Higgs/BSM Lectures - Valencia - May 2015

1. 11/05: **EW theory and Higgs mechanism** (2h30)
    1. n->p e barnu_e: Pauli '30, Fermi '32-34, nu_e and nu_mu
    2. current-current interaction
    3. SU(2)xU(1) vs Georgi-Glashow
    4. Gargamelle exp.
    5. pi -> e barnu_e vs pi -> mu barnu_mu and V-A structure of the weak interaction
    6. SM Higgs mechanism - W and Z masses
    7. SU(2)xU(1)->U(1)em, number of degrees of freedom before and after EWSB
    8. rho parameter
    9. custodial symmetry
        SO(4)/SO(3)
        SO(4)~SU(2)xSU(2)
        rho=1
        W_L and Z_L as pions of SU(2)xSU(2)/SU(2), Sigma matrix, unitary gauge
ex 1: 2-body decay and 3-body decay
ex 2: higgs self-couplings, general expression of the rho parameter

2. 12/05: Goldstone equivalence theorem (2h30)
    1.h->WW - computation in the unitary gauge and using the Goldstone's (using the Higgs potential)
    2. h -> Wb - computation in the unitary gauge and using the Goldstone's (using the Yukawa interaction)
    3. validity of the Goldstone eq. theorem: m << E << 8 pi m/g
    4. expression of longitudinal polarization vector and eps_L (k) ~ k/mW (1+ O(m_W^2/E^2))
    5. WW scattering in the unitary gauge: cancelation of the E^4 terms
    6. pi-pi scattering
    7. Higgs contribution to WW scattering: a^2=1
    8. unitarity bound on the Higgs mass
    9. Higgs unitarization for WW->hh
    10. Higgs unitarization for WW->ff
ex 3: scalar vs. pseudo-scalar Higgs: threshold behavior in h->ff
ex 4: partial wave decomposition, additional factor \sqrt{\pi} in NDA

3. 13/05: RG effects in Higgs potential, hierarchy problem (2h30)
    1. triviality bound
    2. stability bound
    3. Finite temperature corrections
    4. vc/Tc = 4 B v^2/ mh^2 with B= (2 mW^3+ mZ^3)/(6 pi v^3)~ 6 10^-3
    5. General discussion on the problem of quadratic divergences, relevant operators.
    6. computation of the quadratically divergent diagrams
    7. Coleman-Weinberg potential
ex 5: EW phase transition with H^6 potential
ex 6: beta function

4. 14/03: Higgs low-energy theorems, Higgs and new physics (2h30)
    1. remark on the importance of h->gg and h->gam gam as test of naturalness
        H->gg top quark loop: diagrammatic computation and mt->infinity limit,
        remark on (non-)decoupling,
        short discussion on the Higgs production channels at the LHC
    2. HGG effective vertex: matching with diagrammatic computation
    3. HLET from alpha_s running
    4. HLET for h->gamgam
    5. Higgs couplings modifications due to cH
    6. SILH basis and power counting (hbar dimensions)
    7. connection with a,b,c
    8. Higgs primaries
    9. RG running and h->gam gam
    10. SO(5)/SO(4) composite Higgs models. Computation of cH
ex 7: computation of S and T from dim. 6 operators
ex 8: non-linear field redefinition from cH

Extra material (if time permits or if there is strong interest): Future prospects
    1. SM deformations: BSM primaries
    2. double Higgs production: threshold behavior, access to Higgs self-coupling, access to top Yukawa coupling
    3. boosted Higgs channel
    4. off-shell Higgs production
    5. flavor violating Higgs couplings