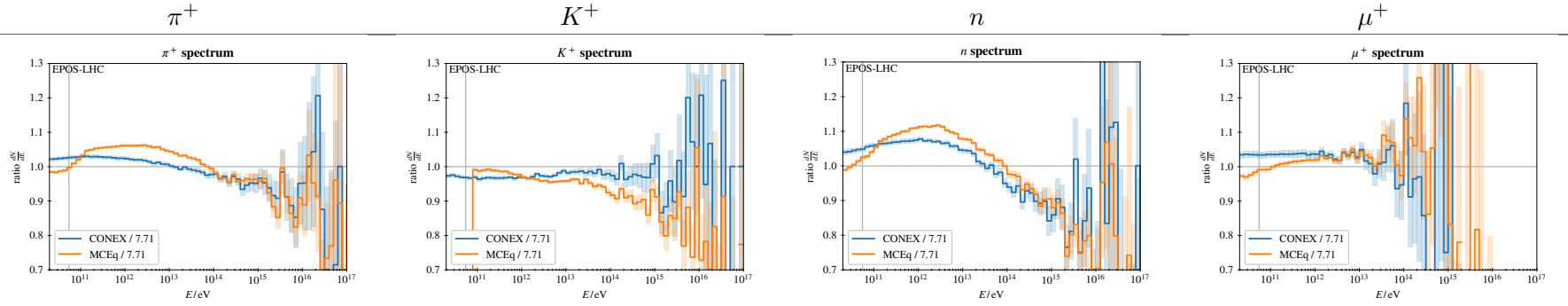
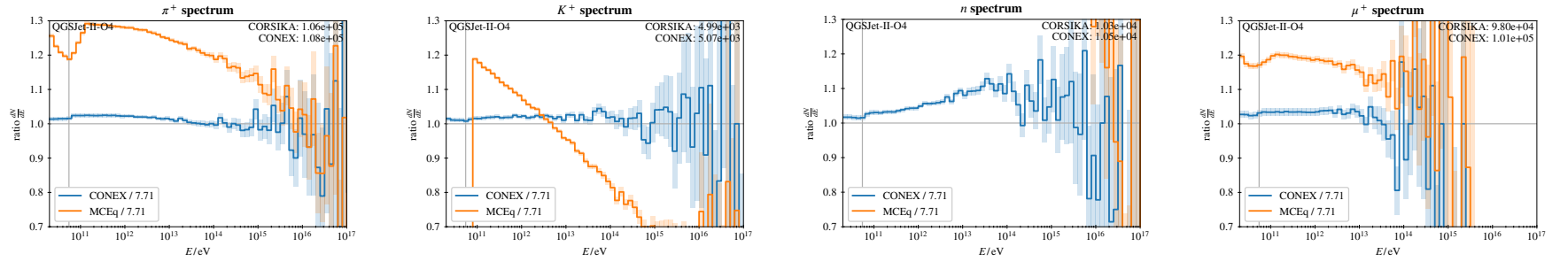


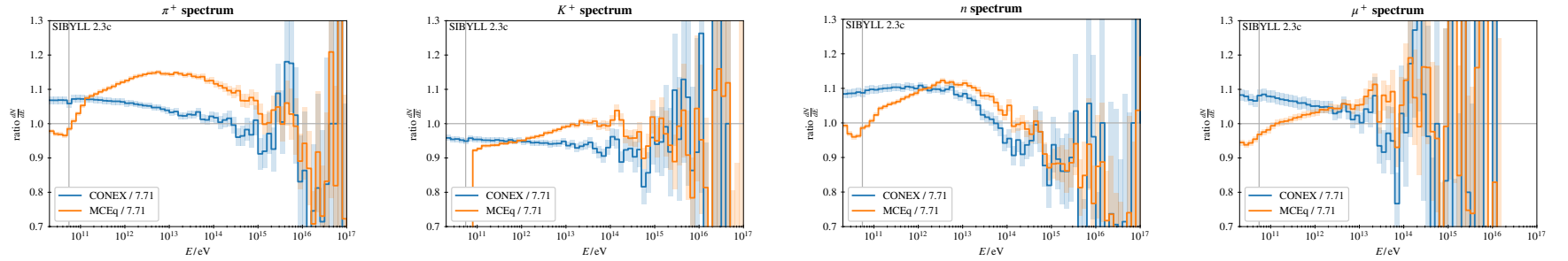
EPOS



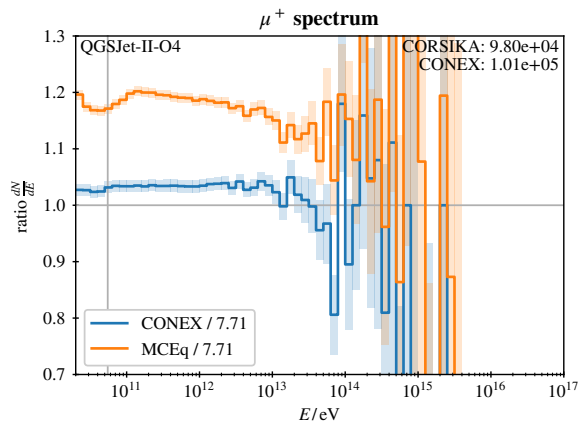
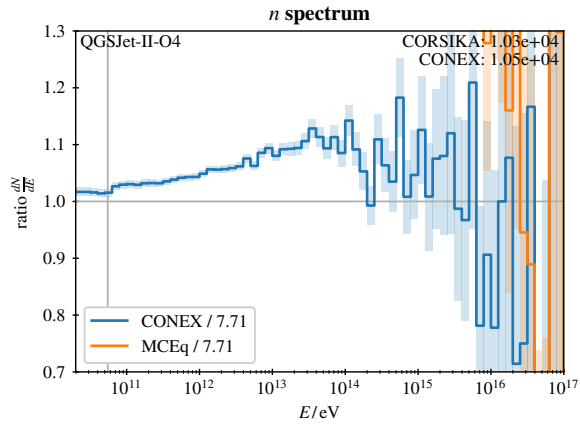
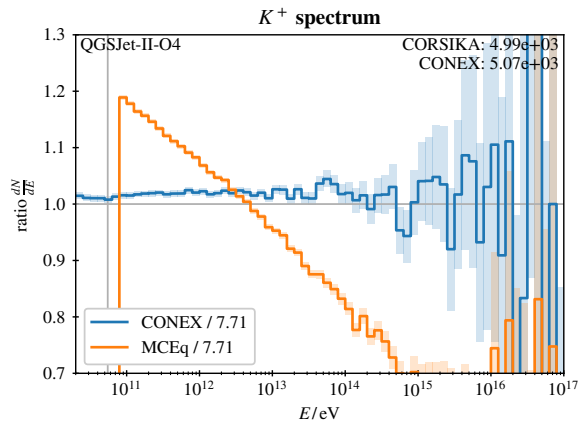
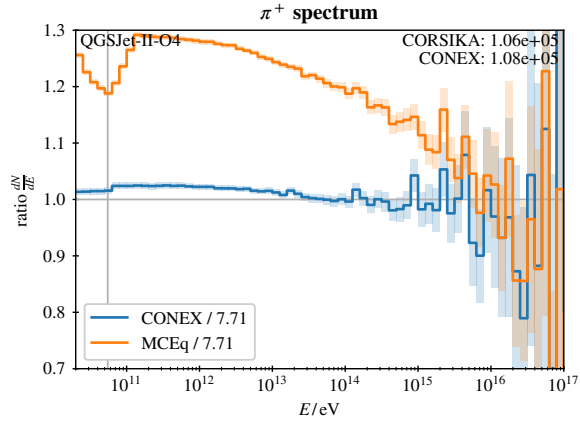
QGSJet-II-04



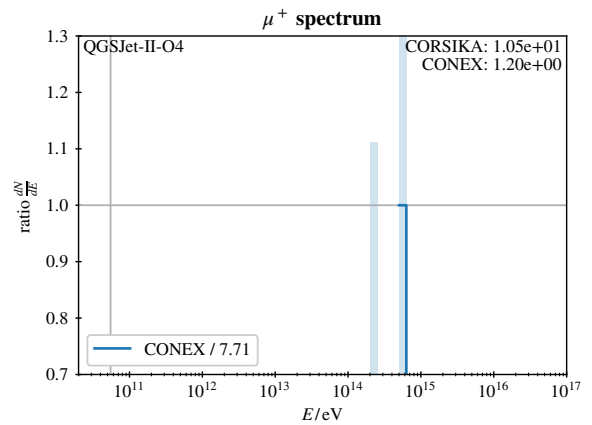
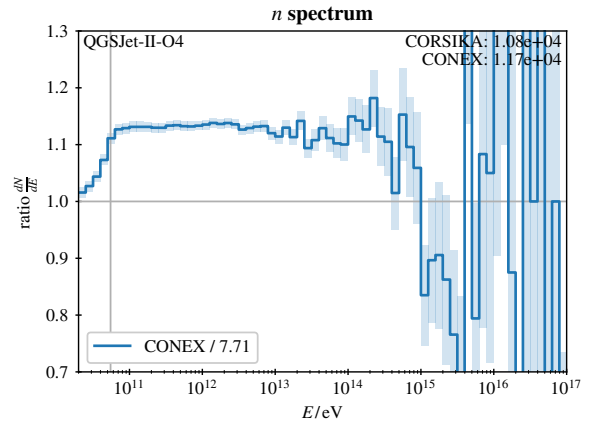
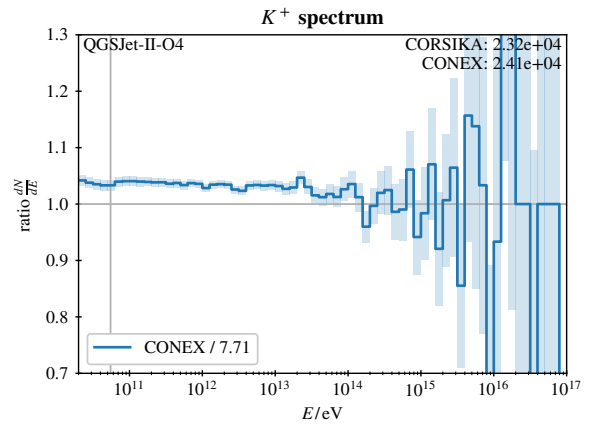
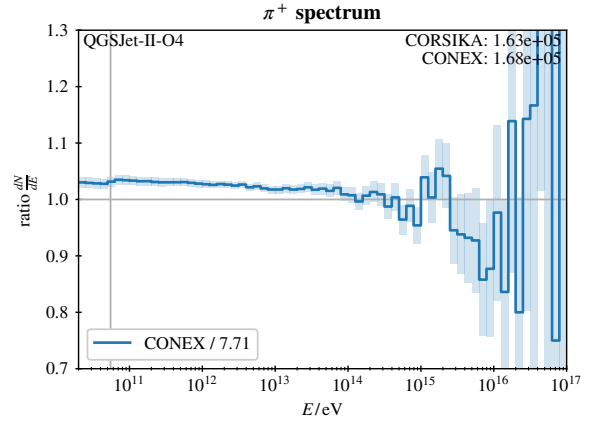
SIBYLL 2.3c¹



standard



no decays



general setup: US standard atmosphere, observation level $7 \text{ km} \hat{=} 420 \text{ g cm}^{-2}$

MCEq code

```
def spectrum_MCEq(model, energy=1e18, height=7e3):
    mceq = MCEqRun(interaction_model=model, theta_deg=0, primary_model=None)
    mceq.set_density_model(('CORSIKA', ('USStd',)))
    mceq.set_single_primary_particle(energy / 1e9, pdg_id=2212)
    X_grid = np.array([0, mceq.density_model.h2X(height*1e2)])
    print("looking at ", X_grid[-1], "g/cm2, height ", height, "m")
    mceq.solve(int_grid=X_grid)
    mag = 0

    piPlus = mceq.get_solution('pi+', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    piMinus = mceq.get_solution('pi-', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    kPlus = mceq.get_solution('K+', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    kMinus = mceq.get_solution('K-', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    muPlus = mceq.get_solution('mu+', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    muMinus = mceq.get_solution('mu-', mag=mag, grid_idx=len(X_grid)-1) / 1e9
    n = mceq.get_solution('n0', mag=mag, grid_idx=len(X_grid)-1) / 1e9

    ...
```