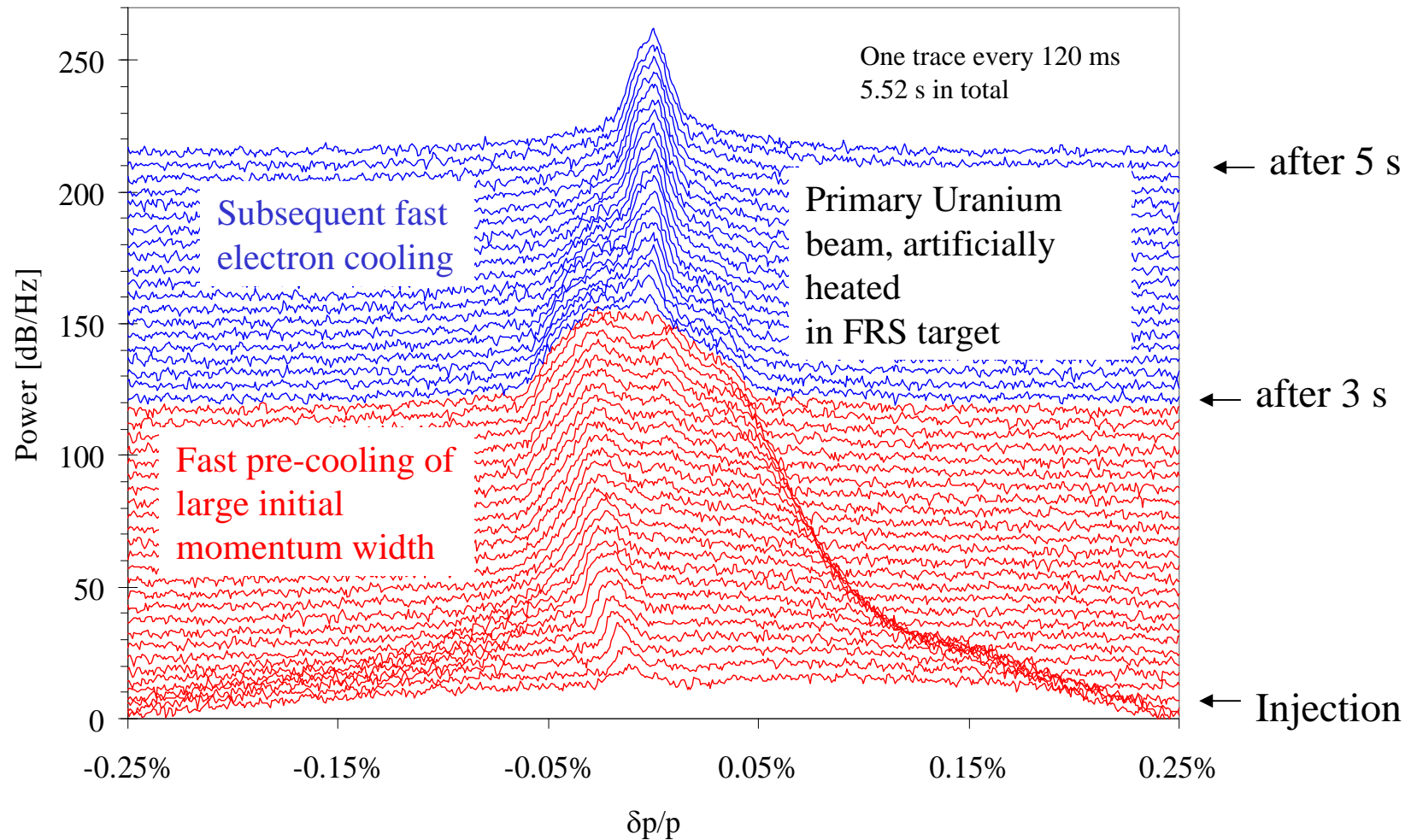# Stochastic Cooling in CR/RESR

F. Nolden

ESR Stochastic Cooling Experience

Overview of
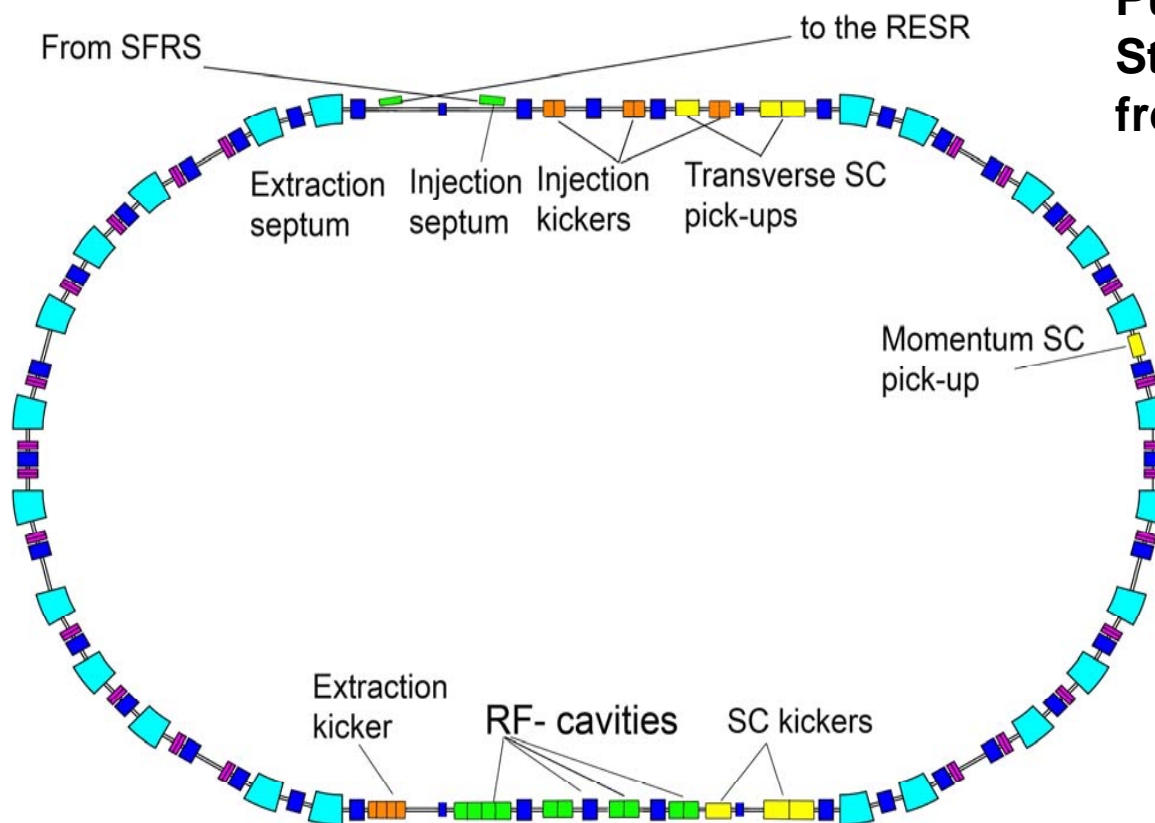# pbar Stochastic Cooling Systems

- CR: Stochastic Preccoling of both pbar ($\beta=0.97$) and radioactive ion ($\beta=0.87$) beams, $N=10^8$ per shot
- RESR: Accumulation only of pbar beams up to $N=10^{11}$ (10^3 shots, repetition time 10 s)

CR

	injection	cooled (2 σ)
momentum spread	$\pm$ 3 %	0.1 %
emittances	240 mm mrad	5 mm mrad

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CR Collector Ring

From SFRS

to the RESR

Extraction septum

Injection septum

Injection kickers

Transverse SC pick-ups

Momentum SC pick-up

Extraction kicker

RF- cavities

SC kickers

Purpose:
Stochastic Cooling of
fresh secondary beams

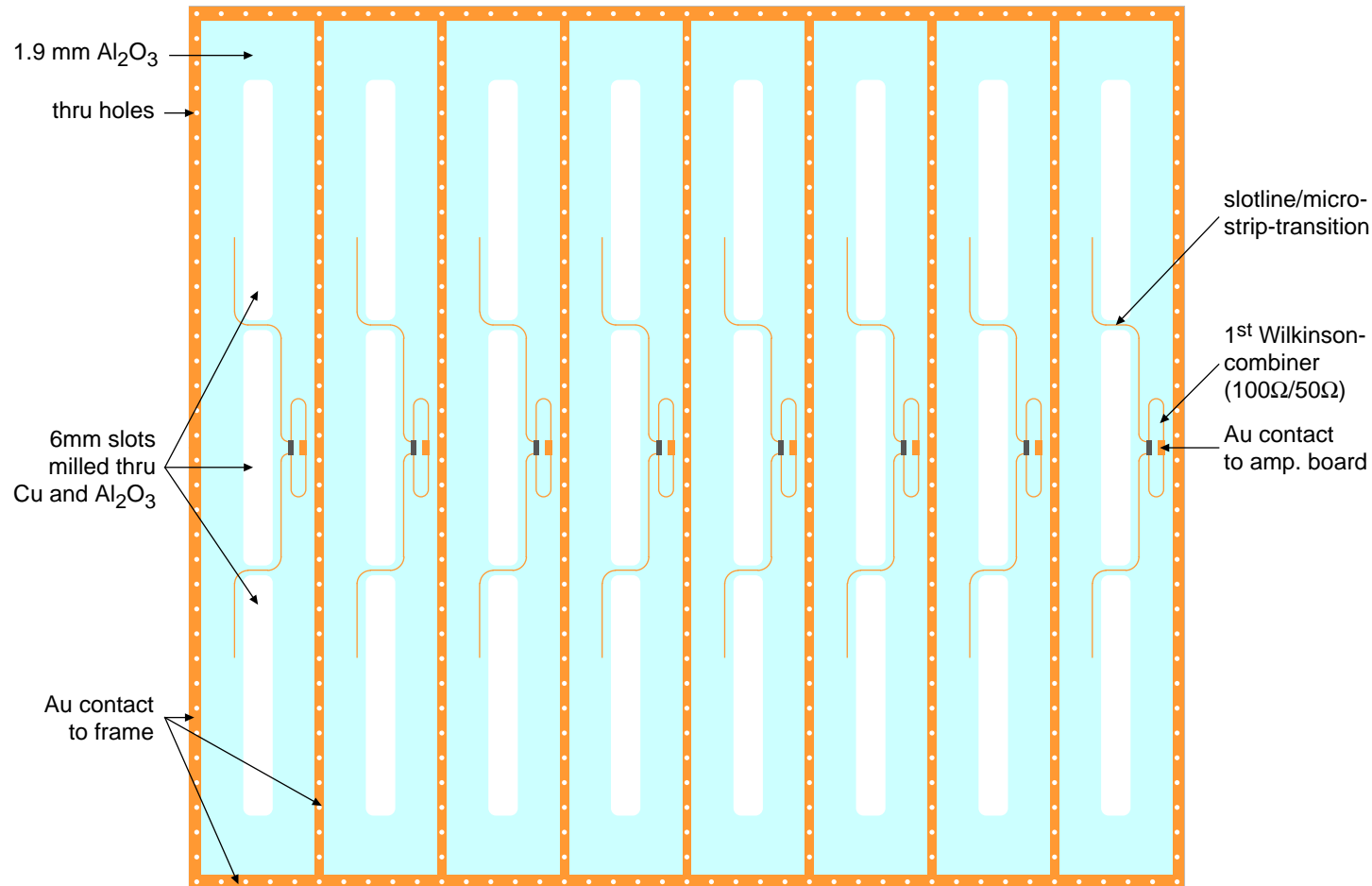|		
Circumference	216.25	m
Max. bending power	13	Tm
Number of dipoles	24	
of quadrupoles	40	
of sextupoles	24	
of inj.kickers	3	
of extr.kickers	1	
of RF cavities	5 (10)	
of S.C. tanks	7	

GSI

CR Hardware Parameters

- 3 Pick-up tanks @ 2m length
- 3 Kicker tanks @ 2m length
- 1 more Pick-up tank for RIB's

- 3 kicker tanks @ 2m length
- All tanks have movable electrodes
- All electrode structures based on slotlines
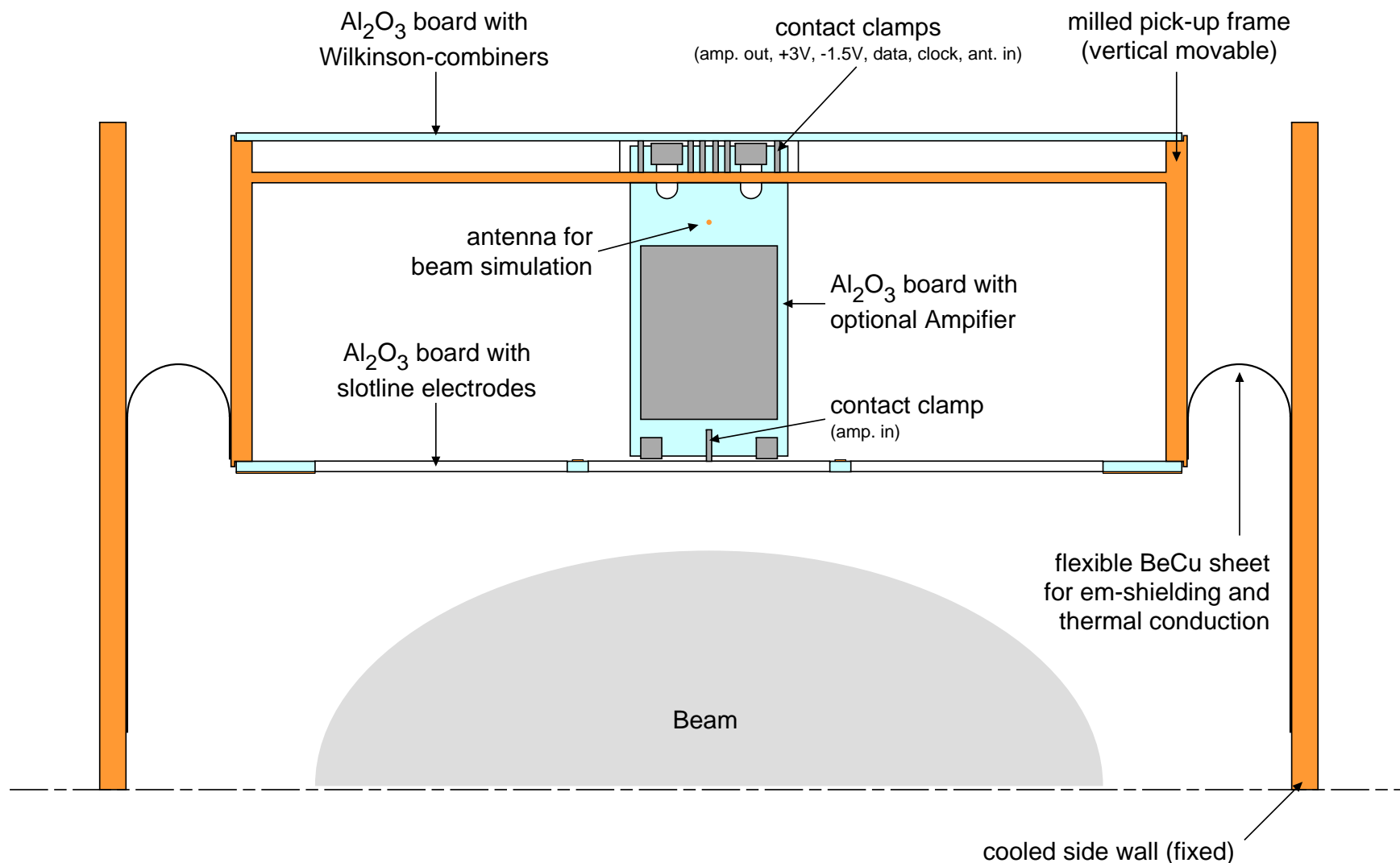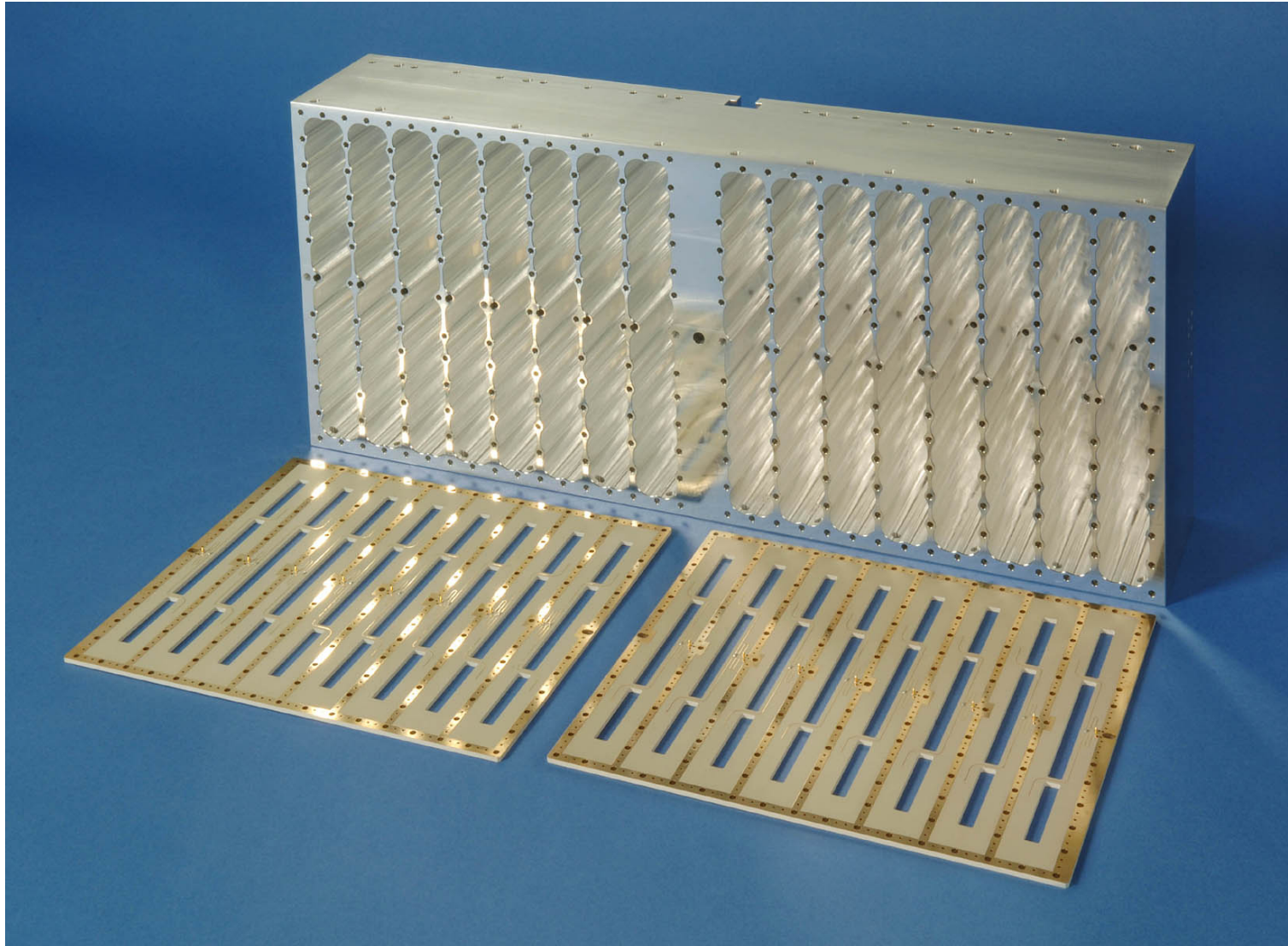- 4.8 kW cw power @ 1-2 GHz

Cu or Au

thru holes

6mm slots
milled thru
Cu and Al_2O_3

Al_2O_3
bridges

Rear Side of Slotline Electrode

Slotline Structure Development

Al$_2$O$_3$ board with
Wilkinson-combiners

contact clamps
(amp. out, +3V, -1.5V, data, clock, ant. in)

milled pick-up frame
(vertical movable)

antenna for
beam simulation

Al$_2$O$_3$ board with
optional Ampifier

Al$_2$O$_3$ board with
slotline electrodes

contact clamp
(amp. in)

flexible BeCu sheet
for em-shielding and
thermal conduction

Beam

cooled side wall (fixed)

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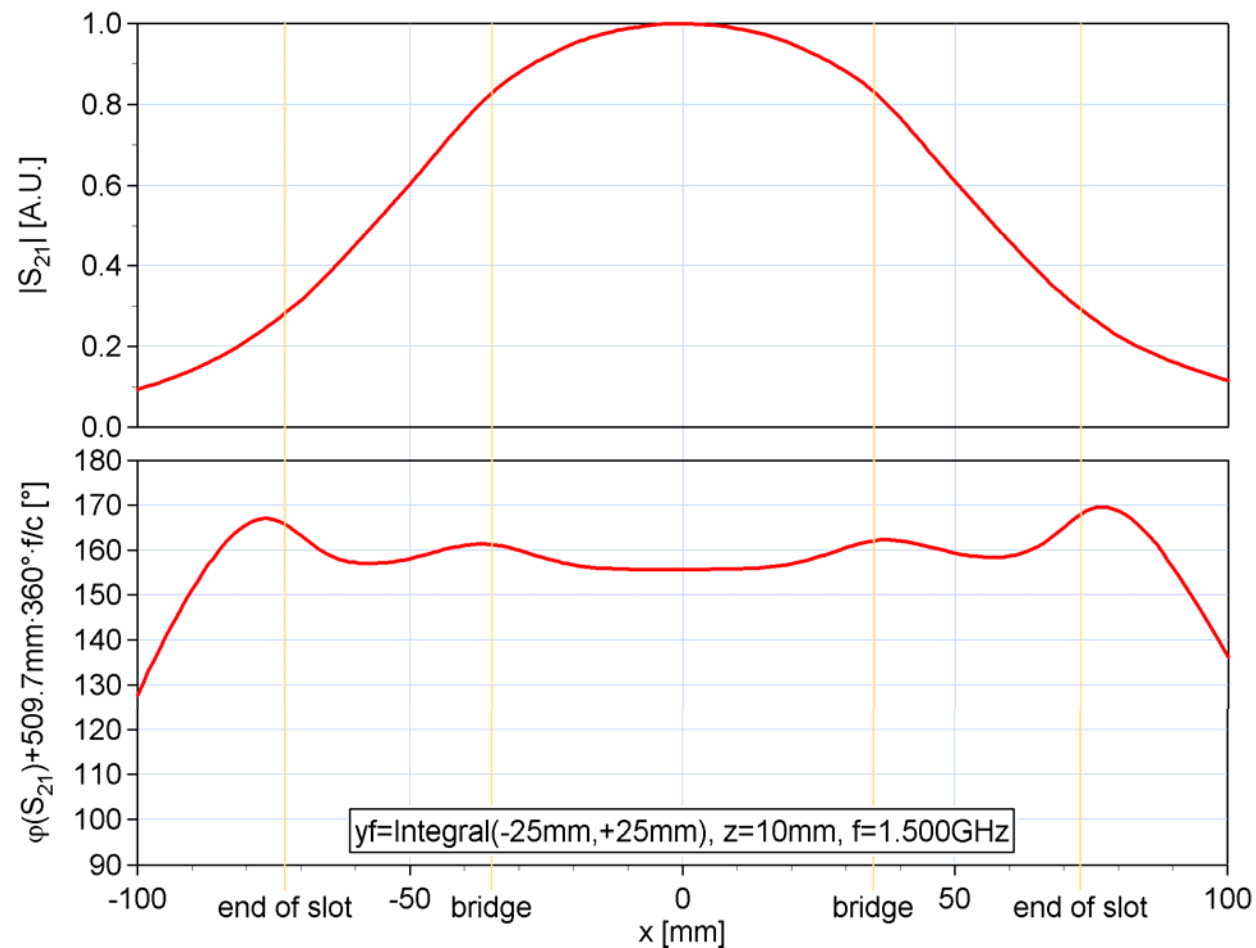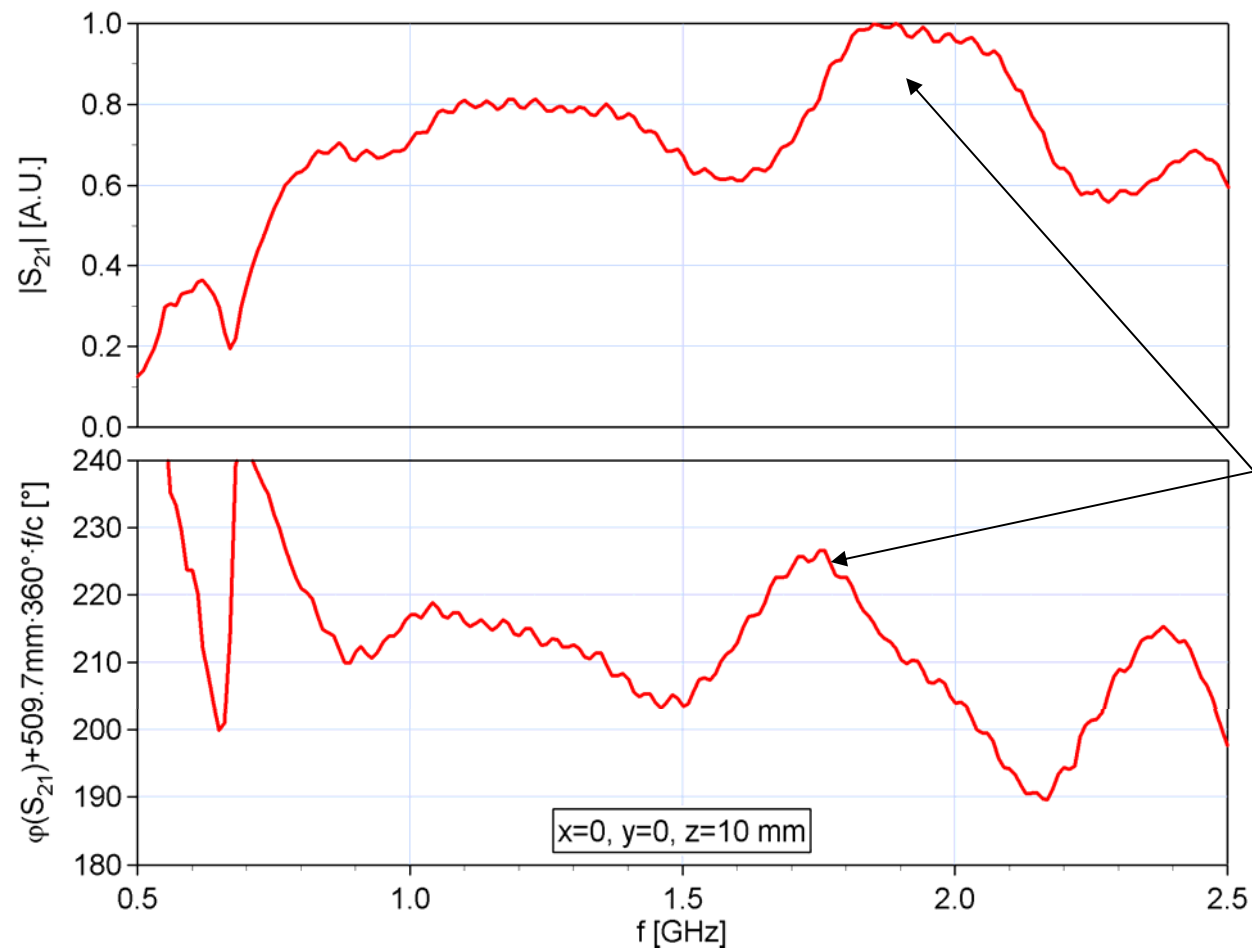# Aluminum Body for Slotline Electrodes

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Measured Electrode Response vs. horizontal deviation

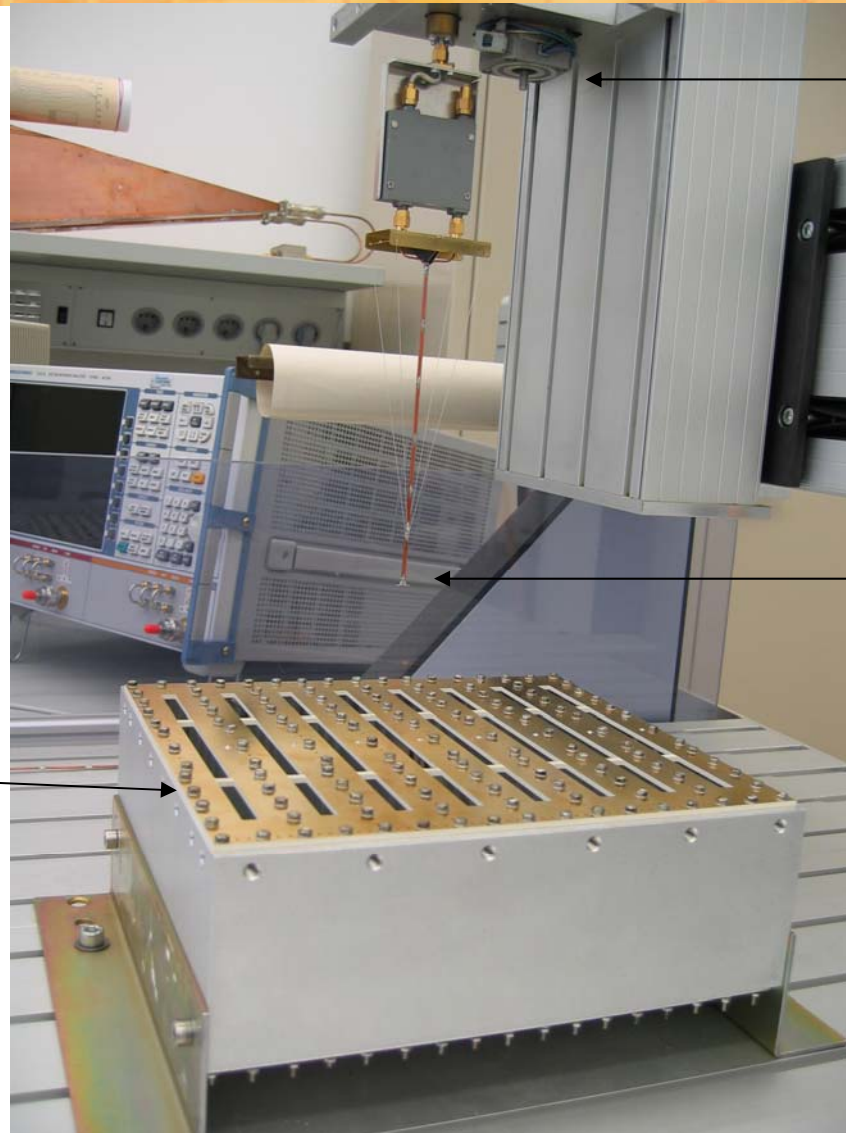# Measured Electrode Response vs. frequency

Ripple due to bad junctions has been made smaller meanwhile

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Field Measurement

3D + 1 movable
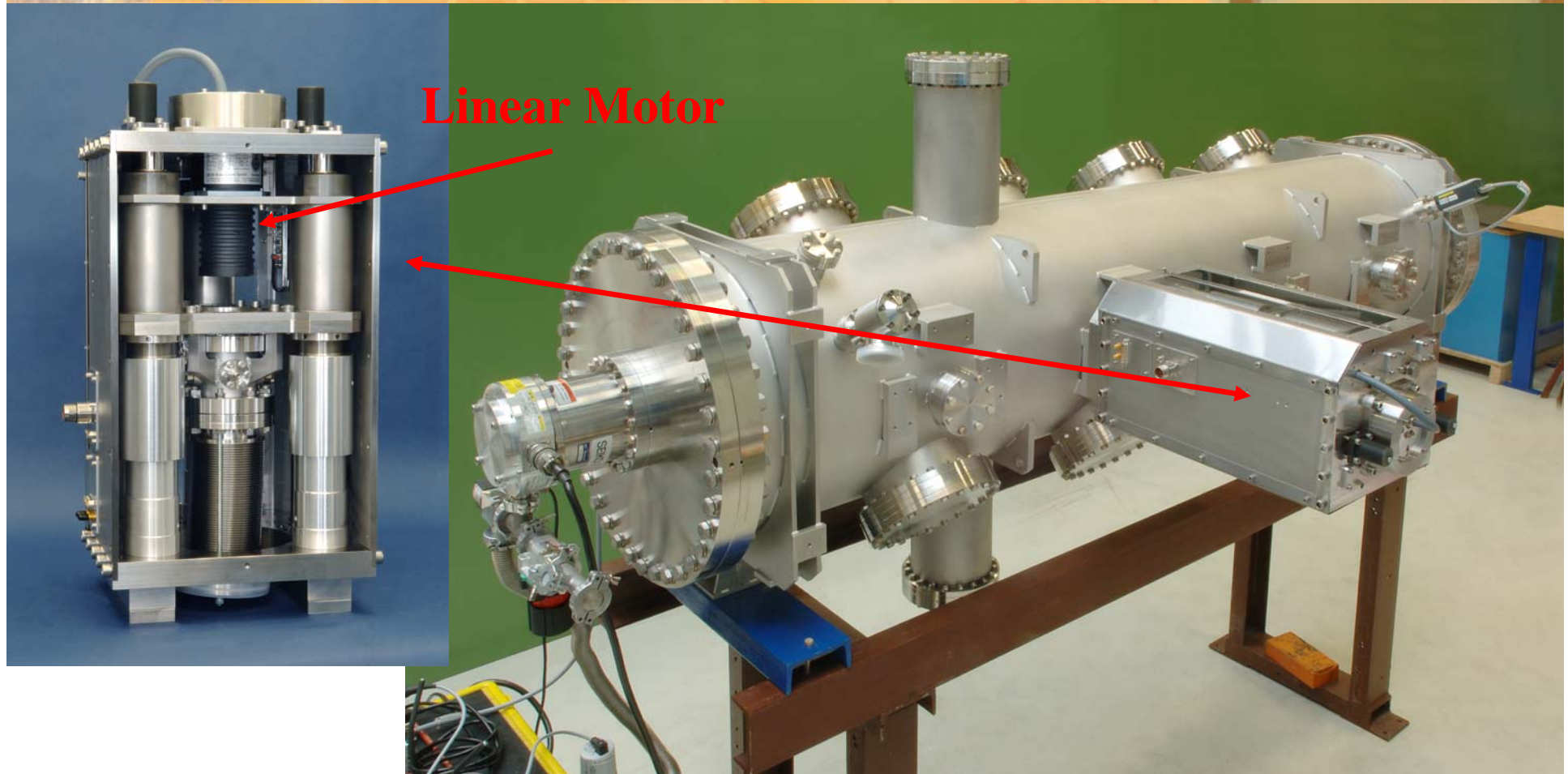probe carrier

Field probe

Module with
8 Slotlines

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Prototype Tank
with Movable Electrodes

Linear Motor

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Power Amplifier

max. amplitude ripple ± 1 dB

max. phase nonlinearity 10°

water cooling

2×100 W cw @ 1-2 GHz

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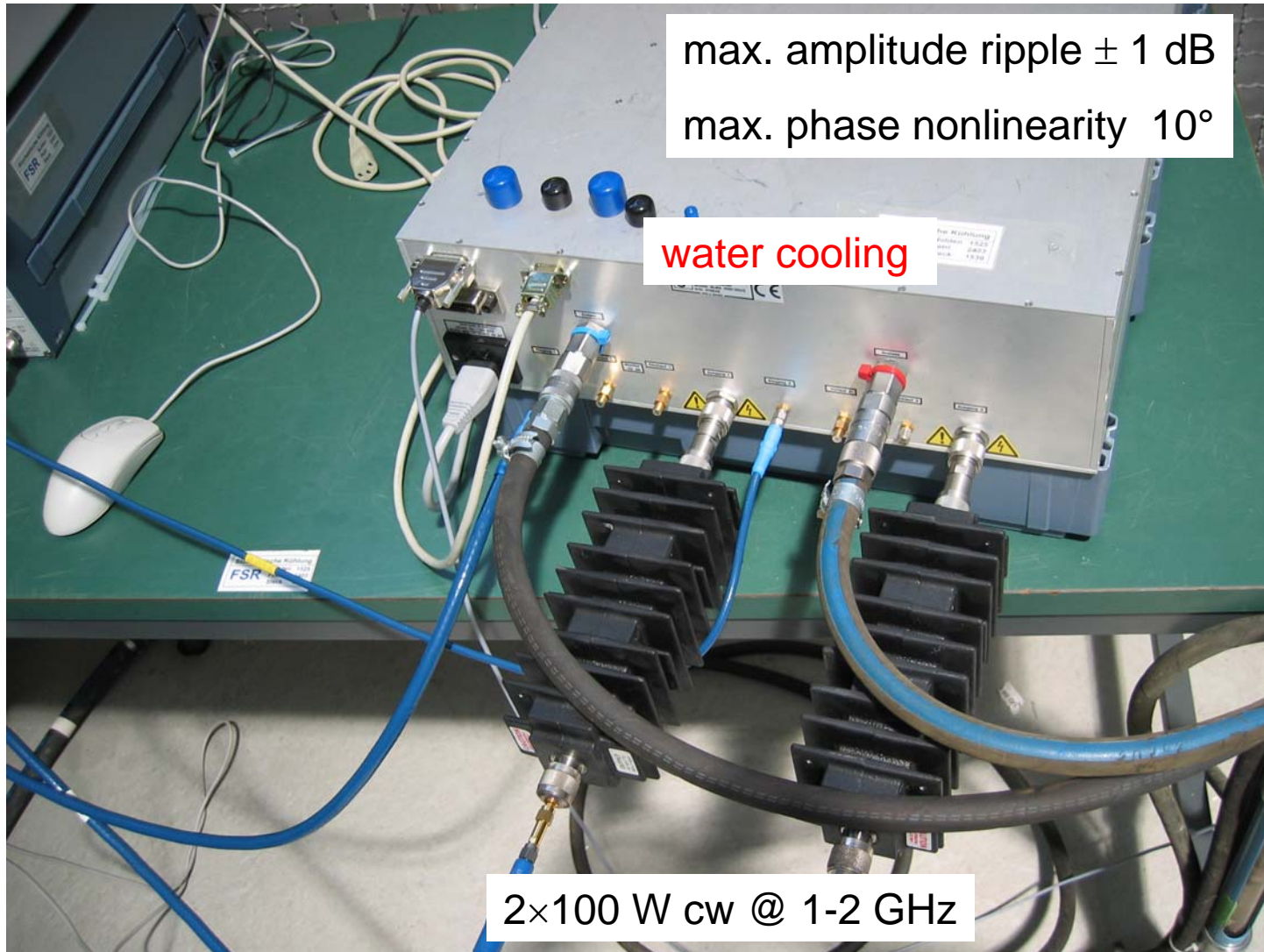
Purpose of RESR

- Accumulation of antiprotons
  - for HESR (PANDA)
  - and low energy antiproton experiments (FLAIR)
- Deceleration of RIBs (NESR internal experiments)
- Deceleration of antiprotons towards ER (only for AIC)
- Electron cooling of antiprotons (only for AIC)

AIC: antiproton-ion collider F.Nolden MAC Meeting July 2009

GSI

RESR Parameters for Antiprotons

Kinetic energy [MeV/u]	**3000**
Ring circumference [m]	**239.91**
Transition γ_T	γ_T = **3.06 for HESR** γ_T = **6.11 for deceleration**
Frequency Slip $\eta = \gamma^{-2} - \gamma_T^{-2}$	η = **-0.05 for HESR** η = **+ 0.03 for deceleration**
Revolution frequency [MHz]	**1.21**
Number of injected ions from CR	$1 * 10^8$
Number of accumulated ions	$< 2 * 10^{11}$
Injection cycle time [s]	**10**

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RESR Stochastic Cooling

Extraction towards NESR

Injection from CR

horizontal

vertical

longitudinal (accumulation)

Extraction towards HESR

F.Nolden MAC Meeting July 2009

RESR Twiss Functions

Betatron amplitude functions [m] versus distance [m]

horizontal PU

50.0000

accumulation PU:
- $\beta_y < 3m$

0.000   59.978

Dispersion functions [m] versus distance [m]

15.0000

- $D = 13\ m$

vertical PU

0.000   59.978

-15.0000

Horizontal ──────   Vertical ─ ─ ─ ─ ─ ─

GSI
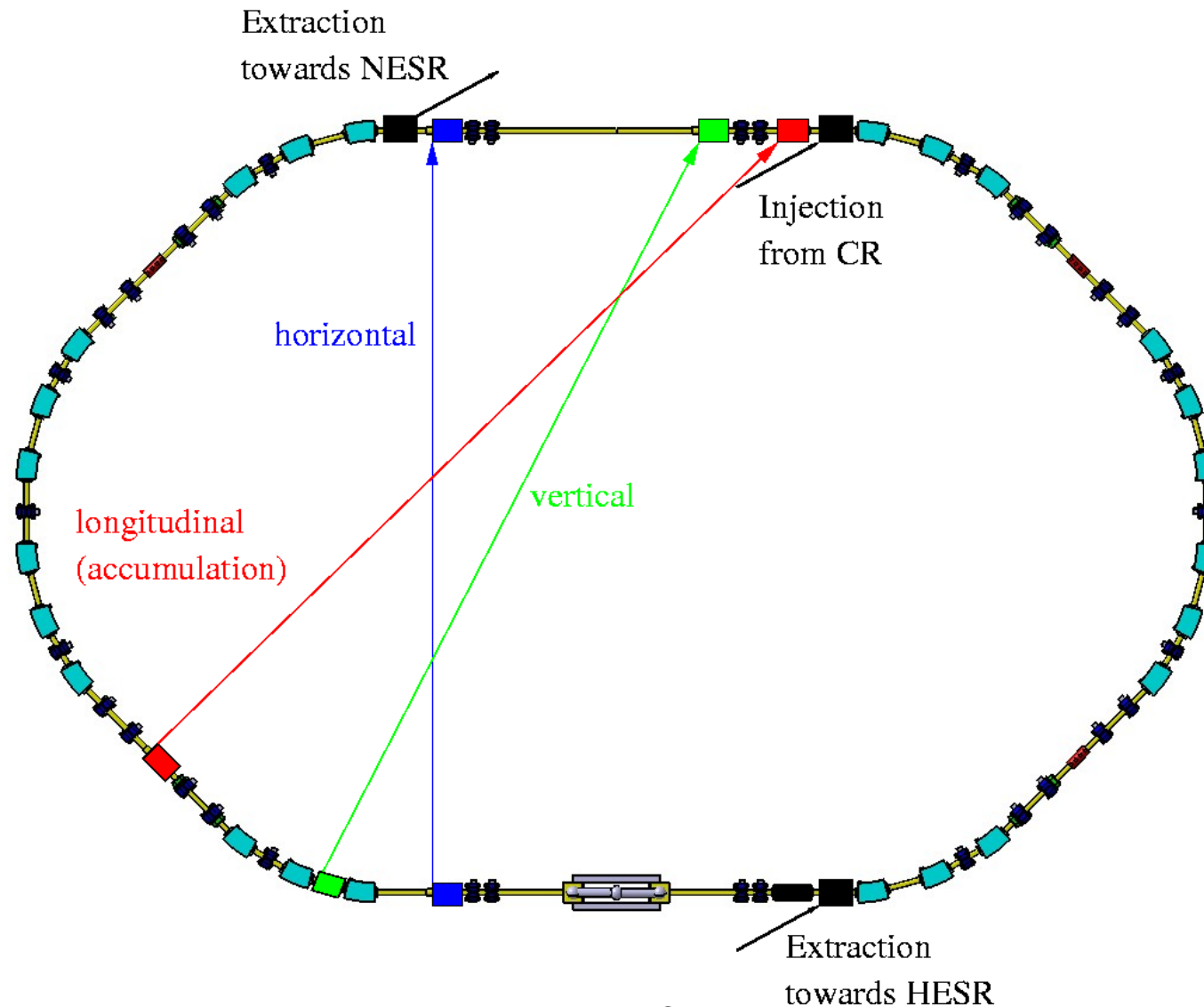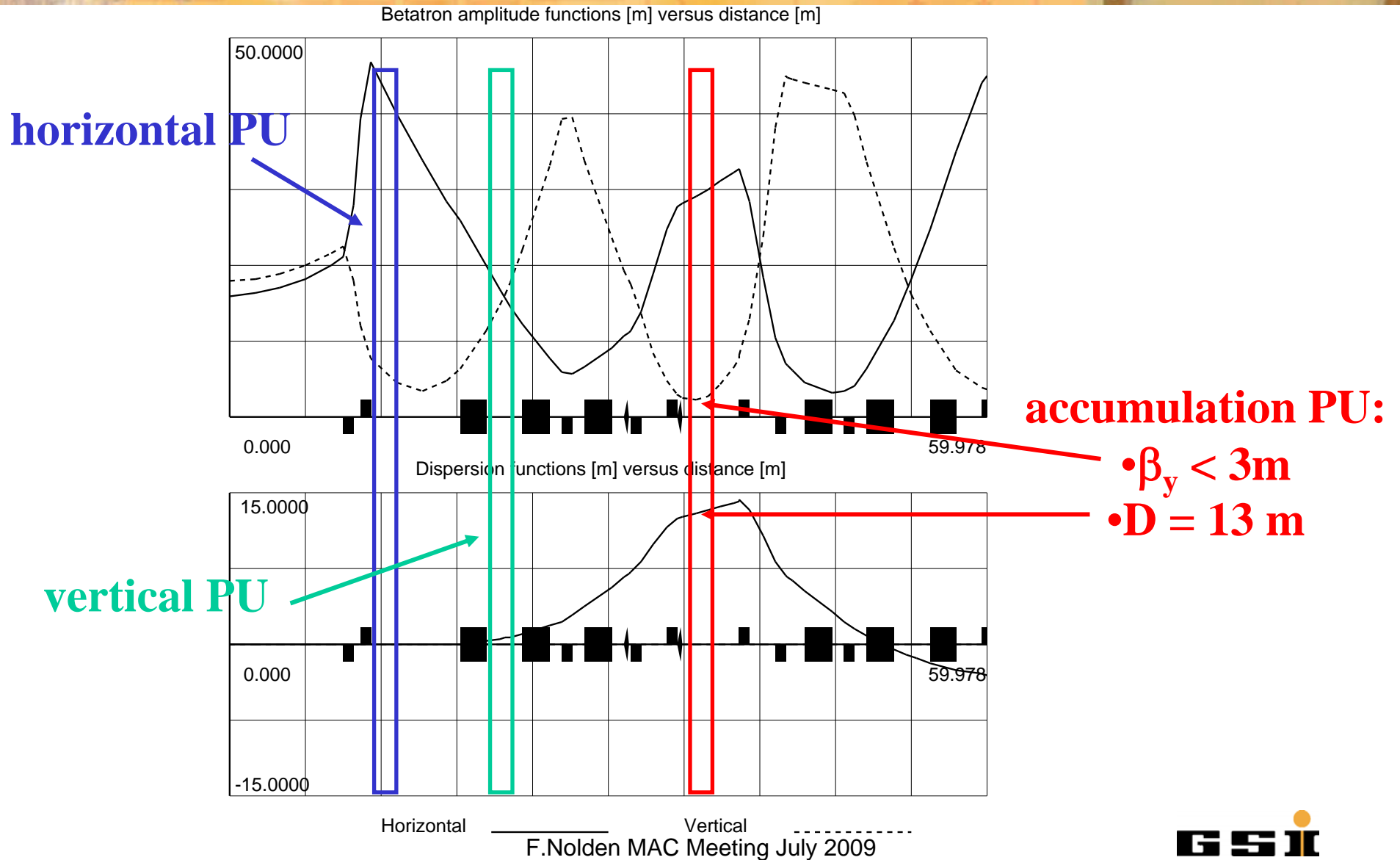
Antiproton Accumulation (1)

stack tail

beam deposit

partial aperture injection kicker

vacuum chamber at momentum pick-up

stack core

injected beam

$\delta p/p$ = 0.32 %

$\delta p/p$ = 0.5 % (?)

$\delta p/p$ = 0.08 %

160 mm

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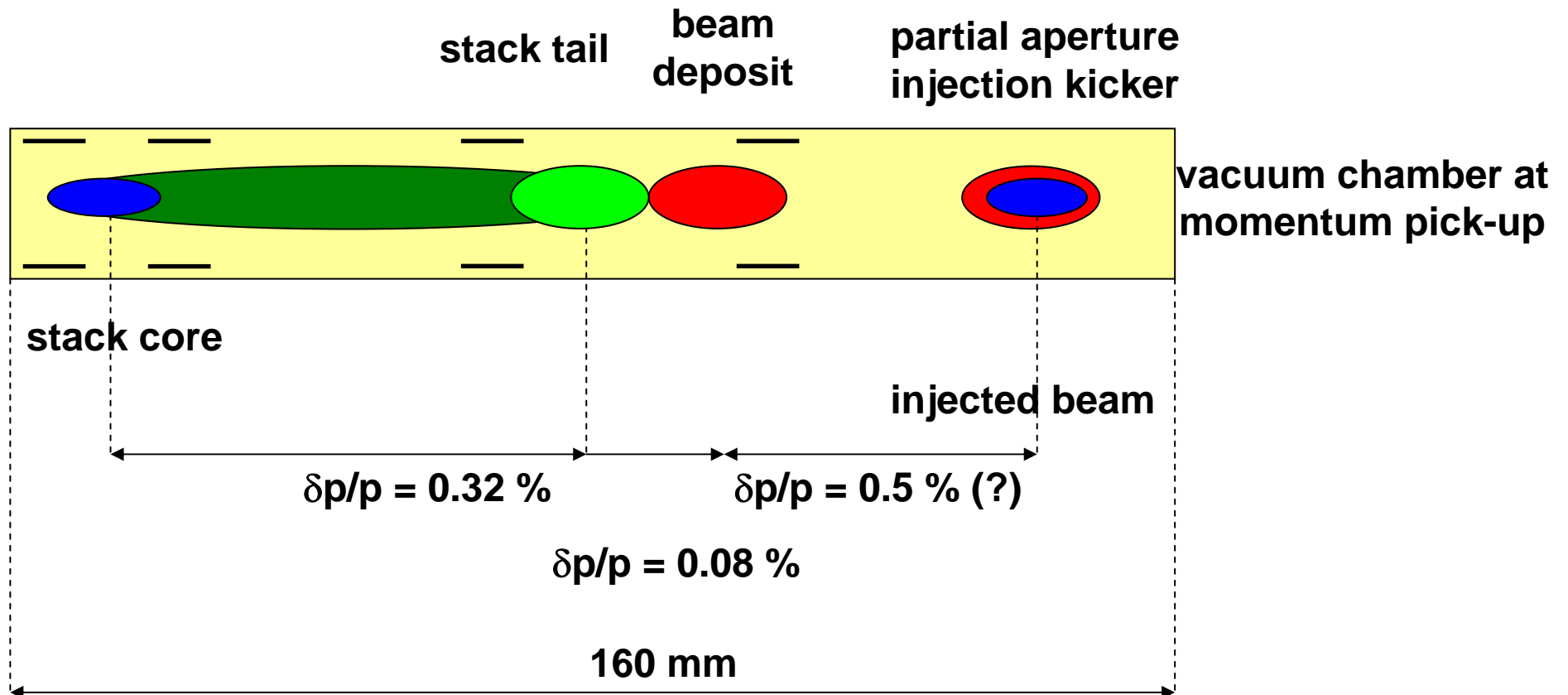
RESR longitudinal pick-up
(D. Möhl, L. Thorndahl)

290 mm (right core electrodes)

10

230 mm (left core electrodes)

202 mm (auxiliary tail electrodes)

180 mm (tail electrodes)

40

40 mm

20

20

20

40

140

80

40

Δr (mm)

11.4

40

22.8

11.4

ΔE (MeV)

Acceptance limit

Injection orbit

Deposit

Stack core

Acceptance limit
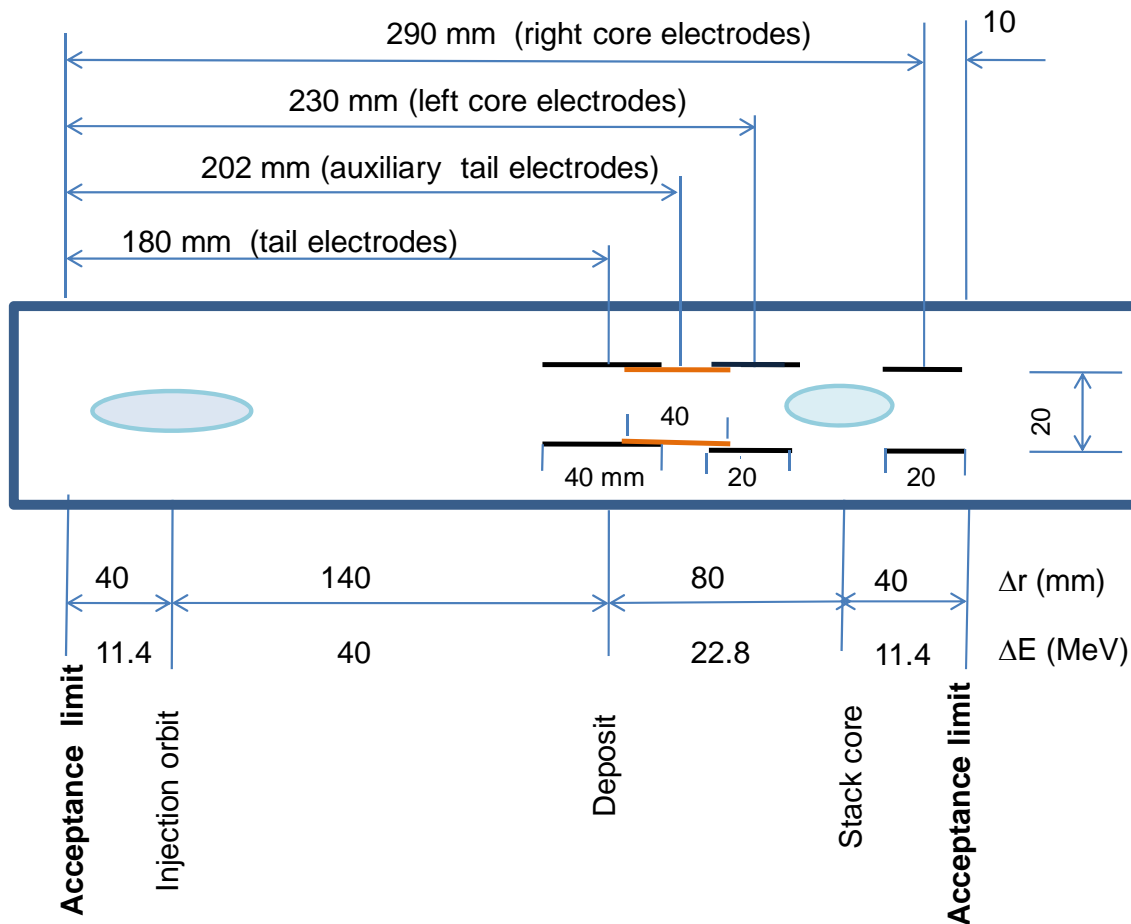
Accumulation Simulation Results
(D. Möhl, L. Thorndahl)

Total rms power: 310 W @ 1-2 GHz

35 mW @ 2-4 GHz

Installed cw power: 2 kW @ 1-2 GHz

2 W @ 2-4 GHz