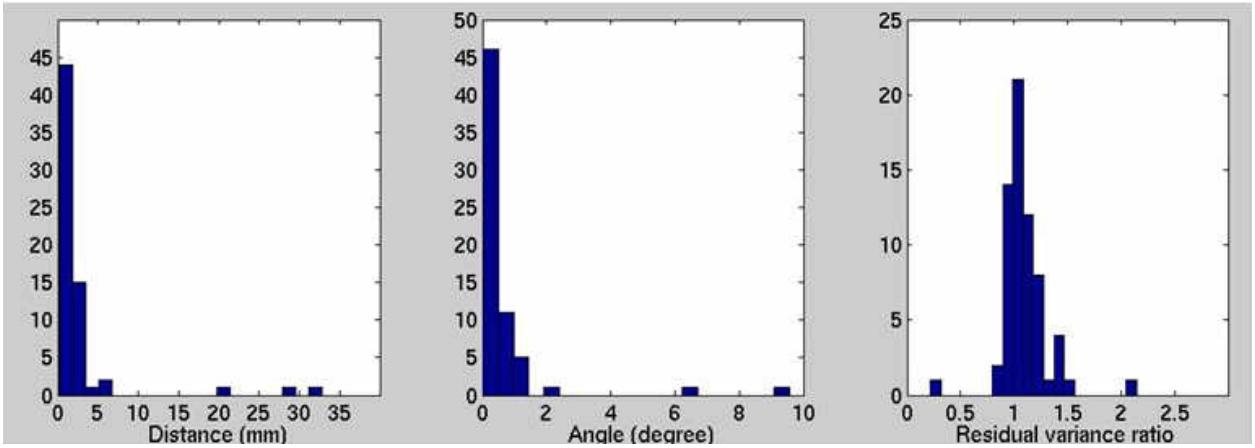
DIPFIT vs BESA study using the spherical head model

Arnaud Delorme, 2005

We (AD) checked the results of fitting equivalent dipoles with DIPFIT (spherical model) against results of BESA(3.0) for independent components of data recorded in a working memory task in our laboratory. There were 72 channels, of which 69 were used for dipole fitting. In particular, we excluded tow EOG channels and the reference channel. We performed ICA on data from three subjects and fit all 69 resulting components with single dipoles using BESA (see the BESAFIT plugin Appendix) and DIPFIT. We then compared only those dipoles whose residual variance was less than 15% (see plot below).



Distances between equivalent dipole locations returned by DIPFIT1 and BESA(3.0) were less than 3 mm (left panel) Note: The outliers were infrequent failures to converge by either algorithm. Dipole angle differences were below 2 degrees (middle panel). Residual variances (mismatch between the component scalp map and the model pole projection) were near equal (right panel). A few dipoles were localized with residual variance below 15% by DIPFIT but not by BESA (4 of 213 components); a few others with residual variance below 15% by BESA but not by DIPFIT (8 of 213 components). Optimization nonlinearities may account for these small differences between the two algorithms, as the solution models used in the two programs are theoretically identical.

The main advantage of using DIPFIT over BESA for localization of equivalent dipoles for independent component scalp maps is that it is integrated into MATLAB and EEGLAB, and can be used in batch processing scripts. BESA has additional capabilities not relevant to DIPFIT. Succeeding versions of BESA did not allow a batch processing option.

Spherical model error

The following article in Frontiers Corrected Four-Sphere Head Model for EEG Signals claim "errors in the formulas [for the spherical model] both in the original paper and in the book", and then refer to a 1998 paper and 2006 book. It seems to me that Srinivasan made an error in 1998 that was copied in his contribution to Nunez' book in 2006. However, the author have not looked up

the original original work, which as far as we know is https://www.ncbi.nlm.nih.gov/pubmed/95707 which is from 1979. And note that in the 2nd half of the ’80s and certainly in the ‘90s the 4-concentric-sphere model was widely already (e.g. in BESA above). The version of BESA we used to compare with Dipfit was BESA 3.0 which was likely release before 1998 since it was released before BESA 99 (in 1999).

Our implementation in Dipfit (and Fieldtrip) was programmed by Robert Oostenveld and is based on the Habilschrift (sort of advanced PhD thesis that only exists in Germany) from Bernd Lutkenhoner from 1992. That habilschrift is not available in pdf or online, but Robert Oostenveld has a paper copy. The reason Robert Oostenveld used that description is that it includes coordinate transformations for the dipole to be off from the z-axis, i.e. at a arbitrary location in the brain. Right now, until proven wrong, we don’t see a reason why the implementation in Dipfit would be wrong, or that it would be based on an incorrect published description.

There is another function to perform spherical source localization in Brainstorm https://github.com/brainstorm-tools/brainstorm3/blob/master/toolbox/forward/bst_eeg_sph.m which is an approximation (Dipfit uses an exact computation, albeit a series expansion that is truncated by default at order 60). It would be worth to compare the results of this function with the result of Dipfit.