Minutes for the first informal workshop on physics potential at STF

On December 30 2012, we have the first informal workshop on physics at Super-tau-charm factory (STF). Since it is informal one, we only invited a few people who are involving in the BESIII experiment, especially, key experts on the fast simulation framework for STF. They are Shuangshi Fang, Guangshun Huang, Gang LI, Hai-Bo Li, Beijiang Liu, Xiaohu Mo, Haiping Peng, Ronggang Ping, Qing Qin, Xiaoyan Shen, Changzheng Yuan, Ye Yuan, Yuan Zhang, Zhengguo Zhao,Yangheng Zheng and Kai Zhu. Prof. Z. X. Zhang was invited to join the workshop since he had good experience on the organization of Z factory, from which we learned a lot. Here is the minutes for this workshop:

1. Changzheng Yuan： XYZ at super-tau charm-factory
   This talk summarized the experimental status in the world on higher charmonium states. Both B factories were closed, and the proposed experiments, PANDA, super-B are still under R&D or constructions. Experiments at LHC can also study charmonium production and decays, however, high and complicated backgrounds are expected at LHC. From this point of view, the STF will be one of the best places to probe higher charmonium states near the production thresholds, and provides low level background. Changzheng addressed that the combined production cross-sections for many processes could be ranged from pb to a few nb, which are very small. We need a STF with luminosity at 10^{36} /cm^2/s, for example, the study of C=+ higher charmonium states in the radiative transitions of higher ψ states, and the study of charged charmonium candidates. He made rough estimations of the sensitivities at STF with one year's integrated luminosity. A few processes should be selected to perform fast MC simulations, so that we can learn the expected sensitivities, and tell people that we need a STF to identify the properties of these XYZ / higher charmonium states.
2. Shuangshi Fang, Light hadron physics
   This presentation is focused on the light hadron physics at STF. Shuangshi mentioned that it would be an idea place to search for exotic states with high statistics in charmonium decays to light hadrons. Especially, the production rates are low for exotic states, and a machine with higher luminosity is needed. For rare charmonium decays, such as weak decays, rare and forbidden decays (Lepton flavor violation processes), we really need a STF. He also mentioned the rare $\eta/\eta'/\omega/\phi$ meson decays which are important to test QCD and probe new physics at low energy. We suggested that Shuangshi should make a proposal to select a few key physics measurements which should be studied with fast MC simulations, and tell us the expected sensitivities at STF.
3. Kai Zhu and Xiaohu Mo: Tau physics at STF
   In this talk, Kai discussed searches of rare decays of tau lepton. According to his estimation, about 10^8 /year tau pairs will be produced just above the threshold, and about 3.5×10^9 tau pairs produced at 4.25 GeV, which is comparable to the super-B factory. The "smoking gun" decay modes for new physics searches are charged lepton-flavor-violation (cLFV) decays: $\tau\to\mu\gamma$, $\tau\to\mu\mu\mu$. Especially, for the $\tau\to\mu\gamma$, we expect relatively smaller background events from $e^+e^-\to\gamma\mu^+\mu^-$ process than that at B factory. He also talked about measurements of CP violations in tau decays with polarized electron beam. One can use the angular distribution to look for the CP asymmetry in tau decays. Tau physics will be one of the most important

topics at STF, especially, observations of neutrino oscillation indicate violation of lepton flavors, therefore, the charged lepton flavor may be also violated. However, in the Standard Model (SM), even considering the tiny neutrino mass and mixing parameters, the predicted rate for cLFV is still less than 10^{-54}. So any observable cLFV will be evidence of new physics beyond the SM. At STF, the expected reach for $\tau \to \mu\gamma$ will be 10^{-9}-10^{-10} which is two order of magnitude higher than the current limits. The most important topic in tau lepton is the CP violation in tau lepton decays, which must be signal beyond SM. We need a polarized beam to probe this kind of CP asymmetry. In the proposed STF in Russia, it seems that polarized beam can be realized in the future. Kai and our colleagues will perform a fast MC simulation to study the reaches of these observables.

4. Hai-Bo Li: Rare and forbidden decays of charm mesons

   Rare decays of charm include Flavor –changing-neutral current(FCNC), LFV, Lepton-number-violation processes. For the FCNC in charm sector, the rate is highly suppressed by GIM and low down type quark mass (b quark). For $c \to u$ transition, the predicted rate from SM short distance is lower than 10^{-8}. There is no any observation of the short distance (SD) effect in charm sector. The rate from long distance (LD) contributions could reach 10^{-6} due to the vector dominant processes in the SM. BESIII experiment is expected to reach the long-distance effect. It is crucial to separate SD from LD so that one can test possible new physics effect (since the new physics can only enter in the loop level and change the LD contributions). Possible observables are forward-backward asymmetry, CP-odd asymmetry, and lepton-pair-mass dependent distributions. For the LFV and LNV processes, any observation will indicate new physics beyond the SM.

   We are looking for sensitive observables, especially, the interference between SD and LD amplitudes, which may lead to lineshape distortion of vector mesons, and may produce observable CP or forward-backward asymmetry. We will do some fast MC simulation to see the reaches at STF. In fact, we are working on these rare/forbidden decays with BESIII dataset.

5. Yangheng Zheng: CPV in charm sector

   The SM prediction for the CP violation (CPV) in charm sector is less than 0.1%, any observation of CPV at percent level may indicate phase from new interaction. Recently, LHCb experiment reported a measurement of 0.82% for the asymmetry difference between A_cp(KK) and A_cp(pipi), and the significance on the asymmetry is more than 3.5 sigma. It is hot topic for charm physics. However, future improvement at LHCb will be hard since the measurements will be limited by the systematic error which is 0.11%. Experiments at e+e- machine will provide more measurements on the CPV in charm with under-control of systematic uncertainties. With a luminosity of 10^{36} /cm^2/s at STF, the reach of CPV in charm can reach <0.1% level, but we need perform MC simulations to understand this points, especially, for the singly Cabbibo suppressed modes with multi-pions in the final states, which cannot be studied at LHCb experiment. In charm sector, for CPV measurements, we have to measure the CP asymmetries in different modes as much as possible, so that we can clarify the source of phase.

6. Guangshun Huang: charmed baryon at STF

The lowest state of charmed baryon is Λc, and all of the decay rates of Λc is measured relative to Λc→pkpi decay mode, which itself is not a model-independent measurement. The decay rate of Λc→pkpi suffers from large uncertainty of about 20%. There is still no absolute measurement of this decay rate. At STF, the center-of-mass energy can reach 4.6-5.0 GeV with high luminosity. According to Belle's measurement suing ISR process, the production cross-section of Λc pair is about 0.5nb. A STF will provide unique opportunity for the study of charmed baryon decays. According to Guangshun's estimation, about 4 million Λc pairs will be produced per day with 10^{35} /cm^2/s luminosity at STF. It will be possible to study the rare charmed baryon decays, such as FCNC processes at STF. Possible CP violation in the charmed baryon decays can also probed at STF. It will be great to do MC simulations on a few rare decay modes of Λc. The double tag efficiency should be studies in order to make absolute measurements and measurements of semileptonic decays. Guanshun estimated that the single and double tag efficiencies could reach 50% and 25%, respectively, according to BESIII detector. The lineshape near the threshold of Λc pair can also be studied.

7. Ronggang Ping: Hyperon physics at a STF; Generators at STF

The decay rate of J/ψ and ψ(3686) into Λ, Σ, Ξ, and Ω pairs can reach $10^{-3} - 10^{-4}$. The STF will provide a great chance for us to study the rare decay of these hyperons. We can search for CPV in hyperon decays. The reaches for rare hyperon decays will be $10^{-7} - 10^{-8}$, which can be used to test HyperCP candidates for the FCNC decay. At the STF, the background is very clean since one can tag hyperon decays by fully reconstructing one of the hyperons so that decays with neutrinos in the final states can be well measured. It will be great if we can make some MC simulations to test the reaches of CPV measurements and rare decay searches.

For the generators, we urge to have the BESIII generators ready for STF, some of them, for example, study of CP in tau and Λc decays may need polarized beam, for this purpose, we need to tune these generators so that we can make some fast MC simulation. In the next meeting, we expect to see some tests.

8. Ye Yuan and Haiping Peng: Idea for fast simulation at STF:

The idea of the framework for fast simulation is presented based on BESIII analysis Framework. It is key step for us to move forward. With generators at BESIII, we expect to see the framework ready as soon as possible. We would like to get results before the next meeting.

9. Zhengguo Zhao: Concept design of detectors at STF:

In general, the current BESIII detector is able to run at a STF for most of charmonium physics. However, we need to improve ability of the detector for particle identification (PID), especially, for charm meson and charmed baryon decays, we need pi/k PID up to 1.2 GeV. We also need a new type of muon detectors, since many physics related to the decays involving muon lepton in the final states have to be considered in the STF. These are two key issues for the detector at STF. We expect to see a concept design of the detector soon.

10. Yuan Zhang and Qing Qin: Concept deign of accelerator for STF:

Thanks Yuan and Qing to give us a nice survey on the accelerators at STF. We may need a machine with luminosity of 10^{36} /cm^2/s, which may be very hard to reach. But according to the concept design from Russia, 10^{35} /cm^2/s machine could be available with the so called "crab-waist" technique. The Russia's concept design is reviewed and can be considered as the start point of Chinese machine. For a 10^{36} /cm^2/s machine, we may need more study, for example, to have a longer circumference, such as 1200 meter. Is it possible, we may need a simulation from accelerator experts.

This a short summary of the informal workshop, and we expect to have our next meeting in the end of Feb. 2013. Hopefully, you can make progress next time. We really urge Ye, Haiping and Ronggang to present us framework for both fast simulations and generators. Tests of the framework should be done before next meeting. Please send us e-mail if they are ready.

For the time being, we set up the next meeting after spring festival, please let us know if you have any idea.

By the way, we have set up a indico page for STF working group, in the future, all of these presentation will be put on the following page:
http://indico.ihep.ac.cn/categoryDisplay.py?categId=195
The password to access the above page is stf123

We may also set up a HyperNews forum for the working group, any progress and requirements can be documented in the forum when you exchange e-mails for discussions.

This is tentative minutes, which is very preliminary, please feel free to send me e-mail if I missed anything.

Hai-Bo Li for STF working group.