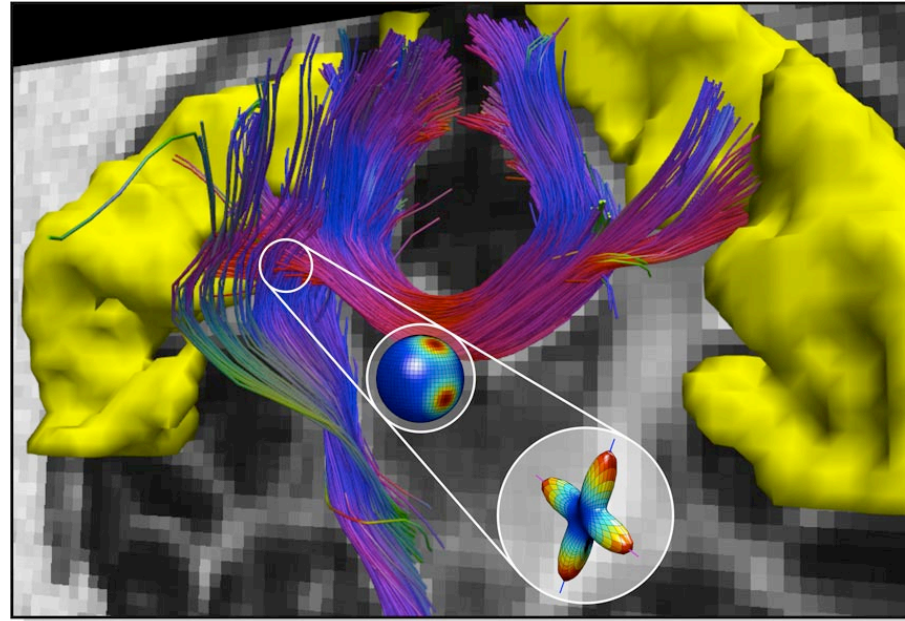


# Diffusion MRI reconstruction contest / workshop



May 02<sup>nd</sup>, 2012



*Centre Convencions Internacional Barcelona (CCIB)  
Barcelona, Spain*



# Today's agenda

- Summary of the contest
- Presentations from each team
- Results and ranking
- Round table discussion

# **The contest**

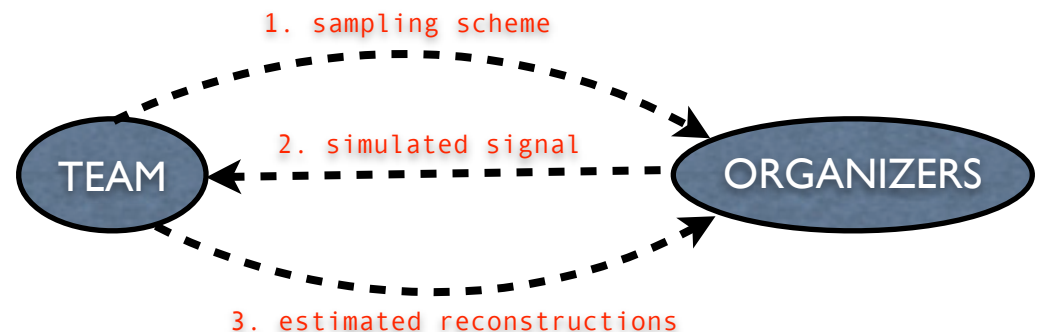
# The contest: an overview

- **MOTIVATION:**

- recently, *many methods* have been proposed to reconstruct dMRI data
- *no comprehensive comparison* among various methods exist
- *compare different methods* using the same framework

- **STRUCTURE:**

- *training data* was released to teams for testing their methods on a known ground-truth
- evaluation of reconstructions performed on *testing data* with unknown ground-truth



# The contest: synthetic data

- Signal simulated with classical **Multi Tensor model**

$$E(\vec{q}) = E_0 \sum_{i=1}^M f_i \exp(-b \hat{q}^T \mathbf{D}_{(i)} \hat{q})$$

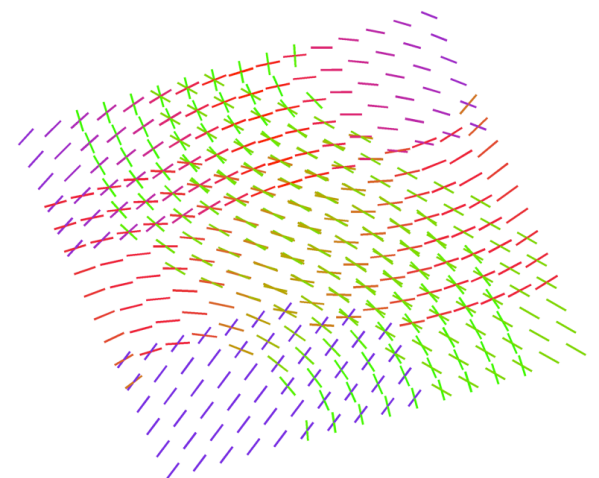
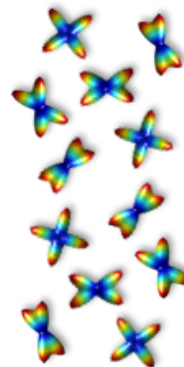
- **Rician noise** was added with several SNR ( $5 \leq \text{SNR} \leq 40$ )

$$E_{\text{noisy}} = \sqrt{(E + \epsilon_1)^2 + \epsilon_2^2}$$

where  $\epsilon_1, \epsilon_2 \sim \mathcal{N}(0, \sigma^2)$  and  $\sigma = \frac{E_0}{\text{SNR}}$  .

- Two synthetic **phantoms**

- Independent Voxels
- Structured Field



# The contest: evaluation criteria (1/2)

## 1) Estimation of the ODF

$$MSE = \frac{\|ODF_{true} - ODF_{estimated}\|_2^2}{\|ODF_{true}\|_2^2}$$

$$KL = \sum_{\hat{q}} ODF_{estimated}(\hat{q}) \ln \frac{ODF_{estimated}(\hat{q})}{ODF_{true}(\hat{q})}$$

# The contest: evaluation criteria (1/2)

## 1) Estimation of the ODF

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$$KL = \sum_{\hat{q}} ODF_{estimated}(\hat{q}) \ln \frac{ODF_{estimated}(\hat{q})}{ODF_{true}(\hat{q})}$$

## 2) Number of fiber compartments

$$Pd = \frac{|M_{true} - M_{estimated}|}{M_{true}}$$

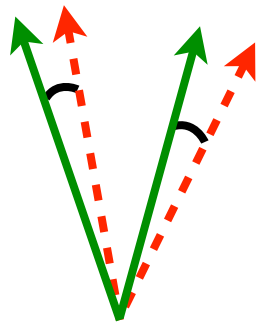
$n^-$  = number of under-estimated compartments

$n^+$  = number of over-estimated compartments

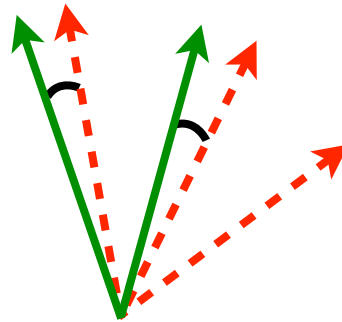
# The contest: evaluation criteria (2/2)

## 3) Angular error

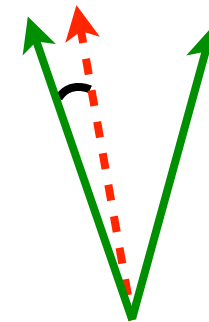
$$AE = \arccos \left( \vec{d}_{true} \cdot \vec{d}_{estimated} \right) \frac{180}{\pi}$$



$$M_{true} = M_{estimated}$$



$$M_{true} < M_{estimated}$$



$$M_{true} > M_{estimated}$$

- $AE_1$ : average over all true and estimated compartments
- $AE_2$ : same as  $AE_1$ , but uses a weighted average (volume fractions  $f_i$ )
- $AE_3$ : same as  $AE_1$ , but doesn't consider missing/extra fibers



# The contest: final ranking

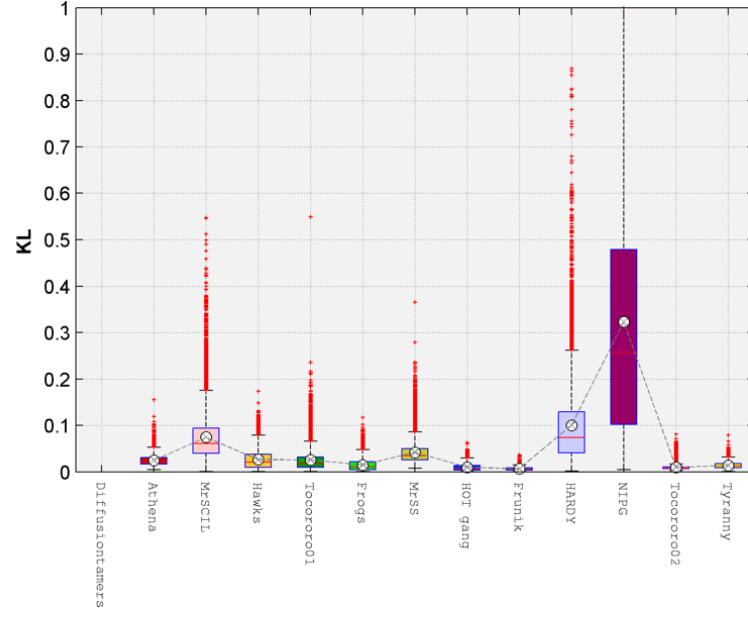
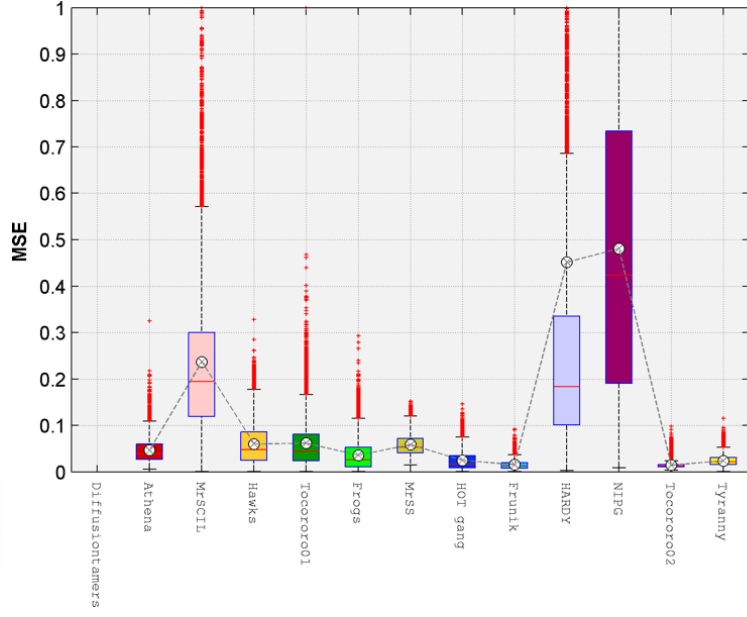
- The **final ranking** is based on:
  - overall performance on Testing\_IV phantom
  - overall performance on Testing\_SF phantom
  - performance at specific crossing angles: 30°, 45°, 60°
  - 3 error metrics: MSE, Pd, AE<sub>1</sub>
  - 3 levels of noise: SNR = 10, 20, 30
- **45 separate rankings**, with points assigned according to the relative position in each:  
 $1^\circ \rightarrow 25, 2^\circ \rightarrow 18, 3^\circ \rightarrow 15, 4^\circ \rightarrow 12, 5^\circ \rightarrow 10, 6^\circ \rightarrow 8, 7^\circ \rightarrow 6, 8^\circ \rightarrow 4, 9^\circ \rightarrow 2, 10^\circ \rightarrow 1$
- The team collecting more points is the **winner**

# **The methods**

# Results and ranking

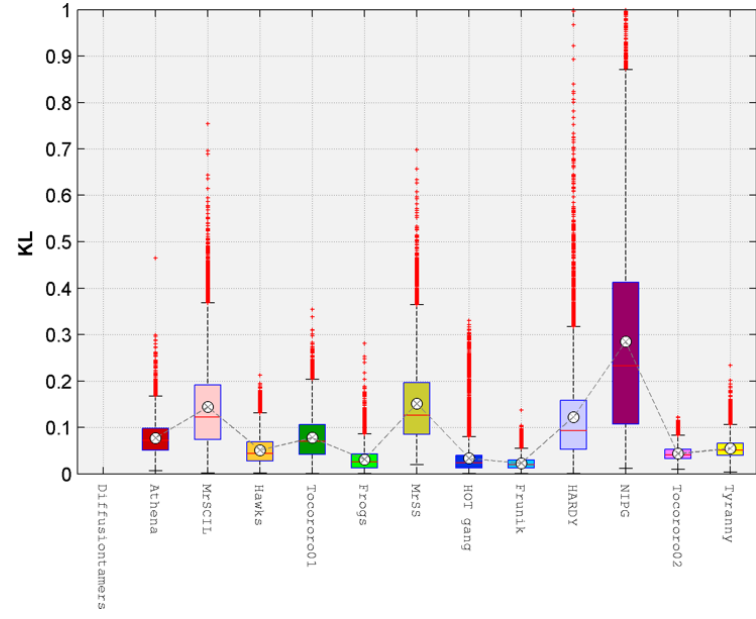
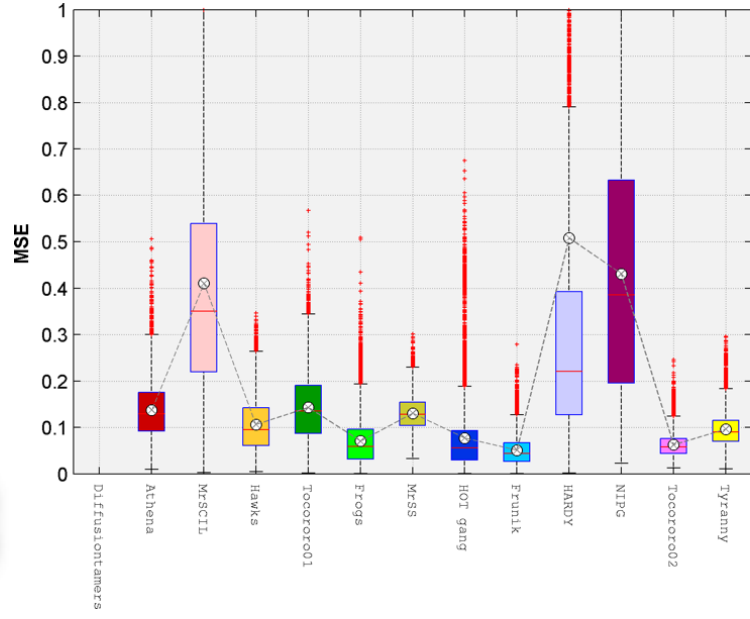
# Results: overall IV <sub>(1/6)</sub>

ODF estimation  
SNR = 30



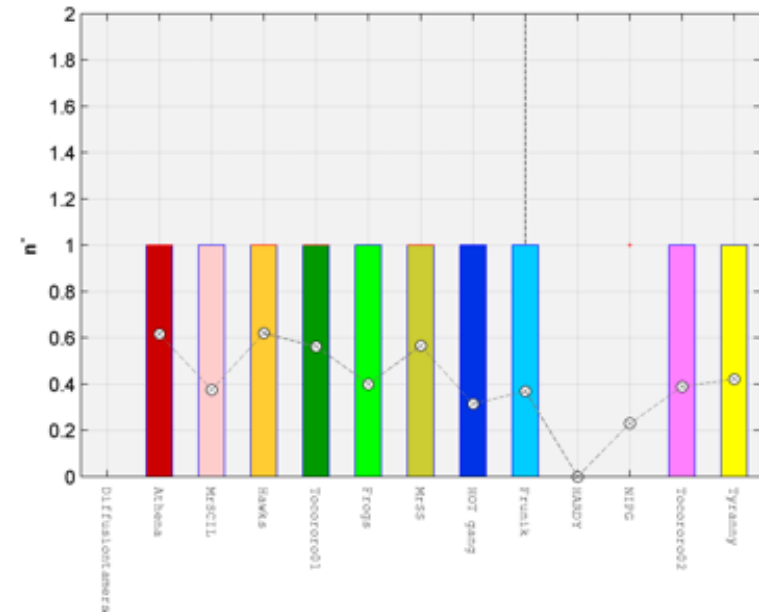
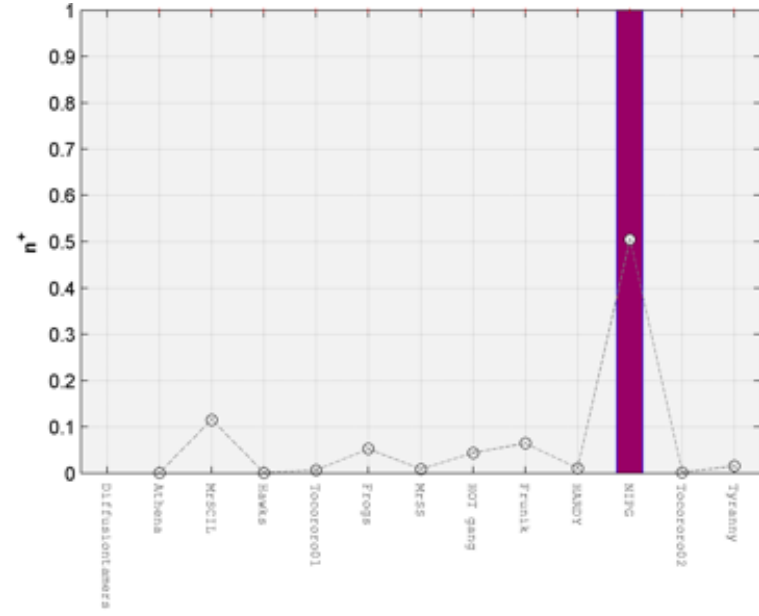
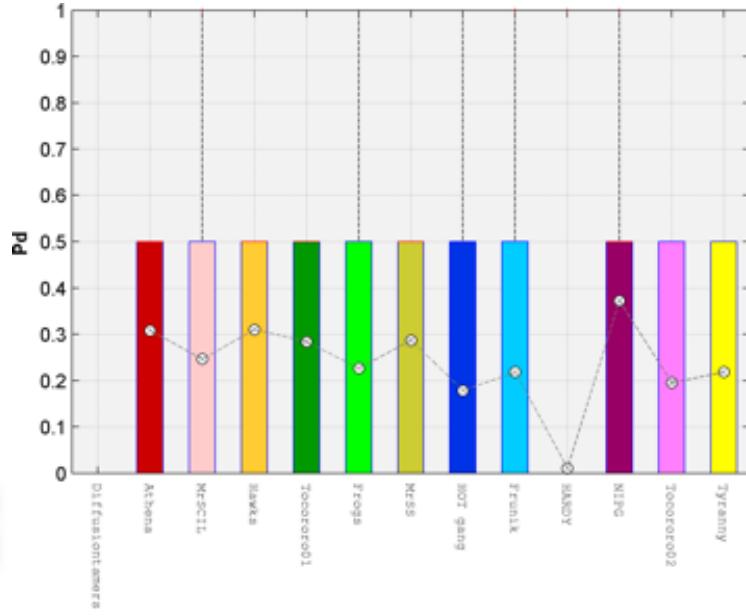
# Results: overall IV <sub>(2/6)</sub>

ODF estimation  
SNR = 10



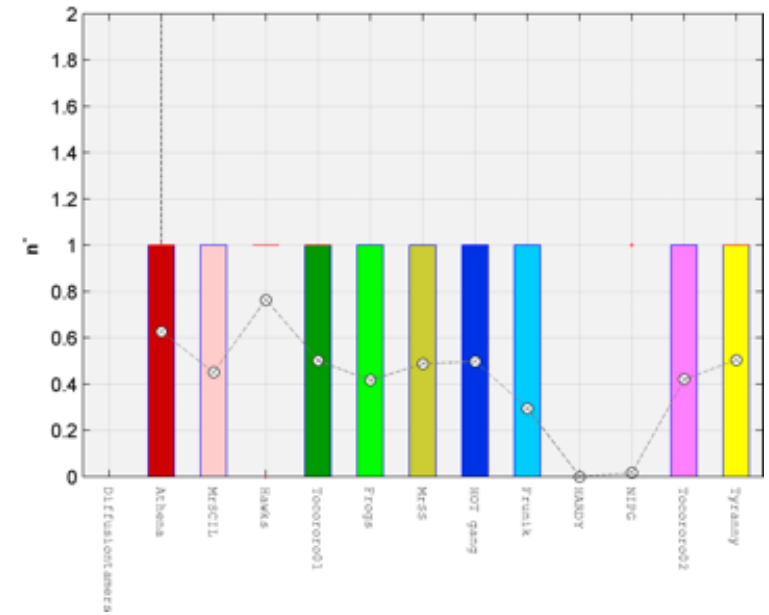
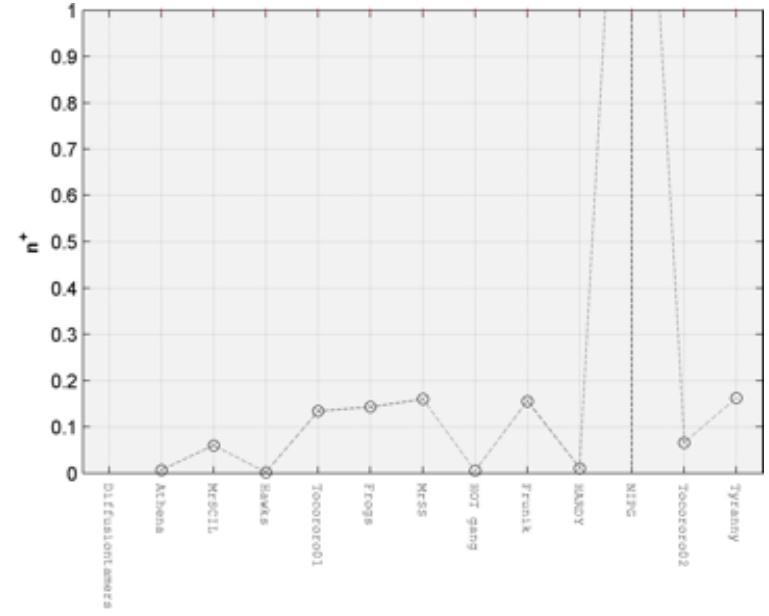
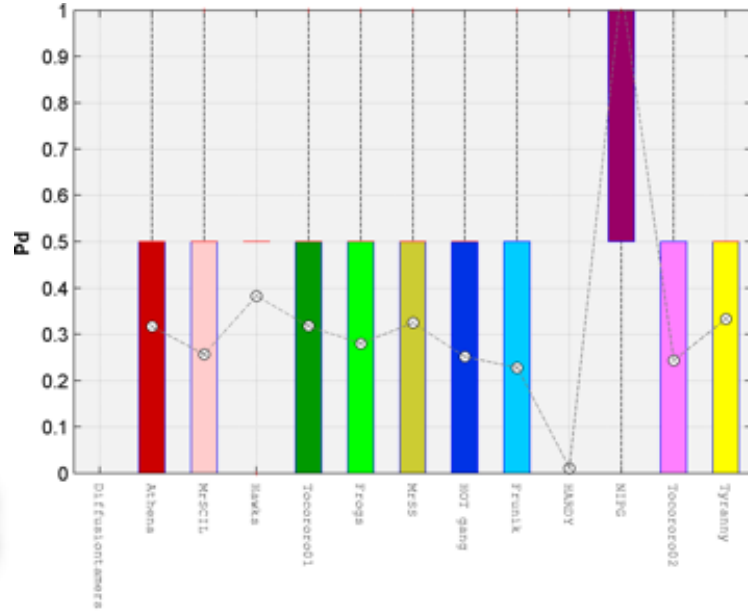
# Results: overall IV <sub>(3/6)</sub>

# compartments  
SNR = 30



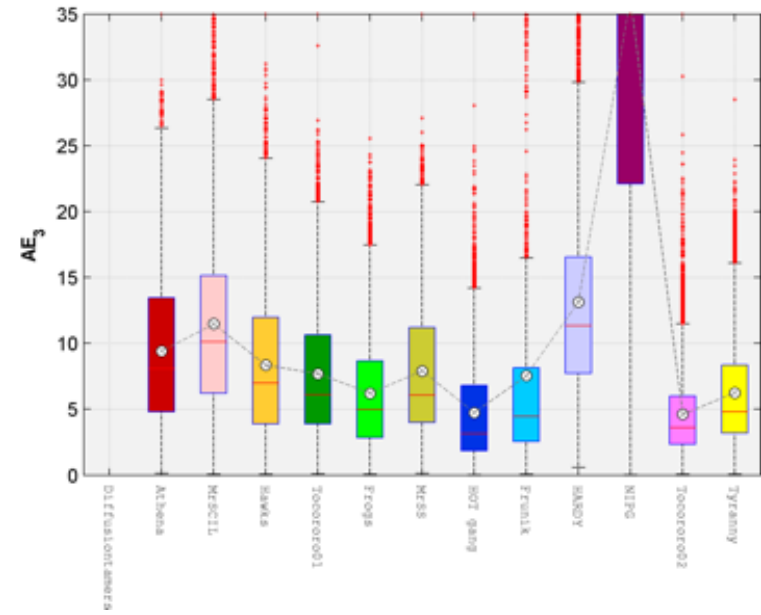
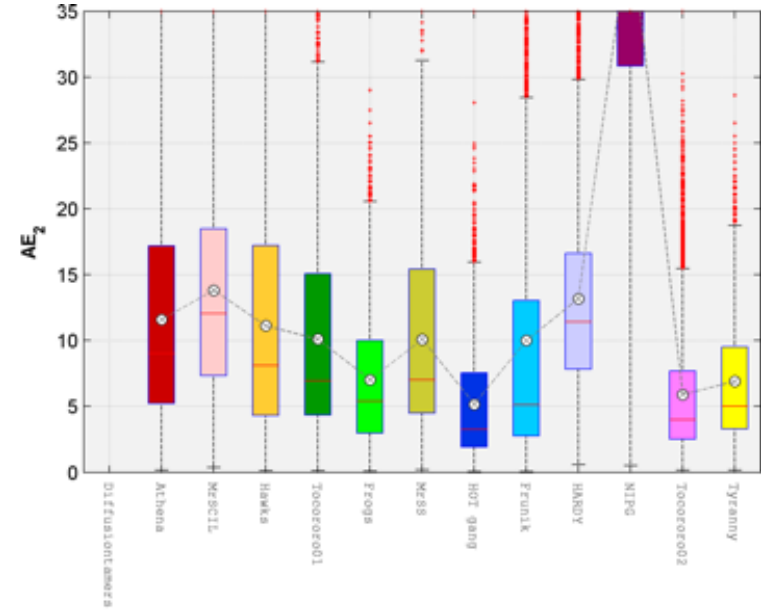
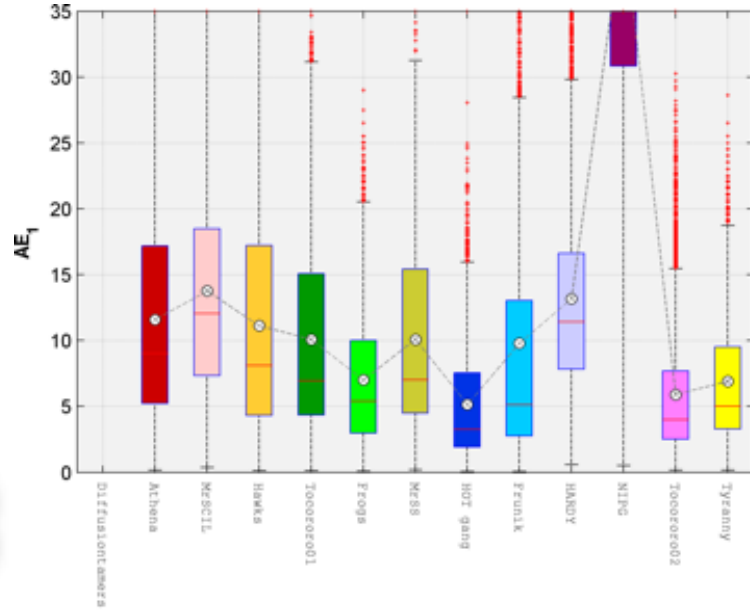
# Results: overall IV <sub>(4/6)</sub>

# compartments  
SNR = 10



# Results: overall IV <sub>(5/6)</sub>

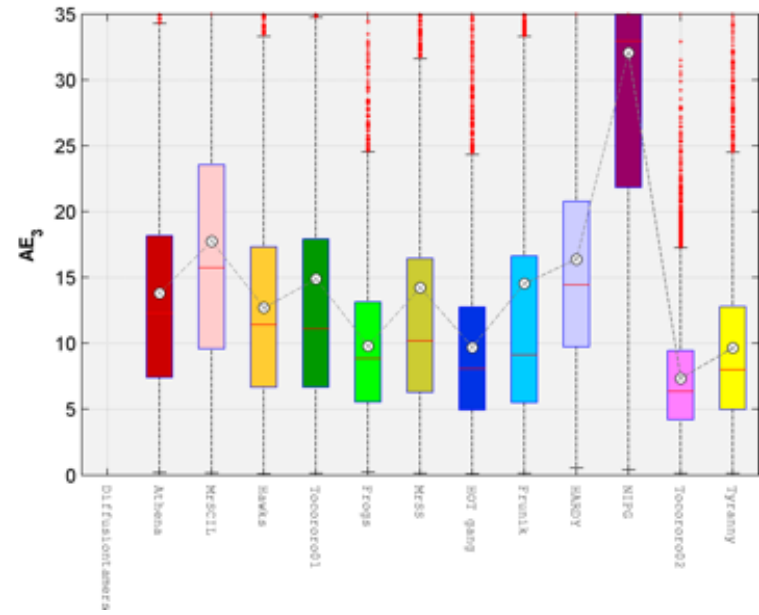
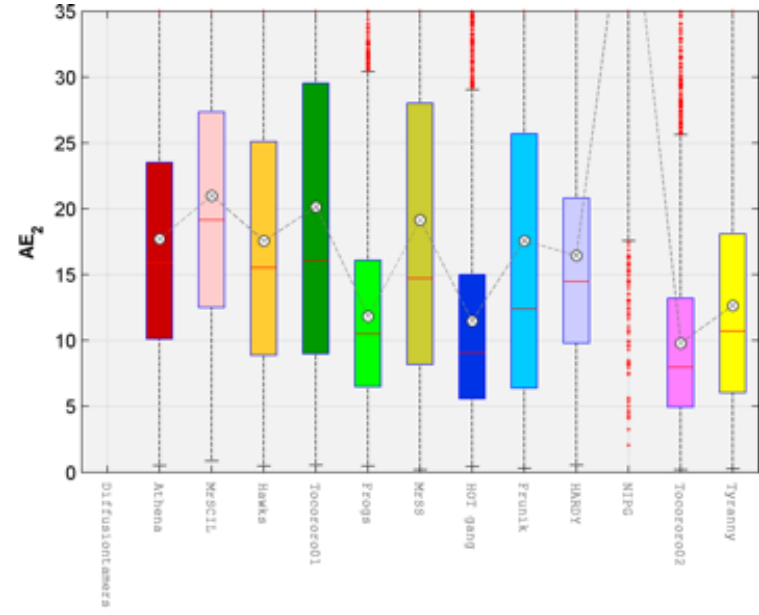
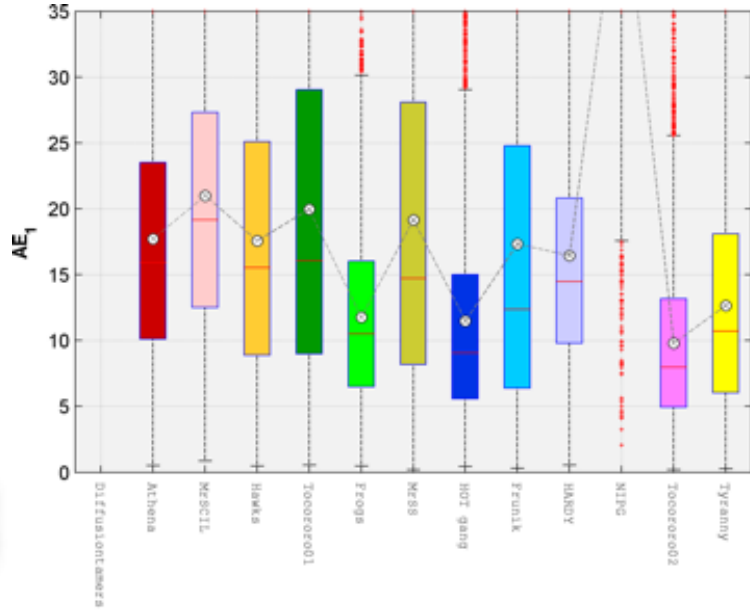
Angular error  
SNR = 30





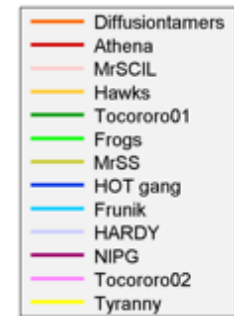
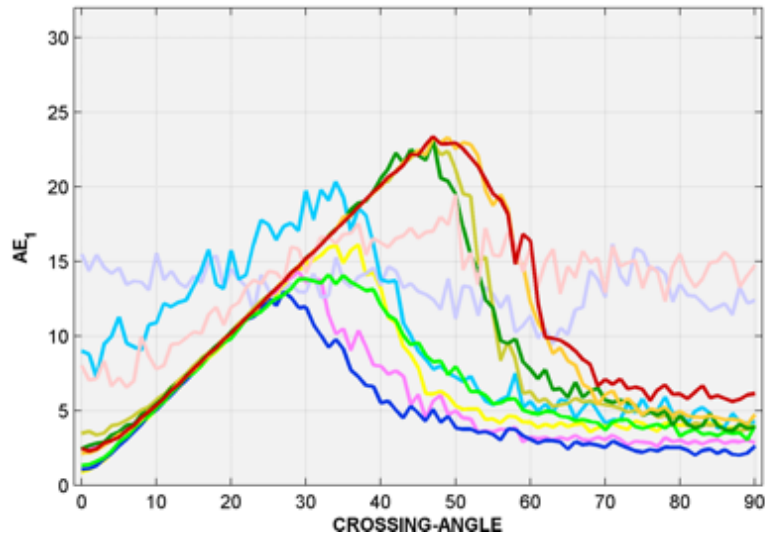
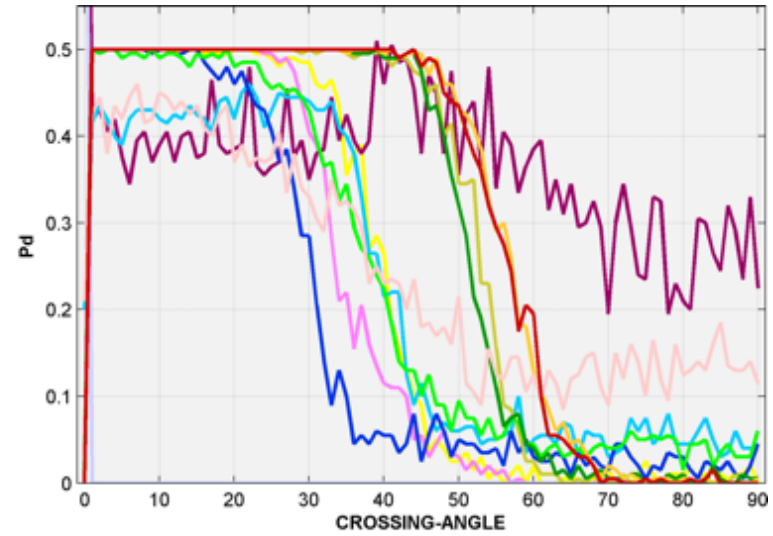
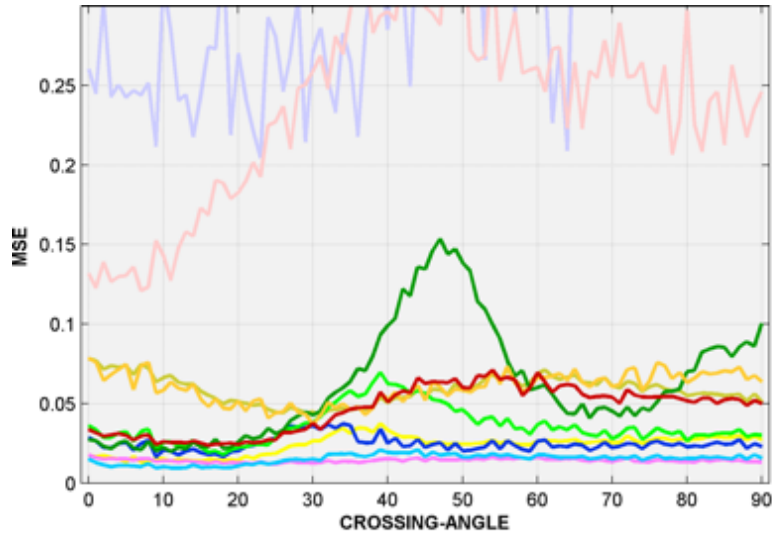
# Results: overall IV <sub>(6/6)</sub>

Angular error  
SNR = 10



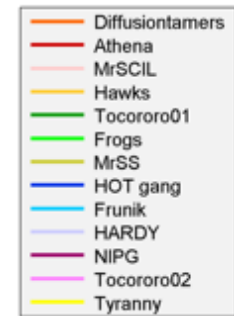
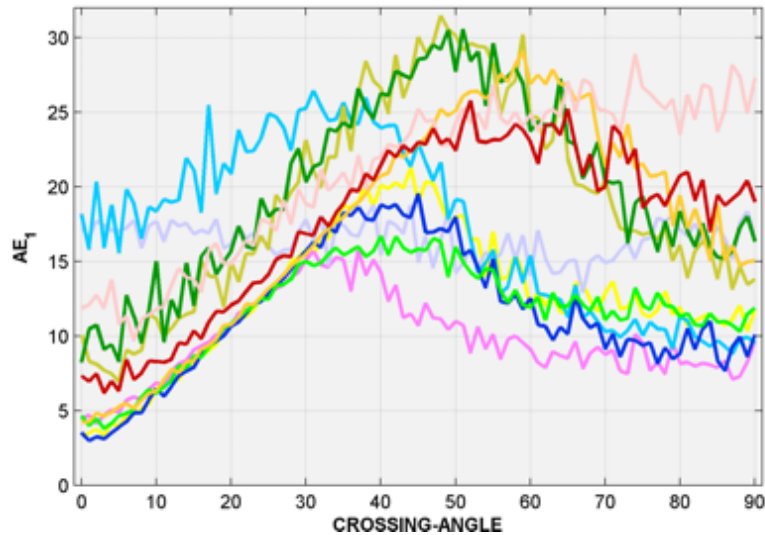
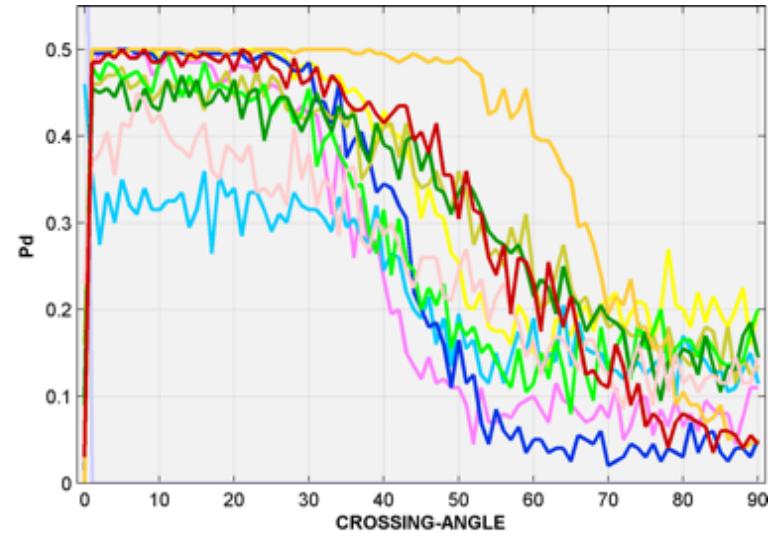
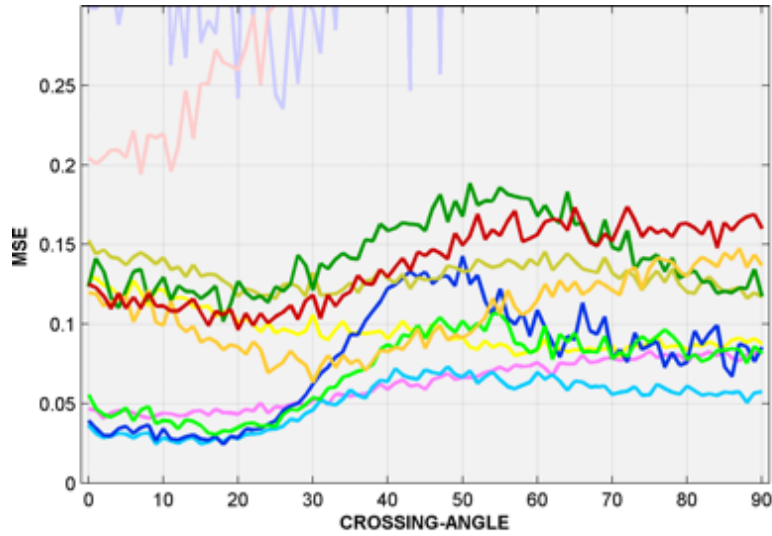
# Results: crossing-angle <sub>(1/2)</sub>

SNR = 30



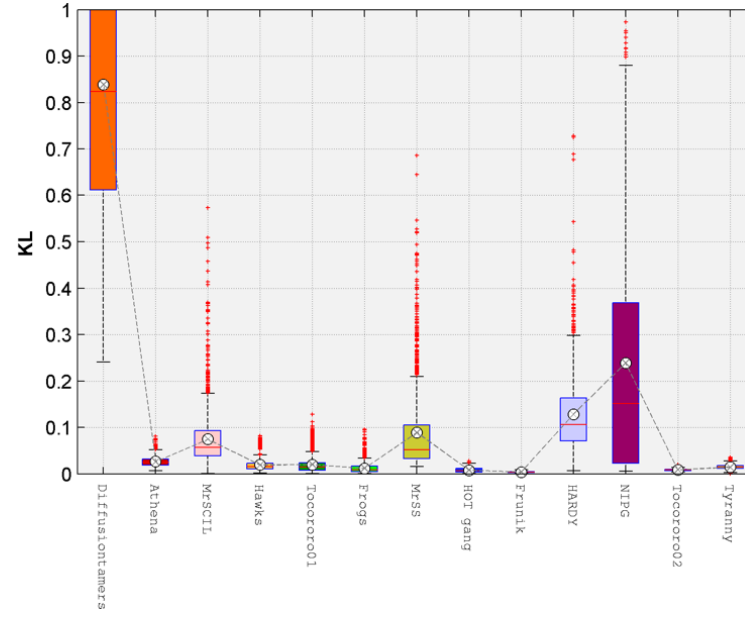
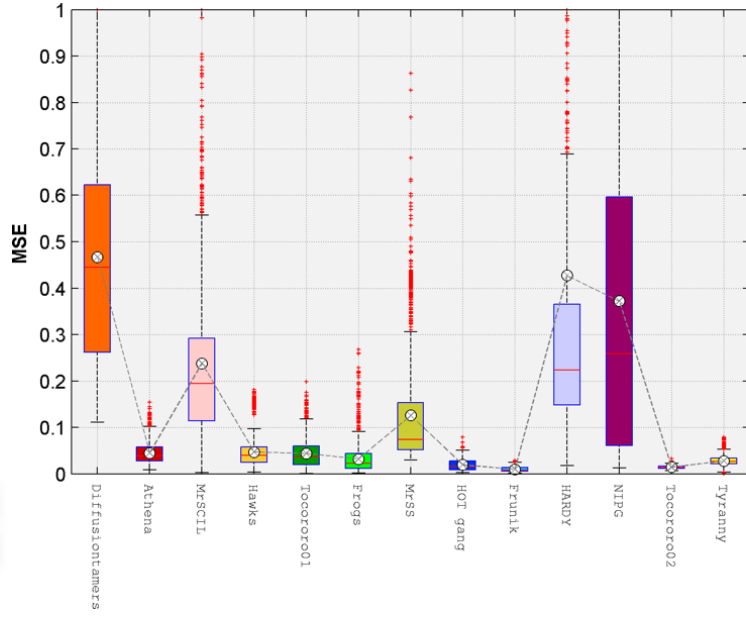
# Results: crossing-angle <sub>(2/2)</sub>

SNR = 10



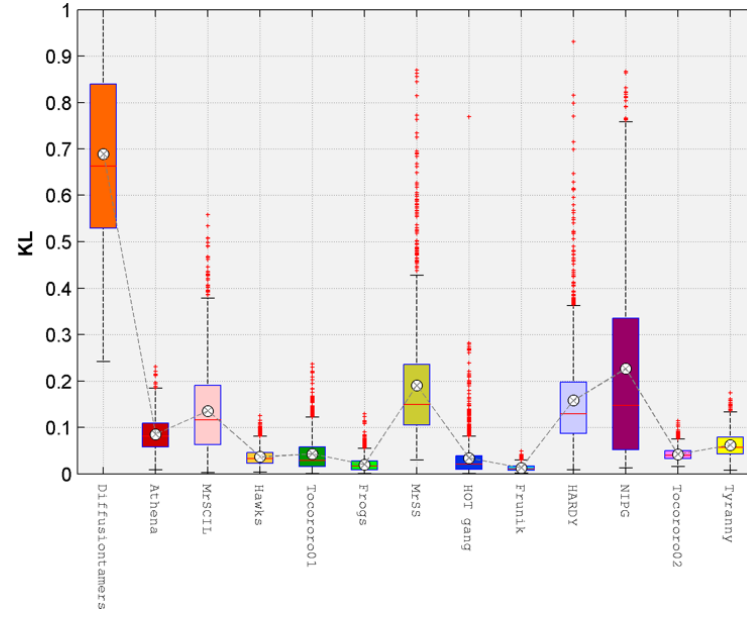
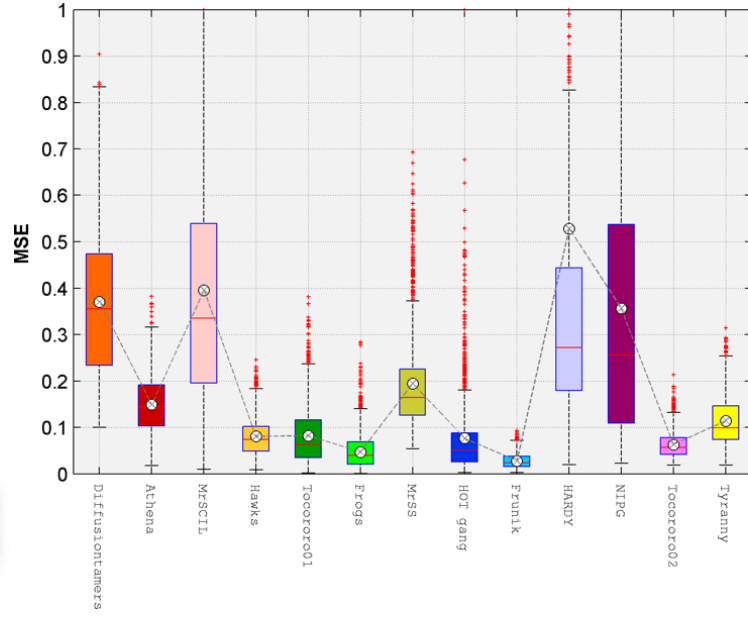
# Results: overall SF<sub>(1/6)</sub>

ODF estimation  
SNR = 30



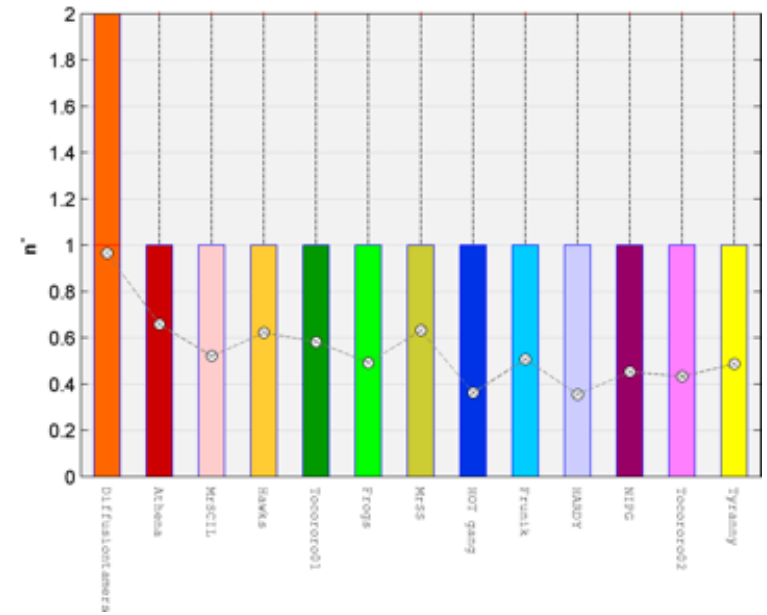
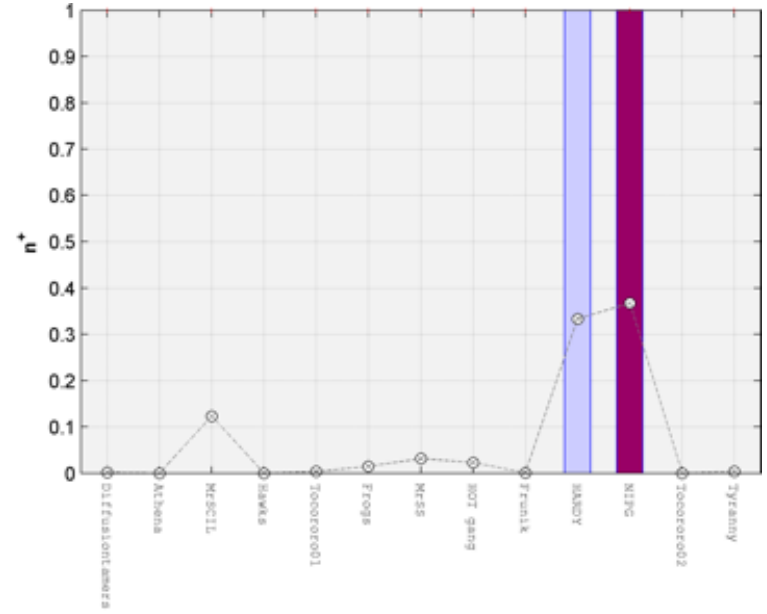
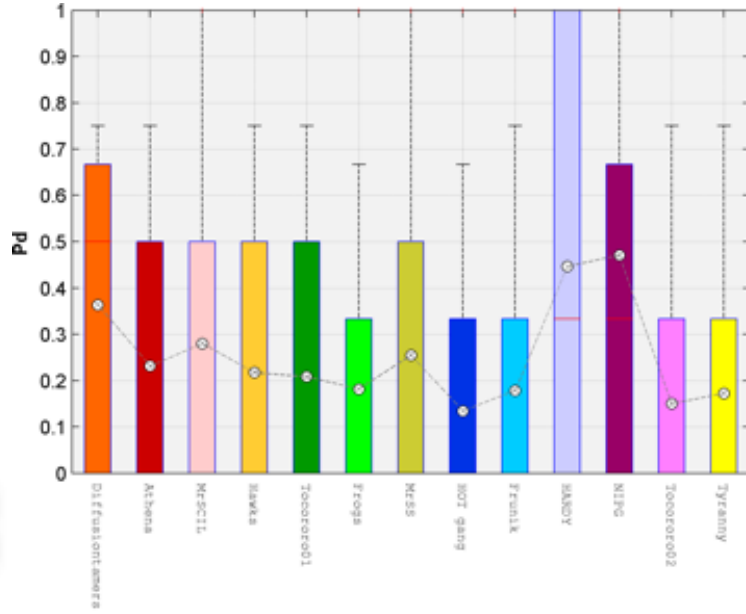
# Results: overall SF <sub>(2/6)</sub>

ODF estimation  
SNR = 10



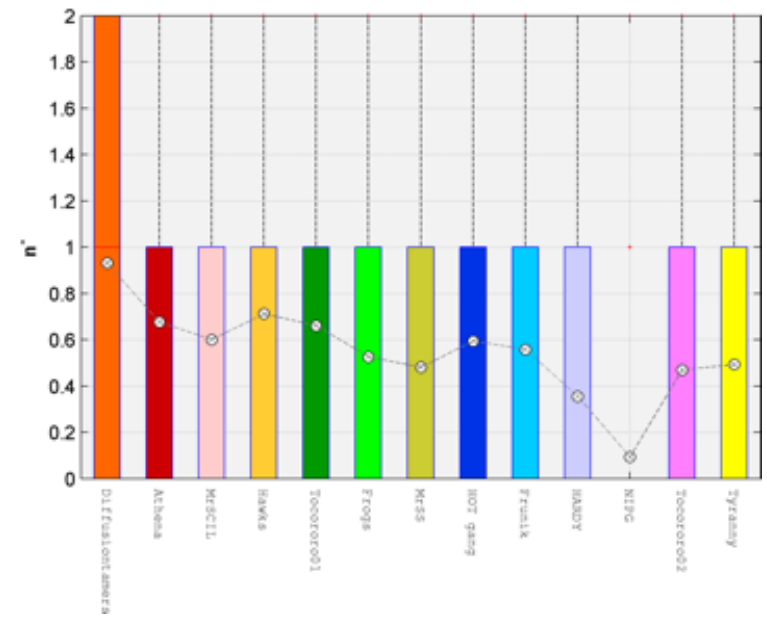
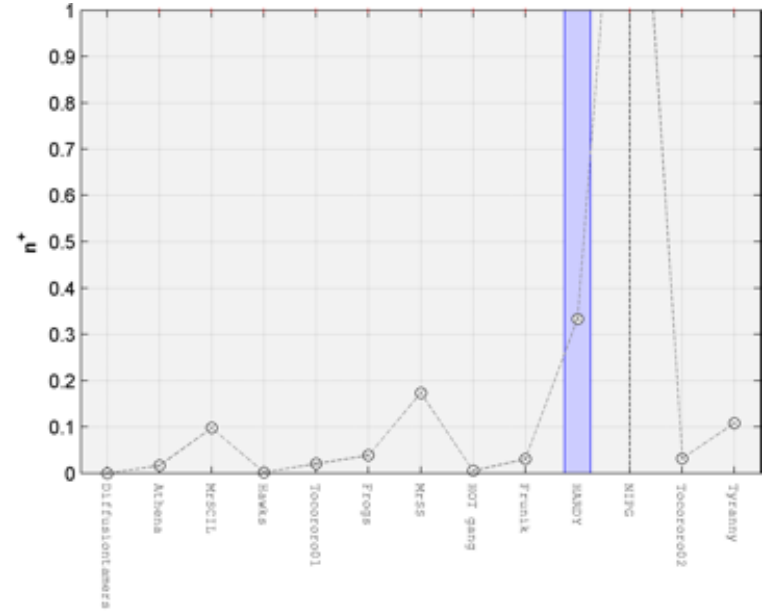
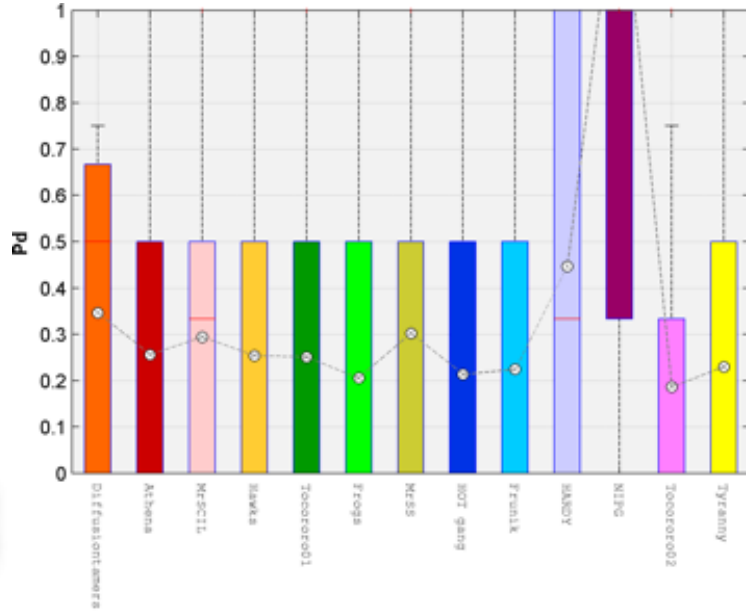
# Results: overall SF <sub>(3/6)</sub>

# compartments  
SNR = 30



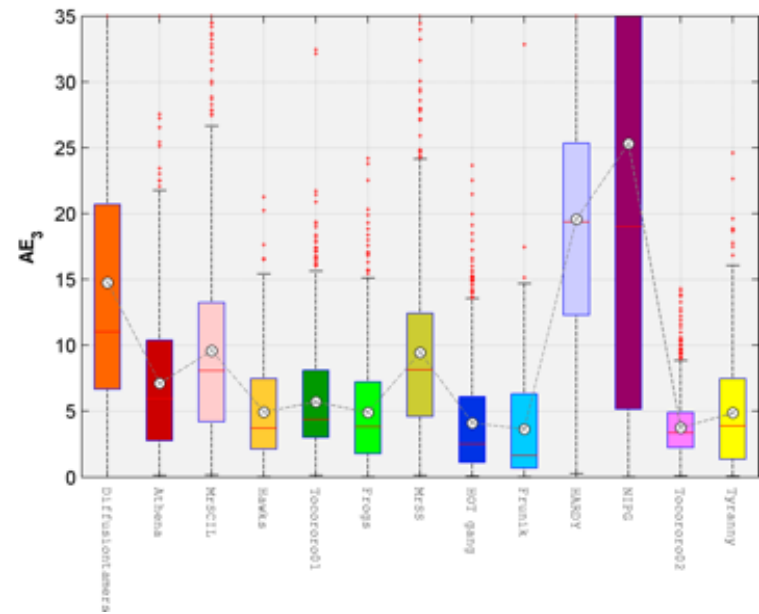
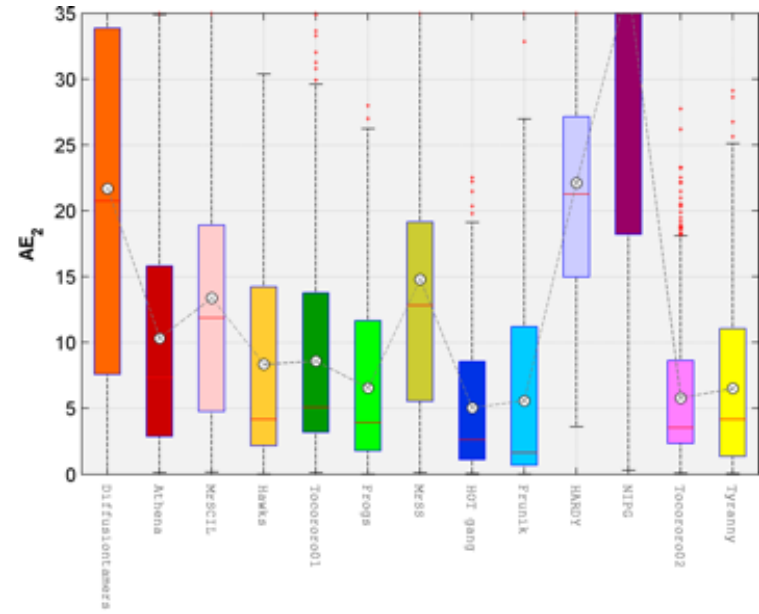
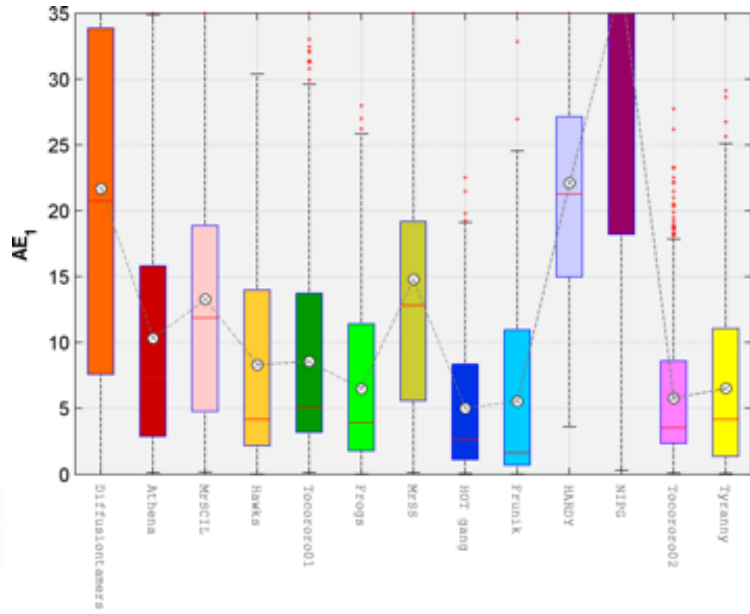
# Results: overall SF <sub>(4/6)</sub>

# compartments  
SNR = 10



# Results: overall SF <sub>(5/6)</sub>

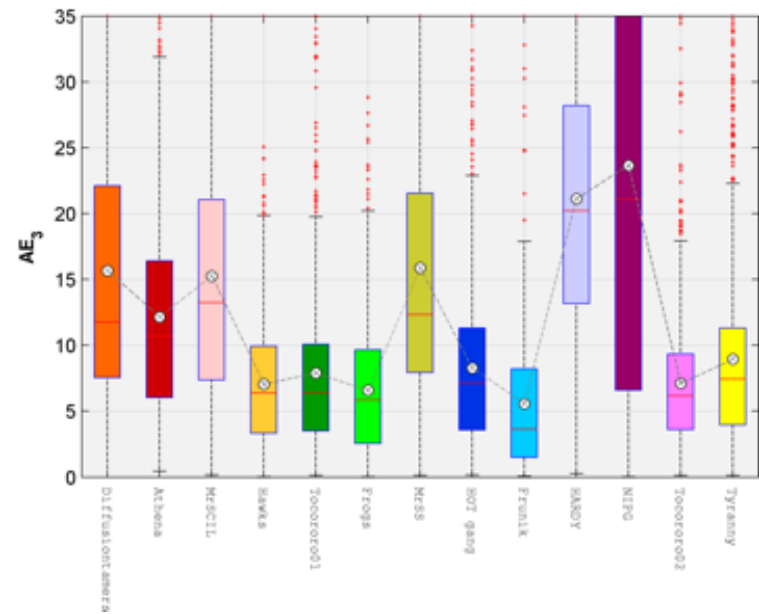
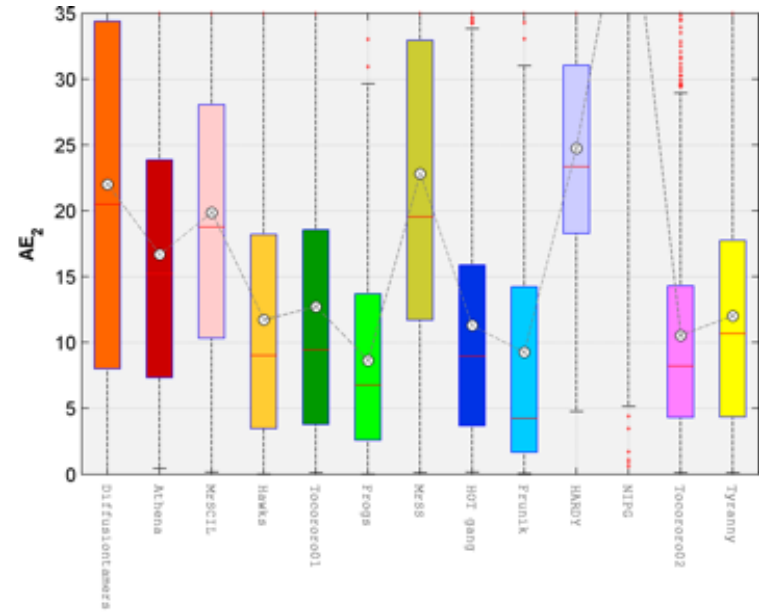
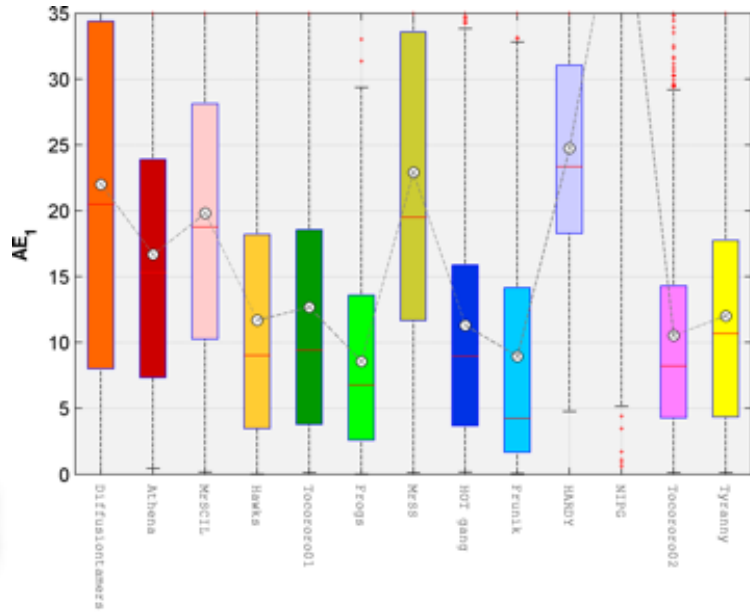
Angular error  
SNR = 30





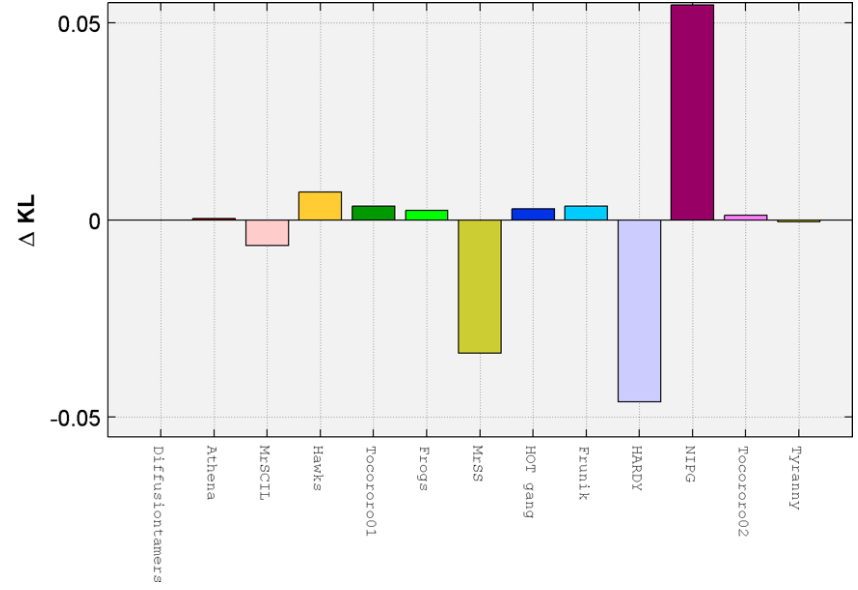
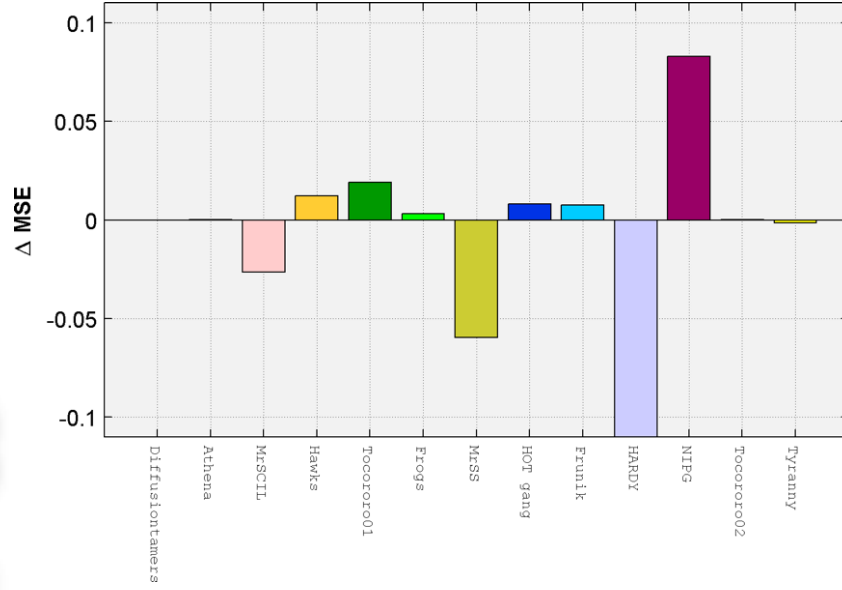
# Results: overall SF <sub>(6/6)</sub>

Angular error  
SNR = 10



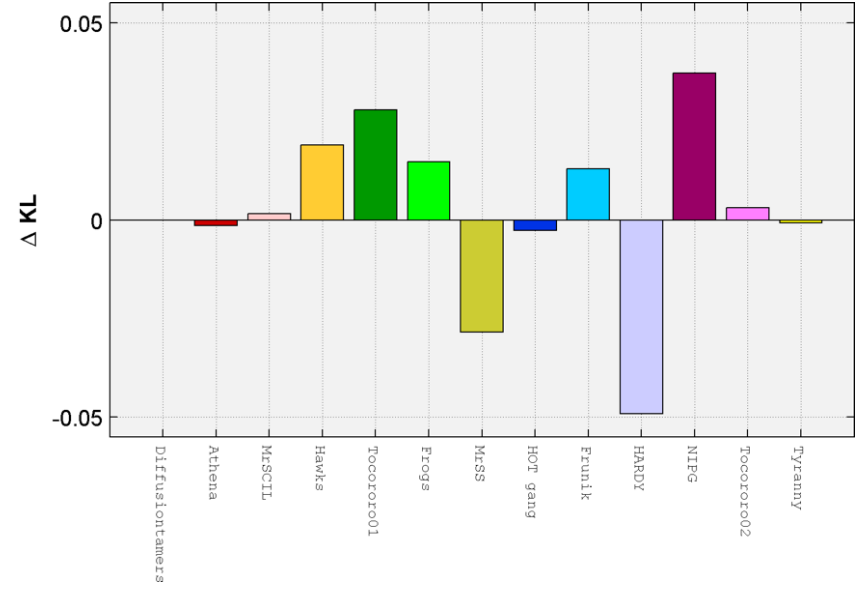
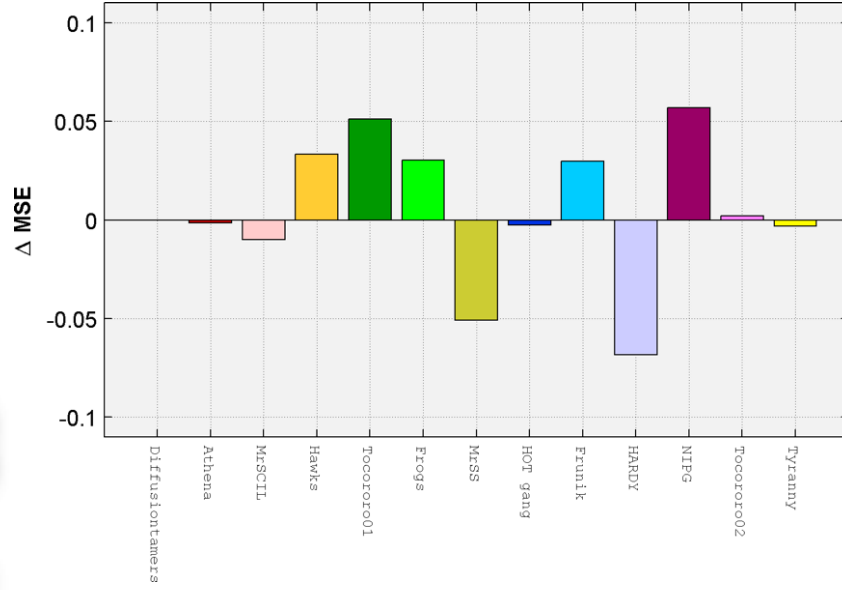
# Results: IV $\Rightarrow$ SF enhancement <sub>(1/6)</sub>

ODF estimation  
SNR = 30



# Results: IV $\Rightarrow$ SF enhancement (2/6)

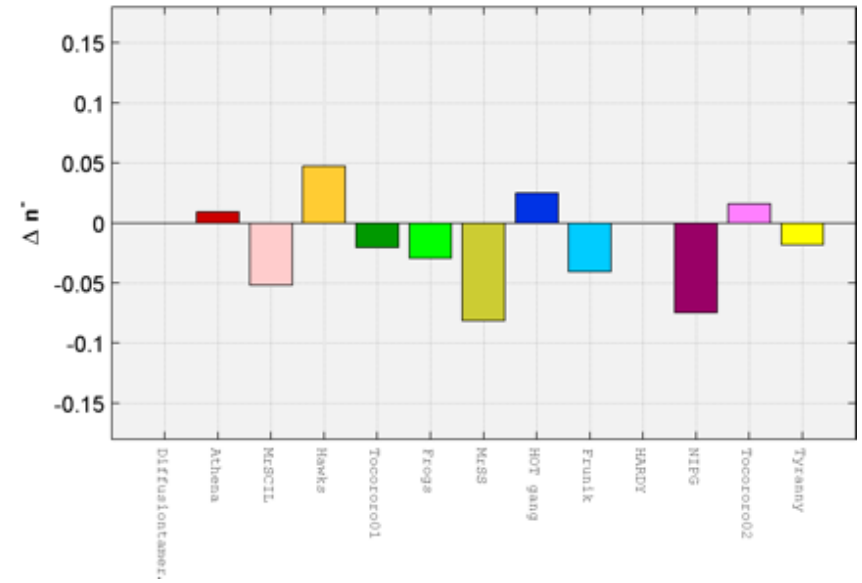
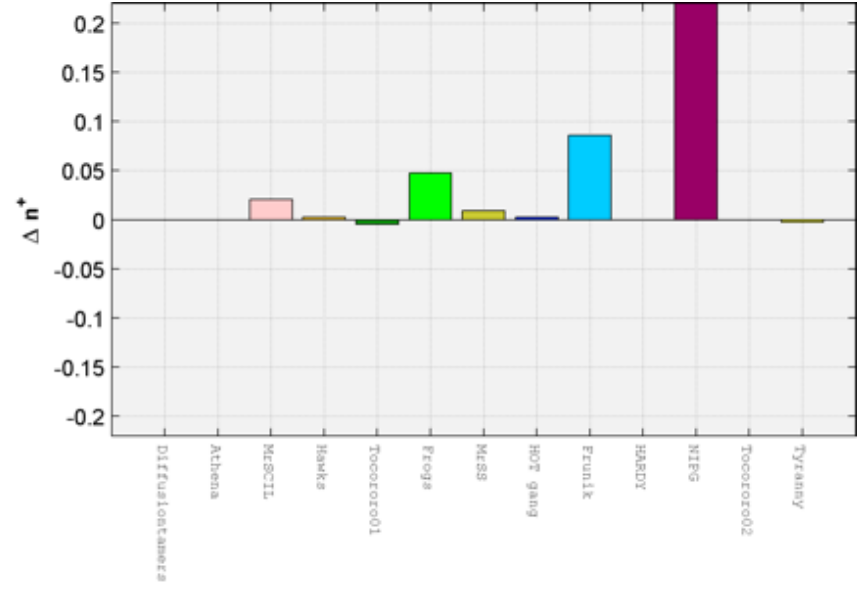
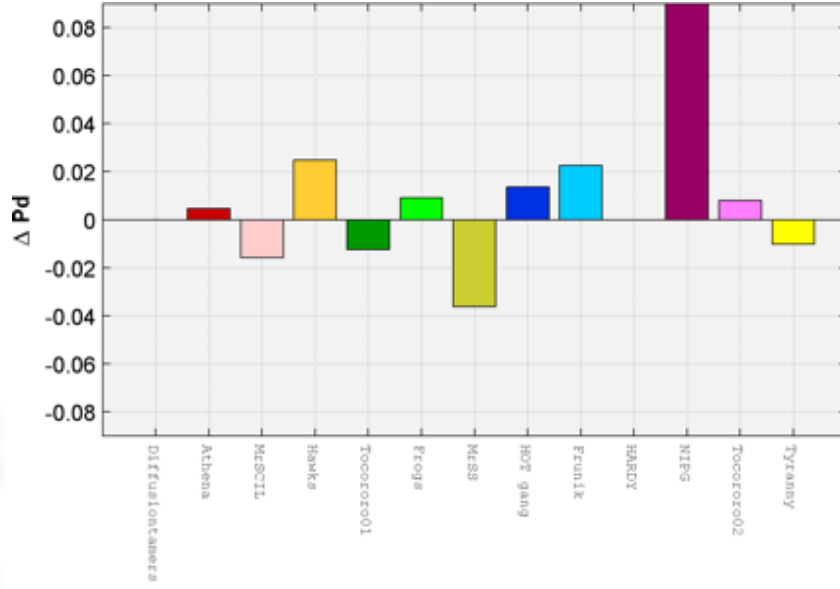
ODF estimation  
SNR = 10



# Results: IV $\Rightarrow$ SF enhancement <sub>(3/6)</sub>

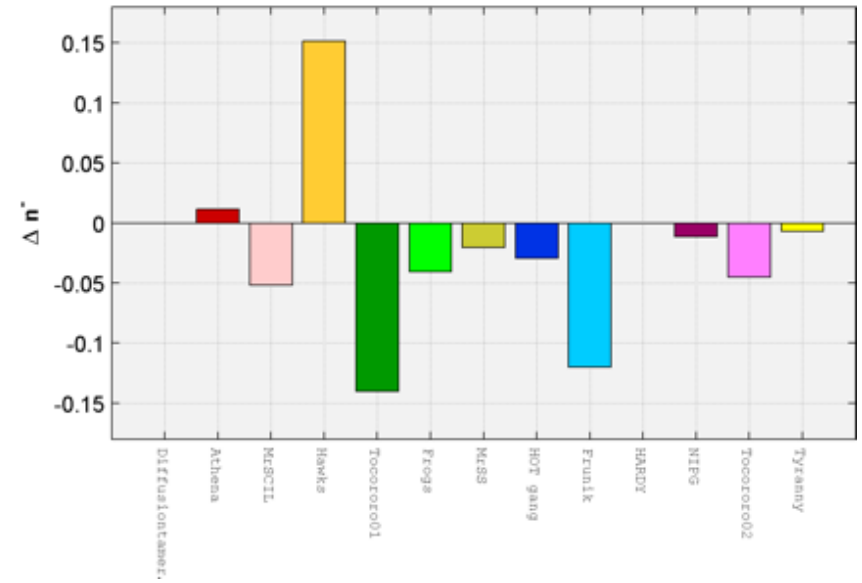
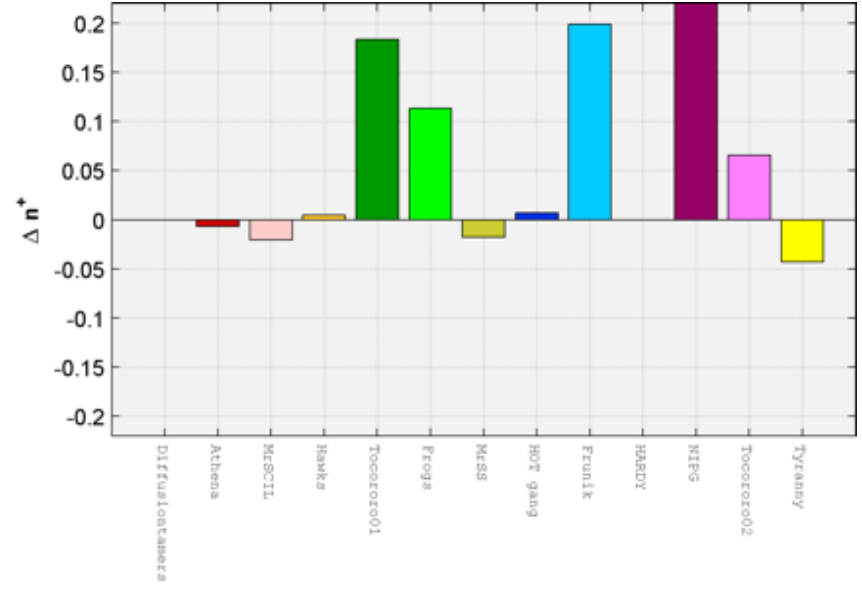
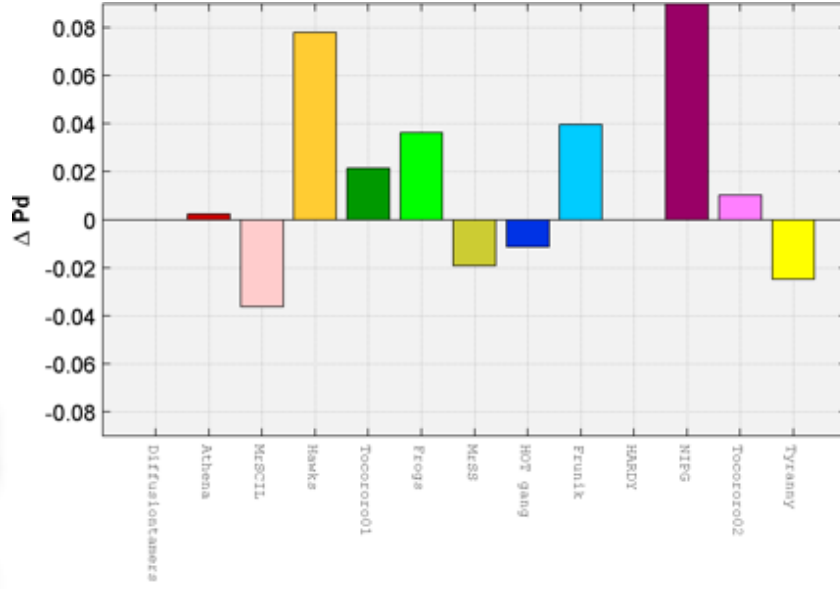
# compartments

SNR = 30



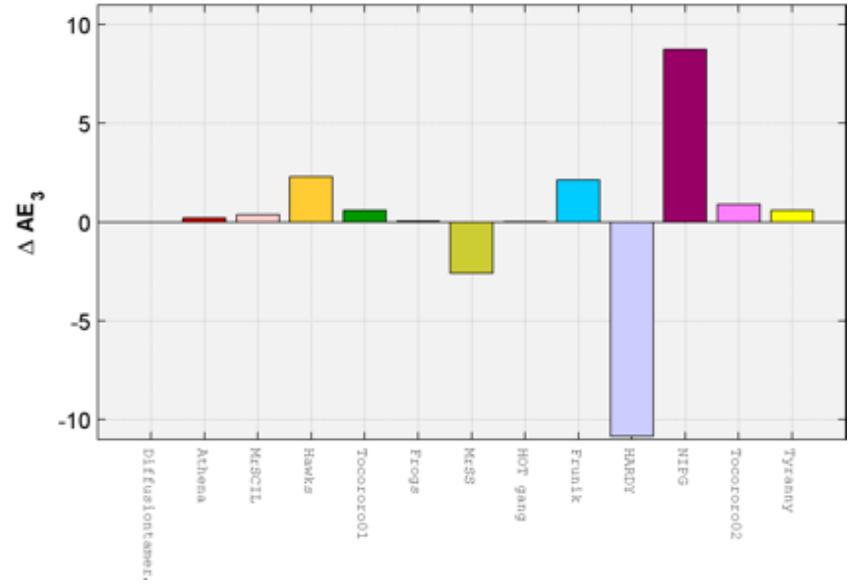
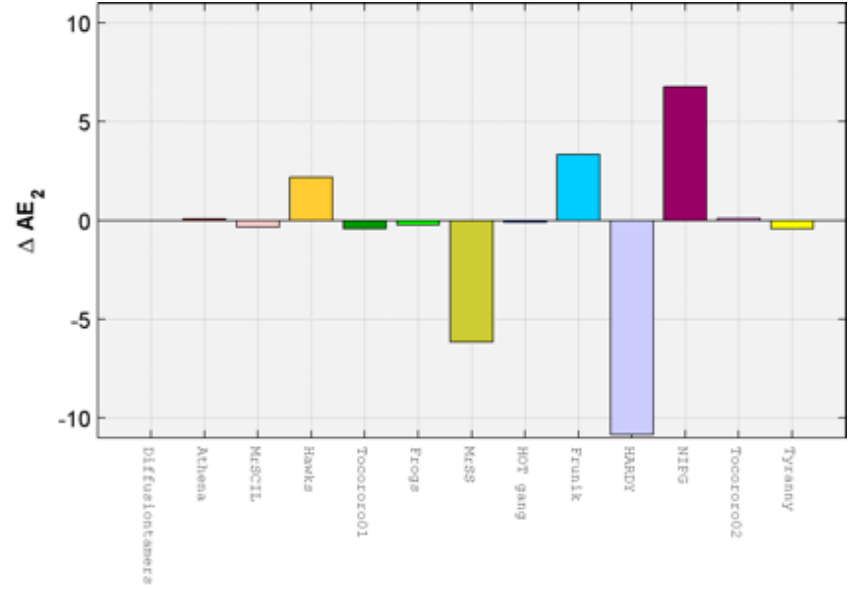
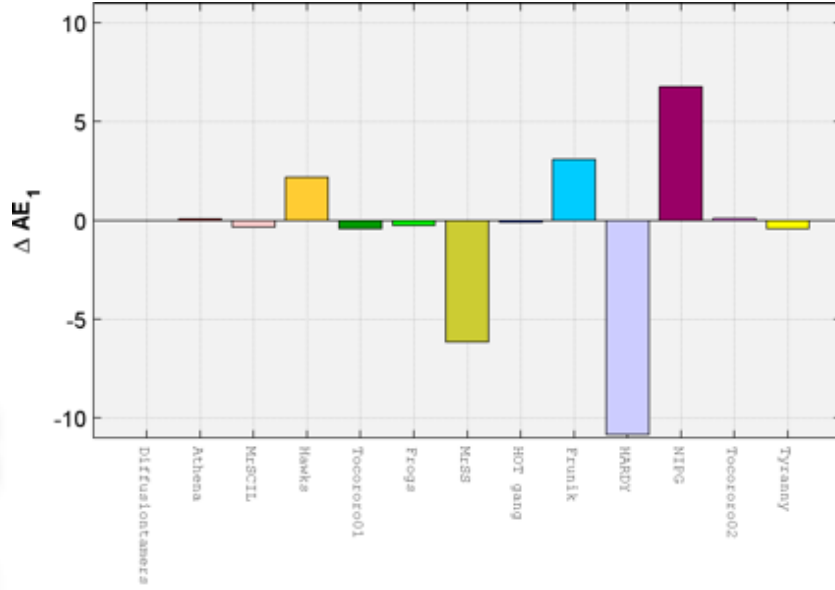
# Results: IV $\Rightarrow$ SF enhancement (4/6)

# compartments  
SNR = 10



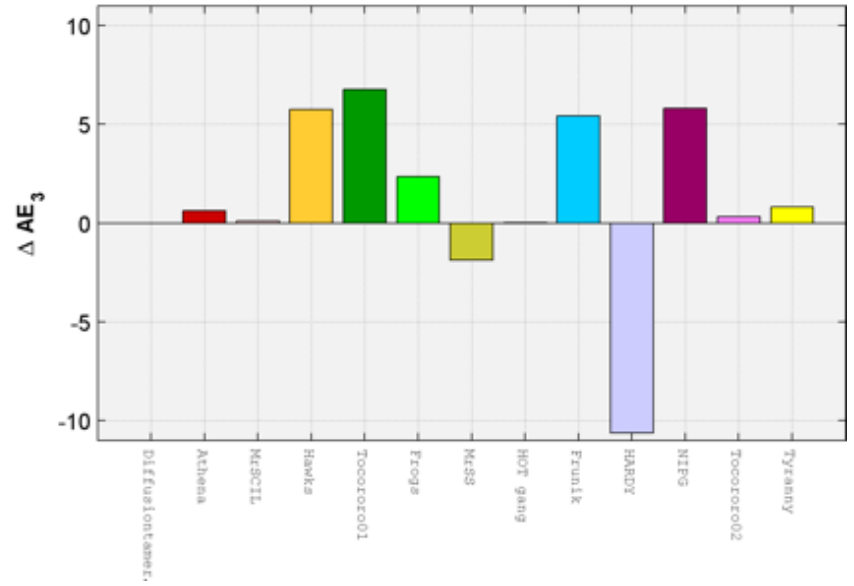
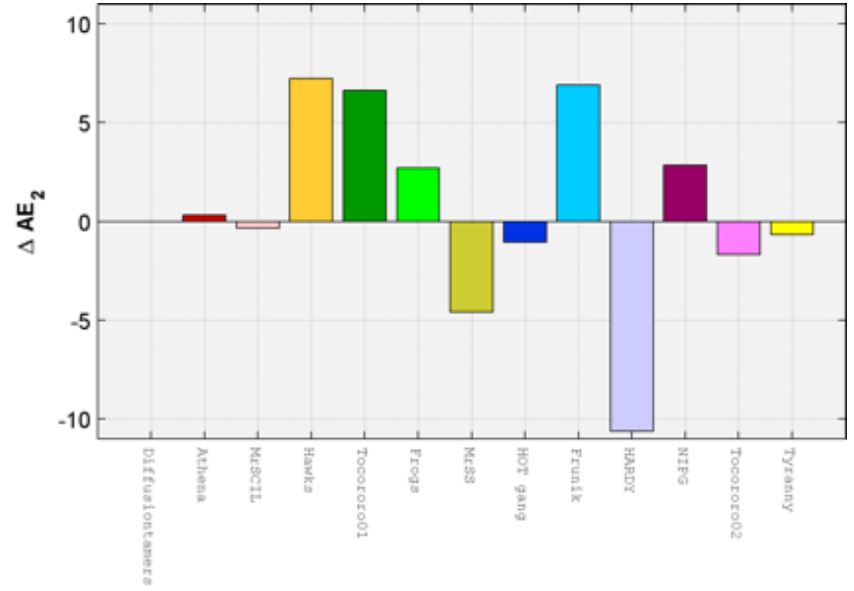
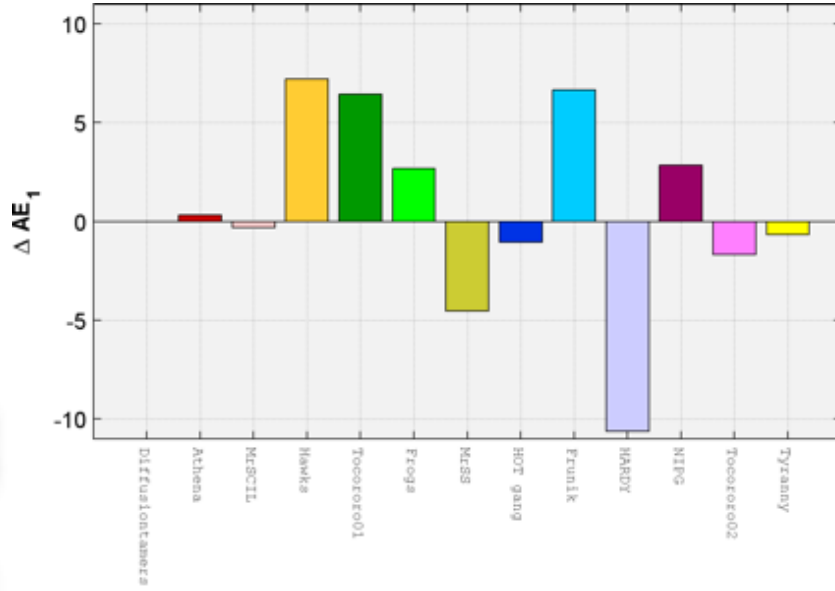
# Results: IV $\Rightarrow$ SF enhancement <sup>(5/6)</sup>

Angular error  
SNR = 30



# Results: IV $\Rightarrow$ SF enhancement <sup>(6/6)</sup>

Angular error  
SNR = 10



# Final ranking

*“...we believe that in this competition  
everyone are winners...”*



# Final ranking

## No weighting

1°	<b>Tocororo02 (257)</b>	<b>847</b>
2°	<b>HOT gang (64)</b>	<b>700</b>
3°	<b>Frunik (64)</b>	<b>622</b>
4°	Frogs (48)	531
5°	Tyranny (257)	493
6°	HARDY (82)	422
7°	Hawks (30)	229
8°	Tocororo01 (37)	192
9°	MrSS (60)	164
10°	Athena (15)	160
11°	MrSCIL (24)	146
12°	NIPG (256)	38
13°	Diffusiantamers (12)	1

# Final ranking

## No weighting

1°	<b>Tocororo02 (257)</b>	<b>847</b>
2°	<b>HOT gang (64)</b>	<b>700</b>
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12°	NIPG (256)	38
13°	Diffusiantamers (12)	1

## exp(nS/257)

	<b>HOT gang (64)</b>	<b>747</b>
	<b>Frunik (64)</b>	<b>708</b>
	<b>Frogs (48)</b>	<b>699</b>
	Athena (15)	412
	HARDY (82)	392
	Hawks (30)	373
	Tocororo02 (257)	323
	Tocororo01 (37)	295
	MrSCIL (24)	279
	MrSS (60)	191
	Tyranny (257)	111
	Diffusiantamers (12)	13
	NIPG (256)	2

# Final ranking

## No weighting

1°	<b>Tocororo02 (257)</b>	<b>847</b>
2°	<b>HOT gang (64)</b>	<b>700</b>
3°	<b>Frunik (64)</b>	<b>622</b>
4°	Frogs (48)	531
5°	Tyranny (257)	493
6°	HARDY (82)	422
7°	Hawks (30)	229
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## exp(nS/257)

	<b>HOT gang (64)</b>	<b>747</b>
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	HARDY (82)	392
	Hawks (30)	373
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	Tocororo01 (37)	295
	MrSCIL (24)	279
	MrSS (60)	191
	Tyranny (257)	111
	Diffusontamers (12)	13
	NIPG (256)	2

## sqrt(nS)

	<b>Athena (15)</b>	<b>720</b>
	<b>HOT gang (64)</b>	<b>612</b>
	<b>Frogs (48)</b>	<b>606</b>
	Frunik (64)	583
	Hawks (30)	442
	HARDY (82)	353
	MrSCIL (24)	341
	Tocororo01 (37)	316
	Tocororo02 (257)	269
	MrSS (60)	156
	Tyranny (257)	80
	Diffusontamers (12)	65
	NIPG (256)	2

# **Round table discussion**

# Discussion

- **Results:** is there a real “winner”?
- **Evaluation framework:** pitfalls, improvements, comments
- What have we **learned**? Where to go from here?
- **Propositions:**
  - common journal paper?
  - online shared evaluation tool? <http://vision.middlebury.edu>