# Prospects of CKM elements $|V_{cs}|$ and decay constant $f_{D_s^+}$ in $D_s^+ \to l^+\nu_l$ decay at STCF

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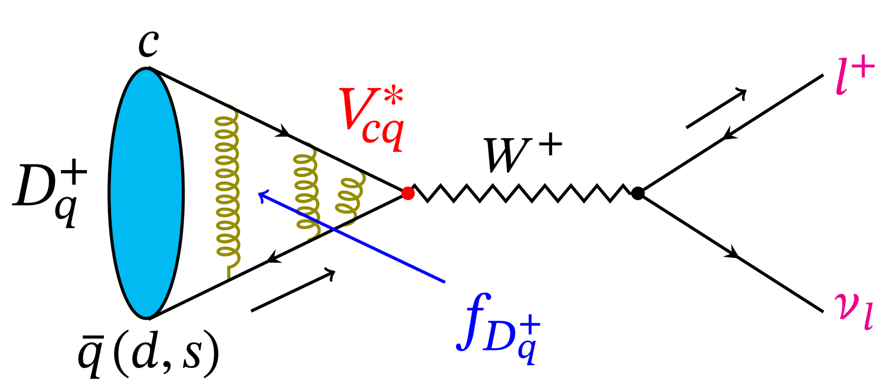
## Introduction

**In the SM**

- $D_s$ pure leptonic decay:

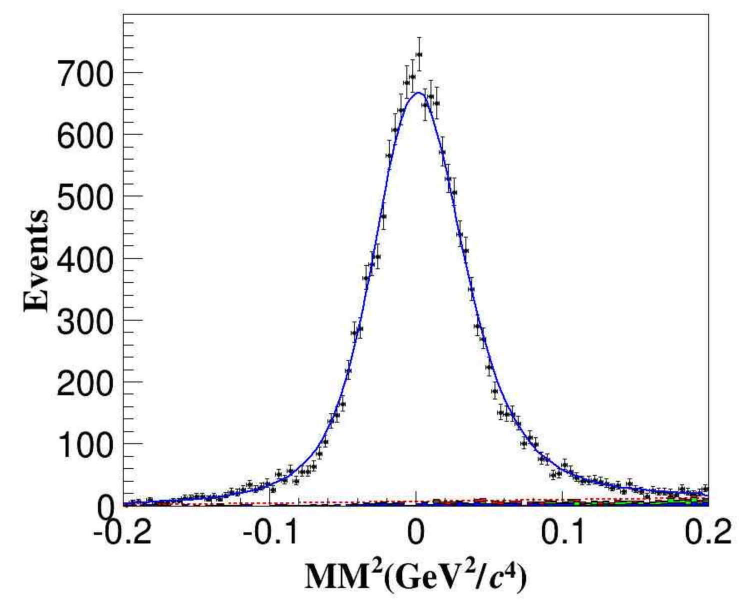


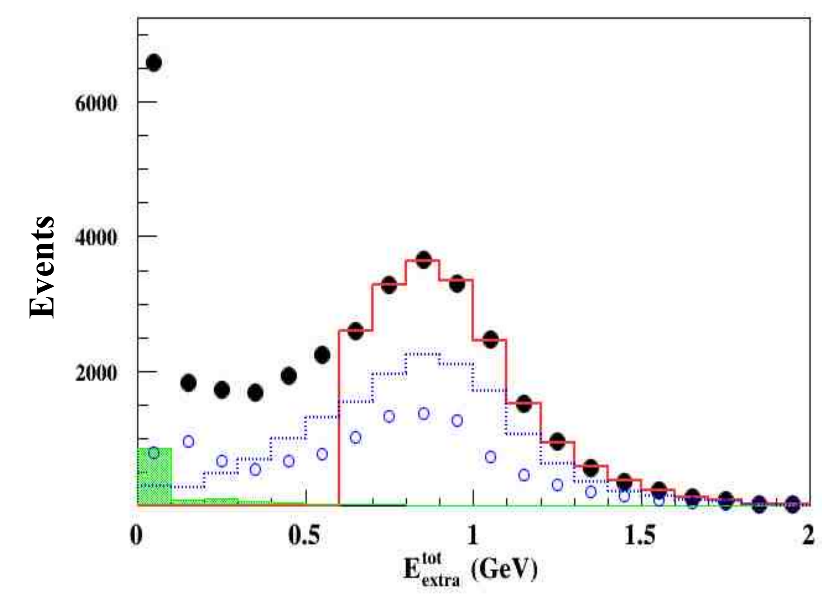

$$\Gamma(D_s^+ \to l^+\nu_l) \propto |f_{D_s^+}|^2 \cdot |V_{cs}|^2$$

- Precise measurements of $f_{D_s^+}$ and $|V_{cs}|$ are essential to probe new physics beyond the Standard Model (SM).
- Up-to-date results of $|V_{cs}|$ and $f_{D_s^+}$ are still limited by statistics uncertainty in the measurement of $D_s^+ \to l^+\nu_l$.
- Future precise measurement of $D_s^+ \to l^+\nu_l$ is critical to calibrate various theoretical calculations of $f_{D_s^+}$ and test the unitarity of the CKM matrix.

## Analysis of $D_s^+ \to l^+\nu_l$

$e^+e^- \to D_s^+D_s^-$ 0.1 ab$^{-1}$ @4.009GeV



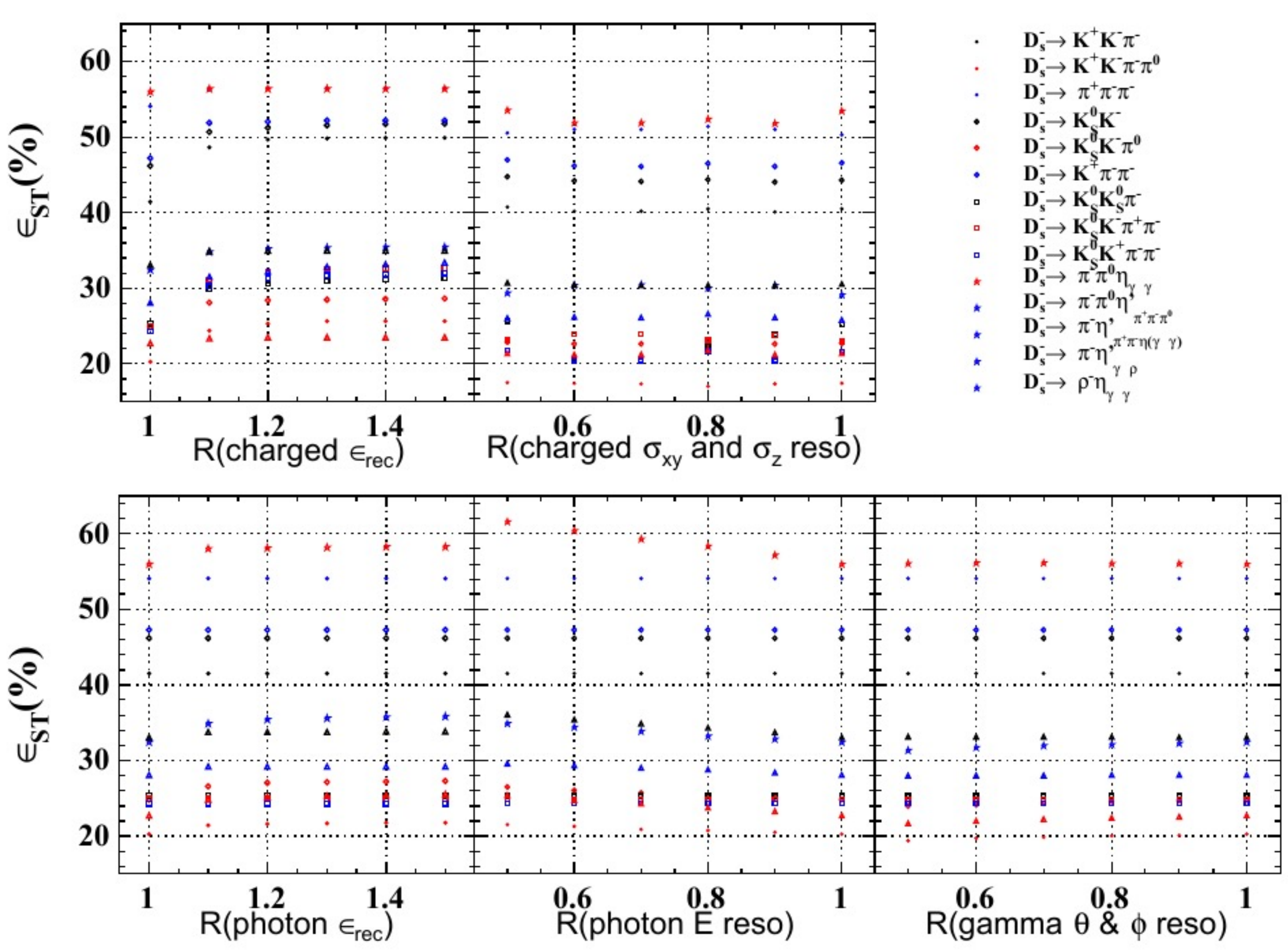




- Analysis method is double tag method.

  14 single tags are reconstructed, whose total Branch fraction is $(30.57\pm1.05)\times10^{-2}$ .
- The branch fraction is $(5.61\pm0.05)\times10^{-3}$ by $D_s^+ \to \mu^+\nu_\mu$.

  The branch fraction is $(5.49\pm0.06)\times10^{-2}$ by $D_s^+ \to \tau^+\nu_\tau$.
- Statistical sensitivity of BF is 2.7 times better than BESIII.

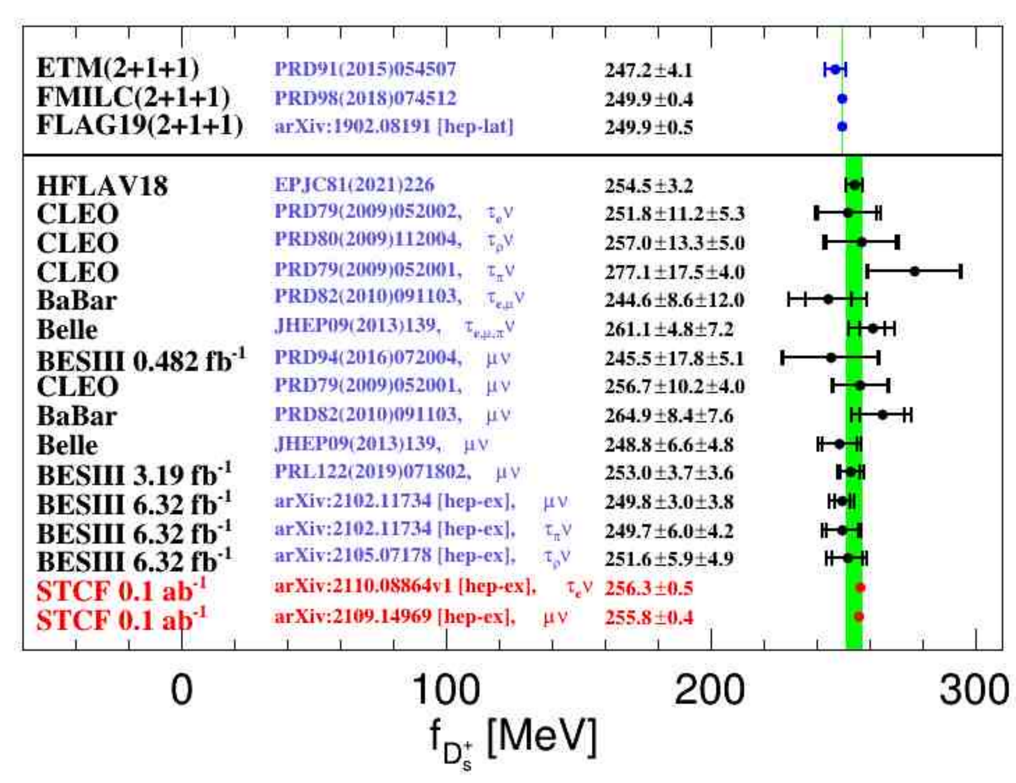
## Optimization of $D_s^+ \to \mu^+\nu_\mu$

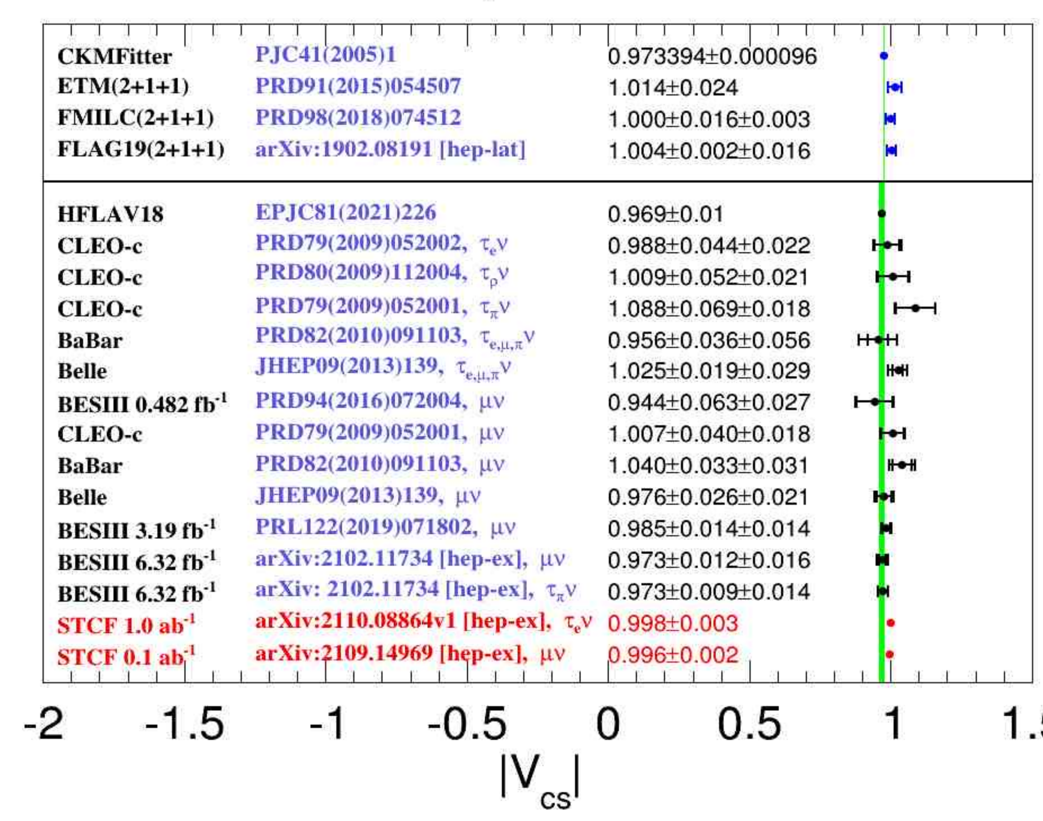



- Optimized response of tracking efficiency for low momentum charged pion is 72.19% at $p_T = 0.1\,\mathrm{GeV}/c$.
- Detection efficiency of photons is 97.32% at 0.2 GeV.
- $\pi/k$ mis-identification rate of 1% with the PID performance.
- $\pi/\mu$ mis-identification rate of 3% with the MUD performance.
- Detection efficiency for ST is increased by a factor of 1.1 to 1.2.
- Efficiency for selecting $D_s^+ \to \mu^+\nu_\mu$ is increased by a factor of 1.3.

## Results of $D_s^+ \to l^+\nu_l$

Combined results from these BESIII measurements and PDG values




$\mu^+\nu_\mu$: $f_{D_s^+} = 255.8 \pm 0.4$ MeV, $|V_{cs}| = 0.996 \pm 0.002$

$\tau^+\nu_\tau$: $f_{D_s^+} = 256.3 \pm 0.5$ MeV, $|V_{cs}| = 0.998 \pm 0.003$

$$R_{\tau/\mu} = \frac{\bar{\Gamma}(D_s^+ \to \tau^+\nu_\tau)}{\bar{\Gamma}(D_s^+ \to \mu^+\nu_\mu)} = 9.79 \pm 0.05$$

## Summary

- Unprecedented precision to be achieved at STCF will provide a precise calibration of QCD and a rigorous test of SM.
- Accuracy of LFU test can be improved obviously experimentally, which makes it promise to search for the new physics beyond SM.