Tribute to Pascal Elleaume

M. E. Couprie, Synchrotron SOLEIL

Pascal's former first PhD student

J. M. Ortéga, Lab. Chimie Physique, Orsay Univ.

Acknowlegments to J. M. Filhol

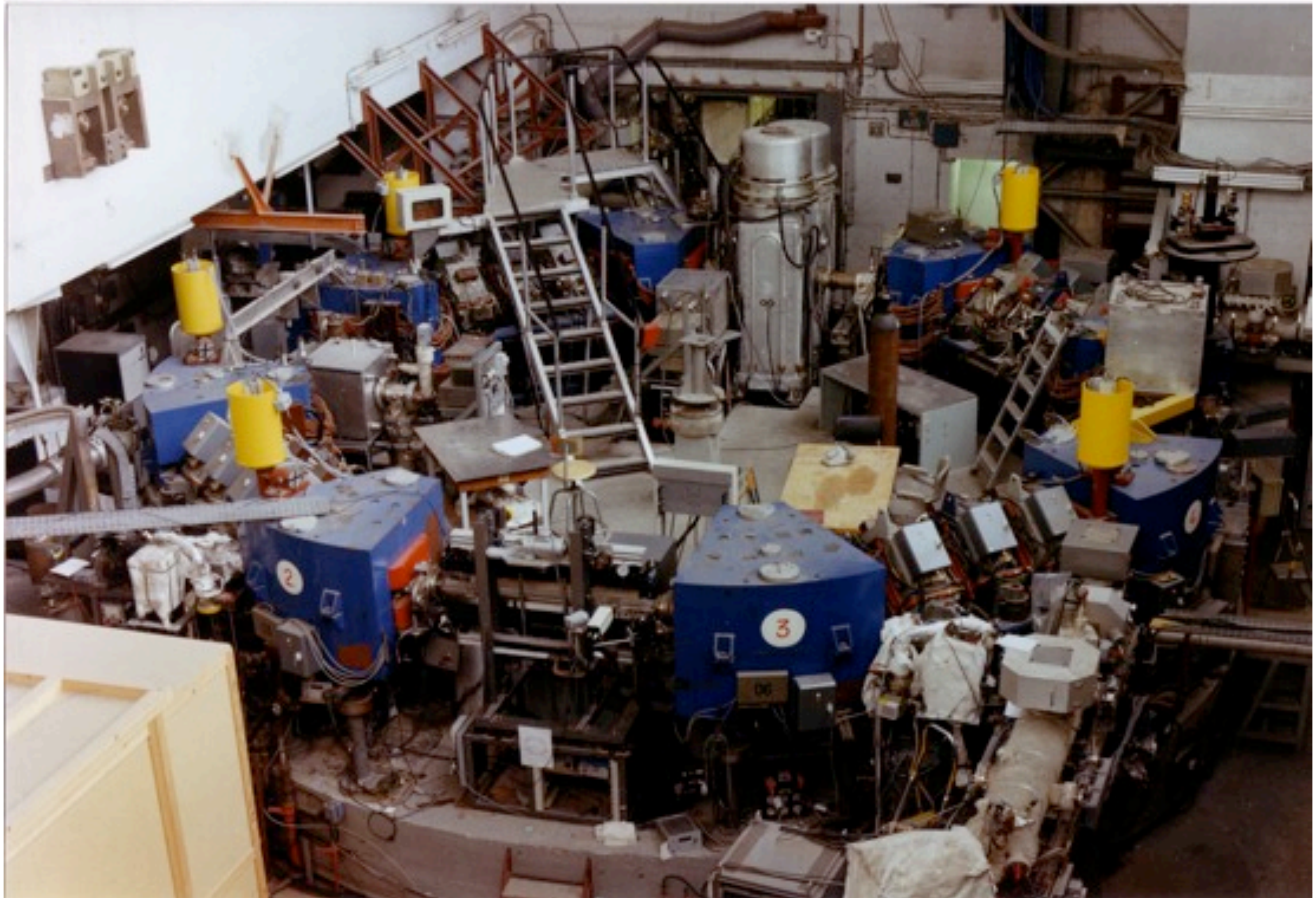
to Pascal

École Normale Supérieure de Physique (Ulm)
«Thèse de troisième cycle at LKB»
1979 : Hired as PhD student on the ACO FEL (ACO/Stanford collaboration (J.M. J. Madey))

He demonstrated very soon a tremendous activity and a great theoretical and experimental talent.

1983 : ACO FEL lasing
1984 : Thèse d'état : «Laser à électrons libres sur l'anneau de collision d'Orsay» (Y. Petroff, Y. Farge)
Jury : Castaing, Cohen Tannoudji, Farge, Renieri, Rigny
Conception of the Super-ACO FEL
End of 1986 : ESRF : head of the insertion device group
2001 : Head of Machine division at ESRF
2011: March 19 : killed in an accident in French Alps, at 55 years old

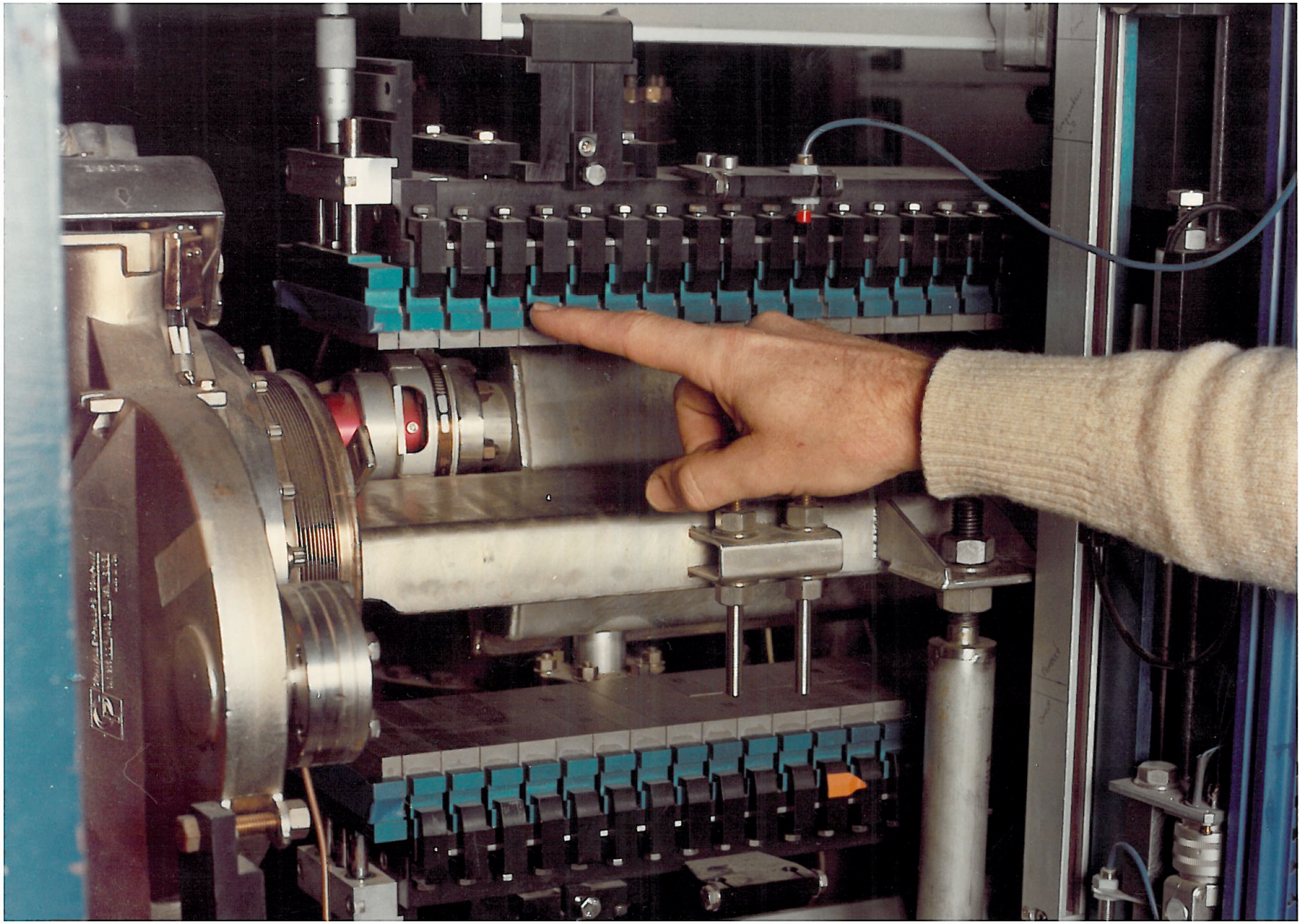
The Orsay/Stanford collaboration on ACO FEL



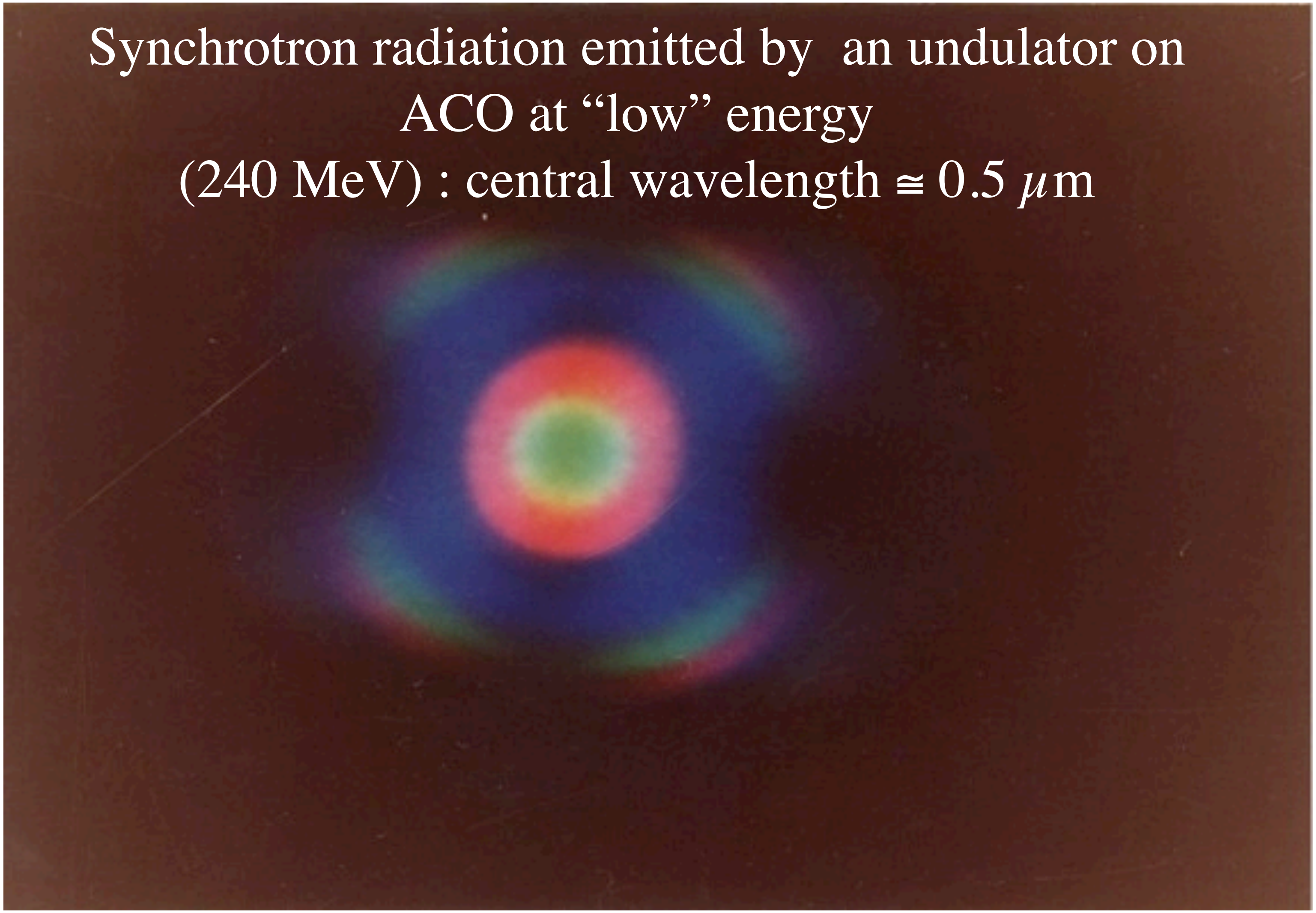

Proceedings Castefgondolfo Conference

Undulator and optical klystron analysis

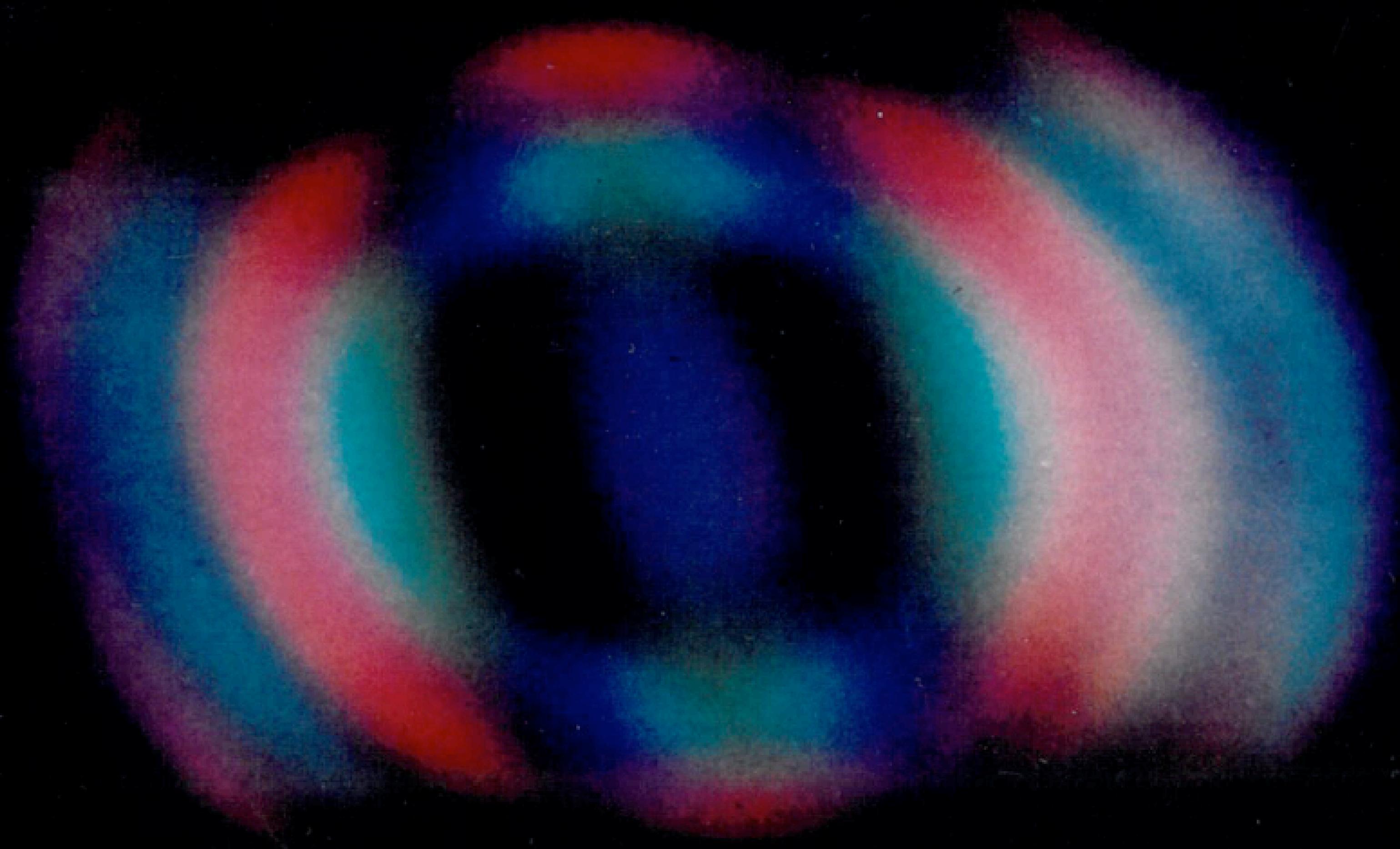
Pascal showing the ACO undulator



Undulator and optical klystron analysis



Begining of March, scanning images of ACO undulator radiation at the request of Pascal for a CERN school- My last exchanges and laughs



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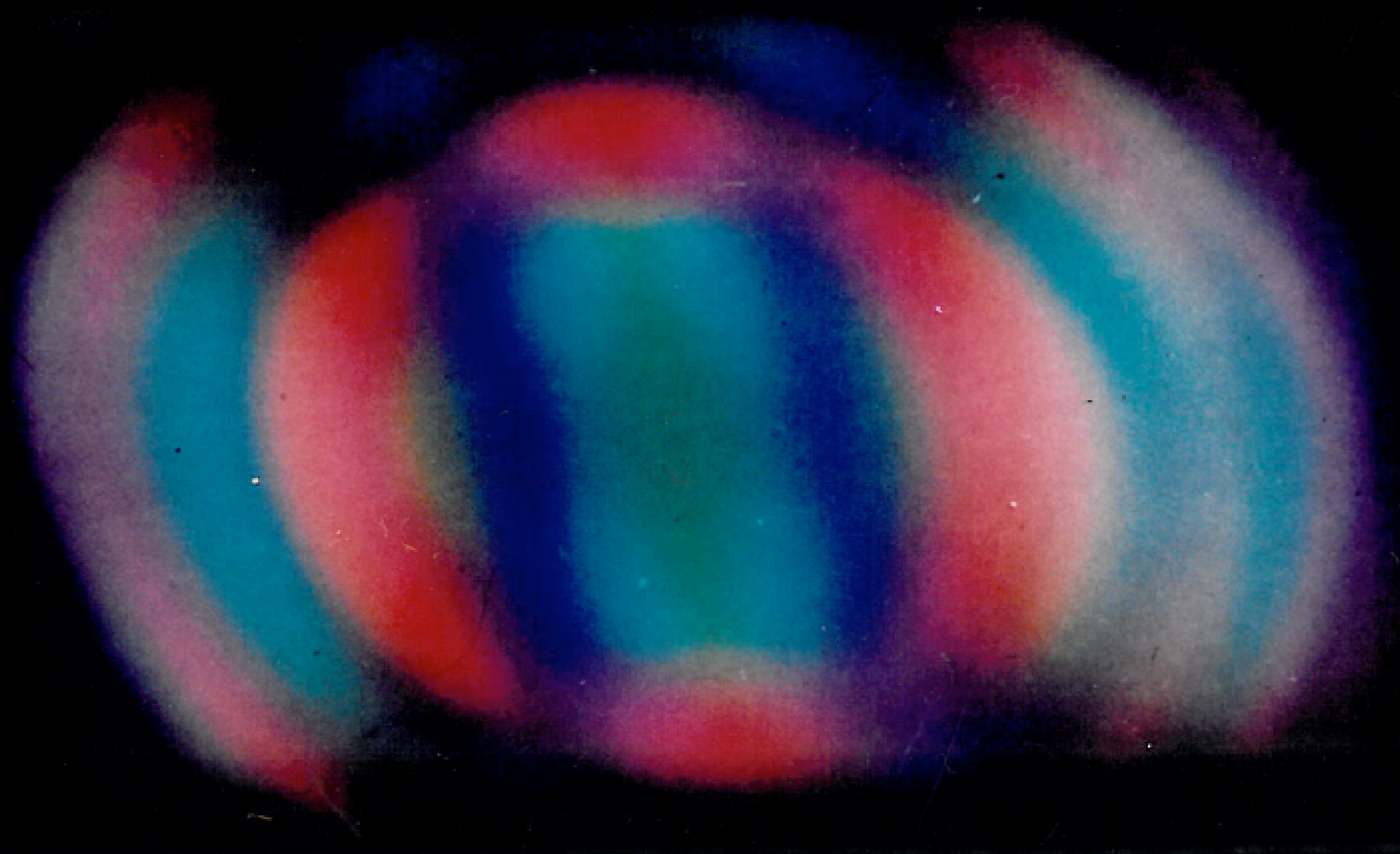

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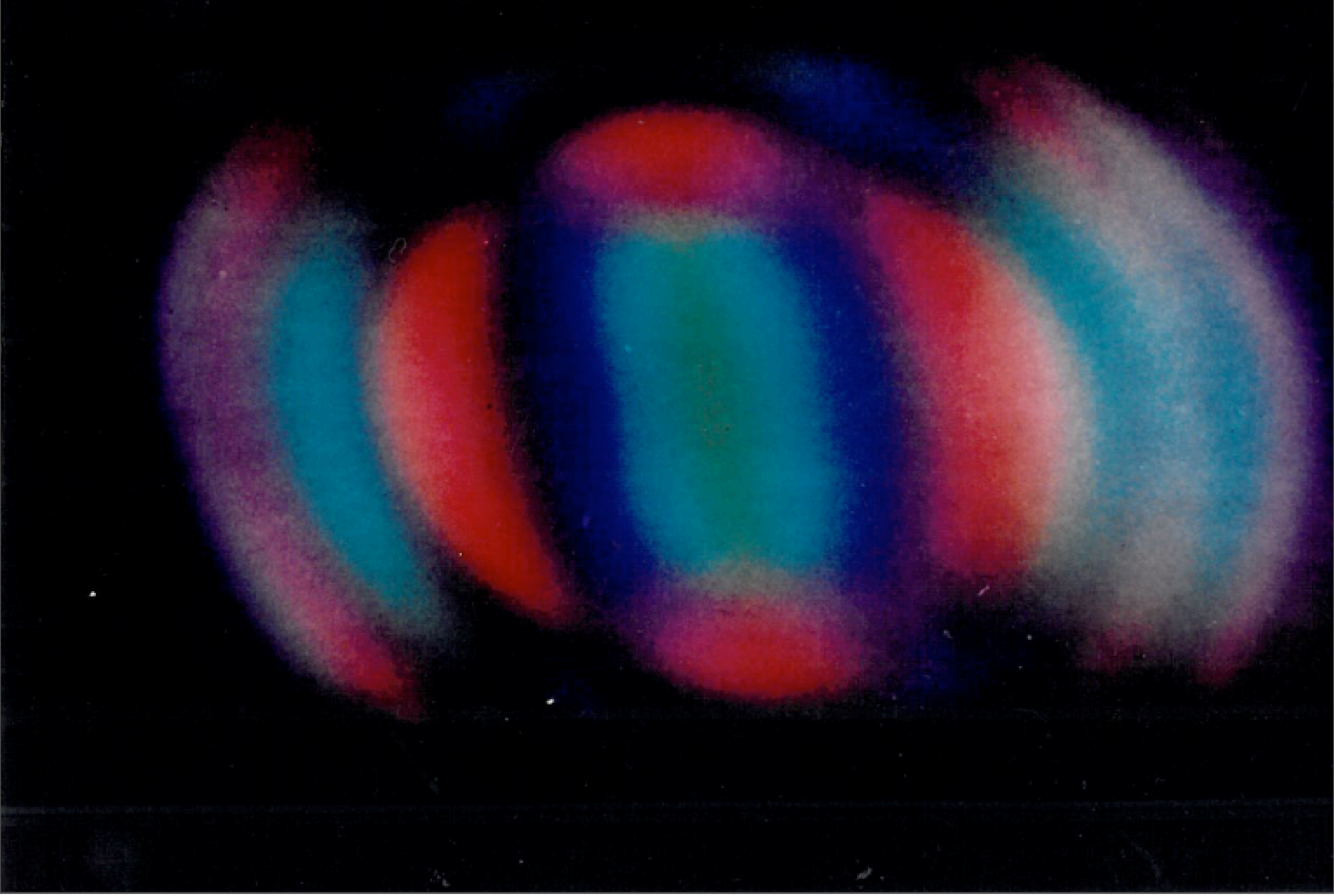

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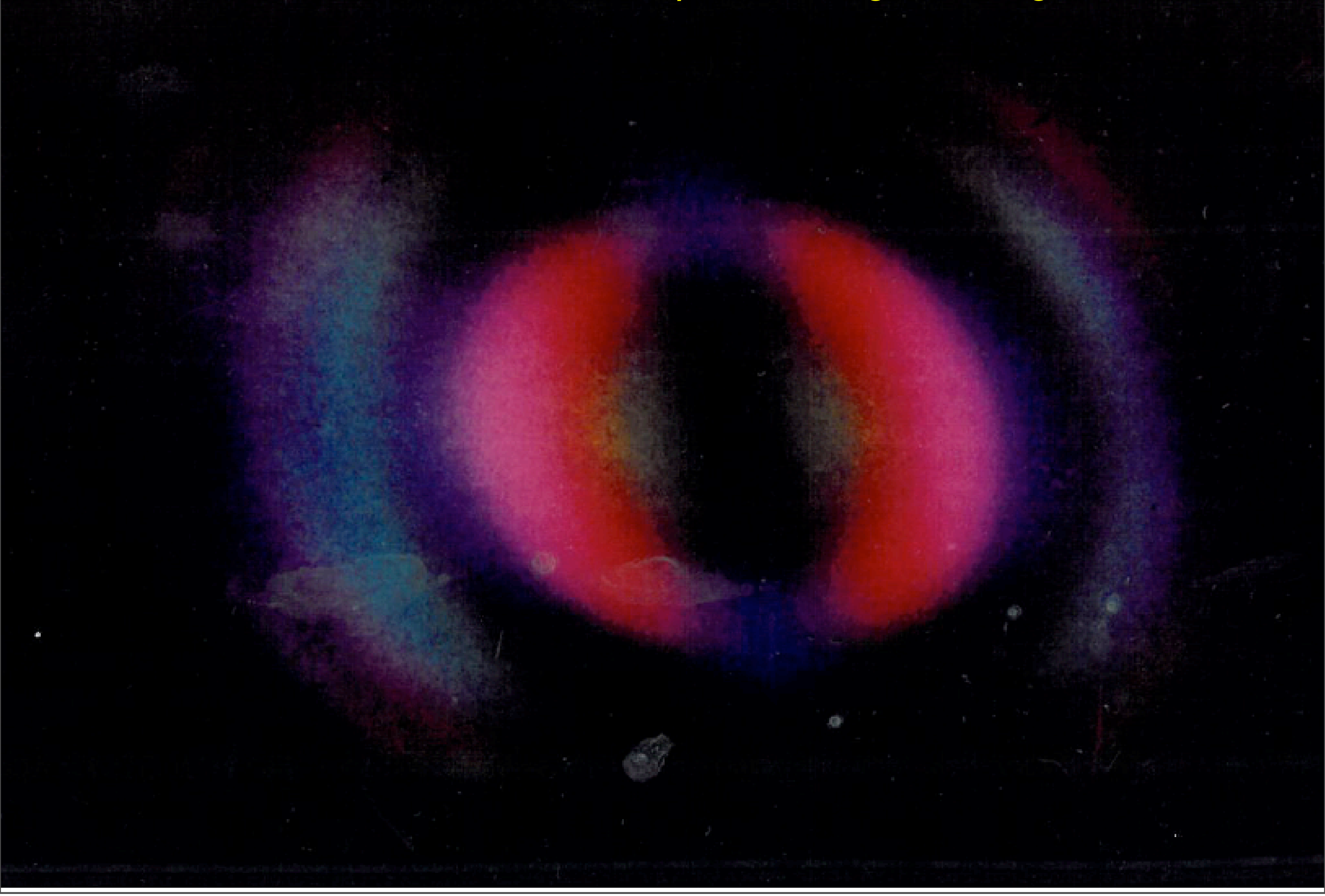

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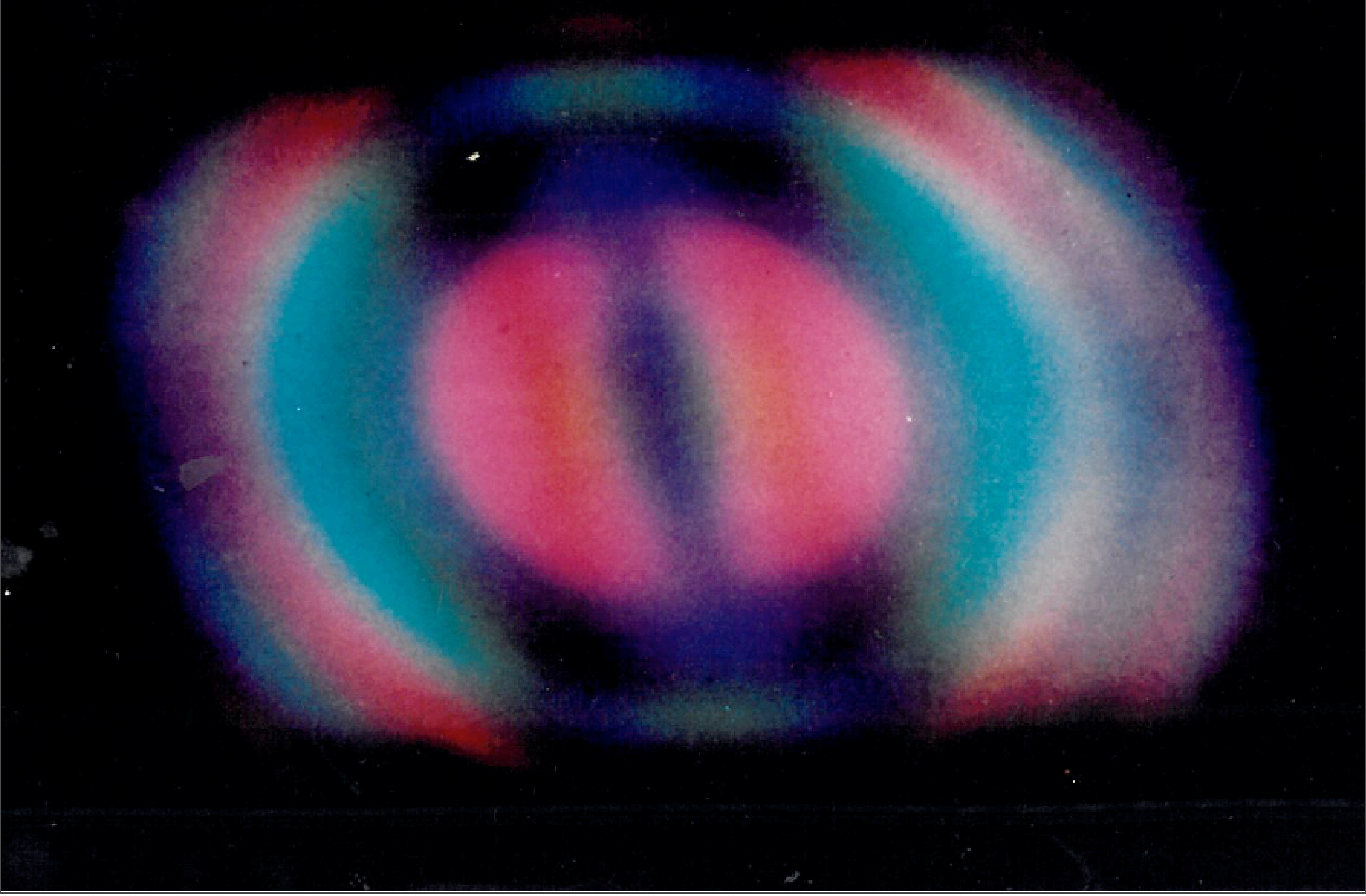

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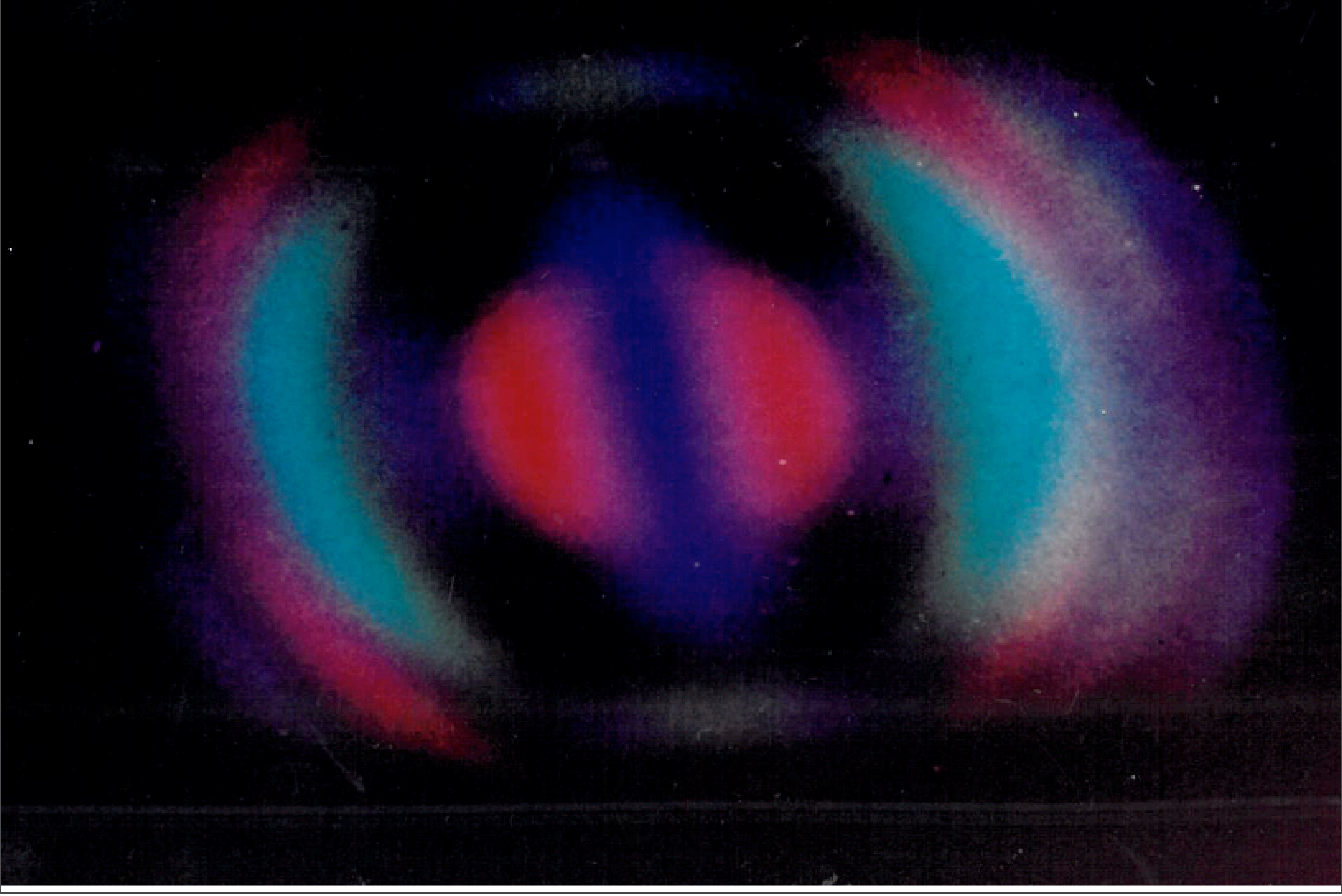
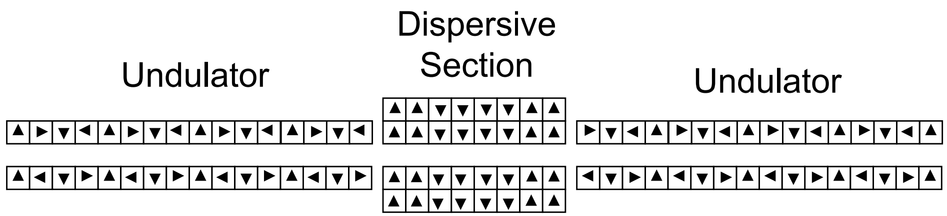


I. Pascal's contribution to FEL

Optical klystron



Not enough gain with the single undulator

Visit to Budker Institute : discussions with N. Vinokurov

«Optical klystron : spontaneous emission and gain» in Free Electron Laser Generators of Coherent radiation, Physics of Quantuum electronics, vol 8-9, 1982, 119-15, Paper at ONR workshop on FEL (Sun Valley) 1981
Proceedings of Bendor FEL Conf, 1982, J. Phys. C1, 44, 1983, 333-352

analysis of the spontaneous emission : inhomogeneous broadening (energy spread, angular spread, beam transverse dimensions)
optical klystron gain

Construction of an optical klystron at ACO

D.A.G. Deacon, M. Billardon, P. Elleaume et al, Optical klystron experiments for the ACO storage ring FEL, Appl. Phys. B34, 1984, 207-219

The optical klystron had been first invented and studied at Novosibirsk. Pascal derived a new method of calculation based on the « Madey theorem » relating the gain to the spontaneous line shape. This method was very elegant and powerfull and permitted a complete and very physical analysis of the gain.

Optical klystron

Appl. Phys. B 34, 207–219 (1984)

Applied Physics B Photo-physics and Laser Chemistry

Optical Klystron Experiments for the ACO Storage Ring Free Electron Laser

D. A. G. Deacon[1], M. Billardon[2], P. Elleaume[3], J. M. Ortega[2], K. E. Robinson[4], C. Bazin, M. Bergher, M. Velghe[5], J. M. J. Madey[4], and Y. Petroff

L.U.R.E., L.P. CNRS 008, Bâtiment 209-C,
Université de Paris-Sud, F-91405 Orsay, France

Received 2 January 1984/Accepted 20 March 1984

Abstract. To improve the gain in the Orsay storage ring Free Electron Laser (FEL) experiment, the 17 period permanent magnet undulator has been modified to form an optical klystron (OK). We report the measurement of spontaneous emission and the effects on it of energy spread and angular spread. Gain and laser induced bunch lengthening measurements with the OK are also reported and are in very good agreement with the FEL classical theory. The spontaneous emission spectrum which is easy to measure with good signal to noise ratio, turns out to be a very good diagnostic tool for *energy spread and angular spread measurements* on storage rings. The factor of four increase in the small gain obtained by converting the undulator NOEL into an OK was the critical factor in the recent operation of the ACO storage ring laser above threshold.

Optical klystron

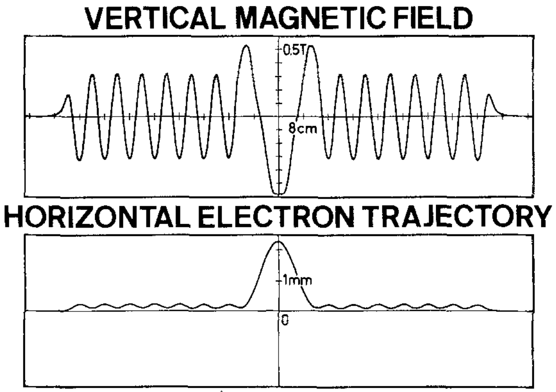


Fig. 1. Vertical magnetic field calculated for the Orsay optical klystron (gap: 33 mm) and the corresponding calculated horizontal electron trajectory at an energy of 240 MeV

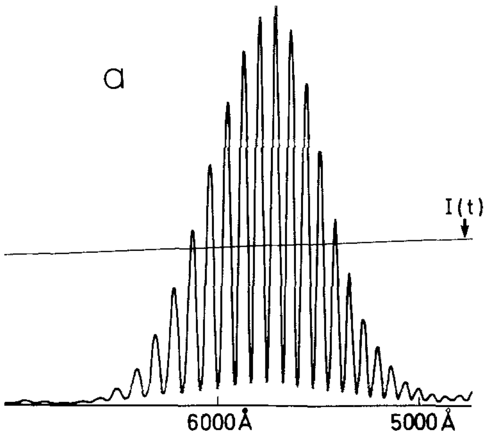


Fig. 3. Spontaneous emission spectrum $dI/d\lambda d\Omega$ measured for an electron energy of 238 MeV and a magnetic field parameter of $K = 2.09$ at low current where the modulation is almost total. The current decay $I(t)$ is superimposed

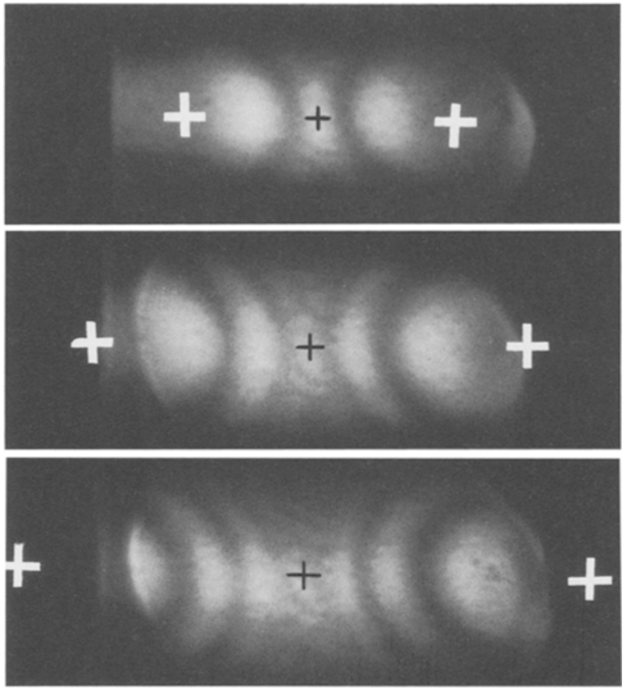
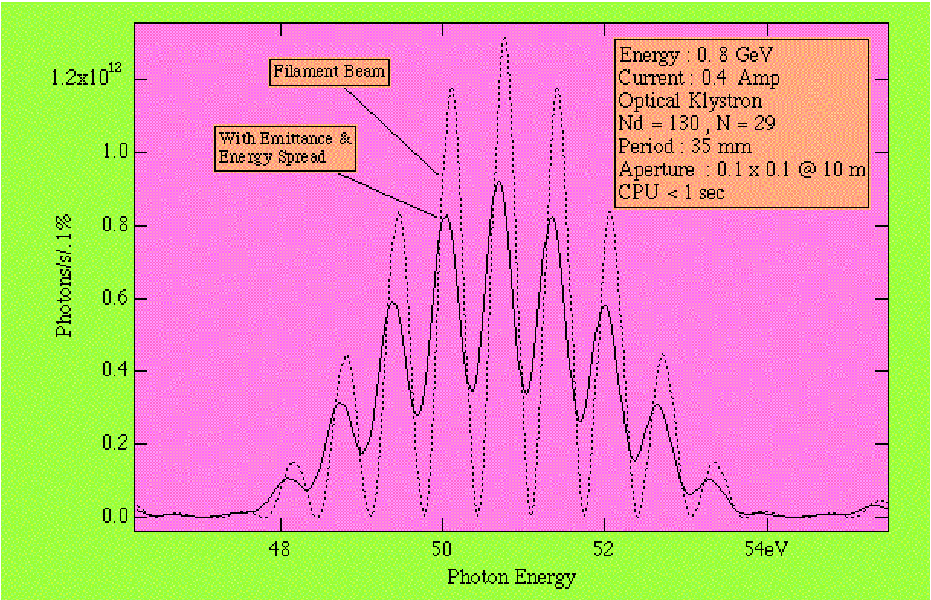


Fig. 13. Three photographs filtered at 5500 Å of the interference structure produced in the optical klystron at large gap. From top to bottom, the magnetic field is increased by closing the gap. The beam axis is marked by the black cross at the center of each pattern, and the points A and B calculated from the magnetic field strength in the OK are marked with white crosses

Optical klystron

Fringe blurring induced by electron energy spread
and emittance

$$\lambda = \frac{\lambda_0}{2\gamma^2}(1 + \frac{K^2}{2} + \gamma^2\theta^2)$$



V, 8/22 , P. Elleaume, CAS, Brunnen July 2-9, 2003.

Undulator construction

After the team has had difficulties with the electromagnetic dispersive section of the optical klystron, Pascal redesigned it with permanent magnets, thus solving the problem.
This point was very important since the final optical gain of the ACO OK was about 1.001, which made that obtainig lasing was a true challenge !
As a result the ACO team won in 1983 the « competition » to obtain the 1st « second FEL » in the world (after the pioneering Madey's experiment in 1977), which was also the 1st on a storage ring and the 1st in visible. In 1984/85, the group made also the 1st demonstration of UV and VUV coherent light production by a laser seeded Optical Klystron.

1983 : the lasing of the ACO FEL (Orsay)

VOLUME 51, NUMBER 18 PHYSICAL REVIEW LETTERS 31 OCTOBER 1983

First Operation of a Storage-Ring Free-Electron Laser

M. Billardon,[a] P. Elleaume,[b] J. M. Ortega,[a] C. Bazin, M. Bergher, M. Velghe,[c] and Y. Petroff
Laboratoire pour l'Utilisation du Rayonnement Electromagnétique, Université de Paris-Sud, F-91405 Orsay, France

and

D. A. G. Deacon,[d] K. E. Robinson, and J. M. J. Madey
High Energy Physics Laboratory, Stanford University, Stanford, California 94305
(Received 1 August 1983)

A storage-ring free-electron laser oscillator has been operated above threshold at a visible wavelength $\lambda \simeq 6500$ Å.

A visible Free Electron Laser in France, a string of firsts for an Orsay-Stanford collaboration : the first free electron laser in the visible, in a storage ring and in Europe, A. R. Robinson, Science 221, 937-939, Sept 1983

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FIG. 1. Normalized laser power as a function of rf frequency and equivalent mirror displacement. Curve a is recorded close to the maximum gain/loss ratio and curve b close to the laser threshold. The shift between the two curves is probably due to some slight cavity-length drift.

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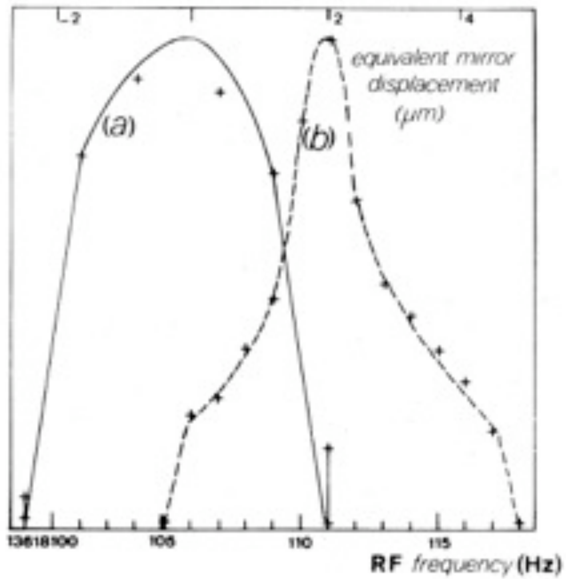

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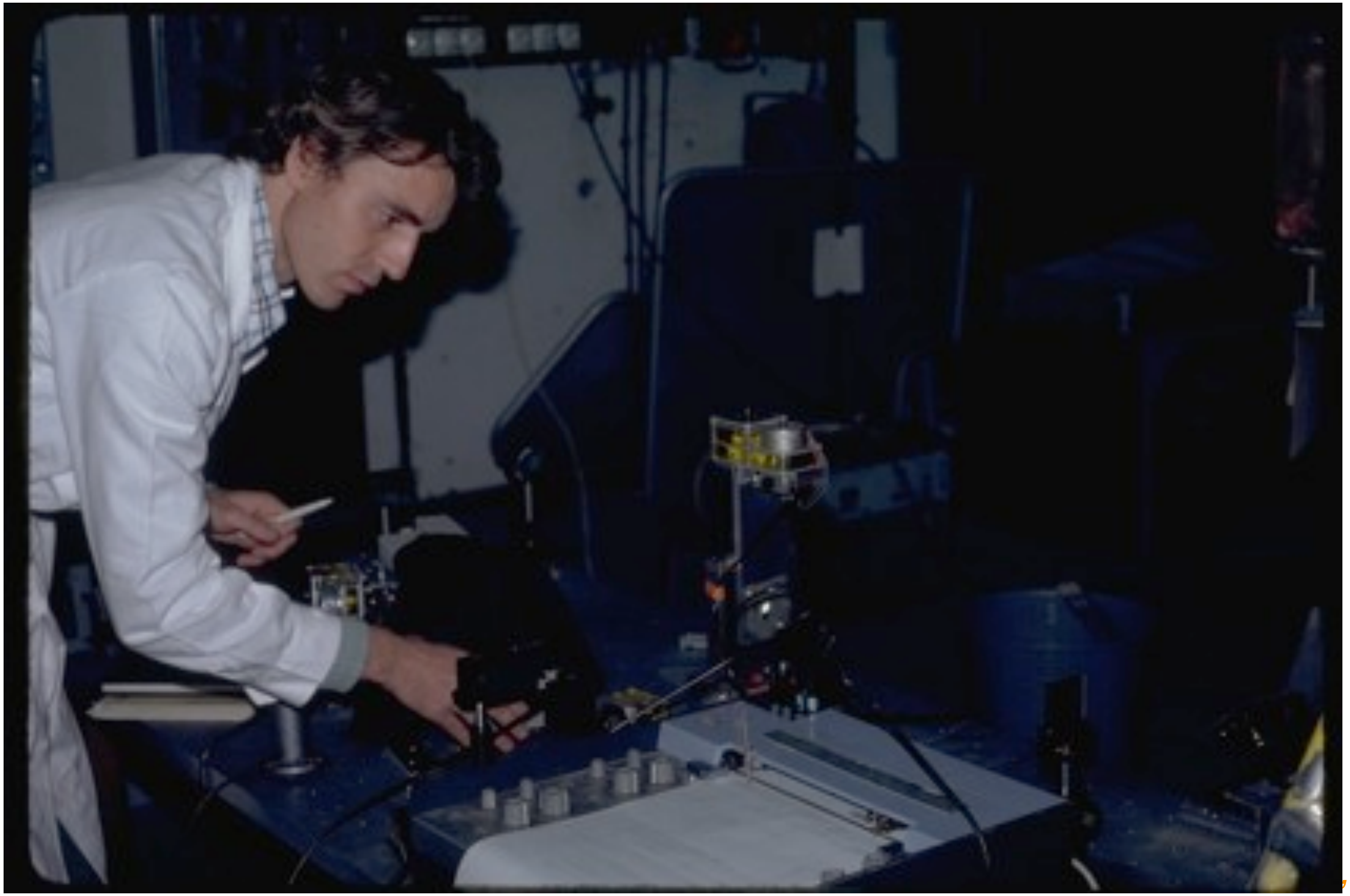
I. Pascal’s contribution to FEL

1983 : the lasing of the ACO FEL (Orsay)

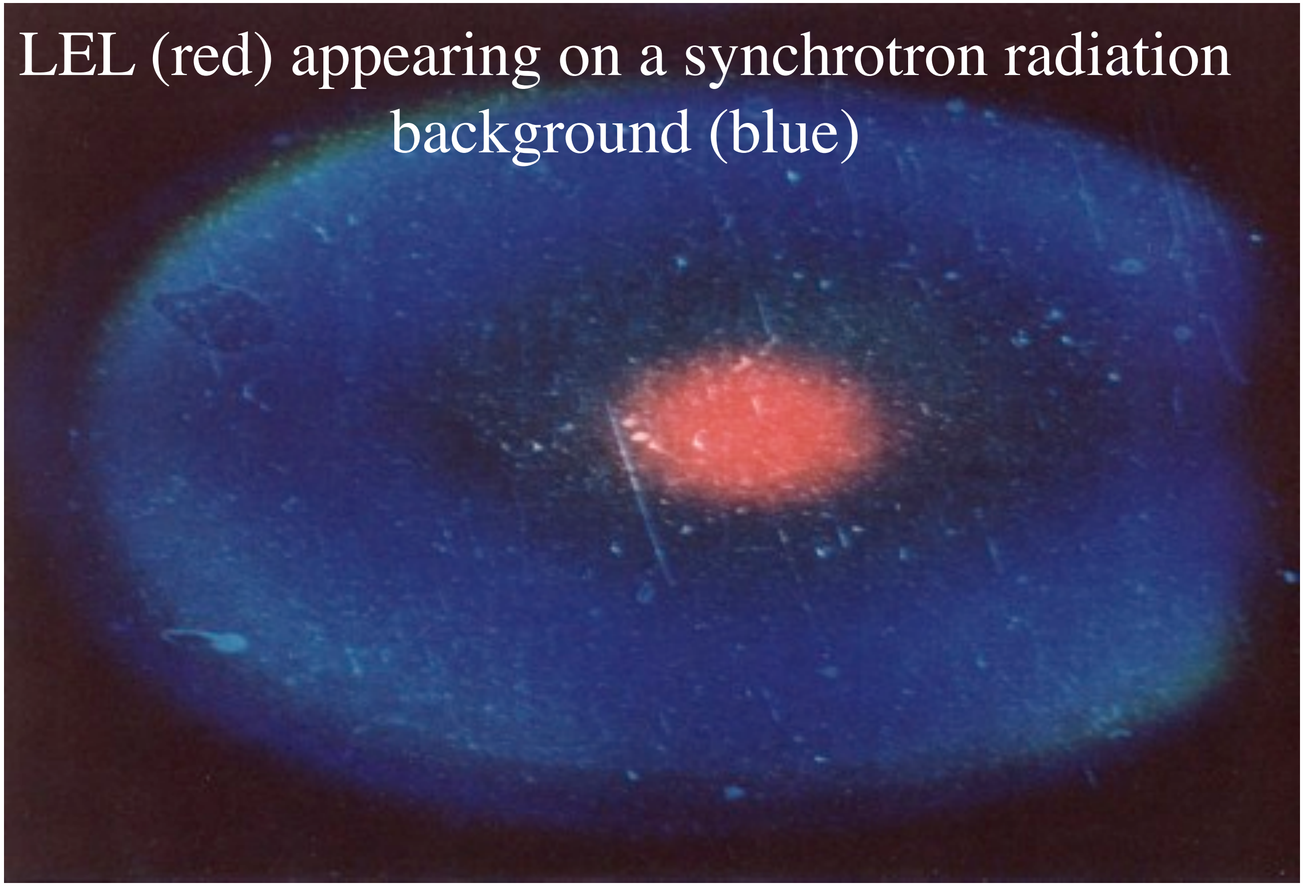
from stored spontaneous emission to lasing, following the PM on the plotter



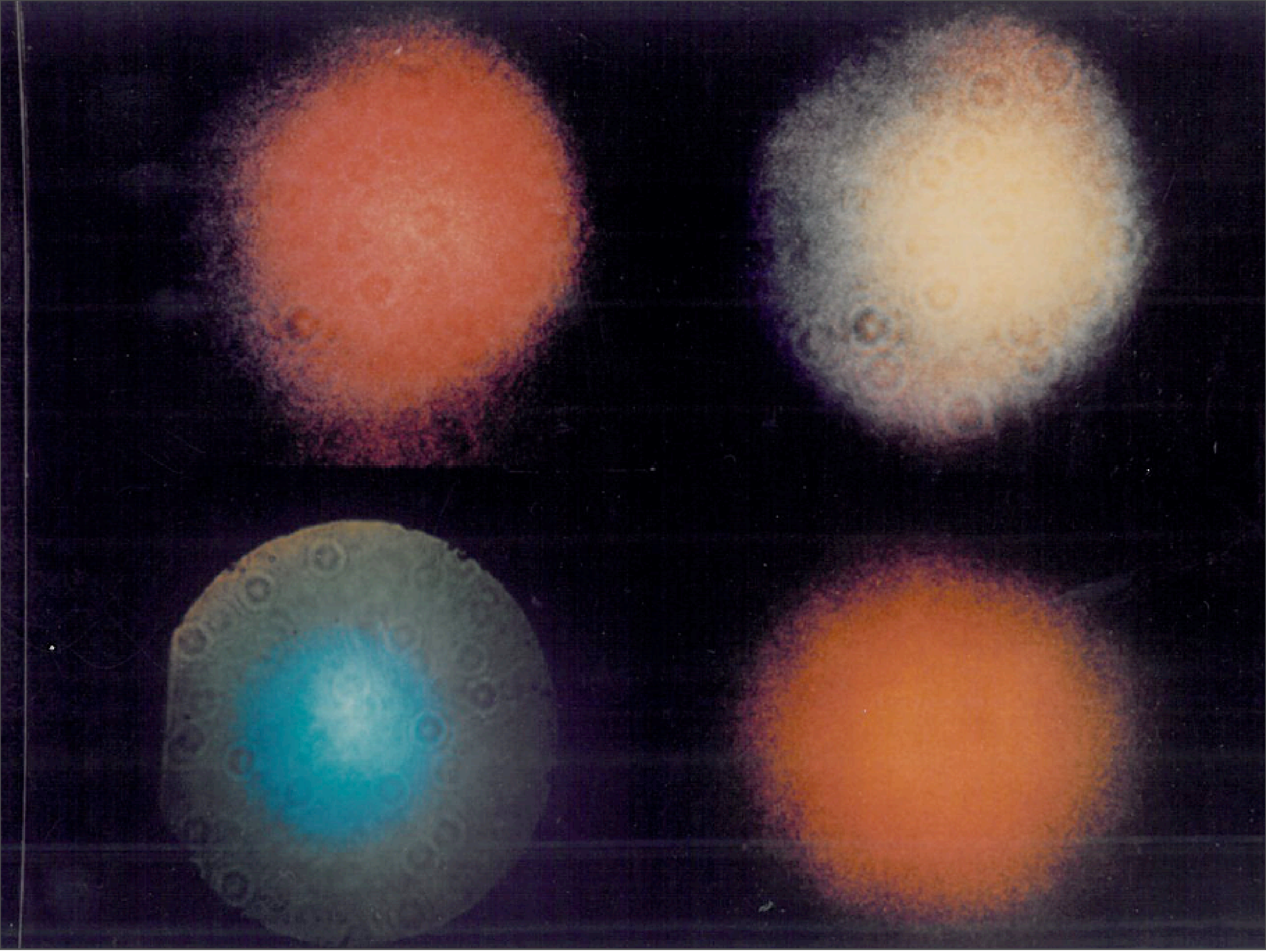
Picture D. Deacon

, 2011

1983 (June 21) : the lasing of the ACO FEL (Orsay)



- Second FEL in the world after Stanford (1977)
- Great hope put in recirculating machine
- First FEL in the visible



mardi 9 août 2011

Coherent Harmonic generation

VOLUME 53, NUMBER 25 PHYSICAL REVIEW LETTERS 17 DECEMBER 1984

Optical Frequency Multiplication by an Optical Klystron

B. Girard,[a] Y. Lapierre,[b] J. M. Ortega,[c] C. Bazin, M. Billardon,[c] P. Elleaume,[b] M. Bergher, M. Velghe,[d] and Y. Petroff

Laboratoire pour l'Utilisation du Rayonnement Electromagnétique, Université de Paris-Sud, F-91405 Orsay, France

(Received 25 June 1984)

We report the first observation of the emission of coherent light by an electron beam bunched at 1.06 μm by a Nd-doped yttrium aluminum garnet laser focused into an optical klystron. An enhancement of 10^2 to 10^3 over its spontaneous emission level at 355 nm has been observed in these experiments performed at the ACO storage ring at Orsay.

Coherent Harmonic generation

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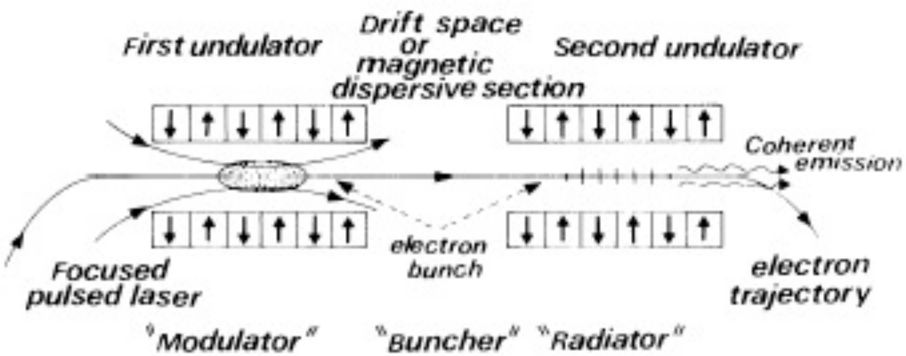

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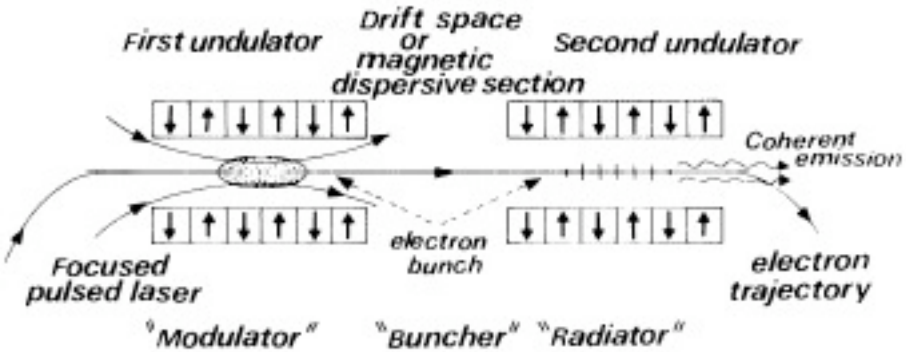

An **external laser is** focused in the “modulator”, which results in an energy modulation. It produces a density modulation in the dispersive section. Due to its anharmonicity, the laser harmonic frequencies are amplified in the radiator. This effect allows to produced **short wavelengths** at a **lower electron energy.**

I. Pascal's contribution to FEL

Coherent Harmonic generation

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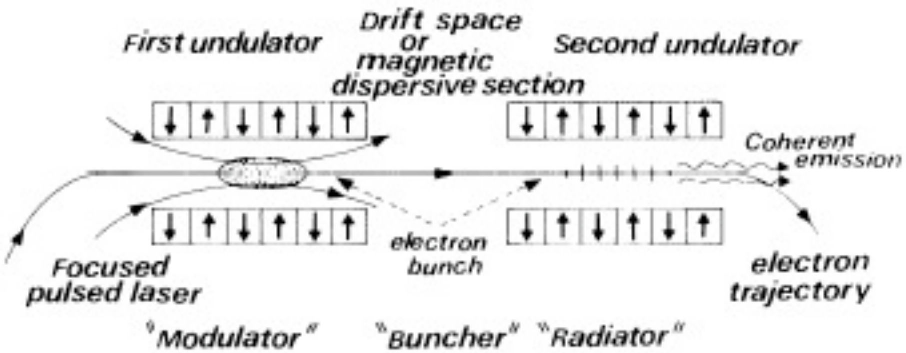

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In 1986, the 5th harmonic at 10.6 nm was reached

Macro/micro-temporal structure

After the first observations of the « unstable » behavior of the storage ring FEL, Pascal derived a theory of its dymamical behavior. It was based on a simple set of 2 coupled differential equations taking into account the dynamics of the storage rings. He was then able to reproduce all the experimental results as well at start-up and properties at laser saturation. Further analysis, using this same set of equations led to the discovery of the chaotic nature of the SRFEL (Billardon et al.)

He studied also the transverse and longitudinal (« supermodes ») behavior of the laser, thus providing a complete picture of the SRFEL.

P. Elleaume, Storage ring FEL theory , NIM A 237, 1985, 28-37
P. Elleaume, macro-temporal structure of storage ring FELs, J. Physique 45 (1984) 997-1001
P. Elleaume, Micro-temporal and spectral structure of SRFELs, NIMA 237, 1985, 38-40
"Micro-temporal structure of storage ring FELs" (IEEE Journal of QE, Vol 21, July 1985)"Micro-temporal structure of storage ring FELs" (IEEE Journal of QE, Vol 21, July 1985)

Macro/micro-temporal structure

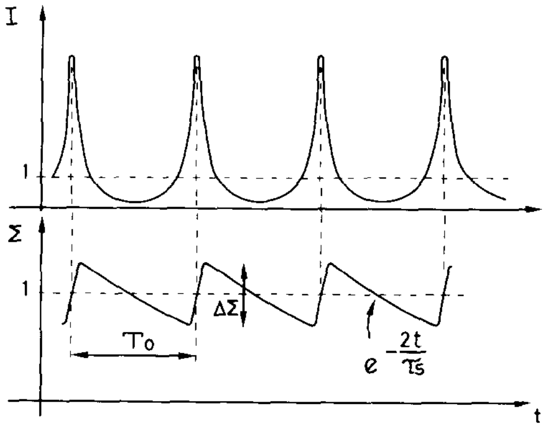

Fig. 3. Dimensionless laser intensity and energy spread in a pulsed storage ring free electron laser

$$\frac{\mathrm{d}I}{\mathrm{d}t} = \frac{1-\Sigma}{\tau_0} I,$$

$$\frac{\mathrm{d}\Sigma}{\mathrm{d}t} = 2\frac{I-\Sigma}{\tau_s},$$

where I and Σ are the dimensionless laser intensity and the additional squared energy spread (or bunch length when saturating by bunch lengthening), τ_s is the synchrotron damping time and τ_0 is the laser rise time:

$$\sigma_L = \sigma\sqrt{\mathscr{E}_0/\mathscr{E}},$$

$$\Delta\lambda = \frac{\lambda^2}{2\pi s}\sqrt{\mathscr{E}_0/\mathscr{E}},$$

Supermodes

Transverse modes

• Case of Gaussian spherical wavefronts for undulator, tapered undulator and optical klystron : the gain spectrum no longer proportional to the slope of the spontaneous emission. generalised filling factor

Electron dynamics in Free Eelectron Laser resonator, W.B. Colson, P. Elleaume, Applied Physics B29, 1982, 1-9

• Transverse modes dynamics including diffraction effects and pulse propagation
Transverse modes dynamics in a Free Electron Laser, P. Elleaume, D. Deacon, Applied Physics B33, 1982, 1984, 9-16

• Mirror degradation due to synchrotron radiation


ALLONGEMENT
TRONS

Insertion devices

Simulations codes : B2E, RADIA, SRW ....

Design, construction and measurement
- measurements benchs, terminations
- variety of IDS : HELIOS, asymetric wiggler, 3T PPM wiggler, in vac. cryogenic

Radiation analysis/ related optics (pinhole camera, new types of X ray optics...)
Brightness section of the Accelerator Physics Handbook with K. J. Kim

Effect on electron beam (kick-map approach...)

Storage ring for Synchrotron Radiation

«indisputable worldwide leadership of the ESRF in terms of brightness, reliability, availability and service to users» F. Sette

ESRF upgrade

ESRF NEWSLETTER

No. 35: June 2001

ESRF > Science > Newsletter > June 2001

Newsletter - In Brief

Change of Director in the Machine Division

March 1, 2001

Jean-Marc Filhol, Machine Director since January 1997, resigned from his functions on 14 February 2001 to take up a leading role in the construction of the French synchrotron SOLEIL. In his new position as deputy project director, he is more particularly in charge of the construction of the Machine and of the infrastructure.

Pascal Elleaume was appointed as Director of the ESRF Machine Division and began his term of office on 1 March 2000, following the earlier-than-expected departure of J.M. Filhol. Pascal graduated in physics at the Ecole Normale Superieure in Paris and obtained the "Agrégation de Physique" in 1978. After a one-year stay at the University of California, Berkeley, he joined the CEA (Saclay) in 1980, where he carried out PhD and postdoctoral studies on the development of the first storage ring based free electron laser operating in the visible range of the spectrum. P. Elleaume joined the ESRF in 1986, in the early days of the project. He was given the task of defining the expected performances from the insertion devices and has contributed significantly to the "Red Book", i.e. the foundation phase report. During the construction phase, he was given the responsibility of setting up the Insertion Devices group which, under his leadership, has designed, built and optimised all the ESRF's insertion devices (more than 60 segments are installed on the ring today). The quality and variety of the ESRF's insertion devices are unique in the world and their innovative concepts have had a strong impact on insertion device technology. Since 1991, he has also been involved in the development of various machine diagnostics based on X-rays (ID6 beamline, pinhole cameras) and scientific software (Xray, Radia, SRW).

Various machine committees

Storage ring for Synchrotron Radiation

P. Elleaume and F. Fillon, French Prime Minister at ESRF, 1994, Official ESRF inauguration

Many thanks to Pascal :

- for his contribution to the fields of FEL and Synchrotron Radiation

and

- for educating me in these fields, giving me the great passion and scientific rigour for FEL and synchrotron radiation
- for personal links (and making me discover mountain ski in Nevache...)