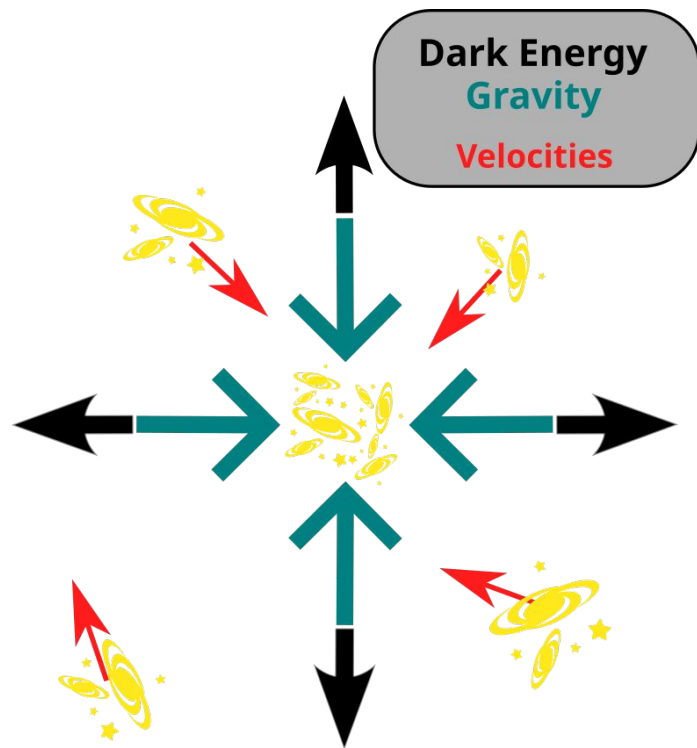**DESC PROJECT ANNOUNCEMENT :**
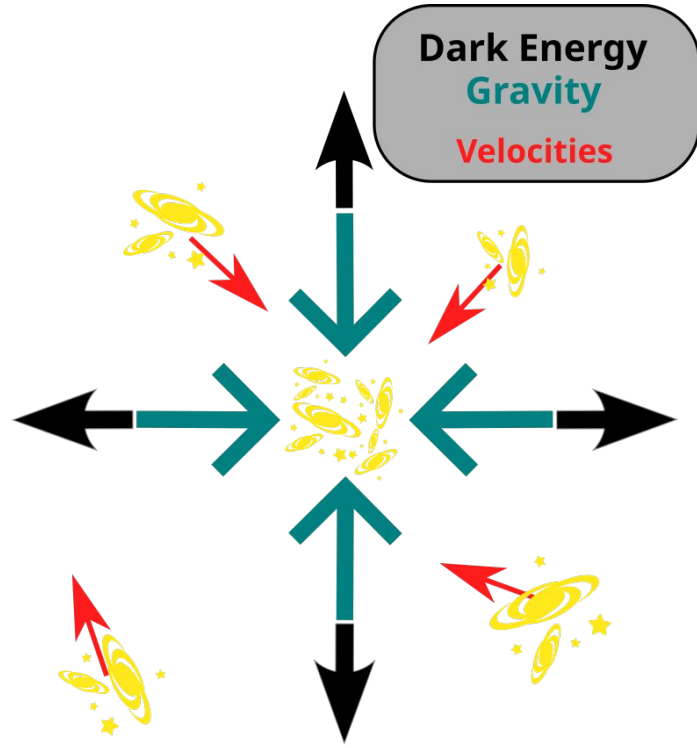
Constraining Structure Growth and Modified Gravity Using LSST low-z SN Ia PVs and Weak Lensing

Co-leads: Bastien Carreres & Niko Sarcevic

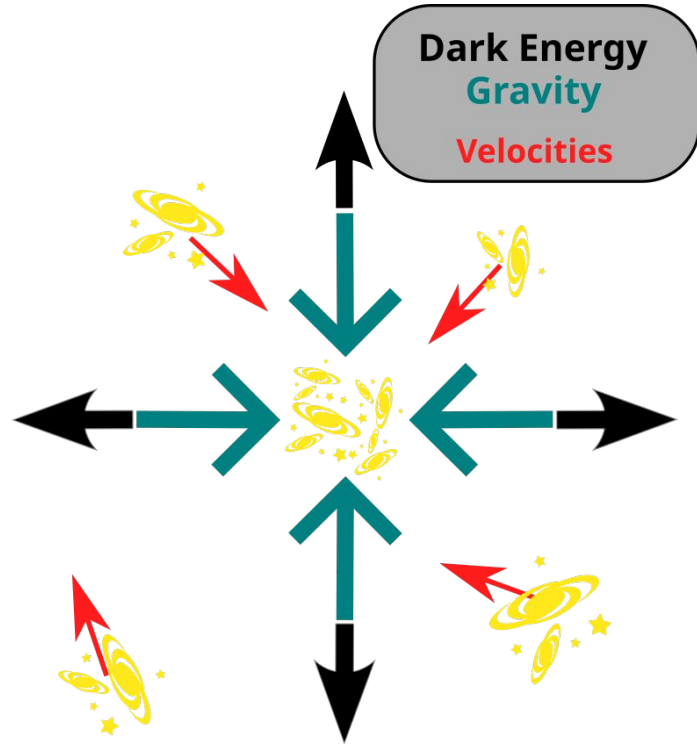# Growth of Structure

Growth of Structure

Growth of Structure is often parametrized by $f\sigma_8$:

σ_8: amplitude of matter density fluctuations – How matter is clustered?

f: growth-rate – How the clustering of matter is evolving?

Growth of Structure

Dark Energy
Gravity
Velocities

Why probing Growth of Structure?

- Test of GR+LCDM model

- Discriminate between modified gravity and dynamical dark energy

Growth of Structure & Modified Gravity

In this project we are interested in the modified growth parametrization ($\boldsymbol{\mu}$ –$\boldsymbol{\Sigma}$)

Modified equations:

$$-k^2\Psi \equiv 4\pi G a^2 \mu(a,k)\rho\Delta,$$
$$-k^2(\Phi + \Psi) \equiv 8\pi G a^2 \Sigma(a,k)$$

Parametrization in CCL:

$$\mu(a,k) = 1 + \mu_0 \frac{\Omega_{DE}(a)}{\Omega_\Lambda}\left[\frac{1 + c_1\left(\lambda H(a)/k\right)^2}{1 + \left(\lambda H(a)/k\right)^2}\right]$$

$$\Sigma(a,k) = 1 + \Sigma_0 \frac{\Omega_{DE}(a)}{\Omega_\Lambda}\left[\frac{1 + c_2\left(\lambda H(a)/k\right)^2}{1 + \left(\lambda H(a)/k\right)^2}\right]$$

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Free parameters

Project overview

Project (current) main question:

How good LSST SN Ia PVs + WL could constraint modified gravity parameters ?

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Main motivation:

LSST SN Ia PVs and WL are complementary probe to constrain modified gravity

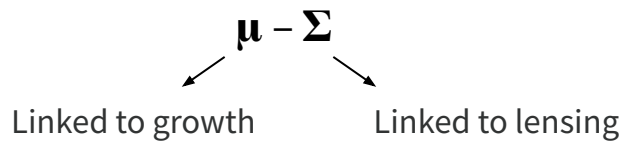# Constraining modified gravity

$$\mu - \Sigma$$

Constraining modified gravity

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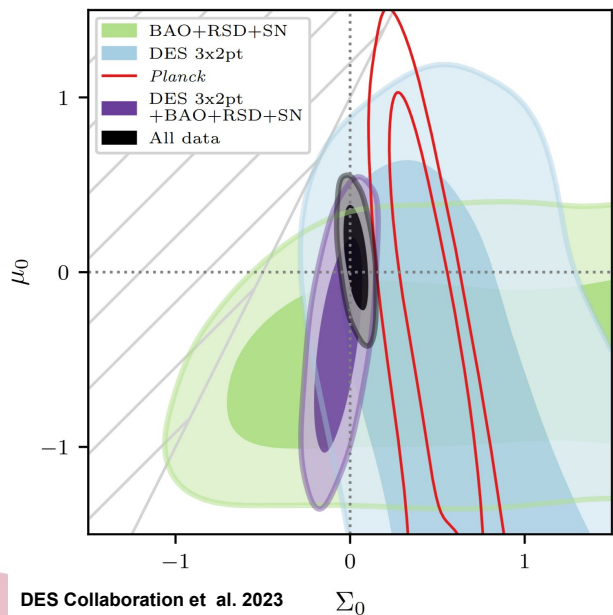Linked to growth

Constraining modified gravity

$$\mathbf{\mu} - \mathbf{\Sigma}$$

Linked to growth   Linked to lensing

Constraining modified gravity: Weak Lensing

μ — Σ

Linked to growth   Linked to lensing

DES Year-3 results:

DES Collaboration et al. 2023
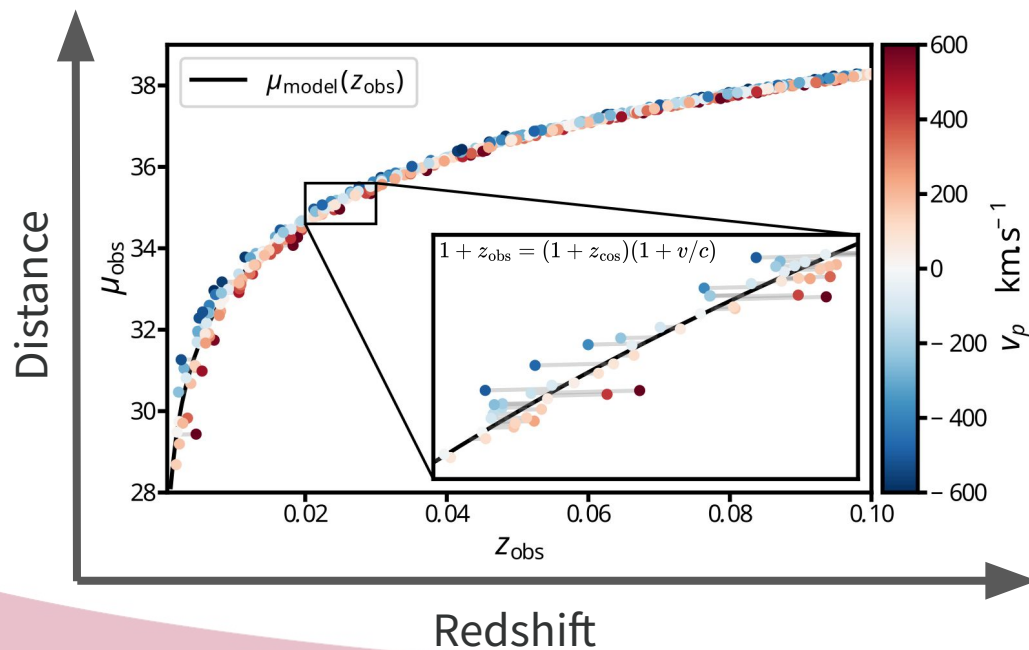
Weak lensing

Constraining mostly Σ and degenerate in μ

Constraining modified gravity: SN Ia PVs

μ — Σ

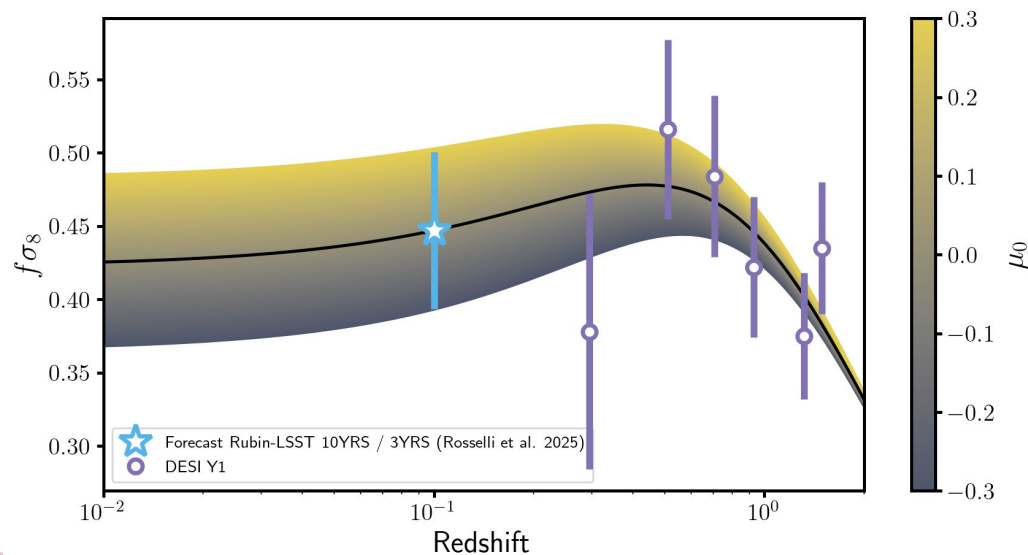Linked to growth   Linked to photon path

SN Ia Peculiar velocities

$$\mathcal{L}(f\sigma_8; v_p) \propto (2\pi)^{-\frac{N}{2}} |C(f\sigma_8)|^{-\frac{1}{2}} \exp\left(-\frac{1}{2}\boldsymbol{v_p}^T C(f\sigma_8)^{-1}\boldsymbol{v_p}\right)$$

Constraining modified gravity: SN Ia PVs

$\boxed{\boldsymbol{\mu}} - \boldsymbol{\Sigma}$

Linked to growth   Linked to photon path

SN Ia Peculiar velocities

Constraining $\boldsymbol{\mu}$

Project objectives

Short-term:

- Develop a combined Fisher matrix framework for SN Ia PV and 3x2pt
- Produce LSST forecasts for constraints on μ, Σ (e.g., scale independent parameters μ_0, Σ_0 and scale dependent c_1, c_2 and λ)

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Long-term:
- Expand to a full joint likelihood framework with MCMC-based inference.
- Apply the methodology to LSST data upon availability.

Current project pipeline
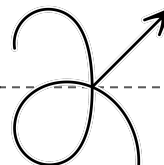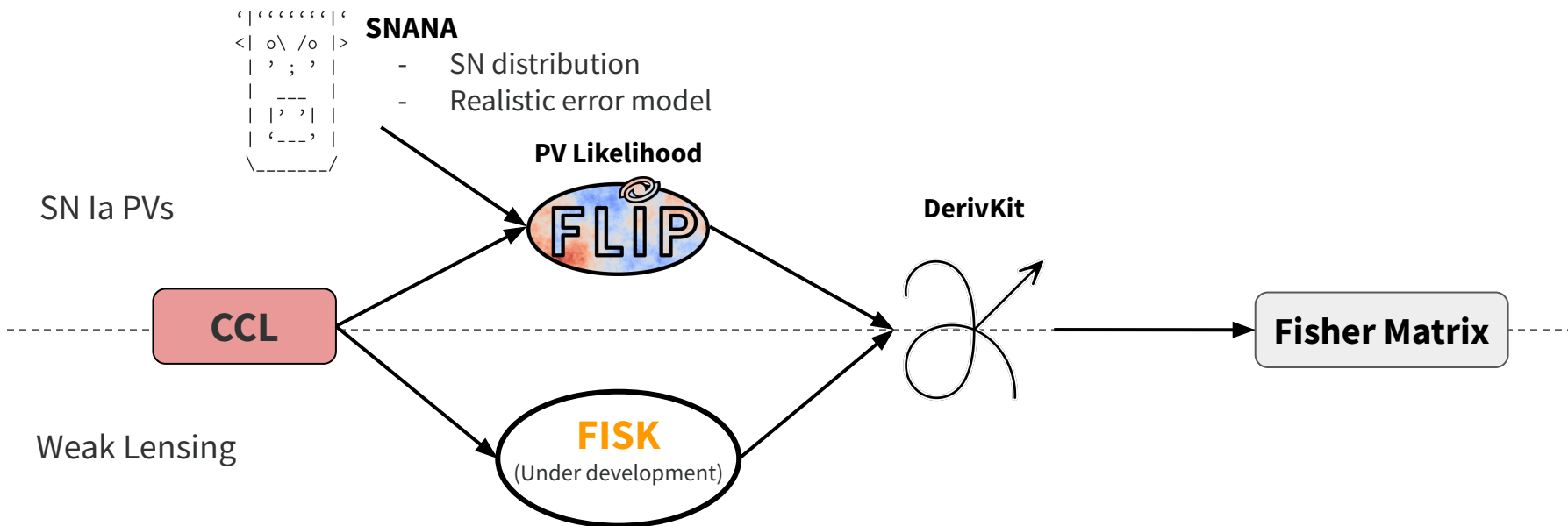
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Happy to collaborate !

Thanks for your attention !