Progress of the Super Tau Charm Facility in China

Cong GENG (耿聪)
Sun Yat-sen University (中山大学)
For Super Tau-Charm Facility working group

19/09/2025, HOL2025, Peking University

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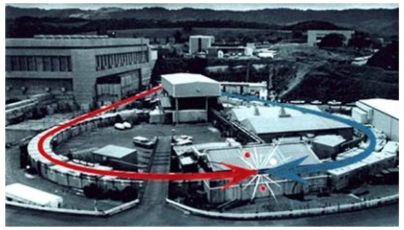
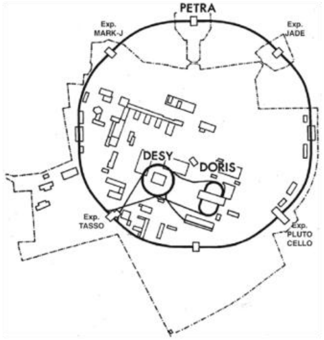
Colliders in Particle Physics

- The most effective experimental approach, artificially generating massive amounts of elementary particles, and studying the production and decay mechanisms
- Different energy regions, significant discoveries: heavy flavor quarks, tau leptons, W/Z bosons, and Higgs

SPEAR, USA





PETRA, Germany

Tevatron, USA

LHC, Switzerland

1974, Charm quark

1979, Gluon

1995, Top quark

2012, Higgs

1975, Tau lepton

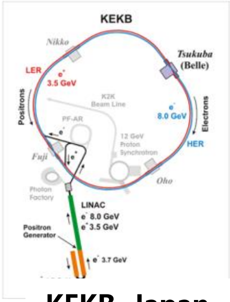
1983, W/Z bosons

2001, CPV in B meson

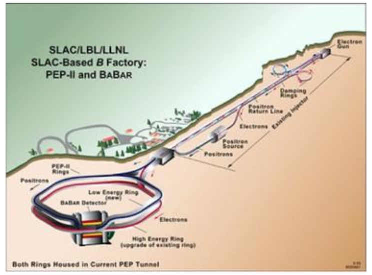
2013, $Z_c(3900)$

SLAC, USA

SPS, Switzerland



KEKB, Japan



PEP-II, USA

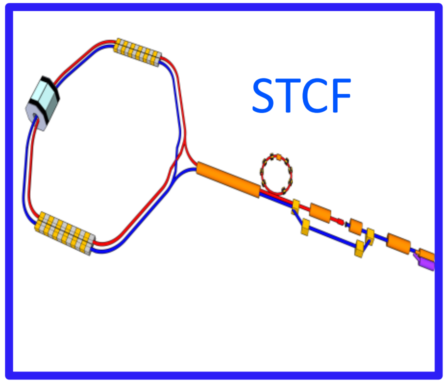
BEPC-II, China

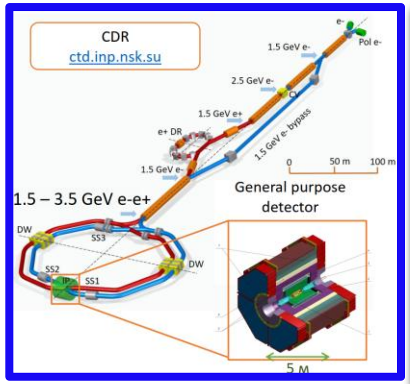
New Generation

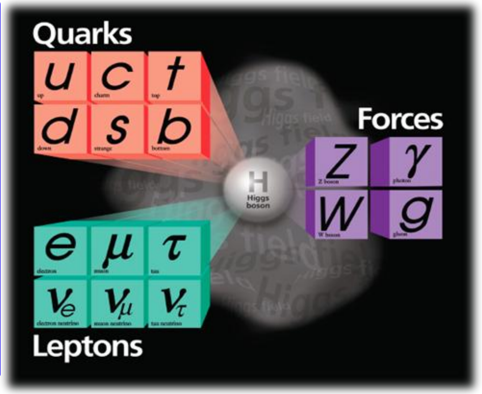
Significantly higher energy, luminosity and detection accuracy

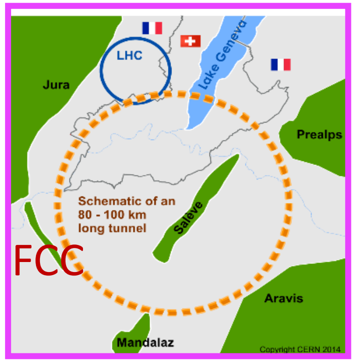
Higer luminosity by factor ~50-100

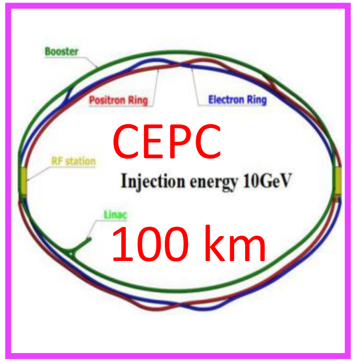
Higher energy by factor ~3-10

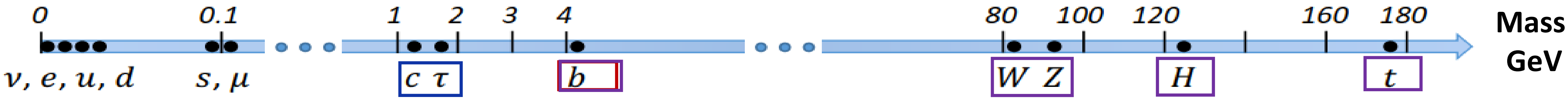










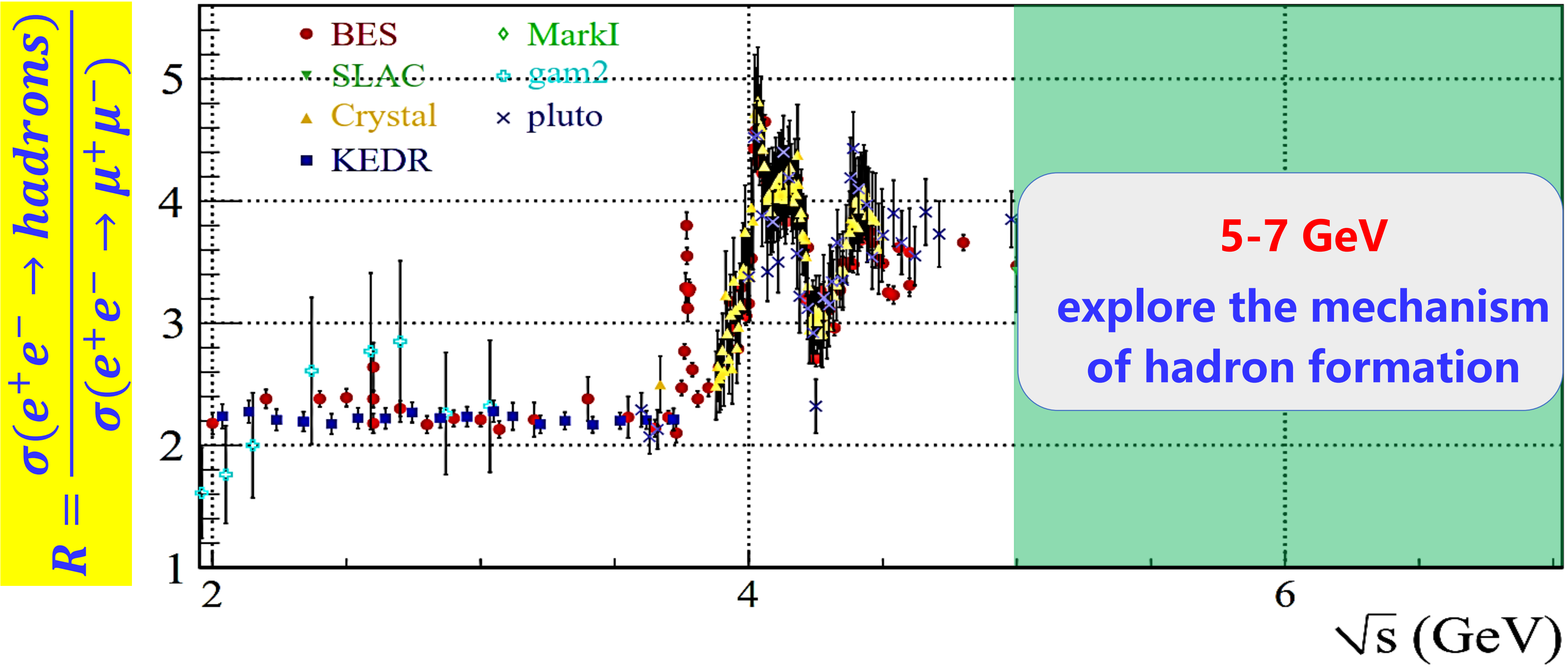


◆ **High luminosity frontier**:
hadron production mechanism and inner structure, exotic states, nature of strong interactions, NP in the c/b quarks and τ-lepton …

Complementary
Irreplaceable

◆ **High energy frontier**:
Origin of elementary particle mass, nature of electroweak, quark-gluon plasma, NP via Higgs particle …

Unique Physics in τ-Charm Region



- **Unique Energy Region:** transition Region between Perturbative and Non-perturbative QCD
- **Rich hadron spectra:** glueballs, multi-quark states, hybrid …
- **Ultra high cross-section:** rich resonances, charmonium …
- **Threshold effect:** hadron/lepton pairs, quantum correlation

Scientific and Project Objectives

Nuclear Structure:
Understand the mysteries of Nuclear Form Factors

Asymmetry:
Discover the CP violation in hyperons

QCD confinement:
Explore quark formation in hadrons

A revolutionary new-generation facility, providing unprecedented data size and measurement precision

CMS Energy	2-7 GeV
Peaking Luminosity	5×10^{34} $cm^{-2}s^{-1}$
Upgrade Potential	Higher energy, Higher luminosity, Polarization

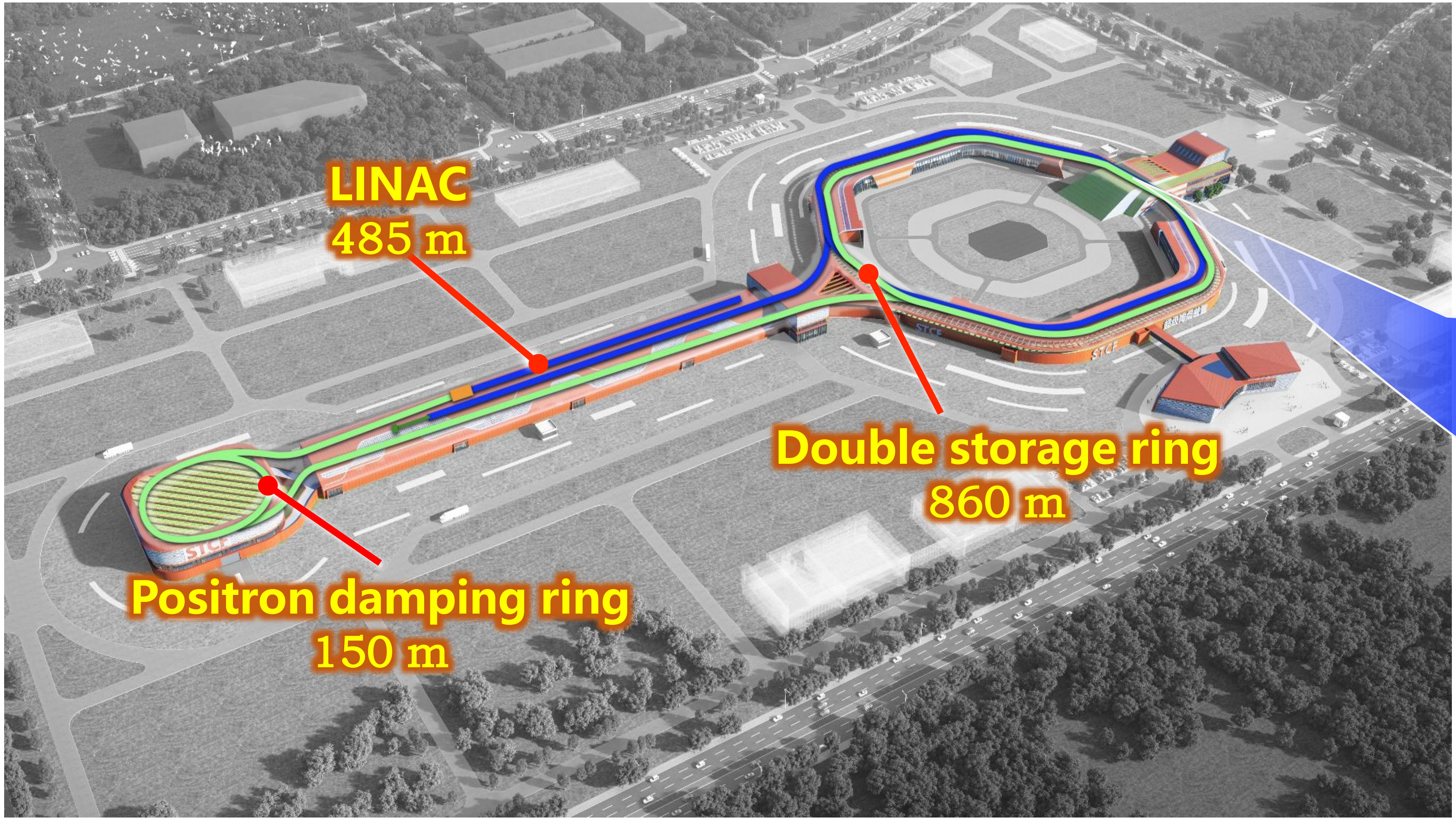
Momentum Res.	0.5%@1GeV
Energy Res.	2.5%@1GeV
Particle ID	K/π 4σ@2 GeV
Event Rate	400 kHz

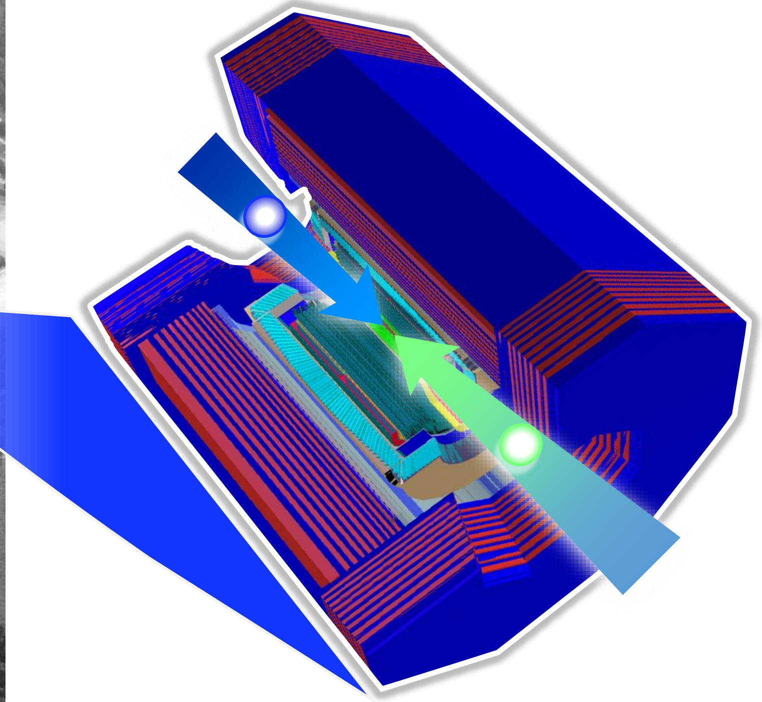
long-term stable operation within high luminosity and wide energy range

high-precision measurements within high irradiation and event rate

New Project: Super Tau-Charm Facility

- New generation **GeV-region electron-positron collider**
- Unique platform for exploring hadron structures and fundamental symmetries





Detector

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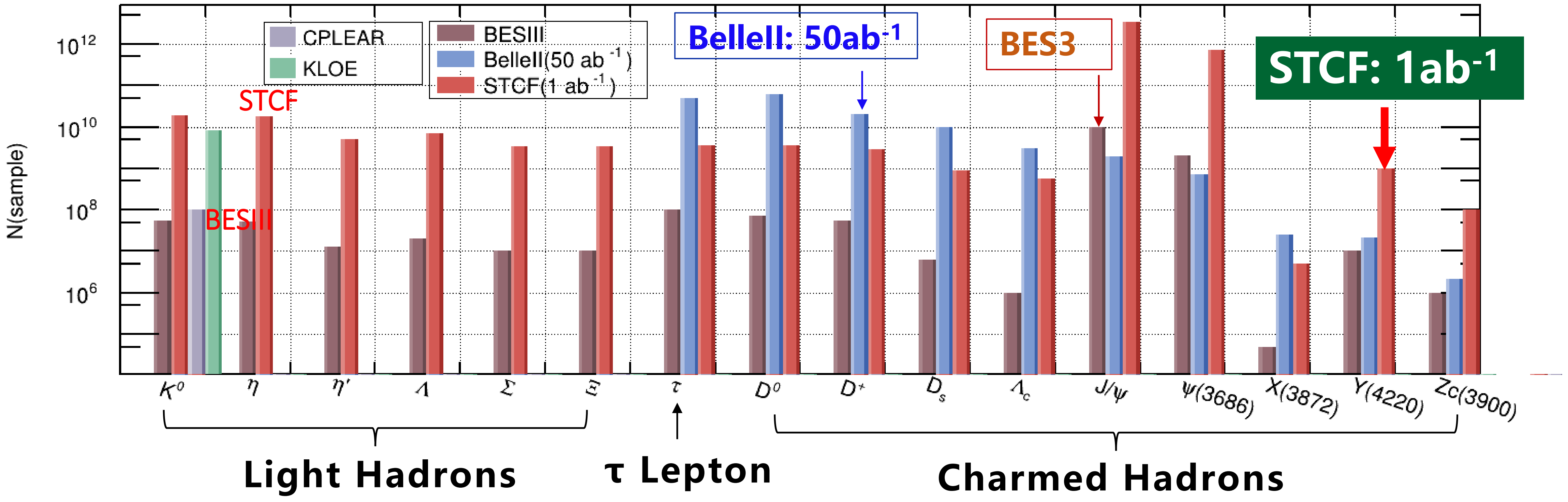
Super Large Data Samples

Factory: not only for τ-charm, but also XYZ, hyperons, light hadrons



Super Lage Data + High Res. + Low Bkg → High Precision

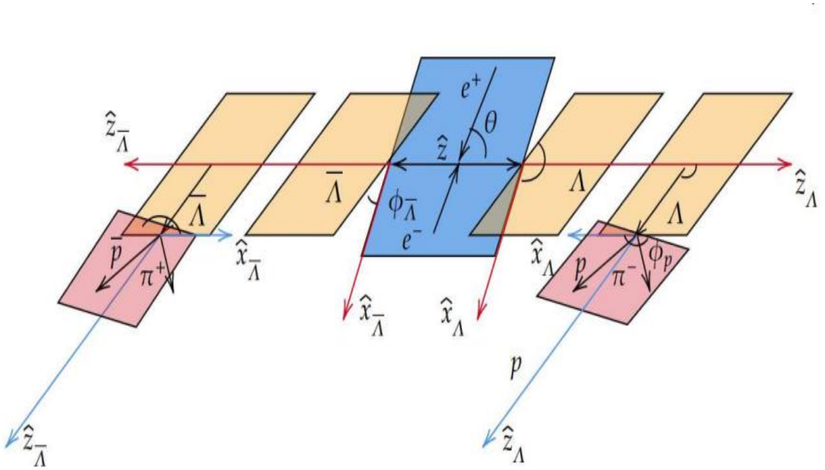
To understand the mysteries of hadron formation and interactions

Physics I: Asymmetry

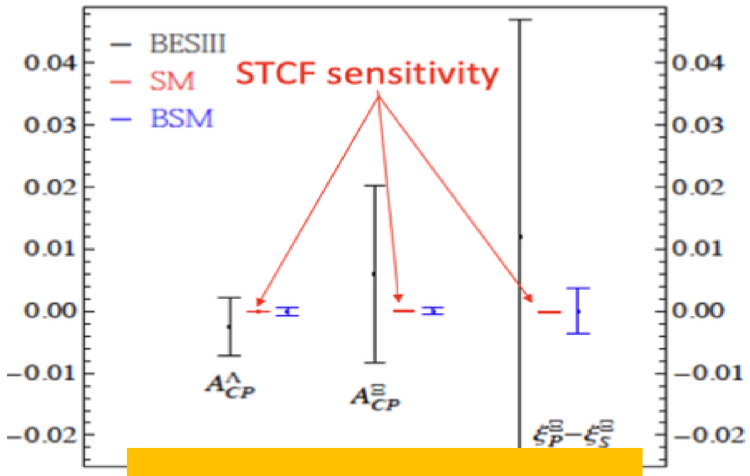
- **The CP violation observed in current experiments is far from sufficient to explain the mystery of antimatter disappearance.**
- **Only the CP violation of hyperons and charmed baryons has not been discovered, which is one of the last unexplored frontiers in hadron physics**

CP violation in Hyperons

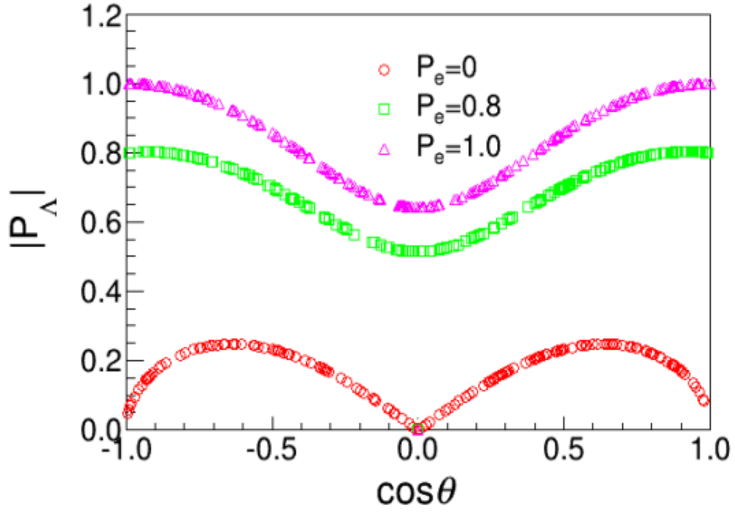
Quantum Correlation



X.G. He et al. Sci.Bull. 67 (2022) 1840-1843:



SM: 10^{-4}~10^{-5}



$$\sigma_{A_{CP}} \approx \sqrt{\frac{3}{2}} \frac{1}{\alpha_1 \sqrt{N_{sig}} \sqrt{\langle P_B^2 \rangle}}.$$

- $e^+e^- \to J/\psi \to Y\bar{Y}$: **abundant hyperon pairs**
- **Sensitivity of CPV observable: 10^{-4}**
- **Polarization increases the sensitivity**

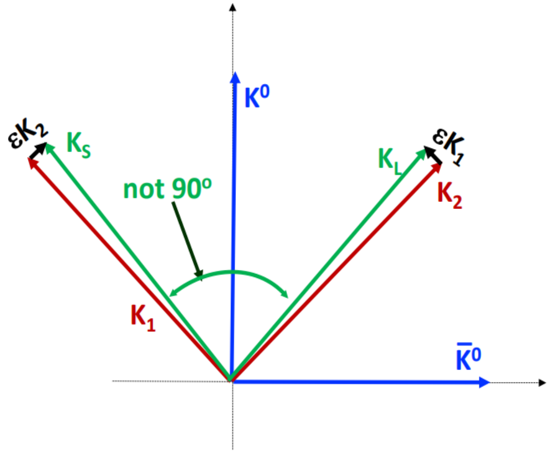
$1\times10^9\ \Lambda\bar{\Lambda},\ \langle P_B^2\rangle=0.1 \Longrightarrow \sigma_{A_{CP}} \sim 1.4\times10^{-4}$

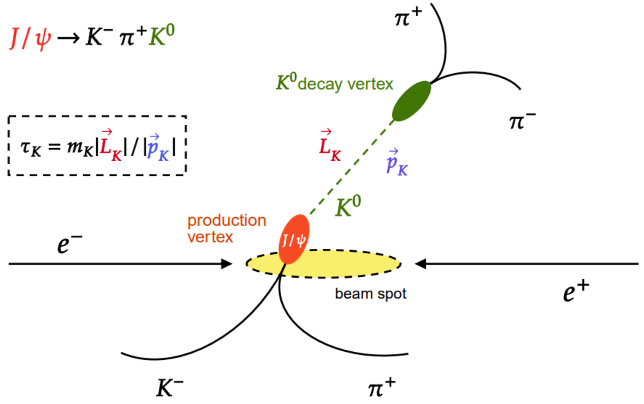
$1\times10^9\ \Lambda\bar{\Lambda},\ \langle P_B^2\rangle=0.8 \Longrightarrow \sigma_{A_{CP}} \sim 5\times10^{-5}$

Reach sensitivity of SM prediction with 1-year data at STCF

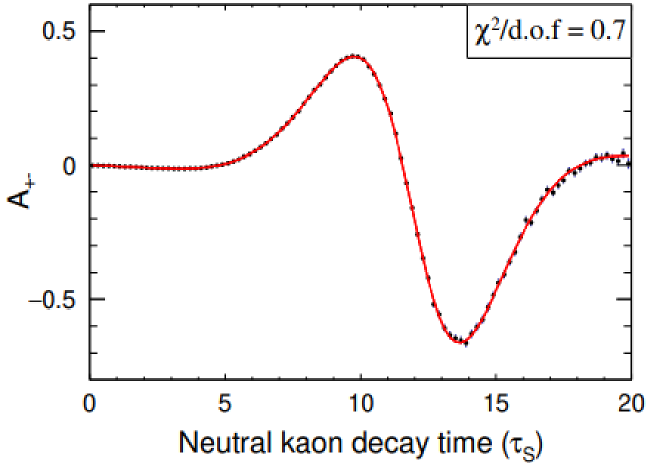
Asymmetry in $K^0 - \bar{K}^0$

CPT test to probe the new physics beyond SM





arXiv : 2209.12551



- $K^0 - \bar{K}^0$ **flavor tagging** via $J/\psi \to K^0 K^- \pi^+ / \bar{K}^0 K^+ \pi^-$
- $K_1 - K_2$ **CP tagging** by reconstructing $\pi^+\pi^-$ or $\pi^+\pi^-\pi^0$
- Precise determination of K^0 decay vertex ⇒ essential for time-distribution

- The phase in CP parameter ϕ_{+-} used to set limits on CPT violation
- sensitivity of ϕ_{+-} is $\mathcal{O}(10^{-3})$ at STCF ⇒ **one magnitude better than PDG average**

CP Subject in STCF

arXiv:2502.08907

CP violation studies at Super tau-charm facility

Hai-Yang Cheng[a], Zhi-Hui Guo[b], Xiao-Gang He[c], Yingrui Hou[d], Xian-Wei Kang[e], Andrzej Kupsc[f,g], Ying-Ying Li[h], Liang Liu[h], Xiao-Rui Lyu[d], Jian-Ping Ma[i], Stephen Lars Olsen[j,k], Haiping Peng[h], Qin Qin[q], Pablo Roig[m,n], Zhi-Zhong Xing[o], Fu-Sheng Yu[p], Yu Zhang[q], Jianyu Zhang[d], Xiaorong Zhou[h]

[a]*Institute of Physics, Academia Sinica, Taipei, 11529, China*
[b]*Hebei Normal University, Shijiazhuang, 050024, China*
[c]*Shanghai Jiao Tong University, Shanghai, 200250, China*
[d]*University of Chinese Academy of Sciences, Beijing, 100049, China*
[e]*Beijing Normal University, Beijing, 100875, China*
[f]*National Centre for Nuclear Research, Warsaw, 02-093, Poland*
[g]*Uppsala University, Uppsala, SE-75120, Sweden*
[h]*University of Science and Technology of China, Address One, 230026, China*
[i]*Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, 100190, China*
[j]*High Energy Physics Center, Chung-Ang University, Seoul, 06974, Korea*
[k]*Particle and Nuclear Physics Institute, Institute for Basic Science, Daejeon, 34126, Korea*
[l]*Huazhong University of Science and Technology, Wuhan, 430074, China*
[m]*Departamento de Física, Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional, Mexico City, AP 14740, CP 07000, Mexico*
[n]*IFIC, Universitat de València – CSIC, Paterna, E-46980, Spain*
[o]*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, 100049, China*
[p]*Lanzhou University, Lanzhou, 730000, China*
[q]*University of South China, Hengyang, 421001, China*

Abstract

Charge-parity (CP) violation in the tau-charm energy region is one of the promising areas to search for. The future tau-charm facility of next generation is designed to operate in a center-of-mass energy from 2.0 to 7.0 GeV with a peak luminosity of 0.5×10^{35} cm^{-2}s^{-1}. Huge amount of hadrons and tau (τ) leptons will be collected with good kinematic constraint and low-background environment. In this report, possibilities of CP violation studies in tau-charm energy region and at the future tau-charm facility are discussed from various aspects, *i.e.* in the production and decay of hyperons and τ lepton; in the decay of charmed hadrons. The CPT invariance test in $K^0 - \bar{K}^0$ mixing is also presented.

Preprint submitted to PHYSICS REPORTS *September 25, 2024*

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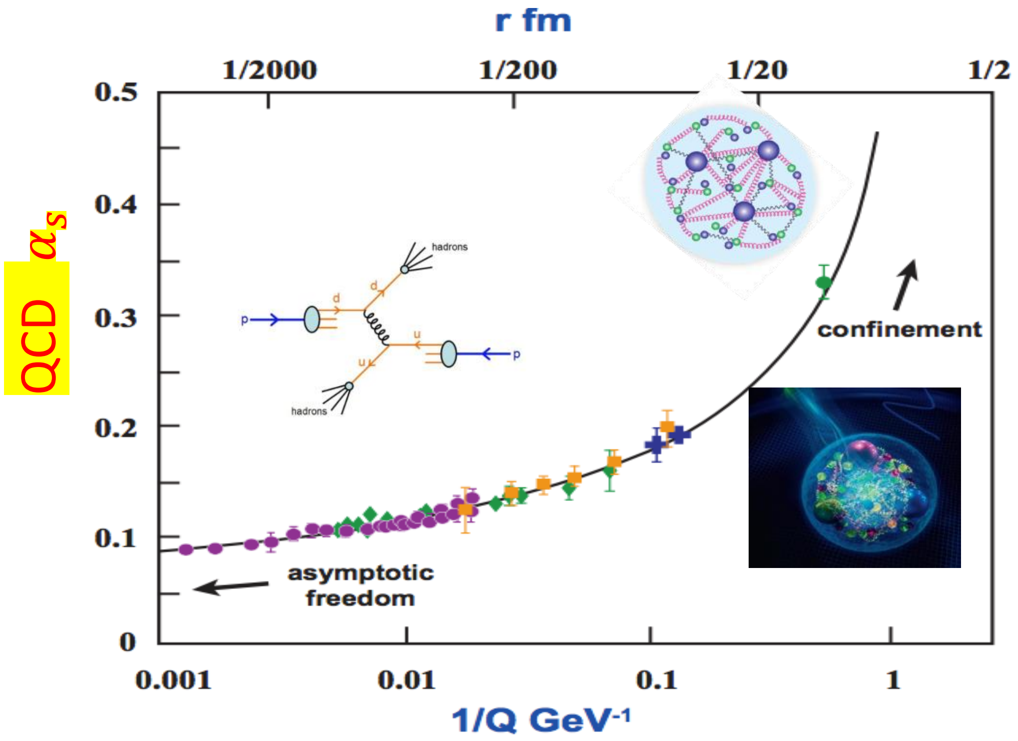
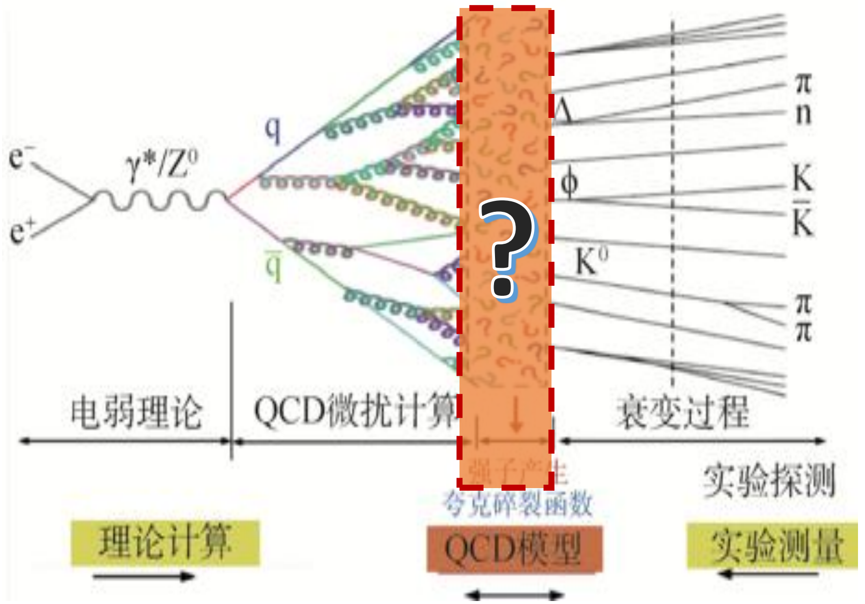
Physics II: Confinement

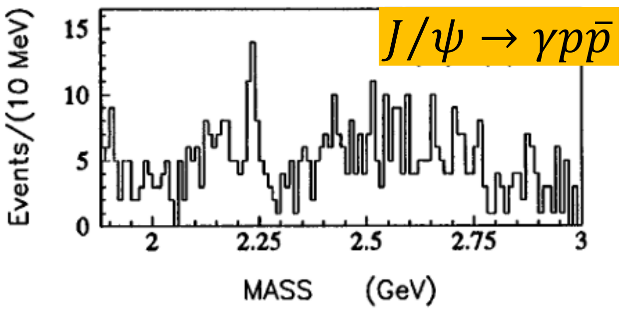
- **Non-perturbative effect is the major bottleneck for precision measurements**
- **Hadrons and nucleons are essential probes: hadron spectra, nuclear structures, fragmentation functions**



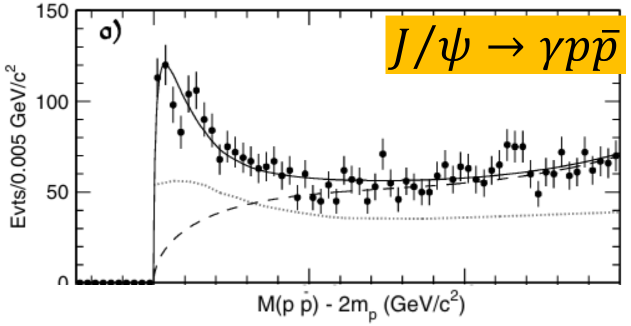


More Data, Finer Structures

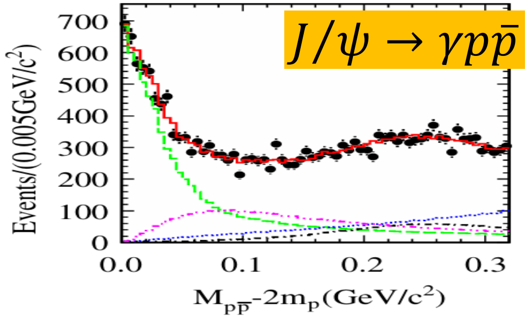
1996, 8 M J/ψ's
PRL 76, 3602



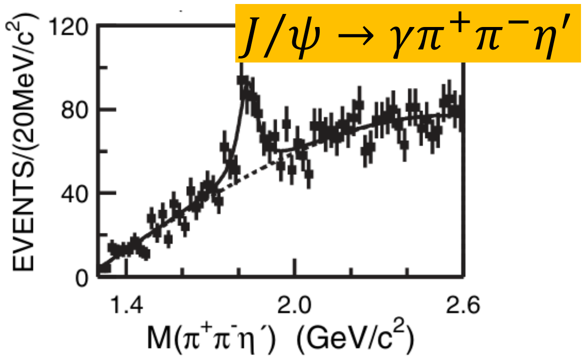
2003, 58 M J/ψ's
PRL 91, 022001



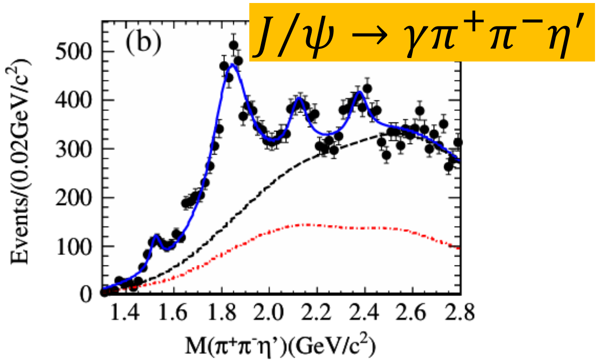
2012, 225 M J/ψ's
PRL 108, 112003



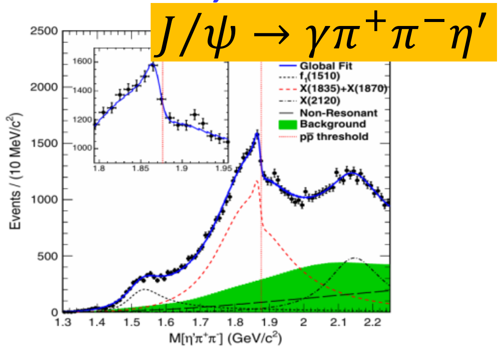
2005, 58 M J/ψ's
PRL 95,262001



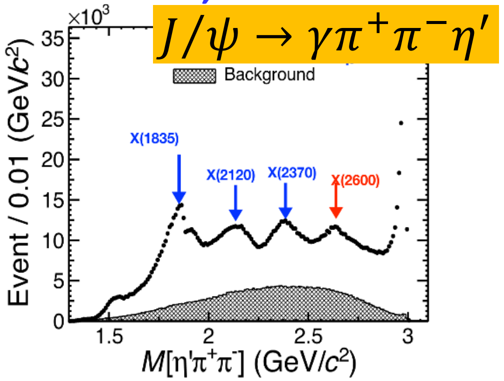
2011, 225 M J/ψ's
PRL 106, 072002



2016, 1.1 B J/ψ's
PRL 117,042002



2022, 10 B J/ψ's
PRL 129, 042001



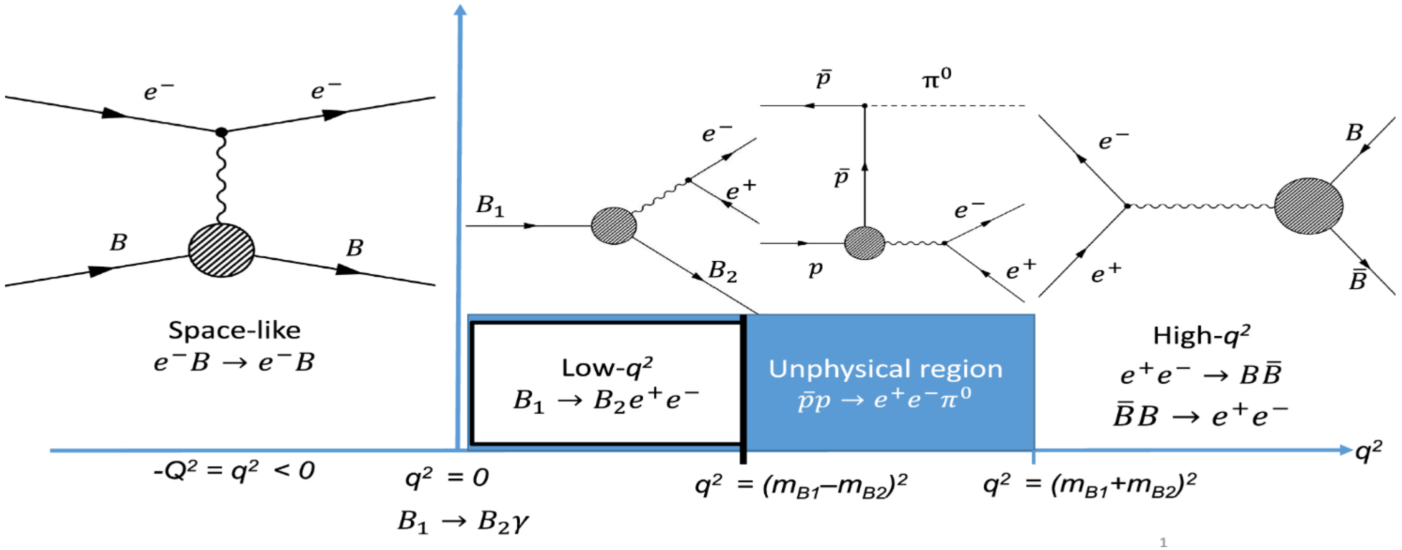
You never have enough J/ψ events!

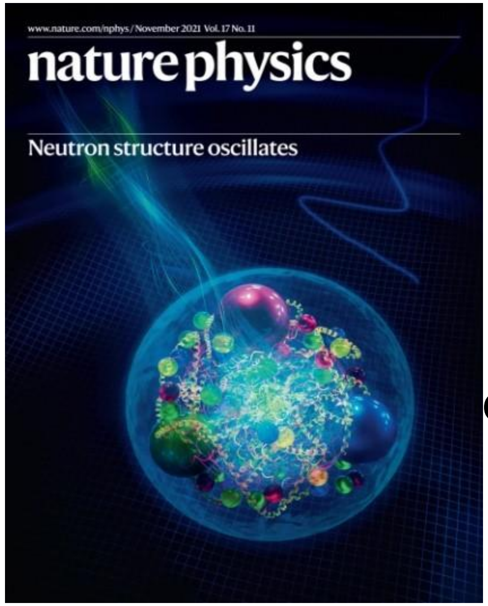
— Stephen Lars Olsen

Talk on " Symposium on 30 years of BES Physics" , (2019)

Prospect of EMFFs in STCF

- ◆ Form Factors: non-perturbative effect, incalculable precisely
- ◆ Essential Input for the PDFs (critical uncertainty in hadron colliders)
- ◆ ee colliders provide the most clean samples





Year 2021 Neutron EMFFs measurements

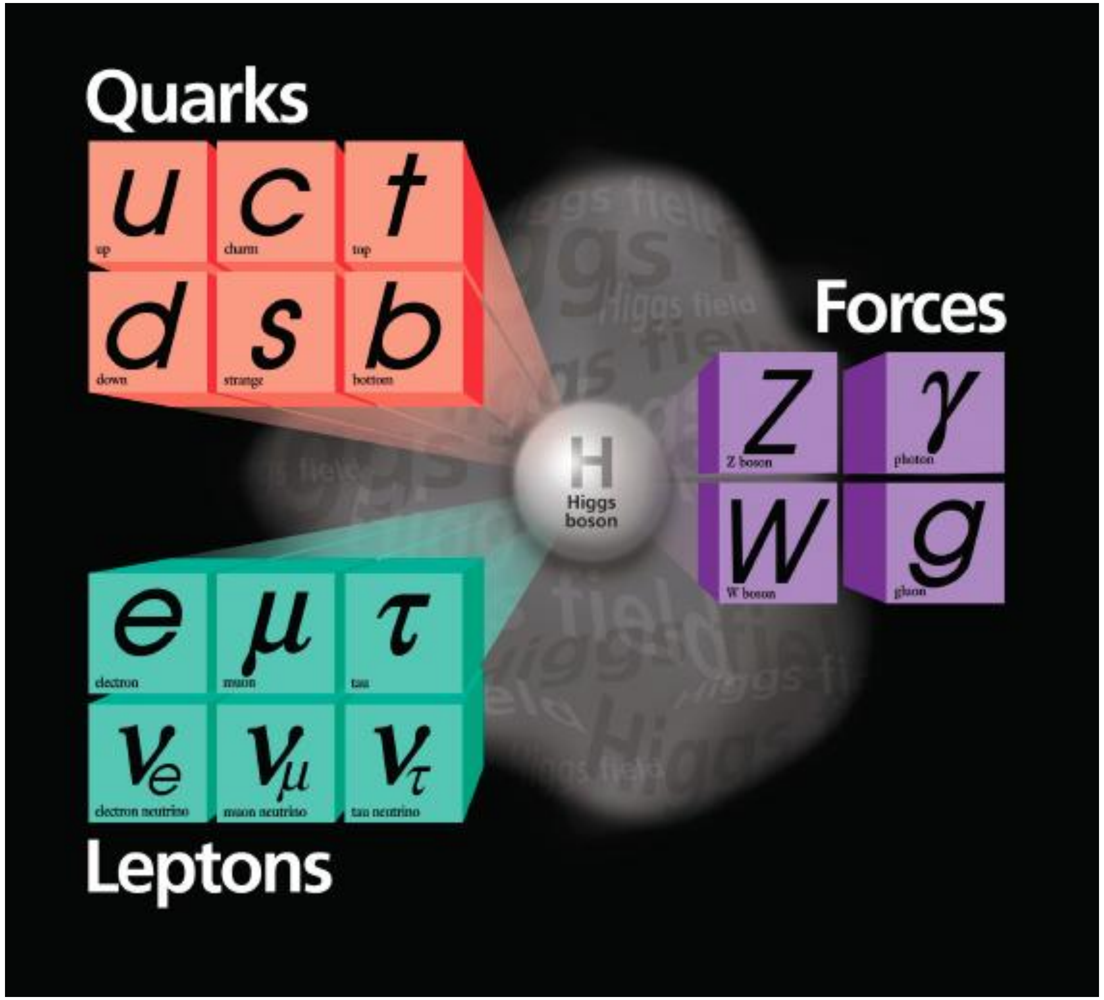
First Cover Article of《Nature-Physics》at BESIII

STCF potential：

- Provide the most precise multidimensional FFs distributions for q^2 ~4-50 GeV^2
- Polarized beam can further improve measurement accuracy and quality
- Critical input for experiments EIC、EicC、Jlab

Physics III: SM Parameters

Precise measurement is the critical approach for new physics investigation



Masses

Parameter	Value	Method
m_u	1.9 MeV	Lattice
m_d	4.4 MeV	Lattice
m_s	87 MeV	Lattice
m_c	1.3 MeV	Collider
m_b	4.24 MeV	Collider
m_t	173 GeV	Collider
m_e	511 keV	Non-collider
m_μ	106 MeV	Non-collider
m_τ	1.78 GeV	Collider
m_z	91.2 GeV	Collider
m_H	125 GeV	Collider

Couplings

Parameter	Value	Method
α	0.0073	non-collider + collider
G_F	1.17x10^{-5}	Non-collider
α_s	0.12	Lattice + collider

Flavour and CP violation

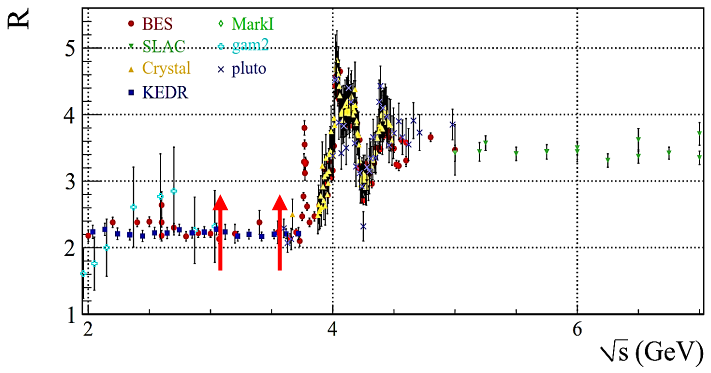
Parameter	Value	Method
θ_{12} (CKM)	13.1°	Collider
θ_{23} (CKM)	2.4°	Collider
θ_{13} (CKM)	0.2°	Collider
δ (CKM-CPV)	0.995	Collider
θ (strong CP)	~0	Non-collider

- **SM contains 19 free parameters: Quark and Lepton masses, CKM matrix, Couplings**
- **Basic physical quantities: R value etc**

R value measurement

One of the most fundamental physical quantities, directly reflecting the quark flavor and color, and providing experimental input for theoretical calculations of fine structure constants and anomalous magnetic moments of muons

$$R = \frac{\sigma(e^+e^- \to hadrons)}{\sigma(e^+e^- \to \mu^+\mu^-)}$$



- Running of fine structure constant $\Delta\alpha_{em}$

$$\Delta\alpha(s) = 1 - \alpha(0)/\alpha(s) = \Delta\alpha_{lepton}(s) + \Delta\alpha_{had}^{(5)}(s) + \Delta\alpha_{top}(s)$$

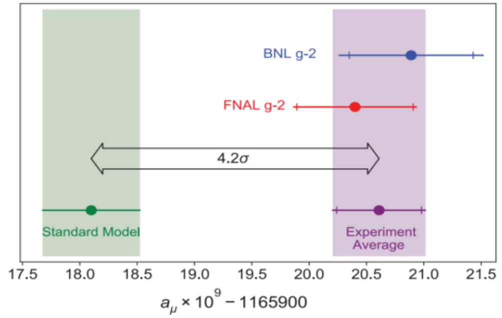
Eur. Phys. J. C 80, 241 (2020)

Source	Contribution($\times 10^{-4}$)
$\Delta\alpha_{lepton}(M_Z^2)$	314.979 ± 0.002
$\Delta\alpha_{had}^{(5)}(M_Z^2)$	276.0 ± 1.0
$\Delta\alpha_{top}(M_Z^2)$	-0.7180 ± 0.0054

- $\Delta\alpha_{had}^{(5)}(s)$ should be calculated with R value:

$$\Delta\alpha_{had}^{(5)}(s) = -\frac{\alpha s}{3\pi} \mathrm{Re} \int_{E_{th}}^{\infty} ds' \frac{R(s')}{s'(s' - s - i\varepsilon)}$$

- Muon anomalous magnetic moment a_μ



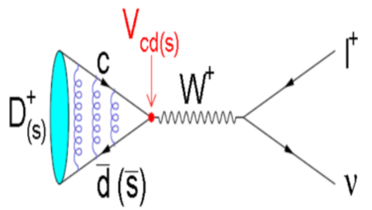
- SM : $a_\mu^{SM} = a_\mu^{QED} + a_\mu^{Weak} + a_\mu^{Had}$
  - Hadronic Vacuum Polarization (HVP) and Light-by-Light (HLbL) in a_μ^{Had} dominate uncertainty
- HVP contribution is calculated with R value with dispersion relation:

$$a_\mu^{\text{LO-HVP}} = \left(\frac{\alpha m_\mu}{3\pi}\right)^2 \int_{4m_\pi^2}^{\infty} ds \frac{R(s)K(s)}{s^2}$$

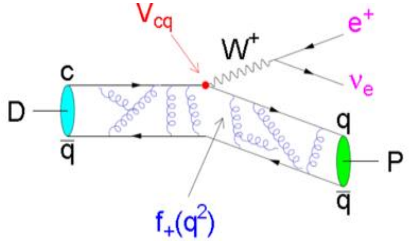
CKM Matrix

Unitarity breaking of the CKM matrix : the new generation quarks !

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}$$



$$\Gamma(D^+_{(s)} \to \ell^+ \nu_\ell) = \frac{G_F^2 f_{D^+_{(s)}}^2}{8\pi} \,|V_{cd(s)}|^2\, m_\ell^2 m_{D^+_{(s)}} \left(1 - \frac{m_\ell^2}{m_{D^+_{(s)}}^2}\right)^2$$



$$\frac{d\Gamma}{dq^2} = \frac{G_F^2}{24\pi^3} |V_{cs(d)}|^2 p^3_{K(\pi)} |f_+^{K(\pi)}(q^2)|^2$$

	BESIII	STCF	Belle II
Luminosity	2.93 fb^{-1} at 3.773 GeV	1 ab^{-1} at 3.773 GeV	50 ab^{-1} at $\Upsilon(nS)$
$\mathcal{B}(D^+ \to \mu^+\nu_\mu)$	$5.1\%_{stat}$ $1.6\%_{syst}$ [8]	$0.28\%_{stat}$	–
f_{D^+} (MeV)	$2.6\%_{stat}$ $0.9\%_{syst}$ [8]	$0.15\%_{stat}$	–
$\|V_{cd}\|$	$2.6\%_{stat}$ $1.0\%^{*}_{syst}$ [8]	$0.15\%_{stat}$	–
$\mathcal{B}(D^+ \to \tau^+\nu_\tau)$	$20\%_{stat}$ $10\%_{syst}$ [9]	$0.41\%_{stat}$	–
$\frac{\mathcal{B}(D^+ \to \tau^+\nu_\tau)}{\mathcal{B}(D^+ \to \mu^+\nu_\mu)}$	$21\%_{stat}$ $13\%_{syst}$ [9]	$0.50\%_{stat}$	–
Luminosity	3.2 fb^{-1} at 4.178 GeV	1 ab^{-1} at 4.009 GeV	50 ab^{-1} at $\Upsilon(nS)$
$\mathcal{B}(D_s^+ \to \mu^+\nu_\mu)$	$2.8\%_{stat}$ $2.7\%_{syst}$ [10]	$0.30\%_{stat}$	0.[illegible]$\%_{stat}$ [illegible]8$\%_{syst}$
$f_{D_s^+}$ (MeV)	$1.5\%_{stat}$ $1.6\%_{syst}$ [10]	$0.15\%_{stat}$	–
$\|V_{cs}\|$	$1.5\%_{stat}$ $1.6\%_{syst}$ [10]	$0.15\%_{stat}$	–
$f_{D_s^+}/f_{D^+}$	$3.0\%_{stat}$ $1.5\%_{syst}$ [10]	$0.21\%_{stat}$	–
$\mathcal{B}(D_s^+ \to \tau^+\nu_\tau)$	$1.9\%_{stat}$ $2.3\%^{\dagger}_{syst}$	$0.24\%_{stat}$	$0.6\%_{stat}$ $2.7\%_{syst}$
$f_{D_s^+}$ (MeV)	$0.9\%_{stat}$ $1.2\%^{\dagger}_{syst}$	$0.11\%_{stat}$	[illegible]
$\|V_{cs}\|$	$0.9\%_{stat}$ $1.2\%^{\dagger}_{syst}$	$0.11\%_{stat}$	–
$\bar{f}^{\mu\&\tau}_{D_s^+}$ (MeV)	$0.9\%_{stat}$ $1.0\%^{\dagger}_{syst}$	$0.09\%_{stat}$	0.3$\%_{stat}$ 1.0$\%_{syst}$
$\|\bar{V}^{\mu\&\tau}_{cs}\|$	$0.9\%_{stat}$ $1.0\%_{syst}^{\dagger}$	$0.09\%_{stat}$	–
$\frac{\mathcal{B}(D_s^+ \to \tau^+\nu_\tau)}{\mathcal{B}(D_s^+ \to \mu^+\nu_\mu)}$	$3.6\%_{stat}$ $3.0\%^{\dagger}_{syst}$	$0.38\%_{stat}$	$0.9\%_{stat}$ $3.2\%_{syst}$

Theory : 0.2% (0.1% expected)

Theory : 0.2% (0.1% expected)

Theory : 0.2% (0.1% expected)

- The stat. errors in | V_{cs} | and | V_{cd} | measurements will reach the expected theoretical level, and syst. errors will become critical.
- The decay of Tau and hyperons will provide opportunities for improving the measurement accuracy of | V_{us} | and | V_{ud} |

STCF Sensitivities and Comparisons

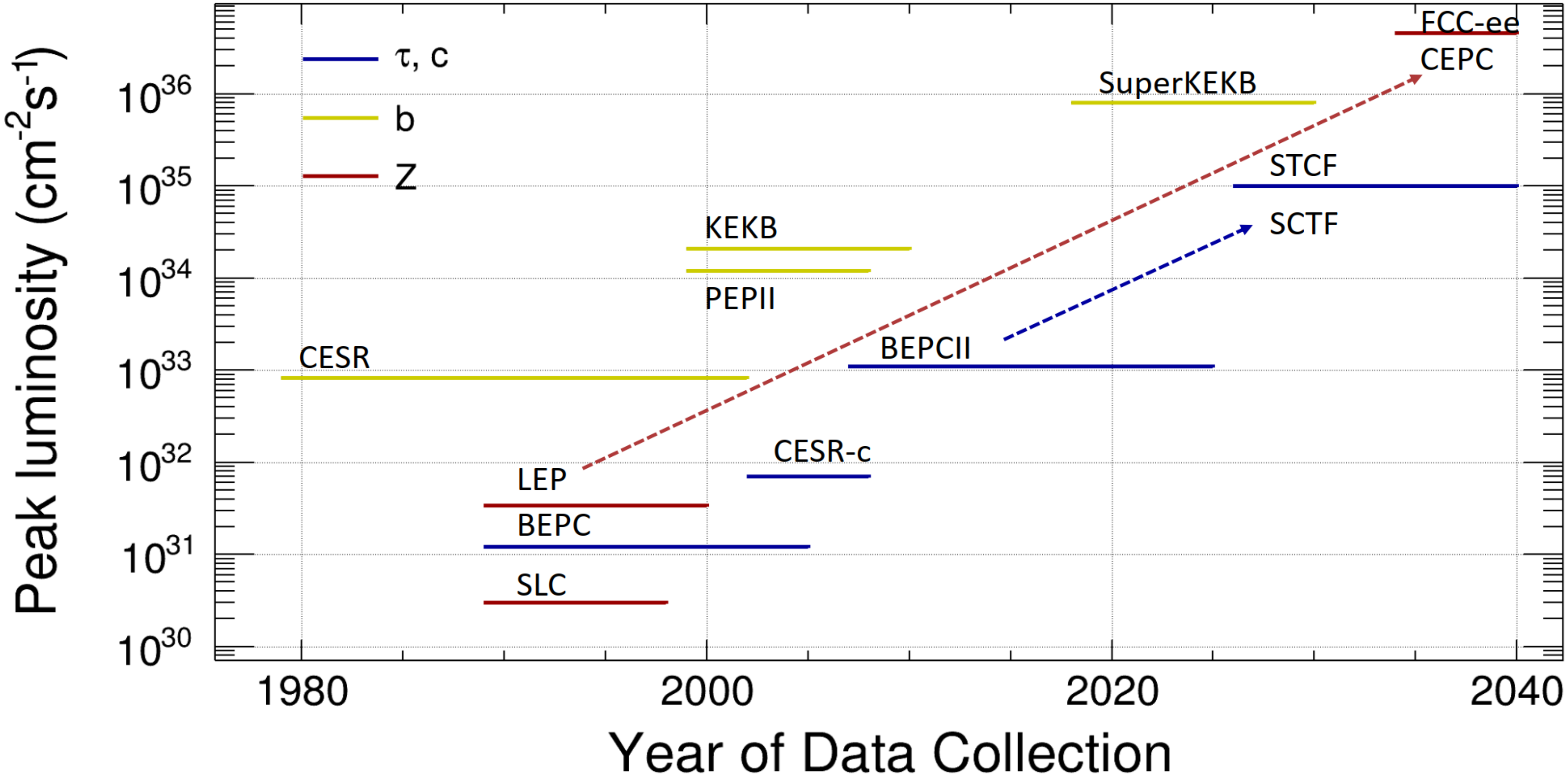
Physics goal	Observable	BESIII	Current world best	STCF prospect(1 ab^{-1})
Fundamental Symmetry	A_{CP} in hyperon decay	0.005	0.005	$\mathcal{O}(10^{-4})$
	weak phase in hyperon decay	1.2°	1.2°	0.04°
	Δ_{CP} in tau decay	-	0.25%	$\mathcal{O}(10^{-3})$
	EDM of hyperon	-	$\mathcal{O}(10^{-16})$ $e$cm	$\mathcal{O}(10^{-21})$ $e$cm
	EDM of tau	-	$\mathcal{O}(10^{-17})$ $e$cm	$\mathcal{O}(10^{-18})$ $e$cm
	cLFV in $\tau \to \mu\mu\mu$	-	2.1×10^{-8}	$\mathcal{O}(10^{-9})$
	cLFV in $J/\psi \to e\mu$	4.5×10^{-9}	4.5×10^{-9}	$\mathcal{O}(10^{-11})$
	cLFV in $J/\psi \to e\tau$	7.5×10^{-8}	7.5×10^{-8}	$\mathcal{O}(10^{-10})$
Quark Confinement	$N_{Y(4260)/Z_c/X(3872)}$	$10^7/10^6/10^4$	$10^6/10^5/10^6$	$10^9/10^8/10^6$
	Pentaquarks	-	P_cs in $J/\psi p(\Lambda)$	$\sigma_{J/\psi p\bar{p}} \simeq 4$ fb
	Di-charmonium	-	di-ψ	$\sigma_{J/\psi c\bar{c}} \simeq 10$ fb
	$N_{J/\psi/\psi(3686)}$	$10^{10}/10^9$	$10^{10}/10^9$	$10^{12}/10^{11}$
	Collins effects	0.3	0.3	$\mathcal{O}(10^{-3})$
	Baryon form factors	10%	10%	$\mathcal{O}(10^{-2})$
Physical Quantities	R value	3%	3%	$\mathcal{O}(10^{-3})$
	tau mass	160 keV	120 keV	$\mathcal{O}(10)$ keV
	$\lvert V_{us}\rvert$	-	1%	$\mathcal{O}(10^{-3})$
	$\lvert V_{cd}\rvert$	1.2%	1%	$\mathcal{O}(10^{-3})$
	$\lvert V_{cs}\rvert$	1.4%	1.4%	$\mathcal{O}(10^{-3})$
	Sys. unc. of γ from D decay	0.4°	0.4°	0.1°
	α_s	-	1.5%	$\mathcal{O}(10^{-3})$

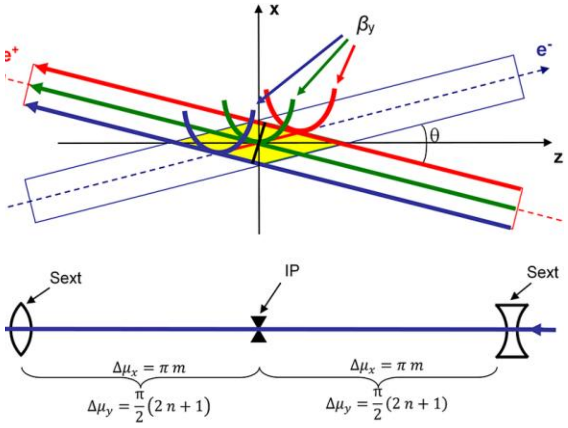
CONTENTS

Collider Development

1st Generation	2nd Generation	3rd Generation
Single ring	Double-ring More bunches Low b_y@IP	Double-ring Large Ib and crossing angle Extremely low b_y@IP

$$L = \frac{\gamma n_b I_b}{2 e r_e \beta_y^*} \xi_y H$$

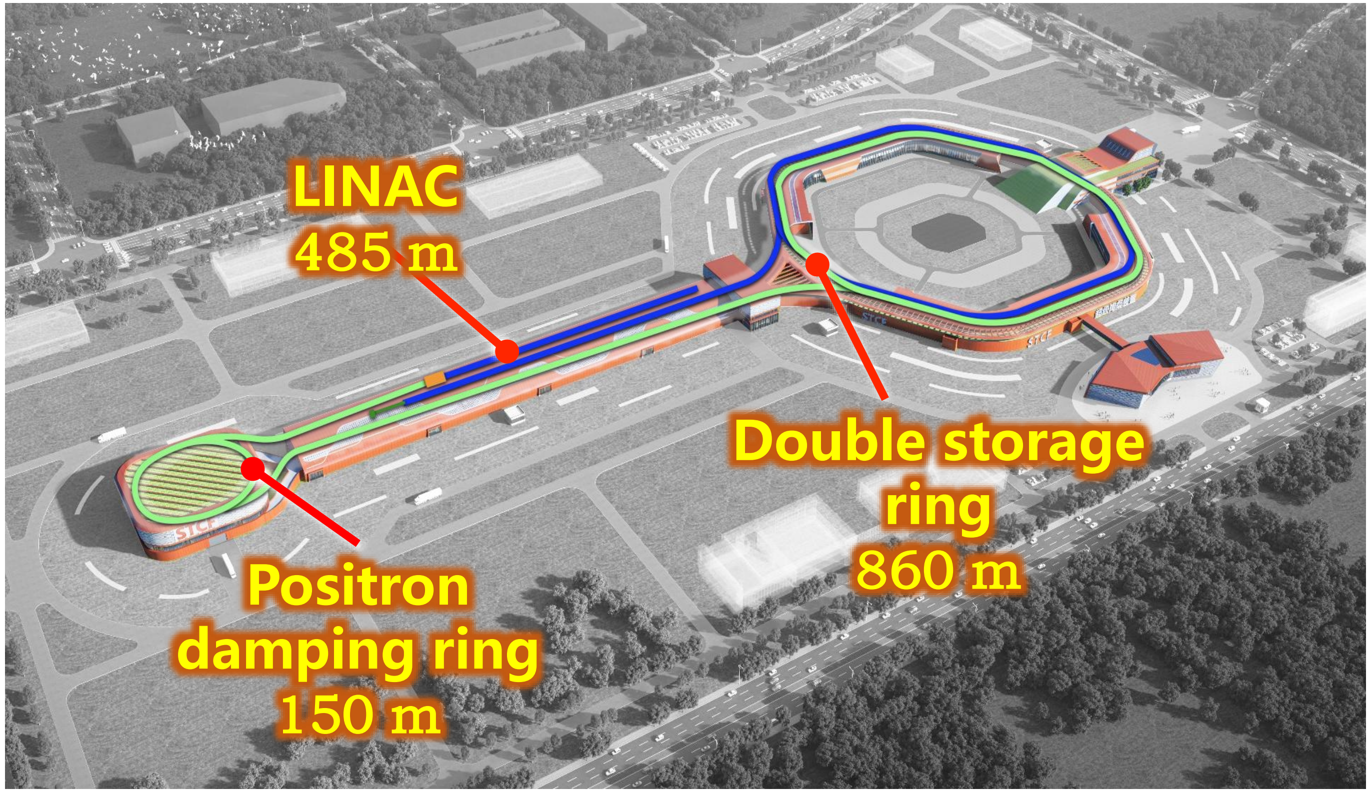




Large Piwinski Angle + Crab Waist

STCF Design Goals and Accelerator

- Core design goal:
  - CMS energy: 2-7 GeV
  - Luminosity: $>5\times10^{34}$ $cm^{-2}s^{-1}$ @ 4GeV
  - Upgrading potential: polarized beam, higher luminosity




arXiv > physics > arXiv:2509.11522

Physics > Accelerator Physics

[Submitted on 15 Sep 2025 (v1), last revised 16 Sep 2025 (this version, v2)]

Conceptual Design Report of Super Tau-Charm Facility: The Accelerator

Jiancong Bao, Anton Bogomyagkov, Zexin Cao, Mingxuan Chang, Fangzhou Chen, Guanghua Chen, Qi Chen, Qushan Chen, Zhi Chen, Kuanjun Fan, Hailiang Gong, Duan Gu, Hao Guo, Tengjun Guo, Chongchao He, Tianlong He, Kaiwen Hou, Hao Hu, Tongning Hu, Xiaocheng Hu, Dazhang Huang, Pengwei Huang, Ruixuan Huang, Zhicheng Huang, Hangzhou Li, Renkai Li, Sangya Li, Weiwei Li, Xuan Li, Xunfeng Li, Yu Liang, Chao Liu, Tao Liu, Xiaoyu Liu, Xuyang Liu, Yuan Liu, Huihui Lv, Qing Luo, Tao Luo, Mikhail Skamarokha, Shaohang Ma, Wenbin Ma, Masahito Hosaka, Xuece Miao, Yihao Mo, Kazuhito Ohmi, Jian Pang, Guoxi Pei, Zhijun Qi, Fenglei Shang, Lei Shang, Caitu Shi, Kun Sun, Li Sun, Jingyu Tang, Anxin Wang, Chengzhe Wang, Hongjin Wang, Lei Wang, Qian Wang, Shengyuan Wang, Shikang Wang, Ziyu Wang, Shaoqing Wei, Yelong Wei, Jun Wu, Sang Wu, Chunjie Xie, Ziyu Xiong, Xin Xu, Jun Yang, Penghui Yang, Tao Yang, Lixin Yin, Chen Yu, Ze Yu, Youjin Yuan, Yifeng Zeng, Ailin Zhang, Haiyan Zhang, Jialian Zhang, Linhao Zhang, Ning Zhang, Ruiyang Zhang, Xiaoyang Zhang, Yihao Zhang, Yangcheng Zhao, Jingxin Zheng, Demin Zhou, Hao Zhou, Yimei Zhou, Zeran Zhou, Bing Zhu, Xinghao Zhu, Zi'an Zhu, Ye Zou

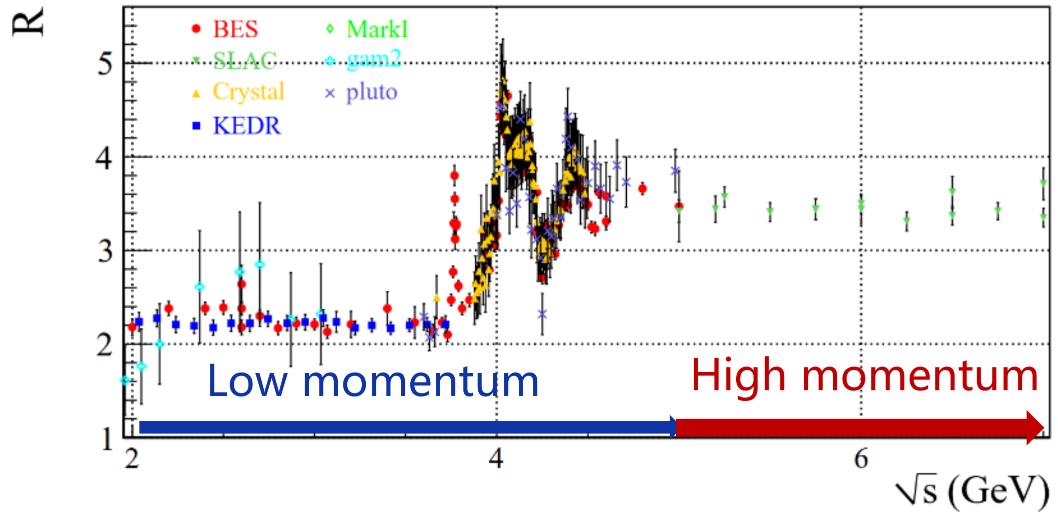
Electron-positron colliders operating in the GeV region of center-of-mass energies or the Tau-Charm energy region, have been proven to enable competitive frontier research, due to its several unique features. With the progress of high energy physics in the last two decades, a new-generation Tau-Charm factory, Super Tau Charm Facility (STCF) has been actively promoting by the particle physics community in China. STCF holds great potential to address fundamental questions such as the essence of color confinement and the matter-antimatter asymmetry in the universe in the next decades. The main design goals of STCF are with a center-of-mass energy ranging from 2 to 7 GeV and a peak luminosity surpassing 5*10^34 cm^-2s^-1 that is optimized at a center-of-mass energy of 4 GeV, which is about 50 times that of the currently operating Tau-Charm ... an injector ... STCF a... acceler... CF project aims to secure support from the Chinese central government for its construction during the 15th Five-Year Plan (2026-2030) in China.

NEW!

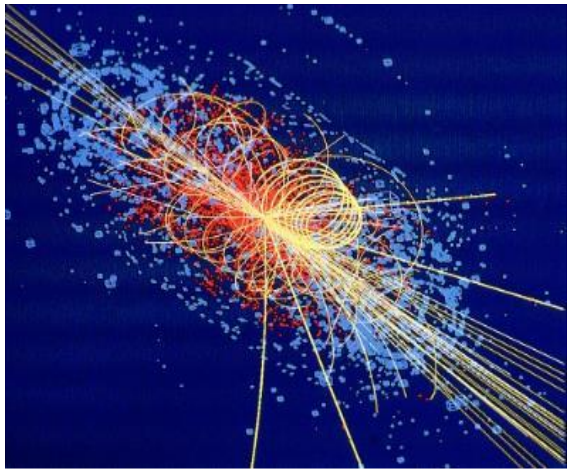
CDR released in 15/09/2025
arXiv: 2509.11522

Challenges for Detector Design

Wide Energy region E_{cm} : 2-7 GeV



Peak Luminosity ~5 × 10^{34} $cm^{-2}s^{-1}$

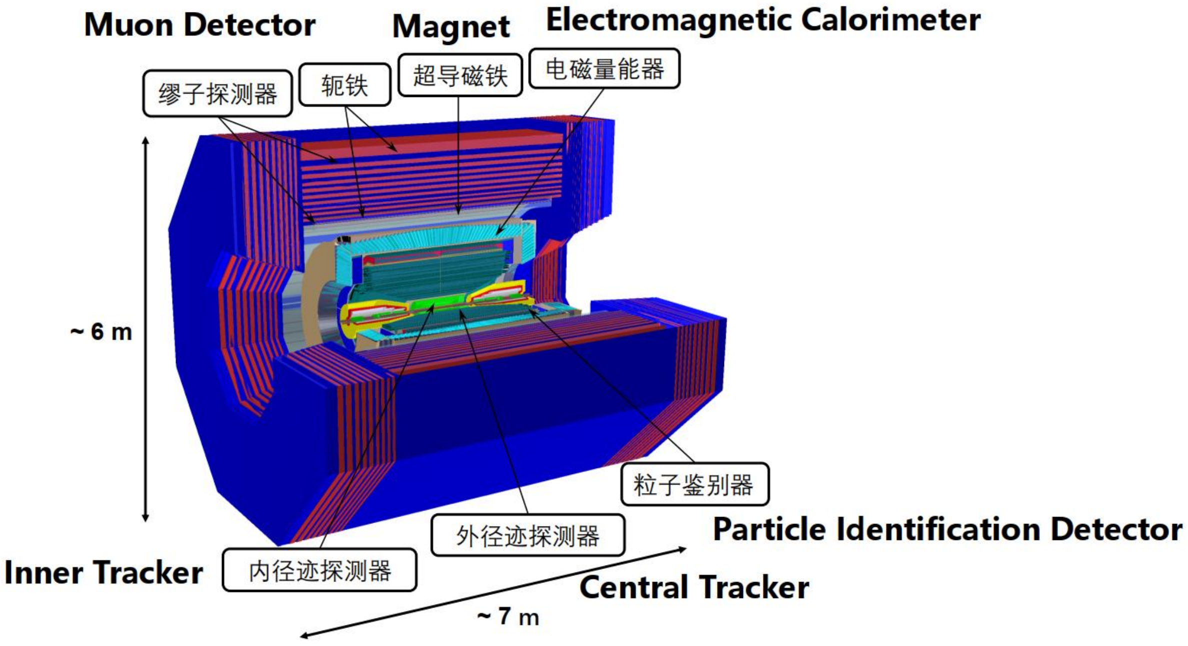


Physical signal rate ~400 kHz

High counting rate ~1 MHz/cm^2

High data rate ~10 GB/s

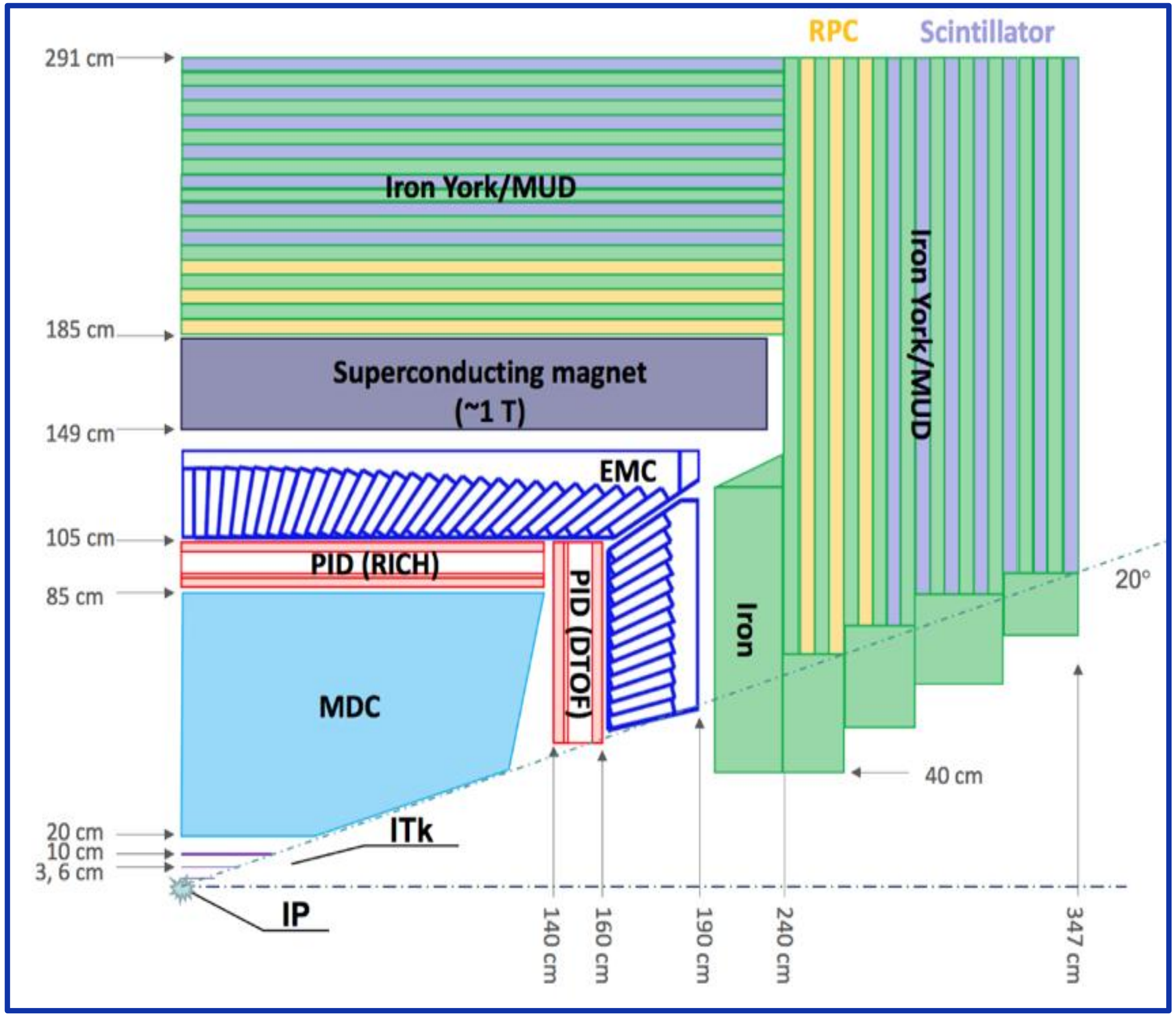
High radiation background ~4 kGy/y,~$2\times10^{11} n_{eq}/cm^2/y$



Main performance

Geometric coverage :	94%×4π
Momentum res. :	σ_p/p ~ 0.5% @ 1GeV
Energy res. :	σ_E/E ~ 2.5% @ 1GeV
Hadron PID:	π/K separation ~4σ @ 2GeV
Muon ID:	ε_μ>95%, $\varepsilon_{miss\text{-}ID}$<3% @ 1GeV

Detector Layout

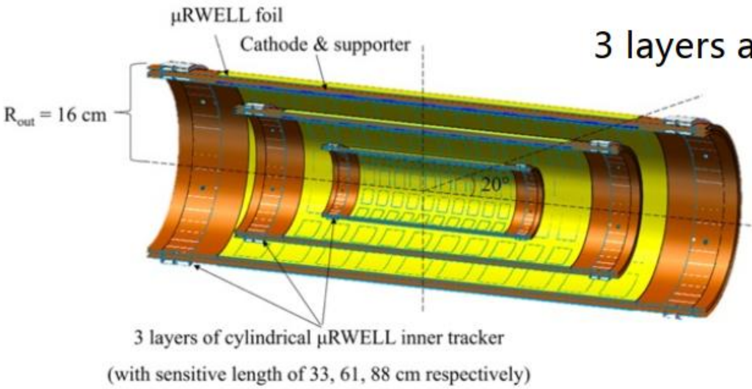


- Inner tracker (ITK, two options)
  - MPGD: cylindrical MPGD
  - Silicon: CMOS MAPS
- Central tracker
  - Main drift chamber (MDC)
- Particle identification (PID)
  - Barrel (two options):
    1. RICH with CsI-MPGD
    2. Barrel DIRC-like TOF
  - Endcaps: DIRC-like TOF (DTOF)
- Electromagnetic Calorimeter (EMC)
  - pure CsI + APD
- Muon detector (MUD)
  - RPC + scintillator strips
- Magnet
  - Super-conducting solenoid, 1 T

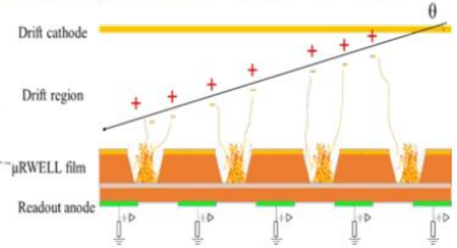
Tracking System: ITK + MDC

σ<130μm， Trk Eff>90%@0.1GeV/c and >99%@0.3GeV/c，σ_p ~0.5%@1GeV/c

ITK Gaseous option : MPGD

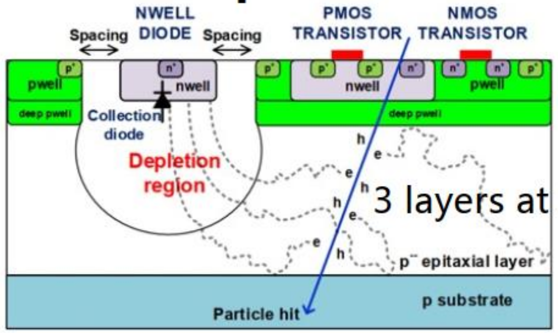


3 layers at 6cm, 11cm and 16 cm



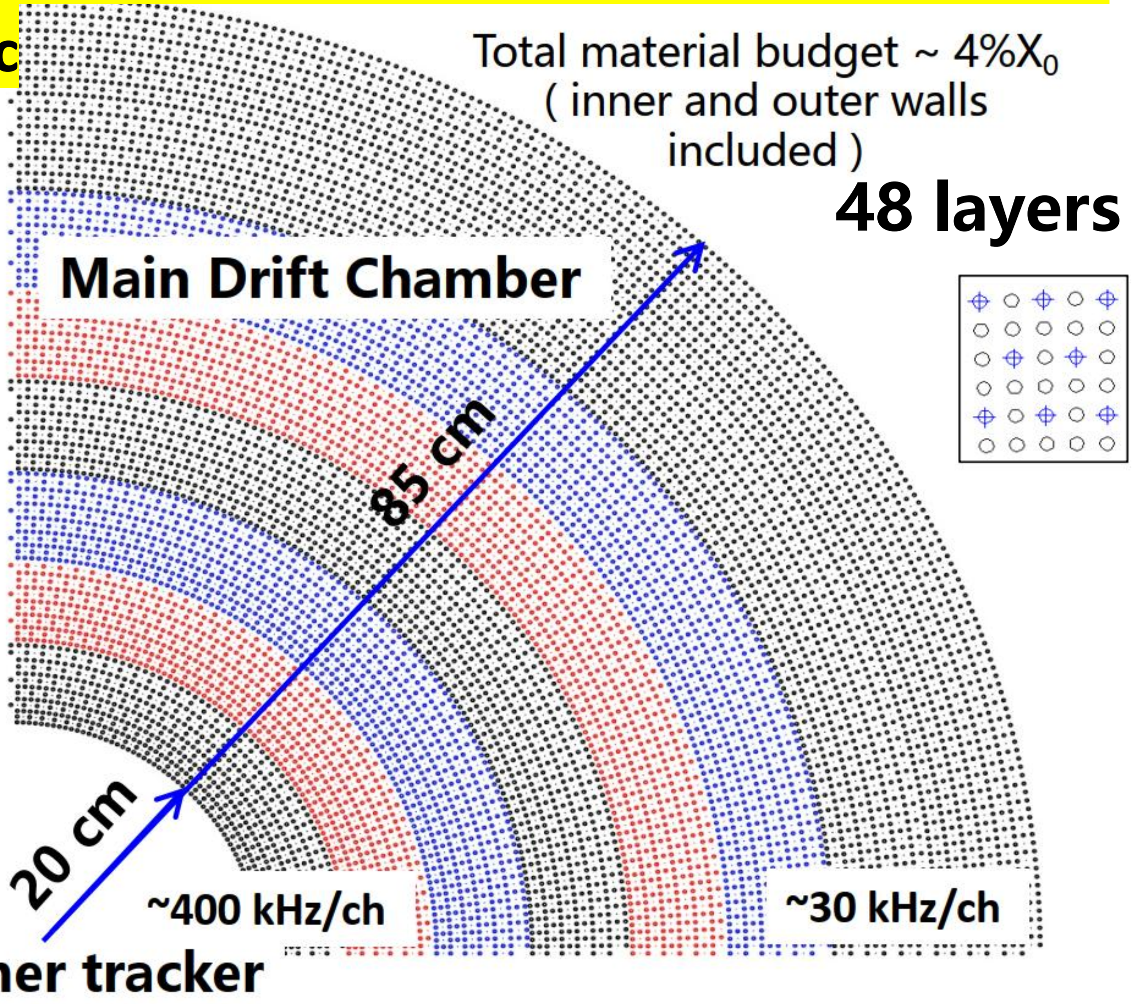
Material budget ~ 0.3%X_0/layer

ITK Silicon option: CMOS MAPS



单片有源像素探测器

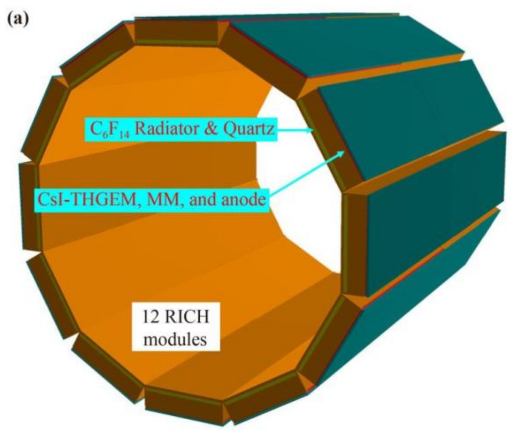
3 layers at 3.6cm, 9.8cm and 16 cm

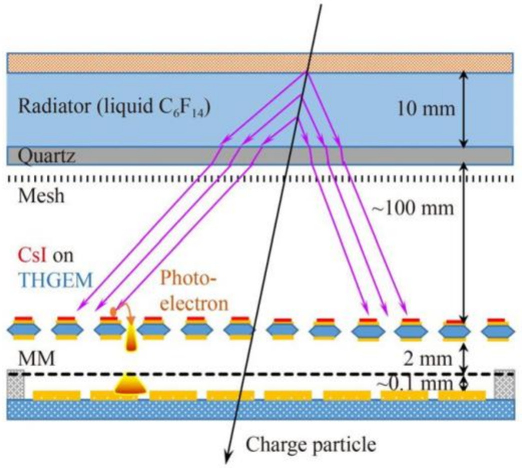


Inner-outer separate designs to accommodate different levels of radiation background

PID System

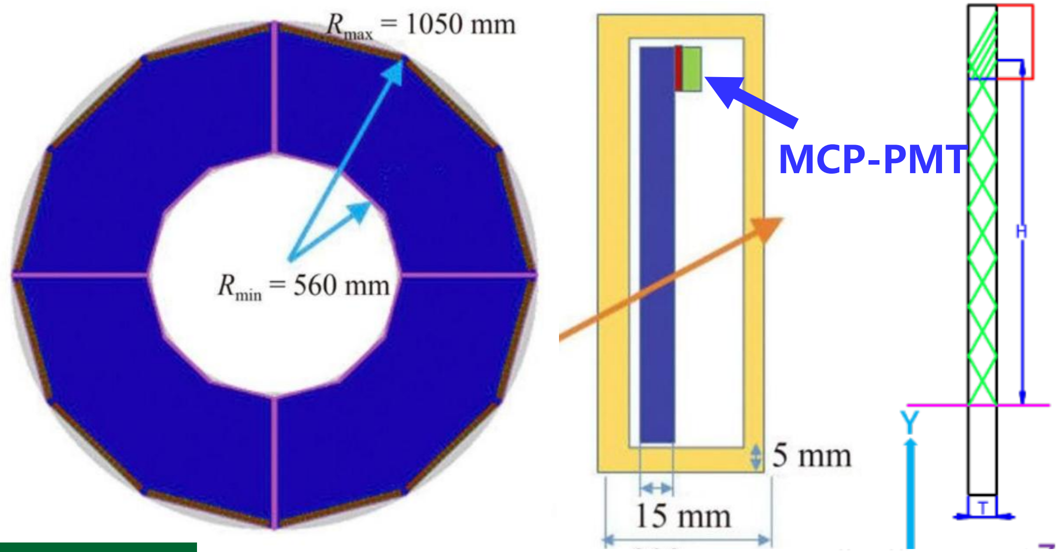
Barrel PID: A RICH detector using MPGD (THGEM with CsI + MM) for photon detection





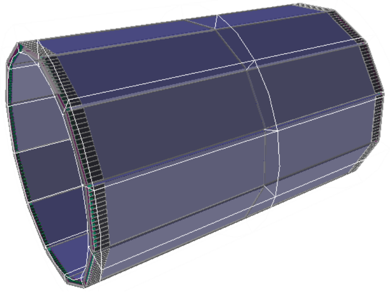
Material Bugdet < $0.3X_0$

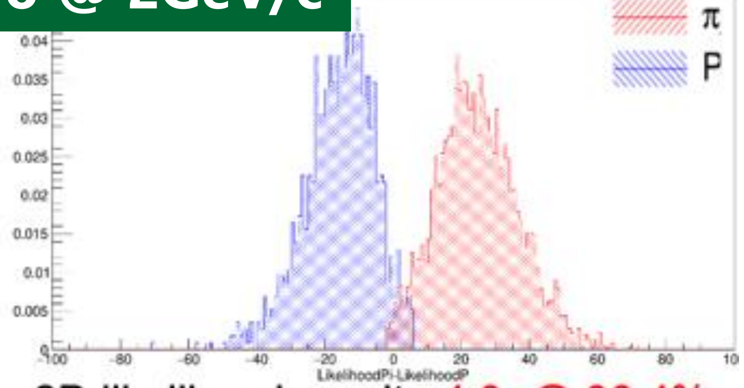
Endcap PID: A DIRC-like high-resolution TOF (~ 30 ps), quartz plate + MCP-PMT



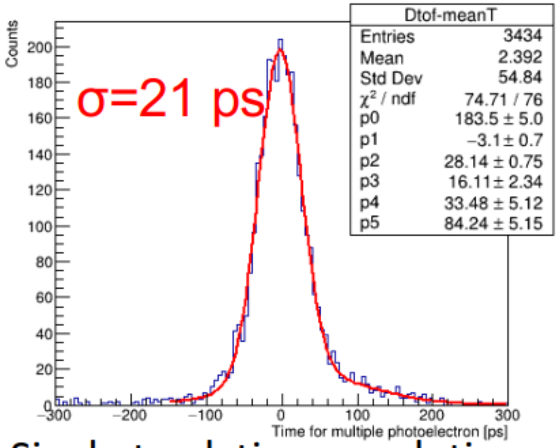
π/K separation 4σ @ 2GeV/c

Alternative option, BTOF: the same technology as the endcap PID





2D likelihood result ~4.0σ@ 98.4% e

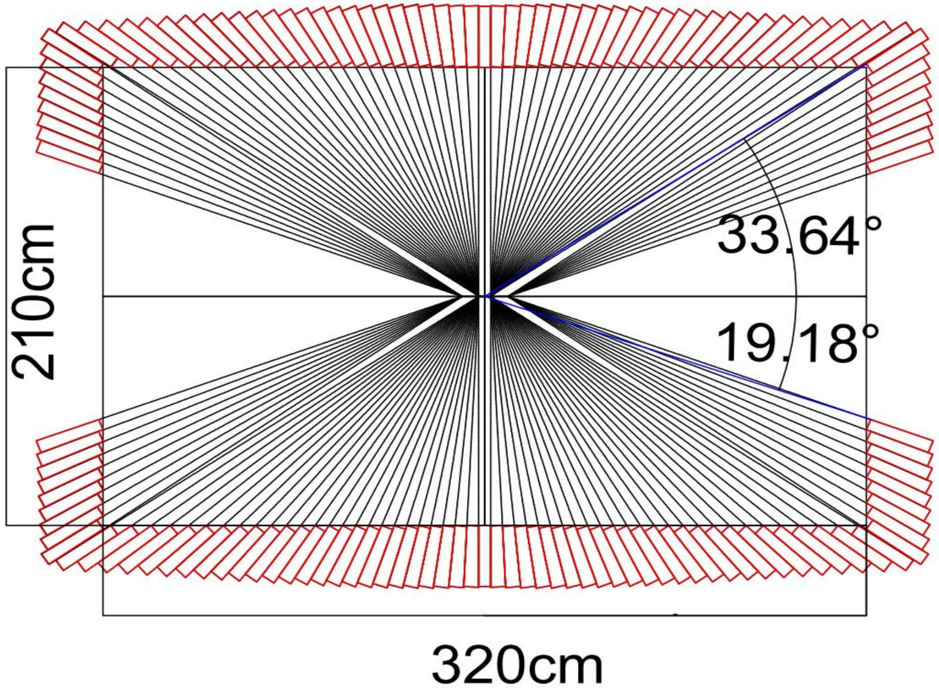


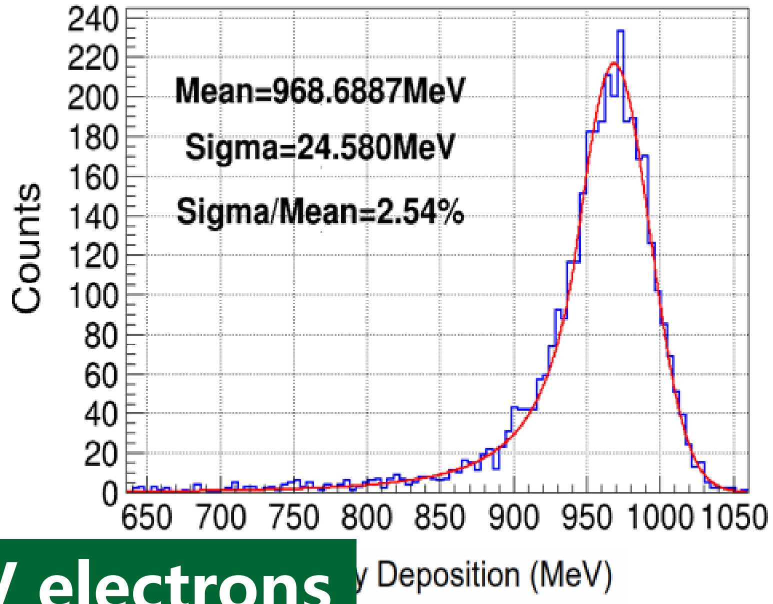
Single track time resolution

Electromagnetic Calorimeter

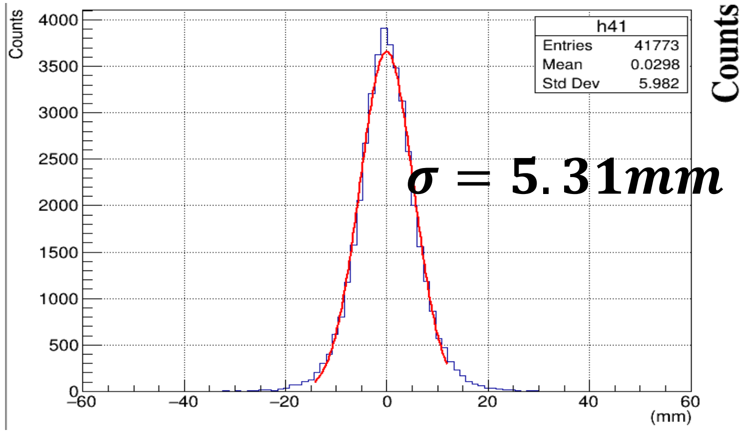
EMC: A pure-CsI crystal calorimeter to tackle a high level of background (~1MHz/ch)

- **Crystal size : 28cm ($15X_0$) 5×5 cm^2**
- **~ 8670 crystals**
- **4 large area APDs, (1×1 cm^2) to enhance light yield**

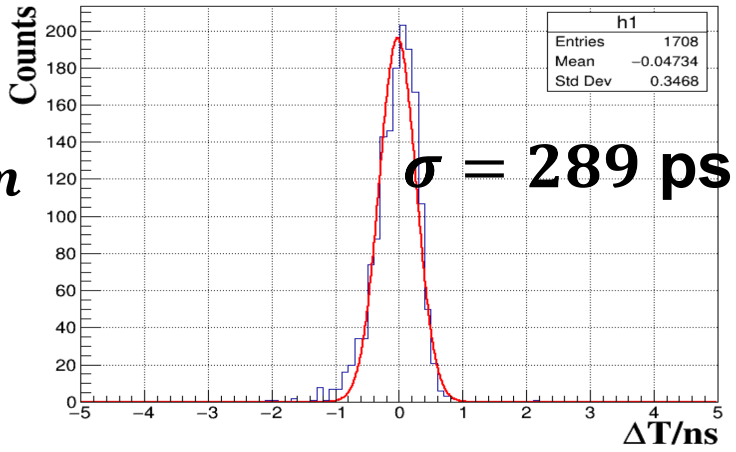




1 GeV electrons



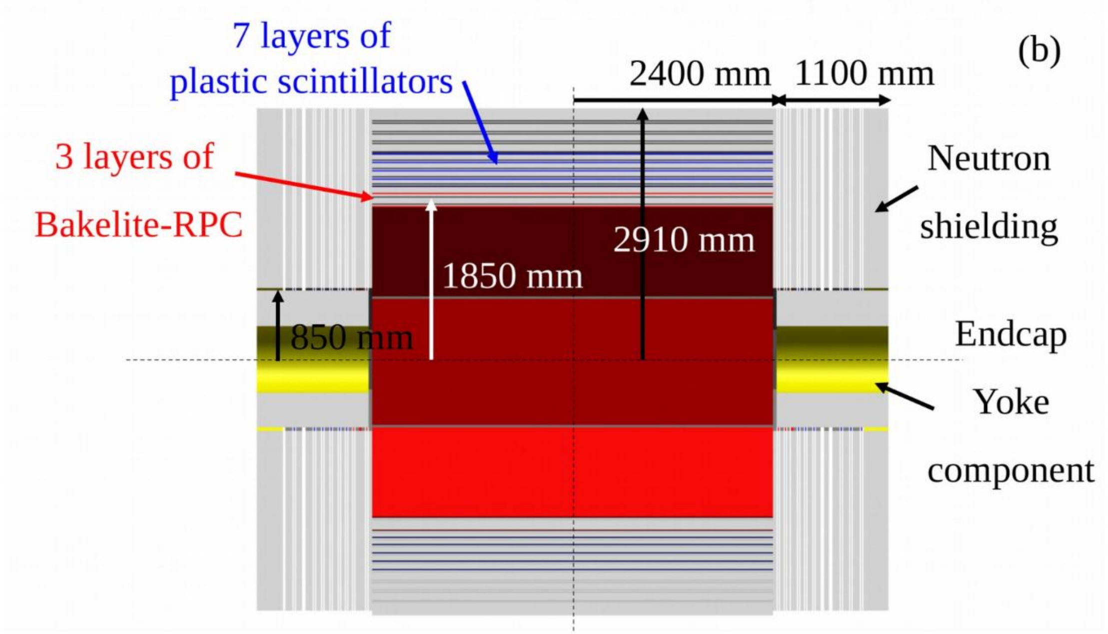
$\sigma = 5.31mm$



$\sigma = 289$ ps

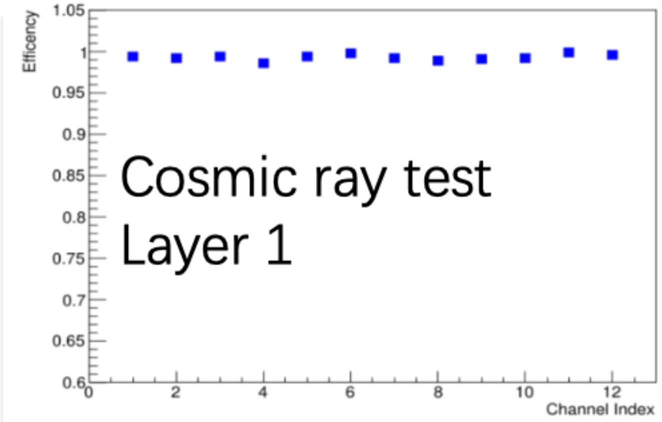
Muon Detector

MUD: A RPC-scintillator hybrid detector to optimize muon and neutral hadron ID

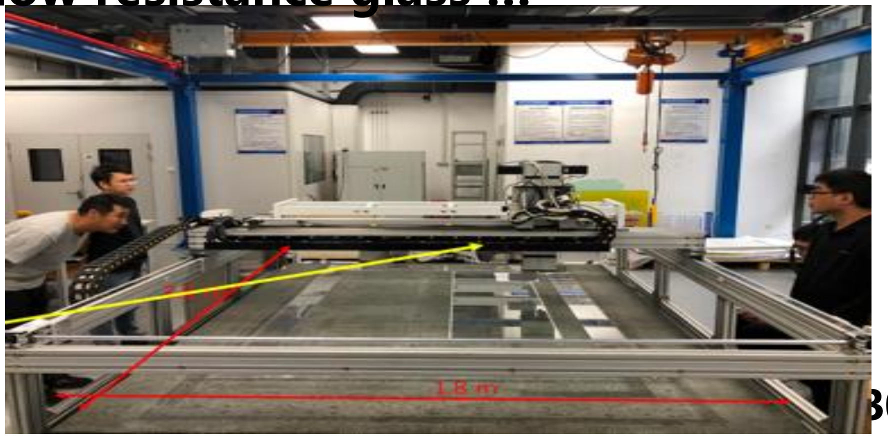


Parameter	Baseline design
R_{in} [cm]	185
R_{out} [cm]	291
R_e [cm]	85
L_{Barrel} [cm]	480
T_{Endcap} [cm]	107
Segmentation in ϕ	8
Number of detector layers	10
Iron yoke thickness [cm]	4/4/4.5/4.5/6/6/6/8/8 cm
(λ=16.77 cm)	Total: 51 cm, 3.04λ
Solid angle	79.2% $\times$ 4π in barrel
	14.8% $\times$ 4π in endcap
	94% $\times$ 4π in total
Total area [m^2]	Barrel ~717
	Endcap ~520
	Total ~1237

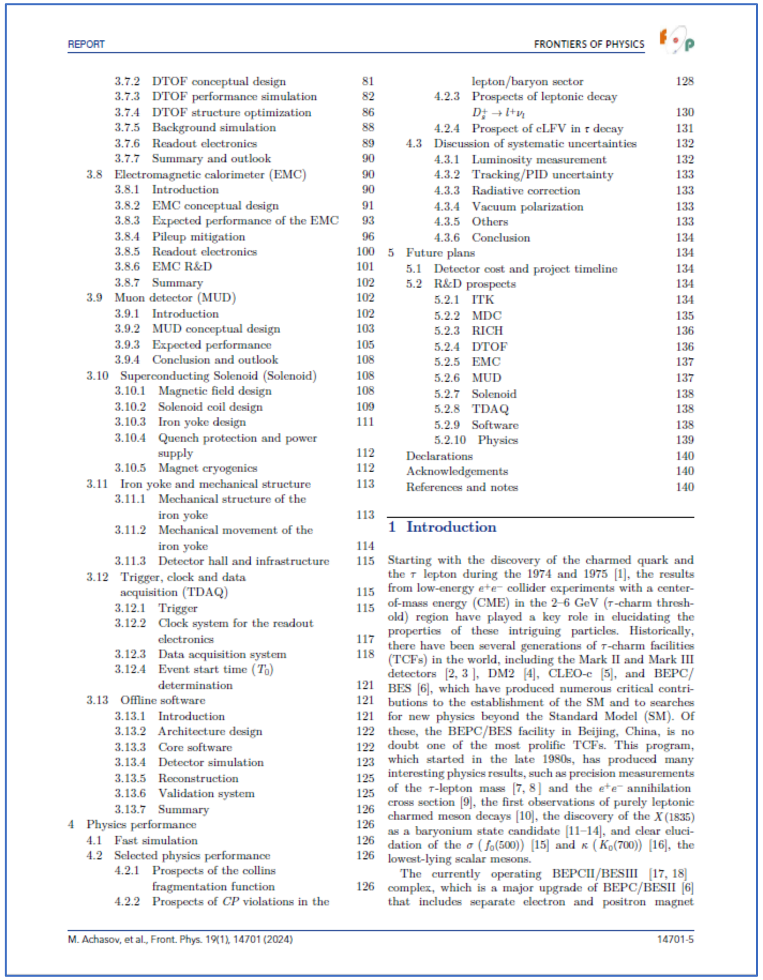
Scintillator prototype



RPC prototype： different air gaps, low resistance glass …



Conceptual Design Report

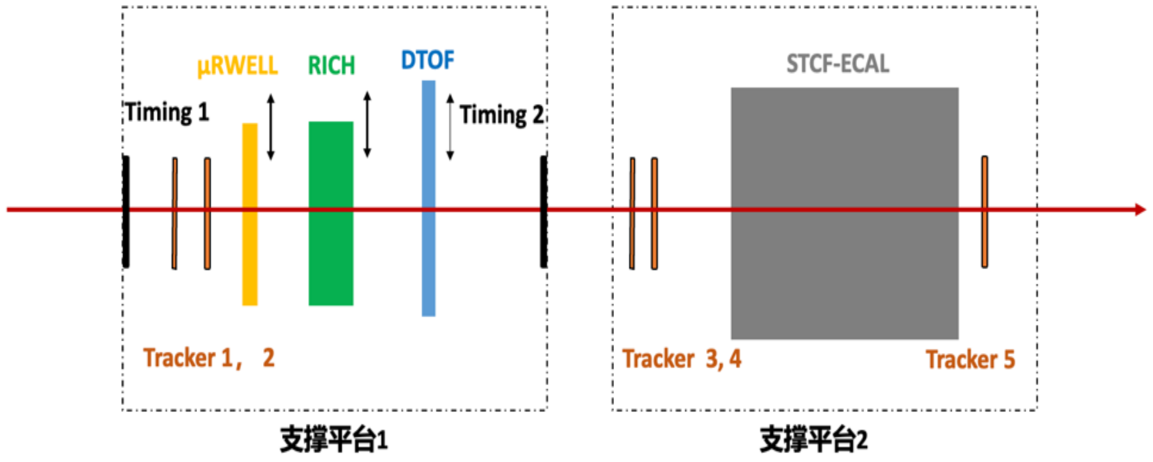


82 institutions, 453 authors

arXiv:2303.15790

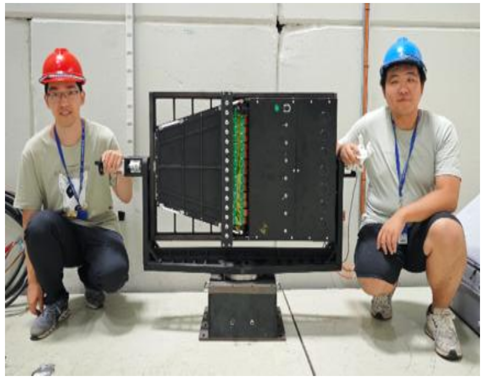
Combined Beam Test

A test beam campaign for a combined system (DTOF, EMC, DAQ)



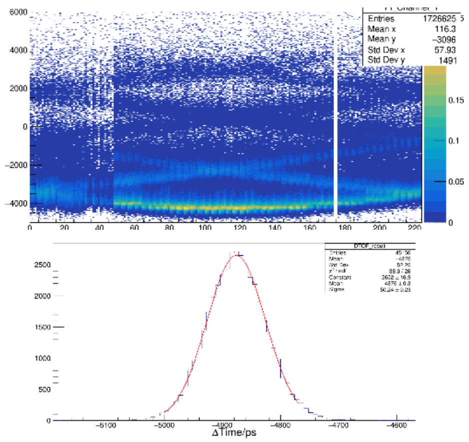
CERN PS T9 beam line (July 31 – August 14，2024)

DTOF prototype

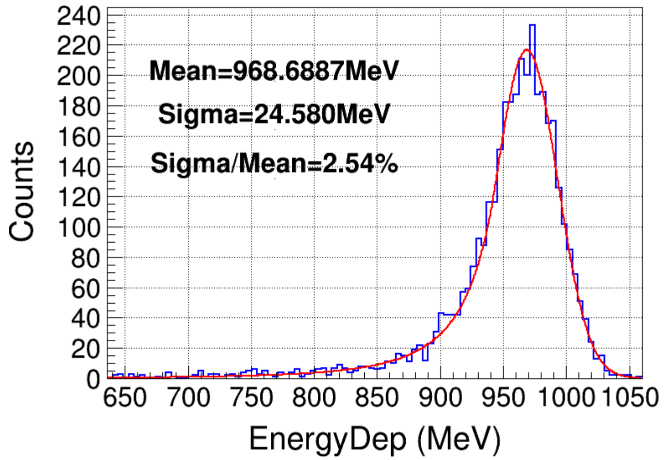


EMC prototype

DTOF: σ_t~25 ps

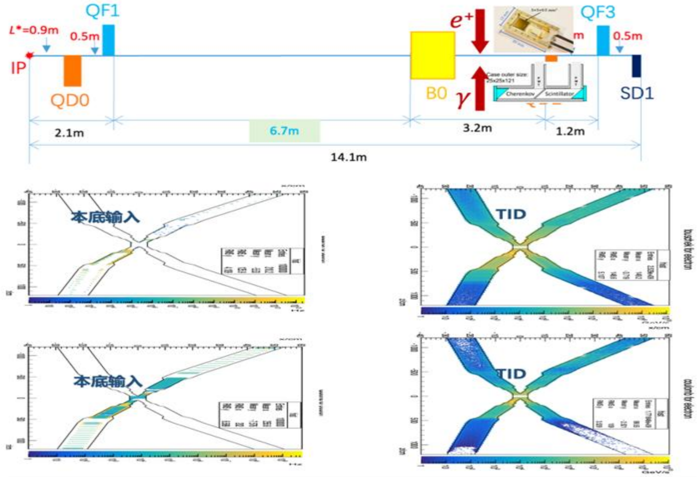


EMC: σ_E/E ~2.5%

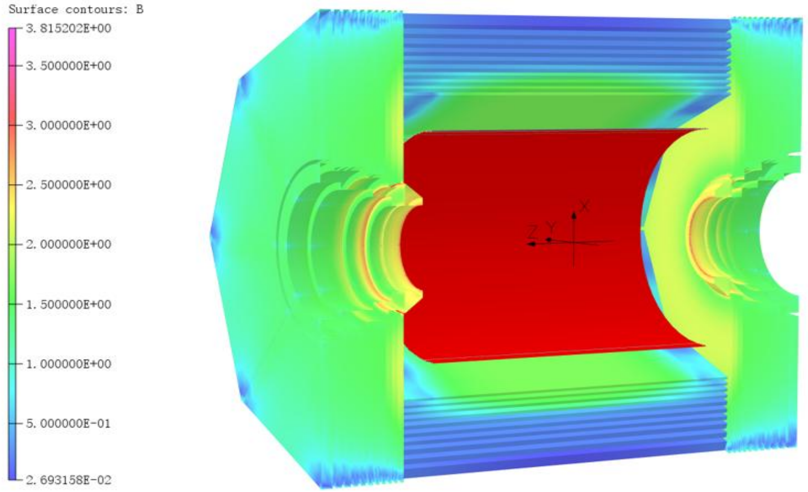


Other Systems

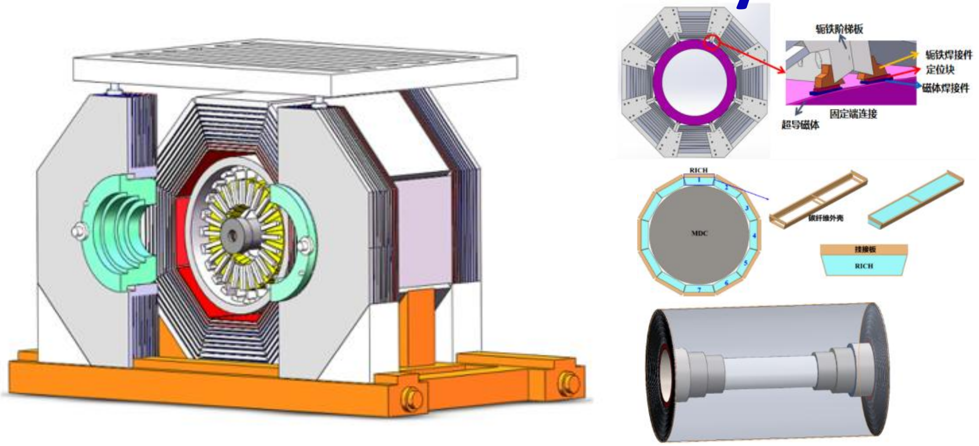
Forward System



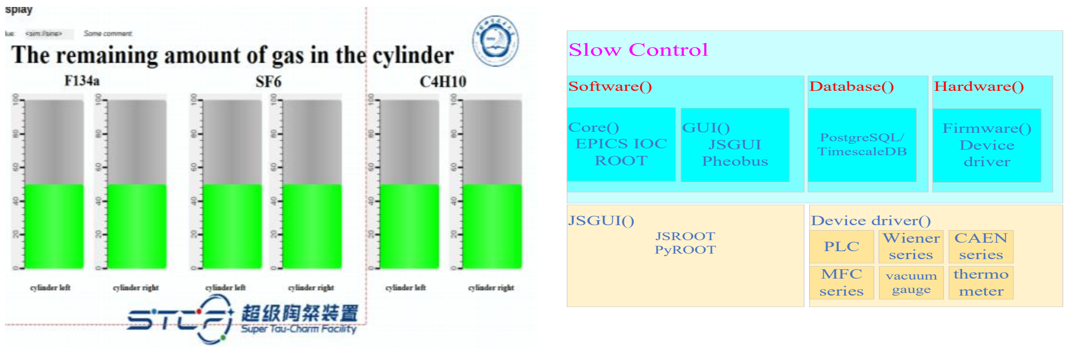
Superconducting magnet



Detector mechanical system



Detector control system

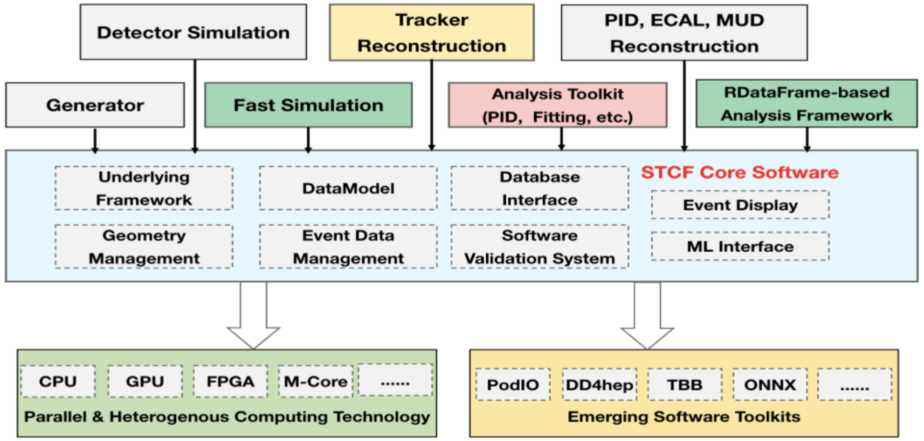


Software Progress and Achievements

◆ Offline software system OSCAR (Offline Software of Super Tau Charm Facility) : performance and scheme optimization of detectors, and physics feasibility study

International advanced technology:

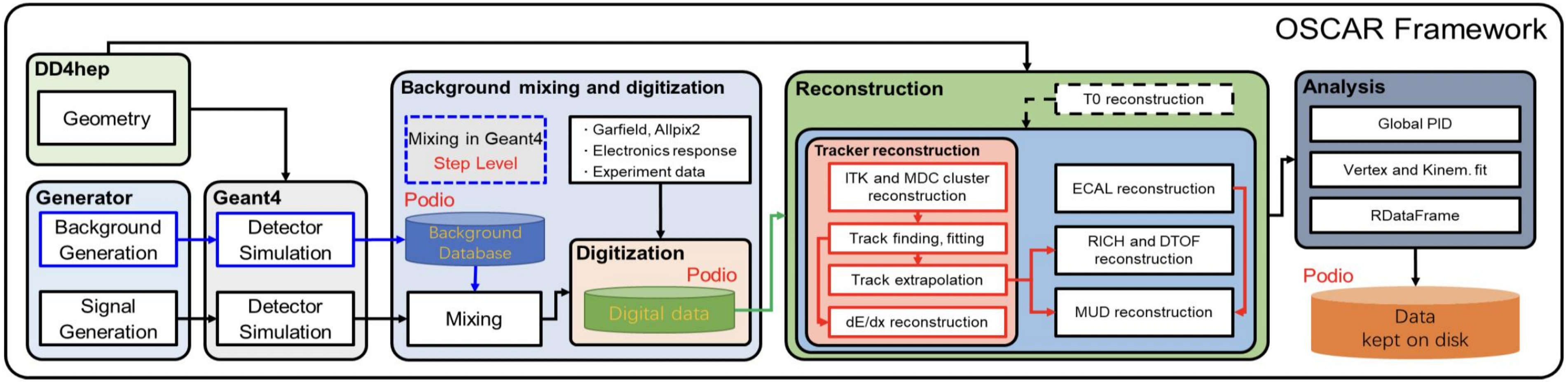
- PODIO: Efficient and Rapid Event Model Definition Tool
- DD4hep: Efficient and flexible geometric definition Tool for detectors
- TBB: Intel Multi Threading Building Module
- OneAPI: Intel's Cross Architecture Programming Model
- ONNX: Open source for deep learning model
- SNiPER: China's independently developed new software framework
- ACTS: track reconstruction software tool at ATLAS



◆ Developed OSCAR important component, built a complete offline data processing and analysis process; released more than 20 versions

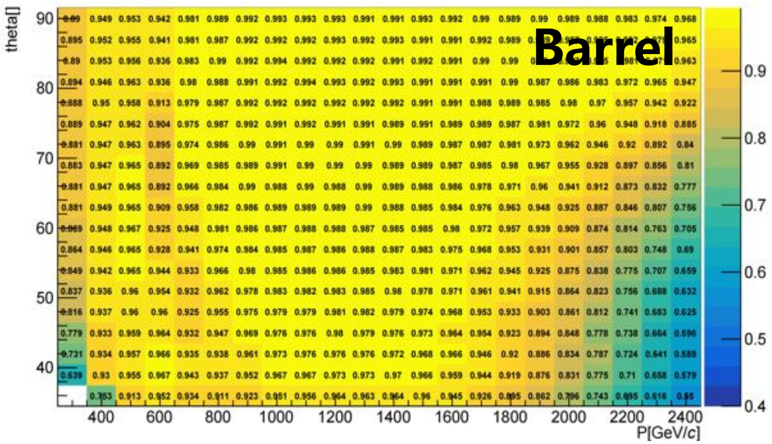
Core components:

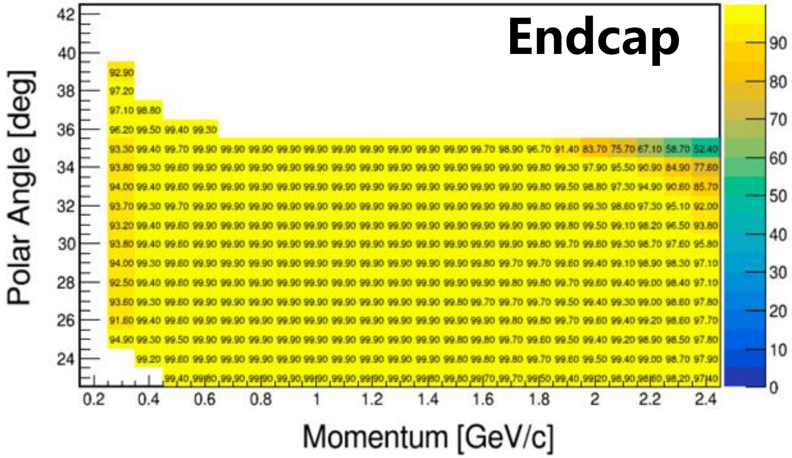
- Core software
- Event generation
- Detector simulation
- Background mixing
- Event reconstruction
- Physics analysis
- Event display
- Performance test



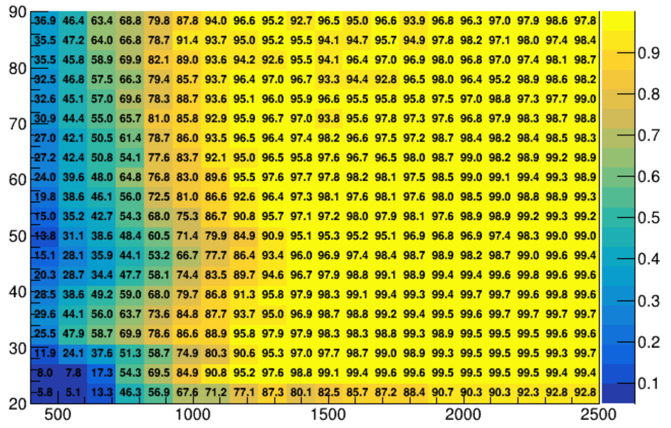
Performances with Full Simulation

PID: Pion ID eff. >97% @ mis-ID (K->pi)=2%



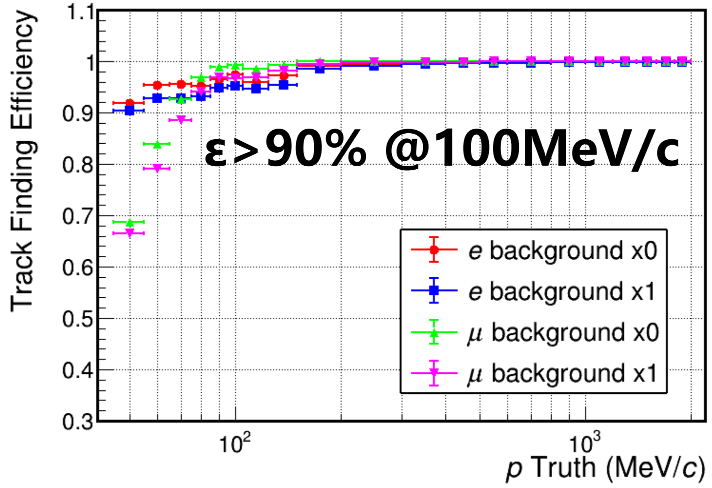


Muon ID eff. @ pi suppression=30

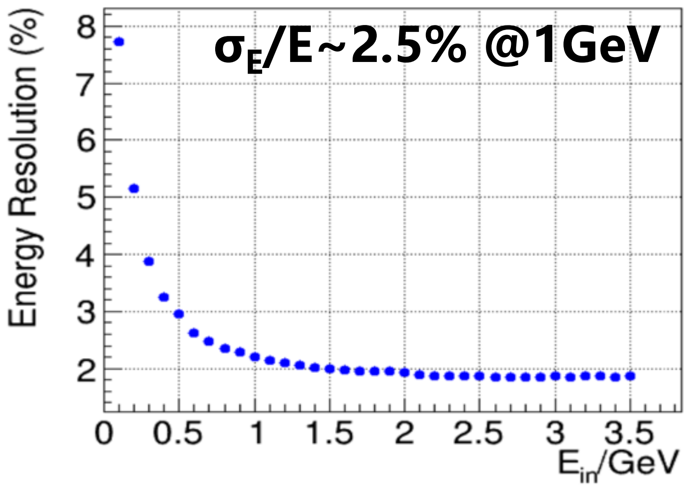


eff. ~> 90% when p ~>1GeV/c

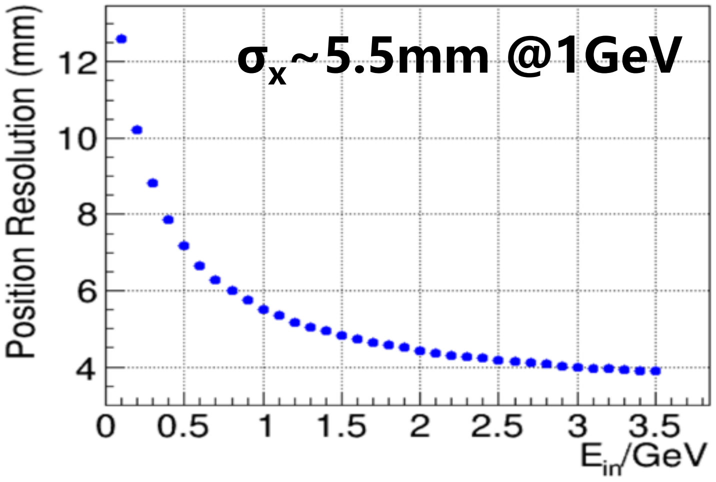
Tracking efficiency



EMC energy resolution



EMC position resolution



Physics Tasks with Full Simulation

STCF

Symmetry

Topics	Processes	Students
Baryon CPV and EDM	$J/\psi \to \Lambda\bar{\Lambda}, \Xi^+\bar{\Xi}^-$	Mingyu Yu (SDU), Jianyu Zhang (UCAS),Xiao Chu (FDU),Yue Xu (FDU)
τ physics (QE, CPV and LFV)	$\tau \to \pi(\pi\pi^0)\nu$, $\tau \to 3\mu$, $\tau \to K_S\pi\nu$, Radiative decays	Mingyi Liu/Chentao Bao (USTC), Hailin Li (ZZU) , Ruixiang Li (USTC)
Charm mixing and CPV	C-even correlated $D\bar{D}$	Yinghao Wang (LZU), Qiang Lan (USC)
CPV in Λ_c^+ decays	$\Lambda_c^+ \to \Lambda K^+, \Sigma^0 K^+, \Sigma^+ K_S$	Hongjian Wang (LZU)
CP and CPT in $K_s \to \pi^+\pi^-$	$J/\psi \to K_s K\pi$	Huibin Zhang (UCAS)

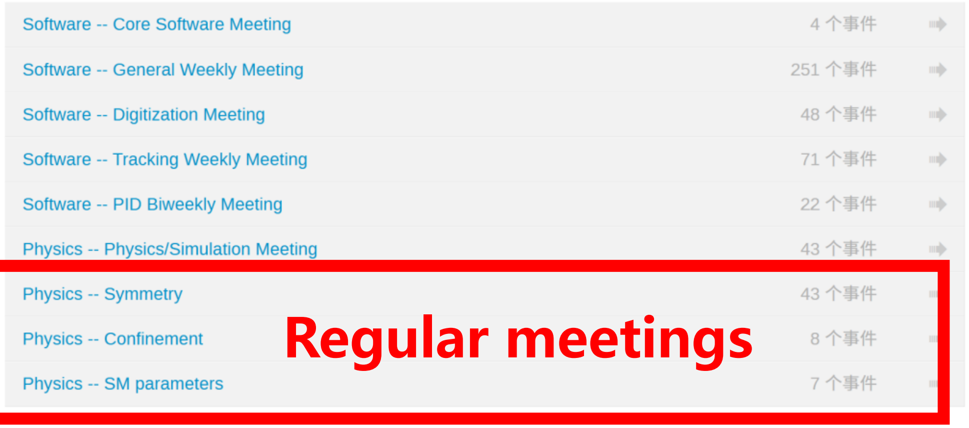
Confinement

Topics	Processes	Students
Di-Charmonium	$e^+e^- \to J/\psi\eta_c, J/\psi J/\psi$	Zhuojuan Dong (SYSU), Xiaoshen Kang (LNU)
Exotic States	Zc(3900) , $J/\psi p\bar{p}$	Hang Zhou (USTC), $\pi\pi$ Zikang Chen (SYSU)
Hyperon Decays	$\Sigma^+ \to \gamma p$, $\Lambda \to pe\nu$, $\Xi^- \to \Lambda e\nu$	Junxian Zhou (FDU), Xu Han (USTC), Yong Song (USTC),
Form Factorrs and Fragmentation Functions	$e^+e^- \to p\bar{p}, KK, \pi\pi, K\pi$	Yuncong Zhai (SDU), Wenhui Tian (SYSU), Dejie Wei (JNU)

SM parameters

Topics	Processes	Students
R-value related	Two photon physics	Jie Wang/Chunhui Chen (CUG)
τ mass	$e^+e^- \to \tau\tau$	Hailin Song (USTC)
CKM elements	$D \to \pi\mu\nu, D_s \to \mu\nu, \tau\nu$ $D \to$inclusive	Qingyuan Huang (UCAS), Jiahui Qiao (USC), Hongrui Liu (CCNU)
Strong Phase	$D_0 \to K\pi\pi^0$	Chen Wang (LZU)
Strong Coupling α_s	$\tau \to \ell\nu\nu, \pi\pi^0\nu$	Shanshan Li (HNU)

15 institutions
35 graduate students, 23 faculties



Regular meetings

CONTENTS

Development and Advancement

2011

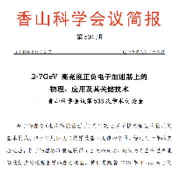
Super Charm-tau Factory

Zhengguo Zhao

On behalf of ???

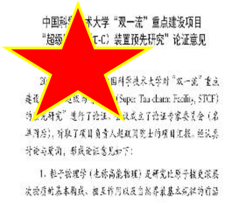
Proposed at "Workshop for acc. based high energy physics development strategy"

2015



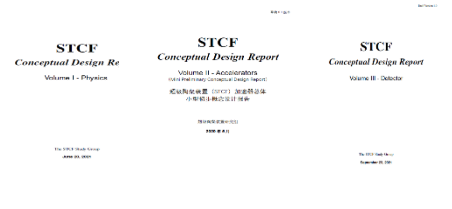
Fragrant Hills Science Forum
Demonstrated its importance and necessity, Urging to lauch fesibility study and R&D

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

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

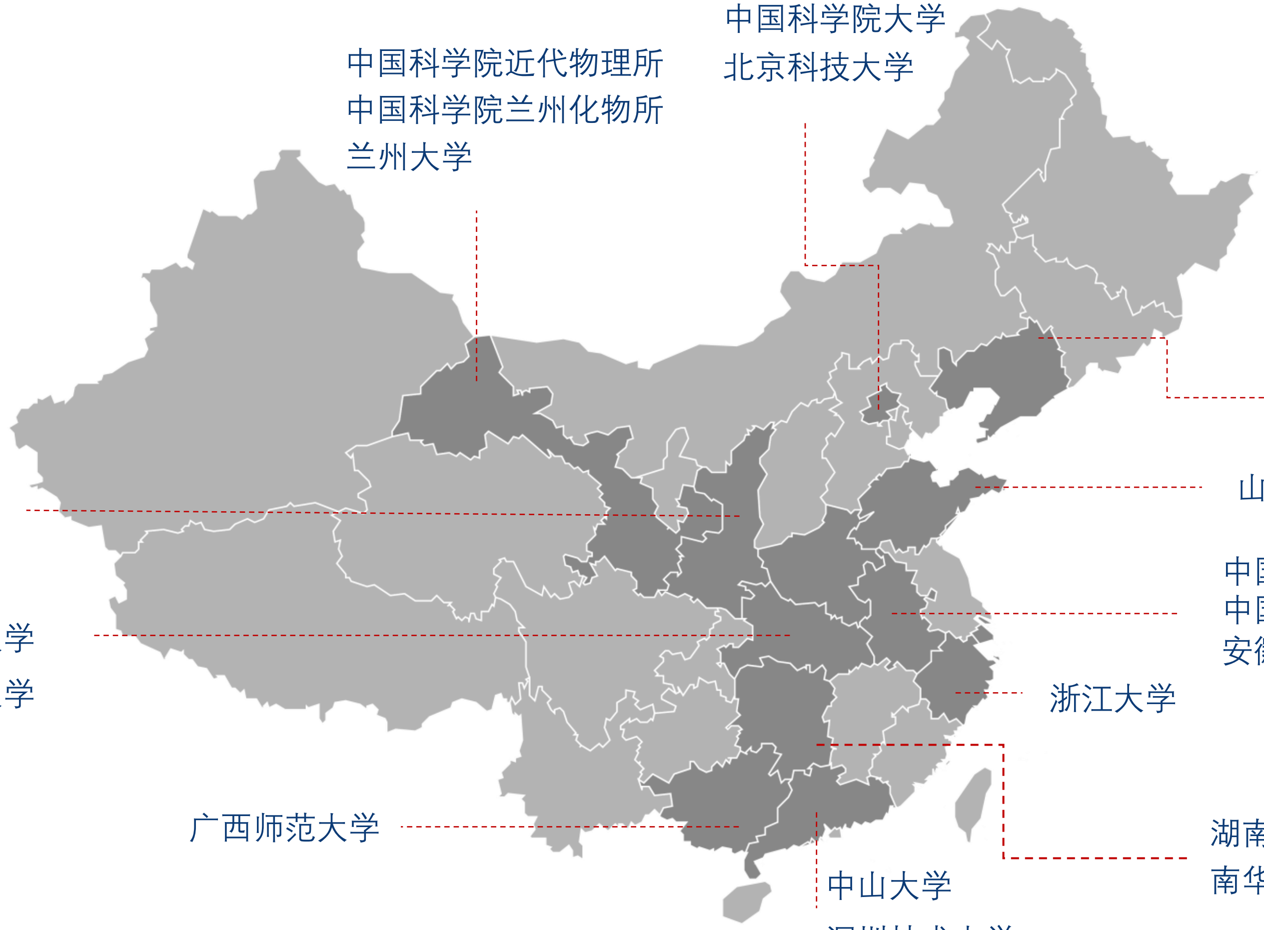
1st International Advisory Committee meeting (Offline)
A impressed report with valuable comments and recommendations

2024.09

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

Domestic Institutions in R&D

Key technology R&D : 25 Institutions, more than 170 researchers and 140 graduate students



其他参与物理研究单位：

北京大学
中科院高能所
中科院理论所
上海交通大学
北京师范大学
武汉大学
中国地质大学
辽宁大学
南京师范大学
南京大学
河北师范大学
南开大学
华南师范大学

Meetings and Conferences

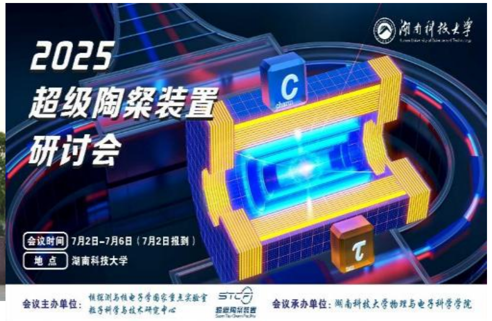
Time	Place	Content
2018.10	Hengyang (USC)	STCF
2019.03	Beijing (UCAS)	STCF: Physics
2019.07	Hefei (USTC)	STCF: Accelerator
2019.08	Hefei (USTC)	STCF: Phys. & simulations
2019.11	Beijing (UCAS)	STCF: CDR
2020.08	Hefei (USTC)	STCF: From CDR to TDR
2022.12	Guangzhou (SYSU)	STCF: R&D kick-off
2023.07	Zhengzhou (ZZU)	STCF: Collaboration
2024.07	Lanzhou (LZU)	STCF: R&D progress
2025.07	Xiantan (HUST)	STCF: R&D progress

- 200+ attendees from 20+ countries
- 125 talks: 20 plenary, 105 parallel
- Several other experiments

Intensively, fruitfully and impressively

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
2025.11	Huangshan， China	7^{th} FTCF

Hunan University of Science and Technology



International Cooperation

Collaboration with CERN, BINP/JINR (Russia), KEK (Japan), IJCLab (France), and other organizations. Extensive and in-depth technical exchanges and substantive cooperation

Collaboration with LHCb-TORCH group

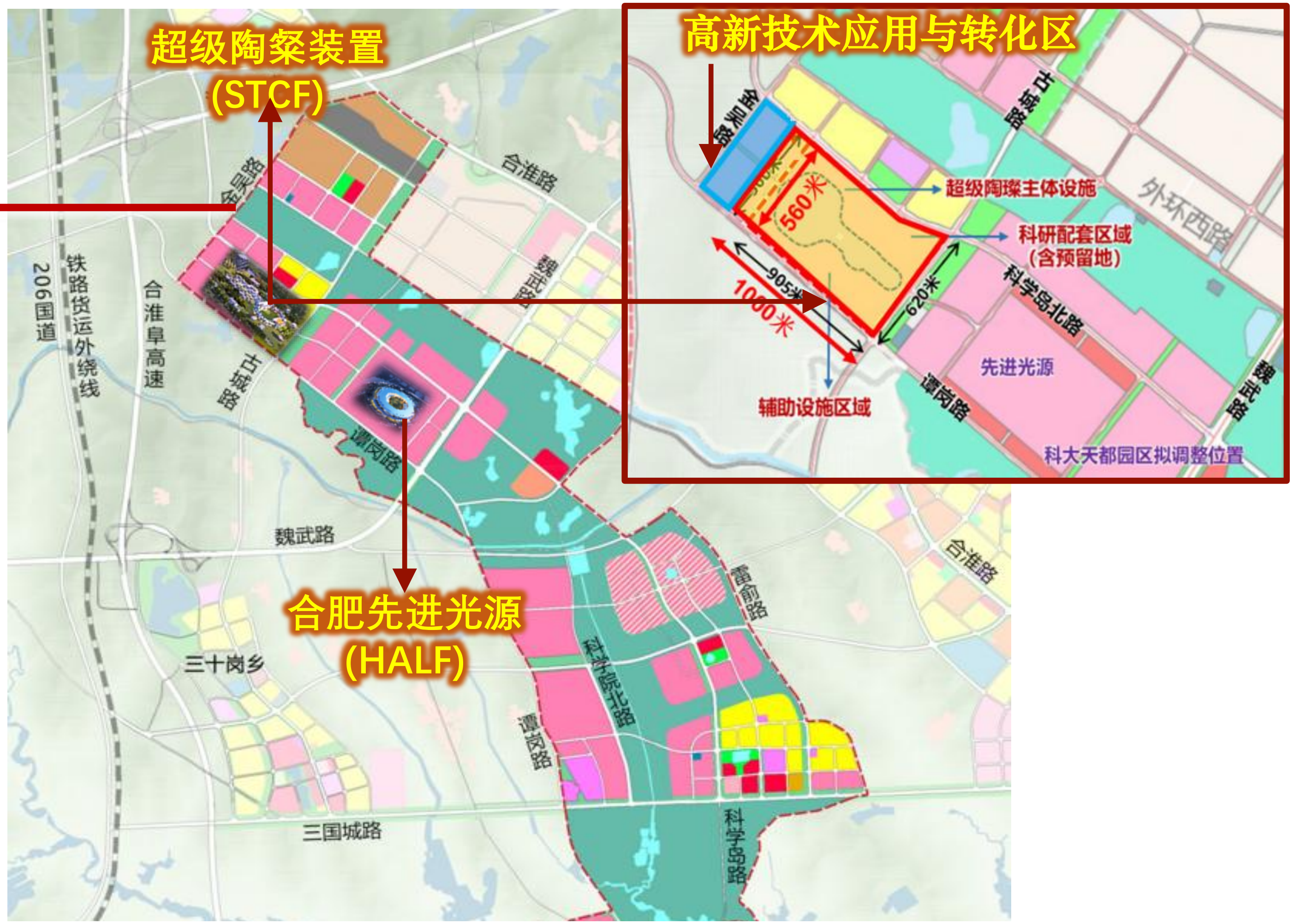
Collaboration with CERN Thin Film Deposition Laboratory

Collaboration with CERN gas detector

Collaboration with BINP accelerator experts

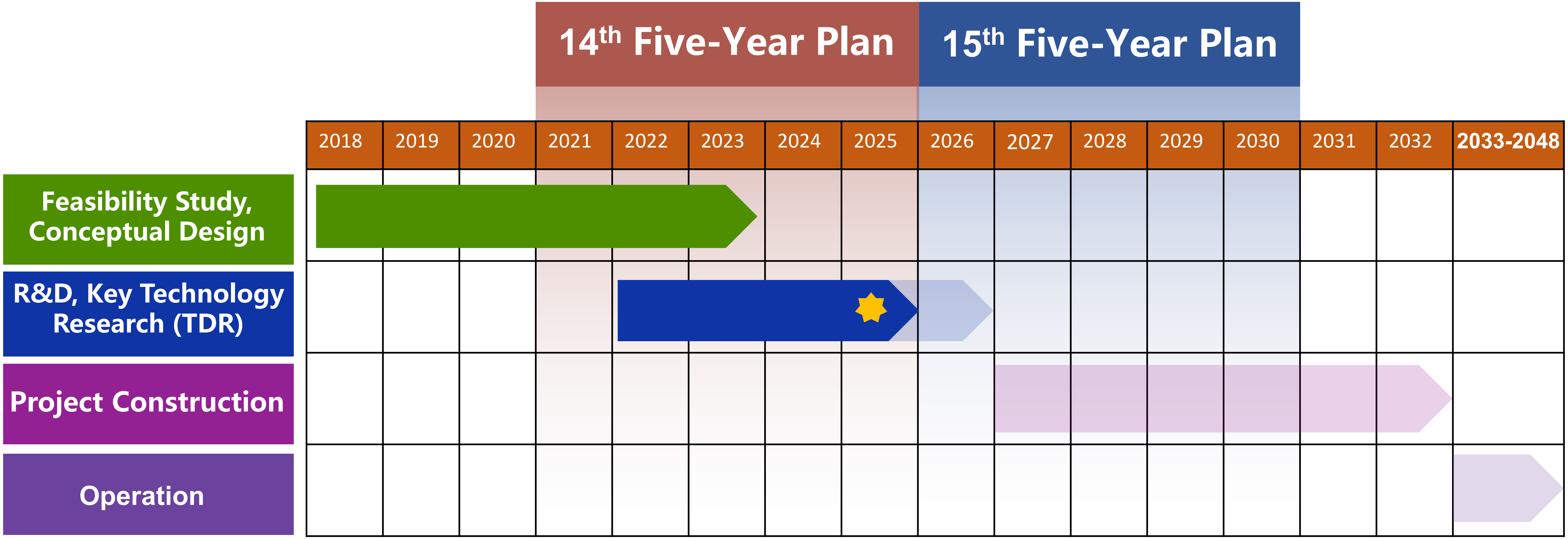
Communication with the JINR team

Collaboration with KEK accelerator experts



8 big scientific projects under construction or planned in the "city".

Time-Table


14th Five-Year Plan
15th Five-Year Plan
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033-2048
Feasibility Study, Conceptual Design
R&D, Key Technology Research (TDR)
Project Construction
Operation

CONTENTS

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 a few years, 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).
- Expanding international collaboration and exploring synergies with other projects are crucial. All forms of collaboration are welcome.

Thanks！

谢谢！

Thanks for the invitation！

感谢组委会的邀请！