



Collaboration between high schools in Japan and Argentina for cosmic-ray research using CosmicWatches



Takeshi Nakamori (Yamagata U)
on behalf of the authors

Outreach & Education #122



Background

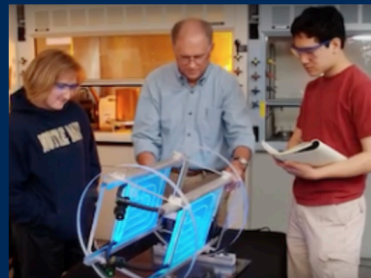
- STEM education and research-based activities are highly promoted worldwide. Argentina & Japan are also included.
- Particle and astrophysics (incl. CR) are generally hard to reach for high school students, due to technical reasons.
- CR muons are easy to touch. We, scientists, can provide instruments, lectures and continuous support for students with potential interests.
- QuarkNet is one of the most successful framework and must be a good reference case.

<https://quarknet.org/>

For Teachers



For Students



For Researchers

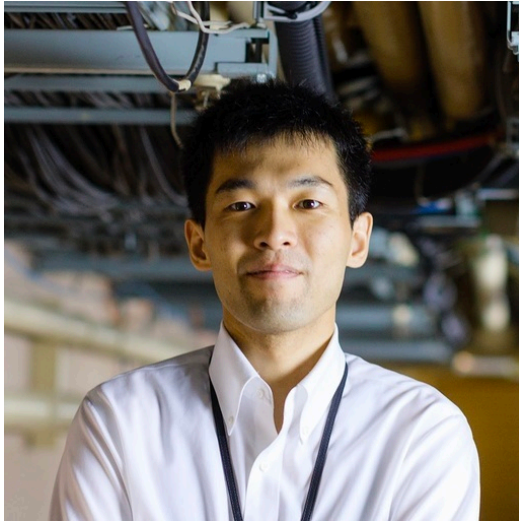


LHC & Fermilab

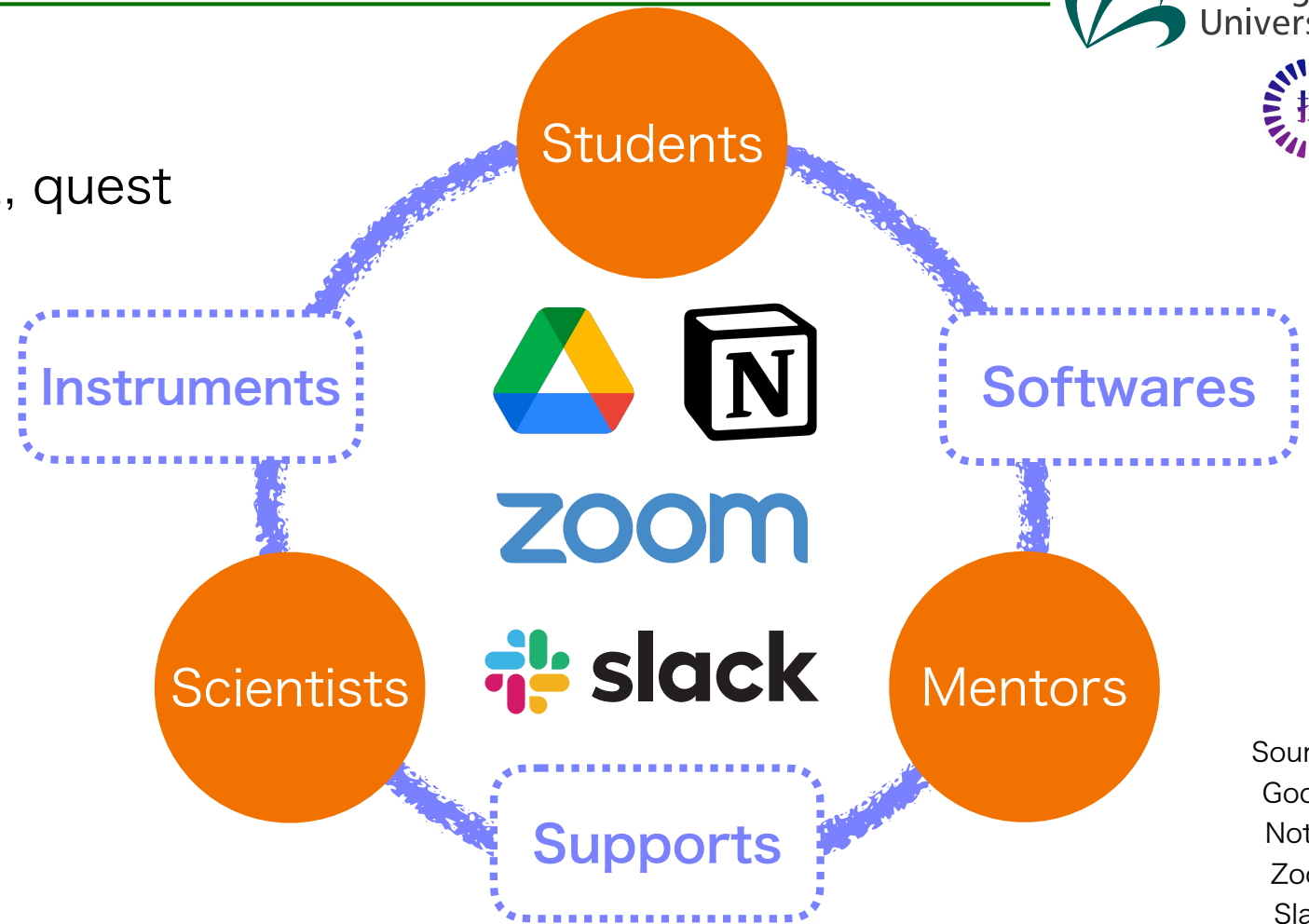


Tan-Q

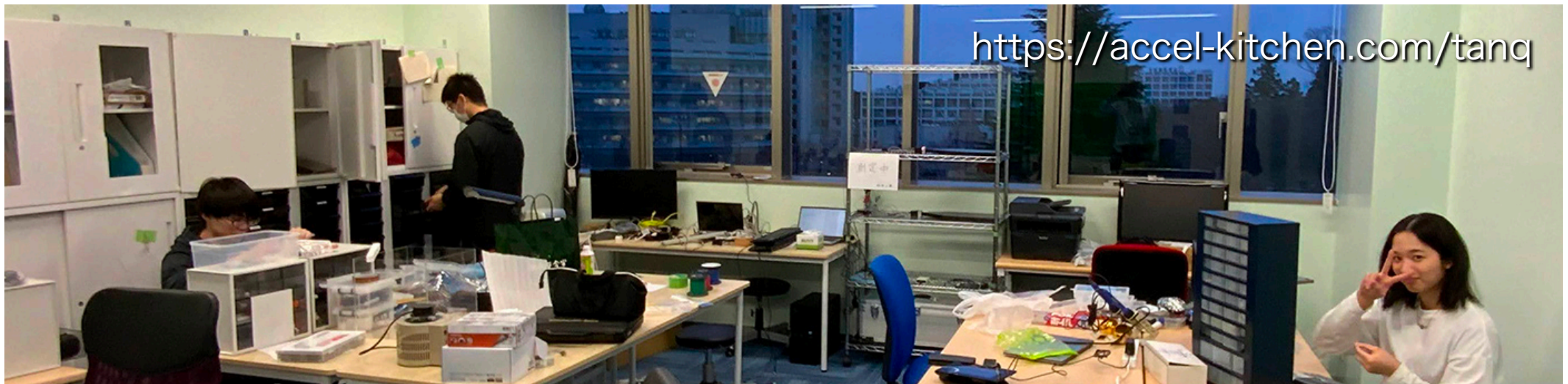
探Q=探求=research, quest



PI: K. S. Tanaka
(Tohoku U -> PSI)



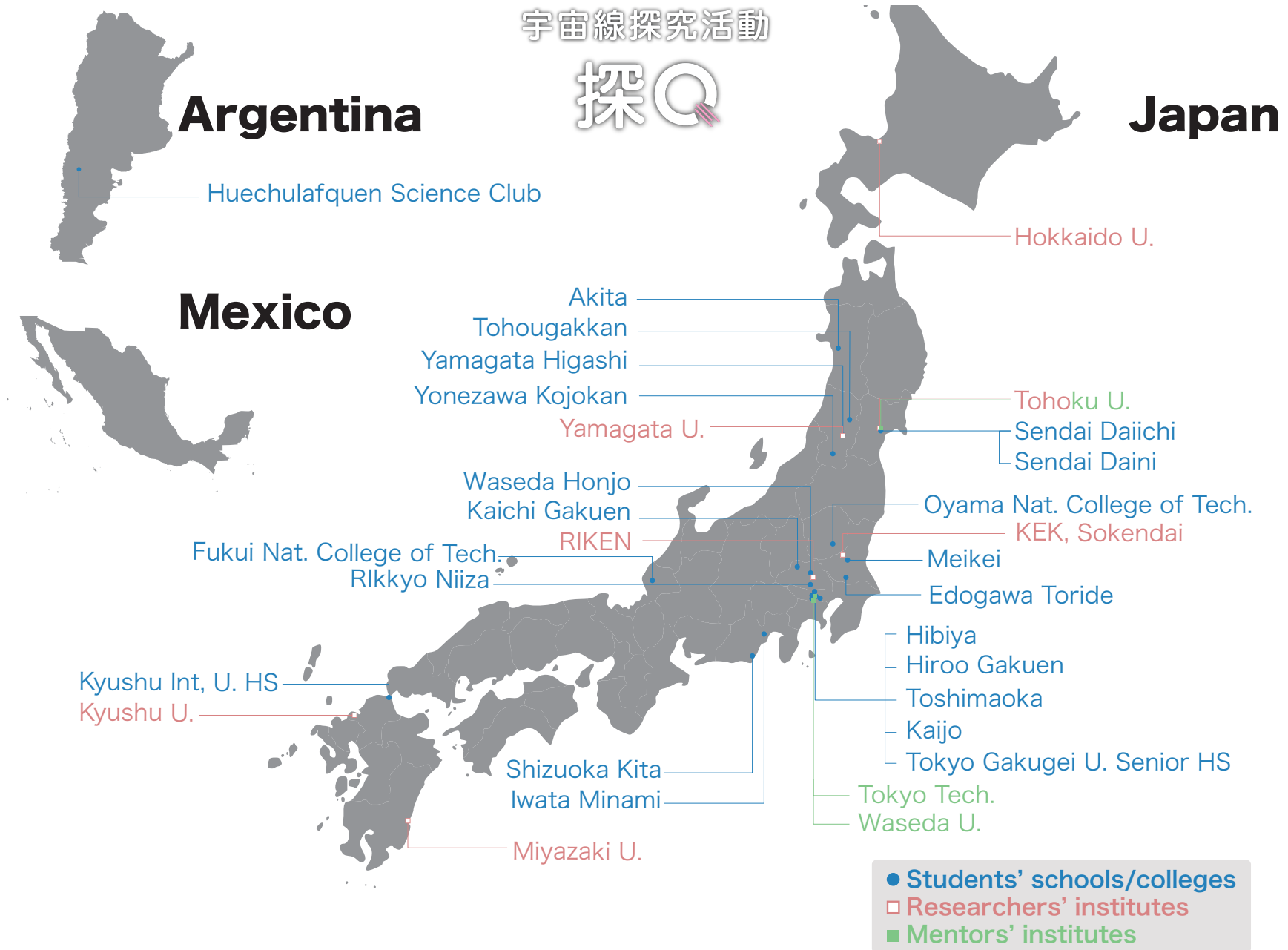
Sources:
Google
Notion
Zoom
Slack





Tan-Q (2021 Apr)

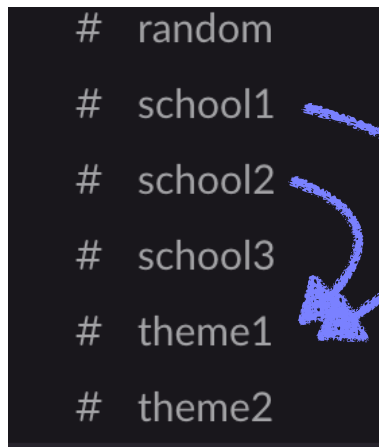
宇宙線探究活動



More communication

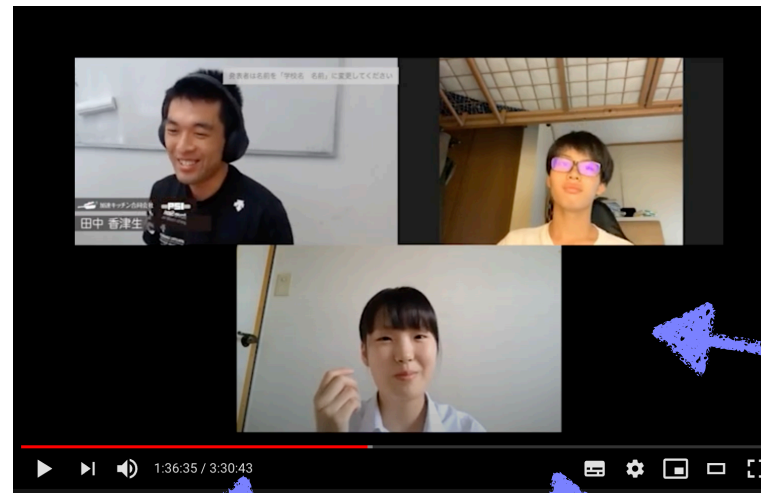
Inter-schools/groups

Intra-Tan-Q + external



School (or team)-wise
& theme-wise channels

Biannual meeting on **zoom** webinar



Others
in Tan-Q

Guest
scientists

Open to
public

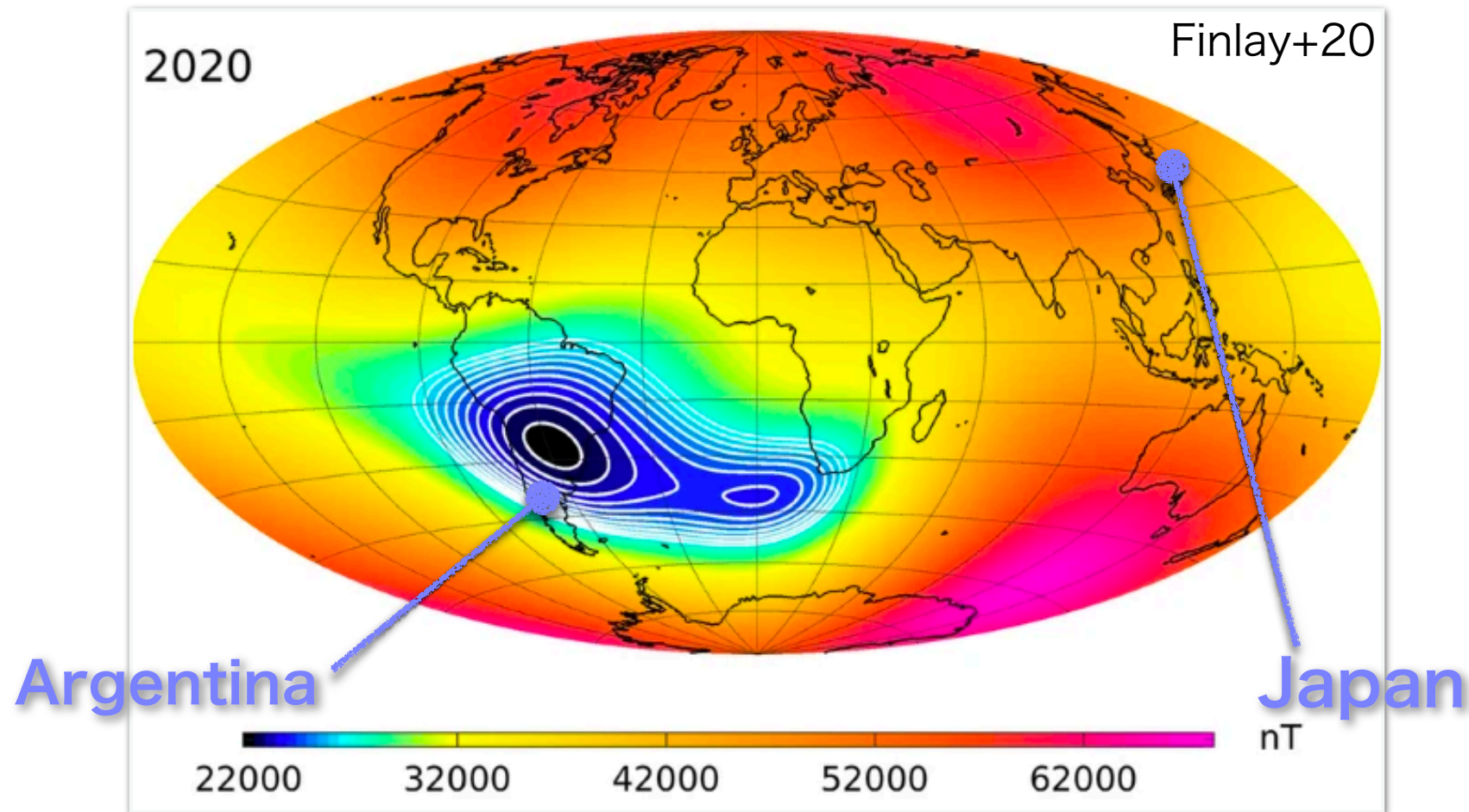
Case: AR-JP collaboration



126489	2020-12-14-00-02-38.805725	54605841	103	22.23	2181178	19.72
126490	2020-12-14-00-02-39.307604	54606223	159	27.66	2181211	19.61
126491	2020-12-14-00-02-39.698776	54607300	97	21.75	2181244	19.61
126492	2020-12-14-00-02-40.772446	54608062	319	57.64	2181277	20.25
126493	2020-12-14-00-02-41.540307	54608430	99	21.91	2181282	19.72
126494	2020-12-14-00-02-41.907542	54608502	99	21.91	2181287	19.50
126495	2020-12-14-00-02-41.980979	54608756	56	16.76	2181292	20.25
126496	2020-12-14-00-02-42.233974	54608924	92	21.32	2181297	20.04
126497	2020-12-14-00-02-42.401633	54609574	224	38.29	2181330	19.61
126498	2020-12-14-00-02-43.054109	54610027	207	35.26	2181363	19.61
126499	2020-12-14-00-02-43.507192	54610708	352	66.89	2181368	19.72
126500	2020-12-14-00-02-44.190096	54610814	60	17.43	2181373	19.61
126501	2020-12-14-00-02-44.294498	54611146	504	143.61	2181406	19.61
126502	2020-12-14-00-02-44.630530	54611256	217	37.04	2181411	19.61
126503	2020-12-14-00-02-44.739446	54611281	291	50.97	2181416	20.04
126504	2020-12-14-00-02-44.771589	54611325	326	59.13	2181421	19.61
126505	2020-12-14-00-02-44.823363	54612697	312	55.68	2181455	20.04
126506	2020-12-14-00-02-46.181774	54613359	480	130.21	2181489	19.50
126507	2020-12-14-00-02-46.845721	54613808	96	21.67	2181494	19.61
126508	2020-12-14-00-02-47.290276	54614240	83	20.46	2181527	20.04
126509	2020-12-14-00-02-47.724822	54614476	398	85.63	2181532	19.61
126510	2020-12-14-00-02-47.962926	54614660	88	20.96	2181537	20.04
126511	2020-12-14-00-02-48.145910	54614937	92	21.32	2181542	19.50
126512	2020-12-14-00-02-48.424844	54615189	184	31.36	2181575	20.25
126513	2020-12-14-00-02-48.677499	54615408	88	20.96	2181580	19.61



Scientific objective



- Weaker B-field and lower rigidity in South Atlantic Anomaly.
- Higher CR rate is expected, as well as secondary muons.
- To observe the μ rate excess in Argentina w.r.t. in Japan.

CosmicWatch

Developed & distributed Axani et al.

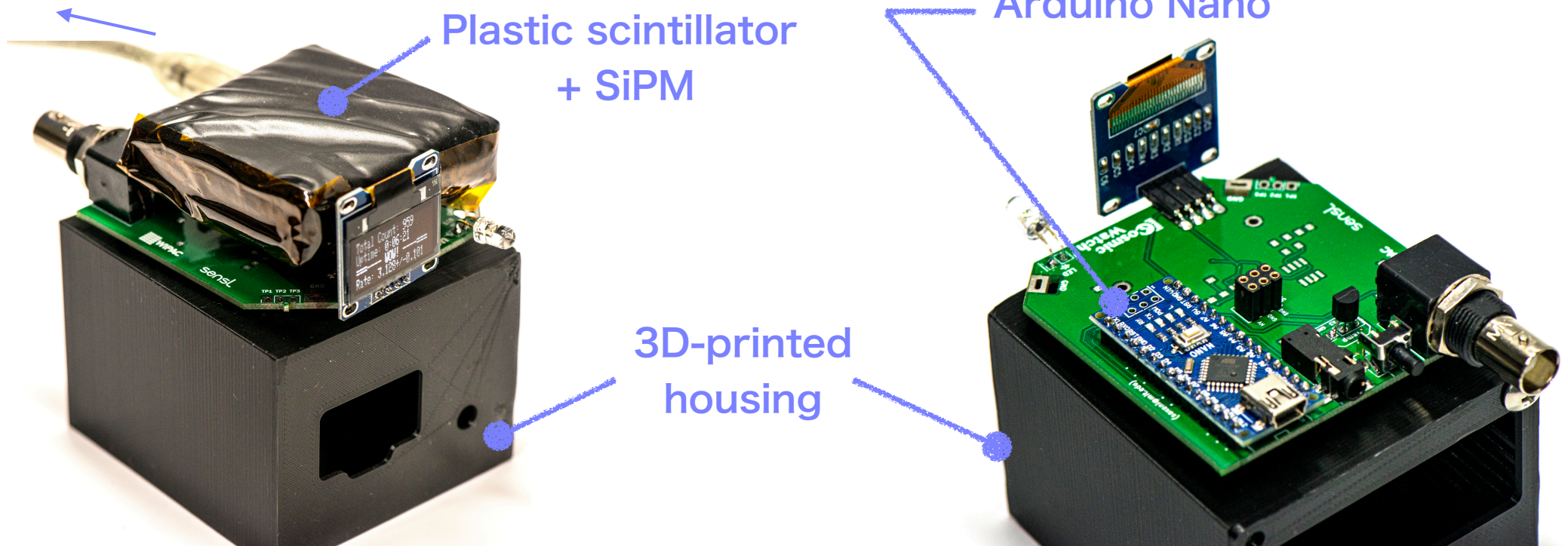
- CW is handy, usb-powered desktop muon detector.
- PCB design & Arduino src are open-source on github.
<https://github.com/spenceraxani/CosmicWatch-Desktop-Muon-Detector-v2>
- The mentors constructed and distributed to each sites.
- Data for analysis : **time stamp**, pulse height (**ADC** values)

To PC via USB

Plastic scintillator
+ SiPM

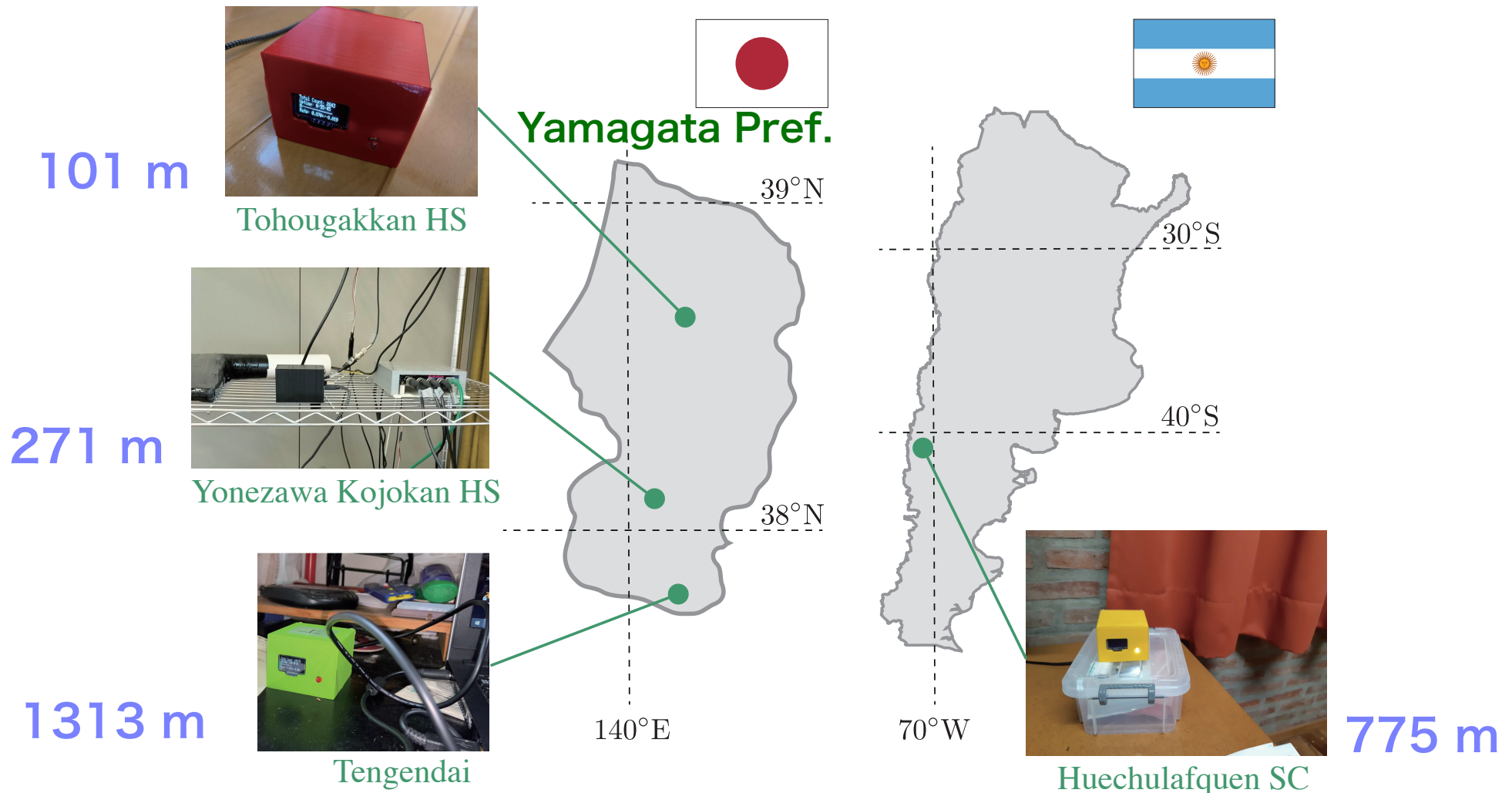
Arduino Nano

3D-printed
housing



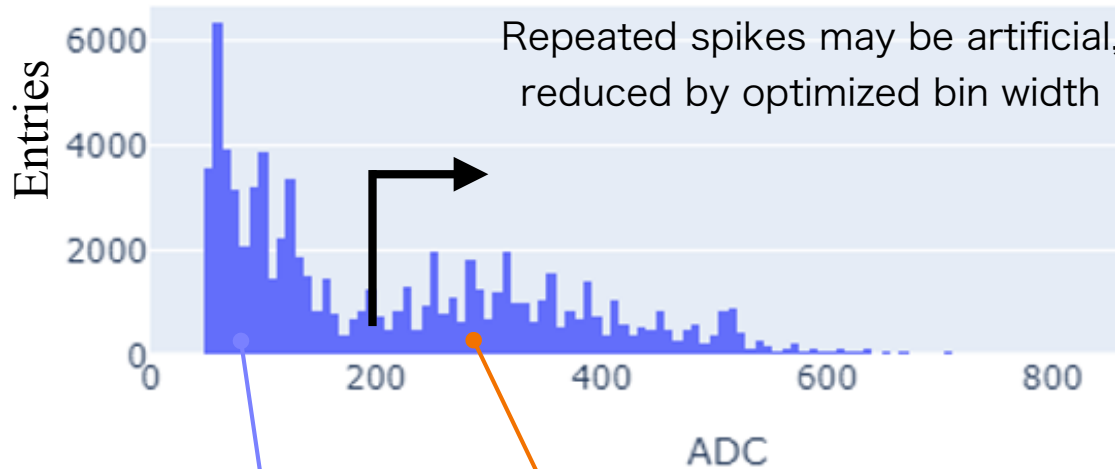
Observation sites

- Rate-alt dependence must be considered before the comparison.
- Narrow range observations are good for smaller uncertainties.
- Observations are performed in Jan - Mar 2021 for all the sites.



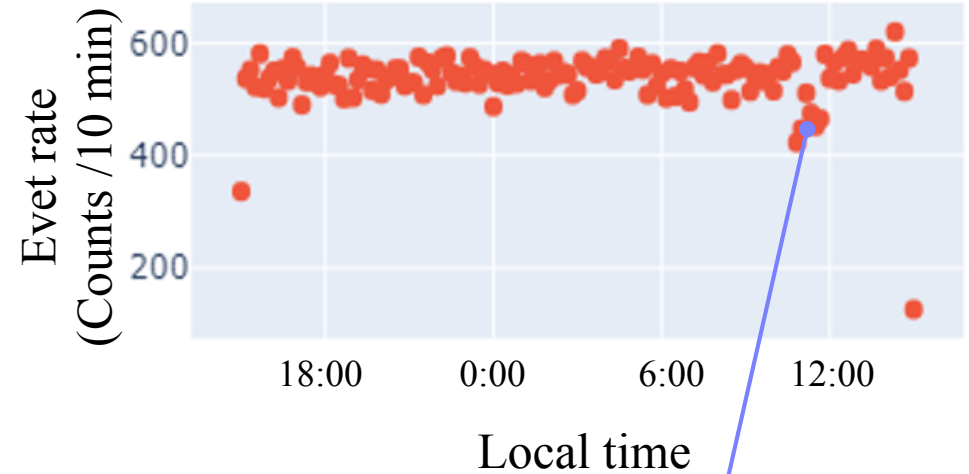
Students' analyses (1/2)

Data cleanings



Thermal noises
+ 'edge' μ events

Reliable μ events

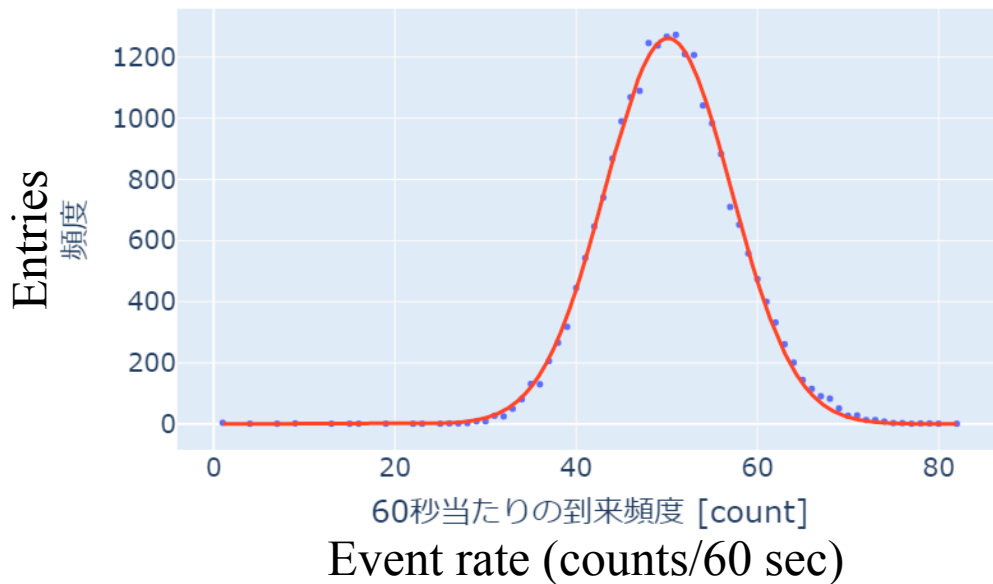


Possible trouble in DAQ
or data writing

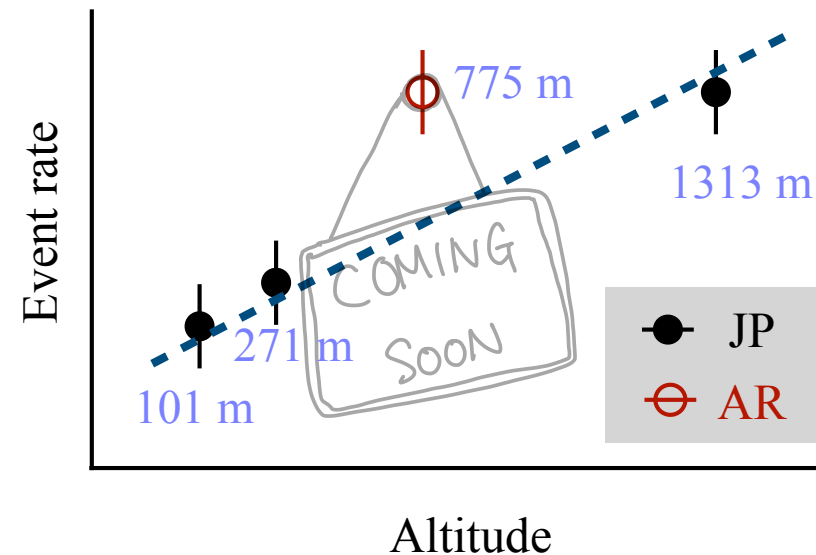
- Working on Google Colaboratory, with the mentors' support.
- ADC cuts to select good quality μ events.
 - Referencing previous studies by other groups in Tan-Q
- Time cuts to exclude rare but unstable DAQ intervals.

Students' analyses (2/2)

Data taken in Argentina



Plots in future



- Analyzed the month-long data sets for all the 4 sites.
- Event rates are consistent with Gaussian for each site.
- Will derive the alt-rate dependence with appropriate errors.
- Currently studying statistics and error analysis with the mentors.
- Will report the upcoming results somewhere in the near future.

Discussion & summary

- The high schools students observe and analyze the CR μ , aiming to detect the rate excess near the SAA.
- Further studies are worth consideration.
 - CWs in coincidence mode
 - More precise rate-alt relation by adding other place data
 - Comparison with CR models (*e.g. EXPACS; Sato+15, 16*)
 - Long-term monitoring of the SAA
- Tan-Q and CosmicWatch provide an exceptional opportunity for students to research CR with international contacts.