DISCUSSION

cont. of Natasa's talk on H→ZZ deacays @3 TeV*

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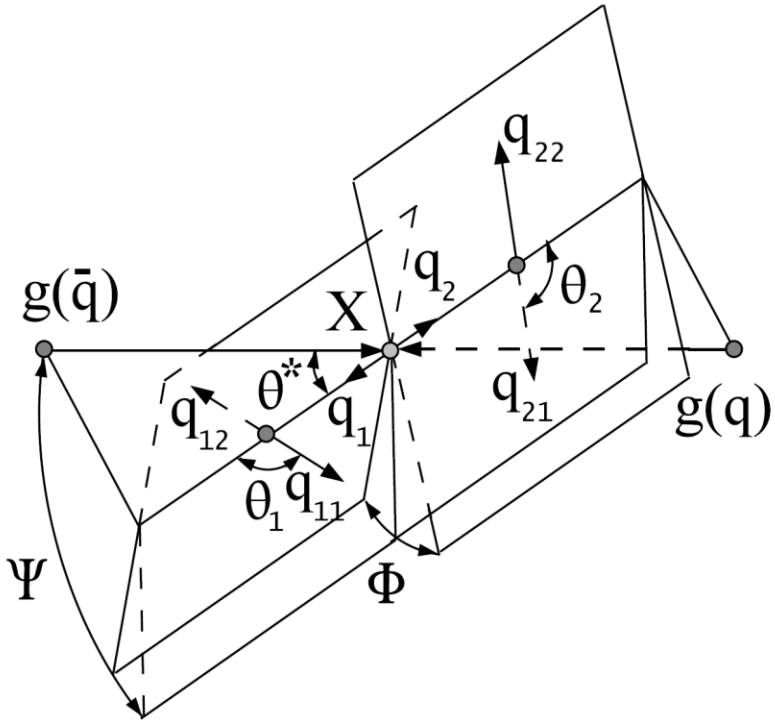
Towards CPV measurement in H→ZZ*

- Questions:
  - What is the (ideal) signal?
  - How to generate it?

What is the (ideal) signal?

- $e^+e^- \rightarrow X(q) \rightarrow V_1(q_1)\, V_2(q_2)$,
- $V_1 \rightarrow f(q_{11})\, f(q_{12})$, $V_2 \rightarrow f(q_{21})\, f(q_{22})$ where:
  - X = H
  - V_1 = Z (vector boson is on-shell Z boson)
  - V_2 = Z* (vector boson is off-shell Z boson)
  - q_{ij} - momenta of the final state **particle** from on-shell (i=1) or off-shell (i=2) Z boson decay into particle (j=1) or **antiparticle** (j=2)



- It is important to distinguish between particle and anti-particle in order not to scramble CPV information
- What to do in case of qqll final state where there will be ambiguity in the sign of charge due to the presence of up and down type of quarqs?

What is the (ideal) signal?

- Possible solution is to tag $Z \rightarrow bb$ decays

where b-tagging + jet charge can identify (with some purity) particle/antiparticle

  - What leaves approximately 15% of the (existing) signal – 5650 qq, ee($\mu\mu$) events@ 5 ab^{-1}
  - This will vary when bbll signal is treated in the full preselection+MVA chain
  - But, it principal it's ~ 800 events in 5 ab^{-1}
  - *Already preselection will cut the half*
- What sensitivity one can expect?
- Should 4l final state be more pure?
- ...but with <300 events in 5 ab^{-1}

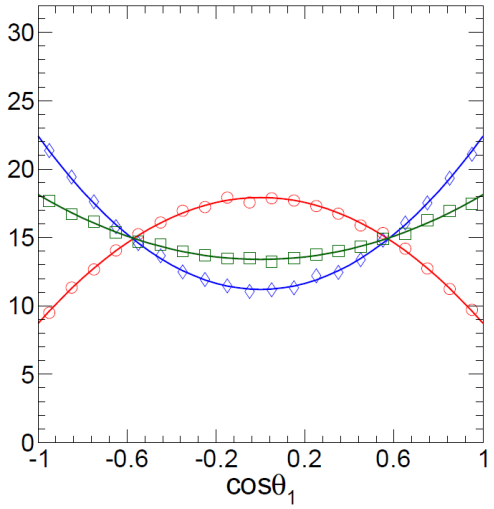
What to expect?

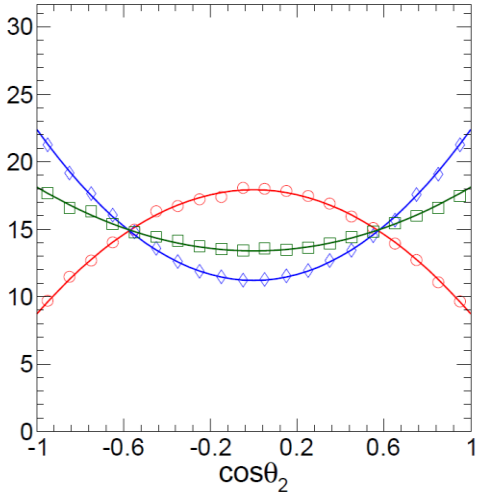
- We have limited statistics of the signal to a few hundreds of events
- Signal with jets is contaminated with particle-antiparticle ambiguities through jet(charge) reconstruction and flavor tagging
- With those limitations we have to be sensitive to *shifts in phase* of sensitive observables (α: 0, π/2):

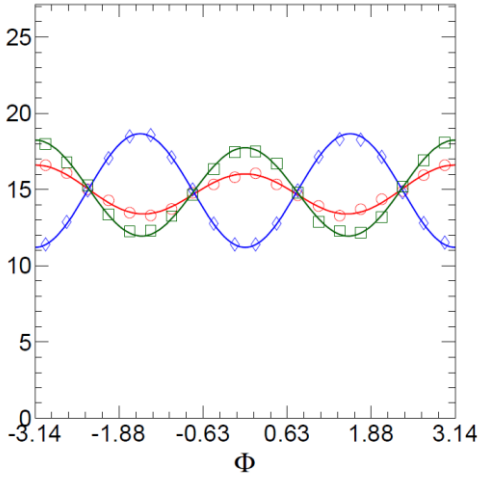
$$H = J_0{}^+ \cos\alpha + J_0{}^- \sin\alpha,$$

arXiv:1208.4018 [hep-ph]

J_m^+ (red circles), J_h^+ (green squares), J_h^- (blue diamonds)

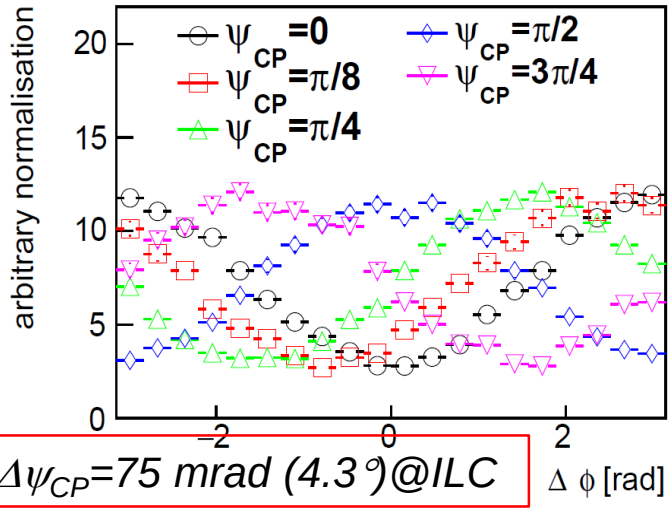




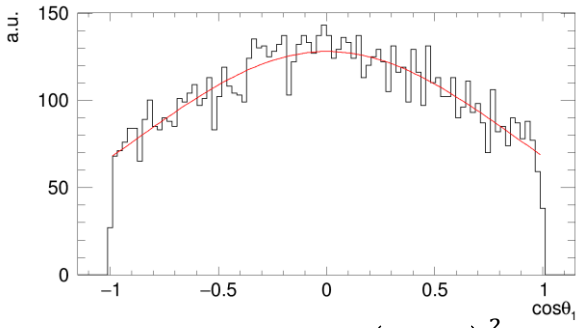


What to expect?

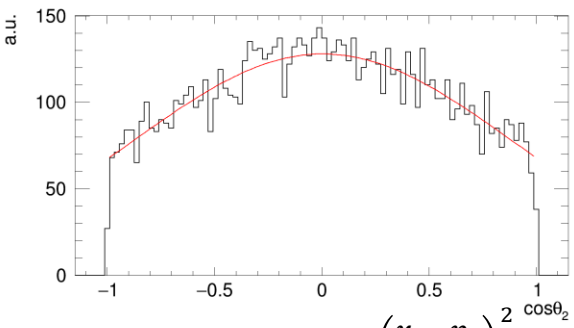
- With those limitations we have to be sensitive to *shifts in phase* of sensitive observables (angles)
- It is actually quite similar to the shift of CPV sensitive angle in H→ττ



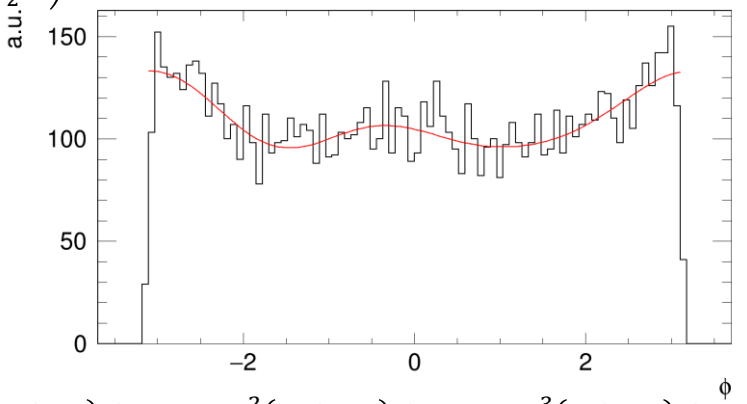
$\Delta\psi_{CP}$=75 mrad (4.3°)@ILC



$f = 128 \cdot \exp(-0.5 \cdot \left(\frac{x - p_1}{p_2}\right)^2)$



$f = 125.9 \cdot \exp(-0.5 \cdot \left(\frac{x - p_1}{p_2}\right)^2)$



$f = p_0 \cdot \cos(x + p_1) + p_2 \cdot cos^2(x + p_3) + p_4 \cdot cos^3(x + p_5) + p_6$

https://arxiv.org/abs/1804.01241v1

$f_i' = a_i \cdot cos(f_i + 2\alpha) + b_i$

From the reconstructed signal, one can simultaneously fit the mixing angle α (ψ_{CP})

How to generate signal?

- This was also an issue because WHIZARD (O'Mega) could not use the full matrix elements to generate scalar/pseudoscalar interactions with (vector) bosons and fermions.
- Until Version 2.8.1 that can accommodate UFO model

  http://feynrules.irmp.ucl.ac.be/wiki/HiggsCharacterisation

  `HC_UFO_JRR.ar.gz`

We are grateful to Juergen Reuter from the WHIZARD Developers group for that!

Open questions

- How to actually proceed – with what signal: bbll (l=e, μ), 4l or…?

to look into ττ?

- As it is known that the CPV effect is *smaller* in H→VV decays
- Further, are going to need samples of the dedicated signal (different mixing angles) – *Collaboration support needed*
- We would like to have *consensus* on this study (again, support from a Collaboration) because it is a *PhD topic*