Skiron : A beamline for Advanced Chiroptical Spectroscopies

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Abstract:

Skiron: bending magnet beamline for advanced chiroptical spectroscopies in solids, liquids and gases.

Two branches:

A: (windowless , in vacuum) , monochromatic circularly polarized phtons in the wavelength range 400- 30 nm (3-40 eV) with helicity switching frequency of ~1 kHz . CD spectroscopy in a unprecedented energy range will be possible, allowing to explore the optical activity of electronic transitions involving deep molecular orbitals of relevant organic molecules.

B: λ: 400-~130 nm, linearly polarized light and a new development which will allow to measure in real time the complete Mueller polarization matrix of solutions, solids or thin films and , in his way, to simultaneously determine the linear and circular dichroism of anisotropic systems.

Outline:

1.- Introduction

- Basic concepts
- Selected examples of chiral phenomenology
- Experimental aspects, commercial apparatus, transmission…
- Synchrotron Radiation Circular Dichroism

2.- Motivation of Skiron.

- Branch A: deep molecular orbitals, gas and liquid jets photoemission
- Branch B: CD in ansisotropic media. Linear dichroism. Mueller matrix imaging

3.-Conceptual optical design

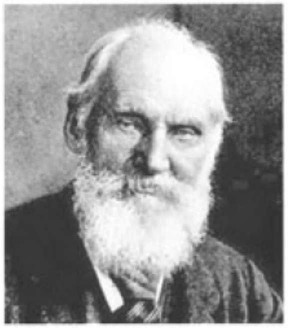
4.- Instrumental aspects

5.- Estimated Cost

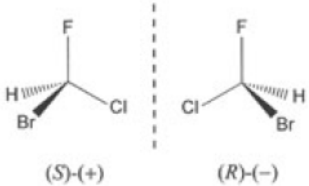
6.- Potential users and scientific impact

Chirality (enantiomorphism)

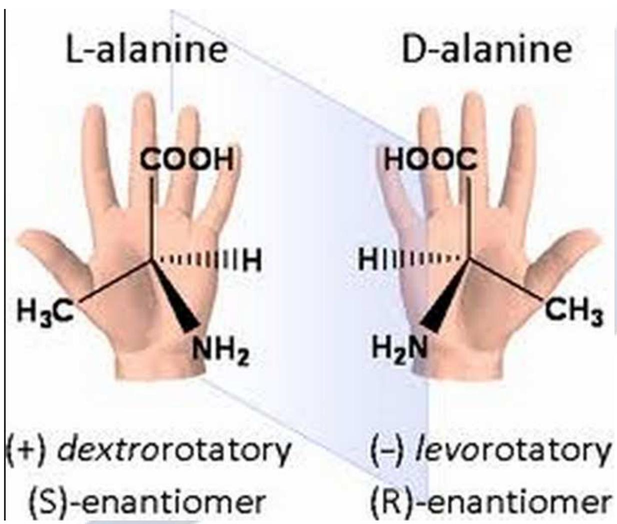
Lord Kelvin's definition of chirality.

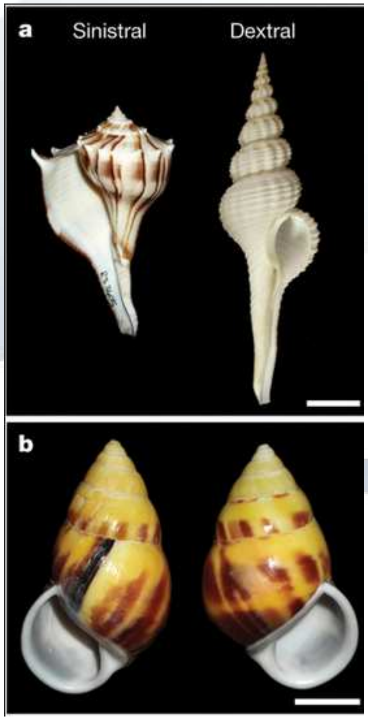


I call any geometrical figure or group of points, *chiral*, and say that it has chirality if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself.

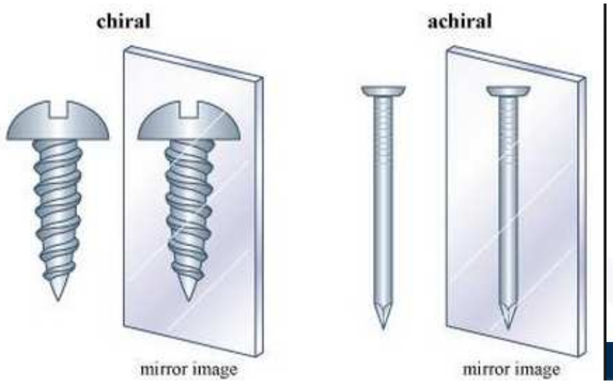


Chirality is ubiquitous in nature:



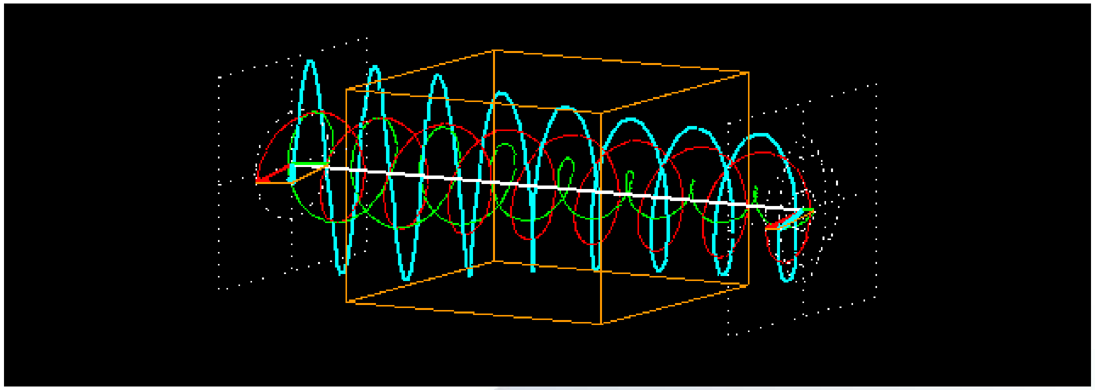


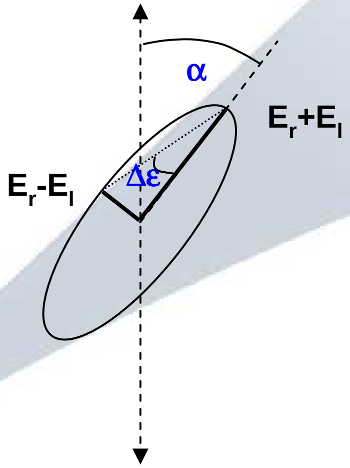
Plants



Chirality is closely linked to optical activity: dichroism and rotary power

Dichroism (Fresnel)
Incoming plane wave (vertical blue) = CR (red) +CL(green)
Exit wave: reduced amplitude, elliptical polarization:
CR green: absorbed, CL red: non absorbed





The difference in absorption coefficients causes different magnitudes of $\mathbf{E_r}+\mathbf{E_l}$ and $\mathbf{E_r}-\mathbf{E_l}$ which determine the ellipticity angle $\Delta\varepsilon$.
The difference of refraction index for right and left circularly polarized light originates the rotation α of the ellipse that describes the electric vector.

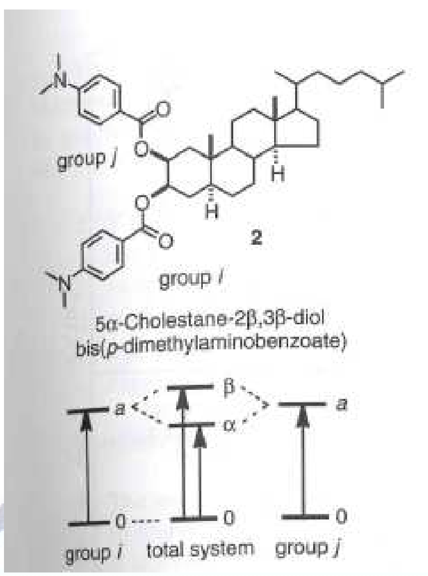
•The rotary power R (~α) and the ellipticity are related via
$$R \propto \int \frac{\Delta\varepsilon(\lambda)}{\lambda} d\lambda$$

•Rosenfeld (1928) :

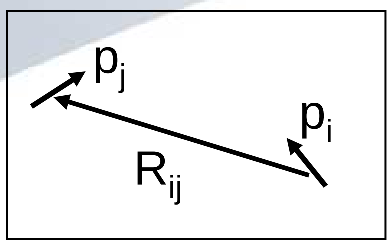
$$R = \mathrm{Im}\{\langle 0 / p / a \rangle \bullet \langle a / m / 0 \rangle\}$$
p: electrical dipole
m: magnetic dipole

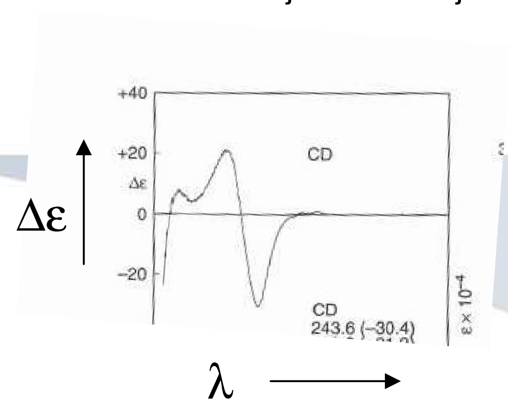
Second order effect: R ~10^{-4} ; CD = $(I_{right} - I_{left})/(I_{right}+I_{left})$ ~10^{-4}

•Exciton model to describe CD lineshape (1948 Davydov)



$R\alpha \sim +\mathbf{R}_{ij} \bullet (\mathbf{p}_i \times \mathbf{p}_j)$ $R\beta \sim -\mathbf{R}_{ij} \bullet (\mathbf{p}_i \times \mathbf{p}_j)$

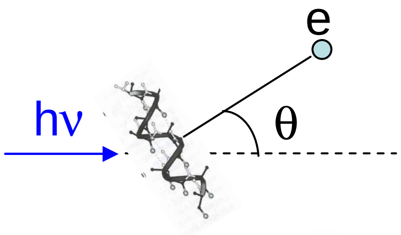




bisignate

- Ritchie (1976) : Asymmetric photoemission

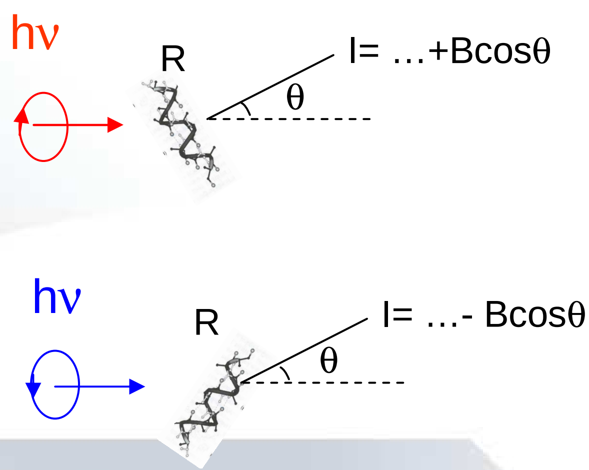
Randomly oriented chiral molecule:



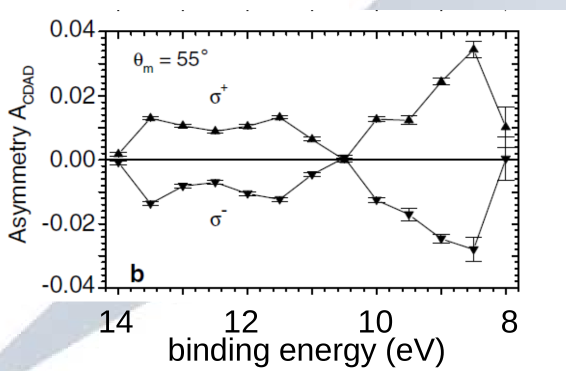
$$I(\theta)=\frac{\sigma}{4\pi}\left[1-\frac{\beta}{2}\left(\frac{3}{2}\cos^2\theta-\frac{1}{2}\right)\pm B\cos\theta\right]$$

+ dextrorotatory molecule
- levorotatory molecule

or



- Heizmann et al. (2004).
  Bessy, bending magnet , gas phase camphor



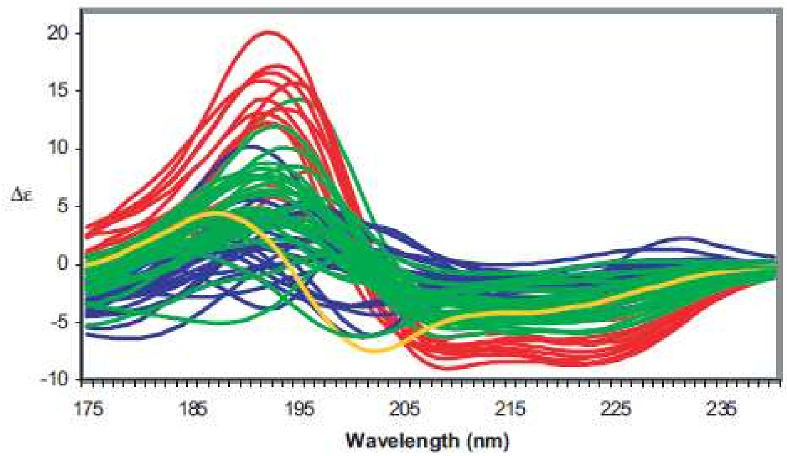
CD~10^{-2}

Examples of chiral spectroscopy

- Secondary structure of proteins

Biomolecules in solution: most extended application

Wallace et al.
72 spectra data set

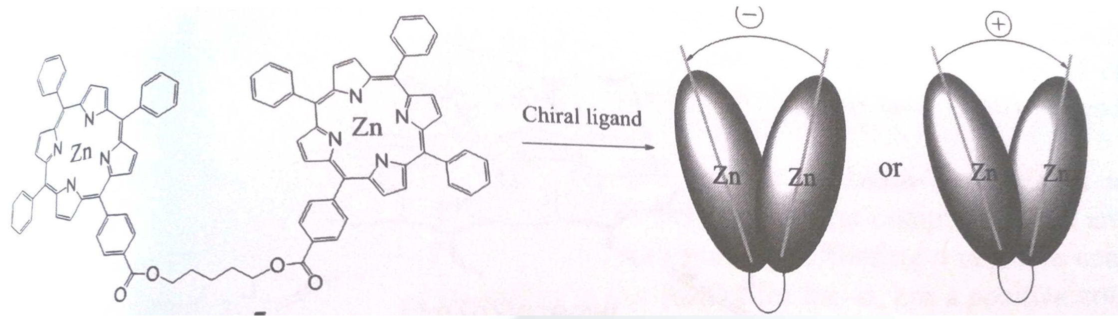


CD spectra of all the component proteins of the data base. The spectra of the mainly α-helical proteins are in red, the mainly β-sheet in blue , the mixed helical/sheet in green and the " other" are in yellow.

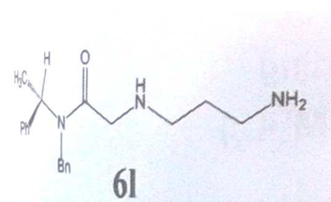
Examples of chiral spectroscopy. Chiral amplifiers

Molecules of weak optical activity chemically (covalently) bonded to initially achiral flexible molecules as porphyrines, produce intense CD due to the deformation of the porphyrine which induces chirality.

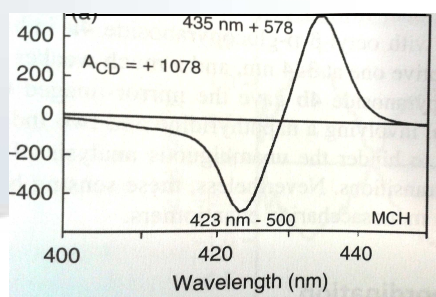
a



b



c



(a) zinc porphyrines may adopt two configurations upon binding with a chiral ligand they resemble scissors either right or left handed.
(b) (b) diamine ligand.
(c) ellipticity $\Delta\varepsilon$ in cm-1(mol/liter)-1 versus wavelength.
    The intense bisignated CD is a consequence of the interaction of the excitons

Examples of chiral phenomena: Switching supramolecular chirality

Supramolecular chemistry relies on the formation of intermolecualr bonds through a variety of interactions
Including electrostatic, van der Waals, hydrophobic, H-bonding, π-stacking, adsorption, entrapment …
The combined action of circular light and chiral structures may produce conformational changes…
Electronic CD is the main technique to investigate these phenomena

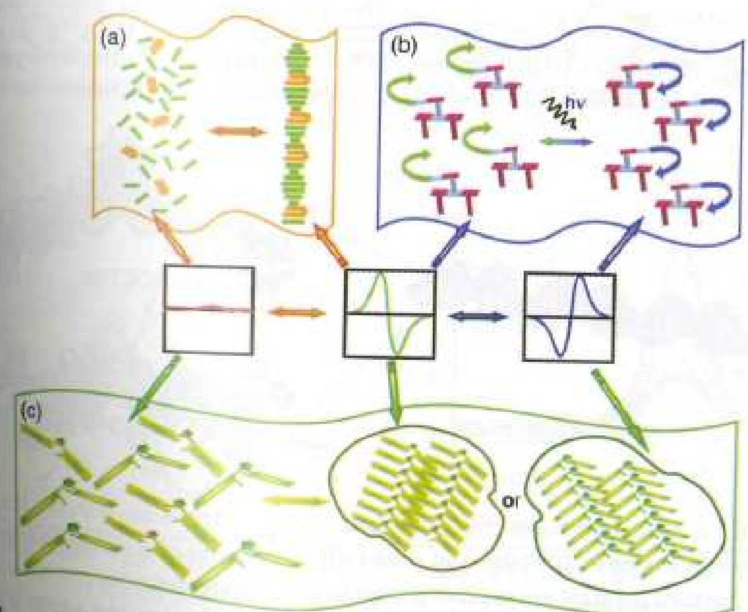
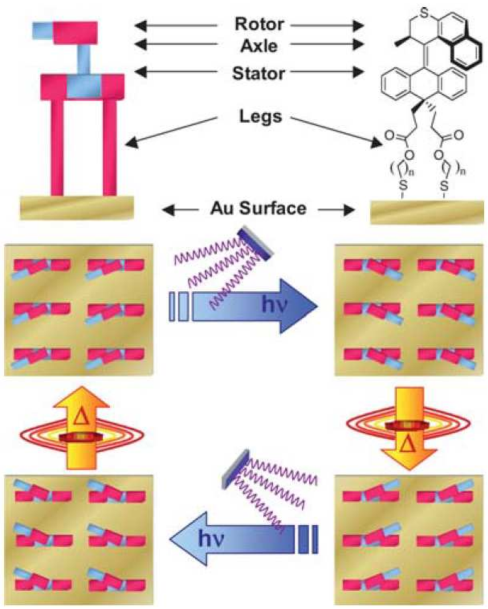
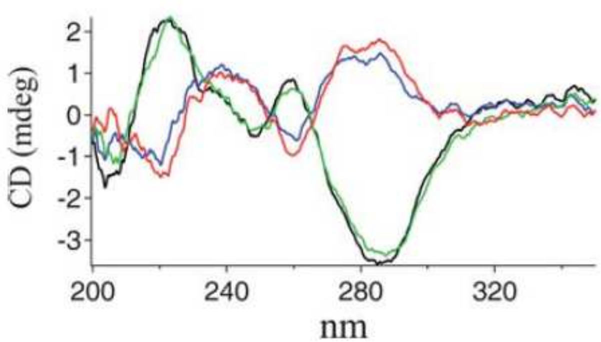


Figure 8.1. Dynamic chirality at the molecular and supramolecular level detected by CD spectroscopy. (a) A chiral molecule can direct achiral molecules to self-assemble into chiral supramolecular structures. (b) A chiral molecular switch or motor undergoes conformational changes that include inversion of molecular helicity. (c) Chiral molecules can self-assemble into chiral supramolecular structures, the chirality of which is determined by the enantiomer in excess.

Example: Molecular motor on a surface

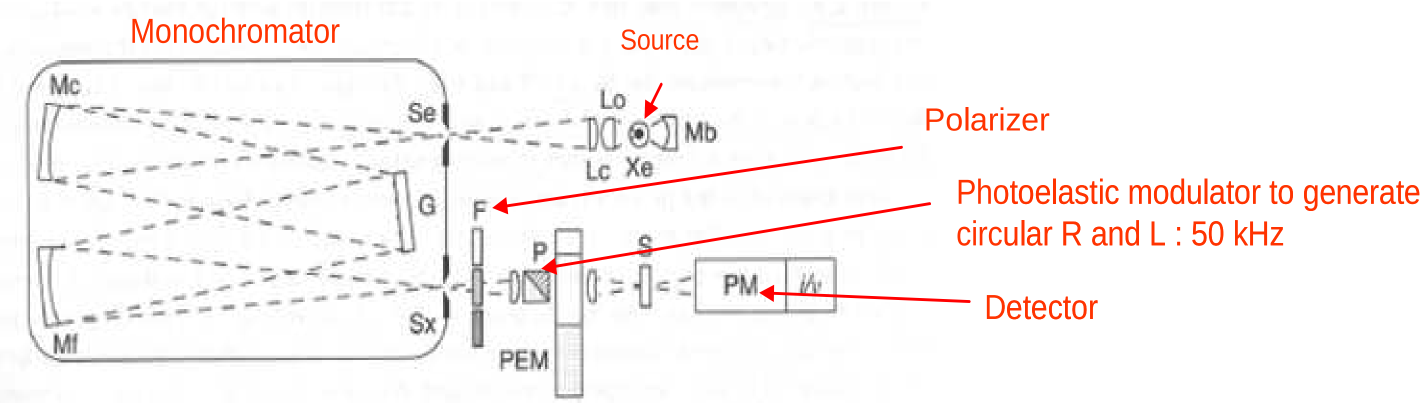




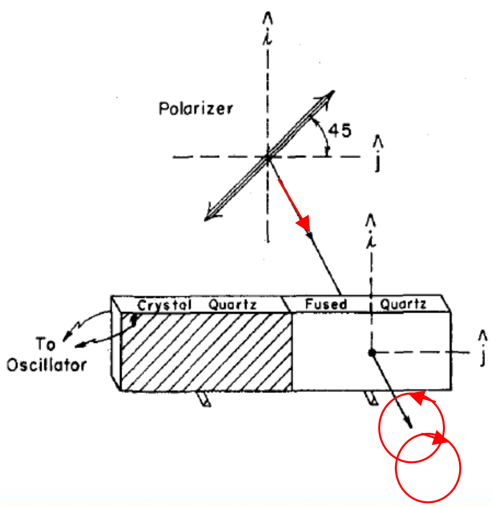
The thiol molecular layer, di-sulphur terminated, was adsorbed on a very thin film of Au (5nm) deposited on a coated quartz substrate.
The S-Au bond is strong enough to have the “legs “ of the thiol molecule firmly anchored on the metal. The head of the thiol is connected to the rest of the molecule by an axis that allows its rotation with a proper stimulus. The surface concentration of thiol molecules was about 10^{14} cm-2 . The initial spectrum (black) shows an inversion of the signal when the enantiomer is generated (red) by means of UV irradiation.

(Feringa et al.)

Almost 100% of the operating CD setups are based on an optical scheme, developed more twenty years ago, that has proven to be extremely good:

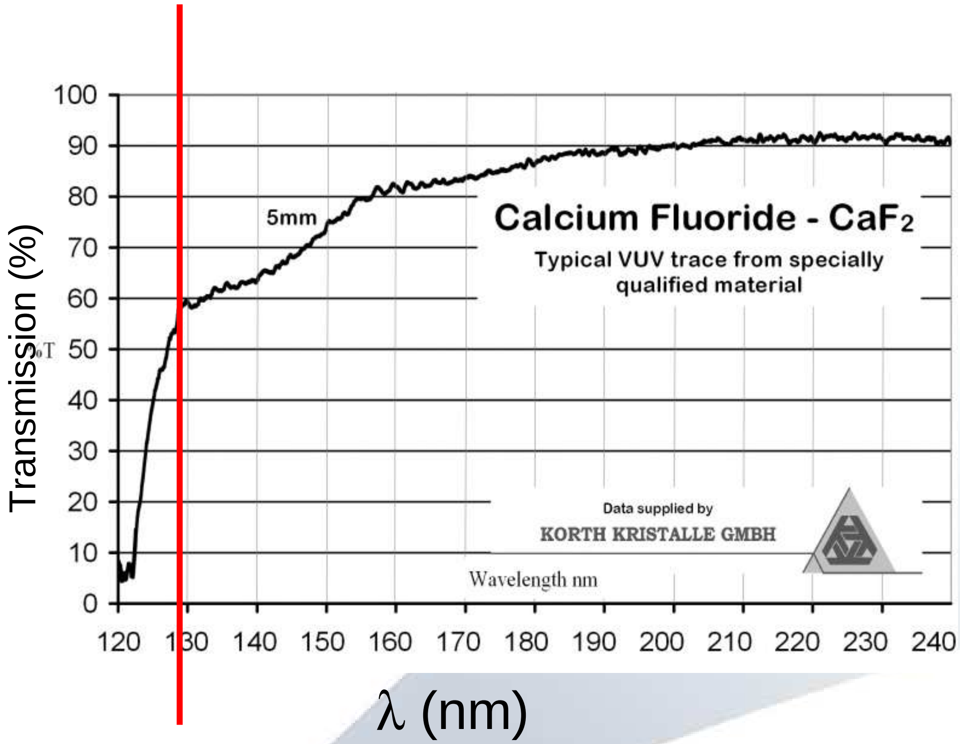


Photoleastic modulator



A periodically (~50 kHz) varying strain provokes oscillatory variations of the refraction index which originated phase changes resulting on R or L circular light at the exit

The transmission of filters and PEMs is determined by the band gap of the crystals which defines the available spectral range



130 nm – **9.5 eV**

All published CD spectra end at λ = 130 nm or above.

Synchrotron Radiation SRCD.

The enhanced flux of SR compared to laboratory discharge lamps has been used to improve the quality of the CD spectra

1980: Synchrotron Radiation Center of the University of Wisconsin-Madison: first spectra with much better signal to noise ratio than lab equipments

1990-2000: major growth of SRCD

At present ~14 beamlines worldwide. More than 4000 papers in 2007-2010 included SRCD for proteins

Table 1. *Characteristics of SRCD Beamlines* (2010)

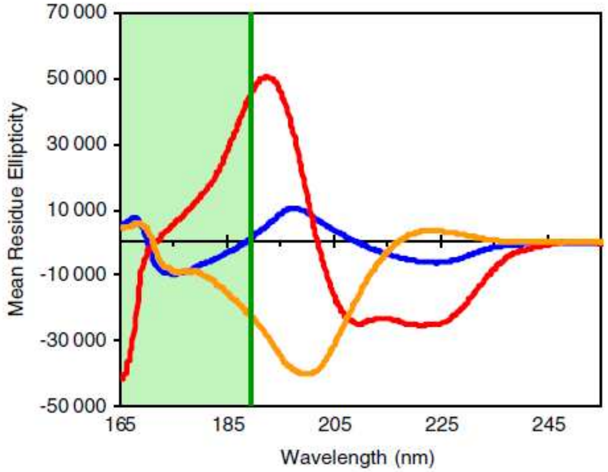
SRCD Beamline ID	U11	U9b	3.1	CD12	UV1	CD1	BL15	4B8
Synchrotron	NSLS	NSLS	SRS	SRS	ISA	ISA	HISOR	BSRF
Location	USA	USA	UK	UK	Denmark	Denmark	Japan	China
current status	operational	operational	closed	closed	operational	operational	operational	operational
added features	LD	SF,LD,F		SF	LD	LD		TJ,F
energy (Gev)	0·8	0·8	2·0	2·0	0·58	0·58	0·7	2·5
wavelength range	120–300	160–1500	130–350	100–700	130–450	115–350	140–310	120–350
max flux@ 240 nm (ph/s)	3·00E+12	9·00E+12	3·00E+10	2·50E+13	1·50E+11	1·00E+12	2·00E+10	8·00E+10
max flux@ 180 nm	2·50E+12	2·00E+12	4·00E+10	2·50E+13	1·50E+11	1·00E+12	8·00E+10	2·00E+11

SRCD Beamline ID	3m_NIM-C	04B1	BL-5B	B23	DISCO	CD12	U25	
Synchrotron	BESSY2	NSRRC	TERAS	Diamond	Soleil	ANKA	NSRL	AS
Location	Germany	Taiwan	Japan	UK	France	Germany	China	Australia
current status	operational	operational	operational	commission	commission	develop	develop	planning
added features	CF	SF(p)	LD	SF(p)	SF(p)			
energy (Gev)	1·9	1·5	0·3–0·8	3·0	2·75	2·5	0·8	3·0
wavelength range	130–300	130–330	70–250	120–300	120–600	120–350		
max flux@ 240 nm (ph/s)	2·00E+11	1·00E+11					1·50E+12	
max flux@ 180 nm	5·00E+10	1·00E+11					2·00E+12	

All in bending Magnets and utilize PEMs except TERAS

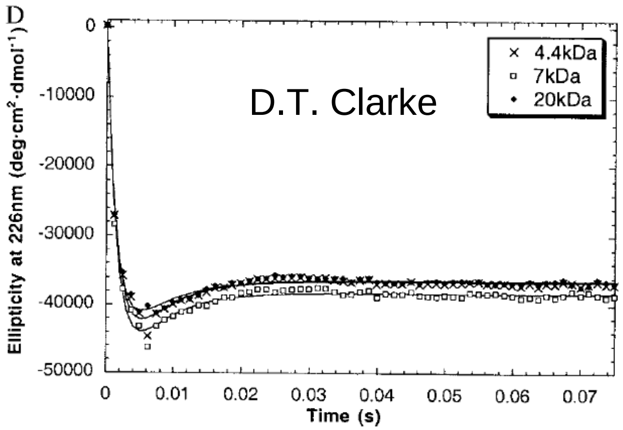
TERAS: small helical undulator source
DESIRS: e.m. helical undulator

The available photon flux generated at synchrotrons is about 2-3 orders of magnitude higher than laboratory instruments allowing to extend the usable wavelength range to short wavelengths even with low transmitting optical elements



Comparison of the wavelength ranges of conventional CD and SRCD spectra of several proteins. SRCD allows to probe the green area in addition to the white area measured in conventional laboratory CD instruments .

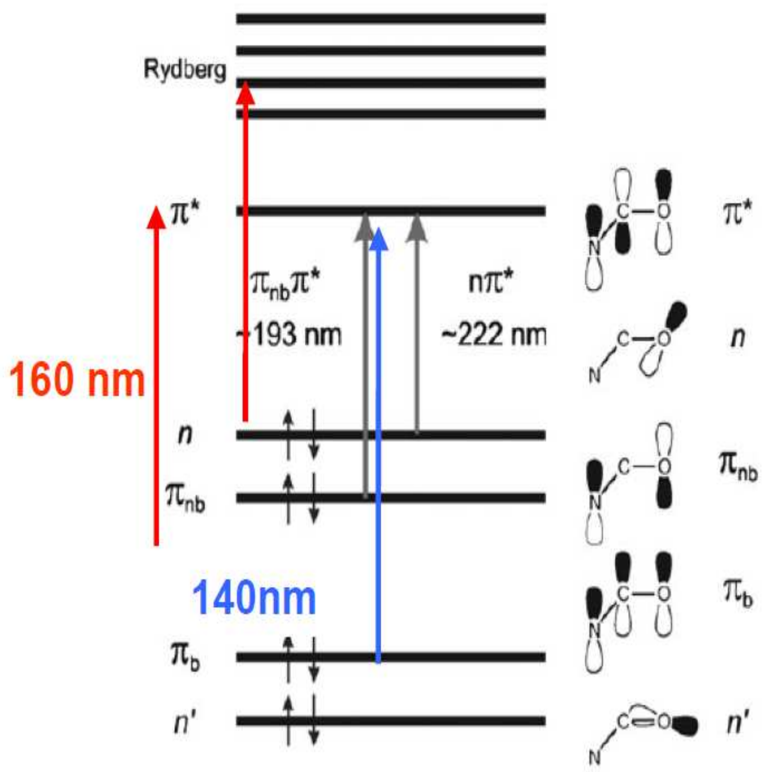
Example. Time resolved <1ms (on a second generation source)



Temporal evolution of the ellipticity at 226 nm revealing the kinetics of the a helix folding rate. A fast initial decay till 5 ms is followed by a slower kinetics

Motivation of Skiron. Branch A: Investigate CD of deep molecular orbitals

Consider the familiar amide group

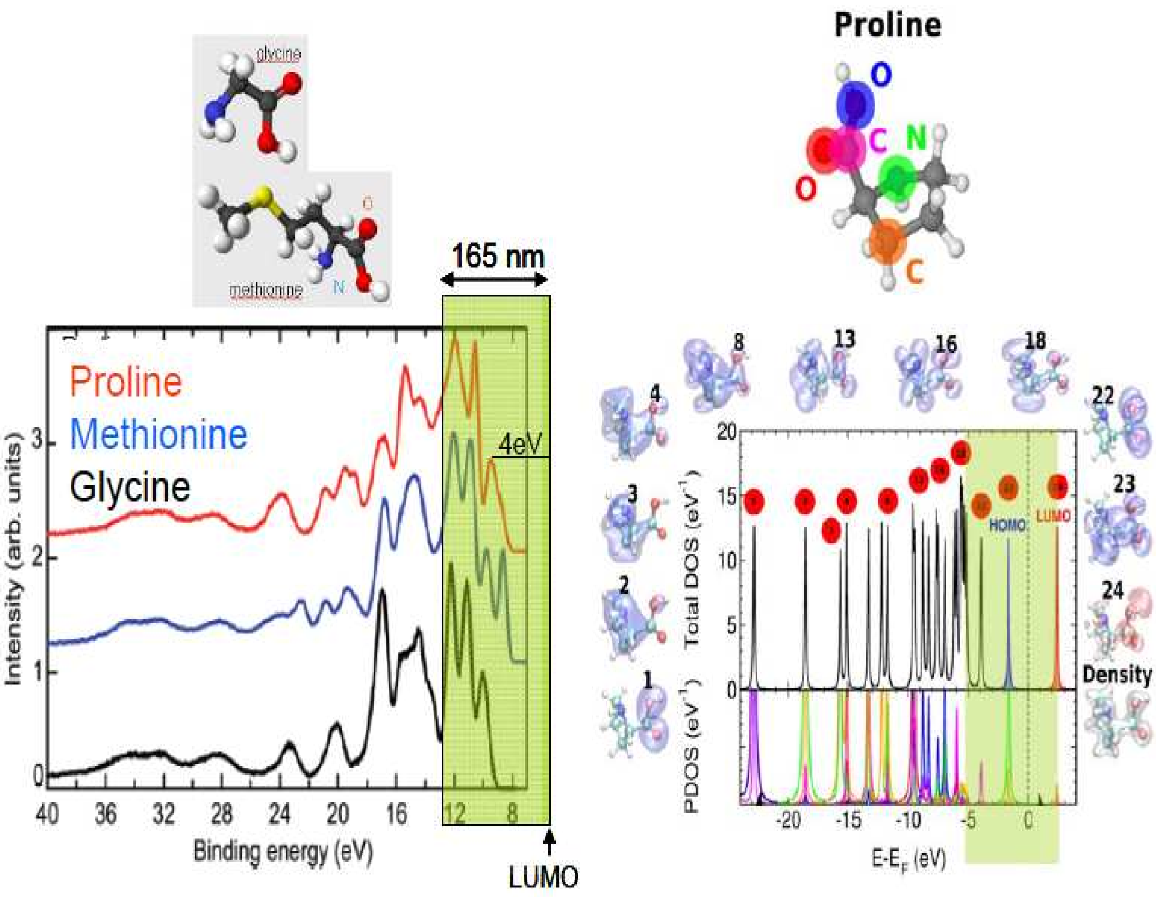


193 nm positive band in a helix and a negative one at 208 nm from exciton splitting

160 nm shortest λ with conventional apparatus

π_b and n. to π^* non accessible

Gas phase photoemission of simple aminoacids



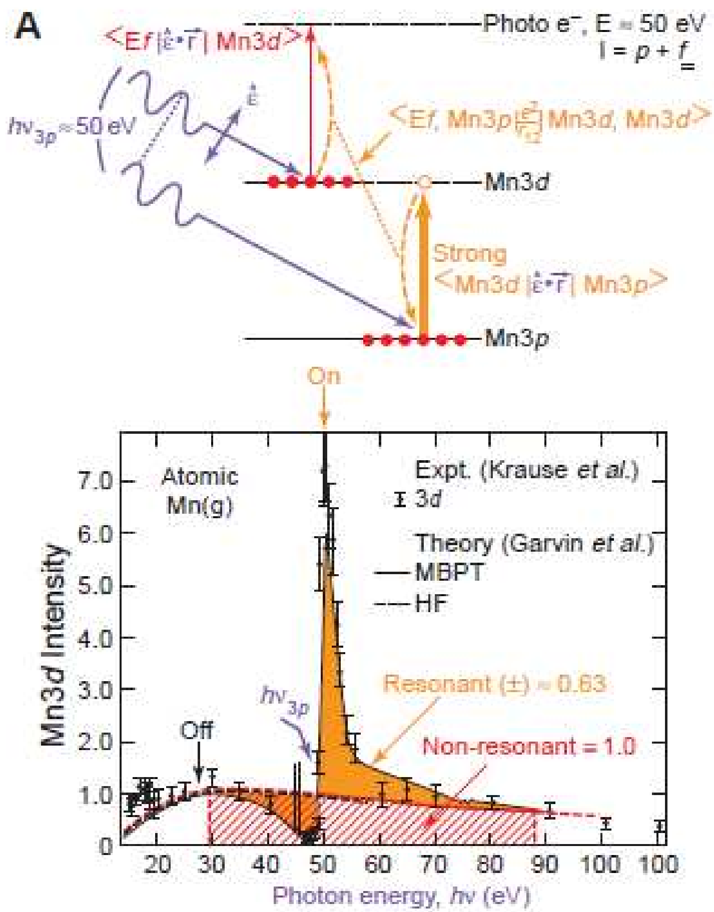
The HOMOs are at 9/10 eV binding energy and from HOMO to the continuum not reached

In proline only 18,22, 24 are possible

Increased photon energies would allow to excite additional electronic transitions that might be optically active and provide additional spectroscopic information. That comprises transitions from deep molecular orbitals to the LUMO or transitions from occupied orbitals to the continuum

Resonant photoemission

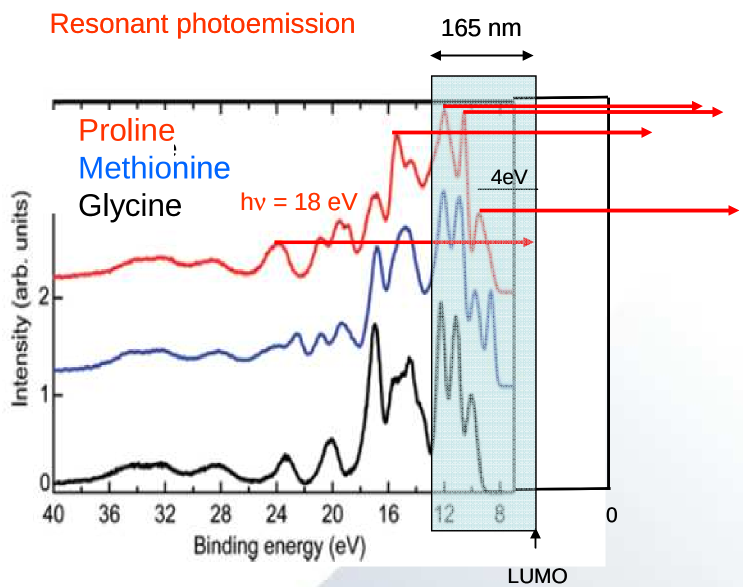
In addition to standard photoemission, resonant photoemission offers new oppostunities



Top:
Schematics of the resonant process due to the interaction of the two optical transitions. The strong dipolar transition 3p-3d couples to the photoemission channel 3d-continuum.

Bottom:
Photoemission intensity from 3d to the continuum vs photon energy. The colored orange region indicates the resonant part of the intensity.

Resonant photoemission

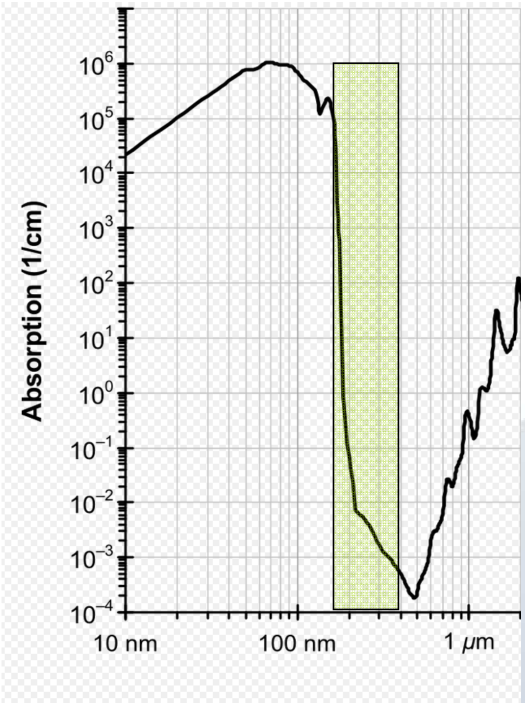


Examples of possible resonant photoemission at hν = 18 eV in proline molecules.

several resonant process from the upper molecular orbitals to the continuum are in principle possible and might result in increased photoemission yields and perhaps in distinct optical activity.

Summarizing, we consider that the above arguments and examples provide a basis to expect that interesting scientific results may emerge from exploring the optical activity of deep molecular orbitals which is the main motivation of the branch A of Skiron.

Deep molecular orbitals of molecules in solutions: the opacity of water below ~150 nm

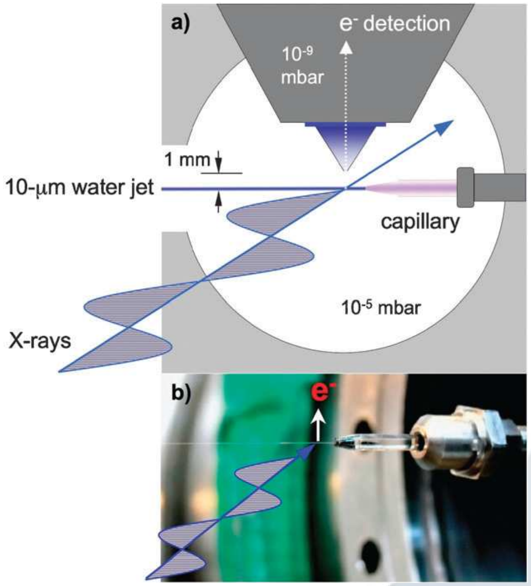


Optical absorption of liquid water. The rectangular green area denotes the wavelength range available from existing laboratory instruments and beamlines. At λ= 160 nm the 1/e attenuation length is ~102 μm and at l = 140 nm is ~0.05 μm . There is a "hard wall" in transmission for λ ≤ 150 nm approximately .

Liquid jets

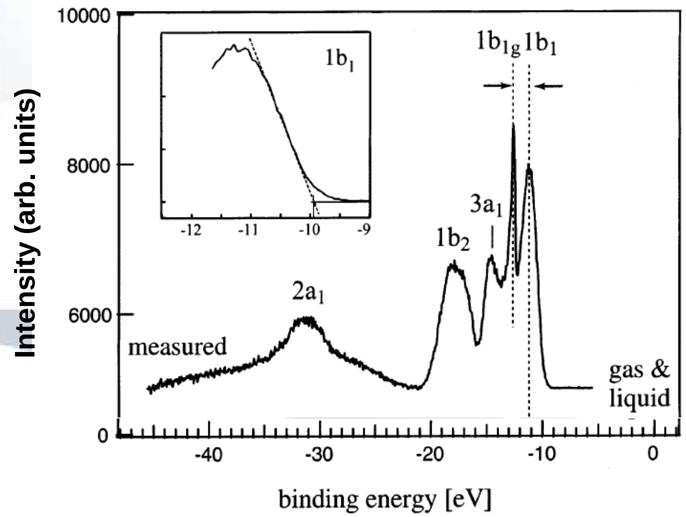
To circumvent the water "hard wall " photoemission is a solution:

Liquid jet photoemission (Faubel)



Schematics of the liquid jet system.
The liquid jets are formed by establishing a pressure of 5-20 bar of liquid in the back side of a 10-15 mm diameter nozzle situated at ~2mm from the photon beam direction and at ~1 mm from the entrance nozzle of an electron energy analyzer with one stage of differential pumping.

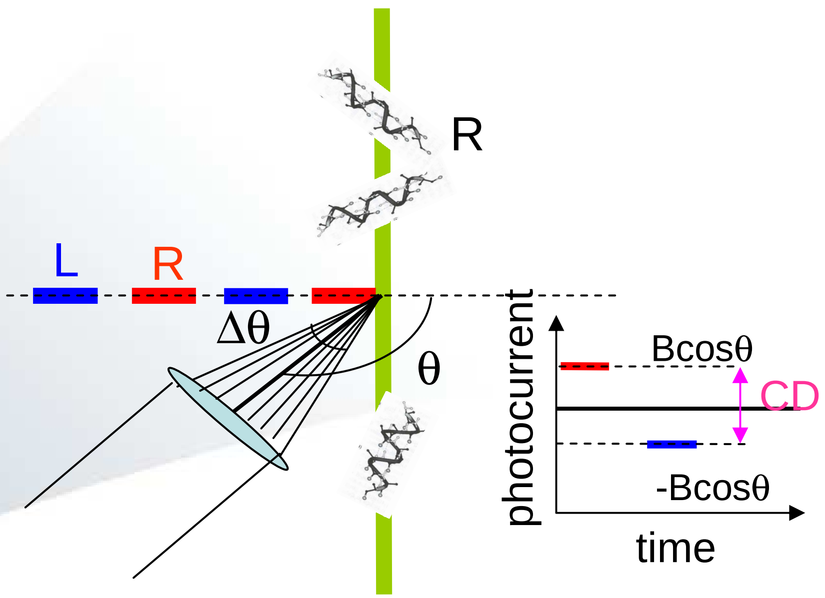
Valence band photoemission from liquid water (hν = 60 eV). The molecular orbitals are indicated. The sharp peak 1b1g arises from vapor at the vicinity of the liquid jet. The zero binding energy refers to the vacuum level.



Skiron branch A motivation . Summary:

Skiron aims to explore the optical activity of deep molecular orbitals of molecules in solution by means of electronic CD measurements using asymmetric photoemission from liquid jets.

Measuring the difference in photocurrent originated from the absorption of right and left circularly polarized light within a fixed $\Delta\theta$ angular range).



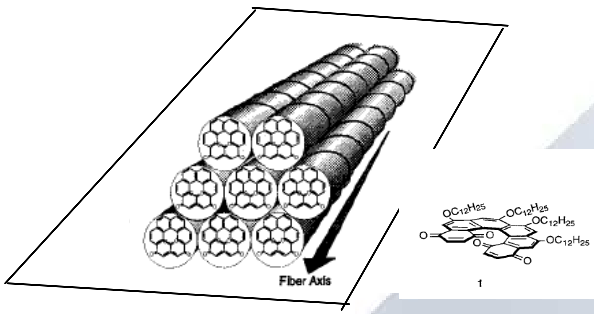
As a secondary application, gas phase studies may be considered but this will be somewhat marginal since other beamlines as DESIRS are highly specialized in this area.

Motivation of Skiron : Branch B

CD measurement in anisotropic media

The optical activity of anisotropic media consist of circular and linear dichroism and birefringence.

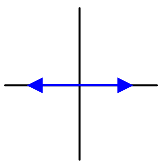
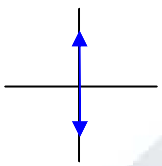
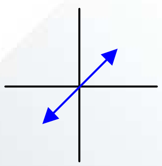
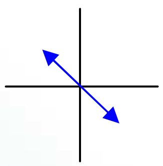
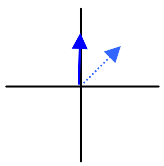
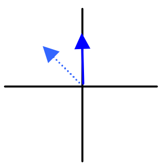
This is the case, for example, of chiral molecules of elongated shape that self assemble in a preferred direction , or thin films



Linear dichroism : differential absorption between linear polarized light along or normal to the fiber axis

Skiron B branch: complete polarization analysis: anisotropic systems

The Stokes vector

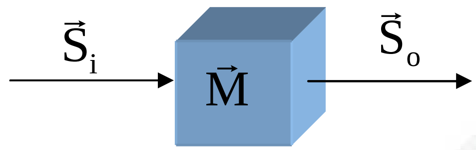
I_0	I_{90}	I_{+45}	I_{-45}	I_r	I_l
					

S_0 : total intensity

$S_1 : I_0 - I_{90}$

$S_2 : I_{+45} - I_{-45}$

$S_3 : I_r - I_l$



$$\vec{S}_o = \vec{M}\vec{S}_i$$

$$\vec{M} = \begin{pmatrix} M_{00} & M_{01} & M_{02} & M_{03} \\ M_{10} & M_{11} & M_{12} & M_{13} \\ M_{20} & M_{21} & M_{22} & M_{23} \\ M_{30} & M_{31} & M_{32} & M_{33} \end{pmatrix}$$

Basic retardances and absorbances

n_x: refraction index in direction x ; k_x : absorption coeff. in deirection x

Effect	Symbol	Definition
Isotropic phase retardation	η	$2\pi nd/\lambda_0$
Isotropic amplitude absorption	κ	$2\pi kd/\lambda_0$
x-y linear birefringence	LB	$2\pi(n_x-n_y)d/\lambda_0$
x-y linear dichroism	LD	$2\pi(k_x-k_y)d/\lambda_0$
45° linear birefringence	LB’	$2\pi(n_{45}-n_{135})d/\lambda_0$
45° linear dichroism	LD’	$2\pi(k_{45}-k_{135})d/\lambda_0$
circular birefringence	CB	$2\pi(n_{-}-n_{+})d/\lambda_0$
circular dichroism	CD	$2\pi(k_{-}-k_{+})d/\lambda_0$

Mueller matrix for samples with mixed anisotropies

* First order approximation (thin film layer, solutions with low concentration)

$$\begin{pmatrix} 1+\frac{1}{2}(LD'^2+LD^2+CD^2) & -LD+\frac{1}{2}(CB\cdot LD'-LB'\cdot CD) & -LD'+\frac{1}{2}(LB\cdot CD-CB\cdot LD) & CD+\frac{1}{2}(LB\cdot LD'-LB'\cdot LD) \\ -LD-\frac{1}{2}(CB\cdot LD'-LB'\cdot CD) & 1+\frac{1}{2}(LD^2-LB'^2-CB^2) & CB+\frac{1}{2}(LD\cdot LD'+LB\cdot LB') & LB'-\frac{1}{2}(CB\cdot LB+CD\cdot LD) \\ -LD'-\frac{1}{2}(LB\cdot CD-CB\cdot LD) & -CB+\frac{1}{2}(LD\cdot LD'+LB\cdot LB') & 1+\frac{1}{2}(LD'^2-LB^2-CB^2) & -LB-\frac{1}{2}(CB\cdot LB'+CD\cdot LD') \\ CD-\frac{1}{2}(LB\cdot LD'-LB'\cdot LD) & -LB'-\frac{1}{2}(CB\cdot LB+CD\cdot LD) & LB-\frac{1}{2}(CB\cdot LB'+CD\cdot LD') & 1-\frac{1}{2}(LB^2+LB'^2-CD^2) \end{pmatrix}$$

Commercial equipment and SR beamlines operate with one photoelastic modulator

The measurement of the dichroic absorption = M03 = CD+½(LB.LD'-LB'.LD)

If the sample has linear dichroism or birefringence M03 ≠ CD

Commercial equipment and SR beamlines operate with one photoelastic modulator

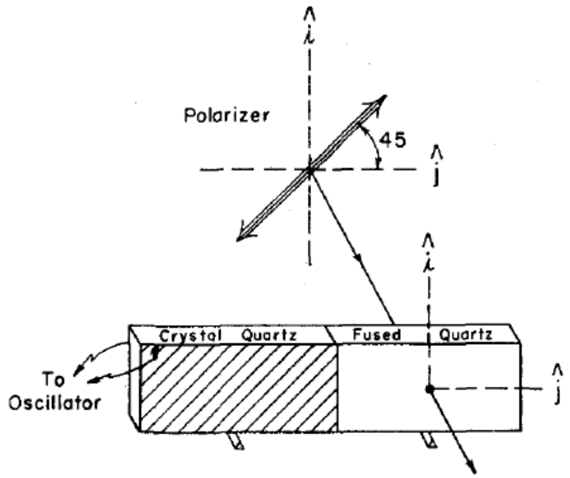


FIG. 1. Polarization modulator.

The measurement of the dichroic absorption = M_{03} = CD+½(LB.LD'-LB'.LD)

If the sample has linear dichroism or birefringence $M_{03} \neq$ CD. This occurs often in thin films, molecules in a non isotropic environment, fibrous proteins … and may lead to incorrect interpretations if the linear effects are ignored.

Recently a 4-PEM device has been built allowing:

Simultaneous measurements of all 16 Mueller matrix elements in real time without moving any optical component

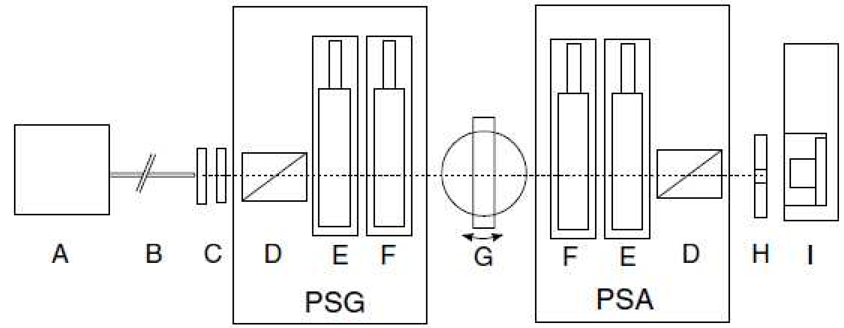
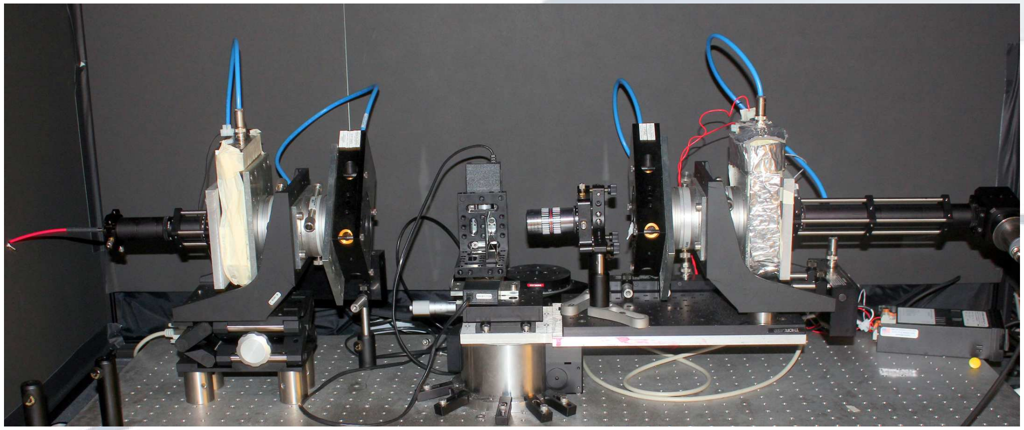


Fig. 3. Schematic diagram of the 4-PEM. Light travels from left to right. A, xenon arc lamp and monochromator; B, optical fiber; C, lenses; D, polarizer; E, PEM at 90°; F, PEM at 45°; G, sample and rotation stage; H, iris; I, detector.

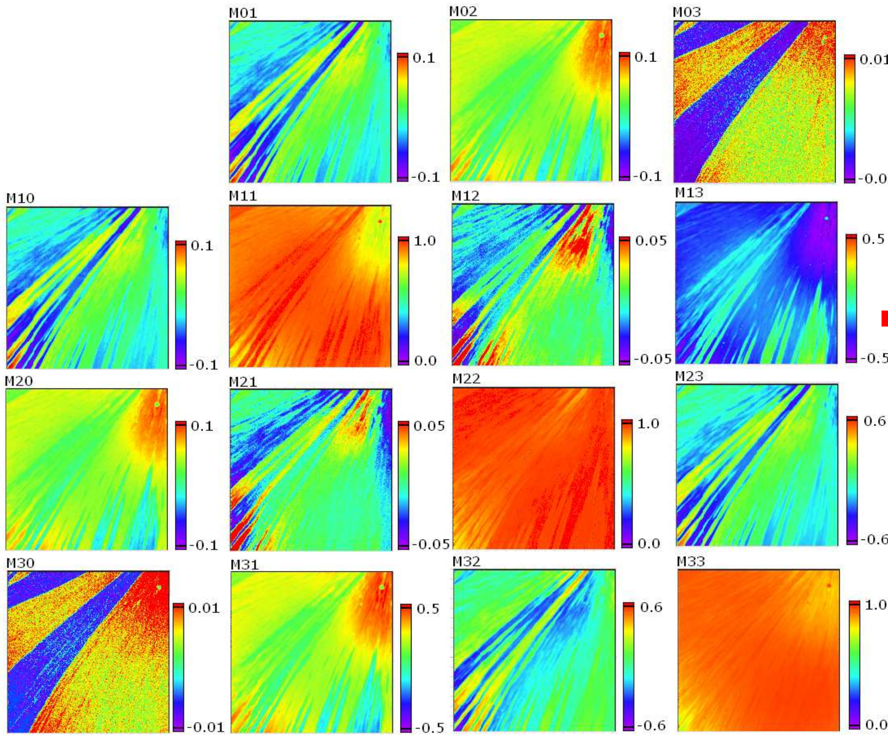
(O. Arteaga, B. Khar
Applied Optics, **51**, 6805 (2012))



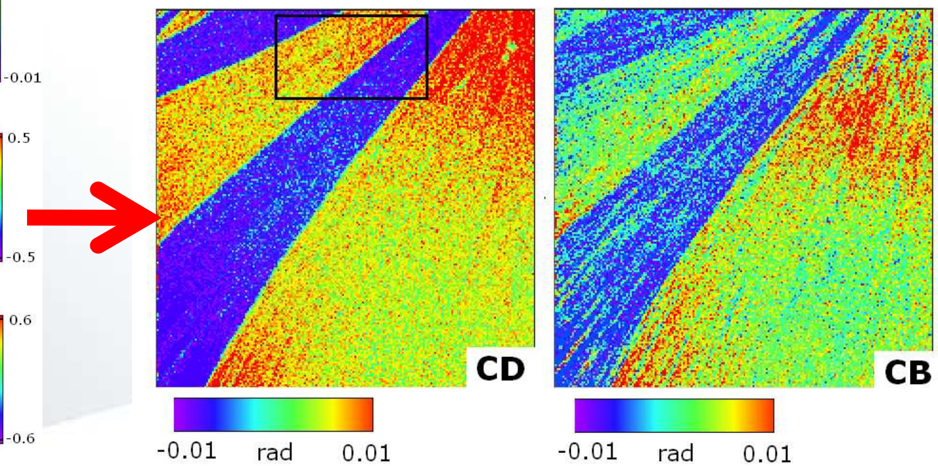
The side branch of skiron will use horizontally polarized BM radiation and a 4 PEM device in air.

Applications examples:

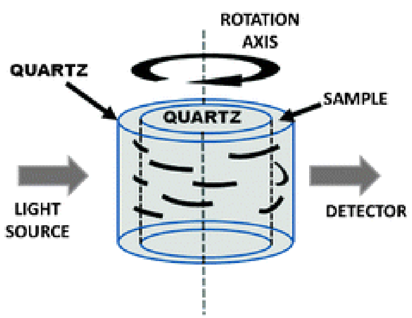
Chiral domains in polycrystalline samples of benzil crystallized from the melt



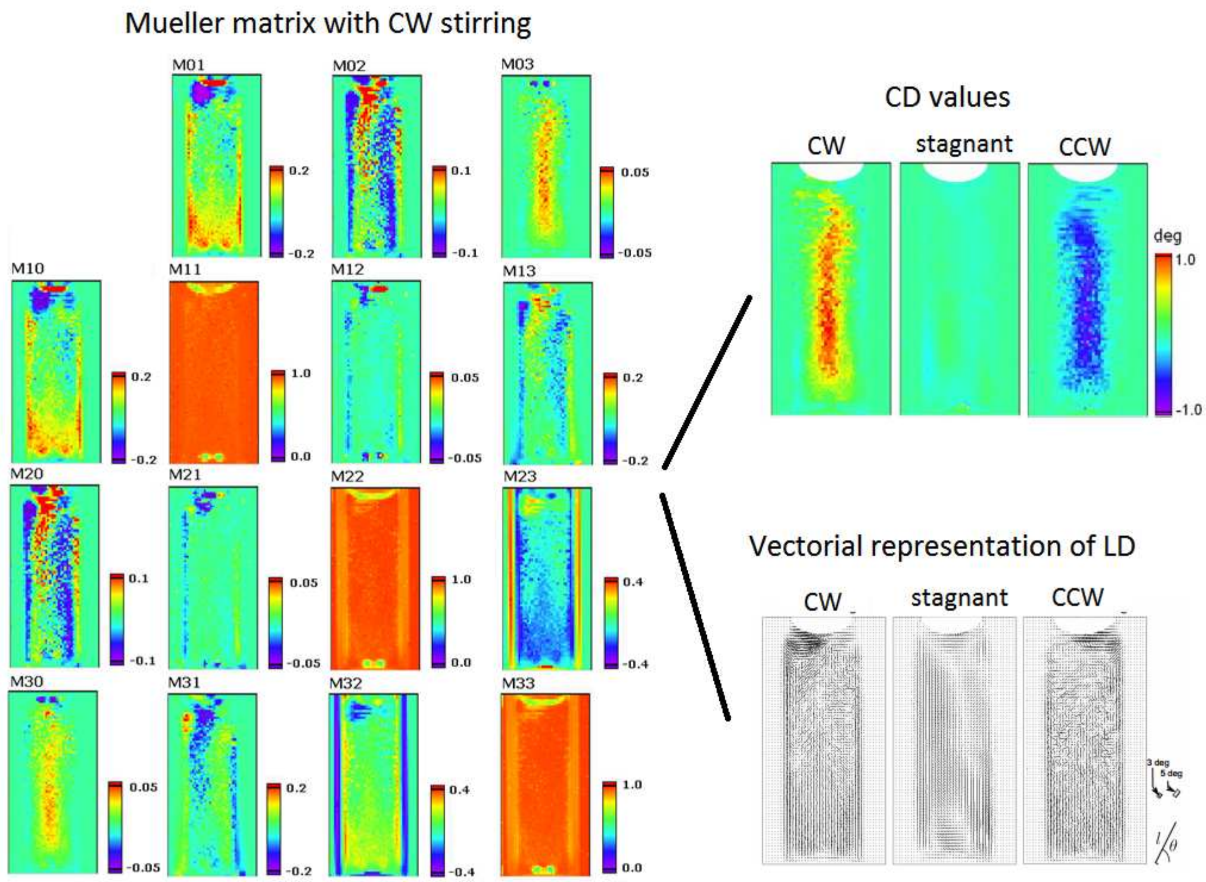
8x8 mm^2



λ = 400 nm

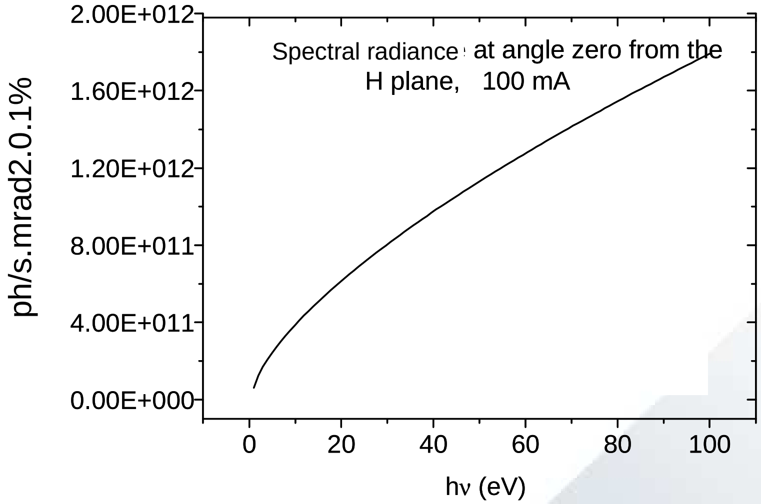


(Left) Normalized spatially resolved Mueller matrix of clockwise (CW) stirred solution of J-aggregates measured at 485 nm. The dimension of each frame is 29 mm x 14.4 mm. (Right) CD and LD values as obtained from the Mueller matrix for CW, CCW stirring and in stagnant conditions.



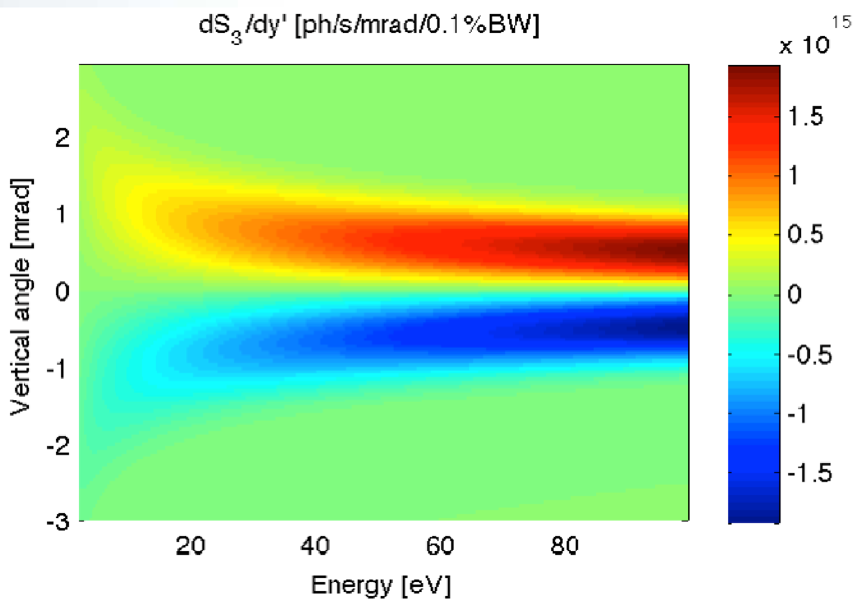
Skiron : Conceptual optical design

Source properties

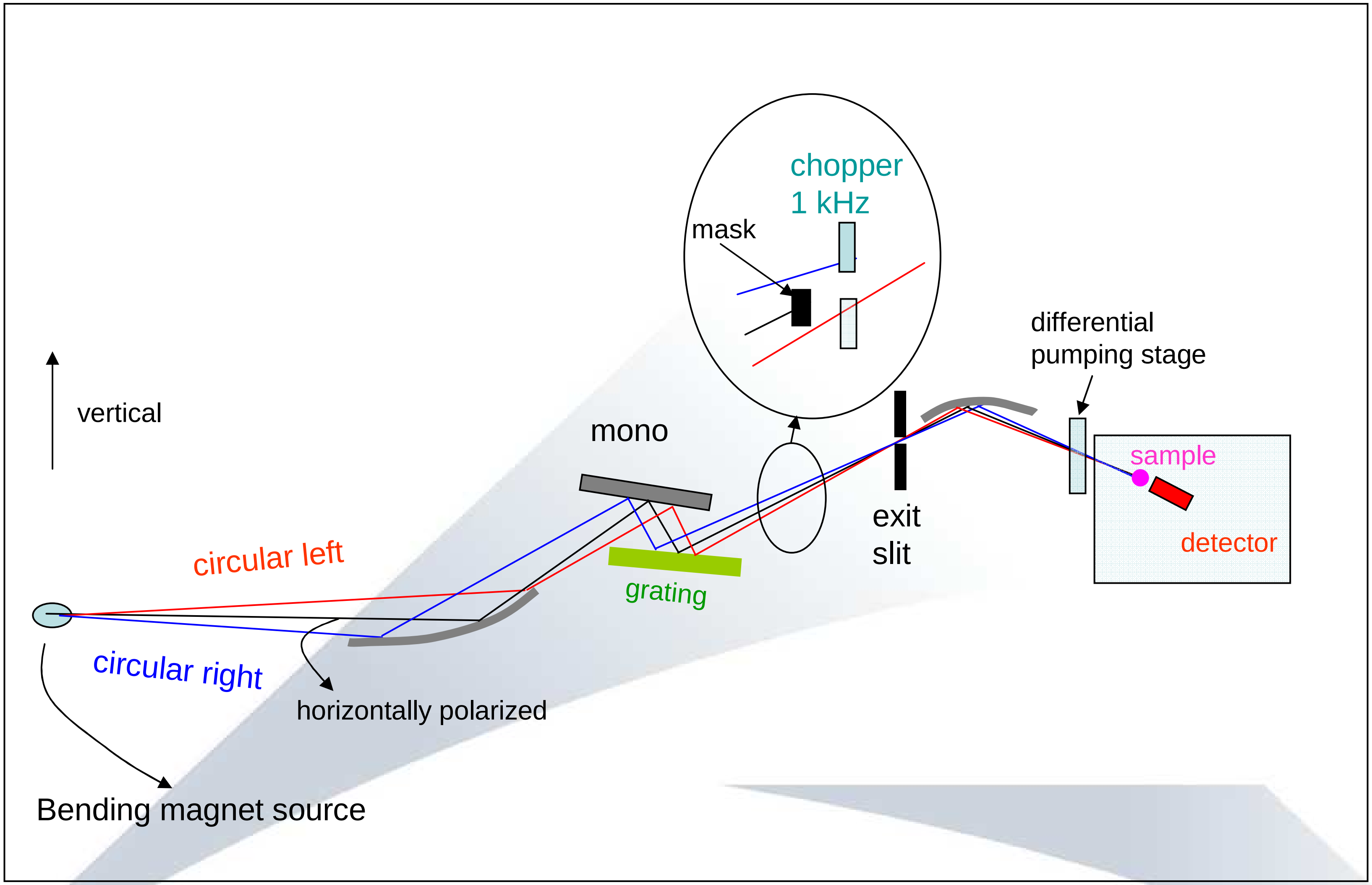


Circular polarization

$$S3 = \pm 2\sqrt{IxIy}$$



Skiron: schematic optical principle

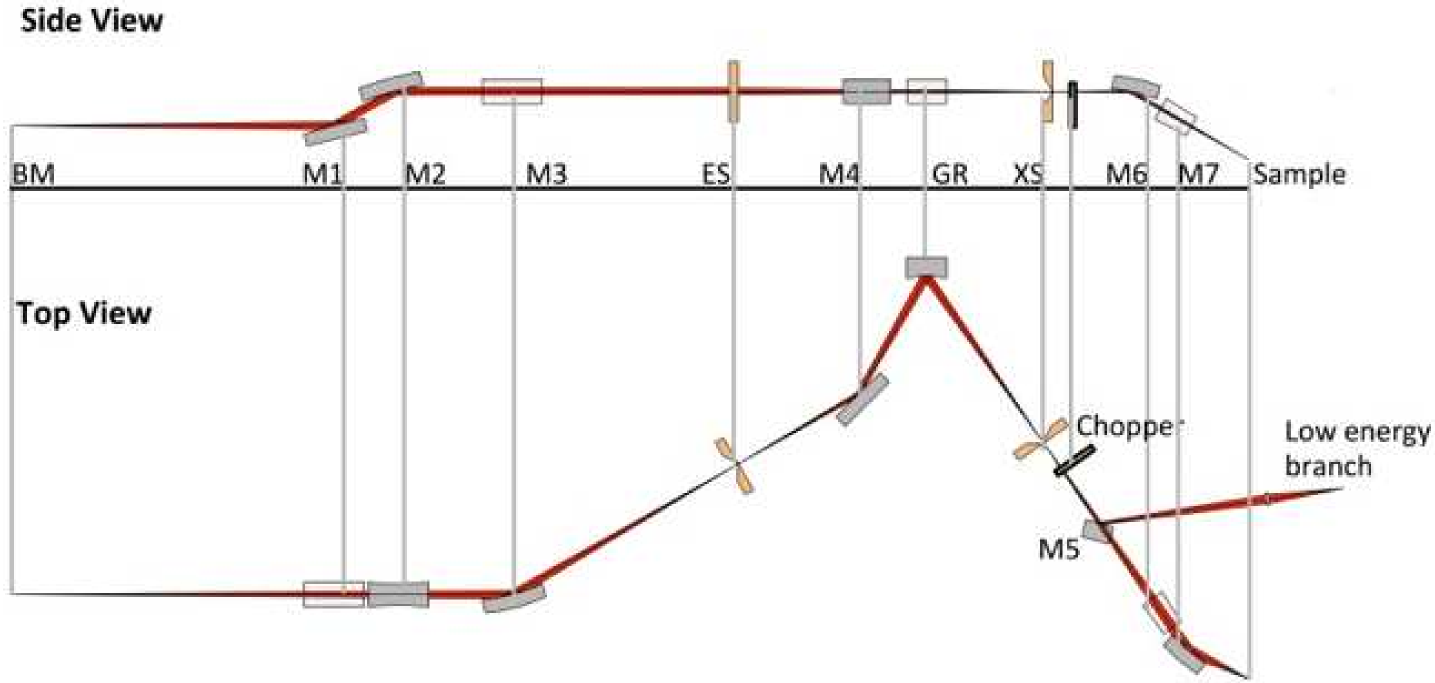


windowless from source to sample

Preliminary Optical design

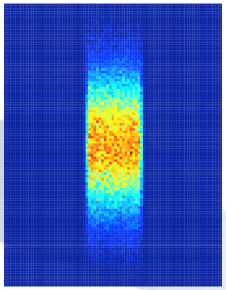
General considerations:

- Symmetry respect the H plane to equally weight R and L polarizations
- Large vertical acceptance to achieve high polarization rate
- Large horizontal acceptance to maximize flux
- 4-60 eV scanning moving only the grating. One or two gratings.
- Fit in the Alba experimental hall



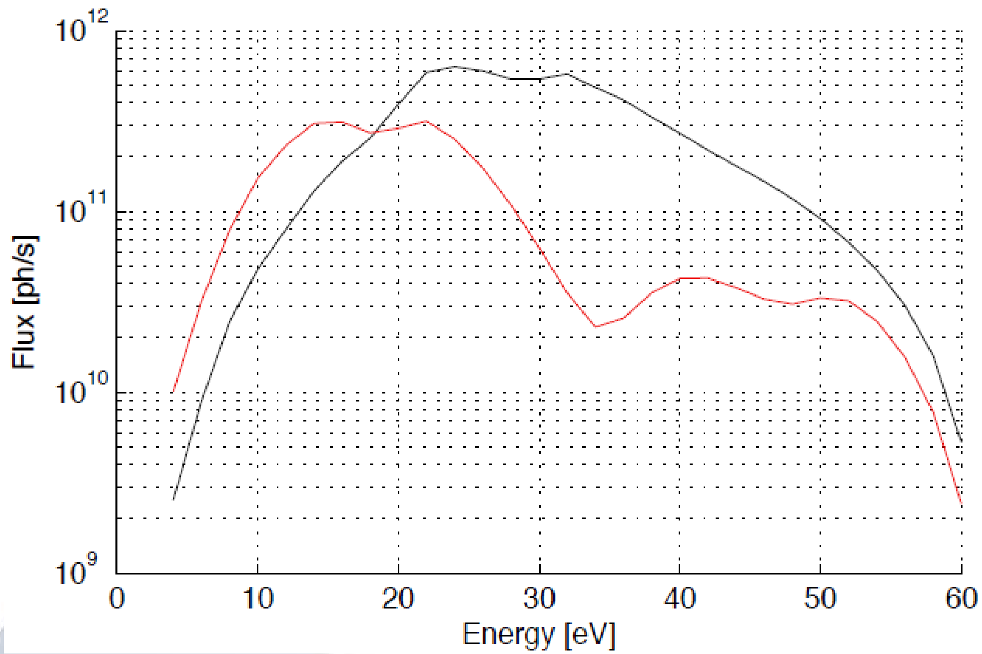
M1: flat, absorbs power, water cooled (referee)
M2: plano elliptic, V focusing at exit slit (XS)
M3: " " H focusing at entrance slit (ES)
M4: flat, deviates to grating
Gr: spherical grating: H focusing to XS
Ch: chopper
M5: Flat mirror do deliver beam to branch B
M6-M7: KB mirror pair focusing at the sample

Sample



17(H)x32(V)μm^2

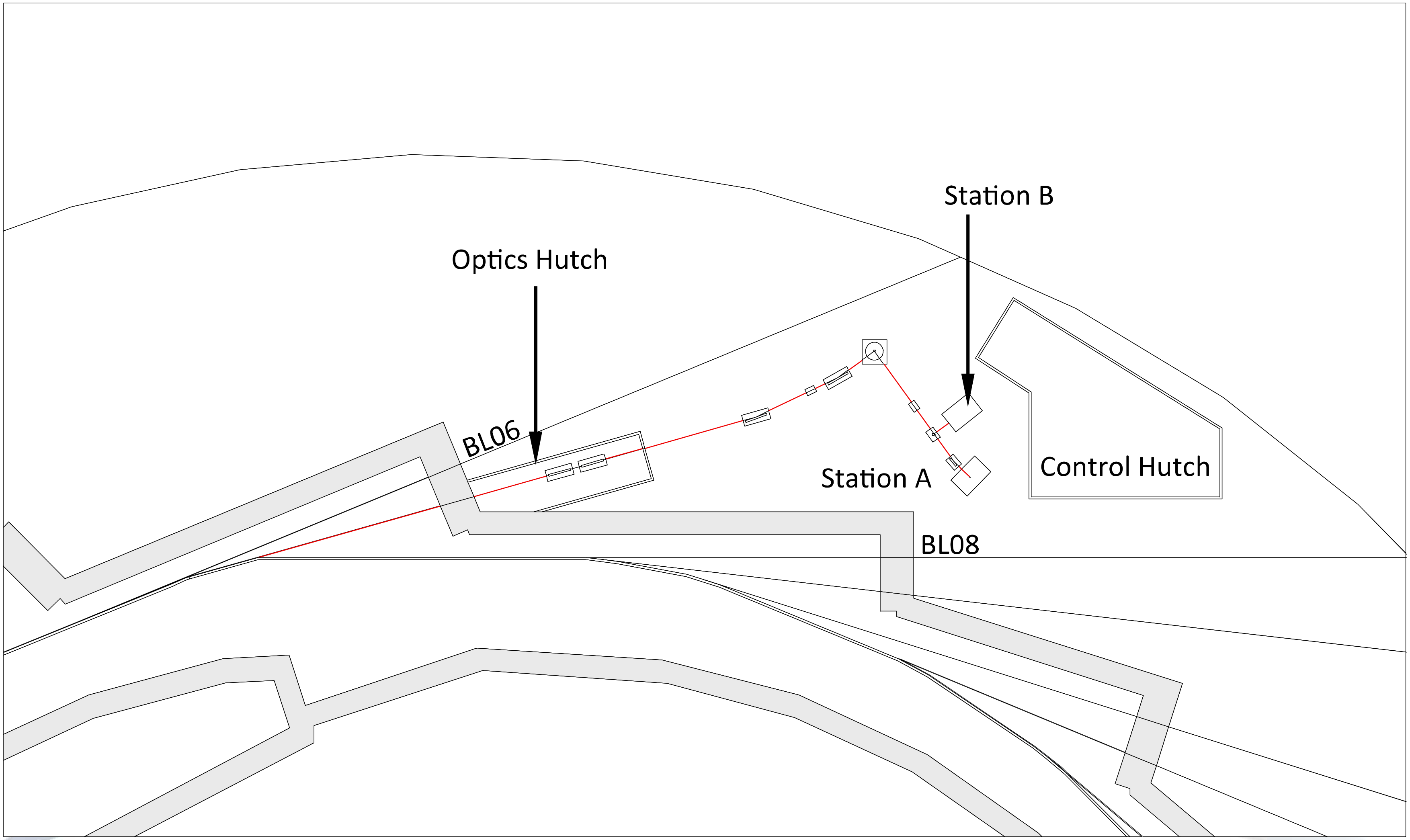
Flux on the sample. Corrected fig 4.15 (referee)



(400 mA, 3 mrad H, all V)

Figure 4.15. Flux on sample, at the actual resolution. The black curve corresponds to a grating without inversions of the S3 component. The red curve corresponds to a grating with high efficiency for the low energies.

Layout of Skiron in the Experimental Hall



Mirror reflectivity

Two key issues: Reflectivity and phase shifts

1) Reflectivity : Al coating is good choice but not realistic (referee).
   Need to think on other

2) Phase shifts : The changes of phase of the s and p components may affect S3 values significantly. Need to be careful with this.

The present design allows control of the phase l changing the angles of M1 and M2

Instrumental aspects

A unique feature of Branch A is the ~1kHz chopping of R and L .
Why this is important ?

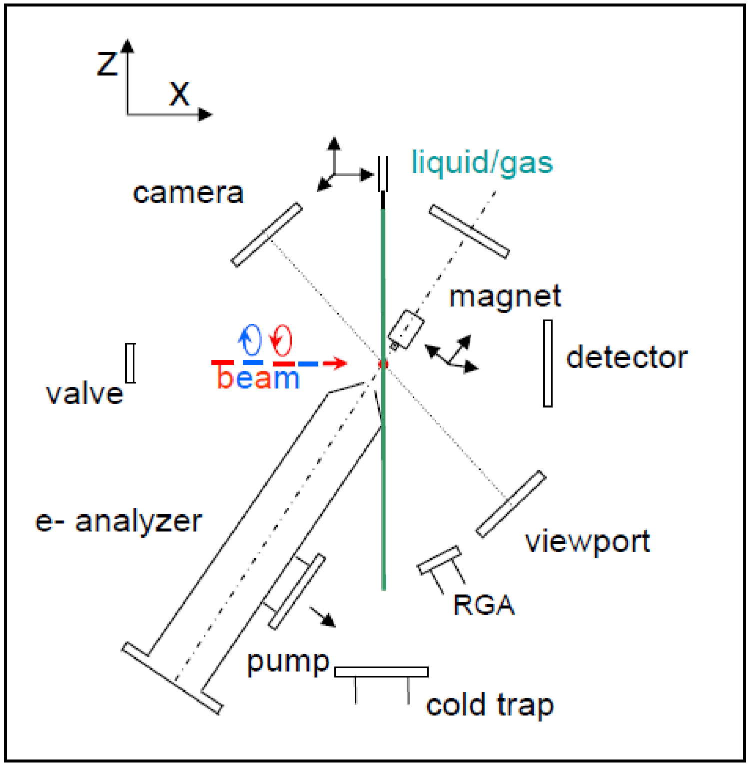
1 kHz is above: eigenfrequencies of vibrations
50 Hz + harmonics electronic noise
150 Hz Alba feedback loop
50-100 Hz roughing pumps
630 Hz turbo pump 1200 l/s

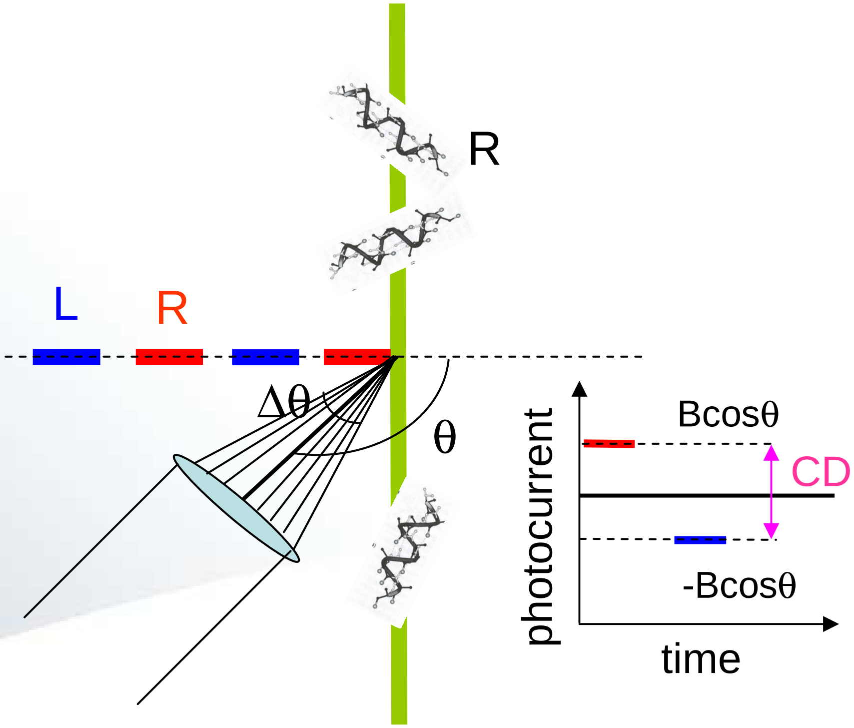
We would like to reach CD of 10^{-4} or less. To achieve it, more important than the photon flux is the S/N which may be increased a lot by Fourier filtering.

The S/N is determined NOT by the $\sqrt{N}$ statistical fluctuations of the photon flux but by the drifts of the signals

(Commercial instruments operate at ~50 kHz successfully to measure CD ~10^{-3} - 10^{-4})

End Station. Branch A





Electron analyzer : electrostatic or Time Of Flight (hybrid filling) ?

Estimated Costs

	kilo euro
Front end	165
Personnel Safety System	76
Optics hutch	100
Fluids	50
Mechanical installations	80
Electrical installations	52
Conventional hutch (including furniture and climatization)	38
Computing equipment and infrastrucure (cables, network, PLC, icepaps, computers..)	78
Computing and control: External Manpower	68
Mechanical hardware (frames, motion…)	150
Vacuum components (pumps , valves , gauges)	175
Diagnostics	50
Optics: monochromator	250
Optics : M1,M2, M3, M4 and M5 mirrors and mechanics	750
Optics: M6-M7 mirrors KB pair	180

End station A	
Electron analyzer with electronics	170
Vacuum chamber and positioning hardware	60
Turbo pums and roughing (2)	40
Liquid jet complete set up	55
Diagnostics detector and mounting	25
Ancillary	50
End station B	
4 PEM	92
Optics harware (windows, filters optomechanics ..)	17
Detector	18
Optical table	40

Precision mechanics	11
Computers and control	11
Ancillary	25
Total	2876
Contingency 10%	288
TOTAL	**3163**

Potential Users and scientific impact.

Branch B:

In Spain there are 30 operating Laboratory equipments from Jasco. Their users are potential users of Skiron

Branch A:

Unprecedented experiments. Hopefully will attract scientists at national and international level.

U Autonoma Madrid - Ctro. Biología Molecular Severo Ochoa
Universidad de Sevilla – F. Ciencias – Química Inorgánica
U La Laguna - Instituto Universitario de Bio-Orgánica (IUBO)
U La Laguna - F. Biología - Biología Animal
U Autonoma Barcelona - F. de Ciencias - Servei d'Anàlisi Química
U Santiago Compostela - F. Química - Química Orgánica
U Granada - F. Ciencias - Química Física
U Complutense Madrid - F. Químicas - Bioquímica
U Alcala Henares - F. Ciencias - Química Física
U Granada - F. Ciencias - Química Física
U Alcala Henares - F. Farmacia - Química Física
Universitat de Barcelona - Serveis Suport Recerca
U Santiago Compostela - F. Química - Química Orgánica
U Miguel Hernandez - Inst. Biología Molecular y Celular
U Almeria - F. Ciencias Experimentales - Área Bioquímica y Biología Molecular
Universitat de Barcelona - Serveis Suport Recerca
Inst. de Química Orgánica General – CSIC
CIC BioGUNE-Biología Estructural
Universidad de Oviedo. – F. Química –Química Física
Centro de Investigaciones Biológicas – CSIC
Universidad de A Coruña - Servicios Centrales de Investigación
Universidade de Vigo - Centro de Apoyo Científico y Tecnológico a la Investigación (CACTI)
U Malaga - Servicios Centrales de Apoyo a la Investigación (SCAI)
Universidad de Sevilla CSIC - Inst. Bioquímica Vegetal y Fotosíntesis
CIC NanoGUNE Consolider
UDL - Universitat de Lleida
CIC biomaGUNE
U Autonoma Madrid - F. Ciencias - Química Orgánica
U Granada - Ctro. Instrumentación Científica
Universidad de Córdoba - El Servicio Central de Apoyo a la Investigación (SCAI)

Risk assessment

1) Are there scientific developments elsewhere that could affect the research foreseen at the beamline?

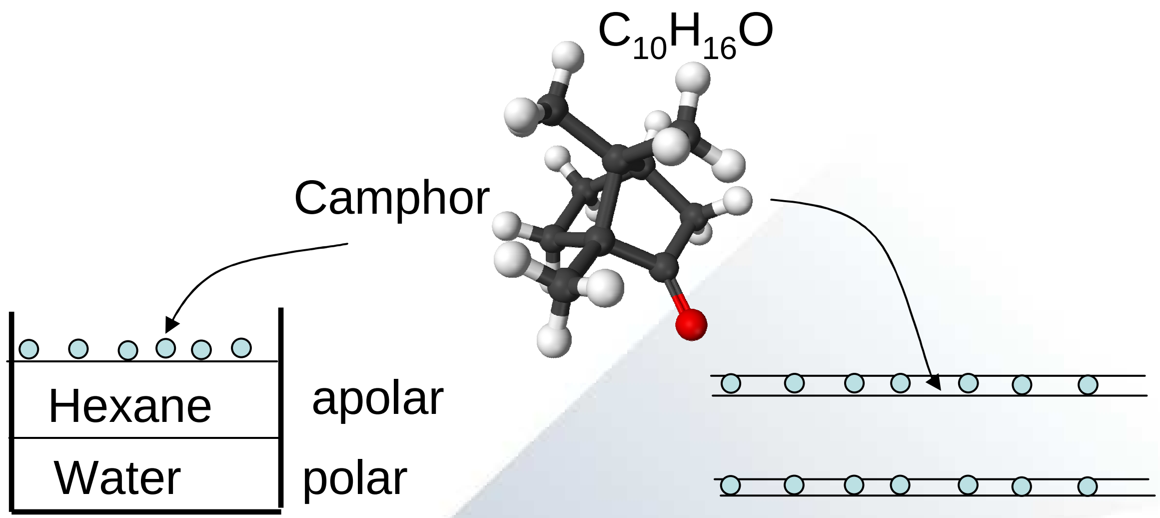
2) Which are in your view the risks that could delay, increase costs of or make realization of the beamline impossible.

The beamline is challenging but perfectly feasible. If a TOF electron analyzer is the preferred option, the associated development and optimization might cause delays

3) Have you identified any specific technical risks?
I would no call it risk, but rather development and optimization:

- optimum optical design and mirror coating
- optimum electron detection efficiency
- optimum Fourier filtering and beam diagnostics …

Branch A: a) Water jet with an amphiphilic surfactant
b) Molecule floating at the surface

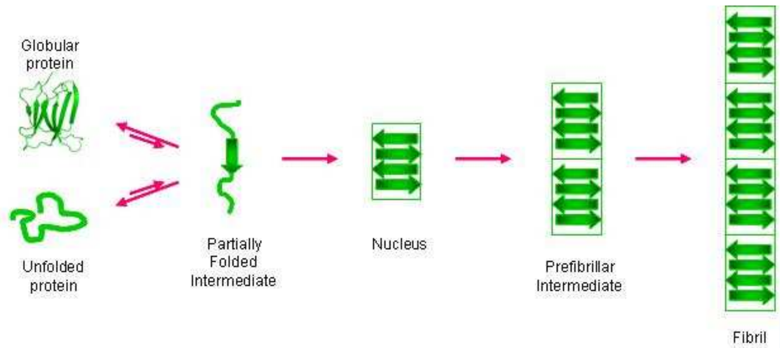


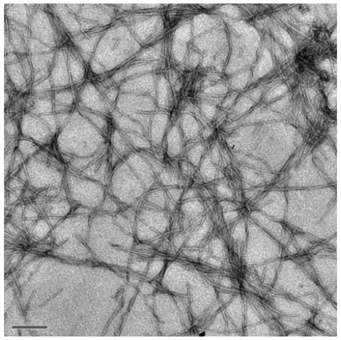
2.- Industrial use?

3.- European leading .Branch A is unique world wide

Branch B.

1.- Measurement of UV spectrum CD fibrous proteins. E.g. Amyloids and prions

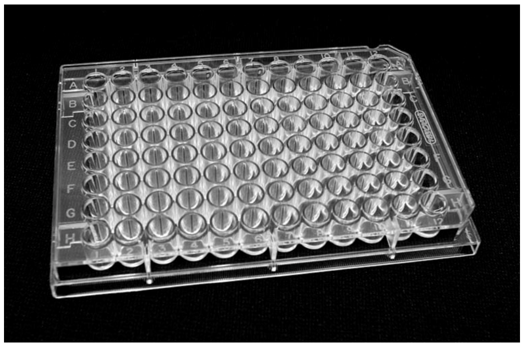


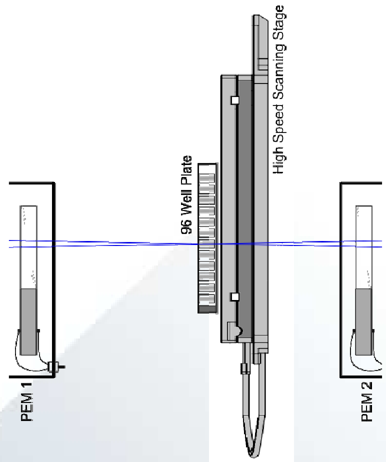


These fibrils participate in diseases such as Parkinson or Alzheimer.

Branch B.

2. industrial application: CD measurements in well plate arrays





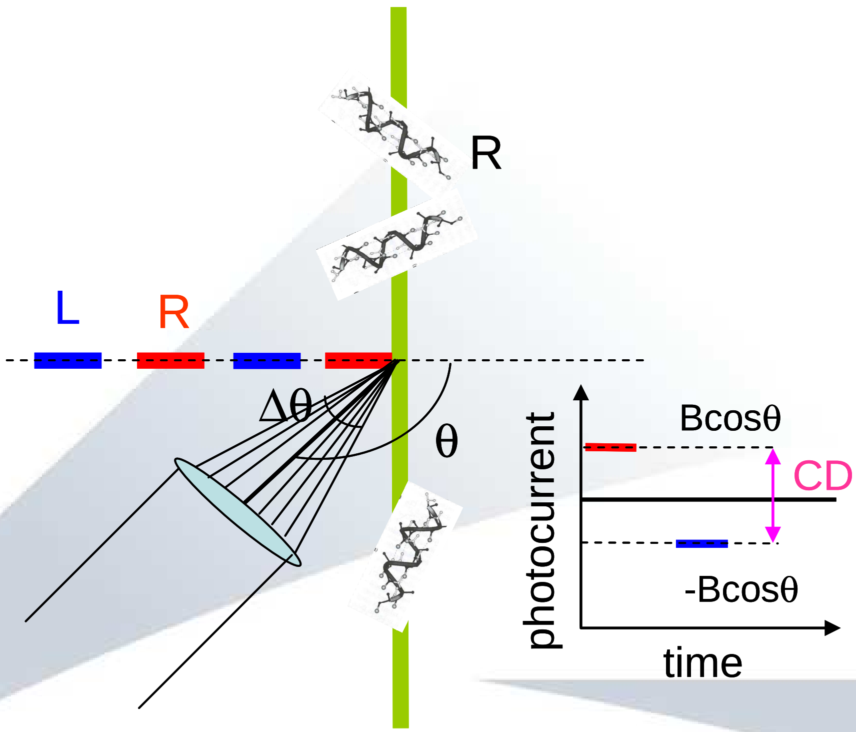
The Mueller matrix technique allows CD measurements in well plate arrays despite the large birefringence of the well plates walls.

A whole 96-well plate could sampled in about 5 minutes.

3. European leading.

The beamline would be the European leader in CD/LD spectroscopy, since no other laboratory or synchrotron facility would offer state of the art capabilities for CD sensing.


Barracudas, Cap de Creus, Girona
Thanks for listening


R
L
R
Δθ
θ
Bcosθ
CD
photocurrent
-Bcosθ
time