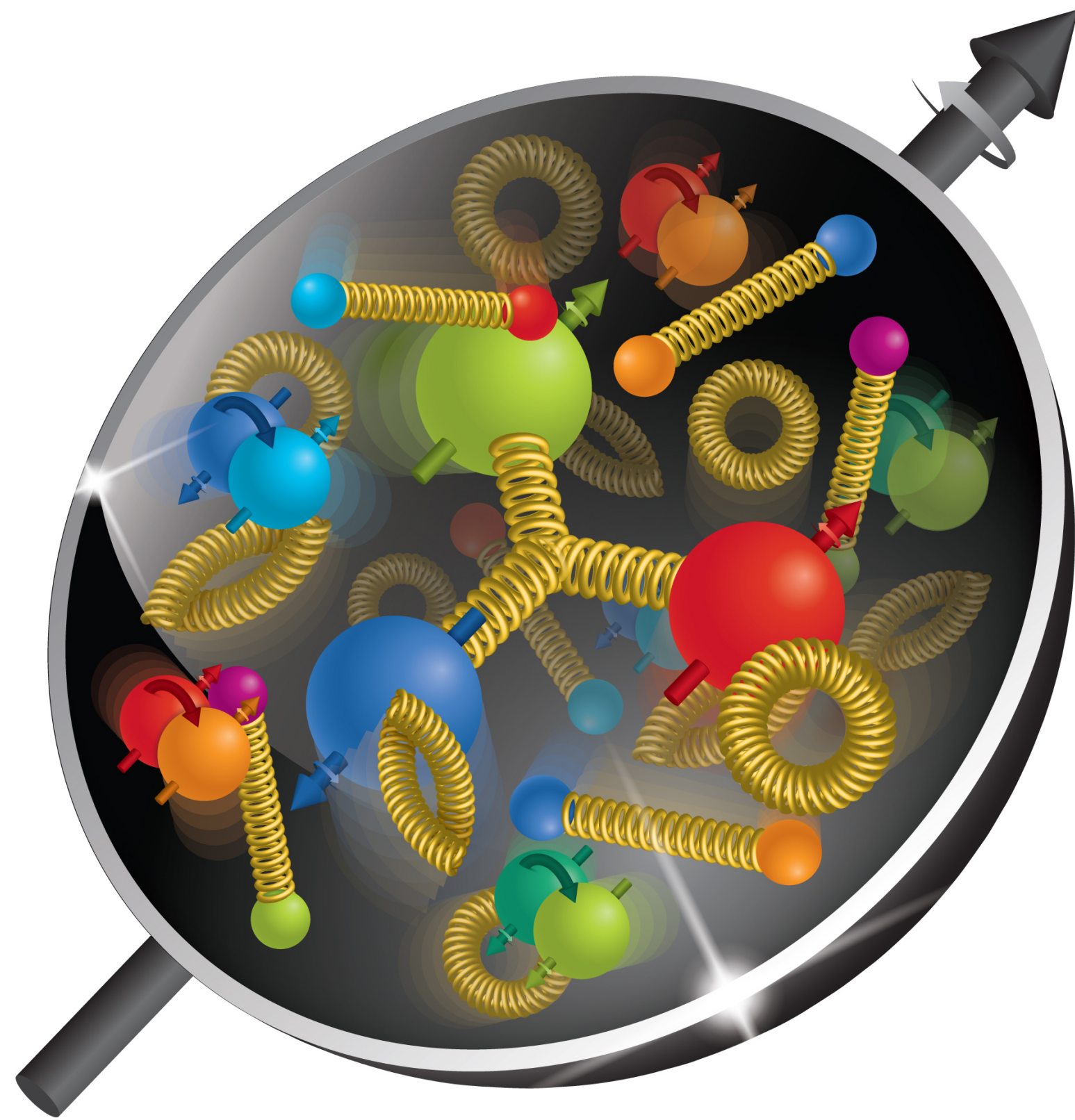


Outreach Opportunities at the EIC

2024 EIC User Group Meeting – Bethlehem, PA (Lehigh University)



Fernando Antonio Flor
Yale University

Early Career Workshop
July 22nd, 2024

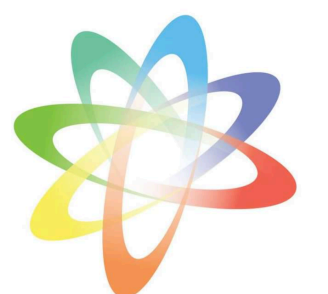


U.S. DEPARTMENT OF
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**YALE PATHWAYS
TO SCIENCE**
Inspiring the next generation of scientists



Let Us Smash Some Protons

- Run thru *Yale Pathways Program*

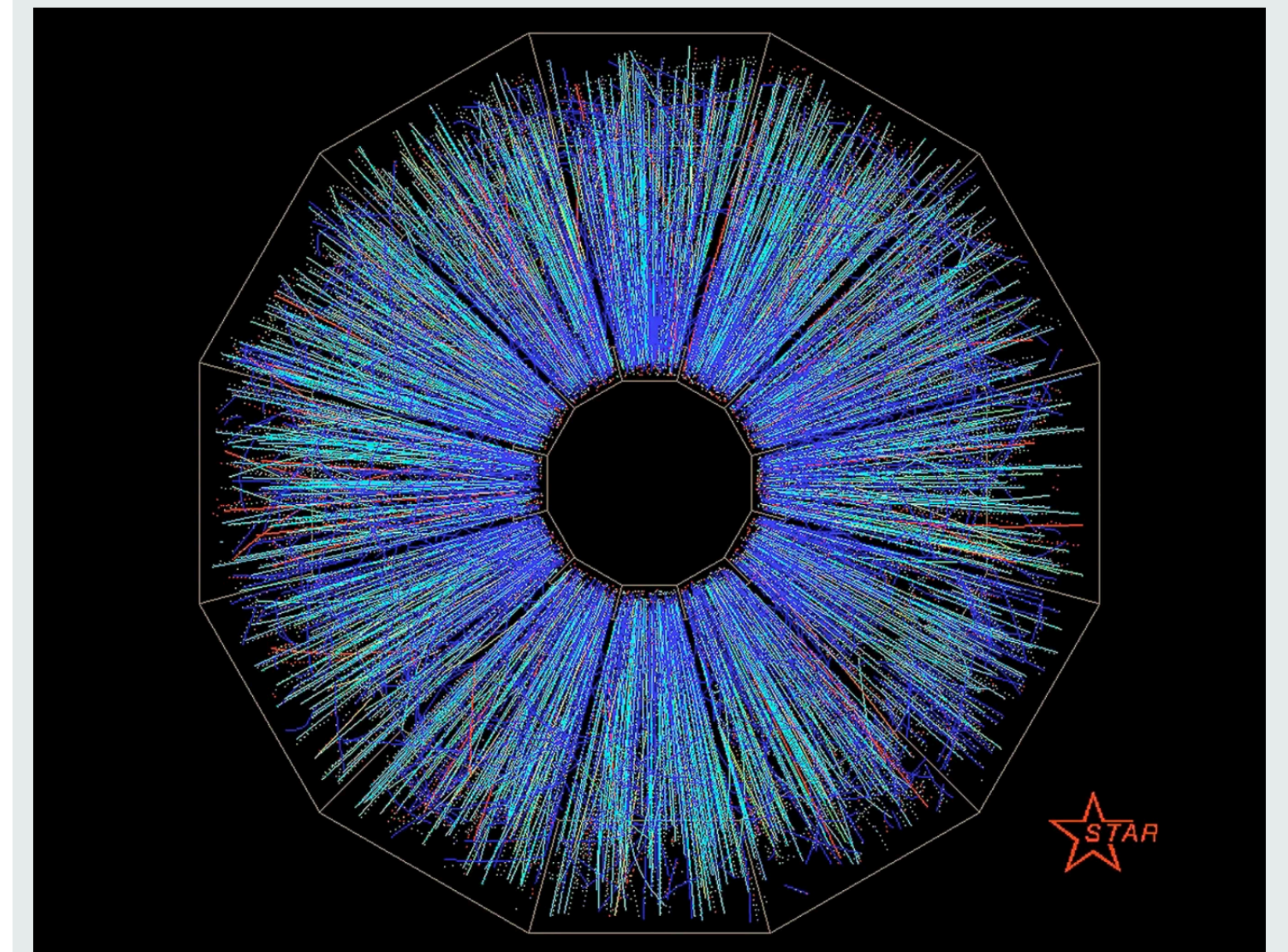
- Spearheaded at New Haven, CT by *Raghav Kunnawalkam Elayavalli* ca. 2022
- Expanded to Nashville, TN the following year

SEPTEMBER 14, 2023 | 4 MIN READ

To Get Kids Interested in Science, We Have to Let Them Do Science

A pilot program for high schoolers offers a blueprint in getting students involved in cutting-edge particle physics research

BY RAGHAV KUNNAWALKAM ELAYAVALLI



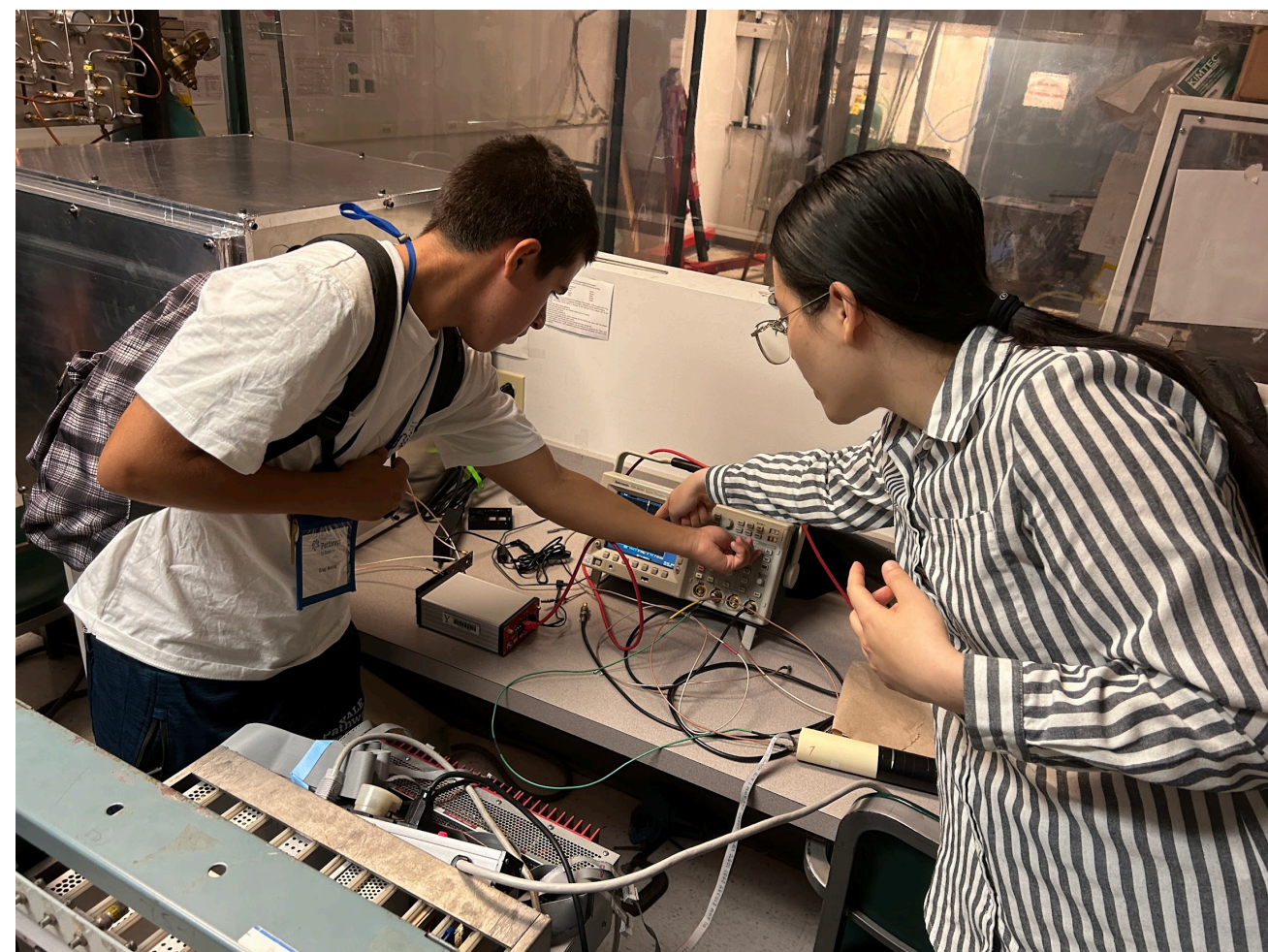
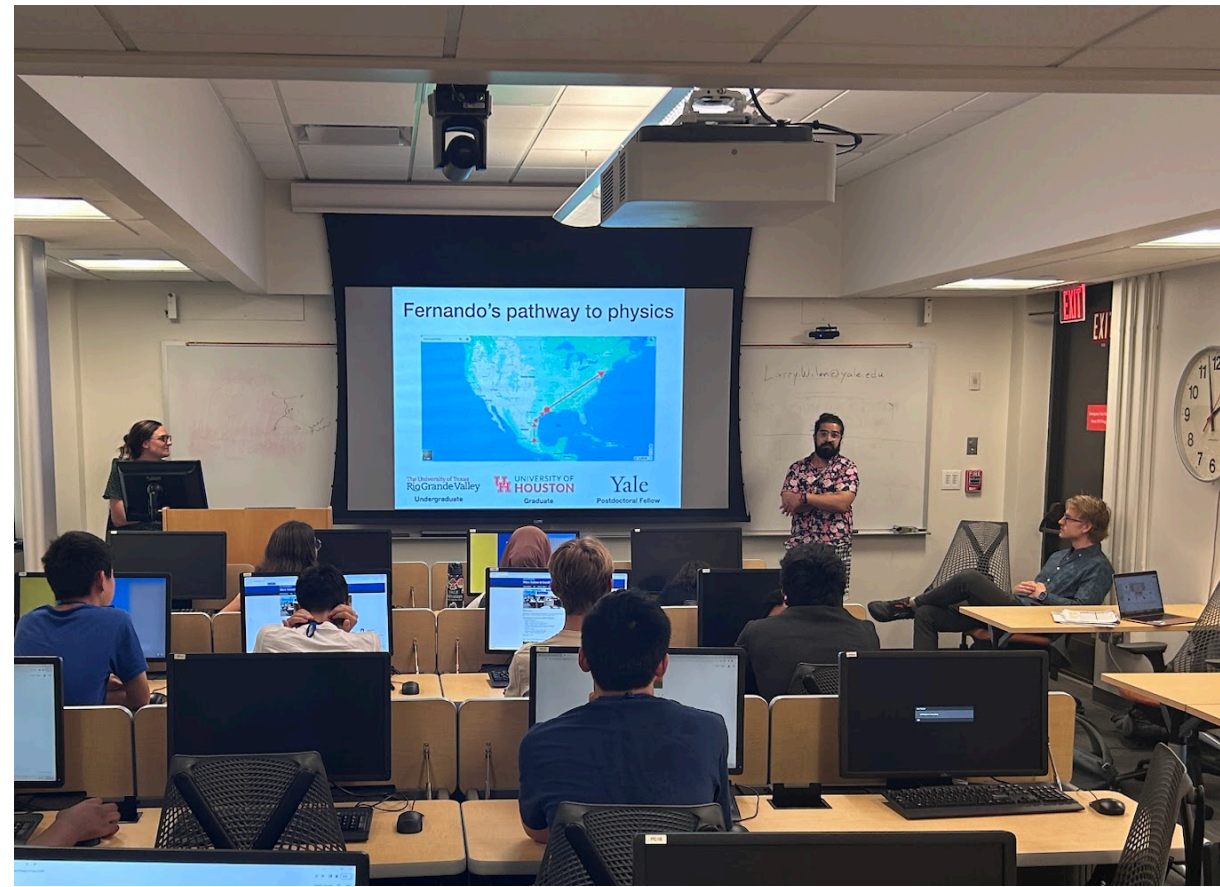
[Link to Scientific American Article](#)



Let Us Smash Some Protons

- Run thru *Yale Pathways Program*
 - Spearheaded at New Haven, CT by *Raghav Kunnawalkam Elayavalli* ca. 2022
 - Expanded to Nashville, TN the following year
- Weeklong Program for High School Students (~14 students per session)
 - Lecture-based days introducing students to subject matter (e.g. QCD, EIC Physics, etc.)
 - Mixed with *in silico* experimentation in *PYTHIA* thru *Jupyter Notebooks* ([link](#))
 - One day is dedicated for a visit to Yale University's Wright Laboratory
 - Additional day dedicated for building a *Miniature DIY Cloud Chamber*
- Organized by admixture of faculty, postdocs, graduate and undergraduate students
- Relatively minimal barriers to entry and low overhead costs
- Easy to replicate and adapt to various audiences and diverse settings

Let Us Smash Some Protons



Computer Programming

Computer code is a language used to communicate with computer processor. (Today we will use Python!)

Lets make some plots!
Since we have converted the output of the collision into
Question: What grade are you in?



plot of the energies of the particles resulting from

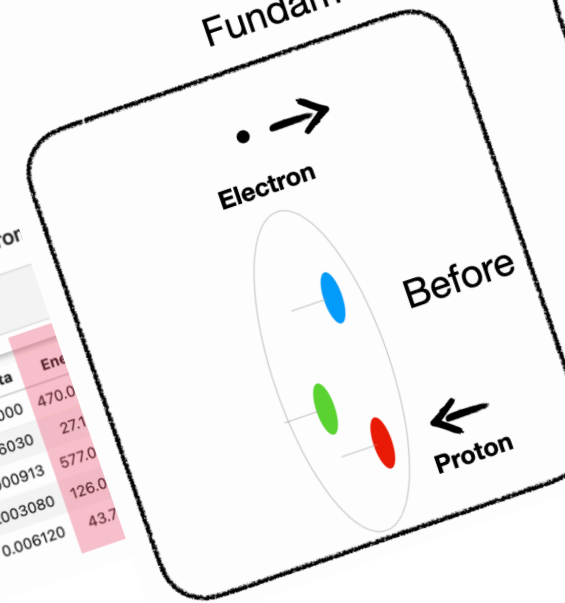
```
Event_Particles['Energy'].plot.hist()
```

	id	pt	phi	eta	theta	Ent
0	11.0	8.6400	0.88400	-4.6900	3.120000	470.0
1	211.0	0.1630	-1.97000	5.8000	0.006030	27.3
2	-211.0	0.5270	2.27000	7.6900	0.000913	577.0
3	211.0	0.3880	0.94200	6.4800	0.003080	126.0
4	-211.0	0.2670	0.62600	6.7800	0.006120	43.7

Histograms

Energy/Momentum Conservation

Fundamental constraint



Let's "smear" our results

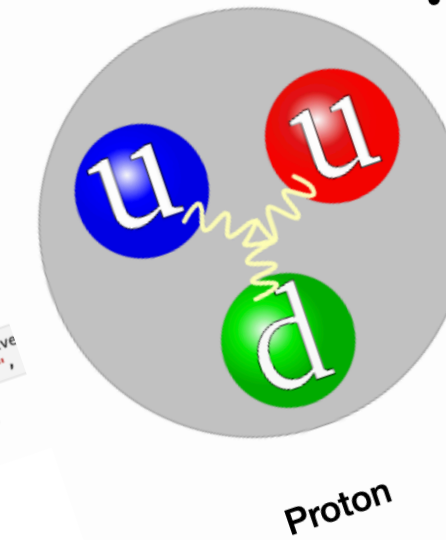
Make a 2D histogram of Detector vs. True Energy:

```
import matplotlib as mpl
max_e = 500
plt.figure(figsize=(6,5))
plt.hist2d(Event_Particles['Energy'],
           Event_Particles['Detector-level energy [GeV]'],
           colorbar=True)
plt.xlabel('Truth-level energy [GeV]')
plt.ylabel('Detector-level energy [GeV]')
```

Compare number of particles?

```
print("Average truth-level event multiplicity:",
      Average truth-level event multiplicity: 36.7)
print("Average detector-level event multiplicity:",
      Average detector-level event multiplicity: 34.3)
```

Where does the hadron mass come from?



- Up quark mass ~ 2 MeV
- Down quark mass ~ 5 MeV
- Proton mass ~ 1000 MeV

Where does the "missing" mass of the proton come from???

Howdy! The sum of 2 MeV + 2 MeV + 5 MeV is...
2 MeV + 2 MeV + 5 MeV = 9 MeV

RHIGscape @ Yale University



- Run thru *Yale Pathways Program* in parallel with weeklong workshop
 - Adapted from *INFN's HEPscape* ([link](#))
- Single day, hour-long enrichment session (~14 students per session)
 - *Escape Room* engaging participants in Simulated Detector Shift Scenario (imminent beam dump)
 - Split into two rooms – *Detector 1 and Detector 2* (can be scaled up to more rooms)
 - Includes a series of puzzles/riddles related to EIC and Heavy Ion Physics
 - e.g. proton mass, proton structure, color charges, partons, beam dumps, detector statuses, etc...
 - Promotes problem solving, critical thinking, teamwork, effective communication
- Organized by admixture of faculty, postdocs, graduate and undergraduate students
 - Capable to traveling to BNL and local High Schools
- Relatively minimal barriers to entry and low overhead costs
- Easy to replicate and adapt to various audiences and diverse settings



HEPscape

High Energy Physics Escape Room

RHIGscape @ Yale University



Detector: _____

Detector: _____

Down

1. The carrier of the electromagnetic force, ...
2. A particle that is made of an odd number of ...
3. The antimatter opposite of an ...

Across

1. ... theory
2. ... the future EIC are located here
3. ... number of an element is determined by ...
4. ... of quarks and gluons is described by ... Dynamics



TPC Status

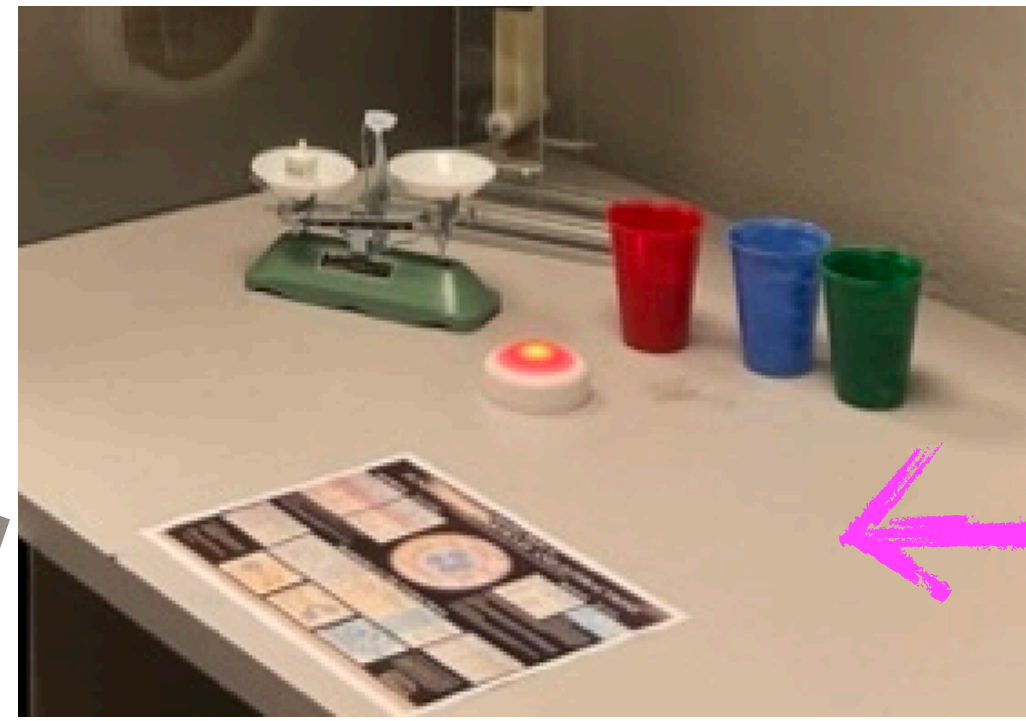
Red OFF Green ON Blue STAND-BY

BEMC Status

Red OFF Green ON Blue STAND-BY

IN CASE OF BEAM DUMP: FOLLOW DETECTOR STATE: αβγδϵζ

938 DAYS SINCE LAST MAINTENANCE



THANK YOU!



Special Thanks to:

*Sierra Cantway, Andrew Tamis, Youqi Song,
Morgan Knuesel, Ananya Rai, Isaac Mooney, Prakhar Garg,
Laura Havener, Raghav Kunnawalkam Elayavalli and Helen Caines*