

# Advanced Camera Research at NHK

~ "Super Hi-vision" Camera  
with 8k x 4k Pixels ~

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# Outline

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- Our Goal
- Camera System
  - Camera head
  - Image sensor
  - Signal processor
- Camera Characteristics
  - Resolution
  - Signal-to-noise ratio
- Applications



# Our Goal

## Future TV System with Greater Sensation of Reality



### Effects

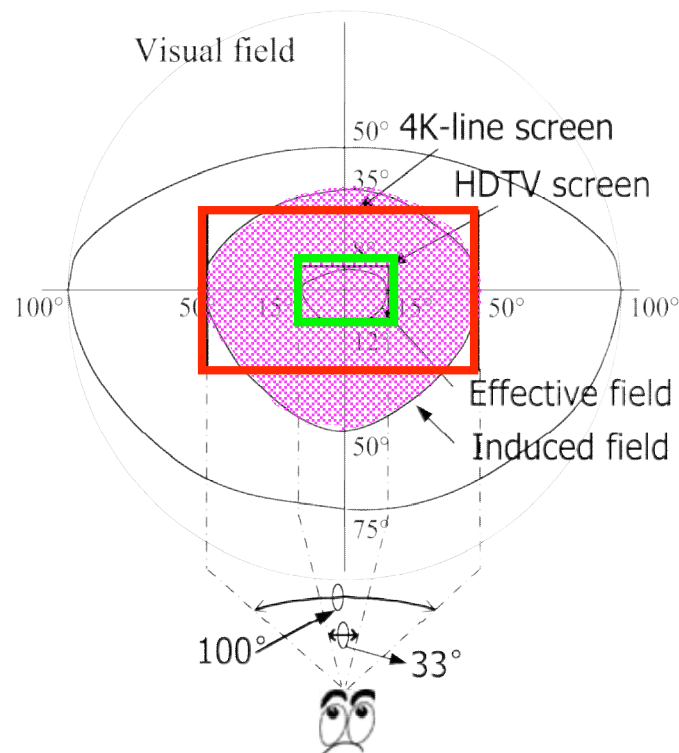
- High sensation of reality as if we are there
- More exciting in live TV programs

### Our objectives

- Examine physical and psychological effects
- Enhance sensation for future TV system



# Why 8k?



Viewing angles of displays for **HDTV** and **8k x 4k pixel** image system

- The sensation of reality increases with the viewing angle and saturates at around 100 deg. Horizontally\*1
- The spatial resolution of Human vision perceives 60 pixels per deg.\*2



Requirement of 8k pixels  
in the horizontal direction

\*1:T. Hatada, et al., "Psychophysical Analysis of the Sensation of Reality Induce by a Visual Wide-Field Display," SMPTE Journal, Vol.89, pp.560-569, 1980

\*2:High-Definition Television, p.6 Van Nostrand Reinhold, New York, 1992



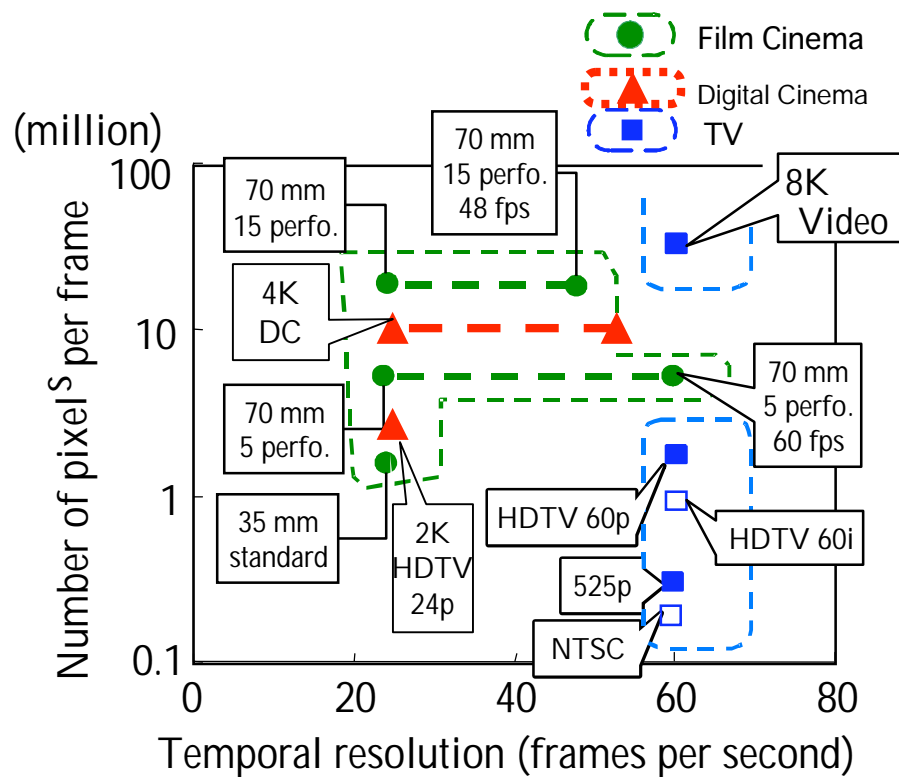


# System Specifications

Parameters	HDTV (60i)	8K x 4K system “Super Hi-vision”
Lines per picture height	1080	4320
Samples per active line	1920	7680
Scanning format	2 : 1 interlace	Progressive
Aspect ratio of image	16 : 9	16 : 9
Frame rate (Hz)	29.97	59.94



# System Resolution



(Note) Film resolution assuming when distributed (70 pixels per mm.)



# "Super Hi-Vision"



Camera Head



Projection Display



Display Theater



# Camera Specifications

System	7680 x 4320 pixels 60 frames per sec. progressive scanning
Optical format	approx. 1.25 inch
Lens	5x zoom f = 12 ~ 60 mm F2.1
Color imaging method	Four-pickup imaging (GGBR) (Diagonal pixel offset between green imagers)
Image sensor	8M- pixel CMOS
Power consumption*	300 W
Weight*	40 kg

\* Include zoom lens, lens servo system, viewfinder, and optical transmitter.



Newly developed

Year 2004

1.25" CMOS

Zoom lens

Weighs 40kg

Previously developed

Year 2002

2.5" CCD

Fixed focus lens

Weighs 80kg





# Camera System (outline)

Camera Head

E/O Transmit.

Optical Fiber Cable

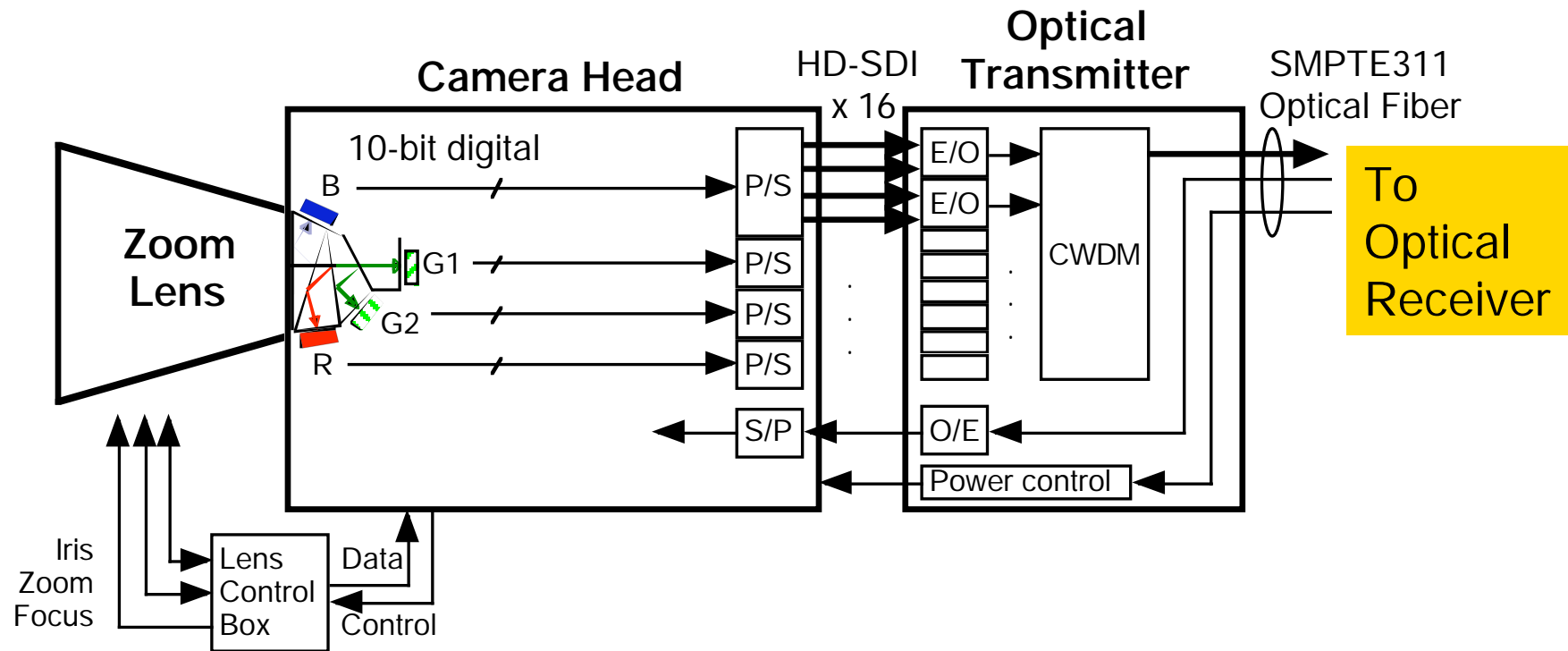
Signal Processor

O/E Receiv.

Camera Control Unit



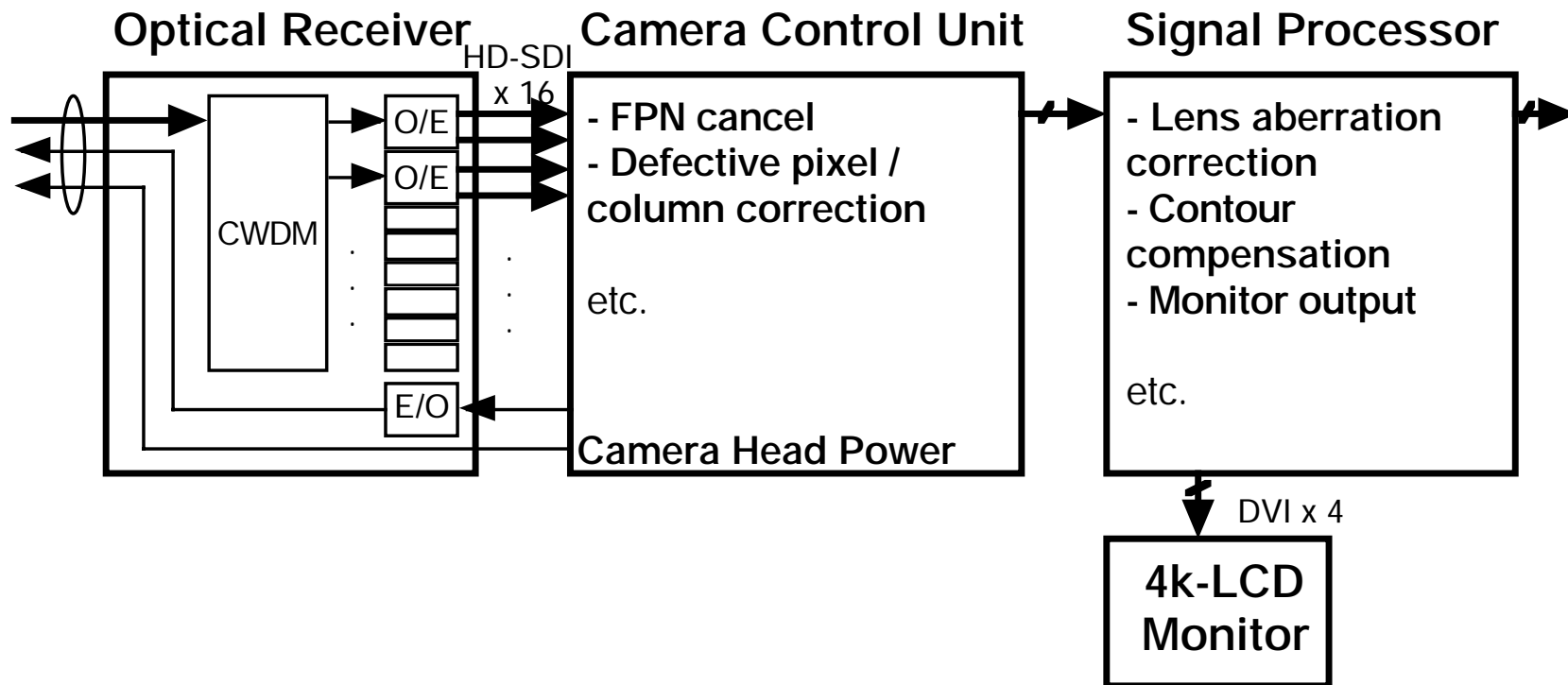
# Block Diagram (Head)



# Block Diagram (Process)

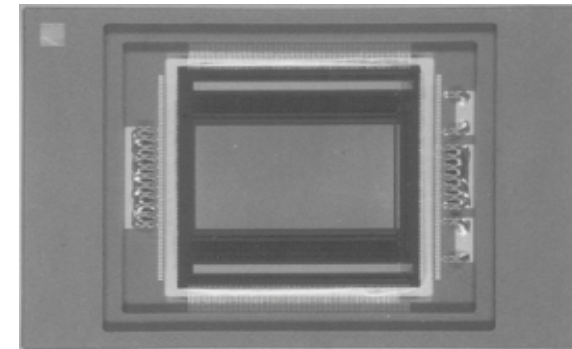
From  
Camera Head

To  
Recorder or Projector

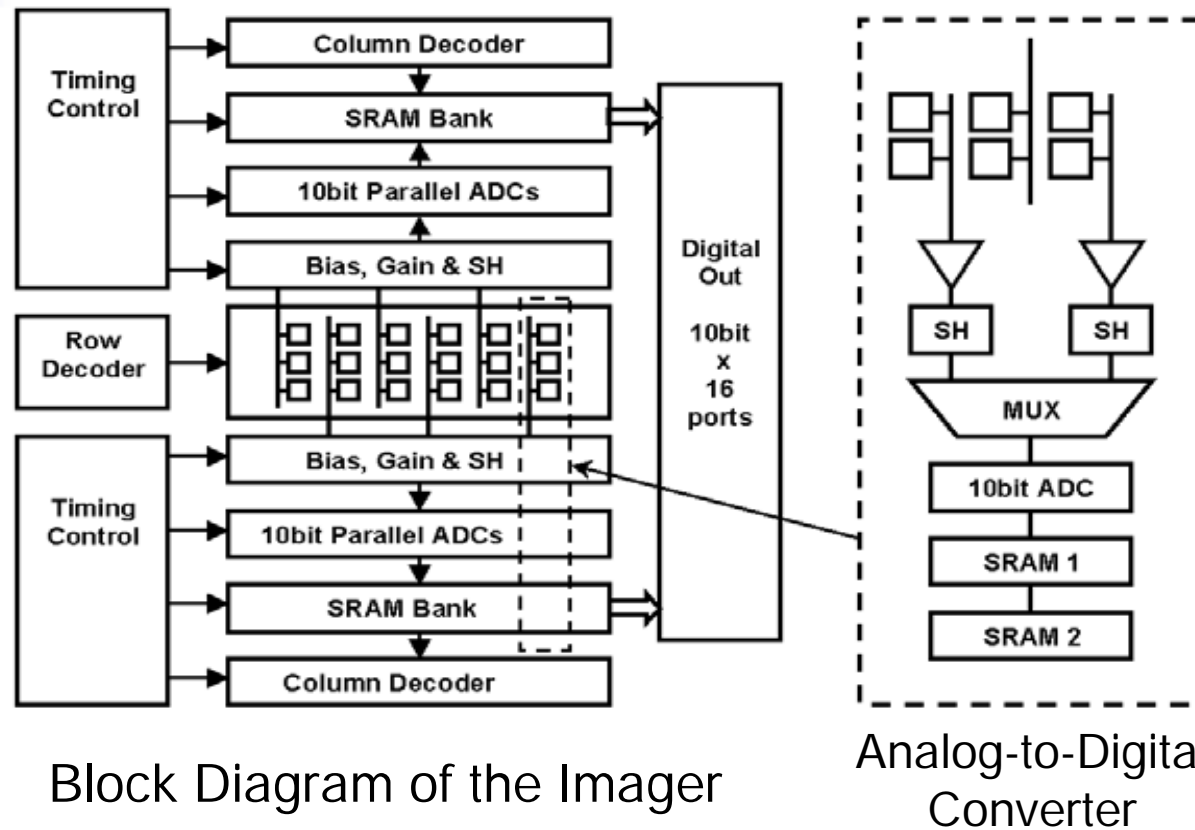


# 8M-pixel CMOS Imager

Pixel number (Horizontal x Vertical)	Effective: 3840 x 2160 Total: 3936 x 2196
Pixel size	4.2 $\mu\text{m}$ x 4.2 $\mu\text{m}$
Scanning	60 frames per sec. Progressive
ADC	1968 Column parallel
Output	10-bit digital 16 parallel
Frequency	49.5 MHz
Pixel aperture	68%



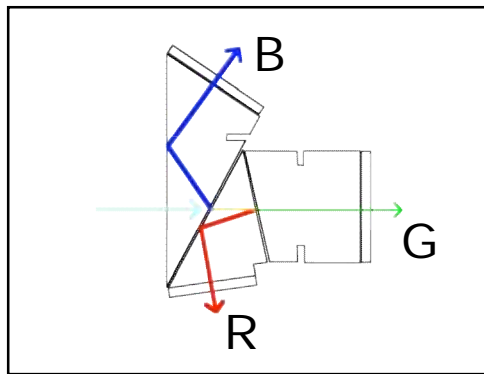
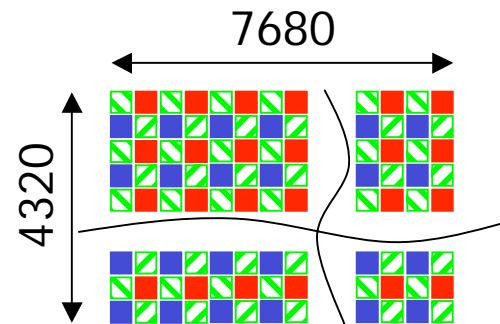
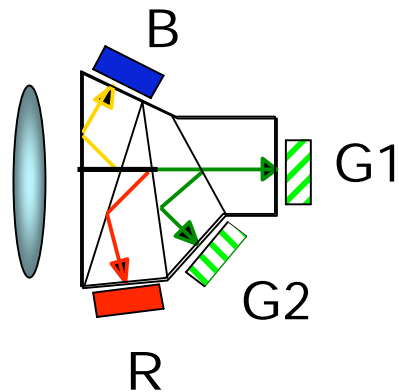
# 8M-pixel CMOS Imager



Reference: I. Takayanagi et al., "A 1-1/4 inch 8.3M pixel digital output CMOS APS for UDTV application", Proceeding of ISSCC2003, 12-3, February 2003



# Four-pickup Imaging



Usual Three-pickup Imaging

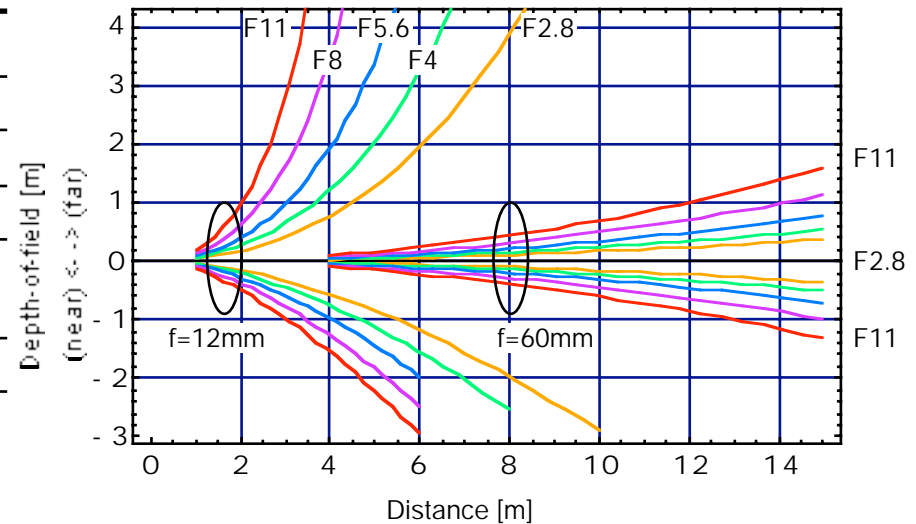
- Two imagers for Green channel
- Diagonal Pixel Offset between G1, G2, R, B channel Imagers
- Total Pixel Count of 7680 x 4320 (Similar to 32M-pixel Single-Chip Color Device)





# Zoom Lens

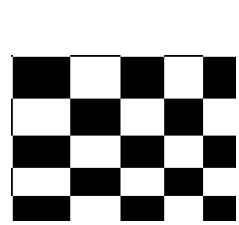
Focus length	12mm~60mm
Zoom	5x
Iris	F2.1
M.O.D.(from front lens)	1 m (0.07 m macro)
Shooting angle	67 ~ 15 deg.(Horizontal) 41 ~ 8 deg.(Vertical)
Weight	Approx. 8 kg (lens only)
System equipments	Servo module System controller Zoom demand Focus demand



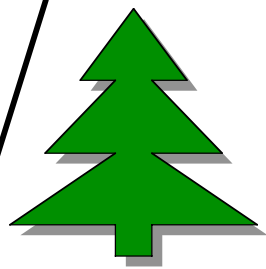
Depth-of-field Calculations



# Lateral Chromatic Aberration Correction



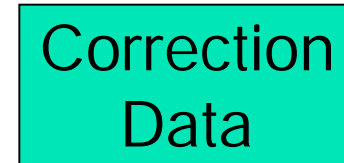
Pattern Chart



Location Shooting



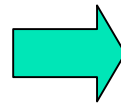
Video Signal



Lens Parameter



Before



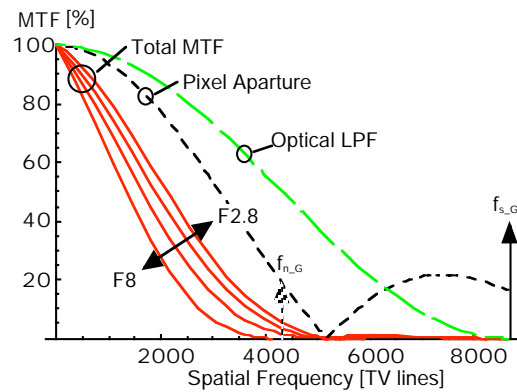
After



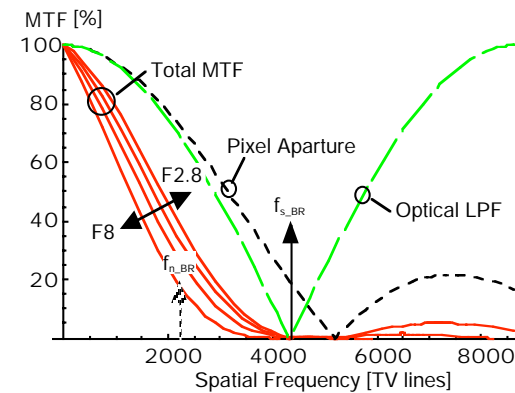


# MTF Characteristics (Calculated)

With  
Opt LPF

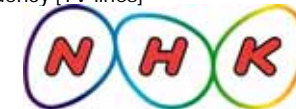
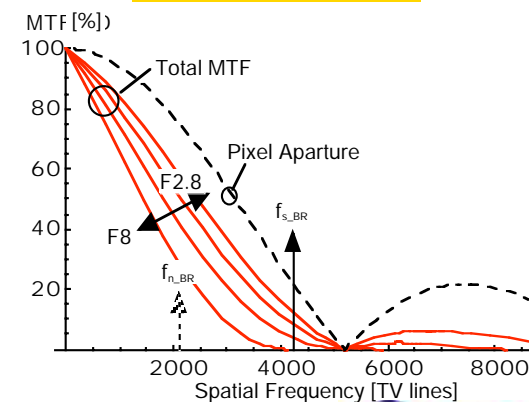
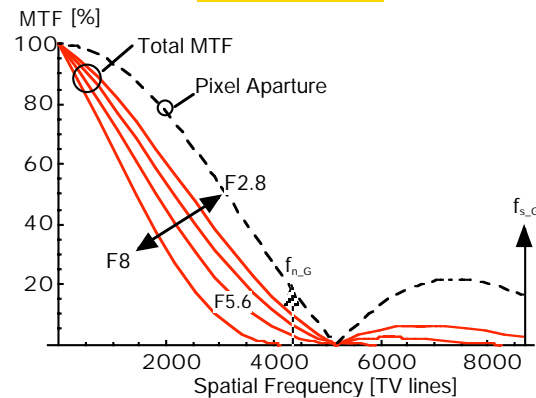


Green

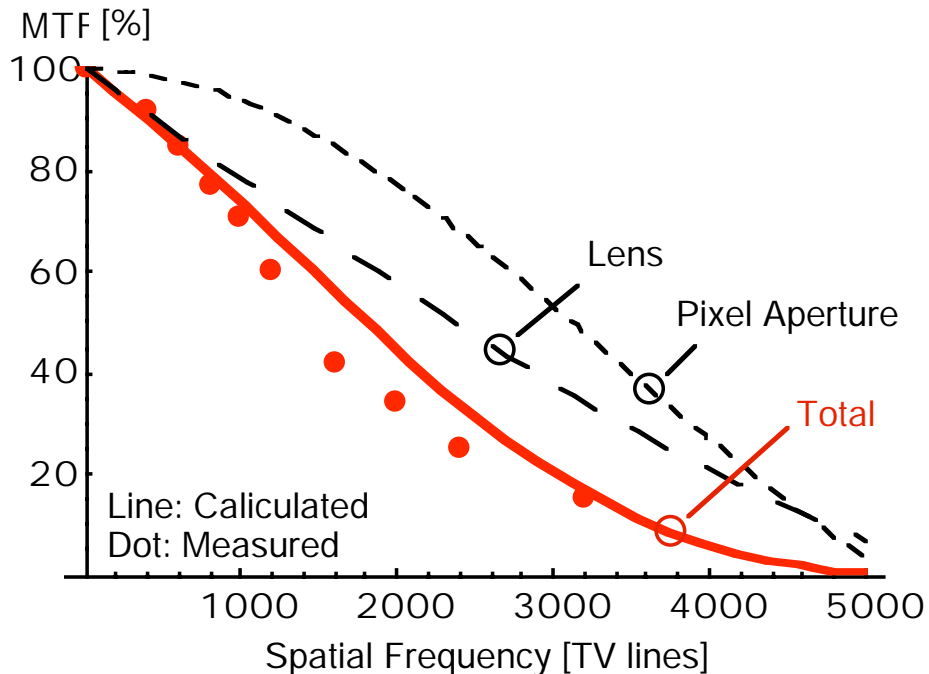


Blue / Red

Without  
Opt LPF



# MTF Characteristics (Measured)



Measured and Calculated at:

- Green Channel
- Vertical Direction
- Fixed Focal Length of  $f=18\text{mm}$
- F-stop of F5.6
- MTF from AR by Coltman's equation

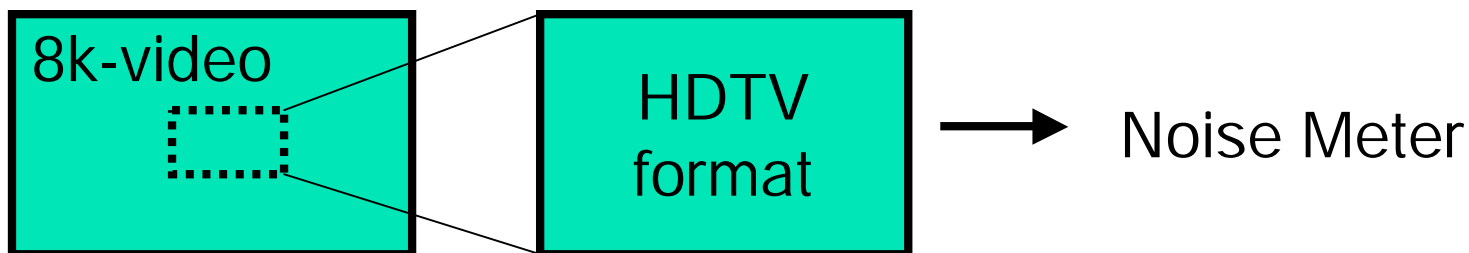


Limiting Resolution was about 3200 TV Lines



# Signal-to-Noise Ratio

## Measurement



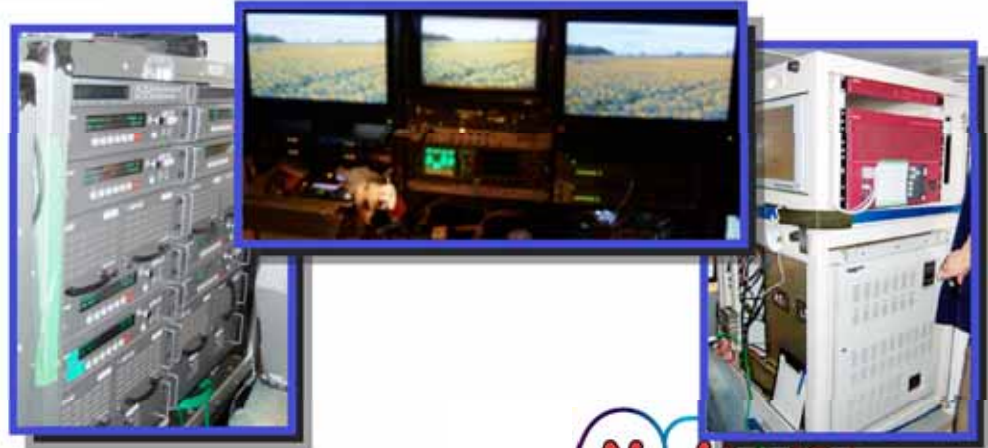
Extracted 1/16 from 8k x 4k pixel video,  
and converted into 1080/60i format

## Result

SNR	Approx. 45dB (on HDTV format)
Sensitivity	2000 lux, F2.8
Dynamic range	200%



# Location Shooting



# Super Hi-Vision theatre



Exhibited at EXPO2005

**1.56 million** people visited  
the theatre during 185 days

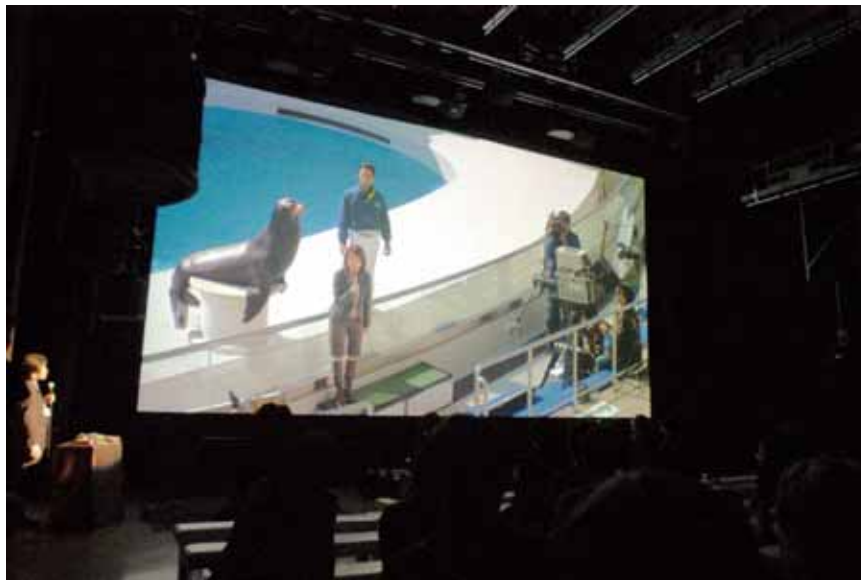
"Hi-Smile" Attraction

Audience are shot in the waiting  
area, and the video is then  
reproduced on the screen when  
they enter the theatre



# Applications(1)

- Future TV system providing enhanced sensation of reality
  - Live Event



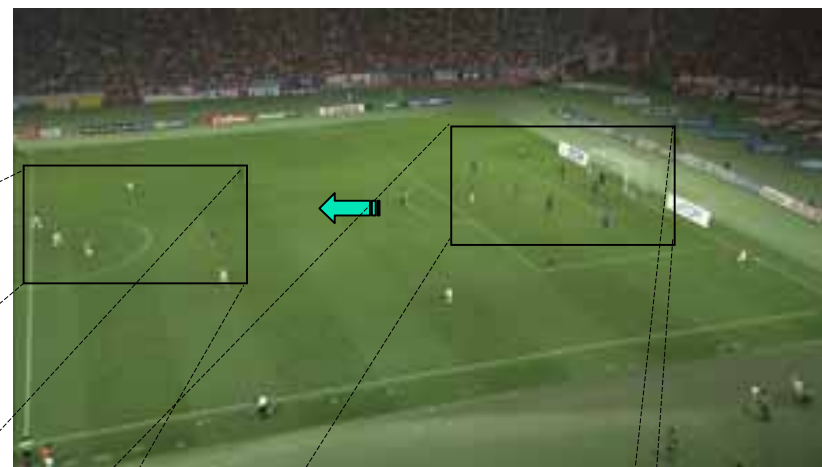
260 Km 24Gbps  
Uncompressed  
Transmission Test



# Applications(2)

- Video sources for SDTV/HDTV
  - Electric zooming
  - Image extraction

SHV (8K-image)



HDTV (2K-image)





# Summary

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- “Super Hi-vision” camera system with 8k x 4k pixels was developed
- We also developed 8M-pixel CMOS digital imager, 5x zoom lens, and a lateral chromatic aberration corrector
- The limiting resolution was 3200 TV lines, and the SNR on HDTV format was approx. 45 dB under 2000 Lux, F2.8, Dynamic range of 200 %
- Various kinds of “Super Hi-Vision” programs have been performed: World Expo theater, live broadcasting, long distance relaying, electrical zooming for HDTV, etc.

