everything is driven by the Sun it's like the missing piece of the puzzle we don't know truly what physics is going on in that region because we've never been there

EGS program chief engineer verify no constraints to launch

[Music]

and liftoff

now passing through max Q Max and dynamic pressure welcome to space

dynamic pressure welcome to space

welcome to the rocket range I'm Joshua Santoro even though our Sun shines bright in the sky it is shrouded in
in this episode we'll sit down with scientists working to get us closer to the Sun than ever before first up we talk with a project scientist on the Parker Solar Probe mission that will be launching soon attempting to fly inside the sun's atmosphere in order to unlock its many secrets um the big mystery we're trying to solve is why is it current is so hot next we talk with the researcher working on a cryogenic coating that could get us even closer but his goal is not to go to the Sun
it's to store uh rocket fuel in space

while keeping it from boiling off a

critical breakthrough needed to help us

explore farther into space liquid

hydrogen hydrogen has to be done at 20

Kelvin I mean you're talking getting

you're getting close to absolute zero

when you talk liquid hydrogen

NASA's Parker Solar Probe will be the

first ever mission to travel directly

into the sun's atmosphere about four

million miles from our star's surface

with me in the booth today is dr. Nikki

Fox she's from the Johns Hopkins
and is also the project scientist for the Parker Solar Probe mission. Dr. Fox was also involved in this mission.

We are celebrating 60 years of NASA this month and I understand that this mission is older than NASA, yes, that's right. So, the Parker Solar Probe was first thought of and first proposed in 1958, so it's also going to turn 60 years as well as NASA this year. But when the agencies were forming, so NASA, the National Science Foundation, and really the Department of Defense, and you know, what do we want to do with this newfound thing called space? What do we need a big
agency for that you know these big grand

missions that we really just really want
to do and so they pulled together a
committee it was chaired by John Simpson
co-chair by James Van Alen and they had
a panel of experts and they came up with
these missions that were just big and
shiny and that's what everybody wanted
to do one of those missions was a
spacecraft to go into the Sun's corona
so it that's where Solar Probe they
want to probe the sun's corona and it
was a high priority for all this time in

the decadal surveys in the NASA roadmaps
a solar probe has been there since then

other countries other agencies have tried to do it but it's really taken 60 years for technology to catch up with our dreams and we're now sitting on the verge of making this come true and so it does predate NASA and I wouldn't say that we are competitive but we are faster hotter and closer than anything has ever been before in fact I always like to call this call the mission the coolest hottest mission Under the Sun and so you talk about technology catching up and I'm assuming
that it has to do with the heat involved

because we've been sending things out into space for decades now so is that

the challenge the technology of getting close to the Sun and how hot are we

talking there are many different challenges with paka Solar Probe it

isn't just the heat and we can talk about the heat obviously we're going to

3 million degree plasma the big mystery

we're trying to solve is why is that

corona so hot the surface of the Sun is

about 6,000 degrees centigrade 10,000 degrees Fahrenheit and now we're talking
about plasma that's 3 million degrees

you walk away from a campfire you don't

suddenly get hotter and get colder and

so why is this bizarre thing happening

and the only way we can answer that

question is to travel into this region

where this plasma this coronal material

is three million degrees and so

obviously we have to have materials that

are specially developed they can't melt

also they can't change their properties

and so we have this very highly

elliptical orbit it looks like a petal

of a flower we go very close to the Sun

on one side and then we come out around
the orbit of Venus on the other side and

so we're going super hot and then very

cold and if you think of taking any

material that you know and you heat it

and cool it and heat it and cool it and

well it's either gonna become elastic

it's gonna become brittle whatever it's

going to change its properties and so

these materials have to withstand these

incredible changes in heat but also it's

miniaturization it's getting technology

into small packages we are traveling at

thirty thousand miles an hour or 118
miles a second and we have to keep our heat shield between us and the Sun and so the spacecraft is incredibly incredibly independent she's a plucky little spacecraft going out there and looking after herself because if we have any kind of fault the spacecraft has to know how to correct that fault it takes like eight minutes to go from the Sun to the earth we don't have time to joystick this spacecraft she has to correct herself and so if you think of the shear technology that would have taken to do that in 1958 you're
talking four city blocks worth of buildings with computer power in them not easy to get off the ground I mean if you think in 1958 you wanted to talk to somebody you went to the wall where your rotary dial phone was attached and you made your phone call now we all have iPhones and we probably do everything except make a phone call with them you know the whole way we communicate I mean it's a last-ditch attempt if you have to make a phone call now by the time you tried texting an instant messenger and
Instagram and Snapchat and you've done

00:06:06,790 --> 00:06:12,100
all those things true and so just the

00:06:09,009 --> 00:06:15,579
sheer way that the society has changed

00:06:12,100 --> 00:06:18,129
is dramatic and that's very good

00:06:15,579 --> 00:06:20,500
demonstration of what we needed to do to

00:06:18,129 --> 00:06:23,170
be able to get Parker Solar Probe into

00:06:20,500 --> 00:06:25,180
orbit so we were talking about this for

00:06:23,170 --> 00:06:26,800
decades as a priority and just really

00:06:25,180 --> 00:06:28,990
didn't touch it or has it really been

00:06:26,800 --> 00:06:31,569
worked on for 60 years now there have

00:06:28,990 --> 00:06:33,850
been many many incarnations of a Solar

00:06:31,569 --> 00:06:36,969
Probe that I think there was a Russian

00:06:33,850 --> 00:06:39,700
one called Firebird you know JPL had a

00:06:36,970 --> 00:06:42,070
design the Johns Hopkins Applied Physics

00:06:39,699 --> 00:06:43,959
lab had a different design it looked
kind of like a bullet and it was gonna

go super close but it was going to go

out to Jupiter kick out of the kind of

the plane of the Sun and the earth and

then come up and go over the pole and go

down sort of north-south if you like

past the Sun but they were very

expensive missions they required some

kind of nuclear RTG some kind of you

know power source and they were very

very expensive they took a long time to

get into the orbit and then they got you

know a few hours were

of data if you like and so it really was
just the ability to afford all of the technology to come up with a mission design that would allow us to go where we need to go and do it for a reasonable price so that was where the mission used to be called Solar Probe plus and that's where the plus came from we changed and wist we stay in the ecliptic plane so you put the Sun and the earth and you stay in that sort of plane there and we don't use any kind of RT G's we use solar solar cells and you may look at me and say hey Niki well duh you're going to the Sun why wouldn't you use solar
power that's a no-brainer

except what happens if you leave your iPhone in the car on a beautiful Florida day it overheats and solar panels are extremely sensitive to heat and so we have to find a way to keep them cool and so they you know we have them they're articulated kind of on a shoulder joint and so they can move out and they can also kind of twist around so that we can maximize the amount of power and minimize it by tucking them all the way in as we get close to the Sun we also cool them with water and again and not a
very exotic material but the best

00:08:22,529 --> 00:08:28,979
coolant that we have and we run water

00:08:27,060 --> 00:08:30,389
through the veins like the veins in your

00:08:28,980 --> 00:08:32,670
your hand

00:08:30,389 --> 00:08:33,929
they run between each of the solar cells

00:08:32,669 --> 00:08:36,509
all the time

00:08:33,929 --> 00:08:38,399
continually keeping those cells cool and

00:08:36,509 --> 00:08:41,279
so you know it's taken a lot to get the

00:08:38,399 --> 00:08:42,840
technology but also to bring it in in a

00:08:41,279 --> 00:08:44,879
really good mission design that does the

00:08:42,840 --> 00:08:46,350
science we want to do I have the benefit

00:08:44,879 --> 00:08:48,230
of sitting across the table from you so

00:08:46,350 --> 00:08:50,250
I know the answer to this question but

00:08:48,230 --> 00:08:52,200
did you start working on this sixty

00:08:50,250 --> 00:08:52,850
years ago and if not when did you do
that

very good plastic surgeon no I started working on this mission in 2010 so I'm a relative newbie to the mission there are people who've been working on it for a lot longer than that even this particular incarnation there have been people working on it for well over a decade so I'm a little new and and how has this been from a personal perspective because I know that we talk to people all the time and we hear similar stories we've spent a decade or more working on this and giving our
lives to this project so how is that been for you kind of through this process and getting read for launch so I think for me it's been a very personal journey you know I started working on the mission late in 2010 and about six weeks after I accepted my position my husband died very suddenly leaving me with a one-year-old and a three year old and my life kind of fell apart you know I felt like I can't take on anything I'm you know I'm never gonna be able to do anything and the way this team kind of gathered around and
supported me through this period it was

almost like I used Solar Probe as a
grief kind of solving mission you know

there were things I could come in I

could actually do things I could could

make this thing work and just the

tremendous support of you know people

that just said God you need to pick up

your kids tonight do you need groceries

so what can we do to help you and the

science team also you know my first

science team meeting where I had to

stand up and lead them and you know I

was nervous and one of the principal
investigators just said hey you know I

00:10:35,129 --> 00:10:38,129
thought it might be nice just come and

00:10:36,539 --> 00:10:39,839
have dinner with my wife and I and you

00:10:38,129 --> 00:10:41,639
know you don't have to do anything big

00:10:39,840 --> 00:10:43,259
in the evening it'll be low stress for

00:10:41,639 --> 00:10:46,199
you and we'll just give you some food

00:10:43,259 --> 00:10:48,419
and just the sort of the people

00:10:46,200 --> 00:10:51,120
realizing this person is really falling

00:10:48,419 --> 00:10:52,469
apart and they're really hurting and we

00:10:51,120 --> 00:10:54,990
are going to support you through it so

00:10:52,470 --> 00:10:56,759
they're like a family I come down to

00:10:54,990 --> 00:10:58,169
Astrotech here and I walk in the door

00:10:56,759 --> 00:11:00,450
and everyone's like hey Nikki how's it

00:10:58,169 --> 00:11:03,569
going you know and and it's just such a

00:11:00,450 --> 00:11:05,820
friendly lovely highly professional
highly skilled best at the you know in
the world at what they do but real
people that see someone that's really
struggling and they'll all band together
and help that person be successful and
so this mission is deeply personal for
me I put my husband's name on the
spacecraft my children are all excited
about daddy's gonna orbit the Sun
forever and you know it's a very
personal thing I'm sure that that
extends now beyond just the trust of
this personal relationship with people
into a professional engineering and
problem-solving reality of your team

absolutely I mean when you know when we have an issue

a technical issue people just deal with

it nobody panics they say okay we've got

a technical issue we're gonna do it

we're gonna come up with a plan we're gonna do this we're gonna do the action

items we're gonna status it and we're going to get through it you know my

project manager and Eid Reisman from the

Applied Physics lab he he always says

you know you work on the missions the missions are fantastic the technology is
great the science is awesome but it's

the relationships you make with the

people that stay with you for life and

it's really true that's awesome so kind

of getting back to Parker Solar Probe

how close are we getting to the Sun

obviously coming out past Venus is

pretty far from the Sun so what are our

distances like here and compared to

earth so you know I often say people ask

me well how close cuz you're getting so

excited it must be really close and I

say oh yeah we're just gonna get just

below four million miles from the Sun

below four million miles from the Sun
surface and I always get people that

look at me like oh I thought you said

you were gonna get really really close

because what I'd like you to say is be

like we're gonna just like drive right

into the side exactly

I want a blaze of glory if I put the Sun

on the earth in the either side of the

football field at the touchdown in the

goal area American football I can I can

translate and you know we'd have Venus

about the 27 yard line of the Earth's 27

you've have mercury at about the sun's

some of those big coronal loops that

you see come out they can come out to
maybe the 15-yard line but you know welcome to the main event Parker Solar Probe who's gonna tuck and run all the way to the 4 yard line so in the red zone knocking on the door for the touchdown let's go Ravens it's very close you know on a meter scale it's four centimeters away on a football field it's four yards away it's really close we you know we tend to not think about just the sheer scales but the Sun is 93 million miles away so getting to 3.7 million miles is super close and it's in that region where all the
excitement happens and so last year a lot of us here were treated to this amazing celestial site when we had the total solar eclipse and you saw that beautiful hazy atmosphere that the corona it's basically the outer atmosphere of the Sun the reason it's called Corona is because it's Latin for crown it does look like a crown around the Sun so the corona that's what solar scientists really live for that's where we're going and so what you were looking at is basically where Solar Probe will be orbiting how long is gonna take to
get there so we are a very busy team at

the very beginning we launched on a
delta 4 heavy with an upper stage from
right here at Kennedy Space Center a
delta 4 heavy the reason we need such a
big launch vehicle is on we're tiny by
the way the spacecraft is tiny we look
like a little hood ornament on the top
of the delta 4 heavy and we are so small
and we're so mass constrained because we
need to be thrown away from the earth
essentially as fast as possible with a
huge amount of energy because we don't
want to be influenced by the Earth's
orbit around the Sun we don't want to be 

00:14:55,299 --> 00:15:01,120 
dragged around with the earth we want to 

00:14:58,059 --> 00:15:03,729 
go in towards the Sun just six weeks 

00:15:01,120 --> 00:15:06,399 
after launch we will fly past the planet 

00:15:03,730 --> 00:15:08,769 
Venus for the first time we use Venus 

00:15:06,399 --> 00:15:10,419 
for gravity assists and a lot of people 

00:15:08,769 --> 00:15:12,399 
are familiar with the idea of you know 

00:15:10,419 --> 00:15:14,979 
we do slingshots around Jupiter 

00:15:12,399 --> 00:15:16,448 
New Horizons for example did one and 

00:15:14,980 --> 00:15:18,339 
took more than a year off its journey to 

00:15:16,448 --> 00:15:20,318 
Pluto because it was able to speed up 

00:15:18,339 --> 00:15:22,630 
using Jupiter and really we use it more 

00:15:20,318 --> 00:15:26,250 
like a little handbrake turn to kind of 

00:15:22,629 --> 00:15:28,509 
just focus and turn the spacecraft in 

00:15:26,250 --> 00:15:30,909 
towards the Sun so we're now going
directly to the Sun about six weeks

after we passed Venus we are in the corona for the first time so it's a very busy time as we had to Commission all the instruments get all the subsystems on get everything working we are traveling at four hundred and thirty thousand miles an hour 118 miles a second New York to Tokyo in much less than a minute it's Listerine Spieth you know it's it's sort of DC to Philadelphia in a second you know it's it's just incredible how fast we are moving that's that's why we're small
that's why we need to move so fast we
to not be in any way influenced by the
earth we want to go to the Sun and study
the corona
so you're hurtling towards the Sun at
unbelievable speeds how do you not burn
up in the heat of the Sun that feels hot
on a floor today from 93 million miles
Solar Probe when she is at her closest
to the Sun will experience just a little
bit less than 500 times the Sun that we
see here so essentially 500 Suns in the
sky at the same time beating down on us
is what Parker Solar Probe will
experience we have a wonderful heat shield sits out the front of our spacecraft the spacecraft itself is very small about a meter across about a meter and a half tool the whole spacecraft stands about three meters tall she's very small the heat shield sits at the top we lovingly call that our eight-foot frisbee because it is a big disc and it's very thin it's only four and a half inches thick obviously one of our biggest technology developments was coming up with that heat shield when i tell people what it's made with they
always sort of look at me like oh I

thought it would have been something

really exotic it's made out of carbon

there are two phase sheets that are very

thin they're eight feet in diameter very

thin and they're made from like a

graphite epoxy so something that you

would have in a nice bicycle or your

golf clubs or a nice tennis racket in

between the the two phase sheets there

is a carbon carbon foam it has the

texture very similar to that horrible

green florist foam that you get that

always sort of falls apart so we have to

handle it very very carefully it's about
97% air and that is a tremendous way to
to keep everything cool and on the very
front of it we have our whiter than
white plasma sprayed it's a bit like a

ceramic coating it's an alumina and it's
plasma sprayed so we say it's plasma
ties in that you heat it so much that it
basically dissociates and you fire it
from a gun a paint gun and coat the
front of the spacecraft with that and
that's actually going to reflect a
tremendous amount of the sun's energy
before the heat shield even has to deal
with that interesting
so I'm assuming that that end is pointed

towards the Sun and everything else kind

of hides behind it absolutely that that

basically creates a nice shade our heat

shield is so good that the front side of

the heat shield will be at temperatures

of about 2500 degrees Fahrenheit

1,400 degrees centigrade but those

instruments that are on the main body of

the spacecraft they're a little warmer

than room temperature it's a sort of

basically not even a hot Florida day

it's a you know it's a pleasant Florida

day it's about 80 degrees Fahrenheit
that those instruments are working out and so that is mind blowing as well

that you can actually manage to cool the environment that much most of the instruments set on that main body the spacecraft and they kind of look sort of sideways around the heat shield however we have do have a couple of brave guys that sit out in the in the full environment we have for sort of radio antennas their electric field antennas that come out and they are on each side of the heat shield so they make a nice cross shape so we can do full
sweeps and get all of the data we want

they're very thin whips they're made of niobium and there's like tubes of niobium and they they stick out and then we have an instrument that I always think of as the bravest little instrument on the spacecraft because it is not a thin tube of me it's a big honking instrument and it's a it's a Faraday cup so we call it the Solar Probe cup SPC Faraday cups have been flown for years and years they're very simple instruments they measure particle populations but getting one that can survive this incredible heat and cool
and heat and cool it's a really important instrument because it's looking at exactly what is coming towards the spacecraft right now you know there's no hiding no hiding behind the shade no peeping around the side it's looking at what we're flying into and so it's a very important instrument for us one of my questions concerns would be that you're gonna have plasma coming around the edge of your heat shield are you expecting this thing to have issues with that so one of the things that's it's difficult to
visualize you know I explained well

the heat shield gets really hot and

everything else is in the shade and

people will say but well

you've still got three million degree

plasma all around you why are you not

still feeling the the effects of it but

if you think of being on the beach here

you're sitting under an umbrella you

have essentially a heat shield but

you're still incredibly hot sure because

the sand has absorbed all of the heat

and you've got a lot of convection and

you've got winds you've got current
things that are blowing in space there
are no there's no convection there's no
there's no real atmosphere in the same
way so space is cold around you there's
no there's no sort of plasma that can
come around because there's nothing to
sort of blow it into the side of the
spacecraft and service the side of the
spacecraft will stay nice and and sort
of cool at this about 80 degree
fahrenheit level but the the way the
that we're traveling we will see a great
deal of different temperatures on the
heat shield as we get close and then we
get cold and so we do know that the heat

shield will kind of deform on orbit it

will sort of maybe puff up like a drum

it may even do a kind of potato chip

income goal where you know maybe two

sides are gonna go up and two tides are

gonna go down is this like a melting

heat shield we're looking at here it's

not melting it's just changing you know

it's gonna get bigger in certain

points and smaller and other points as

it's getting it's you know it's gonna

get very hot and we know the shape will

change and so we have this design of the

way we attach the heat shield to the
spacecraft is again ajust a breathtaking
piece of technology and we have there on
rather like shoulder joints again so you
can you can imagine as the thing is
changing the whole sort of attachment
fixture is moving with it it's kind of
giving into it and it's never going you
know it's not going to just snap off
it's going to kind of move true as the
heat shield deforms in different ways at
different times and different distances
from the Sun the other thing is we we
have to minimize the the amount of heat
that gets conducted into the spacecraft
and so the whole heat shield is attached

with six carbon bolts only which is amazing to me that

sounds like not a lot a spacecraft

headed to the sign right but you know

we've obviously tested and tested and

they're sort of they're called and pipe

and structures they like inverted pie

pans that we are on the backside of the

heat shield and you'll see them in some

of the the pictures of the when you see

our heat shield actually attached to the

spacecraft you can see these pie pans

and then we have this just beautiful
titanium welded structure that is it
it's like I don't know said like a cone shaped that is attached to the main body of the spacecraft and then goes up and out and the heat shield attaches on the top of this their structure and I can tell you that I have I'm not it will probably surprise you I'm not a welder but I have engineer's who I've seen kind of go almost weepy at the beautiful quality of the welding of this structure it is just phenomenal and it's made of titanium and that's what holds our heat shield to the spacecraft so people who
appreciate great engineering and really

00:23:53,990 --> 00:23:59,420
cool technology this is a moment to geek

00:23:56,240 --> 00:24:01,730
out on that it really is and not only

00:23:59,420 --> 00:24:03,860
does this truss hold our heat shield in

00:24:01,730 --> 00:24:07,250
place but it also holds the cooling

00:24:03,859 --> 00:24:09,679
system for the solar panels so it's an

00:24:07,250 --> 00:24:11,269
amazing piece of technology how should

00:24:09,680 --> 00:24:13,009
people kind of relate to this mission

00:24:11,269 --> 00:24:15,109
because there's a sexiness to the idea

00:24:13,009 --> 00:24:16,460
of like flying near the Sun but what are

00:24:15,109 --> 00:24:18,439
you learning to help people and why

00:24:16,460 --> 00:24:22,279
should people be really interested in

00:24:18,440 --> 00:24:24,890
this so the big mysteries are really why

00:24:22,279 --> 00:24:27,139
the corona is so hot why it's so active

00:24:24,890 --> 00:24:29,420
so where you see this 3 million degree
temperature the plasma itself the

coronal material suddenly gets so

energized that it can move away from the

Sun and it sort of bathes all the

planets that kids are continual

streaming we call it the solar wind and

Jean Parker for whom the mission was is

named actually predicted there would be

a solar wind

when I first stumbled across the

mathematics that established the solar

wind it was 1957 I was thirty years old

we're essentially a boulder in the
stream that is flowing from the Sun all the time and so you know here we are we are now we're interacting with this solar wind and so it gets very accelerated it carries with it the sun's magnetic field it carries a lot of plasma it carries a lot of particles and the earth has a magnetic field also when those fields are in the opposite direction just like like poles repel opposite poles attract it will actually allow these two magnetic fields to kind of join it lets all of this energy in from the solar wind lots of great
physics happens all around the earth but

the result is space weather so the nice

part of space weather is the beautiful northern and southern lights okay

the northern and southern lights are essentially a large current system flowing in the sky it's like having a big wire with a current flowing across it a really pretty one very pretty very dangerous one if it happens to be flowing over a power grid at the time all currents need to have somewhere to close if the ground is not conducting they will look for something else to
close through very nice of you you've

671 00:26:14,539 --> 00:26:18,109 actually provided a power grid for them

672 00:26:16,099 --> 00:26:20,959 they can actually flow through the power

673 00:26:18,109 --> 00:26:23,359 grid and cause big damage so you know

674 00:26:20,960 --> 00:26:25,250 we've had catastrophic failures of power

675 00:26:23,359 --> 00:26:27,168 grids we've had burnouts we've had Brown

676 00:26:25,250 --> 00:26:30,230 Arts we've had all kinds of issues if

677 00:26:27,169 --> 00:26:32,450 you lose your power grid everything goes

678 00:26:30,230 --> 00:26:34,730 down now think how reliant we are on

679 00:26:32,450 --> 00:26:36,830 technology you cannot you can't move

680 00:26:34,730 --> 00:26:38,660 money your bank is no longer working you

681 00:26:36,829 --> 00:26:40,369 can't put gas in your car you can't all

682 00:26:38,660 --> 00:26:43,730 these things if you lose your power

683 00:26:40,369 --> 00:26:46,219 eventually you'll have no clean water so

684 00:26:43,730 --> 00:26:48,470 these these are big issues that we deal
with of course satellites get damaged because you let all these particles in and they can get damaged because the radiation belts pump up everything is driven by the Sun we have great models that predict you know you see a big event on the Sun and we predict what that's going to do to earth right now these models have a gap in them it's like the missing piece of the puzzle because we don't know truly what physics is going on in that region because we've never been there and so we'll make transformational improvements in our
ability to be able to protect how the
earth is going to respond to our
ever-changing Sun and so it's it's a
great mission it's a mission of
discovery it's a voyage into the unknown
that we're going to there be dragons
it's amazing from the scientific point
of view but it does have a big societal
impact because that star is there it's
doing whatever it wants to do and we
have to live in the atmosphere of that
Sun so it really does affect everybody
what NASA does is discover the unknown
which is a challenging thing to do dr.
Fox appreciate you and your efforts and your team and your hard work we wish you all the best.

ghosts Parker Solar Probe and thanks dr. Fox coolest tates mission Under the Sun

as dr. fox was talking about the coatings for the Parker Solar Probe heat shield it reminded me we have some similar work happening in our own Applied Physics lab as it turns out this technology is evolving really fast yeah I got a phone call recently from one of the big aerospace companies look at one
of the one of the big ones and they

728
00:28:25,750 --> 00:28:30,309
contacted me and they said we think this

729
00:28:28,210 --> 00:28:32,769
technology is awesome we want to see it

730
00:28:30,309 --> 00:28:34,960
fast-tracked we want to store liquid

731
00:28:32,769 --> 00:28:36,759
oxygen on the moon that's our goal and

732
00:28:34,960 --> 00:28:38,590
we know we can only do that with your

733
00:28:36,759 --> 00:28:40,839
coating that's dr. Bob Young Quist with

734
00:28:38,589 --> 00:28:42,819
me in the booth he spent over 25 years

735
00:28:40,839 --> 00:28:45,189
solving problems and inventing solutions

736
00:28:42,819 --> 00:28:46,689
for shell ground support since the

737
00:28:45,190 --> 00:28:48,430
shuttle program ended in 2011

738
00:28:46,690 --> 00:28:51,009
he's been freed up to do more pure

739
00:28:48,430 --> 00:28:54,610
research today he's here to talk with me

740
00:28:51,009 --> 00:28:56,170
about radiation protection I understand

741
00:28:54,609 --> 00:28:57,729
you're developing a coating that could
help future missions get closer to the Sun then even Parker Solar Probe oh yes yes the right now the state of the art and optical solar reflectors is based on silver and quartz the best the best reflection of solar power that you can buy as basically a quartz layer on top of silver and that has the astonishing result of still absorbing 6 percent of the sun's energy that's a lot of energy and you get close sure and the Parker Solar Probe people couldn't even use that because the silver would melt how close they're getting I mean the Parker
Solar Probe is outstanding. It's an incredible piece of engineering and they have a really effective and-and-and shield that they've developed to help lock the sun's radiation but there's always things you can do to improve on these absolutely and we believe that our coatings would allow you to reflect away more of the sun's energy so that your shield wouldn't get as as hot and you can keep the shield temperature down you can get closer the Parker Solar Probe the heat shield gets really really hot you don't
00:29:58,029 --> 00:30:01,930
want to sit under a broiler okay

771
00:30:00,609 --> 00:30:03,309
this thing's hotter than a broiler I

772
00:30:01,930 --> 00:30:05,080
don't want to sit on that right so they

773
00:30:03,309 --> 00:30:06,669
put about four inches of carbon foam in

774
00:30:05,079 --> 00:30:08,470
there docked as an insulator okay and

775
00:30:06,670 --> 00:30:11,380
that's great it works but we would

776
00:30:08,470 --> 00:30:14,019
rather do is let our shield radiate that

777
00:30:11,380 --> 00:30:16,300
heat backwards okay and put in a

778
00:30:14,019 --> 00:30:17,740
silvered reflector so the inferred

779
00:30:16,299 --> 00:30:19,659
radiation that would normally hit us

780
00:30:17,740 --> 00:30:21,180
bounces off that silver reflector and

781
00:30:19,660 --> 00:30:23,160
gets thrown off to the side

782
00:30:21,180 --> 00:30:27,240
I see so we would rather use a radiative

783
00:30:23,160 --> 00:30:29,970
shield than a big thick piece of okay a

784
00:30:27,240 --> 00:30:31,950
carbon shield okay um so assuming that

and assuming we have a very good reflective surface we believe we can get

maybe ten times closer to the Sun Dan

the Parker Solar Probe so I think

they're getting about four million miles

so you're talking about getting in the

range of point four point four million miles

so 400 miles which again from the surface of the Sun coming from here on earth 93 million miles

yeah that's an incredibly close

incredibly cuz so future emissions could

incredibly close to the Sun which again from the

could pull on you guys

not to create great scientific
instruments for their spacecraft about
to help them protect those spacecraft
even better that's exactly right in fact
I was um invited to go talk to the
coatings are one option you know they
could be brought to bear to help get
even closer to the Sun than the Parker
Solar Probe
so let me talk a little bit about some
more applications yeah that'd be awesome
I love to hear okay so the original
request was that we'd be able to take a
liquid oxygen to Mars and we
demonstrated theoretically and then
built our coatings we put them into a we
actually built a chamber that we could
chill down to 40 Kelvin you're all know
I'm almost absolute zero chill things
down put our samples in there and hit
them with what light and look and see
whether they were absorbing or not okay
and so far we've done quite well on
those tests the coatings are holding up

we need to do a little more work but

we're demonstrating we can keep things cold in space you kind of blew past this

but you built a chamber to test things at 40 Kelvin well yeah we have a cryogenics lab at the Kennedy Space Center okay and they have something called a cryocooler which will take you down to about 20 Kelvin which is liquid hydrogen temperature sure when we put heat loads on it and add structure to that surface it comes up to maybe 40 Kelvin so we're really operating at
about 40 Kelvin so it's very very cold

00:32:24,480 --> 00:32:26,880 which is an accomplishment on its own to

00:32:25,769 --> 00:32:28,440 be able to test with that but you guys

00:32:26,880 --> 00:32:29,850 are getting a chance to test it in an

00:32:28,440 --> 00:32:32,070 actual environment yeah we tweeter

00:32:29,849 --> 00:32:34,428 coatings is fantastic we have a chamber

00:32:32,069 --> 00:32:36,048 that we evacuate and chill down to vary

00:32:34,429 --> 00:32:38,059 temperatures we paint the walls all

00:32:36,048 --> 00:32:39,769 black okay if you were sitting in there

00:32:38,058 --> 00:32:42,648 it would be as if you were sitting out

00:32:39,769 --> 00:32:44,298 in you know deep space Wow very cold

00:32:42,648 --> 00:32:45,618 environment variable black environment

00:32:44,298 --> 00:32:46,999 and then there's a little window at the

00:32:45,618 --> 00:32:48,829 top but we can bring in what radiation

00:32:46,999 --> 00:32:50,868 we want that does simulate various
wavelengths sort of bring in a simulated

Sun sure now it's hard to simulate the

Sun exactly yeah no doubt yeah but we
can we can make ballpark simulations I
don't want to I don't wanna say this
testing replaces an actual testing space

but it's an it's a good step and yeah

people up at the Glenn Research Center

are working with us building a higher

fidelity version of that system cool so

your talk about applications I wanna get

back to that

yeah so they're the people at Glenn that

we're working with they're very
interested in taking propellants into
space and storing them there's a lot of
interest out there and taking liquid
natural gas into space and preserving it
you know liquid oxygen into space and
preserving it without active cooling
being able to take this stuff on a long
long mission rather than having to save
nitrogen tetroxide you actually take a
look at oxygen and liquid oxygen has
much more oxygen in it and nitrogen
tetroxide which is the other material
this coffin use as an oxidizer so you
gain a lot of weight advantage if you
can take liquid oxygen and not have to

add a lot of cryocoolers and cherm

active cooling kind of systems you could

put a tank out in space and it would get
cold it would just the middle way

radiation into the background of the of

the universe and get colder and colder

and colder and you would be able to

store liquid oxygen in space which is

pretty cool which is really called 1990
Kelvin okay very very cold which is

roughly like negative 350 yeah

Fahrenheit yeah yeah in that area in

that area yeah but right now we can't do

NASA Kennedy - Rocket Ranch Podcast E02_ Some Like It Hot_tv7feLPTqeU - transcript (automated).txt[15/09/2019 16:00:33]
that because we don't have any coatings

00:34:19,429 --> 00:34:24,588
that reflect away enough of the sun's

00:34:21,318 --> 00:34:26,509
energy so a few years back I approached

00:34:24,588 --> 00:34:29,210
what's called Nayak the NASA Institute

00:34:26,510 --> 00:34:30,889
for advanced concepts and they agreed to

00:34:29,210 --> 00:34:34,010
fund me to see if I could come up with a

00:34:30,889 --> 00:34:36,260
better coating and we soon realized the

00:34:34,010 --> 00:34:41,419
answer to this problem had been achieved

00:34:36,260 --> 00:34:42,740
by the optics community in the 1960s the

00:34:41,418 --> 00:34:46,940
same problem they couldn't come up with

00:34:42,739 --> 00:34:46,939
a good reflective coating and they

00:34:44,690 --> 00:34:48,349
realized the way to make a good coating

00:34:46,940 --> 00:34:51,019
is to use

00:34:48,349 --> 00:34:52,789
white scatterers think of snow clouds

00:34:51,018 --> 00:34:54,949
okay you know these things are bright
white and they're bright white because

they don't absorb the visible light that

your eyes can see they just bounce it

all around sure little particles and

they scatter that light back at you and

they're very very efficient at that they
don't absorb essentially absorb almost

nothing and so all that light has to go

somewhere so eventually it all gets

scattered back big snowbank

you know saw a salt shaker you know

cotton fiber so all these things are

white because they're scatterers so if

you want to make a really good reflector
of energy what you do is you say to yourself over what spectral band am i interested do i want to scatter ultraviolet as well don't want to scatter infrared your how what do i want to scatter you find a material that won't absorb that energy you know some sort of base material make sense grind it up into a powder okay and maybe sintra mix a little water make a clay and sorry centering is what we do basically what you did when you were in seven eighth grade when you made clay and you put it into a kiln and you fired
it up that kind of thing okay so you're

basically just taking this stuff making

a powder add a little water and make a

paste squeeze it into a mold put it in

an oven a kiln fire it pull it out and

you're done you got a tile that will

scatter energy over whatever band you

chose and so you can make your own shape

exactly you make your own shape and you

can make this stuff arbitrarily thick

and you can make it out of pretty much

whatever material that you want okay so

we chose the material originally called

barium fluoride which is an optical
material that is transparent from the ultraviolet through the visible through the near-infrared the mid infrared into the four even where you're the heat your body's giving off goes right through this stuff interesting yeah so it's very broadband so you can grind we actually buy it as a powder make these tiles out of it and these things should theoretically and so far to the best of our measurements scatter away the majority of the sun's energy theory says if you coat a tank of this stuff at the Earth's distance from the Sun the tank should get well below liquid oxygen
temperatures so can I coat my house in this like it's Florida it's high summer
time is coming can I keep my house cool with this stuff you could you could but there are cheaper approaches here on earth here on earth the ozone layer blocks a lot of the UV okay so you don't have to worry about that stuff the atmosphere won't transmit a lot of that infrared so people have come up with cheaper white coatings okay and barium fluoride got you barium fluoride is ideal for when you're above the ozone layer and you get
that really there's a lot of really harsh ultraviolet coming off the Sun you know that doesn't make it to the ozone sure and so down here on earth at ground level you know things aren't quite as bad it's not quite the spectral extent of the Sun that we have to worry about in space so if my house is on the moon oh is this what I want yeah this is what you want okay so this is beyond Earth this is kind of the right solution for what we want but let me talk about I got talking to some of the
people from the Jet Propulsion lab okay

one of our centers out in California

that's right and I gave a presentation

to them concerning my mic coating and

its ability to get closer to the Sun you

know then the Parker Solar Probe

currently able reach and they raised two

very interesting issues the

possibilities the first one is they

would like to better test Einstein's

genral theory of relativity okay and

they need a very strong gravitational

field to do that okay so they would like

to get close to the Sun and park like an
atomic clock and watch and see how time passes close to the Sun interesting and

try to help continue to validate Einstein's theories interesting but the other topic they raised is truly fascinating they would like mankind to begin its first interstellar missions they would like us able to launch I'm not a pioneer and Voyager to take you know a hundred years to get any substantial distance they would like an actual mission that's going so vast that it flies out of the solar system and can reach some point between the stars between our star and say Alpha Centauri
sure it can look back at us sure and we can start to image our actual solar system from some distance out okay and see what things really look like out there and what the environment is truly like we're just conjecturing now but this is a mission to get out there and really do it okay the only way right now with current technology to go that fast it's the slingshot around the Sun Oh interesting they have to get closer than interesting yeah then about a million miles from the surface of the Sun that's
that is terribly interesting so we've

seen gravity assists with missions like

new horizons even partner Solar Probe is

gonna do a few with Venus but we're

talking about doing it off of the saw

for the Sun itself so you take the

biggest gravitational field you have in

the solar system and you're gonna

slingshot around it you're gonna use it

as your gravity assist do you know did

they give you a sense of how fast

they're talking if they can pull this

off how fast they're that that slingshot

will give them what speed they'll get I
mean it comes to hundreds of kilometers

a second i don't quote me or you are
gonna quote me we all hold you to it but
told you hundreds of kilometers a second
okay I feel really really bad it's
really really fast okay there they
actually give their distances there
their speeds in terms of astronomical
units in other words the distance from
the Sun to the earth astronomical units
per year and what they want to do is
leave Pluto sure flying past Pluto and
still be moving at about 20 astronomical
units a year we heard from the Parker
Solar Probe folks that the corona which

1070
00:40:34,608 --> 00:40:39,199
comes out a great distance from the Sun

1071
00:40:36,199 --> 00:40:40,789
is hotter than the Sun itself so how

1072
00:40:39,199 --> 00:40:42,680
does this kind of coding help you get

1073
00:40:40,789 --> 00:40:44,150
even closer because obviously you're

1074
00:40:42,679 --> 00:40:47,239
talking about the ability to get closer

1075
00:40:44,150 --> 00:40:47,930
under a million miles is the corona not

1076
00:40:47,239 --> 00:40:50,778
an issue

1077
00:40:47,929 --> 00:40:53,719
yeah the corona under the analysis that

1078
00:40:50,778 --> 00:40:55,969
I've done the corona is not a serious

1079
00:40:53,719 --> 00:40:58,519
issue because the density of material is

1080
00:40:55,969 --> 00:41:01,099
very very low there's really very little

1081
00:40:58,518 --> 00:41:04,458
material there you know that the Sun has

1082
00:41:01,099 --> 00:41:07,579
a photosphere that's very dense and you

1083
00:41:04,458 --> 00:41:09,649
know 6,000 degrees Kelvin so do you know
it's hot but not incredibly hot then you

got this all that sounds really hot I

know but you got this transition region

they call it the transition region and

above that the corona starts okay

Coronas around a million degrees much

much hotter but it's very very sparse

there's very few particles there in fact

the solar wind when you go out leave the

Earth's magnetic field the solar wind

has come

two particles that have an effective

temperature on the order of a million

degrees but there's only one particle
per cubic centimeter there's almost no

particles there you're seeing that the

emission from the Sun of these particles

that have a lot of energy but there's

not a lot of them so the corona it does

extend out from the Sun it is very high

temperature but there's very little

energy content to it I want to ask you

so we talked about repelling the heat

and radiation is this enough to protect

humans if I take a capsule to Mars one

of the challenges we know of is the

radiation from the Sun how can I protect

myself with this okay well the different
kinds of radiation okay

yeah that's man that's so important to

try block is the stuff you see

it's the mostly the visible light coming

off the Sun the the the visible and

ultraviolet and infrared irradiance the

light that's hitting you now the Sun

also has solar wind coming off with your

particles Sheratons electrons and that's

a source of radiation that's easily

blocked unless there's a solar flare if

there's a solar flare then you get a lot

of particles in a high-density with a
lot of energy now you have to go to a

safe room I'm going to block yourself

our coatings don't help with that now

you're talking okay you know PI higher

radiant high high levels of particles

with high energies and then there's

galactic cosmic radiation which just

sounds awesome to say that like it just

sounds really cool I'm sure a lot of

dangerous well they're the remnants of

supernovae okay and so they're bad and

the sun's magnetic field gets rid of a

lot of it but the really nasty stuff

still reaches the earth the Earth's

magnetic field blocks most of the rest
but when you're above the Earth's magnetic field you're subject to being hit by galactic cosmic radiation and these are the nuclei of things like iron like an iron nuclei that's coming at you so fast there's no electrons stuck to it anymore it's just a bullet see that doesn't sound cool it just sounds scary no yes yeah galactic cosmic radiation is scary but that's a whole nother another world the nuclear thermal propulsion program needs to take a liquid hydrogen to Mars okay I mean liquid hydrogen hydrogen has to be done
at 20 Kelvin I mean you're talking getting you're getting close to absolute here

when you talk liquid hydrogen okay even with our coating even optimally with our coating we cannot block enough of the sun's energy to maintain liquid hydrogen so you have to have active cooling onboard okay but we can make it better sure yeah we can lower the heat load on these liquid hydrogen tanks with our coating sure and the nuclear thermal propulsion people have come to us and have talked to us about flexible
versions of our coatings very thin
layers that can be just sprayed on and
we're currently making significant advance in that direction with some funding from the nuclear thermal propulsion agency so that's one direction that we're going is coming up with in versions of the coating the performance is not as good as a very thick coating so how does that work because you've talked about it's just kind of reflecting that energy yep so do you still need a thickness there to really be effective what we're doing is
no different from white paint okay in

1184
00:44:35,778 --> 00:44:39,349
the fundamental understanding okay so a

1185
00:44:37,789 --> 00:44:41,509
thicker coat yet covers up the darker

1186
00:44:39,349 --> 00:44:43,278
colors go to Home Depot buy the best

1187
00:44:41,509 --> 00:44:44,869
quality white paint cigars and put it on

1188
00:44:43,278 --> 00:44:47,329
the wall and paint over a black surface

1189
00:44:44,869 --> 00:44:48,470
yeah didn't you look at it you go is

1190
00:44:47,329 --> 00:44:50,390
that good enough now it's kind of

1191
00:44:48,469 --> 00:44:51,230
brownish yeah so you put another layer

1192
00:44:50,389 --> 00:44:53,868
okay whiter

1193
00:44:51,230 --> 00:44:55,880
I got you more layers you put the whiter

1194
00:44:53,869 --> 00:44:58,369
it gets okay there's no there's never an

1195
00:44:55,880 --> 00:44:59,720
dead to that okay you can keep on the

1196
00:44:58,369 --> 00:45:01,548
thicker and thicker and thicker but

1197
00:44:59,719 --> 00:45:04,548
there's a course a place where you have
so little sure you know loss you know

I've liked actually getting through all

that white paint being absorbed by that

black under layer that you don't care

anymore sure and when we talk about a

layer what are we talking about

thickness wise

well they spray on coatings that we're

doing are probably 100 microns I have

four thousand seven inch five thousand

seven inch five thousandths yeah for the

thin core for a coat yeah for this for

spray on coating for this that's not if

you want to get a really good
performance we're talking a couple of millimeters okay ten so so a tenth of an inch so that gives you a really really a good effective yeah yeah we're resistance to sun's energy yeah that's awesome yeah with the newer materials it will hopefully that gets improved a little bit we still have some optimization going on but some were in that ballpark so with fast tracking what does that timeline look like are we talking like a couple years ten years but you know the problem with doing research and
and development is you tend to make these long several months not much happens and then there's this leapfrog and suddenly you have things work better or suppose you step back a bit so I'm hesitant to say in a year we'll have it work her you know like like the barium fluoride we started off with we discovered and found experimentally we can't get water off of it very easily and so we're actually changing to a different material right now okay and we're looking at other options because the barium fluoride even though it's
great and we'd be really good to go to

00:46:26,119 --> 00:46:29,779
the Sun because the sun's heat would

00:46:27,500 --> 00:46:31,579
bake off the water it's not the

00:46:29,780 --> 00:46:33,410
appropriate material to use to get

00:46:31,579 --> 00:46:35,360
really cold because of that its water

00:46:33,409 --> 00:46:37,219
isn't is something that absorbs some

00:46:35,360 --> 00:46:39,380
ultraviolet and some infrared and it's

00:46:37,219 --> 00:46:41,209
not the material of choice so we don't

00:46:39,380 --> 00:46:44,090
want that water in there so obviously

00:46:41,210 --> 00:46:46,490
some some details and some hurdles along

00:46:44,090 --> 00:46:47,660
the way what's the what's the process of

00:46:46,489 --> 00:46:49,339
developing a technology like this

00:46:47,659 --> 00:46:50,690
obviously like you've made some really

00:46:49,340 --> 00:46:52,820
good progress you're learning more

00:46:50,690 --> 00:46:54,460
you're adapting and adjusting the the
00:46:52,820 --> 00:46:57,350
approach so where do you go from here

00:46:54,460 --> 00:46:59,599
well there's actually a multiple
directions that we're going and a lot of

00:46:57,349 --> 00:47:01,549
that is based on a variety of customers

00:46:59,599 --> 00:47:03,610
within ten years there are 200 more

00:47:01,550 --> 00:47:07,039
astronomical units how they start

00:47:03,610 --> 00:47:10,639
getting substantial distances yeah

00:47:10,070 --> 00:47:12,410
that's awesome

00:47:10,639 --> 00:47:14,420
yeah that's so cool hey is it possible

00:47:12,409 --> 00:47:15,739
to block out too much radiation can I

00:47:14,420 --> 00:47:17,150
can I create something that's too
effective is there a problem with you

00:47:15,739 --> 00:47:19,849
well well like in our early analysis we
showed that as you're flying to Mars and
you're blocking all the sun's or
substantial amounts of a sun's energy
it's a possibility that the liquid
oxygen can freeze okay people don't want
it to freeze sure you can't get at it
sure we've actually I'll come back to us
and say don't get too cold we want some
pressures or we can pull out that oxygen
as we need it it's probably easier to
just not put as many layers yeah so
that's an easy problem probably to deal
with it is also these other sources of
heat you can conduct heat from other
parts of your craft you can actually pick up infrared warmth from planets from Mars or from the earth they give the earth gives off a huge amount of heat you know as a radiating warm body so when you're up in orbit when when the orbiter was in orbit they have a radiative heat rejection system that works when they're facing the Sun it does not work when they the earth interesting how they turn and face the earth there's so much infrared heat coming off the earth the orbiter starts heating up and they
can't keep it cool inside they have to

00:48:19,199 --> 00:48:23,129
actually turn and face away from the

earth towards the Sun or space so I mean

00:48:23,130 --> 00:48:25,559
these things are all kind of

00:48:24,119 --> 00:48:28,230
counterintuitive I mean you would think

00:48:25,559 --> 00:48:30,299
the Sun is your big source of heat but

00:48:28,230 --> 00:48:33,150
when you're in low-earth orbit the earth

00:48:30,300 --> 00:48:35,160
is radiating from this huge extent sure

00:48:33,150 --> 00:48:42,090
it's a huge object so the heat is coming

00:48:35,159 --> 00:48:40,349
from all directions at you the Sun is

00:48:37,110 --> 00:48:42,090
just one point in the sky so that that

00:48:40,349 --> 00:48:43,500
that heat issue is something you really

00:48:42,090 --> 00:48:45,690
have to keep in mind when you're

00:48:43,500 --> 00:48:48,300
orbiting Mars or orbiting the Earth

00:48:45,690 --> 00:48:50,940
yeah that's it's crazy to kind of make
the mental leap from understanding the
world and kind of how heat and things
work around us in an atmosphere but when
you get to a vacuum of space yeah it's a
different game everything is ready to
the temperatures of the planets the
temperatures you know of the moons you
work out the temperature of the moon
itself and all you really need to know
is that the Sun is hitting it with
radiation and you can work all the
numbers and you get a really good
estimate for the temperature of the moon
on the side facing the Sun the same with
the earth you know the earth's temperature is heavily dictated you know by its interaction of the Sun there's a little bit of internal heat coming up from the core but for the most part the Earth's attempt earth and the moon and the planets their temperatures are set by their interaction of the Sun and that's all radiative awesome dr.

Jung Quist appreciate your time today this has been phenomenal good luck to you and your team well thank you so much for having me I appreciate it that's our show thanks for stopping by the rocket
range and special thanks to our guests.

our son scientist Dr. Nicky Fox and

dr. Bob kraut coatings extraordinaire Dr. Bob

young quest to learn more about all

things son you can head to nasa.gov slash son they are also several NASA podcasts you can check out to learn more

about the science happening all over our

centers at nasa.gov slash podcasts and

shout out to our intern Madison Tuttle

who helped make the rocket range

possible our sound man Lauren may three

headed ER Michelle stone our producer

Jessica Wanda and our production manager

00:50:13,230 --> 00:50:17,010
Amanda Griffin tune in next month as we

1355
00:50:15,659 --> 00:50:18,629
can hear how experts are working to

1356
00:50:17,010 --> 00:50:20,789
despite failure isn't enough

1357
00:50:18,630 --> 00:50:23,369
when you human lives are on the line and

1358
00:50:20,789 --> 00:50:26,420
remember on the rocket ranch even the

1359
00:50:23,369 --> 00:50:26,420
sky isn't the limit