

# PRISM-FFAG

## injection/extraction studies

Akira SATO  
Osaka University

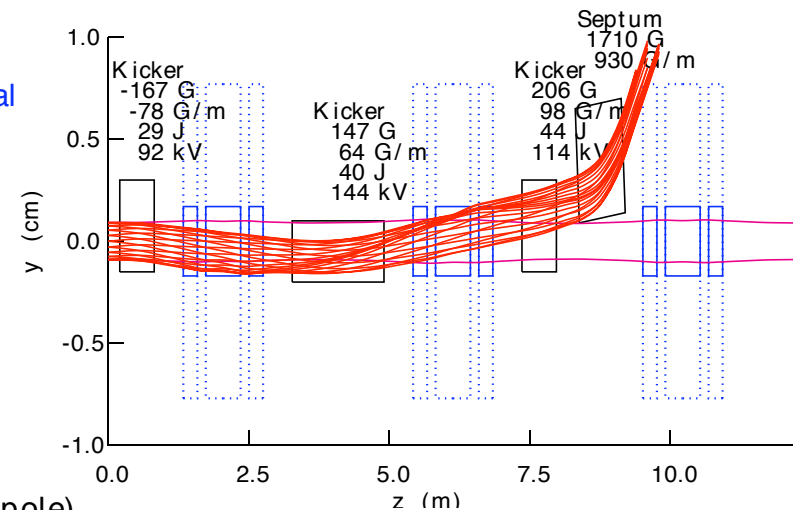
FFAG05 @ Fermi Lab.  
3rd Apr. 2005  
revised 9th Aug. 2005

# Injection/Extraction Issue

- B.Palmer proposed vertical injection/extraction

## Conclusions on Injection/ Extraction

- Vertical injection/ extraction much easier than horizontal
  - Needs Much less Magnetic energy
  - Needs much lower Voltage
  - Chromatic correction easy
- But Remaining Design Questions
  - Needs larger vertical apertures in special magnets
  - Kicker Energy still much greater than normal kickers
  - Need two pulses in each kicker
  - Kicker aspect ratio unnatural
  - Needs gradient in kicker field ( dipole + skew quadrupole)
- Study needs repeating with real fields and beam
- But this looks plausible



\* I studied that scheme with the present PRISM design.

field clumps, real gap size,

TOSCA field for FFAG magnets,

hard edge field for kickers and septums, geant3 tracking code

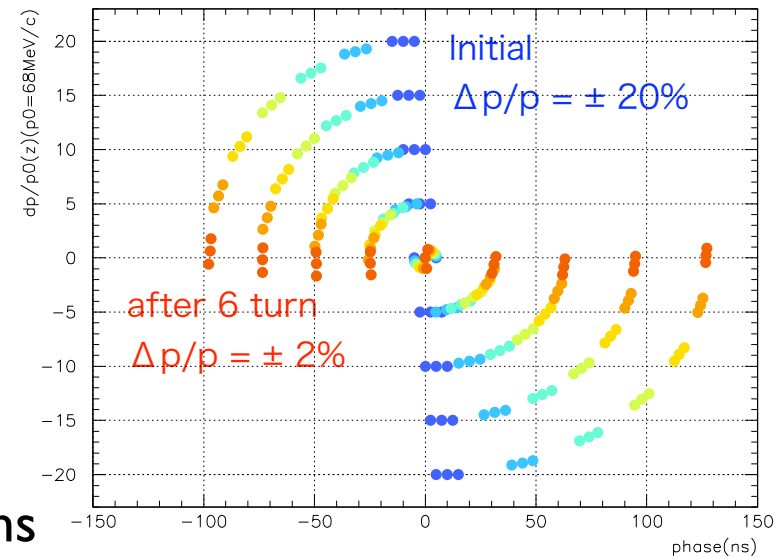
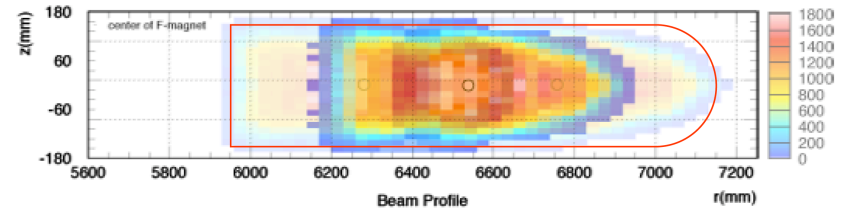
# Muon Beam

- at Injection

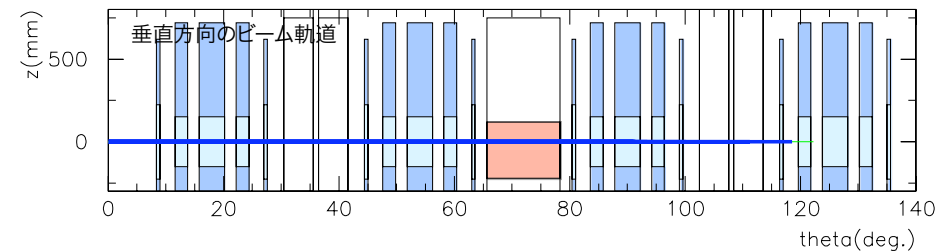
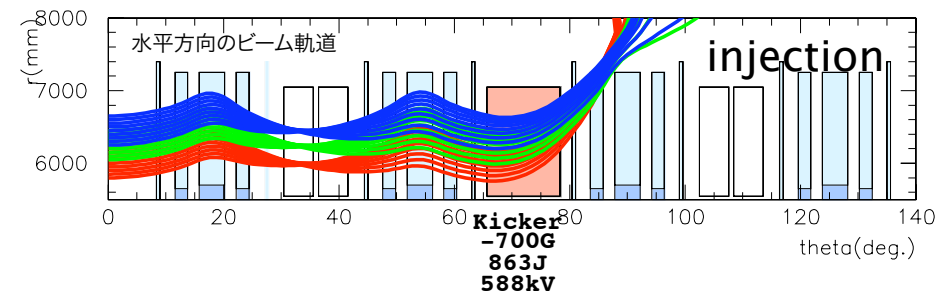
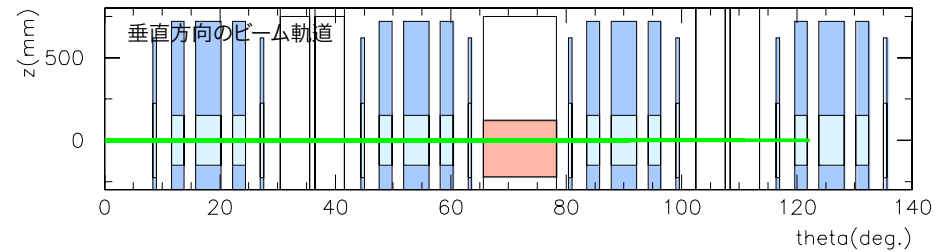
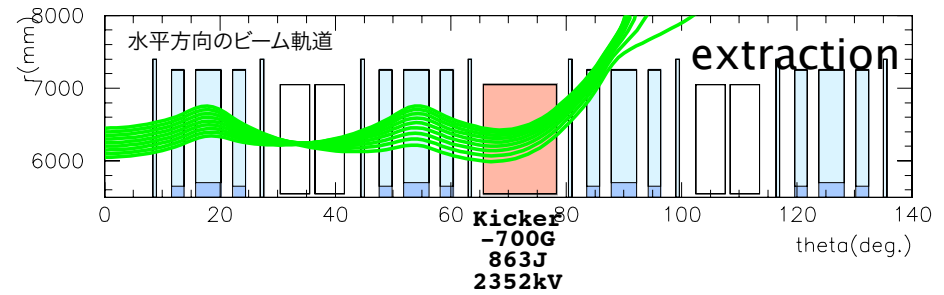
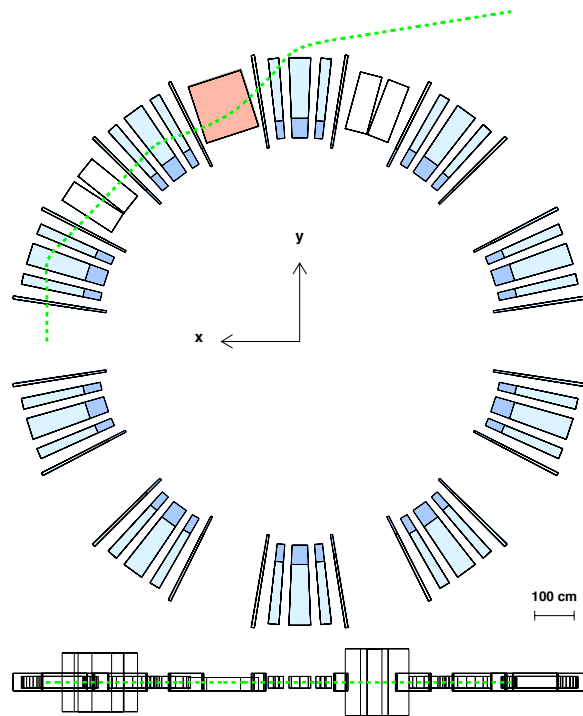
- momentum :  $68\text{MeV}/c \pm 20\%$ 
  - beam size
    - $100\text{cm} \times 30\text{cm}$
  - time dist.:  $40\text{ns} (/270\text{ns})$ 
    - kicker fall time  $< 230\text{ns}$

- at Extraction

- momentum :  $68\text{MeV}/c \pm 2\%$ 
  - beam size
    - $70\text{cm} \times 30\text{cm}$
  - time dist. :  $200\text{ns} (/270\text{ns})$ 
    - kicker rise time  $< 70\text{ns} - 100\text{ns}$



# Horizontal Injection/Extraction



# Horizontal Injection/Extraction

	B (T)	Gradient (T/m)	rise time (ns)	fall time (ns)	Length (cm)	Height (cm)	Width (cm)	Single Turn Voltage (kV)	Stored Energy (J)
Injection	-0.07	0	200	200	140	120	30	-588	863
Extraction	-0.07	0	50	1000	140	120	30	-2352	863

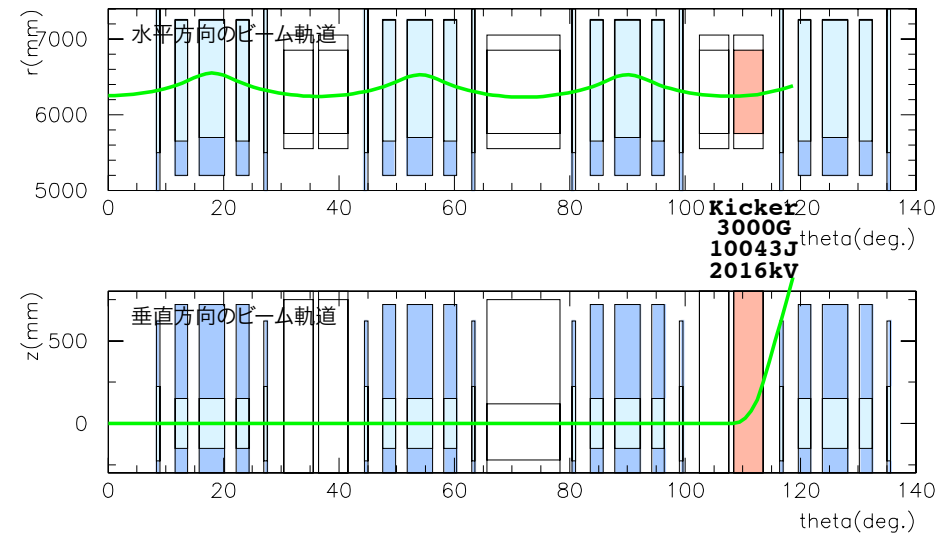
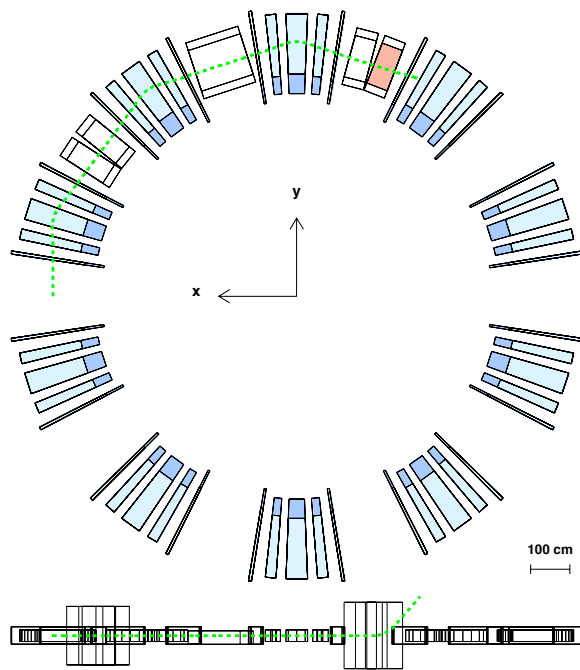
## B.Palmer's results

Length	cm	122.5
Width	cm	120
Height	cm	34
Kicker Field	T	0.108
Rise time	ns	50
Stored Energy	J	2038
Single turn Voltage	kV	3162

$$U = \frac{B_y^2 \cdot L \cdot X \cdot Y}{2\mu_0}, V = \frac{B_y \cdot X \cdot L}{t_{rise}}$$

# Vertical Injection/Extraction

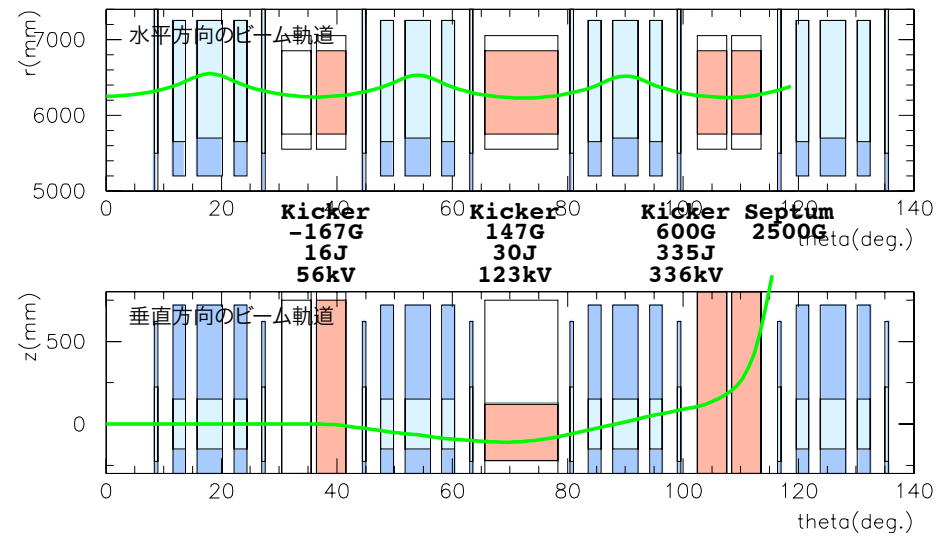
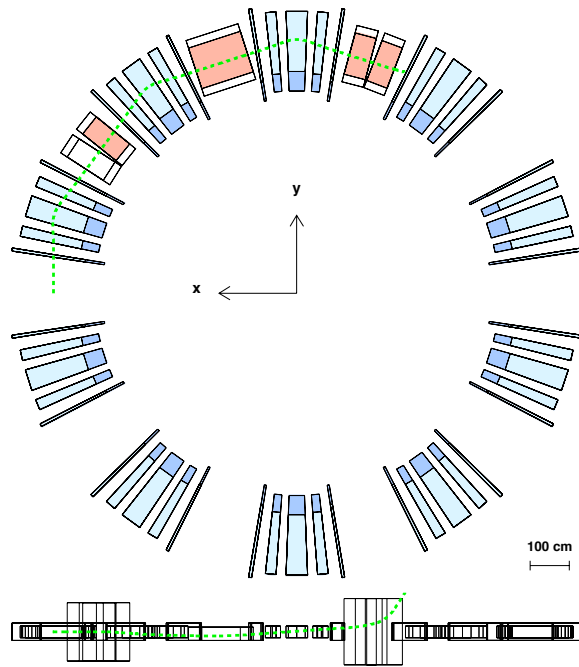
## One Kicker



# Vertical Injection/Extraction

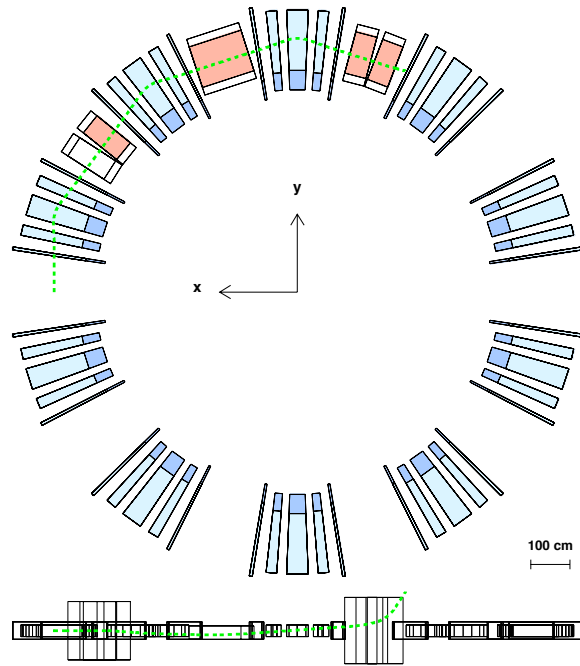
Kicker x3 + Septum

R.B.Palmer @ FFAG04

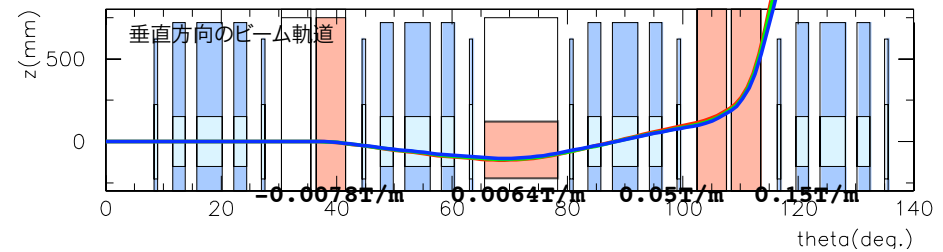
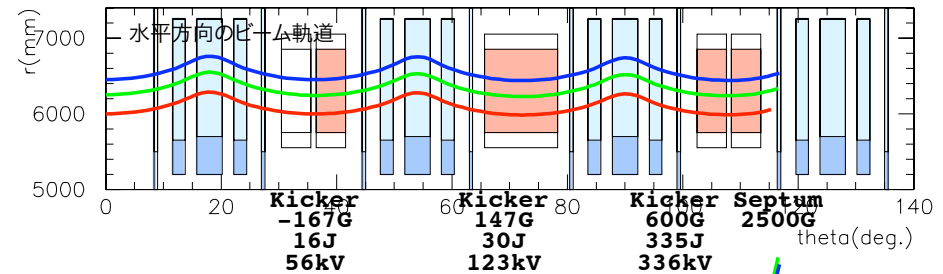
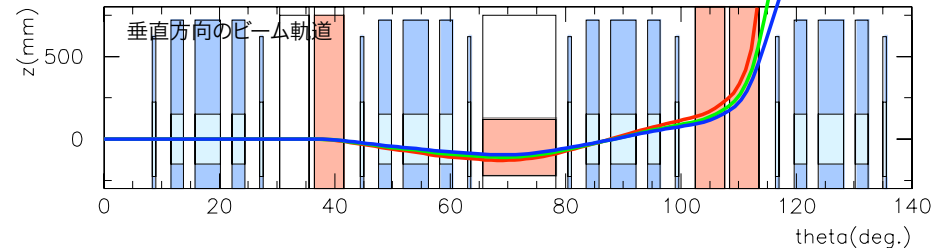
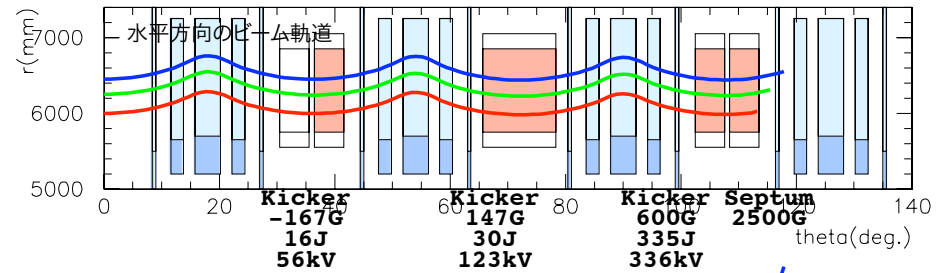


# Vertical Injection/Extraction

## Momentum Dispersion



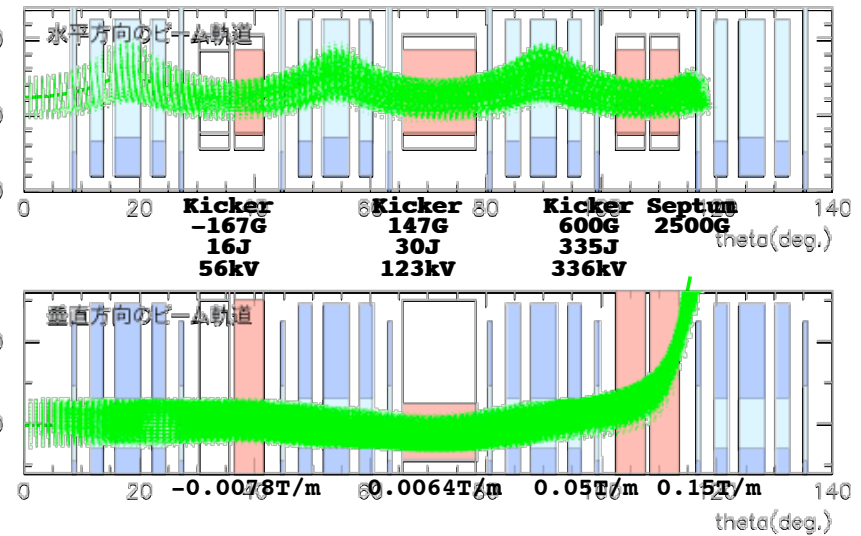
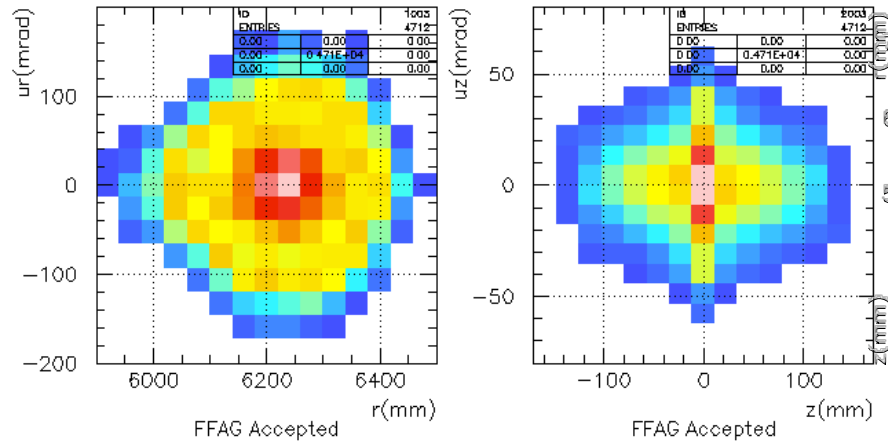
Add Skew Quadrupole  
moment



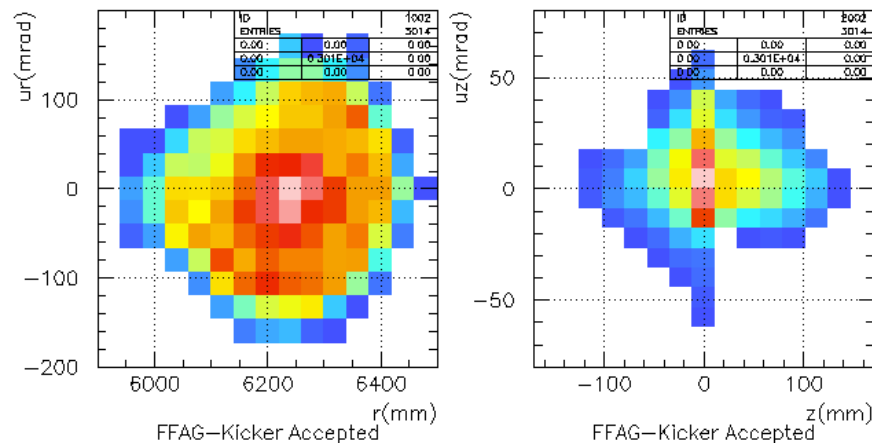


# Vertical Injection/Extraction

FFAG's 4D Acc. :  $1.0G(\text{mm mrad})^2$



FFAG-Kicker's 4D Acc. :  $0.64G(\text{mm mrad})^2$



- $(\text{FFAG})/(\text{FFAG-Kicker}) = 64\%$

# Vertical Injection/Extraction

	B (T)	Gradient (T/m)	rise time (ns)	fall time (ns)	Length (cm)	Height (cm)	Width (cm)	Single Turn Voltage (kV)	Stored Energy (J)
Kicker1	-0.0167	-0.0078	50	200	56	30	95	-56	16
Kicker2	0.0147	0.0064	50	200	140	30	95	123	30
Kicker3	0.0600	0.0500	50	200	56	50	95	336	335
Septum	0.2500	0.1500	50	200	56	80	95		

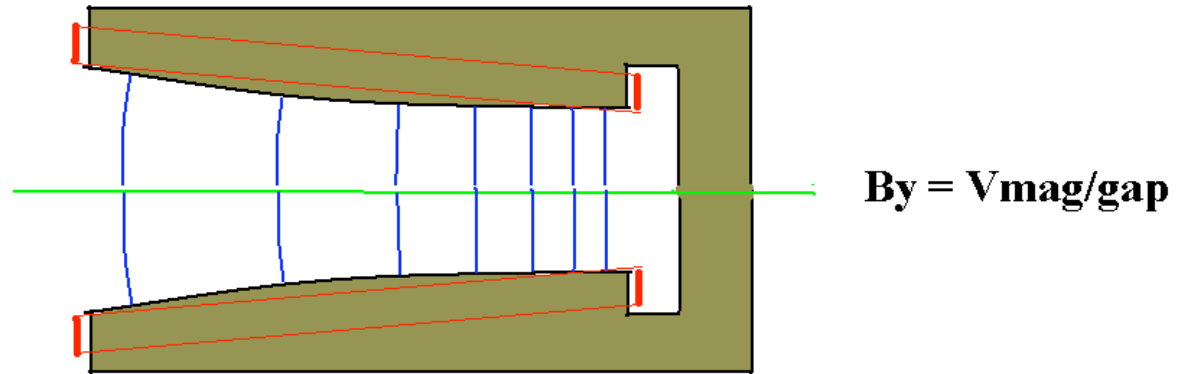
## B.Palmer's results

		dz m	len m	ht m	wid m	tilt deg	B G	Grad G/m	V <sub>o</sub> kV	U J
1	Kicker	0.51	0.61	0.45	0.95	0	-167	-78	92	29
2	Kicker	0.00	1.63	0.30	0.95	0	147	64	144	40
3	Kicker	-.51	0.61	0.45	0.95	0	206	98	114	44
4	Septum	0.61	0.82	0.56	0.95	4	1710	930		
Max (Total)									144	(113)
Horiz		0	1.22	.34	1.2		1080		3160	2038

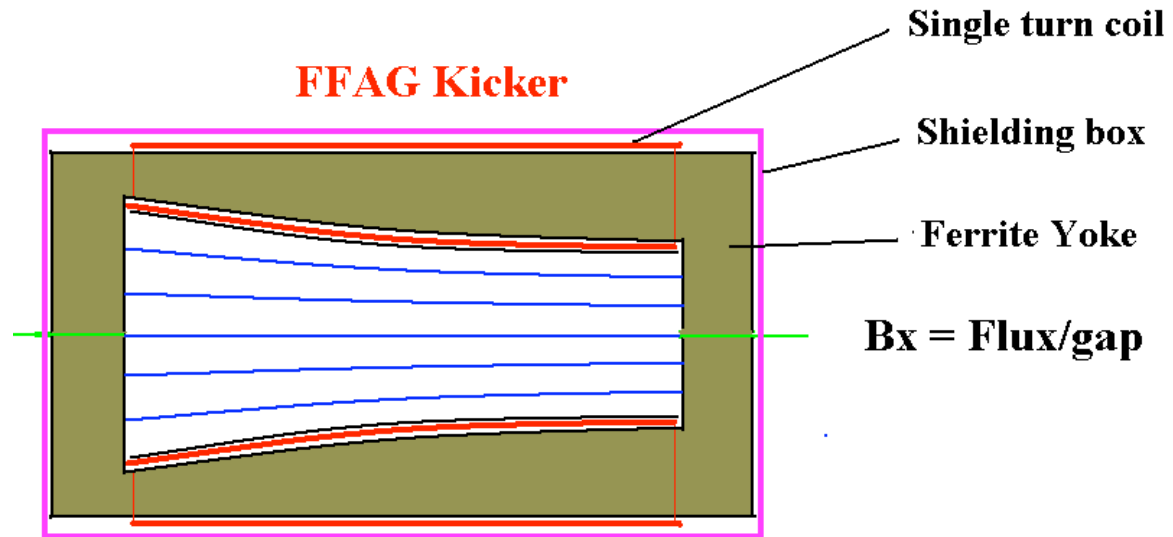
- It would work with the present PRISM design.

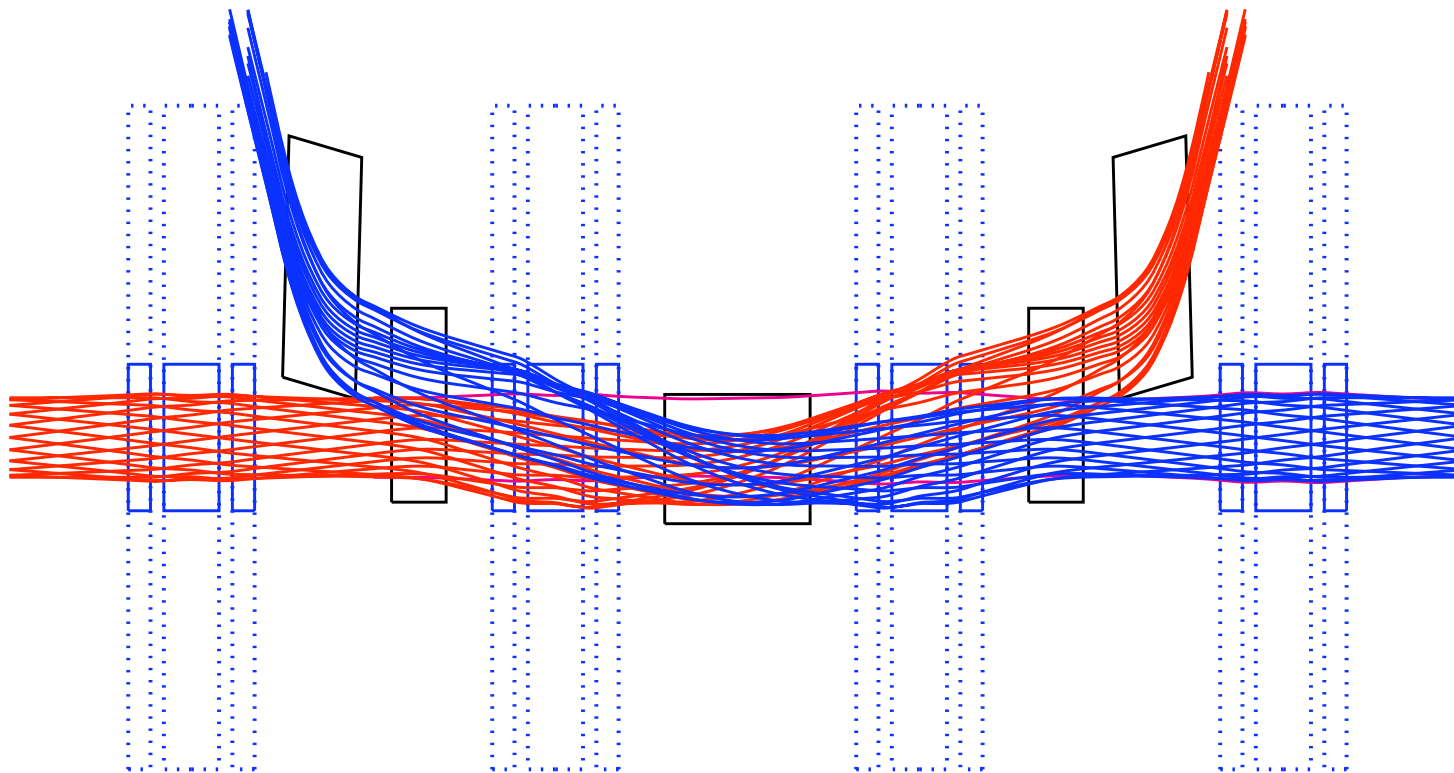
**End**

### FFAG Magnet



### FFAG Kicker





R.B.Palmer @ FFAG04