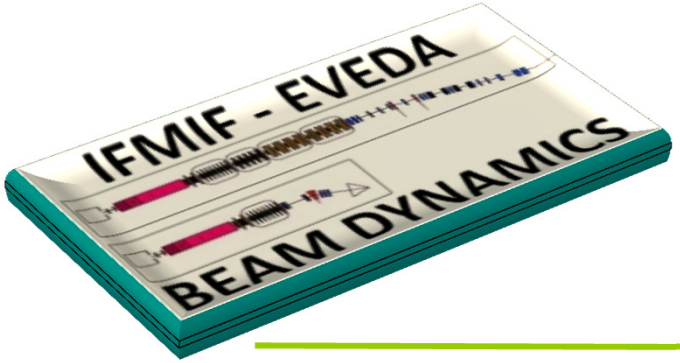
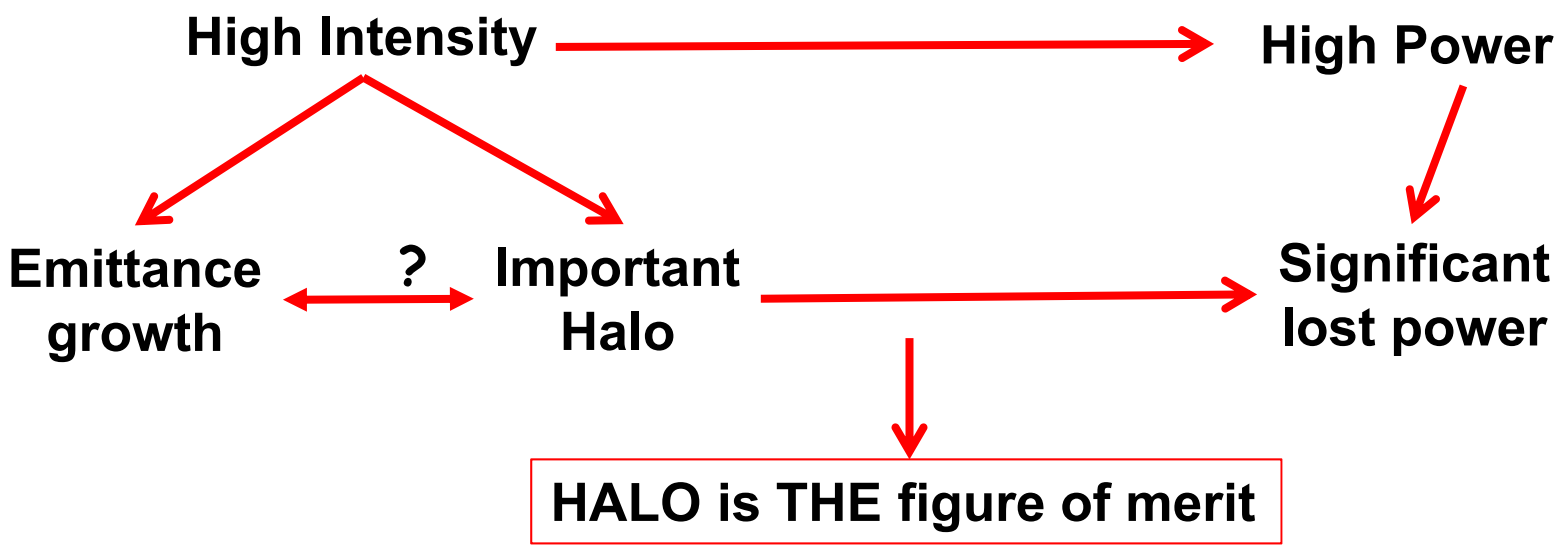
Introduction to the Discussion: Beam Halo Definitions and its Consequences

P. A. Phi NGHIEM et al.



The HALO



BUT: what is Halo ? precisely and quantitatively ?

Lattice optimisation and beam measurement:
what and how much to improve and to measure ?

Is there a connection with emittance growth ?

ALLEN & WANGLER, PRSTAB,5,124202 (2002)

The halo parameter contains additional information as to the beam state, since we find that it is possible to have
emittance growth without halo growth
(however, halo growth always implies emittance growth).
As with emittance, the halo parameter is invariant under
linear forces. Thus, halo growth is necessarily the result of nonlinearities.

The HALO parameter

HALO'03: no consensus for a definition of the halo

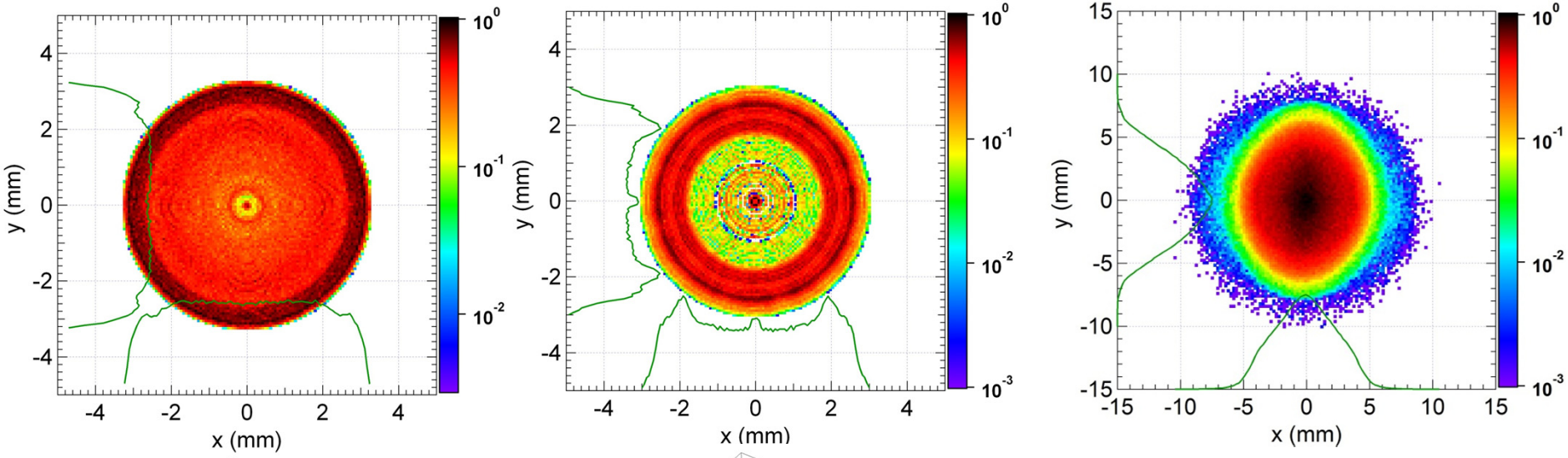
But then the most used: Definition based upon comparison between "far" and "close" beam center

4^{th} / 2^{nd} moment (Wangler & Crandall and Allen & Wangler)
n / 1 sigma
…

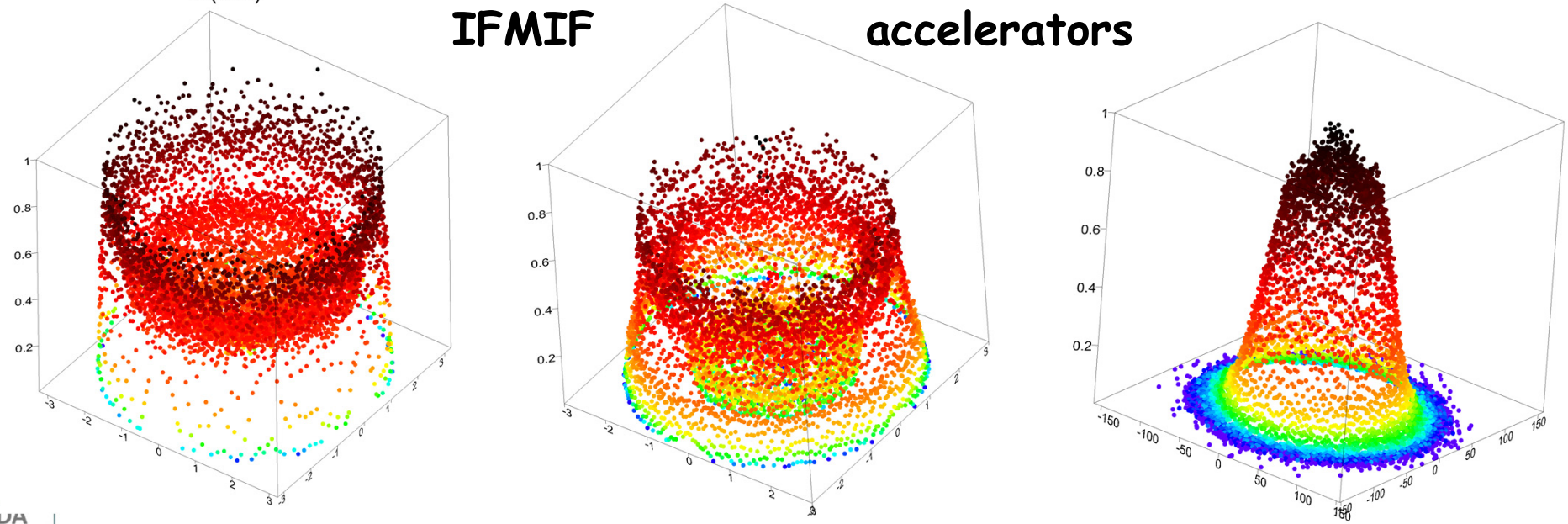
→ an idea of the relative importance of the halo

Inconvenience:
- abstract parameter
- not a value specifying the halo itself
- decide in advance where should be the halo, where should be the core

Various situations



IFMIF accelerators



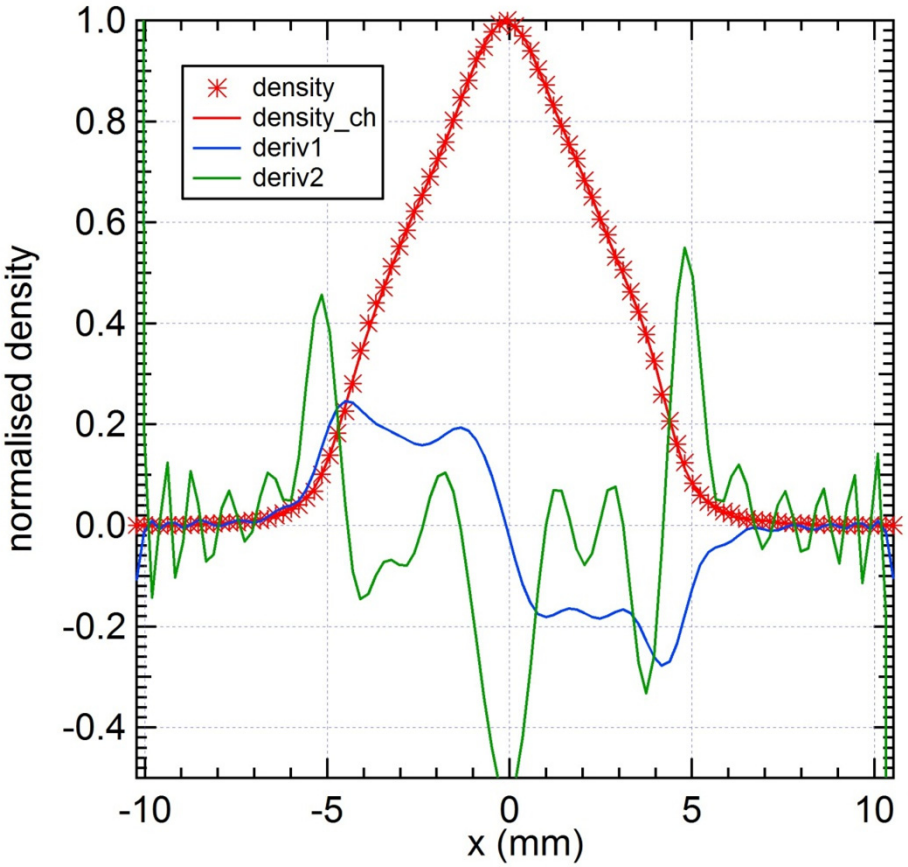
Physics of two "gas" of particles

For a gas of particles where there is a slowly varying density gradient, we can consider that this gas is composed of two different parts: when there exists a border between them
→ where the gradient variation is the steepest
→ where the second derivative of the density is maximum.

The diffusion equation
$dn/dt = D\Delta n$
states that the diffusion is maximum where the Laplacian of the density is maximum: this is the border between the two parts

1 dimension: max of the second derivative
n dimensions: max of the Laplacian

Example

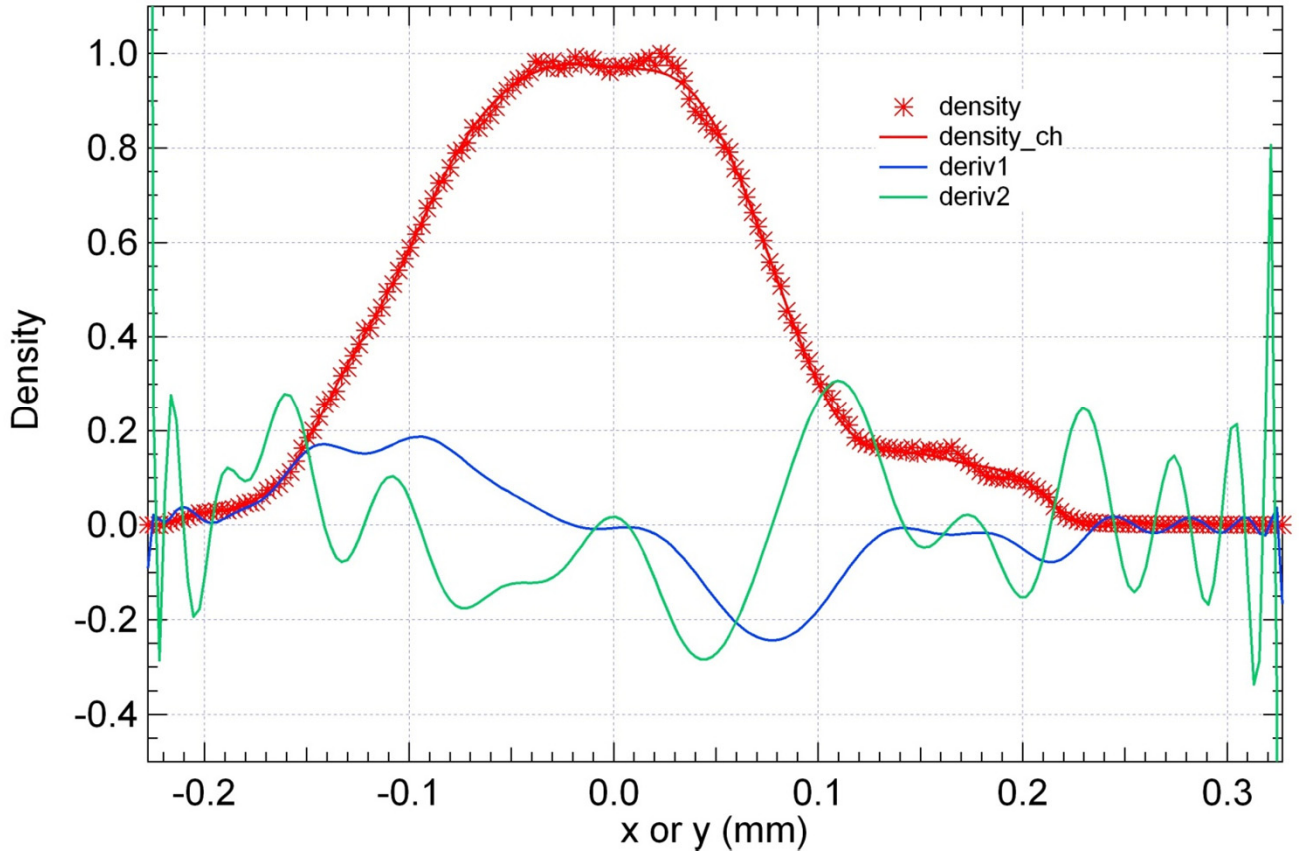


Once the limit core-halo is defined, the halo can be chracterised by

→ its size / whole size

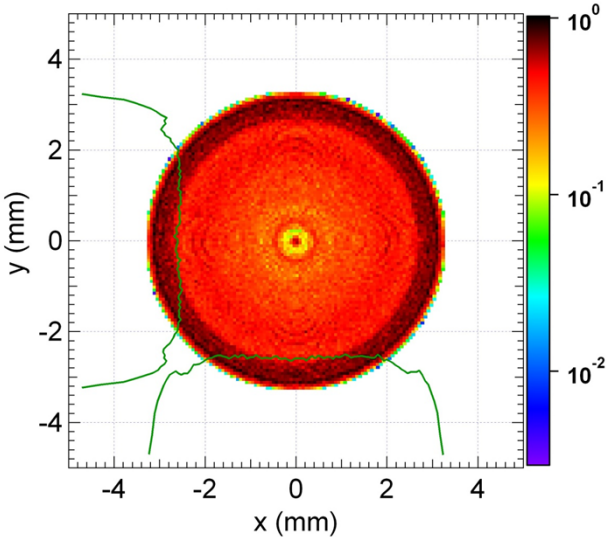
→ the number of particles within it / whole number of particles

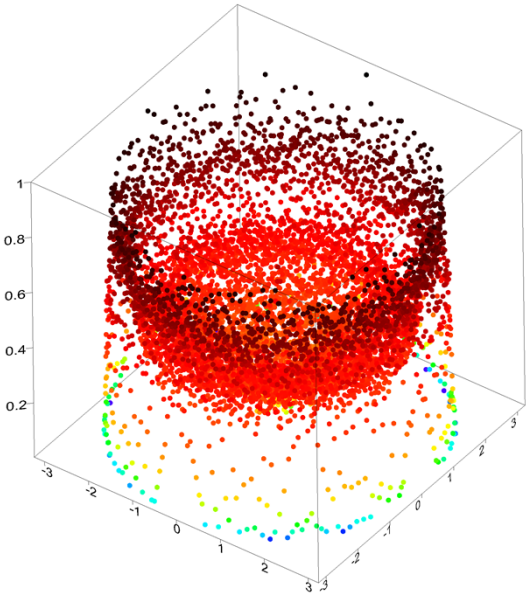
Example

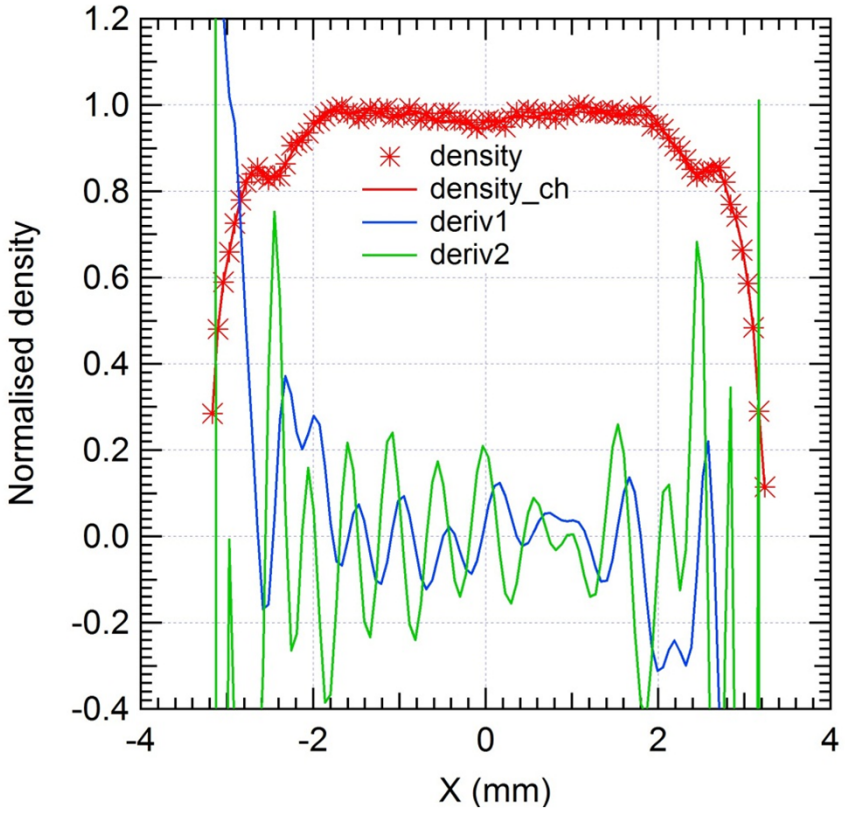


Caution: numerical derivative ! use Spline and Chebychev

Extraction output

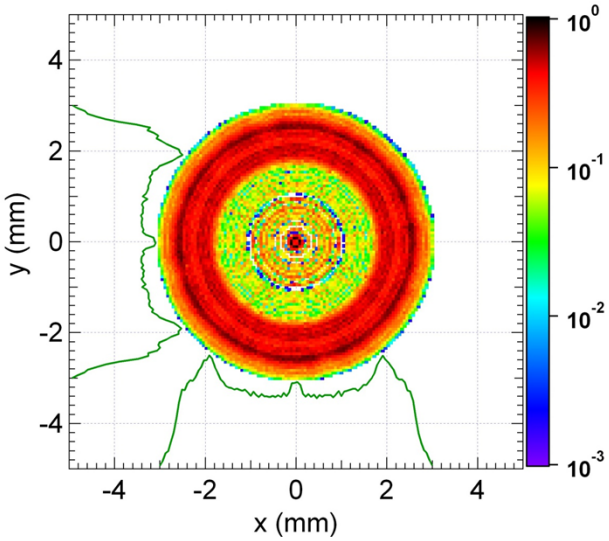


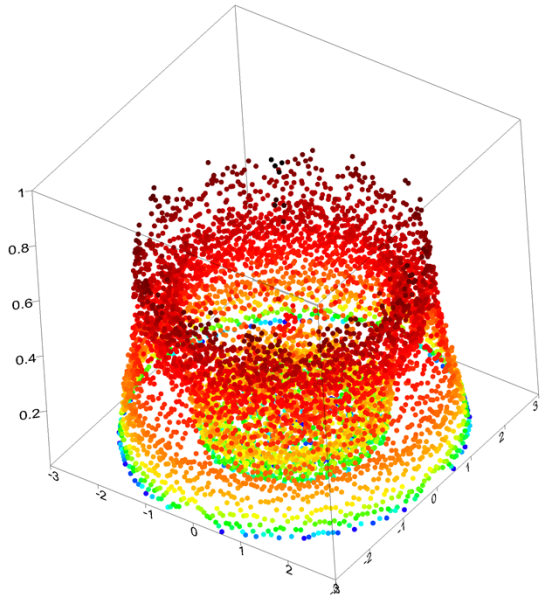


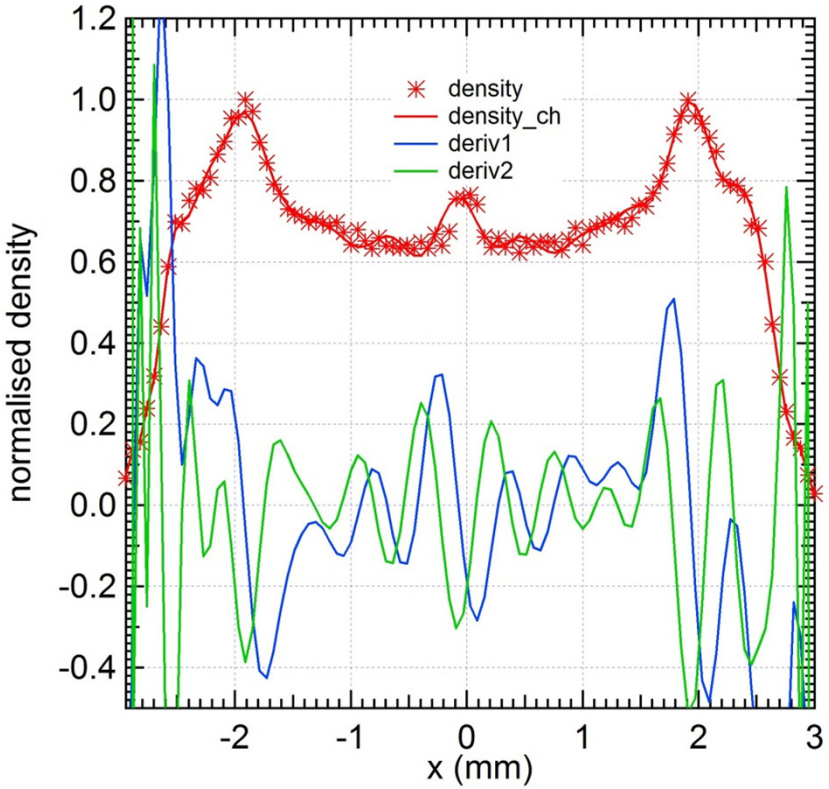


out LEBT-v1

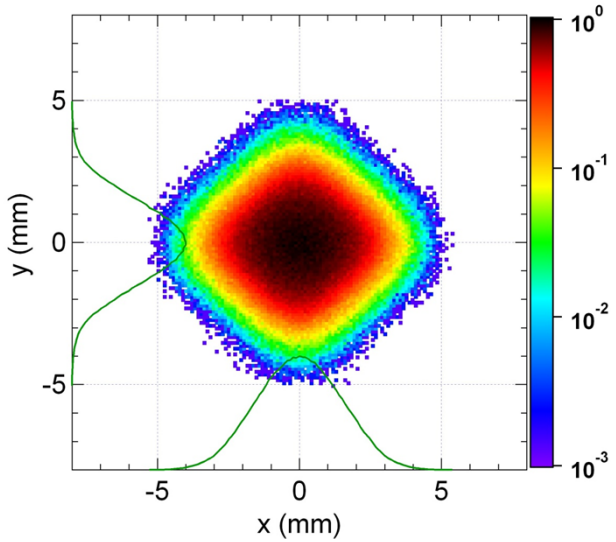
LEBT output

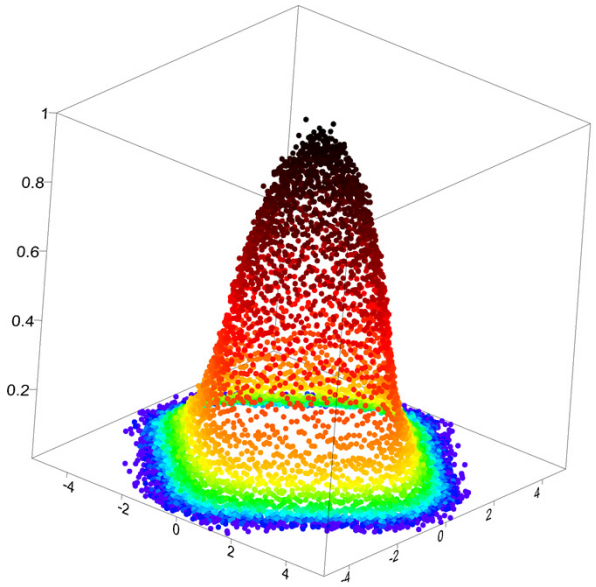


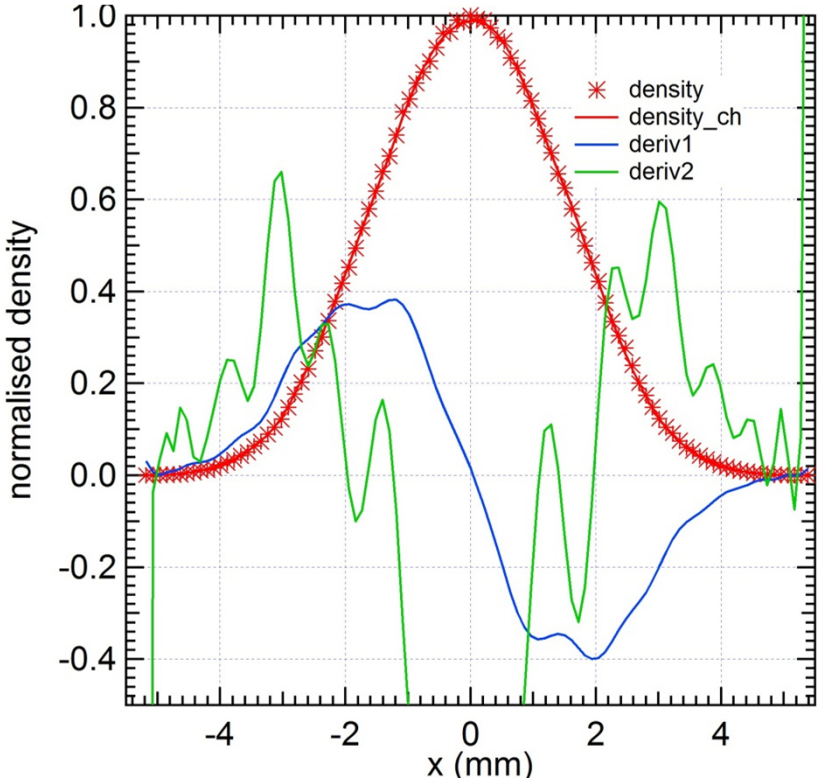




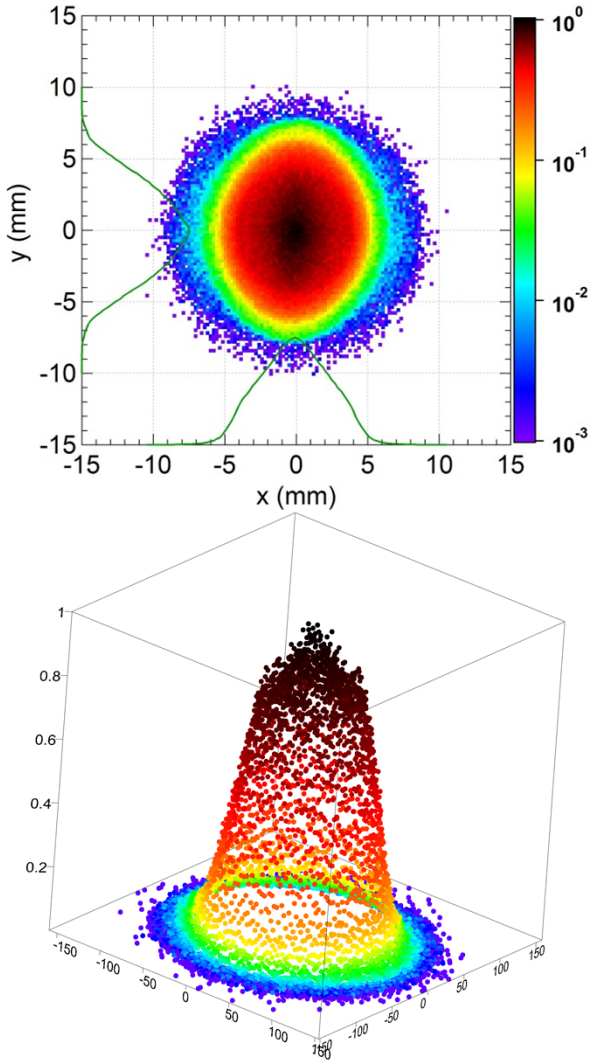
RFQ output

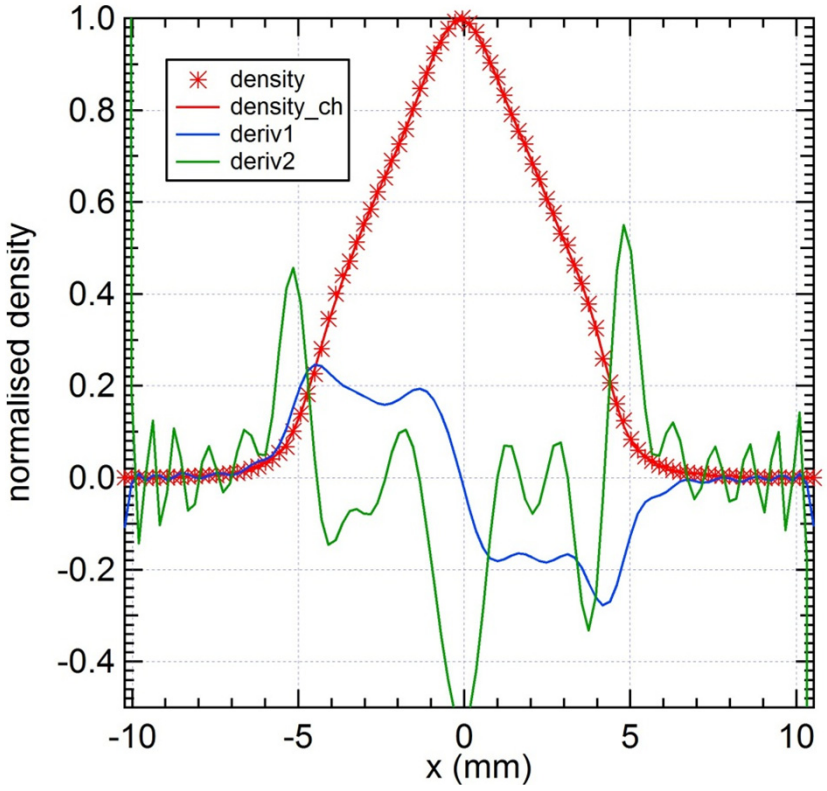

y (mm)
x (mm)
5
0
-5
-5
0
5
10^{0}
10^{-1}
10^{-2}
10^{-3}


1
0.8
0.6
0.4
0.2
-4
-2
0
2
4

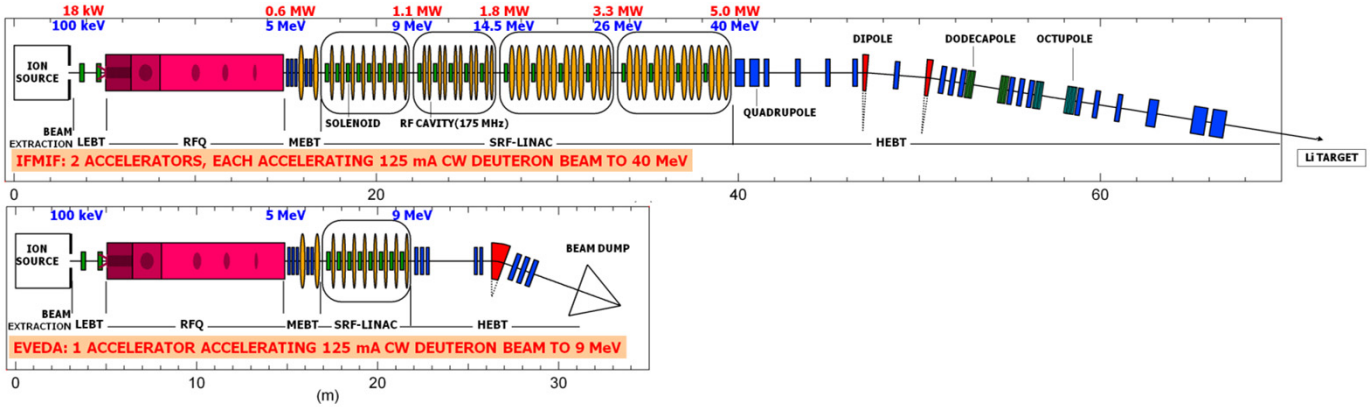

normalised density
x (mm)
density
density_ch
deriv1
deriv2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-4
-2
0
2
4

SRF Linac output (IFMIF LIPAc)





The context

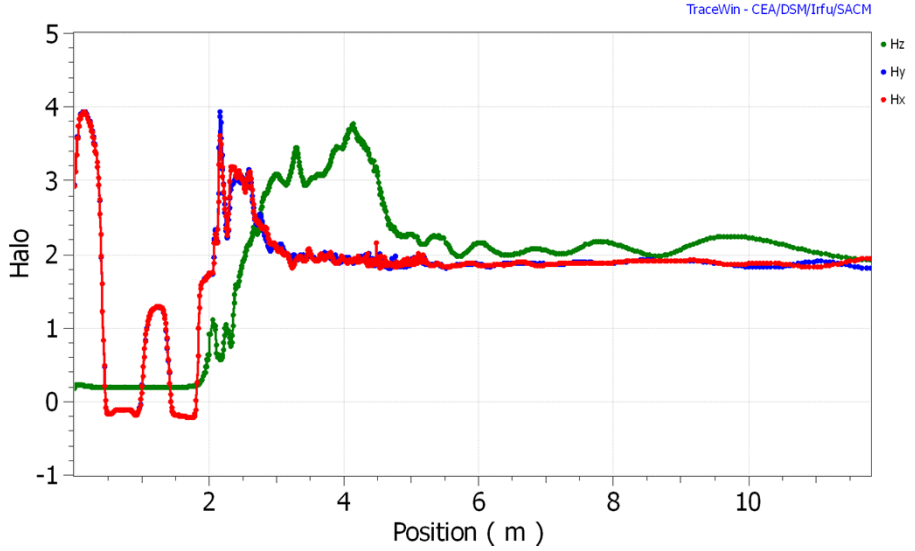


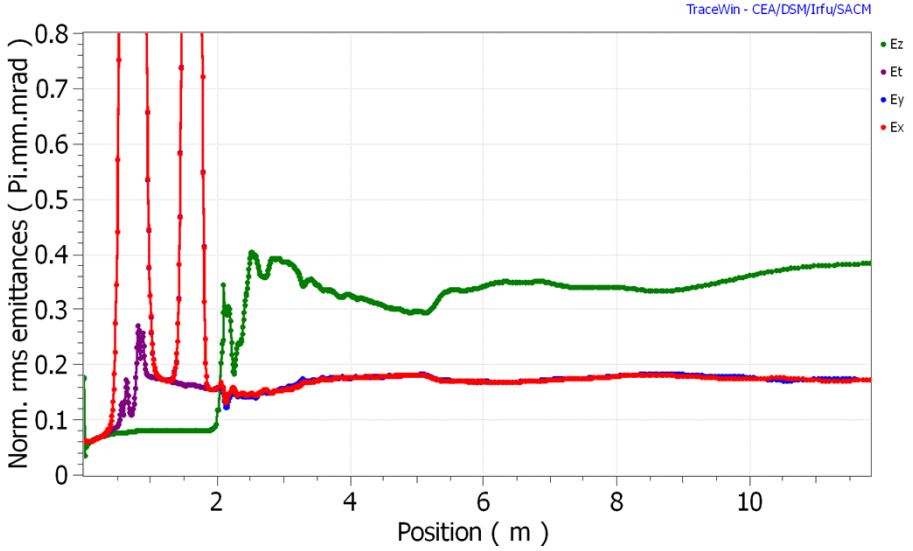
125 mA CW
9 MeV: 1.1 MW
40 MeV: 5 MW

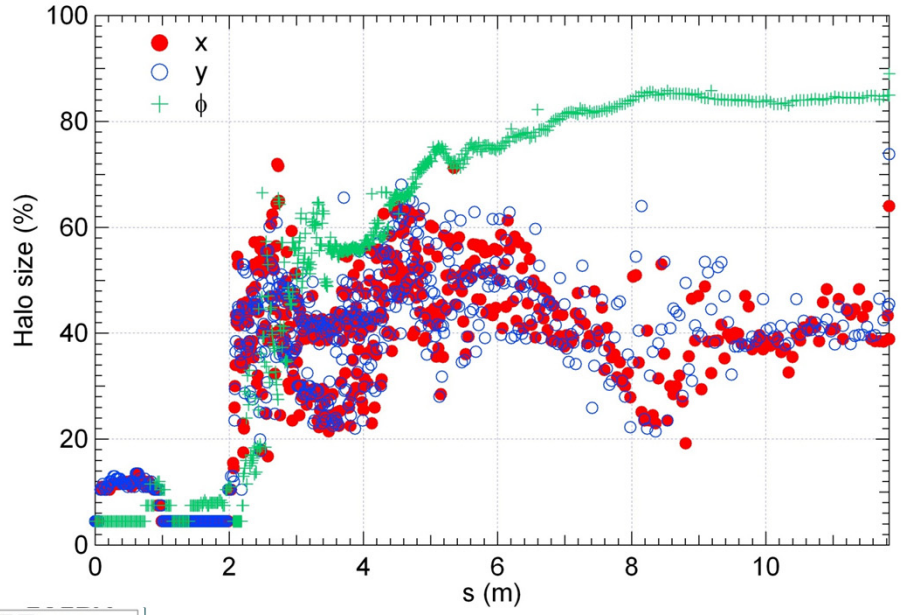
simultaneously

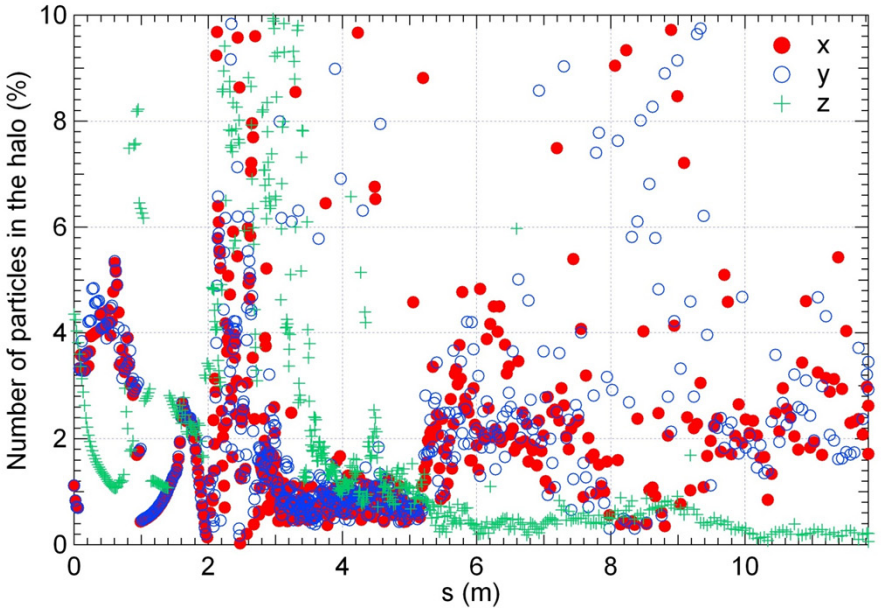
Very high space charge
Very high beam power

IFMIF LIPAc 1st part
LEBT - RFQ

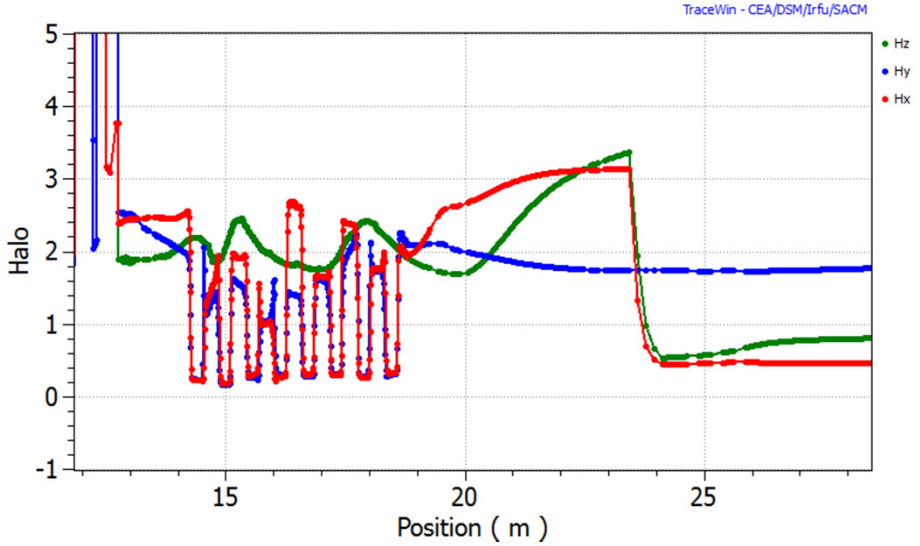


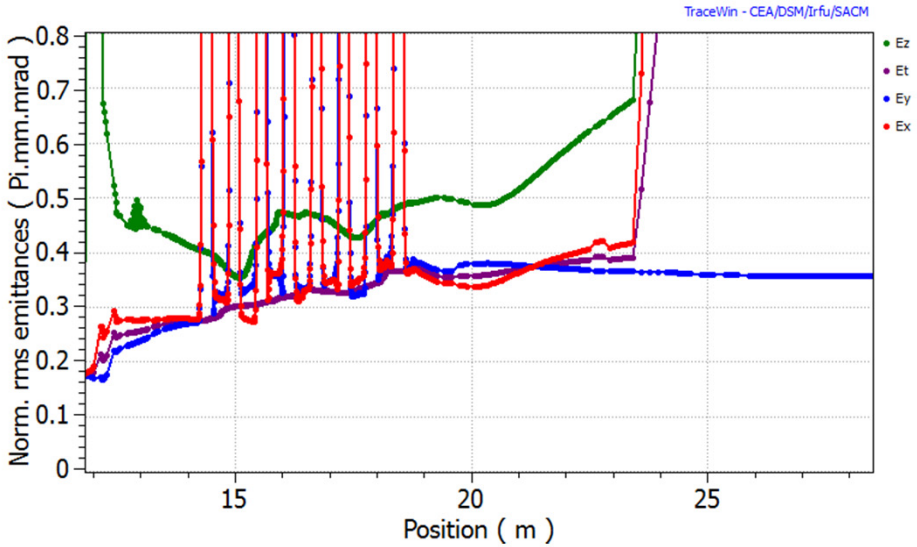


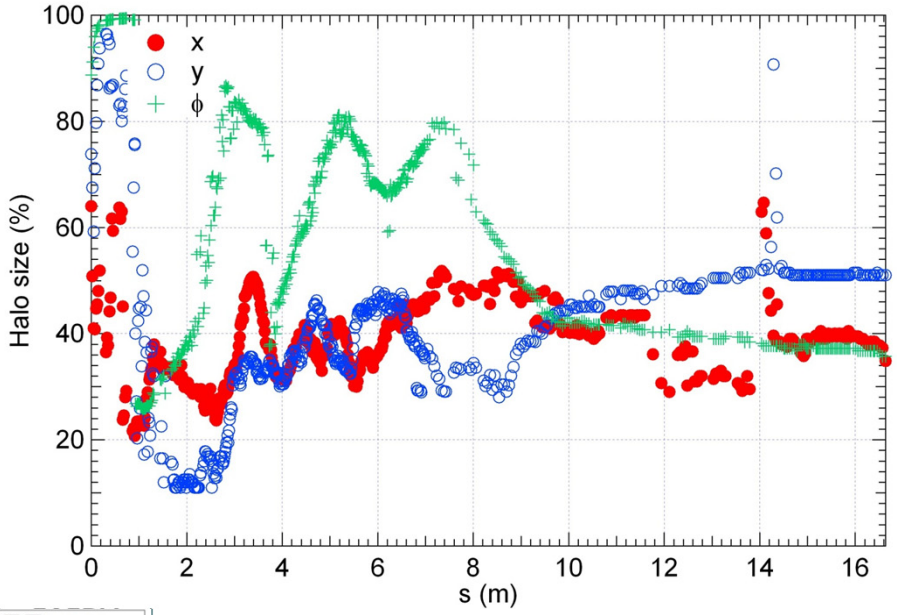


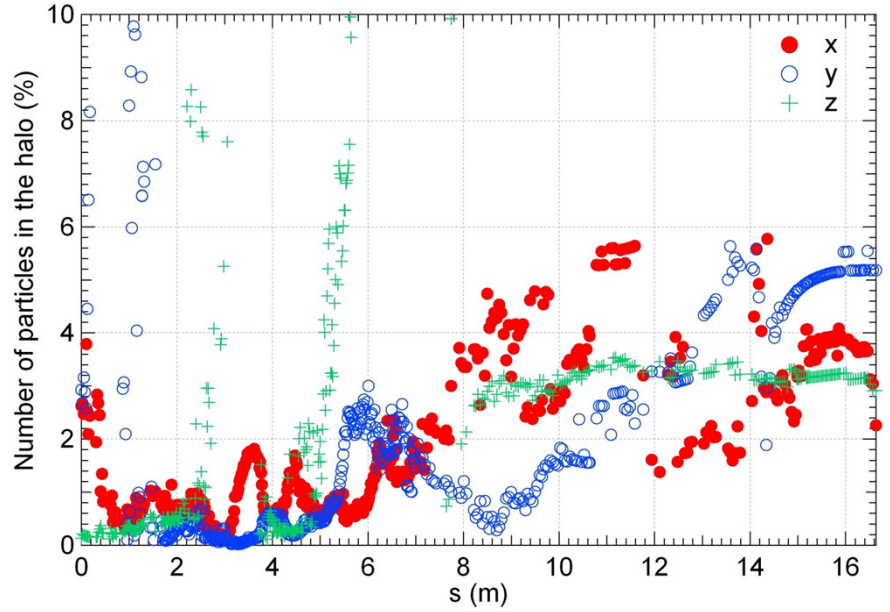


IFMIF LIPAc 2nd part
MEBT - SRF Linac - HEBT

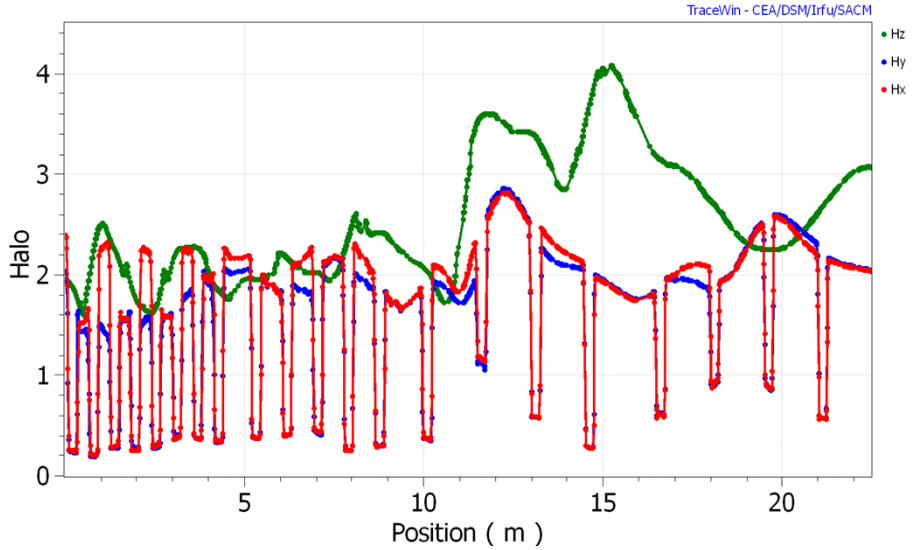


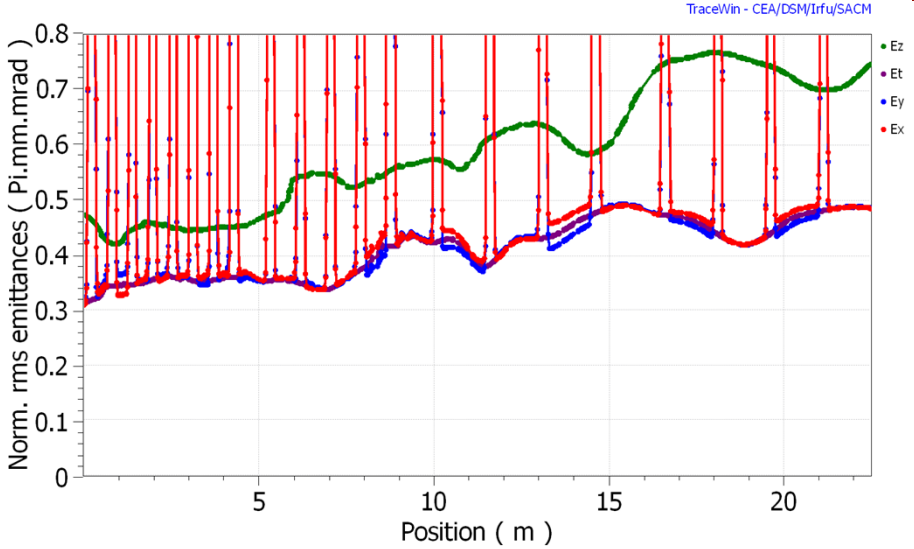


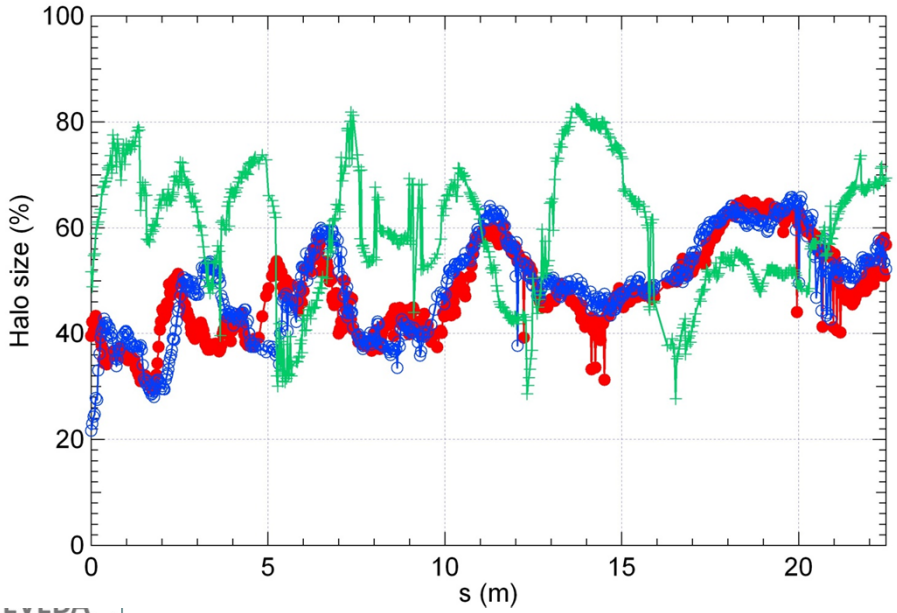


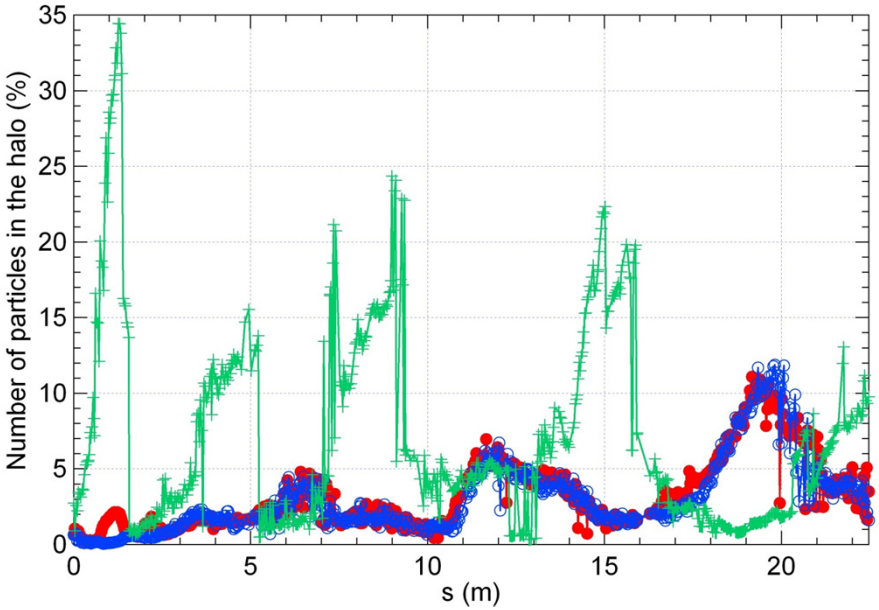


IFMIF- SRF Linac (case 1)

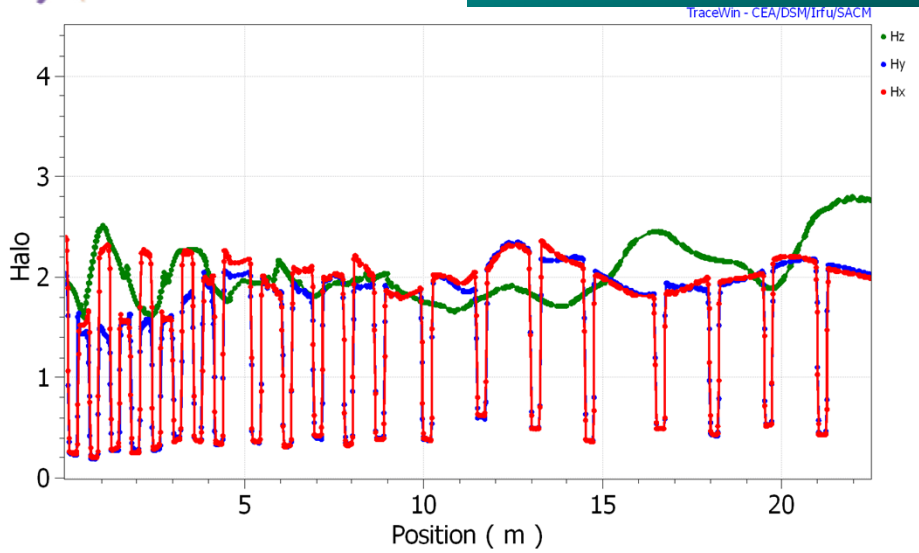


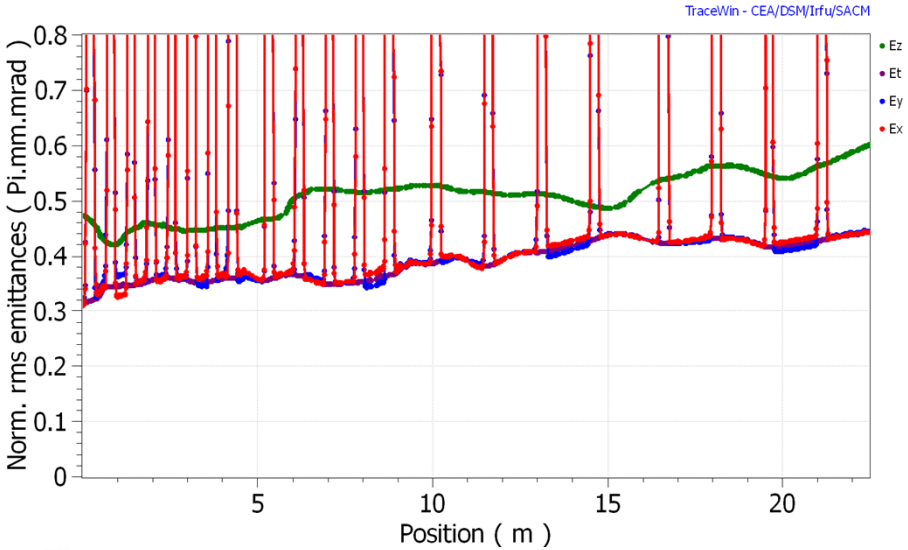


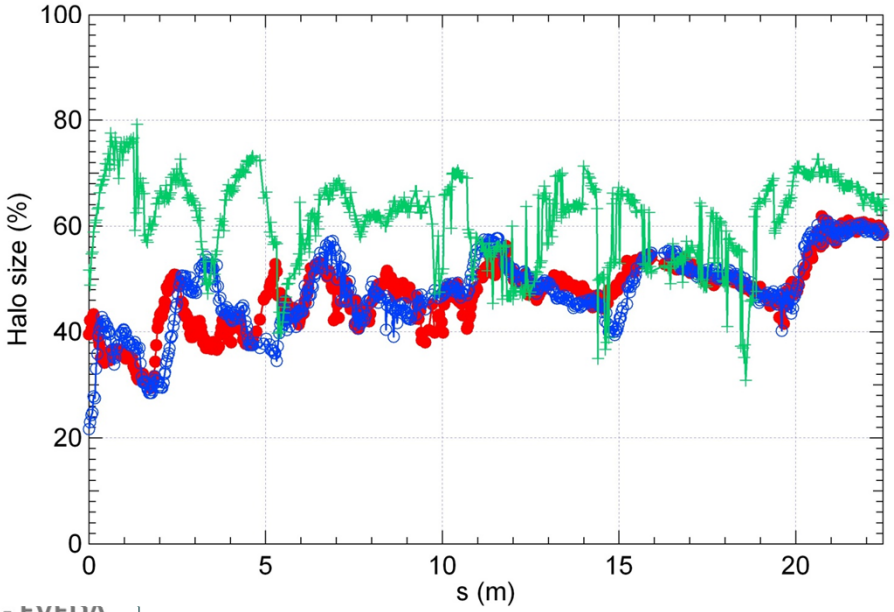


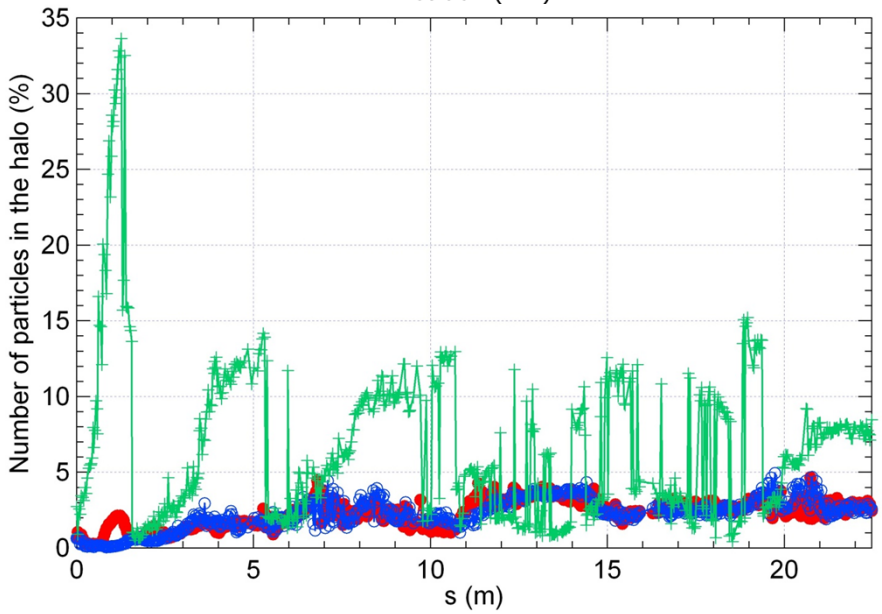


IFMIF- SRF Linac (case 2)









VERY FIRST conclusions

- Connections between Halo Parameter and Emittance are not clear
- Halo size (%) or/and NbrPart (%) seem to correspond to Emittance growth
- Even seem to be more detailed beam decscription, more pertinent than Emittance
- Noisy
- To be further explored…

DISCUSSION

- Other definitions of Halo ?
- Evidence of connections between Halo and Emittance ?
- …