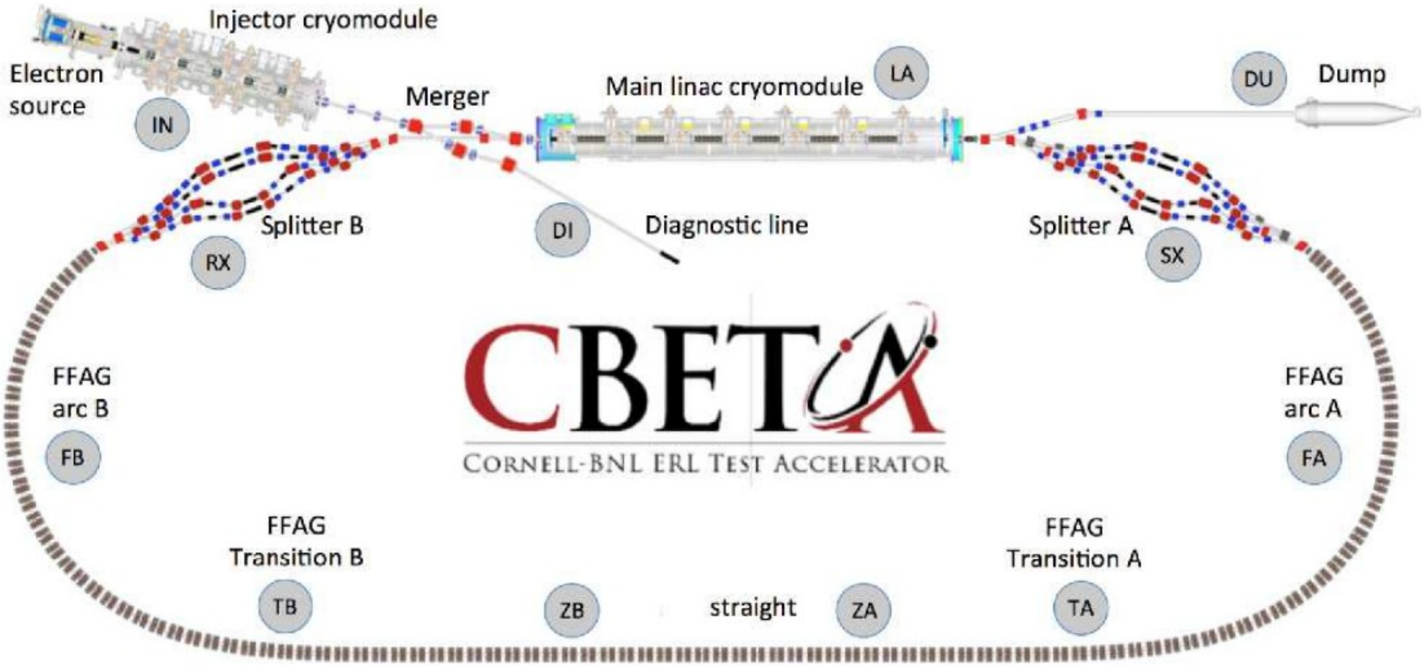
Wednesday's tutorial
CBETA with field maps

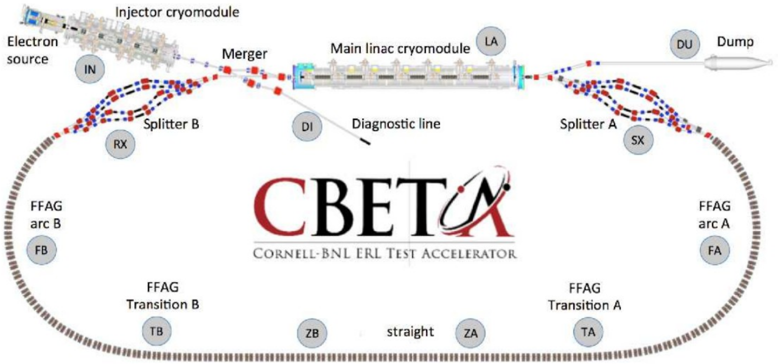
These slides come in complement to the detailed

exercise_1.pdf and *exercise_2.pdf*.



Organizing the work

- Exercises 1 (FFAG return loop) and exercise 2 (4-pass ER) are based on a series of folders which reflect the structure of the ERL:



CBETA/

documentation/ FFAGLoop/ linac/ SX/ 4pass_ER/ exercises/ fieldmaps/ RX/

arcCell complete FA FB TA TB ZA ZB

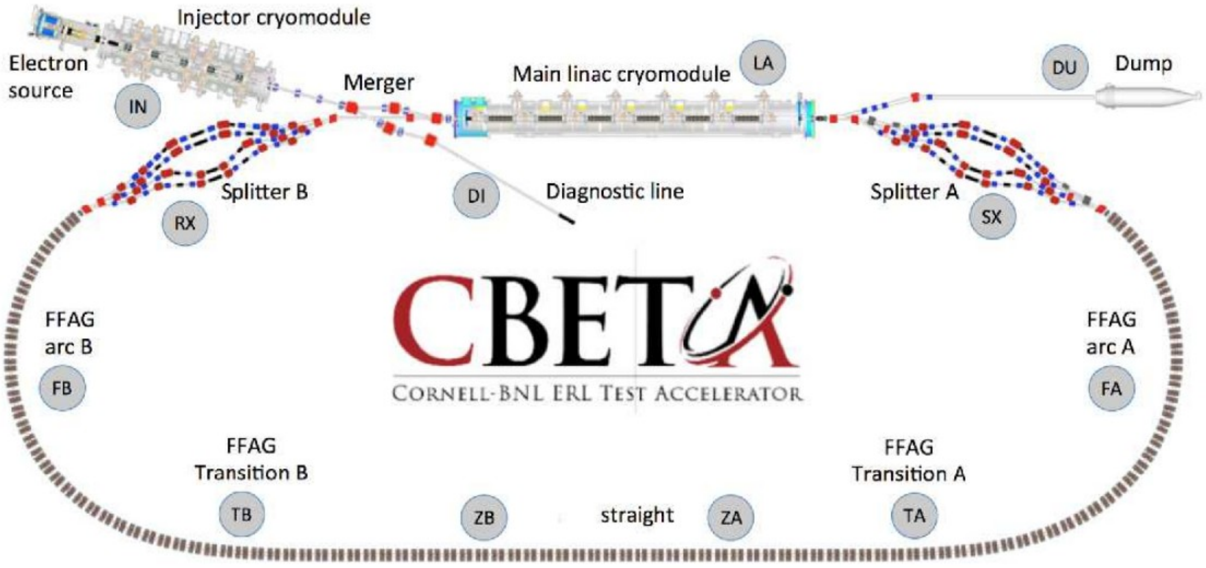
- In exercise 1: (i) get the periodic functions of the cell → in 'CBETA/FFAGLoop/arcCell'
  (ii) get optical functions at the start of the FFAG loop, same folder
  (iii) Run the complete FFAG loop → in 'CBETA/FFAGLoop/complete'

- Exercise 2 takes place in CBETA/4pass_ER

- In both cases, zgoubi.dat sequence 'INCLUDEs' the various pieces, as needed, from these folders.

EXERCISE 1

In this exercise we are interested in computing and plotting, at the four design energies: 42, 78, 114 and 150 MeV,
- the orbits,
- the betatron and dispersion functions,
along the permanent magnet loop: FA-TA-ZA-ZB-TB-FB (about 200 magnets)



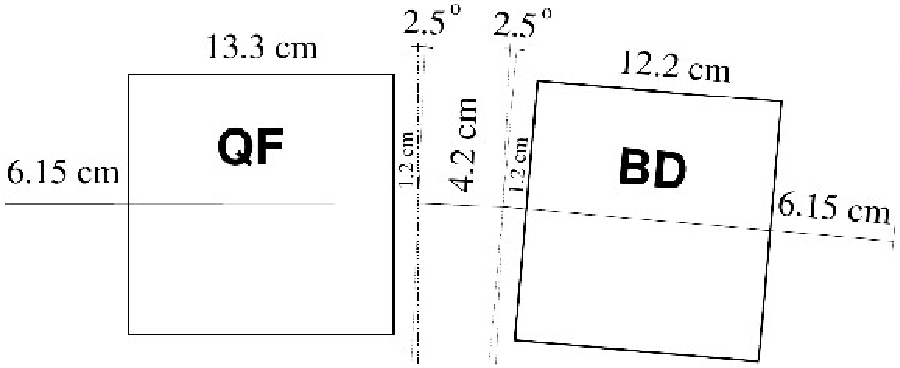
Exercise 1

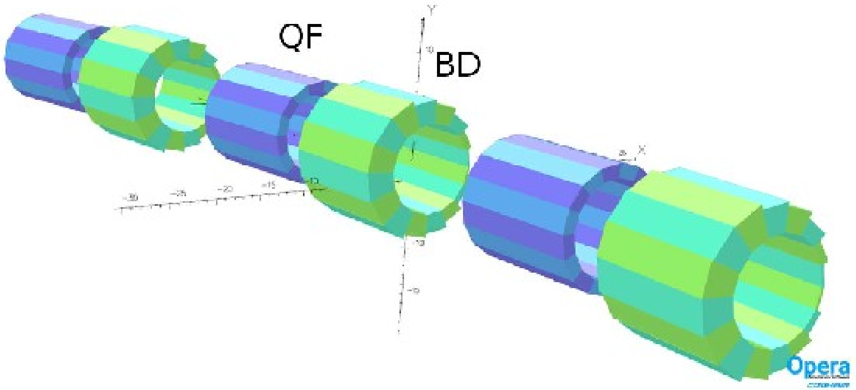
FA and FB arc cell

- **This is the cell modeled in zgoubi**

  - it could use an analytical field model for QF and for BD, for instance 'MULTIPOL' since the previous tutorials (PSR, ESRF),

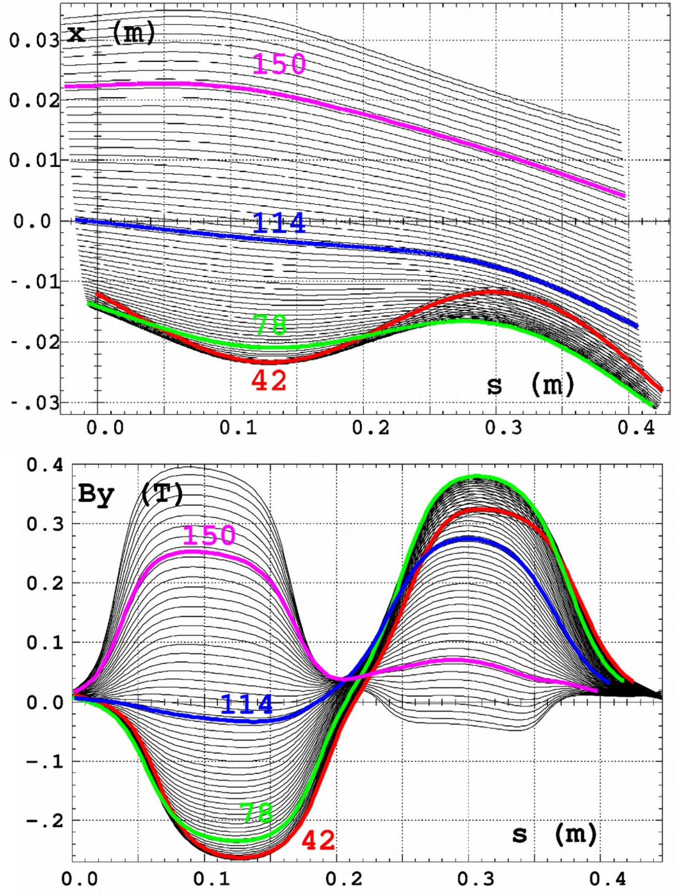
  - however today we deal with a simulation based on the use of *OPERA field maps*, instead, keyword 'TOSCA' in zgoubi





Exercise 1

1/ This is what we want to compute and plot: periodic orbits and field across an FA cell



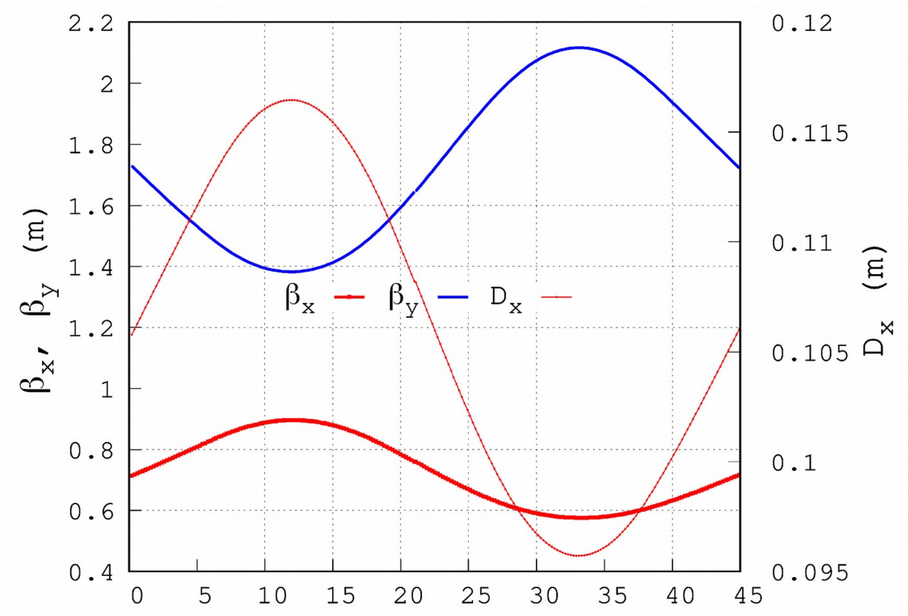
The FA (or FB) arc cell sequence,
keywords in blue, field map file name in red

```
'DRIFT'    FA.PIP03\1#1
5.600000000000001
!-------------------------------------------------------------------
'DRIFT'
-33.35          ! = (80cm - 13.3cm)/2
'TOSCA' FA.PIP03\FA.QUA03\1
0 0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1 15.1  1.
./QF-V6p5_x+-4p1y+-1p3z+-40_stp1mm_integral_2D.table
0 0 0 0
2
.2
2   0.00000000E+00  0.00000000E+00  0.00000000E+00
'DRIFT'
-33.35          ! = (80cm – 13.3cm)/2
!-------------------------------------------------------------------
'DRIFT'    FA.PIP03\1#2
1.200000000000000
'CHANGREF' FA.PATCH03\1
ZR  -2.49981490
'DRIFT'    FA.BLK02\1#1
2.100000000000000
'MARKER'   FA.BPM02\1
'DRIFT'    FA.BLK02\1#2
2.100000000000000
'CHANGREF' FA.PATCH04\1
ZR  -2.49981490
'DRIFT'    FA.PIP04\1#1
1.200000000000000
!-------------------------------------------------------------------
'DRIFT'
-33.9          ! = (80cm - 12.2cm)/2
'TOSCA' FA.PIP04\FA.QUA04\1
0  0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1  15.1  1.0
./BD_v6_x+-4p1_y+-1p3_x+-40_stp1mm_integral_2D.table
0 0 0 0
2
.2
2   0.00000000E+00 -1.90000000E-02  0.00000000E+00
'DRIFT'
-33.9          ! = (80cm – 12.2cm)/2
!-------------------------------------------------------------------
'DRIFT'    FA.PIP04\1#2
6.700000000000000
```

Exercise 1

2/ This is what we want to compute and plot now: optical functions across an FA cell.

Below is the case of 42 MeV energy:



The FA (or FB) arc cell sequence, keywords in blue, field map file name in red

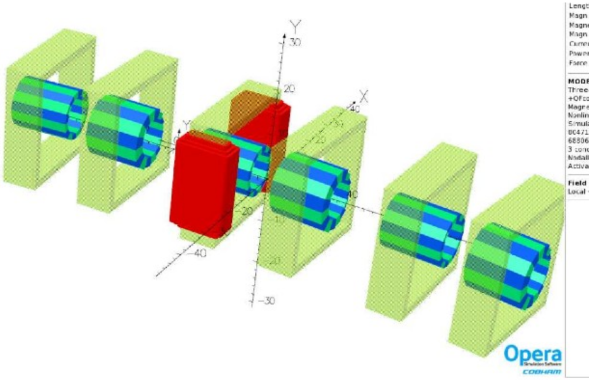
```
'DRIFT'   FA.PIP03\1#1
5.600000000000001
!-----------------------------------------------------------------
'DRIFT'
-33.35          ! = (80cm - 13.3cm)/2
'TOSCA' FA.PIP03\FA.QUA03\1
0 0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1 15.1  1.
./QF-V6p5_x+-4p1y+-1p3z+-40_stp1mm_integral_2D.table
0 0 0 0
2
.2
2   0.00000000E+00  0.00000000E+00  0.00000000E+00
'DRIFT'
-33.35          ! = (80cm – 13.3cm)/2
!-----------------------------------------------------------------
'DRIFT'   FA.PIP03\1#2
1.200000000000000
'CHANGREF' FA.PATCH03\1
ZR  -2.49981490
'DRIFT'   FA.BLK02\1#1
2.100000000000000
'MARKER'   FA.BPM02\1
'DRIFT'   FA.BLK02\1#2
2.100000000000000
'CHANGREF' FA.PATCH04\1
ZR  -2.49981490
'DRIFT'   FA.PIP04\1#1
1.200000000000000
!-----------------------------------------------------------------
'DRIFT'
-33.9          ! = (80cm - 12.2cm)/2
'TOSCA' FA.PIP04\FA.QUA04\1
0  0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1  15.1  1.0
./BD_v6_x+-4p1_y+-1p3_x+-40_stp1mm_integral_2D.table
0 0 0 0
2
.2
2   0.00000000E+00 -1.90000000E-02  0.00000000E+00
'DRIFT'
-33.9          ! = (80cm – 12.2cm)/2
!-----------------------------------------------------------------
'DRIFT'   FA.PIP04\1#2
6.7000000000000001#2
6.700000000000000
```

Exercise 1

3/ (i) Add the half-BD section just upstream of FA cell

(ii) Add a FIT[2] (vary optical functions at start to get macth at exit)

```
 'MARKER'   FA.MAR.BEG\1
 'DRIFT'    FA.PIP00A\1#1
1.200000000000000
 'DRIFT'
-36.95          ! = (80cm - 6.1cm)/2   (50cm is field map extent)
 'TOSCA' FA.PIP00A\FA.QUA00\1
0 0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.0E+00
HEADER_8  ZroBXY
801 83 1 15.2  1. 1e-10
./BDH-v6_x+-4p1_y+-1p3_z+-40_stp0p1_integral_2D.table
./BDH-corrector_2D.table
0 0 0 0
2
.2
2  0.00000000E+00 -1.90000000E-02  0.00000000E+00
 'DRIFT'
-36.95          ! = (80cm - 6.1cm)/2   (50cm is field map extent)
 'DRIFT'    FA.PIP00A\1#2
1.200000000000000
 'CHANGREF' FA.PATCH00\1
ZR  -1.08747390
 'DRIFT'    FA.PIP00B\1
3.3000000
```




```
'FIT2'
 8
 1 30 0 [-3.,3.]
 1 31 0 [-200.,200.]
 1 40 0 9.5
 1 41 0 9.5
 1 42 0 9.5
 1 43 0 9.5
 1 46 0 [-1.,1.]
 1 47 0 [-1.,1.]
 8  1e-10
 3  1 2 #End -1.28235115E+00  .2 0   !   These are the orbit values and optical
 3  1 3 #End -1.20023364E+02  2. 0   !   functions, at end of periodic FA cell
 0 1 1 #End  0.346084   .2 0
 0 2 1 #End -2.542387   1. 0
 0 3 3 #End  0.322542   .2 0
 0 4 3 #End  1.996305   1. 0
 0 1 6 #End -0.010223   .01 0
 0 2 6 #End  0.076642   .02 0
```

Figure out what these variables and constraints are

(iii) followed by the FA cell (note the corrector field maps, introduced here)

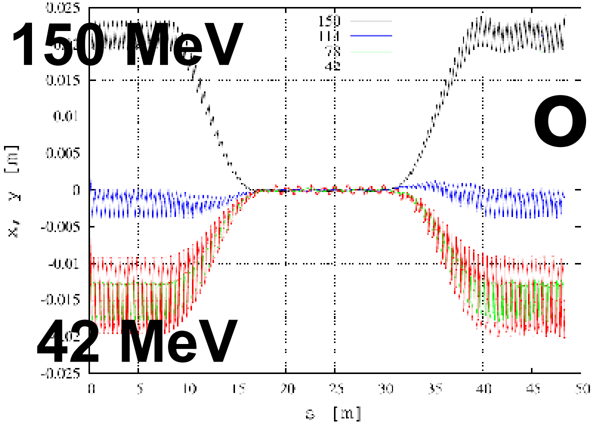
```
'DRIFT'    FA.PIP03\1#1
5.600000000000001
!----------------------------------------------------------------
'DRIFT'
-33.35          ! = (80cm - 13.3cm)/2
 'TOSCA' FA.PIP03\FA.QUA03\1
0 0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1 15.2  1.  1e-10
./QF-V6p5_x+-4p1y+-1p3z+-40_stp1mm_integral_2D.table
./QF-corrector_2D.table
0 0 0 0
2
.2
2  0.00000000E+00  0.00000000E+00  0.00000000E+00
 'DRIFT'
-33.35          ! = (80cm – 13.3cm)/2
!----------------------------------------------------------------
 'DRIFT'    FA.PIP03\1#2
1.200000000000000
 'CHANGREF' FA.PATCH03\1
ZR  -2.49981490
 'DRIFT'    FA.BLK02\1#1
2.100000000000000
 'MARKER'   FA.BPM02\1
 'DRIFT'    FA.BLK02\1#2
2.100000000000000
 'CHANGREF' FA.PATCH04\1
ZR  -2.49981490
 'DRIFT'    FA.PIP04\1#1
1.200000000000000
!----------------------------------------------------------------
 'DRIFT'
-33.9          ! = (80cm - 12.2cm)/2
 'TOSCA' FA.PIP04\FA.QUA04\1
0  0
-9.76000000E-04  1.00000000E+00  1.00000000E+00  1.00000000E+00
HEADER_8  ZroBXY
801 83 1  15.2  1.0   1e-10
./BD_v6_x+-4p1_y+-1p3_x+-40_stp1mm_integral_2D.table
./BD_corrector_2D.table
0 0 0 0
2
.2
2  0.00000000E+00 -1.90000000E-02  0.00000000E+00
 'DRIFT'
-33.9          ! = (80cm – 12.2cm)/2
!----------------------------------------------------------------
 'DRIFT'    FA.PIP04\1#2
6.700000000000000
```

Exercise 1

4/ This is what we want to check, eventually: orbits and optical functions along the complete permanent magnet return loop

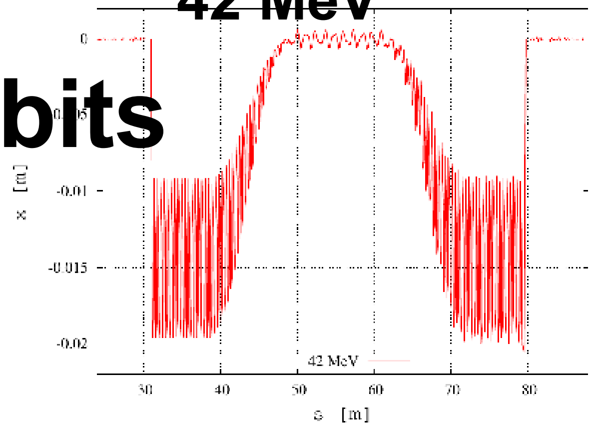
150 MeV

42 MeV



42 MeV

orbits



Optical functions
42 MeV
First meters of FA arc