EUROPEAN SPALLATION SOURCE

Accelerator Tuning and Beam Profile Measurements

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on behalf of WP2 Beam Physics

www.europeanspallationsource.se
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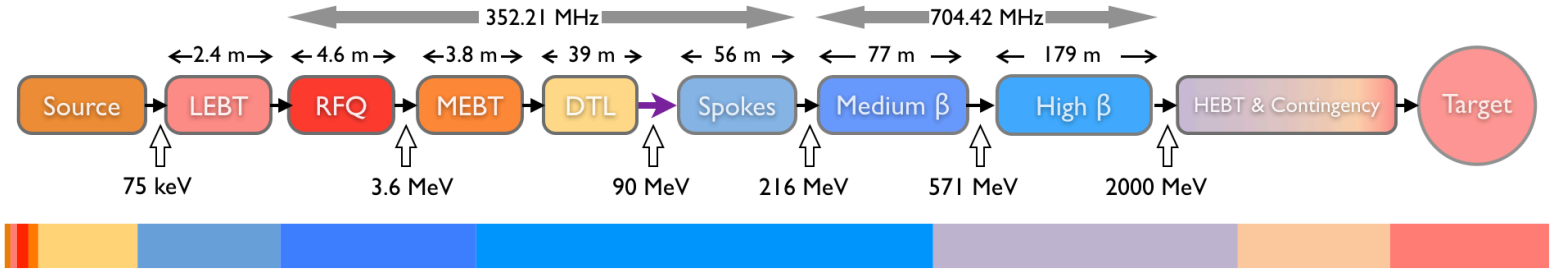
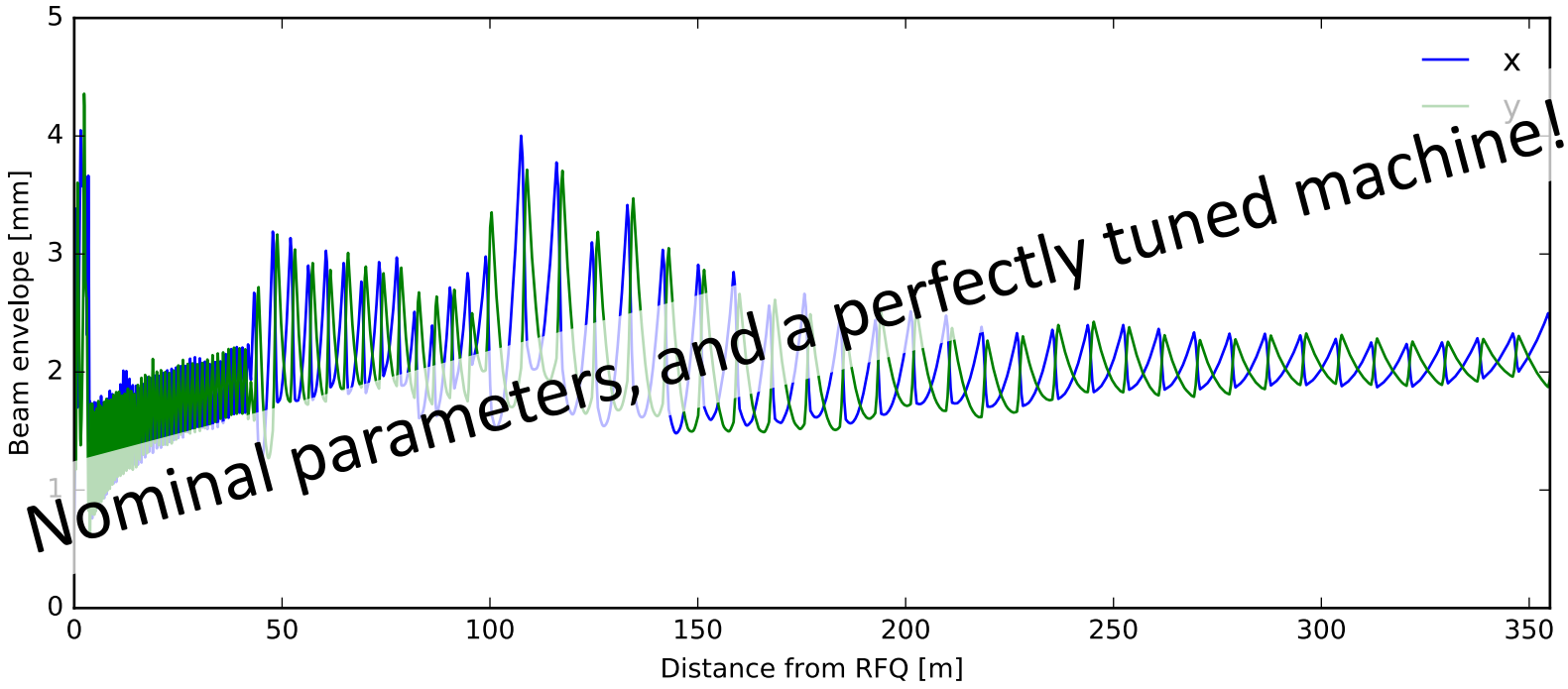
The ESS Linac

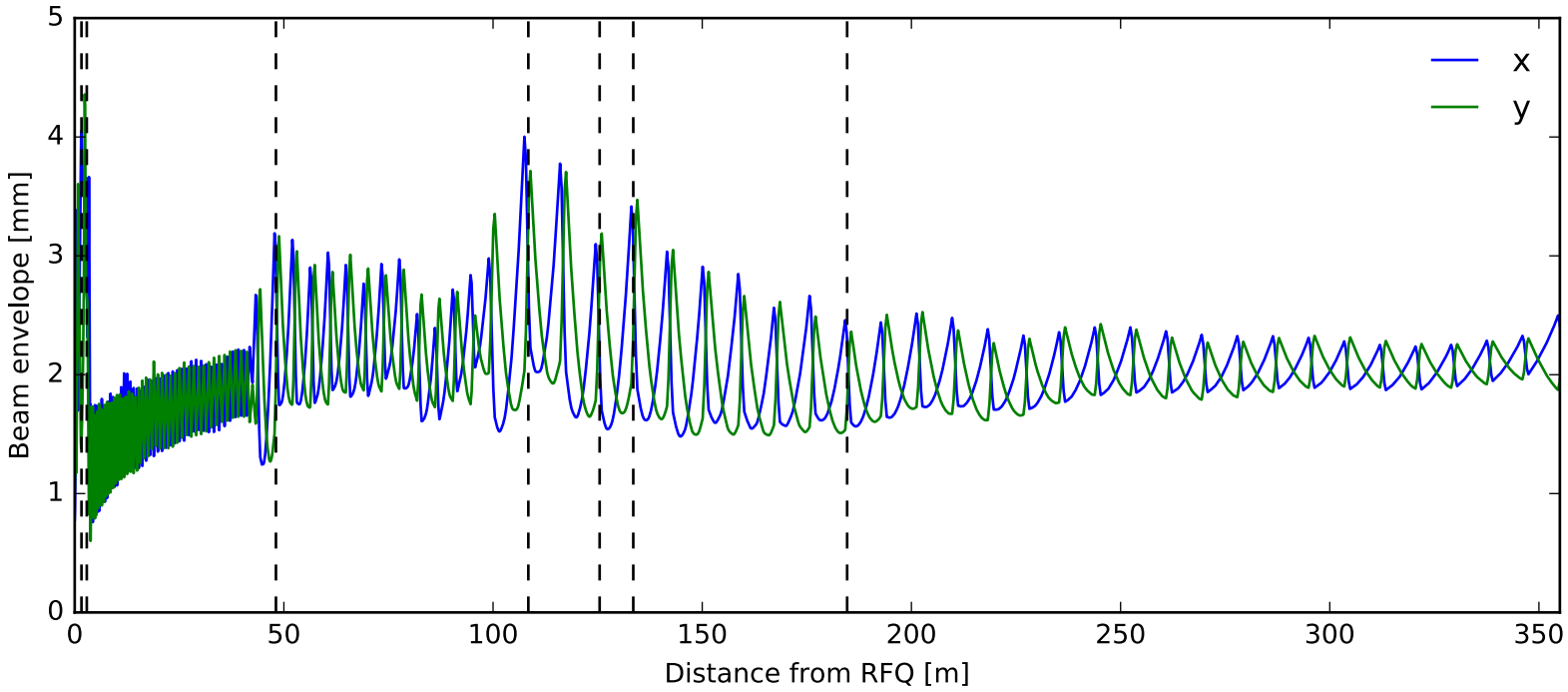


	Length (m)	# Magnets	# Cavs	# Sections	Power (kW)
LEBT	2,38	2 Solenoids	—	1	—
RFQ	4,6	—	1	1	1600
MEBT	3,98	11 Quads	3	1	15
DTL	38,9		5	5	2200
LEDP + Spoke	55,9	26 Quads	26	13	330
Medium Beta	76,7	18 Quads	36	9	870
High Beta	178,9	42 Quads	84	21	1100
Contingency + HEDP	130,4	32 Quads	—	15	—
DogLeg	66,2	12 Quads + 2 Dipoles	—	1	—
A2T	46,4	6 Quads + 8 Raster	—	1	

Beam physics – beam envelopes

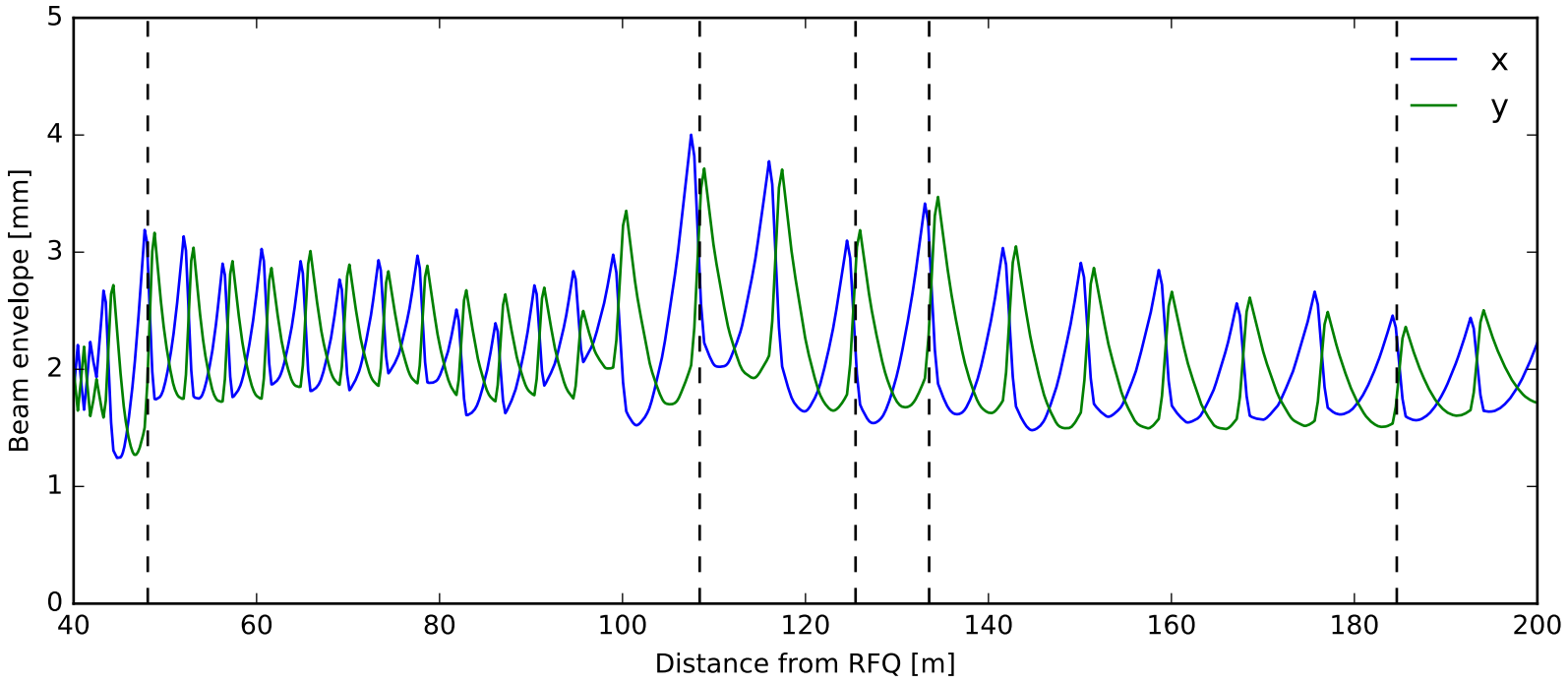


Beam physics – beam envelopes



NPM locations

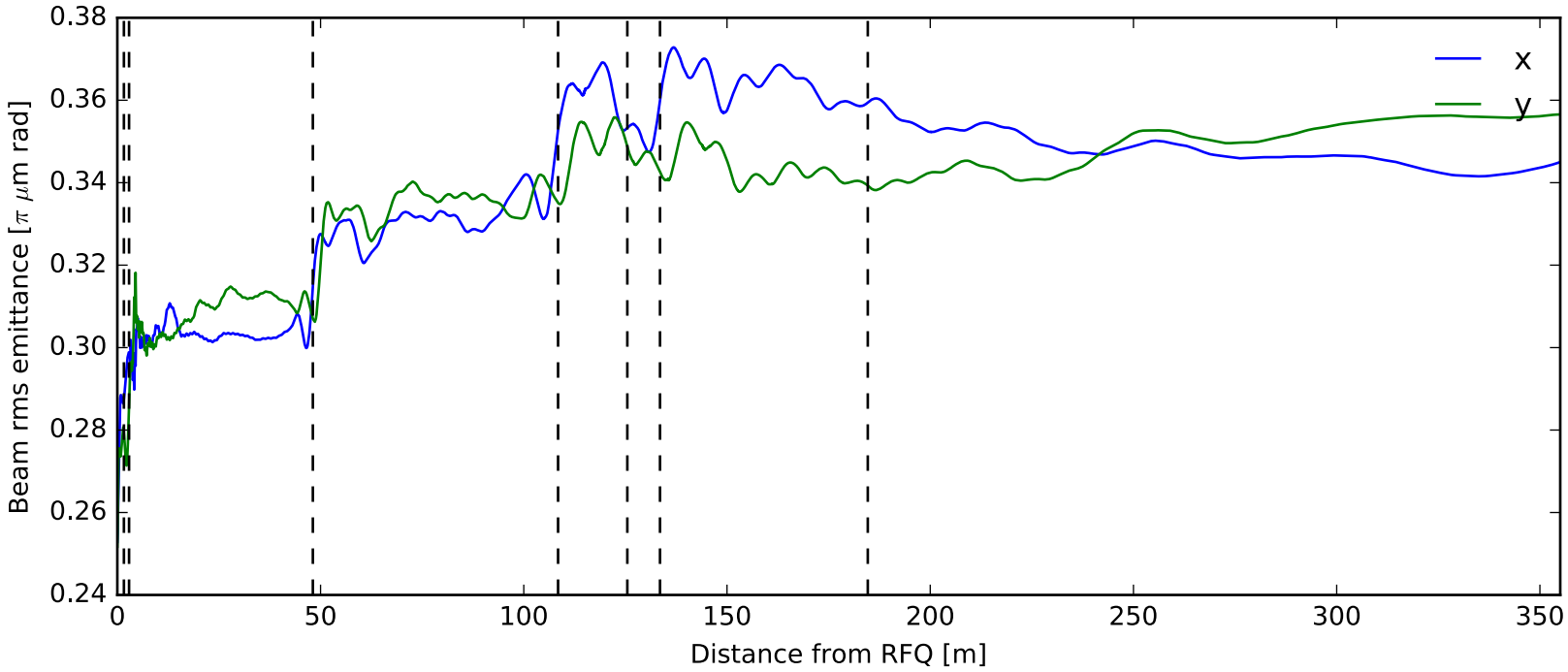
Beam physics – beam envelopes



NPM locations in cold linac

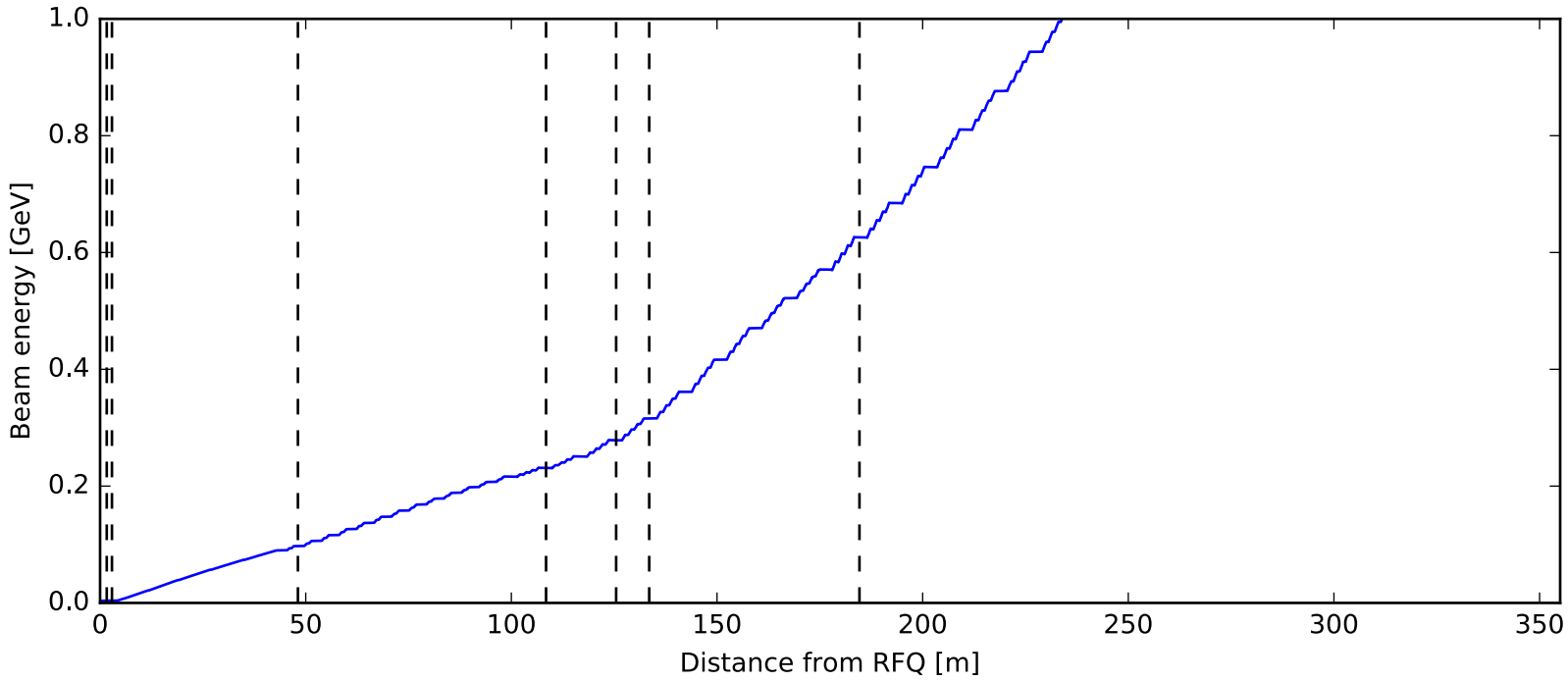
Beam physics – emittances

- Emittance growth limited to 10%/section -> 100% emittance growth total for linac
- Early commissioning will probably see emittance growth well beyond this



Beam physics – beam energy

- Note that before RF tuning, beam will not accelerate
  -> this is **max** energy at NPM location



Beam physics – transverse distributions

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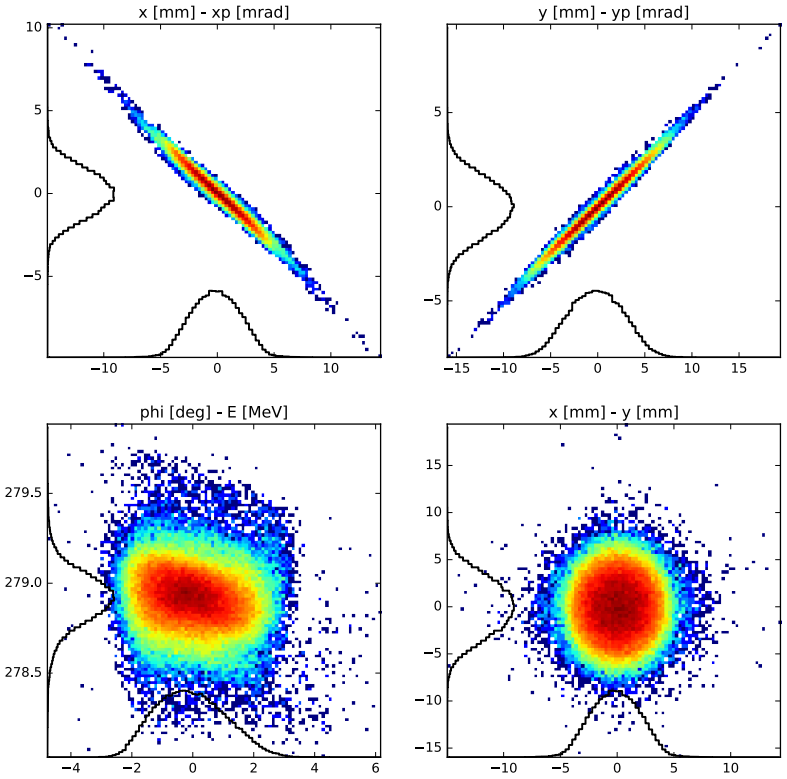
Transverse distribution – MB #2



Requirements

- Proton beam instrumentation shall function over a peak beam current range of 3 mA to 70 mA
- Proton beam instrumentation shall function over a proton beam pulse length range of 5 µs to 2.980 ms
- Unless specifically stated, all instrumentation shall be able to perform the measurements and report the relevant PV data at a repetition rate of 14 Hz
- The transverse beam profile shall be measured with a total measurement error in the RMS extension of the beam of less than ±10%
- The transverse beam profile shall be measured with a total measurement error in the 95% extension of the beam of less than ±10%
- The transverse beam profile measurement shall have a dynamic range of 1000

Requirements

A few more items which (to my knowledge) are not yet in Doors, but we understand them as already considered.

- A beam profile measurement is provided from both transverse planes
- The transverse beam profile shall be measured over a minimum range of +/- NN nominal beam sigma from the theoretical beam axis, or a minimum of NN % of the physical aperture

Beam Commissioning – rough steps

1. Thread the probe beam through to (intermediate) dump
2. Align trajectory
3. Match transversal optics, RF phase&amplitude scan, iterate..
4. Watch carefully for any changes while pulse length and repetition rate is increased towards the full beam power

Where NPM's may be useful

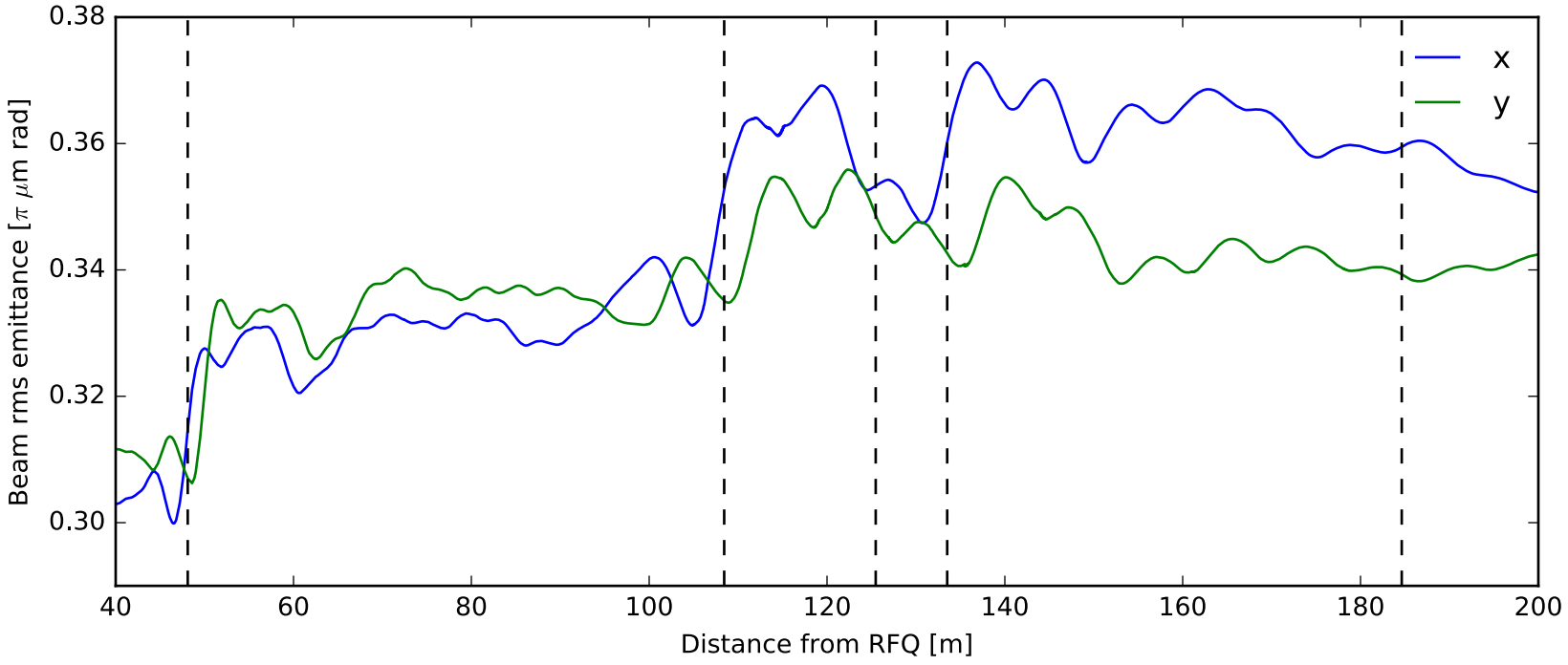
- When beam power is too high for wire scanners, either directly (damage wire) or indirectly (inducing too high losses)
- Monitoring pulse stability
- Beam position measurement (LEBT in particular)
- As a complementary confirmation of other profile measurements
- As a backup instrument (e.g. broken wire)

.. as I see it

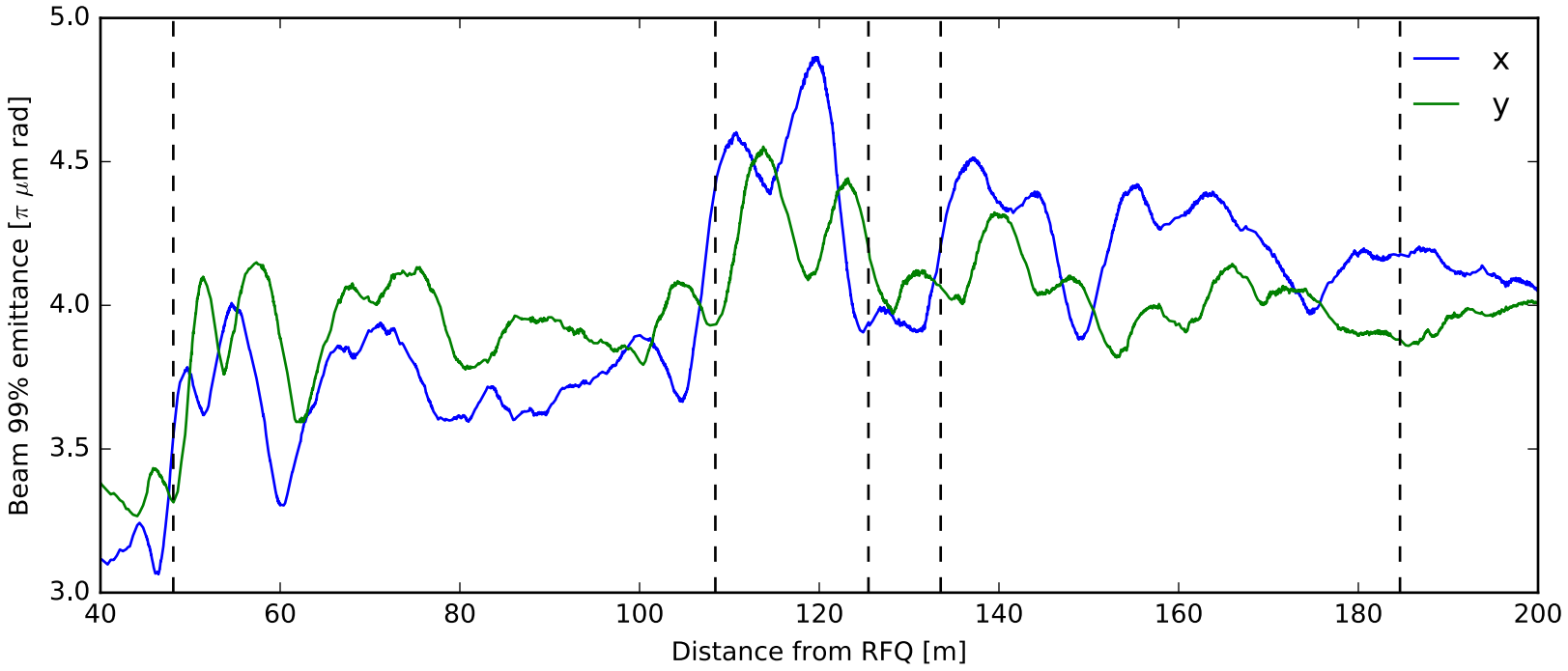
We sincerely hope the NPM's will help us

make the ESS beam great again!

Backup

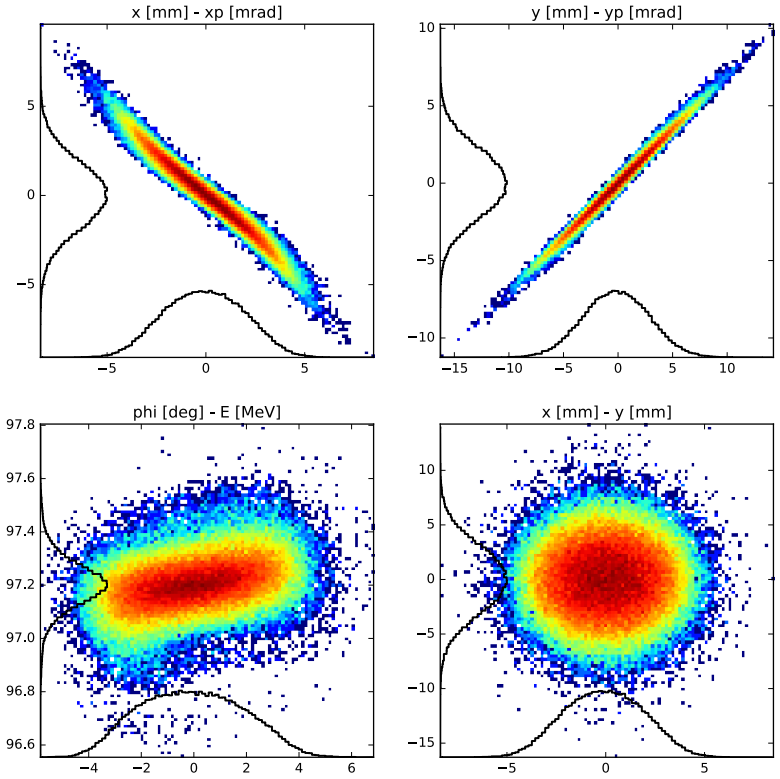

0.38
0.36
0.34
0.32
0.30
Beam rms emittance [π μm rad]
40
60
80
100
120
140
160
180
200
Distance from RFQ [m]
x
y

Backup


5.0
4.5
4.0
3.5
3.0
Beam 99% emittance [π μm rad]
40
60
80
100
120
140
160
180
200
Distance from RFQ [m]
x
y

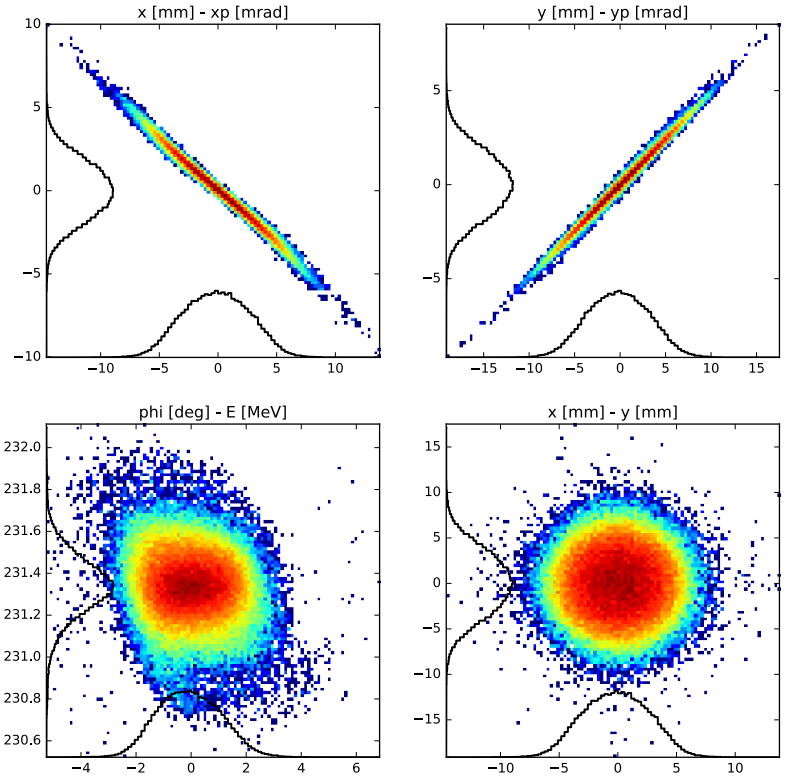
Backup

Transverse distribution – Spoke #1



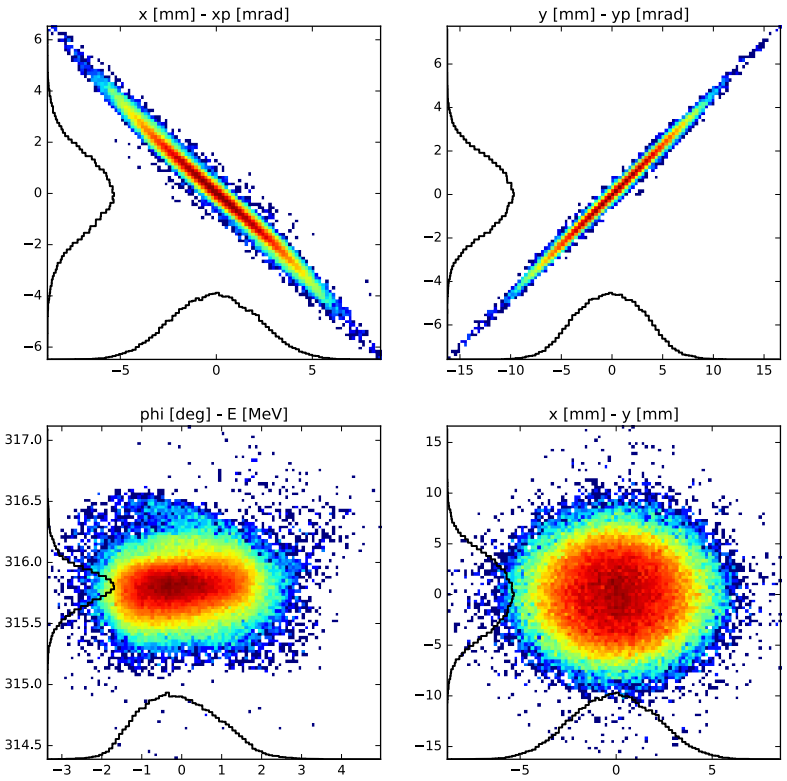
Backup

Transverse distribution – MB #1



Backup

Transverse distribution – MB #3



Backup

Transverse distribution – HB #1