Meeting of NMI Directors and
Member States Representatives

BIPM, 23rd October 2013

The measurement of appearance

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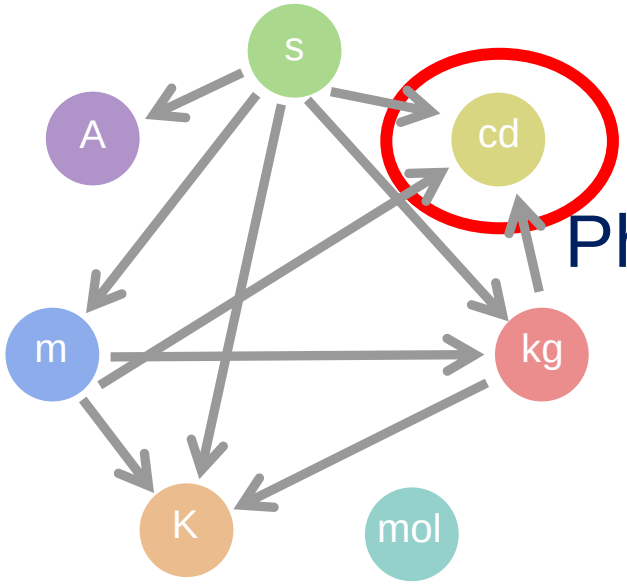
Laboratoire commun de métrologie LNE-CNAM

Introduction



Photometry

Div 1, Div2

Measurement of appearance

- SI Brochure, Annexe 3
- Workshop on Physiological Quantities and SI Units (BIPM, 16-17 November 2009)

Measurement of appearance

What is appearance?

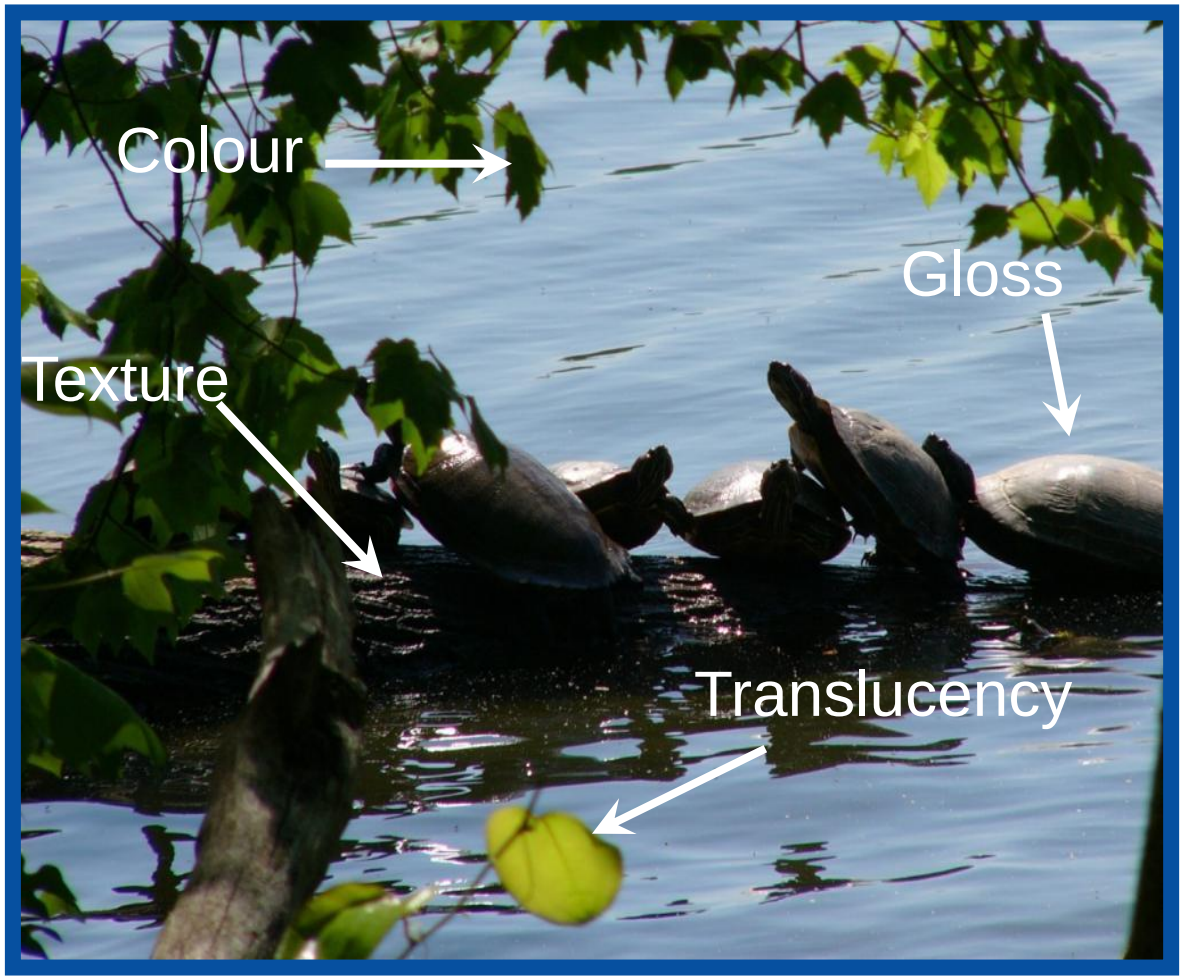
Definition

« Aspect of the visual experience by which the things are recognized »

What is appearance?

What is appearance?

Attributes of the visual appearance



Attributes of the visual appearance

- Enrich our perception of the world
- Are involved in the esthetic and the choice of an object

→ It is essential to control these attributes in the industrial world

Food industry

Cosmetics

Fashion and textile

Packaging

Architecture real and virtual

Automotive

Attributes of visual appearance

- Enrich our perception of the world
- Are involved in the esthetic and the choice of an object

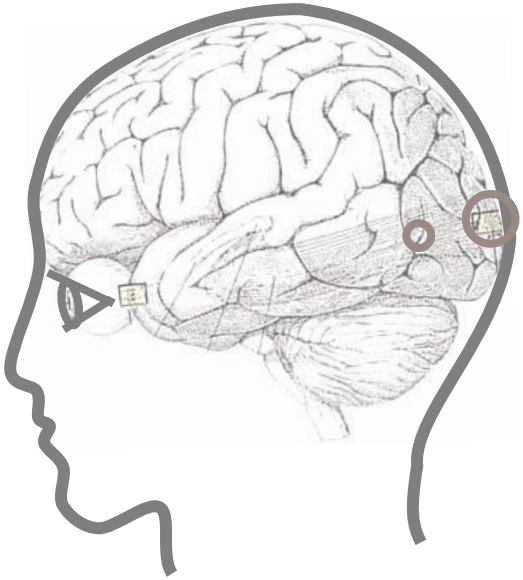
↳ It is essential to control these attributes

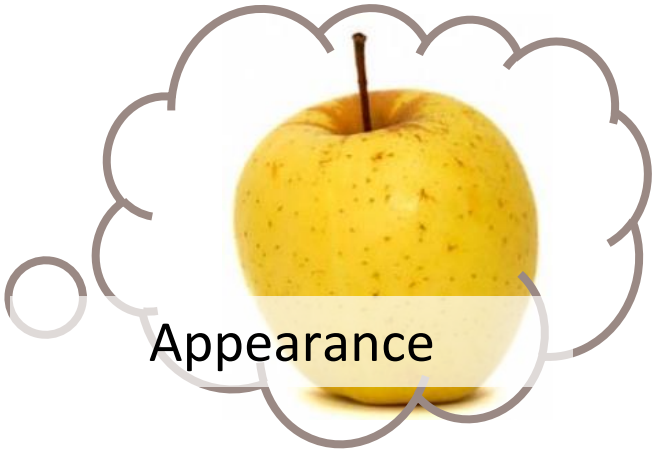
↳ Development of a metrology of appearance to provide references and methods

The measurement of appearance

Measurand

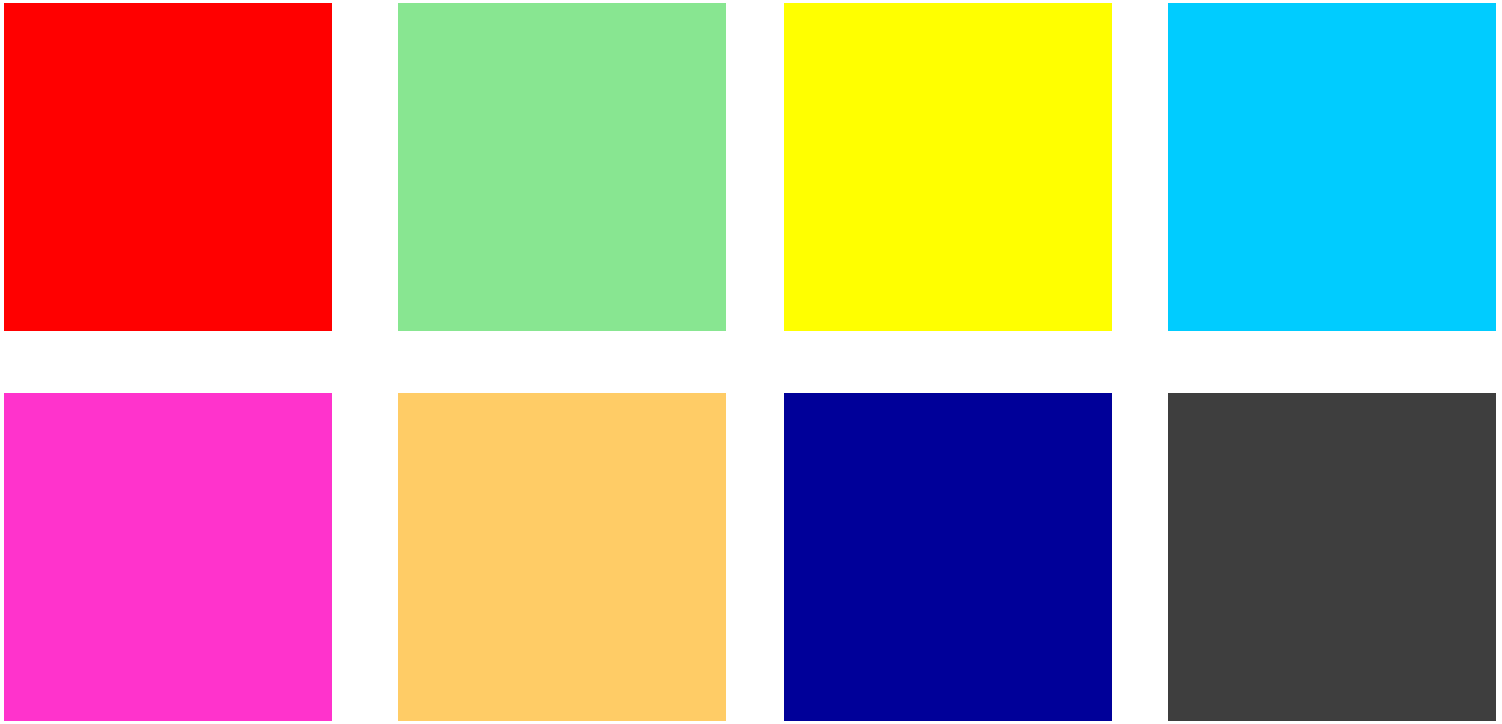
Physical Stimulus



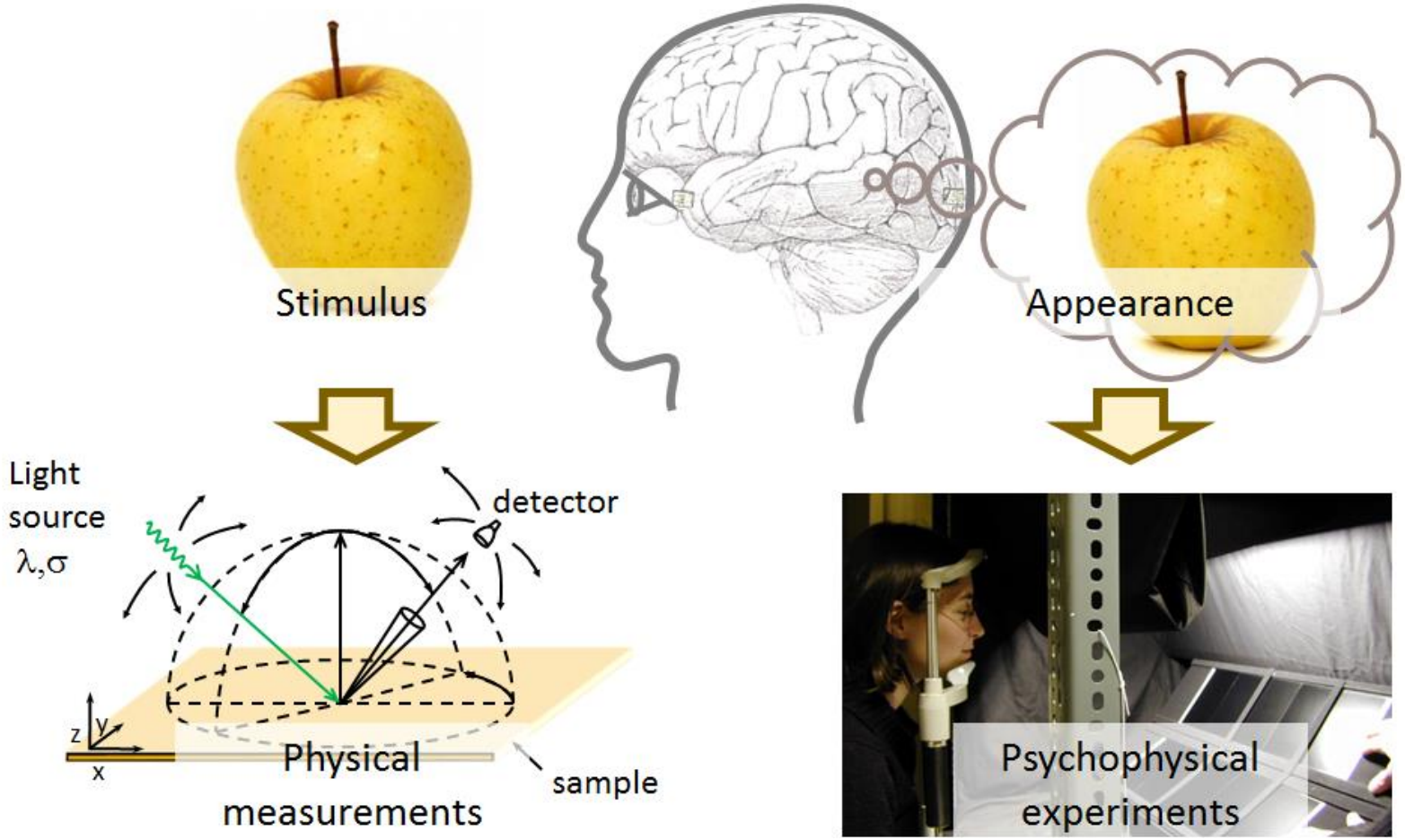


Appearance

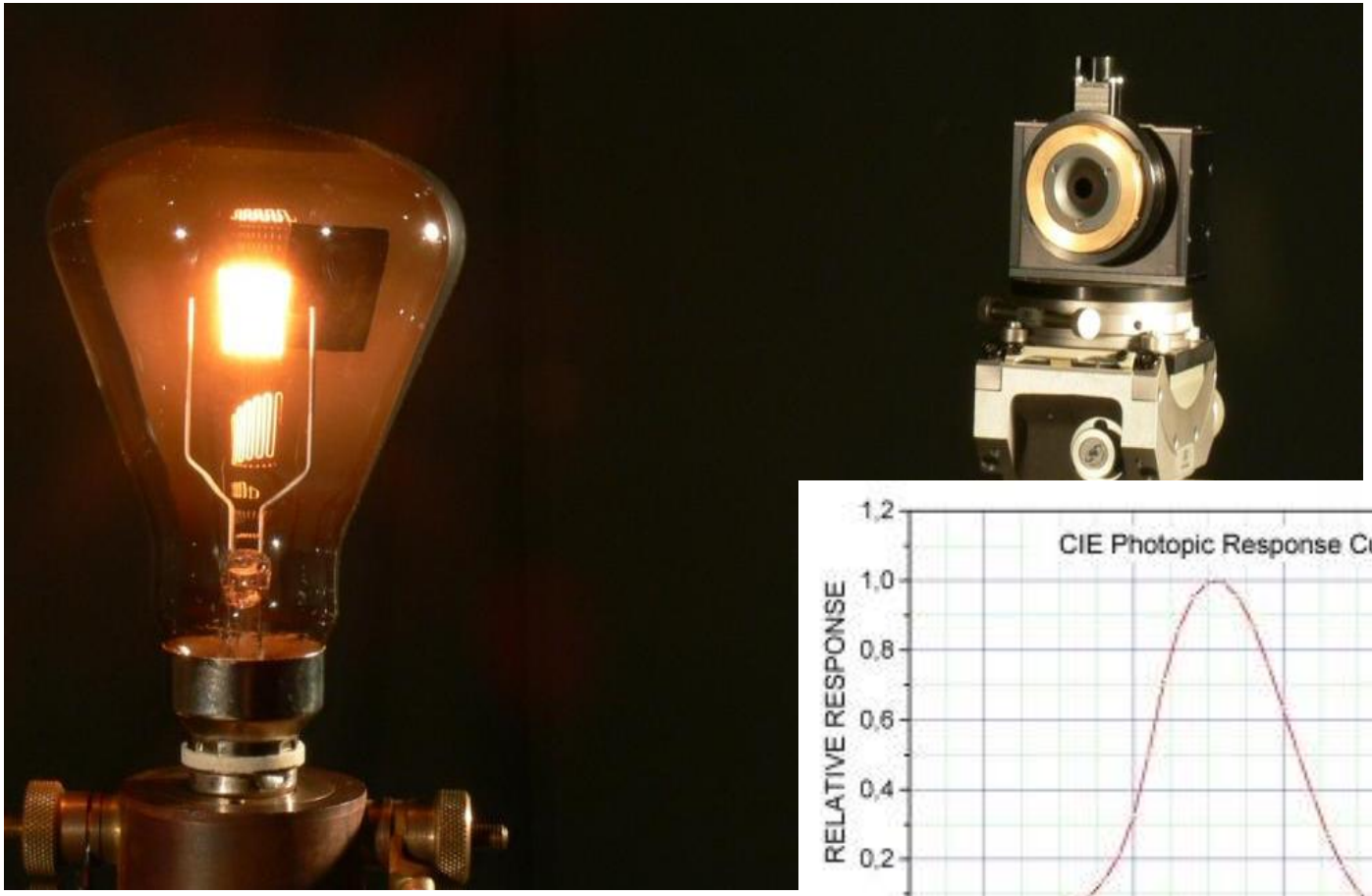
Measurand



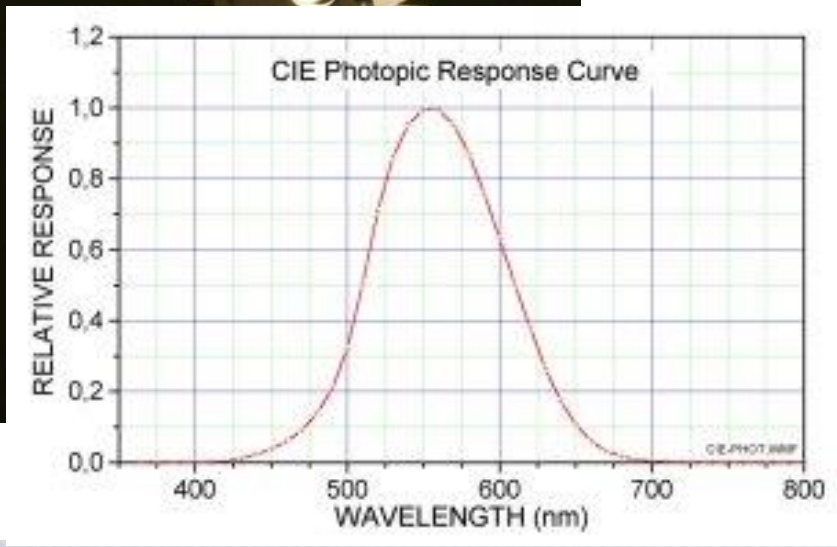
Method


Stimulus
Appearance
Light source λ,σ
detector
z
y
x
Physical measurements
sample
Psychophysical experiments

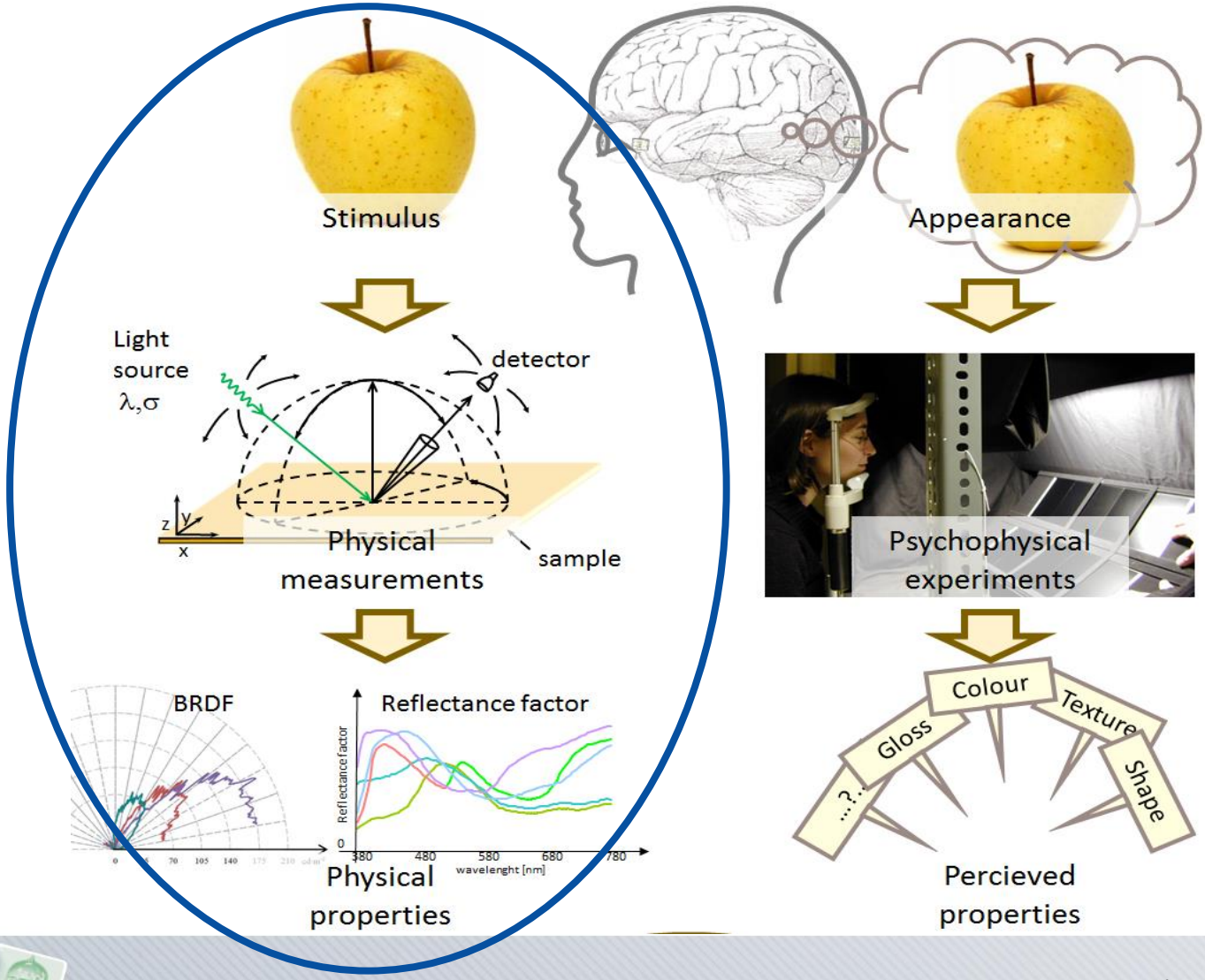
The candela



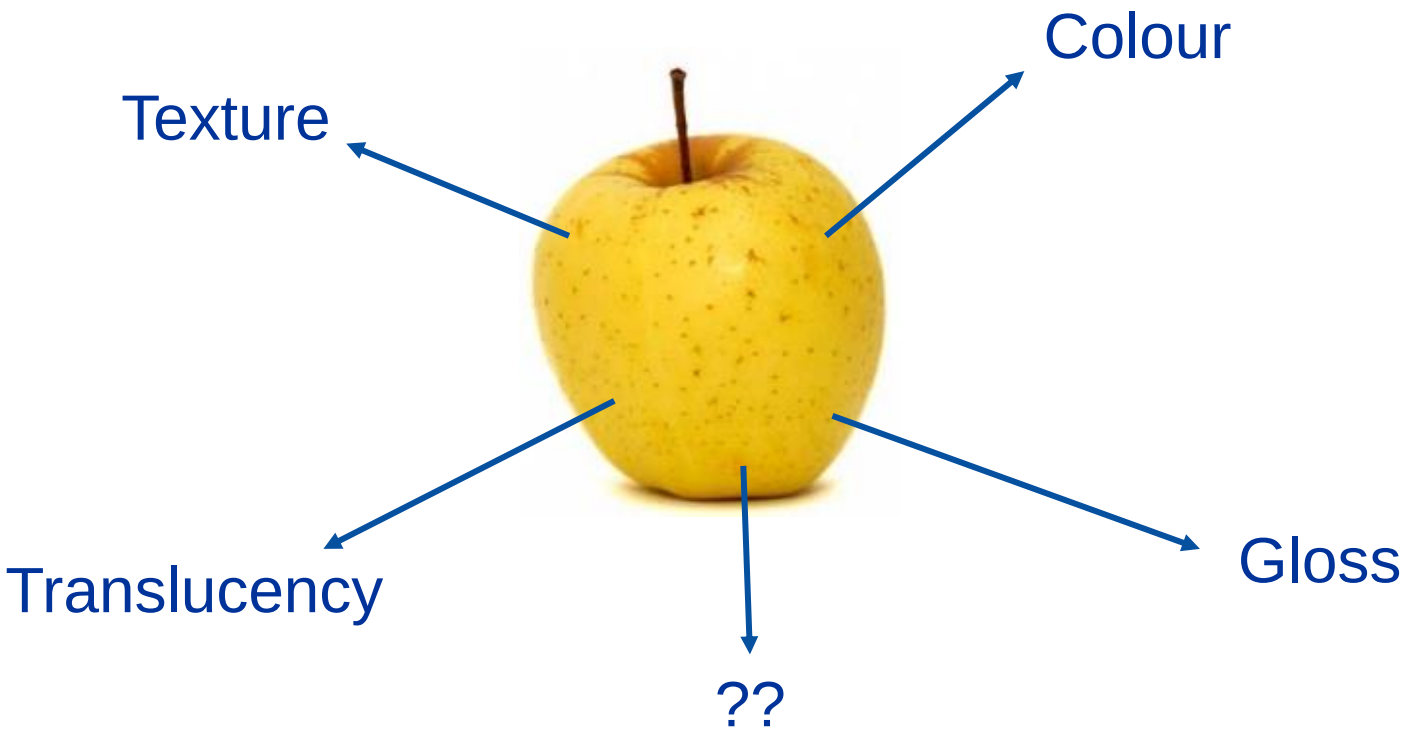
CIE 1924, 6th session



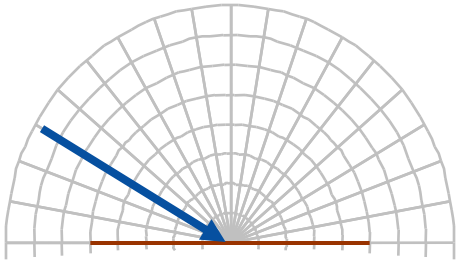
Physical approach

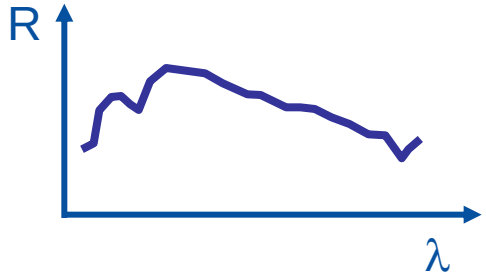


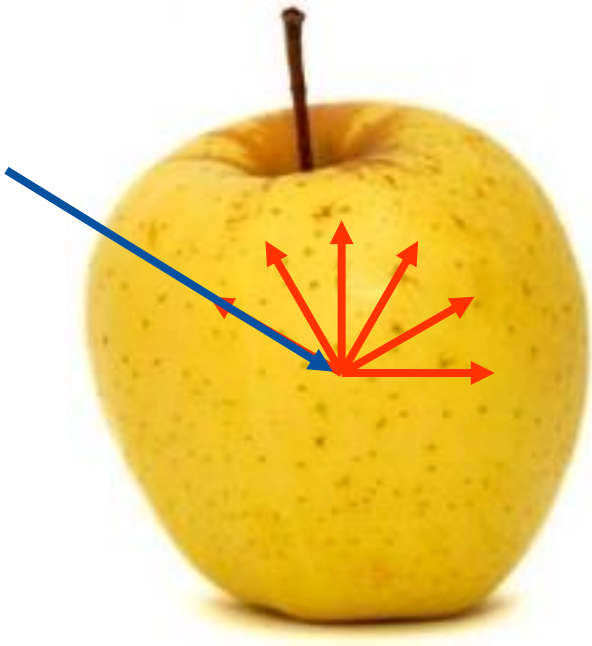
Measurement of the attributes of appearance

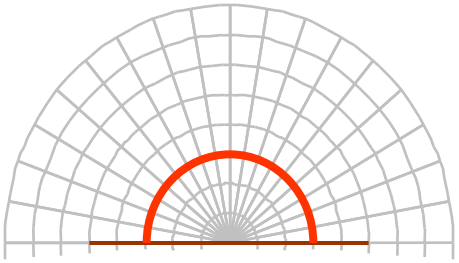


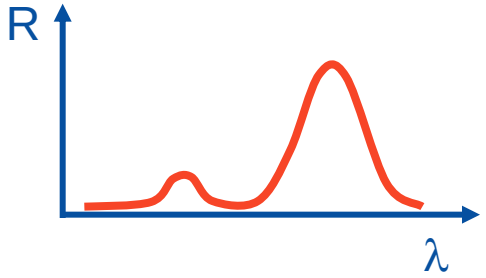
Colour







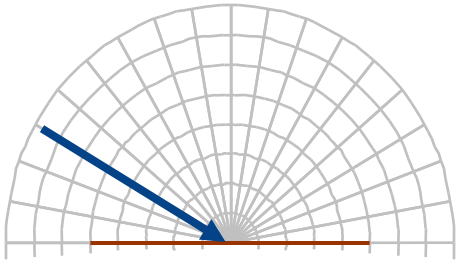


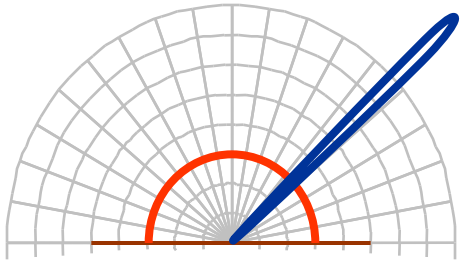


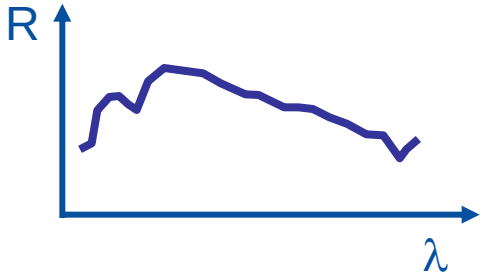
The colour comes from the spectral repartition of the light reflected by the material

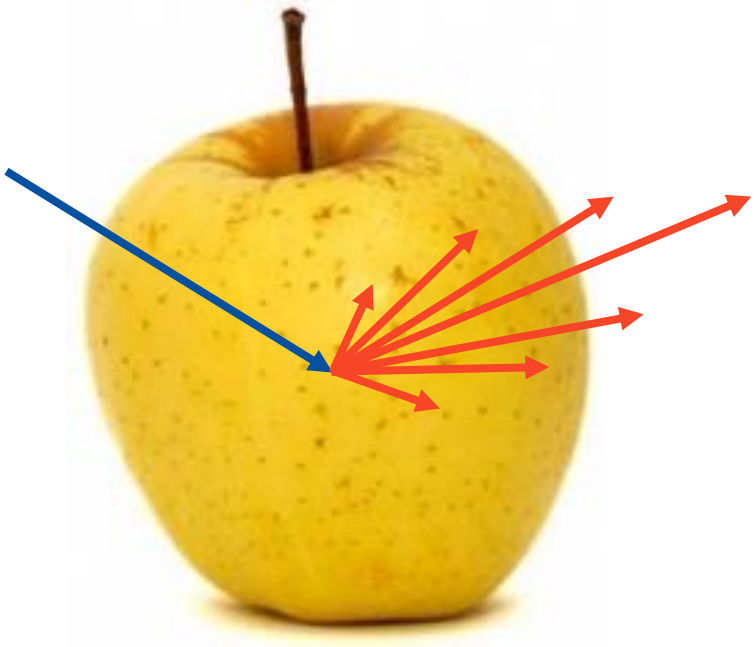
Physical approach

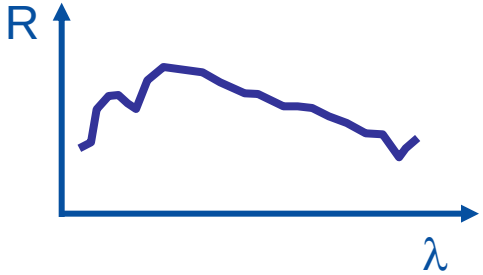
Gloss





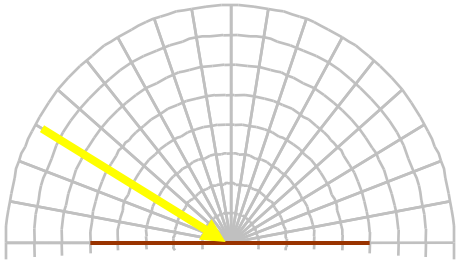


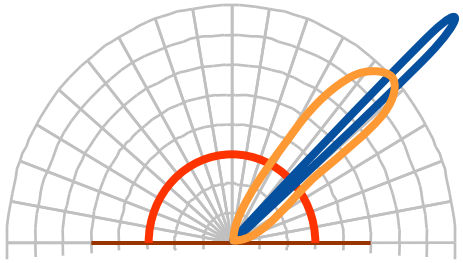


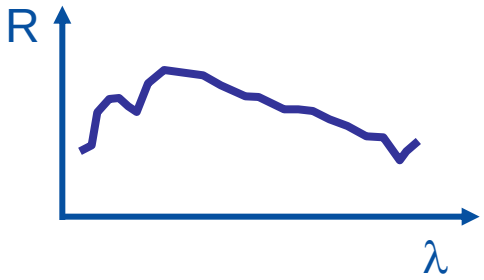


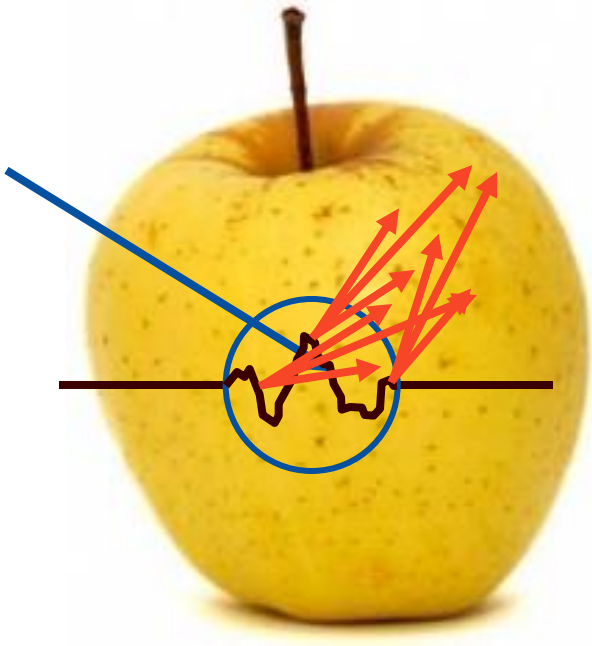
The gloss comes from the angular repartition of the light reflected by the surface

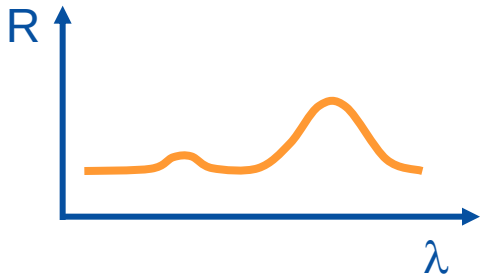
Texture





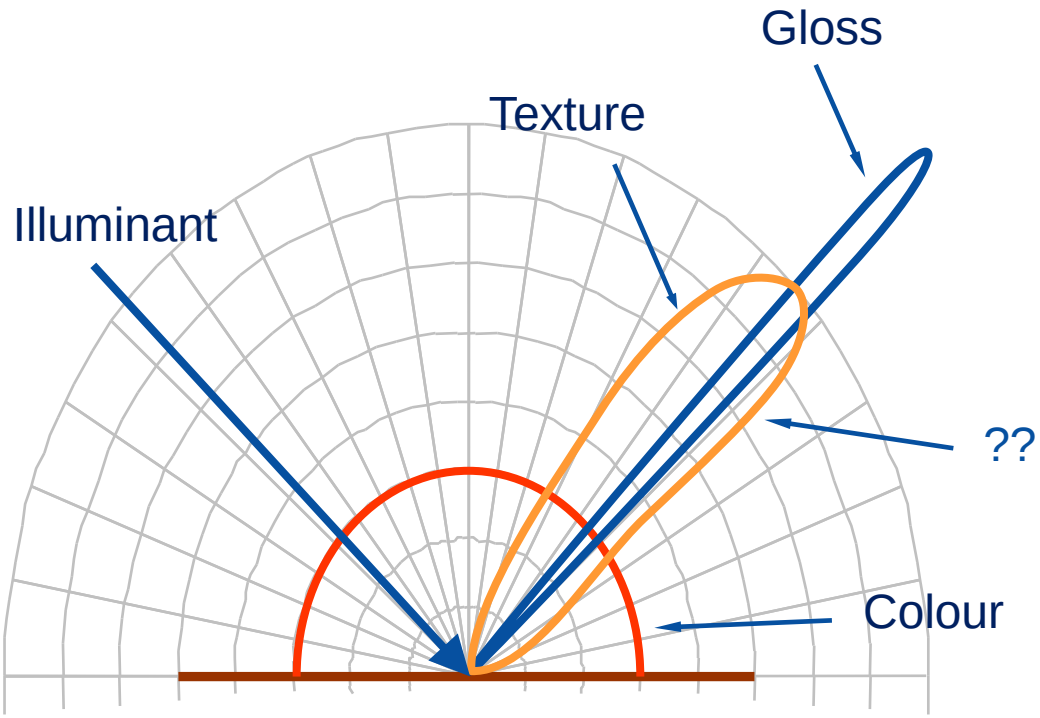






The texture comes from the spatiale repartition of the light reflected by the material

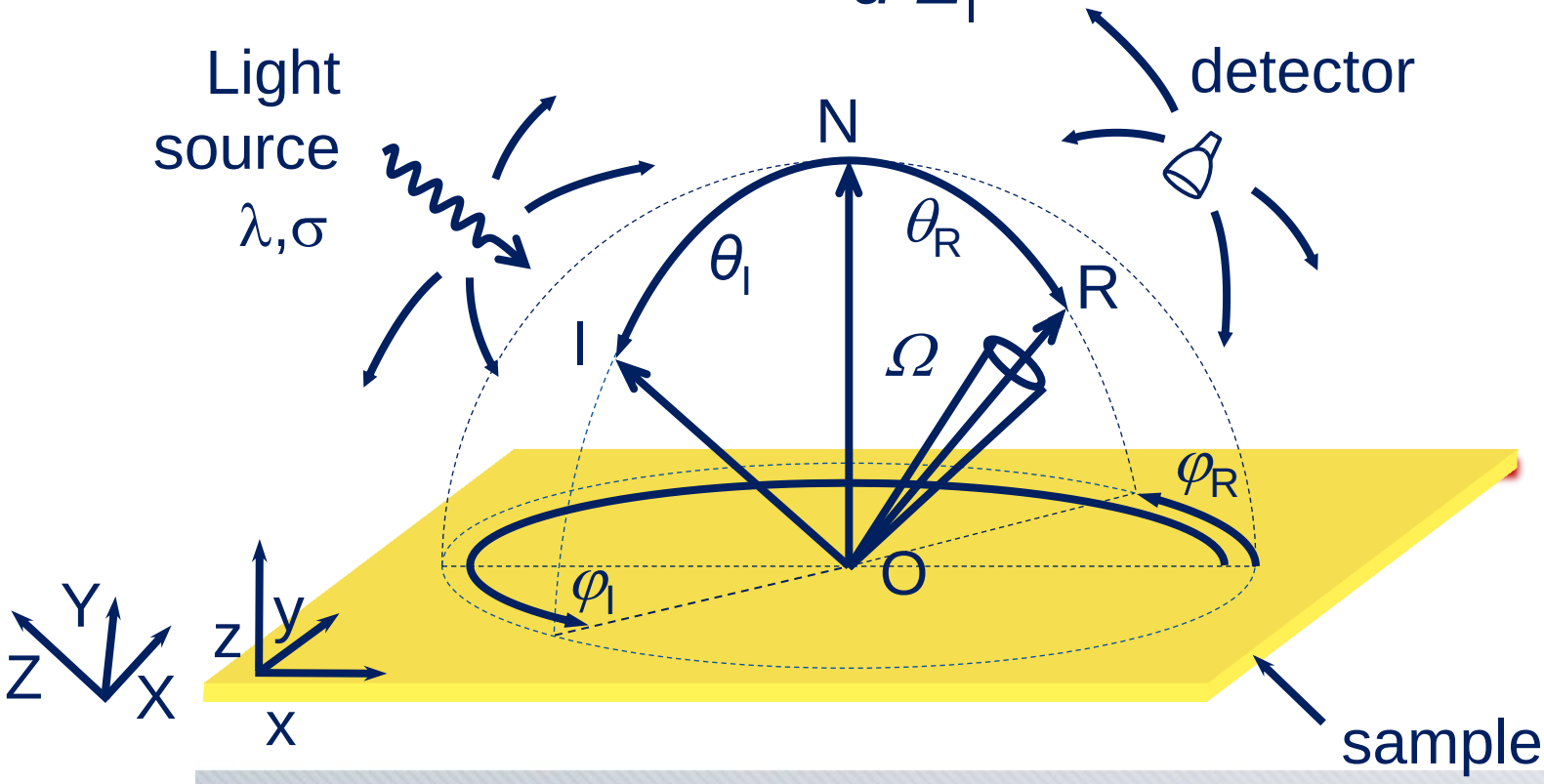
BRDF
(Bidirectionnel Reflectance Distribution Function)



The BRDF is the relevant quantity to characterize the appearance of an object

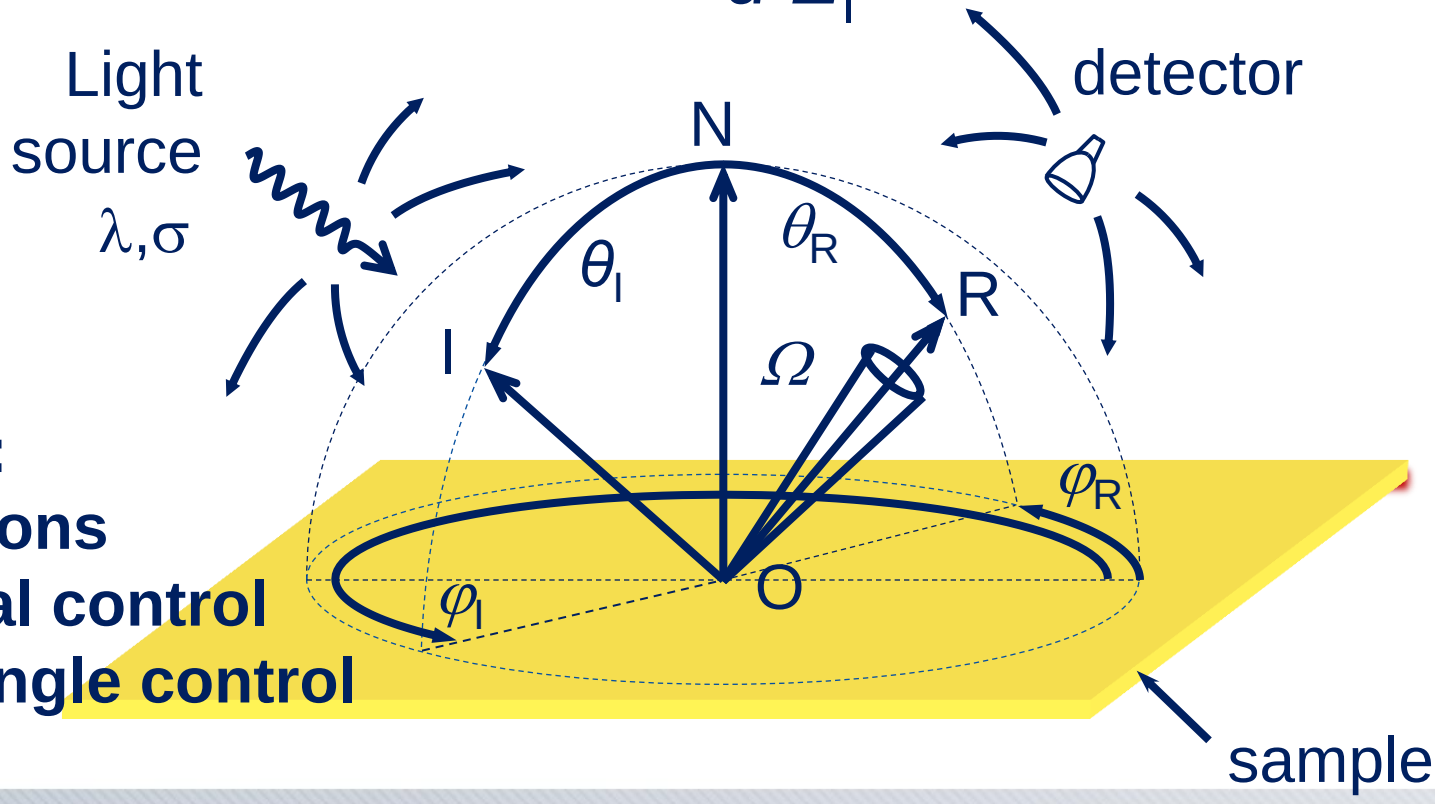
BRDF

$$f(\theta_I\ \varphi_I\ \theta_R\ \varphi_R\ \lambda\ \sigma) = \frac{d L_R}{d E_I} \quad (sr^{-1})$$



The gonioreflectometer

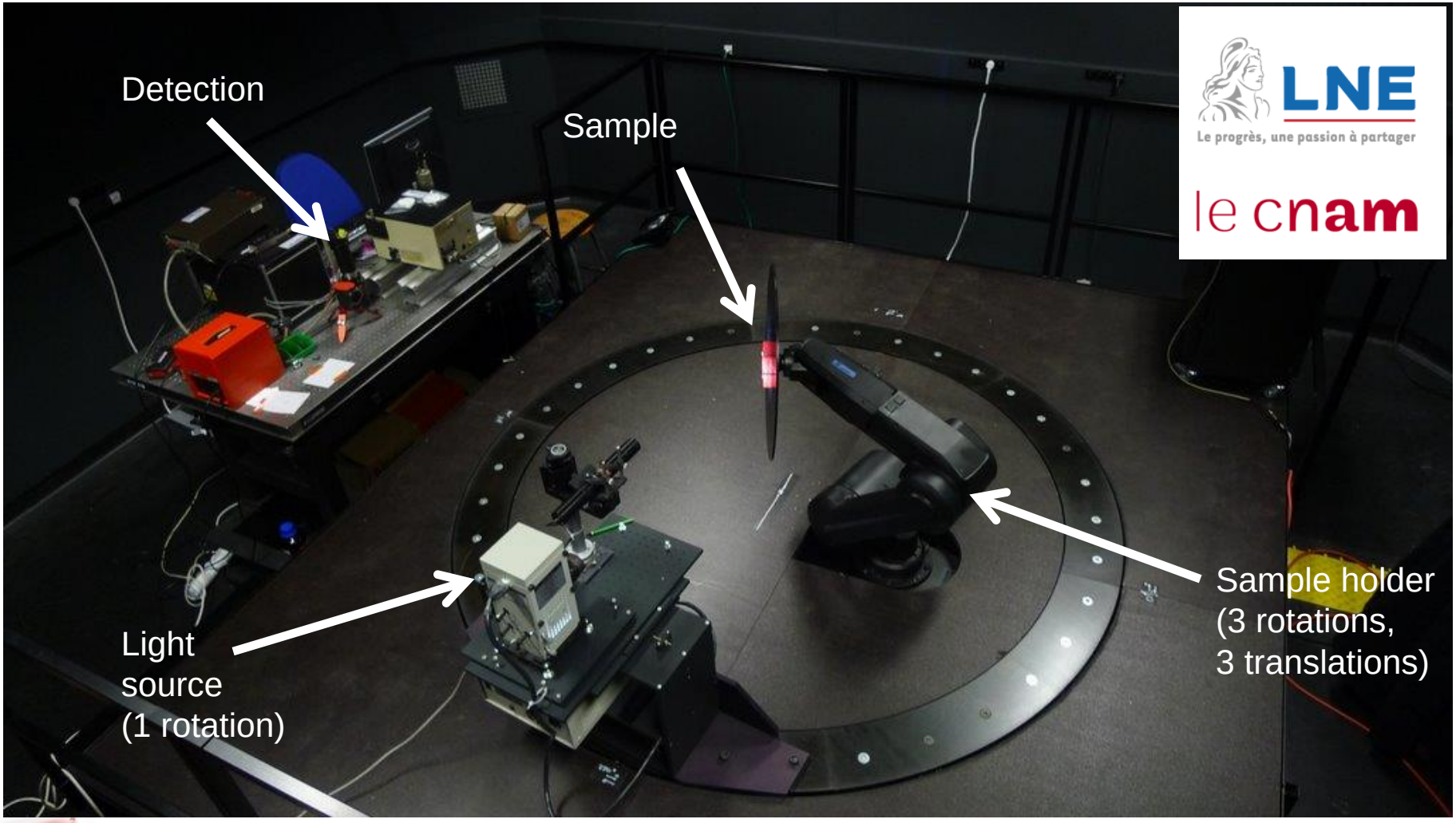
$$f(\theta_I\ \varphi_I\ \theta_R\ \varphi_R\ \lambda\ \sigma) = \frac{d L_R}{d E_I} \quad (sr^{-1})$$



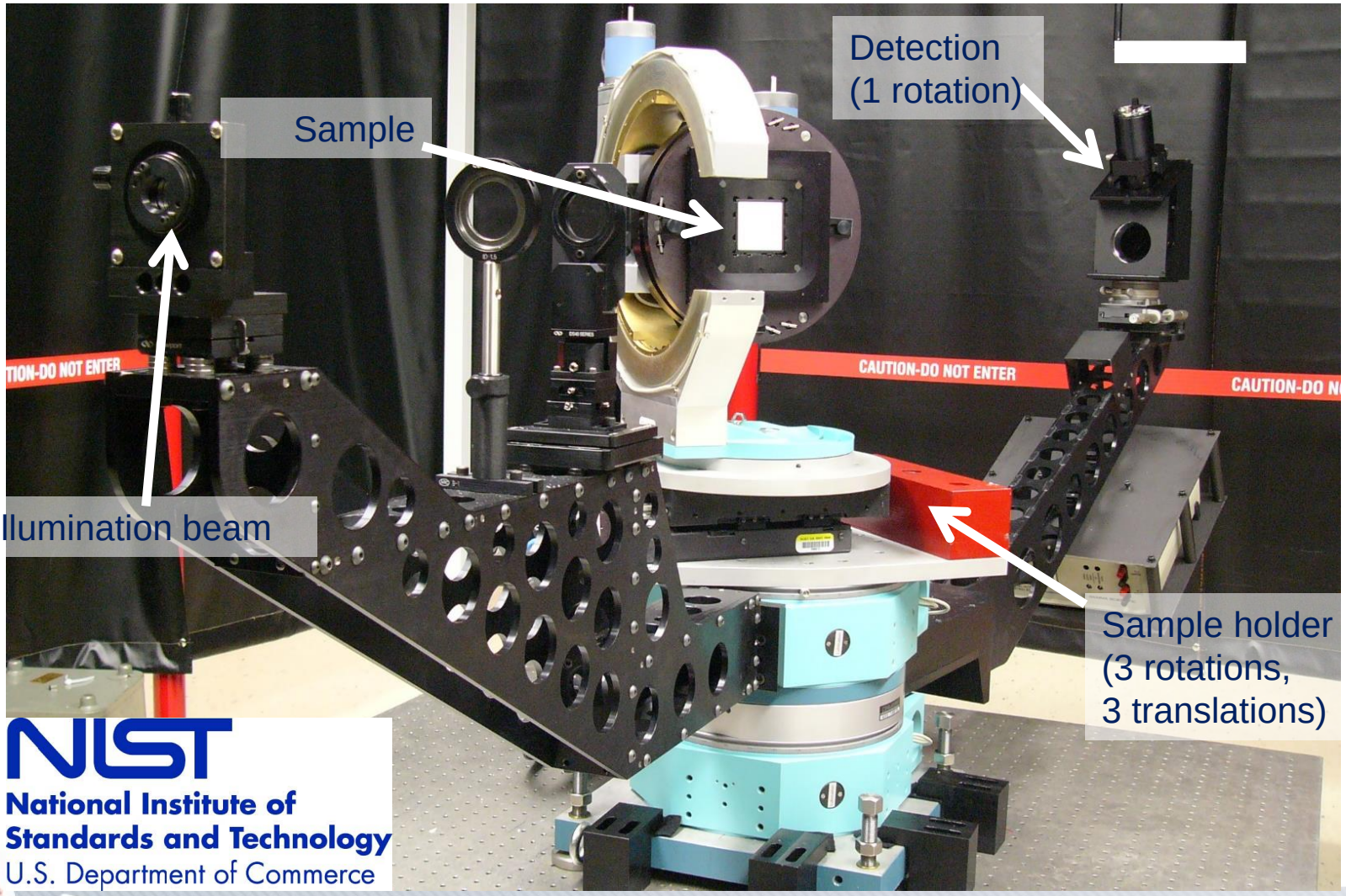
Required:

- **4 rotations**
- **Spectral control**
- **Solid angle control**

Gonioreflectometer

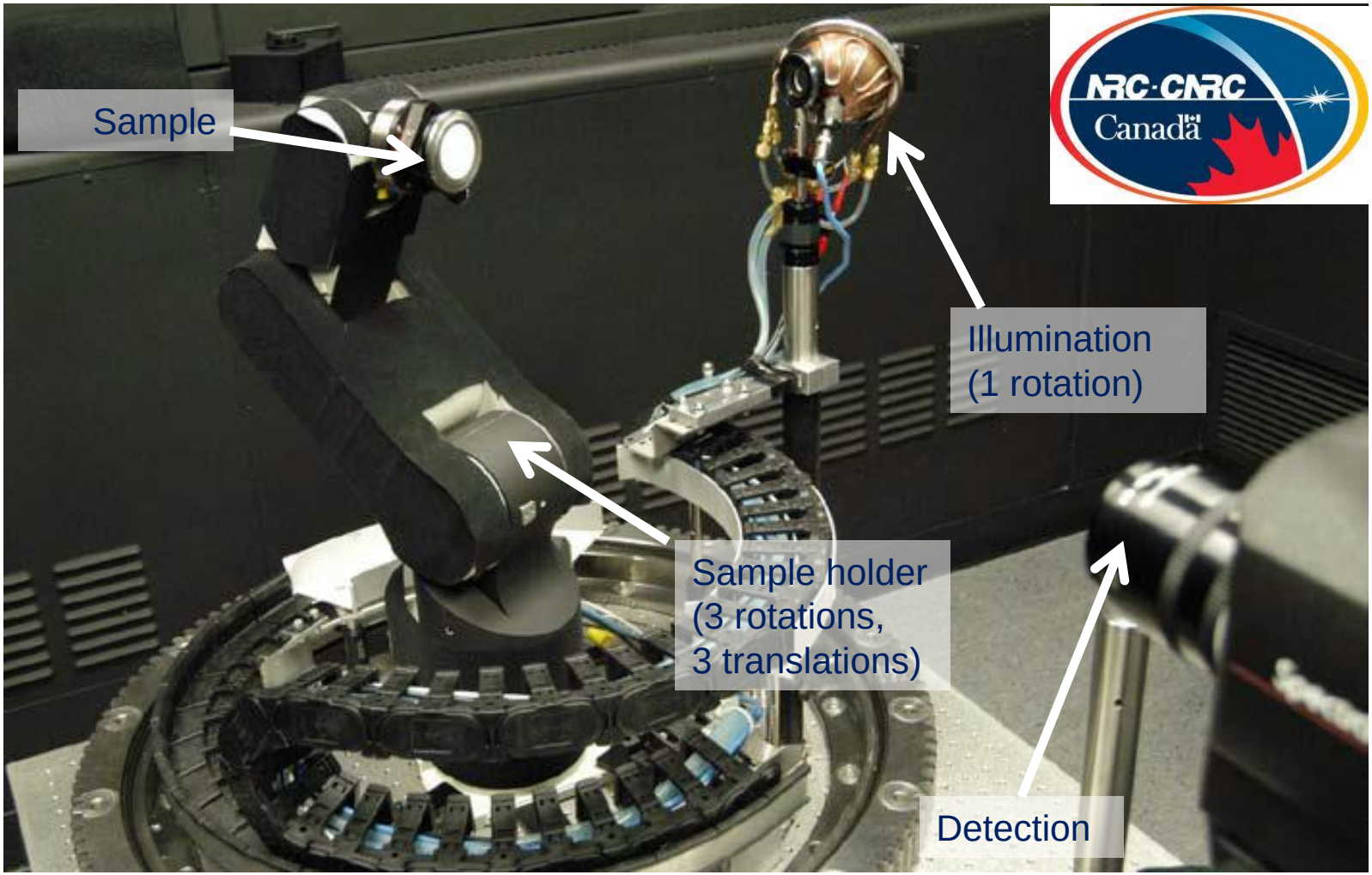


Gonioreflectometer

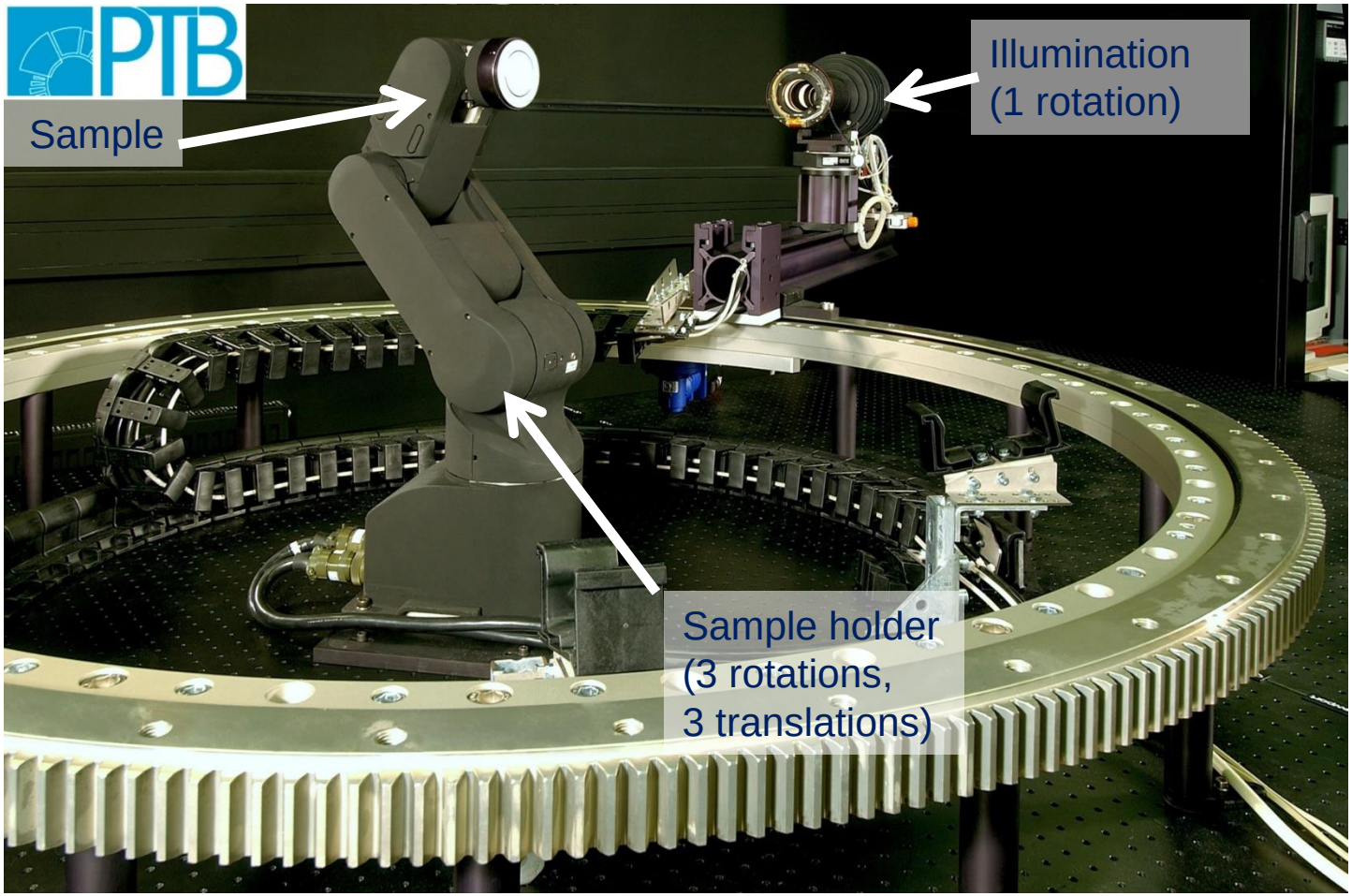


National Institute of Standards and Technology
U.S. Department of Commerce

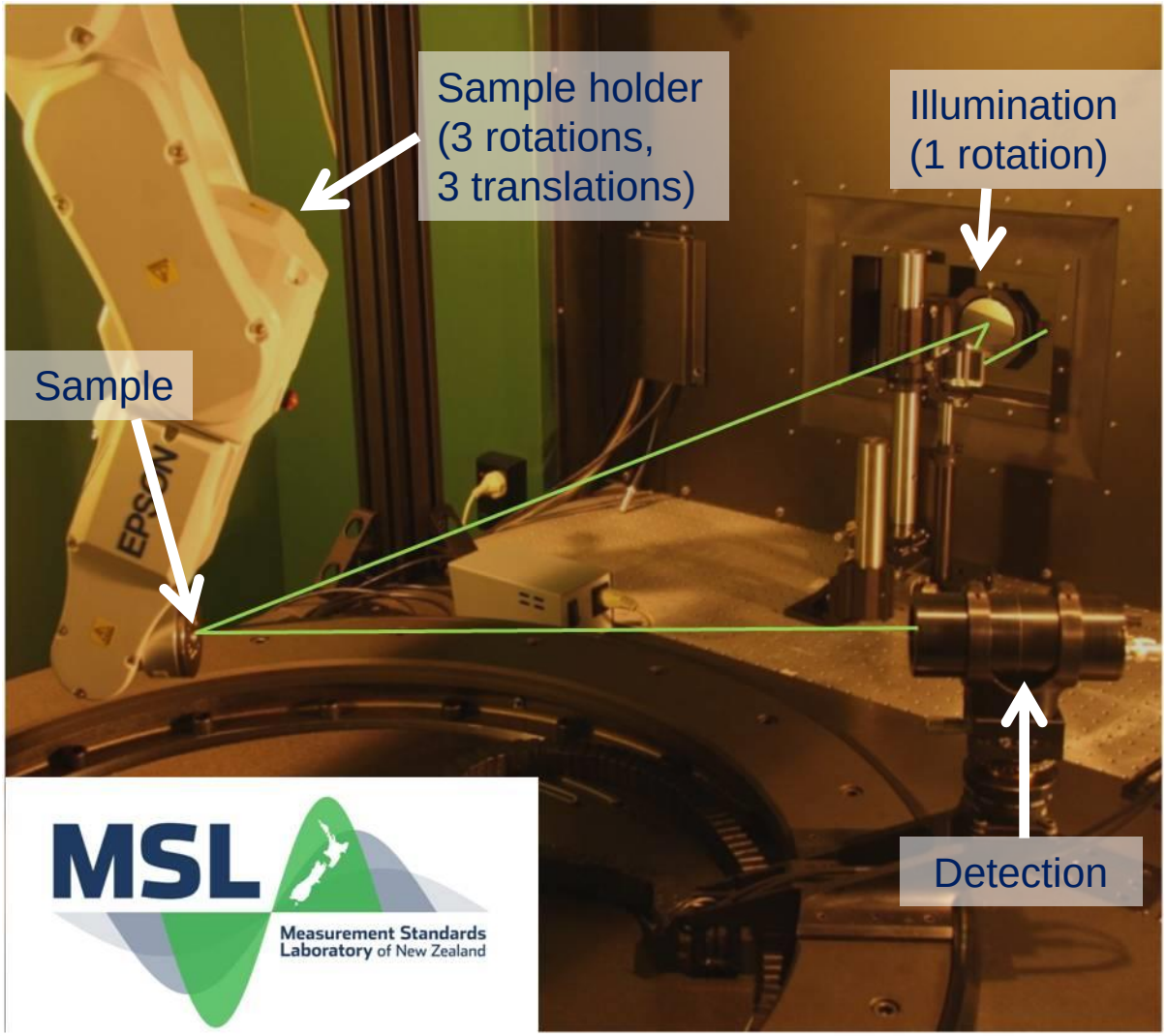
Gonioreflectometer



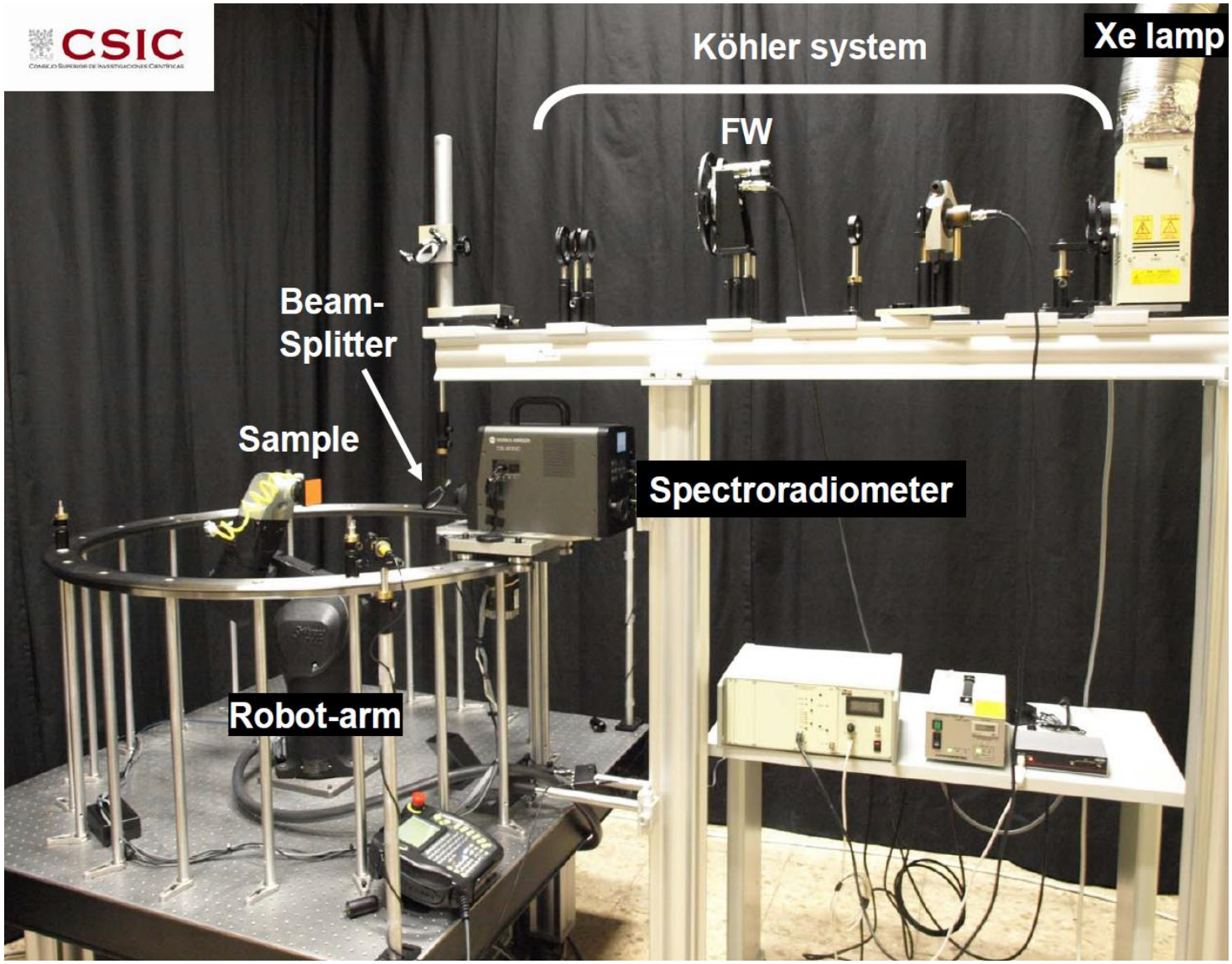
Gonioreflectometer



Gonioreflectometer

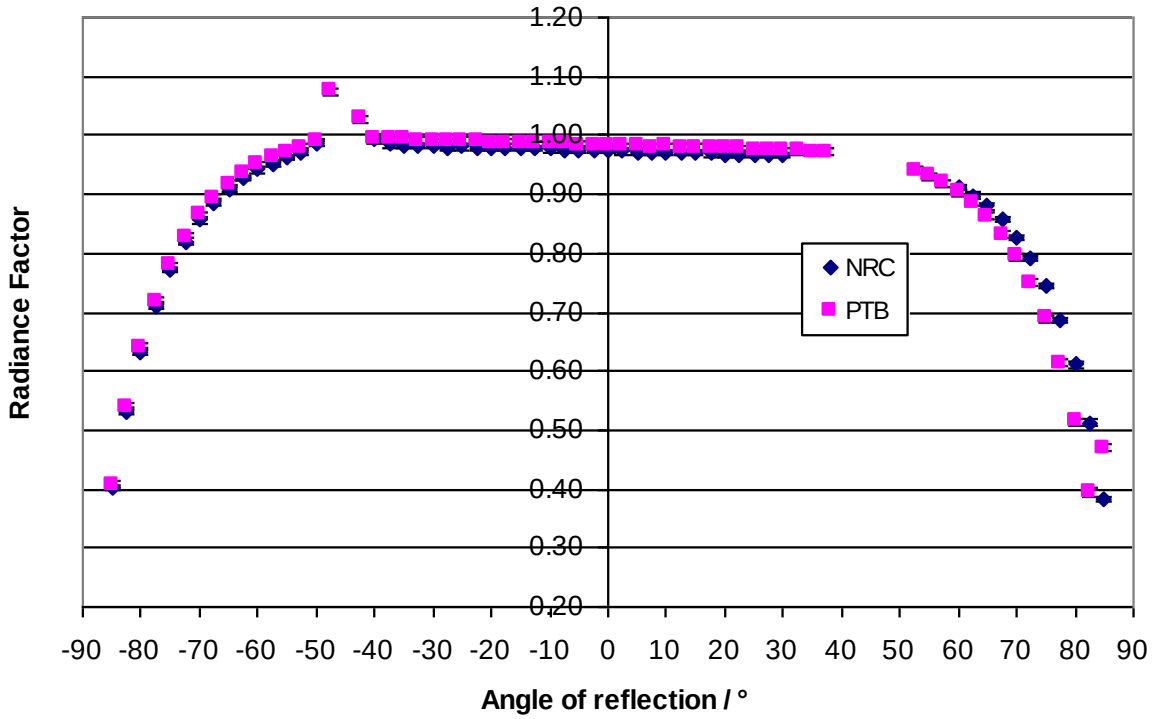


Gonioreflectometer



State of the art

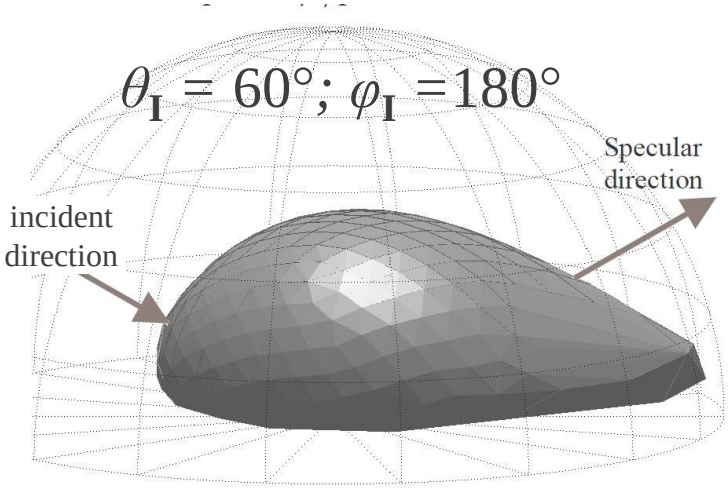
Begining of comparisons



Relative expanded uncertainty <0,8%

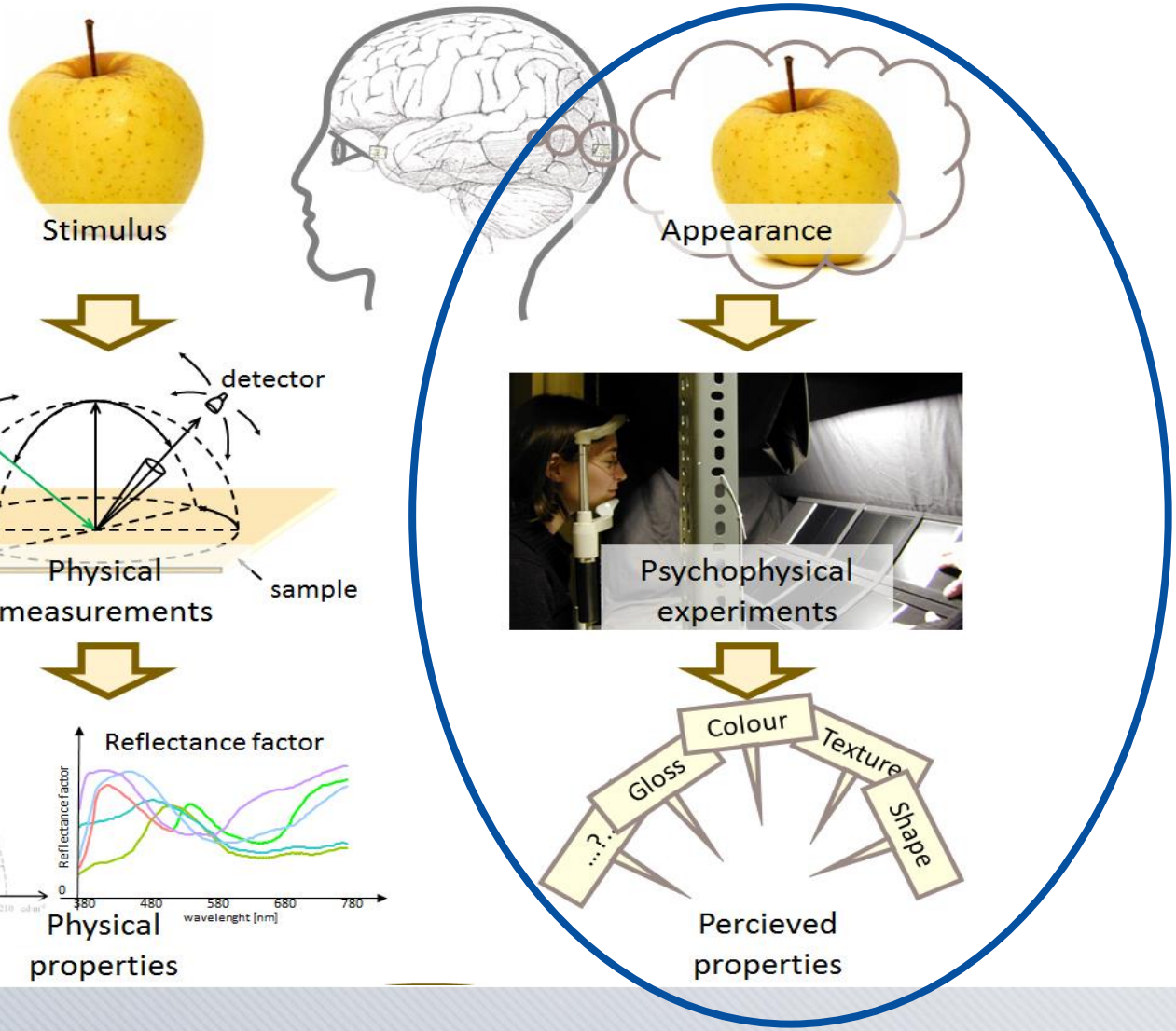
Baribeau, Niel, Hauer, Höpe, NEWRAD 2011

Future

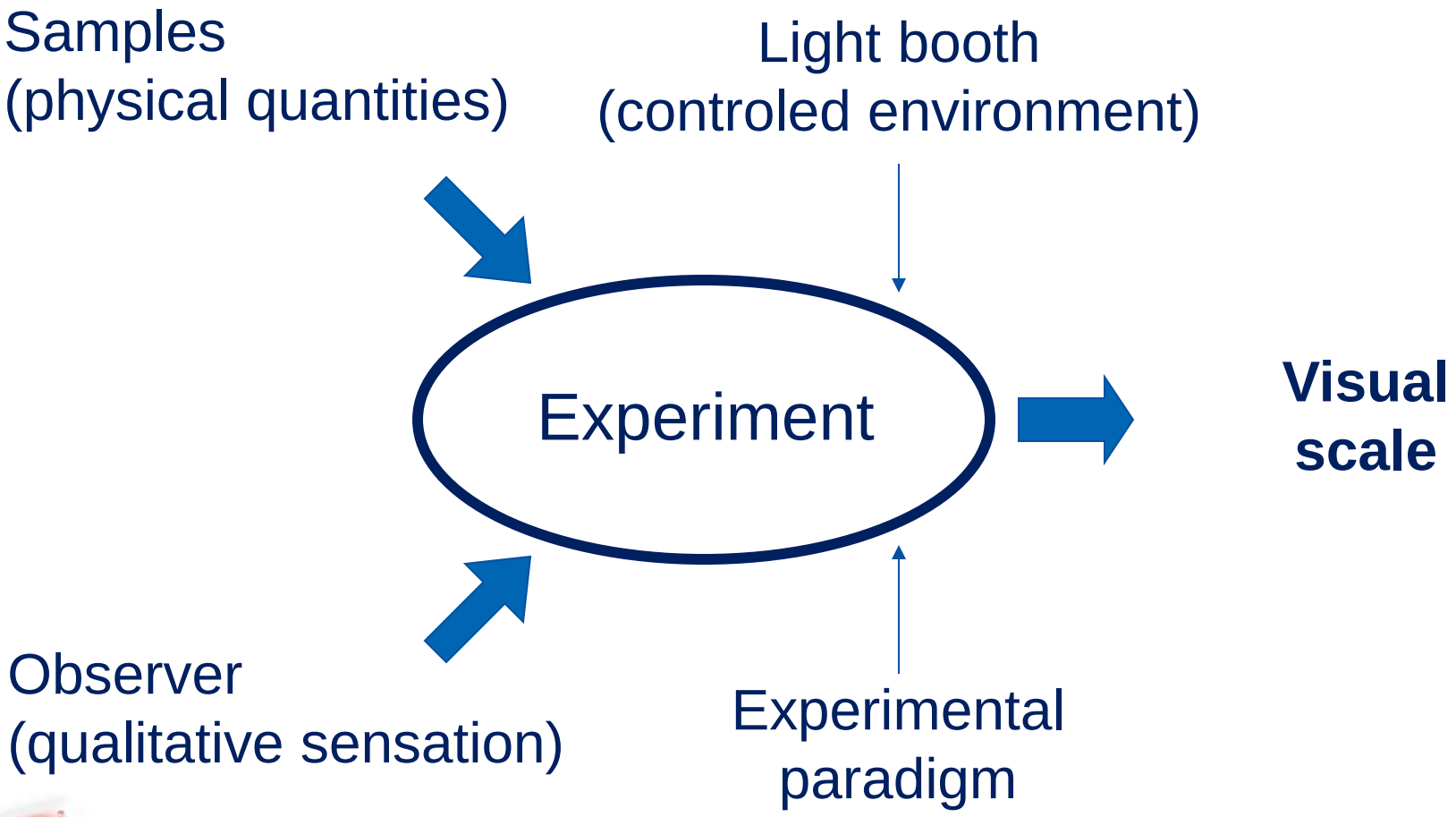


- Comparisons
- Data handling
- Recommanded configuration
- Models
- Spectral developments (NUV, NIR, fluorescence)
- Angular resolution developments (gloss)

Phychophysical approach



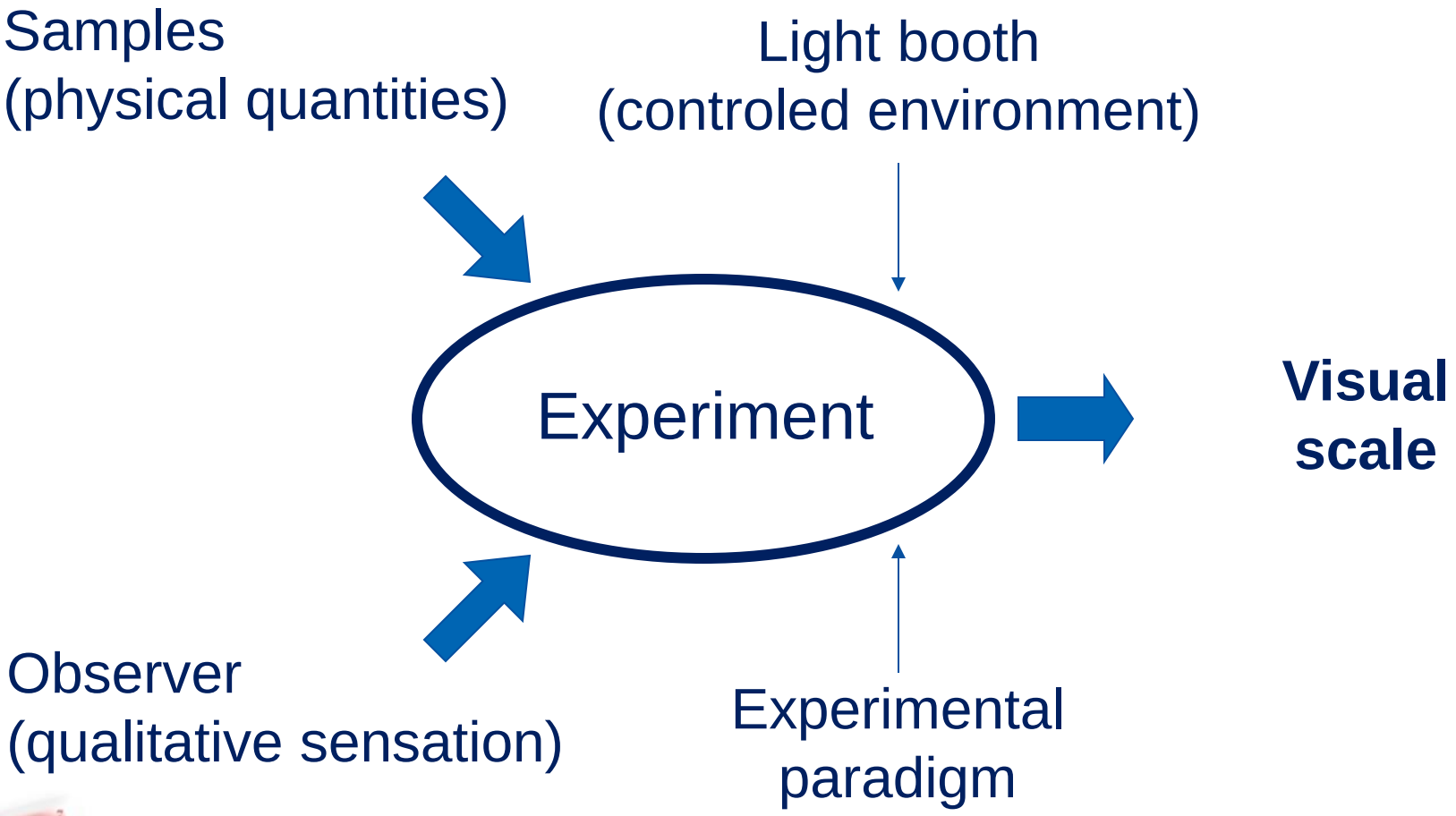
Phychophysical experiments



Example for gloss

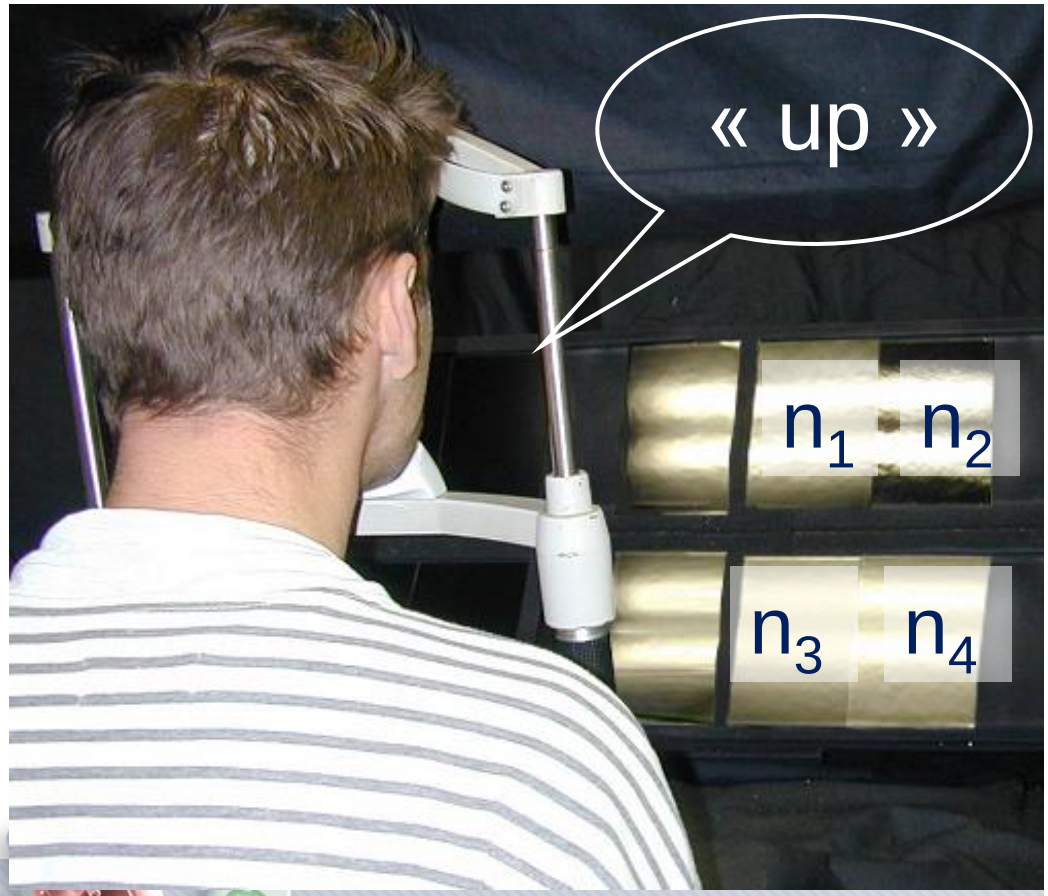
Picture : Jean Le Rohellec

Phychophysical experiments



Experimental paradigm

Pair comparison



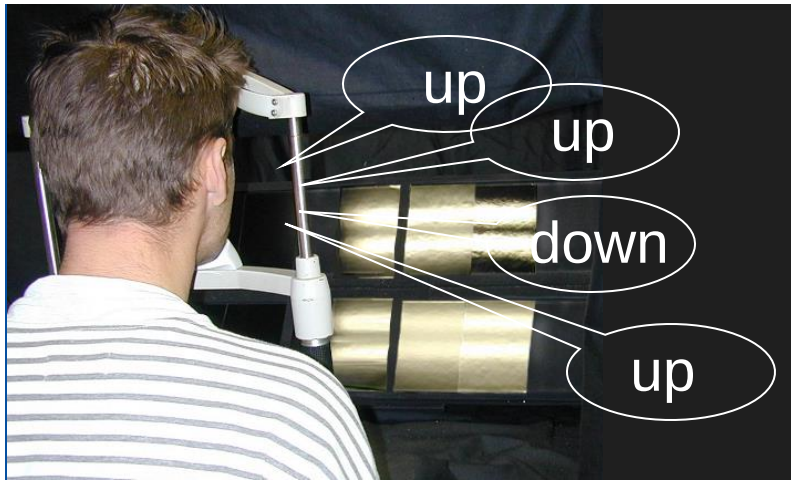
Question:

« On which pair the different is the highest? »

$$\psi_1 - \psi_2 > \psi_3 - \psi_4$$

Visual scale

For 10 samples, we have **210** pair comparisons



ψ_1-ψ_2 > ψ_3-ψ_4
ψ_1-ψ_3 > ψ_6-ψ_8
ψ_1-ψ_3 < ψ_9-ψ_{10}
ψ_6-ψ_7 > ψ_9-ψ_{10}
ψ_1-ψ_2 < ψ_3-ψ_4
⋮
ψ_3-ψ_4 < ψ_5-ψ_6
ψ_2-ψ_3 > ψ_5-ψ_9
ψ_5-ψ_7 < ψ_8-ψ_{10}
ψ_4-ψ_5 > ψ_6-ψ_7
ψ_7-ψ_8 > ψ_9-ψ_{10}
ψ_5-ψ_6 > ψ_7-ψ_9

210

Visual scale

Introcution of a « variable of decision »

$$\psi_1 - \psi_2 > \psi_3 - \psi_4$$

Pair 1

Pair 2

$$D(n_1, n_2 ; n_3, n_4) = (\psi_1 - \psi_2) - (\psi_3 - \psi_4) + \varepsilon > 0$$

Uncertainty

[1] L.T Maloney & J. N. Yang, soumis, 2003

Visual scale

$$D(n_1, n_2 ; n_3, n_4) = (\psi_1 - \psi_2) - (\psi_3 - \psi_4) + \varepsilon > 0$$

ε → Gaussian $\mathcal{N}(0, \sigma)$

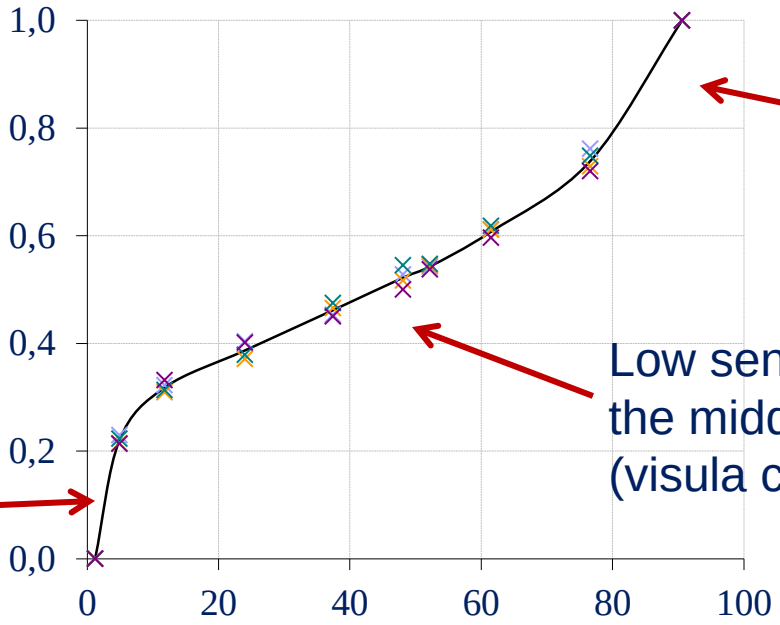
$\psi_1, \psi_2, \ldots, \psi_{10}$ → Visual sensation of glossy samples

= 11 unknown < $\psi_1, \ldots, \psi_{10}$, σ

Visual scale

We obtain the vector : $\psi[\hat{\psi}_1; \hat{\psi}_2; \ldots; \hat{\psi}_{10}]$

« visual scale » for the 10 samples n_1, n_3, …, n_{10}



Visual scale for gloss
(perceptive metric)

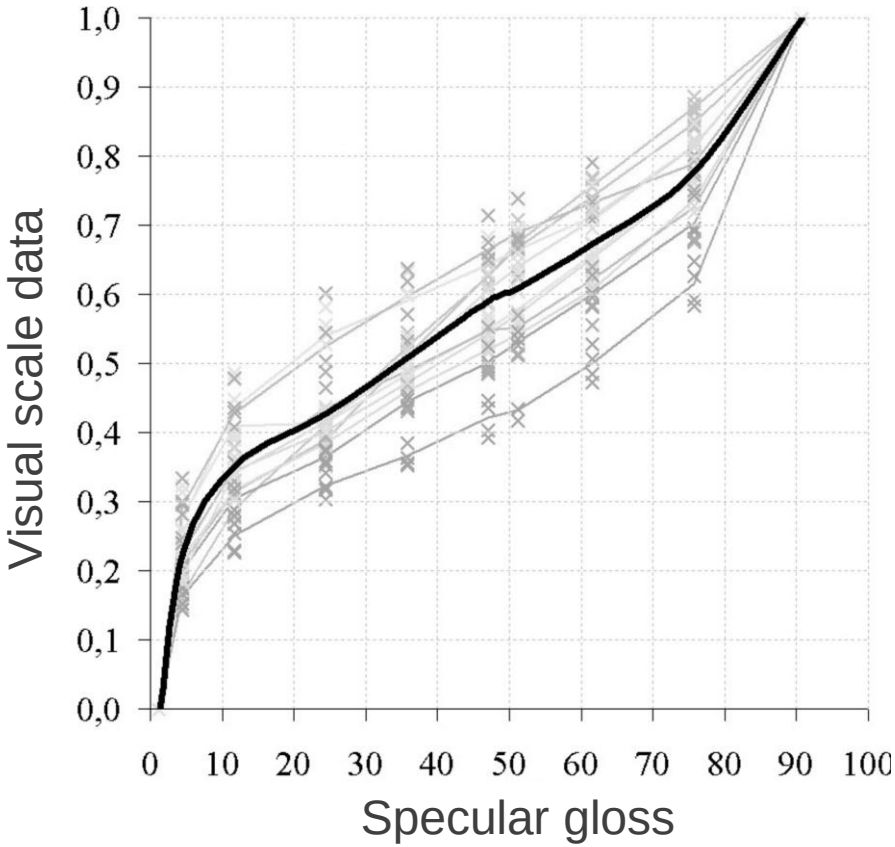
High sensitivity in
the very glossy
(car painting)

Low sensitivity in
the middle
(visula conflict)

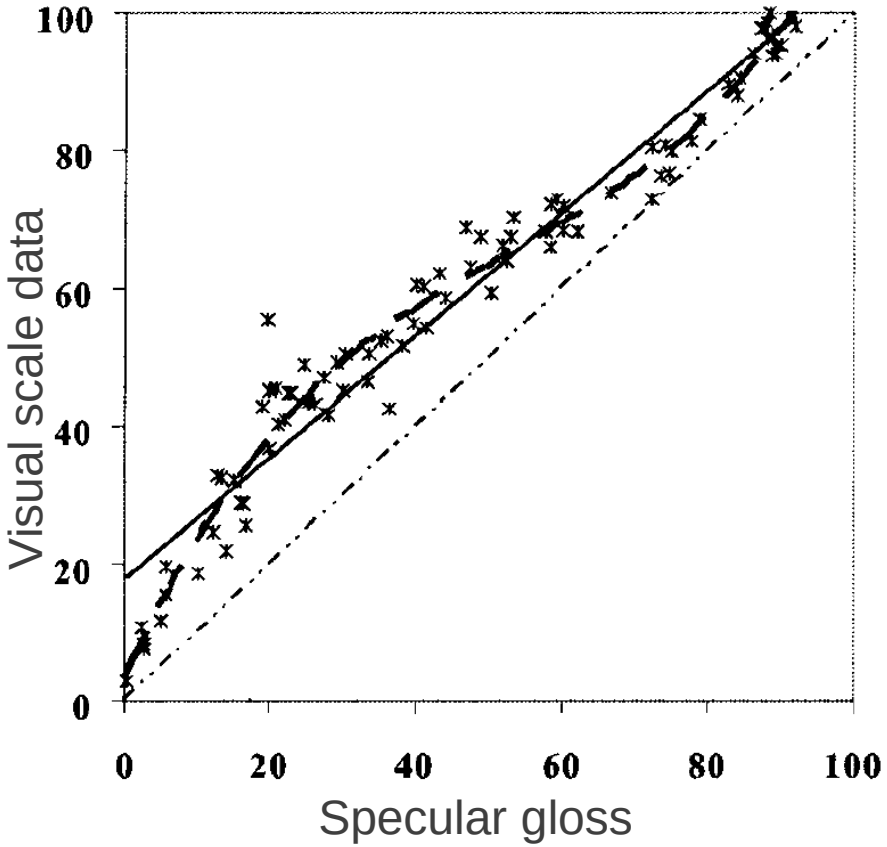
Very high
sensitivity in
the mat

Variability, reproductibility

Obein et al, J. Vis, **10**(9), 18 (2005)



Ji et al, J. Opt. Soc. Am. A **23**, 22-33 (2006)



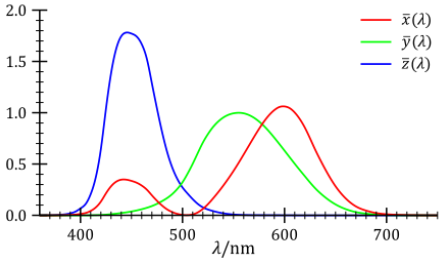
Toward a standard observer?

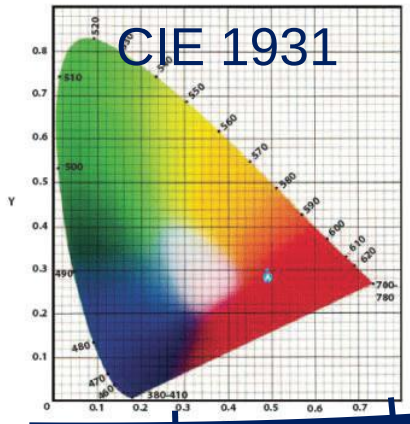
Psychophysical approach

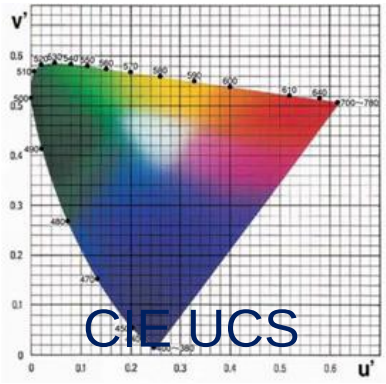
Past and future

Total appearance measurement

Div 1, Div2







Translucency

Gloss

Texture

MApNet

2013

2006

2002 CIE CAM02

1997 CIE CAM97s

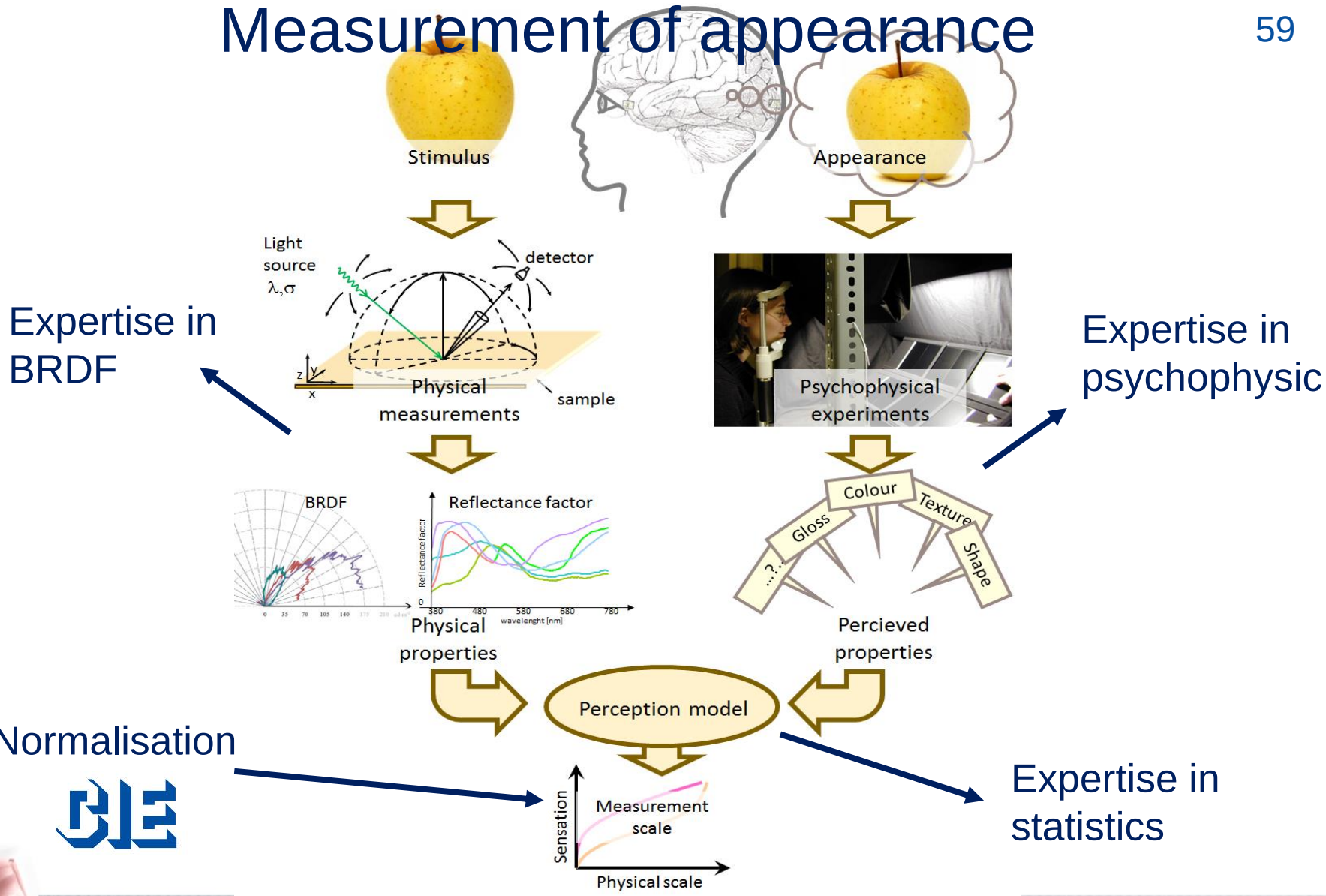
1976

1964

1931

1921

Measurement of appearance



JRP xDReflect
Multidimensional Reflectometry for Industry

EURAMET
European Association of National Metrology Institutes

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

JRP xDReflect Consortium

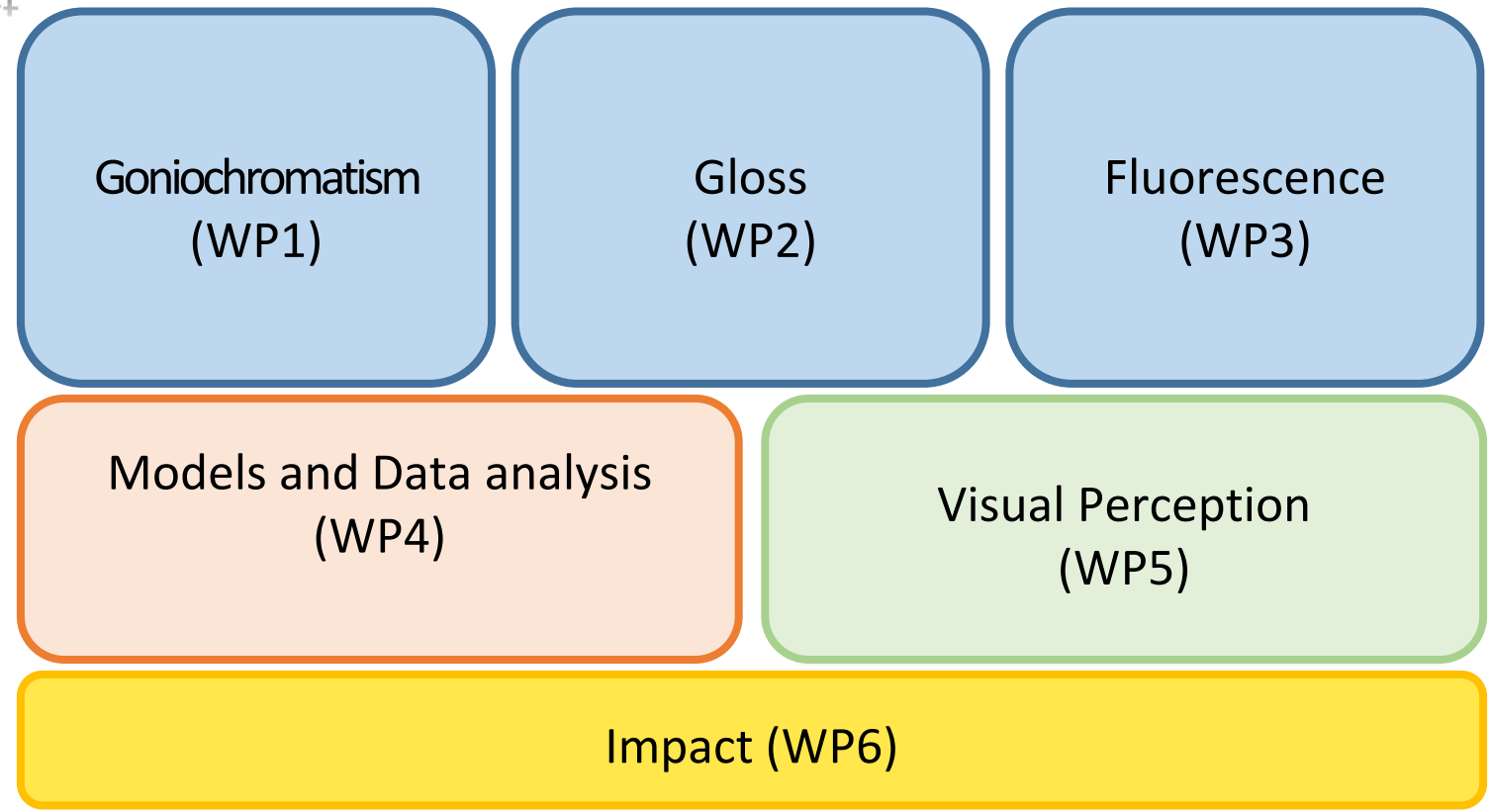
Universitat d'Alacant
Universidad de Alicante

KAHO

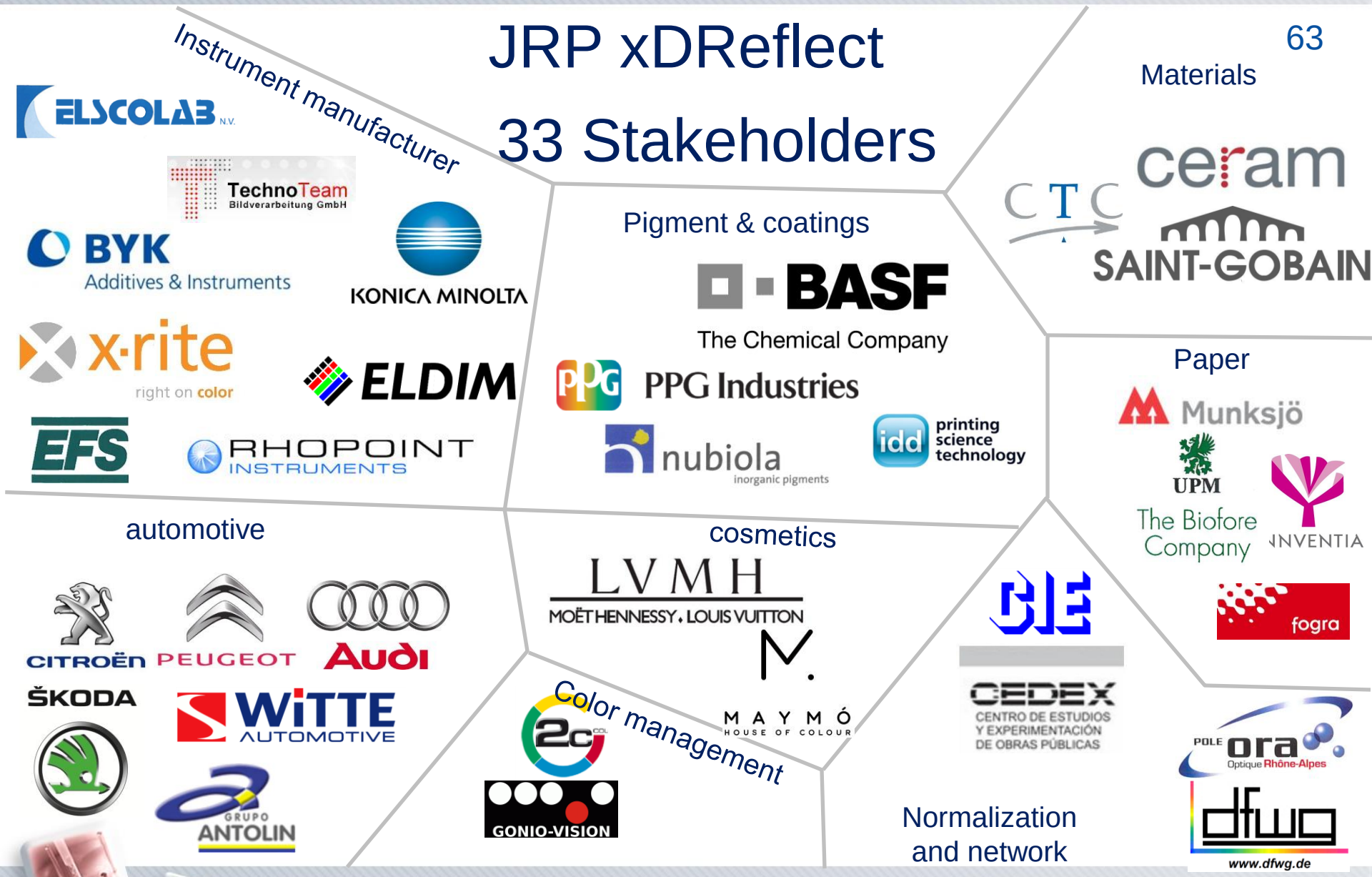
le cnam · CMI · CSIC · MSL Measurement Standards Laboratory of New Zealand · SP · INRiM Istituto Nazionale di Ricerca Metrologica · PTB · MIKES

INNVENTIA

JRP xDReflect

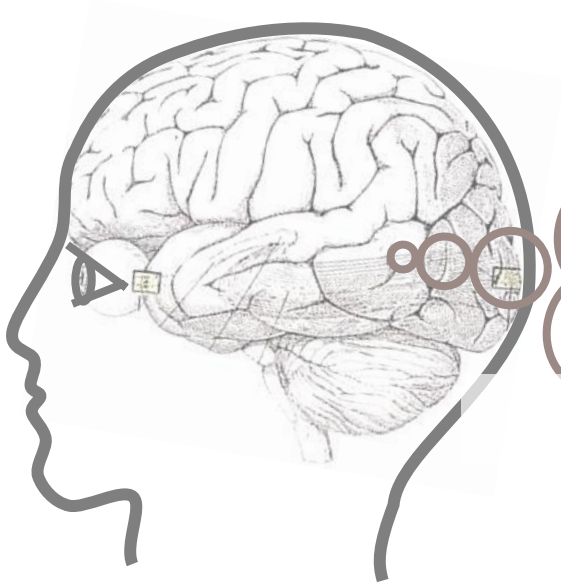


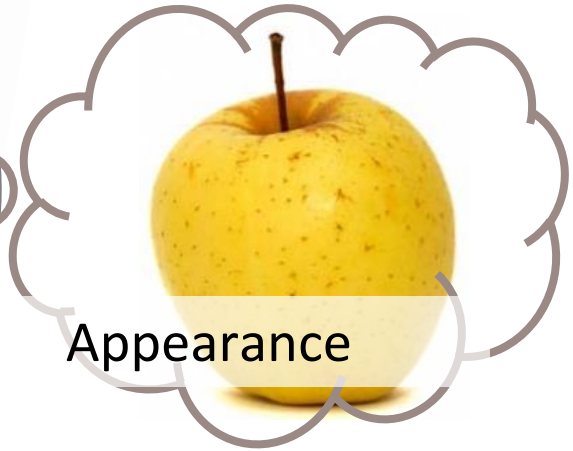
Conclusion


JRP xDReflect
33 Stakeholders
Instrument manufacturer
ELSCOLAB N.V.
TechnoTeam Bildverarbeitung GmbH
BYK Additives & Instruments
KONICA MINOLTA
x-rite right on color
ELDIM
EFS
RHOPOINT INSTRUMENTS
Pigment & coatings
BASF The Chemical Company
PPG PPG Industries
nubiola inorganic pigments
idd printing science technology
Materials
CTC
ceram
SAINT-GOBAIN
Paper
Munksjö
UPM
The Biofore Company
INVENTIA
fogra
automotive
CITROËN
PEUGEOT
Audi
ŠKODA
WITTE AUTOMOTIVE
GRUPO ANTOLIN
cosmetics
LVMH MOËT HENNESSY • LOUIS VUITTON
MAYMÓ HOUSE OF COLOUR
Color management
2c
GONIO-VISION
CEDEX CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS
Normalization and network
POLE ora Optique Rhône-Alpes
dfwg www.dfwg.de

Measurement of appearance

Physical Stimulus





Appearance

Thank you for your attention