In Honor of

Herwig Schopper's

85th Birthday

In memory of Mrs. Ingeborg Schopper,
who made Professor Schopper's work possible.

Our sympathies to the Shopper family:
Herwig, Doris and Andreas.

PHYSICS

Optics and solid state physics

Nuclear physics

Elementary particle physics

Detector development

Accelerator technology

SOME THREE HUNDRED PUBLICATIONS

Optics and solid state physics

R. Fleischmann und H. Schopper,
Die Bestimmung der optischen Konstanten und der Schicht-dicke absorbierender Schichten mit Hilfe der Messung der absoluten Phasenänderung
Z. Physik 129, 285 (1951)

R. Fleischmann und H. Schopper,
Verfahren zur genauen Messung absoluter Lichtphasen an nicht-absorbierenden und absorbierenden Schichten
Z. Physik, 130, 304 (1951)

H. Schopper
Die Untersuchung 'dicker' Metallschichten und ihrer Oberflächen-schichten mit Hilfe der absoluten Phase
Z. Physik 130, 427 (1951)

H. Schopper
Die Untersuchung 'dünner' absorbierender Schichten mit Hilfe der absoluten Phase
Z. Physik, 130, 565 (1951)

H. Schopper
Die Bestimmung der optischen Konstanten und der Schichtdicke beliebig dicker Schichten mit Hilfe der absoluten Phase
Z. Physik 131, 215 (1952)

R.Fleischmann und H.Schopper
Ein photometrisches Präzisionsverfahren zur Messung absoluter Lichtphasen mit Hilfe eines phasengleichen Gesichtsfeldes
Z. Physik 131, 225 (1952)

H.Schopper
Zur Optik dünner doppelbrechender und dichroitischer Schichten
Z. Physik 132, 146 (1952)

H.Schopper
Die Erzeugung von linear polarisiertem Licht mit Hilfe einer dünnen absobierenden Schicht
Optik 9, 498 (1952)

H. Schopper
Zur Deutung der optischen Konstanten der Alkalimetalle
Z. Physik 135, 163 (1953)

H. Schopper
Die Erzeugung von linear polarisiertem Licht durch Reflexion an beschichteten Metallen
Optik 10, 426 (1953)

H. Schopper
Ein optisches Kalkspatinterferometer mit wellenlängenunabhängigem Intensitätsausgleich
Z. Physik 135, 516 (1953)

H. Schopper
Die optischen Anomalien und der Aufbau dünner Metallschichten
Fortschritte der Physik II, 275 (1954)

H. Schopper
Die optische Untersuchung der Diffusion von Metallen ineinander
Z. Physik 143, 93 (1955)

H. Schopper
Neuere optische Verfahren zum Bestimmen der Dicke dünnster Schichten, auch Korrosionsschichten
Forschung Bd. 22/Heft 2 (1956)

H. Schopper
Untersuchungen an dünnen Alkalimetallschichten
Zeitschr. f. Physik 174, 125-135 (1963)

15 PAPERS

Zeitschrift für Physik Bd 135, S 516-522 (1953)

Ein optisches Kalkspatinferferometer mit wellenlängenunabhängigem Intensitätsausgleich

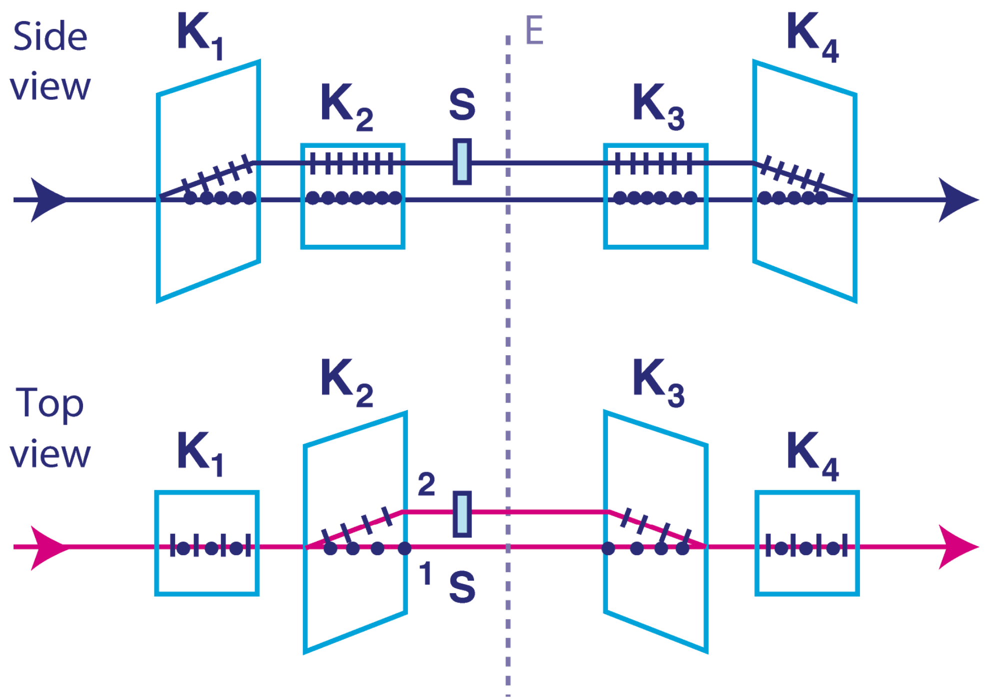
Von

H. Schopper

Mit 3 Figuren im Text.

(Eingegangen am 23. Mai 1953.)

An Interferometer which changes polarization independent of wave length



Linearly polarized light hits K_1 which divides it into two linearly polarized bundles.

Both then hit K_2 (rotated by 90°). Both bundles after K_2 have passed the same optical length and have the same phase.

K_3 and K_4 are arranged mirror-symmetrically ⟶ both bundles join together again.

S causes change of phase of one bundle ⟶ elliptically polarized light ; can be measured.

1264 ting rd

Nuclear Physics

H. Schopper
Circular Polarization of γ-rays: Further Proof for Parity Failure in β Decay
The Phil. Mag. 2, 710 (1957)

S. Galster and H. Schopper
Circular Polarization of Internal Bremsstrahlung Produced by β-Rays
Phys. Rev. Lett. 1, 506 (1958)

H. Schopper and H. Müller
Lepton Conservation and Time Reversal in β-decay
Il Nuovo Cimento X,Vol. 13, 1026 (1959)

G. Hartwig and H. Schopper
β –γ Circular Polarization Correlation of Sb124
Phys. Rev. Lett. 6, 293 (1960)

S. Galster and H. Schopper
Circular Polarization of Internal Bremsstrahlung Accompanying β Decay
Phys. Rev. Lett. 6, 293 (1960)

P. Bock and H. Schopper
Search of a Parity Violation in the Nucleon-Nucleon Interaction
Phys. Lett. 16, 284 (1965)

P. Bock, B. Jenschke, H. Schopper
Search of a Parity Mixing in 180Hf by a Measurement of the Circular Polarization of γ Rays
Phys. Lett. 22, 316 (1966)

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33 PAPERS

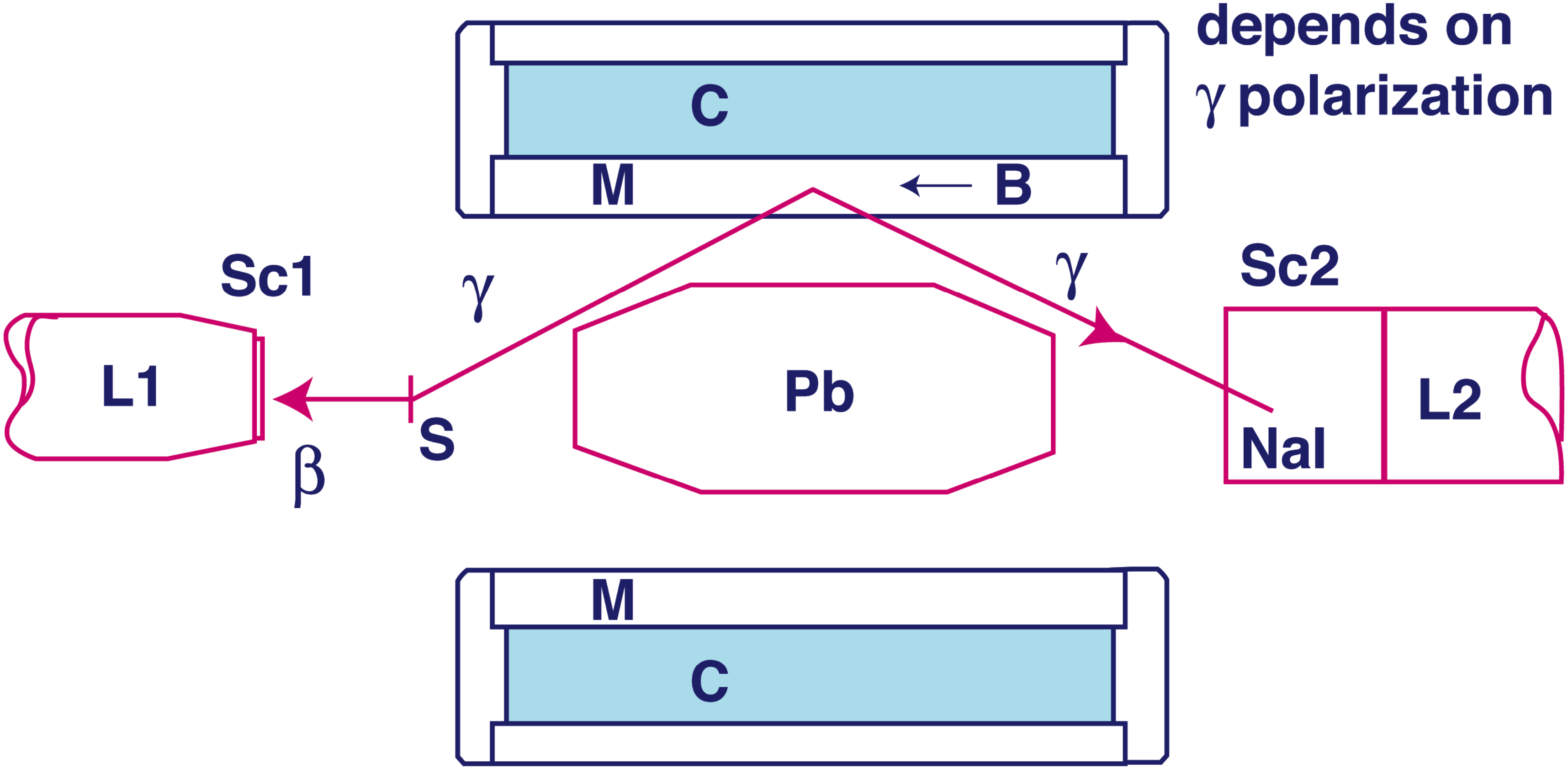
Circular Polarization of γ-rays : Further Proof for Parity Failure in β Decay

By H. Schopper
Cavendish Laboratory, Cambridge†

[Received March 14, 1957]

Lee and Yang (1956) suggested several experiments for testing the conservation of parity in weak interactions. Two of these have been performed (Wu *et al.* 1957, Garwin *et al.* 1957‡) and have shown that parity is not conserved. Results of a third experiment (thought impracticable by Lee and Yang) are reported here. They confirm the expectation that the γ-rays emitted after β-decay at an angle θ relative to the β-particle should show circular polarization proportional to $\cos\theta$.

Compton scattering depends on γ polarization



1275 ting rd

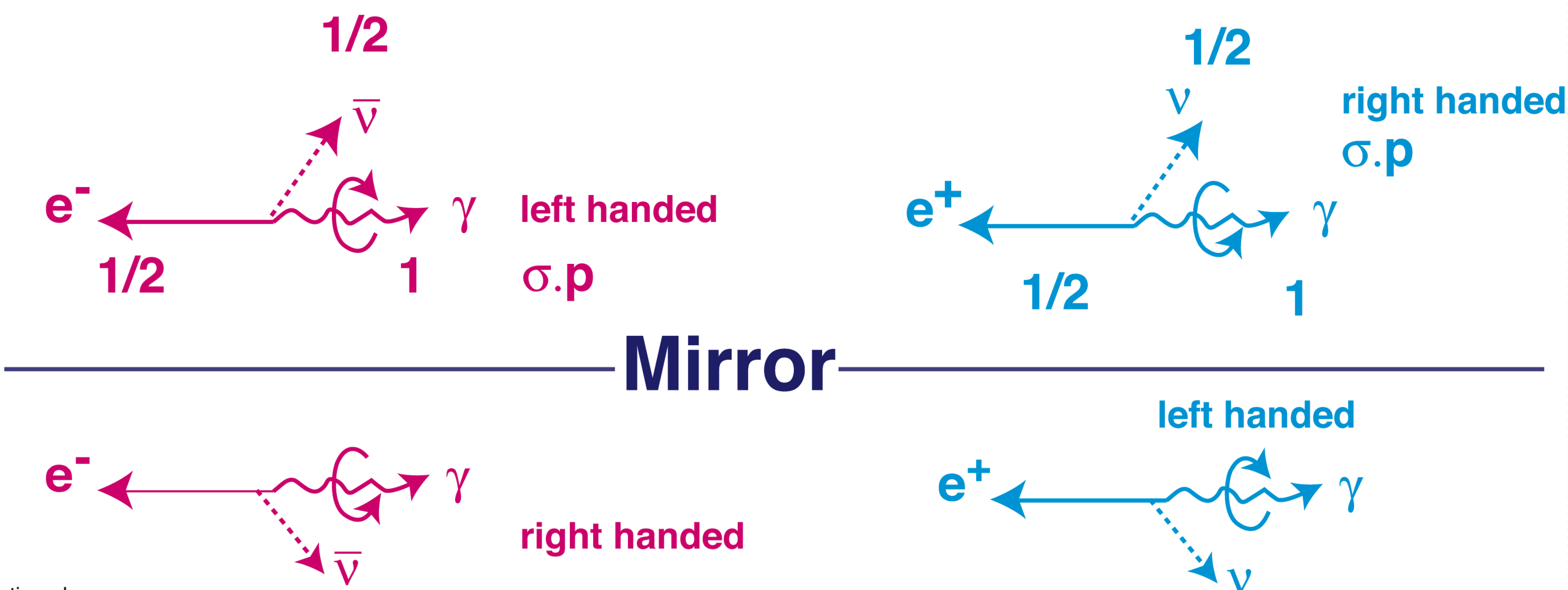
$$^{60}Co \rightarrow {}^{60}Ni^{**} + e^- + \bar{\nu}$$

$$\hookrightarrow {}^{60}Ni^{*} + \gamma$$

$$\hookrightarrow {}^{60}Ni + \gamma$$

$$^{22}Na \rightarrow {}^{22}Ne^{*} + e^+ + \nu$$

$$\hookrightarrow {}^{22}Ne + \gamma$$



1276a ting rd

$$Asy = \frac{B\uparrow - B\downarrow}{B\uparrow + B\downarrow} (\%)$$

	Asy	polarization (%)
^{60}Co	$+2.16 \pm 0.36$	$+26 \pm 4$
^{22}Na	-2.33 ± 0.52	-28 ± 6

CONCLUSION

- **Polarization non zero**

  =>parity violated

- *Co* **and** *Na* **give opposite polarization**

  =>neutrino and antineutrino have opposite helicity

Lepton Conservation and Time Reversal in β-decay.

H. SCHOPPER and H. MÜLLER

Institut für Kernphysik - Universität Mainz

(ricevuto il 17 Giugno 1959)

Summary. — It was investigated which conclusions can be inferred from β-decay experiments taking into account experimental errors but without making theoretical assumptions.

Prior to the time of parity violation in β-decay it was thought that the only way to test the conservation of leptons was the double β-decay or the inverse β-decay. However, discussing the theoretical results obtained by PAULI (1), KAHANA and PURSEY (2) and LÜDERS (3) in the light of the recent experiments it becomes evident that lepton conservation can be checked only in single β-decay experiments (*). Furthermore it can be shown that the negative result found in ordinary time reversal experiments allows no conclusion about time reversal invariance as long as maximum breakdown of parity or conservation of lepton charge has not been established.

1. – General considerations.

The discussion of β-decay is usually based upon the interaction density (**)

$$(1)\quad \begin{cases} \mathscr{H} = \sum_{i,\alpha} \bar{\psi}_P O_i \psi_N [\bar{\psi}_e O_i (C_i^\alpha \psi_\alpha + D_i^\alpha \gamma_5 \psi_\alpha^c] + \text{h. c.} \\ i = S, V, T, A, P \qquad \psi_R = (1-\gamma_5)\psi_\nu \qquad \psi_R^c = (1-\gamma_5)\psi_\nu^c\,, \\ \alpha = R, L \qquad \psi_L = (1+\gamma_5)\psi_\nu \qquad \psi_L^c = (1+\gamma_5)\psi_\nu^c\,, \end{cases}$$

(1) W. PAULI: *Nuovo Cimento*, **6**, 204 (1957).
(2) S. KAHANA and D. L. PURSEY: *Nuovo Cimento*, **6**, 1469 (1957).
(3) G. LÜDERS: *Nuovo Cimento*, **7**, 171 (1958).
(*) We shall not consider here the decay of mesons which might involve different kinds of interactions.
(**) We use the notation of KAHANA and PURSEY (2).

Among the first phenomenologic papers to study time reversal

Elementary Particle Physics

At Cornell 1.3 BeV and DESY electron accelerator

- Structure of the proton and neutron, *Phys.Rev.Lett. 7, 141 and 144 (1961) and 6, 286 (1961)*

- Form factors of the proton and neutron, *Phys.Rev.Lett. 6, 286 (1961).* It was shown that the original measurements of form factors by Hofstadter were wrong

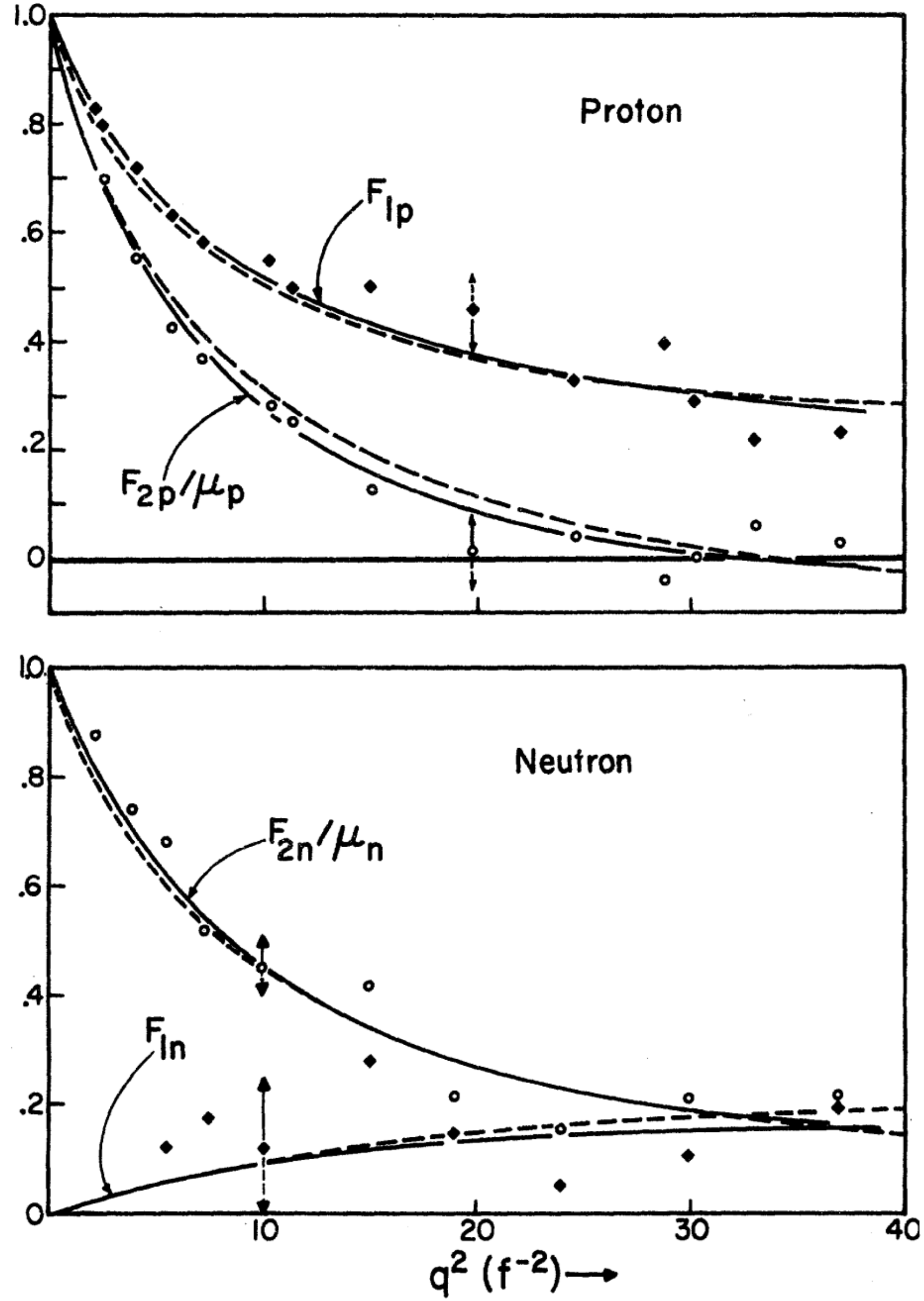
- Elastic electron-proton scattering at momentum transfers up to 110 fermi^{-2}, *Nuov.Cim. 48,140 (1967) and other publications*

SCATTERING OF Bev ELECTRONS BY HYDROGEN AND DEUTERIUM*

R. M. Littauer, H. F. Schopper,† and R. R. Wilson
Laboratory of Nuclear Studies, Cornell University, Ithaca, New York
(Received July 21, 1961)

Table I. Differential cross sections for elastic scattering of electrons of energy E_0 by protons, and peak cross sections for scattering by deuterons. All parameters in the laboratory frame. Schwinger correction applied.

E_0	Proton $(d\sigma/d\Omega)\times 10^{32}$ (cm^2/sr)			Deuteron $(d^2\sigma/dE'd\Omega)\times 10^{33}$ (cm^2/Mev sr)		
(Mev)	45°	90°	135°	45°	90°	135°
317		6.04 ±0.24	1.21 ±0.08		2.14 ±0.14	0.623 ±0.080
387	92.5 ±4.0	3.61 ±0.15	0.790 ±0.031	31.2 ±2.0	1.29 ±0.05	0.307 ±0.026
407	81.0 ±1.9			31.2 ±0.7		
465		1.91 ±0.06	0.296 ±0.019		0.635 ±0.04	0.130 ±0.011
552	37.5 ±1.1			10.9 ±0.3		
565		0.815 ±0.08	...		0.330 ±0.03	...
600		0.99 ±0.03	0.178 ±0.008		0.333 ±0.015	0.0638 ±0.004
664	22.0 ±0.7			5.88 ±0.3		
720		0.388 ±0.017	0.0732 ±0.005		0.132 ±0.010	0.0248 ±0.0032
800	10.4 ±0.5			2.68 ±0.15		
836		0.212 ±0.01	0.0302 ±0.005		0.0448 ±0.003	0.0121 ±0.0026
941	6.63 ±0.3			1.39 ±0.06		
974		0.080 ±0.014	0.0272 ±0.004		0.0147 ±0.003	0.0083 ±0.0024
1050	4.68 ±0.2			0.76 ±0.04		
1136		0.0362 ±0.0028	0.0117 ±0.004		0.0107 ±0.003	0.0033 ±0.0015
1166	3.24 ±0.17			0.61 ±0.06		



Proton
F_{1p}
F_{2p}/μ_p
Neutron
F_{2n}/μ_n
F_{1n}
1.0
.8
.6
.4
.2
0
10
20
30
40
q^2 (f^{-2})→

Our values of $F1n/\mu_n$ are positive and between 0.1 and 0.2, in agreement with the earlier Stanford results[7] calculated with a modified Jankus theory.[8,5]

This disagrees, however, with the reinterpretation of the Stanford results by Durand,[4] which yields values of $F1n/\mu_n$ that are small or may even go negative.

IL NUOVO CIMENTO Vol. XLVIII A, N. 1 1° Marzo 1967

Elastic Electron-Proton Scattering at Momentum Transfers up to 110 fermi^{-2}.

H. J. BEHREND, F. W. BRASSE, J. ENGLER and H. HULTSCHIG

Deutsches Elektronen Synchrotron - Hamburg

S. GALSTER, G. HARTWIG and H. SCHOPPER

Institut für Experimentelle Kernphysik der Technischen Hochschule und des Kernforschungszentrums Karlsruhe - Karlsruhe

E. GANSSAUGE

Physikalisches Institut der Universität - Marburg

(ricevuto il 19 Settembre 1966)

Summary. — Using the internal beam of DESY elastic electron-proton cross-sections were measured at various angles between 32° and 130°, and with momentum transfers of $q^2 = 39, 60, 80$ and 110 fm^{-2}. Two single-quadrupole spectrometers, movable around a common liquid-hydrogen target, were used for analysing the momentum of the scattered electrons. Čerenkov and shower counters discriminated against pion and low-energy background. As a cross-section reference, recoil protons from elastic scattering at $q^2 = 10$ fm^{-2} were used, with a quantameter serving as an intermediate monitor. The data are consistent with the Rosenbluth formula, giving real form factors G_E and G_M. Both continue to decrease with increasing momentum transfer, but somewhat faster than indicated by measurements performed so far.

2. – The experimental arrangement.

A survey of the apparatus is shown in Fig. 1. Two nearly identical spectrometers, each consisting of one quadrupole, could be moved around a com-

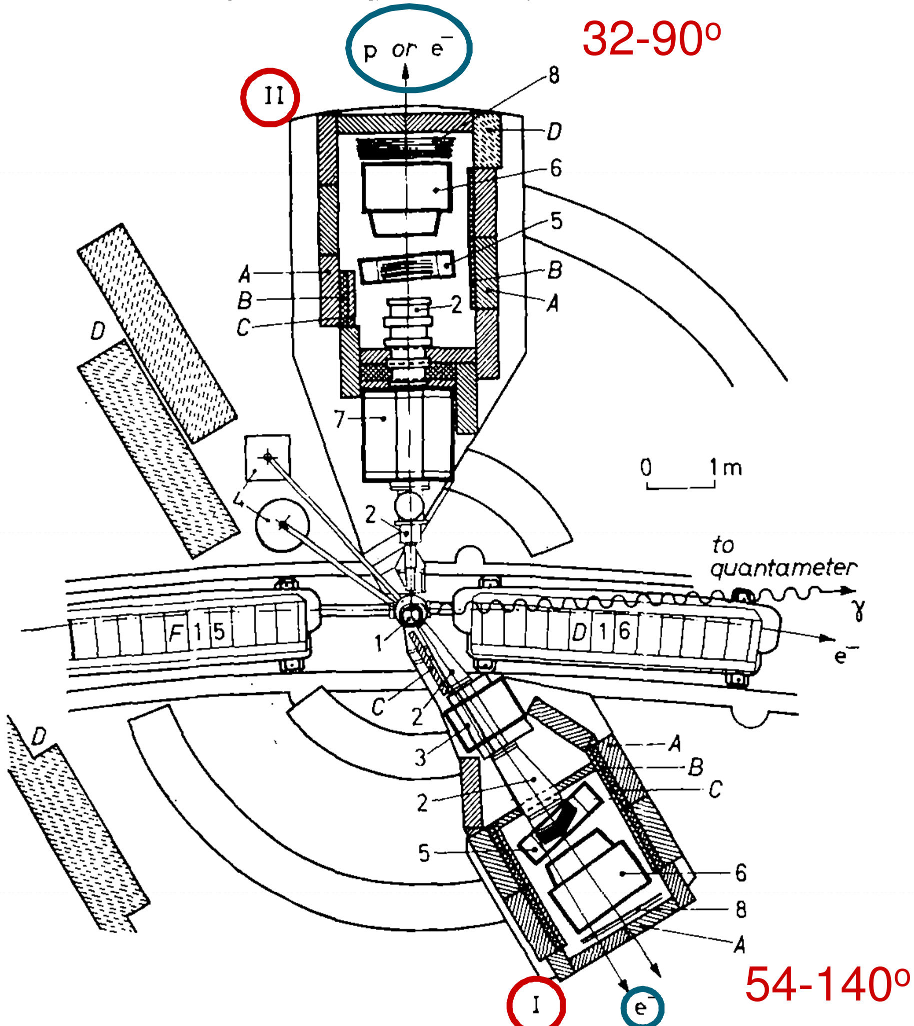


Fig. 1. – Plan of the experimental arrangement: I - spectrometer 1, 54° ÷ 140°; II - spectrometer 2, 32° ÷ 90°; 1) scattering chamber with liquid H_2 target; 2) vacuum chamber with entrance slits; 3) halved quadrupole magnet QC/2; 4) target supply and He dewar; 5) scintillation counters; 6) gas Čerenkov counter (threshold); 7) quadrupole magnet QA; 8) shower counter; shielding: *A*) iron blocks; *B*) B_4C-CH_2 plates + paraffine; *C*) lead blocks; *D*) concrete blocks.

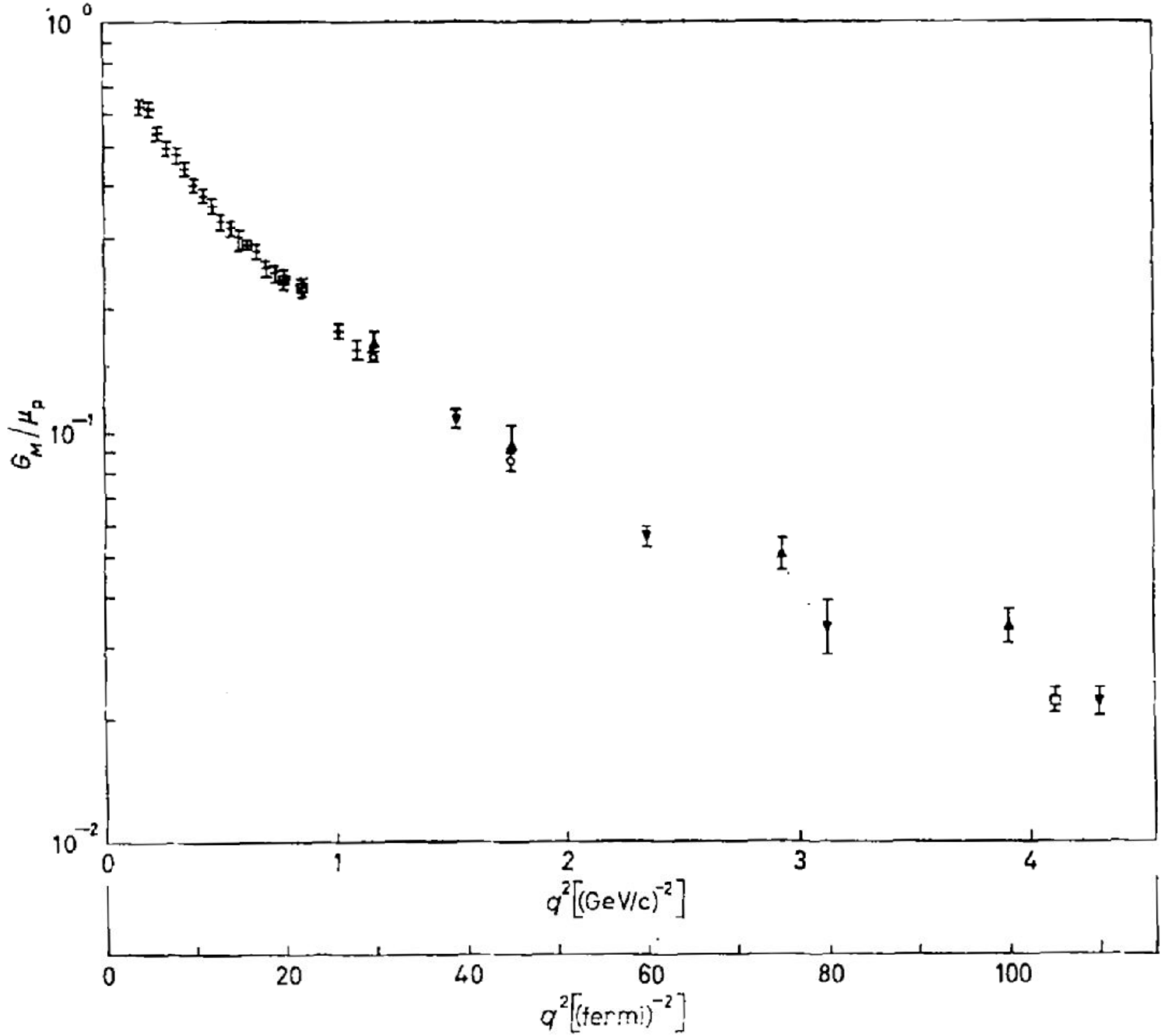


Fig. 13. – The magnetic form factor G_M/μ. + JANSSENS *et al.* ([6]); ▲ CHEN *et al.* ([5]); ▼ this work; □ combined data, see Table V; ○ combined data, see ([14]).

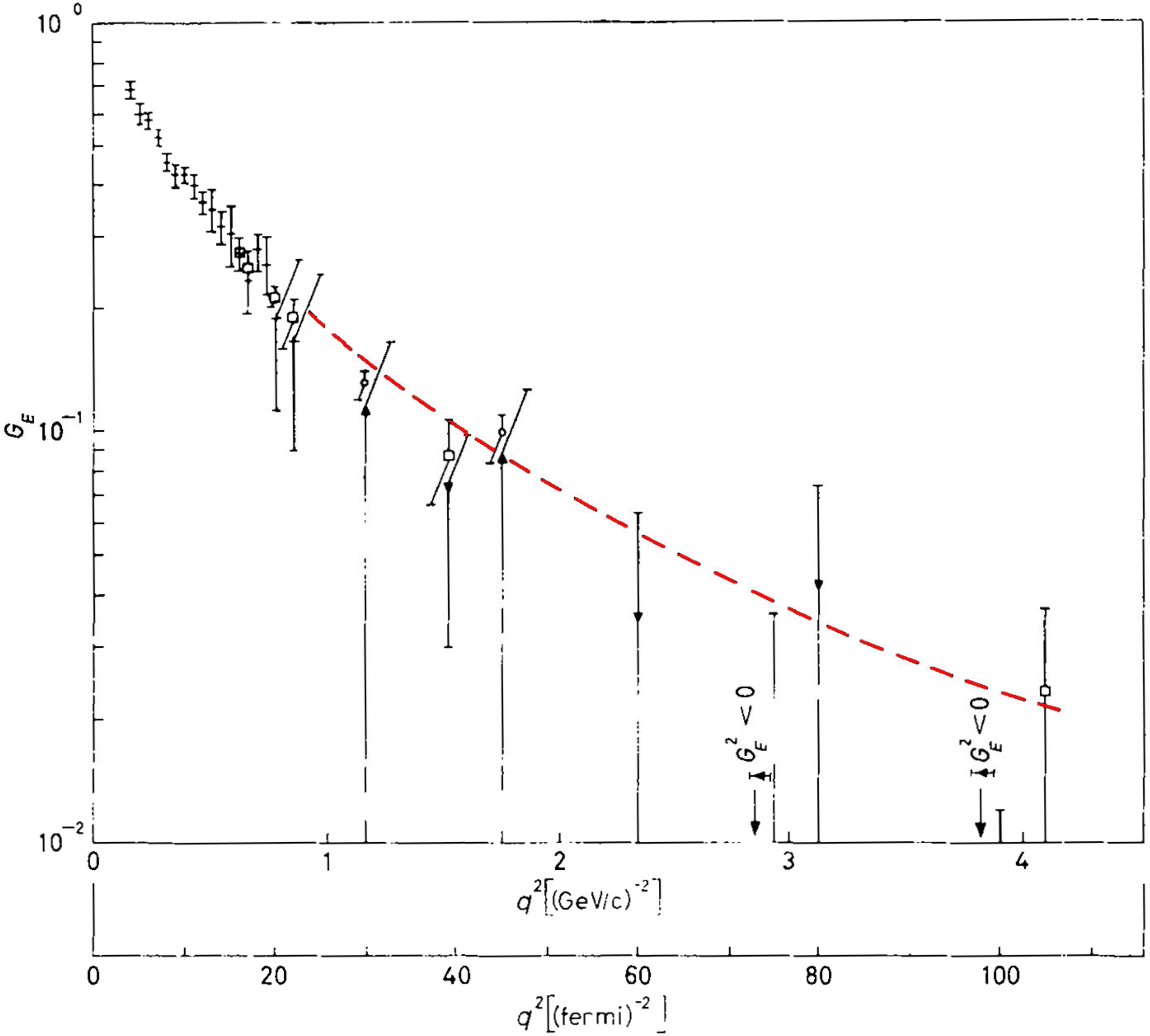


Fig. 14. – The electric form factor G_E *vs.* q^2. The dashed line is a smoothed curve of G_M/μ. + JANSSENS *et al.* [6]; △ CHEN *et al.*; ▼ this work; □ combined data, see Table V; ○ combined data, see [14].

CONCLUSION

1. **No Deviation from Rosenbluth Formula**

2. **Real values of G_e, G_M**

$$G_e(q^2) = G_M(q^2)/\mu$$

Elementary Particle Physics

Unique Contribution on Neutron-Proton Physics

Neutron-Proton and Neutron-Nuclei total cross section, N-P elastic and charge exchange scattering was systematically studied at PS, ISR and Serpukhov...

Hadron calorimetry technique was invented to measure neutron energy and direction

Nucl.Instr.Meth. 106, 189 (1973)

Elementary Particle Physics

Neutron physics at CERN and Serpukhov

- Total Cross Sections of n-p and n-d at 10 GeV/c Neutron Momentum *Physics Letters Vol.27B, No, 9, 599 (1968)*
- n-p Elastic Scattering in the forward direction between 4 and 16 GeV *Physics Letters 29B, 321 (1969)*
- n-p Total Cross Sections between 8 and 21 GeV/c *Physics Letters 31B, 669-672 (1970)*
- n-A Total Cross Sections between 8 and 21 GeV/c *Physics Letters 32B, 716-719 (1970)*

- Measurement of n-p Charge Exchange Scattering at 8, 19 and 24 GeV/c *Physics Letters 34B, 528-532 (1971)*

- Inclusive Neutron Spectra at the ISR
  Nucl. Phys. B84, 70-82 (1975)

- N-P Elastic Scattering from 10 to 70 GeV/c
  Nucl. Phys. B91, 266-278 (1975)

- N-P Charge Exchange Scattering from 9 to 23 GeV/c
  Nucl. Phys. B110, 205 (1976)

N-P charge exchange Scattering from 22 to 65 Gev/c

NEUTRON-PROTON TOTAL CROSS-SECTIONS BETWEEN 8 GeVc AND 21 GeVc

Volume 3lB. number 10 PHYSICS LETTERS 11 May 1970

J. ENGLER, K. HORN, F. MOENNIG, P. SCHLUDECKER ,W. SCHMIDT-PARZEFALL. H. SCHOPPER *, P. SIEVERS
and H. ULLRICH
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R. HARTUNG and K. RUNGE
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Yu. GALAKTIONOV
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Received 6 April 1970

Neutron-proton total cross-sections were measured in the momentum range from 8 GeV/c to 21 GeV/c with an accuracy of better than 2~ using a 0 ° neutron beam at the CERN Proton Synchrotron.
The np total cross-section drops from 39.7 mb at 8 GeV/c to 38.5 mb at 21 GeV/c. and thus follows closely the pp total cross-sections in this momentum interval.

NEUTRON-NUCLEUS TOTAL CROSS-SECTIONS BETWEEN 8 GeV/c AND 21 GeV/c

J. ENGLER, K. HORN, F. MONNIG, P. SCHLUDECKER, W. SCHMIDT-PARZEFALL *, H. SCHOPPER *, P. SIEVERS * and H. ULLRICH

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and

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Received 4 August 1970

Total cross-sections for neutrons on Be, C, Al, Cu and Pb have been measured to an accuracy of about 1% at average neutron momenta of 8, 11, 14 and 21 GeV/c. For all elements they drop smoothly by about 3% between 8 and 21 GeV/c, and have a momentum dependence similar to the pp and np total cross-sections. Indeed if the cross-sections are normalized to the np total cross-section, no momentum dependence can be observed. The data are compared with calculations based on the Glauber model.

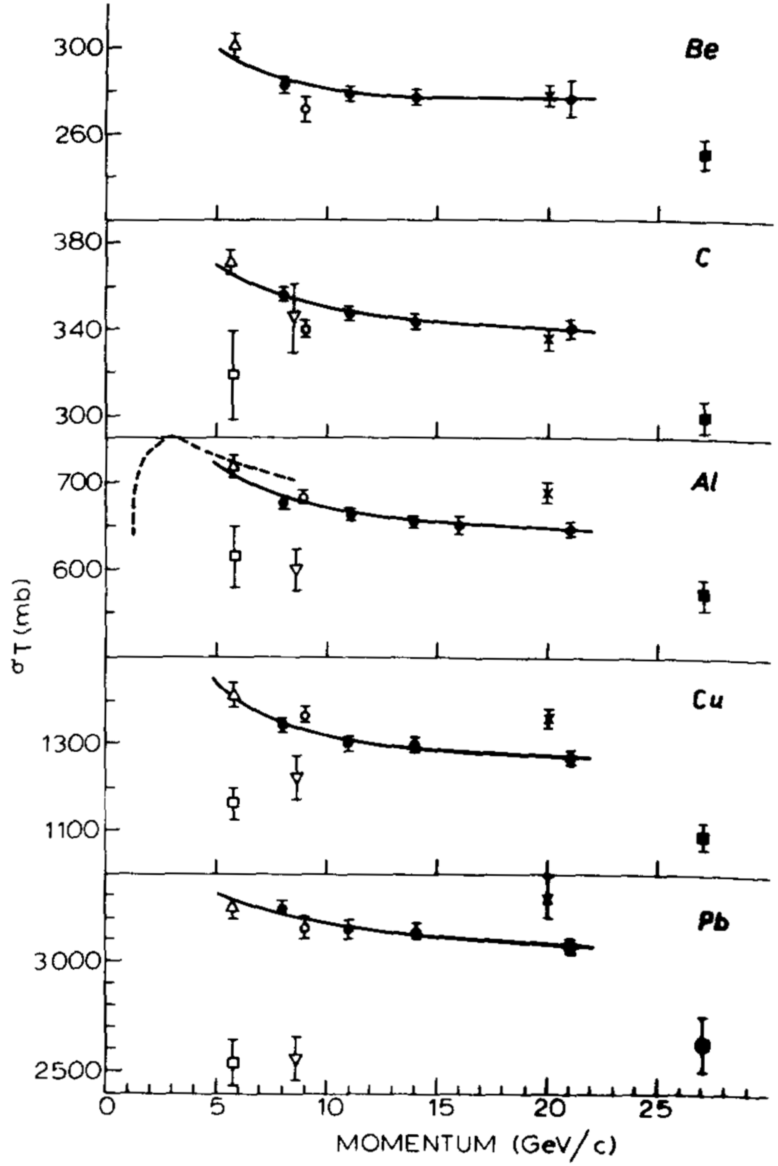

Fig. 1. Total cross-sections of neutrons and protons for nuclei. Neutron data points: ■ Ref. [3], Δ Ref. [4], ∇ Rev. [6], □ Ref. [7], ○ Ref. [2], ● this experiment. Proton data points: × Ref. [5], - - - Ref. [8]. The solid line is a handfit curve through the data points of Refs. [2], [4], and this experiment.

Measure σ_T to 1% on Be, C, Al, Cu, Pb at 8, 11, 14, 21 GeV/c

If one fits the data to the formula,

$$\sigma_{tot} = 2\pi \{R^2 - \tfrac{1}{2} X_o^2 [1 - (R^2/X_o + \Lambda)\exp(-R^2/X_o)]\}$$

where Xo is the mean free path of a neutron in nuclear matter, and R = $r_o A^{1/3}$,

Result:

a) **The unit radius remains essentially constant $r_o = 1.25$ fm**

b) **Early measurements were wrong**

c) **The energy dependence of σ_{NA} is the same as σ_{pp} or σ_{NP}**

Nuclear Physics B84 (1975) 70–82. North-Holland Publishing Company

MEASUREMENT OF INCLUSIVE NEUTRON SPECTRA AT THE ISR*

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CERN, Geneva, Switzerland

Received 20 June 1974
(Revised 30 August 1974)

Abstract: With a total absorption counter, inclusive neutron spectra have been measured at four ISR energies and at angles of 20, 66 and 119 mrad. The spectra show scaling behaviour in the variables x and $p_{\perp}$. Pion exchange is found to be important at large x values.

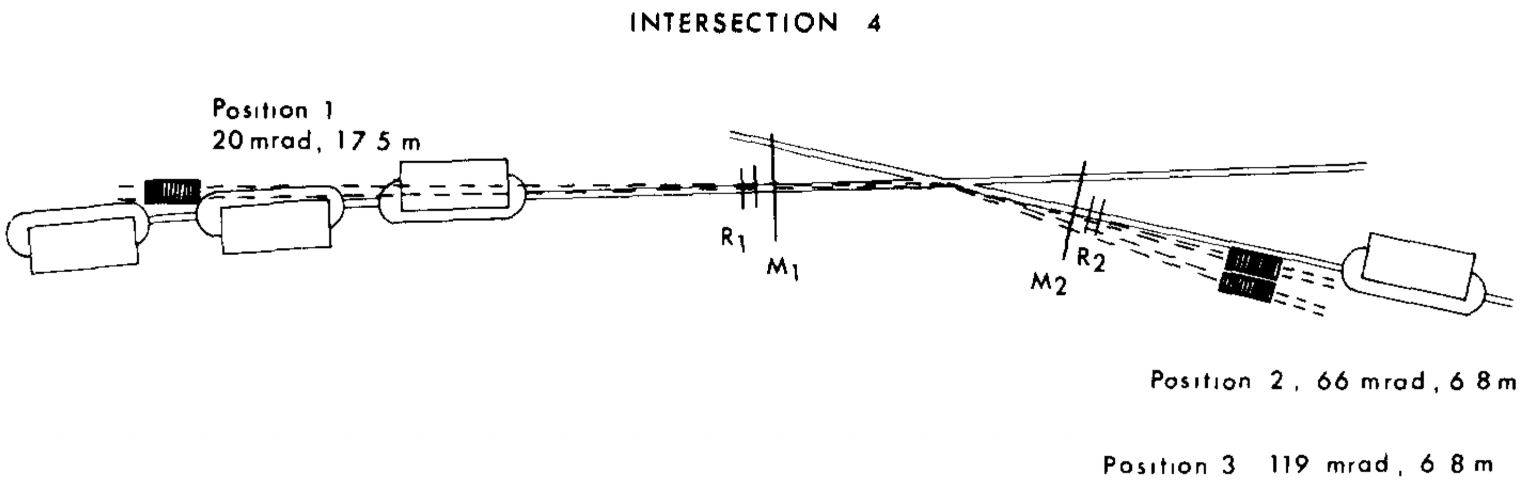

Fig. 1a.

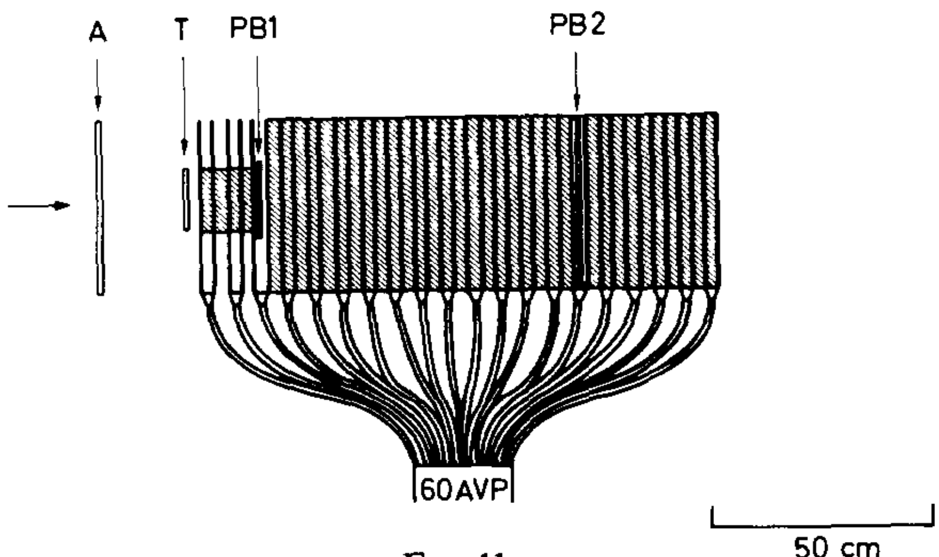

Fig. 1b

Fig. 1. Experimental set-up at the ISR and details of STAC.

(Sampling Total Absorption Calorimeter)

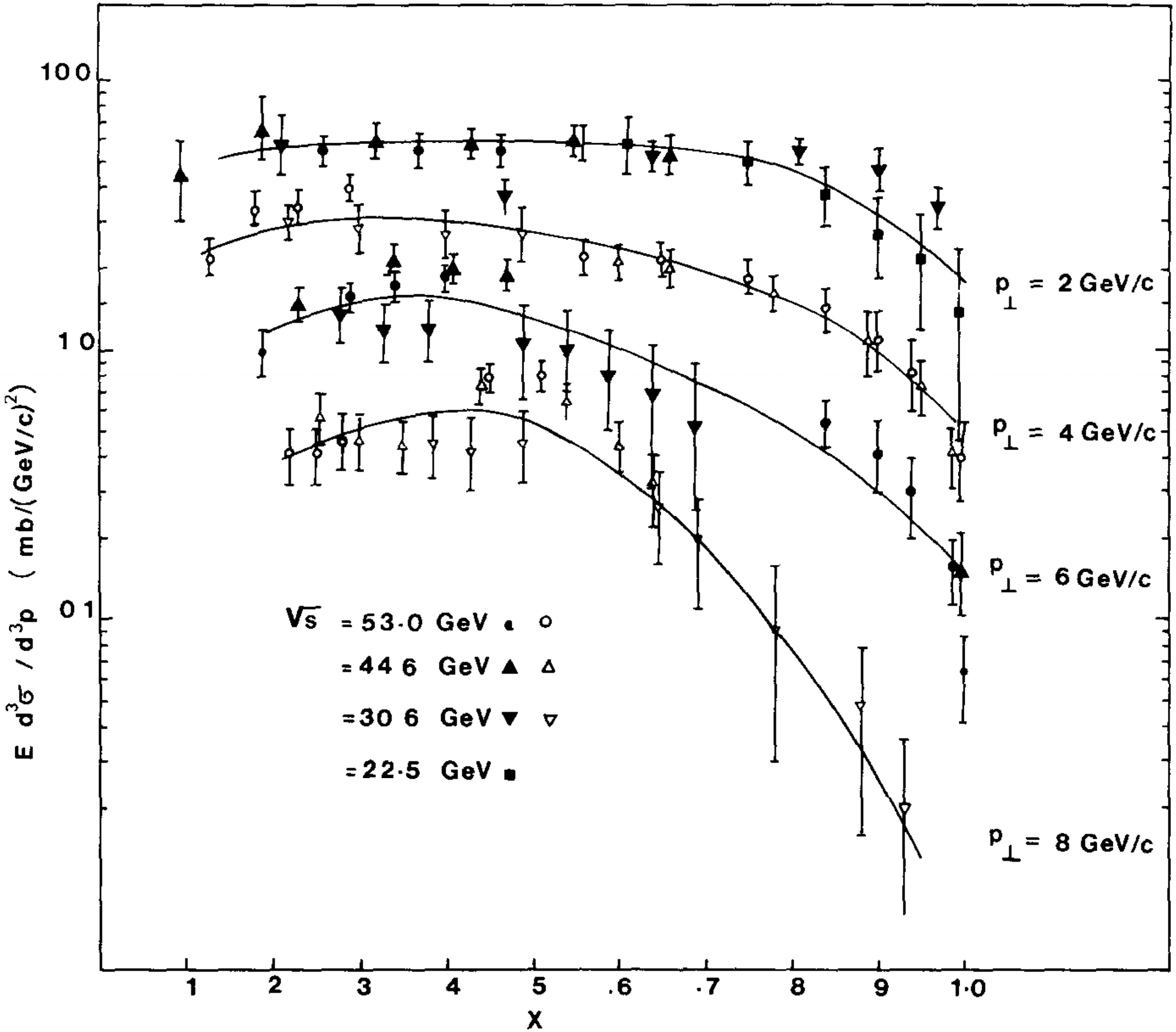

Fig. 6. Cross sections as a function of the Feynman variable x for different transverse momenta. The solid lines are given to guide the eye.

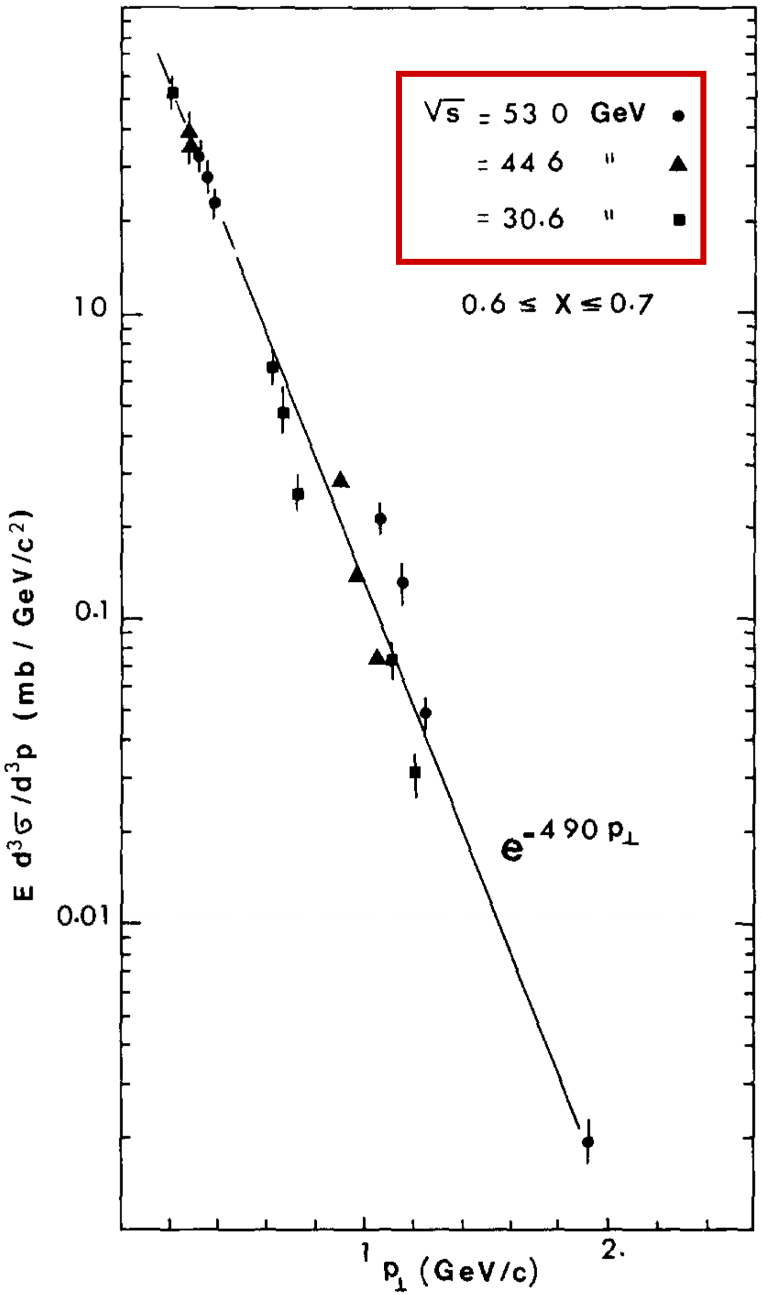

Fig. 5. Cross sections of neutron production as a function of transverse momentum $p_\perp$, high x region.

$$E\frac{d^3\sigma}{d^3p} = |G(t)|^2 \left(\frac{s}{M^2}\right)^{2\alpha(t)-1} \sigma_{tot}(M^2, t)\,,$$

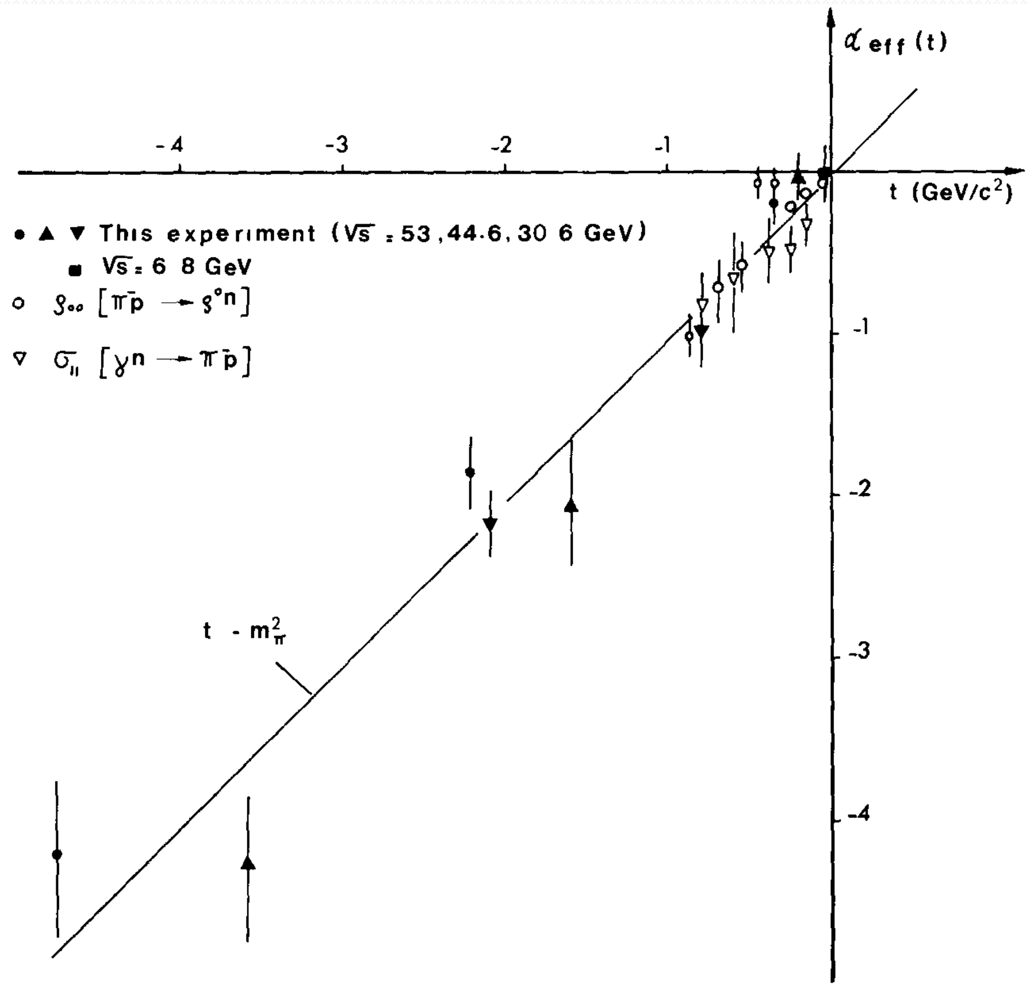

Fig. 8. The effective trajectory as determined from slopes of the inclusive neutron spectra in fig. 7. The point at $\sqrt{s} = 6.8$ GeV is taken from ref. [7].

CONCLUSION

1. SCALING IN X AND $P_{\perp}$ (Independent of s)
2. NO PEAK AT x=1. (as in pp)
3. MEASURE POMERON TRAJECTORY

Nuclear Physics B91 (1975) 266–278

NEUTRON-PROTON ELASTIC SCATTERING FROM 10 TO 70 GeV/*c*

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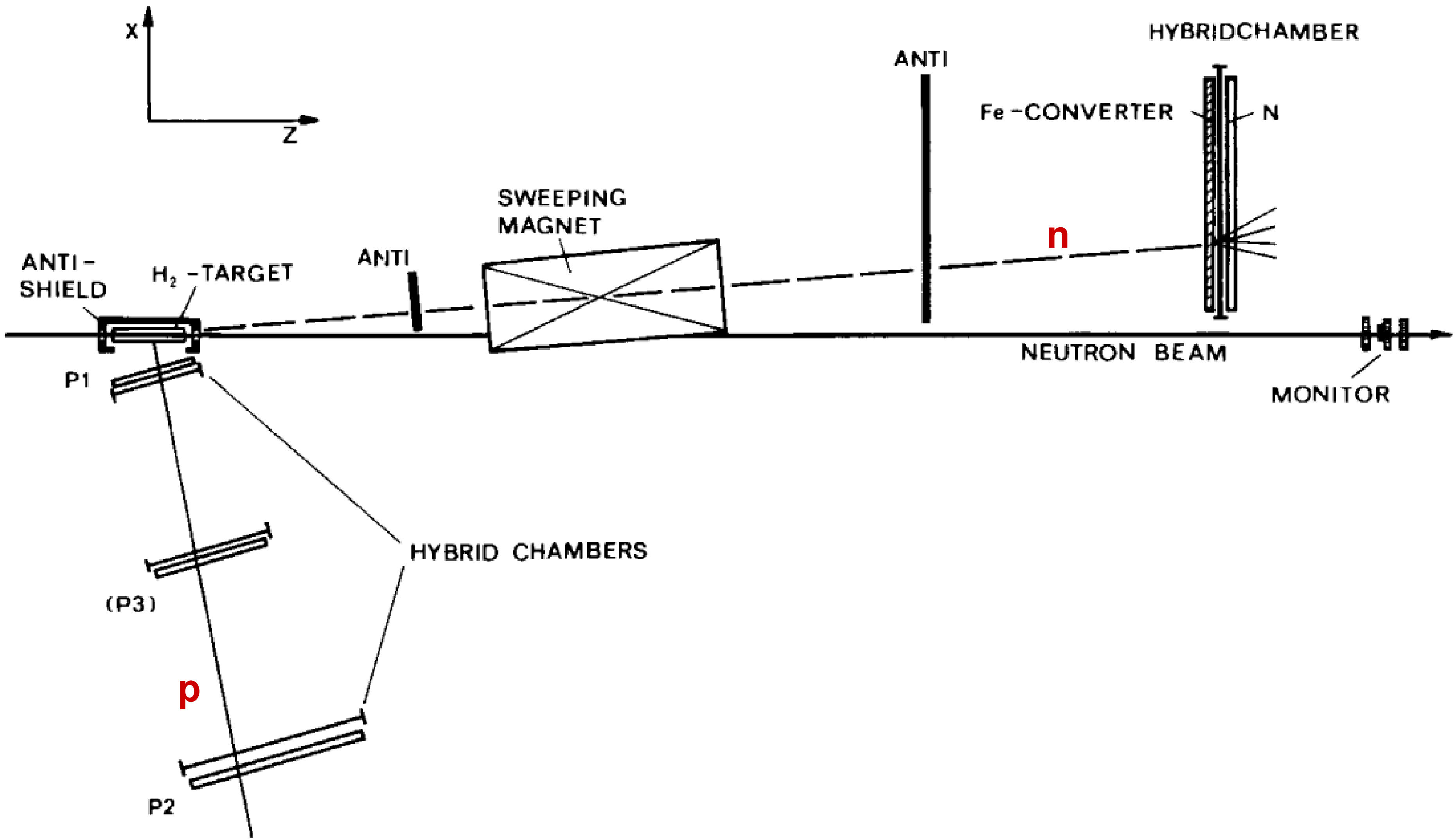
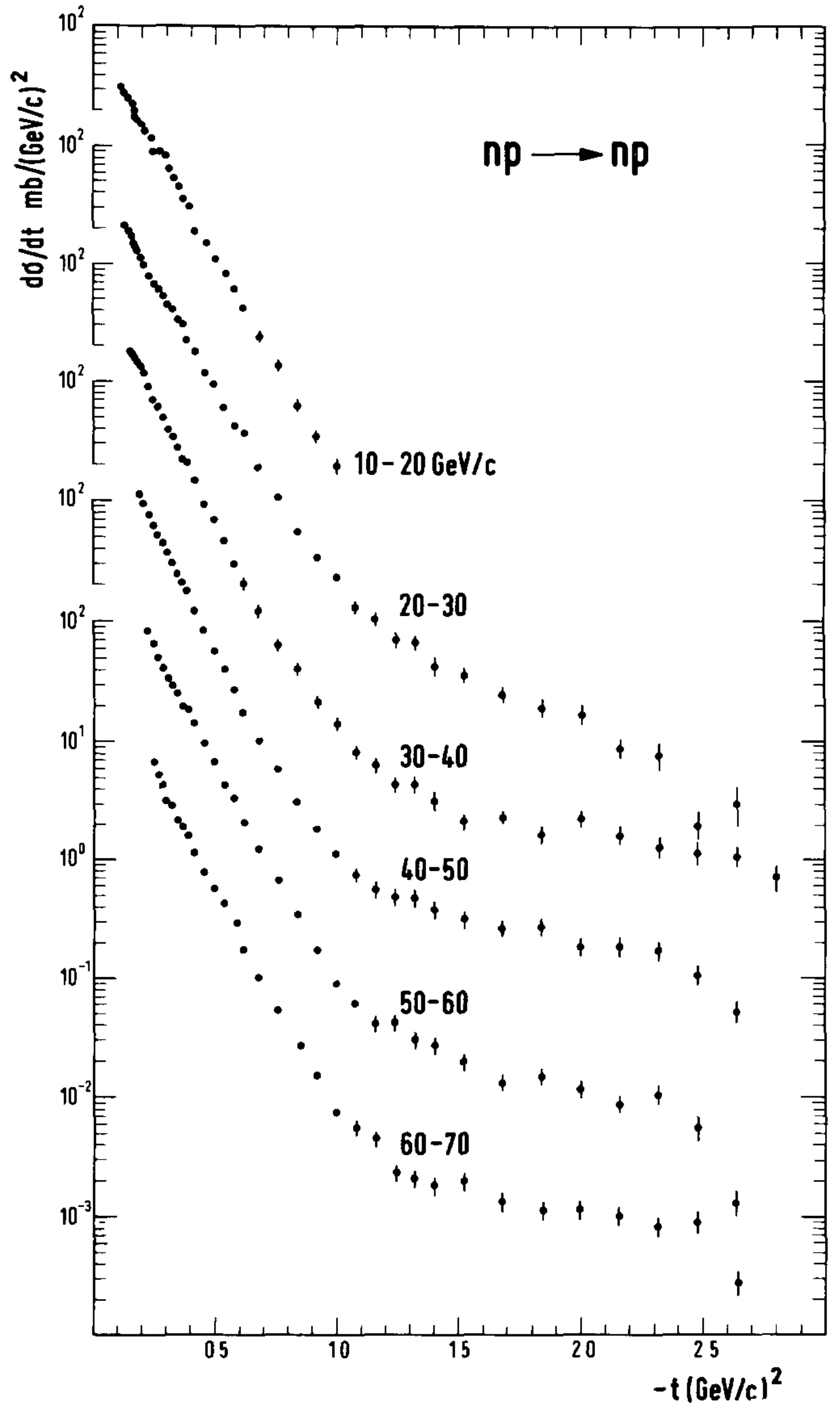
Received 27 January 1975



X
Z
HYBRIDCHAMBER
ANTI
Fe -CONVERTER
N
SWEEPING
MAGNET
n
ANTI-
SHIELD
H_2 -TARGET
ANTI
NEUTRON BEAM
MONITOR
P1
HYBRID CHAMBERS
(P3)
p
P2



np ⟶ np
dσ/dt mb/(GeV/c)²
10 - 20 GeV/c
20-30
30-40
40-50
50-60
60-70
-t (GeV/c)²

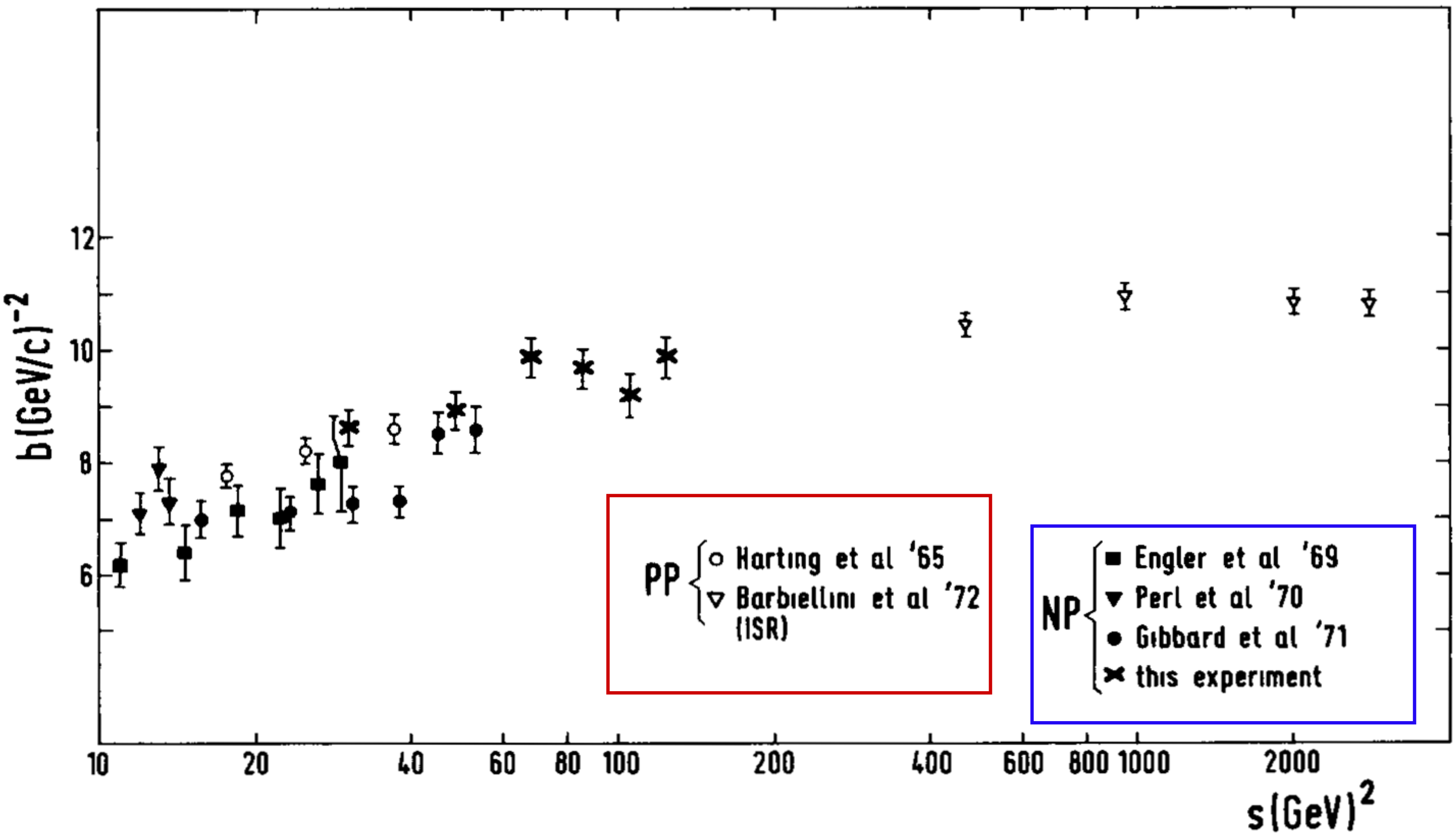


Fig. 6. Slope parameter b for elastic np (solid symbols) and pp scattering (open symbols). All values for $|t| \geqslant 0.13$ (GeV/c)^2.

The forward peak and the break at about $|t| = 1\ GeV/c^2$

are very similar to corresponding pp data

MEASUREMENT OF NEUTRON-PROTON CHARGE EXCHANGE SCATTERING AT 8, 19 AND 24 GeV/c

Volume 34B, number 6 PHYSICS LETTERS 29 March 1971

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Institute for Theoretical and Experimental Physics, Moscow, USSR

Received 1O February 1971

The t-dependence of the differential cross-section for elastic neutron-proton charge exchange scattering has been measured at 8, 19.2 and 24 GeV/c. The extremely narrow peak in the forward direction, previously observed for momenta up to 8 GeV/c persists at the higher momenta, and the t-dependence shows practically no change with energy. Approximate values of the absolute cross-section were also determined for these momenta.

NEUTRON-PROTON CHARGE-EXCHANGE SCATTERING FROM 22 TO 65 GeV/c

Nuclear Physics BIIo (1976) 189-204© North-Holland Publishing Company

A. BABAEV, E. BRACHMANN, G. ELISEEV, A. ERMILOV,
Yu. GALAKTIONOV, Yu. GORODKOV, Yu. KAMISHKOV, E. LEIKIN,
V. LUBIMOV, V. SHEVCHENKO, V. TIUNCHIK and O. ZELDOVICH
Institute for Theoretical and Experimental Physics, Moscow, USSR and
Moscow State University, Moscow, USSR

V. BOHMER, J. ENGLER, W. FLAUGER *, H. KEIM, F. MONNIG,
K. PACK and H. SCHOPPER *
InstitutfuerExperimentelleKernphysik, Karlsruhe, Germany and
CERN, Geneva, Switzerland
Received 9 October 1975
(Revised 22 March 1976)

The differential cross sections for neutron-proton elastic charge-exchange scattering have been measured with a two-arm technique for incident neutron momenta between 22 and 65 GeV/c and for values of the momentum transfer squared between 0.002 and 0.8 (GeV/c) 2. The sharp forward peak observed previously at lower energies is also present at momenta up to 65 GeV/c; however the s dependence of the cross section is slowing down.

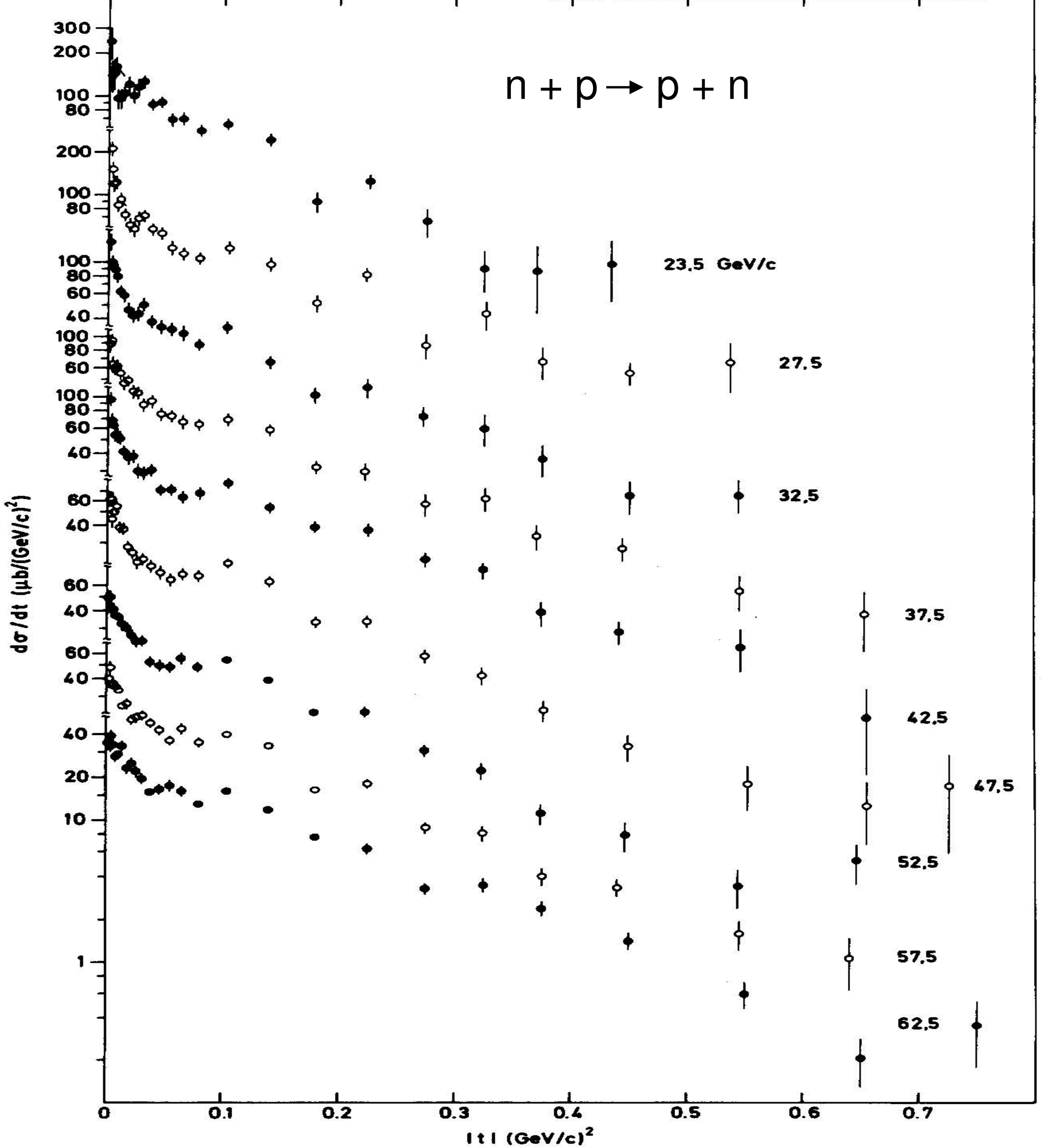


Fig. 5. Neutron-proton charge-exchange differential cross sections $d\sigma/dt$ *versus* $|t|$ for neutron momenta between 22 and 65 GeV/c.

Accelerator Physics

H. Schopper
The use of AVF-Cyclotrons for Nuclear Physics
KFK 310 (1965)

J. Halbritter, R. Heitschold, P. Kneissel, H. Schopper
Coupling losses and the measurement of Q-values of super-conducting cavities
KFK 758 (1968)

H. Schopper
Is the electron ring accelerator ERA useful for the acceleration of heavy ions ?
KFK – Externer Bericht 3/69-18 (1969)

---

13 PAPERS

A. Citron, H. Schopper

"Superconducting proton linear accelerators and particle separators"

In Lapostelle / Septier, linear accelerators

Amsterdam (1970)

Scientific Leadership

- 1957 **Director** of the Institute for experimental nuclear physics, University of Mainz
- 1961 Professor at the University of Karlsruhe and **Director** of the Institute of the Technische Hochschule and the KfK Karlsruhe;
- 1970-73 Division Leader and **Director** at CERN;
- 1973-80 **Director General** of DESY
- 1981-88 **Director General** of CERN

Construction of two of World's largest

$e^+ e^-$ accelerators

PETRA

LEP

y94514

VICTOR F. WEISSKOPF
ELLEN WEISSKOPF

No. 137

53-59/113
01

Feb. 9 1979

PAY TO THE ORDER OF Sam Ting $ 20.00

Twenty 00/100 DOLLARS

Cambridge Trust Company
Cambridge, Massachusetts 02138

Victor F. Weisskopf

FOR Lost bet as to who is first, Peter or Pep!

⑆0113⑉0059⑆ ⑈04⑉781⑉3⑈11

37045

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DESY 79/79
December 1979

NEW RESULTS IN e^+e^- ANNIHILATION FROM PETRA

by

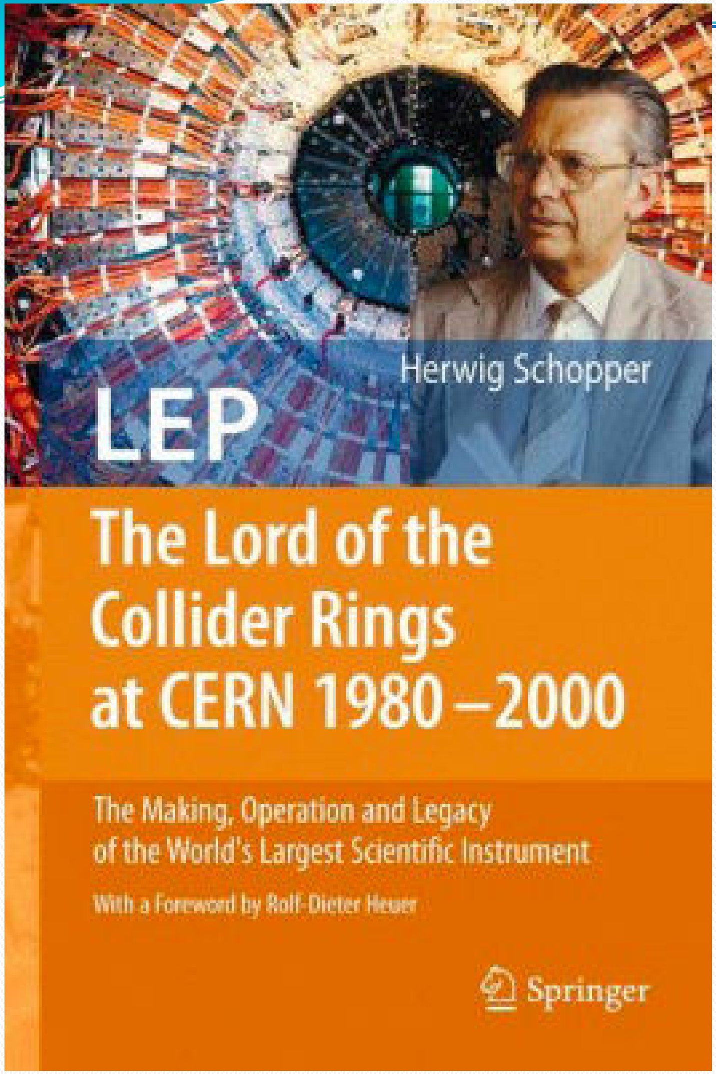
H. Schopper

NOTKESTRASSE 85 · 2 HAMBURG 52

LEP Approval

- **Herwig Schopper was Director-General during the approval and construction of the Large Electron Positron collider**.
- “My first personal experience with LEP was a rigorous examination in the Committee of Council. One delegation was against my nomination as Director-General suspecting that I would favour the German DESY site for LEP instead of CERN. After I had explained my intentions the delegate concerned received new instructions by telephone during a coffee break; I was elected unanimously, and the approval procedure for LEP could start.
- While the approval of LEP was still pending, Margaret Thatcher visited CERN. On her arrival she told me that she wanted to be treated as a fellow scientist and not as Prime Minister. She surprised me with the question why we intended to build a circular machine instead of two opposing linear colliders, a very pertinent question and proving her excellent briefing for the visit. I explained to her that in the case of LEP a circular machine was more cost effective. She accepted the argument and asked how big the tunnel would be for the next project after LEP. To my reply that the LEP tunnel would be the last ring at CERN she retorted: “Why should I believe you? When I visited CERN the first time John Adams told me that the SPS tunnel would be the last.” Nevertheless, she stated at a press conference that she had been convinced that the funds at CERN were used efficiently, and subsequently the United Kingdom approved LEP.”

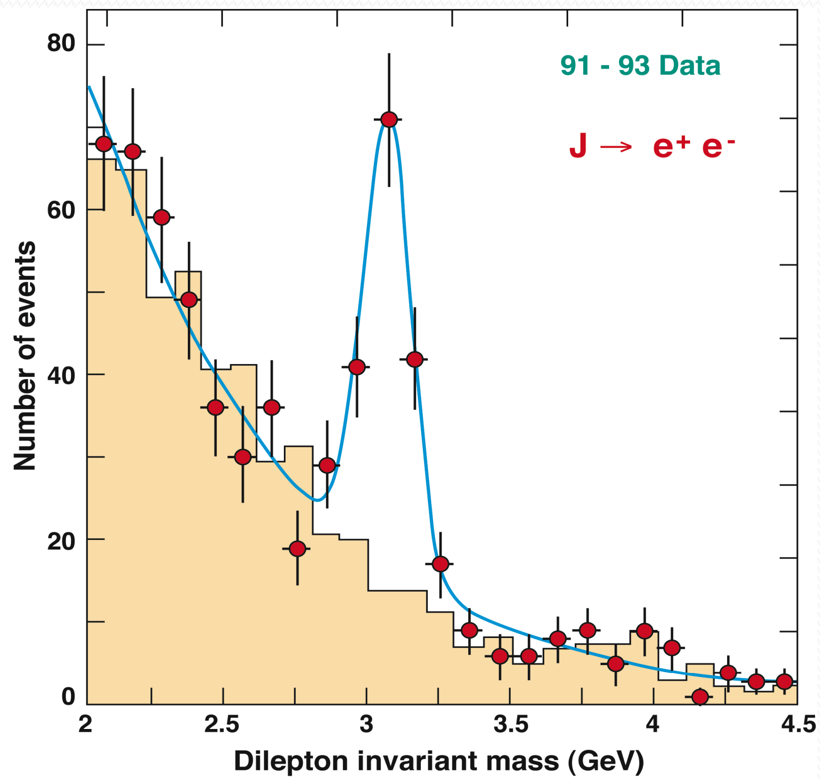
- The director-general, Herwig Schopper (centre), with Henri Laporte (right) in charge of civil engineering, and LEP project leader Emilio Picasso inside a mock-up of the LEP tunnel in 1983.



Written by the main protagonist responsible for making LEP a reality, this is the definitive inside story of a remarkable machine and the many thousands of scientists and engineers from around the world, whose efforts contributed to the new knowledge it produced.

Elementary Particle Physics

H. Schopper's work on heavy quark decays at L3 at LEP

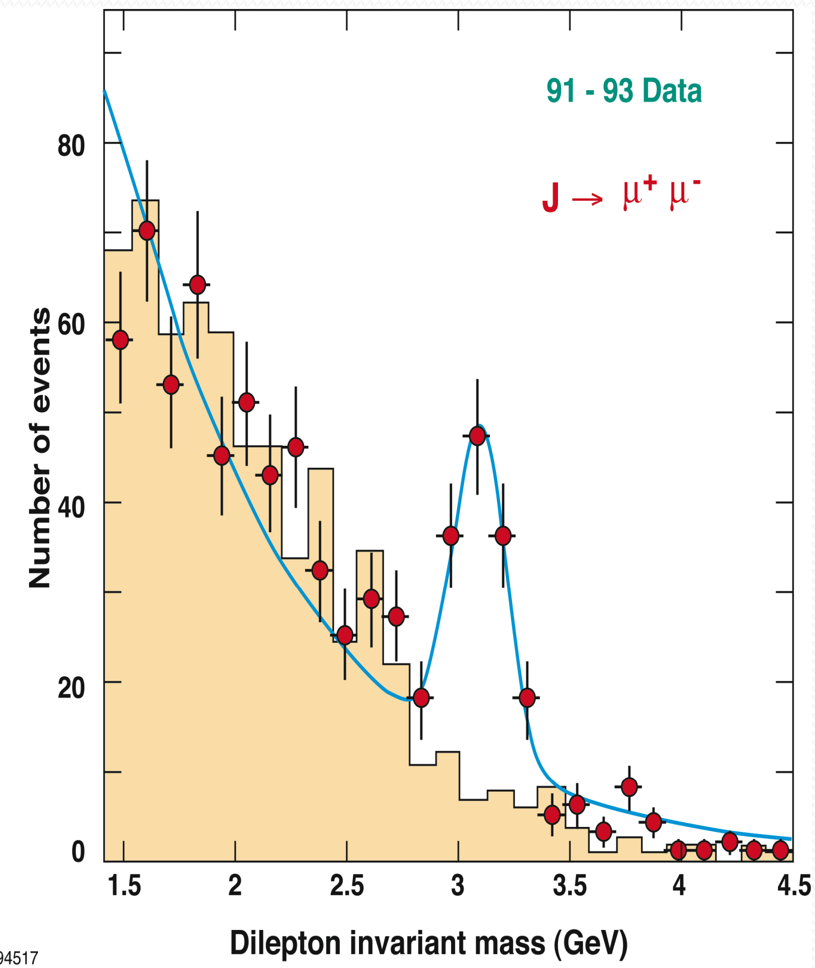


Br (Z → J + X) = (4.1 ± 0.7 (stat) ± 0.3 (sys)) 10^{-3}

Br (b → J + X) = (1.3 ± 0.2 (stat) ± 0.2 (sys))10^{-2}

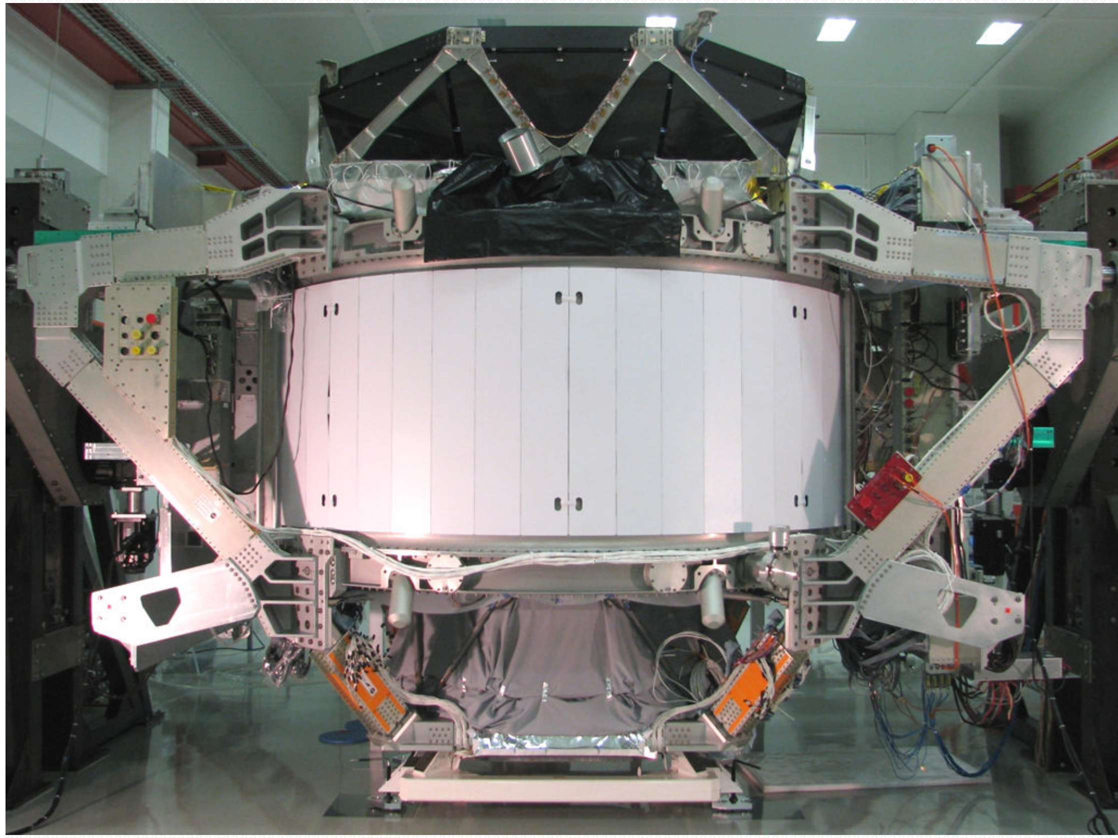
Br (Z → $q\bar{q}g^*$; g* J + X) < 7.0 10^{-4} at 90% CL.

y94518



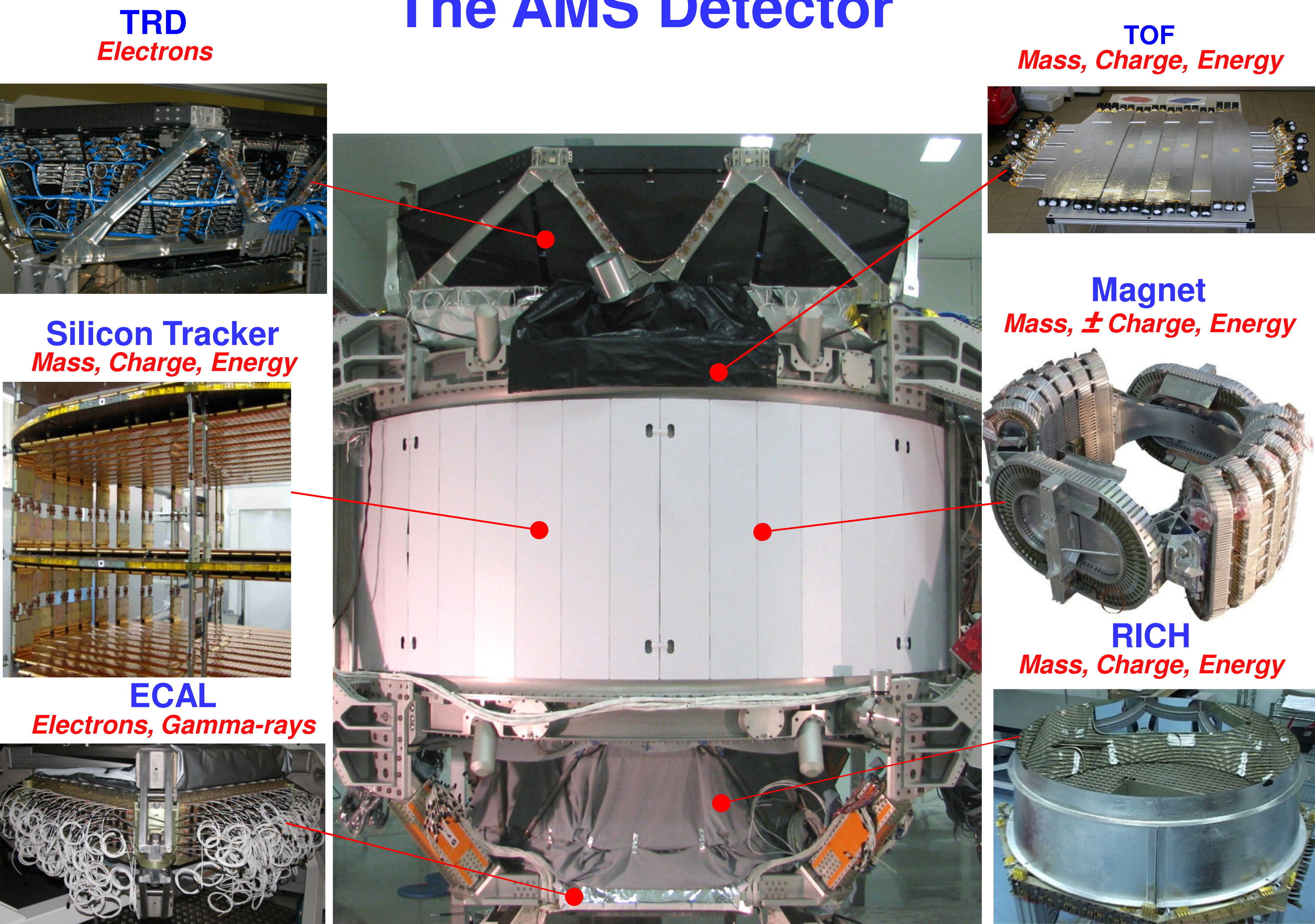
y94517

The AMS Detector

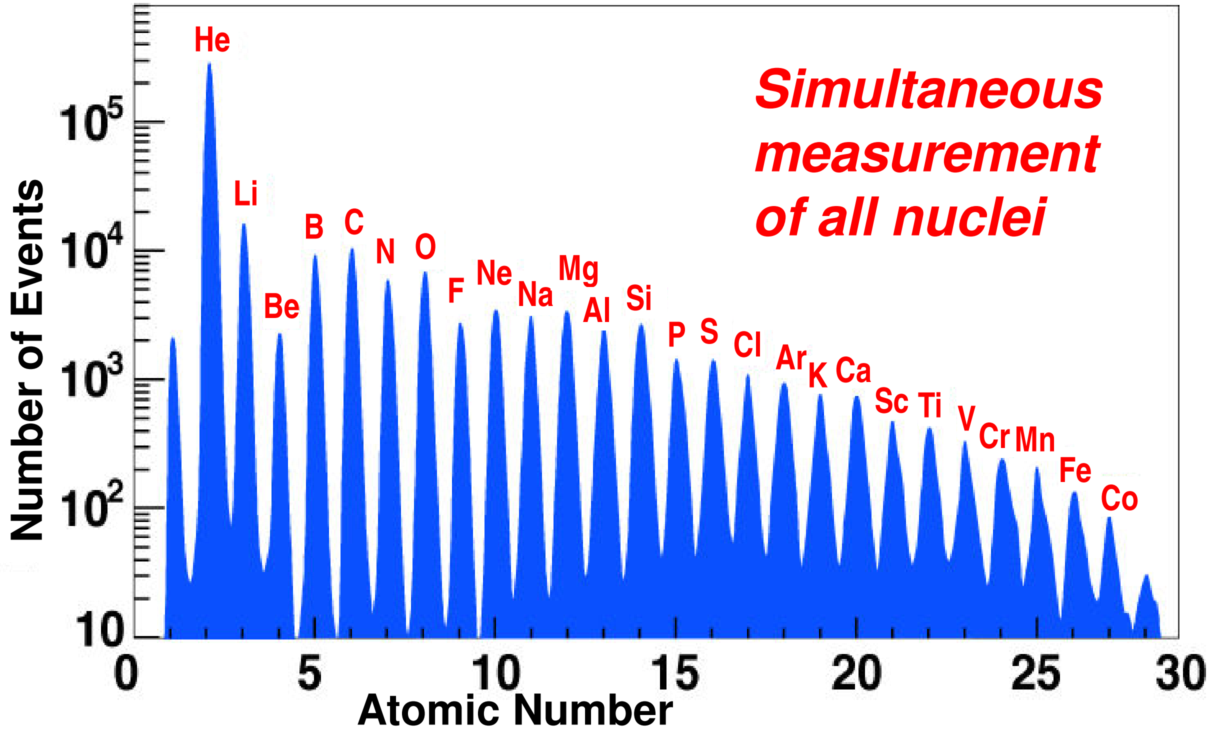


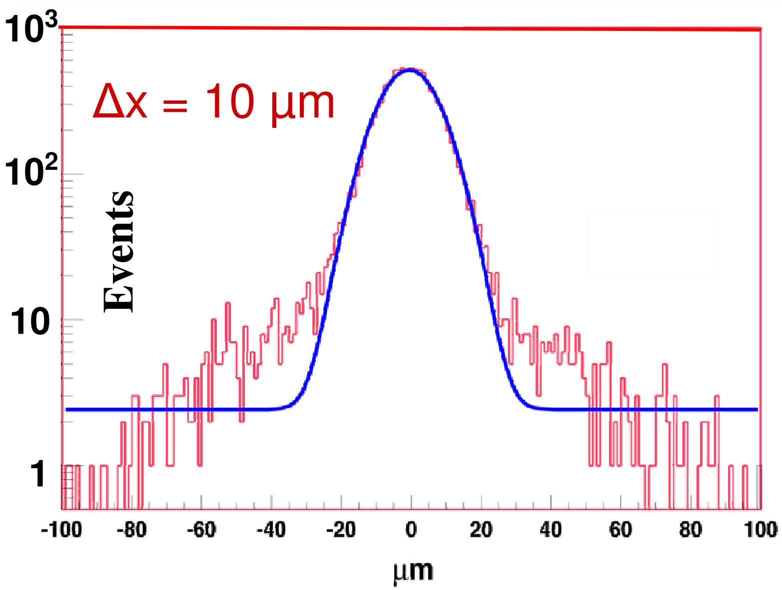
Herwig Schopper is a senior advisor and keeps an interest in its development.

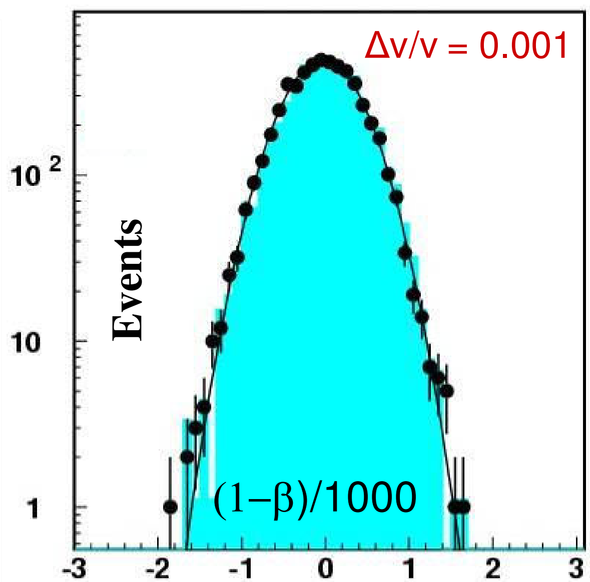
The AMS Detector

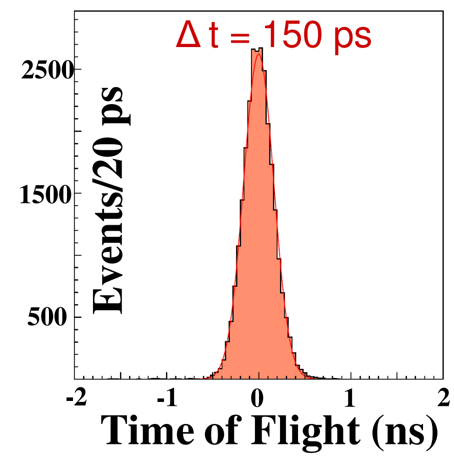


Test results from accelerator







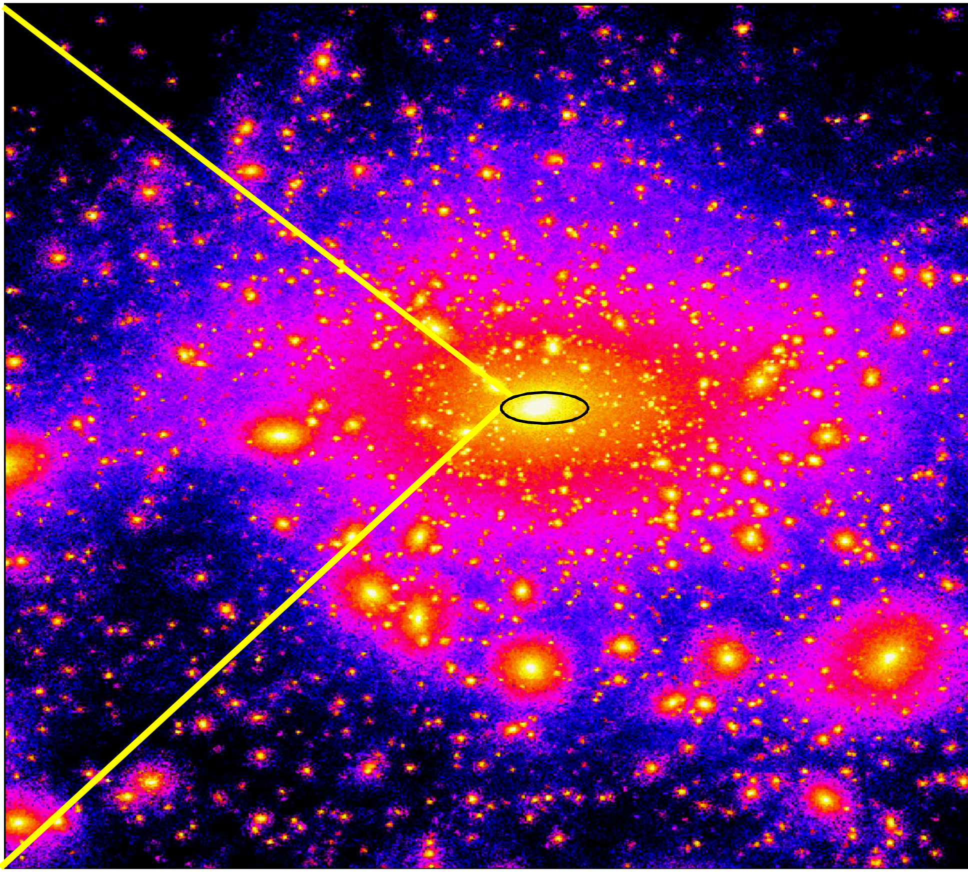


y04K513_05

The scientific goals of AMS include:

Search for the Origin of Dark Matter

A Galaxy as seen by telescope

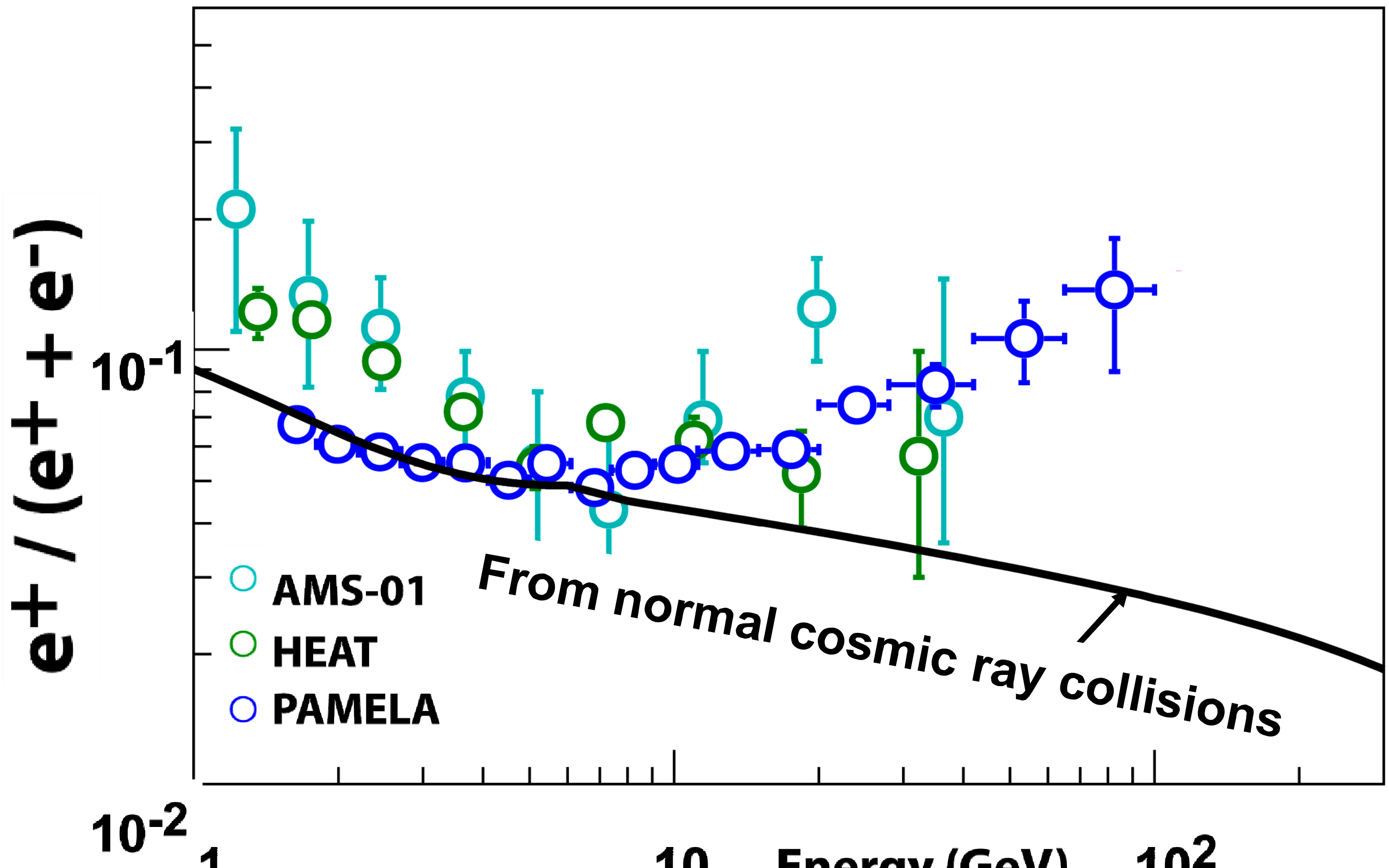


If we could see Dark Matter in the Galaxy

The leading candidate for Dark Matter is a SUSY neutralino (χ^0)

Collisions of χ^0 will produce excess in the spectra of e^+, e^- different from known cosmic ray collisions

First proposed by John Ellis



The leading candidate for Dark Matter is a SUSY neutralino (χ^0)

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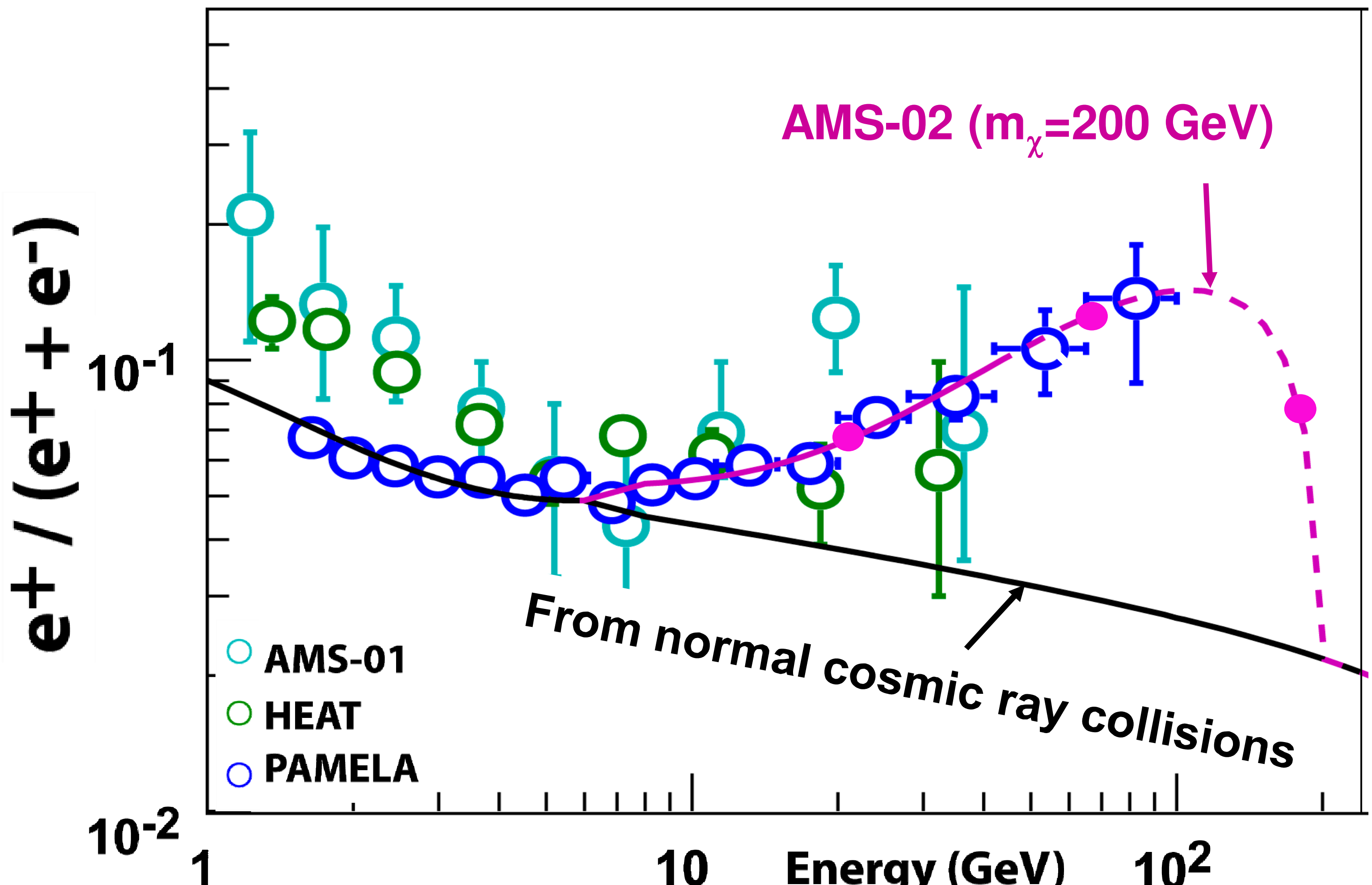
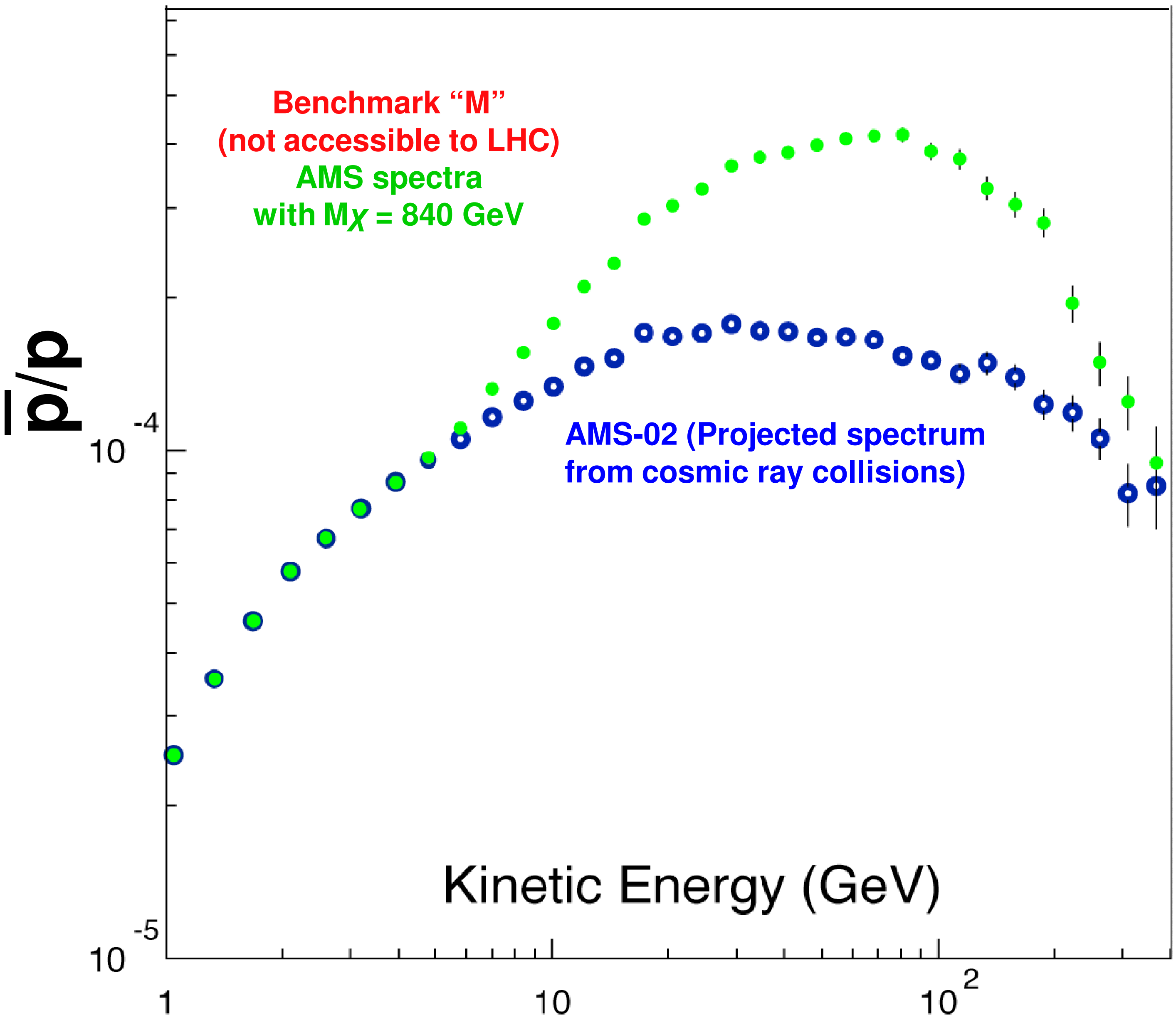
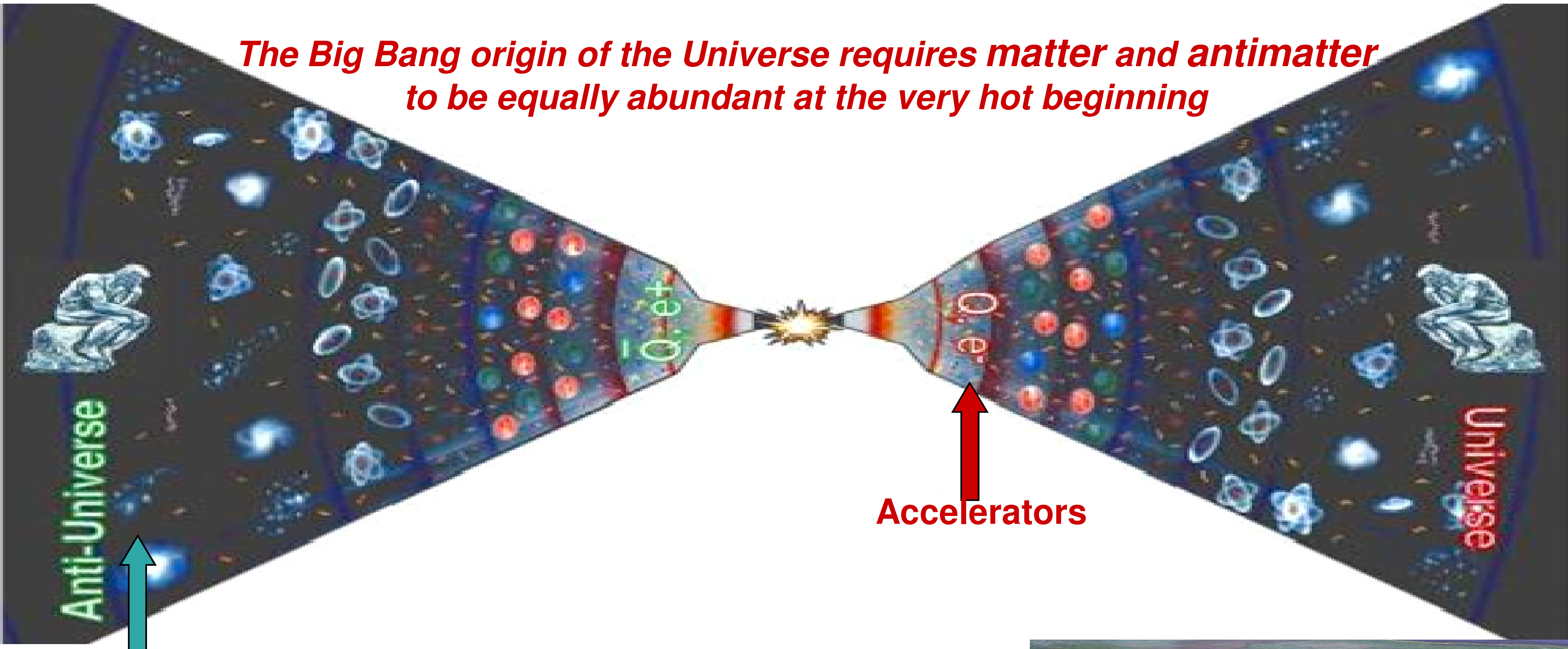




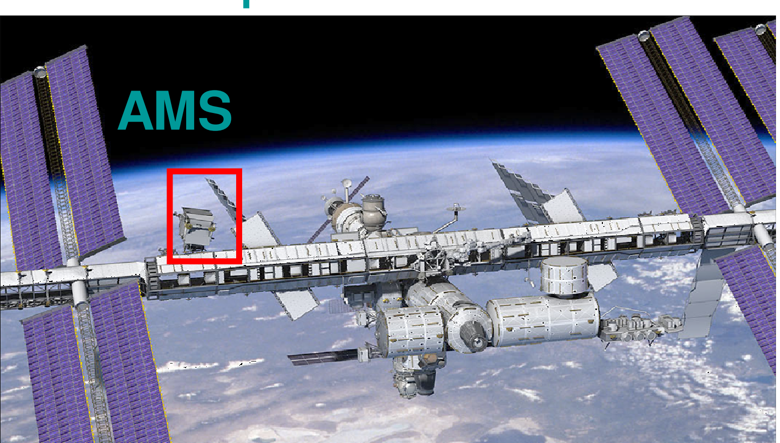
We thank John Ellis for pointing this out to us

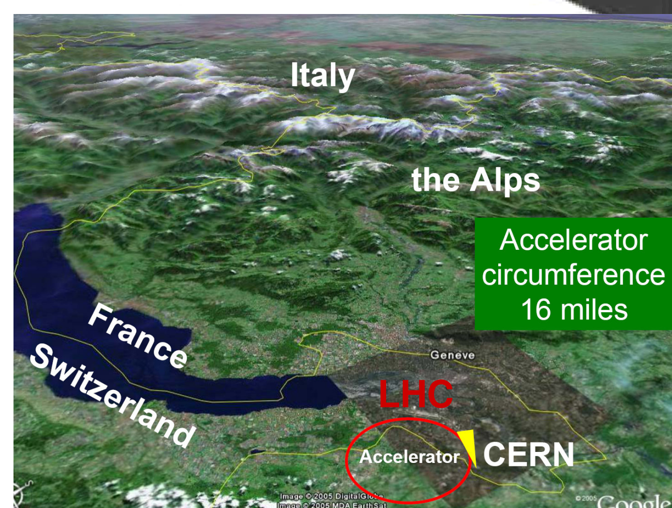
Physics examples

Search for the existence of Antimatter in the Universe



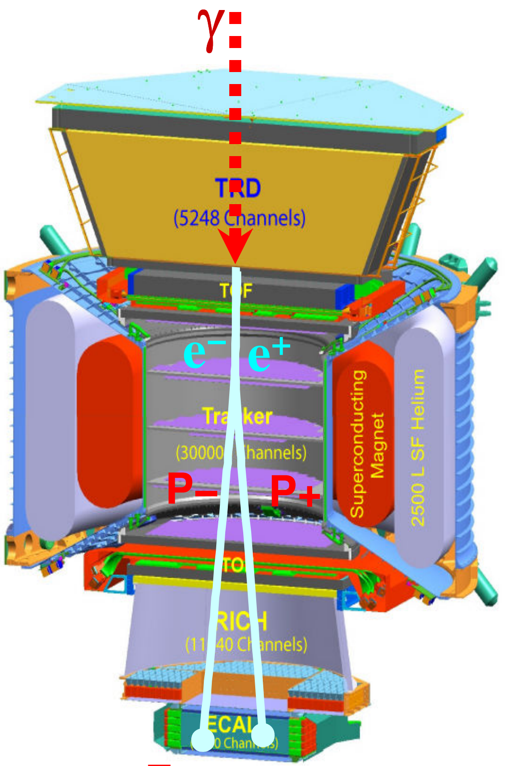
AMS in Space



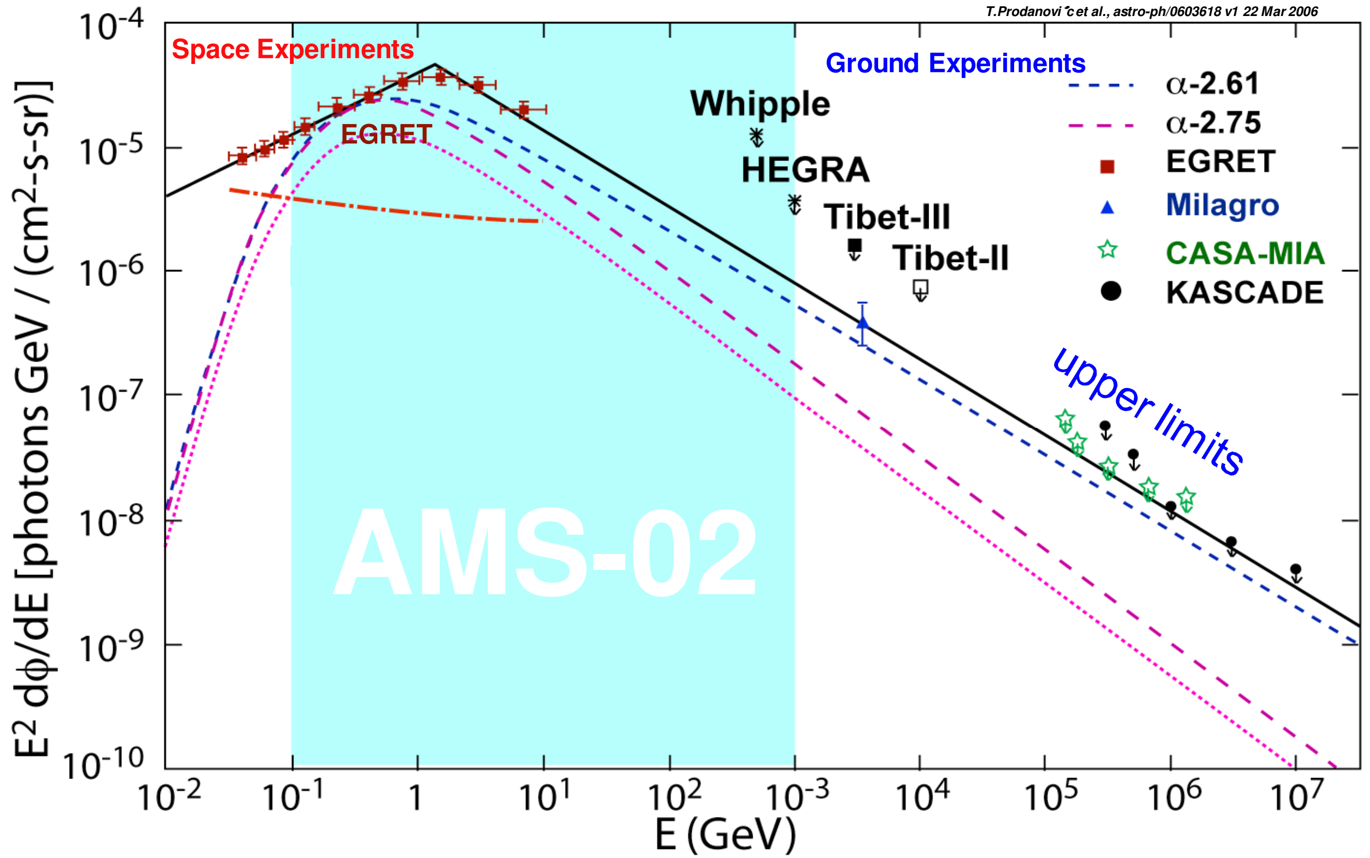


AMS Physics example

Study of high energy (0.1 GeV – 1 TeV) diffuse gammas



Unique constraints
$P^+ = E^+ = P^- = E^-$



The diffuse gamma-ray spectrum of the Galactic plane
40° < 1 < 100°, |b| < 5°

1. **Pointing precision of 2 arcsec from Star Tracker**
2. **UTC time (from GPS, μsec accuracy) allows to relate AMS measurements with other missions**

Both the Star Tracker and GPS were suggested by Herwig Schopper

AMS Photon Detection — EGRET — GLAST

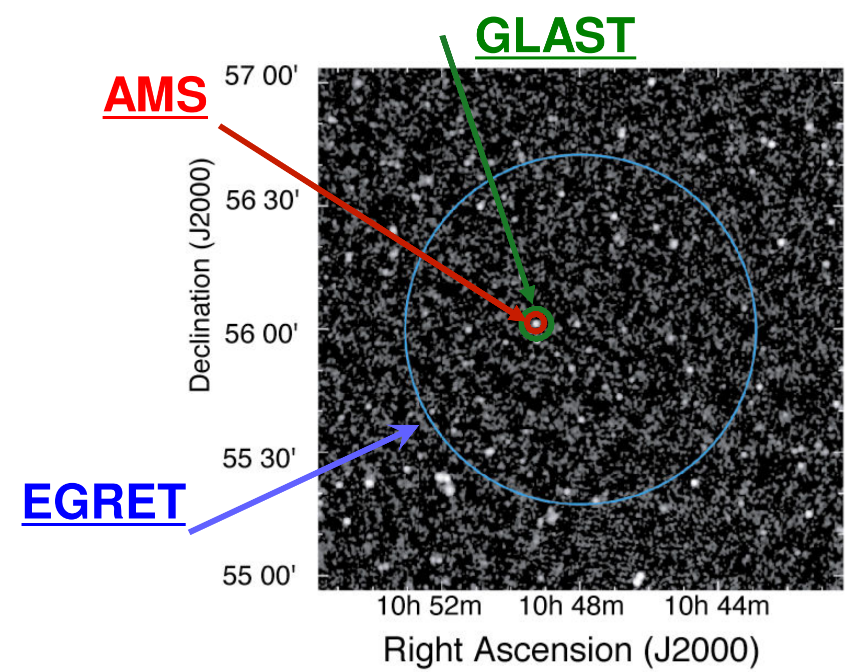
Magnetic Spectrometer — Non-Magnetic Shower Detectors

A. Identify gamma rays from → e^+e^- with magnetic pair spectrometer

GLAST: Identify γ with 8 X_0 calorimeter only

	AMS	EGRET	GLAST
Energy resolution	ΔEγ(10 GeV)=1.5%	ΔEγ=20-25%	ΔEγ(10 GeV)=6%
Angular resolution	Δθγ < 2 arc-sec	Δθγ ~ 30 arc-sec	Δθγ ~ 5 arc-sec
Energy Range	0.1 Gev – 1 TeV	0.03 GeV – 1 GeV	0.01 GeV – 300 GeV
Signal/Background	~ 10-8		
Timing Resolution	1 microsec (with GPS)		

B. Redundant energy measurement with 16 X_0 calorimeter

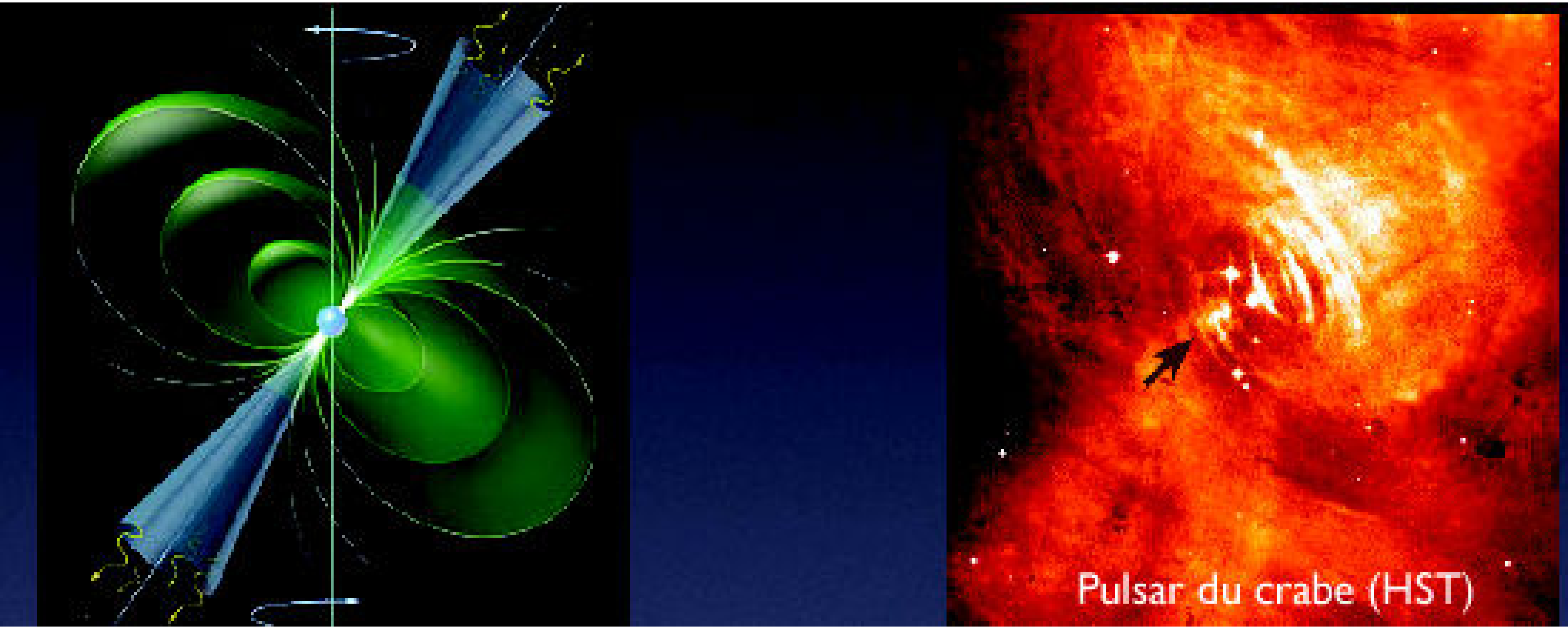


Pulsars in the Milky Way:

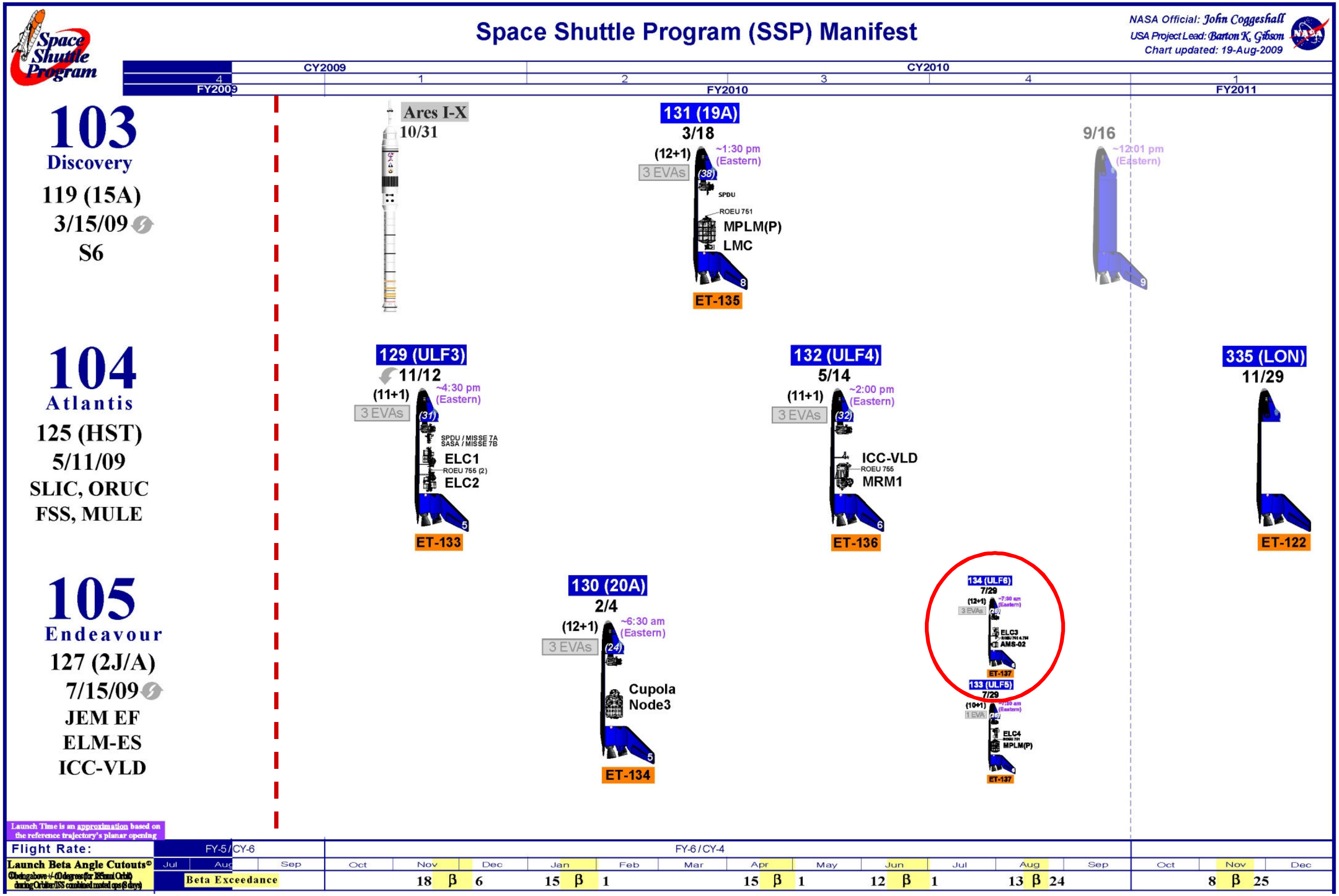
Pulsar: neutron star sending radiation in a periodic way.
Emission in radio, visible, X and gamma

(current measured precision to millisec with energy ~ GeV)

AMS: energy spectrum for pulsars in the 100 MeV – 1 TeV and pulsar periods measured with μsec time precision



Similar studies can be made for Blazers and Gamma Ray Bursters



AMS is manifested on flight STS-134, scheduled to lift off at 07:30am July 29, 2010.

Herwig, we do hope you will be there on this occasion!

AMS FLIGHT STS-134 ASTRONAUTS

Mark E. Kelly
(Captain, USN)

Gregory H. Johnson
(Colonel, USAF, Ret.)

E. M. “Mike”Fincke
(Colonel, USAF)

Roberto Vittori
(Italian Air Force Colonel)

Andrew J. Feustel
(Ph.D.)

Gregory Errol Chamitoff
(Ph.D.)

will be at CERN on October 13 - 16, 2009

BOOKS

- **Particle Accelerators** **Vieweg & Sohn 1955 and Pitman & sons 1967;**
- **Weak Interaction and Nuclear Beta-decay** **Gordon and Breach 1965;**
- **Materie und Antimaterie**
  Piper 1989;

Scientific Leadership

- 1977 Chairman of the Association of German Large Research Laboratories AGF,
- 1992-94 President of Deutsche PhysikalischeGesellschaft, member of the Scientific Council of the Joint Institute for Nuclear Research Dubna, Russia, member of Kuratorium of the Max-Planck-Institute for Plasmaphysics, Garching,
- 1994 member of UNESCO Physics Action Council and chairman of the Working Group on Large Facilities
- 1994-1996 President of the European Physical Society, Chairman of Scientific Council of Regional Office for Science and Technology of Europe UNESCO,
- 2003- President of International Council of SESAME.

Recognitions

- **Dr. Honoris Causa: University Erlangen, State University Moscow, University Geneva, University of London, Joint Institute of Nuclear Research, Dubna, and Institute for High Energy Physics (Russian Academy of Sciences), Russia;**

- **1957 Physics Prize of the Academy of Sciences Göttingen,**
- **1958 Carus-Medal of the Academia Leopoldina at Halle,**
- **1978 Ritter-von-Gerstner-Medal,**
- **1984 GroßerSudetendeutscherKulturpreis,**
- **1985 Golden Plate Award American Academy of Achievement(USA),Gold Medal Weizman Institute (Israel),**
- **1989 Grosses Bundesverdienstkreuz,**
- **1990 Forum Engelberg Prize**
- **1991 Wilhelm-Exner-Medal (Österreich);**
- **Honorary Member of the Hungarian Academy of Sciences**
- **1994 J.E.Purkyne_ Memorial Medal of the Academy of Sciences of the Czech Republic;**
- **1996 Order of Friendship, Russian Federation, President Yeltsin**
- **2003 Grand Cordon of the Order of Independence, King Abdullah II of Jordan;**
- **2004 UNESCO Albert Einstein Gold Medal;**
  Tate Medal of American Institute of Physics;
  Medal of Honour, Cairo University;
  Silver Medal of SESAME International Council
- **2005 UNESCO-Denmark Niels Bohr Gold Medal**

Congratulations

on your
extraordinary contribution
to scientific leadership

to nuclear physics
and
particle physics