

# Domography and High Frame Rate

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## Abstract

*Pertaining to my research about the future cinema, especially the change of the visual dramaturgy in context of 'new' technologies like 3D, full dome, VR, HFR and so on, I will outline the importance of visual narration. Full dome by its nature allows many different viewpoints. For example, it is important to understand how the viewer moves their head during each shot and to know what is achievable. In two full dome studies (Leicester Nov. 2016, Denver Feb. 2017) I was able to consider habituation, feelings/perception, perception of focus, quality and rhythm, also presence and immersion. This paper shows some results of the studies and how HFR can support spatial films in their dramaturgy. Also, I will outline the change of the visual dramaturgy in the dome - how the 'domography' should be made to fascinate the audience. It is important to consider these aspects because we need a qualitative use of the new technologies – not for a 'cinema of attraction' (Gunning 1990) but to attract the audience with a cinema of qualitative and attractive narration.*

## Keywords

Full dome, Spatial, Cinema, Visual dramaturgy, High Frame Rate

## Introduction

Creating qualitative narrative films with high entertainment value is a keystone of immersive productions for full dome. It is, of course, useful to produce with a high technical standard, but without having the magic touch for a qualitative use related to the story, it will only be one in the row of attraction hunting full dome films. Like in canvas cinema it is necessary to use the audio-visual tools and the technical support to create qualitative, story based full dome films. The "mission is to advance the art and technology of immersive digital experiences" (Naefus et al. 2017, 2) in a 360° dome environment.

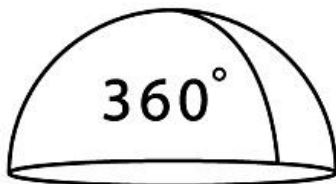


Image 1 – Full dome ©Karim, wiki.nepda.eu, CC: BY NC SA

## Domography

*Domography* means the art of photography and camerawork in full dome filmmaking. Aspects of composition, field of view, focus, depth of field, framing, lighting and camera movement are all important factors to full dome cinematography.

When comparing these processes to traditional flat screen cinematography there are many similarities, but there are also significant differences. The primary purpose of *domography* is storytelling. Before making any decisions, it is important to understand the story point behind each shot. It is not enough to the *domographer* to simply highlight what is happening, making it look and feel good. It is the *domographers* job to captivate the audience by emphasising the action and keeping them immersed in the story.

There are three types of shots in full dome cinematography:

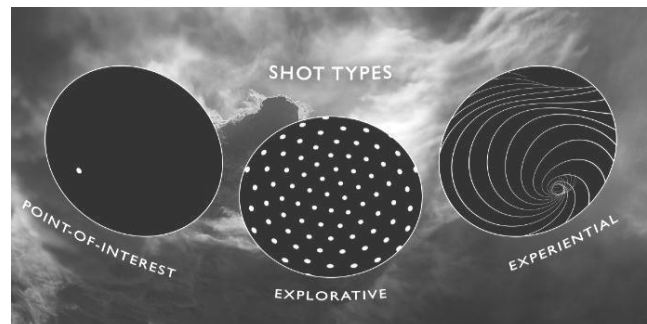


Image 2 – Domography shot types. ©NSCcreative 2016

The point of interest shot, the explorative shot and the experiential shot.

The point of interest shot is where those one particular point that the audience should be looking at is in the viewers focus at any given moment. It is an essential element for a story that should be seen to make sense. The explorative shot is one way allowing the audience to explore the dome independently. This means that each audience member could be looking in completely different directions at any given moment. [Chapter *Full dome study UK* will show, which direction to look at the audience prefer.]

The experiential shot is where physical immersion takes over, and the experience is the key outcome of the shot, although this type of shot can cross over with the first two shot types.

It is an important distinction to make when designing the shots. Its peripheral vision can be more important than

any effect shots coming before or after. In design, there are visual principles that help to construct an image and analyse how successful it is. These principles are often used in filmmaking and can be directly related to full dome.

To direct a viewer's eye, an image needs the point of emphasis. An image without emphasis can be difficult to read and lead viewers searching around the dome to find what they should be looking at. This can sometimes be the desired effect, but can also cause frustration, if essential story elements are missed.

A composition may have more than one point of interest or one that should dominate. The more complicated an image is, the more important is to add a point of emphasis. It is not hard to add emphasis, but it should be done as subtly as possible to remain part of the overall design. By understanding what attracts the eye, the domographer can then devise methods to minimise areas of distraction and creating more emphasis in the areas that should be getting the viewer's attention.

The primary method for achieving emphasis is by establishing contrast. (see Calahan 2003) Contrast can be achieved through shape, size, colour, texture or brightness. A focal point results when one element differs significantly from other elements. The difference interrupts the overall pattern which automatically attracts the eye. Contrast and brightness are easy for the eye to see. Lighting is a key factor to create emphasis and directing the eye of view.



Image 3 – Emphasis through a sparkling outline. ©We are stars, NSCcreative 2016

When an object breaks grouping by not being similar or near to any other object, it calls attention to itself. Emphasis can be achieved using expected angles and others edges to lead the eye towards a focal point. Also, eye lines from characters can direct focus around the dome. A strong perspective point orients the audience ready for the reveal in the sweet spot.

Because of the human need to self-recognition, human or anthropomorphic characters will naturally attract more attention to inanimate objects. We are especially drawn to the face and eyes.

Moving objects are very effective at attracting our attention. But in a scene where everything is moving, we are similarly attracted to the only object that isn't moving. [Chapter *Conclusion* outlines the need for High Frame Rate for natural feeling of motion.]

Objects that feel as though they made fall over, obsessive as a danger. Unbalanced objects are distracting and call attention to themselves. When a whole scene is off-balance, it can feel uncomfortable. The discomfort can be desirable if it enhances the story point.

The brain automatically read large objects to be nearer and more important than smaller objects. In addition to size grabbing attention, the brain will notice an object which appears out of proportion or naturally size.

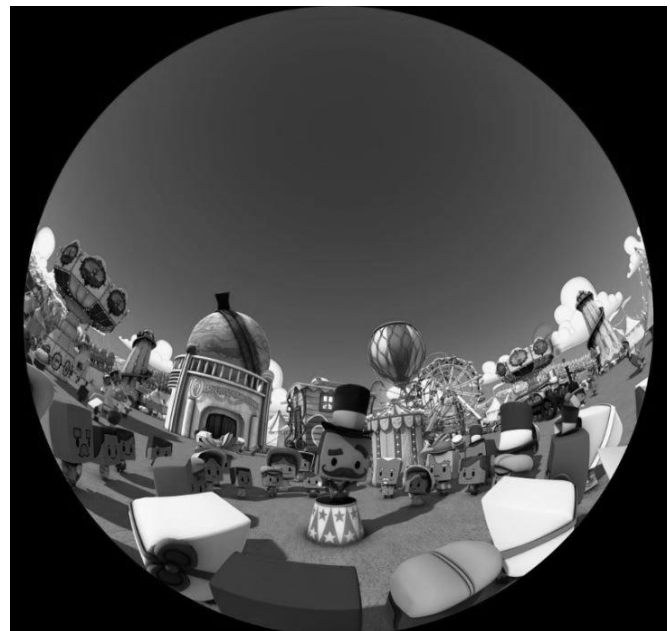


Image 4 – The time master is stood on a platform making it dominate the scene. ©We are stars, NSCcreative 2016

One of the uses of stereoscopic depth is to allow to draw attention to specific objects in the foreground. The depth of field is useful for directing a viewer's attention to the subject which is in focus. It can also change the feeling of the scene, so it needs to have the right motivation. It works particularly well with microscopic subject matters. So although we are discussing these principles in isolation, the examples make it easy to see how they interrelate. Sometimes it is necessary to use multiple techniques to bring attention to the exact area of the dome. Sometimes having a shot majority, a strong focal point to fight against the audience expectations to see the key story elements. It is most likely to need to shift the point of interest around the dome. This can be achieved by dynamically changing the area of emphasis using the visual principles. We have already talked

about and manipulating the scene to keep control of unavoidable actions.

Camera motion is a huge component of most shots we work on. It can guide the eye from one element of a scene to another. We like to see where we are going and so naturally our gaze gravitates towards the direction of movement. The effect of this can be different, depending on the seating situation. [Chapter *Full dome study UK* gives an answer on what seating situations the audience prefer.] Pulling the camera back can cause someone in a swivel chair to turn around to see where they are going. In fixed seating, they can draw attention to peripheral objects as they appear in view.

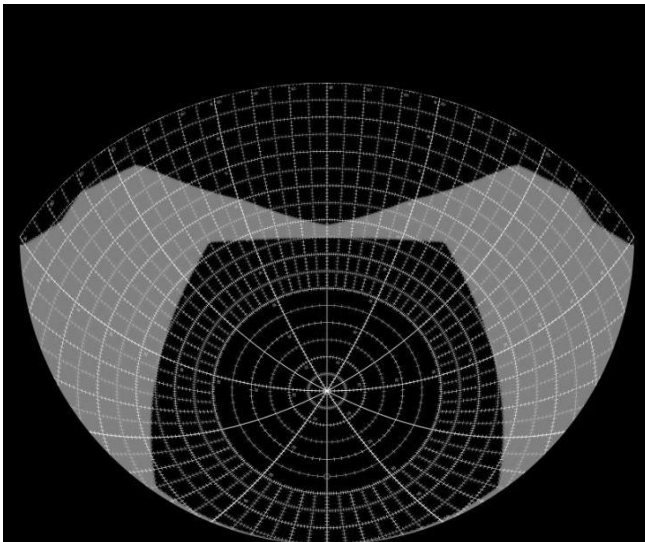


Image 5 – Grey: Field of View in full dome. Black centre: FOV in VR headset. ©NSCcreative 2016

The field of view of the human eye is important to understand when trying to maintain or shift the point of interest in a shot. The great section of this image represents the field of view of the human eye when looking at the centre of the grid. It is almost 180 degrees across. It also goes below the edge of the dome. If we have the field of view of a standard VR headset, we can see that we lose a lot of peripheral information. This is potentially valuable real estate for story elements.

The peripheral vision can restrict how we draw our attention to other story elements either in the same shot or between shots. When creating edits, this field of view should be considered to allow the viewers easily reorient from one shot to another. In transition from one shot to another shot with something entering our space from the right, one could easily miss an important moment. It could also be used to enhance emotional impact if one wants the viewer not to notice an element until it explores the frame.

In an immersive film, not every shot has to be visually immersive. If going from an explorative shot to the point of interest shot, it is important to know how to use these principles to regain the attention of the audience, whose direction of view could be very different from the one we need.

Timing is key. Unlike in a flat screen production background, one has to slow everything down. When moving from an explorative shot to the point of interest shot, it needs enough time to reorient the people before revealing important story elements.

Every film and every sequence shot in a film comes with its set of unique challenges. It is always possible to create a dynamic, immersive film - but it is necessary to give the audience moments of freedom to explore as well as controlling very precisely where we want them to look. A good *domographer* looks at every element in every shot and keeps asking the question, how does this help the story.

## Full dome and High Frame Rate studies

In my research about "Future Cinema" I was able to conduct some empiric studies about High Frame Rate (HFR) in canvas cinema (102 data sheets) and in full dome cinema (129 data sheets). In the audience surveys, I was able to consider habituation, feelings/perception, perception of focus, quality, and rhythm, and also presence and immersion. For the full dome studies, NSCcreative provided me with their full dome film "We are stars" in 30fps and 60fps (in 4K), in a long (25:51min) and a short version (1:20min). The studies were done at the Fulldome Festival UK with mixed audience (4-5th Nov 2016, Leicester, UK – 55 data sheets) and at the IMERSA Fulldome Conference with full dome professionals (22-26nd Feb 2017, Denver, US – 74 data sheets). Plus, with the help of film analysis, we get a clearer look what the results mean.

## About the film

"We Are Stars" is an animation film about the emergence of humanity from the Big Bang, the development from the smallest molecule (from which stars also exist) to the development of planets and creatures like ourselves. Designed by NSCcreative for children over six years [and adults also]. The full dome film is playable in the variants 2D + 30fps, 2D + 60fps and 3D + 60fps per eye, in resolutions like 4K and 8K - and is also watchable in VR in 3D + 45fps per eye.

It begins with a flight over a funfair, through the roller coaster, just past the fire-eater, to the time master with the tent. He invites us to learn the secrets of our origins. In the tent, the curtain of the universe is opened with a view into the past, and we see the emergence of the Big Bang: from the first molecules and particles to the formation of our planet and the first creatures, finally to the birth of our humanity. After all the camera flies back out of the tent, it is already in the evening at the fairground, through the roller coaster, to the hill, where the small comic creatures stand. The little one lets the balloon fly into the evening sky. With an accompanying pan, the camera turns its gaze into the starry sky. Credits.

## Full dome study at FDUK 2016

In the audience study (to cross where applicable, answer scales (5-point), and open answers) at *FullDome Festival UK*, “We are Stars” was the only full dome film with 60fps. All other films were shown in 30fps. I have chosen other narrative full dome films to compare: “Incoming!”, “The Secret World of Moth”, “Jules Verne’s Voyage” and “Secrets of Gravity”.

From 191 seats 2/3 was seated and at least 55 people filled in the survey afterwards. The average age was 39,93 years. 53% stated that they are “male”, 43% give no answer to that questions, 4% had chosen “other”. The gender “female” was not chosen. This could mean that no woman has answered to that survey, or that women were answering but at last, have decided to give no answer to that question. However, there were women at the festival.

The data reveal that most represented were full dome artists (20%), producers (20%) and filmmakers (14%). To choose more than one option was possible.

At the general question “How important is the technical visual quality for you when watching films?” 64% said the quality in cinema is “very important” and 29% said it is “important”. About the quality at home, only 29% said it is “very important”, and 18% said it is “important”. Someone said to “visiting better visual quality cinemas more often” another one prefers the cinema because of the “immersion and deepness of the experience”. “One of the advantages of going to the cinema is to see the film in its full glory”. [Similar outcome at the IMERSA study as you will see in the next chapter.]

In Leicester, the National Space Centre has a unidirectional dome with non-movable seats. It is a spherical and 10% tilted dome with 18m diameter. (fddb.org 2017) 56% preferred to sit “in the centre”, 32% preferred to sit “at the back”. “Side” (5%) and “front” (7%) were chosen less. For the spot of the film action, they preferred the front/middle (62%). The side was chosen with 20% and the back with 18%. 51% like to move their head around to get the action, but “did not want to get whiplash from having every scene in a full dome show require to pan the head around wildly to see what missing and make sense of things”. It is useful for curiosity to use the room outside of our visual field, “if it is used in a creative way and not too often” so that “it does not become painful” (statements done in the survey).

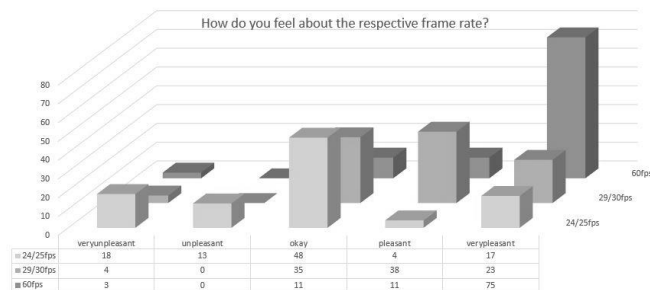


Image 6 – How do you feel about the respective frame rate? 60fps in the last dark grey row. ©Kiessling 2016

According to this study at the FDUK2016 following statements could be made to the acceptance of a High Frame Rate of the audience:

Most people could get used to 60fps (40%) easily, and a few (13%) could imagine more. 29/30fps was chosen with 30% and 24/25fps with 14%. (Various answers possible). Most (75%) people felt “very pleasant”, and 11% felt “pleasant” at 60fps. (see image 6) 23% felt “very pleasant” at 29/30fps, and only 17% felt “very pleasant” at 24/25fps.

People percept 60fps as “smoother, more life-like and sharper”, it makes “the horizontal action more clear”, and “it is necessary on a big screen for good perception for fast movement. Better would be more, but it is almost impossible to create this high frame rate on a commercial way” (statements from the survey).

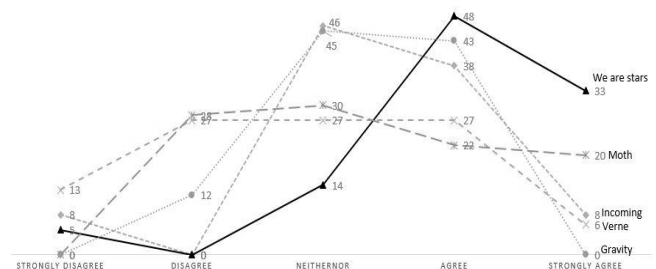


Image 7 – I felt immersed in the film. “We are stars”, the 60fps film, is the dark grey row. ©Kiessling 2016

The film “We are Stars” in 60fps was consistent high rated at the part of presence and immersion. Outstanding with 81% (“agree” and “strongly agree”) with the statement “I felt immersed in the film.” (image 7), and with 53% at “I felt a childlike wonder.” (image 8). 42% said they “agree” and “strongly agree” to “I lost awareness of my real surrounding”. Except “Secrets of Gravity” with 40%, all other films get 10% or less agreement. My film analyses reveal that “We are stars” and “Secrets of Gravity” are both often using flights and dives through the universe and the room itself, in different speeds. At the statement “It felt like I could touch it” the film “We are stars” got 42% agreement. Just “Secret World of Moth” got 45% agreement. The other films got 11% or less. Film analyses reveal that at some shots the moths were filmed with macroscopic three-dimensional X-Ray shots (not moving). Also in a 2D full dome film with 30fps, this gives an enormous 3D impression of the object. People were amazed by this “stunning visuals” (statement in the survey).

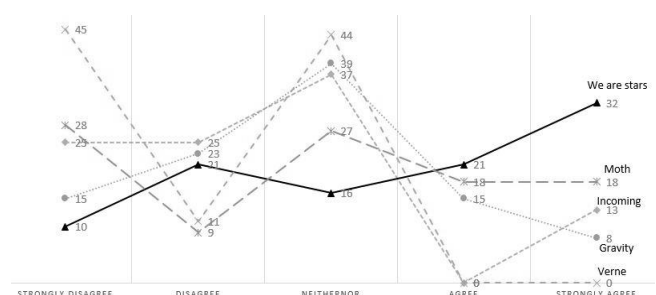


Image 8 – I felt a childlike wonder. “We are stars”, the 60fps film, is the dark grey row. ©Kiessling 2016

At the agreement (“agree” + “strongly agree”) to the statement “I felt the film was in the room.” also both films were high rated: “We are stars” with 56% and “Secret world of Moth” with 64%. (The other films were “agree”d: “Incoming!” with 45%, “Jules Verne’s Voyage” with 30%, and “Secret World of Gravity with 25%). To play ‘in the room’ “makes the film feel like it is using the dome to its fullest potential”. “Make use of the immersive nature of the dome!” (statements from the survey)

At the part about the visual quality “We are stars” convinced with his richness of detail (82% “convincing”) and the visual sharpness (72% “pleasant” and “very pleasant”). Second best was “Secret world of moth” with 63% on both questions. The other films were situated in the middle field or lower.

At the key element motion “We are stars” was also high rated. For 79% of the audience, the camera movement was “pleasant” and “very pleasant”. Moreover, 86% felt “pleasant” and “very pleasant” with the object motion (see image 9).

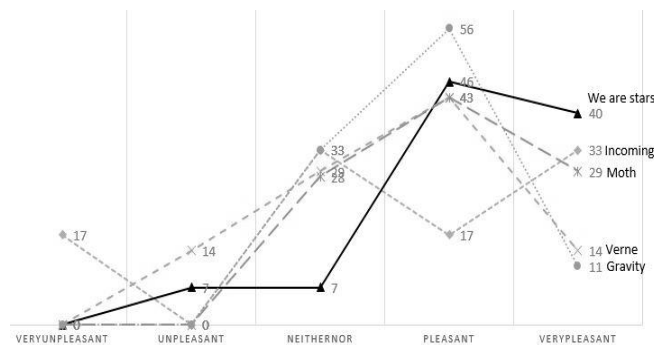


Image 9 – I felt the moving of the objects was ... - “We are stars”, the 60fps film, is the dark grey row. ©Kiessling 2016

## Full dome study at IMERSA 2017

In Denver, the Museum of Nature and Science hosts the Charles C. Gates Planetarium. It is a spherical unidirectional dome with non-movable seats, 25% tilted, with 17m diameter. (Loch Ness Productions 2017) In this study the film “We are stars” was not compared to other films, it was, as a sequel, compared to itself. Because of the lack of time, shown only in the short trailer version. (In the moment I prepare a study with the long version to compare.) At first the 30fps version were shown, then the 60fps version were shown, and third, a side-by-side version (left 30fps, right 60fps) were shown. Afterwards, people got ten minutes to fill in the online survey. (Also paper versions were available for the people, who do not like or were not able to do it online.) This time done with a control group of ten people, who was not aware of the order of the frame rate versions. Only one of ten were distracted by this. In this survey, the audience could cross where applicable, answer scales (5- and 7-point), and give open answers. From 125 seats (not full filled), 81 people logged into the online survey, plus 12 people done the paper survey, but at least 74 data sheets were able to evaluate. The average age was 42,7 years. 76% stated that they are

“male”, 16% female, 8% give no answer to that questions. Mostly represented were people with a technical background (incl. full dome operators, programmers, engineers, equipment vendors) (29%), producers (20%) and filmmakers (20%).

At the general question “How important is the technical visual quality for you when watching films?” 58% said the quality in full dome is “very important” and 24% said it is “important”. About the quality in cinema, 47% said it is “very important”, and 20% said “important”. About at home, only 25% said it is “very important”, and 11% said it is “important”. This seems nearly similar to the first study, although here was added the environment “full dome”.

Although it was a professional full dome audience, it was hard to see the difference between the 30fps and 60fps version, because “the filmmaker did a good job of avoiding motion that would highlight judder” (statement at the survey). Most of them (61%) preferred the 60fps version. At the question “How do you feel about the respective frame rate?” 43,5% felt “very pleasant”, and 29% felt “pleasant” at 60fps. 12% felt “very pleasant”, and 25% felt pleasant at 30fps. “To which frame rate could you get used to?” (various answers possible) 46% preferred 60fps, 32% preferred 30fps, 18% liked 120fps and 4% said other. 30% chosen more than one option (like 30+60fps, or all three answer options).

It was hard to deduce immersion at this short version, and in the results only a minimal difference in the outcome was visible. Compared to the 30fps, the 60fps version has a 15% higher result at the statement “I felt immersed in the film.”, 14,5% higher at “I felt like I lost awareness of my real surrounding.” and 13% higher at “I felt an expansion of consciousness.” – for this, the study with the longer version will be more significant.

At the part about the visual quality, 60fps was the winner also in this short version. 30% rated the visual quality as “excellent” and 34% as “very good”. (instead 30fps: 7% “excellent” and 20% “very good”). Said at the impression about the visual sharpness at 60fps: 25% felt it as “very sharp” and 33% “sharp”. (30fps: 3% “very sharp”, 14% “sharp”). Moreover, the audience felt with 30% “very pleasant” and with 40% “pleasant” about the sharpness of 60fps. (30fps: 6% and 19%). The richness of detail at 60fps was rated with 29% as “most convincing” and with 26% as “very good”. (30fps: 7%, 16%) 31% “strongly agreed” with the statement “It felt like I could see more”. This matches with the results from the 96fps study from the Zurich University of the Arts: “Eye tracking analysis revealed that high frame rates (96 fps) produced a higher number of fixations than standard frame rates (24 fps).” (Iseli and Loertscher 2016)

People felt the movement in general at 60fps was “very pleasant” (29%) and “pleasant” (35%). (30fps: 12%, 16%). Especially at the shots with strong movement, most people prefer the higher frame rate like “at high speed moving camera and objects like the part with the dinosaurs or the asteroids” (statement from the survey).



Image 10 – Camera flight beneath through a dinosaur. ©We are stars, NSCcreative 2016

## Domography and HFR

With this first two studies, my concern is to outline the requirements of visual narration in a 360° environment. (Also another study with 120fps in full dome and a VR study is prepared.)

Especially for spatial films like full dome, 3D, (and VR), HFR gives the opportunity for a higher qualitative outcome.

The bigger the screen and the lower the frame rate, the more details one sees and also the details of the motion blur. This can be unpleasant if one sees nothing more than blur, but can be minimised by more frames per second. The image stays in focus. Especially for big screen productions in high resolution like full dome, this is a significant advantage. The study from Katy Noland (related to UHD) reveals that

to match the degree of motion blur to the spatial resolution for non-tracked motion, a frame rate of around 140 frames per second (fps) is needed for UHD-1 [...] For tracked motion, where we are much more sensitive to blur, around 700 fps is needed. (Noland 2013)

In *Domography* motion is a key element. HFR produces a stronger corporality of moving objects. Because of the less judder, the contour is better viewable and constant in the whole movement. This gives a stronger impression of the moving (3D-) element and is directly related to immersion. The viewer is nearly able to ‘grab’ it – mostly children love to do this with 3D-graphic-elements – in full dome, 3D, (and VR). “Of course, for a perfectly stationary scene, there would be no benefit of increased frame rate.” (Wilcox et al. 2015, 10) But motion is the element in spatial films to drive the story forward. People enjoy the motion in the whole area of the dome.

The useful elements for emphasis like contrast and stereoscopic depth benefit from the contour emphasising high frame rate. It is also helpful to minimise areas of distractions (like motion blur and juddering). Faces seem clearer and can reveal emotions and micro expressions. Near moving objects benefit from HFR with a clear shape, and so give us a more comfortable feeling.

Moreover, if it is possible to use dynamical frame rate (in a soft dynamical curve, not in blocks), perhaps with a single frame projection, then HFR can also be used as a dramaturgical element.

## Conclusion

According to this two full dome studies with 30fps and 60fps, and related to my earlier HFR study with 96fps (see Kiessling 2016) following statements can be made: The audience prefers the higher frame rate. Quality does matter. 60fps or higher takes only a little getting used. It is brilliant in details, focus and visual quality. It gives a stronger impression of reality and immersion, has a stronger emotional impact and has no judder, is clearer, sharper and smoother. The HFR vision seems more like our natural vision. This matches with the results of Kuroki and their study about 240fps:

The power spectral characteristics of the EEG in the case of a translating image stimulus at 240fps were found to be closer to those in the case of a real translating image stimulus [...]. It could be considered that motion images with a high frame rate results in human brain activity that is closer to that in the state of viewing a natural scene. It appears that, consequently, the viewer is able to have a perception of motion image quality that is closer to the impression when viewing a natural scene. (Kuroki et al. 2014, 197)

Also, the results are consistent with the other HFR studies

and suggests there is a strong preference for the smoother motion provided by higher frame rates. [...] Overall, [the] data suggests that the improvement in moving-image quality provided by higher frame rates is both perceived and appreciated by viewers. (Wilcox et al. 2015,10)

All known studies have nearly the same positive results about High Frame Rate. So at least it is not a question of the acceptance and experience of the audience. It will be the financial and technical aspect that drive the challenge.

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Kiessling, Maren; Bradbury, Aaron 2017. *Domography and High Frame Rate*. Communication presented in AVANCA | CINEMA 2017 – International Conference Cinema – Art, Technology, Communication, Avanca, Portugal, 26-30 July