WP 1.1
Scalable Solutions for Probabilistic Modelling and Uncertainty Quantification

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- PDRA:
  - Ahmed K. Eldaly (July 2019-Dec. 2021)
- Associated PhDs:
  - Dan Yao (until Oct. 2021)
  - Kristofer Drummond (CENSIS/Leonardo, since Jan. 2020)

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EPSRC
Engineering and Physical Sciences Research Council

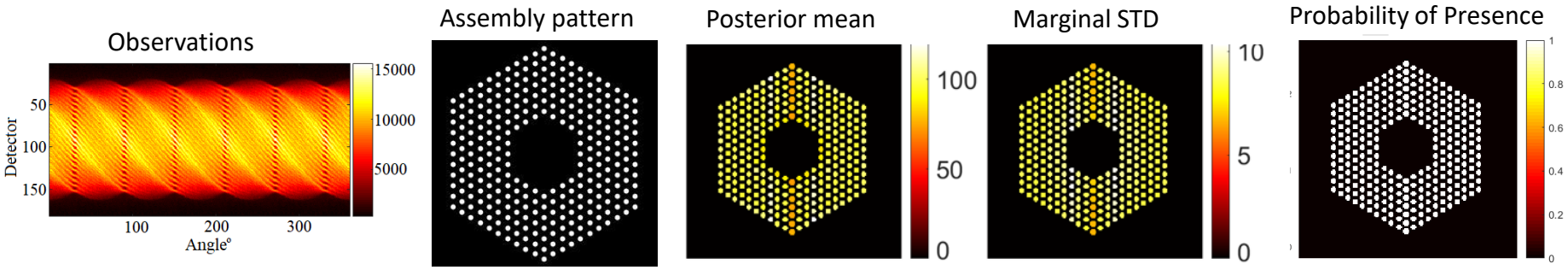
Aims and objectives of the work package

- Development of tools for uncertainty quantification for large-scale inverse problems
- Typical challenges:
  - High-dimensional and/or multimodal imagery
  - Highly ill-posed problems (noisy measurement, compressed data,…)
  - Non standard noise statistics
- Methods investigated
  - High-dimensional Markov chain Monte Carlo (MCMC) methods
  - Approximate Bayesian methods (variational inference)
  - Bayesian filters for dynamic problems

Uncertainty Quantification (UQ) via simulation methods

Activity Estimation and Uncertainty Quantification for Passive Gamma Emission Tomography

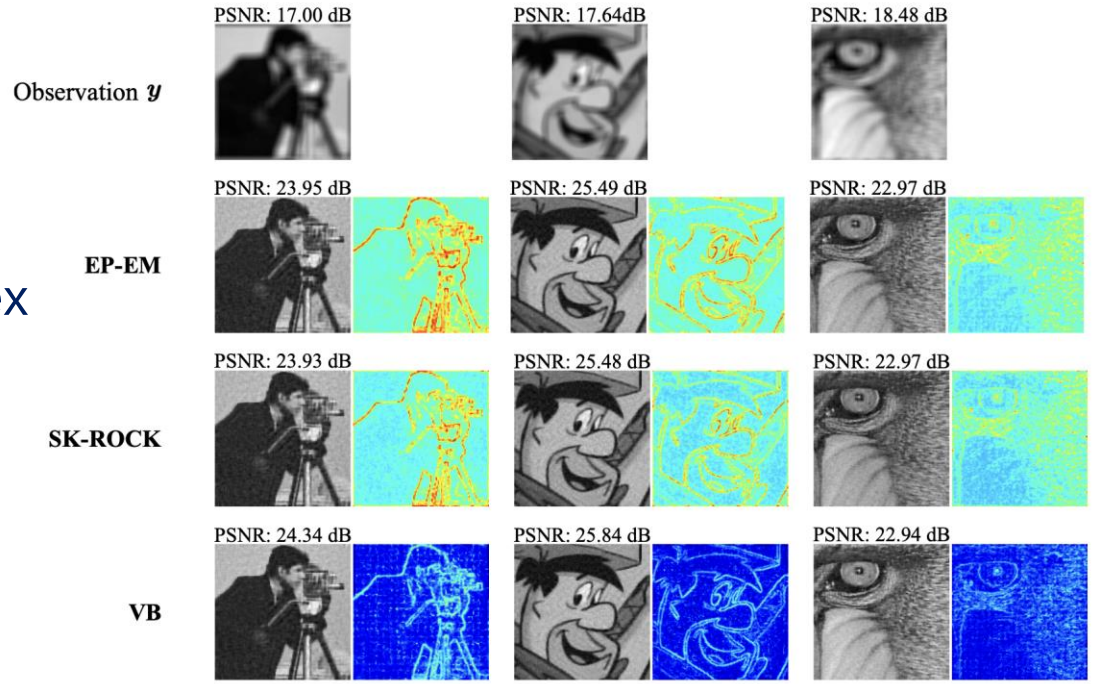
- Poisson and Gaussian noise models
- Hierarchical Bayesian model with different image priors
- Bayesian inference using MCMC
  - Posterior means and uncertainty quantification (marginal variances)



A. K. Eldaly et al. ‘’Bayesian Activity Estimation and Uncertainty Quantification for Passive Gamma Emission Tomography’’, J. of Imaging, 2021.

Approximate inference for scalable UQ

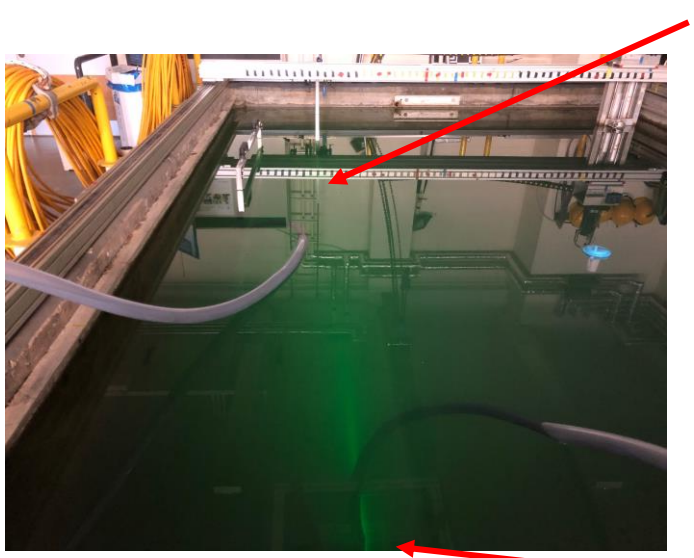
- Expectation-Propagation for linear inverse problem
  - Patch-based and non-convex image priors
  - Hyperparameter estimation (on-going).
  - Application to deconvolution

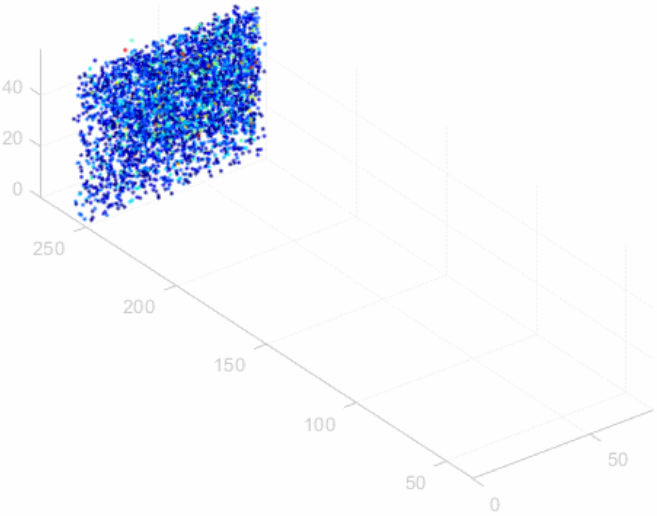


- D. Yao et al., "Patch-Based Image Restoration using Expectation-Propagation", SIAM J. Imaging Sci., 2021, to appear.
- D. Yao et al., "Fast Scalable Image Restoration using Total Variation Priors and Expectation-Propagation ", 2021, submitted (available on arxiv)

Scalable 3D imaging

- Real-time implementation
  - Algorithm comparison (10fps)
  - Underwater experiments (3.4m) – Single-photon group (HWU)





  - Collaborations with Leonardo UK and MBDA

- Kris Drummond et al., ''Joint surface detection and depth estimation from single-photon Lidar data using ensemble estimators'', SSPD 2021, Edinburgh.
- J. Tachella et al., "Real-time 3D reconstruction from single-photon Lidar data using plug-and-play point cloud denoisers", Nature Comm., 2019.