FETS Chopper Development

Status Report

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FETS Chopper Development

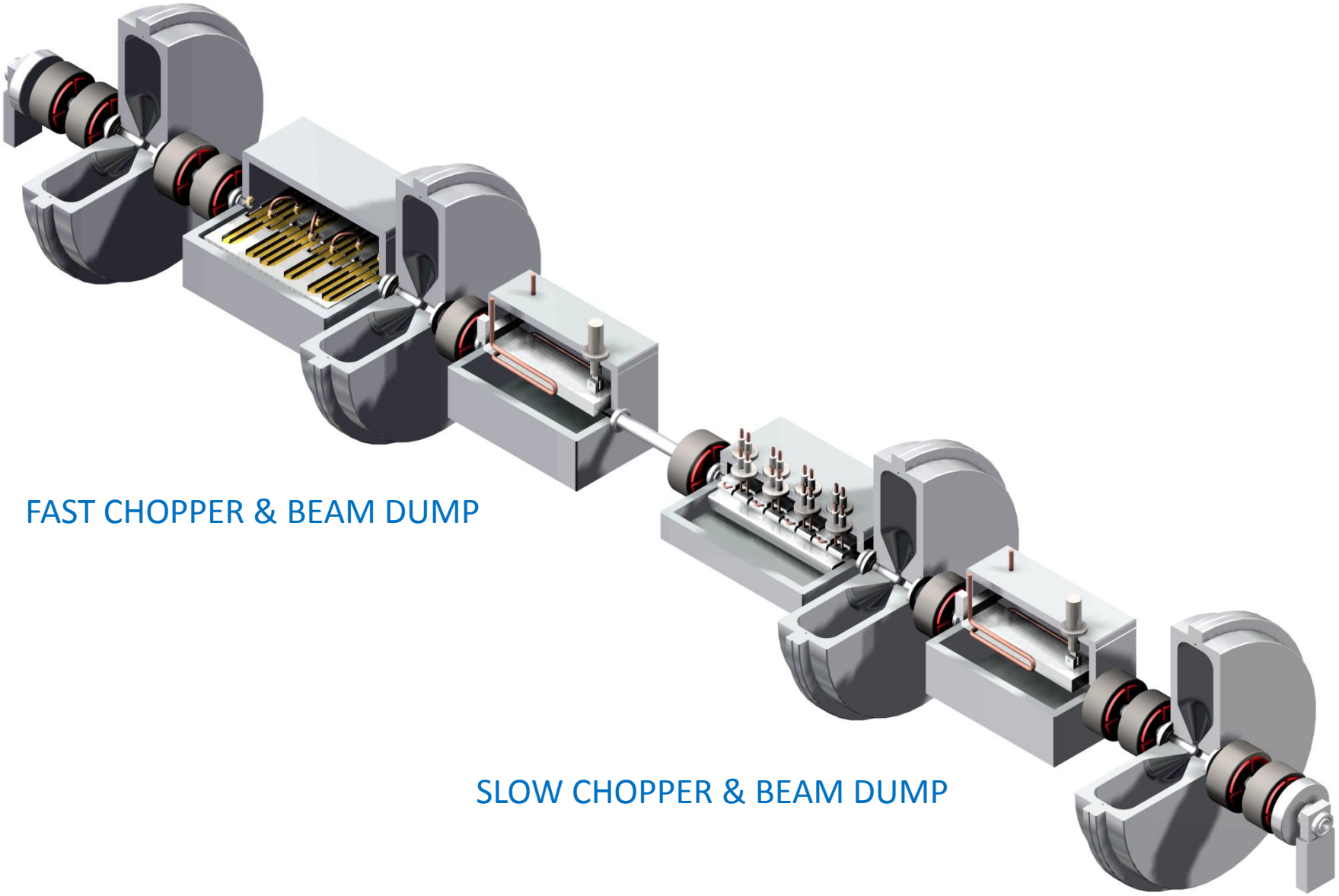
Recent activity:

2011:

- Dimensional optimisation of strip-line Slow-Wave electrode designs (See IPAC 2011 paper)
- Preliminary design of timing system for fast and slow chopper systems.
- Identification and purchase of key timing system components (Tek HFS 9000) and T&M equipment.

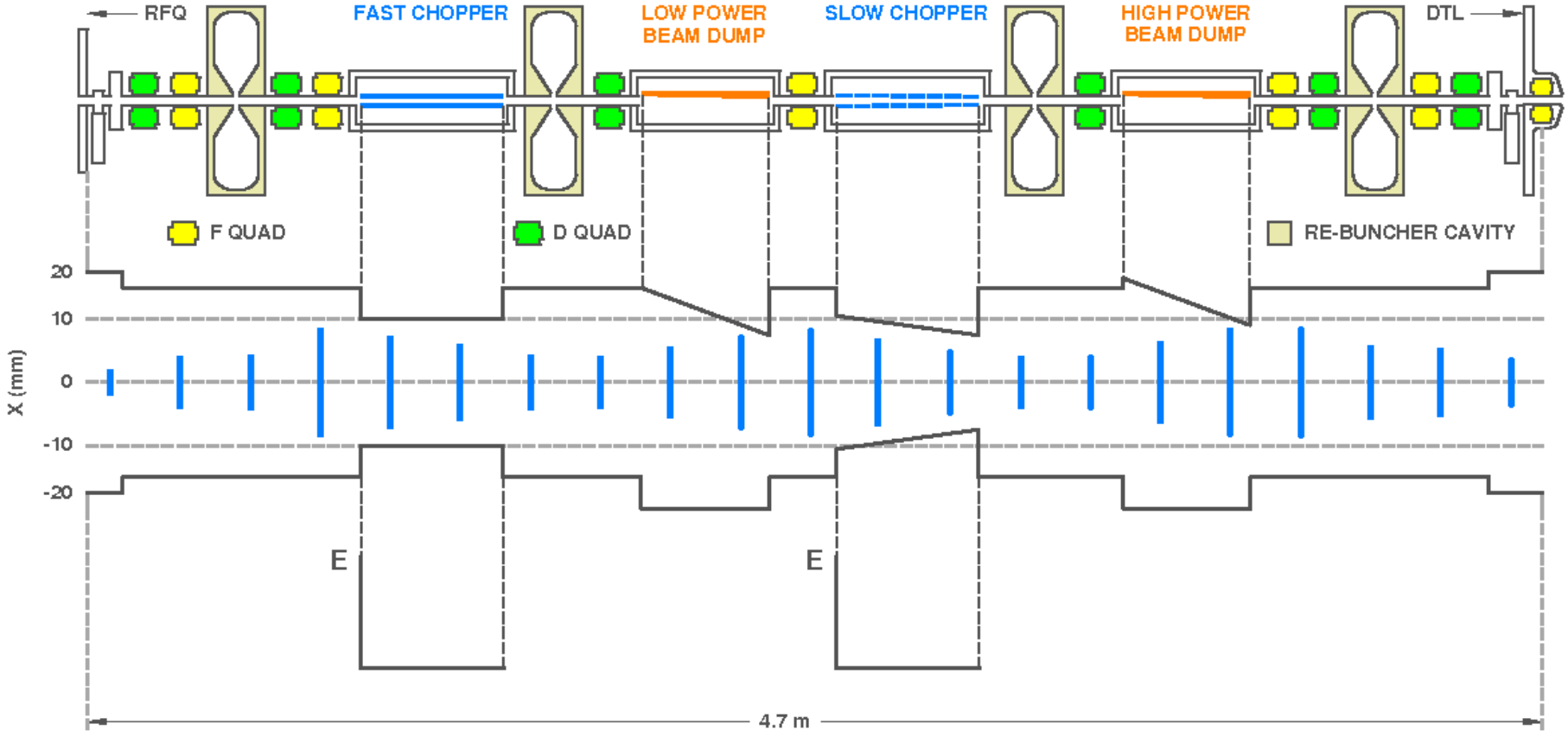
2012:

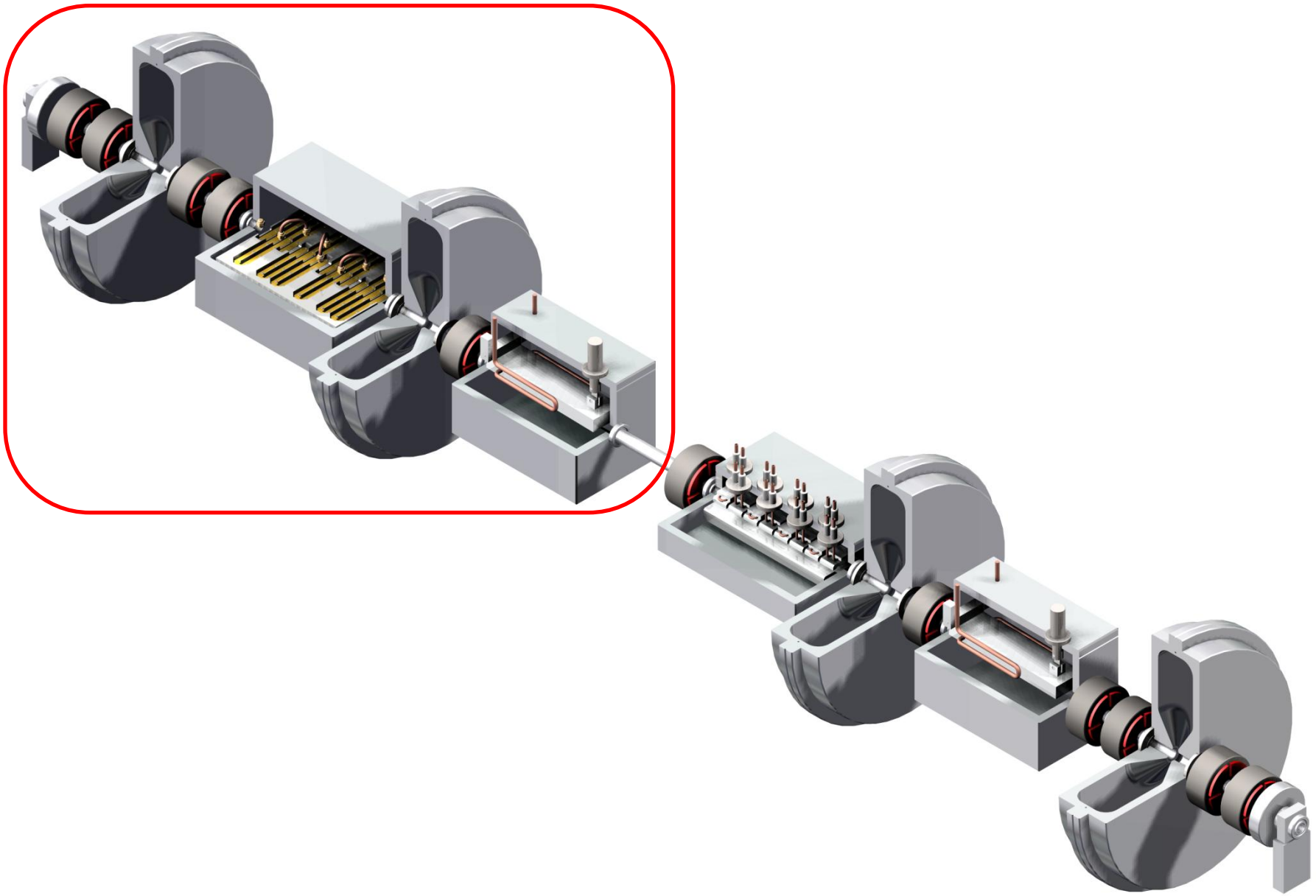
- Drafting of 3D CAD layout of FETS MEBT based on scheme A optical design
- Development of ‘micro-strip on ceramic’ Slow-Wave electrode design (based on CERN model) in CST Microwave and EM Studio.

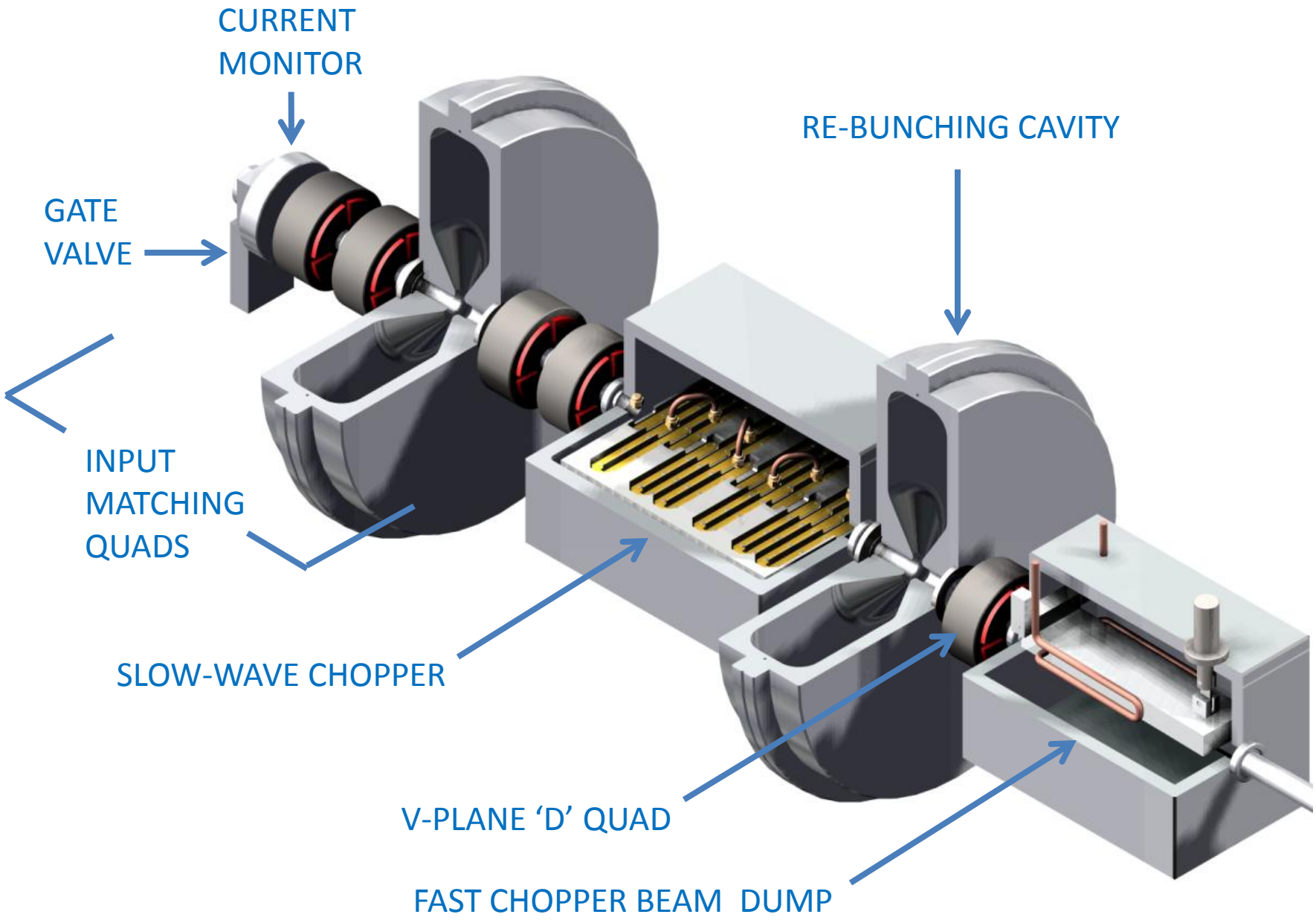

FAST CHOPPER & BEAM DUMP
SLOW CHOPPER & BEAM DUMP

FETS MEBT Scheme A – some original parameters

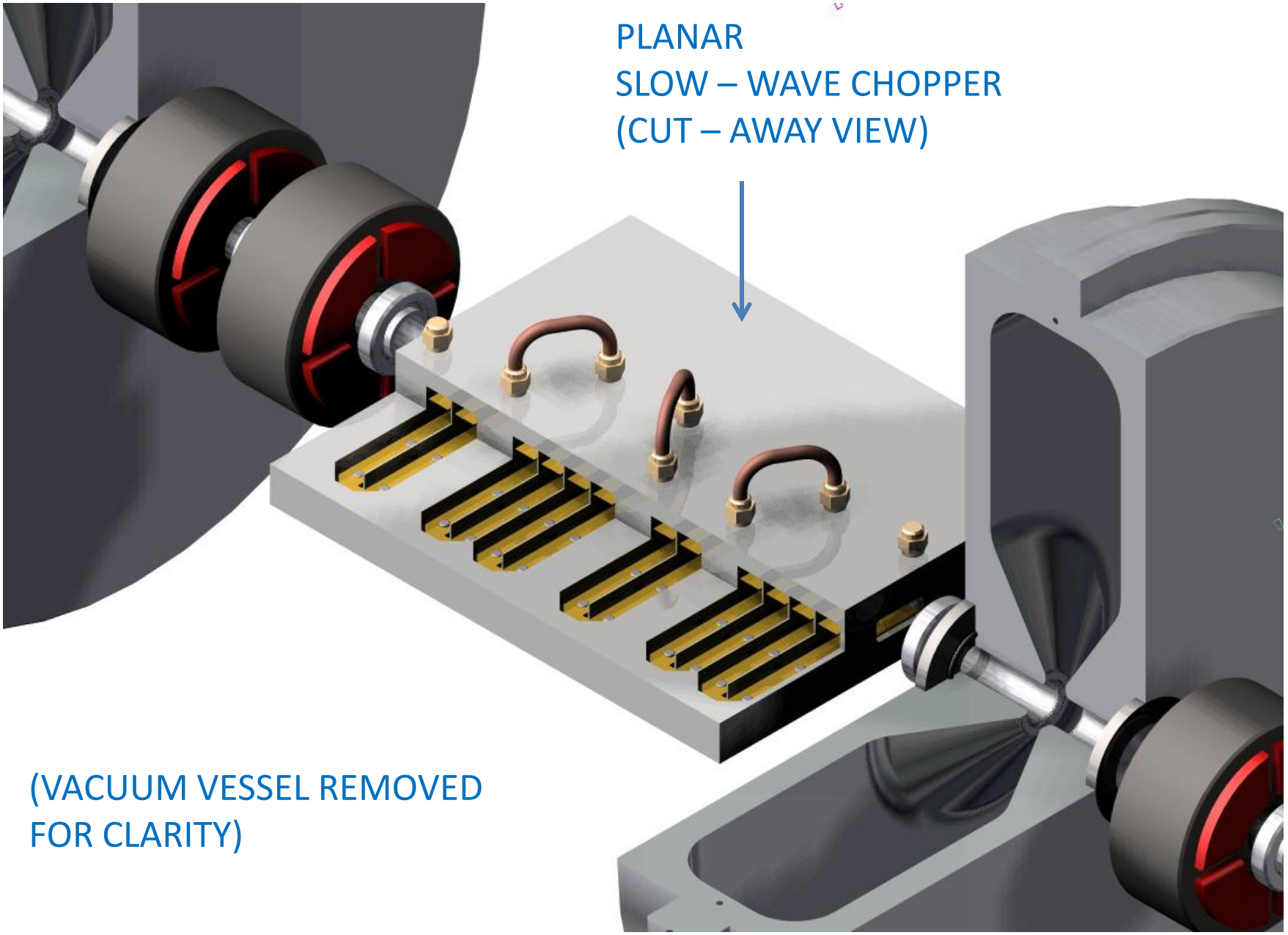
3.0 Mev H^- @ 60 mA
Input distribution: GPT simulation of CERN IPHI RFQ output distribution
Beamline length: 4.750 m
All quad apertures 0.0175 m radius
Aperture limiting vac. vessel internal radius: 0.015 m
All quad lengths 0.070 m
Cavity angular frequency @ 324 MHz: $2\pi f=2.03575e9\ s^{-1}$
Cavity gap: 0.0215 m
Chopper 1 length: 0.450, Gap: 0.02 m
Chopper 2 length: 0.450, Gap: 0.018 m (average)
Chopper 1 coverage factor: 0.82
Chopper 2 coverage factor: 0.85
Chopper deflection is in Y-plane (was X-plane)
Dumps are 0.400 m long and are conical in the GPT model.
CH1 potential: ±1.28 kV
CH2 potential: ±1.35 kV


RFQ
FAST CHOPPER
LOW POWER BEAM DUMP
SLOW CHOPPER
HIGH POWER BEAM DUMP
DTL
F QUAD
D QUAD
RE-BUNCHER CAVITY
X (mm)
20
10
0
-10
-20
E
E
4.7 m

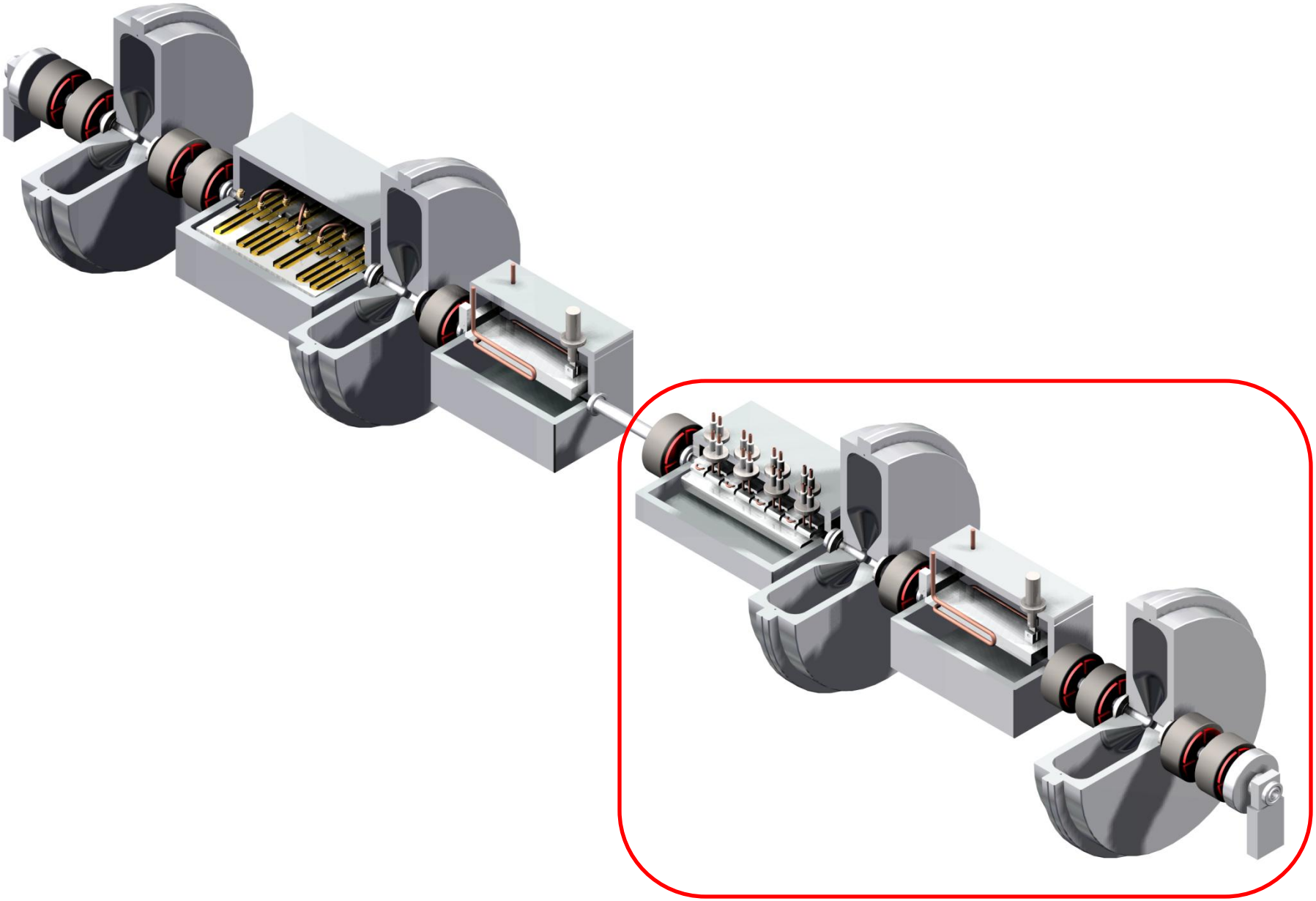


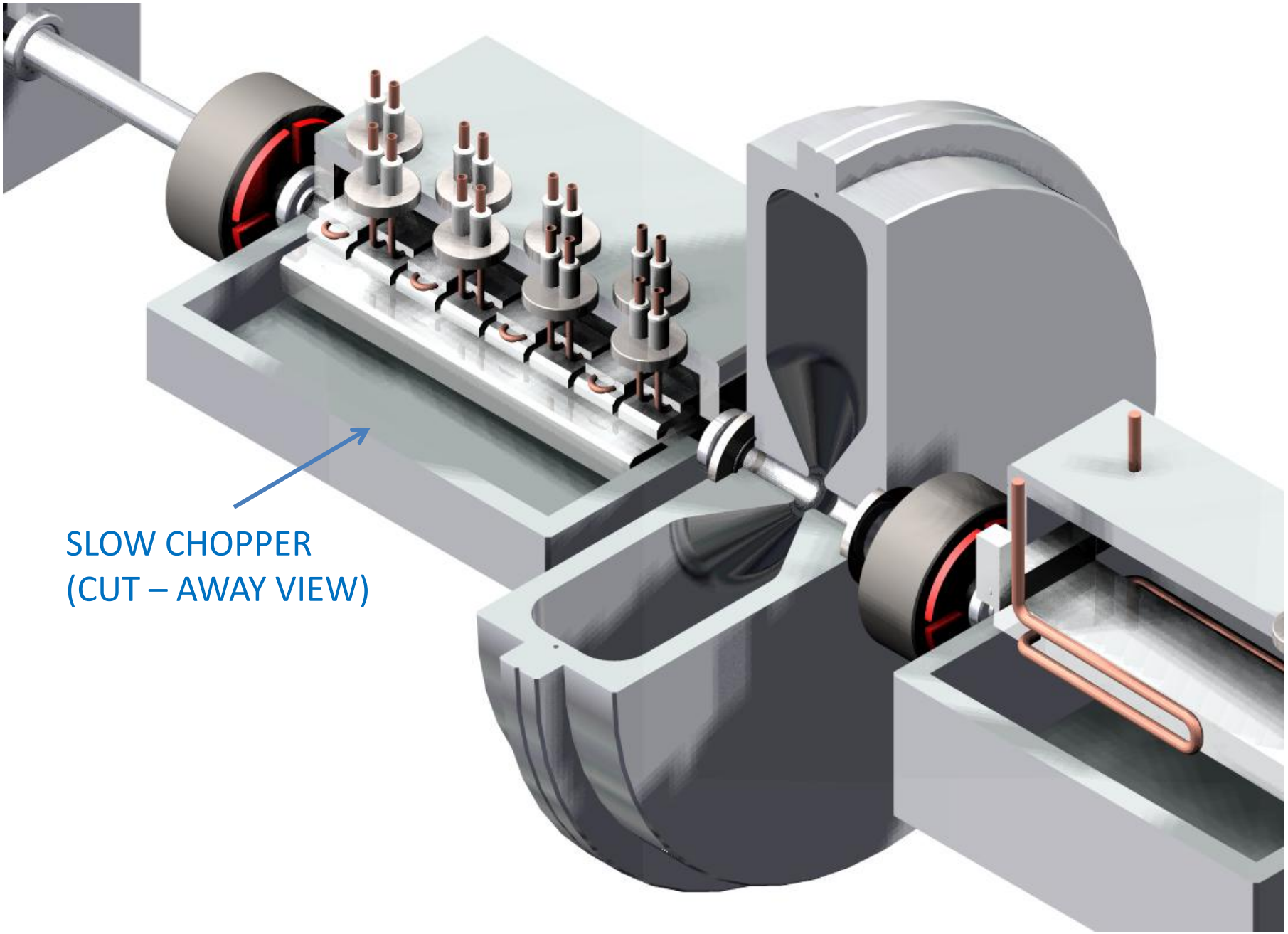

CURRENT
MONITOR
RE-BUNCHING CAVITY
GATE
VALVE
INPUT
MATCHING
QUADS
SLOW-WAVE CHOPPER
V-PLANE ‘D’ QUAD
FAST CHOPPER BEAM DUMP

PLANAR
SLOW – WAVE CHOPPER
(CUT – AWAY VIEW)

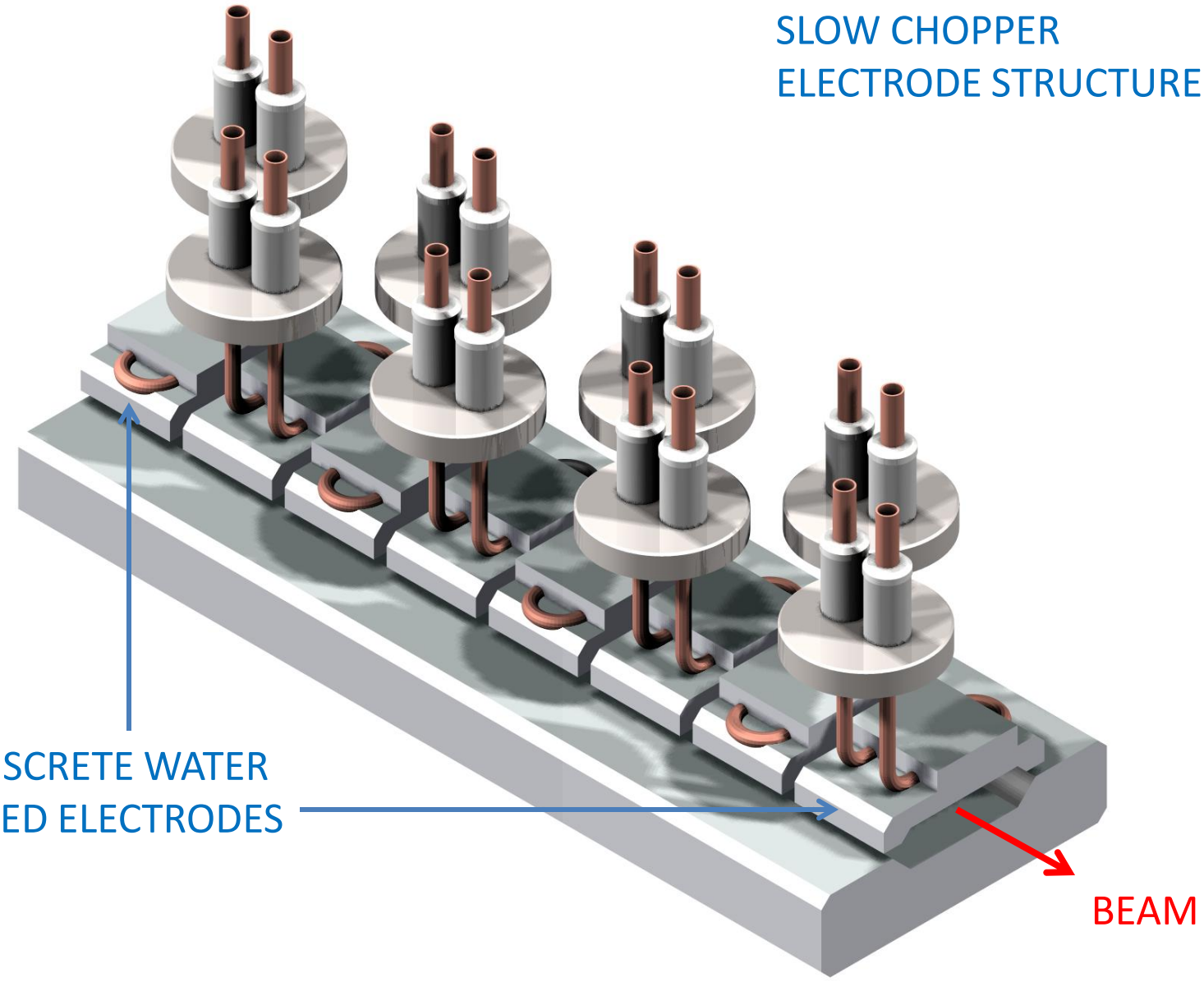


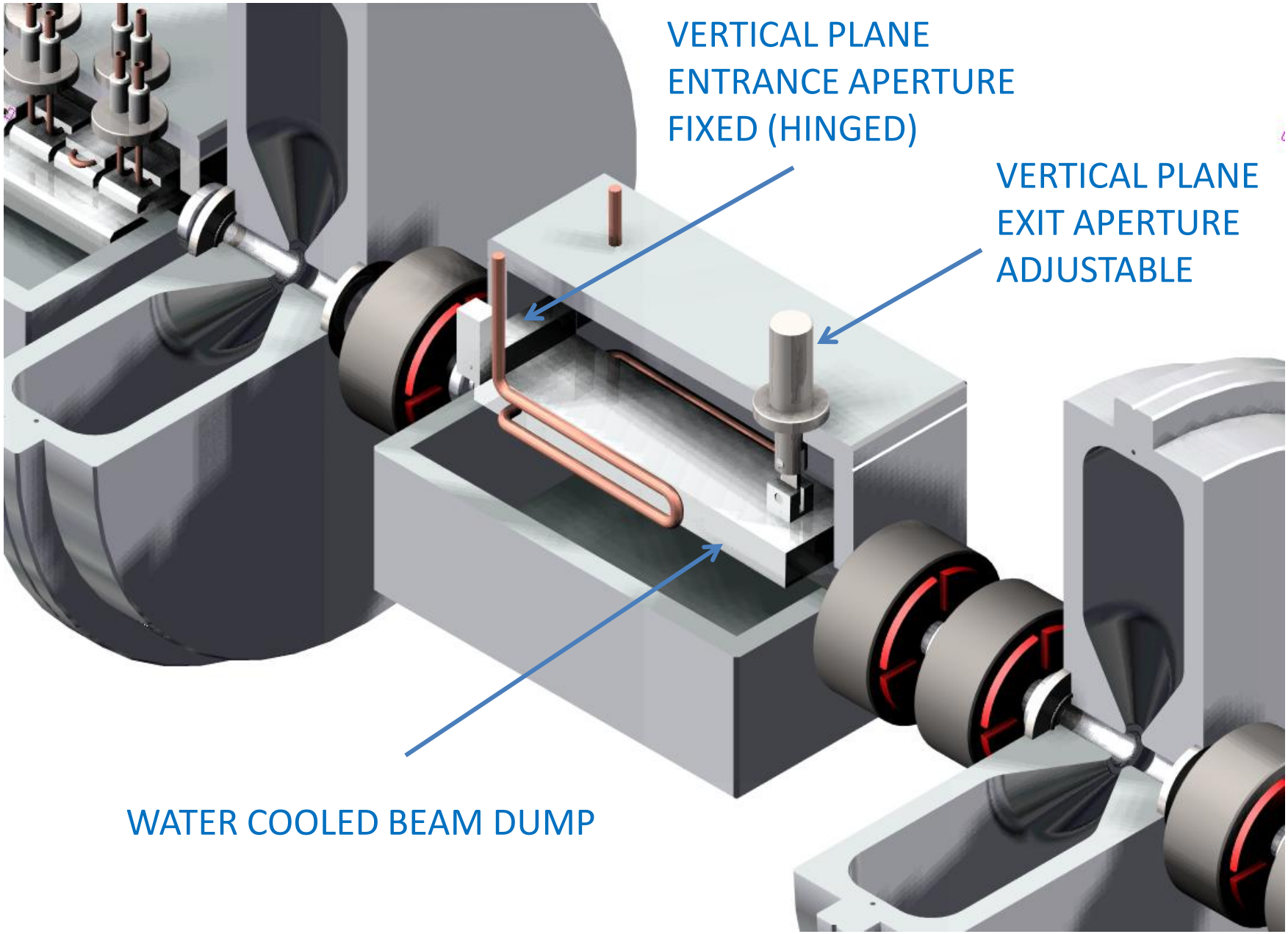
(VACUUM VESSEL REMOVED
FOR CLARITY)




SLOW CHOPPER
(CUT – AWAY VIEW)

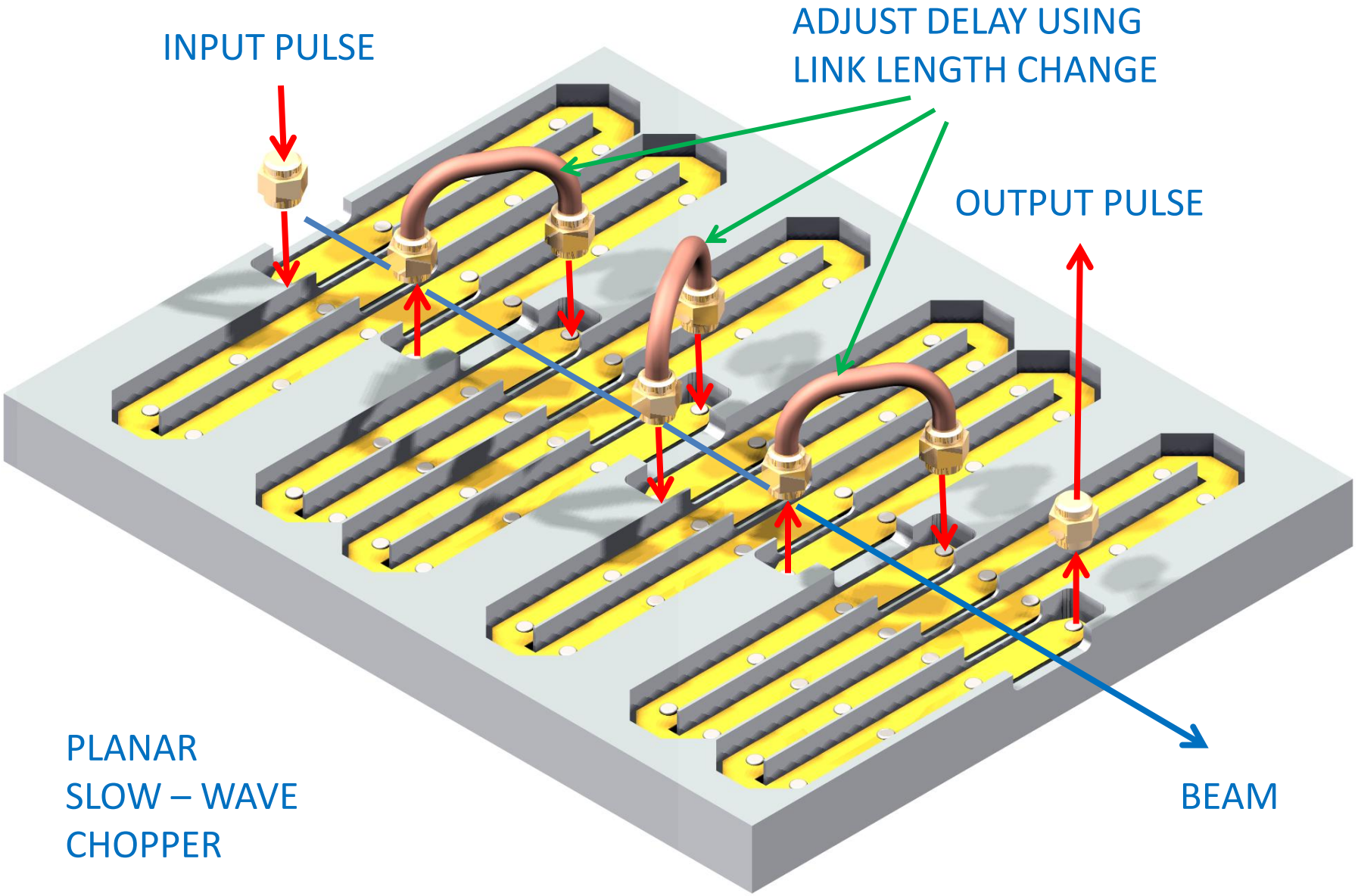
SLOW CHOPPER ELECTRODE STRUCTURE



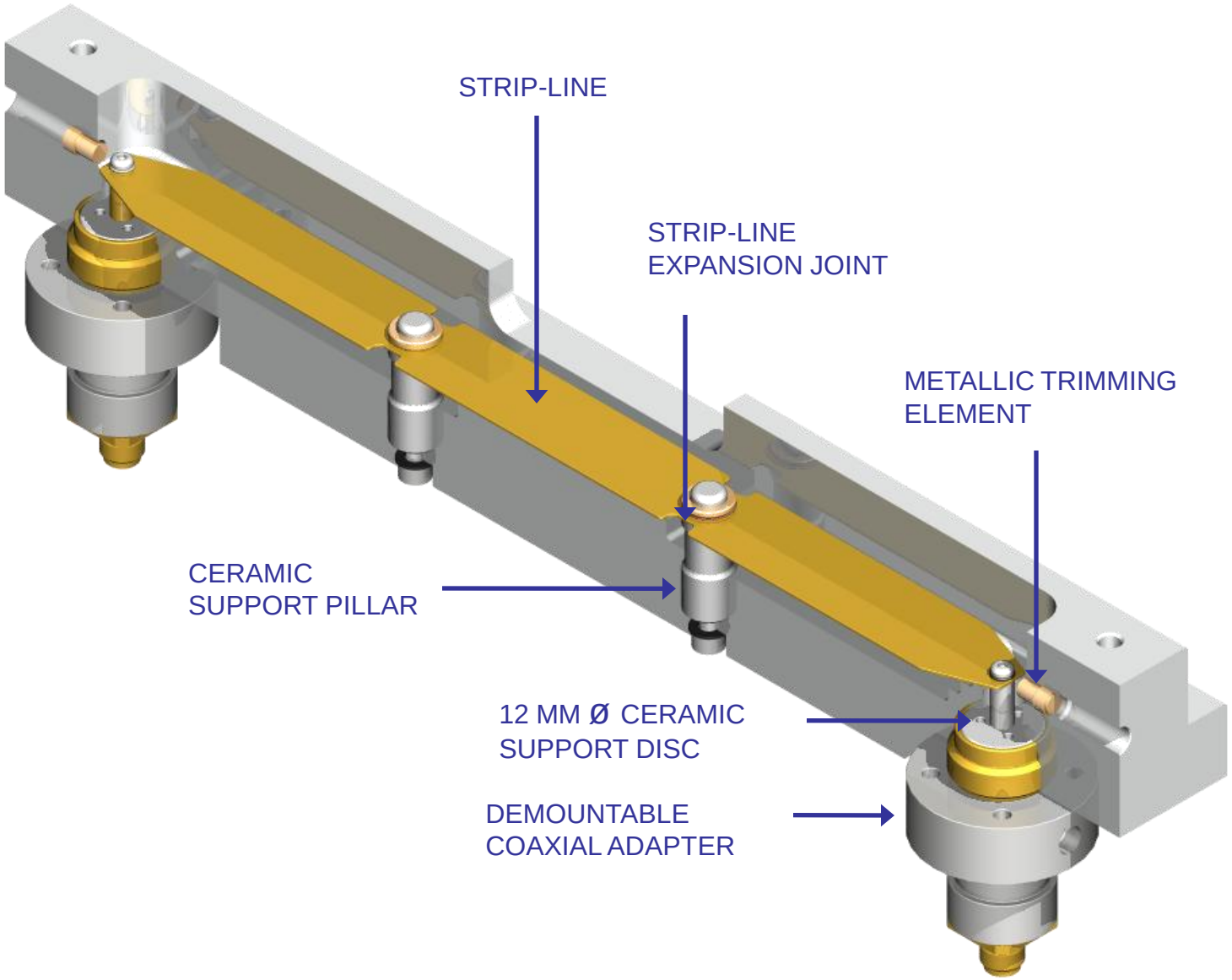

VERTICAL PLANE
ENTRANCE APERTURE
FIXED (HINGED)
VERTICAL PLANE
EXIT APERTURE
ADJUSTABLE
WATER COOLED BEAM DUMP

Slow-Wave electrode development

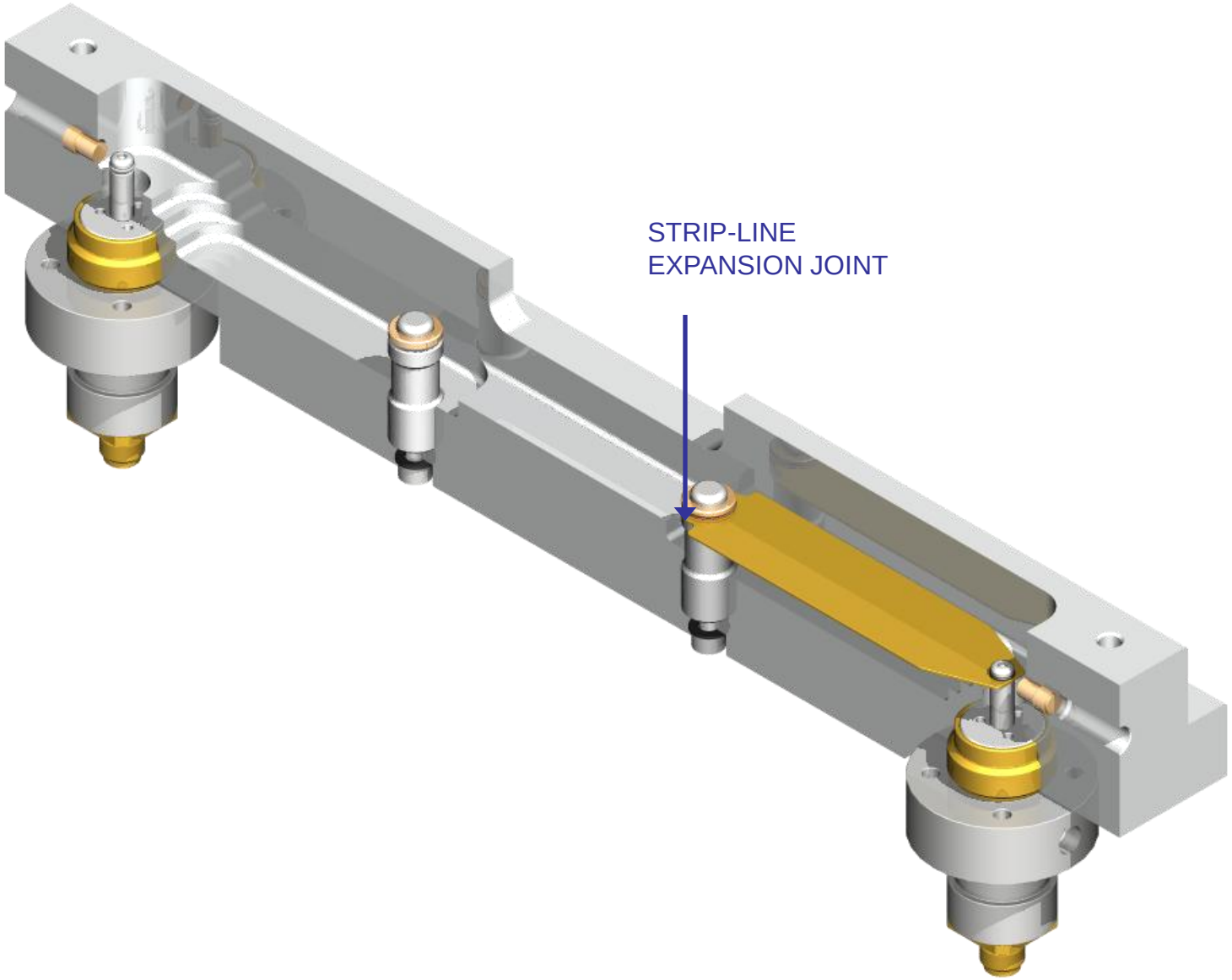
- Planar strip-line
- Helical strip-line
- Micro-strip on ceramic


INPUT PULSE
ADJUST DELAY USING
LINK LENGTH CHANGE
OUTPUT PULSE
PLANAR
SLOW – WAVE
CHOPPER
BEAM

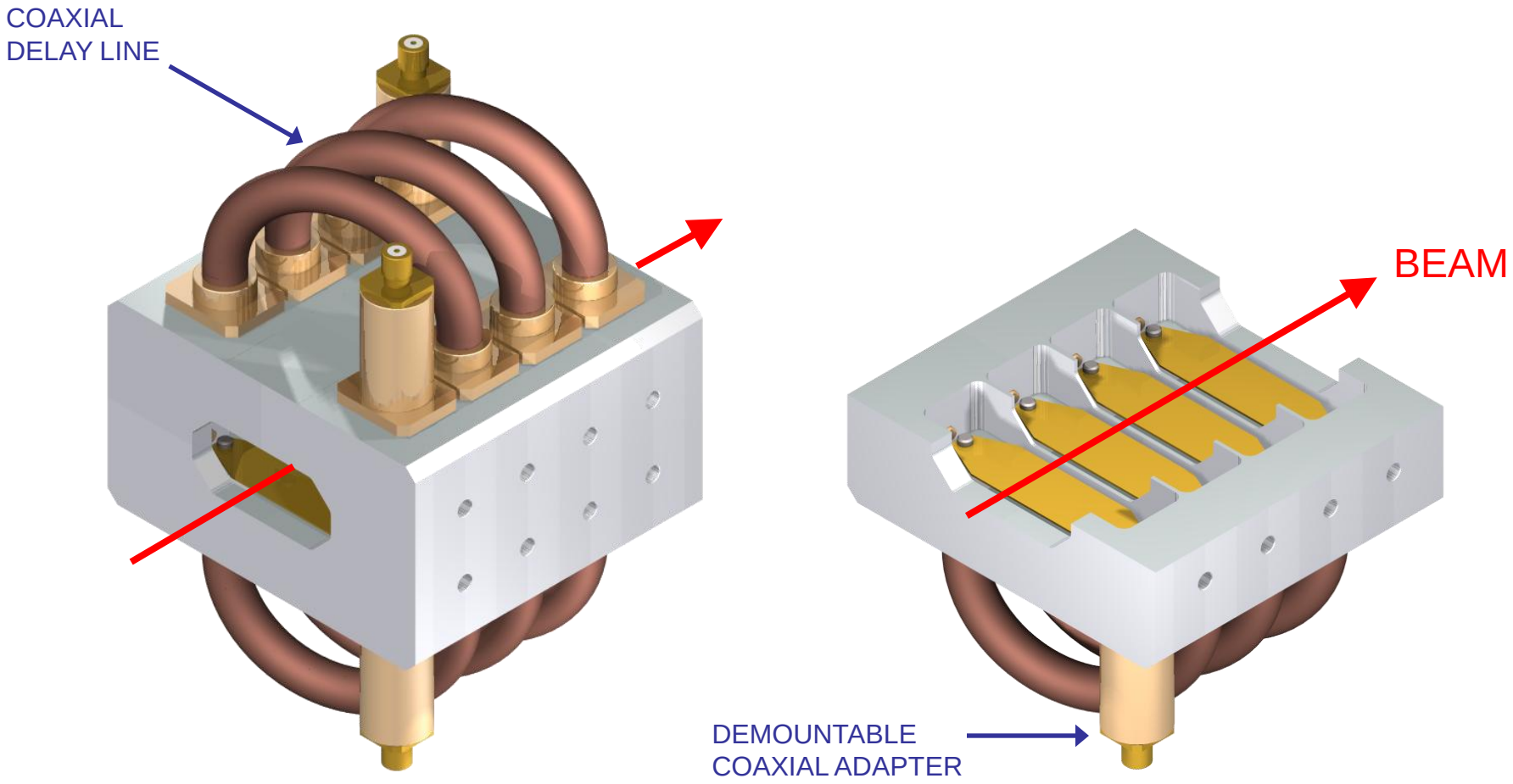
Planar short length prototype

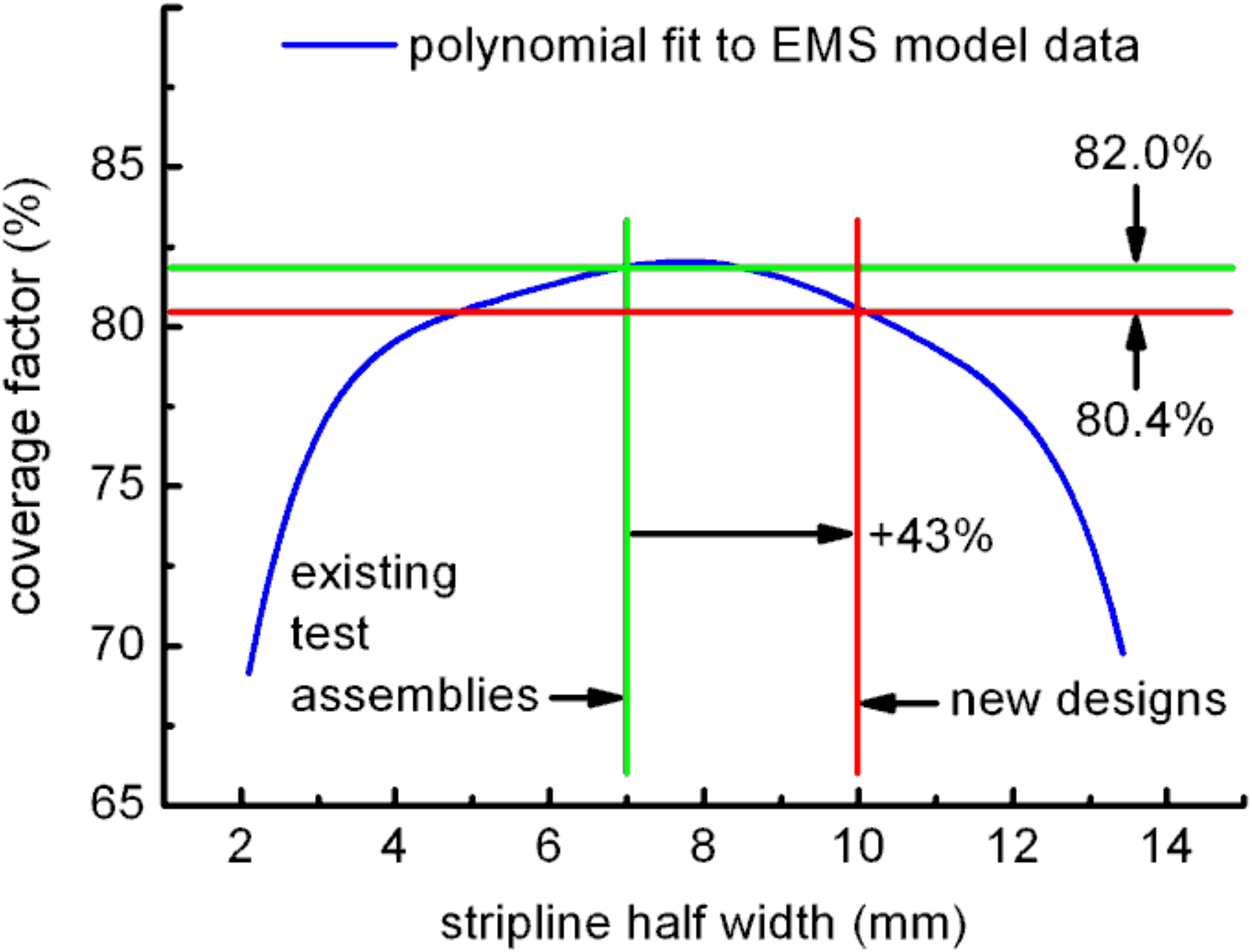


Planar short length prototype

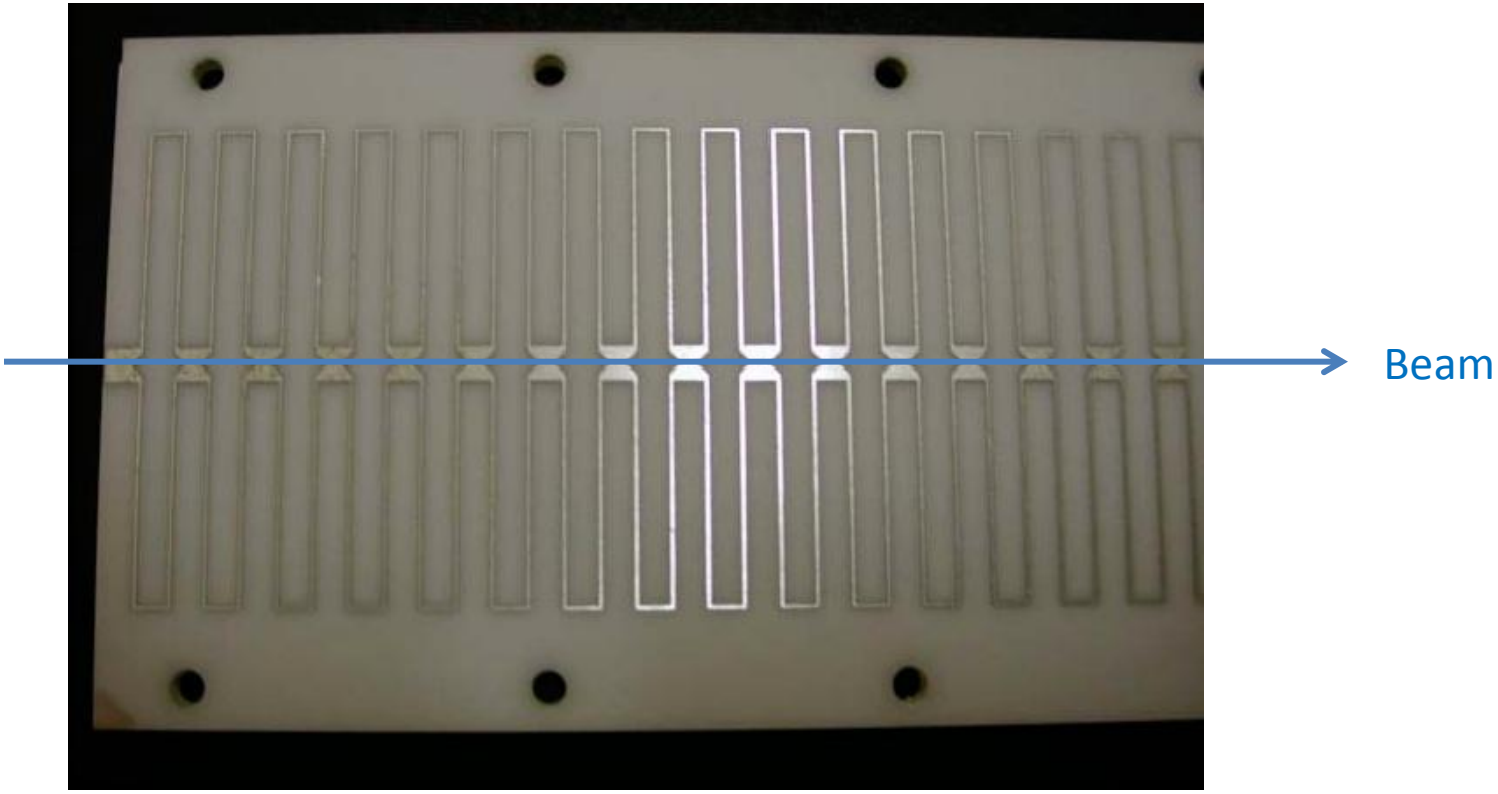


Helical short length prototype

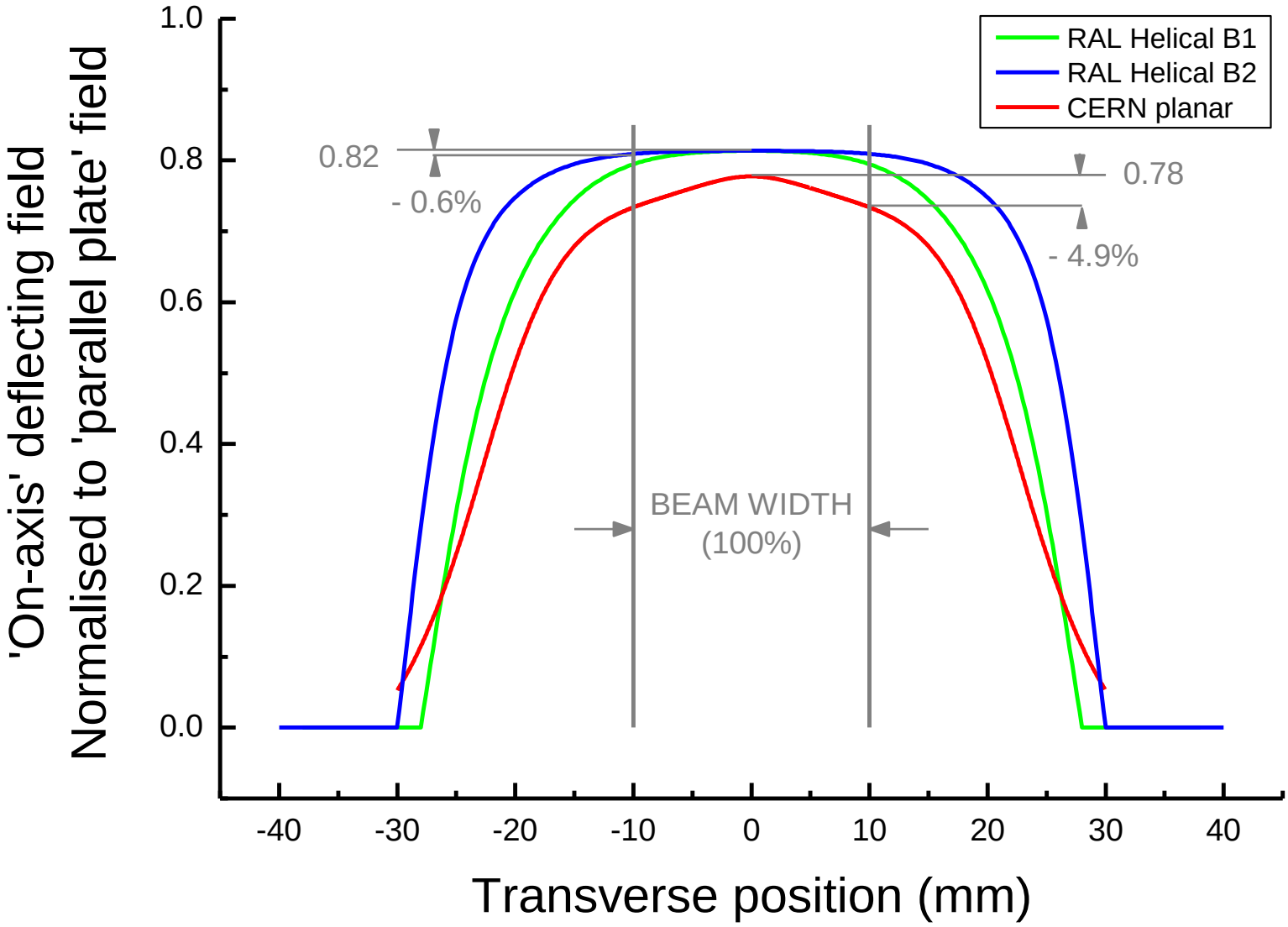



polynomial fit to EMS model data
82.0%
80.4%
+43%
existing
test
assemblies
new designs
coverage factor (%)
85
80
75
70
65
2
4
6
8
10
12
14
stripline half width (mm)

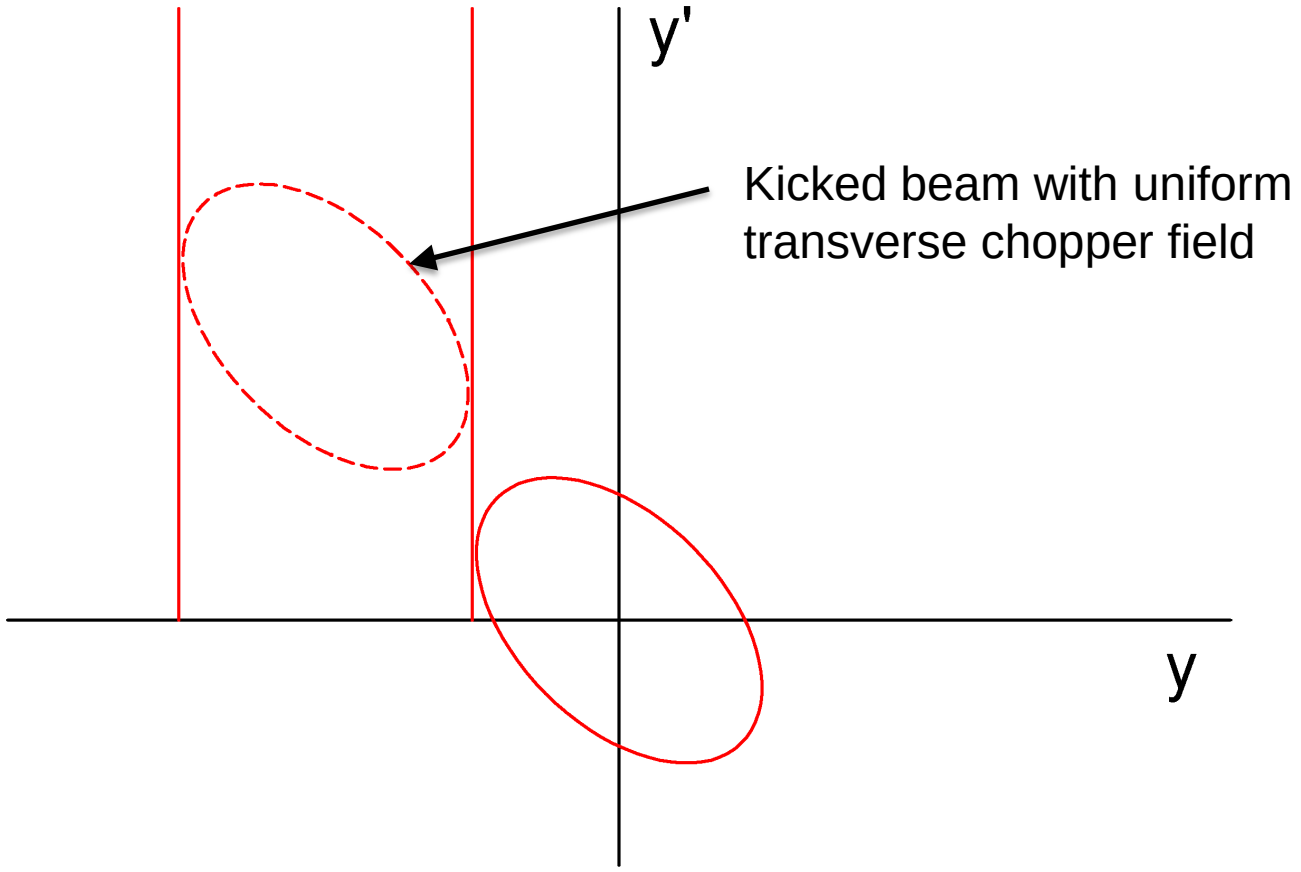
CERN LINAC 4 FAST CHOPPER STRUCTURE



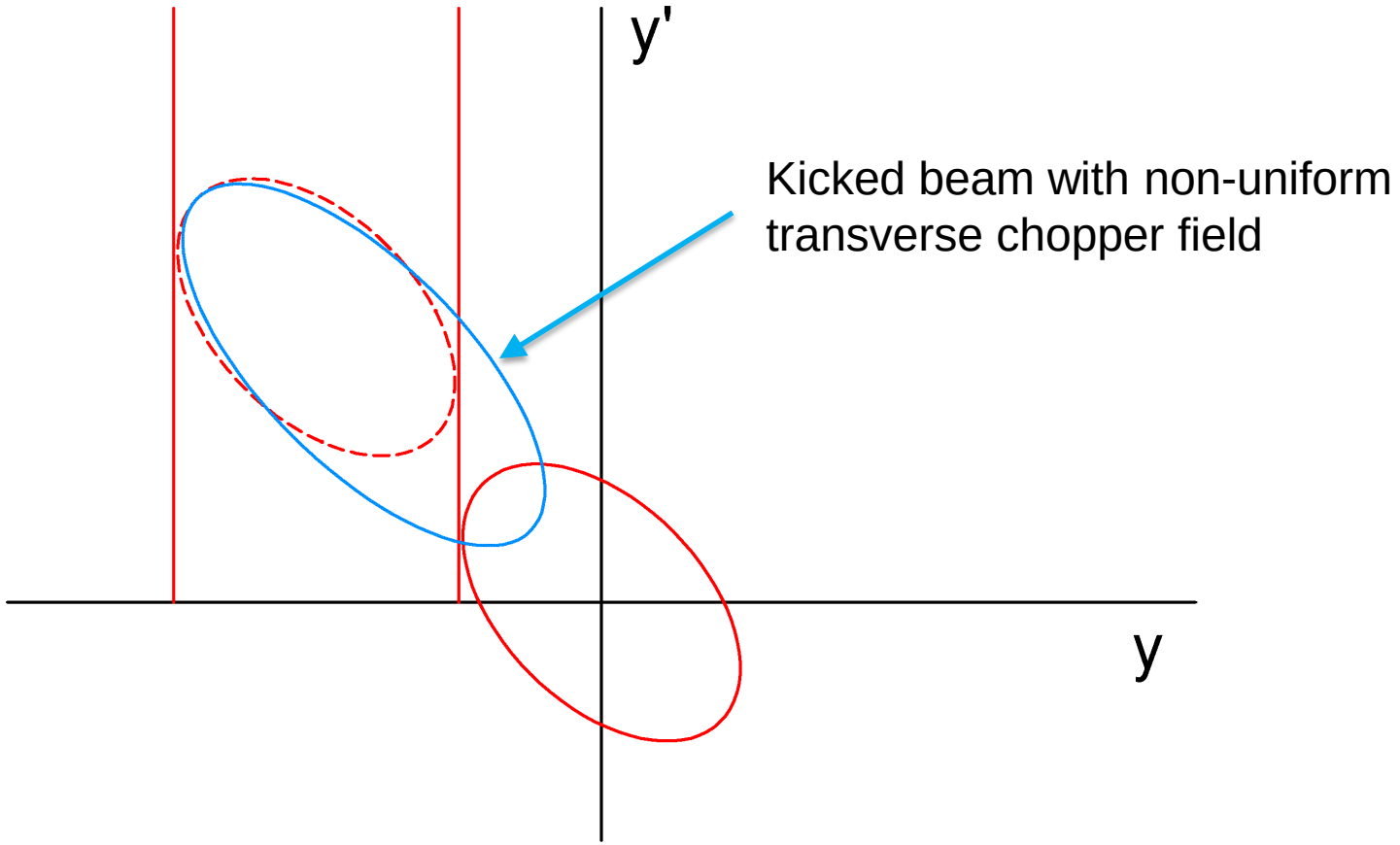
‘On-axis field in x, y plane



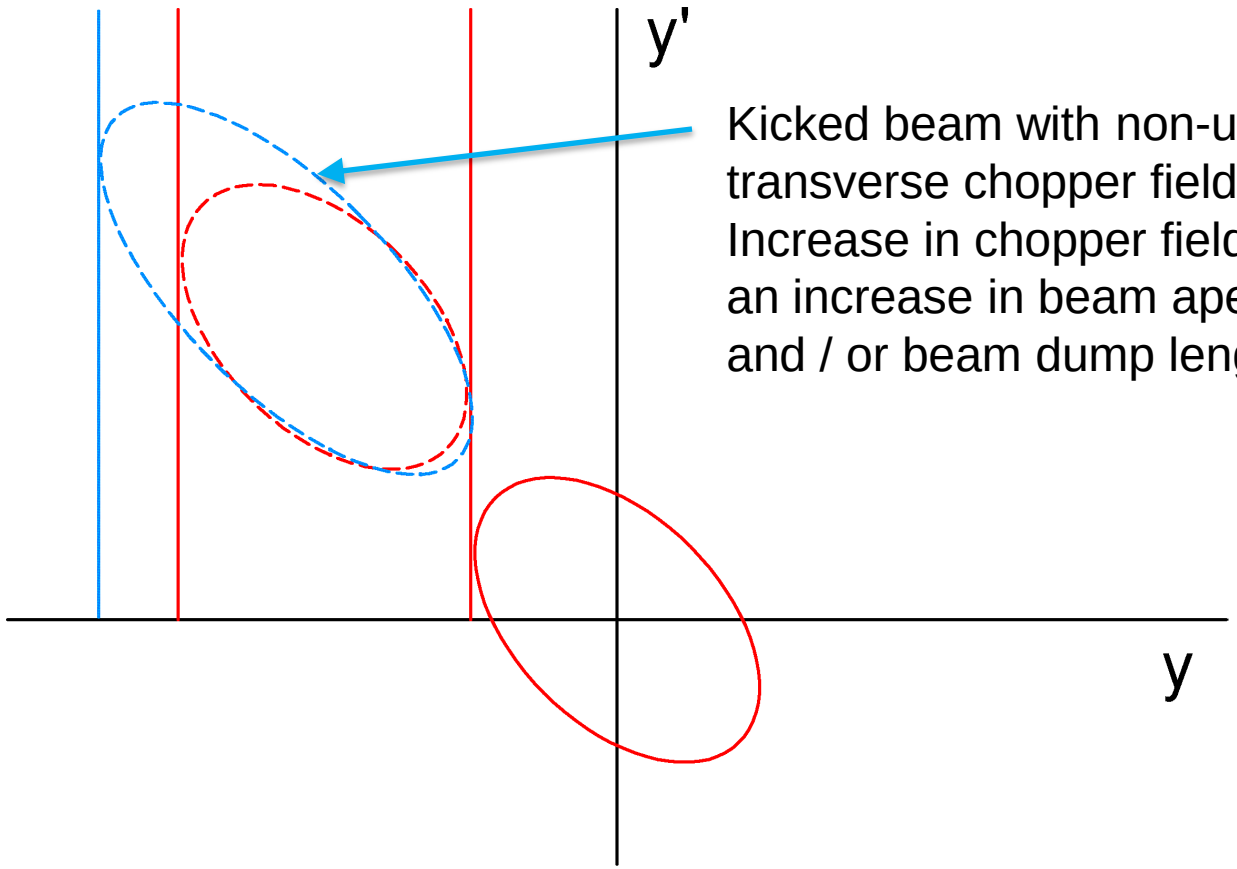
Phase space plot at entrance to chopper beam dump



Phase space plot at entrance to chopper beam dump



Phase space plot at entrance to chopper beam dump



Kicked beam with non-uniform transverse chopper field requires Increase in chopper field and an increase in beam aperture and / or beam dump length

RE-VISITING CERN DESIGN WITH A VIEW TO IMPROVING COVERAGE FACTOR AND FLATNESS OF TRANSVERSE FIELD DISTRIBUTION

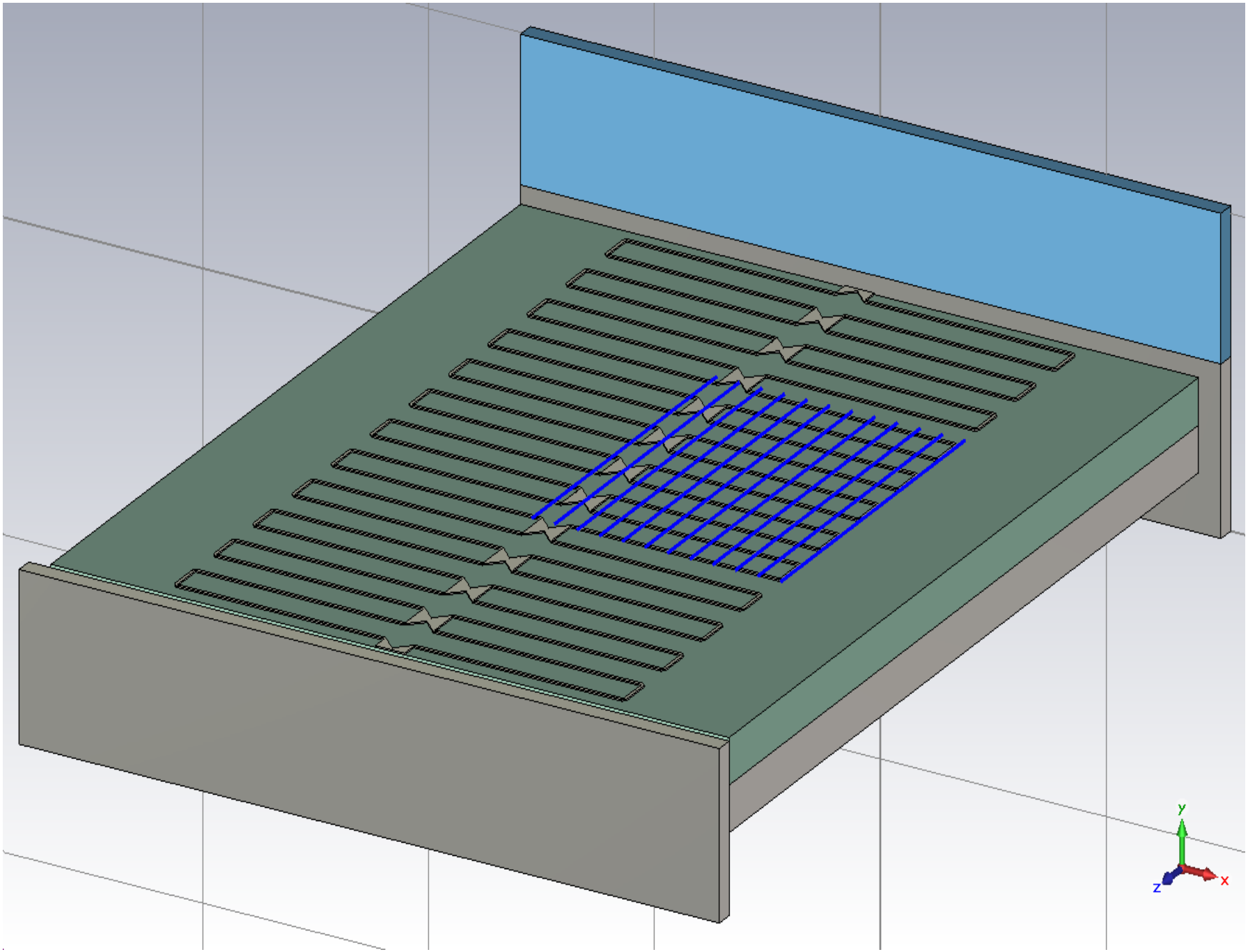
MOTIVATION:

PRINTED CIRCUIT ON CERAMIC MAY BE A BETTER COMPROMISE BETWEEN PERFORMANCE AND COST THAN CURRENT PLANAR OR HELICAL DESIGNS.

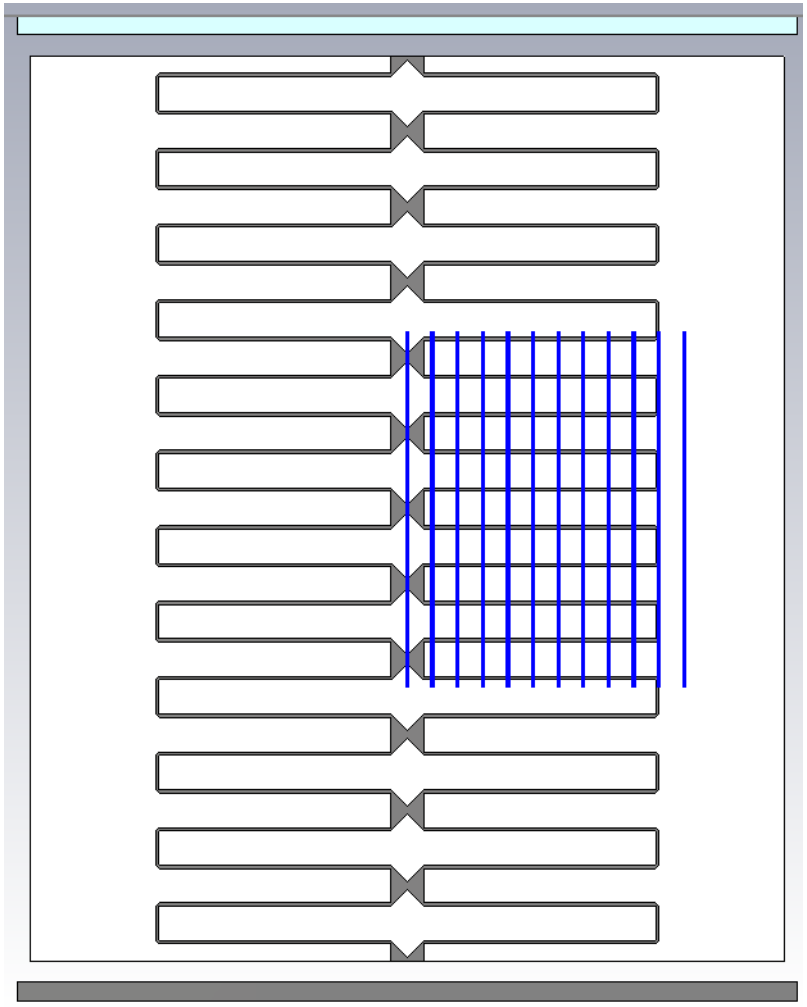
DESIGN OPTIONS:

CHOICE OF CERAMIC SUBSTRATE – ε_r , $\tan\delta$, & κ

CONDUCTOR TECHNOLOGY – THIN FILM, THICK FILM, DBC


y
x
z

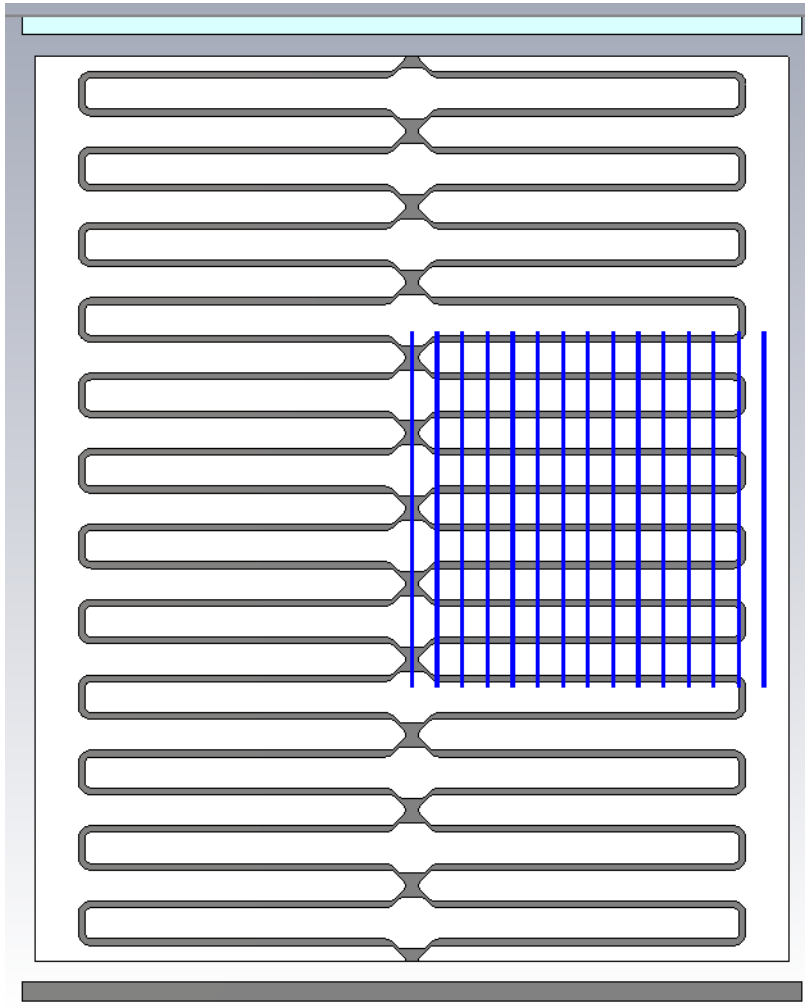
Old design (CERN)



meander width = 40.00 mm

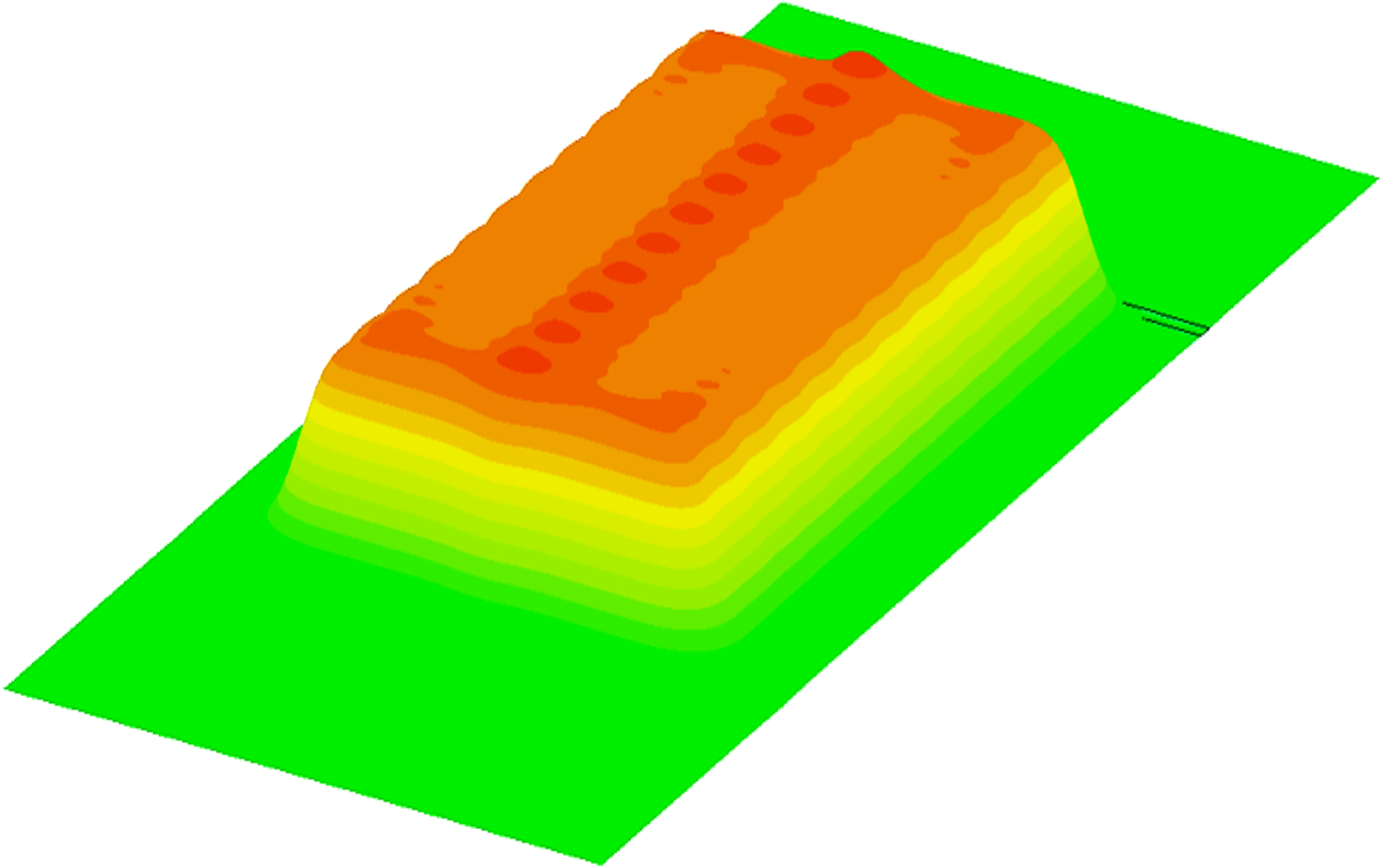
micro-strip width = 0.26 mm

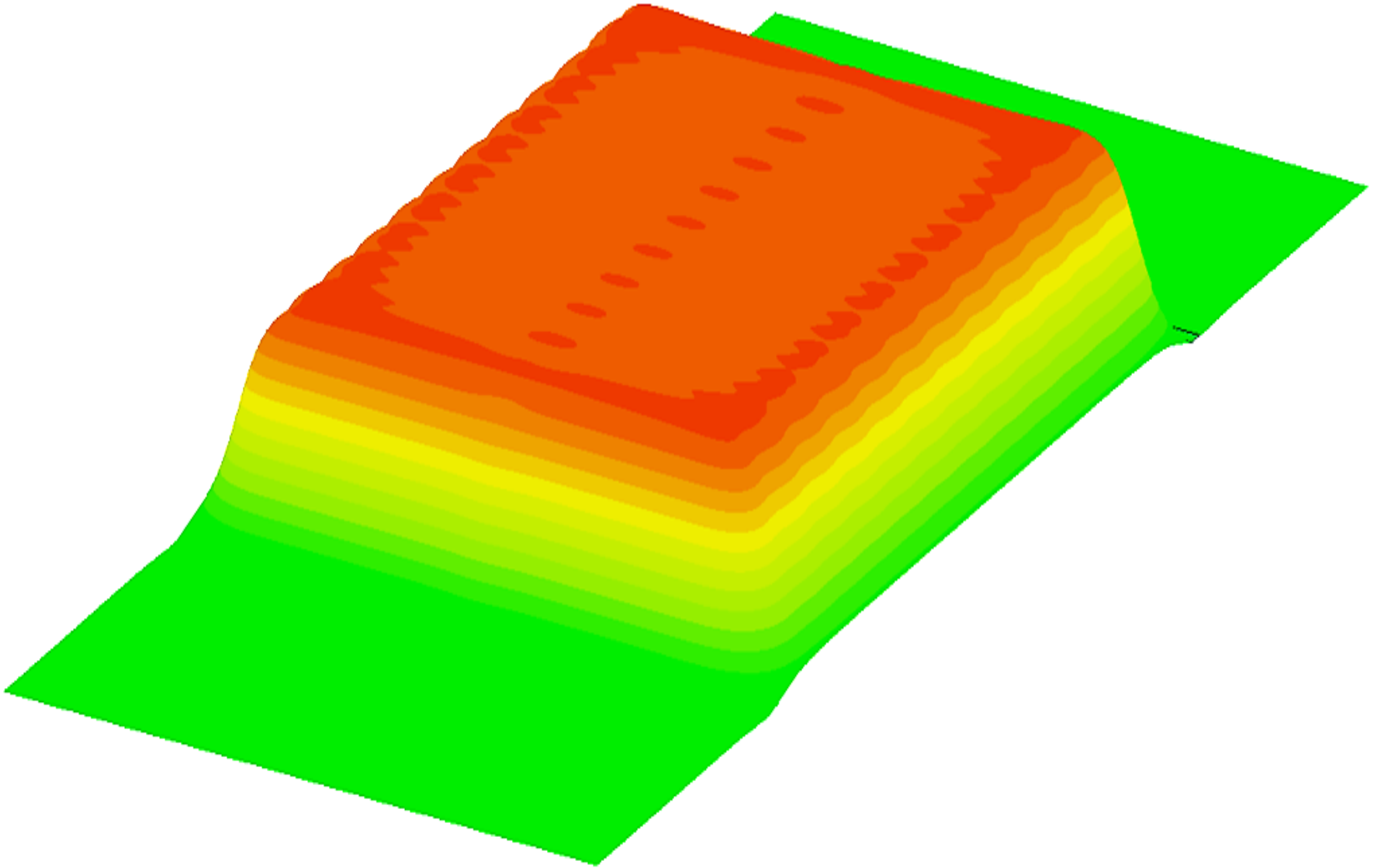
New design

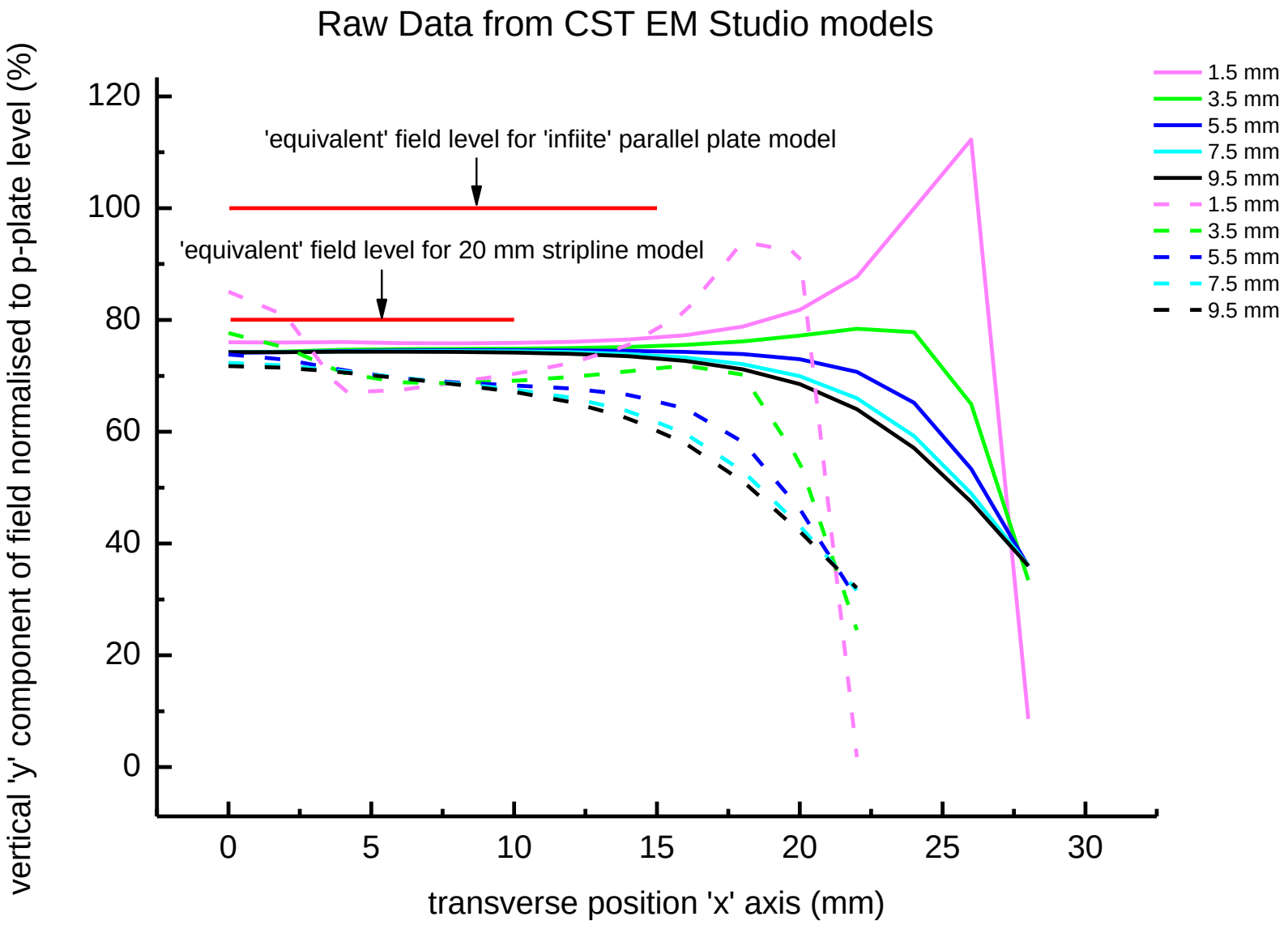


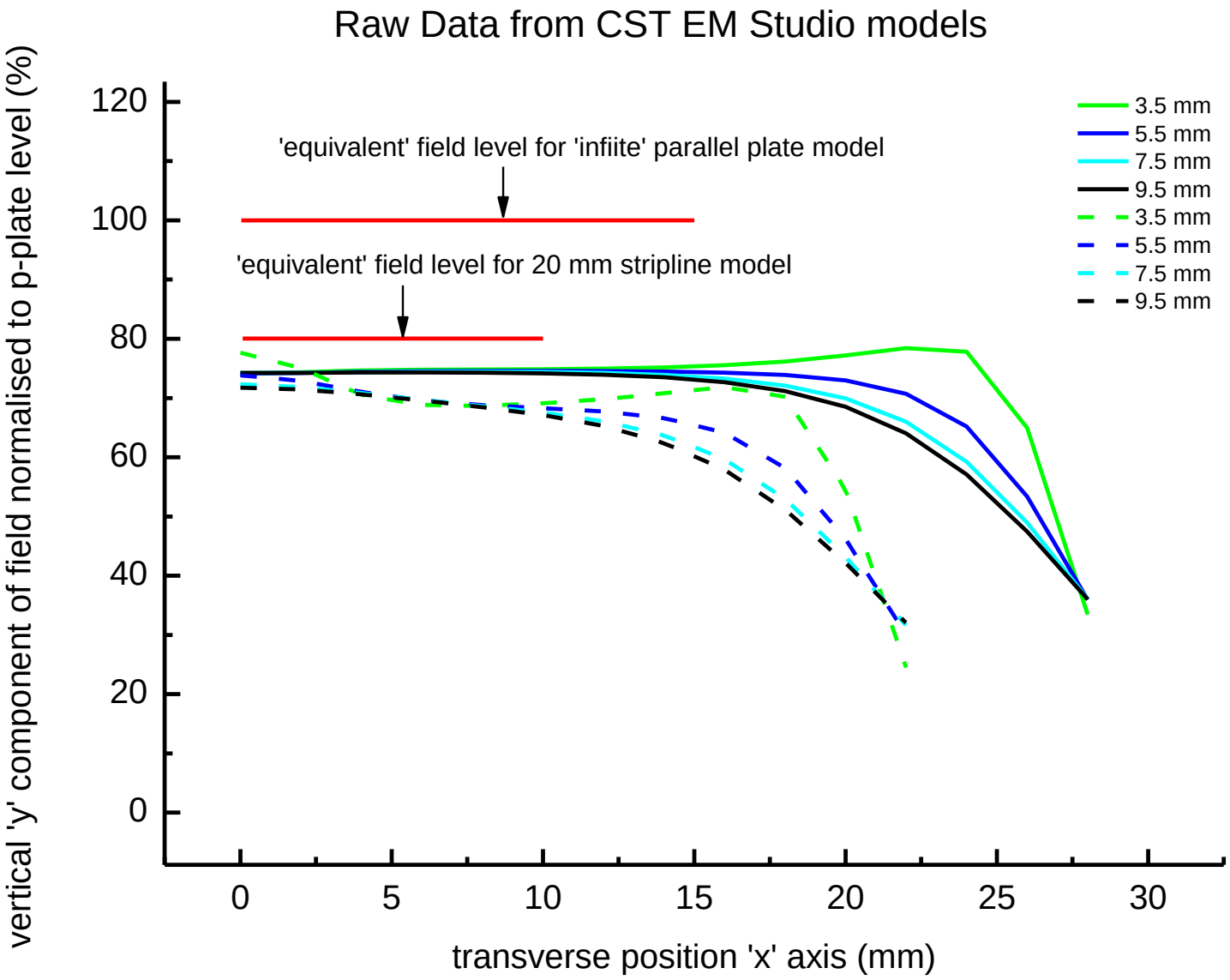
meander width = 53.12 mm

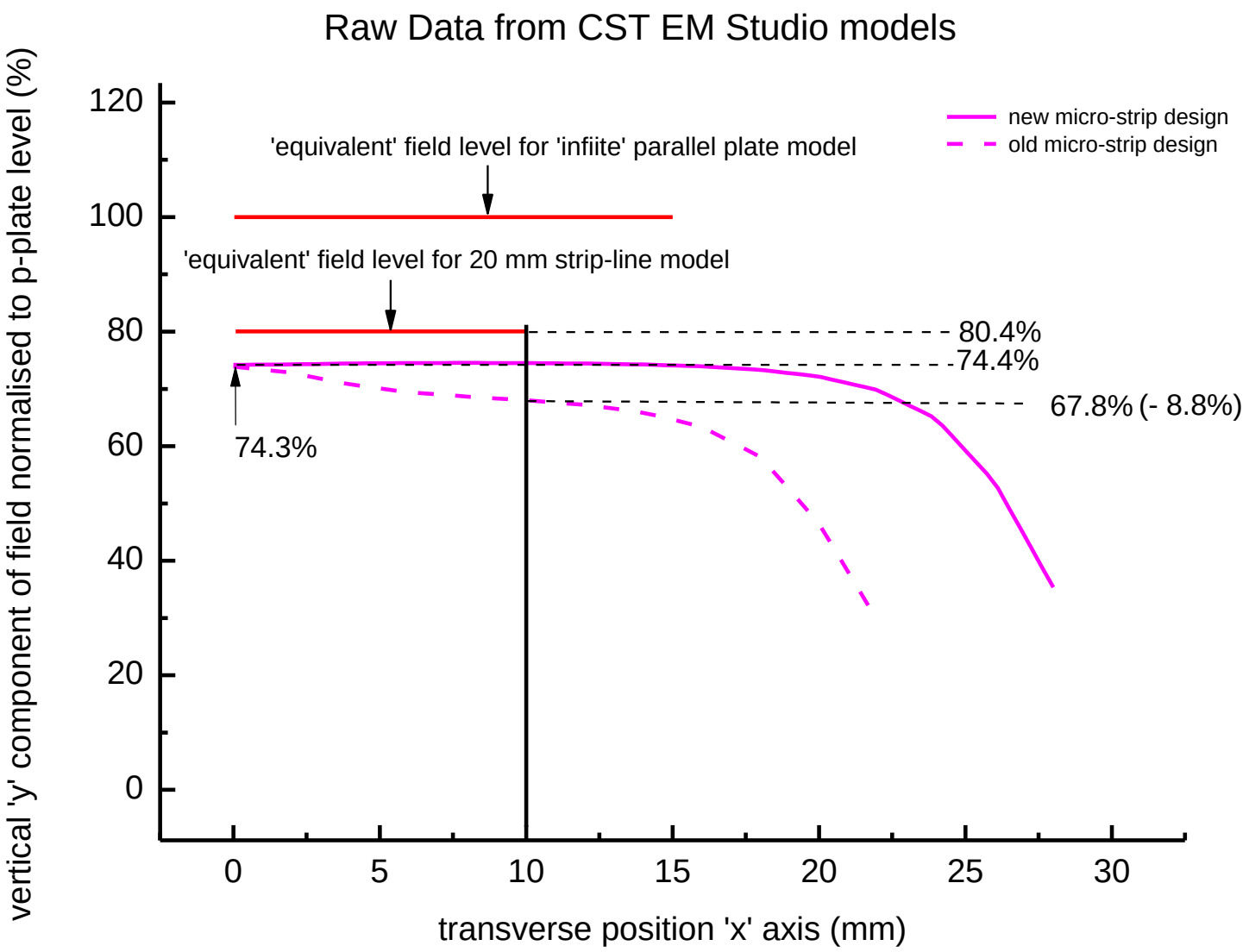
micro-strip width = 0.54 mm






Raw Data from CST EM Studio models
'equivalent' field level for 'infiite' parallel plate model
'equivalent' field level for 20 mm stripline model
vertical 'y' component of field normalised to p-plate level (%)
transverse position 'x' axis (mm)
0
20
40
60
80
100
120
0
5
10
15
20
25
30
1.5 mm
3.5 mm
5.5 mm
7.5 mm
9.5 mm
1.5 mm
3.5 mm
5.5 mm
7.5 mm
9.5 mm


Raw Data from CST EM Studio models
'equivalent' field level for 'infiite' parallel plate model
'equivalent' field level for 20 mm stripline model
3.5 mm
5.5 mm
7.5 mm
9.5 mm
3.5 mm
5.5 mm
7.5 mm
9.5 mm
vertical 'y' component of field normalised to p-plate level (%)
120
100
80
60
40
20
0
0
5
10
15
20
25
30
transverse position 'x' axis (mm)


Raw Data from CST EM Studio models
new micro-strip design
old micro-strip design
'equivalent' field level for 'infiite' parallel plate model
'equivalent' field level for 20 mm strip-line model
80.4%
74.4%
67.8% (- 8.8%)
74.3%
vertical 'y' component of field normalised to p-plate level (%)
transverse position 'x' axis (mm)
120
100
80
60
40
20
0
0
5
10
15
20
25
30

Summary

Models and prototypes of the RAL helical and planar strip-line slow-wave designs have demonstrated that both will probably produce full scale structures with the required transmission line characteristics, coverage factor and field uniformity. However, the designs have many high precision parts, and manufacturing costs will be significant.

A decision was made early in the year to re-visit the CERN micro-strip design, with a view to improving coverage factor and field uniformity. Transmission line characteristics, coverage factor, and field uniformity, have been modeled in CST Microwave and EM studio, for both the original and new designs.

Recent results indicate that some improvement in coverage factor and field uniformity can be achieved, and that if the new design can be manufactured, then this may offer a better compromise between performance and cost than the existing strip-line designs

The next step will be to manufacture a short length prototype.