Injection Design for IOTA

Sergey Antipov

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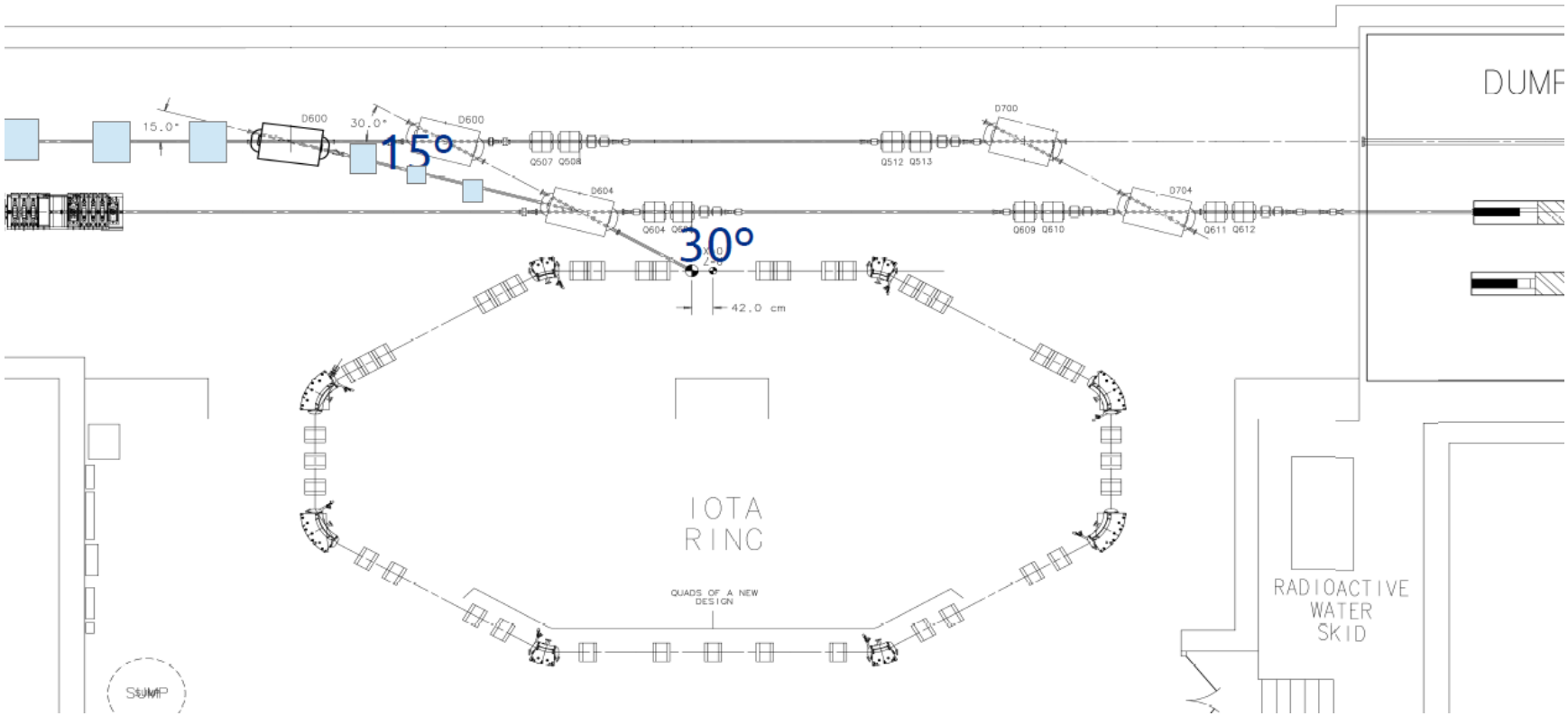


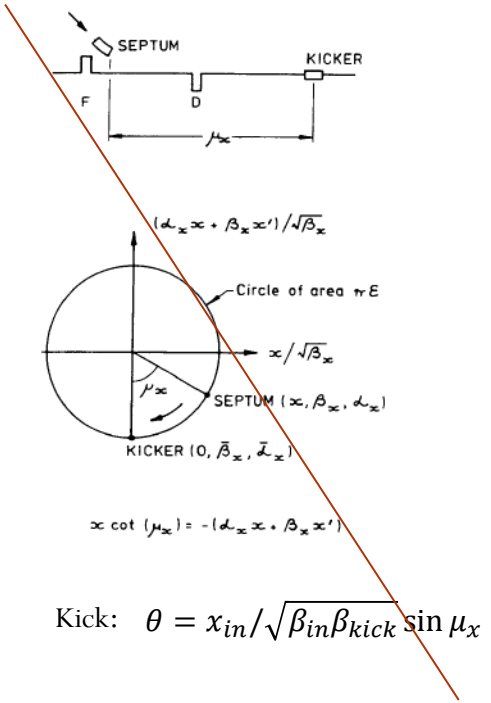
Drawing by A. Vivoli

Main Requirement - Flexibility

- Single-turn injection
- Currently we have 4 sets of optics, and more to come
- Proton injection – min changes

- Cannot have quadrupoles between septum magnet and injection kicker.

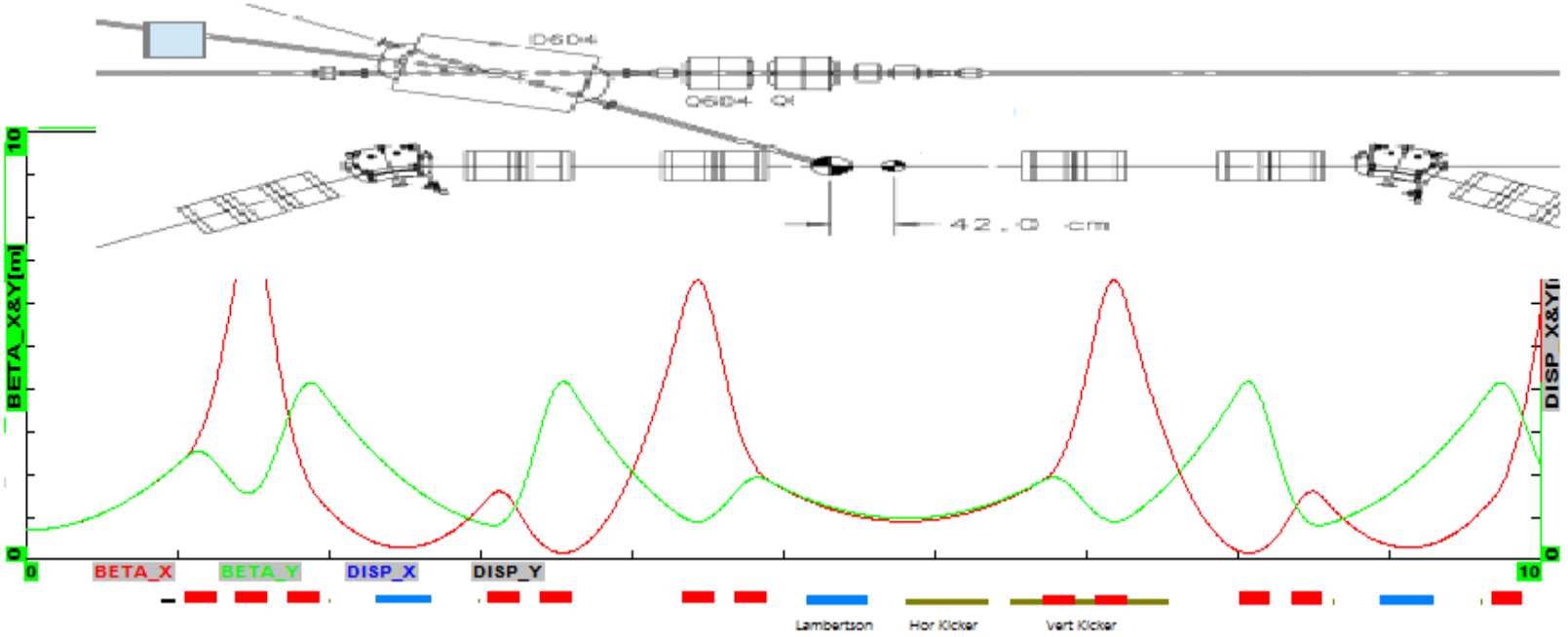
- Also, space is tight



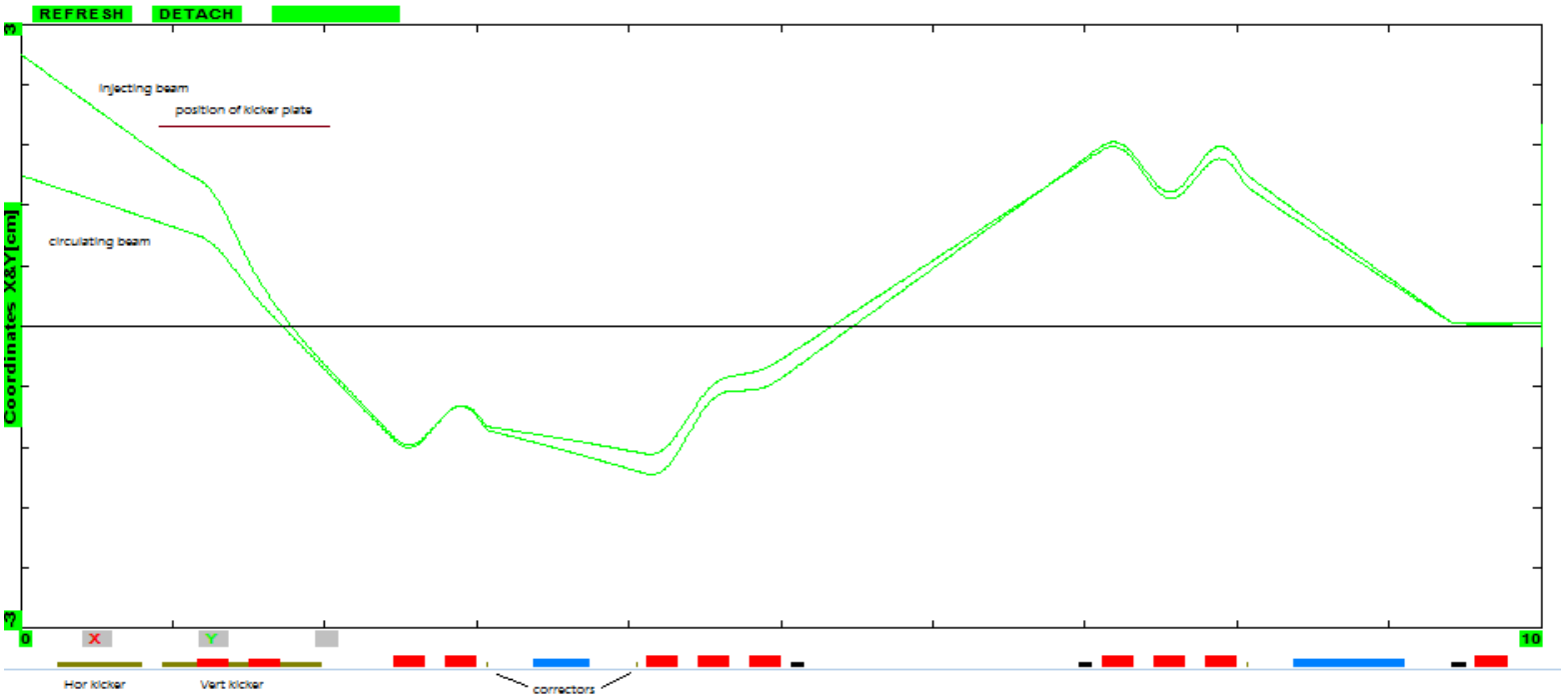
Kick: $\theta = x_{in}/\sqrt{\beta_{in}\beta_{kick}} \sin \mu_x$

Elements and their Positions

- Lambertson septum magnet + vertical and horizontal stripline kickers
- Injection in the vertical plane



Trajectories



- At least 2 mm to physical aperture at any point
- Orbit bump:
  - Correctors at the sides of bending dipoles;
  - Integrated strength – less than 10 kG-cm;
  - No extra correctors needed

Fast Stripline kickers

Main advantage: low cost

Requirements

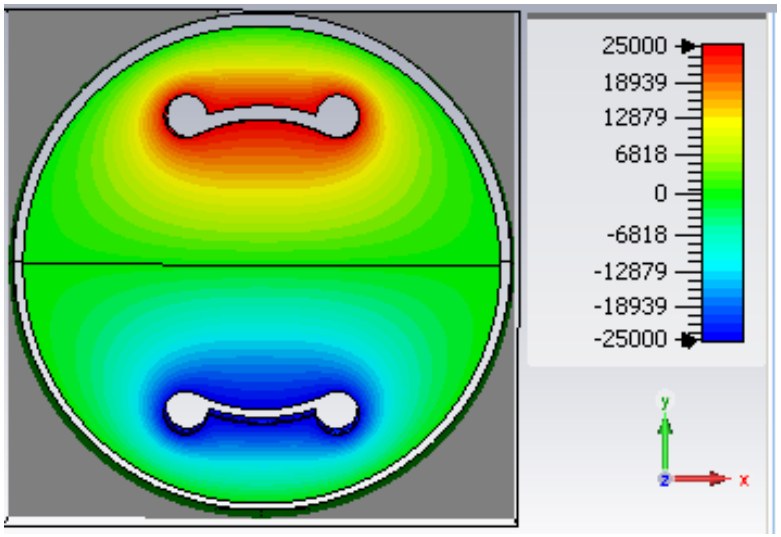
- Fast: ~ 100 ns pulse duration, including rise/fall and any after pulse oscillations
- Kick:
  - Full aperture -> up to 17 mrad vert, 9.5 mrad hor
  - Adjustable from 0 to max for IO experiments
- Uniform field
- E < 50 kV/cm the edges
- Fit into quadrupoles –> outer aperture limit 70 mm
- Do not reduce the physical aperture significantly

Engineering process:

- Electrical design – Sergey Antipov
- Mechanical design – Alex Didenko
- Power supplies – Reuse from Tevatron kickers, Dan Wolff, Chris Jensen
- HV Feedthroughs – Order from Ceramtec, Chris Jensen, Sergey Antipov

Unified Design for Horizontal and Vertical Kickers

The field is pretty uniform



2D map of electric potential in the kicker

Voltage	**± 25 kV ***
Radius:	
• Pipe	33 mm
• Plates	20 mm
Thickness:	
• Pipe:	2 mm
• Plates:	2 mm
Opening angle	70 deg
Edge rounding radius	3 mm
Wave impedance:	
• Odd mode	50 Ohm
• Even mode	55 Ohm
Max E-field	13 kV/cm
Length:	
• Horizontal	55 cm
• Vertical	100 cm

* 10 % reserve

Lambertson magnet

Main advantage - DC

Functional Requirements

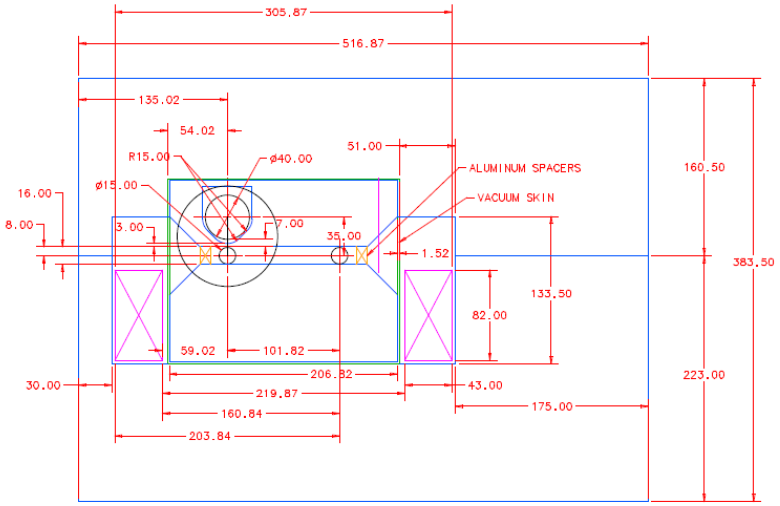
- Angle 30 deg -> integrated field 262.7 kG-cm
- Field uniformity $3*10^{-3}$ – for protons
- 15 mm aperture for injecting beam (ε_N up to $0.5*10^{-6}$ m)
- Min aperture reduction for circulating beam
- Integrated leakage field:
  - Dipole < 800 G – less than 5 mm orbit distortion without correction
  - Gradient < 50 G – Should not change beta-functions by more than 1 %
  - Octupole harmonic << 100 G/cm^2 – Octupole component of nonlinear potential
- No saturation – field less 1 T
- Coil current ~ 500 A - then can be fed in series with dipoles, no extra PS needed

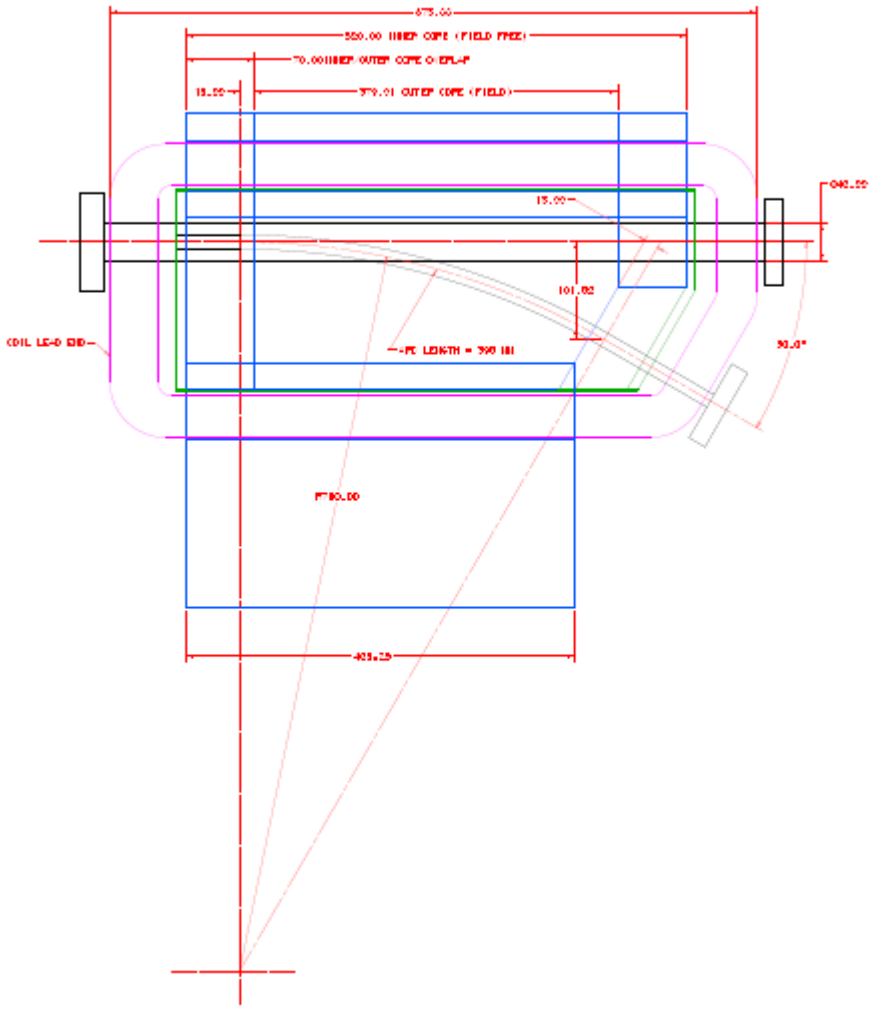
Lambertson Design - Roles

- Initial concept – Sasha Makarov (TD)
- Optimization, Magnetic design – Sergey Antipov
- Mechanical design – Alex Didenko

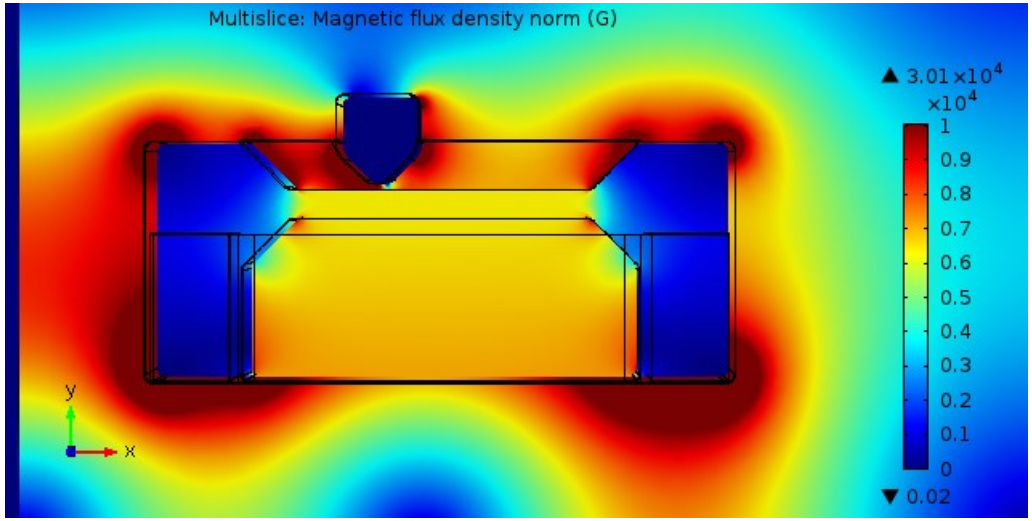
First Draft

by Sasha Makarov

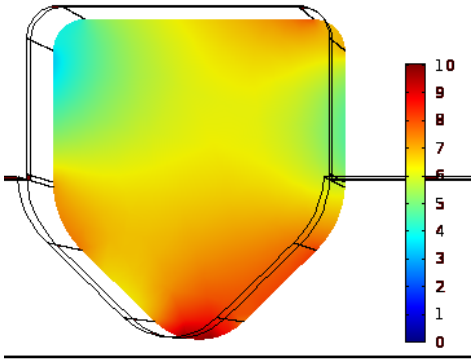




Uniform field in the gap and low strayed field



Field in the hole:



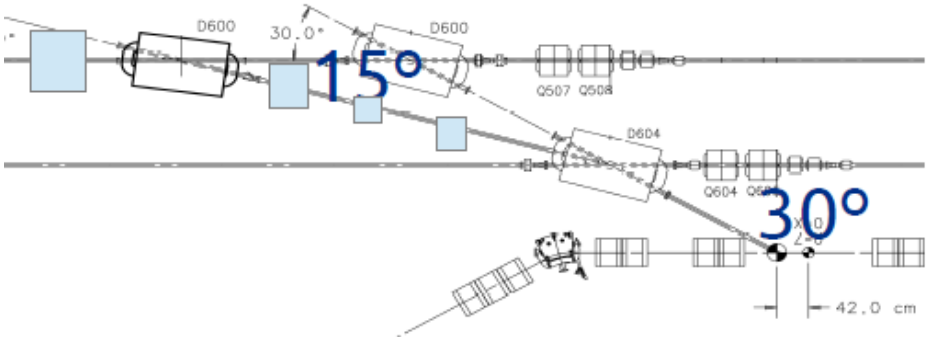
Field in the gap	**6.85 kG**
Length:	
• Magnetic	40 cm
• Total	60 cm
Integrated field	260 kG-cm
Total current	9000 A
Number of coils	18
Coil current:	
• Total	500 A
• Density	4 A/mm^2
Max field	1.2 T
Leakage filed:	
• Dipole integral	420 G-cm
• Grad integral	30 G
• Sext integral	10 G/cm
• Oct integral	~ 0
Power consumption	1 kW

Beamline

By Alessandro Vivoli

Matching the Lattice Functions

- 3 Quads in the beamline
- No strict tolerance requirements for IO



IO	OSC
$\beta_x = 0.93m, \alpha_x = 0.29$	$\beta_x = 6.90m, \alpha_x = 0.02$
$\beta_y = 0.93m, \alpha_y = 0.29$	$\beta_y = 1.10m, \alpha_y = 0.14$
$D_x = -0.24m, D'_x = 0$	$D_x = -0.10m, D'_x = 0$
$D_y = D'_y = 0$	$D_y = D'_y = 0$

Additional slides

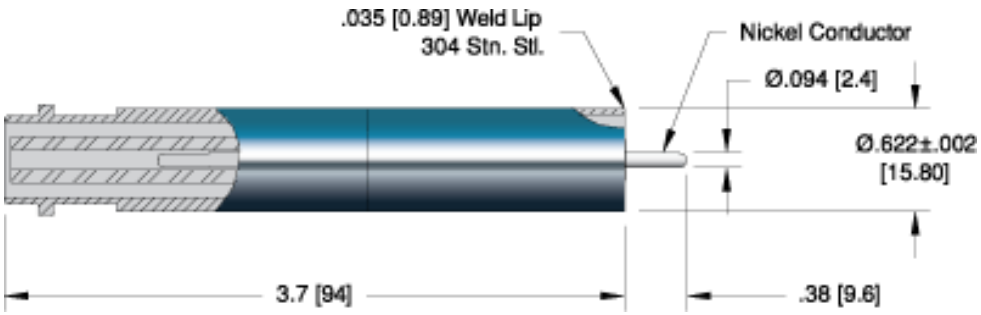
Functions at Elements

For integrable optics design

Element	β_x, cm	β_y, cm	α_x	α_y
Lambertson	100	100	0.4	0.4
Hor kicker	100	100	-0.4	-0.4
Vert kicker	435	125	-7.8	1.9

Kicker: Feedthroughs and Connectors

- Ordered Ceramtec 18089-1-W + 8208-02 coax connectors
- Testing:
  - Wave impedance: 55 Ohm for 10-50 MHz
  - Breakdown tests under vacuum – to be conducted



Materials

Housing: 304 Stainless steel
Pin: Nickel
Insulation: Alumina ceramic
Flange: 304 Stainless steel
Magnetic Materials: Yes

Voltage Rating 20 kV DC

Current Rating 16.5 Amps

Temperature Range
-269° C to 450° C, ISO KF -25° C to 205° C

Pressure @ 20°C
250 PSIG (17 Bar), ISO KF 0 PSIG

Leak Rate $<1x10^{-10}$ atm-cc/sec (He)