The Edge Series Two
Meteor Chasers

Scene	Content	T/C in 10.00.00
Title Seq': The Edge		Music in 10:00:00 music out 10:02:25
New Mexico. Desert landscape. Caption: Arizona, USA Desert road, lonely Diner	Music	10:00:21
Int. Diner. TV playing- US news report	V/O: … here is the south west we're going to have one of the best views of the big Leonid meteor storm in the world because it's going to be completely dark here when the storm is at its height …	10:00:34
CU TV report Leonid animation	V/O: … The main event is due to happen at about three AM on November eighteenth and it promises to be a spectacular show …	10:00:43

TV report	COMM: … The Leonid meteors come from a comet named Temple-Tuttle that orbits the sun every thirty-three years. When the earth passes through the streams of rock fragments that come from the comet they burn up leaving fiery trails, a great natural firework display.	10:00:50
Int Diner. TV Meteor devastation Atom bomb. Up & past Diner Int. Camper on the move. Steve Evans & Andrew Elliot both passengers	COMM: The Leonids pose no threat to us but there are objects in our solar system that could wipe out all life on earth. It's all a question of size. Siberia, 1908. 2000 square miles of devastation was caused by a giant meteor strike, more powerful than the Hiroshima Bomb. The orbits of comets shift as they lose material when the come close to the sun meteors that come from them can be used to track the comets path. And that's where these men come in. Steve Evans and Andrew Elliott are astronomers from the UK who specialise in the study of meteors.	10:01:05 10:01:15 10:01:25 10:01:35

Desert - Team setting up equipment		They are part of a huge international effort to map the orbits of Near Earth Objects, a project that may well save humanity from the fate of the dinosaurs.	
Dusk – Andrew and Steve MCU's Steve and Andrew setting up equipment Sunset	COMM: But there is something that distinguishes the two British Scientists – they are amateurs. Steve Evans sells computer components and Andrew Elliott is a vet. But alongside their professions, they're also top astronomers in their field, natural Meteor Chasers.		01.53
Leonid Meteor Shower blazes across the sky Caption: Meteor Chasers Fade to black	Music		10:02:10

Starscape (NASA)	COMM: We have been studying the universe for thousands of years. Our knowledge is vast but there is so much more to know. The resources of full-time, paid astronomers are stretched to the limit. Fortunately there is another cohort of scientists who shoulder a great part of the burden …	10:02:26
Mark Armstrong	COMM: … gifted amateur astronomers. One of the greatest concentrations of this part-time talent is in Britain.	10:02:43
Sir Martin Rees	SYNC: In astronomy there are certain branches of the subjects where the amateurs play an important role because what they are doing is scanning the whole sky every night. And so what is often happened is that its been the	10:02:51

	amateurs who have been the first to draw attention to a particular exploding star or comet etc.	
Neil Tanvir	SYNC: Amateurs now with fairly modest size telescopes in particular with CCD cameras are able to make observations which are of professional quality. The great thing about the amateurs is the large numbers of them. Frequently what we really need in astronomy is a lot of data being brought to bear on a particular field in order to make progress.	10:03:08
Int. car. Steve Evans, driving	COMM: It doesn't matter who collects the data, amateur or professional, so long as it's	10:03:30

	long as it's accurate. And that	

knowledge could one day lead us to the stars or prevent the extinction of humanity.

Int. car. Steve driving. Intv. Steve Evans Caption: Steve Evans	SYNC & V/O: I think astronomy is one of the few sciences, if not the only science if not the only science left that ordinary people without really expensive equipment or without huge amounts of knowledge can actually make real contributions to science, something that you couldn't do in nuclear physics for example. I'm sure it's not possible for amateurs to be involved.	10:03:42

Steve setting up monitoring camera.	COMM: Not all astronomy has to be done with huge telescopes on the tops of mountains. Steve works from his back garden and yet he is a leading light in a pan-European meteor tracking programme with Dutch amateurs and Czech professionals.	10:04:05
Intv. Steve Evans – Setting up equipment	SYNC & V/O: All the meteors we see in the night sky are originally derived from comets. At certain times of the year the earth encounters the debris which has been laid down fairly recently by a comet. That we term a meteor stream. The information that we can derive from the orbits of the meteors can give us an understanding of the evolution of the meteor stream. But it can also give us clues as to what is gonna happen	10:04:18

	to the stream in the future	
Steve Evans I/V & setting up kit	SYNC & V/O: There are two main pieces of equipment , the 1st component is the actual image intensifier itself, which amplifies any available light. This 1 amplifies the available light by 50, 000 times. We put a lens on the front of the intensifier to form an image on the front screen. And then to actually record the image on the rear screen, we use a standard hi-8 camcorder. I'm working in collaboration with another amateur, and effectively what we are doing is we are recording or monitoring the same parts of the sky. And hopefully we'll	10:04:45

	record the meteor actually simultaneously from 2 locations on the earth's surface.	
Andrew Elliott with equipment	COMM: Steve and Andrew use photographs as well as video.	10:05:25

Intv. Andrew Elliott Caption: Andrew Elliott	SYNC & V/O: This is basically a Meteor camera, it uses two photographic cameras. Which will take pictures through the night, about 4/5 min duration. The rotating shutter breaks up the trail of the meteor when it passes through. So you are able to get an estimation of the speed of the meteor through it.	10:05:28
Andrew setting up video camera. Meteor tracks on screen	COMM: Using simple equipment Andrew and Steve can record very clean and accurate images of meteors striking the atmosphere. The video data gives them an accurate time of appearance and the photographs, clear against the streaks of the star field, tell them the position of the meteor in the sky. The breaks in the trail give	10:05:59

	them the speed and Steve uses these three elements to compute the orbit of each meteor.	
Steve Evans with computer measuring meteor	SYNC & V/O: There's actually the segment of the meteor and the start of the meteor break. We are gonna measure that. And you can as see the meteor starts to get brighter that the segments Become more readily visible. You can see what I'm doing is actually measuring the end of every break.	10:06:13

Columns of figures	Steve V/O & SYNC:: The software carries out the calculations and you can see there are lots of calculations involved. And right at the bottom it gives us the info we are really interested in which is the radial. And orbital elements of the meteor.	10:06:33
Data Trailer Park Caption: November 15th 2001, Albuquerque, New Mexico	COMM: The data Steve and Andrew gather is sent to their professional colleagues at the Ondrejov Observatory in the Czech Republic. They use it to map the orbits of asteroids and comets. But the whole team has come to Albuquerque, New Mexico, to track the Leonids. Funds are limited so transport and accommodation has to come at a reasonable price but still have enough room for	10:06:50 06.59

	eight people and a lot of equipment.	
Looking at camper	SYNC: OK There a little different inside but basically the same inside Various Incidental Chatter	10:07:12

Steve, Andrew et al, loading campervan in Albuquerque. Cloudy skies	COMM: The team has arranged observing sites within a few kilometres of their base in Albuquerque. But the weather has turned against them. Heavy clouds will prevent any sight of the Leonid meteors. The team has to find clear skies and quickly, but no one can agree on where they might be.	10:07:35
Hans and Pavel arguing Clouds over mountains SYNC argument	SYNC & COMM: There is not so good forecast for south west it is better to go west. We've gotta go South west, we've lost a day ain't we and we'll be really struggling to make the time up. Incidental chatter … is it possible to have 1 station here and 1 there. No it is too close. What's this distance?	10:07:53

Arguing on back of golf cart	COMM: It’s vital that they find somewhere to observe from because this will be the last chance to see the peak of the Leonids, in ideal conditions, for 66 years. Continued argument	10:08:22
Campervans leave site Moody dusk shots of driving	COMM: Finally a decision. They'll head West to Arizona but to escape the cloud front they have to travel at least 400 KM. There is no guarantee that the weather will be any better or that they will find a site to observe from. But it’s their only hope of seeing the Leonids.	10:08:35
Driving at night	COMM: Steve and Andrew are interested in Near Earth Objects but most UK amateurs, like the professional colleagues, are particularly active in the exploration of	10:08:52

deep space.

CU Meat on wooden slab. Chopper comes down and cuts it. MCU Dennis Buczynski serving customers in his shop	COMM: One of the leading observational astronomers in the UK is Dennis Buczynski, a butcher in the north of England. His astronomical career started when he went to look for a bright comet that was predicted to be visible in the western sky.	10:09:03

Intv. Dennis I/cut with serving customers etc.	SYNC & V/O: I went to look for it but I never saw it And there were quite a few people there at the time. I'd borrowed a small telescope from my friend. I was able to look at a couple of the planets. I just went to the library and read as much as I could. It went from being an interest to an obsession after that. That's how I started in 1974. I joined the British Astronomical association and became involved in some of their observing sections. It was only really when I found that we were able to do work that was useful to professional scientists that I took it really seriously.	10:09:20

LS across valley to Dennis' house and dome in the garden Dennis walks to Dome	COMM: With a team of friends, Dennis has built a 33cm telescope in his garden. When he started like all other astronomers, Dennis used conventional photography but advancing technology has transformed his work.	10:10:06
Sir Martin Rees CCD camera & telescope	SYNC: All of astronomy depends on advanced technology and the most important development in the last 20 years perhaps, apart from the availability of space techniques, has been the replacement of photographic plates by charge coupling devices, these are solid state chips which are very sensitive to faint lights. This allows telescopes to detect faint lights 100 times more efficiently. And this means that not only professional, big telescopes do 100 times better but the amateurs with a 10-inch telescope can do the things that required a large telescope in the photographic era.	10:10:20
Starscape	COMM: The relative brightness of stars, as we see them from earth, is expressed by their magnitude figure. The higher the number the fainter the	10:11:00

	star. But they can be brighter or dimmer depending on their intensity or how far from earth they are, so astronomers have to be expert in distinguishing the true nature of the stars they observe.	
Dennis & telescope	SYNC & V/O: When we look at stars with this type of telescope, we are generally looking at very faint objects which are impossible to see with the naked eye. In fact, even if you looked through the telescope with your eye, you still wouldn't be able to see them you would need an electronic detector to see them, the very faint objects. But they are very important objects as well.	10:11:19
Building Mount Palomar	COMM: The famous Mount Palomar Telescope, largest in the world when it was completed in 1948, conducted a complete survey of the stars down to magnitude 20. All stellar data and discoveries are measured against it. Now, amateurs like Dennis Buzcynski are making it obsolete with their home built telescopes.	10:11:40

Dennis opening his observatory	COMM: For people like Dennis this means that they are able to look hundreds of millions of light years into the universe and do science that would previously have been the preserve of professionals.	10:12:01
Sir martin Rees	SYNC: There are some types of stars which are variable, they pulsate or they explode. We also find a large fraction of stars are in binary systems. There are pairs of stars revolving around each other, you see variations in there light if for example eclipses the other during its orbit. You can infer things about a star like about how heavy they are which you cant infer if you see the singly. And the volume of data which is involved in these studies is colossal.	10:12:11
Dennis Buscynski	SYNC & V/O: It's particularly suited to amateur groups because we are not restricted by time we don't have to apply for telescope time. Because we have our own telescope in our own observatory. We can set up on a star and stay on it all night long.	10:12:47

Variable star book Dennis exits dome and enters shed	COMM: British amateurs have been studying and recording data on variables since the formation of the British Astronomical Association in 1890 – and people like Dennis are carrying on that vital work on every clear night.	10:13:08
Dennis in shed	SYNC: Well, we go and find a star in this list of stars here, which are bright stars. And we'll set the position of the telescope and the telescope will slew to that particular position. We will then take images and these images look like this. This particular star is WZ Sagitar and it's a very famous cataclysmic variable and has only been seen erupting 4 times since it was 1st discovered. A cataclysmic variable can vary in brightness over a period of a couple of hors from the faintest to the brightest. Bu t then they take a few months to disappear back to the faintest levels. So these levels we will measure over a couple of months and send it off to the professionals.	10:13:23

Campervan up & past & down road in Petrified Forest national park Int van. Travelling	COMM: Back in the desert, the Meteor Chasers have crossed into Arizona and found clear skies but it has taken hours to escape the clouds and they are well behind schedule.	10:14:15
Camp site, setting up equipment Steve and Andrew chat & Hans setting up and chatting Czechs cooking Setting up equipment	COMM: By midday they manage to identify one site at a camp ground just outside the town of Holbrook They are here to check on the predictions of two professional astronomers, David Ashur and Rob McNaught, who say that the peak of Leonid activity will occur at three AM on the eighteenth. That's still 40 hours away but tonight they have to make sure that all their sensitive equipment is operating properly. If it fails the whole trip will be wasted	10:14:29 10:14:52

Single van on road	COMM: The Czech team, accompanied by Steve Evans, head north for at least 100 km to find a site for a second observing point.	10:15:15
Andrew setting up	COMM: Andrew Elliott is part of the southern team.	10:15:26
Andrew	SYNC: This is what proper astronomers do, to come out here and do this, to go back to basics having to actually go out and look at the sky with all this equipment to set up which is quite a professional set-up and its got to be done properly. It can take a lot out of you. When you have a shower like this you observe right through the night to the early hours and then roll into bed at six-o-clock in the morning and hopefully get	10:15:30

some sleep.

Hazel opening her telescope	COMM: There are hundreds of men and women in Britain engaged in serious astronomy. Most use CCD technology but some, like Hazel McGee, prefer more traditional methods.	10:15:58
Intv. Hazel McGee Hazel at telescope	SYNC: & V/O: I am a visual observer I am observing variable stars. Quite often I can look in my telescope and see a blank piece of sky in the field night after night and then suddenly	10:16:10

I'll look in the telescope and there is a bright star in the field and of course the field looks completely different.

The pattern of the stars looks completely different and if it' something I was expecting I feel satisfied And if its something I wasn't expecting I feel even more satisfied – that's exciting.

Hazel adjusting telescope and making observations	COMM: Hazel has been observing for nearly 10 years. She, and the dedicated amateur scientists like her acquire an enormous amount of data. But to have real meaning that information has to be shared with astronomers around the world. SYNC: LL Lyra, 143 … etc	10:16:42

Guy Hurst answers phone Rostrum: The Astronomer	COMM: Guy Hurst, President of the BAA, who recently retired from his work with a bank, runs The Astronomer Magazine, the amateurs' bible.	10:17:00
	SYNC & V/O: The way the system really works is that TA collates the monthly observations, we publish them within 20 days of the last date they were made in a very raw form, but the professionals regularly monitor the magazine. They sometimes want urgent information because they are planning a programme themselves. So rapid publication is very useful relationship between professional and amateur. What's happened is the professional astronomers have moved into x-rays, IR, UV	10:17:10

	and as these gaps have been left behind, the improvement in technology has enable the amateurs to step into those areas that need doing – they need regular monitoring. The classic is the asteroid. Everybody is agreed that we need to track and find new asteroids especially those that threaten us and follow them long enough to predict where they might go. Amateurs are doing that as well now.	
Czechs arrive at Antelope Mesa Set up kit	COMM: After three hours driving and frantic searching the northern team finds an ideal spot. It's called Antelope Mesa, 1700 metres above see level and far from any light pollution.	10:18:15 Music in 10:18:06 music out 10:18:30

Steve & Pavel set up cameras Moving van	SYNC: Various incidental chatter …What's he doing with the van? Is he bringing it closer?	10:18:30
COMM: Antelope Mesa is perfect for observing but it's taken too long to find it. It's five-o-clock and the sun has dipped below the horizon, in twenty minutes it will be dark and they still have to set up and test all of the experiments. If they miss this opportunity there won't be another – the pressure is beginning to tell.		10:18:57
Steve setting up – dial	SYNC: I haven't had so much fun since I had my wisdom teeth out.	10:19:18
Steve & Pavel setting up cameras - sunsets	SYNC & COMM: It is a measure of the dedication of these part-time scientists that they have paid their own way to come here. All the money for flights, the camper-van hire, the transport of equipment, the equipment itself, comes out of their own pockets.	10:19:27 music in 10:19:30 music out 10:19:50

Mark Armstrong' Cottage Mark from cottage to observatory Mark opens observatory roof	COMM: Part time or professional – astronomers receive little recognition for their work. But sometimes an individual achieves something that gets their name in the history books. Mark Armstrong is part of the foremost UK Supernova Patrol. Up to 1996 no UK Astronomer, professional or amateur, had found a supernova. Mark discovered the first. But why are supernovae so important?	10:19:52

Margaret Penston Caption: Dr. Margaret Penston, MBE – Vice president of the Royal Astronomical Society Supernova explodes Mark & telescopes	SYNC: Supernovae are a massive explosion of a massive star Astronomers know from studying many examples of these that the intrinsic brightness, the intrinsic luminosity of these type 1 supernovae are all the same. So if their intrinsic brightness is the same then you can work out how far away they are. Just the same as when we look out at night at the street lamps – we know that all street lamps are about the same the ones that are more distant appear fainter than the ones that are at the end of your driveway. In exactly the same way astronomers can work out how far away these supernovae are. Its important to find as many supernovae as possible in as faint galaxies as possible seeing further and further back in time and learning more about the universe.	10:20:17
Marks Telescopes	COMM: Mark built his own observatory and over the years he has equipped it with some of the best telescope and camera technology available.	10:21:03

Intv. Mark Armstrong Mark and telescopes Mark goes down the hill to cottage & Mark through cottage window	SYNC & V/O: This is a twelve-inch smith casergrain telescope. Its very simple to operate it's a question of telling the telescope at the beginning of the night what star its pointing at and then what I do is let the computer take over but alternatively you can use the handset to go to any object in the sky. It's a question of looking at as many galaxies as you can as often as you can. So a typical November night will start at 7 o'clock and finish at quarter to six.	10:21:12
Mark inside cottage with computers	SYNC & V/O: On this computer you would have the image which has just come down, on this one here you'll display the best image you have taken in the past as a reference image. And its just a question of looking at the two, hopefully you'll have an extra point of light which will be a possible supernova.	10:21:44
CU galaxies on monitor	COMM: Since his first discovery Mark has found over thirty supernovae. But one of his most important discoveries came in May 2001.	10:22:03

Intv. Mark Armstrong	SYNC & V/O: It was a typical observing night and one of the galaxies in the program and I noticed a very faint new object It was only on some of the images but I was confident that there was something there. In the end it took the intervention of the professional astronomers to get the image for me. The resolution of the one metre telescope comes into play here, it turned out it was a core collapse supernova - a massive star - but a low energy event a new object type. A useful object that professional astronomers were pleased that I followed through and there's going to be a paper on it as well.	10:22:11
Night in the desert. Setting up equipment on Antelope Mesa Setting up cameras	SYNC Dial: COMM: It's past midnight. Time to test the equipment. The cameras and videos are fired up. But not everything on Antelope Mesa is running smoothly. The synchronising system on the cameras has gone haywire.	10:22:50 music in 10:22:47 music out 10:23:30

Problems with cameras	SYNC: Is there power? As soon as this gets plugged in its making an exposure and it shouldn't be. … why's it doing that?	10:23:13
More fiddling with cameras Night sky	COMM: Things are going badly at the southern base as well. Their generator has broken down. Thankfully the peak of activity is expected tomorrow night.	10:23:30
Night sky Animation: Gamma Ray Burst	COMM: The Leonid Meteors are very close in astronomical terms. But there are amateurs in the UK who are part of a project which involves the study of gigantic and mysterious explosions of gamma radiation at the edge of the universe.	10:23:42
Dr. Neil Tanvir Caption: Dr. Neil Tanvir	SYNC & V/O: These gamma ray bursts are actually coming to us; the light is coming to us from far away across the universe. Its taken many billions of years to reach the earth but the implications of that these are really enormous explosions the amount of radiation, the power we are talking about is far larger that any previous phenomena that has been studied in the universe.	10:23:58

Shuttle launch	COMM: Several Gamma Ray detection satellites have been launched. But there is no way of knowing where in the sky the bursts will turn up and who on Earth will be best placed to monitor them.	10:24:22
Dr. Neil Tanvir	SYNC: The satellites detect the gamma rays And the most modern ones provide positions within a matter of seconds that now fairly automatically goes out over the internet to follow up observers and any of them that are able to do so can then make observations straight away within minutes of the burst going off.	10:24:34

Guy opening his observatory	COMM: Amateurs are ideally placed to do this observing. Guy Hurst runs the international network of amateur astronomers outside North America. SYNC: The problem for amateurs really is that can they react fast enough, obviously if its daylight in your part of the world you cant do it, but by using an international team then it is possible that someone in the dark area of the sky can get out and make observations. For that reason NASA invited us to Huntsville, Alabama. To get together with a lot of other countries and form a team. A chap in Finland managed to image one, and I think that fired everybody up the fact that one amateur does it always means that it helps the others to respond quickly and they're convinced they can do it too.	10:24:55

Arizona - Night – setting up cameras	COMM: In the Arizona desert it's just past midnight on November 18th – the peak of the Leonid meteor shower is due in about three hours. Things can still go wrong – the weather might close in again, the equipment could fail – again - the predictions about the arrival of the meteors could be proved wrong. But to these meteor chasers it's worth all the effort and sacrifice.	10:25:40
Steve	SYNC: This year is the last opportunity that we'll have to see a Leonid storm under dark skies until 2099. With the best will in the world I don't think I'll be here – so Whatever the difficulties I just had to be here to see this.	10:26:03

Leonids Hans & Andrew looking up	COMM: At about three in the morning, as predicted by Ashur and McNaught, the peak of the Leonid Meteor storm arrived. SYNC: There goes one	10:26:27 music in 10:26:26 music out 10:26:56
Andrew's video: The Leonids burst across the sky	Music COMM: They hoped for a few hundred meteors an hour but two thousand, perhaps more, streaked across the sky. It will take two years to analyse the data collected tonight.	10:26:40
Andrew	SYNC: We've certainly been delighted with what we've seen and everyone here has been whooping with joy at the meteors and the odd very bright ones that've been seen. It certainly makes it all worthwhile, yeah.	10:26:54

Steve	SYNC: When you've been a meteor observer and you go outside on a cold morning, February, March time and there are no meteors about you think maybe 1 or 2 meteors an hour, to see 2000 meteors in an hour is absolutely fantastic and its as good as sex. almost	10:27:05 music in 10:27:28 music out 10:27:54
More meteors End Credits	Music	10:27:29 end of program: 10:28:02