Preparation of SiPMs for Antiproton Gravity Measurements

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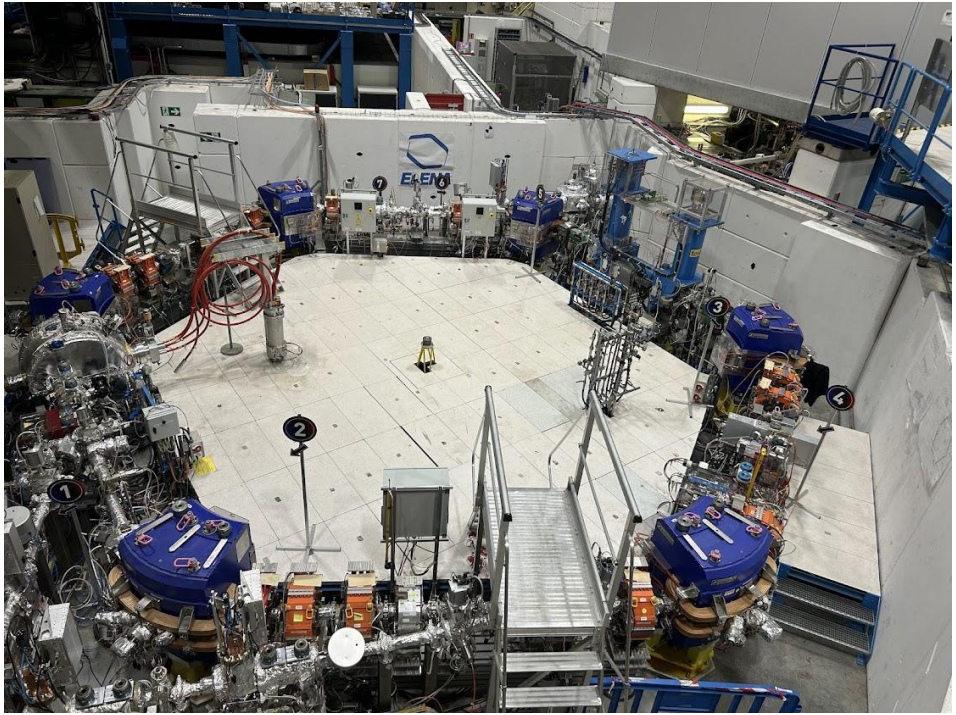
CERN Project

- Goals
  - Connect scintillators around ALPHA-g to hardware so that they can take data.
  - Analyze the count rate that the scintillators detect and compare it to data from 2022 when ALPHA-g was last run.
  - Participate in shifts to help with ongoing experiments at ALPHA

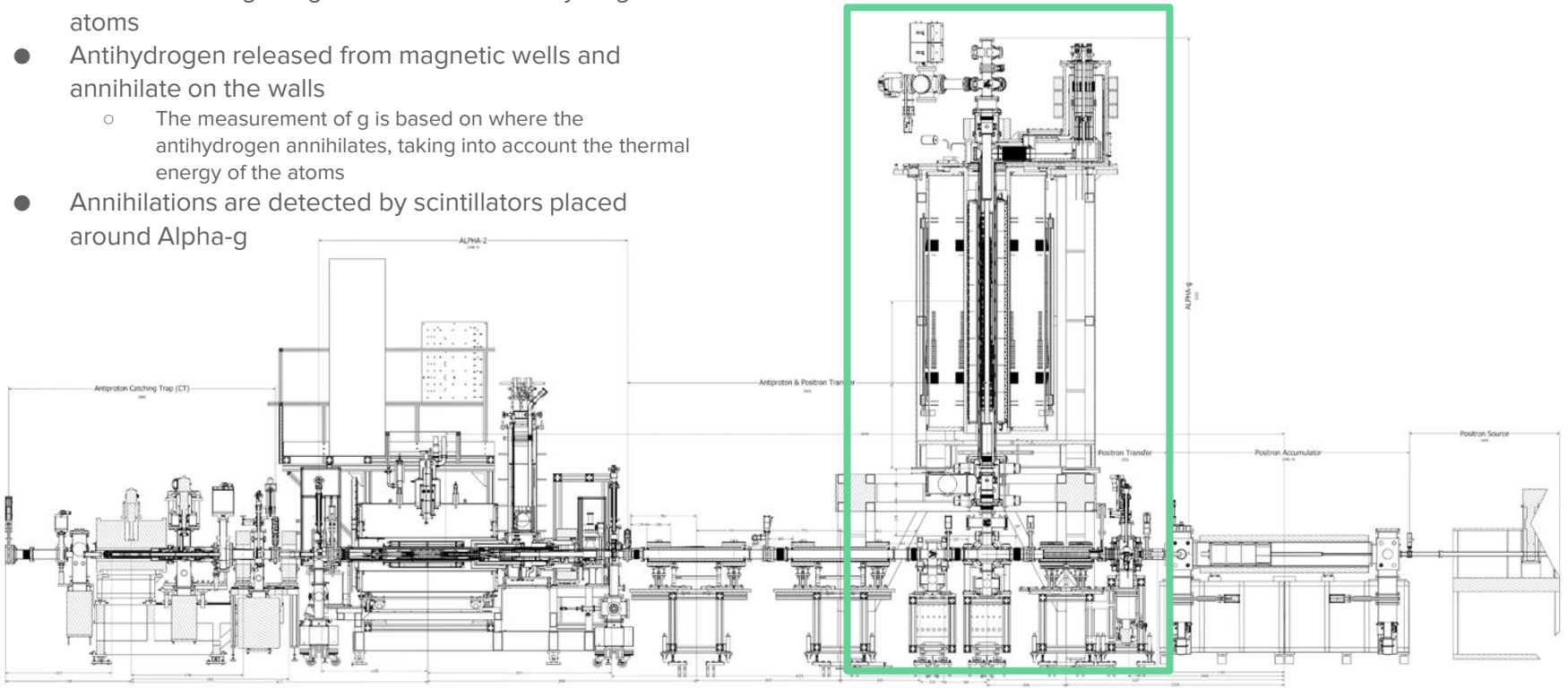
Anti-hydrogen Production At ALPHA

- Anti-protons are injected from the Proton Synchrotron and slowed down in the AD and ELENA decelerators
- Transferred to ALPHA, further cooled with electron plasma, and combined with cold positrons to create anti-hydrogen!
- Anti-hydrogen plasma further cooled with Doppler cooling
- Produces about 150 anti-hydrogen per mixing



Alpha-g

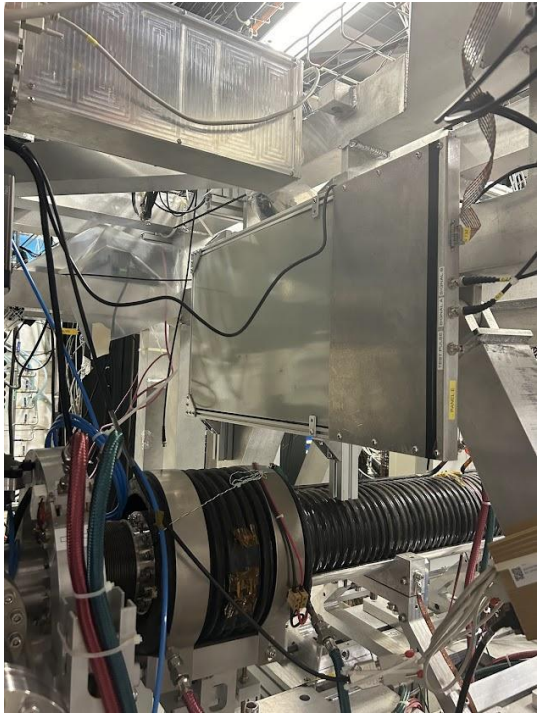
- Goal: measuring the g acceleration of antihydrogen atoms
- Antihydrogen released from magnetic wells and annihilate on the walls
  - The measurement of g is based on where the antihydrogen annihilates, taking into account the thermal energy of the atoms
- Annihilations are detected by scintillators placed around Alpha-g



Scintillators

- Plastic (polyvinyltoluene) scintillators with Silicon Photomultipliers (SiPMs)
  - Charged particle enters scintillator, excites electrons in the atoms. They then fall back to the ground state and release a photon
  - Photon is reflected within the scintillator and then arrives at one of the SiPMs, which amplifies the signal
- 4 rectangular scintillators are positioned around Alpha-g, more will be installed later
  - They are used for counting occurrences of annihilations
- Purpose
  - SiPM A, SiPM D, SiPM F: monitors the mixing triggers
  - SiPM E : counts from cold dumps

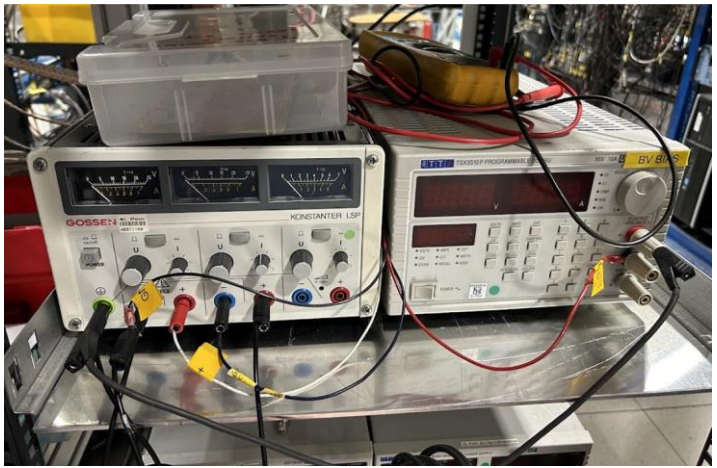
Scintillators



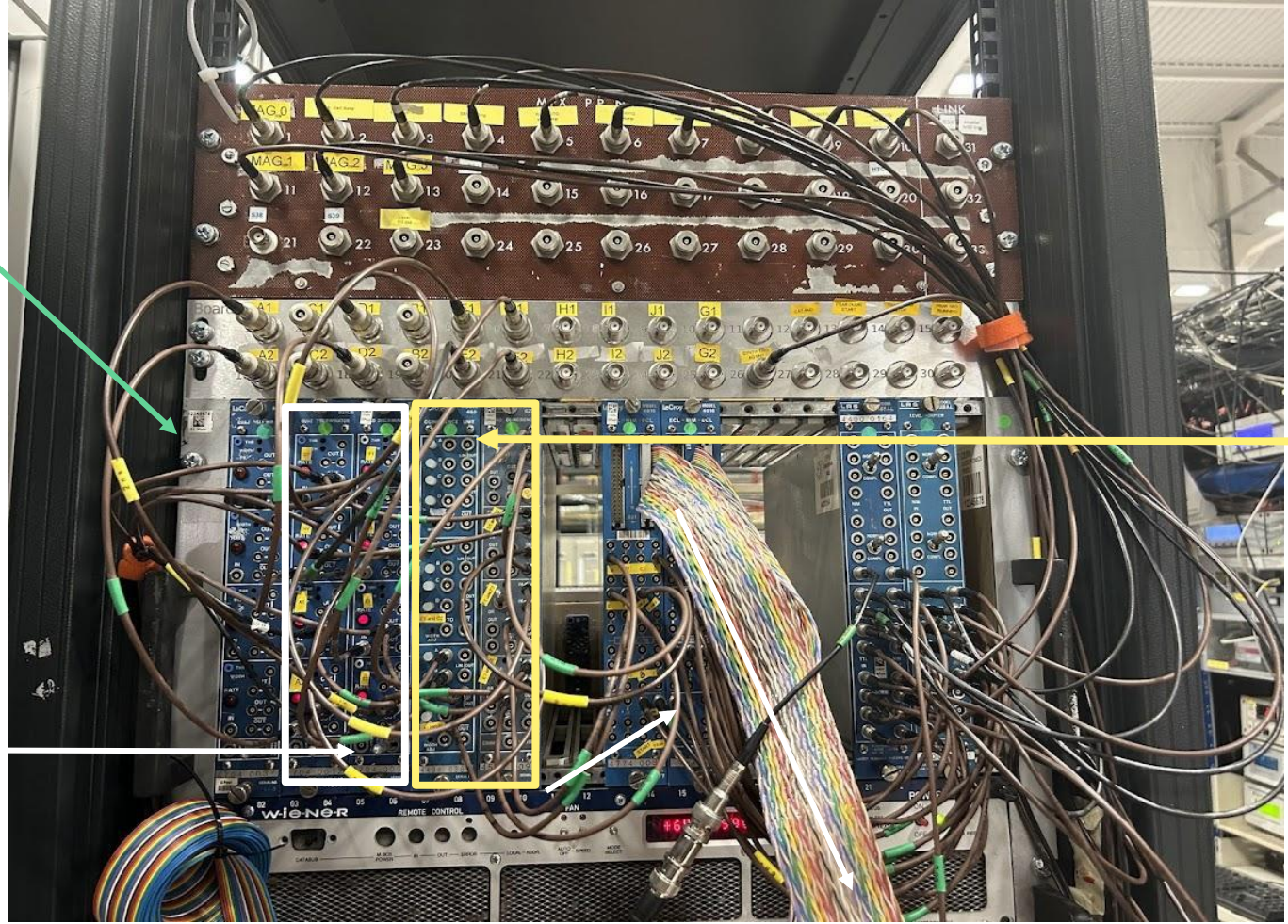
Setting Up Hardware

Connecting Hardware

- Four scintillators connected to modules
  - Two channels + power cables
- Set up power supply
- Connected cables to monitor the start and stop processes of various parts of ALPHA for time coordination



Data received from scintillators using these wires.



Coincidence: Two inputs and two modes. For ‘and’ has to have both inputs send in a true to output a true. For ‘or’, has to have one signal input a true to output a true.

Discriminator: checks that the pulse is at a certain threshold before sending a true (in this case the pulse has to be at least 100 mV to be significant)

Data is then sent to this module and then sent to the counter underneath this shelf.

Connecting Hardware

- The data from the counter is transmitted to a master computer and compiled with other data in the experiment
  - Master computer also sets the time for the experiment

Finding the Average Cosmic Count Rate

Objective

- Develop code that took a file of counts from the scintillators, isolated the counts from the cosmic background, and found the average count rate

Goals

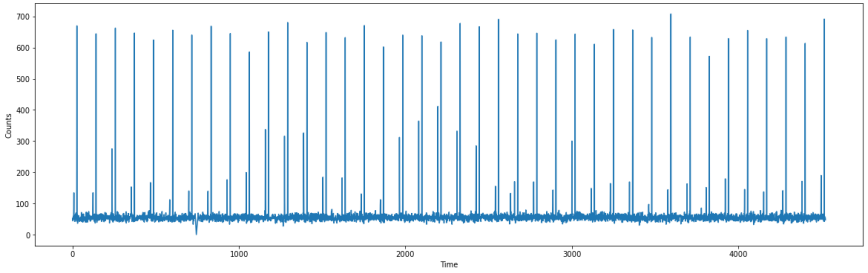
- Suppress spikes from ELENA and AD
- Find the average count rate to 3 sigma

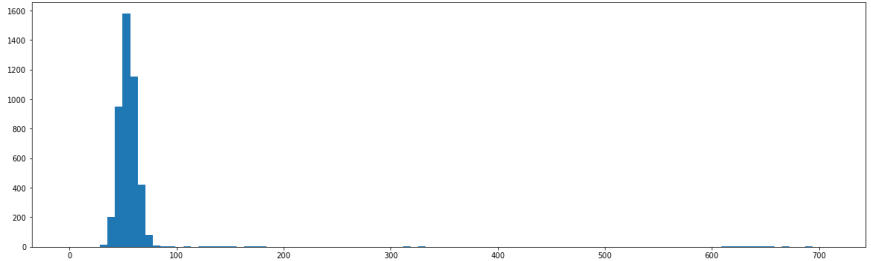
Procedure

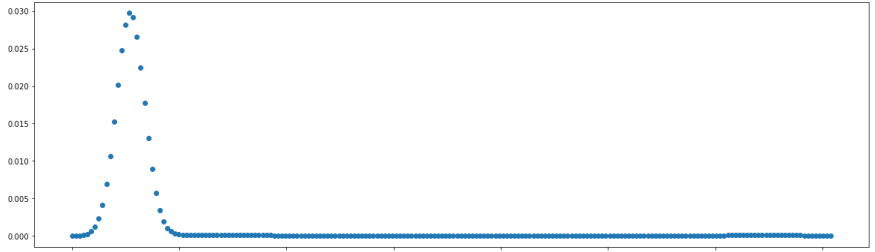
- Estimate average by fitting a series of histograms
  - Pass 1
    - Make a histogram of original data, make a kernel density estimation and fit the result points with a Gaussian distribution
  - Pass 2
    - Make a cut based on which counts are within 3 sigma of the average
    - Make a histogram of original data, make a kernel density estimation and fit the result points with a Gaussian distribution
    - Final result is the average of Pass 2 +/- 3 sigma
- All of this is compressed into an executable file that takes in a data file and returns a pandas dataframe with all the calculated data.

Example: SiPM-A

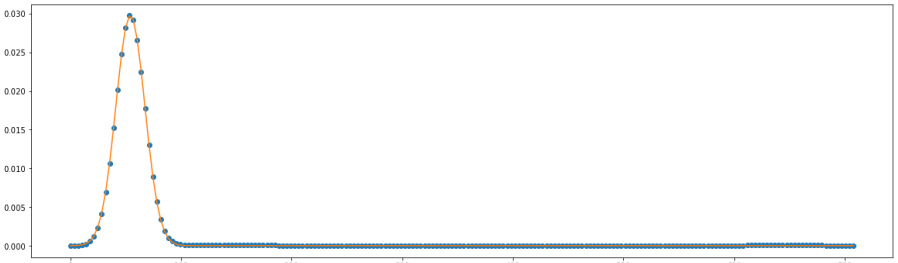
Original data with spikes from AD and ELENA



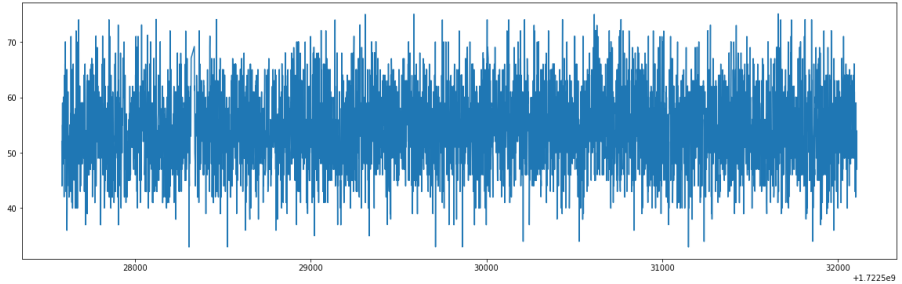


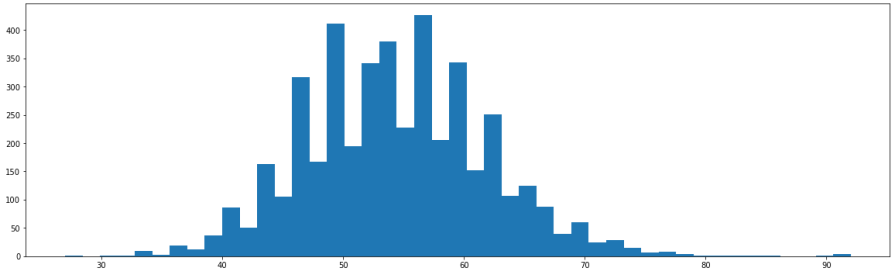


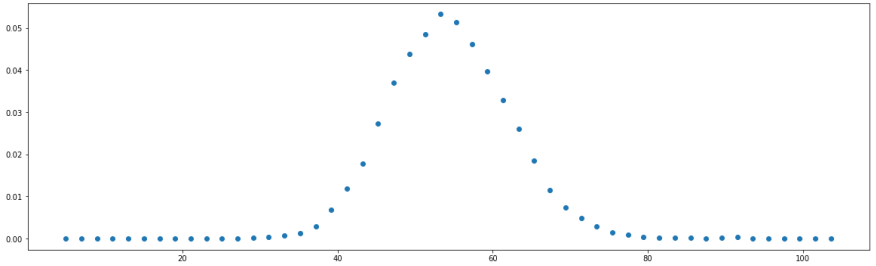
Using KDE to fit the histogram and fit a Gaussian function to the KDE.



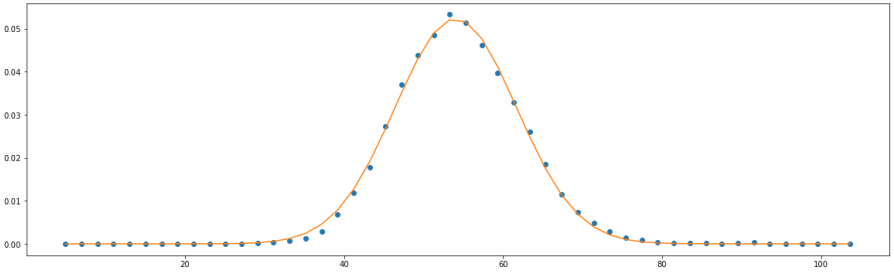
Data without spikes, any count that was not within 3 sigma of the average was removed.







Using KDE to fit the histogram and fit a Gaussian function to the KDE.



Cosmic Rate Results

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2022:
SiPM_A : 59.29 +/- 7.80 Hz

SiPM_D : 58.92 +/- 7.74 Hz

SiPM_E : 52.04 +/- 7.36 Hz

SiPM_F : 67.28 +/- 8.34 Hz

SiPM_A_OR_D : 118.35 +/- 11.07 Hz


2024:

SiPM_A : 54.06 +/- 7.63 Hz

SiPM_D : 54.76 +/- 7.75 Hz

SiPM_E : 48.04 +/- 7.00 Hz

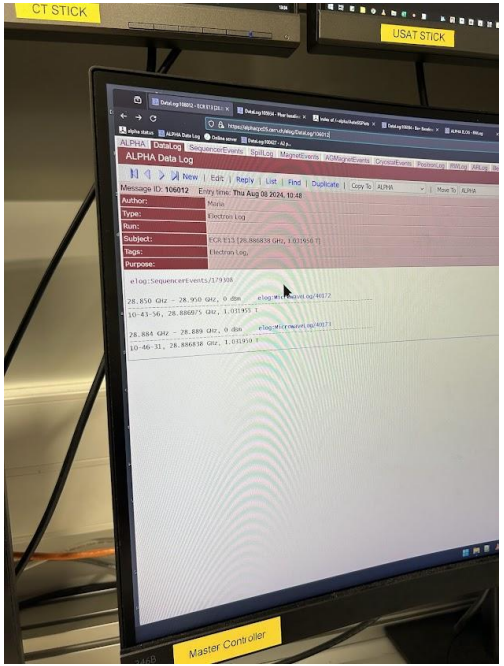
SiPM_F : 61.21 +/- 8.08  Hz

SiPM_A_OR_D : 108.94 +/- 10.72 Hz
```

- Similar within the bounds of the error, so it's good
- About 5-10% decrease in rates between 2022 and 2024, though unsure why
  - Age? Different connections?

Shift Work

- Help with data logging and analysis of ongoing experiments (ALPHA-2)
- Hands-on experiences
  - Cryogenics
  - Unwrapping the ALPHA-g bake
- Production of antihydrogen → stacking

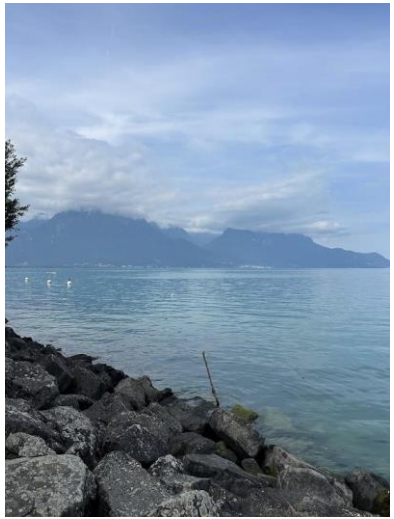


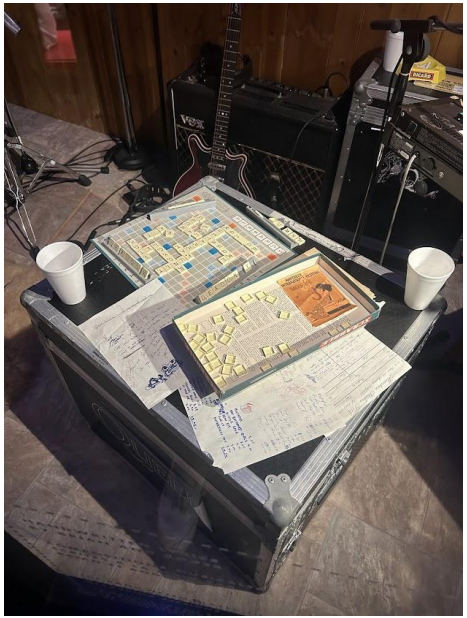
Future Goals

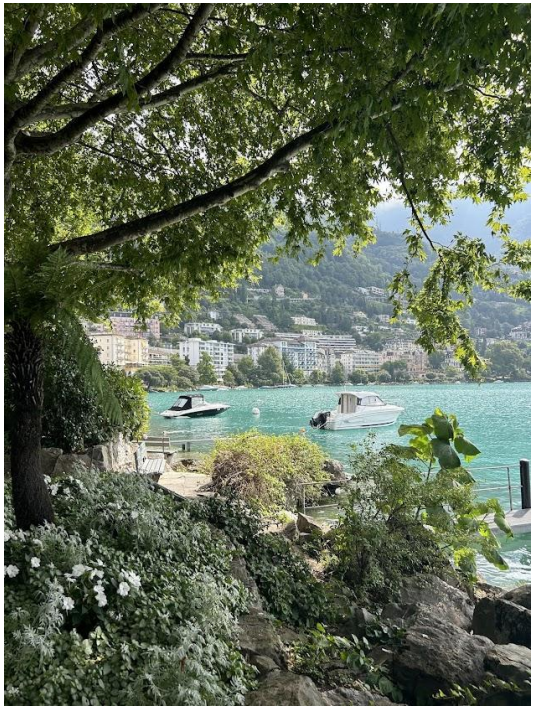
- Cross-calibration with other detectors around ALPHA-g
- Ready for gravity measurements in September

Culture

Lausanne + Montreux

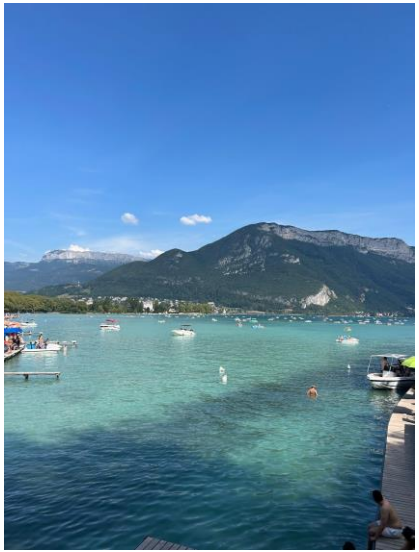




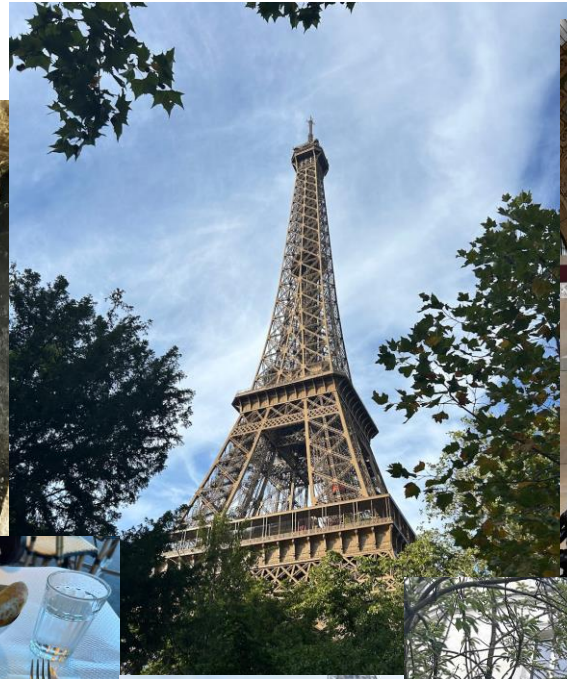


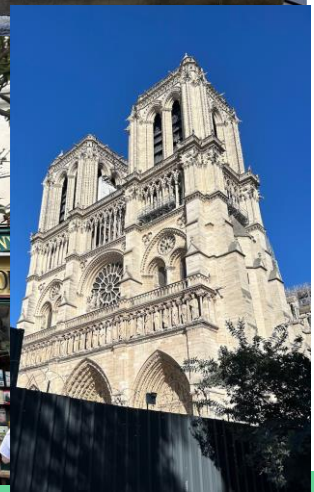
Culture

Annecy



Culture: Paris





Thank You for a Great Summer!

Big thank you...

to the UMich Physics Department for this opportunity...

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