

$\Delta(1905) 5/2^+$  $I(J^P) = \frac{3}{2}(\frac{5}{2}^+)$  Status: \*\*\*\*

Older and obsolete values are listed and referenced in the 2014 edition, Chinese Physics **C38** 070001 (2014).

 **$\Delta(1905)$  POLE POSITION****REAL PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>1750 to 1800 (<math>\approx 1770</math>) OUR ESTIMATE</b>			
1795 $\pm$ 20	SARANTSEV 25	DPWA	Multichannel
1707 $\pm$ 1	ROENCHEN 22	DPWA	Multichannel
1752 $\pm$ 3 $\pm$ 2	<sup>1</sup> SVARC 14	L+P	$\pi N \rightarrow \pi N$
1830 $\pm$ 40	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
1819	HUNT 19	DPWA	Multichannel
1795	ROENCHEN 15A	DPWA	Multichannel
1800 $\pm$ 6	SOKHOYAN 15A	DPWA	Multichannel
1800 $\pm$ 6	GUTZ 14	DPWA	Multichannel
1819	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1793	VRANA 00	DPWA	Multichannel
1829	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

<sup>1</sup>Fit to the amplitudes of HOEHLER 79.

**–2×IMAGINARY PART**

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>260 to 340 (<math>\approx 300</math>) OUR ESTIMATE</b>			
280 $\pm$ 20	SARANTSEV 25	DPWA	Multichannel
127 $\pm$ 4	ROENCHEN 22	DPWA	Multichannel
346 $\pm$ 6 $\pm$ 2	<sup>1</sup> SVARC 14	L+P	$\pi N \rightarrow \pi N$
280 $\pm$ 60	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
253	HUNT 19	DPWA	Multichannel
247	ROENCHEN 15A	DPWA	Multichannel
290 $\pm$ 15	SOKHOYAN 15A	DPWA	Multichannel
290 $\pm$ 15	GUTZ 14	DPWA	Multichannel
247	ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
302	VRANA 00	DPWA	Multichannel
303	HOEHLER 93	SPED	$\pi N \rightarrow \pi N$

<sup>1</sup>Fit to the amplitudes of HOEHLER 79.

 **$\Delta(1905)$  ELASTIC POLE RESIDUE****MODULUS  $|r|$** 

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>15 to 25 (<math>\approx 20</math>) OUR ESTIMATE</b>			
3.7 $\pm$ 1.0	ROENCHEN 22	DPWA	Multichannel
19 $\pm$ 2	SOKHOYAN 15A	DPWA	Multichannel
24 $\pm$ 1 $\pm$ 1	<sup>1</sup> SVARC 14	L+P	$\pi N \rightarrow \pi N$
25 $\pm$ 8	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

5.3	ROENCHEN	15A	DPWA	Multichannel
19 ± 2	GUTZ	14	DPWA	Multichannel
20 ± 2	ANISOVICH	12A	DPWA	Multichannel
15	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
25	HOEHLER	93	SPED	$\pi N \rightarrow \pi N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

### PHASE $\theta$

<u>VALUE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>– 120 to – 30 (≈ – 45) OUR ESTIMATE</b>			
– 92 ± 6	ROENCHEN	22	DPWA Multichannel
– 45 ± 4	SOKHOYAN	15A	DPWA Multichannel
– 114 ± 1 ± 2	<sup>1</sup> SVARC	14	L+P $\pi N \rightarrow \pi N$
– 50 ± 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

• • • We do not use the following data for averages, fits, limits, etc. • • •

– 89	ROENCHEN	15A	DPWA	Multichannel
– 45 ± 4	GUTZ	14	DPWA	Multichannel
– 44 ± 5	ANISOVICH	12A	DPWA	Multichannel
– 30	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$

<sup>1</sup> Fit to the amplitudes of HOEHLER 79.

## $\Delta(1905)$ INELASTIC POLE RESIDUE

The “normalized residue” is the residue divided by  $\Gamma_{pole}/2$ .

### Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta\pi$ , *P*-wave

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.10 ± 0.01	– 109 ± 7	ROENCHEN	22	DPWA Multichannel
0.19 ± 0.07	10 ± 30	SOKHOYAN	15A	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0870	72	ROENCHEN	15A	DPWA Multichannel
0.25 ± 0.06	0 ± 15	ANISOVICH	12A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Delta\pi$ , *F*-wave

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.017 ± 0.002	18 ± 8	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.009	64	ROENCHEN	15A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow \Sigma K$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0020 ± 0.0002	154 ± 6	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.001	– 155	ROENCHEN	15A	DPWA Multichannel

### Normalized residue in $N\pi \rightarrow \Delta(1905) \rightarrow N(1535)\pi$

<u>MODULUS</u>	<u>PHASE (°)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.025 ± 0.010	130 ± 35	GUTZ	14	DPWA Multichannel

**Normalized residue in  $N\pi \rightarrow \Delta(1905) \rightarrow \Delta(1232)\eta$** 

<u>MODULUS</u>	<u>PHASE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.07 $\pm$ 0.02	40 $\pm$ 20	GUTZ	14	DPWA Multichannel

 **$\Delta(1905)$  BREIT-WIGNER MASS**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1855 to 1910 (<math>\approx</math> 1880) OUR ESTIMATE</b>			
1845 $\pm$ 20	SARANTSEV 25	DPWA	Multichannel
1883 $\pm$ 19	GOLOVATCH 19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$
1866 $\pm$ 9	<sup>1</sup> HUNT 19	DPWA	Multichannel
1857.8 $\pm$ 1.6	<sup>1</sup> ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
1910 $\pm$ 30	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
1905 $\pm$ 20	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1856 $\pm$ 6	SOKHOYAN 15A	DPWA	Multichannel
1856 $\pm$ 6	GUTZ 14	DPWA	Multichannel
1818 $\pm$ 8	<sup>1</sup> SHRESTHA 12A	DPWA	Multichannel
1873 $\pm$ 77	VRANA 00	DPWA	Multichannel

<sup>1</sup>Statistical error only. **$\Delta(1905)$  BREIT-WIGNER WIDTH**

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>270 to 400 (<math>\approx</math> 330) OUR ESTIMATE</b>			
315 $\pm$ 20	SARANTSEV 25	DPWA	Multichannel
327 $\pm$ 69	GOLOVATCH 19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$
289 $\pm$ 20	<sup>1</sup> HUNT 19	DPWA	Multichannel
320.6 $\pm$ 8.6	<sup>1</sup> ARNDT 06	DPWA	$\pi N \rightarrow \pi N, \eta N$
400 $\pm$ 100	CUTKOSKY 80	IPWA	$\pi N \rightarrow \pi N$
260 $\pm$ 20	HOEHLER 79	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
325 $\pm$ 15	SOKHOYAN 15A	DPWA	Multichannel
325 $\pm$ 15	GUTZ 14	DPWA	Multichannel
278 $\pm$ 18	<sup>1</sup> SHRESTHA 12A	DPWA	Multichannel
461 $\pm$ 111	VRANA 00	DPWA	Multichannel

<sup>1</sup>Statistical error only. **$\Delta(1905)$  DECAY MODES**

The following branching fractions are our estimates, not fits or averages.

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $N\pi$	9–15%
$\Gamma_2$ $N\pi\pi$	>65%
$\Gamma_3$ $\Delta(1232)\pi$	>48%
$\Gamma_4$ $\Delta(1232)\pi$ , $P$ -wave	8–43%
$\Gamma_5$ $\Delta(1232)\pi$ , $F$ -wave	40–58%

$\Gamma_6$	$N\rho$	$(25\pm 10)\%$
$\Gamma_7$	$N\rho, S=3/2, P\text{-wave}$	17–35%
$\Gamma_8$	$N(1535)\pi$	$< 1\%$
$\Gamma_9$	$N(1680)\pi, P\text{-wave}$	5–15%
$\Gamma_{10}$	$\Delta(1232)\eta$	2–6%
$\Gamma_{11}$	$N\gamma$	0.012–0.036 %
$\Gamma_{12}$	$N\gamma, \text{helicity}=1/2$	0.002–0.006 %
$\Gamma_{13}$	$N\gamma, \text{helicity}=3/2$	0.01–0.03 %

### $\Delta(1905)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$					$\Gamma_1/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		

#### 9–15% OUR ESTIMATE

13 $\pm$ 4	SEIFEN	25	DPWA	Multichannel	
17 $\pm$ 1	<sup>1</sup> HUNT	19	DPWA	Multichannel	
12.2 $\pm$ 0.1	<sup>1</sup> ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$	
8 $\pm$ 3	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$	
15 $\pm$ 2	HOEHLER	79	IPWA	$\pi N \rightarrow \pi N$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
13 $\pm$ 2	SOKHOYAN	15A	DPWA	Multichannel	
13 $\pm$ 2	GUTZ	14	DPWA	Multichannel	
6 $\pm$ 1	<sup>1</sup> SHRESTHA	12A	DPWA	Multichannel	
9 $\pm$ 1	VRANA	00	DPWA	Multichannel	

<sup>1</sup>Statistical error only.

$\Gamma(N\pi\pi)/\Gamma_{\text{total}}$					$\Gamma_2/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT		

#### >65% OUR ESTIMATE

0.85 $\pm$ 0.15	GOLOVATCH	19	DPWA	$\gamma p \rightarrow \pi^+ \pi^- p$	
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$\Gamma(\Delta(1232)\pi)/\Gamma_{\text{total}}$					$\Gamma_3/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		

#### 19 $\pm$ 8

SARANTSEV	25	DPWA	Multichannel	
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$\Gamma(\Delta(1232)\pi, P\text{-wave})/\Gamma_{\text{total}}$					$\Gamma_4/\Gamma$
VALUE (%)	DOCUMENT ID	TECN	COMMENT		

#### 8–43% OUR ESTIMATE

14 $\pm$ 7	SARANTSEV	25	DPWA	Multichannel	
20 $\pm$ 12	SEIFEN	25	DPWA	Multichannel	
8.4 $\pm$ 0.5	<sup>1</sup> HUNT	19	DPWA	Multichannel	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
33 $\pm$ 10	SOKHOYAN	15A	DPWA	Multichannel	
28 $\pm$ 7	<sup>1</sup> SHRESTHA	12A	DPWA	Multichannel	
23 $\pm$ 1	VRANA	00	DPWA	Multichannel	

<sup>1</sup>Statistical error only.

$\Gamma(\Delta(1232)\pi, F\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_5/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>40–58% OUR ESTIMATE</b>			
5 ± 3	SARANTSEV	25	DPWA Multichannel
49 ± 9	<sup>1</sup> HUNT	19	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
64 ± 8	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
44 ± 1	VRANA	00	DPWA Multichannel
<sup>1</sup> Statistical error only.			

$\Gamma(N\rho)/\Gamma_{\text{total}} \quad \Gamma_6/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>25 ± 10</b>			
	SARANTSEV	25	DPWA Multichannel

$\Gamma(N\rho, S=3/2, P\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_7/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>17–35% OUR ESTIMATE</b>			
25 ± 10	SARANTSEV	25	DPWA Multichannel
26 ± 9	<sup>1</sup> HUNT	19	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
< 6	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
24 ± 1	VRANA	00	DPWA Multichannel
<sup>1</sup> Statistical error only.			

$\Gamma(N(1535)\pi)/\Gamma_{\text{total}} \quad \Gamma_8/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt; 1 % OUR ESTIMATE</b>			
< 1	SEIFEN	25	DPWA Multichannel
< 1	GUTZ	14	DPWA Multichannel

$\Gamma(N(1680)\pi, P\text{-wave})/\Gamma_{\text{total}} \quad \Gamma_9/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>5–15% OUR ESTIMATE</b>			
6 ± 2	SEIFEN	25	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10 ± 5	SOKHOYAN	15A	DPWA Multichannel

$\Gamma(\Delta(1232)\eta)/\Gamma_{\text{total}} \quad \Gamma_{10}/\Gamma$

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2–6% OUR ESTIMATE</b>			
4 ± 2	GUTZ	14	DPWA Multichannel

**$\Delta(1905)$  PHOTON DECAY AMPLITUDES AT THE POLE**

**$\Delta(1905) \rightarrow N\gamma$ , helicity-1/2 amplitude  $A_{1/2}$**

<u>MODULUS (<math>\text{GeV}^{-1/2}</math>)</u>	<u>PHASE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.030 ± 0.007	− 35 ± 15	SARANTSEV	25	DPWA Multichannel
0.055 ± 0.004	− 159 ± 2	ROENCHEN	22	DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.053	89	ROENCHEN	15A	DPWA Multichannel
0.025 ± 0.005	− 28 ± 12	SOKHOYAN	15A	DPWA Multichannel

**$\Delta(1905) \rightarrow N\gamma$ , helicity-3/2 amplitude  $A_{3/2}$** 

<u>MODULUS (<math>\text{GeV}^{-1/2}</math>)</u>	<u>PHASE (<math>^\circ</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$-0.072 \pm 0.010$	$-10 \pm 20$	SARANTSEV	25	DPWA Multichannel
$-0.168 \pm 0.020$	$172 \pm 0.9$	ROENCHEN	22	DPWA Multichannel
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$-0.030$	80	ROENCHEN	15A	DPWA Multichannel
$-0.050 \pm 0.004$	$5 \pm 10$	SOKHOYAN	15A	DPWA Multichannel

 **$\Delta(1905)$  BREIT-WIGNER PHOTON DECAY AMPLITUDES** **$\Delta(1905) \rightarrow N\gamma$ , helicity-1/2 amplitude  $A_{1/2}$** 

<u>VALUE (<math>\text{GeV}^{-1/2}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.017 to 0.027 (<math>\approx 0.022</math>) OUR ESTIMATE</b>			
$0.032 \pm 0.008$	SARANTSEV	25	DPWA Multichannel
$0.019 \pm 0.0076$	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
$0.077 \pm 0.010$	<sup>1</sup> HUNT	19	DPWA Multichannel
$0.020 \pm 0.002$	<sup>1</sup> DUGGER	13	DPWA $\gamma N \rightarrow \pi N$
$0.019 \pm 0.002$	<sup>1</sup> WORKMAN	12A	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$0.025 \pm 0.005$	SOKHOYAN	15A	DPWA Multichannel
$0.025 \pm 0.005$	GUTZ	14	DPWA Multichannel
$0.066 \pm 0.018$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
0.018	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$

<sup>1</sup>Statistical error only. **$\Delta(1905) \rightarrow N\gamma$ , helicity-3/2 amplitude  $A_{3/2}$** 

<u>VALUE (<math>\text{GeV}^{-1/2}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-0.055 to -0.035 (<math>\approx -0.045</math>) OUR ESTIMATE</b>			
$-0.075 \pm 0.010$	SARANTSEV	25	DPWA Multichannel
$-0.0432 \pm 0.0173$	GOLOVATCH	19	DPWA $\gamma p \rightarrow \pi^+ \pi^- p$
$-0.053 \pm 0.029$	<sup>1</sup> HUNT	19	DPWA Multichannel
$-0.049 \pm 0.005$	<sup>1</sup> DUGGER	13	DPWA $\gamma N \rightarrow \pi N$
$-0.038 \pm 0.004$	WORKMAN	12A	DPWA $\gamma N \rightarrow \pi N$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$-0.050 \pm 0.005$	SOKHOYAN	15A	DPWA Multichannel
$-0.050 \pm 0.005$	GUTZ	14	DPWA Multichannel
$-0.223 \pm 0.029$	<sup>1</sup> SHRESTHA	12A	DPWA Multichannel
$-0.028$	DRECHSEL	07	DPWA $\gamma N \rightarrow \pi N$

<sup>1</sup>Statistical error only.

**$\Delta(1905)$  REFERENCES**For early references, see Physics Letters **111B** 1 (1982).

SARANTSEV	25	PR C112 015202	A.V. Sarantsev <i>et al.</i>	(Bonn-Gatchina Collab.)
SEIFEN	25	EPJ A61 173	T. Seifen <i>et al.</i>	(CBELSA/TAPS Collab.)
ROENCHEN	22	EPJ A58 229	D. Roenchen <i>et al.</i>	(JULI, GWU, BONN+)
GOLOVATCH	19	PL B788 371	E. Golovatch <i>et al.</i>	(CLAS Collab.)
HUNT	19	PR C99 055205	B.C. Hunt, D.M. Manley	
ROENCHEN	15A	EPJ A51 70	D. Roenchen <i>et al.</i>	
SOKHOYAN	15A	EPJ A51 95	V. Sokhoyan <i>et al.</i>	(CBELSA/TAPS Collab.)
GUTZ	14	EPJ A50 74	E. Gutz <i>et al.</i>	(CBELSA/TAPS Collab.)
PDG	14	CP C38 070001	K. Olive <i>et al.</i>	(PDG Collab.)
SVARC	14	PR C89 045205	A. Svarc <i>et al.</i>	(RBI Zagreb, UNI Tuzla)
DUGGER	13	PR C88 065203	M. Dugger <i>et al.</i>	(JLab CLAS Collab.)
ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman, T.-S.H. Lee	(PITT, ANL)
HOEHLER	93	$\pi N$ Newsletter 9 1	G. Hohler	(KARL)
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP

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