Research on Experimental High-Energy Physics at USTC – a Brief Introduction and Recent Status

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Outline

- Introduction to CPPT
- Projects & Collaborations
  - Detector R&D
- Status / Plans
  - NICA – possible involvement
Physics research fields at USTC

**Astrophysics**
- Active galactic nuclei, galactic center regions
- Galaxies and planets
- Modern cosmology and astrophysics

**Condensed Matter**
- Nano-Science
- Superconductor, Strongly correlated system
- Spintronics, Functional Materials

**Atomic and Molecular Physics**
- Electron Collision
- Atomic and Cold atomic Physics
- Quantum Commun., Quantum computation

**Optics and Quantum Information**
- Optics
- Optics Engineering
- Quantum Information

**Theoretical Physics**
- String/M Theory, Gravity and Supergravity
- Theoretical Partical Physics
- Quantum and Classical Chaos

**Plasma Physics**
- Fusion Plasma Physics
- Laser-plasma Interactions
- Low-temperature Plasma Technology

**Nuclear and Particle Physics**
- High Energy Physics
- Nuclear Physics
- Phenomenology of Particle Physics

**Electronics Technology and Detector**
- Nuclear Electronics
- High-speed Mass Data Acquisition Techniques
- New Detection Techniques and Methods
Brief history of CPPT

✧ 1958 the University of Science and Technology of China (USTC) was founded.
✧ 1970 ‘s our laboratory was established.
✧ 1975 the first Multiple Proportional Wire Chamber was constructed in China.
✧ 1980-90 ‘s we joined international collaborations:
  LEP-L3, LHC-CMS, BEPC-BES, KEKB-Belle, etc.
✧ 2005 the CAS Key Lab of Particle Detection & Electronics was established.
✧ 2009 the full TOF detector was successfully installed in RHIC-STAR.
✧ 2010 the Center of Particle Physics & Technology was established.
✧ 2011 the Lab was promoted as the National Key Lab of Particle Detection & Electronics of CAS and now under construction.
✧ Now, we joined over 10 collaborations working on many research fields.
The Key Lab

4300 m² space
1 conference room
5 seminar rooms
1 video meeting room
## CPPT Research Team

<table>
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<tr>
<th>Direction</th>
<th>Professor</th>
<th>Asso. Prof.</th>
<th>Assi. Prof.</th>
<th>Postdoc</th>
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8 Guest professors  
1 Master Chair Professorship
CPPT Research Strategy

Physics

Theory

Experiment

Hardware
- Detector
- Electronics
- DAQ, DCS

Software
- Detector simulation
- Calibration
- Reconstruction
- Tools

Data analysis
- Event generator
- Physics analysis

National Key Lab for particle detection and electronics

USTC has the complete system for the research of nuclear and particle physics
Laboratories

GEM test system

MRPC module test system

LMRPC cosmic-ray test stand

Dark room
Laboratories

Large Clean room

Working in the clean room

Liquid & ultrasonic clean room

Wiring

High resolution position det.
Laboratories

Ultra-fast pulse testing

High-speed electronics testing

Temperature & humidity control system

ps-level timing test

Sea petroleum prospecting electronics R&D platform
Detector Prototyping

- MRPC
- GEM
- MicroMEGAS
- MWPC
- Long strip MRPC
Detector Prototyping

BGO array prototype - DAMPE

BSO crystal array prototype - CEMC

PMT of large dynamic range
Electronics

ASIC - Layout of the QTC chip

FPGA TDC Utilizing Carry-Lines for interpolation
FPGA TDC with Multiple Clocking

14bit 320MSPS time-interleaved ADC
8bit 4GSPS time-interleaved ADC
8chs 10bit 5GSPS digitalization based on SCA
Mega-science projects

**Accelerator based**

- BES-III at BEPC-II
  - Tau-charm physics
- BELLE at KEK
  - B, tau-charm physics
- D0 at Tevatron
  - Top, w, B-physics

**Non-accelerator based**

- Daya Bay / JUNO
  - Neutrino physics
- LHAASO
  - Cosmic ray observatory
- DAMPE - Space Satellite
  - Dark Matter search
- LAMOST
  - Survey Telescope
- Petroleum Prospecting Detector, electronics

**Additional Projects**

- ATLAS at LHC
  - Higgs, SUSY, top, exotic, Heavy-Ion ...
- STAR at BNL
  - Heavy-Ion, EIC ...
- CEE at CSR
  - Heavy-Ion and nuclear
BES-III Collaboration

5 countries, 37 institutions, 217 authors

TOF electronics  Trigger system  Event display
448 chs <25ps. Will upgrade to 1728chs, <20ps
LHC – ATLAS

USTC contribution:
- TGC trigger
- R&D for muon upgrade
- Commissioning

Physics analysis:
- Diboson studies
- QCD studies
- Search for SUSY and Higgs

6 faculties, 1 postdoc, >13 graduate students.
Heaviest anti-nucleus in the discovery history.
STAR Experiment

Light hadron spectra
Heavy Flavor
Dilepton
BES high moments
Non-accelerator Based Experiments

- Neutrino experiment at Daya Bay nuclear power plant
- Yang Bajing Cosmic Ray Observatory LHAASO WCDA
- Dark Matter Search in Space ECAL R&D, read-out system
- Large Sky Area Multi-Object Spectroscopic Survey Telescope (LAMOST)
International Collaborations

- GSI
- CERN
- USTC
- CCNU
- Pusan
- Tsukuba
- LBNL
- UoM
- UCLA
- BNL
- FNAL
- UoM
International Collaborations

Guest Professors: Horst Stöcker, Nu Xu, Hans Geog Ritter, Zhangbu Xu, Xinnian Wang, Huanzhong Huang, Fuqiang Wang, Jianping Chen
Master Chair Professorship: Bin Zhou

Near future:
Joint Education & Research Center between CPPT & UoM
Joint Education & Research Center between USTC & Tsukuba Univ.

Looking forward for more collaborations in the future
Joint projects: Detector R&D, Data analysis, Electronics ...

Current projects: gaseous detector / scintillation detector
Long term plan & interest: semiconductor / silicon technology & electronics

Issues & status: funding and man-power
Funding from CPPT itself can not offer continuous collaboration with JINR.
A big particle physics group is not able to join NICA.
People working for STAR focus on eRHIC upgrade, CBM or other non-accelerator projects.
Electronics group is involved in several applied projects, attitude is uncertain.
MRPC TOF

• Very mature MRPC technology
  ✓ RHIC-STAR
  ✓ RHIC-MTD
  ✓ BESIII-ETOF
  ✓ CBM-TOF wall

• Full electronics chain capability
  ✓ FEE
  ✓ Digitalization
  ✓ DAQ
Tracking

GEM/THGEM

NS2 method

30*30 cm²

X-axis: strip

Y-axis: pad

TGEM (thick gap)

TGEM (thick gap)

TGEM’s HV = 3650V

Ming Shao / USTC
MRPC/RPC TOF
Precision tracking – GEM
Calorimeter – EMC / HCAL?
Electronics?
Simulation?
Thank you for your attention!
Computing Center

Simulation

 Astrophysics

 Quantum field
 QCD

 Complexity models
 Phenomenology

 Theory

 Experiment

 Hydrodynamics

 CPU: ~ 800 cores
 Storage: over 200 TB
 Internal network: 10 Gb

 ATLAS Tier3

 STAR data analysis

 BES-III software

 Full loaded environment

 The OpenSolaris Operating System offers unique features designed to help you build and deploy high-performance application services, starting with the Image Packaging System (IPS), continuing to the latest enhancements to the award-winning ZFS and featuring integrated virtualization options that span OS, network and storage — and that's just the beginning.

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 11/24/2009 Crossbow Wins Best Paper at Lisa ’09

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 06/10/2009 OpenSolaris 2009.06 released, new ARM port announced
KEK – Belle Experiment

Physics Goals:
- Observation of CPV in B-meson Decays
- Better understanding of CPV Phenomena

USTC (Z. Zhang, J. Zhao):
- $D^0$-$D^0$bar mixing through decays of $D^0 \rightarrow K^+\pi^-$ and $D^0 \rightarrow K_S\pi^+\pi^-$
- Search for decays of $B^0 \rightarrow J/\psi D^0$bar and $B^+ \rightarrow J/\psi D^0$bar $\pi^+$decay
  PRD 96, 151801 (2006)
- Search for $X(1812)$ state in $B^{\pm} \rightarrow K^{\pm}\omega\phi$ decays
  PRD 99, 131803 (2007)
D0 Experiment

- Started March 2001
  - $E_{cm} = 1.96$ TeV
  - Peak L = $2.1 \cdot 10^{31}$
  - Delivered $\sim 50$ pb$^{-1}$
- Detector commissioning almost complete
- First physics results from $\sim 10$ pb$^{-1}$ at new $E_{cm}$

Physics Program
- Top, W, Higgs
- New Phenomena
- B-physics
- QCD

- Physics analyses at 2TeV Proton-antiProton collider
  - New physics: $e+\mu$ resonance
  - SM precise test: $\sin^2\theta_W$
  - Higgs: $H \rightarrow \gamma\gamma$

PRL. 100, 241803
PRL. 101, 191801
PRL. 102, 231801