



The Crystal Clear Collaboration Silver Jubilee (25 years)

Paul Lecoq
CERN, Genève

The gestation period

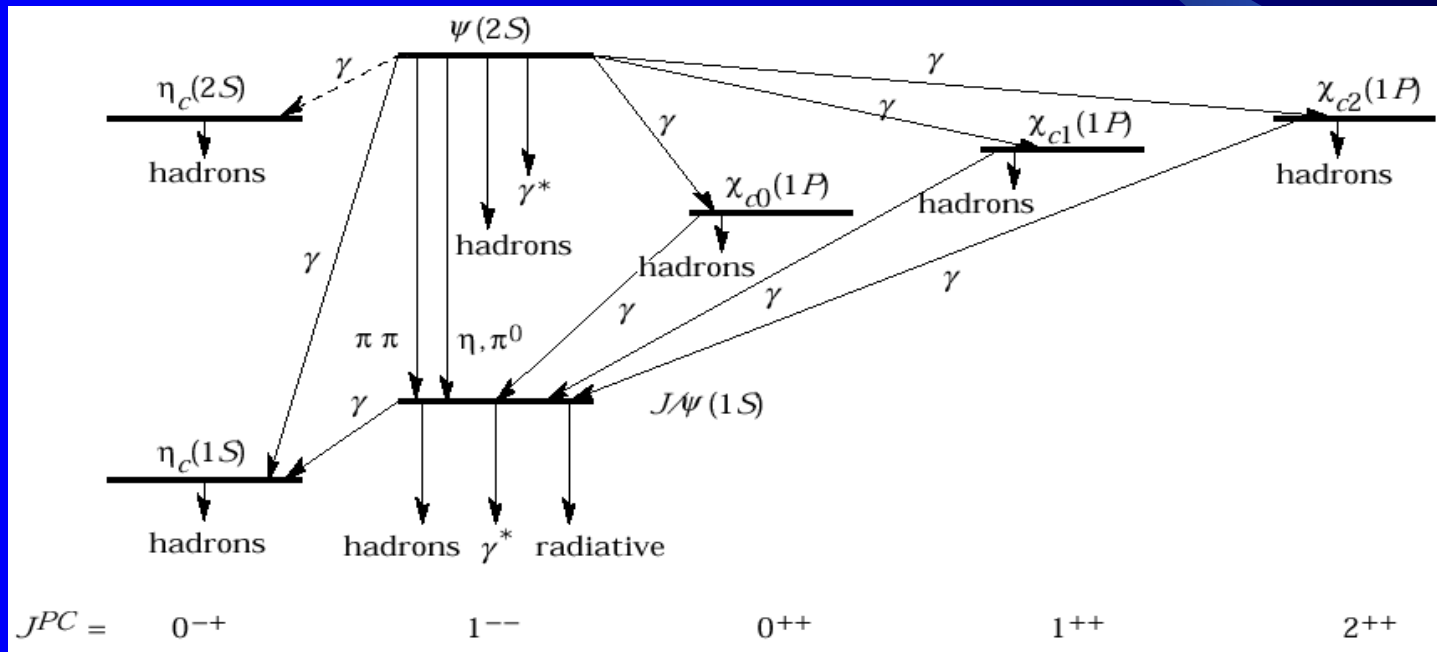


Samuel Ting
Nobel Laureate 1976

October (74) Revolution

J/ψ discovery

Charmonium spectrum:
powerful tool for detailed study of potential models in QCD



most of the states accessible by radiative decays: look for
monochromatic photons of few hundreds MeV

The Crystal Ball

The ancestor of crystal calorimeters

- 672 + 60 NaI:Tl crystals

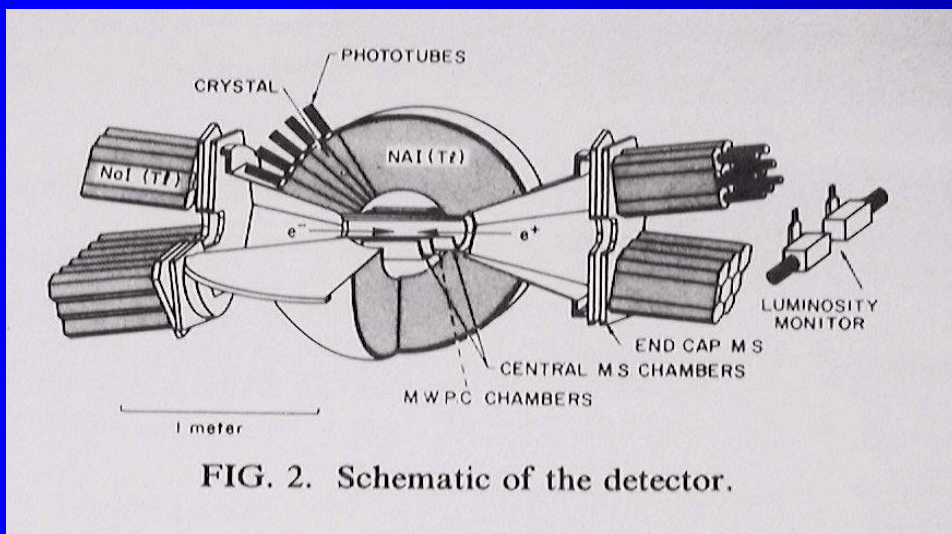


FIG. 2. Schematic of the detector.

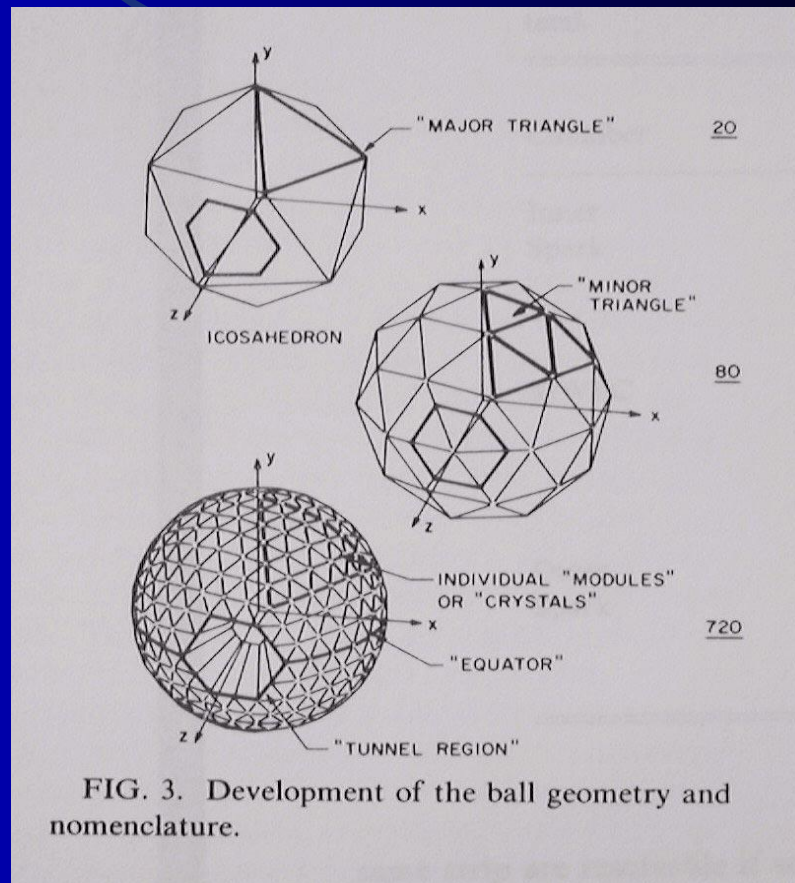
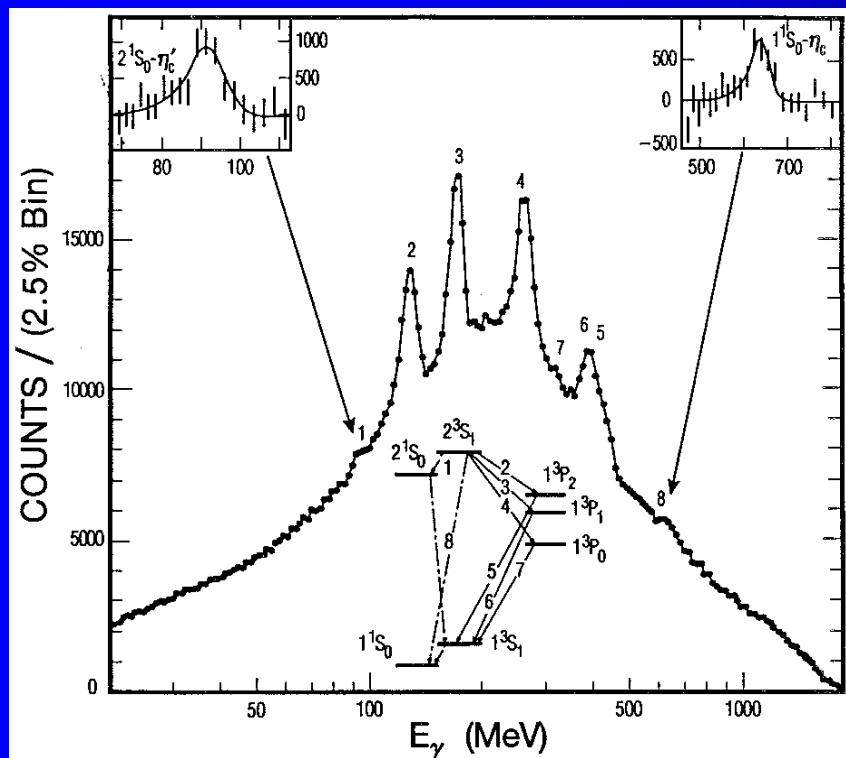


FIG. 3. Development of the ball geometry and nomenclature.



$$e^+e^- \rightarrow \Psi' \rightarrow \gamma X$$

Precise spectroscopy
of charmonium states



L3 experiment at LEP (CERN)



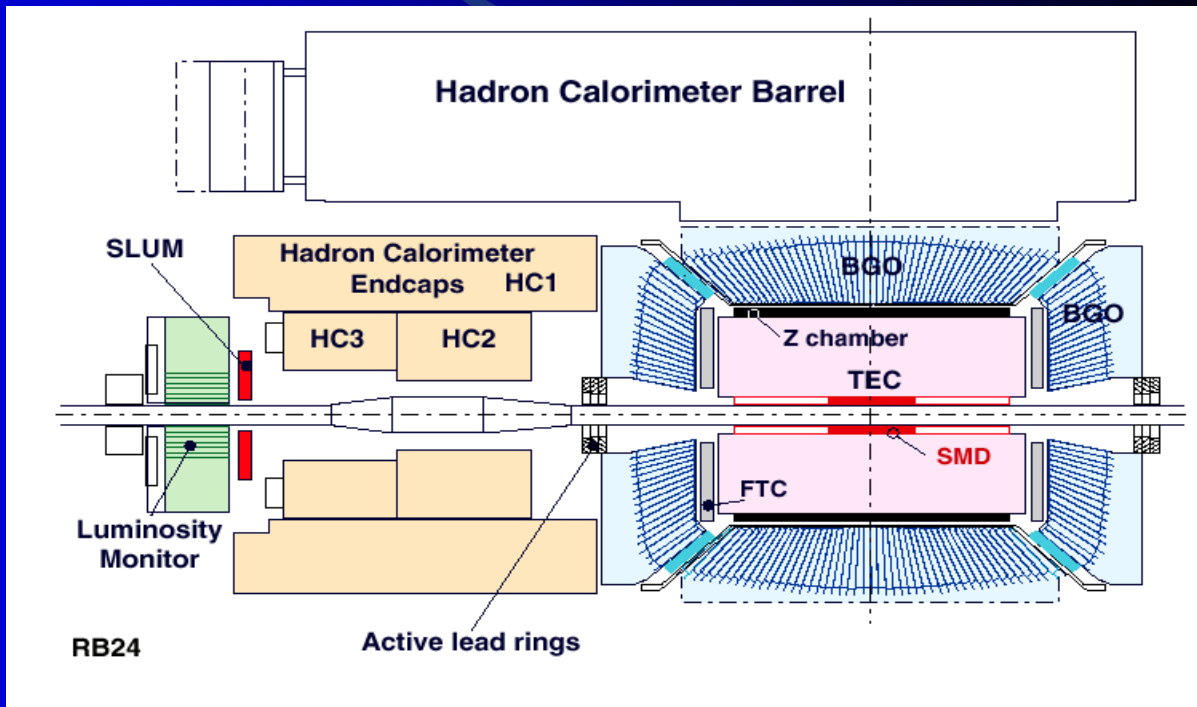
In the meantime the 5th bottom quark has been discovered by L. Ledermann at FNAL
But what about the 6th top quark predicted by the theory?

CERN LIBRARIES, GENEVA
SC00000350
LEPC 83-5 P4

TECHNICAL PROPOSAL

SCP
CERN LEPC
83-5

L3
MAY 1983



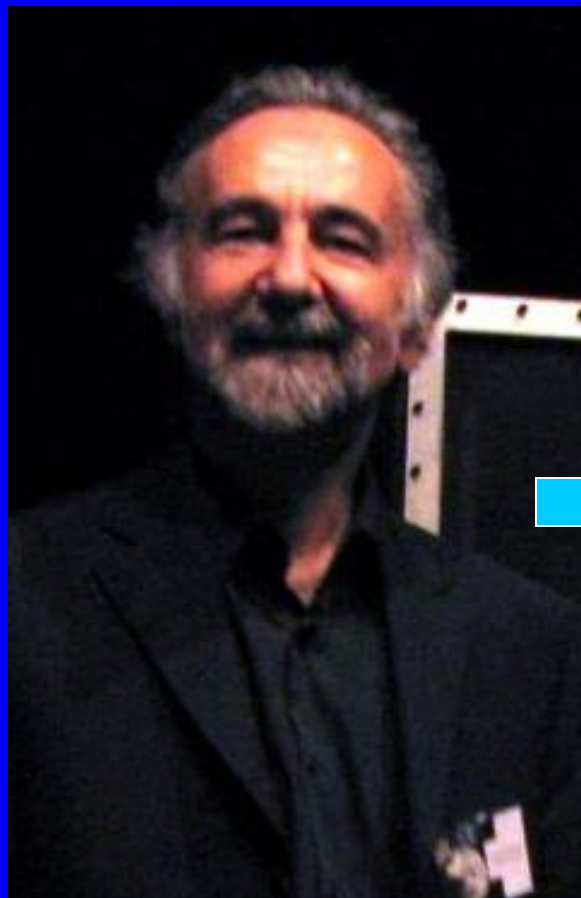
BGO proposed by Eckart Lorenz

L3 BGO calorimeter at LEP



- Main motivation: **toponium radiative decays**
+ Neutrino counting, Higgs, Susy, etc.
- Demonstration of the **scalability of barrel calorimeters**
(Crystal Ball quoted in LoI)
- Technological challenge:
 - few small BGO crystals existing all over the world at the time of approval of the L3 experiment

The Chain Reaction



Jean Paul Martin
IPNL, Lyon



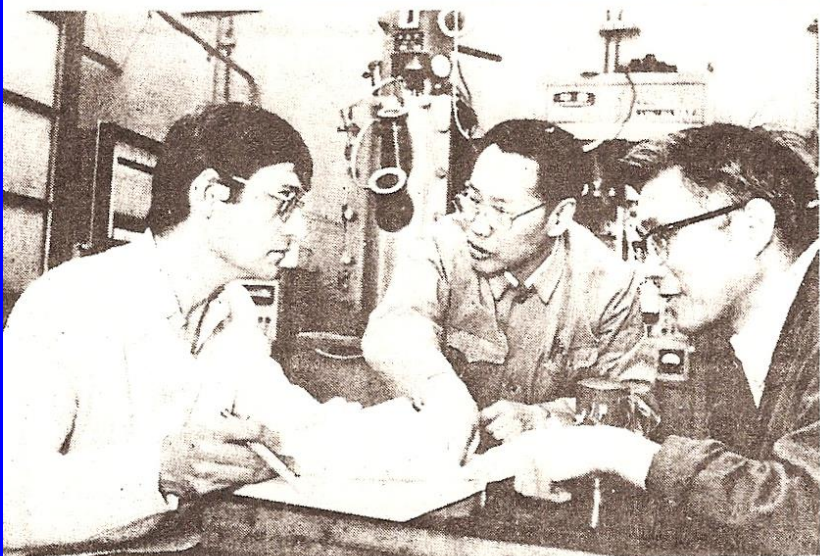
Christian Pedrini
LPCML, Lyon



Marvin Weber
LLNL, USA

香港大公報

版五第 秋立十三 日四廿月六年亥癸曆



歐洲核子研究中心列柯格博士(左)與上海硅酸鹽研究所研究人員一起討論晶體質量及今後加強合作的問題。



上海硅酸鹽研究所
長、均勻性最好
米)之後、最近
體 這個所的晶
後研製成的合成
紅寶石、鉍酸鋁
銀鈉、鉍酸鉛等
達到了國際先進
一新華社王子謹

will—the DAP won a record 24 seats. More important, it supplanted the UMNO-allied Malaysian Chinese Association as the leading parliamentary voice for the country's 6 million Chinese. Despite the risks of antagonizing the Malay majority, the DAP has regularly criticized the 16-year-old New Economic Policy, a cornerstone of Mahathir's administration that aims at reapportioning the country's wealth by giving financial and educational advantages to ethnic Malays. And with the economy at a virtual standstill, many Chinese are clearly feeling less tolerant of programs that grant, for instance, tens of thousands of overseas scholarships to young Malays, while forcing nearly all Chinese students to pay their own way. "If there are expanding opportunities, we are willing to accommodate political necessity," says one ethnic Chinese banker. "But you can't just dismiss 37 percent of the population."

Acid test: Mahathir caused a furor within his own UMNO ranks when he admitted as much during an interview earlier this year. "At the moment, there is no growth," he told the Australian Broadcasting Corp., "so we have decided we will not go ahead with the kind of restructuring we planned." (The interview, never released in Kuala Lumpur's carefully controlled English and Malay press, eventually circulated in foreign publications.) Juggling conflicting racial interests has always been the major test of Malaysian prime ministers—and Mahathir has so far won high marks. But his headstrong style of leadership has recently led to a string of costly decisions, including the fountaining "Look East" policy (which urged Malaysians to emulate Japan), the "Malaysian Car" program (a high-priced effort to replace imports with domestically assembled Mitsubishi sedans) and a call—loudly promoted and then quietly dropped—to boost Malaysia's population to 70 million by the end of the next century.

With so firm a parliamentary mandate, Mahathir may at least need to do less such grandstanding. "We all hope he'll take a fresh look at things and not feel so besieged," says one of the country's top businessmen. "He should prove himself and get the country back on its feet." Mahathir has hinted that strict government cost-cutting measures will be enacted soon. In addition economists predict that the plunging ringgit may have to be devalued. But otherwise Mahathir is saying little about his plans for the new term. On his side are the country's decade-long record of steady development and its clear taste for stability. But unless the economy perks up again soon, the job of preserving Malaysia's uneasy racial harmony could prove to be difficult, even after last week's smashing victory.

SPENCER REISS with FRANK GIBNEY Jr. in Kuala Lumpur

NEWSWEEK/AUGUST 18, 1986

Turning on the Export Tap

Deng tries an economic about-face

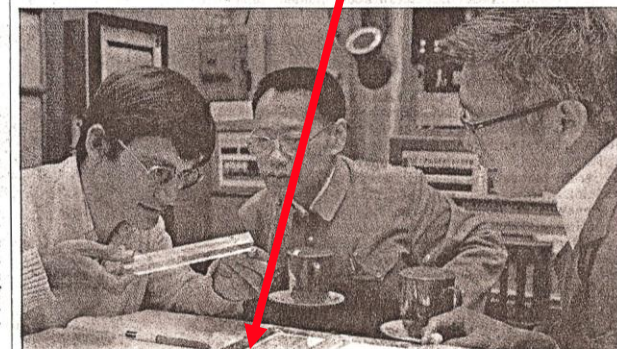
Just last year, China's Guangdong Province was deeply in debt. Deng Xiaoping's economic reforms had freed the Chinese to import products from abroad, and the consumers of the province bought up millions of dollars' worth of goods from nearby Hong Kong. The surge in imports contributed to a precipitous 13 percent drop in China's vital foreign-currency reserves in the first quarter of 1985 and drew sharp rebukes from conservative central planners in Peking. It was the kind of controversy that Deng—whose economic reforms have met enormous resistance—wanted to avoid. Now thanks to the reformers' quick reflexes, Guangdong, along with the rest of the country, has obliged by turning on the export tap; since January, overseas sales from Guangdong alone have jumped 48 percent.

The turnaround is symptomatic of the wrenching changes that Deng has wrought in China's economy—and of the miscalculations that can be made along the way. Deng's 1984 reforms fueled domestic demand for consumer goods, inadvertently encouraging businesses to produce for the domestic markets. Peking also loosened controls on foreign trade and foreign-currency exchange. The unforeseen result was an enormous overseas shopping spree—as in Guangdong—that threatened to drain China's currency reserves and wreck the economy. Exports slumped, and last year the trade deficit ballooned from \$1.4 billion

to nearly \$14 billion. Now, in what seems remarkably quick order, the trade priorities have been redrawn: by orchestrating an export boom, Deng has apparently found a way of silencing his opponents without ditching his reforms.

Tax breaks: The new blueprint is a blend of capitalist incentives and strict communist central planning. Factories with good export records get tax breaks and can keep more of the hard currency their exports earn. Peking has also increased the number of products that require export licenses. Last month the government primed the export pump with a 13.6 percent devaluation of its currency, the yuan.

The effort has apparently begun to pay off: although imports are still rising, China's exports have shot up 14.4 percent so far this year. But Peking still faces limitations on how much it can sell overseas. One major problem is quality, since many Chinese goods are still shoddy. What's more, the country's subsidies for exports such as textiles may soon run afoul of protectionist sentiment abroad. Finally, if China is really going to compete on an international scale, its primitive factory system must be retooled and updated—which will be impossible without huge purchases of foreign-made equipment and technology. Finding a way to finance those imports without running China's economy into the red—or drawing the fire of his political opponents—is Deng's next big challenge.

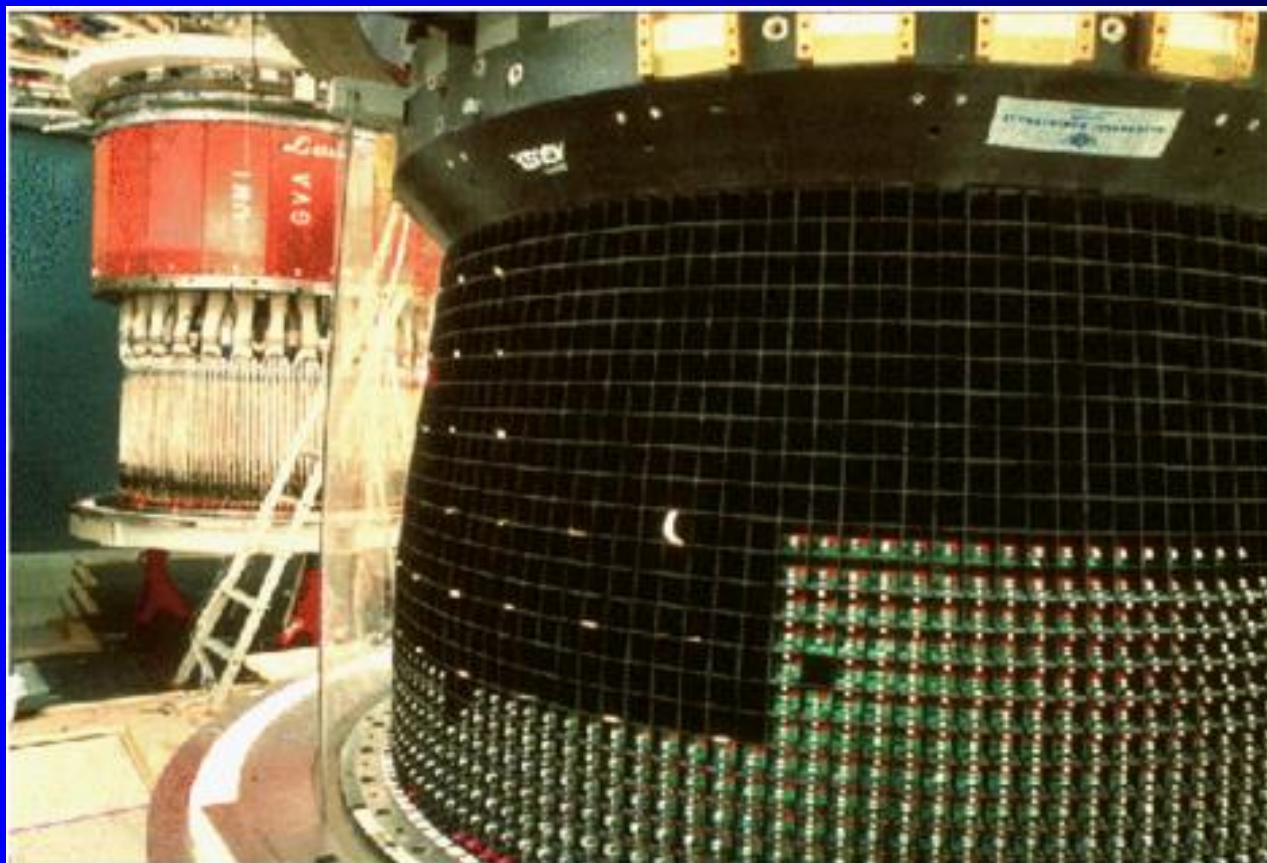


Revving up overseas sales: A foreign importer inspects crystals made in Shanghai

?

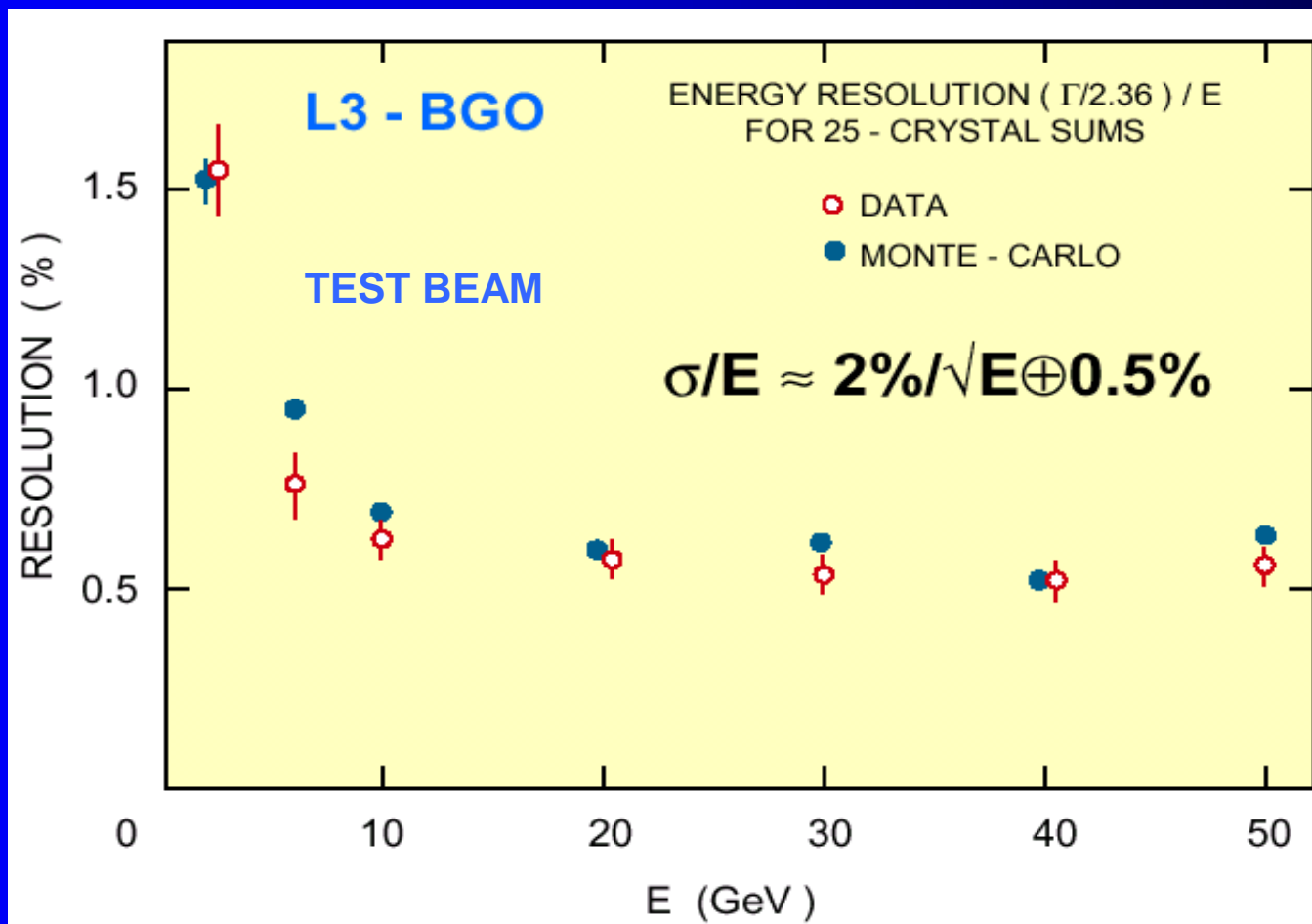
XINHUA

21



12000 BGO crystals
1.5 m³, 11 tons

L3 BGO resolution



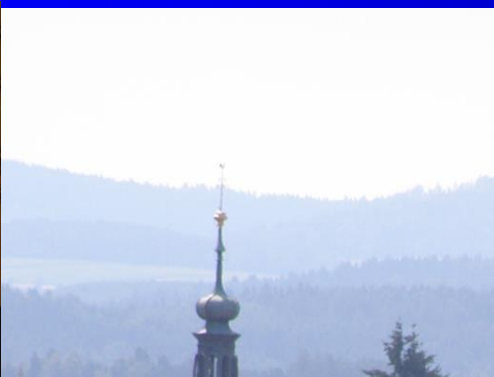
Preserving 5 % constant term required continuous monitor and calibrations, before the installation and during the run

The LHC challenge

- How to detect the Higgs boson?
 - with a very small cross section
 - with a very narrow mass distribution
 - over a huge non-reducible background
- ➔
- Through its decay into two γ rays detected in a high precision crystal-based electromagnetic calorimeter with crystals
 - at least as dense as BGO
 - At least 10 times faster than BGO
 - The science of scintillators was almost non existent
 - All the research was oriented to laser applications, i.e. luminescence \neq scintillation

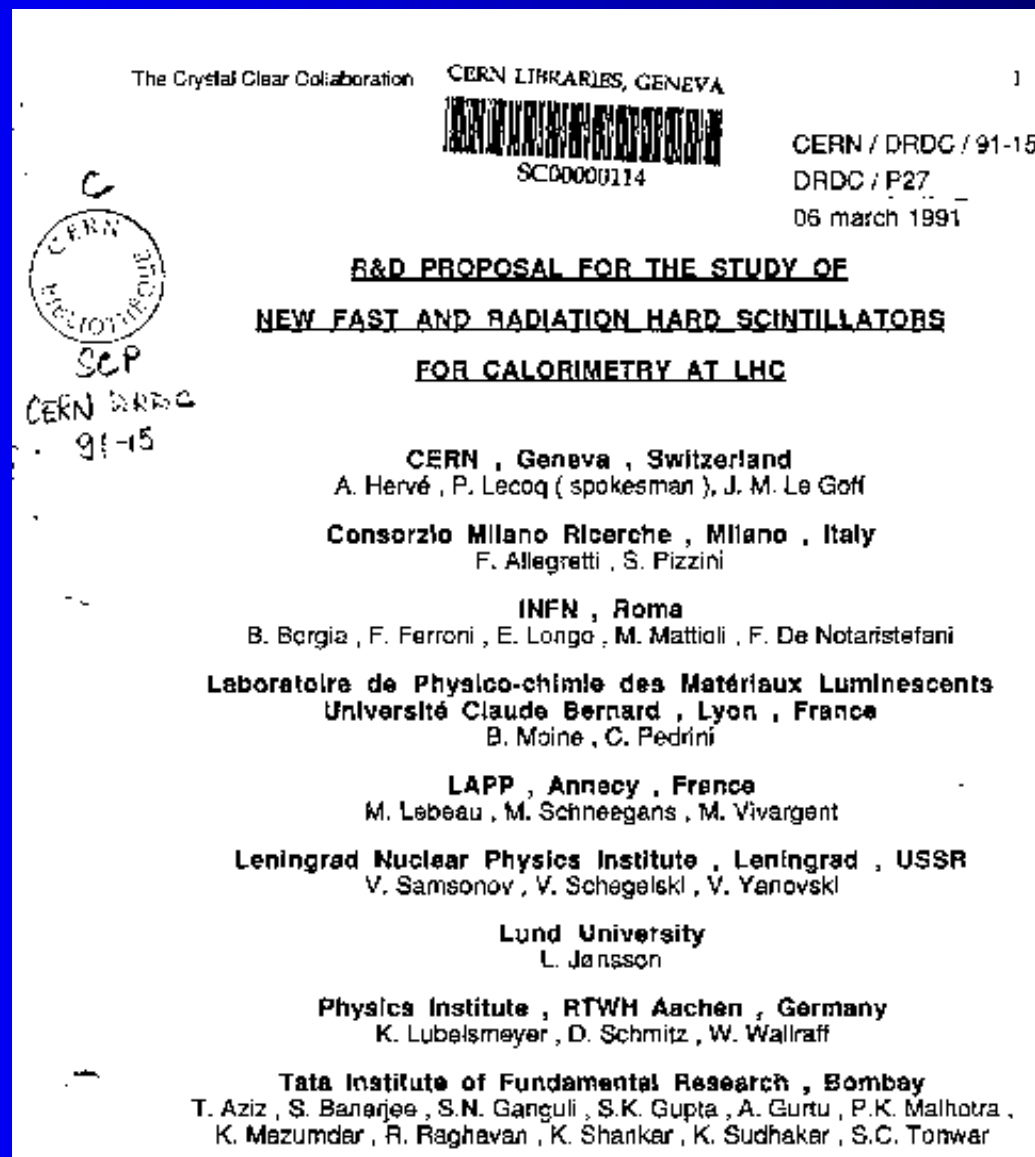
The Birth of Crystal Clear

Spring 1991 C. Pedrini and P. Lecoq invited in Mnichovice by J. Mares

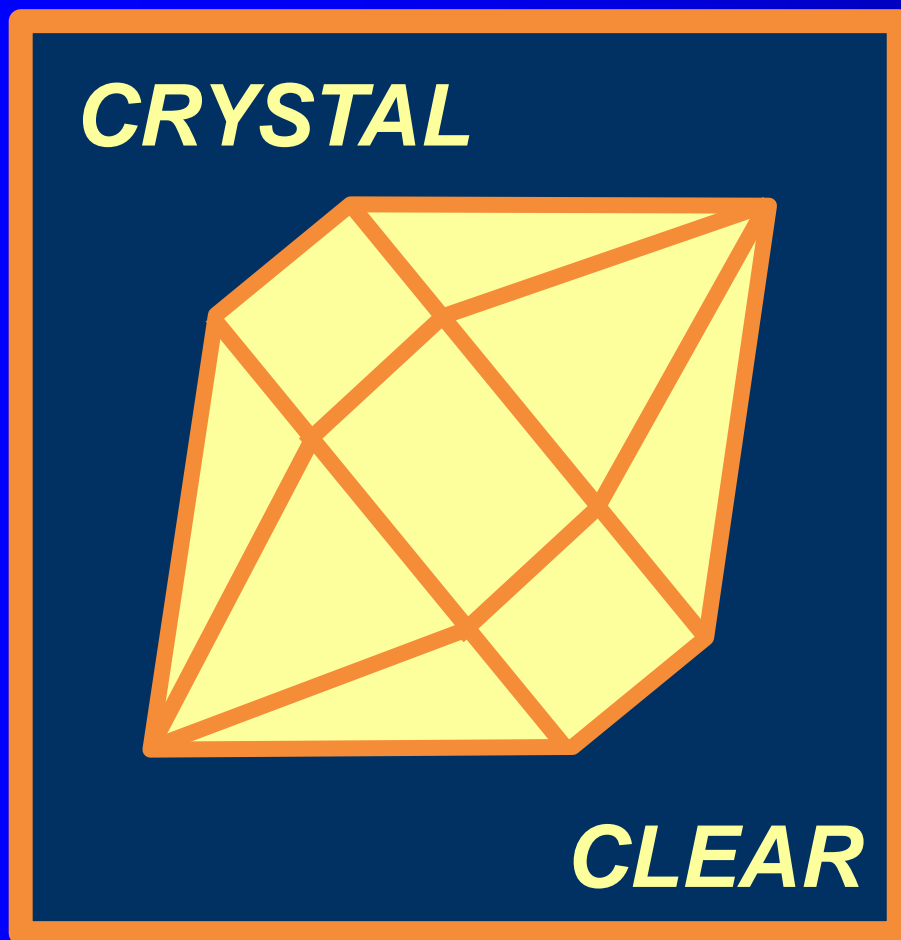




The genesis of Crystal Clear



Crystal Clear Collaboration



- 9 Institutes networking with
 - Luminescence Experts
 - Crystal Growers
 - Commercial Producers
 - End users

40 – 100 Scientists

The CMS Challenge

	NaI(Tl)	BaF ₂	CsI(Tl)	CeF ₃	BGO Bi ₄ Ge ₃ O ₁₂	PWO PbWO ₄
Xo [cm]	2.59 😞	2.03 😞	1.86 😐	1.66 😐	1.12 😊	0.92 😊
ρ [g/cm ³]	3.67 😞	4.89 😞	4.53 😞	6.16 😊	7.13 😊	8.2 😊
τ [ns]	230 😞	0.6 😊 620 😞	1050 😞	30 😊	340 😐	15 😊
λ [nm]	415 😊	230 😊 310 😐	550 😊	310 😐 340 😐	480 😊	420 😐
n@λ _{max}	1.85 😐	1.56 😊	1.80 😐	1.68 😊	2.15 😞	2.3 😞
LY [%NaI]	100 😊	5 😞 16 😞	85 😊	5 😐	10 😊	0.5 😞



CeF3 or not CeF3?



Fermi National Accelerator Laboratory

FERMILAB-Pub-89/169

Cerium Fluoride: A Scintillator for High-Rate Applications *

D. F. Anderson
Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

August 1989

IEEE Transactions on Nuclear Science, Vol. 36, No. 1, February 1989

CERIUM FLUORIDE, A NEW FAST, HEAVY SCINTILLATOR

W.W. Moses and S.E. Derenzo,
Donner Laboratory and Lawrence Berkeley Laboratory,
University of California, Berkeley, CA 94720

THESE de DOCTORAT de L'UNIVERSITE PARIS VI

spécialité : Physique des Solides

Présentée par

Etiennette AUFFRAY

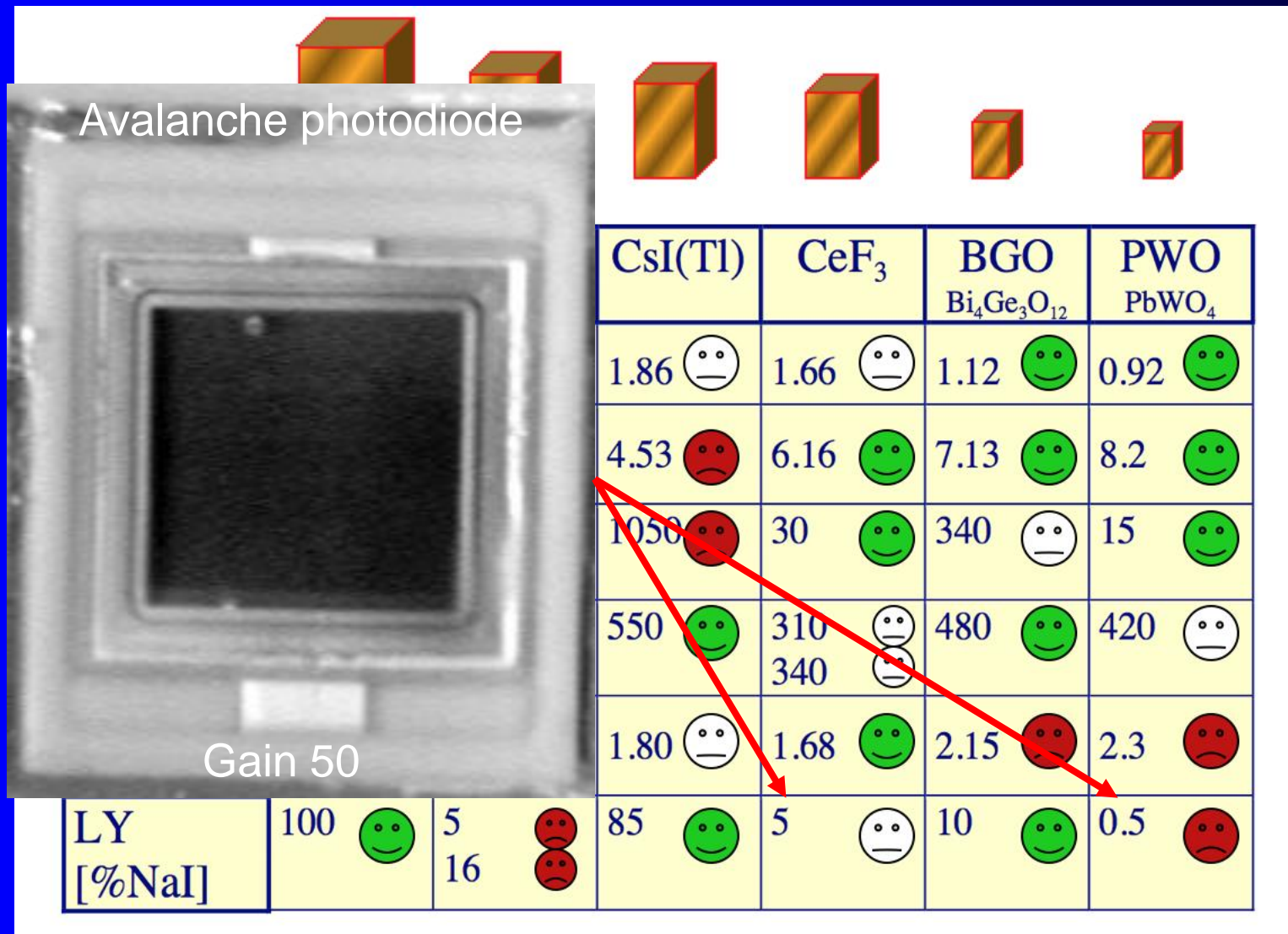
pour obtenir le grade de DOCTEUR de L'UNIVERSITE PARIS VI

Etude des mécanismes de scintillation et des modifications sous irradiation des propriétés du fluorure de cérium en vue de son utilisation en calorimétrie électromagnétique de haute résolution

Soutenue le 10 Mai 1995 devant le jury composé de

MM. J. Bok	Président
P. Lecoq	Directeur de thèse
C. Pédrini	Rapporteur
M. Schneegans	
V. Topa	Rapporteur

The CMS Challenge



Timeline for PbWO_4 Crystals ECAL



Sept 1992: Idea presented at the first SCINT conference in Sept 1992
(few yellowish cm^3 samples)

→ **1993-2008: R&D:** improve rad. hardness: purity, stoichiometry, defects

→ **Oct. 1994: CMS Decision to choose PbWO_4 for the ECAL**

→ **1994-2001: Prototyping:** large matrices in test beams, monitoring

→ **1997-2008: Mass manufacture:** increase industrial capacity, QC

→ **2001-2008: Systems Integration:** tooling, assembly

→ **2007-2008: Installation and Commissioning**

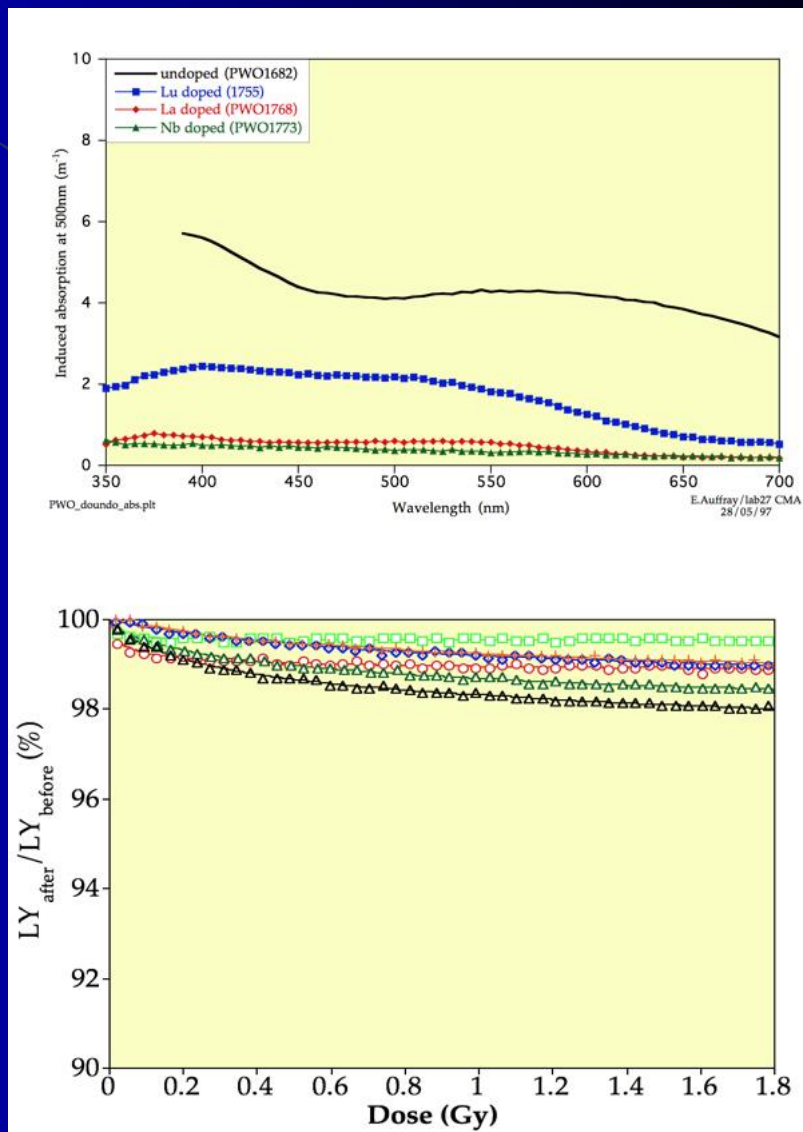
→ **2008 onwards: Data Taking**

Crystal
Clear

CMS

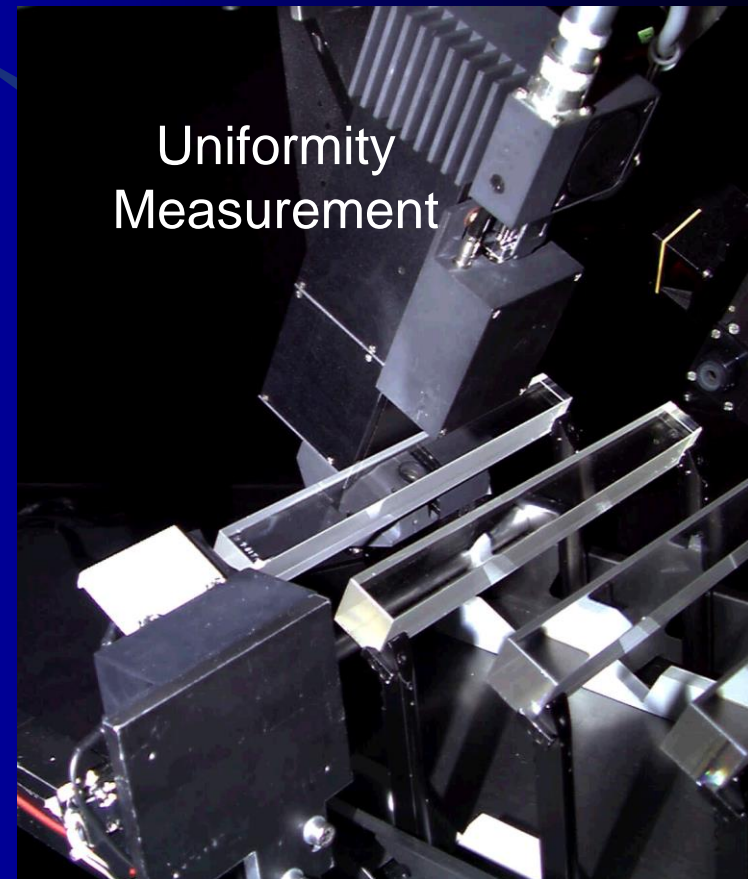
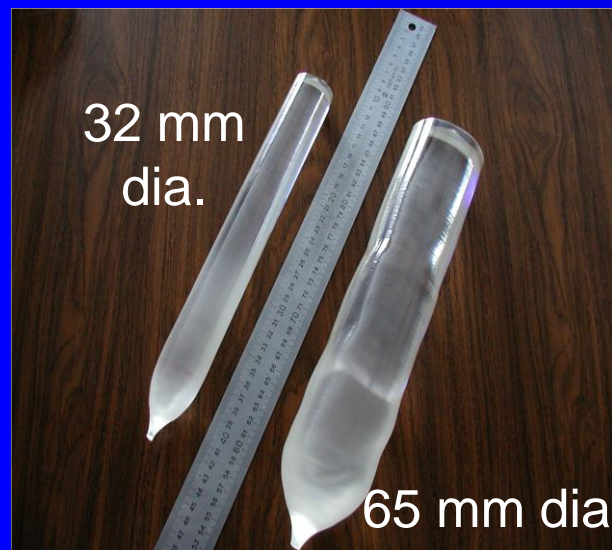
- 1993-1997: Improve radiation hardness by
 - Identifying and reducing impurities down to ppm level
 - Optimizing stoichiometry to reduce O vacancies

- 1997: Heterovalent doping to compensate for remaining vacancies/impurities
 - Trivalent doping
La, Lu, Y, Al
 - Improves transmission and decay
 - Improves Rad. hardness Kobayashi for La: KEK 1997-12
 - CMS Note 97/54, NIM A 402(1998) p75



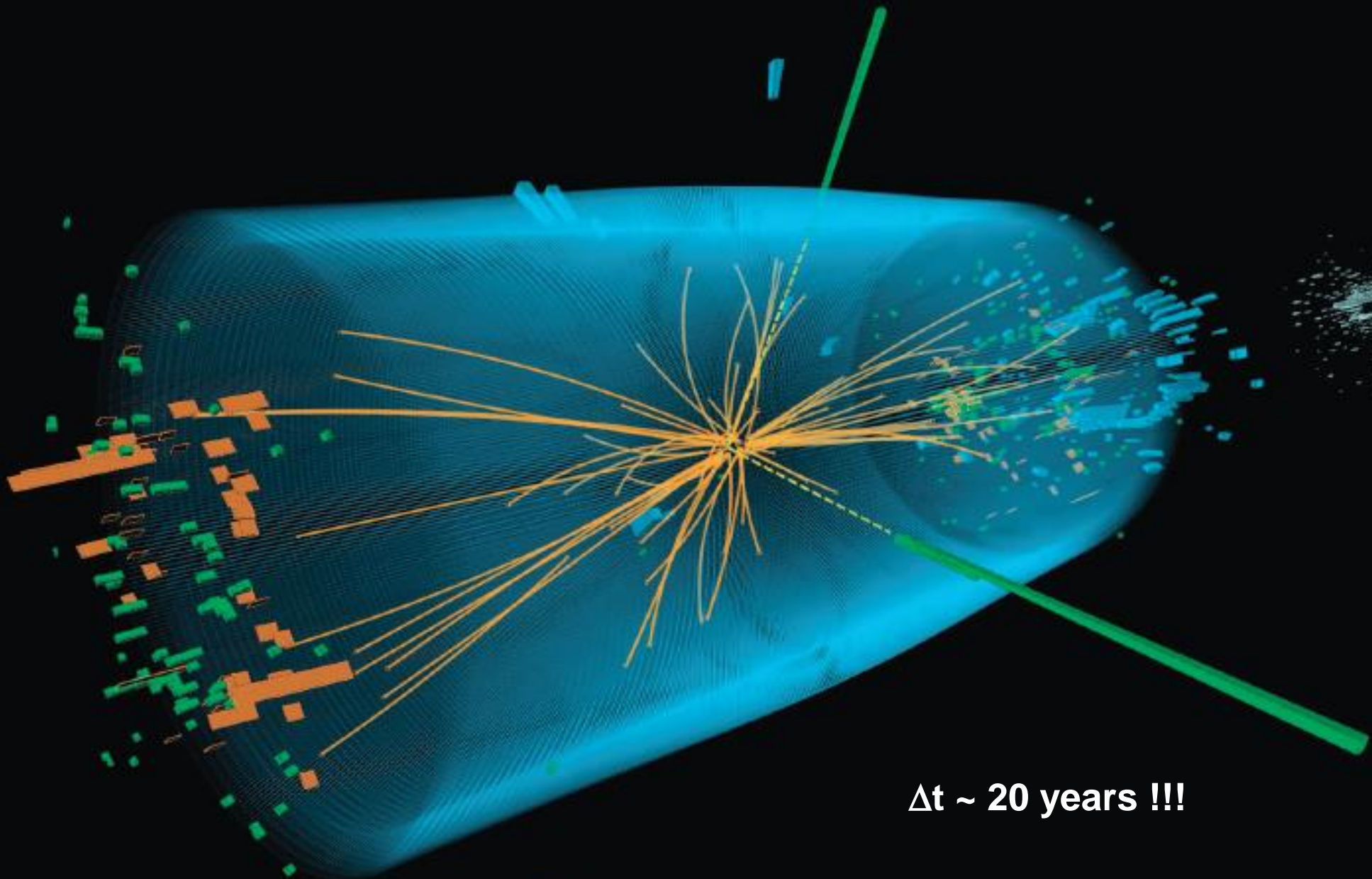
The mass production problem

78,000 Crystals





4th July 2012 : The Higgs Boson!!



$\Delta t \sim 20$ years !!!

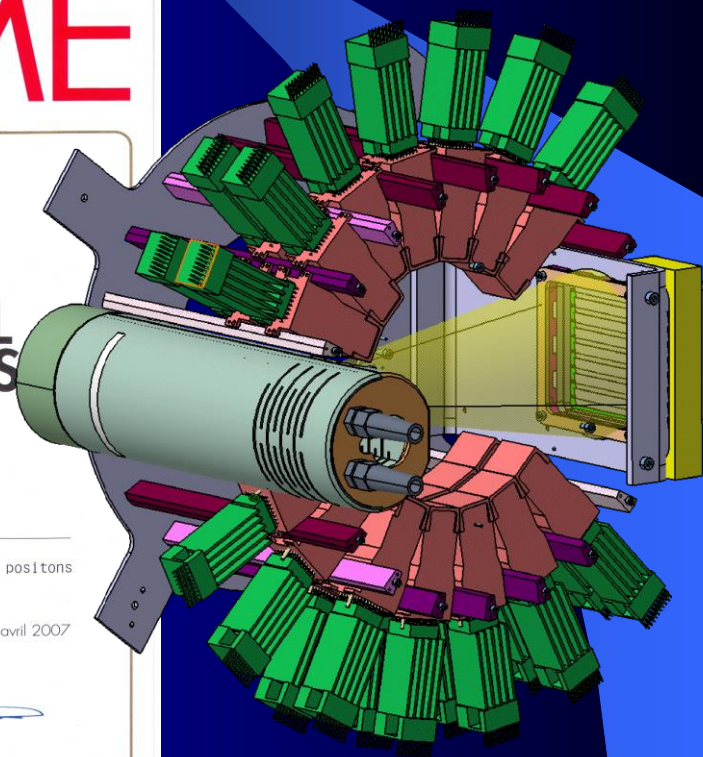
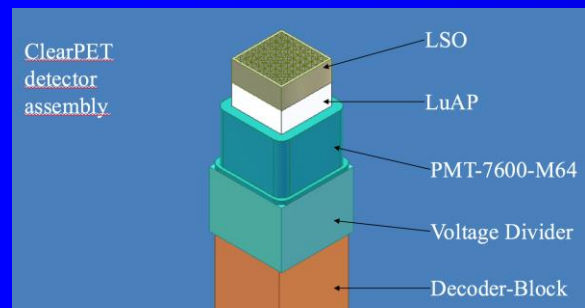
1995: Crystal Clear Collaboration new spokesman Stefaan Tavernier



Redefine CCC missions along two lines:
Continue fundamental studies on scintillators
Open CCC to new application domains, beyond HEP

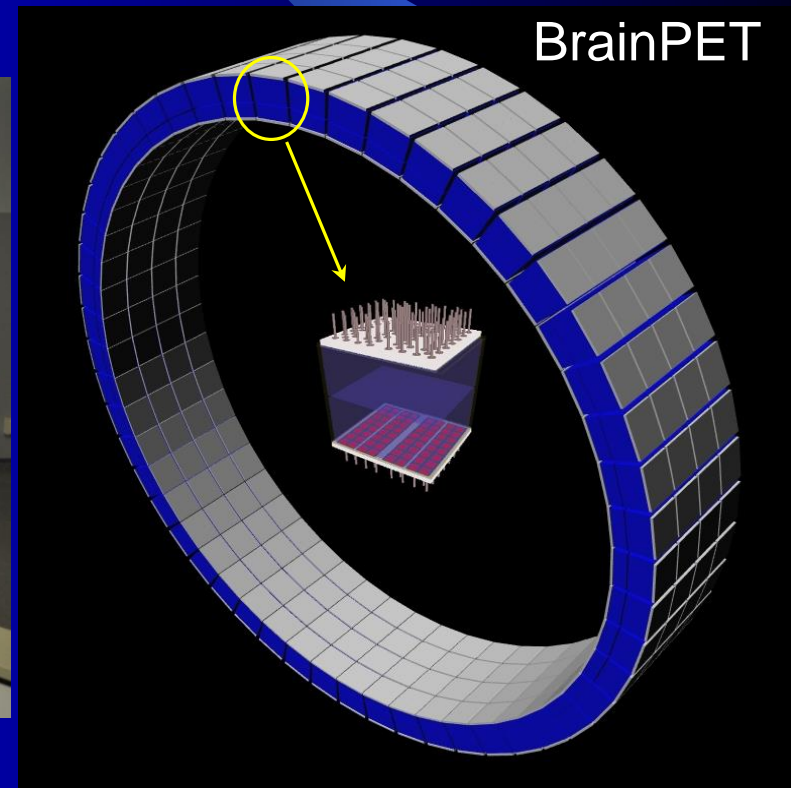
CCC new mission: promote technology transfer to medical imaging

- Need to enlarge the collaboration to bring the missing expertise to the CCC
- 1995: Jülich, CPPM: ClearPET with LuAP/LSO



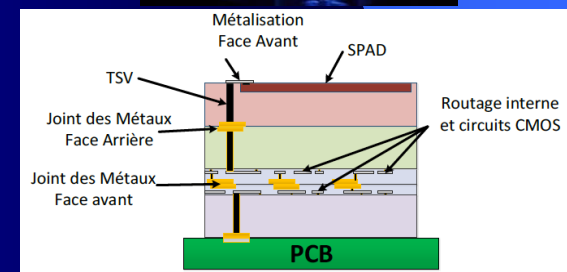
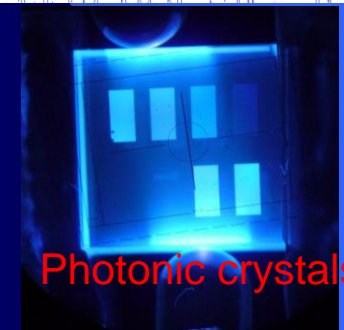
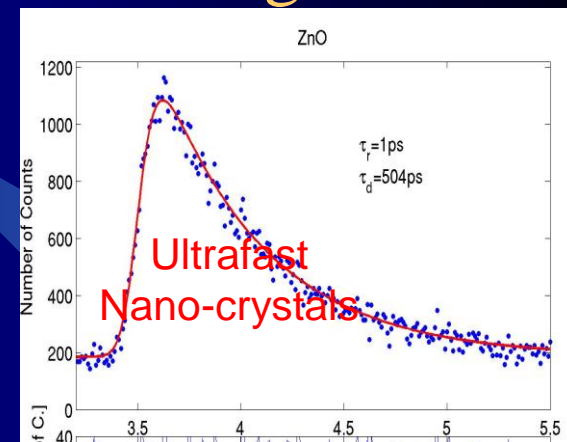
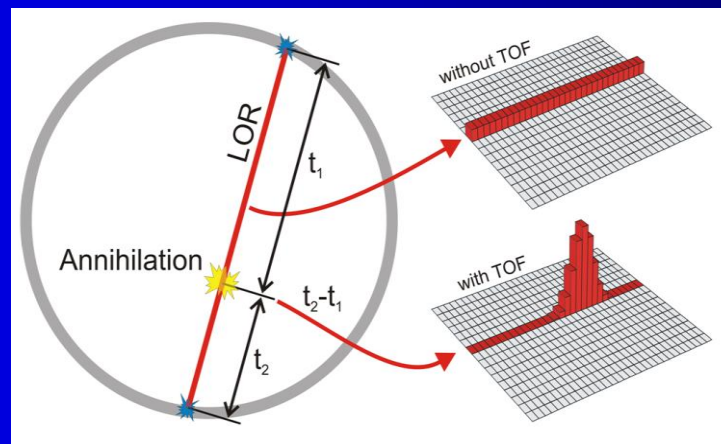
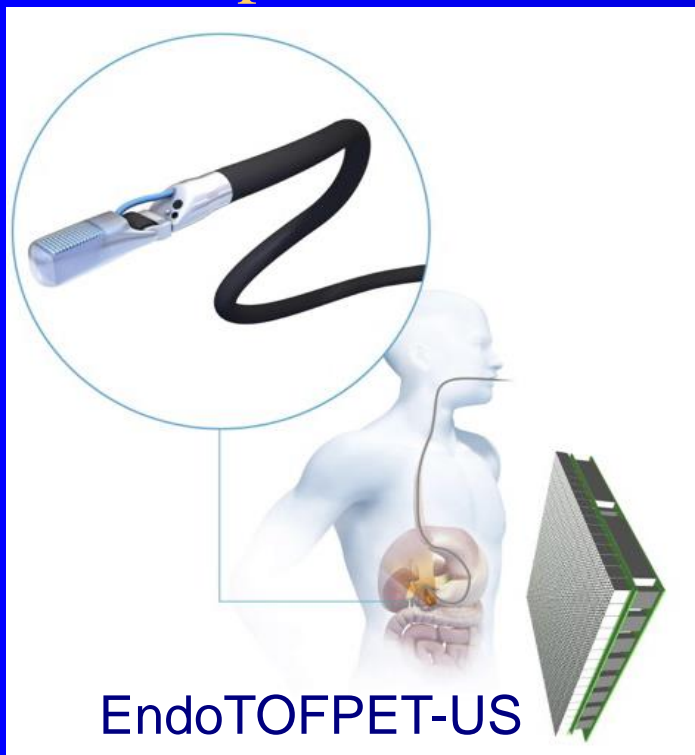
CCC new mission: promote technology transfer to medical imaging

- Need to enlarge the collaboration to bring the missing expertise to the CCC
- 2001: LIP, UNIMIB, DKFZ: ClearPEM (+ Sonic):
- CIEMAT: BrainPET



CCC new mission: promote technology transfer to medical imaging

- Need to enlarge the collaboration to bring the missing expertise to the CCC
- EndoTOFPET-US: 2011
- 10ps TOFPET: 2013

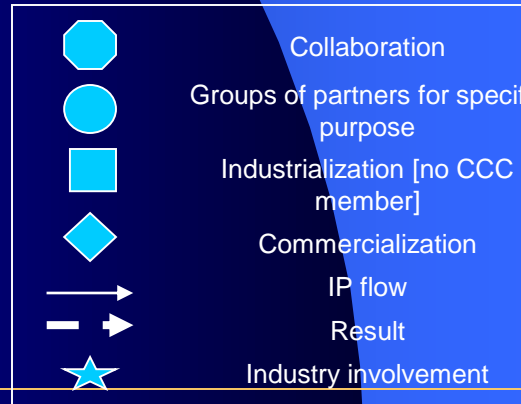
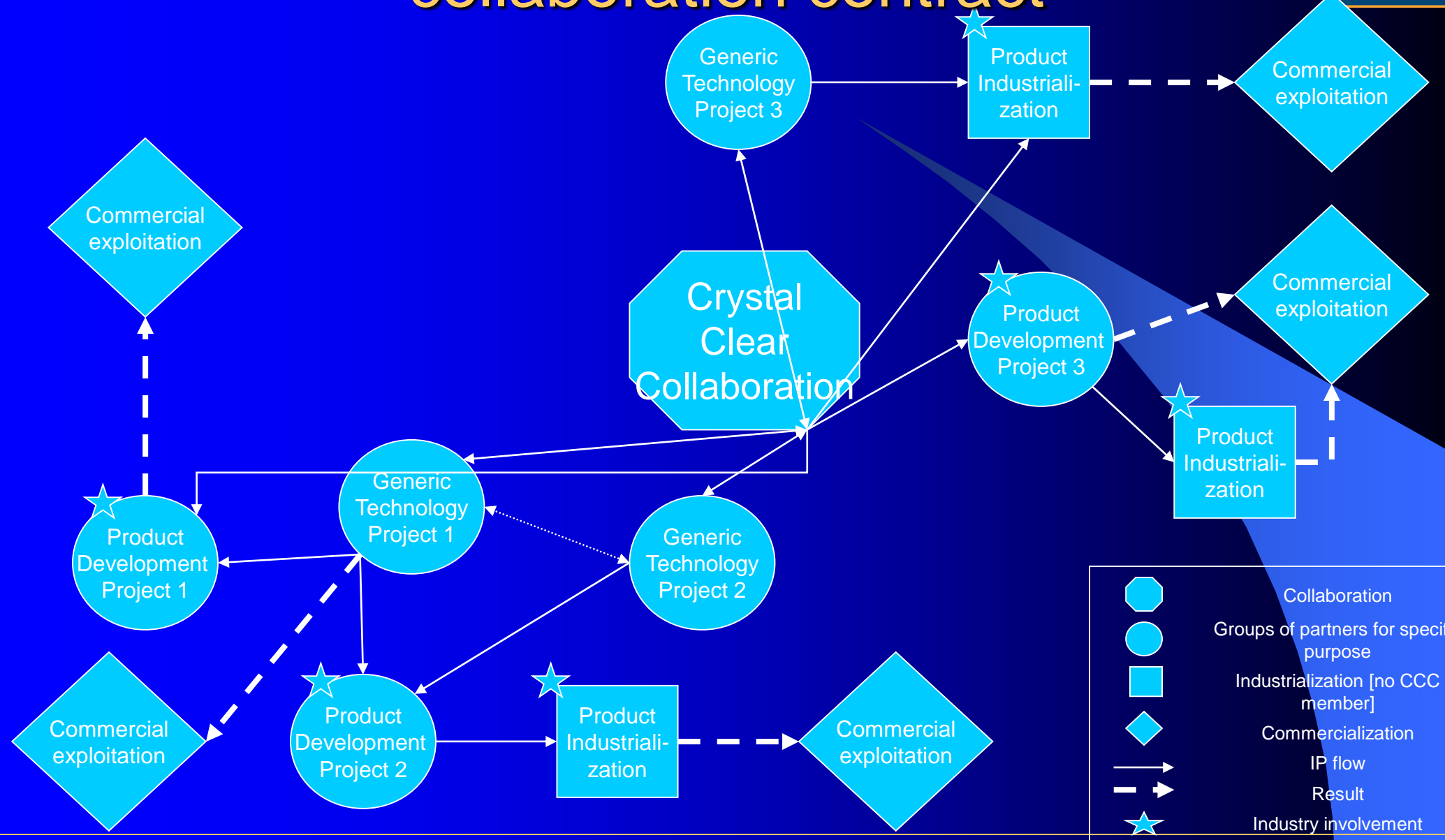


Proposed model for R&D Collaborations between Academia and Industry

The Crystal Clear Collaboration example 1996



Proposed structure for the CCC collaboration contract



K1500/ TT/ PH/ 004C

Agreement between:

1. **The Institute for Physical Research**, Ashtarak, a research institute with its seat at Ashtarak-2, 378410, Republic of Armenia, represented by Dr. A.V. PAPOYAN, Director;
2. **The Vrije Universiteit Brussel (VUB)**, with its seat at Pleinlaan 2, 1050 Brussels, Belgium, represented by Prof. B. VAN CAMP, Rector;
3. **The Forschungszentrum Juelich GmbH**, a research institute with its seat at Leo-Brandt-Str. 52425 Juelich, Germany, represented by Dr. H. FISCHER and Dr. W. JAEK;
4. **The Centre National de la Recherche Scientifique (CNRS)**, a public establishment for scientific and technological research, whose headquarters are at 3 rue Michel Ange 75794 Paris Cedex 16, France, SIREN no. 180 089 013, APE/ NAF code 7219 Z represented by Mr A. MINGUS, Director, who has delegated his signature rights to :
 - Mr B ANDRAL, Rhône-Alpes Regional Delegate, with the seat of the Rhône-Auvergne regional delegation located at 2 avenue Albert Einstein, 69609 Villeurbanne Cedex, France;
 - Mr P. DOUCELANCE, Provence et Corse Regional Delegate, with the seat of the Provence et Corse regional delegation located at 31 chemin Joseph Aiguier, 13402 Marseille, Cedex 7, France;

The Université de la Méditerranée, a public establishment of a scientific, cultural and professional nature, having its registered offices at Jardin du Pharo – 58 Bd Charles Livon - 13284 Marseille Cedex 7. The CNRS is mandated by the Université de la Méditerranée to sign the present contract on its behalf awaiting the “plan quadriennal de développement 2008-2011” of the Université de la Méditerranée, acting for and on behalf of the **Centre de Physique des Particules de Marseille (UMR 6550)** directed by Mr. KAJFASZ;
5. **The Université Claude Bernard Lyon 1**, a public establishment of a scientific, cultural and professional nature, having its registered offices at La Doua, 43 boulevard du 11 novembre 1918, 69622 Villeurbanne Cedex, France, represented by Prof. L. COLLET. The CNRS and the Université Claude Bernard Lyon 1 acting for and on behalf of the **Laboratoire de Physico-Chimie des Matériaux Luminescents (UMR 5620)**, directed by Ms. Marie-France Joubert;

6. **The Institute for Nuclear Problems attached to the Belarussian State University (INP)** with its seat at 11 Bobruiskaya Street, 220050 Minsk, Republic of Belarus, represented by Mr. M. KORZHIK;
7. **The Laboratório de Instrumentação e Física Experimental de Partículas (LIP)**, with its seat at Av. Elias Garcia, 14, 1000-149 Lisboa, Portugal, represented by Prof. G. BARREIRA, President;
8. **The Sungkyunkwan University (SKKU)**, 300 Cheoncheon-dong Jangan-Gu, Suwon, Gyeonggi-do, Korea, represented by Mr. J. DON SEO, President;
9. **The Centro De Investigaciones Energeticas, Medioambientales Y Tecnológicas (CIEMAT)**, Avenida Complutense, 22 E-28040 Madrid, Spain, represented by Dr. J. A. RUBIO RODRÍGUEZ, Director General;
10. **The Deutsches Krebsforschungszentrum (DKFZ)**, Neuenheimer Feld 280, 69120 Heidelberg, Germany, represented by Prof. Dr. WIESTLER, Chairman and Scientific Director and Dr. J. PUCHTA, Administrative-Commercial Director;
11. **The Università Politecnica Delle Marche (UPM)**, Via Breccia Bianca 60131 Ancona, Italy, represented by Prof. Ing. M. PACETTI, Rector;
12. **The European Organization for Nuclear Research, CERN**, an Intergovernmental Organization with its seat at Geneva, Switzerland, represented by Dr. R. AYMAR, Director General;
13. **The Universiteit Gent (UGent)**, with its seat at Sint-Pietersnieuwstraat 25, B-9000 Gent, represented by Prof. P. VAN CAUWENBERGE, Rector;
14. **The Faculty of Sciences of the University of Lisbon**, with its seat at Edifício C5, Campo Grande, 1749-016 Lisboa, Portugal, represented by Prof. N. M. de CARVALHO FERREIRA GUIMARÃES, President - Board of directors of the Faculty of Sciences of the University of Lisbon.

CRYSTAL 2000

CHAMONIX, France, September 22-26, 1992

- MRS94 - San Francisco
- SCINT95 - Delft
- SCINT97 - Shanghai
- SCINT99 - Moscow
- SCINT2001 - Chamonix
- SCINT2003 - Valencia
- SCINT2005 - Alushta
- SCINT2007 - Wake Forest
- SCINT2009 - Jegu Island
- SCINT2011 - Giessen
- SCINT2013 - Shanghai
- SCINT2015 - Berkeley
- SCINT2017 - Chamonix

CRYSTAL 2000

(First SCINT Conference, in 1992)



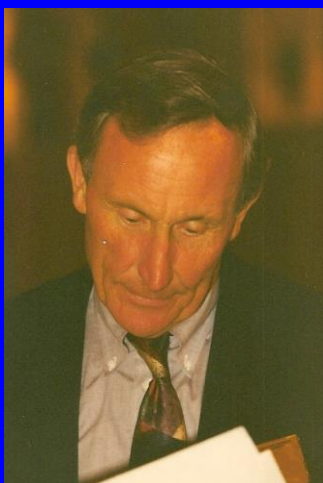
Bill Moses



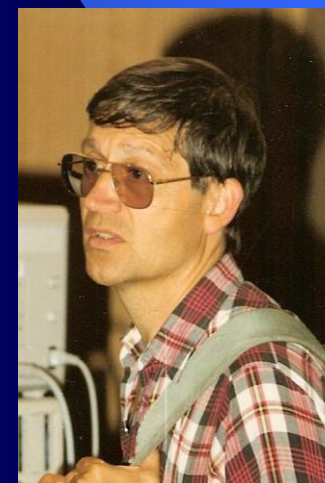
Steve Derenzo



Christian Pedrini



Marv Weber



Paul Lecoq

CRYSTAL 2000

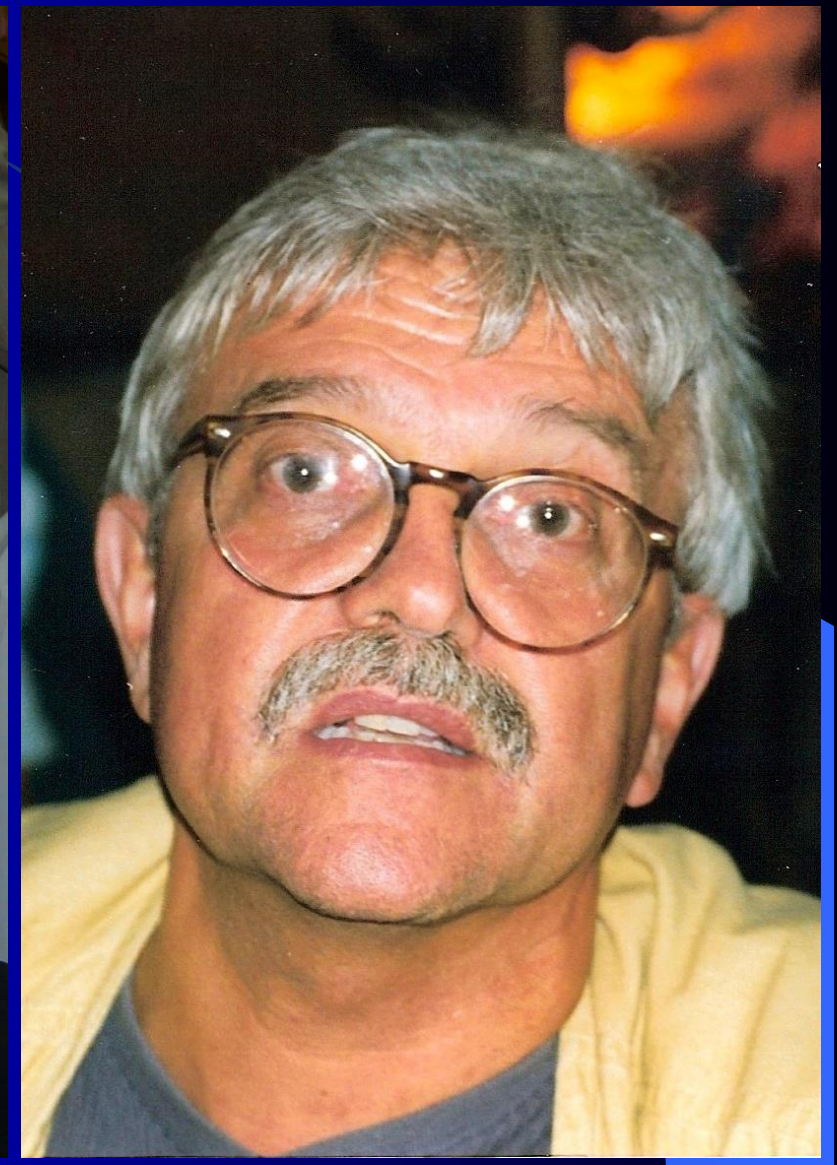
(First SCINT Conference, in 1992)

- 2 major announcements:
 - Lead Tungstate (PWO)
 - To become a major player in HEP and Nuclear Physics
 - 100 tons for CMS, 40tons for Alice, Panda, ...
 - Luthetium Ortho-Silicate (LSO)
 - To become the crystal of choice for PET scanners
 - About 10tons/year

CCC, for Communicating



CCC, for Convincing



CCC, for Converging to a Crystal Clear friendship



Crystal Clear in a nutshell

- Born 25 years ago in 1991 with 9 institutes (now 27)
- More than 650 publications
- 72 theses

			updated list	thesis
1	P. Almeida	Uni Lisbon	yes	yes
2	E. Auffray, P. Lecoq	CERN		
3	R. Chipaux	CEA-IRFU/Saclay	yes	yes
4	Y. Choi	Sungkyunkwan University, Seoul	yes	
5	Y. d'Asseler	UNi Gent		
6	F. Davi, D. Rinaldi	Università Politecnica delle Marche, Ancona	yes	
7	C. Dujardin	ILM	yes	
8	M. Kirm , V. Nagirny	Institute of Physics, University of Tartu		
9	M. Korjik	RINP, Minsk		
10	J. Marton	Vienna		
11	C. Morel	CPPM, Aix Marseille University and CNRS	yes	
12	M. Nikl	Institute of Physics, ASCR, Prague	yes	
13	R. Novotny	Uni Giesen		
14	I. Papakonstantinou	UC London		
15	A. Petrosyan	Astharak	yes	yes
16	U. Pietrzyk	FZ-Juelich / INM-4		yes
17	M. Pizzichemi, M. Paganoni	Università Milano-Bicocca		
18	D. Prox, J. Peter	DKFZ, Heidelberg	yes	
19	P. Rato Mendes	CIEMAT, Madrid	yes	
20	M. Streun	Forschungszentrum Jülich	yes	
21	G. Tamulaitis	Vilnius University	yes	
22	S. Tavernier	Vrije Universiteit Brussel / LIP, Lisbon	yes	
23	H. Tsoumpas	University Leeds		yes
24	J. Varela	LIP, Lisbon		
25	A. Vasilyev	Moscow State University	yes	
26	M. Wedrowski	Oncology Center, Bydgoszcz		
27	K. Ziemons	FH Aachen University of Applied Sciences		

Special Tribute to Etiennette



- Hired at CERN in 1990 at the start of CCC and SCINT
- In 1992 she got a position of Doctoral student to work on CeF3
- She took over Stefan in 2010 as spokesperson of CCC
- She has now the fate of CCC in her hands for, at least, the next 25 years



CCC: a network of expertise and friendship

