Decelerator Linac for Highly Charged Ions

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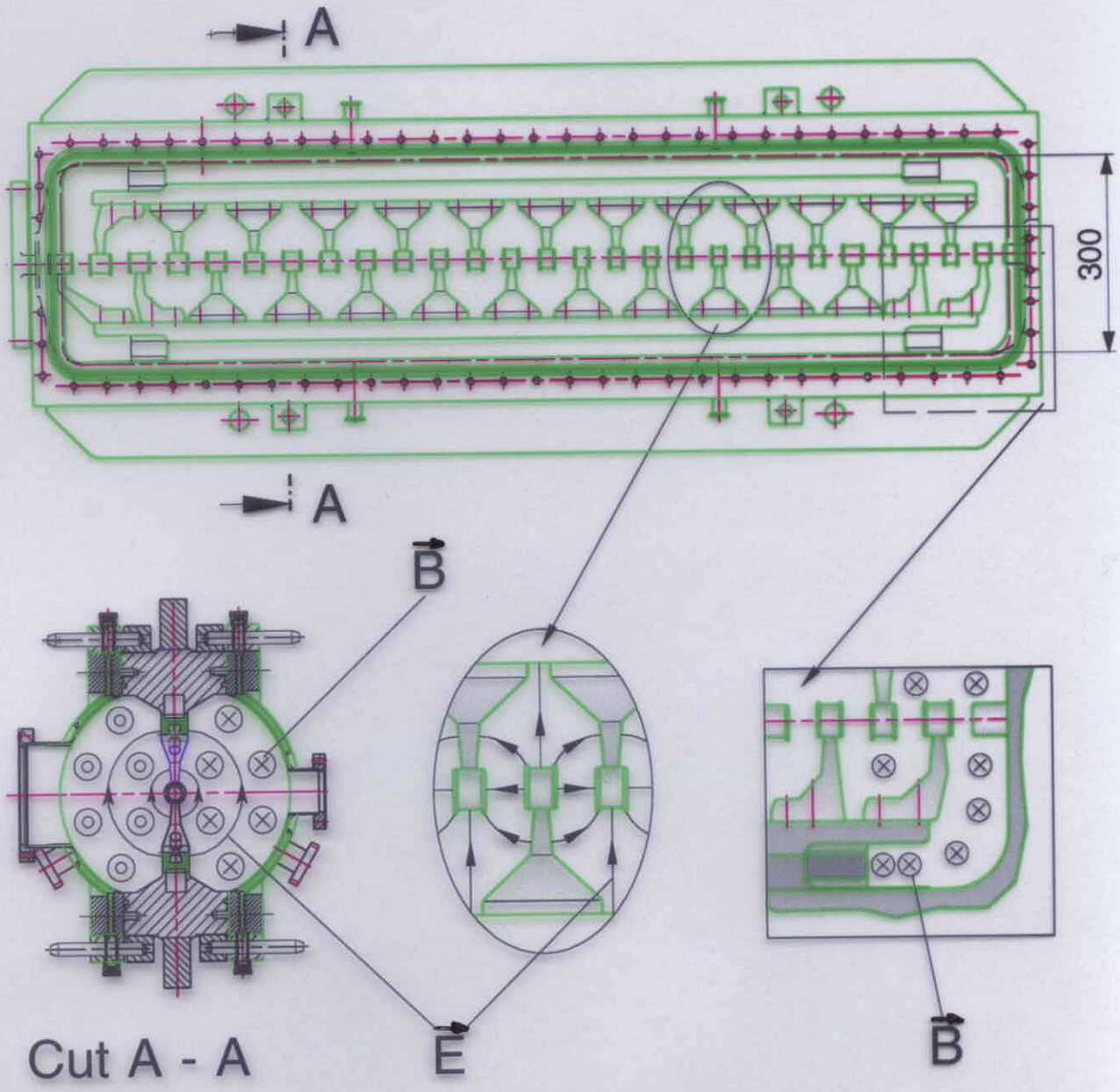
- Expected beam parameters from ESR.
- Results from first decelerator design down to 3.3 A·keV.
- Improved design based on existing rf transmitters.
- Outlook.

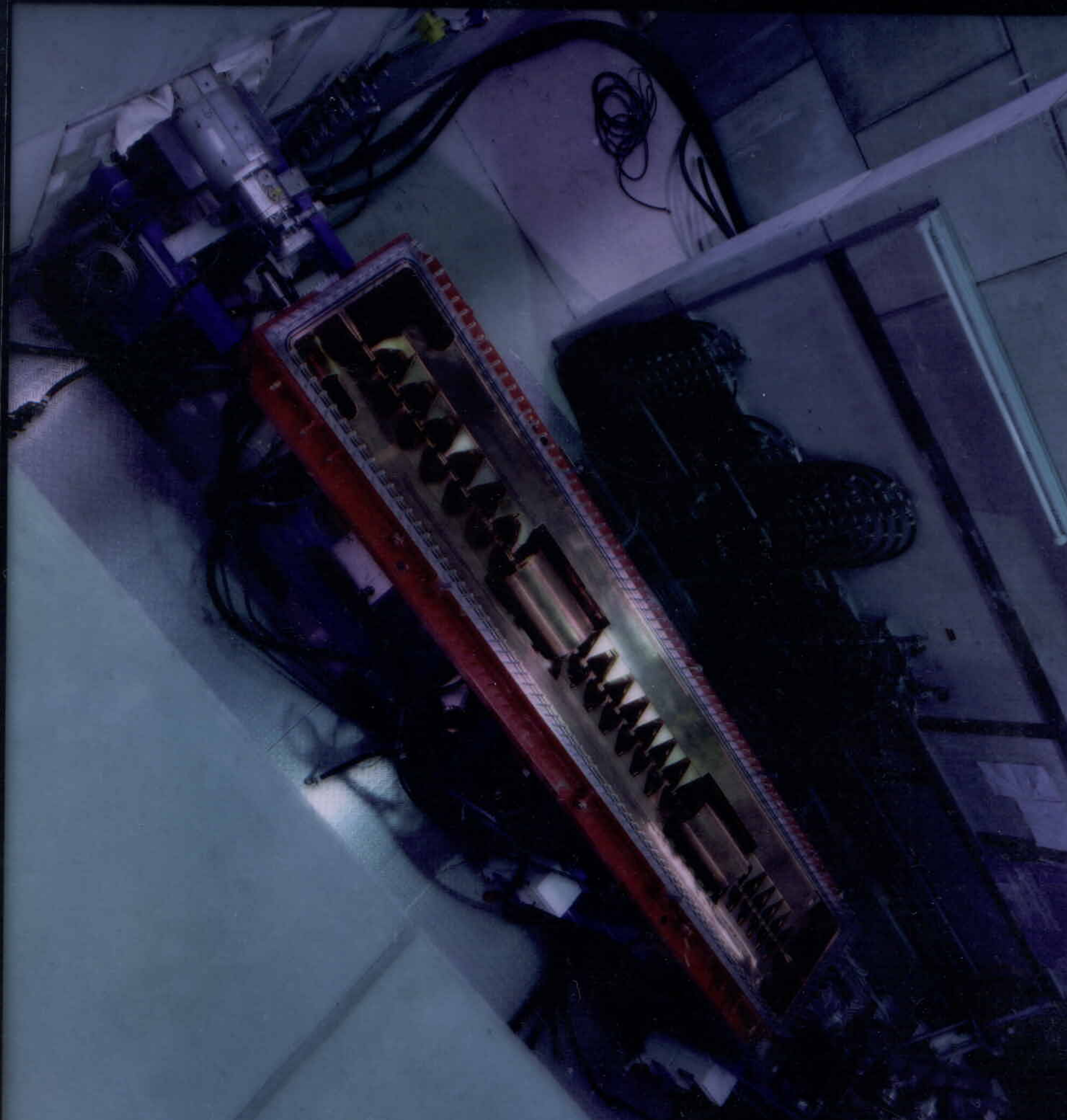
HITRAP Workshop
GSI, December 11, 2002

INTERDIGITAL H-MODE (IH) CAVITY

$H_{11(0)}$ mode, 202 MHz

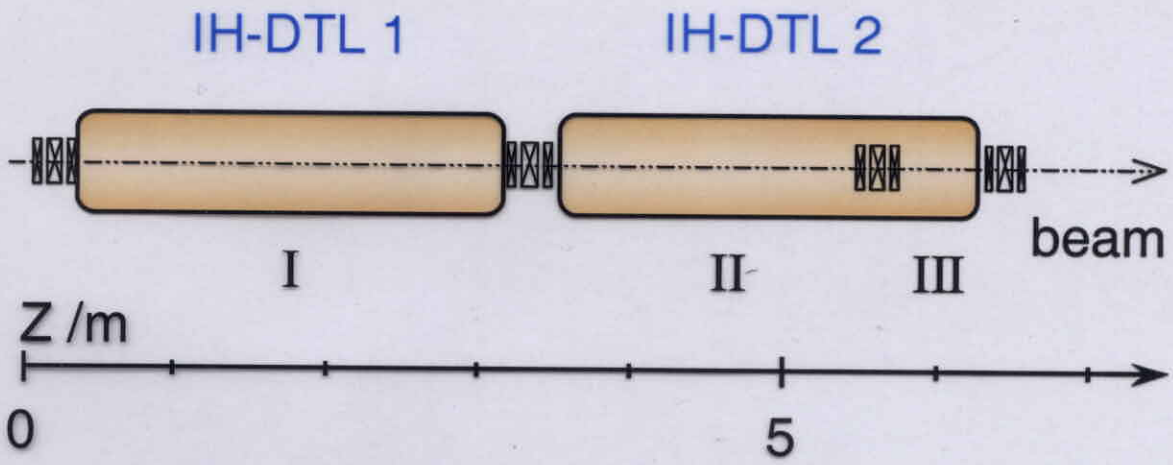
(CERN LINAC 3, Tank 2)





Rc 1959/3

HITRAP decelerator – initial IH-DTL section design

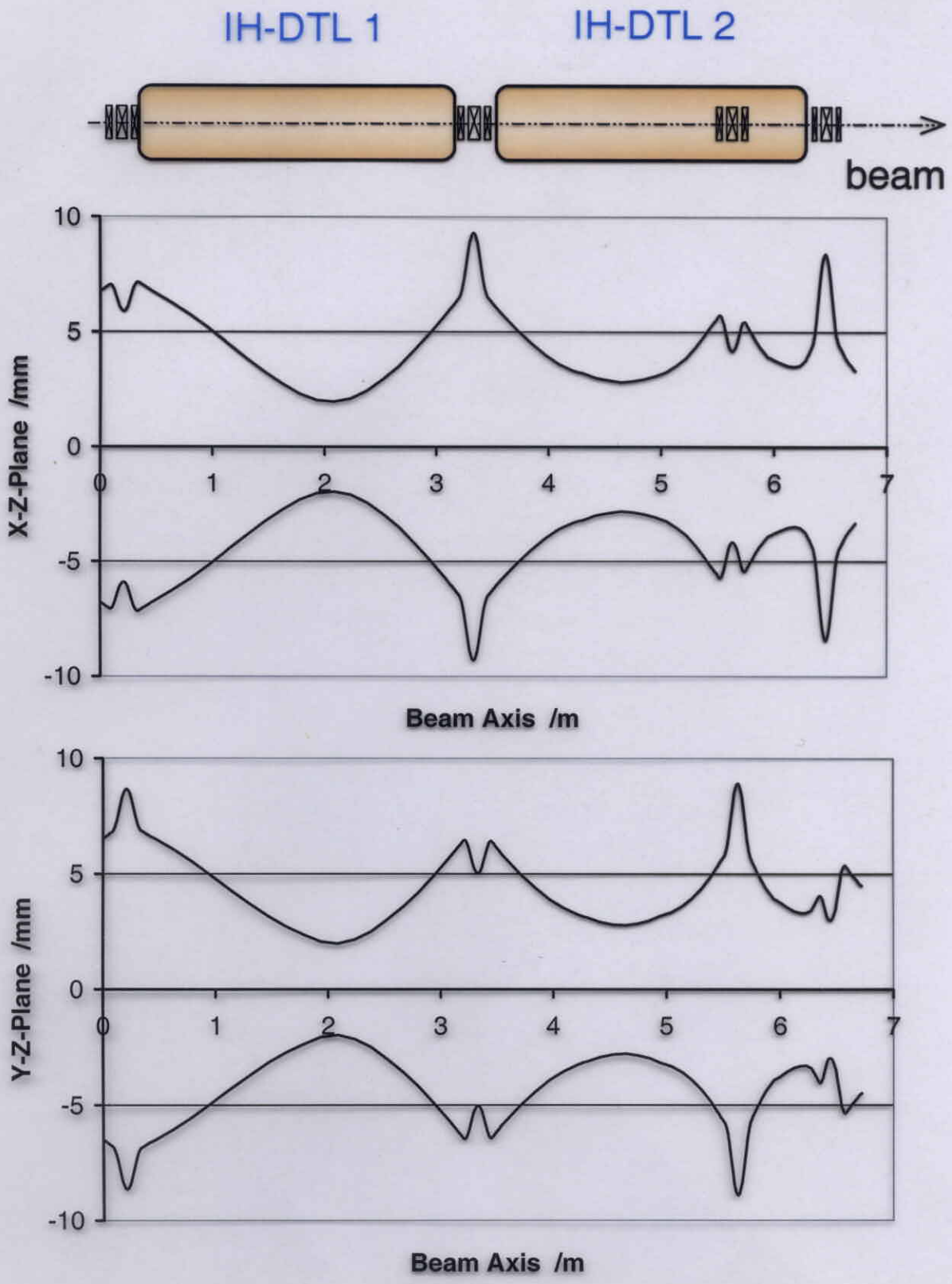


	Section I input	Section I exit	Section II exit	Section III exit
W / A·MeV	7.0	4.3	1.43	0.33
β	0.122	0.096	0.0553	0.0265

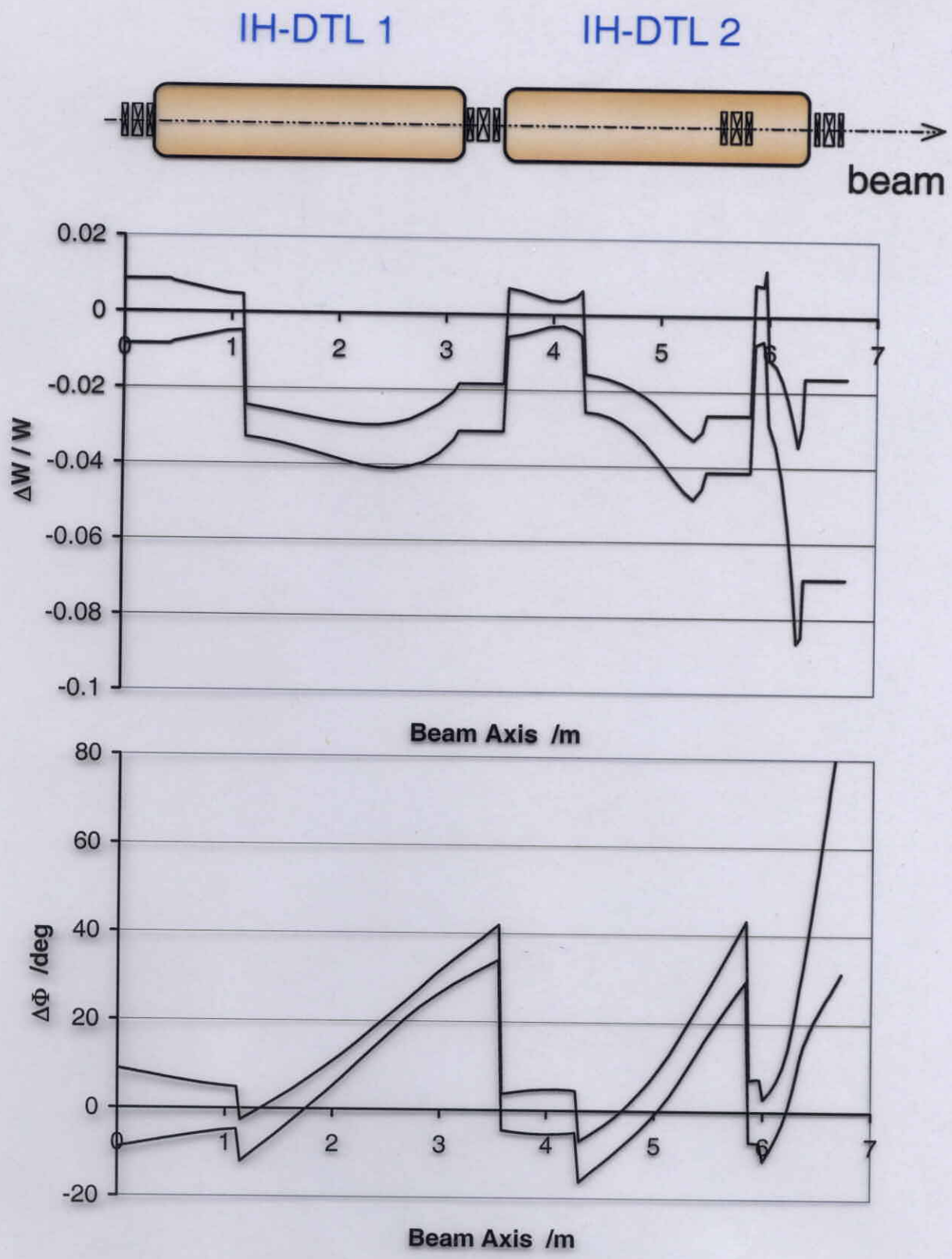
	Section I	Section II	Section III
U_{eff} / MV	8.1	8.6	3.3
Z_{eff} / MΩ/m	100	160	270
L / m	2.8	2.0	0.6
P / kW	234	232	67

$$P = \frac{U_{eff}^2}{Z_{eff} \cdot \cos^2 \bar{\phi}_s \cdot L}$$

IH-DTL: transverse beam envelopes



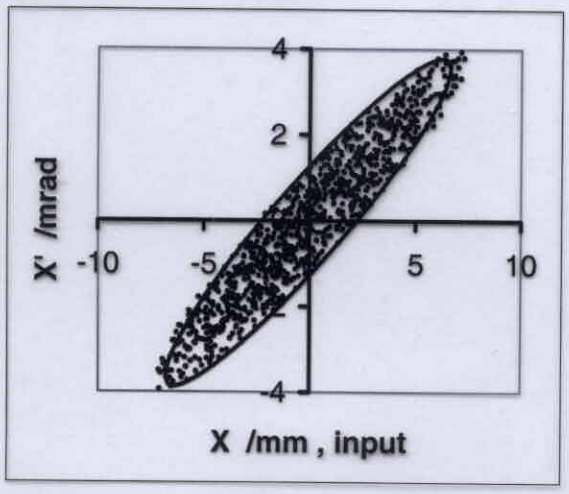
IH-DTL: longitudinal beam envelopes



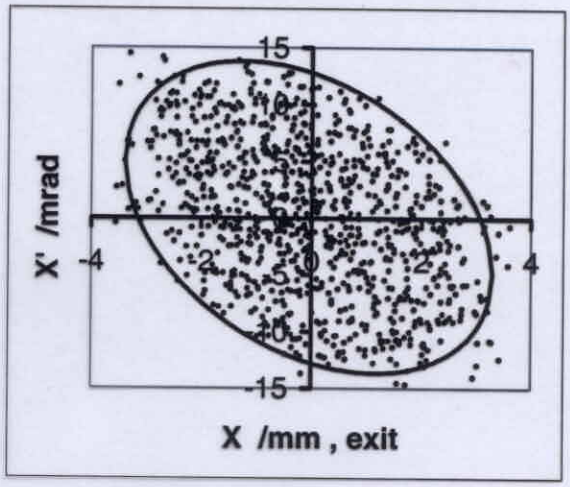
IH-DTL: cluster plots (input / exit)

Goethe-Universität Frankfurt am Main
Johann Wolfgang

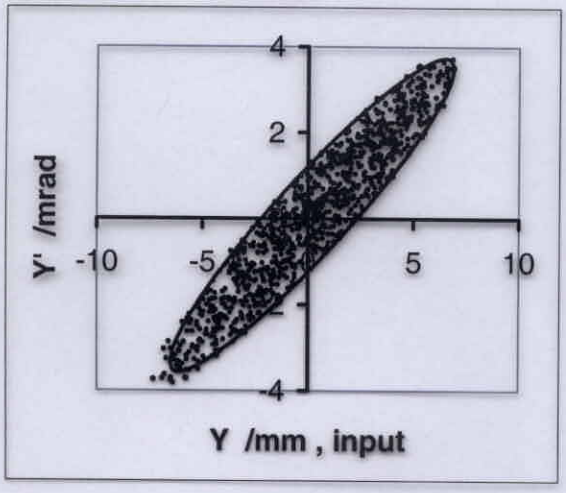
ε_n /mm mrad = 1.0524



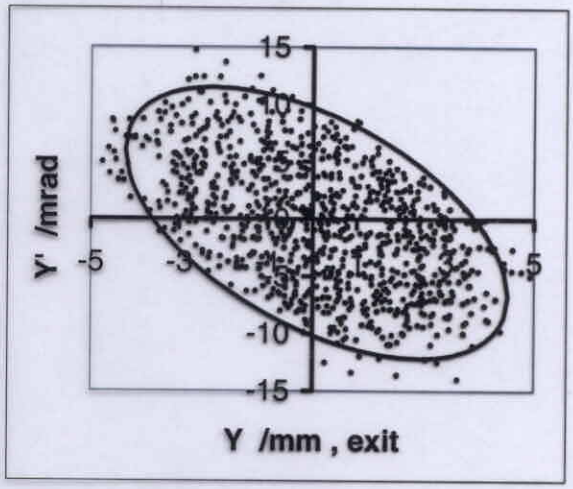
ε_n /mm mrad = 1.1308



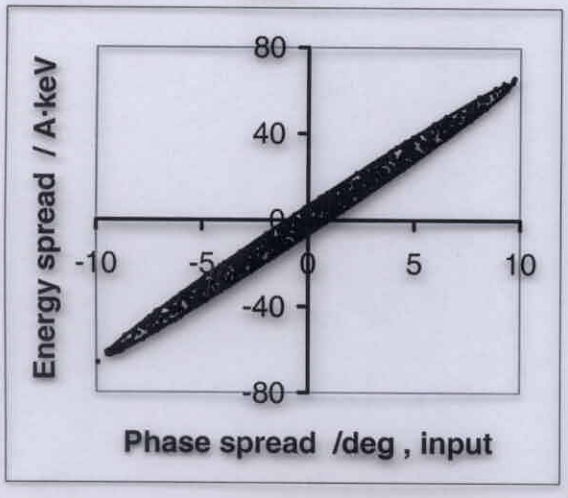
ε_n /mm mrad = 1.0146



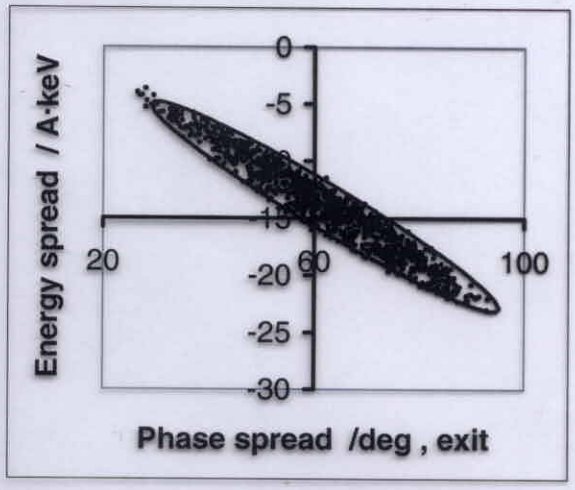
ε_n /mm mrad = 1.1361



ε /A·keV·ns = 1.5894



ε /A·keV·ns = 1.9126



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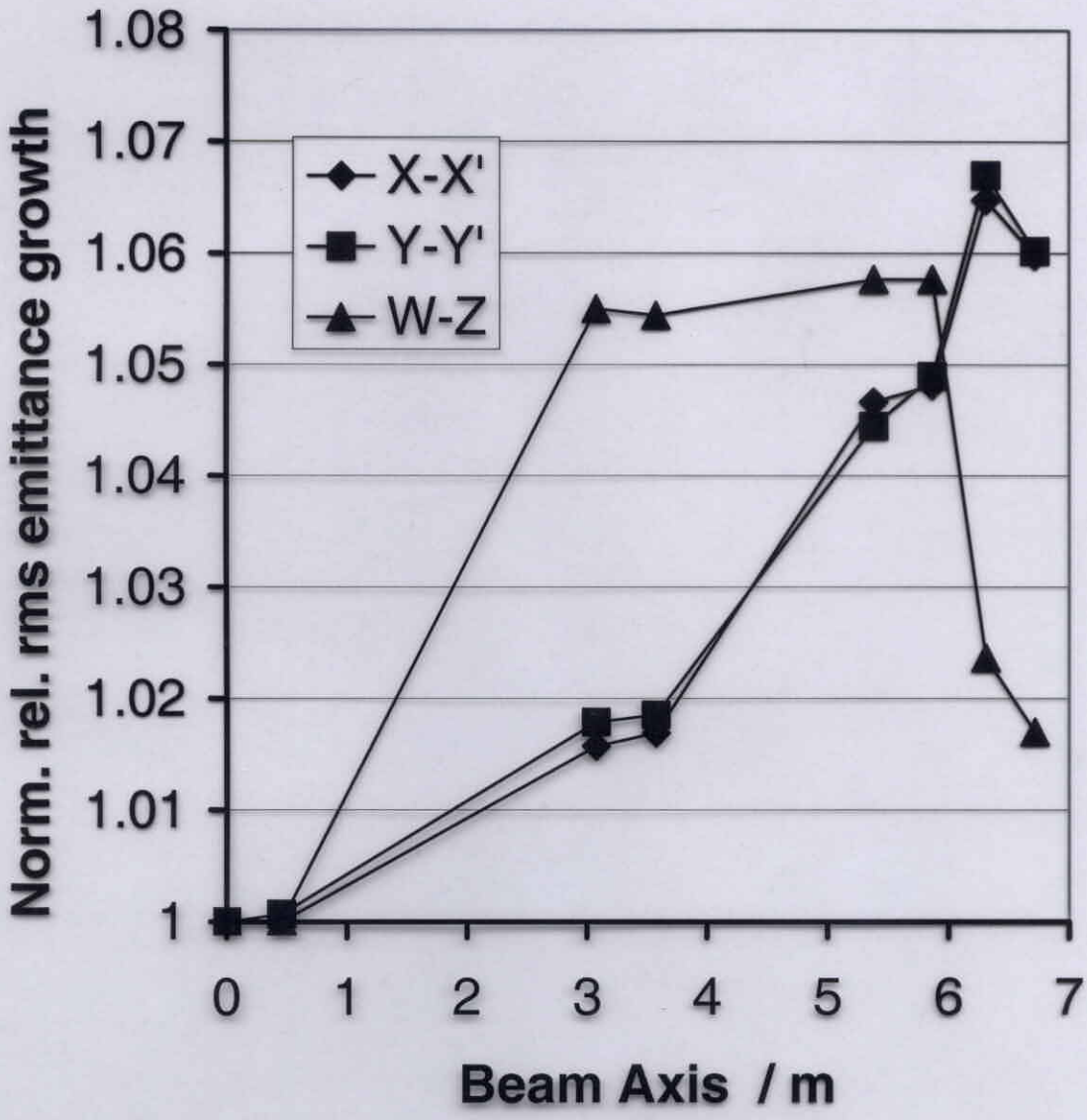
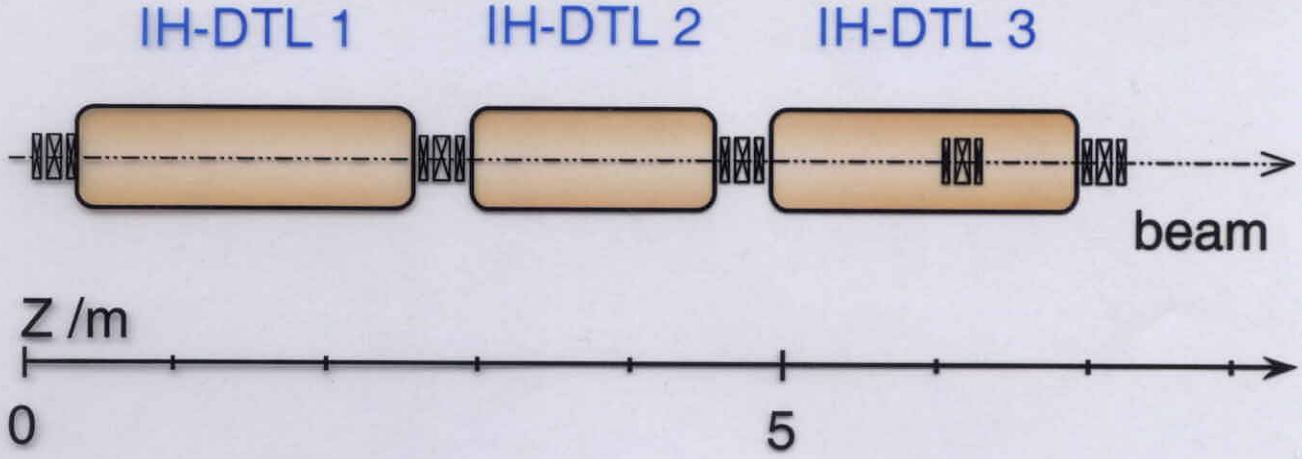
IH-DTL: emittance blow up



HITRAP decelerator – advanced IH-DTL design (P_{max} < 200 kW)

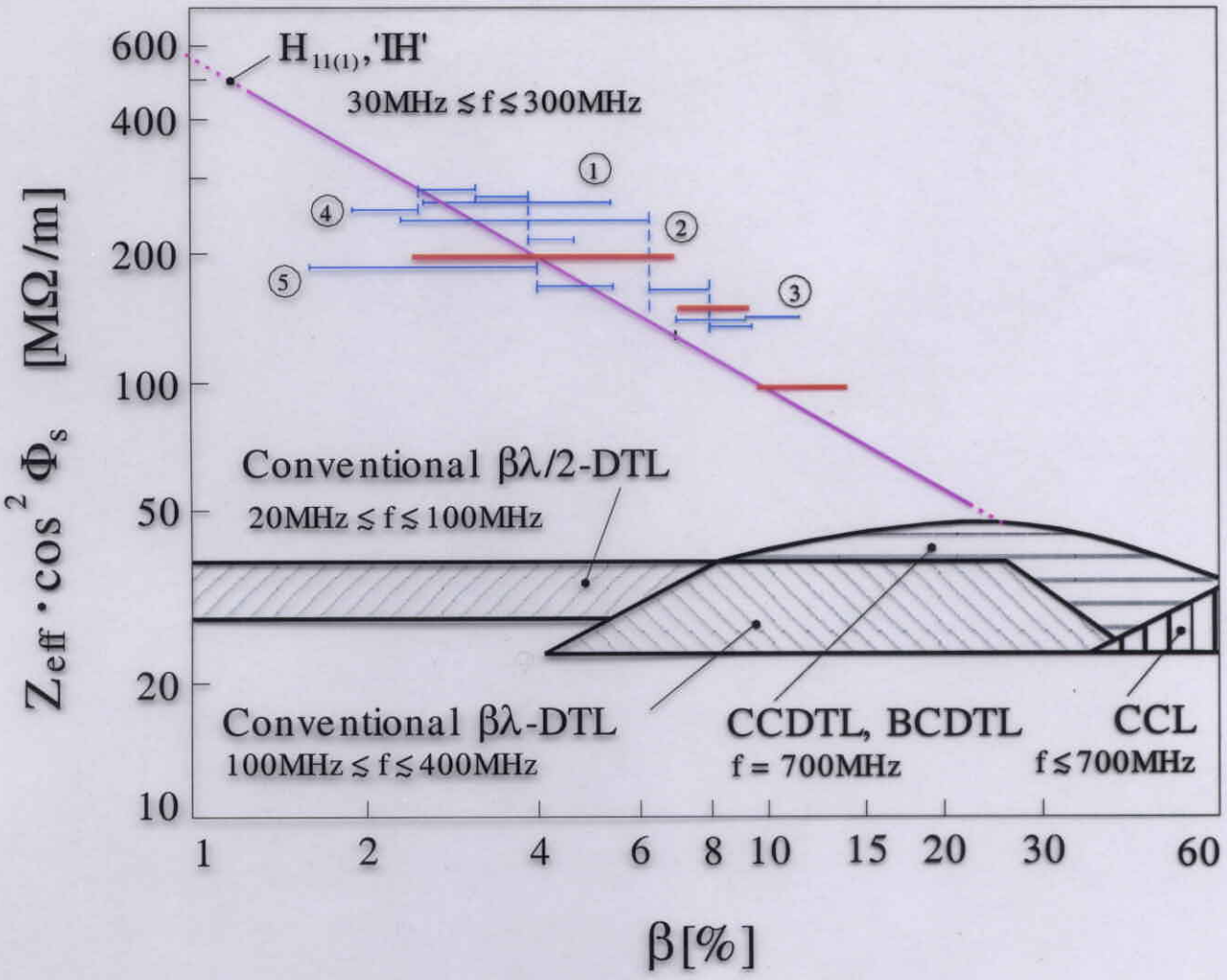


	Tank I input	Tank I exit	Tank II exit	Tank III exit
W / A·MeV	7.0	4.8	2.5	0.33
β	0.122	0.101	0.0731	0.0265

	Tank I	Tank II	Tank III
U_{eff} / MV	6.6	6.9	6.5
Z_{eff} / MΩ/m	100	150	200
L / m	2.2	1.6	2.0
P / kW	198	200	106

$$P = \frac{U_{eff}^2}{Z_{eff} \cdot \cos^2 \overline{\phi}_s \cdot L}$$

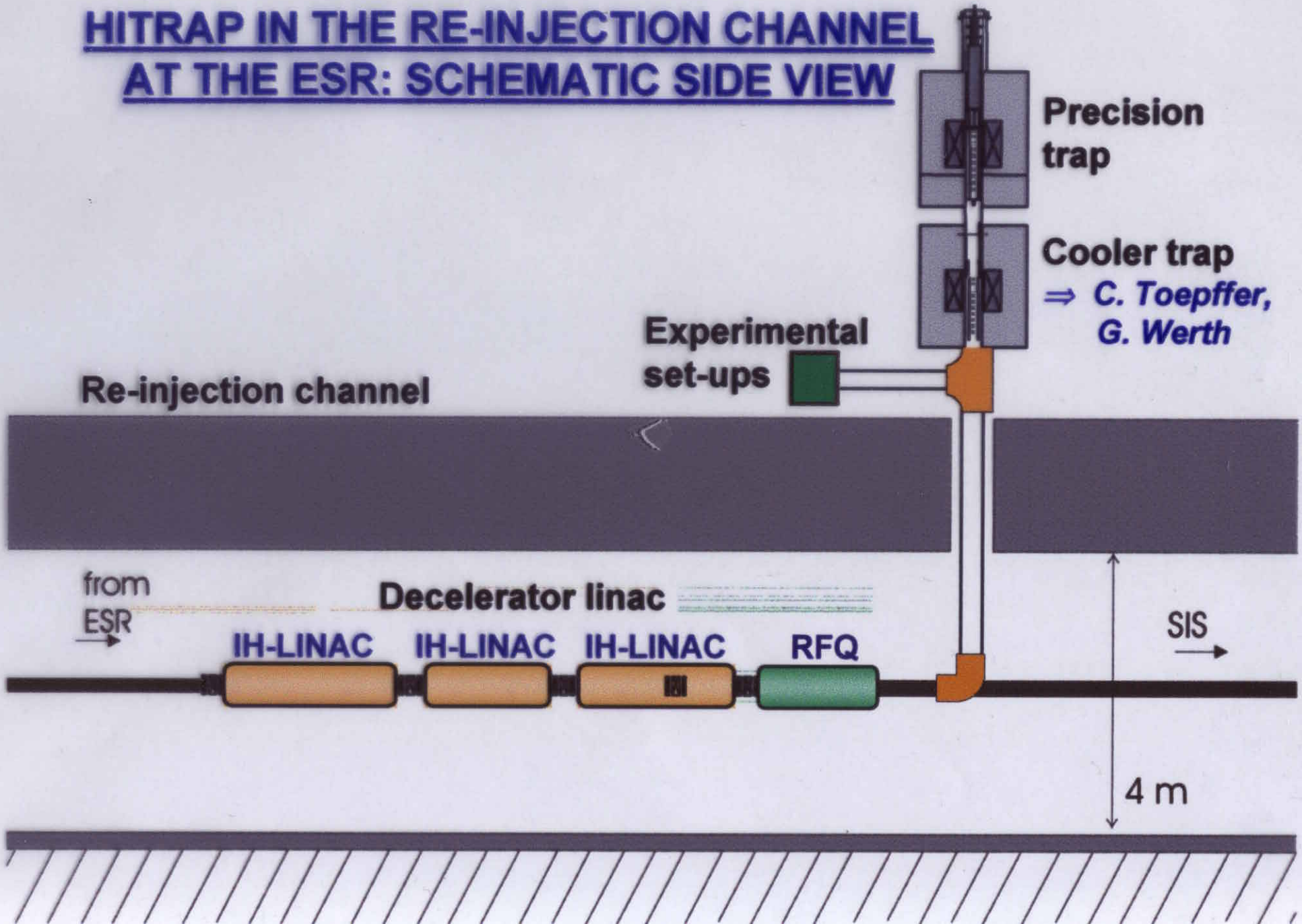
Assumed shunt impedances compared to existing IH-DTL's



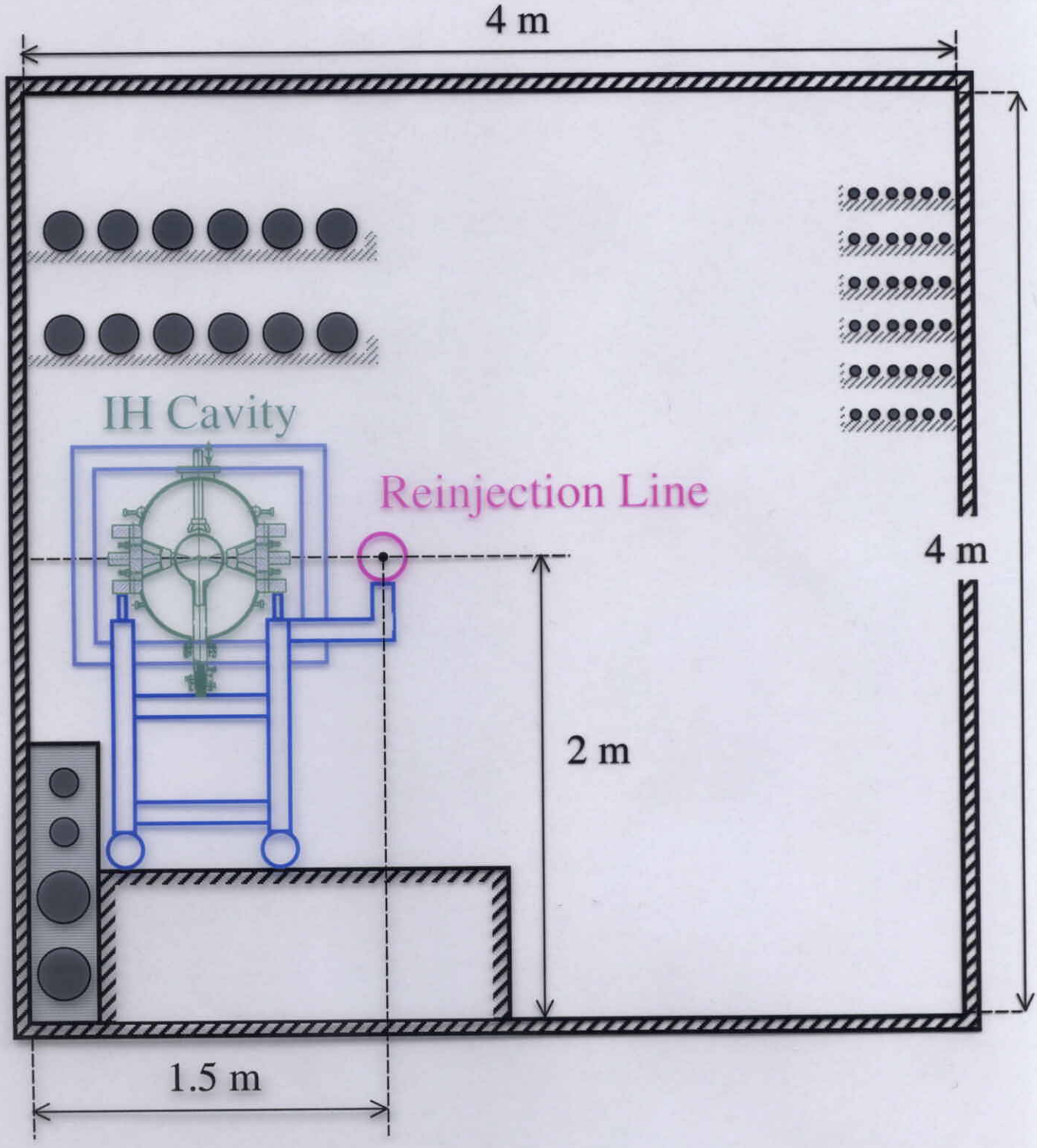
— : Assumed values for decelerator, cavities 1 to 3

(1) HLI-GSI, 108 MHz
(2) LINAC III-CERN, 101/202 MHz
(3) SchweIN, 78.5/157 MHz
(4) ISOL, INS, 51 MHz
(5) HSI-GSI, 36 MHz

HITRAP IN THE RE-INJECTION CHANNEL AT THE ESR: SCHEMATIC SIDE VIEW



Installation within the reinjection beam line



COSTS OF THE HITRAP PROJECT AND SPENDING PR0FILE

Components	Costs [k€]				
	first year	second year	third year	fourth year	sum of four years
Decelerator linac for highly charged ions:					
First and second IH decelerator cavity	70	130	130	70	400
Third IH decelerator cavity	45	105	105	45	300
RFQ decelerator cavity (108 MHz)	15	35	35	15	100
4 quadrupole lenses	45	105	105	95	350
Buncher, steerer, quadrupole lens, diagnostics, 90^0 magnet	30	70	80	45	225
Installation of the existing RF transmitters	0	0	100	100	200
Controls & system integration	0	50	75	100	225
Total decelerator	205	495	630	470	1800
Cooler Penning trap:					
Superconducting magnet	52	78	0	0	130
Mechanical parts, vacuum equipment	7	28	0	0	35
Voltage power supplies	0	20	0	0	20
Total cooler trap	59	126	0	0	185
Transfer line between cooler trap / precision trap:					
Mechanical parts, vacuum equipment, diagnostics	0	25	0	0	25
Total transfer line	0	25	0	0	25
Precision trap					
Precision trap (incl. superconducting magnet)*	0	0	0	0	0
Material for trap modifications, electronics and computers	0	10	35	0	45
Total precision trap	0	10	35	0	45
Transfer line between IH structure and cooling trap					
Mechanical parts, vacuum equipment, diagnostics	0	0	25	0	25
Sum for each years and total sum:	**264**	**656**	**690**	**470**	**2080**

*** The following existing equipment will be used:**

Precision trap, incl. superconducting magnet, RF electronics etc., total value 350 k€

RF transmitter 108 MHz, total value approx. 1600 k€

The costs of the move to the NESR and preparations for antiproton deceleration are estimated to 250 k€

Contribution by the EU (HITRAP RTD Network, essentially manpower): 1900 k€

Conclusions

- A beam energy of 7 A·MeV from the ESR seems realistic
  (9 A·MeV was demonstrated so far).
- 4 RF amplifiers with P_{rf} ~ 200 kW are available at GSI. This allows for a low cost 108 MHz, 21 MV linear decelerator solution.
- Installation in the reinjector beam line is strongly recommended.
  Flexible array on rails possible ; $\Delta x \cong 0.8$ m

Alternatively: 14.5° & 30°-Bendin

Contributions from :

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Since Nov. '02 :

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