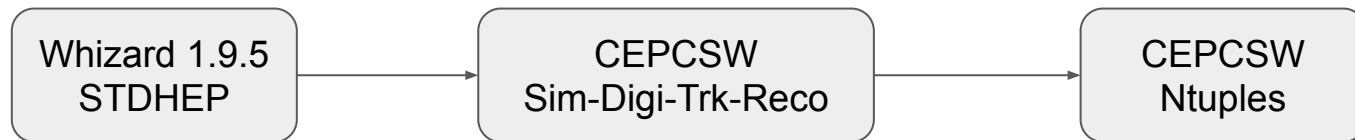


$ee \rightarrow \mu\mu$ forward-backward asymmetry at CEPC

Shuo Han, Jiawei Wan

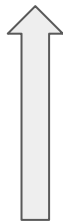
Truth analysis workflow



- In previous studies, $AFB(\mu\text{on}) = 0.023 \pm 0.002$ at Reco level
 - This is suspicious because LEP measured $AFB(\mu\text{on}) = 0.0163 \pm 0.0014$
- Validation at STDHEP today
- Started from Kaili's Whizard example on Gitlab:
<https://code.ihep.ac.cn/zhangkl/whizardais/>
- Directly read STDHEP by Kaili's CEPCSW script
https://code.ihep.ac.cn/zhangkl/cepcsampleproduction/-/blob/main/temp_MC.py

Validation at STDHEP

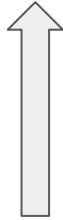
Whizard 1.9.5
STDHEP



- However, with 1M events the AFB without any selection is
 - $AFB = 0.018 \pm 0.001$
 - AFB is smaller than Reco level because
 - ISR is fully considered (no Z mass window)
 - E_{cm} is slightly smaller at 91.18 GeV
- Some corrections are needed on top of the default settings

Validation at STDHEP

Whizard 1.9.5
STDHEP



```
&parameter_input
Me = 0
Mmu = 0.10566
Ms = 0
Mc = 0
Mb = 0
MH = 2000
wH = 10.0
alphas = 1.e-6 /
```

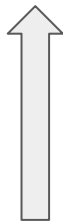


```
&parameter_input
gwidth = T
rwidth = T
mW = 80.377
mZ = 91.1876
mH = 125
wW = 2.085
wZ = 2.4952
wH = 4.1
/
```

- Problem 1: many parameters in whizard.in are incorrect, the default W, Z mass and width are not accurate, and the width of particles set to false
- Problem 2: $\sin(\theta_W)^2$ cannot be set manually in whizard.in, it's hard coded that $\cos(\theta_W) = m_W/m_Z$, it suggests Whizard doesn't have QED correction
- Problem 3: changes in whizard.mdl is not propagated to whizard.out
- Corrections now: manually set W, Z, H mass and width in whizard.in
- After corrections, $AFB = 0.016 \pm 0.001$

Center-of-Mass Frame

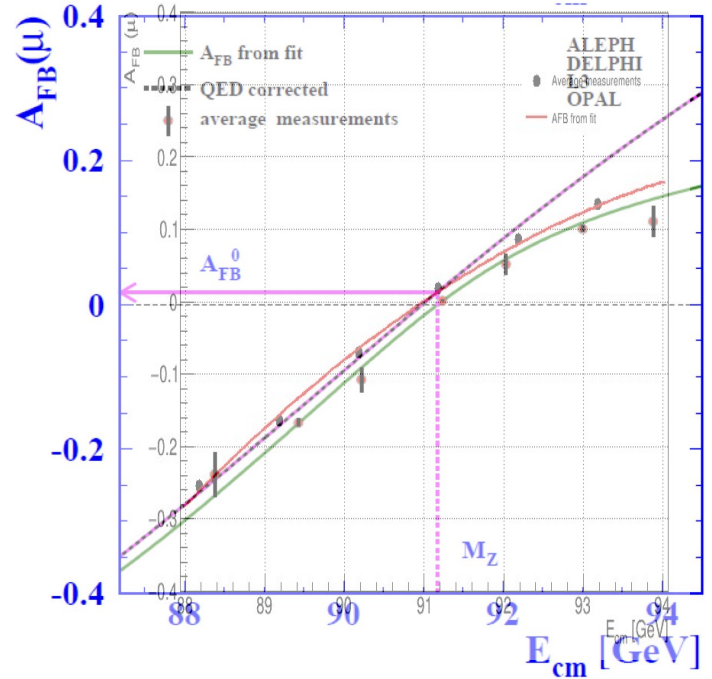
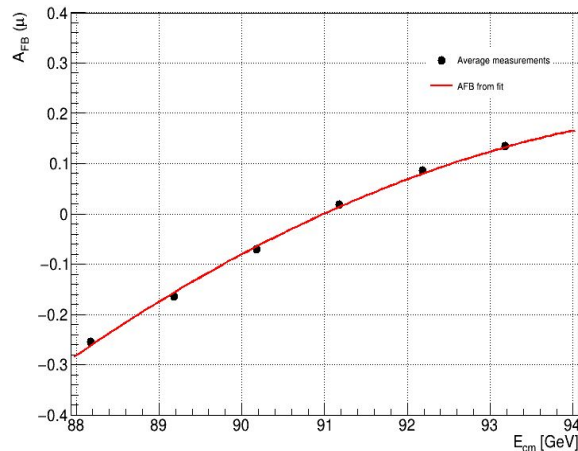
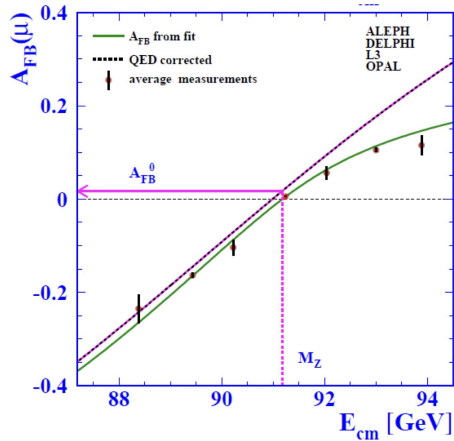
Whizard 1.9.5
STDHEP



- $AFB = 0.016 \pm 0.001$
- Lab Frame: 0.015886
- Center-of-Mass Frame (correct): 0.015928
- Using Lab Frame will bias the result by $\sim 0.3\%$

AFB vs Ecm (by Jiawei)

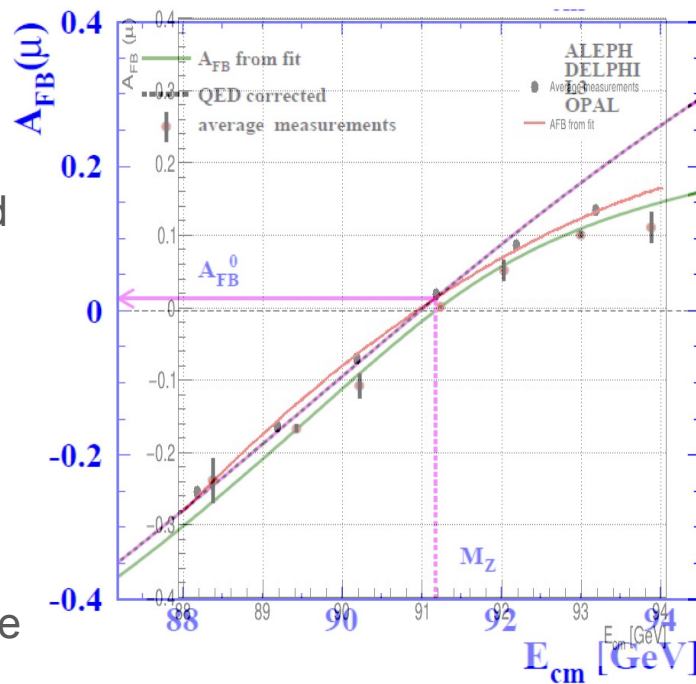
- Dependency of AFB along Ecm
- It looks like Whizard still miss corrections with $E_{cm} > Z$ mass, only the AFB around Z pole is corrected and matching the LEP results
- Needs to be aware of the bias from Whizard calculation



Energy spread uncertainty from AFB vs Ecm

Based on AFB vs Ecm

- AFB when $E_{cm} = 91.18$ GeV:
 - AFB from fit = 0.01413
 - The fit still has uncertainty and will be corrected
- AFB assuming E_{cm} is a Gaussian of (91.18, 0.12)
 - TDR says energy spread is 0.13%
 - AFB with energy spread = 0.01411
- Energy spread uncertainty $\sim 2e-5$ by comparing with/wo energy spread
 - Compatible with FCC-ee study $1e-5$
 - Given stat error is $<1e-5$, it is expected to be the largest uncertainty of this measurement



Recap

- Validations of STDHEP
 - The default setup of Whizard has many parameters incorrect
 - Got reasonable AFB ~ 0.016 at truth level, but It looks like Whizard still miss corrections on the AFB vs Ecm plot when $E_{cm} > Z$ mass, need further verification
 - Uncertainty is $\sim 2e-5$ with/wo energy spread, by fitting the AFB vs Ecm distribution
- Using Lab frame will bias the result by 0.3%, corrected
- Next
 - Follow up the action items above
 - Redesign reco-level selection with muon ID
 - Evaluate the detector acceptance uncertainty (from the theta resolution of a large MC sample)