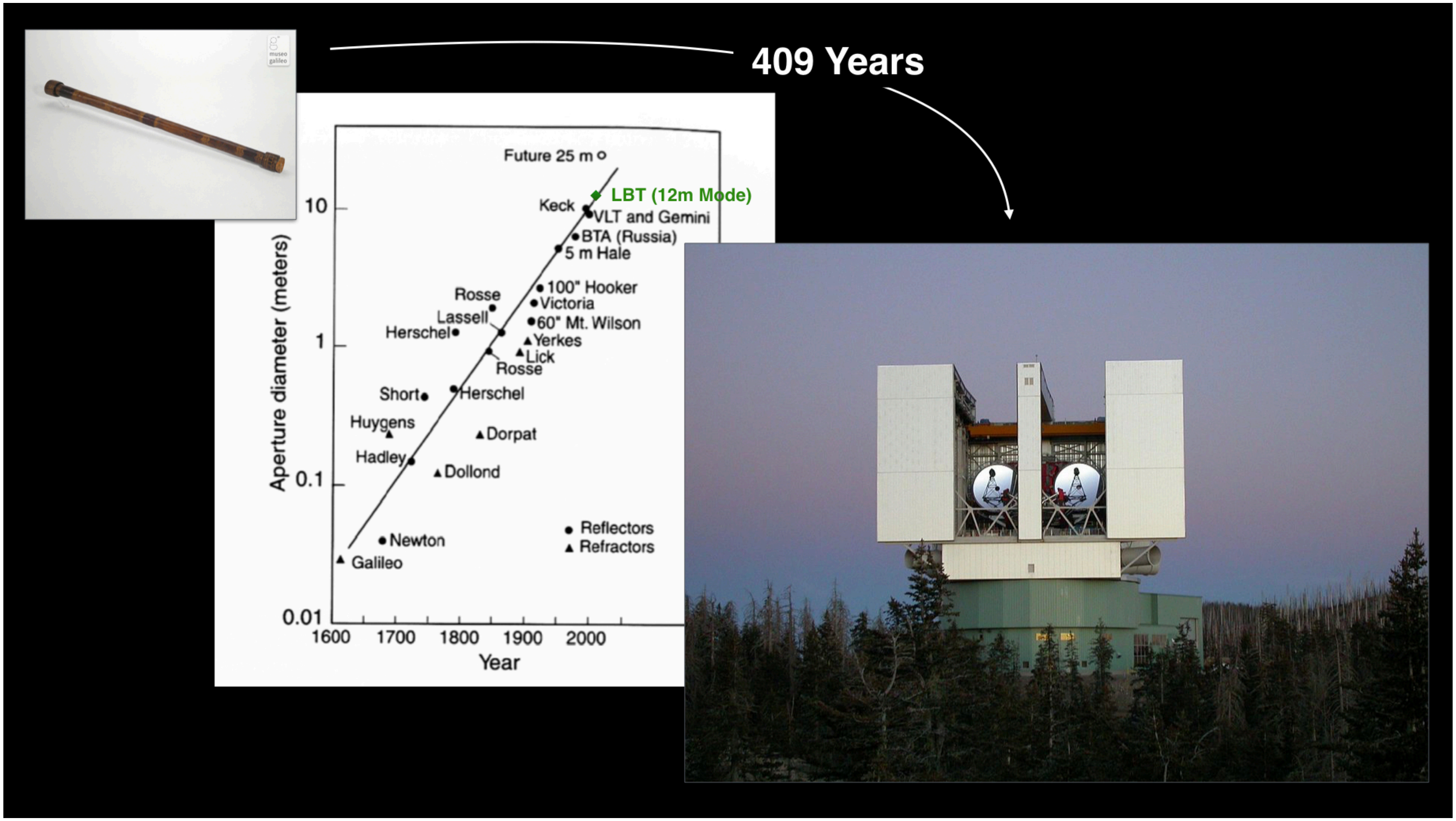
It is important when observing with any telescope to understand the constraints under which the telescope and instruments operate. For this talk I cover these constraints at the conceptual level and don't spend any time on the details of HOW you get the LBT to run efficiently as a binocular telescope. Note that even chameleons have constraints…while hunting they must use both eyes to gain the needed depth perception on their target!

Start with a little background…we live on a rotating planet. From any fixed location on the Earth the sky appears to rotate, so we build telescopes…

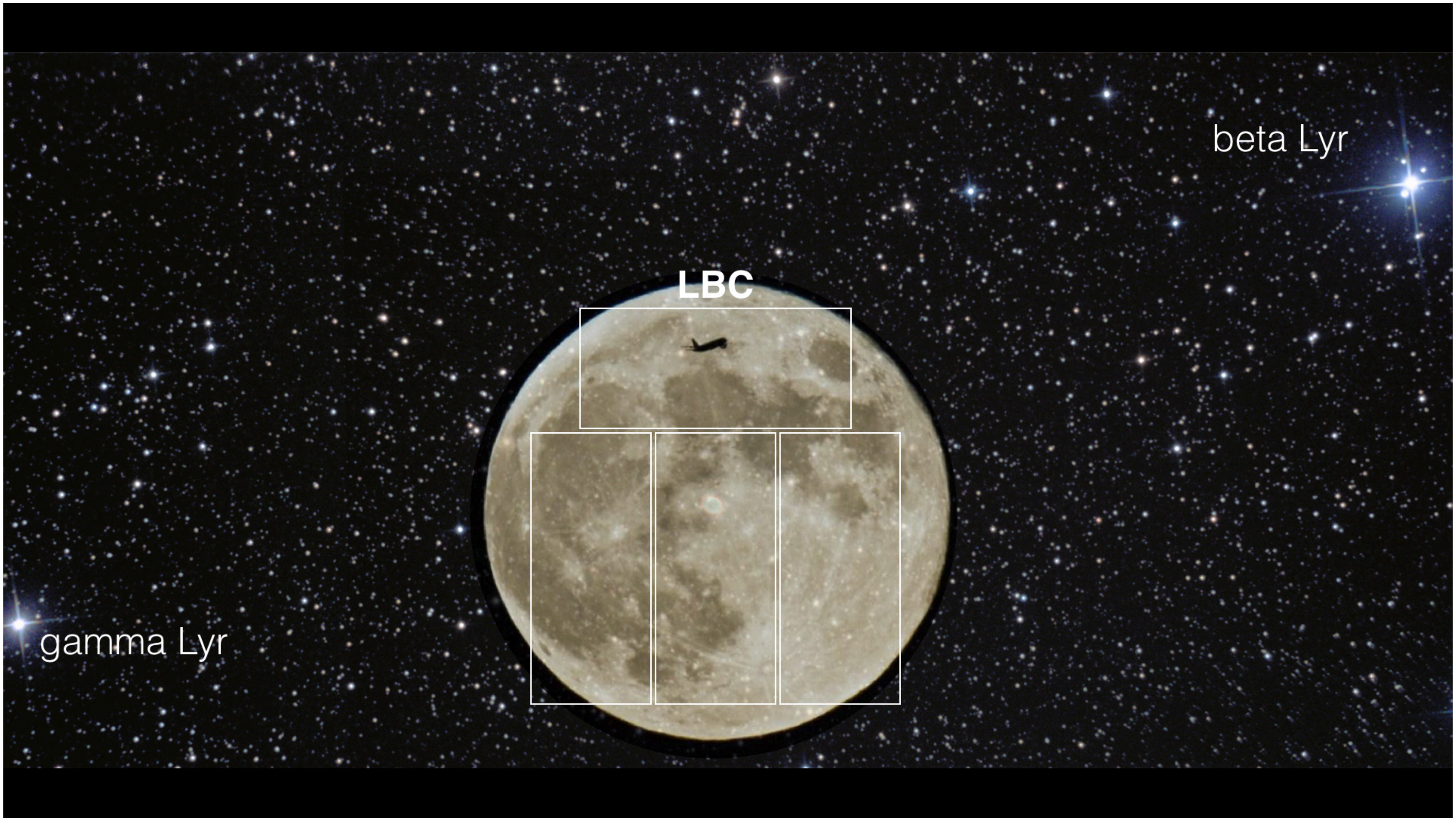


…such as these. Since Galileo first built a telescope and turned it on the sky it has been a little over 400 years. The plot shows that the effective mirror diameter has been marching along to larger and larger sizes. The LBT is near the top right on this plot, showing where it is in its 12 meter mode for the Gregorian instrument pairs. Why do we build telescopes?

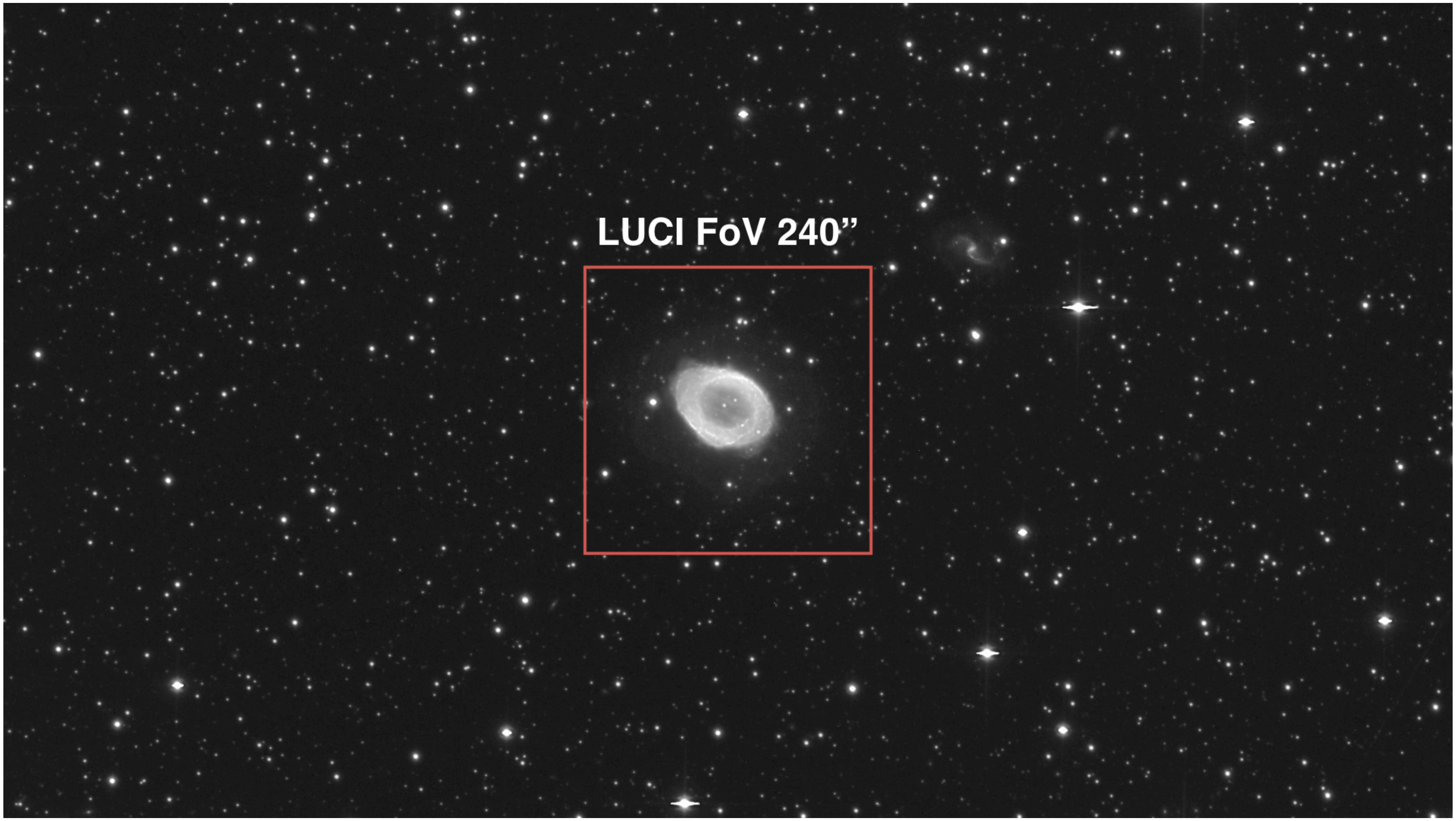
…to freeze the night sky on film or digital detectors so that we can make deeper images like this. Now, you can probably tell from the segment of the Milky Way on the left that this covers a fairly large area of sky…

For comparison this is the apparent size of the full moon. For those familiar with the sky you might recognize the star Vega and the constellation Lyra. This large field of view is not relevant for discussing binocular constraints at the LBT, though, so we will zoom in to the field in the box. For those of you really familiar with the night sky you might know what is next…

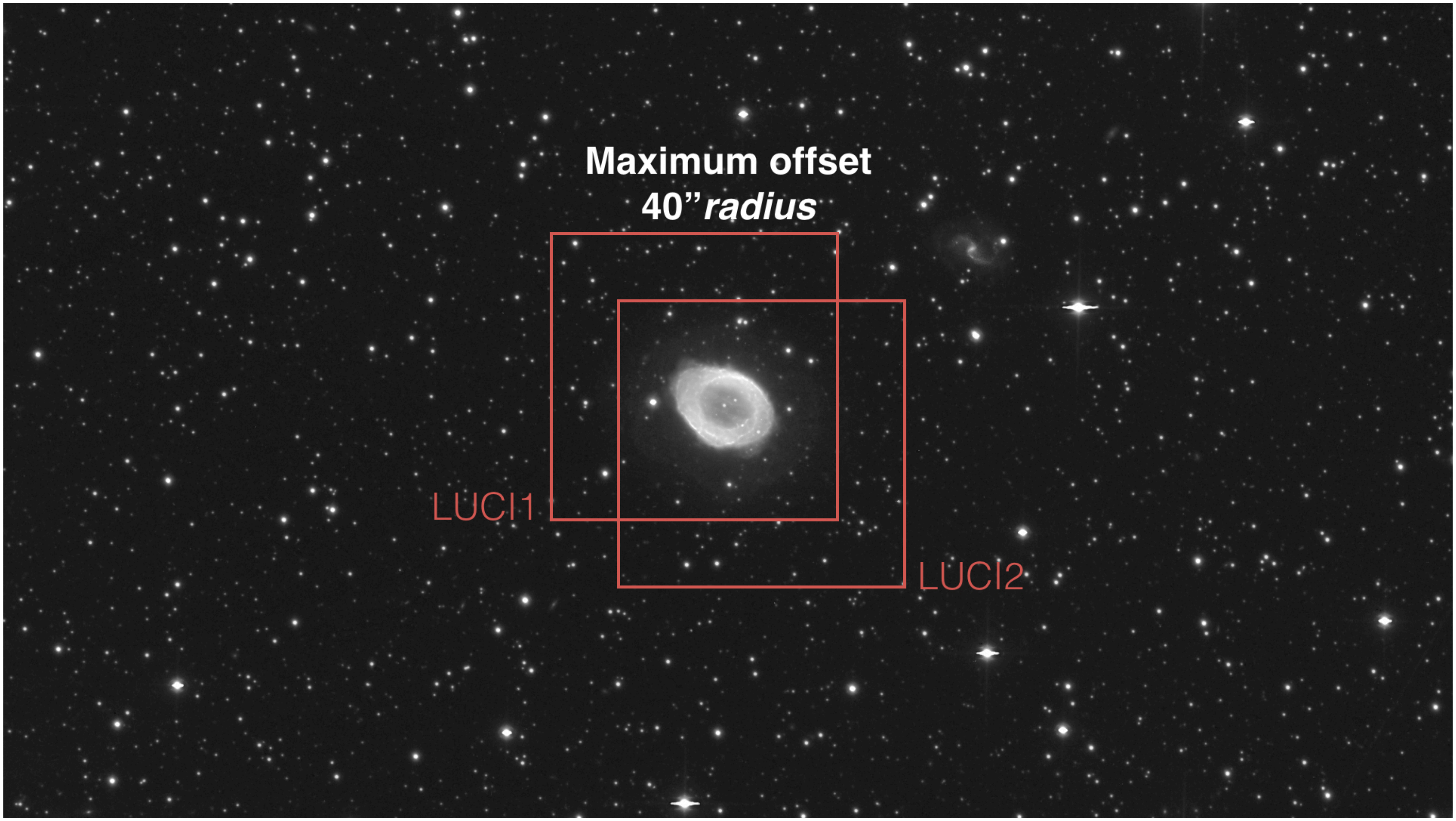
Messier 57 - the Ring Nebula! It is still pretty small here, but we are starting to approach a scale relevant for LBT instrumentation.



Here we show the same field with the footprint of the LBC cameras superimposed on the moon. The separation between beta and gamma Lyra is about 2 degrees. However, in terms of binocular constraints this is still a pretty big field of view, so we zoom in some more…



This is the field of view of the LUCI cameras: 240 arc-seconds. Imaging using LUCI1 and LUCI2 to take an image of the Ring Nebula at the same time. You start off with both sides pointed to the same coordinates on sky. We call this “co-pointed”. This is how the interferometers work all the time…if they did not they would not see the 23 meter fringes. Now, taking this as the starting configuration…



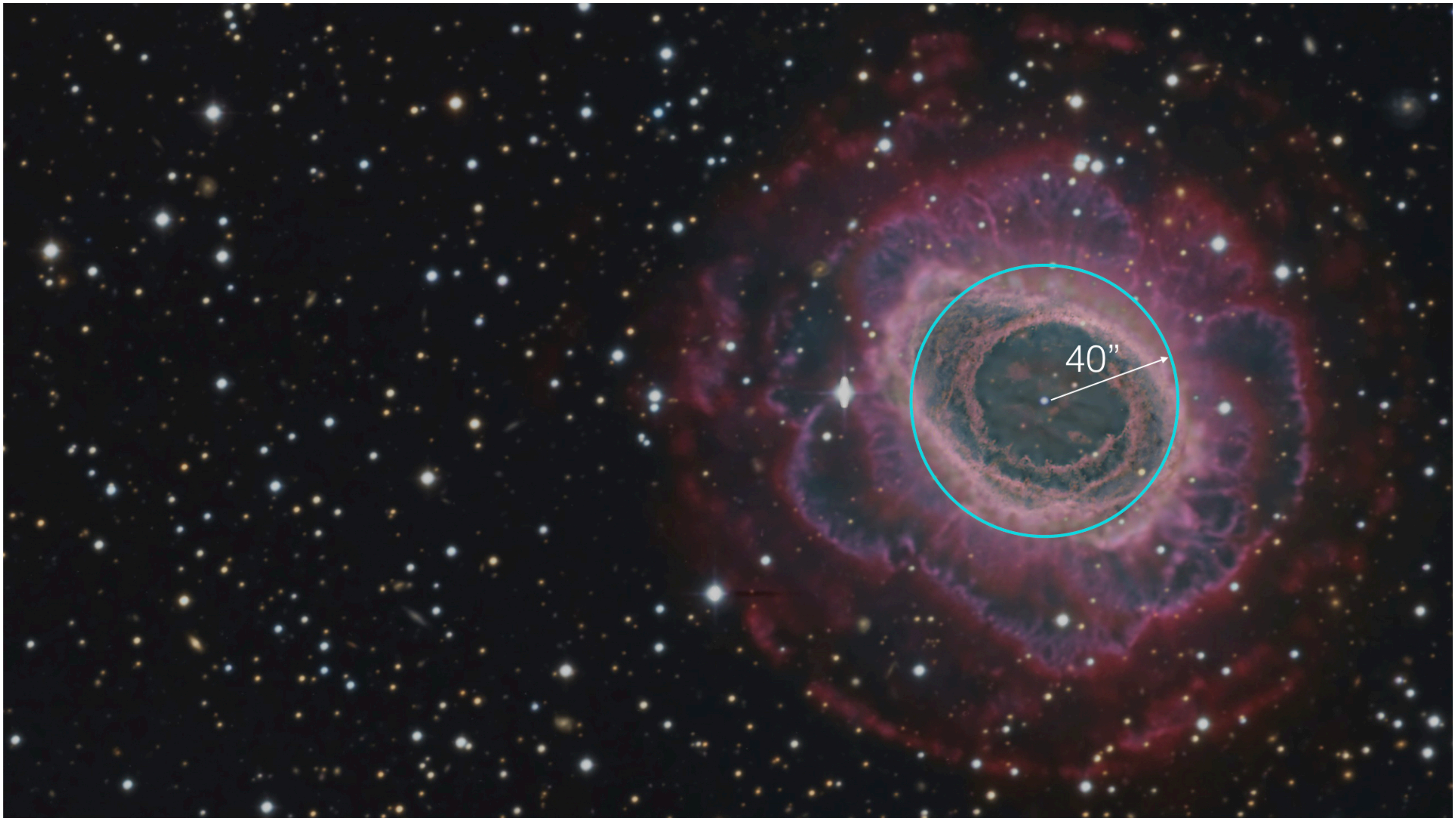
The most you can move either telescope from this starting position is 40 arc-seconds. This is actually a unique feature of the LBT, that you can move the optics so far with respect to the mechanical telescope structure. Their full range is larger than this, but some of the range is used up to keep the telescope collimated or correct for some changes with elevation. We may be able to enlarge this limit when we have more operational experience with the telescope.

Telescope Constraint #1:

The optics can move 40" in any direction from where the two sides are co-pointed

"co-pointing constraint"

Thus we have the first telescope constraint on binocular observing with the LBT. This "co-pointing constraint" is just that you have to stay within 40" radius from where the two sides would be co-pointed. This is how it works (but first we need to zoom in even more):

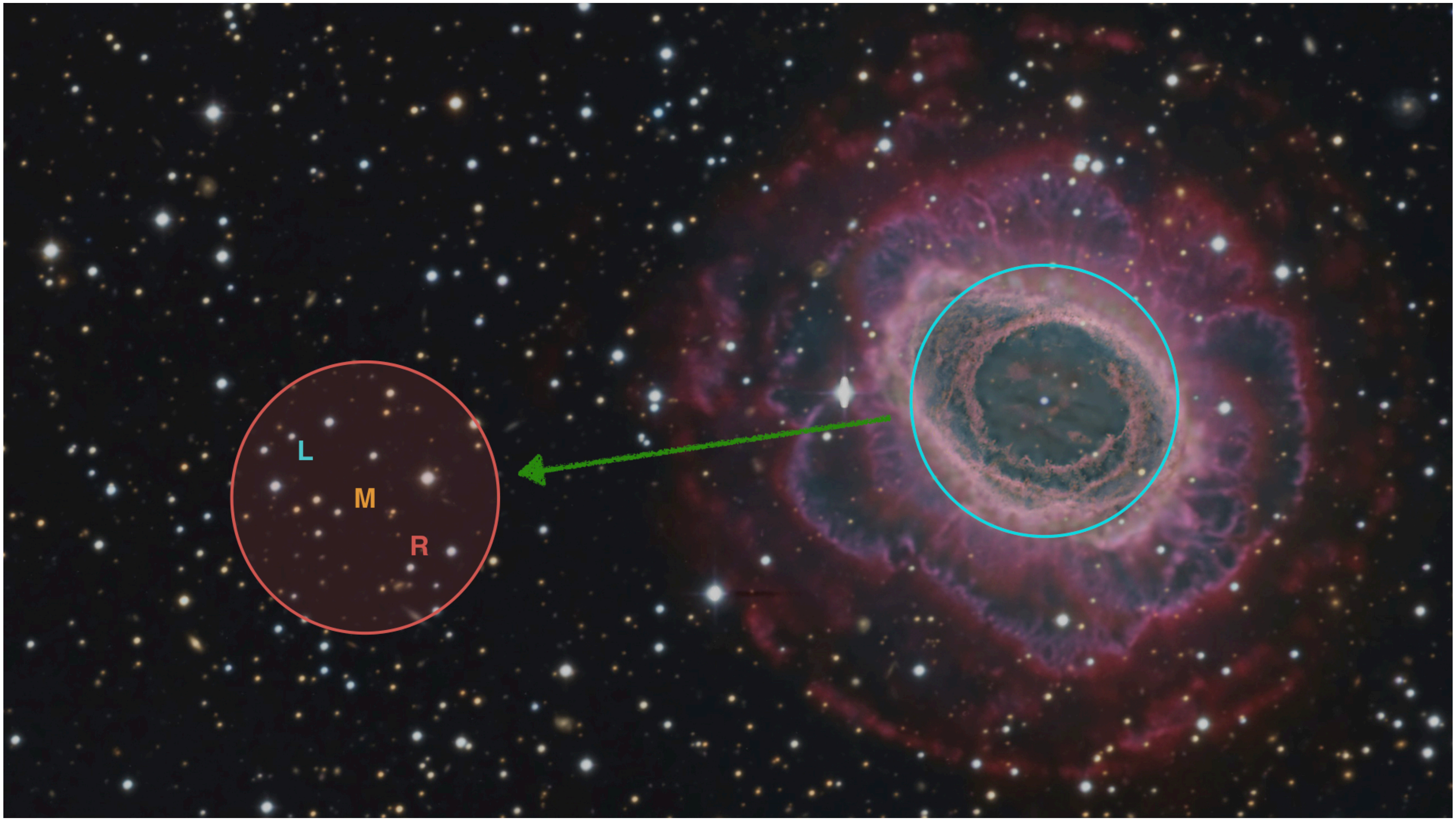


This field of view is about 3.5 arc-minutes high, a little smaller than the LUCI field of view. Consider starting from this position with both telescopes and the mount are all pointed to the central star in the Ring Nebula….

The mount is effectively just open-loop *tracking* this point in the sky, here indicated with an "M". The *optics* on each side are what moves when guiding signals come in from the auto-guiding units. This allows the two sides to act independently.

You are free to dither around the left telescope (L) within this 40" radius circle with no restrictions, completely ignoring what the right side is doing.

The same is true for the right side, of course.



If you want to move anywhere outside the initial circle, BOTH sides must agree because the mount must move. The new point tracked by the mount is the midpoint of where the left and right sides end up pointed, and this defines a new circle of 40" radius in which to observe. As long as you stay within this new circle, both sides can again act independently.

Telescope Constraint #2:

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There is no other constraint on binocular operations from the telescope! The TCS is fully generalized. It treats the two telescopes as completely independent entities within the co-pointing constraint. You can have different instruments, PAs, guide stars, and dithering cadence and pattern. But should you make use of this capability for most normal observations?

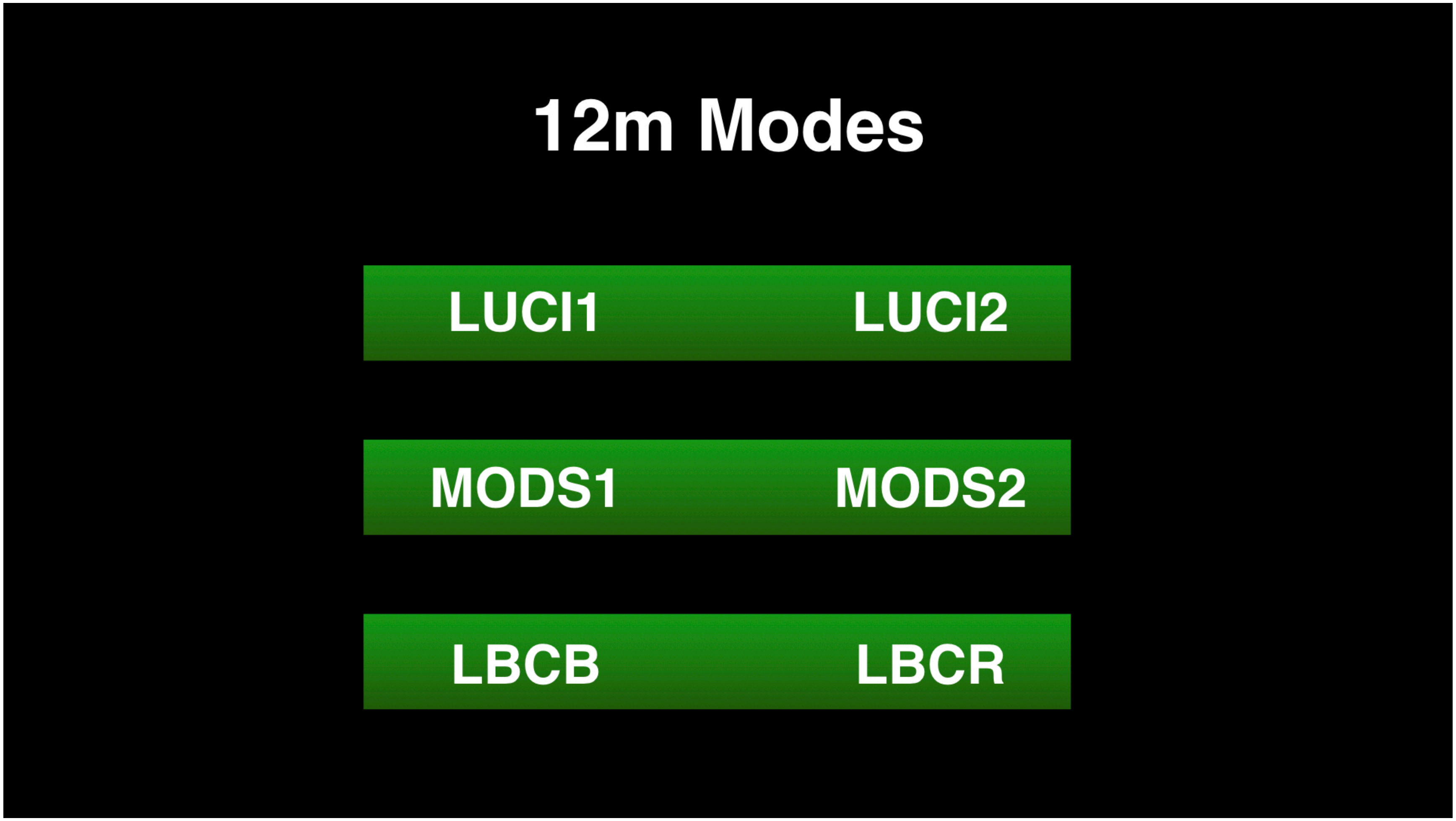
Instrument Combinations:

23m modes: LBTI, LINC

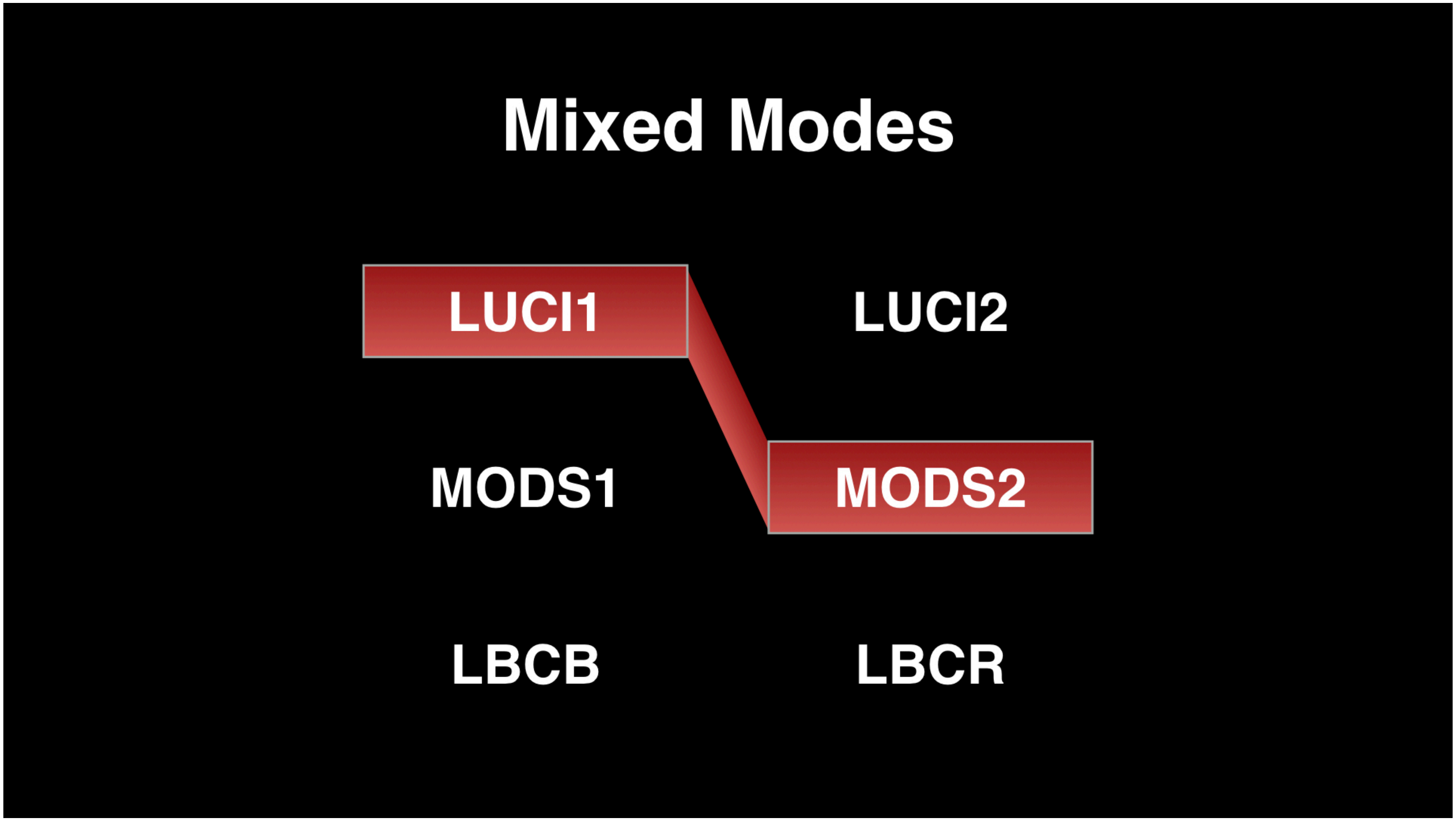
12m modes: “twins”

Mixed modes: LUCI+MODS

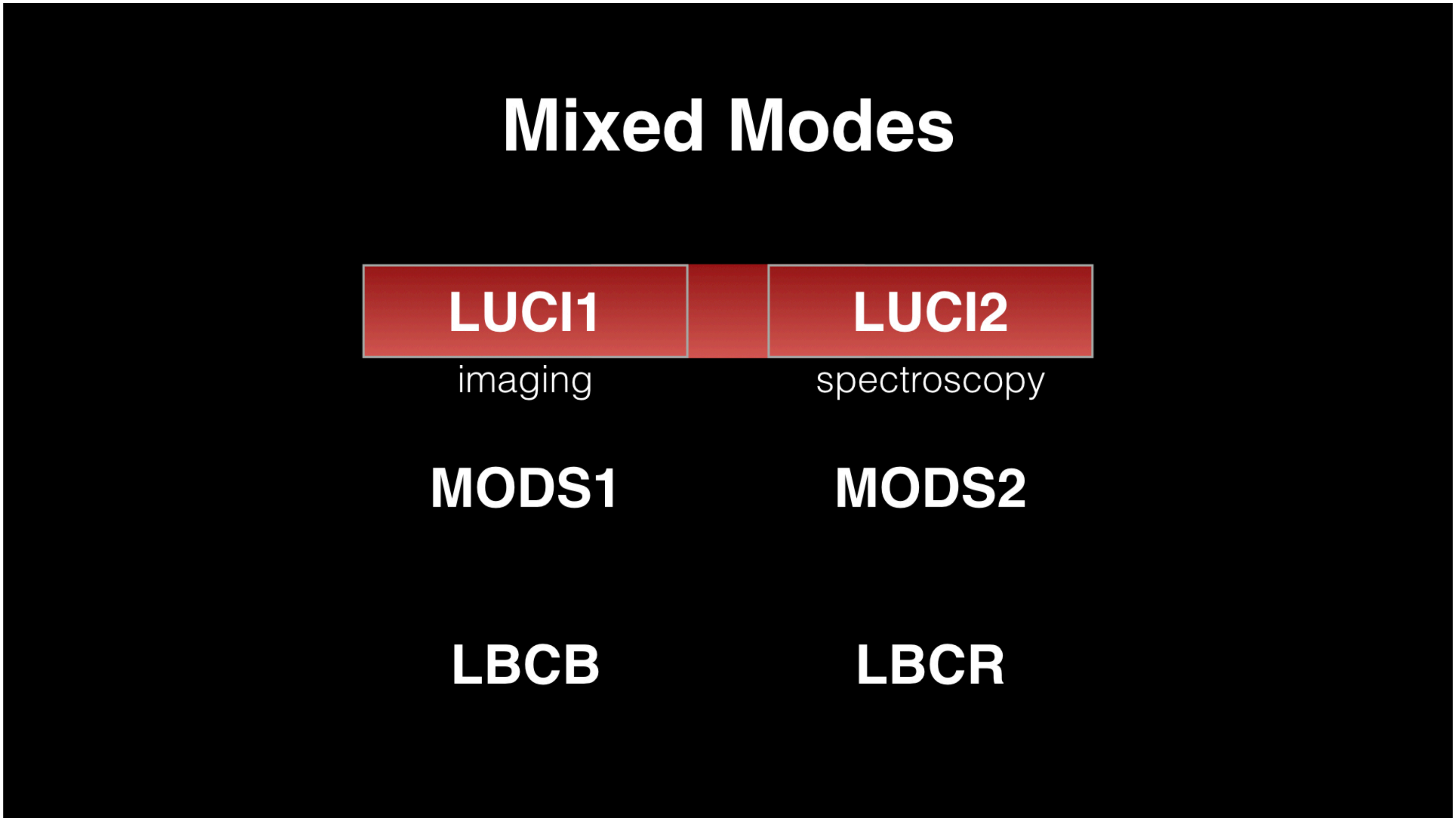
The instruments come with their own sets of constraints. For purposes of this discussion I break down the combinations into 23 meter modes (LBTI, LINC when it reaches NIRVANA), 12 meter modes where instruments are paired with their “twin”, and the generalized mixed modes. The interferometric modes were discussed elsewhere at this meeting, so I only consider 12m and mixed modes using the facility instruments (LBC, MODS and LUCI).



The 12m modes consist of each instrument paired with its twin. There are significant advantages to these modes: the instruments were made to be used together, especially the LUCIs and LBCs where a single operational software package controls both instruments. Overheads are also nearly identical in the 12m modes, as well as sky background count rates. The biggest advantage, however, is that these modes are routinely available NOW!



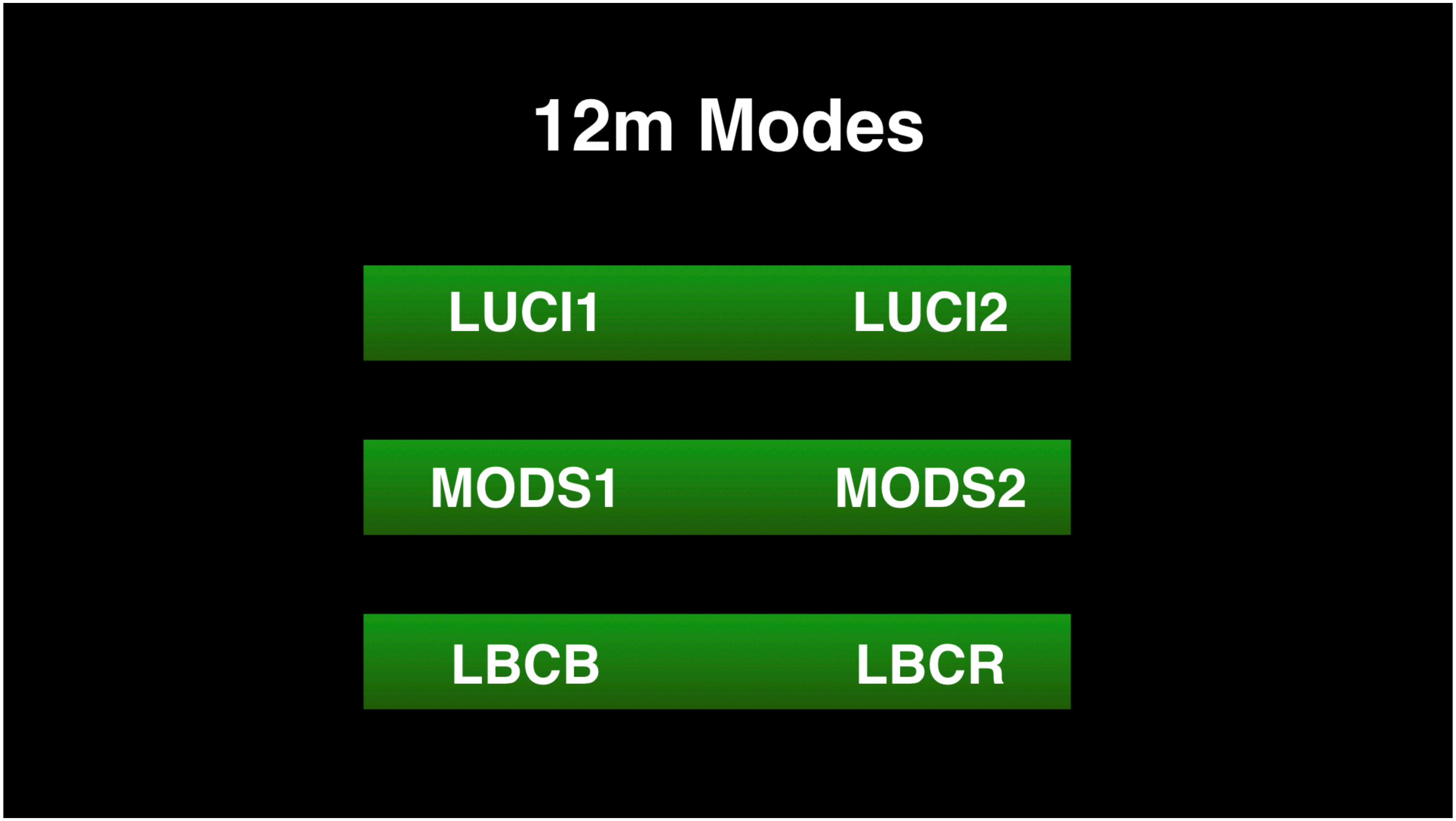
Mixed modes include combinations with different instruments in use on each side. The combination of a LUCI plus a MODS has been by far the most requested mixed mode at the LBT! Mixed modes can also include combinations like LUCI1 + LBCR to take izYJHK photometry of a high redshift source, or LBCB + MODS2 to simultaneously image a cluster in the U band while taking spectra of the brighter sources with a MOS mask.



Mixed modes can also include LUCI1 + LUC2 if you plan to do spectroscopy on one side and imaging on the other! Advantages include wider wavelength coverage, simultaneity, or having the flexibility to adapt to an offline instrument. However, it is much harder to plan efficient mixed mode observations. The overheads and backgrounds are significantly different, exposure times and dithering cadence are mis-matched, and all gap-filled LBC patterns exceed the co-pointing constraint!

Need a good
binocular planning tool!

Efficient binocular observing with the LBT will require a good planning tool! The good news is that this is in the works. Michelle Edwards will discuss this elsewhere at this meeting. A good planning tool will lead you through the process of designing efficient mixed mode observations. You won't need to know the details of how it does this but it is good to understand why, and that is driven by the constraints discussed here.



In most cases, and at least until the full binocular planning tool is completed, we recommend you figure out how to do your observations via 12m twin modes. Four hours of LUCI1 + MODS2 can also be done as two hours of LUCI1 + LUCI2 and another two hours of MODS1 + MODS2. Given the significant difference in the sky backgrounds in the optical and IR bands, the latter 12m modes can be tuned to better reach the required SNR in both sets of data.

Summary

1. SX and DX are functionally independent within the 40" co-pointing constraint
2. Twinned modes are simple and available now, full binocular requires a good planning tool

In summary, the LBT was built to run as two functionally independent telescope within the 40” co-pointing constraint. Twinned modes are available now. With appropriate scheduling and instrument availability this should cover the majority (>85%) of the kinds of observations that are currently carried out at the LBT.


…fine

Credits for images and video pulled from the web:

Slide 1: Chameleon Eyes, Jamie Wagner, Youtube
Slide 2: Star Trails, national Geographic, Youtube
Slide 3: Museo Galileo, Bely & NASA
Slide 4-5: Nick Risinger (SkySurvey.org)
Slide 6-7: Dan @ Pocketrubbish, moon??
Slide 8-9: Gianluca Masi (virtualtelescope.eu)
Slide 11-15: APOD 2009 November 6
Slide 24: DThompson, LBTO

In preparing this talk I mercilessly and relentlessly pulled background images and video from the web to illustrate the points I was trying to make. No permissions were sought. Full credit should go to some truly dedicated folks pursuing their craft (in particular, see SkySurvey.org). It is truly amazing to me how much information is out there, and what can be accomplished by dedicated people pursuing their passions!