WP6 Update

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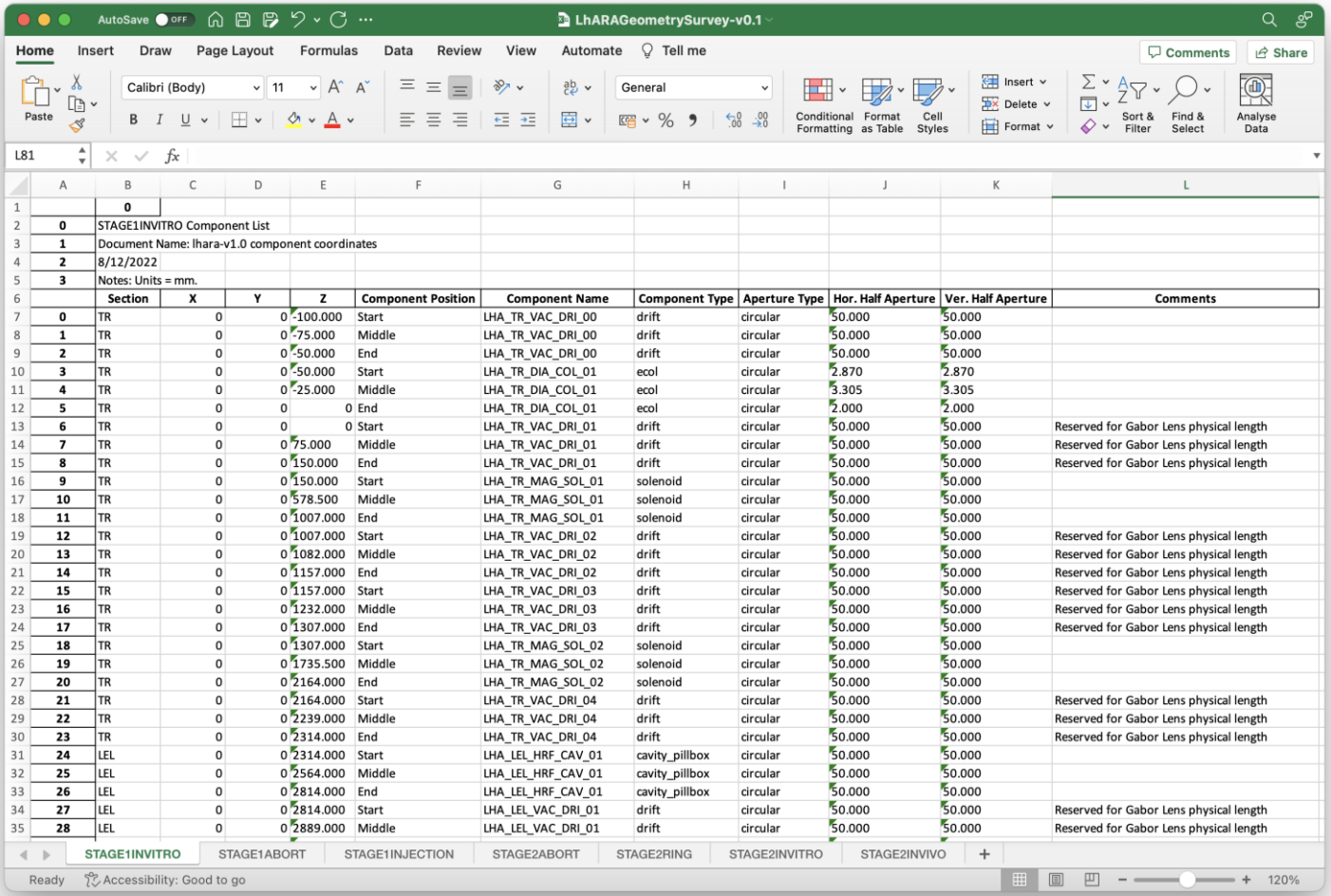
On behalf of WP6

Introduction

- CAD Model
- Updateted schematic
- Baseline changes
- Matching with space charge
- Review of the initial distribution
- Rematching with SCAPA simulated distribution
- Next steps

CAD Model Workflow

- Automatic generation of spreadsheet containing component surveys
- Generated from BDSIM model
- Matches component naming scheme

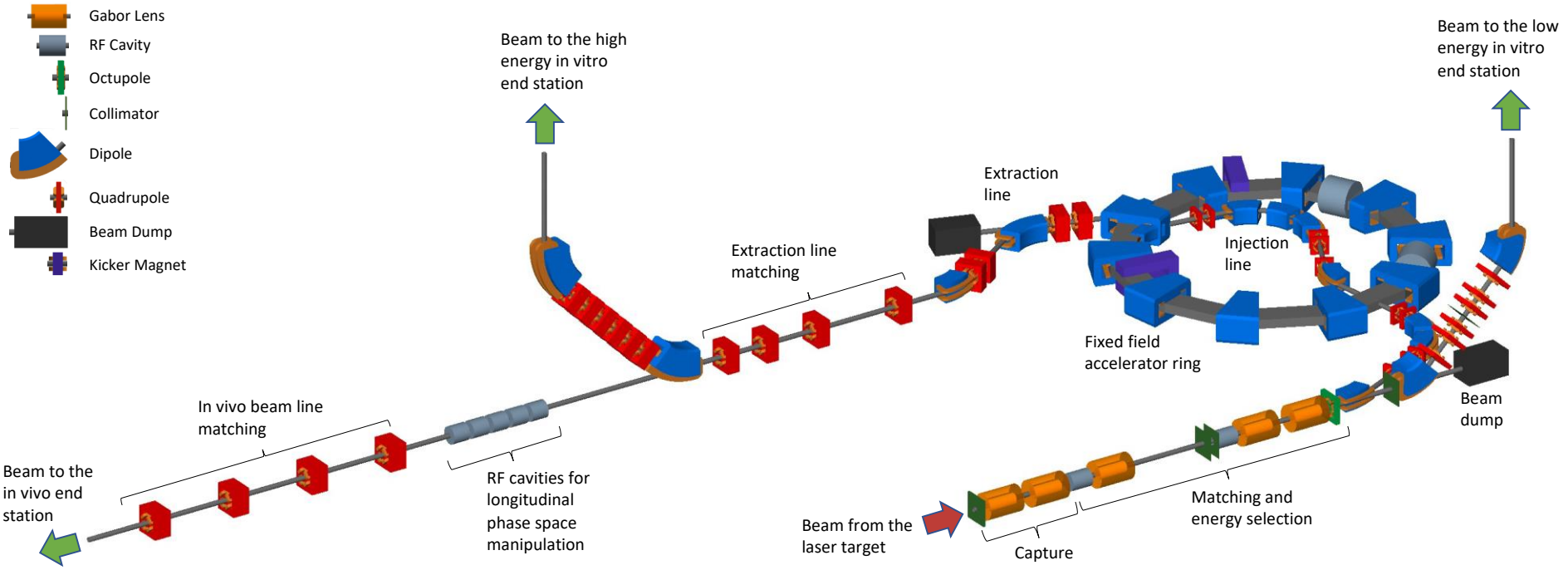


LhARAGeometrySurvey-v0.1

	A	B	C	D	E	F	G	H	I	J	K	L
1		0										
2	0	STAGE1INVITRO Component List										
3	1	Document Name: lhara-v1.0 component coordinates										
4	2	8/12/2022										
5	3	Notes: Units = mm.										
6		Section	X	Y	Z	Component Position	Component Name	Component Type	Aperture Type	Hor. Half Aperture	Ver. Half Aperture	Comments
7	0	TR	0	0	-100.000	Start	LHA_TR_VAC_DRI_00	drift	circular	50.000	50.000	
8	1	TR	0	0	-75.000	Middle	LHA_TR_VAC_DRI_00	drift	circular	50.000	50.000	
9	2	TR	0	0	-50.000	End	LHA_TR_VAC_DRI_00	drift	circular	50.000	50.000	
10	3	TR	0	0	-50.000	Start	LHA_TR_DIA_COL_01	ecol	circular	2.870	2.870	
11	4	TR	0	0	-25.000	Middle	LHA_TR_DIA_COL_01	ecol	circular	3.305	3.305	
12	5	TR	0	0	0	End	LHA_TR_DIA_COL_01	ecol	circular	2.000	2.000	
13	6	TR	0	0	0	Start	LHA_TR_VAC_DRI_01	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
14	7	TR	0	0	75.000	Middle	LHA_TR_VAC_DRI_01	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
15	8	TR	0	0	150.000	End	LHA_TR_VAC_DRI_01	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
16	9	TR	0	0	150.000	Start	LHA_TR_MAG_SOL_01	solenoid	circular	50.000	50.000	
17	10	TR	0	0	578.500	Middle	LHA_TR_MAG_SOL_01	solenoid	circular	50.000	50.000	
18	11	TR	0	0	1007.000	End	LHA_TR_MAG_SOL_01	solenoid	circular	50.000	50.000	
19	12	TR	0	0	1007.000	Start	LHA_TR_VAC_DRI_02	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
20	13	TR	0	0	1082.000	Middle	LHA_TR_VAC_DRI_02	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
21	14	TR	0	0	1157.000	End	LHA_TR_VAC_DRI_02	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
22	15	TR	0	0	1157.000	Start	LHA_TR_VAC_DRI_03	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
23	16	TR	0	0	1232.000	Middle	LHA_TR_VAC_DRI_03	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
24	17	TR	0	0	1307.000	End	LHA_TR_VAC_DRI_03	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
25	18	TR	0	0	1307.000	Start	LHA_TR_MAG_SOL_02	solenoid	circular	50.000	50.000	
26	19	TR	0	0	1735.500	Middle	LHA_TR_MAG_SOL_02	solenoid	circular	50.000	50.000	
27	20	TR	0	0	2164.000	End	LHA_TR_MAG_SOL_02	solenoid	circular	50.000	50.000	
28	21	TR	0	0	2164.000	Start	LHA_TR_VAC_DRI_04	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
29	22	TR	0	0	2239.000	Middle	LHA_TR_VAC_DRI_04	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
30	23	TR	0	0	2314.000	End	LHA_TR_VAC_DRI_04	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
31	24	LEL	0	0	2314.000	Start	LHA_LEL_HRF_CAV_01	cavity_pillbox	circular	50.000	50.000	
32	25	LEL	0	0	2564.000	Middle	LHA_LEL_HRF_CAV_01	cavity_pillbox	circular	50.000	50.000	
33	26	LEL	0	0	2814.000	End	LHA_LEL_HRF_CAV_01	cavity_pillbox	circular	50.000	50.000	
34	27	LEL	0	0	2814.000	Start	LHA_LEL_VAC_DRI_01	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length
35	28	LEL	0	0	2889.000	Middle	LHA_LEL_VAC_DRI_01	drift	circular	50.000	50.000	Reserved for Gabor Lens physical length

- Model zero position:
  - Centre of exit plane of target housing flange

Updated Models

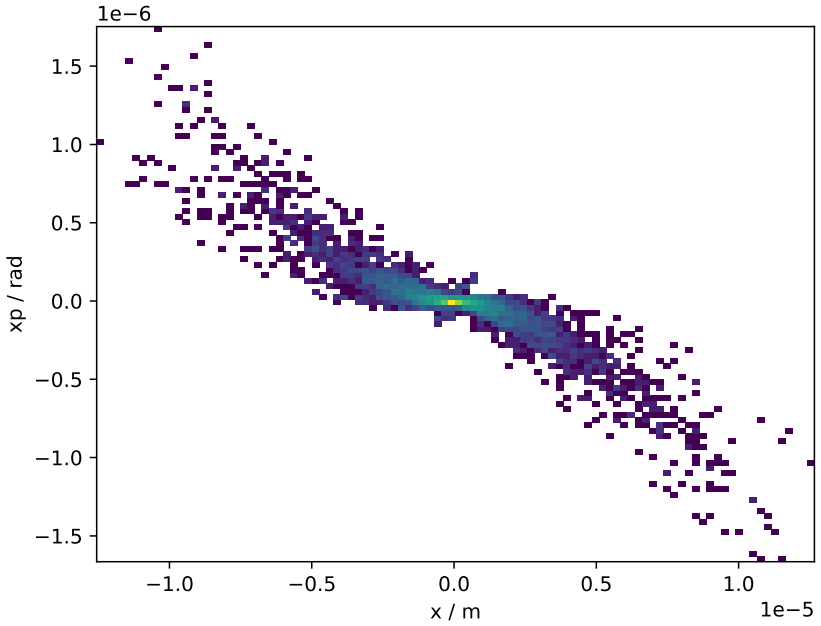


- Updated BDSIM model & schematic diagrams

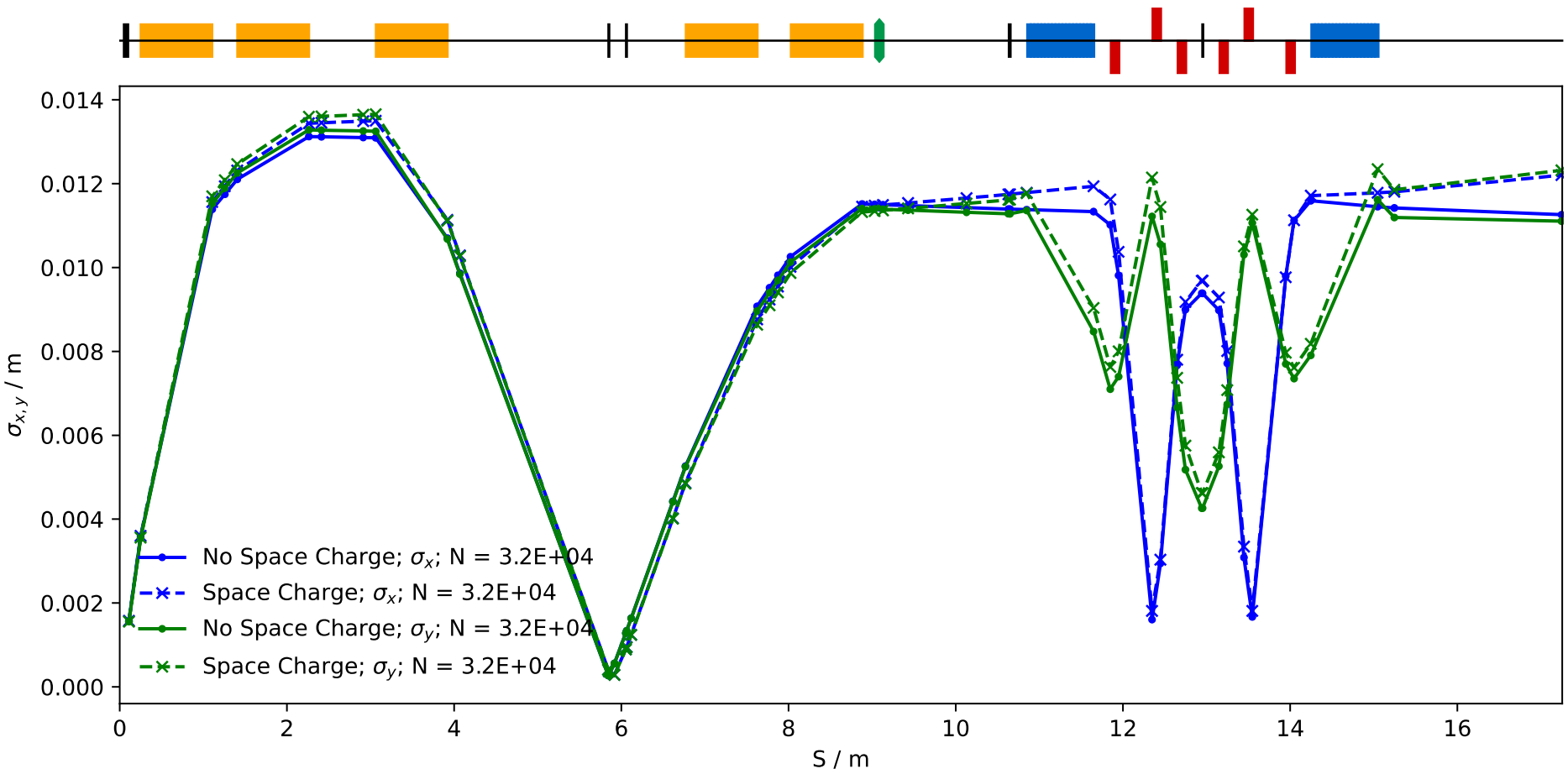
- New model versions:
  - V4.4: main baseline design
  - V5.4: alternative baseline design

Updated Models

- Stage 2 energy selection collimation added
  - 0.2m downstream of stage 1 collimator (GL3 focal length)
  - Settings to be optimised
- 1st Octupole removed:
  - No discernible impact on bunch uniformity
  - Phase space difference at the stage 1 end station (on – off):



Stage 1 Optimisation

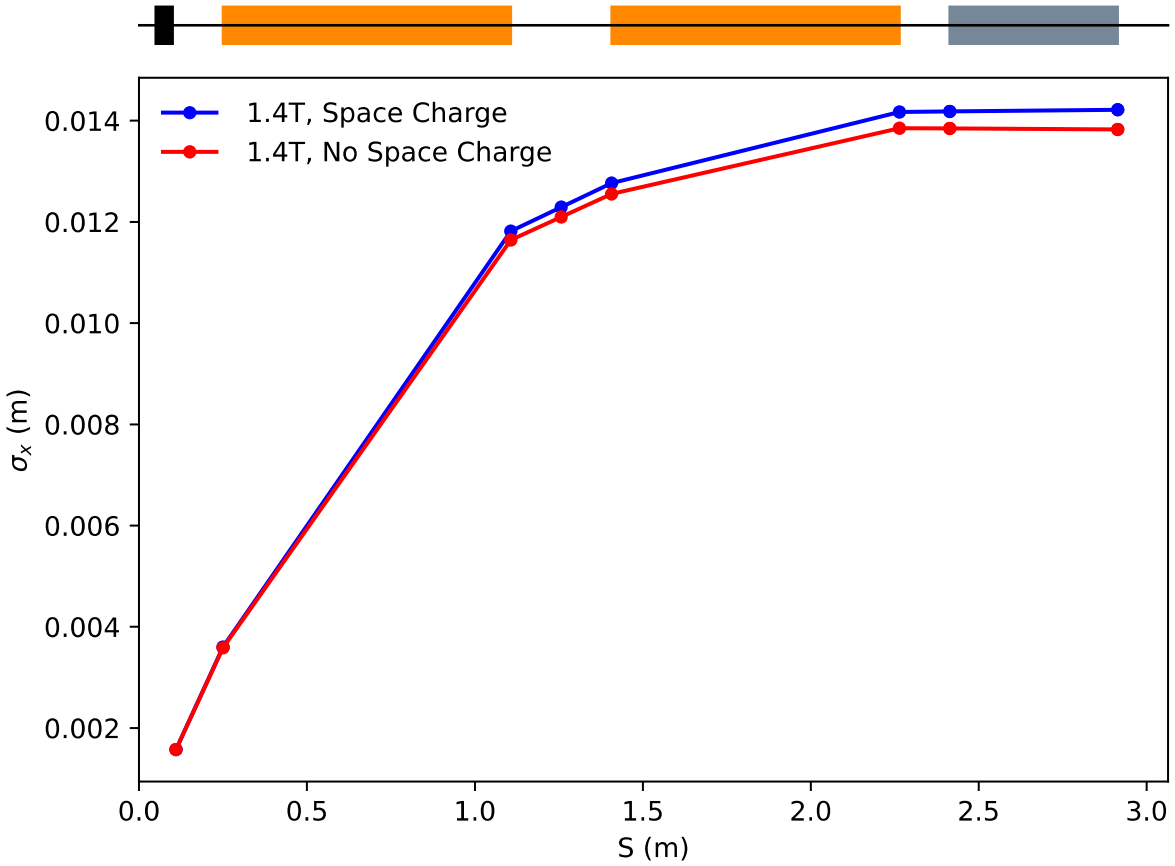


- Sampled beam generated from Smilei (HT)
- Non-parallel beam between GL2 & GL3
  - Requirement – flexibility needed to accommodate RF, shielding wall, etc.

Solenoid Strength Optimisation

- Optimise Gabor lens (solenoid) strengths
  - Ideally constrain solenoids < 1.4T

- Space charge forces still impact performance despite MADX optimisation efforts
  - Neither beams completely parallel
    - ~ 0.2% beam size growth over 0.5m cavity length



- GPT optimisation efforts ongoing.
  - Include GL3, maintain focal point at collimator location

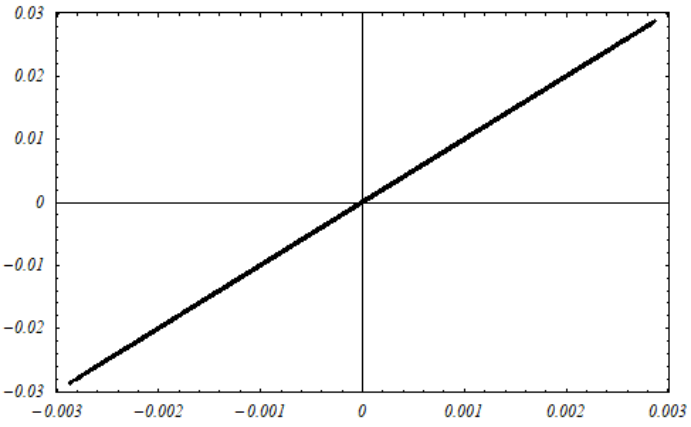
Nozzle effect with SCAPA simulated distribution - transmission

- 71.8% of particles within the energy range (15MeV ±2%) survives the entrance nozzle cut (r=2mm)
- 35.6% of particles within the energy range (15MeV ±2%) survives the exit nozzle cut (r=2.87mm)
  - 40.1% of particles within the energy range (15MeV ±2%) survives the exit nozzle cut (r=2.87mm) if space charge is ignored

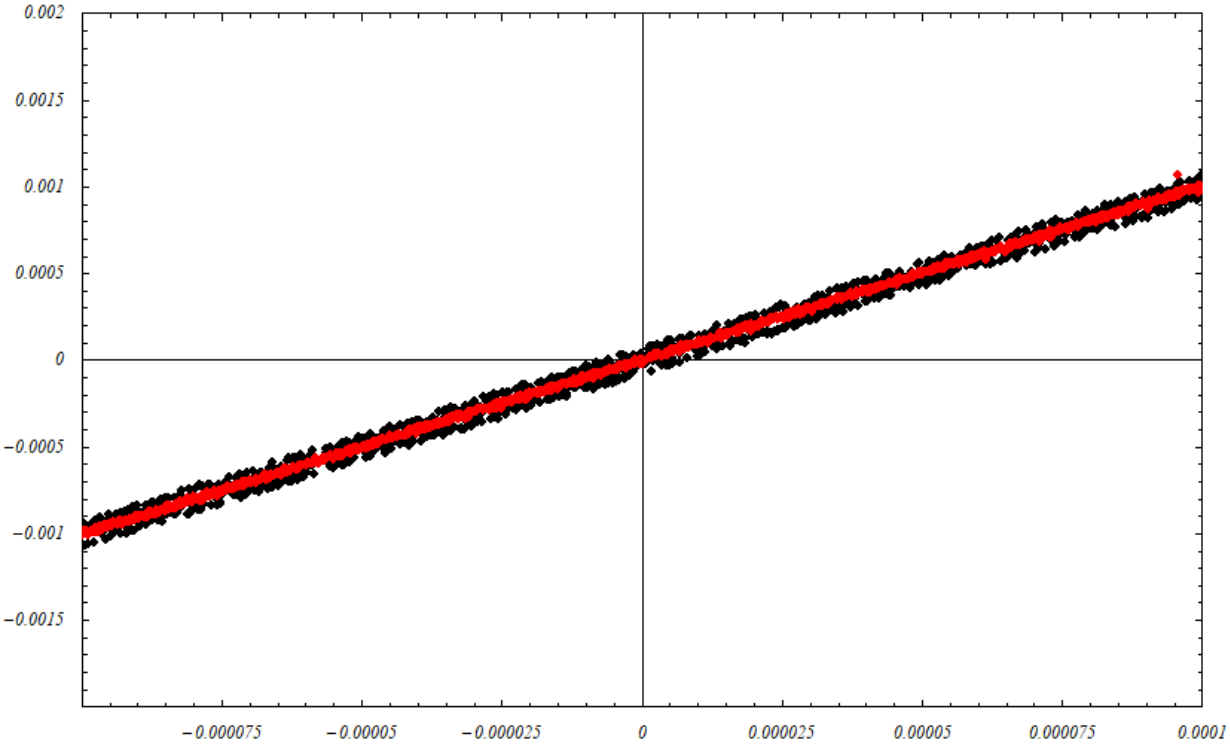
Nozzle effect (beam parameters)

	HT's distribution	SCAPA distribution	SCAPA distribution no-SC
Mean RMS emittance [m]	1.43×10^{-8}	1.26×10^{-7}	5.5×10^{-8}
Mean beta [m]	141.34	12.82	28.8
Mean alpha	-1418.43	-129.79	-288.03

Phase space at the exit of the nozzle (x,x') [m,rad]

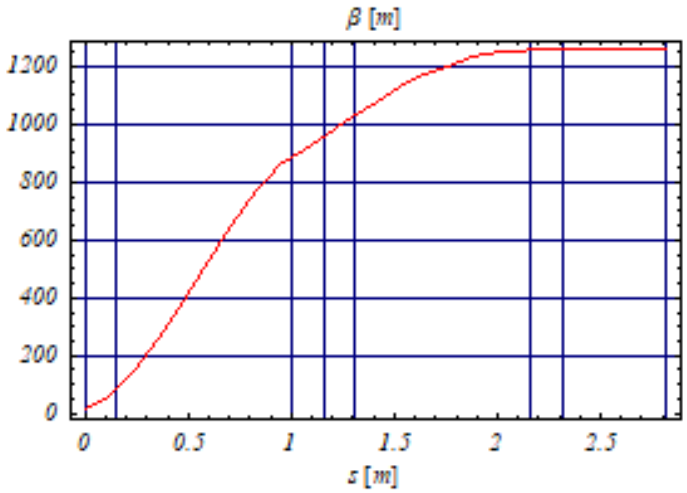


Full



Zoom: black – SCAPA w/o SC, red – HT's

Beam size in the capture section

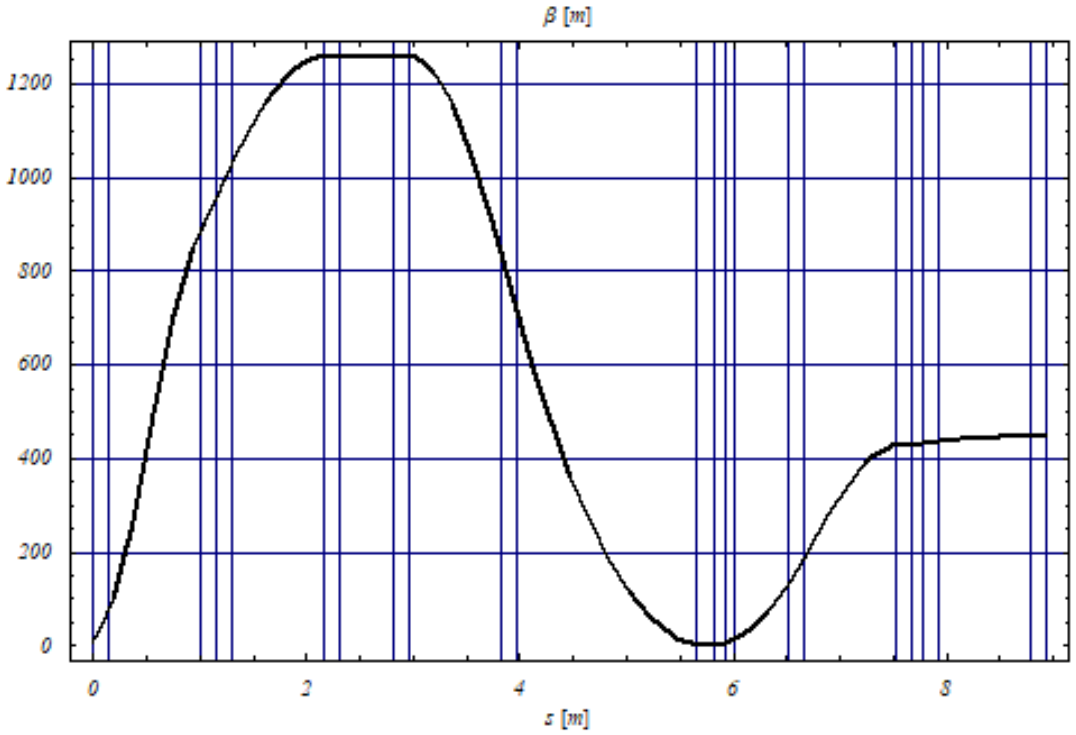


- Beam size at the nozzle exit (2.87mm) -2.26σ
- Beam size at the exit of the second GL with 2.26σ is 28.4mm (77.8% of the cathode radius)
  - What is the max radius of the electron cloud we can use?
  - With the solenoid with the aperture of 36.5mm we could accept the beam up to 2.9σ

Some preliminary conclusions and ideas

- Interesting findings on the SCAPA distribution
  - Sharp cut-off in real space
  - No very large divergence particles
  - hole in the middle for our energy (real space)
  - x/y asymmetry
- Interesting findings on the nozzle effect
  - Phase space inclination and the lab size completely defined by the geometry
  - The difference is in the angular spread spread(SCAPA)/spread(HT)~10
  - SCAPA with SC closer to the preCDR distribution
  - Maximum radius of the beam in the capture section defines, if we need to modify the nozzle or not

Rematched baseline with the SCAPA distribution



- Beam diameter of 3cm can be produced
- Issues with obtaining smaller final beam size
- Issues with matching to the Stage 2

WP6 expectations for GL design

- Focusing of equivalent ~1.4 T solenoid
- Linearity vs r (with sufficient radius)
- Reasonable uniformity vs z
- Stability
- Reproducibility
- Tunability
- Low cost
- Low power consumption
- Scalabilty

Next steps

- To improve flexibility in the Stage 1 matching
- To incorporate space charge in matching
- To find the new injection line
  - We need to do it in any case due to the new wall
- To work on the FFA update