Doctoring Data

Johan de Swart [1], Mart Rentmeester [2], Rob Timmermans [3]

(1) Radboud University Nijmegen

(2) UMC Utrecht

(3) University of Groningen

Contents Part I : np backward scattering

Part I : np backward scattering

1. Introduction to np cross sections
2. np backward scattering
   - Princeton (1974)
   - LAMPF (1978)
   - Freiburg (1978 - 1981 - 1990 - 2000)
   - TRIUMF (1982)
   - Uppsala (1993 - now)
   - IUCF (2005)
3. Adnorm method
4. Doctoring data
5. Conclusion

np cross sections (normalization)

PWA 93 :
- accurate phases, thus
- accurate normalization, because (forget spin)

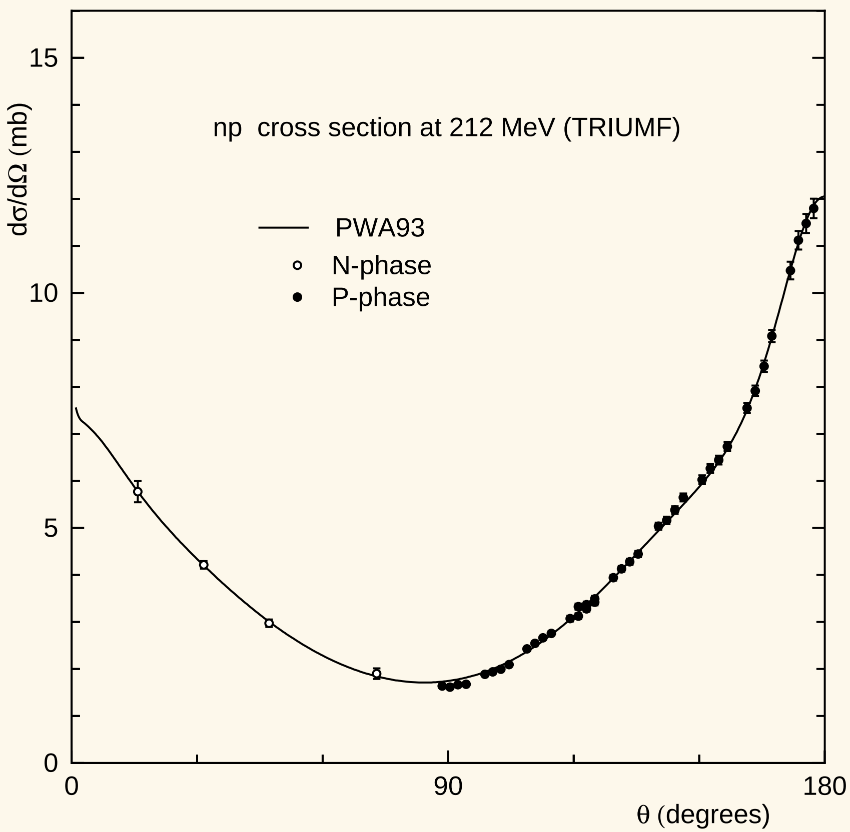
$$\frac{d\sigma}{d\Omega} = |\ f(\theta)\ |^2 \quad \text{and} \quad f(\theta) = \sum (2\ell+1)\, \frac{e^{2i\delta}-1}{2ik}\, P_\ell(\cos\theta)$$

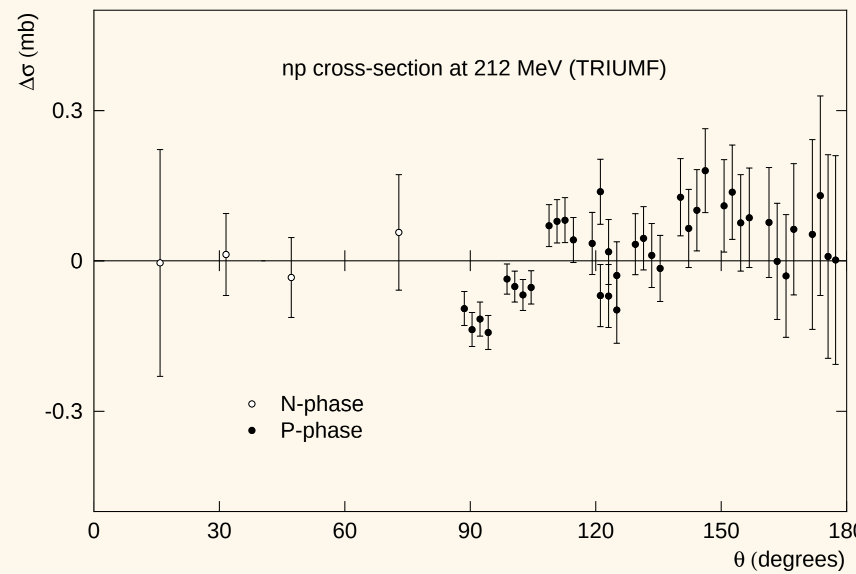
exp :
- measured normalization, datum $(1.0 \pm \Delta N)$,
  should be included in data base
- calculated normalization,
  should NOT be included in data base.
- floated normalization.

Difficulty : Doctoring of data

e.g. Error bars should represent only the statistical errors, but contain almost always a systematic component.

TRIUMF: np cross section at 212 MeV





n-phase: $N_d = 4 \quad \chi^2 = 0.51$

p-phase: $N_d = 39 \quad \chi^2 = 100$

$\Rightarrow \; 6.7 \; sd$

TRIUMF: absolute normalization

- 23 april 1999

  " I know from my own experience at TRIUMF how difficult it is to get the absolute normalisation right.
  We tried very hard and analysed all sorts of effects for 2 years.
  I hope we got it right, but it is one of those places where I have the least confidence. "

- At TRIUMF they measured 3 total cross sections below 350 MeV.
  absolute normalization N = 1.000 (8)
  PWA93: N = 0.954 (7) $\Rightarrow$ 6 s.d.

- At 319 MeV the normalization of the forward data (N-phase) needed renormalization of 8.5 %

TRIUMF: doctoring data

- feb 2001

  " I am unhappy if you renormalise ALL of the data sets.
  Our whole objective was to monitor carefully the neutron intensity, hence obtain ABSOLUTE cross sections.

  (The monitors were ABSOLUTELY normalised.) "

- No errors in relative normalizations can be obtained !!
  Only absolutely normalized data, obviously they think that they can measure normalizations without errors ?!
  RIDICULOUS !

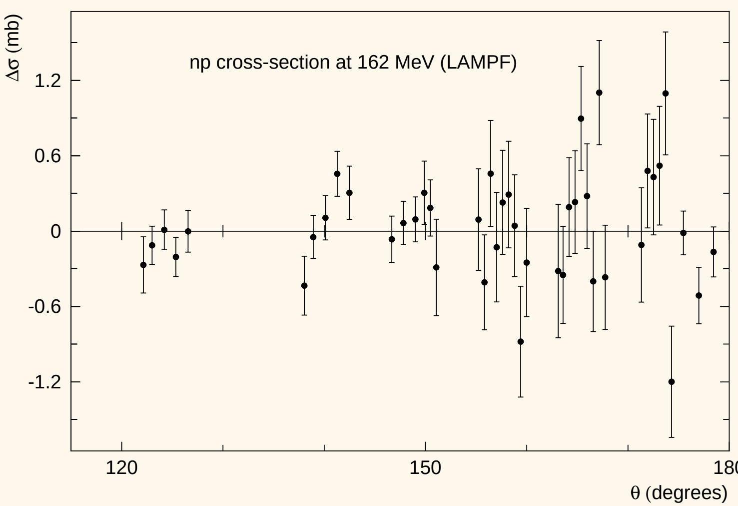
- No statistical errors are available !!
  Only point-to-point errors. These contain systematic components.
  Consequence: An incorrect, lower value for χ^2 .

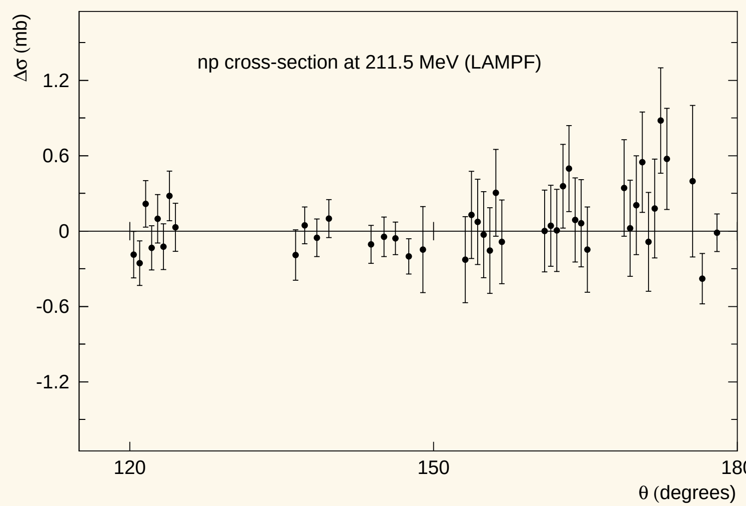
LAMPF: np cross sections

Huge dataset: 162 MeV < T_{lab} < 700 MeV divided over 29 energies

T_{lab} < 350 MeV 11 energies

N_d = 650 $<\chi^2>$ = 639 $\pm$ 39 χ^2 = 714 $\Rightarrow$ 2 s.d.





T_{lab} = 162 MeV N_d = 43
$<\chi^2>$ = 42 $\pm$ 9 χ^2 = 63

T_{lab} = 211 MeV N_d = 43
$<\chi^2>$ = 42 $\pm$ 9 χ^2 = 31

LAMPF: doctoring data

29 data sets with T_{lab} < 700 MeV. Momentum bins of Δp = $\pm$ 20 MeV/c

11 data sets with T_{lab} < 350 MeV

7 data sets with T_{lab} < 270 MeV and non-overlapping angular regions.

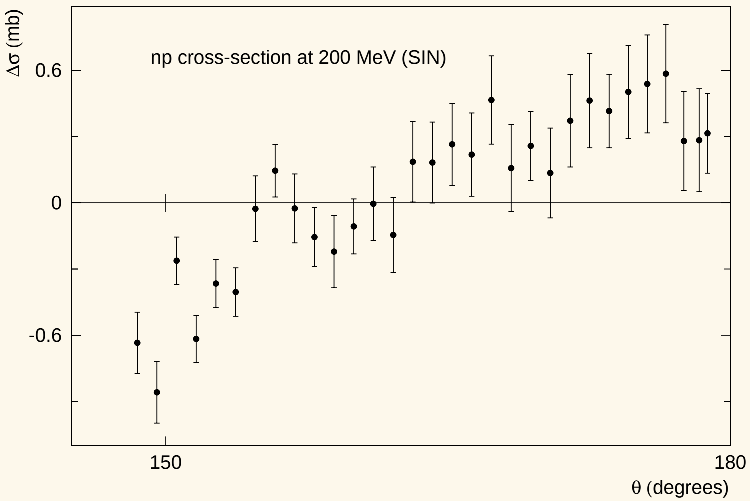
Difficulties with data:

Relative normalization between different angular regions not available.

Data in overlapping angular regions (T_{lab} > 270 MeV) were averaged.

Uppsala group complains about sawtooth behavior of data.

Freiburg: Hürster data (1978)



$$
\begin{aligned}
N_d &= 31 \\
<\chi^2> &= 30 \pm 8 \\
\chi^2 &= 182 \Rightarrow \color{red}{23\ sd}
\end{aligned}
$$

data doctored (Franz 2000):

$$
\begin{aligned}
N_d &= 27 \\
\chi^2 &= 70.6 \Rightarrow \color{red}{6\ sd}
\end{aligned}
$$

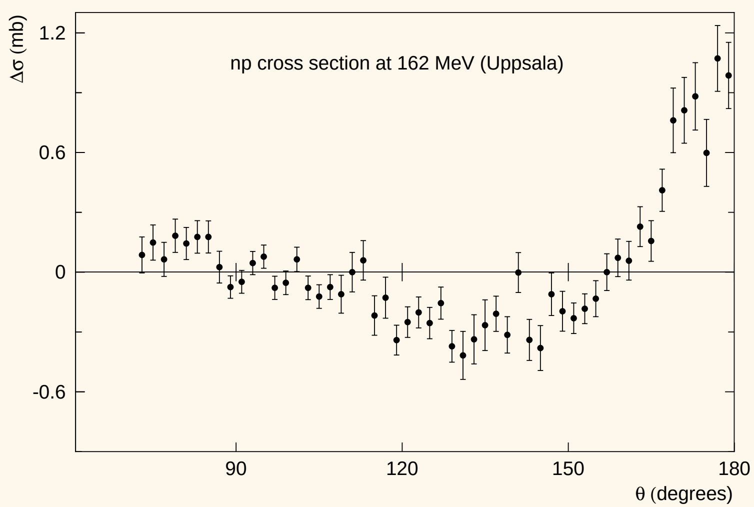
Large data set:

20 energy bins (each 20 Mev wide) with 190 MeV < T_{lab} < 590 MeV

8 energy bins with T_{lab} < 350 MeV centered at

T_{lab} = 200 MeV, 220 MeV, ... , 320 MeV, 340 MeV

Uppsala: np cross section at 162 MeV



Originally:

$N_d = 31$ and $119 < \theta < 180$

PWA93:

$< \chi^2 > = \;\; 30 \pm 8$

$\chi^2/N_d \;\; = 292/31 \Rightarrow \;\; 33\ s.d.$

refit:

χ^2(data) goes down 27.6

χ^2(rest) goes up 7.4

Complaint by experimentalist: . . . .

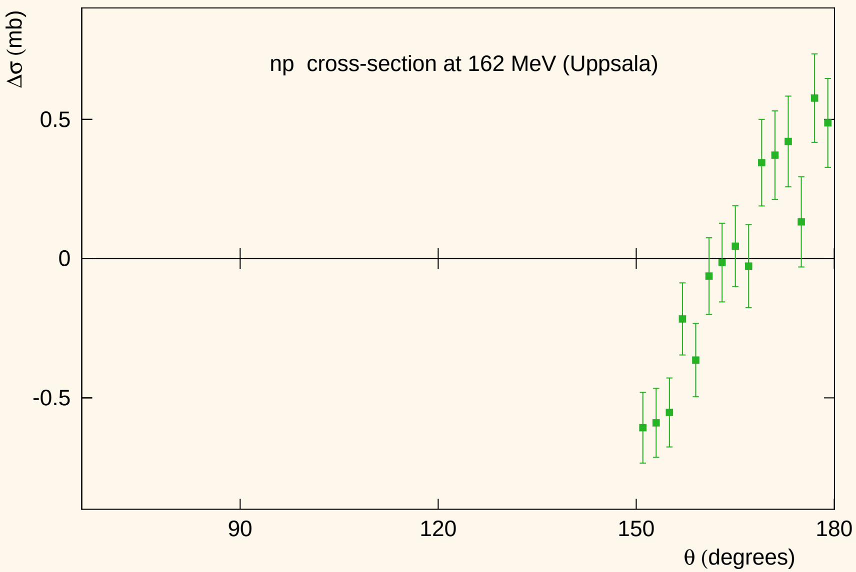
" These data were rejected by applying controversial criteria "

Complaint by us: . . . .

data not as measured, but data were doctored !

data contain LARGE systematic errors . .

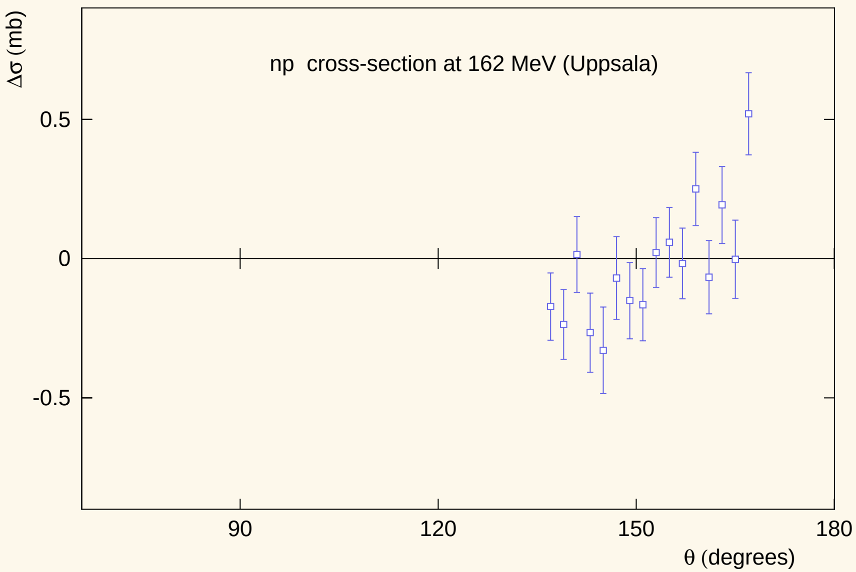
Uppsala: Nijmegen normalization



N_d = 15 χ^2 = 116.6

$\Rightarrow$ 19 s.d.

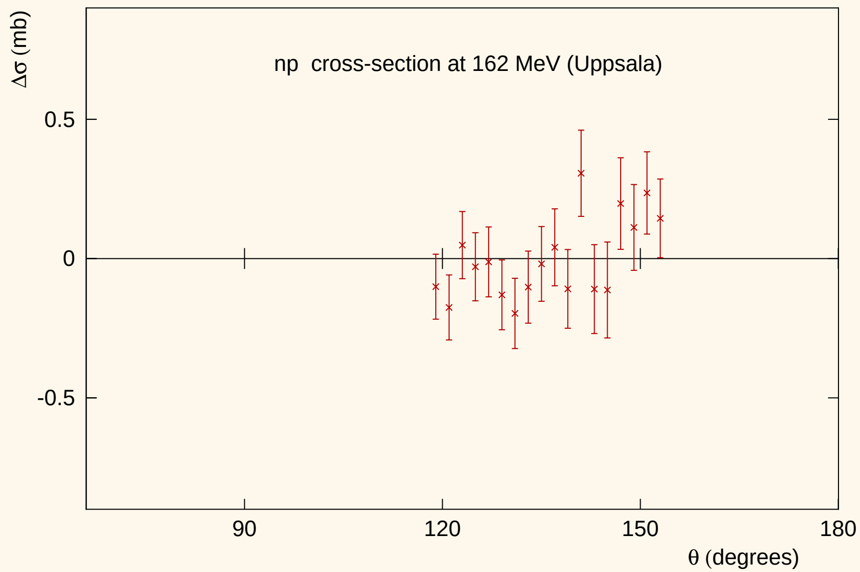
Uppsala: Nijmegen normalization



N_d = 16 χ^2 = 35.2

$\Rightarrow$ 3.7 s.d.

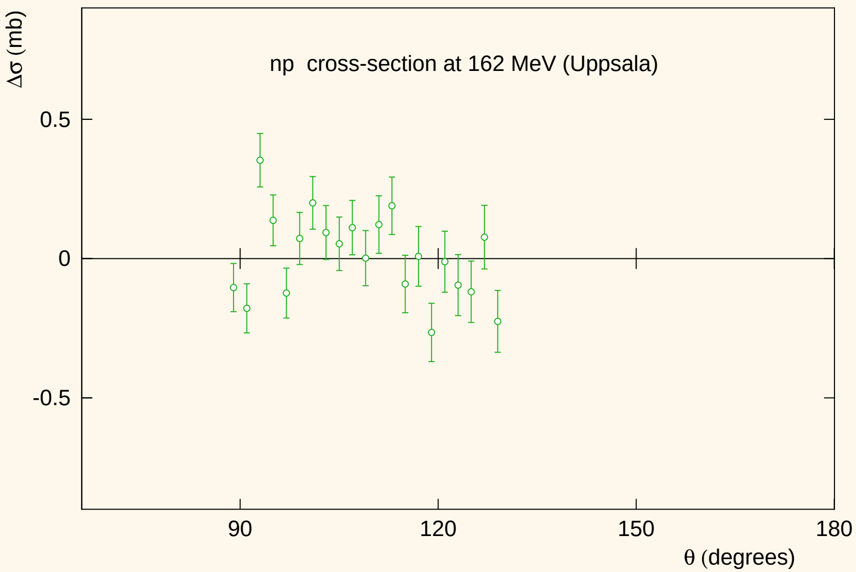
Uppsala: Nijmegen normalization



N_d = 18 $\quad\chi^2$ = 18.5

$\Rightarrow$ 0.3 s.d.

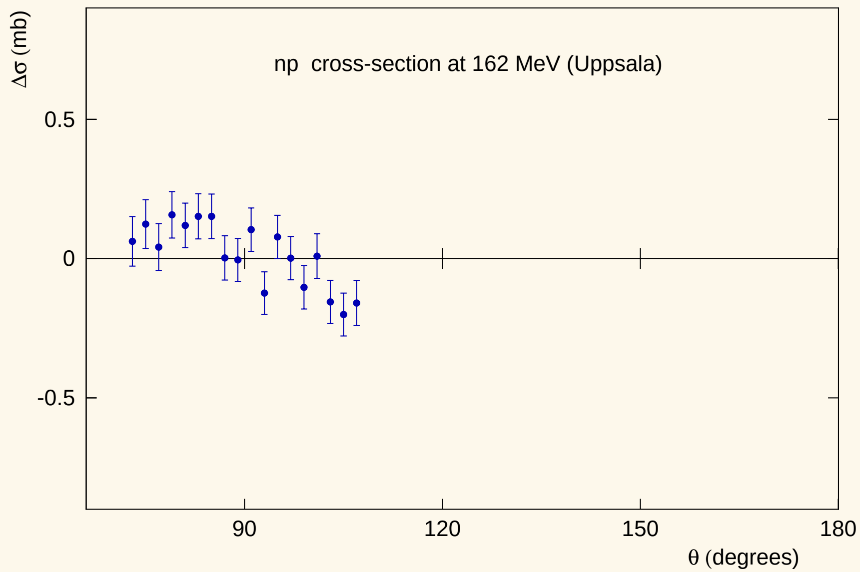
Uppsala: Nijmegen normalization



$N_d = 21 \quad \chi^2 = 49.4$

$\Rightarrow$ 4.6 s.d.

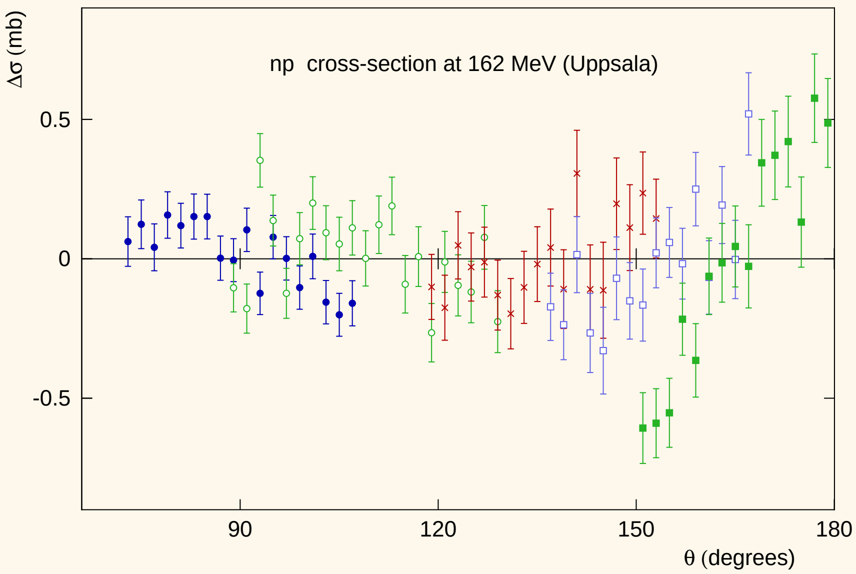
Uppsala: Nijmegen normalization



N_d = 18 $\quad \chi^2$ = 37.5

$\Rightarrow$ 3.5 s.d.

Uppsala: Nijmegen normalization

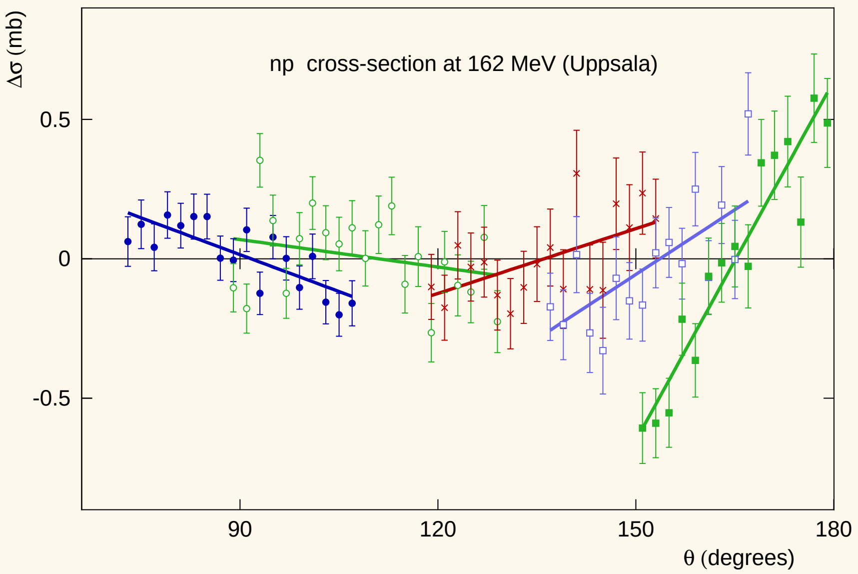


N_d = 15 χ^2 = 116.6
N_d = 16 χ^2 = 35.2
N_d = 18 χ^2 = 18.5
N_d = 21 χ^2 = 49.4
N_d = 18 χ^2 = 37.5

N_d = 88 $< \chi^2 >$ = 83 $\pm$ 13

χ^2 = 257 $\Rightarrow$ 13 s.d.

Uppsala: straight lines

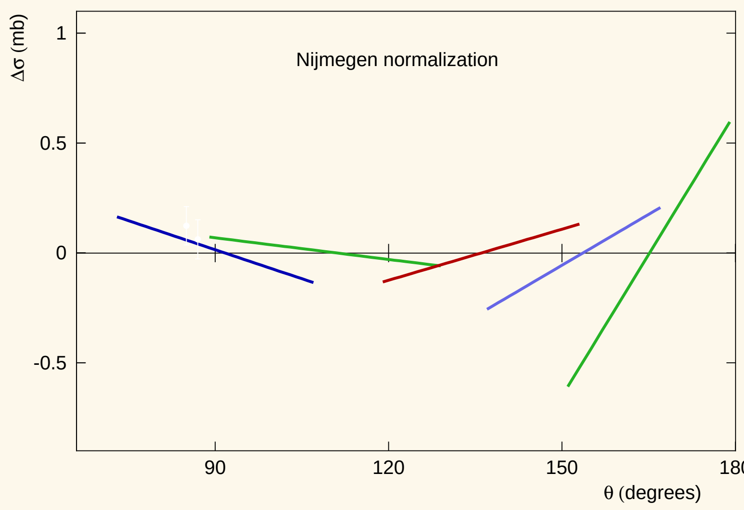


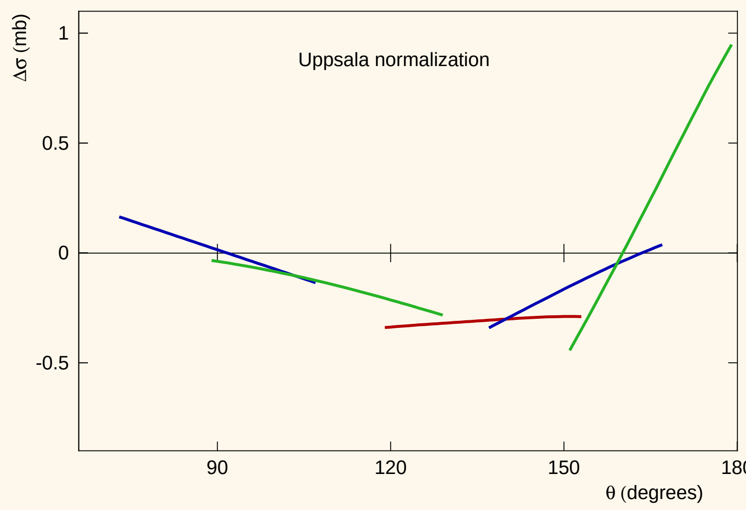
$$\chi^2 = \begin{cases} 116.6 \Rightarrow 10.5 \\ 35.2 \Rightarrow 16.5 \\ 18.5 \Rightarrow 11.8 \\ 49.4 \Rightarrow 45.7 \\ 37.5 \Rightarrow 14.9 \\ \\ 257.2 \Rightarrow 99.4 \end{cases}$$

$$\Delta\sigma = a + b\,(\theta - \theta_0)$$

$$\text{slope } b = \begin{cases} 0.043\ (4) \\ 0.016\ (4) \\ 0.008\ (3) \\ -0.003\ (2) \\ -0.009\ (2) \end{cases}$$

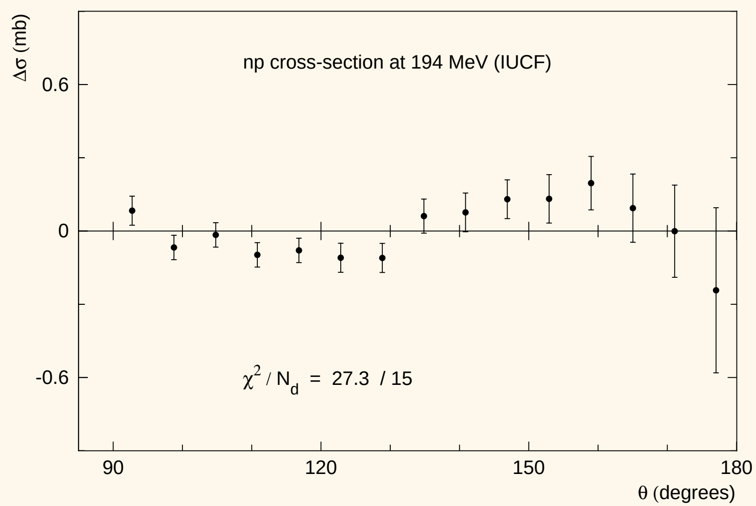
Uppsala: Normalization





- Normalizations (5) were not measured, but doctored .
- Relative normalizations (4) determined by assuming that cross section is continuous . Slope is still discontinuous.
- Data in overlapping regions were averaged .
- Absolute normalization calculated from other sources.
- Data are real sick. They need "radical DOCTORING" .

IUCF: np cross section at 194 MeV



N$_d$ = 15 $\quad < \chi^2 >$ = 14 $\pm$ 5

PWA93: χ^2 = 27 refit χ^2 = 26 $\Rightarrow$ 2.4 s.d.

χ^2 = 26 is considered acceptable ,

when the errors are purely statistical.

What to do ?

- Data from Princeton, Freiburg, Uppsala $\Rightarrow$ Garbage Pail ????
- How much money was involved in doing these experiments ?
  Who wants to guess ?
- Proposed method to save these data from oblivion.
  Angle dependent normalization. Adnorm method.
- No positive response from experimentalists involved in these experiments.

  Only " ... they propose radical DOCTORING ..."
- Conclusion : Let us do this radical doctoring.

  Apply euthanasia to these data sets .

Adnorm Method

The data are in the interval $\theta_{min} < \theta < \theta_{max}$
and $\theta_m = (\theta_{max} + \theta_{min}) \,/\, 2$ is the middle of this interval.

The adnorm $N(\theta)$ is then

$$N(\theta) = N_0 + N_1\,(\theta - \theta_m) + N_2\,(\theta - \theta_m)^2 + \;...$$

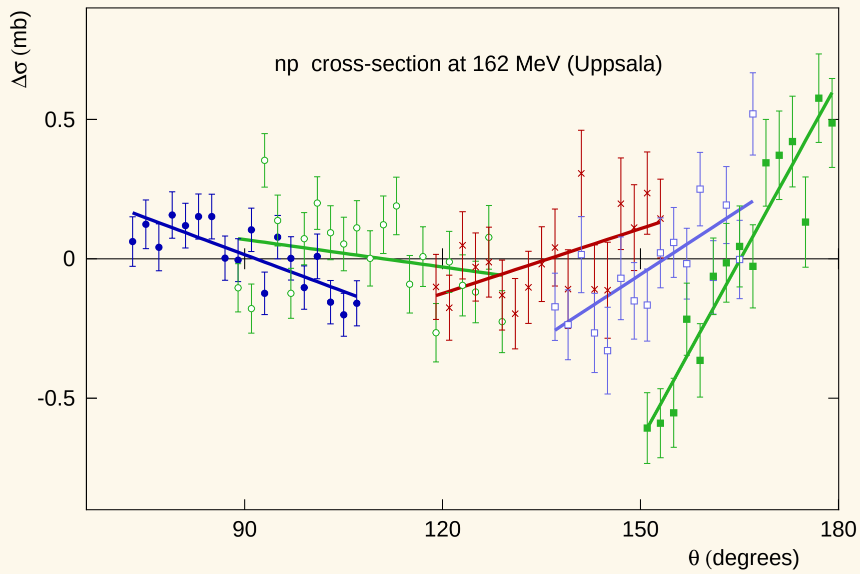
The parameters $(N_1,\, N_2,\, ...\,)$ are only taken unequal to zero,
when they are more than 3 s.d. away from zero.
When they are significant.

Notation: Only $N_0 \quad\Rightarrow\quad \chi^2_0$

$$N_0,\; N_1 \quad\Rightarrow\quad \chi^2_1$$

$$N_0,\; N_1,\; N_2 \quad\Rightarrow\quad \chi^2_2$$

Doctoring the Uppsala data



- N_d = 15 $\quad \chi^2_0$ = 117 $\quad \Rightarrow \quad \chi^2_1$ = 20 $\quad \Rightarrow \quad \chi^2_2$ = 9
- N_d = 16 $\quad \chi^2_0$ = 35 $\quad \Rightarrow \quad \chi^2_1$ = 15
- N_d = 18 $\quad \chi^2_0$ = 18
- N_d = 20 $\quad \chi^2_0$ = 35
- N_d = 18 $\quad \chi^2_0$ = 38 $\quad \Rightarrow \quad \chi^2_1$ = 15

Doctoring the Freiburg data

4 experiments between 1978 and 2000.

8 energy bins (20 MeV wide) with T_{lab} < 350 MeV

exp I	N_d = 216	χ^2_0 = 522	$\Rightarrow$	χ^2_p = 179	for 14 adnorm pars
exp II	N_d = 245	χ^2_0 = 471	$\Rightarrow$	χ^2_p = 239	for 10 adnorm pars
exp III	N_d = 212	χ^2_0 = 516	$\Rightarrow$	χ^2_p = 260	for 10 adnorm pars
exp IV	N_d = 186	χ^2_0 = 630	$\Rightarrow$	χ^2_p = 153	for 11 adnorm pars

Look at the problem this way.   In total 959 data.

32 normalizations	N(d.o.f.) = 927	χ^2_0 = 2139
45 adnorm pars	N(d.o.f.) = 882	χ^2_p = 831

Information contained in 882 pieces of data is still there !!

Doctoring the Princeton data (1974).

9 energy bins with T_{lab} < 350 MeV

N_d = 156	$<\chi_0^2>$ = 147 $\pm$ 17	χ_0^2 = 582	$\Rightarrow$ 26 s.d.
14 adnorm pars	$<\chi_p^2>$ = 133 $\pm$ 16	χ_p^2 = 195	$\Rightarrow$ 4 s.d.

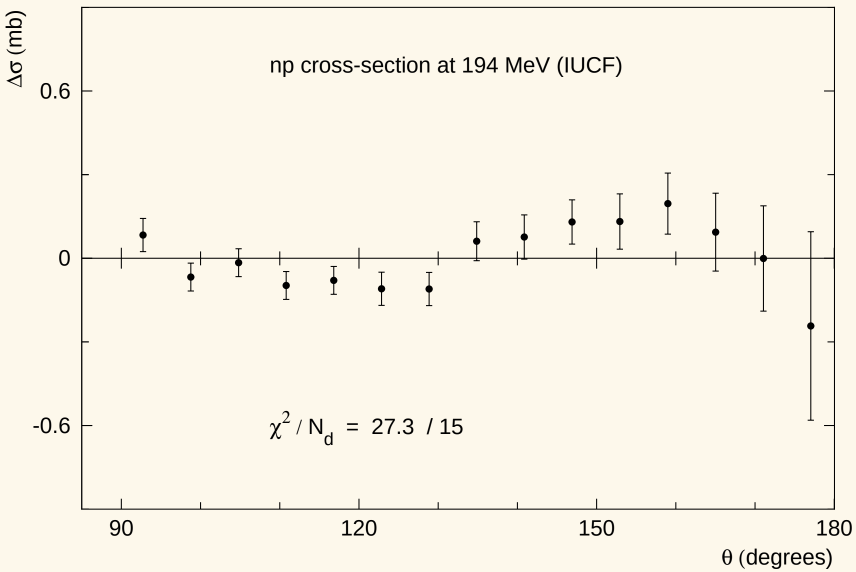
Per adnorm parameter a drop in χ^2 of about 27.

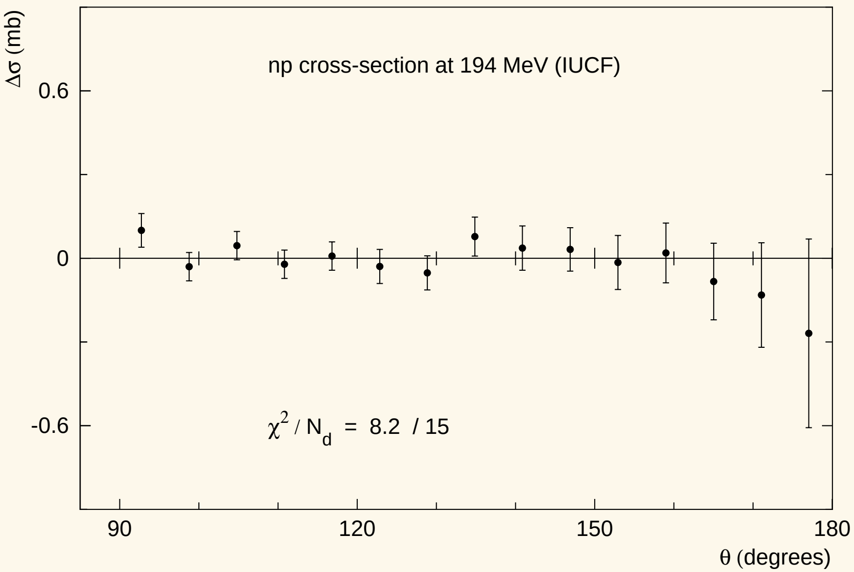
Let us be lenient and doctor some more:

Throw away 3 data points that deviate more than 2.5 s.d.
(this limit was 3 s.d.).

N_d = 153	$<\chi_0^2>$ = 144 $\pm$ 17	χ_0^2 = 540	$\Rightarrow$ 23 s.d.
14 adnorm pars	$<\chi_p^2>$ = 130 $\pm$ 16	χ_p^2 = 169	$\Rightarrow$ 2.4 s.d.

Doctoring the IUCF data ?





N_d = 15 PWA93: χ_0^2 = 27

Adnorm: χ_1^2 = 8.2

$N(\theta) = N_0\ [\,1 + \alpha\ \sin(4\,\theta)\,]$

N_0 = 0.9954 (44)

N_0 = 0.9987 (45)

α = 0.027 (6)

Conclusion

$\pm$ 2000 data (in order of quality ?)

$$\left.\begin{array}{lr} \text{IUCF} & 16 \\ \text{TRIUMF} & 90 \\ \text{LAMPF} & 650 \end{array}\right\} \text{756 data} \qquad 38\,\%$$

$$\left.\begin{array}{lr} \text{Freiburg} & 959 \\ \text{Princeton} & 156 \\ \text{Uppsala} & 100 \end{array}\right\} \text{1215 data} \qquad 62\,\%$$

Contents Part II : πNN-coupling constants

Part II : πNN-coupling constants

1. Historical Introduction
   - Situation in general
   - Situation in Nijmegen
   - Situation around 1990
2. $\pi^{\pm}$pn coupling constants

General situation

• $\gamma\, p \;\rightarrow\; n\, \pi^+$	1950	Ashkin		$f_c^2 \sim$ 0.3
	1954	Bernandini		f_c^2 = 0.065
• $NN \;\rightarrow\; NN$	1952	Lévy		f^2 = 0.054
	1955	Gartenhaus		f^2 = 0.089
	1958	Chew	backward np	
	1959	Cziffra et al.		0.06 < f_c^2 < 0.07
	1968	MacGregor et al.		f_p^2 = 0.081 (5)
	1987	Bergervoet et al.		f_p^2 = 0.0725 (6)
• $\pi N \;\rightarrow\; \pi N$	1953	Chew		f_c^2 = 0.058
	1957	Gilbert (NP med)		f_c^2 = 0.084
	1958	Dave Jackson		f_c^2 = 0.08 (2)
	1973	Bugg et al.		f_c^2 = 0.079 (1)
	1990	Arndt et al.		f_c^2 = 0.0735 (15)
• $\overline{p}\, p \;\rightarrow\; \overline{n}\, n$	1958	Chew	charge exchange	
	1991	Timmermans et al.		f_c^2 = 0.0751 (17)

Situation in Nijmegen

- 1958 – 1974 Interest mainly in YN potentials.
  Couplings $\pi\Lambda\Sigma$, $\pi\Sigma\Sigma$, and πNN.
- 1971 – 1983 " Black Forest Meetings " (Höhler et al.) and
  " Compilation of low-energy parameters and coupling constants. "
- 1975 Nijmegen D potential (NN and YN). f^2 = 0.074
  Used Livermore PWA 1968. χ^2 better than for the Reid potential.
- 1978 Start of Nijmegen PWA.
- 1983 FB - conference in Karlsruhe.

  " We believe that f_p^2 is probably more in the neighborhood
  of 0.075 than of 0.080 "

- 1987 pp PWA 87 f_p^2 = 0.0725 (6) (without magn. moment)
  m_0 = 134.7 $\pm$ 2.1 MeV (134.9766 MeV)
  pp PWA 91 f_p^2 = 0.0751 (6)

Situation around 1990

- 1987 πN - scattering f_c^2 = 0.079 (1)
  pp - scattering f_p^2 = 0.073 (1)

  Conclusion 1 : Large breaking of Charge Independence.

- 1990 pp - result : f_p^2 = 0.073 (1)
  Large CIB : Very unlikely

  Conclusion 2 : πN - result must be wrong

Research topics in Nijmegen around that time

1. $p\,p$ - PWA	Stoks,	de Kok
2. np - PWA	Bergervoet et al.,	Klomp
3. backward np	Rentmeester	
4. $\overline{p}\,p \;\rightarrow\; \overline{n}\,n$	Timmermans	
5. study CIB in cc	Timmermans	

$\pi^{\pm}$*pn-coupling constants*

type	N_d	χ^2	$1000\ f_c^2$
$\sigma_t, \Delta\sigma_T, \Delta\sigma_L$	252	230	75.1 (1.1)
$d\sigma/d\Omega$	1350	1363	75.6 (0.6)
A_y	738	718	74.8 (0.4)
$A_{yy},\ A_{zz}$	86	71	74.4 (0.6)
D_t	43	40	75.1 (1.1)
$R_t,\ R_t',\ A_t,\ A_t'$	43	55	73.1 (1.0)
All	2512	2477	74.8 (0.3)

$\pi^{\pm}$*pn-coupling constants*

LAMPF data:

$T_{lab}(MeV)$	N_d	χ^2	f_c^2
162	43	60	69.9 (3.0)
178	44	44	70.2 (3.1)
211	43	31	72.8 (3.3)
229	49	62	69.5 (3.6)
247	53	39	69.7 (9.3)
304	80	80	74.6 (3.4)
324	82	92	78.9 (4.3)
344	80	75	74.8 (3.9)

Part III : EFT

- Intermediate-range physics is treated very poorly.
  Contributions of mesons like $\eta',\ \sigma,\ \mathrm{a}_0(980),\ \mathrm{f}_0(980),\ \rho,\ \omega$
  are frozen out.
  The spatial extensions of the nucleons and mesons are neglected.
  This affects the shape of the intermediate-range potential !
- Applying χPT to calculate a good NN-potential is therefore
  doomed to failure !
  The coupling constants c_3 and c_4, (in χPT called LEC's) ,
  depend on the order, and on T_{max}, and c_3 comes out too low.
  Such potentials are perhaps good to say $T_{max} \sim$ 5 MeV (?).
  These are the so called "Third (De)generation potentials" ?
- Including higher orders like { N . . . NLO }
  $\Rightarrow$ introduces MORE parameters (easier to get better fits),
  $\Rightarrow$ but does not necessarily introduces better physics.

Closing Remarks

THANKS FOR YOUR PATIENCE.

NO QUESTIONS ALLOWED.

HAVE A NICE LUNCH .