



SRF Photo Injector for Electron-Laser Interaction



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on behalf of
the ELBE and the Rossendorf SRF Gun Crew

LA³NET conference: Laser applications at accelerators, Mallorca, Spain, 25-27th March 2015

Outline



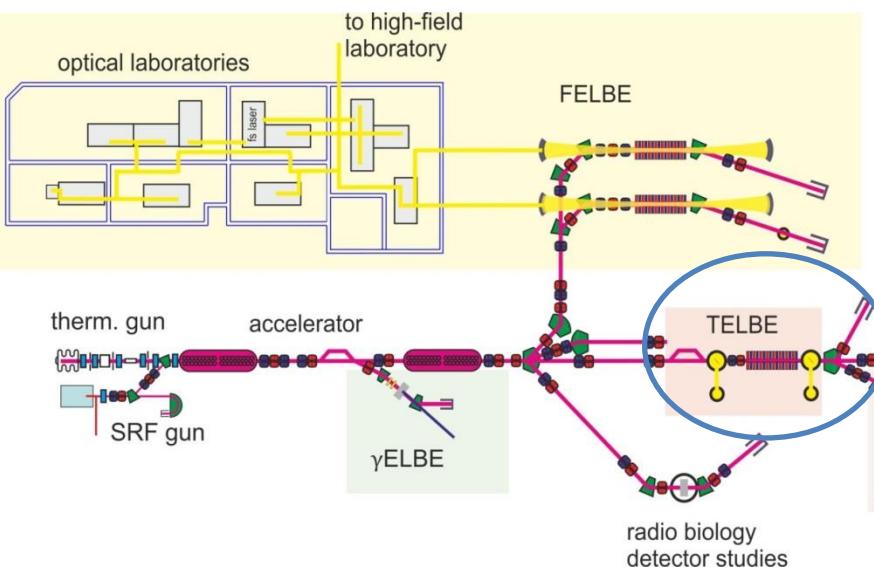
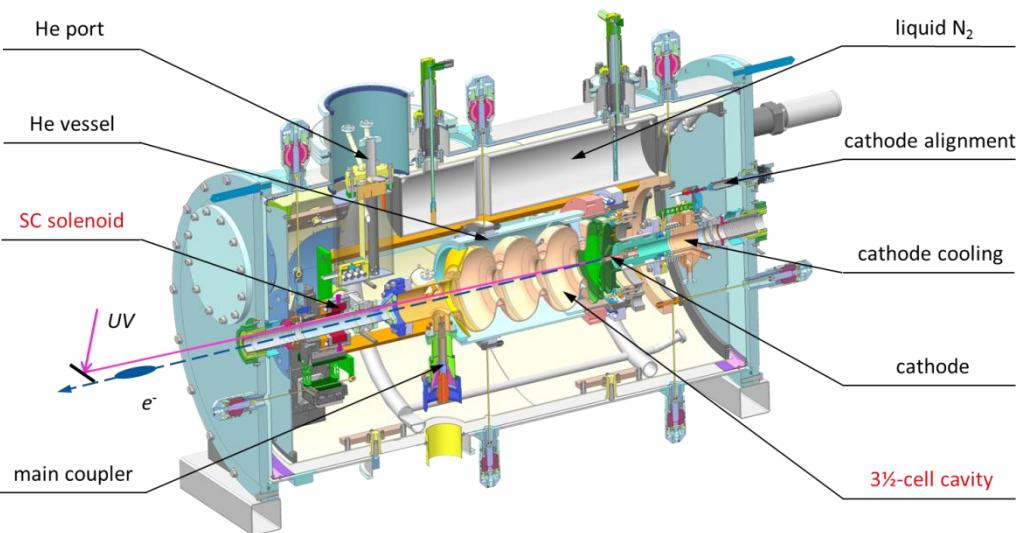
- Motivation
- Simulation design
- Simulation results
- Check with first experiment results



- Motiv.
- Design
- Results
- Check

SRF Gun II @ ELBE

1 nC, 5 MeV electron bunch expected. (500 kHz)

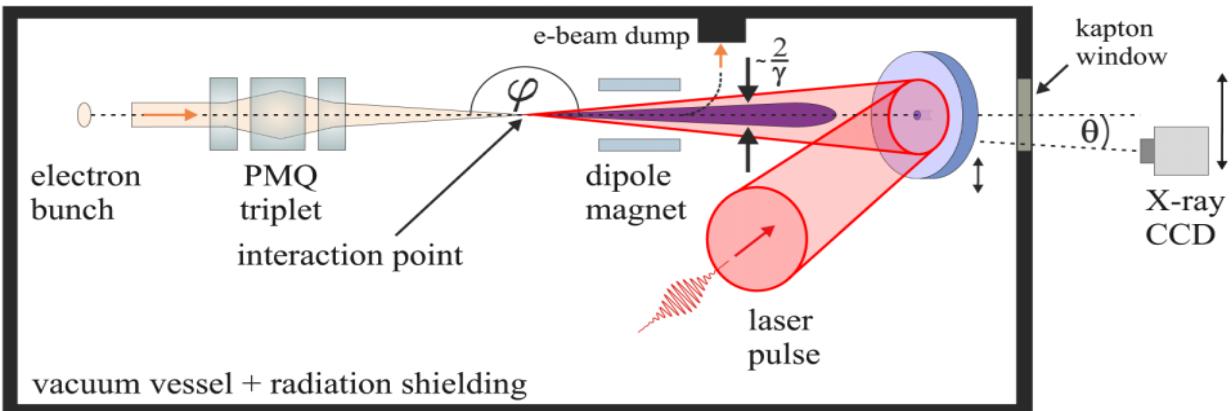


interest of high bunch charge

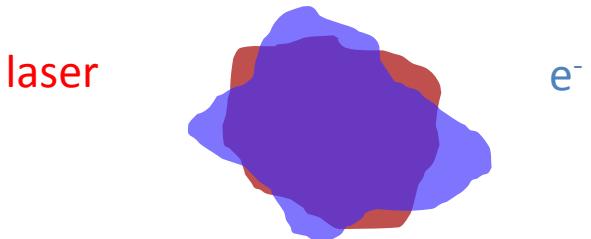
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Compton Back Scattering (CBS) experiment



A. Jochmann, et. al., PRL 111, 114803 (2013)



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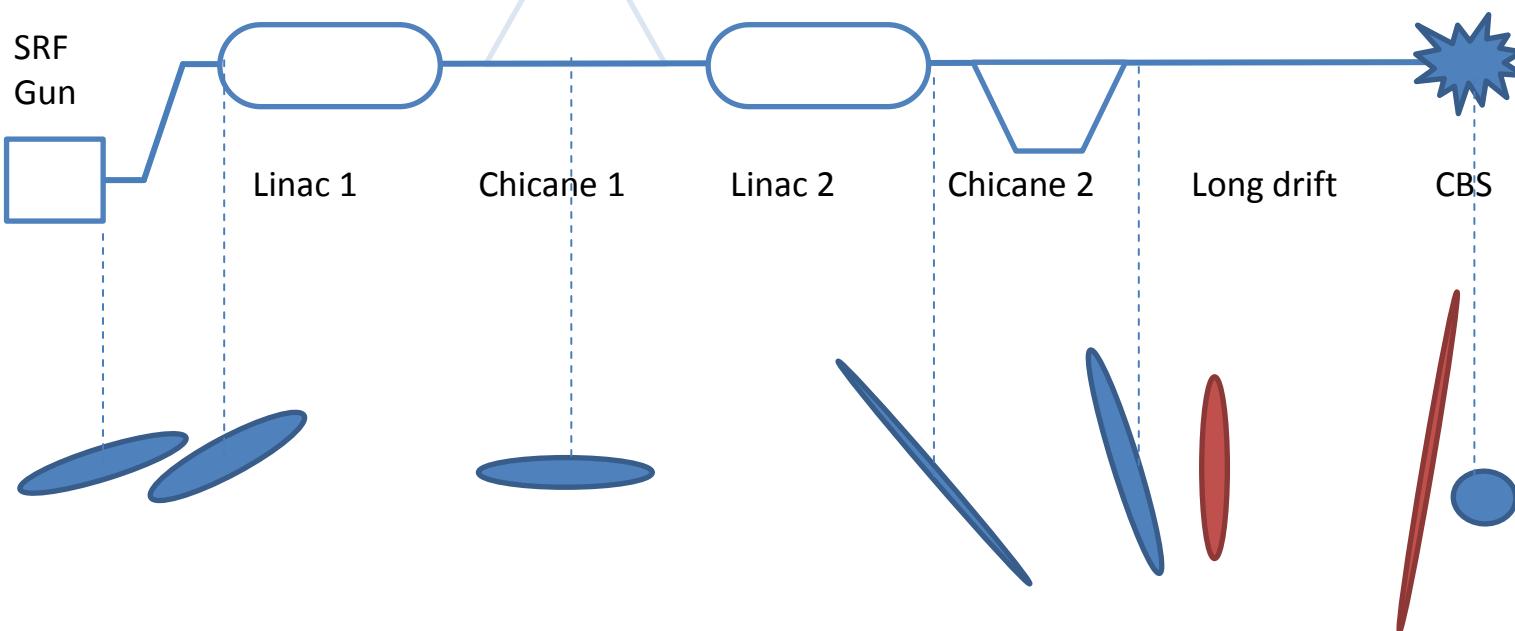
- DRACO laser: 30 μm rms beam size
- e^- must < 30 μm

- Longitudinal → transverse e. g., Energy spread → emittance ↗
- Keep low energy spread
- Longitudinal space charge “benefits” in drift distance



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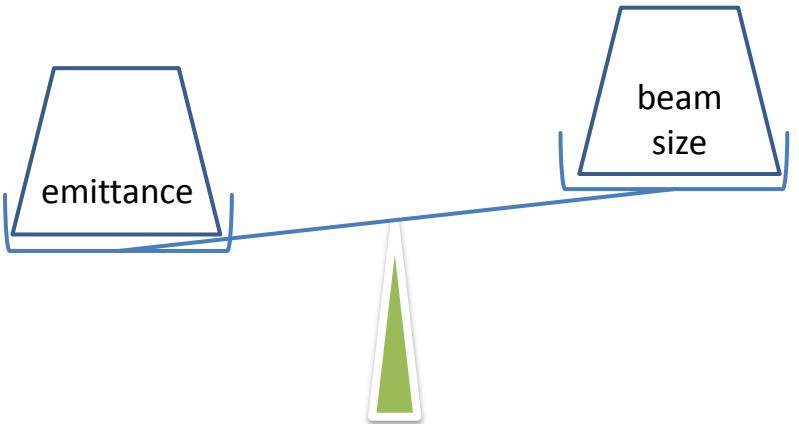


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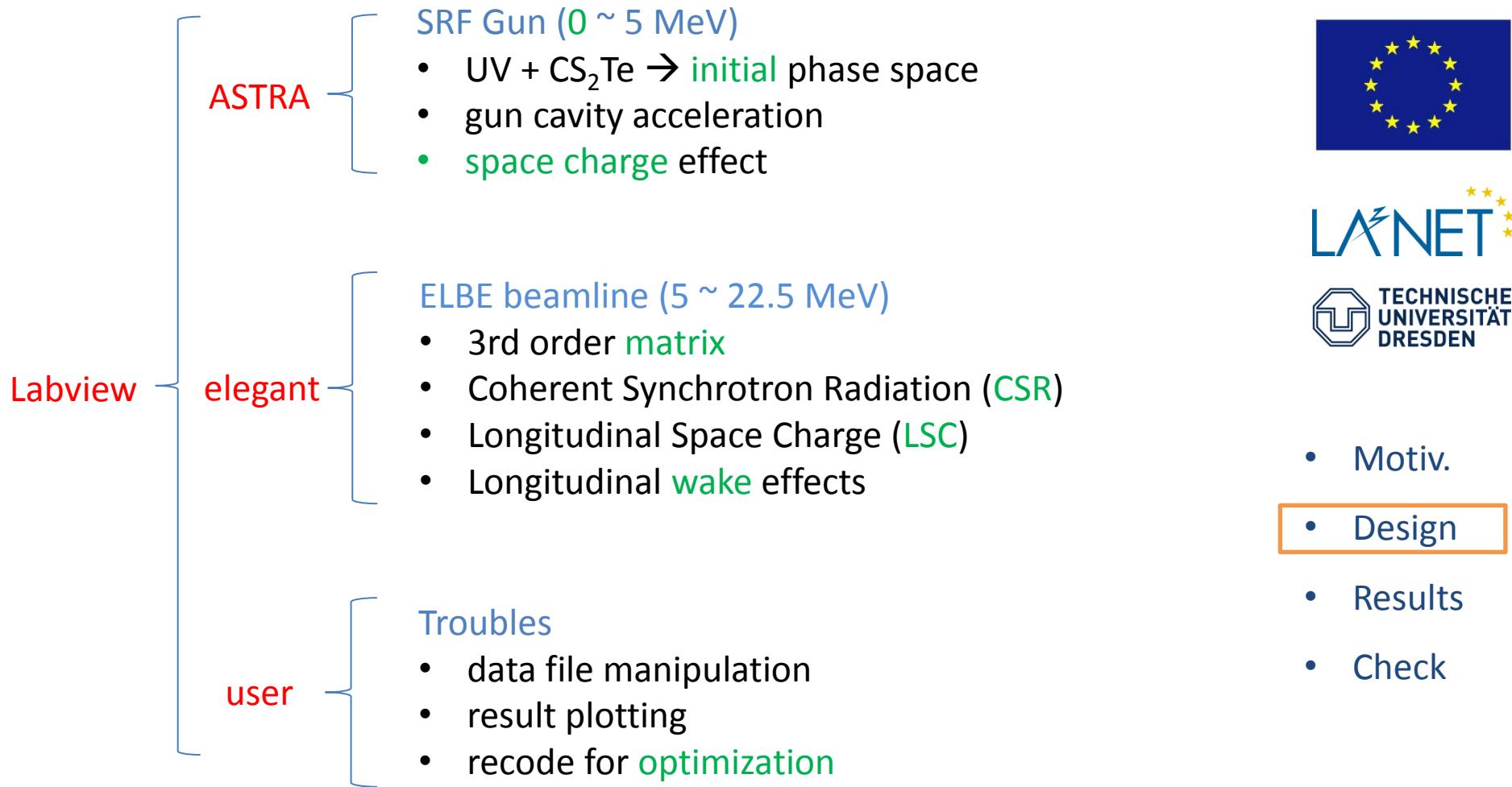
- SRF Gun: **5 free parameters scanning**, tradeoff decision



- 80 m beamline: **35 free parameters, automatic simplex optimization**



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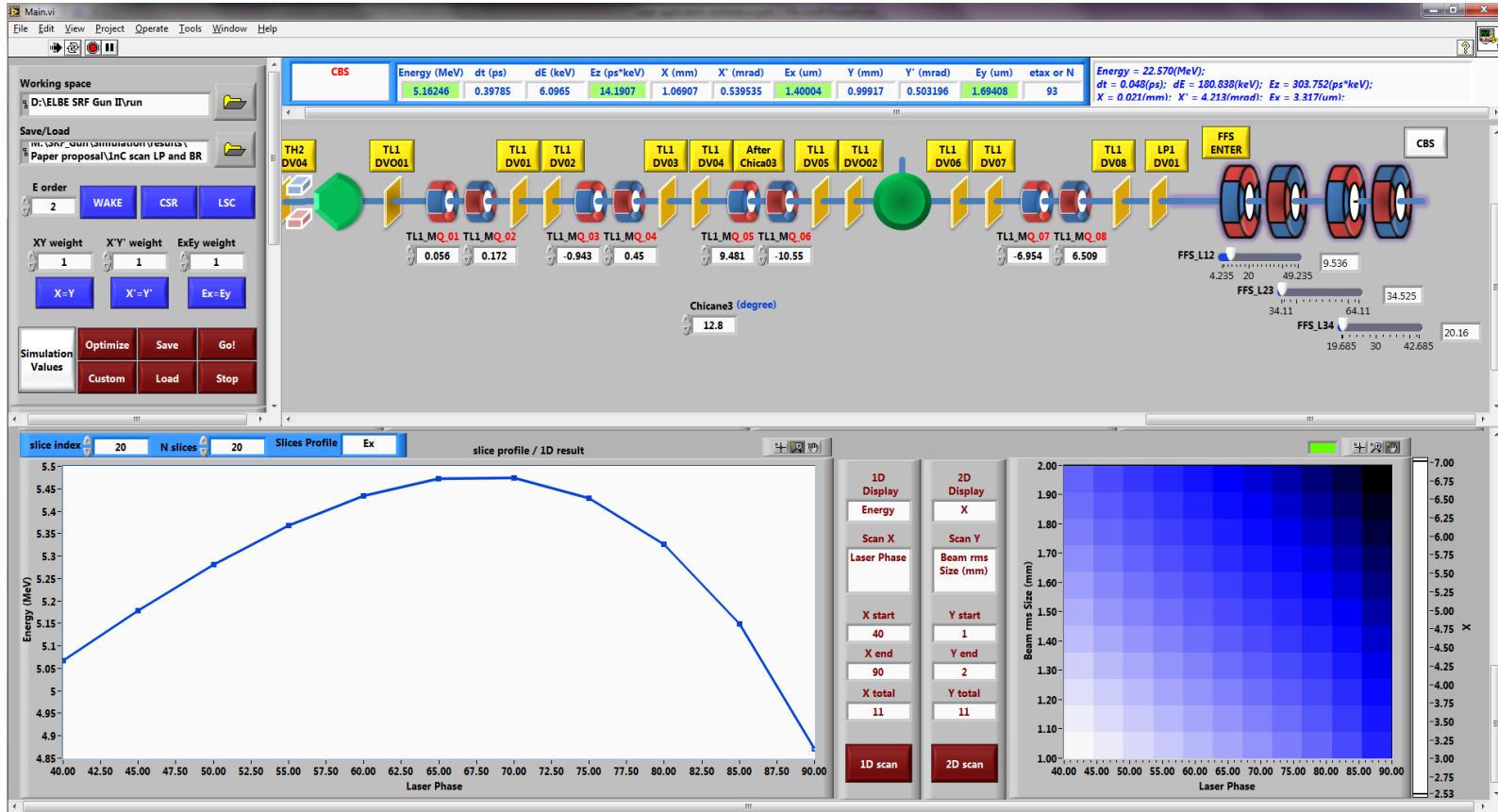


Simulation tool

Make something **alive** after Ph. D. ...



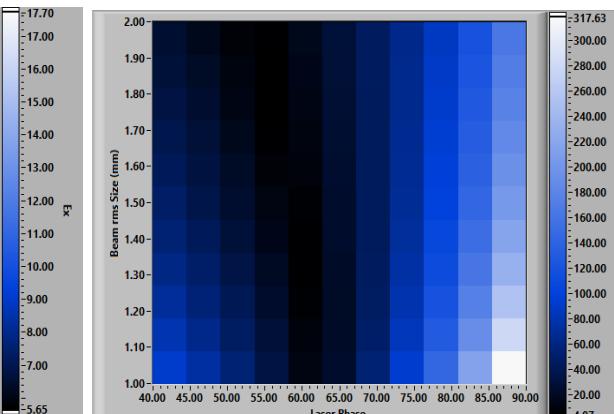
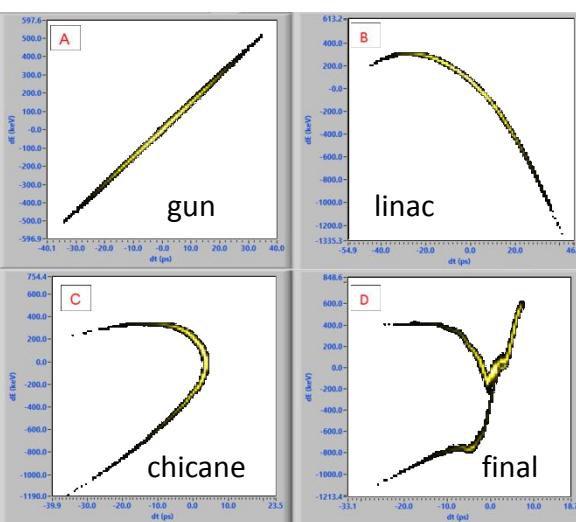
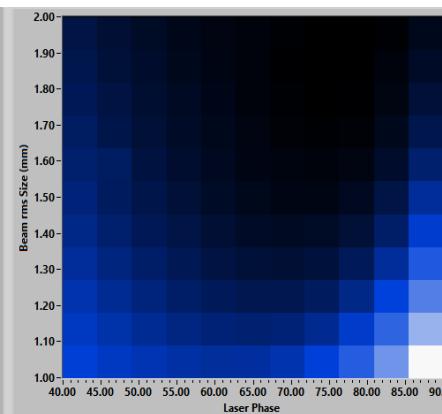
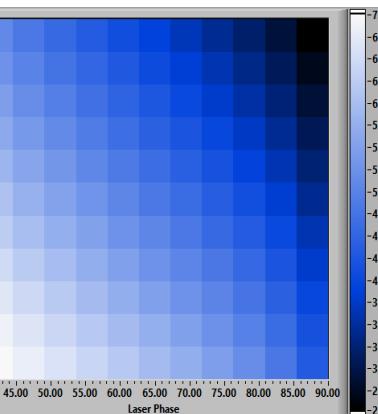
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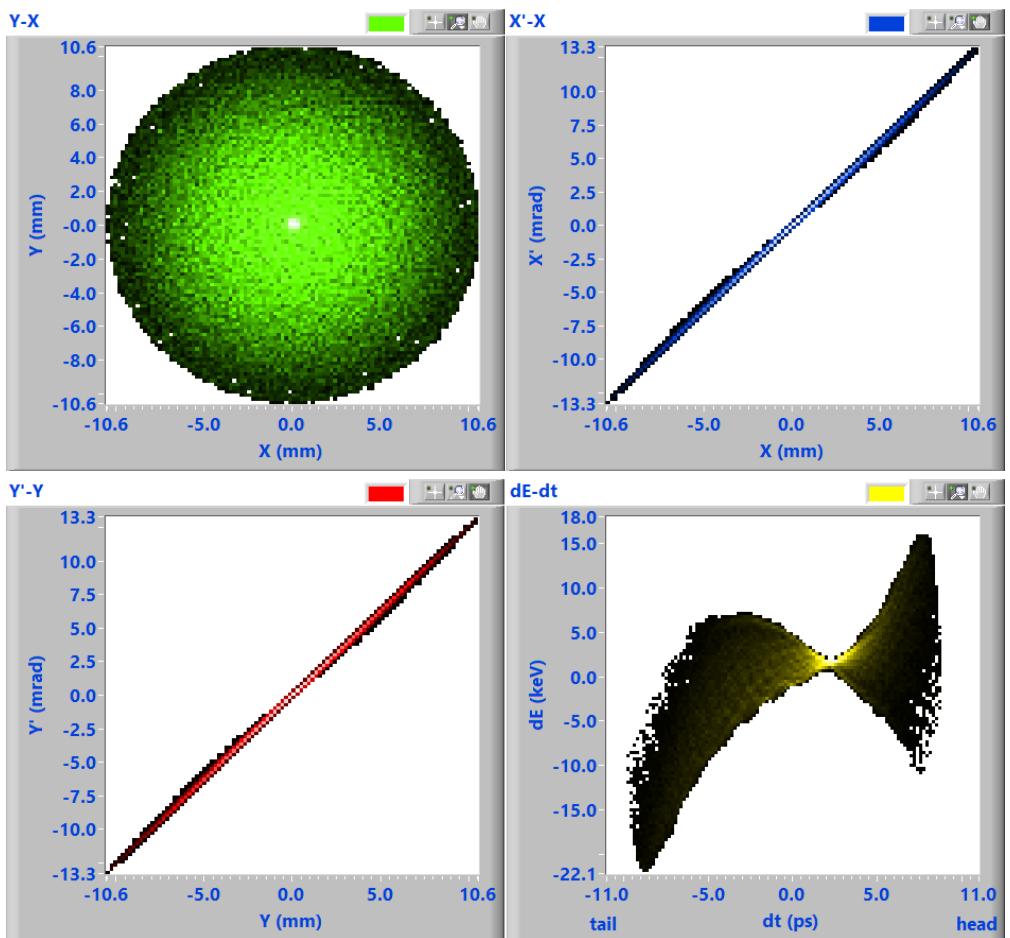
SRF Gun parameters determination



- short UV laser: 1.3 ps, or else:
- Initial beam size: **the larger the better**
- laser phase for energy & energy spread
- cathode position, DC voltage...



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Energy = 5.368(MeV);

$dt = 4.337(\text{ps})$;

$dE = 5.567(\text{keV})$;

$Ez = 17.127(\text{ps} \cdot \text{keV})$;

$X = 4.328(\text{mm})$;

$X' = 5.403(\text{mrad})$;

$Ex = 6.030(\mu\text{m})$;

$Y = 4.328(\text{mm})$;

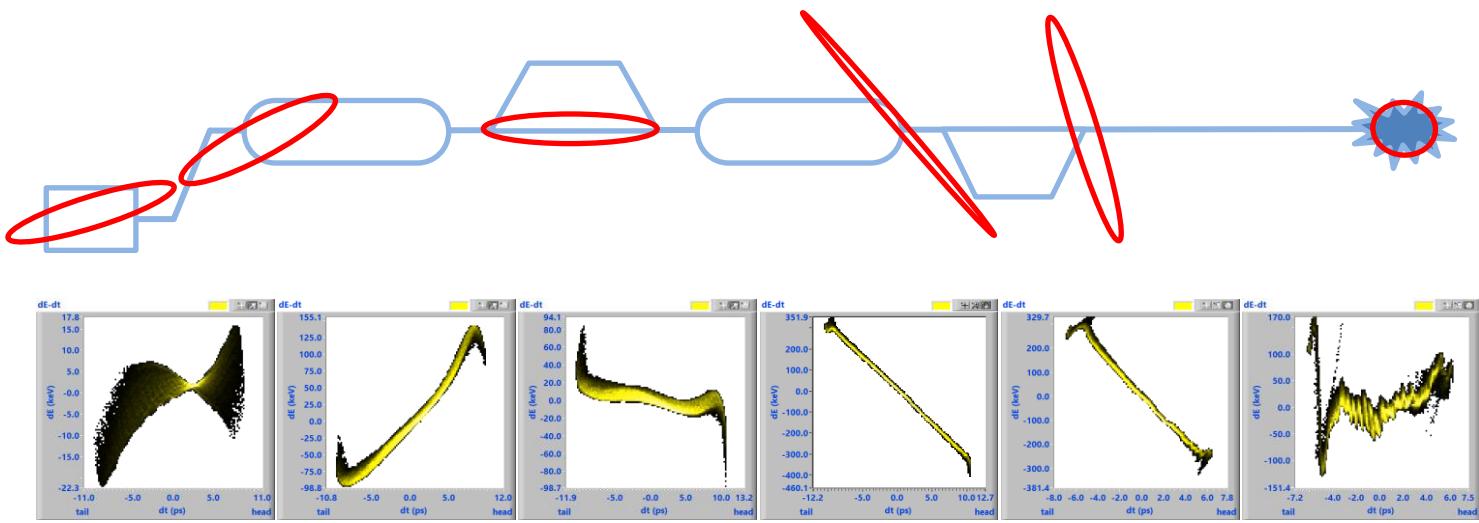
$Y' = 5.403(\text{mrad})$;

$Ey = 6.037(\mu\text{m})$;



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transport results — longitudinal

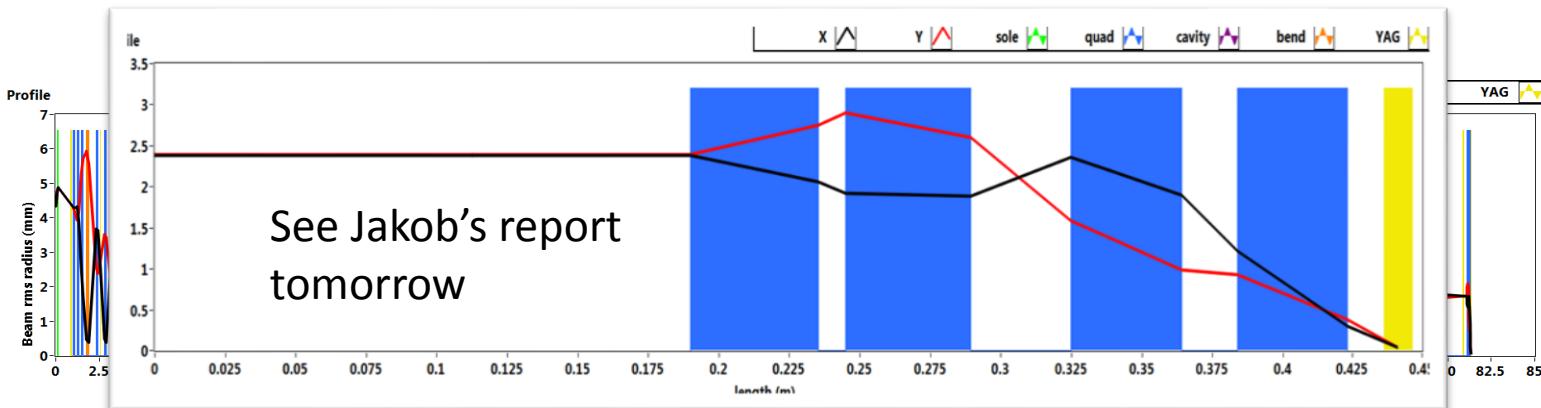


position	gun exit	before Linac 1	after Linac 1	after Linac 2	after Chicane 2	CBS point	Motiv.
energy (MeV)	5.368	5.343	14.970	22.631	22.591	22.567	• Design
dt (ps)	4.337	4.692	5.505	5.489	3.179	2.877	• Results
dE (keV)	5.567	61.923	10.565	173.15	150.588	36.64	• Check
Ez (ps*keV)	17.127	60.995	40.127	41.12	50.79	95.52	

- Energy decrease: longitudinal wakes & coherent synchrotron radiation (CSR)
- dt & dE changes in drift: longitudinal space charge (LSC)



Transport results — transport



Beam parameters at the CBS point

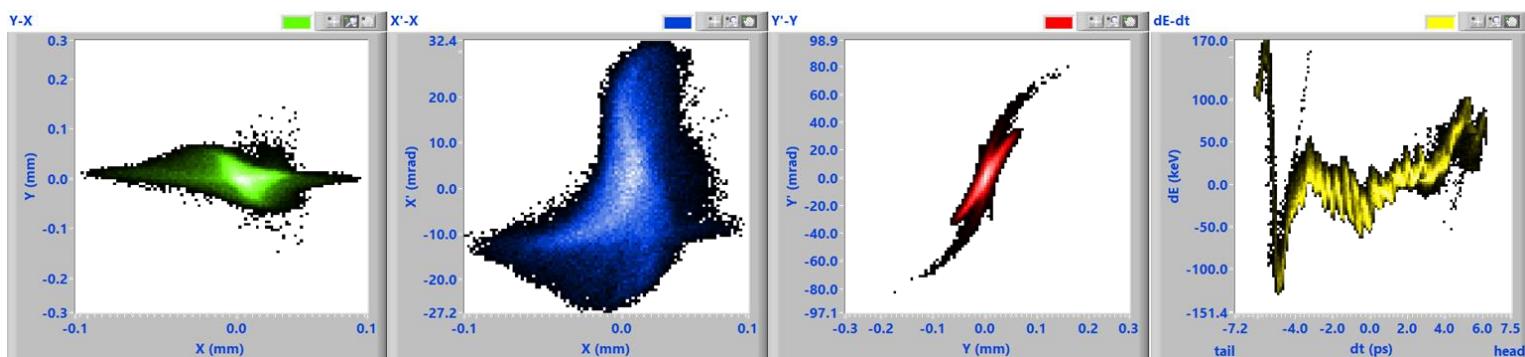
Energy = 22.567(MeV);

dt = 2.877(ps); dE = 36.654(keV); Ez = 95.543(ps*keV);

X = 0.021(mm); X' = 12.091(mrad); Ex = 11.035(um);

Y = 0.021(mm); Y' = 15.762(mrad); Ey = 7.279(um);

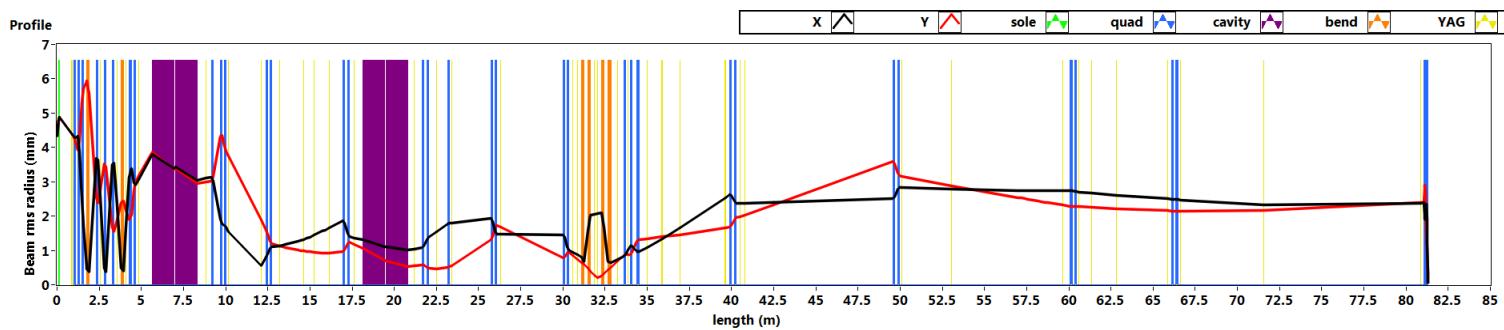
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Compress the bunch to 1 pC



Beam parameters at the CBS point.

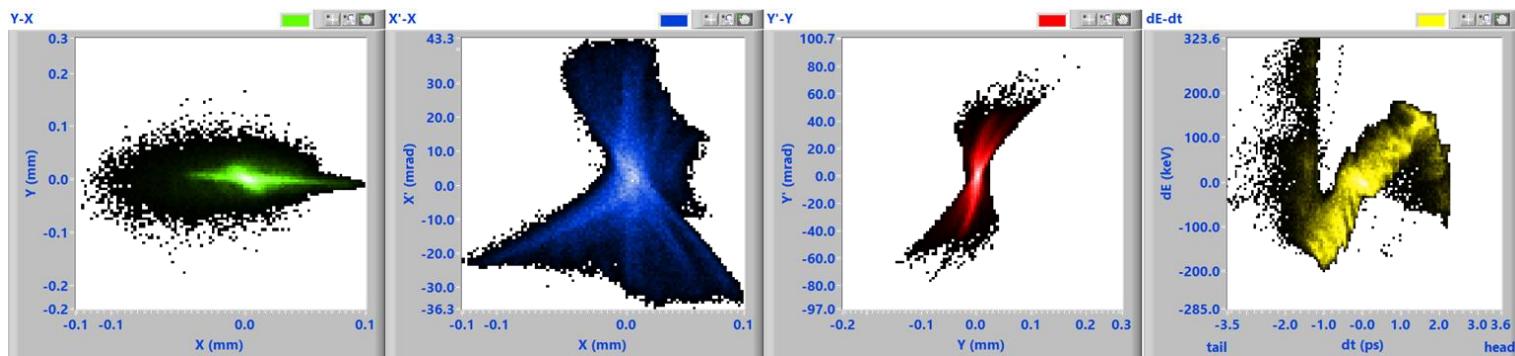
Energy = 22.523(MeV);

$dt = 1.013(\text{ps})$; $dE = 93.29(\text{keV})$; $E_z = 79.106(\text{ps} \cdot \text{keV})$;

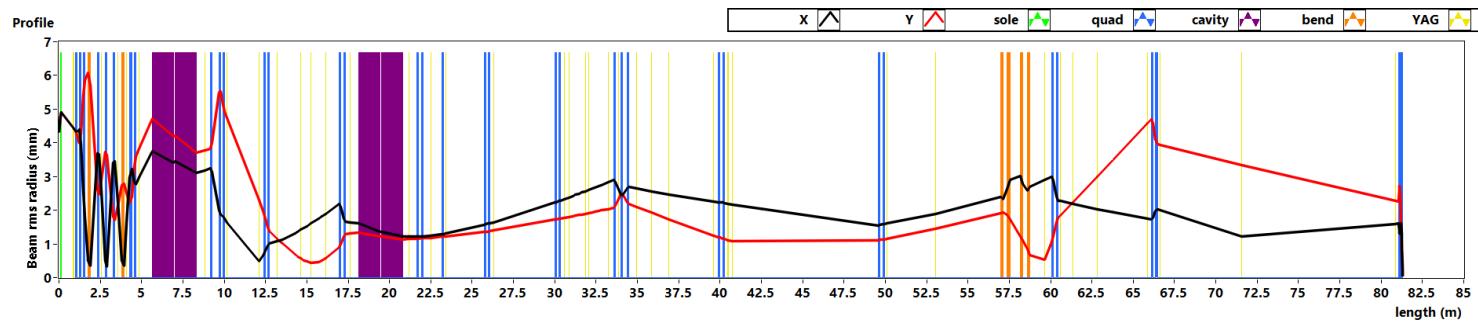
$X = 0.029(\text{mm})$; $X' = 16.446(\text{mrad})$; $E_x = 20.293(\mu\text{m})$;

$Y = 0.028(\text{mm})$; $Y' = 22.122(\text{mrad})$; $E_y = 15.348(\mu\text{m})$;

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For better longitudinal phase space...



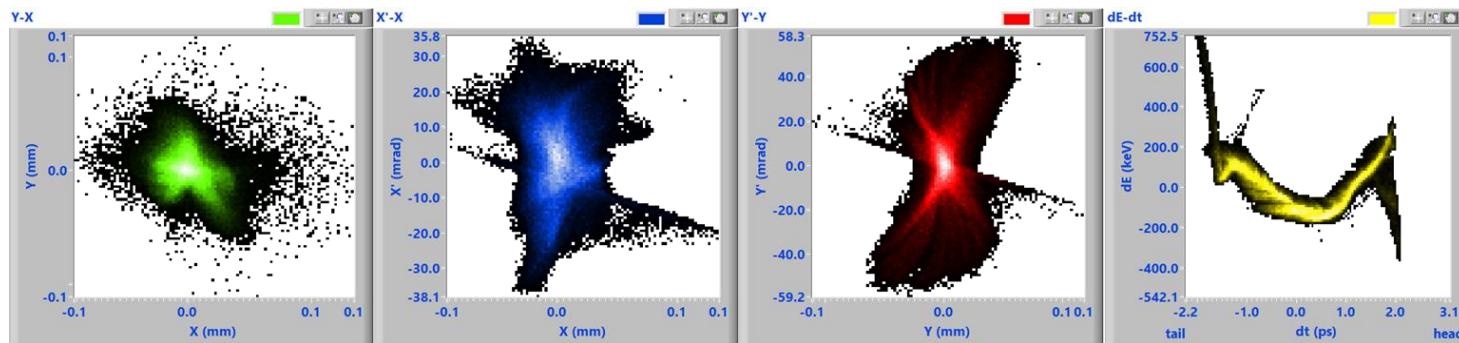
Beam parameters at the CBS point.

Energy = 22.543(MeV);

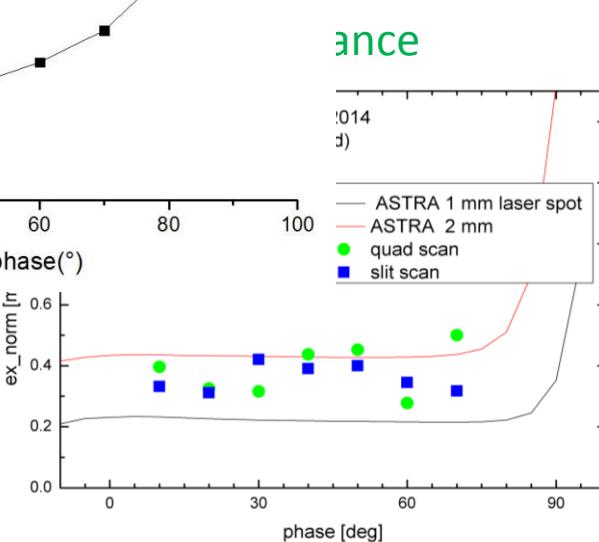
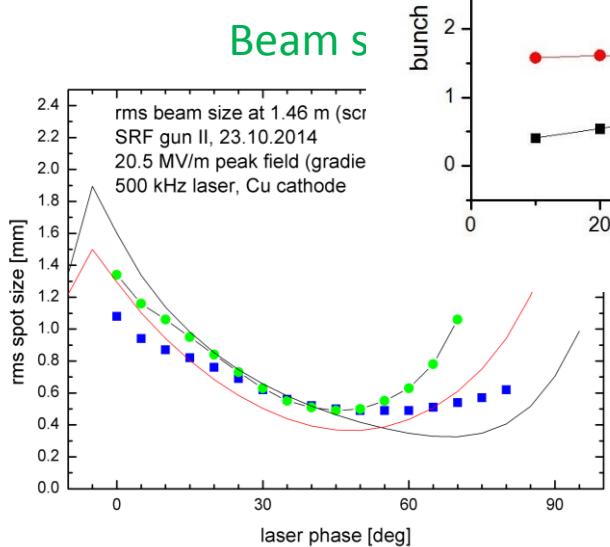
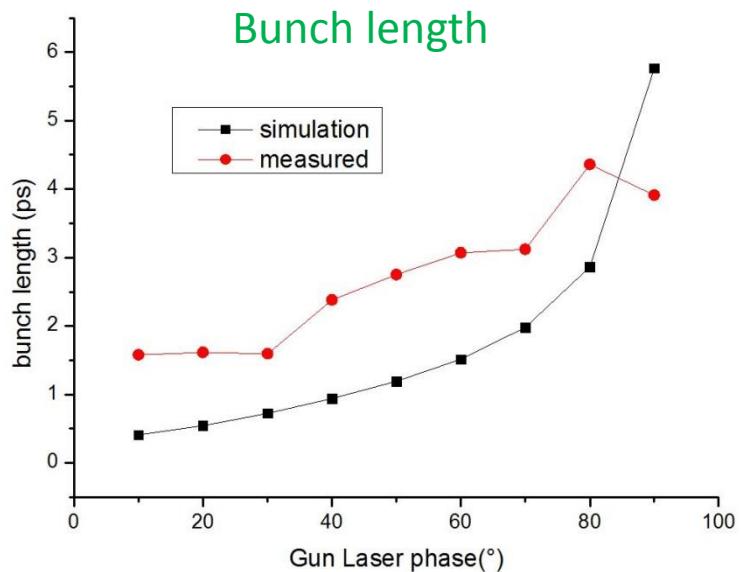
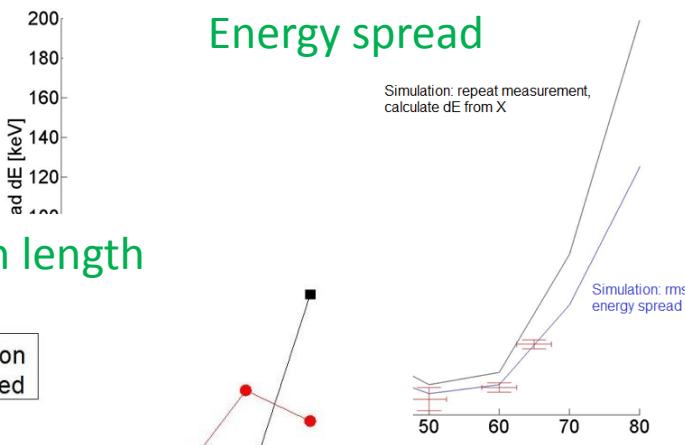
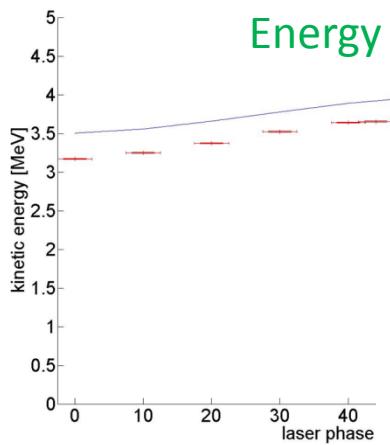
dt = 1.021(ps); dE = 155.495(keV); Ez = 148.965(ps*keV);

X = 0.019(mm); X' = 11.135(mrad); Ex = 9.232(um);

Y = 0.018(mm); Y' = 21.192(mrad); Ey = 16.193(um);



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• Check




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Comparison to experiments

4.5MeV, 1.8 pC, beam transport in dogleg

