FOOT simulations with FLUKA (& shoe)

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SOFTWARE TUTORIAL, 14-15 JUNE 2018

Outline

- A glimpse of the input
  - Bodies & regions
  - Phisics setting
  - Others..
- Management the geometry with shoe: the FOOT style
- Magnetic field: how to

A glimpse of the imput

Physics settings

DEFAULTS		PRECISIO		
PHYSICS		Type: EVAPORAT	Model: New Evap with heavy frag	
		Zmax: 0	Amax: 0	
IONTRANS		Transport: HEAVYION		
RADDECAY		Decays: Semi-Analogue	Patch Isom:	Replicas: 1
	h/μ Int: ignore	h/μ LPB: ignore	h/μ WW: ignore	e-e+ Int: ignore
	e-e+ LPB: ignore	e-e+ WW: ignore	Low-n Bias: ignore	Low-n WW: ignore
		decay cut: 0.0	prompt cut: 0.0	Coulomb corr:

****

GENERAL & PRIMARY *

****

@@@START GENERATED, DO NOT MODIFY:GENERAL@@@ ********************************

PHYSICS		Type: COALESCE	Activate: On	
BEAM		Beam: Energy	E: 0.2	Part: HEAVYION
	Δp: Flat	Δp: 0	Δϕ: Flat	Δϕ: 0
	Shape(X): Gauss	x(FWHM): 0.48	Shape(Y): Gauss	y(FWHM): 0.48
HI-PROPE		Z: 8	A: 16	Isom:
BEAMPOS		x: 0	y: 0	z: -30
		cosx: 0	cosy: 0	Type: POSITIVE
EMFCUT		Type: transport		
		e-e+ Threshold: Kinetic	e-e+ Ekin: 1.0	γ: 1
		Reg: BLACK	to Reg: @LASTREG	Step: 1
EMFCUT		Type: PROD-CUT		
		e-e+ Threshold: Kinetic	e-e+ Ekin: 1.0	γ: 1
	Fudgem: 1	Mat: BLCKHOLE	to Mat: @LASTMAT	Step: 1
DELTARAY		E thres: 1	# Log dp/dx:	Log width dp/dx:
	Print NOPRINT	Mat: BLCKHOLE	to Mat: @LASTMAT	Step: 1
PAIRBREM		Act: Inhibit both	e-e+ Thr:	γ Thr:
		Mat: BLCKHOLE	to Mat: @LASTMAT	Step:

@@@END GENERATED:GENERAL@@@ **

****

Let's start with the geometry

Bodies

Regions

A common practice:
- Body names → Lowercase
- Region names → Uppercase

Beam monitor (1)

Bodies

***Beam Monitor

RPP	BmnShiOu	Al case	Xmin: -7.100000 Ymin: -7.100000 Zmin: -25.500000		Xmax: 7.100000 Ymax: 7.100000 Zmax: -2.500000
RPP	BmnShiIn		Xmin: -5.600000 Ymin: -5.600000 Zmin: -25.500000		Xmax: 5.600000 Ymax: 5.600000 Zmax: -2.500000
XYP	BmnMyl0	Mylar windows	z: -24.502500		
XYP	BmnMyl1		z: -24.500000		
XYP	BmnMyl2		z: -3.500000		
XYP	BmnMyl3		z: -3.497500		
RPP	BmnC00	Cells	Xmin: -5.599990 Ymin: -1.995490 Zmin: -21.645490	Along x	Xmax: 5.599990 Ymax: -0.404510 Zmax: -20.654510
RPP	BmnC10		Xmin: -2.795490 Ymin: -5.599990 Zmin: -20.345490	Along y	Xmax: -1.204510 Ymax: 5.599990 Zmax: -19.354510

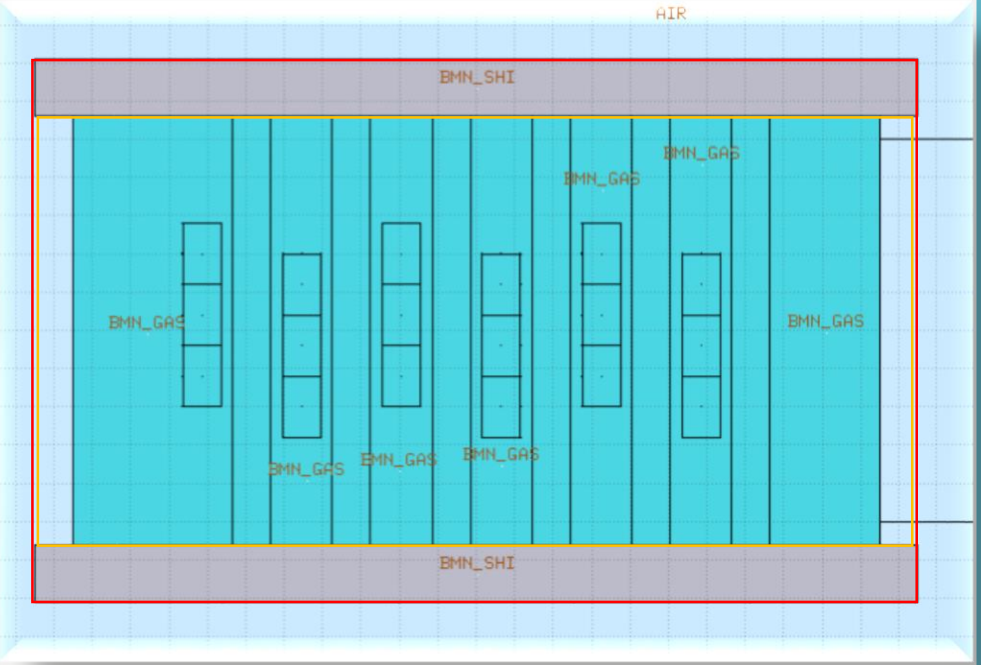
[...]

Regions

***Beam Monitor

REGION	BMN_SHI expr: BmnShiOu -BmnShiIn	Al case	Neigh: 5
REGION	BMN_MYL0 expr: BmnShiIn -BmnMyl0 +BmnMyl1	Mylar windows	Neigh: 5
REGION	BMN_MYL1 expr: BmnShiIn -BmnMyl2 +BmnMyl3		Neigh: 5
REGION	BMN_C000 expr: BmnC00 -BmnS00	Cells	Neigh: 5
REGION	BMN_C001 expr: BmnC01 -BmnS01		Neigh: 5

[...]



Beam monitor (2)

Bodies

Field wires

RCC	BmnF00	x: -5.600000 Hx: 11.200000 R: 0.004500	y: -2 Hy: 0	z: -21.650000 Hz: 0
RCC	BmnF10	x: -2.800000 Hx: 0 R: 0.004500	y: -5.600000 Hy: 11.200000	z: -20.350000 Hz: 0

Along x

Along y

[...]

Sense wires

RCC	BmnS00	x: -5.600000 Hx: 11.200000 R: 0.001500	y: -1.200000 Hy: 0	z: -21.150000 Hz: 0
RCC	BmnS10	x: -2 Hx: 0 R: 0.001500	y: -5.600000 Hy: 11.200000	z: -19.850000 Hz: 0

Along x

Along y

[...]

Regions

Field wires

REGION BMN_FWI Neigh: 5

expr: | BmnShiln + BmnF00 | BmnShiln + BmnF01 | BmnShiln + BmnF02 | BmnShiln + BmnF03
| BmnShiln + BmnF04 | BmnShiln + BmnF05 | BmnShiln + BmnF06 | BmnShiln + BmnF07
| BmnShiln + BmnF08 | BmnShiln + BmnF09 | BmnShiln + BmnF010 | BmnShiln + BmnF011
| BmnShiln + BmnF012 | BmnShiln + BmnF013 | BmnShiln + BmnF014 | BmnShiln + BmnF015

[...]

Sense wires

REGION BMN_SWI Neigh: 5

expr: | BmnC00 + BmnS00 | BmnC01 + BmnS01 | BmnC02 + BmnS02 | BmnC03 + BmnS03
| BmnC04 + BmnS04 | BmnC05 + BmnS05 | BmnC06 + BmnS06 | BmnC07 + BmnS07
| BmnC08 + BmnS08 | BmnC09 + BmnS09 | BmnC010 + BmnS010 | BmnC011 + BmnS011
| BmnC012 + BmnS012 | BmnC013 + BmnS013 | BmnC014 + BmnS014 | BmnC015 + BmnS015
| BmnC016 + BmnS016 | BmnC017 + BmnS017 | BmnC10 + BmnS10 | BmnC11 + BmnS11
| BmnC12 + BmnS12 | BmnC13 + BmnS13 | BmnC14 + BmnS14 | BmnC15 + BmnS15
| BmnC16 + BmnS16 | BmnC17 + BmnS17 | BmnC18 + BmnS18 | BmnC19 + BmnS19
| BmnC110 + BmnS110 | BmnC111 + BmnS111 | BmnC112 + BmnS112 | BmnC113 + BmnS113
| BmnC114 + BmnS114 | BmnC115 + BmnS115 | BmnC116 + BmnS116 | BmnC117 + BmnS117

Gas (no cells)

REGION BMN_GAS Neigh: 5

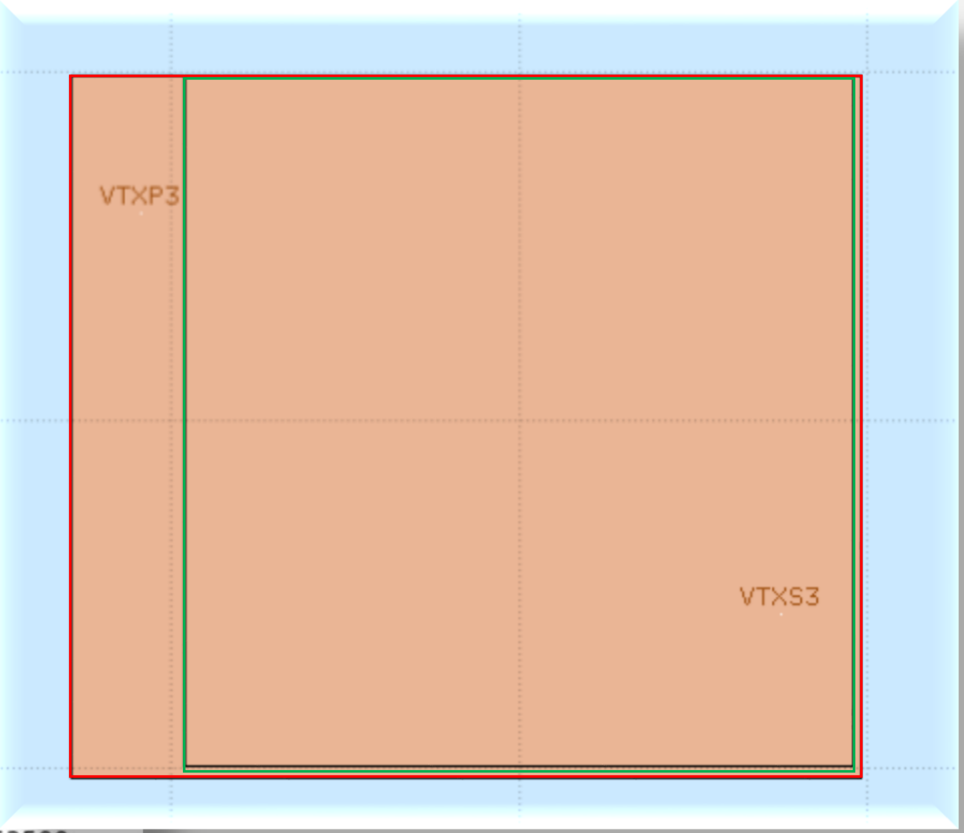
expr: BmnShiln -BmnMyl1 +BmnMyl2
-BmnF00 -BmnF01 -BmnF02 -BmnF03 -BmnF04 -BmnF05
-BmnF06 -BmnF07 -BmnF08 -BmnF09 -BmnF010 -BmnF011
-BmnF012 -BmnF013 -BmnF014 -BmnF015 -BmnF016 -BmnF017
-BmnC00 -BmnC01 -BmnC02 -BmnF018 -BmnF019 -BmnF020

[...]

Target & vertex

Bodies

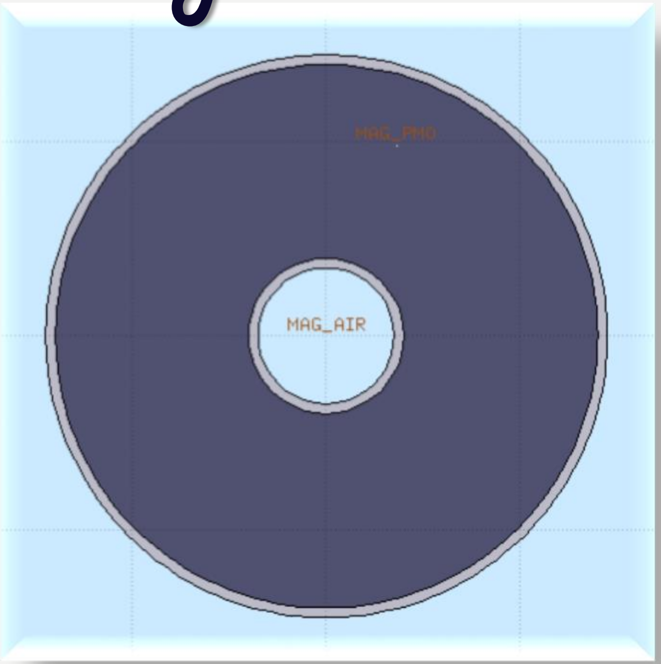
			Min	Max
***Target				
RPP	tgt	Target	Xmin: -0.75 Ymin: -0.75 Zmin: -0.1	Xmax: 0.75 Ymax: 0.75 Zmax: 0.1
***Vertex				
RPP	vtxp0	Vertex sensitive areas	Xmin: -0.982520 Ymin: -1.028400 Zmin: 0.647500	Xmax: 1.28 Ymax: 0.99 Zmax: 0.65
RPP	vtxp1		Xmin: -0.982520 Ymin: -1.028400 Zmin: 0.997500	Xmax: 1.28 Ymax: 0.99 Zmax: 1.00
RPP	vtxp2		Xmin: -0.982520 Ymin: -1.028400 Zmin: 1.997500	Xmax: 1.28 Ymax: 0.99 Zmax: 2.00
RPP	vtxp3		Xmin: -0.982520 Ymin: -1.028400 Zmin: 2.347500	Xmax: 1.28 Ymax: 0.99 Zmax: 2.35
RPP	vtxs0	Vertex passive areas	Xmin: -0.960480 Ymin: -0.993600 Zmin: 0.647500	Xmax: 0.96 Ymax: 0.99 Zmax: 0.652500
RPP	vtxs1		Xmin: -0.960480	Xmax: 0.960480
RPP	vtxs2			
RPP	vtxs3			



Regions

***Target				
REGION	TARGET expr: tgt	Target		Neigh: 5
***Vertex				
REGION	VTXP0 expr: vtxp0 - vtxs0	Vertex sensitive areas		Neigh: 5
REGION	VTXP1 expr: vtxp1 - vtxs1			Neigh: 5
REGION	VTXP2 expr: vtxp2 - vtxs2			Neigh: 5
REGION	VTXP3 expr: vtxp3 - vtxs3			Neigh: 5
REGION	VTXS0 expr: vtxs0	Vertex passive areas		Neigh: 5
REGION	VTXS1 expr: vtxs1			Neigh: 5
REGION	VTXS2 expr: vtxs2			Neigh: 5
REGION	VTXS3 expr: vtxs3			Neigh: 5

Magnets



Bodies

***Magnets

RCC	MagCvOu0	x: 0 Hx: 0 R: 14.5	y: 0 Hy: 0	z: 3 Hz: 10
RCC	MagCvOu1	x: 0 Hx: 0 R: 14.5	y: 0 Hy: 0	z: 15 Hz: 10
RCC	MagPMOu0	x: 0 Hx: 0 R: 14	y: 0 Hy: 0	z: 3.5 Hz: 9
RCC	MagPMOu1	x: 0 Hx: 0 R: 14	y: 0 Hy: 0	z: 15.5 Hz: 9
RCC	MagPMIn0	x: 0 Hx: 0 R: 4	y: 0 Hy: 0	z: 3.5 Hz: 9
RCC	MagPMIn1	x: 0 Hx: 0 R: 4	y: 0 Hy: 0	z: 15.5 Hz: 9

Permanent magnets + Al covers

***Gap for magnets

ZCC	Gap0	x: 0	y: 0	R: 3.5
ZCC	Gap1	x: 0	y: 0	R: 3.5

Magnet aperture

***Magnetic field air region

RPP	MagAir	Xmin: -5 Ymin: -5 Zmin: -16	Xmax: 5 Ymax: 5 Zmax: 44

Magnetic area in air

Regions

***Magnets

REGION MAG_PM0
expr: MagPMOu0 -MagPMIn0
Permanent magnet

REGION MAG_CV0 Neigh: 5
expr: MagCvOu0 -(MagPMOu0 -MagPMIn0) -Gap0
Al cover

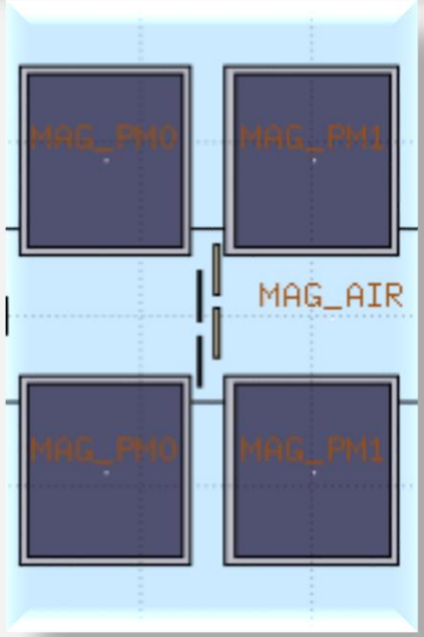
REGION MAG_PM1 Neigh: 5
expr: MagPMOu1 -MagPMIn1
Permanent magnet

REGION MAG_CV1 Neigh: 5
expr: MagCvOu1 -(MagPMOu1 -MagPMIn1) -Gap1
Al cover

***Magnetic field air region

REGION MAG_AIR Neigh: 5
expr: MagAir -tgt -(BmnShIln -BmnMyI0 +BmnMyI3) -(MagCvOu0 -Gap0) -(MagCvOu1 -Gap1) -vtxp0 -vtxp1 -vtxp2 -vtxp3
-itrp2 -itrp23 -itrp44 -itrp65 -itrp4 -itrp25 -itrp46 -itrp67 -itrp8 -itrp29
-itrp50 -itrp71 -itrp10 -itrp31 -itrp52 -itrp73 -itrp0 -itrp21 -itrp42 -itrp63
-itrp12 -itrp33 -itrp54 -itrp75 -itrp1 -itrp22 -itrp43 -itrp64 -itrp3 -itrp24
-itrp45 -itrp66 -itrp5 -itrp26 -itrp47 -itrp68 -itrp7 -itrp28 -itrp49 -itrp70
-itrp9 -itrp30 -itrp51 -itrp72 -itrp11 -itrp32 -itrp53 -itrp74 -itrp13 -itrp15
-itrp17 -itrp19 -itrp34 -itrp36 -itrp38 -itrp40 -itrp55 -itrp57 -itrp59 -itrp61
-itrp76 -itrp78 -itrp80 -itrp82 -itrp14 -itrp16 -itrp18 -itrp20 -itrp35 -itrp37
-itrp39 -itrp41 -itrp56 -itrp58 -itrp60 -itrp62 -itrp77 -itrp79 -itrp81 -itrp83
-itrp6 -itrp27 -itrp48 -itrp69 -msds0 -msds1 -msds2

Magnetic area in air



Inner Tracker

Bodies

Passive elements

RPP	itrp2	Xmin: -9.587000 Ymin: -4.119920 Zmin: 13.390500	Xmax: 6.047000 Ymax: -1.248920 Zmax: 13.391500
RPP	itrp23	Xmin: -9.587000 Ymin: -2.498960 Zmin: 14.608500	Xmax: 6.047000 Ymax: 0.372040 Zmax: 14.609500

[...]

Sensitive zones

RPP	itrs000	Xmin: -3.547000 Ymin: -3.391920 Zmin: 13.382000	Xmax: -1.559800 Ymax: -1.470960 Zmax: 13.387000
RPP	itrs001	Xmin: -1.523000 Ymin: -3.391920 Zmin: 13.382000	Xmax: 0.464200 Ymax: -1.470960 Zmax: 13.387000

[...]

Regions

Passive elements (board)

REGION	ITRP53	expr: itrp53	Neigh: 5
REGION	ITRP74	expr: itrp74	Neigh: 5

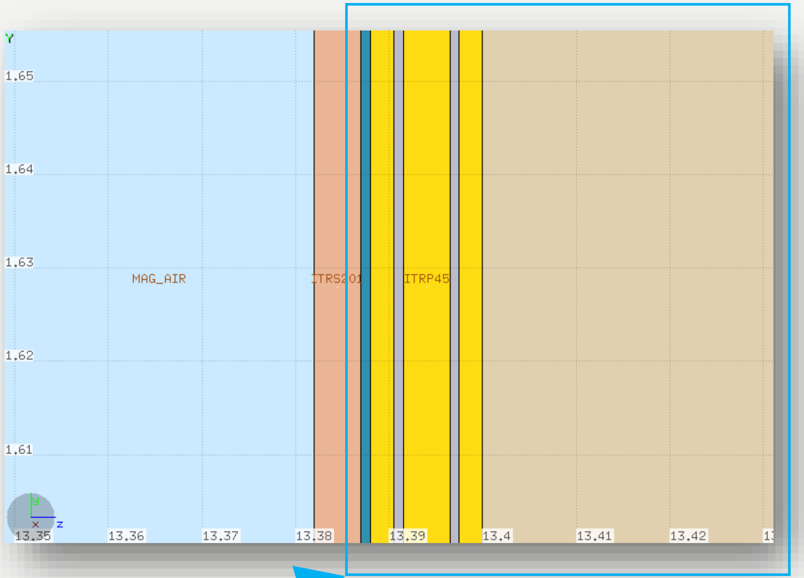
Passive silicon frames

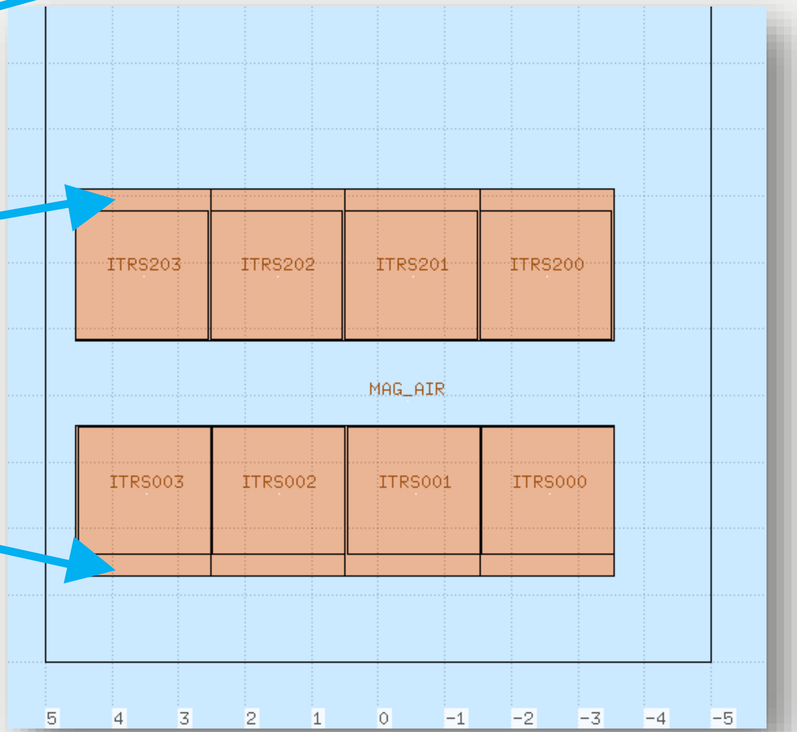
REGION	ITRP13	expr: itrp13 - itrs000	Neigh: 5
REGION	ITRP15	expr: itrp15 - itrs001	Neigh: 5

[...]

REGION	ITRS000	expr: itrs000	Neigh: 5
REGION	ITRS001	expr: itrs001	Neigh: 5
REGION	ITRS002	expr: itrs002	Neigh: 5

[...]



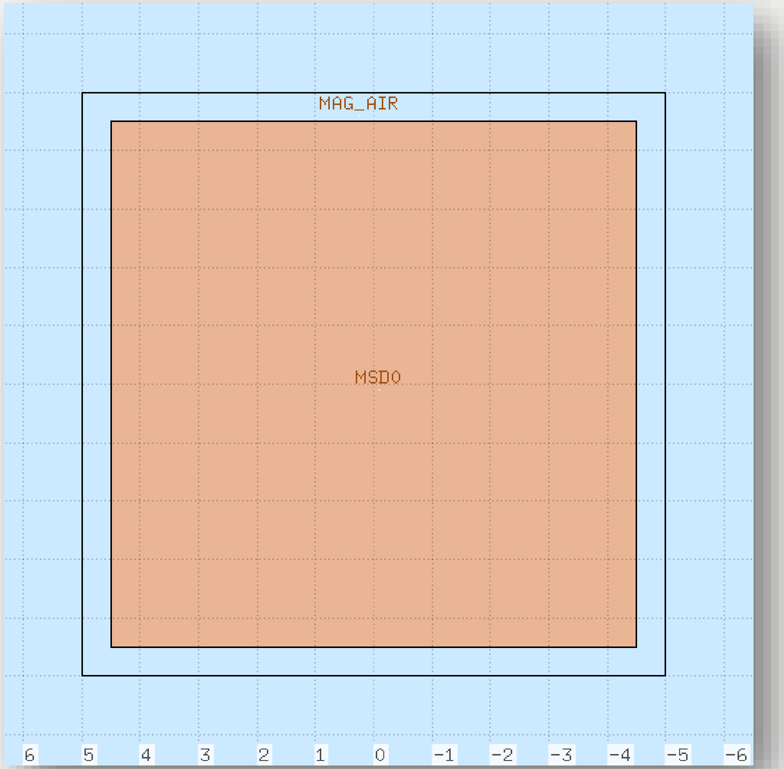


MicroStrip Detector

Bodies

***Micro Strip Detector

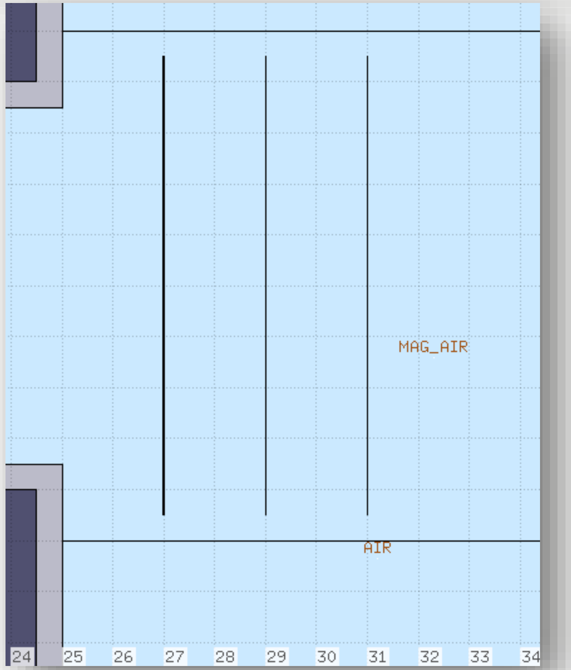
RPP	msds0	Xmin: -4.500000 Ymin: -4.500000 Zmin: 26.992500	Xmax: 4.500000 Ymax: 4.500000 Zmax: 27.007500
RPP	msds1	Xmin: -4.500000 Ymin: -4.500000 Zmin: 28.992500	Xmax: 4.500000 Ymax: 4.500000 Zmax: 29.007500
RPP	msds2	Xmin: -4.500000 Ymin: -4.500000 Zmin: 30.992500	Xmax: 4.500000 Ymax: 4.500000 Zmax: 31.007500



Regions

***Micro Strip Detector

REGION	MSDS0	expr: msds0	Neigh: 5
REGION	MSDS1	expr: msds1	Neigh: 5
REGION	MSDS2	expr: msds2	Neigh: 5



Scintillator

Bodies

```
***Air Box for Scintillator and Calorimeter
RPP    box       Xmin: -23          Xmax: 23
                 Ymin: -23          Ymax: 23
                 Zmin: 98.55        Zmax: 125
***Scintillator
RPP    scn000    Xmin: -22          Xmax: -20
                 Ymin: -22          Ymax: 22
                 Zmin: 99.400000    Zmax: 99.700000
RPP    scn001    Xmin: -20          Xmax: -18
                 Ymin: -22          Ymax: 22
                 Zmin: 99.400000    Zmax: 99.700000
```

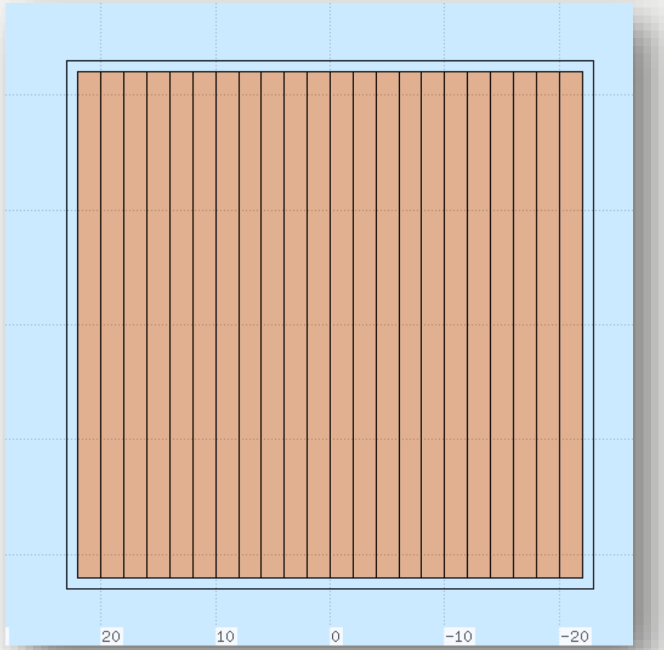
[...]

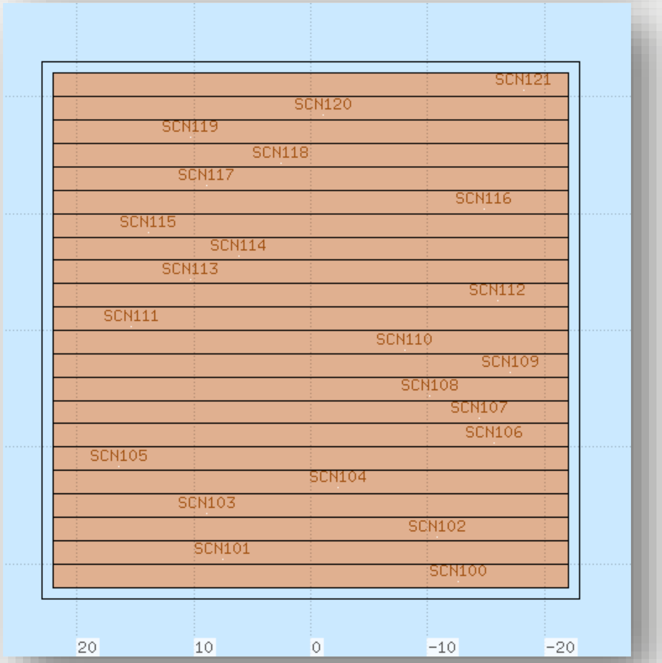
Regions

```
***Air Box for Scintillator and Calorimeter
REGION   BOX                                                              Neigh: 5
   expr: box  -scn000 -scn001 -scn002 -scn003 -scn004 -scn005 -scn006 -scn007 -scn008 -scn009
         -scn010 -scn011 -scn012 -scn013 -scn014 -scn015 -scn016 -scn017 -scn018 -scn019
         -scn020 -scn021 -scn100 -scn101 -scn102 -scn103 -scn104 -scn105 -scn106 -scn107
         -scn108 -scn109 -scn110 -scn111 -scn112 -scn113 -scn114 -scn115 -scn116 -scn117
         -scn118 -scn119 -scn120 -scn121          -cal0 -cal1 -cal2 -cal3 -cal4 -cal5
         -cal6 -cal7 -cal8 -cal9 -cal10 -cal11
         -cal12 -cal13 -cal14 -cal15 -cal16 -cal17
         -cal18 -cal19 -cal20 -cal21 -cal22 -cal23
         -cal24 -cal25 -cal26 -cal27 -cal28 -cal29
         -cal30 -cal31 -cal32 -cal33 -cal34 -cal35
***Scintillator
REGION   SCN000                                                           Neigh: 5
   expr: scn000
REGION   SCN001                                                           Neigh: 5
   expr: scn001
```

[...]

This box is required since scintillator and calorimeter are composed of many bosies that should be subtracted from the body AIR. However, already many bodies are subtracted from AIR. Too many body subtracted → FLUKA error!





Calorimeter

Bodies

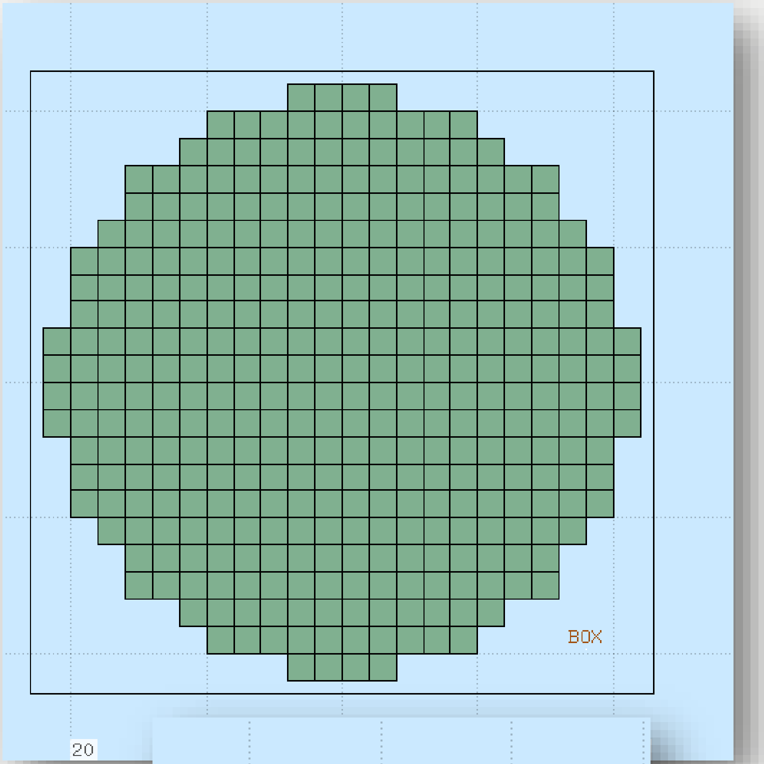
***Calorimeter

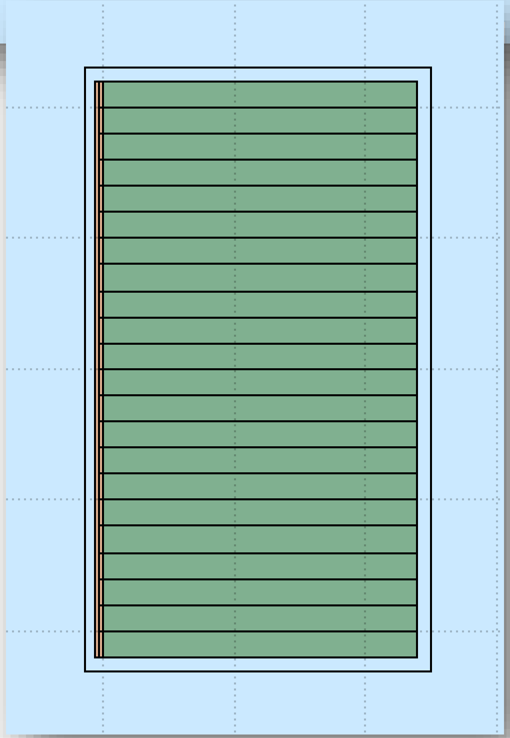
RPP	cal0	Xmin: -4 Ymin: -22 Zmin: 100	Xmax: -2 Ymax: -20 Zmax: 124
RPP	cal1	Xmin: -2 Ymin: -22 Zmin: 100	Xmax: 0 Ymax: -20 Zmax: 124
RPP	cal2	Xmin: 0 Ymin: -22 Zmin: 100	Xmax: 2 Ymax: -20 Zmax: 124

Regions

***Calorimeter

REGION	CAL000	expr: cal0	Neigh: 5
REGION	CAL001	expr: cal1	Neigh: 5
REGION	CAL002	expr: cal2	Neigh: 5





Materials

Definition of a new compound

*** Samario-Cobalto permanent magnet

MATERIAL	Name: SAMARIUM	#	ρ: 7.46
Z: 62	Am:	A:	dE/dx:
MATERIAL	Name: COBALT	#	ρ: 8.9
Z: 27	Am:	A:	dE/dx:
MATERIAL	Name: SmCo	#	ρ: 8.3
Z:	Am:	A:	dE/dx:
COMPOUND	Name: SmCo	Mix: Atom	Elements: 1..3
f1: 2.0	M1: SAMARIUM	f2: 17.0	M2: COBALT
f3:	M3:		

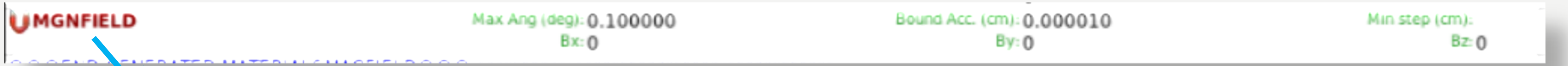
Multiple assigment: regions must have been declared subsequently

Single assigment

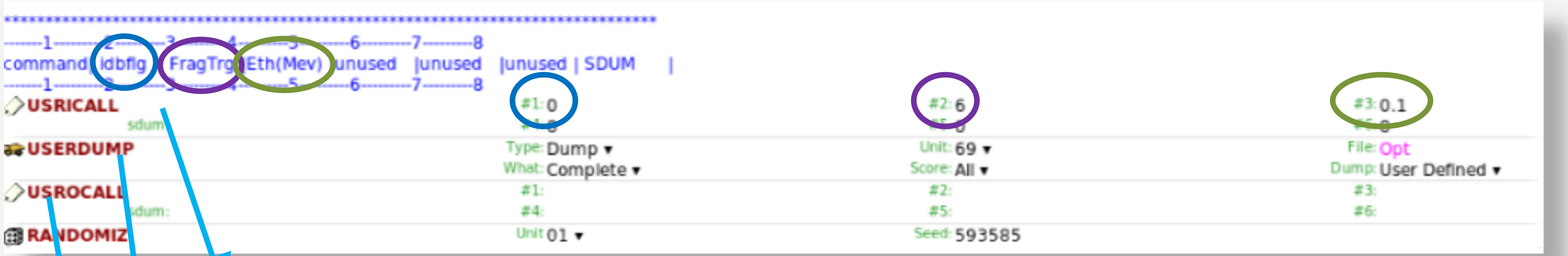
ASSIGNMA	Mat: Mylar	Reg: BMN_MYL1	to Reg:
	Mat(Decay):	Step:	Field:
ASSIGNMA	Mat: Ar-CO2	Reg: BMN_C000	to Reg: BMN_C017
	Mat(Decay):	Step: 1	Field:
ASSIGNMA	Mat: Ar-CO2	Reg: BMN_C100	to Reg: BMN_C117
	Mat(Decay):	Step: 1	Field:
ASSIGNMA	Mat: Ar-CO2	Reg: BMN_GAS	to Reg:
	Mat(Decay):	Step:	Field:
ASSIGNMA	Mat: ALUMINUM	Reg: BMN_FWI	to Reg:
	Mat(Decay):	Step:	Field:
ASSIGNMA	Mat: TUNGSTEN	Reg: BMN_SWI	to Reg:
	Mat(Decay):	Step:	Field:
ASSIGNMA	Mat: Polyethy	Reg: TARGET	to Reg:
	Mat(Decay):	Step:	Field: Magnetic
ASSIGNMA	Mat: SILICON	Reg: VTXP0	to Reg: VTXS3
	Mat(Decay):	Step: 1	Field: Magnetic
ASSIGNMA	Mat: ALUMINUM	Reg: ITRP2	to Reg: ITRP73
	Mat(Decay):	Step: 1	Field: Magnetic
ASSIGNMA	Mat: Epoxy	Reg: ITRP0	to Reg: ITRP75
	Mat(Decay):	Step: 1	Field: Magnetic

Magnetic regions

Call to user routines



Calls the routine magfld.f that handles the magnetic field.



The meaning of WHAT(1),...,WHAT(6), SDUM is defined by the user. A call to the user-written routine usrini.f with 6 WHAT numerical values and one character string SDUM as arguments is issued every time this card is read.

The meaning of WHAT(1),...,WHAT(6), SDUM is defined by the user. A call to the user-written routine usrout.f with 6 WHAT numerical values and one character string SDUM as arguments is issued every time this card is read.

This command activates calls to the user routine mgraw.f and to its entries BXDRAW, EEDRAW, ENDRAW, SODRAW, USDRAW

Further information in the slides about user routines.

Management of input & geometry: the FOOT style

ROOT & FLUKA geometry

- Geometry needed by both:
  - detector MC simulation (FLUKA);
  - track reconstruction (hit position, Multiple Scattering, alignment, …)
- On the **Reco side**:
  - include positions, materials, mag. field;
  - basically managed by Genfit;
  - use ROOT classes of TGeometry;
- On the **FLUKA side:**
  - all defined with parameter files, **logic completely different** from ROOT;

- **FOOT' approach:** one code take the same input and produce 2 output (automatic, no error, fast changes after the fist super-time-consuming implementation);
  - **Input:** foot_geo.h (will become a text file…) + foot.inp;
  - **Code:** single main/macro (MakeGeo.cxx) calls each detector geometry class;
  - **Output:** FLUKA par files (foot.geo, foot.inp) + TGeometry objects

- ROOT geometry NEEDED ONLY in reconstruction;
- FLUKA par files production NOT NEEDED during reconstruction runs (RecoTools)
- FLUKA par files **can be** produced using a separate run (**MakeGeo.cc macro)**

Geometry production controlled by **GlobalParameter**: can run together or separately

Further information in the slides of the Software tutorial by **M. Franchini.**

MakeGeo (1)

- **shoe/Simulation/MakeGeo.cxx:** simple macro, just a main function;
  - Define **Mag. Field**
  - Define **Materials**
  - Build **detectors pieces** (obj matrix), **assign material** to each piece, check if the magnetic field is present;
  - **Write** the FLUKA parameter files; Needed by routines!
- **Compile & run**:
  - cd shoe/Simulation/
  - source CompileGeo.sh (remember to compile libs/src first)
  - ./makeGeo

All the detectors geometry is handled by the geometry classes in the libraries. A modification in foot_geo.h is not effective until libraries are compiled again!

MakeGeo (2)

```
genfit::FieldManager::getInstance()->init(new FootField( "SummedSingleMap_NoRot.table" ) ); // variable field
// genfit::FieldManager::getInstance()->init(new FootField( "DoubleDipole.table" ) ); // variable field
// genfit::FieldManager::getInstance()->init(new FootField("DoubleGaussMag.table")); // variable field

Materials* listMaterials = new Materials() ;
listMaterials->PrintCompMap();
```

Initialization of magnetic field

```
    // GlobalFootGeo footGeo;
    TAIRparGeo* stcGeo = new TAIRparGeo();
    TABMparGeo* bmGeo = new TABMparGeo();
    TAVTparGeo* vtxGeo = new TAVTparGeo();
    TAITparGeo* itrGeo = new TAITparGeo();
    TAMSDparGeo* msdGeo = new TAMSDparGeo();
    TATWparGeo* twGeo = new TATWparGeo();
    TACAparGeo* caGeo = new TACAparGeo();

    //  si costruisce le coordinate di ogni oggetto geometrico e sensibile
    stcGeo->InitGeo();
    bmGeo->InitGeo();
    bmGeo->ShiftBmon();
    vtxGeo->InitGeo();
    itrGeo->InitGeo();
    msdGeo->InitGeo();
    twGeo->InitGeo();
    caGeo->InitGeo();
```

Initialization of detectors geometry

Makegeo(3)

```
geofile << vtxGeo->PrintBodies(  );
geofile << itrGeo->PrintBodies(  );

geofile << "* ***Magnets\n";
geofile << "RCC MagCvOu0    " << MAG_X << " " << MAG_Y << " "
        << MAG_Z - MAG_CV_LENGTH/2. - MAG_DIST/2. << " 0.000000 0.000000 "
        // << MAG_Z - MAG_DIST/2. << " 0.000000 0.000000 "
        << MAG_CV_LENGTH << " " << MAG_CV0_OUTRAD << endl;
geofile << "RCC MagCvOu1    " << MAG_X << " " << MAG_Y << " "
        << MAG_Z - MAG_CV_LENGTH/2. + MAG_DIST/2. << " 0.000000 0.000000 "
        // << MAG_Z + MAG_DIST/2. << " 0.000000 0.000000 "
        << MAG_CV_LENGTH << " " << MAG_CV1_OUTRAD << endl;
geofile << "RCC MagPMOu0    " << MAG_X << " " << MAG_Y << " "
        << MAG_Z - MAG_PM_LENGTH/2. - MAG_DIST/2. << " 0.000000 0.000000 "
        // << MAG_Z - MAG_DIST/2. << " 0.000000 0.000000 "
        << MAG_PM_LENGTH << " " << MAG_PM0_OUTRAD << endl;
```

Print the bodies in geo file (non-detectors bodies are not handled by classes)

```
geofile << vtxGeo->PrintRegions(  );
geofile << itrGeo->PrintRegions(  );

geofile <<"* ***Magnets\n";
geofile <<"MAG_PM0      5 MagPMOu0 -MagPMIn0\n";
geofile <<"MAG_CV0      5 MagCvOu0 -(MagPMOu0 -MagPMIn0) -Gap0\n";
geofile <<"MAG_PM1      5 MagPMOu1 -MagPMIn1\n";
geofile <<"MAG_CV1      5 MagCvOu1 -(MagPMOu1 -MagPMIn1) -Gap1\n";
```

Print the regions in geo file (non-detectors regions are not handled by classes)

Makegeo(4)

```
outfile << "ASSIGNMA    BLCKHOLE     BLACK\n";
outfile << "ASSIGNMA         AIR       AIR\n";

outfile << stcGeo->PrintAssignMaterial();
outfile << bmGeo->PrintAssignMaterial();
outfile << "ASSIGNMA    Polyethy    TARGET                            1\n";
outfile << vtxGeo->PrintAssignMaterial();
outfile << itrGeo->PrintAssignMaterial();
outfile << "ASSIGNMA        SmCo   MAG_PM0\n";
outfile << "ASSIGNMA    ALUMINUM   MAG_CV0\n";
outfile << "ASSIGNMA        SmCo   MAG_PM1\n";
outfile << "ASSIGNMA    ALUMINUM   MAG_CV1\n";
outfile << "ASSIGNMA         AIR   MAG_AIR                            1\n";
outfile << msdGeo->PrintAssignMaterial();
outfile << "ASSIGNMA         AIR       BOX\n";
outfile << twGeo->PrintAssignMaterial();
outfile << caGeo->PrintAssignMaterial();

outfile << PrintCard("MGNFIELD",TString::Format("%f",MaxAng),
                     TString::Format("%f",BoundAcc),"",
                     TString::Format("%f",Bx),TString::Format("%f",By),
                     TString::Format("%f",Bz),"") << endl;
// outfile << "MGNFIELD    0.100000  0.000010          0.000000  0.000000  0.000000" << endl;
```

Print material for each region

```
ofstream paramfile;
paramfile.open("ROUTINES/parameters.inc");

paramfile << bmGeo->PrintParameters();
paramfile << vtxGeo->PrintParameters();
paramfile << itrGeo->PrintParameters();
paramfile << msdGeo->PrintParameters();
paramfile << twGeo->PrintParameters();
paramfile << caGeo->PrintParameters();

paramfile.close();
```

Print parameters file (in fortran)

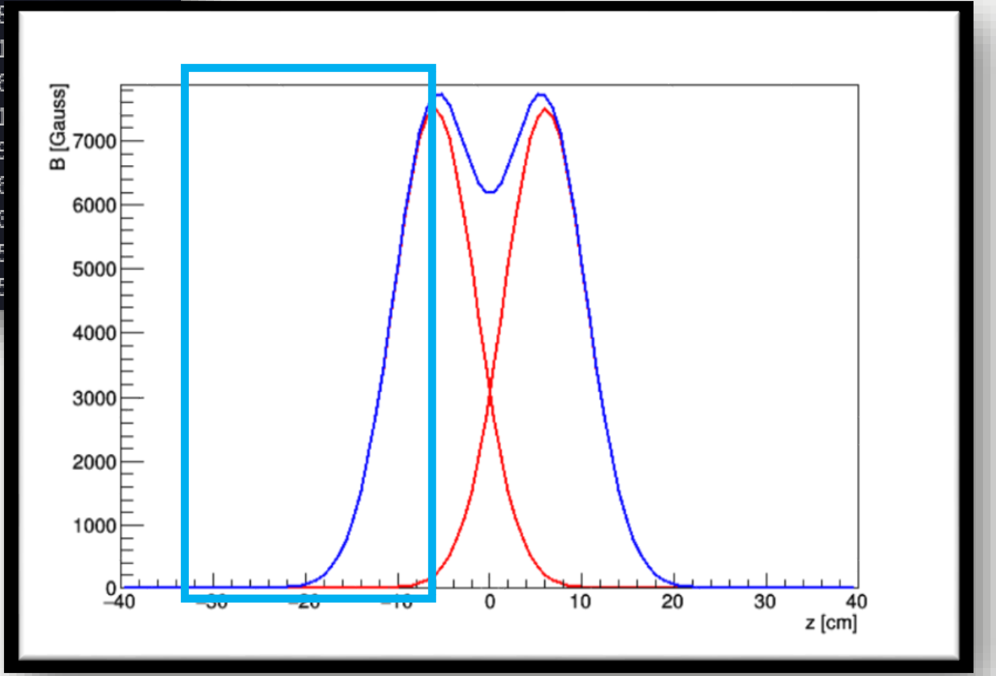
Magnetic field: how to

Magnetic field map

x	y	z	Bx	By	Bz
63945	21	21	145		
-5.000000	-5.000000	-22.000000	-5.549254	30.965339	-0.000000
-5.000000	-5.000000	-21.500000	-5.578702	30.984809	-2.117146
-5.000000	-5.000000	-21.000000	-5.776178	31.111578	-4.157248
-5.000000	-5.000000	-20.500000	-5.773638	31.515483	-6.194417
-5.000000	-5.000000	-20.000000	-6.016018	32.003768	-8.154052
-5.000000	-5.000000	-19.500000	-6.289680	32.632538	-10.281330
-5.000000	-5.000000	-19.000000	-6.726908	33.621049	-12.945227
-5.000000	-5.000000	-18.500000	-7.193384	34.561779	-15.649857
-5.000000	-5.000000	-18.000000	-7.750477	35.755211	-18.188532
-5.000000	-5.000000	-17.500000	-8.325049	37.080605	-20.716670
-5.000000	-5.000000	-17.000000	-9.225554	38.656683	-23.954178
-5.000000	-5.000000	-16.500000	-10.288543	40.310373	-27.477590
-5.000000	-5.000000	-16.000000	-11.206972	42.005556	-31.166651
-5.000000	-5.000000	-15.500000	-12.314589	44.095620	-34.787421
-5.000000	-5.000000	-15.000000	-13.590477	46.426573	-38.8
-5.000000	-5.000000	-14.500000	-15.133879	49.010705	-44.1
-5.000000	-5.000000	-14.000000	-16.757145	51.969408	-49.6
-5.000000	-5.000000	-13.500000	-18.661688	55.221109	-56.1
-5.000000	-5.000000	-13.000000	-21.085349	59.128759	-62.9
-5.000000	-5.000000	-12.500000	-23.821297	63.054492	-70.6
-5.000000	-5.000000	-12.000000	-26.885180	67.403054	-79.0
-5.000000	-5.000000	-11.500000	-30.464817	72.220677	-88.5
-5.000000	-5.000000	-11.000000	-34.553693	77.599648	-99.5

Single magnet magnetic map (Claudio Sanelli):

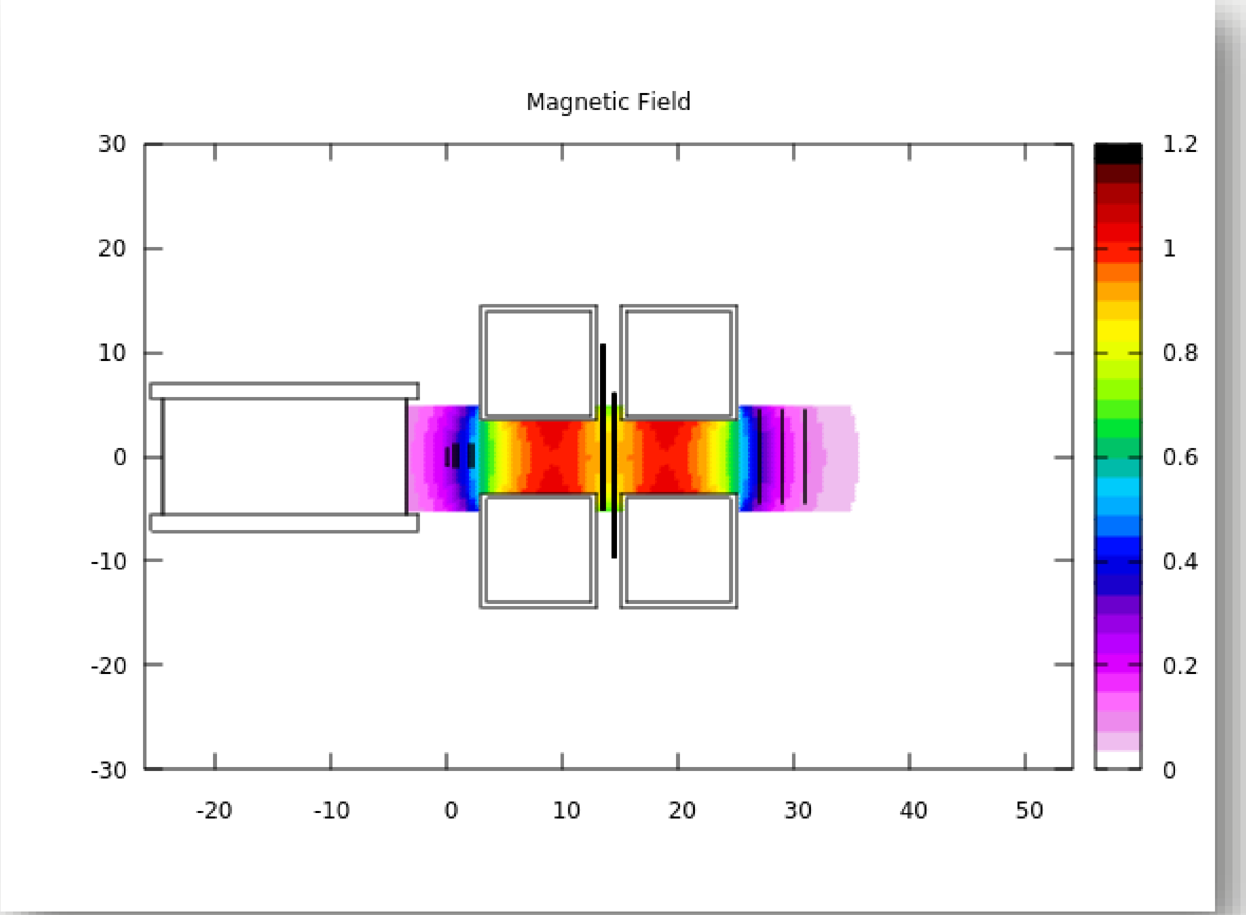
- 10*10*30 cm3
- 0,5 cm steps

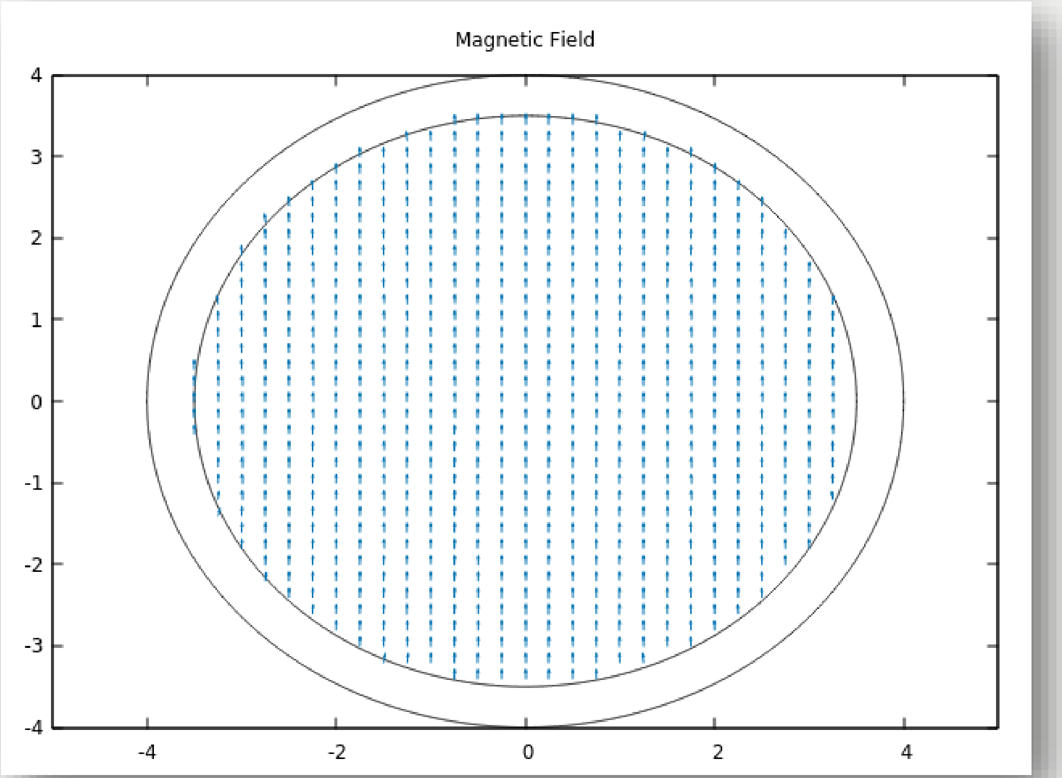


A c++ code is available to produce the total map for two magnets, according to their distance and starting from Sanelli's map.

Magnetic field in FLUKA

The magfld routine, called by card MGNFIELD interpolates the point given in the magnetic map.



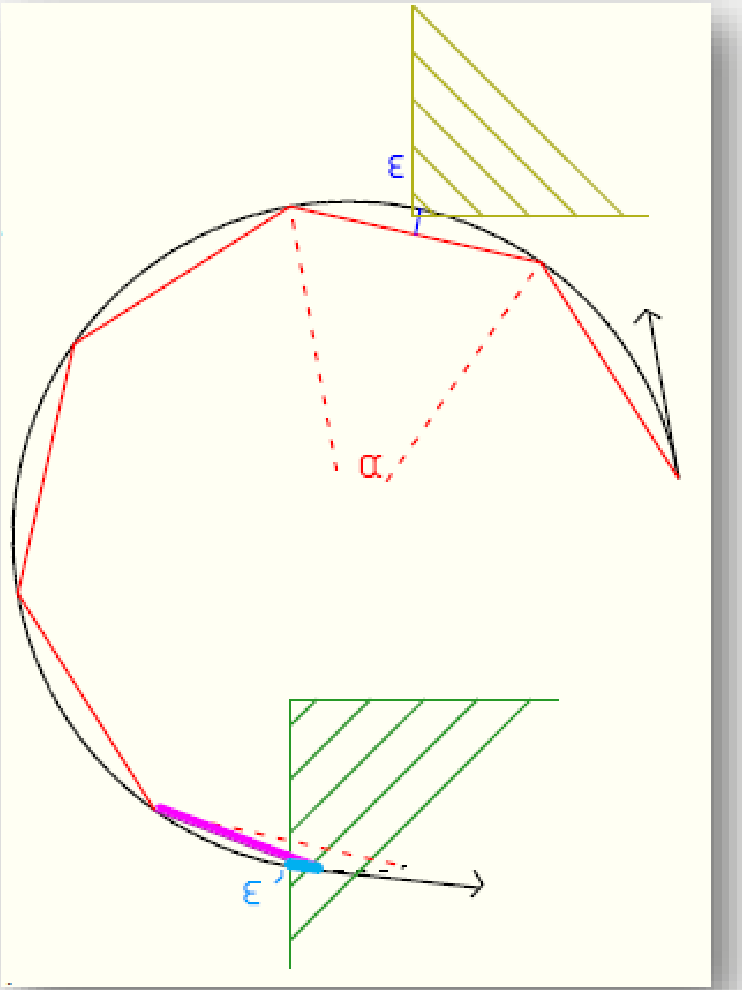


Inside one magnet gap

FLUKA tracking in magnetic field

When tracking particles in magnetic field, FLUKA, like many other MC codes, makes use of a different tracking algorithm since, the analytic solution for the crossing of a helix with a generic surface could be rather time consuming.

Magnetic field tracking is performed by **iterations** until a given accuracy when crossing a boundary is achieved.



Meaningful user input is required when setting up the parameters defining the tracking accuracy.

- The true step (**black line**) is approximated by linear sub-steps. Sub-step length and boundary crossing iteration are governed by the required tracking precision.
- The red line is the path actually followed,
- The magenta segment is the last substep, shortened because of a boundary crossing
- The end point is ALWAYS on the true path, generally NOT exactly on the boundary, but at a distance < ε' (light blue arc) from the true boundary crossing. The ε' value has to be specified by the user (we neglected this in the first releases)