

PHYSICS AT THE INTERSECTING STORAGE RINGS

Ugo Amadi
TERA Foundation

Thanks to Luigi Di Lella and Chris Fabjan

27 January 1984 - 13 years later

**Last meeting of the the
Intersecting Storage Rings Committee (ISRC)**



Maurice Jacob:

First period 1971-74: “a brilliant start”

Second period 1975-77: “a somewhat difficult time”

Third period 1978-83: “a very active and interesting programme”

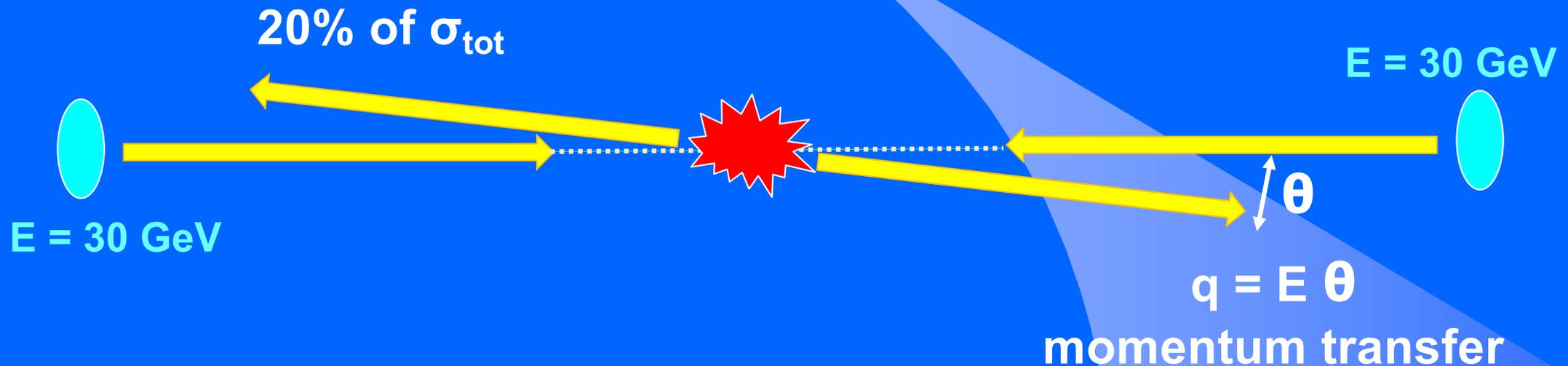
- **The ISR was the only CERN collider built without a specific physics goal:**
 - no Intermediate Bosons,
 - no Z and W detailed studies and Higgs searches,
 - no searches of the Higgs and of Supersymmetric particles
- * **The program was shaped by the dominant view at the time: proton-proton collisions are SOFT processes**
- **The ISR Committee favoured the “PS approach”:**
 - many experiments performed by small groups

Dominant view: particles are created in SOFT processes

INELASTIC COLLISIONS



ELASTIC COLLISIONS (shadow)



FIRST PERIOD
1971-74

Major instrument
for inelastic collisions

Split Field Magnet
1973

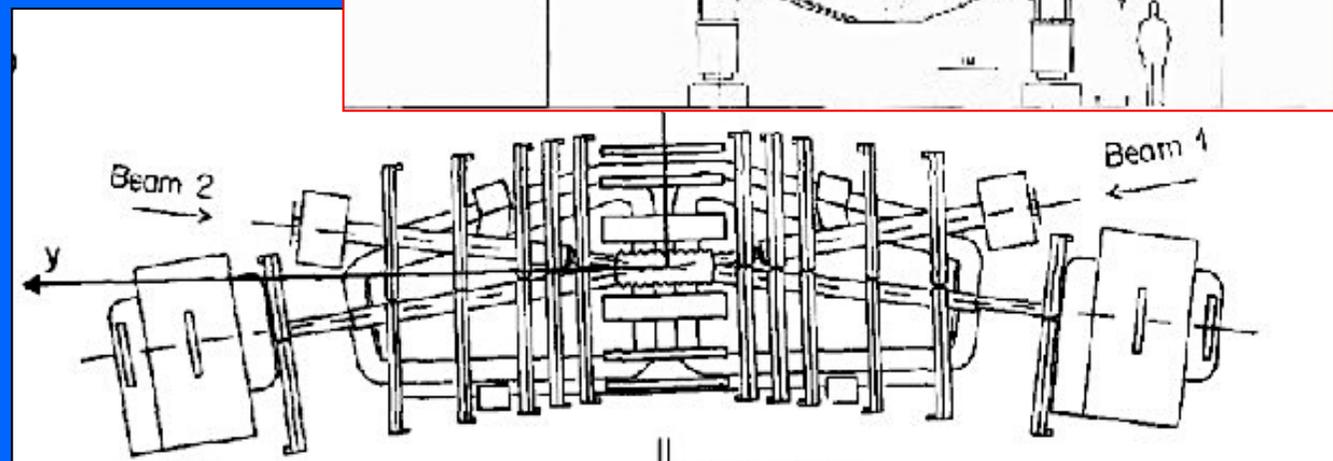
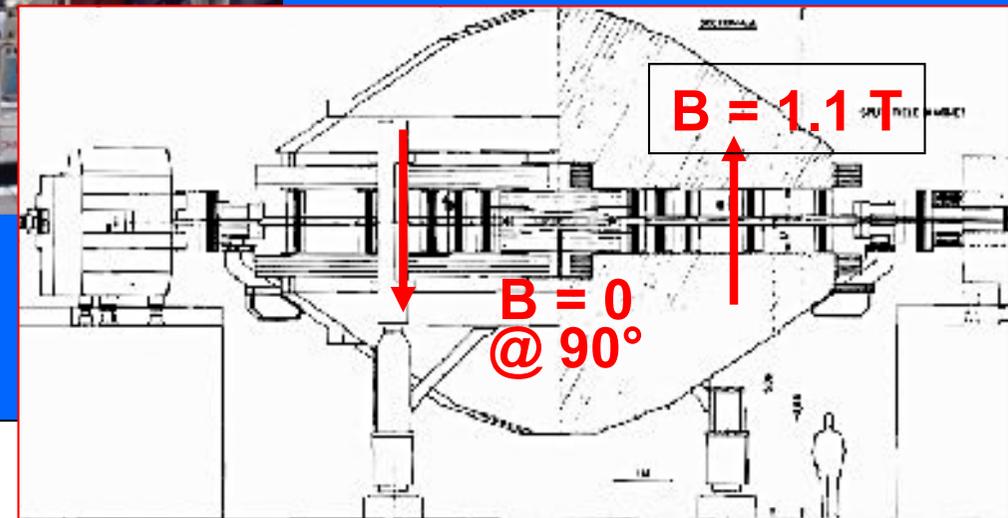
1000 tons

ISRC rejected other proposals

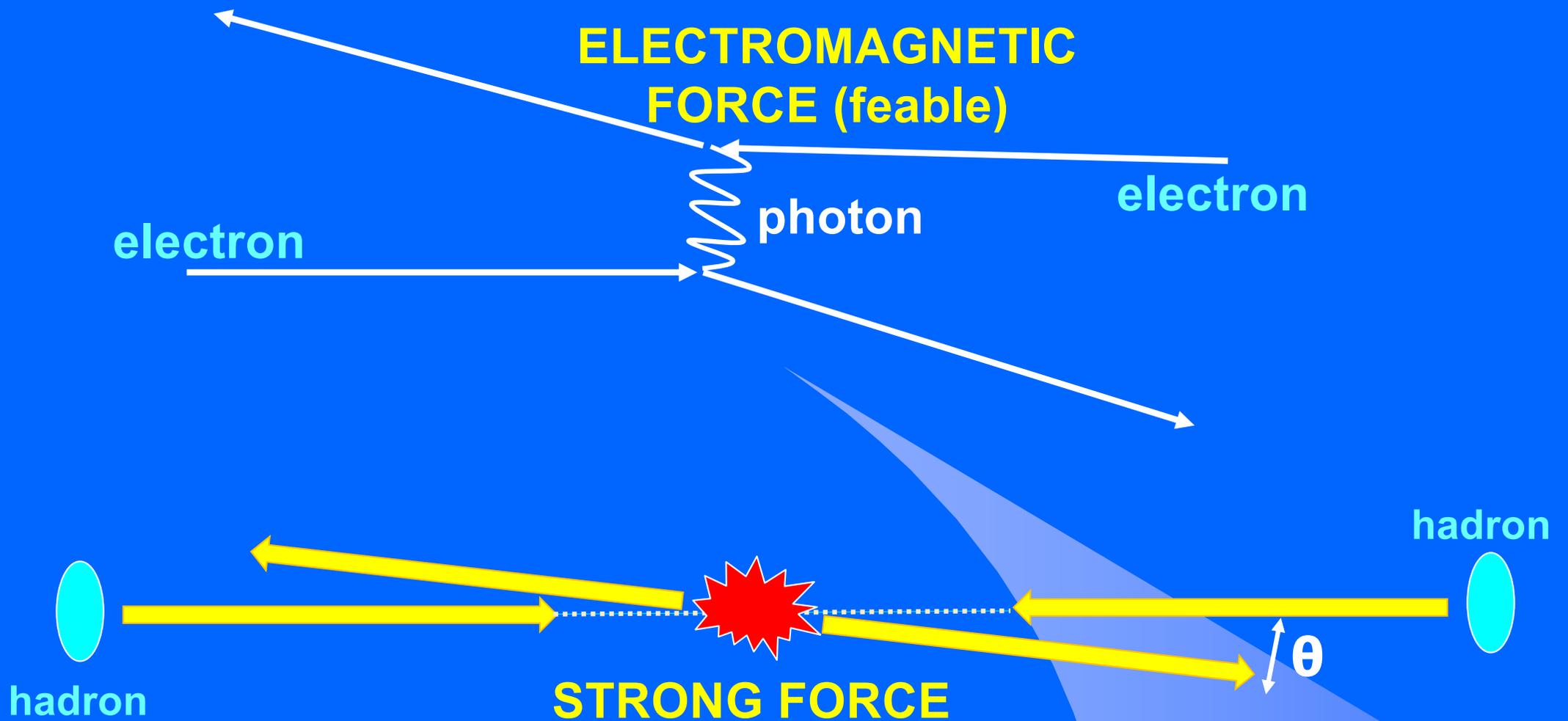
20 MWPC
70,000 wires !

Only 5 years after first MWPC

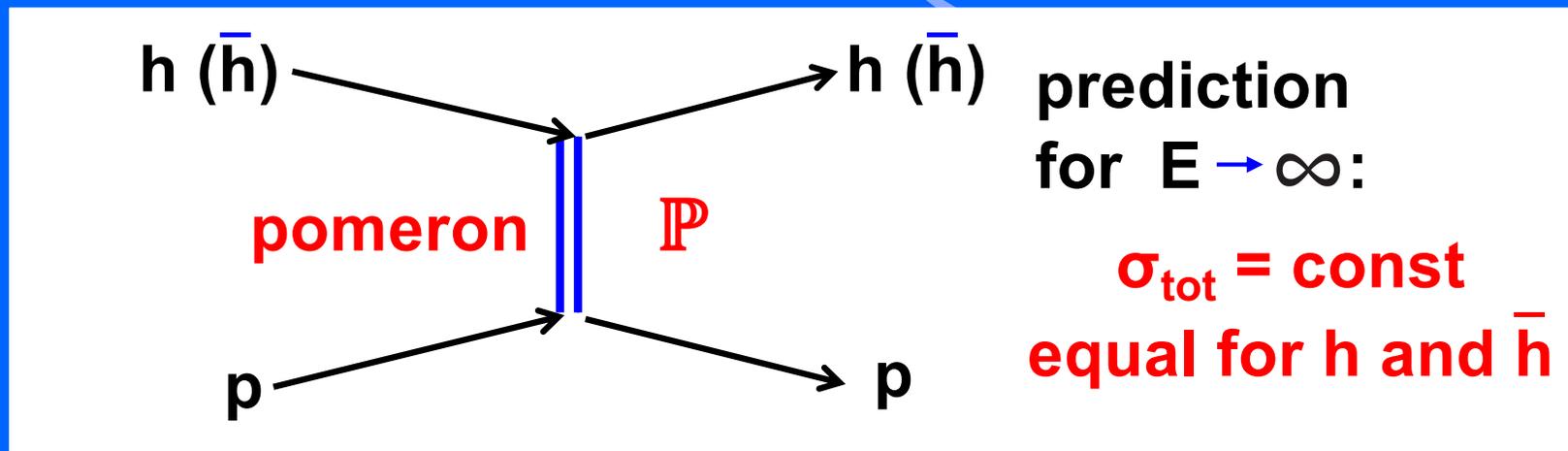
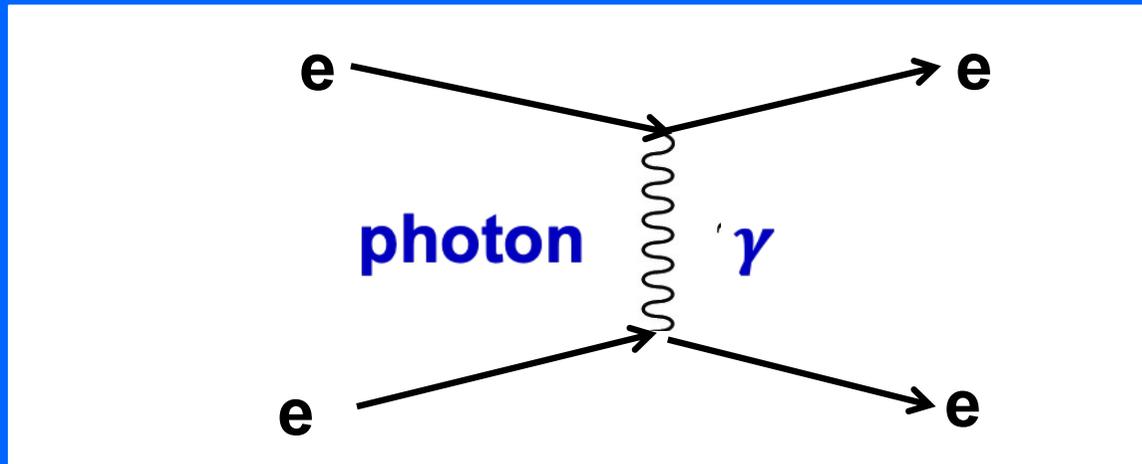
50 years of hadron colliders - UA - 18.10.21



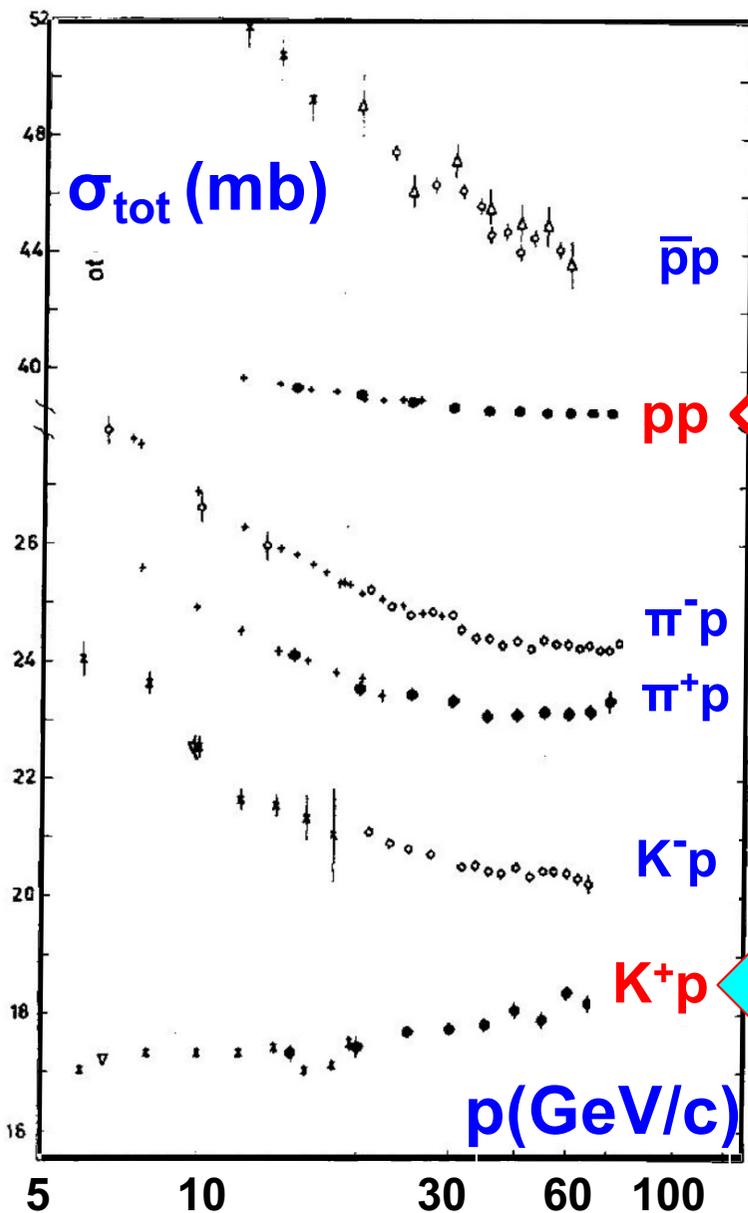
Hadron-hadron collisions were described in the framework of the Regge theory



Elastic scattering between two hadrons is due to the exchange of the same Pomeron trajectory



In July 1971 Serphukov data confirmed the prediction



TOTAL CROSS SECTIONS OF π^+ , K^+ AND p ON PROTONS AND DEUTERONS
IN THE MOMENTUM RANGE 15-60 GeV/c

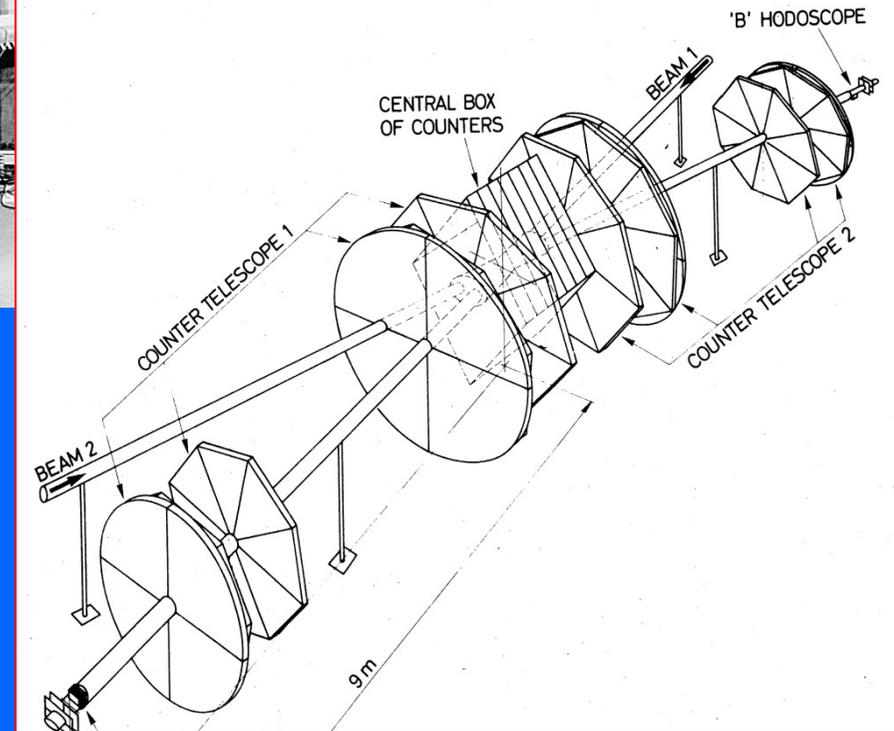
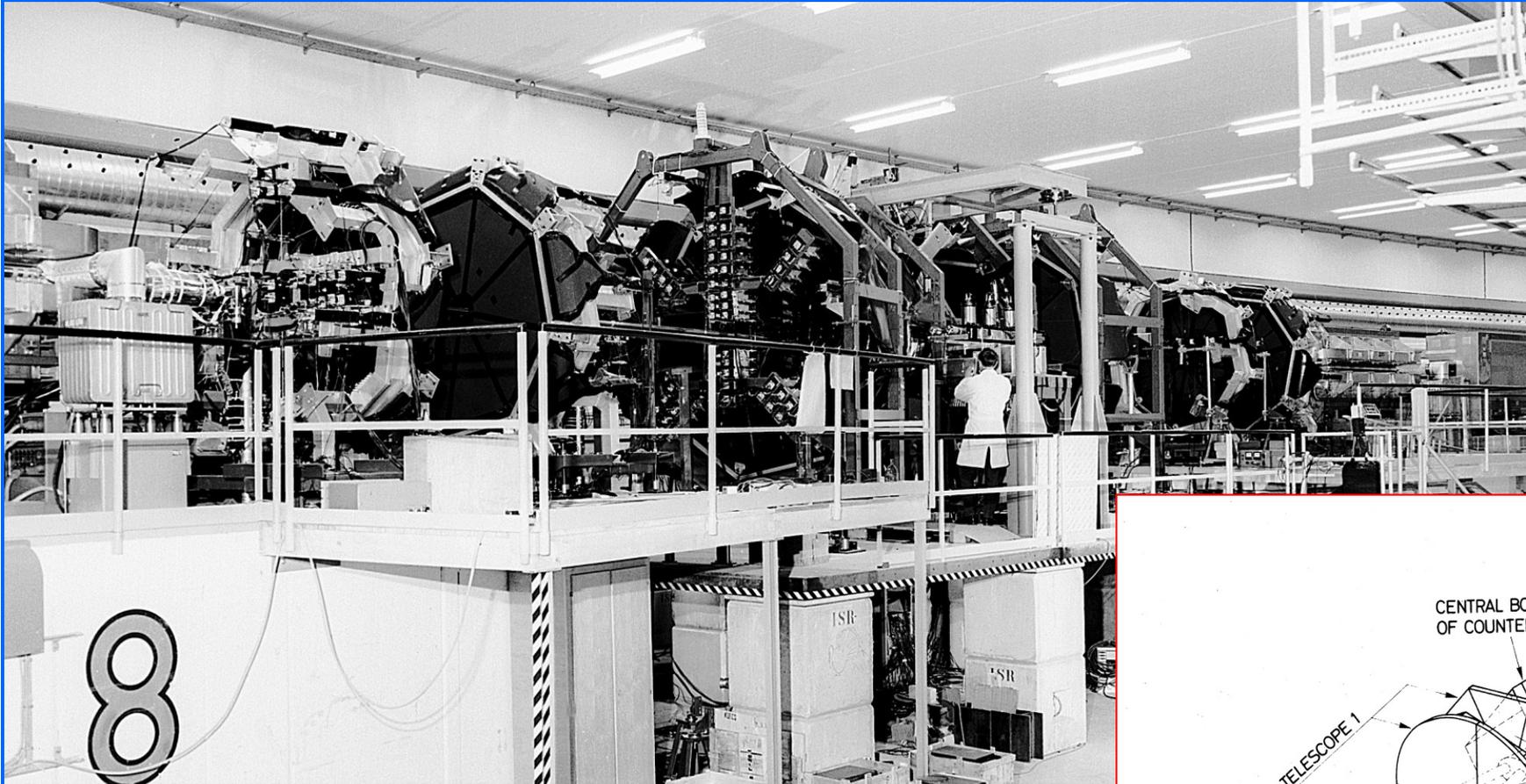
S. P. DENISOV, S. V. DONSKOV, Yu. P. GORIN, A. I. PETRUKHIN, Yu. D. PROKOSHKIN
D. A. STOYANOVA, J. V. ALLABY* and G. GIACOMELLI**
Institute of High Energy Physics, Serpukhov, U.S.S.R.

Received 30 July 1971

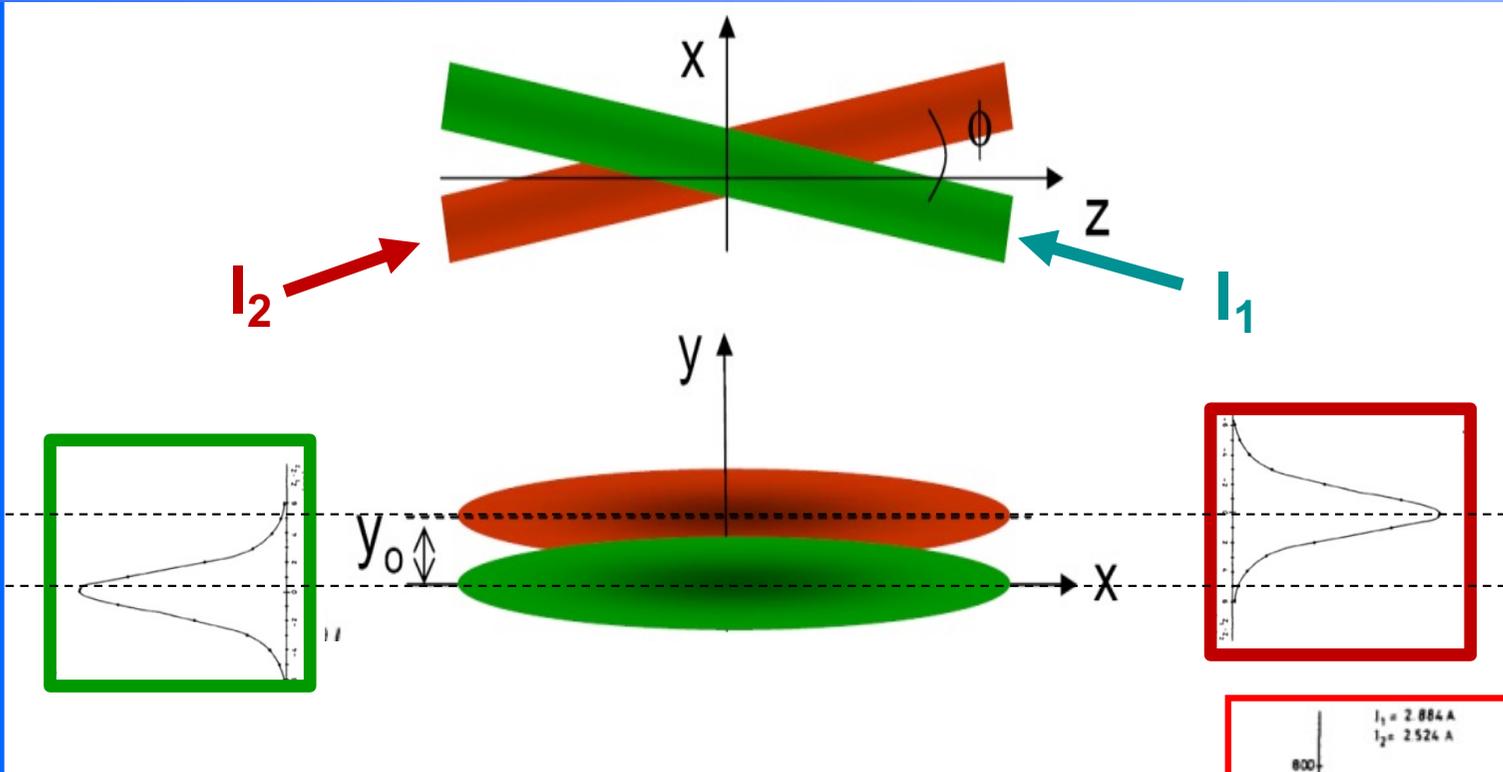
PROTON-PROTON ASYMPTOPIA IS
ALREADY REACHED AT $E_{\text{beam}} = 100 \text{ GEV}$

This figure suggests that the total cross-section for K^+p will approach the asymptotic value from below

*In IR-8 the total cross section was measured by the
Pisa - Stony Brook Coll.*

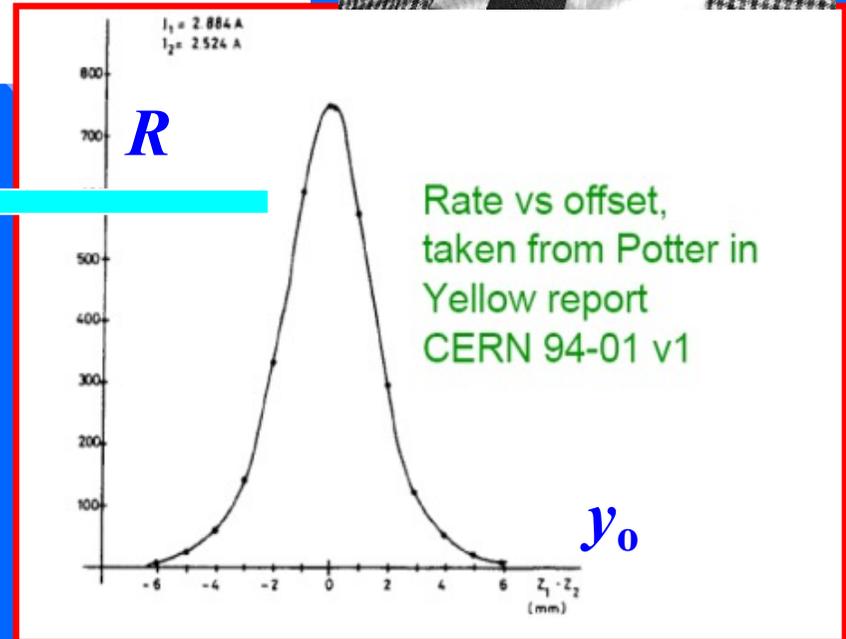


The luminosity was measured with the method invented by Simon van der Meer

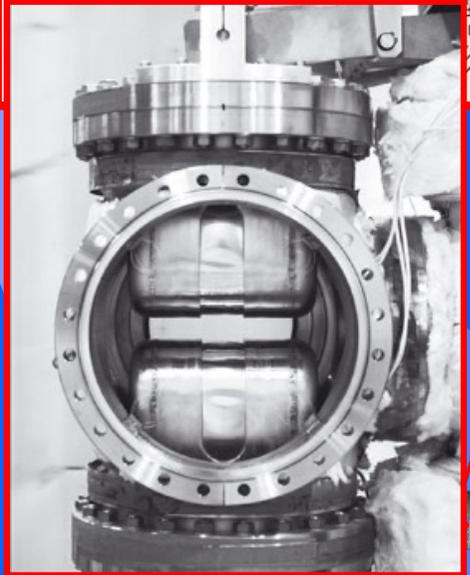
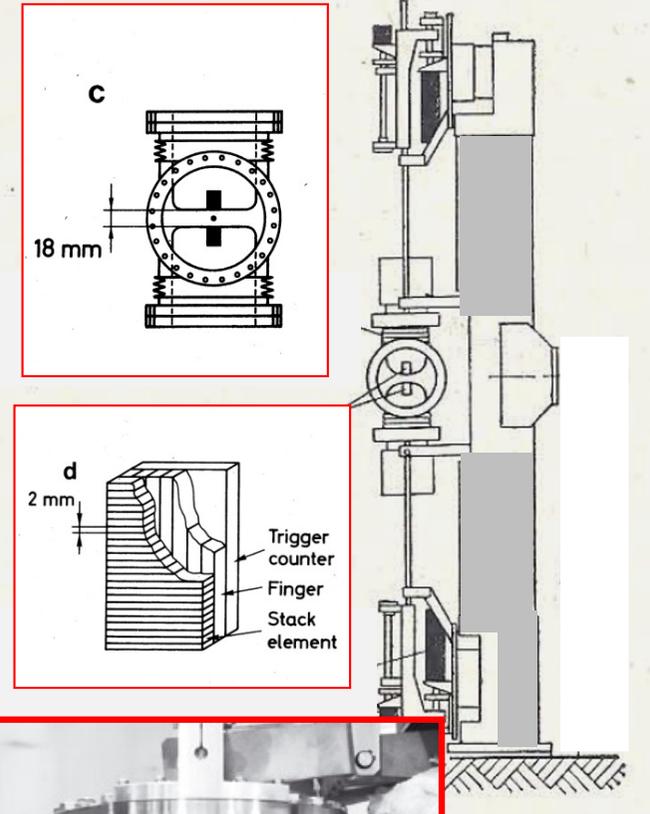
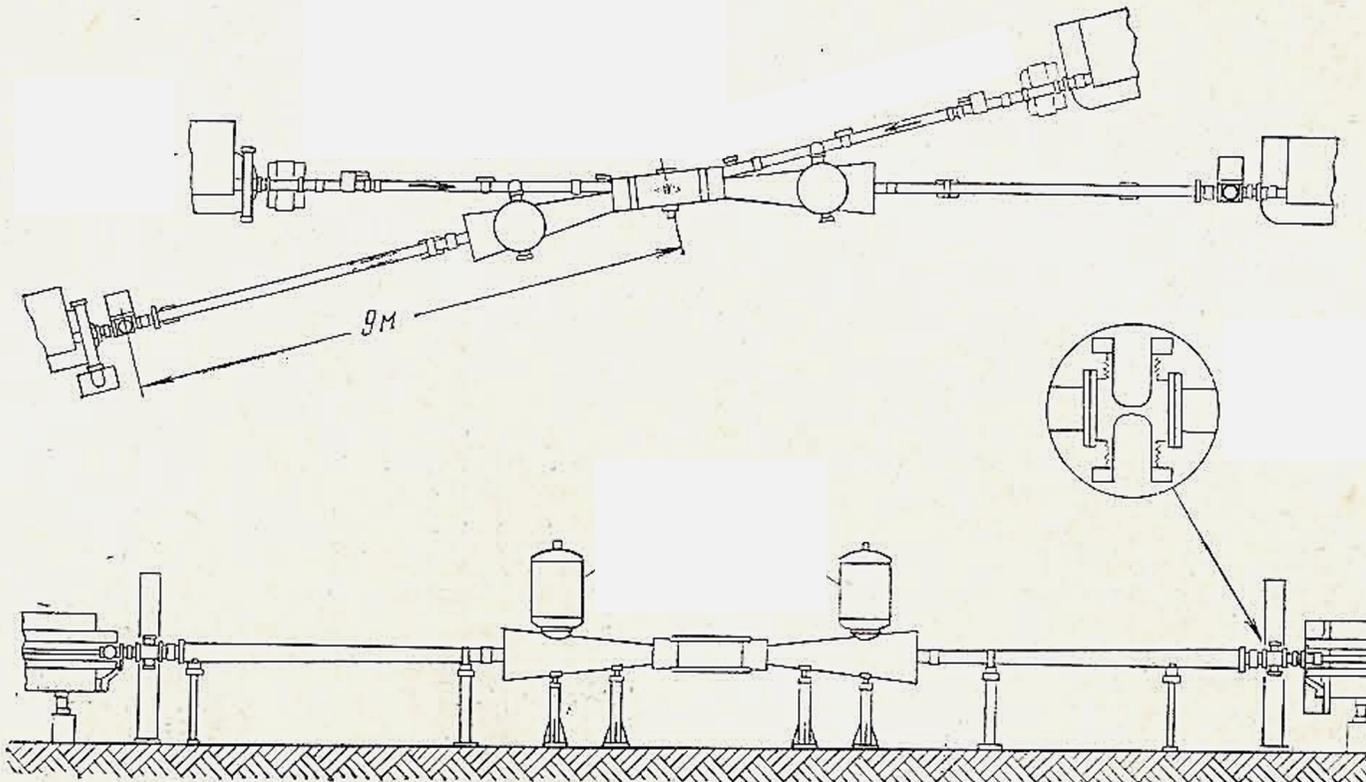


h_{eff} = effective beam height

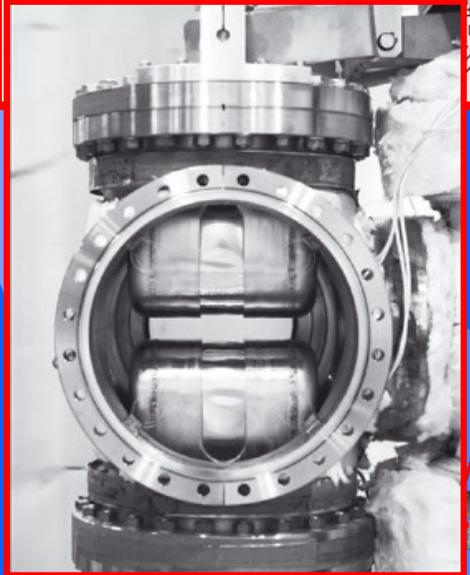
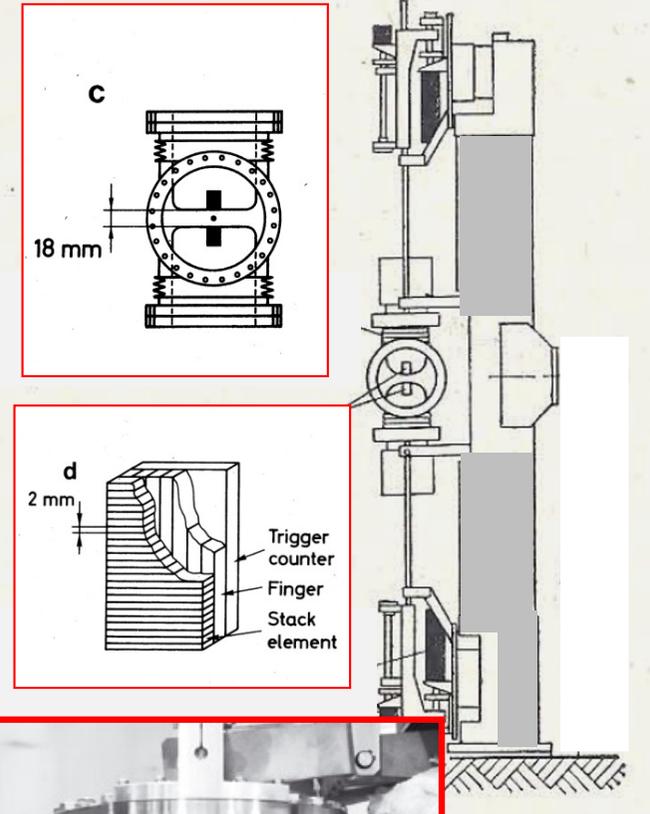
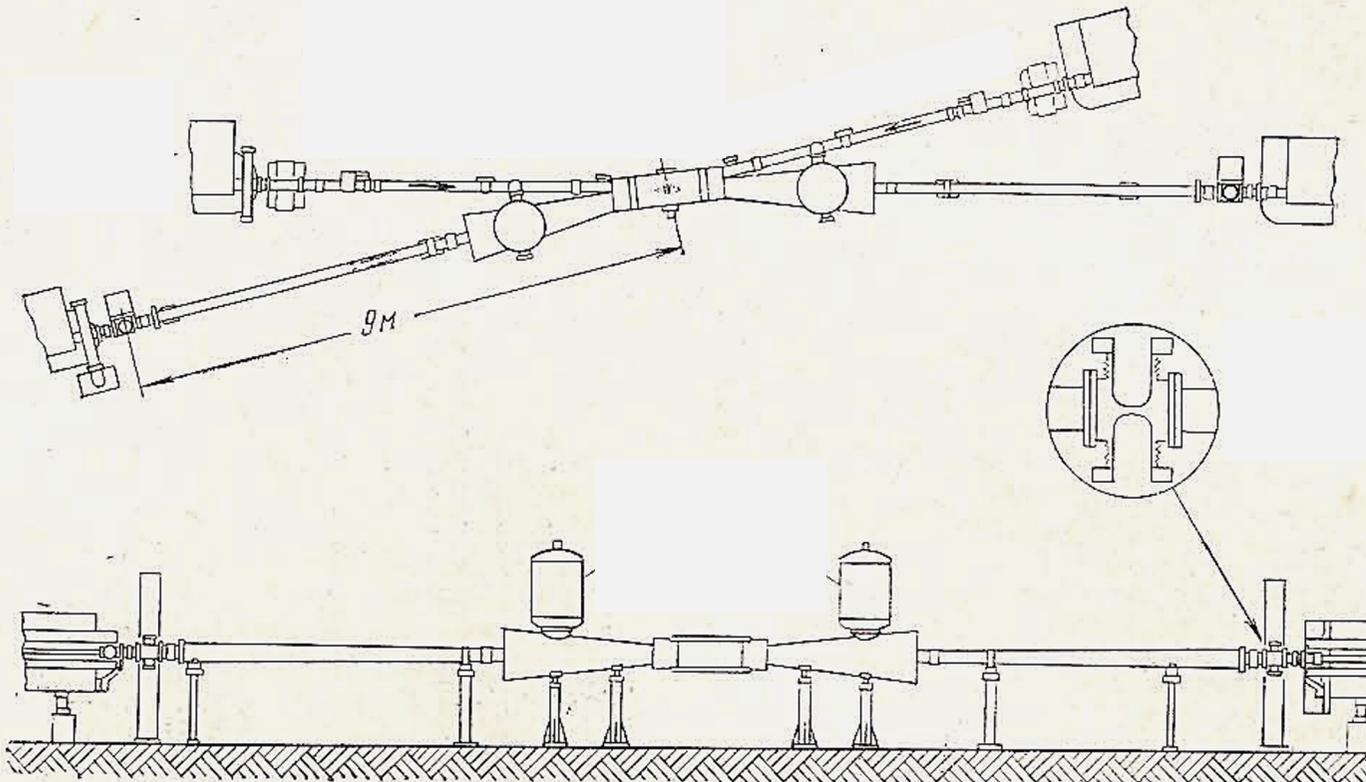
$$\text{Luminosity} = K \frac{I_1 I_2}{h_{\text{eff}}}$$



In IR-6 the total cross section was measured by the CERN-Rome Coll. through the forward elastic x-section



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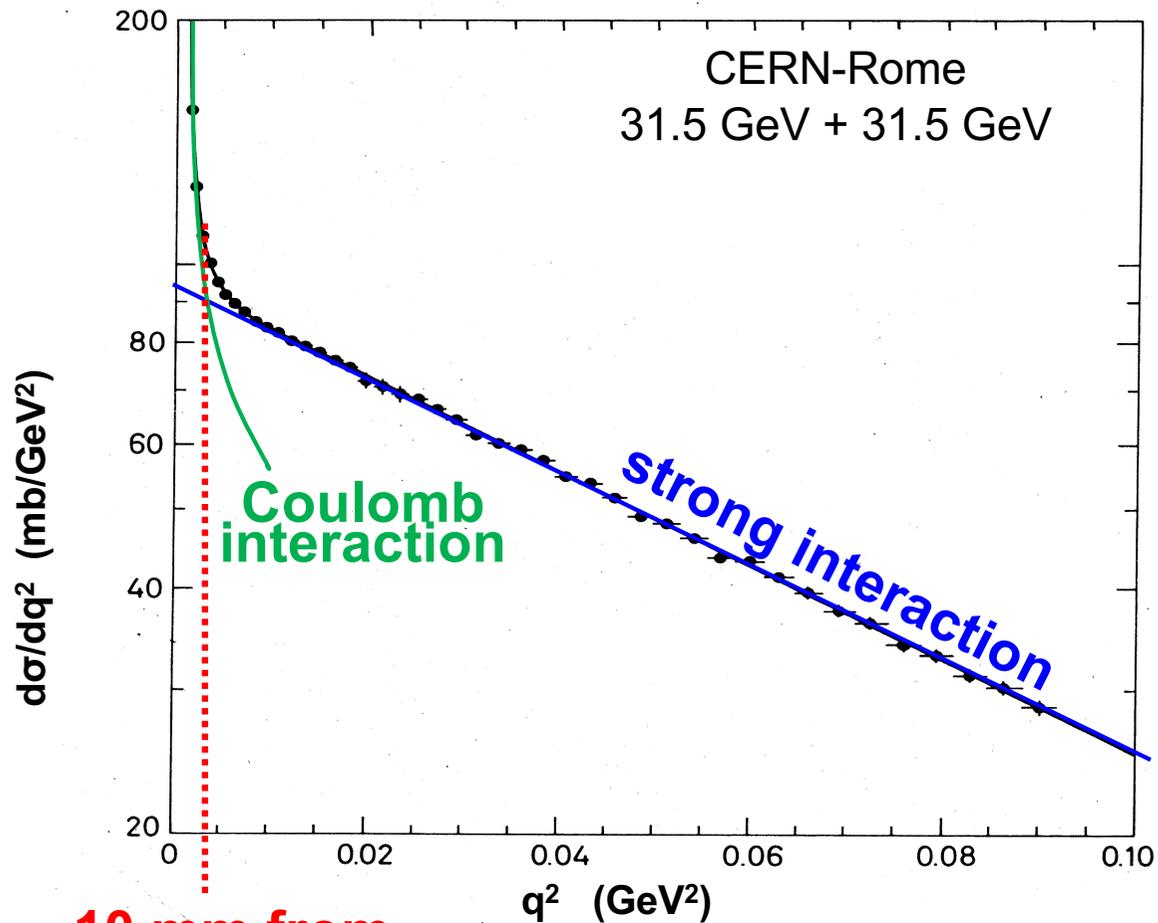


**“Les pots de Rome “
= Roman pots**

Behaviour of the elastic cross-section

S-matrix theory:

$$\text{Scattering amplitude} = A(q^2) [i + \rho(q^2)]$$



10 mm from
beam axis

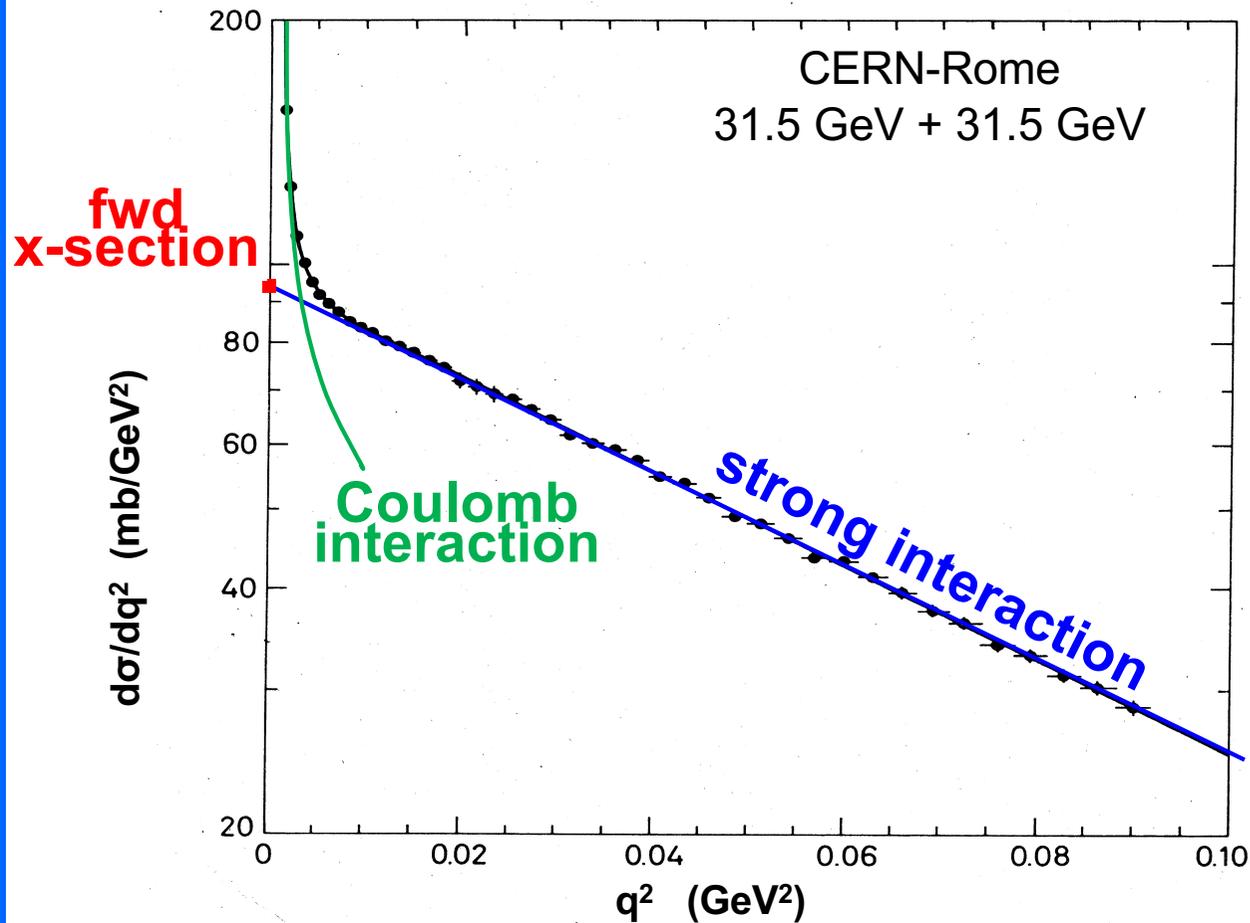
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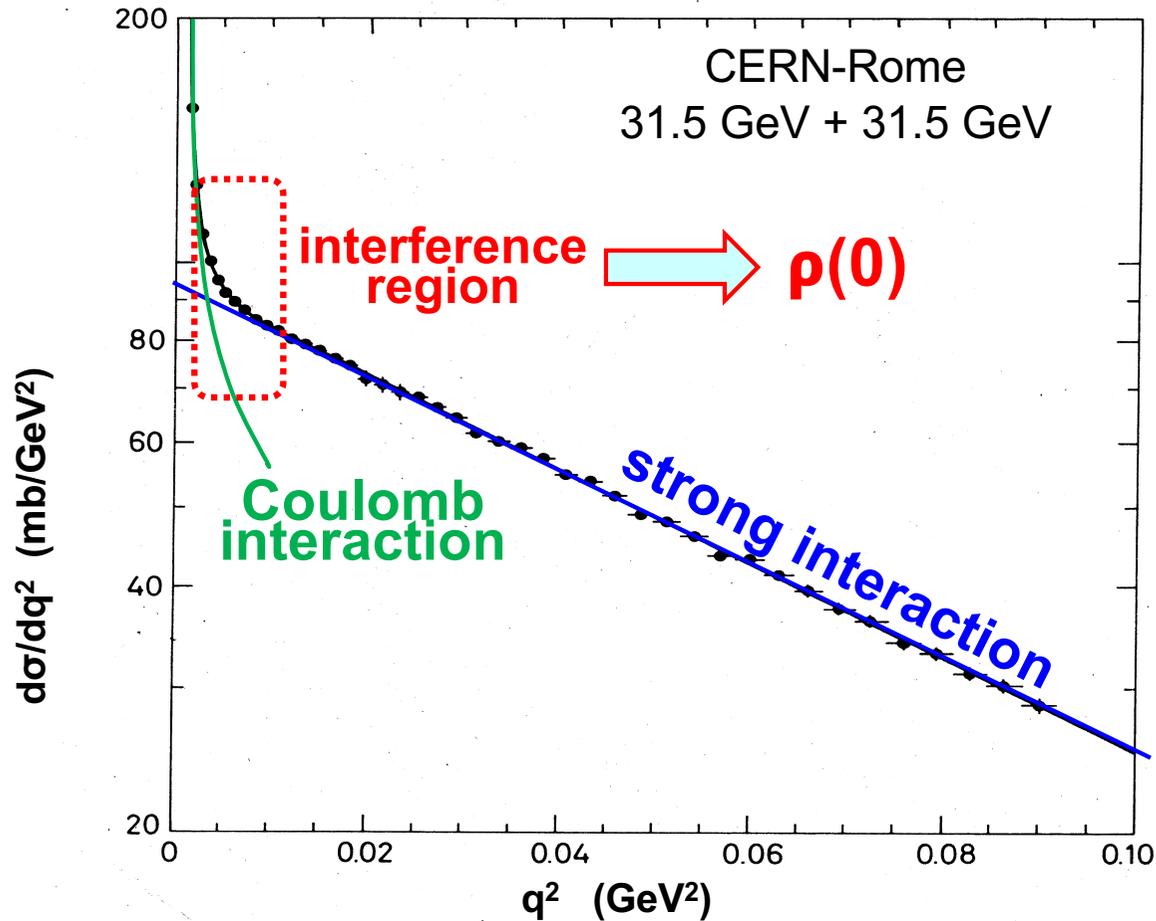
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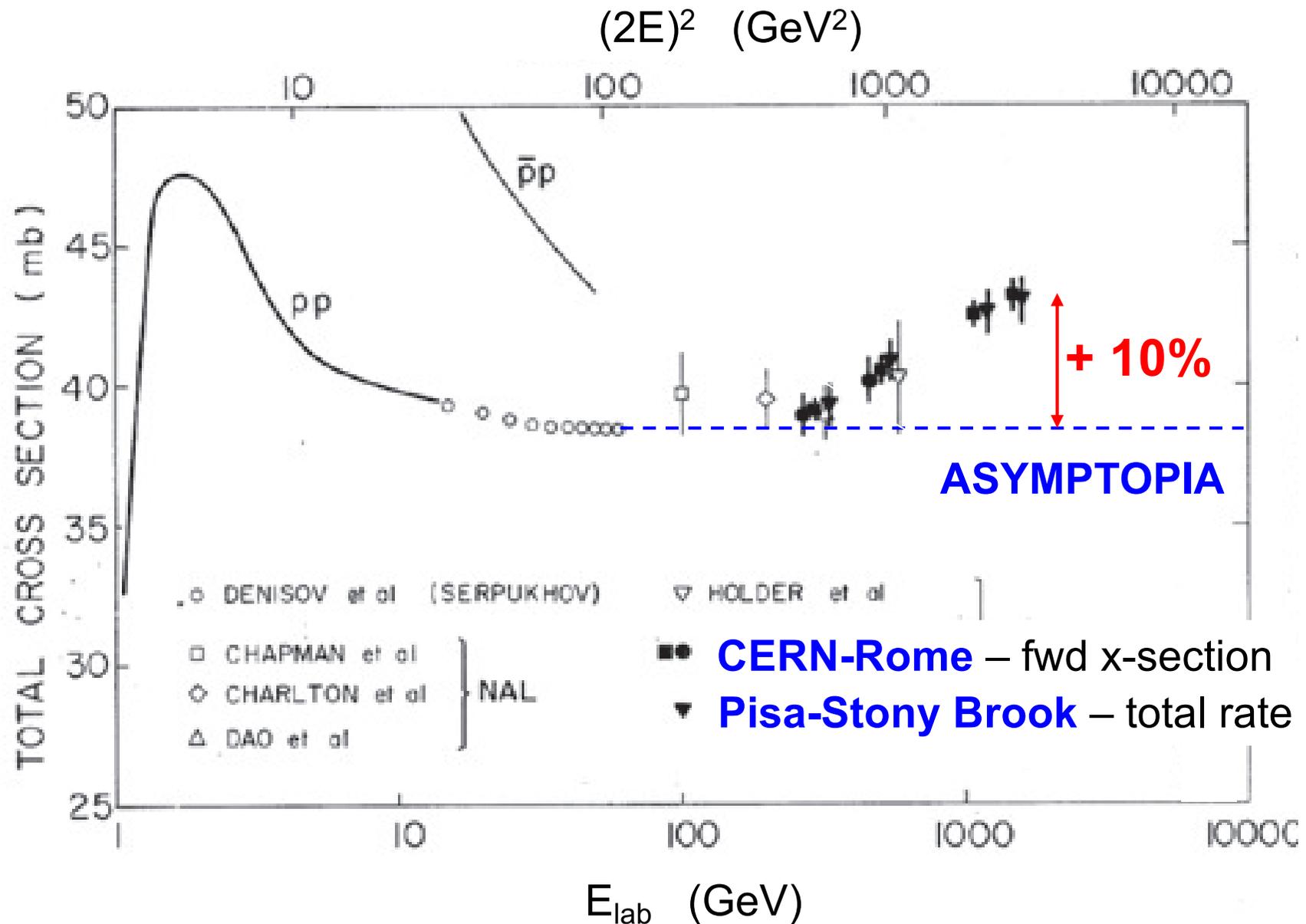
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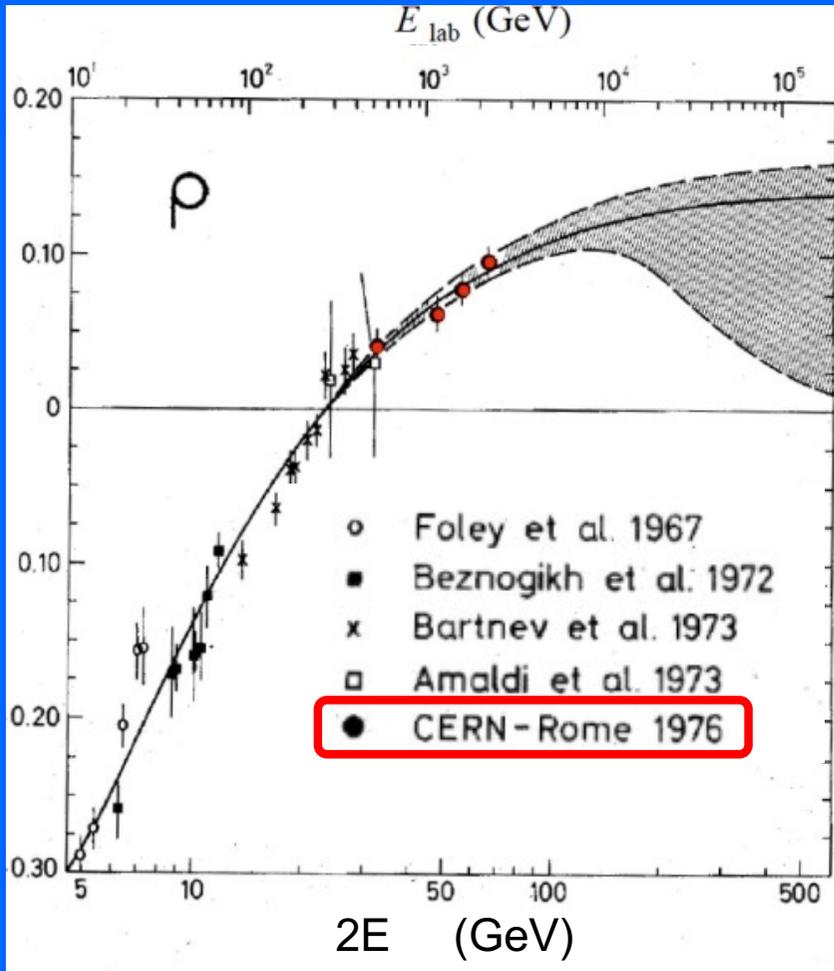
2. Dispersion relation:

$\rho(0)$ expressed as an
 integral over all energies
 of $\sigma_{\text{tot}}(E)$

In 1973 the two Collaborations found that 1. Asymptopia does not apply to protons; 2. the Pomeron is much more complicated

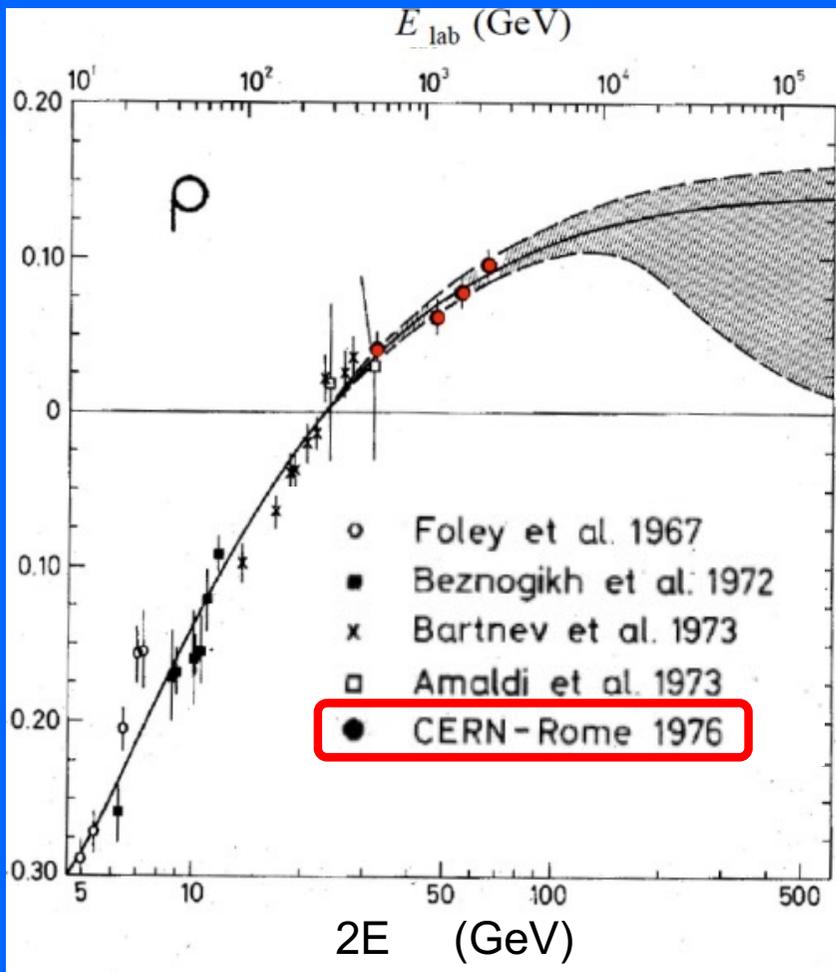


In IR8 the CERN-Rome Coll. measured ρ with new Roman pots

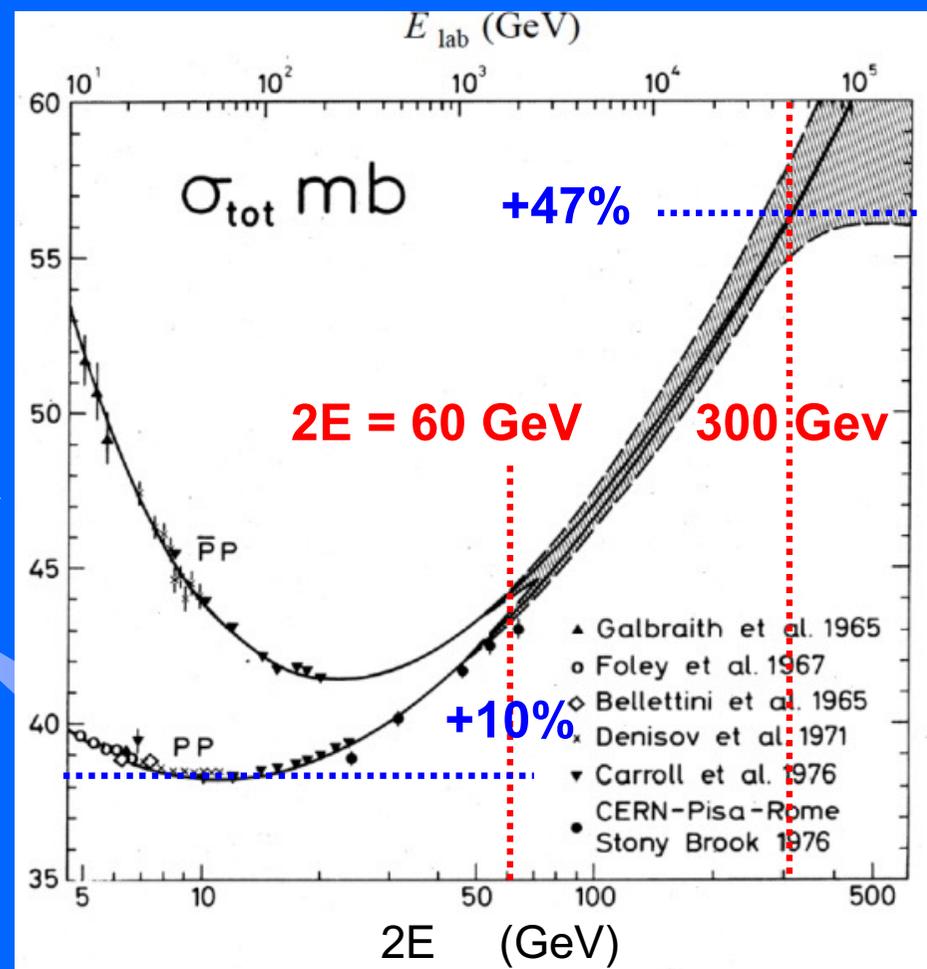


1976

IN IR8 with new Roman pots the CERN-Rome Coll. measured ρ

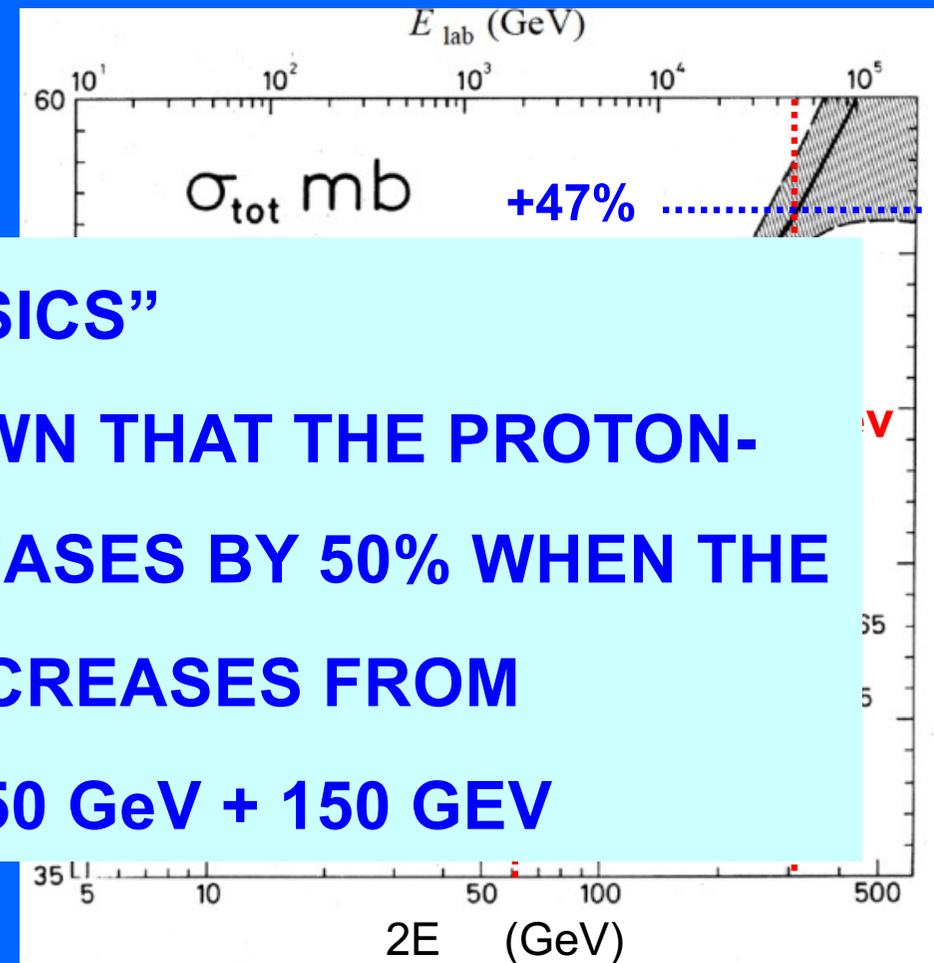
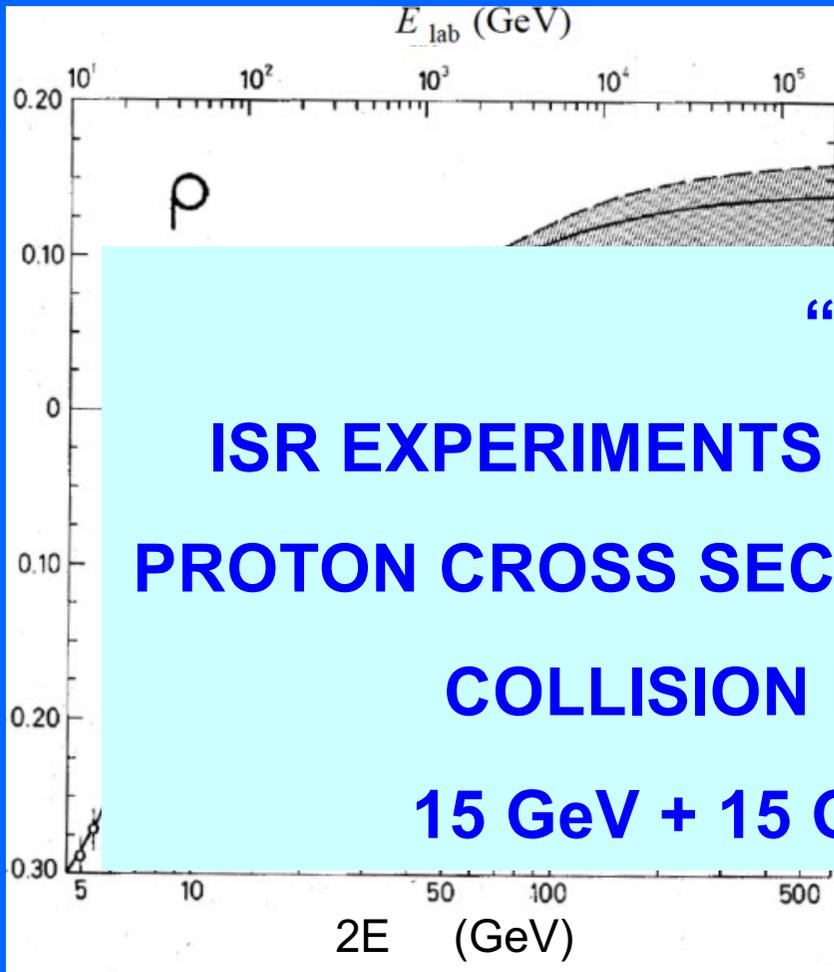


Dispersion
relation



1976

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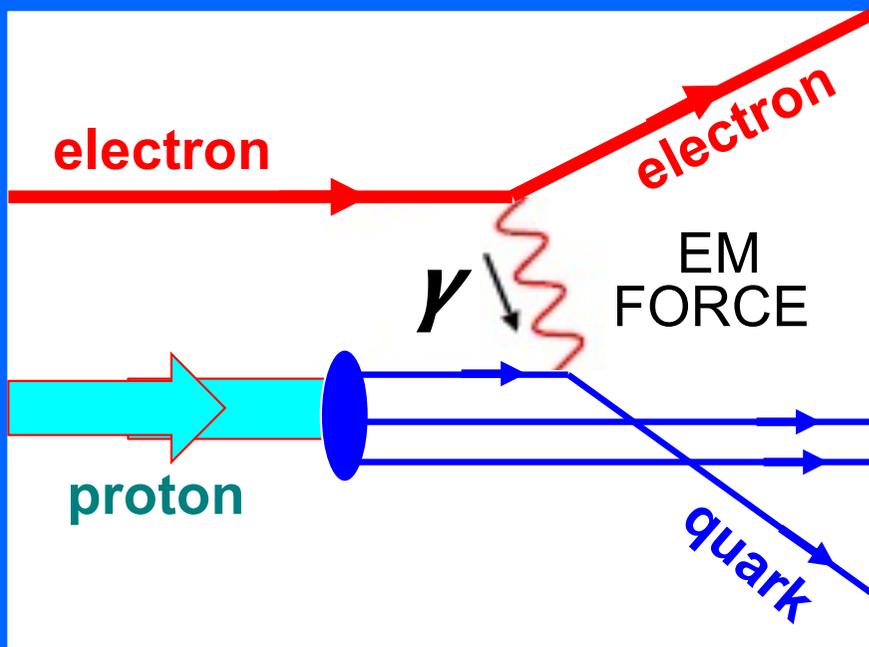


“SOFT PHYSICS”

**ISR EXPERIMENTS HAVE SHOWN THAT THE PROTON-
PROTON CROSS SECTION INCREASES BY 50% WHEN THE
COLLISION ENERGY INCREASES FROM
15 GeV + 15 GeV to 150 GeV + 150 GEV**

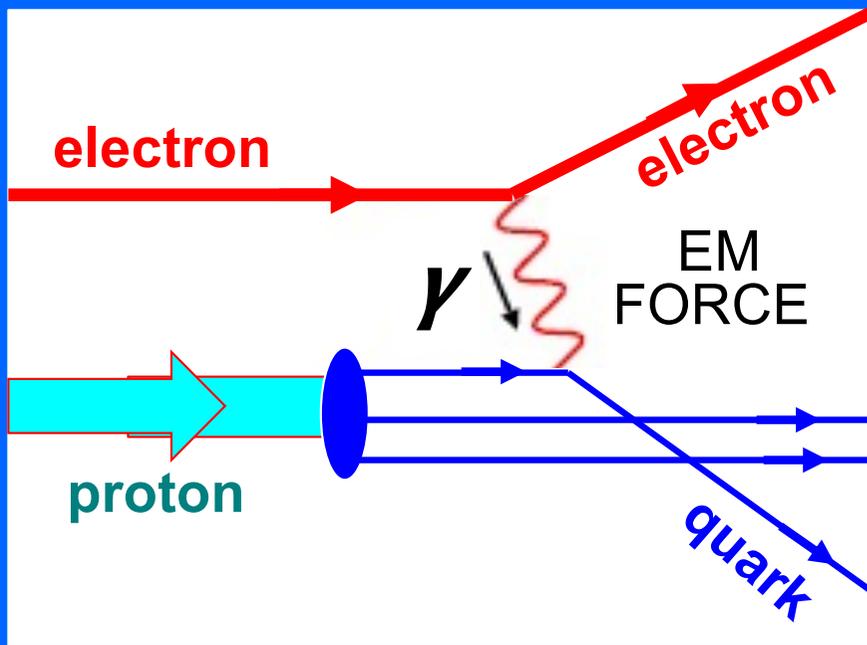
1976

"HARD" PHYSICS: The XVI HEP Conference – 1972 – Batavia

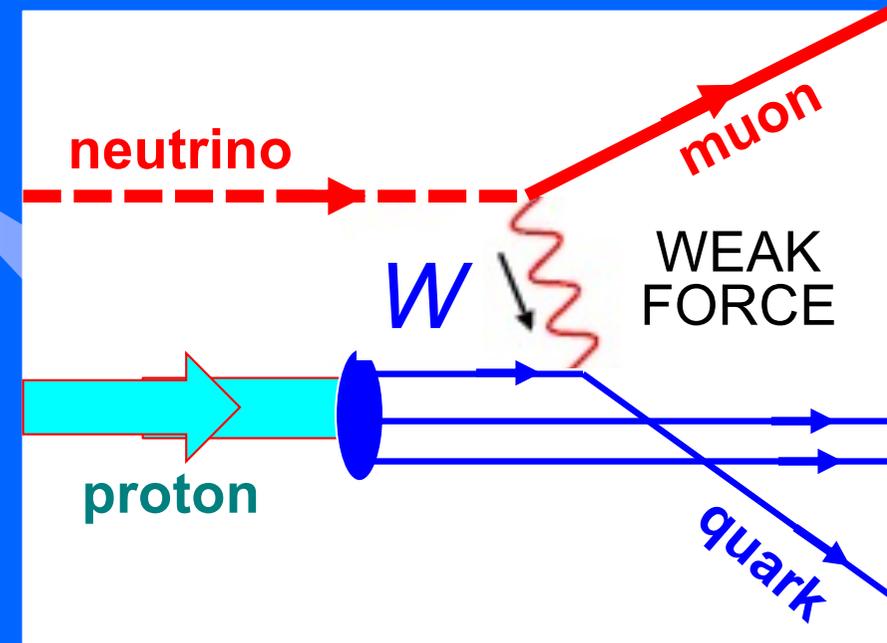


SLAC
ELECTRON deep inelastic scattering:
"partons" exist within protons
and partons are probably quarks

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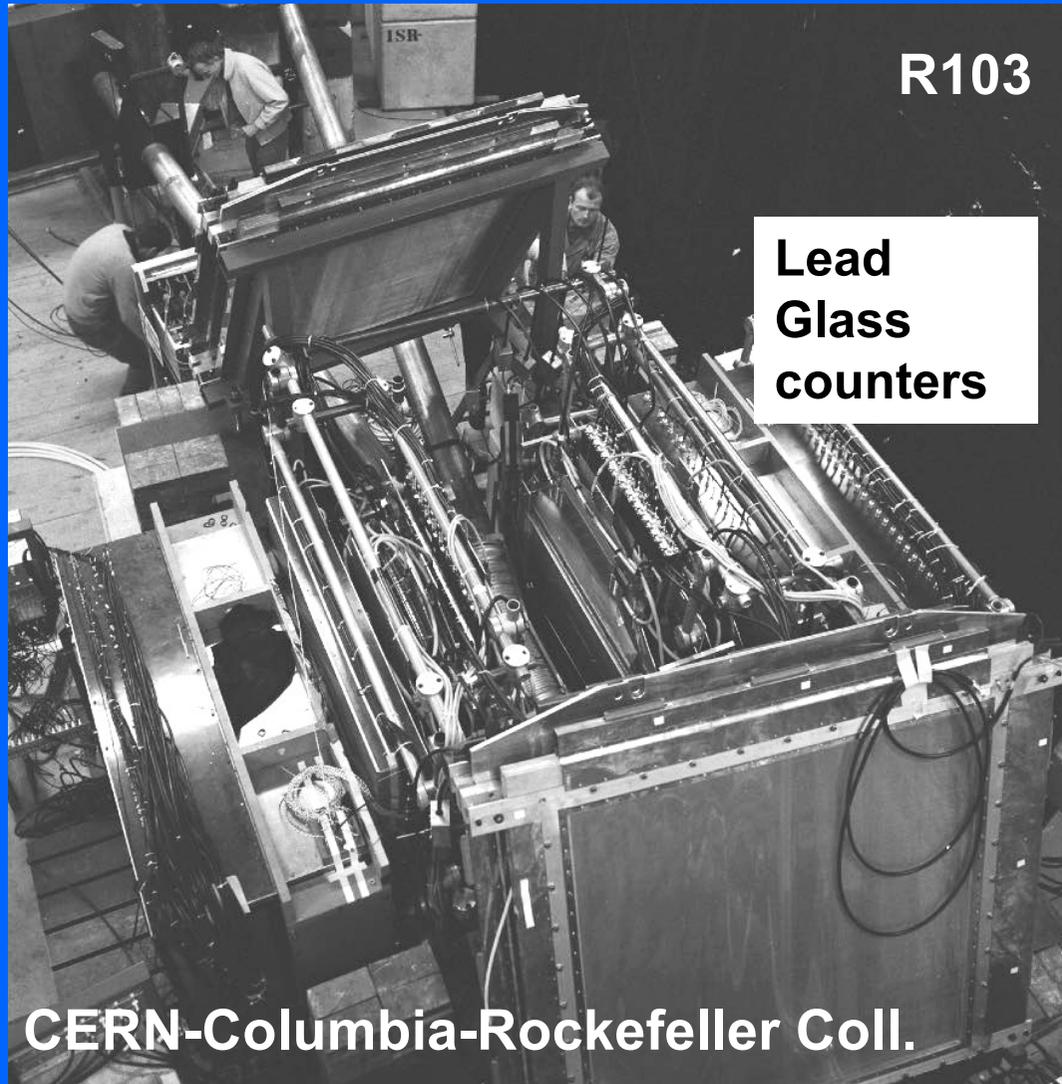


SLAC
ELECTRON deep inelastic scattering:
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GARGAMELLE:
NEUTRINO 'deep' inelastic scattering:
first evidence that "partons" are quarks

At the same Conference ISR Collaborations announced the discovery of large transverse momentum hadrons



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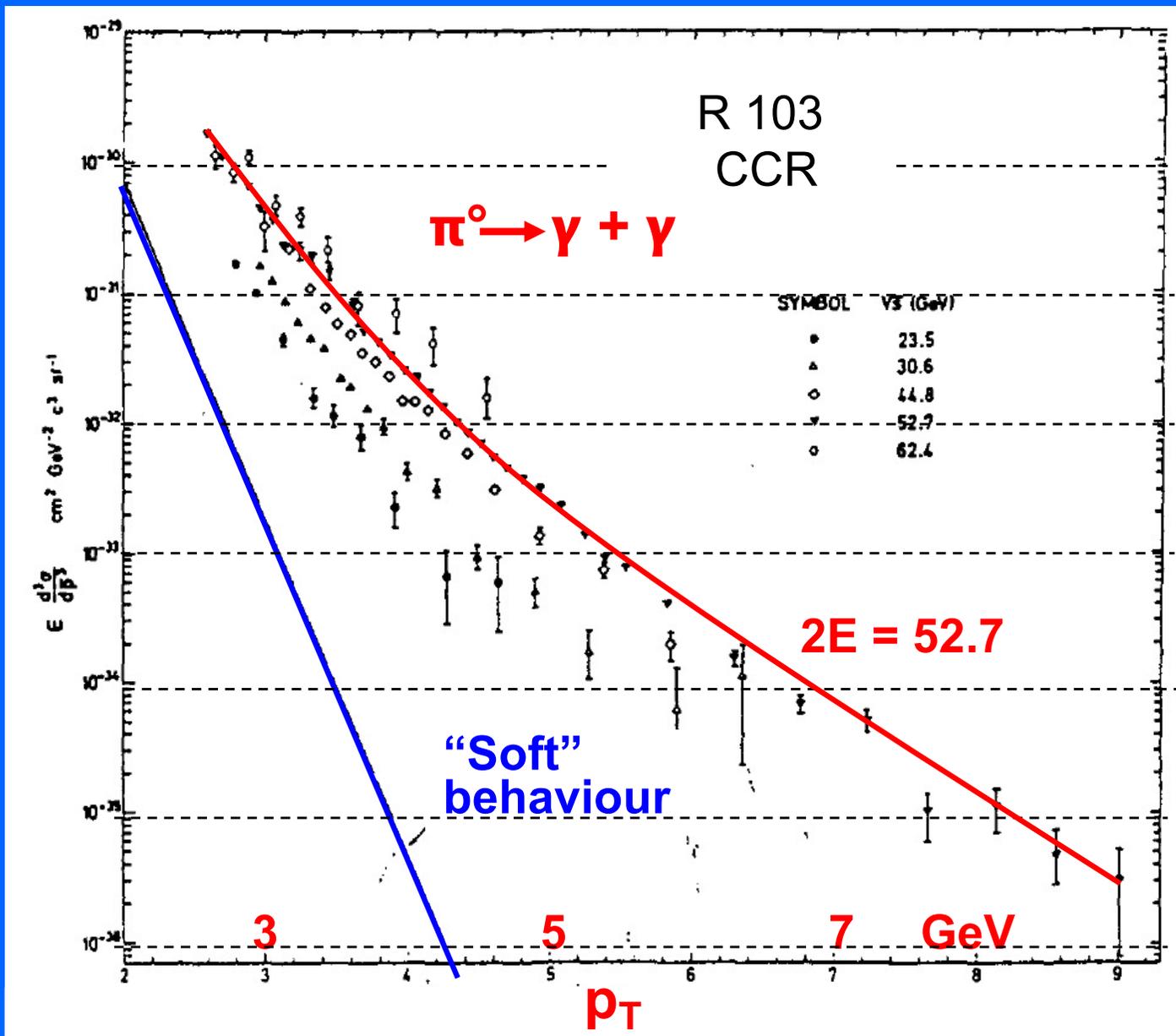
R203

Large magnet +
Cerenkov counters



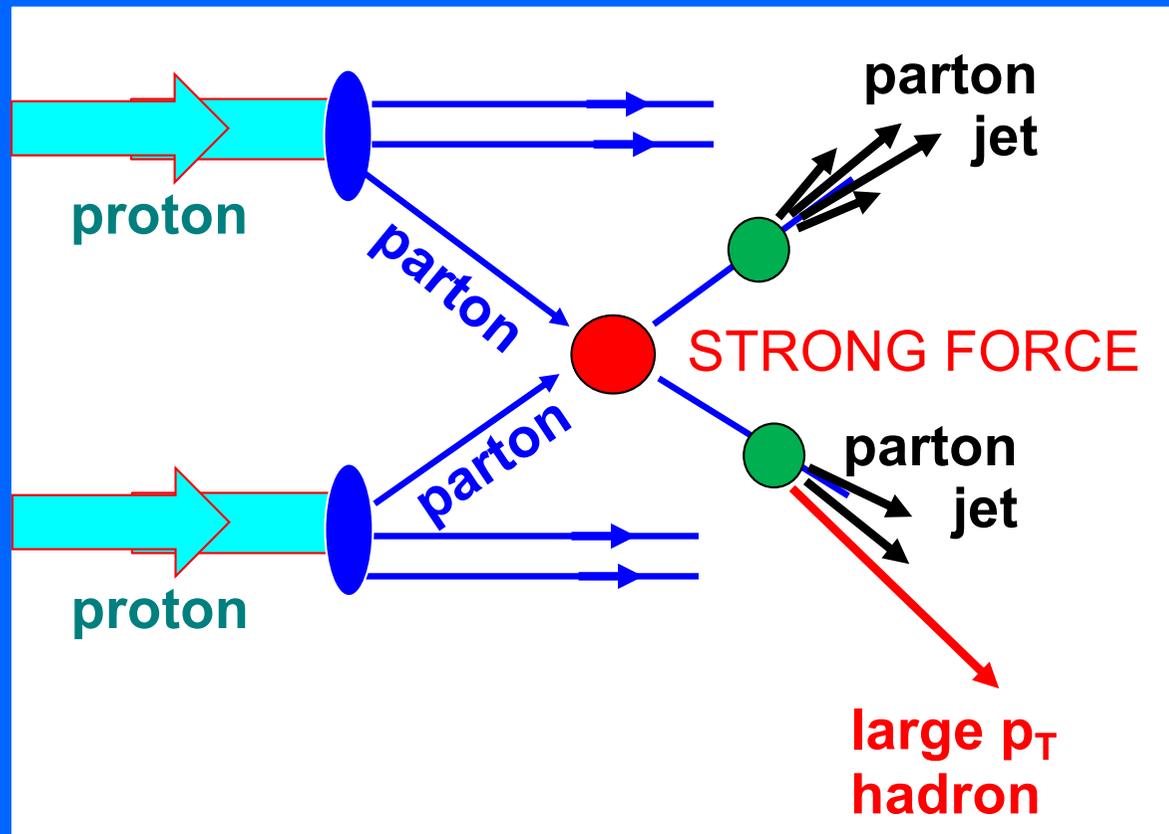
Upgraded detector of the British-Scandinavian Coll.

Large p_T data presented by CCR at the 1972 Conference



Just one figure

Parton interpretation of the new phenomenon



Parton interpretation of the new phenomenon

“HARD PHYSICS”

**ISR EXPERIMENTS HAVE SHOWN THAT PARTONS BEHAVE
AS POINTLIKE OBJECTS ALSO WHEN THEY INTERACT
THROUGH THE STRONG FORCE**

NEXT: DETECT JETS

hadron

Frustration was felt in Sept 74 when J/psi was announced

Experiment R103

CERN-Columbia-Rockefeller Coll.

The two-arm trigger was dominated by $\pi^0 \rightarrow \gamma + \gamma$

To write on tape less than 10 evts/s, cuts were set above 1.5 GeV thus excluding J/psi

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Experiment R103

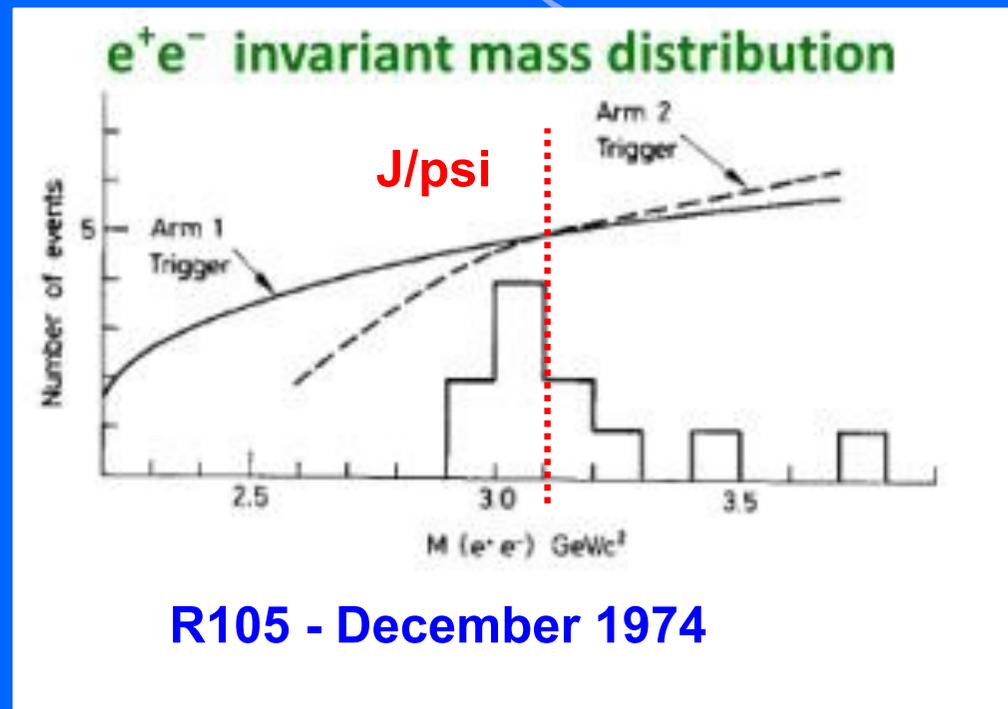
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Luigi Di Lella

“An ISR discovery prevented a more important discovery”



1975-1977: "A SOMEWHAT DIFFICULT TIME"

No instrument to trigger on jets and to study them

AND

ISRC was very hesitant in approving large coverage magnetic detectors

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In 1976 organized a WG to evaluate Solenoid vs Toroid

The results were seminal for the Axial Field Spectrometer and for the detectors of the future proton-antiproton collider

1978-1983 "A VERY ACTIVE AND INTERESTING PROGRAM"

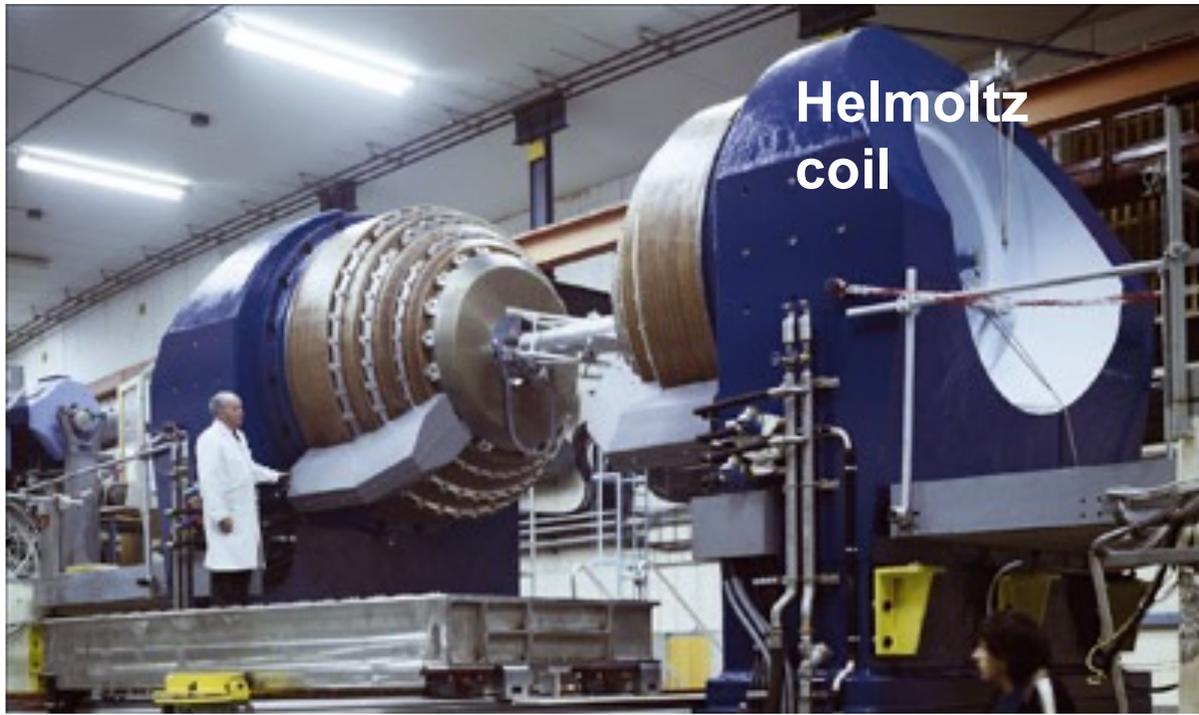
R108

SUPERCONDUCTING SOLENOID

CERN-Columbia-Oxford-Rockefeller Collaboration

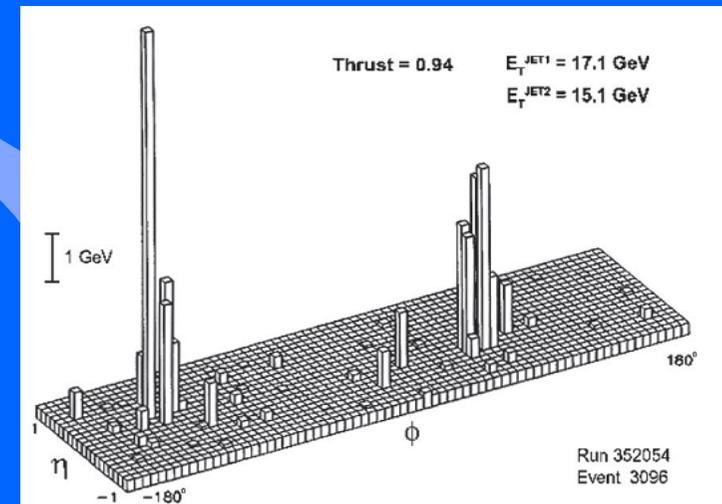
With cylindrical drift chambers and two arrays of glass Cherenkov counters

1978-1983 "A VERY ACTIVE AND INTERESTING PROGRAM"



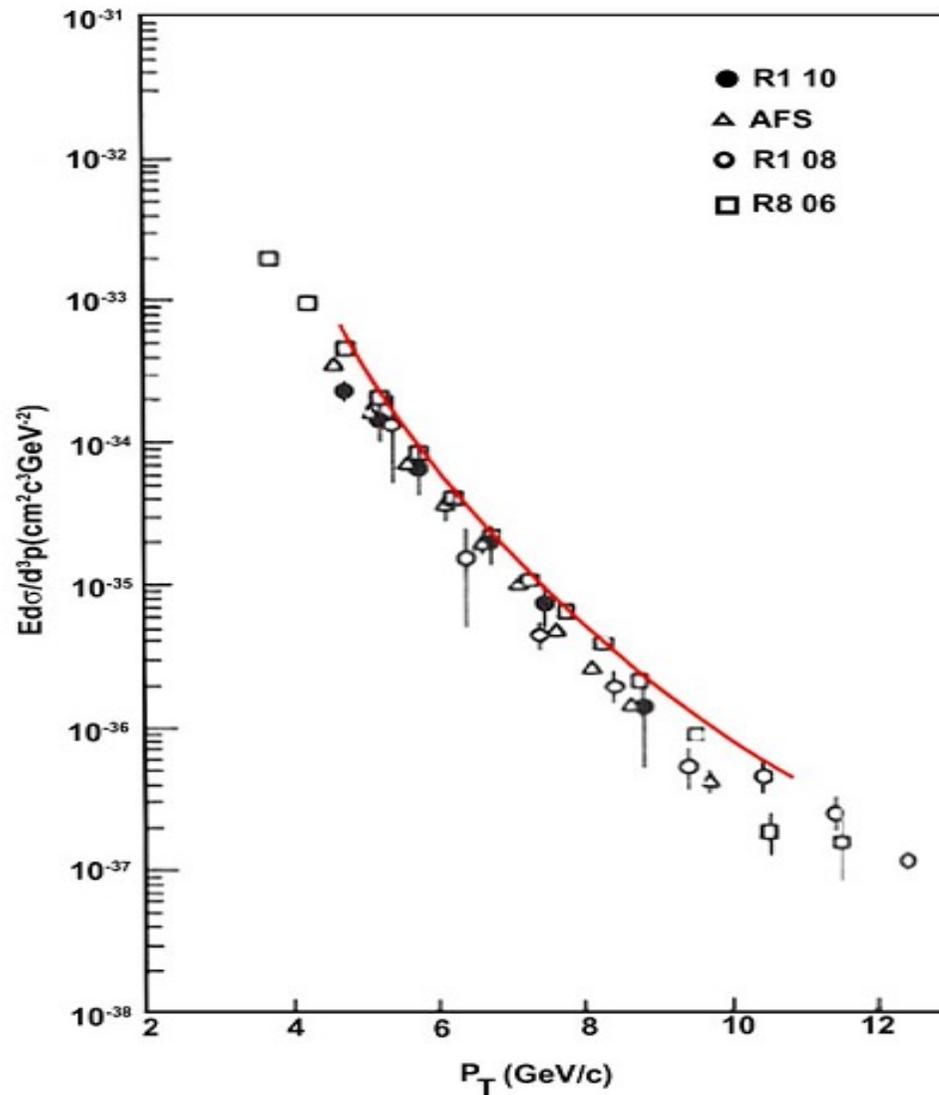
AXIAL FIELD
SPECTROMETER
with liquid Ar calorimeter
And U hadron-calorimeter

BNL, CERN, Copenhagen,
Lund, Pennsylvania,
Rutherford, Tel Aviv



Evidence for jet production

An important discovery: single photons at large p_T



AFS

BNL, CERN, Copenhagen, Lund,
Pennsylvania, Rutherford, Tel Aviv

R108

CERN, Oxford, Rockefeller

R110

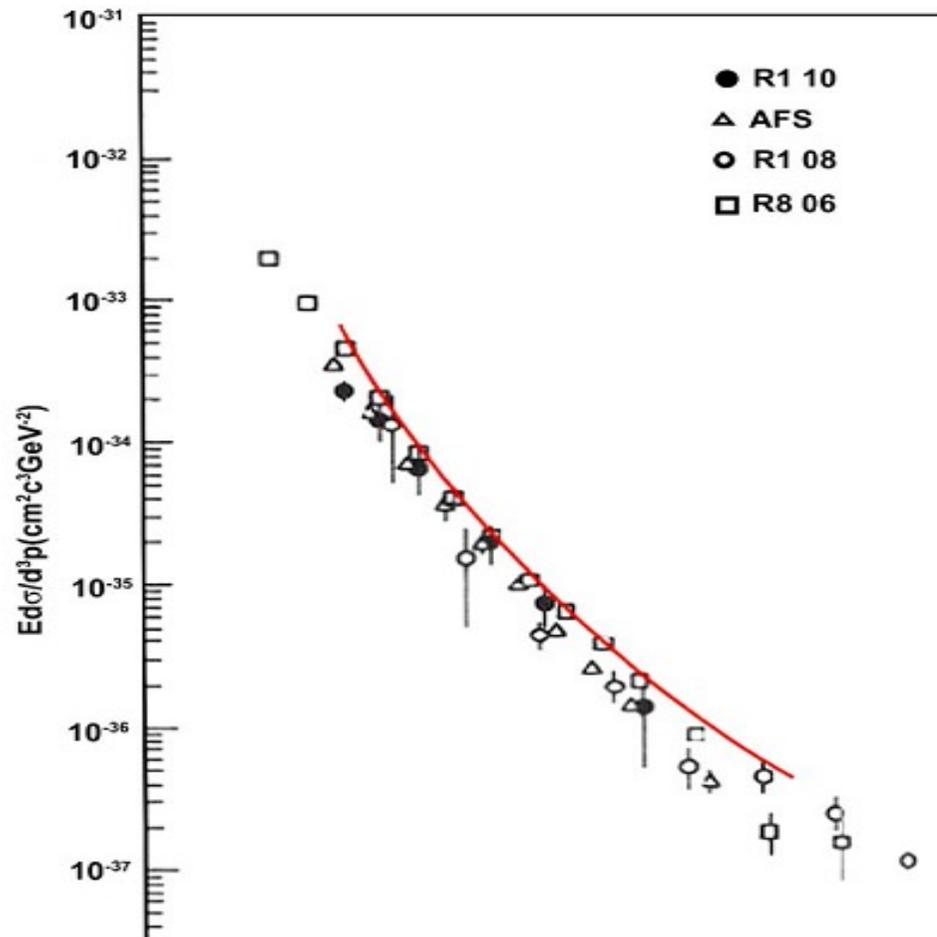
CERN, Oxford, Rockefeller

R806

Athens, Brookhaven, CERN

Early experimental indication of the validity of QCD

An important discovery: single photons at large p_T



AFS

BNL, CERN, Copenhagen, Lund,
Pennsylvania, Rutherford, Tel Aviv

R108

CERN, Oxford, Rockefeller

R110

CERN, Oxford, Rockefeller

R806

Athens, Brookhaven, CERN

BUT

lack of general recognition of the importance of ISR hard physics

No time to speak of other results obtained within the “very active and interesting programme” of the third period

- **First observation of charmed-hadron production in hadronic interactions**
- **Studies of the Drell-Yan process → Proton structure function for medium x - values**
- **Experiments on the emergence of jet structure and dominance at high E_T**

40th Anniversary of the First Proton-Proton Collisions in the CERN Intersecting Storage Rings (ISR)

CERN-2012-004
24 May 2012

10 years ago

Authors: U. Amaldi
P. J. Bryant
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We, who worked at the ISR, tend not to attach much importance to this lack of recognition because for us the main legacy has been to have taught us how to make optimal use of the proton-antiproton collider....

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We tend to see the ISR and the proton-antiproton colliders, both at CERN and at the Tevatron, as a lineage, father and sons, the success of the latter being indissociable from the achievements of the former.