

# A Wrinkle In Spacetime

Connecting Gravitational Waves and Albert Einstein with Blackfoot Culture

Corey Gray

APS National Mentoring Community Conference 2020

January 7, 2020













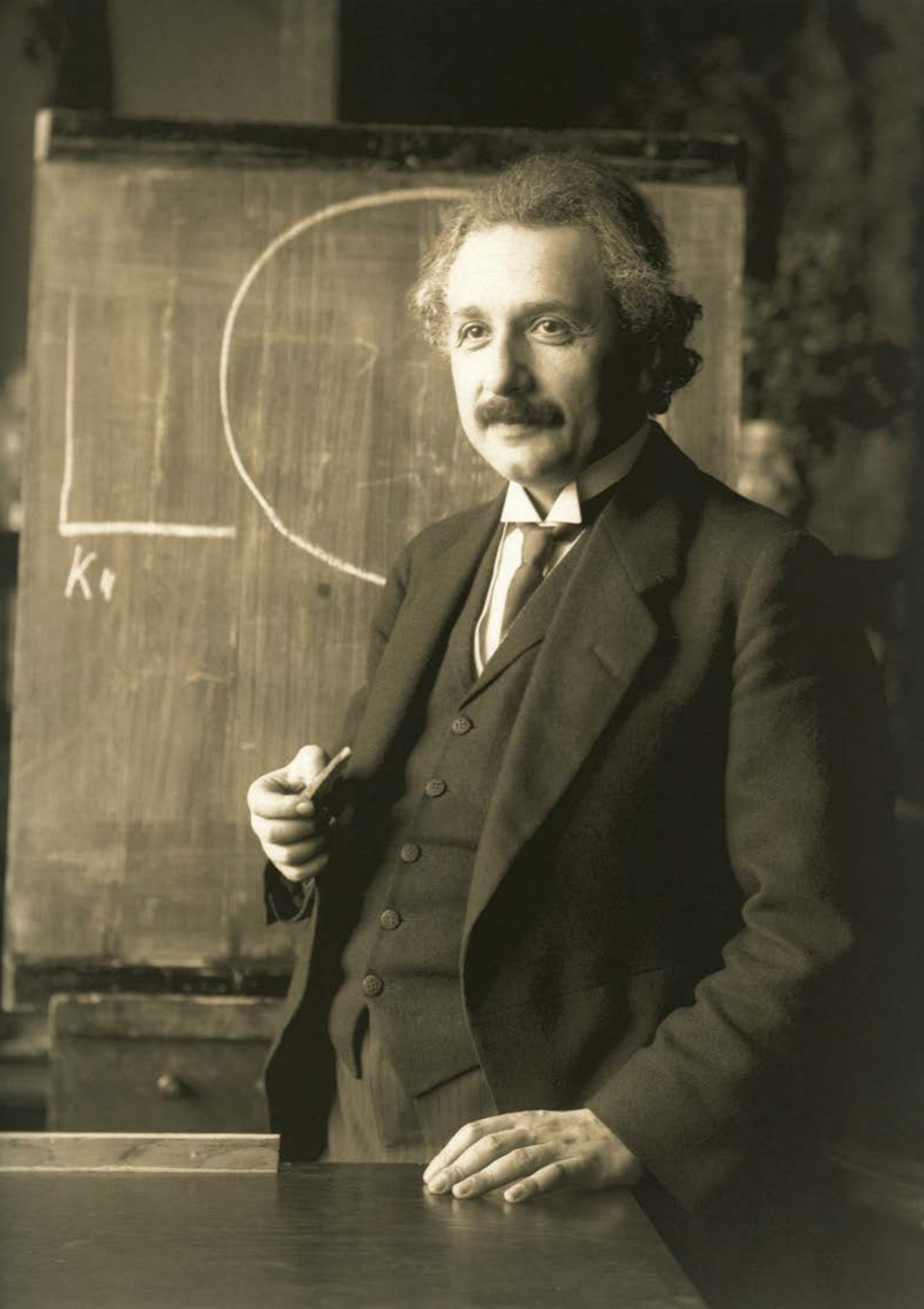


W. A. MYERS ELEMENTARY SCHOOL

Mr. Williams, Principal  
Mrs. Clemens - Grade 4

1981 - 1982





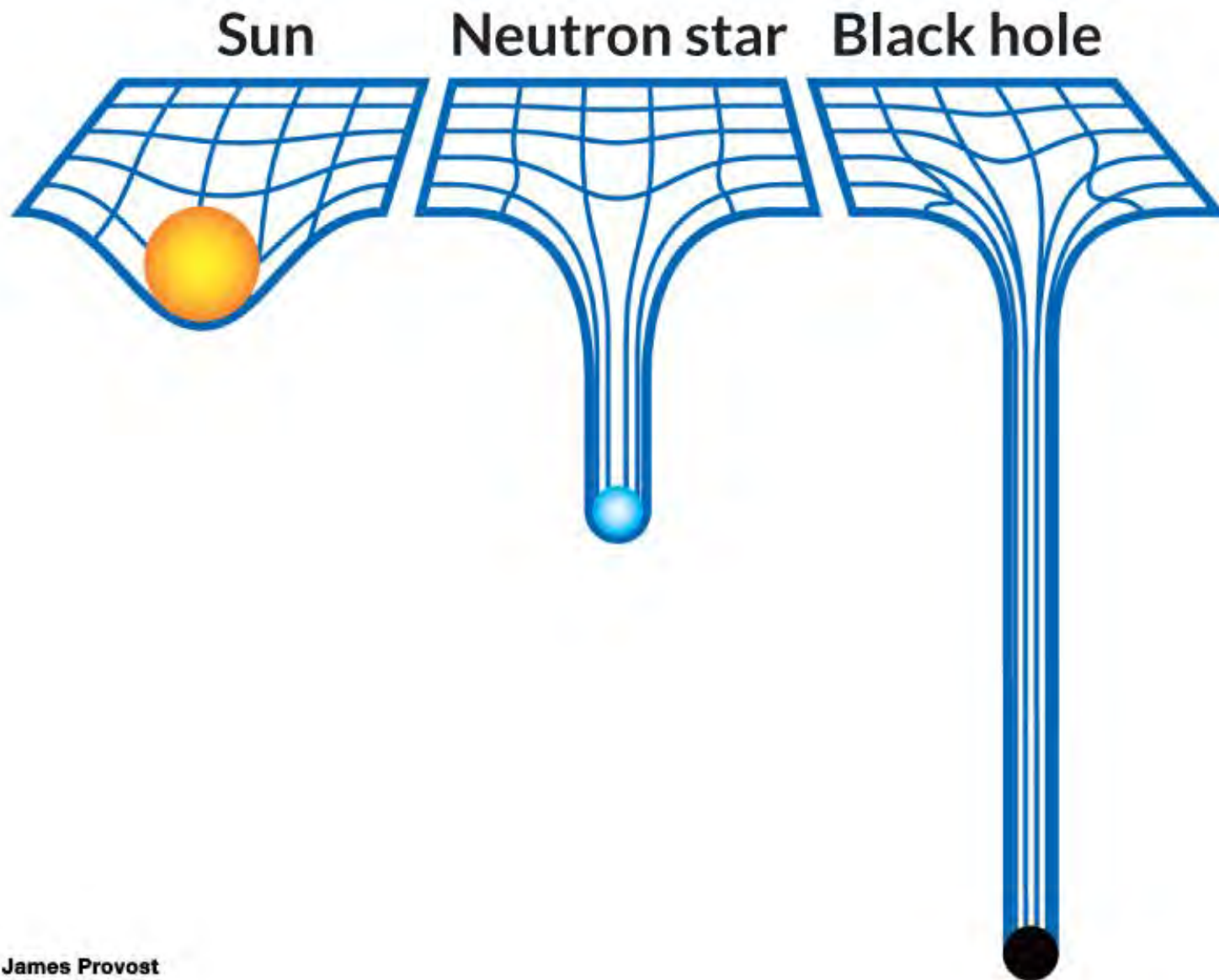
# 1915

The General  
Theory  
Of  
Relativity



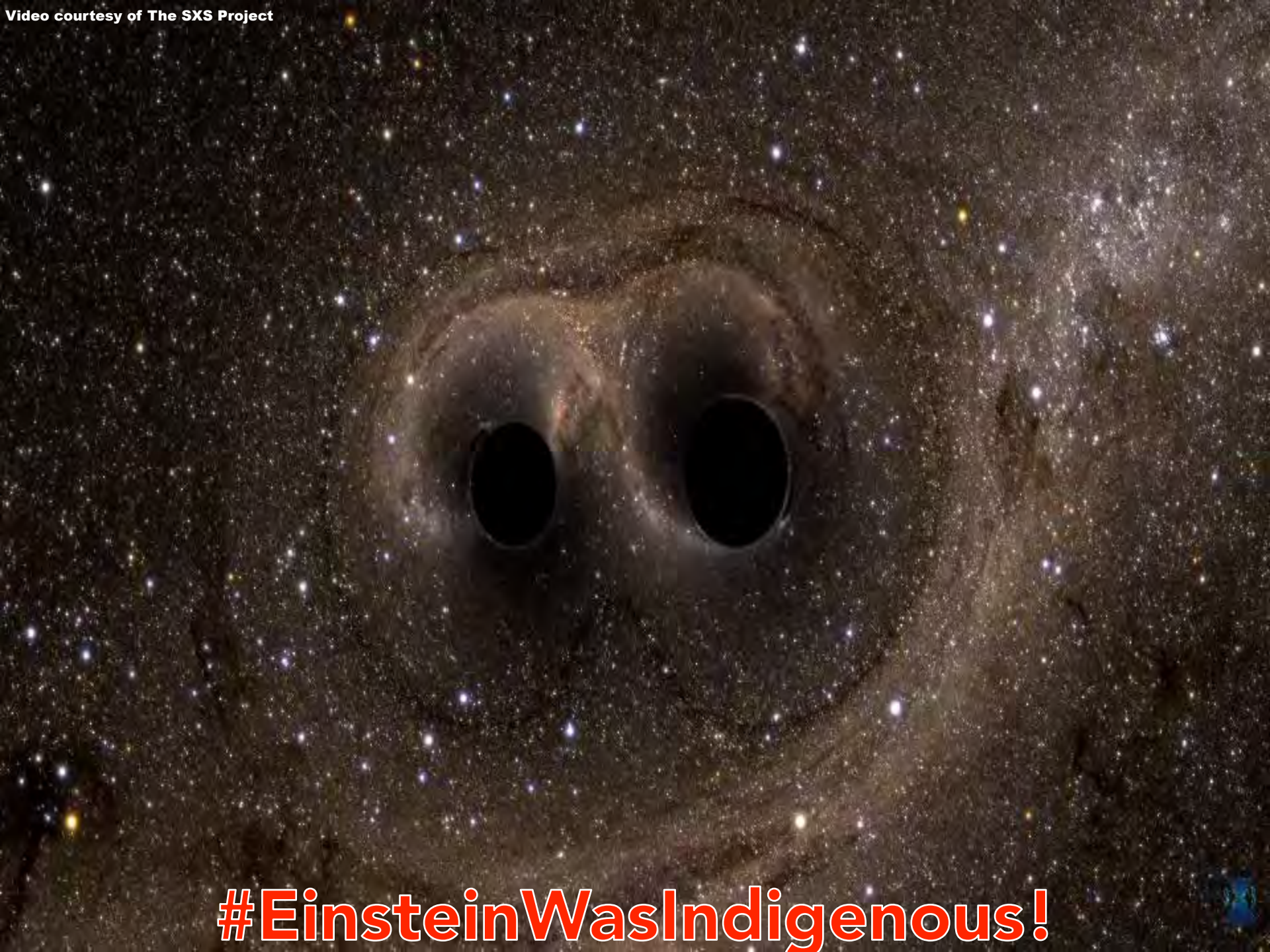
**“Matter tells space how to curve, space tells matter how to move.”**

**~ John A.Wheeler**







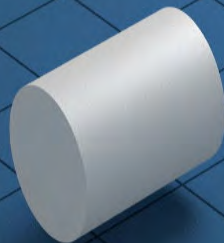


**#EinsteinWasIndigenous!**

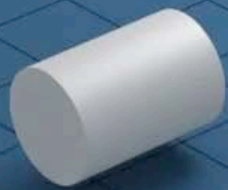


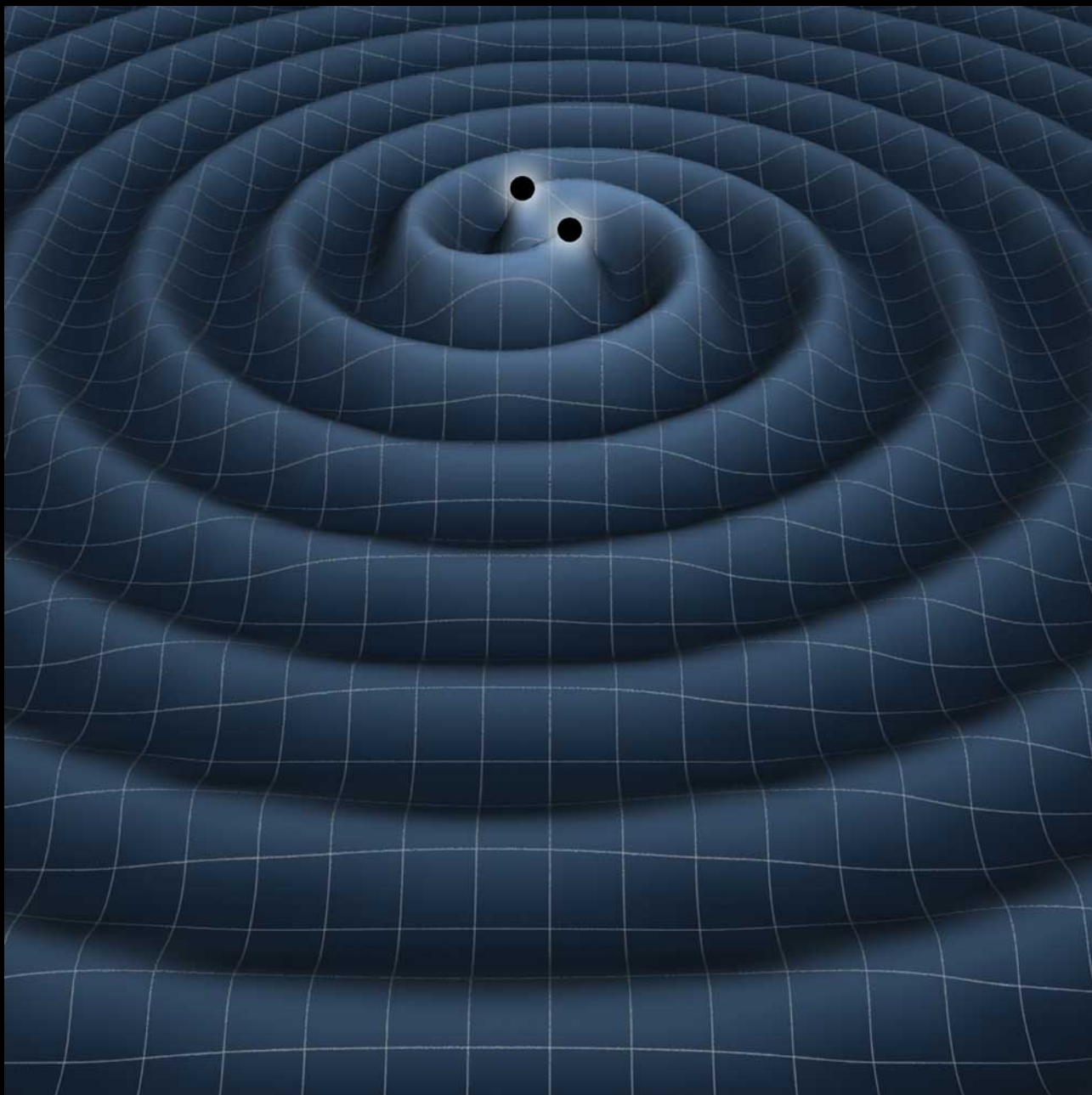
# LIGO

(Laser Interferometer Gravitational wave Observatory)









**How LIGO Observes Gravitational Waves**

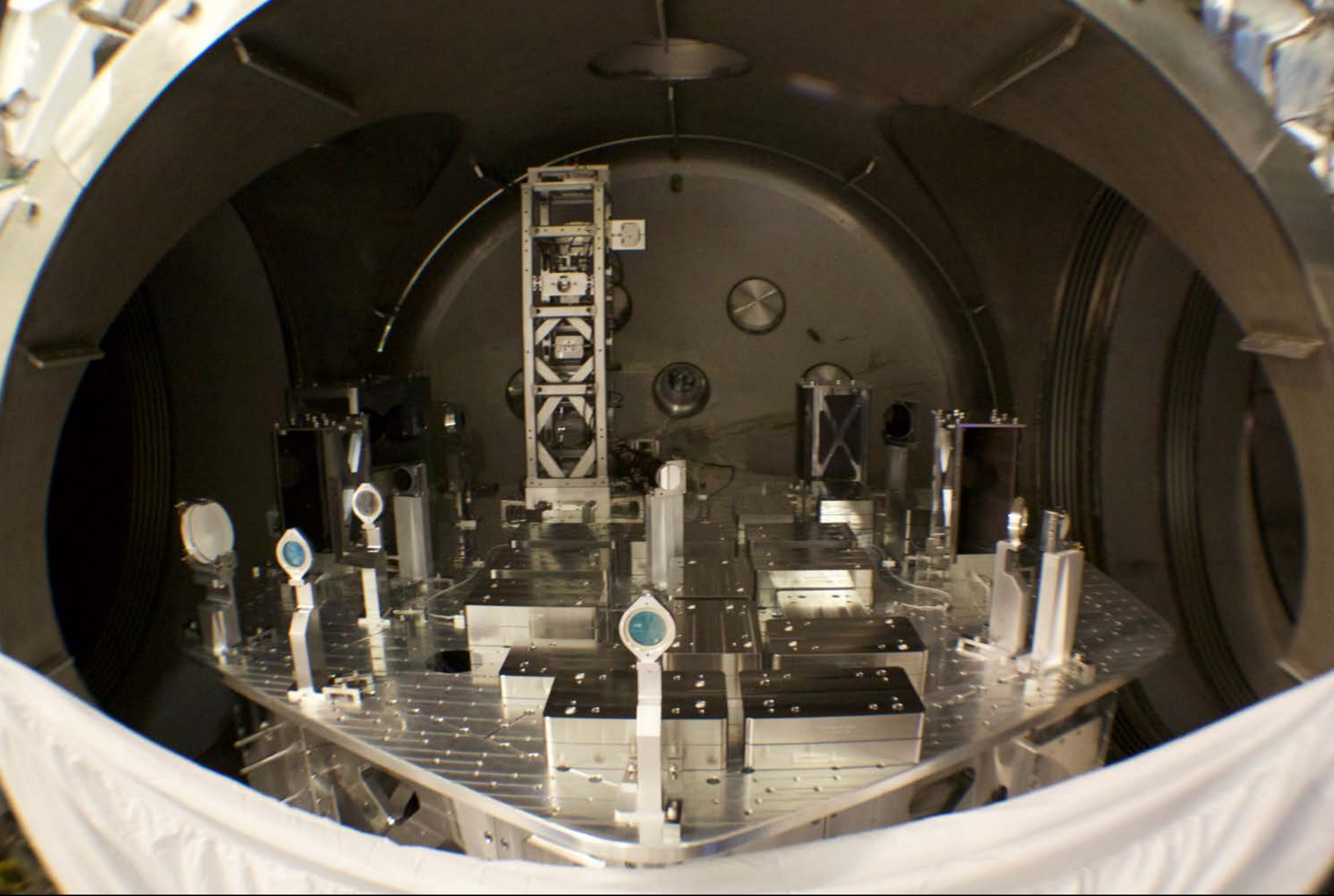




**LIGO!**

(WA state...there's another one in Louisiana)





**CLOSER LOOK AT OUR MACHINE**

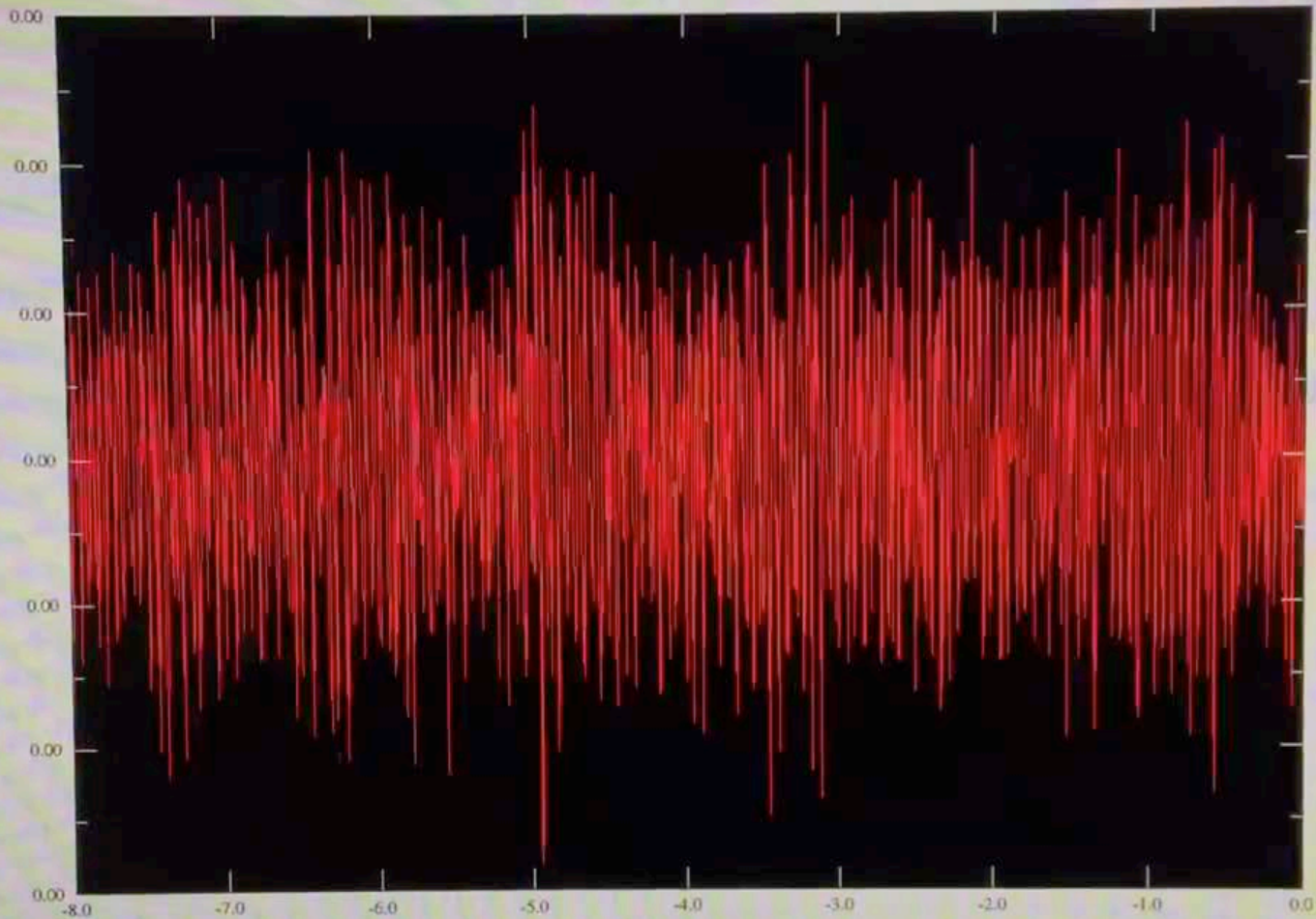


**DETECTORS**



DAQS Data Display 1 Channel at 17-03-21-12-12-45

Ch 1: H1:CAL-DELTA\_EXTERNAL\_DQ



spectra

Navigation and control buttons for the DAQS Data Display interface:

- Search (magnifying glass icon)
- Home (house icon)
- Zoom in (Z icon)
- Zoom out (Z icon)
- Previous view (left arrow icon)
- Next view (right arrow icon)
- Previous channel (down arrow icon)
- Next channel (up arrow icon)
- AutoT (Auto Tune)
- AutoO (Auto Offset)
- ZX (Zoom X)
- ZY (Zoom Y)
- AX (Axis X)
- AY (Axis Y)
- PZ (Plot Z)
- Pu (Plot U)
- Pe (Plot E)
- Cy (Cursor Y)
- SD:1 (SD Slot 1)
- CW:0 (Clockwise 0)
- Exit

spectra (

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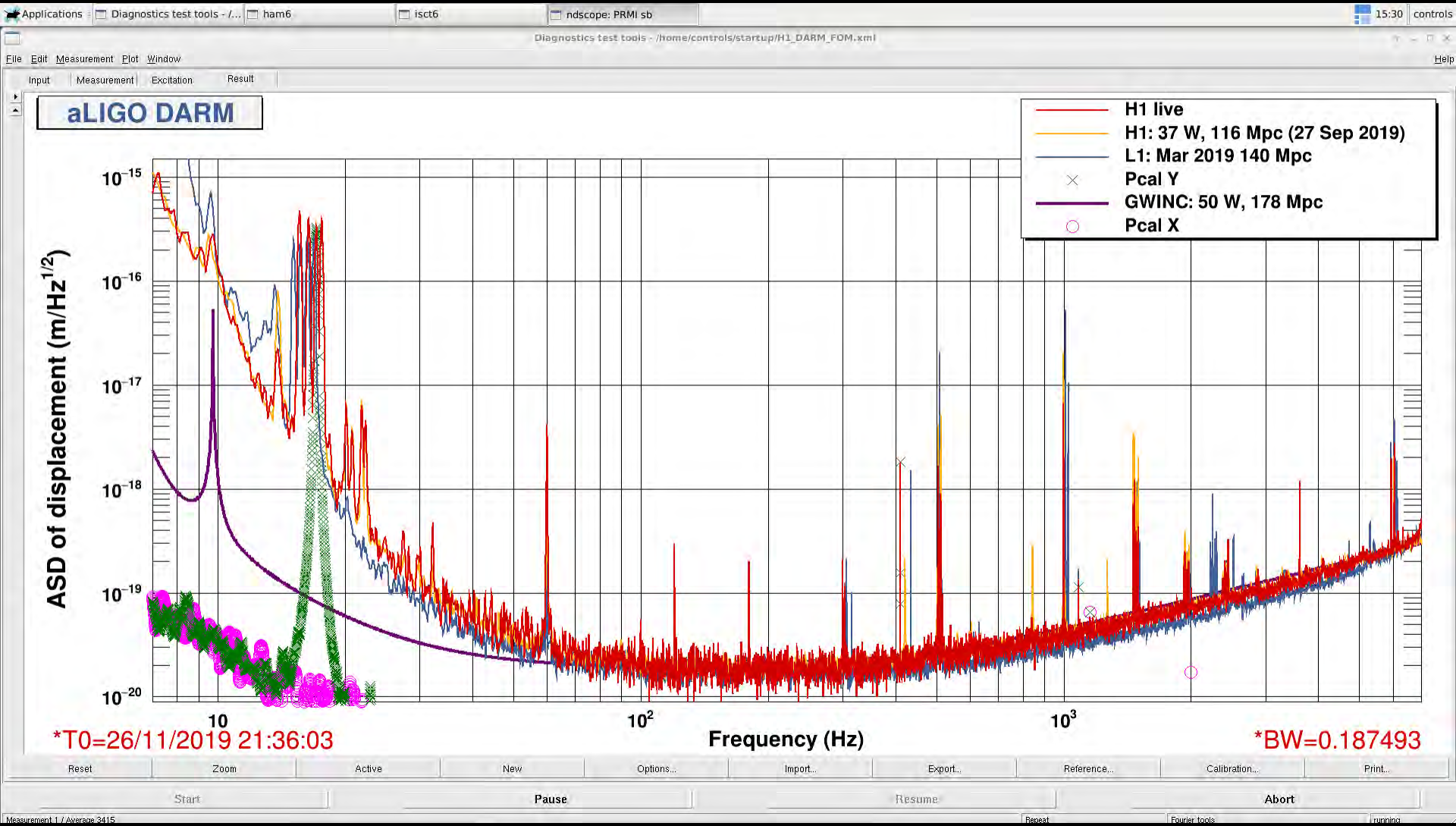
2: /home/cont

Instructio

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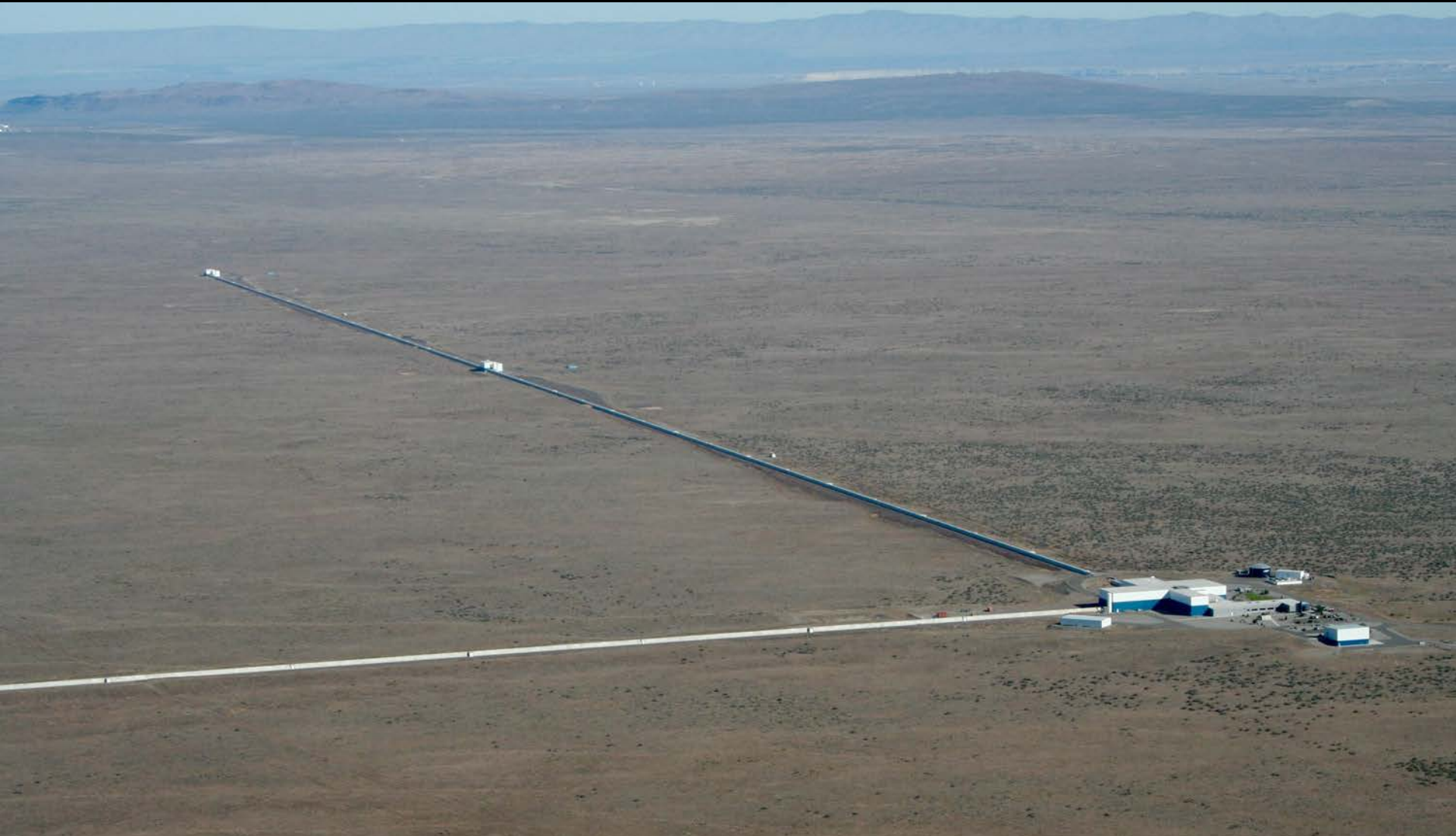






**The Light: Where Gravitational Waves Hide!**  
(turned into an electrical signal)

# A Drive Down An Arm





# Corner Station to End-X



# End-X to Corner Station





A long time ago in a galaxy far,  
far away....

# The Detection

**September 14<sup>th</sup> 2015**

**29 & 36 Solar Mass Black Hole  
Merger**

**1.3 Billion Years Ago**

2:50 AM on a Monday

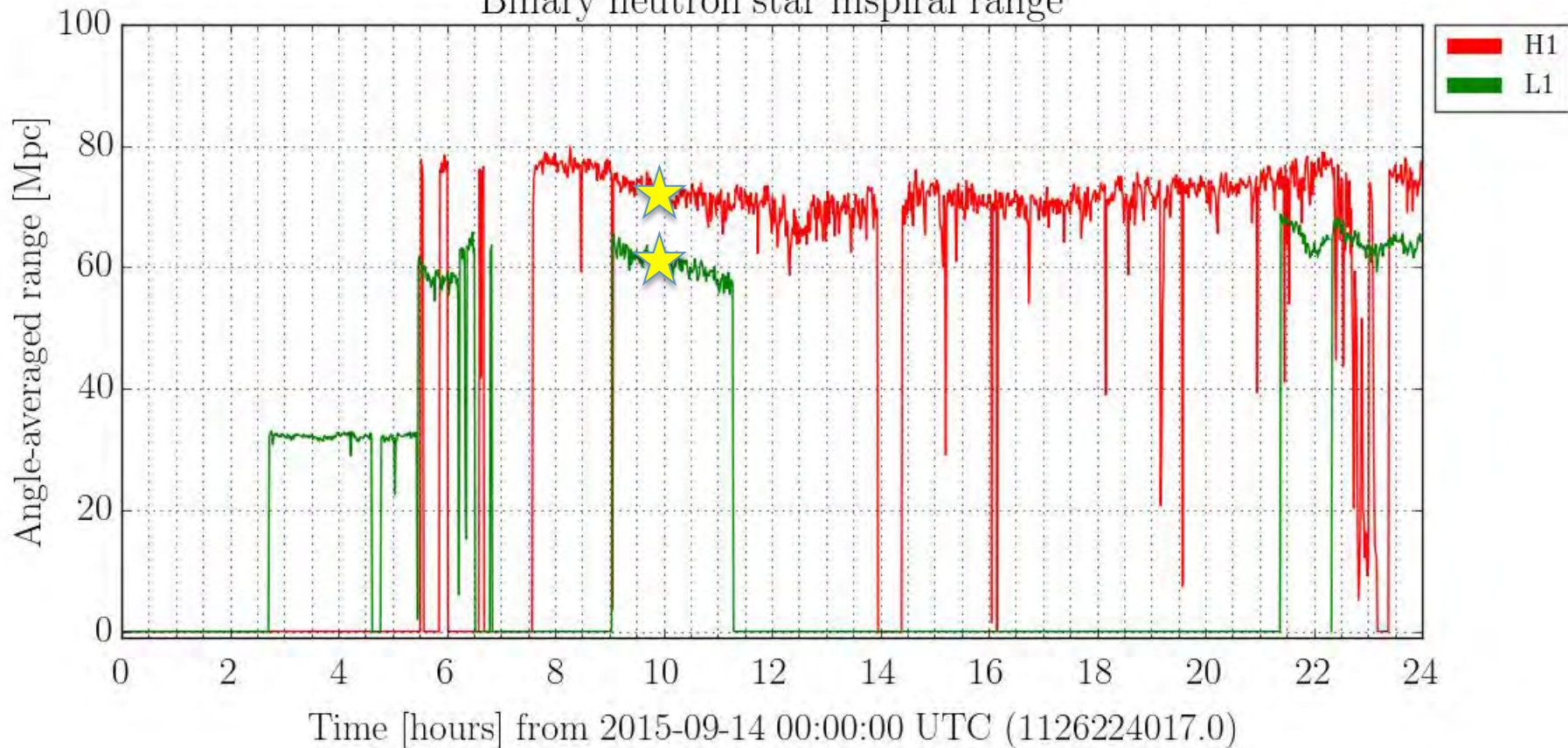


**GW150914:  
Binary  
Black Hole  
Merger**





## Binary neutron star inspiral range

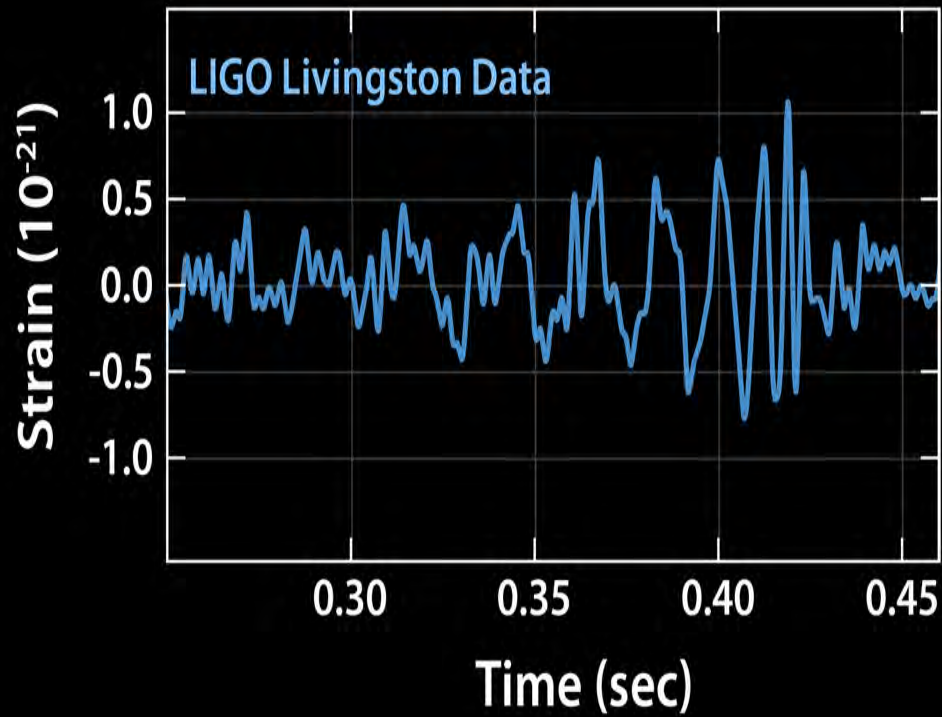


# Inspirational Range for H1 & L1

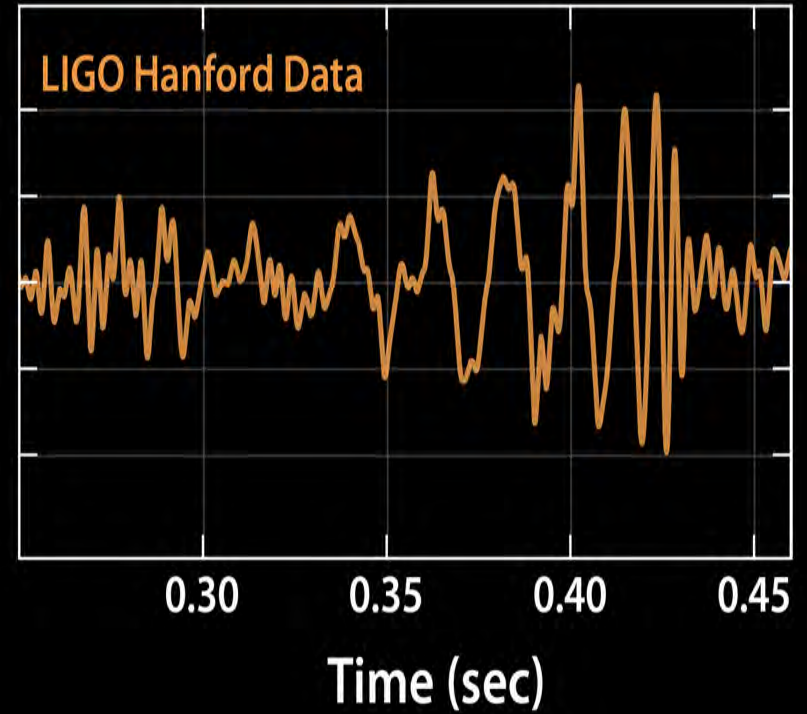
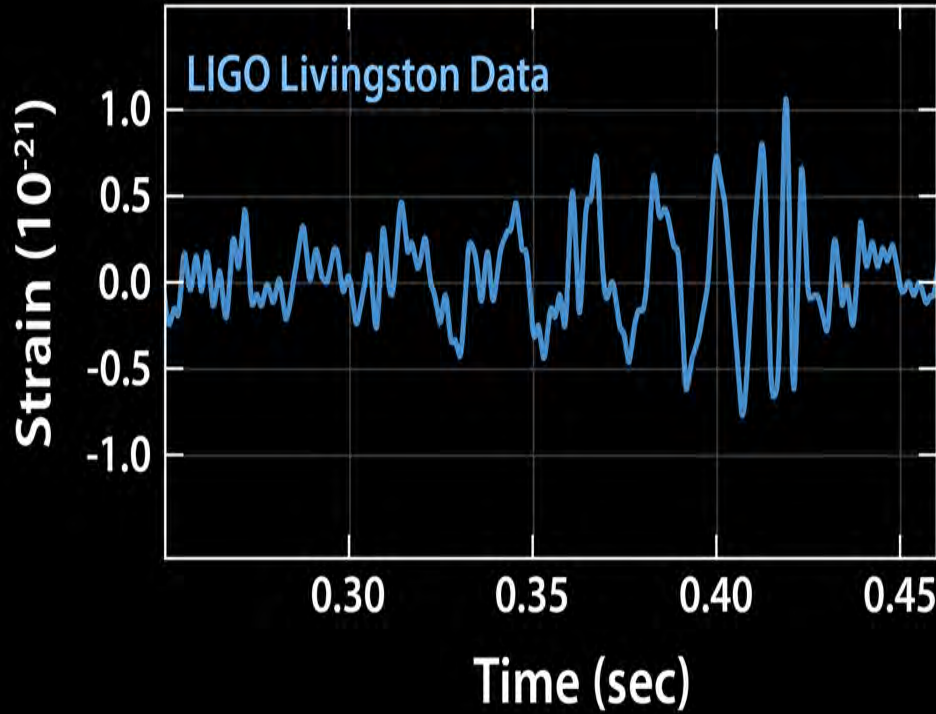
**(80 Megaparsecs = 260,000,000 light years)**



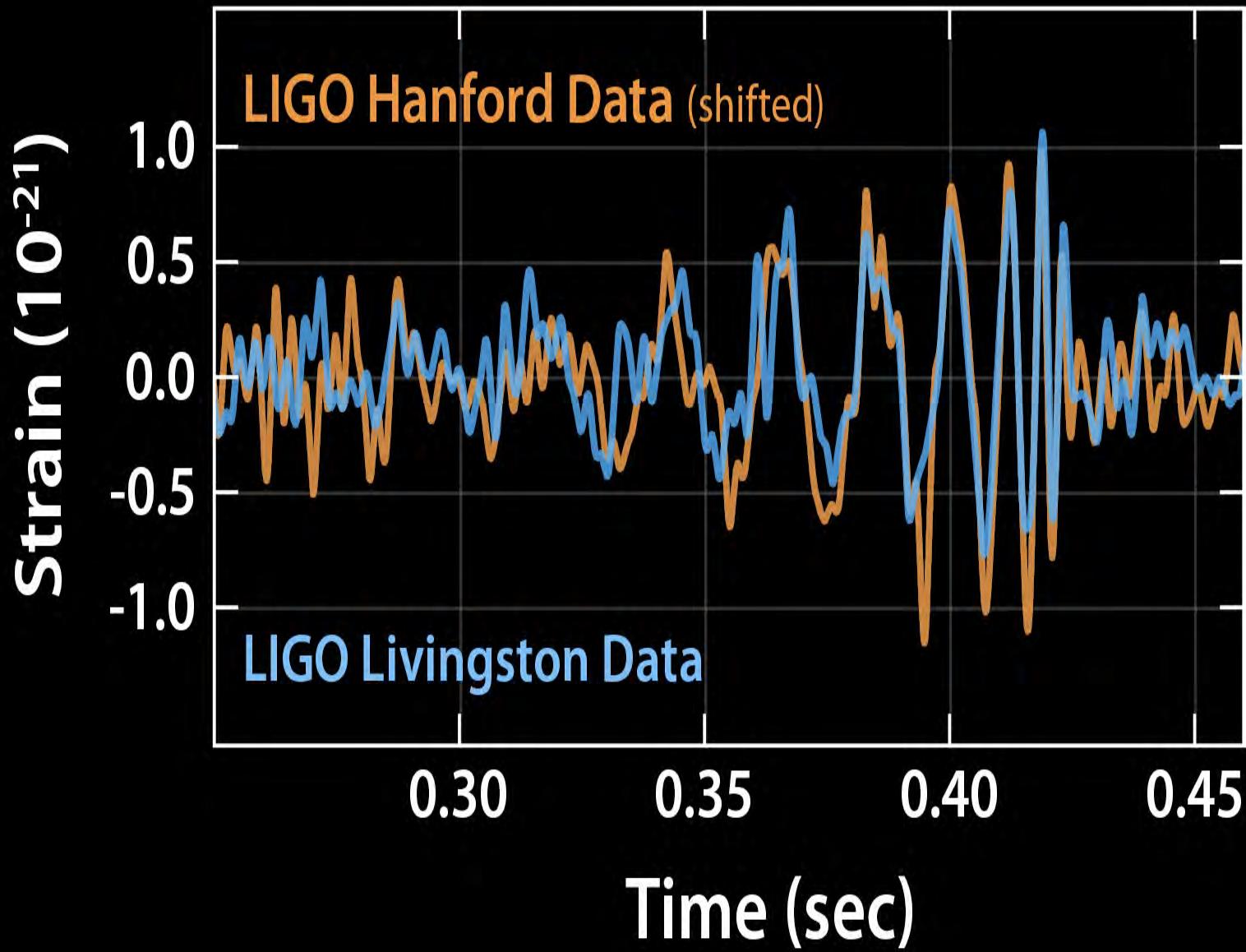
September 14<sup>th</sup> 2015



2:50 AM PST







# An Hour Later That Morning!

[detchar] Very interesting event on ER8



Inbox x

lsc x



**Marco Drago** <marco.drago@aei.mpg.de>

Sep 14, 2015, 3:55 AM



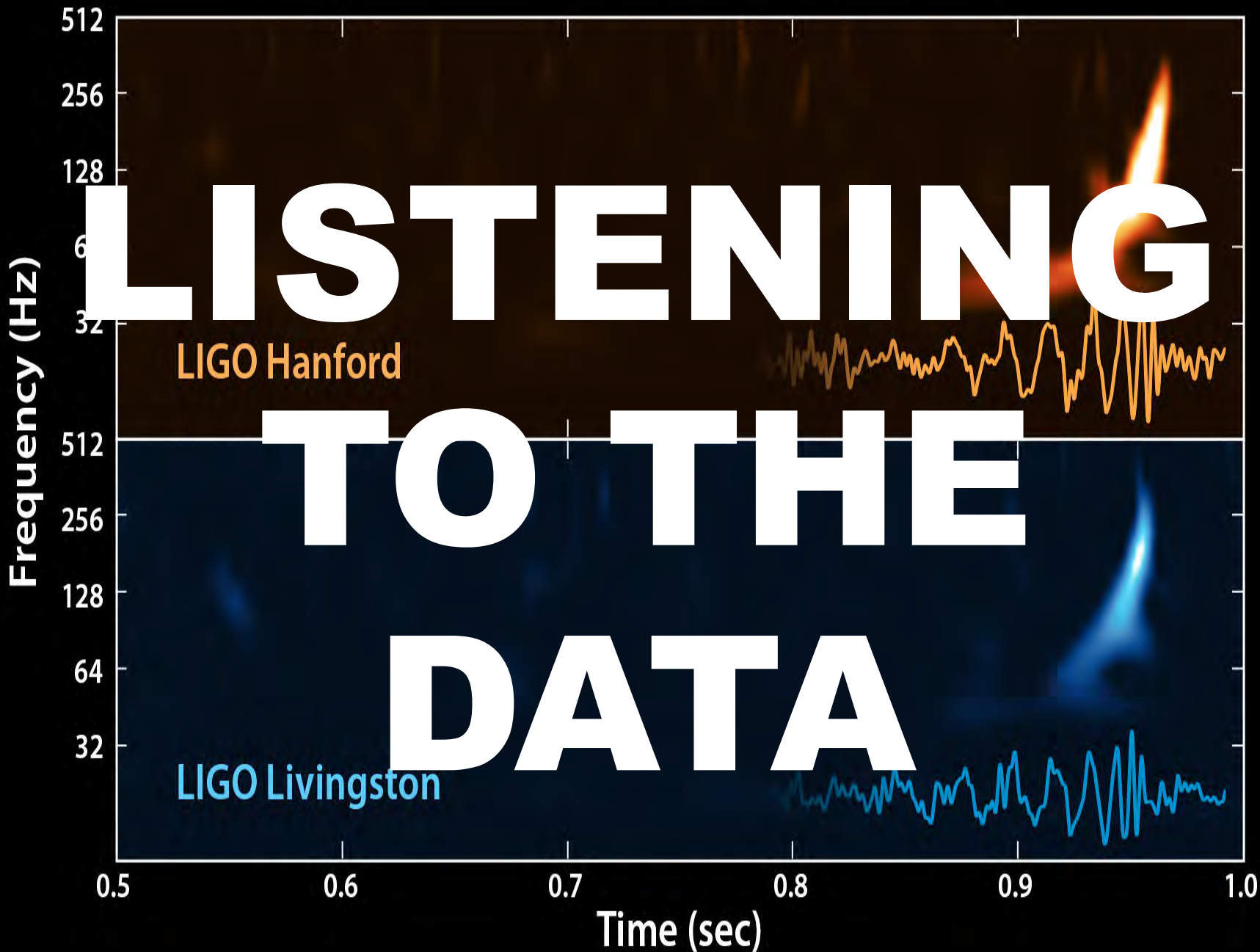
to burst, cbc@ligo.org, The, Calibration, dac, , , losc-devel, lsc-all@ligo.org

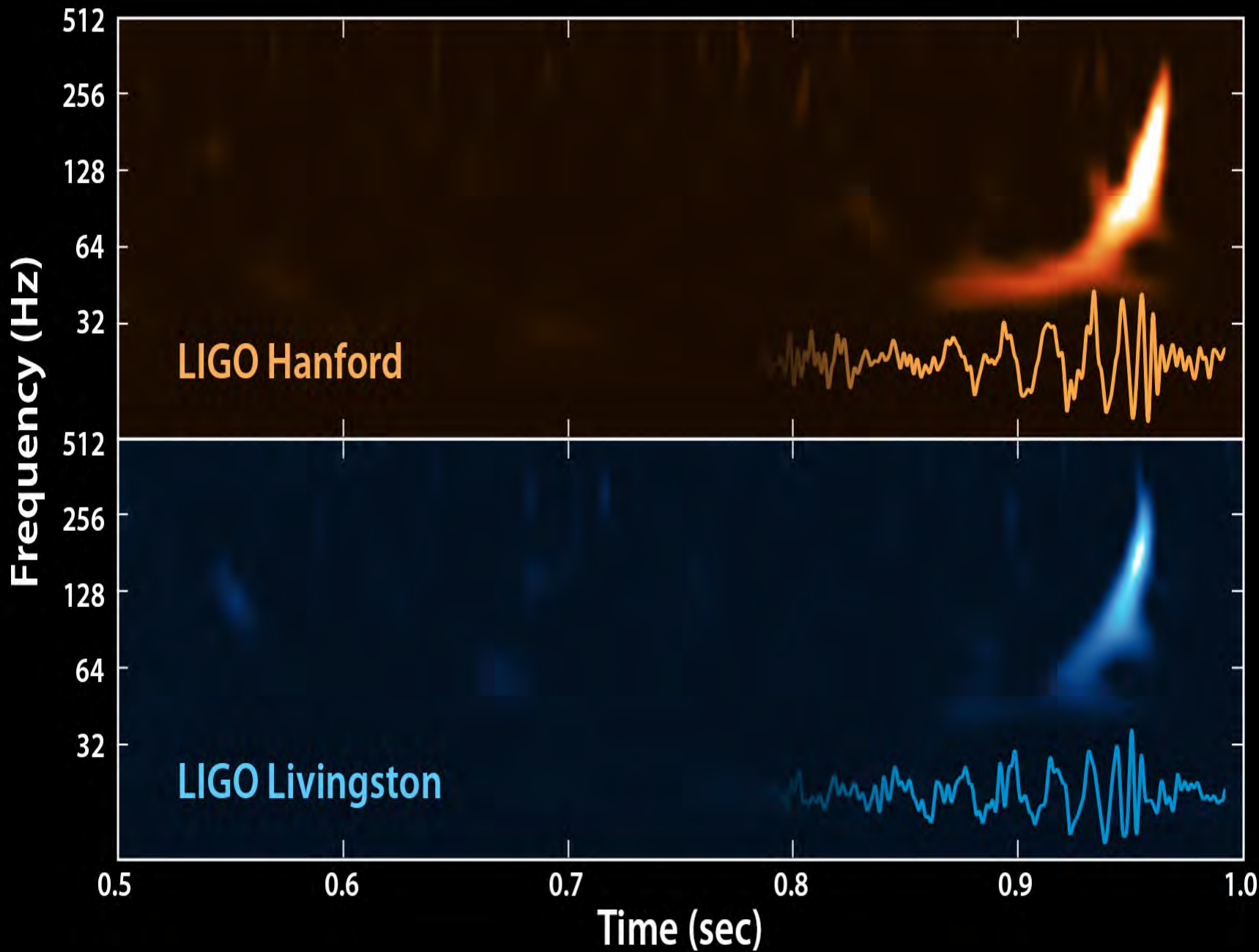
Hi all,

cWB has put on gracedb a very interesting event in the last hour.

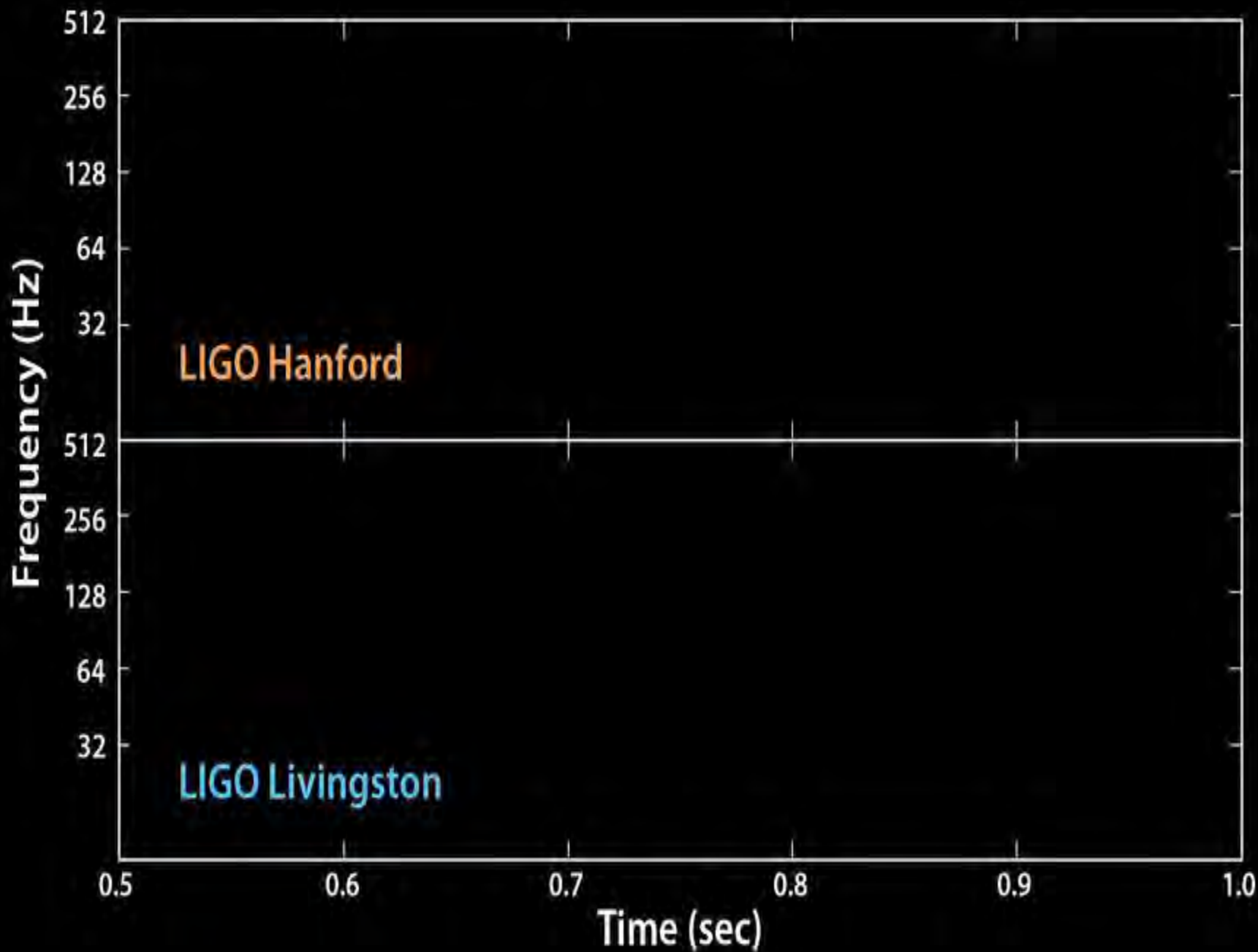
<https://gracedb.ligo.org/events/view/G184098>

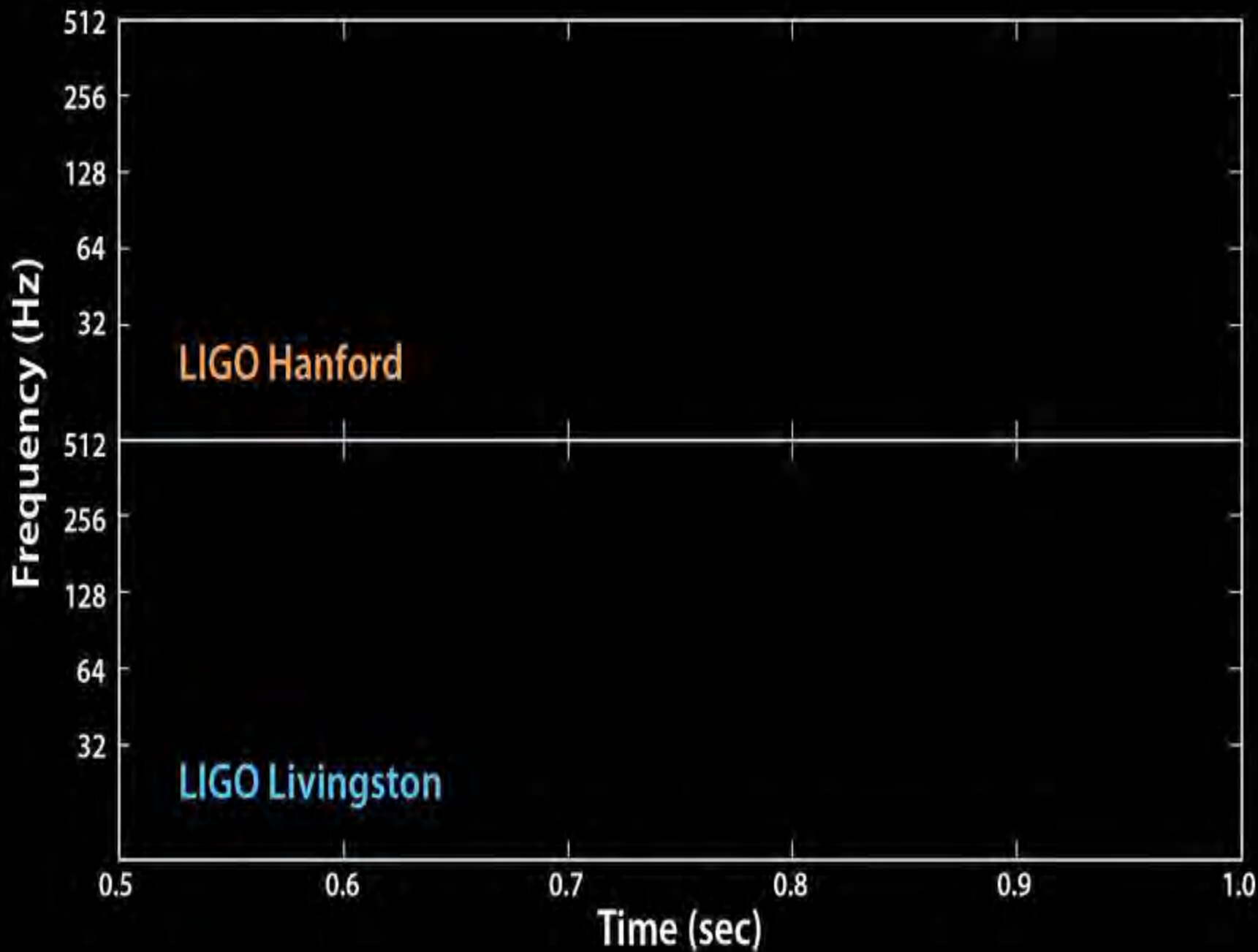




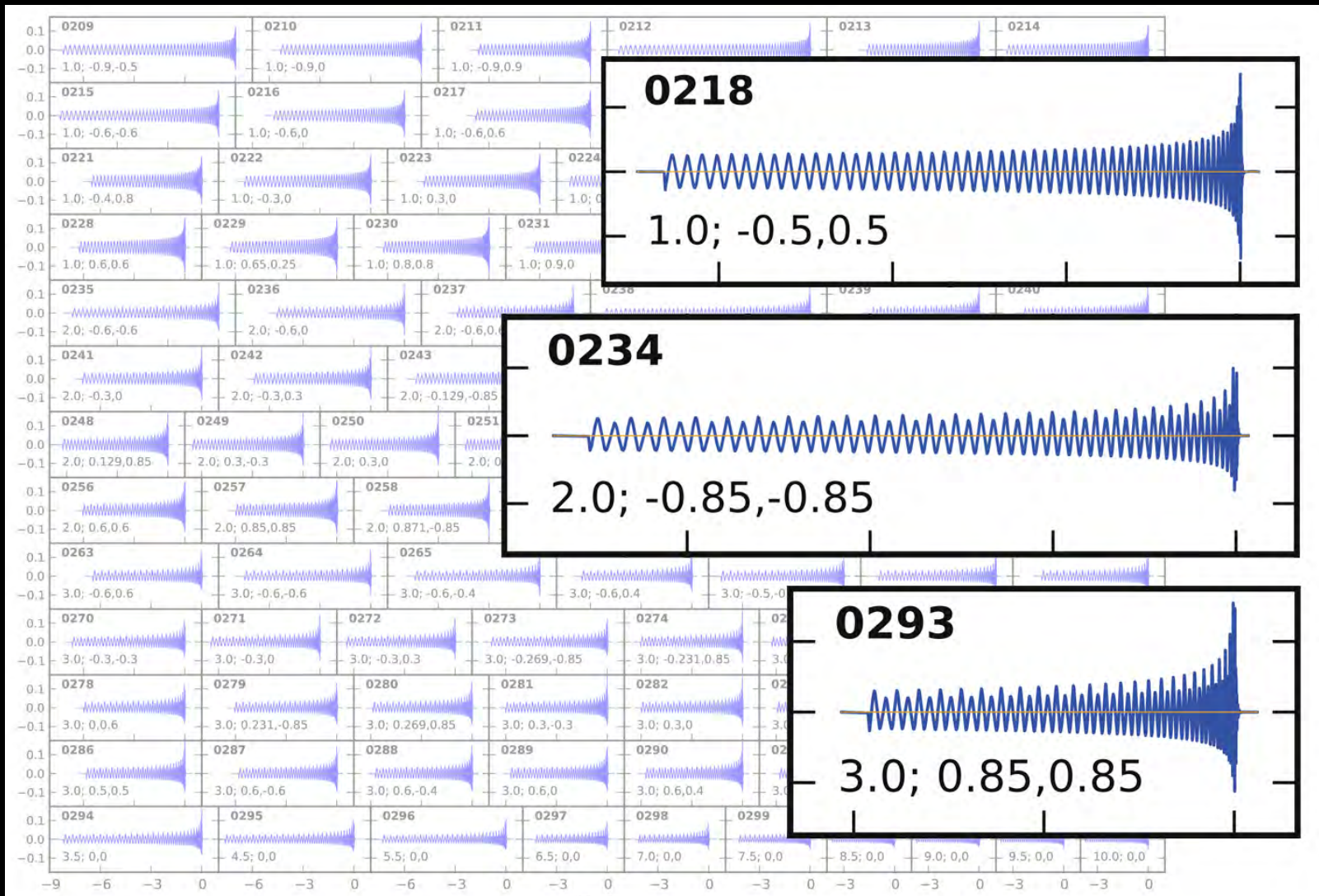








# Numerical Relativity & Advanced LIGO





# Einstein's Gravitational Field Equations



## Keeping A Secret & Surviving The Rumor Mill

*“Rumor of a gravitational wave detection at LIGO Detector. Amazing if true. Will post details if it survives.”*

*~Tweet from **Sept 25, 2015***

*“My earlier rumor about LIGO has been confirmed by independent sources. Stay tuned! Gravitational waves may have been discovered!! Exciting.”*

*~Tweet from **Jan 11, 2016***



# National Press Conference

## 2/11/16, Washington, D.C.!



Photo courtesy of Kai Staats



Credit: CBS, Big Bang Theory





President Obama   
 @POTUS



Following

Einstein was right! Congrats to @NSF and @LIGO on detecting gravitational waves - a huge breakthrough in how we understand the universe.

RETWEETS

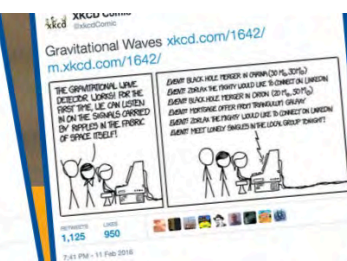
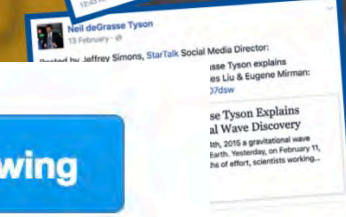
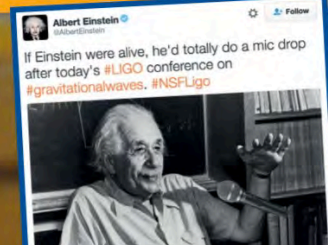
9,489

LIKES

21,085

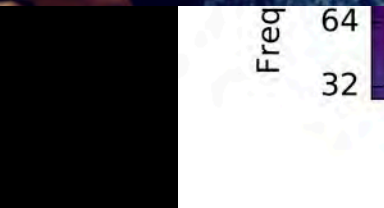
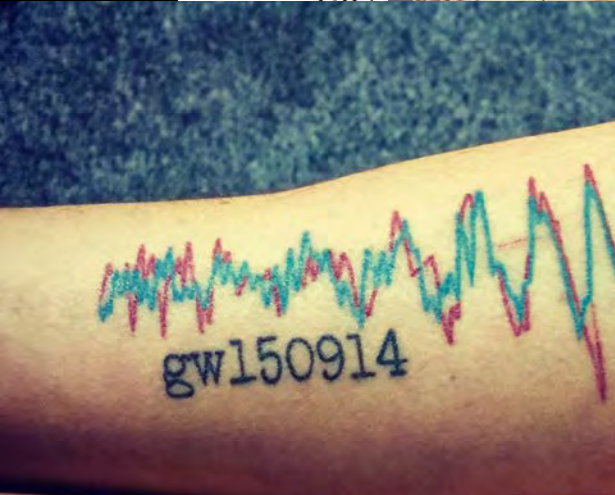


3:43 PM - 11 Feb 2016





# GW150914 Ink!





# LIGO's Press Release Translated into Blackfoot & Other Languages

GRAVITATI  
PREDICTIO



Free & Indian Country Today

This Week From Indian Country Today Newsletter

**JUNE 2016**

**NewsPaper**

**WAVES FROM COLLIDING BLACK HOLES**

LIGO Scientific Collaboration (LSC) and professor...  
 physics and astronomy at Louisiana State University...  
 "Because of their lighter mass, they spent more...  
 - about one second - in the sensitive band of the...  
 black holes in our universe."

**MARCH 2016**

**COVERS GRAVITATIONAL WAVES**

...in the desert of... I floated in a haze. Everything changed.  
 We did not immediately announce our discovery...  
 to the world. We had to make sure the data was truly...  
 a gravitational wave event. For the next five months...  
 hundreds of LIGO scientists from the LIGO Scientific...  
 Collaboration undertook the task of analyzing the...  
 data, drafting a paper of the discovery, and toward...  
 the end, planning how to make the announcement!

It was a marvel to see... this whole process. I have...  
 been with the projects for...  
 "18 LIGO years". In the art...  
 of physics, this is a huge...  
 discovery, and it is humbling...  
 to be a part of it.

Before... The...  
 Announcement on February...  
 11<sup>th</sup>, 2016, our outreach...  
 group was preparing &...  
 worked with them. The...  
 topic of translating the...  
 Press Release...  
 me up...  
 thought...  
 Wiksike

**NIKI**

**(SA AA KISONI) MARCH 2016**

OBITUARIES

BUSINESS PHOTOS

Courtesy Corey Gray

ton State, where he is the...  
 i from a collision of two

**IO Operator**

**s Shoes, Finds**

**Waves (and**

**of His Own)**

3/16

scientific inquiry

lysmic

ts unleash

s into the fabric of



# An August To Remember!

My Other Favorite Detection 😊



**COREY GRAY**

**Abuduuxbiisiiya o?bigimskAasts**

**(Gravitational Waves)**

**GRASS DANCE SPECIAL**

**Piiksapi Memorial Arbor**

**Aug 10, 2017**



**1st Prize: \$1000 + jacket**

**2nd Prize: \$500 + hoodie**

**3rd Prize: \$200 + hoodie**

**4th Prize: \$50 + hoodie**

**5th Prize: \$50 + hoodie**



# Gravitational Wave Grass Dance Special At Siksika Nation Fair 2017









# In The Control Room The Night of Aug 17th

(My 2<sup>nd</sup> Detection of the week! 😊)



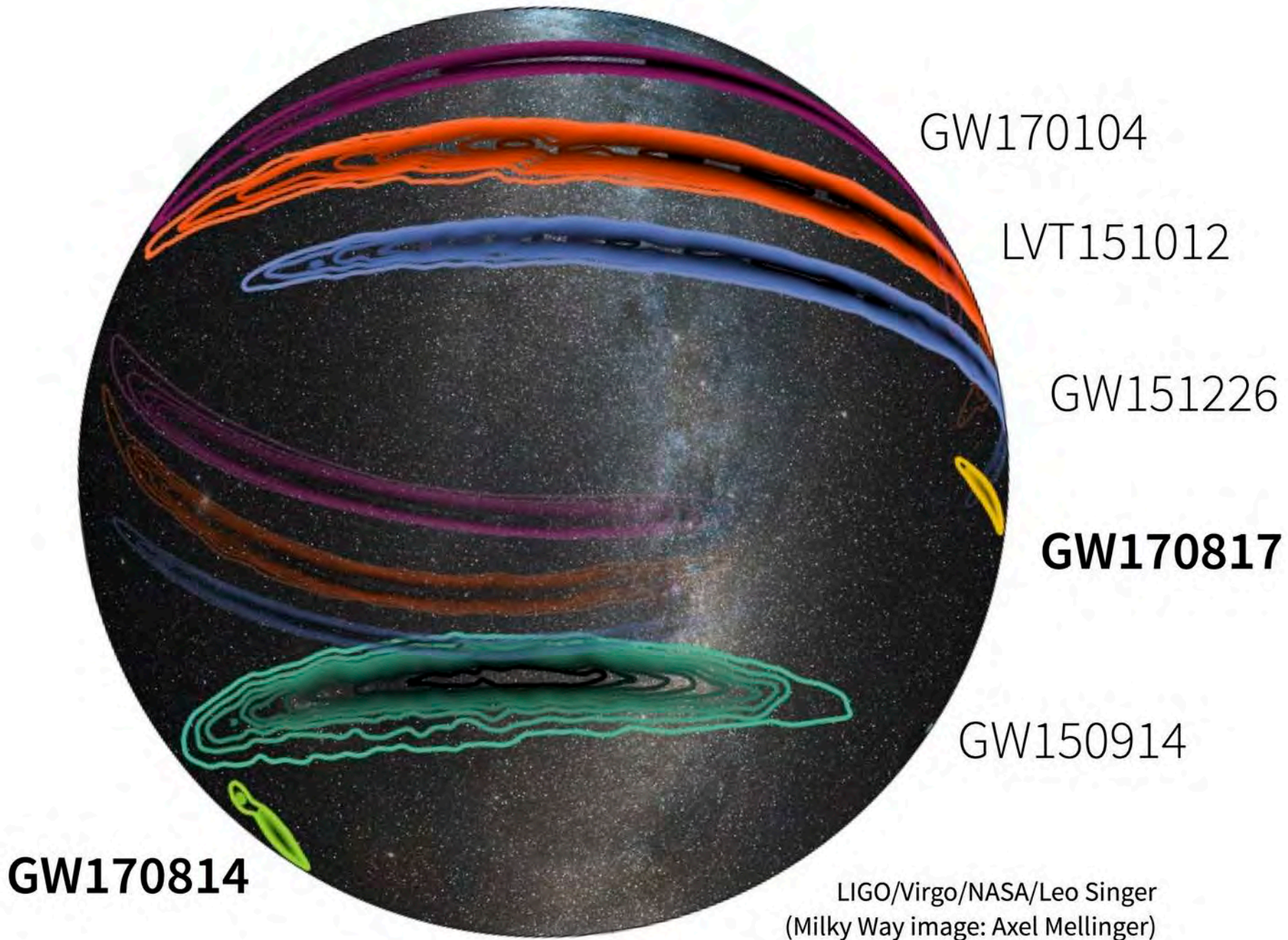
**“Gamma Ray Burst”**



**“G-Wave Candidate” ???**



**Follow-up Alert: “SUBJECT: LIGO/Virgo G298048: Identification of a GW CBC Candidate”**

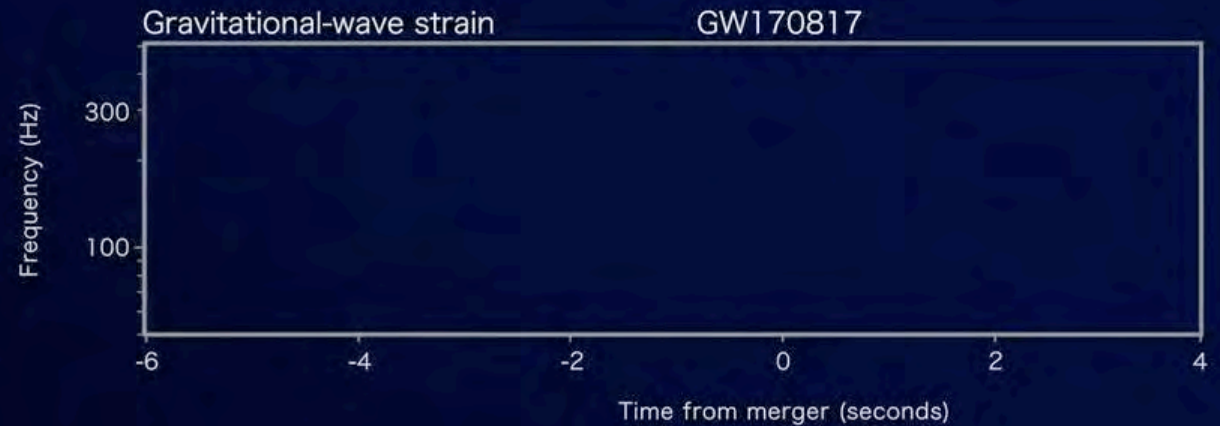




# The Chirp & Short-GRB



LIGO



# A Movie Of The Event





# Optical Follow-up Begins: Multi-Messenger Astronomy!

JVLA (radio), photo from NRAO/AUI and NRAO



Chandra Satellite (X-ray), photo from NASA



# October 3, 2017

The Nobel Prize in Physics 2017

## Nobelpriset i fysik 2017

KUNGL. VETENSKAPS AKADEMIEN  
THE ROYAL SWEDISH ACADEMY OF SCIENCES

Med ena hälften till  
With one half to:




Rainer Weiss  
LIGO/VIRGO Collaboration

och med den andra hälften gemensamt till  
and with the other half jointly to:



Barry C. Barish  
LIGO/VIRGO Collaboration



Kip S. Thorne  
LIGO/VIRGO Collaboration

3 October 2017 © Kungl. Vetenskapsakademien

KUNGL. VETENSKAPS AKADEMIEN  
THE ROYAL SWEDISH ACADEMY OF SCIENCES



NILS MÅRTENSSON



GORAN K. HANSSON



OLGA BOTNER

KUNGL. VETENSKAPS AKADEMIEN  
THE ROYAL SWEDISH ACADEMY OF SCIENCES

**2017 Nobel Prize in Physics: Rainer Weiss, Barry C. Barish, Kip S. Thorne**

Credit: JONATHAN NACKSTRAND/AFP/GETTY IMAGES



# 2017 Nobel Laureates



Nobel Media / Ill. N. Elmehed

**Rai Weiss (MIT)**

**Barry C. Barish, Kip S. Thorne  
(Caltech)**







# What's Going On Now?

## O3!!

GraceDB - event ID: G333674  
50% area: 162 deg<sup>2</sup>  
90% area: 488 deg<sup>2</sup>

HOME PUBLIC ALERTS SEARCH Database LOGIN

### LIGO/Virgo O3 Public

Detection candidates: 48

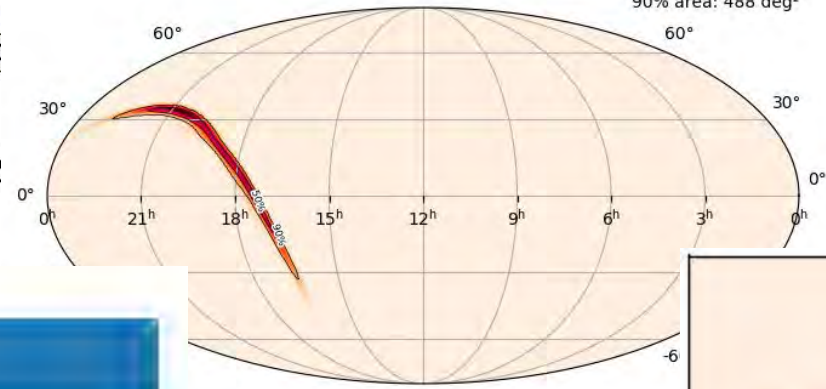
BBH **>99%**

Terrestrial <1%

NSBH 0%

MassGap 0%

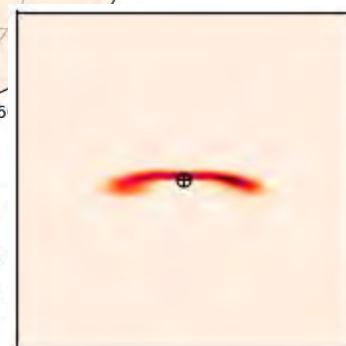
BNS 0%



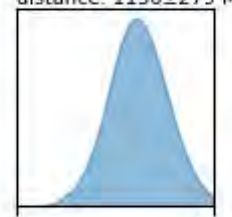
Jan. 29, 2020  
06:54:58 UTC  
[GCN Circulars](#)  
[Notices](#) | [VOE](#)

Jan. 28, 2020  
02:20:11 UTC  
[GCN Circulars](#)  
[Notices](#) | [VOE](#)

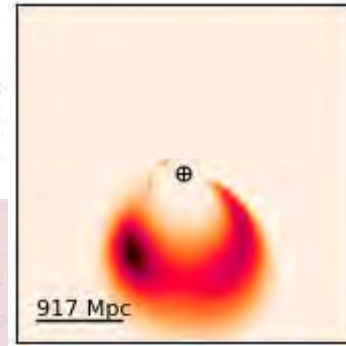
Jan. 16, 2020  
11:56:42 UTC  
[GCN Circulars](#)  
[Notices](#) | [VOE](#)



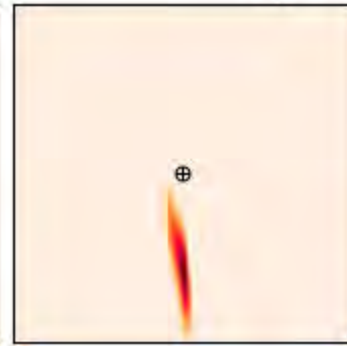
event ID: G333674  
distance: 1136±279 Mpc



0 1834 Mpc



917 Mpc



[S200116ah](#) NSBH (>99%)

Follow LIGO on Twitter & Facebook for the latest!

# 03 So

# 2019

# Far!

# 2020

January

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

February

Su	Mo	Tu	We	Th	Fr	Sa
						1
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9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

March

Su	Mo	Tu	We	Th	Fr	Sa
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10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

January

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
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12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February

Su	Mo	Tu	We	Th	Fr	Sa
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2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

March

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

April

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June

Su	Mo	Tu	We	Th	Fr	Sa
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9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

April

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June

Su	Mo	Tu	We	Th	Fr	Sa
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9	10	11	12	13	14	15
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23	24	25	26	27	28	29
30						

July

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7	8	9	10	11	12	13
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21	22	23	24	25	26	27
28	29	30	31			

August

Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September

Su	Mo	Tu	We	Th	Fr	Sa
						1
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July

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16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

August

Su	Mo	Tu	We	Th	Fr	Sa
						1
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16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

September

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

October

Su	Mo	Tu	We	Th	Fr	Sa
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6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November

Su	Mo	Tu	We	Th	Fr	Sa
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3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

October

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

December

Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					



# In The News...



3.7X

07:40:48 AM



What's  
Next?





# Coyote's Crazy Smart Science Show Season 2 in 2020 on APTN!





# We Need More Indigenous Scientists!



**With Native Astronaut John Herrington!**



**Image courtesy Ron Tso**

**Neil DeGrasse Tyson & Ron Tso!**

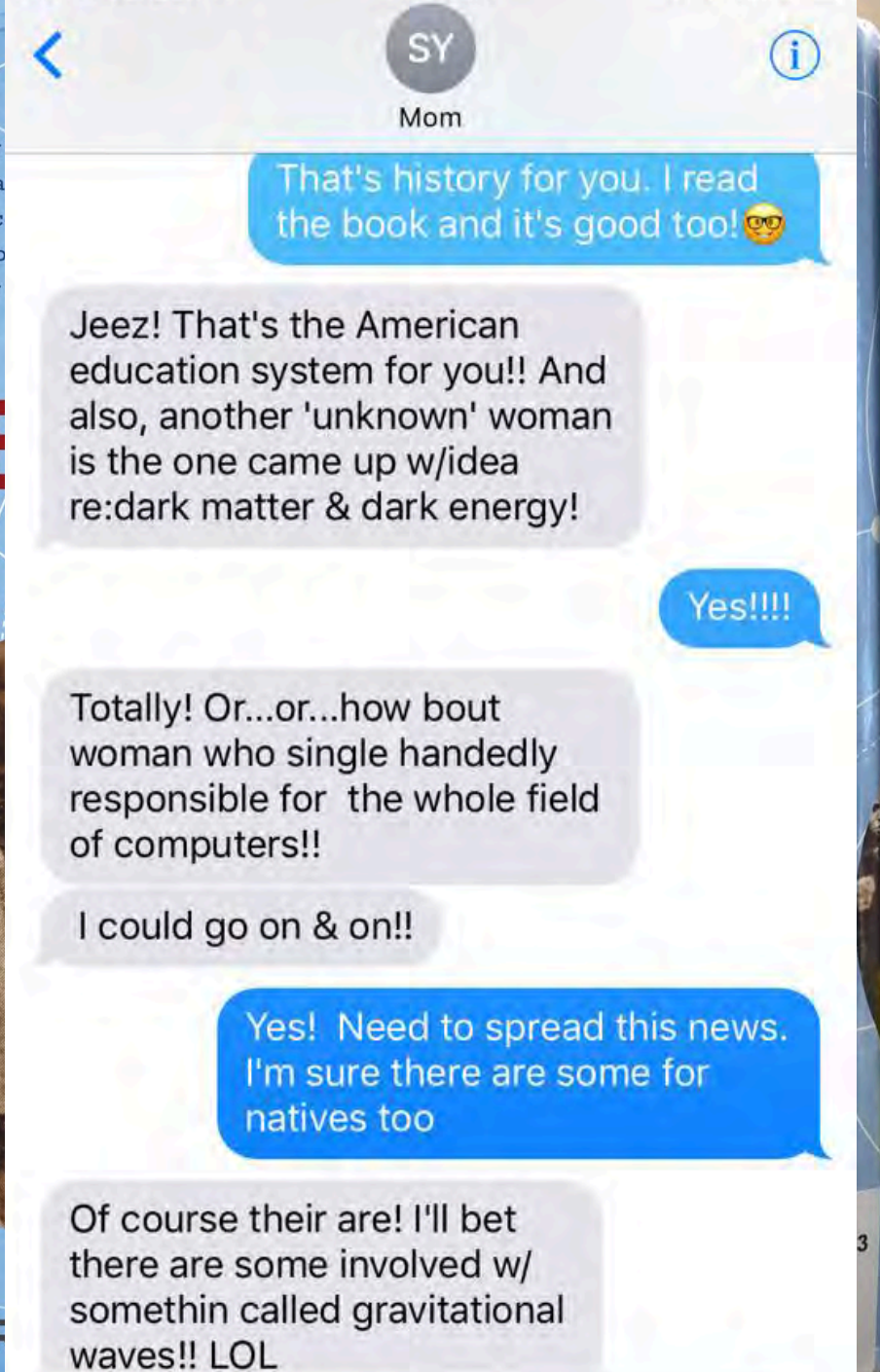


# Blackfoot Scientists!



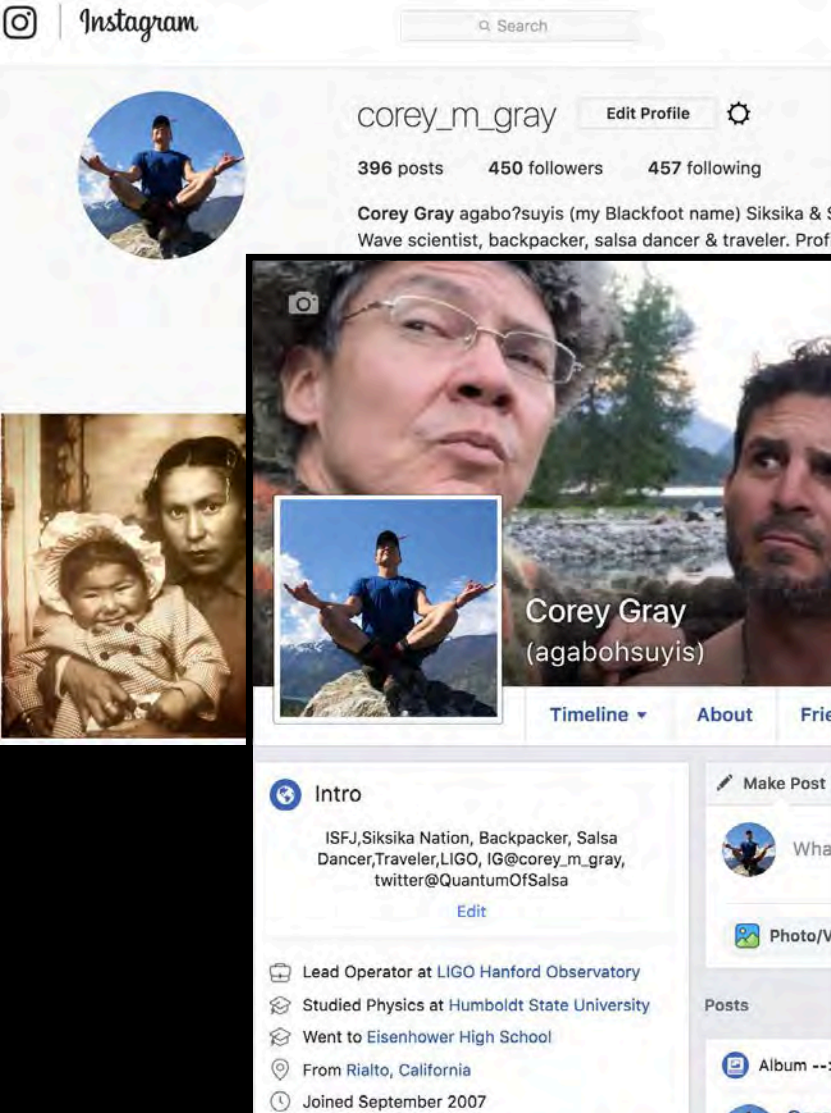
**Rob Cardinal (Siksika Nation)**  
STEAM Coordinator For Siksika Schools!

# Hidden Figures!





# Social Media: #SILS2018 😊



**corey\_m\_gray** Edit Profile ⚙️  
396 posts 450 followers 457 following

Corey Gray agabo?suyis (my Blackfoot name) Siksika & Siksika Nation. Wave scientist, backpacker, salsa dancer & traveler. Prof

**Corey Gray (agabohsuyis)**  
Timeline About Friends

**Intro**  
ISFJ, Siksika Nation, Backpacker, Salsa Dancer, Traveler, LIGO, IG@corey\_m\_gray, twitter@QuantumOfSalsa

Lead Operator at LIGO Hanford Observatory  
Studied Physics at Humboldt State University  
Went to Eisenhower High School  
From Rialto, California  
Joined September 2007



**Corey Gray (agabo?suyis)**  
@QuantumOfSalsa

Backpacker. Salsa dancer. Traveler. Gravitational wave hunter. Siksika Nation. Scottish. ISFJ IG@corey\_m\_gray

West Richland, WA  
instagram.com/corey\_m\_gray/  
Joined December 2015

148 Photos and videos

**Tweets** Tweets & replies Media

Pinned Tweet  
**Corey Gray (agabo?suyis)** @QuantumOfSalsa · 17 Feb 2017  
No idea #ScientistsWithTattoos was trending--Had to REPRESENT. #GravitationalWaves #LIGOLove #ScientistsWithInk @sonia\_zarate @LIGO @sacnas



Corey Gray added a new photo — at University of Lethbridge.  
19 hrs · Lethbridge

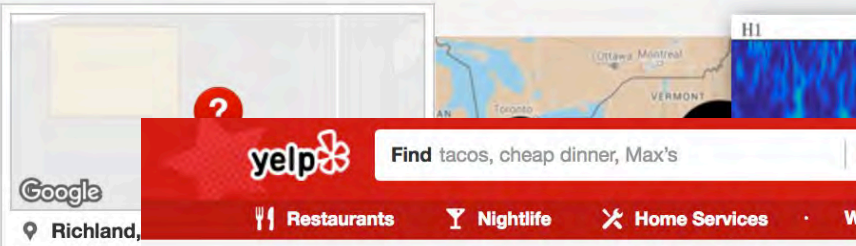
**MIND BLOWN.**  
Listening to a Japanese woman speak Blackfoot! ❤️  
She teaches linguistics at University of Montana.  
Their talk: "Blackfoot Word Melody & Second Language Acquisition"...



# LVT151012

☆☆☆☆ 1 review Details

Education Edit



Richland, WA

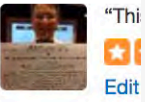
Find tacos, cheap dinner, Max's

Restaurants Nightlife Home Services

# GW151226

☆☆☆☆ 1 review Details

Education Edit



## Ask the C

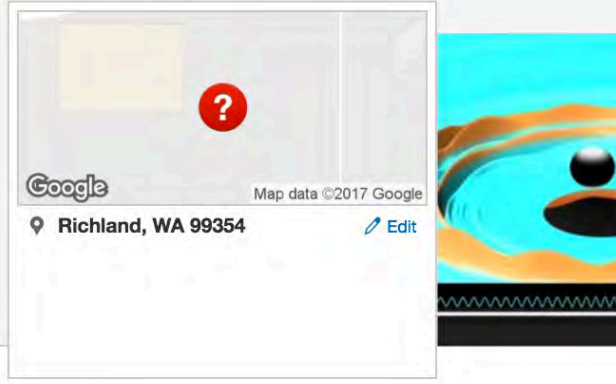
Yelp users have

Ask a Question

## Reviews

Search within t

Corey G.  
West Richland, WA  
70 friends  
1543 reviews  
1637 photos



Corey G. "GW151226 is the second..."  
☆☆☆☆☆  
Add Photo Edit Review

## Ask the Community

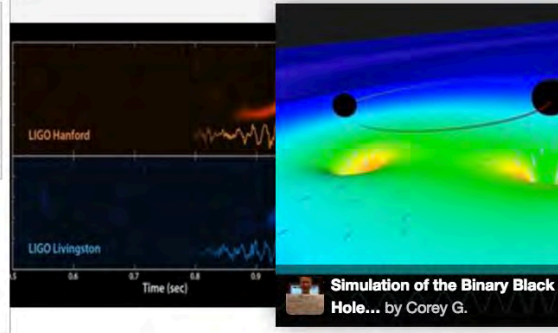
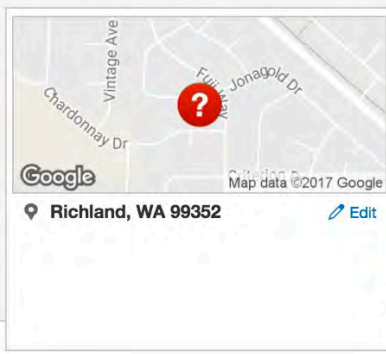
Yelp users haven't asked any questions yet about GW151226.

Ask a Question

# GW150914

☆☆☆☆ 1 review Details

Education Edit



"LIGO's first detection of..."  
☆☆☆☆☆  
Edit Review

Add Photo Share Bookmark

## Ask the Community

Yelp users haven't asked any questions yet about GW150914.

Ask a Question

## Reviews

Search within the reviews Sort by Yelp Sort Language English (1)

Corey G.  
West Richland, WA  
70 friends  
1543 reviews  
1637 photos

☆☆☆☆☆ 3/27/2017 First to Review

LIGO's first detection of gravitational waves, on it's own, is surely 4-star worthy: decent neighborhood, heavy ambiance & excellent/fast service.

But The Chirp Which Shook The Science World surely deserves 5 stars because it was fast, accurate, and best.

Corey G.  
First to review

Browse nearby



# Some Advice!

- **INTERNSHIPS!!**
- **Find Your Passion** (travel, dance, hiking, etc.)



# Made In The CSU 2018!



## Made in the CSU

Meet some of the three million remarkable California State University alumni making a difference in the lives of the people of California and the world. The alumni highlighted here are leaders in every major industry in the state, and all point to one common element in their success: a California State University education.

**Julie Miller-Phipps**  
*Helping California Thrive*

**Dominique Braud**  
*Funny Business*

**Mourad Lahlou**  
*Culinary Master*

**Corey Gray**  
*Making Waves*

**Kim Ruiz Beck**  
*Feeding Generations*

**Mike Hopkins**  
*Industry Innovator*

**Francisco Gaviña & Leonor Gaviña-Valls**  
*Taste Of Tradition*



**COREY GRAY**  
Lead Operator | Caltech - LIGO (Washington)  
HUMBOLDT STATE BS, Dual Degrees in Physics and Applied

Gray is the lead operator at LIGO (Laser Interferometer Gravitational-Wave Observatory) Hanford Observatory and part of the group of researchers that confirmed the existence of gravitational waves, marking a major discovery for the field of astronomy.

He now manages the operator team for the detector in Washington that discovered the existence of gravitational waves produced by two colliding black holes. The finding, announced by scientists Albert Einstein predicted in 1916, was confirmed by the discovery of gravitational waves.

Gray is a member of the team whose founders were awarded the Nobel Prize in Physics in 2017.

He was the first to produce...

Tesia Johnson HSU Alumni at CA State Capital (July 2018)



# Blackfoot Translations of Albert Einstein's Gravitational Waves by Sharon Yellowfly



## Word Categories: *Conceptual*

- **Gravitational Waves**
  - Abuduuxbiisiiya o?bigimskAAsts
  - “*Stick Together Waves*”
- **Interferometer**
  - Anatsiwayagidutsim gii idumuya issxgwibiists
  - “*light splitter & marry/union measurements*”
- **Scientist**
  - mugagyabiguwAx
  - “*all encompassing smart people*”
- **Electromagnetic**
  - babusuxbiisiists
  - “*lightening stickies*”
- **Gamma Rays**
  - igaguu esstuumsKuutsp aanatsiists AsAxgaasimya
  - “*many provisions of self-strengthened lights exploding*”



## Word Categories: *Literary License*

- **General Theory of Relativity**
  - bisaatsinsiimaan
  - “*beautiful plantings*”
- **Chirp**
  - biiXiini\_gi
  - “*bird singing*”

# NPR!

(National Public Radio, March 2019)



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How A Cosmic Collision Sparked A...

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SPACE

## How A Cosmic Collision Sparked A Native American Translator's Labor Of Love

March 31, 2019 · 5:17 PM ET  
Heard on All Things Considered



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# LIGO Press Releases Translated Into Blackfoot!

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5:05 / 14:42



Analytics Video Manager

Gravitational Waves Press Release Translated into Siksika Language

 Corey Gray  
[Channel settings](#)



Ryan Reynolds Tim  
Into Stephen's Mon  
The Late Show with Step  
Recommended for you



Iterative Drawing - T  
Way to Improve

# Translation: Reading

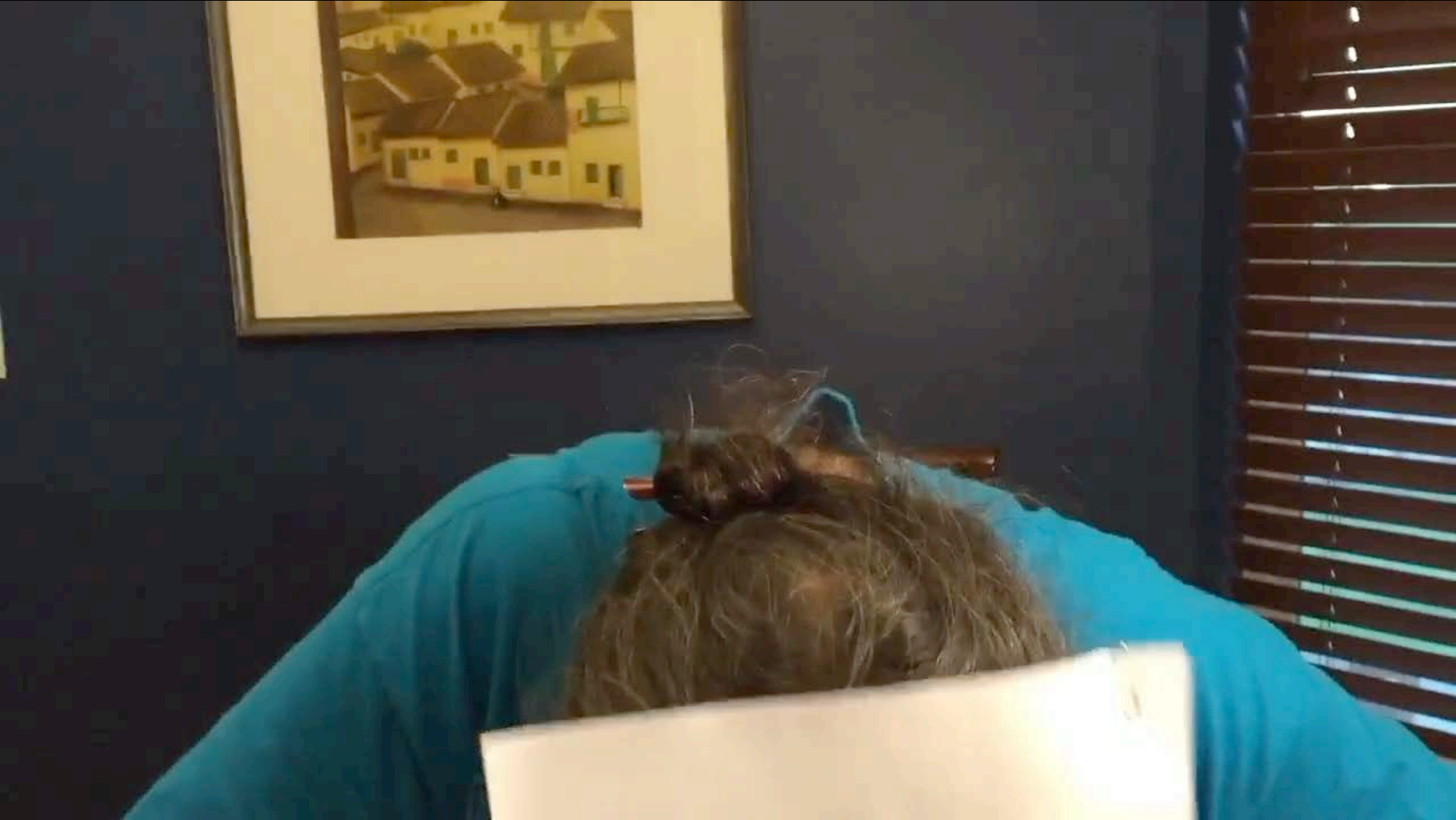




# Translation: Finish!

o?paigimskeets miim LIGO  
nessxgatsimyaa.

Translation: Blooper 😊





**Finis**

**Extra Slides**



# NPR!

(National Public Radio, March 2019)



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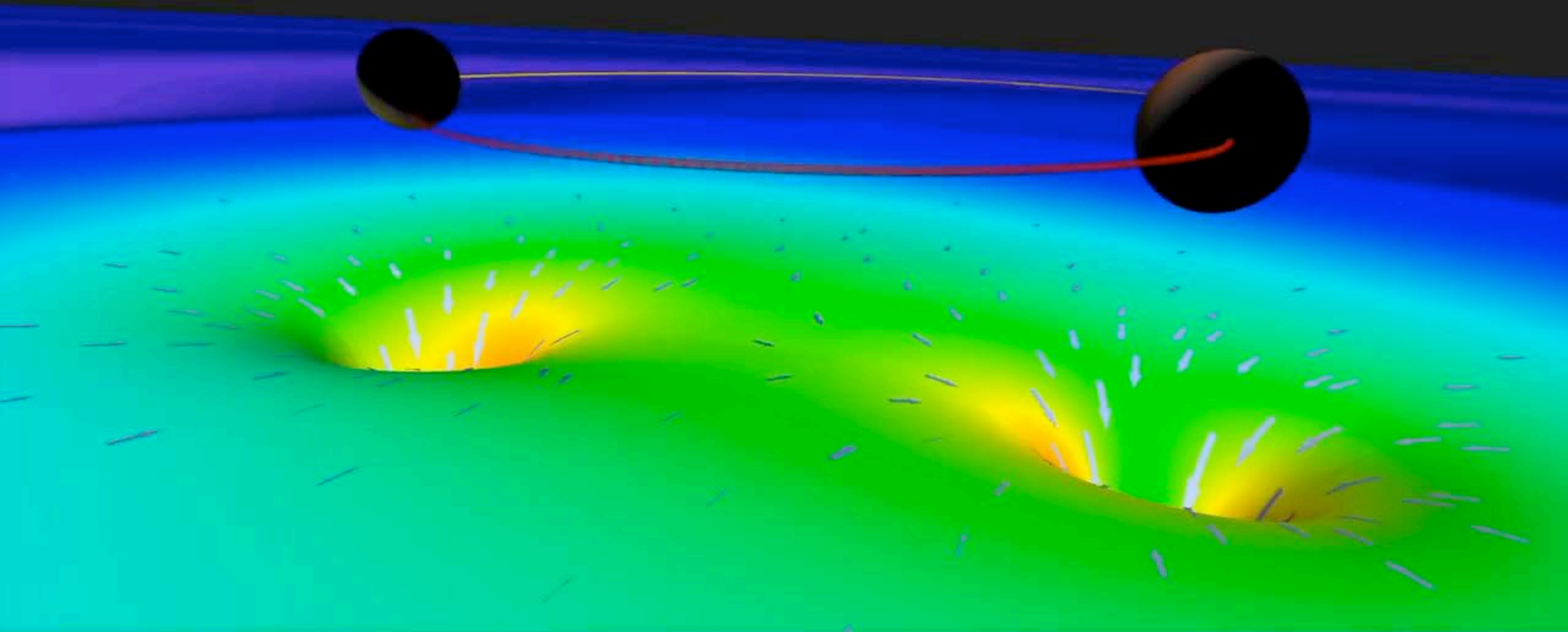
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-0.41s







LIGO  
@LIGO

#S190930s and #S190930t are candidate #GravitationalWaves and @ego\_virgo in the first six runs. That's a remarkable \*three\* times as the number of confirmed detections as #O1 and #O2 combined!



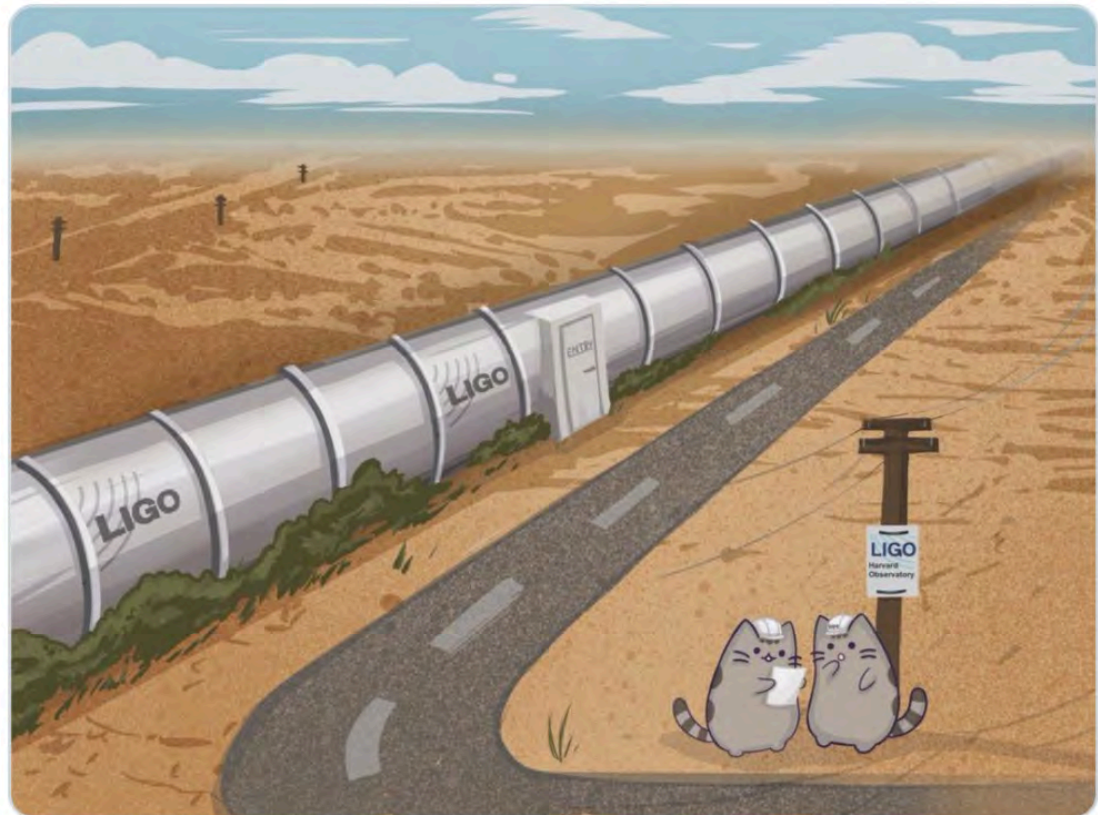
7:48 AM · Oct 4, 2019 · Twitter Web App

LIGO Retweeted



MPI GravPhys  
@mpi\_grav

#Science #Pusheen by @TheLabArtist visits the @LIGO @LIGOWA beamline looking for Gravitational Waves! [tumblr.co/ZifChW2IDAqG7](https://tumblr.com/ZifChW2IDAqG7). More great STEM illustrations at [sciencepusheen.tumblr.com](https://sciencepusheen.tumblr.com). #GravitationalWaves



12:10 AM · Oct 15, 2019 · TweetDeck

# LIGO's Press Release Translated into Blackfoot & Other Languages

Corey Gray <gray\_c@ligo-wa.caltech.edu> Feb 3, 2016, 9:24 AM

to Joey

Hey Joey (just sending to you),

I have a question about translations, but my question is fairly specific and for a very small group, but it could be a unique opportunity, if it could work.

Would it be OK to ask my mother (a fluent speaker of [Blackfoot] language) if she could translate the Summary

If I were to do it *before* the press release, this would be a good mom this document (the one Martin attached in this email). I should say that my mom is removed from the social media

So yeah, I would have to also have to see how "do" we can attempt a translation. She has written a Blackfoot version of technical words in it.

Anyway, it was just a thought. :)

And if this is something I should present to my mother, I can do that, too. :)

Thanks!

C.

Joey Key joey.key@utrgv.edu via utrgv... Feb 3, 2016, 11:19 AM

to Corey

Hi Corey,

I think this would be great and I assume that you consider your mother a trusted collaborator! If you stress that this is confidential and embargoed she can start working on it before the press conference. If it is ready by the time of the press conference we can post it then, but we can also post it when it is ready if it is later.

Please post it here: <https://wiki.ligo.org/EPO/DiscoveryTranslations> and we will add it to the website.

thank you,

Joey

**And a conversation  
with  
Dr. Joey Key!!**



LIGO MEASURED GRAVITATIONAL WAVES FOR THE FIRST TIME ON SEPTEMBER 14TH, 2015.



GRAVITATIONAL WAVES  
TCH AND SQUISH THE  
BRIC OF THE UNIVERSE.  
SINE THE MONA LISA  
SING ON THE WALL...

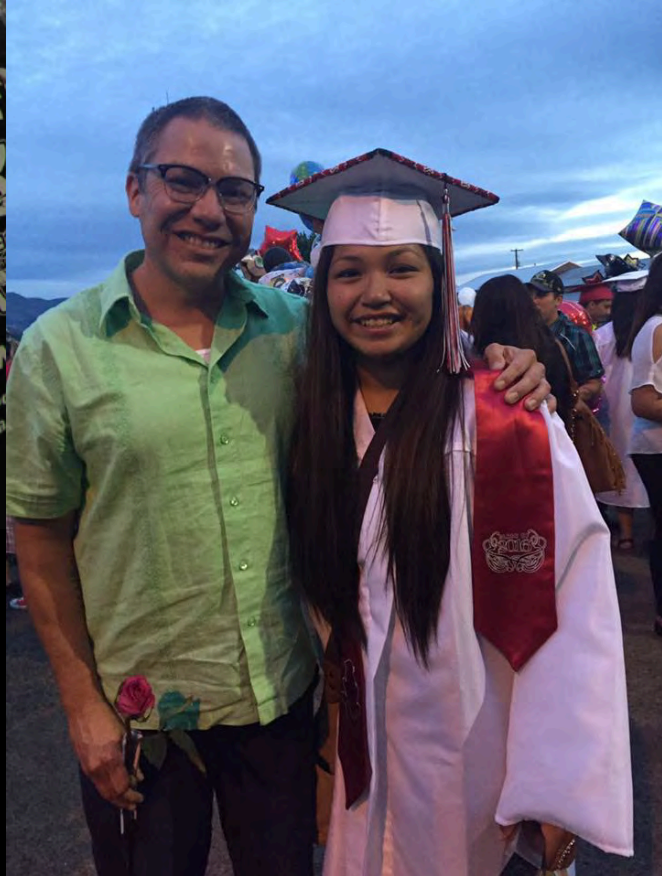
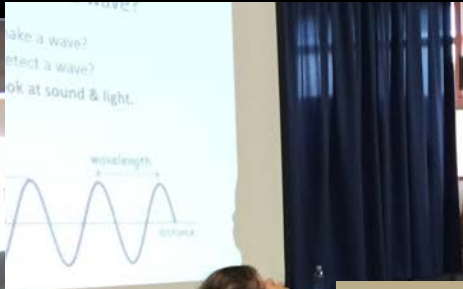


# Experience At HSU





# Sharing With Indian Country!





Time: -0.63 seconds

