International Conference on Muon Catalysed Fusion and Related Topics (MFC-2007)

Sixty Years of Muon Catalyzed Fusion

S.S. Gershtein

JINR, Dubna, Russia, 18 Jun 2007

F.C. Frank, Nature **160,** 525 (1947)

A.D. Sakharov, Lebedev Inst. (report) (1948)

Ya.B. Zeldovich, Dokl.Ac.Nauk. **95,** 493 (1954)

L.W. Alvarez et al, Phys.Rev. **105**, 1127 (1957)

$$\varepsilon = -\frac{1}{2}\mu^*; \qquad \mu^* \quad \frac{1}{1+\frac{1}{M}} \approx 1 - \frac{1}{M}$$

$$\varepsilon_0 = -\frac{1}{2}$$

$$V = -\frac{1}{2M}\Delta_{\vec{R}}$$

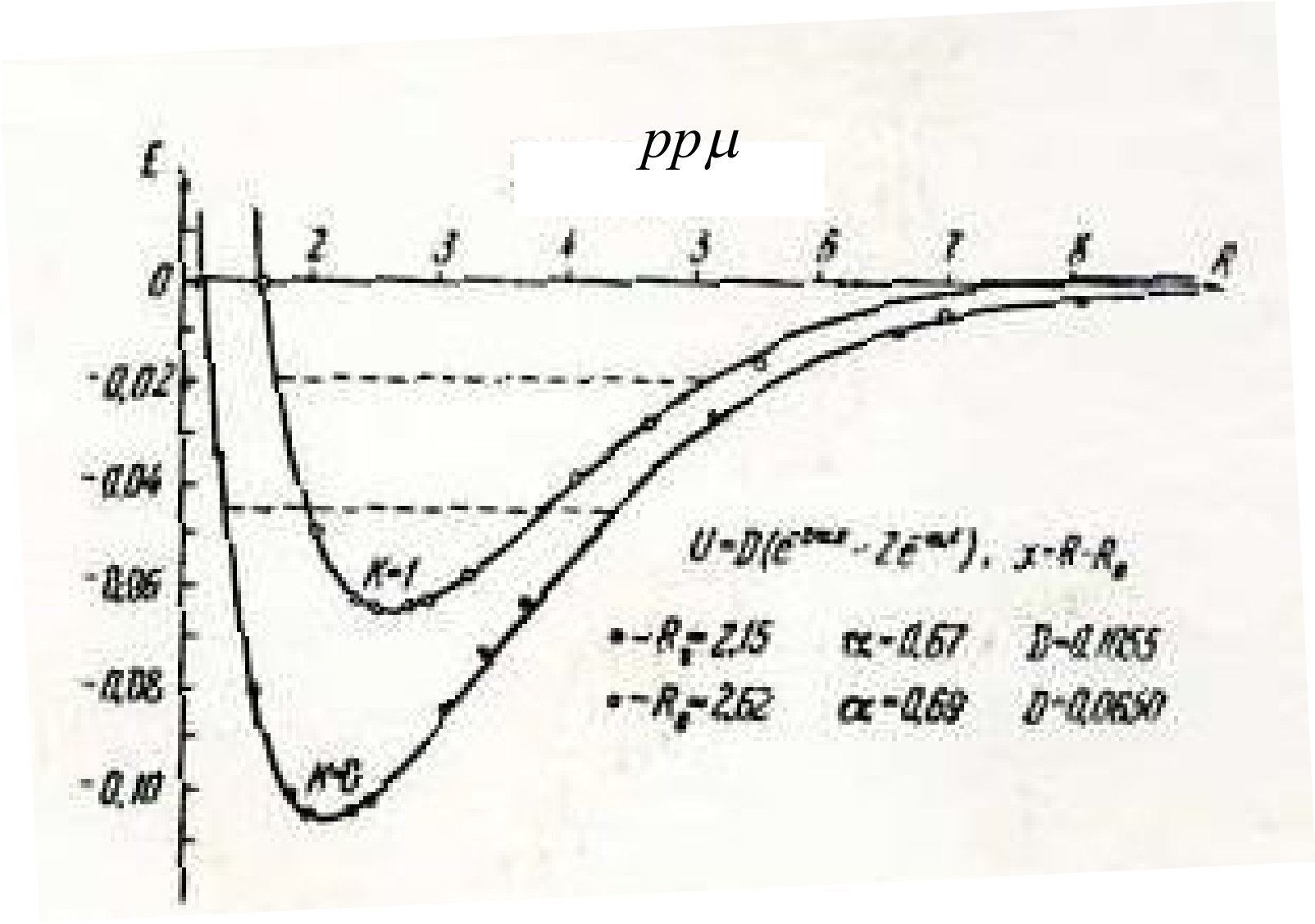
$$\Delta\varepsilon \quad \int \psi_0^*(r)\left(-\frac{1}{2M}\Delta_{\vec{R}}\right)\psi_0(r)\,d\tau$$

$$\psi_0(r) = \frac{1}{\sqrt{\pi}} e^{-|\vec{r}-\vec{R}|}$$

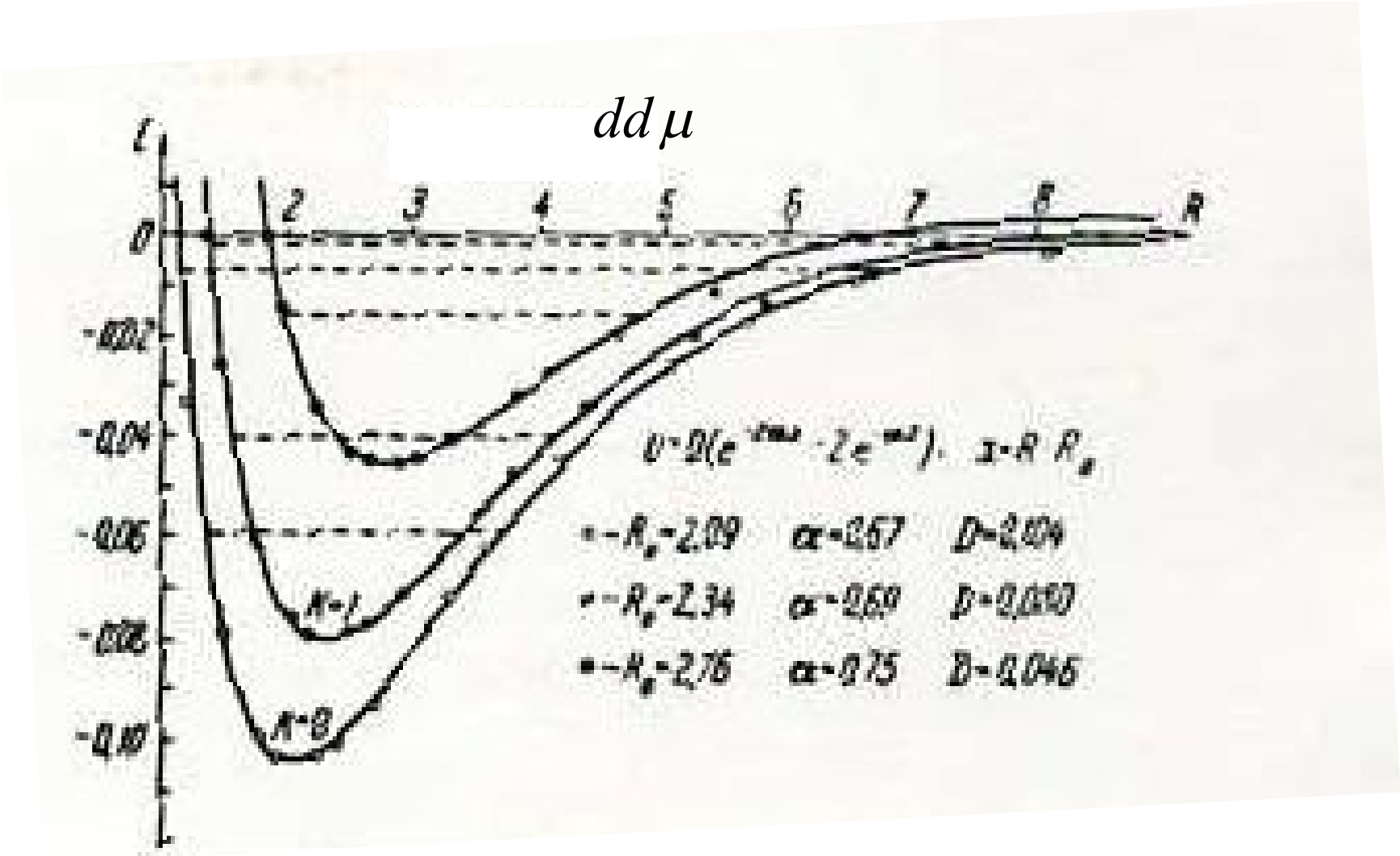
$$\Delta\varepsilon \quad \frac{1}{M}\int \psi_0^*\left(-\frac{1}{2}-\frac{1}{r}\right)\psi_0 d\tau = \frac{1}{2M}$$

$$\varepsilon = \varepsilon_0 + \Delta\varepsilon = \quad -\frac{1}{2}+\frac{1}{2M} \approx -\frac{1}{2}\mu^* + O\left(\frac{1}{M^2}\right)$$

$pp\mu$


E
0
2
3
4
5
6
7
8
R
-0.02
-0.04
-0.06
-0.08
-0.10
K=1
K=0
U=D(e^{-2αx} - 2e^{-αx}), x=R-R_e
•—R_e=2.15 α=0.67 D=0.1055
•—R_e=2.62 α=0.69 D=0.0650

$dd\,\mu$



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June 15, 1962

Dr. S. S. Gershtein
Joint Institute for Nuclear Research
Dubna
USSR

Dear Sir:

Dr. Roger H. Hildebrand of the University of Chicago has suggested that I contact you concerning muon transfer to isotopes of Helium. In Dubna report number D-768, Dr. Filippov, et al. state that you proposed certain theoretical arguments to explain the low rate of transfer of the muon to He^3. As we are investigating muon reactions in liquid hydrogen and deuterium, we would be most interested in your comments concerning this problem.

Thank you for your kind cooperation.

Yours truly,

John H. Doede

John H. Doede
High Energy Physics

JHD:ssm

CARNEGIE INSTITUTE OF TECHNOLOGY
SCHENLEY PARK
PITTSBURGH 13, PENNSYLVANIA

DEPARTMENT OF
PHYSICS

August 23, 1960.

Professor S. Gerstein
Joint Institute for Nuclear Research
Head Post Office
P.O. Box 79
Moscow, U.S.S.R.

Dear Professor Gerstein:

Thank you for your kind letter and reprints. I am enclosing a copy of the talk I will give in Rochester on muon capture.

Concerning capture on impurities, in a recent preliminary experiment by Hildebrand and Schiff, at Chicago, 15 atoms of neon per million atoms of hydrogen were dissolved in liquid hydrogen causing a considerable muon capture rate. From their results it follows that the results reported by the Carnegie Tech group might be explained by the presence of a very small amount of dissolved oxygen, nitrogen, or carbon. Apparently at sufficiently low concentrations, condensation is inhibited. The Carnegie Tech group is working on reducing the amount of impurities before further experiments are done.

The interpretation of the experiments done at 95% deuterium may not be correct. The analysis presented in Phys. Rev. Letters assumed (implicitly) that the transition of d_μ to the $F = \frac{1}{2}$ state occurs already at 2% deuterium concentration. If the transition of d_μ to $F = \frac{1}{2}$ occurs between 2% and 95% deuterium concentration then the analysis must take into account the dependence of the observed regenerations on the hyperfine state of the $(pd)_\mu$ molecule. All this depends on the rate of the reaction $d_\mu + d \rightarrow d + d_\mu$ with $F = \frac{3}{2}$ going to $F = \frac{1}{2}$. This has been mentioned by you and if you have calculated the rate I would appreciate knowing it. We continue here a theoretical and experimental study on muon catalysis and captures in hydrogen-deuterium mixtures.

Sincerely yours,

Lincoln Wolfenstein

Lincoln Wolfenstein.

CARNEGIE INSTITUTE OF TECHNOLOGY
SCHENLEY PARK
PITTSBURGH 13, PENNSYLVANIA

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Sincerely yours,

Lincoln Wolfenstein

Lincoln Wolfenstein.

Columbia University in the City of New York | Irvington-on-Hudson, N. Y.

DEPARTMENT OF PHYSICS

NEVIS LABORATORIES
P. O. Box 137 914 LY 1-8100

October 6, 1961

Professor S. S. Gershtein
Joint Institute for Nuclear Research
Dubna
U.S.S.R.

Dear Professor Gershtein:

A new Dubna report, "$\mu^- + He^3 \rightarrow H^3 + \nu$", A. I. Filippov, et.al., attributes to you calculations concerning the transfer of muons from the μp system to other atoms, i.e.,

$$\mu p + Z \rightarrow p + \mu Z$$

Presumably, the failure to observe transfer to He^3 in the diffusion chamber was due to the already saturated transfer to the alcohol vapor. Not having a large supply of He^3, I had planned to do this experiment with a multi-cell proportional counter filled with a H^2-He^3 mixture. I believed that, crudely

$$\sigma_{transfer} \sim Z^2$$

$$\sigma_{transfer} \sim Z^2$$

I would greatly appreciate any information you could provide concerning this problem.

While personally disappointing, the success of this important experiment on $\mu^- He^3$ is most impressive. I am glad to report that the Columbia group - L. Lederman, E. Bleser, J. Rothberg, E. Zavattini and myself - have just completed our first measurement of $\mu^- + p \rightarrow n + \nu$ in liquid hydrogen. Several hundred events have been recorded and the data looks promising.

We have also measured the yield of fusion γ-rays from liquid hydrogen as a function of time and deuterium concentration in an improved version of the Liverpool experiment. Preliminary analysis indicates that

$$\lambda_{p\mu} \rightarrow p\mu p \approx 0.5\ \mu s$$

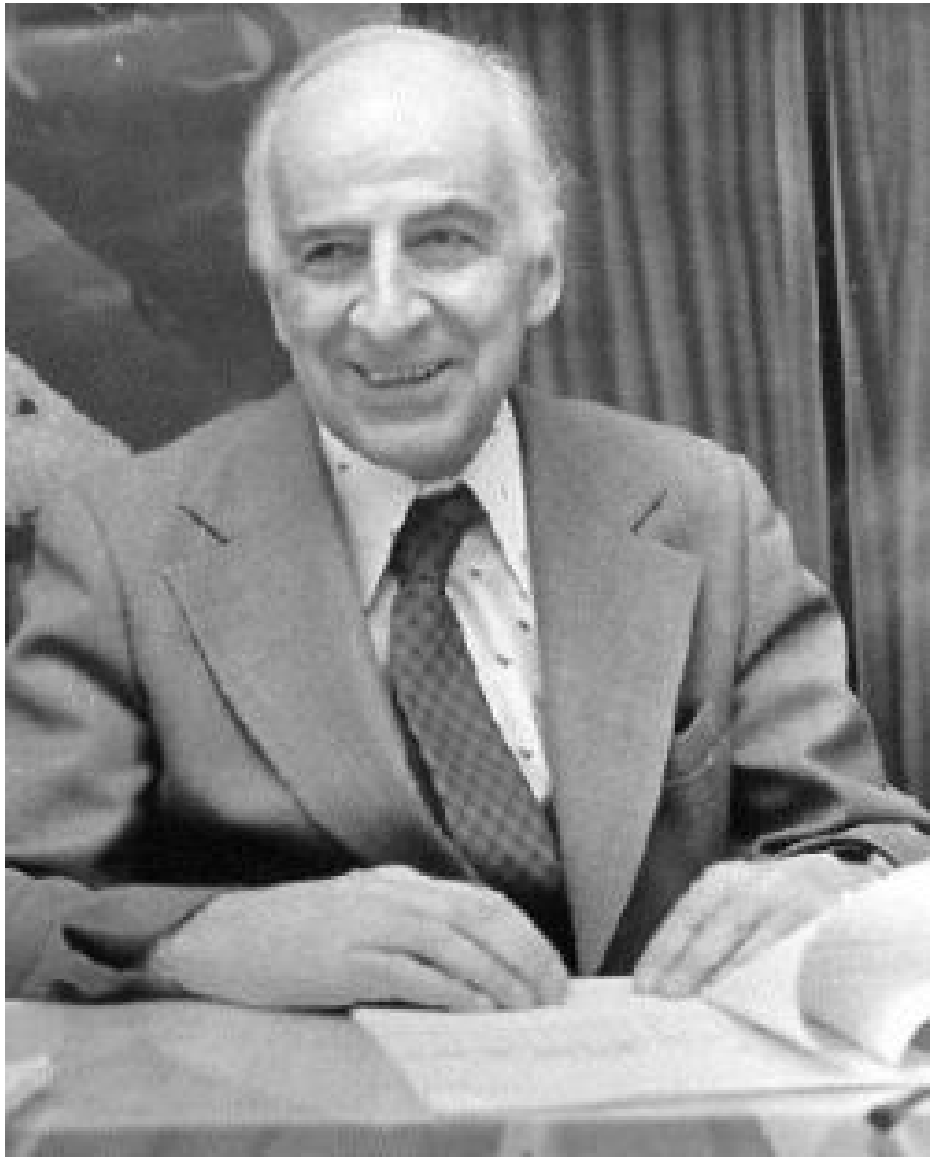
If detailed analysis verifies this relatively slow rate, we will study the possibility of freezing the hydrogen in order to slow the rate even further. It should then be possible to observe the capture from the atomic μp system as well as the molecular ion.

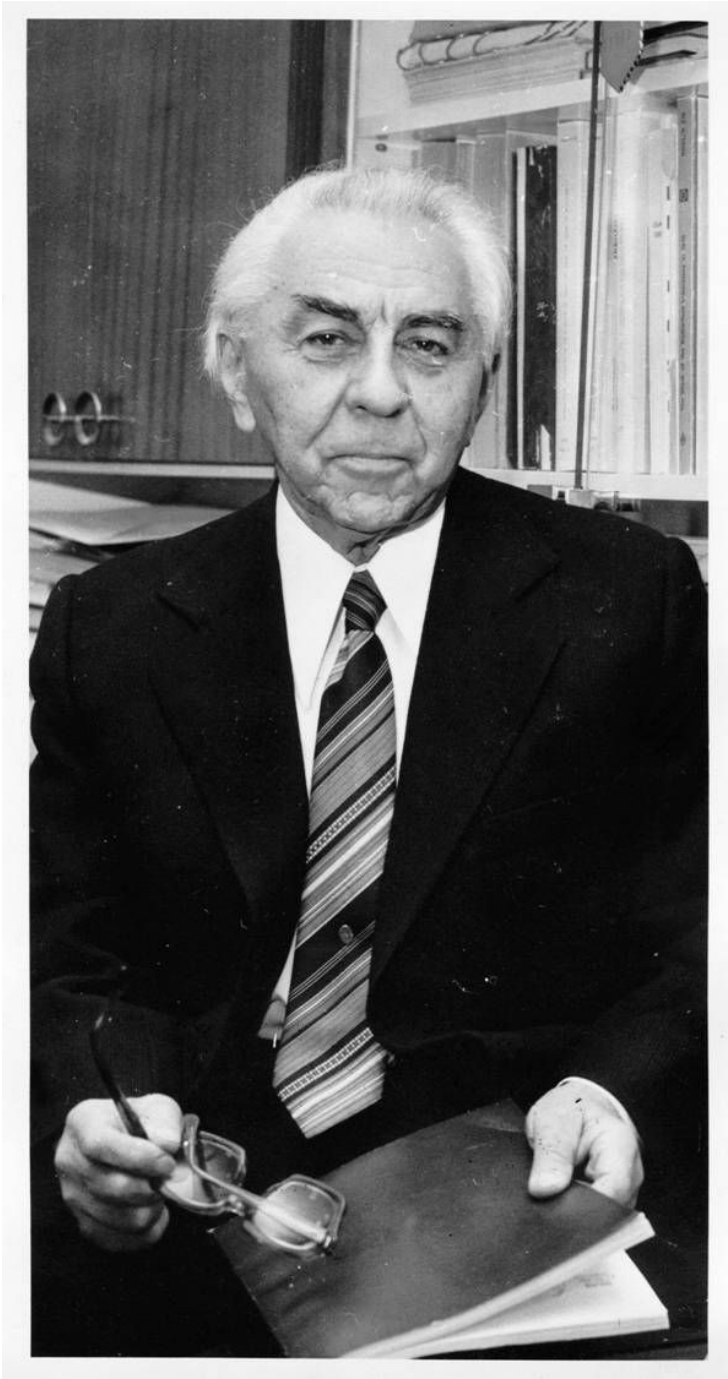
Sincerely yours,

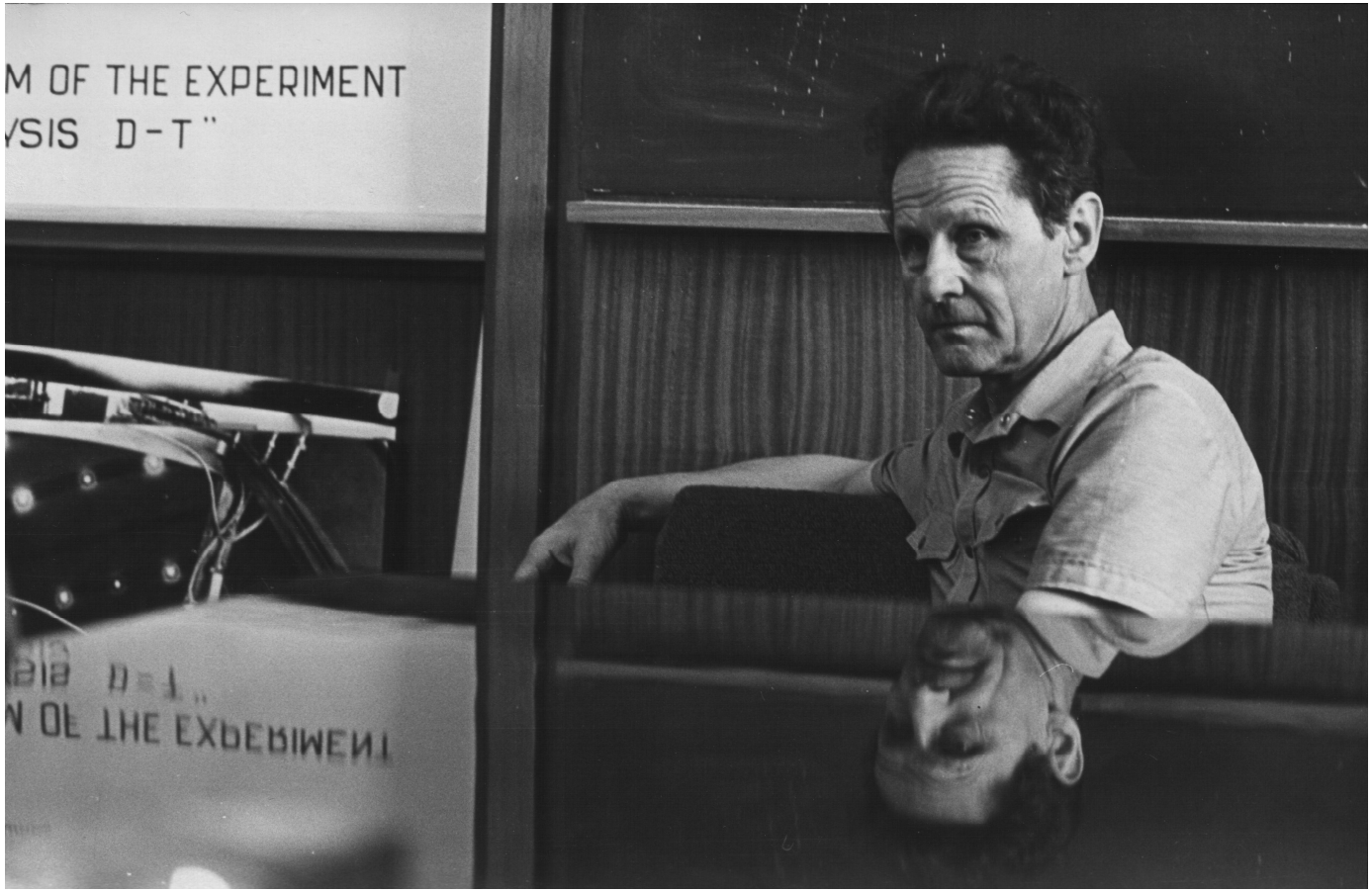
Jerome Rosen

Jerome Rosen
Assistant Director
Cyclotron Development

JR:dk



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μCF

- A. Sakharov
- Ya. Zeldovich
- L. Alvarez
- E. Teller
- E. Wigner
- S. Weinberg
- L. Lederman
- C. Rubbia
- L. Wolfeinstein