Science Performances Verifications

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Euclid top science requirements

R-L0	The Euclid Mission will by itself allow us to • understand the nature of the apparent acceleration of the Universe and • test gravity on cosmological scales from the measurement of the cosmic expansion history and the growth rate of structures.
R-L0.1	To determine the nature of the apparent acceleration, Euclid will distinguish effects produced by a cosmological constant from those produced by a dynamical dark energy. This must be done by achieving a minimum *FoM*≥400 from Euclid data alone.
R-L0.2	To experience effects of gravity on cosmological scales, Euclid will probe the growth of structure and will separately constrain the two relativistic potentials, Ψ and Φ. This can be done by achieving an absolute 1σ precision of 0.02 on the growth index, γ, from Euclid data alone.

- All requirements on the Euclid Mission (survey, instrument, satellites, data processing) are derived from these two requirements.
- SPV are exercises where the mission is simulated using CBE to check these two top level requirements are met.

SPV2

- SPV2 to *inform* MCDR
- Derive FoM and accuracy on γ using Fisher Matrix formalism for the combined probes GCs and WL

$$FoM = \frac{1}{[\det(C_{w_0,w_a})]^{1/2}}$$

$$f(z) = d\ln\delta_m/d\ln a = \Omega_m(z)^\gamma$$

- Also derive biases for WL

	Euclid Mission Performance Document	**Ref.:**	EUCL-IAP-EUC-DP-00244
		Issue:	2.0
		Date:	04/10/2018
		Page:	1/130

Title:	Euclid Mission Perfomance Document	**Issue:**	2.0
Date:	October 4, 2018		
Reference:	EUCL-IAP-EUC-DP-00244		
Custodian:	Hervé Aussel		

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R. Scaramella	ECSURV Lead		
J. Stadel	SWG-CS		
Y. Wang	SWG-GC Lead		

SPV2

- SPV2 was run 2017-2019 to inform MCDR
  - Delivery of MPD V2.0 oct 4, 2018
  - Updated results presented oct 19, 2018:
    - scenarios for DR1 and DR3
    - effects of modelling of Hα emitters
    - Assumptions on the parameters allowed to be fixed.
  - Updates presented at MCDR panel meetings
  - When the exercise is completed, version 2.1 of the MPD will be issued.

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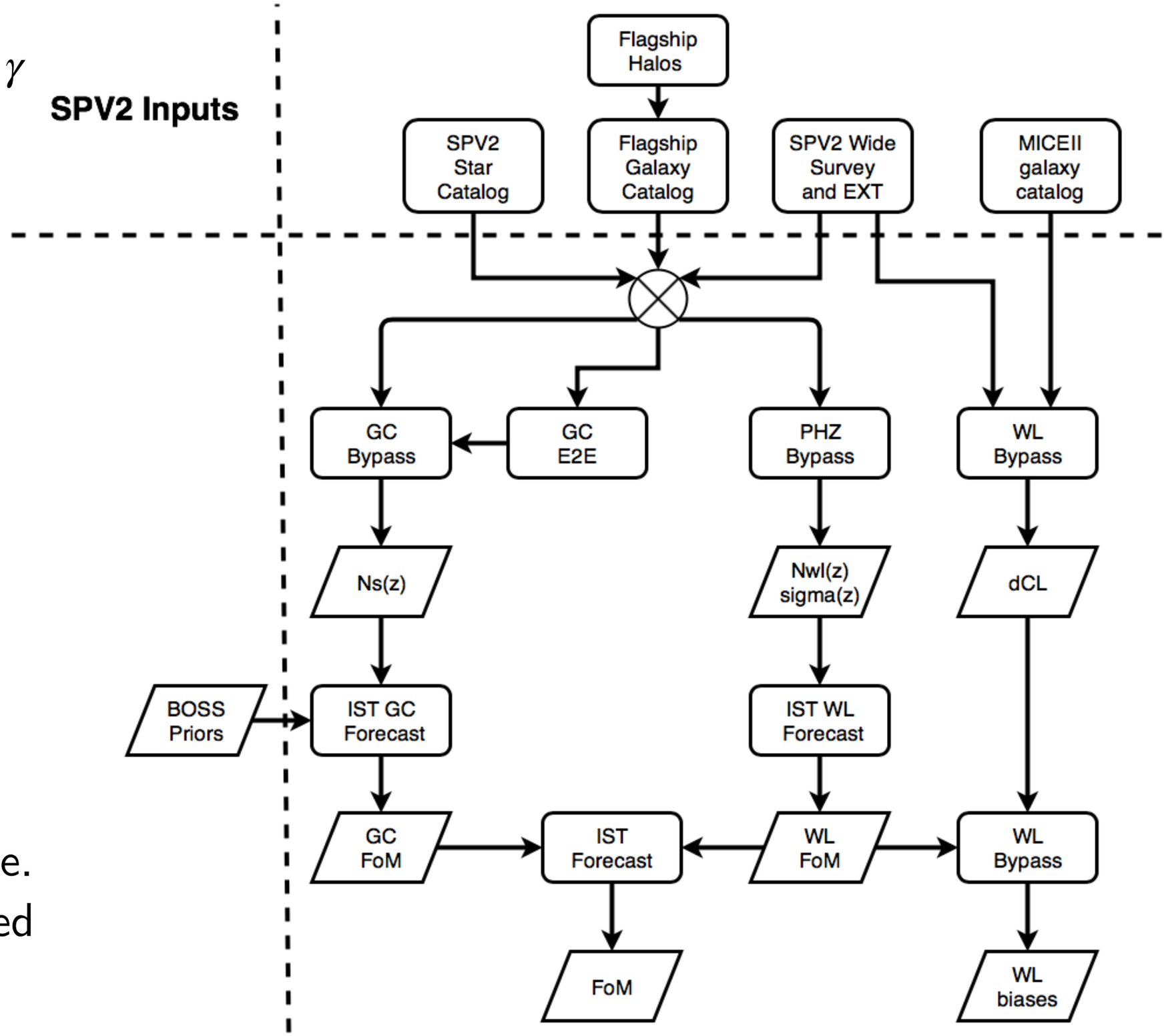
SPV2

- FoM and accuracy on γ are derived independently on the GCs side and WL side using a Fisher matrix formalism
  - GCs:
    - BAO + RSD
  - WL:
    - shear-shear: WL
    - pos-pos: GCp
    - shear-pos: XC
- They are combined assuming independence.
- Biases were also derived on the WL side.



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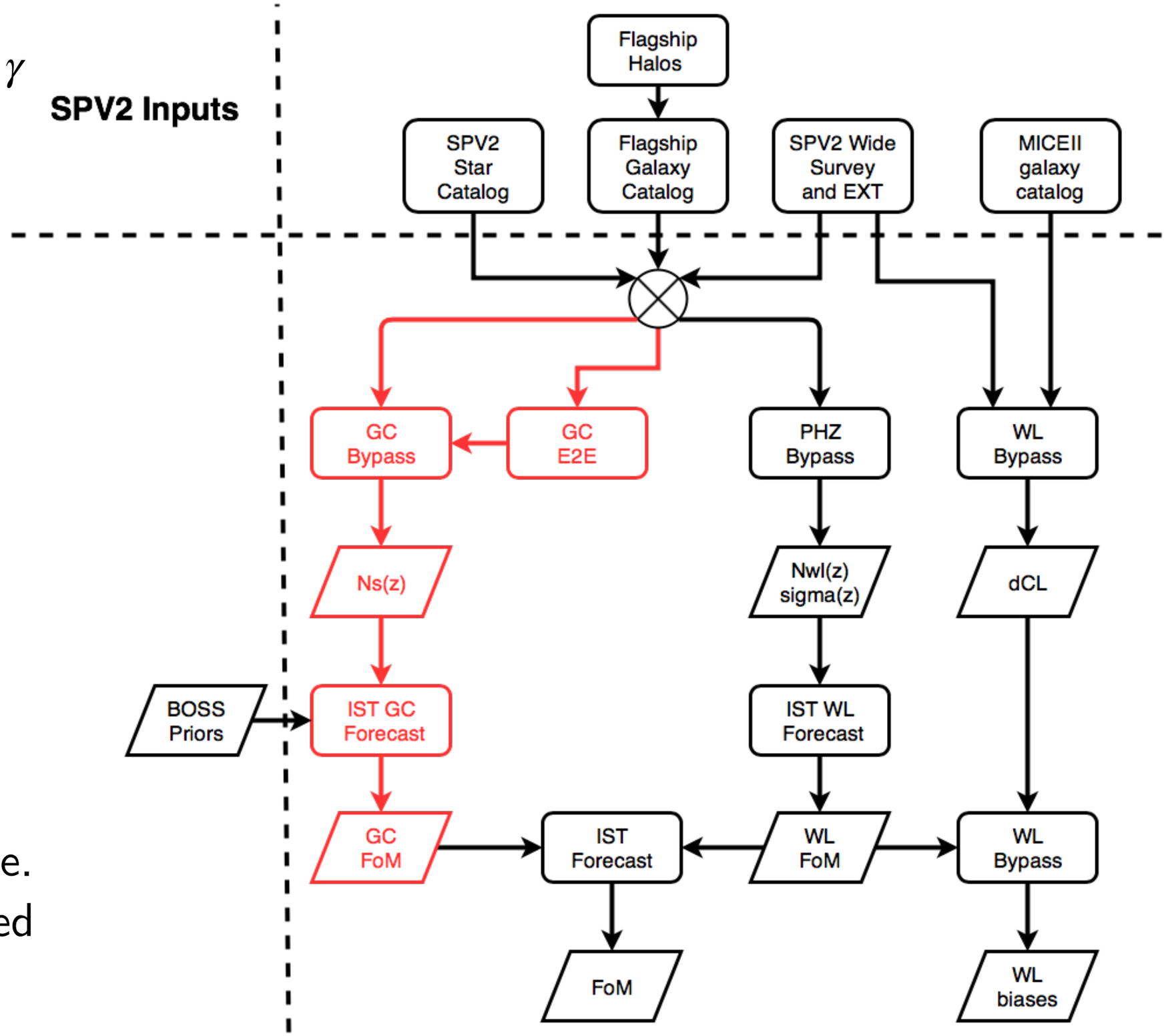

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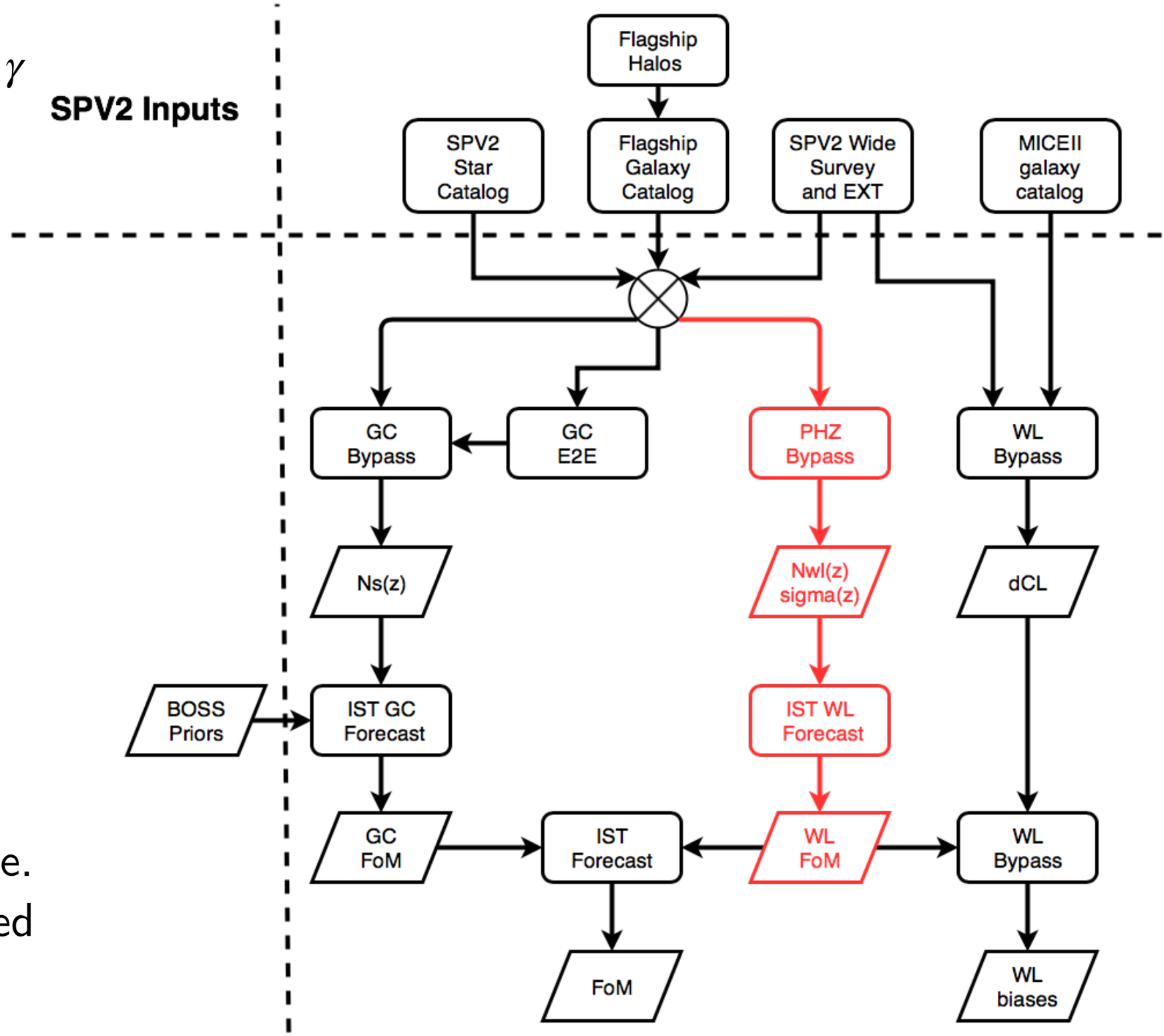

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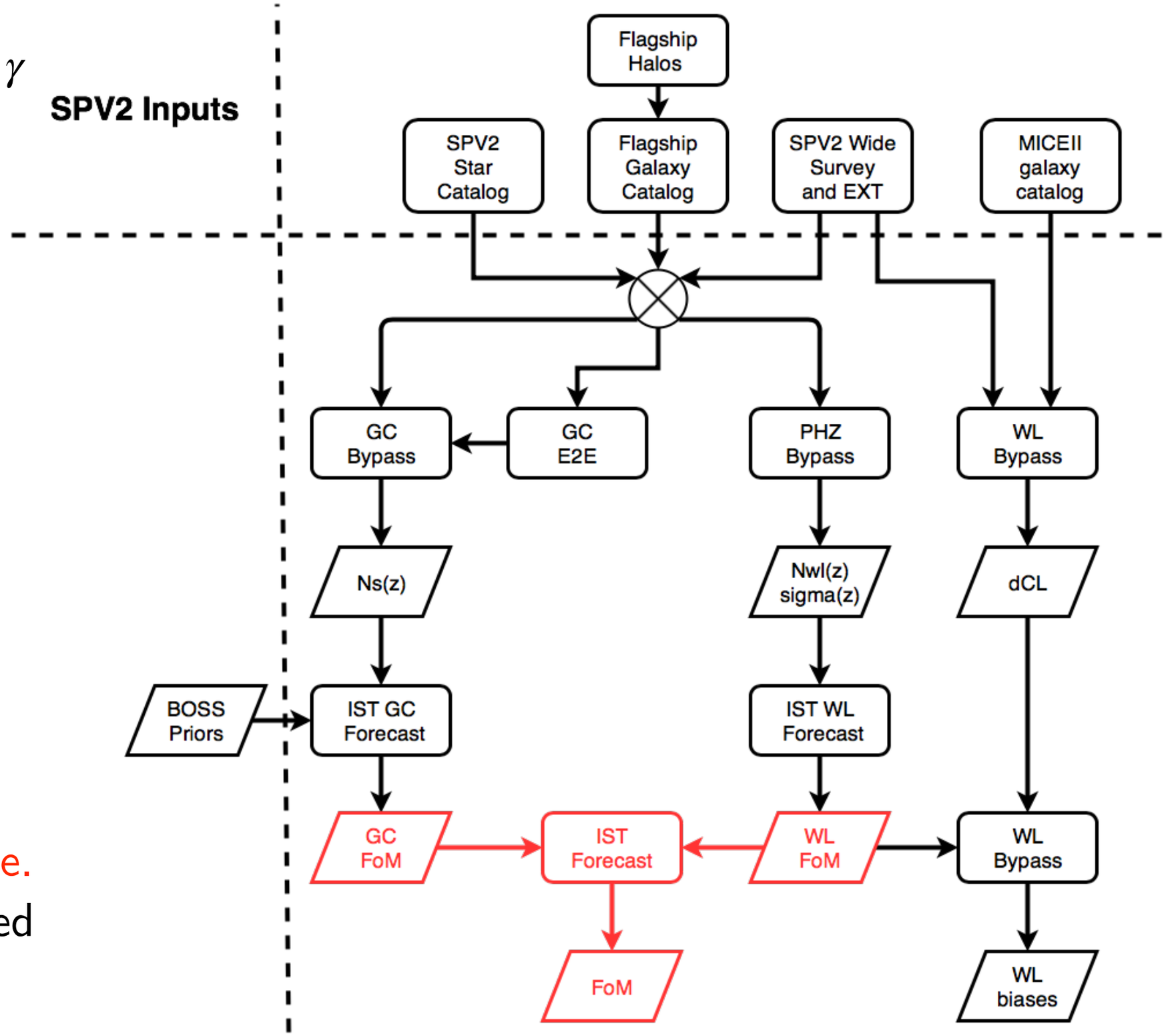

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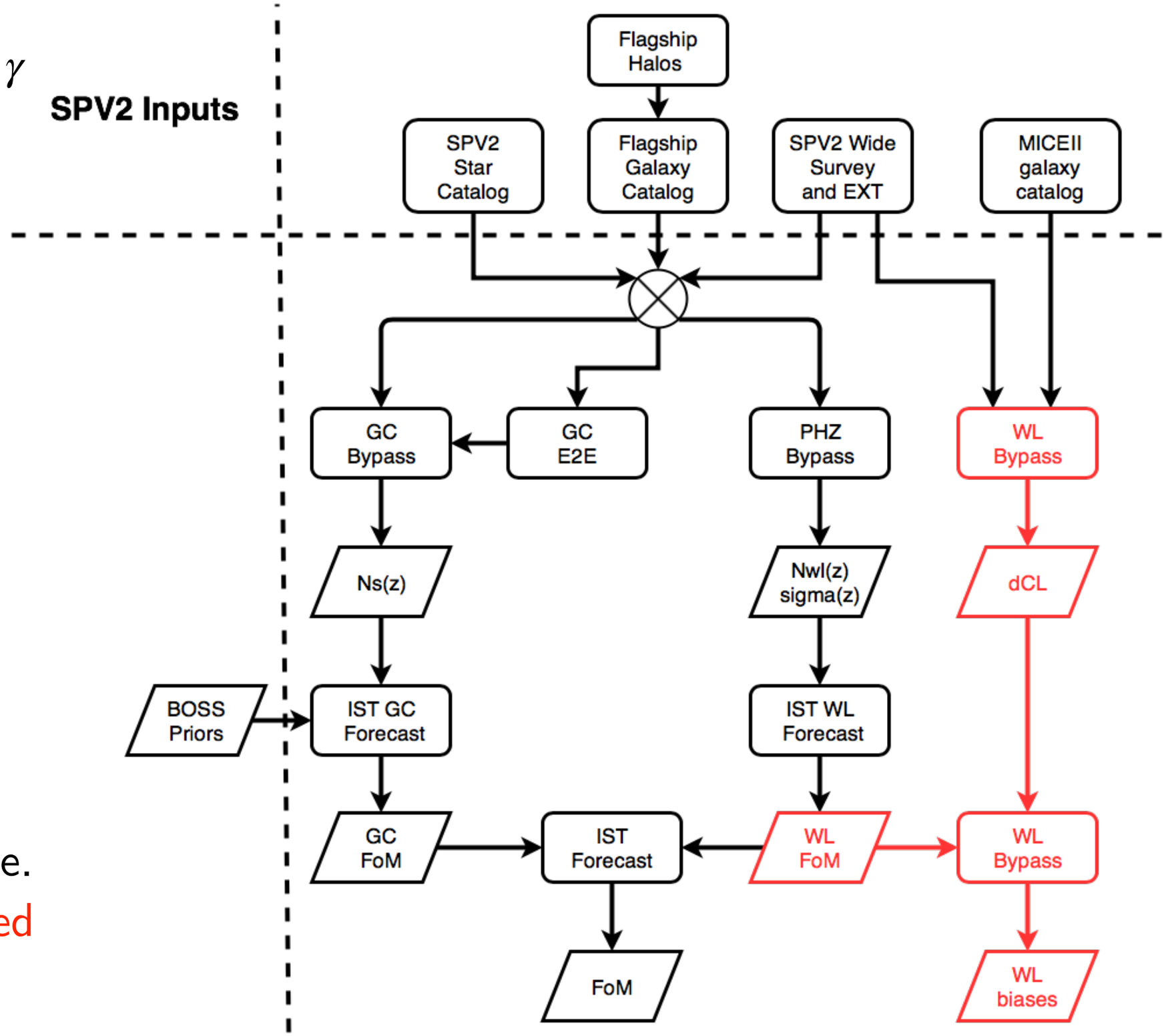
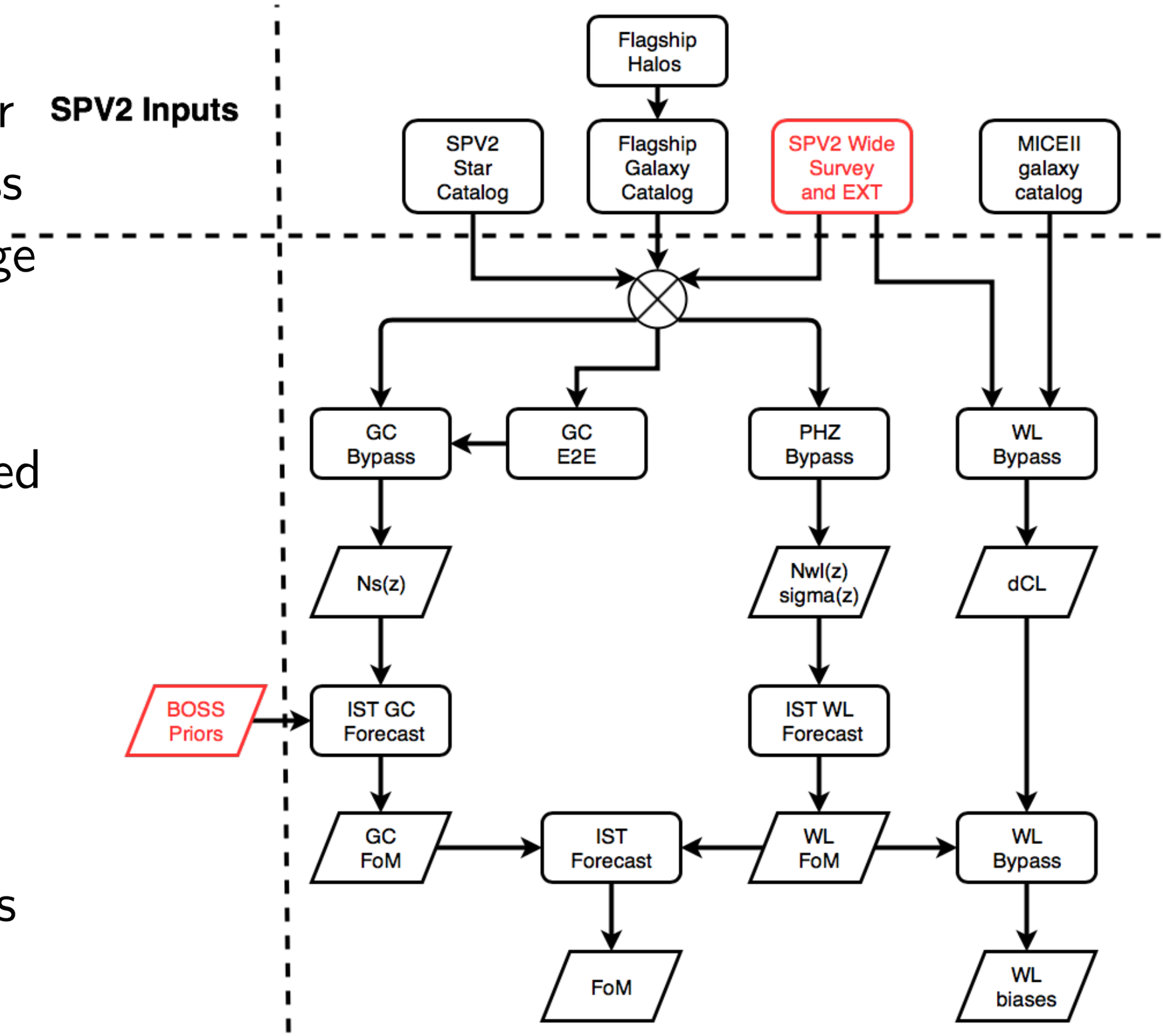
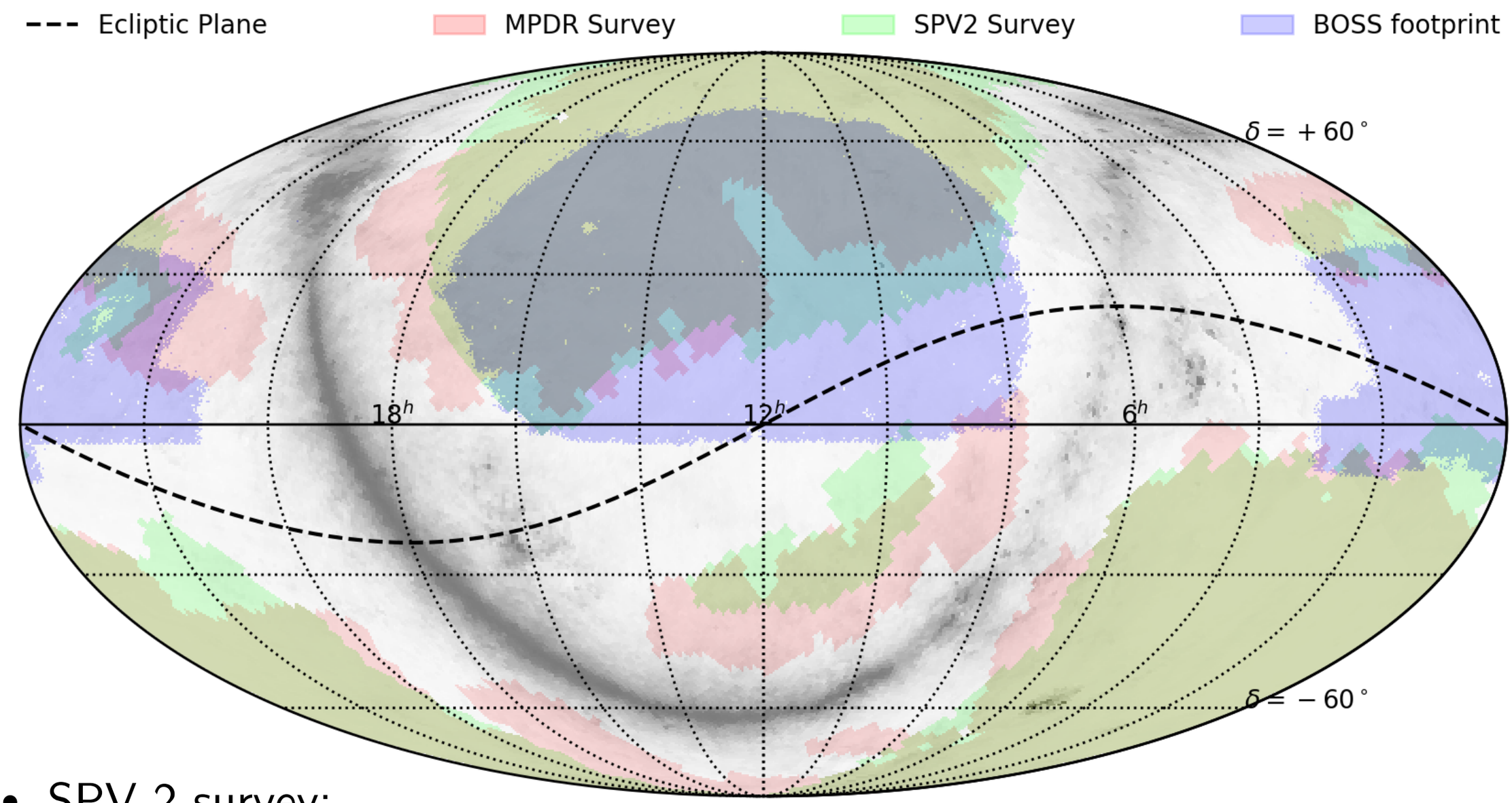


SPV2 Survey and External Data

- BOSS
  - Only external prior to compensate loss of redshift coverage
- Survey:
  - Provided by EC-SURVEY, described in MOCD-B
- EXT
  - Euclidized photometric data.
  - Depending on availability, various scenarios are possible.

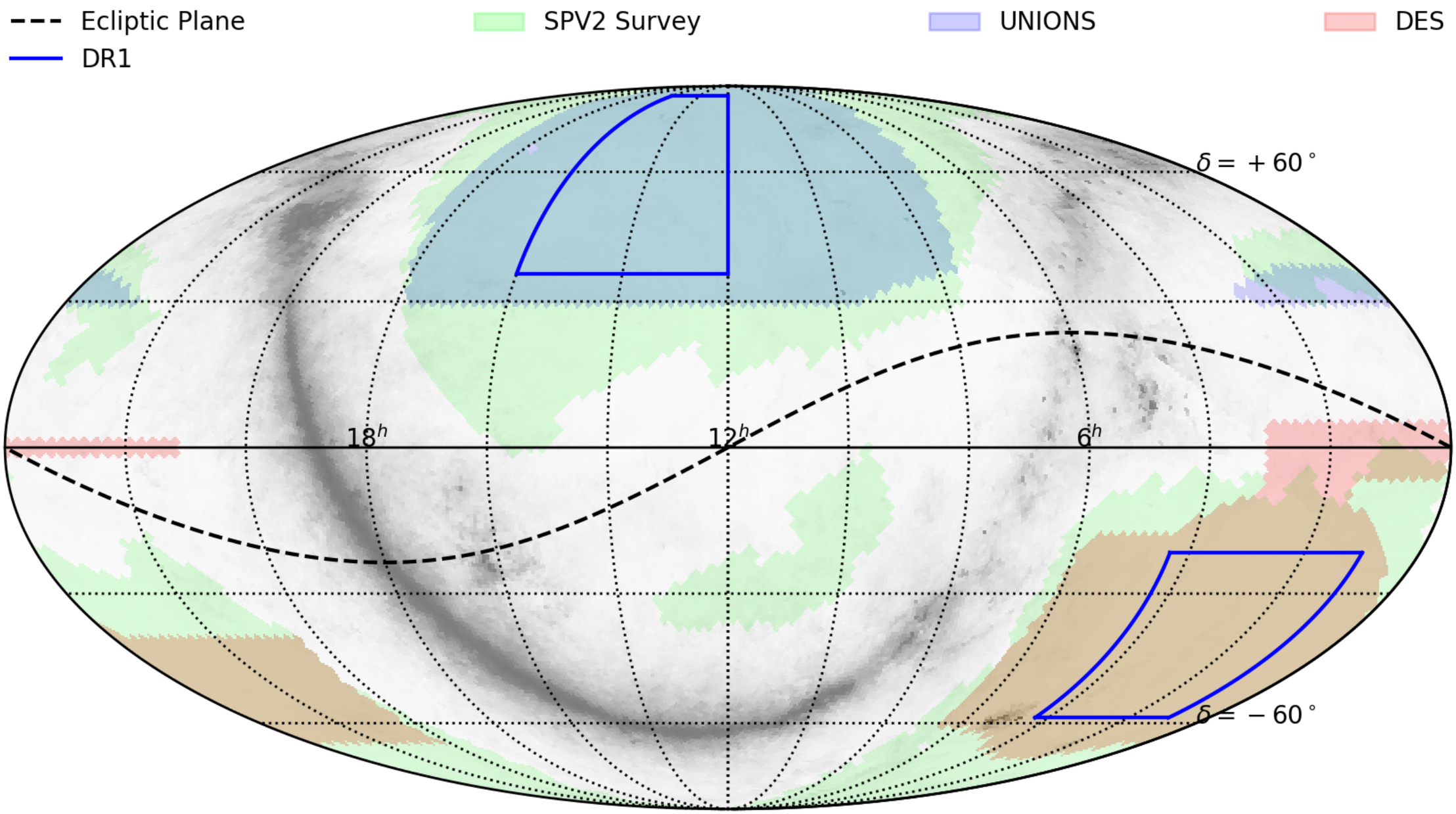


SPV2 Survey



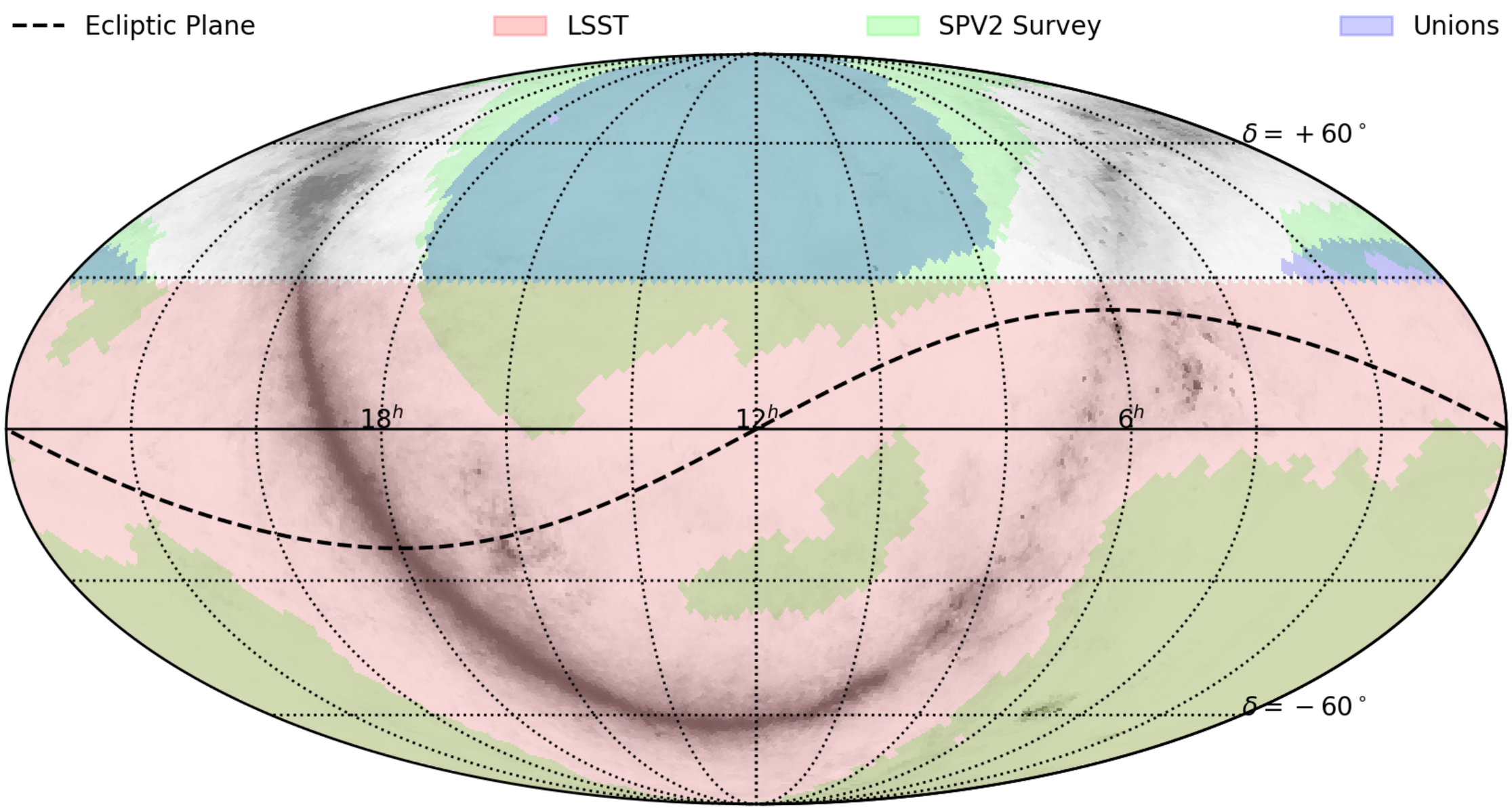
- SPV 2 survey:
  - 15459 sq. deg. observed in 5.85 yr.
  - Optimized for GCs
- BOSS data to make up for the loss of redshift coverage with the switch to a Wide survey with the red grism only.

SPV2 Scenarios: “DR1”



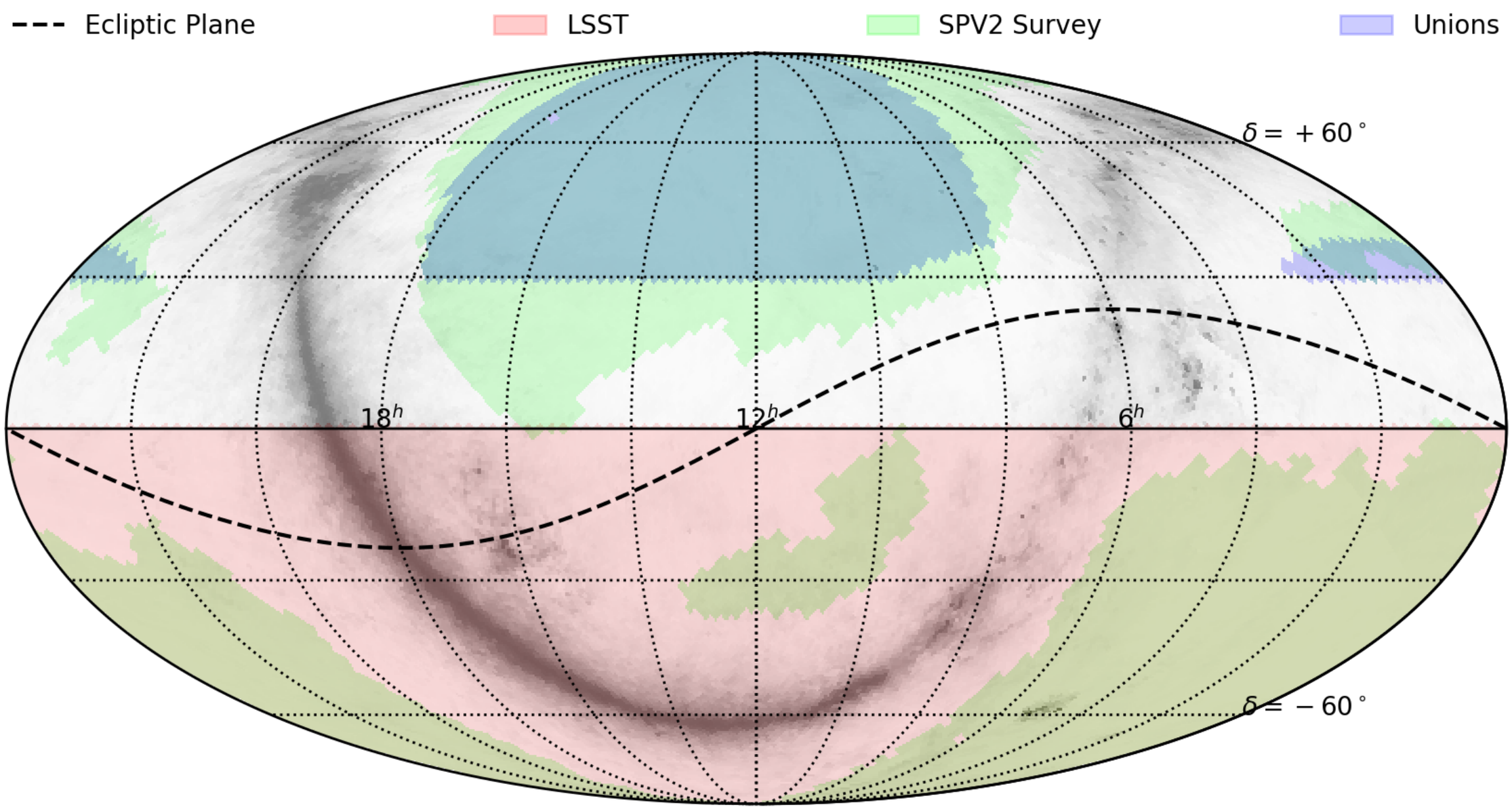
- DR1 : after 1 year of survey. 2800 square degree
  - 1400 square degree in the South over DES
  - 1400 square degree in the North over UNIONS

SPV2 Scenarios: “DR3 best”



- DR3 best: end of mission with SPV2 survey, 15459 square degree
  - Assumes LSST coverage $\delta < 30^o$
  - Assumes UNIONS coverage at $\delta > 30^o$ match SPV2 survey

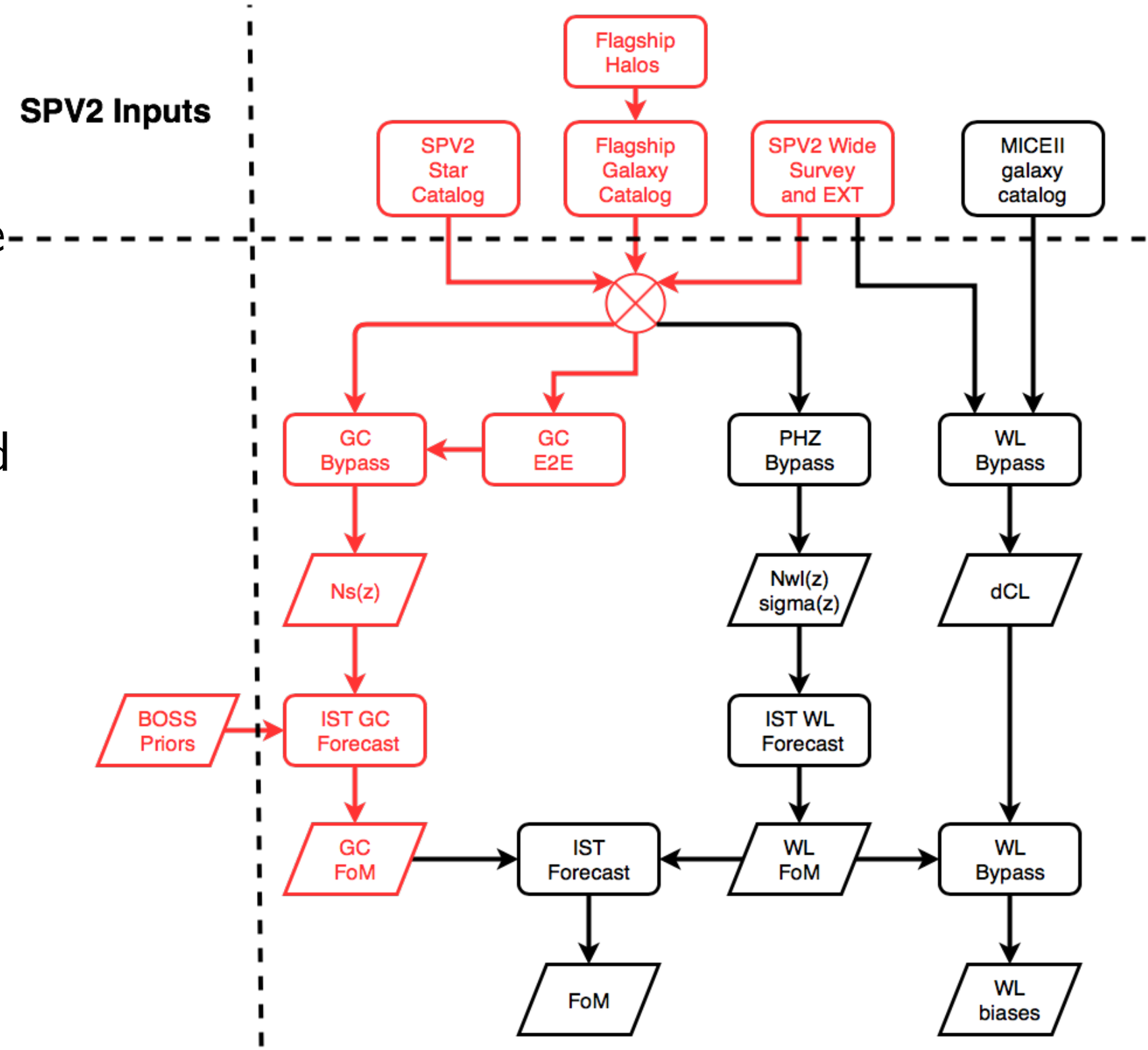
SPV2 Scenarios: “DR3 secure”



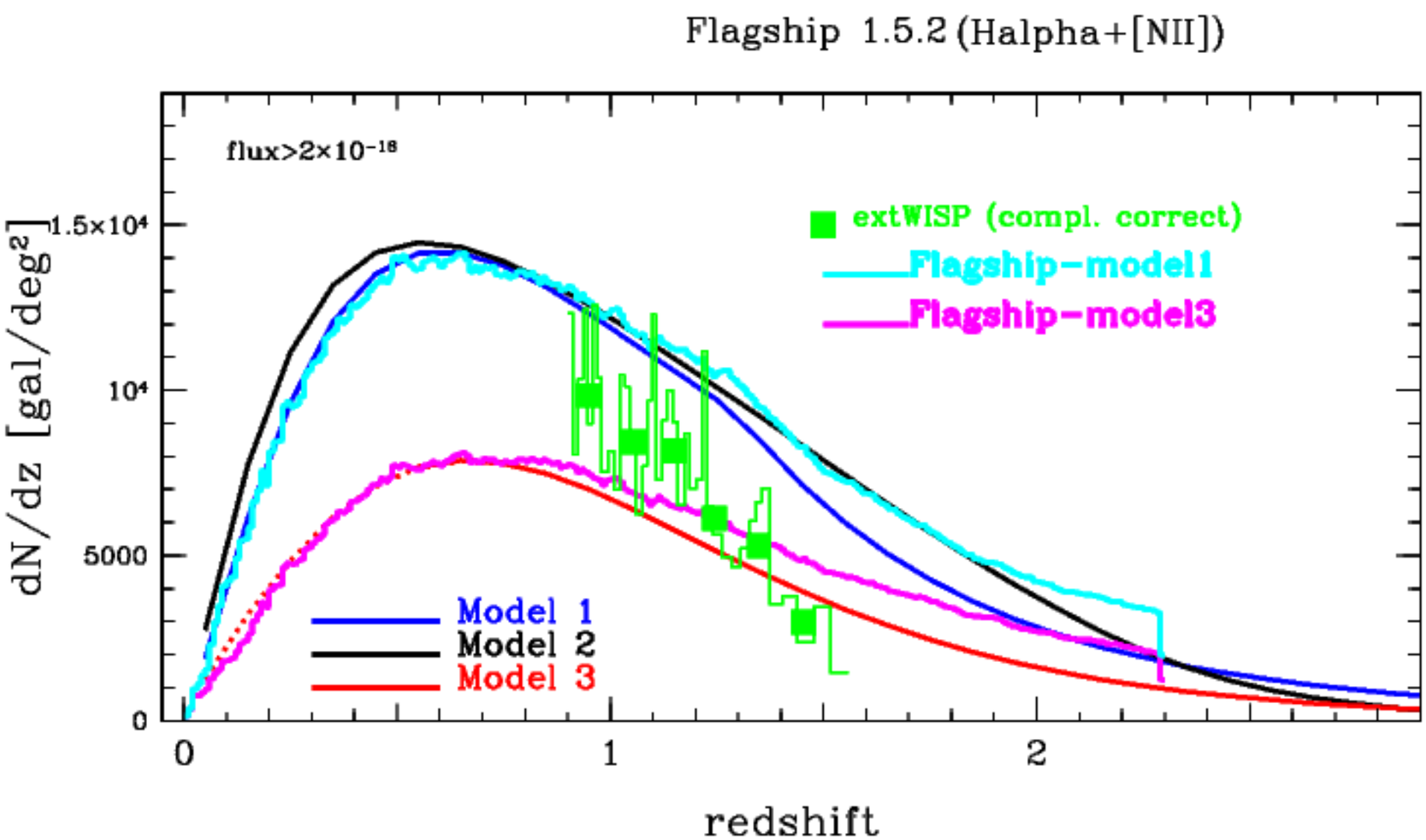
- DR3 best: end of mission with SPV2 survey, 15459 square degree
  - Assumes LSST coverage $\delta < 0^\circ$
  - Assumes UNIONS coverage at $\delta > 30^\circ$ match SPV2 survey (different from v2.0 secure definition that uses PS2 DR1 depths)
  - Loss of ≈2000 square degree for WL (but not for GCs)

SPV2 NISP Spectroscopy

- BOSS
  - Only external prior to compensate loss of redshift coverage
- Survey:
  - Provided by EC-SURVEY, described in MOCD-B
- EXT
  - Euclidized photometric data.
  - Depending on availability, various scenarios are possible

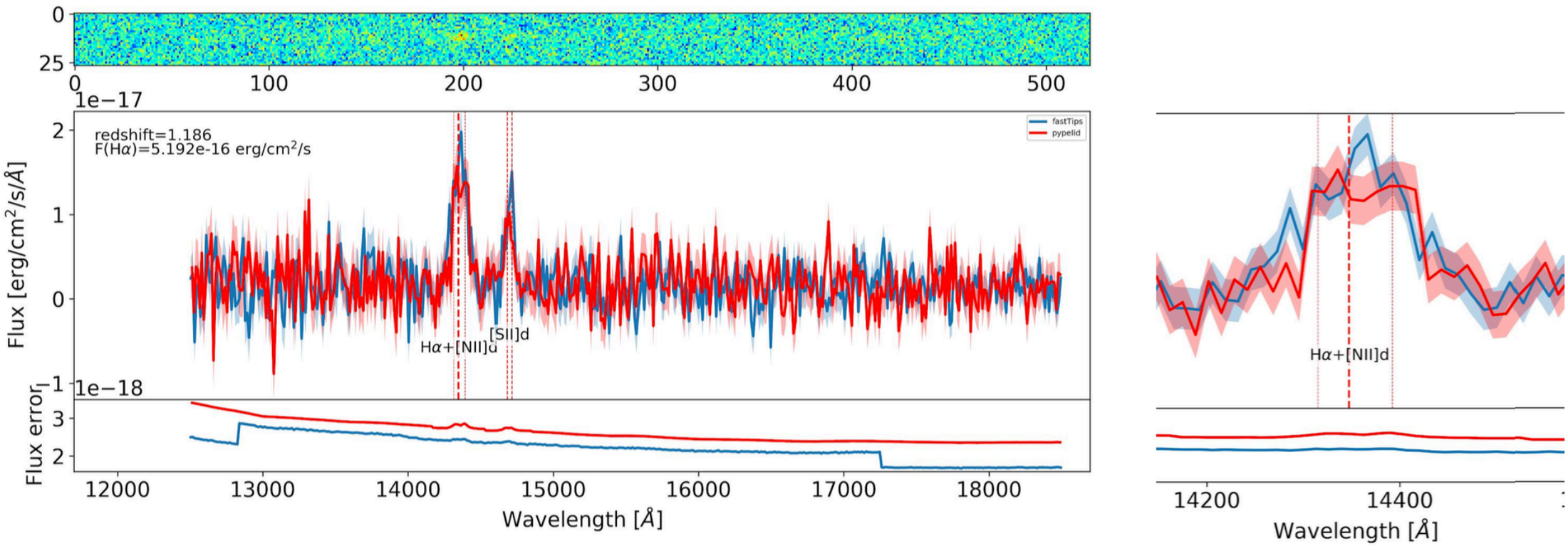


SPV2 GCs



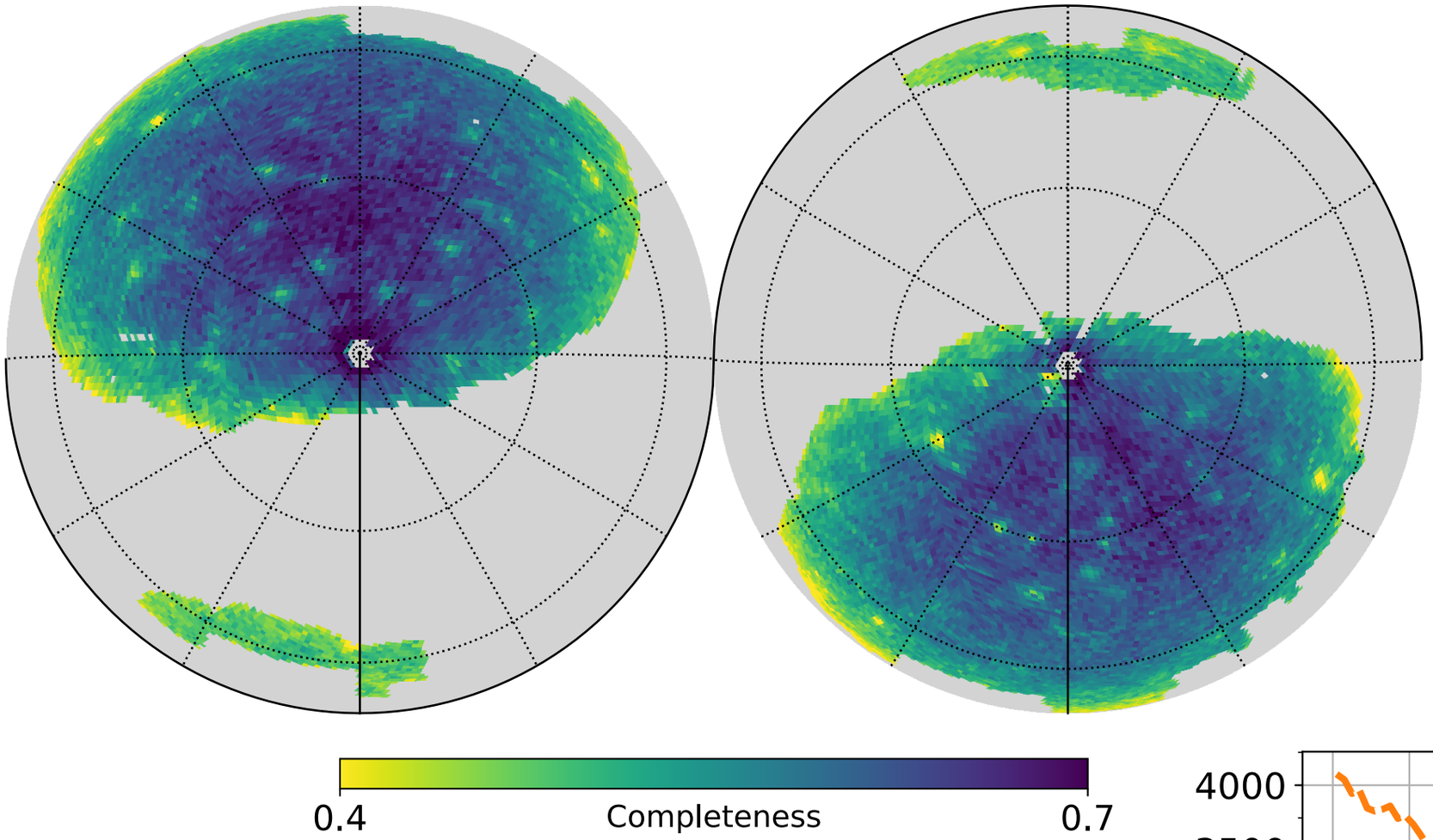
- Conservative H number counts: Pozzetti+16 model3 used
- WISP counts from Bagley+18
- Additional simulations are being run with model1

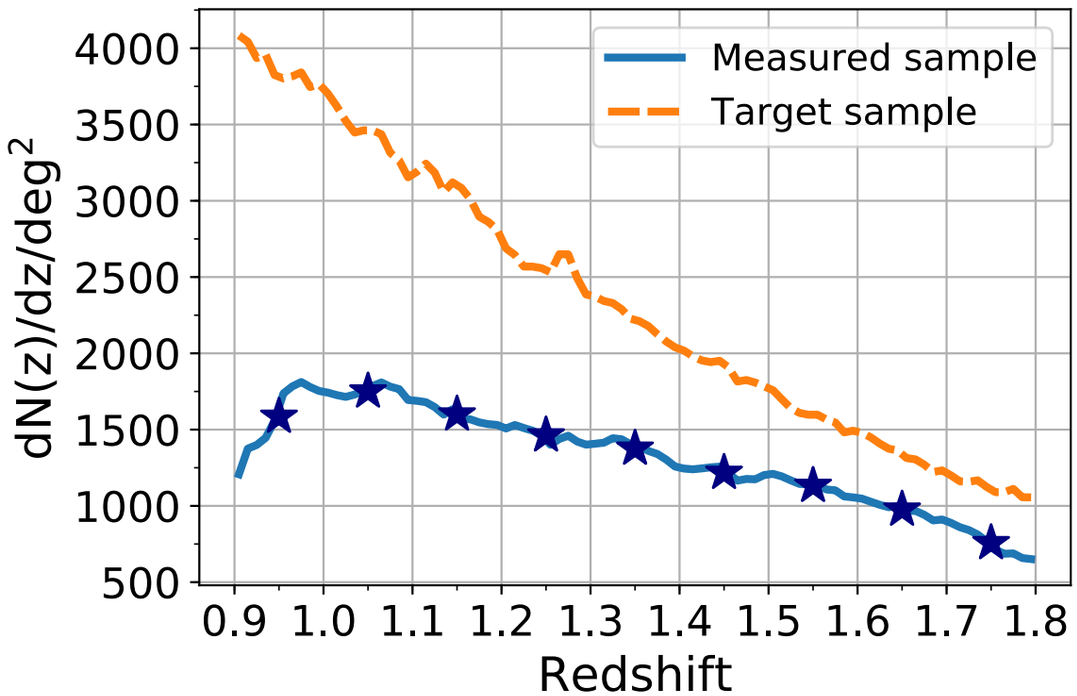
SPV2 NISP Spectroscopy: fastTIPS + AMAZED - Pypelid



- Pypelid is the GC Bypass.
- It is calibrated against E2E simulations with SGS tools
  - OU-SIM fastTIPS to produce 1D spectra.
  - OU-SPE AMAZED for the redshift measurement.
- Both tools have been debugged by SPV2:
  - Good agreement on the fluxes and lines profiles and position
  - Good agreement on the redshift measurement
  - Pypelid noise > fastTIPS noise, but this has been traced to a problem with fastTIPS.

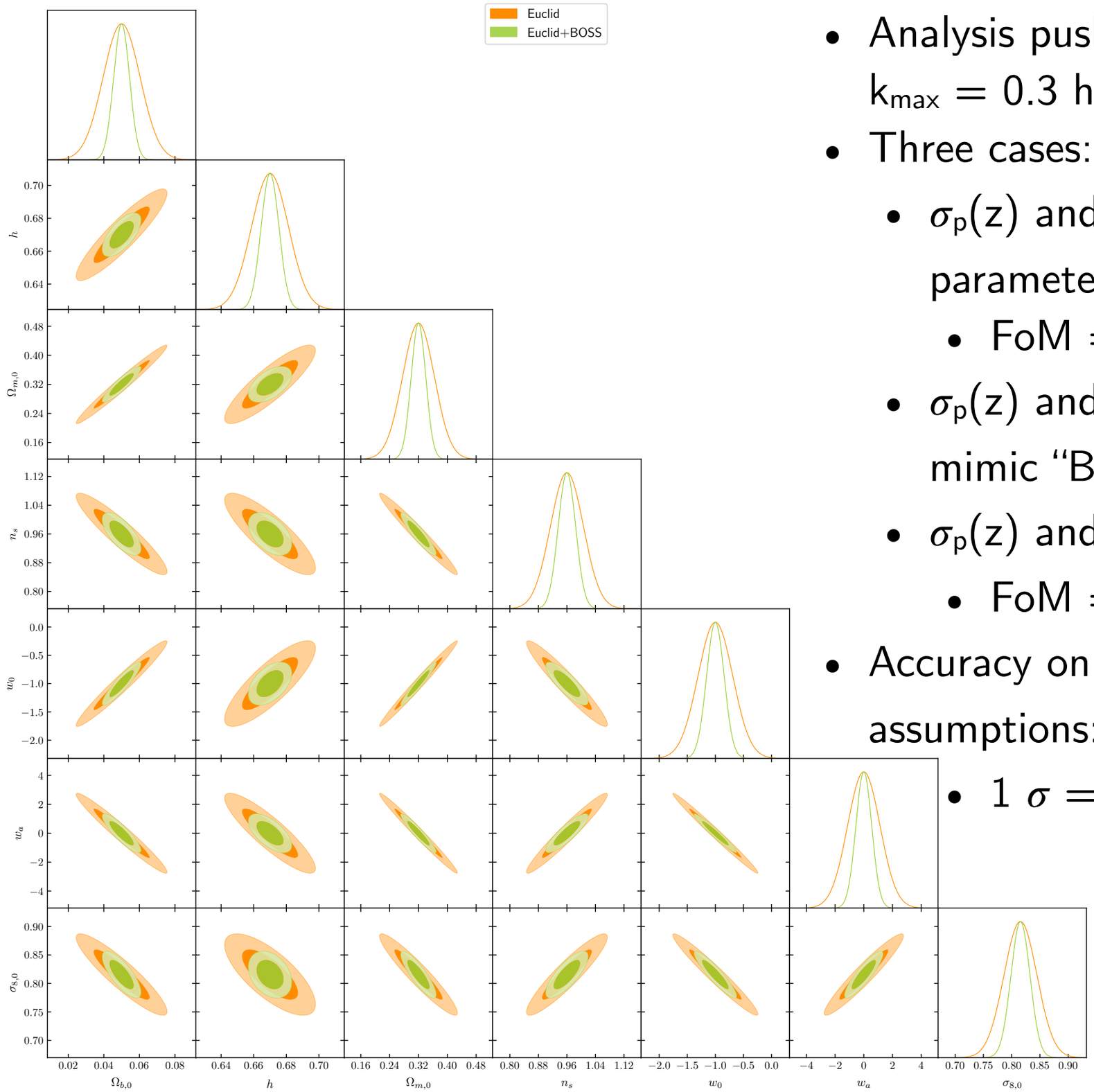
SPV2 GCs Bypass





- GC bypass derives the number counts of sources with measured redshift

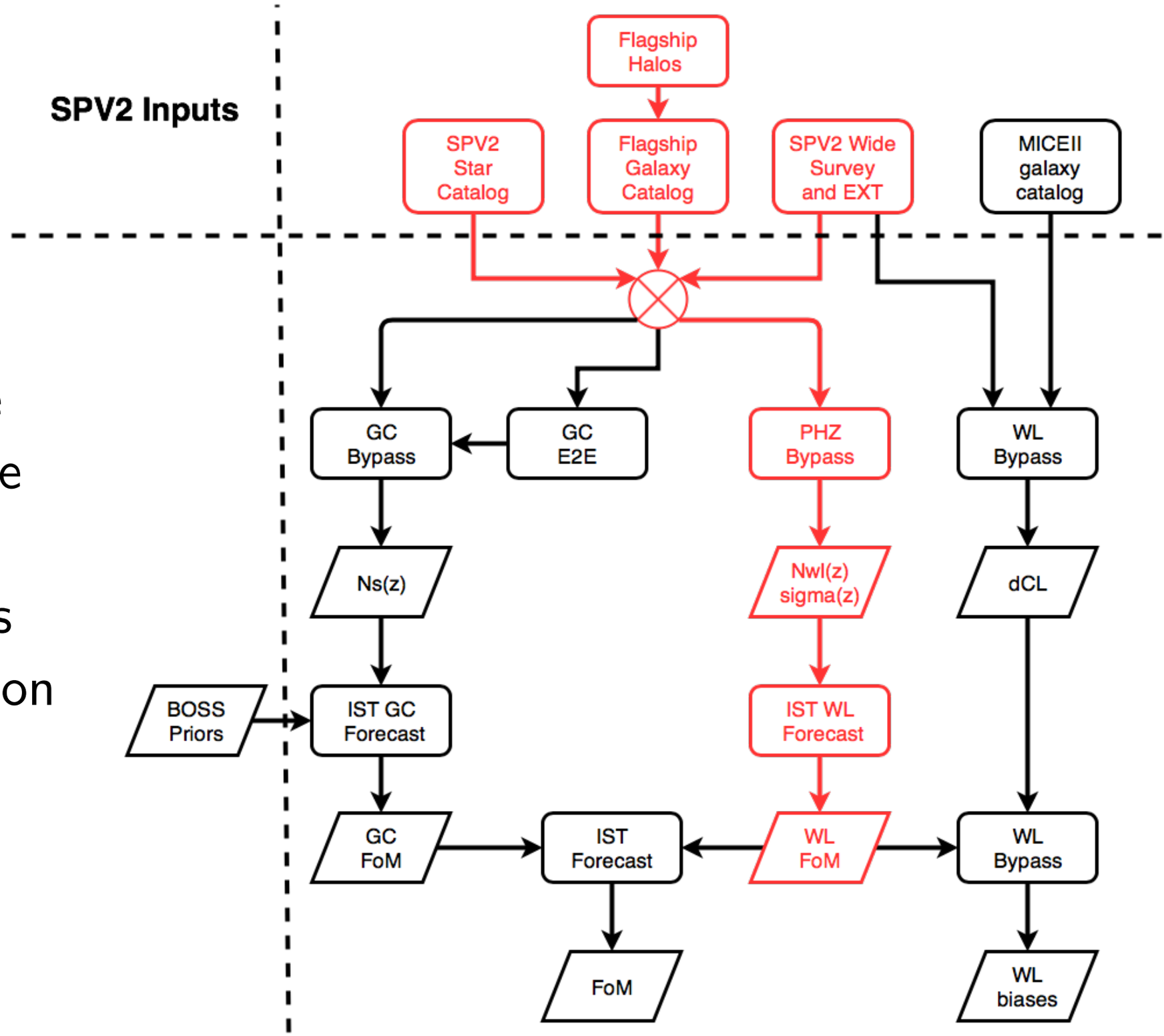
GCs FoM and accuracy on γ



- Analysis pushed to the non-linear regime: $k_{max} = 0.3$ h/Mpc
- Three cases:
  - $\sigma_p(z)$ and $\sigma_v(z)$ treated as nuisance parameters:
    - FoM = 24.70
  - $\sigma_p(z)$ and $\sigma_v(z)$ not independent to mimic "Baryon Reconstruction" methods
  - $\sigma_p(z)$ and $\sigma_v(z)$ known
    - FoM = 32.55
- Accuracy on γ has little dependence on the assumptions:
  - $1\ \sigma = 0.11$

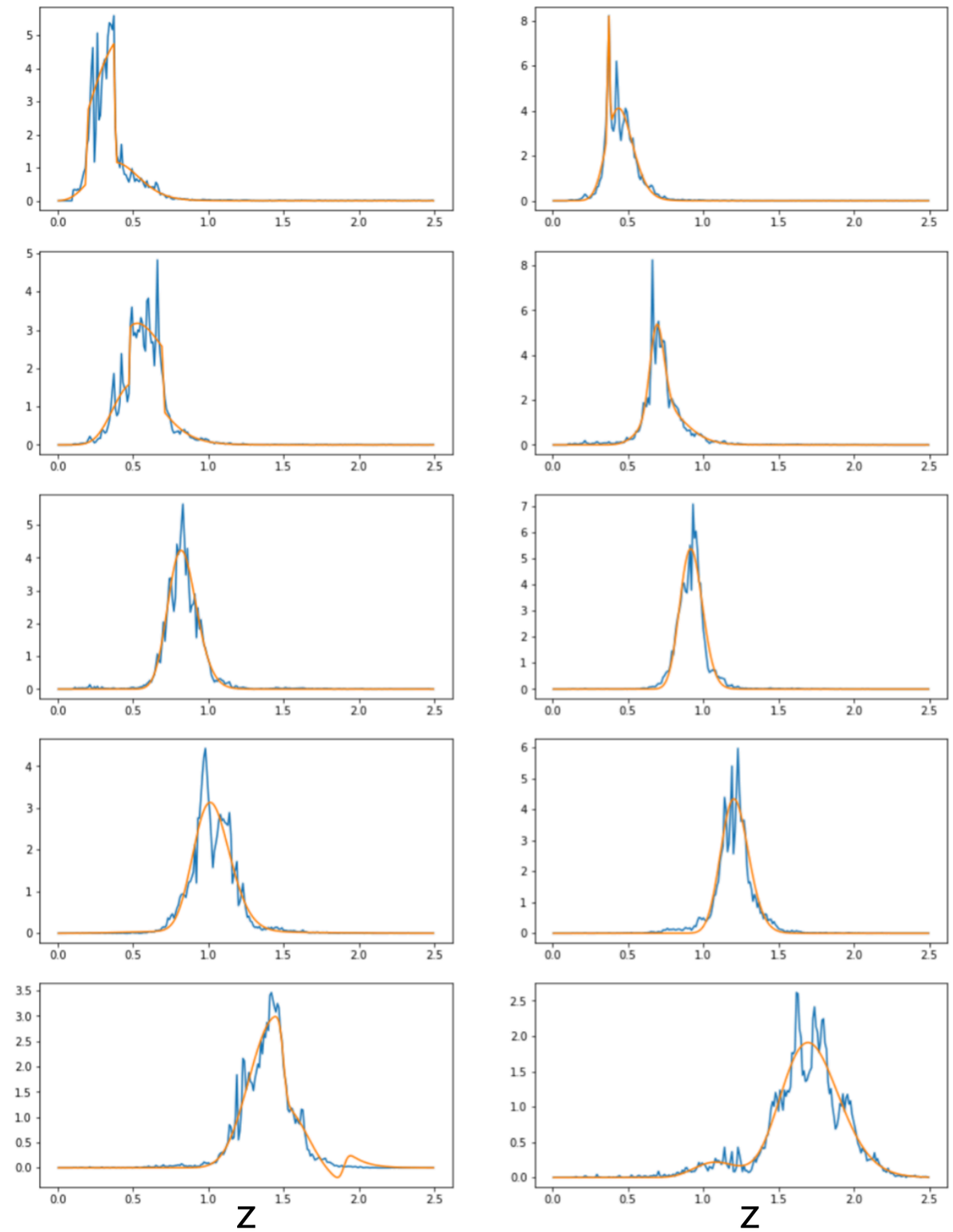
SPV2 Weak Lensing

- WL FoM is derived from the N(z) of sources with a shape measurement and the precision of the photometric redshifts for the characterisation of the tomographic bins.



OU-PHZ redshift determination

Bin	z_{il}	z_{iu}
1	0.200	0.362
2	0.362	0.497
3	0.497	0.634
4	0.634	0.734
5	0.734	0.843
6	0.843	0.948
7	0.948	1.086
8	1.086	1.254
9	1.254	1.523
10	1.523	2.000



- Use Phosphoros to test photometric redshifts quality

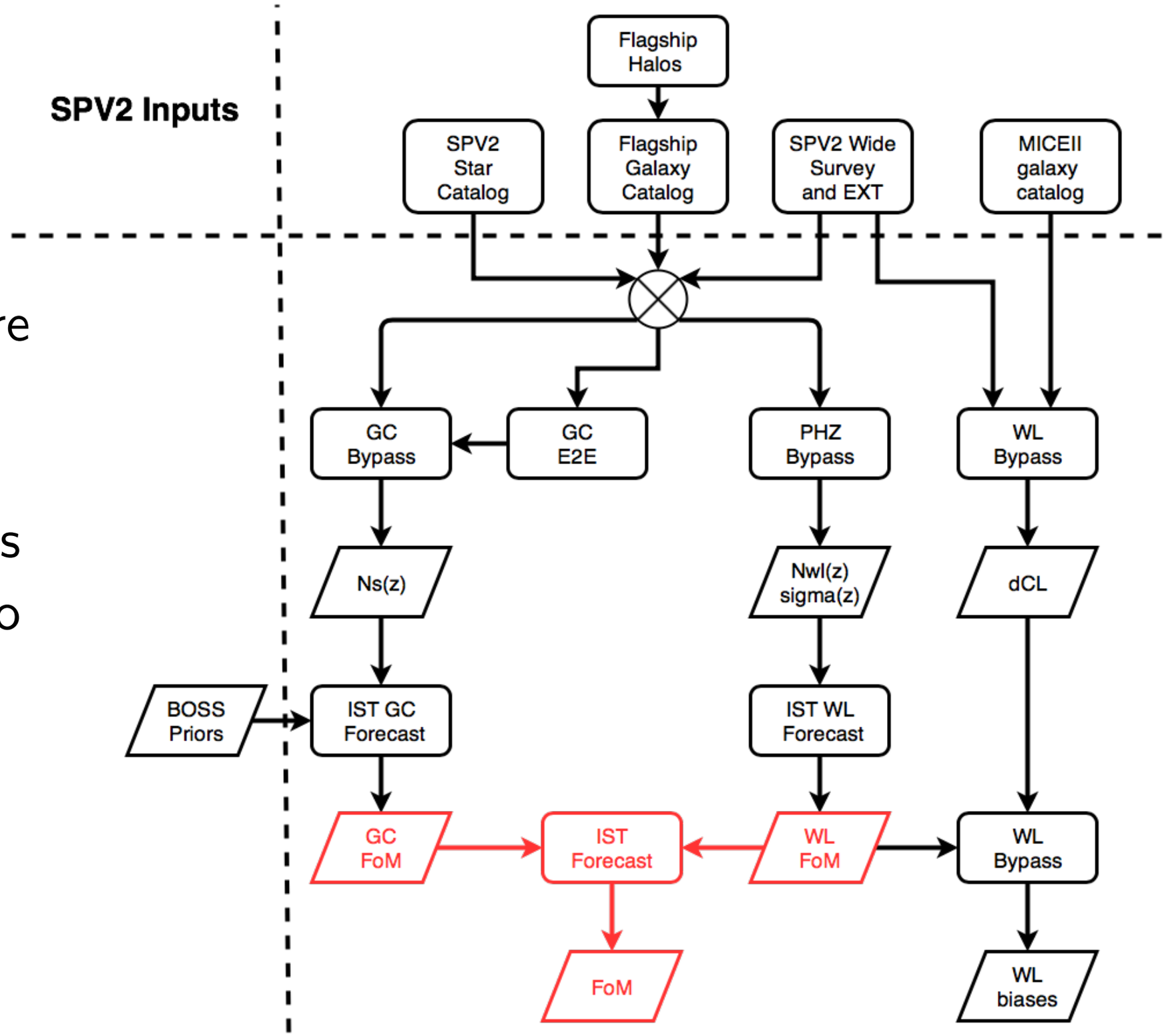
OU-PHZ redshift determination

Bin	DR1 South	DR1 North	DR3 South	DR3 North
1	0.71	0.76	0.84	0.86
2	0.86	0.85	**0.90**	**0.90**
3	0.74	0.82	0.87	0.84
4	0.73	0.80	0.86	0.84
5	0.85	0.84	**0.91**	**0.90**
6	**0.94**	**0.91**	**0.96**	**0.95**
7	0.88	0.87	**0.92**	**0.90**
8	**0.90**	**0.90**	**0.94**	**0.93**
9	**0.91**	**0.90**	**0.93**	**0.92**
10	0.84	0.82	0.88	0.87

- OU-PHZ requirements:
    - Tails:
        - 90% of the stacked distribution should lie within 0.15(1+z)
- This requirement does not apply to the bins individually
- Values in bold meet the requirement per bin
- DR3 South meets the requirement

SPV2 Combined FoM

- GCs and WL FoM are combined assuming independence.
- This approximation is valid because the two samples are disjoint.



SPV2 hypothesis

	Red Book	MPD v 2.0	MPD v 2.1
Area	15000 sq. deg.	15454 sq. deg. DR3 best	15454 sq. deg. DR3 best, DR3 secure & DR1
PHZ	no outliers $\sigma(z)/(1+z) = 0.05$ 10 redshift bins $0.001 < z < 2.5$	10% outliers $\sigma(z)/(1+z) = 0.05$ 10 redshift bins $0.001 < z < 2.5$	outliers from OU-PHZ (< 10%) $\sigma(z)$ from OU-PHZ for each bin 10 redshift bins $0.2 < z < 2.0$
GCs	N(z): Geach+10 $0.7 < z < 2.0$	N(z): Pozzetti+16 model3 $0.9 < z < 1.8$ + BOSS prior	N(z): Pozzetti+16 model1 and 3 $0.9 < z < 1.8$ + BOSS prior
WL	30 arcmin^2 123 x 123 FM IA prior lmax=5000	30 arcmin^2 22 x 22 FM No IA prior lmax=3000 and 5000	30 arcmin^2 22 x 22 FM No IA prior lmax=3000 and 5000 25% degradation for non-gaussian covariance
GCs	linear BAO peak: $k_{max} = 0.2$ h/Mpc	non-linear BAO damping: $k_{max} = 0.3$ h/Mpc σ_p, σ_v fixed or free	non-linear BAO damping: $k_{max} = 0.3$ h/Mpc σ_p, σ_v fixed, free, BAO reconstruction

SPV2 Combined FoM

	FoM Model3 l_{max}=3000	FoM Model3 l_{max}=5000	FoM Model1 l_{max}=3000	FoM Model1 l_{max}=5000
v 2.0 DR3 best	227	347 (400 fixing σ_p and σ_v)	n/a	n/a
v 2.1 DR1	31	54	34	57
v 2.1 DR3 secure	202	360	241	408
v 2.1 DR3 best	223	400	263	449

- Uses realistic option for GCs to account for BAO reconstruction for the treatment of σ_p and σ_v
- The goal of 400 can be reached when pushing the analysis to $l_{max} = 5000$ in the non linear regime.

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SPV2 Accuracy on γ

	FoM Model3 l_{max}=3000	FoM Model3 l_{max}=5000	FoM Model1 l_{max}=3000	FoM Model1 l_{max}=5000
v 2.0 DR3 best	0.019	0.019	n/a	n/a
v 2.1 DR1	0.063	0.059	0.060	0.057
v 2.1 DR3 secure	0.028	0.027	0.024	0.023
v 2.1 DR3 best	0.027	0.026	0.024	0.023

- Uses realistic option for GCs to account for BAO reconstruction for the treatment of σ_p and σ_v
- The loss of redshift coverage between v2.0 and v2.1 (v 2.0: 0.001<z<2.0 v 2.1: 0.02<z<2.0) results in a loss of accuracy on γ.
- SPV2 is investigating to use the full flagship redshift range.

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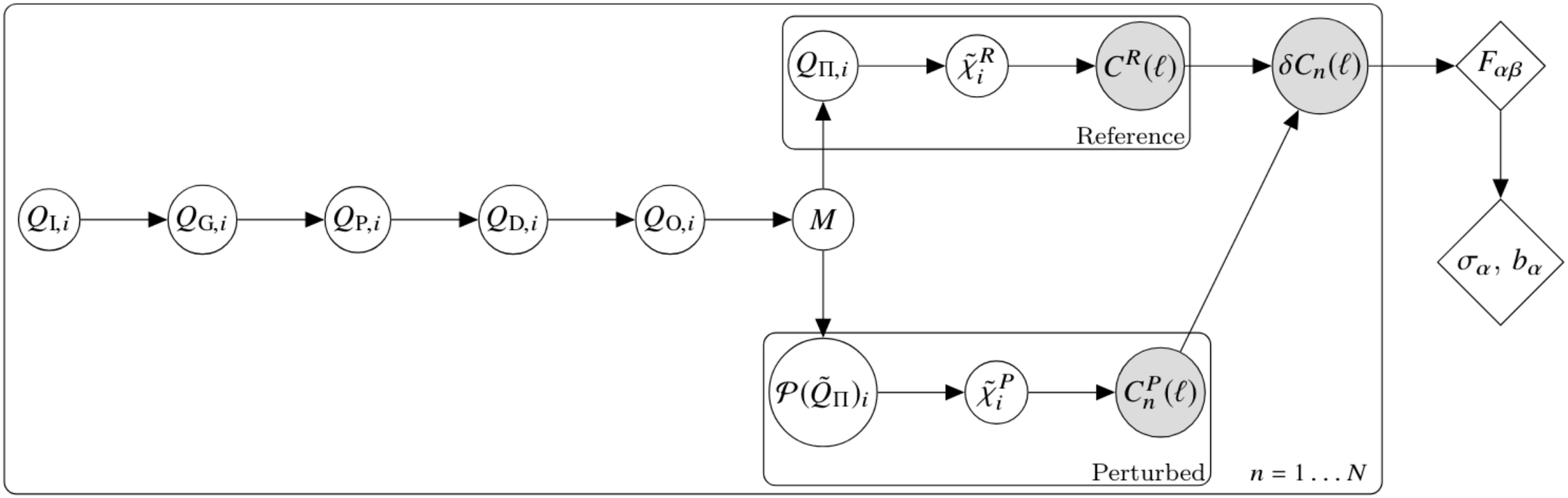
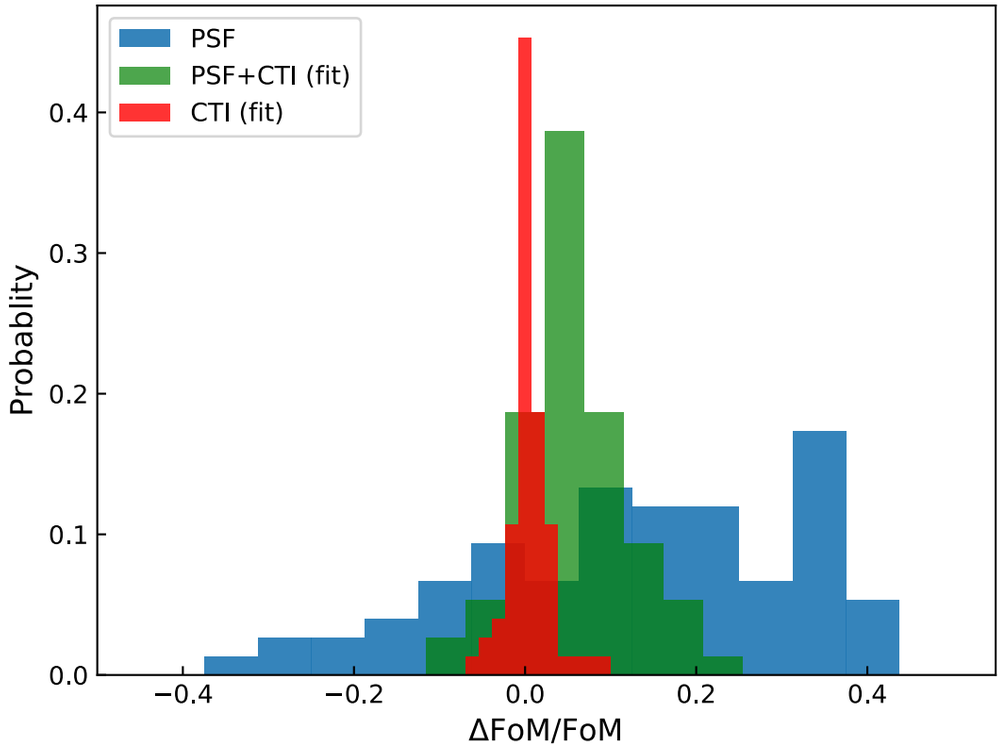
SPV2 WL bypass



- Derive an impact of systematics on the FoM (WL only) and the biases introduced on the DE equation of state parameters.



Conclusions for SPV2

- FoM and accuracy on γ meet the requirements
- The assumptions on the GCs are using conservative number counts and transmissions, and there is margin in the optic transmission from MCDR.
- WL forecast are using an a VIS instrument as required, except for the QE measurements. Testing of FM will be important to check that CTI is behaving as the models predict.
- PHZ quality show that it will be close to requirements using the template fitting code. There is a margin of improvement using neural network code. It will be important to secure the 2000 sq degree of LSST coverage $0 < \delta < 30^{o}$ as it translate into a 10% loss on the FoM
- SPV2 is ongoing and will be completed in April 2019 when all the calibrations runs are completed. Version 2.1 of MPD will be issued with final results.

Goals for SPV3

- Study the feasibility of the Wide calibration derived from the Deep survey.
- Conduct a joint study of the GCs and WL probes, as these calibrations break their independence.
- Use a full likelihood analysis using the IST:Likelihood codes.
- Calibrate all bypasses with full E2E SGS processing.
    - Will only be possible with SC8
- Add other cosmological probes if possible (but the requirement remain on GCs + WL).

Flagship 2.0 Reference

- Flat Standard LCDM with massive neutrinos and radiation fluctuations as well as GR corrections.

- Ωm= 0.319
- Ωb= 0.049
- $\Omega\Lambda$= 0.681 - ΩRAD -$\Omega\nu$ ¶
- Σmν= 0.06 ev (minimal, with linear fluctuations)
- TCMB= 2.7255 K (to determine RAD, with linear fluctuations)
- $\sigma 8$ = 0.83 (maybe we should shift to specifying As now instead)
- h = 0.67
- ns= 0.96
- w0= -1
- wa= 0
- zstart = 200

Flagship 2.0 Resolution and size

- Wide
  - Particle mass = 1×10^9 h^{-1} M⊙
  - Box side length = 3600 h^{-1} Mpc
  - Derived quantities
    - Mean interparticle separation = 0.224 h^{-1} Mpc
    - Mean particle density = 88.54 h^3 Mpc^{-3}
    - Particle Number = 16000^3 = 4.13 trillion
  - Output:
    - Full-sky light cone to a depth $z < 2.3$ particles and Rockstar Halos
    - Healpix maps of projected masses, velocities, potentials and time derivative of potentials.
    - Rockstar (and FoF) halos at 100 time slices
    - Merger trees of halos and orphaned galaxies in time slices and in the light cone
    - Power spectrum on 100 time slices (no time to implement bispectrum)

Flagship 2.0 Resolution and size

- Deep
  - Particle mass = 1×10^8 h^{-1} $M_\odot$
  - Box side length = 1000 h^{-1} Mpc
  - Derived quantities
    - Mean interparticle separation = 0.104 h^{-1} Mpc
    - Mean particle density = 885 h^3 Mpc^{-3}
    - Particle Number = 9600^3 = 885 billion
  - Output
    - 10 light cone beams of 20 sq.deg to a depth $z < 5$ particles and Rockstar Halos
    - Sparse Healpix maps of projected masses, velocities, potentials and time derivative of potentials.
    - Rockstar (and FoF) halos at 100 time slices
    - Merger trees of halos and orphaned galaxies in time slices and in the light cone
    - Power spectrum and bispectrum on 100 time slices

Flagship 2.0 output

- For now, only M200b outputted.
- Discussion to have on the injection of galaxies.