MSEv - MSE velocity survey

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on behalf of ***Science Reference Observation #5: Peculiar Velocities @ high-z/cosmology WG:***

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GOAL: Structure and dynamics of the cosmic web up to ~1Gpc.

The SRO-5 proposes MSE as a means to realize a velocity survey (MSEv) exceeding the Cosmicflows-2 volume by a factor of 150, and extending the forthcoming TAIPAN and ASKAP (WALLABY) velocity surveys in the Northern hemisphere by a factor of 14 and 4, respectively

SCIENCE CASE:

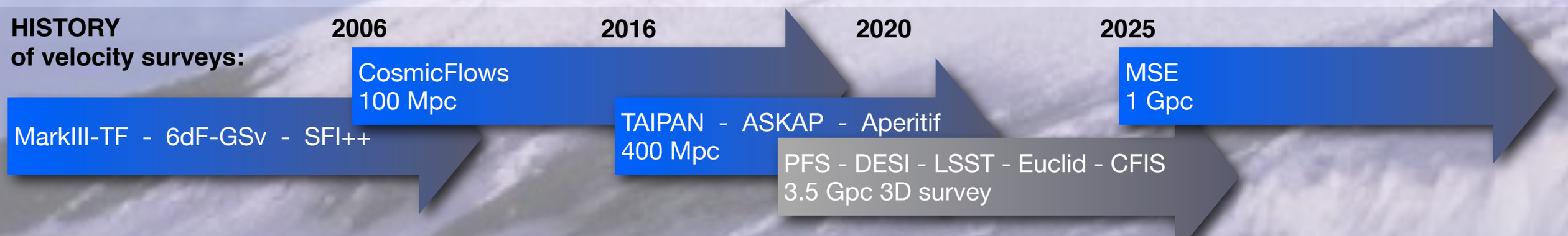
i. cosmic-web dynamics - galaxy formation - environment relationship
ii. velocity auto- and cross-correlation functions (clustering) → low-z test of modified theories of gravity, complementary to Euclid
iii. CMB dipole + homogeneity scale + genuine probe of backreaction mechanism (precision cosmology)

METHODS & KEY NUMBERS:

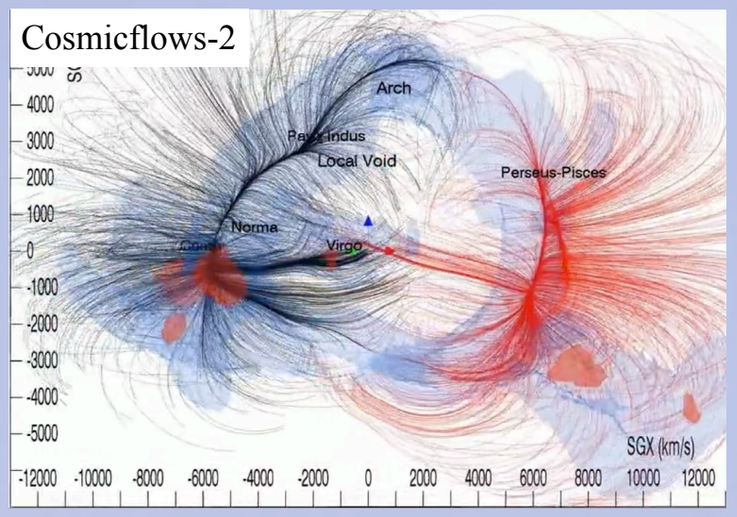
- 24,000 square degrees v-survey (3π beside the Milky Way)
- 1 million of early-type and late-type galaxy velocities up to redshift $z \lesssim 0.25$
- galaxy number density and sampling similar to Cosmicflows-2
- distances by Fundamental Plane and Tully-Fisher techniques

Mauna Kea Spectroscopic Explorer (MSE)
11m telescope, FoV =1.5 deg^2
λ370-1400 nm, R=2000/6500/20,000
3200+800 fibres (low-mid +hig res)

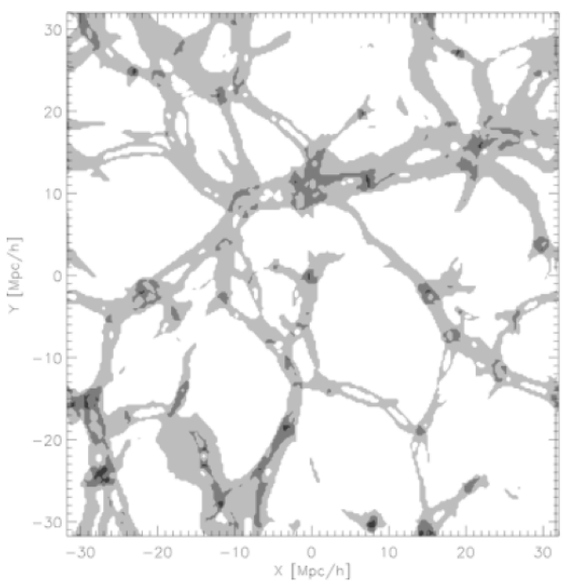
HISTORY of velocity surveys:

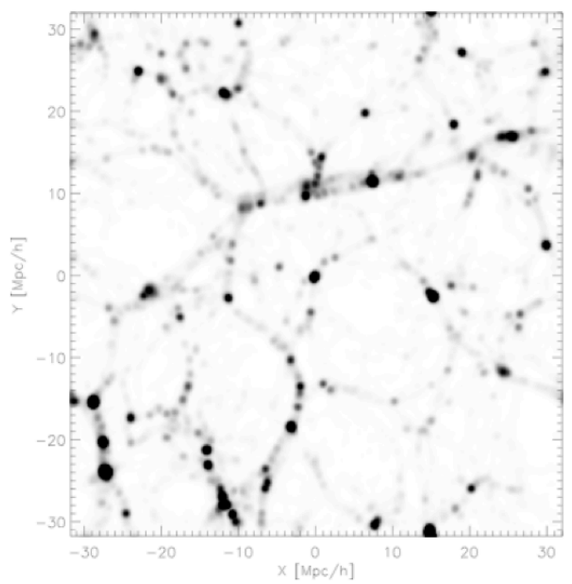


1. LOCAL DYNAMICS ➠ VELOCITY-BASED COSMIC WEB ➠ GALAXY FORMATION



Courtois et al. 2012, 2013; Tully, Courtois et al. 2014

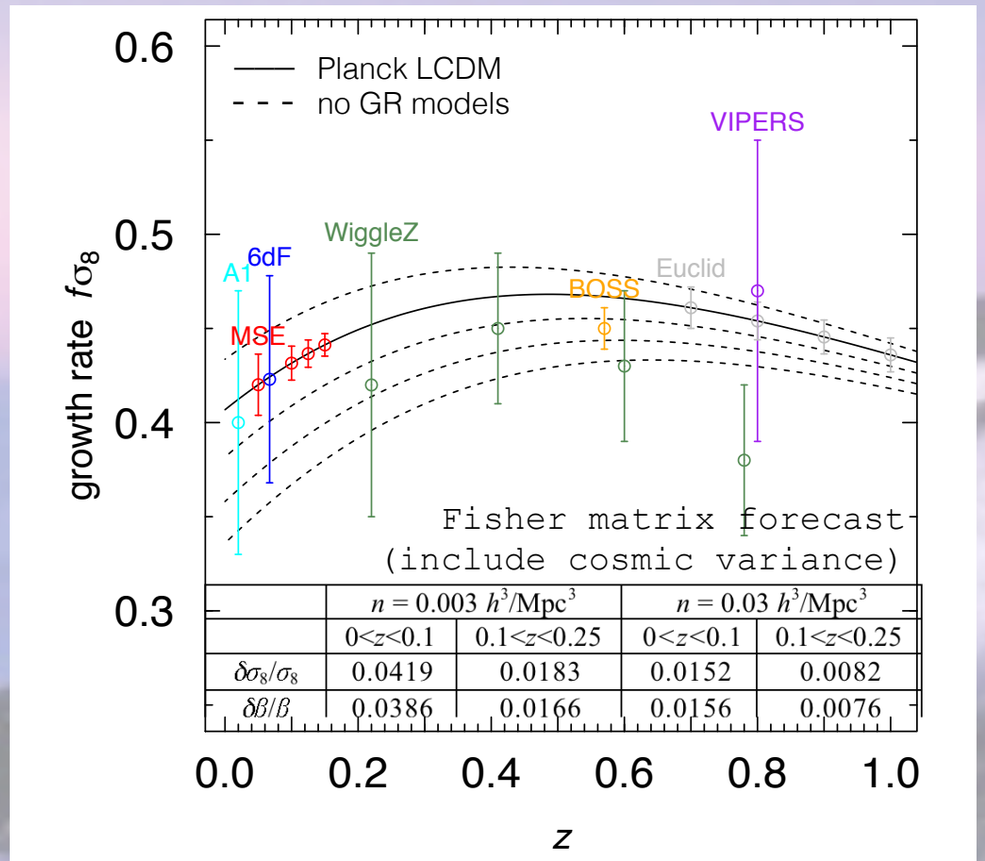




Cosmic-web components (voids, filaments, sheets, and knots in white, light gray, dark gray, and black, respectively) reconstructed from the velocity shear tensor (V-web, *left*) and the density field (*right*), which allows for ~10 times lower resolution scale (adapted from Hoffman et al. 2012, based on N-body simulation study). The V-web allows for resolving cosmic structures down to 0.1Mpc/*h*.

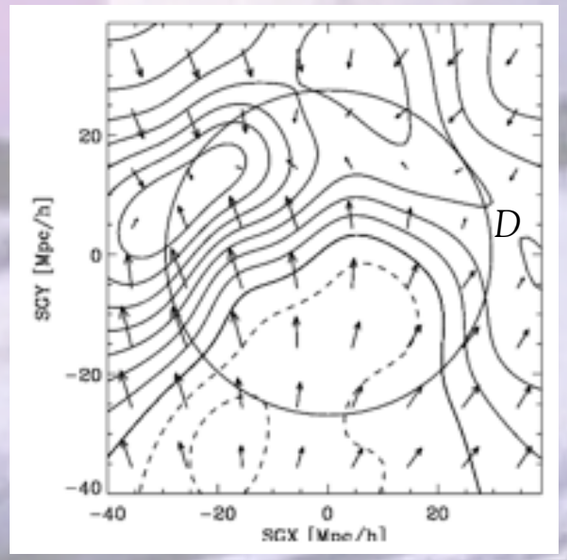
- *MSEv will be the only survey that could disentangle the reality of a cosmological bulk flow surviving the 800 Mpc scale as claimed by clusters observations (Kashlinsky et al. 2011)*
- *MSEv volume = 150 x Cosmicflows-2*

2. VELOCITY CORRELATION FUNCTIONS



	$n = 0.003\ h^3/\mathrm{Mpc}^3$		$n = 0.03\ h^3/\mathrm{Mpc}^3$	
	$0<z<0.1$	$0.1<z<0.25$	$0<z<0.1$	$0.1<z<0.25$
$\delta\sigma_8/\sigma_8$	0.0419	0.0183	0.0152	0.0082
$\delta\beta/\beta$	0.0386	0.0166	0.0156	0.0076

3. KINEMATICAL BACKREACTION



Averaged dynamics of a domain D (Buchert eqs):

$$3\left(\frac{\dot{a}_{\mathscr{D}}}{a_{\mathscr{D}}}\right)^2 - 8\pi G\langle\rho\rangle_{\mathscr{D}} - \Lambda = -\frac{\langle R\rangle_{\mathscr{D}} + Q_{\mathscr{D}}}{2}\ ;$$

$$3\frac{\ddot{a}_{\mathscr{D}}}{a_{\mathscr{D}}} + 4\pi G\langle\rho\rangle_{\mathscr{D}} - \Lambda = Q_{\mathscr{D}}\ ;$$

$$\langle\rho\rangle^{\cdot}_{\mathscr{D}} + 3\frac{\dot{a}_{\mathscr{D}}}{a_{\mathscr{D}}}\langle\rho\rangle_{\mathscr{D}} = 0\ .$$

$$Q_{\mathcal{D}} = \frac{2}{3}\mathrm{Var}[\mathrm{div}\,\boldsymbol{v}]_{\mathcal{D}} - 2\langle\sigma_{ij}[\boldsymbol{v}]\sigma^{ij}[\boldsymbol{v}]\rangle_{\mathcal{D}}$$

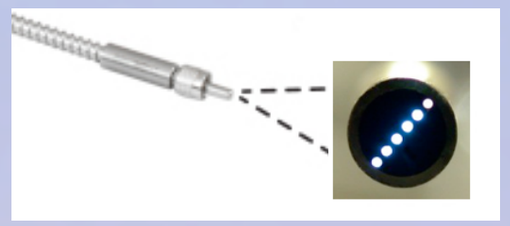
- *MSEv provides the direct, genuine probe of the backreaction conjecture: depending on the average scale, Q_D is dynamically equivalent to both dark matter and dark energy.*

FEASIBILITY - SRO PHASE 1

▸ Spectroscopy requirement for MSEv

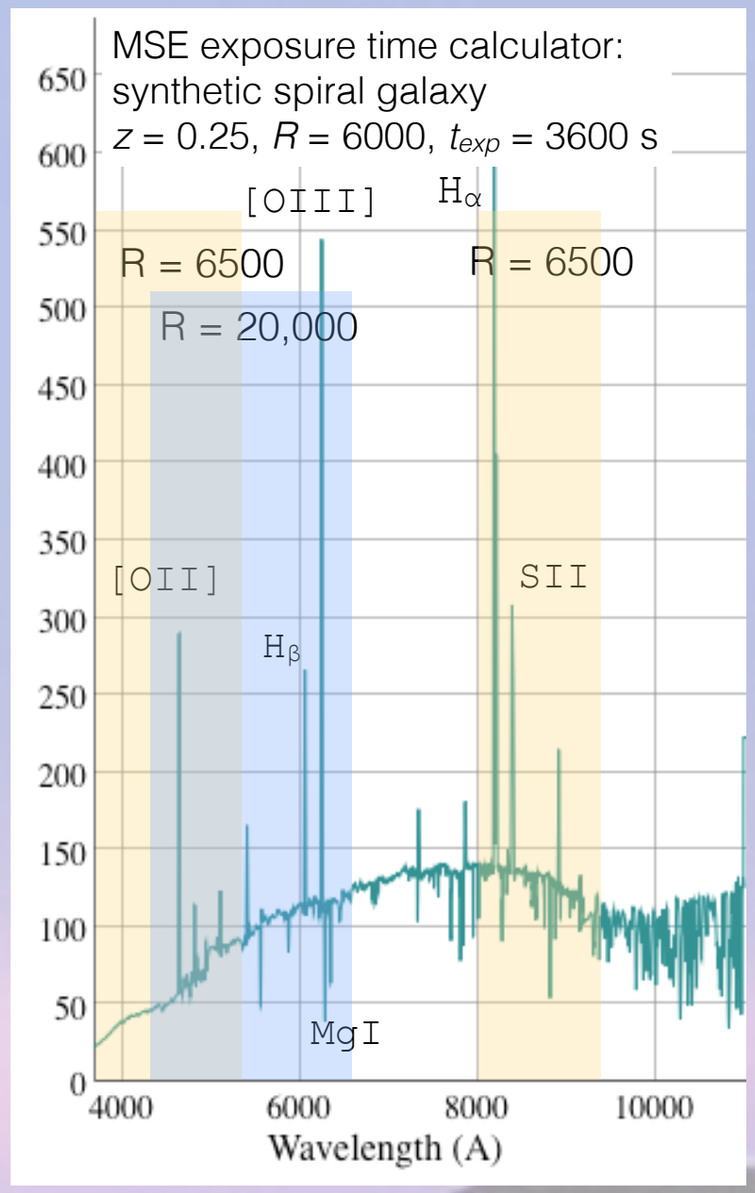
Best option:
24,000 deg², 3900-8600Å
Hα, [OIII], [OII], Hβ, NaD
96 gal/deg² = 144 gal/FoV

+ requirement: multi-IFUs, with linear 7-fibres bundles, to be aligned to the targets' maximum photometric axis

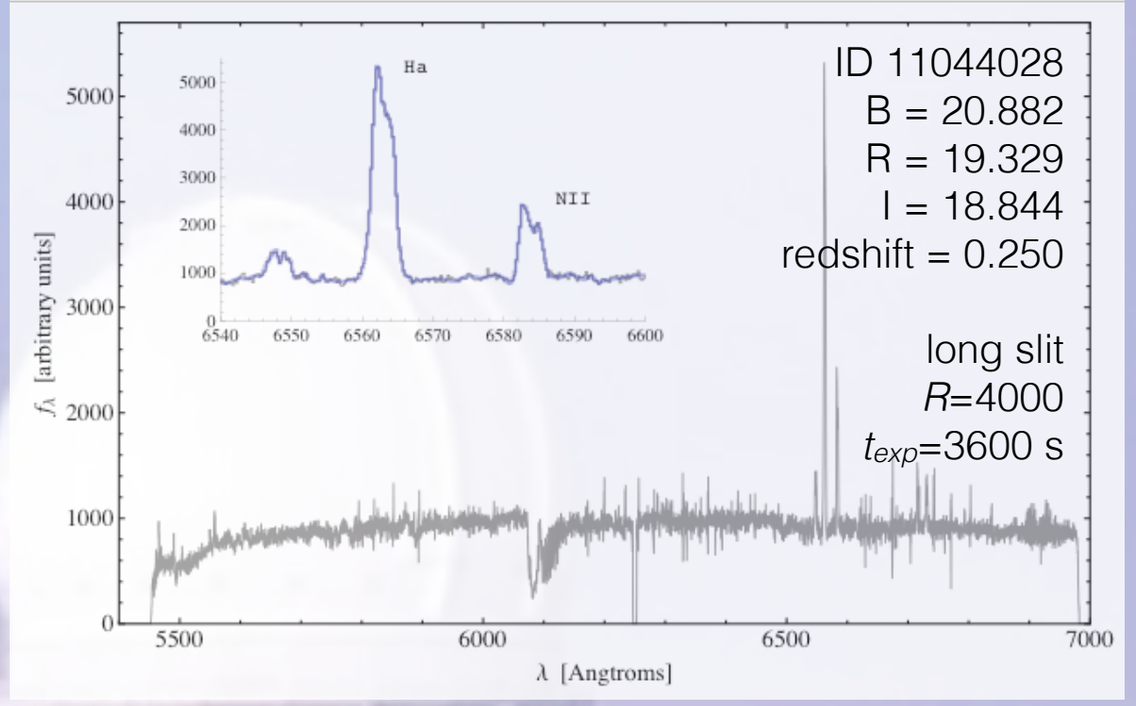


(other fibre-bundle modes or technologies can be envisaged)

144 targets x 7-fibres bundles = 1008 fibres/FoV (actual MSE baseline: 4000 single fibres)
➠ *16 Million spectra*



DEEP2 @ DEIMOS, Keck-II (⌀10m)



▸ velocity accuracy requirement for FP (TF) method
≲ 60 (30) km/s (~TAIPAN); R= λ/Δλ =5900 @ 7800Å assures velocity accuracy σ= 24 km/s (Newman+ 2013, DEEP2 @ DEIMOS, Keck-II)

▸ Photometry requirements for MSEv
fig. right: Luminosity distribution of targets per square degree with redshift z < 0.25 and magnitude i < 24.5 (estimated from ACS-COSMOS): among the ~24,000 targets (black line), about 13,000 have been classified as galaxies (up to i < 24), of which 3% are elliptical galaxies (red), 87% spirals (blue thin); 0.4% are spirals with angular size larger than 4.5" (blue thick), i.e. encompassing 5 fibres with diameter 0.9" each. The recommended magnitude limit are r < 24.5 , i < 24.5, J < 15.2. Photometric follow-up by CFIS & Euclid.