ESS LINAC FOR ESSNUSB

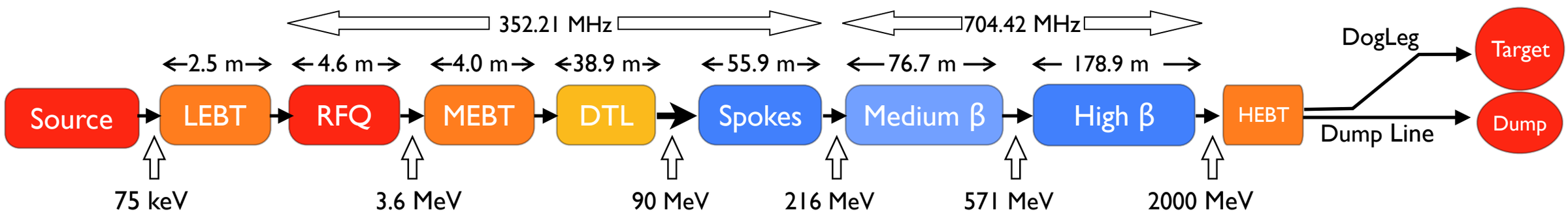
Mamad Eshraqi
for the linac team

2018 Nov 07
ESSnuSB annual meeting

Strasbourg, France

ESSnuSB has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777419.

THE ESS LINAC

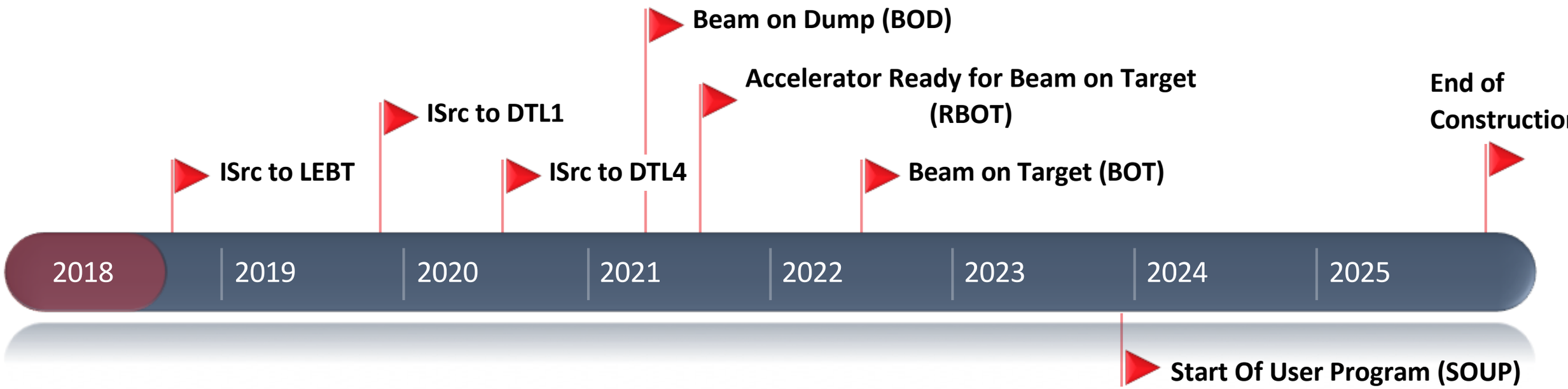


	Length	No. Sections	No. Magnet	#Cav x $\beta_{g/(Opt)}$	Power (kW)	IK partner
LEBT (from Plasma)	2.7	1	2 Solenoids	—	—	INFN-LNS
RFQ	4.5	1	—	1	1600	CEA Saclay
MEBT	4.0	1	11 Quads	3	15	ESS-Bilbao
DTL	38.9	5	PMQs	5	2200	INFN-LNL
LEDP + Spoke	55.9	13	26 Quads	26 x (0.50)	330	IPNO
Medium Beta	76.7	9	18 Quads	36 x 0.67	870	LASA / CEA
High Beta I (~1.3 GeV)	93.7	11	22 Quads	44 x 0.86	1100	STFC / CEA
High Beta II	85.2	10	20 Quads	40 x 0.86	1100	STFC / CEA
Contingency + HEDP	132.3	15	32 Quads	—	—	Elettra
DogLeg	64.4	1	12 Quads + 2	—	—	Elettra
A2T	44.7	1	6 Quads + 8	—		Aarhus Uni
	603.0					

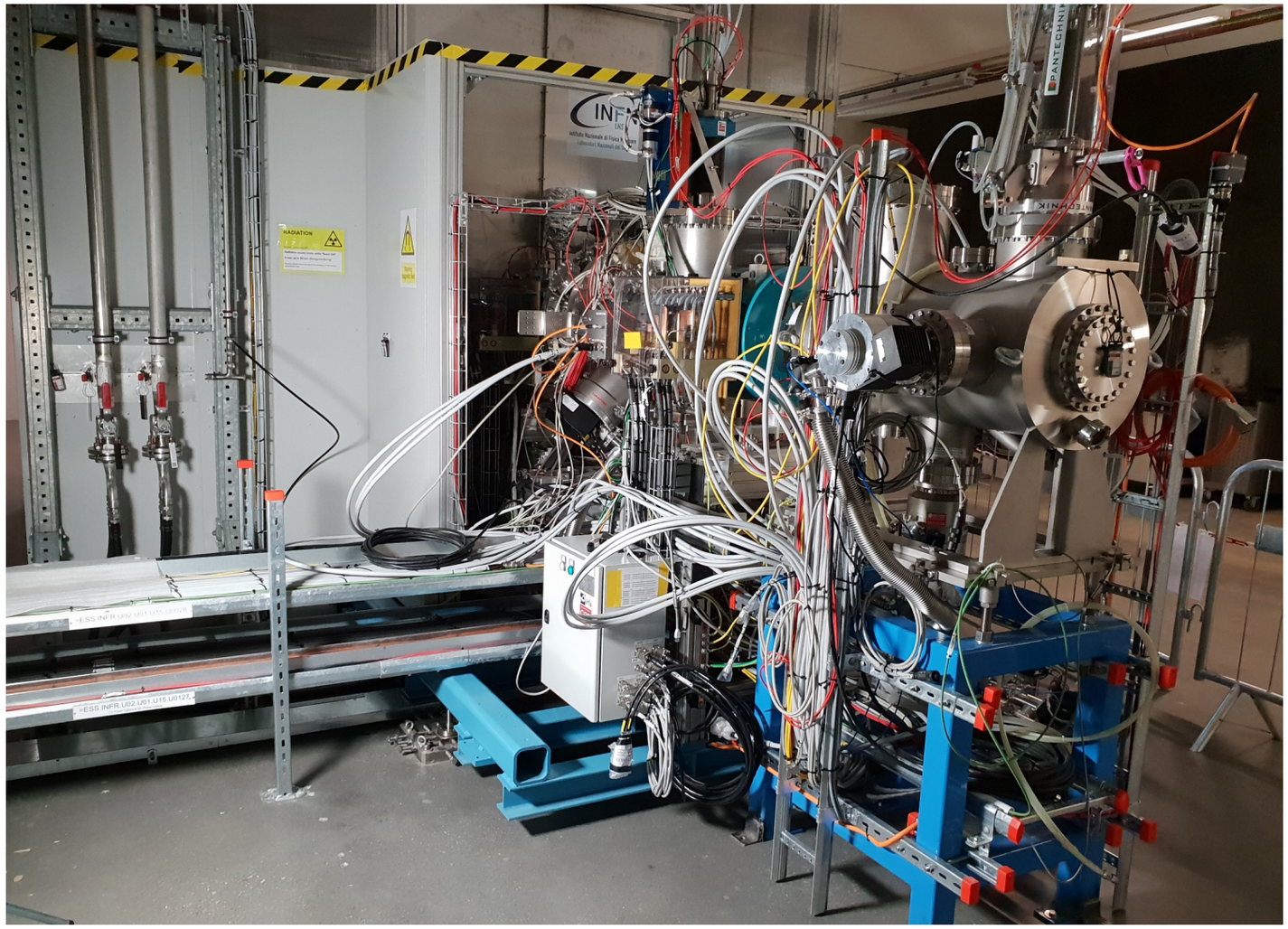

2018 Aug 06

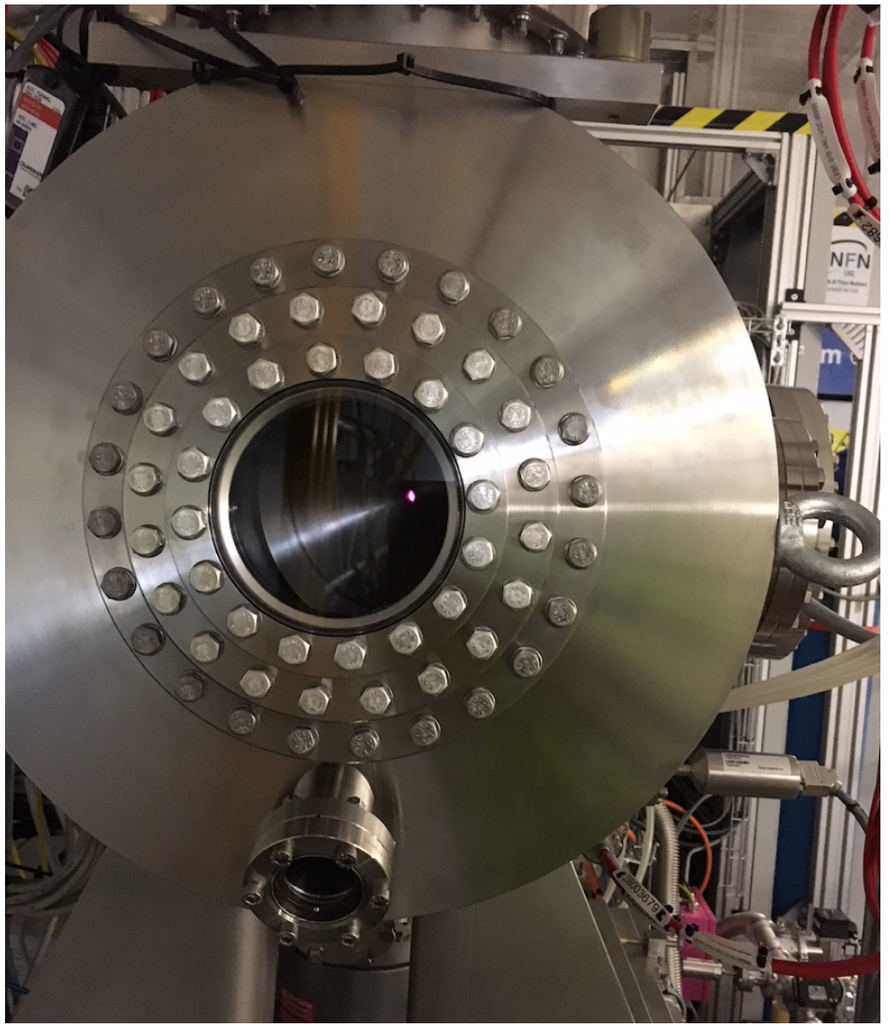
. . . some time in the future

THE BIG PICTURE



First Plasma at ESS





RF; Team, Gallery, Installations

TARGET

WP03 (LINAC) TEAM

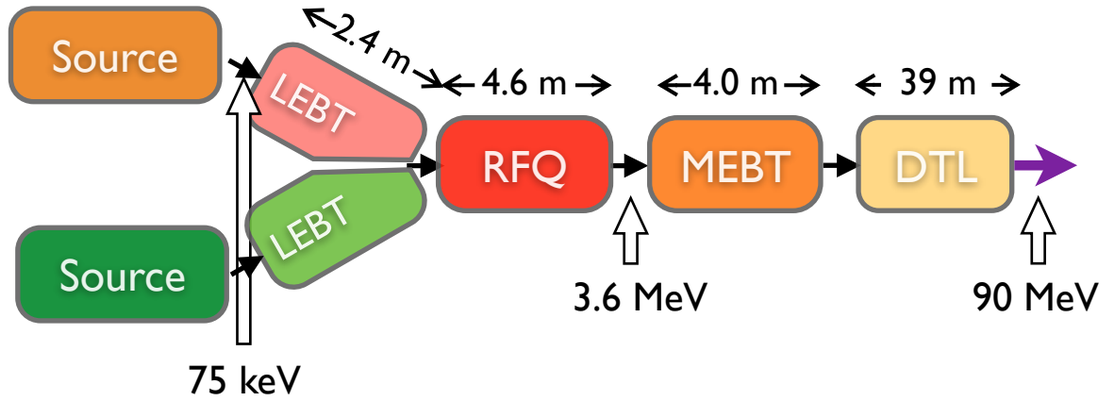
- Mamad Eshraqi (ESS)
  - WP leader
- Roger Ruber (Uppsala University)
  - Deputy WP leader
- Björn Gålnander (ESS)
  - Accelerator physicist
- Aaron Farricker (CERN)
  - Accelerator physicist
- Open Recruitment (ESS)
  - PostDoc
- Colleagues at ESS and UU

Required Changes in the Linac

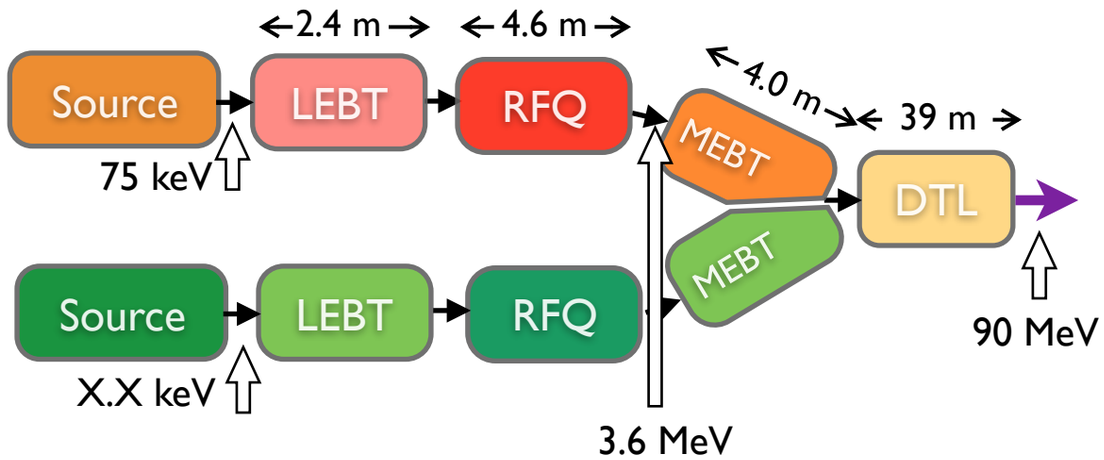
	IS+LEBT	RFQ	MEBT	DTL	Spoke	Medium beta	High beta	High beta+
New device	New	~New	~New	—	—	—	—	New
Cooling	—	Additional	Additional	Additional	Additional	Additional	Additional	
Tunnel	Device capacity / pipes / temperature				Cryo-line/Cryomodule/Coupler/Waveguide			
Gallery	Cooling skids / Klystron cooling / pipes				Klystron cooling / pipes / skids?			New
RF	—	Additional	Additional	Additional	Additional	Additional	Additional	
		Klystron	Amplifier	Klystron	Tubes / LLRF			Klystron
		Modulator	PC	Modulator	Modulator / Power converters			Modulator
Cryo	—	—	—	—	Additional	Additional	Additional	
					Cryoline / Cryo plant			
Magnets	Partially	—	Partially	—	Corrector			

H⁻ Source and LEBT

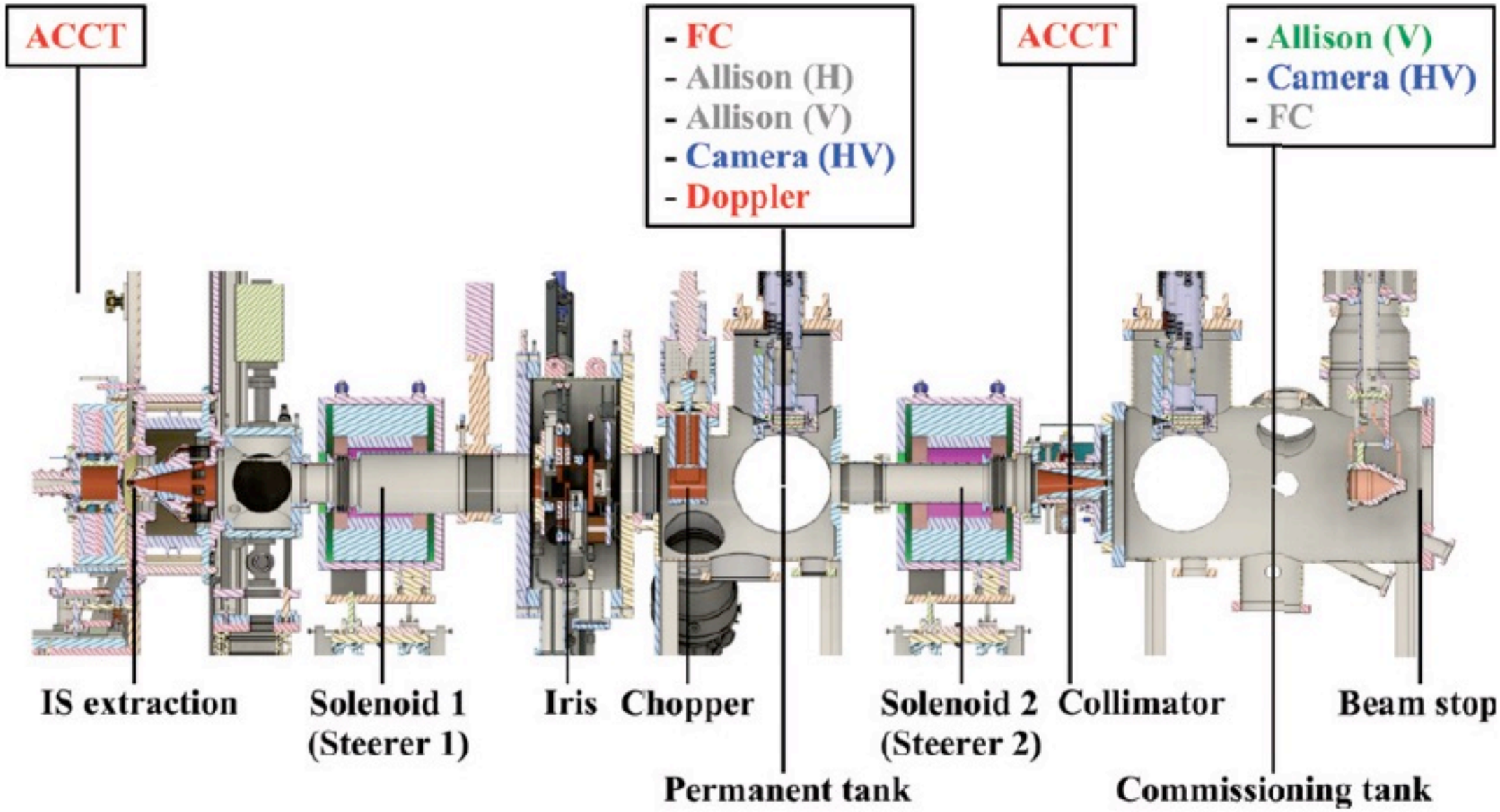
- A new H- source is needed for the production of high intensity H- beam.
  - The new source will be at the same energy as the proton source, this would require the two beams to be merged in the LEBT, same RFQ and a modified MEBT will be used



  - The new source could have a different energy from the proton source, a new RFQ and MEBT are needed and the two beams will be merged in the MEBT

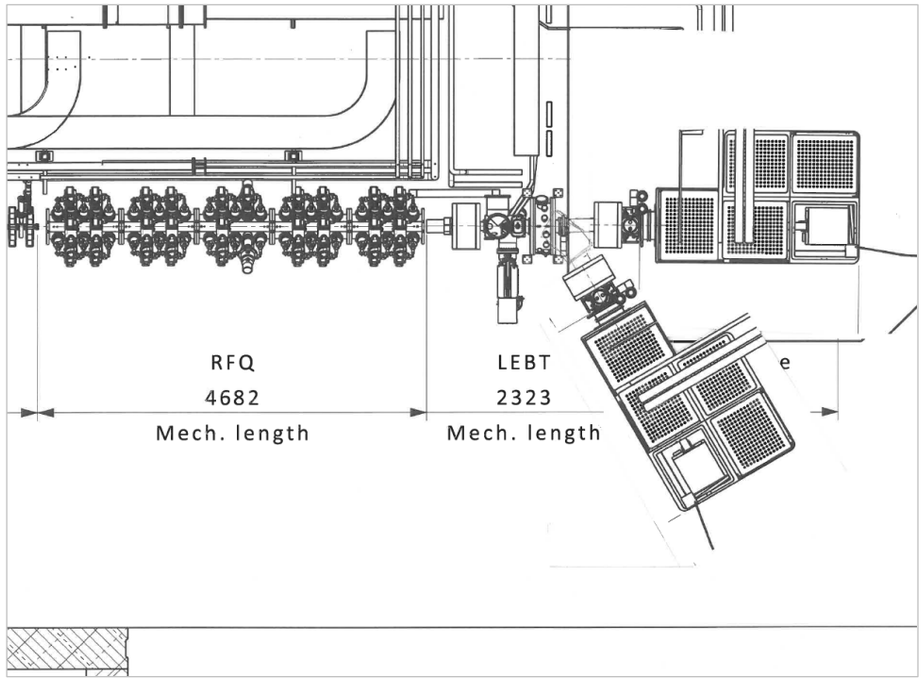


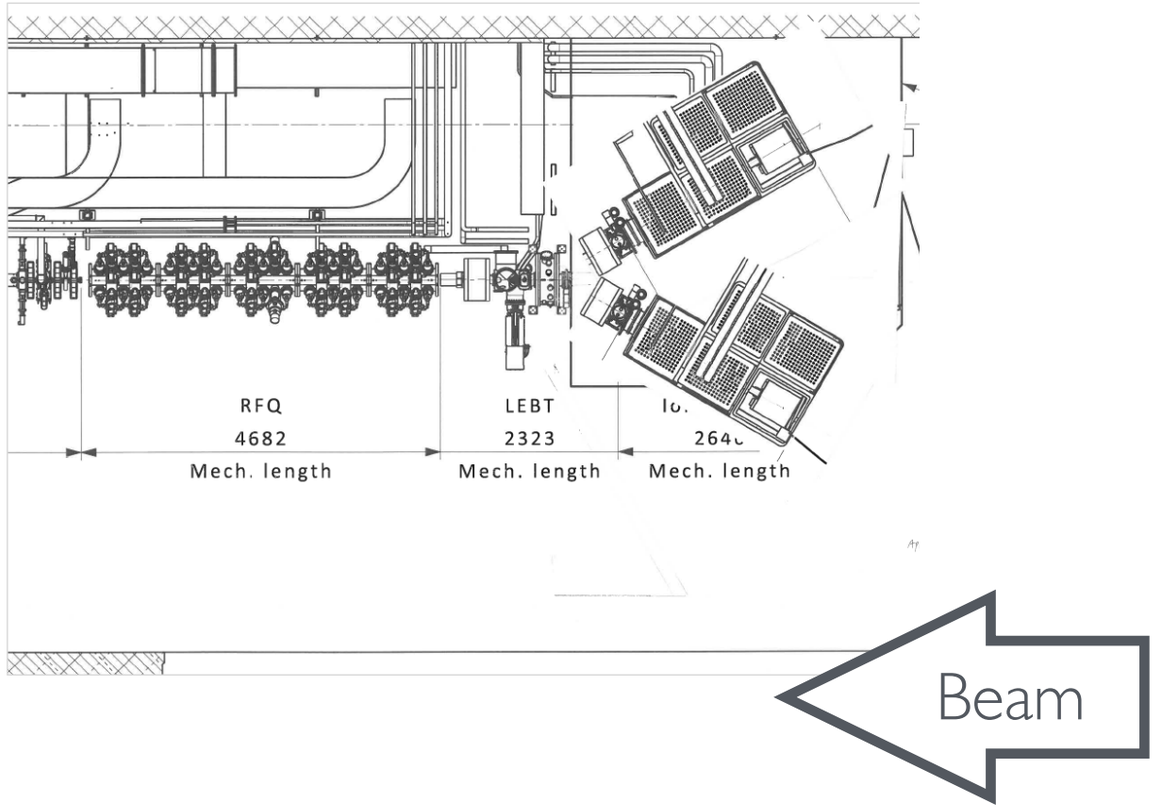
ESS LEBT



R. Miyamoto et al. IPAC 2018

PRELIMINARY LAYOUTS





- The +60° layout requires a pulsed dipole for merging the beam
  - The proton source is less affected

- The ±30° layout requires a DC dipole for merging the beam
  - Proton source and beam are affected

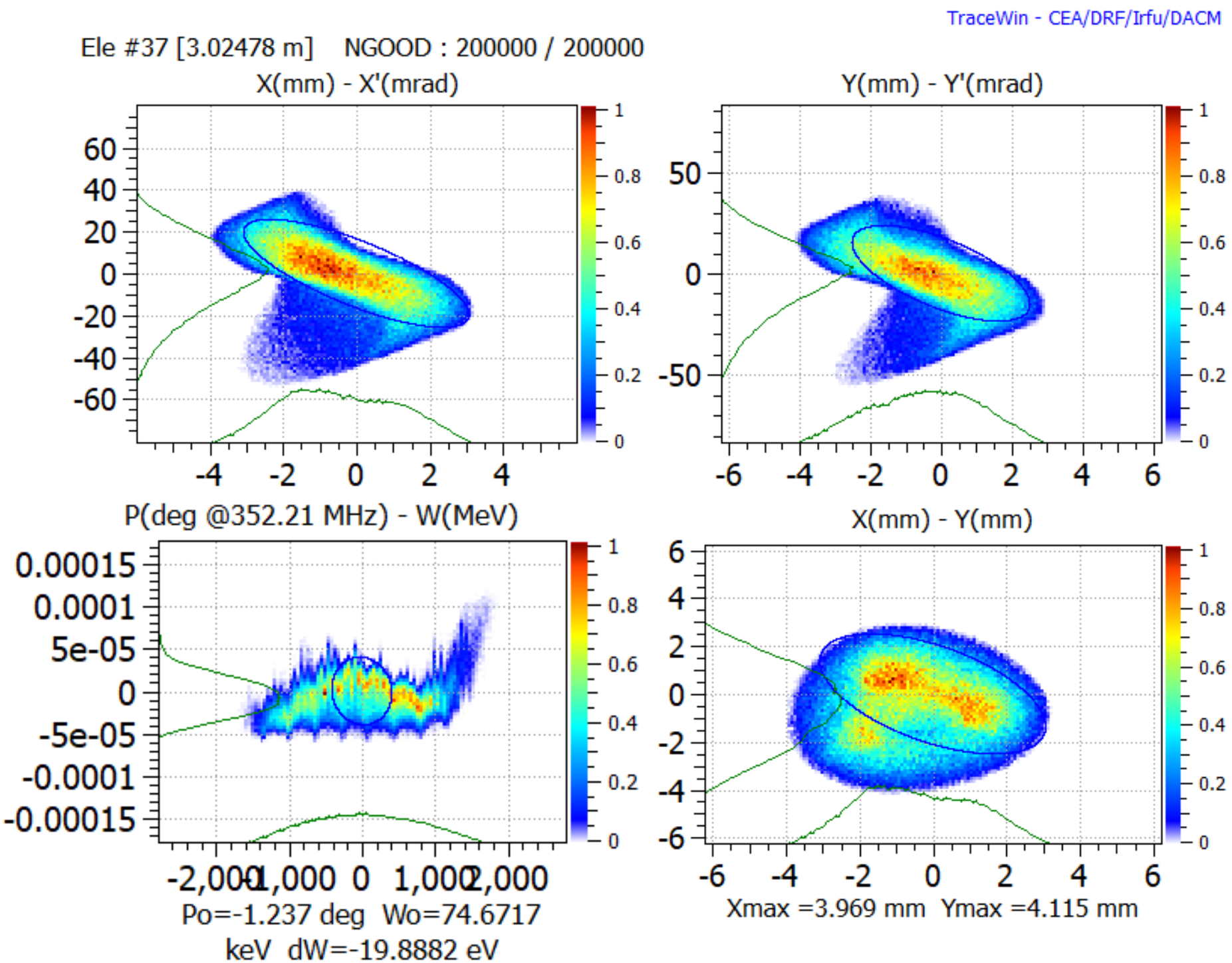
Björn Gålnander

BEAM AFTER +60° LEBT

Input:
proton beam dist from IS
e 0.15 mm mrad (norm)

Solenoid 1 : 0.15 T
Solenoid 2 : 0.23 T

Output:
x-x' a=1.1 , b=0.15, e=0.23
y-y' a=1.0, b=0.15, e=0.23



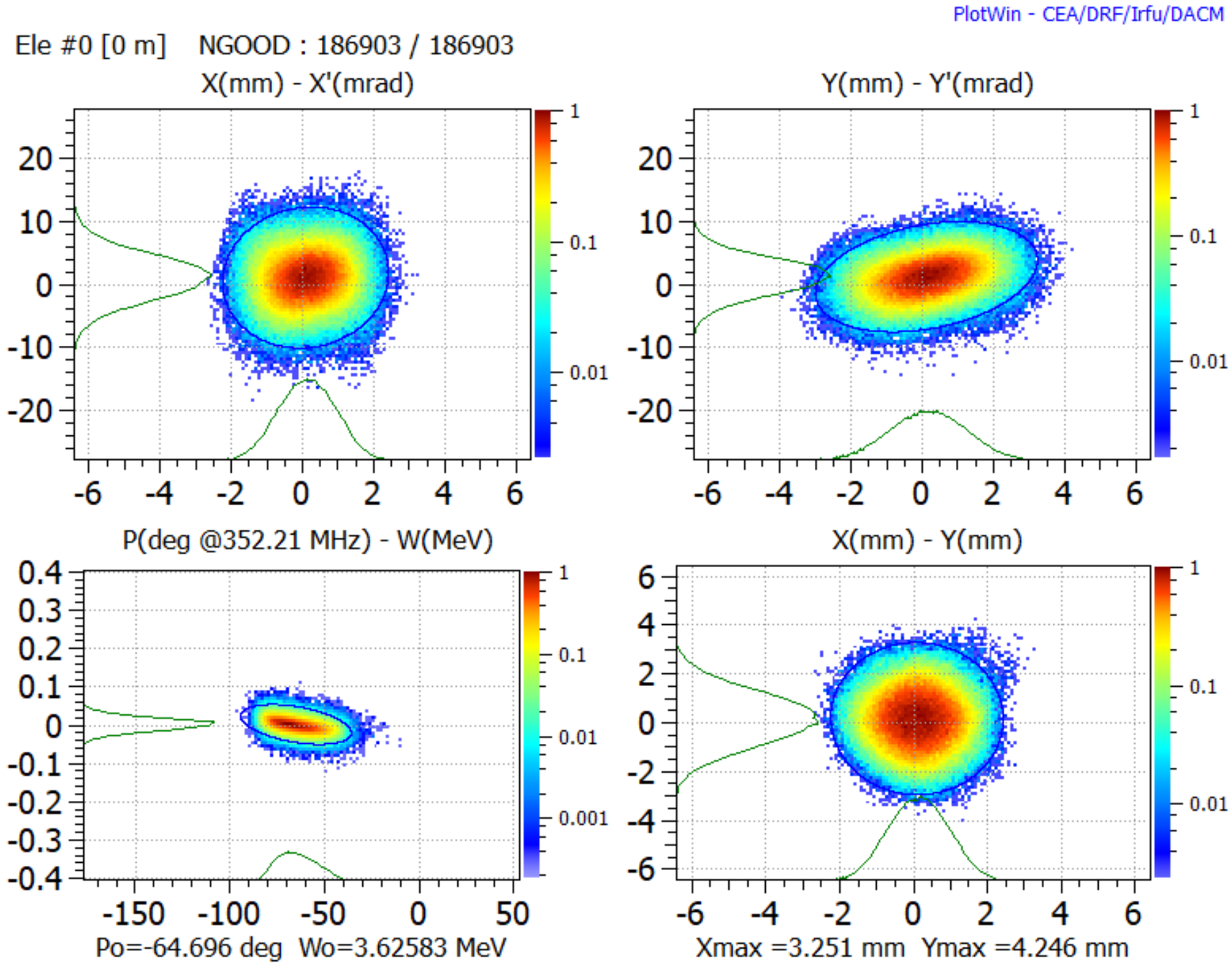
Björn Gålnander

BEAM AFTER RFQ

Tracking of H- beam, from ion source to end of RFQ Transmission 93%
e 0.25 p mm mrad (norm)

Solenoid 1 : 0.15 T
Solenoid 2 : 0.23 T
(similar as for proton beam)

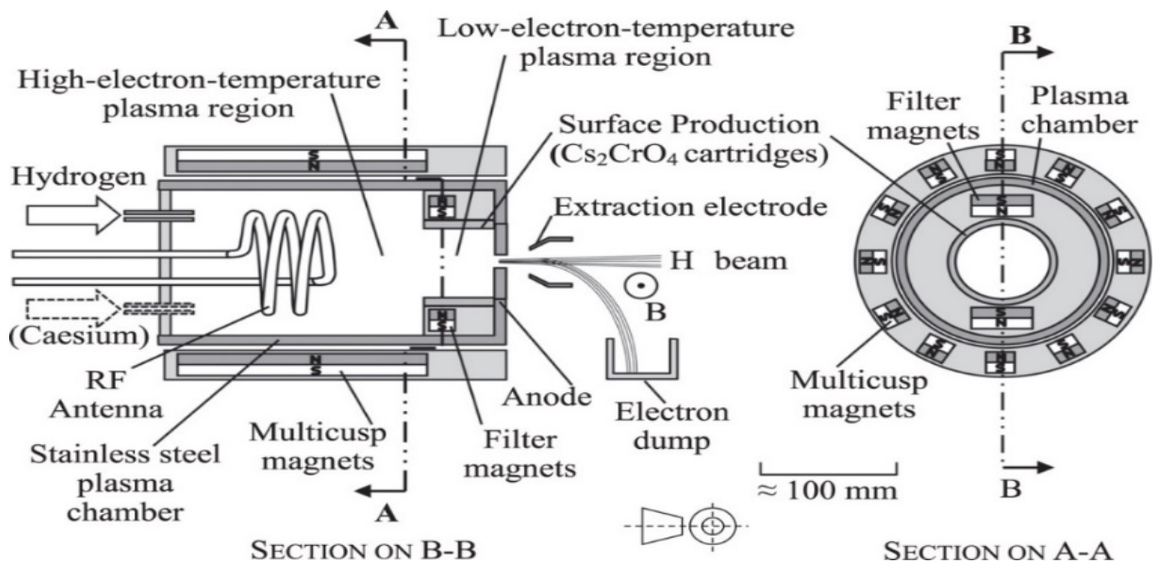
Output:
x-x' a=0.07 , b=0.21, e=0.25
y-y' a=0.3, b=0.37, e=0.25



Björn Gålnander

H^- Source Options

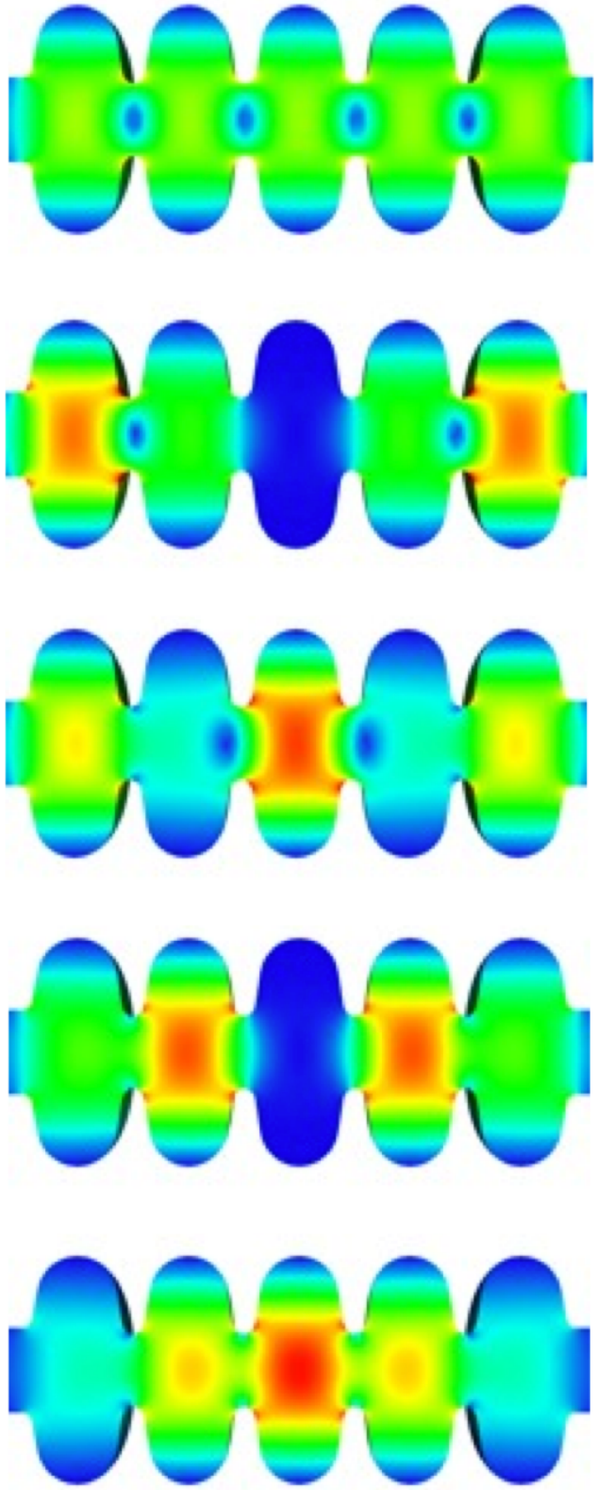
- •Requirements for the ion source:
  - 65-80 mA at about 4% duty cycle,
    - Beam on target 50 mA at 2.5 GeV or 62.5 mA at 2.0 GeV, excluding the chopping
  - Preferably 75 keV (same as proton source).
- Experience at SNS and J-PARC with ion sources of similar performance. (Linac 4, H − beam, but only about 0.1 % duty cycle)
  - Internal RF antenna multicusp volume and surface source with Cs
- Not considered to be a show-stopper

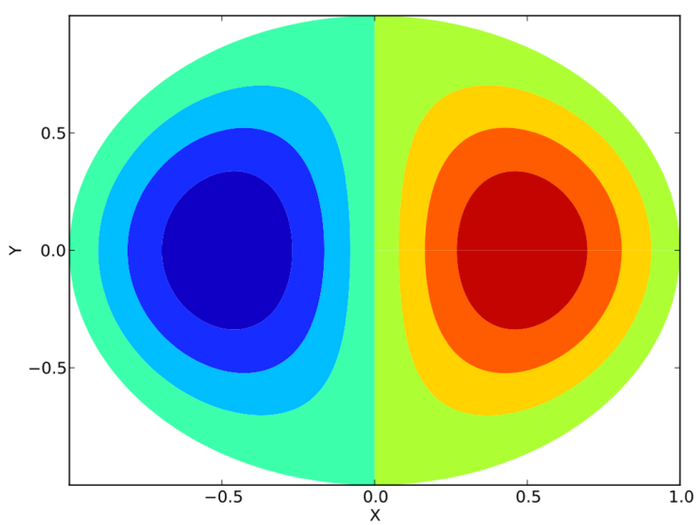


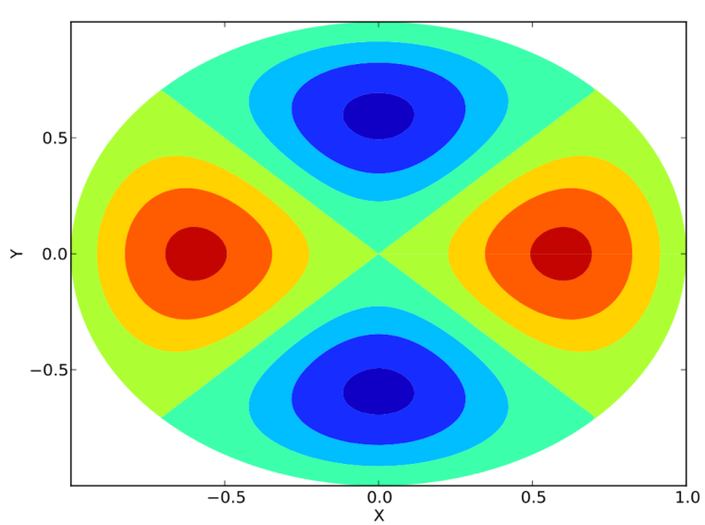
D. Faircloth and S. Lawrie, New J. Phys. 20, 2018

HOMs and SOMs

- Creating an extraction gap in the ring requires a high frequency chopping in the linac, which could excite HOMs in the SC cavities.
  - Could lead to emittance growth and beam losses
  - Could increase the dynamic heat load
- SOMs could also deteriorate the beam quality and lead to losses



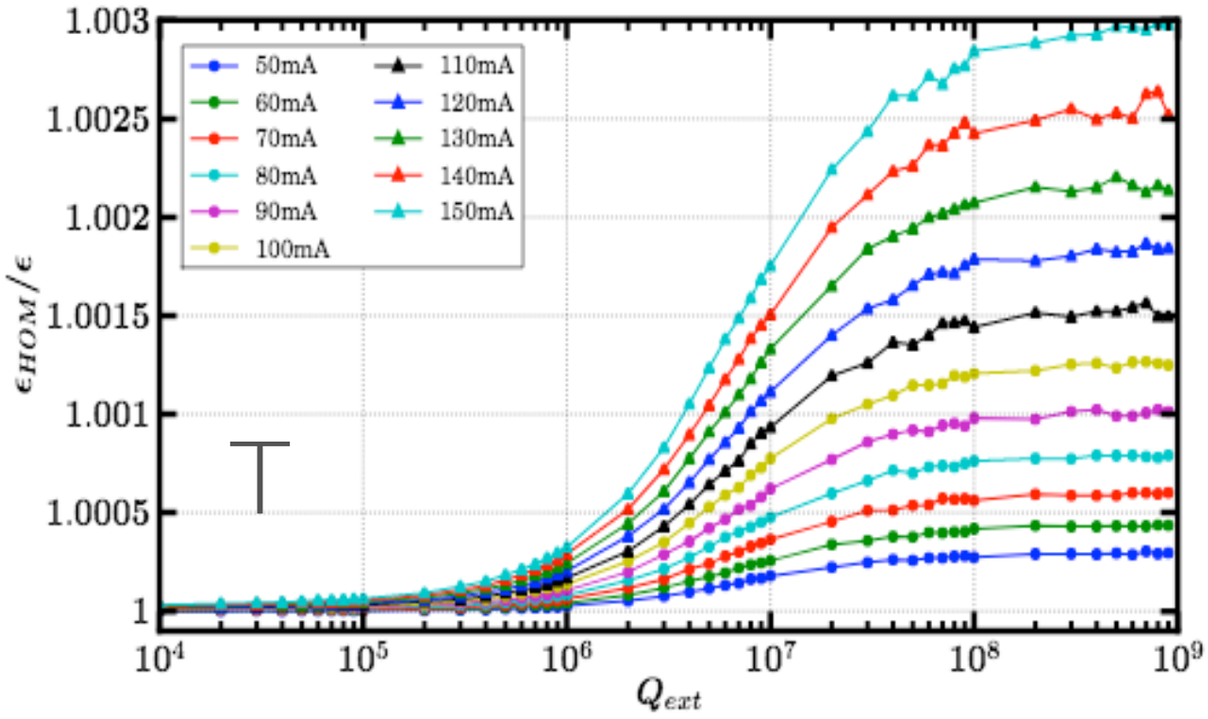


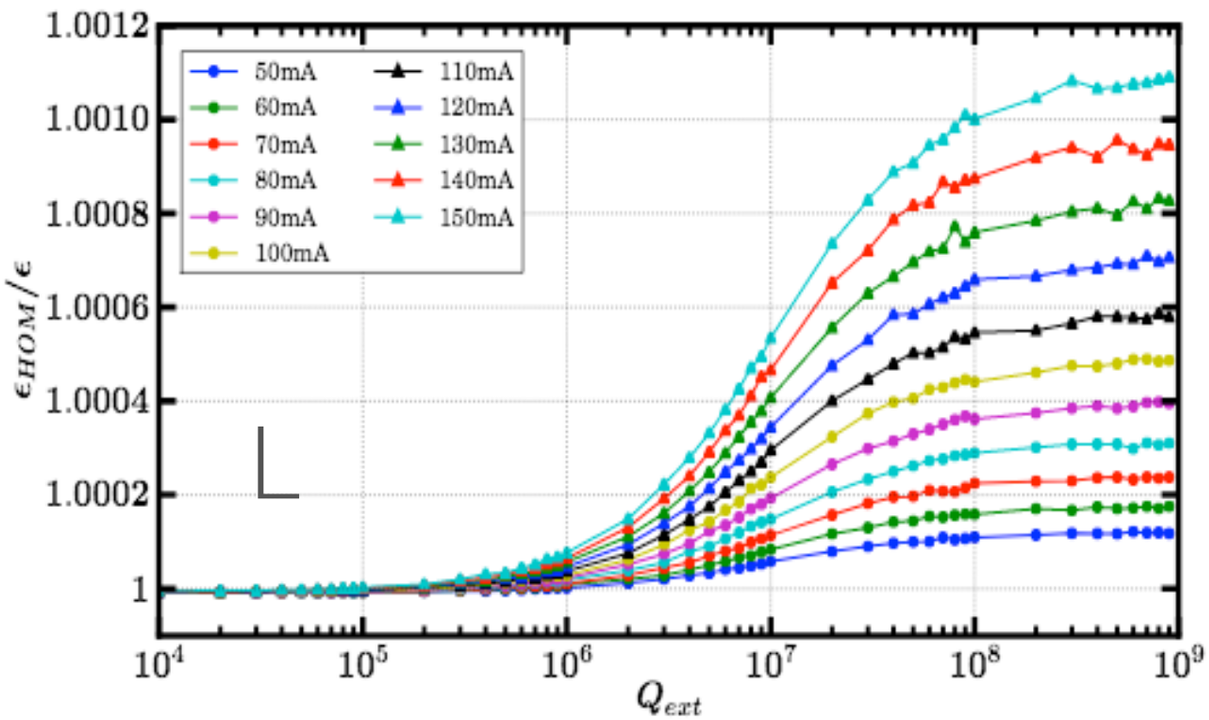


Robert Ainsworth

HOM SIMULATIONS

- Simulations of the HOMs for the ESS linac *(2.5 GeV, 50 mA and bigger acceptance at the MBL)* does not indicate any emittance growth for the expected Qex values in the absence of the extraction gap.

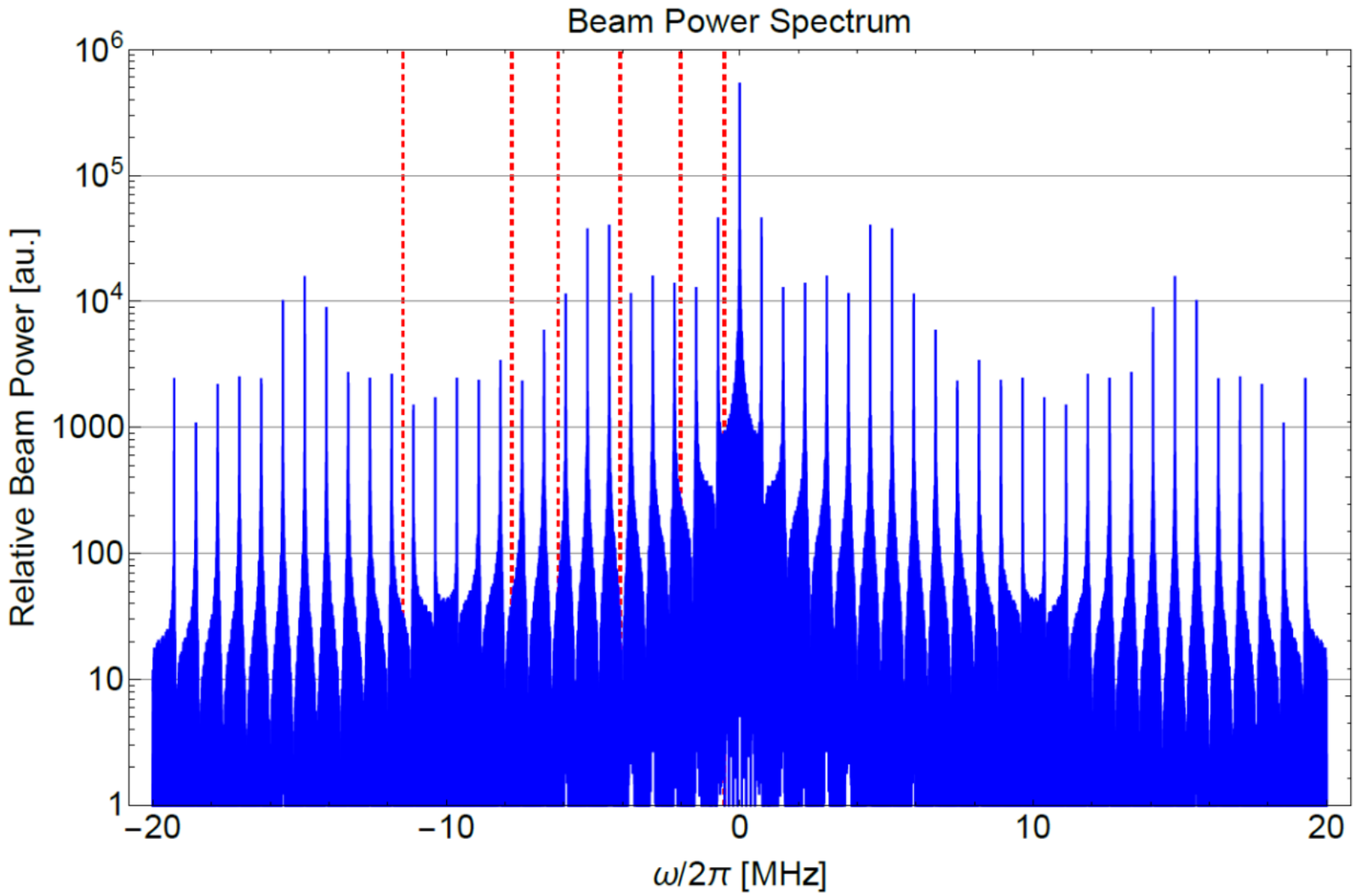




Robert Ainsworth

SOM Analysis

- Preliminary results from simulations of SOM effects in medium beta cavities. With an extraction gap in the pulse structure.
  - The closest side band is damped by a factor of 20.



Aaron Farricker

SOM SIMULATIONS

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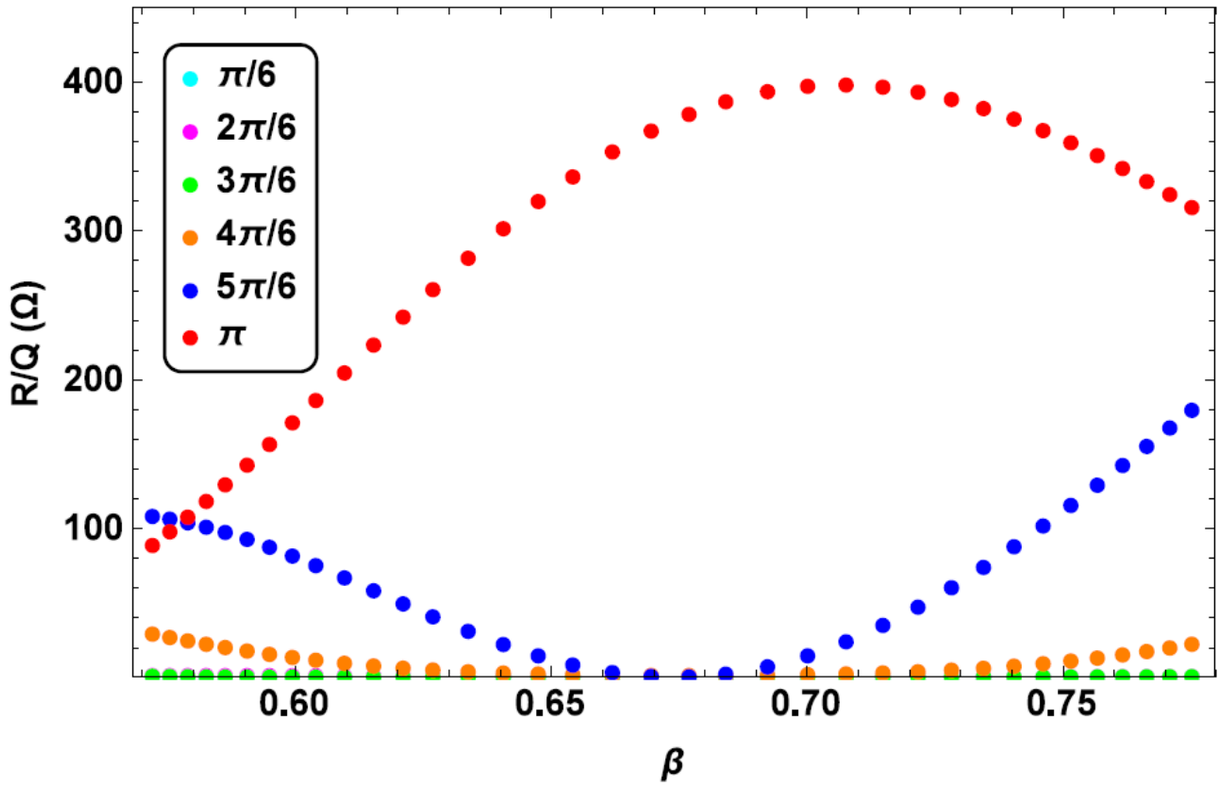

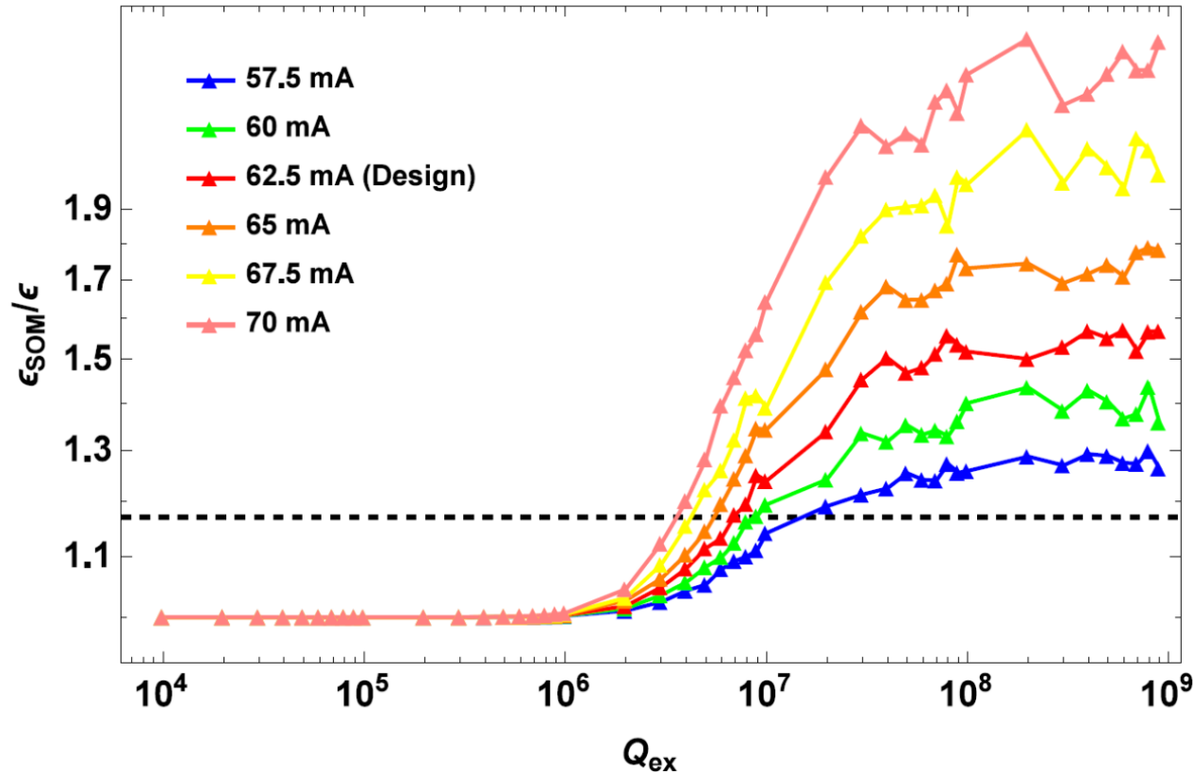

Aaron Farricker

AREAS TO BE STUDIED FURTHER

- H- Source
  - Detailed study
  - Conceptual drawings
- Losses
  - Gas stripping
  - Blackbody radiation
  - Intrabeam stripping
  - Lorentz stripping
- HOMs/SOMs
  - Analysis
  - Simulations
- LLRF, BI, and MPS at higher rep. rate.
- Steerer magnets and transfer line

- Activities requiring more interactions with the local team
  - Civil engineering work
  - Additional high voltage power lines
  - Work on the RF power supplies

EUROPEAN SPALLATION SOURCE

Thank you!

ESSnuSB has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777419.