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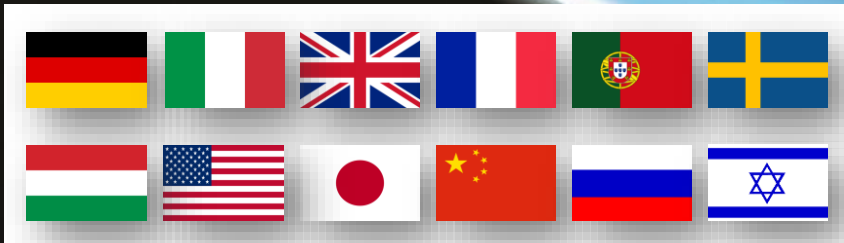


6D Characterization of Witness Beam before Injection in LWFA

B. Marchetti

1st EuPRAXIA Collaboration Week

DESY, 19-23 June 2017



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Characteristics of Witness Beams

From EuPRAXIA parameter table LWFA with external injection:

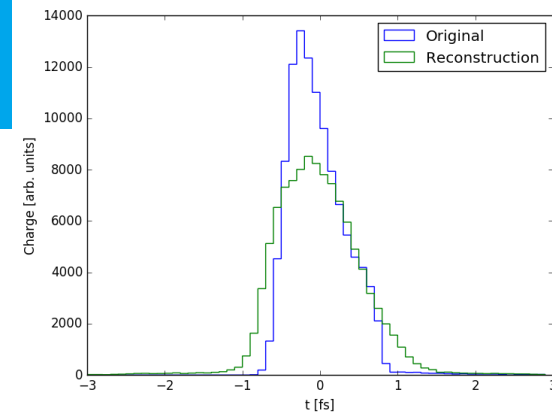
Quantity	Symbol	Baseline value	Range of exploration	
			Lower limit	Upper limit
RF injector beam: at entrance of plasma 2				
Energy	E	160 MeV	100 MeV	200 MeV
Charge	Q	50 pC	10 pC	50 pC
Bunch length (RMS)	τ	38 fs	3 fs	30 fs
Peak current per bunch	I	3 kA	1 - 10 kA	
Shaped profile	-	Gaussean	triangular	
Total energy spread (RMS)	σ_E/E	0.2 %	0.2 %	
Transverse normalized emittance	$\epsilon_{N,x}, \epsilon_{N,y}$	1 mm mrad	1 mm mrad	
Transverse norm. slice emittance	$\epsilon_{N,x,S}, \epsilon_{N,y,S}$	tbd	tbd	
Slice length	Z_s	tbd	tbd	
Jitter, beam to global reference (RMS)	$\sigma_{\Delta t}$	10 fs	10 fs	

- At SINBAD we are investigating the range $Q=0.5\text{pC}-30\text{pC}$, especially **the limit in the characterization of very low charge and ultra-short e-bunches**.

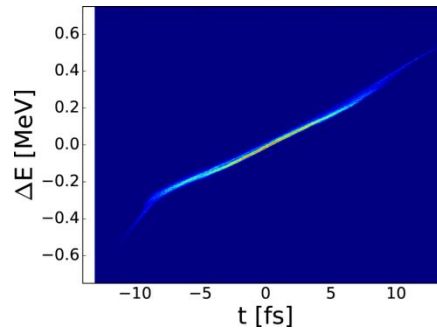


6D e-Beam Characterization includes

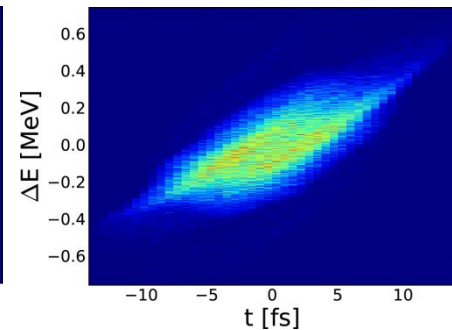
➤ Bunch Length and Longitudinal Charge Profile



➤ Longitudinal Phase Space



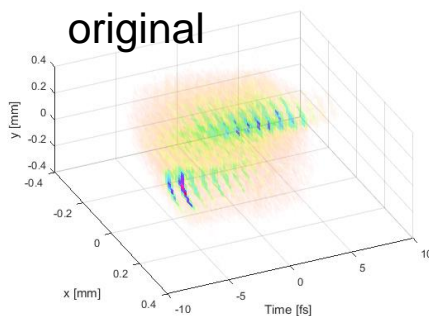
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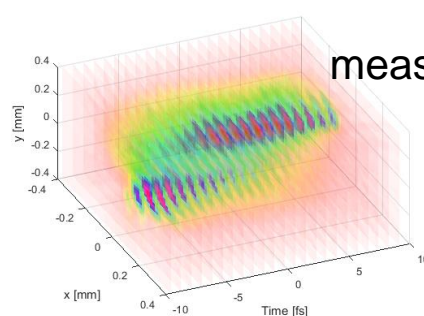
measured

➤ Slice emittance on different transverse planes

➤ 3D Reconstruction of e-Bunch Charge (new technique, relies on novel design of TDS not yet experimentally tested)



original



measured

Simulations by D. Marx,
More details in joint WP3-WP5
Meeting Wednesday 16.00-18.00

General idea of Lattice Design

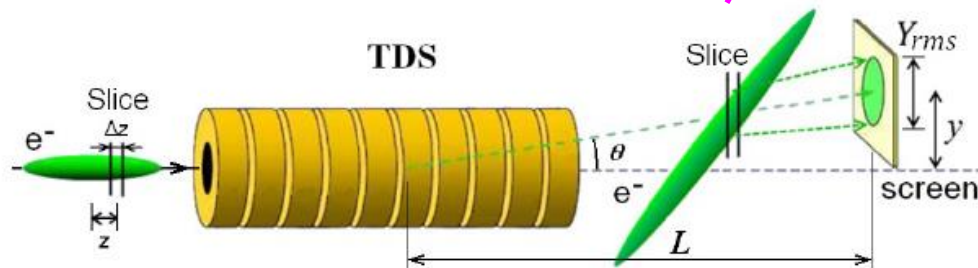
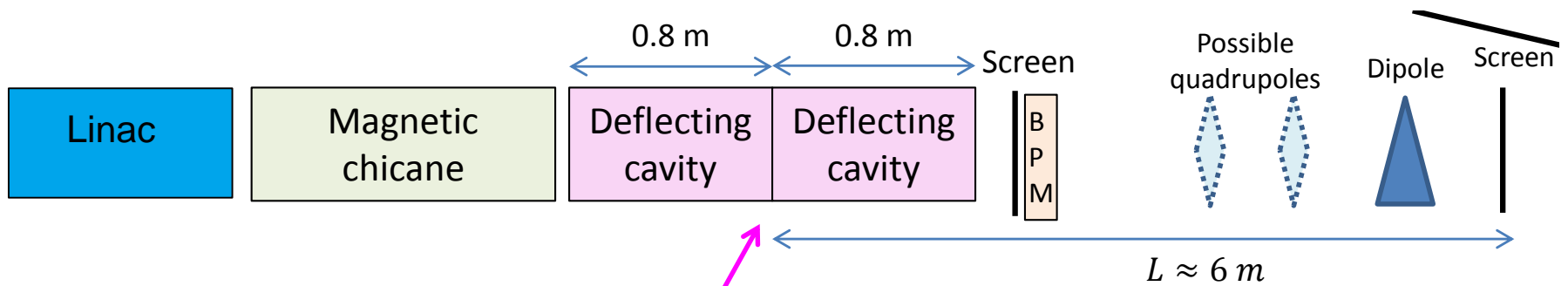


Fig. Credits: D. Malyutin PhD thesis

- > High frequency ~12 GHz (X-band) allows 3-4 times higher resolution than S-band

Longitudinal Resolution:

$$\mathcal{R}_{t,e} = \frac{\sigma_{y0}}{S_y} = \frac{\sqrt{\beta_y(s)} \epsilon_y E}{\sqrt{\beta_y(s) \beta_y(s_0)} \sin(\Delta\phi_y) e \omega V_y}$$

e-bunch:

- Energy E
- Vertical emittance ϵ_y

RF cavity:

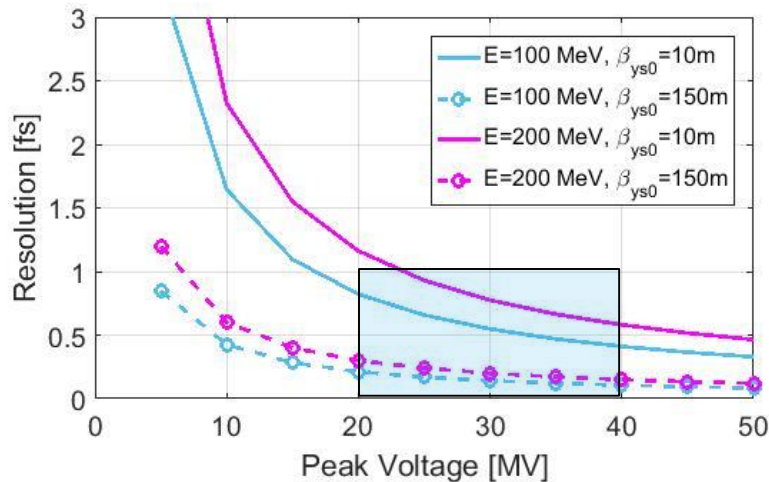
- Frequency $f = \omega/(2\pi)$
- Peak deflection voltage V_y

Resolution Range EuPRAXIA case

$$\epsilon_n = 0.3 \text{ mm} \cdot \text{mrad}$$

$$\Delta\varphi = \pi/2$$

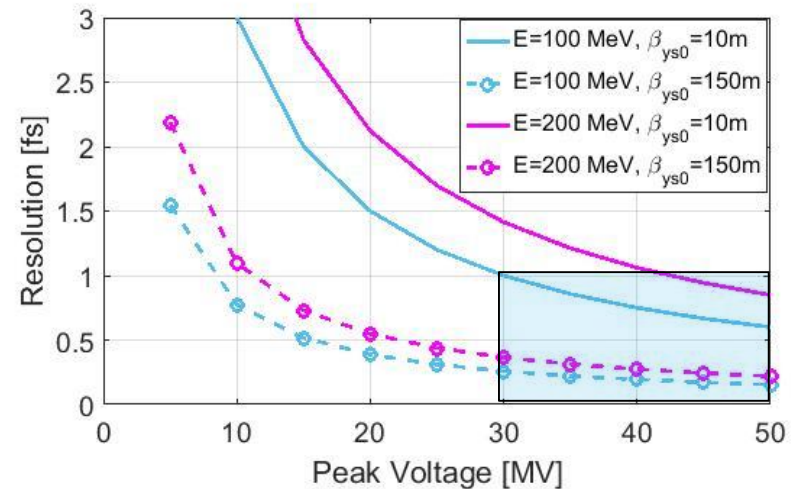
$$f = 12 \text{ GHz}$$



$$\epsilon_n = 1 \text{ mm} \cdot \text{mrad}$$

$$\Delta\varphi = \pi/2$$

$$f = 12 \text{ GHz}$$



- Typical β function after bunch compression $< 30\text{m}$.
- At low energies (100 MeV) the e-beam evolves relatively quickly (the e-bunch properties change along a few m drift or matching lattice).



Technical Issues to be addressed in the WP5 discussion

Resolution & lattice design:

- At which energy is/are the diagnostics line/s?
- High β - low V option vs low β - high V option
- Integration of diagnostics line with focusing to plasma

Limits high voltage TDS operation:

- RF Phase jitter
- Arrival time beam jitter
- Temperature stability of the cavity

Limits high resolution measurement at low charge

- Signal to noise ratio on the measurement screen

