Blinding for DES-Y3 cosmology analyses

Jessie Muir, University of Michigan

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Others working on this: Franz Elsner, Gary Bernstein, Dragan Huterer, Hiranya Peiris,

The Dark Energy Survey (DES)

- ~400 scientists from ~30 institutions, 7 countries
- 4-m Blanco telescope at Cerro Tololo Inter-American Observatory (CTIO) in Chile
- Mapping galaxy positions and shapes over 1/8 of the sky out to z~1

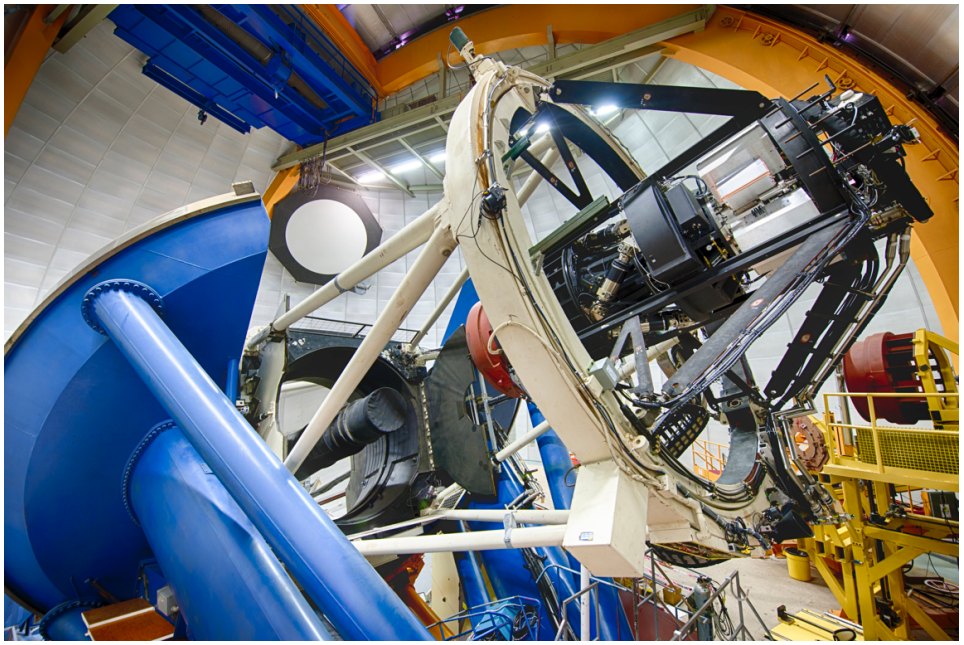
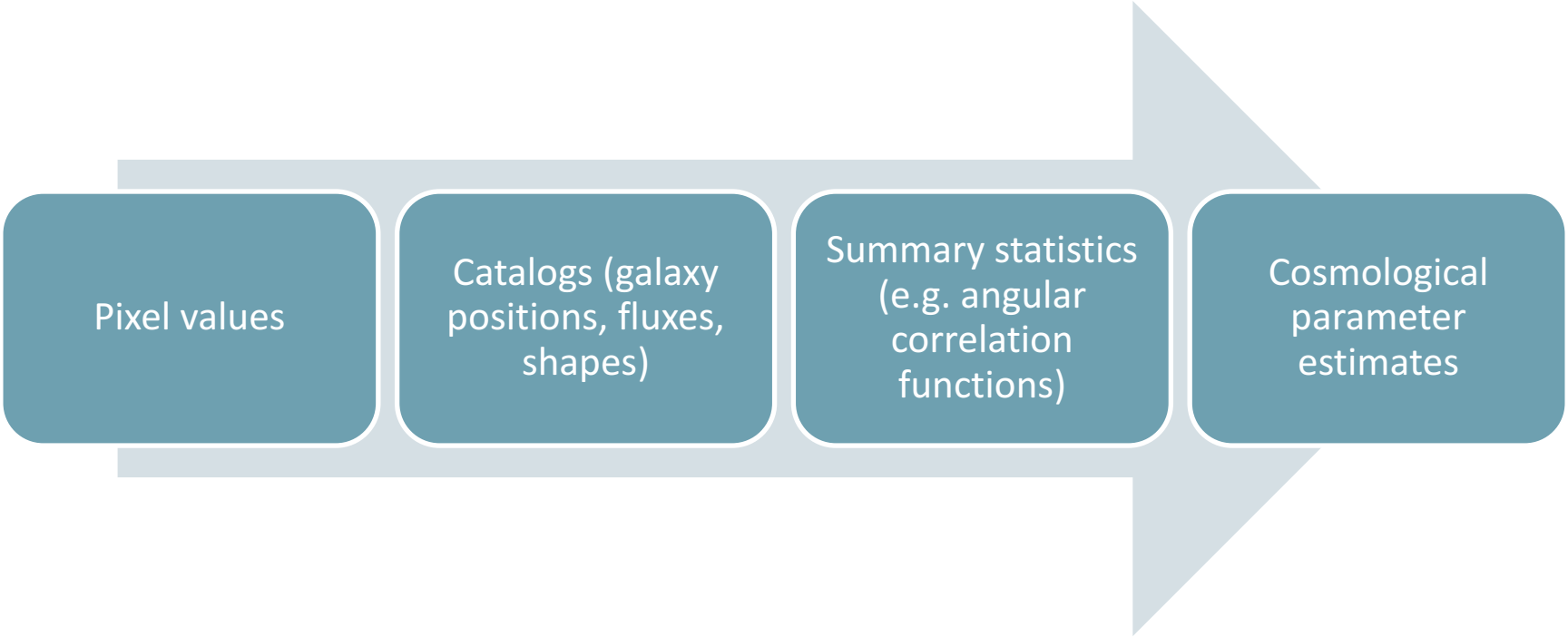


Image credit: Reider Hahn, Fermilab

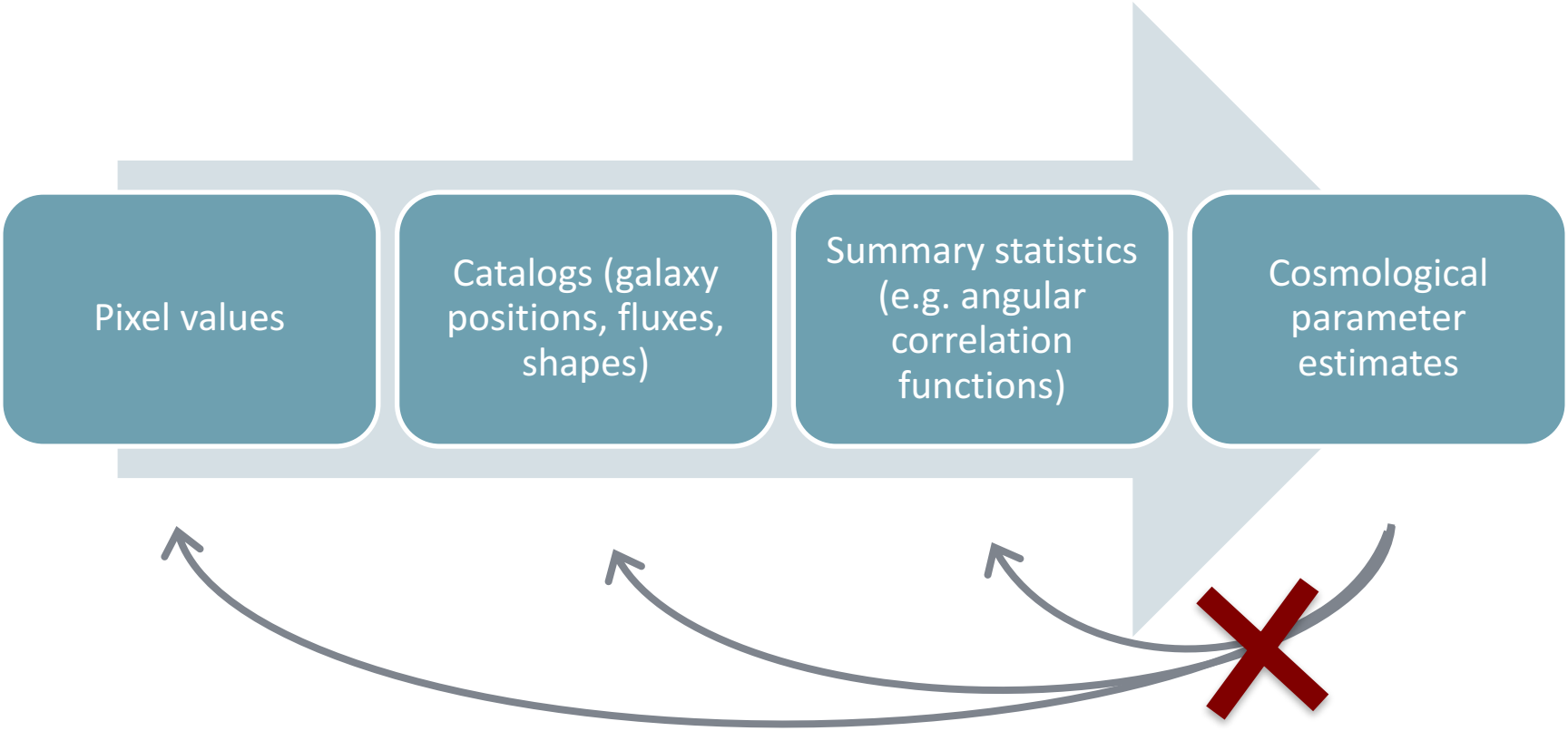
Multiprobe blinding for DES

- 3x2pt key project will constrain cosmology using
  - Galaxy angular correlation
  - Shear – shear correlations
  - Galaxy – shear correlation (galaxy –galaxy lensing)
- For DES Y1 analysis – shear catalogs are blinded, which affects these 2pt measurements separately
- For combined analysis, want a blinding scheme that preserves consistency between probes.

Blinding for the DES analysis



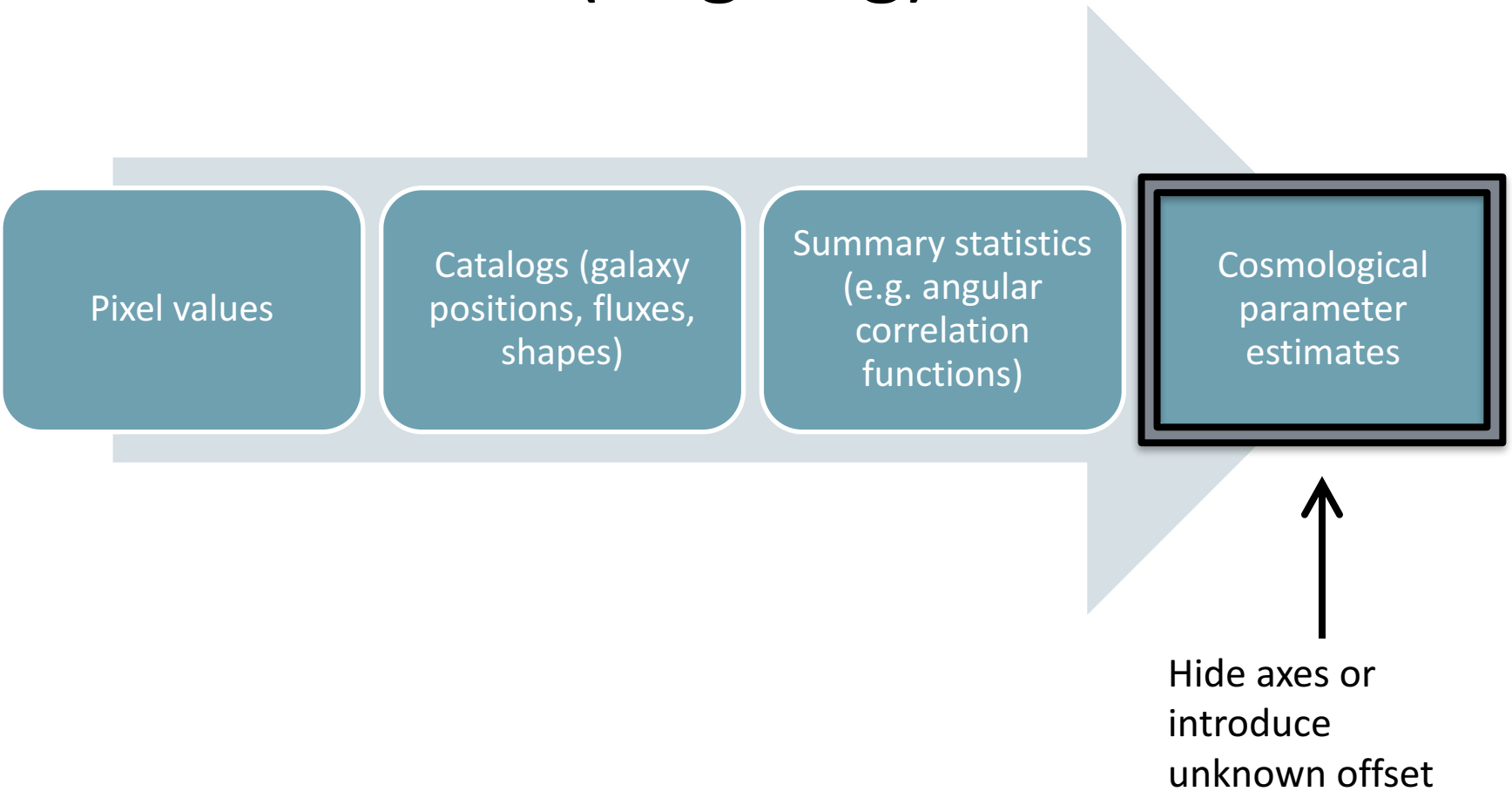
Blinding for the DES analysis

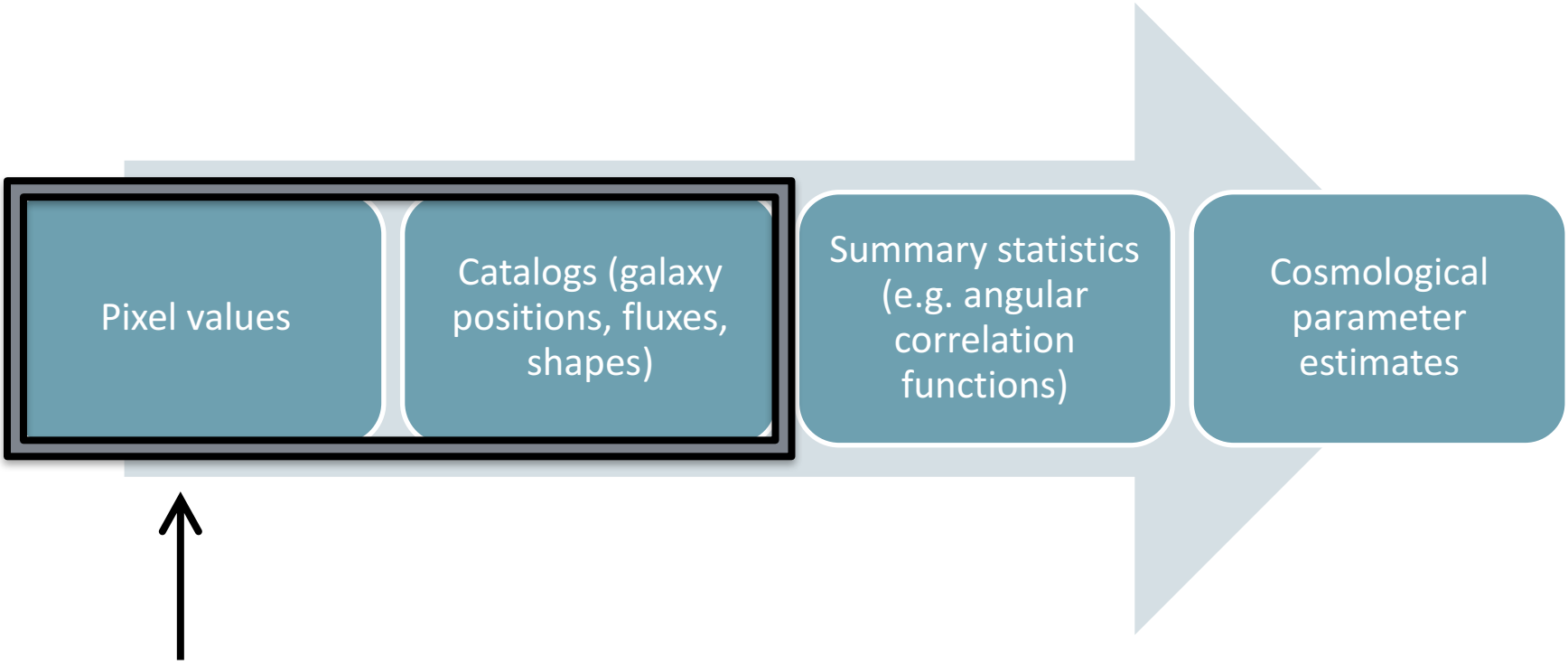


Requirements

- Shift output cosmological parameters
- Preserve inter-probe consistency
- Preserve ability to test for systematic errors

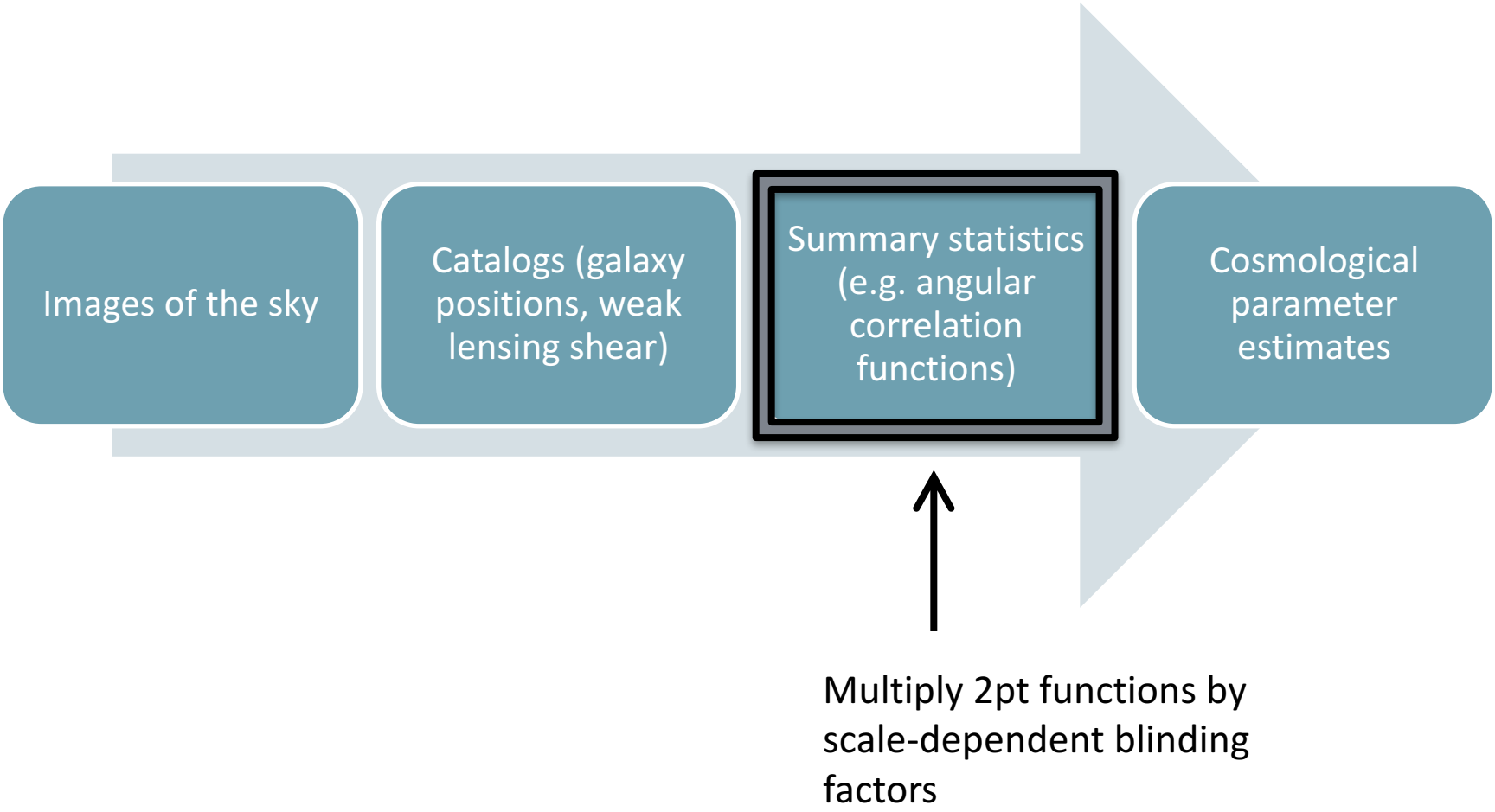
Blinding for DES Year-1 analysis (ongoing)



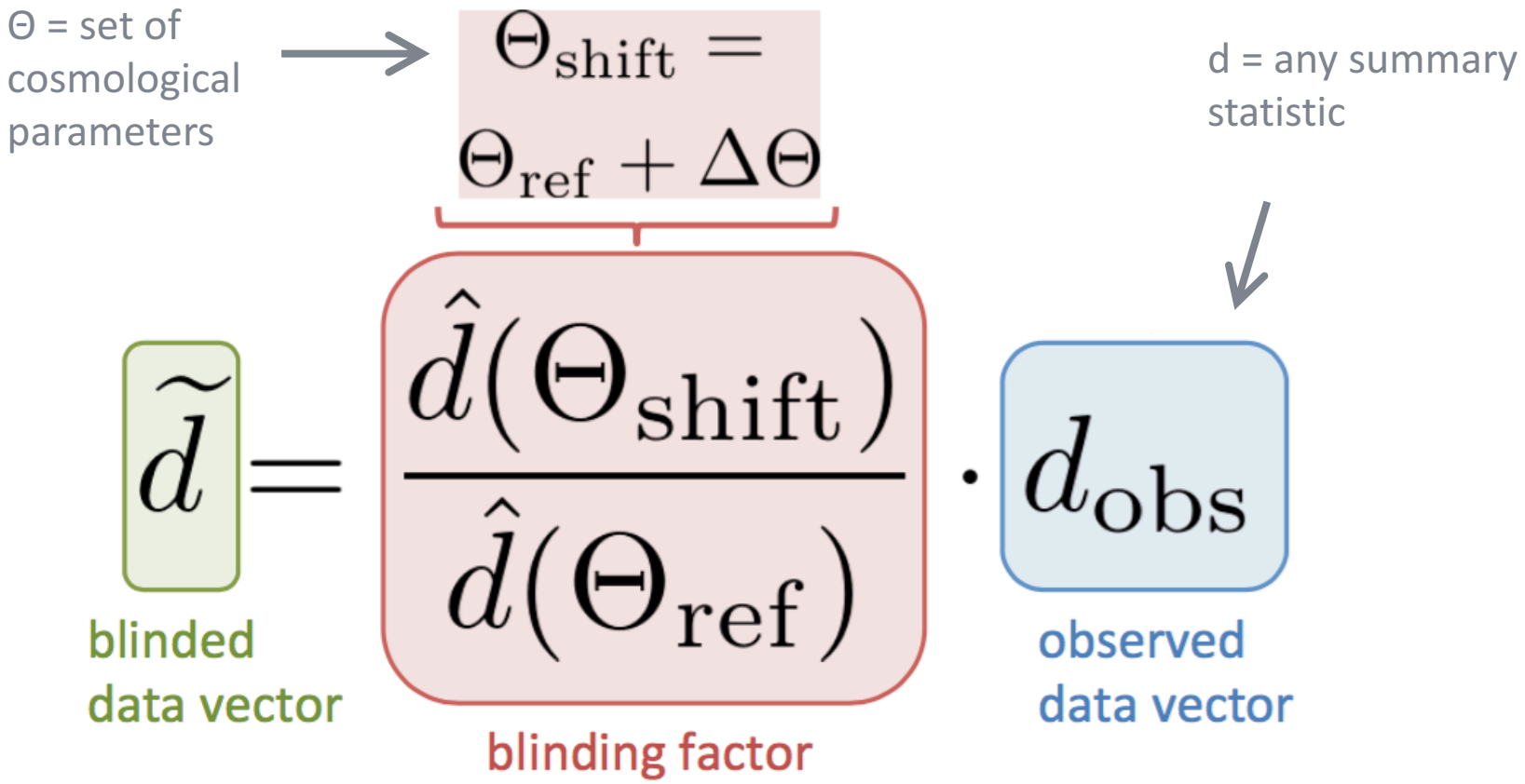


Making changes here (salting?) is impossible (?) to do in away that preserves consistency

More robust scheme for Year-3 analysis

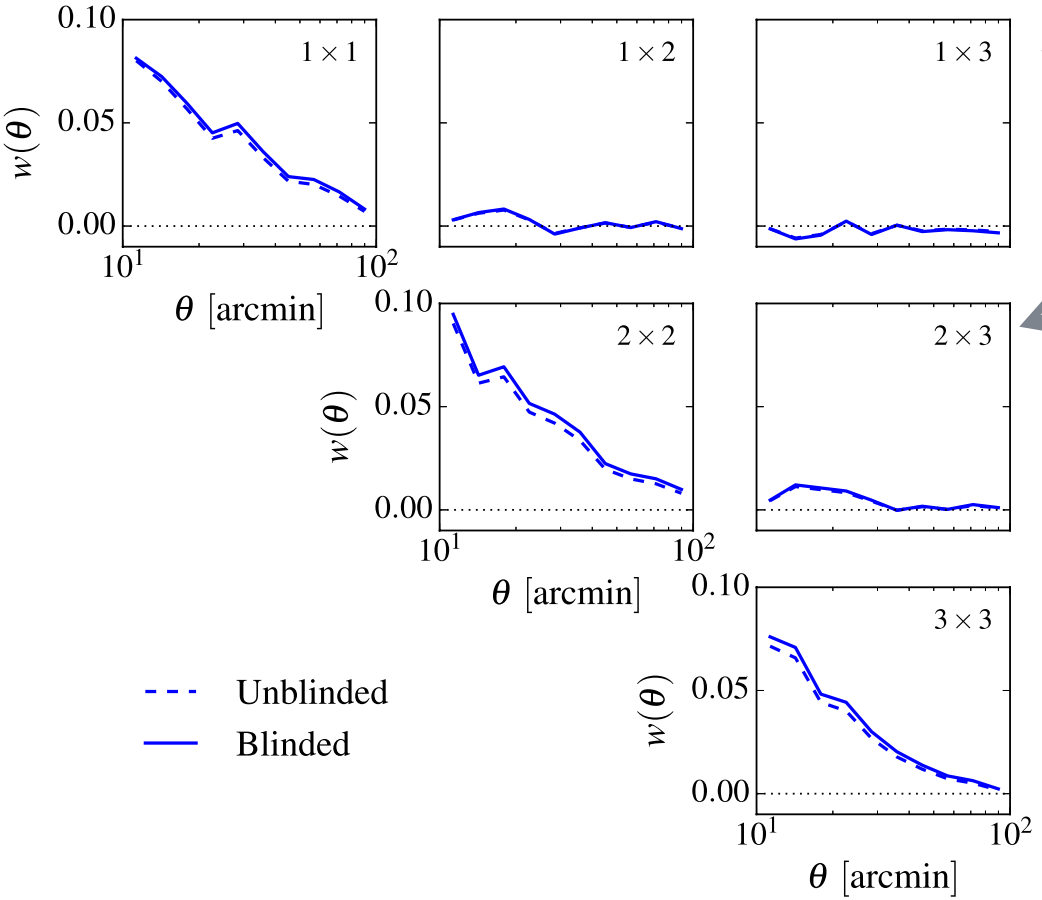


Strategy for Y3: Linearly scale summary statistics



Example on simulated data vector:

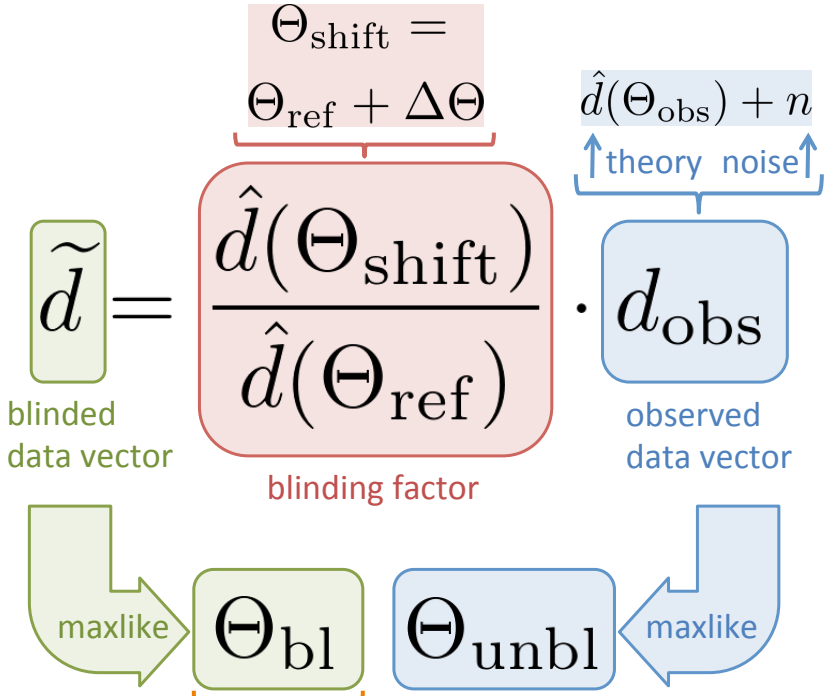
Galaxy-galaxy correlation function



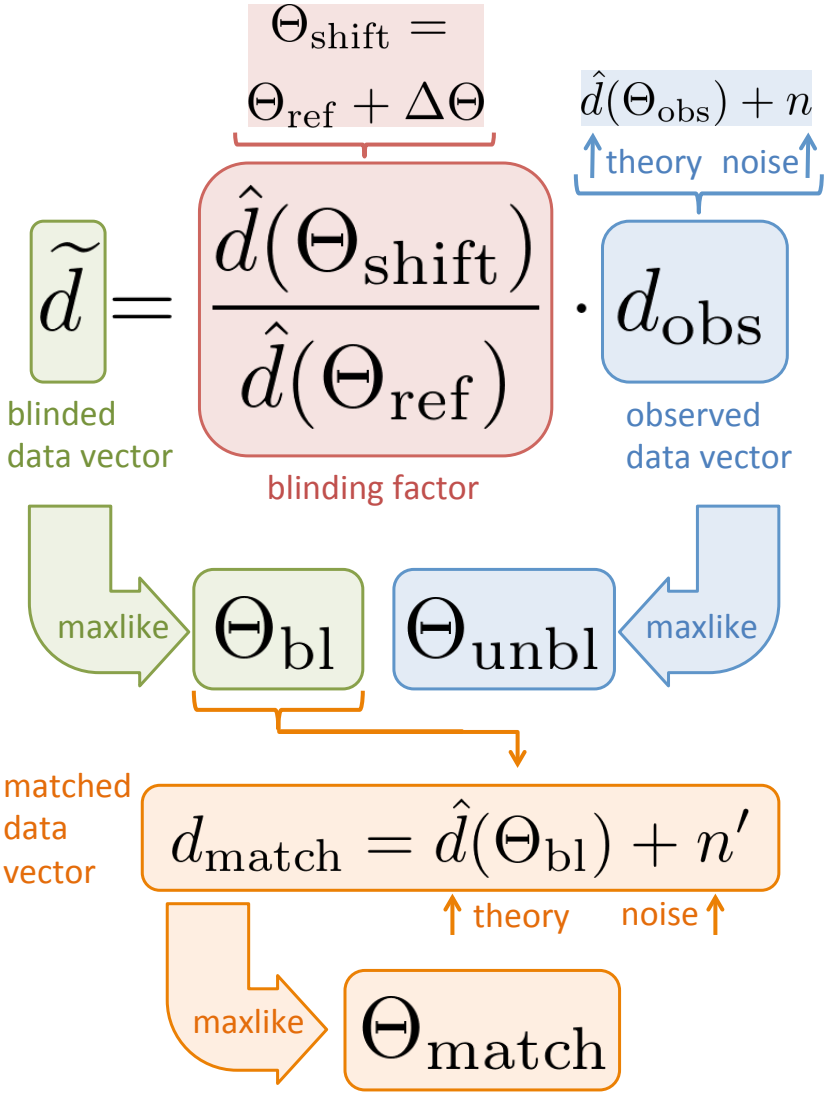
Redshift bin labels

Credit: Franz Elsner

Test: Is the blinded data vector consistent with a valid cosmology?



Test: Is the blinded data vector consistent with a valid cosmology?



Test: Is the blinded data vector consistent with a valid cosmology?

$$\tilde{d} = \frac{\hat{d}(\Theta_{\rm shift})}{\hat{d}(\Theta_{\rm ref})} \cdot d_{\rm obs}$$

$\Theta_{\rm shift} = \Theta_{\rm ref} + \Delta\Theta$

$\hat{d}(\Theta_{\rm obs}) + n$ (theory + noise)

blinded data vector

blinding factor

observed data vector

maxlike → $\Theta_{\rm bl}$

$\Theta_{\rm unbl}$ ← maxlike

matched data vector

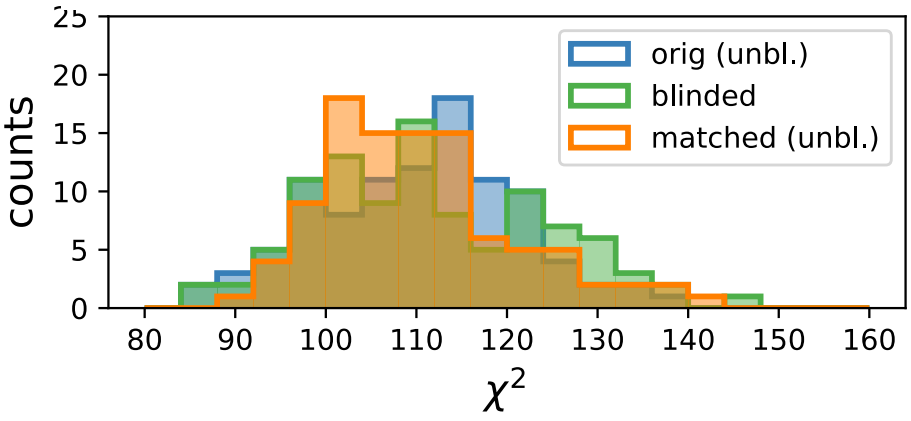
$$d_{\rm match} = \hat{d}(\Theta_{\rm bl}) + n'$$

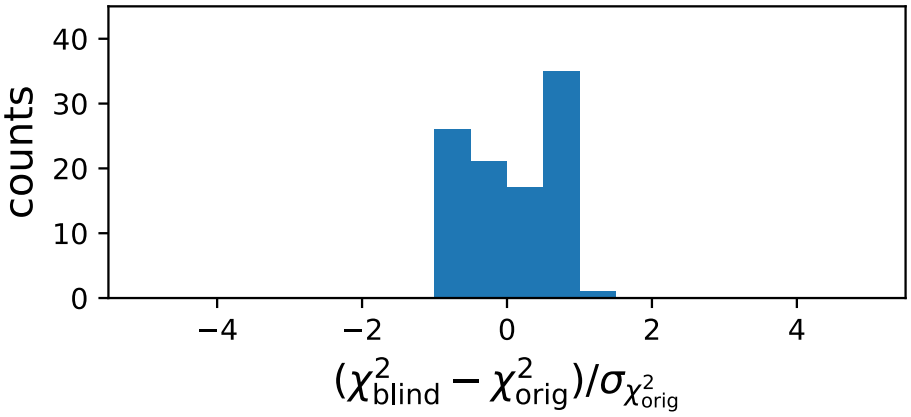
(theory + noise)

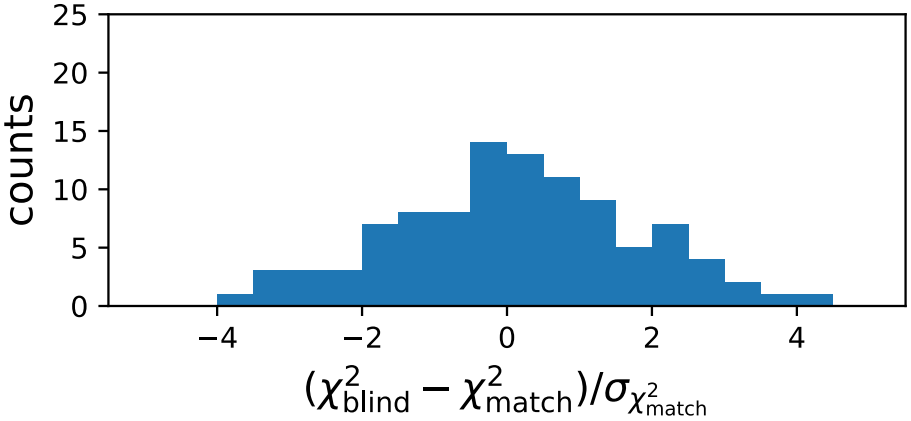
maxlike → $\Theta_{\rm match}$

Varying only w and Ω_m

$\Theta_{\rm obs}$ at ~3σ from $\Theta_{\rm ref}$, $\Theta_{\rm shift}$ at ~5σ from $\Theta_{\rm ref}$







Test: How does blinding affect the best fit Θ?

$\Theta_{\rm shift} = \Theta_{\rm ref} + \Delta\Theta$

$d_{\rm obs} = \hat{d}(\Theta_{\rm obs}) + n$ (theory + noise)

$$\tilde{d} = \frac{\hat{d}(\Theta_{\rm shift})}{\hat{d}(\Theta_{\rm ref})} \cdot d_{\rm obs}$$

blinded data vector

blinding factor

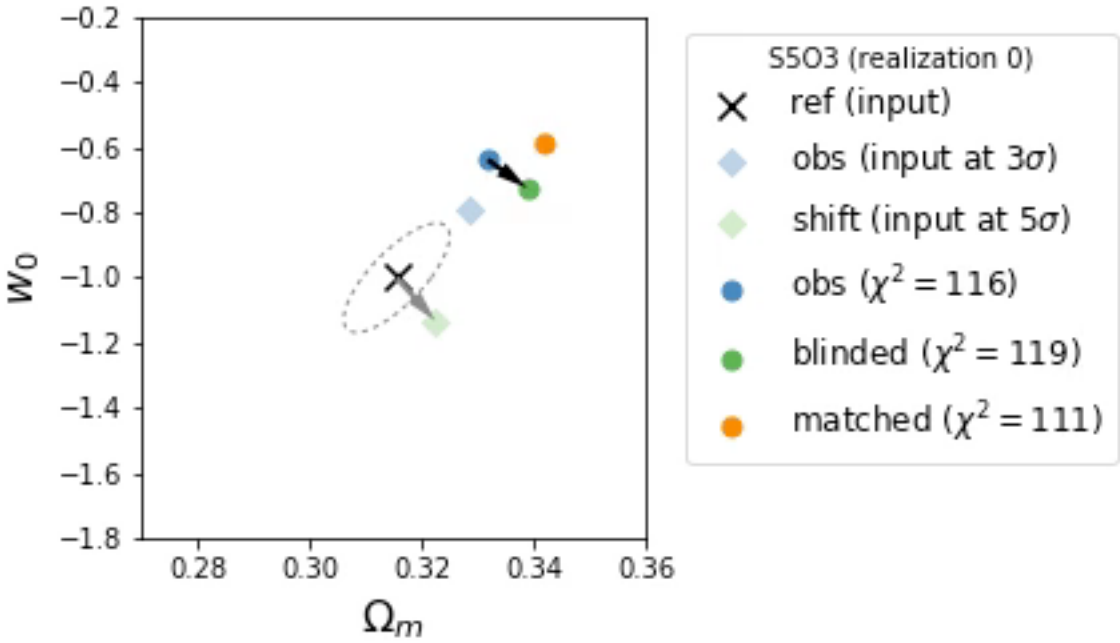
observed data vector

maxlike → $\Theta_{\rm bl}$ ← maxlike $\Theta_{\rm unbl}$

matched data vector

$$d_{\rm match} = \hat{d}(\Theta_{\rm bl}) + n'$$ (theory + noise)

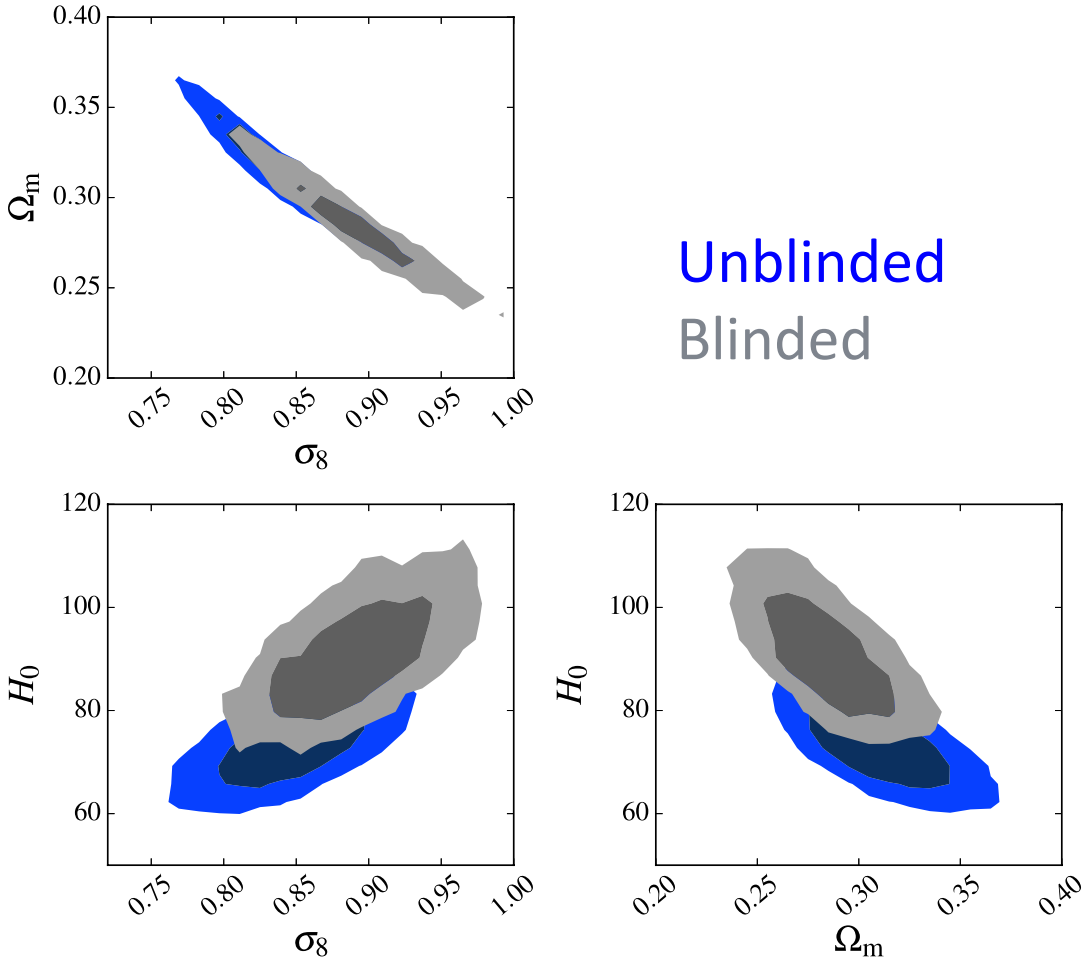
maxlike → $\Theta_{\rm match}$



In general:

$$\Theta_{\rm shift} - \Theta_{\rm ref} \approx \Theta_{\rm bl} - \Theta_{\rm unbl}$$

✓ Shifts output cosmology



Unblinded

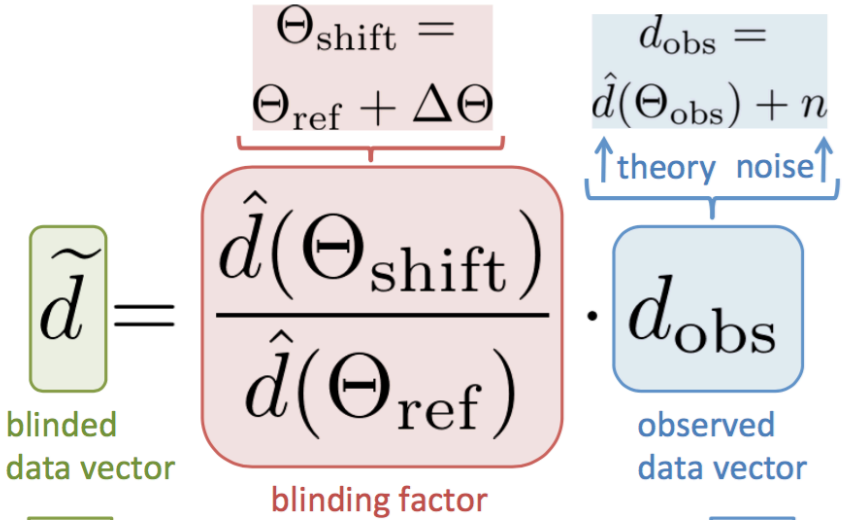
Blinded

Credit: Franz Elsner

Plans for implementation

Blinding factors computed and applied by software module which can be inserted into pipeline.

- Comes with file containing ~100 draws of $\Theta_{\rm shift}$
- Using string seed, pseudo-randomly select one.
- Generate blinding factors using settings already in pipeline.
- To unblind, just remove blinding module and rerun



Summary

- To avoid experimenters' bias, we are blinding the DES cosmological analysis.

- For DES Y3 combined analyses: until pipeline finalized, multiply all summary statistics by linear blinding factors
  - Factors are the ratio between theory values of summary stat for blindly drawn shifted cosmology and known reference cosmology
  - Shifts best fit cosmology in a predictable way
  - Preserves inter-probe consistency & ability to do systematics tests