

# Polarized Beams and Experiments at the Argonne ZGS

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# Some Polarized People

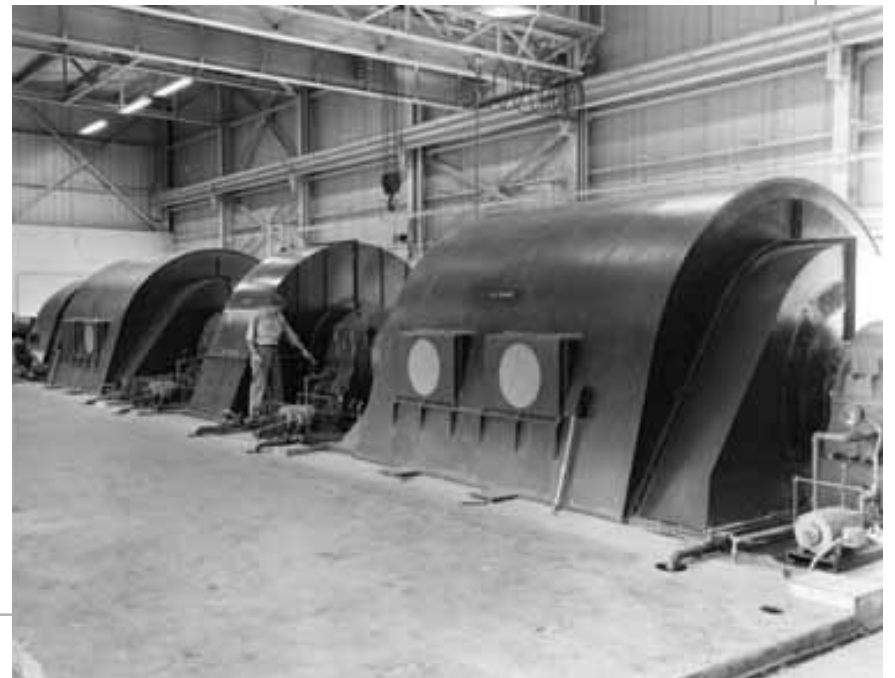




# Caveats

- The Argonne ZGS was a long time ago. I have tried to rely on contemporaneous documents (as instructed by my historian son Adam) rather than fragile memories. However, some people here today know and remember more than I do. I apologize in advance for mistakes and welcome corrections.

ZGS Motor Generator Set

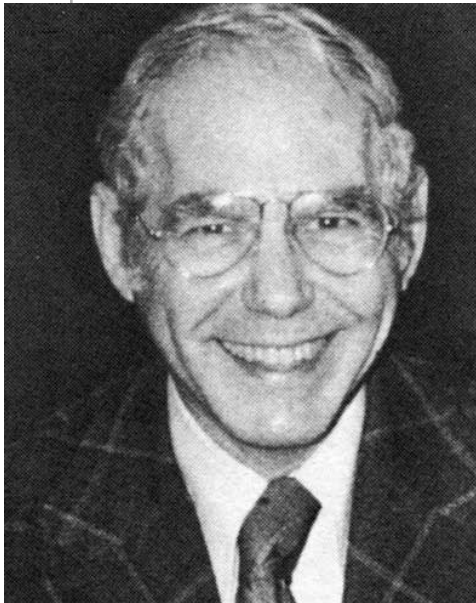


# Historical Context



- June 27, 1959: Ground is broken for the ZGS
- November 24, 1959: The CERN PS begins operation
- July 29, 1960: The AGS begins operation
- September 18, 1963: The ZGS operates at full energy for the first time
- November 22, 1963: John Fitzgerald Kennedy is assassinated

# Historical Context



- The Argonne Zero Gradient Synchrotron is dedicated at a gala dinner on December 4, 1963. Lab Director Albert Crewe announces at the dinner that Bob Sachs is moving from Wisconsin to become Associate Director at Argonne.
- The newly inaugurated President Lyndon Johnson decided to cancel the MURA FFAG accelerator that was to be built at Stoughton, Wisconsin.
- Bob Sachs loses many of his friends (K. C. Wali)—at least for a while...
- November 1, 1967: Robert Duffield becomes Argonne Director



# Historical Context



- November 1, 1966: Argonne Universities Association becomes part of the Argonne management structure
- April 1, 1973: Bob Sachs becomes Argonne Director
- July 11, 1973: World's first high energy polarized proton beam accelerated at Argonne ZGS
- July 1, 1979: Walter Massey becomes Argonne Director
- October 1, 1979: The ZGS is shut down

# Physics Context



- Most extensive review is Akihiko Yokosawa *Reviews of Experimental Results from the Polarized Beam Program at the Argonne ZGS*, Physics Reports **64**, 47-86 (1980)
- In 1960, accelerator physicists were already convinced that the ZGS could be unique by accelerating polarized proton beams
- Didn't happen because:
  - Source intensity was not sufficiently high
  - Polarized beams limited experiments to  $pp$  not  $\pi p$ , etc.
  - Spin physics was not that popular

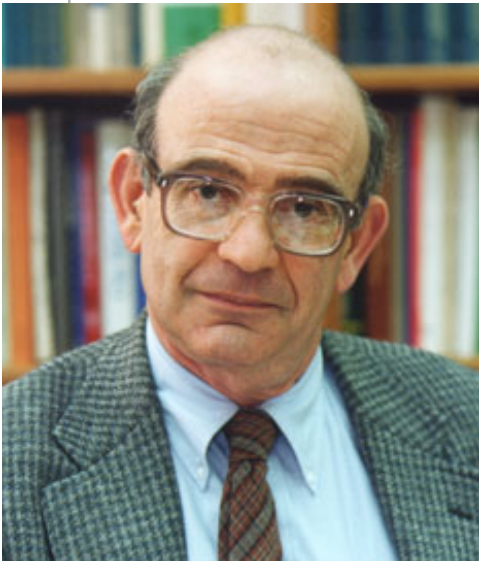
# Physics Context



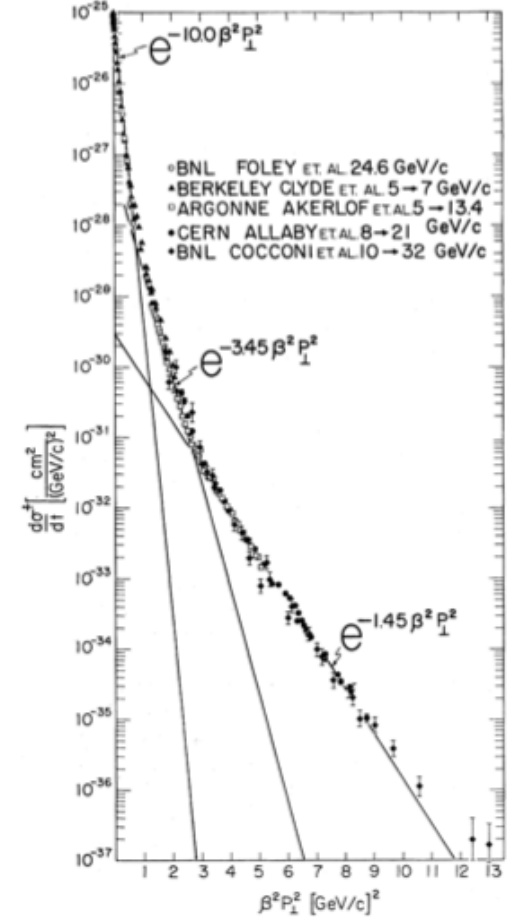
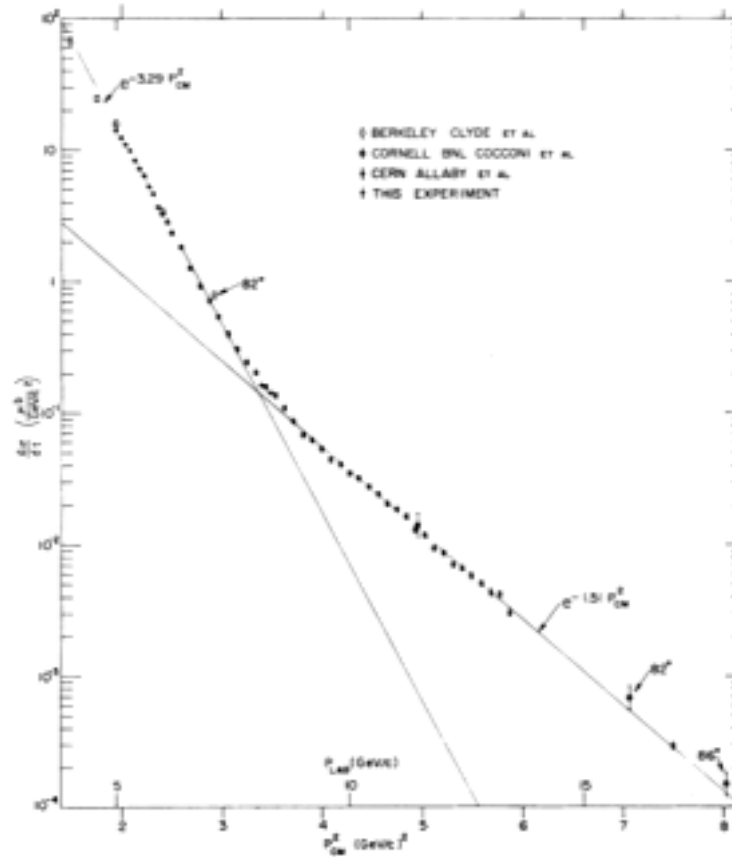
- By 1973, the ZGS polarized beam began operations. What happened?
- Polarized targets became available enabling polarized beam-polarized target measurements
- A polarized beam would make the ZGS a unique facility. *As unique measurements usually bring many surprises, we have observed many exciting and unexpected results in nucleon-nucleon scattering using polarized beams*



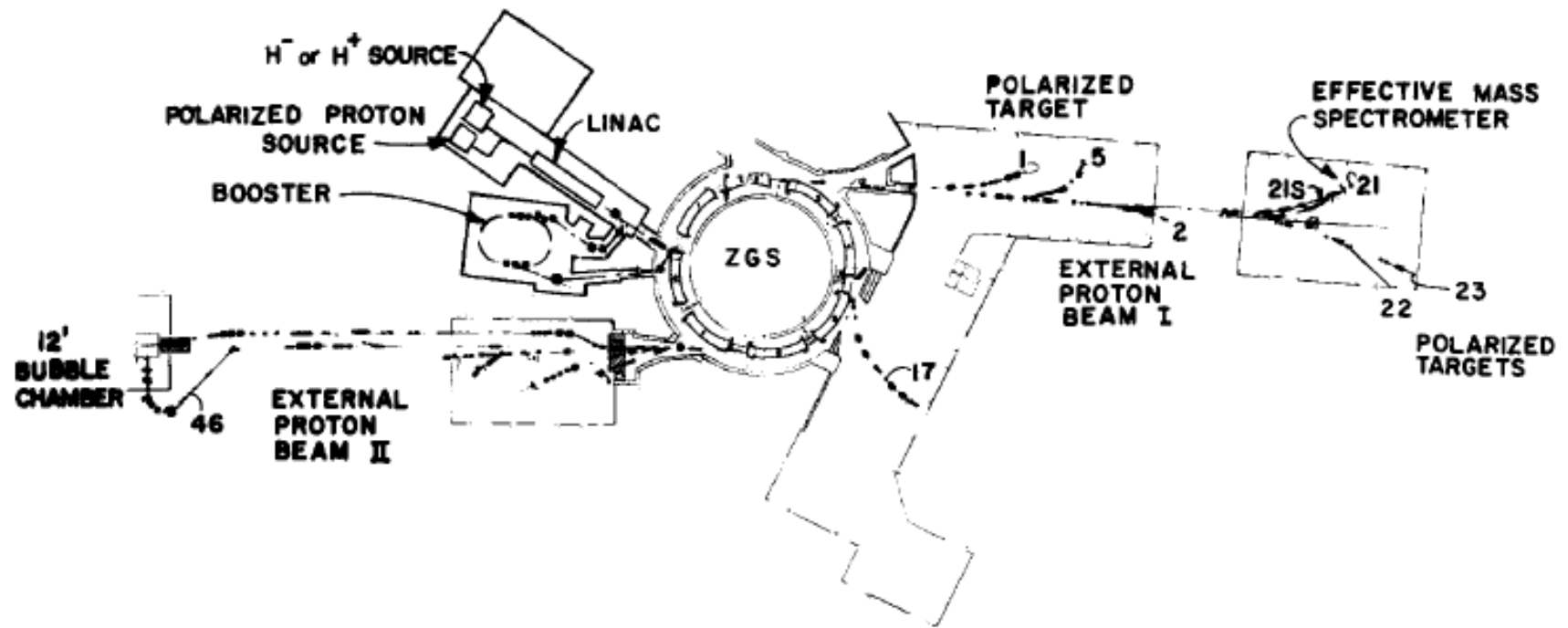
# pp Scattering



ADK is active in  
AUA



# Polarization at the ZGS



# Polarization at the ZGS



- Beam Parameters:
  - Momentum: 1-12.8 GeV/c
  - Polarization: protons 71%, deuterons 55%
  - Intensity: up to  $9 \times 10^{10}$  circulating protons; 30% extracted
  - Beam Lines: Up to 6 simultaneous; 3 with polarized targets



# ZGS Polarized Beams



Bob Diebold-no  
photo

- Beam 1: PPT V: Elastic Scattering
- Beam 2: Parity Violation
- Beam 5: Elastic and inelastic scattering
- Beam 21: Effective Mass Spectrometer
- Beam 22: PPT III: Elastic scattering, total cross sections
- Beam 23: PPT VI: Elastic scattering, total cross sections

# Physics Results (Roberts)

- 43 Polarized Proton and 4 Polarized Deuteron Experiments were completed at the ZGS in 6 years
- Total and elastic cross sections for pp and pn scattering from 1 to 12 GeV/c with both parallel and transverse polarization
- Asymmetries in inclusive production of  $\pi$ , K, etc.
- A search for parity violation in the pp total cross section with a longitudinally polarized beam
- Inelastic reactions such as production of  $\pi^+\pi^-$ , etc.

# Physics Results (Yokosawa)

- Structure in the nucleon-nucleon system and dinucleon resonances
- Determination of scattering amplitudes
- Nucleon nucleon elastic scattering at high transverse momentum
- Asymmetries in inclusive proton proton scattering
- Search for parity violation in pp scattering at 6 GeV/c



# Physics Results

- Large spin effects in low energy pp scattering

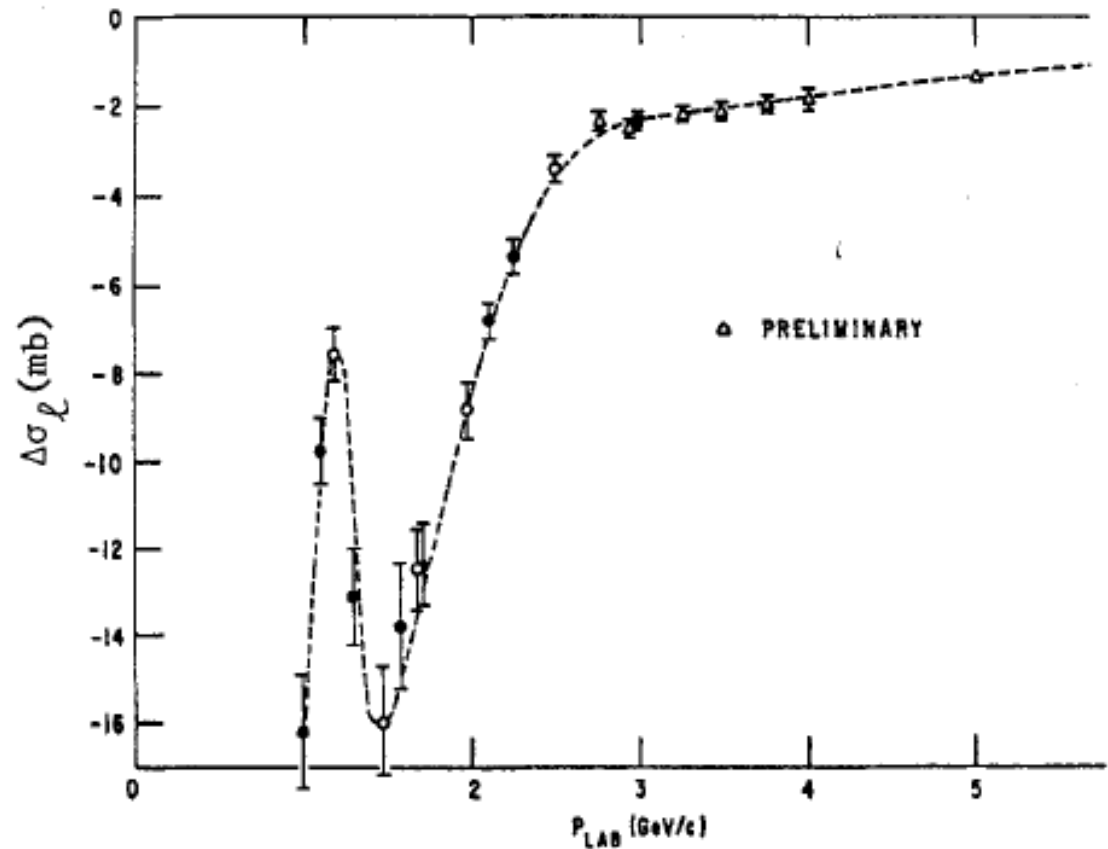
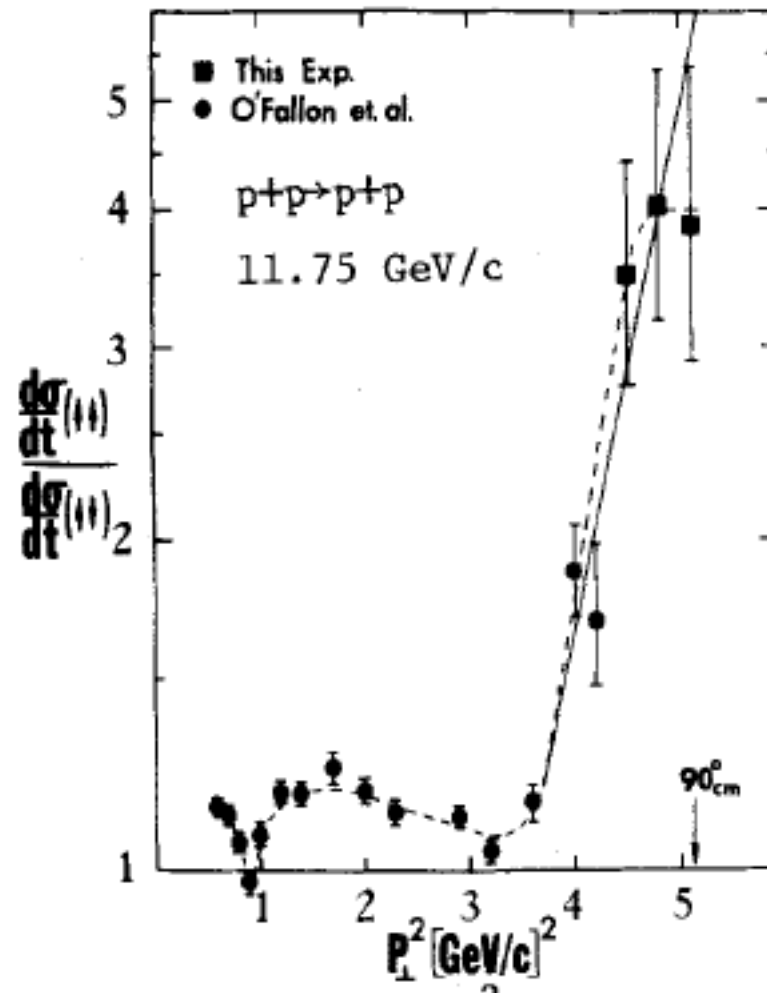


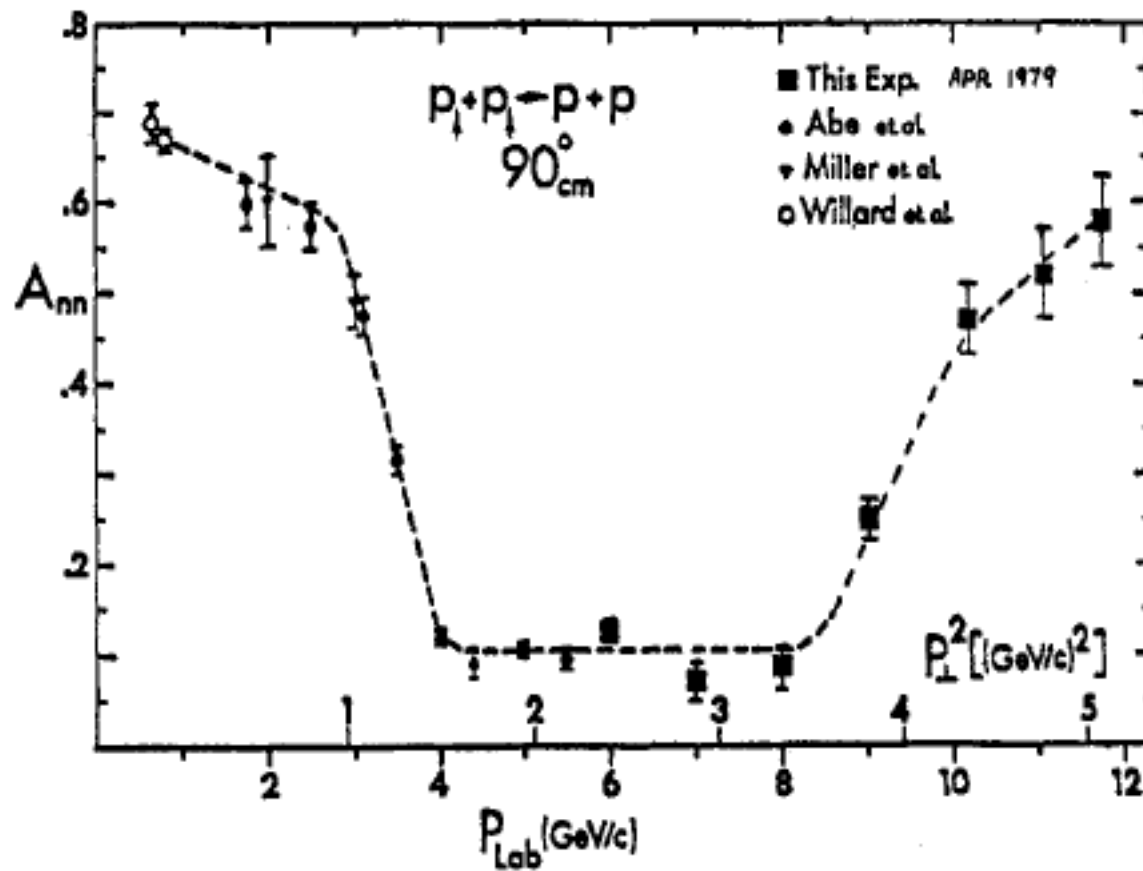
Fig. 5.  $\Delta\sigma_\ell$  for p-p scattering.

# Physics Results

- Unexpectedly large spin dependence in pp scattering at large transverse momenta

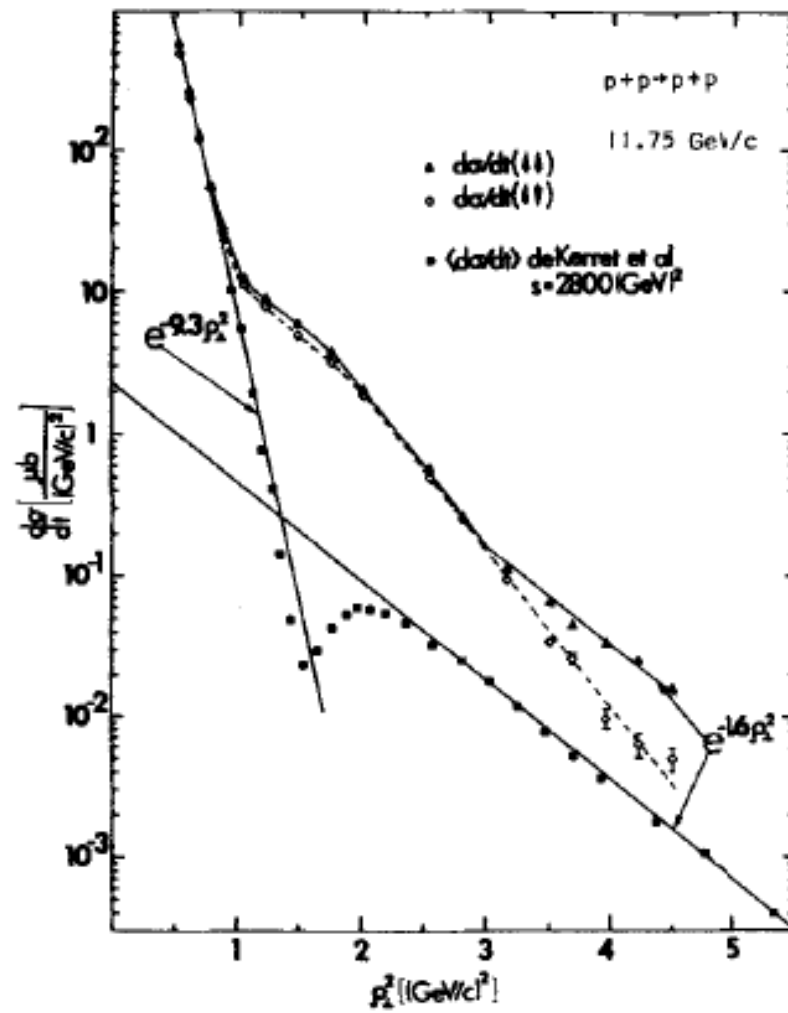


# Physics Results

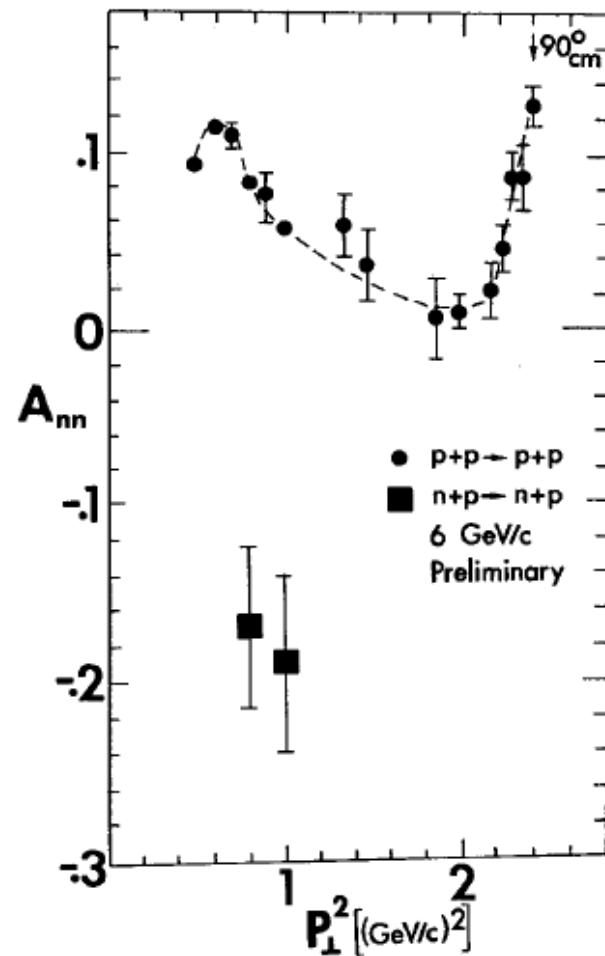




# Physics Results



# Physics Results



# Summary

Observation of structures in the nucleon–nucleon system seems one of the most startling things to happen in the experiments with polarized proton beams. Results of measurements of various observables in the structure region strongly suggest the existence of a number of dinucleon resonances. The large asymmetry observed at high  $p_{\perp}$  is dramatic, and has been suggested by some to be due to the constituent nature of the nucleon. With respect to the pp scattering amplitudes, more than 13 observables have been measured at 6 GeV/ $c$  and this attempt is the first precedent of the scattering-amplitude determination.

Aki Yokosawa, 1980



# Dedication



- Lazarus Gershon Ratner 1923-2000
- Larry taught me physics and much more! A truly kind and gentle man.