Von den Atomkernen in den Mikro- und Makrokosmos

Aus den Ruinen zum KIT-CETA

Herwig Schopper

Talk in German, slides in English
1945 Karlsruhe in ruins (town and physics)

Castle

Market place

Now reborn, town and physics
Looking back 50 years I am deeply impressed by the incredible development of Nuclear and Particle Physics (experimental and theoretical) at Karlsruhe.

I cannot cover all events of past 50 years, in 30 min - impossible
Just some highlights
Apologies for omissions

Thanks to all who have provided material for this talk:
New beginning of physics with (big) bang

Several chairs at TH Karlsruhe were filled within a few months in 1960

1960 **Werner Buckel**, Festkörperphysik (Nachfolger Gerthsen), **Stöckmann, Falk**
19.7.1960 **Gerhard Höhler**, Theoretische Kern- und Teilchen Physik
22.8. 1960 **Herwig Schopper**, Experimentelle Kern- und Teilchenphysik

**HS appointed as Director of two Institut in**
**for Experimentelle Kernphysik IEKP**
one at Research Center Karlsruhe FZK
the other at University

My condition: **unification of the two instituts**
,formale Zweiteilung des Instituts (TH und KFZ)
soll im wissenschaftlichen Bereich nicht in Erscheinung treten‘

Buckel

Höhler
Reasons for Unification of two Institutes

Advantages for both, university and research center

University offers:
- free environment necessary for creative research,
  no ‘directed’ research (Auftragsforschung)
- contact with students, decisive to find excellent collaborators

Research centre offers:
- technical infrastructure and financial planning necessary for large projects of nuclear and particle physics
- basic research contributes to stability of research centre, since independent of technical and economic fashions
First tasks at University in 1960 ff

1. **New Buildings** were desperately needed: new Highrise, lecture halls
2. A **new and modern curriculum** had to be agreed upon and lectures organised (balance between nuclear-particle physics and condensed matter physics)

Hochhaus ready 1967
Institut Theoretische Kernphysik
established at University

Gerhard Höhler: World expert for Pion-Nucleon interaction
(has written a ‘bible’ in Landoldt-Börnstein)

Pilkuhn: mesic, antiprotonic atoms

Genz: Symmetries, several popular books

H.-M. Staudenmaier: decay processes, symmetries

Julius Wess: Father of Supersymmetry Theories (with Zumino)

5.10.1990, Johann Kühn successor of Höhler, Particle-Phenomenology

New name of Instituts:
Institut für Theoretische Teilchenphysik TTP
First tasks at Research Centre FZK

get a building, preliminary at Erwin Becker‘s institute

Design and construction of ‘double‘ IEKP

How it started

Soon we could move in!
1. Phase of IEKP (unified)
1960 – 1973

Start with Nuclear physics

First modest possibilities to do research with equipment brought along and with colleagues following from Erlangen and Mainz
H.Appel, H.Behrens, Galster, Hartwig, H.Müller

Parity violation experiment 1957 (Cambridge, UK)
\( \beta - \gamma \) circular polarisation correlation

Thought impossible by Lee and Yang
\( \gamma \) circular polarisation scattering from magnetised iron

Exploited in many ways (many thesis):
e.g. nuclear spectroscopy
matrix elements of beta transitions
Circular polarisation of Internal Bremsstrahlung

following
- beta decay
- K capture

Many publications
Other activities in nuclear physics

Nuclear reactions using KA Cyclotron
Polarized particles
Source for Polarized Protons
Polarized Neutrons
E. Boschiz, H. Brückmann, W. Kluge, L. Schänzler, H. Ullrich, Ch. Weddingen

Magnet to rotate neutron spin
Institutsfeste
New Doctors are produced and celebrated
Transition to Elementary particle physics

1. Electron – Nucleon Scattering at DESY, Hamburg

I had learned e-N scattering at Cornell (R.R.Wilson) 1960

first experiment at DESY from 1963 by Karlsruhe group
Elastic electron scattering on Proton and Neutron, internal target
(D.Wegener, D.Fries, et al)

Electromagnetic Formfactors to higher q-values
Finer details of Nucleon Structure
2. Neutron –Scattering at CERN und Serpuchov UdSSR

Invention of Hadron-Calorimeter 1967

Sampling Total Absorption Counter

name „STAC“ not popular

J. Engler, K. Runge, H. Müller et al

Smiled at by all experts:
not competitive with magnetic spectrometer,
now in every collider experiment

First optimisation of a detector by simulation (Monte Carlo)
(meters of Punch Cards for IBM Computer)

First strike on Soviet Territory by students from Karlsruhe

First at CERN PS, ISR
from 1970 at Serpuchov

Minister Riesenhuber at CERN
Investigation of mesonic atoms at SC and PS at CERN
Discovery of antiprotonic atoms
Citron, Backenstoss, Koch, Tauscher,...

Meson spectroscopy with Crystal Barrel Detector at antiproton ring LEAR at CERN
Cierjacks, Koch, Kunze, Matthäy, Weddigen,...

More than 100 Publikationen
Candidat for Glueball-Grundstate (f0(1500))
Initiated antiprotonic part of FAIR-Project at GSI
High energy Proton accelerator at KA?

KFZ seemed to offer excellent conditions for construction of accelerator, cooperation with France

Proposal Proton Synchrotron 40 GeV, complementary to DESY and CERN

Look for reinforcement:

Anselm Citron, 6.4.1965
Elementary particle physics

Arnold Schoch, 1965 to 23.7.1967 (deceased), accelerator expert

Werner Heinz, 1969 bis 31.12.1984 (deceased), successor Schoch
National accelerator project abandoned:
- CERN proposes 300 GeV Super Proton Synchrotron 1970
  (Germany: either SPS or national project)
- Resistance in FZK
  (emphasis on 'reactor station', fast breeder)

Basic Research at Research Centre??

**Schnurr**
Scientific Director of FZK

**Greiffeld**
Administrative Director of FZK
Foundation of Arbeitsgemeinschaft der Grossforschungszentren
Now Helmholtz Association
Technological developments

Accelerators and detectors:
- First European studies of Supraconducting RF Cavities
  first application for particle separators at CERN and Serpuchov
  knowhow to CERN (LEP) and many accelerators
- Proton SC Linac Prototyp at IEKP (2 cooling plants at 30 K)
  first cryogenic at FZK

Supraconducting Magnets
W. Heinz, J. Halbritter (origine of ITP)

Use of computers (in particle physics experiments)

Basic research has introduced new technologies at FZK which became basis for new applications
  e.g. SL magnest for fusion TOSCA
No time to discuss importance of teaching and role of students

One example *(Allow me small diversion!)*: 
Isa Khubeis from Jordan, 
Diplom Mainz, PHD in KA, Prof. Uni. of Jordan  
(German degrees very appreciated in Middle East) MSc?? 
Vice-Präsident Al Balqa Univeristy 

Help to establish SESAME Synchrotron 
Radiation Lab in Jordan (2000) 
(under umbrella of UNESCO like CERN) 
By establishing contacts with King
FZK (Manfred Popp) provided help for birth of SESAME
SESAME Building (Near Amman) is copy of ANKA

SESAME International Organisation (like CERN)
Only two institutions with objective: science for peace
Member States: Bahrein, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine, Turkey
2. Phase IEKP

Schopper disappears in April 1973 to Hamburg (DESY and Uni), difficulties in appointing successors (took more than 5 years!)
End of unification, IEKP dissected into 4 institutes:

**Nuclear and elementary particle physics I at FZK**
- Bernhard Zeitnitz 1978! to 1997 (retirement)
- Hans Blümer 1999 until now
  (Neutrinos, Cosmic Showers)

**Nuclear Physics II at FZK**
- Anselm Citron until 1991 (Retirement)
  - Medium energy physics, (Disolved at retirement)

**Technical Physics at FZK, Supraconductivity**
- W. Heinz 1969 bis 1984
- P. Komarek 1985

**Nuclear and particle physics at Uni**
- Klaus Schubert 1988 bis 1993
  (Chair at Dresden)
- Thomas Müller 1996 until now
KARlsruhe-Rutherford-Middle-Energy-Neutrinos

Neutrino-physics at Rutherfordlab’s spallation source ISIS
also strong source for neutrinos
Zeitnitz et al

Many interesting results:
Limits for ν-oscillations (appearance) $\nu_\mu \rightarrow \nu_e$

interesting situation:
result of LSND wrong?
or antisymmetry between neutrinos and antineutrinos?
(new FNAL-Minos results)
3. Phase: towards KIT- CETA

'Great Unification‘ 2009 concerns:

University with Research Centre

Theory with Experiments
Supersymmetry, Non-relativistic quantum chromo dynamics
Perturbative quantum field theory, Collider phenomenology

Technology with Physics
Computing and Networking, Cryogenic technology

Including Cooperation with Associated Institutes:
Institut for Technical Physics (ITeP),
Institut for Processdata analysis and Elektronics (IPE)
Steinbuch Centre for Computing (SCC).
One of the largest concentrations for this domain of physics in the world has been created Competitive on worldwide scale
Unification became basis for recognition of ‘University of Excellence’

Visit Senate UNI KA at CERN 6. Oktober 2006

E. Umbach, H. Hippler
KCETA has not only impressive past, but also bright future

Some very short remarks concerning highlights of ongoing and future activities to complete picture
These are logical continuation of earlier activities
More information by following speakers
Measurement of neutrino mass from betadecay of tritium
Can only be performed at FZK:
Tritium technology,
Large equipment

KATRIN

Neutrino mass different from 0
How big?
Great mystery!

Only experiment in the world of this kind
Electron-Neutrino-Mass:
Best present limit <2.2 eV,
KATRIN 0.3 eV

International collaboration G.Drexlin et al
CMS at LHC CERN

One of the 3 big experiments

KCETA involved in CMS since 1995, R/D for silicon strip detectors and Microstrip gas detectors, radiation hardness studies at the cyclotron of FZK construction of large scale prototypes for feasibility tests.

The Karlsruhe (Campus South): about 35 physicists and technicians Th. Müller, W. de Boer, M. Feindt
CMS at LHC

LHC running for p-p at 3.5+3.5 TeV most of time in 2010
Results will be report by Joachim Mnich

Not only machine works very well, but also experiments

Beginning of November until 6 December Pb + Pb

CMS works even for Lead !

First observation in Pb-Pb, 9. November 2010

Z-> μ+μ- and Z-> e+ e-
Hottest nuclear matter
(Cosmic primary matter)
Normal hadrons play no role
Quarks and gluons

Jet quenching in quark-gluon matter
First observation and study

Normal jet pair
back-to-back, equal energies

Pb-Pb collisions
WLCG serves a community of more than 8,000 physicists around the world with near real-time access to LHC data, and the power to process it. Store, distribute and analyse the 15 Petabytes (15 million Gigabytes) of data annually more than 140 computing centres in 34 countries.

Layers:
- Tier 0 CERN
- Tier 1 in the world 11, one at KIT
- Tier 2 at large universities and labs
- Tier 3

Grid KA plays essential role:
- interface for all universities and labs in Germany

Günter Quast et al., many partners at KIT
11 Tier 1 nodes
Cosmics rays
from Kaskade to Auger

Kaskade (Grande) im FZK

B. Zeitnitz, H. Kampert, H. Ullrich

Large detector array at FZK
To investigate cosmic air showers
252+37 Detektorstationen

Now also used for LOPES (Radioantennen)

What is origin of extremely energetic cosmic showers?
What is their energy distribution and nuclear composition?
Extension of KASKADE to higher energies
In Argentinian pampas

1600 Water tanks combined with 4 Air Fluorescence Light detectors

KCETA biggest single group in collaboration
**Main results:** Form of spectrum due to different mass components

**Cut-off at high energies exists!**

H. Schopper, 50. Jahrestag für Kern-und Teilchenphysik at KIT
Suche nach dunkler Materie

EDELWEISS in Frejus tunnel W.de Boer et al

Recoil energy of Weak Interacting Massive Particle detected with Bolometers

Only 4% of matter in cosmos is 'normal' 23% Dark matter, what is it?

320 g Germanium at 0.017 K

Data taking started 2007, some results (exclusions) More bolometers being added
AMS Antimatter Spectroscopy

Only magnetic spectrometer in space (on Space Station)
Search for antimatter and dark matter

W.de Boer et al

Transport from CERN to Cap Canaveral
Conclusions

- During last 50 years excellent results (experiments and theory)
- Research of highst quality at forefront of nuclear and particle physics and fully competitive
- Full integration into international collaborations
- Success based on competence and enthusiasm of collaborators, old and young
- Cooperation between FZK and Uni was essential
  I am very happy about ‘great unification‘ in KIT_CEAT
- All conditions for an equally successful future are there

Best wishes for the next 50 years