Polarized Beams and Experiments at the Argonne ZGS

Marvin L. Marshak, University of Minnesota

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Some Polarized People
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.
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
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
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
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 πp, etc.
- Spin physics was not that popular
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*
ADK is active in AUA
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

- 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

Bob Diebold-no photo
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 π, K, etc.
- A search for parity violation in the pp total cross section with a longitudinally polarized beam
- Inelastic reactions such as production of π⁺π⁻, 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
Large spin effects in low energy pp scattering

Fig. 5. $\Delta\sigma_\ell$ for p-p scattering.
Unexpectedly large spin dependence in pp scattering at large transverse momenta
Physics Results
Physics Results

The figure shows data for the reaction \(p+p\rightarrow p+p\) at an energy of 11.75 GeV/c. The plot displays the dependence of the invariant cross section \(\frac{d\sigma}{dt}\) on the square of the pseudorapidity \(p_t^2\) (in GeV/c²). The data points are labeled as follows:

- **dav'dt**: Measurements by different collaborations.
- **dav'dk**: Data from another collaboration.

The plot includes fits to the data with functions such as \(e^{-0.3p_t^2}\) and \(e^{-0.6p_t^2}\). The energy of the collisions is specified as \(s=2800\) GeV².
Physics Results
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.