Forward Lighting: Problems, Research, Countermeasures

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OUTLINE

- Glare complaints and problems
- Differences between HID and Halogen headlamps
- Factors affecting Discomfort and Disability glare
- Hypotheses about glare complaints
- Preliminary research findings
- Future research directions

Forward Lighting Glare Concerns

- Over 4600 responses to request for comments on glare
- Public wanted reduced glare from:
  - Auxiliary Lamps
    - Fog Lamps
    - Driving Lamps
    - Auxiliary Low Beam Lamps
  - High-mounted headlamps
  - High Intensity Discharge *(HID)* Lamps

Glare Consequences Identified by Public

- Causes annoyance and road rage
- Reduces vision
- Increases difficulty of using mirrors
- Distracts drivers; Causes eyes to look away from road
- Causes drivers to stop driving at night
- It hurts the eyes
- Causes fear of being in crash

National Survey

Glare has been:

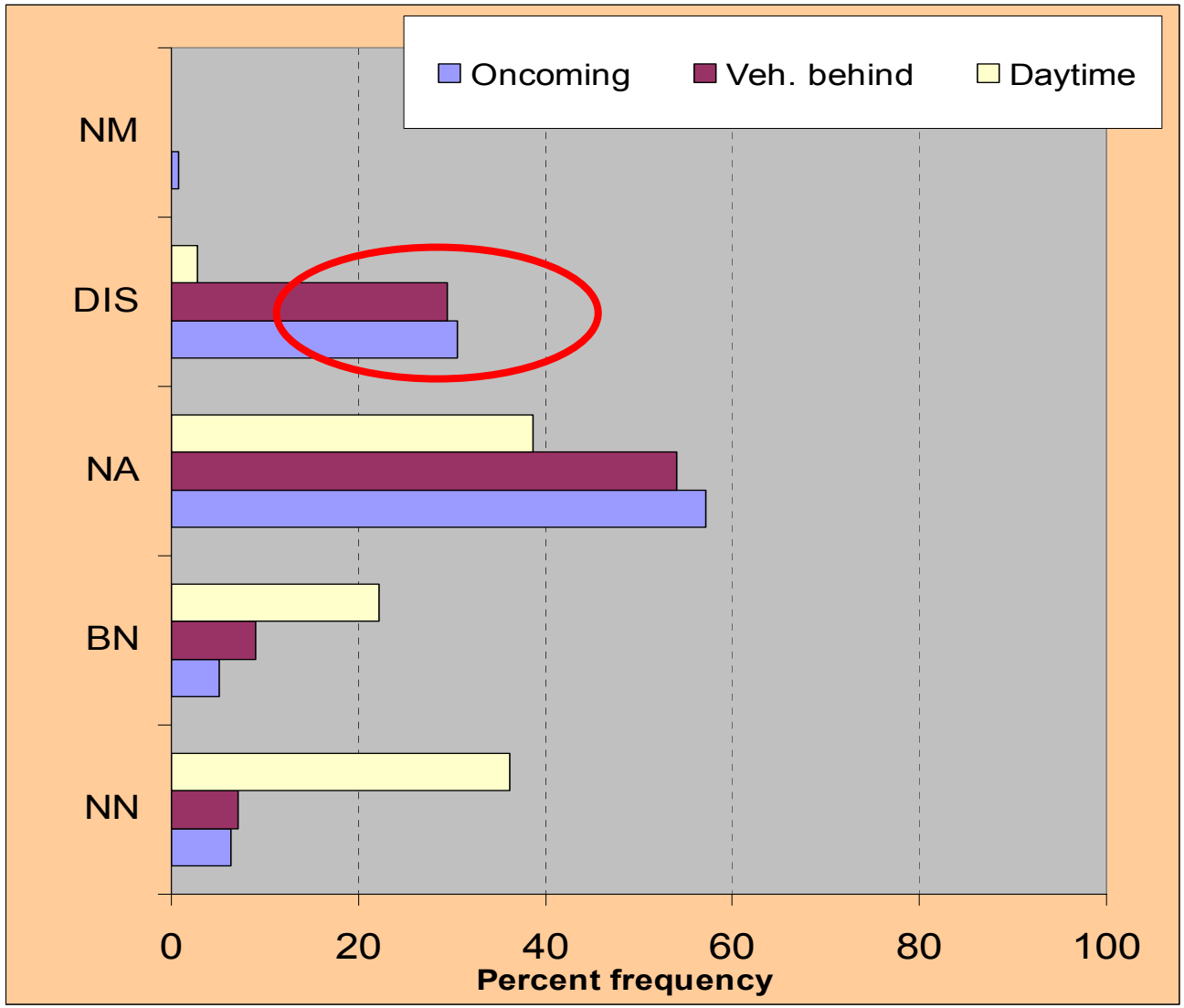
-Cause of crash, Near Miss

-Disturbing

-Noticeable but Acceptable

-Barely Noticeable

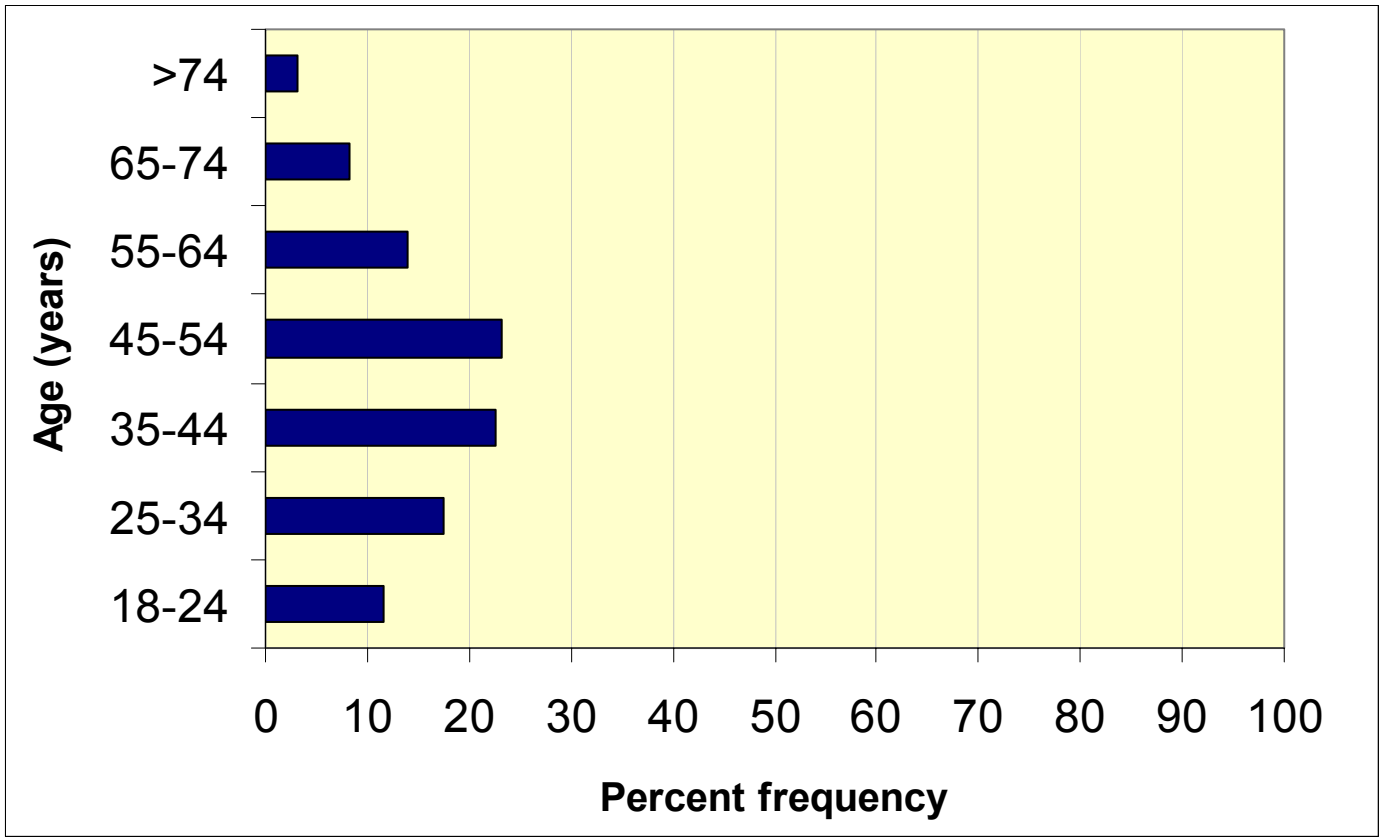
-Not Noticeable



From Bureau of Transportation Statistics, 2002

(sample size~4321)

Oncoming Glare Rated ‘Disturbing’ by Each Age Group



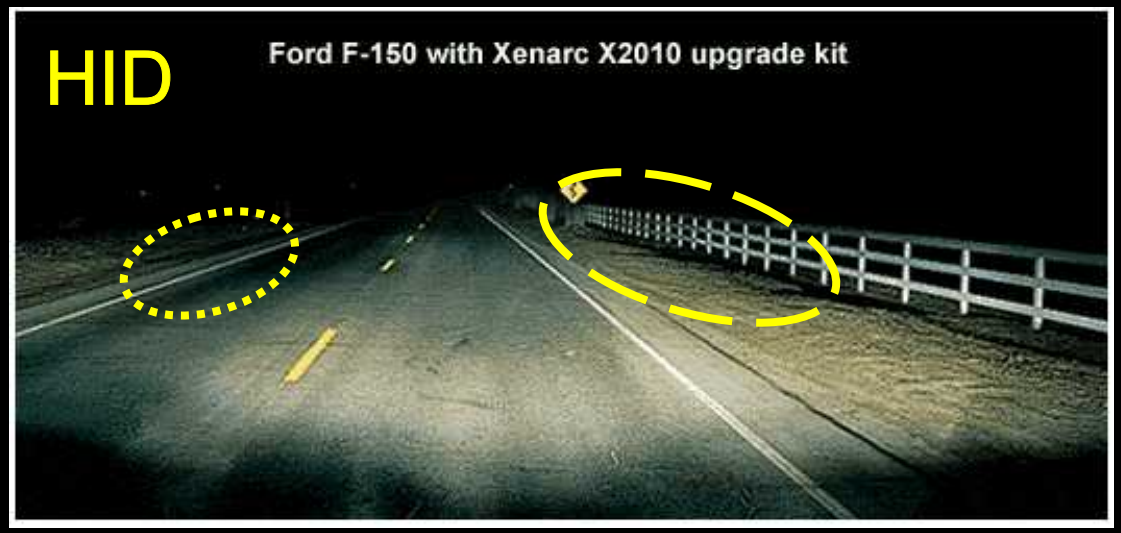
From Bureau of Transportation Statistics, 2002

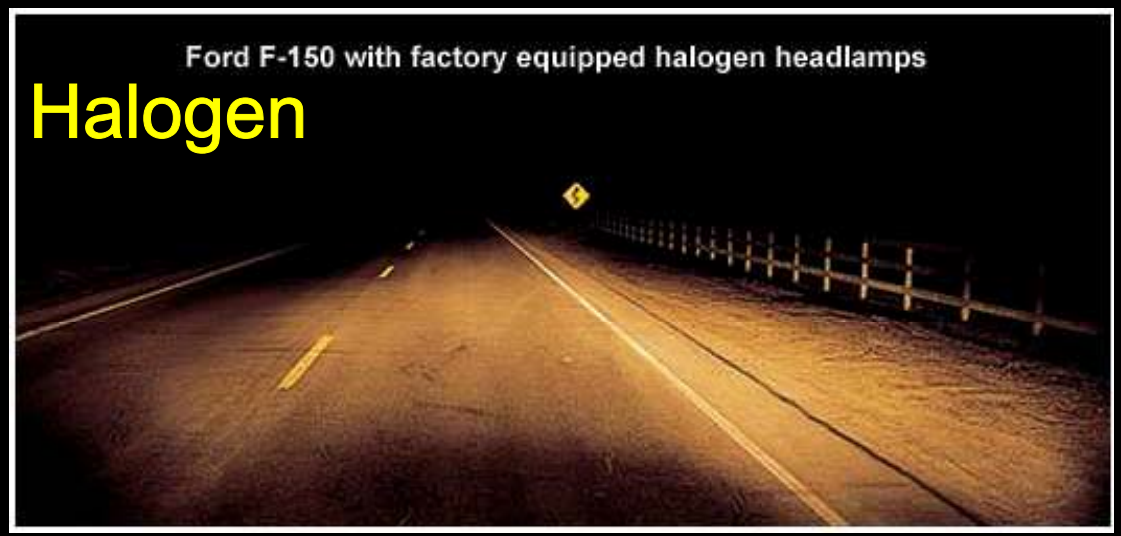
Sample size ~ 1373

Key Research Questions

- **Why are drivers complaining about headlamp glare?**
- **What rulemaking options might reduce glare problems?**
  - **New photometric specifications**
  - **Reduced mounting height**
  - **Improved aim (static and dynamic)**
  - **Others (e.g., washing systems, lamp color)**

HID vs Halogen





- **Color**

Blue/white vs. Yellow

- **Vertical Intensity Gradient**

Sharp vs. Gradual

- **Horizontal Intensity**

Wide spread vs. limited spread

Observations about lamp intensity distributions

- Maximum intensities of HID and Halogen overlap
- Variability in photometrics within and between lamp types
- Median values show higher intensities for HID below horizontal and away from straight ahead direction
- Questions remain about differences in illuminance at oncoming drivers eyes when lamps are at different heights, misaimed, on curves, and on hills

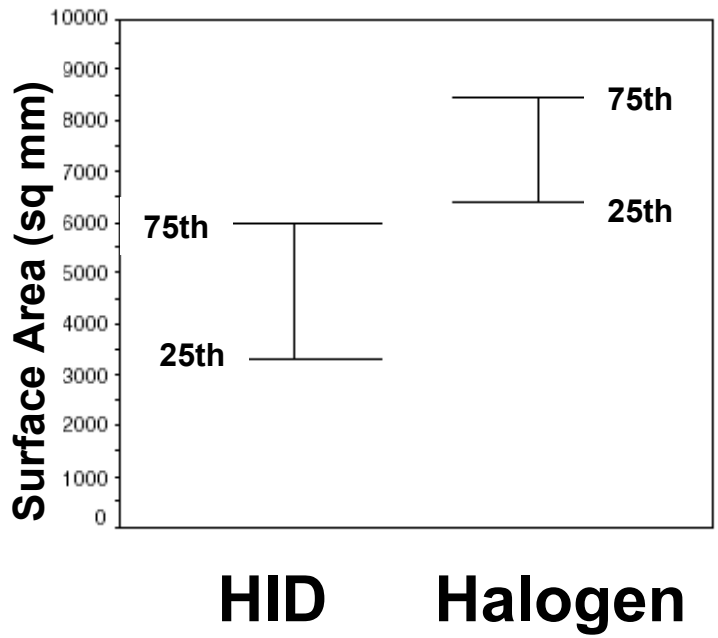
Lens Optics:
2003 Mercedes Benz E/C Class

Projector optics:
2002 Audi A6

Complex reflector optics
2003 Acura RL

Lamp Design Differences

- **Lamp size (luminous area)**



- **Aiming methods**

From UMTRI research, 2002

Two Types of Glare

- **Discomfort**
  - **Subjective, measured w/De Boer scale**

Just Noticeable		Satisfactory		Just acceptable		Disturbing		Unbearable
9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**

  - **Influenced by: illuminance from glare source, task difficulty, ambient brightness, angle from line of sight**
  - **May affect performance through distraction and eye strain**
- **Disability**
  - **Direct effect on visibility distance**
  - **Increases with glare intensity, driver age, and smaller angle from line of sight**

Hypotheses

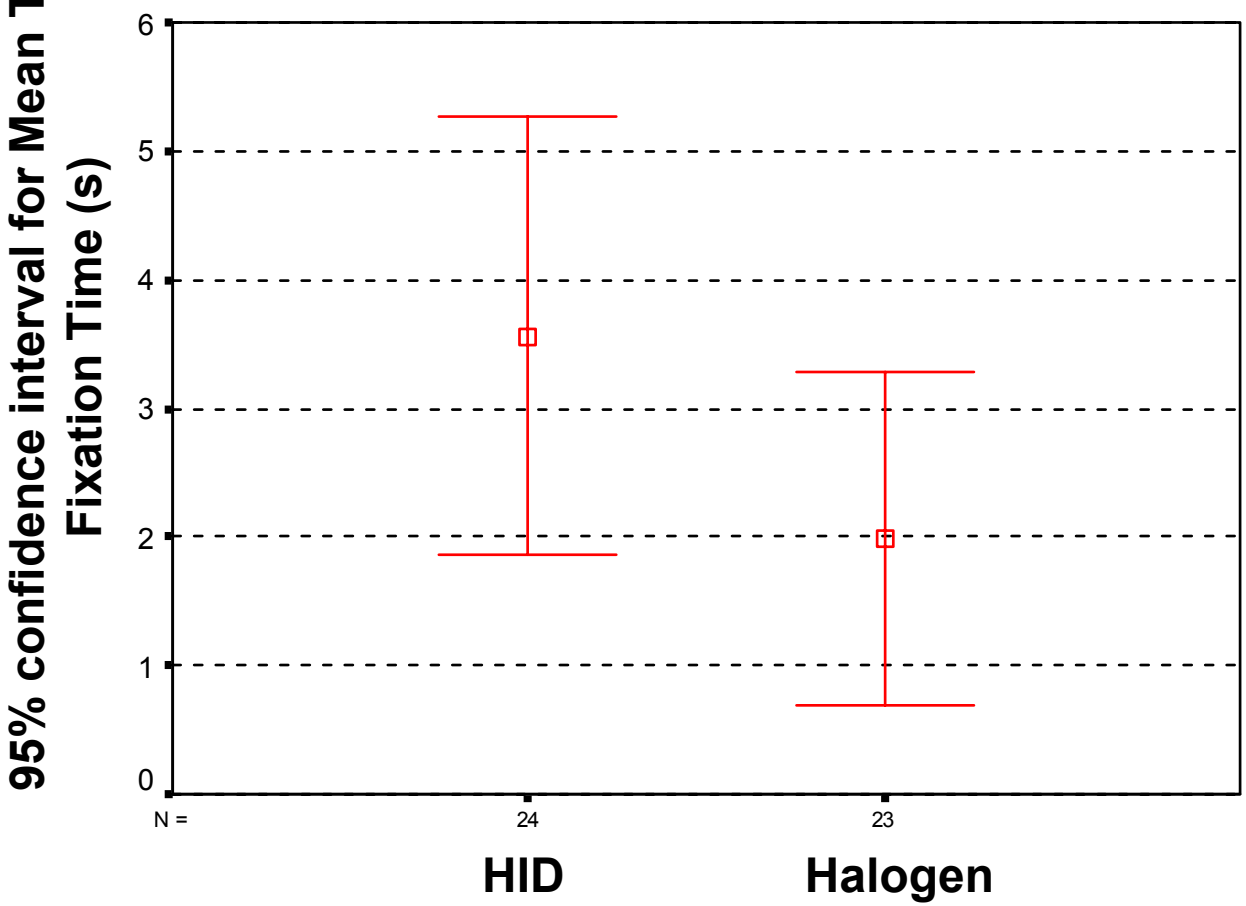
- HID Blue color: Novelty attracts attention
- HID Blue color: Eyes more sensitive
- Wider Beam Pattern: Drivers exposed to glare longer during meeting scenarios
- Sharper intensity gradients: More sensitive to misaim, flickering
- Smaller lamps: Brighter luminance

NHTSA Glare Research

at U of Iowa (completion: Summer, 2003)

1. **Obtain photometric and spectral distributions of a sample of HID and halogen low beams**
2. **Use computer model to compare glare and visibility for HID and halogen beam patterns in different meeting scenarios**
3. **Conduct on-road eye-fixation study to find out if drivers take longer and more frequent looks at blue headlights**

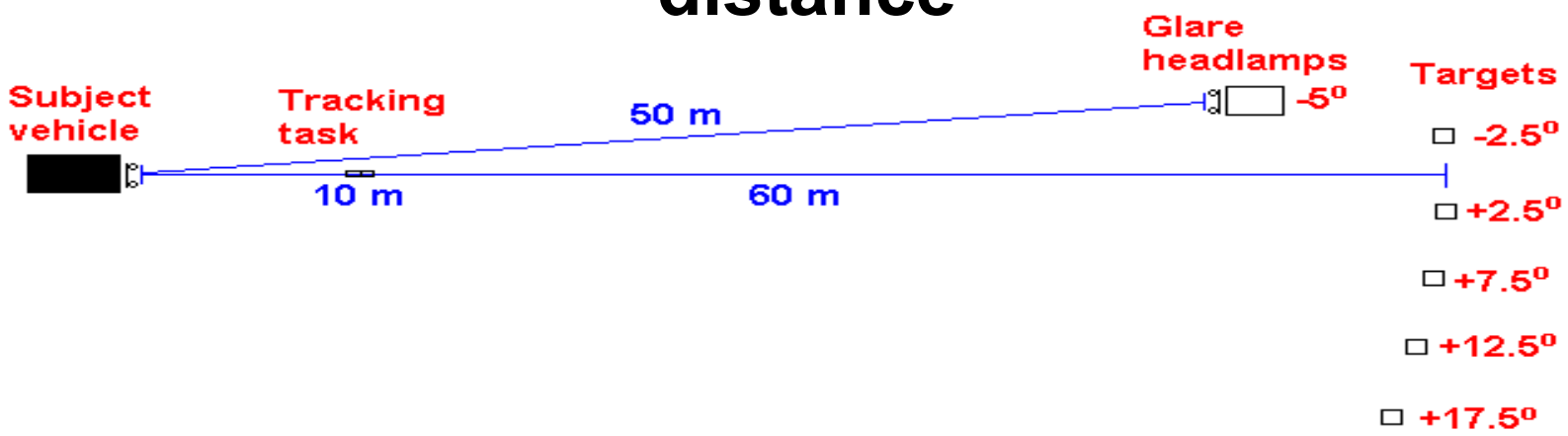
Preliminary Results of Eye Fixation Study



NHTSA Research

(at Rensselaer's Lighting Research Center,completion 6/2003)

Measure effects of spectral distribution, lamp size, and illuminance on glare and seeing distance



- Illuminance: 0.2, 1, 5 lx (500, 2500, 12500 cd)
- Spectrum: halogen, blue-filtered halogen, HID
- Size/luminance: 9 cm^2/1400000 cd/m^2, 26 cm^2/480000 cd/m^2, 77 cm^2/ 160000 cd/m^2

Preliminary Findings

	Disability Glare	Discomfort Glare
Illuminance	Significant	Significant
Spectrum	Not Significant	HID Significant
Size	Not Significant	Not significant But trend

Preliminary Conclusions: Intensity, Spectrum, Lamp Size

- **Current FMVSS method to photometer lamp intensity seems sufficient to predict disability glare for foveal and peripheral vision**
- **For discomfort glare,**
  - **illuminance has greatest effect**
    (implications for beam intensity and aiming)
  - **spectrum is much smaller effect**
    (HID more discomforting)
  - **size much less so**

NHTSA Research

(at Rensselaer's Lighting Research Center,completion 6/2003)

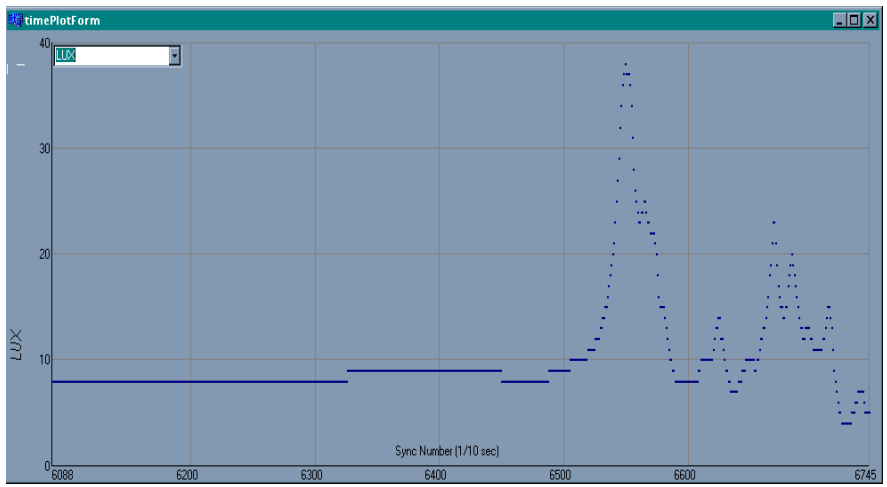
Evaluate feasibility of a glare limiting adaptive headlight system which reduces intensity as a function of ambient lighting

Objectives:

- **Investigate how low headlamp intensity could be reduced on lighted roads while maintaining drivers' visual performance**
- **Determine improvement in discomfort and disability glare**

Future Glare Research

- **Use photo-logging technique to study real world glare exposure and effects on driving behaviors (2003-04)**



Future Research (2003-04)

- Determine effect of duration & intensity of HID glare exposure on driver re-adaptation time
- Quantify the level of misaim of different headlamp designs; assess effect of lens dirt
- Further exploration of Adaptive Forward Lighting to determine whether it can increase visibility and reduce glare
- Evaluate safety implications of other new lighting technologies, e.g., LED headlights