MDI - Simulation Studies

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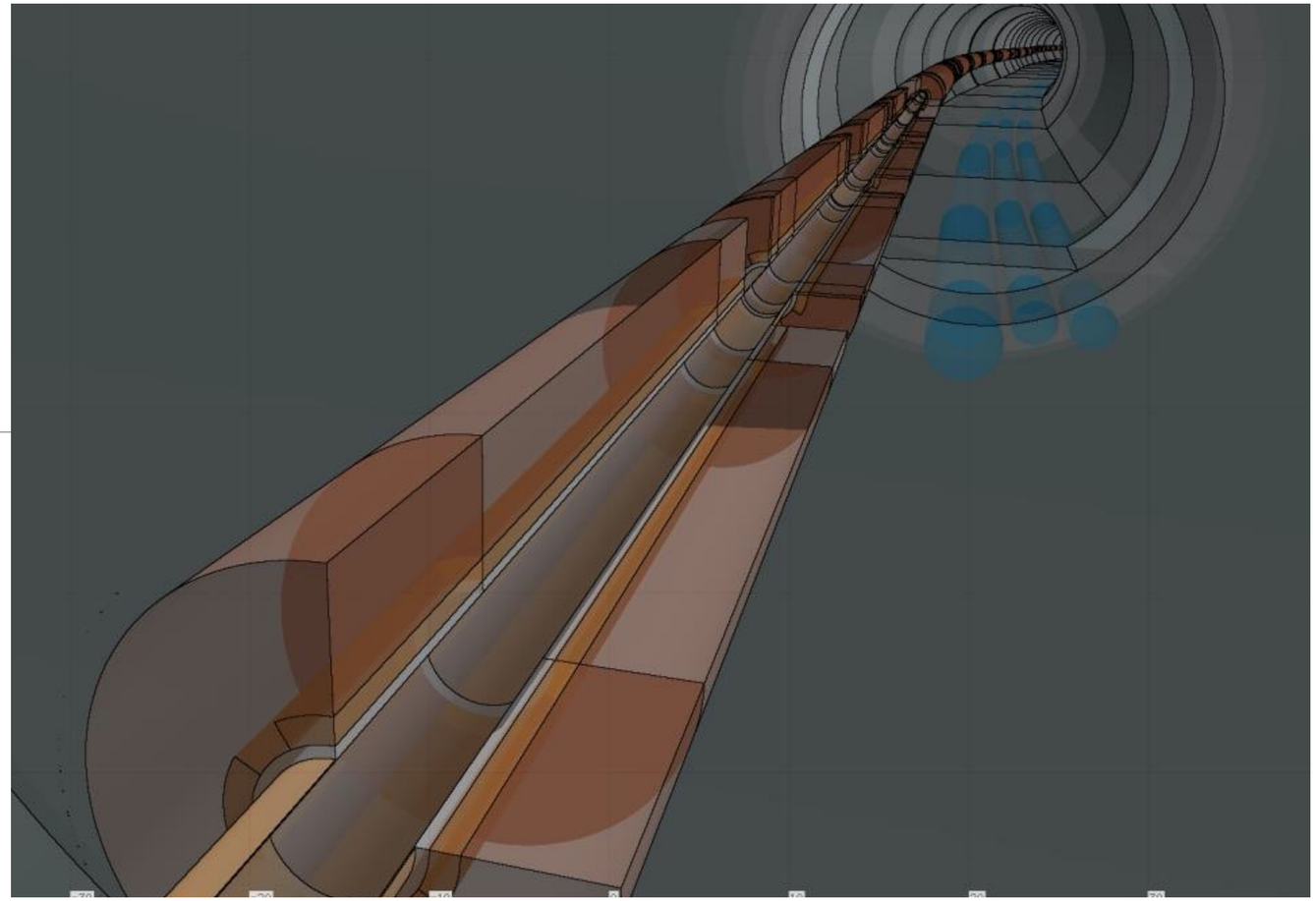
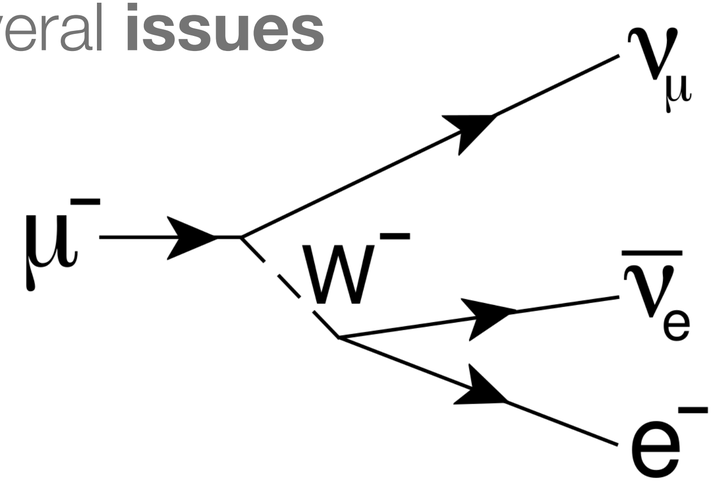


MEETING INFN-accelreatori
12.10.20

- Muons' **decay** all along the machine leads to several **issues**



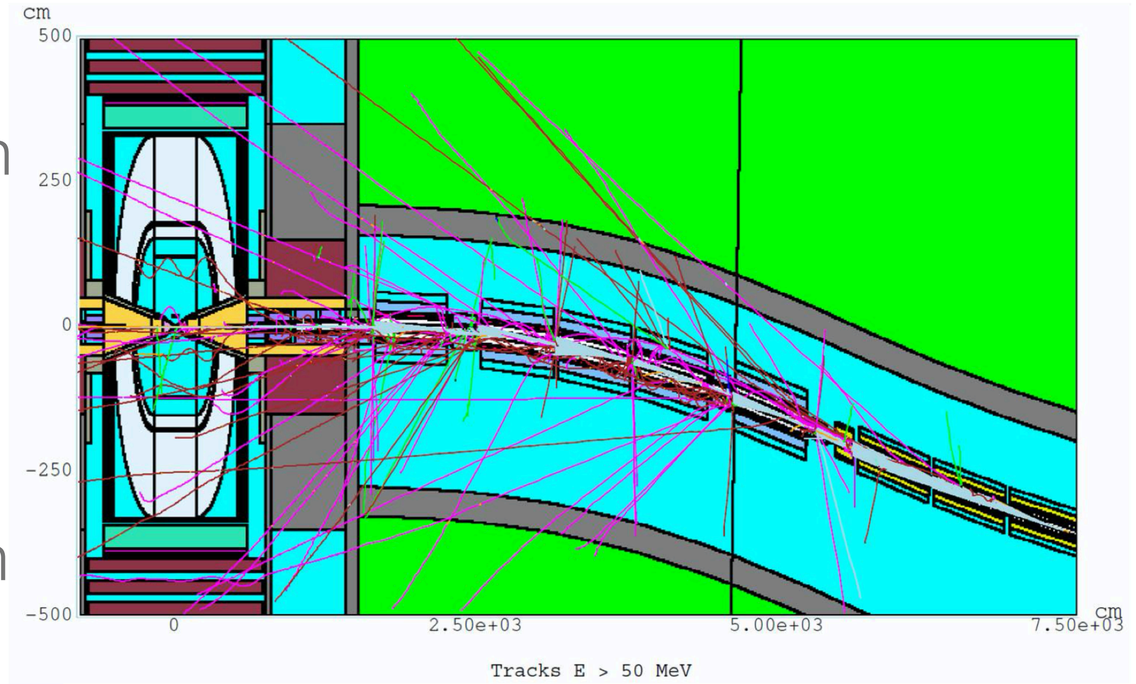
What about decay products!?

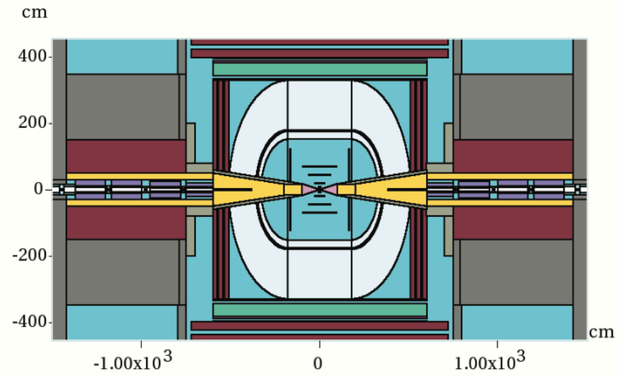
- Magnet quenching
- Detector background
- Radiation protection

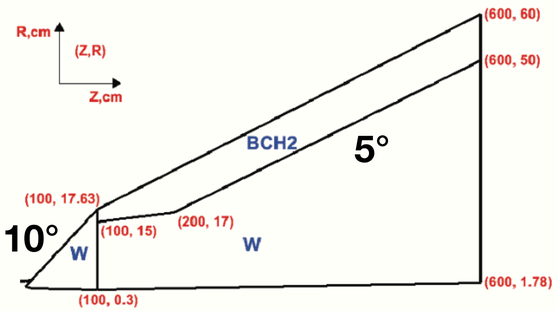
Huge amount of interesting physics!

ARE WE ABLE TO SEE IT?!

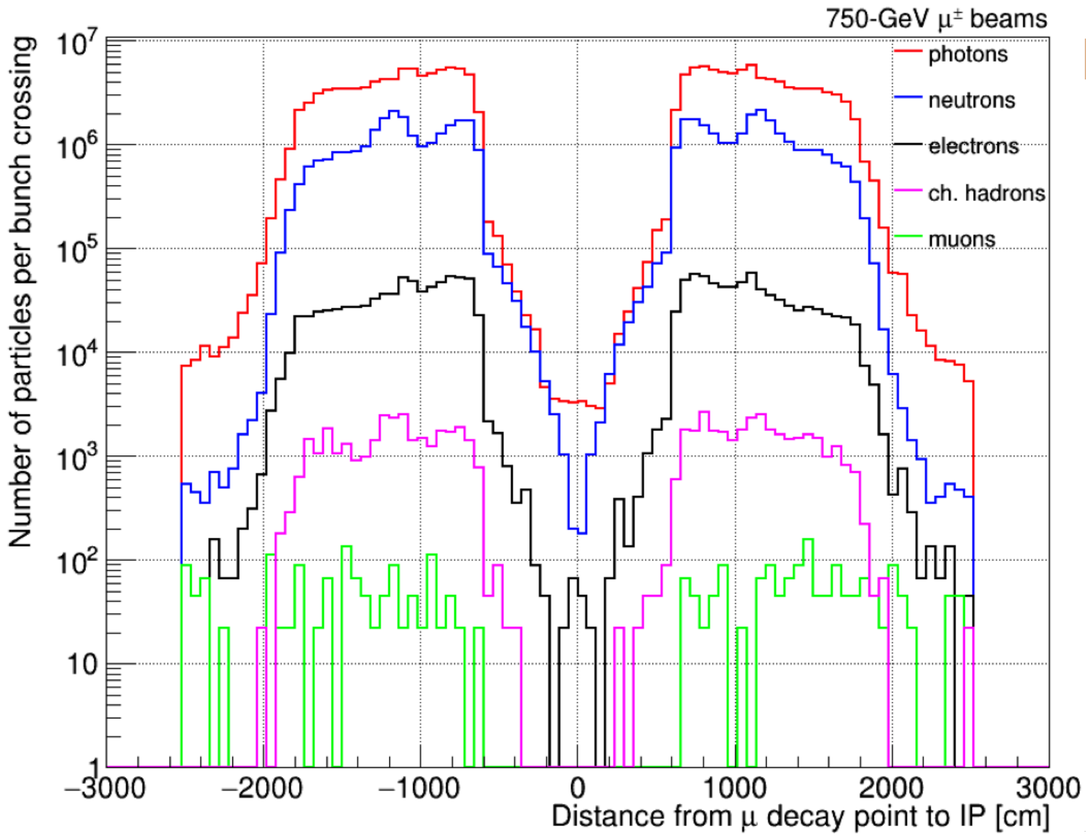
- **Beam Induced Background** (BIB) in the detector can severely impair its performances
  - **MAP** developed a realistic simulation of BIB in the detector by implementing a model of the tunnel and accelerator **±200m** from the interaction point, **@E_{cm} = 1.5 TeV**
  - Secondary and tertiary particles from muon decays are simulated with *MARS15* then transported to the detector
  - **Two tungsten nozzles** play a crucial role in background mitigation inside the detector



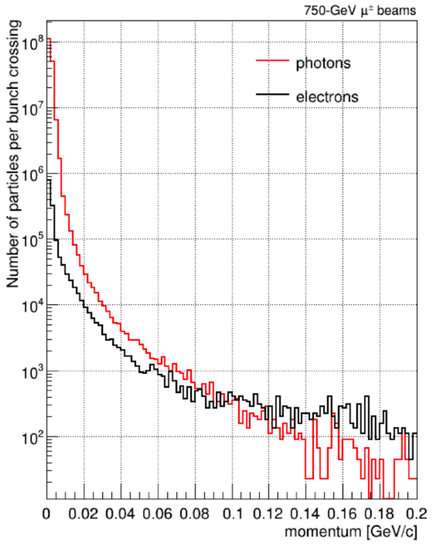


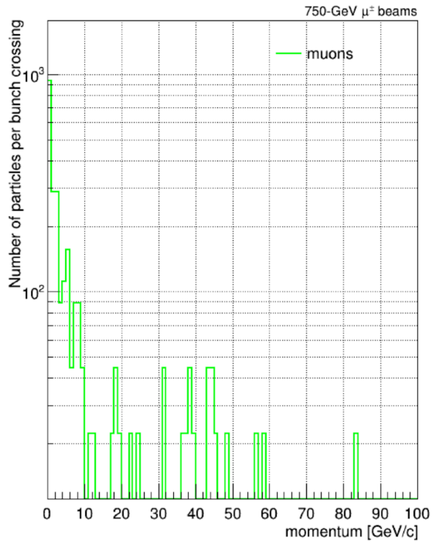


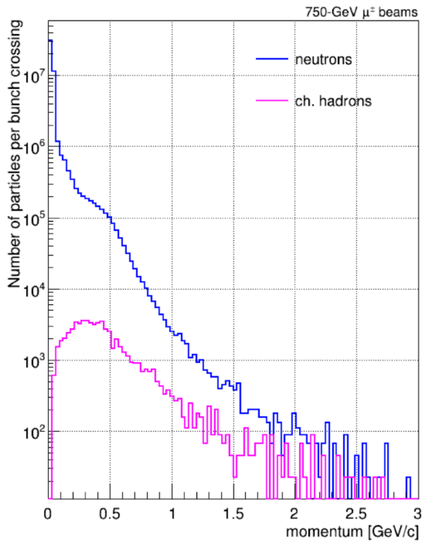
- **MAP results** for BIB @ E_{cm} = 1.5 TeV



Beam Induced Background comes from ~25 meters from the IP







$P_{e/g}$~MeV, $P_{n\,/ch.h}$~500 MeV, P_{mu}~10GeV

BIB @ Muon Collider, let's frame the issue:

- A Muon Collider has outstanding physics capabilities
- Beam Induced Background can impair detector performances
  - This bkg depends on both Center Of Mass energy and Machine Design
- A first study for the 1.5TeV CM case was done within the MAP program.
  A study for 125GeV CM has been done (see N. Bartosik's talk)
- Results suggest challenging physics measurements are possible!

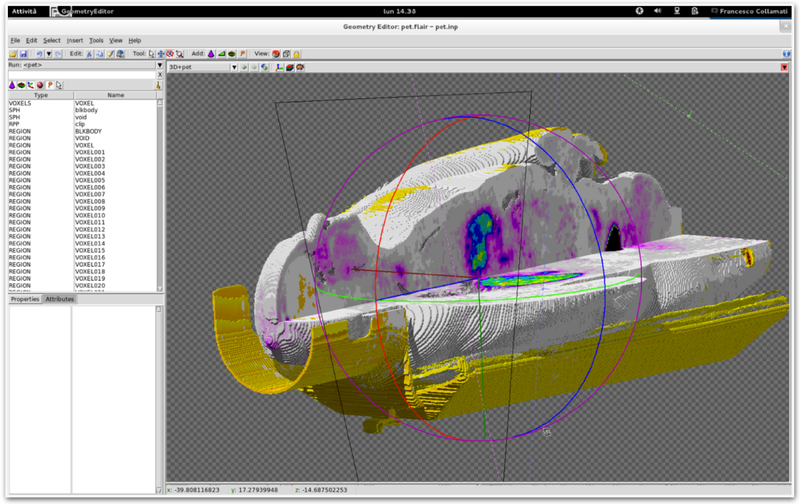
Beam Induced Background must be kept strictly under control!

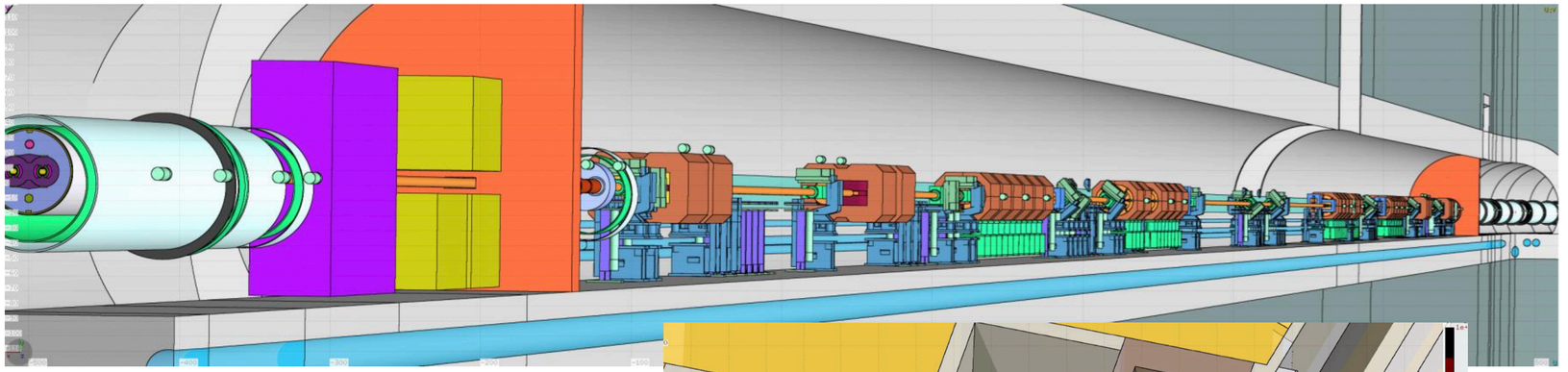
…in each machine configuration!

- ✓ Change beam energy
- ✓ Change machine optics
- ✓ MDI optimisation (nozzle..)

Need for a **flexible** tool to go **from machine optics** to Monte Carlo **simulation**

- **FLUKA** is one of the most common general purpose Monte Carlo software, and is the established standard for example for *radio protection* studies
  - Natively supports very complicated and detailed geometries





- Ideal if coupled with automation tool for geometry construction!

✦**FLUKA LINE BUILDER** is a program aimed at automatically build accelerator geometries, consists of 2 parts:

Fluka Element DataBase

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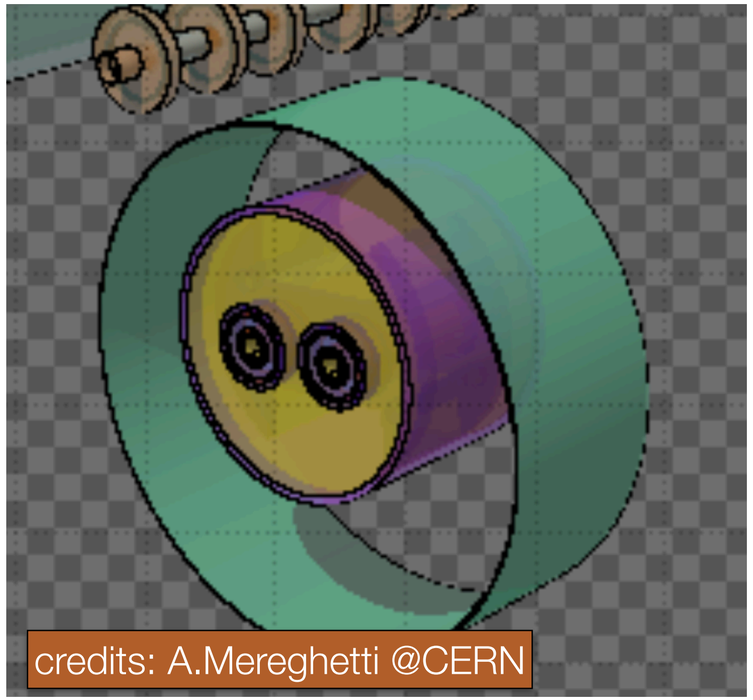
 > tree fedb/
fedb/
├── [4.0K]  assemblies
├── [4.0K]  bodies
│   ├── [ 787]  myacc_MBS.bodies
│   ├── [ 254]  myacc_MBSORI.bodies
│   └── [ 103]  myacc_MQBODY.bodies
├── [4.0K]  materials
│   ├── [2.3K]  materials.inp
│   ├── [ 251]  myacc_MBS.assignmat
│   ├── [ 135]  myacc_MBSORI.assignmat
│   └── [  96]  myacc_MQBODY.assignmat
├── [4.0K]  regions
│   ├── [ 404]  myacc_MBSORI.regions
│   ├── [1.8K]  myacc_MBS.regions
│   └── [  90]  myacc_MQBODY.regions
├── [4.0K]  stepsizes
├── [2.1K]  structure.py
├── [1.3K]  structure.pyc
├── [4.0K]  test
│   ├── [  18]  expand.sh -> ../tools/expand.sh
│   ├── [2.1K]  flair-autosave.pickle
│   ├── [4.1K]  myacc_MB.inp
│   ├── [1.5K]  myacc_MBorig.inp
│   ├── [1000]  myacc_MQ.inp
│   ├── [ 193]  pippo.inp
│   ├── [  21]  template.inp -> ../tools/template.inp
│   ├── [3.8K]  TestElement_exp.inp
│   ├── [ 865]  TestElement.inp
│   └── [  23]  TestElement.sh -> ../tools/TestElement.sh
└── [4.0K]  tools
    ├── [6.9K]  cut.py
    ├── [ 679]  display_elem.inp.template
    ├── [3.0K]  display_elem.sh
    ├── [1.1K]  expand.sh
    ├── [2.0K]  find_paths.py
    ├── [1.2K]  find_paths.pyc
    ├── [6.0K]  roto_traslate.py
    ├── [6.3K]  scan-fedb.py
    ├── [1.1K]  split.py
    ├── [ 796]  template.inp
    ├── [ 13K]  test_assembly.py
    └── [2.1K]  TestElement.sh
```

Collection of models of single accelerator devices in Ascii files



credits: A.Mereghetti @CERN

Line Builder

myacc_MBSORI.regions - emacs@pcbe16165

File Edit Options Buffers Tools Help

Save Undo

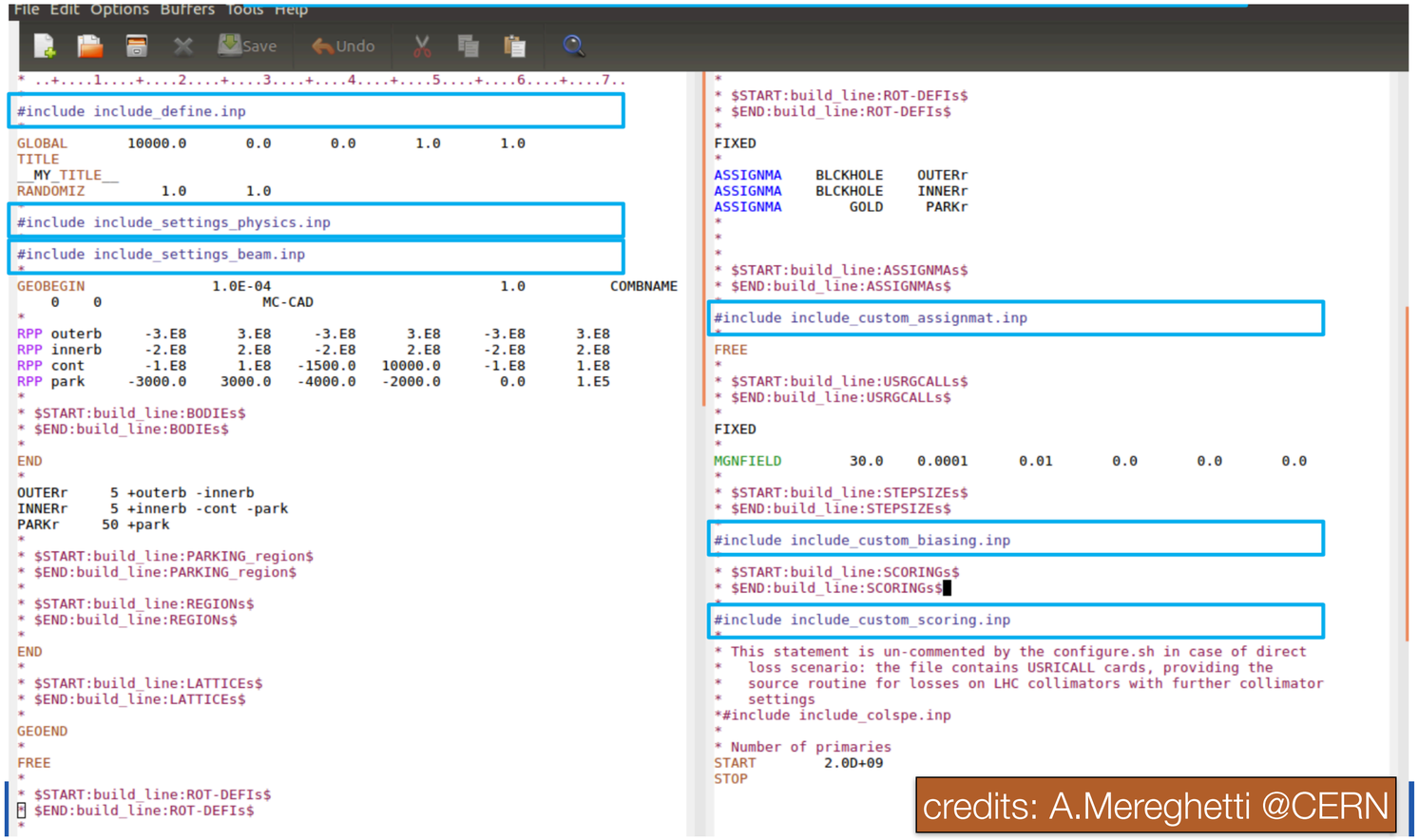
```
*
*    . yoke
RPP dipyoke     -200.0 20. -10.0 10.0 -200.0 30.0
YCC MBSORIKo    -200.0 -200.0 210.0
YCC MBSORIKi    -200.0 -200.0 190.0
*    . pipe
XZP MBSObpu     1.5
XZP MBSObpd     -1.5
YCC MBSObpo     -200.0 -200.0 203.0
YCC MBSObpi     -200.0 -200.0 197.0
*
-:---  myacc_MBSORI.bodies   All (8,0)      (FLUKA Ovwrt)
*
*    . yoke
MBSOYOKE      5 | +dipyoke +MBSORIKo -MBSORIKi -MBSObpu
                | +dipyoke +MBSObpu  -MBSObpd  +MBSORIKo -MBSObpo
                | +dipyoke +MBSObpu  -MBSObpd  +MBSObpi  -MBSORIKi
                | +dipyoke +MBSORIKo -MBSORIKi +MBSObpd
*    . pipe
MBSOBPVC      5 +dipyoke +MBSObpu -MBSObpd +MBSObpo -MBSObpi
*    . out
MBSOOUT_      5 | +dipyoke -MBSORIKo
                | +dipyoke +MBSORIKi
*
-:---  myacc_MBSORI.regions   All (4,14)     (FLUKA)
* dipole:
* ..+....1....+....2....+....3....+....4....+....5....+....6....+....7..
ASSIGNMA         IRON  MBSOYOKE
ASSIGNMA       VACUUM  MBSOBPVC                          1.0
ASSIGNMA       VACUUM  MBSOOUT_
*
-:---  myacc_MBSORI.assignmat   All (5,14)     (FLUKA)
```

Bending Dipole Prototype

✦**FLUKA LINE BUILDER** is a program aimed at automatically build accelerator geometries, consists of 2 parts:

Fluka Element DataBase

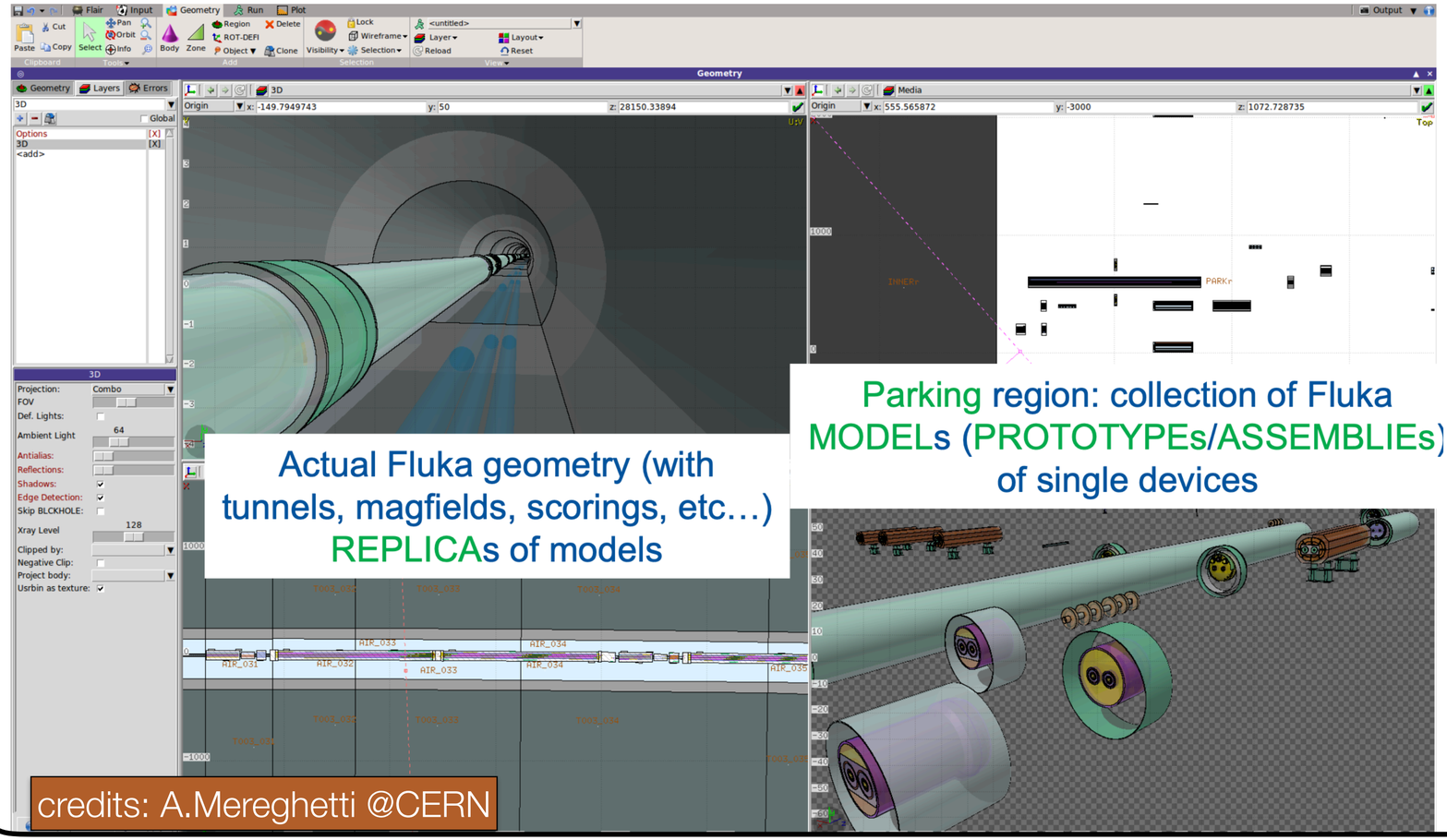
Line Builder



Python (v2.7) program that inserts the needed magnetic elements in a pre-existent “template geometry” based on machine optics

✦**FLUKA LINE BUILDER** is a program aimed at automatically build accelerator geometries, consists of 2 parts:

Fluka Element DataBase



Line Builder

FINAL RESULT

Once the geometry has been built in FLUKA, we can simulate whatever we want..!

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@ PARTICLE         %06s "PROTON"
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@ CHARGE           %le           1.0000000000000000
@ ENERGY           %le           1.3712601863056616
@ PC               %le           1.0000000000000000
@ GAMMA            %le           1.4614739302545872
@ KBUNCH           %le           1.0000000000000000
@ BCURRENT         %le           0.11463416918410078
@ SIGE             %le           0.0004500000000000
@ SIGT             %le           0.0755000000000000
@ NPART            %le  199999999999.99996948242187500
@ EX               %le           0.0000017106018439
@ EY               %le           0.0000017106018439
@ ET               %le           0.0010000000000000
@ BV_FLAG          %le           1.0000000000000000
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@ ALFA             %le           0.02452735406345014
@ ORBITS           %le          -0.0000000000000000
@ GAMMATR          %le           6.38520212960327616
@ Q1               %le           2.23430396971649170
@ Q2               %le           2.39886628492304776
@ DQ1              %le         -13.15027500931211080
@ DQ2              %le         -12.03854917694575200
@ DXMAX            %le           3.72418111948598485
@ DYMAX            %le          -0.0000000000000000
@ XCOMAX           %le           0.0000000000000000
@ YCOMAX           %le           0.0000000000000000
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@ DYRMS            %le           0.0000000000000000
@ DELTAP           %le           0.0000000000000000
@ SYNCH_1          %le           0.0000000000000000
@ SYNCH_2          %le           0.0000000000000000
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@ SYNCH_4          %le           0.0000000000000000
@ SYNCH_5          %le           0.0000000000000000
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@ ORIGIN           %16s "5.05.01 Linux 64"
@ DATE             %08s "11/06/19"
@ TIME             %08s "14.17.20"
* NAME              KEYWORD                    S                    L                 TILT                 KICK                HKICK                VKICK                ANGLE
$ %s                %s                        %le                  %le                 %le                  %le                  %le                  %le                  %le
 "MYACCEL$START"    "MARKER"    0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
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 "S.ARC.12"         "MARKER"    0.3999999999999991   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
 "DRIFT_1"          "DRIFT"     0.4499999999999996   0.1000000000000009   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
 "MB.1T2"           "SBEND"     2.0707963267948966   3.1415926535897932   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   1.5707963267948966
 "DRIFT_2"          "DRIFT"     3.6915926535897929   0.1000000000000009   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
 "E.ARC.12"         "MARKER"    3.7415926535897932   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
 "DRIFT_3"          "DRIFT"     4.1490926535897940   0.8149999999999995   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000   0.0000000000000000
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```
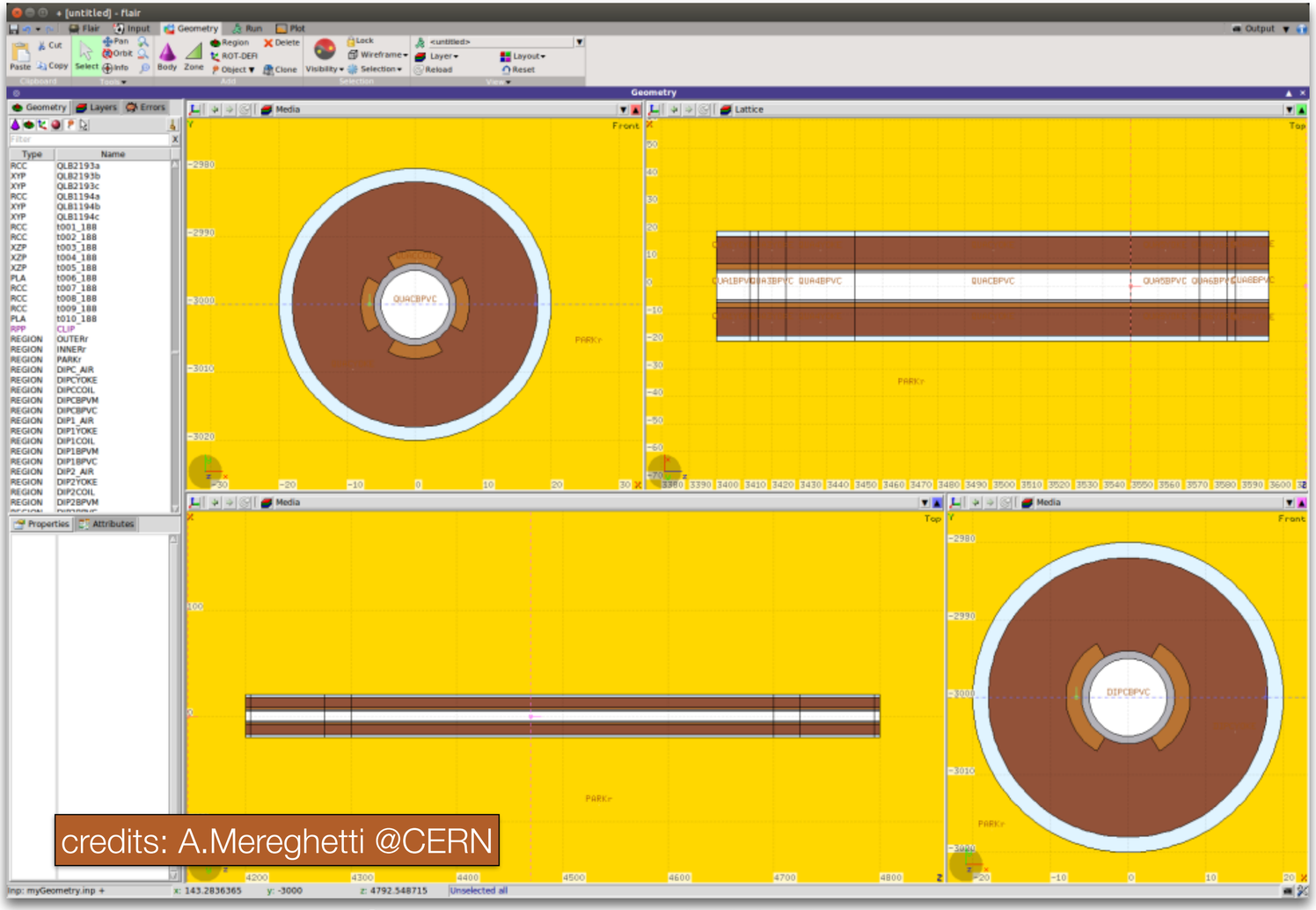
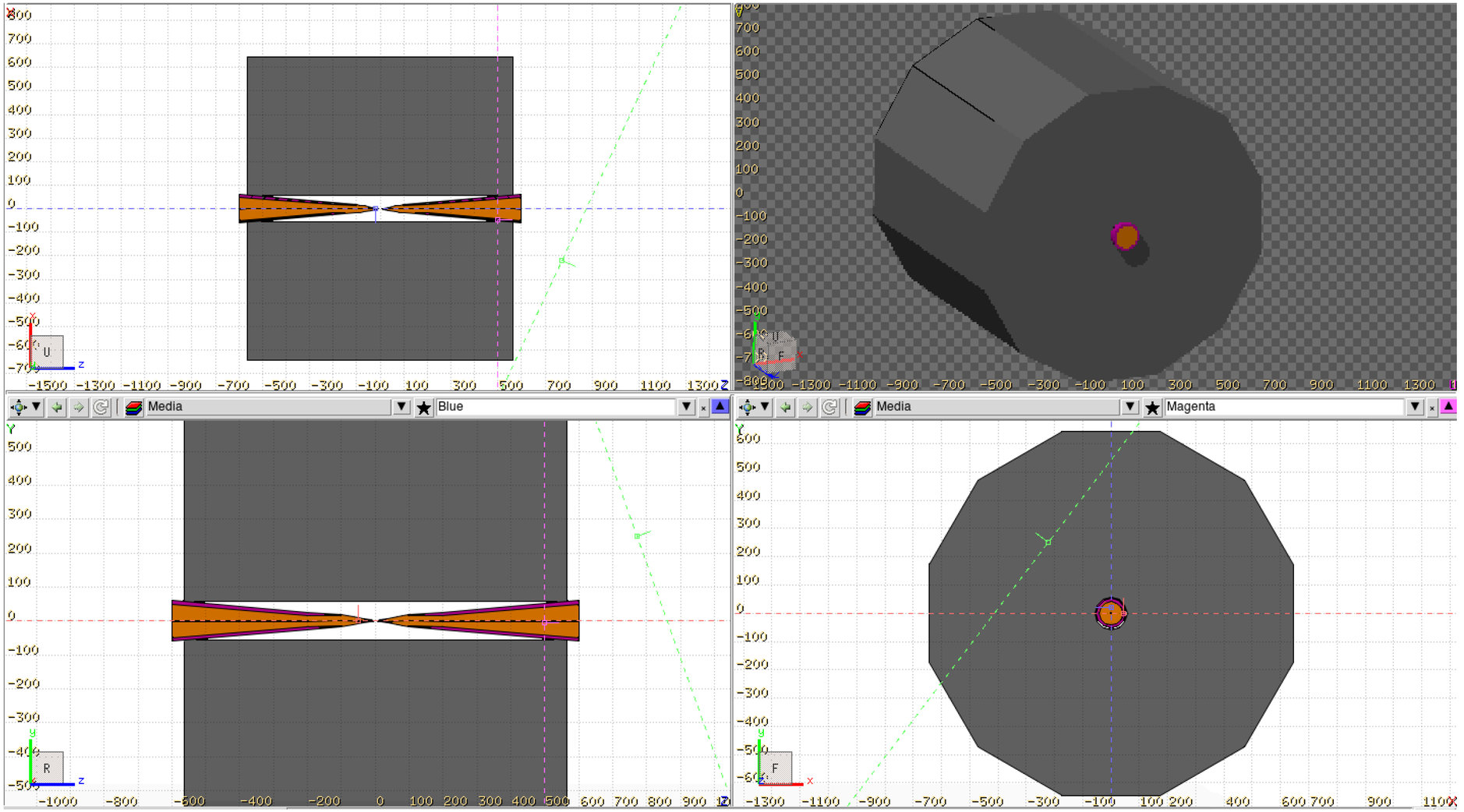

First goal: reproduce MAP results @ 1.5TeV CM

- We started from the muon collider **machine optics** from **MAP** Studies
  - ➡ Old optics format! (Mad-8)
  - ➡ Different conventions from LHC studies
  - ➡ Very limited use of markers

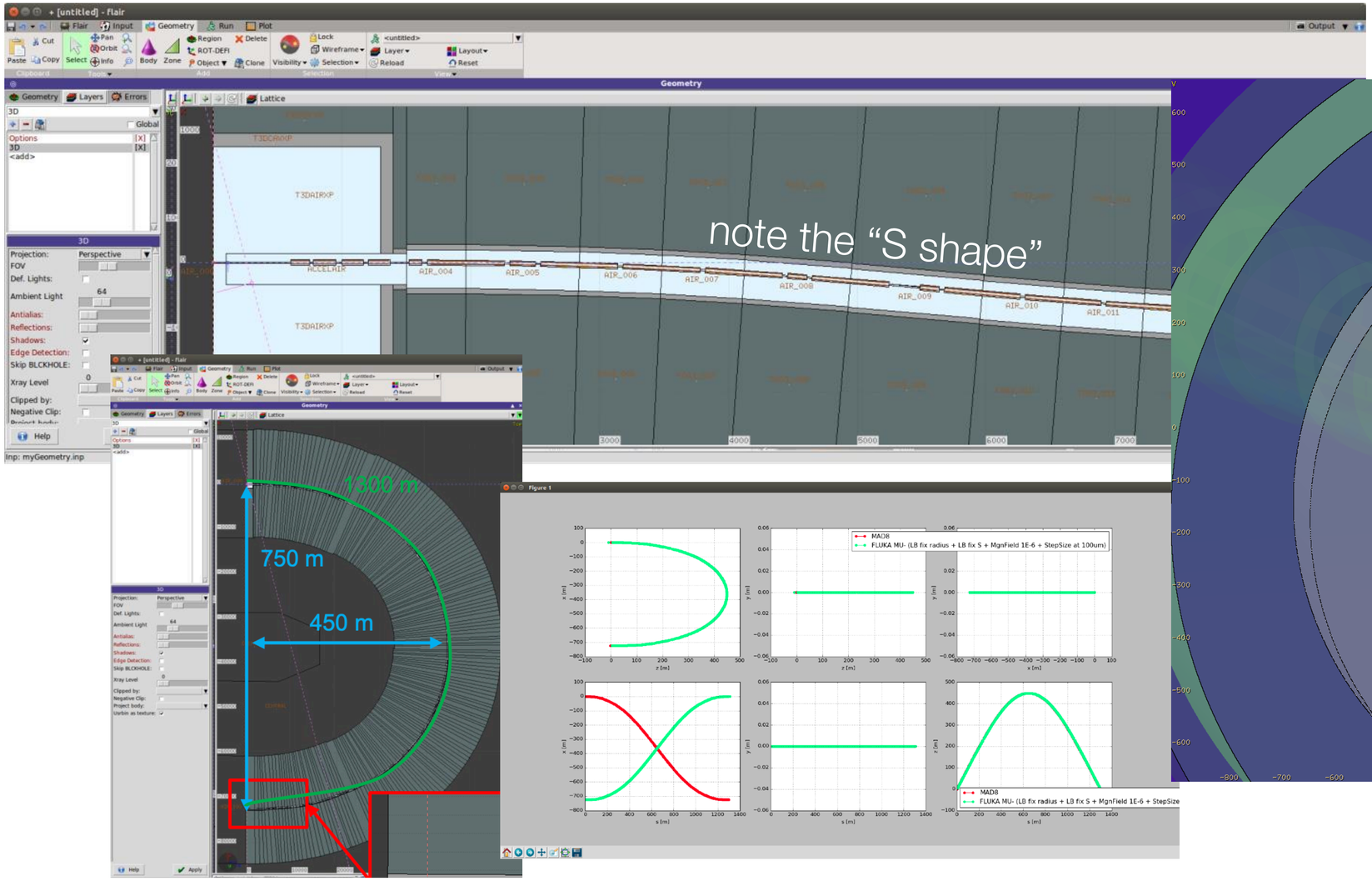
- A first **Fluka Elements Data Base** has been developed with some “First order” magnetic elements geometries: *Dipoles, Quadrupoles* and *Sextupoles*

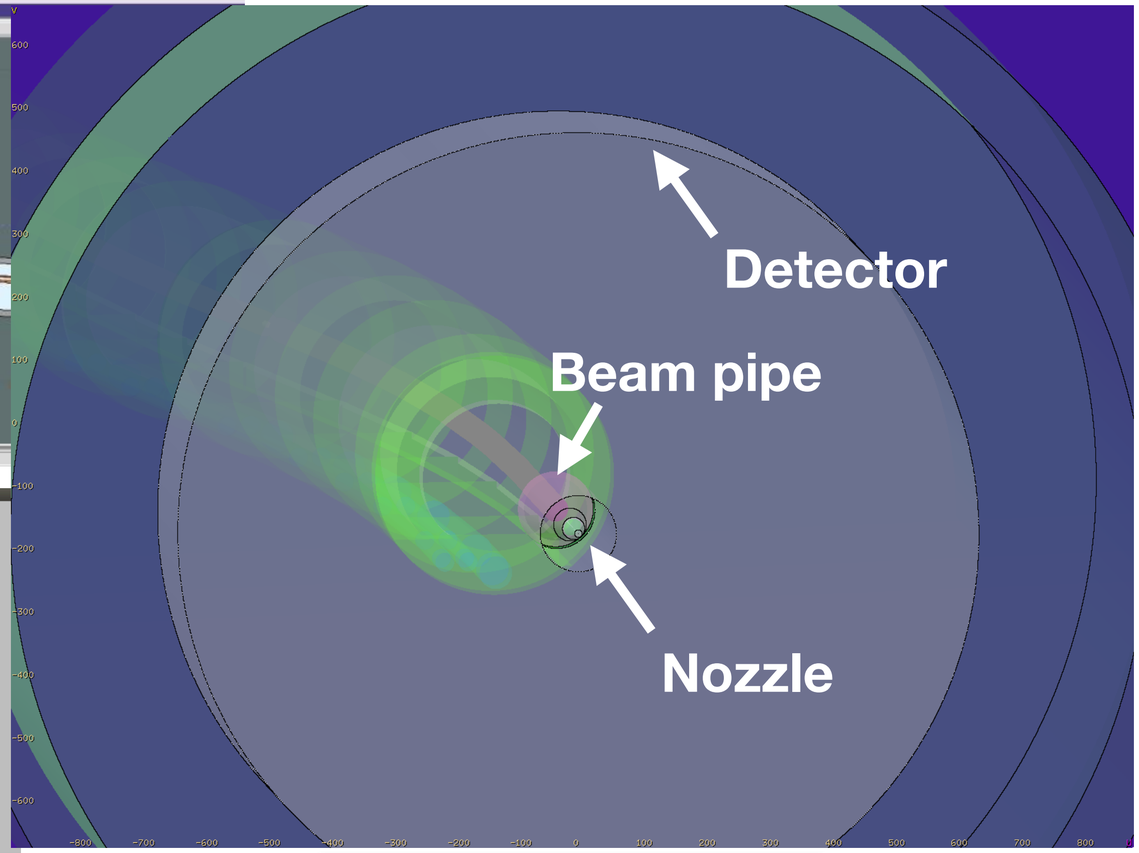


- The **detector** (w/ nozzle) has been added to the geometry (via an automatic script working on its *.gdml* file)



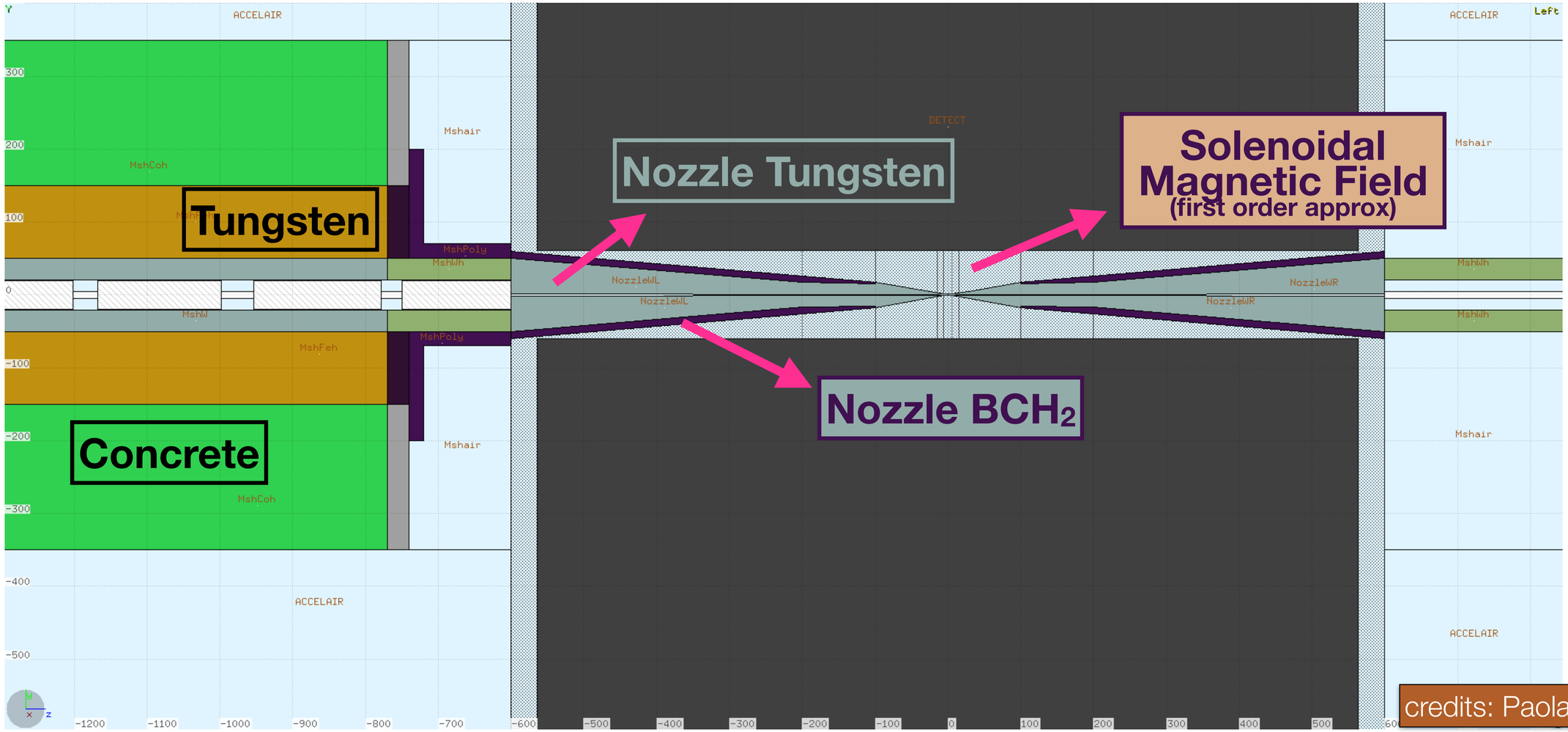
- A very first geometry of the whole muon collider (half ring) has been produced…





credits: A.Mereghetti @CERN
P. Sala @ INFN-Mi

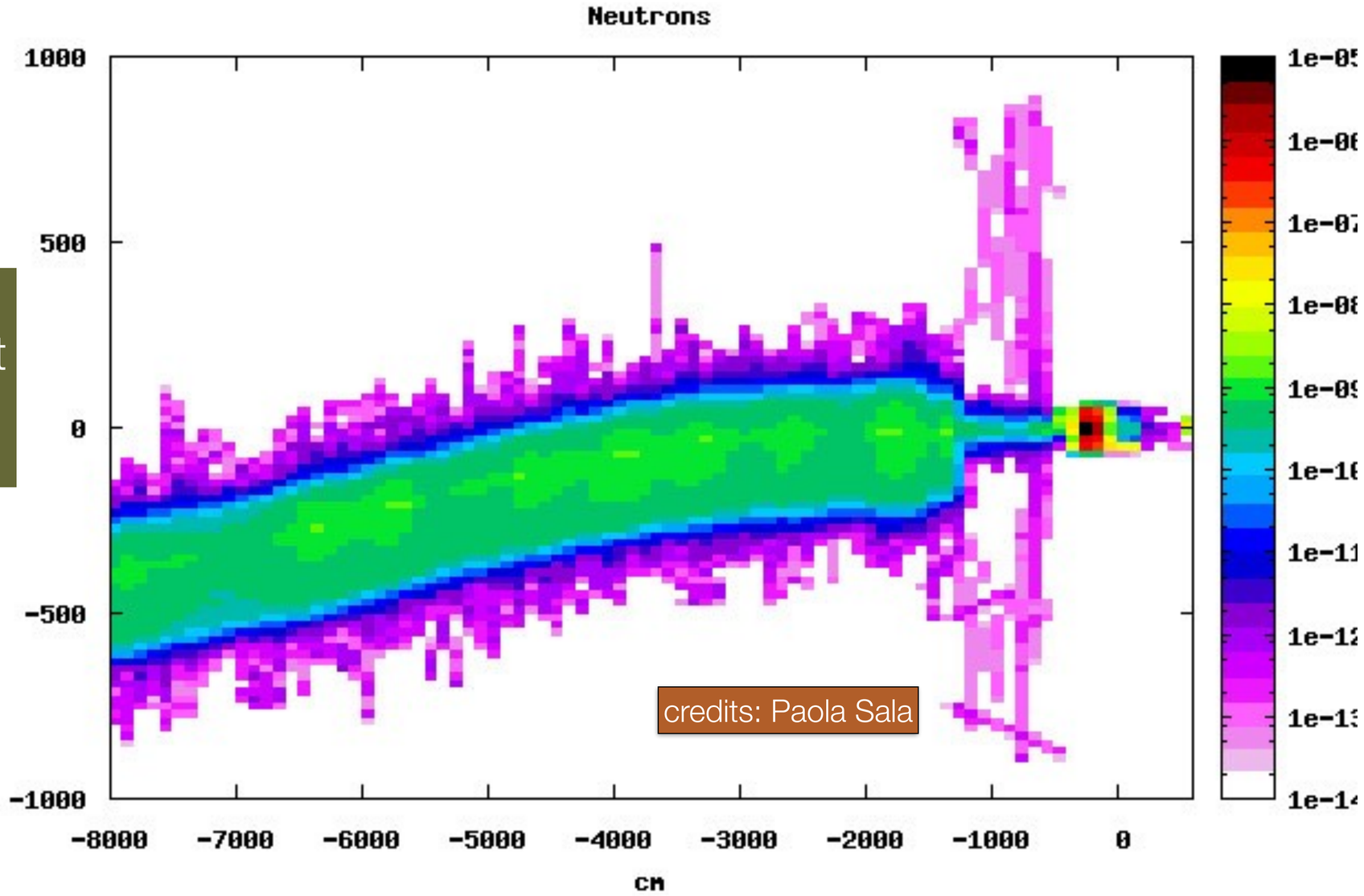
Machine Geometry: MDI



- We fire 750GeV μ^+ from the opposite IP, biasing μ decay in the last 100m to have good statistics

A DUMP output file is produced with all the relevant tracks information at the entrance of the detector

…to be fed to detector simulation



To Sum Up

- **Beam Induced Background** in the experimental area of a Muon Collider is mainly due to **muon decays** and can impair physics measurements
- A powerful **flexible tool** for **simulating** such sections of the machine starting from the optics is needed
- **FLUKA Line Builder** has been chosen and started to use with first descriptions for optics element and detector

THANK YOU FOR YOUR ATTENTION!