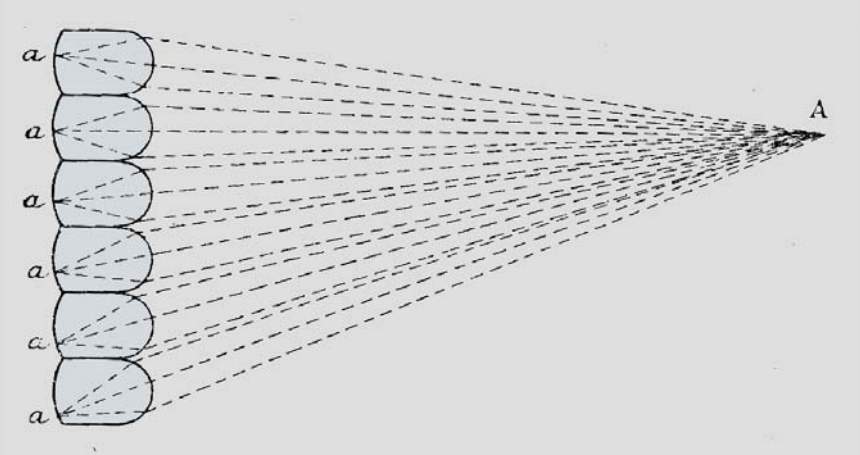
# 100 Years Light-Field




Todor Georgiev
Senior Research Scientist II
Photoshop

March 1908 - March 2008

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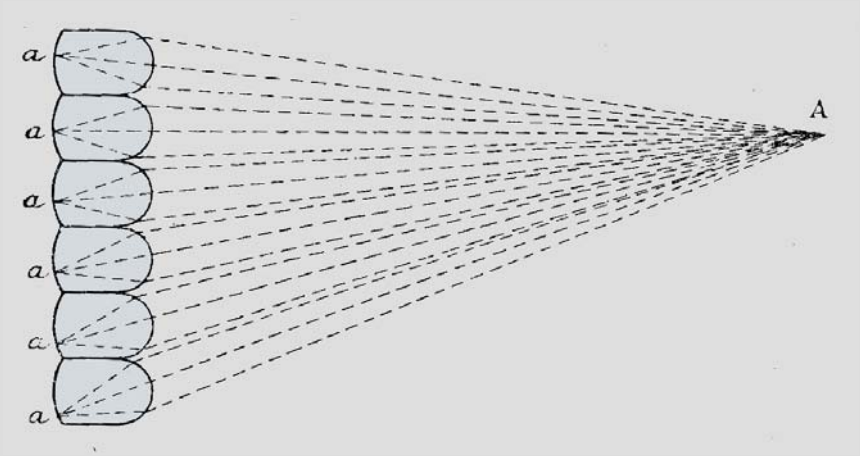
# “Directional Imaging”




Todor Georgiev
Senior Research Scientist II
Photoshop

March 1908 - March 2008

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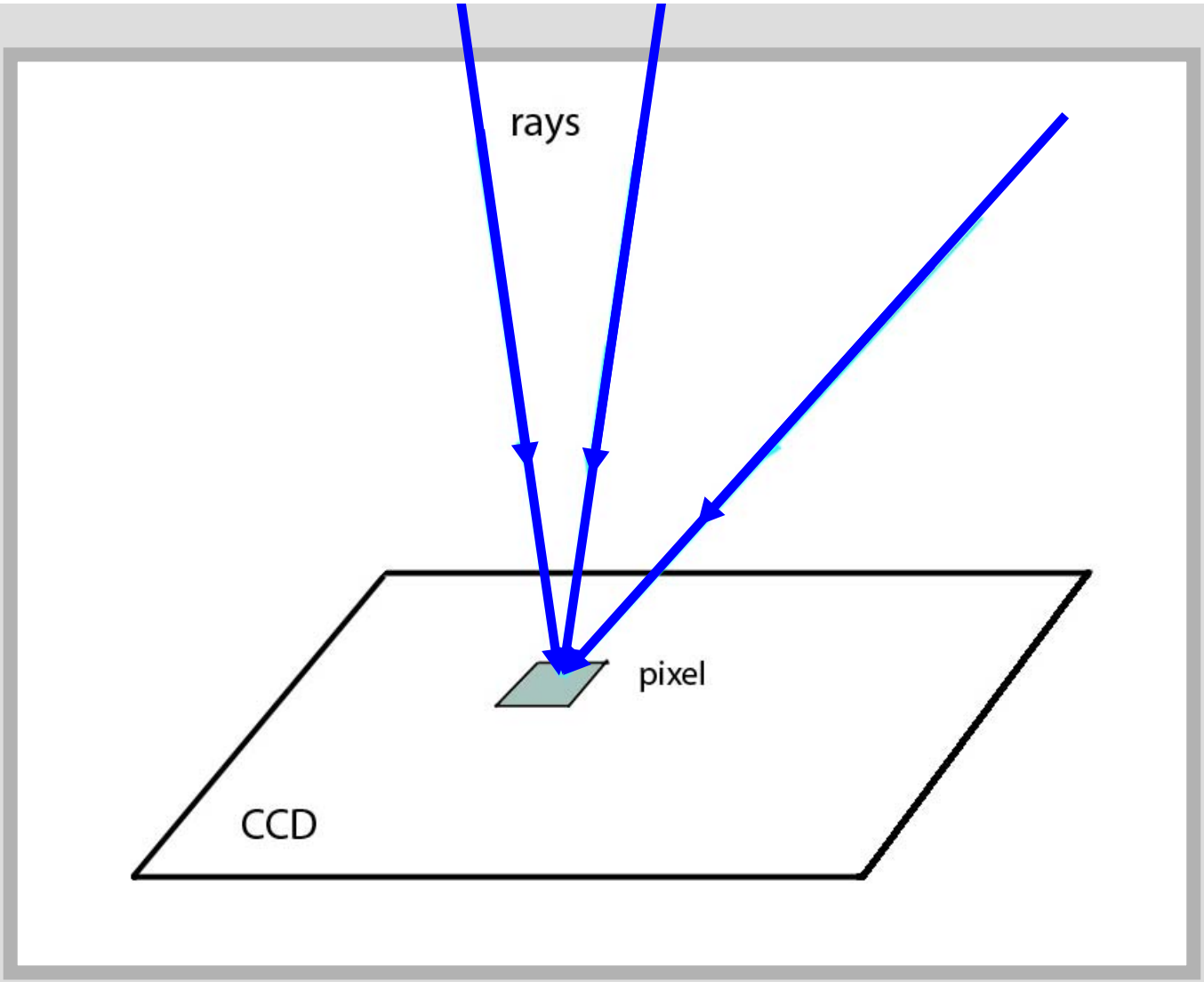
# What is **Light-Field** ?

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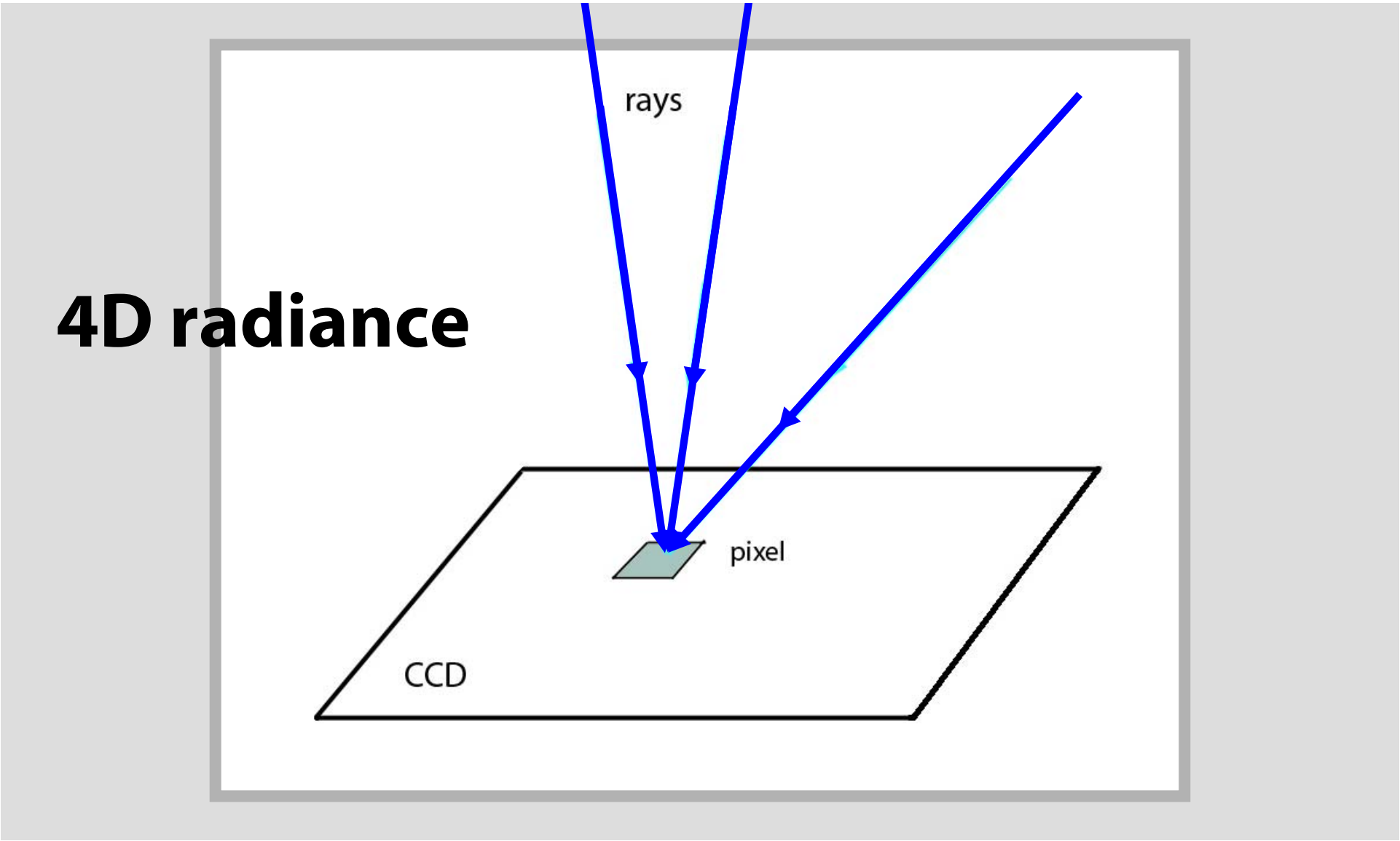
# What is **Light-Field** or **directional** imaging?

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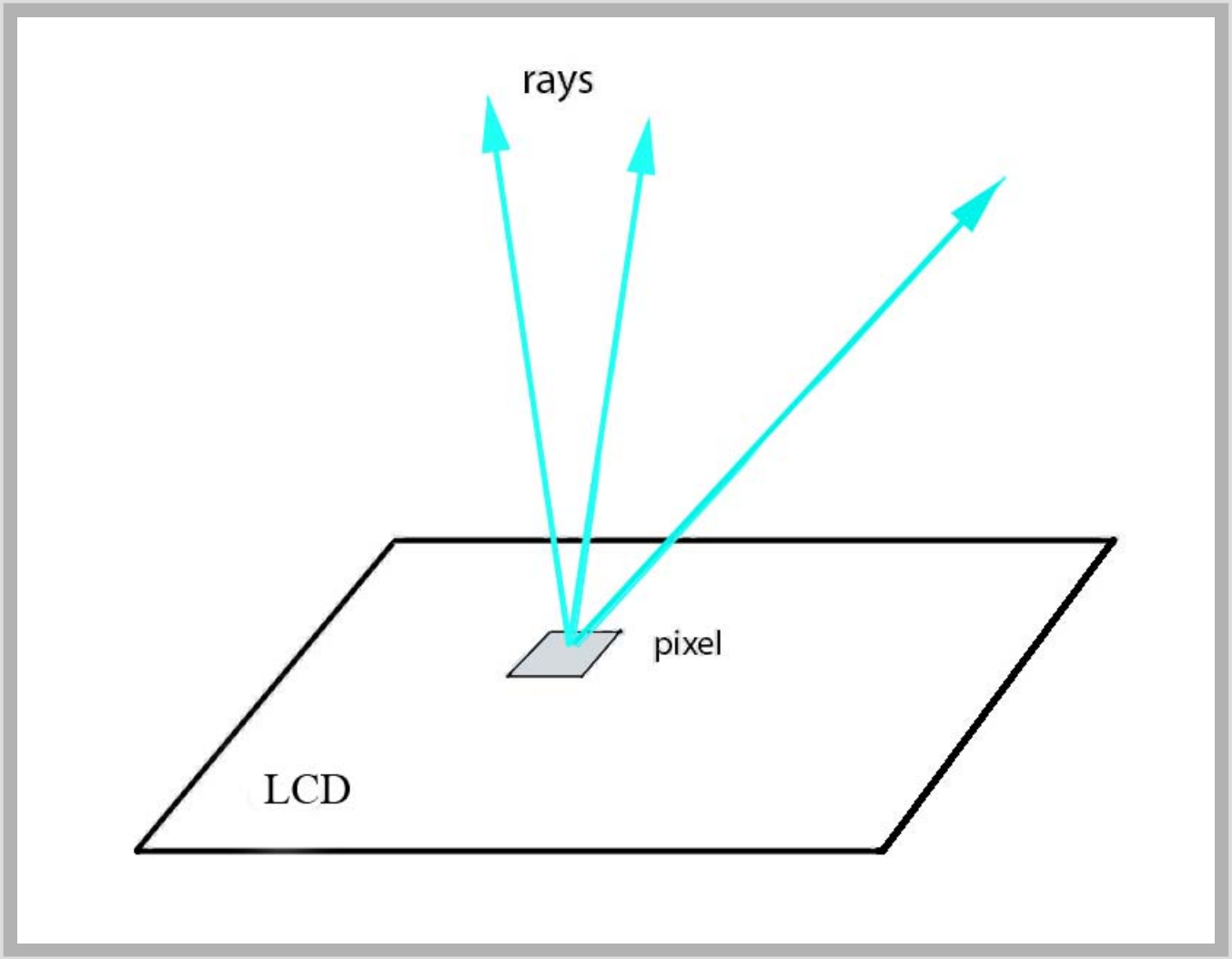
# What is **Light-Field** or **directional** display?

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What could we do if we didn't throw away directional info at each pixel?

## We are talking about 4D images, not cheap stereo glasses.

- Focus the image after the fact. No more blurry pictures!
- Control the focus of every pixel with a "focus brush"
- Move the camera after the fact
- Select objects automatically – based on depth information
- Insert objects into a scene – with proper occlusion based on depth

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# Lippmann 1908

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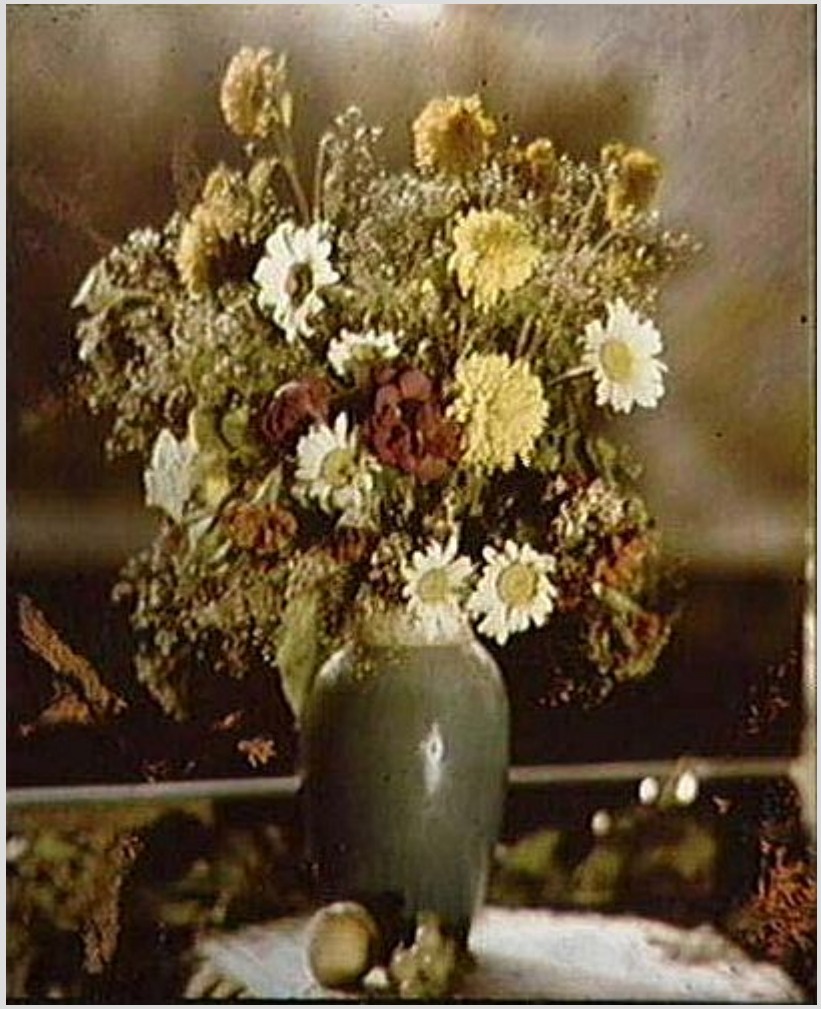
# About Lippmann



Nobel Laureate for Color Photography

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# About Lippmann

Lippmann was the thesis advisor of Marie Curie

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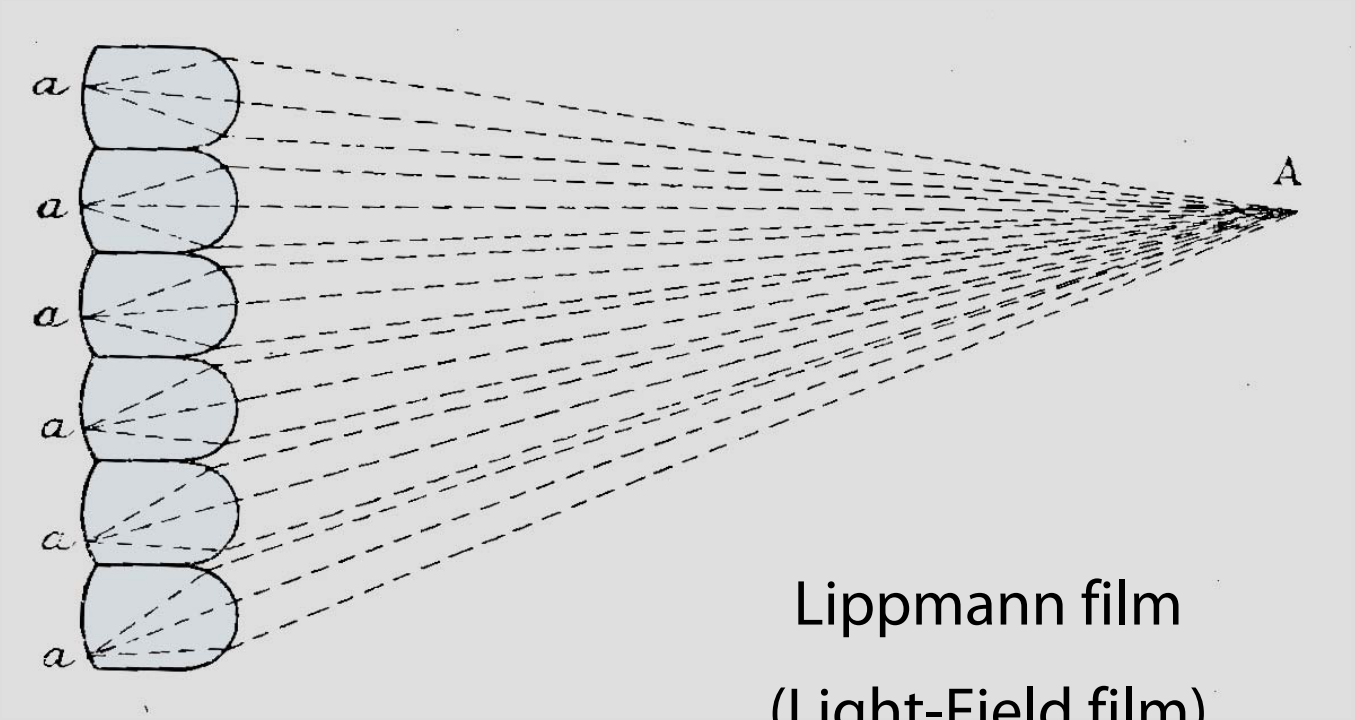
# About Lippmann




Lippmann film

(Light-Field film)

**Integral Photographs (Light-Field Photography) 1908**

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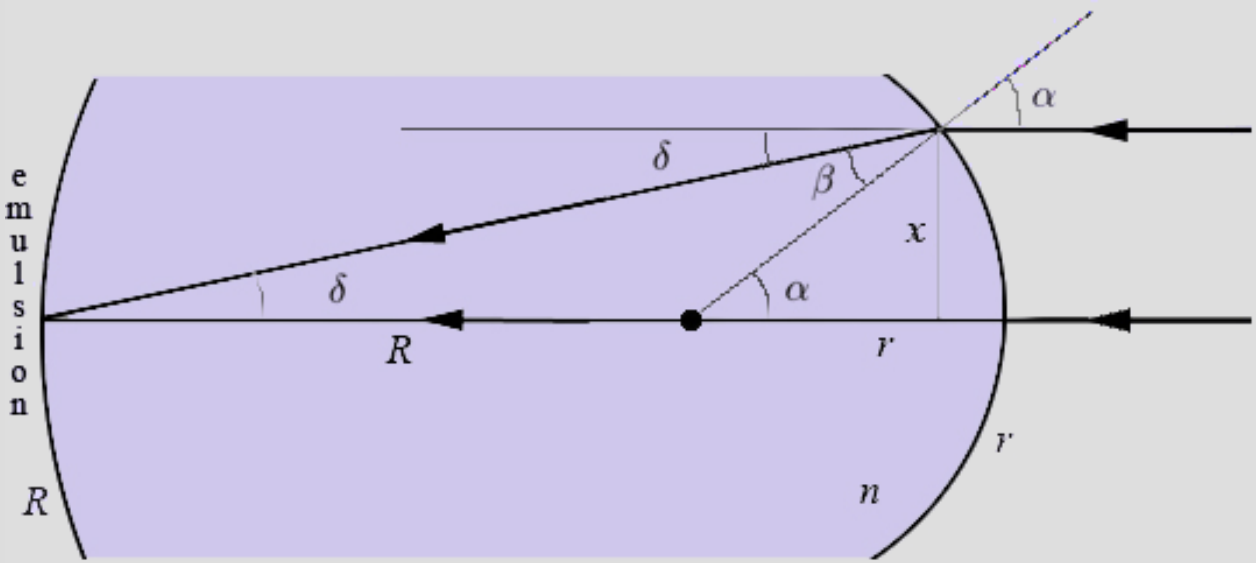
# Light-Field film

Deriving the lens curvature equation for a section of Lippmann's film "Light-Field film"




$$\frac{sin\alpha}{sin\beta} = n$$

$$\delta = \alpha - \beta = \alpha(1 - \frac{1}{n}) = \alpha\frac{n-1}{n}$$

$$(R + r)\delta = x$$

$$(R + r)\frac{x}{r}\frac{n-1}{n} = x$$

$$\frac{R}{r} + 1 = \frac{n}{n-1}$$

$$\frac{R}{r} = \frac{1}{n-1}$$

$$\frac{r}{R} = n - 1$$

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# Sokolov 1911

?

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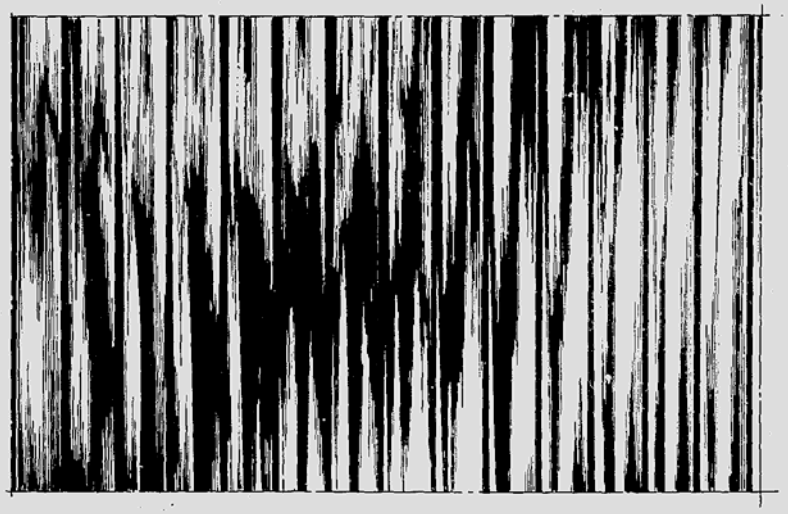
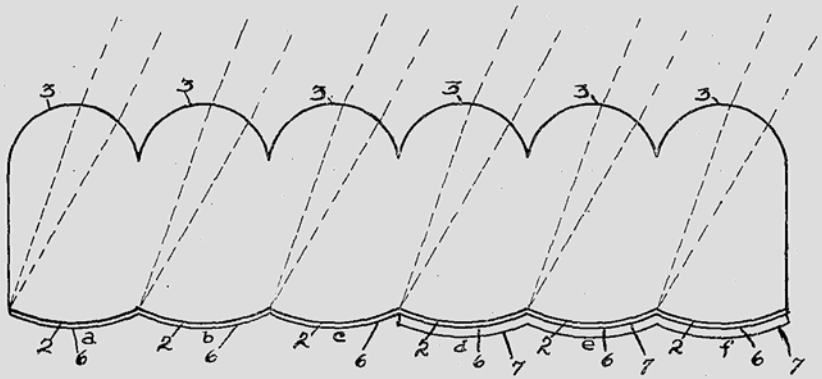
# Ives 1930 (Lenticulars)



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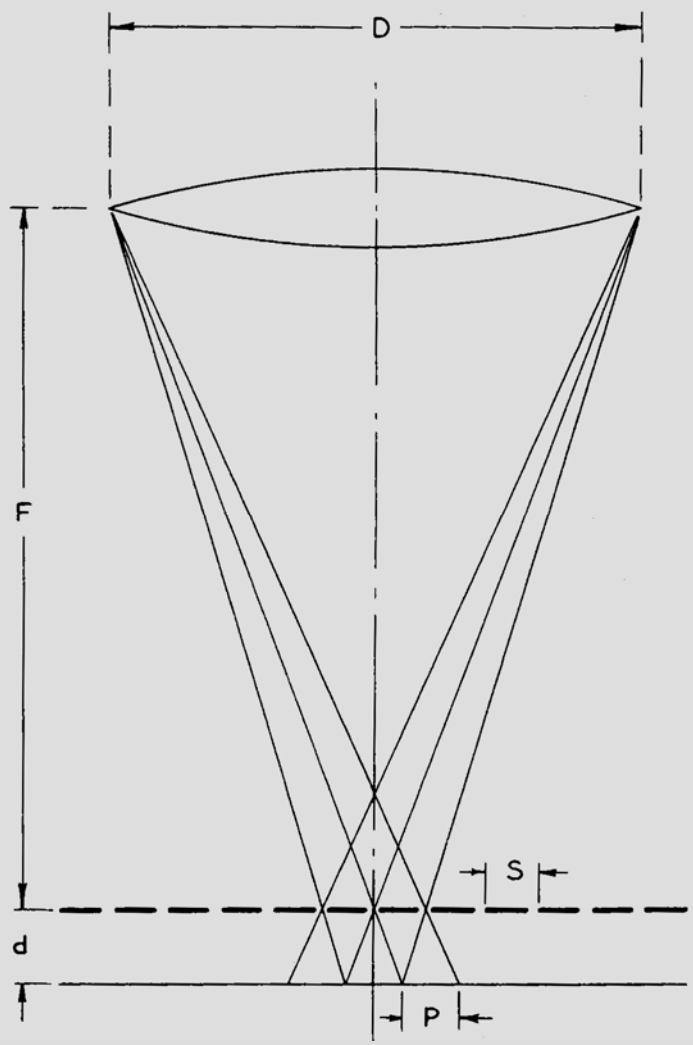
# Ives 1930 (Large Lens)

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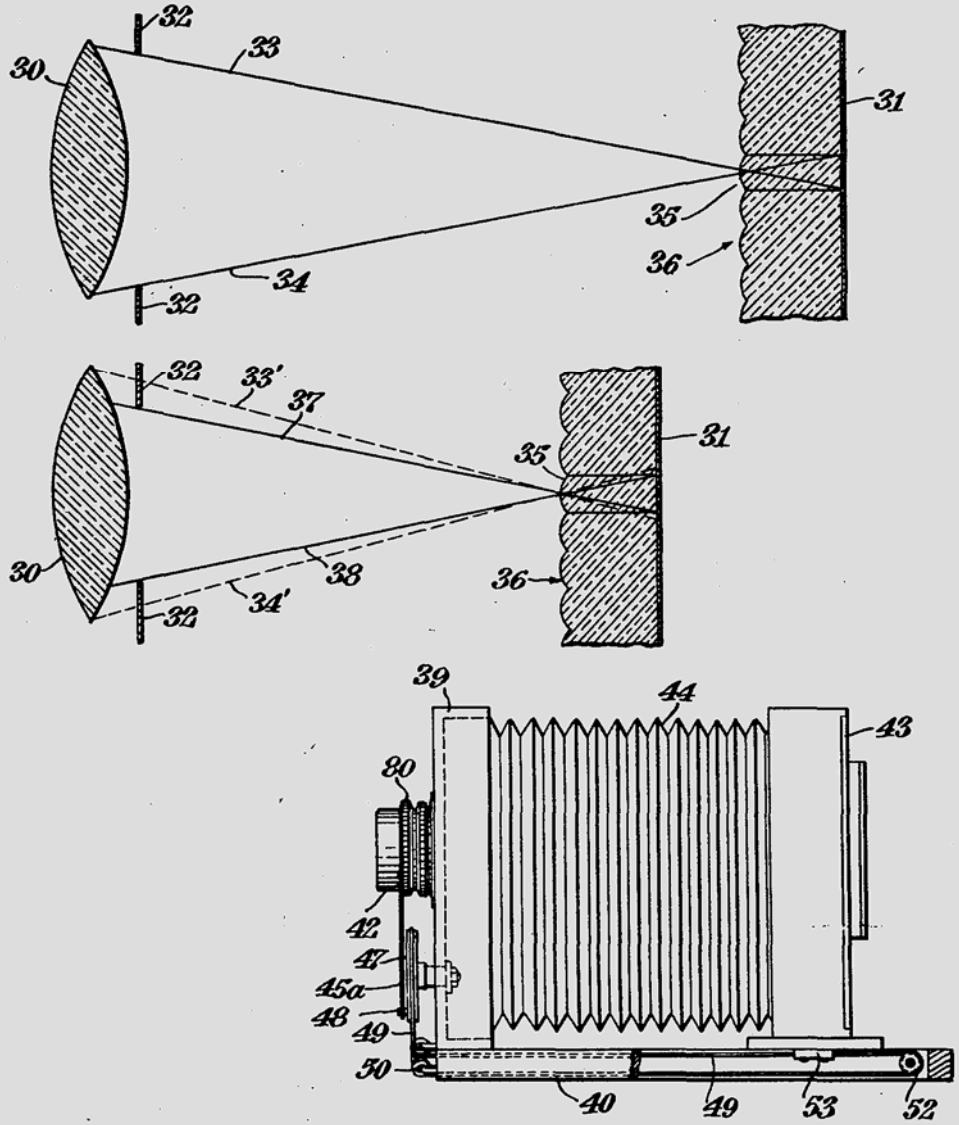
# Coffey 1935 (F/# matching)

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# Ivanov (1948) 2 million lenslets

?

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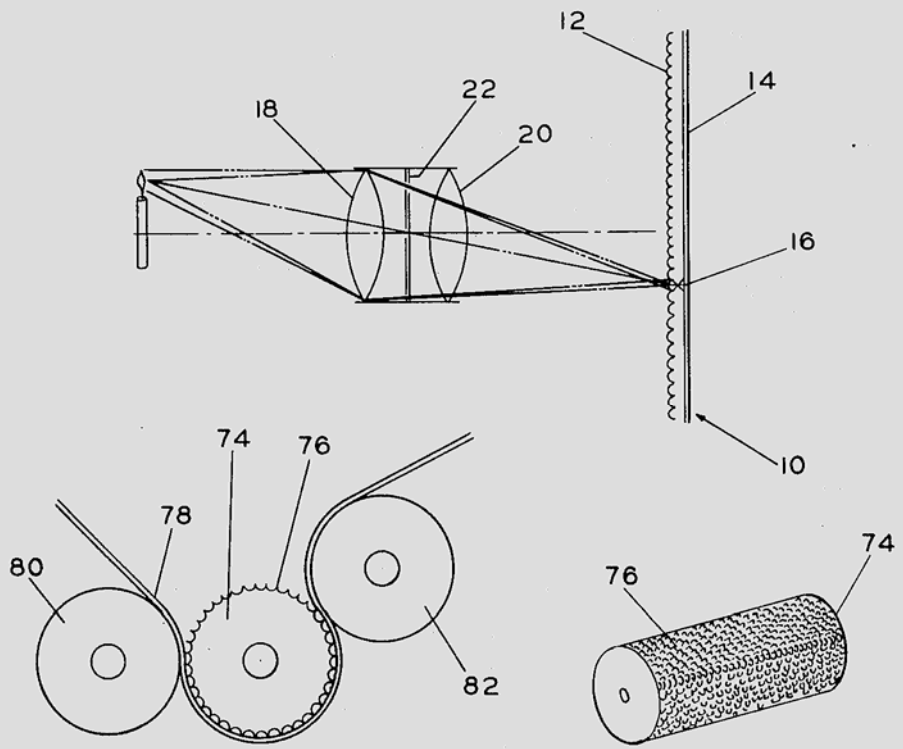
# Gruetzner (1952) commercial camera

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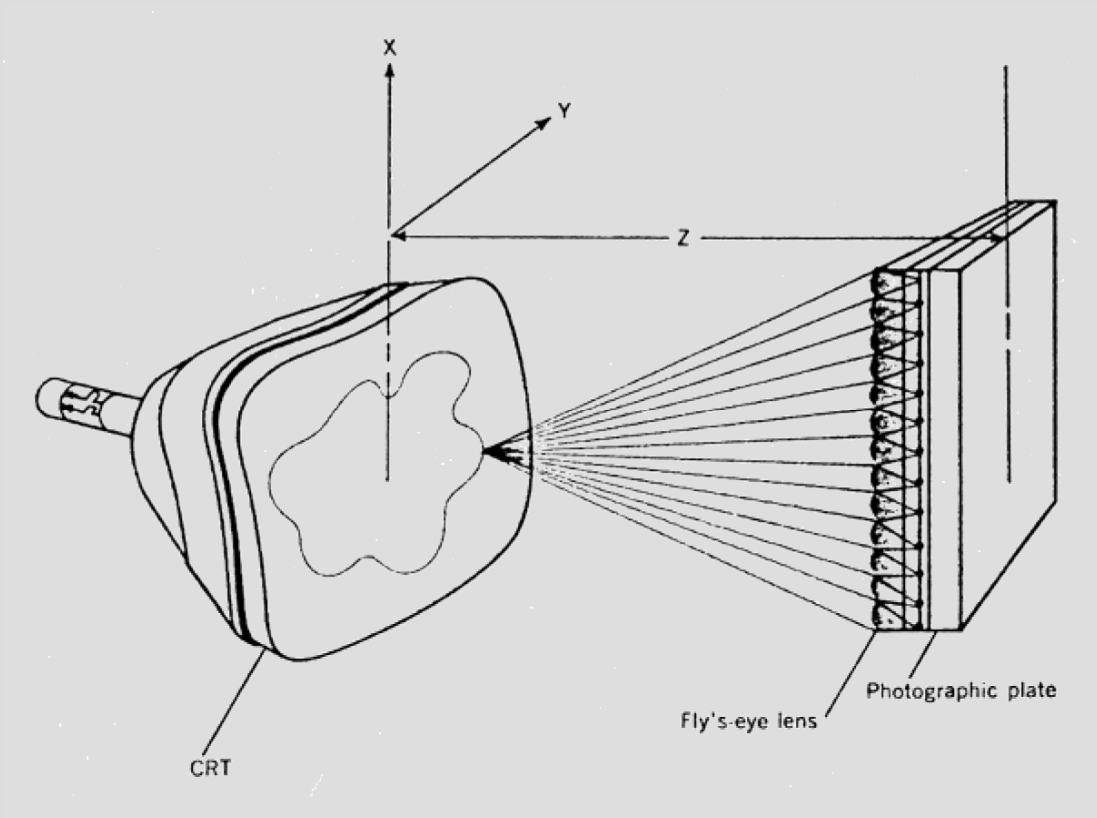
# Chutjian 1968 (First Digital Light-Field)




This was done before the first digital camera (Kodak 1975)!
(Note: The first digital camera had 0.01 Megapixels; the first digital lightfield camera - 0.1 Megapixels)

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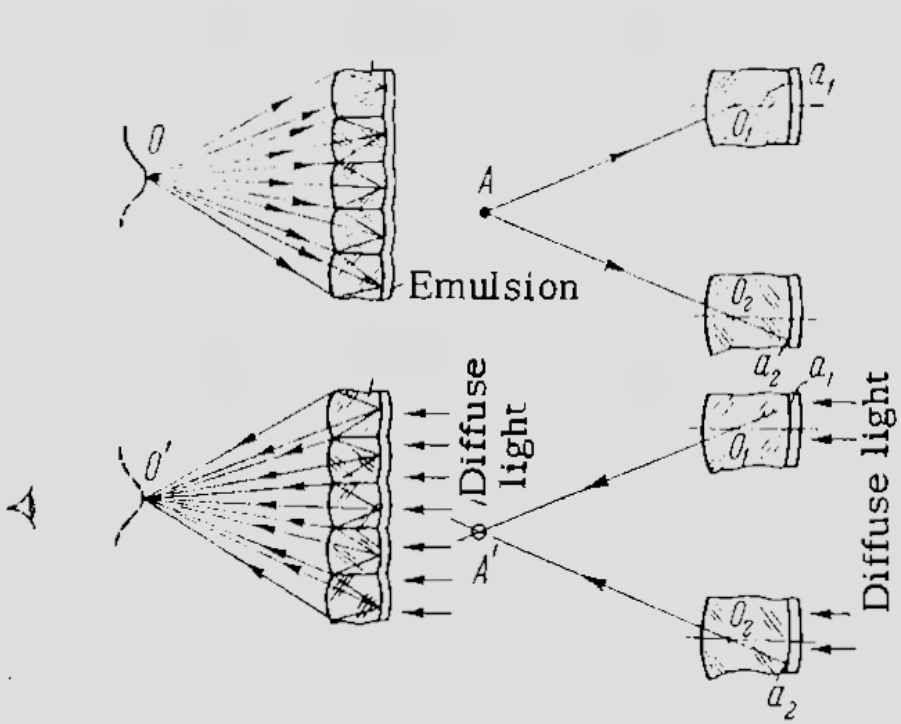
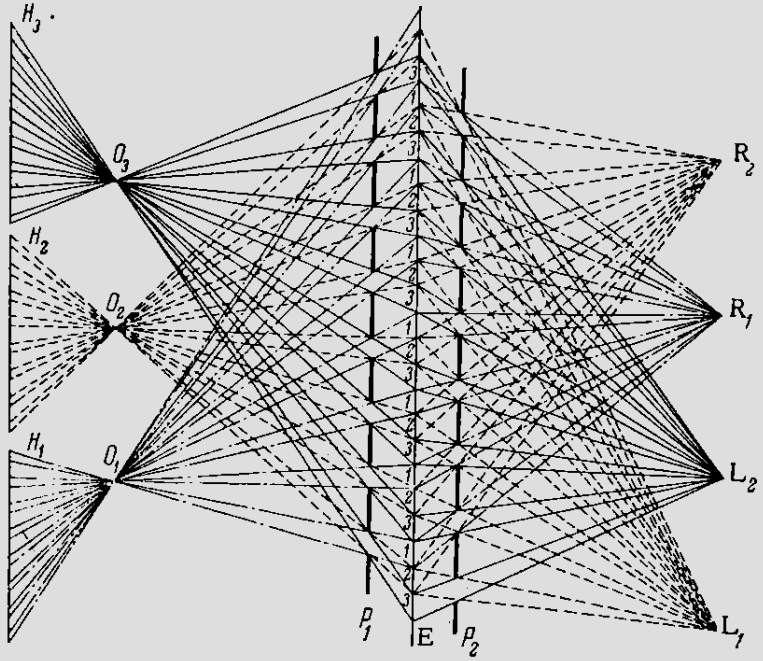
# Dudnikov 1970 - 1982 (detailed research)



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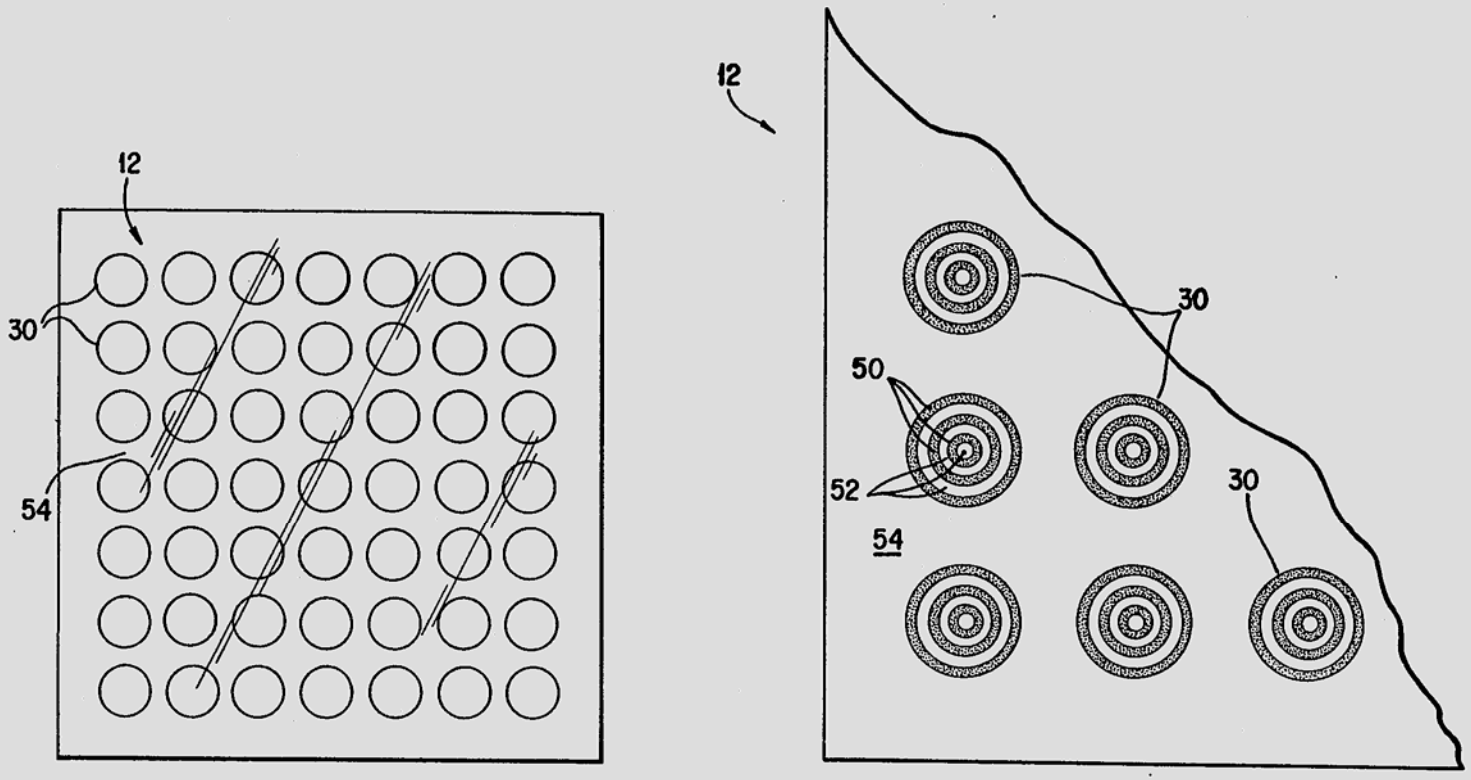
# Ivars 1988 (Diffraction lenses)

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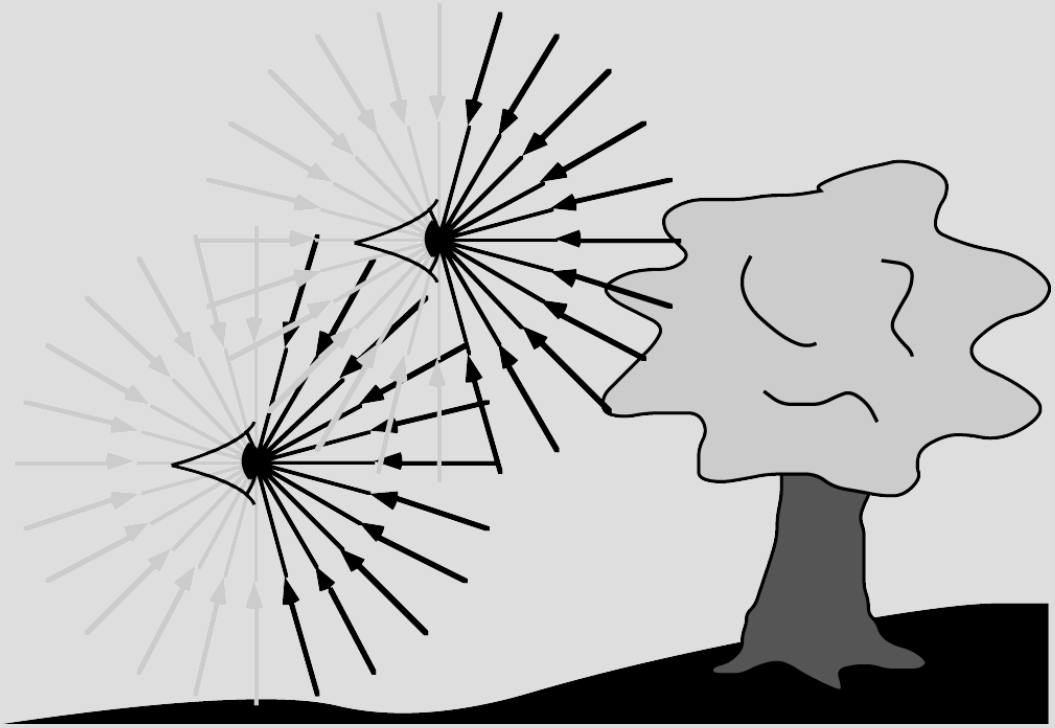
# Adelson 1991 (Plenoptic Function)



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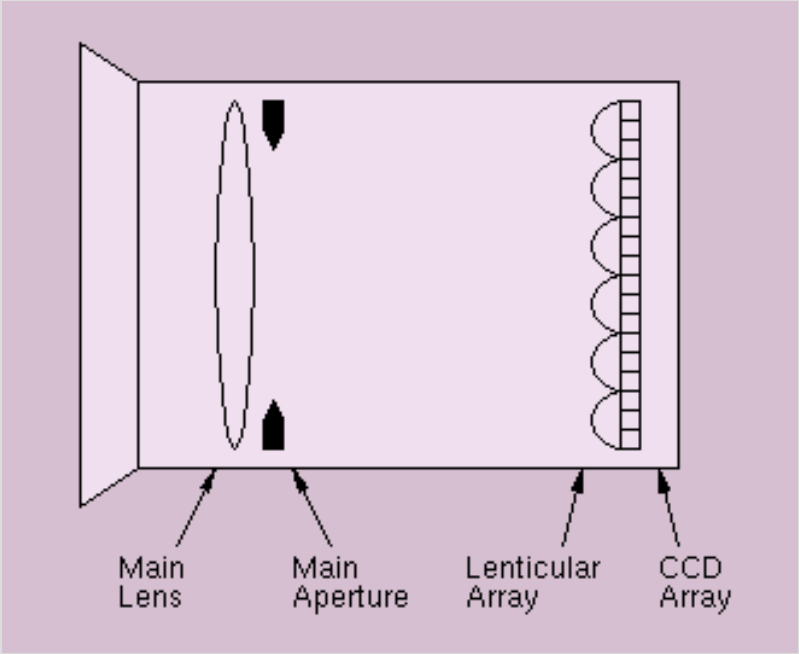
# Adelson 1992 (Plenoptic Camera)

Designed with the idea to solve **Computer Vision** problems

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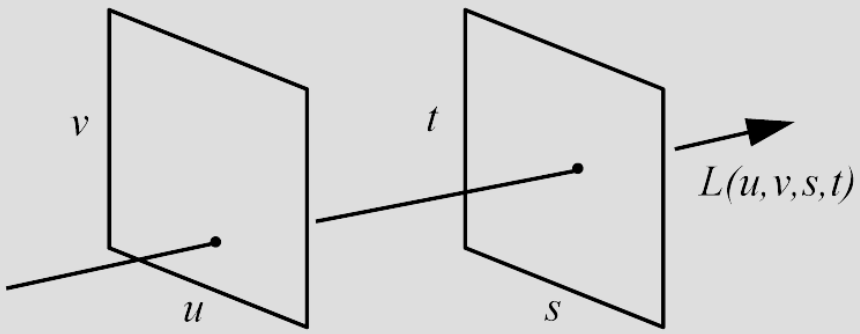
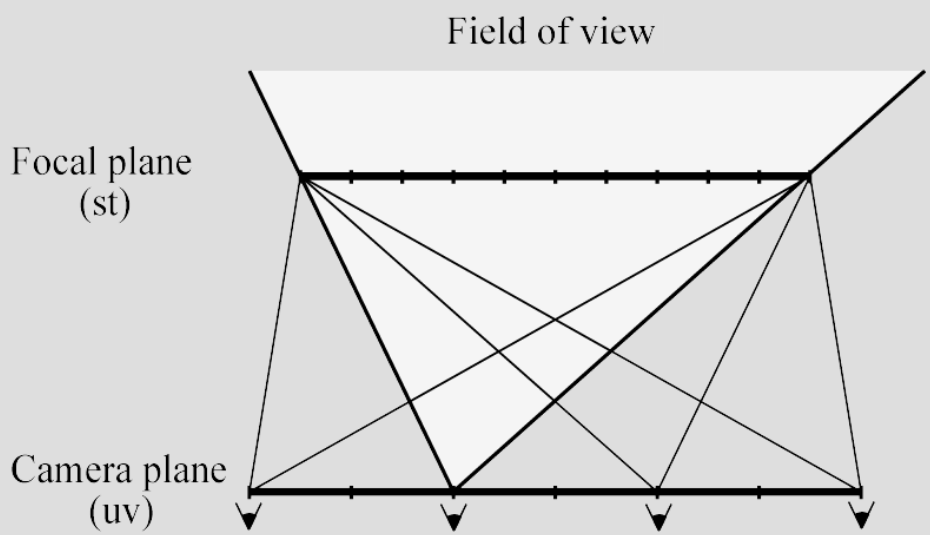
# Levoy 1996 (Light Field Rendering)

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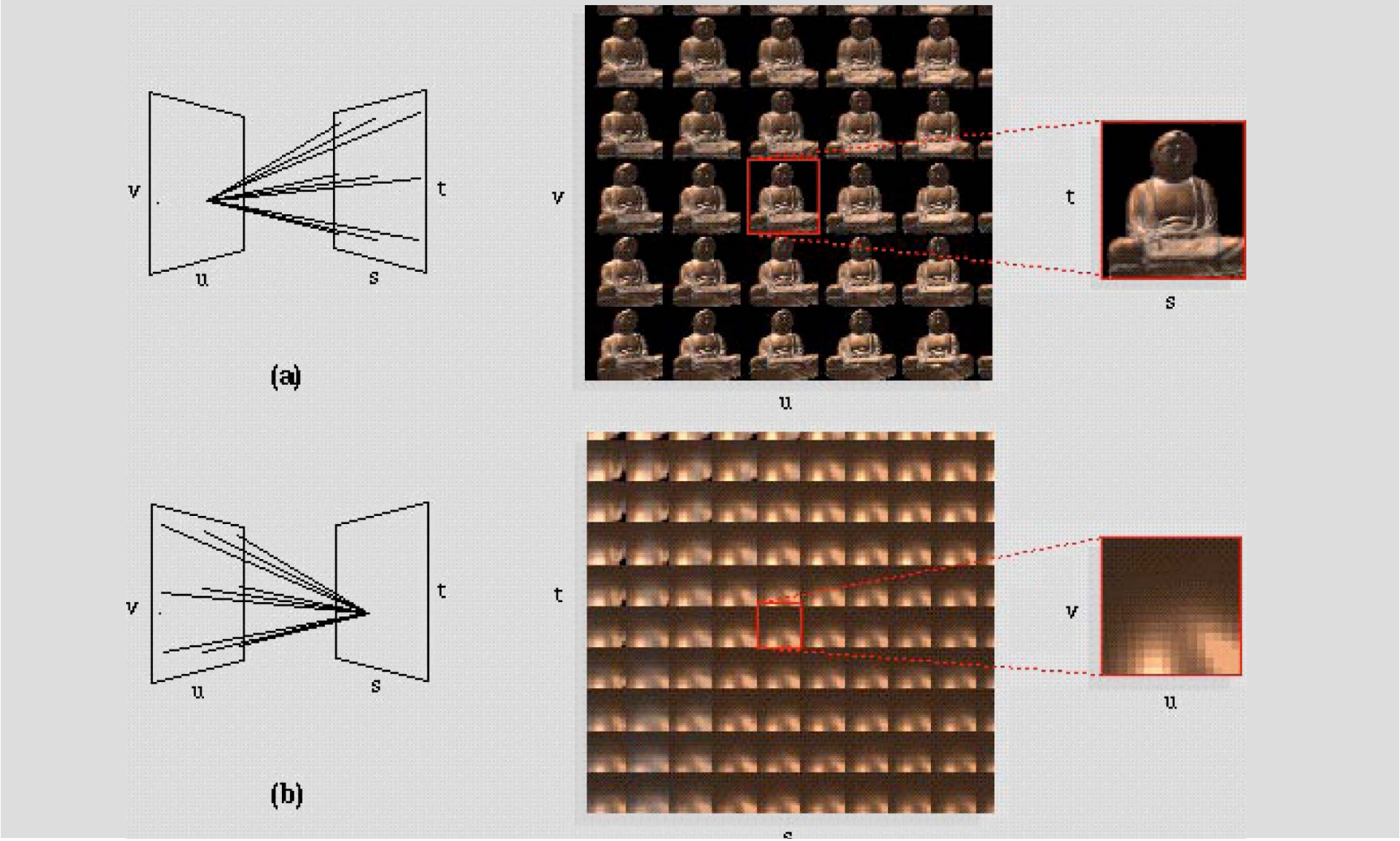
# Levoy 1996 (Light Field Rendering)

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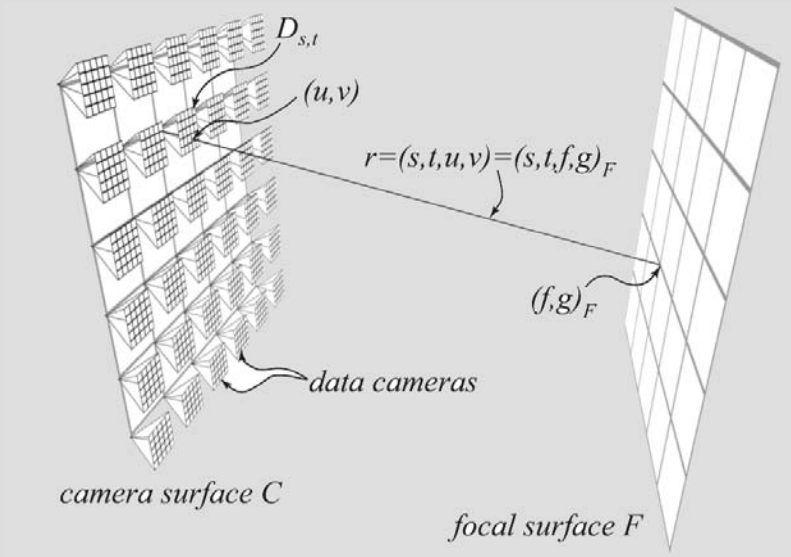
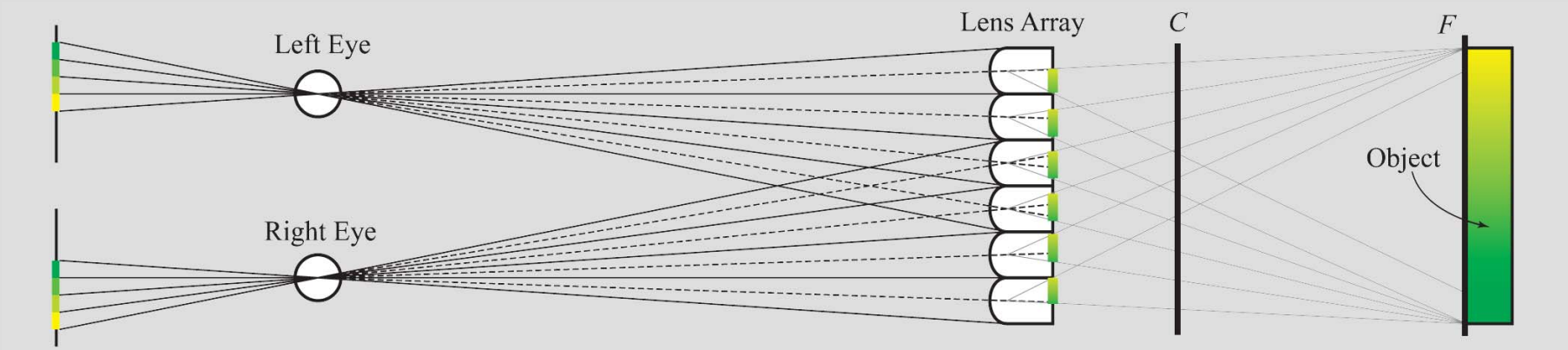
# Isaksen 2000 (Light Field "Reparametrization")

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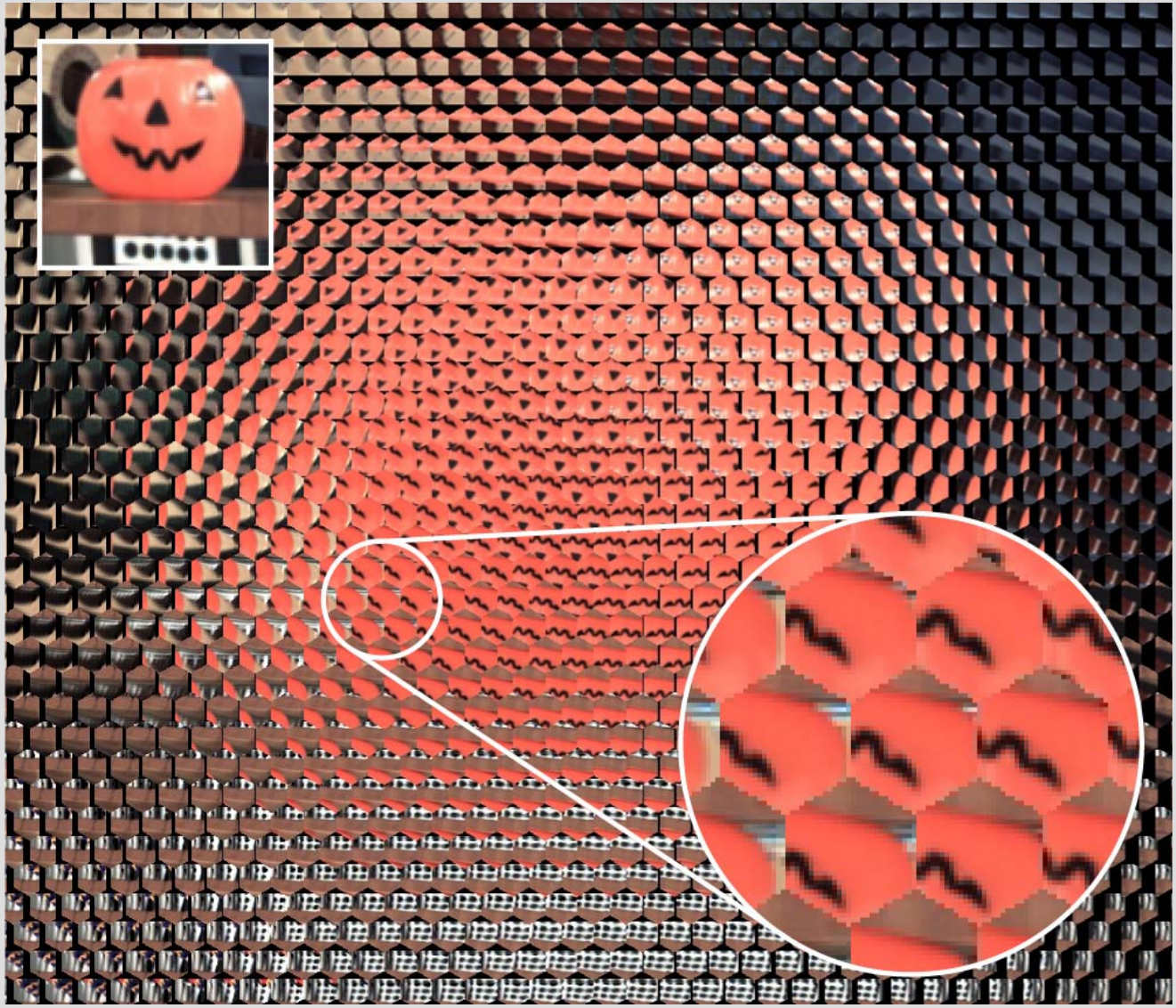
# Isaksen 2000 (Light Field “Reparametrization”)



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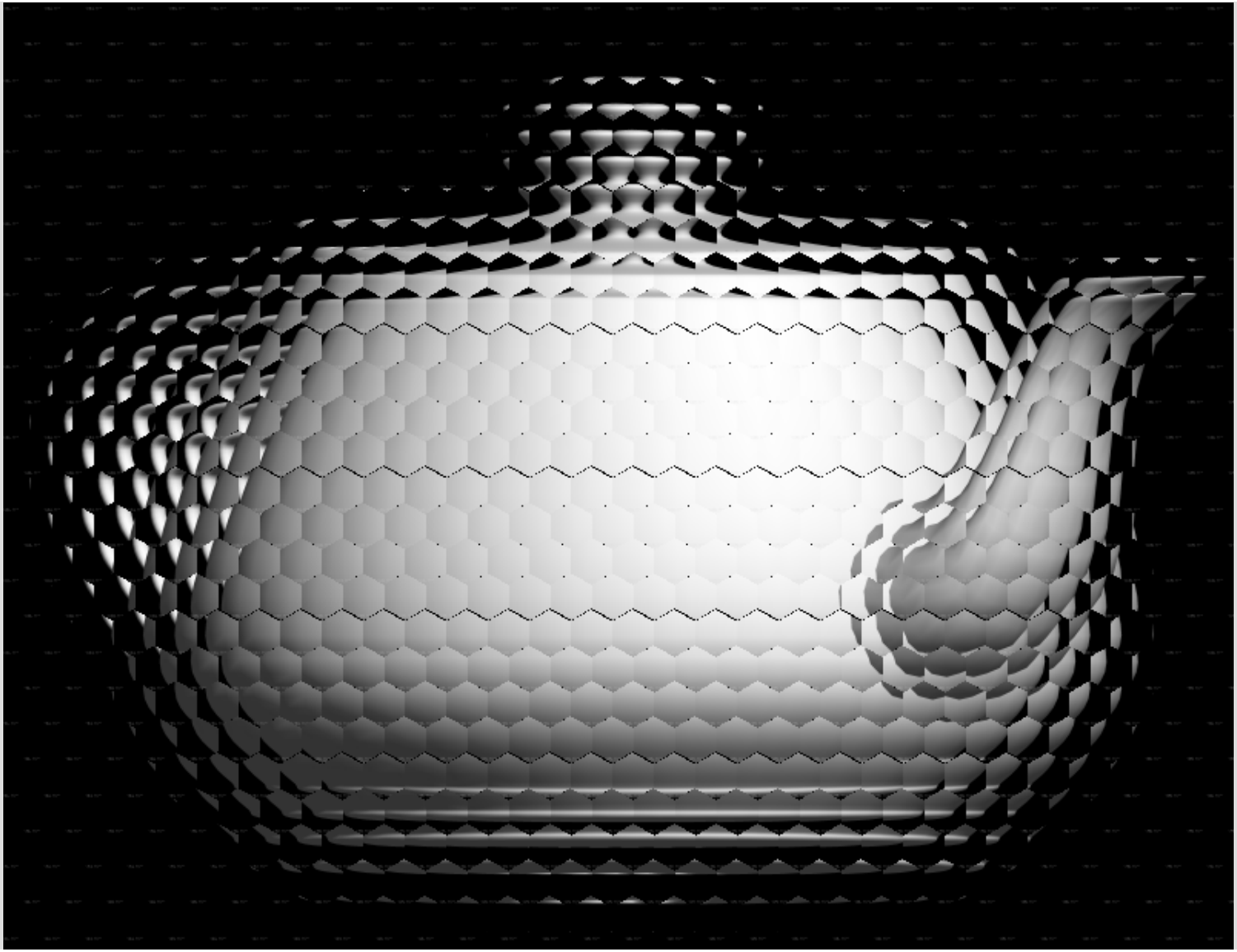
# Billy Chen 2002 (Autostereoscopic Display)



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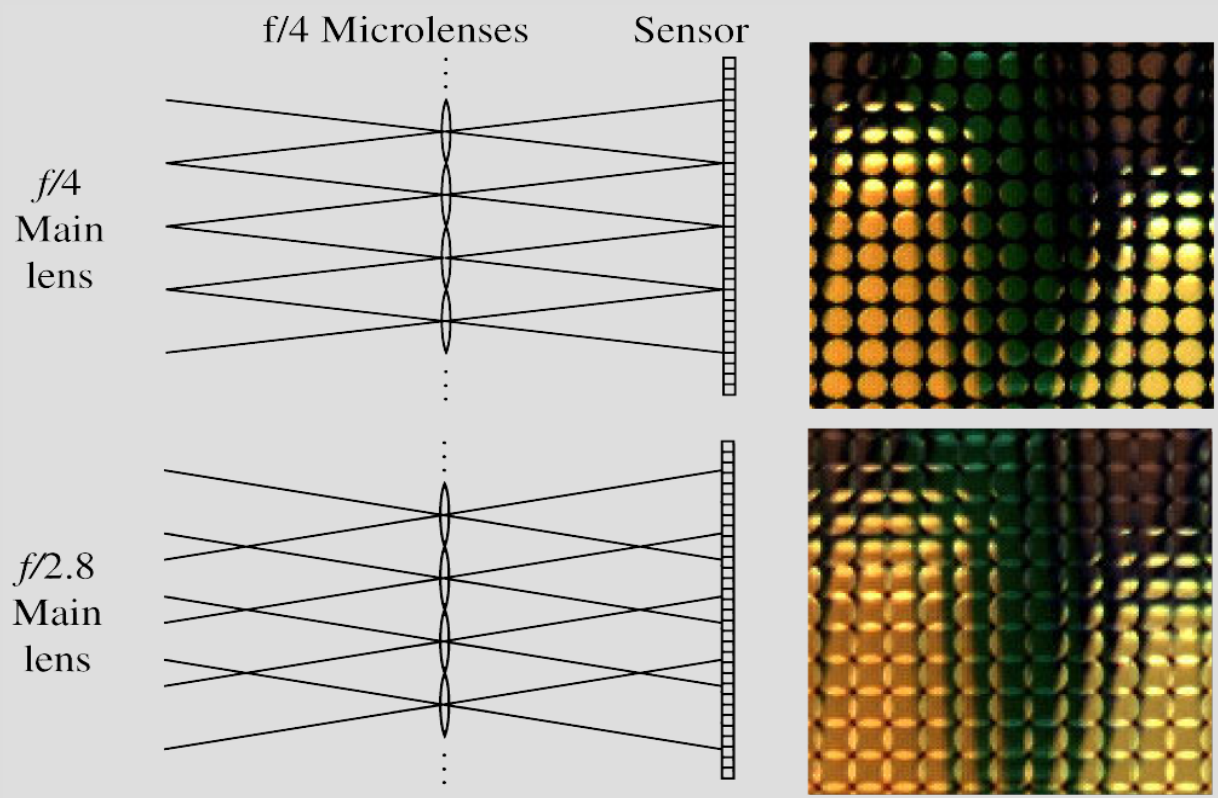
# Ng 2005 (Hand-Held Plenoptic Camera)




**Note:** The first digital camera (1975) produced image 0.01 Megapixels.
The first digital lightfield camera (2005) produced image 0.1 Megapixels. Ren is 10 times better!

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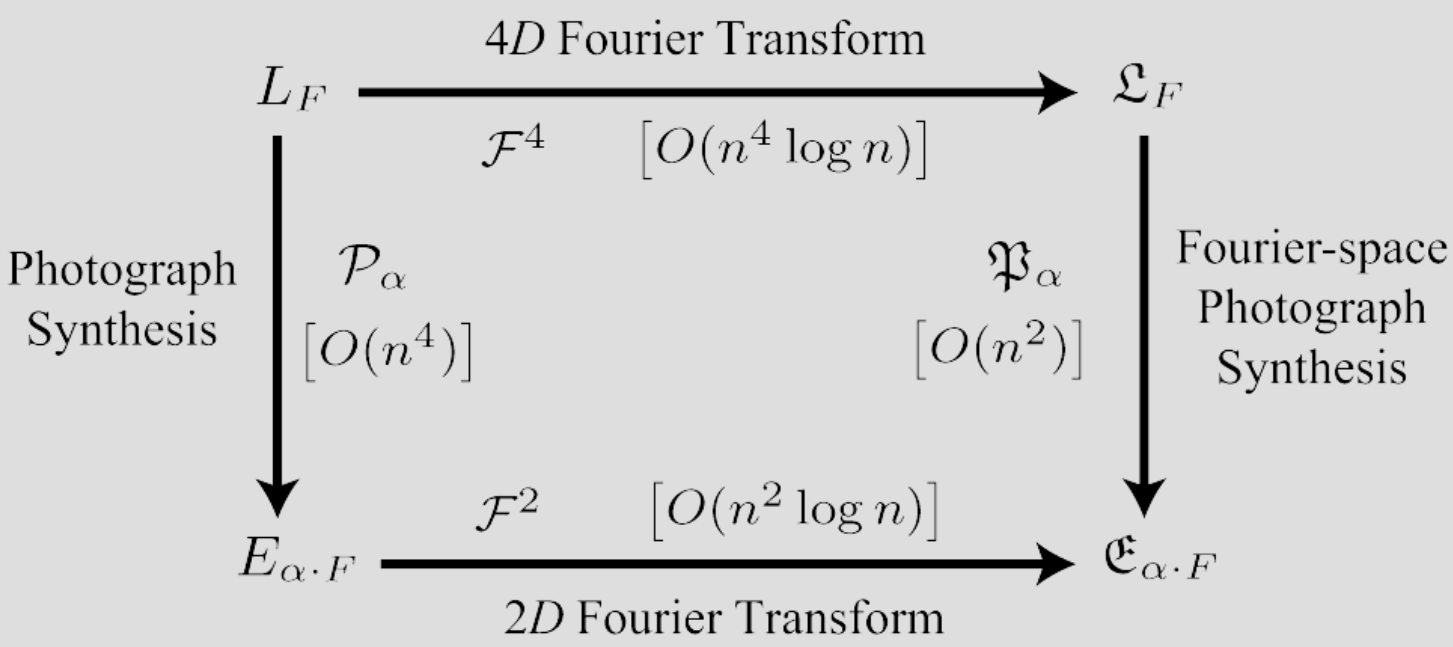
# Ng 2005 (Fourier Slice Refocusing)

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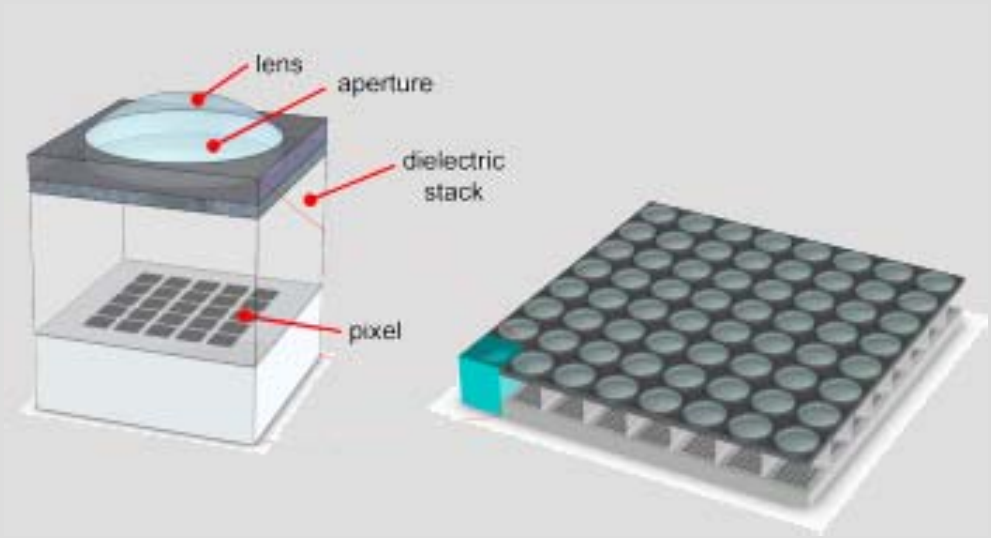
# Fife 2008 (“Light-Field” Chip)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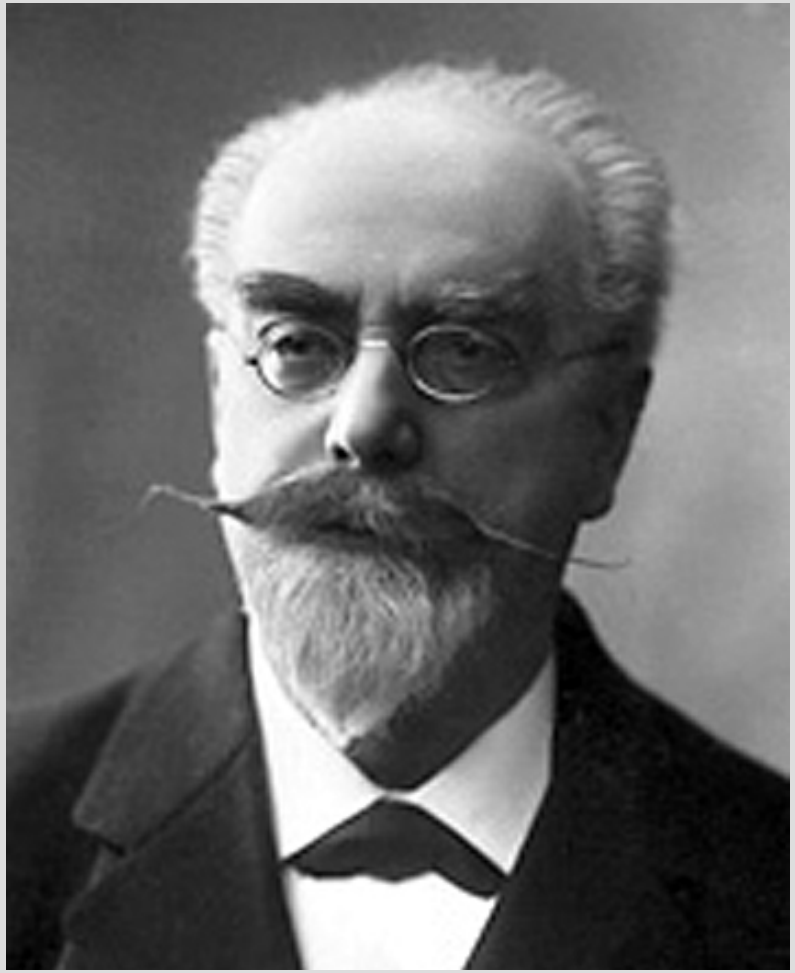
# For 100 Years Lippmann's idea has been **Possible**…



**Now Radiance Photography is Practical!**

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