INDIANA COOLER (1981 – 2002) – ARCHIVE

The 'Indiana Cooler' was a storage ring for light ions consisting of a circular magnet lattice of about 100 m in circumference. It was part of the Indiana University Cyclotron Facility (IUCF). Initially, the IU Cyclotron delivered the ion beam for the ring; eventually a dedicated Injector Cyclotron was added. The Cooler ring was built specifically for the purpose of exploiting the novel technology of electron cooling which made the use of an internal target possible. For more, see: H.O. Meyer, *The Indiana Cooler: a Retrospective*, Annu. Rev. Nucl. Part. Sci. 2007. 57:1-31

During my involvement with the Cooler, many documents concerning the construction and commissioning of the machine and covering much of the conducted research have accumulated in my files. After some culling and ordering, I have submitted these documents to the **Indiana University Archives**. The material is contained in five boxes. Each box comes with a detailed table of content.
Hans-Otto Meyer, April 2018

Box 3: Polarized Internal Target Experiments (PINTEX)

Plans to install an internal polarized gas target produced by an atomic beam source from Wisconsin University preceded the completion of the Cooler. This section documents the conception, planning and realization of the measurement of elastic scattering of polarized protons on polarized protons (CE35). It includes installation and performance of the ABS. The PINTEX collaboration members were IUCF, Indiana U, U of Wisconsin, U of Western Michigan and Pittsburgh U.

0 History: polarized internal target ABS for IUCF
- Correspondence Haeberli – Meyer on polarized gas targets (8/83)
- Correspondence between Haeberli, Hanna, Igo and Miller (1985)
- Proposal to measure pp spin correlation coefficients at 185 MeV (Ross, 11/91)
- Job list for CE35 (7/92)
- Equipment needs, installation details
- Research with the ABS: the first 2 ½ years (Meyer, Haeberli, 7/93)
- A-region budget request (11/93)

1 A-REGION SETUP

1.1 floor plan, general layout
- alignment (chamber, cell)
- A-region end windows

1.2 scattering chamber
- design, drawings
- outgassing tests
- chamber vacuum
- feed throughs
- nose cone design and test
- new end cap design for 45deg measurement

1.3 detector geometry
- detector positions
- angle restrictions
- hole in F detector

1.4 hardware, beam-related
- tune, worst-case beam envelopes
- beam position monitors
- A-lift combo modification (Sloan 5/9/94)

1.5 various hardware items
- strip chart recorder
- FLIM with position wires, plan for halo positioner

2 DETECTORS

2.1 CE01 detectors
- UV utilization (HOM 3/27/94)
- EA-EB spectra

2.2 Silicon detectors
- Micron Semiconductor: detector orders
- readout electronics (var. prelim. ideas)
- TU Munich electronics
- leakage/noise studies, guard strips
- 241 Am calibration sources
- possible effect of atomic hydrogen (WH 1/12/93)
- Cu grid in front of Silis
- study effect of Cu grid with MC (JH)
- how to set the thresholds (BvP)
- detector dimensions (PVP, HOM)
- sili thickness via punch-through energy

2.3 new E detector (E2)

2.4 new front wire chamber

2.5 45deg detectors

2.6 var. detector hardware
- BGO detector
- E absorber (old data for planning, BvP 12/22/93)

3 ATOMIC BEAM SOURCE
- Status ABS 7/93
- User's manual (Ross, Wise, 6/93), NIM paper
- var. additions, changes after IUCF installation (83 – 84)
- list of parameters for remote control
- new transition units for H and D (7/99)
- possible deuteron polarization states (4/03)

4 STORAGE CELL

4.1 storage cells designs, performance
- pictures and drawings of cells
- three talks by Haeberli

4.2 Cell designs
- CE08 cell (only left – right)
- many machine drawings
- cell alignment: HAF design (Hans' alignment fixture, 12/92),
- support ("Wise") tower

4.3 foils and coating
- teflon foil mounting instructions (AD 2/4/93)
- teflon foil radiation damage
- thin foils, wire mesh: samples, dE/dx, suppliers
- Polyaramide, Kapton, glue for Kapton
- Teflon coating instructions
- Teflon foil thickness measured (Dezarn, Lozowski, 7/94)

4.4 gas dynamics
- MC of gas flow in cell
- unpol gas flow (regulation, needle valve details)

target thickness from flow
target thickness versus D2 flow (HOM, 1/01)

4.5 polarization in cells

4.5.1. wall depolarization and polarimetry for internal targets

4.5.2. spin exchange effects

5 GUIDE FIELDS

planning, coil construction
Pollock's calculations
field along ABS axis, calc, (REP 5/5/94)
localization of B_x combo
shunt for downstream Bx coil
field measurement (TW 5/13/94)
compensation of MF and John's shunt
field mapping along ABS and cell (Lorentz, Wise, Rathmann, 12/95)
general field of a Helmholtz coil (Mathcad)

7 INDIVIDUAL RUNS

7.1. Madison target test (Feb 1993), move to IUCF (May 1993)
7.2. C35A, C35B
7.3. C35C (19-25 Nov 1993)
7.4. C35D (9-17 Feb 1994)
7.5. C35E (29 Mar - 5 Apr 1994)
7.6. C35F (flipper test)
7.7. C35G (14-23 Jul 1994)
7.8. C35H
7.10. checklists (before, after, during run)

8 BEAM

8.1 beam current, energy

energy for all runs (Pancella)
luminosity considerations
PCT performance during CE25
PCT analysis (JH, many entries)
beam lifetime data

8.2 beam polarization

flipper, how to set flipper controls
polarized beam during CE25 (REP 12/30/92)
beam pol analysis using He data (BvP 2/26/94)
data from C35D (AD)
beam up/dn yield ratios (AR 2/28/94)
1 flip/cycle: what does one learn (HOM)
ordering of CIPIOS sextupole permanent magnets

8.3 longitudinal beam polarization

calculations of stable spin direction, proposals for lbp
solenoids (hardware)
steering in C-region (Pollock)
new precession solenoid

8.4 G polarimeter

8.5 down-ramping of beam energy

9 DATA ACQUISITION, CYCLE ORGANIZATION

9.1 electronics

VME front end (future)

trigger condition

9.2 cycle timing
- spin sequence
- unpol target, beam admixture
- spin handling and spin bits

9.3 Polarization flipping analysis
- middle of cycle, fig of merit (calc)
- C35H asymmetry (FLIPCE35.MCD)

9.4 Accumulation of beam from cycle to cycle

10 POLARIZED TARGET PERFORMANCE
- target thickness measured, calculated
- target polarization vs guide field strength
- target polarization after flip of field
- unwanted components
- target pol in C35D (AD)
- yield ratios, different spin states
- meas. pol vs vertex position
- target thickness vs holding field (TR 3/27/95)
- target polarization in CE35H
- polarization reversal vs. time

11 EVENT ANALYSIS
11.1 event definition
- conditions and cuts in spectra
- theta-E cut
- rejection fractions, "efficiency", survey
- scintillator multiplicities (E double fires, TR 5/2/94)
- sign conventions, bit assignements
- banana plot studies

11.2 wire chambers
- wire chamber multiplicities (BvP 4/28/94)
- effect of SUBA and MXMULT (BL 6/10/94)
- WC, beam offsets (PVP, FR)

11.3 silicon detectors
- performance aspects
- position algorithms
- energy, position threshold from He data (BvP 2/26/94)
- voltage dependence of ghost locus population
- gain shifts deduced from α peaks
- big file on position algorithm, determining
- sili_gns.dat input
- sili gain studies (Rathmann 10/26/95)

11.4 analysis without uv chamber (small angles)
- small angles (Rathmann, 11/95)
- vertex reconstruction
- scale drawing of small-angle region

11.5 new track reconstruction (PPTRACK)
- geometric calib.CE35H (Pancella 11/26/94)
- beam position studies
- position and tilt shifts (Lorentz)

12 RESULTS OF TESTS

12.1 results involving the 45deg detectors

- background in 45deg data (BvP 3/7/94)
- sili position for ev9
- 45deg data with sili coincidences (11/4/94)
- evidence of unwanted p_x component (5/4/95)

12.2 phi distribution

- events in phi valley (C35C, AR, 12/11/93)
- phi distribution shifts
- background in phi spectrum (C35C, TR)

12.3 varia

- background studies
- banana peel studies
- δ-rays from Teflon foil
- accidentals (Rinckel 3/1/95)
- beam current dependences (Rinckel 9/26/94)

13 YIELD ANALYSIS

13.1 Strategy, formalism

- basic formalism, analysis strategy (HOM 12/12/93)
- Haeberli formalism, diagonal scaling
- Math of diagonal scaling
- Error analysis when applying diagonal scaling
- Numerical test

13.2 analysis code

- Program YTOA (HOM, 11/69)
- Comparisons with Sperisen and Dezarn

13.3 calibration

- A_y input to analysis code
- Calibration point, extrapolation to 200 MeV
- Normalization procedures

13.4 various topics

- Unwanted polarization components
- Evaluation of unpolarized runs
  - Simulate beam shifts and angle misalignments (Pancella, Hardie, 2/96)
- Absolute theta precision (Pancella, 4/96)
- Averaging over runs
- Non-ideal azimuth angles
- CE35 Simulation code

13.5 analysis summaries and results

- A_{ik} from runs E,D
- A_{ik} from run H (sort 1-3)
- A_{ik} from run G
- which results to include
- CE35 analysis, masterlist and summary
- CE35 analysis: results (Dezarn, 10/95)

14 COLLABORATION MEETINGS

- 4 March 1992
- 20 July 1992
- 22 Jan 1994 (Madison)
- 25 May 1994
- 11 Feb 1995
- 20 May 1995 (Madison)

16 Nov 1995 (IUCF)
5 May 1996 (IUCF)
10 Feb 1996 (Madison)
25 Jan 1997 (Kalamazoo)
15 June 1998 (IUCF)
12 Feb 2000

15 BGO barrel

PINTEX detector extension to improve break-up measurements. We went through with planning and purchased the BGO crystals but never implemented the device. As a group, we decided that it is better, during the final years, to spend time taking data rather than building new equipment.
Status report 8/01
BGO geometrical acceptance study (HOM, 9/01)
Scale drawings
Time plan 7/01
Correspondence between Rinckel and Pancella

16 Ph. D. Theses (not complete)

W.A. Dezarn, Spin-correlation coefficients in $\vec{p}\vec{p}$ elastic scatterin at 197 MeV
B. Lorentz, Measurement of $\vec{p}\vec{p}$ elastic scattering at 197 MeV with longitudinal polarized beam and target