TRIUMF

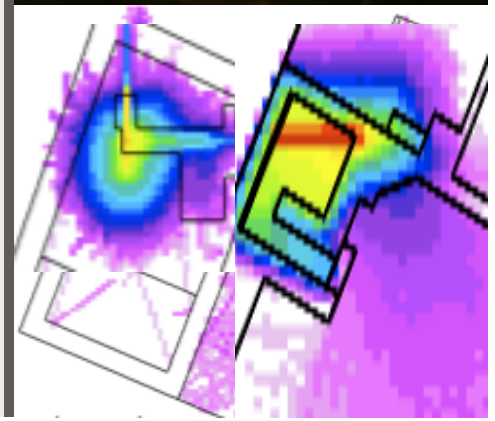
Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

TWO STEP METHOD FOR SHIELDING SIMULATION

2nd Fluka Advanced Course and Workshop TRIUMF

September 17, 2012

Aurelia Laxdal TRIUMF



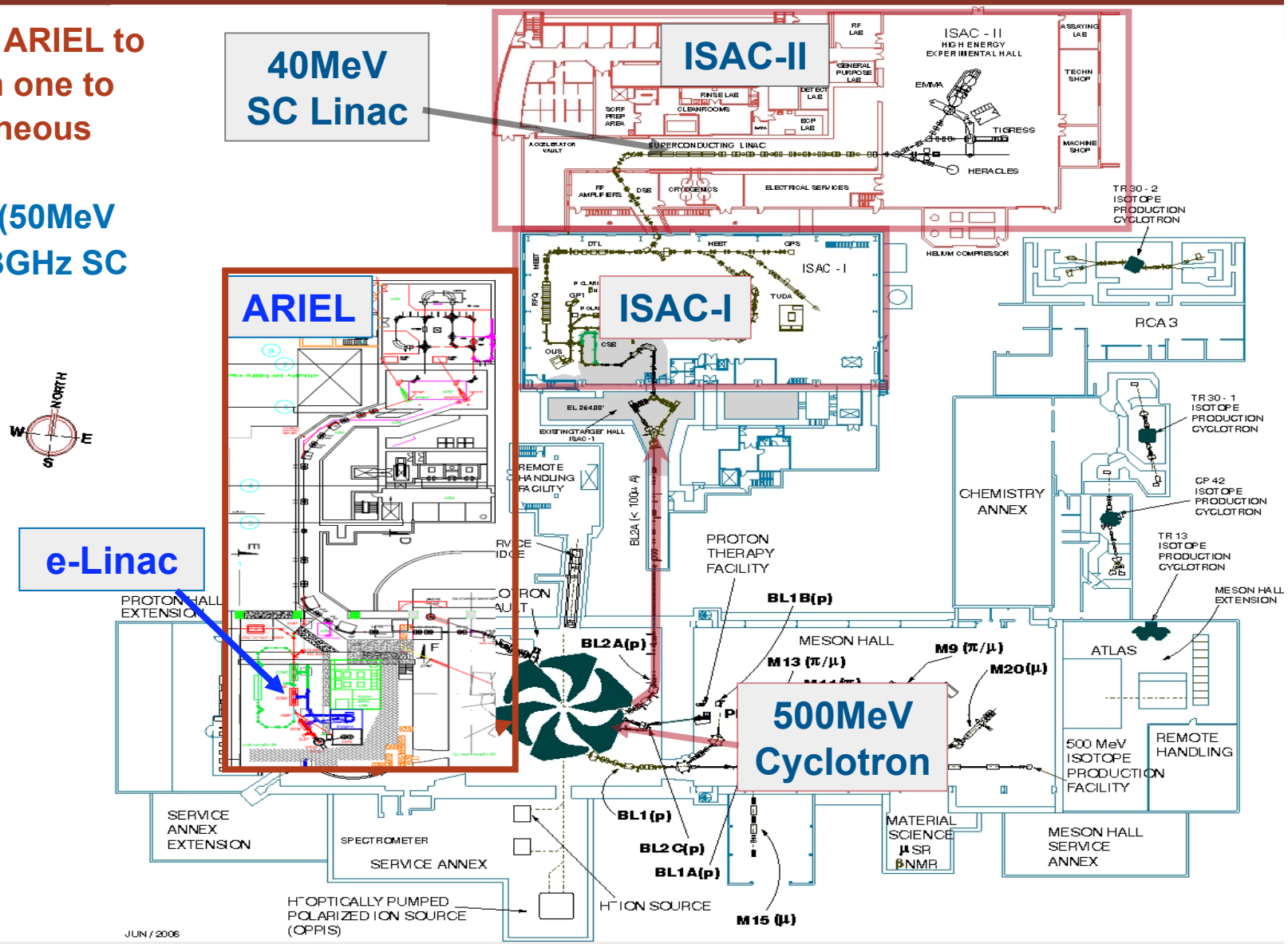
Overview

- Introduction:
  - Present
  - Future: adding Advanced Rare IsotopE Laboratory (ARIEL)
- ARIEL target stations:
  - p+ target station: 100μA at 500MeV
  - e- target station: 10mA at 50MeV
- Proton target station overview & adjacent areas
- Standard simulation to determine the necessary shielding for the Laser Ion Source (LIS) setup
- Alternative solutions:
  - use a Two-Step method
- File manipulation for the Two-Step method
- Results
- Conclusions

TRIUMF

ARIEL at TRIUMF

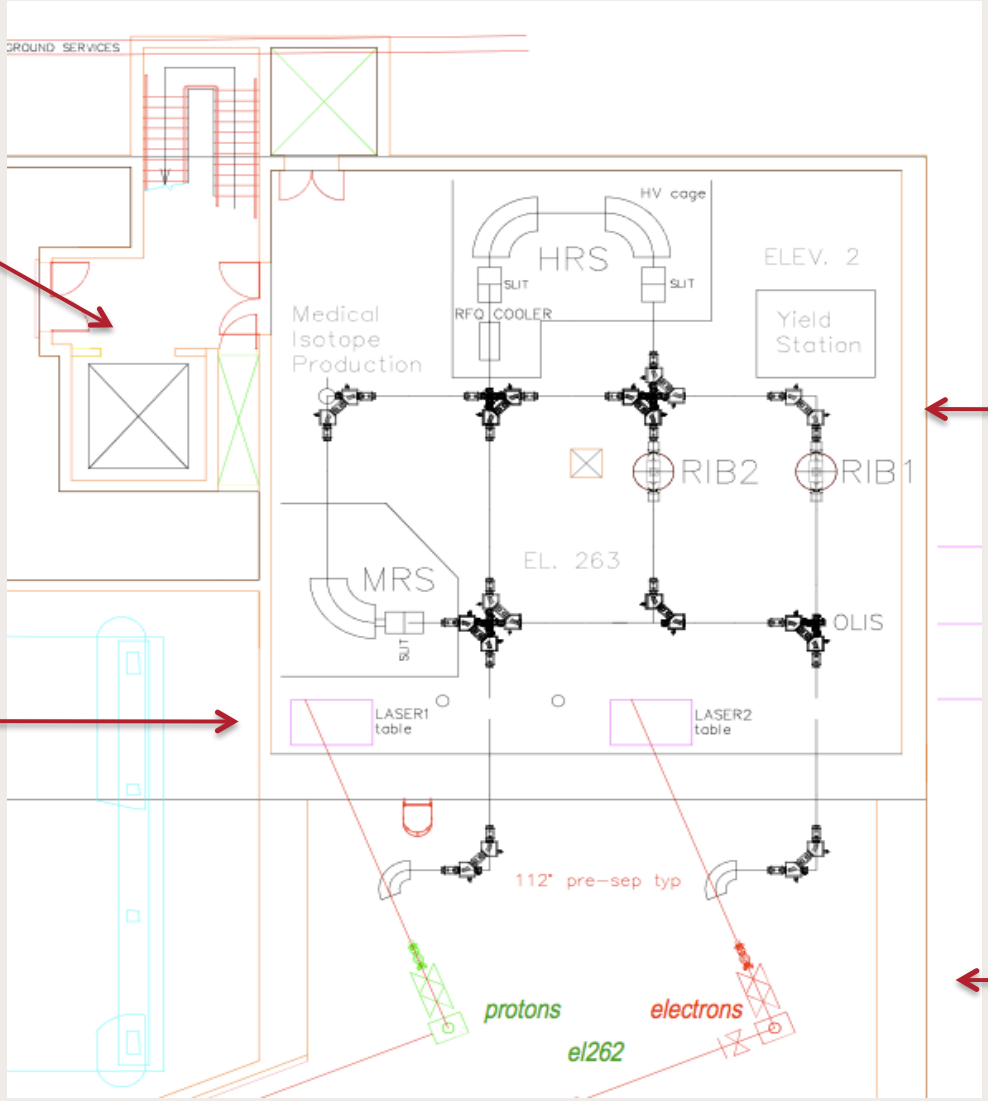
- Now adding ARIEL to increase from one to three simultaneous beams
- Add e-Linac (50MeV 10mA cw - 1.3GHz SC linac)



TRIUMF

ARIEL target stations

Low Occupancy Area



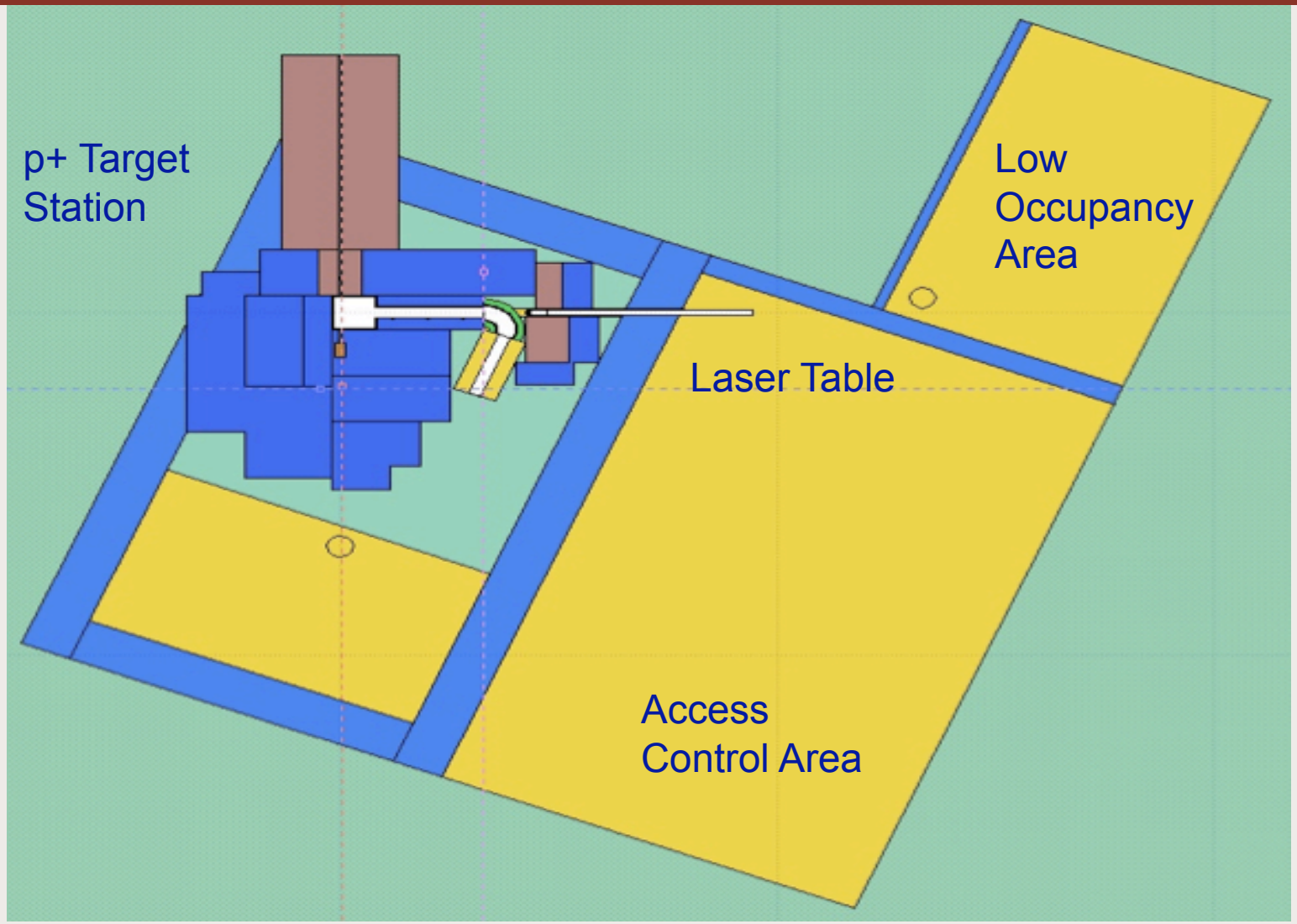
Access Control Area

Laser Tables

Target Stations

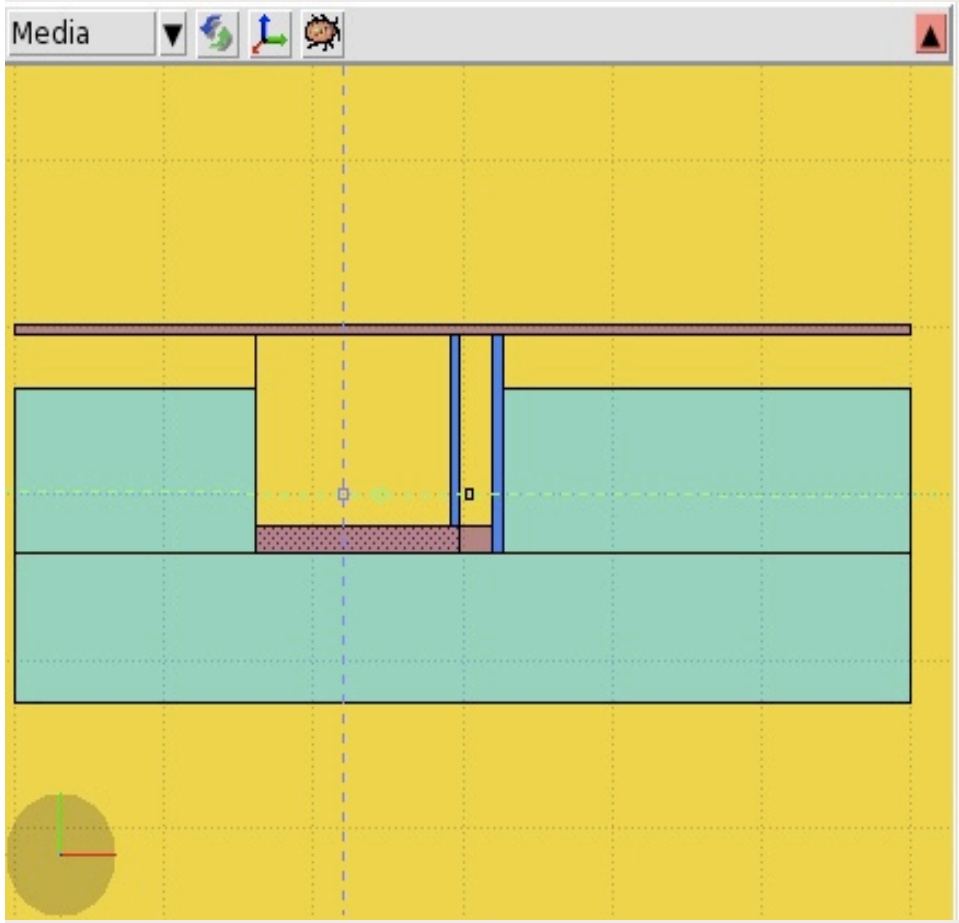
TRIUMF

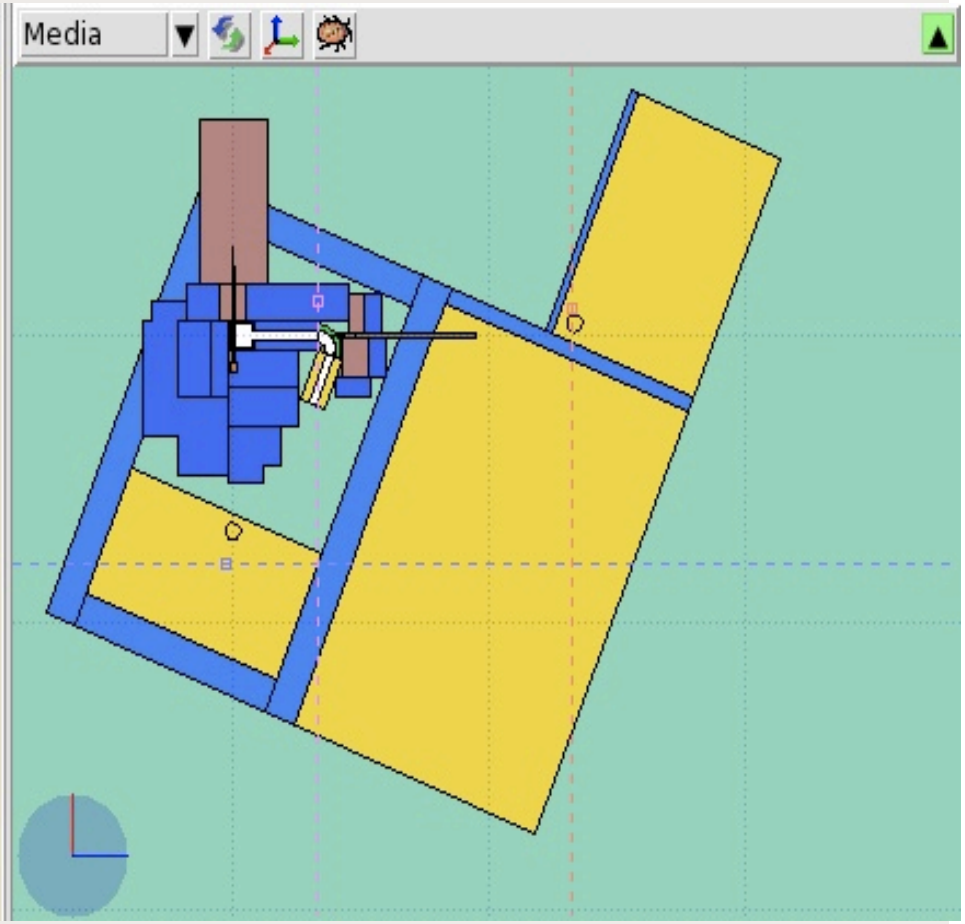
Proton Station & LIS beam pipe - top view



TRIUMF

Elevator & Stairs Locations





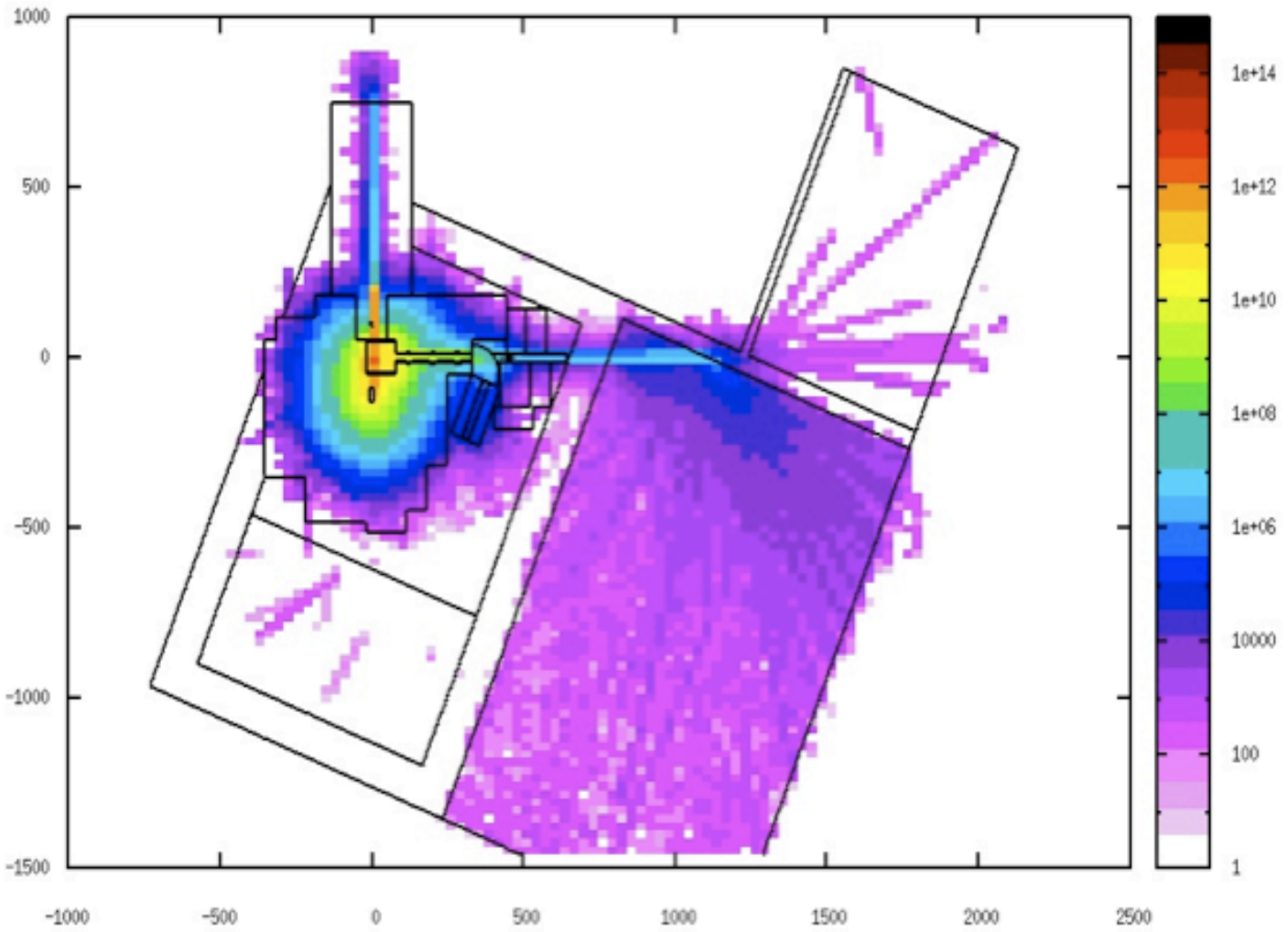
Results: B2 level

- TRIUMF's limit for Low Occupancy Area: 10μSv/hr

- Recommendations: additional localized shielding to the north of the LIS table to allow occupancy during beam operation

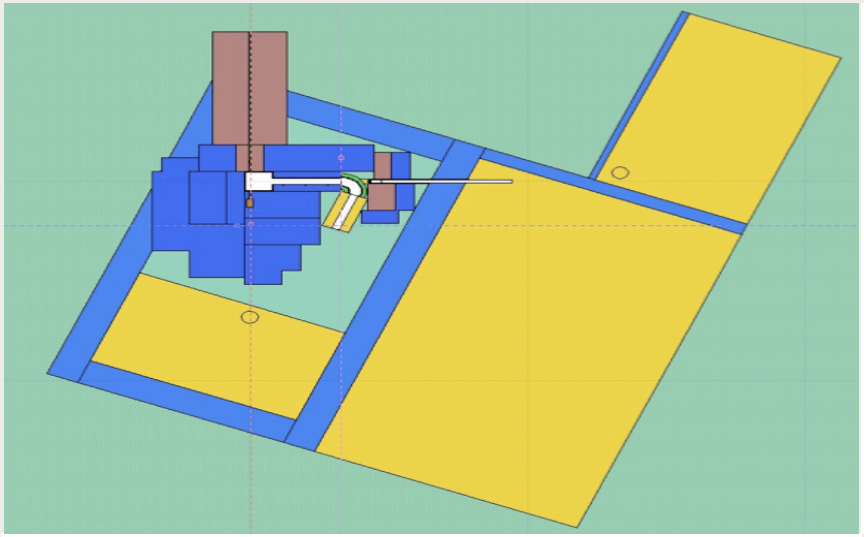
MAZE

Dose (μSv/hr) 100μA of p+ at 500MeV on UCx target

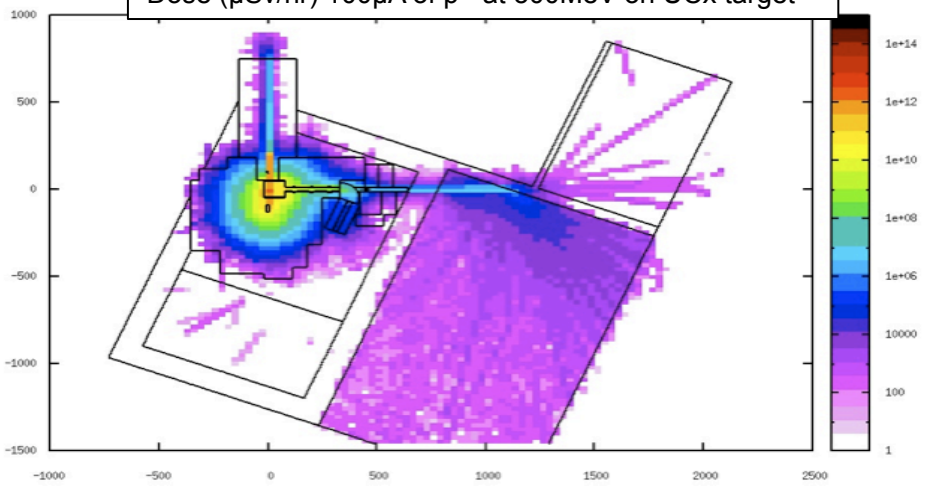


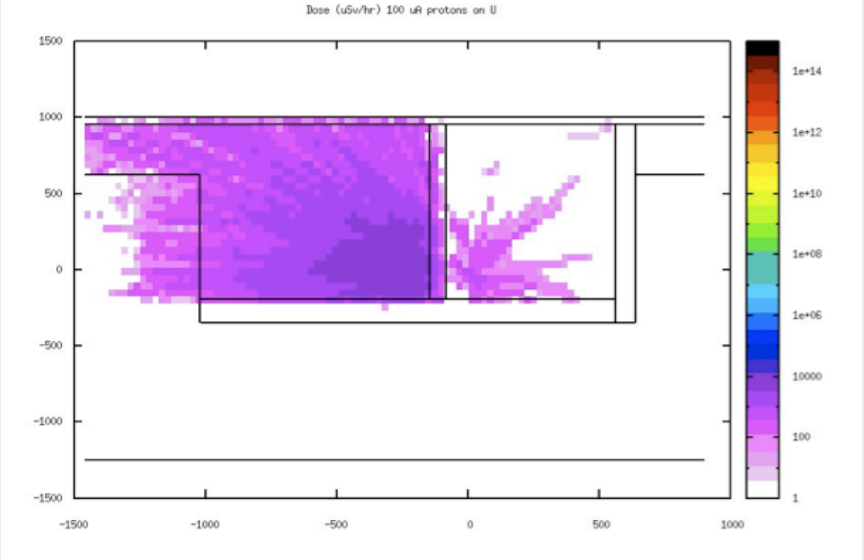
TRIUMF

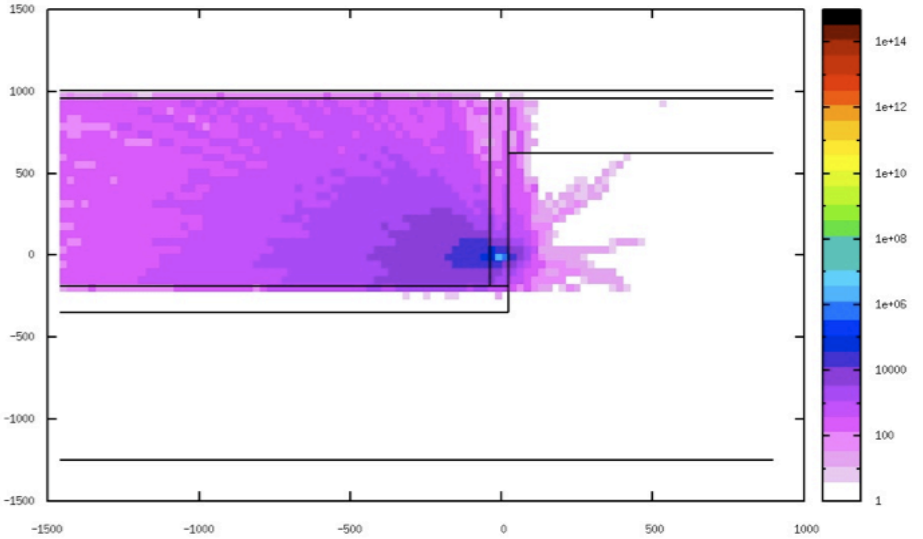
Results: summary



Dose (μSv/hr) 100μA of p+ at 500MeV on UCx target







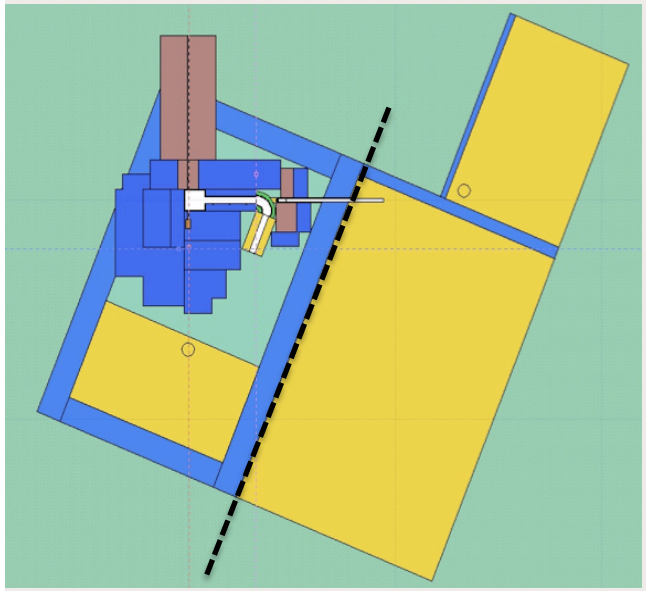
TRIUMF

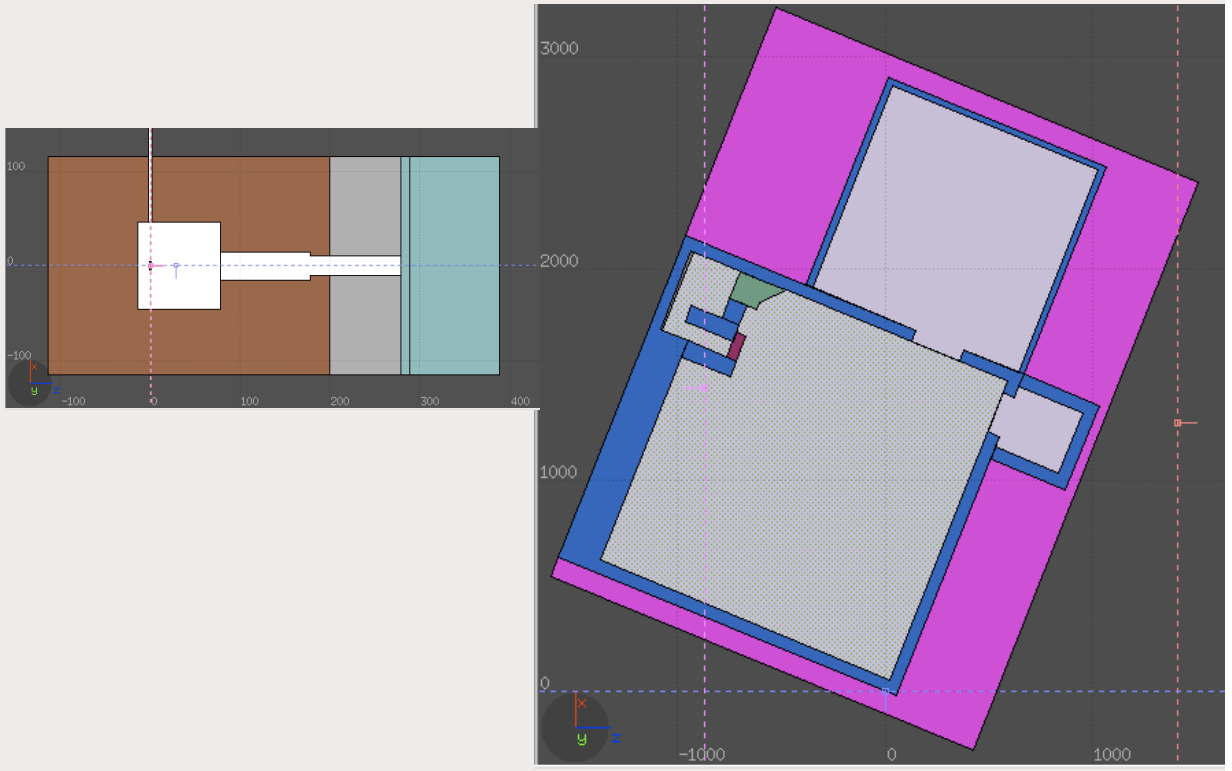
Alternative Solution

1. General method

2. Two-Step method

REPLACE

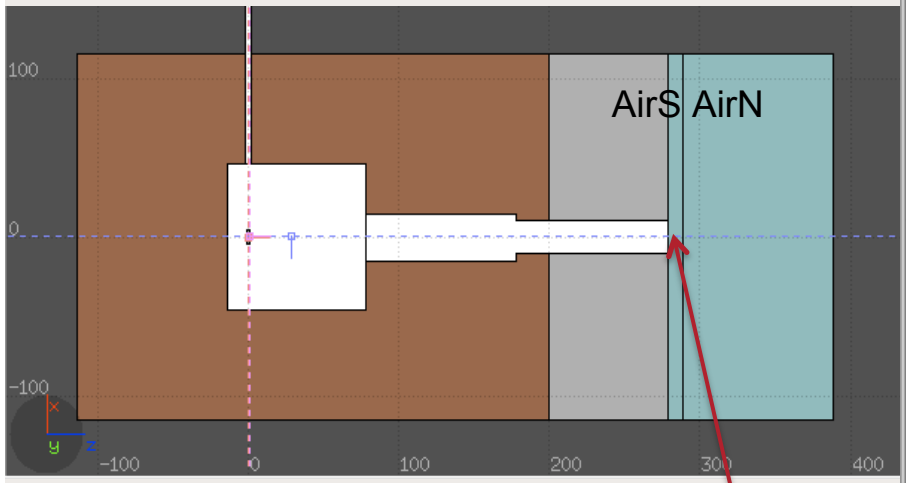




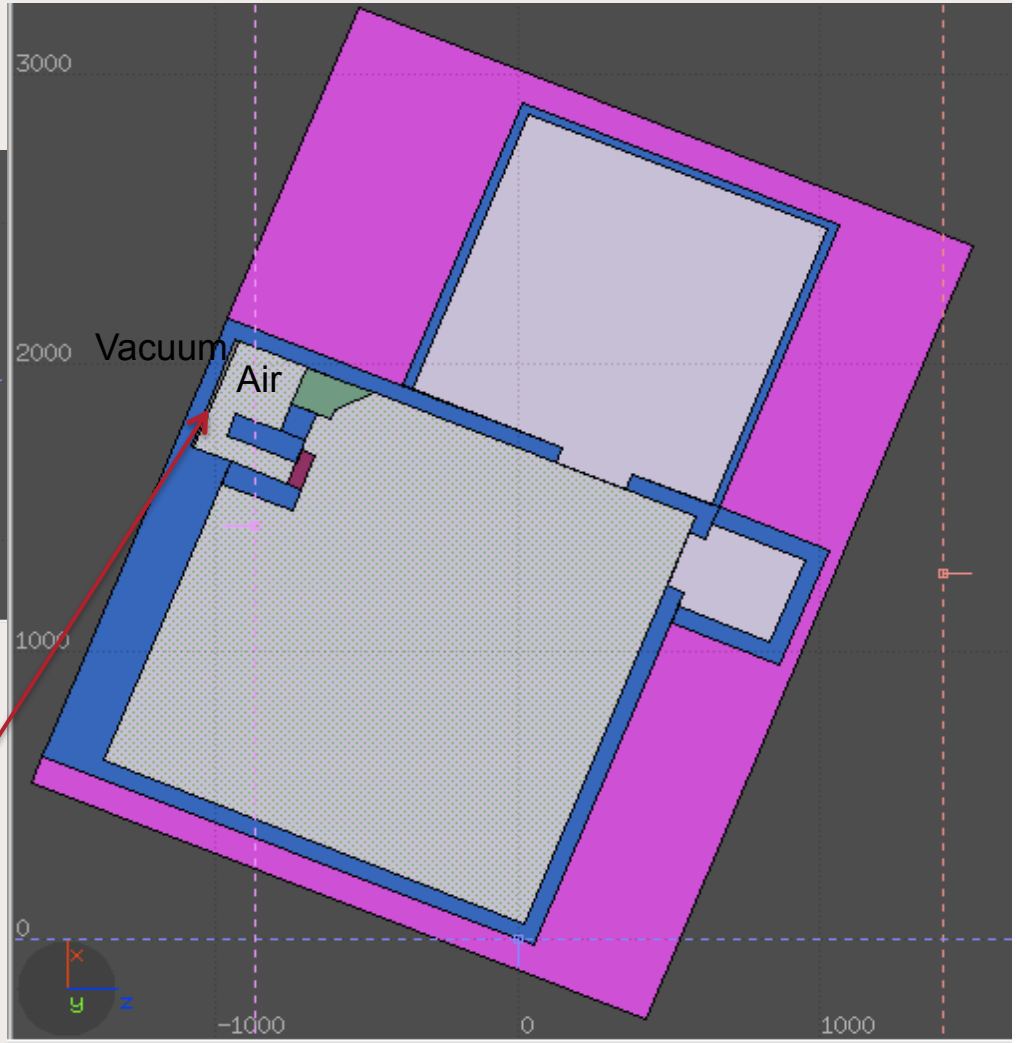
TRIUMF

Two-Step Method

First Step



Second Step



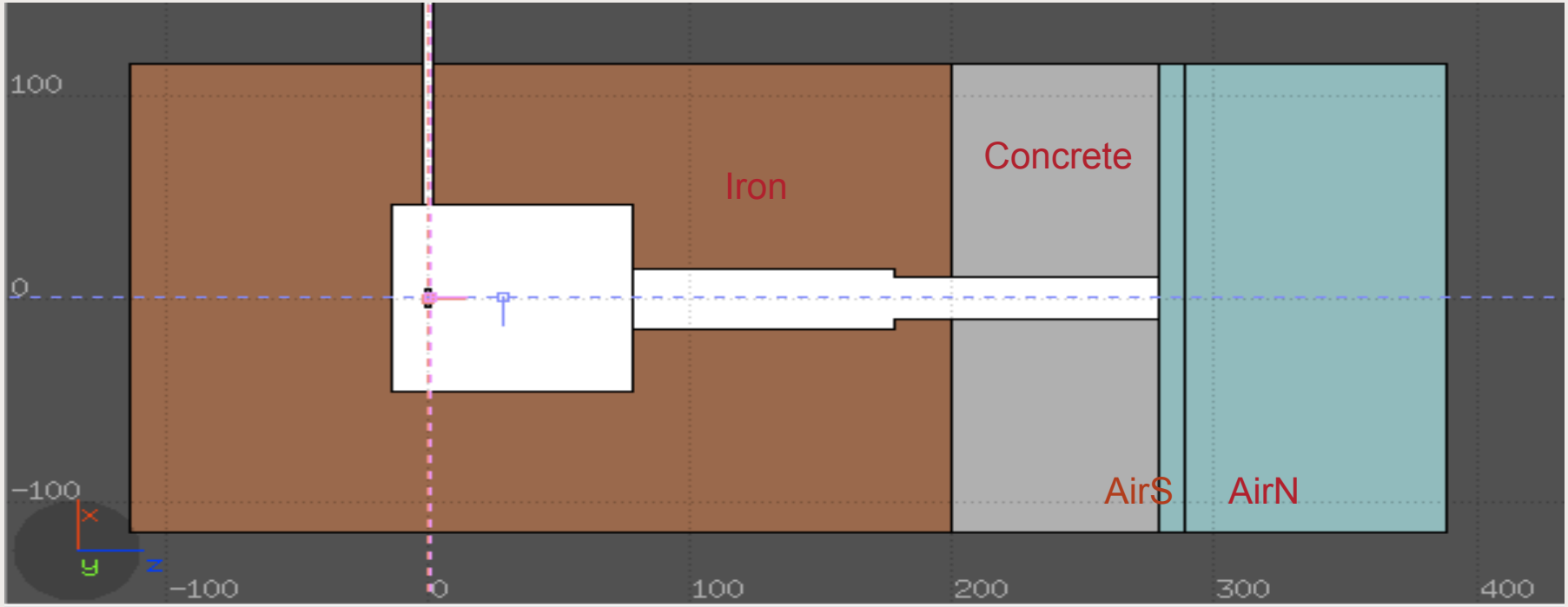
- First Step: score the hadrons crossing the Air Regions: position, angle, energy & weight;

- Second Step: input them from the Vacuum Region

TRIUMF

First Step – How?

1. Scoring: USERDUMP card
2. Do a coordinate transformation
3. Compile: Use & Modify mgdraw.f user routine of the first file
4. Concatenate the data files after the Run(s) -> output first step -> input second step
5. Check the results: the output and the data file



First Step - USERDUMP card

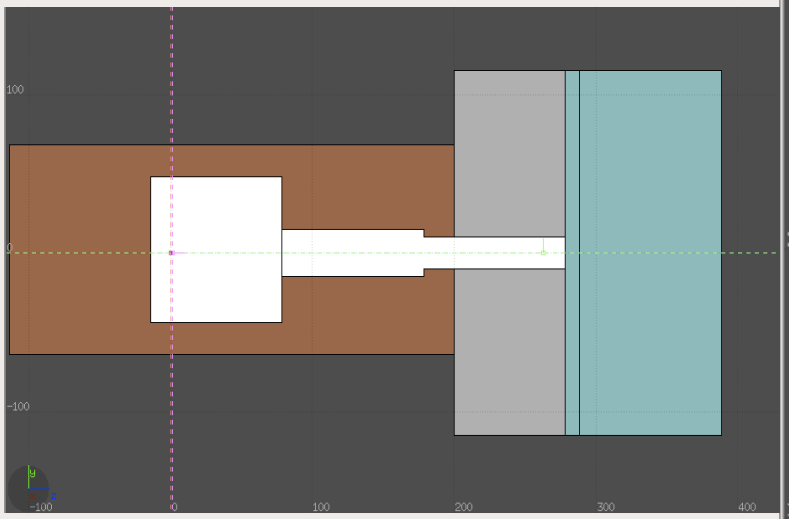
1. Scoring: USERDUMP card

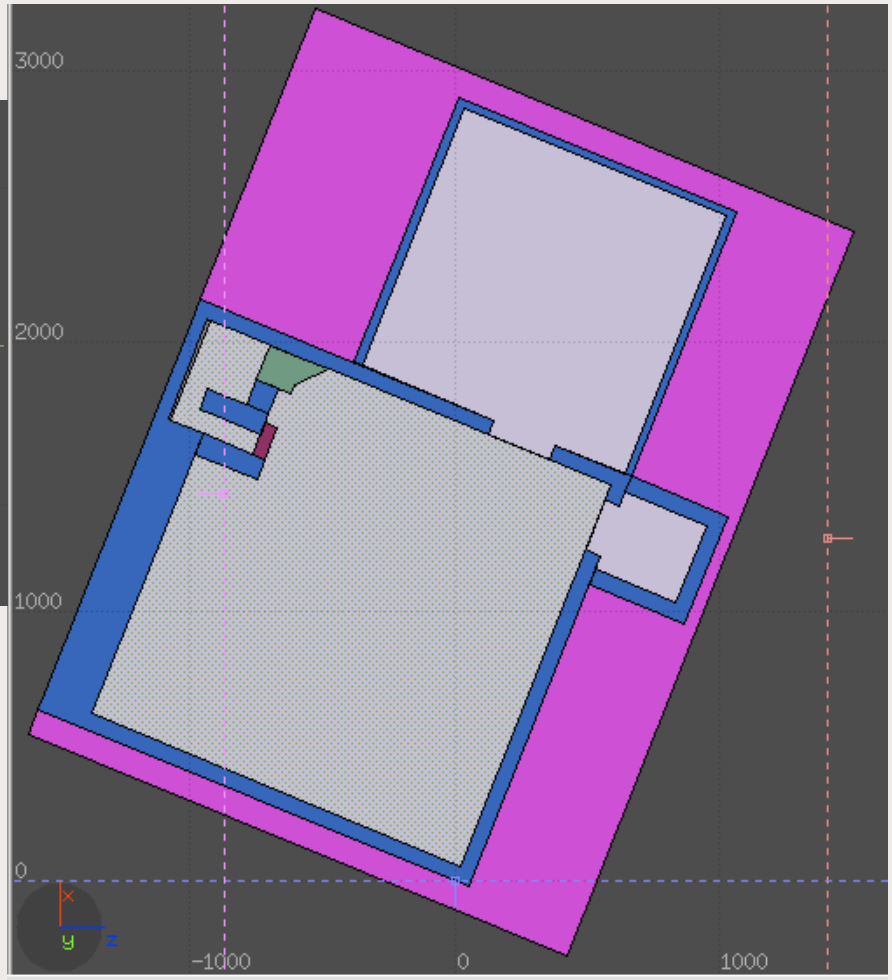
- Defines a phase space file to be written.

TRIUMF

First Step - coordinate transformation

2. Coordinate transformation





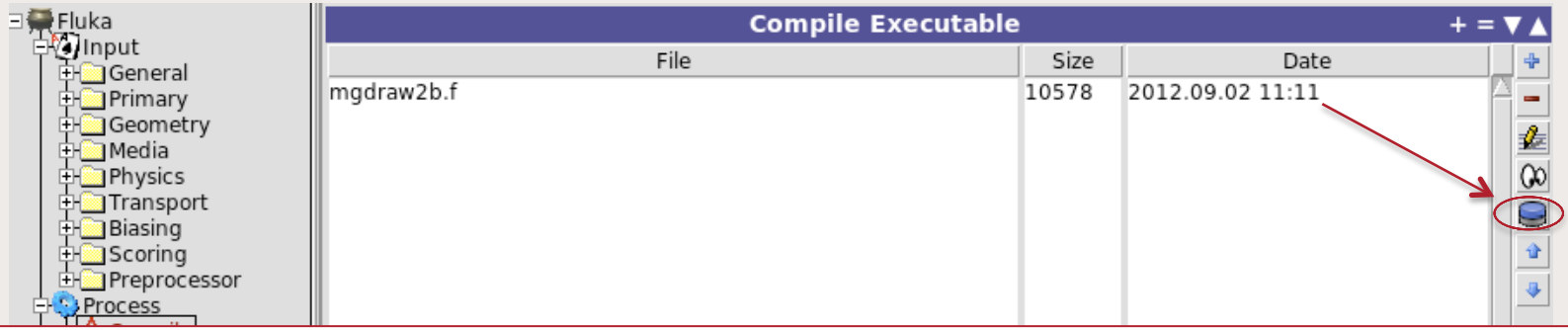
In FORTRAN:

XSCO=XSCO + 1859.11

ZSCO=ZSCO - 1093.78

TRIUMF

First Step - mgdraw.f user routine




```
*                                                                      *
      ENTRY BXDRAW ( ICODE, MREG, NEWREG, XSCO, YSCO, ZSCO)
      IF(.NOT. LFCOPE)THEN
       LFCOPE=.TRUE.
       OPEN (UNIT=47, FILE="srcNEUT", STATUS='UNKNOWN')
      END IF
* Write in event file the position of the particle crossing the boundary
* its direction cosines,its energy and weight.
      CALL GEOR2N ( MREG, MREGNAM, IERR1 )
      CALL GEOR2N ( NEWREG, NREGNAM, IERR2 )
       IF(MREGNAM .EQ. "AirS" .AND. NREGNAM .EQ. "AirN" .AND.
     & (JTRACK .EQ. 1 .OR.JTRACK .EQ. 8 .OR.JTRACK .EQ. 13 .OR.
     &  JTRACK .EQ. 14 .OR.JTRACK .EQ. 23))THEN
* Shift the x and z coordinates for the new geometry:
       XSCO=XSCO+1859.11
       ZSCO=ZSCO-1656.43
       WRITE(47,*)JTRACK,XSCO,YSCO,ZSCO,CXTRCK,CYTRCK,CZTRCK,
     & ETRACK-AM(JTRACK),WTTRACK
       END IF
*  100  FORMAT(8(E10.4,1X))
      RETURN
*
*=======================================================================*
```

coordinate transformation

1 - proton
8 – neutron
13 – pion+
14 – pion-
23 – pion-zero

TRIUMF

First Step – Checking the Results

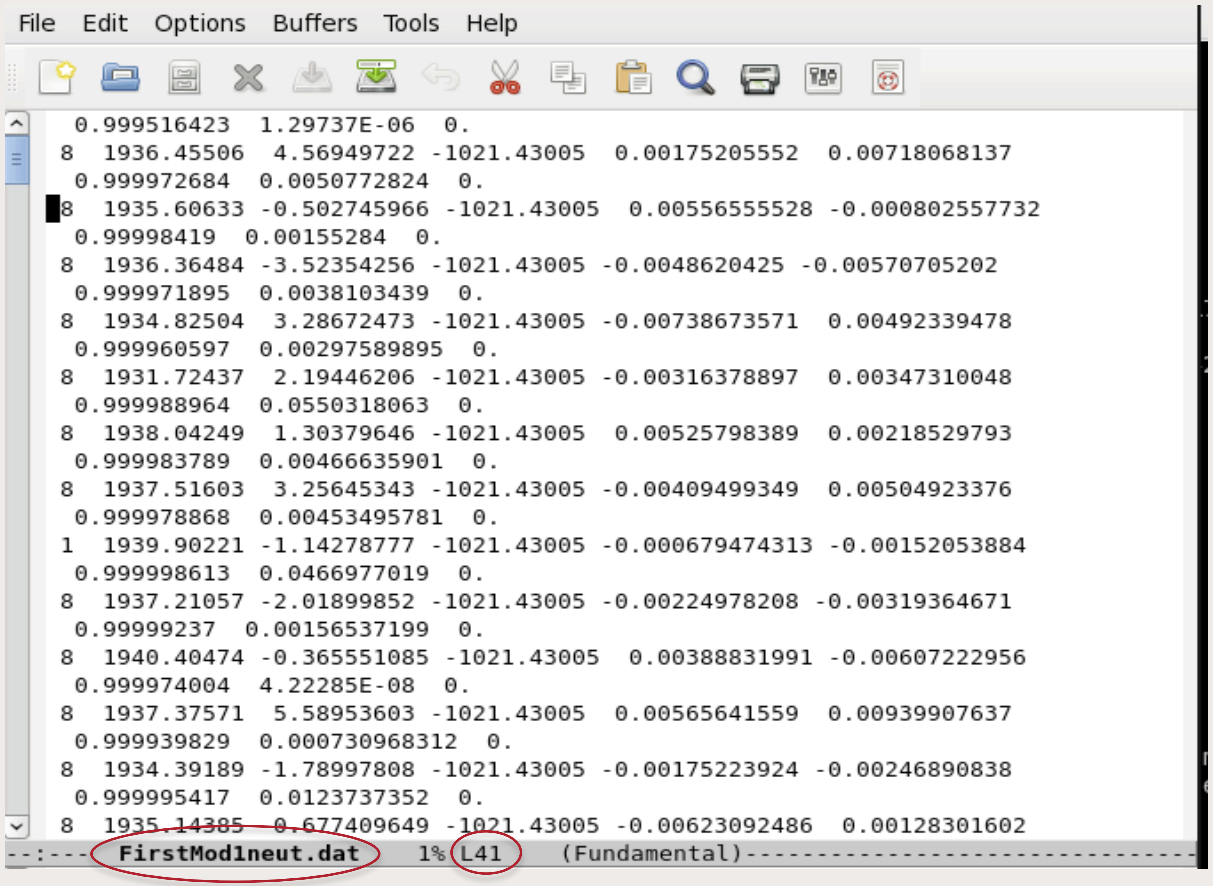
FirstA-001_fort.56	56	310	2012.08.31 20:59
FirstA-001_fort.54	54	2326	2012.08.31 20:59
ranFirstA-001	-file-	1651	2012.08.30 19:08
FirstA-001.out	FLUKA out	171082	2012.08.31 20:59
FirstA-001_srcNEUT	-file-	20446	2012.08.31 20:59
FirstA-002.out	FLUKA out	170593	2012.08.31 22:25
FirstA-002_fort.54	54	2326	2012.08.31 22:25
FirstA-002_srcNEUT	-file-	23668	2012.08.31 22:25
FirstA-002_fort.55	55	64238	2012.08.31 22:25
ranFirstA-002	-file-	1651	2012.08.31 20:59

```
8  1940.82207 -0.58650769 -1021.43005  0.00829271167 -0.00133180802
 0.999964728  0.00266983597  0.
1  1940.0558 -1.81006416 -1021.43005  0.00306237128 -0.00273399738
 0.999991574  0.0132999552  0.
8  1925.94277  0.851876395 -1021.43005 -0.812045381 -0.250975075  0.526871722
 0.00120935  0.
8  1932.36131  0.0597017901 -1021.43005 -0.00705415101 -0.000174097706
--:---  FirstJ-002_srcNEUT   23% L96    (Fundamental)------------------------------
```

First Step – The Output File

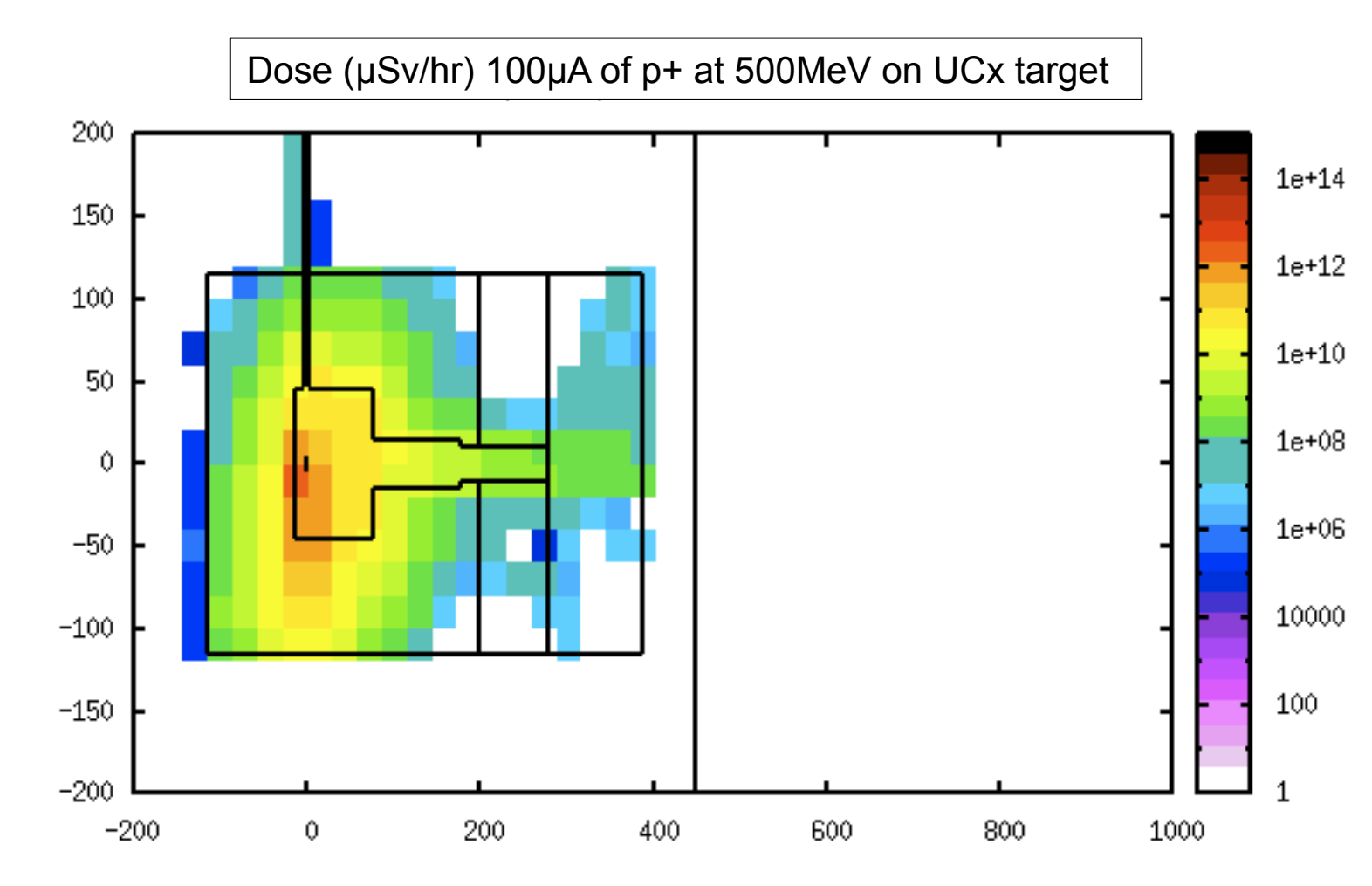
- Concatenate the data files:

  >cat *srcNEUT FirstMod1neut.dat



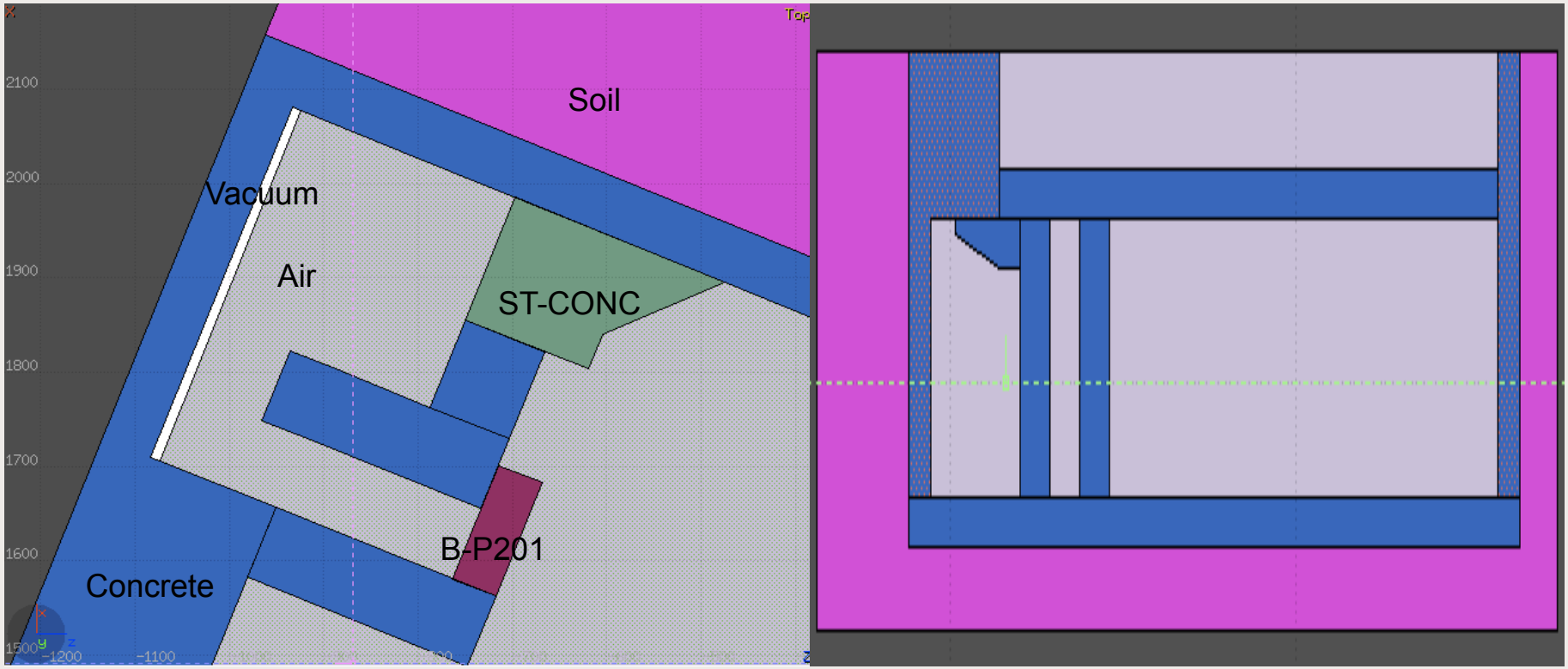
Output First Step -> Input Second Step

First Step – Results/USERBIN Plot



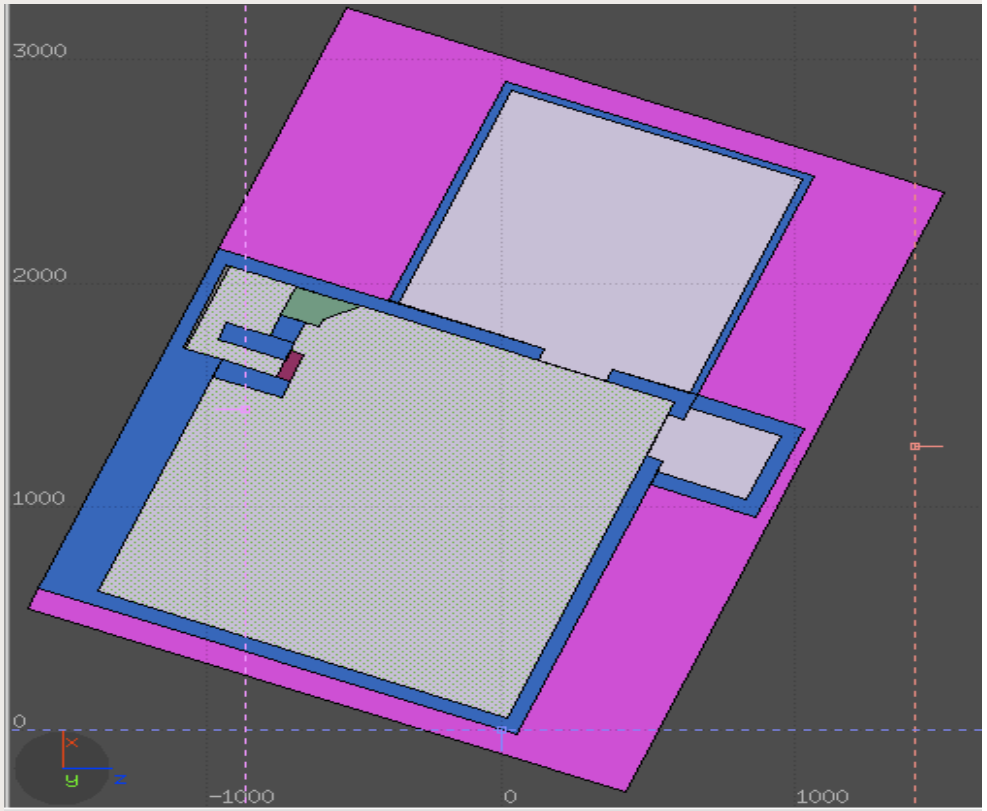
Second Step - Maze

Second Step: input/launch the hadrons from the Vacuum Region



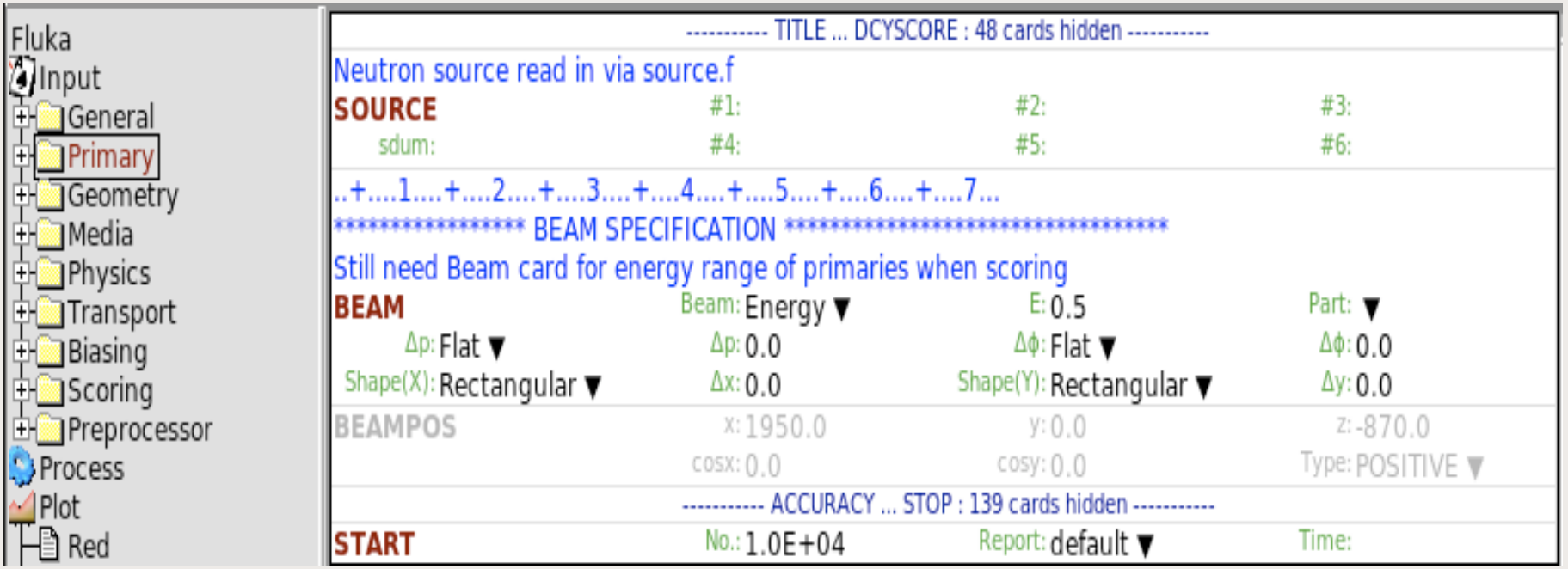
Second Step – How?

1. In **Primary**: SOURCE card + BEAM card
2. In **Compile**:
   - Use & Modify source.f user routine -> source2b.f
   - Use soevsv.f user routine
3. Check the results
4. Normalize accordingly

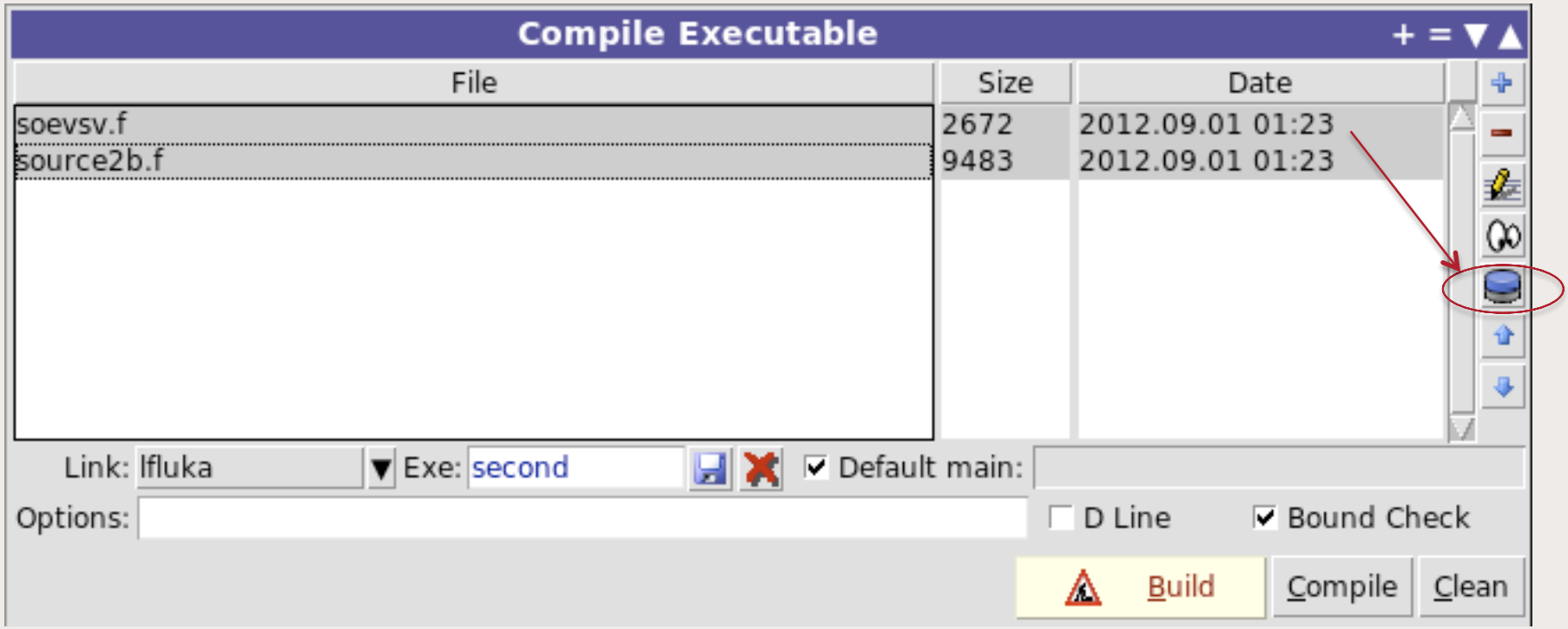


Second Step – Primary

In **Primary**: SOURCE card + BEAM card



Second Step – Compile (1)



Second Step – Compile (2)

Use & Modify source.f user routine -> source2b.f

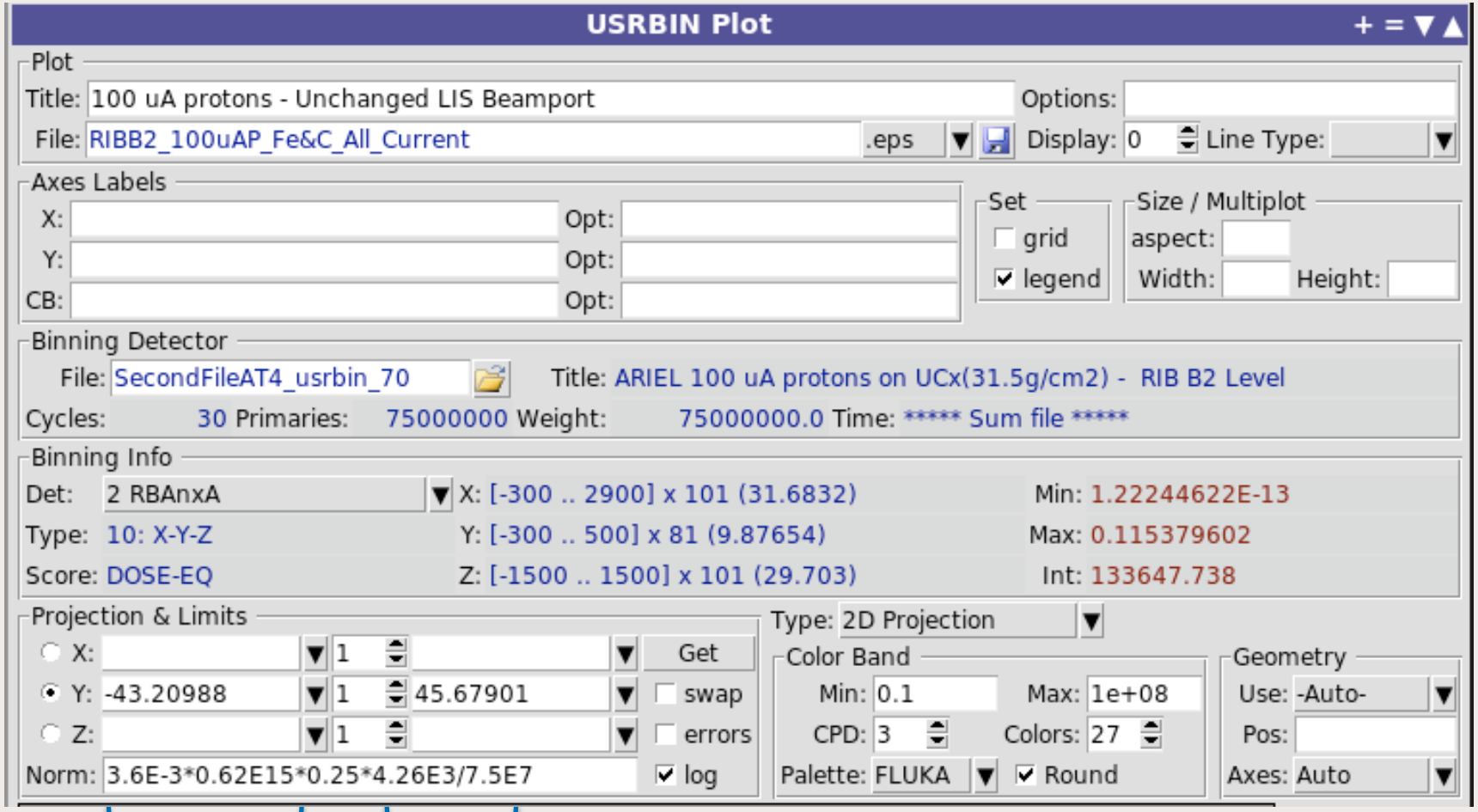
```
*  +-------------------------------------------------------------------*
*  |  First call initializations:
      IF ( LFIRST ) THEN
*  |  *** The following 3 cards are mandatory ***
         TKESUM = ZERZER
         LFIRST = .FALSE.
         LUSSRC = .TRUE.
*  |  *** User initialization ***
         WRITE(LUNOUT,*)
         WRITE(LUNOUT,'(a,132a)') ("*",i=1,132)
         WRITE(LUNOUT,*)
         WRITE(LUNOUT,*) "Source Collision file for ARIEL RIB B2 Level"
         OPEN(UNIT=41, file='./FirstMod1neut.dat', status='old')
         WRITE(LUNOUT,*)
         WRITE(LUNOUT,*)
         DO i = 1,nlines
           READ(41,*,END=501) IZbeam, Xbpos(i), Ybpos(i), Zbpos(i),
     &           Xbdir(i), Ybdir(i), Zbdir(i), Tener(i), Bweig(i)
           Jbeam(i) = IZbeam
         END DO
 501     CONTINUE
         Nfile = I-1
         CLOSE(41)
         WRITE (LUNOUT,*) "Source file number of lines", Nfile
         WRITE(LUNOUT,'(a,132a)') ("*",i=1,132)
         XDUMMY = 101.D+00
       END IF
```

Second Step – Compile (3)

Use & Modify source.f user routine -> source2b.f

```
* Wt is the weight of the particle. Use no biasing in generating the
* source file so that the particle weight should be one. Note for low
* energy neutron the weight can be different than one.
      WTFLK  (NPFLKA) = Bweig(line)
      WTFLK  (NPFLKA) = 1.0D+00
      WEIPRI = WEIPRI + WTFLK (NPFLKA)
      IJBEAM = Jbeam(line)
* Particle type (1=proton.....). Ijbeam is the type set by the BEAM
* card. Here it is input as the appropriate particle.
```

Second Step – Normalization

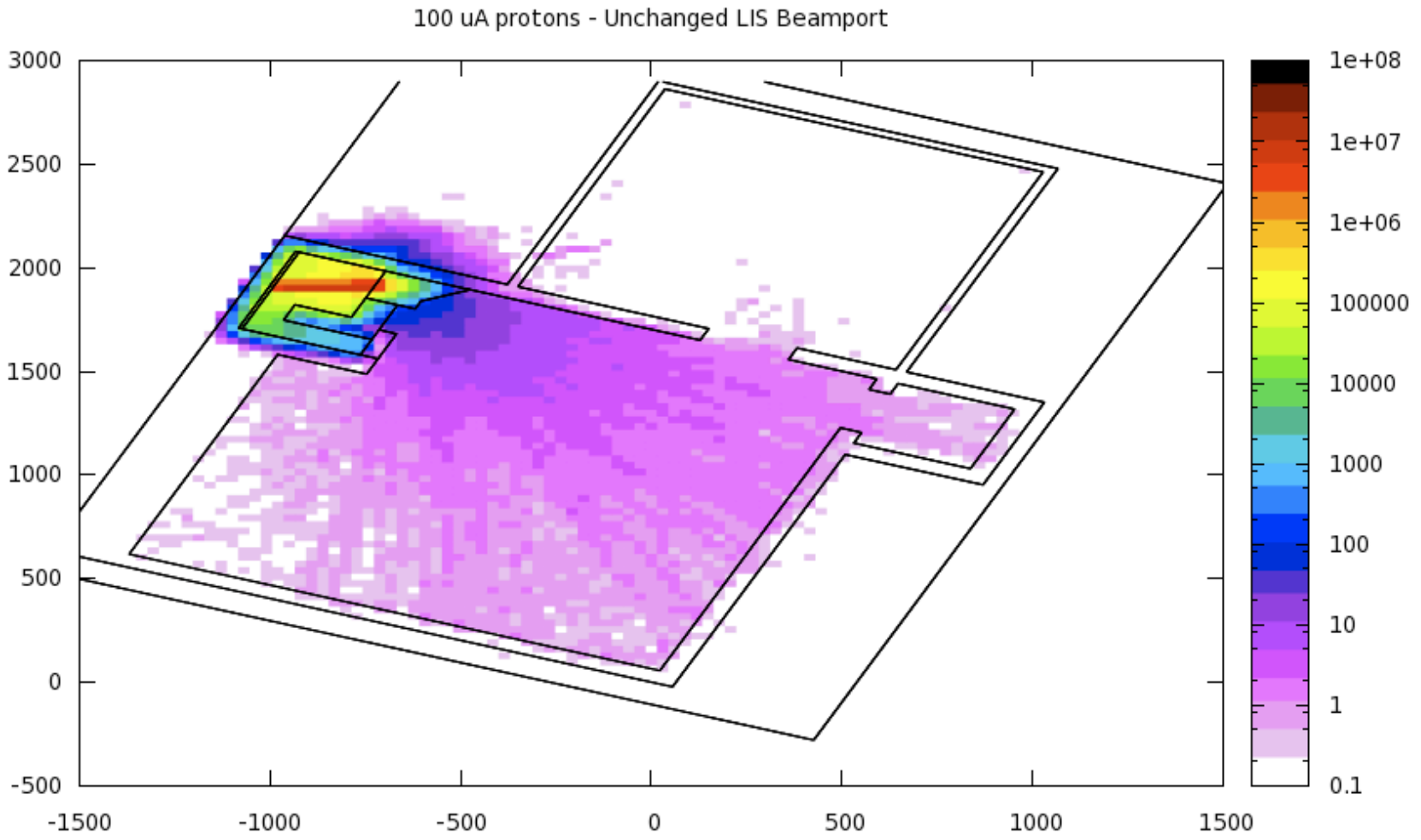


1st step normalization

SCORING normalization: # of hadrons scored / # of primaries

TRIUMF

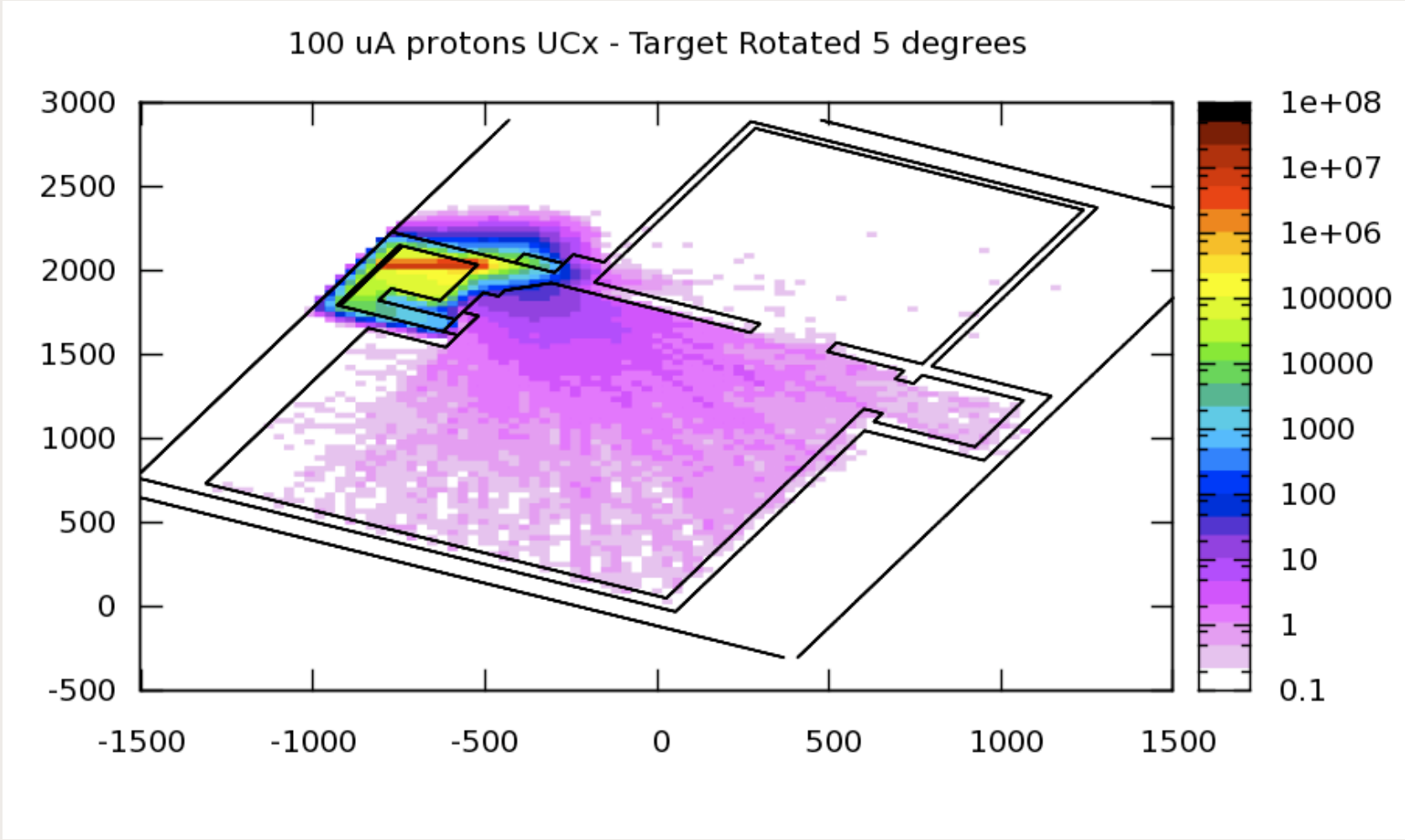
Second Step – USRBIN for Normal Target



TRIUMF

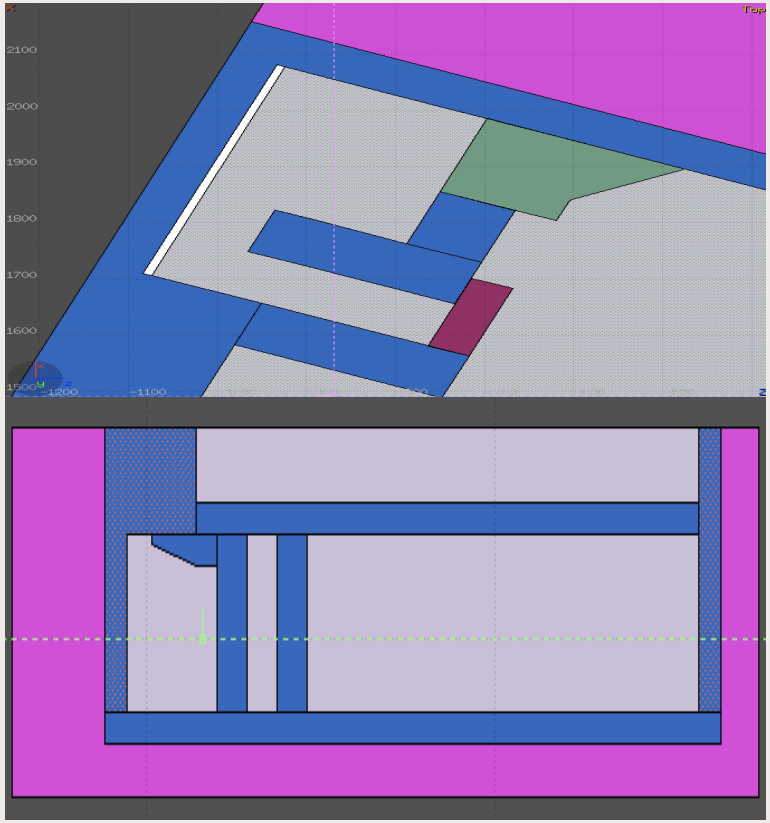
Second Step–USRBIN for 5 degrees Rotated Target

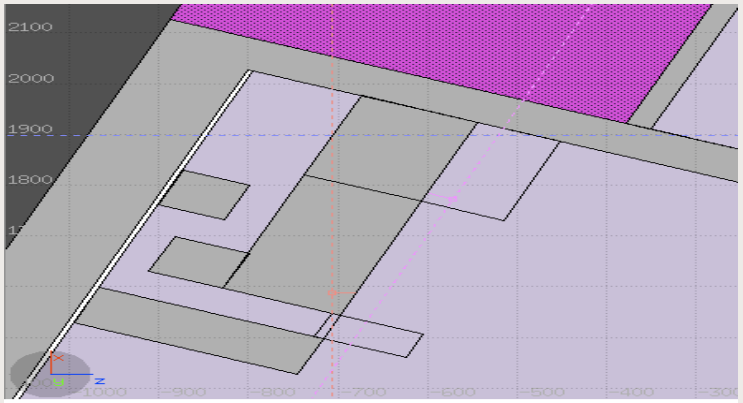
Used ROT-DEFI to rotate the target 5 degrees

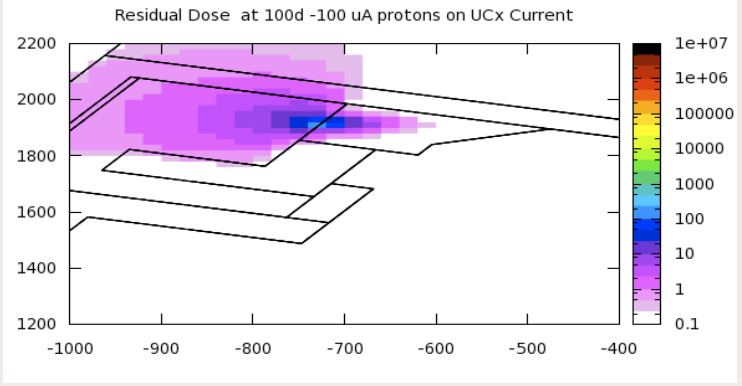


Conclusions

- Saves CPU time
- Cannot Bias
- Flexibility in changing the geometry to achieve the optimal solution
- Flexibility in activation assessments







TRIUMF

Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire
et en physique des particules

Thank you!
Merci

Acknowledgements:
Anne Trudel, TRIUMF

TRIUMF: Alberta | British Columbia | Calgary Carleton | Guelph | Manitoba | McMaster Montréal | Northern British Columbia | Queen's Regina | Saint Mary's | Simon Fraser | Toronto Victoria | Winnipeg | York