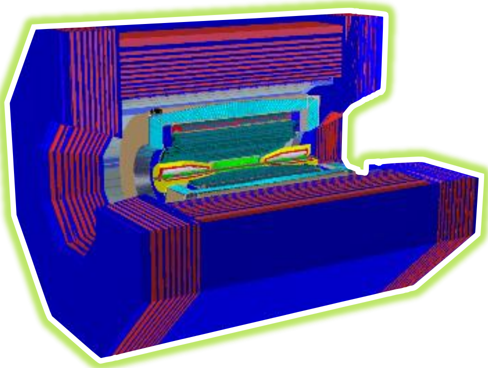
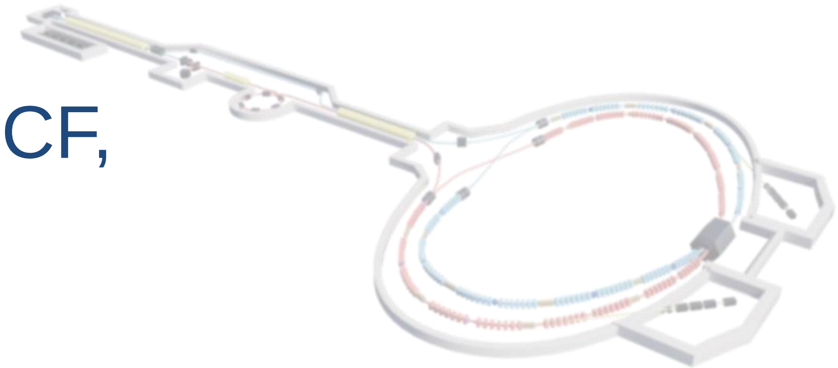
Overview of Super Tau-Charm Facility (STCF)

Yangheng Zheng
On behalf of the STCF working group
University of Chinese Academy of Sciences



6^{th} International Workshop on FTCF,
November 18, 2024

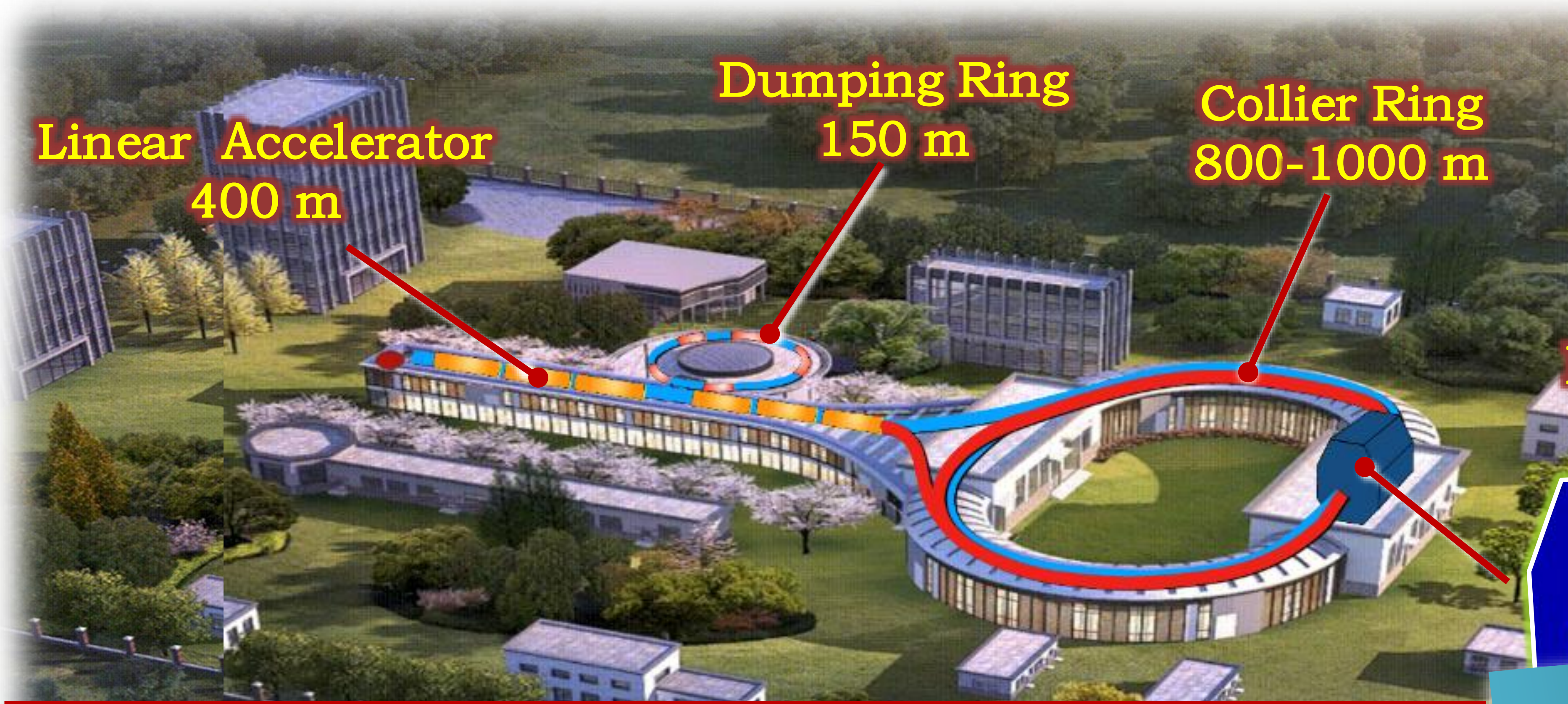


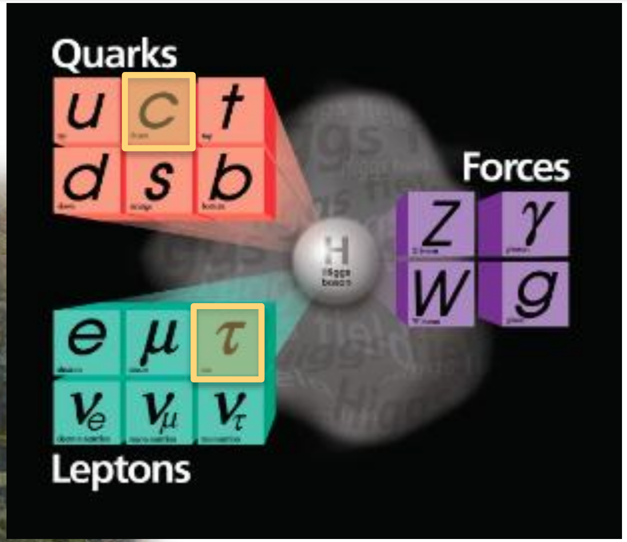
Outline

- Introduction
- Project Promotion and Progress
- Physics Potential (updated)
- Accelerator and Spectrometer (some highlights)
- Summary

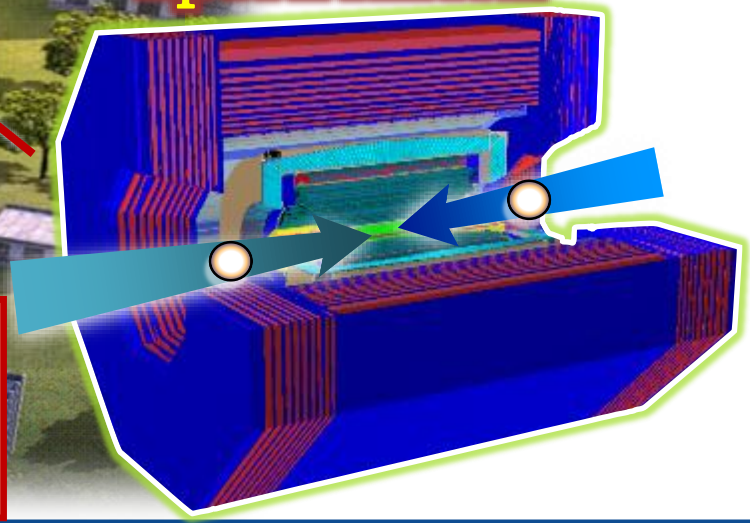
Super Tau Charm Facility (STCF)

A factory producing massive tau lepton and hadrons, to unravel the mystery of how quarks form matter and the symmetries of fundamental interactions



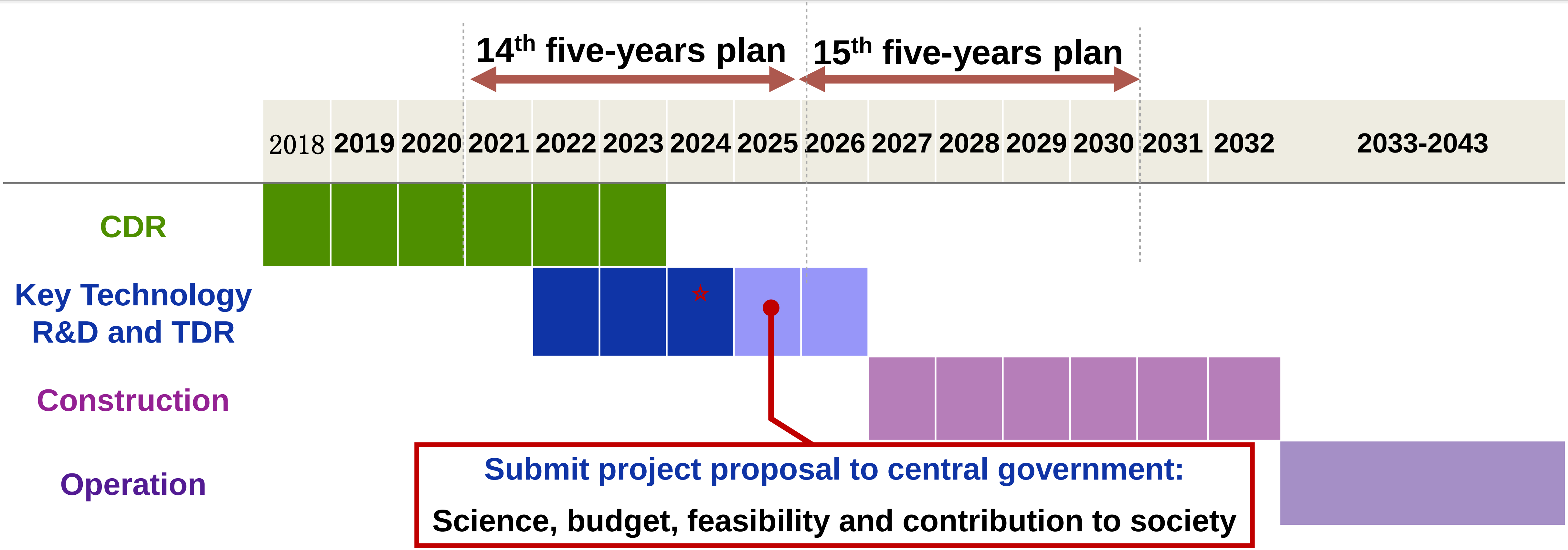


New generation Spectrometer



- E_{cm}= 2-7 GeV , $\mathcal{L} > 0.5\times10^{35}$ cm^{-2} s^{-1}
- Potential for upgrade to increase luminosity and realize polarized beam
- Site: 1 km^2 , Hefei's suburban "Future Big Science City"

Tentative Project Schedule



- 14th five-years plan : Conceptual design and R&D of Key technology, 364 M CNY
- 15th five-years plan : Construction 6 years, 4.98 B CNY
- Operating for 10-15 years, upgrade for 3 years, operating again for ~10 years

Project Development and Advancement

2011


Super Charm-tau Factory

Proposed at "Workshop for acc. based high energy physics development strategy"

2015


香山科学会议简报

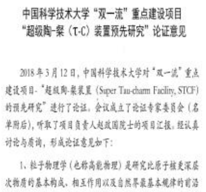
Fragrant Hills Science Forum
Demonstrated its importance and necessity,
Urging to lauch fesibility study and R&D

2017


中共安徽省委文件

Hefei Comprehensive National Science and Technology center,
STCF listed as large science facility to be promoted

2018



USTC "double first-class" key project
Launch the feasibility study and conceptual design

2021

Conceptual Design report
Publish the CDR for the physics and Detector, formulate the preliminary CDR for accelerator

2022.4

Government of Anhui Province and Hefei City
Launch the STCF Key Technology R&D

Project Development and Advancement

2023.08

Key technology R&D project kick-off and strategy development meeting

Over 170 attendees, including 30 academicians of CAS

2023.12

Budget Review for Key technology R&D project

Approval for 364 M RMB

2024.01

1st International Advisory Committee meeting (Offline)

A impressed report with valuable comments and recommendations

2024.05

1st National Consultative Committee meeting

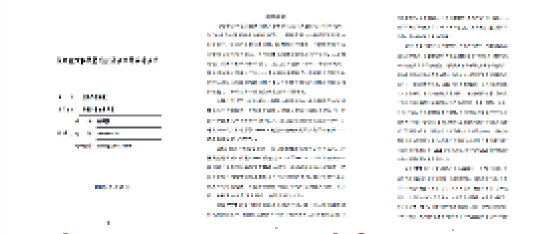
Valuable feedback and recommendations

2024.09

Project proposal editor broad kick-off meeting

A proposal includes Science, budget, feasibility and contribution to society

2024.09



The pre-proposal for Major National Science and Technology Infrastructure Projects under the 15th Five-Year Plan submitted to CAS

2024.10

2nd International Advisory Committee meeting (Online)

A impressed report with valuable comments and recommendations

Project Organization

USTC Leading Group
Coordinator : (USTC President)
Deputy-Coor: Y. Fu
Member : Y. Jiang, X.P. Wang, J.L. Yang, J.S. Deng, T. Xue

Project Overall Support Team
Coordinator : USTC president
Member : Leader of Collaborate institute / university, Chief Scientist

USTC Working Group
Coordinator : Y. Fu (USTC Vice President)
Deputy-Coor: F.W. Sun, Z.J. Za, G. Zhao, D.L. Feng, Y.A. Chen
Member : G.F. Zhao, Z.G. Zhao, Z.R. Yao, L.Z Gong, H.F. Liang, H.P. Peng, Y.Q. Xue, K. Qu

Academic Secretariat Team
Coordinator: Z.W. Yang
Member : X.L. Lyv, X.R. Zhou, W.B. Yan, J.B. He, F.K. He, A.L. Zhang, Z.H. Guo, Q.P. Hu

Project Management Office
Director: M. Shao
Member: J.D. Liu, D.D. Hu, Y.Y. Wang, L. Wang, W.B. Yan, A.L. Zhang, Q.P. Hu, X.R. Zhou, Y.Y. Li

International Advisory Committee

National Consultative Committee

Science and Technology Committee

Project Promotion Committee

Project Execute Team
Chief Scientist : Z.G. Zhao
Project Manager : Z.G. Zhao
Deputy Manager : H.P. Peng, Y.B Leng, Y.H. Zheng
Chief Engineer : J.Y. Tang
Deputy Engineer : L.X. Yin, S.B. Liu, J.B. Liu

Accelerator Team
(including 15 sub-system)
Coordinator: J.Y. Tang
Deputy-Coor: Q. Luo

Spectrometer Team
(Including 13 sub-system)
Coordinator: J.B. Liu
Deputy-Coor: Q. Liu, L. Zhao, Y. Qian

Technical Team
Civil Engineering, Infrastructure, Common Technology,

Physics and Software Team
Coordinator: X.T. Huang
Deputy-Coor: X.R. Zhou, X.C. Ai

International Advisory Committee (IAC) and National Consultative Committee (NCC)

(IAC，22 members)

Name	Institutions
Guy Wilkinson (Chair)	Oxford
Frank Zimmermann (Co-chair)	CERN
Mikihiko Nakao	KEK
Alexander E. Bondar	Novosibirsk, IYF
Makoto Tobiyama	KEK
David G. Hitlin	Caltech
Stephen Lars Olsen	Chung Ang University
Marica E. Biagini	Frascati
Tord Johansson	Uppsala U.
Marek Karliner	Tel Aviv U.
Eugeny Levichev	Novosibirsk, IYF
Alexey Petrov	University of South Carolina
Tom Browder	Hawaii
Wolfgang Gradl	Mainz
Ikaros Bigi	Notre Dame
Antonio Pich	Valencia U., IFIC
Hongwei Zhao	Institute of Modern Physics, CAS
Zhentang Zhao	Shanghai Advanced Research Institute, CAS
Kuang-Ta Chao	Peking University
Yuanning Gao	Peking University
Yugang Ma	Fudan University
Bingsong Zou	Institute of Theoretical Physics, CAS

(NCC, 24 members)

组长	赵光达	北京大学
副组长	赵红卫	中国科学院近物所
	赵振堂	中国科学院上海高研院
	高原宁	北京大学
成员	蔡荣根	中国科学院理论所
	邓建军	中国工程物理研究院
	封东来	中国科学技术大学
	何多慧	中国科学技术大学
	何小刚	上海交通大学
	李建刚	中国科学院等离子体所
	柳卫平	南方科技大学
	罗民兴	北京计算科学研究中心
	马余刚	复旦大学
	欧阳晓平	西北核技术研究所
	欧阳钟灿	中国科学院理论所
	沈肖雁	中国科学院高能所
	史生才	中国科学院紫金山天文台
	万宝年	中国科学院等离子体所
	吴岳良	中国科学院大学
	夏佳文	中国科学院近物所
	向涛	中国科学院理论所
	许怒	中国科学院近物所
	詹文龙	中国科学院
	张肇西	中国科学院理论所

1st International Advisory Committee meeting (face to face meeting for 2 days: Jan, 2024)


Report of first meeting of International Advisory Committee for the Super Tau Charm Facility

Maria Enrica Biagini, Ikaros Bigi, Alex Bondar, Tom Browder, Kuang-Ta Chao, Yuanning Gao, Wolfgang Gradl, David Hitlin, Tord Johansson, Marek Karliner, Eugeny Levichev, Yugang Ma, Mikihiko Nakao, Stephen Olsen, Alexey Petrov, Antonio Pich, Makoto Tobiyama, Guy Wilkinson, Hongwei Zhao, Zhentang Zhao, Frank Zimmermann, Bingsong Zou

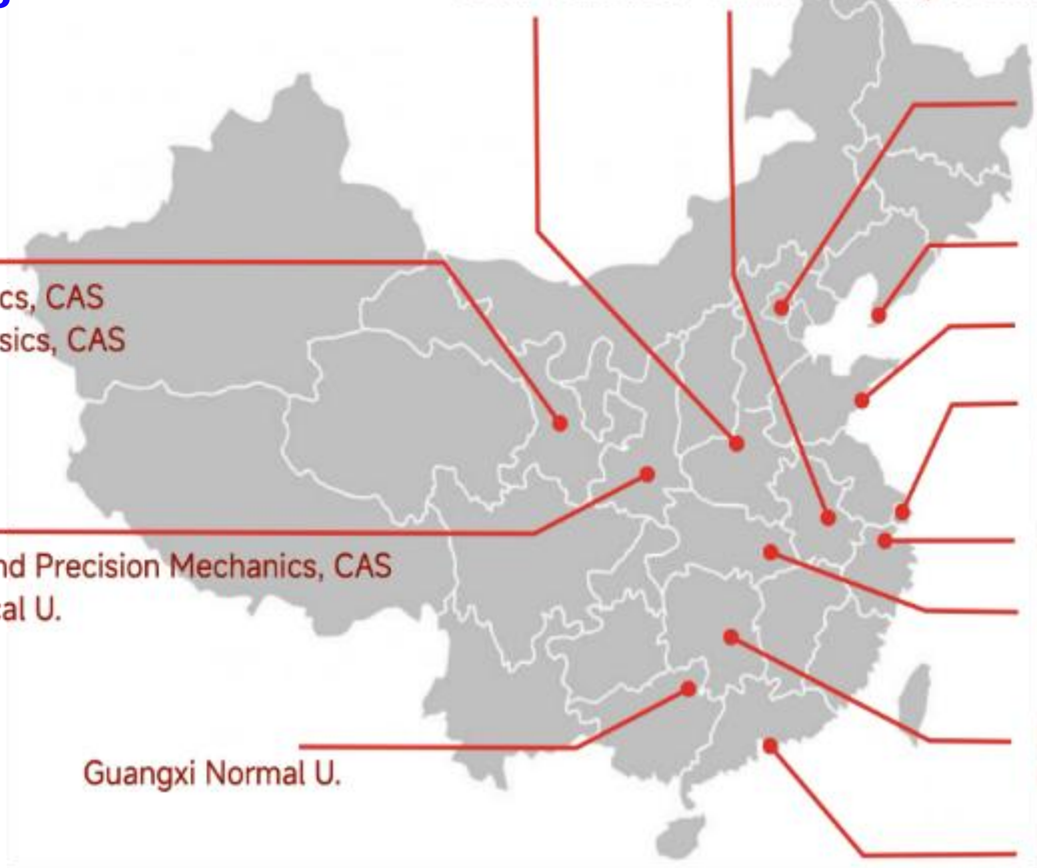
2 Executive summary

STCF will be unique facility with a broad and impressive physics reach. It will allow for results of world-leading precision in many important topics, and has significant discovery potential. It will ideally complement the other facilities that are currently operational or are foreseen for the 2030s and 2040s, and will be of great interest to the international particle physics community. The principal challenge of the project lies in the accelerator. Here the intended luminosity will exceed by two orders of magnitude that previously achieved in the same energy regime. The IAC is pleased to recognise the significant progress on the STCF accelerator design that has occurred since the establishment of a dedicated Accelerator Division led by Prof. J.Y. Tang. The demands on the detector are less formidable, but should not be underestimated given the extreme event rate and size of data samples foreseen.

Team & International Collaboration

25 universities/Institutes:

170 faculties and 140 graduate students



Ongoing efforts to strengthen collaboration with BINP, KEK, DRD and others, especially on accelerator development

Regular Meeting

Weekly or biweekly meeting

	周一	周二	周三	周四	周五
上午		[illegible]	[illegible]	[illegible]	[illegible]
下午	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
晚上	[illegible]				

Monthly or quarterly meeting

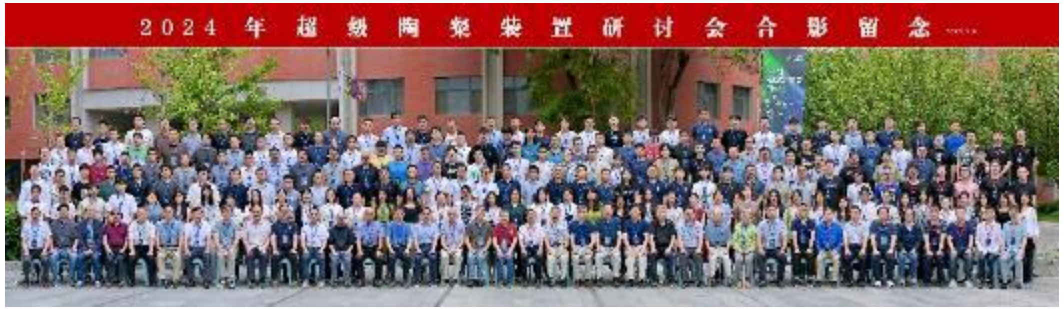
	三月	四月	五月	六月	七月	八月	九月	十月	十一月	十二月
上午	[illegible]			[illegible]			[illegible]			
下午	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

indico

STCF文档		4 events
Accelerator	123	123 events
Detector	217	217 events
Physics & Software	362	362 events
Accelerator-Detector Joint meetings		empty
Conference Talk Review & Rehearsal		5 events
项目办公室	110	110 events
STCF项目总体例会	68	68 events
Management Meetings		29 events
建议书起草小组		1 event
学术秘书组会议		4 events
园区规划和设计		2 events
International Advisory Committee		2 events
咨询委员会（National Consultative Committee ）		1 event
Steering Committee		1 event
Domestic Meeting		2 events

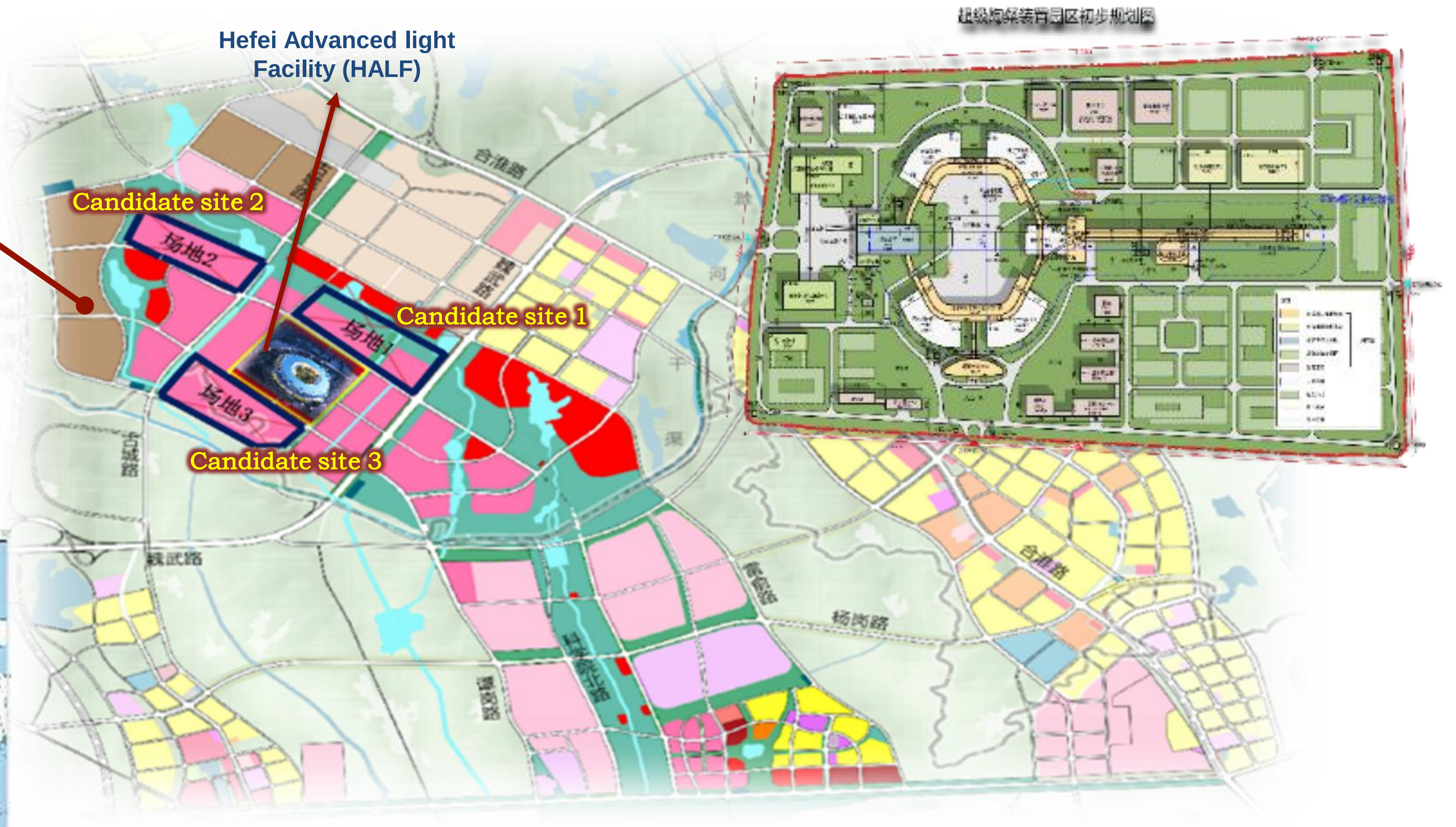
International and Domestic Workshop

Time	Place	Content
2018.10	Hengyang (USC)	STCF
2019.03	Beijing (UCAS)	STCF: Physics
2019.07	Hefei (USTC)	STCF: Accelerator
2019.08	Hefei (USTC)	STCF: Phys. & simulations
2019.11	Beijing (UCAS)	STCF: CDR
2020.08	Hefei (USTC)	STCF: From CDR to TDR
2022.12	Guangzhou (SYSU)	STCF: R&D kick-off
2023.07	Zhengzhou (ZZU)	STCF: Collaboration
2024.07	Lanzhou (LZU)	STCF: 15^{th}-five-year plan



Time	Place	Content
2015.01	Hefei, China	Workshop on Super tau-Charm Facility in China
2018.03	Beijing, China	Workshop on Super tau-Charm Facility in China
2018.05	Novosibirsk, Russia	Workshop on Super tau-Charm Facility in Russia
2018.12	Paris, France	1^{st} FTCF (Joint International Workshop)
2019.08	Moscow, Russia	2^{nd} FTCF
2020.11	Online, China	3^{rd} FTCF
2021.11	Online, Russia	4^{th} FTCF
2024.01	Hefei, China	5^{th} FTCF
2024.11	Guangzhou, China	6^{th} FTCF

Site : Hefei Future Big Science City

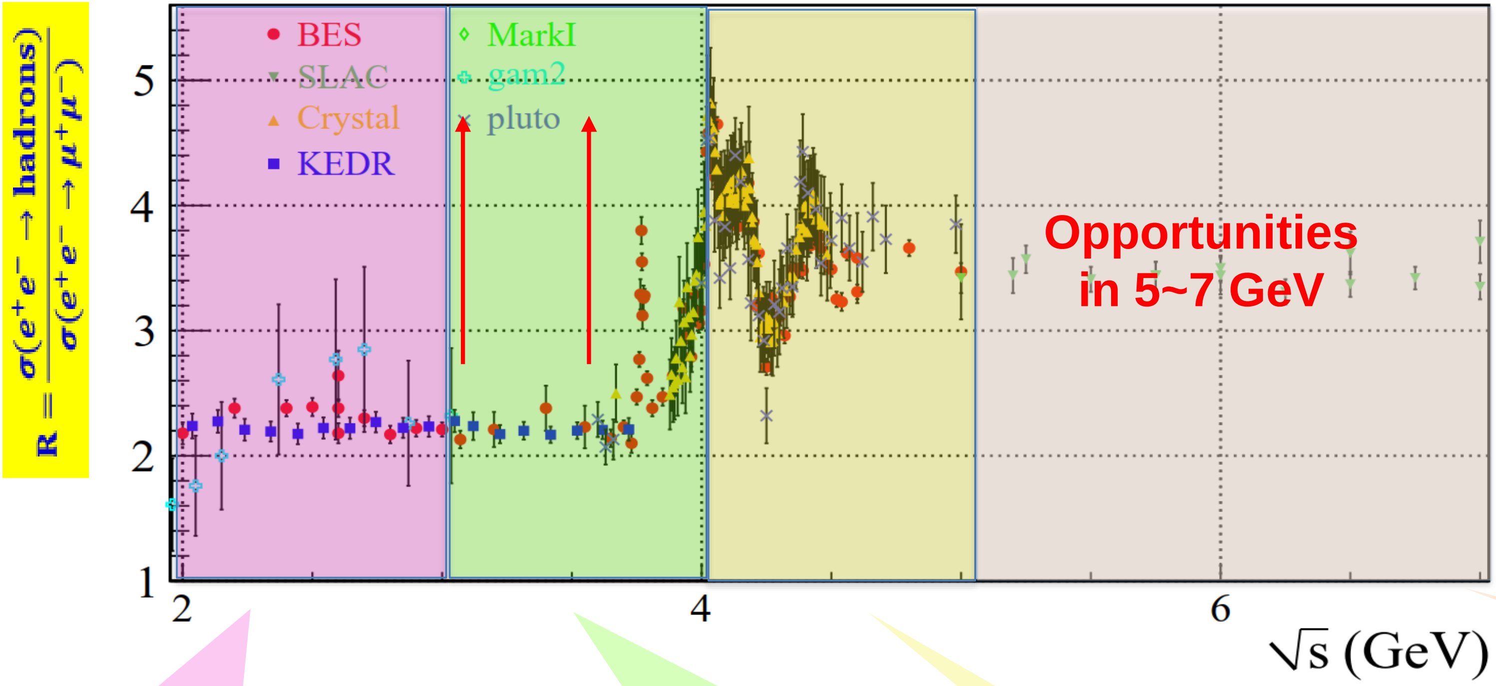


- Ongoing geological exploration and microseismic testing at **three candidate sites** to support the final site selection
- **Civil engineering design** work is in progress

Financial Support

Year	Funding Agency (Institution)	Project Type	RMB
2018-2021	USTC	Double First-Class key project	20.0 M
2021-2026	CAS	International Partnership program	5.0 M
2022-2027	MOST	National Key R&D Program of China	17.5 M
2023-2025	Anhui/Hefei/USTC	Key Technology R&D Project	364.0 M
2023-2027	NSFC	Key Group Project	14.0 M
Total			420.5 M

Physics at the Tau-Charm Energy Region



Unique Features τ-c facilities:

- Transition region between perturbative and non-perturbative QCD
- Threshold effects and quantum correlation of pair production of hadrons and τ leptons
- Rich resonance structures, large production X-sec for charmonium(-like) states and exotics

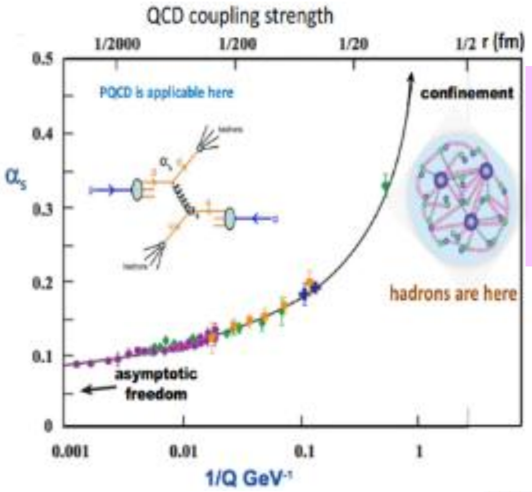
- Hadron form factors
- $Y(2170)$ resonance
- Mutltiquark states with s quark
- R value / g-2 related

- Light hadron spectroscopy
- Gluonic and exotic states
- Processes of LFV and CPV
- Rare and forbidden decays
- Physics with τ lepton

- XYZ particles
- Physics with D mesons
- f_D and f_{D_s}
- $D^0 - \bar{D}^0$ mixing
- Charm baryons

- Complete XYZ family
- Hidden-charm pentaquarks
- Search for di-charmonium states
- More charmed baryons
- Hadron fragmentation

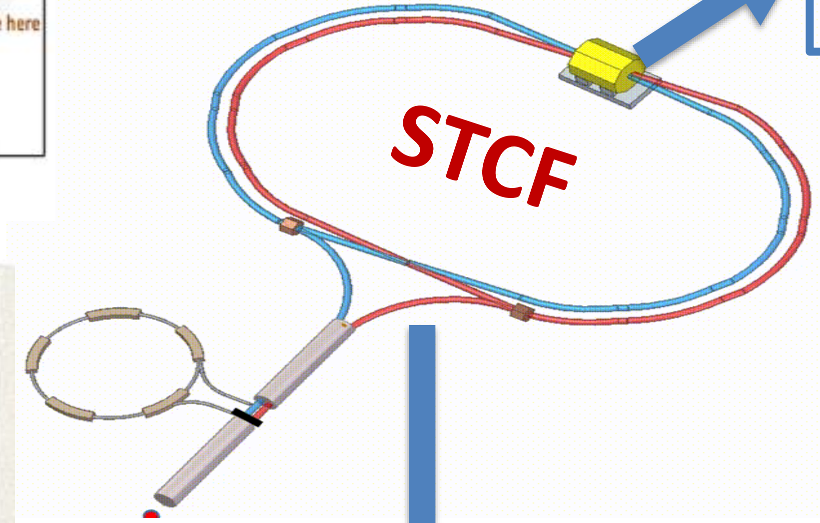
Key Science Questions

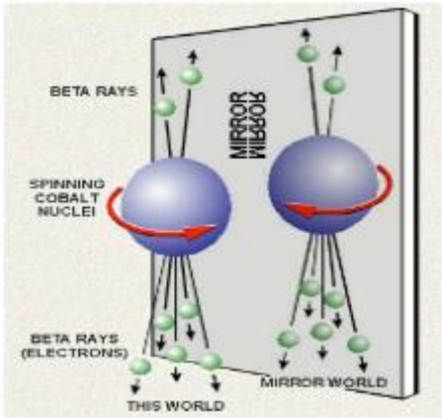


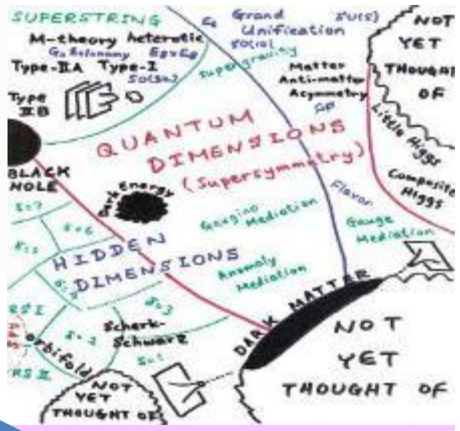
Key question 1:
What is the nature of color confinement?

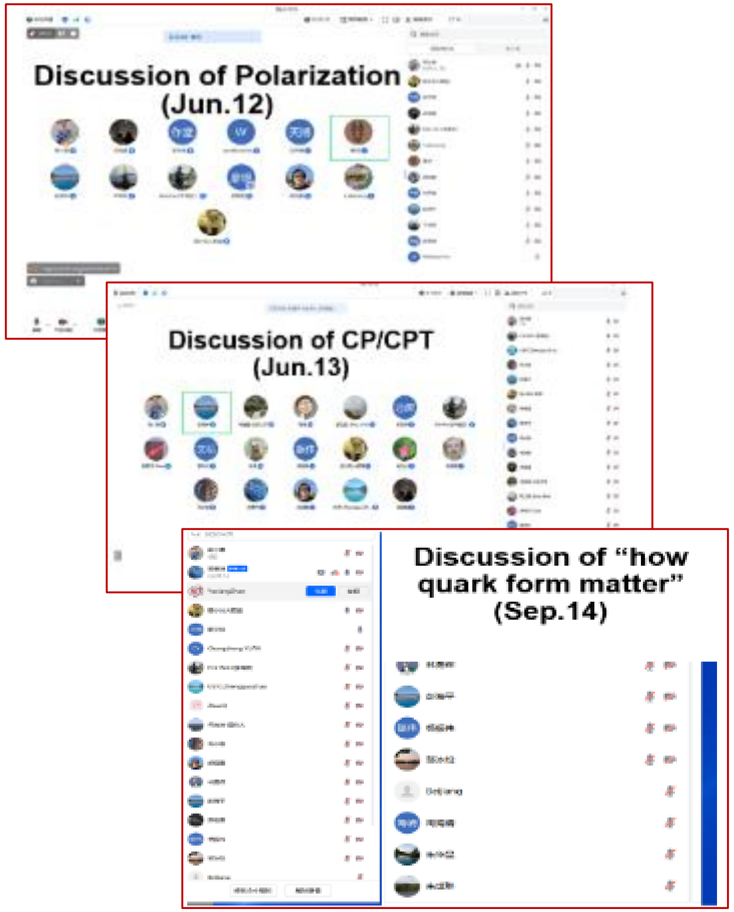
Transition region between perturbative and non-perturbative QCD

Broad physics are anticipated, several mini-workshops were organized to refine the core scientific goals









Key question 2:
New CPV source beyond SM?

Unprecedented large data samples and high-precision measurements

Key question 3:
Any new physics? If so, where?

Flagship Measurements at STCF

STCF aims to reveal the mystery of how quarks form matter and the symmetry of fundamental interactions

Scientific question: how quarks form matter

- **Hadron generation: fragmentation and energy correlator**
- **Exotic hadronic states and more**

Scientific question: symmetry of fundamental interactions

- **CP violation in the hyperon decay**
- **Precise measurements of Strong phases in D decays**
- **New physics search：Ds -> mu nu**

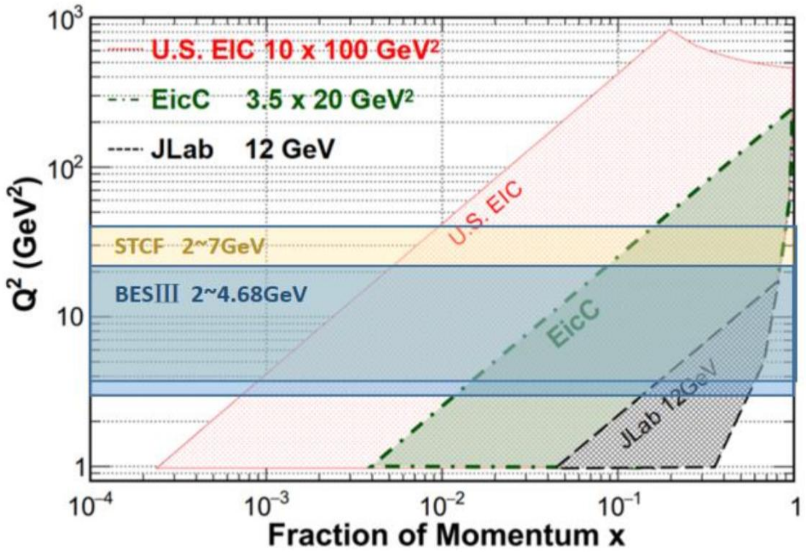
The main considerations：

1. **The uniqueness of the topics, aiming to avoid direct competition with Belle II and LHCb;**
2. **The ease of understanding by the general public, which is beneficial for gaining project approval in China;**
3. **Potential synergies with other experiments such as EIC/EicC, creating a win-win situation. For these reasons, these topics are ranked at the top.**

Hadron Generation

STCF energy region offers a unique opportunity to probe the fundamental mysteries in particle physics: the confinement transition from quarks to hadrons

- **STCF energy range will provide a multi-dimensional accurate measurement of the process of quark smashing into hadrons generated by electron-positron collisions**

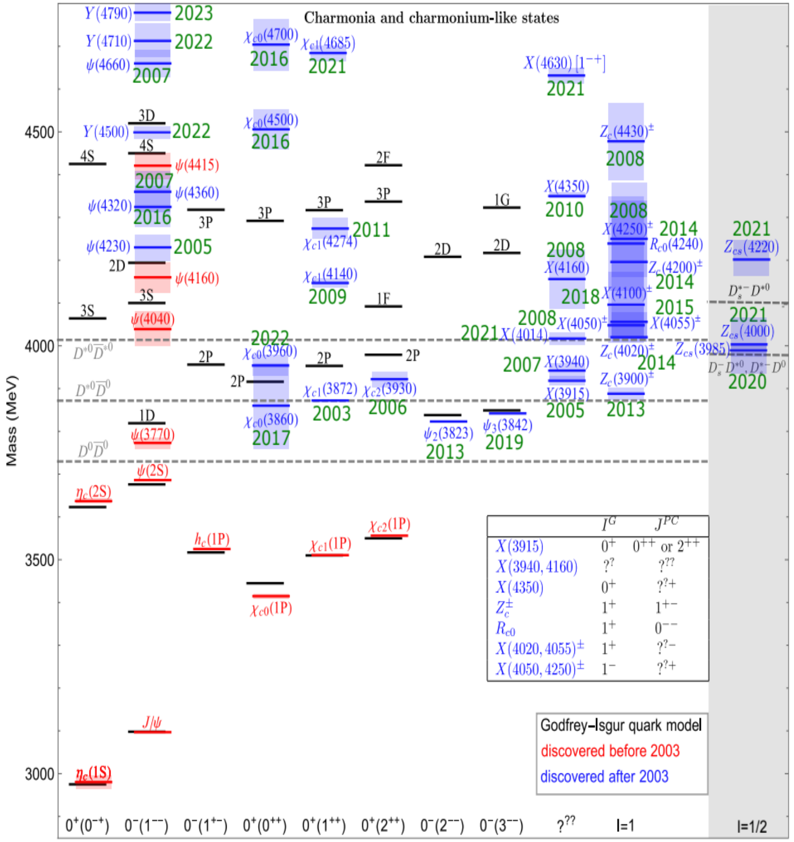


- **Recent breakthroughs in energy correlator studies have revealed that the time evolution of quark hadronization leaves a distinct signature in the angular separation of correlated hadron pairs. The energy region of STCF provides an unprecedented window into the phase space where this transition unfolds, enabling precision measurements of fundamental QCD quantities such as the strong coupling constant and hadron formation time**

Exotic Hadronic States and More

STCF will provide a unique platform for clarifying the mass spectrum of charmed hadrons, and further exploring the physical mechanism of quark confinement and the realization of chiral symmetry breaking in heavy hadrons

- **A large number of hadrons will be produced near or far from the threshold region, characterized by rich structure and strong quantum correlation**
- **STCF will establish a complete XYZ lineage, and searching for strange hadronic states such as charmonium and pentaquark states**
- **Above 5 GeV, a large number of charmonium-like excited states, along with a large number of excited states of charm hadrons, will be generated, providing an experimental basis for establishing reliable and accurate mass spectra of charmed hadron spectroscopy**

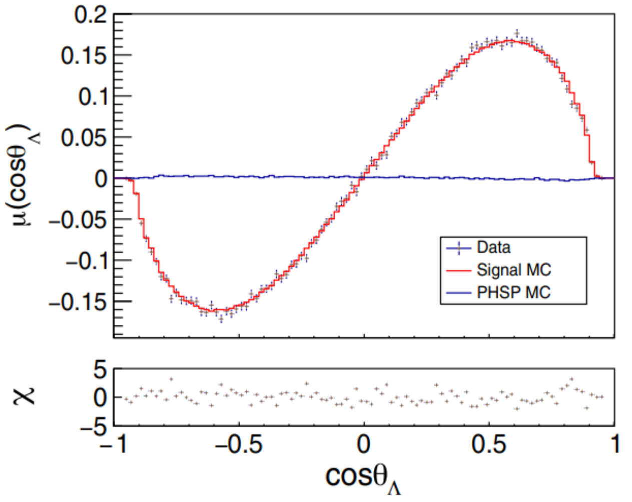


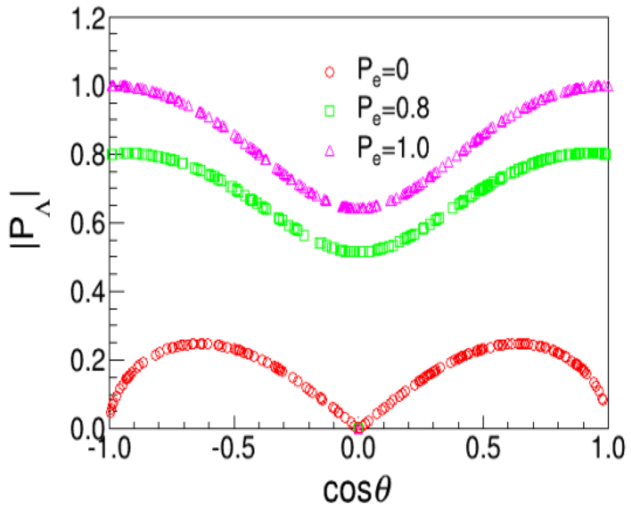
CP Violation in the Hyperons

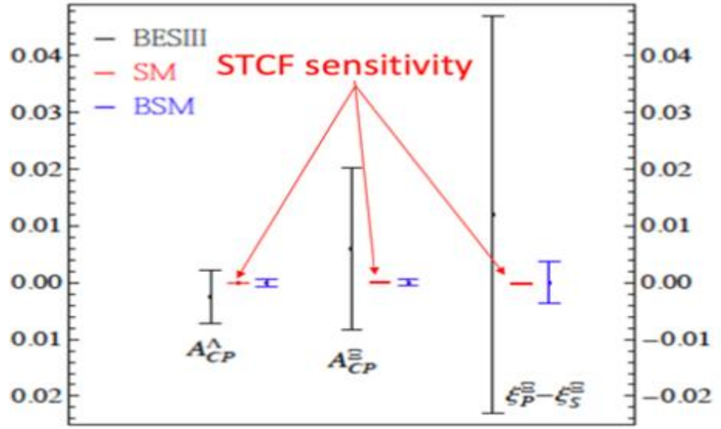
The CPV studies at STCF will greatly help to understand the mechanism of CP symmetry, discover new sources of CP violation and new physical laws

- **Billions** of quantum-entangled hyperon-antihyperon pairs produced by J/ψ decay at STCF, with **clean topology** and **clear initial polarization**, providing a **unique opportunity** for the test of CP symmetry in hyperons

- **The statistical sensitivity of the CP symmetry in hyperon decay will be examined with a precision of 10^{-4}, while 10^{-5} if electron polarization 80%. SM prediction 10^{-4}~10^{-5}. The world best sensitivity**







CP Violation in the Hyperons

The systematic uncertainties are challenging, three different categories :

Those can be studied with the control samples

- **Data/MC difference in tracking, PID etc →Two orders in magnitude improve of control sample → 10^{-4} or better**
- **Input-output check → Larger MC statistics → negligible**

Those can be improved by optimizing the detector design, MC tool and reconstr

Challenging

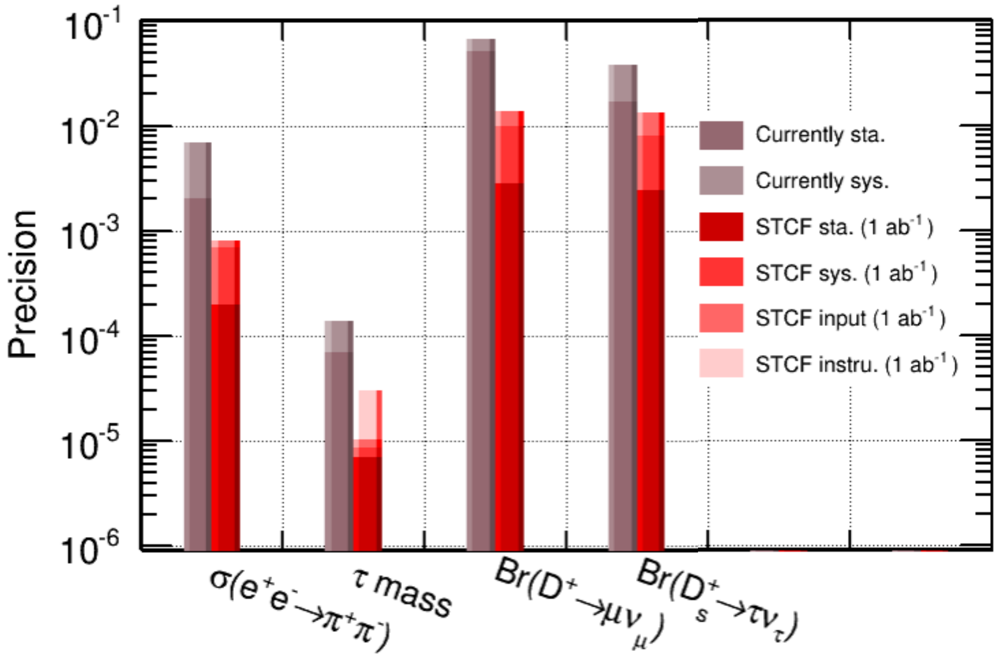
- **Nonuniformity of detection efficiency → examine the decay parameter bin-b... or better**
- **Kinematic fits, photon noise, background etc→ Novel MC tool and reco...ion→ 10^{-4} ?**

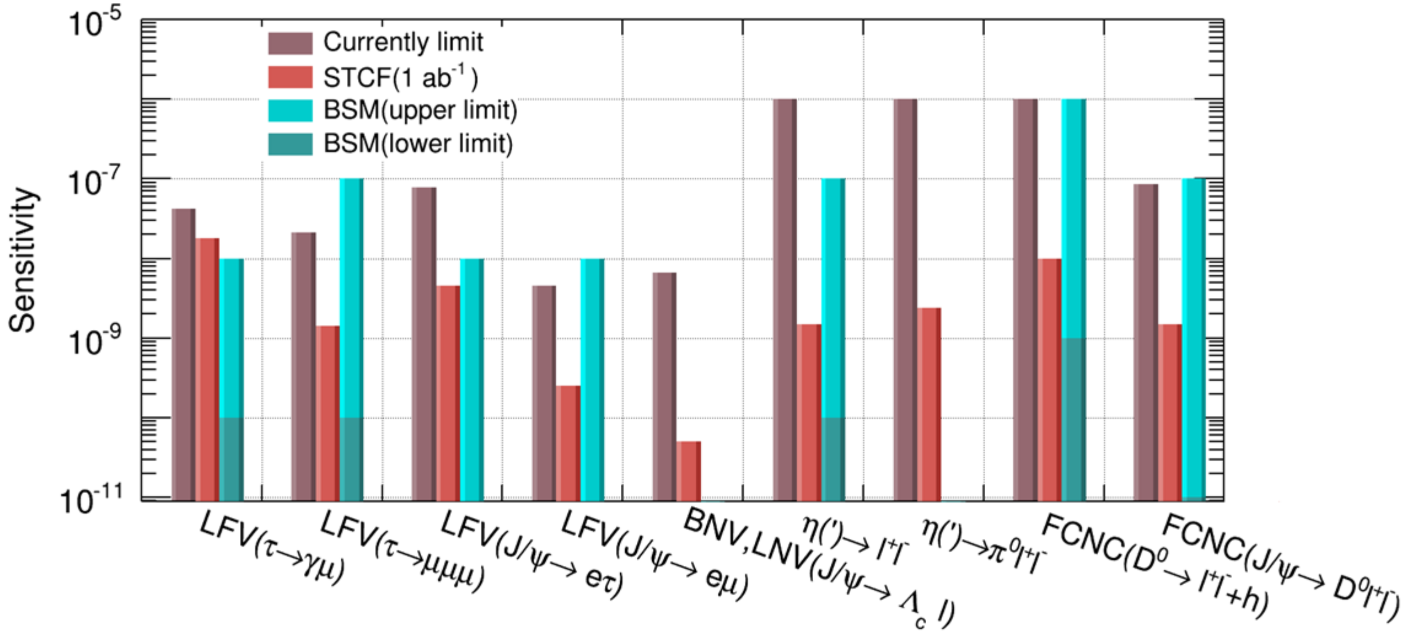
Those associated with the theoretical calculation (next-to-leading order effects)

- **NLO of production → using complete form factor description → negligible**
- **Procession of magnetic moment/de-coherence → including the effects in MC → negligible**

The systematical uncertainty for hyperon CPV at STCF is expected at the order 10^{-4} or better, innovative measurements to minimize systematic are also desired

Precision Measurements and Rare Decays





STCF physics opportunities :

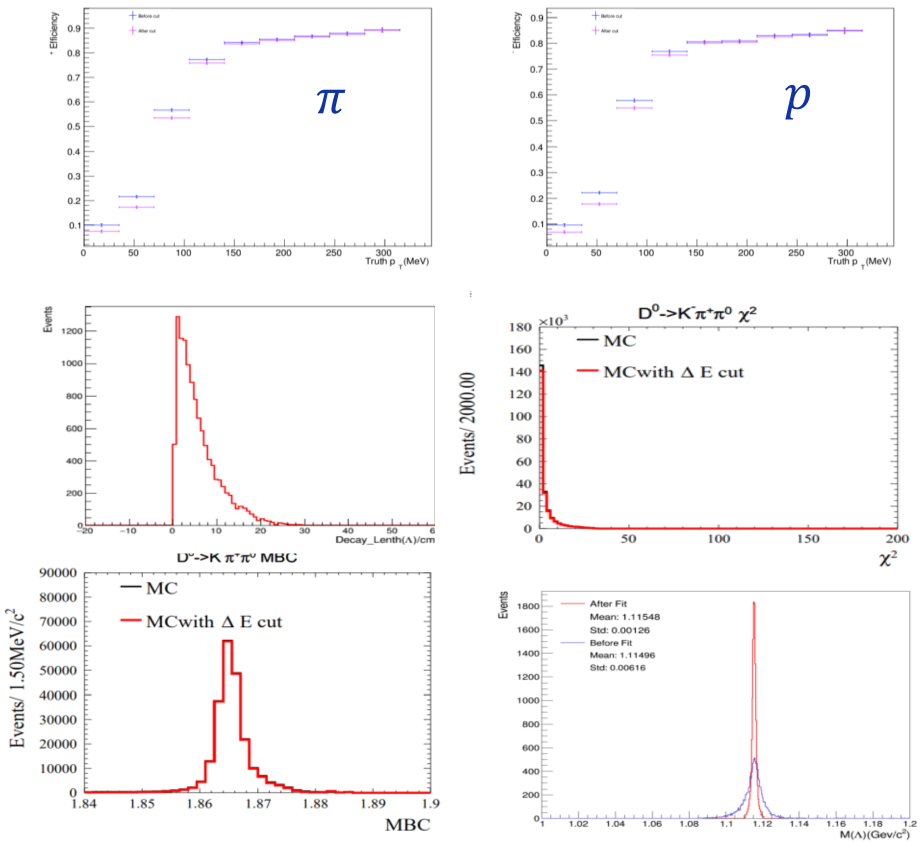
- improve the current precisions of many important measurements by ~1 order of magnitude
- enhance sensitivities to various rare or forbidden decays by ~2 orders of magnitude

Full Simulation Studies

The offline software OSCAR is ready to perform the fully simulation for the studies of physics sensitivity and detector performance as well as the detection design optimization

- **Benchmark process for XYZ particles: $e^+e^- \to \pi^+\pi^- J/\psi$, as well as checking the tracking efficiency, vertex resolution and kinematic fit.**
- **Benchmark process for hyperon CP symmetry test: $J/\psi \to \Lambda\bar{\Lambda}$, as well as checking the tracking efficiency and resolution of particles away from interaction point, and the secondary vertex fit.**
- **Benchmark process for Collins effect: $e^+e^- \to \pi^+\pi^-/KK$+ X, as well as checking the MC generator, PID efficiency and mis-ID of charged particles.**
- **Process that including a neutral π^0: $D^0 \to K^-\pi^-\pi^0$, as well as checking the efficiency and resolution of neutral particles.**
- **Process that used to study π/μ separation: $D^0 \to \pi\mu\nu$**
- **Process that used to study the $K^0 - \bar{K}^0$ system: $J/\psi \to K_s K\pi$**

Tracking efficiency



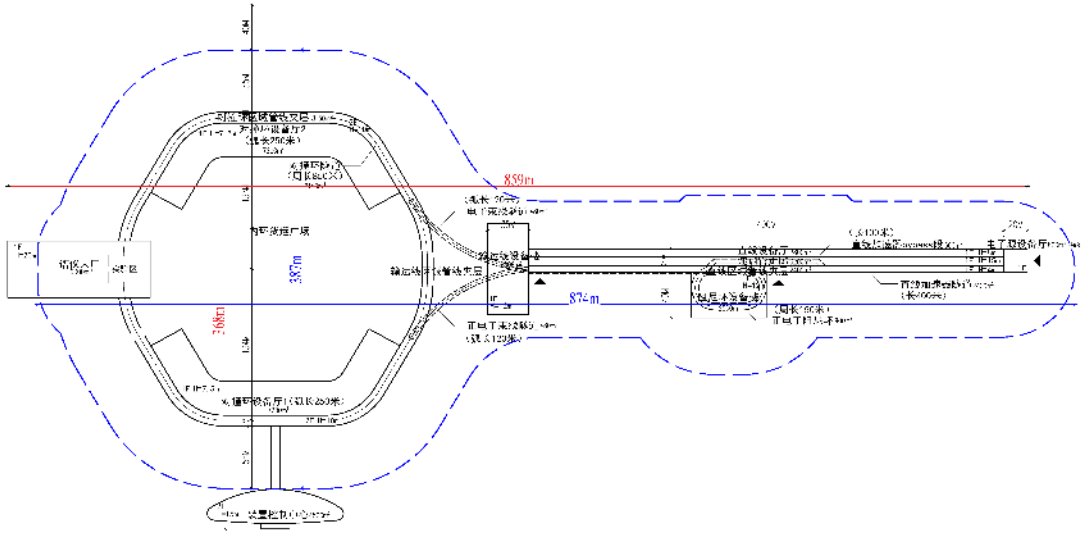
Shortage of Computing resource

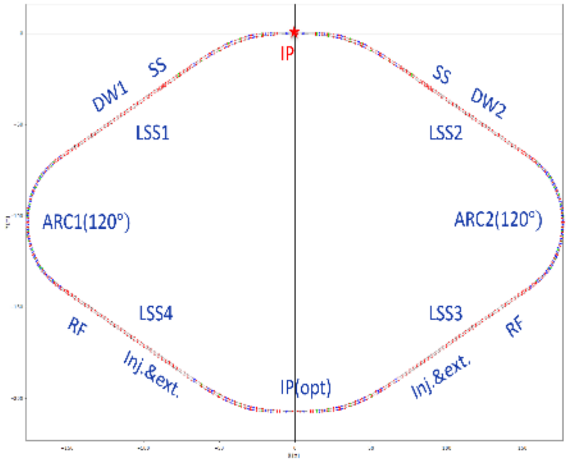
Accelerator

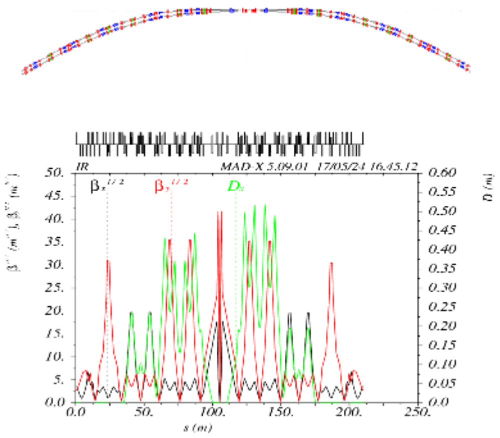
Please see Prof. Jingyu Tang's talk for details

Challenges :

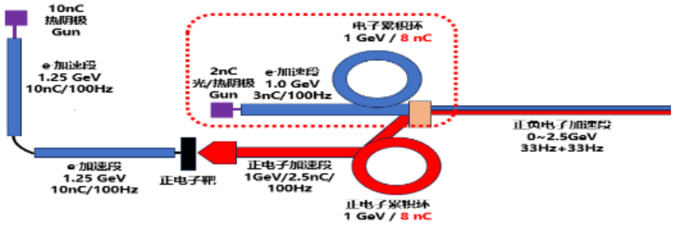
Super-high luminosity, high-quality (high-current, low emittance) e+/e- beams collision (extremely low β*), IR strong nonlinearity and collective effects; stable operation…



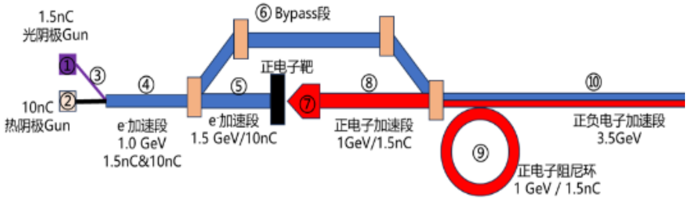




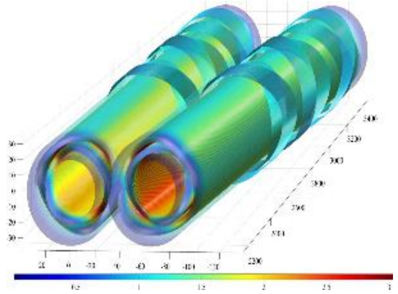
Swap-out injection



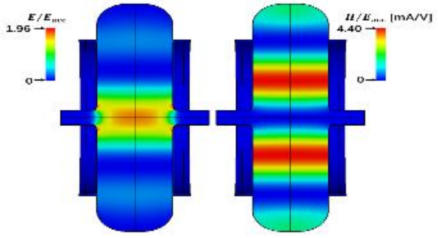
Off-axis injection



Dual aperture superconduct



RF Cavity (TM020)



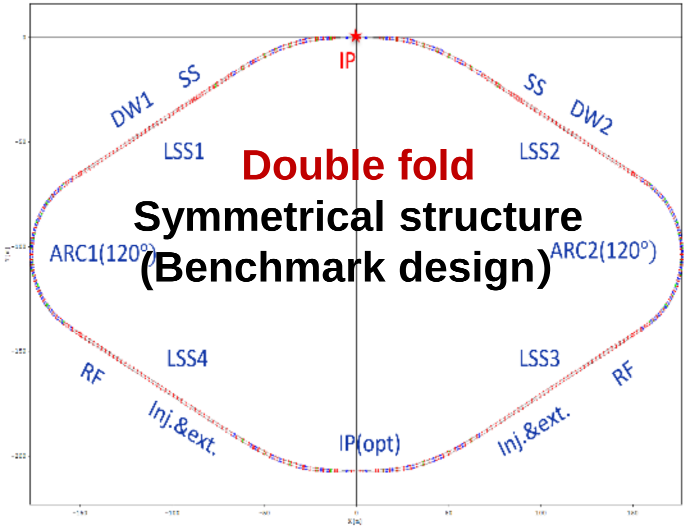
Progress on Accelerator Physics Design

IR physics design

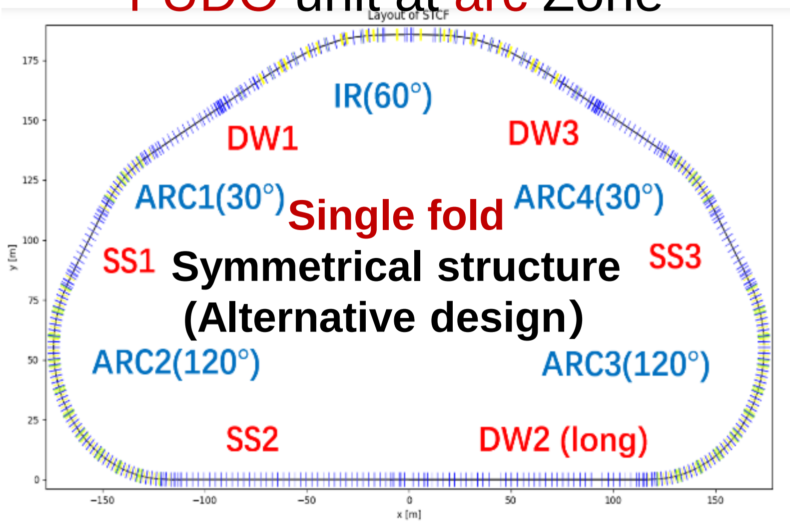
- The key and challenge for STCF accelerator
- New collision scheme: beam param (I_b, ε_x ; nm spot at IP), crossing angle, correlation with the B-B effect [Luminosity need]
- Special optics: Final Focus + Crab Waist (Telescope-Mini β, dispersion, phase advance) [Complexity]
- Strong nonlinearity: Local CC for extreme-low β, fringe-field, crab sextupoles ➔ very small DA and MA [very short beam lifetime]
- Complex MDI: SC magnets, vacuum, cryostat, beam monitors, interface with detector [Iterations]

Parameters	Units	STCF
Optimal beam energy, E	GeV	2
Circumference, C	m	871.76
Crossing angle, 2θ	mrad	60
Revolution period, T	μs	2.908
Horizontal emittance, $\varepsilon_x/\varepsilon_y$	nm	6.857/0.034
Coupling, k		0.50%
Beta functions at IP, β_x/β_y	mm	40/0.6
Beam size at IP,σ_x/σ_y	μm	16.56/0.143
Betatron tune, ν_x /ν_y		32.55/29.57
Momentum compaction factor, α_p	10^{-4}	12.322
Energy spread, σ_e	10^{-4}	8.986
Beam current, I	A	2
Number of bunches, n_b		726
Particles per bunch, N_b	10^{10}	5.00
Single-bunch charge	nC	8.01
Energy loss per turn, U_0	keV	406.8
Damping time, τ_x/ τ_y/ τ_z	ms	28.4/28.6/14.4
RF frequency, f_{RF}	MHz	499.333
Harmonic number, h		1452
RF voltage, V_{RF}	MV	1.8
Synchrotron tune, ν_z		0.0158
Bunch length, σ_z	mm	9.72
RF bucket height, δ_{RF}	%	1.47
Piwinski angle, ϕ_{pwi}	rad	17.61
Beam-beam parameter, ξ_x/ξ_y		0.0027/0.082
Hour-glass factor, F_h		0.87
Luminosity, L	$cm^{-2}s^{-1}$	1.0×10^{35}

Two Lattice Scheme



Modular design at Collision Zone, FUDO unit at arc Zone



➔Take advantage of a new machine, experiences and lessons from SuperKEKB ➔ better design

From preliminary study phase to R&D phase

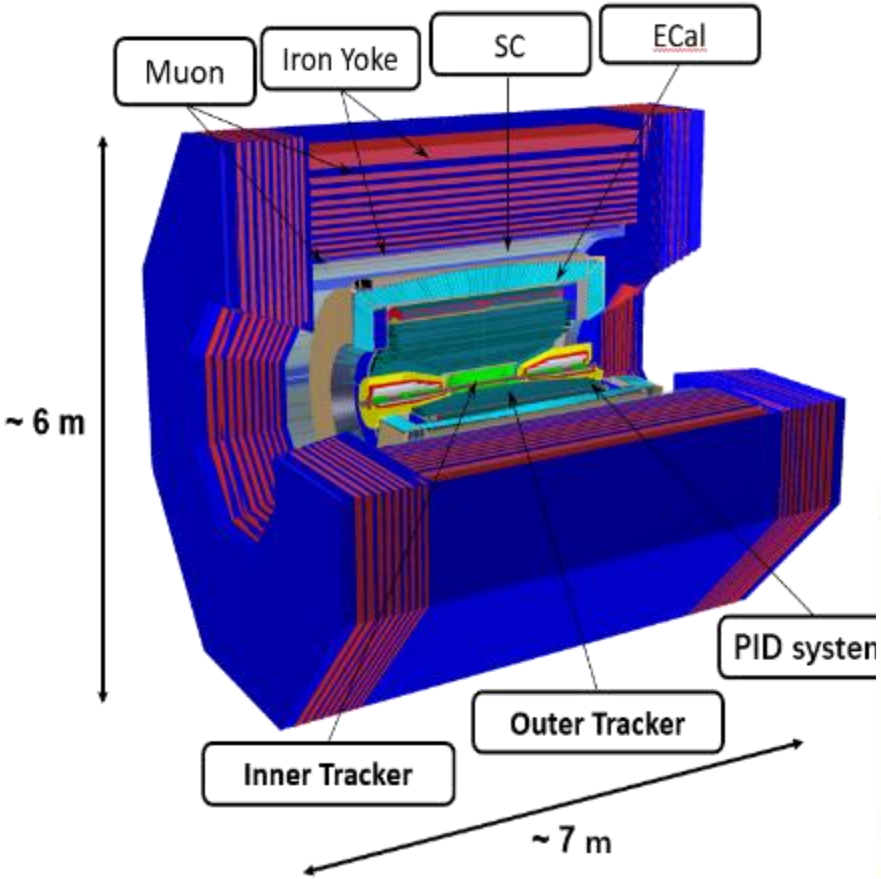
- Preliminary study phase (from 2018 to mid 2023)
  - Very limited manpower (small-portion part-time, students, retired consultants): preliminary conceptual design on the STCF accelerator
  - Supporting the STCF study project
- Key R&D phase (since August 2023)
  - The National Synchrotron Radiation Laboratory (NSRL) has fully engaged in the project, acting as a co-supporter of the STCF initiative.
  - NSRL is focusing on the constr. of HALF (a 4G synchrotron light source, 2023.5 to 2028.9), still limited manpower
  - Domestic collaborations have expanded, with contributions from 8 institutions providing roughly half of the current manpower.
  - About 90 persons, half are students

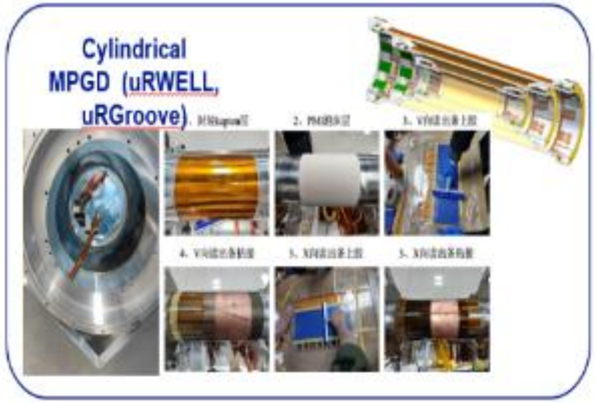
Spectrometer

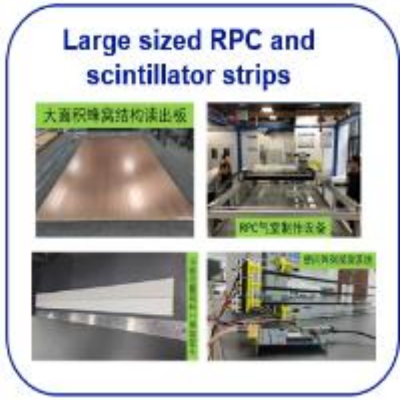
Challenges :

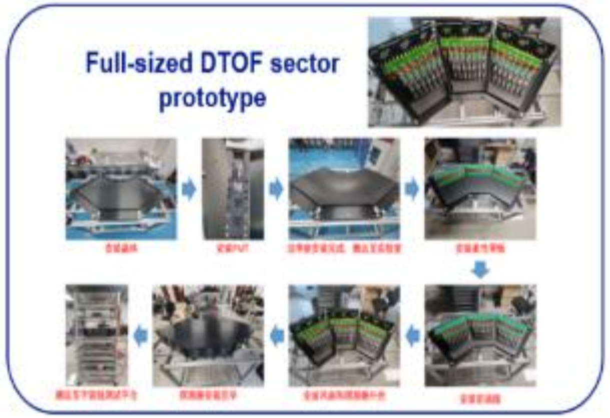
Please see Prof. Jianbei Liu's talk for details

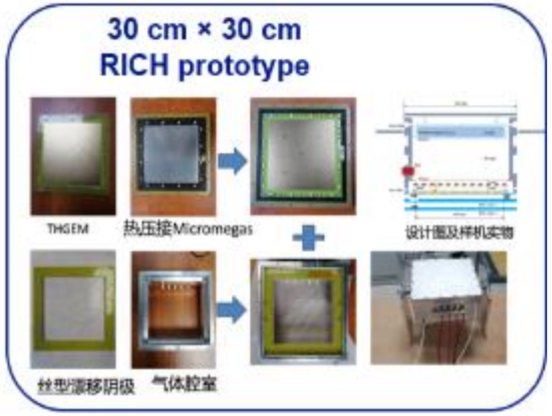
Highly efficient and precise reconstruction of exclusive final states under the extreme conditions of high event rate, large dynamic range, and high radiative hardness

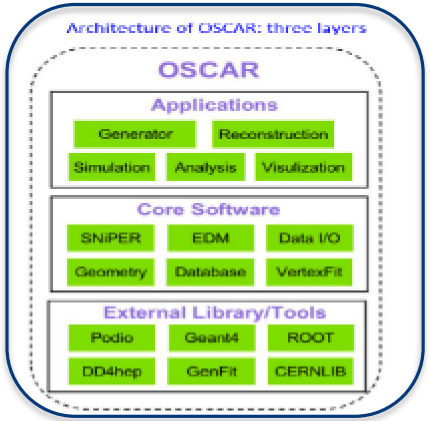






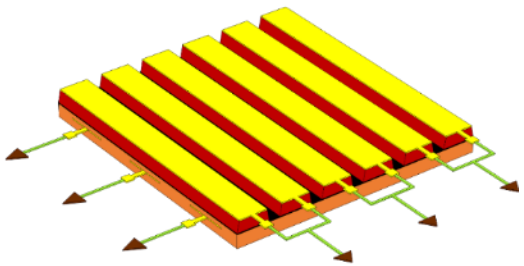


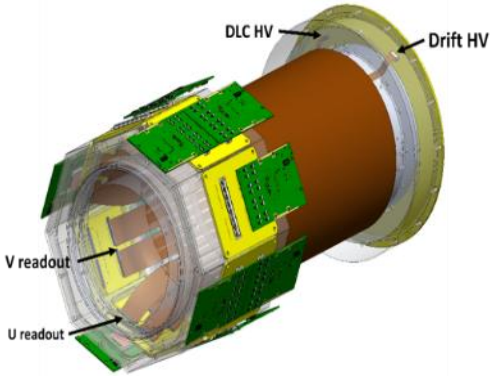




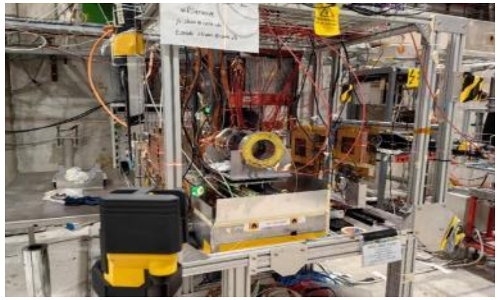
Progress on Inner Tracker

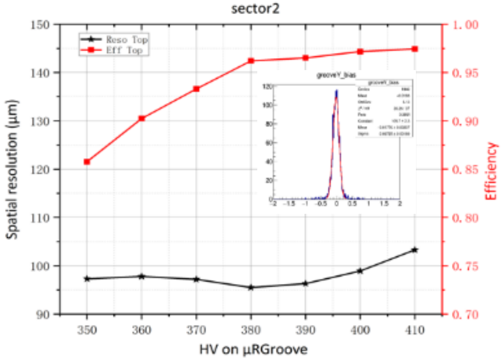
ITK-MPGD

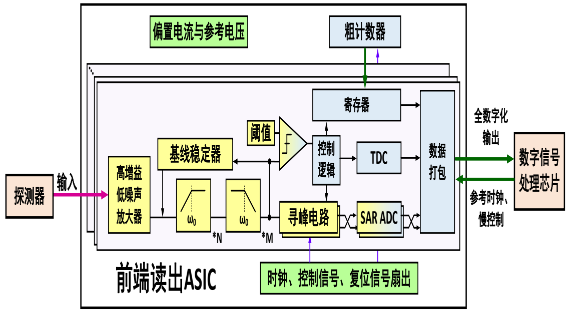




μRgroove, low material ~0.23%X_0, hit rate of 400 kHz/ch

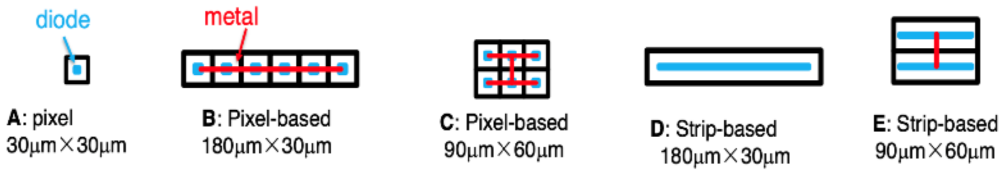




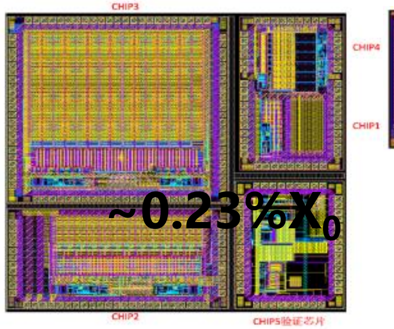


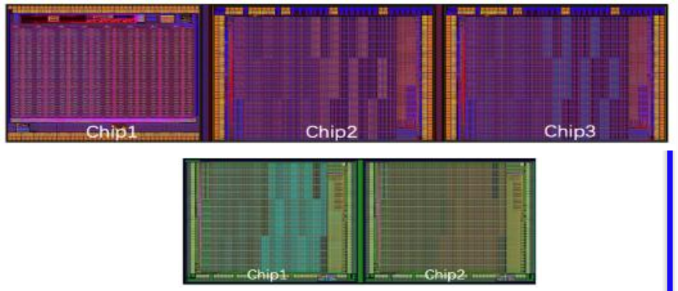
ASIC Specs	Demands
Charge Range	40 fC
Charge precision	~ 1 fC RMS
Time precision	< 10 ns RMS
Max. event rate	4 MHz

ITK-MAPS

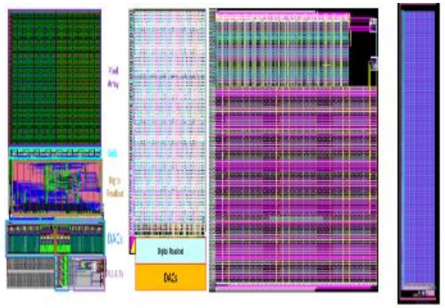


TowerJazz 180nm **NexChip FCIS/BCIS 90nm**





GSMC 130nm

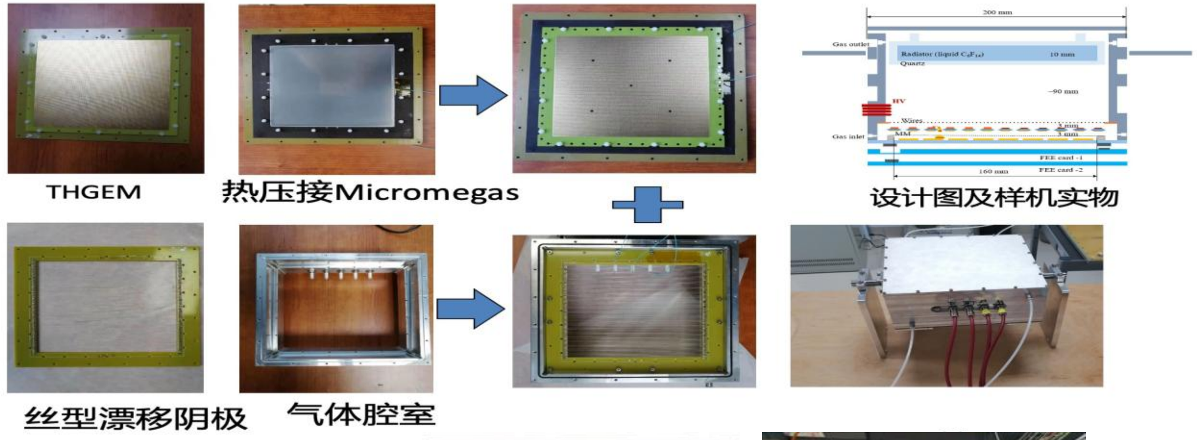


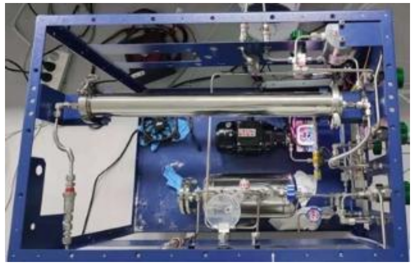
	TJ-MAPS	GSMC-MAPS
Current	**800 nA/pix**	**120*6 nA/pix**
Supply Voltage	1.8 V	1.2 V
Threshold	309.0 e^-	153.8 e^-
ENC	11.4 e^-	5.1 e^-
Mismatch	5.7 e^-	5.8 e^-
t_r @400 e^-	**200 ns**	**81 ns**

- Strip-based: 55.7 mW/cm^2
- Pixel-based: 46.2 mW/cm^2

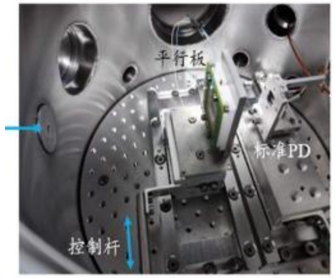
Progress on PID

A **RICH Prototype** with **liquid C6F14 (n~1.3)** radiator

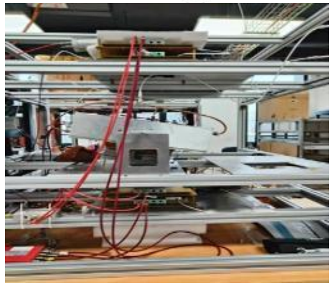




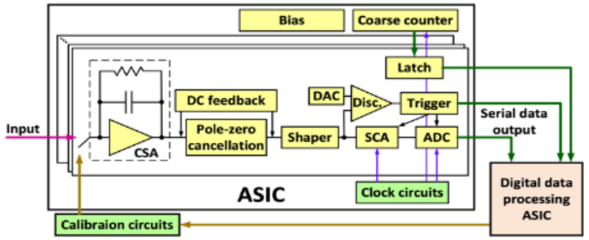
Radiator purifying

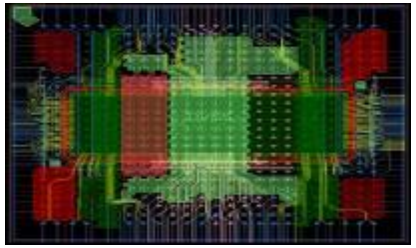


CsI coating



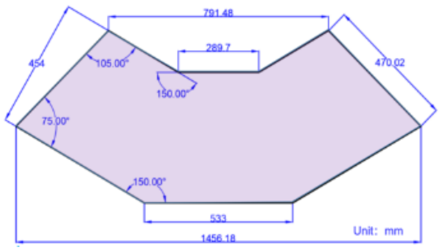
Cosmic-ray test

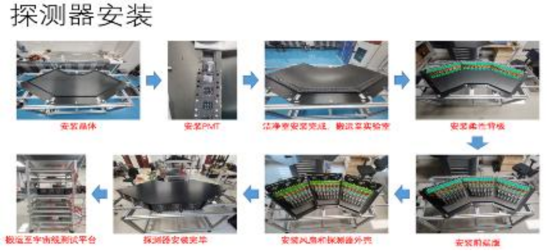


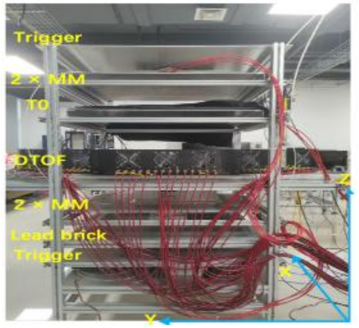


512-channel readout board using the self-developed ASIC

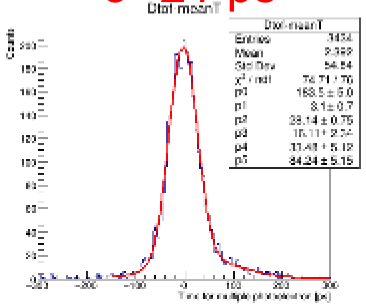
A **full-sized DTOF** prototype, with time resolution **<21 ps** by cosmic rays



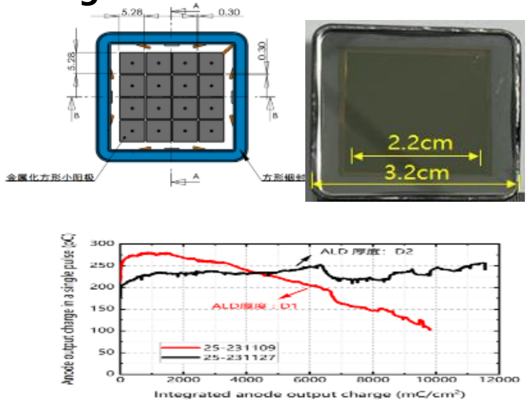




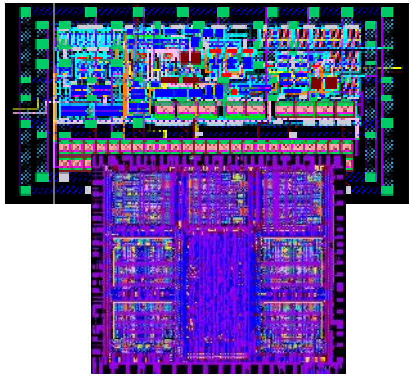
σ=21 ps



Long-life MCP-PMT



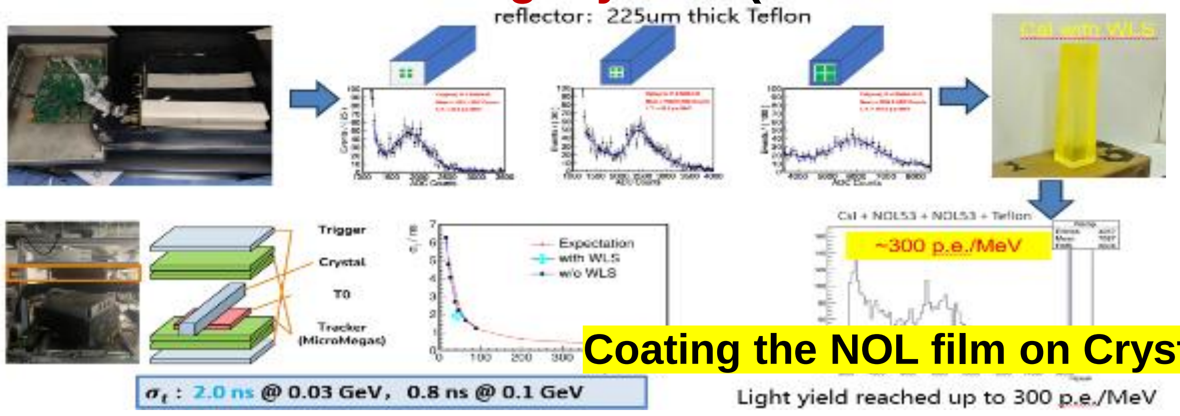
ASIC: FET, TDC



Progress on EMC

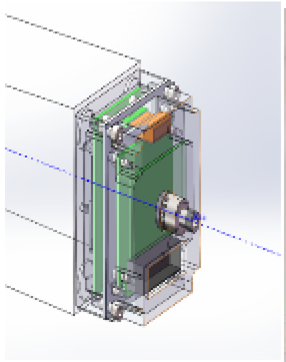
Increase light yields and reduce the pile up effects, time capability is expected

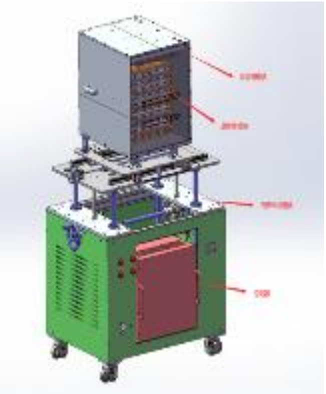
A **wavelength shifter in propagation** scheme to increase the **light yields** (3.5 times）



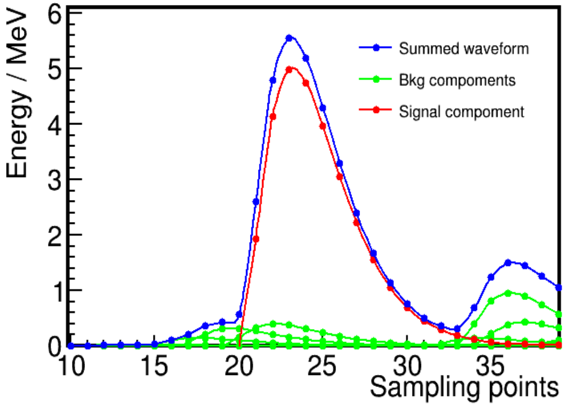
A **waveform digitization electronics** (CSA + Shape + ADC) for the waveform and time resolution

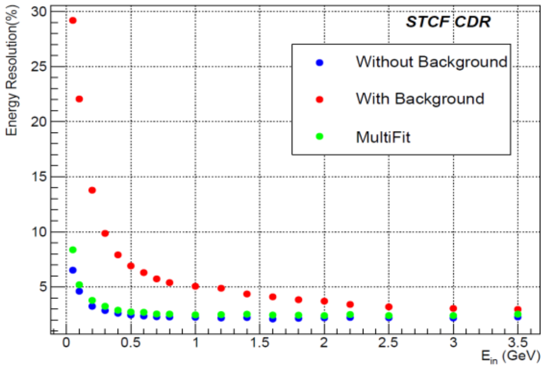
A **prototype** to verify the energy and time resolution





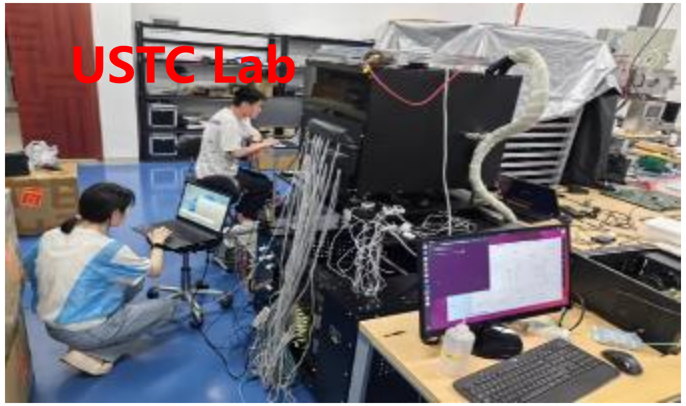
A **waveform fitting** with multiple templates to effectively mitigate the **pileup** effect

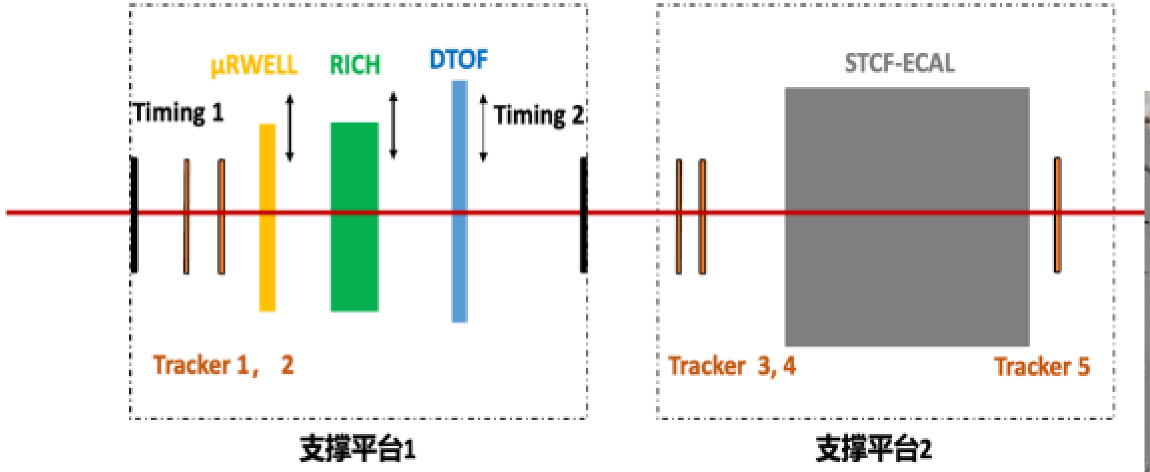




Test Beam Campaign

DTOF and EMC prototypes are combined in a single TDAQ system for test beams





Starting from July 31，Lasting for 2 weeks，CERN PS T9 beam line

Summary

- STCF has a rich physics program with breakthrough potential in the studies of how quarks form matter and symmetry of fundamental interactions (CPV), and beyond. It is, therefore, an important project in the precision frontier of HEP and of great interest to the international HEP community.
- With the strong backing from the local governments, the key technology R&D project is progressing as expected in the past few month, and significant progress has been made. The project organization has been further strengthened, and the flagship physics objectives have been refined.
- Aiming for construction approval from central government during the 15th Five-Year Plan (2026-2030). The proposal is currently in preparation, with the initial draft totaling ~ 1,000 pages, and is expected to be completed by early 2025
- Expanding international collaboration and exploring synergies with other projects are crucial. All forms of collaboration are welcome

Thank you !

Preliminary Construction Cost

Sub-Systems	Construction Budget (million RMB)
Accelerator - Injector	850
Accelerator – Collider Rings	2, 500
Detector	750
Civil Construction	880
Total	4, 980

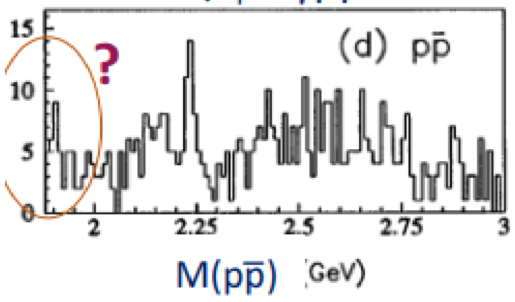
Preliminary Construction Cost

Sub-Systems	Construction Budget (million RMB)
Accelerator - Injector	850
Accelerator – Collider Rings	2, 500
Detector	750
Civil Construction	880
Total	4, 980

Exotic Hadronic States and More

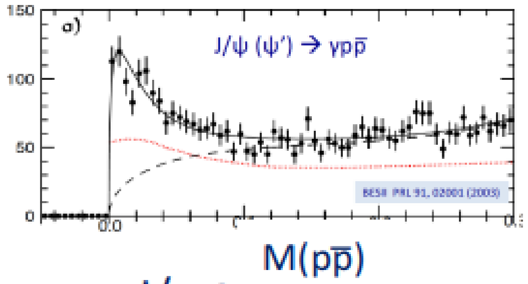
1996: 8 M J/ψ's

J/ψ→γpp̄

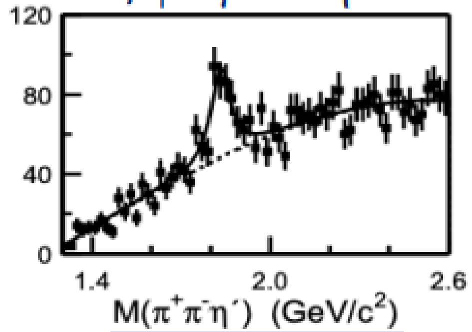


PRL 76, 3502

2002: 58 M J/ψ's

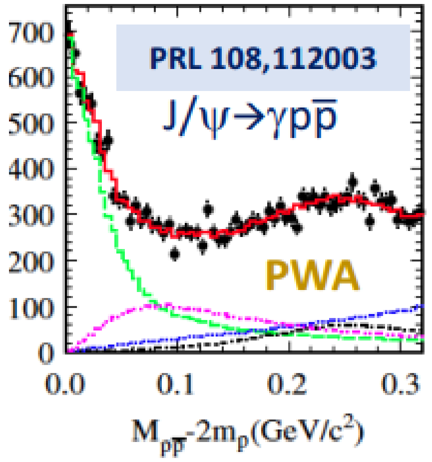


J/ψ→γπ⁺π⁻η'

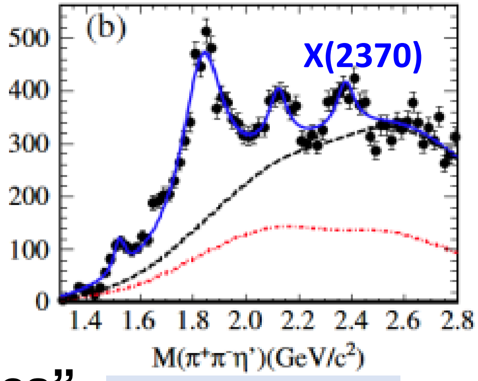


PRL 95,262001

2011: 225 M J/ψ's



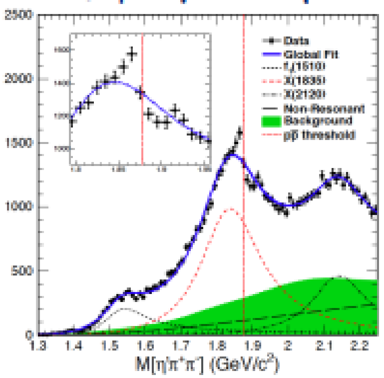
J/ψ→γπ⁺π⁻η'



PRL 106,072002

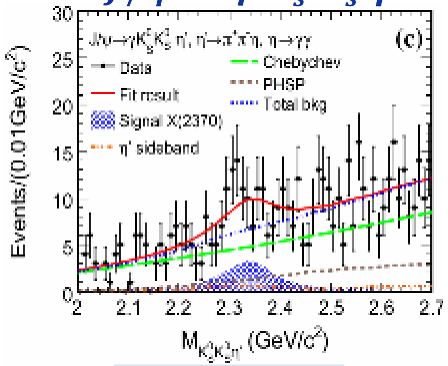
2016: 1.3 B J/ψ's

J/ψ→γπ⁺π⁻η'



PRL 117,042002

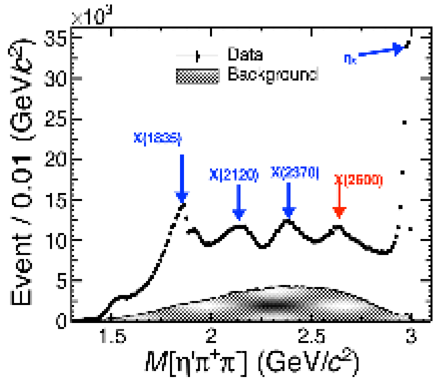
$J/\psi \to \gamma K_S^0 K_S^0 \eta'$



EPJC 80,746

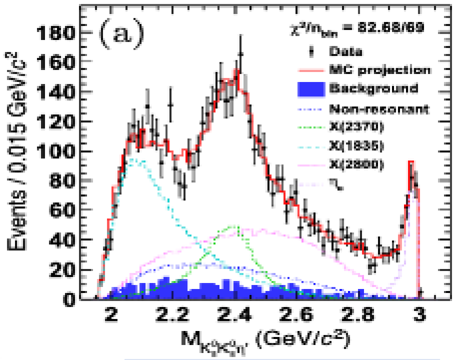
2022: 10B J/ψ's

$J/\psi \to \gamma\pi^+\pi^-\eta'$



PRL 129, 042001

$J/\psi \to \gamma K_S^0 K_S^0 \eta'$



PRL 132.181901

0^{-+} Pseudoscalar Glueball-like

You never have enough J/ψ events!

— Stephen Lars Olsen

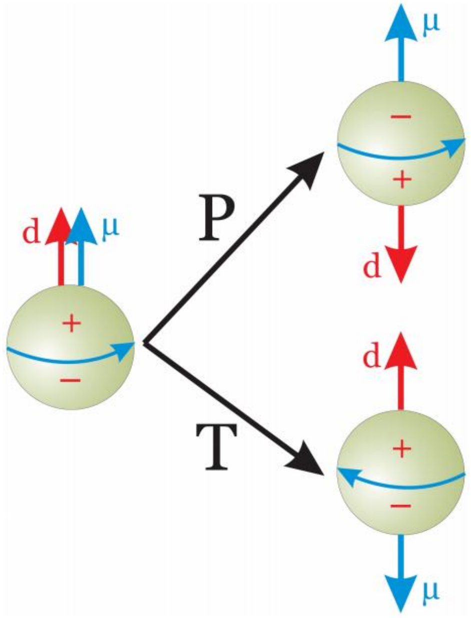
Talk on "Symposium on 30 years of BES Physics"

Thanks the huge production cross section and high luminosity of STCF

CP Violation in the Hyperons

Great opportunity for Systematic measurement of the EDMs of the hyperon family!

μ: magnetic dipole moment
d: electric dipole moment

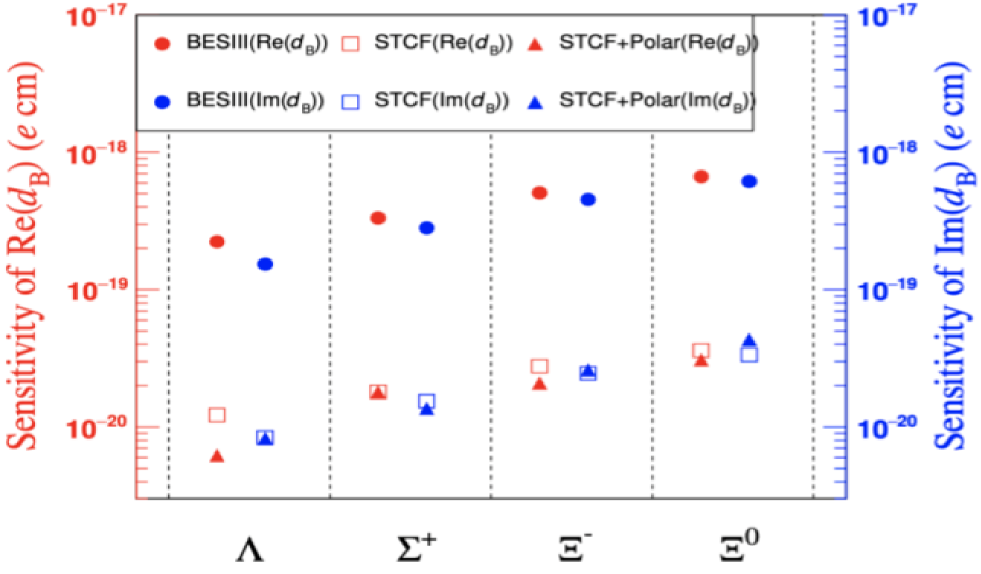


Non-zero EDM will violate P and T symmetry: T violation ↔ CP violation, if CPT holds

Detailed dynamics in J/ψ decay to hyperon pair can been studied:

$$\mathcal{A} = \epsilon_\mu(\lambda)\bar{u}(\lambda_1)\left(F_V\gamma^\mu + \frac{i}{2M_\Lambda}\sigma^{\mu\nu}q_\nu H_\sigma + \gamma^\mu\gamma^5 F_A + \sigma^{\mu\nu}\gamma^5 q_\nu H_T\right)\nu(\lambda_2)$$

X.G.He, J.P. Ma, Phys.Lett.B 839(2023)137834



(a)Sensitivity of $Re(d_B)$ and $Im(d_B)$

SM: $\sim 10^{-26}$ e cm

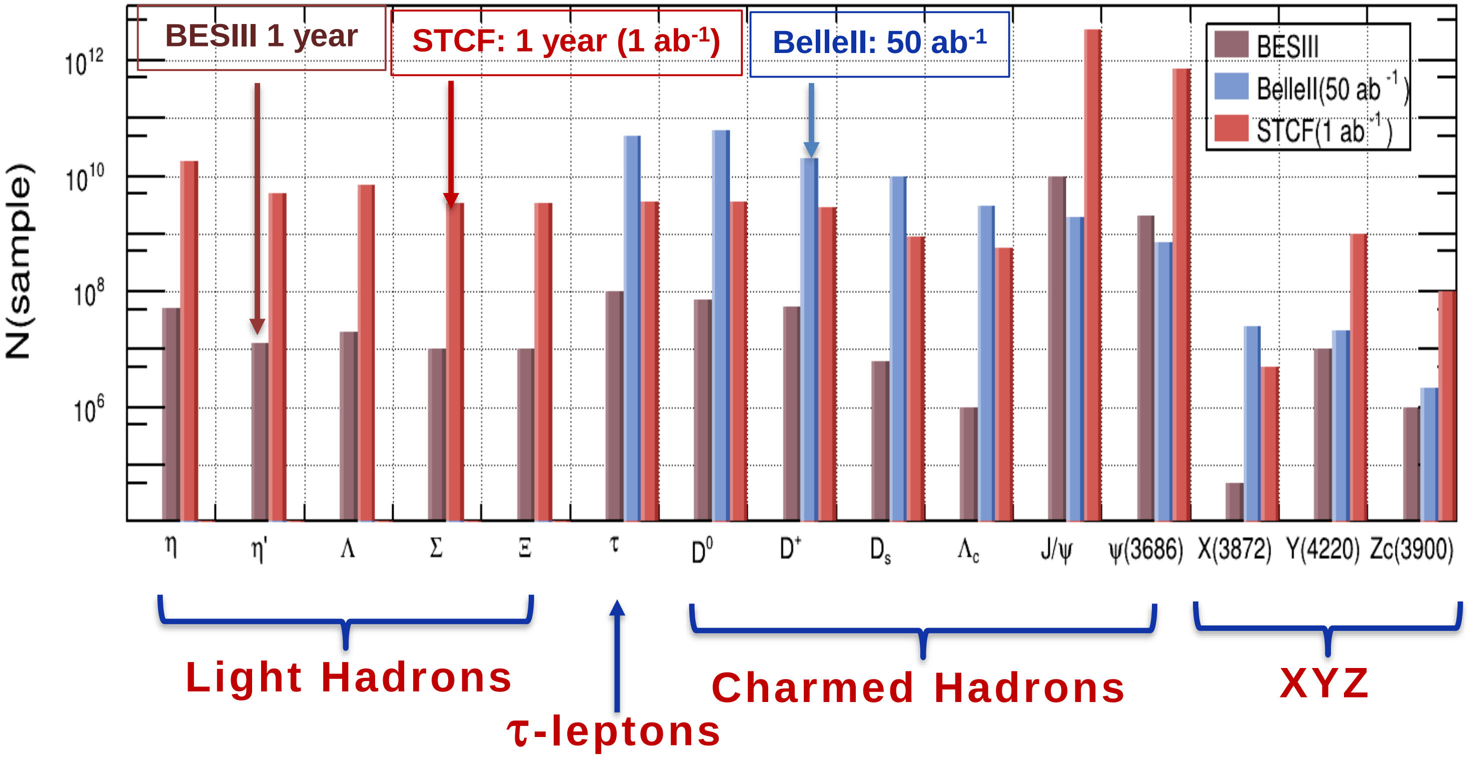
BESIII: milestone for hyperon EDM measurement
$\Lambda\ 10^{-19}$e cm (FermiLab 10^{-16} e cm)
first achievement for Σ^+,Ξ^- and Ξ^0 at level of 10^{-19}e cm
a litmus test for new physics

STCF: improved by 2 order of magnitude

These results will provide strong constraints on the theoretical model and achieve the world best precision ever.

Unique Data Samples

Not only a τ-charm factory, but also a factory for XYZ, hyperons and light hadrons

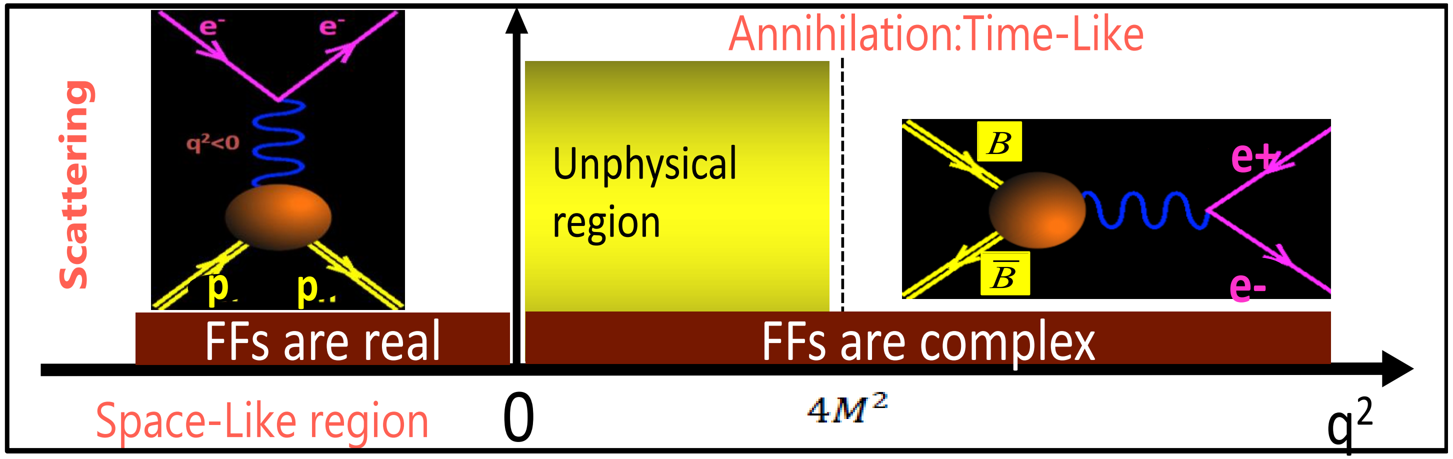


CME (GeV)	Lumi (ab^{-1})	Samples	σ(nb)	No. of Events	Remarks
3.097	1	J/ψ	3400	3.4×10^{12}	
3.670	1	$\tau^+\tau^-$	2.4	2.4×10^{9}	
3.686	1	$\psi(3686)$	640	6.4×10^{11}	
		$\tau^+\tau^-$	2.5	2.5×10^{9}	
		$\psi(3686)\to\tau^+\tau^-$		2.0×10^{9}	
3.770	1	$D^0\bar{D}^0$	3.6	3.6×10^{9}	
		$D^+\bar{D}^-$	2.8	2.8×10^{9}	
		$D^0\bar{D}^0$		7.9×10^{8}	Single tag
		$D^+\bar{D}^-$		5.5×10^{8}	Single tag
		$\tau^+\tau^-$	2.9	2.9×10^{9}	
4.009	1	$D^{*0}\bar{D}^0+c.c$	4.0	1.4×10^{9}	$CP_{D^0\bar{D}^0}=+$
		$D^{*0}\bar{D}^0+c.c$	4.0	2.6×10^{9}	$CP_{D^0\bar{D}^0}=-$
		$D_s^+D_s^-$	0.20	2.0×10^{8}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.180	1	$D_s^{+*}D_s^-$+c.c.	0.90	9.0×10^{8}	
		$D_s^{+*}D_s^-$+c.c.		1.3×10^{8}	Single tag
		$\tau^+\tau^-$	3.6	3.6×10^{9}	
4.230	1	$J/\psi\pi^+\pi^-$	0.085	8.5×10^{7}	
		$\tau^+\tau^-$	3.6	3.6×10^{9}	
		$\gamma X(3872)$			
4.360	1	$\psi(3686)\pi^+\pi^-$	0.058	5.8×10^{7}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.420	1	$\psi(3686)\pi^+\pi^-$	0.040	4.0×10^{7}	
		$\tau^+\tau^-$	3.5	3.5×10^{9}	
4.630	1	$\psi(3686)\pi^+\pi^-$	0.033	3.3×10^{7}	
		$\Lambda_c\bar{\Lambda}_c$	0.56	5.6×10^{8}	
		$\Lambda_c\bar{\Lambda}_c$		6.4×10^{7}	Single tag
		$\tau^+\tau^-$	3.4	3.4×10^{9}	
4.0–7.0	3	300-point scan with 10 MeV steps, 1 fb^{-1}/point			
> 5	2–7	Several ab^{-1} of high-energy data, details dependent on scan results			

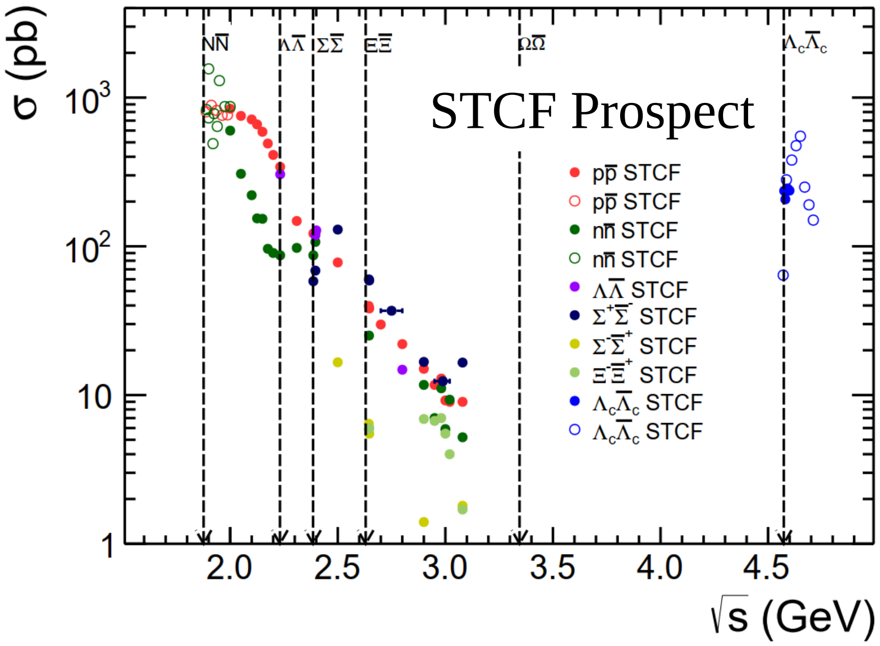
10 years data taken proposal

Exotic Hadronic States and More

Electromagnetic form factors of nucleon



Eic/EicC ⟷ **STCF**



- **Threshold production** provides the unique opportunities to measure the time-like Electromagnetic form factors as well as the inner structure of nucleon.
- **STCF will improve the measurement with 1-2 order in precision, will reveal near-threshold cross section singularity as well as the G_E and G_M behavior, such as the oscillation when it varied with the center-of-mass energy, the evolution of the phase**