MICROBUNCHING INSTABILITY STUDIES FOR MAGNETIC AND HYBRID COMPRESSION SCHEMES.

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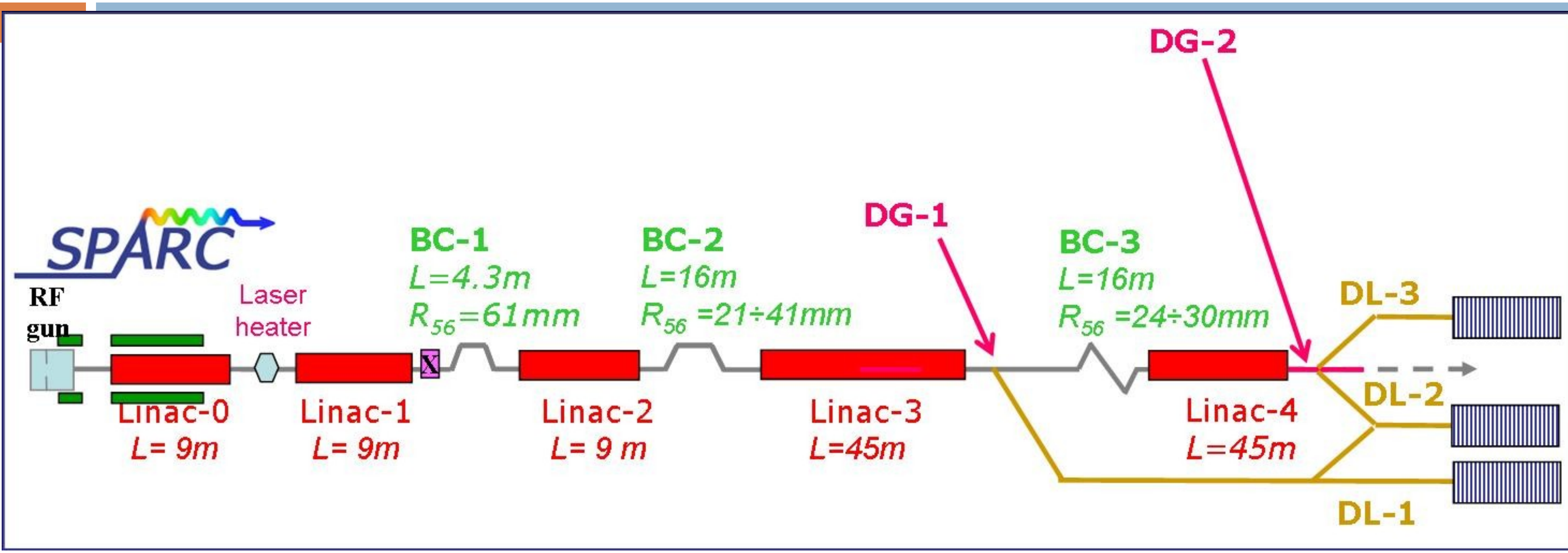
Outline

- The SPARX linac layout:
  - 2 compression schemes to analyze for LE & HE
- The input beams:
  - improved statistics
- Tracking results w LH
- Genesis simulation results.
- Conclusions

SPARX schematic layout



Energy	***(GeV)***	***E***	***1÷1.5***	***2.4***
Peak current	(kA)	I_{pk}	1	2.5
Normalized transverse emittance *slice*	(μm)	ε_n	1	1
Correlated energy spread	(%)	σ_δ	0.1	0.1
Radiation wavelength	(nm)	λ_r	40÷3	3÷0.6

Parameter list

Reference beam parameters						
	Low energy beam			High energy beam		
Set name	LE-A	LE-B	LE-C	HE-A	HE-B	HE-C
Beam energy (GeV)	0.96 – 1.5			1.92 - 2.64		
Peak Current (kA)	>1	>0.6	>1	>2.3	>1.0	>0.3
Energy spread (slice)	$<3 \times 10^{-4}$			$<2 \times 10^{-4}$		
Emitt. (slice, mm-mrad)	<1.1	<0.7	<1.1	<1	<0.5	<0.1
Twiss β (m)	~6			~10		

Low energy beam :

- WP1= Velocity Bunching + BC2/BC3
- WP2= BC1+BC2/BC3

Parameter list 2/2

U1

VUV-EUV Undulator parameters

Period	***3.4 cm***
Undulator length	2.278m
No. of Periods	67
Gap (min/max)	8.1 / 25 mm
K max	3.275
Remanent field (effective)	1.2 T
Blocks per period	4

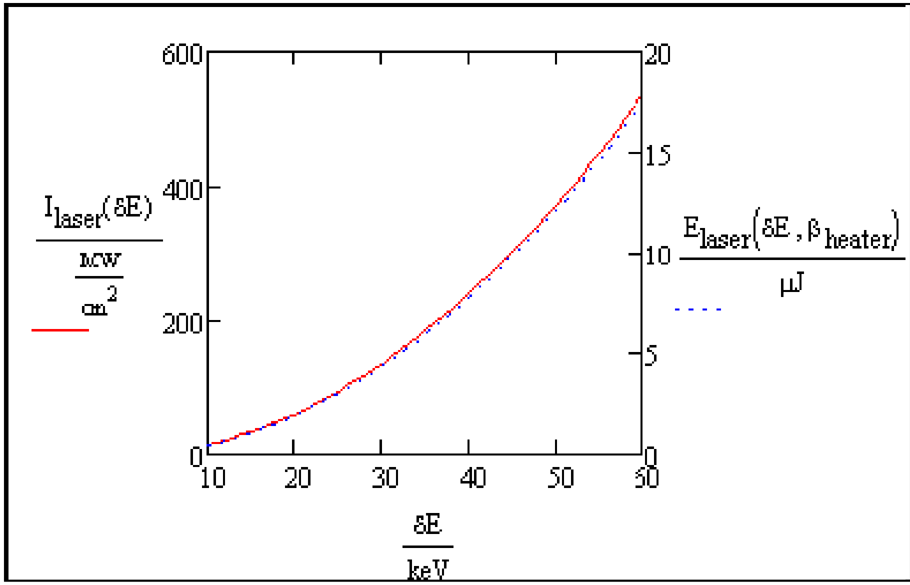
EUV-Soft X-ray Undulators parameters

UM1 – Undulator sequence (4 segments)	
Period	4cm
Undulator length	2.278m
No. of Periods	55
Gap (min/max)	8.1 / 25 mm
K max	3.27
Remanent field (effective)	1.21 T
UM2 – Undulator sequence (12 segments)	
Period	2.8cm
Undulator length	2.156m
No. of Periods	77
Gap (min/max)	8.1 / 25 mm
K max	2.3
Remanent field (effective)	1.21 T
UM3 – Undulator sequence (4 segments)	
Period	2.2cm
Undulator length	2.20m
No. of Periods	100
Gap (min/max)	6.1 / 25 mm
K max	1.9
Remanent field (effective)	1.21 T

U2

Laser heater parameter list

electron Energy	160 ÷220 MeV
transverse rms beam size	200 μm
undulator period	0.05 m
undulator parameter	3.00÷2.13
undulator length	0.50 m
laser wavelenght	800 nm
laser rms spot size	200 μm
laser peak power	1÷25 MW
rms local energy spread	50÷400keV



The input beams:

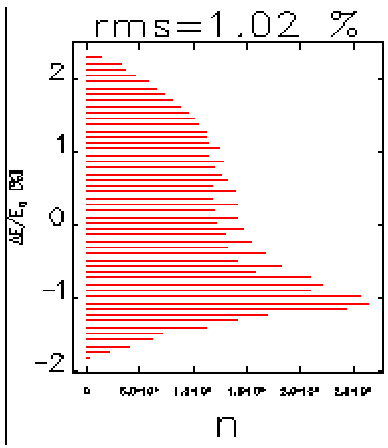
BEAM 1 (WP1): Sparc w RF compression: "RFc"	**BEAM 2 (WP2):** Sparc basic: "nc"
$I \approx 350$ A	$I \approx 100$ A
$\varepsilon_{n\ x,y} \leq 1$ mm mrad	$\varepsilon_{n\ x,y} \leq 1$ µrad
$\sigma_z \approx 280$ µm	$\sigma_z \approx 900$ µm
$\sigma_\delta \approx 1\%$	$\sigma_\delta \approx 0.15\ \%$
$E_0 \approx 163$ MeV	$E_0 \approx 217$ MeV
$Q = 1$nC	$Q = 1$nC
No Xband	Xband upstream BC1

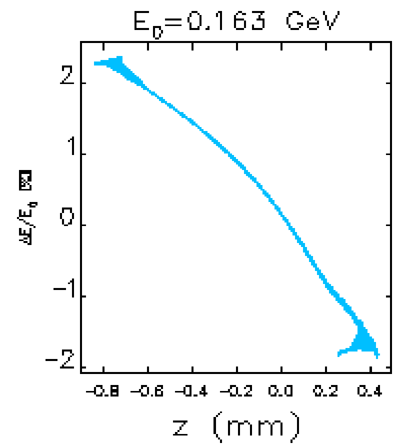
Superimposed modulation at cathode:

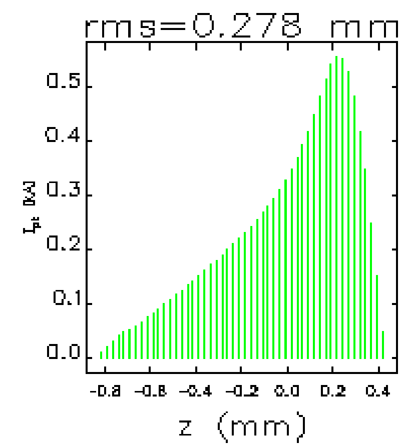
$\lambda = 150\ \mu$, Amp. $=10\ \%$

Input beam Phase Space & slice features

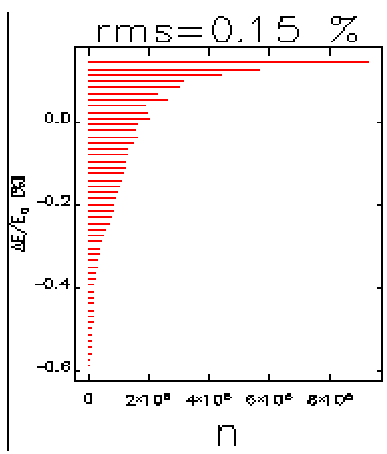
Rfc

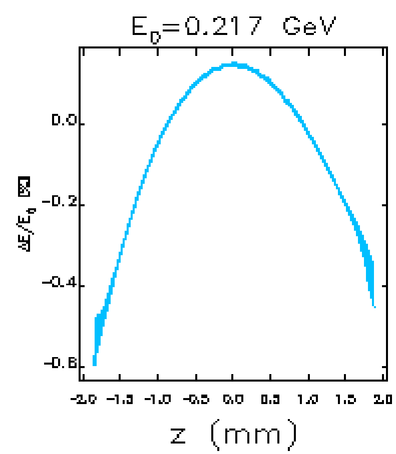


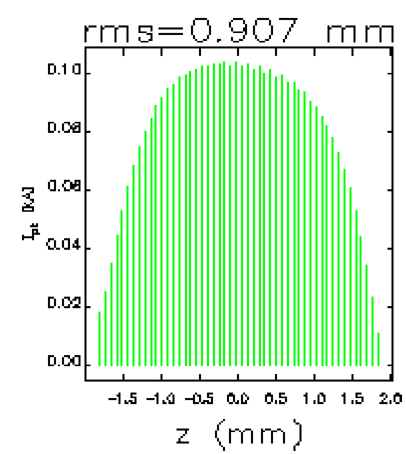




nc

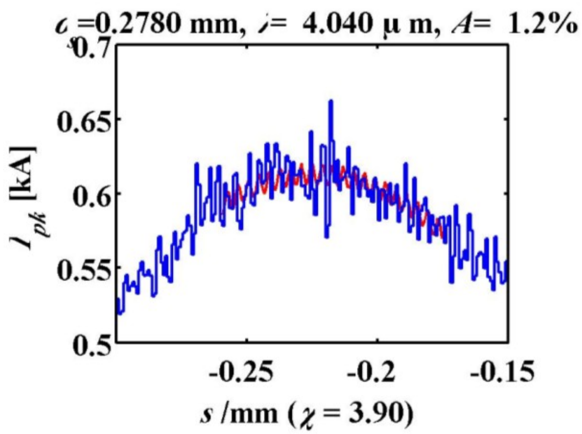


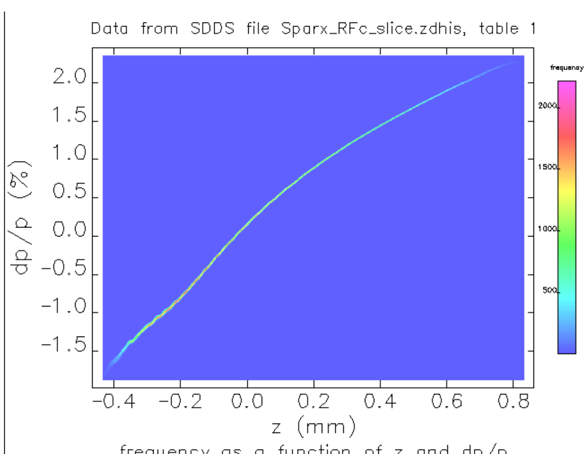




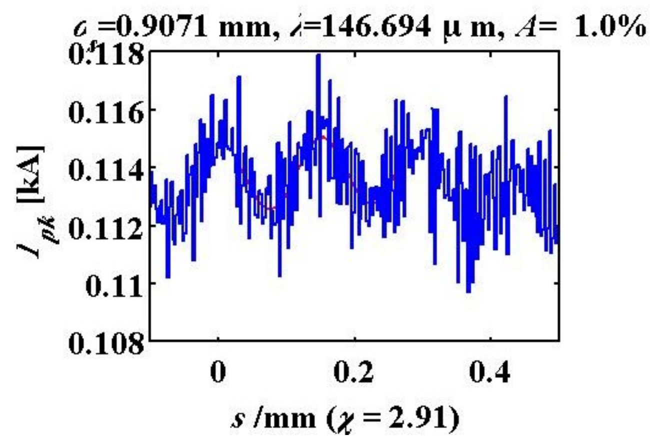
Input beam Phase Space & slice features

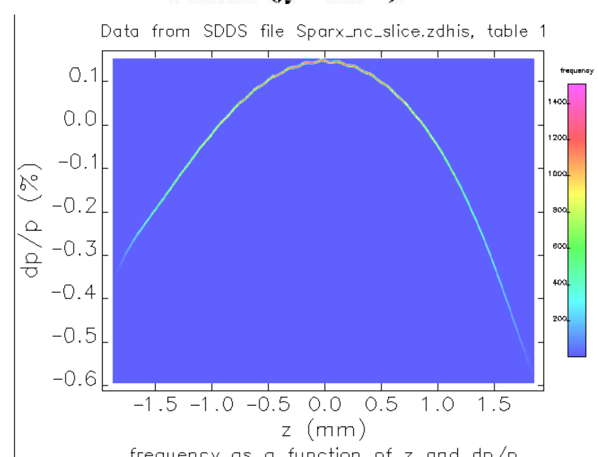
Rfc





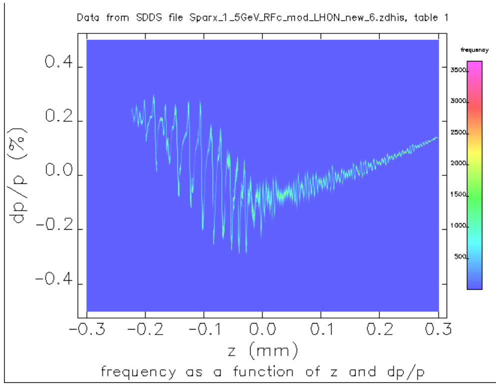
nc

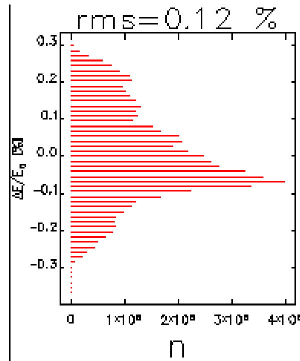


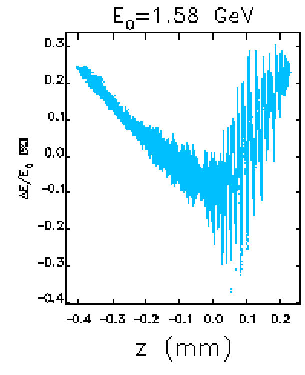


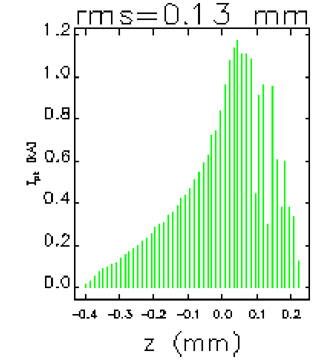
Xband on-off with vb

RFc Xband OFF

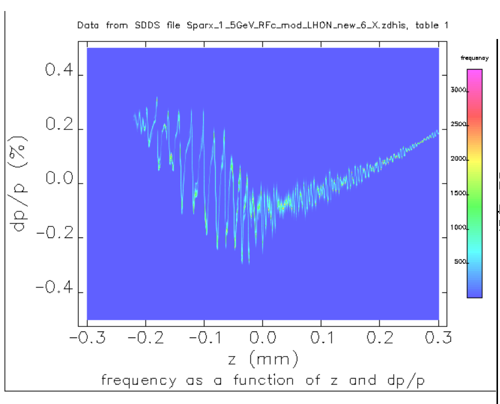


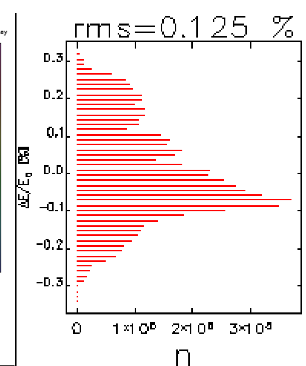


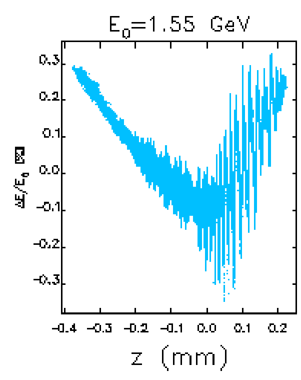


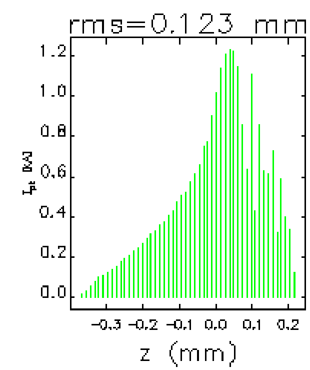


RFc Xband ON



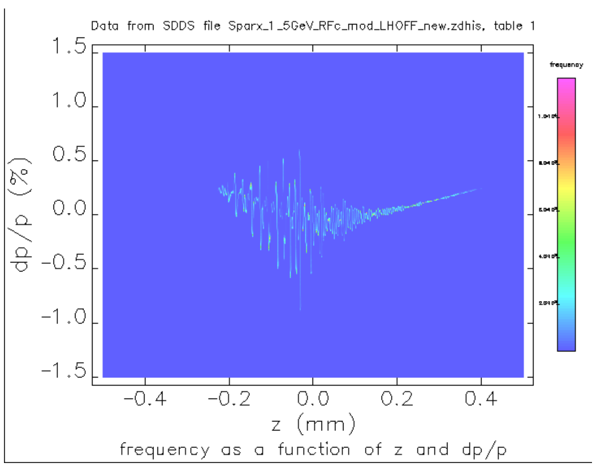


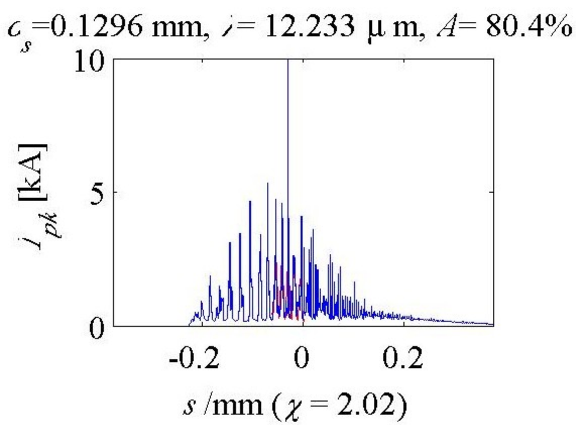




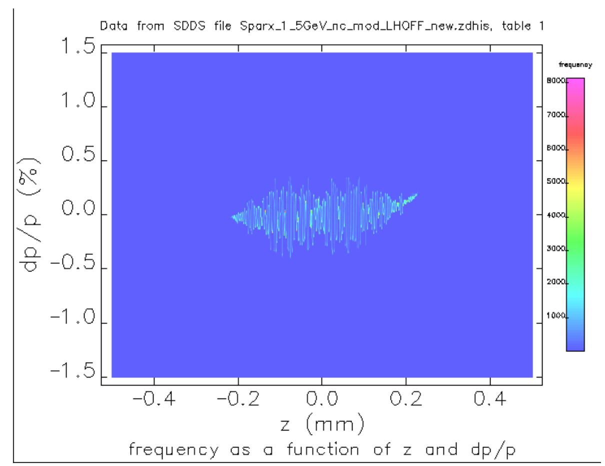
At 1.5GeV DL1 dogleg end:

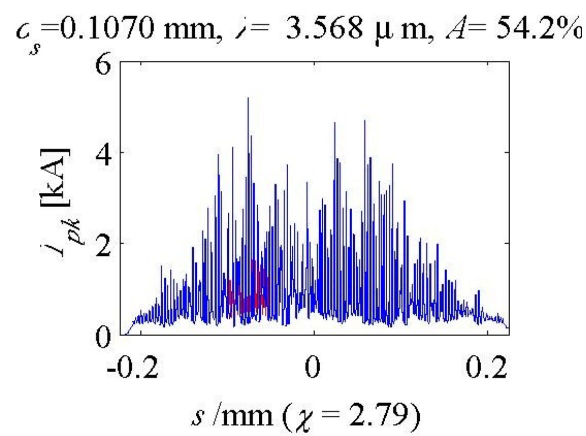
Rfc LH OFF





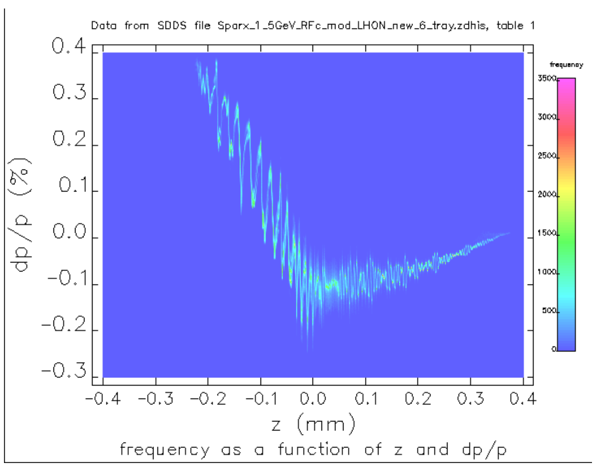
nc LH OFF



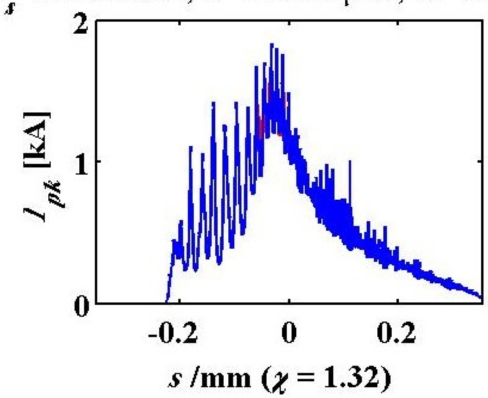


At 1.5GeV DL1 dogleg end:

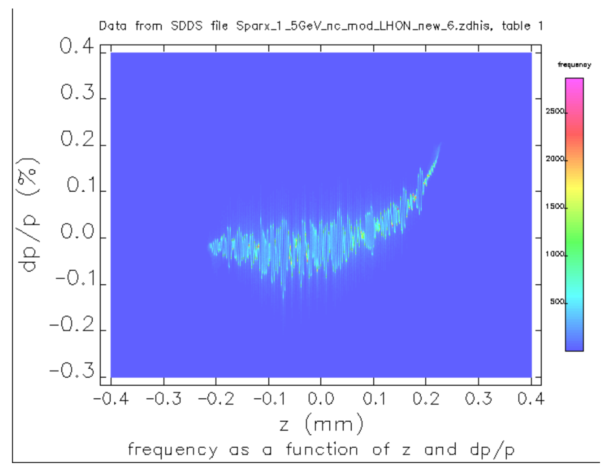
Rfc LH 25 MW



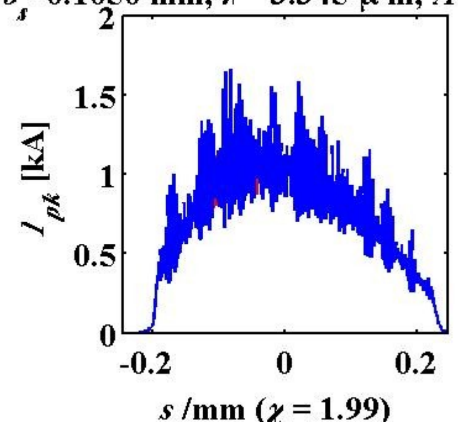
σ_s=0.1215 mm, λ= 11.539 μ m, A= 16.3%



nc LH 10MW

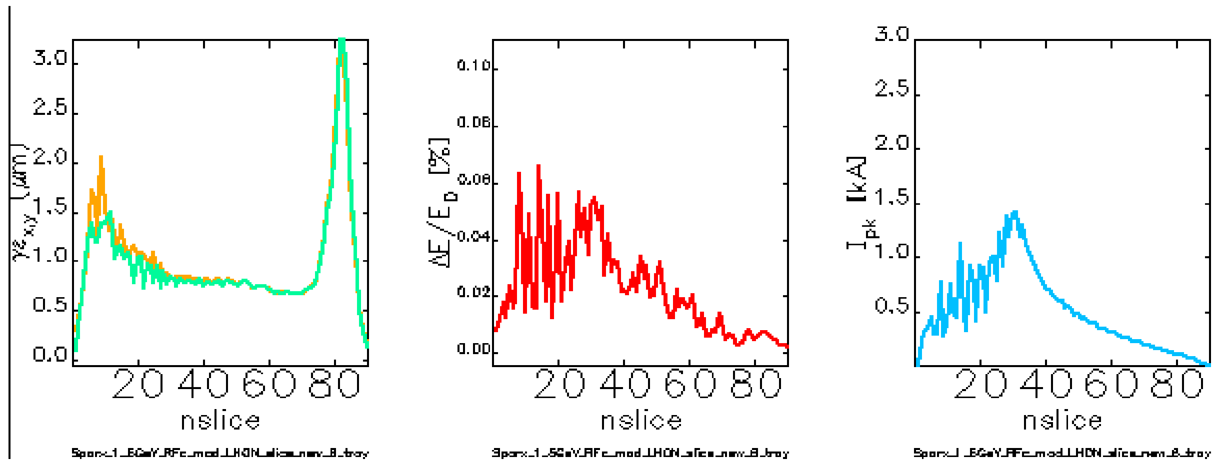


σ_s=0.1050 mm, λ= 3.345 μ m, A= 16.5%



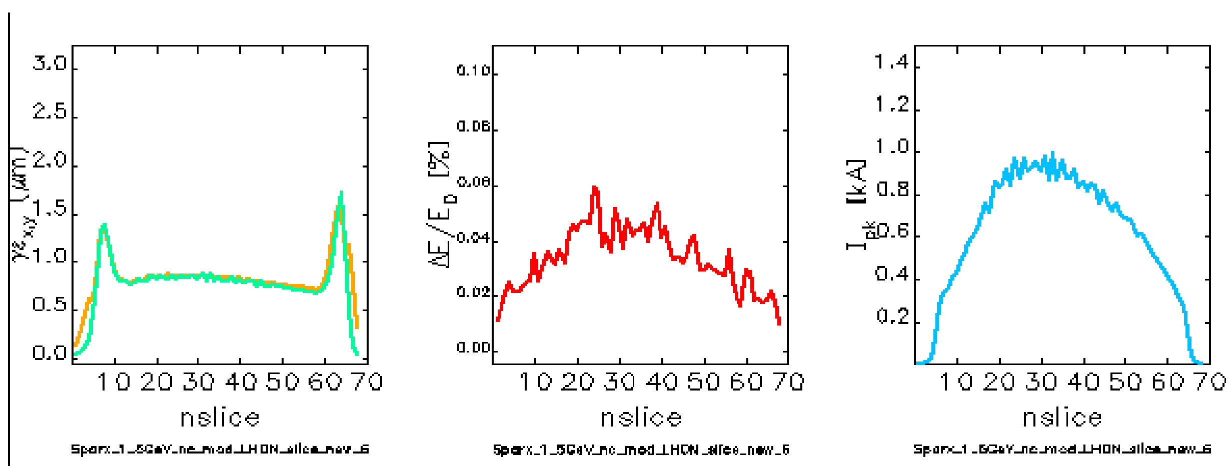
At 1.5GeV DL1 dogleg end:

Rfc :LH P_{peak}=25 MW

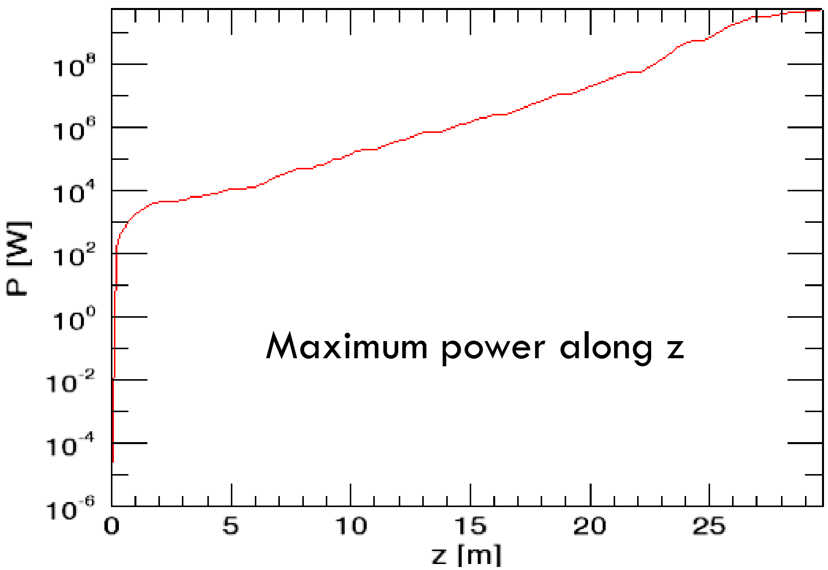


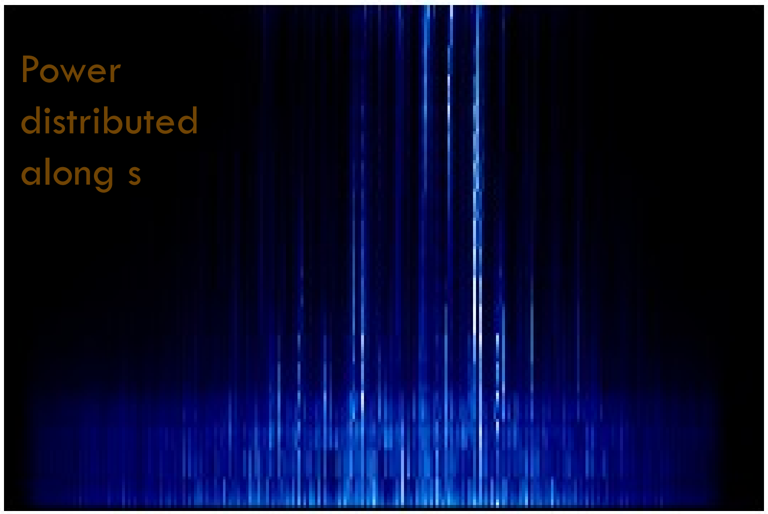
$L_{slice} \approx 7\ \mu m$

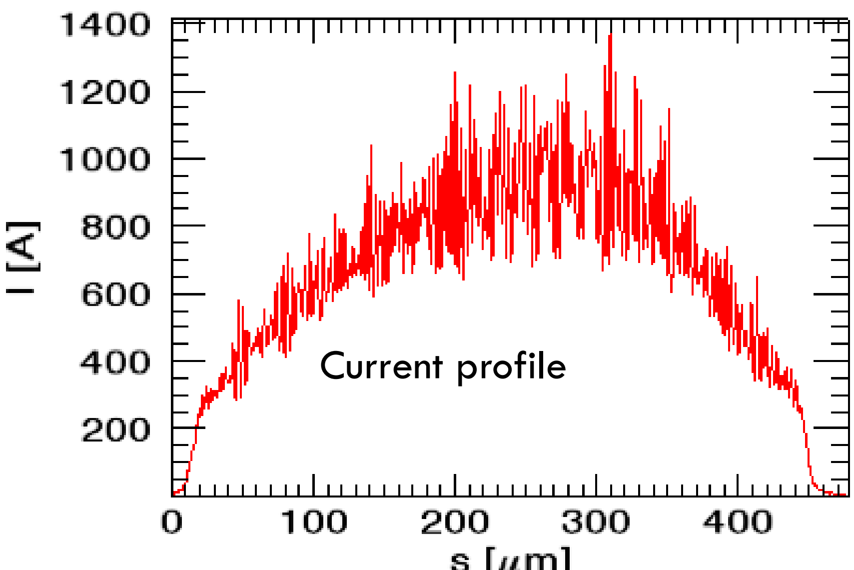
nc:LH P_{peak}=10 MW

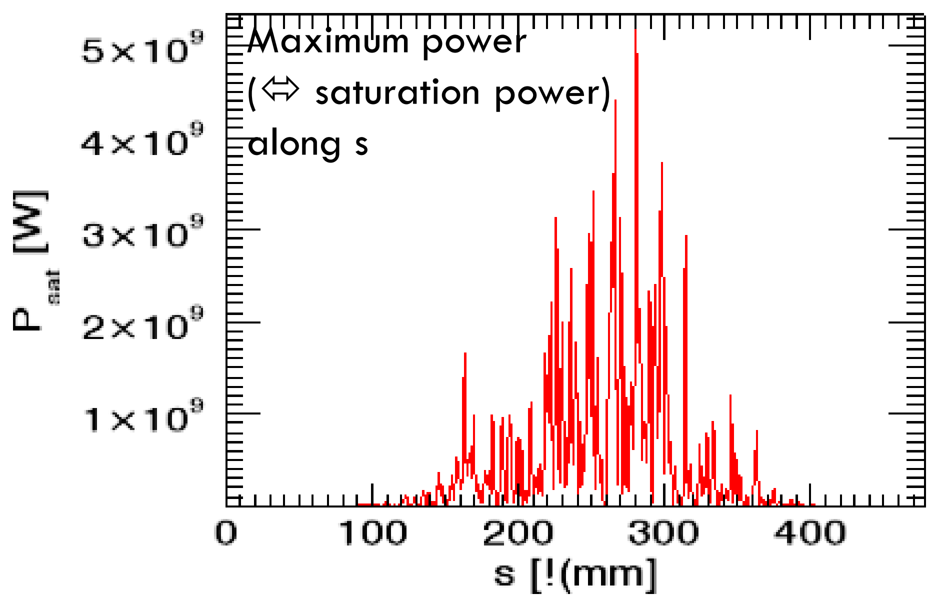


VUV 10 nm – 1 kA Non-compressed

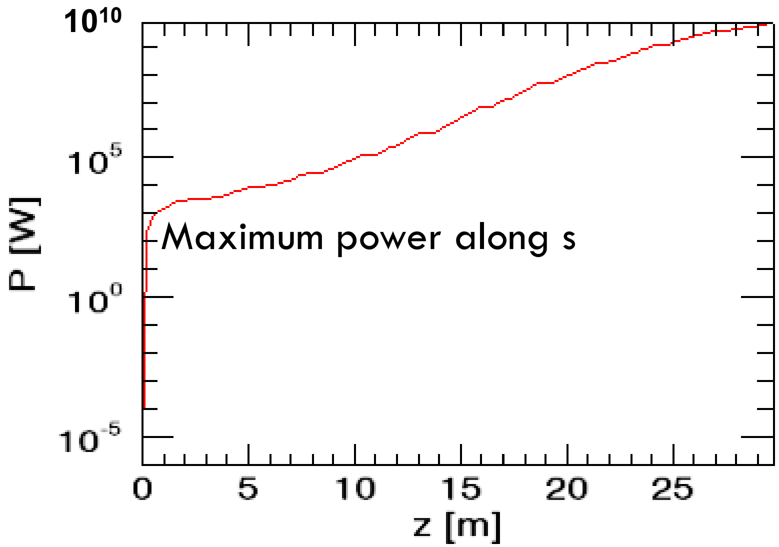


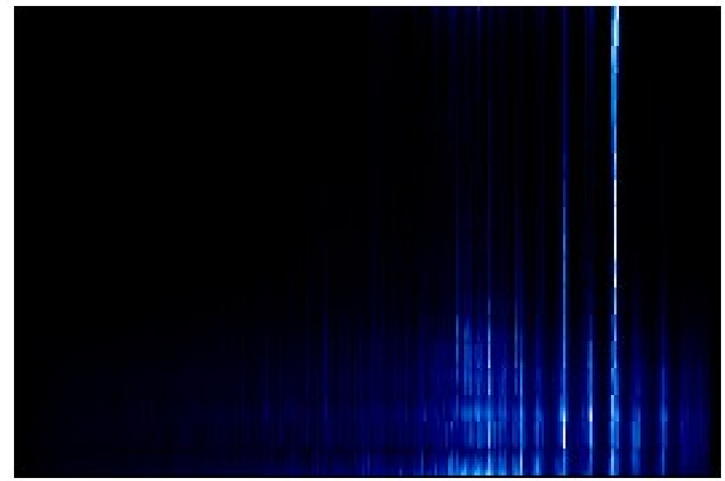


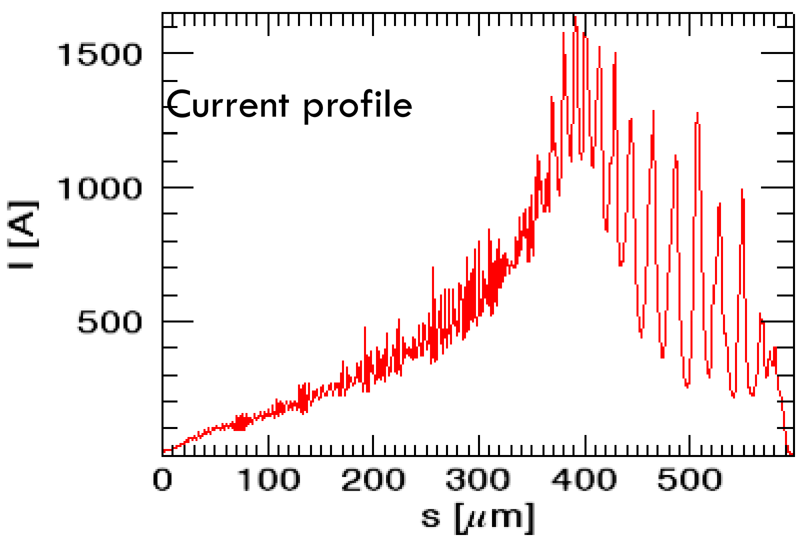


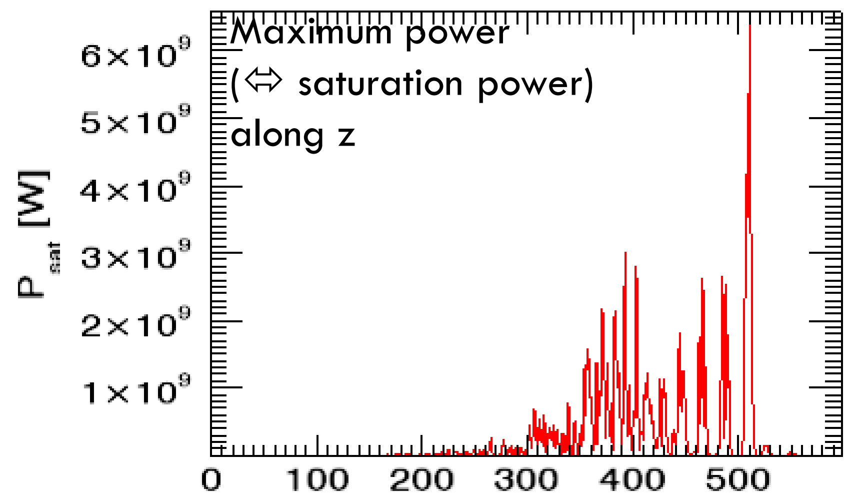


VUV 10 nm – 1 kA RF compressed



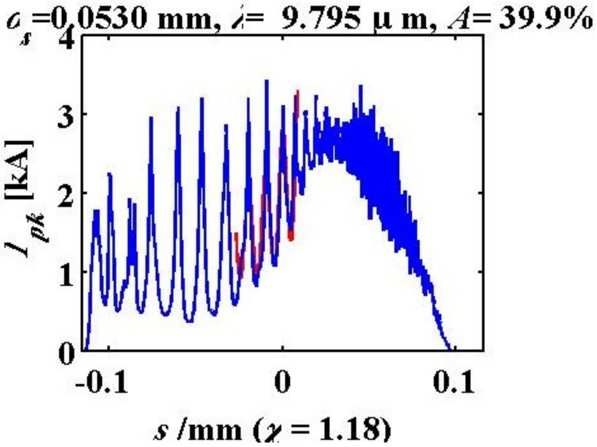


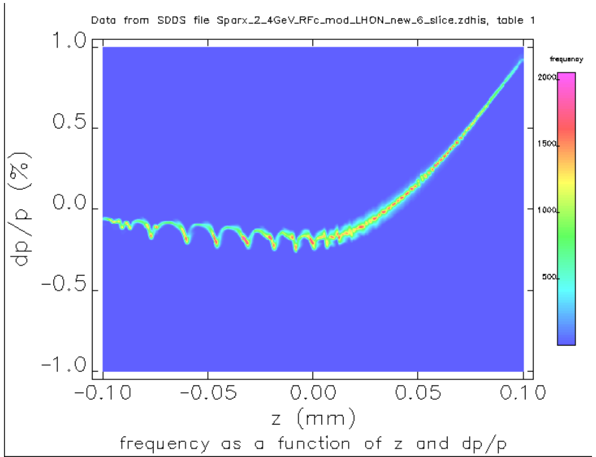




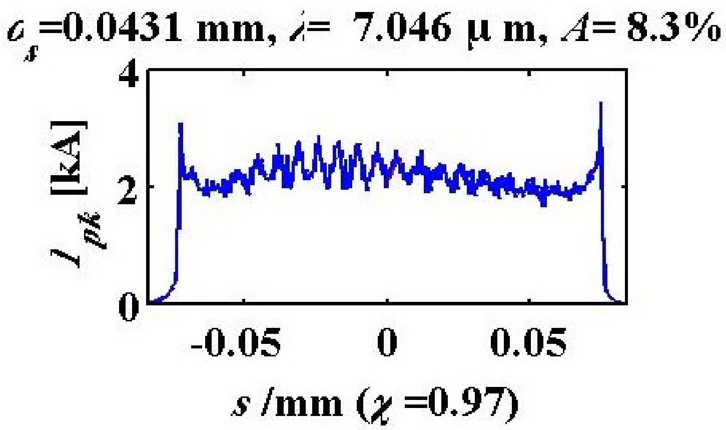
At 2.4 GeV DL3 dogleg end:

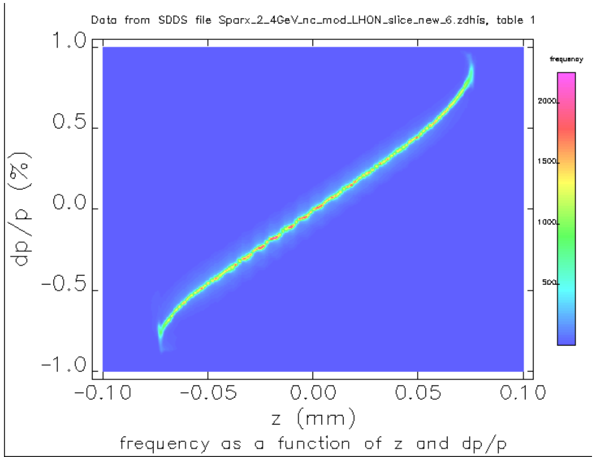
Rfc LH P_{peak}=10 MW





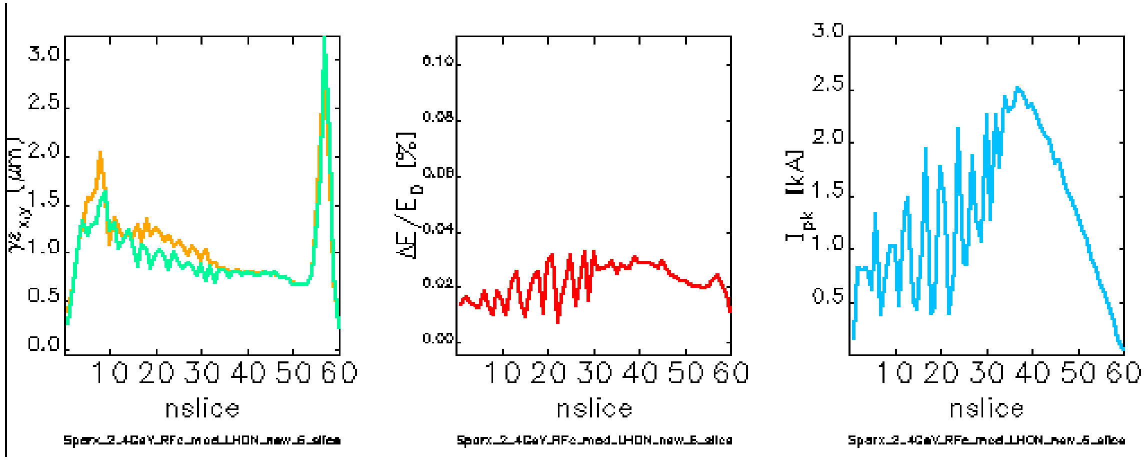
nc LH P_{peak}=10 MW





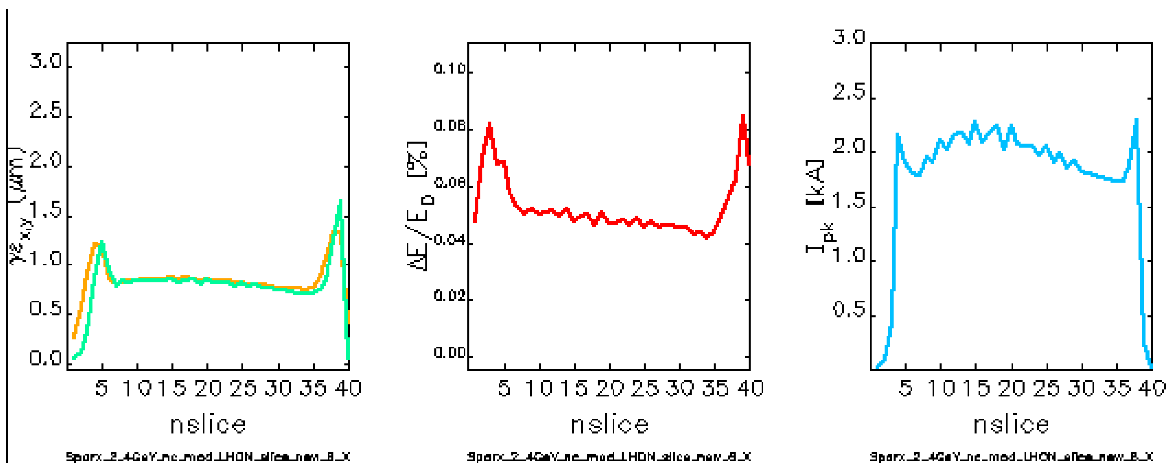
At 2.4 GeV DL3 dogleg end:

Rfc :LH P_{peak}=10 MW



$L_{slice} \approx 4\ \mu m$

nc:LH P_{peak}=10 MW



Conclusions

- Two WP, i.e. two compression schemes, for the SPARX FEL have been analyzed from the point of view of sensitivity to the microbunching instability effect.
- The case described is somewhat extreme and also the LH effect has been kept on the edge of the SASE Saturation trying to enhance the wp intrinsic features.
- The "RFc" case allows to avoid the X-band linearization prior the compression, but the induced instability looks harder to master at low energies comparing with the "nc" case.
- At higher energies the effect is less severe for the two schemes
- What next:
  - The noise modulation that comes out downstream the photoinjector in the RFc case would probably require more effort in carrying out the numerical simulation
  - Significant contribution can come from the comparison with the experimental results obtained and future for the two compression schemes respectively.