CIFAR CANADIAN INSTITUTE FOR ADVANCED RESEARCH

CITA ICAT Canadian Institute for Theoretical Astrophysics L'institut canadien d'astrophysique théorique

CITA = **Cosmic Information Theory & Analysis**
*from **SuperWeb simplicity** to **complex Intermittency** in the Cosmic Web*
Studying the Cosmic Tango *Universe=System+Res, =Data+Theory*

Dick Bond

CIFAR Cosmology & Gravity Program: >1985, Bond Director 2002-17 => CIFAR Gravity & the Extreme Universe Program Sr Fellow 17-22 CITA: 6+ faculty, ~20 PDFs & Sr RAs + ~20 grad students; Bond: projects 4 grad students, 3 SrRAs, 2 (++) PDFs, 3SUGs+1VMSc +..

Cosmic standard model SMc = *x*CDM, *x*=dark energy+*tilt*: what is U made of?
Planck13-15-17 *CMB, CvB, GW, dark matter, baryons, dark energy/modGravity*, CIB:

$$\rho_{dm}/\rho_b = 5.43 \quad \rho_{de}/\rho_{dm} = 2.53 \quad \Omega_m = 0.32 \pm .009, \quad \Omega_\Lambda = 0.68 \pm .009 =>$$

BSMc Beyond the SMc *eg* $\Omega_\Lambda(t,x)$, neutrino properties, inflation anomalies

How Structure in the Universe Arose?: *fluctuation generation in curvature from an early* **inflaton:** *reconstruct* ln $a(x,t)$ ~ *phonons, isocurvature, Gravity Waves r* **HEAT** *(coherence + quantum noise => incoherence via entropy generation) via* nonlinear lattice simulations of multiple scalar fields at the end of inflation dynamical systems KS S **=> CMB/LSS Anomalies from EarlyU intermittent non-Gaussianity cf. perturbative non-Gaussianity,** *correlated & uncorrelated =>* **CITA in CMB + LSS large surveys**

CMB*ology* precision cosmic parameters *Planck* 2013-15-17 intensity + polarization + *ACTpol* + *BKP* +*SPT* => *Spider, Advanced ACTpol CCATp* => *Simons Obs* => *CMB Stage 4*, … **& LSS***ology* CHIME, COMAP, Euclid … **& cross correlations:** *CMBxLSS = webXweb*

morphs *into the nonlinear* **Cosmic Web:** **Mocking Heaven** *clusters* SZ, *filaments, voids; galaxies Mass-peak-patches, N-body, gas: Lens, tSZ, kSZ, CIB,CO, HI (21cm,Hα,Lyα) optical*

*Line Intensity Mapping* constrained patch stacks **fate** *(dynamical, coupled?)* *dark energy*

Mocking Heaven's Web *with PeakPatches*++ 🍁

Dick Bond @ DAA Jamboree 17

Planck, AdvACT, SO, CMB-S4, CCATp, EUCLID, LSST, CHIME, HIRAX, COMAP, ...SKA

Line Intensity Mapping and Line Absorption Mapping fLIMfLAM

CITA mini-industry: Marcelo Alvarez, Dick Bond, George Stein & Battaglia, Codis, van Engelen & FIRE: Lakhlani + Murray + Hopkins + Berger & Connor Bevington, Bruno Régaldo-Saint Blancard, Ronan Kerr, Louis Pham

need **End to End mocks: BSM, nonG, DE/modG, Mnu, …**
need **all signals to be correlated, 1, 2, 3, .. Npt**
need **speed to build ensembles & explore BSM**

CIB   tSZ   HI CHIME   weak lens   Optical   kSZ
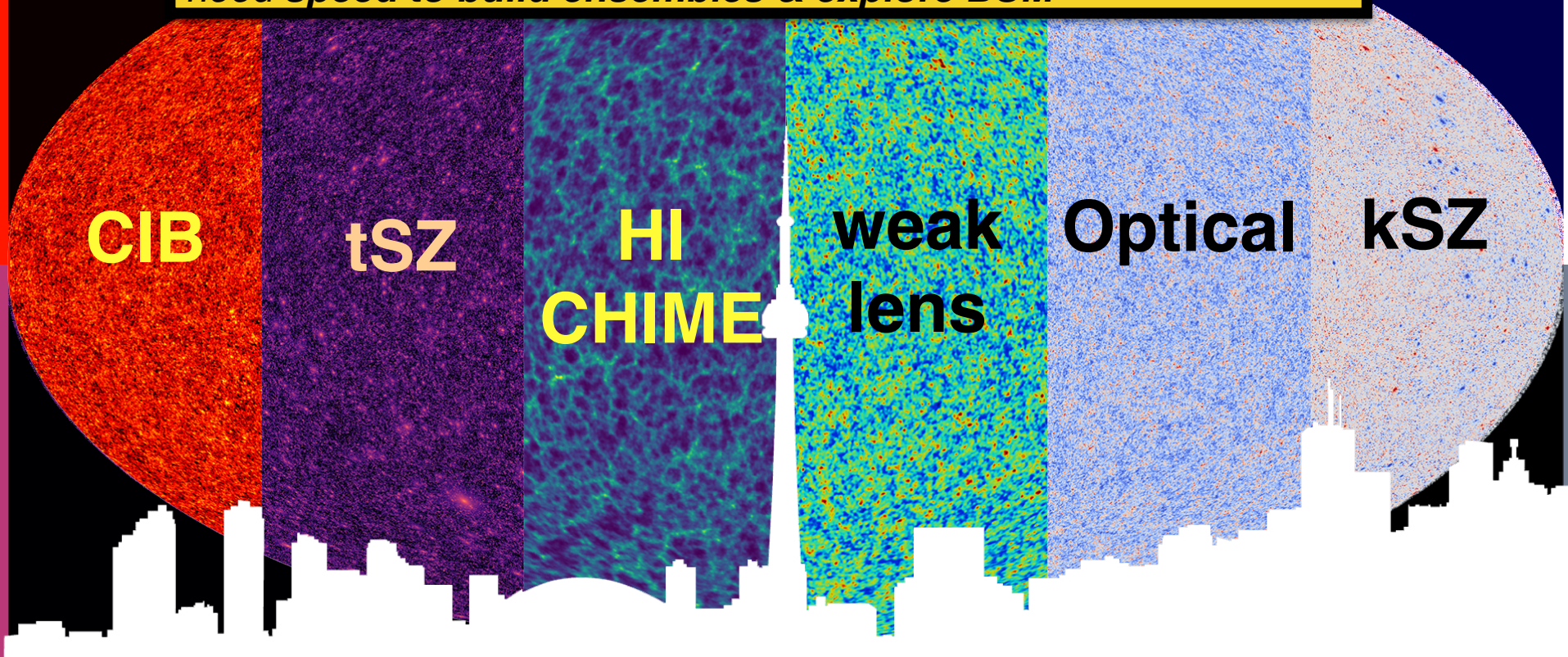
Planck 2015 XII: Full Focal Plane Sims: FFP8 ensemble of 10K **End**to**End** mission realizations in 1M maps. instrument noise + CMB + PSkyModel + .. *(25M NERSC CPU hrs)*