Nuclear Physics Spring Meeting, Cologne March 8-12, 2004

@

Spinobservables in Proton-Proton Elastic Scattering

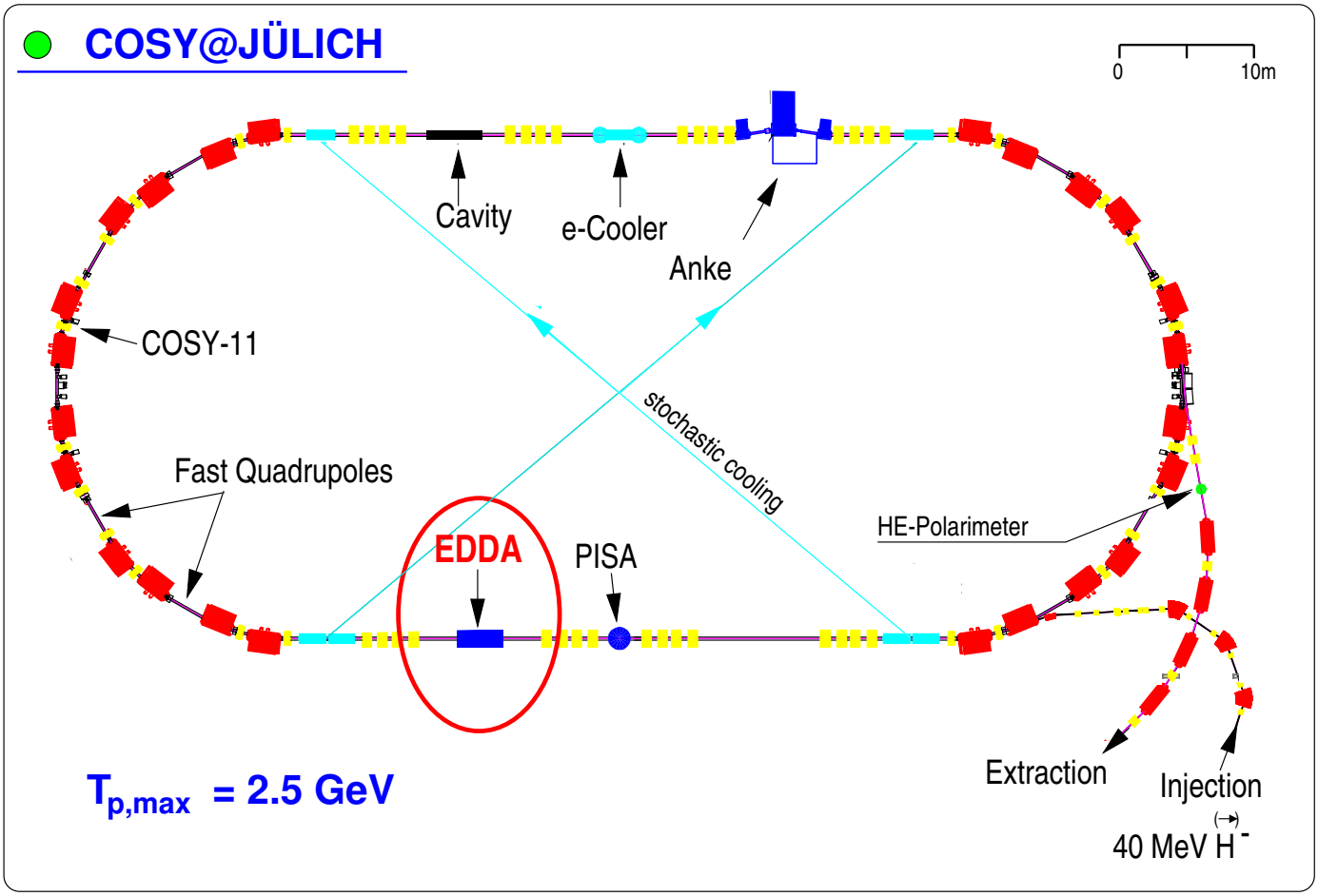
H. Rohdjeß, ISKP Uni-Bonn
für die EDDA-Kollaboration (Bonn, Hamburg, Jülich)

$\overset{(\rightarrow)}{p}\ \overset{(\rightarrow)}{p} \longrightarrow p\ \ p$ $\quad T_p = 0.25 \ldots 2.6$ GeV

$\frac{d\sigma}{d\Omega}$	A_N	A_{NN}	A_{SS}	A_{SL}

Experimental Technique

COSY@JÜLICH



$T_{p,max}$ = 2.5 GeV

internal experiment

p + CH_2 fiber	→	$\frac{d\sigma}{d\Omega}$	√
p + $\vec{p}$ atomic beam	→	A_N	√
$\vec{p}$ + $\vec{p}$ atomic beam	→	A_{NN} A_{SS} A_{SL}	(√)

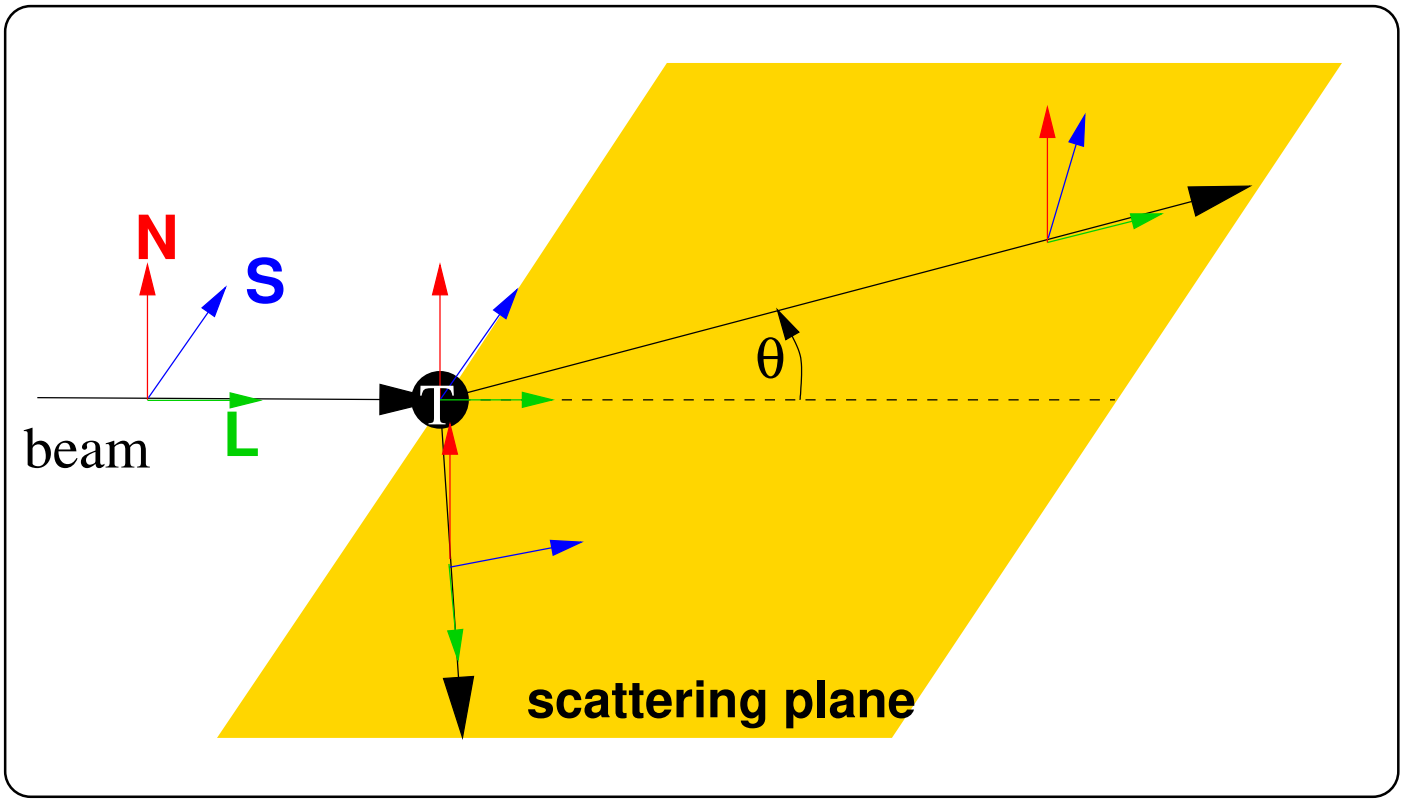
excitation functions

DAQ during acceleration / (deceleration)

T_p = 300 .... 2500 MeV in 2 s

small energy steps p p → B_2 → p p

Γ? W_R?



Phase Shift Analysis (PSA)

- **partial wave decomposition**

$$S_J = e^{2i\delta_J} \quad ; \quad \vec{J} = \vec{L} + \vec{S}$$

- **constraints**

e.g.: $L > L_{max}$: OPE

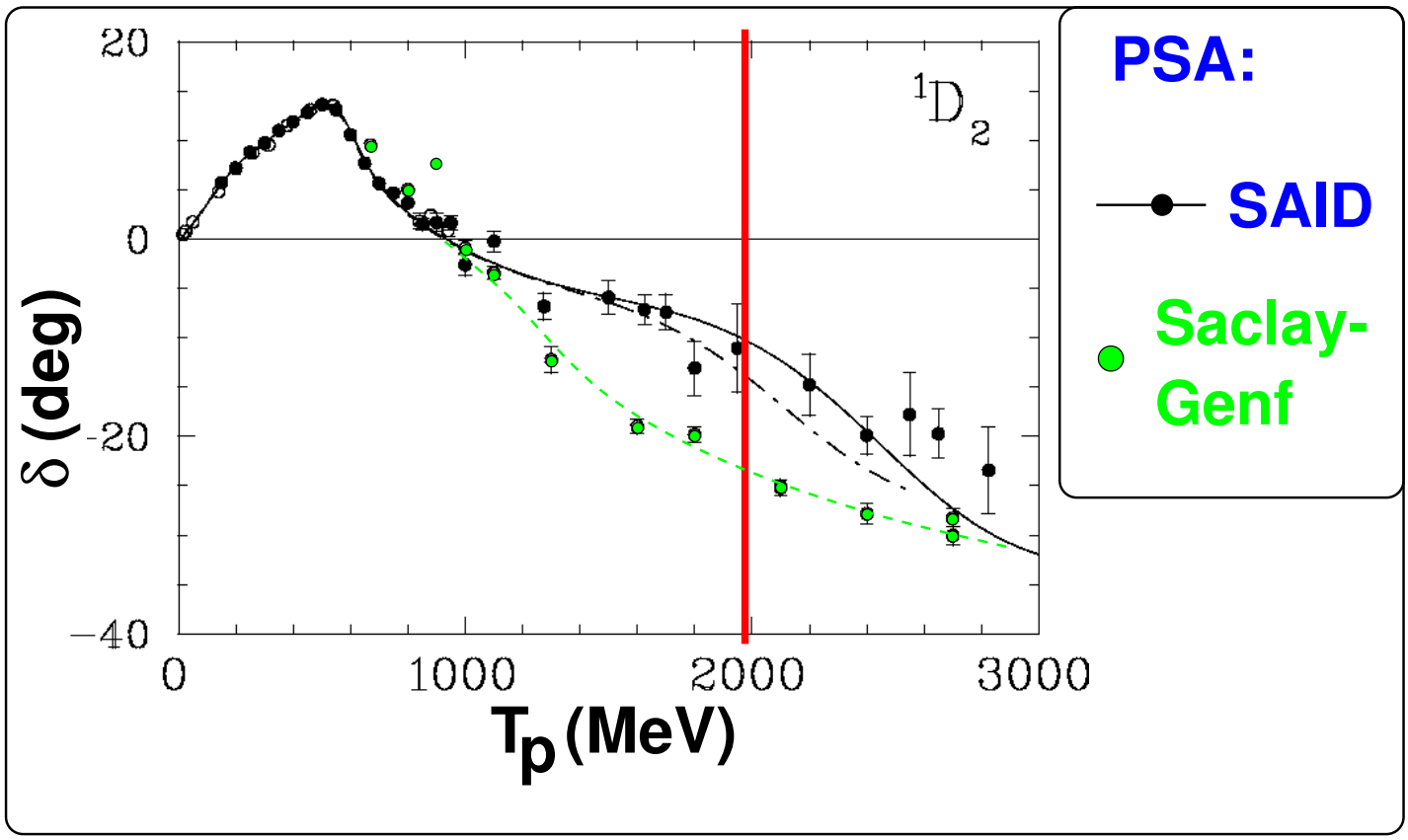
➡ **predicitive power !!**

e.g. VPI (SAID) R. Arndt et al.

$T_p \in$ 0-3 GeV : 23000 / 12000 pp / np data points

⟷ **theory**

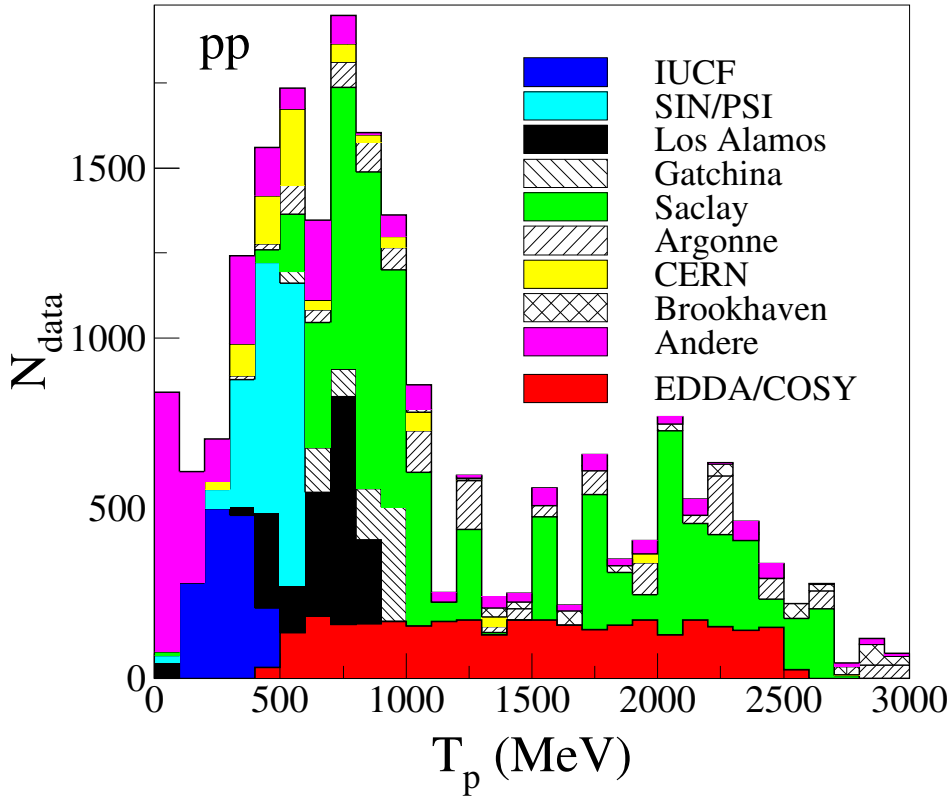
ambiguities in phase shifts

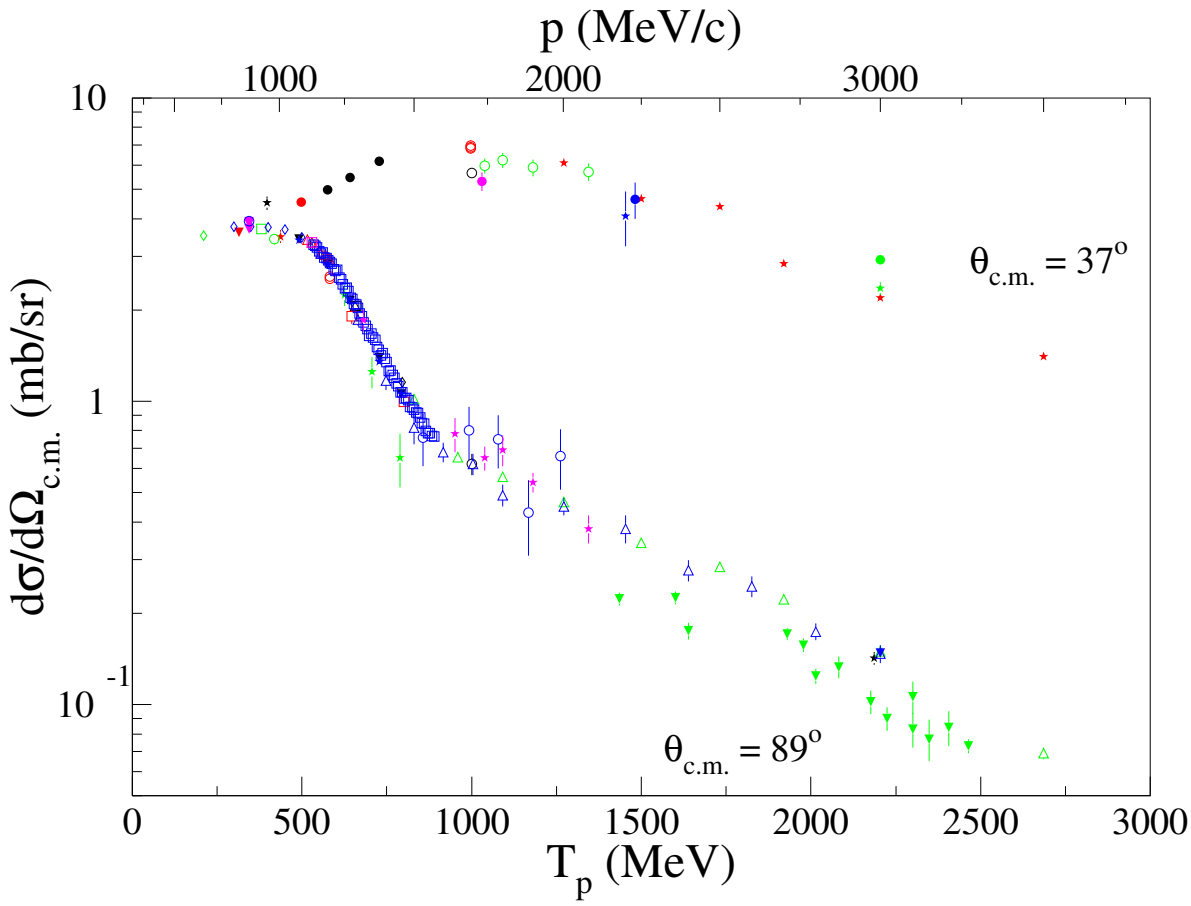


Bystricky, Lechanoine-Leluc, Lehar Eur. Phys. J. C4, 607 (1998)

Arndt, Strakovsky, Workman, Phys. Rev. C62, 034005 (2000)

NN Database

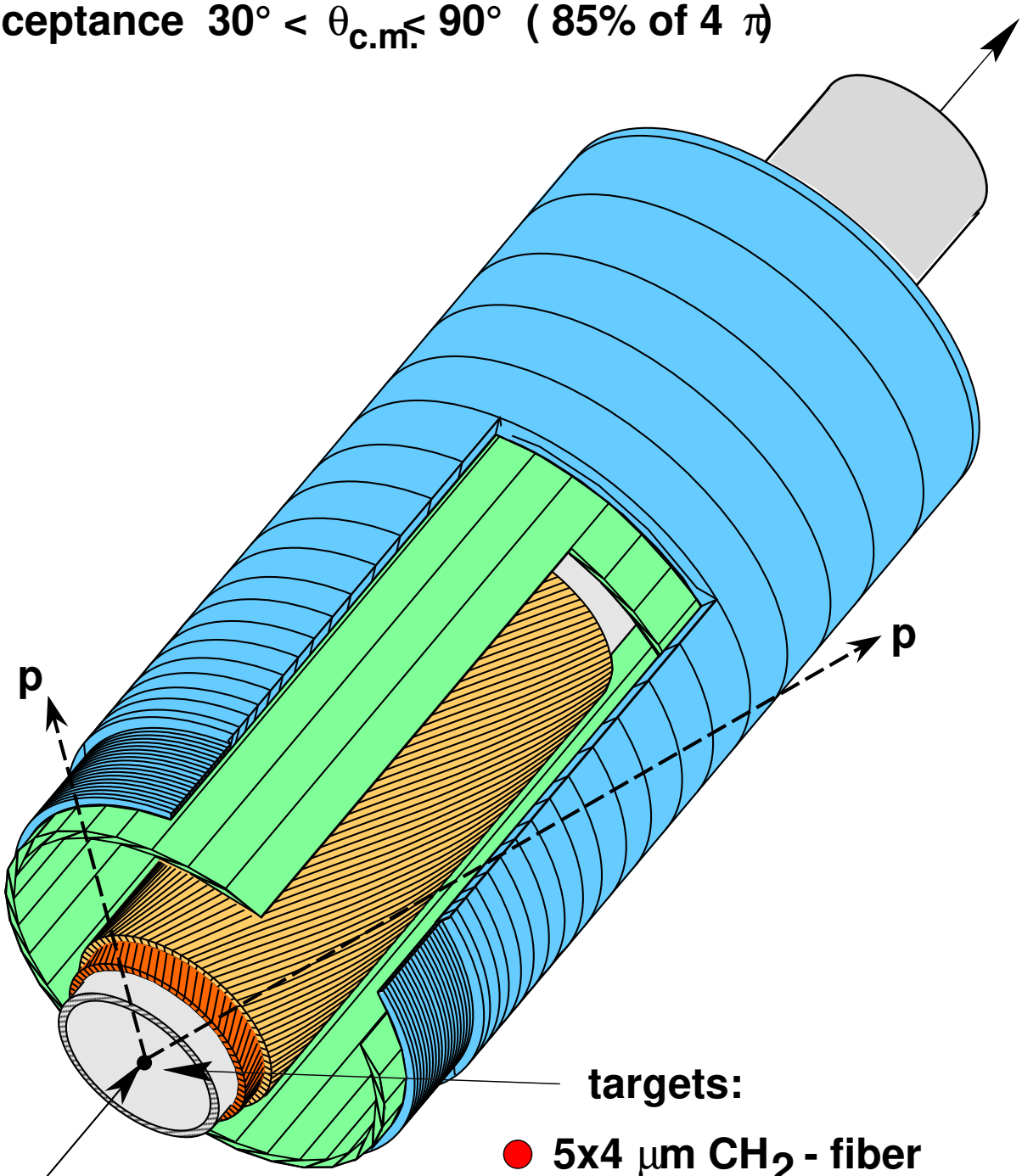

pp
IUCF
SIN/PSI
Los Alamos
Gatchina
Saclay
Argonne
CERN
Brookhaven
Andere
EDDA/COSY
N_{data}
0
500
1000
1500
0
500
1000
1500
2000
2500
3000
T_p (MeV)


p (MeV/c)
1000
2000
3000
10
1
10^{-1}
$d\sigma/d\Omega_{c.m.}$ (mb/sr)
$\theta_{c.m.} = 37^o$
$\theta_{c.m.} = 89^o$
0
500
1000
1500
2000
2500
3000
T_p (MeV)

EDDA@COSY: Detector

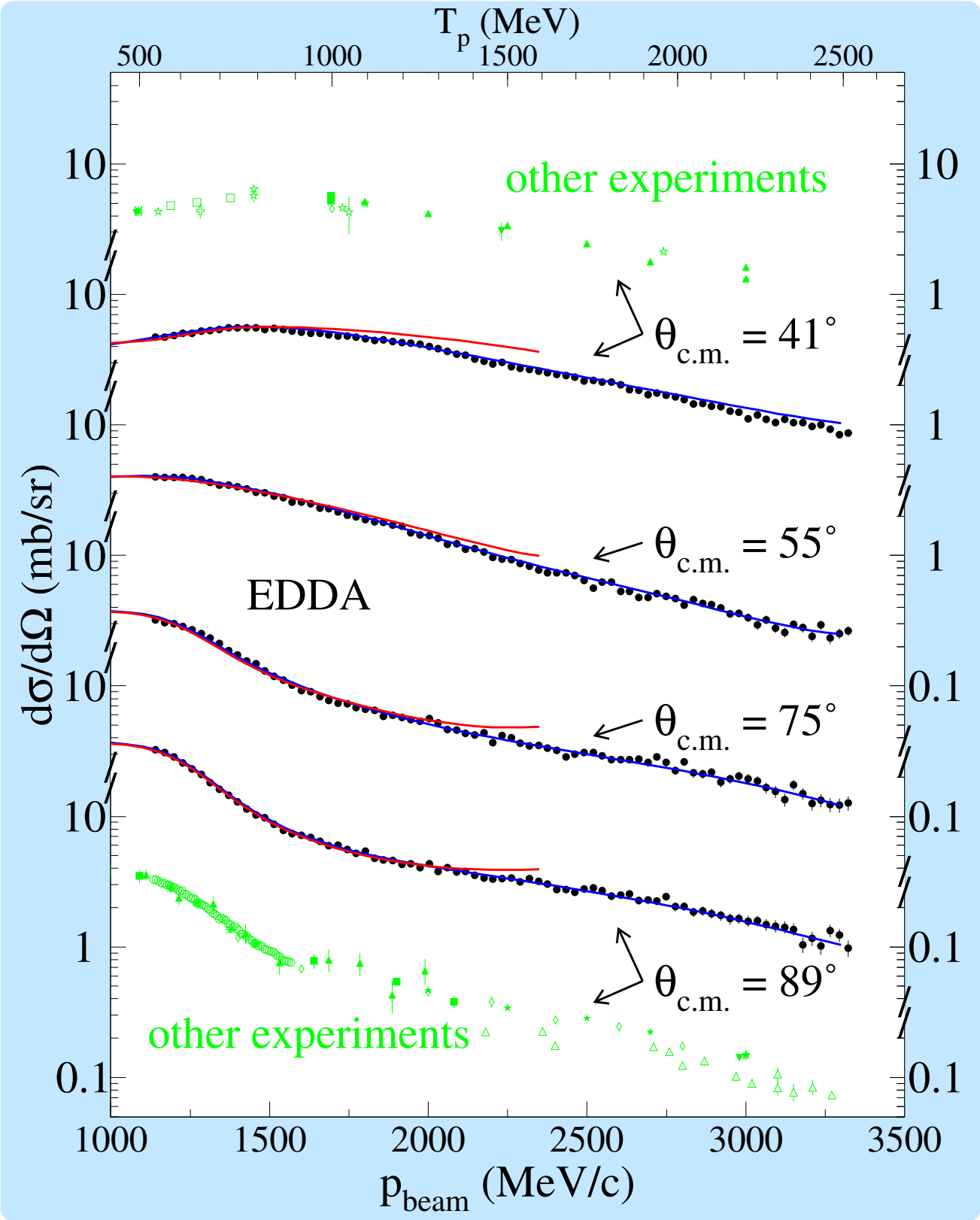
Bonn,Hamburg,Jülich

- acceptance 30° < $\theta_{c.m.}$ < 90° (85% of 4 π)



EDDA Results: $\frac{d\sigma}{d\Omega}$

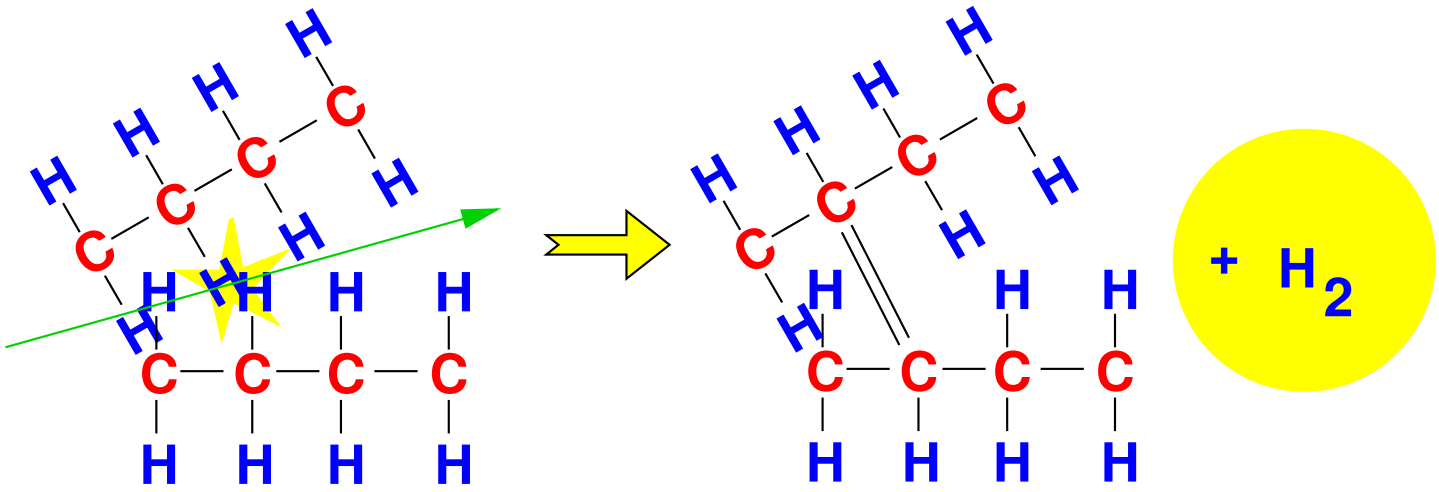
D.Albers et al.*Phys. Rev. Lett.* **78**, 1652 (1997)



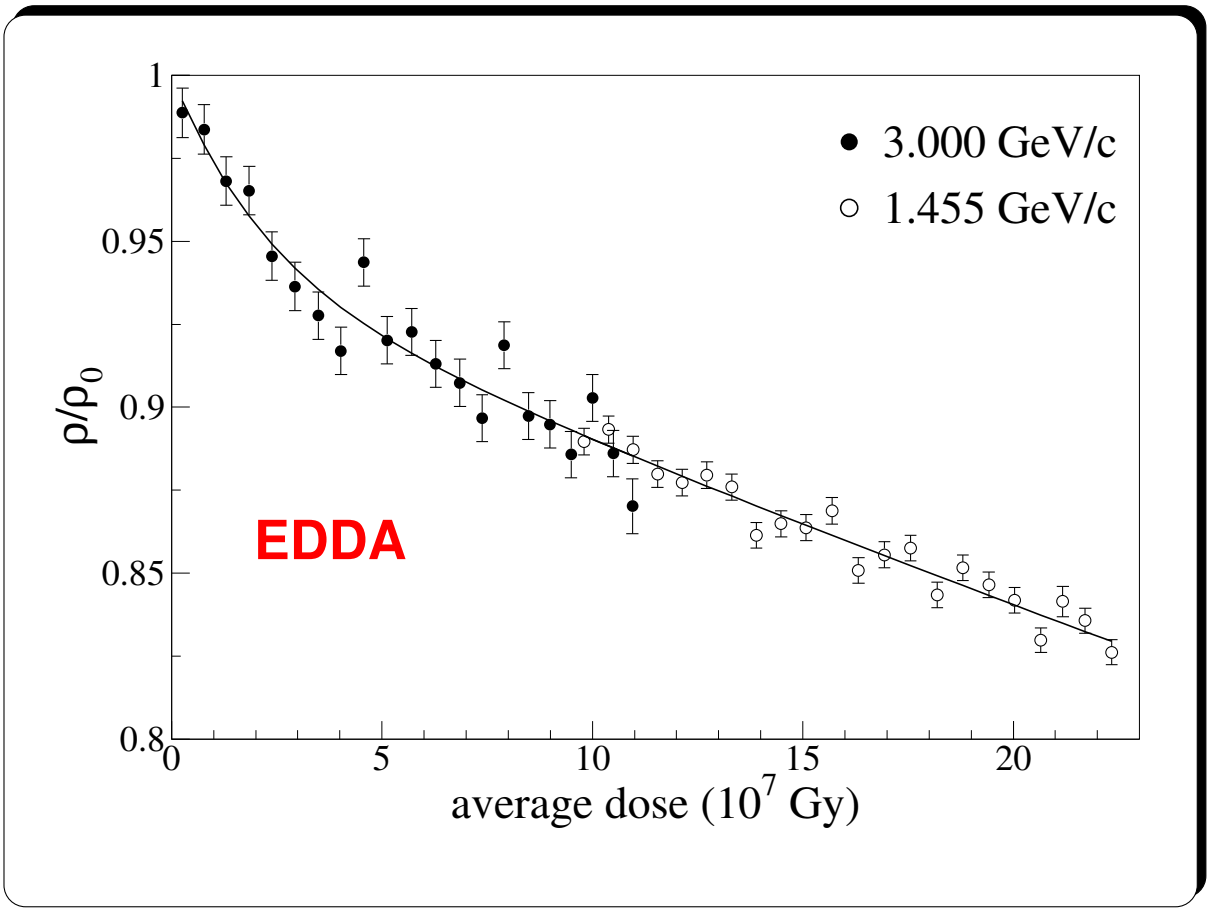
SAID PSA: SM94, SM97

Radiaton Damage of CH_2-Targets

"cross linking" (+ chain scission)



Loss of Hydrogen (10% / 12h)

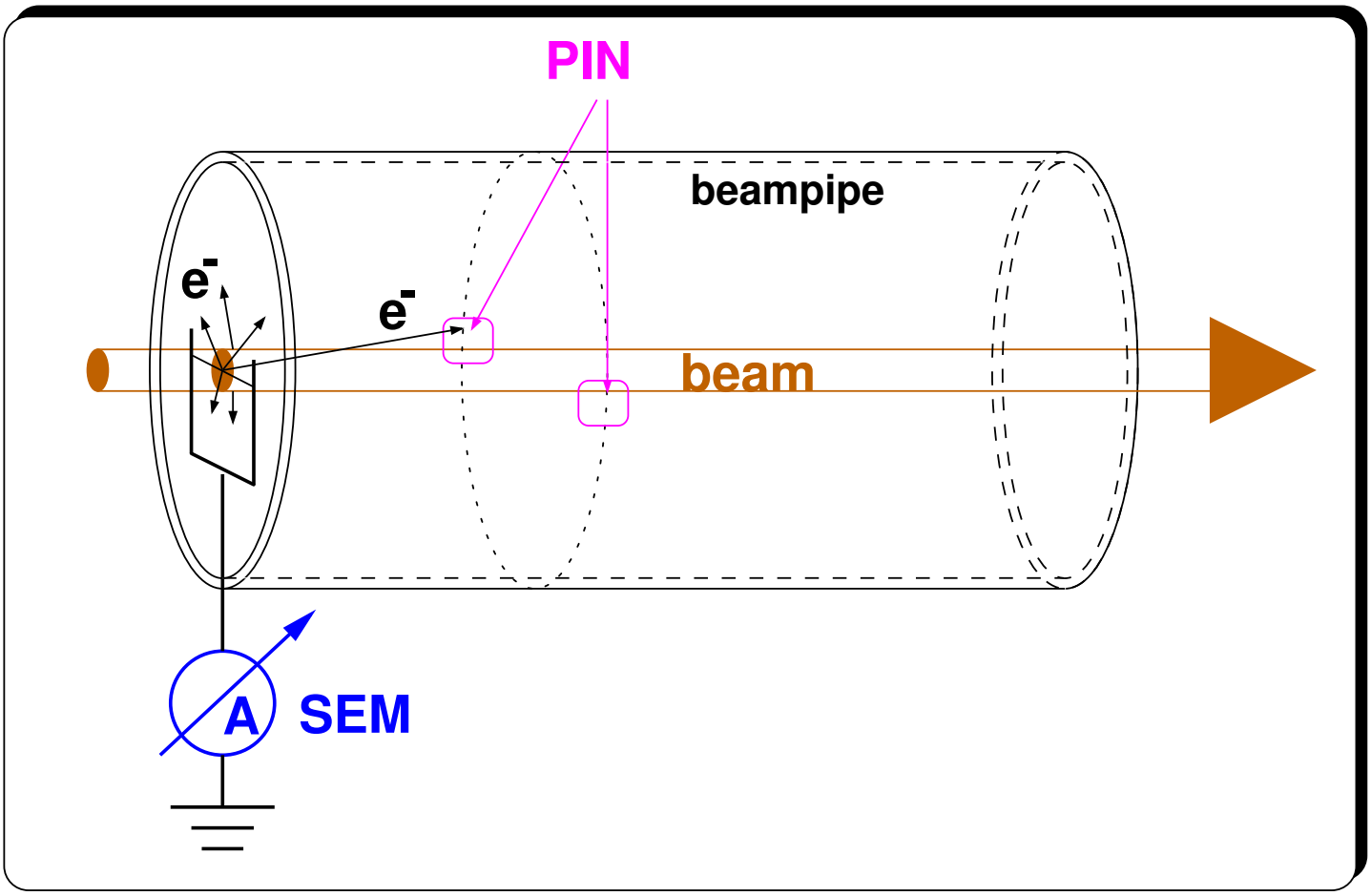


Normalization

relative:

- e (p, e) p

$R_{PIN} \propto \sigma_{ROSENBLUTH}$



- secondary electrons

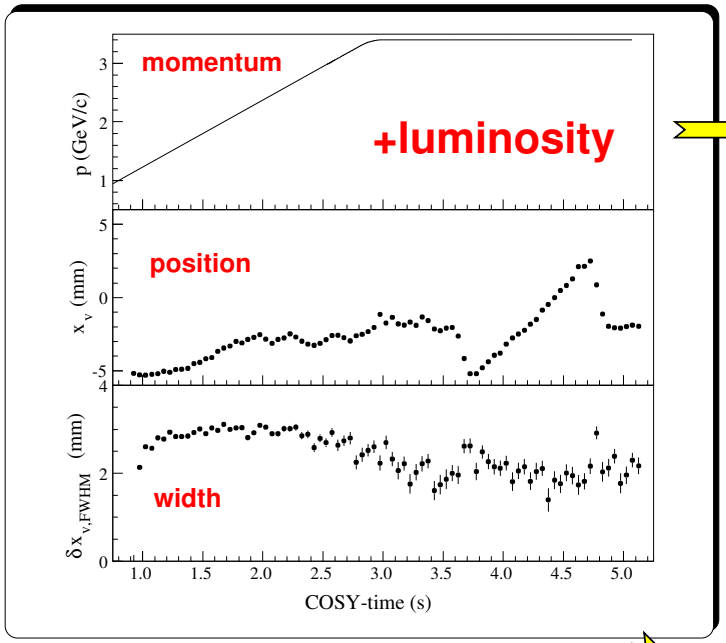
$I_{SEM} \propto \Delta E$

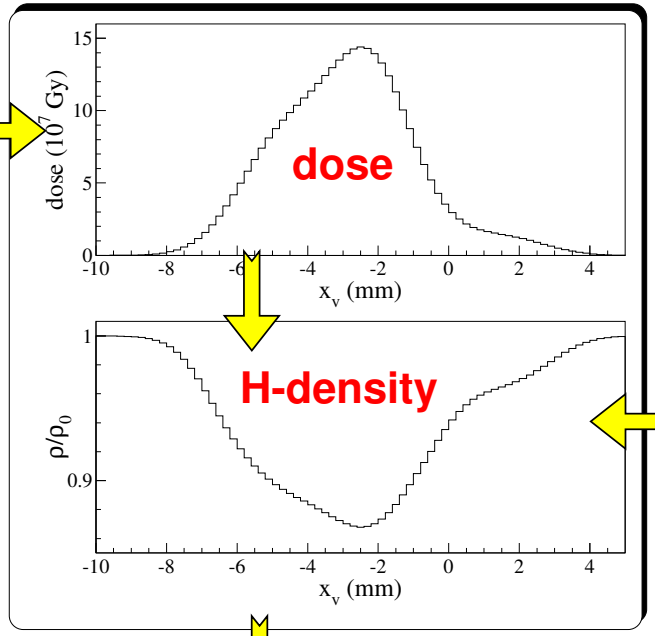
absolute:

T_P = 793 MeV ⟶ 1%

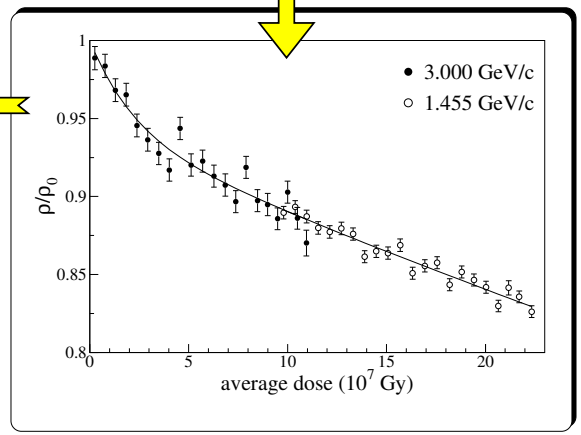
Simon et al. (LAMPF), Phys. Rev. C48, 662 (1993)

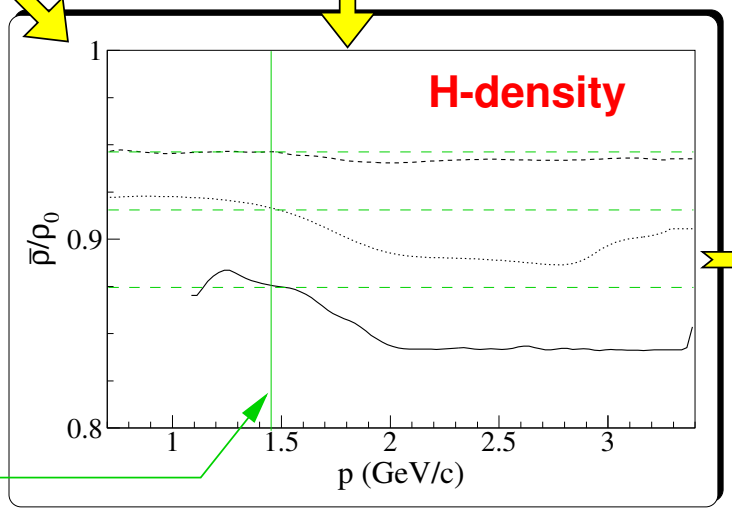
Radiaton Damage of CH_2-Targets





Data at fixed momentum



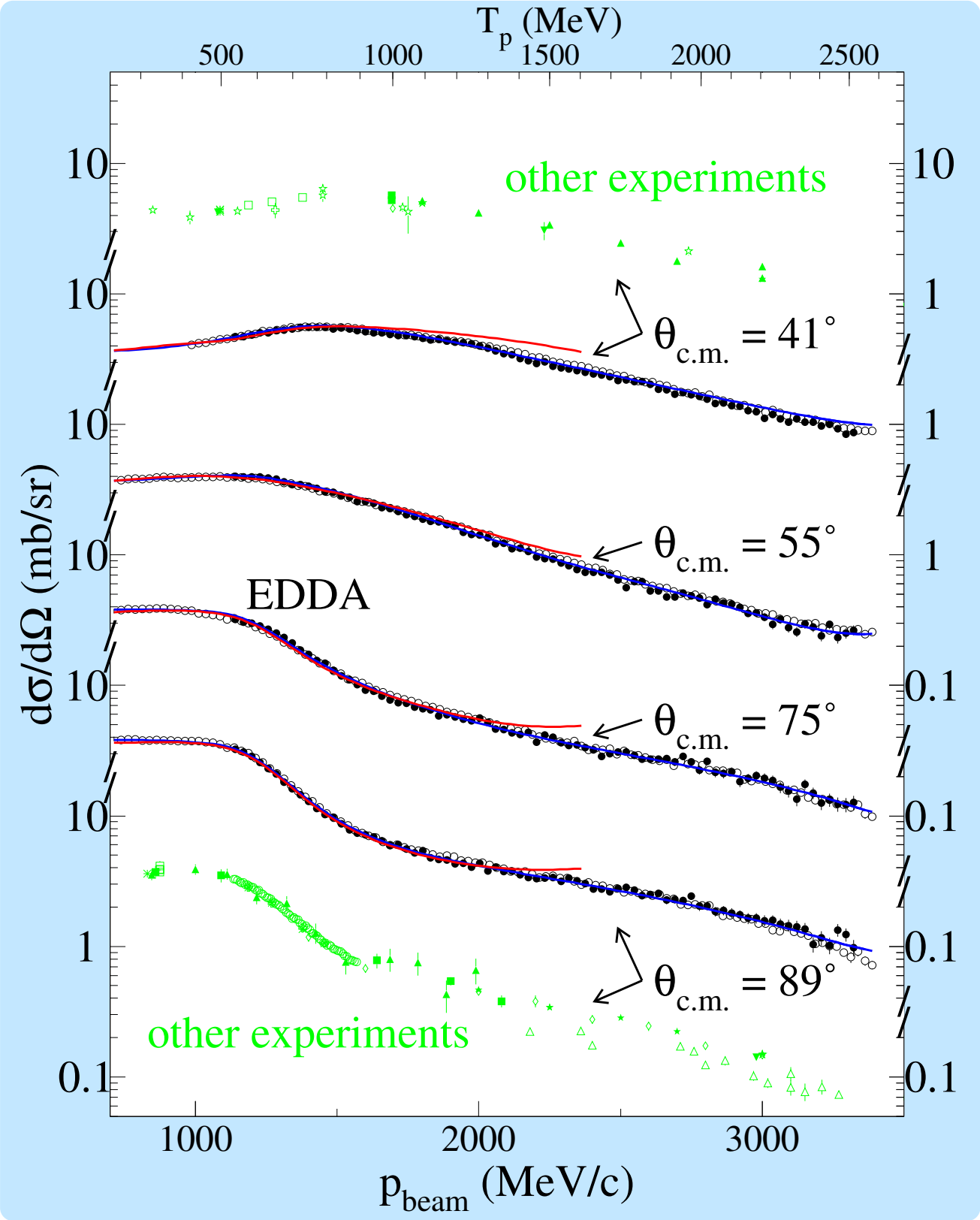


correction factor

absolute normalization

EDDA Results: $\frac{d\sigma}{d\Omega}$

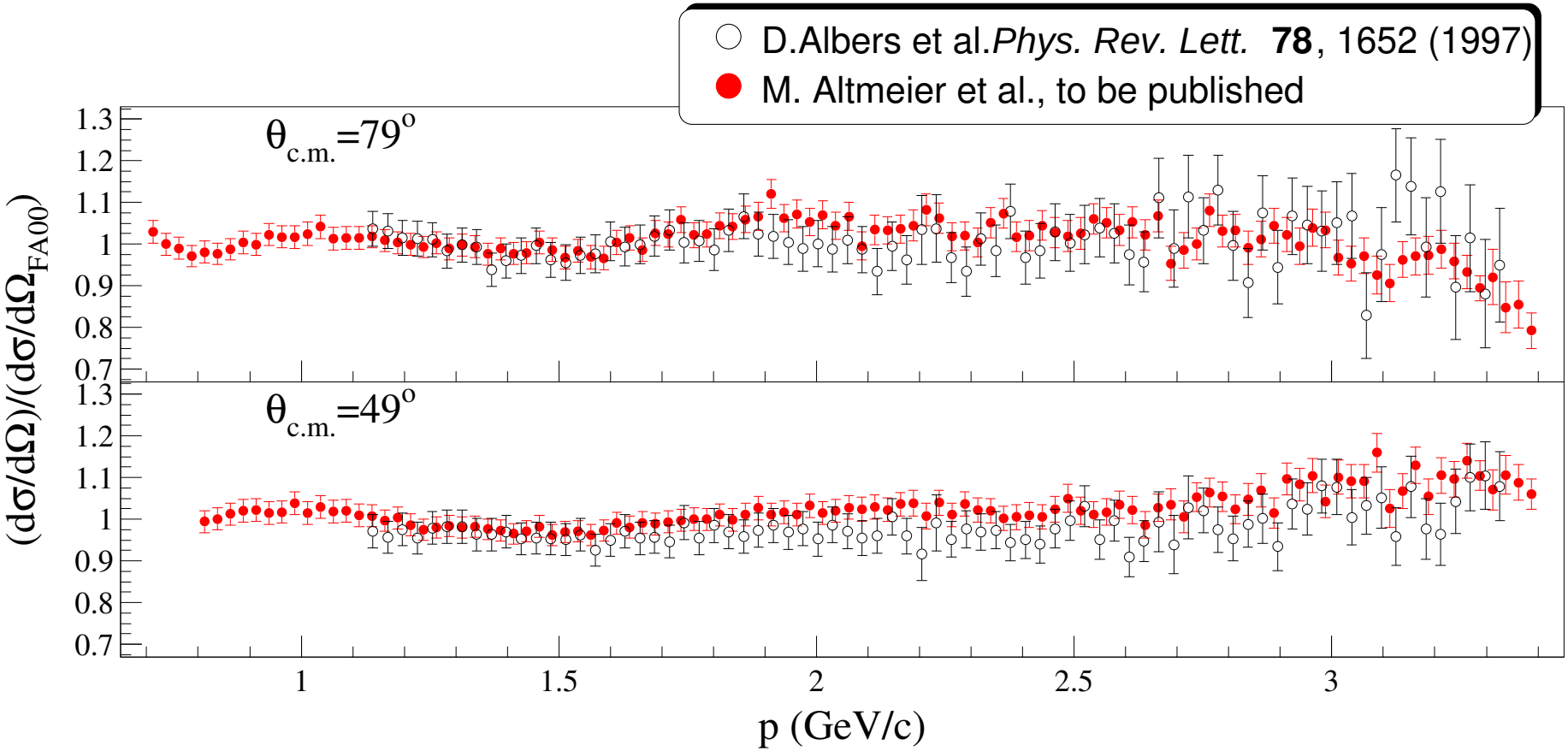
- ● D.Albers et al.*Phys. Rev. Lett.* **78**, 1652 (1997)
- ○ M. Altmeier et al., to be published



SAID PSA: SM94, SM97

updated analysis of unpolarized data: $\frac{d\sigma}{d\Omega}$

- increased statistical precision
- reduced contribution from pC scattering
- correction for radiation damage of CH_2-targets
- larger momentum range



Dibaryons

- color singlet states

	Baryons	Mesons	
Why are	$q\,q\,q$	$q\,\bar{q}$	observed
but not	$q\,q\,q\,q\,\bar{q}$ $q\,q\,q\,q\,q\,q$	$q\,q\,\bar{q}\,\bar{q}$	??

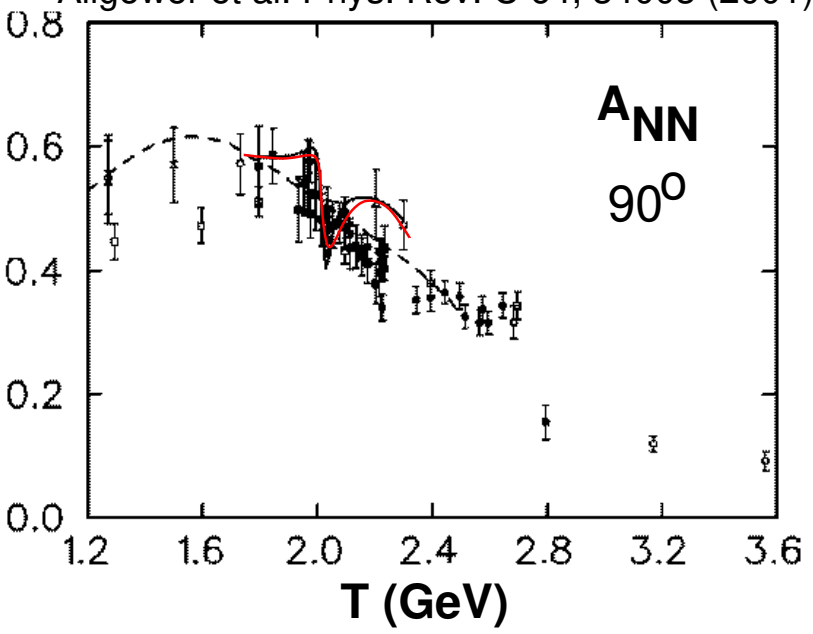
- numerous theoretical predictions for I=1 ,S=0 : $W_R \approx$ 2.1 ... 2.7 GeV

  $\Gamma =$ 10...150 MeV

  no experimental evidence !

NN@Saturne

Allgower et al. Phys. Rev. C 64, 34003 (2001)



EDDA@COSY

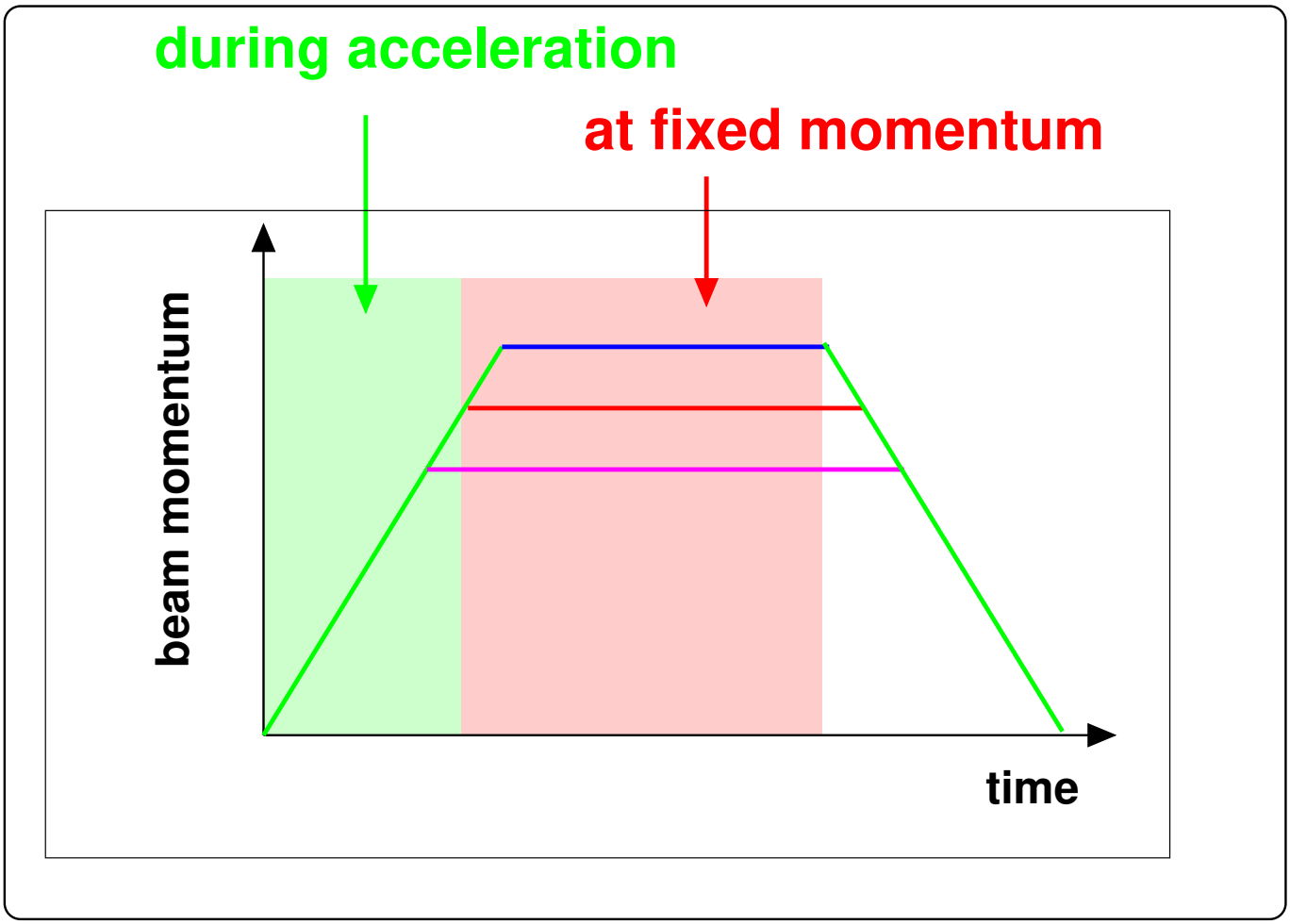
upper limits for $\eta_{el}=\Gamma_{el}/\Gamma_{tot}$

W_R = 2.2 ... 2.8 GeV
Γ = 10 ... 100 MeV

$\eta_{el} >$	0.09	$(^1S_0)$
	0.05	$(^1D_2)$
	0.10	$(^3P_0)$
	0.03	$(^3P_1)$
	0.06	$(^3F_3)$

excluded with 99% confidence level

Data Taking with $\vec{p}\,\vec{p}$



spin-orientations: beam (p) + target(q)

$$\frac{\sigma}{\sigma_0}(\phi) = 1 + A_N\{(p_y + q_y)\cos\phi + q_x \sin\phi\}$$

$$+ A_{NN}\{p_y q_y \cos^2\phi - q_x p_y \sin\phi\cos\phi\}$$

$$+ A_{SS}\{p_y q_y \sin^2\phi + q_x p_y \sin\phi\cos\phi\}$$

$$+ A_{SL}\; p_y q_z \cos\phi$$

Results: Analyzing Power

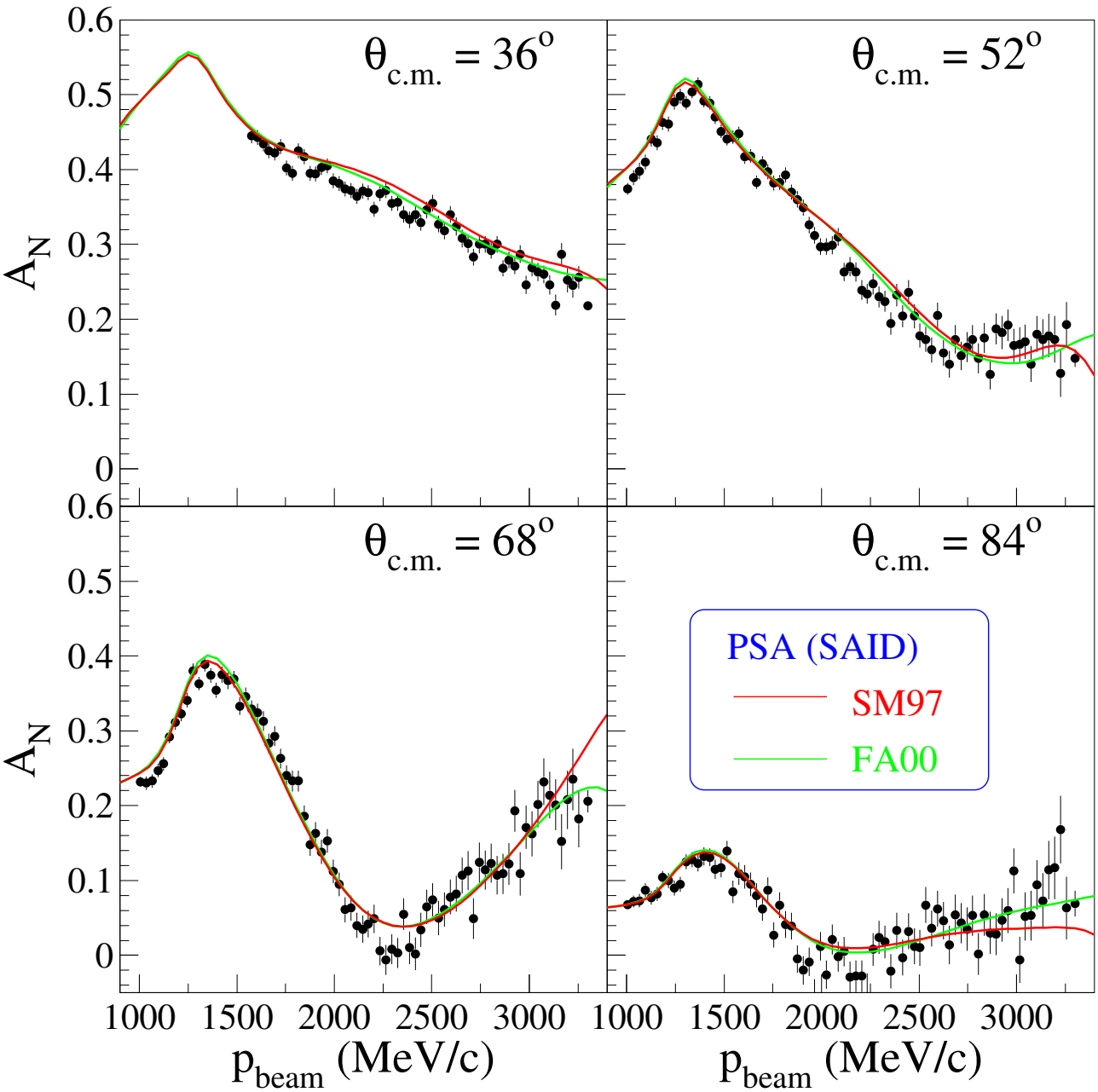
M.Altmeier et al. *Phys. Rev. Lett.* **85** ,1819 (2000)

$p\vec{p}$

25×10^6 Events

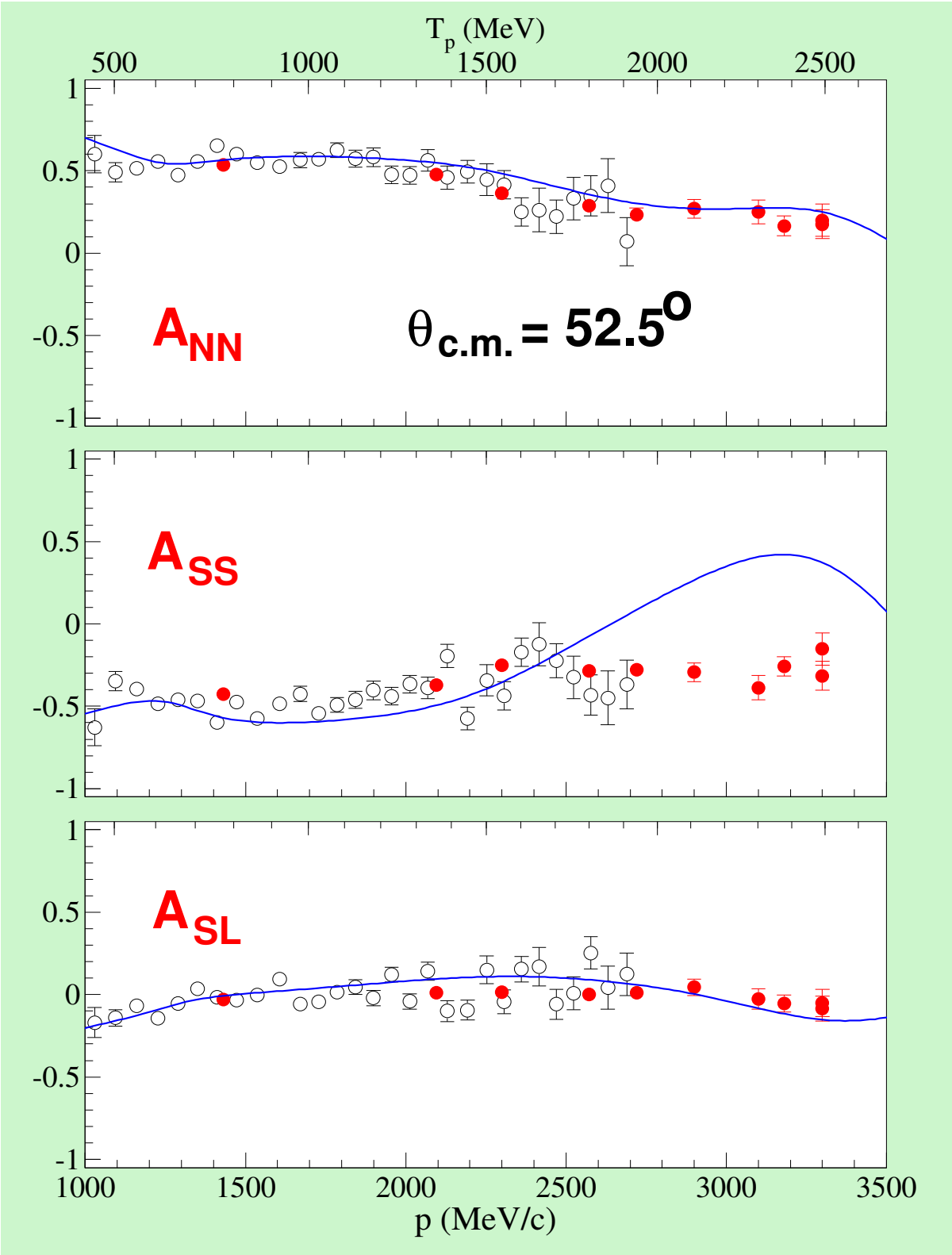
$\Delta\theta = 4°$

$\Delta p = 30$ MeV/c



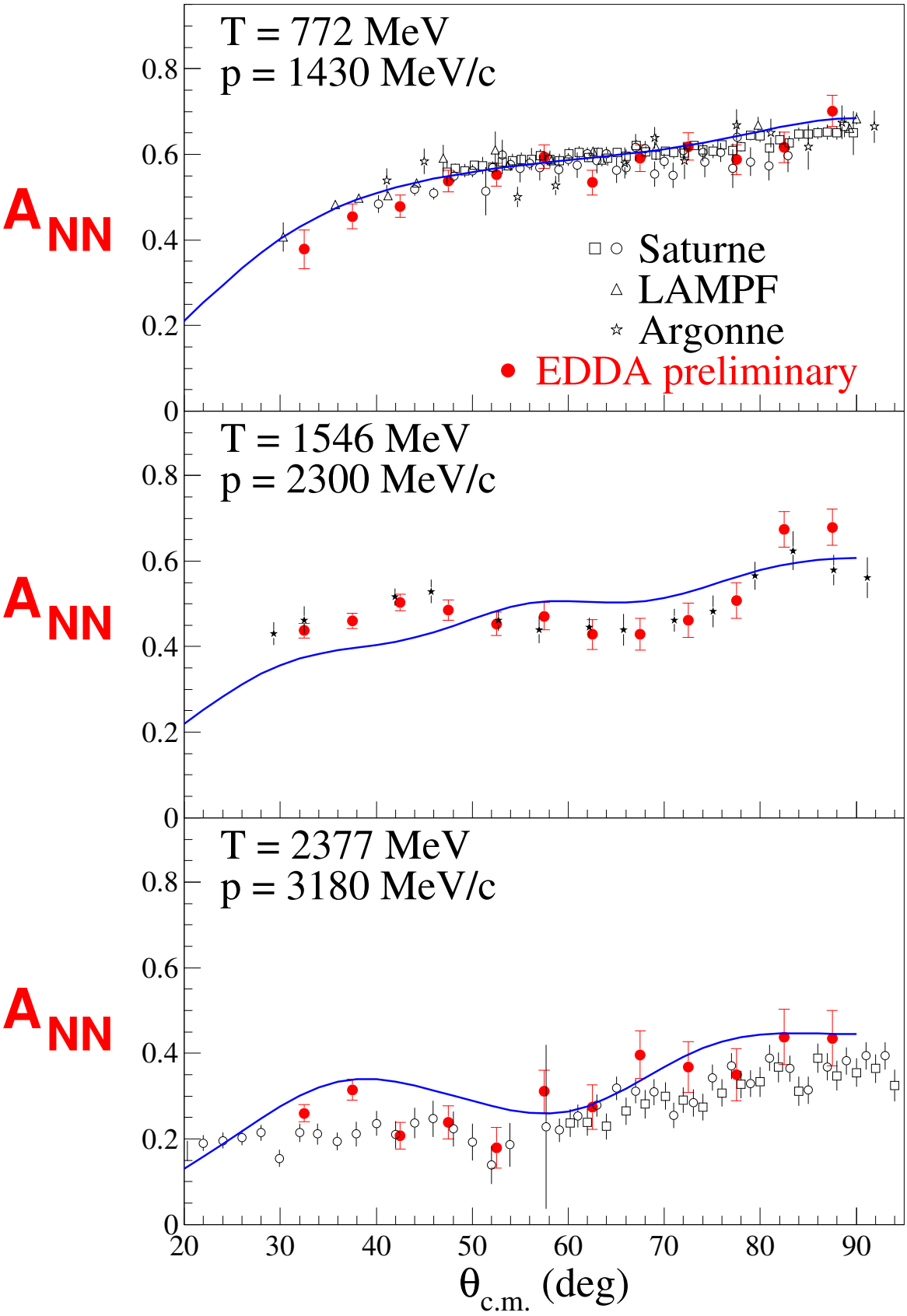
Anregungsfunktionen

EDDA preliminary



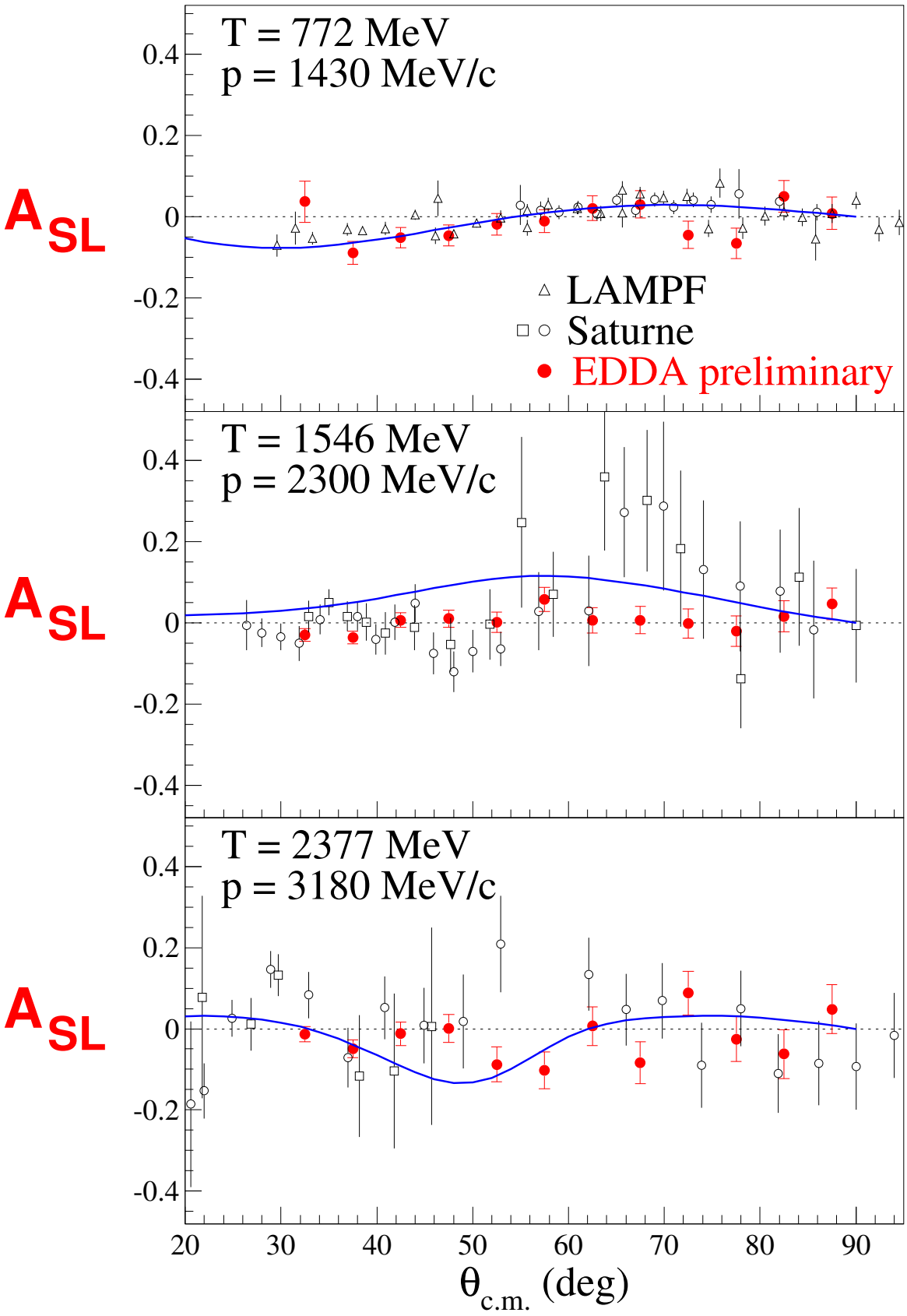
——— PSA (SAID SM00)

Spinkorrelationsparameter



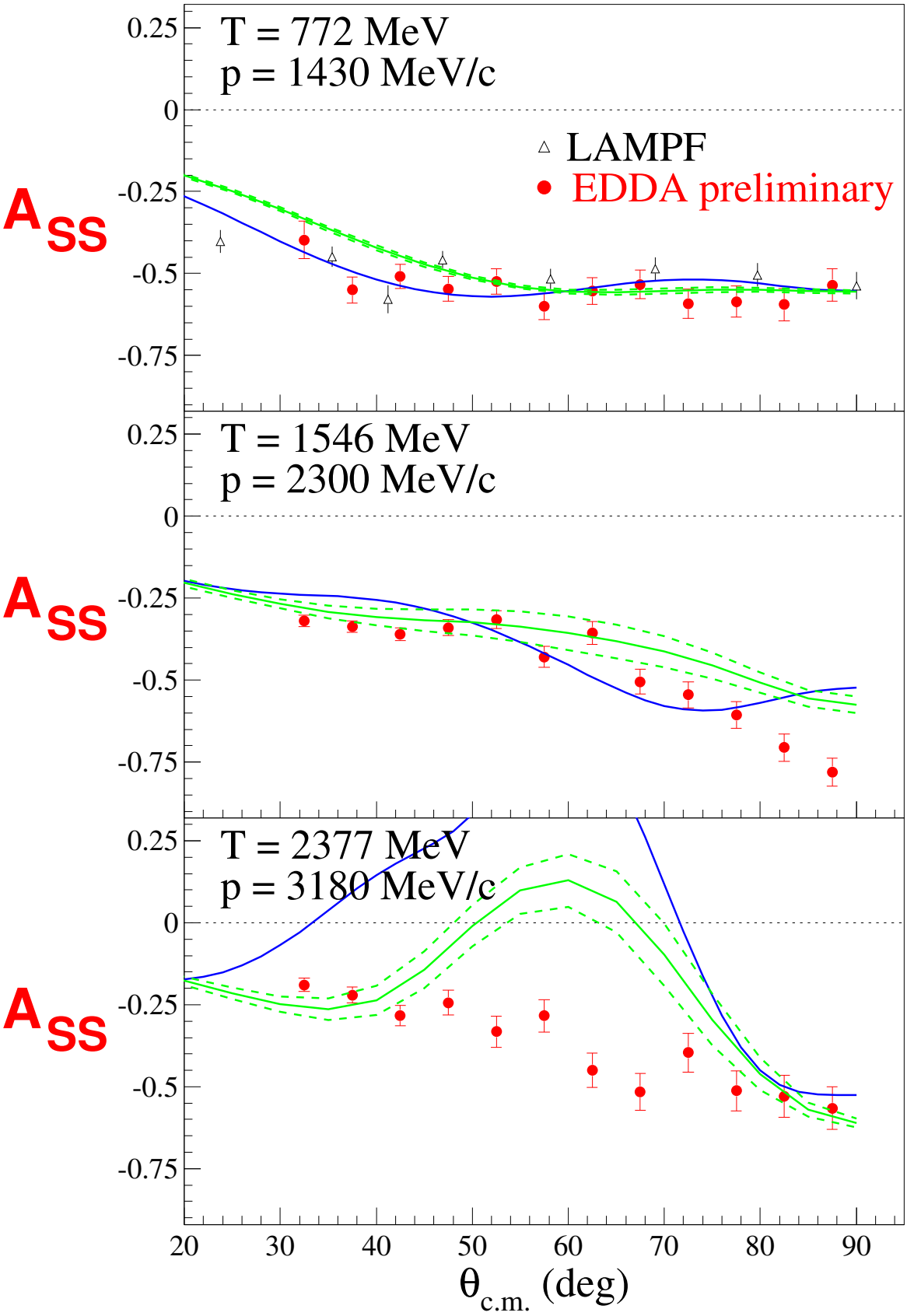
PSA: SAID(SM00)

Spinkorrelationsparameter



PSA: SAID(SM00)

Spinkorrelationsparameter



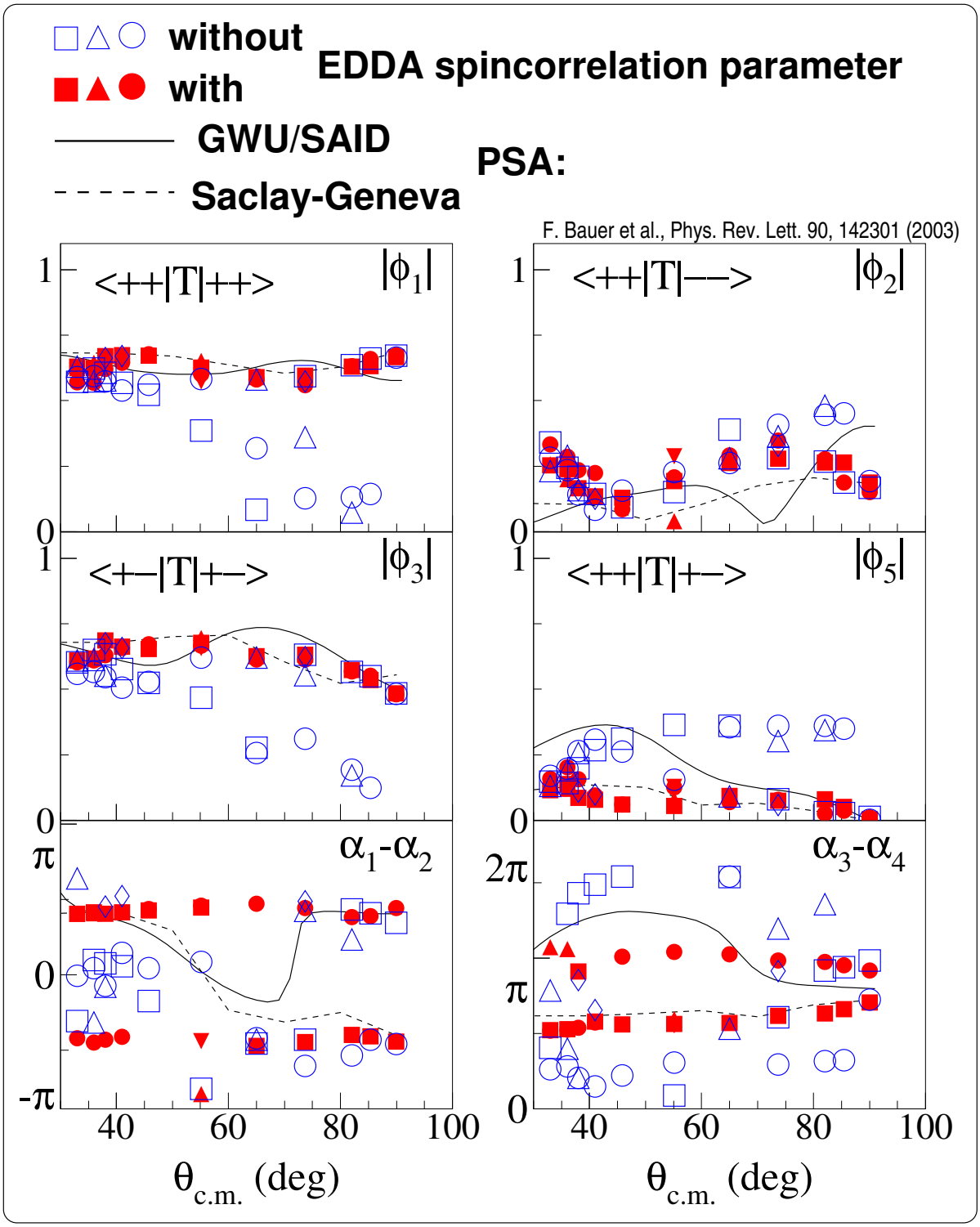
PSA: SAID(SM00) Saclay-Genf

Amplitude Reconstruction

Helicity-amplitudes: $\phi_k = |\phi_k|\, e^{i\alpha_k}$

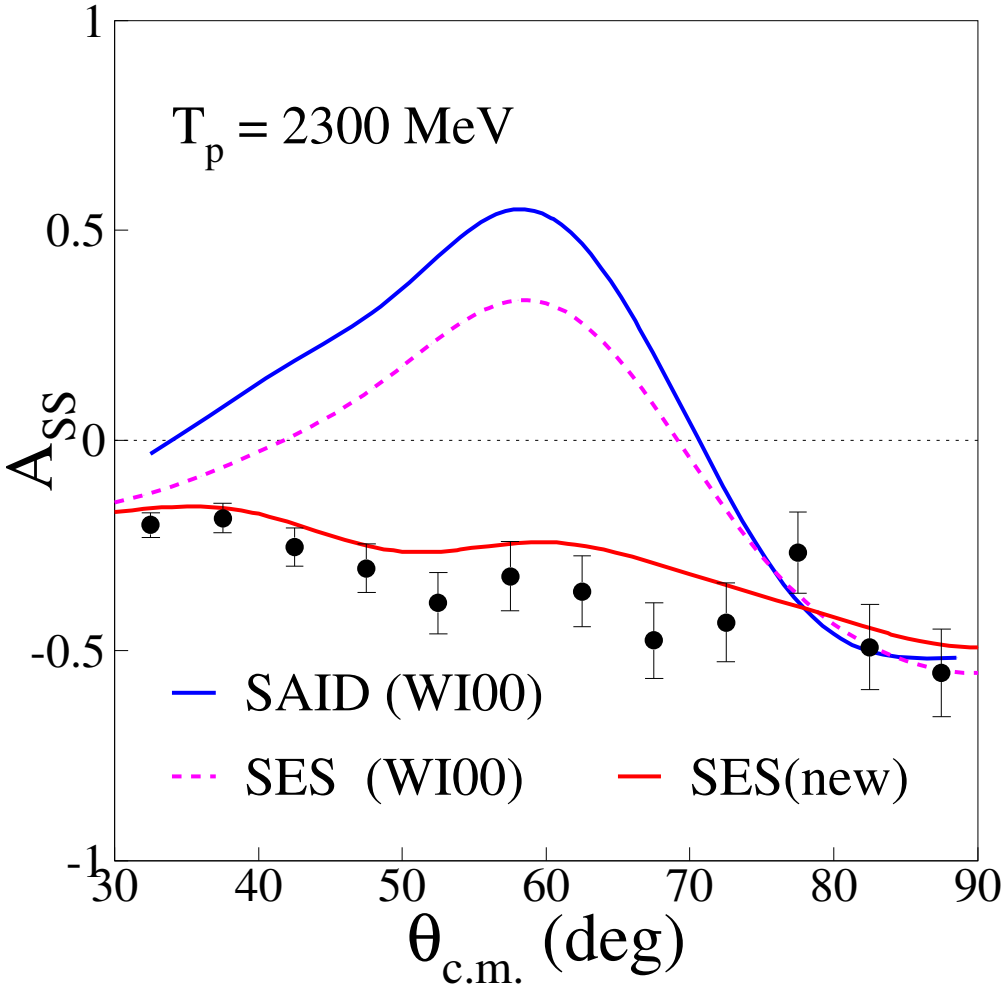
Observables: e.g.

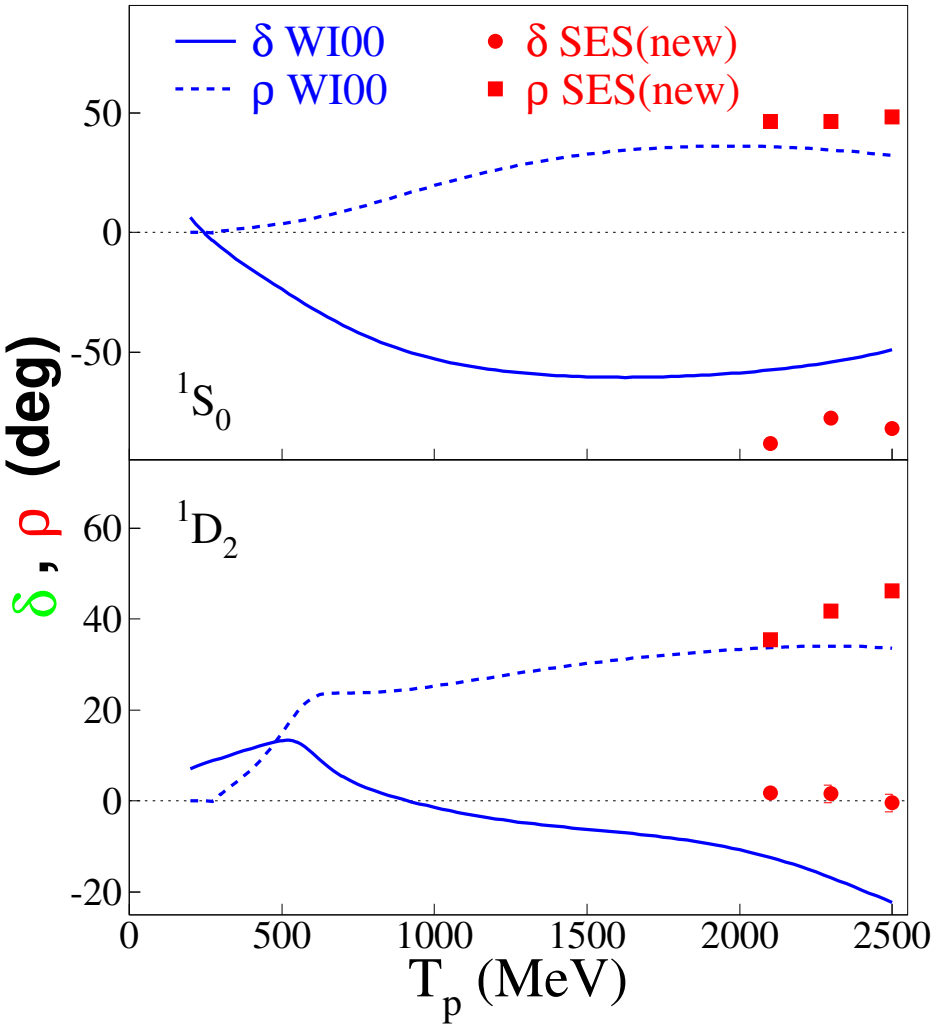
$$A_{SS}\sigma_0 = |\phi_1||\phi_2| \cos(\alpha_1 - \alpha_2) + |\phi_3||\phi_4| \cos(\alpha_3 - \alpha_4)$$



F.Bauer et al., Phys. Rev. Lett. 90, 142301 (2003)

A_{SS} : Influence on PSA





Status of Theory

Low Energy 0-300 (500) MeV

- phenomenological potentials
- meson exchange (e.g. Bonn,Paris) 80s
- effective field theory (χPT) > 1990

?

COSY-Energies 0.5 -2.5 GeV

inelastic channels
resonances
short-range

?

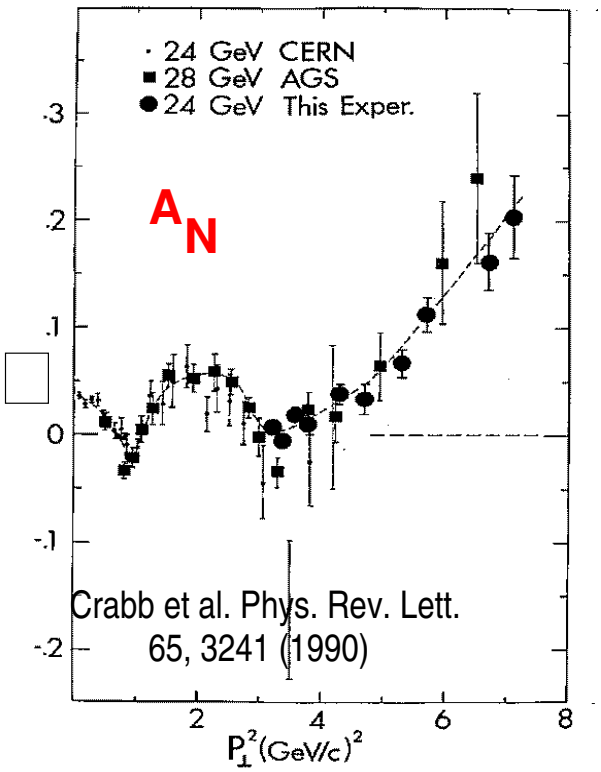
High Energy >> 10 GeV

- Regge-theory
- pQCD (s,t $\longrightarrow \infty$)

$d\sigma/dt \propto F(\theta)/s^{10}$

$\phi_5 = \langle ++|T|+-\rangle = 0$

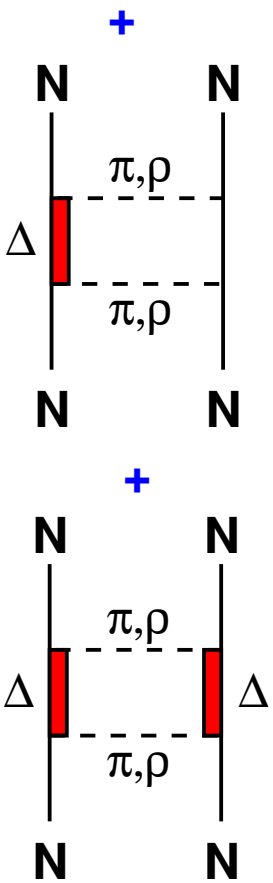
$\Rightarrow A_N = 0$



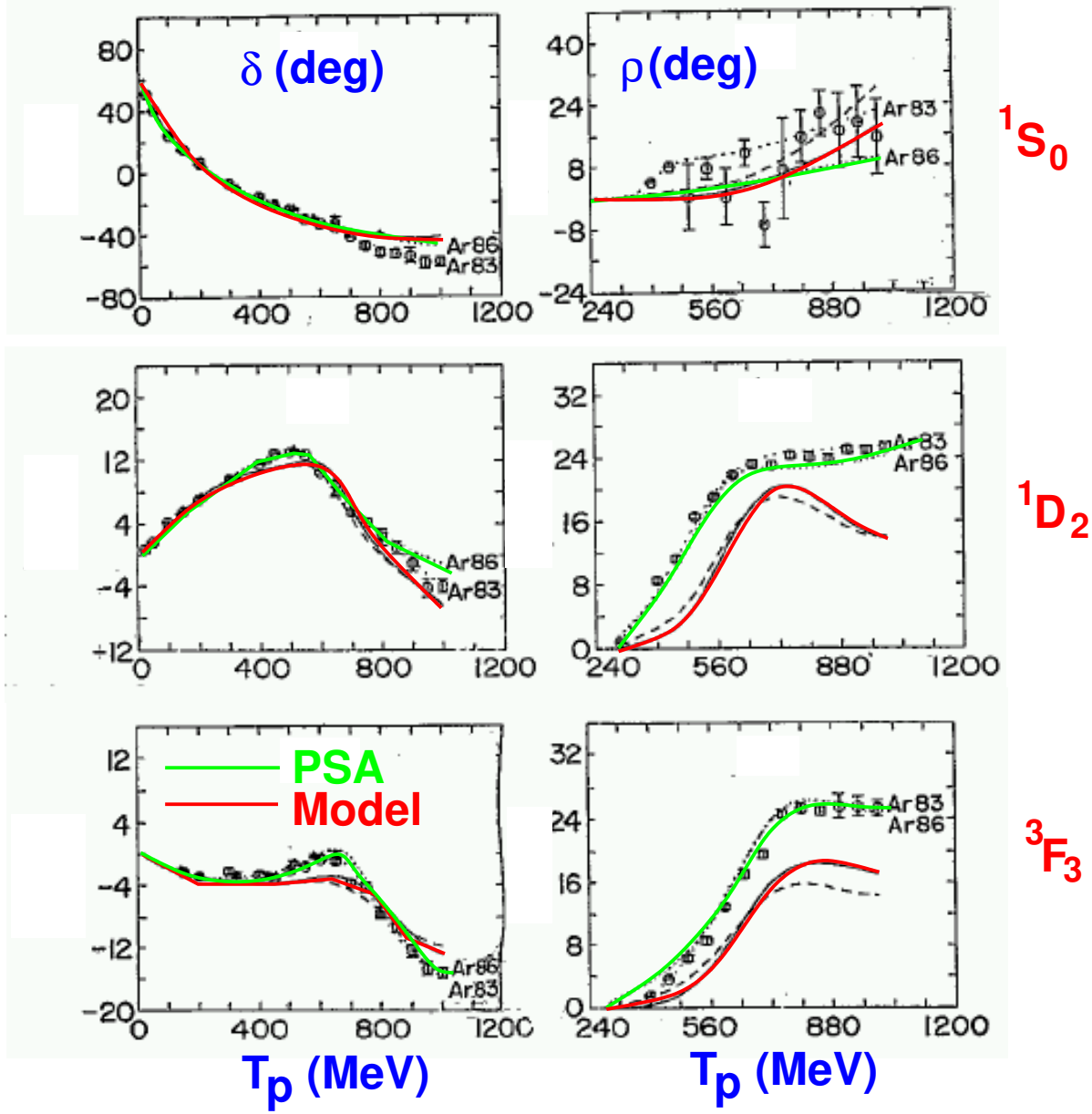
Meson Exchange Model

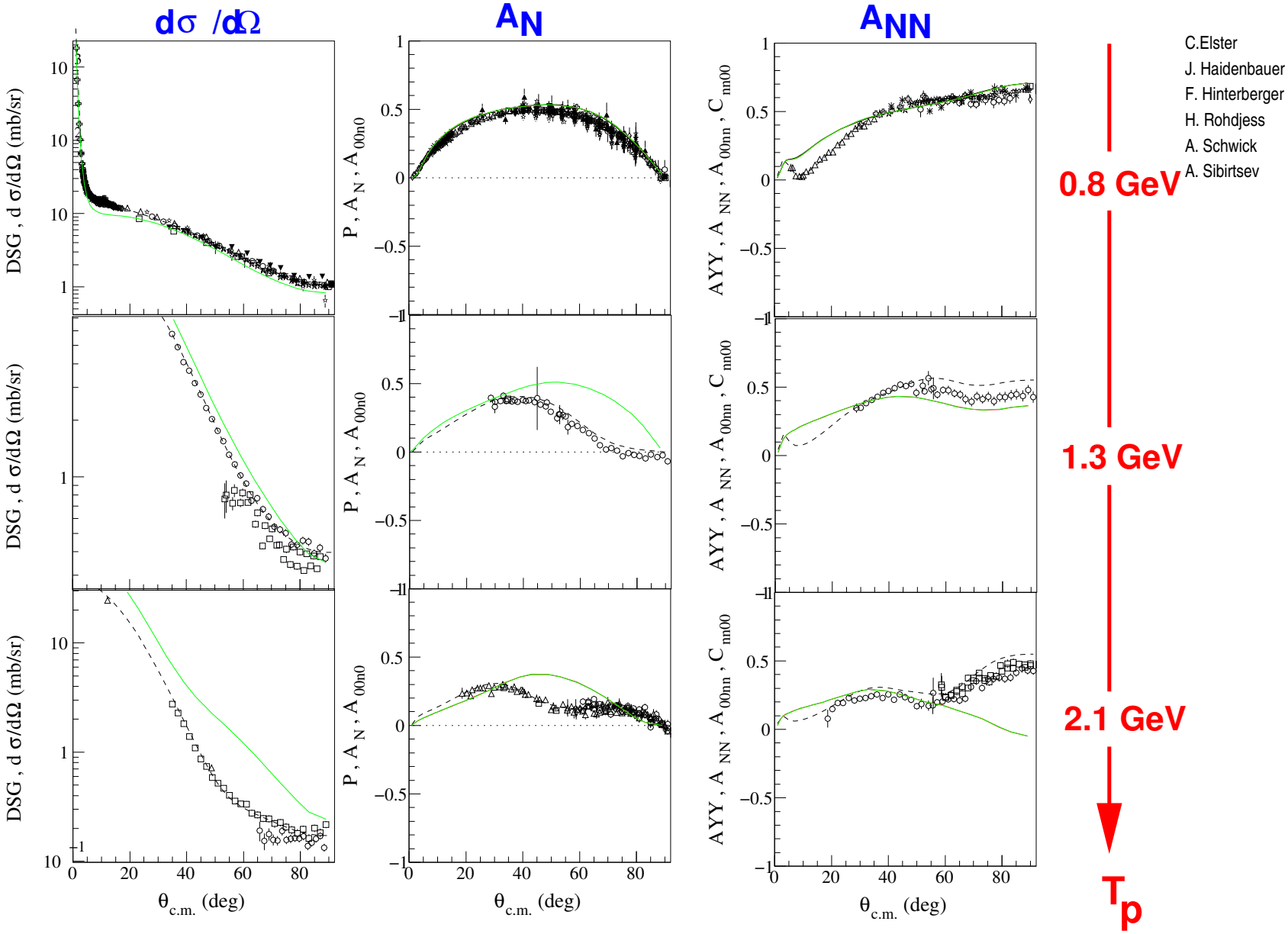
OBE

$\pi,\rho,\omega,\sigma,\delta,\eta$



Elster/Holinde/Schütte/Machleidt Phys.Rev.C38, 1828 (1988)




dσ /dΩ
A_N
A_NN
DSG , d σ/dΩ (mb/sr)
P , A_N , A_00n0
AYY , A_NN , A_00nn , C_nn00
θ_c.m. (deg)
0.8 GeV
1.3 GeV
2.1 GeV
T_p
C.Elster
J. Haidenbauer
F. Hinterberger
H. Rohdjess
A. Schwick
A. Sibirtsev

Conclusion

$\frac{d\sigma}{d\Omega}$: updated analysis increased precision

⇒ resonant contributions excluded

W_R = 2.2...2.8 GeV , Γ = 10...100 MeV

η_{el} > 3..10% with 99% CL

A_N : polarization standard in COSY energy range

A_{NN} $\underline{A_{SS}}$ A_{SL}

⇒ reduce ambiguities in amplitudes

⇒ PSA

< 1 GeV ✓

> 1 GeV ?

Theory for NN → NN above 1 GeV?

⇒ work has started

The EDDA Collaboration

Spokesmen: J. Bisplinghoff, F. Hinterberger and W. Scobel,

M. Altmeier, F. Bauer, J. Bisplinghoff, K. Büßer, M. Busch,
T. Colberg, L. Demirörs, C. Dahl, F. Dohrmann, P.D. Eversheim,
O. Eyser, O. Felden, R. Gebel, M. Glende, J. Greiff, R. Groß-Hardt,
F. Hinterberger, R. Jahn, E. Jonas, H. Krause, R. Langkau,
C. Lehmann, T. Lindemann, J. Lindlein R. Maier, A. Meinerzhagen,
O. Nähle, C. Pauli, D. Prasuhn, H. Rohdjeß, D. Rosendaal,
P. von Rossen, N. Schirm, W. Scobel, H.J. Trelle, K. Ulbrich, E. Weise,
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