Linear NS-FFAG design

Tips and tricks for using ZGOUBI

Caveat(s)

- My experience in using ZGOUBI for linear NS-FFAGs is for *proton* FFAGs for PAMELA.
- I have tried to identify useful parts of this experience for ZGOUBI users modelling EMMA.
- We have a very varied audience… (some ZGOUBI experts, some new users, some who wish they could skip out for coffee…)

Outline

- For new users: where to start
  - Pyzgoubi interface
- Choosing a ZGOUBI element
- Example using DIPOLE-S
- Including errors in lattices
- Common pitfalls & errors
  - I hope to highlight these as we go along

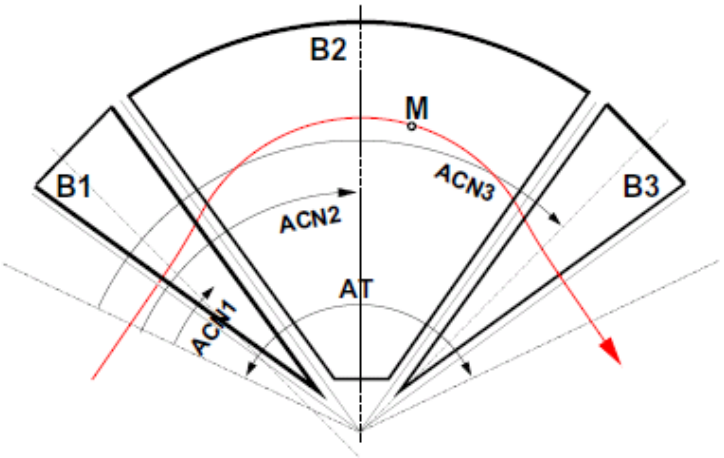
New users

- Use an interface! i.e. Pyzgoubi
  - See talk by S. Tygier
- Example: First go!

TIP: Use Pyzgoubi!

Choosing a ZGOUBI element

- DIPOLE-S
- FFAG
- MULTIPOL
- EMMA? TOSCA?



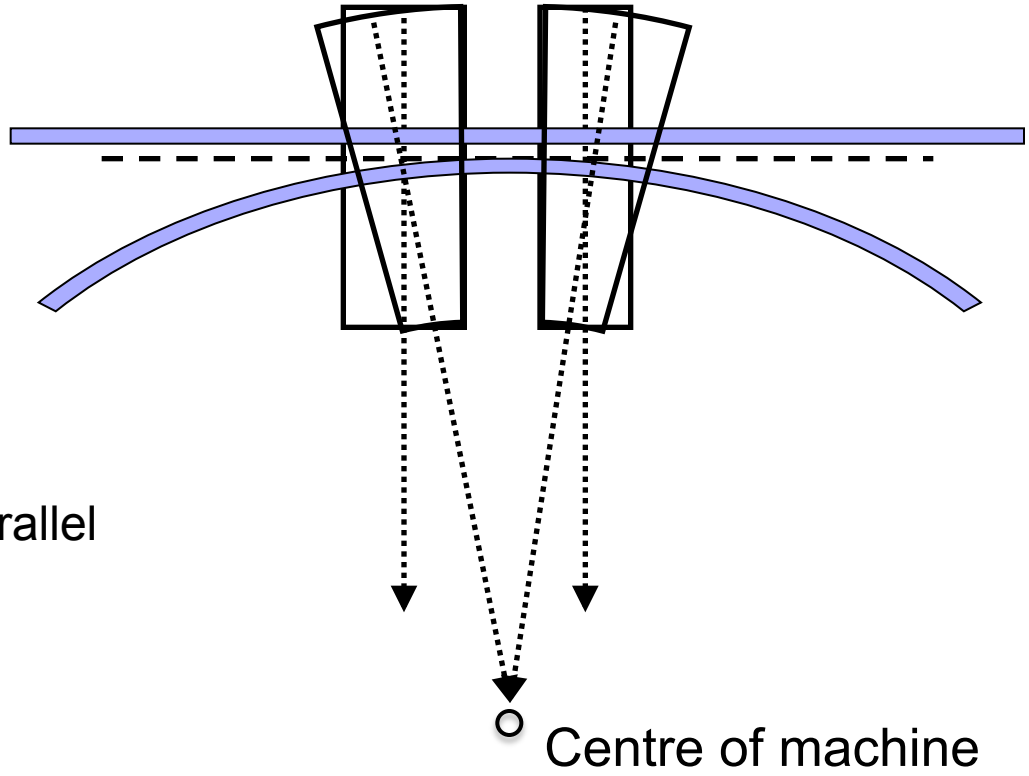
Using DIPOLE-S

Problem: We have rectangular magnets, how do we describe this in the DIPOLES element?

1. Use the new DIPOLE-C element when available (see D.Kelliher's talk)
2. Come up with an elaborate method to make it work…
3. Give up

TIP: Sometimes its easier to write your own element – if you know FORTRAN!

Using DIPOLE-S



Want field lines to be parallel with magnet faces, NOT curved around machine centre!

Using DIPOLE-S

- Make R (reference radius) very large
- Magnet faces are effectively parallel
- Magnetic field lines OK

TIP: Make sure the magnetic fields look as you expect

Using large radius…

DIPOLE-S description in ZGOUBI manual:

$$B_z(R,\theta) = B_{z0}F(R,\theta)(1 + b_1(R-RM)/RM + b_2(R-RM)^2/RM^2 + \ldots)$$

Multipole description:

$$B_y + iB_x = B_1 \sum (b_n + ia_n)\left(\frac{Z}{R_r}\right)^{n-1}$$

Where B_1 is the dipole field and $Z = x + iy$

$$b_1 = b_1^{poly} \quad b_2 = scale \cdot b_2^{poly} \quad \left(b_3 = scale^2 \cdot b_3^{poly}\right)$$

Etc… easy in linear case!

Using field maps – look out!

- See H.Witte's talk
- BNORM = doesn't work!
- MOD=1 (symmetry)
- NF=1+IZ/2
- Easier to say IZ=2(NF-1) – as you know NF usually, but not IZ…

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TOSCA	**2-D and 3-D Cartesian or cylindrical mesh field map**		
IC, IL	see *CARTEMES*	0-2, 0-2	2*I
BNORM, XN,YN, ZN	Field and X-,Y-,Z-coordinate normalization coefficients	4*no dim.	4*E
TITL	Title. Start with "FLIP" to get field map X-flipped		A80
IX, IY, IZ, MOD[.i]	Number of nodes of the mesh in the X, Y and Z directions, $IZ = 1$ for single 2-D map ; *MOD* : operational and map *FORMAT* reading mode[1] *MOD*≤19 : Cartesian mesh ; *MOD*≥20 : cylindrical mesh ; *.i*, optional, tells the reading *FORMAT*, default is '*'.	≤ 400, ≤ 200, ≥ 1, ≥ 0[.1-9]	3*I
FNAME[1] $(K = 1, NF)$	Names of the NF files that contain the 2-D maps, ordered from $Z(1)$ to $Z(NF)$. If *MOD*=0 : $NF = 1 + [IZ/2]$, the NF 2-D maps are for $0 \le Z \le Z_{max}$, they are symmetrized with respect to the $Z(1) = 0$ plane. If *MOD*=1 : $NF = IZ$, no symmetry assumed ; $Z(1) = Z_{max}$, $Z(1 + [IZ/2]) = 0$ and $Z(NF) = -Z_{max}$. If *MOD*=12 : a single *FNAME* file contains the all 3-D volume. If *MOD*=20-22 : other symmetry options, see *toscap.f* routine...		A80
ID, A, B, C [A', B', C' B'',etc., if $ID \ge 2$]	Integration boundary. Ineffective when $ID = 0$. ID = -1, 1 or ≥ 2 : as for *CARTEMES*	≥ −1, 2*no dim., cm [,2*no dim., cm, etc.]	I,3*E [,3*E,etc.]
IORDRE	If $IZ = 1$: as in *CARTEMES* If $IZ \ne 1$: unused	2, 4 or 25	I
XPAS	Integration step	cm	E
If Cartesian mesh (see MOD) :			
		1-2, 2*cm, rad	I, 3*E

TIP: Just because it tracks, that doesn't mean it's right!

Including Alignment Errors

- Again: which ZGOUBI keyword to use?

TRAROT, CHANGREF, AUTOREF, YMY?

TRAROT: Translation-Rotation of the reference frame

This procedure transports particles into a new frame by translation and rotation. Effect on spin tracking, particle decay and gas-scattering are taken into account (but not on synchrotron radiation).

May ' 09

TRAROT : Translation-Rotation of the reference frame

UNDER DEVELOPEMENT. Check before use.

This procedure transports particles into a new frame by translation and rotation. Effect on spin tracking, particle decay and gas-scattering are taken into account (but not on synchrotron radiation).

Sept ' 09

TIP: Always have the latest version of the manual!!

Alignment Errors

- Changref: will hopefully be updated to include vertical errors too…

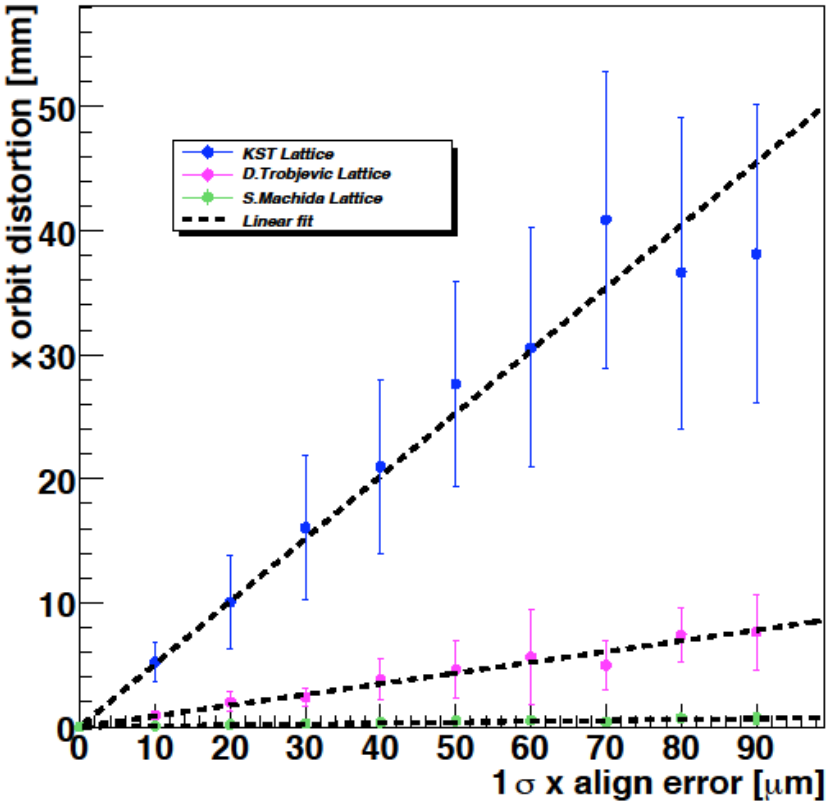
CHANGREF	Transformation to a new reference frame		
XCE, YCE, ALE	Longitudinal and transverse shifts, followed by Z-axis rotation	2*cm, deg	3*E

Alignment errors

- Need to construct one zgoubi.dat file with ALL cells
- Random generator for changref
- Be VERY careful about your random generator!
- My routine for including errors was in ROOT, but would be easier in python
- (I may re-write this in python if wanted by the community…)

More complicated things...

- Once you have the basics down, can run large studies, parameter scans etc…
- Example: comparison of error sensitivity of various lattices for PAMELA



This is plotted in ROOT, but you can use your favourite package…

Summary

- Use Pyzgoubi
- Sometimes its easier to write your own element – if you know FORTRAN
- Make sure the magnetic fields look as you expect
- Just because it tracks, that doesn't mean it's right
- Always have the latest version of the manual

Questions?

Thanks for listening.