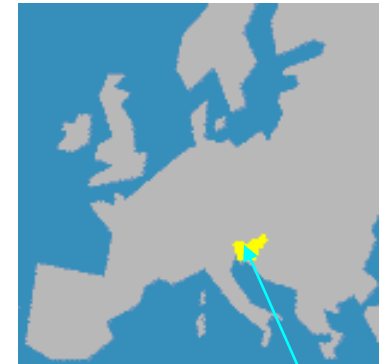


IJS-DP-11236



Ljubljana, SI

# Active LCD light filters - summary

Balder “Spin-off” of Jozef Stefan Institute

Authors:

Bernarda Urankar  
Dusan Ponikvar  
Silvano Mendizza  
Silvija Pirs  
Uros Rozina  
Erik Gomezel  
Matej Bazec  
and  
Bojan Marin  
Janez Pirs



# Balder's new-gen line of products ADC-Plus



Balder – “spin-off” of Jožef Stefan Institute (IJS),

Founded to transfer the LCD technology developed at IJS into the world market

Typical applications → **niche products** in the field of personal protection (PPE)





# Optical light shutters – very specialized niche products

## Typical applications:

- personal protection applications
- stereovision
- optical elements

## Very special requirements $\Rightarrow$ leading away from typical laptop PC or TV solutions:

- **superior optical performances:**
  - very high ( $\geq 100.000$ ) and angularly independent light attenuation
  - symmetry around the normal to the LCD plane
  - low optical distortion
  - very low light scattering
- **electrically variable light attenuation**
- **very high switching speeds**



# Balder's competitive advantages

- Balder's products – first class
- DIN Plus 1/1/1/1
- Reasonably lower sales prices than the “top competitor – 3M”
- “New Generation” product developed:
  - Essential improvement of electronics
  - Angular compensation of the light attenuation
- The only products on the World market that comply with the Intl. Standard EN379 for maximum optical performance CE 1/1/1/1

# CERTIFICATE

Registration number / Reference mark P3115BL/R0

The company

**BALDER d.o.o.**  
**Optoelectronic elements and  
measuring systems**

Teslova ulica 30  
1000 LJUBLJANA  
SLOVENIA

Applicant's code BL

hereby receives the confirmation that the product/s

**automatic welding filters with variable shade**

of the type

**Grand DS ADCplus, Grand ES ADCplus**

conforms to

**DIN EN 379:2009-07**

**Certification Scheme Eye Protection: Category II-Products acc. to PPE-Directive (Edition:  
2010-07)**

and is granted the licence to use the mark



This Certificate is valid until 2015-07-13.

Test report(s): 11311-PZA, 11312-PZ, 11310

Identification: 4/9-13 B 1/1/1/1/379 DIN

See annex for further information.

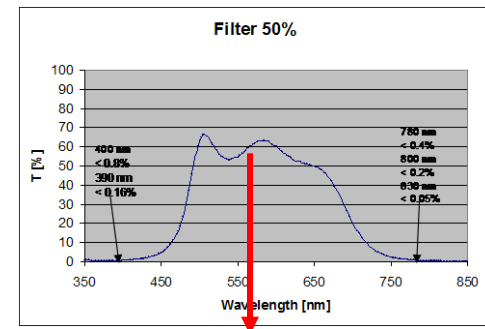
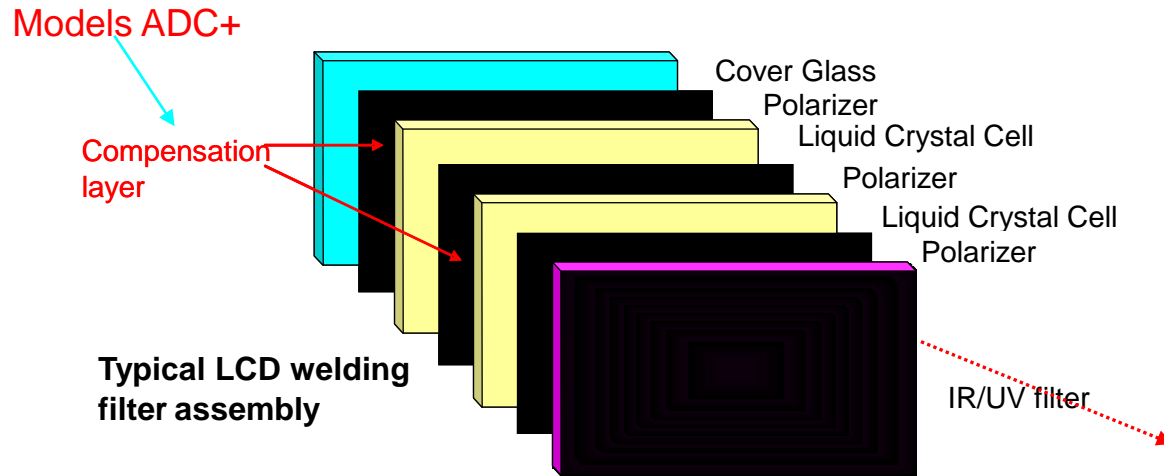
DIN CERTCO Gesellschaft für  
Konformitätsbewertung mbH  
Alboinstraße 56, 12103 Berlin



2010-07-14 *U. Fallscheer*  
Dipl.-Ing. Ute Fallscheer

# Balder's ADC filter - basic concept

Multilayer structure:



**COLORS!**

# Perspectives

**Multilayer ADF structure comprising 2 LCD light shutters and IR/ UV filter is known for more than 20 years**

**No important innovation has been made by now** except that basic materials have improved a lot → affecting switching speed, power consumption, life time and overall ADF appearance

**Balder has a strong scientific and technological back-up of IJS:**

- Computer modeling – new LCD light shutter concept development
- LC alignment and functional surface analyses
- LCD light shutter prototyping
- World – wide contacts with world centers of LCD research and technology development

**Balder is the first to introduce a major innovation (8 patents):**

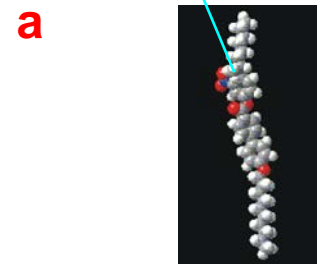
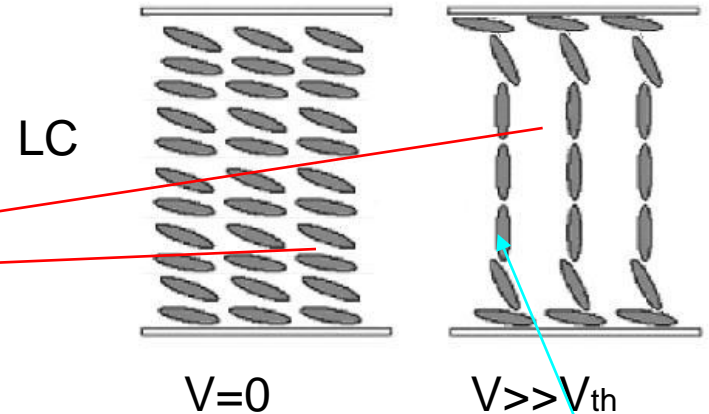
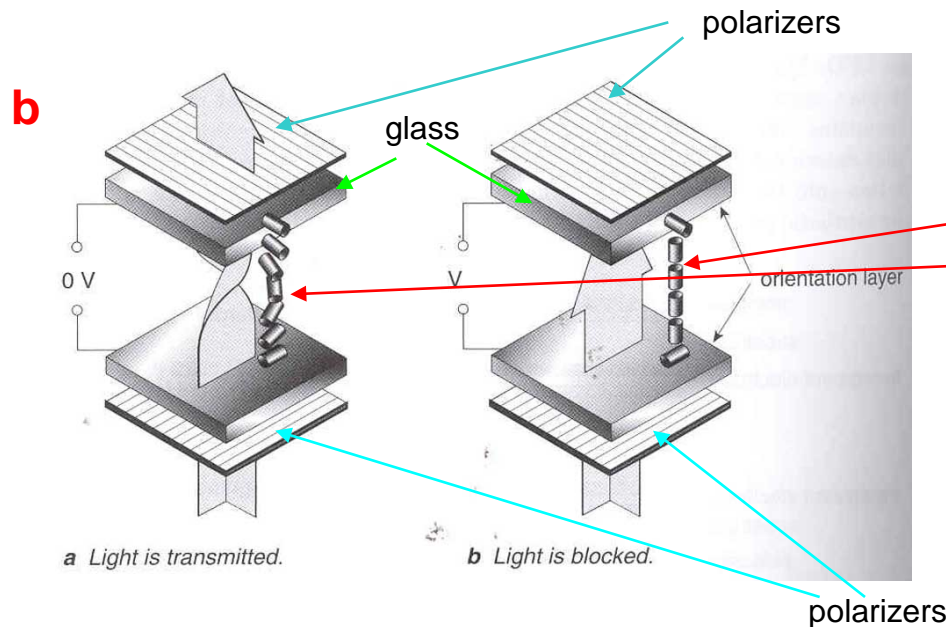
- Angular compensation of light attenuation (in the phase of transfer to regular production: **ADC+ models**)
- Increased (3 times) light sensitivity (in production)
- Reduced power consumption:
  - DC balanced low frequency driving for single shade products (in production)
  - DC balanced low frequency driving for variable shade products – still in development

# Basic concepts of LCD light shutter operation

Operation based on electrically controlled birefringent properties of LC

Standard TN LCD (90°-twist) concept

Electrically controlled birefringence



Typical LC molecule - rod

**c** Balder's new-gen product ADC concept → highly twisted light shutter - 230° twist of LC molecules

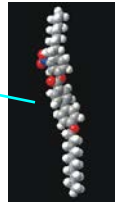
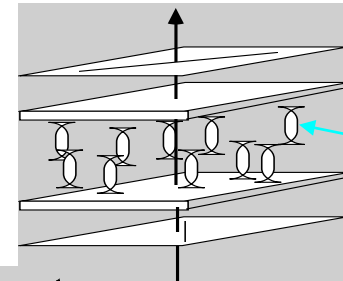


# Details: Angular dependence – main considerations

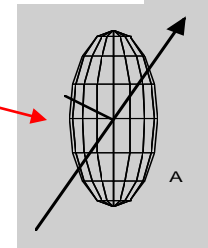
## Origin of the angular dependence: of the LCD ADF:

- Positive birefringence of LC molecules ( $n_e - n_o > 0$ )
- Symmetry of the LC molecular orientation in a particular LCD light shutter technology

LC- cell



Typical LC molecule - rod



LC-cell birefringence

## Solutions:

- Additional layer of negative birefringent material (oppositely deformed polymer macromolecules – squashed balls)



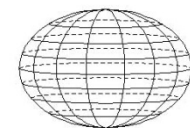
## Optical birefringence of LC and polymer layer compensate each other

- Use of LC structure with higher symmetry than conventional TN LCD  $\Rightarrow$  HTLS

Polymer macromolecule



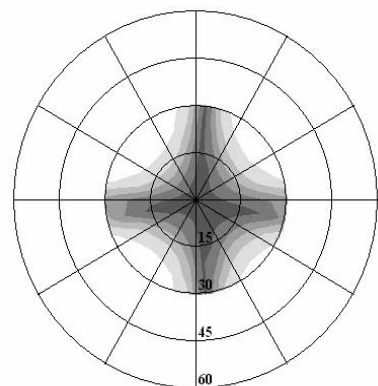
deformed



Stress inducing polymerization

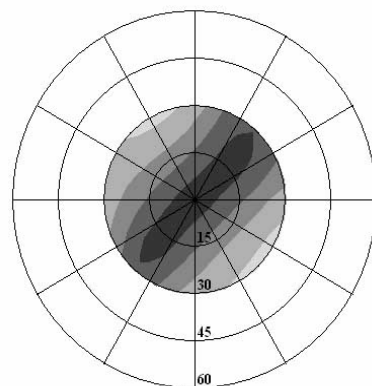


# Balder's ADC+ - Comparison with other LCD concepts (i.e. TN LCD) - Single shade products:



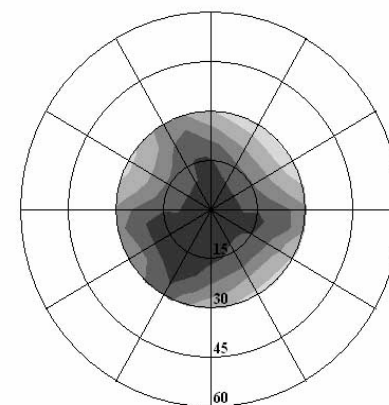
1200 1600 2000 2200 2300

a) Standard TN LCD



1200 1600 2000 2200 2300

b) Compensated TN LCD



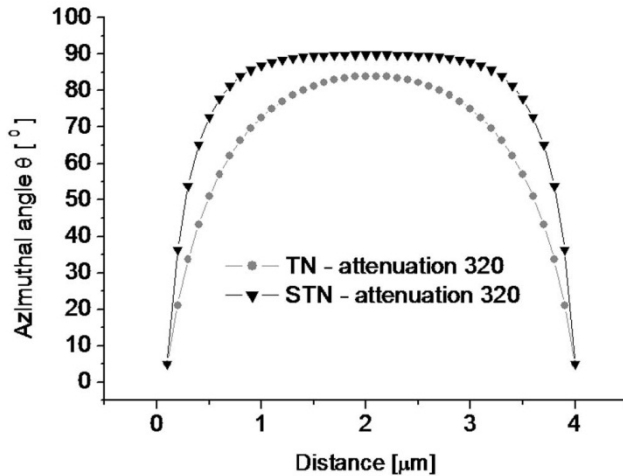
1200 1600 2000 2200 2300

c) Compensated HTLS  
Balder's ADC+ new gen products

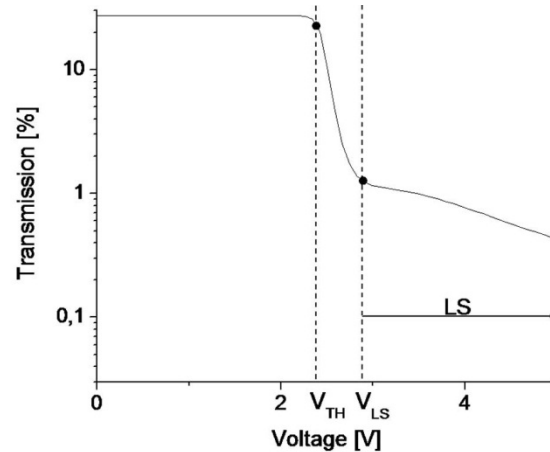
Computer modeling of the light attenuation for a fixed shade 11 single LC-cell autodarkening filter for different LCD light shutter concepts

# Basic advantages of super-twisted LC structures

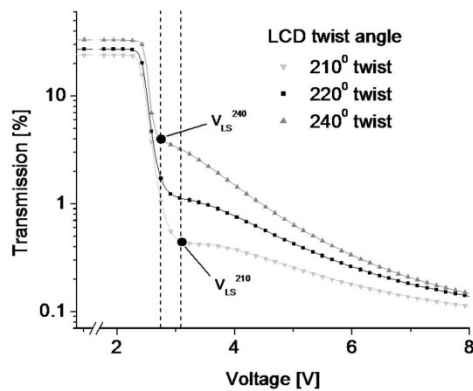
Better homeotropic alignment:



Dual slope T/U characteristics:



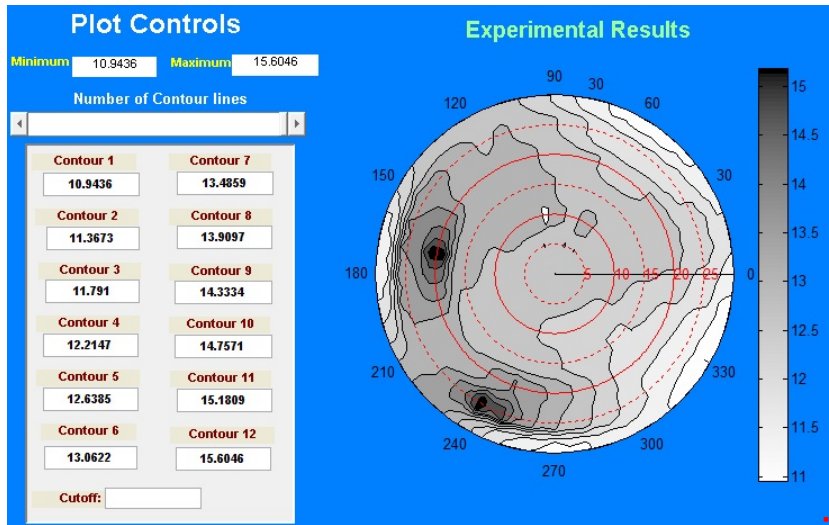
Adjustment of the T/U characteristics by LC-twist



**Optimization of LC structure to:**

- battery driven ADF control electronics
- Simple, cheap negative birefringent c-plate compensation layers

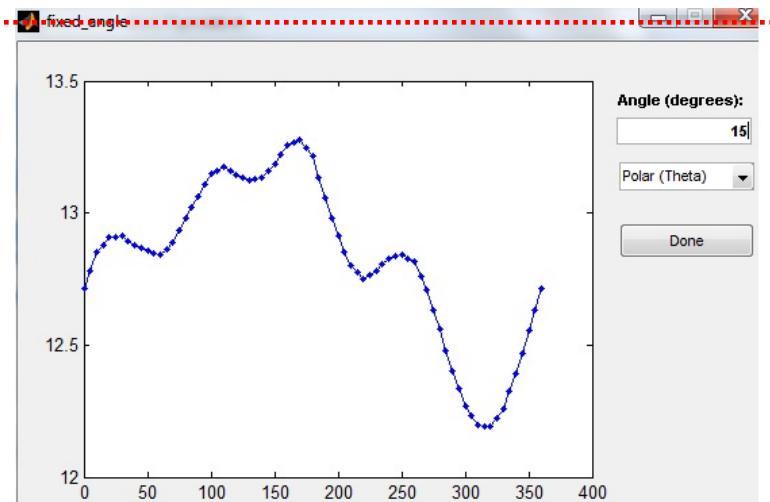
# “Class 1” solution ↔ ADC-Plus



Light attenuation (shade 13) at the limiting angle 15° (EN 379 – Standard)

Shade 13 light attenuation –  $\Theta/\Phi$  representation

Class 1 limit



# Industrial property

**New-gen ADC+ products - covered by 7 patents; the overall Balder's intellectual property is as follows (9 patents +10 limited licenses):**

1. "High contrast, wide-viewing angle LCD light filter" EP 1883854 B1; US 8,026,998 B2 (Free, unlimited, non-transferable license from Jozef Stefan Institute)
2. Continuation in part US patent application US 2012/0002121 (Free, unlimited, non-transferable license from Jozef Stefan Institute)
3. "High Contrast, Wide Viewing Angle LCD Light-Switching Element" EP 1625445, US 7,420,631 (Free, unlimited, non transferable license from Jozef Stefan Institute)
4. "Driving scheme and electronic circuitry for the LCD electrooptical switching elements" EP 1131669; US 7,061,462 B1,
5. "Process for manufacturing of the polymer compensation layer for LCD optical light shutter and the construction thereof", EP 1192499; DE 600 27 565.5-08; GB ; US 7,132,133 B1 (Free, unlimited, non-transferable license from Jozef Stefan Institute)
6. "Glare Shielding Device and Process for Operating the Same": US 5,315,099 and EP 0 550 384; (Free, unlimited, non-transferable license)
7. "~Use of Microprocessor in ADFs": US 6,881,939 (Free, unlimited, non-transferable license)
8. "~Use of switching power supply, solar cell and delay function in ADFs" US 5,751,258
9. (Free, unlimited, non-transferable license)
10. "~Increased sensitivity for ADF" – patent application in preparation
11. "~ Use of Surface mode technology in LCD light shutters other than ADFs" (Free, limited, non-transferable license - e.g. medical applications
12. US 6,815,652, US 6,855,922, US 7,005,624, US 6,841,772, US 7,180,047, US2007145234 and US 7,026,593 US 7,446,292 US 6,884,987 (Free, limited, non-transferable license

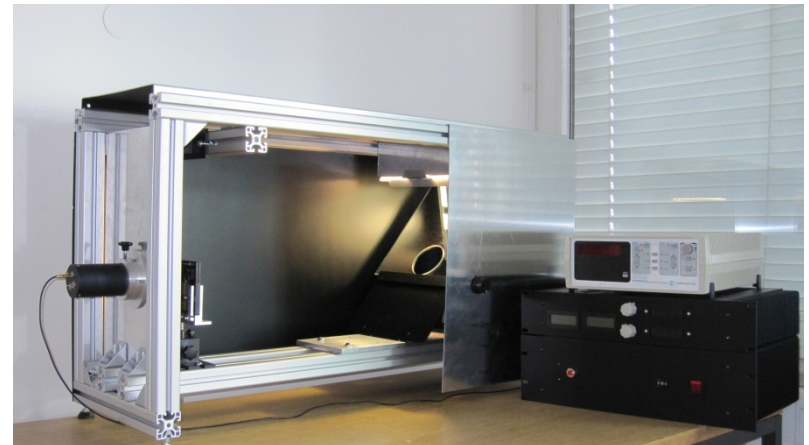
# International standard Organization ISO

On the grounds of Balder's /IJS's research/business results the International Standard Organization (ISO) invited Balder and IJS to participate in the "expert group" ISO/TC94/SC6/WG2 and WG4 preparing **new World Standard for Eye Protection.**

In particular Balder and IJS contributed:

- Test for angular dependence
- Test for light sensitivity of the light detection electronics of the ADF
- New ISO standard Xe-plasma light source simulating welding light

To be published in J. Appl. Optics and as an Internal publication of German TÜV



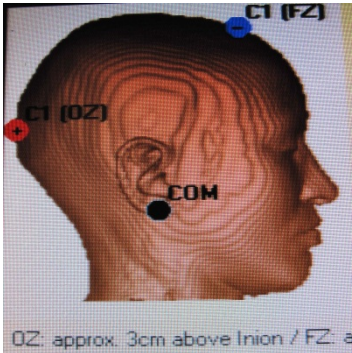
# Medical evaluation of the eye hazard with ADFs

- Fast changes of the light intensity → considerate stress for human eye
- Present Safety Standards → predominantly focused on permanent eye damage (lasers,..)
- Specific temporary hazards like temporary blindness, reduced color/pattern recognition, eye fatigue,.... are **not adequately specified yet**
- New ISO Standard “**welding light source**” offers ideal experimental conditions for medical studies of these phenomena, as it can be used **under clinical conditions**
- Medical equipment for this kind of studies → typically based on measurements of electrical potentials of the “eye nerve”:
  - VEP; electrodes mounted above the visual center in the cortex
  - ERG; electrodes directly on the eye surface

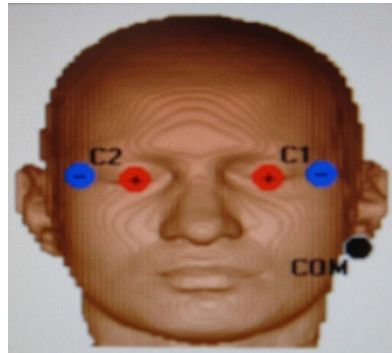


# Medical evaluation - continue

Typical electrode positioning:



VEP

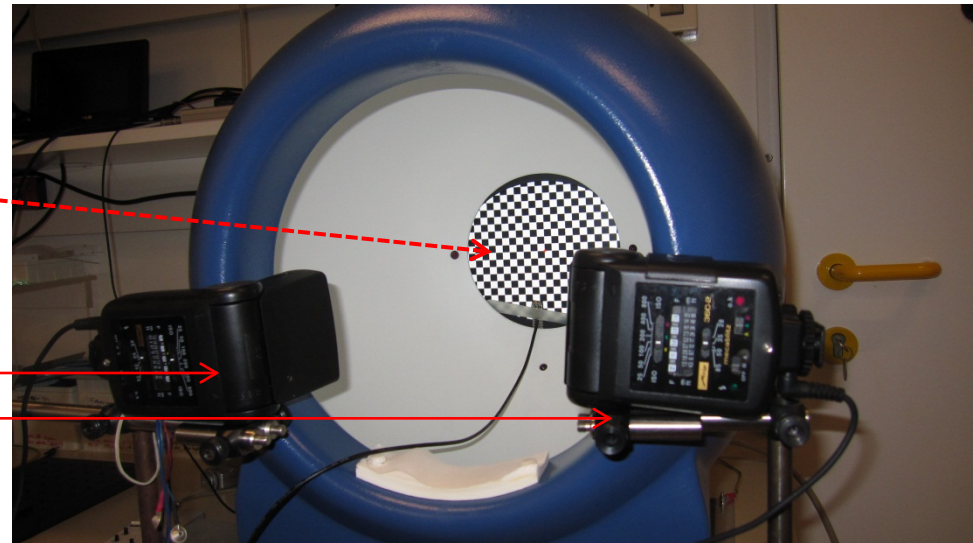


ERG

Changing light pattern resulting in Eye-nerve response (VEP, ERG)

Photographic flash for "blinding" the eye

Tomey EH 1000:  
To measure also transient phenomena

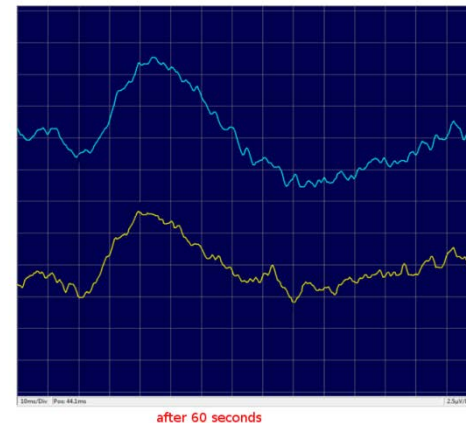
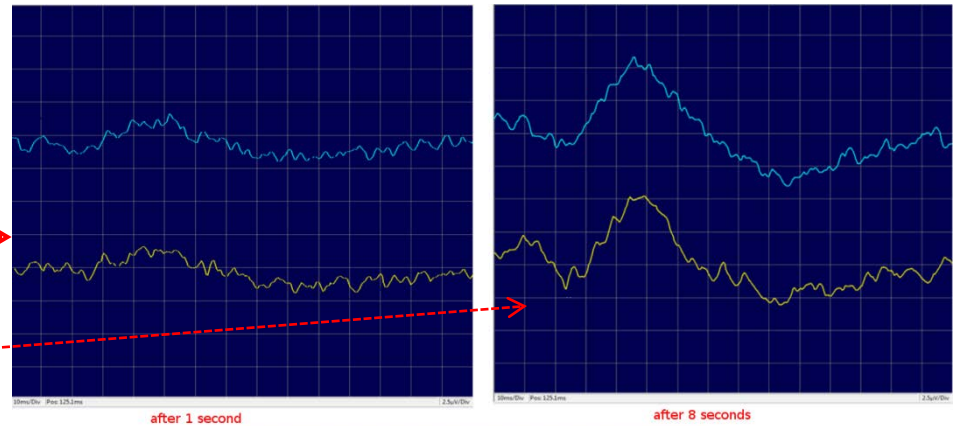




# Medical evaluation - continue

ERG signal for the left and for the right eye:

- 1s after exposure to the light flash
- 8s after exposure to the light flash
- 60s after exposure to the light flash



⇓  
Temporary blindness can be studied

# APPENDIX

# Scenes from Balder's production



**Laminate assembling**

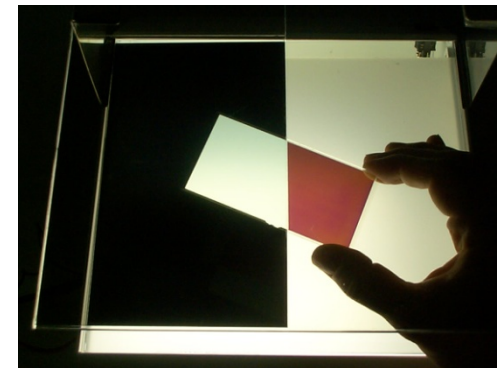


**Polarizer lamination**



**UV/IR filters**

**LCD inspection**

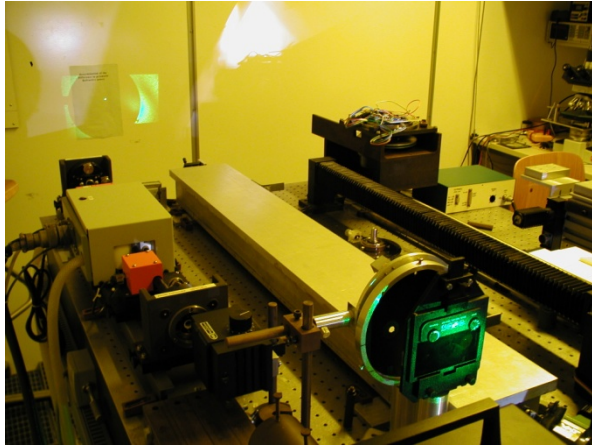




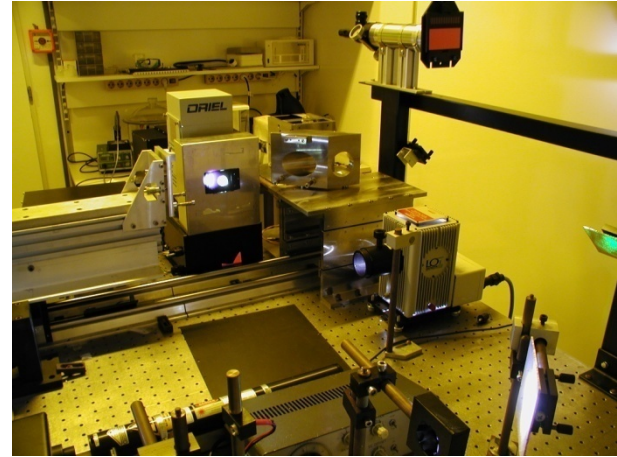
LCD lab – general view  
Balder PPR 2011



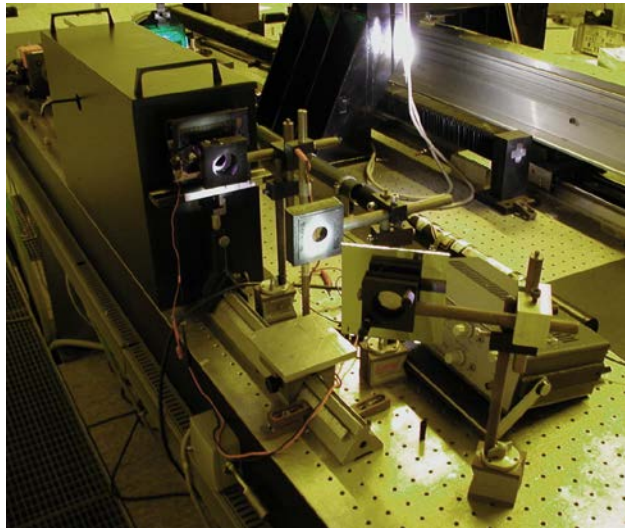
# Test equipment according to EN 167, EN 168 and EN 379



Prismatic refraction power



Spherical and prismatic refraction power



Light scattering (diffusion)



Spectrophotometer