Academia Sinica

Prof. WONG, Henry

HT Wong & TEXONO Group – Profiles

HT Wong

- ☑ PhD Caltech 1990 -- Double Beta Decay with Xe136 TPC @ Gotthard !!
- ☑ CERN Fellow & Staff 1992-96 -- CHORUS Neutrino Oscillation
- ☑ AS Faculty >1997 -- TEXONO Program, Reactor Neutrinos, Dark Matter …

TEXONO Program

- Neutrino Physics at Kuo-Sheng Reactor Neutrino Laboratory (KSNL)
  - ⊕ *Dark Matter in CDEX @ CJPL*
  - ☑ Taiwan (AS, INER, KSNPS, NTU, NDHU)
  - ☑ India (BHU)
  - ☑ Turkey (METU,DEU)

Assets (Expertise) of TEXONO Group:

- ☑ Kuo-Sheng Reactor Neutrino Laboratory (28 m from Core) – SM/BSM ν-e scattering, neutrino electromagnetic properties, ν-N coherent scattering …
- ☑ Sub-keV germanium detector experience
- ☑ Established working relationships with groups from China, India, Turkey
- ☑ Theory Collaborators *[JW Chen (NTU) ; CP Liu (NDHU) …]*
  - ↳ Interface of atomic, nuclear and particle physics + detector physics
- ☑ AS-HEP-ATLAS Group -- GRID Tier-1 Computing
  - ↳ AMS ⇨ KAGRA ⇨ Other Big Data Projects ……

Why Here ? :

- ☑ A natural next-step for Ge techniques
- ☑ Ge : room to advance *[& to maneuver from evolution of neutrino results …]*
- ☑ Explore/Develop international program/"operating system" at a new facility CJPL, *[in addition to neutrino physics….]*
- ☑ Different/Complementing working modes and scientific output as KSNL program

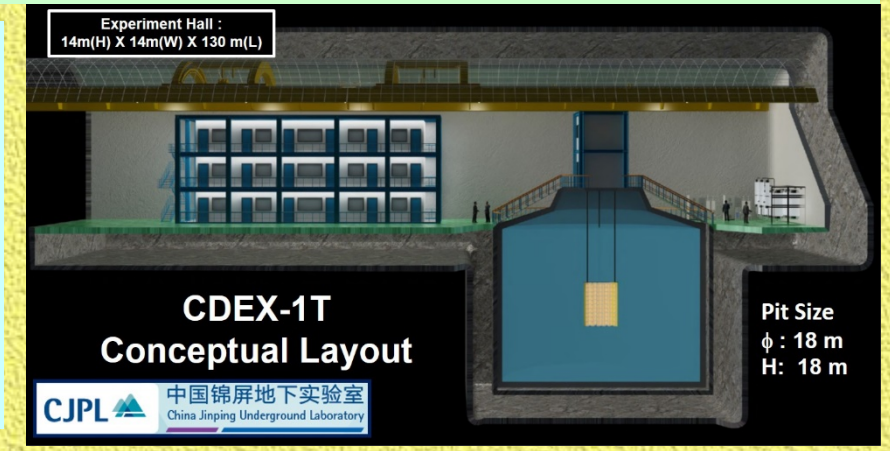
Offers/Opportunities :

- ⚐ CJPL is (among) the world's deepest underground facility
- ⚐ CDEX group has strong connections & backing & SOPs from a (successful) industry

Proposal :

Invite international partnership to pursue the Ge-1T-DBD program at CJPL *(e.g. @ the 18-m pit @ CJPL-2)*

⇨ TDR ~5 years.



Sichuan University

LIN, Shin-Ted

CDEX group at SCU (Sichuan University)

(China Dark matter Experiment established in 2009)

Members

- **Faculties :** Tang, Chang-Jiang Xing, Hao-Yang.Zhu, Jing-Jun. Lin, Shin-Ted.
- **Graduate students :** Du, Qiang. Zhang, Cai-Xun, Li, Xue-Yang. Hu Chao.(Three master & One PhD students will join in soon.)
- Collaborate with TEXONO.

Physics Program

- ✓ Pursuing light WIMPs searches.
- ✓ Future Goal- Neutrinoless double beta decay.
- ✓ Diversity researches including neutrino physics as well as exotic dark matter.

Facility

CJPL (*JinPing Underground Lab.*) in Sichuan

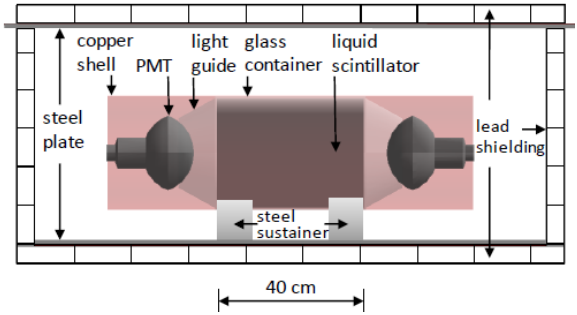
CJPL's ground site

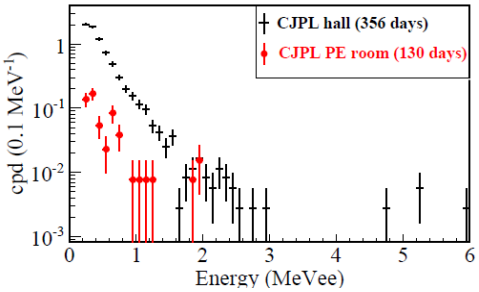
Facility at SCU

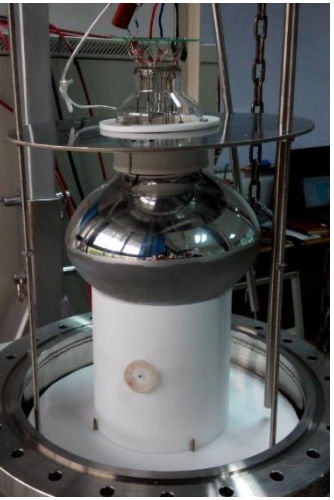
- van de Graaff accelerator.

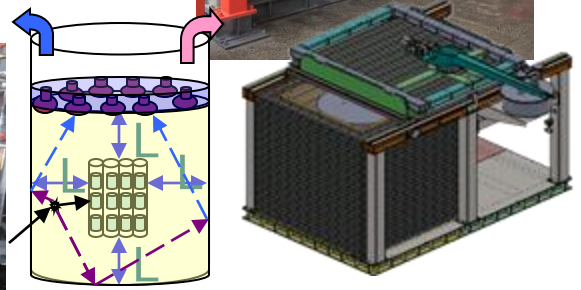
SCU's tasks

- ✓ Neutron measurements at CJPL.
- ✓ Test of CDEX-10 for the cryogenic system.
- ✓ Study of prototype liquid Argon detector.
- ✓ Joint in data analysis of dark matter searches.
- ✓ Detector response interactions for background understanding via nuclear and atomic physics together with TEXONO-theory group.







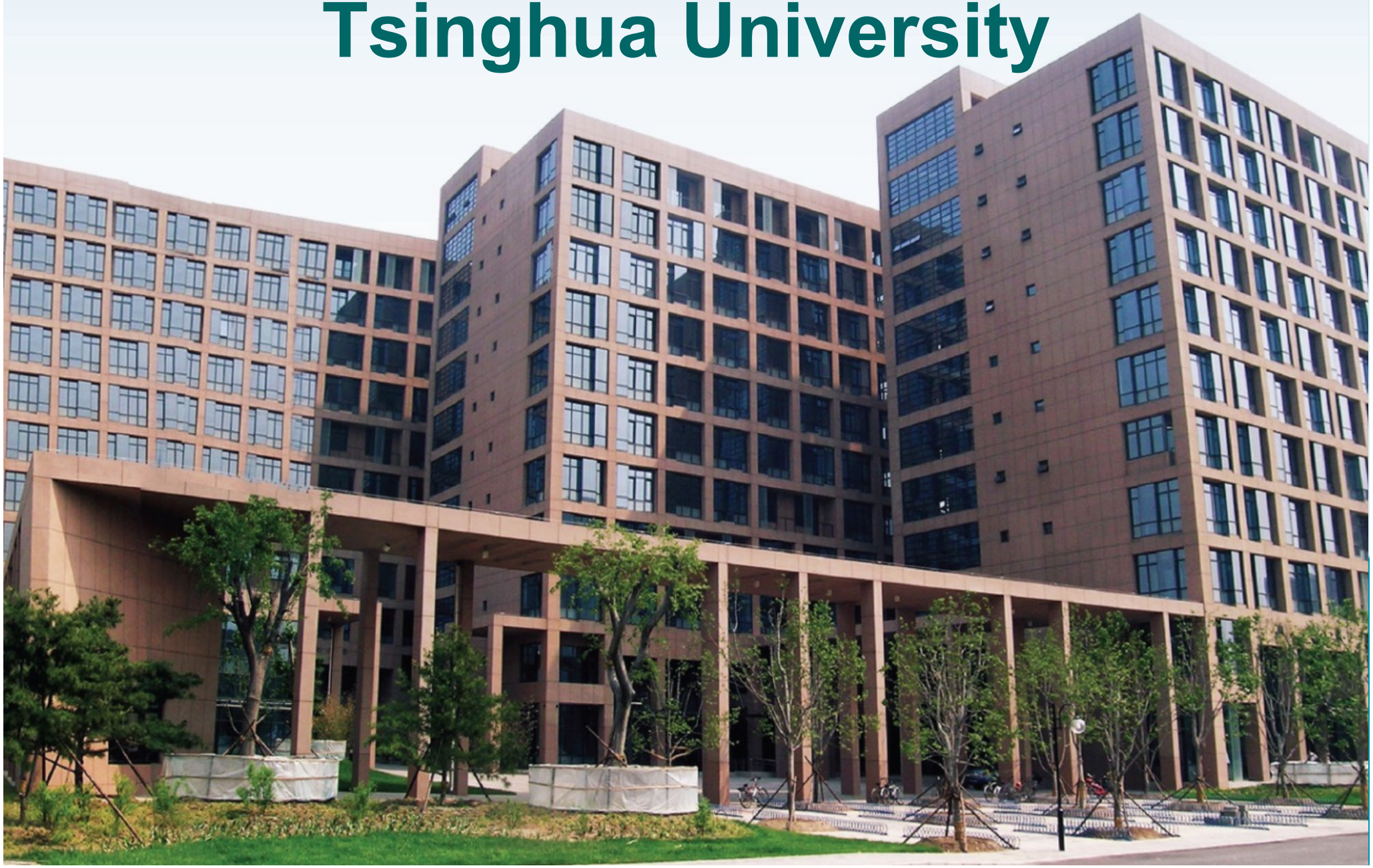


Tsinghua University

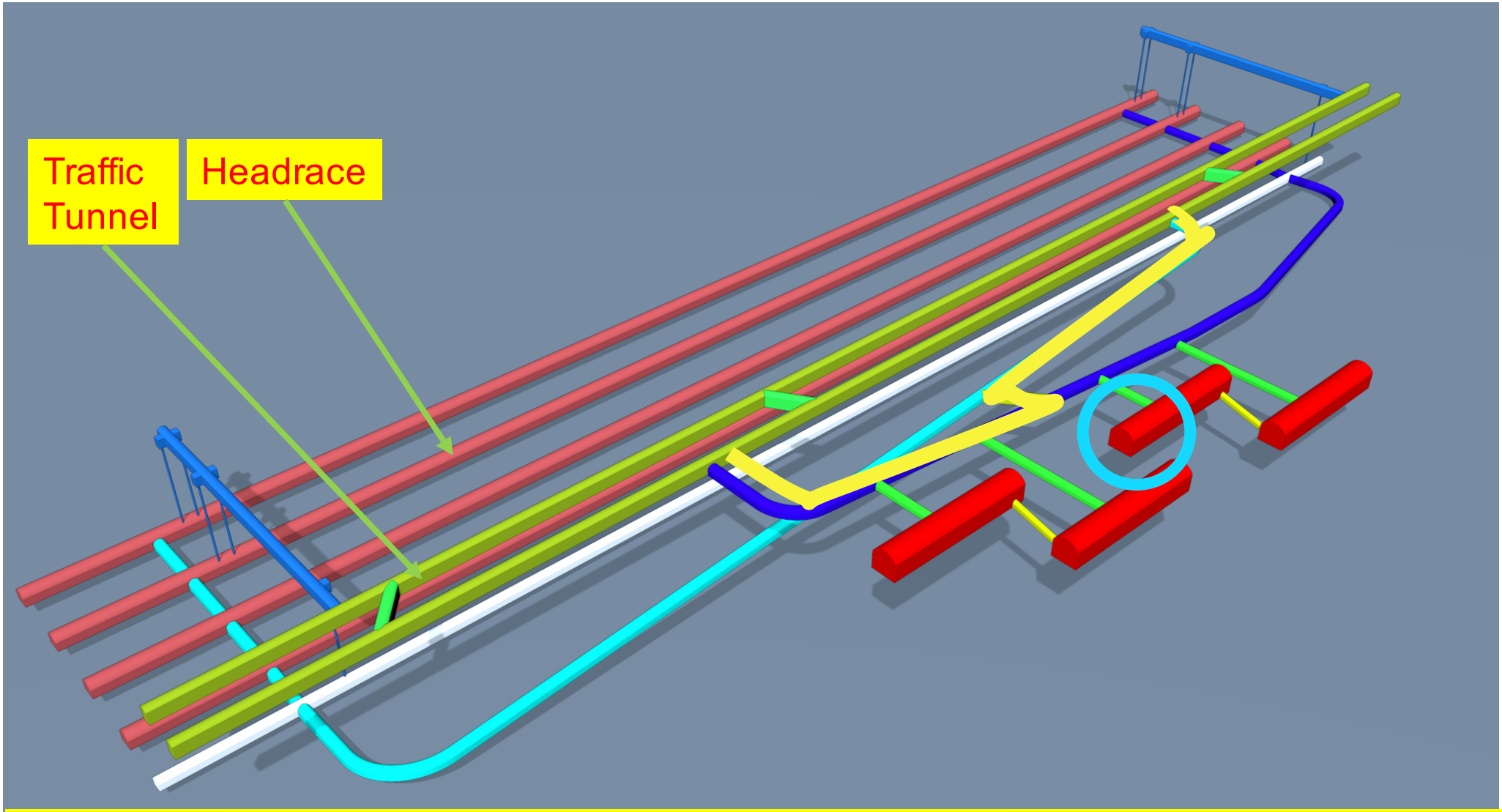
Dr. YUE, Qian

Department of Engineering Physics

Tsinghua University



CJPL led by Tsinghua university



- **Four 14m*14m*130m main halls**
- **Total Volume： ~300K m³**

Lab owned by Department of Engineering, Tsinghua university

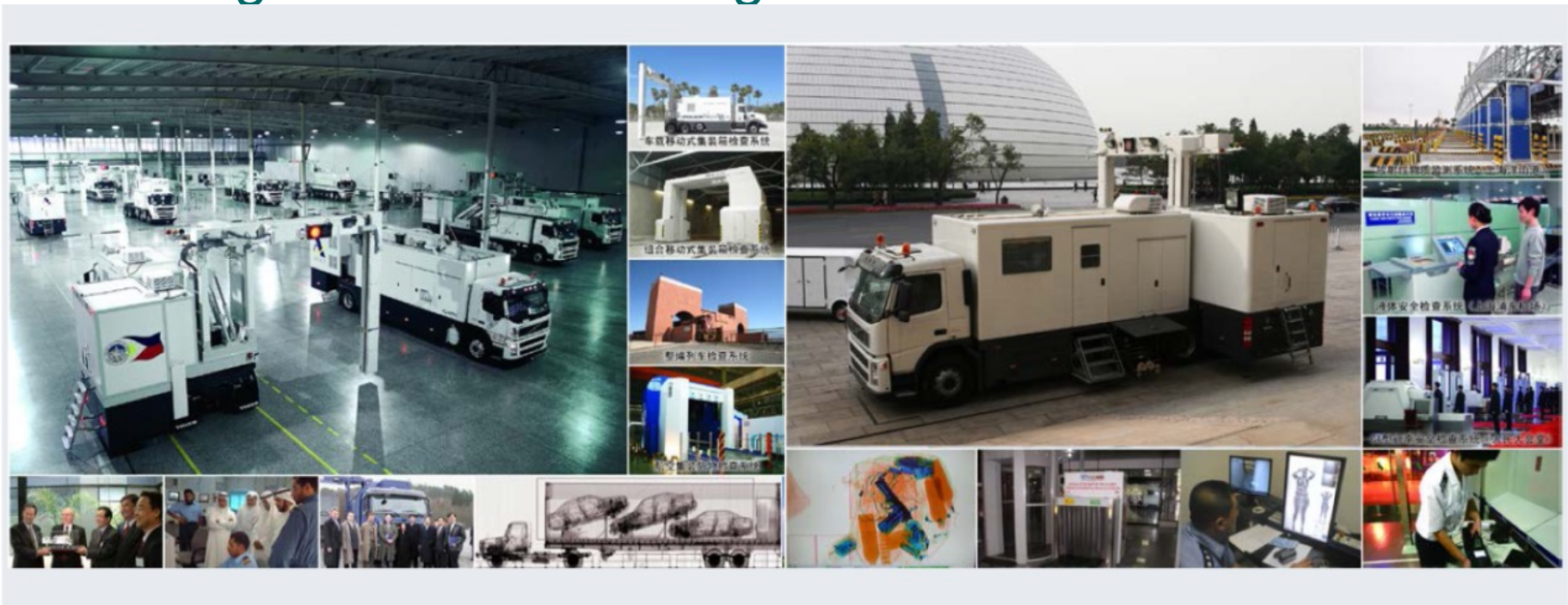
- Semi-conductor Detector including HPGe, CZT;
- Ge crystal growth lab
- Electronice lab including LN-FE and (FPGA)-FADC
- Radioactive protection and Screening facilities;
- Isotope Enrichment group
- Neutron detector lab
- ……

Team of Department of Engineering, Tsinghua university

- 11 professors, join in CDEX;
- 8 professors has strong relationship with CDEX;
- 15 doctor students join CDEX;
- ~20 technical persons join CDEX.

Company tied relationship with DEP, THU

- NUCTEC company, more then 1000 workers;
- The largest security inspection company in the world;
- ~ RMB 4 Billion ($ 0.7 Billion) each year;
- Much experience on detector mass production and strong technical team organization.



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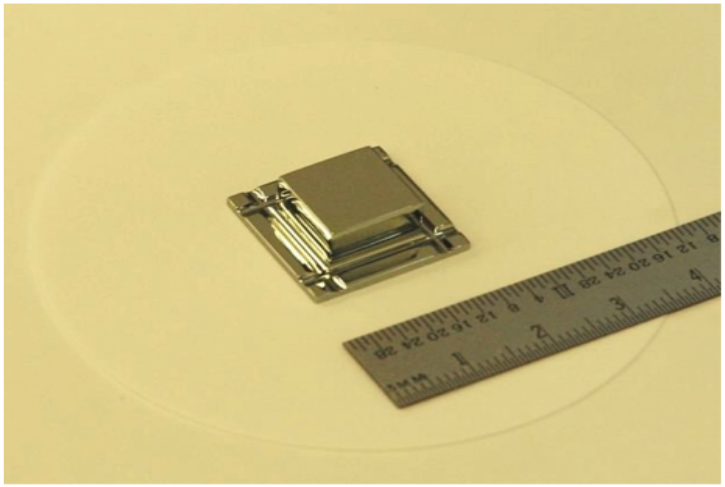
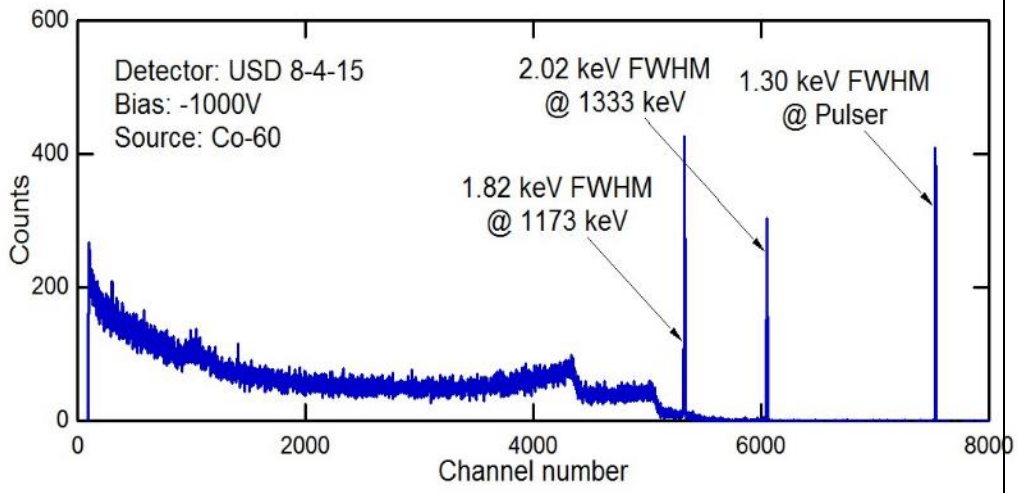
The University of South Dakota

MEI, Dongming

He-Ge Crystal Growth Method

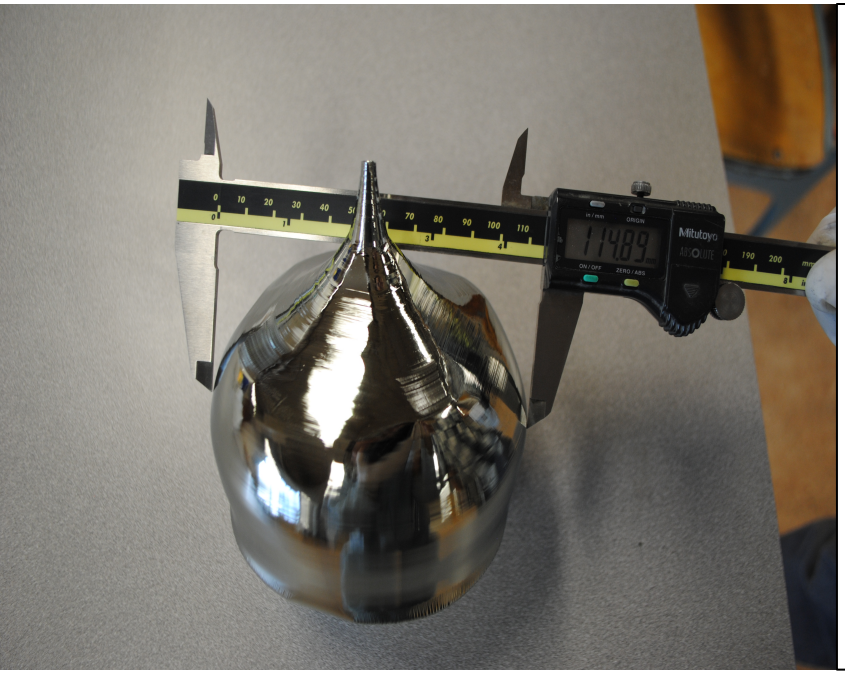
Dongming Mei's Group





- Mark Amman at LBL made four detectors with a size about 1 cm^3
- Impurity varies between $1.5x10^{10}/cm^3$ to $6x10^{10}/cm^3$
- The noise for each detector was measured using pulsars
- This allows us to study intrinsic statistical variation with respect to the level of impurity and mobility

Apply for a NSF PIRE Program



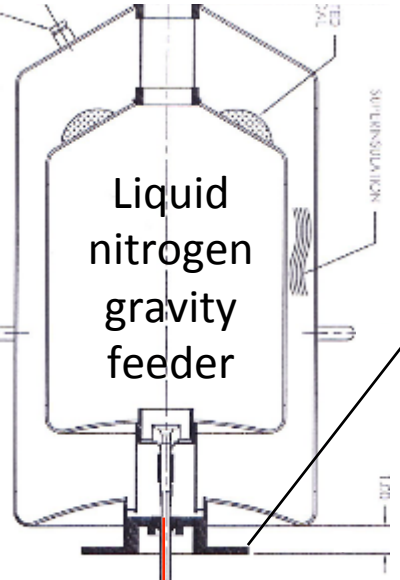
- **Since we grow large size crystals with diameters up to 12 cm, we plan to make a big PPC detector, 10 cm in diameter, 4 cm in length, and 3 kg in mass, for testing resolution and pulse shape properties**
- **Internal amplification detector**
- **P-type segmented detector**

PIRE Collaboration:

Domestic institutions: USD, SDSU, BHSU, DSU, TTU, Tesax A&M, LBL

International Institutions: MPI, Germanium, ASIOP, Taiwan, Tsinghua, China, Sichuan University, China, Canberra France, INFN-LNL, Italy

Liu's Scanning station design



Liquid nitrogen gravity feeder

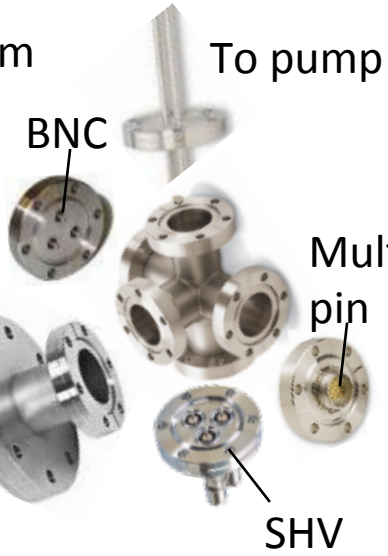
All flanges are of CF type except for the one to gravity feeder

Rotary feedthrough

Collimated calibration source

Linear feedthrough ports

Vacuum gauge port



To pump

BNC

Mul

pin

SHV

Insert

Detector

Liquid nitrogen pipe

Cold plate

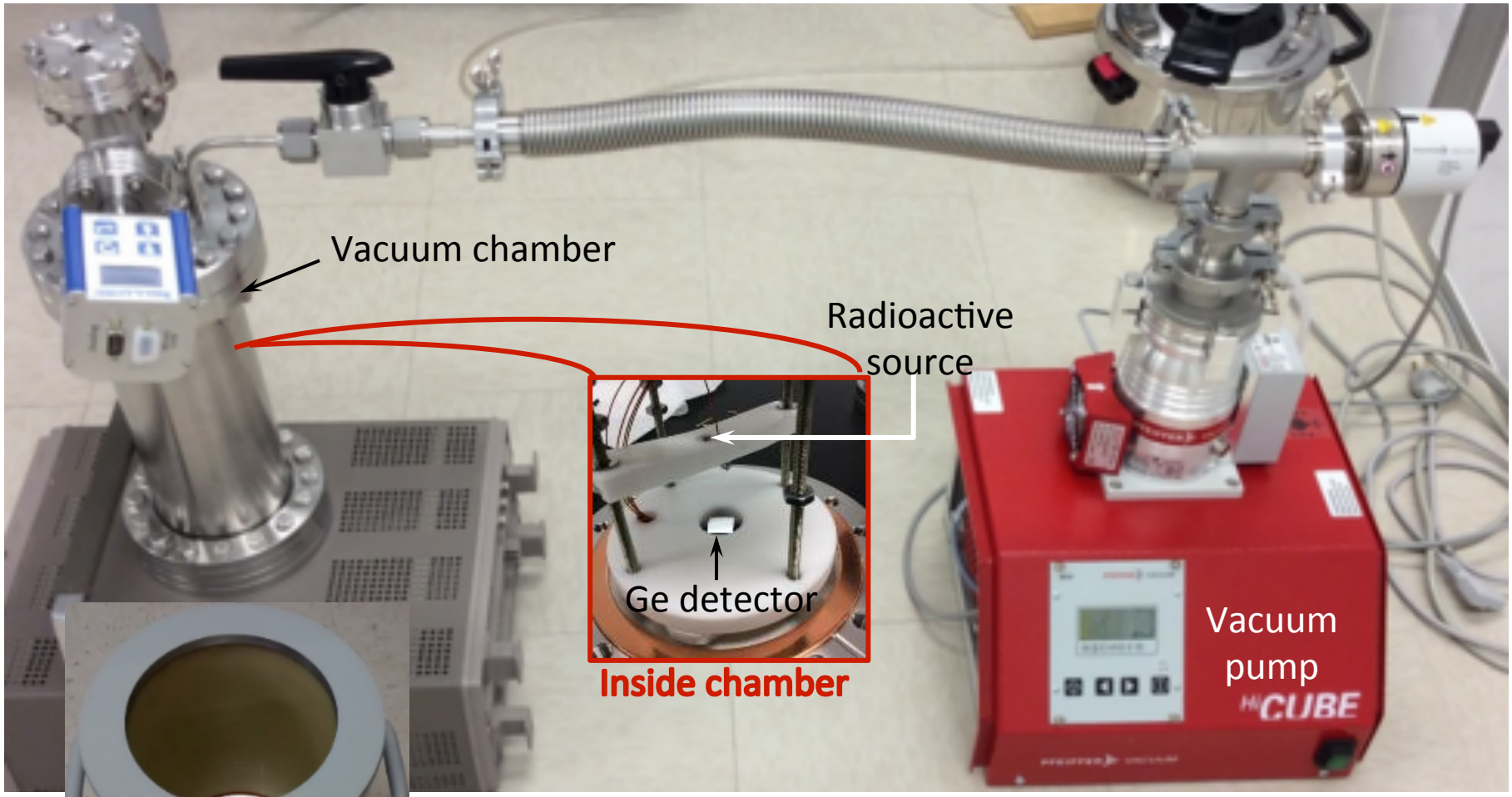
Linear feedthrough port

Electronic & gas feedthrough port

12-inch scanning station

Scanning station

Fast measurement station



Open liquid nitrogen container

Pumping, cooling down, measurement & warning up in 1 day!

Xu's group at the USD

Wenqin Xu is currently a member of MJD and will start as an assistant professor at the University of South Dakota in August/2016

Three main focus:

1. Physics Analysis and Simulations
    - Experience in data analysis, physics modeling and simulation, and software development.
    - Major contributor in background determination at MJD.
    - Will continue to work on
        - understanding the backgrounds in the next generation experiment,
        - and developing corresponding background mitigation techniques,
        - and performing simulation studies on new detection systems required for active shielding.
    - Will continue to work on exploring new physics topics in the next generation experiment.

2. Data Acquisition
    - Experience in both software and hardware of the Data Acquisition (DAQ) Systems at MJD and other experiments.
    - Will continue to work on developing and improving DAQ systems challenged by the large scale and complicities in the next generation experiment.
    - Will collaborate and contribute to new detector/hardware systems under development, especially to the DAQ sub-systems.

Xu'group at the USD

3. Radio Assay

- The Black Hills State University Underground Campus (BHUC) is a clean room low background counting facility at the 4850' level of Sanford Underground Research Facility, and it will host multiple radio assay systems.
- We are working in conjunction with other groups, including UNC-CH, to establish a radio assay system with HPGe detectors at BHUC.
- We help develop the radio assay system and will calibrate and operate the detectors to perform the assays.

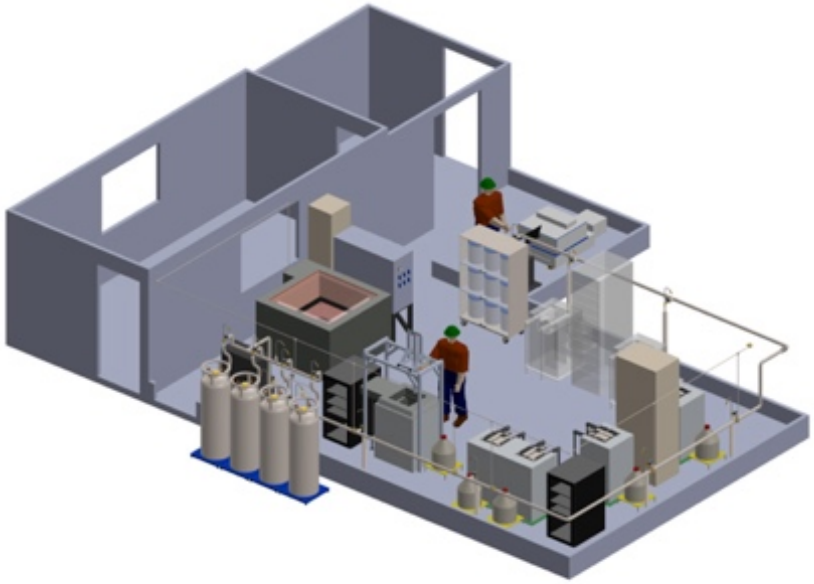


Photo courtesy of David Taylor, Sanford Lab. A design drawing of BHUC.

Photo courtesy of Sanford Lab. Researchers from the Black Hills State University working at BHUC

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South Dakota School of Mines and Technology

CHRISTOFFERSON, Cabot-Ann

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Cabot-Ann Christofferson

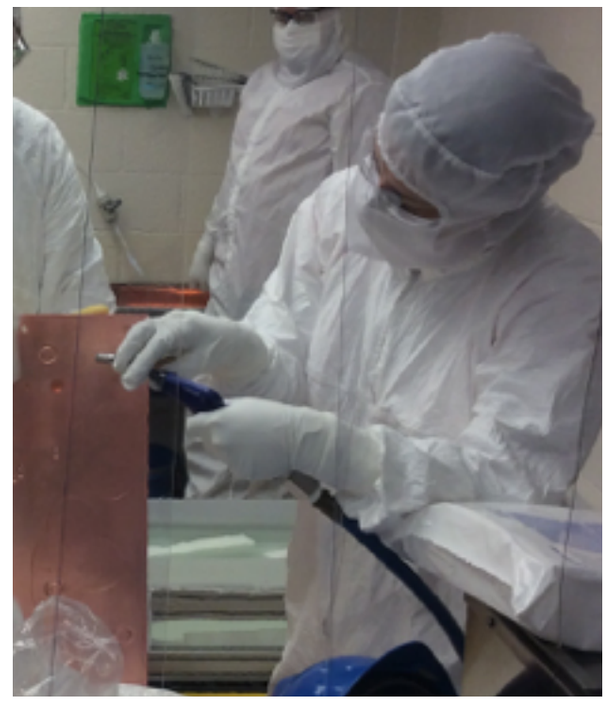
students in physics, chemistry, chemical engineering, and material science

Majorana Demonstrator

Electroforming Lead
Host Laboratory Lead
Liaison to SURF

Chemistry

Cu (and alloys) electroforming
Chemical cleaning and passivation techniques
Chemical purification and reprocessing
Full chemical analysis and material testing lab



Underground Laboratory

Integrated safety management
Material transportation and logistics
Laboratory coordination and planning

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University of South Carolina

Vincente Guiseppe

PROJECTS

FACULTY

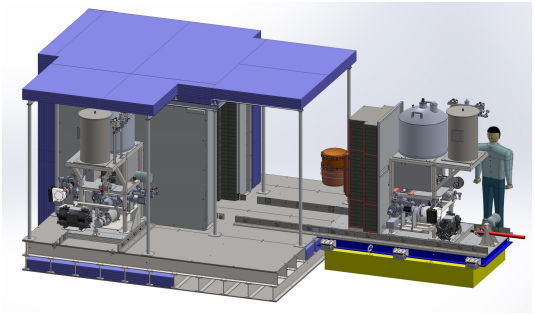
Frank Avignone

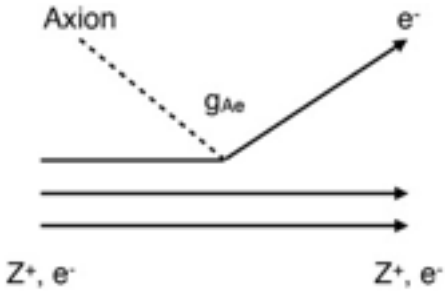
Vincente Guiseppe

David Tedeschi

(3 others on CUORE)

- Neutrinoless Double Beta Decay
  - IGEX, MJD, CUORE
- Dark Matter searches
- Solar Axions
- Nuclear Physics





MAJORANA DEMONSTRATOR

- ^{enr}Ge reduction and processing
- Managing shield design and its construction
- Data production and Run Information Database

MATERIALS

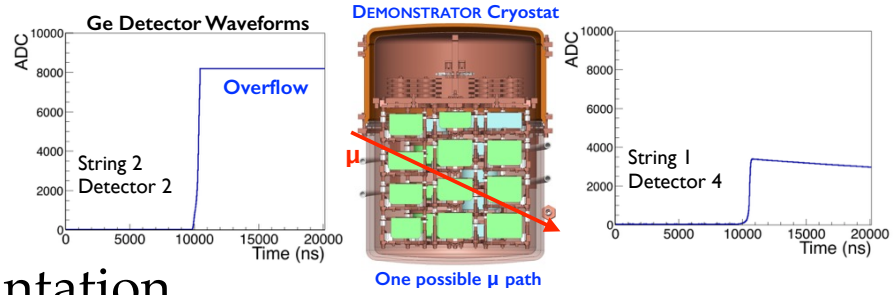
- ^{enr}Ge processing, reduction, zone refining, recycling, chemical processing
- Low background shield procurement, design, cleaning, assembly
- Ultra-low background materials

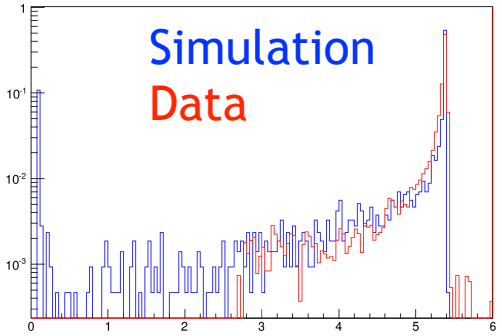
BACKGROUNDS

- Radon progeny deposition and implantation modeling
- Evaluation of surface contamination cleaning
- Muon and neutron induced cosmogenics
- Radon reduction and clean assembly

DATA ANALYSIS

- Monte Carlo simulations and validation
- Data processing and production



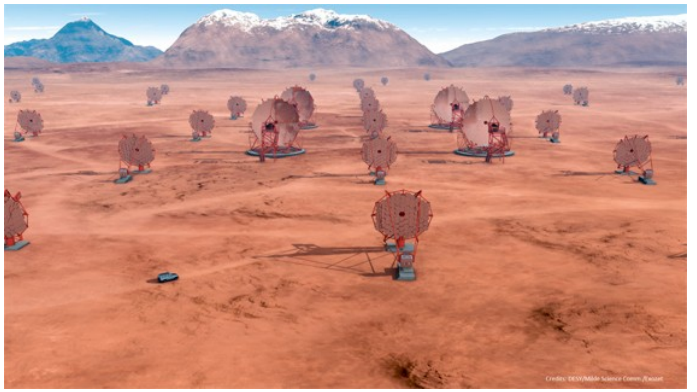


MPI Heidelberg

Hofmann

MPI HD- division Hofmann/Hinton

main activity of the group: Cherenkov telescope array (CTA)



Concerning GERDA:

- Werner Hofmann initiated GERDA,
- responsible for cryostat + infrastructure, DAQ
- for Phase II: detector holder
- small group of ~4 FTE (incl. Schwingenheuer)
  but with big mechanical workshop
- pulse shape analysis for coax detectors
- independent event (energy) reconstruction

MPI Heidelberg

Manfred Lindner

Facilities for 0νββ at MPIK

Manfred Lindner
Division of Particle and Astroparticle Physics at MPIK

Overall View

Interested in a GERDA-based 200kg Ge^{76} project:

- based on existing GERDA infrastructure
- defined by physics goal (not just a R&D facility or a test-bench)
- with a focused collaboration (size/cost, expertise & tasks)
- timely preparation with BSM L-violation in mind
  ←→ TeV scale new physics ←→ LHC, LFV
  → R&D & preparation parallel to phase II data taking

Comparison to a ton-scale project:

200kg*5y = 1 t*y + lead time = during LHC times

exit strategy: BI insufficient, LHC excludes everything, …

1000kg*10y = 10 t*y + lead time → O(20 years)

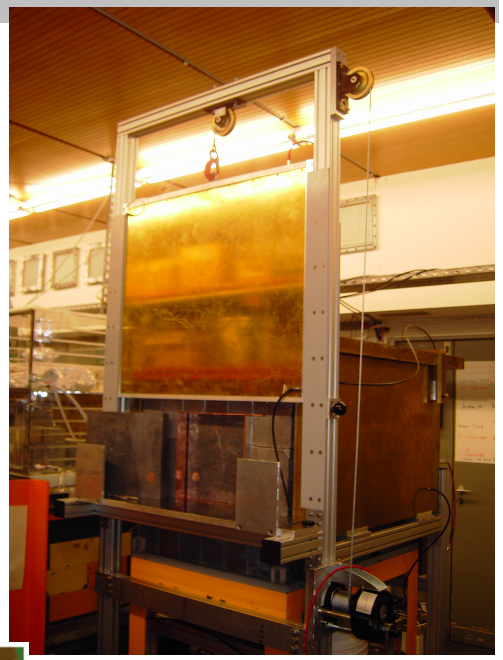
for $m_{\beta\beta}$:
Sqrt(10) ≃ 3

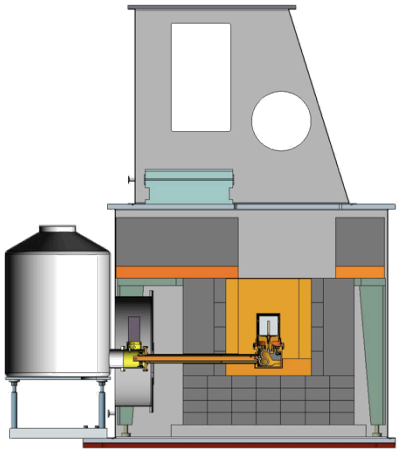
→ very different time scales, costs, politics, sociology

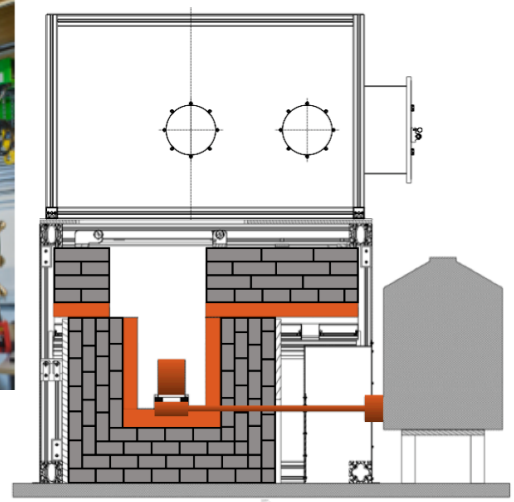
←→ other 0νββ options…

MPIK Material γ-Screening Facilities

- Different screening stations @MPIK underground lab (1mBqkg for $^{226}Ra/^{228}Th$)
- GEMPIs (with LNGS) @LNGS (10μBq/kg) world's most sensitive
- New: GIOVE @MPIK (50μBq/kg)







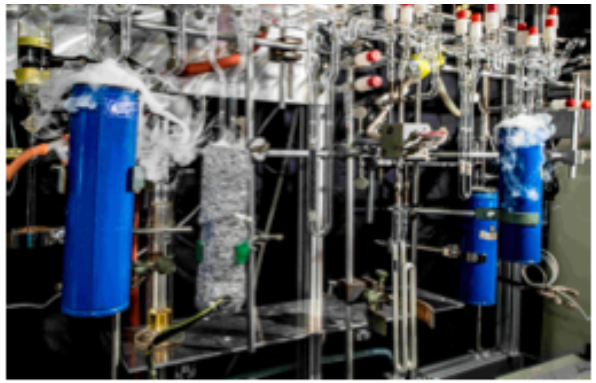
→ **extensively used for MPIK projects: GERDA, XENON, …**

MPIK Rn Screening Facilities

Gas counting systems
@ LNGS and @ MPIK

^{222}Rn emanation technique:

- sensitivity = few atoms/probe
- large samples ←→ absolute sens.
- non-trivial; not commonly available; routine @MPIK
- established numbers:



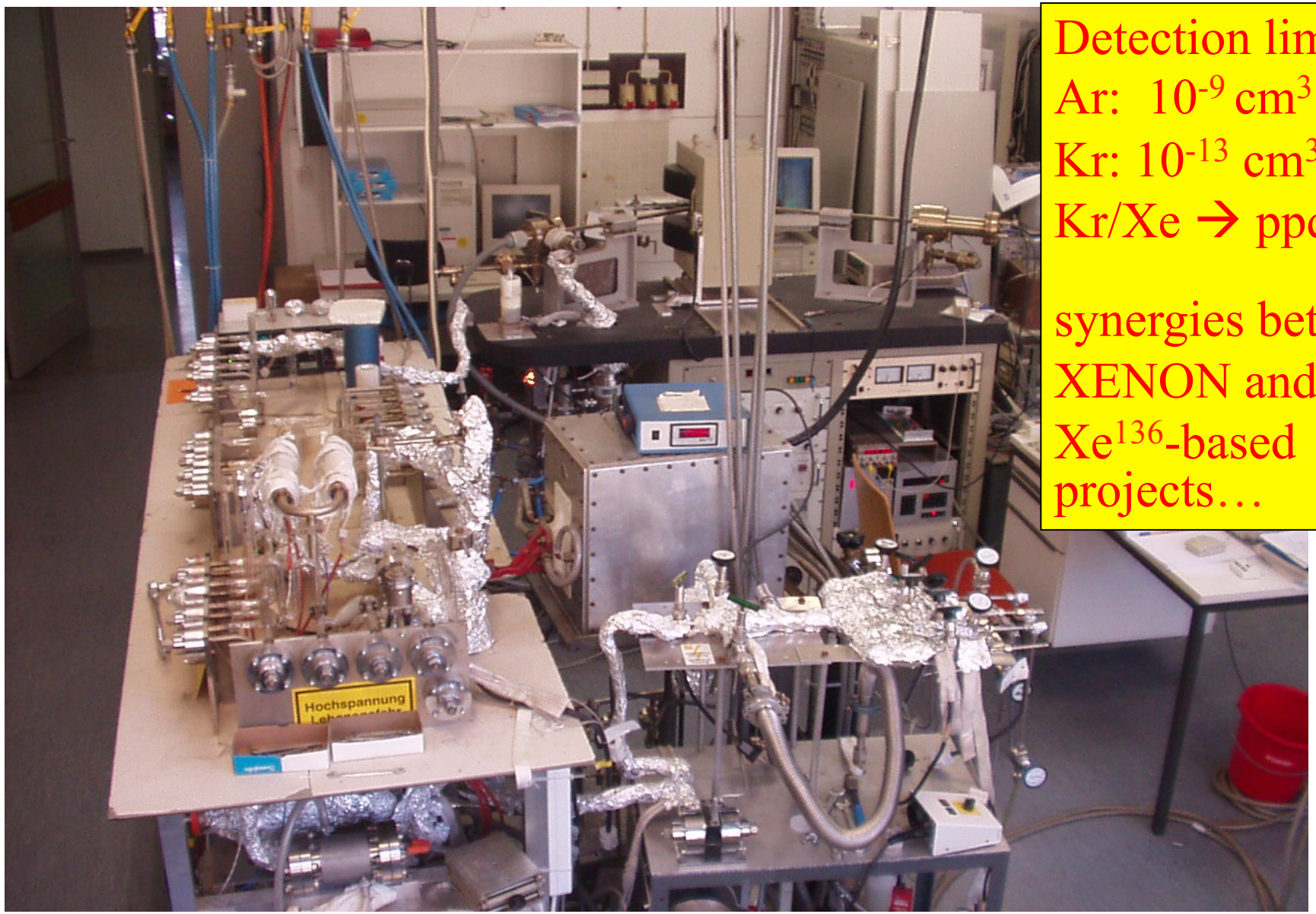
Nylon (Borexino) < 1μBq/m^2
Copper (Gerda): 2μBq/m^2
Stainless steel (Borexino): 5μBq/m^2
Titanium (preliminary): (100 ± 30) μBq/m^2

- on-going construction of an automatized system (many samples)

Rn Control

Rn material screening
material treatment
→ online removal
system for Xe-gas

MPIK Rare Gas Mass Spectrometer



Detection limits:
Ar: 10^{-9} cm^3
Kr: 10^{-13} cm^3
Kr/Xe → ppq

synergies between XENON and Xe^{136}-based projects…

BEGE Development, Data Base, LArGe

- **ASTERIX and OBELIX (BEGE detector R&D)**
  - → detailed tests of detector variations
  - → combined with extensive simulations
  - → important improvements → better detectors possible
    e.g. significantly reduced leakage currents
- **Extensive MPIK materials data base (γ-scr., Rn, …)**
  - → Info from past and current projects plus MPIK expertise
- **LArGe @LNGS (available for GERDA I+II)**
  - → co-owned by MPIK and TUM
  - → could be used for a 200kg project

Summary: Interested in a 200kg double beta project based on GERDA within an adequate collaboration

Jagiellonian University, Krakow, PL

Jagiellonian University, Krakow, PL

- People: M. Wojcik, G. Zuzel, M. Misiaszek, K. Panas, K. Pelczar, N. Frodyma
- GALLEX/GNO, Borexino, GERDA, DarkSide
- Experience in low-background techniques:
  - Radon: detection, emanation, diffusion, daughters…
  - Studies of alpha/beta surface/bulk activities, cleaning techniques
  - Purification of gases (down to $\mu Bq/m^3$)
  - Data analysis (Bx/GD PSD)
- Equipment : Rn assay systems, large surface alpha spectrometer, alpha/beta spectrometers, MS spectrometer, on-surface 60% n-type gamma spectrometer, Rn diffusion set-up

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MPI Munich

CALDWELL, Allen

Max Planck Institute for Physics

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

- One of 82 Max Planck Institutes
- About 300 staff & visitors & students
- Strong mechanics & electronics shops
- Interested senior scientists: Iris Abt, Bela Majorovits, Allen Caldwell

Interests & Contributions:

- Purchased ^{enr}Ge for GERDA Phase II, coordinated reduction & purification
- Cooperation with IKZ on purification & crystal pulling
- In charge of clean room & lock system for GERDA
- Detector studies, neutron background related measurements
- Studying alternate materials for cabling, other uses
- Extensive simulation experience
- Experience on Data Acquisition & processing

MAX-PLANCK-GESELLSCHAFT

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UW CENPA

Jason Detwiler

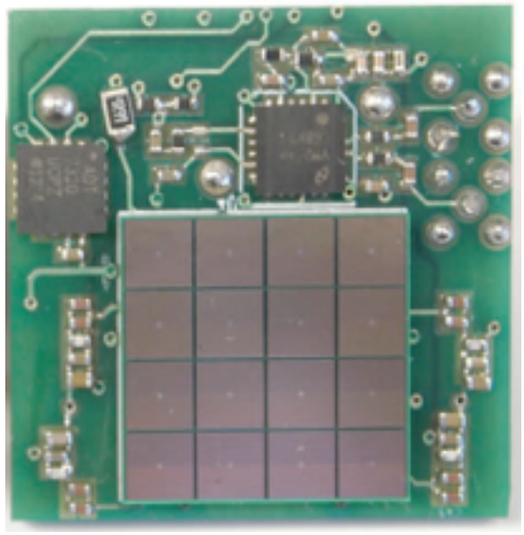
CENPA
Center for Experimental Nuclear Physics and Astrophysics

CENPA

- A nuclear physics laboratory on-campus at UW. ~50 faculty, professional staff, postdocs, grad students
- A DOE “Center of Excellence” (there are only 4)
- Major research areas:
  - Neutrinos (MAJORANA, KATRIN, Project 8, COHERENT, (KamLAND-Zen))
  - Muons (Muon g-2, MuSun, Mu2e)
  - Gravity (Eöt-Wash group: short-range gravity, equivalence principle, G)
  - Axions (ADMX, ADMX Generation II)
  - Fundamental Symmetries (Hg-199 nuclear EDM, He-6 beta decay)
- Close contact with UW nuclear theory and HEP groups, INT

Capabilities

- Agreement between DOE and State of Washington allows **overhead-free** fabrication on UW-labeled items at CENPA
- CENPA Facilities:
  - *Electronics Shop* (2 staff): Analog, digital, surface mount, custom PCB… Recent projects: μ g-2 SiPM detectors, KATRIN veto detector electronics, forward-biased charge-sensitive preamp (60 keVee noise), MAJORANA signal connectors, …
  - *Instrument Shop* (3 staff): CNC mill/lathe, laser cutting, welding … Used extensively by MAJORANA
  - *Tandem Van de Graaff accelerator*. Recent uses: Li7(D,He3)He6, natKr(p,xn)Rb83, KATRIN Si pin diode surface barrier measurement…
  - *Computing center* (cluster, MAJORANA Indico, ELOG, TWiki, doc server)
  - Student shop, hot/cold chemistry rooms, class 1000 clean room, …
- Staff and local experts in vacuum, cryogenics, HV systems, digital / analog electronics, radiation and shielding, mechanical design, thermal design, safety, IT, software…



SiPM detector for μ g-2

MAJORANA string test cryostat

My Group

- People: Clara Cuesta (postdoc), Julieta Gruszko (grad), Micah Buuck (grad), Ian Guinn (grad), Zhenghao Fu (ugrad), Khang Ton (ugrad); Hamish Robertson, David Peterson, Tim Van Wechel, Tom Burritt, Gary Holman, many contributions from other CENPA staff

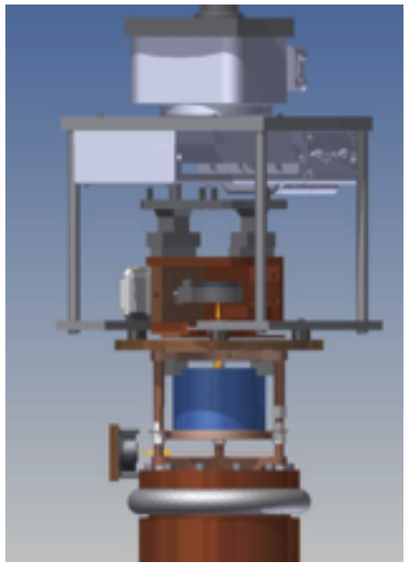
- Clean fabrication (MAJORANA signal cables, on-site construction), HV component testing

- Alpha scanning system

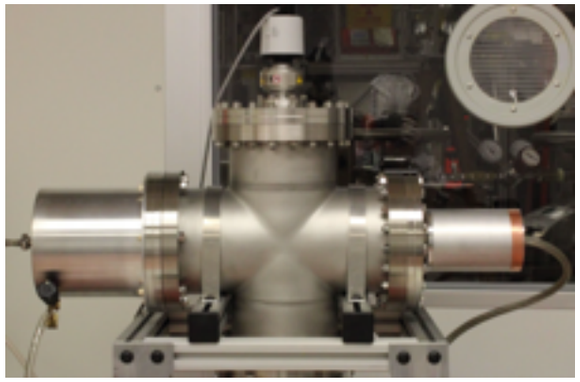
- Simulations and Analysis (background model, analysis framework, signal processing, data cleaning, event building, spectral analysis, …)

- DAQ, assay, parts fabrication, electronics, commissioning; past: LArGe

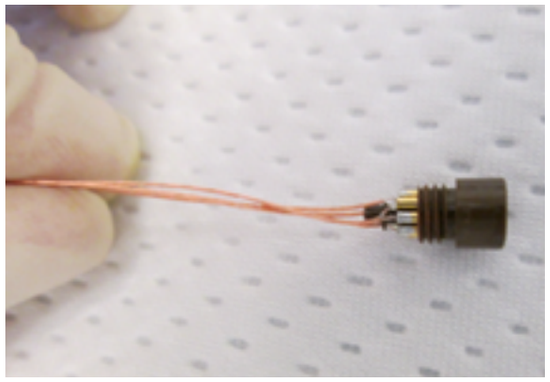
- COHERENT (σ measurements relevant to NME calculations)



alpha scanner design



HV test stand

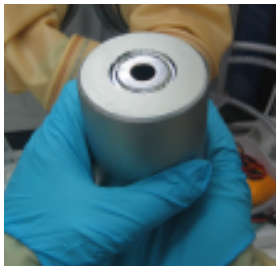


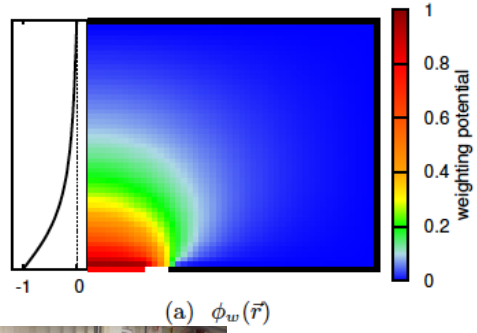
MAJORANA signal connector

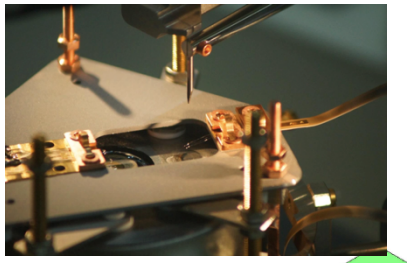
TUM

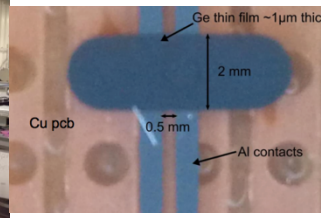
TUM activities in GERDA include:

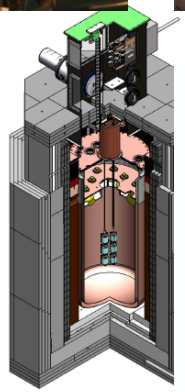
- Coax/BEGe detectors:
  - Development
  - Simulations
  - Contacting / wire bonding
- R&D on VFE low background components
  - Ge-resistors, capacitors, cables
- LAr test stands / Lar veto:
  - LArGe (co-owned with MPIK)
  - TUM test stand
  - TBP evaporation
  - Fibre shroud SiPM
- Special calibration source production at local accelerator
- Software
  - Development and maintenance
  - Data production
- Computing on SuperMUC @ LRZ
- Data storage at LRZ
- Physics analysis

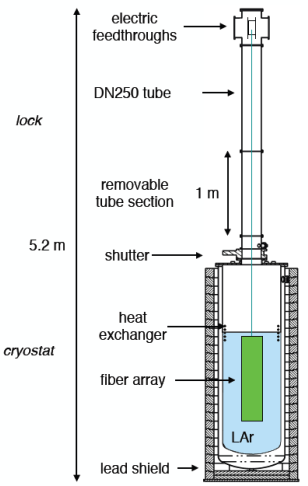


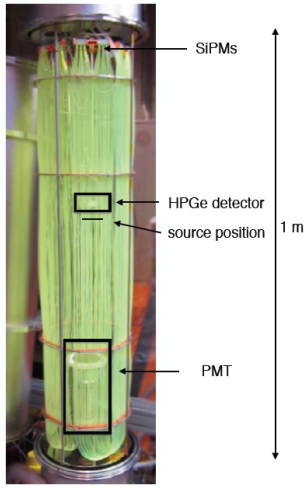






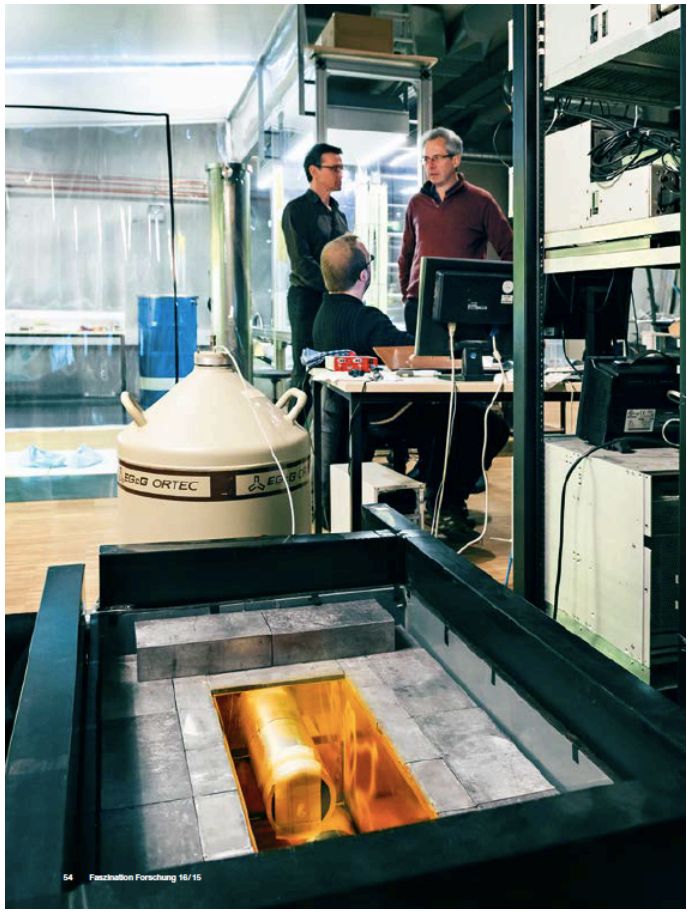






TUM infrastructures for GERDA and NG-Ge76 experiment include:

- Shallow underground laboratory
  - HPGe screening stations
  - Liquid argon test stand
  - Cleanroom detector lab (construction 2016)
- Several UHV / HV thin film production systems
- Workshop specialized on high-purity material machining
- Trace analysis facilities (FRM II 10^{14} n/s, AMS)



CANDLES

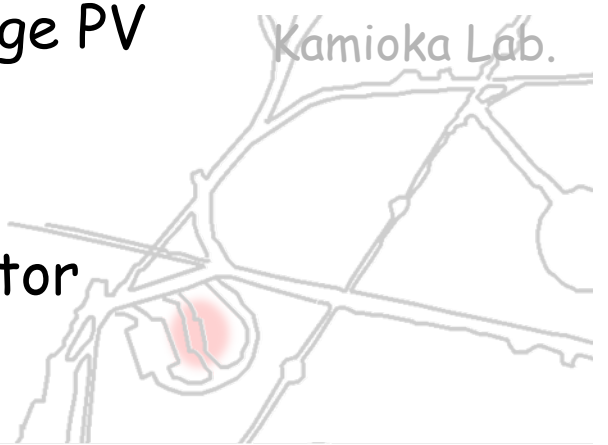
CANDLES

CANDLES: study of ^{48}Ca double beta decay

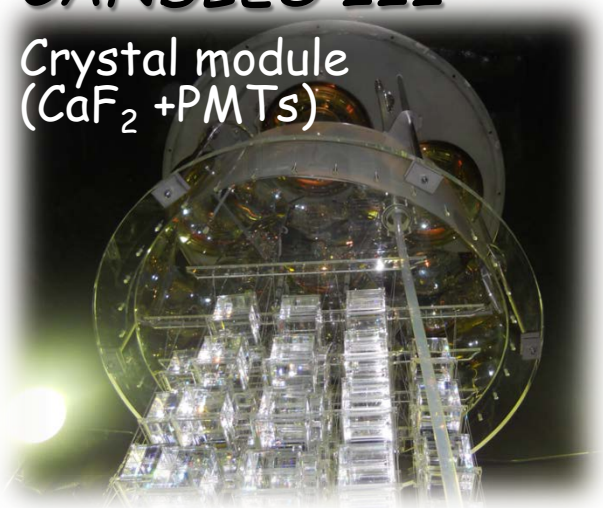
- Highest $Q_{\beta\beta}$ value(4.3MeV): least BG large PV
- Scalable: CaF2 (transparent)

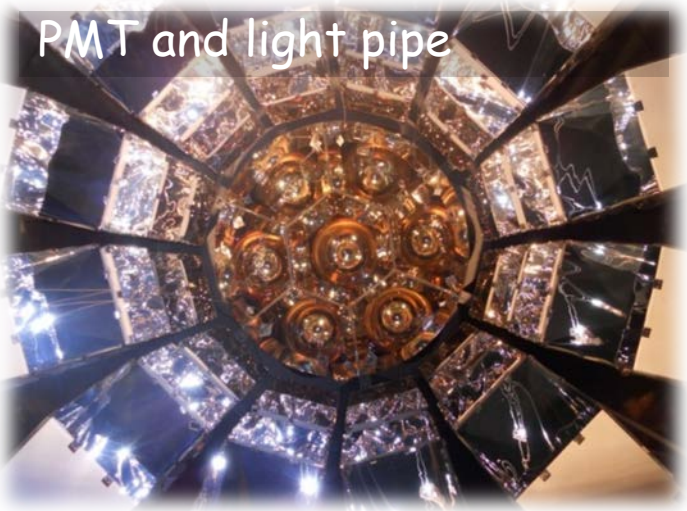
Current CANDLES III

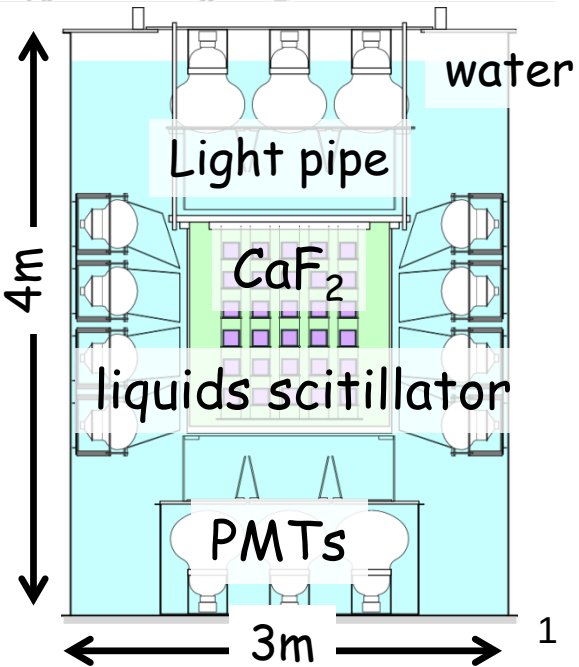
- CaF_2(305kg,0.187%^{48}Ca) + liquid scintillator
- E resolution: PMT light guide + cooling
- BG: schield (PB + B sheet)
- 1 ev/year (3 ev/ton) but 0.2% NA



CANDLES III

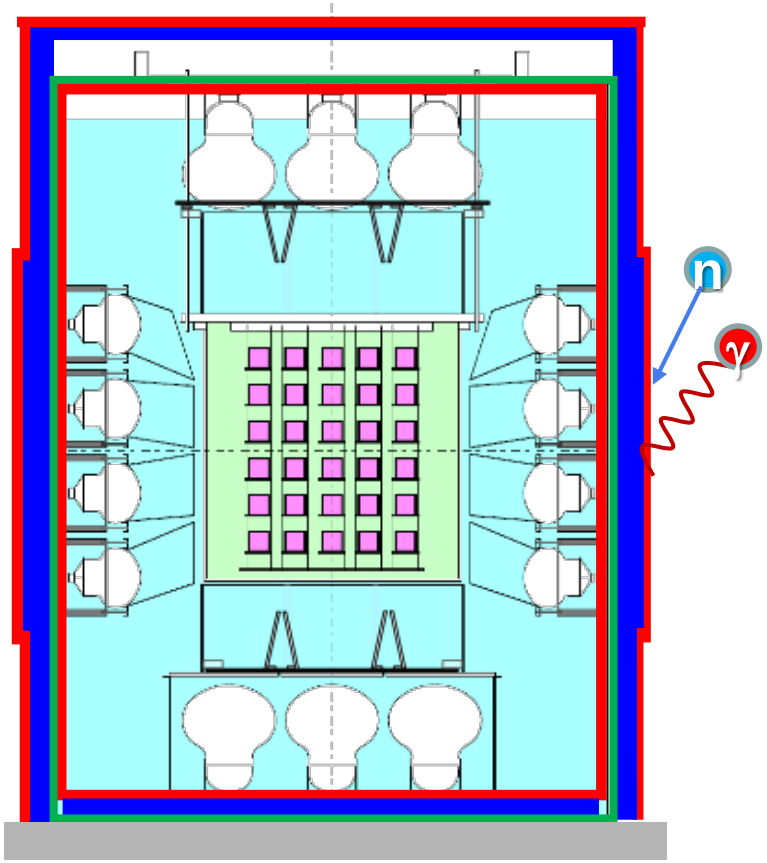






CANDLES : future (IV, V)

CANDLES shield



- CANDLES
  - CaF_2 crystal
    - Scintillating bolometer
  - ^{48}Ca enrichment
    electrophoresis, crown ether

⇓

- Futuer sensitivity
  - CaF_2 scintillator (IV)
    $\langle m_\nu \rangle$ ~ 80meV
  - $^{48}CaF_2$ bolometer (V)
    $\langle m_\nu \rangle$ ~ 9meV

Physikalisches Institut, U. Tübingen

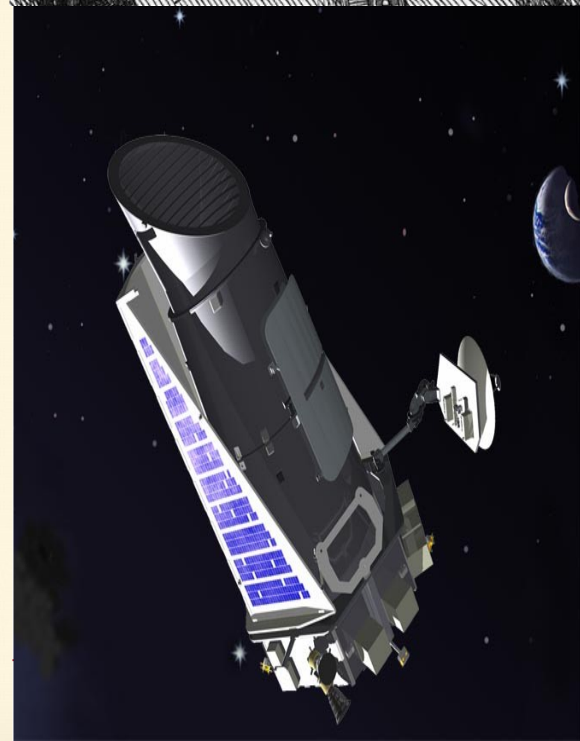
Josef Jochum

2 senior / 6 PhD / 3 Master

GERDA
CRESST
Double CHOOZ
ECHO

Muon veto
SiPM

	E	D	G	H	S	P
Daniel Hemming Kreß 88 Aug: 21. S1 1/4.	B	a	A	A	a	A
Mathias Röthlin Bietigheim 88 Aug: 21. S1 1/4.	a	A	A	A	A	A
Tiersfelt-						
Michael Stöver Grötzingen 88 Dec: 23. S1. —	B	A	A	a	A	A
Balthasar Sterkmayer Sindelfingen 88 Dec: 22. S1.	e	a	A	A	a	A
Jos. Thomas Thüringen 87 Jan: 17. S2 —	a	A	A	A	A	A
Andreas Oesterlin Herrenberg 87. Aug: 16. S2 1/4.	a	A	A	a	A	A
Nicolaus Weinlich.	3	A	a	a	a	a
Paulus Pfersinger Weissenau 89. Jan. 17 S1.			a			
Josephus Pfersinger Weissenau 89 Jan. 16. S1.			Â			
Jacobus Lonhardt Nürtingen 89. Maij 20. S 1/2. —	A	A	A	A	A	A
Bartholomeus Tuchbaur Nürtingen 89 Maij 22 S 1/2	a					
Casparus Ercoleus 89 Maij 20. S 1/2 —	b	a	A	a	a	a
Laurentius Faber Kirchheim 89 Maij 20 S 1/2	a	A	A	A	a	A
Balthasar Eberhart Herrenberg 89 Maij 19. S 1/2	.	A	A	a	a	a
Jacobus Lutz Göppingen 89 Maij 20. S 1/2 —	a	A	A	a	A	A
Joannes Riecker Schorndorf 89 Maij 22 S 1/2 —	B	A	A	a	a	A
Joannes Keppler Leomberg 89 Sept 18 S 1/4. —	a	A	A	A	A	A
Martinus Krapp Sontheim 89 Sept: 19. S 1/4 —	a	A	A	A	a	A
Thobias Dauber Illingen 88. July 17 S1 1/2. —	a	A	A	A	a	A
Conradus Hasselmayer Constatt 89 Maij 22. S 1/2 —	b	A	A	A	a	A
Sebast: Seyffer Vaihingen 89 Maij 23. S 1/2.	9	a	A	A	a	A
Andreas Spindler	3	a	a	a	b	B
Georgius Heinrich Marbach 89 Maij 23. S 1/2	3	A	A	A	B	B



University of Tennessee, Knoxville

Neutrinoless Double Beta Studies at the University of the Tennessee

Meeting on the Next Generation ^{76}Ge Experiment
Munich, Aprl 27, 2016

Activities:

KamLAND-Zen - limited responsibilities (writing committee)

MJD – M&A coordination, Muon veto system

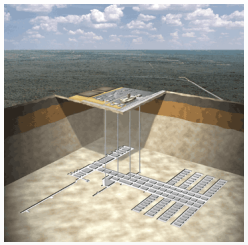
Yuri Efremenko

M&A Task Coordination of Assays at Multiple Facilities

Gamma Counting

Oroville (LBNL)
180 m.w.e.

KURF (UNC)
1400 m.w.e.

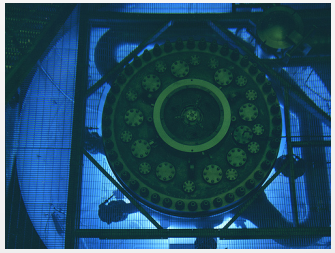


WIPP (LANL)
1600 m.w.e.

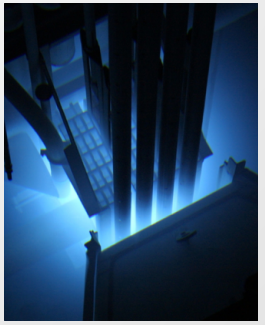
Gran Sasso
3800 m.w.e

NAA

MNRC (U.C. Davis) 2 MW
$1.5 \cdot 10^{13}$ n/cm^2 sec^{-1}



HFIR (ORNL) 85 MW
$4 \cdot 10^{14}$ n/cm^2 sec^{-1}



Pulstar (NCSU) 1 MW
$4\text{-}8 \cdot 10^{12}$ n/cm^2 sec^{-1}

ICP-MA and GD-MS

PNNL

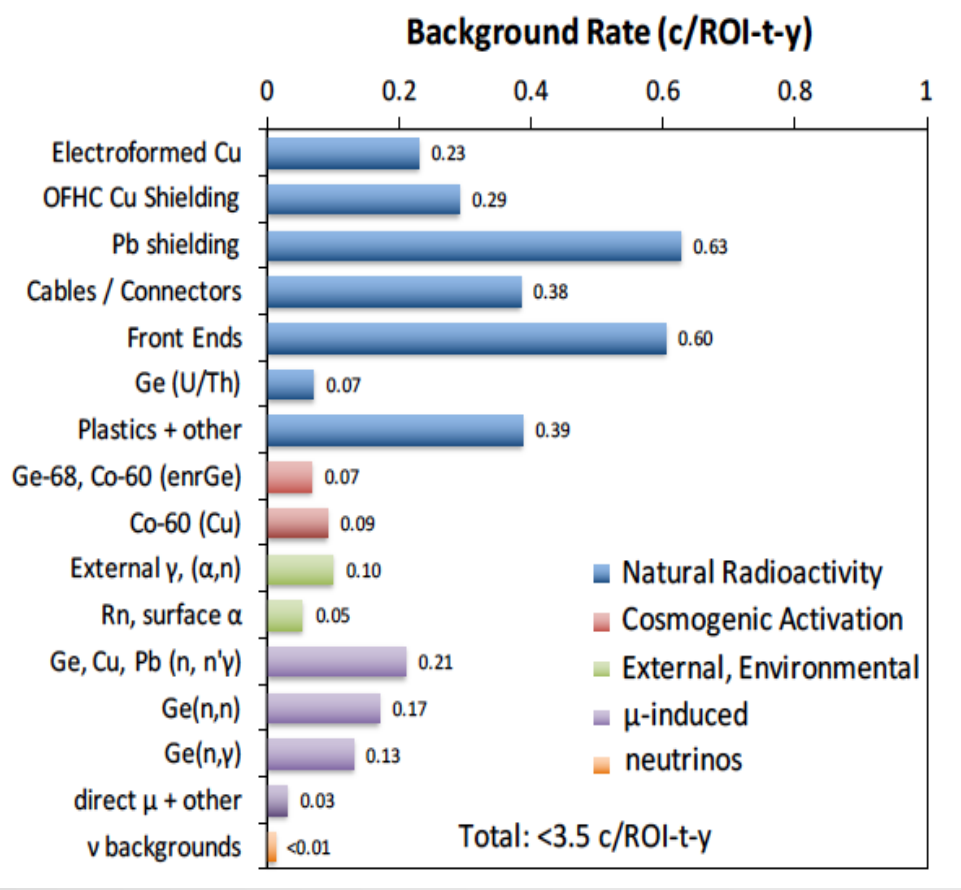
ORNL

LBNL

Canadian
Research Council

IPTM, Russia

Assay Results:



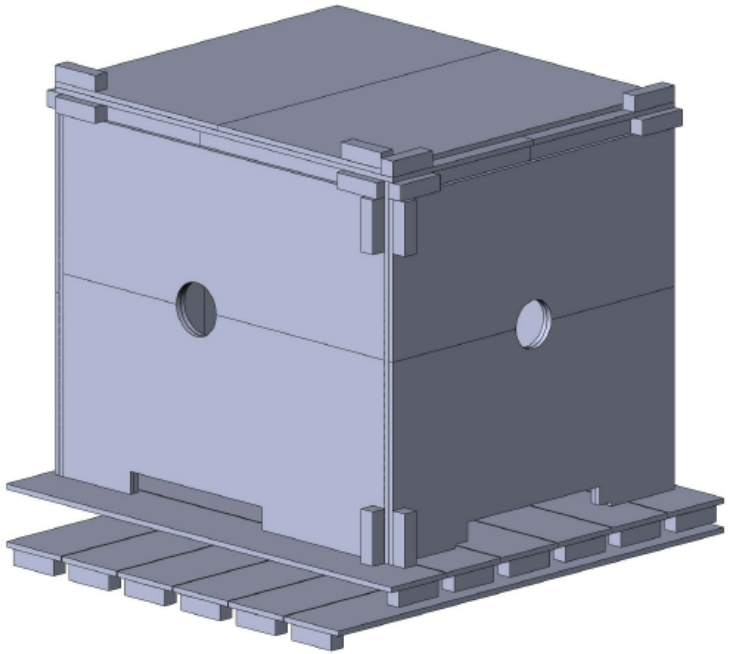
The MAJORANA DEMONSTRATOR Radioassay Program

N. Abgrall[a], I.J. Arnquist[b], F.T. Avignone III[c,d], H.O. Back[e,f,1], A.S. Barabash[g], F.E. Bertrand[d], M. Boswell[h], A.W. Bradley[a], V. Brudanin[i], M. Busch[j,f], M. Buuck[m], D. Byram[k], A.S. Caldwell[l], Y-D. Chan[a], C.D. Christofferson[l], P.-H. Chu[h], C. Cuesta[m], J.A. Detwiler[m], J.A. Dunmore[m], Yu. Efremenko[n], H. Ejiri[o], S.R. Elliott[*,h], P. Finnerty[p,f,2], A. Galindo-Uribarri[d,q], V.M. Gehman[h,f], T. Gilliss[p,f], G.K. Giovanetti[p,f], J. Goett[h], M.P. Green[d,f], J. Gruszko[m], I.S. Guinn[m], V.E. Guiseppe[c], R. Henning[p,f], E.W. Hoppe[h], S. Howard[l], M.A. Howe[p,f], B.R. Jasinski[k], R.A. Johnson[m,3], K.J. Keeter[b], M.F. Kidd[g], O. Kochetov[i], S.I. Konovalov[g], R.T. Kouzes[h], B.D. LaFerriere[h], A. Leon[m], J.C. Loach[l,4], J. MacMullin[p,f], S. MacMullin[p,f,5], R.D. Martin[k,12], R. Massarczyk[h], S. Meijer[p,f], S. Mertens[a], M.L. Miller[m], J.L. Orrell[h], C. O'Shaughnessy[p,f], N.R. Overman[h], A.W.P. Poon[a], K. Pushkin[p,f], D.C. Radford[d], J. Rager[p,f], K. Rielage[h], R.G.H. Robertson[m], E. Romero-Romero[n,d], M.C. Ronquest[h,6], A.G. Schubert[m,6], B. Shanks[p,f], M. Shirchenko[i], K. Smolek[p,f,11], N. Snyder[k], D. Steele[h,10], A.M. Suriano[l], D. Tedeschi[d], J.E. Trimble[p,f], R.L. Varner[d], S. Vasilyev[n], K. Vetter[a,13], K. Vorren[p,f], B.R. White[d], J.F. Wilkerson[p,f,d], C. Wiseman[c], W. Xu[b], E. Yakushev[i], C.-H. Yu[d], V. Yumatov[g], I. Zhitnikov[i]

[a]Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA
[b]Pacific Northwest National Laboratory, Richland, WA, USA
[c]Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA
[d]Oak Ridge National Laboratory, Oak Ridge, TN, USA
[e]Department of Physics, North Carolina State University, Raleigh, NC, USA
[f]Triangle Universities Nuclear Laboratory, Durham, NC, USA
[g]National Research Center "Kurchatov Institute" Institute for Theoretical and Experimental Physics, Moscow, Russia
[h]Los Alamos National Laboratory, Los Alamos, NM, USA
[i]Joint Institute for Nuclear Research, Dubna, Russia

Accepted to NIM
~150 entries

Muon Veto System for MJD



Two layers hermetically encapsulate detectors and shielding

32 panels
Total area is 450 ft^2

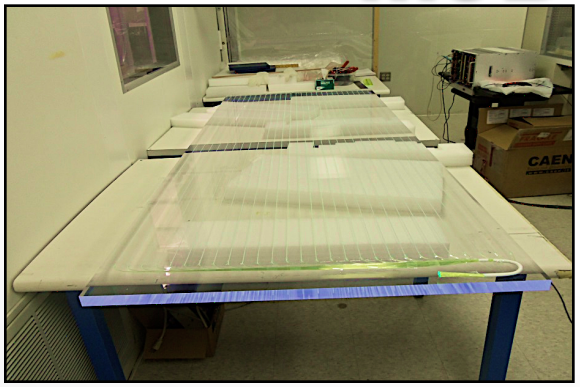
Veto Objectives

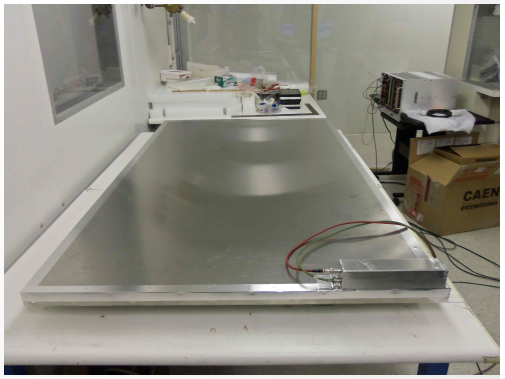
99.9% efficiency for muons

No Gaps

Excellent separation between muons and ambient gammas

MJD Veto

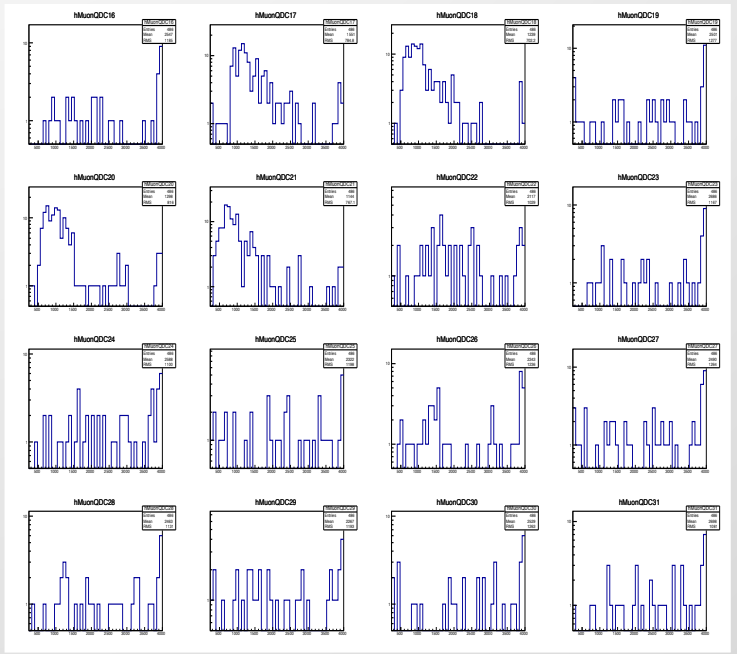


- Extensive R&D to select best component combination were done
- System build on time and below the budget
- Deployed 3 years ago. All panels are running as expected
- First measurement of total muon flux at the Homestake

Muon Flux Measurements at the Davis Campus of the Sanford Underground Research Facility with the MAJORANA DEMONSTRATOR Veto System

N. Abgrall[b], A. Aguayo[b], F.T. Avignone III[c,d], A.S. Barabash[e], F.E. Bertrand[d], A.W. Bradley[a], V. Brudanin[f], M. Busch[g,h], M. Buuck[i], D. Byram[j], A.S. Caldwell[j], Y-D. Chan[a], C.D. Christofferson[k], P.-H. Chu[o], C. Cuesta[i], J.A. Detwiler[i], C. Dunagan[k], Yu. Efremenko[m,*], H. Ejiri[n], S.R. Elliott[o], A. Galindo-Uribarri[d], T. Gilliss[p,h], G.K. Giovanetti[p,h], J. Goett[o], M.P. Green[d], J. Gruszko[i], I.S. Guinn[i], V.E. Guiseppe[c], R. Henning[p,h], E.W. Hoppe[b], S. Howard[k], M.A. Howe[p,h], B.R. Jasinski[j], K.J. Keeter[r], M.F. Kidd[s], S.I. Konovalov[e], R.T. Kouzes[b], B.D. LaFerriere[b], J. Leon[i], A.M. Lopez[m], J. MacMullin[p,h], R.D. Martin[j], R. Massarczyk[o], S.J. Meijer[p,h], S. Mertens[a], J.L. Orrell[b], C. O'Shaughnessy[p,h], N.R. Overman[b], A.W.P. Poon[a], D.C. Radford[d], J. Rager[p,h], K. Rielage[o], R.G.H. Robertson[i], E. Romero-Romero[m,d], M.C. Ronquest[o], C. Schmitt[s], B. Shanks[p,h], M. Shirchenko[f], N. Snyder[j], A.M. Suriano[k], D. Tedeschi[c], J.E. Trimble[p,h], R.L. Varner[d], S. Vasilyev[f], K. Vetter[a,1], K. Vorren[p,h], B.R. White[d], J.F. Wilkerson[p,h,d], C. Wiseman[c], W. Xu[o,2], E. Yakushev[f], C.-H. Yu[d], V. Yumatov[e], I. Zhitnikov[f],
(The MAJORANA Collaboration)

Submitted to NIM



Next step is to study long term correlations between passing muons and signals in GE detectors

UTK Interests is:

Low background materials

Active veto system
(experience with detection of scintillation from LHe and LXe)

Extensive SiPM experience (since 2005)

Available equipment/facilities

- **Clean room**
- **Large Faraday cadge (to test low noise electronics)**
- **Compton spectrometer (measure quenching at low energy)**
- **Vacuum monochromator (study light wave shifting)**
- **PMT/SiPM testing equipment**
- **Machine shop**

University of Zurich

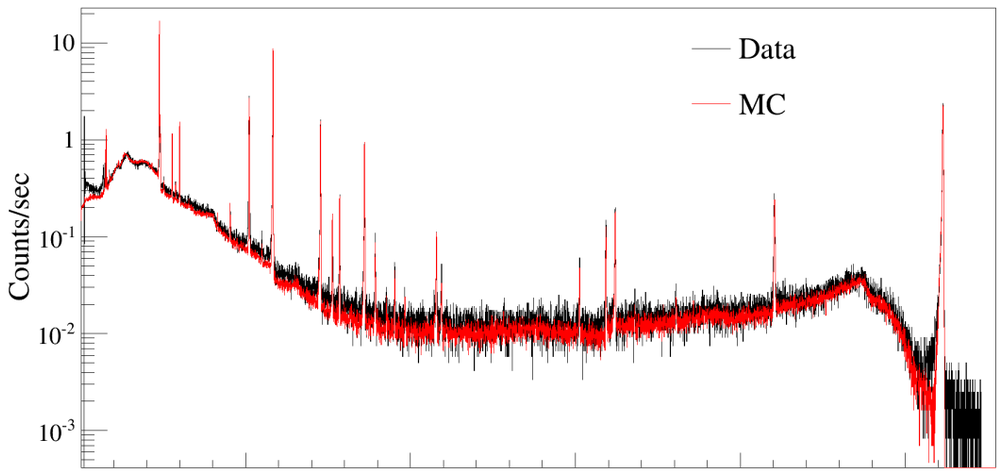
UZH GERDA group

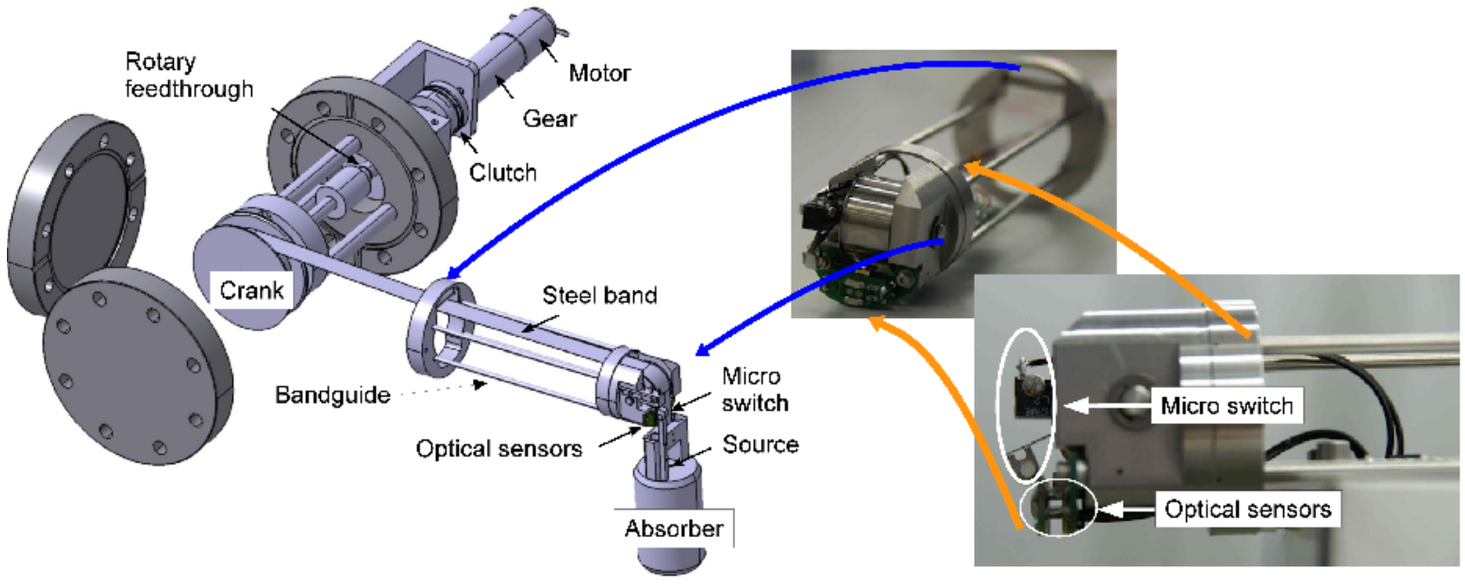
Laura Baudis
University of Zurich

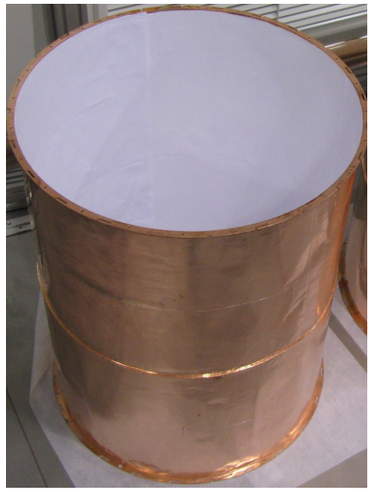
Meeting on the Next Generation ^{76}Ge experiment
Munich, April 25, 2016

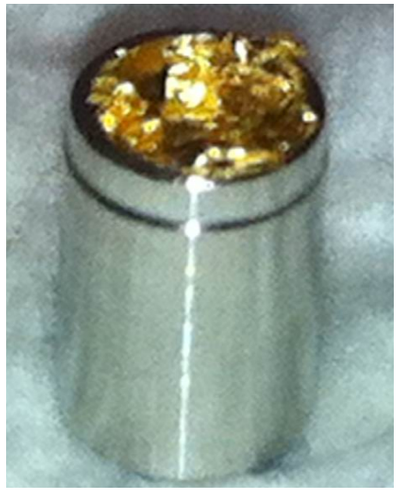
UZH contributions to GERDA

- Calibration systems and low-neutron emission ^{228}Th sources (sources in collaboration with PSI)
- 8.2 x 10^{-7} n/(s Bq) measured with our LiI(Eu) detector at LNGS (factor 7 reduction compared to a commercial source)
- Wavelength shifting of LAr light from VUV to blue region
- Calibration and data analysis





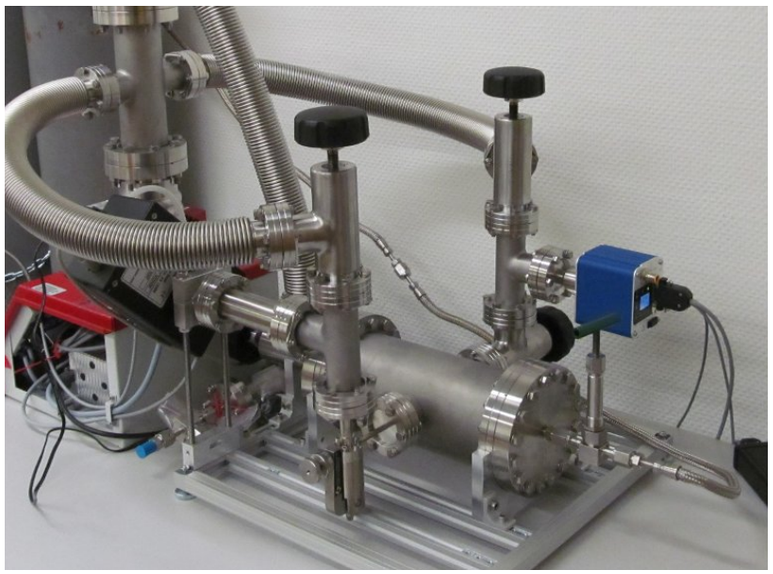




Source	Activity [kBq]
9854	$24.21^{+0.05}_{-0.06}$
9855	$34.20^{+0.06}_{-0.07}$
9856	$30.75^{+0.08}_{-0.05}$
9857	$41.28^{+0.08}_{-0.07}$

Facilities in UZH lab available for GERDA

- LArS: test of 3-inch PMTs with MgF_2 in liquid argon, test of SiPM arrays
- Emanation facility: measure outgassing of materials
- HPGe detector (Gator) at LNGS
- HPGe detector in lab (LAr); material activation studies at Jungfraujoch



Oak Ridge National Lab

Oak Ridge National Lab

Oak Ridge National Lab

- MAJORANA and Advanced Detectors group
- Physics Division, Physical Sciences Directorate
  - David Dean, Division Director
  - Nuclear Structure, Fundamental Symmetries, Nuclear Astrophysics
  - Until recently, operated the Holifield Radioactive Beam Facility
  - GRETINA
  - Fundamental Neutron Physics program at the SNS
  - Neutrino experiments: COHERENT at SNS, PROSPECT at HFIR
  - Nuclear theory

- David Radford
- Chang-Hong Yu
- Alfredo Galindo-Uribarri
- Robert Varner
- James Matta (postdoc, PROSPECT)

Joint Faculty:

- John Wilkerson (UNC-Chapel Hill)
- Matthew Green (NCSU)
- Yuri Efremenko (UT Knoxville)

Relevant Expertise and Experience

- Lead Laboratory for MJD
  - Project Management (JFW, DCR)
  - Project Controls, ES&H, …
  - Integration management (CHY)
- Enriched ^{76}Ge Procurement and Processing
  - Reduction, purification, recycling
  - Underground storage (80 mwe)
  - Quality control; enrichment, chemical purity
  - Nuclear Physics Program manages the Enriched Stable Isotope Pilot Plant

Relevant Expertise and Experience

- HPGe detector modeling
  - Signal simulations, signal processing
  - GRETINA signal decomposition
  - GRETINA signal basis, cross-talk, …
  - Point-contact detectors, segmented detectors
  - Novel detector design, development, testing, characterization
- Data acquisition, data analysis
  - GRETINA electronics working group
  - FRIB DAQ
  - Advanced multidimensional-data analysis software for gamma spectroscopy

JINR

JINR

Konstantin Gusev for JINR group

NG-Ge76 – April 27 2016 – Munich

JINR

- long history of work with semiconductor detectors and plastic scintillators, serious low background experience
  - NEMO, GERDA, Majorana
  - low background spectrometer TGV made from 32 planar HPGe detectors in one cryostat
  - Si and Ge diodes at low temperatures (up to 1 K)
  - segmented planar HPGe detectors
  - …
- our department has been recently renovated, new **clean room** installed
  - ✓ clean bench
  - ✓ chemical hood
  - glove box + test bench – soon
- plans
  - surface passivation
  - R&D for HPGe detectors and VFE

GERDA & Majorana

JOINT INSTITUTE FOR NUCLEAR RESEARCH

- we have participated in:
  - HPGe detector expertise and handling
  - plastic muon veto
  - LArGe
  - Phase II mini-shroud
  - analysis
  - screening at Baksan lab

for NG-Ge76

JOINT INSTITUTE FOR NUCLEAR RESEARCH

- we plan to keep or increase our participation in:
  - HPGe detector expertise and handling ↑
  - plastic muon veto → new one for 1T
  - LArGe – if needed
  - mini-shroud design – if needed
  - analysis ↑

ITEP

ITEP
National Research Center
“Kurchatov Institute”
Moscow
Russia

Vasily Kornoukhov

MAJORANA GERDA meeting

Munich, 25-27 of April, 2016

- Express positive attitude to a 200 kg scale germanium experiment.
- Projected contribution: **76Ge detectors after the HdM and IGEX experiments – already in GERDA facility at LNGS.**

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Institute for Nuclear Research

Institute for Nuclear Research RAS
Moscow
Russia

Vasily Kornoukhov

MAJORANA GERDA meeting
Munich, 25-27 of April, 2016

Projected contribution to 200 kg Ge experiment from INR RAS

- 76Ge detectors after IGEX experiments (together with ITEP) – already in GERDA facility at LNGS
- **Facility**: Baksan Neutrino Observatory INR RAS(first in the world big scale underground facility):
  - Low background underground lab NIKA
  - Low backgroiund underground lab SNEG
- Two HPGe detectors enriched on Ge76 (IGEX experiment) – 1 kg + 1 kg ~ 2 kg
- **Facility** for purification of 76Ge waste (at LNGS)
- Manpower for shifts and R&D