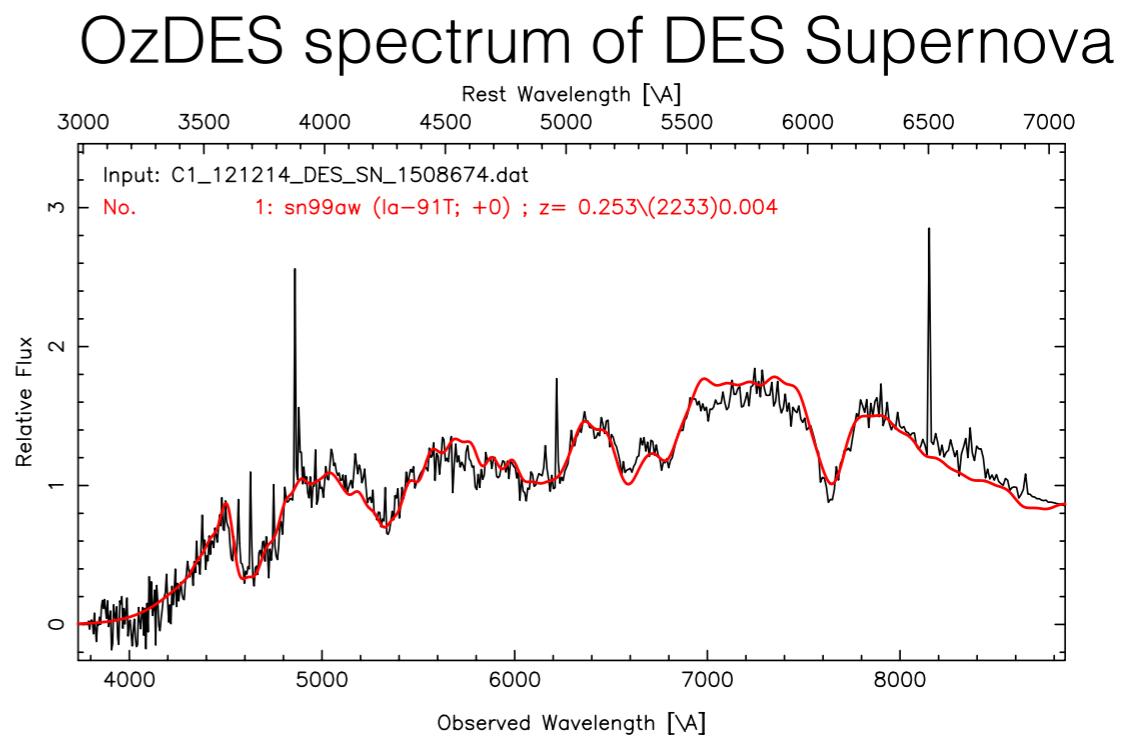


Future Surveys Need Future Analysis

Alex Kim
Lawrence Berkeley National Laboratory

Incomplete Spectroscopy

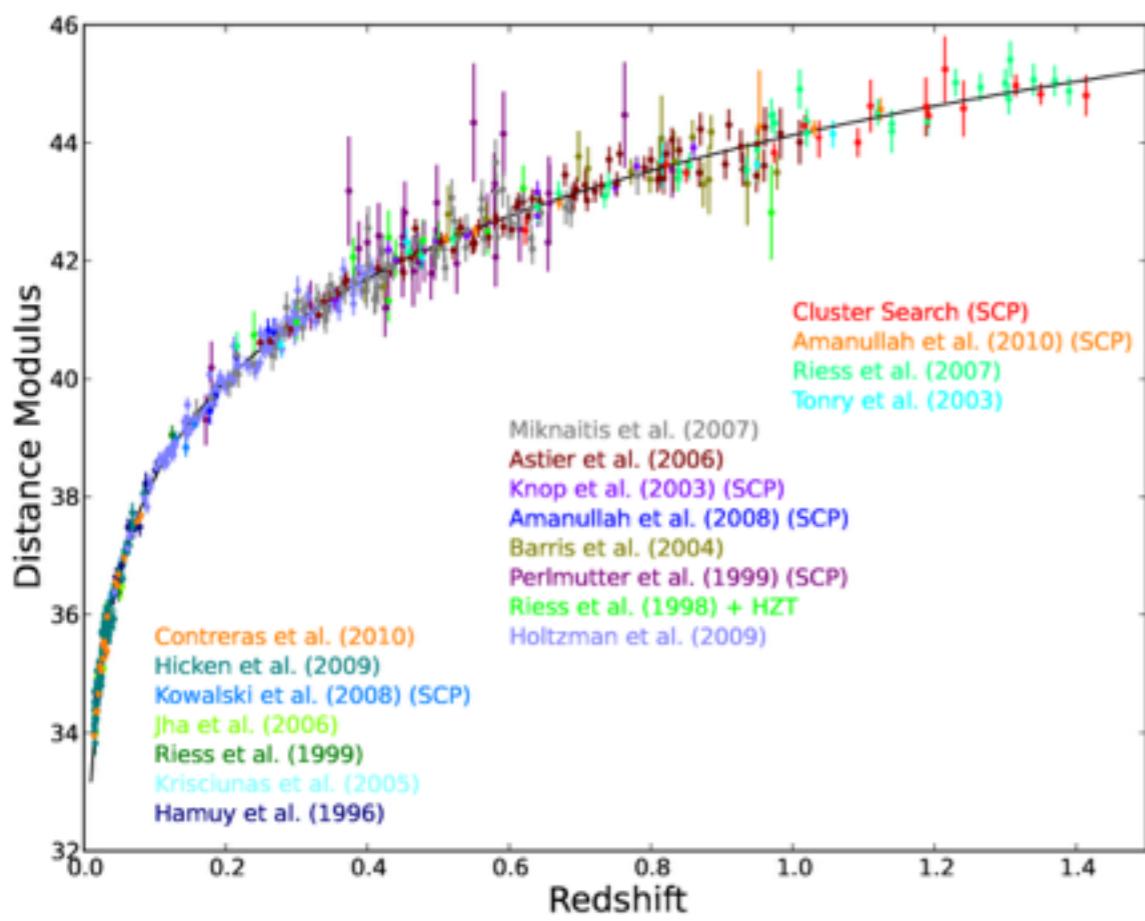
- Spectroscopy gives
 - Transients typed as SNIa
 - Host galaxies identification
 - Highly precise redshift
- No Spectroscopy gives
 - Uncertain type
 - Uncertain host galaxy
 - Imprecise redshifts



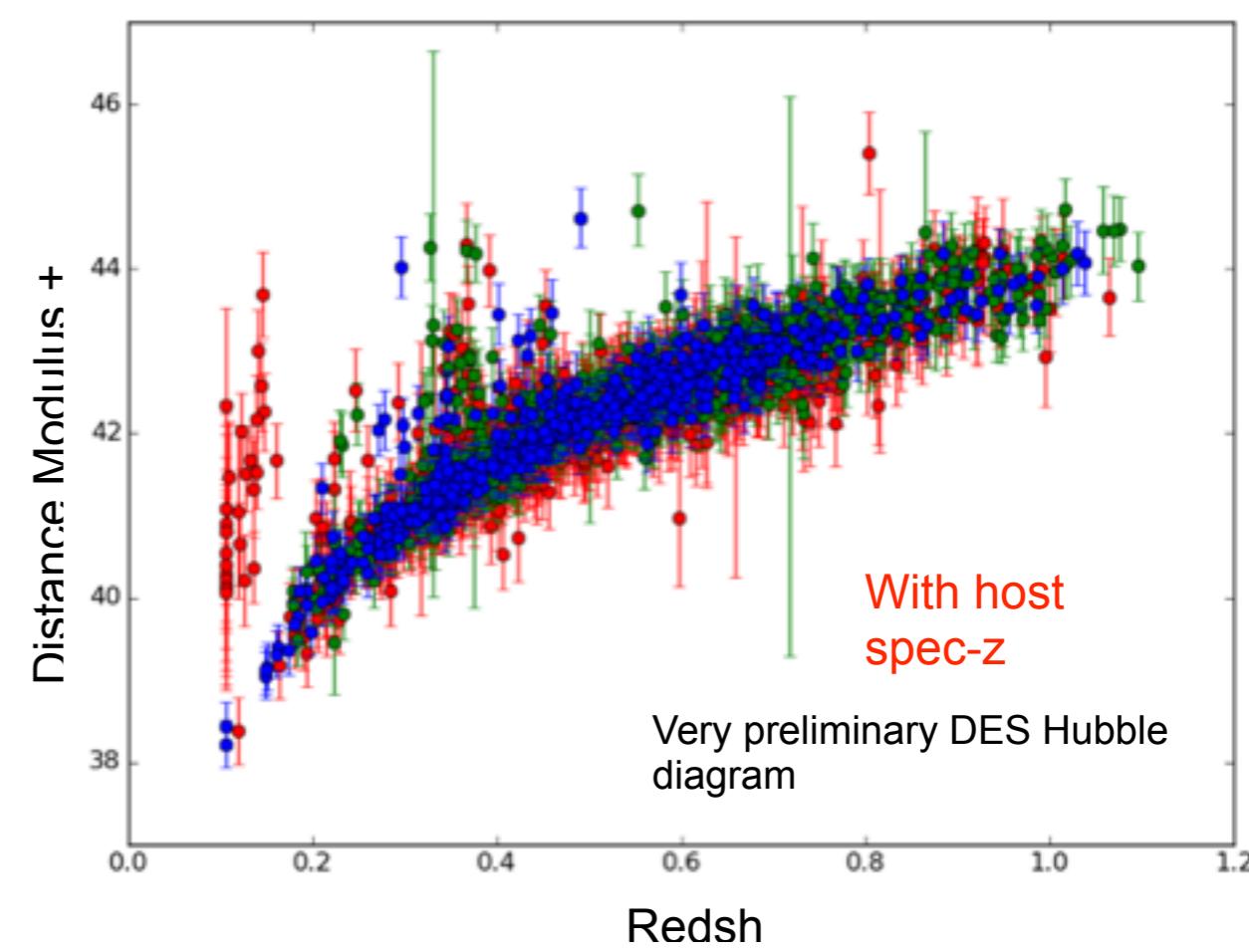
SN Ia

Many Ground-Based Programs Require a Different Kind of Hubble Diagram Analysis

Pre-DES, LSST



DES, LSST



Pre-DES, LSST

UNIVERSAL

SNe Ia,
Populations

Cosmology

INDIVIDUAL
SN

Luminosity

Distance

Flux

OBSERVATORY

Type
Subtype_o

Redshift_o
Phot & Spec

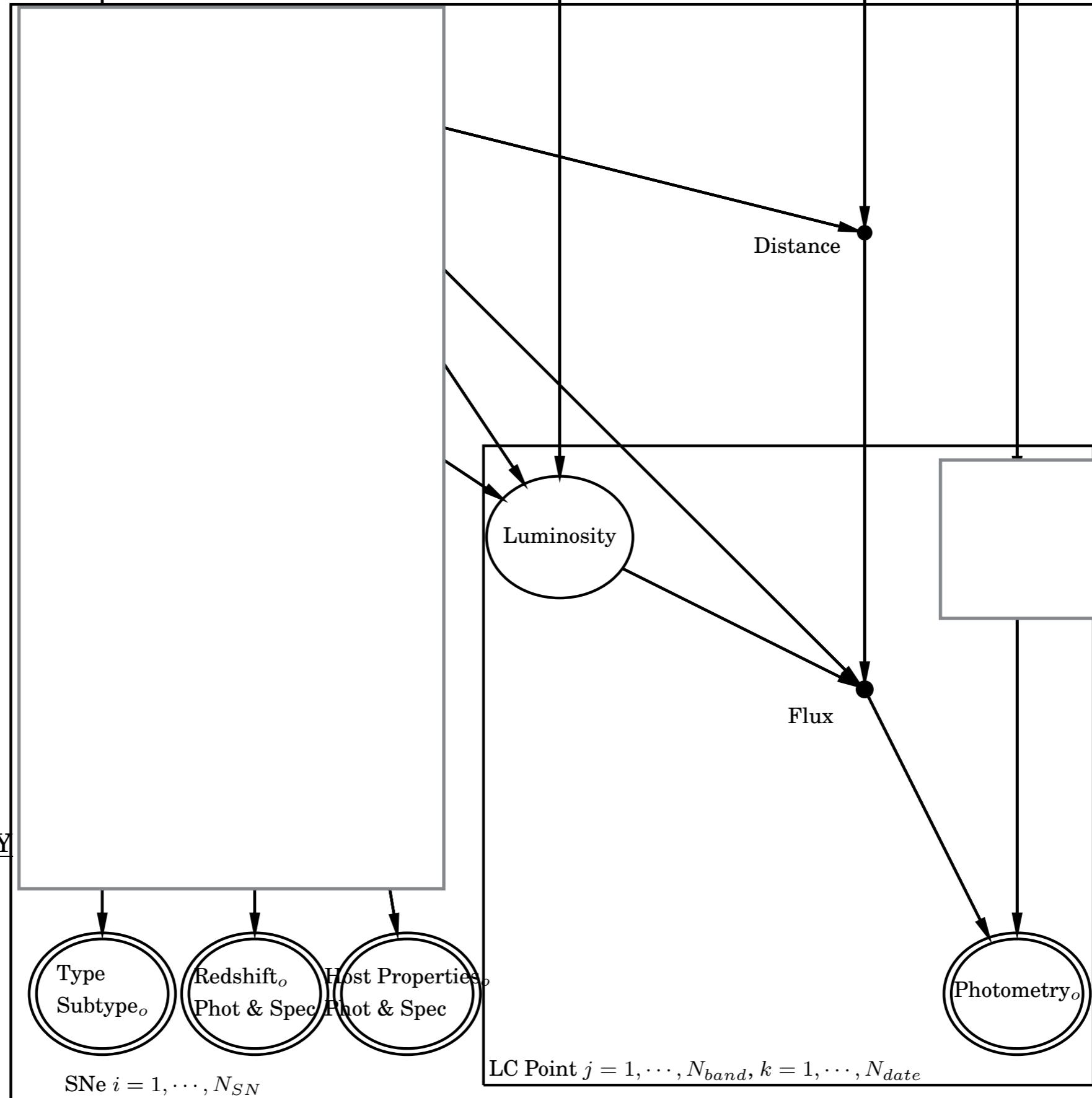
Host Properties_o
Phot & Spec

DATA

SNe $i = 1, \dots, N_{SN}$

LC Point $j = 1, \dots, N_{band}$, $k = 1, \dots, N_{date}$

Photometry_o



UNIVERSAL

Relative Rates

SNe Ia, Non-Ia Populations

Cosmology

Global Throughput

DES,
LSST

INDIVIDUAL
SN

Type Subtype

Host Galaxy
(Redshift)

Luminosity

Throughput

Distance

Flux

OBSERVATORY

DATA

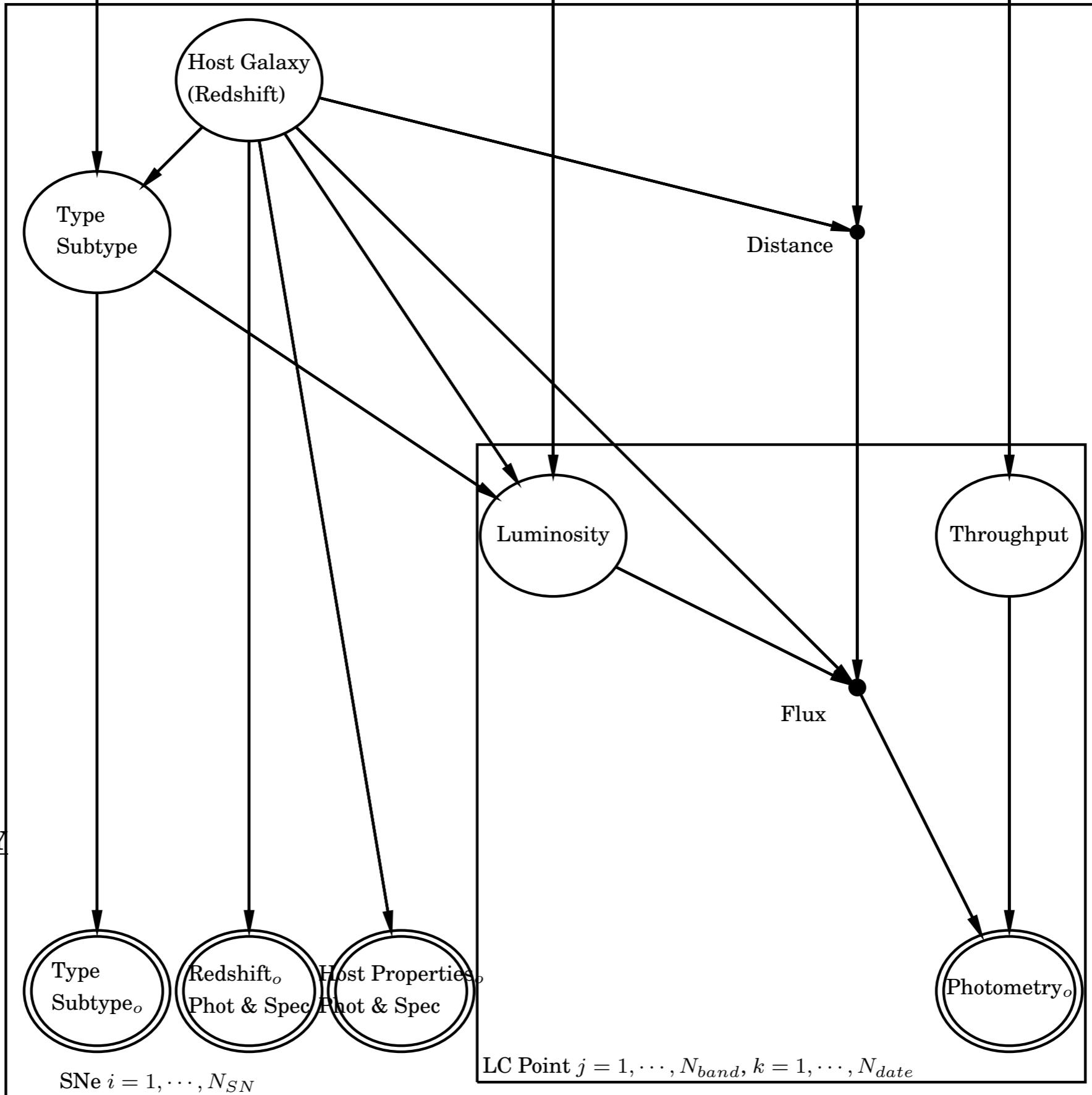
Type Subtype_o

Redshift_o
Phot & Spec

Host Properties_o
Phot & Spec

SNe $i = 1, \dots, N_{SN}$

LC Point $j = 1, \dots, N_{band}$, $k = 1, \dots, N_{date}$



UNIVERSAL

Relative Rates

SNe Ia, Non-Ia Populations

Cosmology

Global Throughput

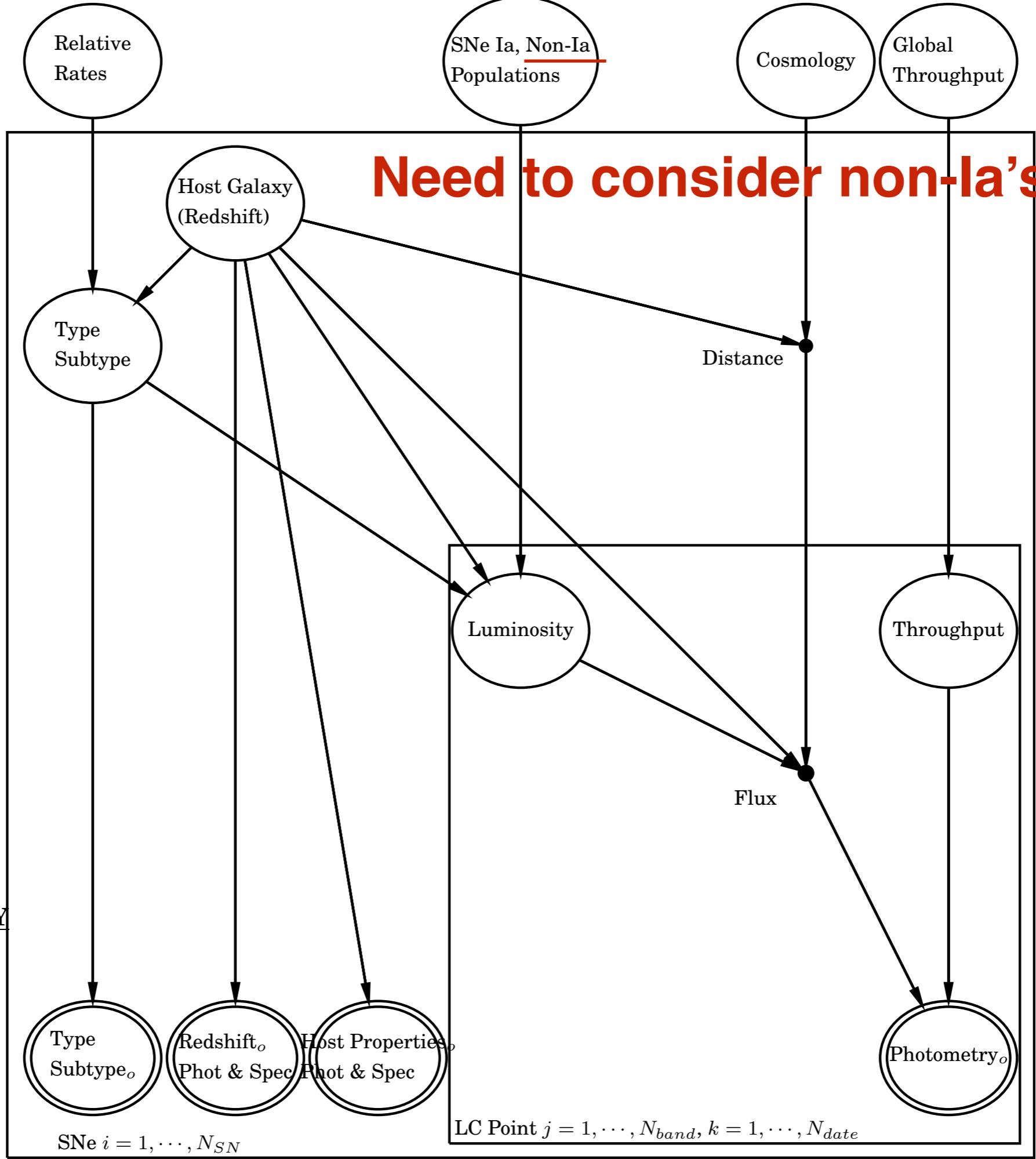
DES,
LSST

Need to consider non-la's

INDIVIDUAL
SN

OBSERVATORY

DATA



UNIVERSAL

Relative
Rates

SNe Ia, Non-Ia
Populations

Cosmology

Global
Throughput

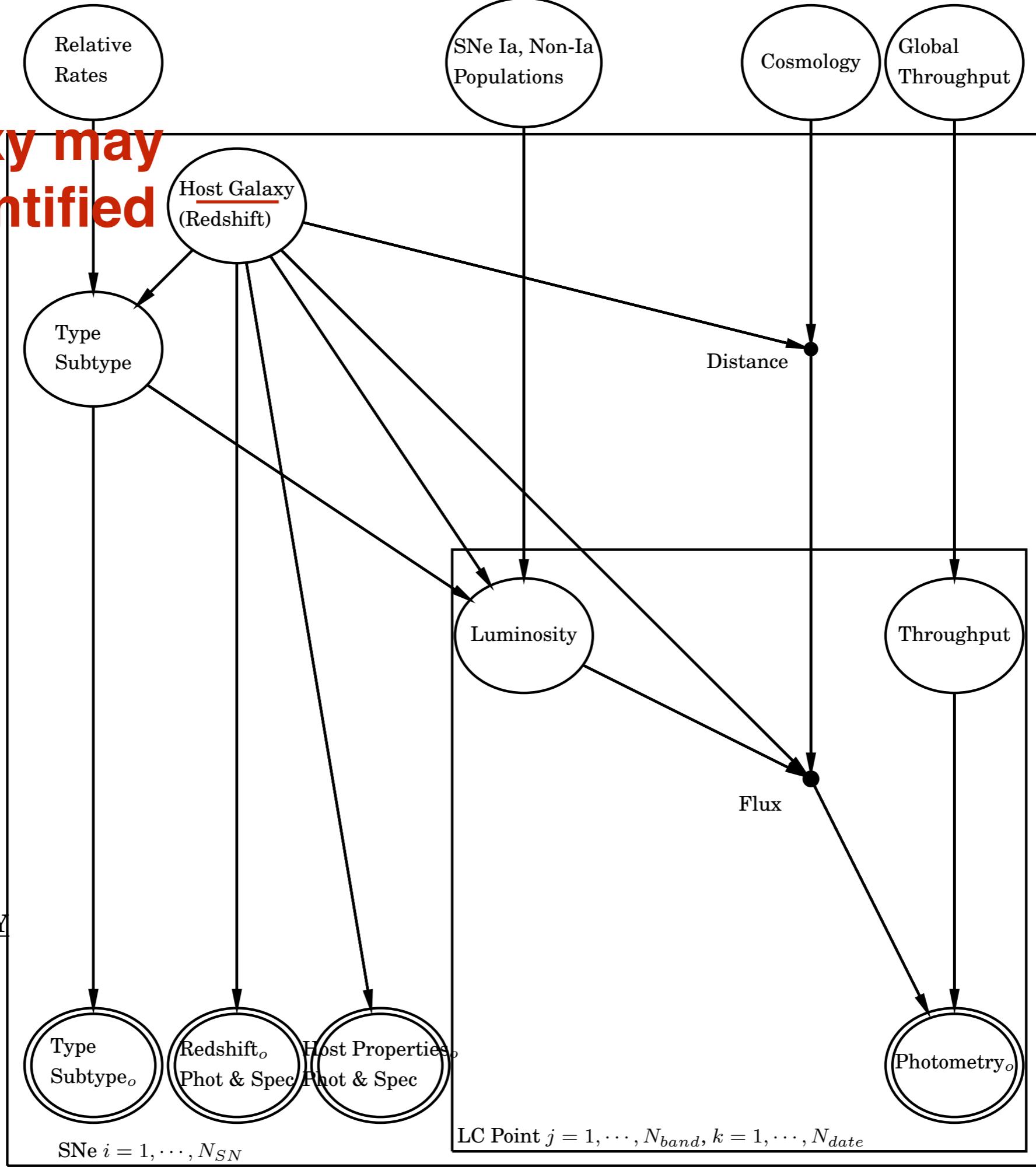
DES,
LSST

**Host galaxy may
be misidentified**

INDIVIDUAL
SN

OBSERVATORY

DATA



UNIVERSAL

Relative
Rates

SNe Ia, Non-Ia
Populations

Cosmology

Global
Throughput

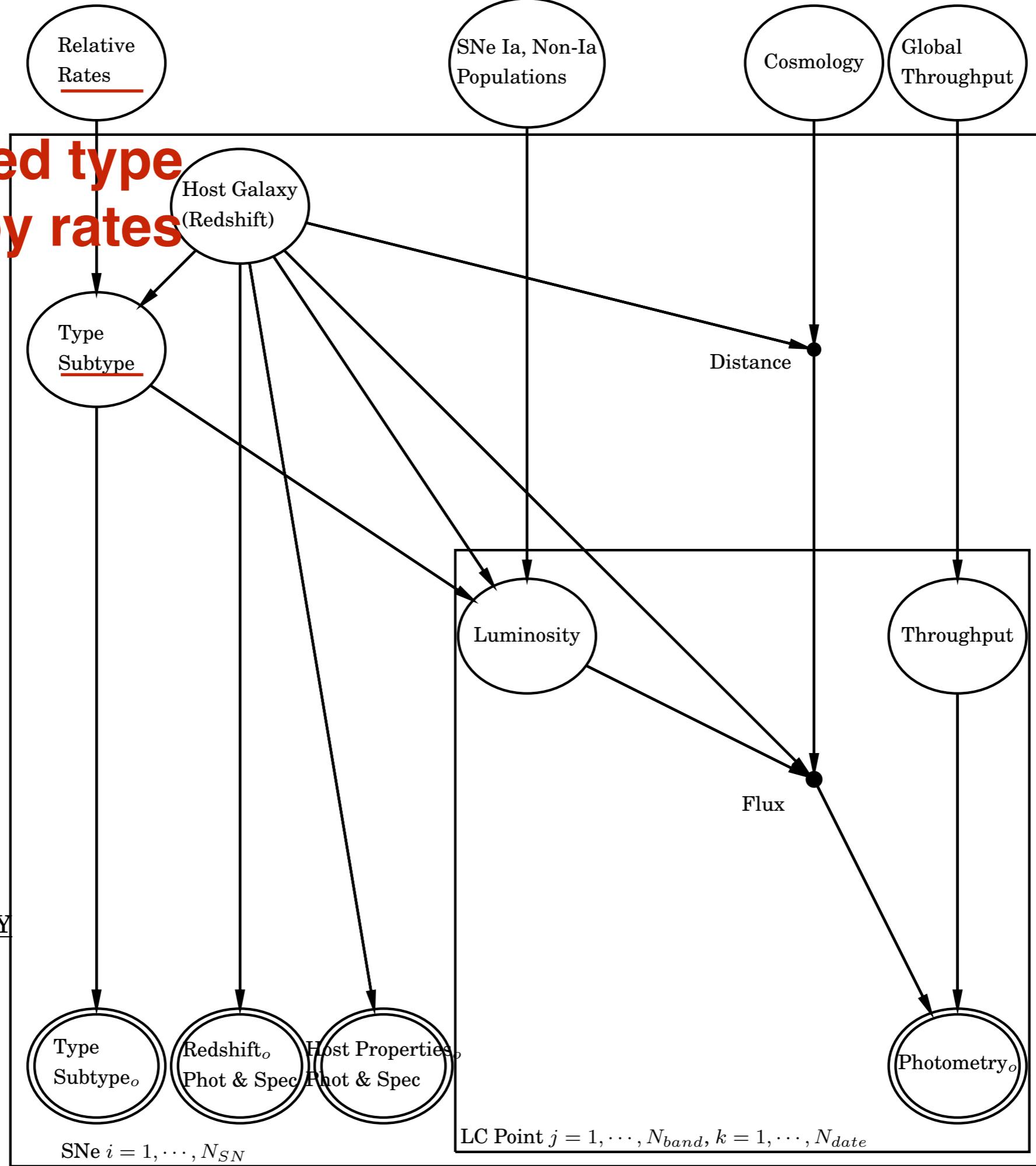
DES,
LSST

Unmeasured type informed by rates

INDIVIDUAL
SN

OBSERVATORY

DATA



DES,
LSST

**Calibration a big source
of uncertainty: expose it**

UNIVERSAL

Relative
Rates

SNe Ia, Non-Ia
Populations

Cosmology

Global
Throughput

INDIVIDUAL
SN

Type
Subtype

Host Galaxy
(Redshift)

Luminosity

Throughput
—

Distance

Flux

OBSERVATORY

DATA

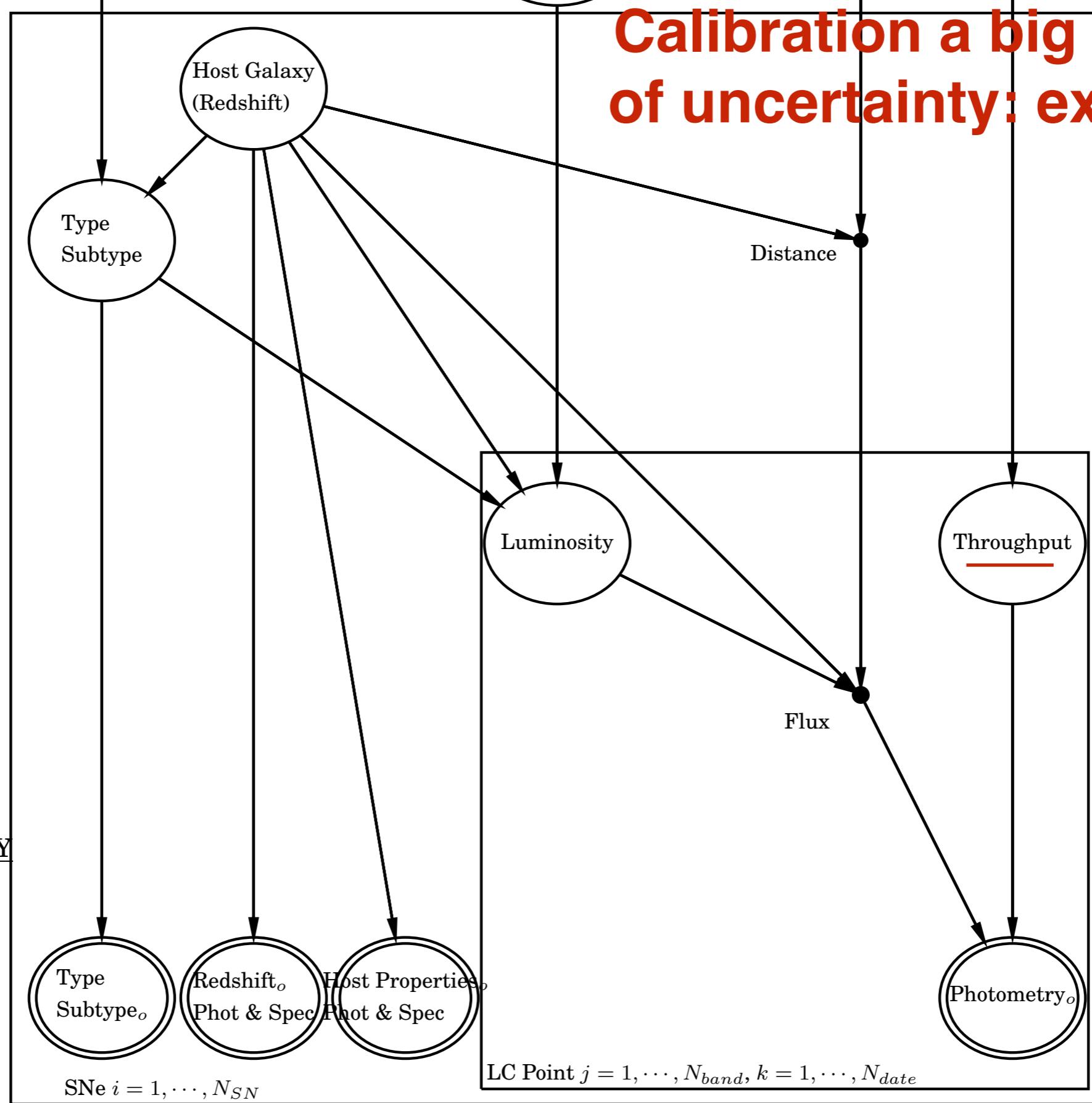
Type
Subtype_o

Redshift_o
Phot & Spec
Host Properties_o
Phot & Spec

Photometry_o

SNe $i = 1, \dots, N_{SN}$

LC Point $j = 1, \dots, N_{band}$, $k = 1, \dots, N_{date}$



Likelihood

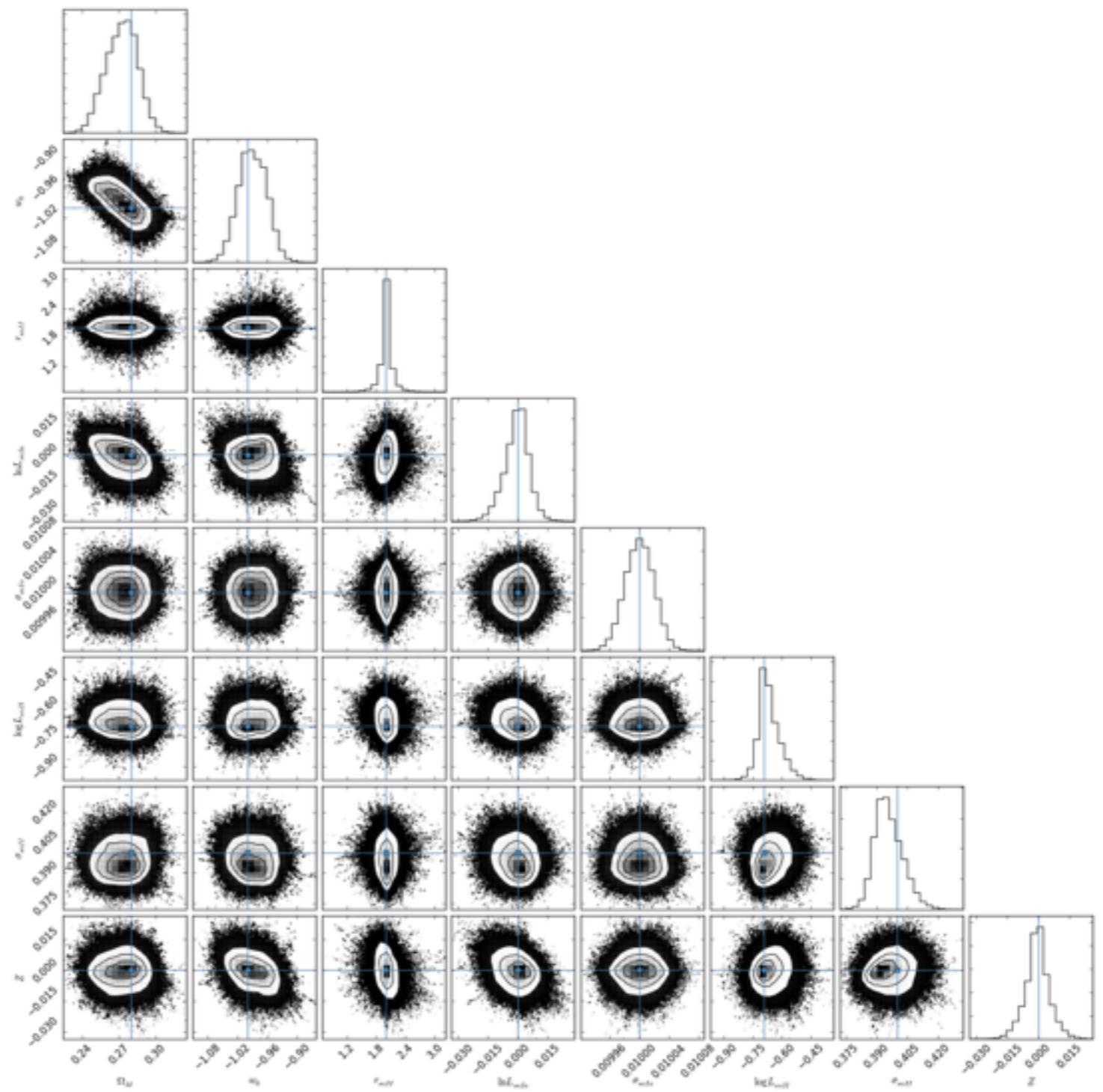
- For one supernova the likelihood is

$$\mathcal{L}(T_o, z_o, c_o | S_c, S_T, z, X)$$

- Read as “probability of measured type, redshift, and counts *given* that supernova is in our sample, has a successful type, and has underlying parameters”
- Sample selection matters in the likelihood

Determining the PDF is a Statistical Challenge

- Able to construct parameter PDF's for ~100 SNe using Affine Invariant MCMC (emcee) but...



Determining the PDF is a Statistical Challenge

- LSST produces $>10^4$ SNe!
 - Each SN is associated with several parameters
- Curse of dimensionality for Metropolis-Hastings MCMC algorithms
- Hamiltonian Monte Carlo is the only algorithm (I know of) that successfully handles such huge parameter sets ...
 - ... but due to an integral in the likelihood I have not got one to work
- A problem for other cosmological probes
- Group mobilizing to solve this problem: Sam Hinton (U. Queensland)