An Updated Reference Time-Domain Survey and Cosmology Forecast with The Roman Space Telescope

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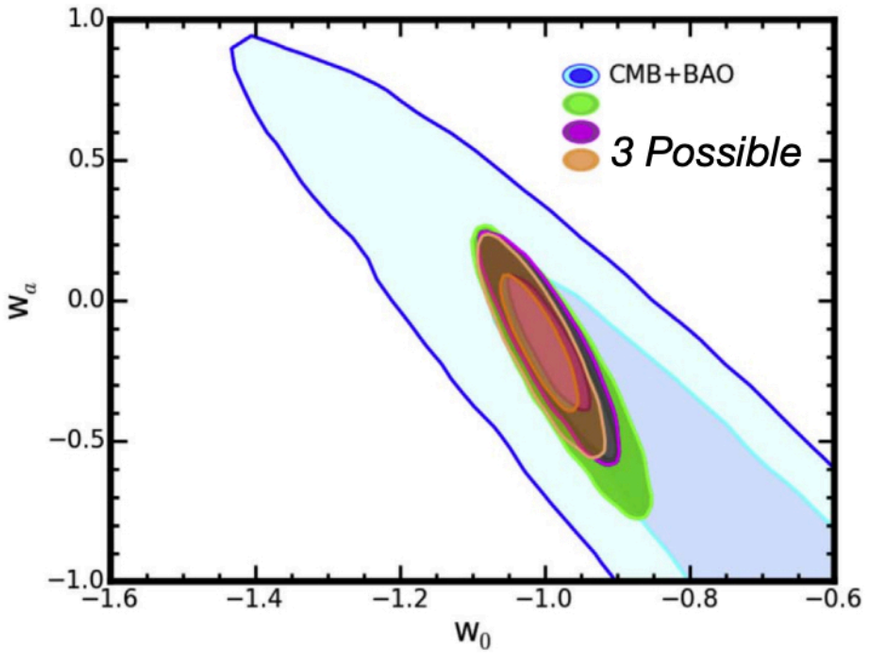
+ Foley SIT

pmacias@ucsc.edu

Roman Cosmology Seminar 1/27/22

Roman Cosmology with Type Ia Supernovae

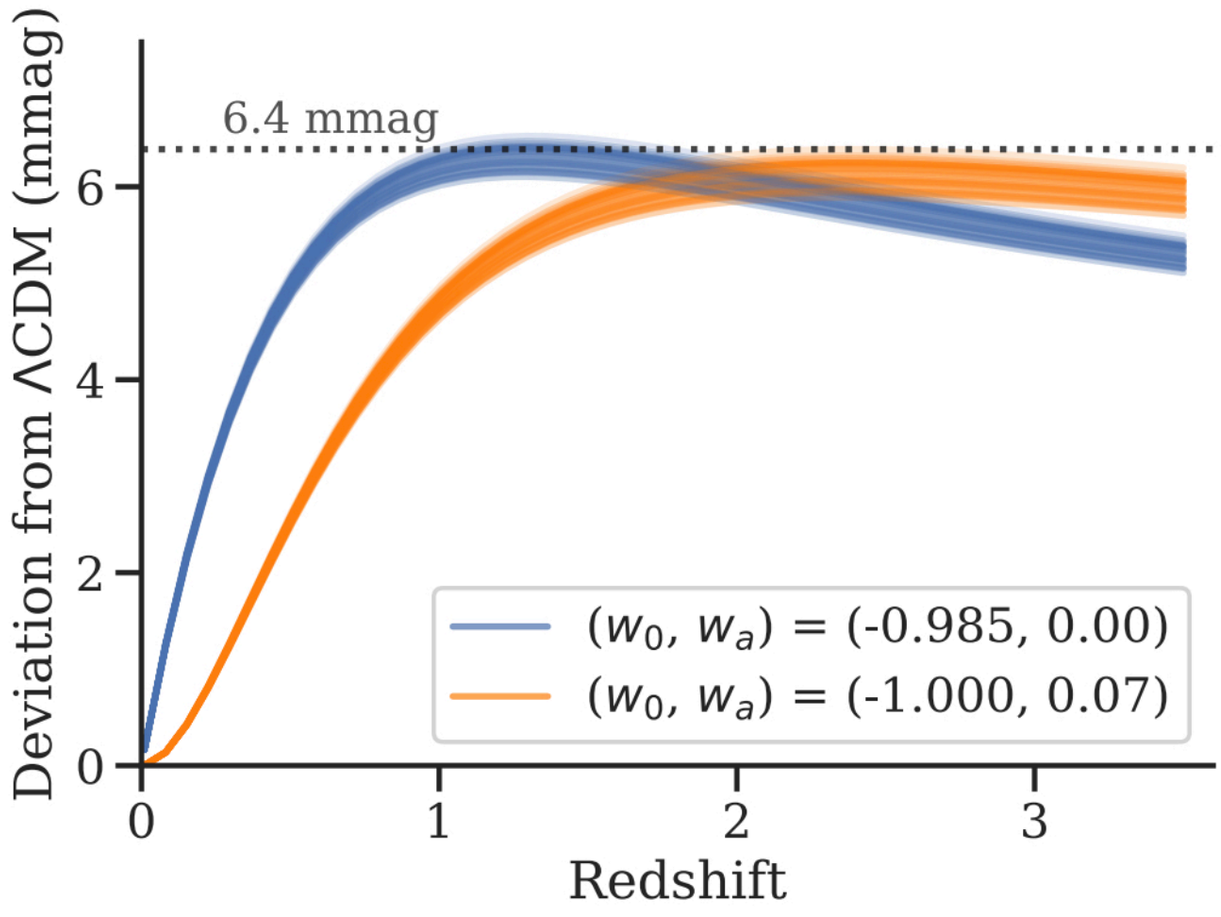
Hounsell et al. 2018



SN Requirement 2.0.1

FoM > 325

The Figure of Merit requirement includes data from the CMB (the Planck Collaboration 2016) and BAO (Anderson et al 2014) .

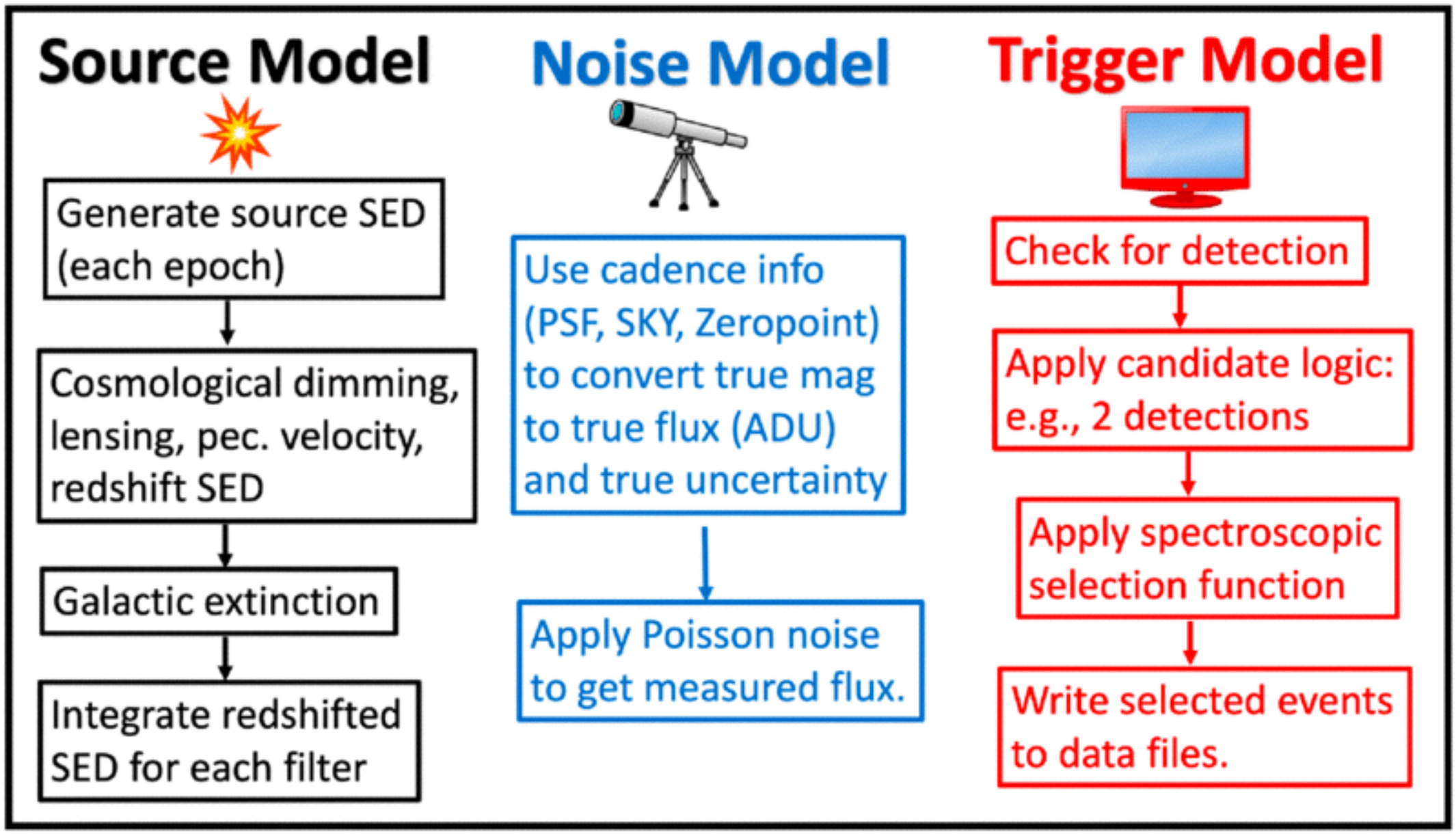


Shaded region shows effect of Ω_M uncertainty

survey is
6 months over 2 years

slide courtesy of Ben Rose

The Supernova Analysis Package (SNANA)



https://github.com/RickKessler/SNANA

Image: R. Kessler

Pippin Pipeline for Supernova Survey Analysis

https://github.com/Samreay/Pippin

survey level choices: cadence, depth, filters, tiers, fields

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Task finished with wall time 0:07:23
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             FOUNDfit_BIAS_FOUND_BIASCOR_G10
CLASSIFY     FITPROBTEST   FITPROBTEST
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BIASCOR      BBC
CREATE_COV   NGRST_COV_BBC
COSMOMC      SN_BANANA_OMW_NGRST_COV_BBC
ANALYSE      BANANA_OMW
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        SNANASimulation NGRST_SIMDATA_G10 task (wall time 1:05:03, 1 jobs, deps
        SNANASimulation FOUND_SIMDATA_G10 task (wall time 1:02:04, 1 jobs, deps
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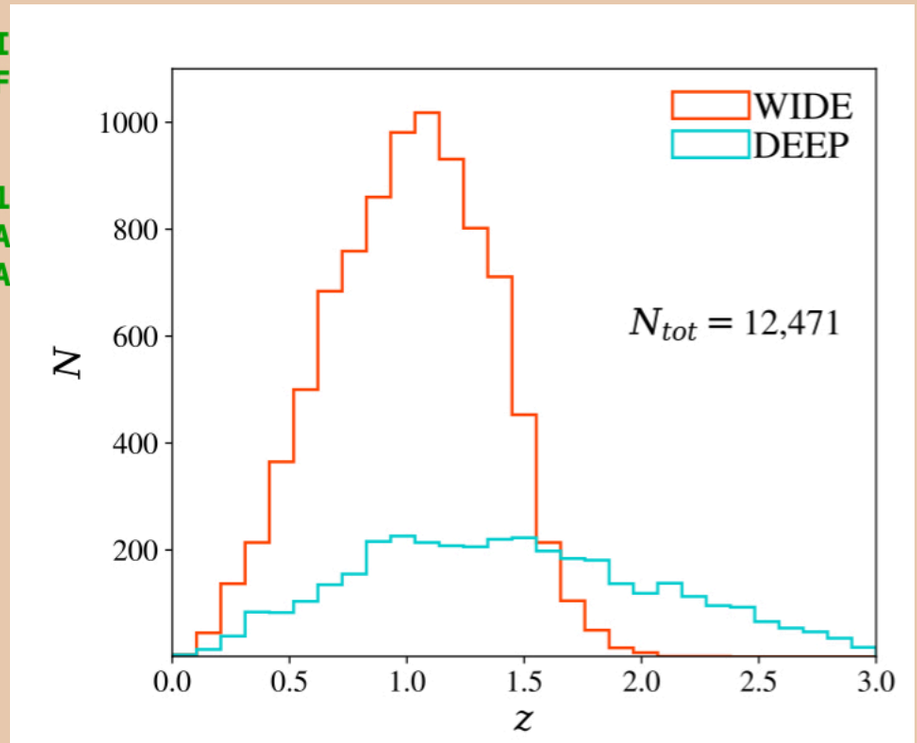
        Aggregator AGG_FOUND_BIASCOR_G10 task (wall time 0:00:13, 1 jobs, deps ['FOUND_BIASCOR_G10'])
        Aggregator AGG_NGRST_SIMDATA_G10 task (wall time 0:00:18, 1 jobs, deps ['FITPROBTEST'])
        Aggregator AGG_FOUND_SIMDATA_G10 task (wall time 0:00:08, 1 jobs, deps ['FOUND_SIMDATA_G10'])
```

1: simulate LCs (output in catalog form)



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Pippin Pipeline for Supernova Survey Analysis

https://github.com/Samreay/Pippin

survey level choices: cadence, depth, filters, tiers, fields

```
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            FOUNDfit_BIAS_FOUND_BIASCOR_G10
CLASSIFY    FITPROBTEST   FITPROBTEST
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            MERGE_FOUNDfit_SIM_FOUND_SIMDATA_G10   MERGE_FOUNDfit_BIAS_FOUND_BIASCOR_G10
BIASCOR     BBC
CREATE_COV  NGRST_COV_BBC
COSMOMC     SN_BANANA_OMW_NGRST_COV_BBC
ANALYSE     BANANA_OMW
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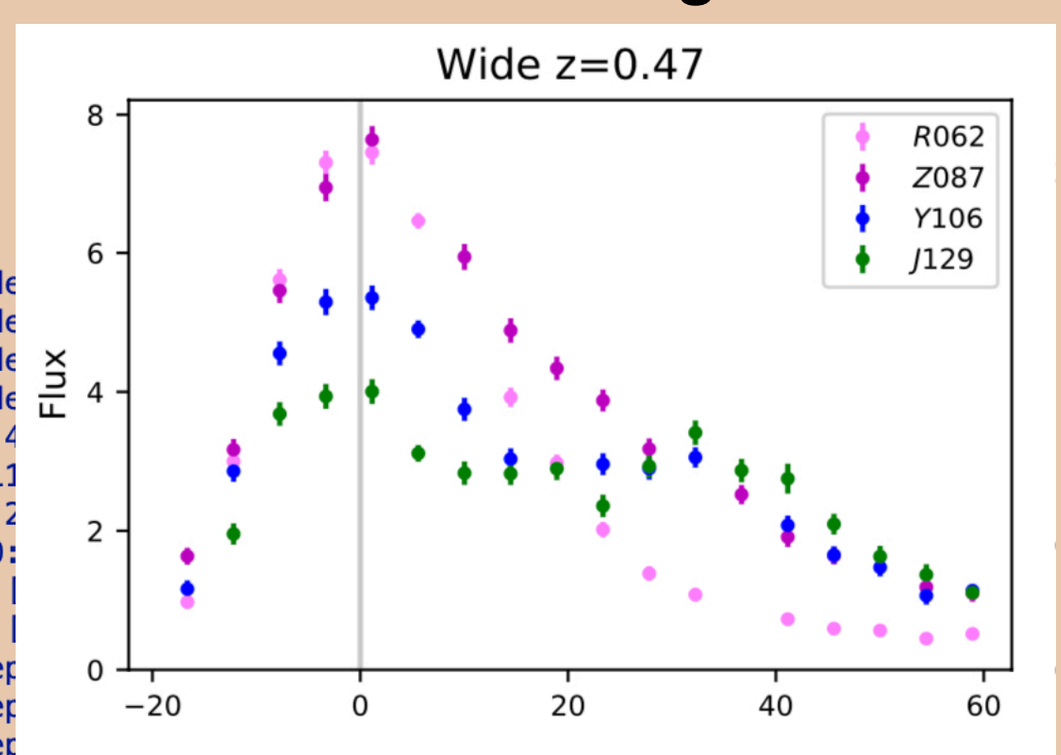
        SNANALightCurveFit NGRSTfit_SIM_NGRST_SIMDATA_G10 task (wall time 2:4
        SNANALightCurveFit NGRSTfit_BIAS_NGRST_BIASCOR_G10 task (wall time 11
        SNANALightCurveFit FOUNDfit_SIM_FOUND_SIMDATA_G10 task (wall time 0:2
        SNANALightCurveFit FOUNDfit_BIAS_FOUND_BIASCOR_G10 task (wall time 0:
        FitProbClassifier FITPROBTEST task (wall time 0:00:00, 1 jobs, deps
        FitProbClassifier FITPROBTEST task (wall time 0:00:00, 1 jobs, deps
        Aggregator AGG_NGRST_BIASCOR_G10 task (wall time 0:00:23, 1 jobs, dep
        Aggregator AGG_FOUND_BIASCOR_G10 task (wall time 0:00:13, 1 jobs, dep
        Aggregator AGG_NGRST_SIMDATA_G10 task (wall time 0:00:18, 1 jobs, dep
        Aggregator AGG_FOUND_SIMDATA_G10 task (wall time 0:00:08, 1 jobs, deps ['FOUND_SIMDATA_G10'])
```

2: fit light-curves



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survey level choices: cadence, depth, filters, tiers, fields

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CLASSIFY     FITPROBTEST   FITPROBTEST
AGGREGATE    AGG_NGRST_BIASCOR_G10   AGG_FOUND_BIASCOR_G10   AGG_NGRST_SIMDATA_G10   AGG_FOUND_SIMDATA_G10
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BIASCOR      BBC
CREATE_COV   NGRST_COV_BBC
COSMOMC      SN_BANANA_OMW_NGRST_COV_BBC
ANALYSE      BANANA_OMW
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        FitProbClassifier FITPROBTEST task (wall time                                                    ASCOR_G10'])
        Aggregator AGG_NGRST_BIASCOR_G10 task (wall t
        Aggregator AGG_FOUND_BIASCOR_G10 task (wall t
        Aggregator AGG_NGRST_SIMDATA_G10 task (wall t
        Aggregator AGG_FOUND_SIMDATA_G10 task (wall time 0:00:08, 1 jobs, deps ['FOUND_SIMDATA_G10'])
```
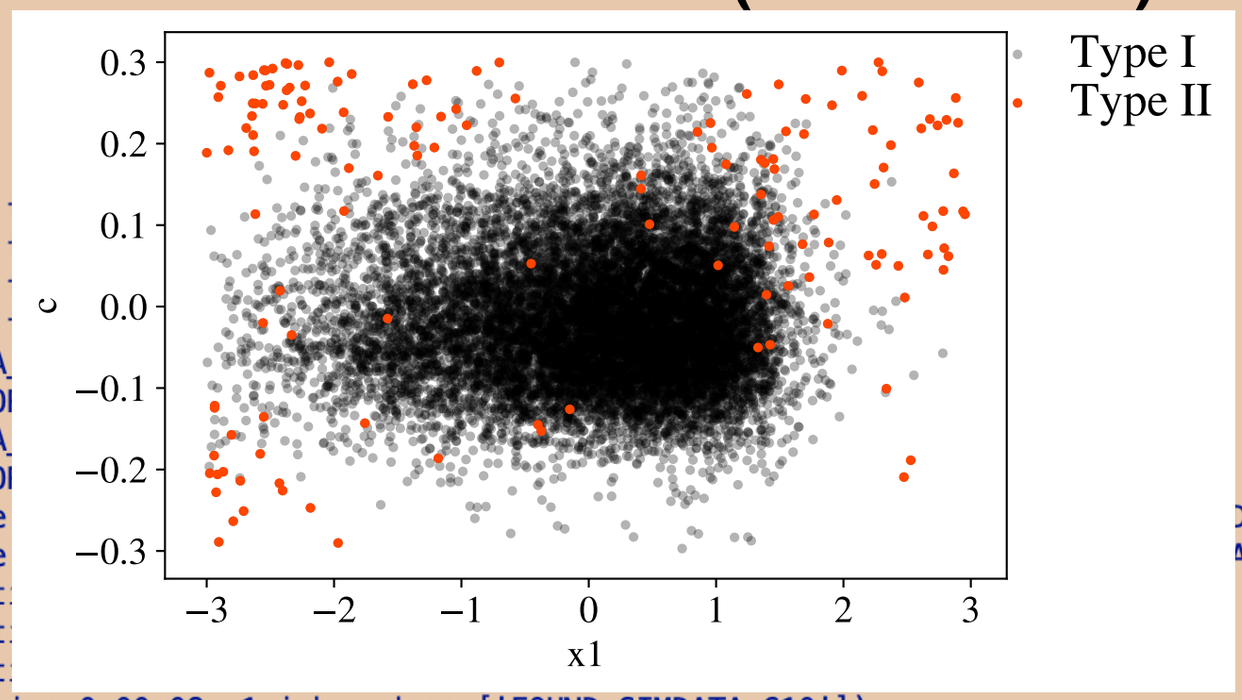

3: transient classification (Helen's talk!)



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Pippin Pipeline for Supernova Survey Analysis

https://github.com/Samreay/Pippin

survey level choices: cadence, depth, filters, tiers, fields

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CLASSIFY    FITPROBTEST   FITPROBTEST
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BIASCOR     BBC
CREATE_COV  NGRST_COV_BBC
COSMOMC     SN_BANANA_OMW_NGRST_COV_BBC
ANALYSE     BANANA_OMW
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6: calculate distances, produce HD

```
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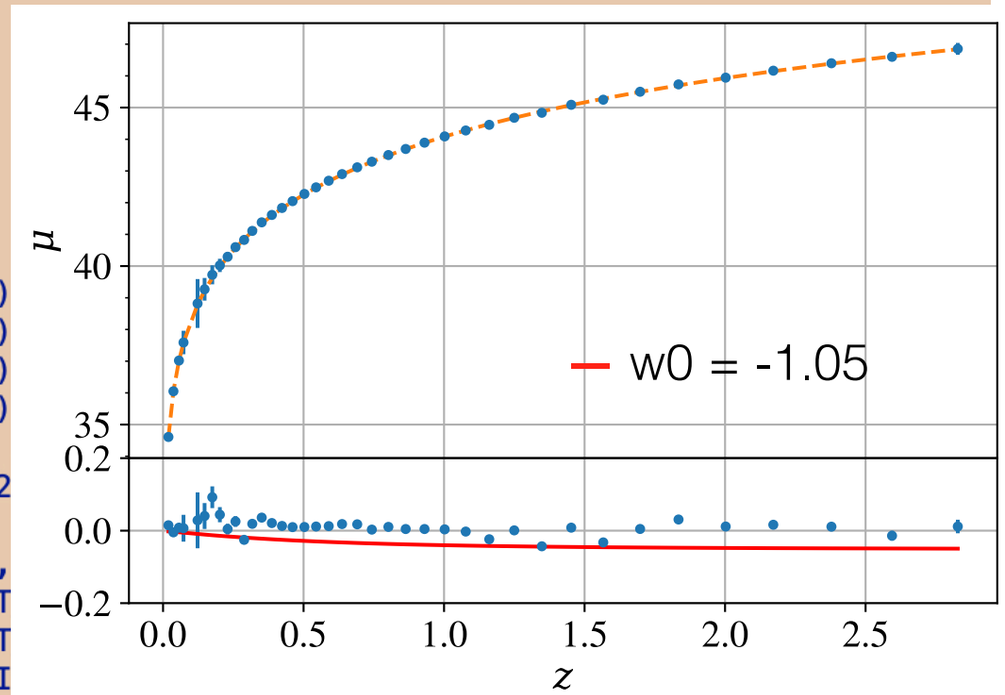
BBC paper



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https://github.com/Samreay/Pippin

survey level choices: cadence, depth, filters, tiers, fields

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             MERGE_FOUNDfit_SIM_FOUND_SIMDATA_G10   MERGE_FOUNDfit_BIAS_FOUND_
BIASCOR      BBC
CREATE_COV   NGRST_COV_BBC
COSMOMC      SN_BANANA_OMW_NGRST_COV_BBC
ANALYSE      BANANA_OMW
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```
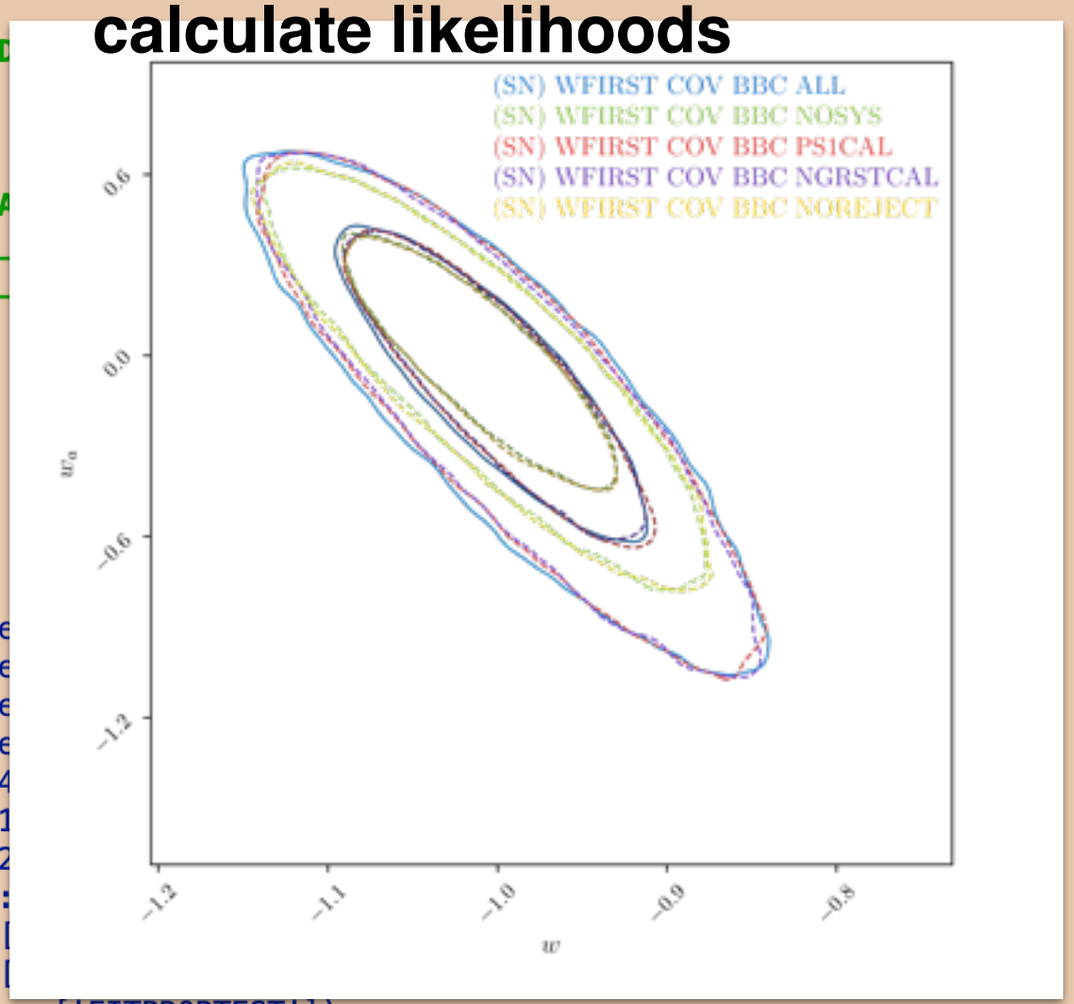

8+9: explore cosmological-parameter space, calculate likelihoods



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SIMULATIONS OF THE *WFIRST* SUPERNOVA SURVEY AND FORECASTS OF COSMOLOGICAL CONSTRAINTS

R. Hounsell,[1,2] D. Scolnic,[3] R. J. Foley,[1] R. Kessler,[3] V. Miranda,[4] A. Avelino,[5] R. C. Bohlin,[6] A. V. Filippenko,[7,8] J. Frieman,[3,9] S. W. Jha,[10] P. L. Kelly,[11] R. P. Kirshner,[5,12] K. Mandel,[5,13,14] A. Rest,[6,15] A. G. Riess,[6,15] S. A. Rodney,[16] and L. Strolger[6]

H18 paper

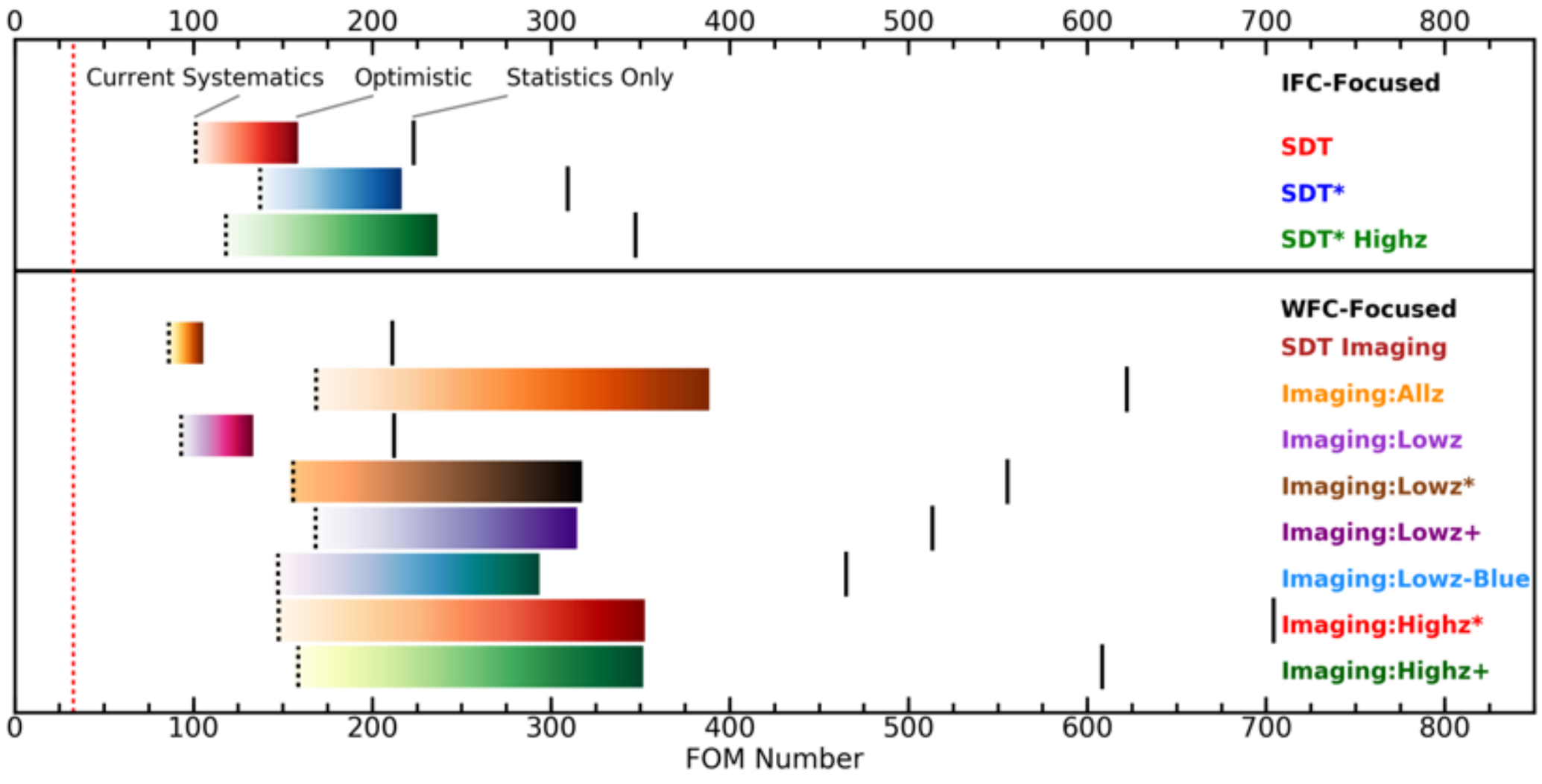


Figure 12. Predicted dark energy FoMs for the simulated *WFIRST* SN survey strategies outlined in Section 5. IFC-focused and WFC-focused strategies are presented in the top and bottom panels, respectively. The gradients for each strategy represent the range of FoMs from $\mathrm{FoM_{tot,curr}}$ (dotted lines) to $\mathrm{FoM_{tot,opt}}$. The thick black lines represent $\mathrm{FoM_{stat}}$. The red dashed vertical line indicates the current FoM value of 32.6 (Alam et al. 2016).

Reference Survey

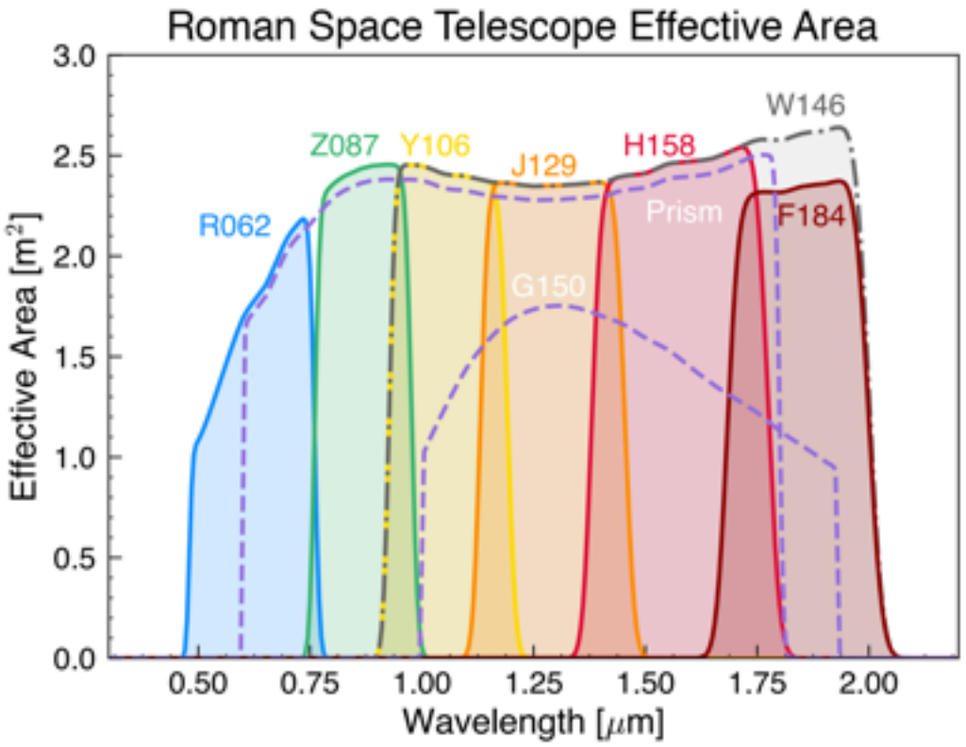
Mode	Tier	$z_{\rm targ}$ *	Filters	Exp.Time+Overhead (s)	No. of Pointings	Area (deg^2)	Time/Visit (hours)	Total SN Ia
25% Spectroscopy Survey								
Imaging	Wide	1.0	RZYJ	160;100;100;100 + 70x4	68	19.04	14.0	8804
Imaging	Deep	1.7	YJHF	300;300;300;900 + 70x4	15	4.20	8.5	3520
Subtotal							**22.5**	**12324**
Spec	Wide	1.0	prism	900 + 70	12	3.36	3.2	831
Spec	Deep	1.5	prism	3600 + 70	4	1.12	4.1	652
Subtotal							**7.3**	**1483**

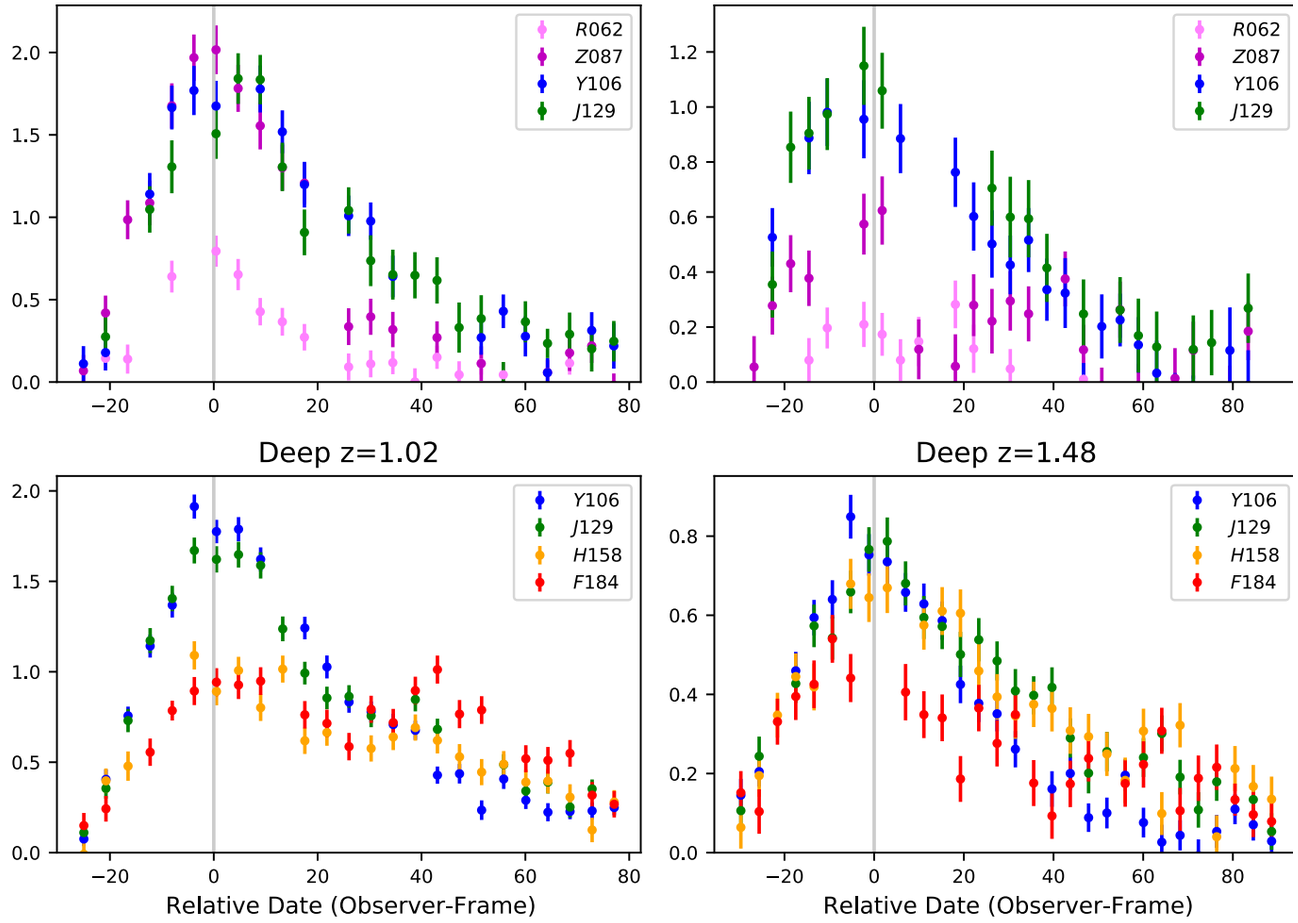
*$z_{\rm targ}$ denotes the redshift where the average SN Ia at peak is observed with S/N=10 per exposure.

Table 1. The 25% reference survey strategy

5000 z >1 SNe!

FoM requirements met





arXiv:2111.03081

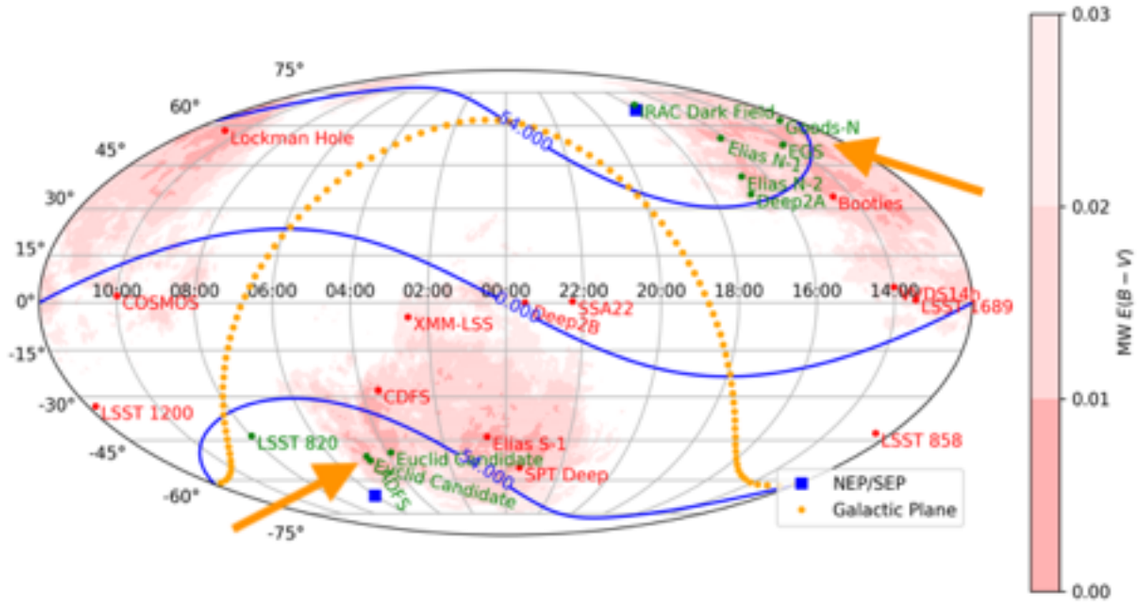
Roman Cosmology Seminar 1/27/22

	F062/R	F087/Z	F106/Y	F129/J	F158/H	F184/F
Wide Tier						
Exposure time (sec)	160	100	100	100	—	—
Single-exposure limiting magnitude	26.4	25.6	25.5	25.4		
125-exposure co-add limiting magnitude	29.0	28.2	28.1	28.0		
Deep Tier						
Exposure time (sec)	—	—	300	300	300	900
Single-exposure limiting magnitude			26.7	26.6	26.5	26.7
125-exposure co-add limiting magnitude			29.3	29.2	29.1	29.3

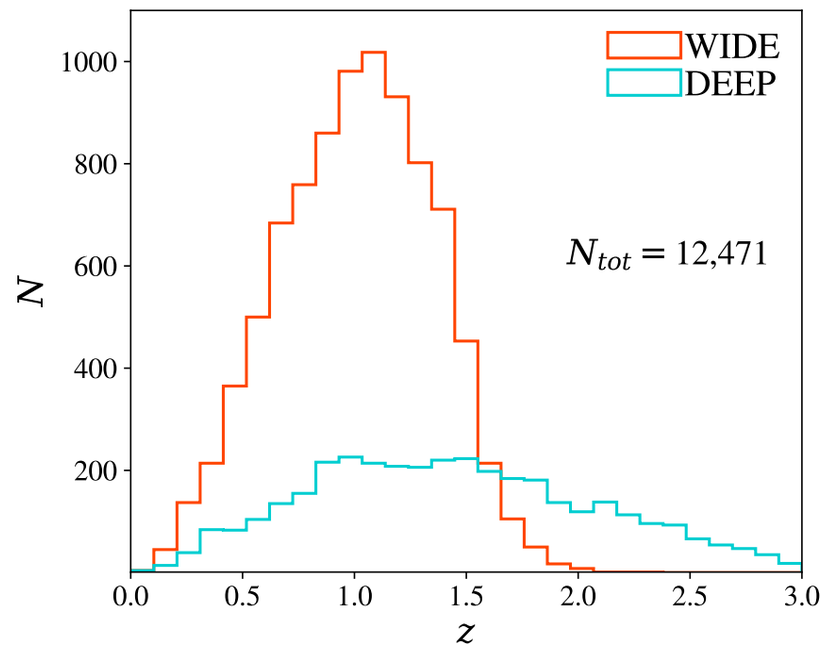
Table 2. Limiting AB magnitudes for isolated point sources. Using a fill fraction of 87% and 144 epochs over the two-year survey, the co-added depths are expected to be ∼2.6 mag deeper.

HUDF: ~30th mag, but 11.5 arcmins^2

redshift distributions



field considerations



details can be found in arXiv:2111.03081

Variations

Mode	Tier	$z_{\rm targ}$ *	Filters	Exp.Time+Overhead (s)	No. of Pointings	Area (deg^2)	Time/Visit (hours)	Total SN Ia
10% Spectroscopy Survey								
Imaging	Wide	1.0	RZYJ	160;100;100;100 + 70x4	82	22.96	16.8	10617
Imaging	Deep	1.7	YJHF	300;300;300;900 + 70x4	18	5.04	10.2	4224
Subtotal							**27.0**	**14841**
Spec	Wide	1.0	prism	900 + 70	4	1.12	1.0	277
Spec	Deep	1.5	prism	3600 + 70	2	0.56	2.0	326
Subtotal							**3.0**	**603**
50% Spectroscopy Survey								
Imaging	Wide	1.0	RZYJ	160;100;100;100 + 70x4	45	12.60	9.3	5826
Imaging	Deep	1.7	YJHF	300;300;300;900 + 70x4	10	2.80	5.8	2347
Subtotal							**15.1**	**8173**
Spec	Wide	1.0	prism	900 + 70	25	7.00	6.7	1731
Spec	Deep	1.5	prism	3600 + 70	8	2.24	8.2	1302
Subtotal							**14.9**	**3032**
75% Spectroscopy Survey								
Imaging	Wide	1.0	RZYJ	160;100;100;100 + 70x4	19	5.32	3.9	2460
Imaging	Deep	1.7	YJHF	300;300;300;900 + 70x4	6	1.68	3.5	1408
Subtotal							**7.4**	**3868**
Spec	Wide	1.0	prism	900 + 70	19	5.32	5.1	2460
Spec	Deep	1.7	prism	10400 + 70	6	1.68	17.5	1408
Subtotal							**22.6**	**3868**

*$z_{\rm targ}$ denotes the redshift where the average SN Ia is observed with S/N=10 per exposure.

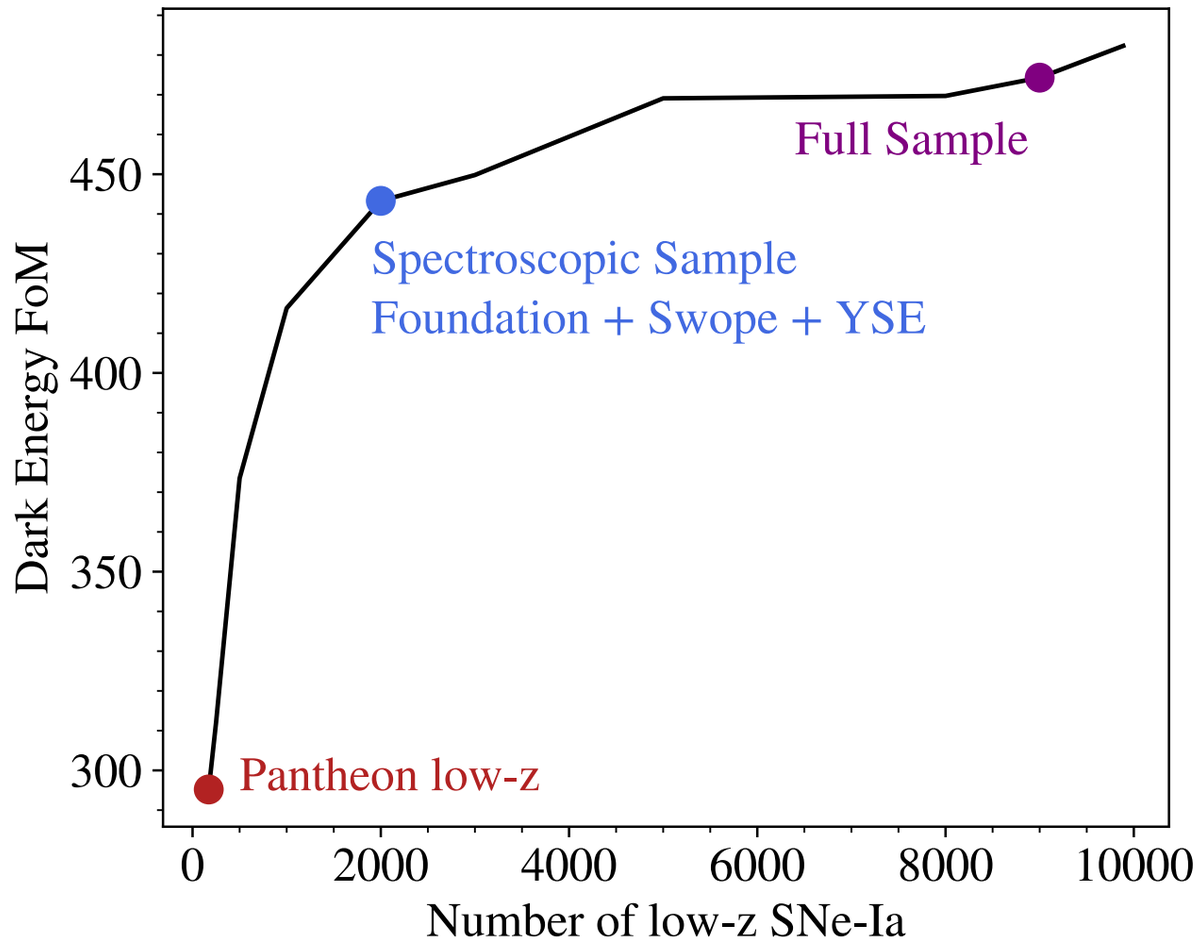
FoM requirements met across variants

details can be found in arXiv:2111.03081

Preparatory Work / Low-z Sample

- low-z sample is necessary to “anchor” Hubble Diagram

- at ~5k SNe this sample saturates in its cosmological utility (systematics limited)



Macias et al., in-prep

Summary

- SNANA + Pippin as a tool for forecasting cosmological constraints with *Roman*

- FoM requirements met for reference survey and variants

- Lots of work/optimization to be done in an evolving landscape!

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