Particle Physics in Poland

(A historical overview)

A.K.Wróblewski – RECFA, Cracow, May 11, 2012

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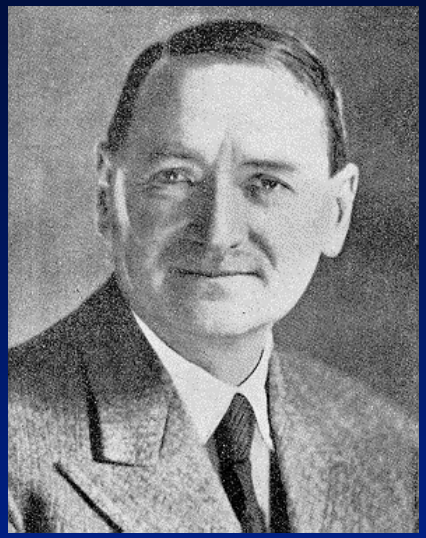
The beginnings

Cosmic radiation in the 1930-ties

- Discovery by Victor Hess in 1912
- ”*Ultragammastrahlung*” or stream of particles?
- Studies of the latitude effect
- Studies of the east-west effect
- ”mesotron” discovered in 1937

Physics centres in Poland 1918-1939

The pioneers



Stanisław Ziemecki

Konstanty Narkiewicz-Jodko

(High School of Agriculture, Warsaw)

1934 – first published paper on the latitude effect

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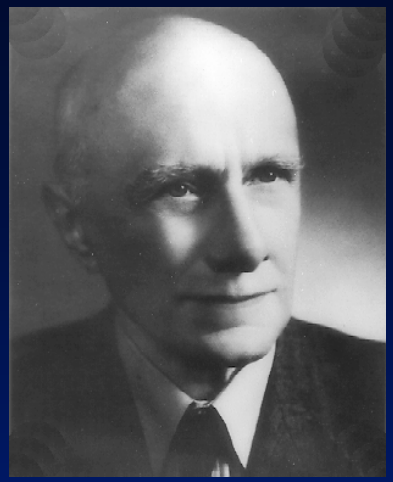
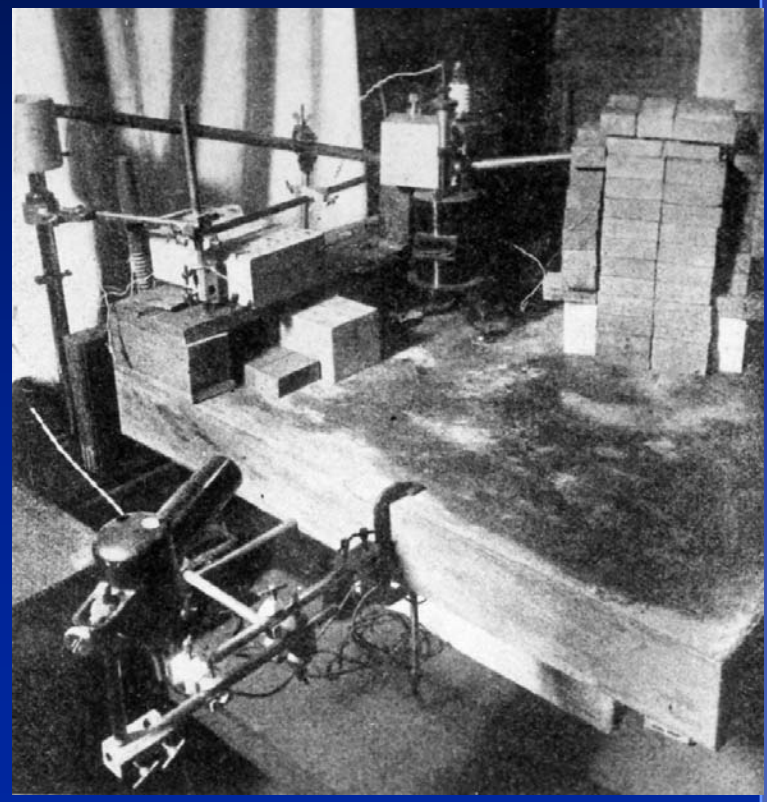


Czesław Białobrzeski

(Division of Theoretical Physics,
University of Warsaw)



Apparatus for measuring
the intensity of cosmic rays
(1935)

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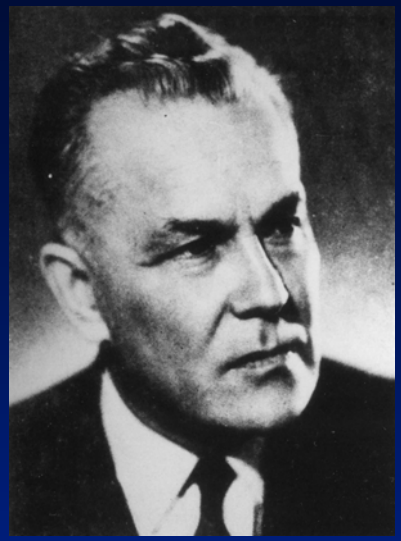

Ignacy Adamczewski

(Białobrzeski's assistant at the Division of Theoretical Physics, University of Warsaw)

First use of Ilford C2 nuclear emulsions exposed (1939) at Kasprowy Wierch in Tatra Mountains (elevation 1985 m)

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Altogether 17 papers on cosmic rays published by 7 Polish physicists 1934-1939

9 *Nature*,
1 *Phys. Rev*.,
1 *J. Phys. Radium*
3 *Acta Phys. Polon*.,
3 *Bull. Acad. Cracoviae*,

(12 published by Ziemecki, 6 by Narkiewicz-Jodko)

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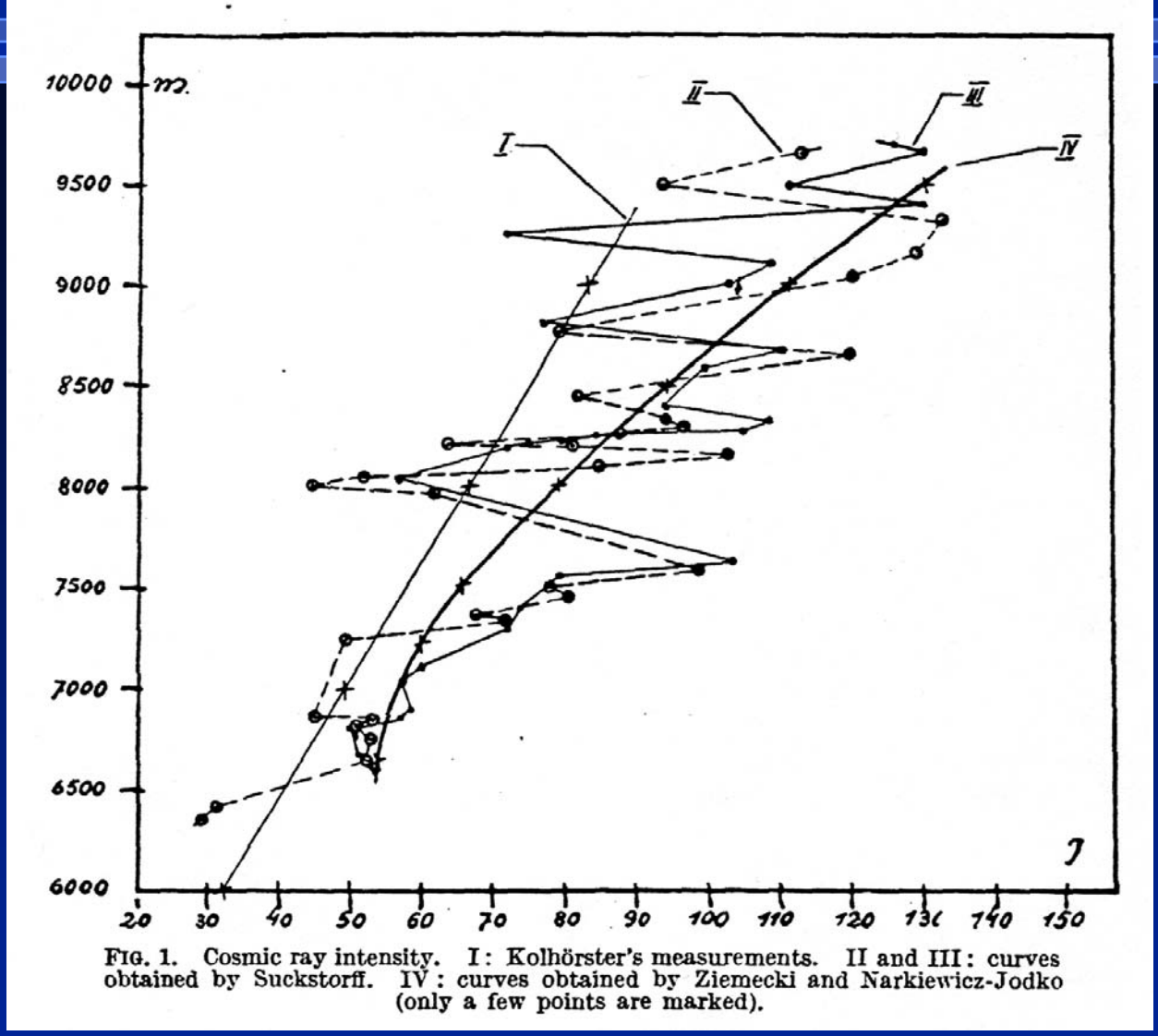

FIG. 1. Cosmic ray intensity. I: Kolhörster's measurements. II and III: curves obtained by Suckstorff. IV: curves obtained by Ziemecki and Narkiewicz-Jodko (only a few points are marked).

S. Ziemecki, K. Narkiewicz-Jodko, Variation of Cosmic Ray Intensity in the Atmosphere, *Nature* **137**, 944 (1938)

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The ”Star of Poland”

The ”Star of Poland”

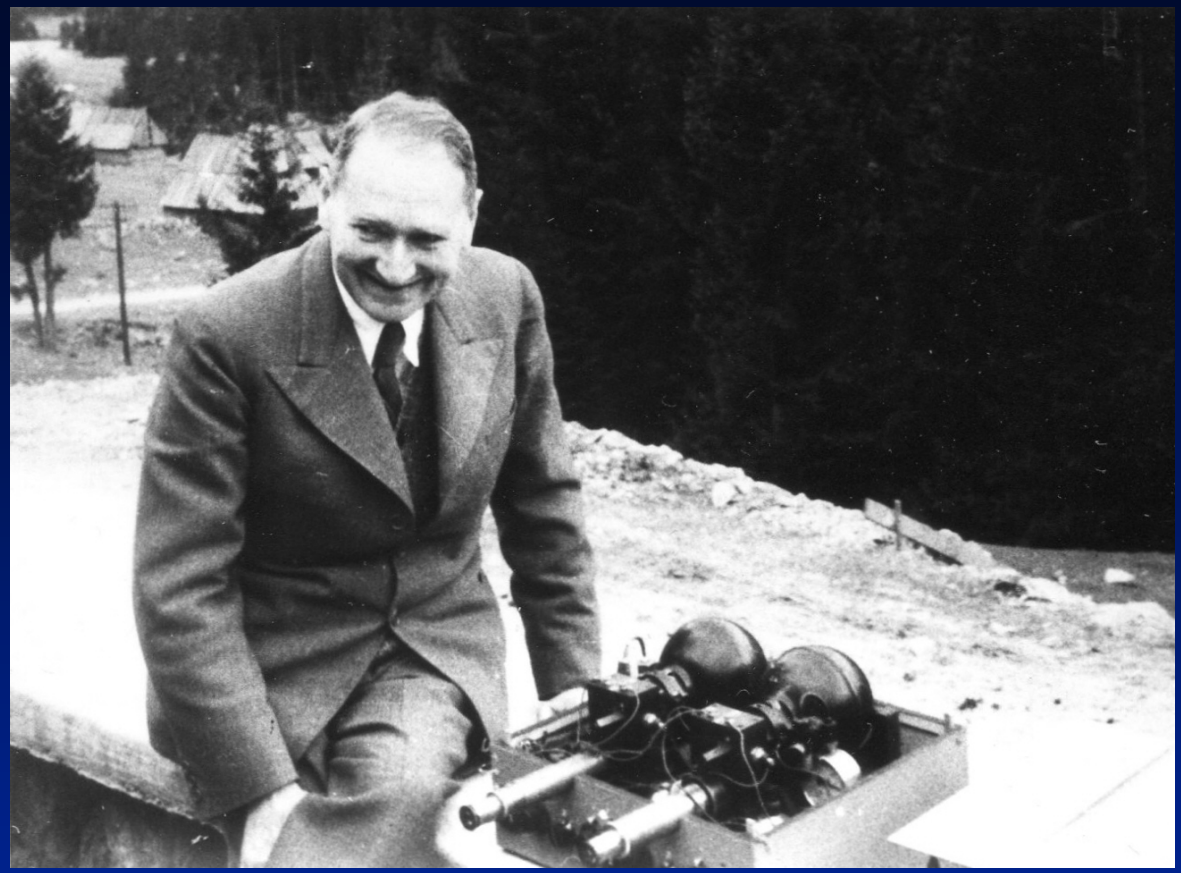
- An ambitious attempt to reach 30 km with a lot of equipment to study cosmic rays
  - G-M counters,
  - ionization chambers,
  - nuclear emulsions

Volume 124790 m^3
Height 120 m
Gondola 2.1 m diam., 140 kg
Mass of all instruments 1350 kg

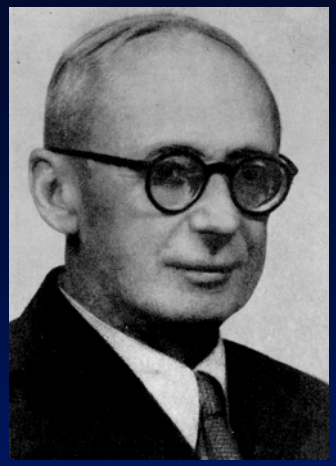
The gondola

The crew

Zbigniew Burzyński
Konstanty Narkiewicz-Jodko
(world record holders,
10883 m in an open class VI baloon)

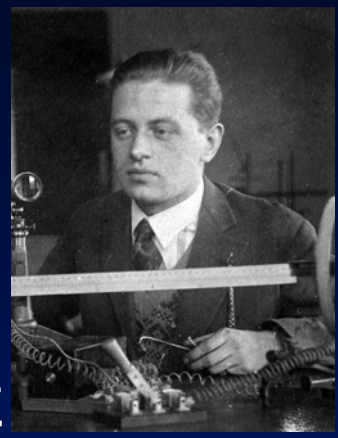


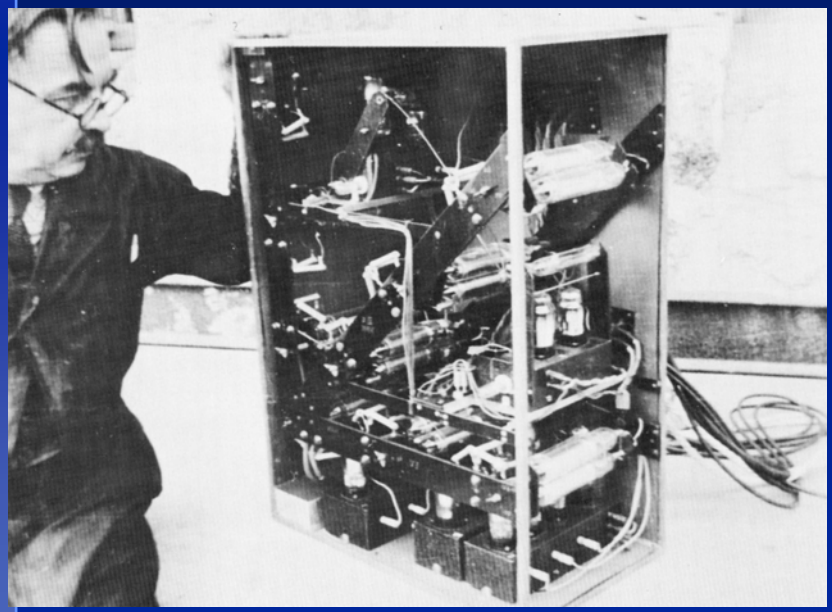
Ziemecki constructed ionization chambers



Mieczysław Jeżewski

Marian Mięsowicz





constructed arrays of G-M counters for directional studies of cosmic rays

(Academy of Mining, Cracow)

The ”Star of Poland”

- Hydrogen-filled baloon was partly damaged by fire during an attempted launch on October 13, 1938
- The launch of repaired and helium-filled baloon, scheduled for September 10, 1939, never took place

Post-war recovery

International Cosmic Ray Conference, Cracow, 6-12 X 1947

Pierre Auger, Gilberto Bernardini, Patrick Blackett, Jacob Clay, Max Cosyns, Walter Heitler, Lajos Janossy, Louis Leprince-Ringuet, Cecil F. Powell, Archibald Wheeler…

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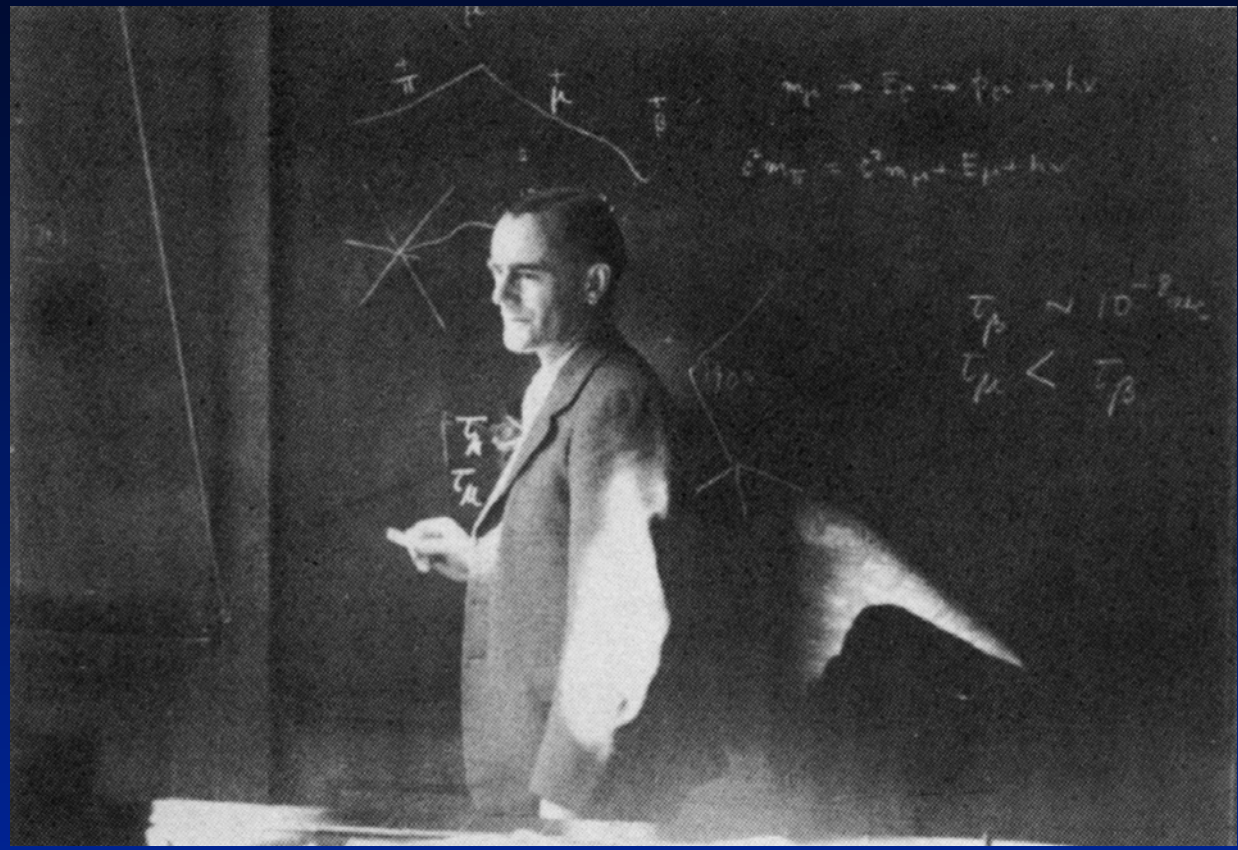

Cecil F. Powell – reporting his discovery of the π-meson at the Cracow Conference (1947)

1949 - Cracow cosmic ray group restored by Mięsowicz

PHYSICAL REVIEW VOLUME 77, NUMBER 3 FEBRUARY 1, 1950

On Some Low Ionizing Radiation Observed by Measurements of Cosmic Radiation at Great Depths

M. MIESOWICZ, L. JURKIEWICZ, AND J. M. MASSALSKI
Physical Laboratory of the Mining Academy, Cracow, Poland

(Received September 22, 1949)

By measurements of twofold, threefold, and fourfold coincidences with a Geiger counter telescope, the underground rays at 660 and 540 m w.e. (water equivalent) have been divided into two components. One of the components is ionizing, discharging the counters with almost 100 percent efficiency, and has a strong maximum in the vertical direction. The other component discharges the counters with a very low efficiency, producing numerous twofold coincidences but practically no threefold or fourfold coincidences. It is isotropic in direction and rapidly absorbed in lead. This second component is thought to be composed of γ-rays of local radioactive origin. The telescope used in these experiments differed from that of Barnóthy and Forró in that it was protected from side showers by anticoincidence counters. The ratio of twofold to threefold coincidences was found to be about 1.4 instead of 20 as reported by Barnóthy and Forró at 1000 m w.e.

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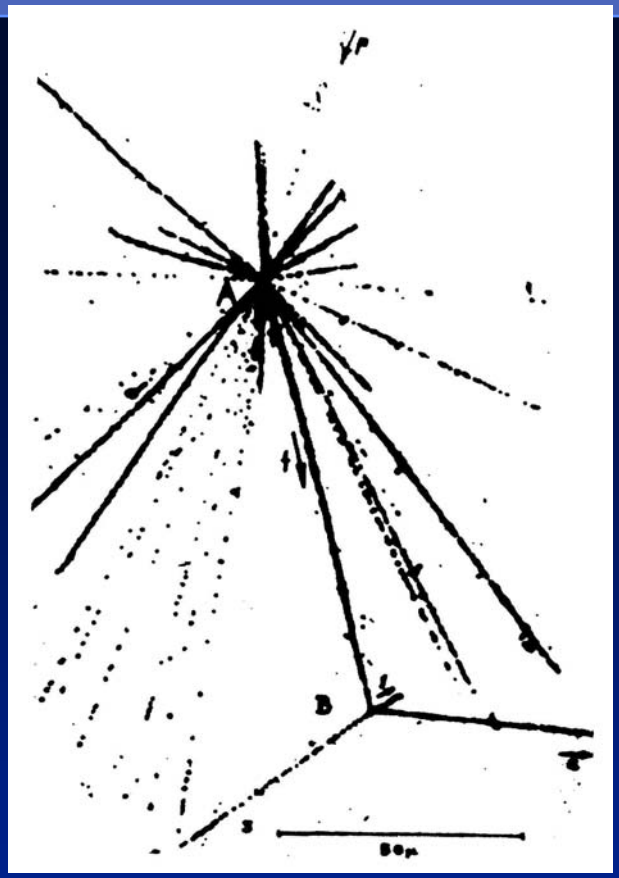

The first hypernucleus was discovered in 1952
by Marian Danysz and Jerzy Pniewski
at the University of Warsaw

”The original discovery suggesting that Λ^0 hyperons can exist not only as free particles but also bound within nuclei was due to Danysz and Pniewski... An excited hydrogen atom, to use the simplest example, consists of a proton and an electron in a state of higher energy than in the normal atom. The analogy might then suggest that the excited nucleon consists of a proton and an associated π^- - that the Λ^0 is a composite particle. Such a view could not have been finally excluded while our knowledge was confined to the decay of the free Λ^0 particle... These considerations suggest that the Λ^0 particle is an excited nucleon in a different sense from that suggested by familiar analogies. We are entering a new field where basically new concepts remain to be established”

C. F. Powell, Excited nucleons, *Nature* **173**, 469 (1954)

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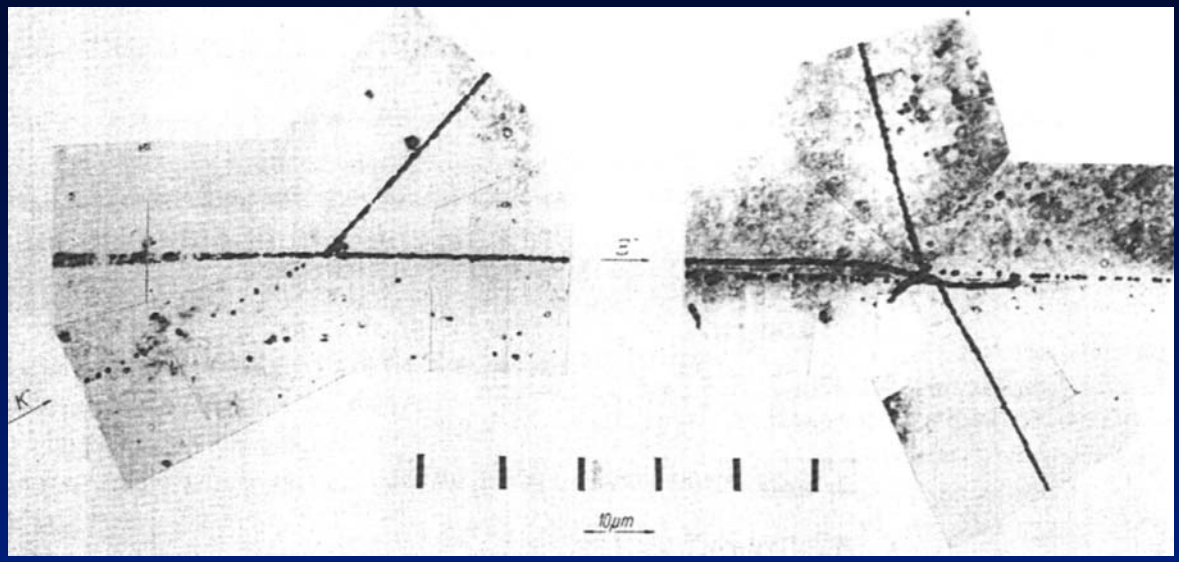
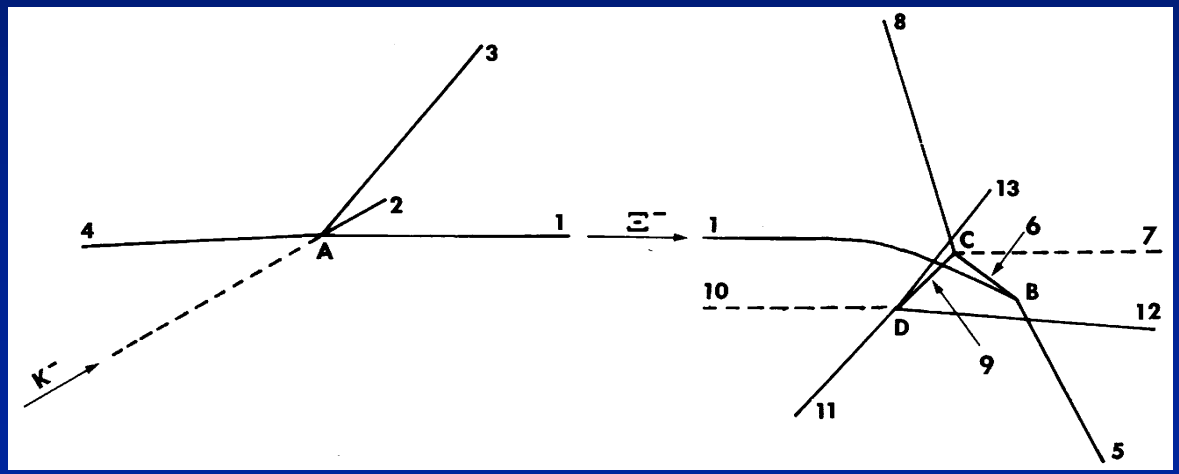
The first double hypernucleus also found in Warsaw (1962)





Danysz, Pniewski, Zakrzewski et al. (European K^- Collaboration)

Warsaw – centre of hypernuclear studies

Danysz – first review talk of hypernuclei (Pisa, 1956)

Filipkowski et al. – first review paper on hypernuclei (1957)

Pniewski & Danysz – discovery of the isomeric states of hypernuclei (1962)

Pniewski – report on the double hypernucleus at the First Conference on Hypernuclei (St.Cergue 1963)

Pniewski et al. – first (failed) attempt to study hypernuclear spectroscopy (Dubna 1968);

Pniewski et al. – succesful beginning of hypernuclear spectroscopy at CERN (1970)

A quasi-normal development (until mid-1989)

A quasi-normal development

1954 – beginning of cosmic ray studies at Łódź
1956 – Poland became member state of the JINR in Dubna
Danysz – one of JINR deputy directors
1958 – Cracow fire-ball model
1960 – first Polish physicists at CERN
1960 – first bubble chamber work in Poland
1964 – Poland granted observer status at CERN
1968 – first hardware attempt in Warsaw
1968 – KAR-65 computer completed in Warsaw
1973 – construction of chambers started in Cracow

1958 – The fireball model

P. CIOK, etc.
1958, Aprile
Il Nuovo Cimento
Serie X, Vol. 8, pag. 166-169

About High Energy Interactions in Nuclear Emulsions.

P. CIOK, T. COGHEN, J. GIERULA, R. HOŁYŃSKI, A. JURAK,
M. MIĘSOWICZ, T. SANIEWSKA, O. STANISZ

Cosmic Ray Department, Institute of Nuclear Research
Warszawa and Kraków, Poland

and

J. PERNEGR

Institute for Physics of Czechoslovac Academy of Science
Praha, Czechoslovakia

(ricevuto l'8 Febbraio 1958)

36 plates of the I-stack, which was exposed in the Po-Valley expedition in 1955, were scanned for photon-electron cascades to find interactions of the highest energy. The plates were also area scanned for jets of lower energy (in both scannings $N_h \leqslant 5$, $n_s \geqslant 6$). Measurements were made of the angular distribution (θ_L) of relativistic tracks. The energy γ_c of the colliding nucleons in the center of mass system was determined for every jet ($\log \gamma_c = \overline{\log \operatorname{ctg} \theta_L}$) (1).

The jets were divided into three groups:

I)	$90 > \gamma_c > 23$	$(1.5 \cdot 10^{13} > E > 10^{12}$ eV)
II)	$23 > \gamma_c > 7.5$	$(10^{12} > E > 10^{11}$ eV)
III)	$7.5 > \gamma_c > 2.2$	$(10^{11} > E > 10^{10}$ eV)

$(E = 2\gamma_c^2 - 1)$

Jerzy Pniewski, Marian Danysz, and **Jacek Karpiński**,
the constructor of the KAR-65 computer
(ca. 0.1 MFLOPS, 26-bit words)

Beginning of the construction of chambers in Cracow

Emulsion experiments involving the Cracow group

Accelerator	beam $[GeV/c]$	Collaboration
Dubna	4.2/nucl Ne^{22}	JINR labs
AGS	10.6/nucl Au	mainly US labs
AGS	14.6/nucl Au	mainly US labs
AGS	20 p	mainly US labs
Serpukhov	60 π^-	JINR labs
Serpukhov	67 p	JINR labs
FNAL	200 p	mainly US labs
FNAL	200 π^-	mainly US labs
FNAL	300 π^-	mainly US labs
FNAL	350 Σ^-	mainly US labs
FNAL	400 p	mainly US labs
FNAL	525 π^-	mainly US labs
FNAL	800 p	mainly US labs
CERN	60,200/nucl O^{16},S^{32}	mainly US labs

Bubble chamber experiments involving Polish groups

Accelerator	beam $[GeV/c]$	target	Collaboration
Dubna	3.3 d	p	Dubna+W
Dubna	3.9 π^-	Xe	Dubna+W
Dubna	4.2 A	C_3H_8	JINR labs(C+W)
Serpukhov	40 π^-	C_3H_8	JINR labs(C+W)
CERN	5,8.2 K^-	p	Bruxelles+CERN+C
CERN	8 $\pi^\pm$	p	Aachen+Berlin+CERN+C+Vienna+W
CERN	16 π^-	p	same+Bonn+Heidelberg
CERN	16 π^+	p	same+Bonn+Heidelberg+London
CERN	21 π^-	d	Cambridge+C+W
CERN	30,64 $\pi^\pm$	Ne	Seattle+Strassbourg+W
CERN	110 K^-	p	Aachen+Berlin+C+London+Vienna+W
FNAL	205,360 π^-	d	Davis+C+Seattle+W

Streamer chamber and hybrid experiments involving Polish groups

Accelerator	beam $[GeV/c]$	target	Collaboration
Dubna	4.5 A	He/Ne	JINR labs(C+W)
Serpukhov	40 π^-	A	MIS(W)
Serpukhov	40 π^-, K, p	A	RISK(W)
CERN	60 O^{16}, S^{32}	He/Ne	NA35(C+W)
CERN	250 π^+, K, p	p, A	NA22(C+W)
CERN	150,200,300 $\pi^-, p, \overline{p}$	A	NA5(C)
FNAL	wide band ν	emulsion	E564(C)
FNAL	150 μ	emulsion	E382(C)
FNAL	500 μ^+	A	E665(C)

Fixed target counter experiments at CERN involving Polish groups

Experiment	Physics topic	Date
PS136(C)	meson spectroscopy	1973÷1975
PS143(W)	N^* resonances	1974÷1976
PS152(W)	hypernuclear spectroscopy	1976÷1977
PS203(W)	$\bar{p} - N$ interactions	1988-
WA1(W)	$\nu - N$ interactions	1974÷1984
WA3(C)	meson spectroscopy	1976÷1980
NA2(W)	electromagnetic interactions of μ	1975÷1985
NA11(C)	charm search in hadroproduction	1978÷1982
NA14(W)	charm search in photoproduction	1978÷1984
NA32(C)	charm decay and production properties	1984÷1986
NA36(C)	heavy ion collisions	1984÷1990
NA37(W)	nucleon structure functions	1985÷1990
NA47(W)	spin-dependent structure functions	1989-
WA93/98(W)	hadron-photon correlations in A-A collisions	1990-

ISR experiments involving Polish groups

ISR 416 (SFM)	Annecy – CERN – Collège de France – Heidelberg – Karlsruhe – Warsaw
ISR 418 (SFM)	Ames – Bologna – CERN – Dortmund – Heidelberg – Berkeley – Lund – Warsaw
ISR 419 (SFM)	CERN – Heidelberg – Warsaw
ISR 420 (SFM)	Ames – Bologna – CERN – Heidelberg – Warsaw
ISR 101	Bombay – Bucharest – Cracow

The DESY Chapter

1979 – first Polish physicists at DESY (LENA, Crystal Ball)
1984 – Cracow & Warsaw groups joined ZEUS
1986 – Cracow group joined H1

1985-1991 construction of HERA with considerable participation (nearly 200 man-years) of Polish scientists, engineers and technicians

International visibility

1961 1st Cracow School of Theoretical Physics in Zakopane

1972 3rd International Symposium on Multiparticle Dynamics in Zakopane

1977 First International Warsaw Meeting on Elementary Particle Physics in Kazimierz

1996 28th ICHEP („Rochester" Conference) in Warsaw

+ many smaller meetings…

Rapporteurs talks by Polish physicists at „Rochester" conferences: Vienna (1968), Kiev (1970), London (1974), Tokyo (1978), Singapore (1990), Warsaw (1996), Vancouver (1998)

Present era
(since 1989)

Poland – CERN member state since July 1, 1991

DELPHI, NMC(SMC), heavy ions

RHIC (BNL), D0 (FNAL)

ZEUS, H1

Superkamiokande, K2K

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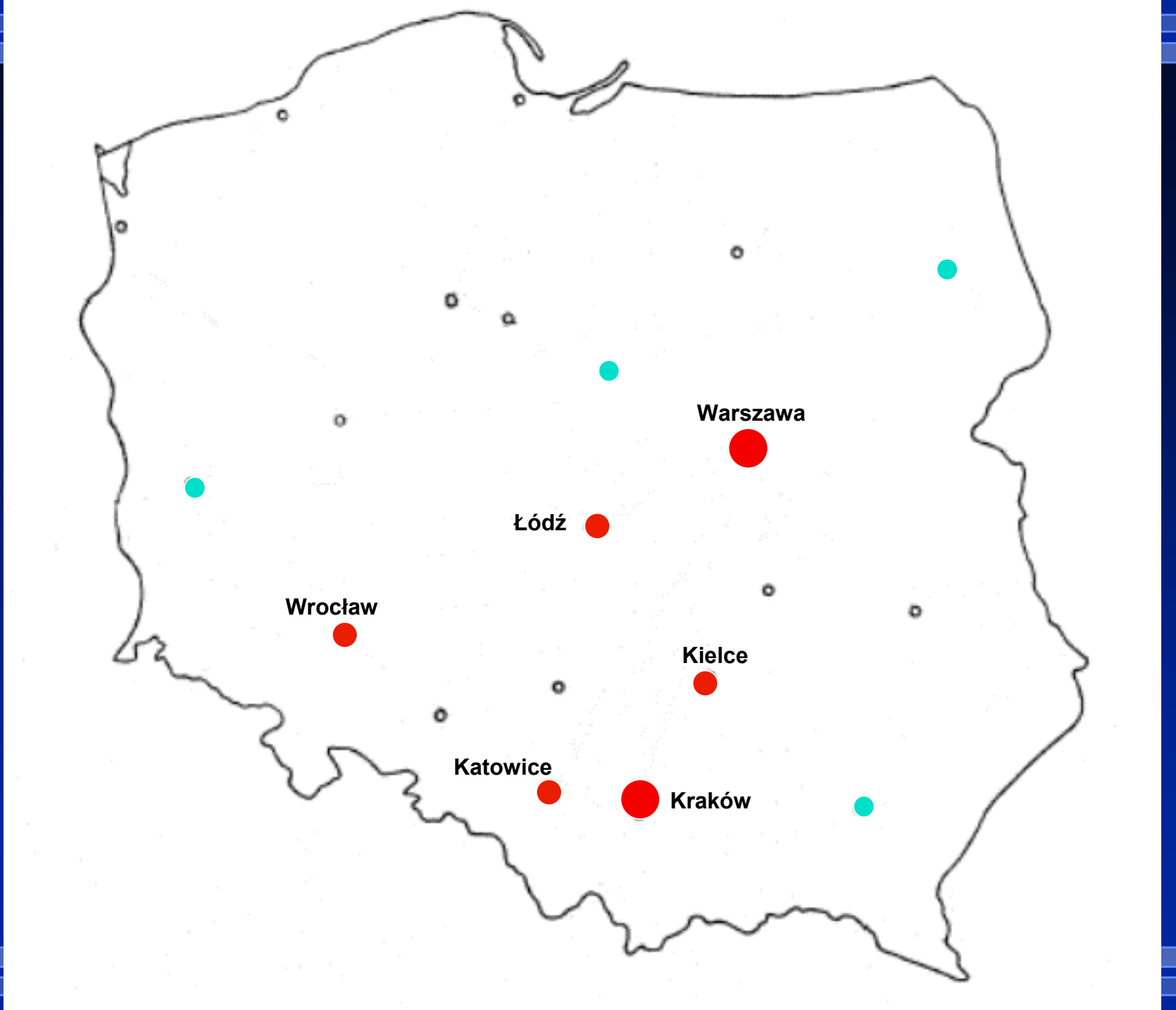
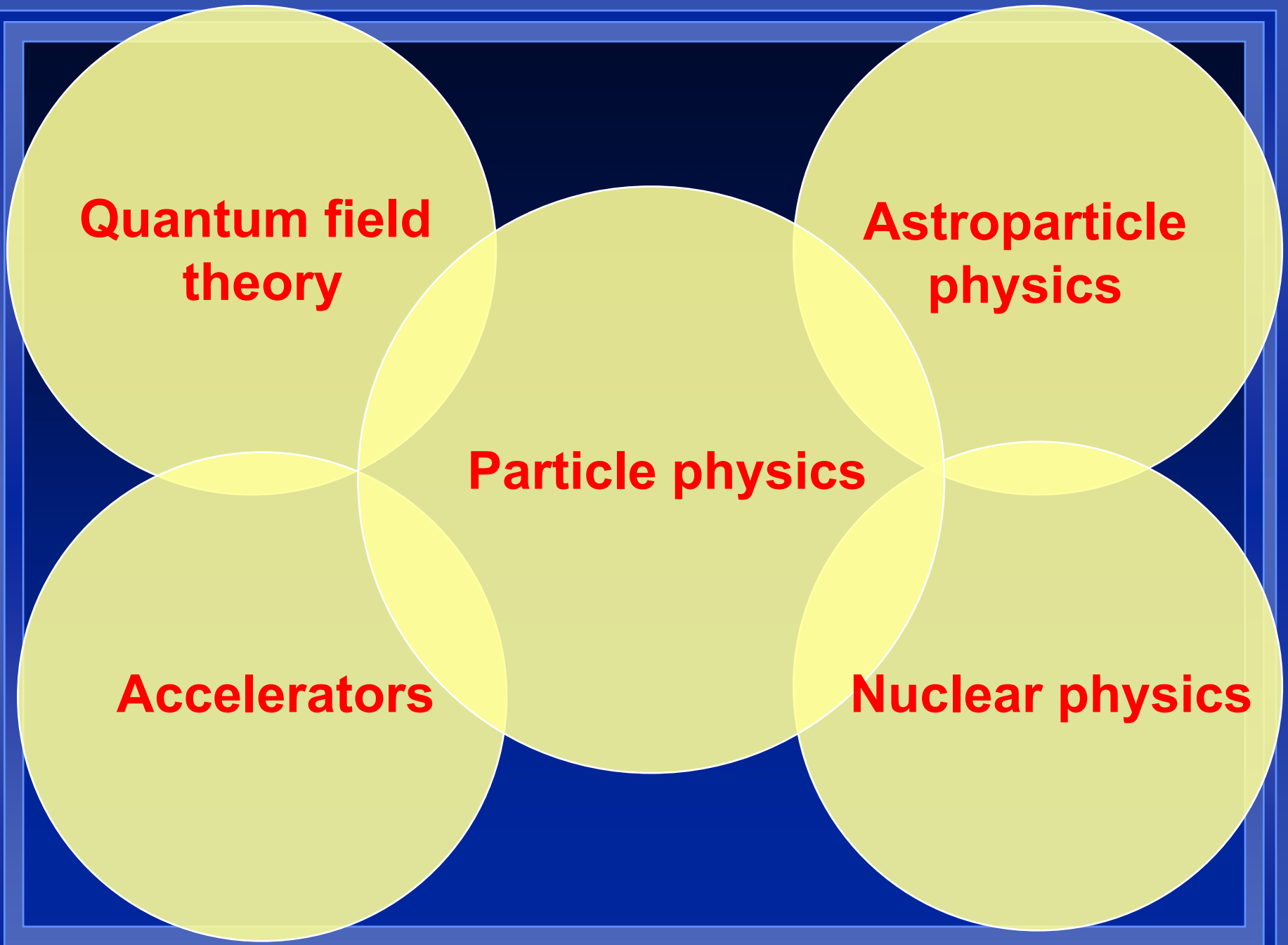
Present centres of particle physics

Katowice	Universiity of Silesia
Kraków	Jagiellonian University, AGH University of Science and Technology Institute of Nuclear Physics
Kielce	Jan Kochanowski University
Łódź	University of Łódź National Centre of Nuclear Research (br.)
Warszawa	University of Warsaw Warsaw University of Technology National Centre of Nuclear Research
Wrocław	University of Wrocław

Also individuals at Białystok, Płock, Rzeszów, Zielona Góra


Warszawa
Łódź
Wrocław
Kielce
Katowice
Kraków


Quantum field theory
Astroparticle physics
Particle physics
Accelerators
Nuclear physics

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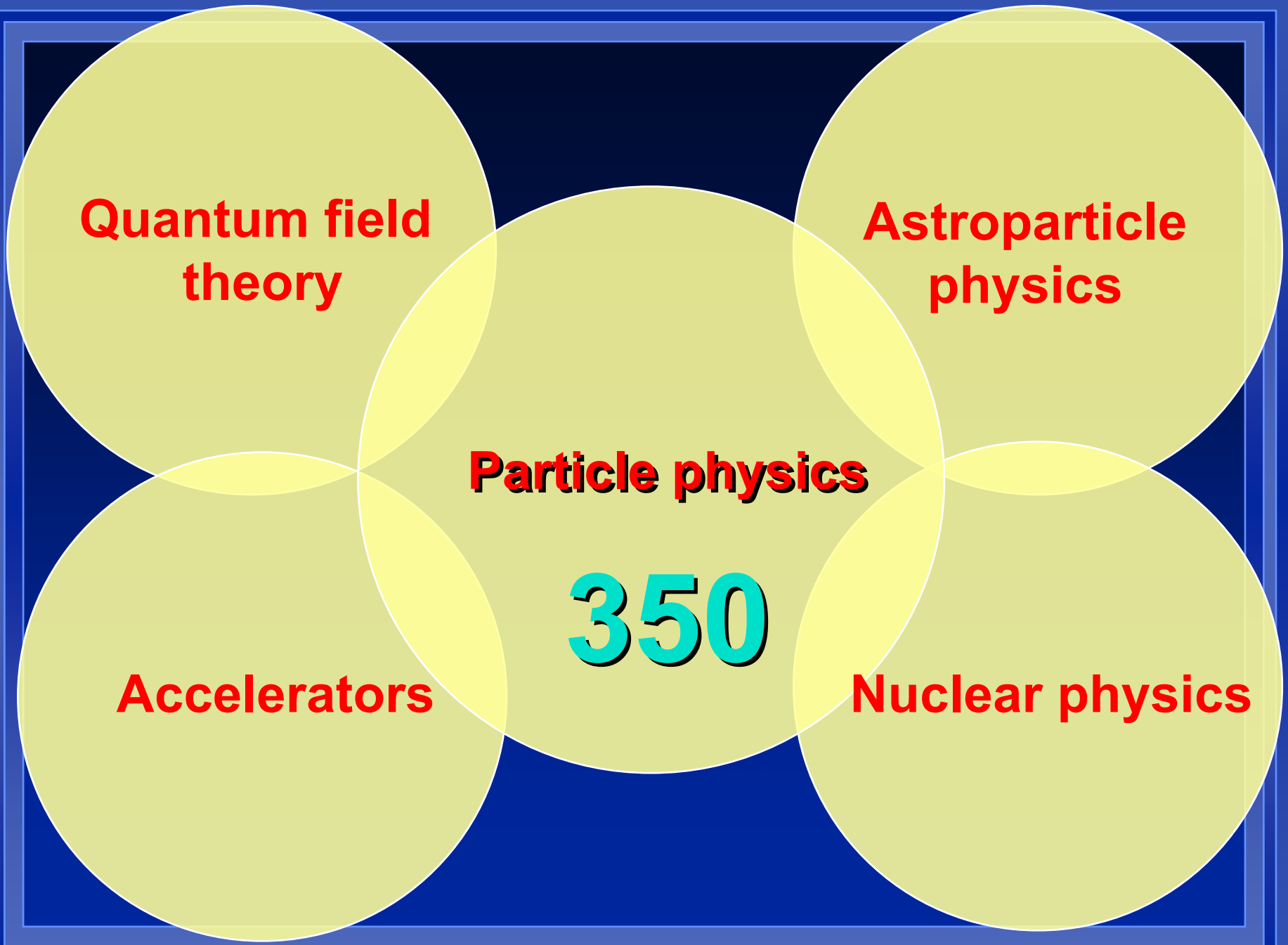
Quantum field theory
Astroparticle physics
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Accelerators
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Present status

Experiments at LHC: ATLAS, CMS, ALICE, LHCb
Non-LHC experiments: COMPASS, Heavy ions

PHOBOS, STAR at RHIC

T2K, ICARUS, MINOS

Cosmic rays: AUGER, KASKADE…

ILC, TESLA

Theory

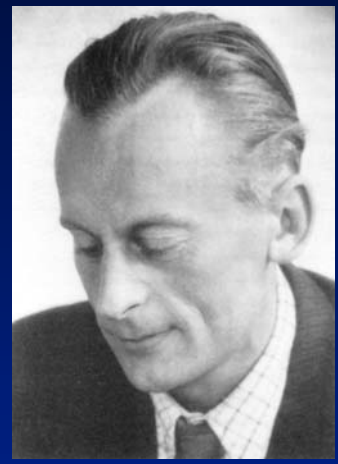
Strong theory groups in Cracow and Warsaw, also at Katowice, Kielce and Wrocław

DIS, quark-gluon plasma, intermittency, radiative corrections, nuclear effects of multiparticle production, SUSY extensions of the Standard Model, chiral models, quantum gravity, fermion masses in Grand Unified Theories, heavy quark decays, hadron spectroscopy, tachyons,…

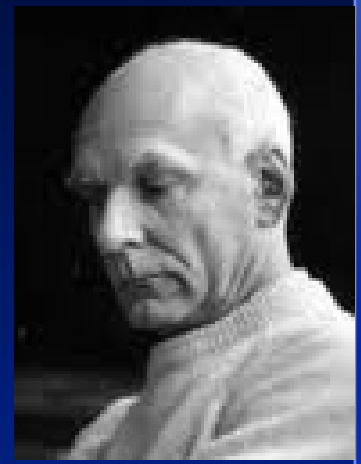
Pro memoriam

Jan Kwieciński
(1938-2003)

Jan Łopuszański
(1923-2008)



Jerzy Rayski
(1917-1993)



Jan Rzewuski
(1918-1994)

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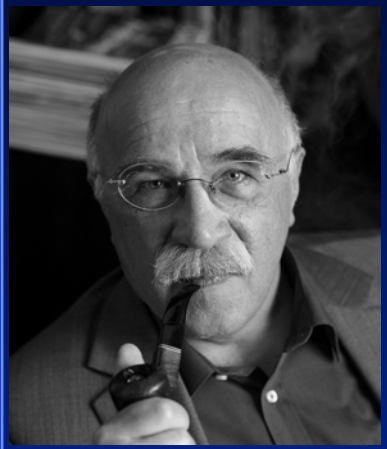
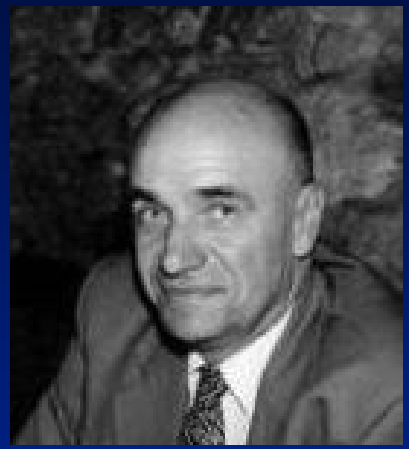
Pro memoriam

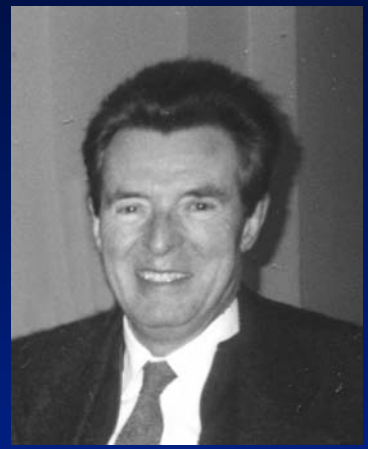


Jan Nassalski
(1944-2009)



Krzysztof Rybicki
(1938-2003)

Jerzy Wdowczyk
(1935-1996)



Janusz Zakrzewski
(1932-2008)

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THE END

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