in the abstract should be the first cited reference in the body.)

Two Optics Classification and Indexing Scheme (OCIS) subject classifications should be placed at the end of the abstract with the `\ocis{}` command. OCIS codes can be found at http://www.osapublishing.org/submit/ocis/.

Notation must be legible, clear, compact, and consistent with standard usage. In general, acronyms should be defined at first use.

#### 3.5.2. Math Notation

Equations should use standard LaTeX or AMSLaTeX commands (sample from Krishnan *et al.* [1]).

$$\begin{aligned} \bar{\varepsilon} &= \frac{\int_0 \infty \varepsilon \exp(-\beta\varepsilon)\,\mathrm{d}\varepsilon}{\int_0 \infty \exp(-\beta\varepsilon)\,\mathrm{d}\varepsilon} \\ &= -\frac{\mathrm{d}}{\mathrm{d}\beta}\log\left[\int_0 \infty \exp(-\beta\varepsilon)\,\mathrm{d}\varepsilon\right] = \frac{1}{\beta} = kT. \end{aligned} \tag{1}$$

## 4. Tables and Figures

Figures and illustrations should be incorporated directly into the manuscript, and the size of a figure should be commensurate with the amount and value of the information conveyed by the figure.

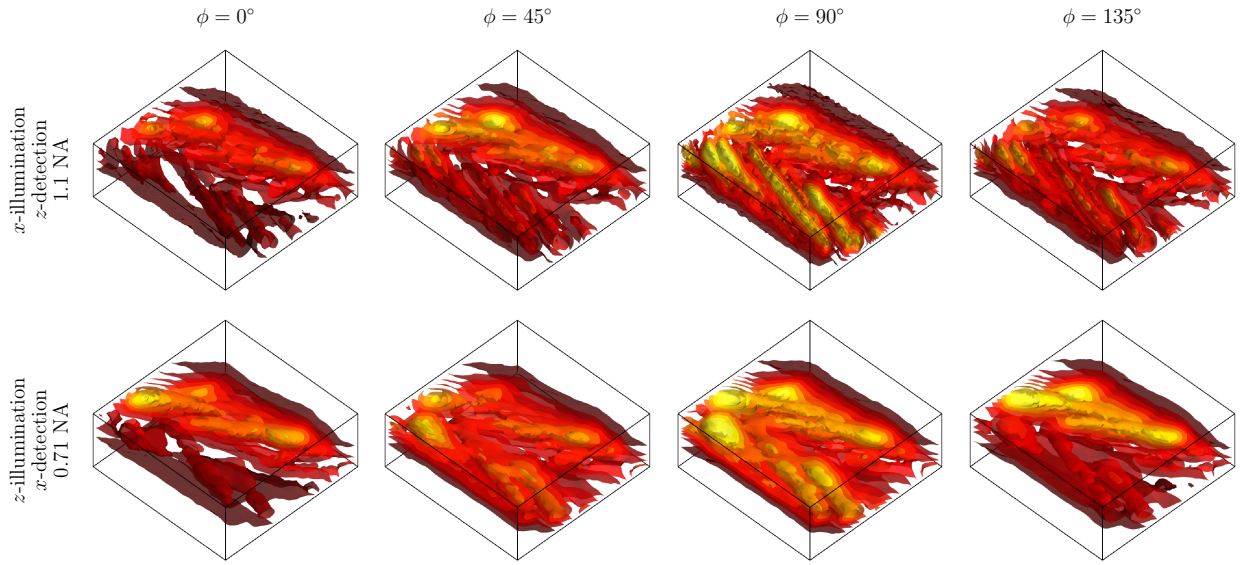


Fig. 1. Sample figure with preferred style for labeling parts.

## 5. References

References should be cited with the `\cite{}` command. Bracketed citation style, as opposed to superscript, is preferred [1–7]. The `osameet2.sty` style file references `cite.sty`. Comprehensive journal abbreviations are available on the CrossRef web site: http://www.crossref.org/titleList/.

### References


1. E. Krishnan, A. M. Shan, T. Rishi, L. A. Ajith, C. V. Radhakrishnan, *On-line Tutorial on LaTeX*, "Mathematics" (Indian TeX Users Group, 2000), http://www.tug.org/tutorials/tugindia/chap11-scr.pdf.
2. C. van Trigt, "Visual system-response functions and estimating reflectance," J. Opt. Soc. Am. A **14**, 741–755 (1997).
3. T. Masters, *Practical Neural Network Recipes in C++* (Academic, 1993).
4. B. L. Shoop, A. H. Sayles, and D. M. Litynski, "New devices for optoelectronics: smart pixels," in *Handbook of Fiber Optic Data Communications*, C. DeCusatis, D. Clement, E. Maass, and R. Lasky, eds. (Academic, 1997), pp. 705–758.

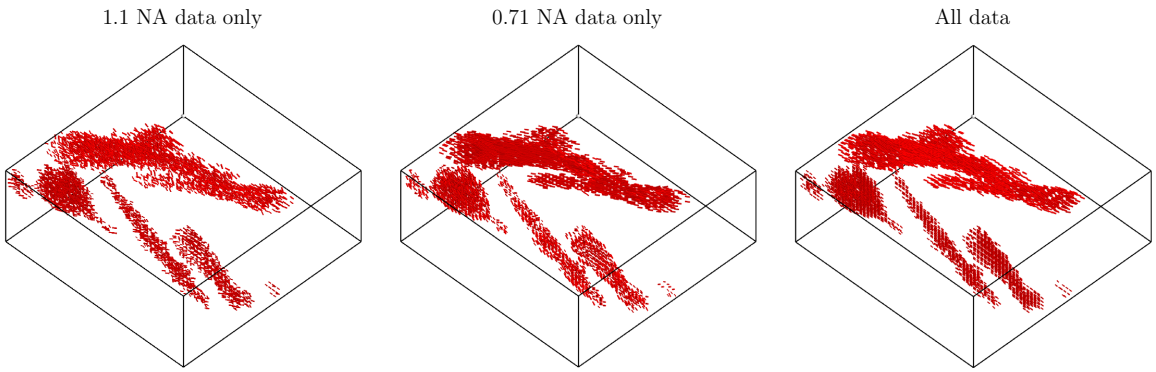


Fig. 2. Sample figure with preferred style for labeling parts.

5. R. E. Kalman,“Algebraic aspects of the generalized inverse of a rectangular matrix,” in *Proceedings of Advanced Seminar on Generalized Inverse and Applications*, M. Z. Nashed, ed. (Academic, 1976), pp. 111–124.
6. R. Craig and B. Gignac, “High-power 980-nm pump lasers,” in *Optical Fiber Communication Conference*, Vol. 2 of 1996 OSA Technical Digest Series (Optical Society of America, 1996), paper ThG1.
7. D. Steup and J. Weinzierl, “Resonant THz-meshes,” presented at the Fourth International Workshop on THz Electronics, Erlangen-Tennenlohe, Germany, 5–6 Sept. 1996.