



# **EyeLink® 1000 Plus** **Installation and Training**

***SR Research Ltd.***

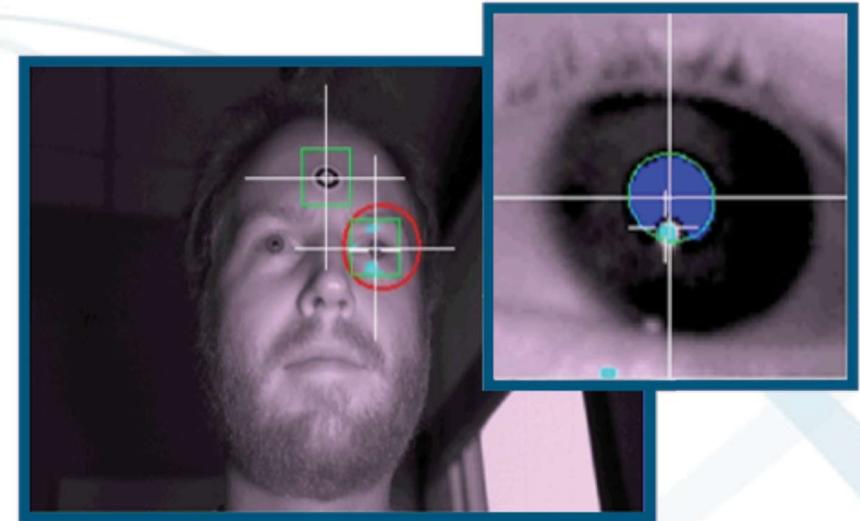
***Toronto / Ottawa, Canada***

# Agenda

- Video-based eye tracking
- The EyeLink Platform
- EyeLink Components
- Terms and Specifications
- System Components
  - Display PC
  - Display API
  - Host PC
- Camera Setup
  - Calibration
  - Validation
- EyeLink Data Structure

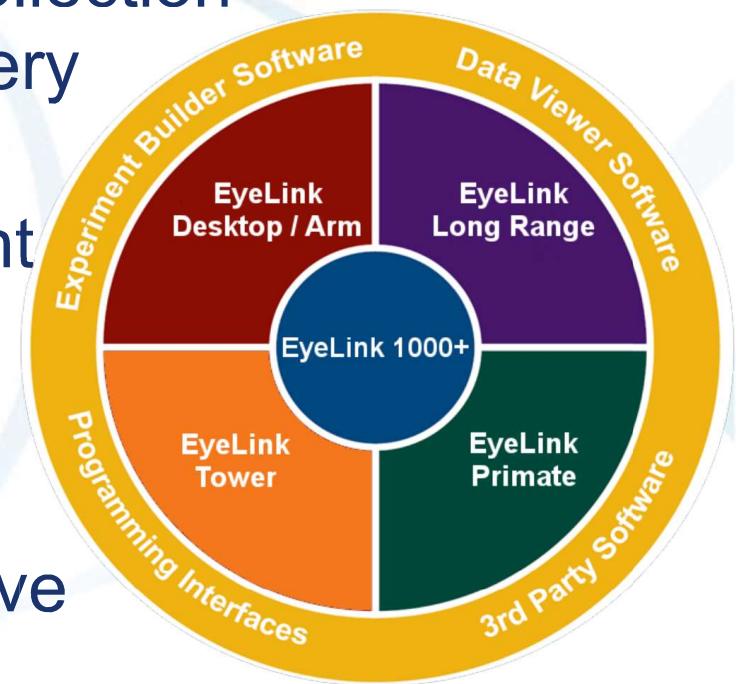
# Video-Based Eye Tracking

- IR camera and illuminator
  - Minimal interference with visual stimulus
- High speed video Image analysis
  - Determine centers of dark pupil and corneal reflection
- Calibration yields predictive model
  - Sample camera image while subject fixates several known locations
  - Induce predictive model

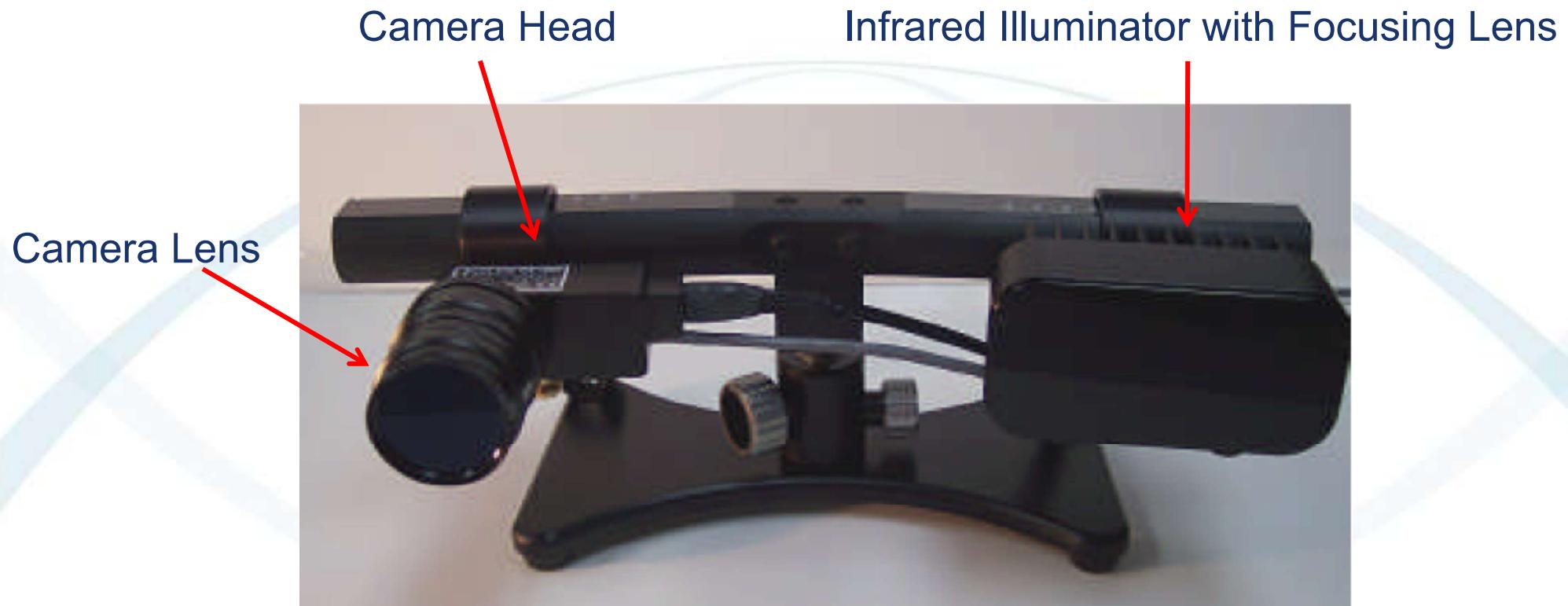


# EyeLink Platform

- Focal Imaging Technology (FIT)
  - Point, focus and track camera
  - Real-time host computer for data collection
  - Display computer for stimulus delivery
- One camera, many mounts
  - Desktop, Tower, Primate, Arm Mount
  - Long range variants for MEG/MRI
- Multiple modes of operation
  - High-precision monocular/binocular
  - Remote mode with head free to move
- Unified software
  - Host eye tracker application
  - Application Programming Interface



# EyeLink Long Range Mount



Different lenses (75mm, 50mm, 35mm) for  
Different distances (overall range: 60-150cm).



# Long Range Screen Mount

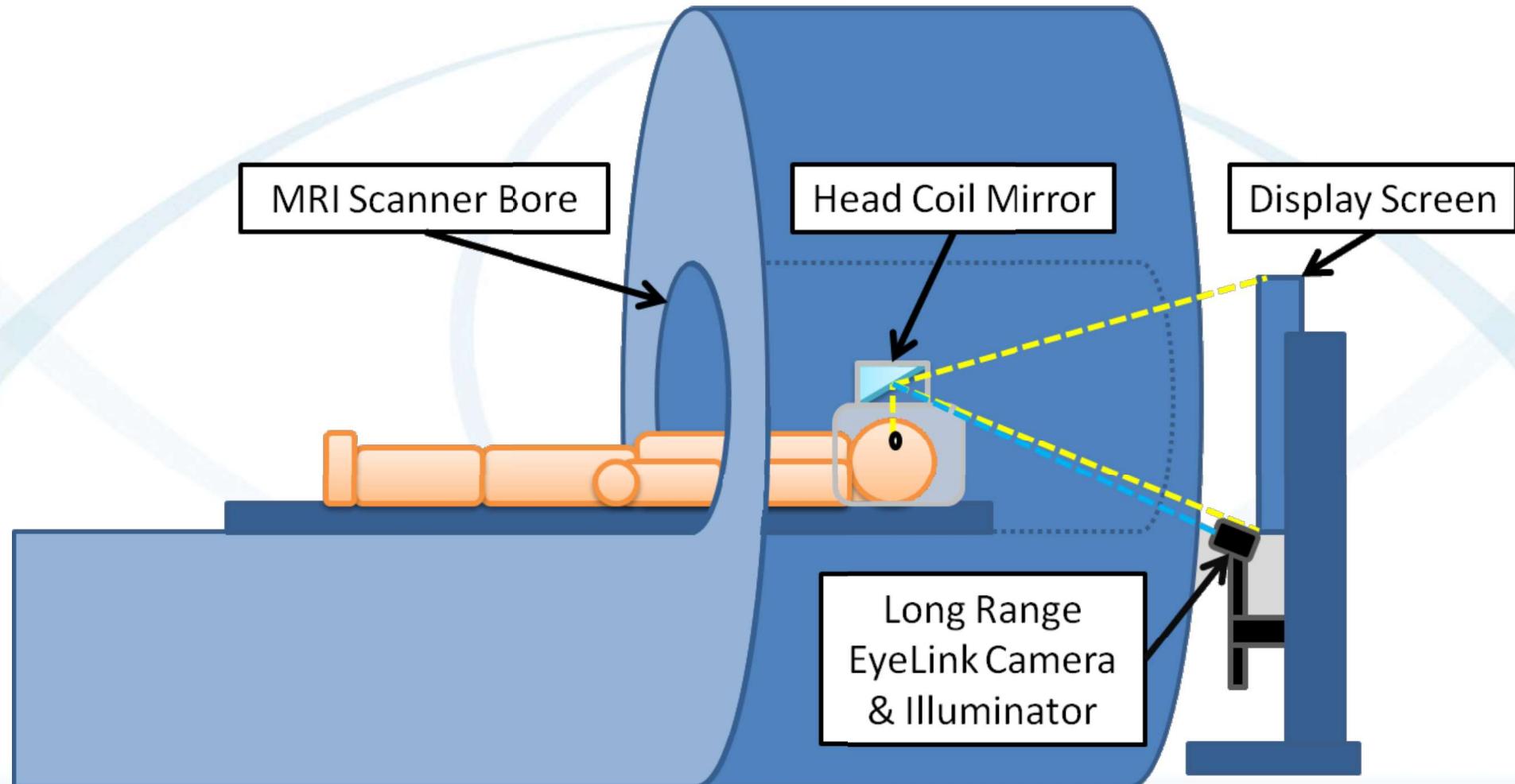


# MRI Head Coil Mirror

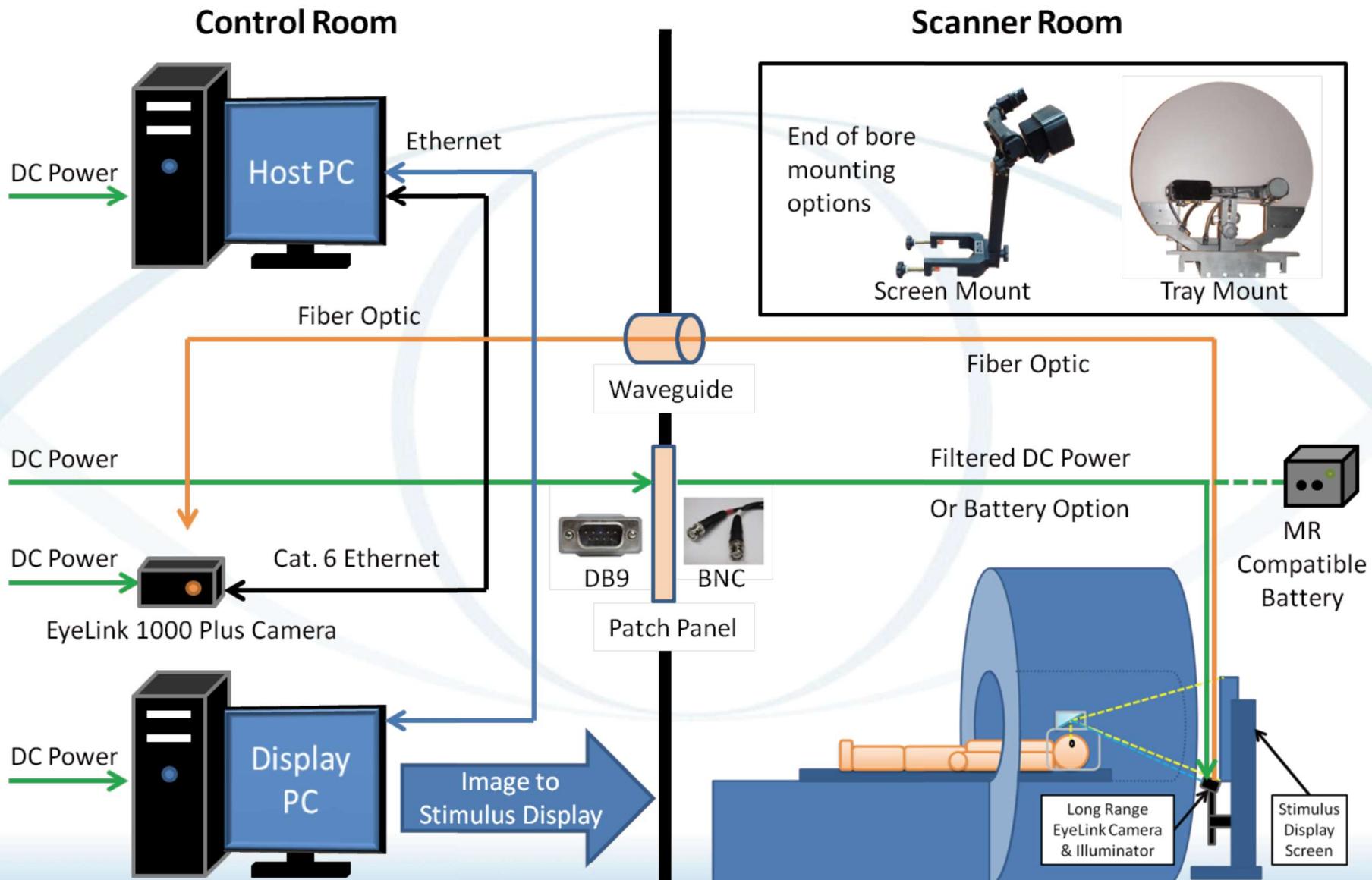


- Make sure you use an approved front surface mirror

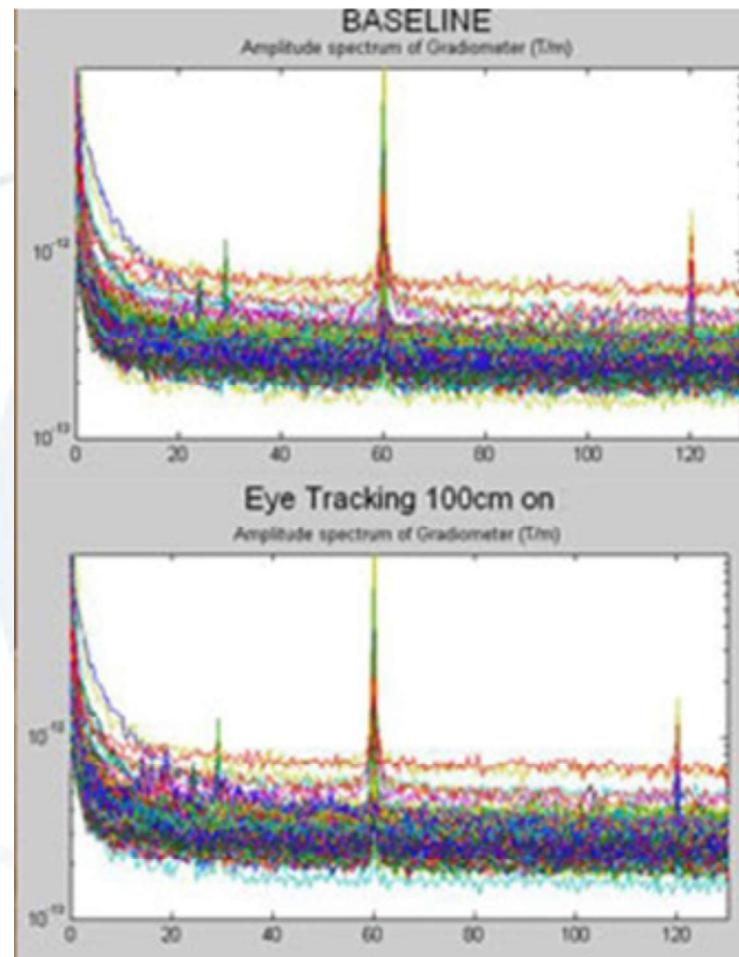
# Typical MRI Configuration



# Long Range System Cabling



# Long Range System Cabling



- No detectable noise with proper cabling  
(Graph from use with MEG)

# Terms and Specifications

- Accuracy
  - Test-retest discrepancy
  - Measure of absolute spatial location
  - Will be best with dominant eye
  - Drift free,  $0.25^\circ$  - $0.50^\circ$  typical
- Spatial resolution
  - Smallest measurable movement
  - Measure of relative spatial location
  - $<0.01^\circ$  RMS in pupil-CR 1000 Hz tracking mode
  - Glasses increase error by about  $0.01^\circ$



# Terms and Specifications

- Temporal resolution
  - How many images processed per second
    - Hz = “samples” per second
  - 2000 / 1000 / 500 / 250 Hz recording
- Tracking Range
  - Portion of subject’s field of view (in degrees of visual angle) that can be accurately tracked
  - Desktop mount: 32° horizontal x 25° vertical
  - Tower mount: 55° horizontal x 45° vertical
- Blink Recovery Time
  - Recover of gaze position after missing data
  - Recover position on next sample



# Terms and Specifications

- Eye Event Resolution
  - Smallest psychological event that is spatially measurable with the system
  - $0.05^\circ$  microsaccades
- Head Movement Compensation
  - Tolerable level of head movements
  - Approximately 2 cm of lateral head movement compensation
- Streaming data delay
  - Time to access gaze data on Display PC via Ethernet
  - 1.4 ms delay (SD=0.4 ms) @ 2000 Hz
  - 1.8 ms delay (SD=0.8 ms) @ 1000 Hz



# The Display PC

- Performs full experimental control
  - Integrate calibration and data collection into one easy step
  - Sets any tracker preference
  - Sends commands to control tracker
- Time stamps experiment events with messages
- Near real-time access to eye sample and event data structures for gaze-contingent paradigms
- Allows focus on stimulus presentation and data processing
  - Ordinary experiment delivery with calls to the underlying EyeLink libraries to interface with the eye tracker

# Display PC API

- Compatible with many stimulus delivery methods
  - Experiment generating packages:
    - Experiment Builder
    - E-Prime
    - Presentation
    - Psychtoolbox (MATLAB)
  - Programming languages:
    - C/C++
    - Python
    - Delphi
    - Any Windows COM language
  - Operating systems:
    - Windows / Mac / Linux



# The Host PC

- Host PC application controls the eye tracker
  - Performs image analysis
  - Performs data recording
  - Performs eye event parsing
  - Configures preferences
- Provides real-time feedback
  - Gaze view: gaze cursor on background image
  - Plot view: eye traces over time
- Send and receive TTL via Parallel Port
  - TTLs received logged directly to EDF

# Gaze View

Call me Ishmael. Some years ago -- never mind how long precisely -- having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen, and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzling November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet, I account it high time to get to sea as soon as I can. This is my substitute for pistol and ball. With a philosophical flourish Cato throws himself upon his sword; I quietly take to the ship.

## Record

TCP/IP Link Open

Stop Recording

Stop  
Recording

Abort Trial

### PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING

CORNEAL	OK
OK	MISSING
MISSING	

Plot View

Duration (sec):

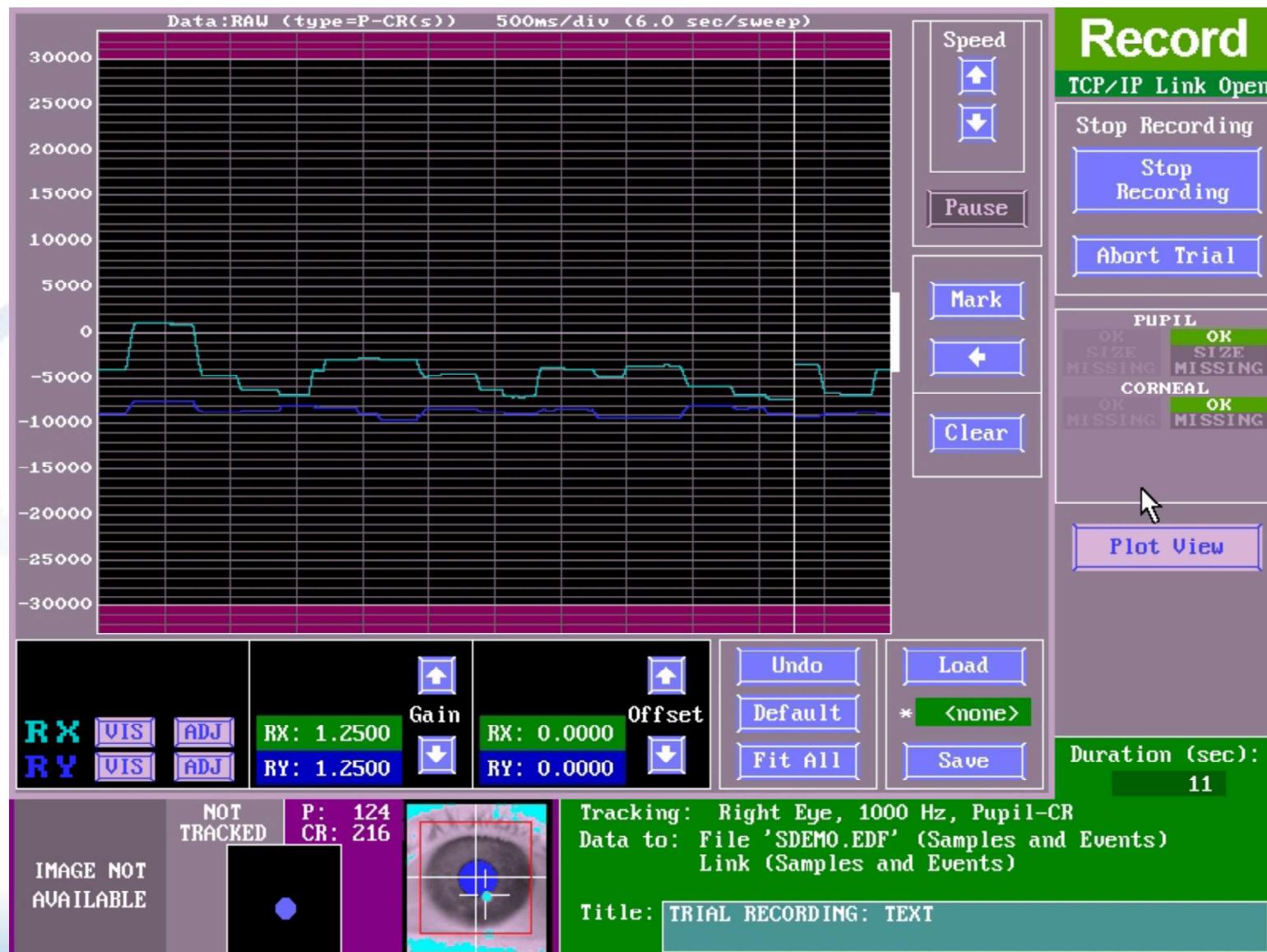
21



Tracking: Right Eye, 1000 Hz, Pupil-CR  
Data to: File 'SDEMO.EDF' (Samples and Events)  
Link (Samples and Events)

Title: TRIAL RECORDING: TEXT

# Plot View



# Camera Setup

- Position camera image
  - Center subject's eyes in global camera image
- Focus camera lens on surface of the eye
- Adjust Pupil and Corneal Reflection thresholds
  - Let the system know which part of the camera image should be considered as pupil and corneal reflection
- Perform Calibration and Validation
  - Calibration induces predictive model
  - Validation tests accuracy of calibrated model

# Camera Setup

**EXP:101% Image Thresholds**

Pupil

Corneal

**Tracking Mode**

**Sample Rate**

**Pupil Tracking**

**Image Display**

**Illuminator Power**



IMAGE NOT  
AVAILABLE

EYE NOT  
AVAILABLE

Pupil: 124  
CR : 216

PUPIL OK  
CR OK

Eye Tracked:

**Camera Setup**

**Desktop Monocular**

**Screens**

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# EyeLink Remote Mode

Image Thresholds

Pupil Corneal

Tracking Mode Pupil-CR

Sample Rate 250 500

Pupil Tracking Ellipse

Image Display Crosshairs

Threshold Coloring

Image->Display PC

Align Eye Window

Illuminator Power 100% 75%

Camera Setup

Desktop Remote

Screens

Exit Setup

Offline

Output/Record

Set Options

Help (F1)

Calibrate

Validate

Drift Correct

Target Thr: 149  
Distance: 578.1 mm

TARGET OK  
DIST OK

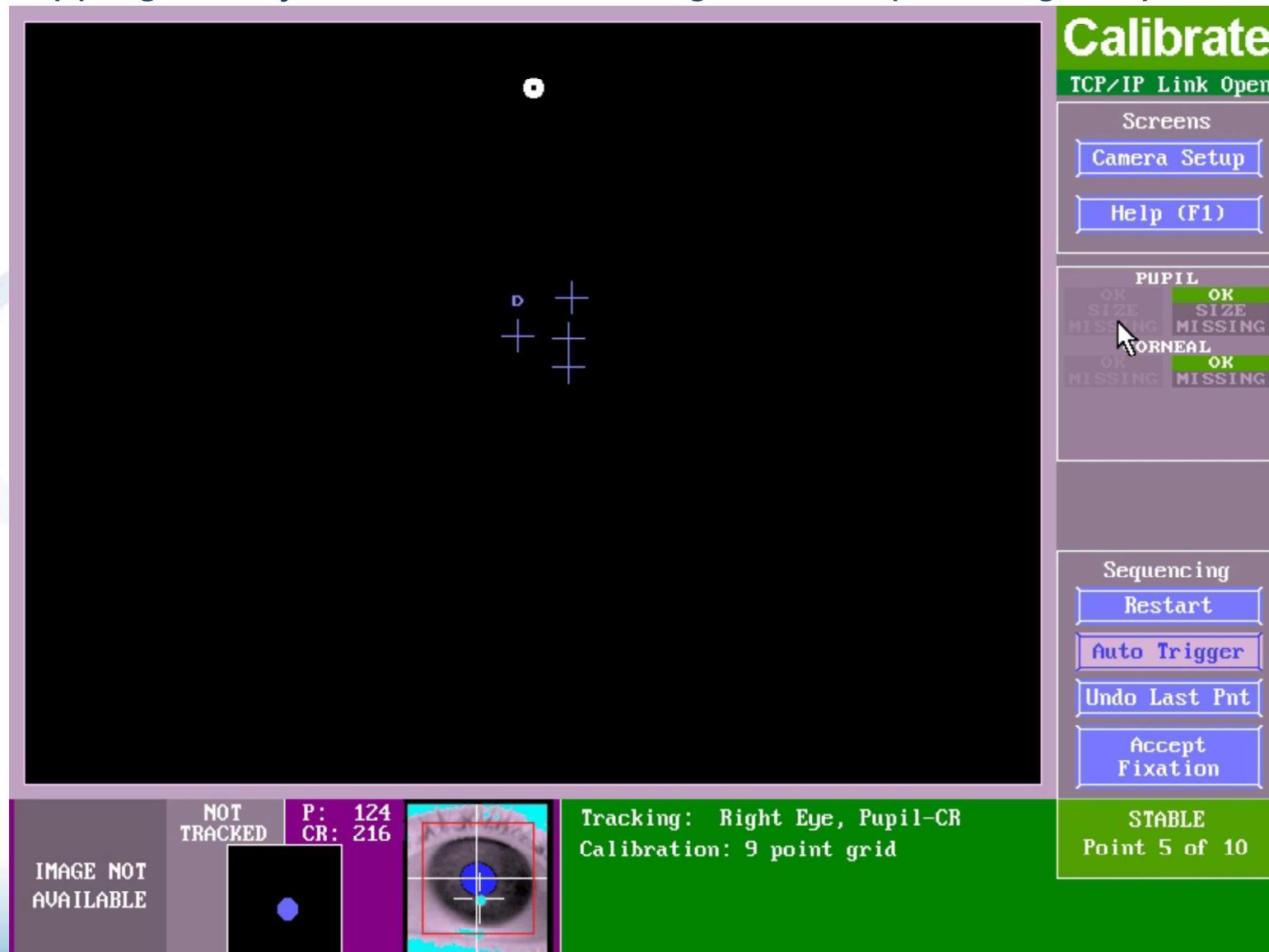
Pupil: 107 AUTO x1.00  
CR : 223 AUTO x1.00

PUPIL OK  
CR OK

Eye Tracked: Left Right

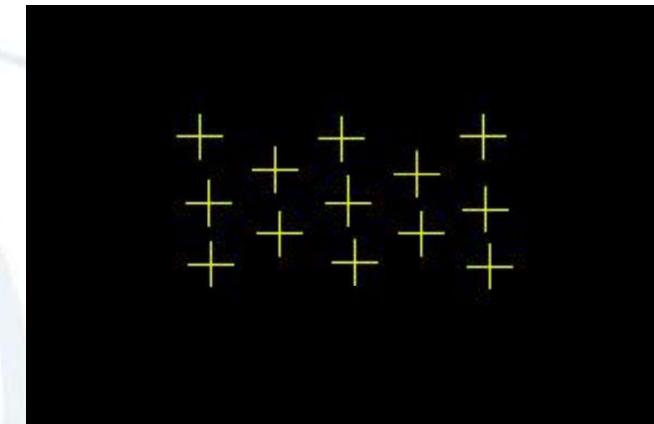
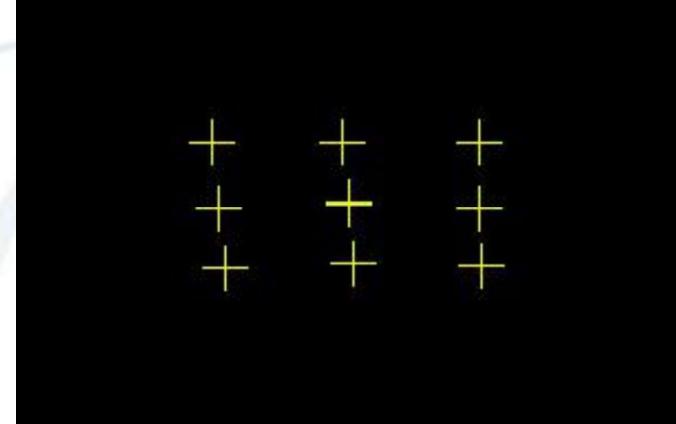
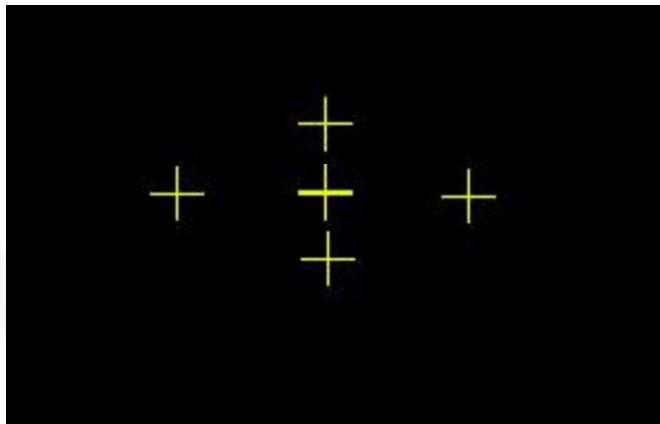
# Calibration

*Mapping raw eye data / camera image data to predict gaze position*

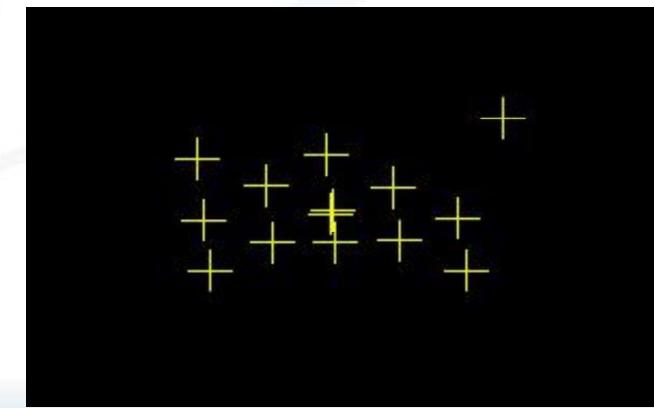
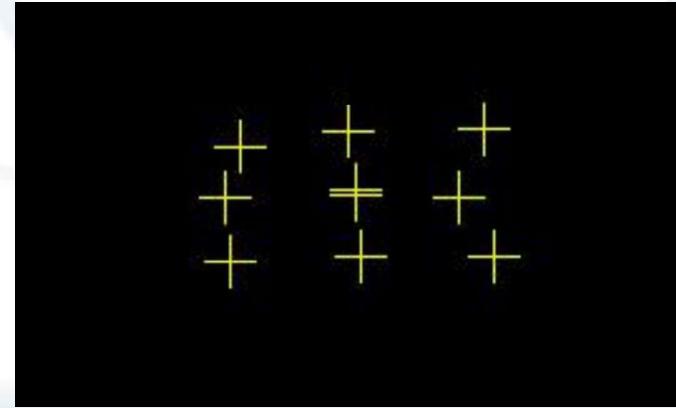
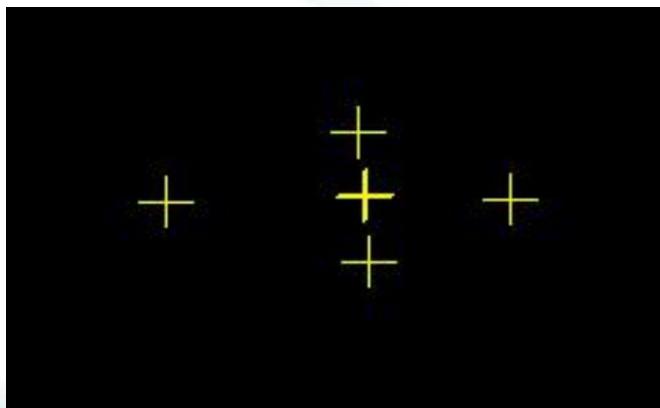


# Calibration

Good Calibration models (symmetrical)



Poor Calibration models (asymmetrical)

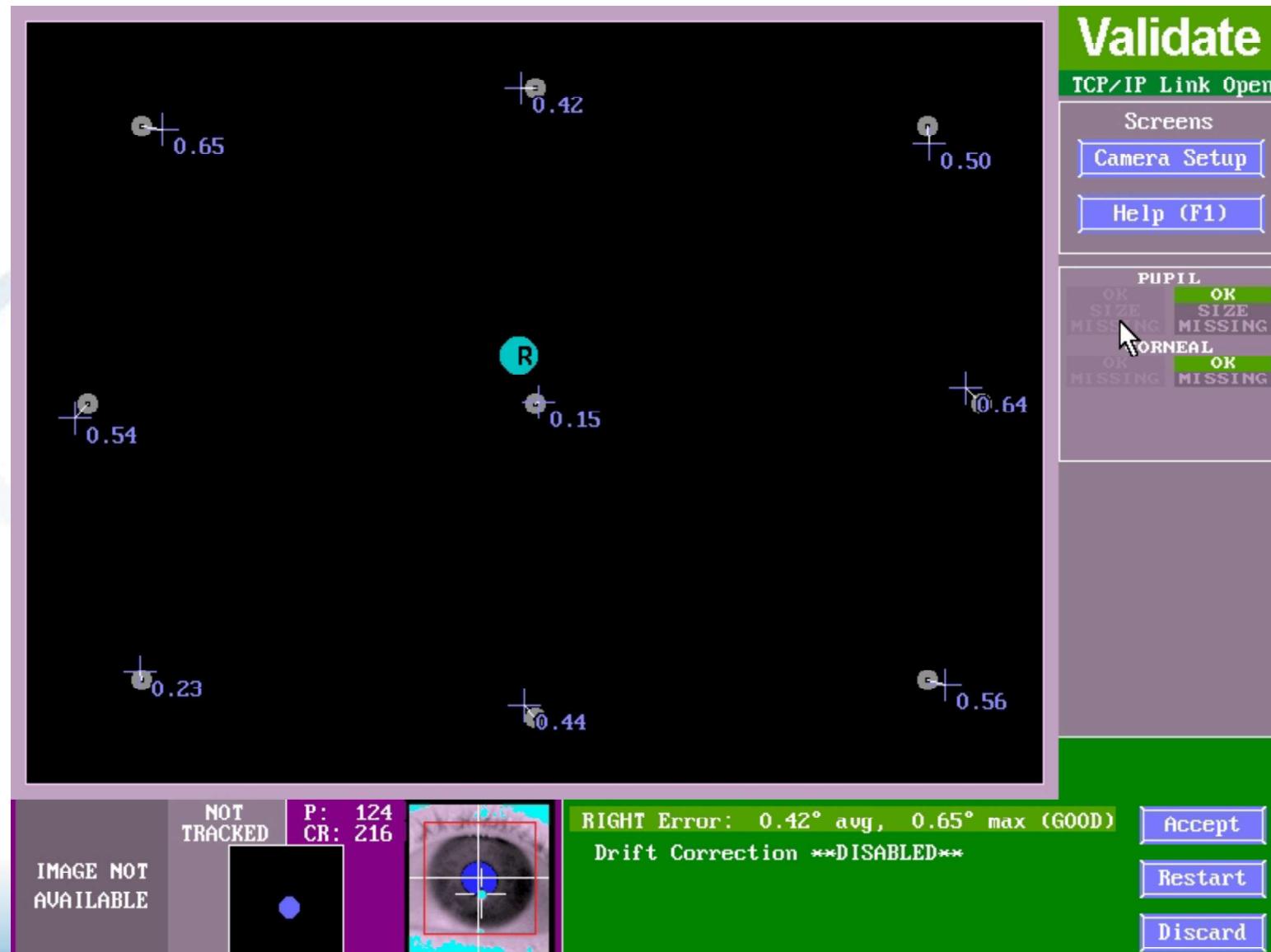


# Validation

- Evaluate predictive model's test-retest accuracy
- Subject re-fixates known locations
  - Difference between predicted gaze position and validation sample is “accuracy”
- Summarizes calibration accuracy
  - Reveals which spatial positions fit least accurately in degrees of visual angle

# Validation

*Checking accuracy level of the calibration*



# EyeLink Data

- EDF file
  - Use EDF2ASC/VisualASC converter to get ASC files
  - Use EyeLink Data Viewer for direct analysis
- What is recorded:
  - Samples
  - Events
    - Saccades, fixations, blinks, messages, buttons

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)

# EyeLink Recording Data

- Samples
  - System time, x, y, and pupil size
  - Optional velocity, resolution, and CR status

6079861	503.7	680.3	972.0	.....
6079862	503.7	680.1	972.0	.....
6079863	503.8	680.1	972.0	.....
6079864	503.8	680.2	972.0	.....
6079865	503.9	680.2	971.0	.....
6079866	503.7	680.1	971.0	.....
6079867	503.7	680.1	971.0	.....
6079868	503.6	680.0	970.0	.....
6079869	503.6	680.1	970.0	.....
6079870	503.7	680.2	970.0	.....

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)

# EyeLink Recording Data

- Saccades
  - SSACC: eye, start time
  - ESACC: eye, start time, end time, duration, start x/y, end x/y, amplitude, peak velocity

SSACC L 6079955

ESACC L 6079955 6079962 8 507.5 682.5 511.9 682.0 0.20 38

...

SSACC L 6080723

ESACC L 6080723 6080763 41 513.8 679.7 633.5 550.5 7.94 285

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)

# EyeLink Recording Data

- Fixations
  - SFIX: eye, start time
  - EFIX: eye, start time, end time, duration, average x/y, pupil size, resolution

SFIX L 1454748

EFIX L 1454748 1454907 160 510.3 4.1 1187 28.45 27.50

...

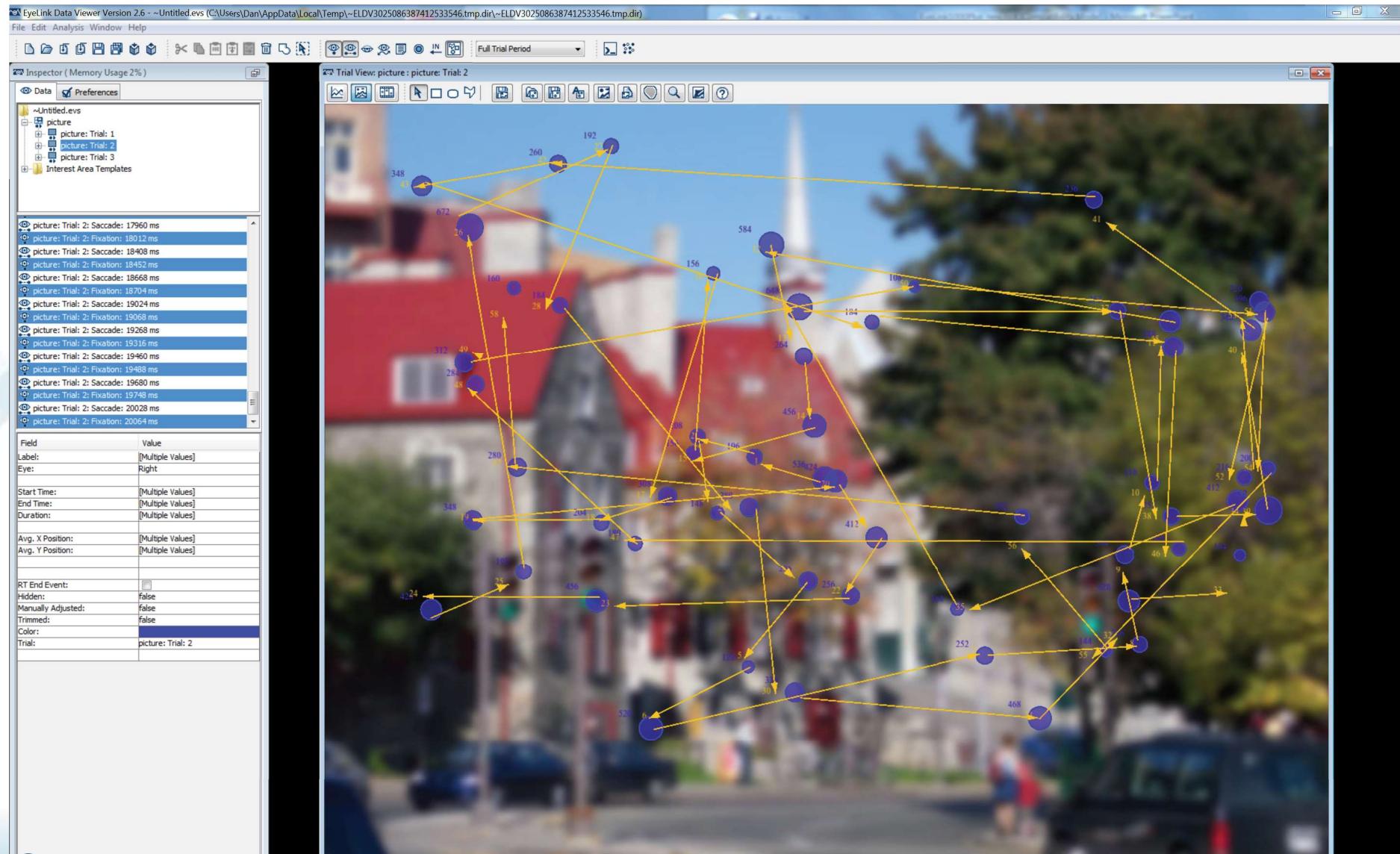
SFIX L 1454919

EFIX L 1454919 1455873 955 514.0 0.3 1361 28.40 27.50

(Please read Chapter 4 of the EyeLink 1000 Plus User Manual)



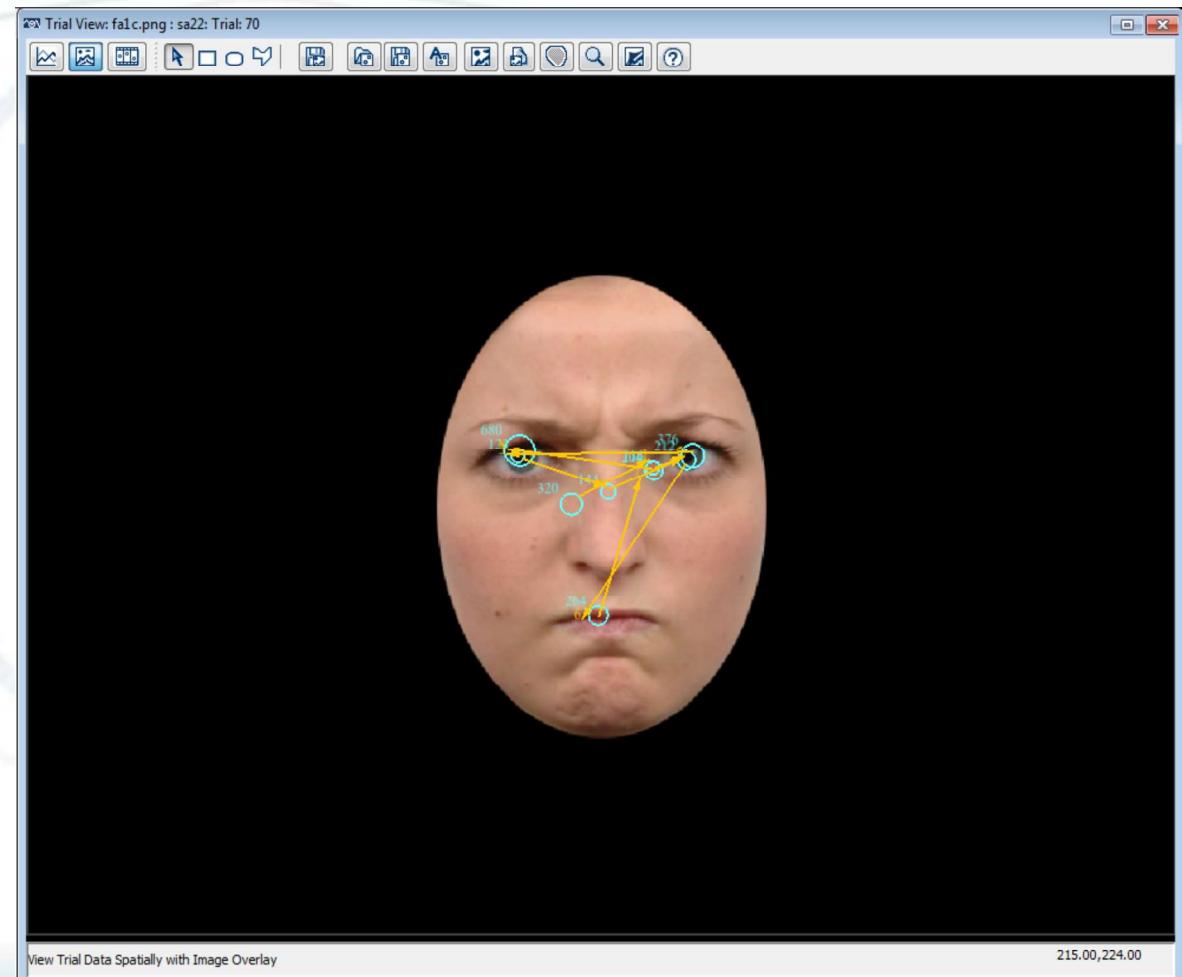
# EyeLink Data Viewer



# EyeLink Data Viewer

Data visualization:

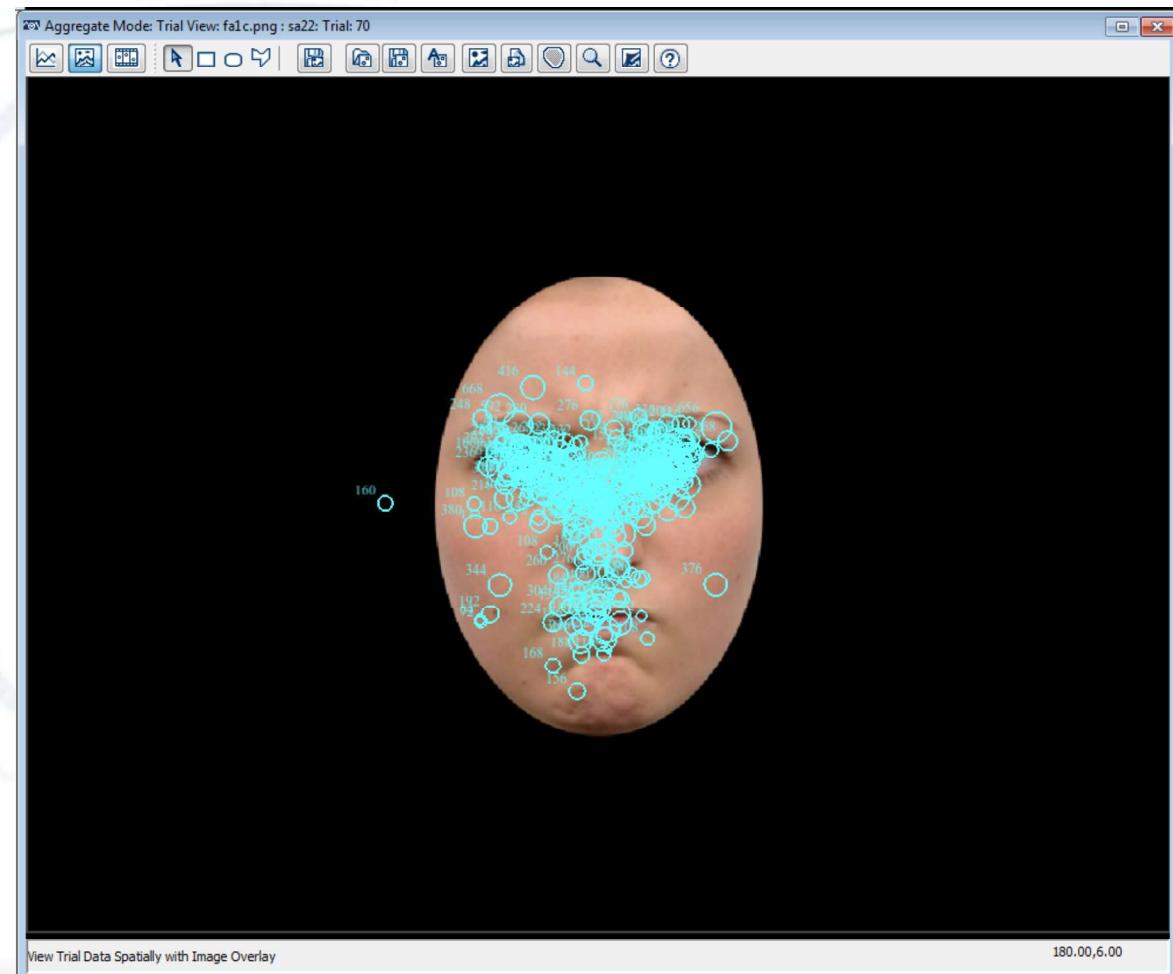
Spatial Overlay View  
superimposes  
saccade and fixation  
scan-path information  
over an image



# EyeLink Data Viewer

Data visualization:

Aggregate Mode  
superimposes data  
from multiple trials /  
participants

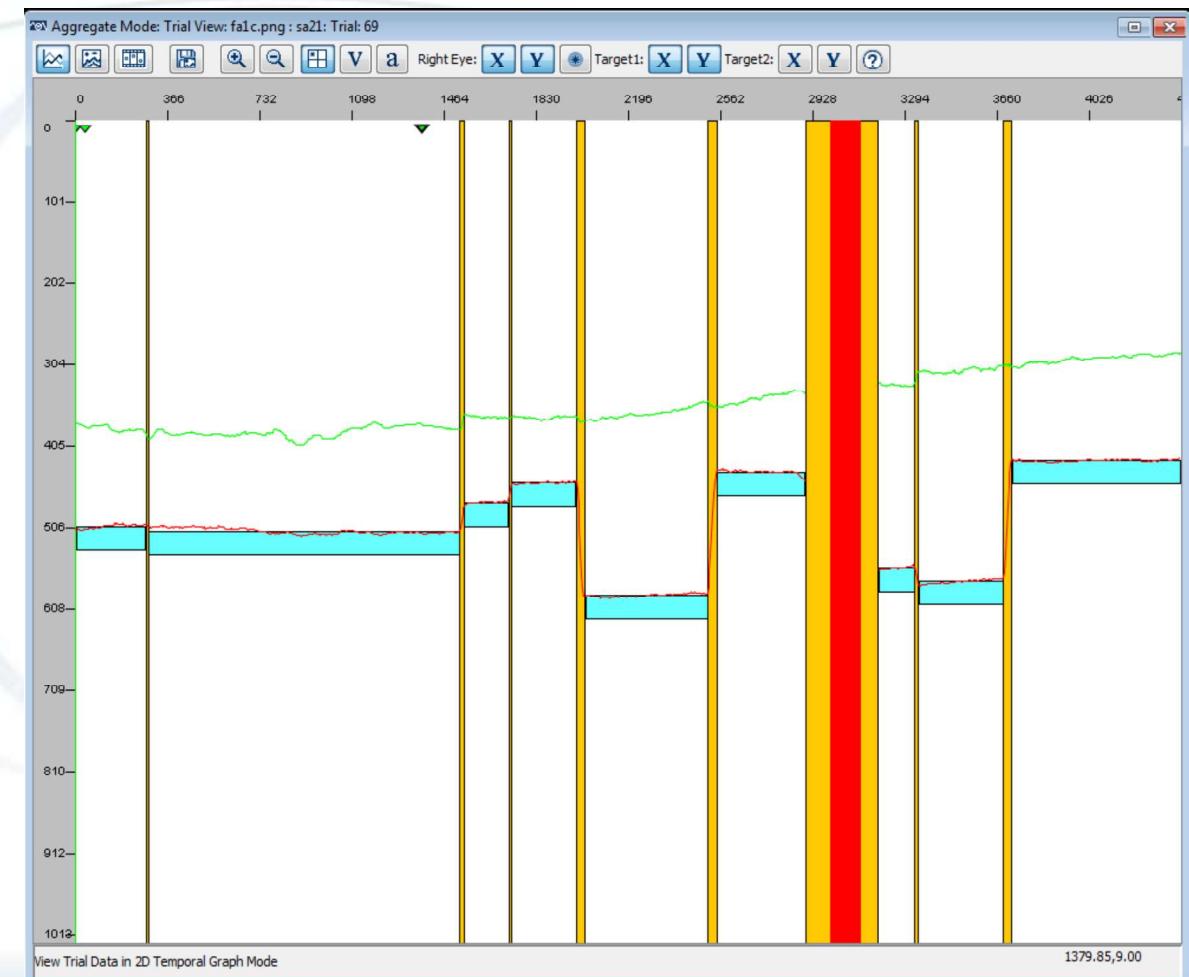


# EyeLink Data Viewer

Data visualization:

Temporal Graph View  
supports visualization  
of eye data over time

Useful for seeing  
when messages  
appear and setting  
Interest Periods



# EyeLink Data Viewer

## Data visualization:

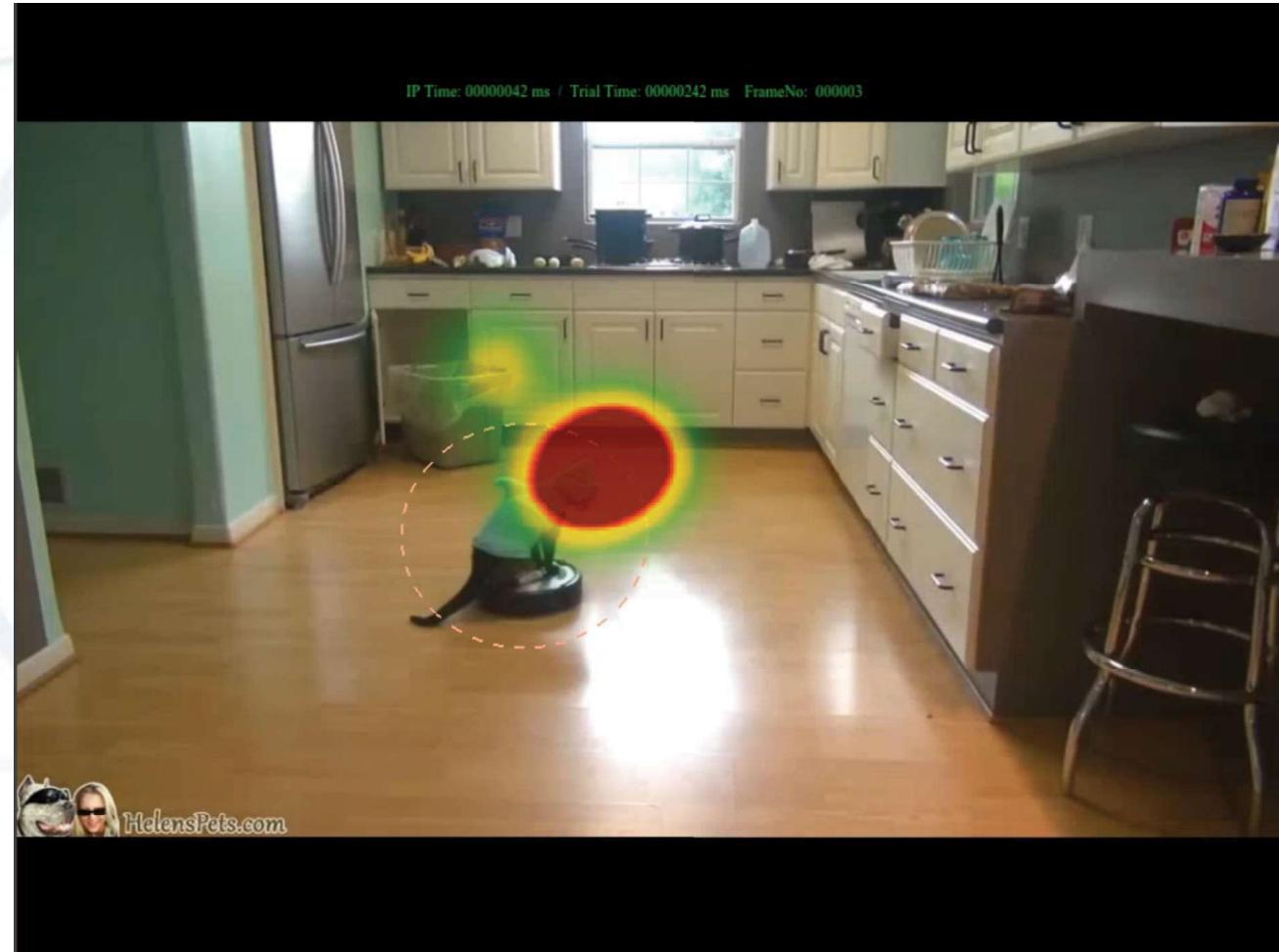
Animation Playback  
View shows a movie of the trial with eye movements overlaid.

Playback speed can be adjusted – helpful for the creation of dynamic interest areas using the Mouse Record technique.



# EyeLink Data Viewer

In Aggregate Mode,  
Animation Playback  
view can show bee-  
swarm and dynamic  
heat maps.



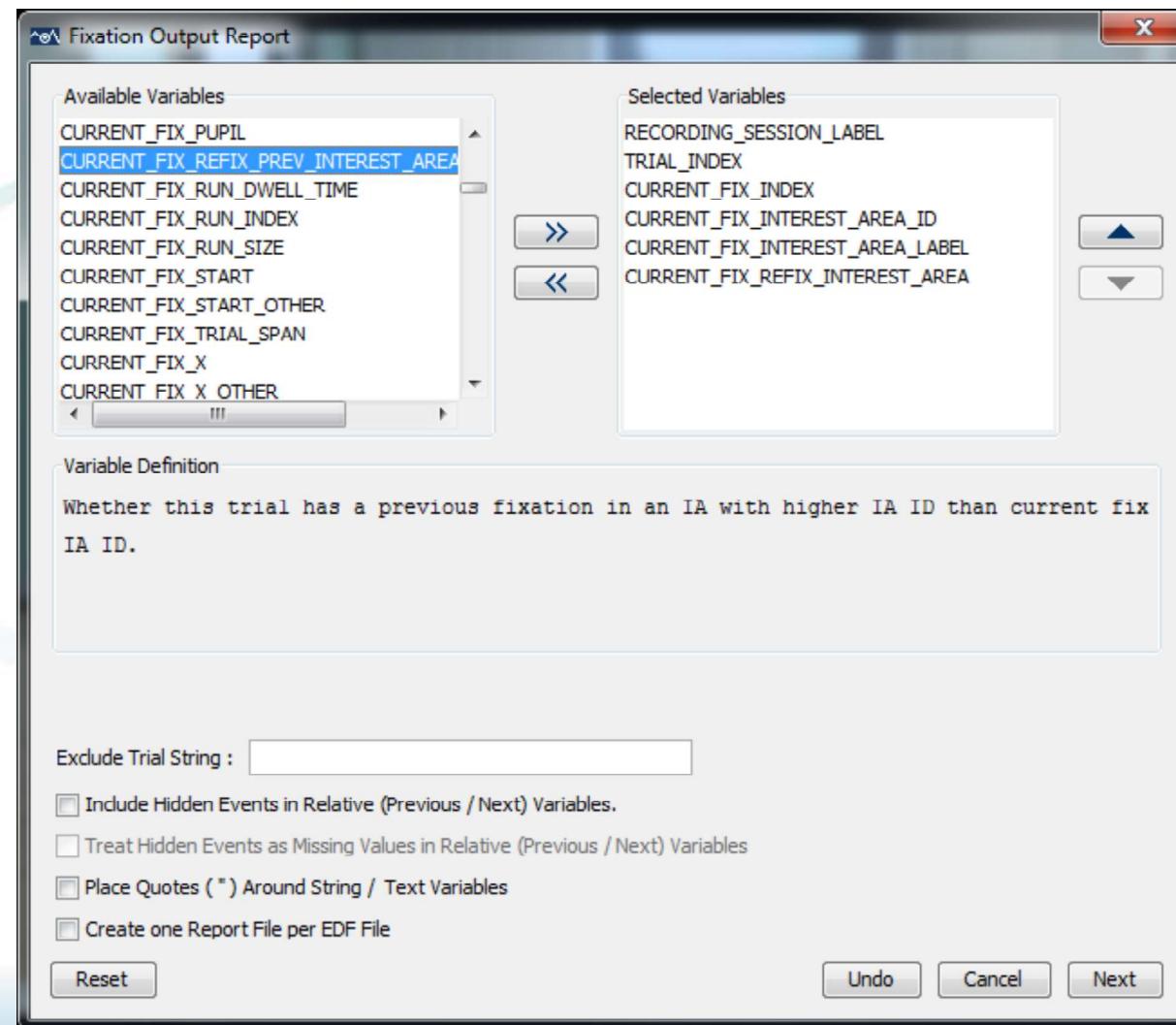


# EyeLink Data Viewer

- Supports both static and dynamic interest areas (rectangular, elliptical, or freeform polygons)
- Create interest periods for temporal data filtering
- Group data using existing or new variables
- Generate heat maps / dynamic heat maps for selected trials
- Output eye sample, fixation, saccade, interest area, or trial-based reports for statistical analysis
- Output binned data for time-series analysis (Visual World Tasks / Dynamic Stimuli)
- Calculate hundreds of dependent measures including most common reading measures
- Highly integrated with SR Research Experiment Builder, E-Prime, Presentation, and any custom stimulus display solution
- Available on Windows, Mac OS X, and Linux

# EyeLink Data Viewer

*Generates detailed Fixation, Saccade, Interest Area, Sample and Trial reports*





# EyeLink Support

- Documents
  - EyeLink 1000 Plus User Manual
  - EyeLink 1000 Plus Installation Guide
  - EyeLink 1000 Plus Quick Start Guide
  - SR Research Experiment Builder User Manual
  - EyeLink Programmer's Guide
  - EyeLink Data Viewer User Manual
- Contact Information
  - Email: [support@sr-research.com](mailto:support@sr-research.com)
  - Phone: 1-613-826-2958 / 1-866-821-0731
  - Support Forum: [www.sr-support.com](http://www.sr-support.com)



# EyeLink Support Forums

**SR Research**  
Support

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Forum

SR Research is pleased to announce the newest addition to our EyeLink series of eye trackers, the **EyeLink Portable Duo**! The EyeLink Portable Duo brings the fast, accurate, reliable eye tracking you've come to expect from SR Research into a compact system that's easy to set up for eye tracking in daycares, schools, homes, or hospitals. Check out [sr-research.com](http://sr-research.com) for more info!

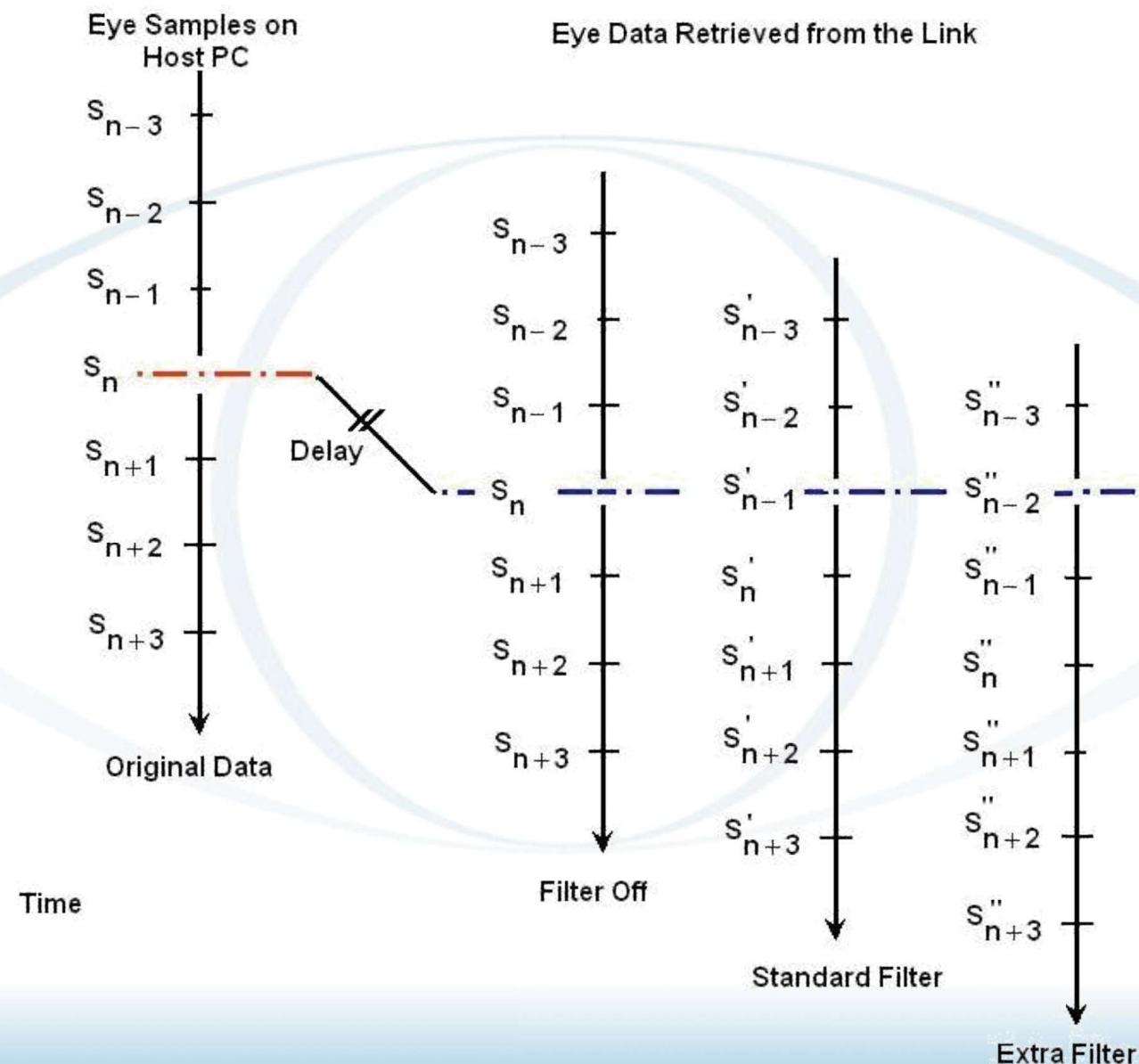
Don't miss out on new developments, features and free software updates from SR Research! Sign up for our mailing list now to stay up-to-date on all things SR Research!

**SR Research Support Site**  
Welcome to the SR Research Support Site.

	Threads / Posts	Last Post
<b>What's New?</b> Updates on the latest software and hardware releases from SR Research Ltd.	Threads: 23 Posts: 23	<a href="#">Introducing Experiment...</a> by Greg 10-21-2016, 02:08 PM
<b>How-Tos</b> Educational Materials	Threads: 1 Posts: 1	<a href="#">Experiment Builder Video...</a> by marcus 07-29-2015, 08:29 PM
<a href="#">Video Tutorials</a> Instructional videos	Threads: 6 Posts: 11	<a href="#">Webinar - Integrating EyeLink...</a> by marcus 12-02-2016, 07:26 AM
<a href="#">Webinars</a> Listings of upcoming webinars and links to recordings of past ones		
<b>Frequently Asked Questions</b> Frequently Asked Questions about EyeLink Usage, Programming, and Data Analysis	Threads: 6 Posts: 140	<a href="#">List of All Data Viewer...</a> by Sam 07-14-2016, 05:35 AM
<a href="#">Experiment Builder FAQ</a>	Threads: 2 Posts: 38	<a href="#">Answers to Experiment Builder...</a> by marcus 02-05-2016, 12:27 AM
<a href="#">Data Viewer FAQ</a>	Threads: 2 Posts: 23	<a href="#">List of All Data Viewer...</a> by Sam 07-14-2016, 05:35 AM
<a href="#">EyeLink Host PC and Hardware FAQ</a>	Threads: 2 Posts: 77	<a href="#">Answers to EyeLink Host PC...</a> by WDM 03-06-2016, 11:06 PM
<b>EyeLink</b> Discussions related to EyeLink system usage	Threads: 1,044 Posts: 4,264	<a href="#">Sampling rate</a> by marcus 12-07-2016, 08:18 PM
<a href="#">EyeLink Usage</a> Discussions on using the EyeLink systems and options, including set-up, calibration, etc.	Threads: 882 Posts: 4,190	<a href="#">eyengd_printf messages not...</a> by marcus 12-08-2016, 05:21 PM
<a href="#">Programming</a> Discussions related to programming the EyeLink systems	Threads: 934 Posts: 3,618	<a href="#">Interest area files from Excel</a> by SR-Brian 12-05-2016, 01:45 PM
<a href="#">Data Viewer</a> Discussions regarding the EyeLink Data Viewer application	Threads: 344 Posts: 1,365	<a href="#">Non-PC Multi Display</a> by WDM 11-29-2016, 12:52 PM
<a href="#">General</a> General Discussions not covered in other EyeLink forums		
<b>Experiment Builder</b> SR Research Experiment Builder discussions	Threads: 2,014 Posts: 8,327	<a href="#">problems adding a scale</a> by sajagis999 12-15-2016, 07:17 AM
<a href="#">E-Builder Usage</a> Discussions on usage of E-Builder software	Threads: 64 Posts: 78	<a href="#">Creating False Memories</a> by daniel1 09-20-2016, 02:56 PM
<a href="#">Examples</a> Example E-Builder projects		
<b>Downloads</b> SR Research Documentation and Software Downloads	Threads: 13 Posts: 14	<a href="#">EyeLink 1000 Plus User Manual</a> by marcus 12-05-2014, 08:36 AM
<a href="#">Manuals</a> Download the latest manuals for the EyeLink systems and applications	Threads: 5 Posts: 5	<a href="#">EyeLink 1000 Plus Host...</a> by Greg 10-14-2014, 09:16 AM
<a href="#">EyeLink Host Software</a> Download the latest EyeLink Host Software (all versions)	Threads: 13 Posts: 18	<a href="#">SR Research Experiment...</a> by Greg 08-04-2015, 02:59 PM
<a href="#">EyeLink Display Software</a> Download the latest Display Software for the EyeLink System	Threads: 4 Posts: 5	<a href="#">EDF2MAT - Converting EDF files...</a> by SR-Brian 09-10-2016, 03:24 PM
<a href="#">Data Analysis</a> Download the latest EyeLink data analysis software		

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# Smart Data Filter



# Host Application

- Camera Setup screen
  - Adjust camera image
  - Calibration
  - Validation
  - Drift Check
- Set Options screen
  - Select preferences / options
  - Set method of recording
- Record screen
  - Real-time gaze cursor / Plot View

# Camera Setup screen

EXP:101%

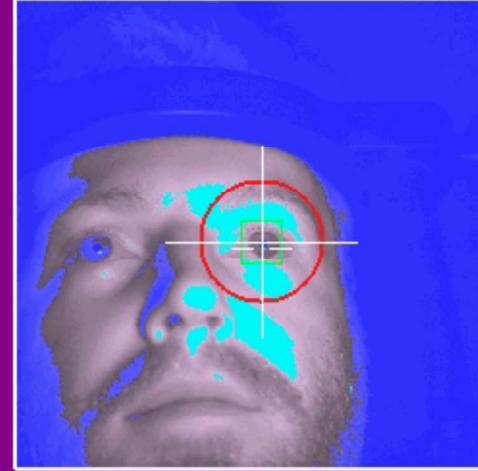


IMAGE NOT AVAILABLE

EYE NOT AVAILABLE

Pupil: 124  
CR : 216

Eye Tracked:

**Camera Setup**

Desktop Monocular

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# Set Options screen

**Set Options**

TCP/IP Link Open

Screens

- Previous Screen
- Camera Setup
- Help (F1)

Settings

- Revert to Last
- Load Defaults

Video Overlay

- Enable Overlay

Recording Data View

- Record View
- Gaze Cursor
- Plotting

Plot

- Gaze
- Angle
- HREF
- Raw

Calibration and Validation

Calibration Type:

Pacing Interval:

Configuration

Select Config...  
Desktop (Level)  
Monocular  
35mm lens  
Stabilized Head  
Camera Level  
CAM-ILLUM

File Data Contents:

- Samples
- Events

File Sample Contents:

- Raw Eye Position
- HREF Position
- Gaze Position
- Button Flags
- Input Port Data

Tracking

Search Limits

Pupil Size Data:

Events and Data Processing

Eye Event Data:

Saccade Sensitivity:

File Sample Filter:

Link/Analog Filter:

# Set Configuration menu

Calibration and Validation		Configuration		Set Options																																				
<b>SET CONFIGURATION</b>																																								
			<b>Accept</b>	<b>Cancel</b>																																				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 15%;">Desktop (Level)</td> <td style="width: 15%;">Monocular</td> <td style="width: 15%;">35mm lens</td> <td style="width: 15%;">Stabilized Head</td> <td style="width: 15%;">Camera Level</td> <td style="width: 15%;">CAM--</td> <td style="width: 15%;">MTABLER</td> </tr> <tr> <td>Desktop (Level)</td> <td>Binoc/Monoc</td> <td>35mm lens</td> <td>Stabilized Head</td> <td>Camera Level</td> <td>CAM--I</td> <td>BTABLER</td> </tr> <tr> <td>Desktop (Remote)</td> <td>Monocular</td> <td>16mm lens</td> <td>Target Sticker</td> <td>Camera Level</td> <td>CAM--</td> <td>RTABLER</td> </tr> <tr> <td>Arm Mount (Remote)</td> <td>Monocular</td> <td>16mm lens</td> <td>Target Sticker</td> <td></td> <td></td> <td>ARTABLER</td> </tr> <tr> <td>Arm Mount (Level)</td> <td>Monocular</td> <td>35mm lens</td> <td>Stabilized Head</td> <td></td> <td></td> <td>AMTABLER</td> </tr> </table>						Desktop (Level)	Monocular	35mm lens	Stabilized Head	Camera Level	CAM--	MTABLER	Desktop (Level)	Binoc/Monoc	35mm lens	Stabilized Head	Camera Level	CAM--I	BTABLER	Desktop (Remote)	Monocular	16mm lens	Target Sticker	Camera Level	CAM--	RTABLER	Arm Mount (Remote)	Monocular	16mm lens	Target Sticker			ARTABLER	Arm Mount (Level)	Monocular	35mm lens	Stabilized Head			AMTABLER
Desktop (Level)	Monocular	35mm lens	Stabilized Head	Camera Level	CAM--	MTABLER																																		
Desktop (Level)	Binoc/Monoc	35mm lens	Stabilized Head	Camera Level	CAM--I	BTABLER																																		
Desktop (Remote)	Monocular	16mm lens	Target Sticker	Camera Level	CAM--	RTABLER																																		
Arm Mount (Remote)	Monocular	16mm lens	Target Sticker			ARTABLER																																		
Arm Mount (Level)	Monocular	35mm lens	Stabilized Head			AMTABLER																																		
<input type="button" value="Search Limits"/> <input type="button" value="Move Limits"/> <input type="button" value="Mouse Simulation"/>			<b>File Data Contents:</b> <input type="button" value="Samples"/> <input type="button" value="Events"/>																																					
Pupil Size Data <input type="button" value="AREA"/> <input type="button" value="DIAMETER"/>			<b>File Sample Contents:</b> <input type="button" value="Raw Eye Position"/> <input type="button" value="HREF Position"/> <input type="button" value="Gaze Position"/> <input type="button" value="Button Flags"/> <input type="button" value="Input Port Data"/>																																					
<b>Events and Data Processing</b>			<b>Settings</b> <input type="button" value="Revert to Last"/> <input type="button" value="Load Defaults"/>																																					
Eye Event Data <input type="button" value="Gaze"/> <input type="button" value="HREF"/>			<b>Video Overlay</b> <input type="button" value="Enable Overlay"/>																																					
Saccade Sensitivity <input type="button" value="NORMAL"/> <input type="button" value="HIGH"/>																																								
File Sample Filter <input type="button" value="OFF"/> <input type="button" value="STD"/> <input type="button" value="EXTRA"/>																																								
Link/Analog Filter <input type="button" value="OFF"/> <input type="button" value="STD"/> <input type="button" value="EXTRA"/>																																								
<b>Recording Data View</b>																																								
Record View <input type="button" value="Gaze Cursor"/> <input type="button" value="Plotting"/>																																								
Plot <input type="button" value="Gaze"/> <input type="button" value="Angle"/> <input type="button" value="HREF"/> <input type="button" value="Raw"/>																																								

# Record screen

Call me Ishmael. Some years ago -- never mind how long precisely -- having little or no money in my purse, and nothing particular to interest me on shore, I thought I would sail about a little and see the watery part of the world. It is a way I have of driving off the spleen, and regulating the circulation. Whenever I find myself growing grim about the mouth; whenever it is a damp, drizzling November in my soul; whenever I find myself involuntarily pausing before coffin warehouses, and bringing up the rear of every funeral I meet, I account it high time to get to sea as soon as I can. This is my substitute for pistol and ball. With a philosophical flourish Cato throws himself upon his sword; I quietly take to the ship.

## Record

TCP/IP Link Open

Stop Recording

Stop  
Recording

Abort Trial

### PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING

CORNEAL	OK
OK	MISSING
MISSING	

Plot View

Duration (sec):

21

NOT  
TRACKED

P: 124  
CR: 216

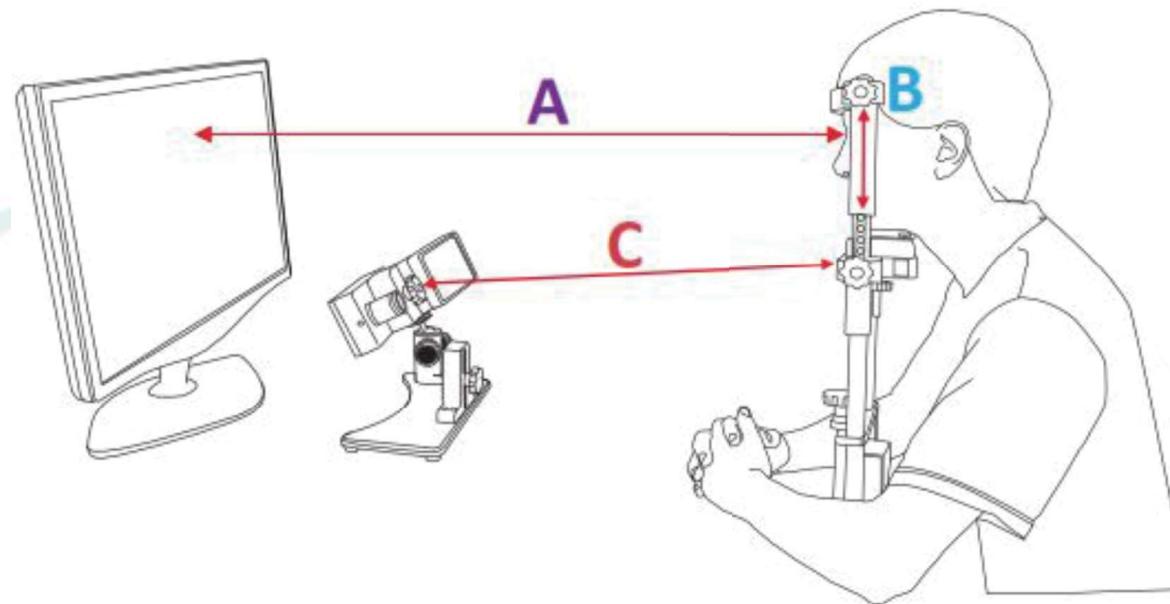
IMAGE NOT  
AVAILABLE



Tracking: Right Eye, 1000 Hz, Pupil-CR  
Data to: File 'SDEMO.EDF' (Samples and Events)  
Link (Samples and Events)

Title: TRIAL RECORDING: TEXT

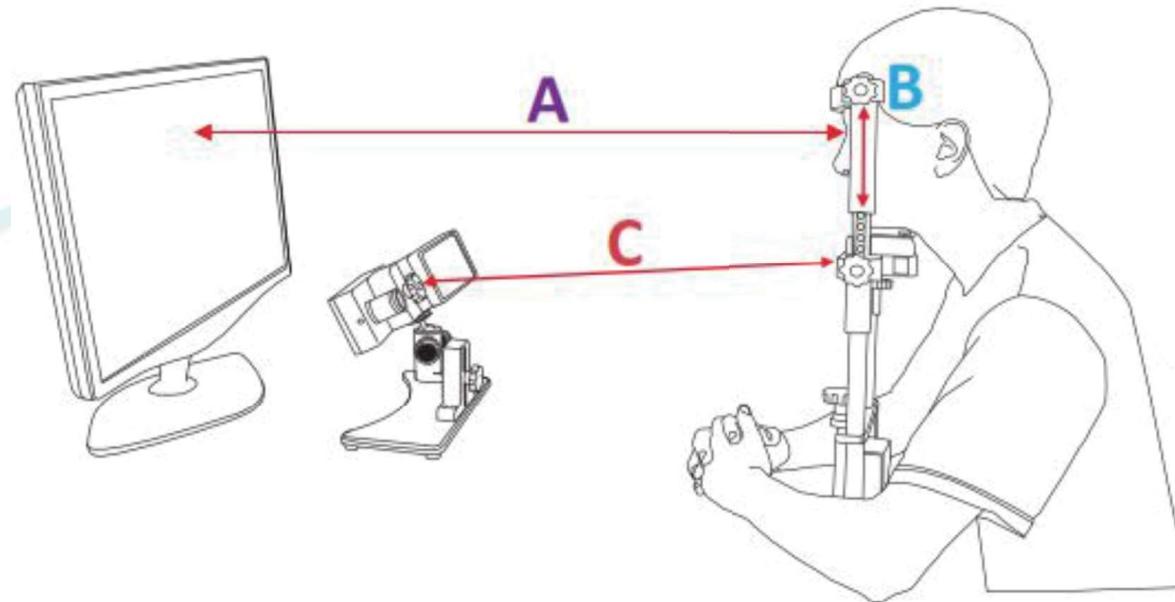
# Physical Setup



A) Position the monitor so that it subtends no more than 32 degrees of visual angle horizontally and 25 degrees of visual angle vertically for the participant.

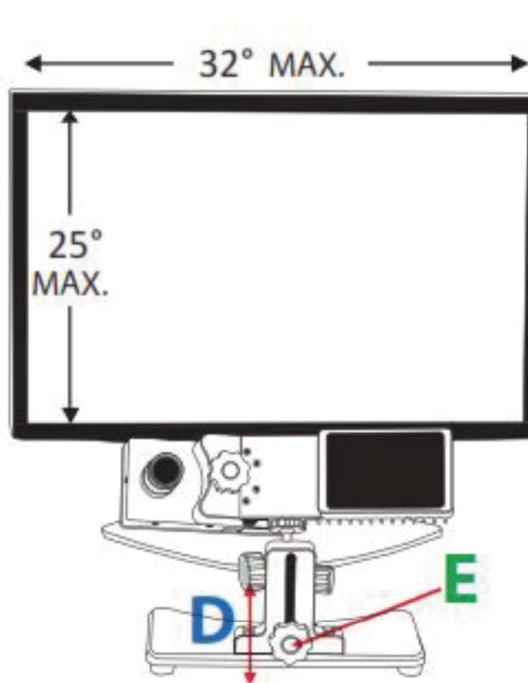
- The eye-to-screen distance should be at least 1.75 times the width of the display to ensure that it falls within the trackable range

# Physical Setup



- B) Position the participant so that the eyes align with the top quarter of the monitor – adjust the chair and/or the head support to ensure this alignment
- C) Position the eye tracker so that the distance from the top knob on the front of the Desktop Mount to the front of the chinrest is 50-55 cm. If using remote mode make sure that the reported target distance on the Host PC is around 60cm (55-60 is ideal for calibration)

# Physical Setup



- D) Adjust the height of the eye tracker so that it is as high as possible without blocking the participant's view of the display
- E) Position the eye tracker so that its bottom knob is centered horizontally with the front of the display

# File Manager

- For the Host software press CTL+ALT+Q to exit back to the File Manager interface
- To access configuration setting select gear icon in top left corner

# Screen Setting

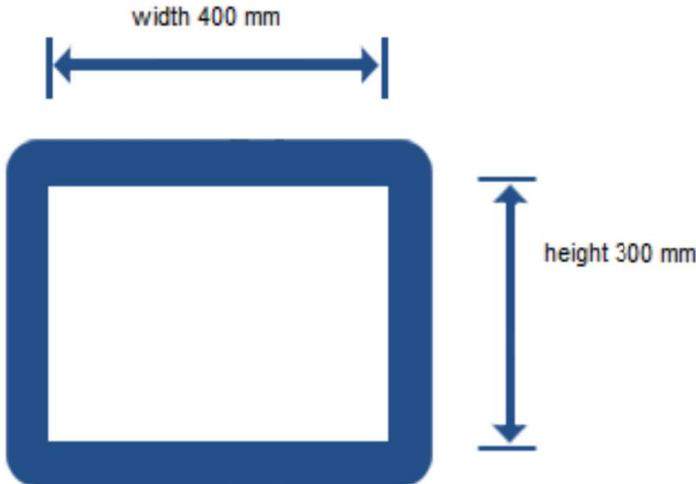
Screen Dimensions

Display Resolution

Eye-to-Screen Distance

Camera-to-Screen Distance

Optimal Target-to-Camera Distance



width 400 mm

height 300 mm

Width of the viewable portion of the Display PC monitor (in millimeters) :

Height of the viewable portion of the Display PC monitor (in millimeters) :

Save

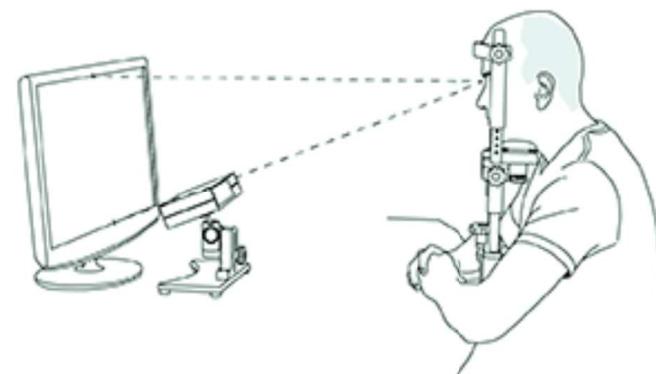
Next

- Enter the physical dimensions of the stimulus display into the screen settings wizard.

# Screen Setting

Screen Dimensions
Display Resolution
Eye-to-Screen Distance
Camera-to-Screen Distance
Optimal Target-to-Camera Distance

distance to top 700 mm



distance to bottom 760 mm

Distance from eye to the top of the viewable portion of the Display PC monitor (in millimeters) :

Distance from eye to the bottom of the viewable portion of the Display PC monitor (in millimeters) :

Save

Back

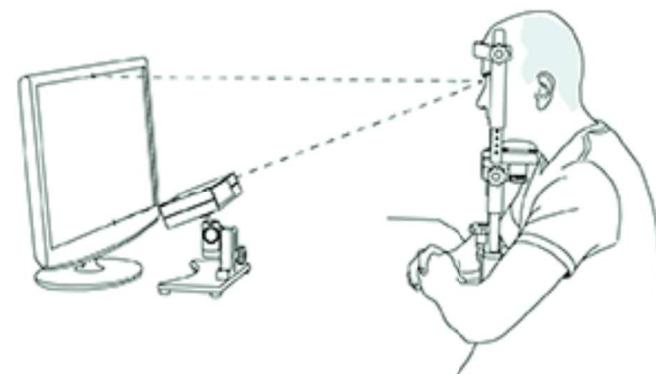
Next

- Enter in the distance from the participant's eye to the top of the display image and the bottom of the display image.

# Screen Setting

Screen Dimensions
Display Resolution
Eye-to-Screen Distance
Camera-to-Screen Distance
Optimal Target-to-Camera Distance

distance to top 700 mm



distance to bottom 760 mm

Distance from eye to the top of the viewable portion of the Display PC monitor (in millimeters) :

Distance from eye to the bottom of the viewable portion of the Display PC monitor (in millimeters) :

Save

Back

Next

- Enter in the distance from the participant's eye to the top of the display image and the bottom of the display image.

# Participant Setup

EXP:101% image thresholds

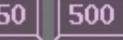
Auto Threshold

Pupil  Corneal 

Tracking Mode

Pupil-CR

Sample Rate

250  500  1K  2K

Pupil Tracking

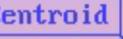
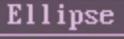
Centroid  Ellipse 

Image Display

Crosshairs

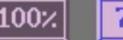
Threshold Coloring

Image->Display PC

Use Search Limits

Mouse Autothresh.

Illuminator Power

100%  75%  50% 

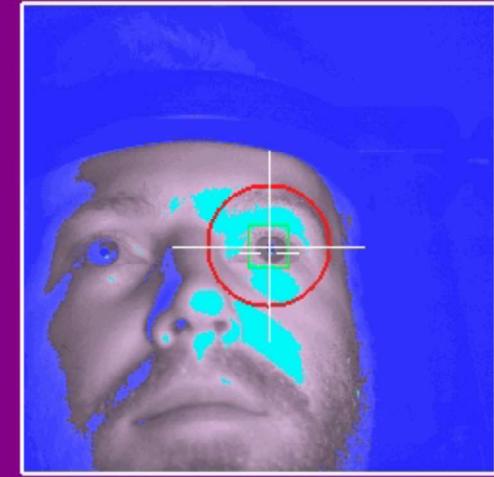


IMAGE NOT AVAILABLE

EYE NOT AVAILABLE

Pupil: 124  
CR : 216

PUPIL OK  
CR OK

Eye Tracked:  Left  Right

Camera Setup

Desktop Monocular

Screens

Exit Setup

Offline

---

Output/Record

Set Options

Help (F1)

---

Calibrate

Validate

Drift Correct

# Participant Setup - Desktop

- 1) Adjust camera angle and position to get a good view of the eye(s)
- 2) Click pupil in the global view to autothreshold  
(Host or Display PC)
- 3) Focus the camera - minimize size of teal CR circle
- 4) Autothreshold and adjust pupil and CR thresholds
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners
    - If the CR is smeared move the Desktop Mount toward the problematic corner until CR is tracked
- 5) Calibration
- 6) Validation
- 7) Recording

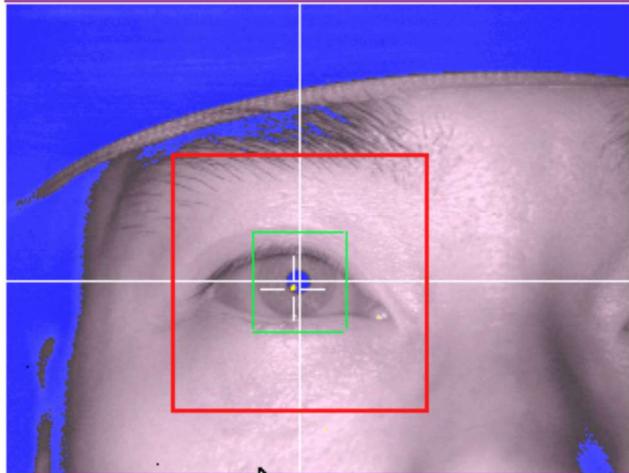
# Participant Setup - Tower

Never adjust the Tower Mount with subject's head in place

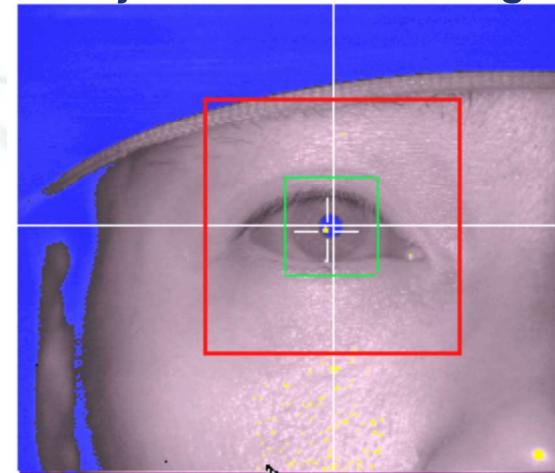
- 1) Set the eye-selection knob to track the dominant eye
- 2) Adjust the mirror angle to get a good view of the eye, or to avoid glasses reflections; adjusting chin position may help too
- 3) Click pupil in the global view to autothreshold (Host Display PC)
- 4) Focus the camera - minimize size of teal CR circle
- 5) Autothreshold and if necessary, adjust pupil and CR thresholds
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners while monitoring threshold quality at all positions
- 6) Calibration
- 7) Validation
- 8) Recording

# Participant Setup

Optimal Eye Position

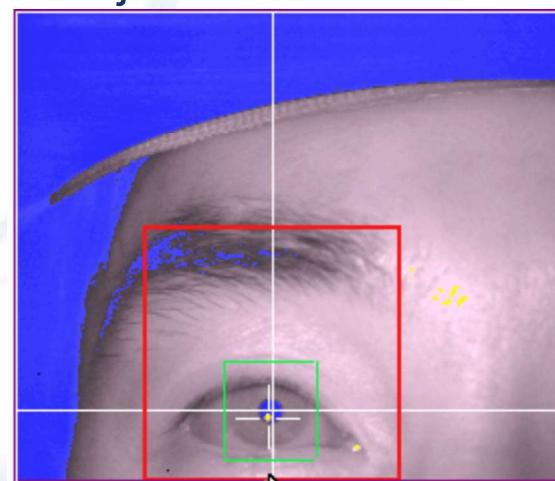


Subject seated too high



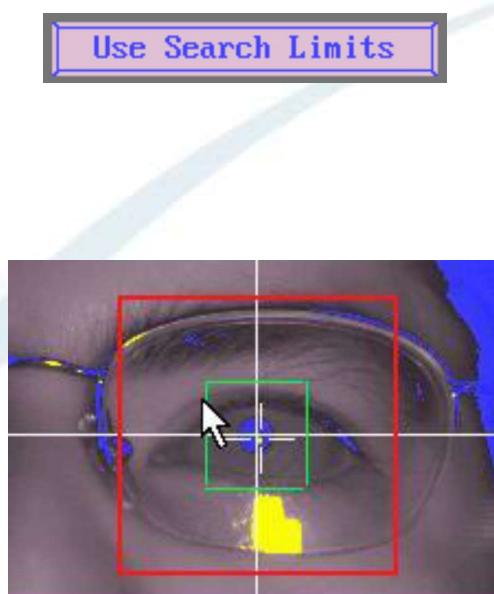
- Adjust chair height so the subject is comfortable and has line of sight to upper part of monitor
- Forehead rest should be just above the eyebrow.

Subject seated too low



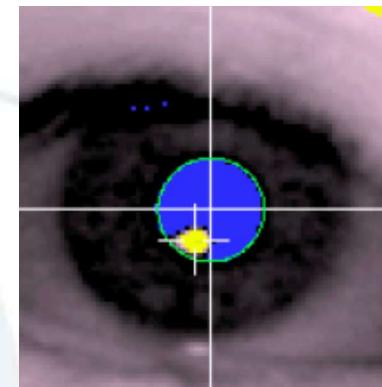
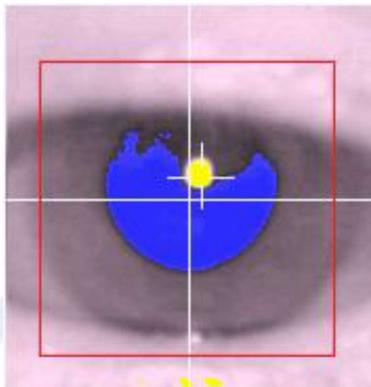
# Participant Setup

- Search Limits (red box) can be used to reduce the area of the image that is searched to find the eye.
- Prevents system from switching to opposite eye.
- You can hold ALT + arrow keys to adjust the size and shape of the search limits.
- Use SHIFT + arrow keys to adjust the position of the search limits



# Participant Setup

## *Centroid vs. Ellipse pupil tracking modes*



### Centroid model fitting:

- Tracks center of a circle fit to thresholded pupil
- Advantages:
  - Highly stable
  - Low noise
- Disadvantage:
  - Position drift if pupil is occluded by eyelid

### Ellipse model fitting:

- Tracks center of an ellipse fit to thresholded pupil.
- Advantages:
  - Decreased drift
  - Overcomes pupil occlusion
- Disadvantage:
  - Slightly higher noise level

# Participant Setup

## *Setting Pupil Threshold*

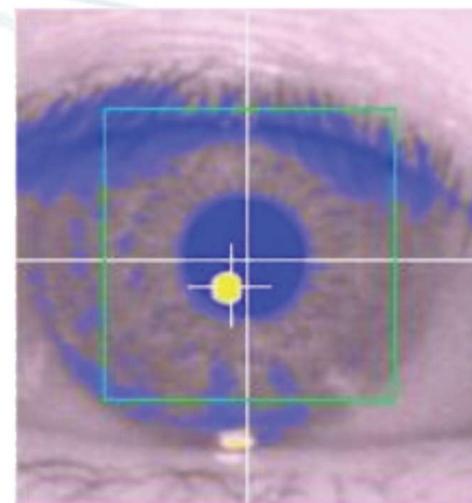
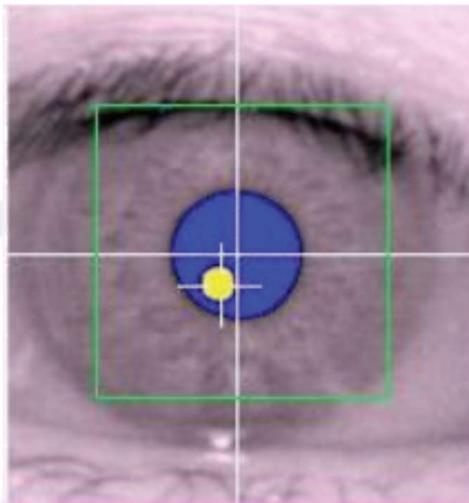


Fig. 1

Pupil threshold can be adjusted automatically, through the Auto-Threshold command, or manually, through the up and down arrows. A threshold too high will result in shadows (Fig. 1), while a threshold too low will result in a noisy signal (Fig. 2).

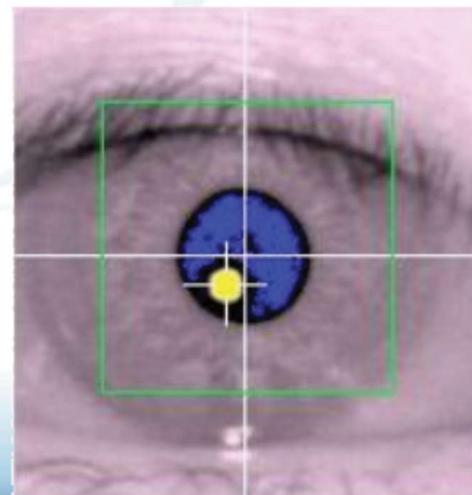
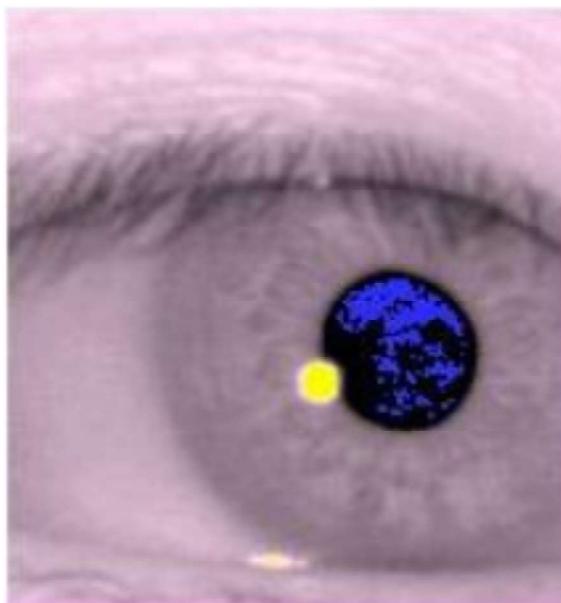


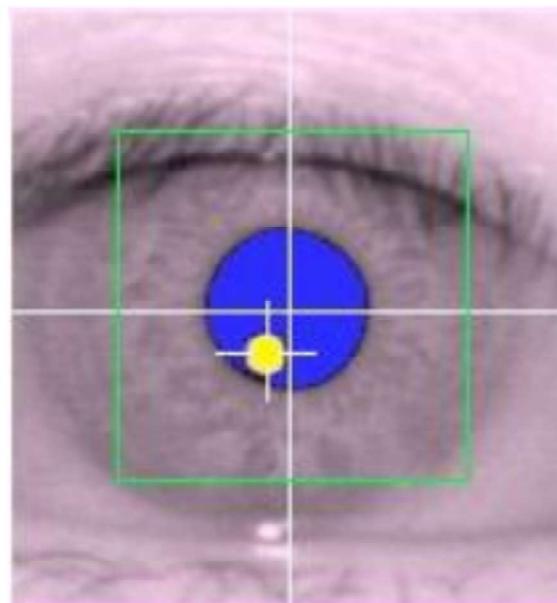
Fig. 2

# Participant Setup

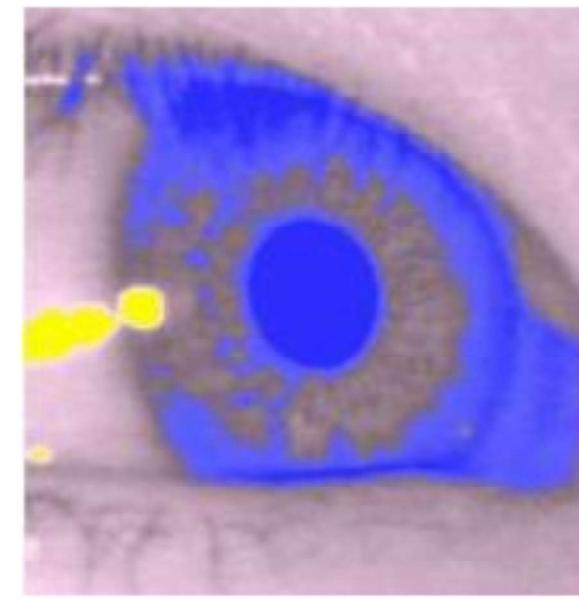
## *Symptoms of Poor Pupil Threshold*



Pupil clipped and lost



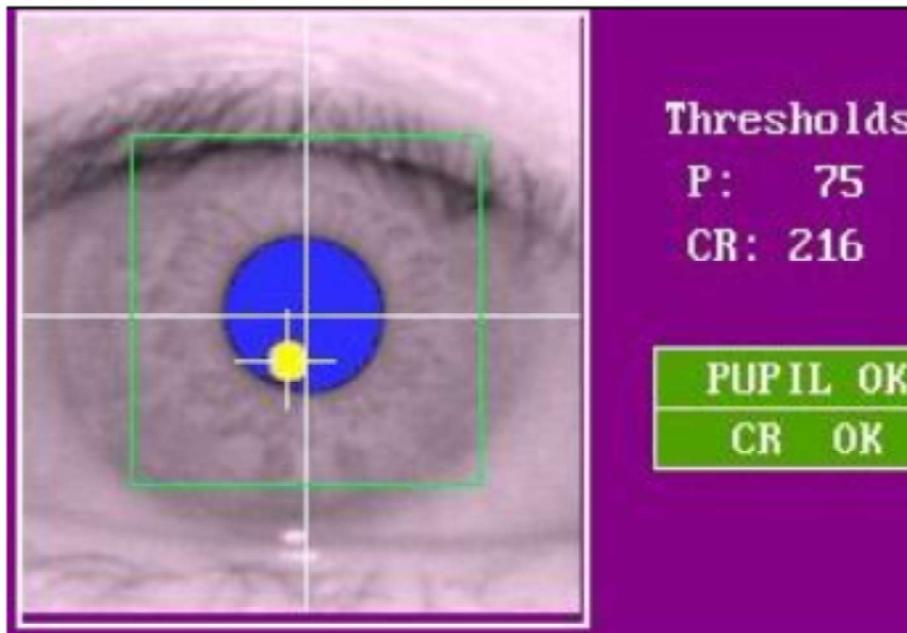
Good



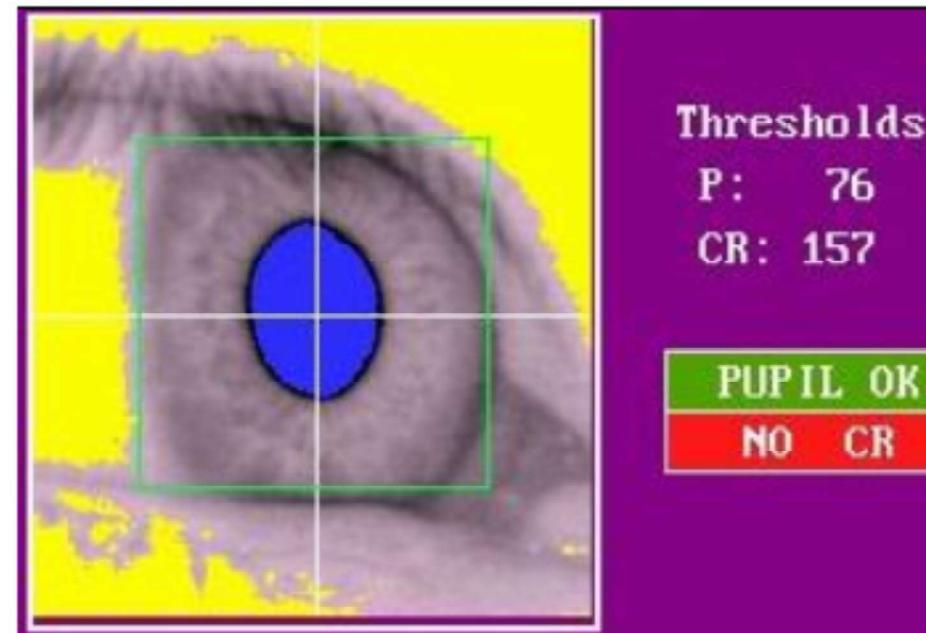
Corner shadow  
captures pupil

# Participant Setup

## *Setting Corneal Reflection (CR)*



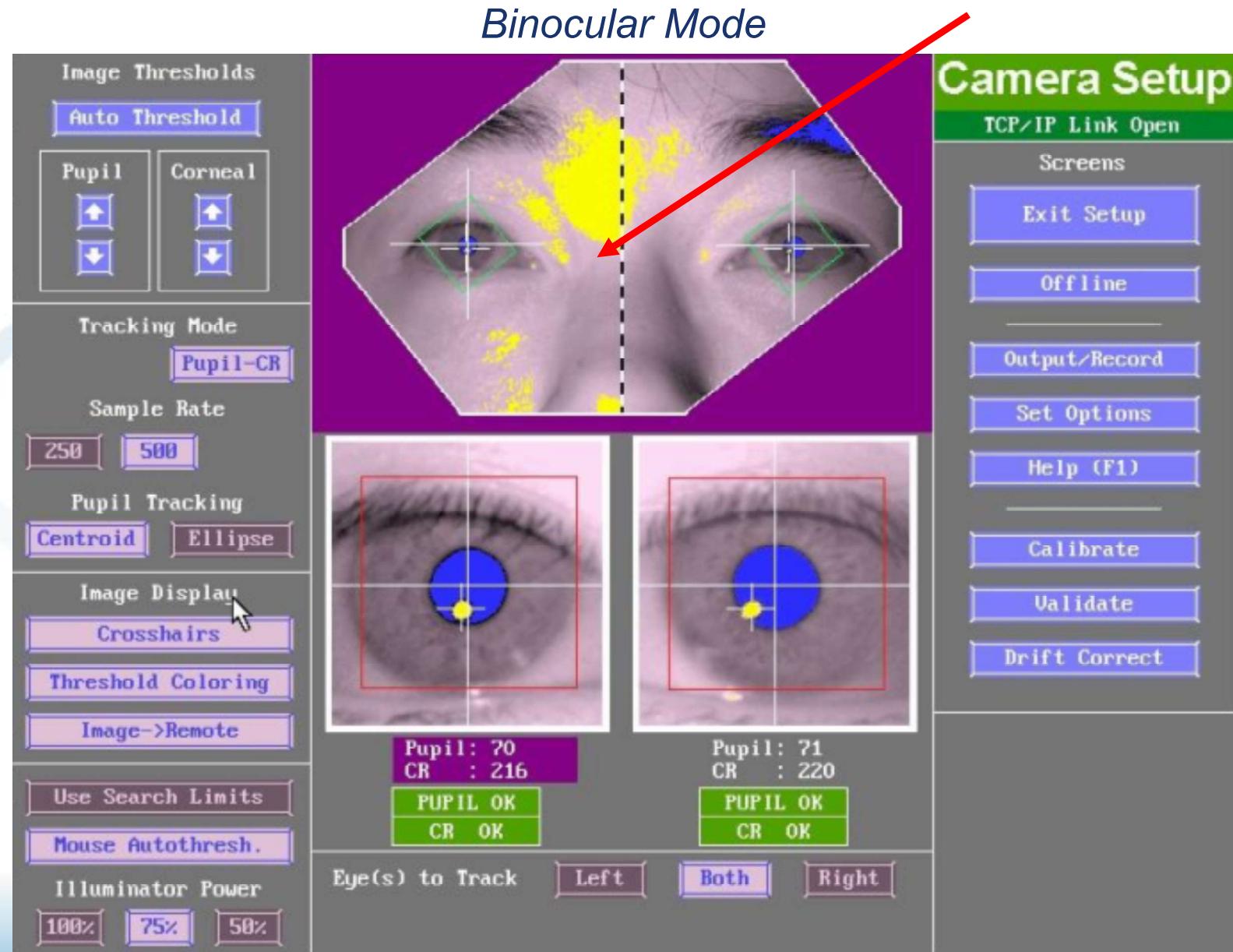
Good corneal reflection



Poor corneal reflection

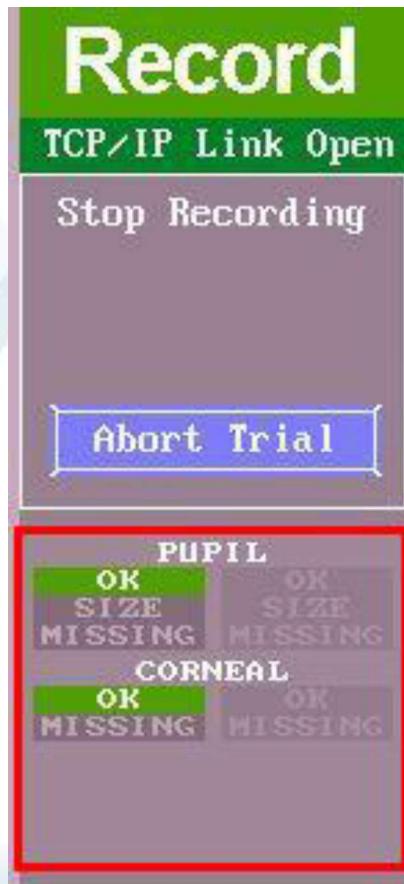
Adjust corneal reflection using + and – keys. Note that the – key increases the thresholded area.

# Participant Setup



# Status Panel

Monitor the status of camera image of the tracked eye throughout setup, calibration, validation and recording phases.



## Pupil:

**OK**: Pupil present and can be tracked at selected sample rate

**SIZE**: Occurs when pupil size is larger than the maximum allowed pupil size

**MISSING**: Pupil not present

## Corneal reflection:

**OK**: CR present and can be tracked

**MISSING**: CR is not present

# Participant Setup - Remote

- 1) Place the target on the subject's forehead
- 2) Adjust camera angle and position to get a good view of the eye and sticker; capture as wide a range of subject movement as possible
- 3) Click pupil in the global view to autothreshold (Host Display PC)
- 4) Focus the camera - minimize size of teal CR circle
- 5) Adjust thresholding bias for pupil and CR
  - If cautious or troubleshooting, check the setup by asking the subject to look at four corners
  - If the CR is smeared move the Desktop Mount toward the problematic corner until CR is tracked
- 6) Calibration
- 7) Validation
- 8) Recording



# Participant Setup - Remote

The screenshot shows the 'Camera Setup' window of the Eyetrak 4 software. The interface is divided into several sections:

- Image Thresholds** (top left): Includes buttons for Pupil (up and down arrows) and Corneal (up and down arrows).
- Tracking Mode** (middle left): Set to "Pupil-CR".
- Sample Rate** (middle left): Set to 250 and 500.
- Pupil Tracking** (middle left): Set to "Ellipse".
- Image Display** (middle left): Includes "Crosshairs" and "Threshold Coloring" buttons.
- Image -> Remote** (middle left): A button for image transmission.
- Align Eye Window** (middle left): A button for aligning the eye window.
- Illuminator Power** (bottom left): Set to 100% and 75%.
- Camera Preview** (top center): Shows a video feed of a person's eyes with tracking markers: a green crosshair over the left pupil and a red crosshair over the right cornea.
- Zoomed Pupil View** (bottom left): A close-up view of the left eye with a green elliptical tracking window.
- Zoomed Target View** (bottom right): A close-up view of a target with a blue elliptical tracking window.
- Tracking Data** (bottom center): Displays "Pupil: 86 AUTO x1.05", "CR : 203 AUTO x1.00", "Target Thr: 142", and "Distance: 594.6 mm".
- Status Buttons** (bottom center): "PUPIL OK" and "CR OK" on the left, and "TARGET OK" and "DIST OK" on the right.
- Eye Status** (bottom center): "Eye Tracked: Left" and "Right".
- Navigation and Help** (right side): Includes "Screens", "Exit Setup", "Offline", "Output/Record", "Set Options", "Help (F1)", "Calibrate", "Validate", and "Drift Correct" buttons.

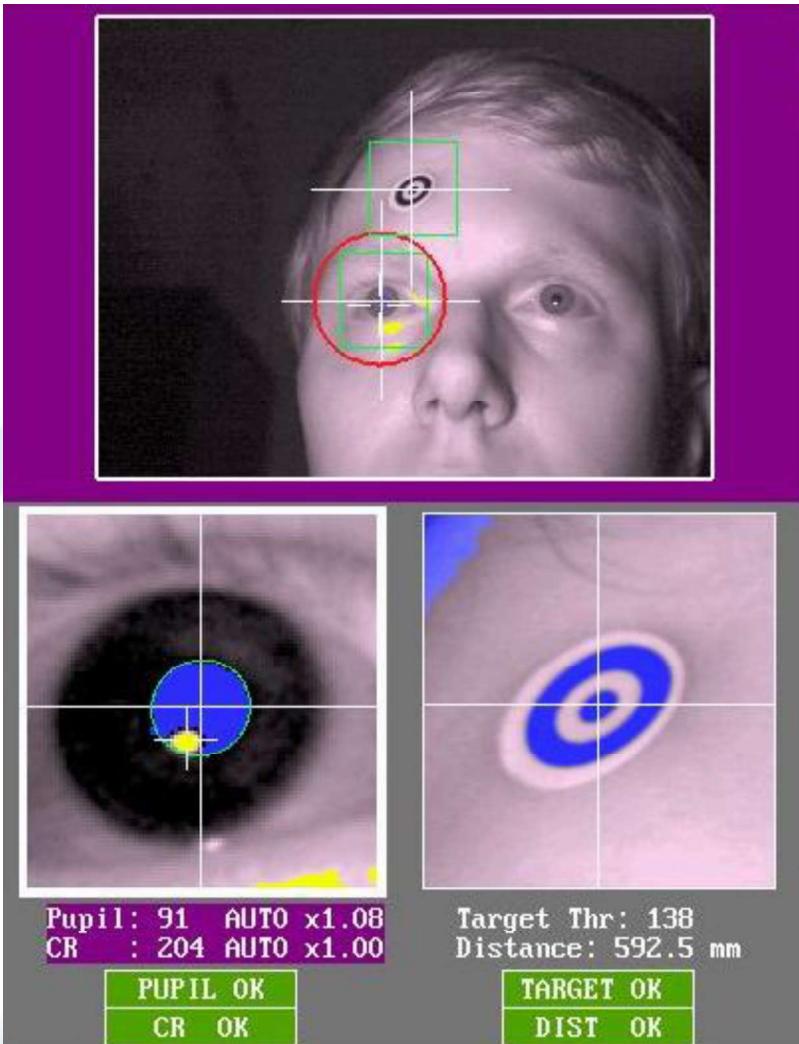


# Participant Setup - Remote

Participant setup becomes a smooth and fast procedure with practice. Follow these steps:

- 1) Use proper lens and set ELCL configuration to “Desktop (Remote)”
- 2) Set the height of the monitor; eye-to-screen distance of about 70 cm
- 3) Place camera right in front of the monitor
- 4) Raise desktop mount to maximize tracking range
- 5) Seat the subject and place the target sticker
- 6) Find the pupil by clicking on the eye image
- 7) Adjust the thresholding bias for pupil and CR
- 8) Check setup by asking subject to look at four corners
- 9) Calibration, validation and recording

# Participant Setup - Remote



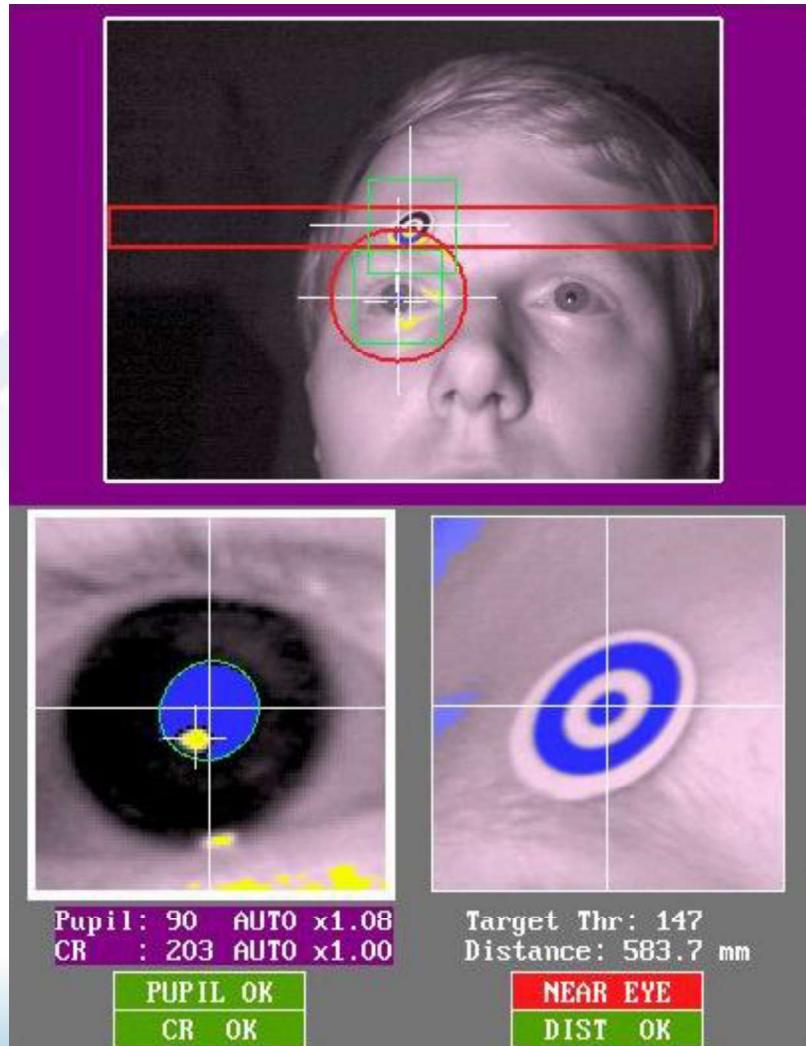
- Place target sticker on the subject's forehead
- The eye and sticker should stay within the camera image when the subject moves
- Ideal target-to-camera distance is 550mm to 600mm for calibration
- For highest accuracy use 13-point calibration

Target Thr: 178  
Distance: 499.2 mm  
**TARGET OK**  
**DIST CLOSE**

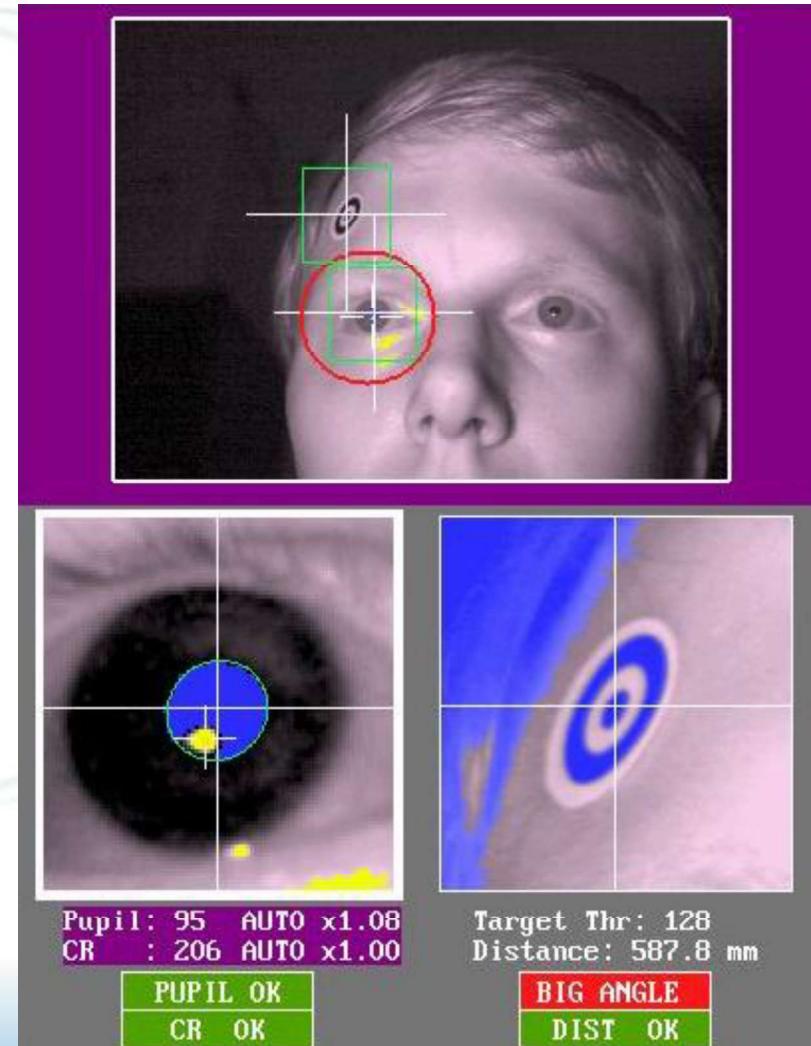
Target Thr: 123  
Distance: 716.4 mm  
**TARGET OK**  
**DIST FAR**

# Participant Setup - Remote

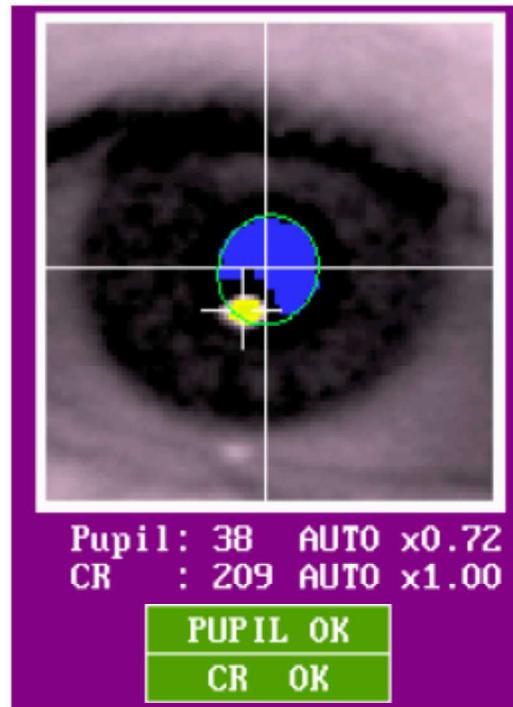
*Target too close to the eye vertically*



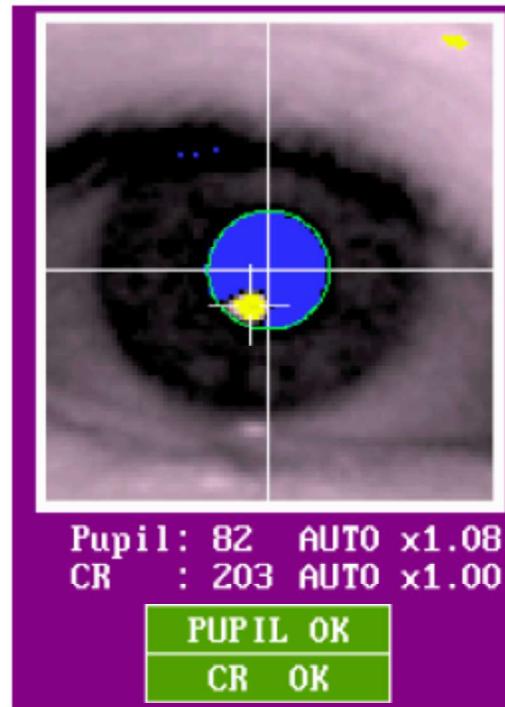
*Target has a large angle*



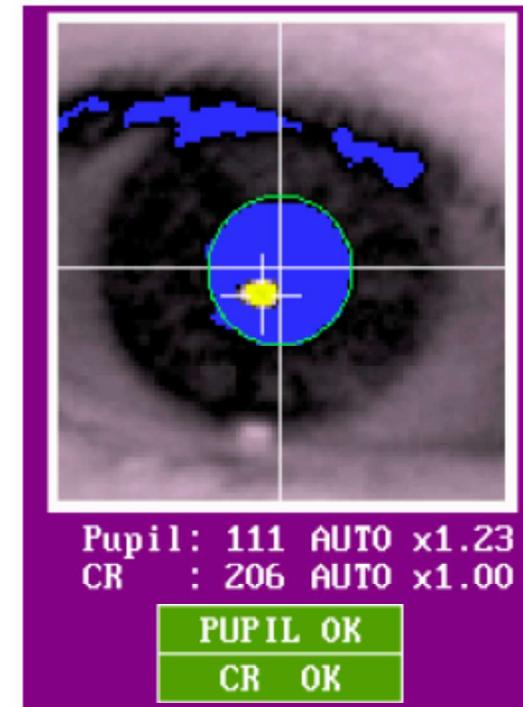
# Participant Setup - Remote



Threshold bias too low



Properly thresholded



Threshold bias too high

Pupil threshold bias adjusted by up and down arrow keys  
(1.08 typical)

CR threshold adjusted by + and – keys (1.00 typical)

# Participant Setup - Remote



- Monitor the thumbnail camera images at the lower left corner of the tracker screen.
- The two dots in the middle panel reflect the target dot and eye position in the camera image
- For reliable tracking, both dots should stay within the red box

# Participant Setup - Remote

## Pupil

**OK:** Pupil present and can be tracked at selected sample rate

**SIZE:** Occurs when the pupil size is larger than the maximum allowed

**MISSING:** Pupil not present

## Status Panel



## Corneal

**OK:** Corneal reflection is present and can be tracked

**MISSING:** Corneal reflection is not present

## Target

**OK:** Target is present and can be tracked

**MISSING:** Target is not present

**NEAR EYE:** Target is placed too close to the eye on the vertical dimension

**ANGLE:** Target has too low an angle to be recognized properly

# Calibration

Calibrate

TCP/IP Link Open

Screens

Camera Setup

Help (F1)

PUPIL

OK	OK
SIZE	SIZE
MISSING	MISSING
CORNEAL	
OK	OK
MISSING	MISSING

Sequencing

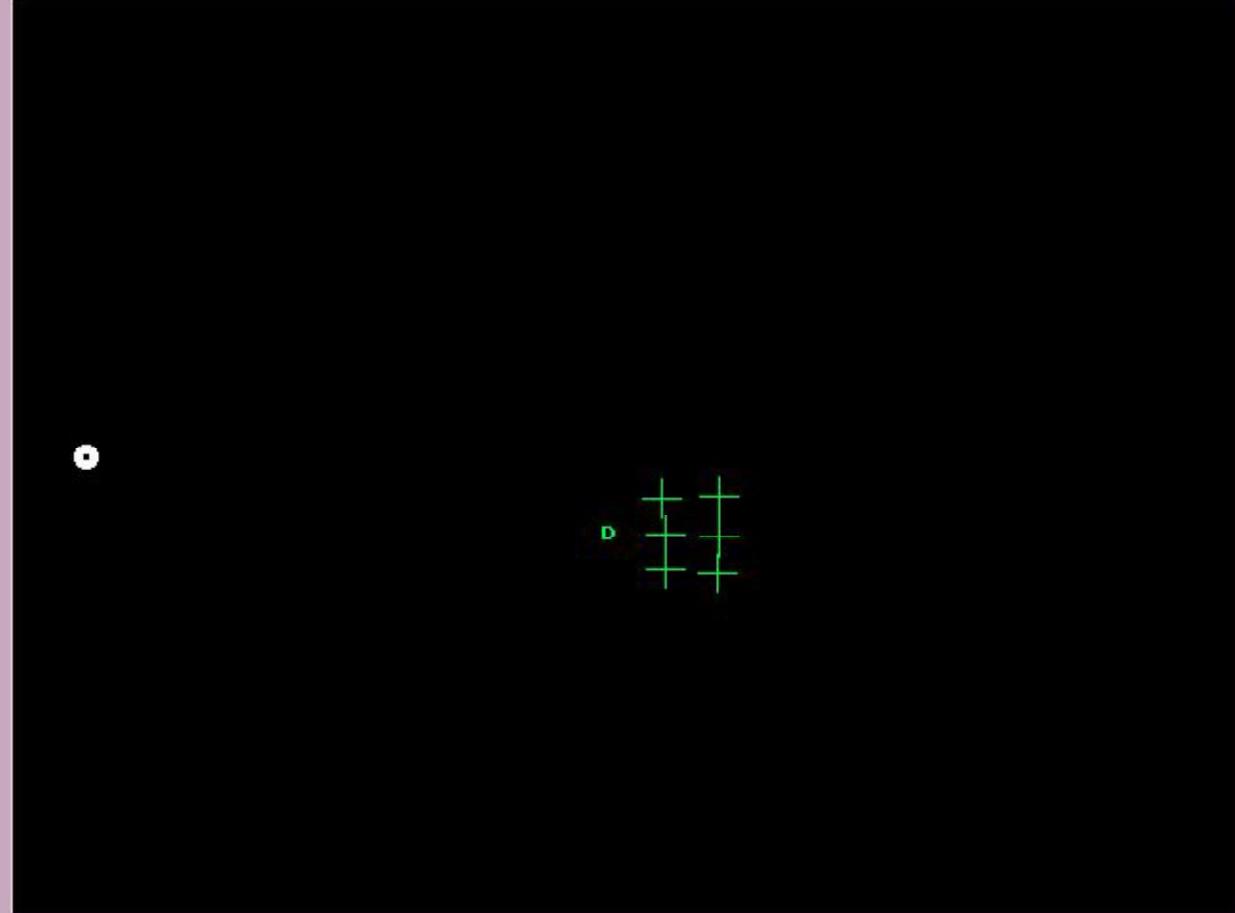
Restart

Auto Trigger

Accept Fixation

STABLE

Point 7 of 10



Thresholds:

P: 101

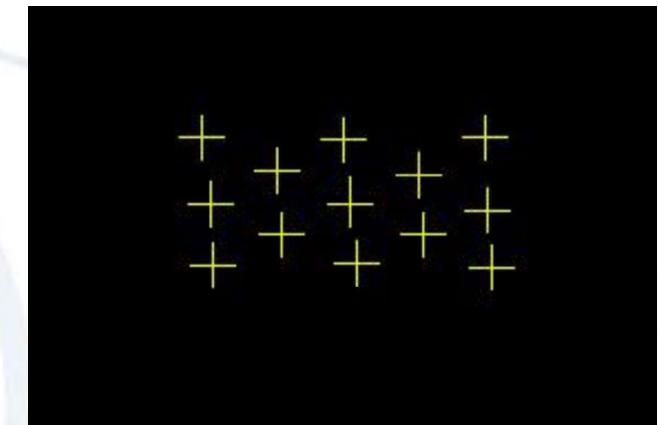
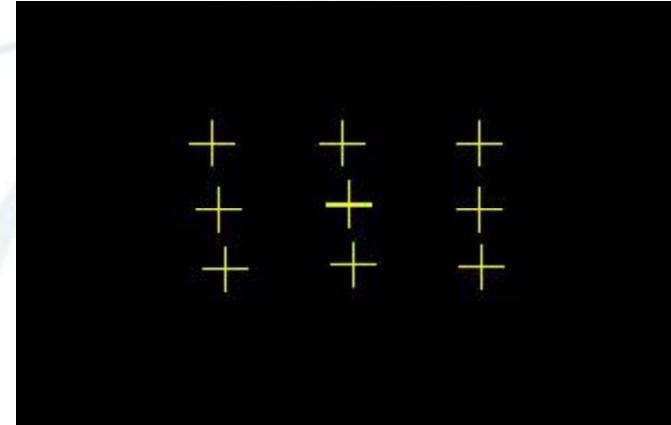
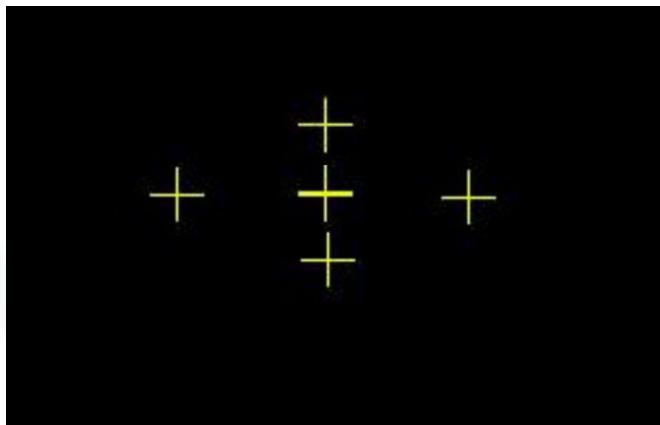
CR: 221

Tracking: Left Eye, Pupil-CR

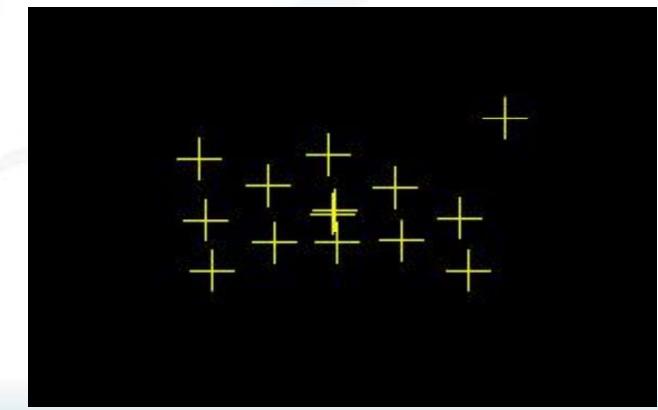
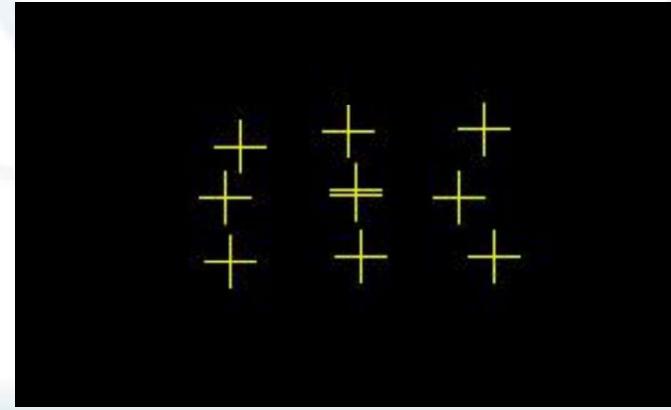
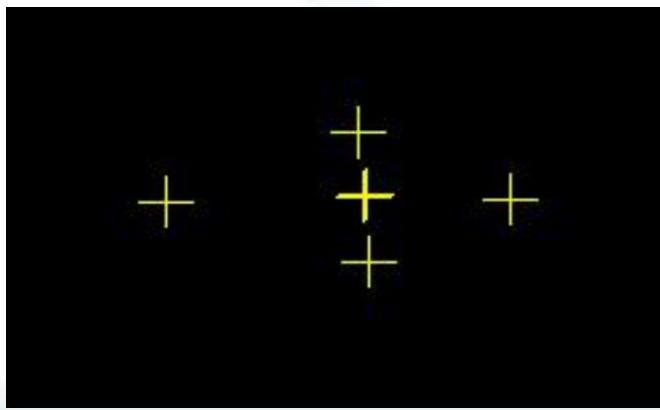
Calibration: 9 point grid

# Calibration

Good Calibration models (symmetrical)



Poor Calibration models (asymmetrical)



# Calibration

- To improve calibration accuracy:
  - Check pupil and CR as the subject looks at all four corners of the display. They should always be visible, well-thresholded, and tracked.
  - Encourage subject to sit still—no head turning!
  - Redo targets by pressing the backspace key
  - Turn on manual accept mode by pressing the SPACE key twice to ensure subject is fixating calibration target
  - Match background color of calibration/validation screen to test displays—change in pupil size due to large brightness differences can cause drift

# Validation

*Checking gaze accuracy of the calibration*



# Validation Results

## Validation Results

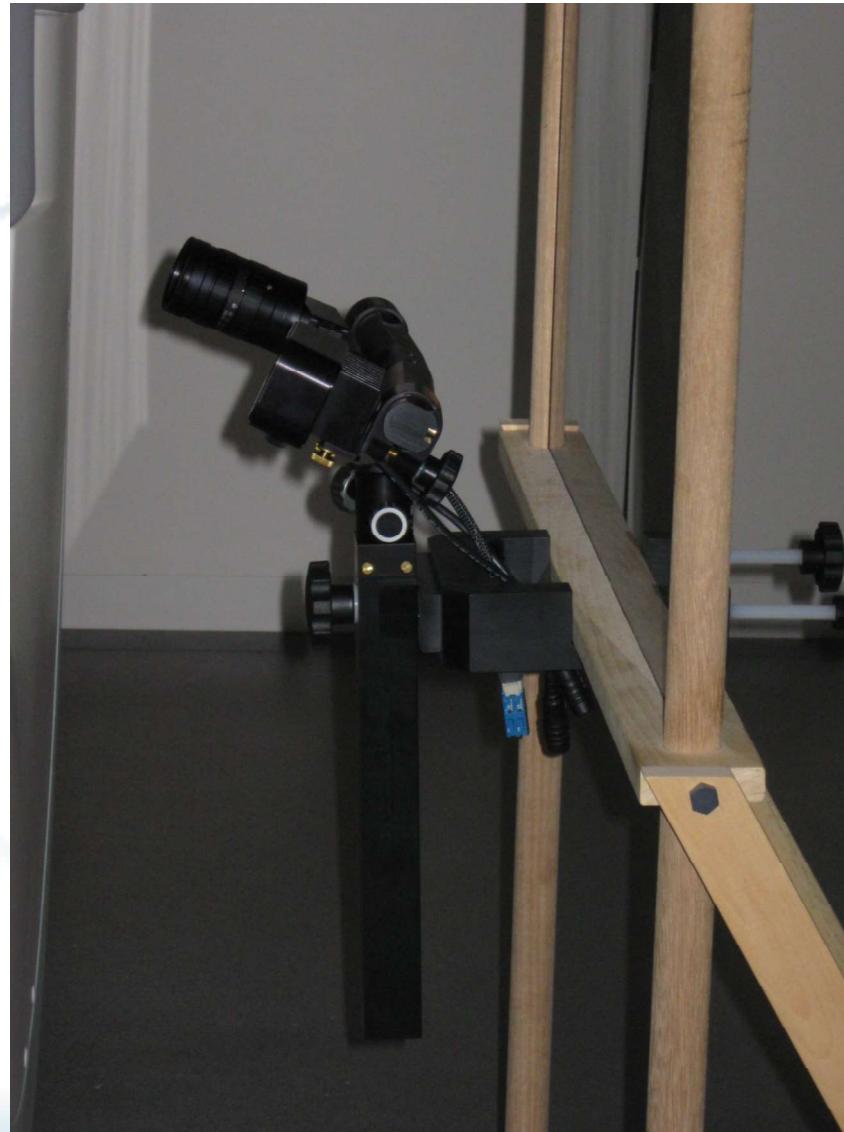
- GOOD (green background): Level of error is acceptable
- FAIR (grey background): Error is moderate; calibration should be improved
- POOR (red background): Error is too high for useful eye tracking

In general, ensure that the average gaze error is within  $0.5^\circ$  and maximum error is within  $1.0^\circ$

# Validation Results

- Optional card for Host PC – usually used for devices like EEG
- Converts Digital Data to Analog Voltages
- Output Gaze X, Y, and Pupil size as voltages over BNC connectors
- Voltage range configurable
- Three Channels per eye being tracked
  - Horizontal Position
  - Vertical Position
  - Pupil Size
- Also allows for extra Digital In/Out (in addition to Parallel Port)
- Quick –
  - Data can be inserted into empty EEG channels
  - Allows for easy alignment with EEG data
- Dirty –
  - Noise is added by D/A and A/D conversion
  - Saccade/Fixation information is lost

# Long Range Screen Mount



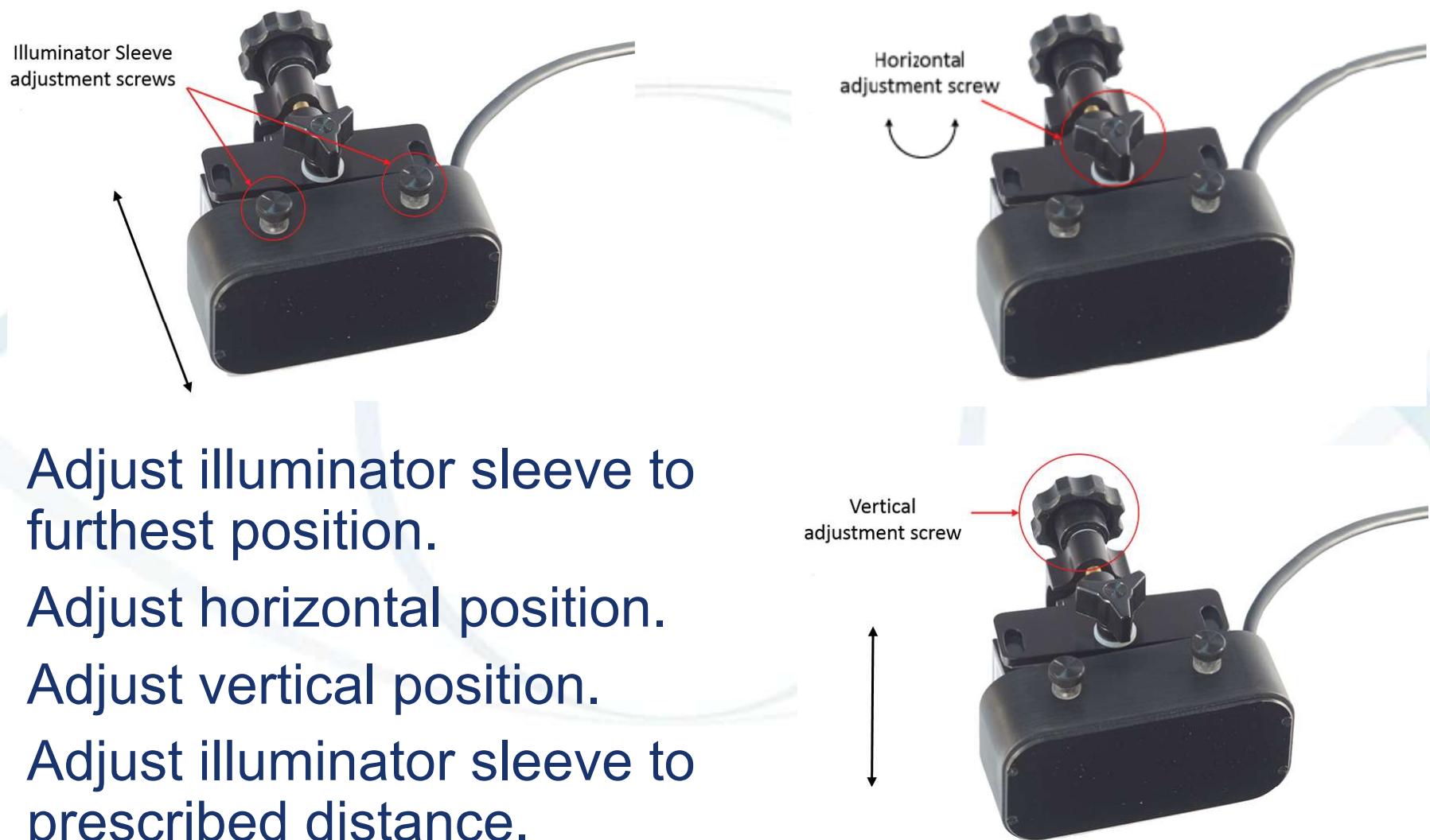
# Long Range Tray Mount



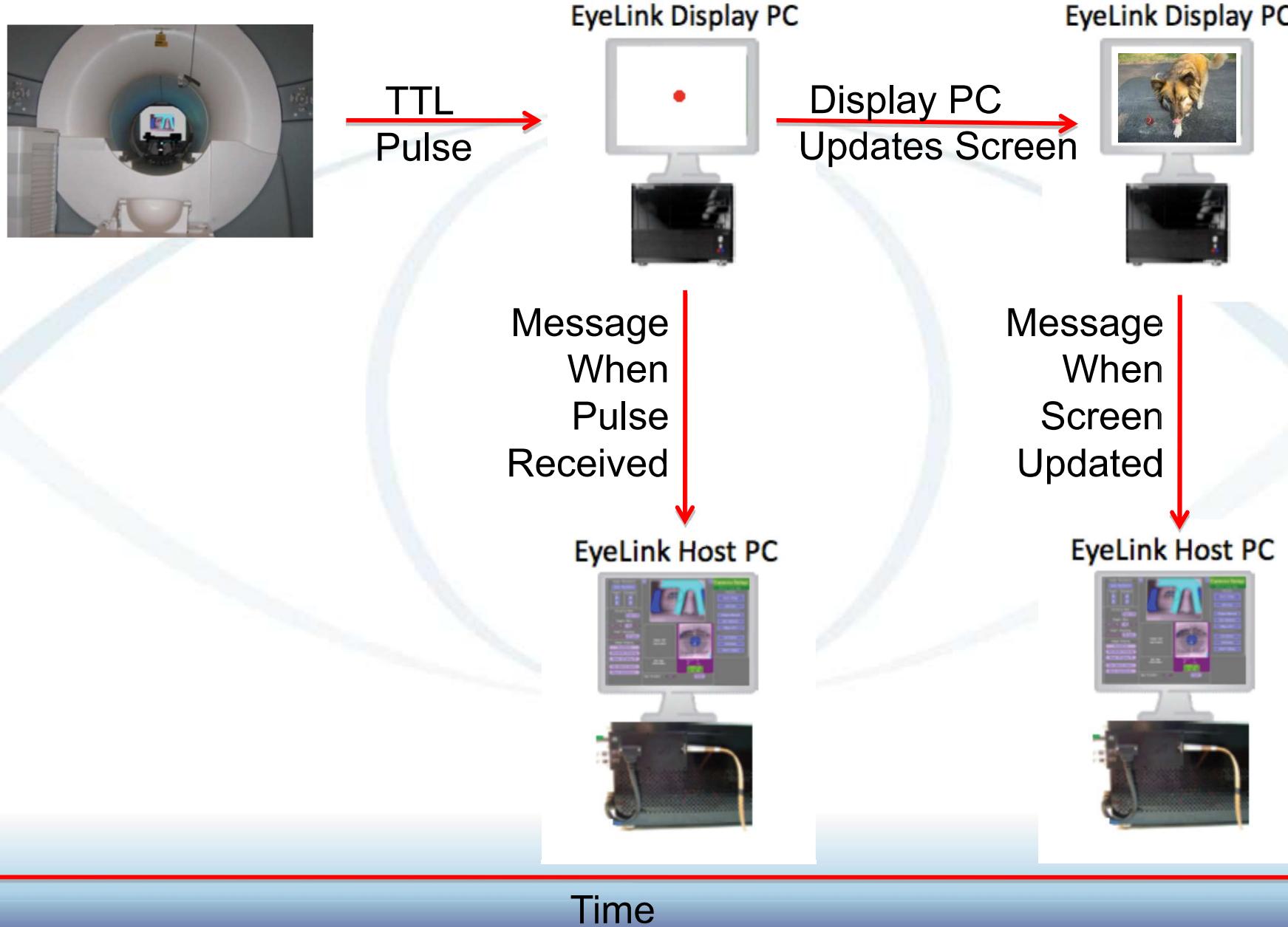
# Long Range Tripod Mount



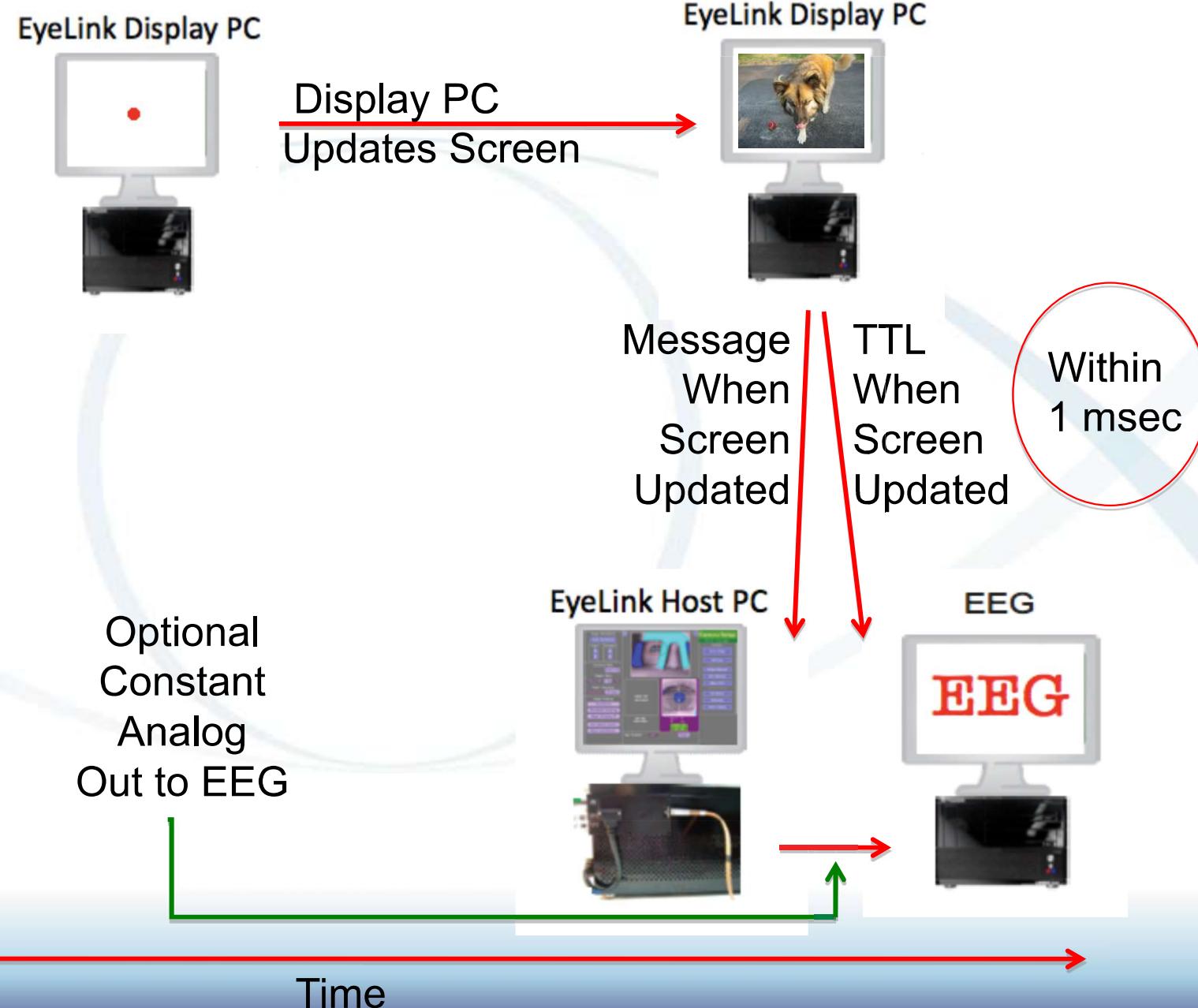
# Long Range Illuminator



# MRI / Eye Tracker Setup



# EEG / Eye Tracker Setup



# EEG / Eye Tracker Setup

OR

