Beam Uniformity

WP6 Meeting Update

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ROYAL HOLLOWAY UNIVERSITY OF LONDON

LhARA Laser-hybrid Accelerator for Radiobiological Applications

JAI John Adams Institute for Accelerator Science

Beam Uniformity

Literature

PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS **10**, 104001 (2007)

Uniformization of the transverse beam profile by means of nonlinear focusing method

Yosuke Yuri, Nobumasa Miyawaki, Tomihiro Kamiya, Watalu Yokota, and Kazuo Arakawa
Takasaki Advanced Radiation Research Institute, Japan Atomic Energy Agency, 1233 Watanuki-machi, Takasaki, Gunma 370-1292, Japan

Mitsuhiro Fukuda
Research Center for Nuclear Physics, Osaka University, 10-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
(Received 16 April 2007; published 29 October 2007)

$$K_{2(n-1)} = 0,$$

$$K_{2n} = \frac{(n-2)!}{(n/2-1)!} \frac{(-1)^{n/2}}{(2\varepsilon\beta_0)^{n/2-1}} \frac{1}{\beta_0 \tan\phi}$$

$$2r_{\mathrm{t}} = \sqrt{2\pi}\sqrt{\varepsilon\beta_{\mathrm{t}}}|\cos\phi|,$$

Paper: Yuri et al (2007)

- Equations for predicting the uniform region that can be generated from a non-linear magnetic field (e.g octupole) and the strength of the magnet required.
- Full width of the uniform region is dependent on σ at the target and phase advance between the multipole and the target, ϕ
- $n\pi$ phase advance gives the maximum value of $2r_t$ which can be used to calculate the maximum possible uniform width of a given beam size for LhARA.

Beam Uniformity
Maximum Uniform Widths

$$K_{2(n-1)} = 0,$$

$$K_{2n} = \frac{(n-2)!}{(n/2-1)!} \frac{(-1)^{n/2}}{(2\varepsilon\beta_0)^{n/2-1}} \frac{1}{\beta_0 \tan\phi}$$

$$2r_t = \sqrt{2\pi}\sqrt{\varepsilon\beta_t}|\cos\phi|,$$

Maximum Width ($2r_t$)

- $\sqrt{\varepsilon\beta_t} = \sigma_t$
- $\cos(\phi) = 1$ ($\phi = n\pi$)

Max uniform width from current spot sizes

Spot Size, 2σ ⌀ (cm)	Full Uniform Width, $2r_t$ (cm)
3.0	1.88
2.0	1.25
1.0	0.00627

Required spot sizes for desired uniform widths

Uniform Width, $2r_t$ (cm)	Spot Size, 2σ ⌀ (cm)
3.0	4.79
2.0	3.19
1.0	1.60

Beam Uniformity

MAD-X Test Configuration

Testing the predictions of the Yuri equations with a test configuration of the Final Focus in MAD-X

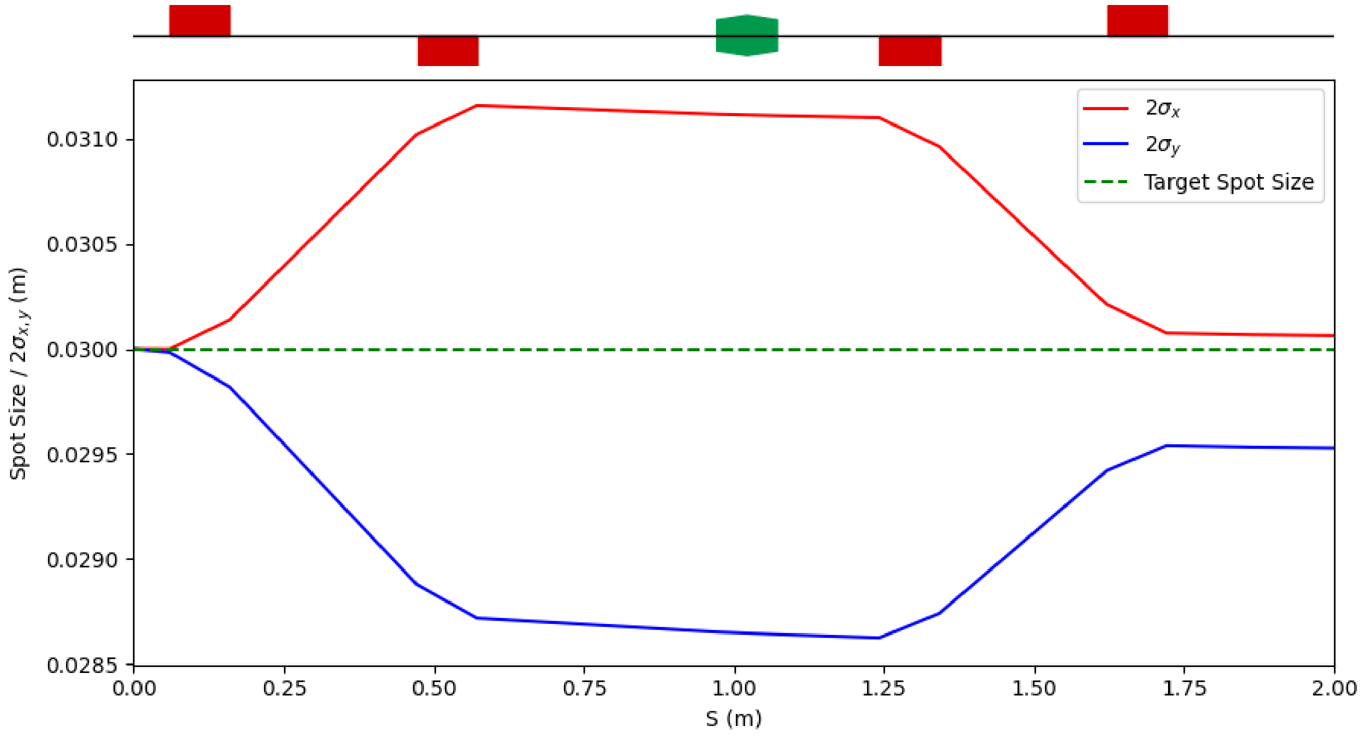
$\varepsilon = 4 \times 10^{-6}$ m

$\beta_t = 13.62$ m

$\phi = 0.07$ rad

$K_{2n} = 21{,}702$

$2r_t = 1.85$ cm



Magnet	QUAD_07	QUAD_08	OCT	QUAD_09	QUAD_10
Strength, k	0.933	0.964	21,702	-0.864	0.861

Beam Uniformity

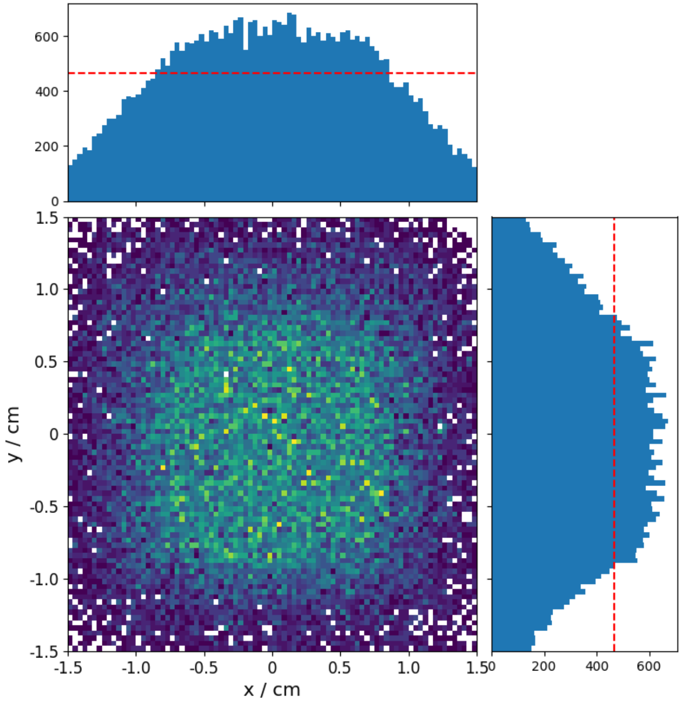
BDSIM Simulation and Uniformity Calculations

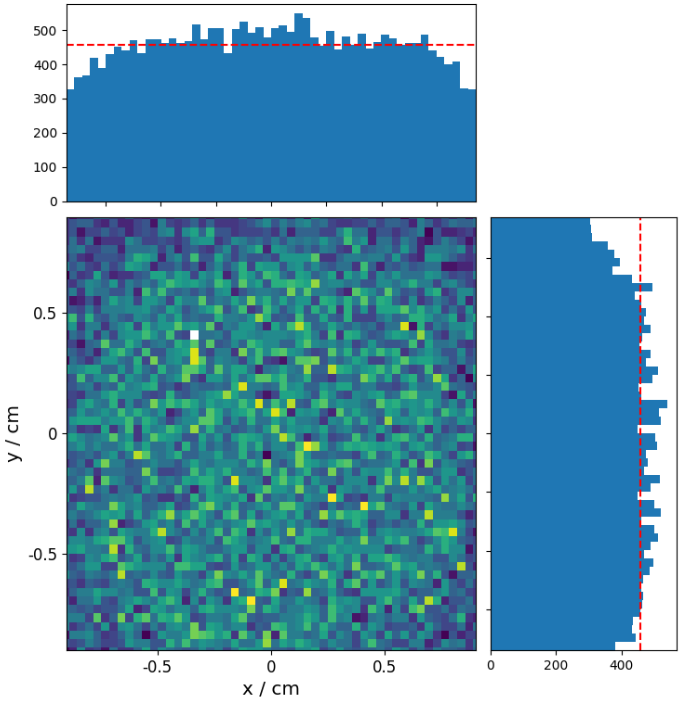
Testing the predictions of the Yuri equations with a test configuration of the Final Focus in BDSIM

K_{2n} = 21,702

$2r_t$ = 1.85 cm

3.0 cm beam of 41,000 Protons (15 MeV)





Examined Width (cm)	X Uniformity (%)	Y Uniformity (%)	Beam Capture (%)
3.0	64.0	63.3	95.5
1.85	89.0	88.3	58.1

Thank You

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