WU2 - Proton Source & LEBT

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Requirements

Proton Energy 75 keV

Large currents (60-**80** mA)

Pulsed operation (**2.86 ms - 14 Hz**)

Low emittance (**0.2** to 0,3 π mm mrad)

Short pulse rise time (100 ns)

Long lifetime (>> 1 month)

Robust extraction system

High reliability (> 99%)

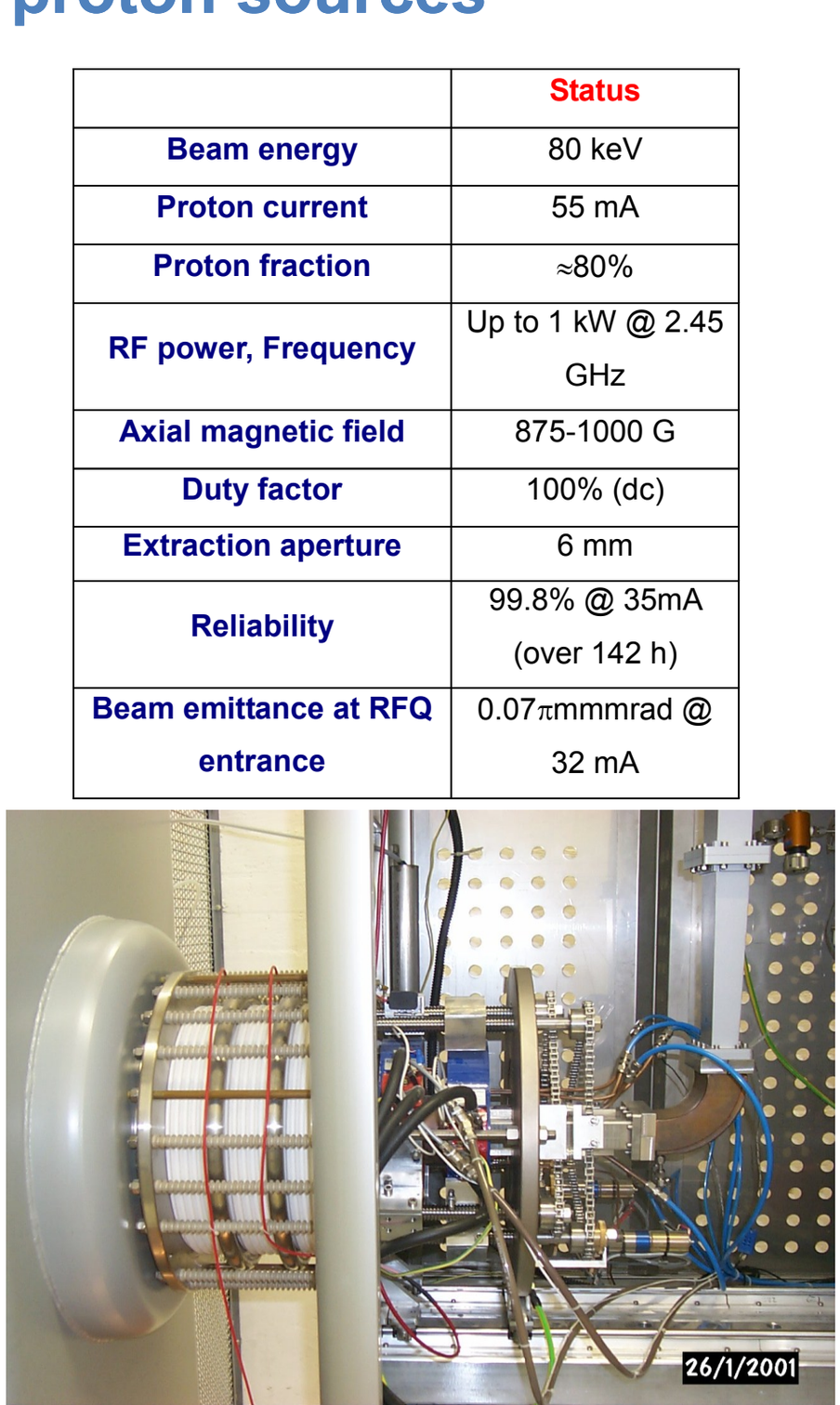
LEBT optimization

Issues: sperimental investigations planned to validate calculations

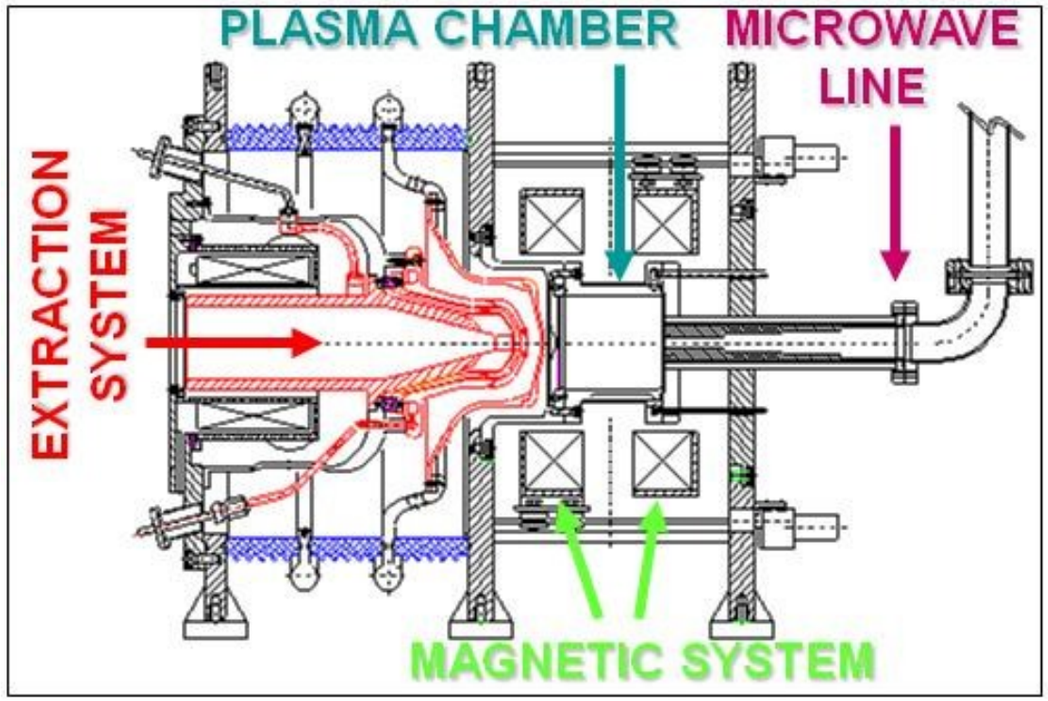
Proton source

Based on knowledge acquired with TRIPS, SILHI and VIS high intensity proton sources

	Status
Beam energy	80 keV
Proton current	55 mA
Proton fraction	≈80%
RF power, Frequency	Up to 1 kW @ 2.45 GHz
Axial magnetic field	875-1000 G
Duty factor	100% (dc)
Extraction aperture	6 mm
Reliability	99.8% @ 35mA (over 142 h)
Beam emittance at RFQ entrance	0.07πmmmrad @ 32 mA

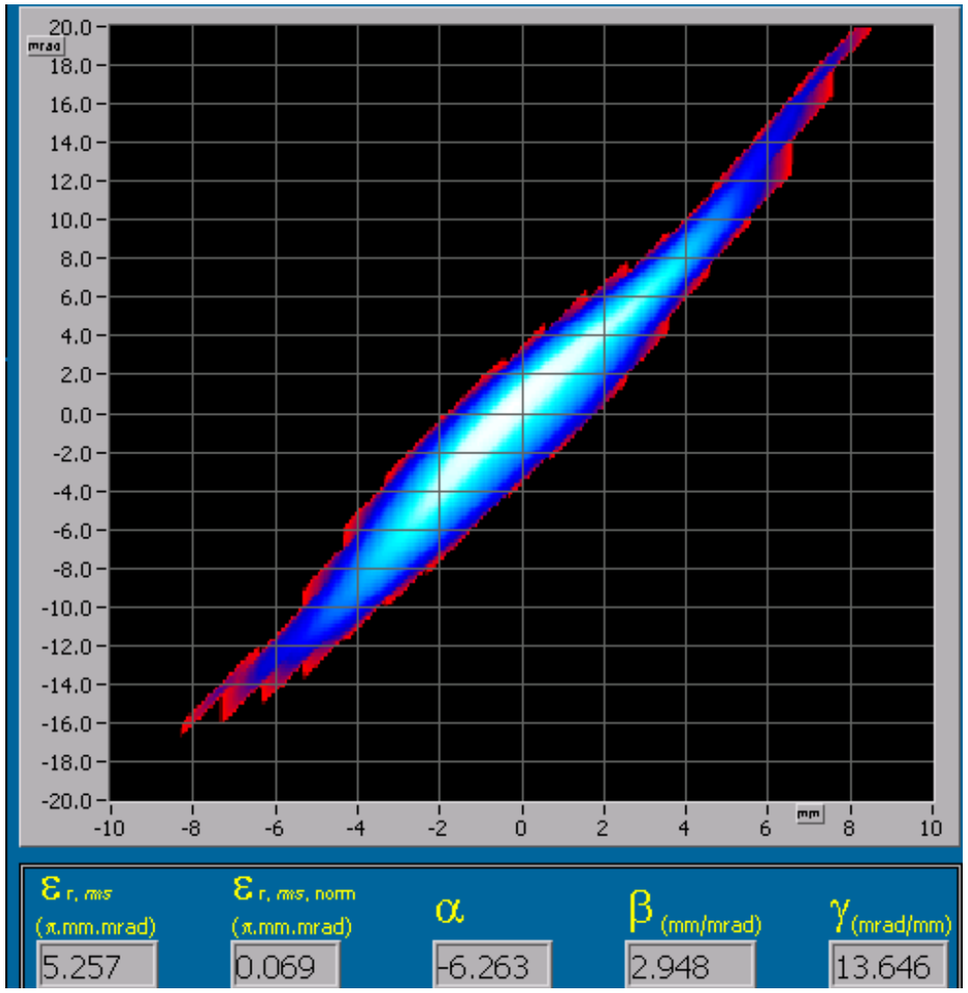


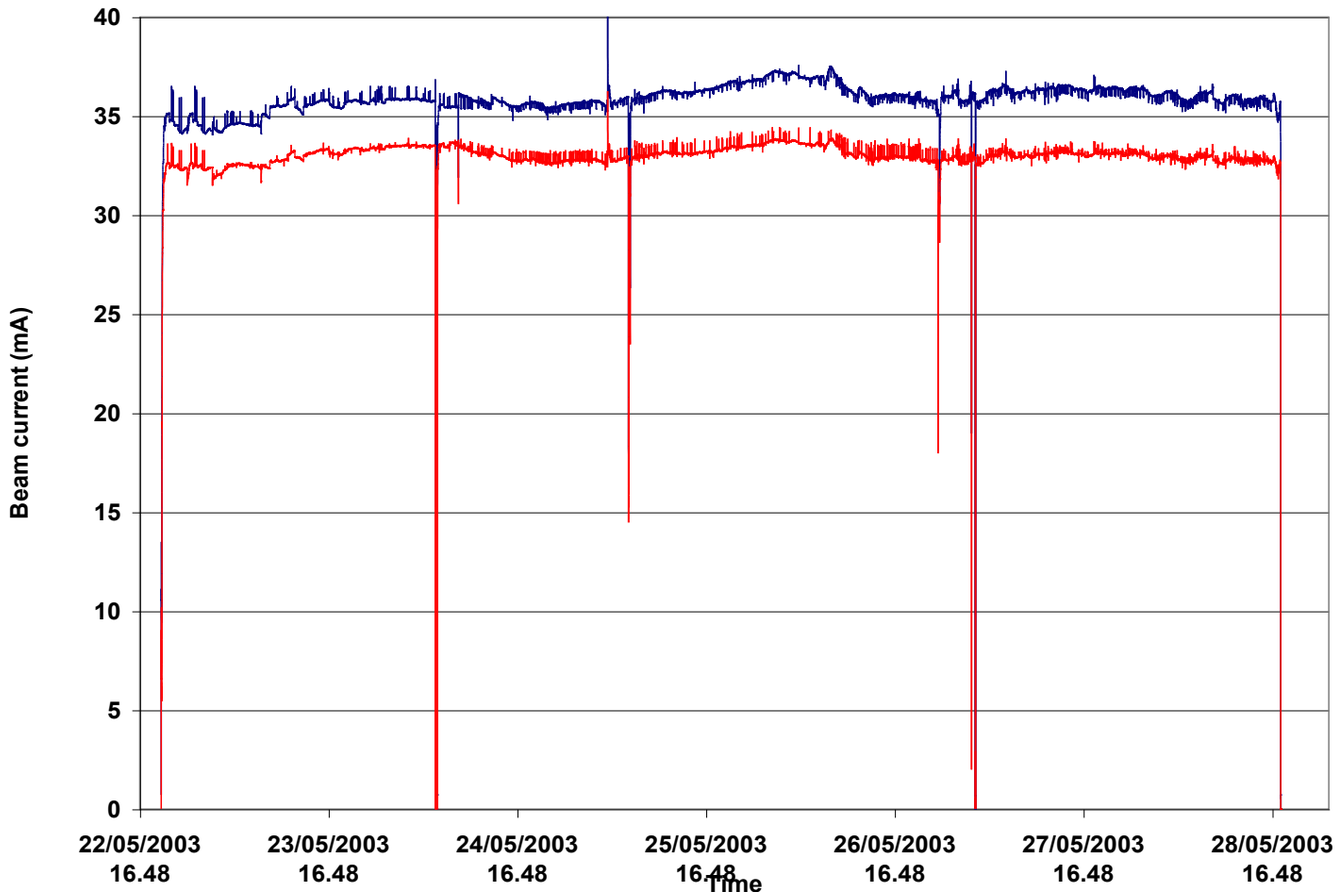
TRIPS

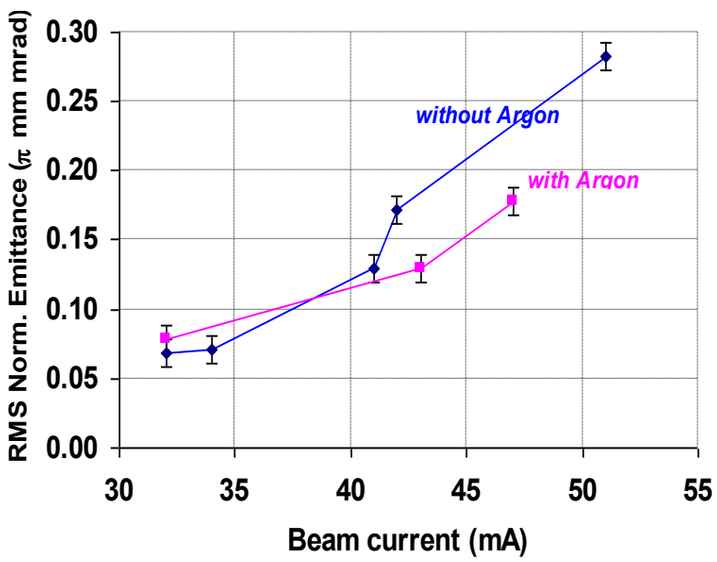


- Movable magnetic system composed by two solenoids
- Five electrodes extraction system

TRIPS emittance and reliability







TRIPS

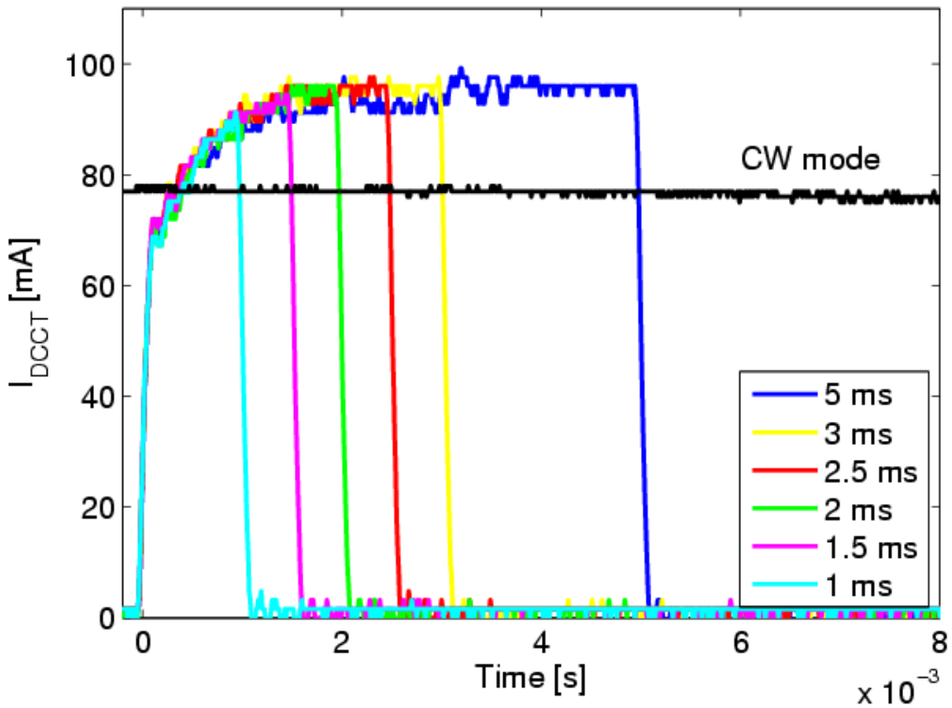
6 mm extr. hole

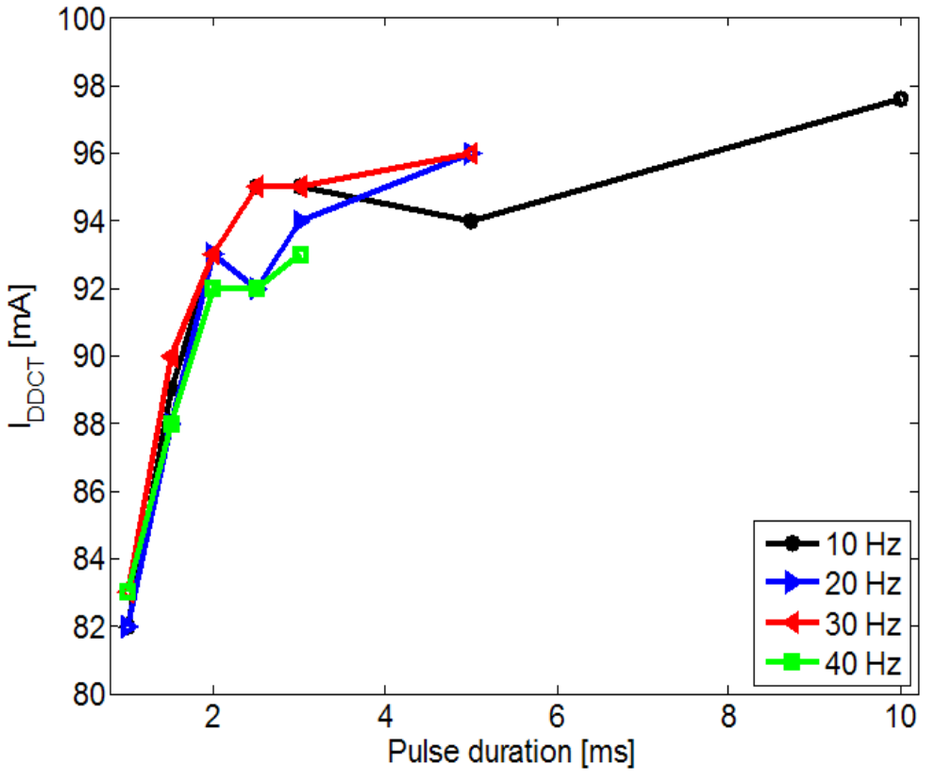
Parameter	
Extraction voltage	80 kV
Puller voltage	42 kV
Repeller voltage	-2.6 kV
Discharge power	435 W
Beam current	35 mA
Mass flow	≈0.5 sccm

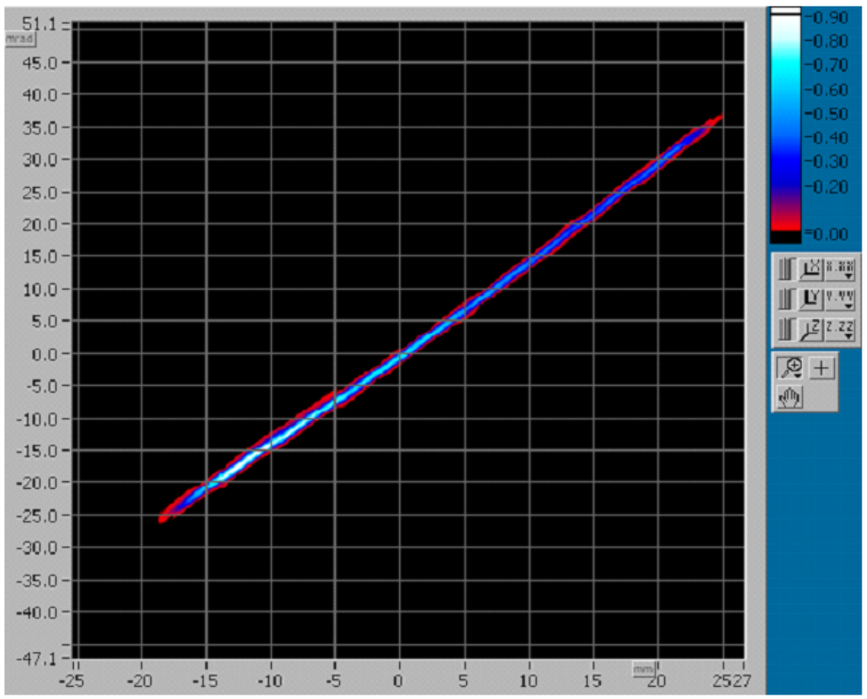
Availability over 142h 25'= 99.8 %

SILHI Proton source tests

I=90mA Vextr=85 kV (ϕ=9mm)





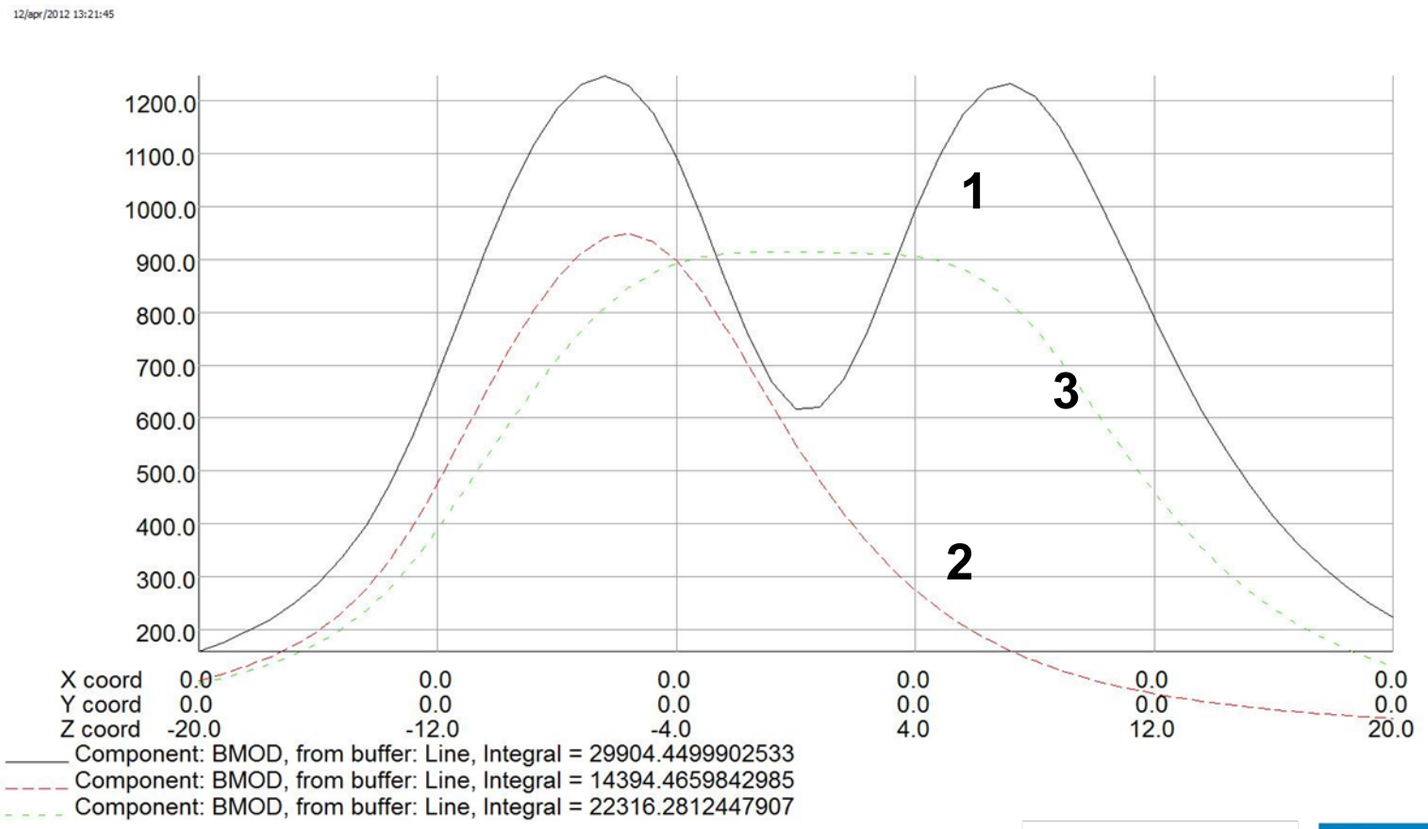


Emittance [π mm mrad]

	10 ms	5 ms	3 ms	2.5 ms	2 ms	1.5 ms	1 ms
10 Hz	0.166	0.156	0.152	0.152	0.156	0.148	0.145
20 Hz		0.162	0.152	0.153	0.144	0.143	0.116
30 Hz		0.144	0.144	0.142	0.142	0.138	0.13
40 Hz		0.148	0.148	0.142	0.134	0.129	0.146

R. Miracoli et al., accepted to RSI

Flexible Magnetic field



UNITS

Length	cm
Magn Flux Density	gauss
Magn Field	oersted
Magn Scalar Pot	oersted cm
Magn Vector Pot	gauss cm
Elec Flux Density	C cm^{-2}
Elec Field	V cm^{-1}
Conductivity	S cm^{-1}
Current Density	A cm^{-2}
Power	erg s^{-1}
Force	dyne
Energy	erg
Mass	g

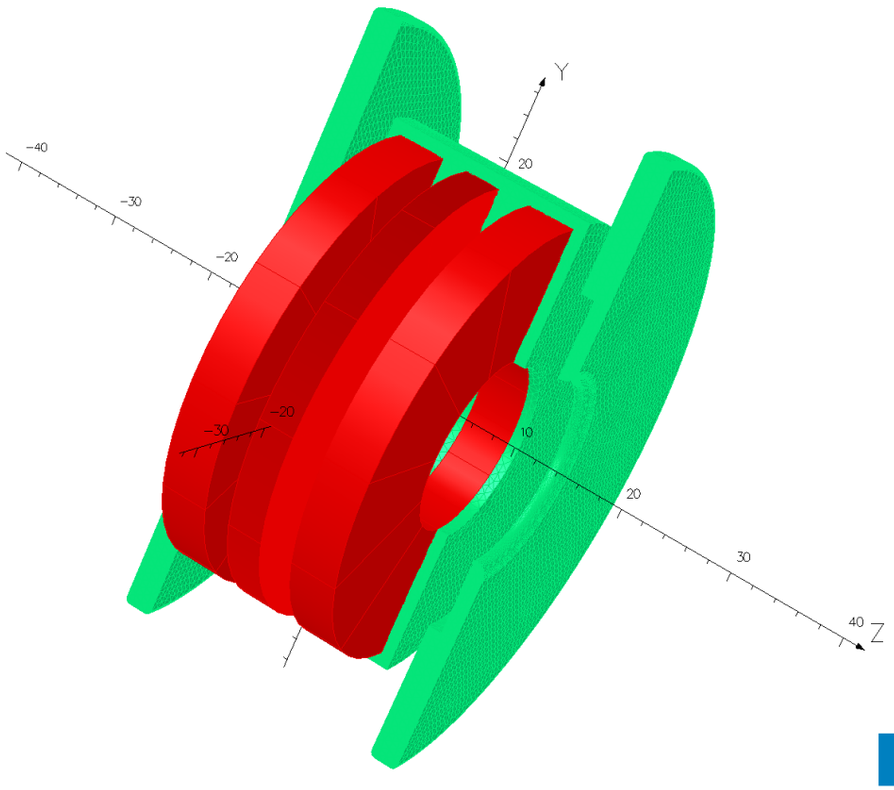
MODEL DATA
modello155--120-170.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
1420225 elements
729806 nodes
3 conductors
Nodally interpolated fields
with B and H by integration
Activated in global coordinates

Field Point Local Coordinates
Local = Global

FIELD EVALUATIONS
Line LINE (nodal-linte) 51 Cartesian
x=0.0 y=0.0 z=-20.0 to 20.0

Opera

1. "Simple mirror";
2. "Magnetic Beach"
3. "Off-Resonance configuration"



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Current Density	A cm^{-2}
Power	erg s^{-1}
Force	dyne
Energy	erg
Mass	g

MODEL DATA
modello3ferro2.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
1420225 elements
729806 nodes
3 conductors
Nodally interpolated fields
with B and H by integration
Activated in global coordinates

Field Point Local Coordinates
Local = Global

FIELD EVALUATIONS
Line LINE (nodal-linte) 151 Cartesian
x=0.0 y=0.0 z=-20.0 to 20.0

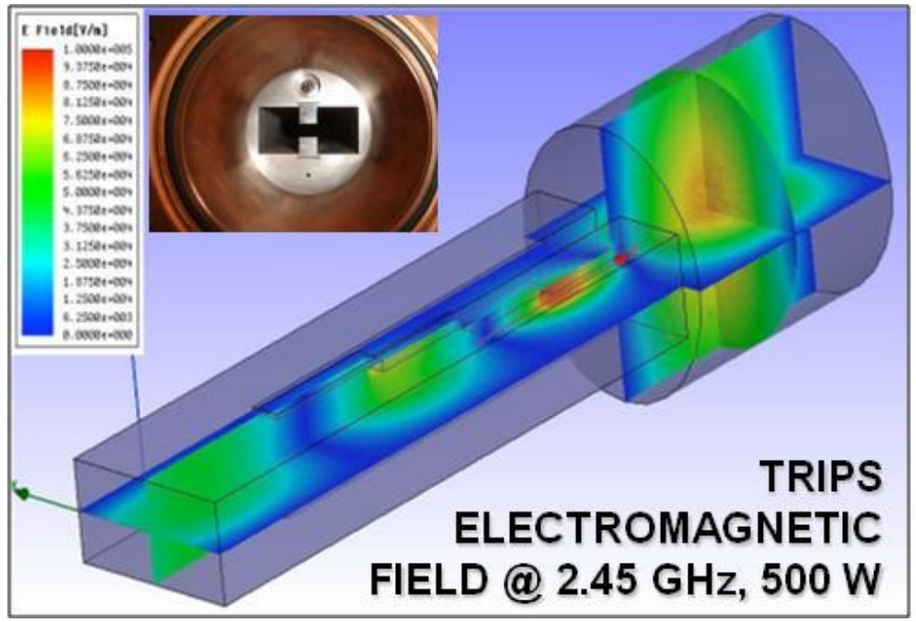
Opera

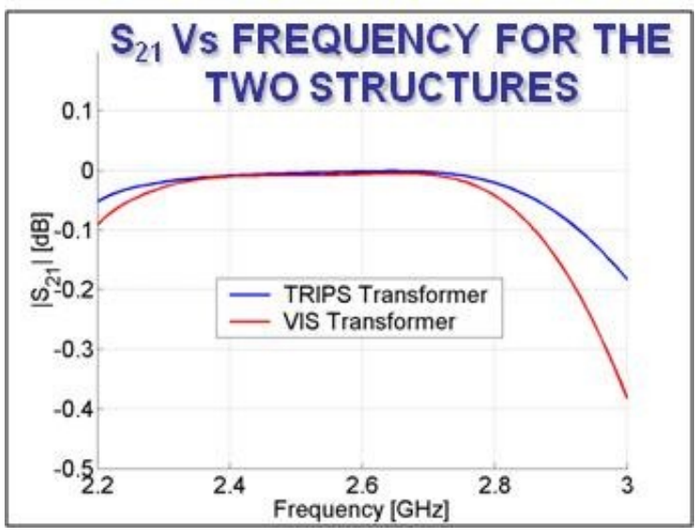
	Inj	Med	Ext
Simple mirror	400	-300	400
Off resonance	155	120	170
Mag. Beach	260	0	0

Microwave coupling study

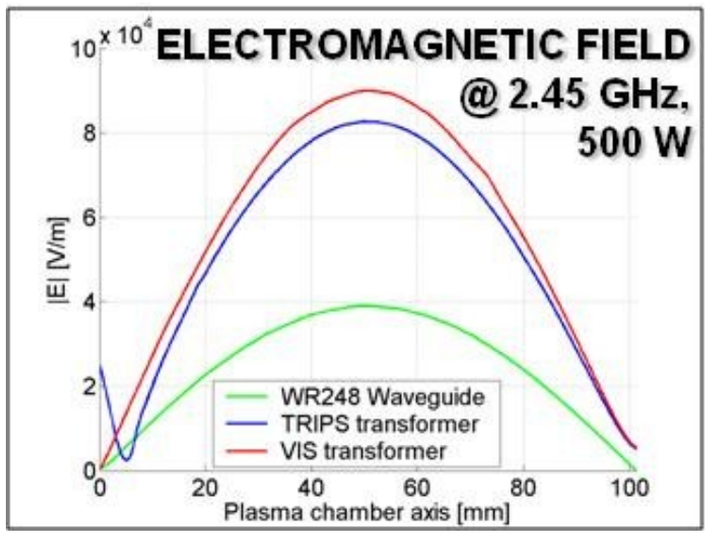
Four step double ridges

Matching transformer coupled to the plasma chamber

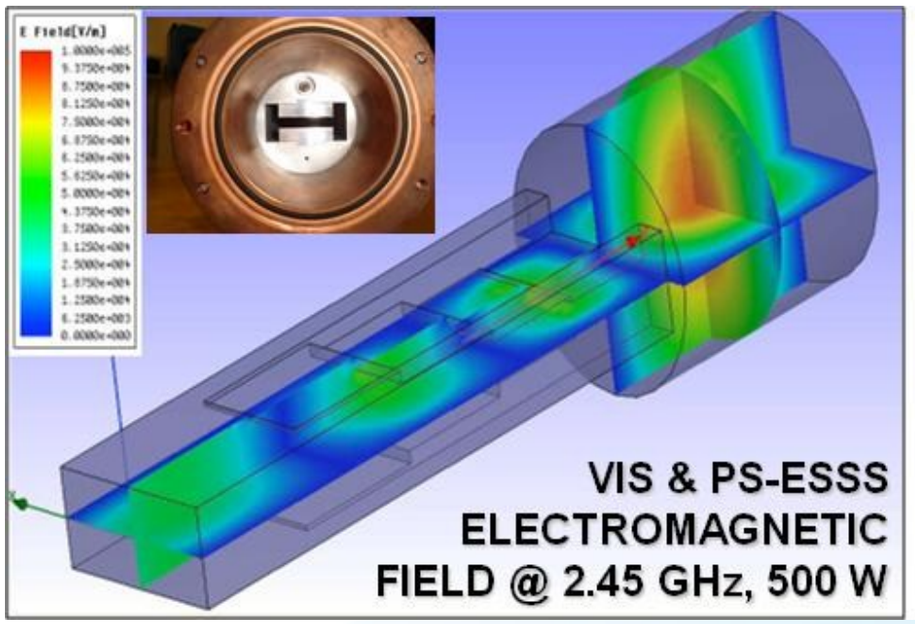




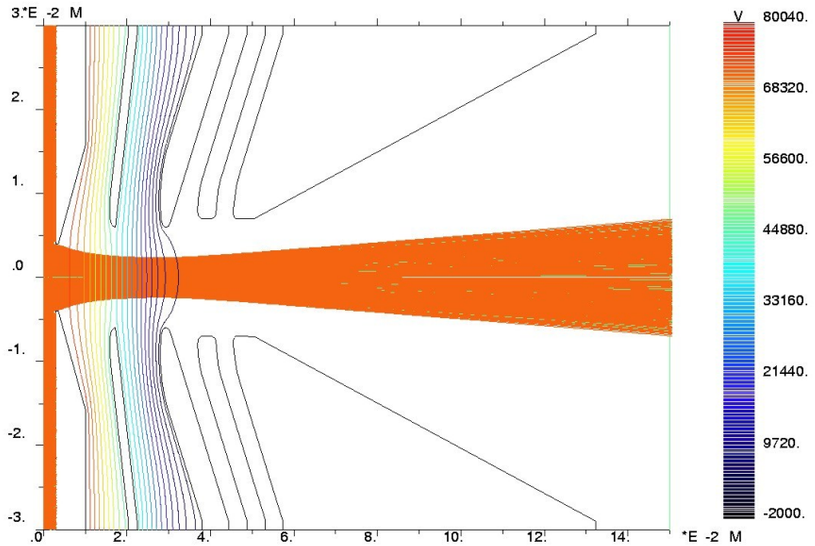
VIS &PS-ESS TRANSFORMER INSERTION LOSS 0.0085 dB @ 2.45 GHz

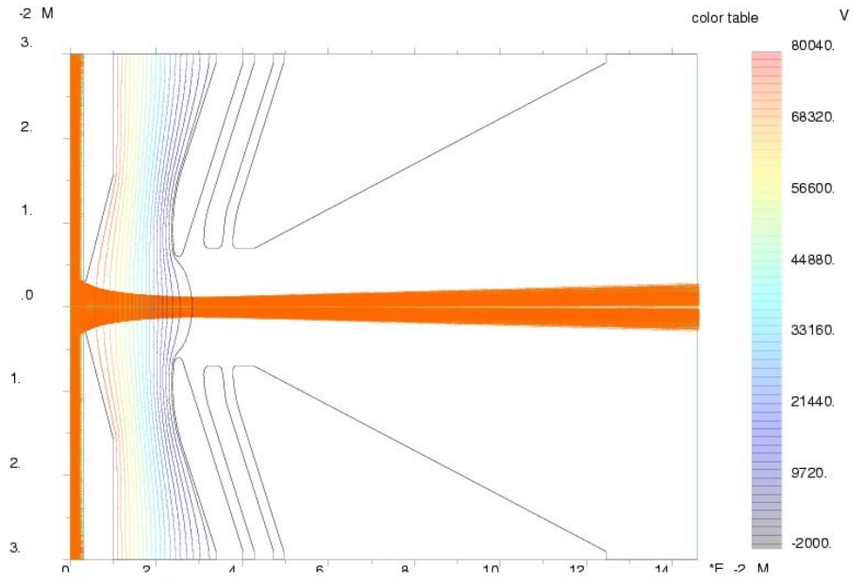


10 % ENHANCEMENT WITH VIS &PS-ESS TRANSFORMER



Beam extraction





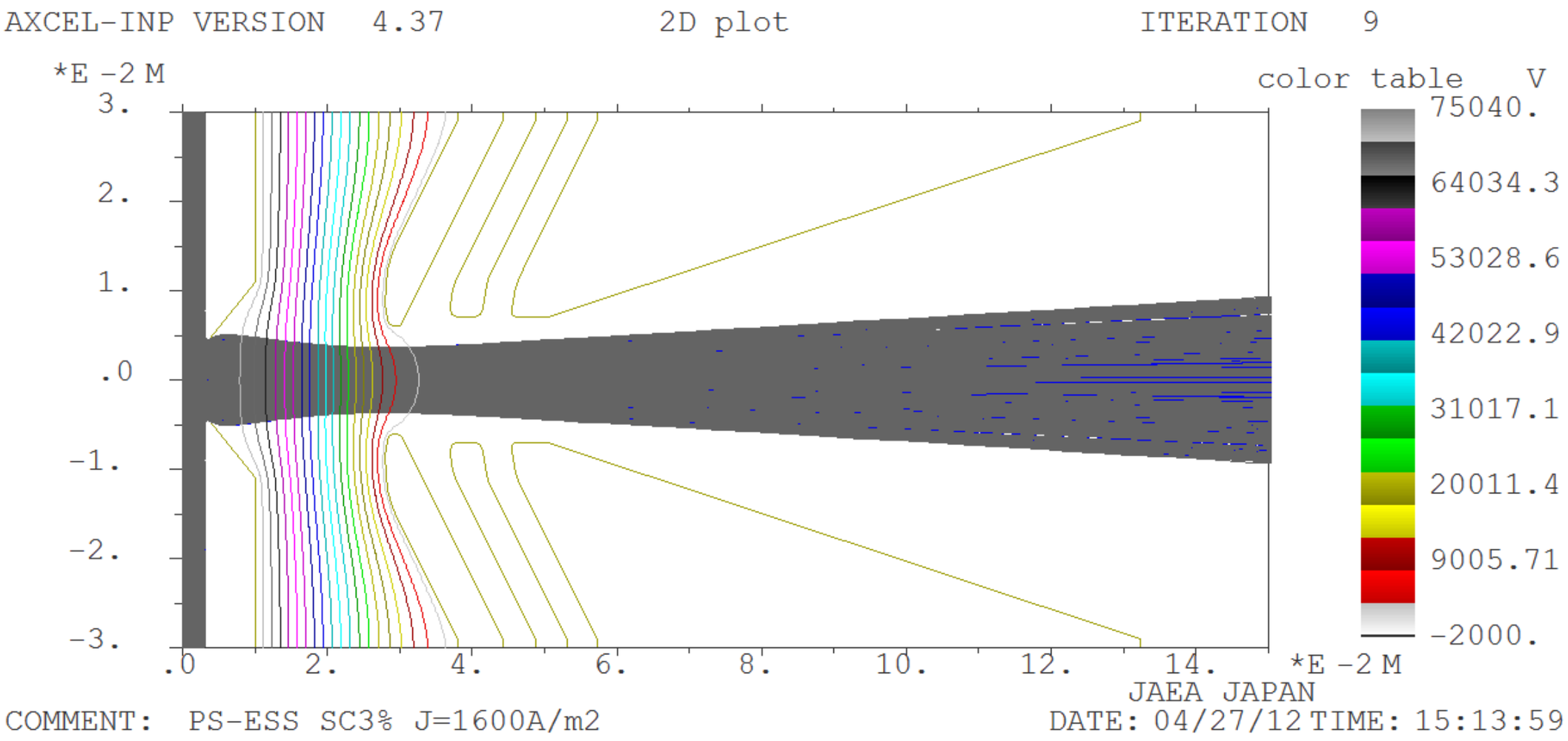
Five-electrode topology (TRIPS, SILHI)

- on-line optimisation of the extracted beam
- wide range of operations
- alignment issues of the overall geometry
- biasing system needed for the intermediate electrode

Four-electrode topology (VIS, LANL)

- optimized for a narrow range of operating current
- no alignment problems
- no biasing system

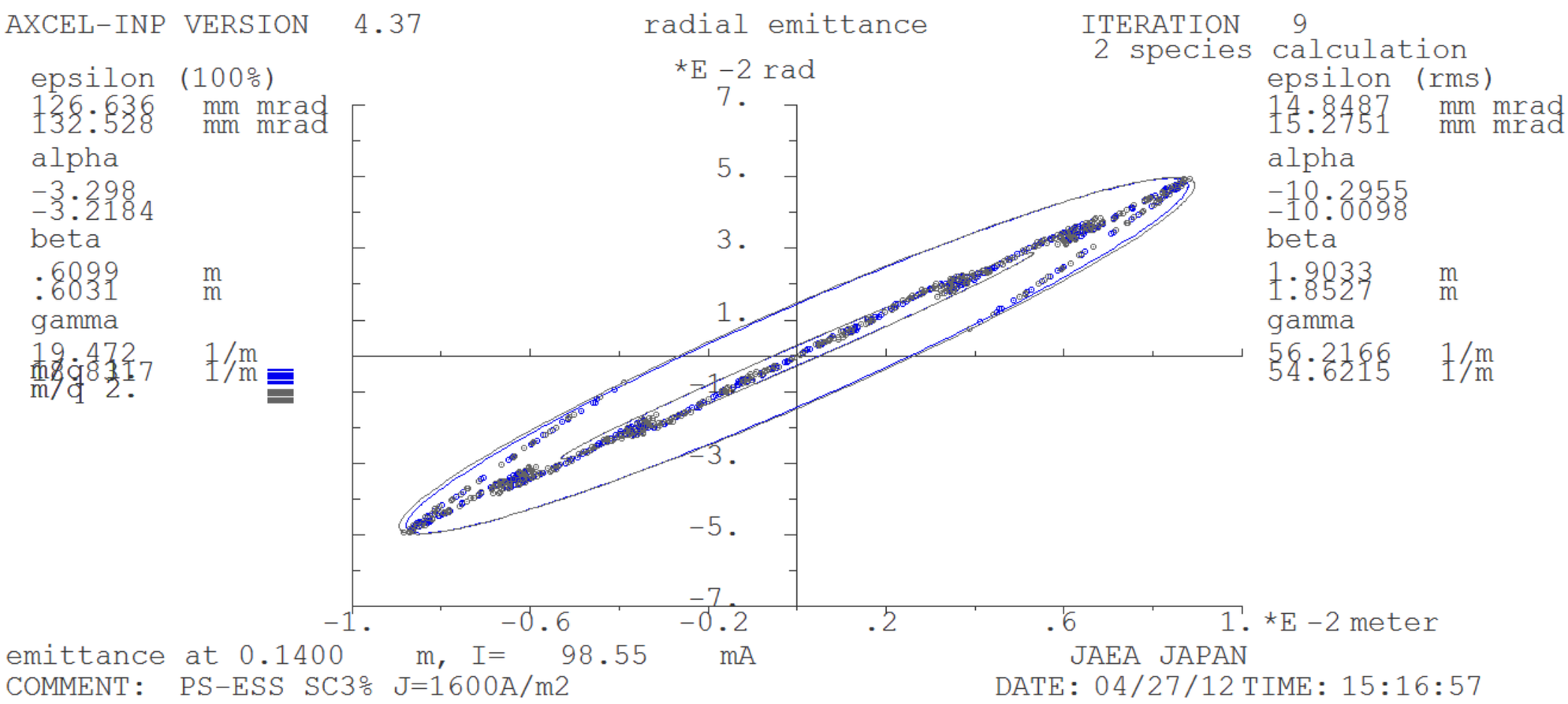
PS-ESS beam extraction



I_{tot}= 98.55 mA

(H^+=90%; H_2^+=10%)

PS-ESS beam extraction

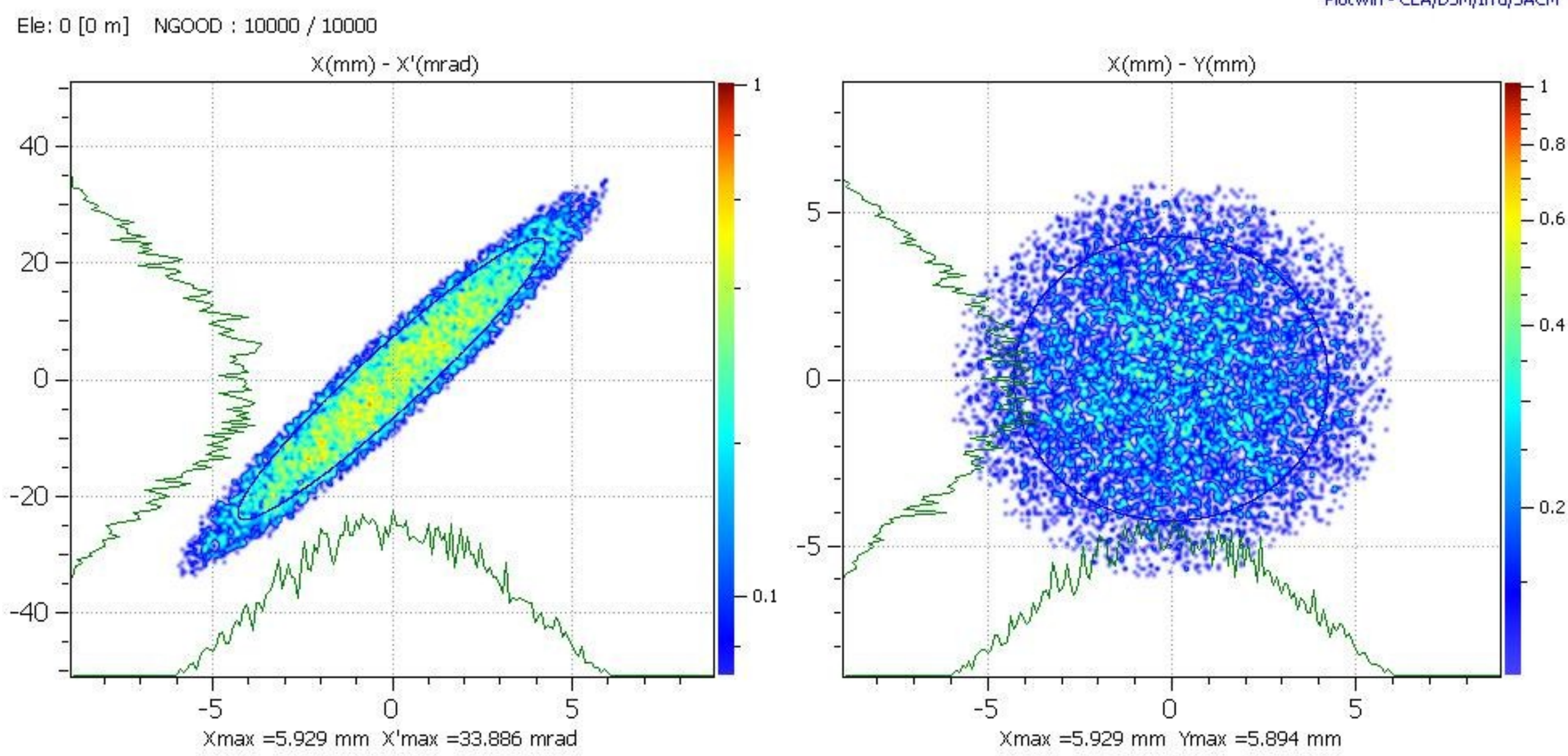


Alpha =-10.2955
Beta = 1.9033

Proton beam emittance rms norm. @ 0.14 m = 0.126 pi mm mrad

AXCEL Beam output @ 0.14 m has been used as input for TRACEWIN simulations.

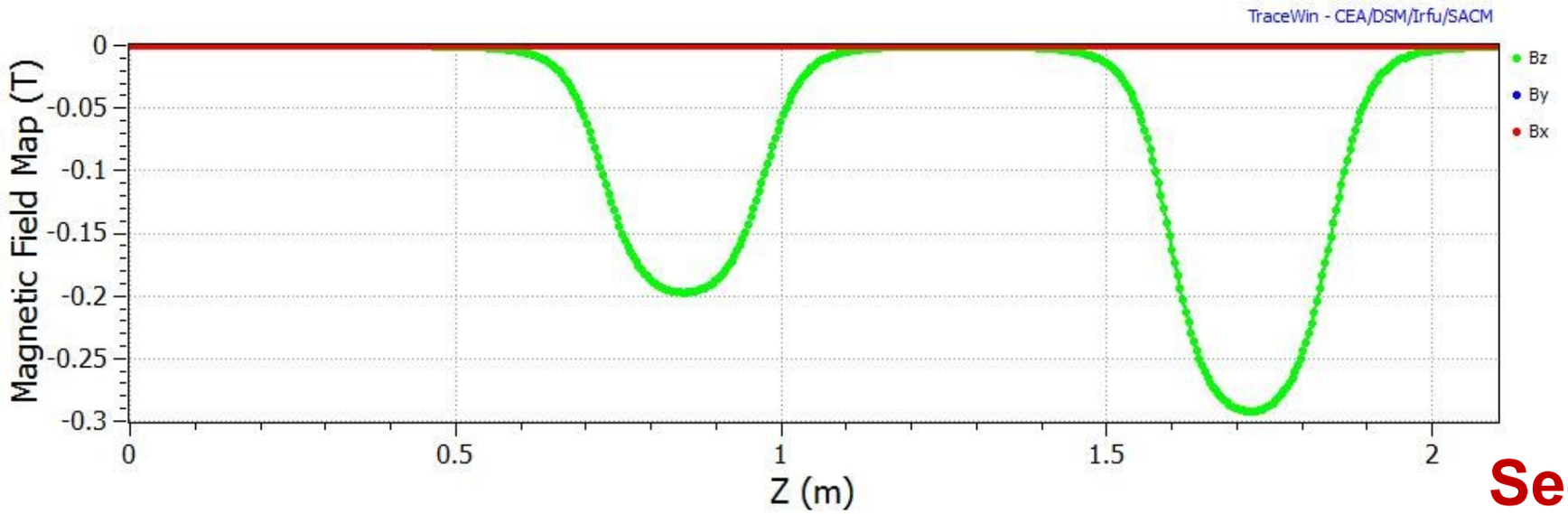
TRACEWIN simulations

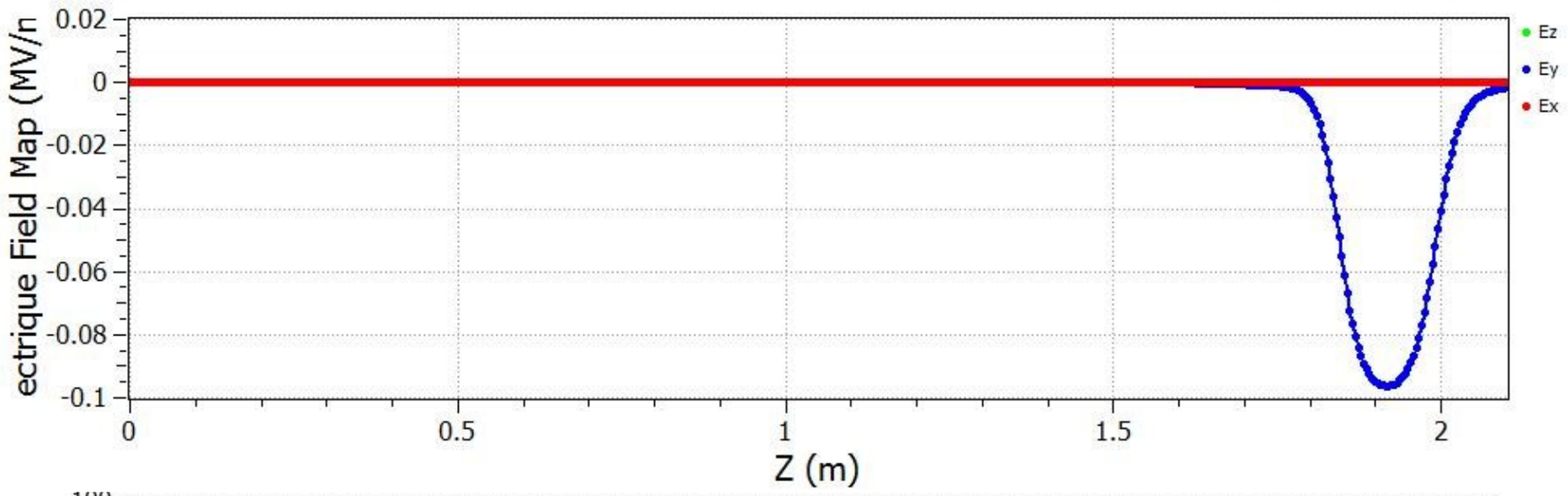


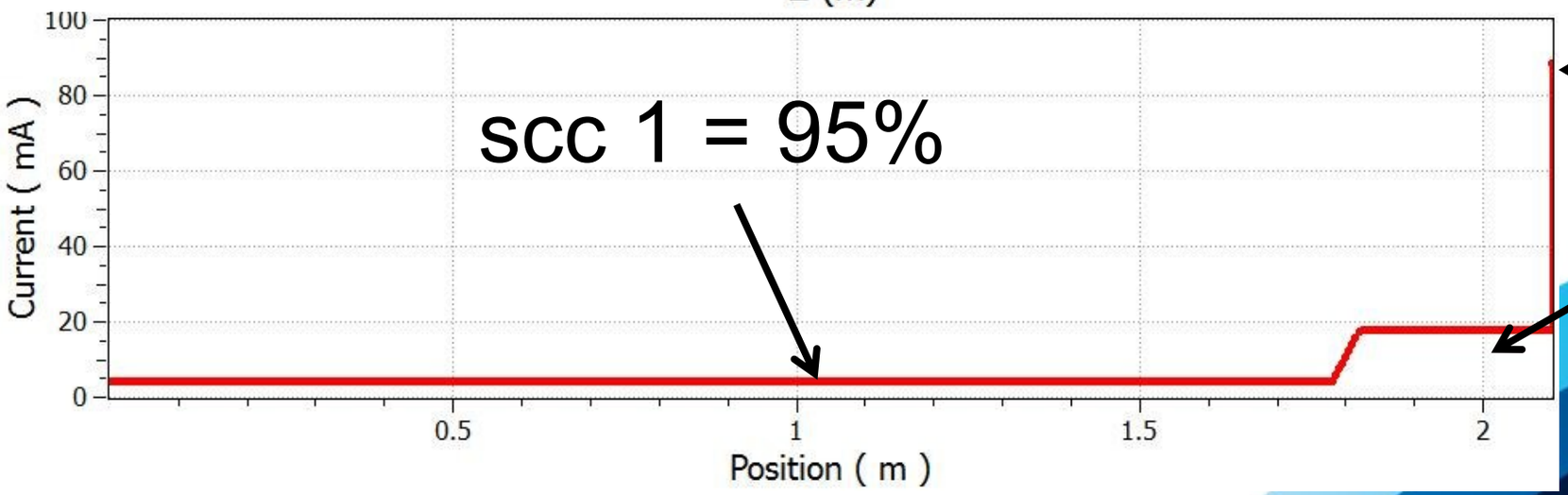
Emit [rms] = 0.1260 Pi.mm.mrad [Norm.]
Beta = 0.6099 mm/Pi.mrad ; Alpha = -3.2980
H^+ current = 89 mA ; Energy = 75KeV

See poster of L. Neri et al.

TRACEWIN simulations

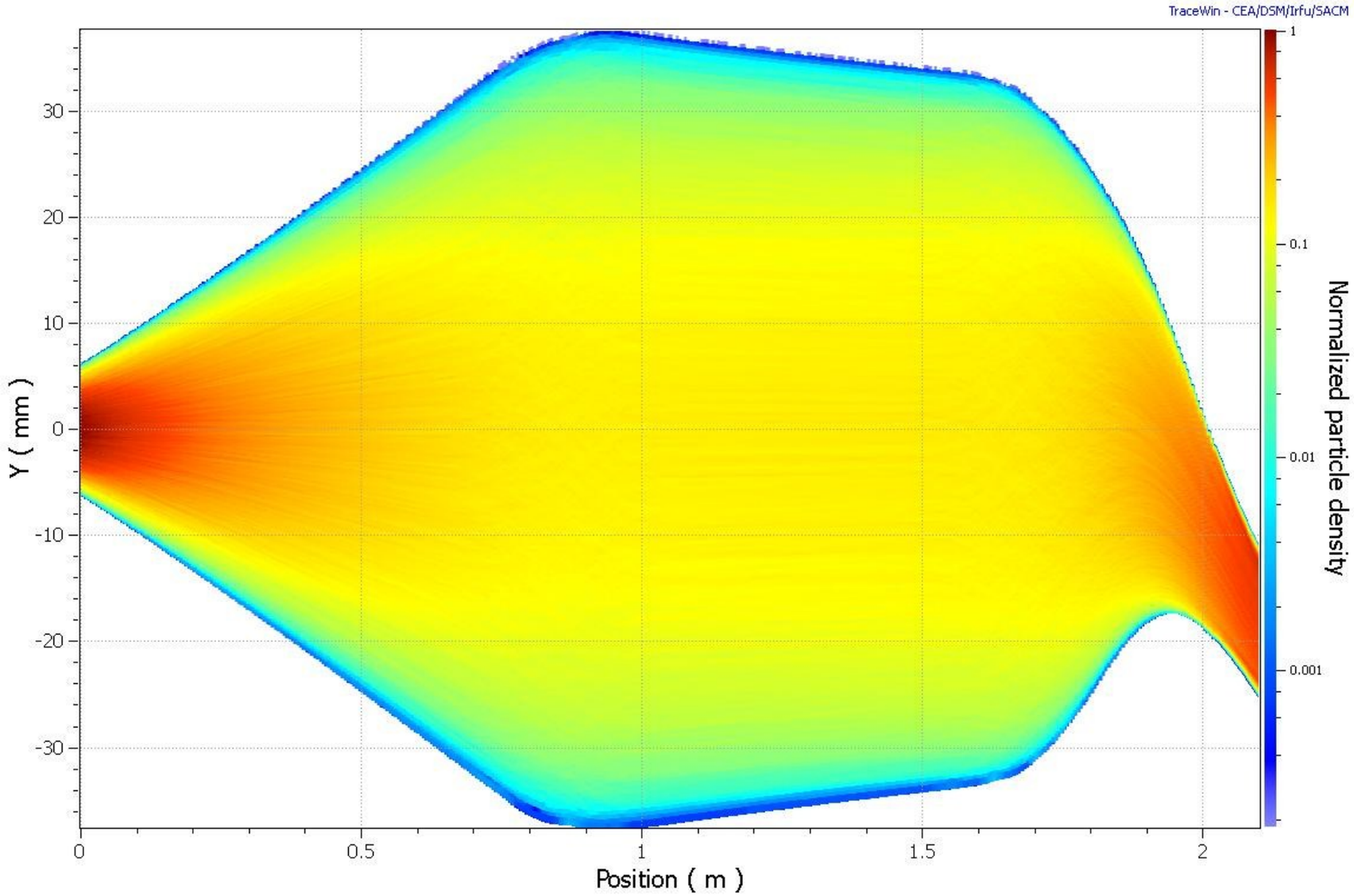






See poster of L. Neri et al.

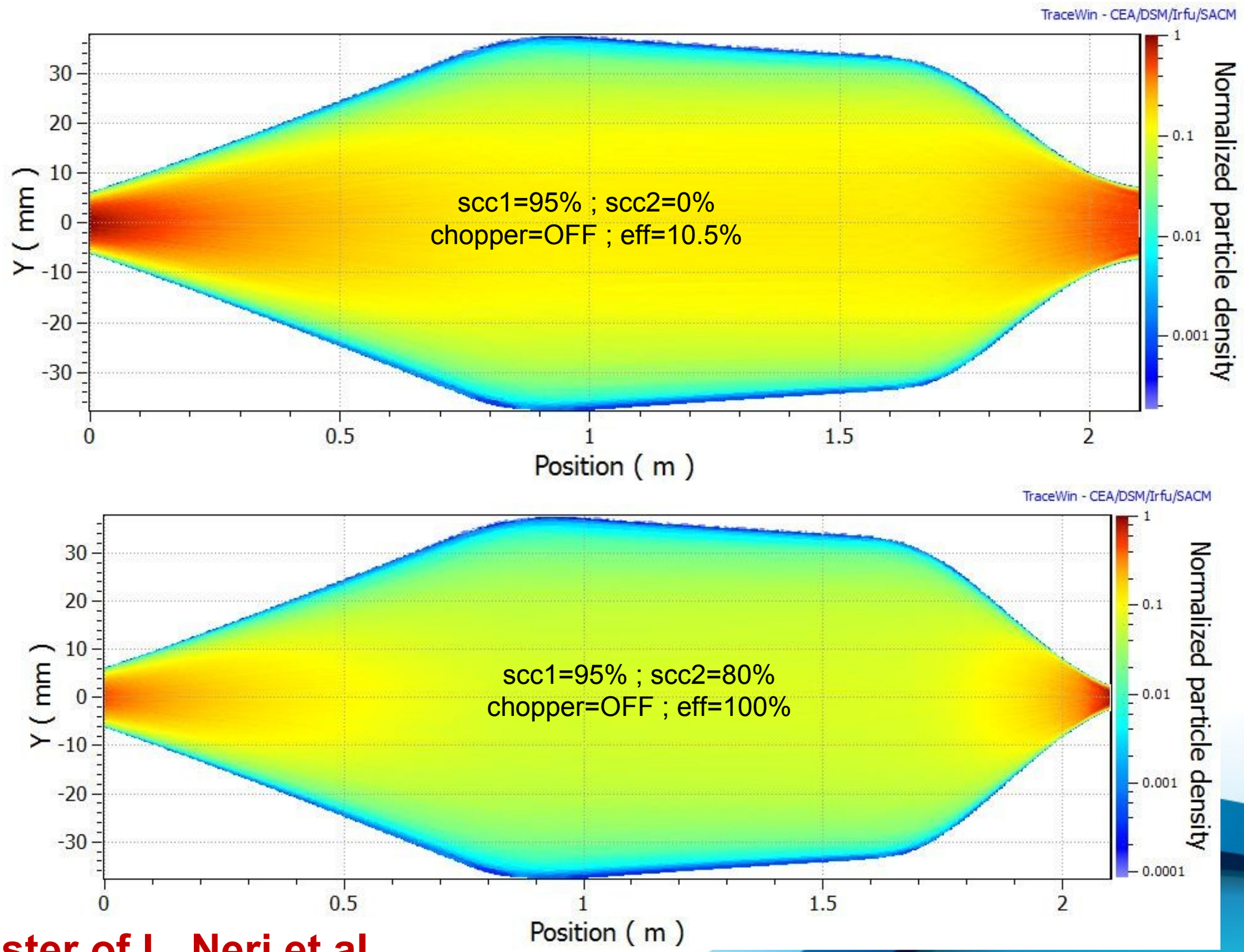
TRACEWIN simulations



scc1=95% ; scc2=0%
chopper=ON

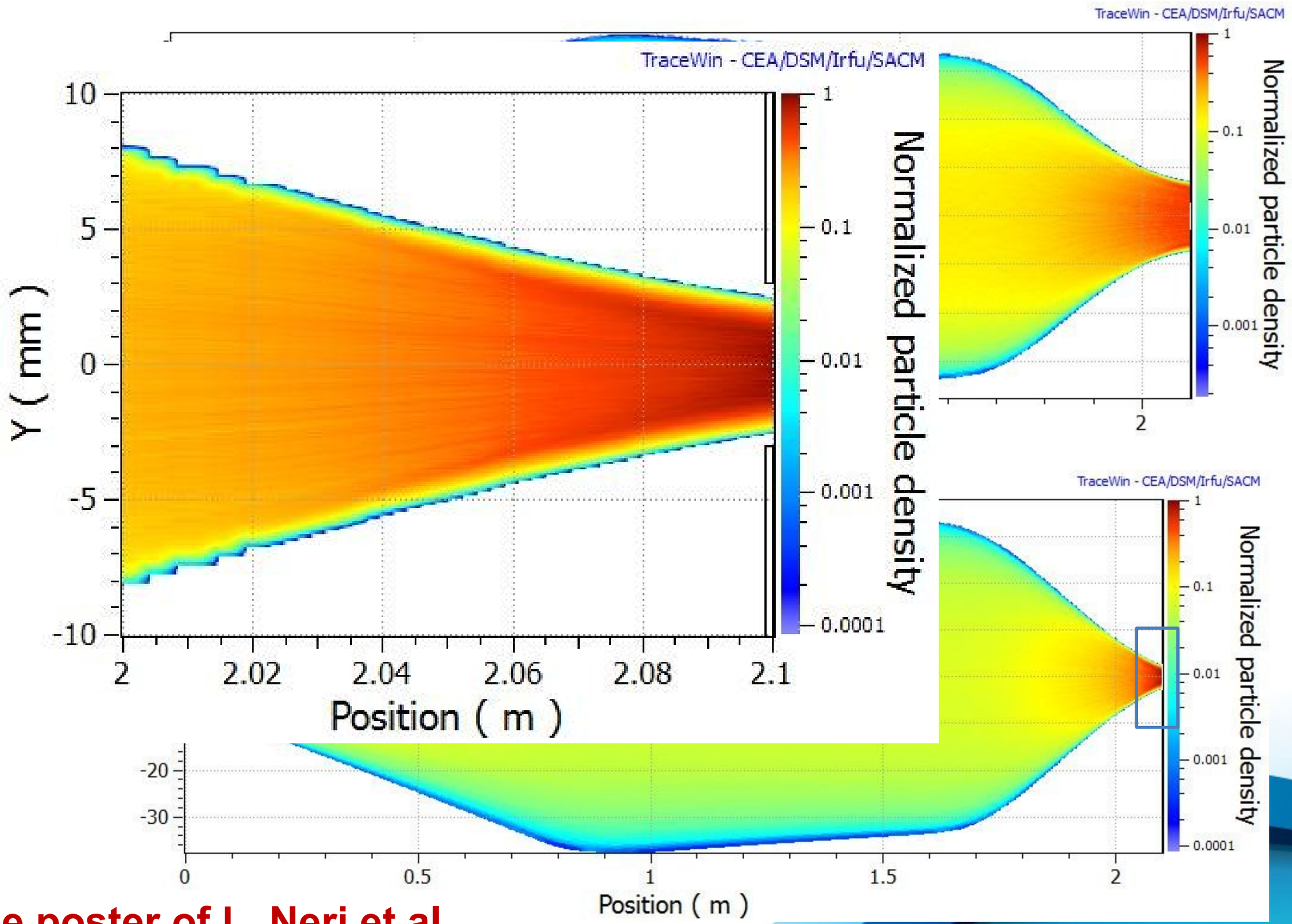
See poster of L. Neri et al.

TRACEWIN simulations



See poster of L. Neri et al.

TRACEWIN simulations



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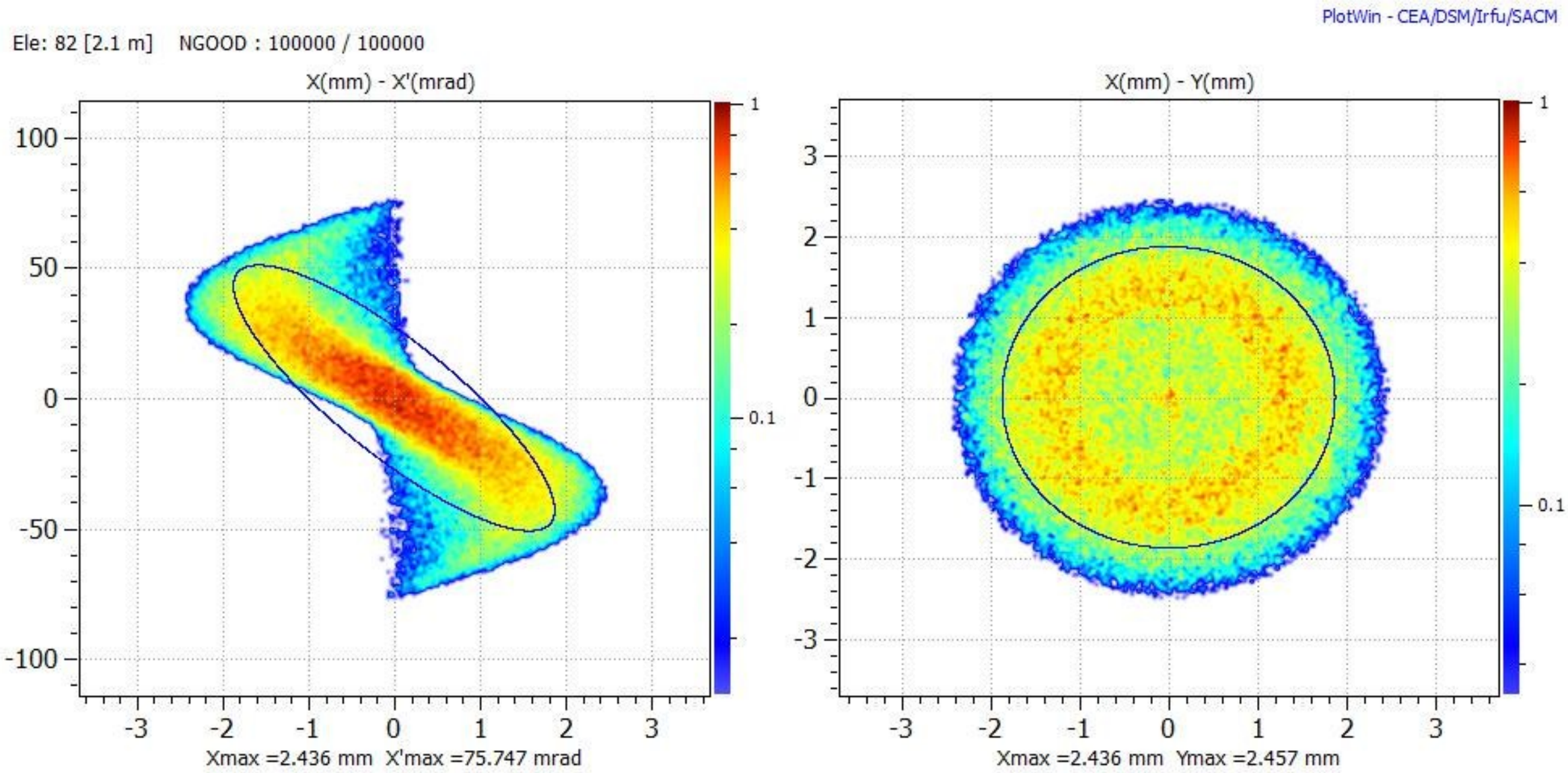
TRACEWIN simulations



Emit [rms] = 0.2145 Pi.mm.mrad [Norm.]
Beta = 0.0687 mm/Pi.mrad
Alpha = 1.5843

See poster of L. Neri et al.

Chopping strategies

Requirements

- Small size
- Rise and fall time less than 100ns
- Repetition rate 14Hz
- Beam energy 75keV
- 100% transmission for a beam size of ±25mm and ±20mrad

CANDIDATE

Chopper after the second solenoid

[1]

(criticalities observed due to the restricted space available)

- Same mechanical design, but smaller size because the collimator at the RFQ entrance can be used as slit
- A smaller beam is expected after the second solenoid and the chopping voltage could be smaller
- More space available for diagnostics in the box within the solenoids
- Beam pulse timing can be checked only after the collimator
- SCC studies still needed

OUTSIDERS

- Chopper and slit between the two solenoids
- Solution with Wien Filter

Isosurface at 4kV

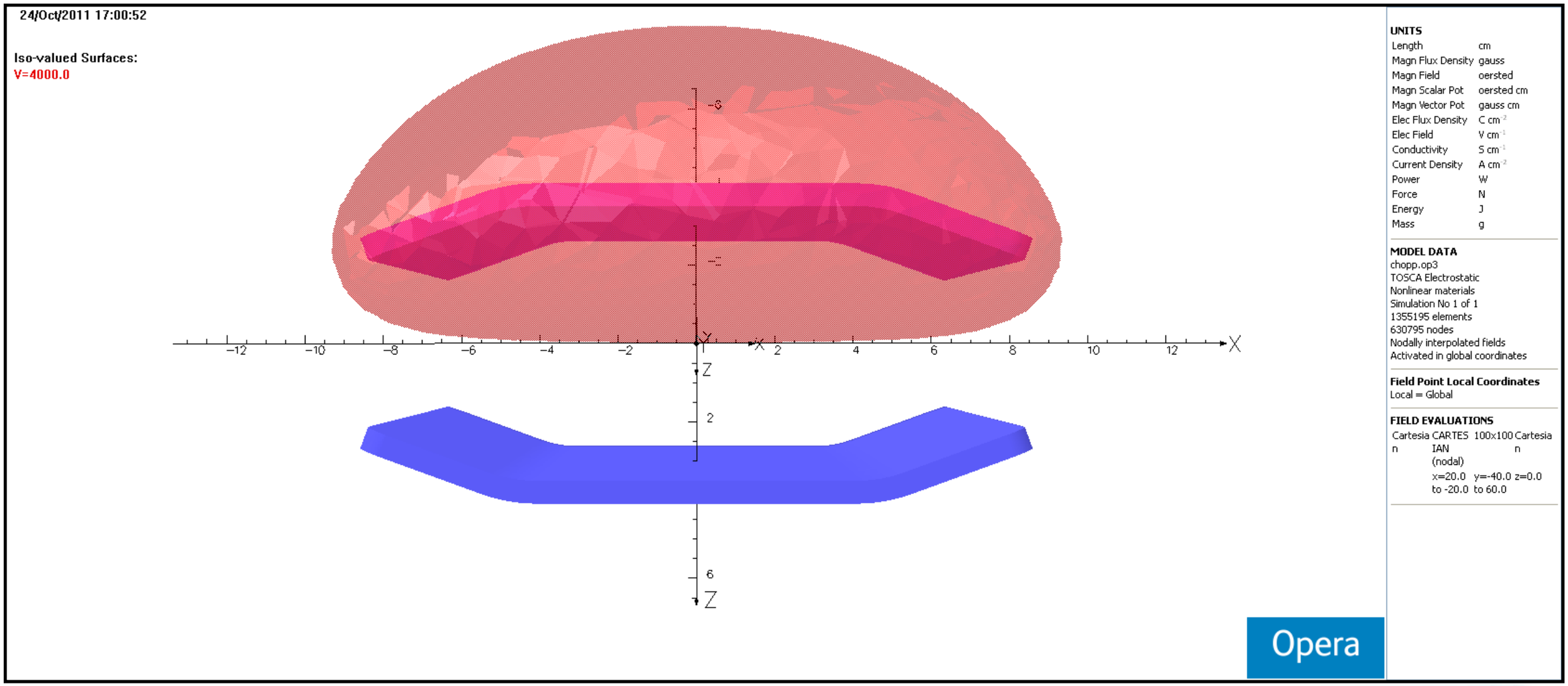
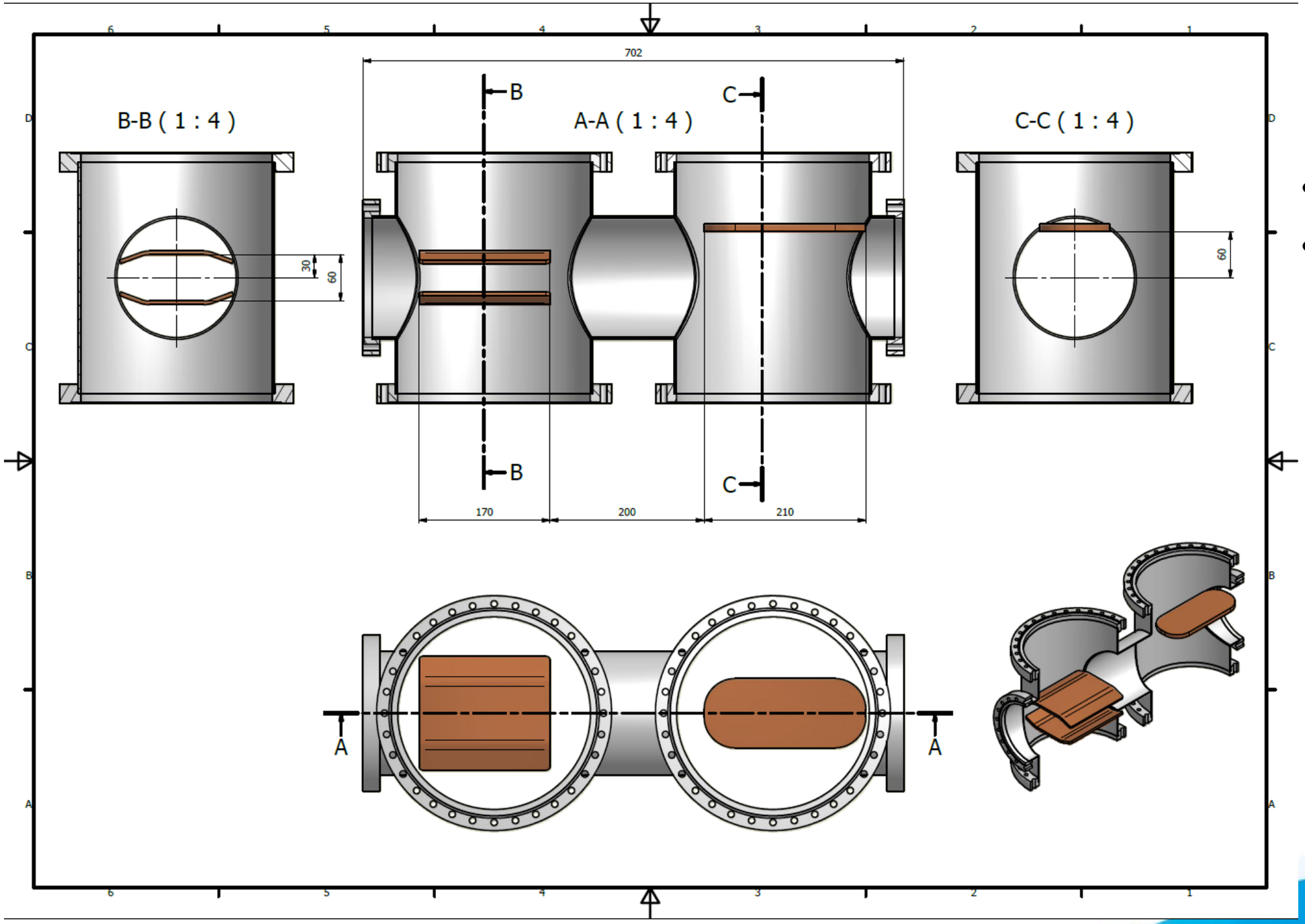


Plate bending angle of 20°
for a flat transversal filed

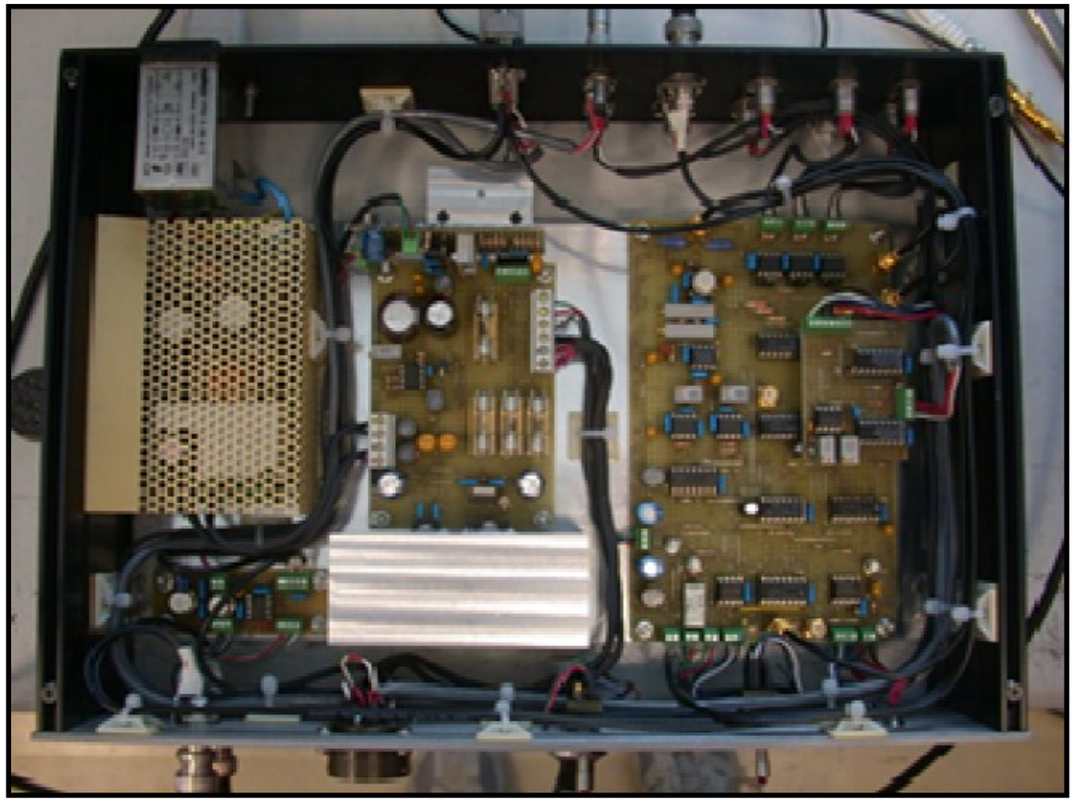
3D prototype (version between solenoids)

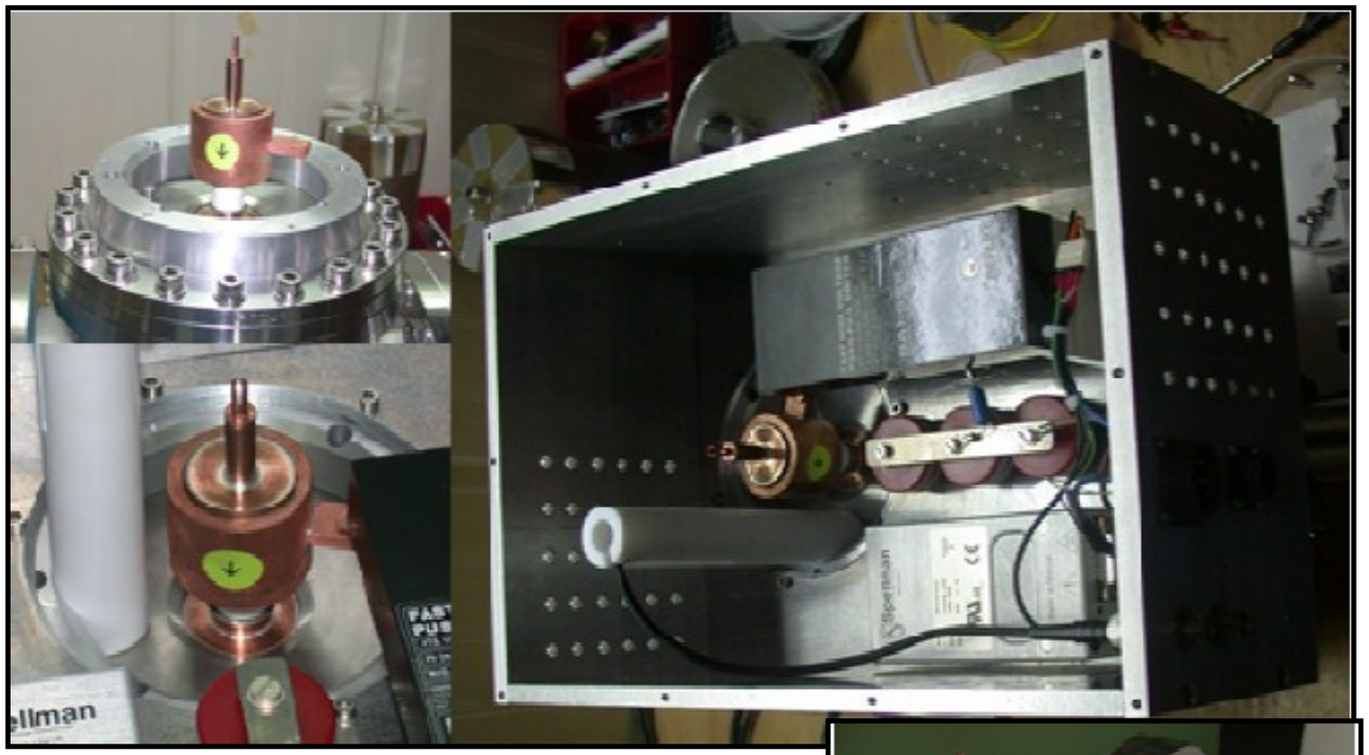


- 70 cm of total length
- Suitable power supply and electronics ready to use

Total length 70cm

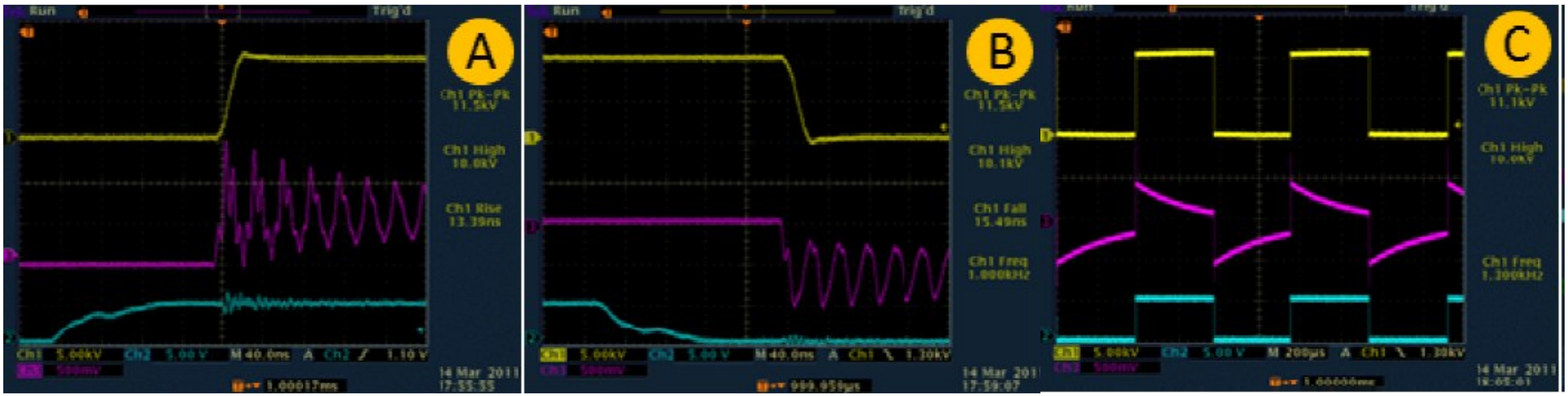
Electronics





- **Built at INFN-LNS and already delivered to GANIL for SPIRAL 2**
- **Now installed at 5 mA deuteron source testbench at CEA-IRFU.**
- **NO SPACE CHARGE ISSUES OBSERVED**

Rise, fall times, repetition rate

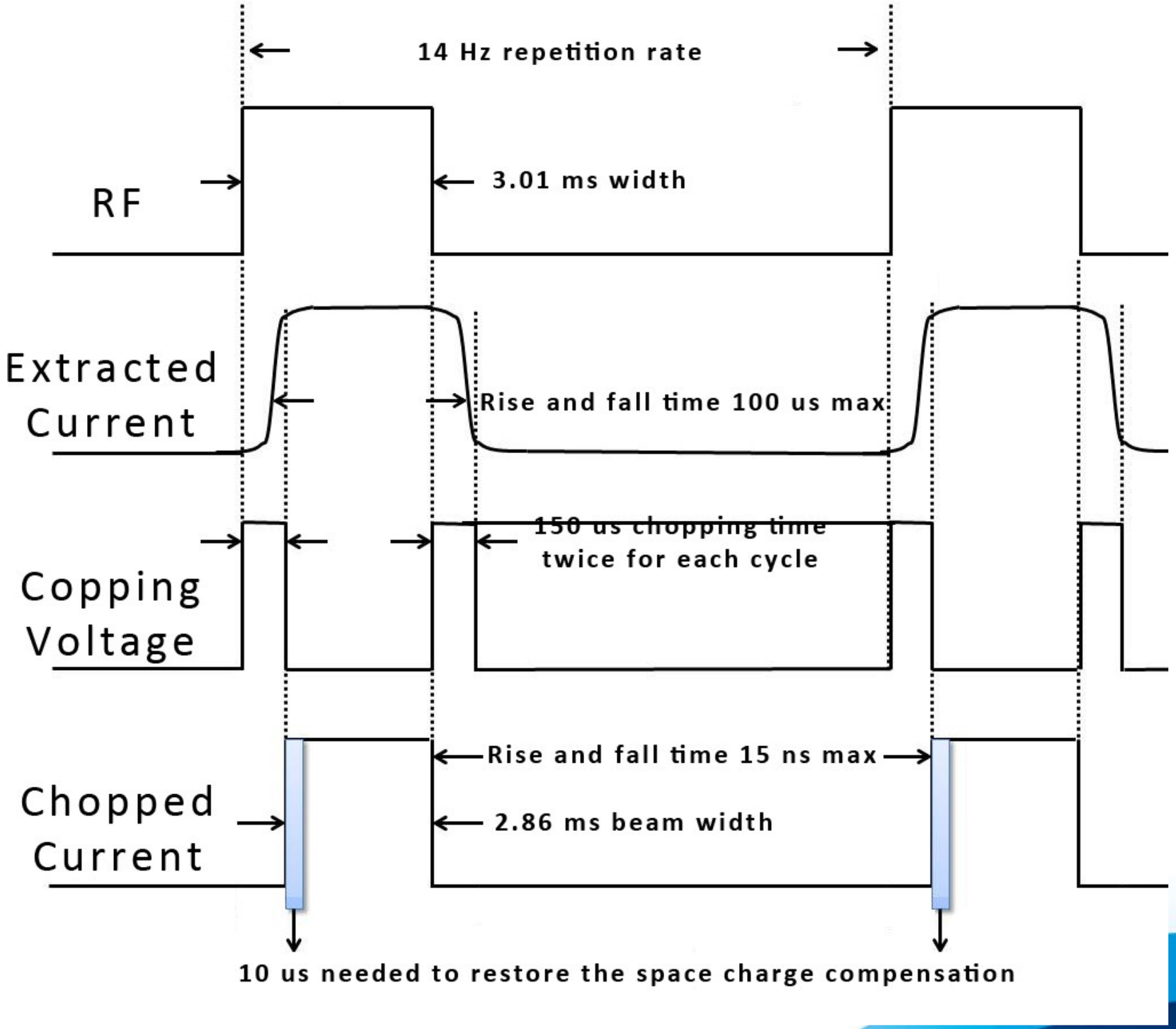


Measured performance (acquisitions at 10 kV):

- ✓ **rise and fall time of 13-15 ns (A,B);**
- ✓ **up to 1.3 kHz of repetition rate (C);**

Yellow= HV signal
Blue= TTL driver
Purple= pick-up signal

Timing


14 Hz repetition rate
RF
3.01 ms width
Extracted Current
Rise and fall time 100 us max
150 us chopping time twice for each cycle
Copping Voltage
Rise and fall time 15 ns max
Chopped Current
2.86 ms beam width
10 us needed to restore the space charge compensation

Expectations & Criticalities

•We are confident to achieve the expected beam current in the required emittance (minor crit. due to the lower operating voltage)

•The reliability issue can be addressed by a proper choice of the magnetic field together with the optimization of the extraction system.

•Layout LEBT under optimization.

•Beam evolution in the 10 us time window needed to restore space charge compensation.
Roadmap: calculations and measurements on the source.

•SCC tests will be carried out at CEA-IRFU within the fall of the year.

Proton source & LEBT

ADU_1.6.2.1.1	Magnetic system design	12/12/2011 → 5/3/2012
ADU_1.6.2.1.4	RF system design	22/6/2012 → Yet done
ADU_1.6.2.1.7	HV system design	20/2/2012→ 31/3/2012
ADU_1.6.2.2.2	LEBT design	9/4/2012 → 10/5/2012

ADU_1.6.2.2.2	LEBT design completion	2/5/2012 → Tbd, manpower criticality
ADU_1.6.2.2.9	Chopper design	30/1/2012 → 10/3/2012
ADU_1.6.2.2.8	Requirement document	31/1/2012 → Yet done
ADU_1.6.2.2.1	Diagnostics	28/5/2012 → Tbd, manpower criticality