Status and prospects of CDEX

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On behalf of CDEX Collaboration
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Outline:

- CDEX experiment introduction
- CDEX-1 results and CDEX-10 status
- CDEX-200 experiment plan
- Summary
China Darkmatter Experiment (CDEX)

- Nature of dark matter unknown.
- WIMPs is one kind of well motivated candidate.

Point-contact HPGe detector (PCGe) :
✓ Low energy threshold (~ 100eVee)
✓ Very good energy resolution
✓ Easy to scale up

CDEX target:
Direct detection of low mass dark matter with tonne-scale PCGe array!
CDEX: China Dark matter EXperiment

Established in 2009.

- Tsinghua University, THU
- Sichuan University, SCU
- Nankai University, NKU
- China Institute of Atomic Energy, CIAE
- Yalong River Hydropower Company, EHDC
- Collaborate with TEXONO and KIMS group.

part members of the CDEX collaboration
CDEX plan

DM sensitivity (cm²)

10⁻⁴⁰
10⁻⁴¹
10⁻⁴²
10⁻⁴³
10⁻⁴⁴
10⁻⁴⁵

1kg PCGe

1kg PCGe upgrade

10kg PCGe Array

PCGe Home-Made

CDEX 200

LT/LN LB VFE

LN/LAr

Electroform Copper

CDEX-1T

CDEX published physical papers:

PRD88, 052004, 2013
PRD90, 032003, 2014
PRD90, 091701, 2014

CJPL-I

CJPL-II
CDEX-1 experiment

1. HPGe technology
   - Designed the first one single module 1kg-scale p-type point-contact Ge detector (1kg-PPCGe)  C1A from 2011
   - Improved the second 1kg-PPCGe  C1B from 2014

2. Active shielding technology: NaI(Tl) used as anti-Compton detector
   - C1A 1kg-PPCGe run
   - C1 20g Ge + NaI(Tl) run  C0 from 2011
   - C1A 1kg-PPCGe + NaI(Tl) run
CDEX-1

20g ULEGe

1kg PCGe

20cm OFHC Copper + 20cm Lead

TAUP 2015 @ Torino
The lowest energy threshold for ~1kg-scale PCGe detector: 400eV

- The first dark matter physical result from China!

W. Zhao et al., Phys. Rev. D 88, 052004 (2013); C1A 1kg-PPCGe

CDEX-1 experiment

TAUP 2015 @ Torino
CDEX-1 result from 20g Array detector

CDEX-1 5g*4 +AC detector

Highlight:
- 177eV lowest ionization energy threshold
- Good direction to lower energy threshold further

PRD90,032003,2014

Projected

-1 day-1 keV

(10 kg-yr ; 100 eV ; 1 kg^-4 keV^day^-1)
CDEX-1 result in 2014

- **Bulk/Surf Discrimination**
- **C1A + NaI(Tl) AC**

- The best sensitivity by PCGe in the world;
- Exclude the regions favored by CoGeNT.

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Q.Yue et al., PRD 90(RC) 091701

TAUP 2015 @ Torino
The development of DM experiment

- Have no definite DM evidences in the low mass and high mass regions;
- Have spaces need to be scanned;
- CDEX will focus on the low mass DM search.
CDEX-10 experiment

- The important stage towards large-scale Ge experiment!
- Performance study of the Ge array detector
- Feasibility study of LAr Anti-Compton detector
PPCGe array detector

Three 3kg PCGe detector
The performance test of Ge array in CDEX-10

- Two 3kg PCGe Array detectors tested in CJPL;
- The energy thresholds and backgrounds are quite good for dark matter experiment;
- The first results planned by the end of this year.
Key technologies towards CDEX-200(1T)

- Ge purification and Ge crystal growth
- HPGe detector fabrication
- Ultra-low background VFE
- Ultra-pure copper for structures and cables
- Large-volume cooling tank
- ……
CDEX-1T – Ge crystal growth

- Zone refining machine
- Czochralski machine
- Cutting & Polishing
- Crystal growth

- The requirement for making P-type Ge detector
  - Impurity density: <3*10^{10} cm^{-3}
  - Dislocation: <5000 cm^{-2}

Achieved
- Impurity density: \( \sim 5 \times 10^{10} \) cm\(^{-3}\)
- The dislocation: \( \sim 5000 \) cm\(^{-2}\) in the center
CDEX Lab for HPGe detector fabrication

- Clean room
- Wet Lab
- Machine-shop
Crystal Processing

- Typical Processing Technology is used

Mechanical Preparation

Lithium Diffusion

Wet Lab

Boron Implant

Boron Implant Accelerator
- 500g point-contact Ge detector has been done successfully, comparable to the commercial product in energy resolution.
- Next plan: PCGe R&D with ultra-low energy threshold and background used for dark matter experiment.
CJPL Electro-form Copper

- Electro-form Copper produced in CJPL for CDEX;

- The Copper background now:
  Th:~44.66 μBq/kg、U:~149 μBq/kg

- Our target in 5 years:
  Th<0.06 μBq/kg、U<0.17 μBq/kg (lower 1000 times)
Cooperation on Ge detector development

Ge meeting @ Munich on March, 2013

Ge meeting @ THU, Beijing on May, 2014
CDEX-200 with LN2 cooling system
CJPL-II development

- Traffic tunnel x 2
- Drainage tunnel
- CJPL-II
- CJPL-I
- Intake
- Diversion tunnel x 4
- 17.5 km

**Total space:** ~300,000 m³

- Connecting Tunnel
- Link Tunnel
- Emergency tunnel
- 4x Lab Halls (130 x 14 x 14 m³)
CDEX-200 space in CJPL-II

- The LN2 cooling and passive shielding system:
  Goal: Background from outside of Ge < $10^{-4}$cpkkd
- The CDEX new space: $\phi 18\text{m} * 30\text{m}$;
- CDEX-200 space ready in 2016.
Summary

• CDEX-1@CJPL has started to run detectors from 2011.

• DM physical results have been published in 2013 and submitted in 2014.

• The 2014y CDEX-1 exclusive curve has disfavored CoGeNT region with identical detector technique and lower energy threshold. New results is coming.

• CDEX-10 with 10kg array detector tested in CJPL and commissioning next month.

• CDEX-200 (2016-2020) preparing the space and key technologies.
Thank you!