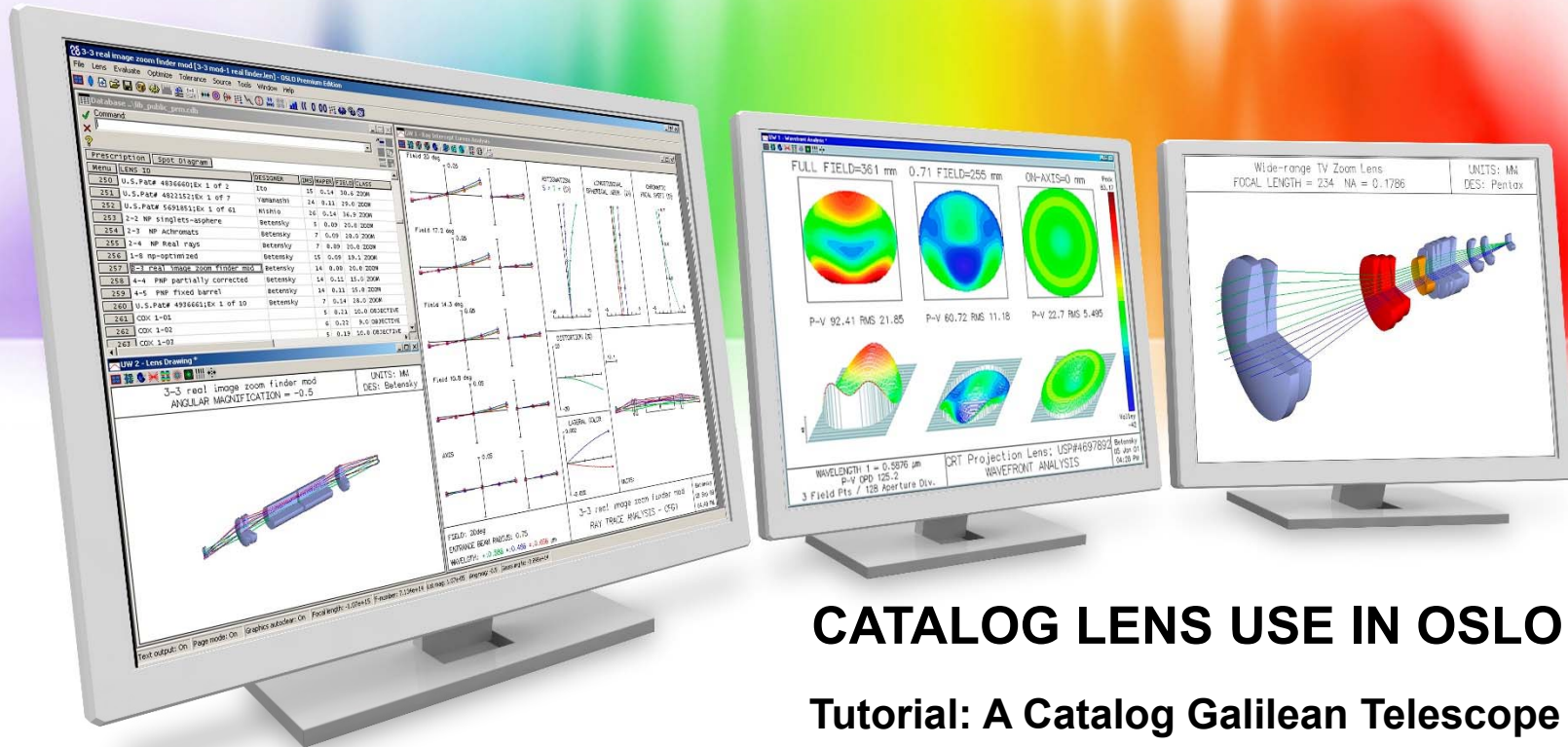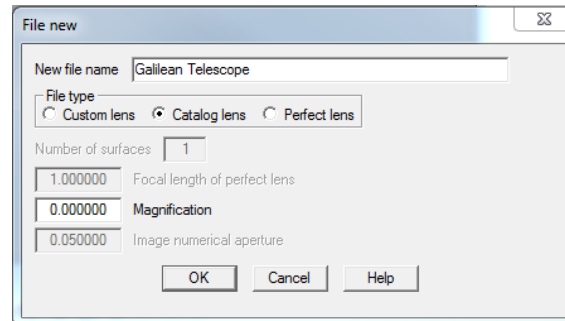# CATALOG LENS USE IN OSLO

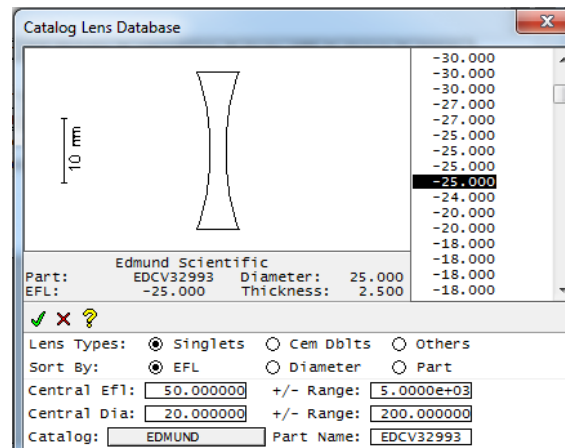## Tutorial: A Catalog Galilean Telescope

Richard N. Youngworth, Ph.D. - Presenter

Tutorial example: creating a Galilean telescope from catalog lenses

- Start a new lens, pick a name and specifically choose a catalog lens.

- Get onto the Edmund catalog (which is an arbitrary choice) and sort by EFL. We'll enter a negative EFL element first as the eye lens. Choose the part number EDCV32993 because it has EFL=-25mm and a diameter of 25mm.

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Tutorial example: selecting the second lens

- A simple Galilean Telescope has a negative and a positive element. Next we choose a positive element that will give is a magnifying power (MP or angular magnification) of 2x for the telescope. To get this MP we need to pick a positive EFL of 50mm since the MP is the EFL of the objective (positive element) times the EFL of the eye lens (negative element).

- Right click on the grouped catalog singlet from the first part and select "Insert Catalog Lens". Choose the part number EPCX32971 because it has EFL=50mm and a diameter of 50mm, so it is bigger than the negative element.

OSLO
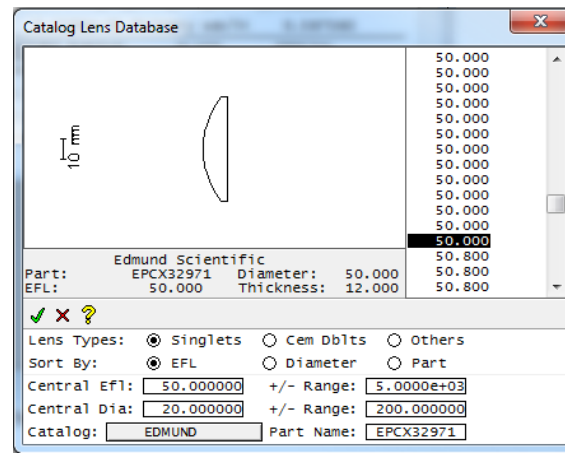
Tutorial example: getting everything in the correct order

- At this point what you have probably has an element over an element. They are also in the wrong order. Next do the following steps:

  - Cut the negative element out (Line 4) and paste it above Line 2.

  - Move the solve for the paraxial marginal ray height to Surface 4.

  - Insert an additional surface above the current Surface 1. Make it the aperture stop.

    - *Optional: under the menu item lens go to lens drawing conditions (or type 'uoc drl' in the command line)and select draw aperture stop and accept it.*

  - At this point parts are in the correct ordering for sequential raytracing but the spacings are still not right. The next step is to correct this problem.

| SRF	RADIUS	
OBJ	0.000000	
AST	0.000000	
2	EDCV32993	
3		
4	EPCX32971	
5		
IMS	0.000000	

OSLO

Tutorial example: setting up light properties

- Before fixing the spacings, we'll set up some reasonable light properties.

- The default wavelengths are reasonable visible values (dFC).

- The entrance beam radius is 12.5mm which completely fills the negative element. What we really want is a value that fills or even overfills the eye pupil nicely. If it is nice and big it will be easier to look through the instrument. Choose a value of 5mm for the entrance beam radius. This is an extremely large eye pupil value of a 10mm diameter which is larger than young children's maximum pupil.

- The field of view will ultimately "walk" the beam on the positive element. Choose a field angle of 5 degrees

  – The purpose here is to show that the light even for these values all gets through our little telescope.

Gen	Setup	Wavelength	Field Points	Variables	Draw On	Group	Notes

Lens: No name		Zoom	1 of 1	Efl	-25.001194
Ent beam radius	5.000000 Field angle	5.000000	Primary wavln	0.587560	

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Tutorial example: correcting the spacings

- We will probably get better performance if the positive element is flipped. The reason is to split the ray bending between the two surfaces since light in our model exits the second side collimated. Flip the positive element in the model (select the group at Surface 4 and use the button to reverse order).

- The distance from the stop to the negative element is the eye relief. Choose a value of 15mm which means that the eye is placed that far in front of the negative element.

- If you have lost the solve on the last surface due to flipping positive element, go ahead and put an axial ray solve on again.

  (Graphic shows where to find the solve if you are not familiar with it. The numbers are after correcting the spacing.)
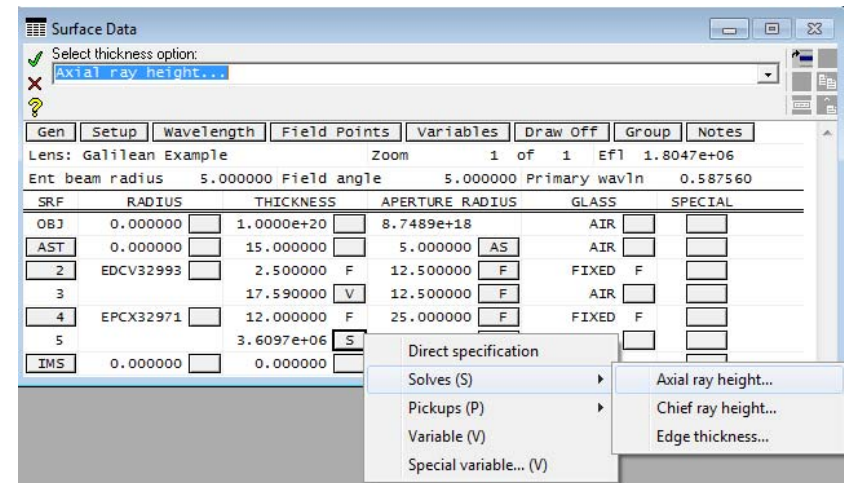
Tutorial example: correcting the spacings

- Eliminate the solve on Surface 2. This distance is critical because it places the positive element in a location to project the beam illuminating the eye out to a far distance. There are two ways to approach this problem:

  – Manually adjust the spacing until you get the solve on surface far to be a long positive number.

  – An alternative is to set up a simple figure of merit do have OSLO solve it. We'll do that here but you can always just change the number until the final distance is a large positive number.
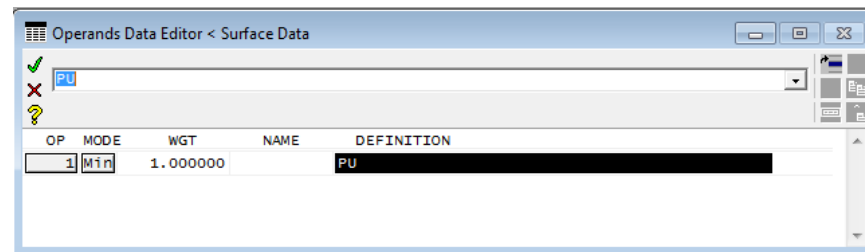
Tutorial example: correcting the spacings

- We need two things to have OSLO help with its optimizer:

  – Make the distance between the lenses a variable (thickness of surface 3)

    • Note I sneakily also changed the lens name to 'Galilean Example' *(optional)*
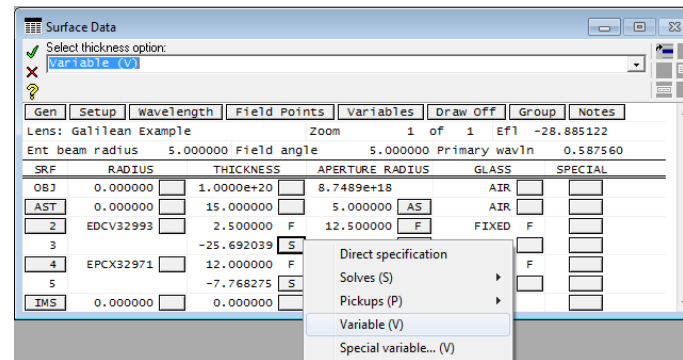
  – Make a merit function that assesses how well collimated the system is in image space. Under the menu for Optimize select Operands (or type 'ose'). If we choose the paraxial angle (PU) for the marginal ray when it is a small value the axial beam will be very close to collimated.

Tutorial example: correcting the spacings

- If needed you can use help to look up operands.

- Now run the DLS optimizer ('ite' or 'Iterate' under optimize) and you will adjust this space to a value that makes the system a telescope. Note the program has a negative value for the last airspace but it is really far away. In practice this only affects the angle of the rays and not what you see, but it makes the rays look a bit ugly. Change the resulting value of Thickness 3 up to 17.59mm.

Tutorial example: concluding remarks

- We went from a blank slate to a little catalog lens Galilean telescope.

- The instrument certainly won't win any awards but can be used as a classroom physics lesson.

- I've included a version of the resulting system file that has two extra operands with no weight that can be used to verify in two different ways the magnifying power of the telescope is 2x (O1 is the ratio of the EFL and O2 is the chief ray angle ratio). If you evaluate the operands ('ope') you get.

```
TW1*
Len Spe Rin Ape Wav Pxc Abr Mrg Chf Tra Sop Ref Fan Spd Auf Var Ope Ite

*OPERANDS
 OP   MODE      WGT        NAME        VALUE    %CNTRB DEFINITION
O 1    M       0.0                    2.000108    0.00 -EFL(4,5)/EFL(2,3)
O 2    M       0.0                    2.000198    0.00 PUC(1,1)/PUC(1,6)
O 3    M       1.000000           -2.7705e-06 100.00 PU
MIN RMS ERROR:    2.7705e-06
```

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