



Interactive Workshop

“Fostering citizens’ role in the advance of ground-breaking research in Fundamental Science” +

1-2 September 2022
10:00 – 17:00 CEST



**hybrid EGO
and ZOOM**



REINFORCE
Research Infrastructures FOR Citizens in Europe

Underground Laboratories possibilities

Pisa Sept 2nd 2022

Aldo Ianni, Laboratori Nazionali del Gran Sasso



Objective of this talk

1. Review some of the activities on Outreach and Citizen Science in Underground Laboratories (ULs)
2. Understand how ULs could improve in this matter
3. Understand how ULs could participate to or join other projects

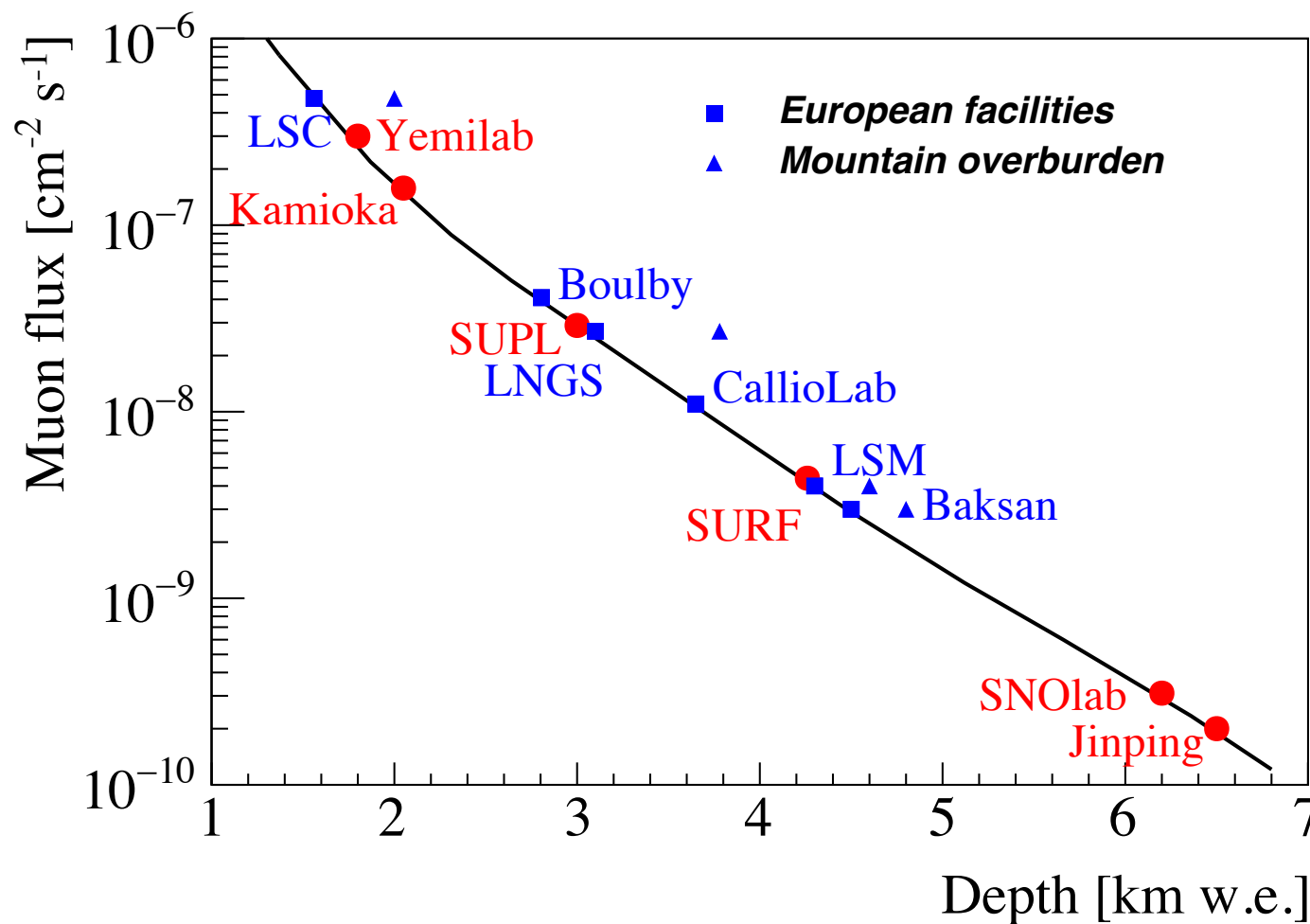
Map of Deep Underground Labs



Acknowledgements:

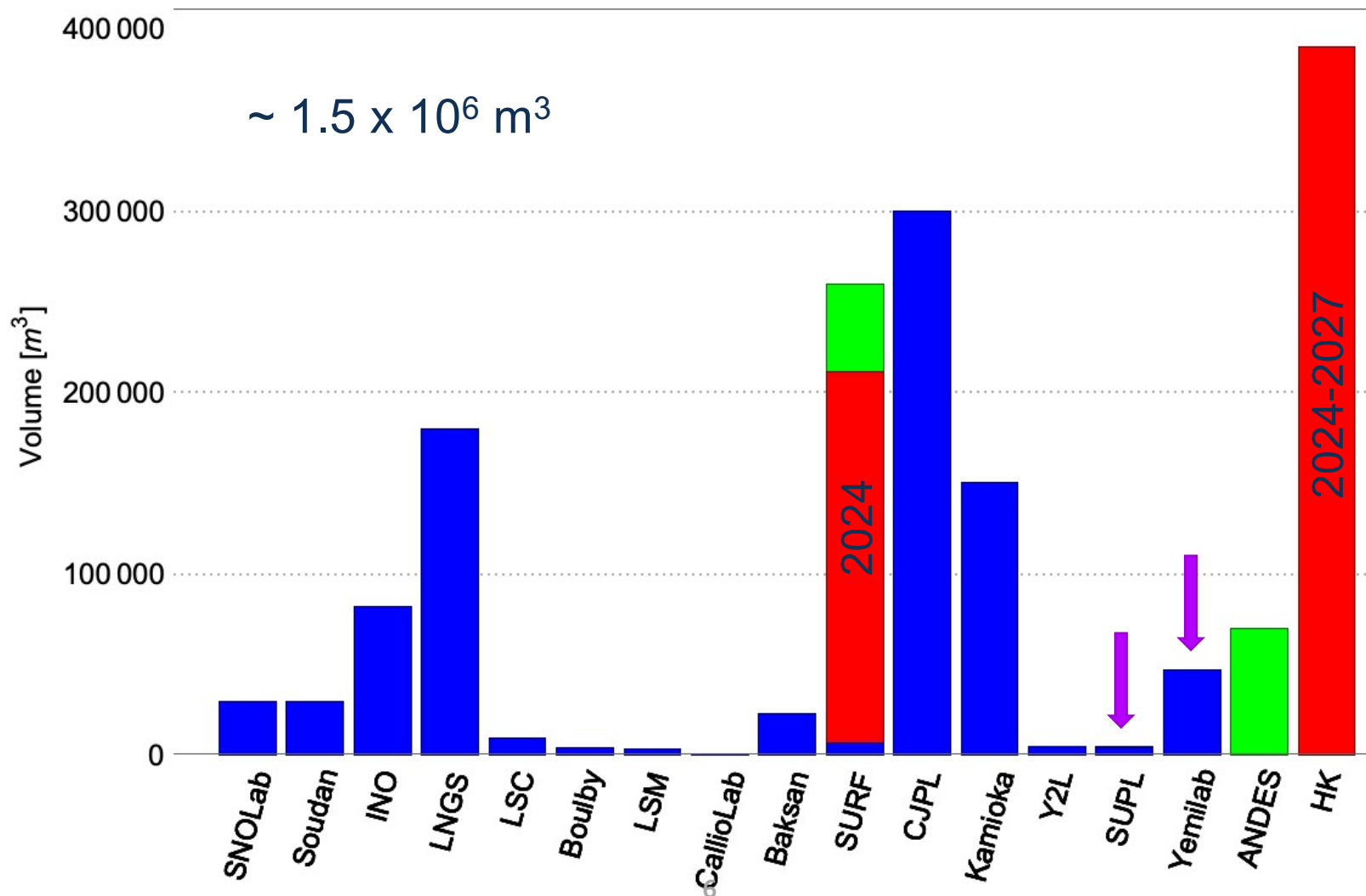
Roberta Antolini/Alessia Giampaoli (LNGS), Sean Pauling/Emma Meehan (Boulby), Carlos Pena-Garay/Yolanda Labarta (LSC), Elisabetta Barberio/Anita Vecchies(SUPL), Jaret Heise(SURF), Shigetaka Moriyama (Kamioka)

Effective depth and muon flux in ULs



In some context
depth is becoming
crucial for next generation
experiments

Underground Labs: excavated volume



Structure of underground facilities

+ **Monolithic:**

- + LNGS with multiple Halls
- + Boulby
- + LSM
- + SNOLAB
- + SUPL
- + Yemilab

+ **Distributed:**

- + LSC with LAB2400 and LAB2500 + train tunnel
- + Baksan
- + CallioLab (multi-level structure inside the mine)
- + Kamioka
- + SURF

Multi-disciplinary in ULs

- + In the last decade ULs are expanding research to neighboring sectors that can benefit of Underground Facilities technologies and infrastructures

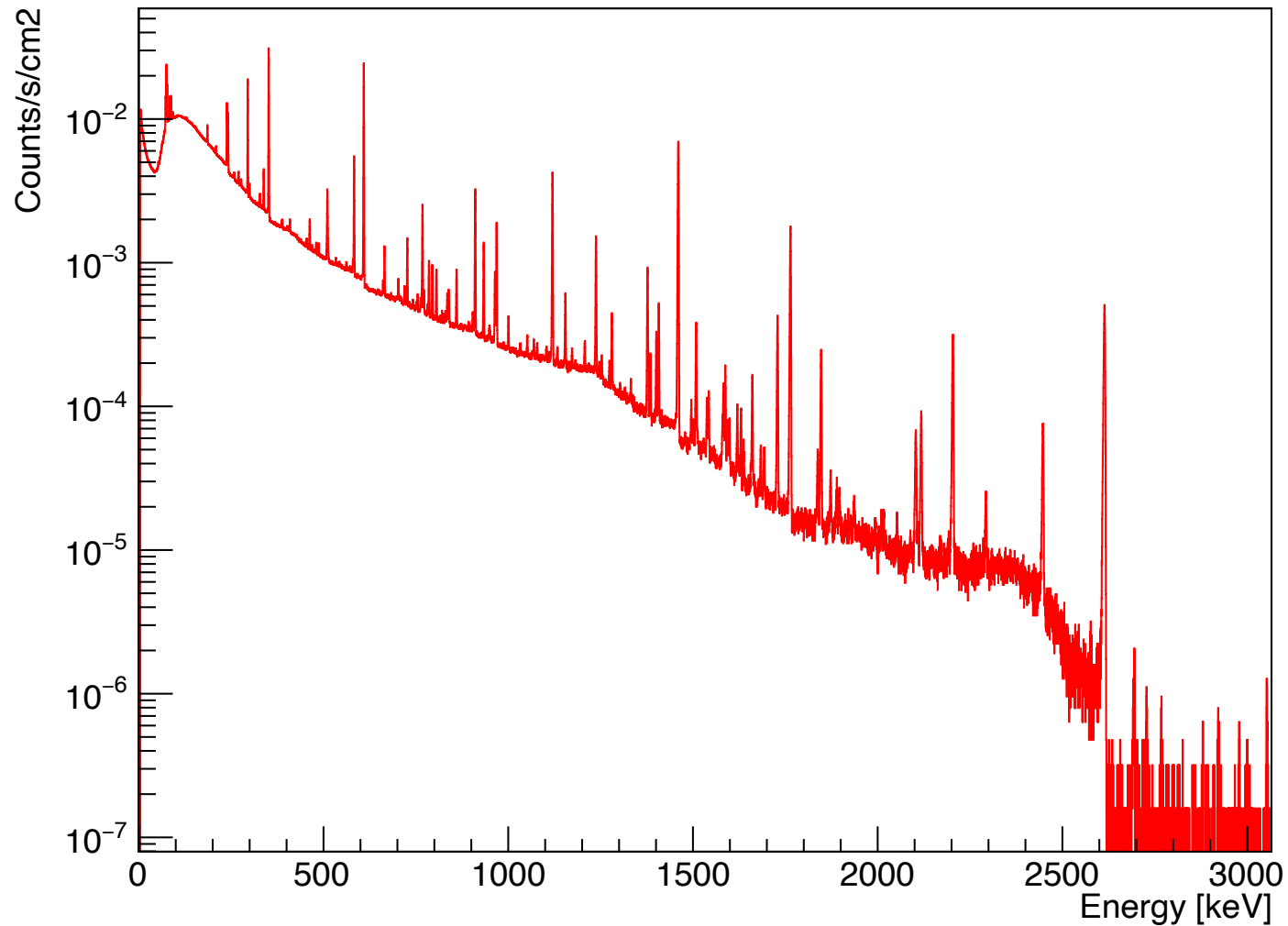
- + Diversify is becoming a key parameter for ULs
 - Technology sharing for gravitational waves search
 - Biology in extreme environments and low radiation biophysics
 - Geophysics

Reinforce connections

- + At present 13 ULs in operation and 2 more upcoming
- + Some 100 experiments running or under construction
- + Some 6000 involved researchers
- + Getting ready to face the future
 - At present there is a general consensus in developing a network between ULs
 - **Collaborate for future Citizen Science and outreach programs**
 - discussion follows
 - only EU labs have 48 HPGe detectors for radio-purity assay with a cross collaboration program
 - plenty of data (measurements, calibration and MC simulations)

Spectrum from a HPGe detector

GeOroel BKG HallA





SURF Outreach



August 2022



Sanford

Underground Research Facility

South Dakota Science and Technology Authority

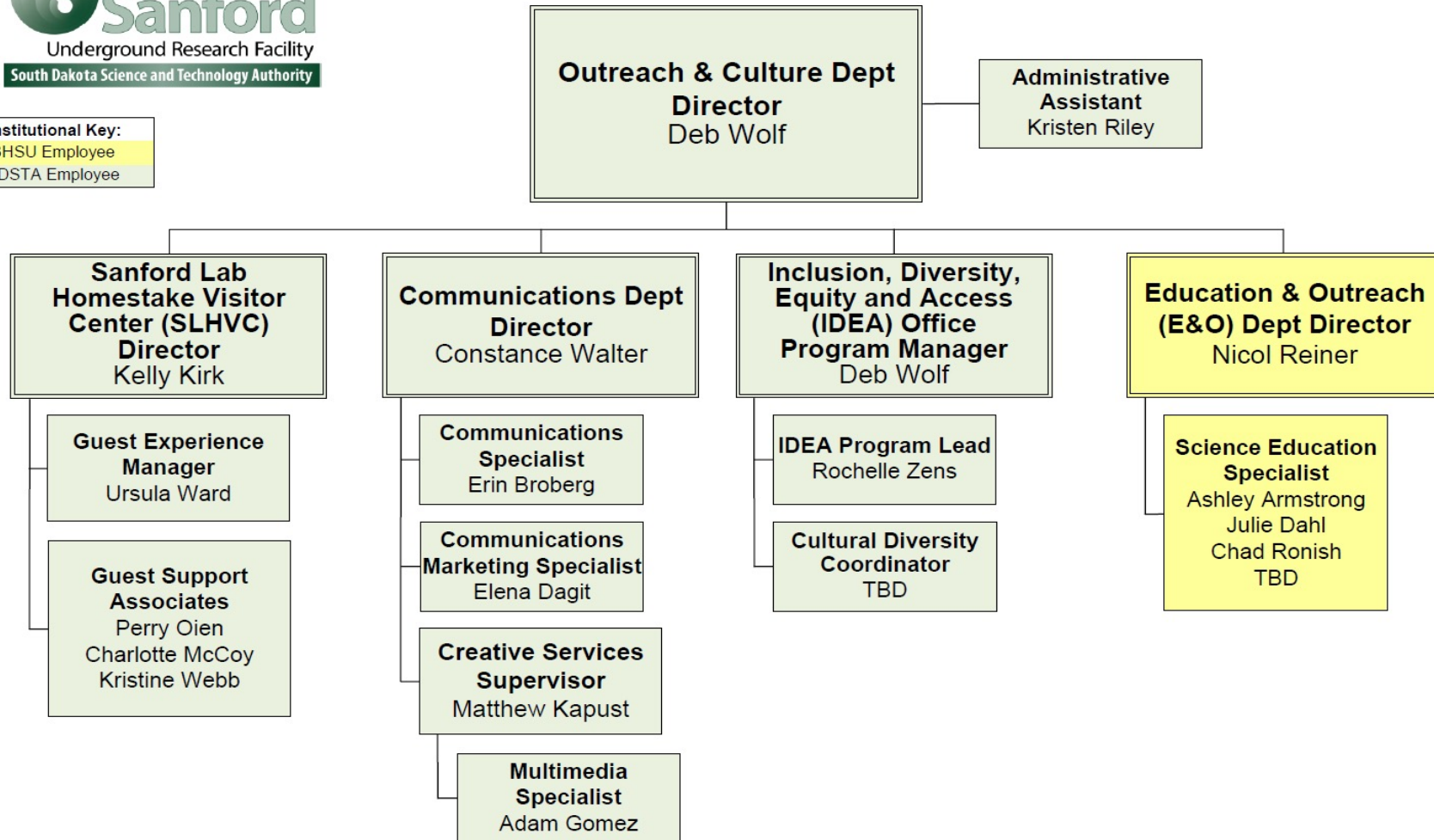
Outreach and Culture: Scope of Work

- **Education and Outreach Department**
 - STEM education experiences for K12 students and teachers
 - Supporting the transition to post-secondary
 - Internships, Davis-Bahcall Scholars, and university teacher preparation programs
- **Communications Department**
 - Internal communications and crisis communication
 - Public outreach, media relations and marketing
- **Sanford Lab Homestake Visitor Center (SLHVC)**
 - Location for outreach and events
 - Opportunities for inter-generational learning
 - Connecting to broader community
- **Inclusion, Diversity, Equity and Access (IDEA) Office**
 - Supporting a welcoming work environment in collaboration with HR office
 - Professional growth for leadership
 - Coordinating communication and relationship with Tribal Nations
 - Living the South Dakota Science and Technology Authority core values

SURF Outreach & Culture Staffing



Institutional Key:
BHSU Employee
SDSTA Employee



SURF Public Outreach

- Deep Talks lecture series Oct - May
- **Neutrino Day** (1000-1500 attendees) since 2008
 - video conf. with scientists from underground
 - public lectures
- Deep Thoughts weekly newsletter
- Sanford Lab Homestake Visitor Center
- SURF presentations



Artist in Residence (AiR)

Program:

- Inspired by the science at SURF
- Each artist contributes one piece to the SURF permanent collection.
- Year 3 artist **Gary Sczerbaniewicz**.





Citizen Science:

- Black Hills Seismic project using underground "Raspberry Shake"
<https://stationview.raspberrypi.org/#/?net=AM&sta=R2760&lat=44.08646&lon=-103.90414&zoom=10.000>
- GEOX™ project involves local high school teachers and students in monitoring ventilation airflows on multiple underground levels

Artist in Residence: examples of artwork

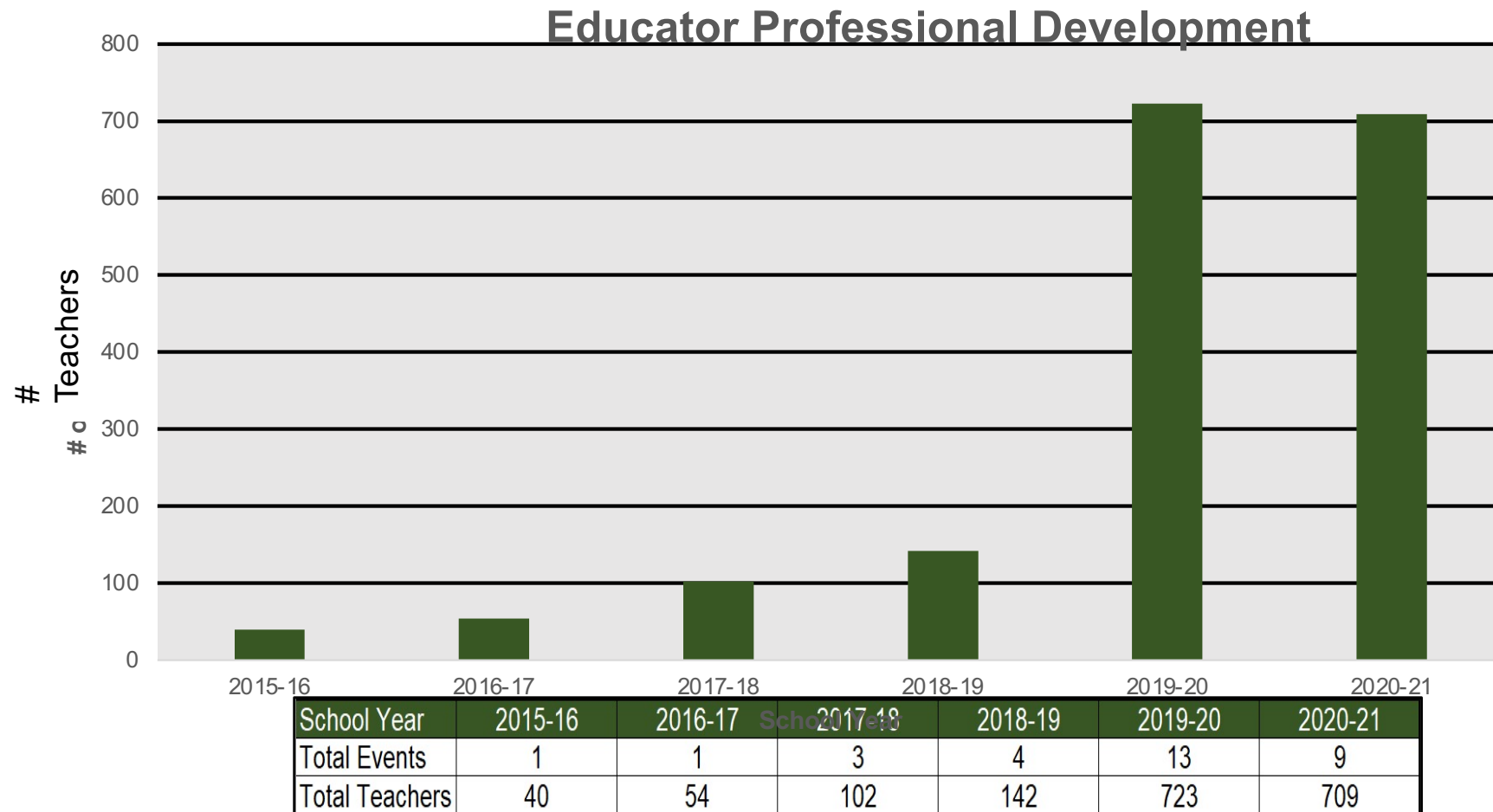


K-12 Education & Outreach

Presentations & Field Trips	Curriculum Units and Resources	Career Exploration and Development	Supporting Teachers
<ul style="list-style-type: none">• K12 presentations• Face to face• Virtual options• Field trips in spring and fall	<ul style="list-style-type: none">• 5-15 hours of fully designed and resourced science curriculum• 17 unique curriculum units available for checkout	<ul style="list-style-type: none">• Davis-Bahcall Scholars Program• Summer internship opportunities• Pre-service educator program support	<ul style="list-style-type: none">• Professional development offerings• Curriculum resources• Science content support• Just-in-time support
			

19,607 K-12 students impacted and over 700 teachers supported 2021-22

Education and Outreach: By the Numbers



Education and Outreach: By the Numbers

School Year	2018-2019 (pre-COVID)	2019 – 2020 (COVID begins)	2020-2021 (during COVID)	2021-2022*
Field Trips	1,117	254	58	419
Classroom Presentations	6,704	3,704	2,005	14,037
Curriculum Units	3,598	3,236	3,384	3,683
Other	1,055	918	298	1,468
Total Student Contacts	12,474	8,112	5,745	19,607

* As of May 31, 2022

Sanford Lab Homestake Visitor Center

Grand opening June 2015

(operated by Lead Chamber of Commerce)

SURF acquired January 2022

Opportunities:

- Amazing site for outreach & events
- Inter-generational learning
- Evolving interactive exhibits, incl SURF science

Events:

- Winterfest
- Chamber Networking
- Deep Talks
- Field Trips
- Road Scholars
- Trolley Tours
- Fireworks Over the Open Cut



- Honor the Past
- Showcase the Present
- Inspire the Future



***Cangleska Wakan* (Sacred Circle) Garden**

Learning across generations

- Stargazing on clear nights
- Gardening alongside master gardeners
- Presentations from local experts

Connecting our communities

- Ceremonial events with regional Tribes
- A gathering space to bring people together
- A stop on trolley tours

Cultivating cultural awareness

- Learn about the culture of the region
- Care for others
- Create a better community



Everything in the Universe is connected
The circle helps to develop connections between
science, education and culture

Gran Sasso Laboratory

- + **Open day:**
 - 1500/1800 participants
 - Underground visit + talks + hands-on experiments
- + **Sharper (SHAring Researchers' Passion for Enhanced Roadmaps during the European Researchers' Night):**
 - 25.000/30.000 participants
 - Hands-on activities
- + **Gran Sasso video game (Physics In Ludic Adventure):**
 - Educational journey into the underground laboratory with its experiments
 - Build a CV in science
- + **Participation to the International Cosmic Day:**
 - Coordinated with LSC
 - **Collect data with Cosmic-Ray-Detector at different orientations**
- + **In preparation** a visitor center and re-opening of underground visit program

Open day and Sharper at LNGS

- + With the collaboration of retired high school physics teachers, simple tabletop experiments are organized
- + Experiments carried out with readily available materials aimed at various topics: electrical circuits, study of motions, optics, vacuum, charging and discharging a capacitor ...
- + WELDING LABORATORY FOR THE CONSTRUCTION OF BRIGHT SPINDLES: Using recycled materials and simple electrical components
- + VOLCANO LAB: Construction of a volcano with easy-to-find materials; discuss how to mitigate volcanic risk for effusive and explosive volcanic activity



VOLCANO LAB



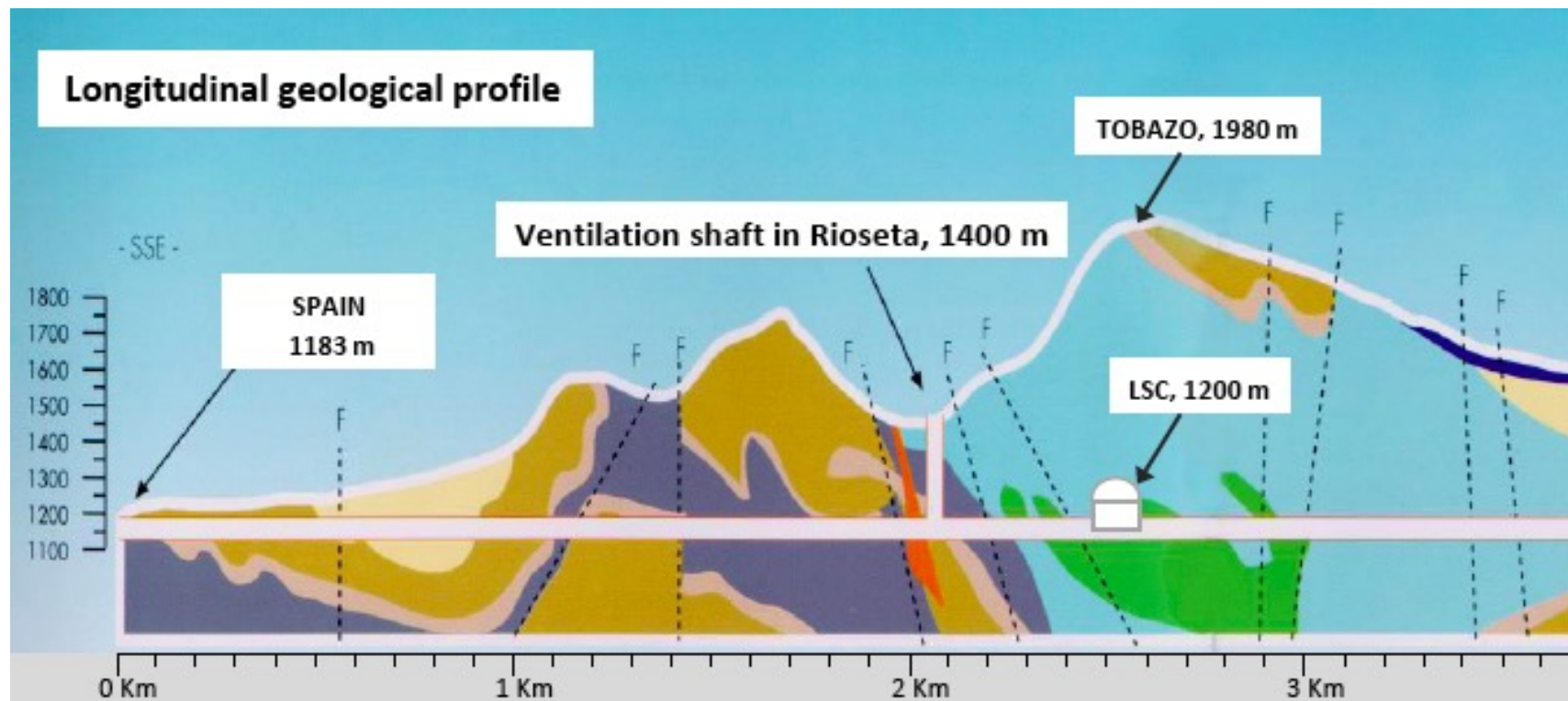
WELDING LABORATORY

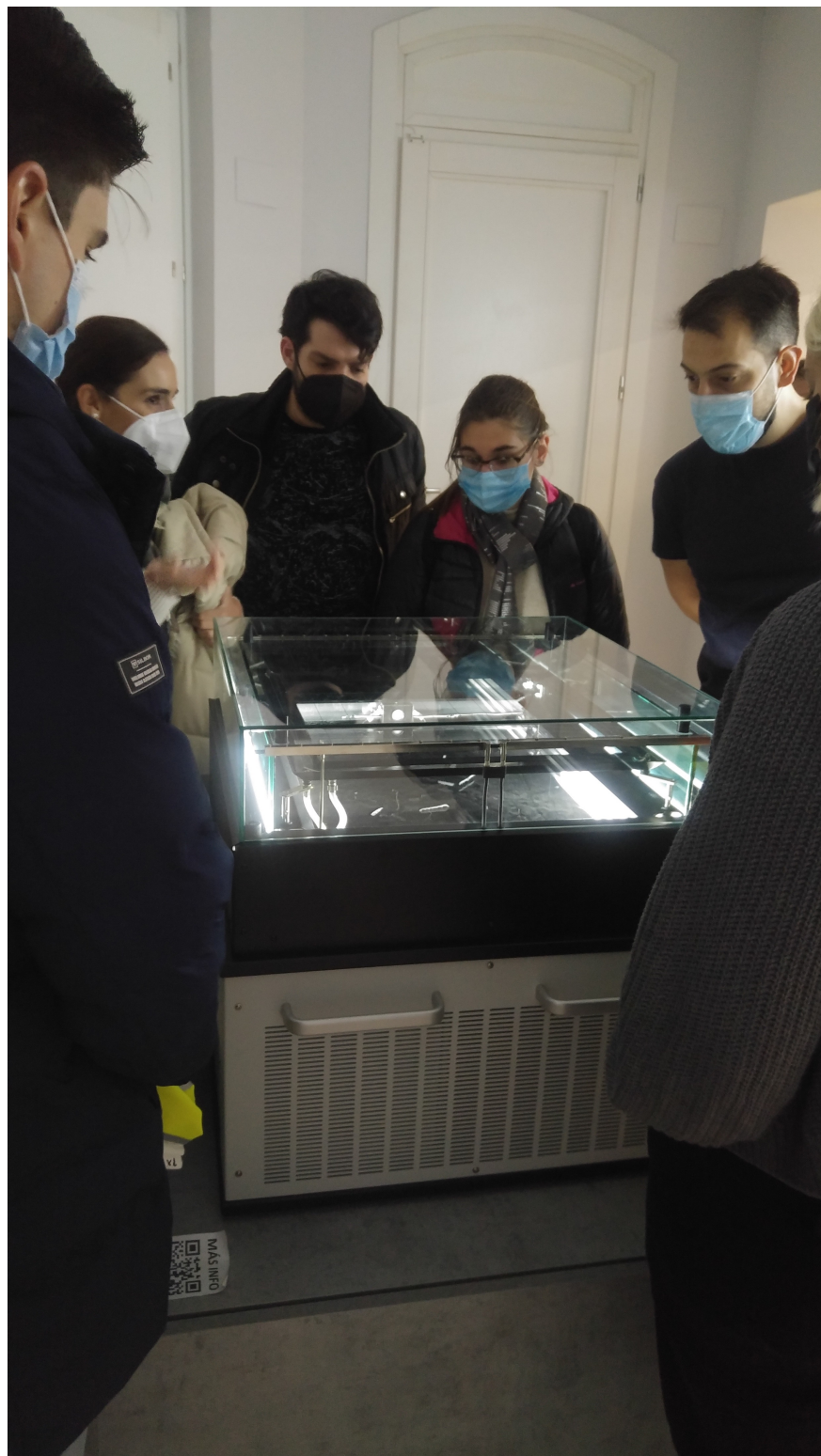


Canfranc Underground Laboratory

- + **Open day:**
 - 300 participants
 - Underground visit + talks + hands-on experiments
- + Participation to the **International Cosmic Day** (<https://icd.desy.de>):
 - Coordinated with LNGS
 - Collect data with Cosmic-Ray-Detector at different orientations
- + Regular visits to the underground laboratory on Fridays upon reservation
 - About 2000 visitors per year
- + **In preparation** a citizen science program to measure the muon flux at different depth along the abandoned railway tunnel to characterize the vertical density of the mountain

Mapping muons flux along tunnel at LSC







Cosmic Day at LSC 2021



Boulby: planned program on public engagement 2022/2023

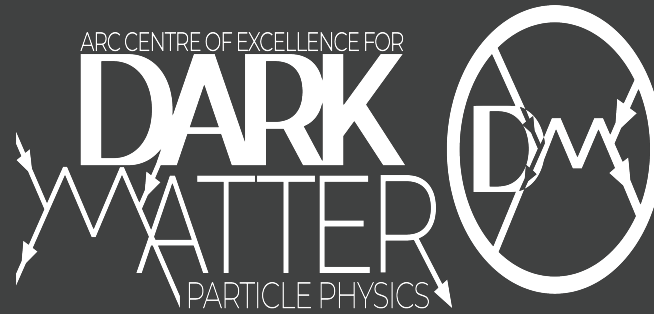
- Program builds on successes of previous years
- Program will focus on (main selected topics):
 - Showcasing Boulby stories and technology
 - Supporting STEM influencers
 - Teachers are a key audience
 - Strong link with Dark Matter UK network
 - Hands-on resources
 - Lego mindstorms
 - Dark matter particles
 - Exploiting Arduino technology
 - Exploiting the physics of the pendulum
 - Support ongoing schools programs with talks, tours and hands-on activities
 - Including remote projects engagement for students
 - Host Nuclear Physics masterclass program focusing on Dark Matter and low background science
 - Boulby will strengthen relationships with local teachers
 - Whitby Museum
 - Participate to new exhibit, storytelling on Boulby and its scientists
 - Dark Matter Day international event

Boulby: Public Engagement metrics 21/22



Boulby Underground Laboratory

Audience	No. of events	participants	No. Educators	No. Students	No. Public	participants)
Overall	22	1419	96	2010	686	45
Public	5	604	0	0	604	0
School - Key Stage 2 (7-11)	3	683	23	644	16	0
School - Key Stage 3 (11-14)	5	807	29	712	66	0
School - Key Stage 4/5 (14-18, GCSE and A-Level)	4	678	24	654	0	0
Educators	3	20	20	0	0	0
Staff	2	45	0	0	0	45
Types of Event	No. of events	participants	No. Educators	No. Students	No. Public	participants)
Visitors to mine	2	14	14	0	0	0
Live talk from mine	0	0	0	0	0	0
Live tour from mine	6	795	34	713	48	0
Live activity from mine	6	768	33	662	73	0
Virtual tour	2	222	0	177	0	45
Virtual talk	3	790	15	458	317	0
Virtual tour and talk	1	228	0	0	228	0
Virtual activity	1	20	0	0	20	0
WX placement	1	0	0	0	0	0
In-person talk off-site	0	0	0	0	0	0
In-person activity off-site	0	0	0	0	0	0

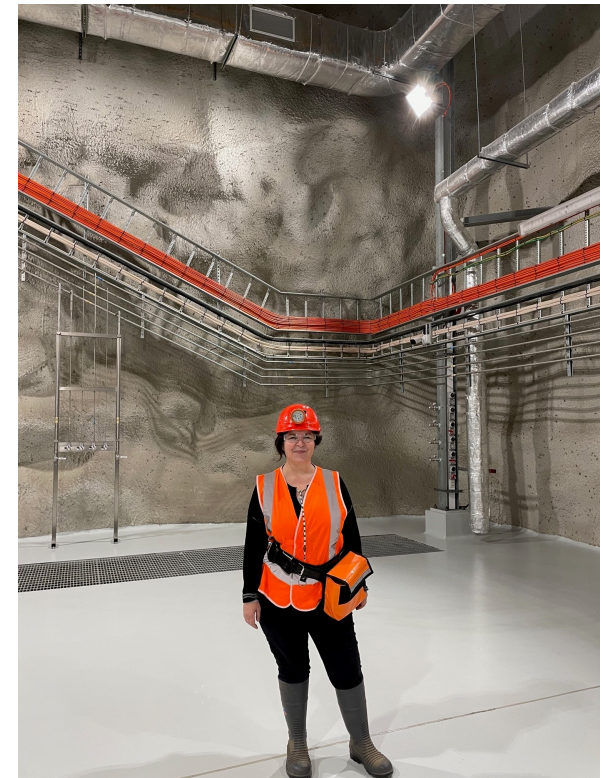


Overview of Education and Outreach Programs for SUPL



Stawell Underground Physics Laboratory (SUPL)

- SUPL Ltd, Stawell Gold Mines and other interested parties will coordinate outreach programs based around SUPL
- Will engage with the local council and other educational and community bodies
- Will explore opportunities and potential support for an outreach/education/interpretive program based around SUPL
- Will seek funding for an outreach facility within Stawell
- Will develop a virtual tour of SUPL through CDM



Why Dark Matter in Education?

- Encapsulates the Nature of Science and Scientific Inquiry
- **Broad Science content** – galaxies, gravity, particles
- **Connections with labs and scientists** – work here in Australia



Why Collaborate with Rural Schools?

- **Highlight STEM pathways for students**
- Increase professional development opportunities and resources for Regional Teachers
- Provide relatable role-models for students, especially girls
- Access of STEM programs to underserved schools

What is the Center for Dark Matter doing?

Dark Matter Partner Schools

- High-impact, long-term engagement with partner schools
- Leverage partnerships to incorporate unique experiences for students and teachers
- Target opportunities for regional students and teachers



Dark Matter Centre ignites student interest at Stawell

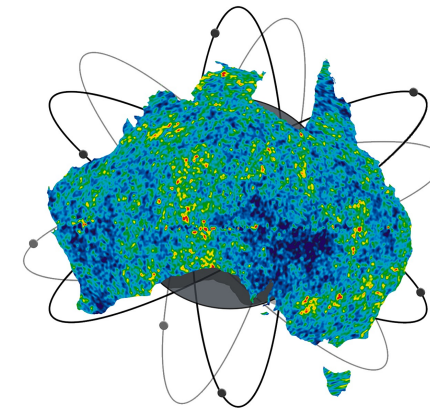
28 July 2021 - <https://www.theweeklyadvertiser.com.au/articles/dark-matter-centre-ignites-student-interest-at-stawell/>

Stawell educational leaders are confident a program linking into the southern hemisphere's first dark matter centre is boosting student enthusiasm for science subjects.

What is the Center for Dark Matter doing?

Science road trips

- <https://www.qdmroadtrip.org/>
- Two Centres of Excellence (CDM and EQUS)
- Diverse cohort of centre scientists
- Supported by National Science Week
- 8-26 August - from Brisbane to Perth
- 25 scientists, 7000km, 40 cities and towns
- 25 rural/regional high schools
- 12 public events
 - pub quizzes, public lectures, physics demos, science-art workshops



NATIONAL
Quantum & Dark Matter
ROAD TRIP

 An Australian Government Initiative

 Inspiring
AUSTRALIA



Outreach activities in Kamioka Observatory

- **Tours and lectures to middle and high school students**
 - About 20 schools per year
- **Super-K Open days**
 - Hosted by Kamioka Observatory
 - One day per year since 2016: 300 visitors to Super-Kamiokande underground laboratory
 - Held virtually since 2020 together with KAGRA and the KamiokaLab science museum
- **Geo Space Adventure(GSA)**
 - Hosted by local citizens in Kamioka-town for more than twenty years
 - 800 visitors for two days to Super-Kamiokande and Kamioka mine



SK open days in person



GSA in 2019



SK virtual open days

Outreach activities in Kamioka Observatory

- Hida Space Science Museum
KamiokaLab
 - developed by Hida City to bring visitors closer to the world of astrophysics research at Super-Kamiokande, KamLAND, and KAGRA in Kamioka Town.
 - We supervised and worked together to prepare it.
 - Open in March 2019. Total number of visitors; about 290 000



Full scale model of Super-K



Experience Super-K on a 7-meter-high screen



Games to learn neutrinos

Outreach activities in Kamioka Observatory

- Super-K Open days
 - 2021 <https://sites.google.com/g.ecc.u-tokyo.ac.jp/sk-kagra-open-day-2021>
 - 2020 <https://sites.google.com/g.ecc.u-tokyo.ac.jp/sk-kagra-online-open-days>
 - World wide live tours of Super-K and KAGRA were held online.
- GSA
 - <https://gsa-hida.jp>
- KamiokaLab
 - <https://www.city.hida.gifu.jp/site/kamiokalab-en/>

Networking and Outreach activities

LNGS and LSC in collaboration have made large and portable muon telescopes for outreach activities

We have developed an App for Android and iPhone to share collected data worldwide (Cosmic Rays Live)

New collaboration underway including SNOLAB and Kamioka

Data collected can be used for Citizen Science programs



LOGO IMAGE

XYZ VIEW

DISTRIBUTION

ANGLES

CRD Cosmic Rays Detector

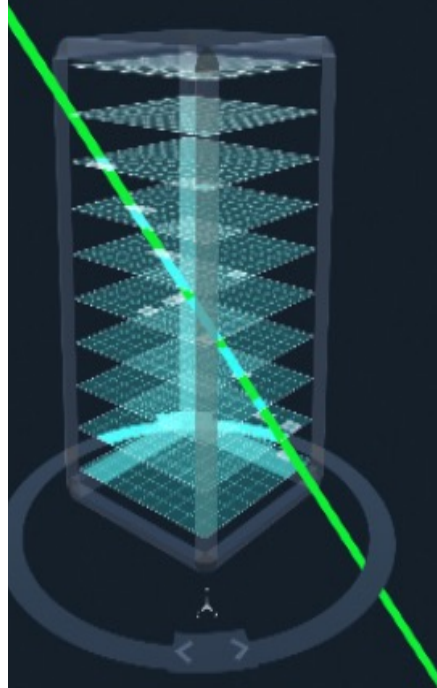
DATA VIEW

Event Data and Time
Unknown

Event ID
ST98C1

Event Location
0020050080100
200600C01800
00000

3D VIEW



X Plane



Y Plane



Z Plane



Plane 10



Plane 5



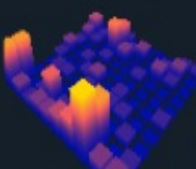
Plane 9



Plane 4



Plane 8



Plane 3



Plane 7



Plane 2



Plane 6



Plane 1



Cos(Theta) 0.7789322

Phi Distribution 141°



STATISTICS

TOTAL EVENTS 60

Strip X total

X-Plane frequency



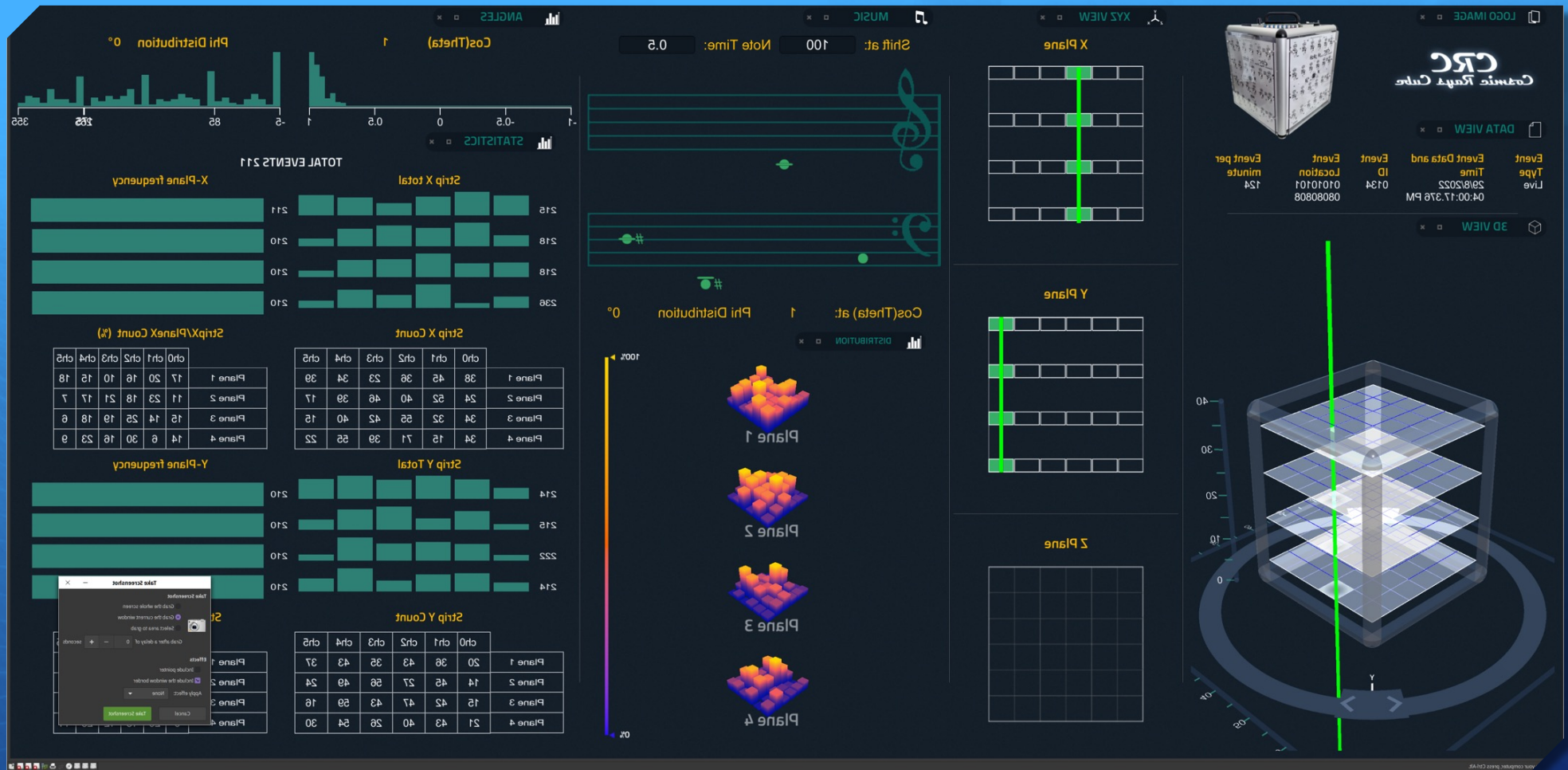
APP for android:
Cosmic Rays Live

Strip X Count

Aldo Ianni, NNN19

ch0	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9
5	2	4	1	0	3	3	1	2	0

ch0	ch1	ch2	ch3	ch4	ch5	ch6	ch7	ch8	ch9
23	9	19	4	0	14	14	4	9	0



Cosmic symphony

Project: collect notes at equinox and solstice to let music composer create a short symphony on given notes. First composition from Spring equinox already played at L'Aquila

Conclusions

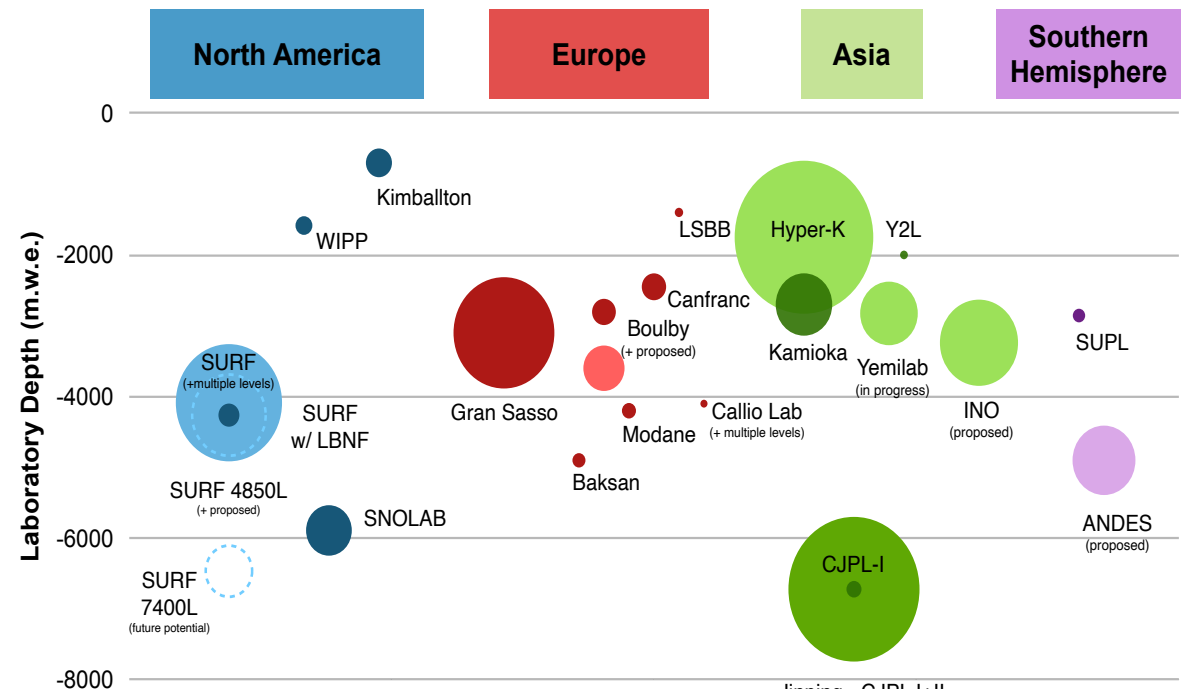
- + 13 active ULs with multidisciplinary research programs
- + rich and diversified outreach activities
 - common interest in supporting STEM teachers and develop CV in science
- + Interest in Citizen Science programs but not all laboratories have specific proposal
 - there are opportunities!
- + Networking and collaboration would be desirable and fruitful in this framework
- + A program to learn about radioactivity from HPGe network in ULs could be a possible proposal to be a network on a citizen science program for ULs

Thank you for your attention!

Underground Facilities

UG Facilities can provide:

- + Unique environments for multi-disciplinary research
- + Local radiation shielding
- + Assay capabilities
- + Material production/purification
- + Environmental control
- + Implementation and operations support
- + Above-ground and underground support facilities (CR, Rn-free CR, ICP-MS, HPGc,)
- + Advance training



Note: Circles represent volume of science space

Adapted from Jaret Heise Snomass CSS 2022

Melbourne Graduate School of Education

- University of Melbourne (MGSE) partnership with CDM
- Leveraging the development of scientific infrastructure (e.g. SUPL) to influence a young person's scientific identity
- Two PhD scholarships on STEM uptake in schools
 - How modern physics can be incorporated into a traditional high school physics curriculum
 - The influence of science outreach on science aspirations and science identity (focus on underrepresented groups)