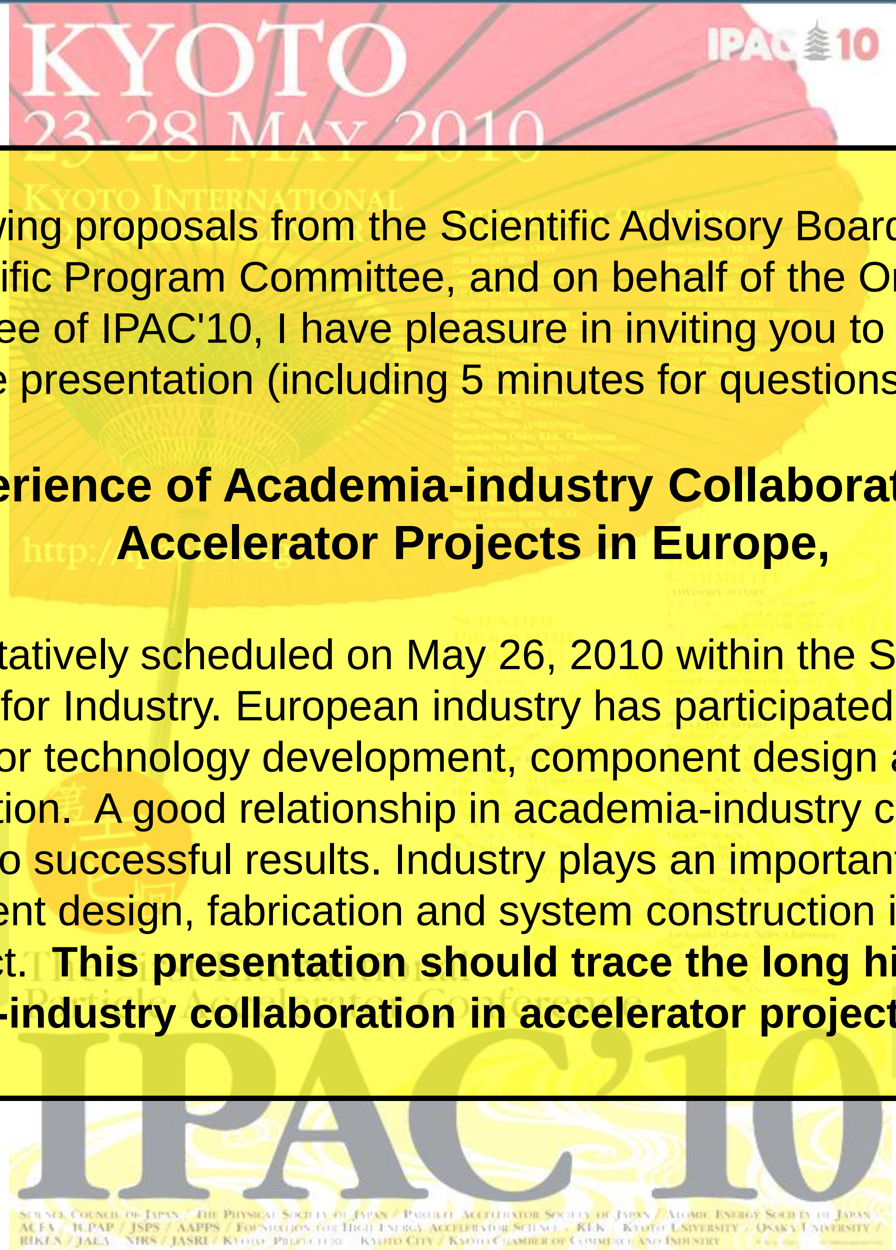
Experience of Academia-Industry Collaboration on Accelerator Projects in Europe

D. Einfeld / CELLS-ALBA



Following proposals from the Scientific Advisory Board and the Scientific Program Committee, and on behalf of the Organizing Committee of IPAC'10, I have pleasure in inviting you to make a 20-minute presentation (including 5 minutes for questions) entitled

Experience of Academia-industry Collaboration on Accelerator Projects in Europe,

tentatively scheduled on May 26, 2010 within the Special Session for Industry. European industry has participated in the LHC Project for technology development, component design and system construction. A good relationship in academia-industry collaboration lead to successful results. Industry plays an important role for component design, fabrication and system construction in the XFEL project. **This presentation should trace the long history of academia-industry collaboration in accelerator projects in Europe.**

Contents

Historical Remarks

After World War II the industries build for electrons, protons and ions the following accelerators:

Cyclotrons, Betatrons, Linacs, Microtrons, Weak focussing Synchrotrons

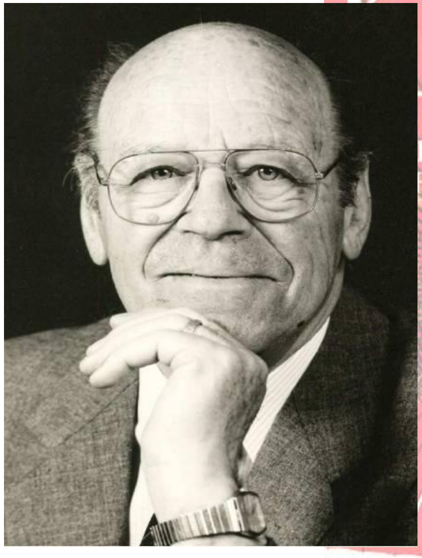
Most if this accelerators were build by the industry as a turn key system. The energy of the accelerated particles was restricted to some MeV's. A change took place with the concept of the strong focussing, invented by E.D.Courant, M.S. Livingston, and H.S. Snyder in 1952.

The first accelerator designed and build according to this concept was the 500 MeV Synchrotron at the University Bonn in Germany. The history of this machine has been published in a book:

Die vier Leben einer Maschine
Das 500 MeV Elektron Synchrotron der Universitaet Bonn
von Ralph Burmeister

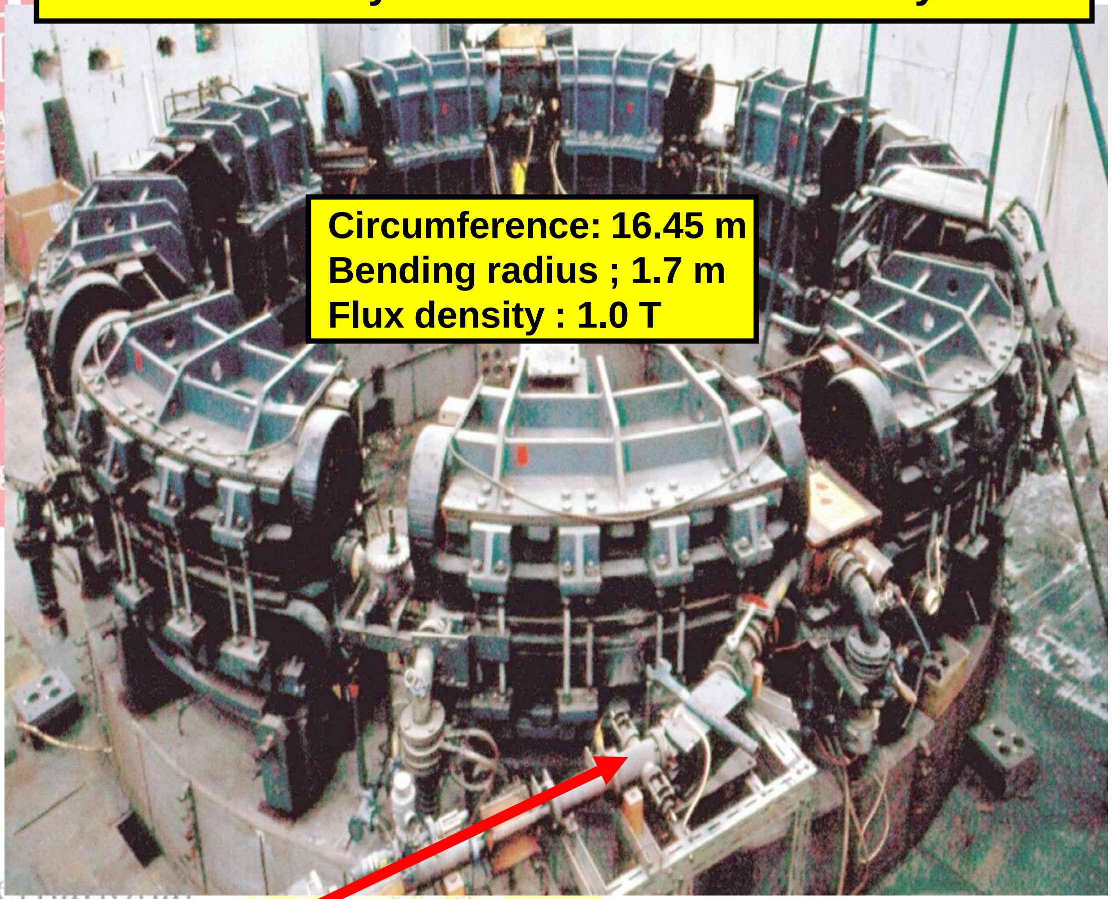
The driving person of this project was Prof. Paul, the Nobel Prize Winner of 1985. Prof Paul wanted to make some "Meson Physics" and for that he needed at least 100 MeV electrons. The Review Committee proposed to go up to 500 MeV.

Historical Remarks



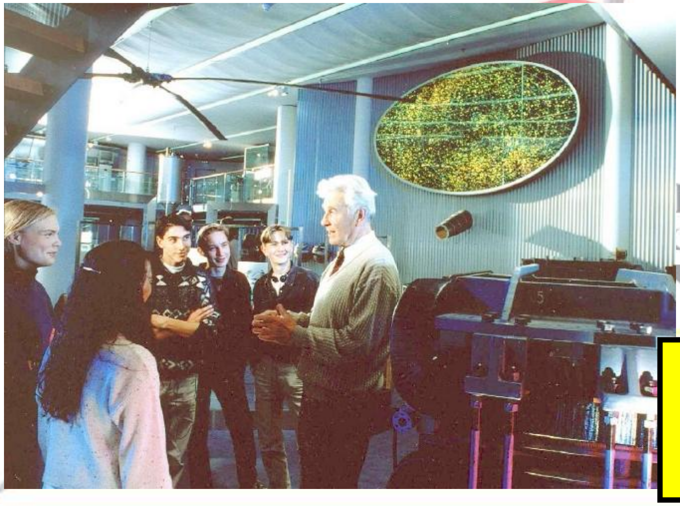
Prof. Paul, Nobel prize 1985

The 500 MeV Synchrotron of the University Bonn



Circumference: 16.45 m
Bending radius ; 1.7 m
Flux density : 1.0 T

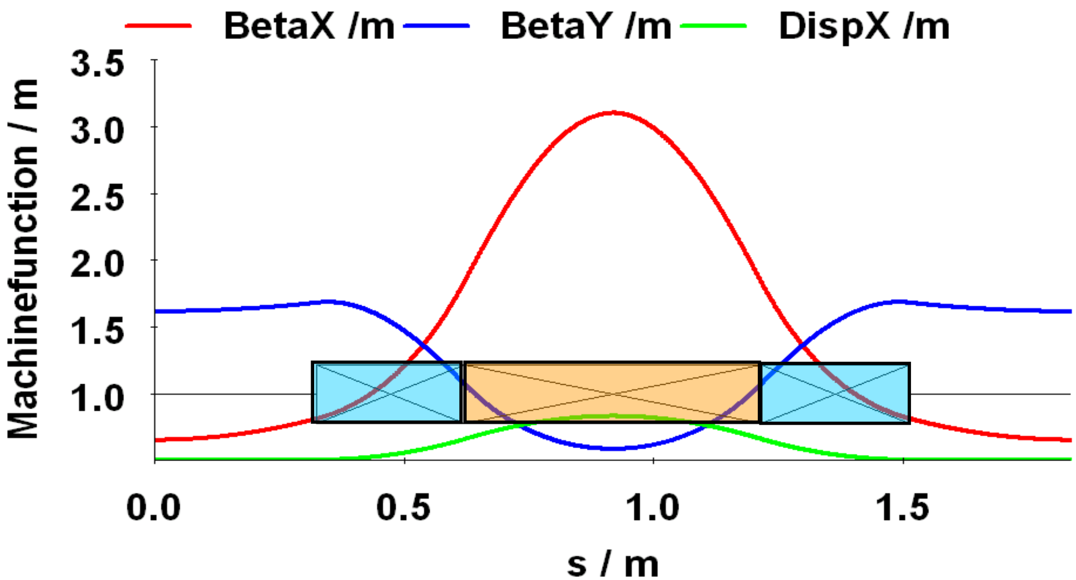
Injected beam: 3 MeV Van-de-Graff (6mT)



Prof. Althoff explaining the machine at the "Deutsches Museum" in Bonn

Historical Remarks

Machine functions of 500MeV synchrotron

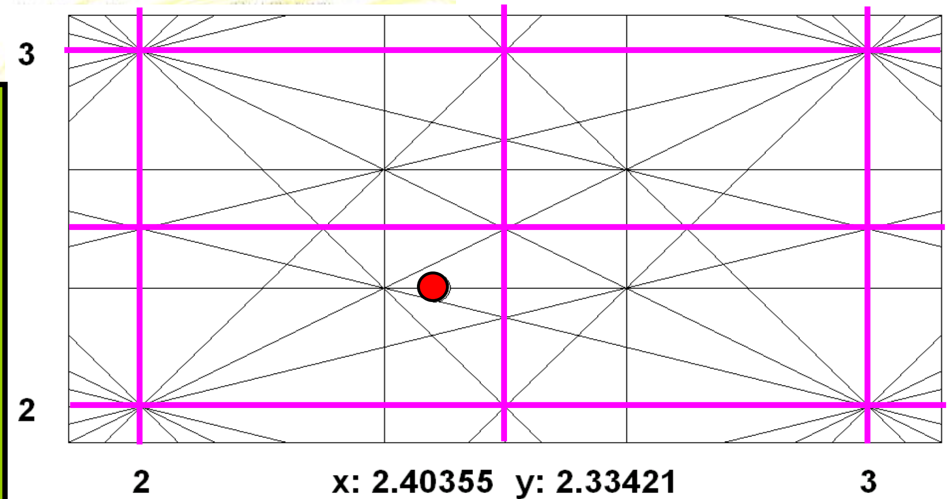


G(D) = 10.06 T/m

G(F) = 8.81 T/m

The pole profile of the focussing and de focussing bending magnets were determined by measurements in an "Electrolytic Trough"

Resonance Diagram



At this time (1952/1953) the forbidden resonance lines were the integer and half integer numbers. Later it was realized that also the third integer is a forbidden resonance line too. To avoid this, the magnets had to be dismantled and some spacers were inserted between the D- and F-focussing magnets

Historical Remarks

By reading this book I realized, that the connection between the Industry and the accelerator laboratories was a bit different as today.

Each component: magnets, power supplies, injection elements, RF-system, vacuum system, etc was designed by the companies and the university. There wasn't any template from which they could make a copy.

For example, for the vacuum chambers two different materials have been used: Ceramic and glass. The manufacturer of the ceramic chamber said: "Making this vacuum chamber with the required coating is very difficult and has some risk. But we will take the risk and take over some additional cost because of the interest to this project".

Another point was different too: All the people who designed the machine were later users of the machine.

For the next generation of accelerators, the group from Bonn proposed:
"To have enough technical staff for the detailed design and preparation of drawings, according to which the industry can manufacture the components (magnets, vacuum system, RF – System, etc). In this case one can save and avoid lot of trouble"

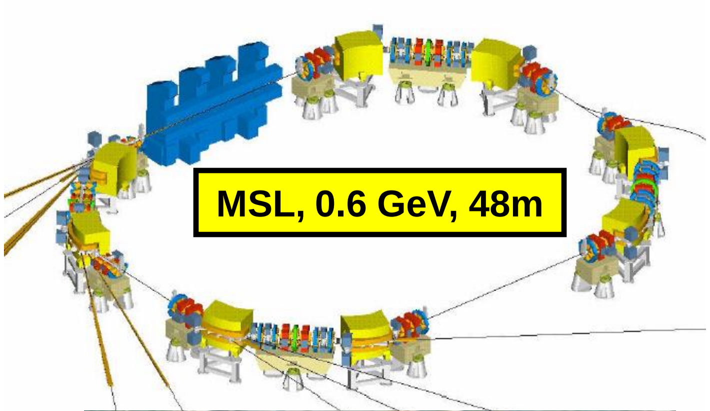
Steps for the production of components

Steps for the production of components

1) Preparation of the CFT documents:
   Technical specifications and administrative clauses
2) Publication of the documents and invitation of companies
   to participate in this CFT – Process
3) Receiving and evaluation of the offers
4) Negotiation with the companies about technical as well financial issues
5) Signature of the contract
6) Kick off meeting with the company
7) Preparation of the design and manufacturing report by the company,
   approved by the laboratory.
8) Production of a prototype and acceptance by the laboratory
9) Production of the component
10) Factory acceptance test (FAT)
11) Site acceptance test (SAT)
12) Finishing of the contract

With this procedure it permanently takes place a technology transfer from the laboratories to the industry (and vice versa).

BESSY Accelerator Complex



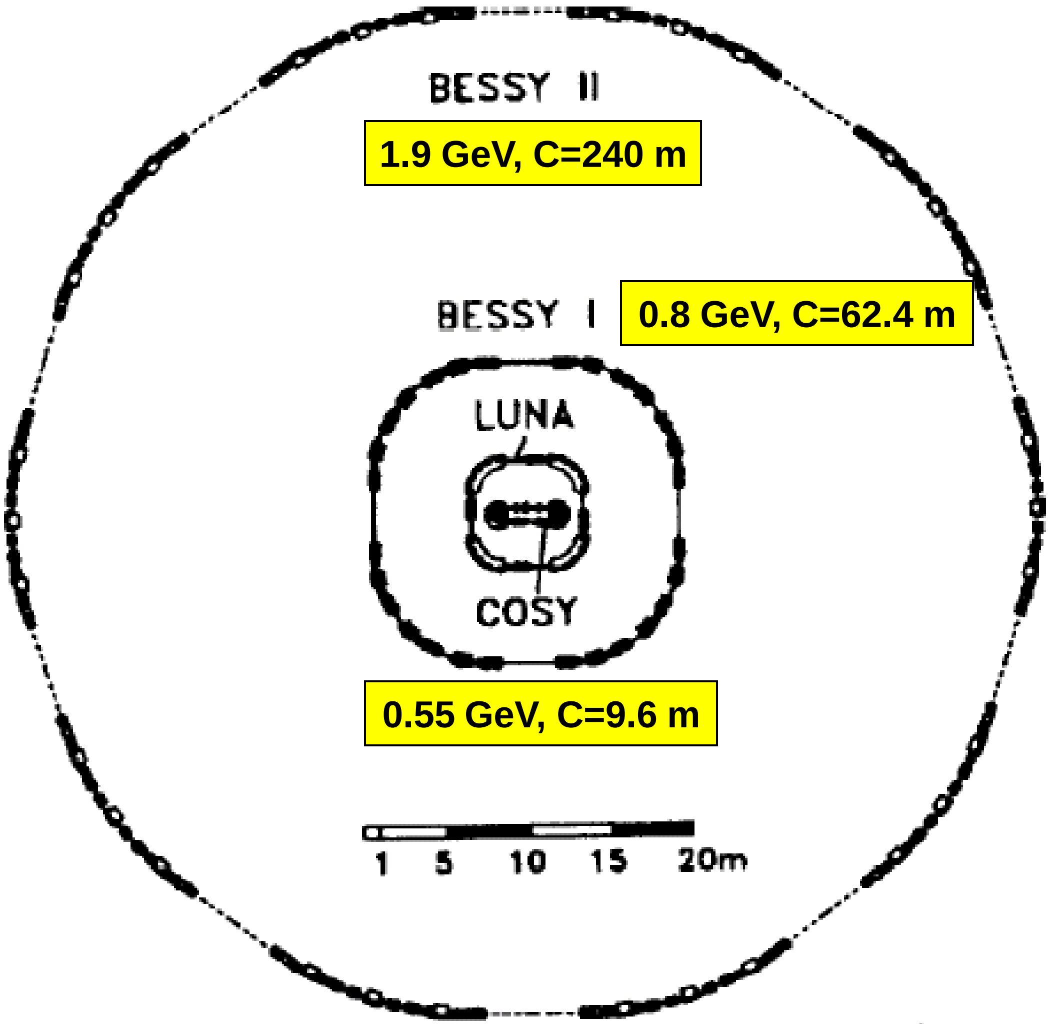
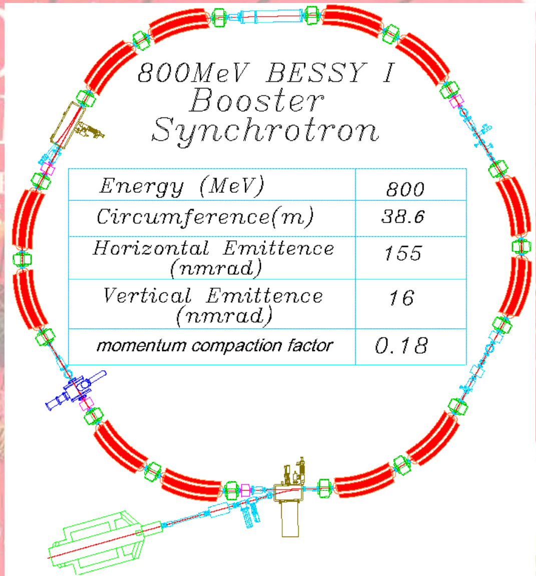
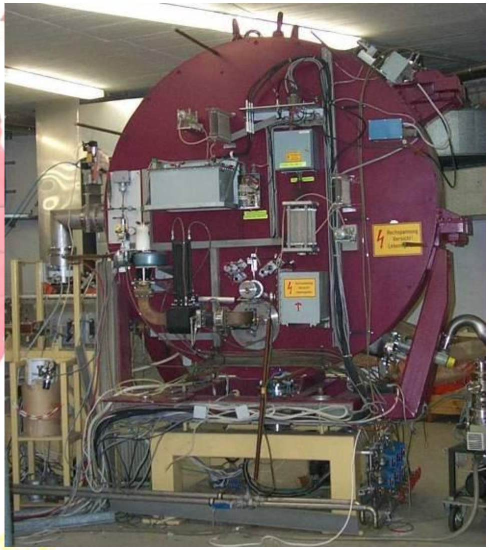


Fig. 1: Footprints for BESSY II, BESSY I (λ_c = 20 Å), the conventional compact source LUNA (λ_c = 22 Å), and the superconducting COSY ring (λ_c = 12 Å).

BESSY I - Injector

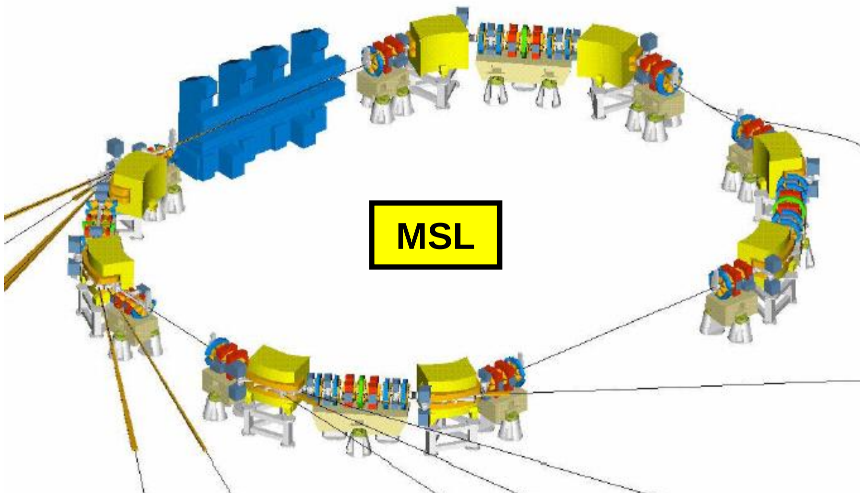




Collaboration between Scanditronix and MAX-LAB

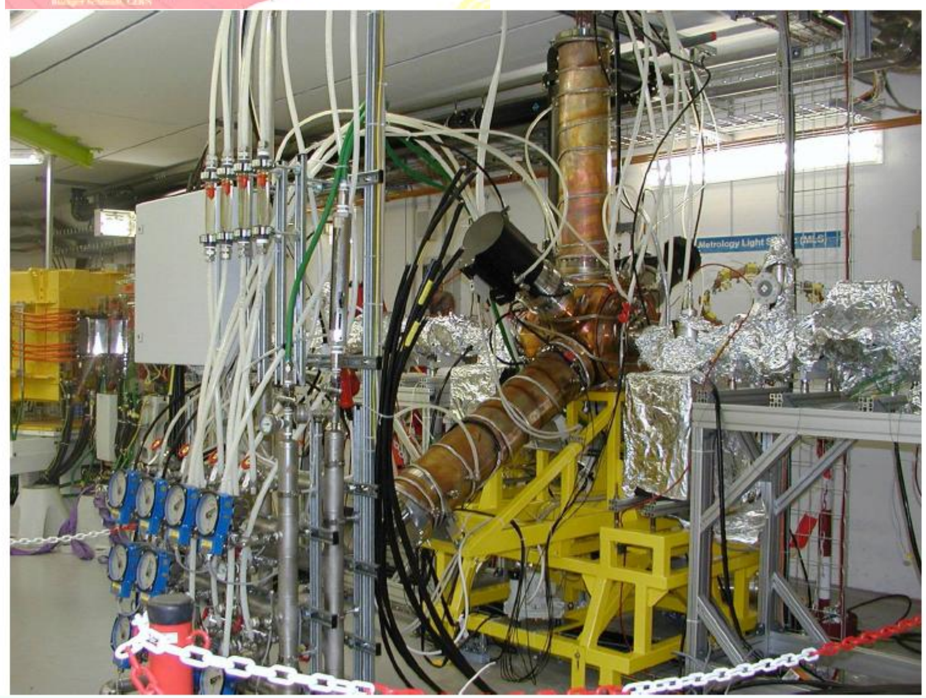
The 800 MeV injector of BESSY I was a turn key system build by Scanditronix. The injector exist of a 22 MeV Microtron and a 800 MeV booster synchrotron. The 22 MeV microtron was a standard product of Scanditronix. For the booster synchrotron Scanditronix made a collaboration contract with MAX-LAB (Mikael Eriksson). Scanditronix made the design, the manufacturing, the installation as well the commissioning of the injector complex. This injector complex, finished in 1982 will also be used as an injector for SESAME

EU-HOM Cavity



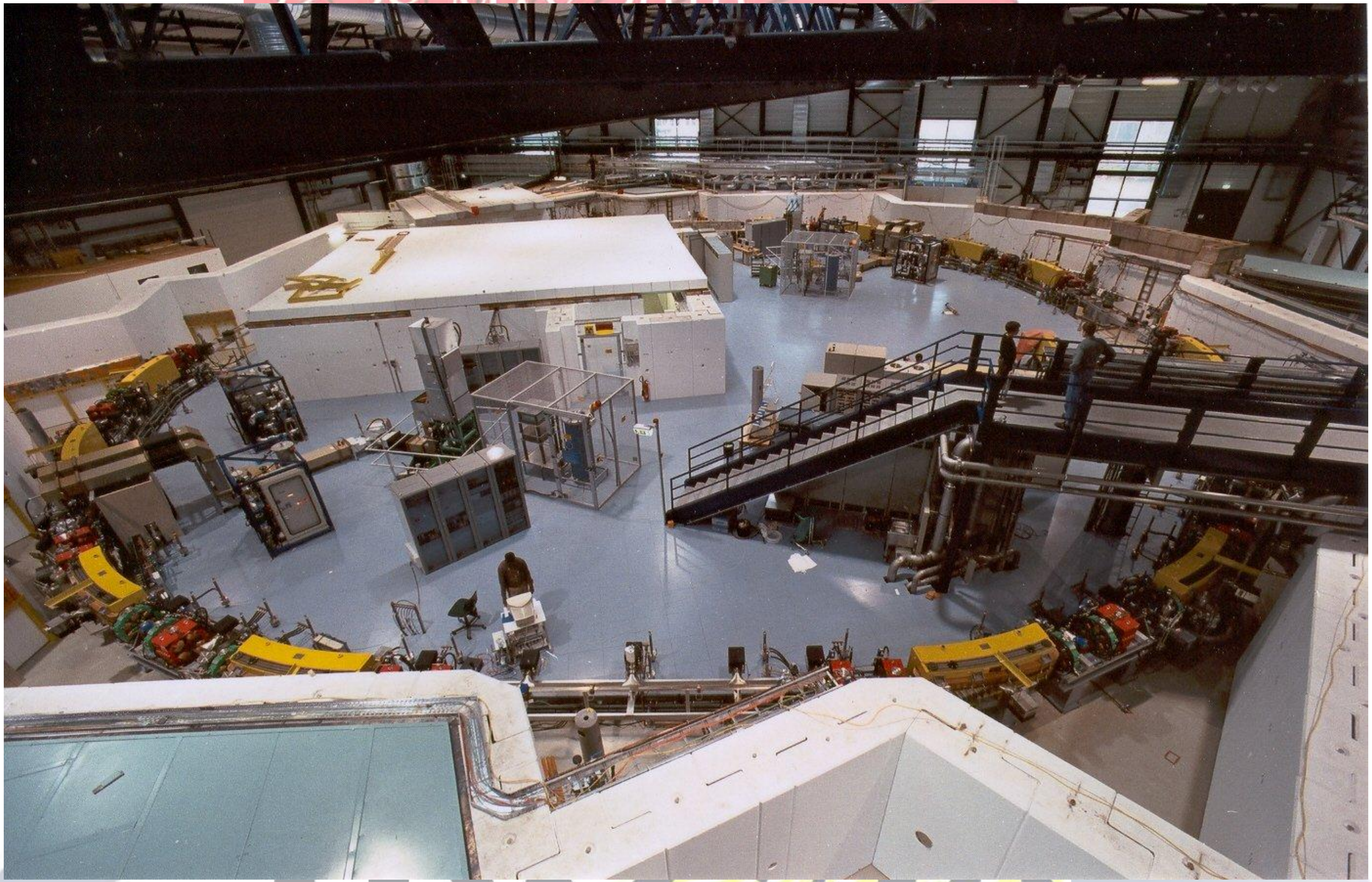
EU-HOM free Cavity of BESSY
For the Metrology Light Source (MLS) a higher order mode free cavity was designed by BESSY (Ernst Weihreter) and build by Industry according to the drawings.

This cavity is also used at ALBA and with some modifications it will be used for the upgrading of the ESRF too.



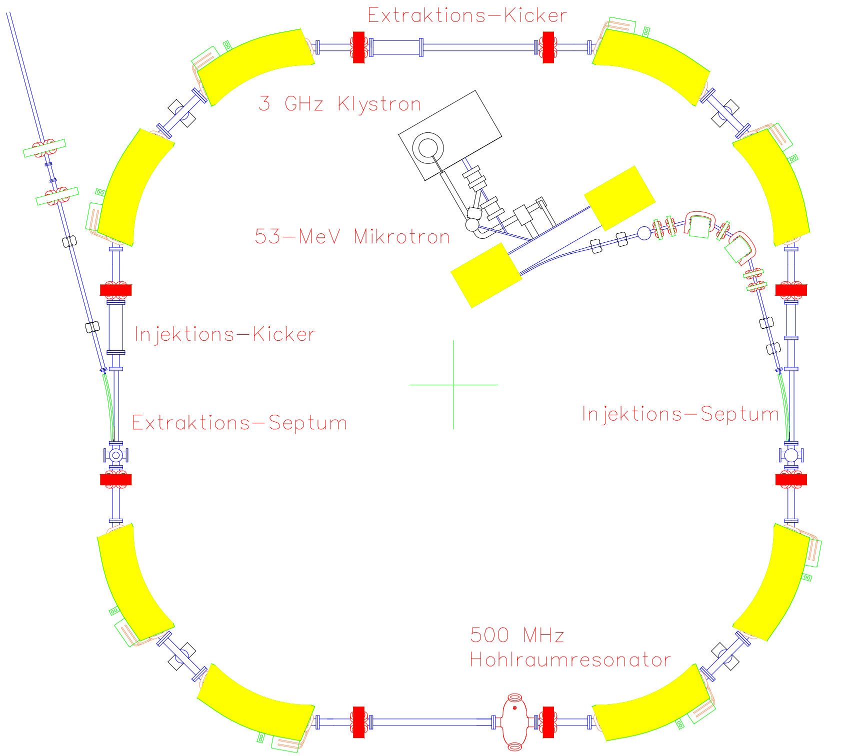
This is the normal way how the industries and the accelerator labs are working together.

ANKA-Complex



2.5 GeV Synchrotron Radiation Source dedicated for Lithography and Analytic

Injector of ANKA



Energy:	500	MeV
Circumference:	26.4	m
Current:	8	mA
Repetition Rate:	1	Hz
Tune (x/y):	1.8/1.2	
Emittance:	150	nmrad
Mom.comp.	0.27	
RF Power:	200	W

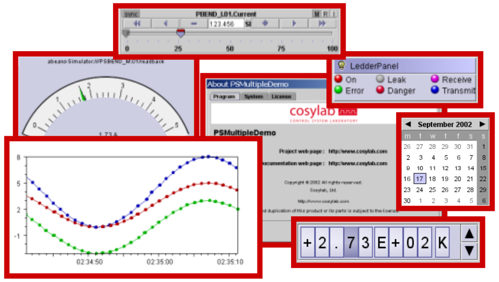
Collaboration between Danfysik and ASTRID

The 500 MeV injector of ANKA was a turn key system build by DANFYSIK.
The injector exist of a 53 MeV Race-Track-Microtron and a 500 MeV booster synchrotron. For this Injector complex Danfysik made a collaboration contract with the University of Aarhus (Soeren Pape Moeller from ASTRID) . Danfysik made the design, the manufacturing and the installation. The commissioning was done by the experts of ASTRID.

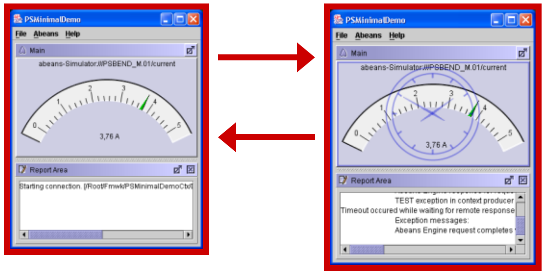
Control system of ANKA

ACS – The First Control System Fully Based on Internet Technologies (1997)

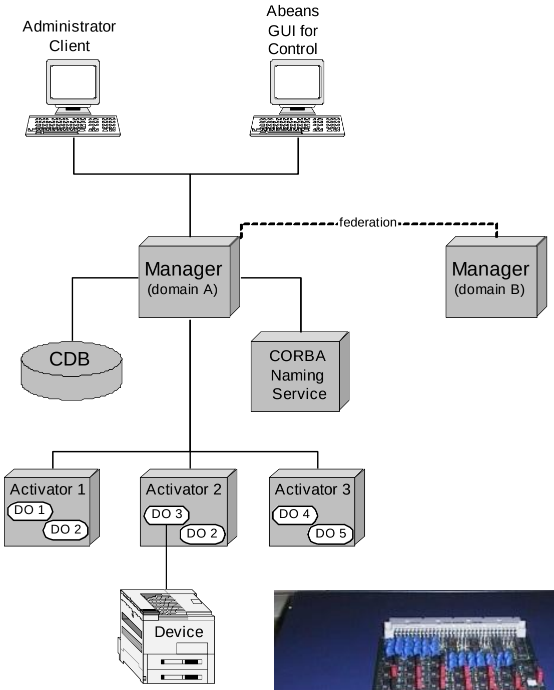
- Java visualization



- CORBA communication



- Network and custom boards



ANKA-Control-System

In the same way as we bought most of the components we bought also the control system. It was more or less a collaboration with Mark Plesko from the Josef Stephan Institute in Slovenia. This was the start of the company COSYLAB

Predstavitev podjetja Cosylab

BPM-Electronics

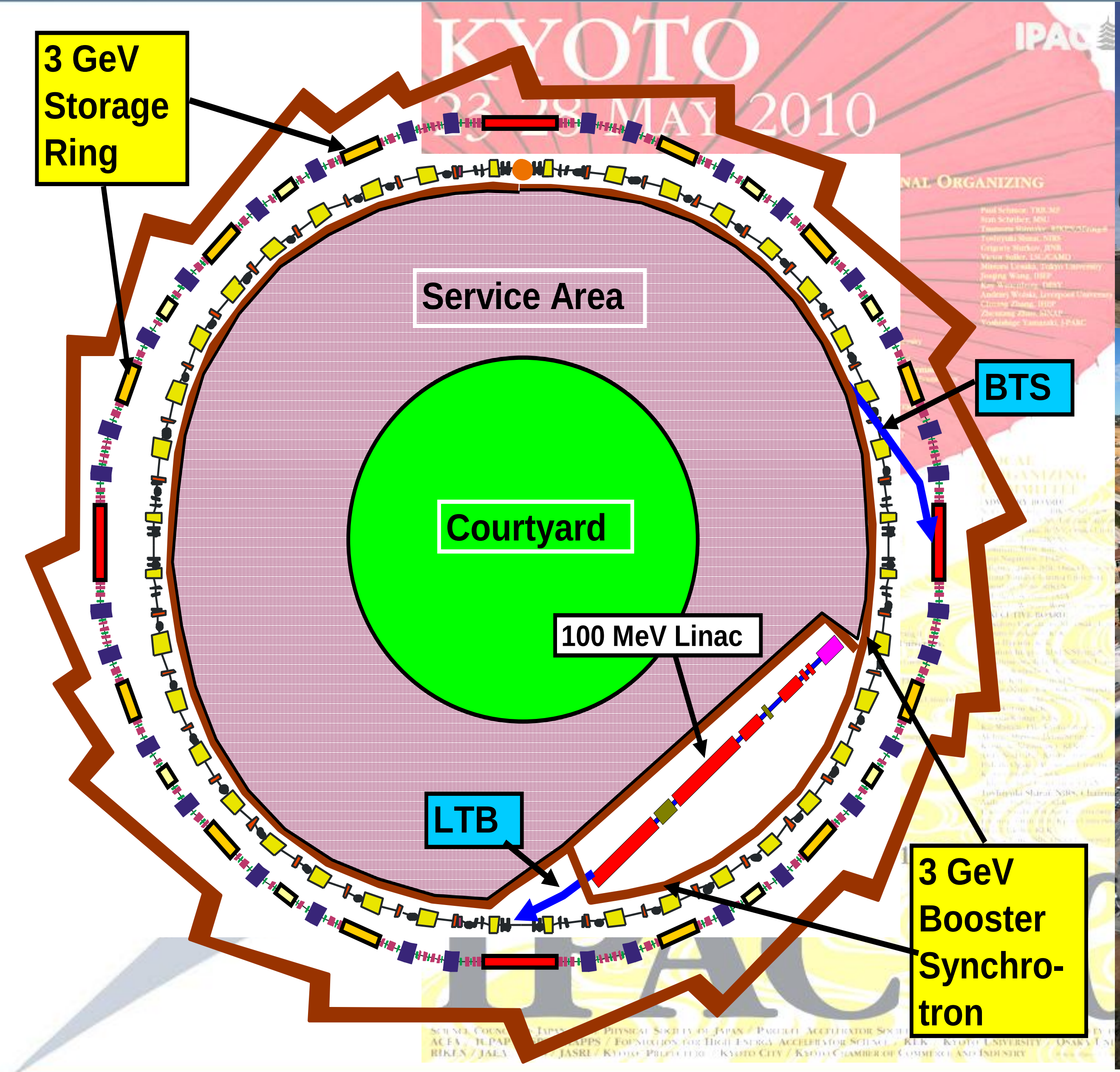
Jefferson Lab
Exploring the Nature of Matter

Most of the new developments for accelerator technologies are coming from the accelerator labs. But I know one example which comes from a company, this are the BPM electronics from I-Tech. Rok Ursic worked at ELETTRA, went over to the Jefferson lab and from there to the SLS. Being at the SLS for some time he founded his own company I-Tech and developed the digital electronics for reading out the BPM (LIBERA). Of course he was inspired by working at the different labs. With this devices you can read out the BPM's turn by turn and most of the modern Synchrotron Light Sources using this system for diagnostic purposes.

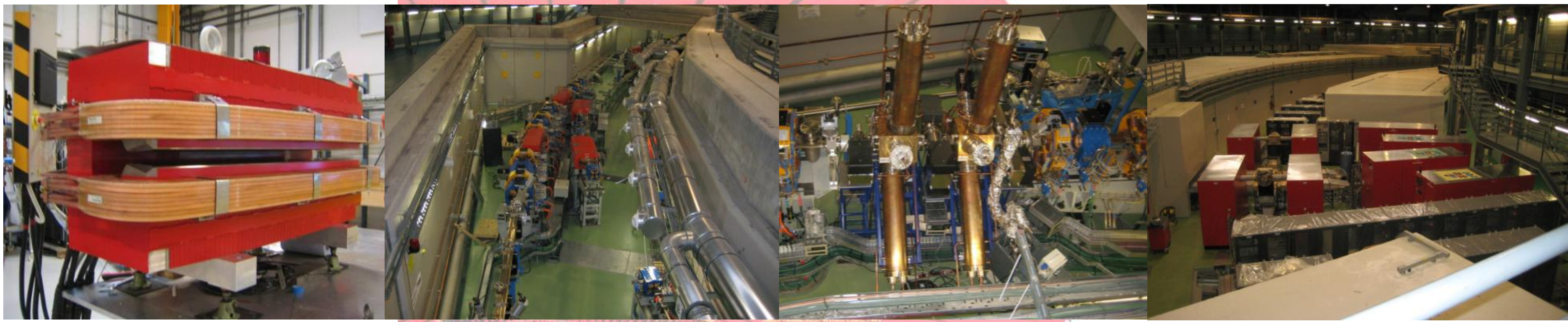
Instrumentation Technologies | I-Tech

| www.i-tech.si |

Accelerator complex of ALBA



ALBA-Contracts

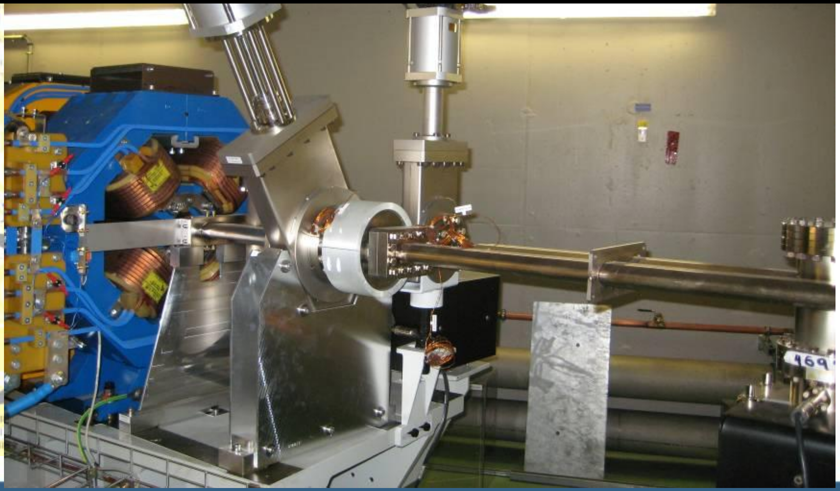


Number	Components	Delay
9	Magnets (storage ring, booster, transfer lines)	2 * 6 month
1	Pulsed magnets	1 * 15 month
4	Power supplies (storage ring, booster, transfer lines)	2 * 15 month
1	Power supplies pulsed elements	okay
13	Vacuum system(chambers, bellows, pumps, etc	1 * 12 month
3	Girders and supports	1 * 8 month
11	RF-System (cavities, WG-system, transmitters, etc)	1 * 18 month
3	Diagnostics	okay
4	Insertion devices	1*5, 1*9, 1*17
1	Front ends	okay
Σ = 50		Σ = 11

(red circle) Because of reorganisation of the company

ALBA-Contracts

Components	Reasons for the delay
Magnets	Magnetic measurements and type of alignment
Pulsed magnets	Problem with the Titanium coating and reorganisatin of the company
Power supplies	Lot of discussions about the regulation card
Vacuum system	Problems with the subcontractor to deliver the right steel
Girders and supports	Problems with the alignment of the milling machine
RF-System	Problems with the circulator (magnets and regulation)
Insertion devices	Problems with the liner and reorganisation fo the company



CERN-RF Collaborations

Comments from Guenther Geschonke (CERN)

1.) Copper system:

All accelerating cavities were developed by CERN, including all accessories. Series production was then done in industry. Industry acted purely as subcontractor according to specifications, without responsibility for the functionality or any system responsibility. The integration (assembly of cavities), adjustments and power conditioning was entirely done at CERN. One firm supplied later complete cavity systems to other accelerator projects.

2.) Superconducting system

After extensive development at CERN the cavities were built by three firms. The know-how of sputtering Nb on the Cu substrate was successfully transferred to industry. The firms had to guarantee the performance of the cavities in terms of accelerating field/Q factor.

3.)RF power plant

Contrary to SLAC, which had its own klystron production, LEP klystrons were developed by industry according to our specifications.

4.)Low level RF system

All electronics systems were developed and integrated by CERN; series production was done in industry. It is very important in my opinion, to fully master the complete system. This proved to be very precious for later repairs, improvements and upgrades.

CERN-RF Collaborations

Comments from Guenther Geschonke (CERN)

5.)LEP injector linac

Accelerating structures were developed by CERN and manufactured by industry. Also the RF transmitters were built by CERN, with klystrons from industry. Modulators for the klystrons did not exist in industry, therefore they needed to be developed and built by CERN. The situation now has changed; one can buy a complete linac from industry including the RF power plant.

Biggest problems: We tried to buy, what we could, however, there was no expertise available neither in accelerating cavities nor in RF power transmitters at the desired frequency and power. It is very important to entirely master such complex systems in house.

6.) Other accelerators

I don't know all machines in enough detail, only a few examples.
The SPS travelling wave cavities were developed by CERN.
The RF transmitters at 200 MHz were built by a company.
Industry provided systems, where they had the required know-how already.
Otherwise they basically acted as sub-contractors and manufacturers of components according to specs.

CERN-RF Collaborations

Comments from Guenther Geschonke (CERN)

7.) The RF system for LHC followed essentially the LEP model.

8.) Klystrons were developed by industry.

9.) I would say, generally the collaboration with industry was good. In my view it is important not to rely on only one supplier.
Example: One klystron manufacturer decided to give up high power klystrons (VALVO). Fortunately we had others.

10.) LEP started with Copper cavities, superconducting technology was being developed, but was not advanced enough for the first phase of LEP.
We have never bought fully dressed cavities from industry.

11.) Some transmitters come from industry; there are a few firms which supply such devices.

Superconducting Magnets for LHC

Magnet production for the LHC is complete!

On 27 November (2006), the LHC teams celebrated the end of production of the machine's main magnets. Some 1232 main dipole and 392 main quadrupole magnets have been manufactured in an unprecedented collaboration effort between CERN and European industry.

The LHC Project Leader Lyn Evans (left) and Lucio Rossi, head of the Magnets, Cryostats and Superconductors Group (right), in front of the final superconducting main magnet delivered to CERN.
Part of the magnet can be seen on the back of the long delivery lorry, extending outside the frame of the photograph.

Superconducting Magnets for LHC

Some of the MCS group members in front of the electronic display panel that showed a score of zero; amongst those in the first row are: Philippe Lebrun (head of AT Department), Lucio Rossi (head of the MCS group), CERN's Director-General Robert Aymar, and Lyn Evans (LHC Project Leader).

Superconducting Magnets for LHC

Comments from Davide Tommasini (CERN) concerning the relationship to the industry for the LHC- superconducting magnet production

1) Technical Specifications:

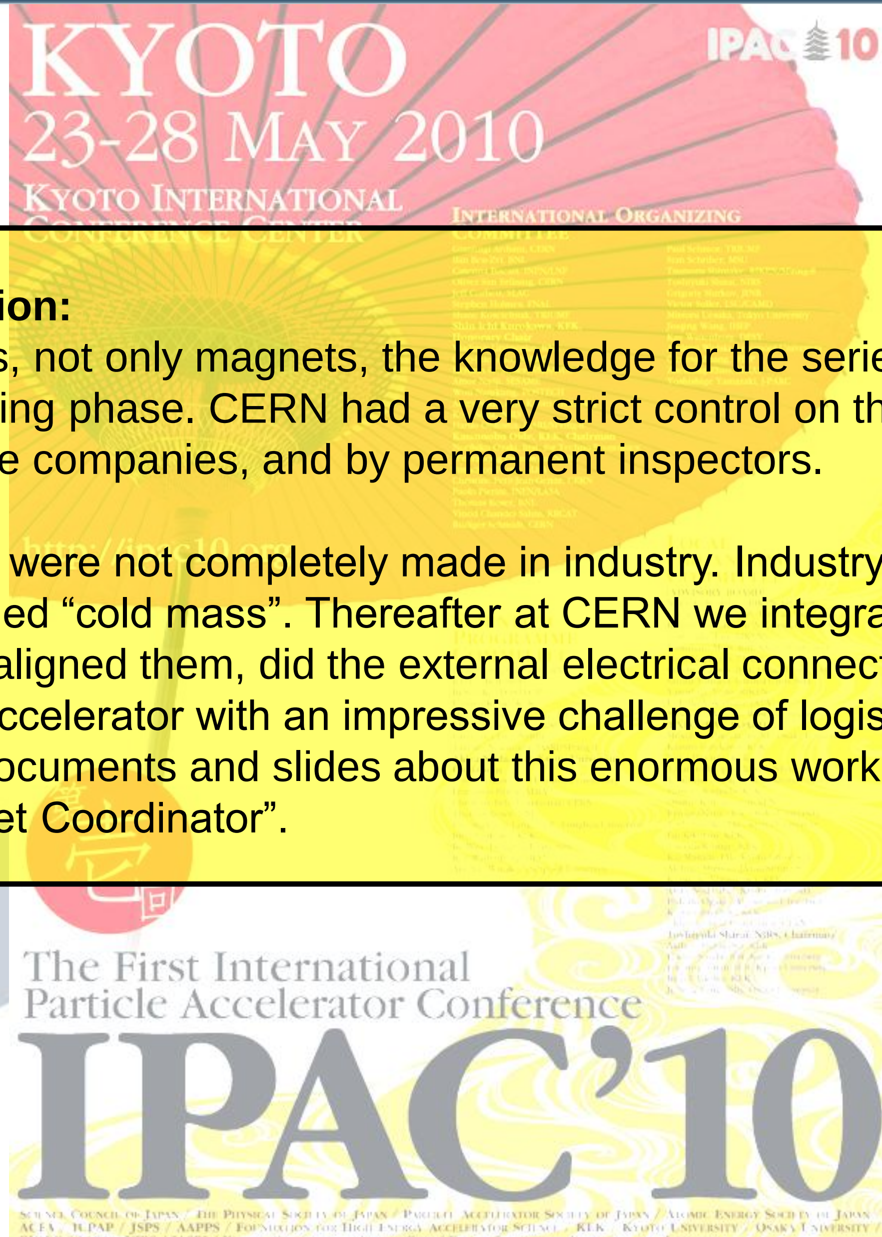
For all main procurements the technical specifications were written by CERN. This was done after an intensive phase of R&D, in most cases carried out together with industrial partners or with intermediate contracts passed to industry. In this aspect, the capabilities of industry were duly taken into account. In certain cases, like the manufacture of the main superconducting dipoles, this passed through a number of technology transfer from CERN to the industry.

Superconducting Magnets for LHC

2) Prototyping:

For all critical components we made prototypes. Prototypes were done at CERN and at industry. For example for the main superconducting dipoles we made at CERN more than 50 short models (1-m long magnets), several long prototypes in the industry, and we made the initial assembly of long components produced in industry at CERN to validate certain assembly procedures (in particular the welding of the helium shells). In summary since the beginning there was an intensive activity of models and prototypes coordinated between CERN and industry, typically at CERN models were done to study basic principles and in industry to study their industrialization. Concerning tests, in certain cases tests were done in industry, and thereafter repeated at CERN, but in the most complicated cases (like for the main superconducting dipoles) they were done only at CERN. During the prototyping phase CERN had identified all manufacturing and tooling procedures. For the series production CERN has imposed most of procedures and tooling, accepting variants where acceptable. CERN has provided most of components, and in certain cases also the tooling. For example for the superconducting magnets CERN has procured the cable, the insulation, the steel, the helium shells and all critical parts. Concerning acceptance, the technical specifications were written after a consolidated experience on models and prototyping. The deviations to the technical specifications for acceptance were marginal.

Superconducting Magnets for LHC



3) Series Production:

For many contracts, not only magnets, the knowledge for the series production acquired during the prototyping phase. CERN had a very strict control on the production, by staff regularly visiting the companies, and by permanent inspectors.

The main magnets were not completely made in industry. Industry made the "core" of the magnet, the so called "cold mass". Thereafter at CERN we integrated the cold masses into the cryostats, aligned them, did the external electrical connection until to the installation in the accelerator with an impressive challenge of logistics. I'll send you separately some documents and slides about this enormous work (which was my specific task as "cryomagnet Coordinator".

Conclusions

1) In general the relationship between the industry and the laboratories is pretty good. The industry wants that you are satisfied with the final product.
2) The industry is capable to build all the accelerator components.
3) The industry is capable to build systems (injectors) for an accelerator complex.
4) Have also in mind that the industry has to earn some money. They have to pay the salaries for there employees and they have to survive.
5) The companies want to have the contract and therefore the promise you a lot of things, sometimes to much. There for:
   a.) Write the "Technical Specifications" for the CFT very careful because it as an appendix a part of the contract. Don't write anything down what you don't understand. Take care for the tolerances, use only tolerances which are achievable by the industry.
   b.) The companies don't give you all the required answer to your specs, please clarify everything in the negotiation about technical issues. Everything has to be clarified before signing the contract.
6) Following up the production of the prototype and the series very careful.
7) Take care for the time schedule (the life is sometimes very complicated).

Thank you very much