

IJS-DP-11222



Ljubljana, SI

Large area LCD light shutters for personal protection Balder Ltd

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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 (≥ 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-10, 11312-PZ-10

Identification: 4/9-13 B 11/1/1/1/379 DIN

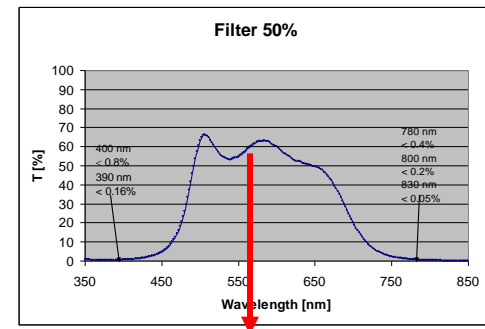
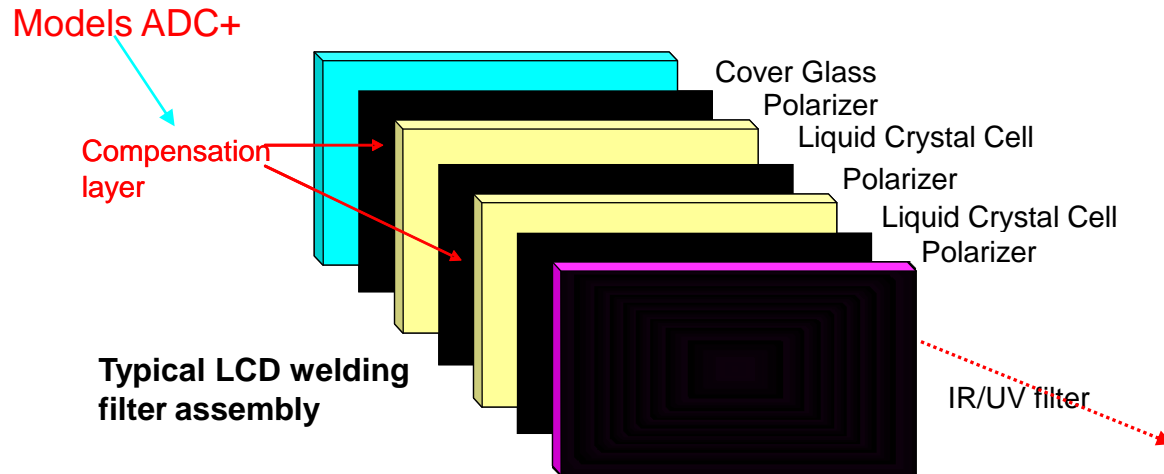
See annex for further information.
DIN CERTCO Gesellschaft für
Konformitätsbewertung mbH
Alboinstraße 56, 12103 Berlin



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):

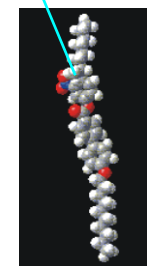
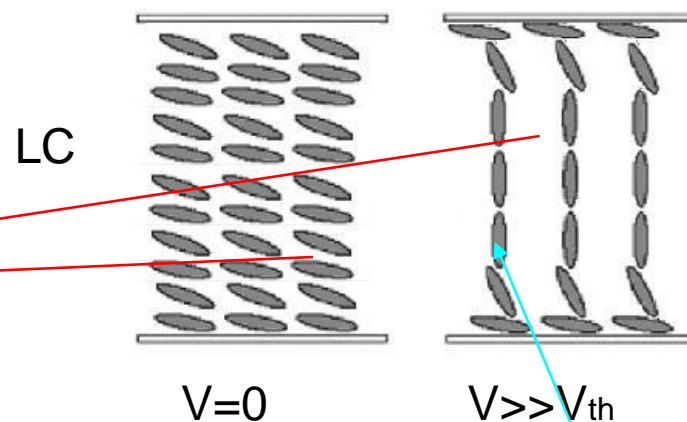
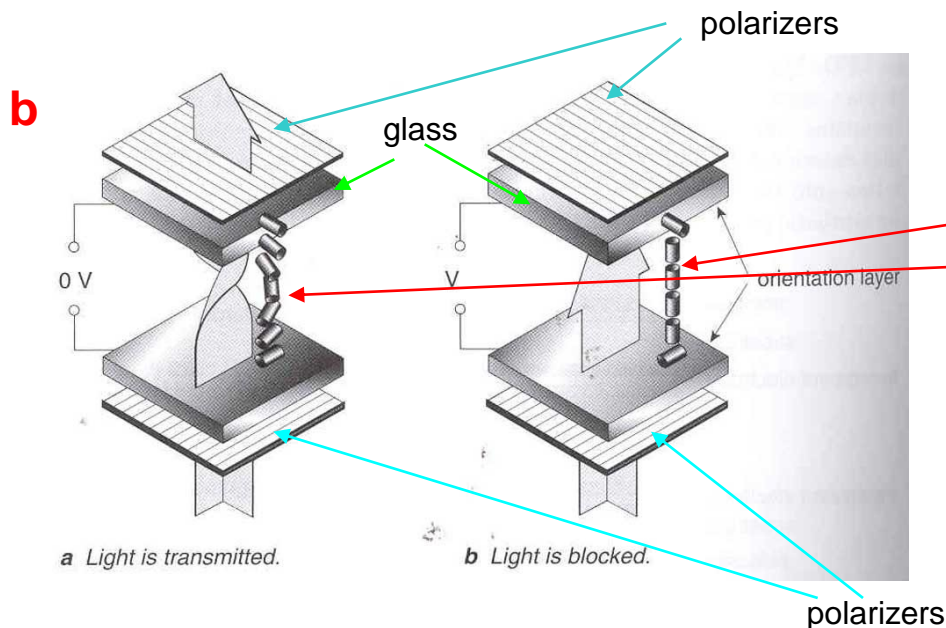
- Angular compensation of light attenuation (in the phase of transfer to regular production: **ADC+ models**)
- Increased (3 times) light sensitivity (in production)
- Reduced power consumption:
 - DC balanced low frequency driving for single shade products (in production)
 - DC balanced low frequency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

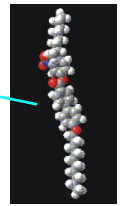
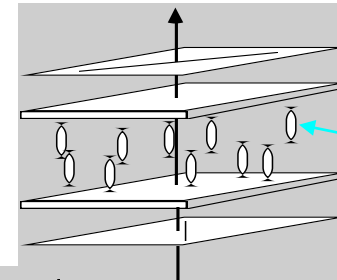
c Balder's new-gen product ADC concept → highly twisted light shutter - 230° twist of LC molecules

Details: Angular dependence – main considerations

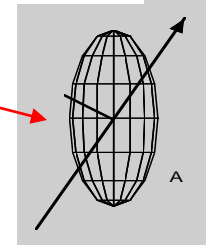
Origin of the angular dependence: of the LCD ADF:

- 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)



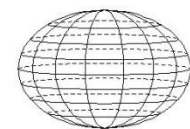
Optical birefringence of LC and polymer layer compensate each other

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

Polymer macromolecule

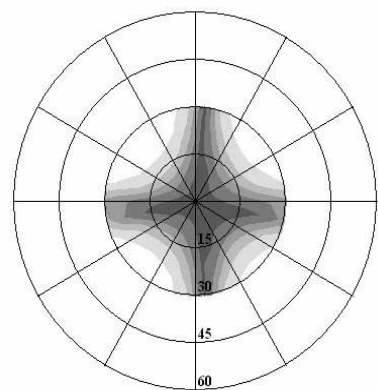


deformed



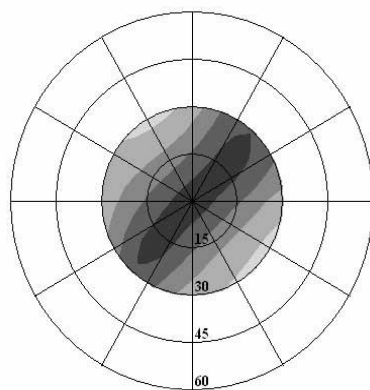
Stress inducing polymerization

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



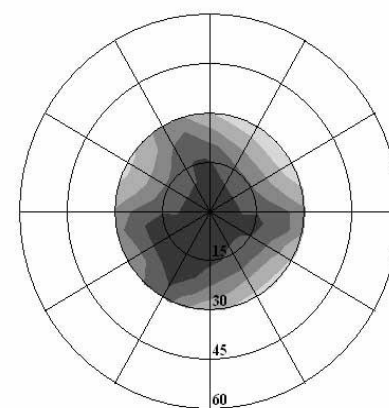
1200 1600 2000 2200 2300

a) Standard TN LCD



1200 1600 2000 2200 2300

b) Compensated TN LCD



1200 1600 2000 2200 2300

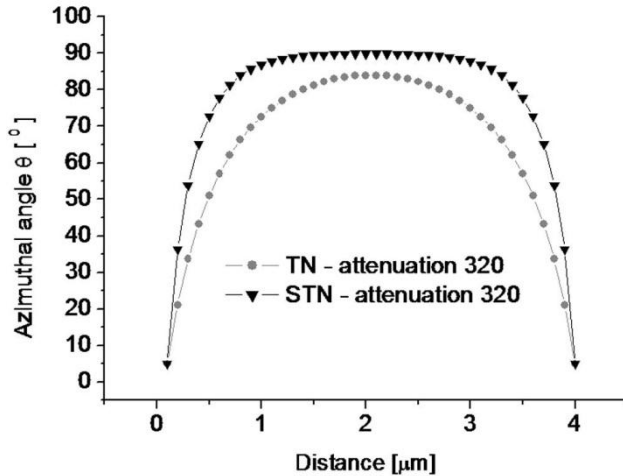
c) Compensated HTLS

Balder's ADC+ new gen products

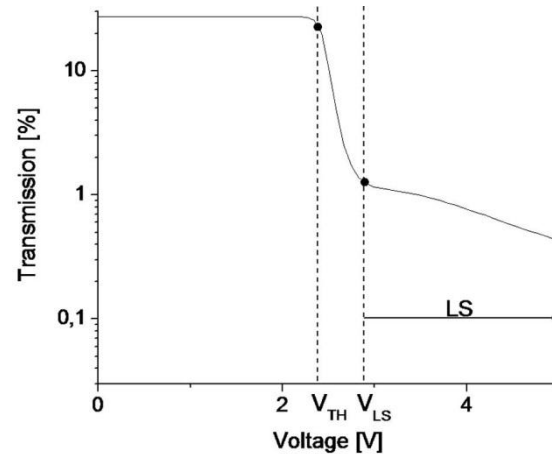
Computer modeling of the light attenuation for a fixed shade 11 single LC-cell autodarkening filter for different LCD light shutter concepts

Basic advantages of super-twisted LC structures

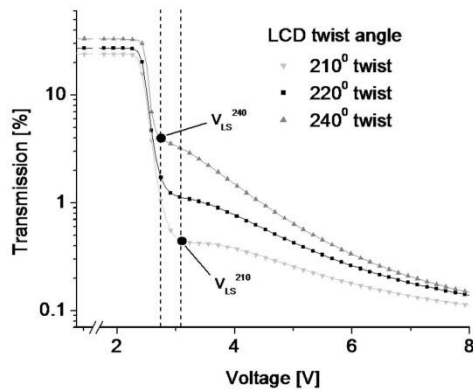
Better homeotropic alignment:



Dual slope T/U characteristics:



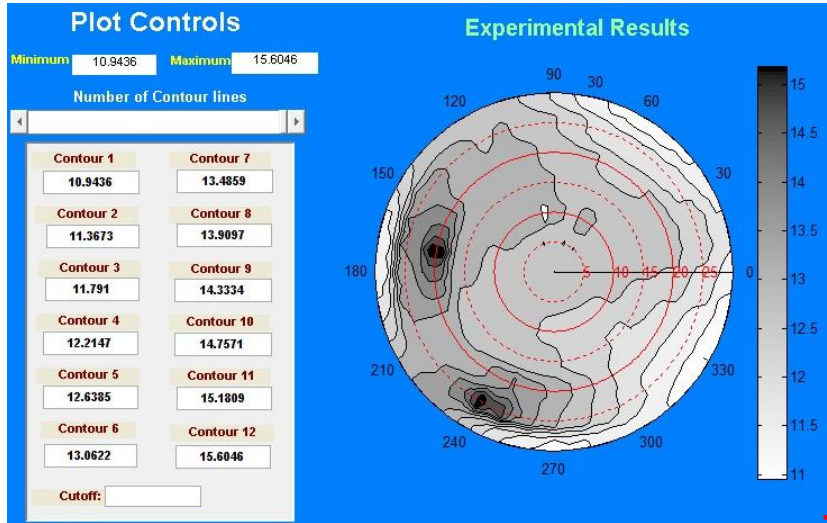
Adjustment of the T/U characteristics by LC-twist



Optimization of LC structure to:

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

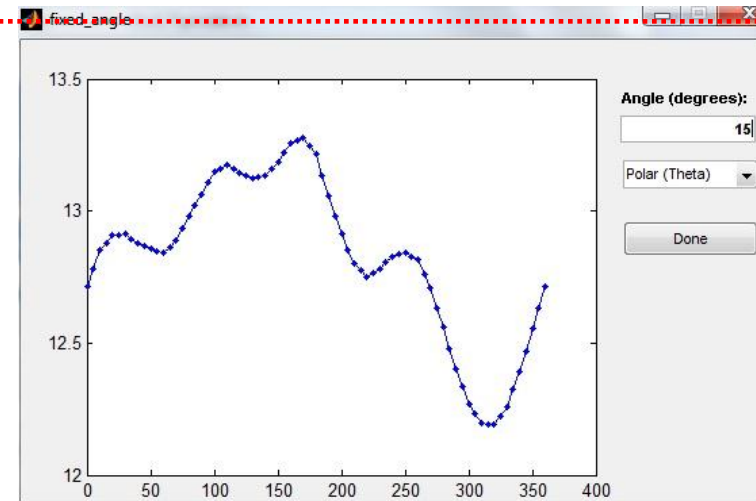
“Class 1” solution ↔ ADC-Plus



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

Shade 13 light attenuation – Θ/Φ 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)

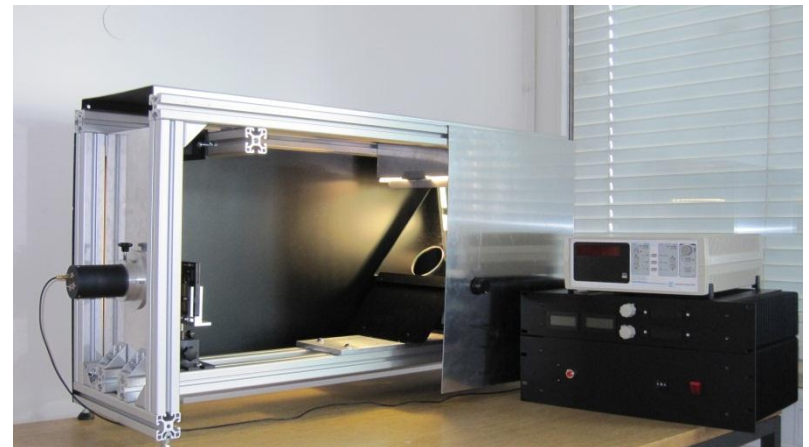
International standard Organization ISO

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

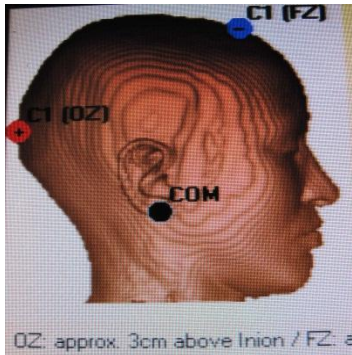


Medical evaluation of the eye hazard with ADFs

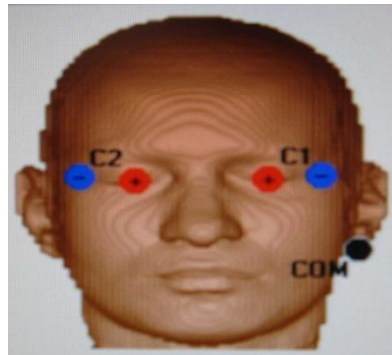
- Fast changes of the light intensity → considerate stress for human eye
- Present Safety Standards → predominantly focused on permanent eye damage (lasers,..)
- Specific temporary hazards like temporary blindness, reduced color/pattern recognition, eye fatigue,.... are **not adequately specified yet**
- 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

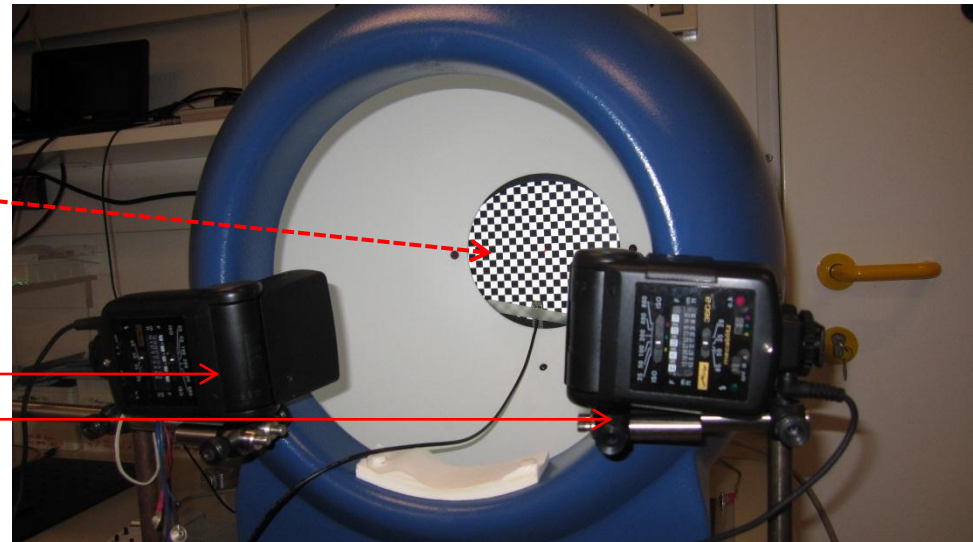


ERG

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

Photographic flash for "blinding" the eye

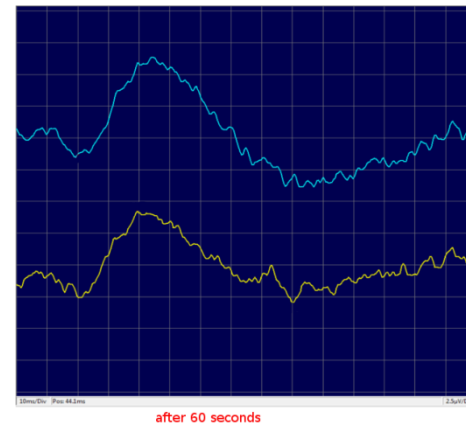
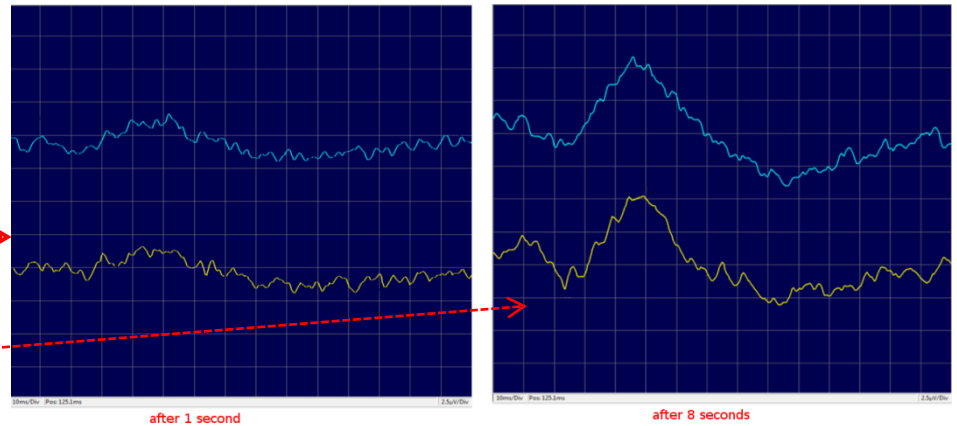
Tomey EH 1000:
To measure also transient phenomena



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

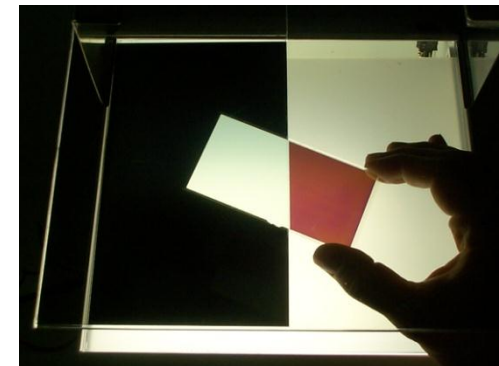


Polarizer lamination



UV/IR filters

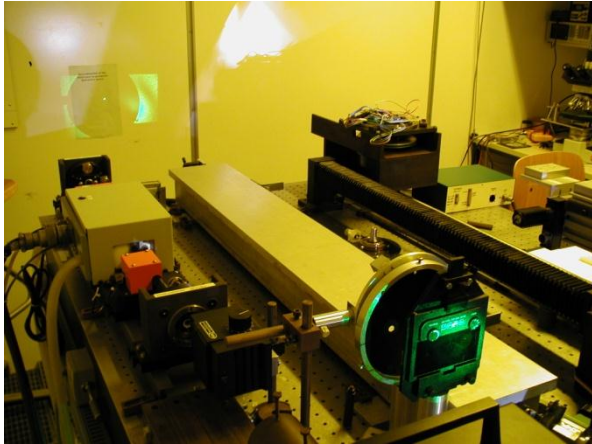
LCD inspection



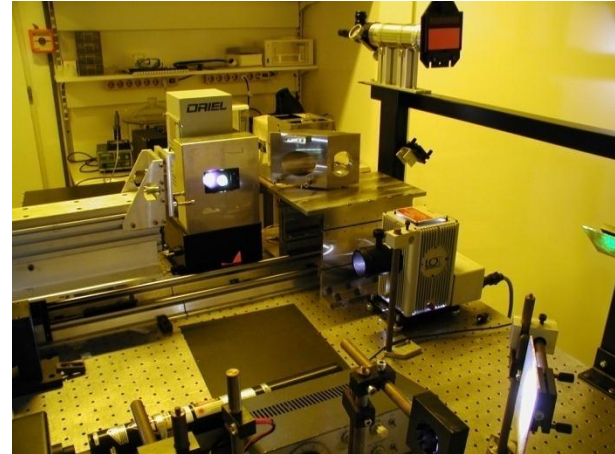


LCD lab – general view
Balder PPR 2011

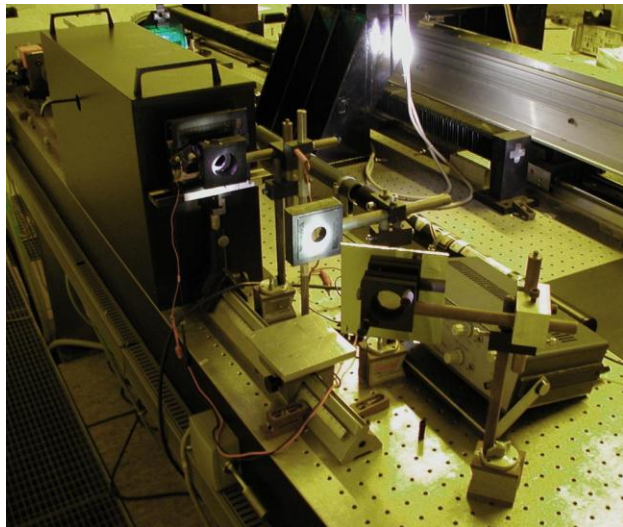
Test equipment according to EN 167, EN 168 and EN 379



Prismatic refraction power



Spherical and prismatic refraction power



Light scattering (diffusion)



Spectrophotometer