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Guest: Benjamin Nachman

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Welcome to this episode of "My Journey as a Physicist" podcast.
Each episode features an interview with a physicist to learn about their work, their interests outside of physics, and their professional journey of how they ended up where they are today. Season two features physicists involved in the particle physics planning community known as "Snowmass". Hope you enjoy today's episode.

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Welcome Benjamin Nachman. Could you introduce yourself? What is your current job?

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So I'm currently a staff scientist at Lawrence Berkeley National lab in our physics division.

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Okay. And then can you kind of explain what your research is? So my research has a couple of

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components. I spend a large part of my time working on

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developing, adapting and deploying machine learning methods for five minute physics.

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I'm the leader of a machine learning group for high energy physics in our physics division

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and in that role, there's development and methods outside of any particular experiment. And then I'm

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connected to a number of experiments we’re applying methods. So I'm in the Atlas collaboration, it’s

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part of CERN and I also participate in the analysis of data from the H1 experiment, which

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was a detector at the HERA collider in DESY. And also some fraction of my time thinking about the

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development of quantum computing and quantum algorithms for a hundred physics as well. So that's my research in a nutshell.

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Okay. Yeah. So like what are some of the goals or questions that you're asking or trying to answer?

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I think ultimately the kind of science goals that drive me are sort of twofold. And one

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is I want to understand like what are the what is the fundamental

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structure. You know, like what is it that makes up the contingence of matter?

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And for that I've been…thinking about how we can use machine learning

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to explore our data, our very high dimensional complex data in new ways.

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Machine learning is a very powerful tool for exploring, identifying small subtle patterns and

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high dimensions which might be the key to unlocking new physics. And so that's that's one component that component and the

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component and the other component, which is sort of in the opposite direction is, it's not going fundamental but sort of the other direction, which is emergent

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and thinking about how various scales emerged from more fundamental ones.

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And there’re interesting quantum effects that can happen in the standard model, in particular what

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unifies both of these areas is to study the strong force. So I'm interested in the emergent

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00:02:18,450 --> 00:02:23,790
properties of the strong force and also the fundamental properties of the standard model as pro would be the strong force.

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And there, the kind of unifying object are jets. So jets are emitted

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streams of particles that result from high energy quarks and gluons.

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And so a lot of my research uses jets as sort of the main object for study. Okay.

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And so is a lot of your work more on like computational side of things? Do you concern

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yourself more as like an experimentalist or a theorist or in between? So I'm definitely an

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experimentalist by training but, uh, these days I'm somewhere, somewhere in between. I would

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00:02:48,120 --> 00:02:52,320
say I'm somewhere between experimentalists and phenomenologist and it's unfortunate that our in

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00:02:52,320 --> 00:02:55,920
our community is very siloed. So people are experimentalists or theorists and

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00:02:55,920 --> 00:02:59,370
and where I fall somewhere in the middle, which is an exciting place to be, but yeah, it becomes a little trickier to label the work. Yeah. So

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what kind of like led to your transition from, you said experimentalist by training,

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what kind of led you down this path then?

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00:03:06,840 --> 00:03:12,000
of like kind of more experimental training to kind of being in this middle ground with computational?

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00:03:12,000 --> 00:03:17,115
I've always been interested in phenomenology between my undergrad and grad school. I spent a year

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at Cambridge where I basically did theory for a year and that was really exciting. And in grad

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school I continued to have some component of my research,

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00:03:25,230 --> 00:03:29,940
you know, be in phenomenology. And it sort of naturally became a bigger and bigger part of what

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I did and now it's, you know, very, it's very integrated I would say. Um it's sort of part of you know one

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00:03:35,280 --> 00:03:39,060
one research program that also kind of merged naturally. When I was in grad school I also

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thought my PhD is in physics but I also did like a PhD minor which is sort of like a master's

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00:03:43,020 --> 00:03:47,130
degree but it was in statistics. And so I got really interested in developing the development of

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statistical methods and their applications in high energy physics. And so that kind of naturally also

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grew into part of my research program and then at Berkeley lab where I am now, I've really

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benefited greatly from collaborations with
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00:04:01,320 --> 00:04:05,340
theorists. Theorist, traditionally theorists. And then you know so my research is sort of kind

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00:04:05,340 --> 00:04:08,490
of naturally moving in that direction and machine learning and quantum

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00:04:08,490 --> 00:04:11,670
computing are two exciting new technologies that I think are

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00:04:11,670 --> 00:04:16,019
are are great for building bridges between communities that have traditionally been separated.

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00:04:16,019 --> 00:04:20,100
And so they're like they provide a language and a framework for for theorist

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and experimentalists you know to work together. To further the science center.

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Okay. And then you kind of like touched on a little bit of like a little bit of the path that you took.

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you know, through academia of like your education but like what got you interested in physics to

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begin with? I've always been interested in physics for longer than I knew it.

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Before I knew what physics was. So I guess I had this art teacher and um when I was a really

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00:04:42,765 --> 00:04:46,860
little kid, you know like seven or eight, and she for some reason, I guess I wasn't very good at artwork,

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00:04:46,860 --> 00:04:51,615

she really tried to steer me towards science. And she taught me about Einstein and

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00:04:51,615 --> 00:04:55,665
uh I got a book on Einstein. In fact she has this story which I either been able to devalidate

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but her claim to fame but her claim to fame is that she was a translator for Einstein in one of his meetings

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uh in some some, you know, I don't know, closed door meeting at the ISS but anyway so

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she got me really really, really excited about physics before I knew what that was. So I was very young.

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And then when I was in high school I, I got involved I was very lucky to get involved in an outreach project from University I'm from Nebraska.

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And there was a project from New York and Nebraska to build cosmic ray detectors on the roofs of

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the high schools in the state of Nebraska. And so we built cosmic ray detectors,

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you know, on the roof of our high school which is just awesome. We'd like basically built these

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00:05:25,450 --> 00:05:29,170
PMT arrays. So there was some hardware component. We did some data analysis.

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00:05:29,170 --> 00:05:33,130

And so I got really hooked and then I really wanted so that got me into experimental energy physics.

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So that was like why high energy physics because that's the physics that I studied basically or I got

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started with. And then when I went to college I like sought out experimental high energy physics and

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from there the rest is history. Oh very nice. And can you say again like where you did your academic studies at?

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So yeah. I did undergrad at Cornell university. And then I went to Cambridge university in England for a year.

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A Churchill scholarship. And I did my PhD at Stanford. And so then I know you're involved with um Snowmass. Now can you kind of describe

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what your involvement with Snowmass is? So Snowmass is broken up into frontiers

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and so they're sort of physics oriented frontiers. So the energy frontier,

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neutrino frontier, rare precision processes, and the cosmic frontier.

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And there are a number of cross cutting frontiers that are method and tool oriented. So there's

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Erie instrumentation and important computing.

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A number of other frontiers also. And so I'm one of the co-conveners of the computational frontier.

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And within computing there are a number of areas. So there are, you know, there's analysis software,

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analysis facilities if you like, high-performance computing, algorithm parallels

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parallelism, then also machine learning quantum computing, re-interpretation data, and

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00:06:42,040 --> 00:06:45,640
long term preservation. All those kinds of topics are essential to competing model that we need to

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think about for the future. What has your participation in Snowmass like meant to you in terms of your involvement there?

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The one thing that I'm really excited about is that the field of computing is changing very very rapidly.

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And if you look at. So Snowmass happens roughly every 10 years. And the last one was in 2013 and

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in 2013 machine learning and quantum computing were basically not mentioned at all.

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Now, quantum computing is basically totally new. And it's still not clear what its impact

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will be in our fields but it's you know very promising technology. Machine learning is having an

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00:07:09,870 --> 00:07:13,620
order one impact on our field already and it's going to continue to grow in its importance.

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00:07:13,620 --> 00:07:16,725
And so the fact that there's been this huge transition and in an area where

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I'm very actively involved in research is really exciting.

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And so to me it's an opportunity to you know, steer the future of our field in the direction I

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think is has the biggest impact on the science that we're trying to accomplish.

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Yeah, so like how big is the group that you kind of work with or are part of and how collaborative

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is like computational work or computing work? In general it's highly collaborative. And one

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thing I really like as I mentioned before is that computing sort of builds bridges between

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communities and it's less siloed than some other areas of our field which I really really enjoy.

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I mean I really like working in collaboration with a number people, theorists, experimentalists, and my work also breaks

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inside and outside of collaborations. So for instance I'm part of the Atlas collaboration. It has

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00:07:54,465 --> 00:07:57,780
3000 people, but the data are proprietary. So it's very

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00:07:57,780 --> 00:08:01,570
difficult to work inside and outside of the collaboration but computing and machine learning

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in particular are kind of bridge that gap. Which I really like. There's also a lot of great standards in the machine learning

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and computing for open access, making data and code public, documentation, this kind of thing which

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I think is really healthy for the future. Yeah. You mentioned that this is kind of like bridging

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different like groups and areas together. How much of that do you like actually interact with

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other people and other other fields or places? A

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lot. I mean part of my role and my position right now is to be exactly

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sort of a connection in between areas. So my even though I'm a collider physicist, that's my

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background, now I've kind of branched out into other areas to create this sort of interdisciplinary machine learning initiative.

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And so I often now talk directly to people who are in cosmology, neutrino physics, uh other areas,

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in dark direction talking about direct detection,

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of course many theorists. And

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that's reflected also in like the papers that I've written. A number of my papers are covering

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thought with theorists and I have a number of ongoing projects that are with people who are

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experimentalists outside of my traditional area of high energy physics. Very nice. And so I'm like I

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don't have much of a computational background, so can you kind

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of like describe of what that even actually

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is? Like in my mind you know I could imagine some people saying like computation and you're just

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running a bunch of like problems and you're like answering you know a bunch of calculations or

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something like that or are you trying to do like more modeling sort of work? Are you just solving

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more complex problems? Can you kind of describe what this looks like overall? Yes. There are three components to this research.

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One is like sort of pencil and paper. So my group develops methods, which and some of the time,

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a lot of the time, that starts by you know pencil and paper or you know chalk on a chalkboard,

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basically like trying to figure out like what are the features that we're looking for in a

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00:09:42,400 --> 00:09:47,110
method and then trying to derive some of the properties of those methods, prove some things, you know, asymptotically. In, you know, simple cases,

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that goes that helps us build intuition then the next step is translating, you know, abstract

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concepts to lines of code and um and then writing some software to be able to implement those ideas.

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And the third stage is scaling up. So taking after we've

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demoed some some method in some you know small limited datasets you know

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to show like “oh we can do this on you know large datasets.” And that requires often

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high-performance computing and, you know, a large parallelism. So then you also mentioned

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that you're a staff scientist at this at this lab. How is that different from say a professor or

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a researcher at like a university? How do these jobs kind of similar or different, if you can speak to that?

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Yeah, Yeah, my position is the national lab equivalent of an assistant professor. So

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I don't have tenure yet, but I'm in a tenure track position.

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And so in that sense it's very similar. I work directly with students and postdocs, so that's

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also very similar. The main difference is that is is with respect to teaching. So my job doesn’t include teaching as

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the main objective. Whereas if you're a university professor the main job is to, is to teach and

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then you know research is a sort of to compliment that. And so

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that's the main difference. Otherwise it's, yeah, I guess very similar.

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We're in a kind of unique position at Berkeley lab in that we're so close to a

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00:10:54,670 --> 00:10:58,120
university. So Berkeley lab is, you know, literally a 10 minute walk from UC Berkeley.

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And so I directly, like in my group, there are postdocs at Berkeley lab but also

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advise students from UC Berkeley and I work with a number of graduate students undergraduate

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students from UC Berkeley. So in that way, you know, my group's competition looks probably a bit

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more like a university group than say other national labs that are further from university. Okay.

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So like when you're were in school, an undergrad as a grad student, did you always

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know that like research was your primary focus or interests that you wanted to pursue? I

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definitely like teaching and I look forward to the opportunity to teach in the future. I mean one of the

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nice things, once again, about having a national lab or university so close is that many

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staff scientists do teach. But like I said it's not our primary objective. So it's the thing that we do

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um you know, when there's time and it's not our number one objective. I would say it wasn't

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00:11:40,180 --> 00:11:43,525
always clear what route I would take. I've grown up in national labs. So my dad was a

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graduate student at Stanford but I did a lot of my research at SLAC, which is another national

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00:11:47,200 --> 00:11:51,265
lab. And so I'm very familiar with like the national lab-university set up. And I think yeah

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there's a lot of flexibility which I really like and, but in the end it's it's it's pretty

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00:11:54,580 --> 00:11:58,945
similar. I really liked working with students and um that's an important part of my research on

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00:11:58,945 --> 00:12:02,560
part of my position. And that's something I'm I'm I'm really excited about.

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00:12:02,560 --> 00:12:06,955

And then, so like kind of throughout your career as a as a physicist

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00:12:06,955 --> 00:12:11,620
if you feel comfortable sharing like were there any obstacles that you had to overcome along the way?

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I think maybe one significant obstacle, which in some sense, I'm still overcoming, but it's kind of

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taken a different form as I've become more senior, although by no means am I senior,

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I'm on the most junior end of senior, think I'm the most junior, Snowmass meaner.

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Is is that my work is sort of naturally interdisciplinary.

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00:12:27,070 --> 00:12:30,910
And one challenge of being in the middle, is that you don't belong to any group.

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00:12:30,910 --> 00:12:33,730
You know, every group thinks you don't really belong to them, you know, even though you're

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00:12:33,730 --> 00:12:37,960
kind of in the middle, and this has been something which was most challenging I would say

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when I was a postdoc in that I worked I was in a particular

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00:12:41,395 --> 00:12:45,340
group but I was I had a position, which had a good amount of freedom and I

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you know, definitely made great use of that freedom, but it means that there was often tension with

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00:12:49,975 --> 00:12:54,070
the rest of the people I worked with because I often would kind of go do my own thing

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and it was kind of in a direction that was not necessarily in the same space as the people in the group were doing

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and I think that sometimes it was difficult to say like you know how does how do I fit into this

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you know picture, this predefined structure, that, you know the world is set out for us. And I'm

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00:13:07,750 --> 00:13:11,290
hoping that you know people come after me who are kind of also working on similar areas like my

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students and postdocs to help build a framework where they don't feel that same

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00:13:14,980 --> 00:13:18,265
you know mismatch and there is somehow like a structure that will

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00:13:18,265 --> 00:13:22,090
accommodate them. I would say that's uh, uh, the biggest challenge.

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00:13:22,090 --> 00:13:26,935
Okay. Yeah. How do you, if you don't mind generally like how do you feel like you can like is

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kind of the stigma or like separation you know kind of like getting

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improving like now over time and how have you been able to connect more with other people?

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It's improving, but slowly,

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unfortunately. I mean it's just the case that because of the way funding and other things are set up it's very siloed.

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And so people who work on even though everyone's excited about interdisciplinary research, no one has a way of basically making it happen.

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So it happened. People are excited if it happens but they don't want to like fund it basically.

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So that's a challenge and uh, I mean the really the way that I made it work was to I would I would think

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it was just like no do be like follow my nose. Do the research that I think is really most

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interesting and impactful. And then I had, I'm really very very fortunate to about have strong

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allies along the way, allies both at Berkeley lab and elsewhere who were able to,

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00:14:11,200 --> 00:14:14,500
you know, who are more senior than me who can vouch for this stuff I was you know saying that

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this is like not totally crazy, it's going in a good direction. And so I want to be allies for the people who come after me,

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00:14:19,660 --> 00:14:22,780
be an ally for the people come after me and also um I do see a growing

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00:14:22,780 --> 00:14:26,710
number of positions like mine that are inherently interdisciplinary.

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00:14:26,710 --> 00:14:32,500
It's still tricky to figure out how to fund them because funding is very siloed. And so our departments and other things but I think it's improving.

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00:14:32,500 --> 00:14:36,160
Like stepping away from physics a little bit, what do you do when you're not working in the lab or doing all this research stuff? Like, do you have any

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00:14:36,160 --> 00:14:40,750
interests or hobbies outside of physics? Uh yeah I like to run and say, I guess my two things

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00:14:40,750 --> 00:14:44,680
I do outside of physics physics, or you know for the most part, I like to run, I like to go squirrel

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00:14:44,680 --> 00:14:48,520
watching. I’m a huge fan of squirrels. And squirrel watching is like birdwatching, find them. They’re

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00:14:48,520 --> 00:14:52,720
adorable. These days I don't do much of either of those things because I have a young daughter who was born a few months ago

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00:14:52,720 --> 00:14:59,125

and she takes all my time outside of outside of research. Congrats and…thank you. Squirrel watching.

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00:14:59,125 --> 00:15:03,010
How does like I have I have followups on that.

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00:15:03,010 --> 00:15:07,990
Yeah. Um, So I, is this just like a tight knit community?

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00:15:07,990 --> 00:15:11,200
I know birdwatching is a, there is a community. Is this just like is there a

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00:15:11,200 --> 00:15:14,650
community of this or just like I like squirrels so I'm going to watch squirrels?

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00:15:14,650 --> 00:15:20,440
Both. I mean there are definitely some very serious people. I'm not I'm not a serious person and I like squirrels, I like watching them but I'm not like I don't have like a

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00:15:20,440 --> 00:15:25,105
guidebook to like you know identify all the squirrels. I did have, I ran squirrel clubs in both my

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00:15:25,105 --> 00:15:31,180
high school and in college too to bring together like minded people and we would go squirrel watch it together. But you know that was

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00:15:31,180 --> 00:15:35,140
that was still a bit informal. Okay. Is this a lifelong interest?

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00:15:35,140 --> 00:15:38,530
It's been going on for quite a while. Yeah.

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00:15:38,530 --> 00:15:43,315

Very very nice. What are you like most proud of that you have accomplished in your work? Yeah.

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00:15:43,315 --> 00:15:47,500
what I'm really really proud of, I mean a number of physics results that I think are genuinely

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00:15:47,500 --> 00:15:51,280
new and innovative, but one thing I'm really excited about it in that work is that

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00:15:51,280 --> 00:15:55,330
I think I've shown that I can, I've developed,

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00:15:55,330 --> 00:15:59,440
you know proposed new methods, then you know prototyped them and then connect them to physics

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00:15:59,440 --> 00:16:02,440
results. There there are a number of people who are developing methods and there are people who

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00:16:02,440 --> 00:16:07,090
are you know producing physics with new ideas. And I'm really proud that I've connected those two ends

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00:16:07,090 --> 00:16:10,180
of the spectrum basically. And that's something that yeah, I'm

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00:16:10,180 --> 00:16:13,390
hoping to continue doing. And it's something that I think is yeah,

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00:16:13,390 --> 00:16:18,280
really proud of my in my research group. Where do you see your career going from here? Are there

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00:16:18,280 --> 00:16:23,440
like next steps that you wanted to achieve? New questions you want to ask? Well at the moment,

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00:16:23,440 --> 00:16:27,625
yeah there's there's uh, the various structures that described at the beginning are I think

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00:16:27,625 --> 00:16:32,590
kind of the beginnings of of research of a research program that is many many years. So no one

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00:16:32,590 --> 00:16:36,415
component for instance is this using machine learning to look for a new physics and in our model

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00:16:36,415 --> 00:16:39,865
independent to look for new physics in our model independent way. It's on it's called anomaly

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00:16:39,865 --> 00:16:43,810
detection. And this is like a really rapidly evolving field.

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00:16:43,810 --> 00:16:47,740
I was lucky to be in at the start and I mean I don't I can't see the end yet. Anyway I

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00:16:47,740 --> 00:16:53,590
mean we're just it's just an incredible amount of work required to broadly broaden our sensitivity to new physics.

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00:16:53,590 --> 00:16:57,640
And so I could I could really see that growing in new ways and I can start to anticipate given

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00:16:57,640 --> 00:17:01,060
the rapid evolution of the technology and methods like where that will go. But I'm definitely

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00:17:01,060 --> 00:17:04,270

excited about it. Yeah. And so then like maybe.

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00:17:04,270 --> 00:17:09,460
I'm curious just like you talked about mentoring some some students in in your work. Do you have

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00:17:09,460 --> 00:17:13,569
any advice for students or young research researchers thinking about

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00:17:13,569 --> 00:17:17,200
being in physics or around the type of work that you do? Yeah, I would say.

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00:17:17,200 --> 00:17:22,900
Um, well yeah. I mean generally advices. I don't know how useful it you know, advices from,

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00:17:22,900 --> 00:17:27,295
from other people about what to do or what not to do but I think something that I have done and

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00:17:27,295 --> 00:17:32,065
I think it's been very, very useful is to kind of follow my nose you know, do the do the

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00:17:32,065 --> 00:17:36,520
follow the research that seems interesting, not the research that seems the most everyone else is doing or that you know

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00:17:36,520 --> 00:17:41,050
is let's say what you what is expected of you. And that I think has been crucial as I you know

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00:17:41,050 --> 00:17:44,350
I move forward in this interdisciplinary path. Yeah. So you kind of said you

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00:17:44,350 --> 00:17:47,830
follow follow your nose and go in what you're interested in. I'm wondering is like how

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00:17:47,830 --> 00:17:54,640
that compliments or goes against like things like Snowmass or just like research in general when

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00:17:54,640 --> 00:17:58,300
it's like we're trying to build these connections of like, where

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00:17:58,300 --> 00:18:01,990
are we as a field and how do you find that compromise between like the field

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00:18:01,990 --> 00:18:06,880
of higher energy or particle physics and like what I individually as an individual want to pursue?

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00:18:06,880 --> 00:18:13,330
Yeah. I think that we really, we need innovation, methodological innovation. And so that will require

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00:18:13,330 --> 00:18:17,710
new ideas trawling. And ideas from other communities And so we do some of this but I think

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00:18:17,710 --> 00:18:21,490
we don't do enough of this which is like looking outside of our community to see if there are

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00:18:21,490 --> 00:18:25,930
things that we can borrow that will allow us to grow. I mean, QIS is one really great example of

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00:18:25,930 --> 00:18:30,070
this where the whole area of quantum sensing is not new, people have been doing it for some time

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00:18:30,070 --> 00:18:34,030
but like it's got give it's been reignited given all the injection of resources on quantum

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00:18:34,030 --> 00:18:38,815
computing and quantum information in general. And so, yeah there that's one one example of like

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00:18:38,815 --> 00:18:43,690
you know, outside forces bringing in but I think we can also you know the grassroots way, look look

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00:18:43,690 --> 00:18:48,625
outside the box. Where can we bring inject new ideas and sort of big picture new ideas, like

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00:18:48,625 --> 00:18:52,810
how are we going to like make the next discovery? And I think in the context of Snowmass we are doing that

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00:18:52,810 --> 00:18:56,410
to some extent. I mean this is on all levels you know like what's the next lead

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00:18:56,410 --> 00:19:02,080
we're going to build for instance like there's some genuinely new ideas that are being thrown out there which I think is fantastic. And then you know all the way.

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00:19:02,080 --> 00:19:07,510
to the ethological level like, how can we best make use of tools and resources that our community

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00:19:07,510 --> 00:19:13,540
standards outside of high energy physics. For a long time for instance, we've kind of developed our own in-house tools but

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00:19:13,540 --> 00:19:17,470
The general data science community has been doing a lot of great toolage recently

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00:19:17,470 --> 00:19:20,500
and a lot of people in our field are using them. We have to, we have to think about like in this

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00:19:20,500 --> 00:19:24,355
context like, you know, what's the compromise between in-house and and you know community

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00:19:24,355 --> 00:19:28,780
standards. Yeah. And so I'm just kind of curious, like the type of work that you do when you

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00:19:28,780 --> 00:19:32,800
say like, work in house with a lot of computational stuff. Are you are you

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00:19:32,800 --> 00:19:36,580
actually like physically located where this equipment is or something? Or is this something that

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00:19:36,580 --> 00:19:39,910
you can just log in from anywhere to do your work?

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00:19:39,910 --> 00:19:44,110
It's exciting. We don't have like a physical lab space indeed. It's like basically it can be anywhere.

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00:19:44,110 --> 00:19:48,910
We do happen to have a GPU supercomputer at Berkeley lab which has 10,000 GPUs which is

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00:19:48,910 --> 00:19:52,900
fantastic. But you know I I have never seen the machine myself. I know where the building I know

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00:19:52,900 --> 00:19:56,200
where the building is but you know, it's kind of irrelevant. Yeah. That's that's really

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00:19:56,200 --> 00:20:01,525
interesting. So yeah. Thank you for coming on and taking the time to talk about your kind of

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00:20:01,525 --> 00:20:05,410
journey as a physicist and what you do. And it was really interesting to learn about your work. Thank

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00:20:05,410 --> 00:20:09,070
you so much for the opportunity. And maybe it just super quick though, I haven't asked anything

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00:20:09,070 --> 00:20:12,820
about you. Could you give like the 32nd version of who you are? Who am I? Oh yes.

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00:20:12,820 --> 00:20:19,495
I'm Brian. So I am a, just finishing up my third year as a physics PhD student at Michigan State.

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00:20:19,495 --> 00:20:25,300
So actually I am not in particle physics or high energy I'm in a physics education research. So

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00:20:25,300 --> 00:20:28,840
all my research is actually on like physics outreach or

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00:20:28,840 --> 00:20:34,510
public engagement and things of that nature.

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00:20:34,510 --> 00:20:37,900
Um, you know, Huey-Wen brought me in and asked me like “Hey do you want.

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00:20:37,900 --> 00:20:40,960
I have this idea for this project, do you will have be a part of it?” And so I've just been working

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00:20:40,960 --> 00:20:44,530
with her on this. That's awesome. Great. Well yeah thank you again so much for the opportunity. It's

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00:20:44,530 --> 00:20:47,530
been great chat. Great. Thanks, you too.

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00:20:47,530 --> 00:21:02,340
We hope you enjoy today's episode. This podcast was created by Bryan Stanley and Professor Huey-Wen Lin. Season two was edited by Varalee Sakorikar. Thank you for listening.