WEBVTT

1
00:00:03.090 --> 00:00:03.870
thomas rizzo: And

2
00:00:05.190 --> 00:00:05.819
thomas rizzo: Renee.

3
00:00:08.730 --> 00:00:09.360
Renee Hlozek: Great.

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00:00:09.420 --> 00:00:21.840
thomas rizzo: I'm here. Okay, so let me introduce Renee Logitech who's from the University of Toronto and she's going to give us an overview of what to expect in the future. Thanks a lot.

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00:00:22.770 --> 00:00:23.850
Renee Hlozek: Thank you so much.

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00:00:24.390 --> 00:00:28.170
Renee Hlozek: And if you cannot hear me, PLEASE SHOUT and I will speak.

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00:00:28.230 --> 00:00:37.680
Renee Hlozek: A little bit louder. But, I'm, I'm really pleased. It's, it's always a daunting task to give a summary talk of such a vibrant and diverse meeting.

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00:00:38.130 --> 00:00:46.950
Renee Hlozek: And so I am a cosmologists I care about all of the almost invisible things you've been learning about from dark matter to neutrinos.

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00:00:47.310 --> 00:00:57.030
Renee Hlozek: And I have a focus on kind of interplay between observations in theory. And so I'll, I'll use this as a theme to really bring some of the stuff together that we've learned about

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00:00:57.600 --> 00:01:12.780
Renee Hlozek: And I want to start with a word of caution and I think, you know, I got my PhD in 2012 and sometimes when we speak to more senior people we get the sense that

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00:01:13.650 --> 00:01:24.480

Renee Hlozek: We're in a difficult time and they're everything that's been done a has been could be done has been done and and I really want to encourage you as you go forward to really remain

12
00:01:26.010 --> 00:01:35.610
Renee Hlozek: Optimistic and curious and push a lot of the assumptions, because I think one of the themes that has come through and this meeting is that there's a lot more work to do, which is super exciting.

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00:01:36.000 --> 00:01:41.130
Renee Hlozek: And the other word of warning, of course, that my talk is a little bit cosmology focus because that's my area of strength.

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00:01:41.790 --> 00:01:47.190
Renee Hlozek: But I've tried to at least connect to some of the other topics that have been brought about in this meeting.

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00:01:48.000 --> 00:02:09.840
Renee Hlozek: Okay, so the, the, it's always good when you give a survey. Talk to think about what goes and what has come before you, and so I decided we're in in a very particular year 2020 and the US astronomy community takes a stock of all of the science that's been happening and every decade and

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00:02:10.860 --> 00:02:20.190
Renee Hlozek: uses that as a yardstick for the successes of the past and how to go forward. And so I'd like to take a look back and see what we'll be talking about in 2010

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00:02:20.580 --> 00:02:30.450
Renee Hlozek: I had was halfway through my PhD and it was an exciting time. And so this screenshot is actually from the cover page of the

18
00:02:31.080 --> 00:02:42.480
Renee Hlozek: Decatur survey in 2010 and particularly the frontiers of science that we're focused on, we're, you know, identification and characterization of habitable exoplanets planets beyond our own solar system.

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00:02:42.990 --> 00:02:47.370
Renee Hlozek: Moving forward to gravitational wave astronomy to focus on time domain astronomy.

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00:02:47.970 --> 00:02:56.760

Renee Hlozek: astrometry so measuring the positions and locations of stars around us and then studying the epoch of realization and it's really amazing. If you look back

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00:02:57.120 --> 00:03:05.550
Renee Hlozek: That we have made significant progress in all of these areas we have James Webb Space Telescope, which is going to be launched in the coming few years.

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00:03:05.850 --> 00:03:13.920
Renee Hlozek: We had the incredible results from Lego that you had a lot of discussion on from Daniel holds and others time domain astronomy, we're almost ready.

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00:03:14.430 --> 00:03:23.490
Renee Hlozek: For St. To start its final phases of construction and the Nancy Grace Robin telescope is significantly advanced in its planning.

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00:03:23.820 --> 00:03:30.750
Renee Hlozek: And Gaia, who has already released a bunch of data releases really really rich data and then we have a lot of

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00:03:31.380 --> 00:03:41.460
Renee Hlozek: Ground based surveys which are working to and have released some data on studying the Epicurean ization and how stars form. So there's really we've been making a lot of progress.

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00:03:41.850 --> 00:03:51.030
Renee Hlozek: And but I want to focus a little bit more. Finally, and say, let's look at what we thought we knew 10 years ago saying about the CB and let's look at ways in which we

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00:03:51.810 --> 00:03:57.510
Renee Hlozek: Were correct and ways in which we have been humbled. So that, of course, the sandy I should state is the cosmic microwave background.

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00:03:58.320 --> 00:04:10.260
Renee Hlozek: Radiation. So it made with 2009 we I watched the launch of the plank satellite. There was launched, together with Herschel, and there was great promise for what plank would deliver

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00:04:10.650 --> 00:04:19.620

Renee Hlozek: On a study of the cosmic microwave background all over the sky and that's when we have in fact seen a lot of great results from plant, which I'll go into it a little bit.

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00:04:21.540 --> 00:04:29.040
Renee Hlozek: The from just before in 2009 years before the launch and there was a page, a couple of papers are predicting what

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00:04:29.430 --> 00:04:34.410
Renee Hlozek: We would measure what what inflationary be modes, we would measure gravitational waves we would measure

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00:04:34.800 --> 00:04:41.760
Renee Hlozek: From inflation and what our prospects were and you can see the W amount five limits. That was a satellite just before plank and

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00:04:42.360 --> 00:04:50.400
Renee Hlozek: On the be mode power spectrum which is, of course, telling us this this ratio of 10 searches to scale. A modes is our

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00:04:51.240 --> 00:05:02.790
Renee Hlozek: Number that you see quoted and and we know that we add that art can be any value depending on your inflationary model. And the key thing here is to push that out sensitivity, so

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00:05:03.990 --> 00:05:15.990
Renee Hlozek: That was where we were before. And what we expected to kind of from plank and other experiments and folks were already working very hard to understand and control for systematics. So there are lots of

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00:05:16.560 --> 00:05:26.190
Renee Hlozek: Systematic to have to understand in order to measure the signals to high fidelity. For example, you're the calibration angle of your, your detectors, the noise level, etc.

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00:05:26.610 --> 00:05:32.430
Renee Hlozek: And so, you know, at the turn of the century. At the turn of the decade that that was really going into full swing and

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00:05:33.030 --> 00:05:41.520
Renee Hlozek: Ground based experiments. So I'm a part of the Atacama cosmology telescope or act. In fact, that's what I was working on at the time here doing my PhD.

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00:05:41.880 --> 00:05:51.120
Renee Hlozek: And act and SPT were already working in the temperature only phase. So they were measuring the temperature of the power of the cosmic microwave background.

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00:05:51.390 --> 00:06:02.460
Renee Hlozek: But they were developing polarization sensitive detectors which is key. If we're going to make more advances in the small scale features of the power spectrum and also a measuring large scale.

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00:06:02.820 --> 00:06:14.250
Renee Hlozek: Be modes from this inflation in the park and at the same time the they will already large scale be mode experiments are bicep and adds the Atacama be mode and search

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00:06:14.730 --> 00:06:24.030
Renee Hlozek: We're working and they were developing some of the hardware and the technical skill to analyze this really complicated data set from the ground as opposed to just from space.

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00:06:25.050 --> 00:06:32.040
Renee Hlozek: So you might say, okay, well that's what was happening 2009 but we were well on our way. So what were we thinking about in 2005

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00:06:32.430 --> 00:06:42.540
Renee Hlozek: It was really fun deep dive to go into the internet. And look, look at all the papers and I think one thing I noticed is that people were quite optimistic about

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00:06:42.960 --> 00:06:49.170
Renee Hlozek: What we needed to do to make a significant detection of tentative scaling mode. In this case, the

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00:06:49.680 --> 00:06:56.520
Renee Hlozek: Language. They're using as to virus. So here the the quote from this paper is 2005 paper was to detect are of

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00:06:57.210 --> 00:07:03.420
Renee Hlozek: Point three is right in the minus three at three sigma, we need to observe 15% of the sky in the cleanest region.

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00:07:03.990 --> 00:07:11.610
Renee Hlozek: Where the desk polarization is less than point 1% the level of its intensity. So what happened when we actually did have something like plank well

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00:07:12.060 --> 00:07:28.140
Renee Hlozek: This is a map of from the plank satellite of the top half of this graph is the polarization fraction and then the bottom half is the sigma. So, if you would think one of the things we wanted was right 50% the sky in a very

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00:07:30.120 --> 00:07:36.420
Renee Hlozek: In a clean region that had very low polarization fraction. And one of the things that came out of plank is that the polarization fraction

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00:07:37.650 --> 00:07:52.830
Renee Hlozek: Was actually reasonably was a little bit higher. There was a more of a variance and then we might have expected. So in that sense, we were a little bit humbled by just how easy or just how difficult that would be to detect and are in even in a clean patch of sky.

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00:07:53.970 --> 00:08:05.190
Renee Hlozek: You may say, Okay, I'm not necessarily only focused on the cosmic microwave background. So what did we think we could do in terms of some of these invisible. A key invisible parameters like the some of the neutrino message which

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00:08:05.490 --> 00:08:13.710
Renee Hlozek: For cosmology, of course, is one of the main ways we can constrain neutrino properties and in other people from 2005 suggested that

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00:08:14.700 --> 00:08:28.980
Renee Hlozek: We could get to error bars of, you know, point one or point oh seven on then to neutrino mass and in EV and just from kind of a combination of CB and power spectrum measurements themselves.

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00:08:29.550 --> 00:08:37.890
Renee Hlozek: AND IF WE HAVE EVER JUMPED TO more realistic forecasts that are made in the last year or so, we realized that this was

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00:08:38.400 --> 00:08:48.480
Renee Hlozek: Not really optimistic, sorry, not really possible. And in fact, even our stage to constraints which we think about is the current you know Atacama cosmology and south pole telescope

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00:08:48.810 --> 00:08:59.520

Renee Hlozek: Constraints, we're getting to around point one EV in terms of the Arab law and it will take another boost in the number of detectors and other

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00:09:00.840 --> 00:09:14.580
Renee Hlozek: Detector upgrade really to get 2.6 and then, you know, one of our targets for the stage for the next generation of experiments is that we get 2.01 EV their boss, so

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00:09:16.080 --> 00:09:22.470
Renee Hlozek: The moral of the story here is that, of course, we always need to be a little bit more pessimistic but that's okay. We make incredible advances anyway.

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00:09:22.890 --> 00:09:30.510
Renee Hlozek: So what did I learn looking back at at 10 years ago. What have I learned. I've learned that polarization measurements are really hard. And this is a slide.

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00:09:30.870 --> 00:09:38.400
Renee Hlozek: From Sylvia Galliano at a recent conference. I went to last year on on detecting beams from space and and as we get more sophisticated

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00:09:38.940 --> 00:09:43.200
Renee Hlozek: analysis techniques we in fact have to develop those because we know that

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00:09:44.040 --> 00:09:56.850
Renee Hlozek: The foreground is always more complicated. The systematics and polarization in terms of the matchmaking, and the beans. Everything is complicated and it's really important to know that even at the level of sampling as well, whether you're using different

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00:09:58.020 --> 00:10:07.920
Renee Hlozek: Cosmology analysis software. They can be differences in the out in the parameters that you get at the end. So it's always important to become more sophisticated and perhaps

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00:10:08.940 --> 00:10:16.470
Renee Hlozek: Become more realistic with time and we of course learned that experiments like plank and others. I'm focusing on plank because it's one of the large

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00:10:16.740 --> 00:10:23.790

Renee Hlozek: Area surveys, because it did the whole sky, of course, plank released amazing math spectra and power and parameters, right. So, this is

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00:10:24.120 --> 00:10:33.360
Renee Hlozek: A plot that you are perfect. You may have seen before it gathered a lot of attention and media, which is just the map of the intensity of desks and then the magnetic field.

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00:10:33.900 --> 00:10:42.900
Renee Hlozek: Direction so sort of shown as these ripples, which shows the correlation between the magnetic field of our galaxy and the desk polarization intensity

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00:10:44.190 --> 00:10:58.410
Renee Hlozek: And so a lot of an ancillary science or foreground science was made possible by plank. So these again are a couple of slides from a recent conference where my colleagues who really care about the magnetic field of our galaxy can use

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00:10:59.010 --> 00:11:08.520
Renee Hlozek: The polarization of starlight and the alignment with the cosmic microwave background to learn a lot about properties of the local gun magnetic field which is really useful. And so we can

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00:11:09.600 --> 00:11:15.060
Renee Hlozek: Build a deeper understanding of our local environment through different kinds of data and

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00:11:15.900 --> 00:11:22.860
Renee Hlozek: The end. One of the key takeaway points here is that in order to do these analyses we really need a

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00:11:23.430 --> 00:11:32.850
Renee Hlozek: Data that are not specific just to one survey, but that are potentially useful from other wavelengths and other other projects. I'll skip over those and

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00:11:33.660 --> 00:11:39.720
Renee Hlozek: What else am I learned. I've learned when when I was younger. So in the early in the early 2000s.

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00:11:40.320 --> 00:11:49.440

Renee Hlozek: We thought that sigma eight or the parameter that describes the clustering of matter, the variance of men on the scale of around eight mega pasik and that was

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00:11:49.890 --> 00:11:56.250
Renee Hlozek: Forecast or predict it to be to be launched to be around one and then has a huge impact on the

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00:11:56.610 --> 00:12:04.320
Renee Hlozek: Number of clusters objects we see. So for example, I think before experiments like and the ground based experiments like act.

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00:12:04.590 --> 00:12:10.410
Renee Hlozek: And and plank as well before they came around, we thought we would just see a lot more clusters. And in fact,

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00:12:10.770 --> 00:12:15.150
Renee Hlozek: And experiments I guess VT active and plank showed us that submitted was no it was a little bit lower.

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00:12:15.450 --> 00:12:23.760
Renee Hlozek: And that meant that cluster science was would be a little bit harder because there were just a lower number of them and you have to work quite hard with everything you got and

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00:12:24.270 --> 00:12:34.860
Renee Hlozek: This is a nice review paper from an immense in 20 2014 which shows a plot of the clusters found by the South Pole telescope survey.

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00:12:35.190 --> 00:12:44.040
Renee Hlozek: And and some of those from rosset and we're starting to fill in this distribution with Richard and as the y axis here is the mass of the cluster.

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00:12:44.430 --> 00:12:51.510
Renee Hlozek: And and so there's a lot of interesting science that you can do, but you need to work really hard to get the bang for your buck for all of the clusters that you have

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00:12:51.930 --> 00:12:56.130
Renee Hlozek: And one of the key takeaway points in this kind of plot is that

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00:12:56.430 --> 00:13:03.330
Renee Hlozek: Your cosmology is telling you, as a function of mass and how many you would expect to this energy. You might hear people say

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00:13:03.570 --> 00:13:10.860
Renee Hlozek: The number of clusters in a certain have a certain mass within a certain rich have been and we can use that to constrain models of dark energy and

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00:13:11.370 --> 00:13:21.300
Renee Hlozek: And modified gravity, potentially, and so the the future surveys, we hope, will give us a lot more constraining power because we'll have large numbers of clusters.

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00:13:23.400 --> 00:13:31.590
Renee Hlozek: And the ground based experiments performed really well. I sort of said this already. This is another plug from the plant collaboration and shows what I think is actually one of the

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00:13:33.210 --> 00:13:42.450
Renee Hlozek: The, the result that I, as a New Scientist was not expecting to be so powerful and was really quite transformative, and that is that you can measure the

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00:13:42.900 --> 00:13:53.190
Renee Hlozek: The week lensing of the CB. The, the distortion of the CME by intervening structures to actually constrain the clustering of metal, the power spectrum.

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00:13:53.490 --> 00:13:58.560
Renee Hlozek: And as a function of scale PF case. So the, the clustering that changes how what the

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00:13:59.160 --> 00:14:11.280
Renee Hlozek: Magnitude of blending that you see and we've done really well from the very first detections have seen the lending in the early 2000s. In this late 2002 very high significant detections. In this case,

93
00:14:11.910 --> 00:14:18.000
Renee Hlozek: The SPT poll cross team collaboration. You can see here the Aero bars are really quite exquisite

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00:14:19.950 --> 00:14:35.940
Renee Hlozek: And similarly, this in a slide from Ben I seen you notice that the sensitivity of maps of the max is really improving incredibly as

as time goes on. So the, the maps. Again, more sensitive in Michael Kay argument. And that allows you then to

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00:14:36.660 --> 00:14:41.880
Renee Hlozek: Be able to remove for brands to understand your systematics and to make really deep maps of the sky.

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00:14:43.080 --> 00:14:57.450
Renee Hlozek: And I don't want to ignore balloons. Of course, there's a lot of innovation happening from an balloon cosmology and I encourage you all this afternoon to watch the launch of spiders are really incredible experiment that was launched from Dr. K in

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00:14:58.560 --> 00:15:07.110
Renee Hlozek: A couple of years ago. And it's a really terrifying video. It did load for three terrifying to watch and these are smaller and slightly cheaper experiments, then you would

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00:15:07.770 --> 00:15:14.550
Renee Hlozek: Cost to put something in space allow you to make us shorter measurements, but potentially more frequently than you would have space mission.

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00:15:16.260 --> 00:15:25.680
Renee Hlozek: And so the the slide from Jeff Philippine he sort of summarizes why ballooning from the Arctic is is useful, particularly as a pathfinder to

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00:15:26.340 --> 00:15:29.130
Renee Hlozek: Either telescope orbital missions that come later on.

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00:15:29.730 --> 00:15:39.300
Renee Hlozek: Okay, so there are lots of experiments. I'm not going to go through all of them, and particularly focused on both the, the large scale so small patches of the sky.

102
00:15:39.570 --> 00:15:48.690
Renee Hlozek: That are measured very deeply to measure be modes and then large aperture telescopes like Act and the SPT that are measuring the small scale features of the cosmic microwave background.

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00:15:49.680 --> 00:15:57.060
Renee Hlozek: And the other thing is that people are still excited about physics beyond the standard model. So as we look to forecast you and

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00:15:57.780 --> 00:16:05.940
Renee Hlozek: The constraints from new surveys, you can start to say, well, what if we, what if we use the fact that for grounds are complicated, and we actually try and learn something about

105
00:16:07.170 --> 00:16:22.740
Renee Hlozek: The properties of different kinds of synchrotron sources in in the galaxy or if we can actually learn something about the modified black body of the demo. Is it affects can we learn something new about physics using the the constraining potential of these new experiments.

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00:16:23.940 --> 00:16:28.350
Renee Hlozek: So, so that's that's what's happened in 10 years and the CB

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00:16:28.710 --> 00:16:40.140
Renee Hlozek: And now we're at 2020 and it's useful to take take stock of where we are. I think one of the things that has come up significantly in the last few years. And in fact, you're just hot off the presses. You've just listened to.

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00:16:40.440 --> 00:16:46.770
Renee Hlozek: An amazing tool by Adam about some of these tensions, right. So we have tensions that have come up in our cosmological

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00:16:47.430 --> 00:16:57.330
Renee Hlozek: Measurements. You know, July 20 2013 and there was a discussion of tensions, there was a my own telescope released some x data which had

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00:16:57.930 --> 00:17:11.220
Renee Hlozek: something to say about tensions and as as recently as the 17th of August micro of anonymous anomalies suggested to be the case at all. The explanation explained by your quantum gravity and

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00:17:11.880 --> 00:17:19.770
Renee Hlozek: Other people saying, well, is the Hubble tension really actually a temperature. Temperature tension and this stuff is exciting and it brings into

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00:17:21.120 --> 00:17:30.300
Renee Hlozek: Focus. I think one of the key challenges right now is how do we move forward in in the next decade. And what do we pay attention to.

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00:17:30.900 --> 00:17:49.560
Renee Hlozek: Now I think this slide is from Aaron redmond's talk from earlier in the meeting. And it's worth repeating that the tensions while sometimes tensions are presented in H naught. There are some interesting tensions in a range of different data sets at in a range of different

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00:17:51.210 --> 00:17:58.920
Renee Hlozek: Kind of areas of cosmology and it's worthwhile looking at them. I think both separately and also holistically to try and understand that.

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00:18:00.960 --> 00:18:09.270
Renee Hlozek: This is the work that I just referenced earlier that where where I add a comma cosmology telescope kind of uses independent data to start

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00:18:11.610 --> 00:18:17.280
Renee Hlozek: Exploring tensions with other data sets and to see if we can make a little bit of sense of those measurements.

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00:18:18.030 --> 00:18:34.230
Renee Hlozek: Now that's not only the case in cosmology tensions and you have a talk by God. Cooley earlier in the meeting talking about tensions in doc meta detection, there are, you know, I just stole this slide, slide from the talk, but of course the diamond Libra.

118
00:18:35.310 --> 00:18:36.450
Renee Hlozek: The first detection of

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00:18:38.340 --> 00:18:43.590
Renee Hlozek: Modulation in the signal from web happened when I was doing my PhD and there's been a lot of back and forth.

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00:18:44.040 --> 00:18:50.160
Renee Hlozek: And discussing you know whether or not it's there and and how folks understand the discrimination of the background and the signal.

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00:18:50.460 --> 00:18:58.530
Renee Hlozek: And how robust city is to independent analysis. And I don't think tensions are bad if unless they unless we just remain siloed.

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00:18:59.010 --> 00:19:07.920
Renee Hlozek: And don't kind of move forward. However, if we use it as an opportunity to really start asking questions of ourselves and others, we can get to a lot of new physics and

123
00:19:09.060 --> 00:19:24.000
Renee Hlozek: Now if you want to find attention, you need to you need to discuss and quantify when two datasets and how to do those sorts of our intention and a lot of folks have been paying attention to this recently. You have folks like now McLaren looking at

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00:19:25.890 --> 00:19:34.800
Renee Hlozek: In the, the volume space of parameter space. How we quantify attentions people like Steven Feeney have developed metrics other folks like

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00:19:36.450 --> 00:19:46.200
Renee Hlozek: Stuff that you're talking in Texas, have their own consistency measures and this is is useful to look through how people quantify tension between experiments and

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00:19:46.920 --> 00:19:52.470
Renee Hlozek: I want to take a slightly different tactic and say, well, now that you've quantified it in whatever method you choose.

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00:19:52.770 --> 00:20:04.140
Renee Hlozek: How do we address tensions, how do we actually move forward in general in cosmology, because I think one of the things, potentially when when when is an early Student You're either just presented with a lot of these things and

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00:20:05.280 --> 00:20:10.650
Renee Hlozek: You they're taking a step factor given or if you feel kind of stuck or confused. And so it's

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00:20:10.950 --> 00:20:20.820
Renee Hlozek: It's, it's interesting to figure out how we might address these now I defined for things that I think we all do, and some to a greater or lesser degree, and I've tried to find examples of that.

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00:20:21.510 --> 00:20:28.080
Renee Hlozek: But I'd be very interested to hear in the question session if folks have other other things they want to raise. Okay.

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00:20:28.680 --> 00:20:37.470
Renee Hlozek: So the first thing that you can do is you can refine your systematics so that would just sort of purple bar, you can realize that your error bars needed

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00:20:38.220 --> 00:20:47.490
Renee Hlozek: Changing where you needed to cut up a certain number of data or you realize that there. You have to refine your analysis technique and that happens all the time. And I think that that's

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00:20:47.940 --> 00:20:57.480
Renee Hlozek: Often, the first thing that any group will try to do because, as scientists with our integrity. We always want to be making our analysis more complete and more extensive

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00:20:58.950 --> 00:21:06.000
Renee Hlozek: And another thing to do is really analyze someone else's data. So this is an example that's just close to home because it was work that I did.

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00:21:06.630 --> 00:21:12.060
Renee Hlozek: But when the plank. When you first release of the plank data came out in 2013 so it was only

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00:21:12.930 --> 00:21:23.340
Renee Hlozek: A few years of their data and we decided to look at that we noticed a few anomalies in some of the noticed some of the systematic tests that were presented by the team.

137
00:21:23.730 --> 00:21:32.700
Renee Hlozek: And they seemed to have failed a couple of those tests. And so we decided to use the data. It's worth saying that the data were made public. And because this is a

138
00:21:33.030 --> 00:21:39.900
Renee Hlozek: An ISA funded mission. So the day, it had to be public. And so we downloaded the maps and started doing redoing the analysis.

139
00:21:40.530 --> 00:21:48.960
Renee Hlozek: And potentially looking for contamination by four grams. And what we found was that there was actually some inconsistencies in the data themselves. So if you looked at the

140
00:21:49.620 --> 00:21:58.050
Renee Hlozek: Spectra that you could take from individual frequency channels. They didn't seem to be consistent with themselves which with each other, which they should be

141
00:21:58.410 --> 00:22:05.370

Renee Hlozek: So we redid the analysis and we presented this and we said that some of these failure modes disappeared in the analysis now.

142
00:22:06.360 --> 00:22:17.790
Renee Hlozek: This is not common to us, of course we analysis happens all the time. This is a recently analysis that I really like. And so one of the tensions that I described a little bit earlier was attention in the

143
00:22:18.240 --> 00:22:30.810
Renee Hlozek: The lending and particularly this an essay, which is sort of a combination of the meta density and the clustering of meta that I spoke about before, and various groups get various different answers. And so the the goal of this

144
00:22:31.830 --> 00:22:41.610
Renee Hlozek: group of scientists that had representation and all of these different collaborations was to develop a common software analysis package and then re analyze all of the data sets.

145
00:22:42.450 --> 00:22:45.360
Renee Hlozek: Together to try it individually and together to see if any of

146
00:22:45.960 --> 00:22:56.100
Renee Hlozek: The constraints moved and this was a great effort because it meant that people had to start talking about their data and their analysis choices and and the results are interesting. Some of the

147
00:22:56.670 --> 00:23:05.550
Renee Hlozek: Individual constraints moved, which you can see if you compare the gray, which is the published results to the color which is the real analysis in in this framework.

148
00:23:06.180 --> 00:23:18.810
Renee Hlozek: And of course, the point of this wasn't just to, to, to, you know, throw throw shade at someone else but was to say, can we actually agree on some analysis choices and then move forward with new data from something like I was t the

149
00:23:19.590 --> 00:23:24.780
Renee Hlozek: Legacy survey of space and time on the Rubin Observatory moving forward. Okay, so you can redo that analysis.

150
00:23:25.530 --> 00:23:36.240

Renee Hlozek: And the other thing that you can do is, you know, you can really analyze your, your kind of the modeling that you do. So Tracy selected give a really interesting talk about looking for and

151
00:23:37.590 --> 00:23:48.570
Renee Hlozek: Don't matter knowledge and signals and how a lot of that really depends on how you understand it the template of the galaxy and how you end the objects in it as well. And so it's worth. It's worth repeating that, you know, even as

152
00:23:49.020 --> 00:23:55.470
Renee Hlozek: You get more data and the techniques of analysis can change and it can have a really big impact on the final.

153
00:23:56.580 --> 00:23:58.110
Renee Hlozek: parameters that you get out of your model.

154
00:23:59.310 --> 00:24:04.260
Renee Hlozek: And as to come back to the plank results. So we published this

155
00:24:05.370 --> 00:24:14.010
Renee Hlozek: Comment that the analysis of the data. And of course, one way that you dress tensions is by taking more days the plank team took more data. And in fact, the

156
00:24:15.180 --> 00:24:19.110
Renee Hlozek: Systematic effects went away and I published a sort of response to our

157
00:24:19.980 --> 00:24:24.240
Renee Hlozek: They figured out what it was in our analysis. What it wasn't the data that was causing this.

158
00:24:24.540 --> 00:24:29.100
Renee Hlozek: And and in fact it wasn't that it was foreground, meaning that they had published a slightly different data combination

159
00:24:29.400 --> 00:24:40.530
Renee Hlozek: Than that they had used internally and that uncovered some of this. And so that's useful that interplay between collaborations and an external people looking at data, I think is really important and

160
00:24:41.490 --> 00:24:49.140

Renee Hlozek: Again, Daniel Holtz spoke to you about constraining cosmology with gravitational waves. And this is the kind of

161
00:24:50.280 --> 00:24:54.600
Renee Hlozek: Measurement where we know we will get more data. And so a lot of the

162
00:24:55.920 --> 00:25:10.080
Renee Hlozek: The ability of new models and new techniques to come down on the evaluation or since that's something a lot of people are focused on right now depends on on what data. So you can prepare yourself, knowing that the data comes, this is really exciting stuff to keep focused on

163
00:25:11.820 --> 00:25:25.380
Renee Hlozek: And finally, you can change your cosmology. Now this is something that when you choose to change your cosmology, of course, depends on your own and how conservative, you are as a scientist. And if you think actually

164
00:25:26.070 --> 00:25:35.130
Renee Hlozek: Your things are more likely to be systematic dominated or cosmology dominated, but it's worth repeating that you know you should, as a, as a young

165
00:25:35.730 --> 00:25:41.220
Renee Hlozek: Theorist and experimentalists you should be open to thinking of new advances in, in theory,

166
00:25:41.700 --> 00:25:46.710
Renee Hlozek: To try and address some of these issues. Obviously, they have to satisfy Occam's razor and and and all of that, but

167
00:25:47.130 --> 00:25:55.980
Renee Hlozek: It's exciting. This example that I show here is a paper by for the villain and others, and where they tried to address the Hubble tension by saying, Well, what if we actually had

168
00:25:56.760 --> 00:26:06.210
Renee Hlozek: A kind of accion effective field, Doc, Doc. Energy model that had this reasonably complicated potential that allows you to get a non negligible early dark energy component

169
00:26:06.480 --> 00:26:23.070

Renee Hlozek: So that you can essentially fix the original problem that we see today that they're they're sort of to Edge nodes, rather than just one. And so that's really important and forms, you know, part of this this Compendium similarly Tim tapes had a really interesting talk about

170
00:26:24.330 --> 00:26:38.580
Renee Hlozek: Understanding doc meta and the kind of the theory space. And again, you know, this is, it's important that as we combine data from accelerators from indirect detection and from cosmology.

171
00:26:39.630 --> 00:26:48.810
Renee Hlozek: being flexible in theory, space is really important as we build things together because it doesn't work unless you have the interplay between theory and

172
00:26:50.370 --> 00:26:56.370
Renee Hlozek: And observations and I would encourage you as much as you can. And I think this this meeting has done a really good job.

173
00:26:56.670 --> 00:27:04.020
Renee Hlozek: Of allowing you to be well versed in the language of all of these different fields because the more you can speak the language of your colleagues.

174
00:27:04.260 --> 00:27:12.540
Renee Hlozek: And in particle physics and your colleagues and cosmology and your colleagues and astrophysics. The, the better handle we have on on all of these different processes.

175
00:27:13.770 --> 00:27:21.060
Renee Hlozek: So what's coming next, I'm very excited about the the future. We have a really wide range of observations.

176
00:27:21.390 --> 00:27:35.430
Renee Hlozek: At least on the cosmology side. And I know that there are lots of advances happening in the political side as well. And one of the first things to notice that we have a there's a space mission coming up, called the Nancy Grace Roman space telescope which will be

177
00:27:37.230 --> 00:27:47.790
Renee Hlozek: complimentary to some of the other space missions that we've had. It's sort of a Hubble telescope. However, it's infrared and and it has a much larger, larger field of view now.

178
00:27:48.660 --> 00:27:53.970

Renee Hlozek: The Roman space telescope will not only studying exoplanets, which is one of the things that was designed to do, but also measure

179
00:27:54.360 --> 00:28:09.600
Renee Hlozek: And type when a supernova, the infrared. So you're building a good a pristine sample and you can do dark energy studies and also will measure we cleansing and share and magnification of galaxies as well. So constrain the clustering in that way that that's so critical crucial.

180
00:28:11.370 --> 00:28:12.480
Renee Hlozek: To actually see the

181
00:28:13.740 --> 00:28:15.630
Renee Hlozek: The tomography of the customer that with time.

182
00:28:17.190 --> 00:28:22.200
Renee Hlozek: And I'm going to hopefully this will play. So this is a video made by the Roman folks.

183
00:28:22.680 --> 00:28:30.810
Renee Hlozek: At at NASA. And also, I just wanted to show. I'm not interested in coronagraph science myself because that's an exoplanet technique, but this just shows

184
00:28:31.440 --> 00:28:38.460
Renee Hlozek: The technique of how using a coronagraph will allow us to find planets around other stars. And I thought that that's just stupid need

185
00:28:38.790 --> 00:28:53.370
Renee Hlozek: To also remind ourselves that and even as a cosmologists. There's a lot of really interesting science happening and I think keeping abreast of those she's is really important. So the current of awful allow us to do really pristine imaging of exoplanets, which is way.

186
00:28:55.770 --> 00:29:02.190
Renee Hlozek: Sphere X is also measuring is going to measure large scale structure and, particularly, it's

187
00:29:03.750 --> 00:29:06.060
Renee Hlozek: Going to be measuring the very fine.

188
00:29:08.340 --> 00:29:18.120

Renee Hlozek: Defined structure of the cosmic microwave background as well as just the clustering galaxies, and this is something that's also now funded

189
00:29:18.570 --> 00:29:24.150
Renee Hlozek: by NASA and will allow a lot of cross correlation science. The benefit of having multiple probes.

190
00:29:24.570 --> 00:29:31.080
Renee Hlozek: And probing different time periods in cosmology is it allows you to learn something about

191
00:29:31.350 --> 00:29:42.840
Renee Hlozek: The evolution with time of the various components because we know that they're coming from slightly different periods in time. And so if you do a cross correlation analysis spatially and you figure out what is common between those different

192
00:29:43.620 --> 00:29:50.220
Renee Hlozek: Sources of light you can build out that picture of how things are changing time to spirit is proving to be very exciting to

193
00:29:50.940 --> 00:30:04.050
Renee Hlozek: From the ground. I'm involved in assignments Observatory and telescope. So I mentioned that I was worked on the Atacama cosmology telescope as a PhD student, you can see act is the thing that looks like a little ice cream cone.

194
00:30:05.130 --> 00:30:09.420
Renee Hlozek: And it's actually the ground shield of a big telescope that's measuring

195
00:30:11.160 --> 00:30:19.230
Renee Hlozek: Light from the big bang at around 2.7 Calvin, but of course it's cool down to nano Calvin to a lot certainly Calvin to allow you to actually measure

196
00:30:19.530 --> 00:30:28.830
Renee Hlozek: And the fluctuations in temperature and polarization of the CB and that ground shield is there because the ground itself is making so much radiation that we have to protect the telescope

197
00:30:29.520 --> 00:30:42.720
Renee Hlozek: Act is this this plateau is very high. It's over 17,000 feet, which means you have a really pristine sky with not a lot of

atmosphere to look through because in the microwave. That's one of the biggest problems.

198
00:30:43.470 --> 00:30:52.860
Renee Hlozek: The Simon's Observatory will look at two different pots sort of two different surveys of the sky. Remember in the beginning of this talk, I talked about how

199
00:30:53.340 --> 00:31:03.630
Renee Hlozek: We want to measure a small area very deeply to get to the large and large scale be modes. So this is to measure the temperature scale ratio to constrain inflation.

200
00:31:03.900 --> 00:31:14.910
Renee Hlozek: And so we have a small survey which will do exactly that and overlap with some of the other experiments I talked about like spider and bicep and kick and then it will have a large aperture survey. So a large

201
00:31:16.020 --> 00:31:25.200
Renee Hlozek: About 40% of the sky maximally overlapping with some of the optical surveys that are coming online, including Alice's tea and and the dark energy.

202
00:31:25.590 --> 00:31:30.330
Renee Hlozek: And spectroscopic instrument or Daisy and this again is crucial because it allows us to say, well,

203
00:31:30.720 --> 00:31:39.930
Renee Hlozek: If at a certain point in the skies their gods today. What is the flux of that galaxy. What this end doing what's the lending doing until you can build up this constraint on on cosmology that way.

204
00:31:40.770 --> 00:31:49.680
Renee Hlozek: And just because tables are important, and I think this sort of links us to the stuff we've been talking about before. These are some of the baseline numbers that we expect

205
00:31:51.600 --> 00:32:02.850
Renee Hlozek: To to have on some key parameters, including the neutrino mass where we hope to get to around point for an EV, and also that will kind of measure the

206
00:32:04.020 --> 00:32:13.530

Renee Hlozek: Fluctuations on small scales very large K to around point 5% and so we'll be able to do really push the boundaries of a lot of our

207
00:32:14.430 --> 00:32:22.260
Renee Hlozek: Understanding of parameters and and also how they connect to particle physics through things like the relativistic species and the new tournaments.

208
00:32:23.040 --> 00:32:31.530
Renee Hlozek: And finally, because it's a Friday. And I want to play you and this is a promotional video for the public actually still find it pretty exciting moving

209
00:32:32.100 --> 00:32:42.330
Renee Hlozek: But one of the big advances that's coming from the ground is going to be from the Verizon Observatory. So the room an observatory is an optical

210
00:32:42.960 --> 00:32:53.580
Renee Hlozek: survey instrument, it will scan the sky and every few days, you know, scan the whole sky every few days and and will allow a wide range of science from

211
00:32:53.940 --> 00:33:03.090
Renee Hlozek: Solar System Science, all the way through to cosmology and I'm mainly involved in the dark energy science collaboration part of this of course slack is a huge and

212
00:33:03.870 --> 00:33:11.730
Renee Hlozek: Partner and and collaborator and in terms of the revision surgery and he has just a cool two minutes. Little promo video which I think you should show also your friends.

213
00:33:26.100 --> 00:33:26.790
Renee Hlozek: Sky.

214
00:33:28.290 --> 00:33:31.050
Renee Hlozek: Our window to the universe beyond

215
00:33:32.220 --> 00:33:32.970
Renee Hlozek: Immense

216
00:33:34.050 --> 00:33:39.510
Renee Hlozek: Mysterious powerful quietly beautiful

217
00:33:41.490 --> 00:33:49.650
Renee Hlozek: Cosmic events at the edge of our imagination unfold in the darkness, ready to be discovered.

218
00:33:54.240 --> 00:33:58.110
Renee Hlozek: When we look at the night sky. We see to the past.

219
00:33:59.220 --> 00:34:05.910
Renee Hlozek: Untold Stories carry through space. I like the great historian of the cosmos.

220
00:34:08.040 --> 00:34:14.880
Renee Hlozek: Technology has evolved over centuries, allowing us to look farther to the edge of our horizon.

221
00:34:16.200 --> 00:34:25.620
Renee Hlozek: We invented telescopes to explore and cameras to capture he's traveling messages, yet the changing Cosmos remains been seen.

222
00:34:28.200 --> 00:34:37.710
Renee Hlozek: A new telescope opens its I think captures at all the objects that who knows the class, even though we cannot see.

223
00:34:40.380 --> 00:34:45.090
Renee Hlozek: Every few nights, because the sky fighting all the history

224
00:34:46.800 --> 00:34:52.530
Renee Hlozek: Within minutes newcomers back to today are carried around here to

225
00:34:58.830 --> 00:34:59.400
Renee Hlozek: Discover

226
00:35:03.900 --> 00:35:04.470
Renee Hlozek: To find out

227
00:35:22.140 --> 00:35:22.680
Renee Hlozek: So,

228
00:35:24.420 --> 00:35:34.200

Renee Hlozek: As we look to the next decade. I wanted to suggest that you have the opportunity also to play.

229
00:35:35.580 --> 00:35:44.490
Renee Hlozek: A role or Radha to observe what's happening. So I started this talk with the summary of the decade old review from Astro

230
00:35:45.780 --> 00:35:56.010
Renee Hlozek: And I was a grad student at the time and I kind of didn't pay attention because I thought it was all over my head. And, and, of course, we're in the next decade planning right now.

231
00:35:56.580 --> 00:36:06.210
Renee Hlozek: And you actually can get involved. There are some the online nature of this planning process means that, in fact, if you go to the link in the slides.

232
00:36:06.480 --> 00:36:13.110
Renee Hlozek: And there's a webinar planned for the next for next week where some of the thinking be from all of the panels.

233
00:36:13.500 --> 00:36:17.250
Renee Hlozek: And so the way the process works is they put a call to the community to write white papers.

234
00:36:17.520 --> 00:36:28.260
Renee Hlozek: Everyone writes a bunch of white papers on both the science and also the experiments that they think are are critical for the next decade. And then the panels kind of evaluate them and decide on what the

235
00:36:28.920 --> 00:36:34.590
Renee Hlozek: Not only the scientific but also the funding priorities are for the US astronomy and so

236
00:36:35.130 --> 00:36:44.760
Renee Hlozek: I really would encourage you to to see what's going on to maybe attend the town hall and to get a real sense for what's important in astronomy and cosmology and and how that links with

237
00:36:45.300 --> 00:36:49.890
Renee Hlozek: A very similar process which is happening now in the US as well, which is the snow max.

238
00:36:50.340 --> 00:36:58.650

Renee Hlozek: Plan, which is the sort of the same thing, but more on the the the particle side. And so I'm involved in in snowmass and we're trying to get the same

239
00:36:59.130 --> 00:37:06.630
Renee Hlozek: White Papers and thinking from the community and it's really exciting time, which I didn't appreciate when I was a grad student. So I'm always encouraging people to take an active

240
00:37:06.930 --> 00:37:14.010
Renee Hlozek: Look at what's happening, because I think you'll learn a lot, particularly as you look forward to the to your next decade and how

241
00:37:14.580 --> 00:37:20.160
Renee Hlozek: The research that you'll be focusing on the things that excite you. So just to summarize, and

242
00:37:20.730 --> 00:37:32.250
Renee Hlozek: I think looking at the future. The, what is going to be important are combining data sets from work, both within field. So how can we do a robust combination of

243
00:37:33.030 --> 00:37:45.720
Renee Hlozek: Detection experiment data, how can we really understand each other. Systematics. Are there ways we can start to do consistency tests can we make the data open. Can we make our software and our technologies open

244
00:37:46.170 --> 00:37:56.100
Renee Hlozek: And also across fields and can we start to play a do a better job of connecting particle physics language and methodologies with cosmology constraints.

245
00:37:56.400 --> 00:38:09.060
Renee Hlozek: Can we understand the balance between exclusion regions and detection regions and what they start to say about our ability to constrain these models and can we do robust joint analyses and can we think of

246
00:38:09.720 --> 00:38:18.780
Renee Hlozek: You know, research projects that cut across fields, because I think that the more creative, we can be in a decent terms of data analysis, the better and and then

247
00:38:19.260 --> 00:38:23.160

Renee Hlozek: In terms of model building, you know, some people lament the fact that the low hanging fruit is gone.

248
00:38:24.150 --> 00:38:33.780
Renee Hlozek: But there are lots of new ideas and around, and we need even more, you know, what have we missed what assumptions. Do we need to overturn as we start to

249
00:38:34.260 --> 00:38:48.840
Renee Hlozek: Realize that the universe may not be simple, but it definitely isn't complicated in the first ways we thought about. So what's next, as we start to plan for that, and how can we push ourselves to do more. And what are the next, what does you know what telescopes and

250
00:38:50.430 --> 00:39:00.690
Renee Hlozek: Particle experiments are coming in the next 20 and 30 years. And how are we going to be part of planning those as we push from the observational side and an experimental side and the theory side.

251
00:39:01.440 --> 00:39:07.320
Renee Hlozek: So thank you all for listening. I hope you have a great rest of the time, and I'll take some questions now.

252
00:39:11.220 --> 00:39:12.060
thomas rizzo: Thanks so much, Renee.

253
00:39:13.080 --> 00:39:17.670
thomas rizzo: I guess we have only a couple of questions. Maybe wants to read one or two.

254
00:39:21.150 --> 00:39:21.780
Richard Partridge: Okay.

255
00:39:24.090 --> 00:39:25.800
Richard Partridge: We have a question about

256
00:39:27.030 --> 00:39:27.720
Richard Partridge: The

257
00:39:28.770 --> 00:39:39.750
Richard Partridge: Standard models in your view in experience. Do you feel like we're pushing beyond the standard model of particle physics or cosmology more now than 10 years ago.

258
00:39:42.900 --> 00:39:43.830
Renee Hlozek: Yeah, I think.

259
00:39:46.620 --> 00:40:00.480
Renee Hlozek: I think the Higgs, the LLC and and the excitement around the Higgs in 2012 which was quite a while ago now and I think that was followed by

260
00:40:01.680 --> 00:40:04.710
Renee Hlozek: Some interesting tension in the sense that

261
00:40:06.330 --> 00:40:23.910
Renee Hlozek: The model seemed to be robust, the standard model seems to be reasonably robust and so I think as we push beyond the standard model, we need to do so in kind of more, as I said, not necessarily that the symbol or the easiest way, but we have to kind of push ourselves to

262
00:40:25.080 --> 00:40:30.840
Renee Hlozek: Take care of the new ones because maybe we'd hopeful big deviations from the standard model really early.

263
00:40:31.170 --> 00:40:42.990
Renee Hlozek: And but we were so far, we haven't seen those. And so I think the. It's not that we aren't that the center model is that we should all go home, but I think it's perhaps going to take a little bit more creativity, then I'm

264
00:40:43.920 --> 00:40:48.330
Renee Hlozek: Not creatively than we've had, but it's going to, we're going to still have to be pretty creative

265
00:40:51.270 --> 00:41:09.480
Richard Partridge: Know, sort of bigger picture question here. There have been surveys, the local universe at lower read chefs. The approximately oh point one in early universe through CSV Z approximately 1000. Are there any plans surveys to scaling intermediate redshift region.

266
00:41:09.900 --> 00:41:17.130
Renee Hlozek: Yeah, that's really great question. And there are actually. So there's one. I didn't, I didn't touch on it, but that's I'm glad I got a chance to talk about it.

267
00:41:17.640 --> 00:41:31.650

Renee Hlozek: And there's a telescope have one of them that I care about is called China's the Canadian hydrogen intensity mapping experiment and and chime is a big to really cool telescope concept. Basically, it's a bunch of

268
00:41:33.330 --> 00:41:40.290
Renee Hlozek: Cylinders that have chicken wire, essentially. So it's measuring 21 centimeter radiation radio so long wavelength.

269
00:41:40.650 --> 00:41:50.160
Renee Hlozek: Radiation and they don't, they're not scalable dishes, they just sort of these troughs of cylinders of this chicken wire and they rely on the fact that the opus, turning to see the whole sky.

270
00:41:50.820 --> 00:42:01.890
Renee Hlozek: And they have very low and angular resolution so they don't measure the patterns on the kind of perpendicular to the line of sight but they had incredible and frequency resolution so they can measure

271
00:42:02.460 --> 00:42:07.920
Renee Hlozek: Sexually, or as what we think of spectral he of course is in the

272
00:42:08.550 --> 00:42:12.990
Renee Hlozek: Redshift direction and they have incredible resolution so chime will make a map.

273
00:42:13.290 --> 00:42:21.990
Renee Hlozek: Of the sky that has that very good depth and it will make it out to around around redshift of three. So from today to chapter three. And so you'll be able to

274
00:42:22.260 --> 00:42:31.890
Renee Hlozek: Measure the tomography of the dark energy, changing as a function of time using China now there are there are others of course that are doing similar things and that

275
00:42:32.280 --> 00:42:36.570
Renee Hlozek: The Sloan Digital Sky Survey, for example, just released a bunch of data about a month ago.

276
00:42:37.140 --> 00:42:48.510
Renee Hlozek: Which has pretty exquisite maps, both in the optical but also measuring quasars and using those to probe the clustering of the

universe. So there are a lot of different probes that intermediate redshift. It is quite difficult.

277
00:42:48.510 --> 00:42:49.230
Because

278
00:42:50.490 --> 00:43:06.600
Renee Hlozek: At some Richard the universe and becomes slightly less bright galaxy. So clusters match and they're harder to measure, but there are lots of different problems measuring and particularly the clustering of meta in between here and and Hi, Richard. Thanks for that question.

279
00:43:08.550 --> 00:43:11.520
Richard Partridge: Okay, we'll just do one more question here.

280
00:43:12.570 --> 00:43:15.900
Richard Partridge: Will the Roman telescope compete with the Webb telescope

281
00:43:17.850 --> 00:43:28.380
Renee Hlozek: Um, so the. That's a really good question. So James Webb and Roman are slightly different. And James Webb is a sort of higher resolution and image that that's

282
00:43:28.860 --> 00:43:37.110
Renee Hlozek: Going to measure a slightly smaller patch of sky, whereas Roman will have spectroscopic capabilities as well and then

283
00:43:37.440 --> 00:43:46.650
Renee Hlozek: Measure images. So they're not actually directly competing. They're also in different time scales, of course, James, what is about to go and Roman will be at least in the, in the next decade.

284
00:43:47.220 --> 00:43:55.650
Renee Hlozek: But they're more complimentary in terms of different kinds of songs. So James Webb, this is a very interesting experiment. If I think of the kinds of survey.

285
00:43:56.730 --> 00:44:07.560
Renee Hlozek: work that I do james webb is slightly less of a survey instrument, and then a focused study on a very high resolution images.

286
00:44:09.720 --> 00:44:11.310
Richard Partridge: Okay, thank you for your

287
00:44:12.390 --> 00:44:15.930
Richard Partridge: Help with answering some of these questions. I'm going to turn it back over to time.

288
00:44:17.040 --> 00:44:25.890
thomas rizzo: Thanks a lot, which and we want to thank you, Renee for giving a very good overview of the few possible futures. We may be hoping to see such

289
00:44:26.280 --> 00:44:46.440
thomas rizzo: Okay, so this is the end of SSI 2020 again I want to thank all the participants, I hope. Next year we hope to see at least some of you here physically at slack for SSI 2020 and stay safe and stay healthy and that's it. Bye.

290
00:44:47.910 --> 00:44:49.410
Renee Hlozek: Thanks, folks. Bye.

291
00:44:50.580 --> 00:44:50.850
grzegorz madejski: Thank you.