Calibration Uncertainties Working Group
IACHEC 2016

Systematic errors in calibration are important, and must be dealt with, either by working to eliminate them, or by providing people with means to deal with them: these are the two main goals of this WG.

Schedule

- Mar 1, WG meeting, 9:00am-10:45am IST
  - Intro to WG and pyBLoCXS, Vinay Kashyap
  - Intro to Cal Concordance, Herman Marshall
  - Updates to XSPEC, Keith Arnaud [skype]
  - Status of Cal Concordance Project, Yang Chen/Xufei Wang/Xiao-Li Meng [skype]
  - Discussion
- Mar 2, Improving Cross-Calibration Status, 9:45am-12:45pm IST
  - Monte Carlo constraints on instrument calibration, Jeremy Drake
  - NuSTAR and PyBlocks, Kristin Madsen [skype]
  - Panel Discussion: what next?

Calibration has Uncertainties

- The fundamental equation of observational astronomy

$$C(i,j,k_1,k_2,t_f,\Delta t;\boldsymbol{\theta}) = \int dt \int dxdy \int dE \cdot f(x,y,E,t;\boldsymbol{\theta})$$

$$R(t,t_f)\ PSF(x,y,E;t)\ RMF(E,k;x,y,t)\ ARF(E;x,y,t)$$

- Calibration analysis inverts the usual analysis method
  - Given ARF, RMF, PSF, evaluate expected model spectrum to compare with observed counts
  - Given known model spectrum, compare with observed counts to evaluate ARF, RMF, PSF

Calibration has Uncertainties

- How to find the uncertainties?
- Once known, how to account for them?
- And then how to minimize them?

Calibration has Uncertainties

- How to find and tabulate the uncertainties?
  - `MCCal`
- Once known, how to account for them?
  - `pyBLoCXS`
- And then how to minimize them?
  - `Concordance`

pyBLoCXS

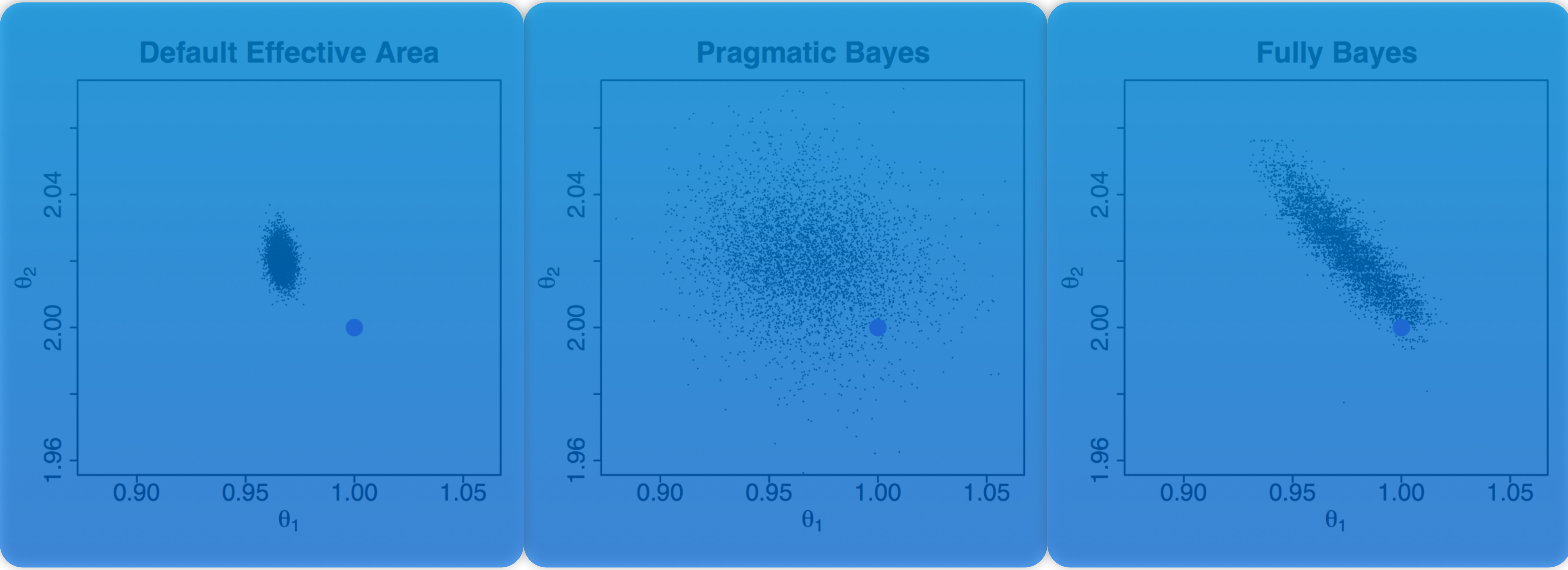
Vinay Kashyap (CXC/CfA)
David van Dyk, Hyunsook Lee, Jin Xu, Jeremy Drake, Pete Ratzlaff, Alanna Connors, et al.

MCMC scheme to incorporate defined calibration uncertainty into analysis

Simulated = Nominal + Bias + randomized components + residuals

fitting to simulated data

$$f(\varepsilon;\theta) = \theta_3\, \varepsilon^{-\theta_1}\, e^{-\theta_2\, \sigma(\varepsilon)}$$



— Jin Xu and Shandong Min

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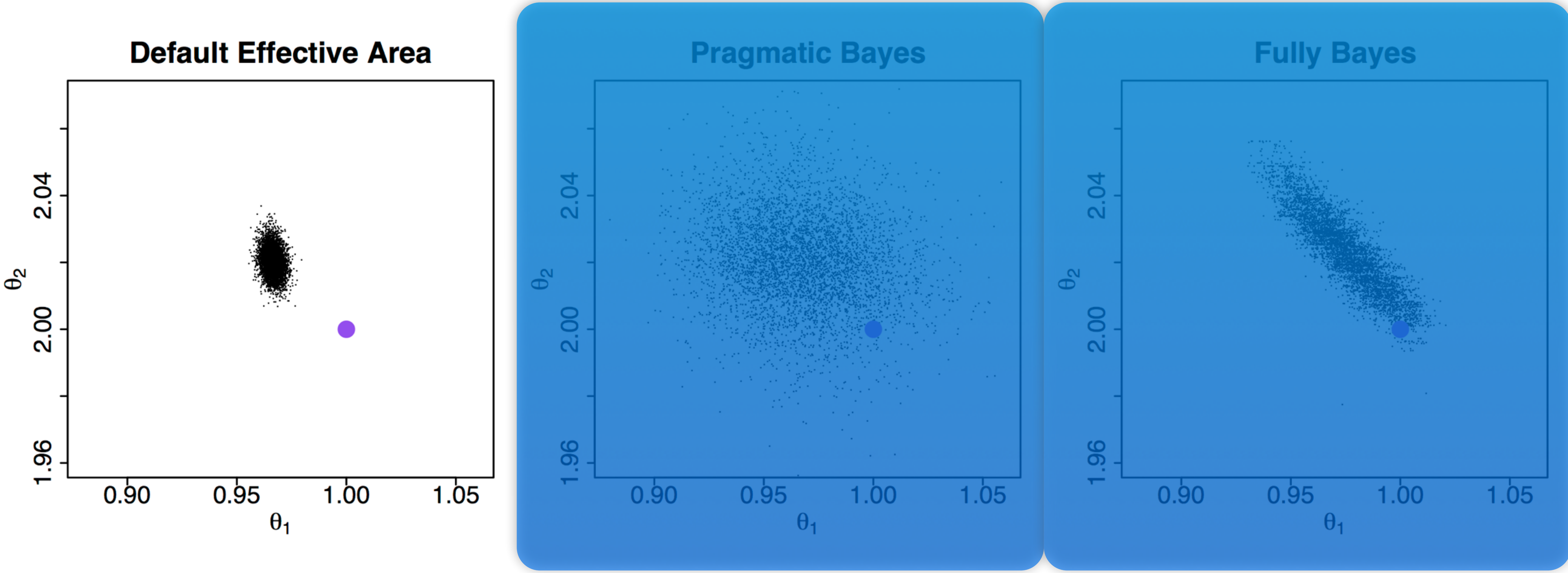

$p(\theta|D,A_0)$

— Jin Xu and Shandong Min

fitting to simulated data

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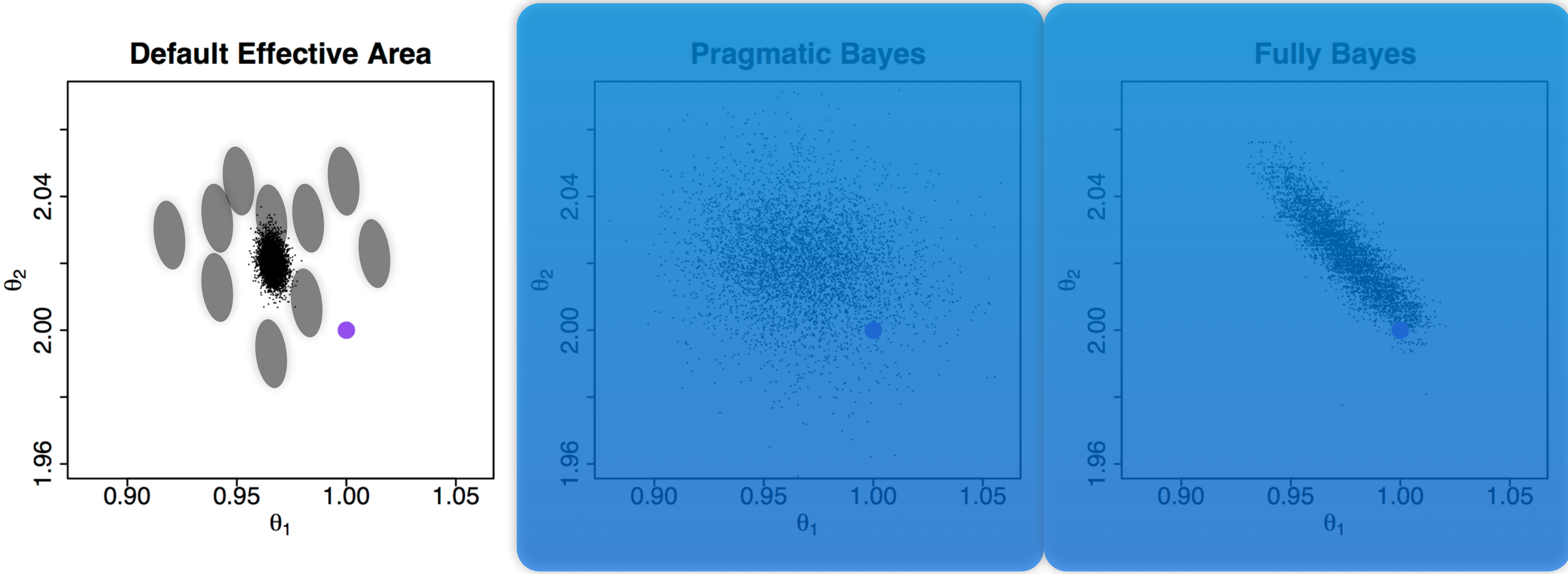

$p(\theta|D,A_0)$

$p(\theta|D,A_i)$

— Jin Xu and Shandong Min

fitting to simulated data

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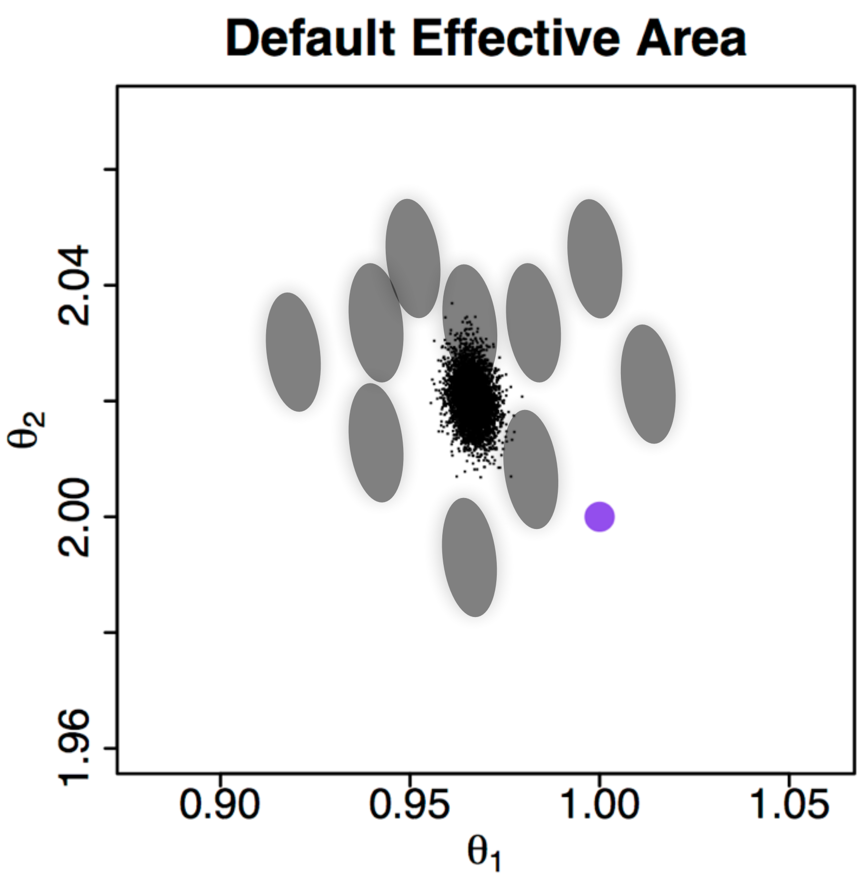
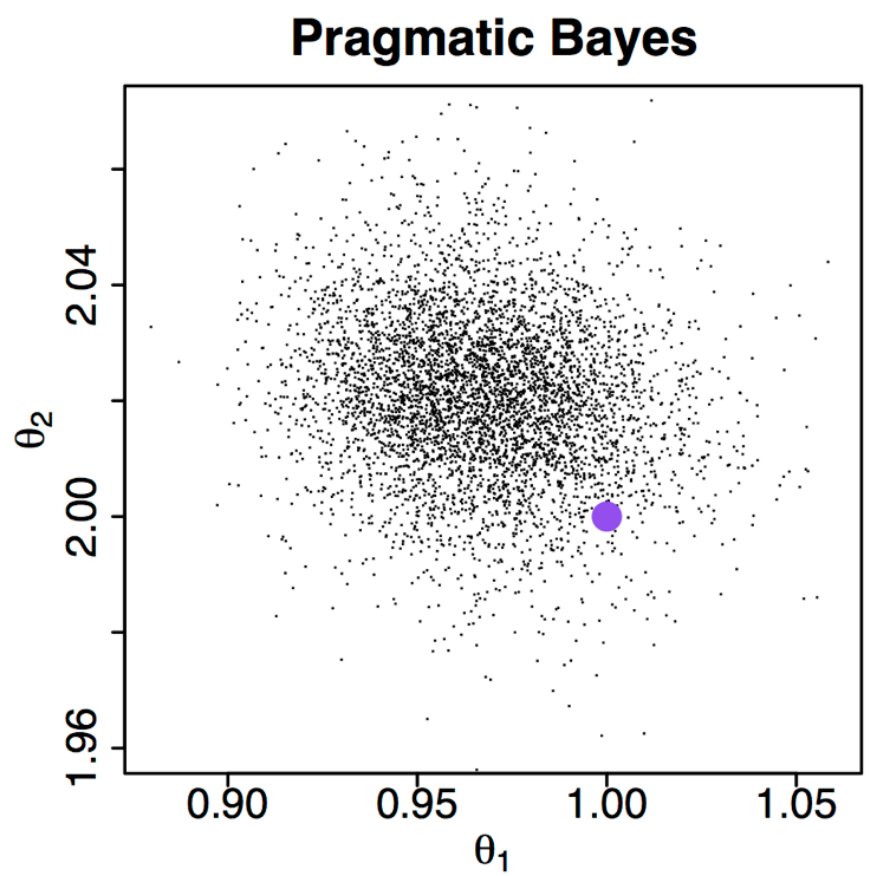
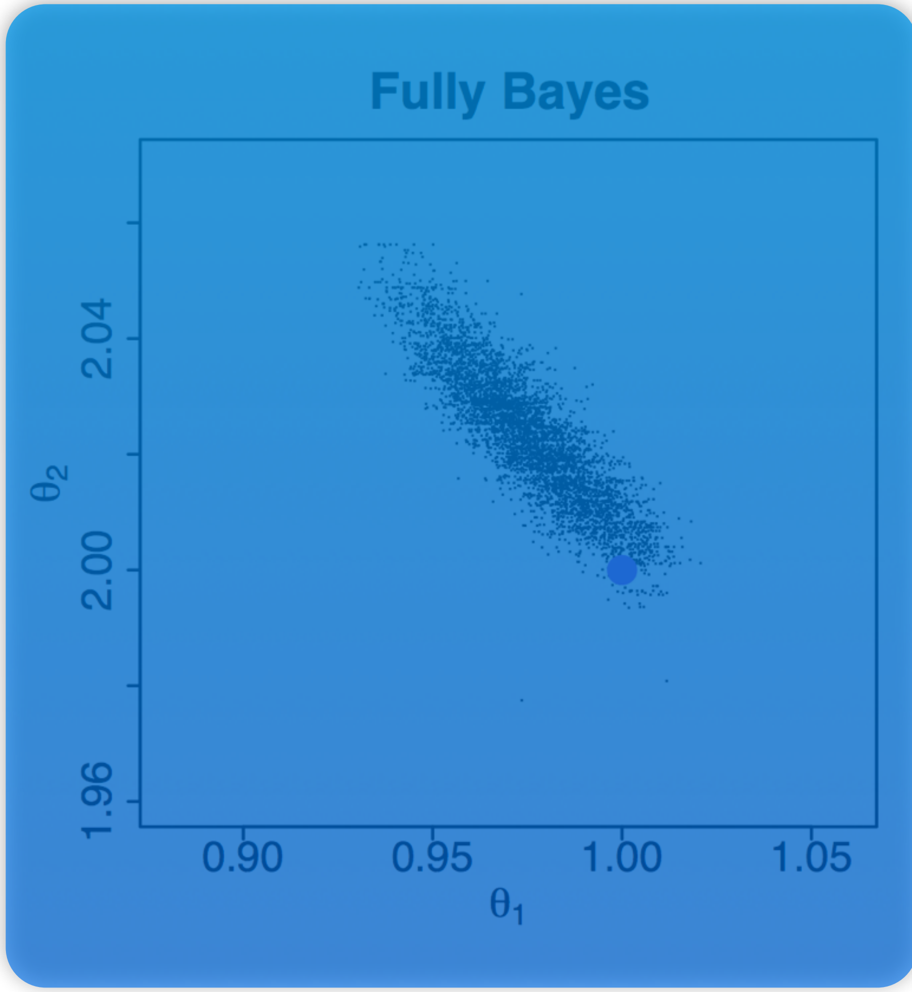






$p(\theta|D,A_0)$

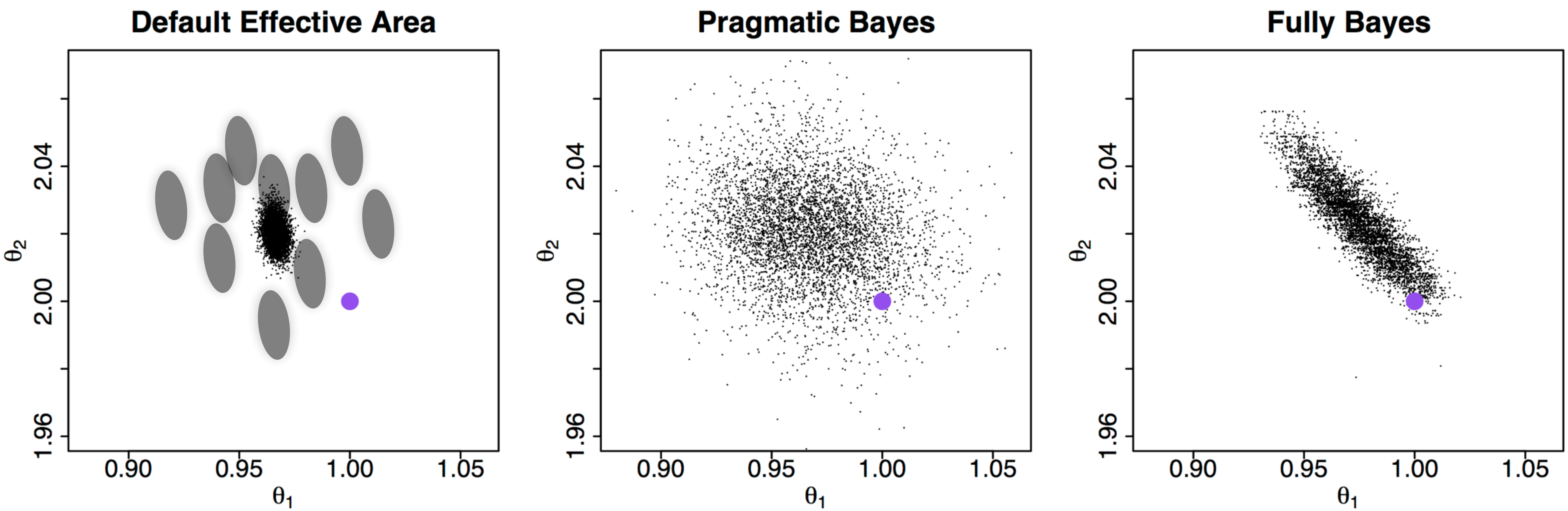
$p(A)\ p(\theta|D,A)$

$p(\theta|D,A_i)$

— Jin Xu and Shandong Min

fitting to simulated data

$$f(\varepsilon;\theta) = \theta_3\, \varepsilon^{-\theta_1}\, e^{-\theta_2\, \sigma(\varepsilon)}$$



$p(\theta|D,A_0)$

$p(A)\ p(\theta|D,A)$

$p(A,\theta|D)$

$p(\theta|D,A_i)$

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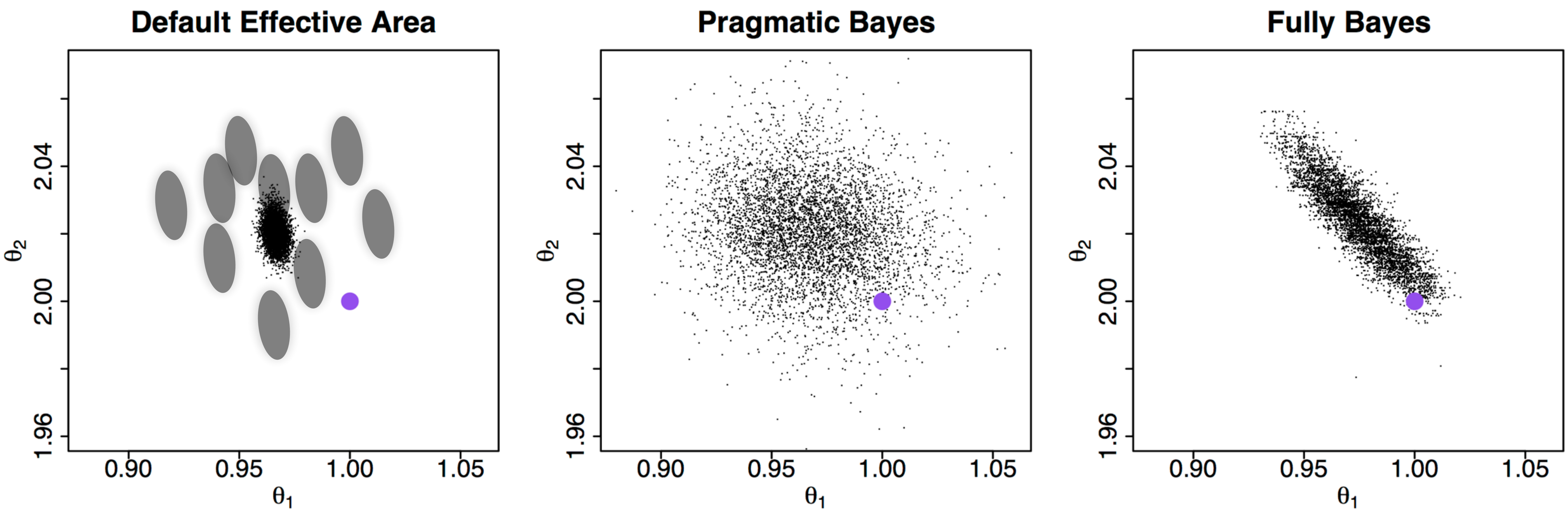
fitting to simulated data

$$f(\varepsilon;\theta) = \theta_3\ \varepsilon^{-\theta_1}\ e^{-\theta_2\ \sigma(\varepsilon)}$$



$p(\theta|D,A_0)$ $p(A)\ p(\theta|D,A)$ $p(A,\theta|D)$

$p(\theta|D,A_i)$ $p(A(\theta'),\theta|D)$

— Jin Xu and Shandong Min

pyBLoCXS resources

- Lee et al. 2011, *Accounting for Calibration Uncertainties in X-ray Analysis: Effective Areas in Spectral Fitting*, ApJ 731, 126 [2011ApJ...731..126L]

- Xu et al. 2014, *A Fully Bayesian Method for Jointly Fitting Instrumental Calibration and X-Ray Spectral Models*, ApJ 794 97X [2014ApJ...794...97X]

- Sherpa (PragBayes): http://cxc.harvard.edu/sherpa/ahelp/pyblocxs.html

- github (FullBayes): https://github.com/astrostat/pyblocxs

- tutorial from IACHEC 2014: http://hea-www.harvard.edu/AstroStat/Demo/pyBLoCXS/IACHEC2014/