Of Ghosts and screens

by Goran Stojmenovik, Senior Product Manager, Barco

Many of you might have heard of the term **'ghosting'** or **'crosstalk'** in combination with '3D'. Some of you might even have seen this effect on a 3D image.

In this article, I'll:

- Describe the ghosting effect
- Explain how it's caused
- Give guidance on what you should consider when choosing a 3D system.

What is ghosting?

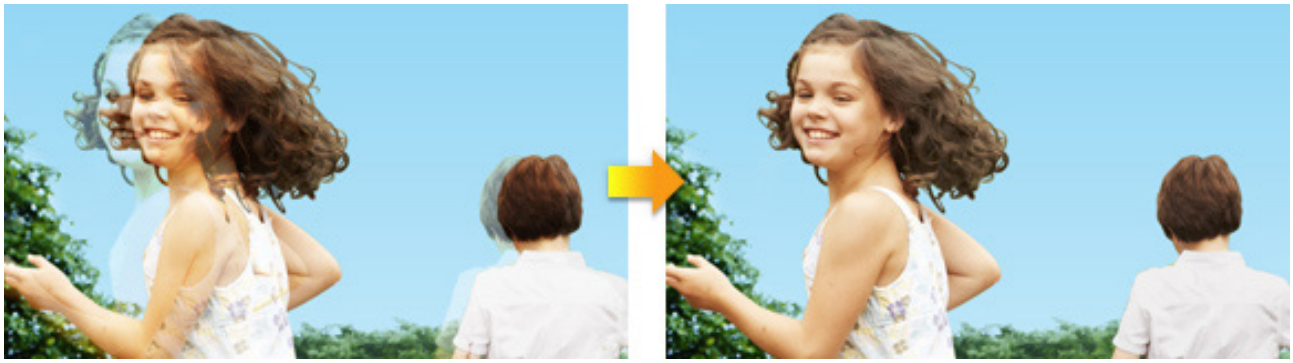
Ghosting is an effect that's seen in a 3D image with your glasses on, where a certain object seems to be followed by a dimmer trail, or where the subtitles have a visible shadow. The other word for ghosting is **'crosstalk'**, which is technically more correct and indicates the source of this effect.

Ghosting is caused by the imperfection of the 3D projection chain, and is mostly visible on polarization 3D systems, at higher 3D brightness levels, and at objects in the image that have a certain 'depth' (towards or away of the viewer).

What causes ghosting?

The essence of 3D projection is splitting images specifically for the left and right eye. However, in a real-life system, this splitting does not work perfectly: there is always some portion of the image going to the unintended eye (left-eye image to the right eye and vice versa – when looking through the glasses of course).

The technical measure of ghosting is **'crosstalk'** expressed in percentages, or the **'stereo contrast ratio'** or **'extinction ratio'** expressed in X:1 value. They are essentially the same: an extinction ratio of e.g. 100:1 means a crosstalk of 1/100=1.0%. Different elements of the projection system can introduce crosstalk: the 3D system (including the glasses), the port window and the screen.



Picture courtesy of Fujifilm, source: http://www.fujifilm-mea.com/files/7013/2610/5929/pic_08_1.jpg

1. 3D systems and glasses

The 3D systems are mostly valued by their efficiency. However, a **higher 3D efficiency** seems to come with a **higher crosstalk**, so this also needs to be taken into account. Typically, the 3D system would be the biggest contributor to ghosting in the 3D image.

Below is a summary of crosstalk and efficiency specifications obtained from the manufacturer's websites.

3D system	Crosstalk	Efficiency
Master Image Horizon	2.0%	35%
GetD 3D GK910	1.5%	30%
Freedeo	2.0%	28%
Volfoni Smart Crystal Diamond	1.0%	28%
DepthQ Cinebright	1.0%	28-31%
RealD XL	Not announced	26%

2. Screens

For **polarization systems used on silver screens**, the screen material also influences ghosting. Most typical screens would have a crosstalk figure of around 0.6% (±0.1%). The difference between screens is negligible when compared to the 3D system. A special screen that has a crosstalk of 0.2% is the RealD Ultimate Screen. However, note that this screen is also installed with screen vibration to reduce speckle.

However, these screen crosstalk figures are only **'on axis'**, i.e. at perpendicular viewing. Looking at larger angles, the crosstalk increases so at 30° or more, the screen crosstalk can easily exceed 1%. So, the **silver screen** is also an important contributor for ghosting, especially when looked at off-center.

3. Port window

Some port window glass will cause a **partial depolarization of the image**, which will also increase 3D ghosting. We don't have much data about this effect but be aware that the choice and placement of a port window is also very important (not only for ghosting but also for throughput, reflections etc.).

4. System crosstalk

The total system crosstalk can be calculated by summing up the crosstalk percentages of the different components in the system. **The higher the crosstalk, the more ghosting will be visible** even in softer transitions in the image.

Different silver screen and polar 3D system combinations can give crosstalk values as low as 1.2%, but more typically about 2.5%. You must add the crosstalk of the port window as well.

In comparison, the total crosstalk of a Barco 6P system on a white screen is only about 0.2% (screen and port window have no impact) which is way below the perceivable threshold and will not give rise to any perceivable ghosting.

5. 3D brightness and content

Ghosting is never 'embedded' in the content; however some content is more prone to ghosting than other. The **content variables that impact ghosting visibility are**:

- **Disparity**, or separation between the left and right image. The more 3D depth an object in the image has, the larger the L-R separation, the thicker and thus the more visible the ghost image will be. Alternatively, for zero depth (image depth positioned at the screen) there is no ghosting.
- **3D brightness:** the brighter the image, the brighter and more visible the 'ghost', especially if it's a ghost image of a bright object on a dark background.
- **Image contrast:** bright objects on a dark background or vice versa, will enhance ghosting visibility.

Reducing ghosting visibility

The post-production process of most movie content is done on white screens, so the producers do not readily see ghosting or correct it. Without a check on a polarization 3D system there is no way to see if any ghosting is apparent until it's too late – which in many cases is only when the film starts screening in the cinemas.

Therefore, it's important to take precaution to **minimize the risk of ghosting in the cinema**. In our experience, going above 6-7fL 3D with the popular polarization 3D systems and silver screens already issues ghosting that can be annoying to some people. In extreme cases, ghosting on some movies will be apparent even at 5fL.

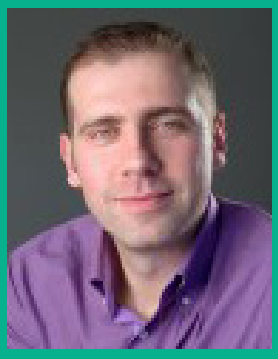
On the contrary, using a Barco flagship laser RGB projector with 6P glasses does not give rise to any visible ghosting even at much higher 3D levels.

Summary

3D ghosting ('shadows' or 'contours' around bright objects in 3D) is caused by **imperfections in the 3D imagery and the screen**. Its visibility is **amplified** at **brighter 3D levels** and also by the **content**.

Most polarization 3D system combinations (3D system and screen) have crosstalk of around 2.5% which can be too much, especially on bright 3D. In such case, we recommend a good balance between the desired 3D brightness, and screen and 3D system choice, not only based on the efficiency figures but also on crosstalk performance to minimize ghosting. In practice, targeting 6-7 fL 3D may provide a good balance for most films.

Barco Laser3D (6P 3D) in combination with Barco flagship laser projector and a **white screen** has a **crosstalk figure of only 0.2%** which is imperceptible and is obviously **the best choice for PLF screens or VIP applications targeting a higher brightness.**



About the author

Goran Stojmenovik is Senior Product Manager at Barco's projection division and is currently working on laser projection for the cinema and other Barco markets. With focus on image quality as well as user experience, Goran has managed different products in Barco since early 2005. Initially he was responsible for professional LCD monitors and software solutions for various Barco professional markets (control rooms, broadcast and post-production). In September 2011 Goran started at Barco digital cinema where he worked on introducing dedicated projectors for post-production as well as on remote service solutions for cinema (CineCare Web). Before joining Barco, Goran Stojmenovik acquired a PhD degree in Engineering Physics at the Ghent University, Belgium. He is based in Belgium.