

# Simulation and Data analysis working group report

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At the  
EXL/R3B collaboration meeting,  
Milano, 03/10/06

# Recent Meetings

2 SWG Meetings since our last EXL/R3B collaboration meeting:

In Paisley (27/01/06): Status on EXL, R3B, HISPEC/DESPEC event generators,  
Manpower problem addressed,  
GEANT4 dilemma

At CERN : meeting with GEANT4 collaborators

- Ion Energy loss and multiple scattering. ATIMA, TRIM G4 comparisons, atomic charge state...
- Drift electrons in gas detectors (ACTAR),
- Low energy neutrons,
- Cross sections and kinematics,
- PDG coding (extension for ions?),
- Hadronic interaction and decay of exotic nuclei,
- Transfer matrices for magnetic elements of the accelerators

Next meeting : possibly in Valencia in January 2007

- SWG Activities were also presented at the NUSTAR annual meeting (24/02/06) and at the NUSTAR Management Board meeting (13/09/06)

## Conclusion of the meeting with the GEANT4 collaboration

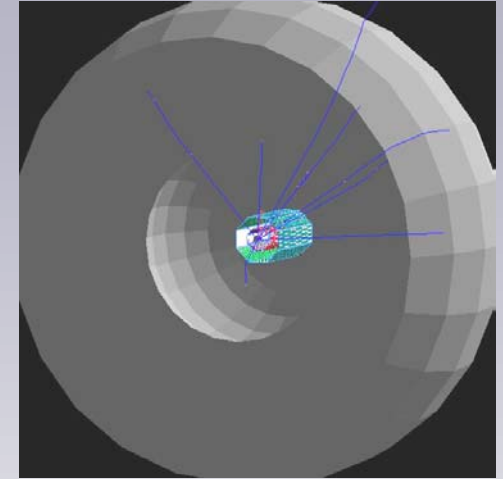
- GEANT4 did welcome the NUSTAR SWG
- GEANT4 priorities = HEP priorities
- They invite us to the GEANT4 Technical Forums (via vrvs)
- No MoU anymore,
- But they need some kind of agreement with institutions/researchers rather than collaborations

# R3B/EXL WG Simulation status

R3B: R3BSim code (<http://www.usc.es/genp/r3b/> )  
(Si tracker + Calorimeter)

Analysis code for (Si + Calorimeter)

Development of standalone programs  
for Newland, TPC, calorimeter,



Code Distribution with Subversion (svn: <http://subversion.tigris.org/>)

The Command to get the R3BSim code is :

```
svn checkout http://fpcongro.usc.es:/R3BSim
```

(login and password to be request to [hapol@fpddux.usc.es](mailto:hapol@fpddux.usc.es) )

EXL: Activities focused on stand-alone program for

- Silicon particle array (ESPA),
- Ion optics,
- Calorimeter

# Output of the R3BSim code = primary tree T

The screenshot shows the TreeViewer application interface. The title bar reads "TreeViewer". The menu bar includes "File", "Edit", "Run", "Options", and "Help". Below the menu bar are fields for "Command", "Option", and "Histogram" (set to "htemp"), along with checkboxes for "Hist", "Scan", and "Rec" (checked). The main area is divided into two panes: "Current Folder" and "Current Tree : T".

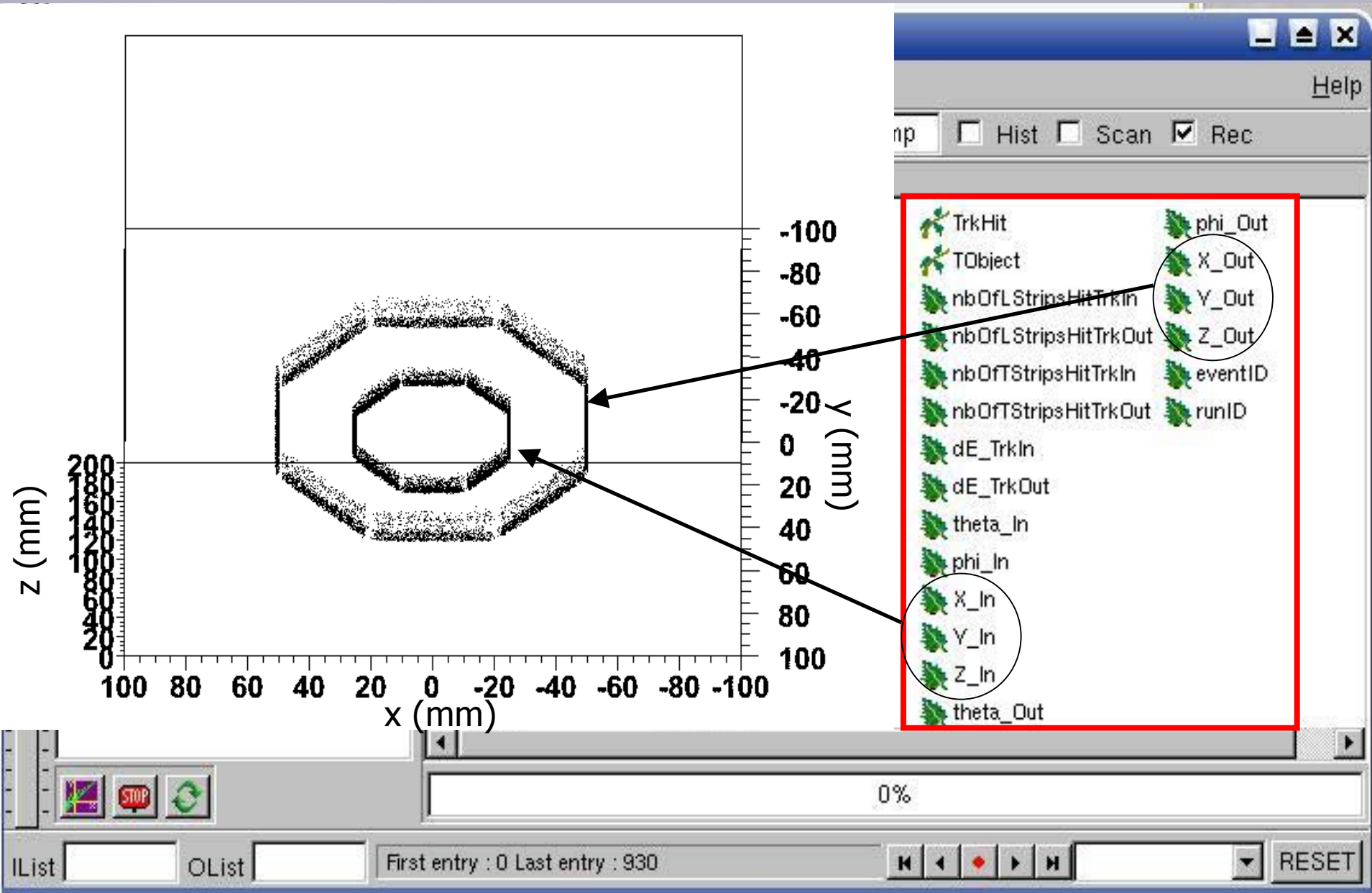
**Current Folder:** Shows a tree structure under "TreeList". It contains three sub-folders: "primaryInfo", "crystalHits", and "trackerHits". The "trackerHits" folder is circled in red.

**Current Tree : T:** Displays a list of variables in a tree structure. The variables are organized into several groups:

- Primary variables: X: -empty-, Y: -empty-, Z: -empty-, primaryInfo.Px, primaryInfo.Py, primaryInfo.Pz, primaryInfo.trackID, primaryInfo.mass, primaryInfo.charge, primaryInfo.polX, primaryInfo.polY, primaryInfo.polZ, primaryInfo.Weight0, primaryInfo.properTime, primaryInfo.x0, primaryInfo.y0, primaryInfo.z0, primaryInfo.eventID, primaryInfo.runID.
- Crystal Hits variables: crystalHits, crystalHits.type, crystalHits.copy, crystalHits.energy, crystalHits.nbOfSteps, crystalHits.energyInZone1, crystalHits.energyInZone2, crystalHits.energyInZone3, crystalHits.energyInZone4, crystalHits.depthFirstStep, crystalHits.timeFirstStep, crystalHits.depthLastStep, crystalHits.timeLastStep, crystalHits.nbOfPrimaries, crystalHits.energyPrimary, crystalHits.thetaPrimary, crystalHits.phiPrimary, crystalHits.eventID, crystalHits.runID.
- Tracker Hits variables: trackerHits, trackerHits.ene, trackerHits.detID, trackerHits.lStripID, trackerHits.tStripID, trackerHits.tof, trackerHits.isOuter.

The "trackerHits" subtree is highlighted with a red box. At the bottom of the window, there are icons for a file, a stop sign, and a refresh button, along with a progress indicator showing "0%".

# Event reconstruction code ► secondary tree



# SWG main priorities

## R3B/EXL

Simulation of test experiments  $\Rightarrow$  **Event generator urgently required as well as information on the detectors to be used**

Implementation of new detectors in the R3BSim code (Newland, TPC)

Couple EXL detectors in a unique code (EXLSim ?)

Complete the detectors with frames, holders, vacuum chamber

Development of the analysis or event reconstruction code

## SWG hot issues

- Still no decision on the Framework
  - not enough expertise in existing framework to make a decision  
→ GEANT4 + ROOT seems the only way we can afford
- What do we do with the GEANT4 collaboration ?
  - FLUKA  $\neq$  GEANT4 despite using several Hadronic physics list in GEANT4 (Mihai Potlog, Bucharest)
- Event generator for key experiments
- Need manpower to simulate test experiments
- No assigned manpower for Development/maintenance of the codes



# What event generator ?

Several existing event generator interfaces have been identified and tested :

- HepMC
- GENBOD
- TGenPhaseSpace

None are really appropriate for us.

⇒ Develop a self-made interface

We need theory output files before to build a flexible interface.

# Event generator for elastic/transfer reactions

= 2-body final state reactions: 2(1,3)4 e.g : (p,p) , (d,p) , (p,d) , ...

- The kinematic of the 2-body reaction provide a simple relation  $T_3(\theta_3)$  for the light ejectile

- The theories provide the reaction cross-section  $\sigma(\theta)$  or  $P_\sigma(\theta) = \int_0^\theta \sigma(\theta) / \sigma_{\text{tot}}$

To propagate the light ejectile in GEANT4, we need to know its kinetic energy  $T$ , its polar angle  $\theta$  and its azimuthal angle  $\varphi$ .

Thus, the event generator is simply as follow :

- a random number between 0 and 1 is used for  $P_\sigma(\theta) \Rightarrow \theta$  is deduced
- The corresponding kinetic energy is then deduced from  $T(\theta)$
- $\varphi$  is chosen randomly between 0 and  $2\pi$

# Event generators for QFS experiments

Case of 3-body final state reactions:  $2(1,34)5$  e.g.: (p, 2p)

- 5 independent kinematic variables are necessary to describe the 3-body final state (e.g.:  $p_3, \theta_3, \theta_4, \varphi_3, \varphi_4$ )

- In the PWIA theory (Debebe, PRC 31 (1985) 1841) , the number of parameter is reduced to 3:

$s = (p_3+p_4)^2$  = total energy of the two outgoing light particles

$u = (p_2-p_5)^2$  = internal momentum of the cluster

$t = (p_1-p_4)^2$  = transferred momentum

Even so, the event generator is still complex

# MOCADI as an Event Generator

(M. Taylor, University of York)

- Monte Carlo code to model ion transport and energy loss (uses ATIMA 1.0) (Nuc. Inst. & Meth. in Phys. Res. B 126, 284)
- Used to optimise experimental setup of FRS at GSI
- Models fragmentation reactions using Goldhaber momentum distribution (Phys. Lett. 53B, 306) (uses EPAX2 for cross-sections)
- Option to output events to an ASCII file (no cross-sections applied !)

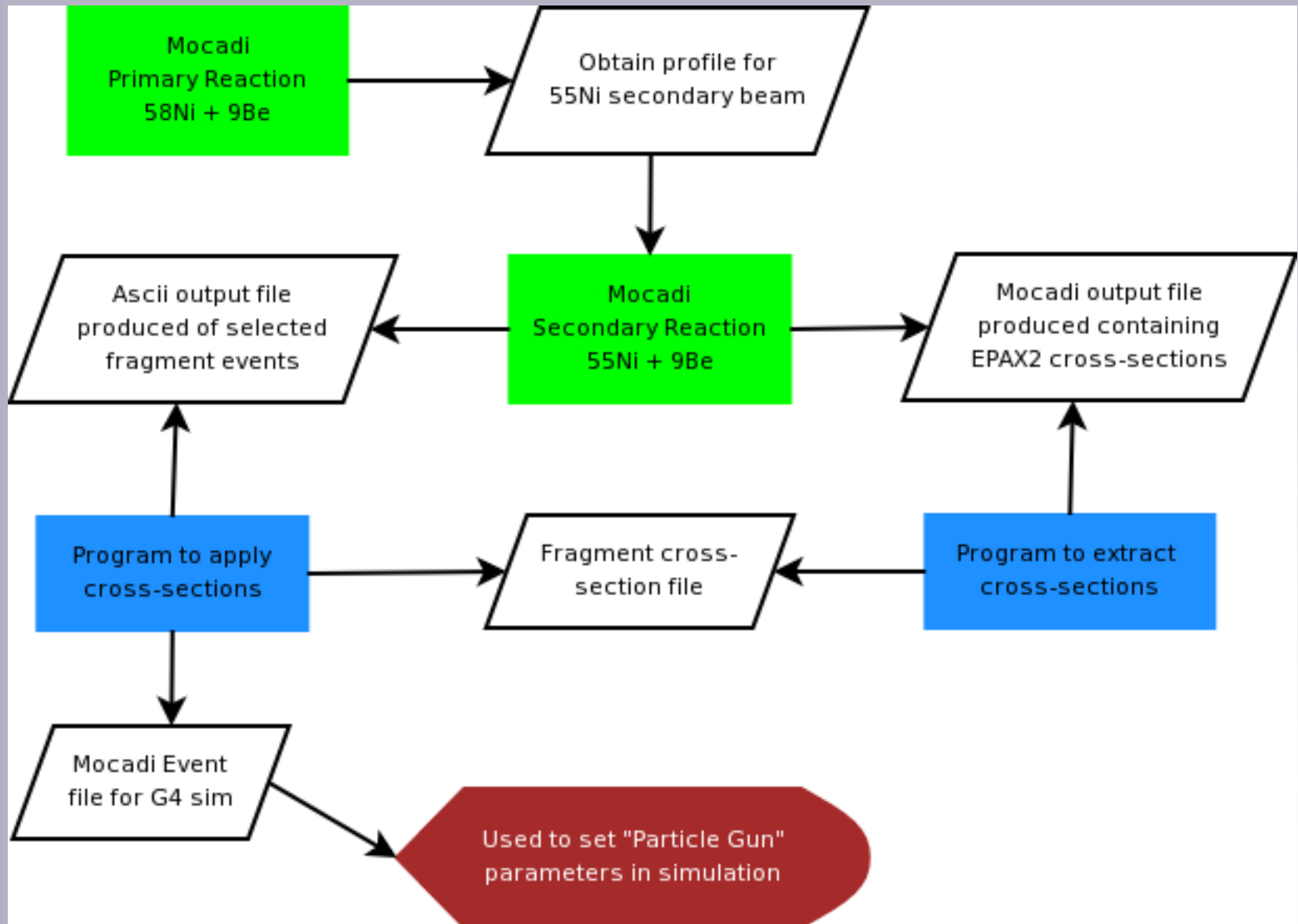
Apr 17, 08:16:22		tmp.asc		Page 1/1																
1	1	3.521330e-02	7.885455e-01	5.776525e-02	1.025083e-01	1.130555e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	1	-2.479133e-02	4.445095e-01	1.447487e-01	-7.913098e-01	1.155950e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	-4.102095e-02	1.029321e-01	-1.724004e-02	-1.240057e-01	1.179450e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	-3.903373e-02	1.300000e-01	1.049742e-01	-2.907250e-01	1.175172e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	-1.118732e-01	8.739247e-02	-1.010298e-02	2.775904e-01	1.104470e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	1	-4.115452e-02	1.221555e-01	-9.785252e-03	-1.158205e-01	1.102377e-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

## Variables outputted

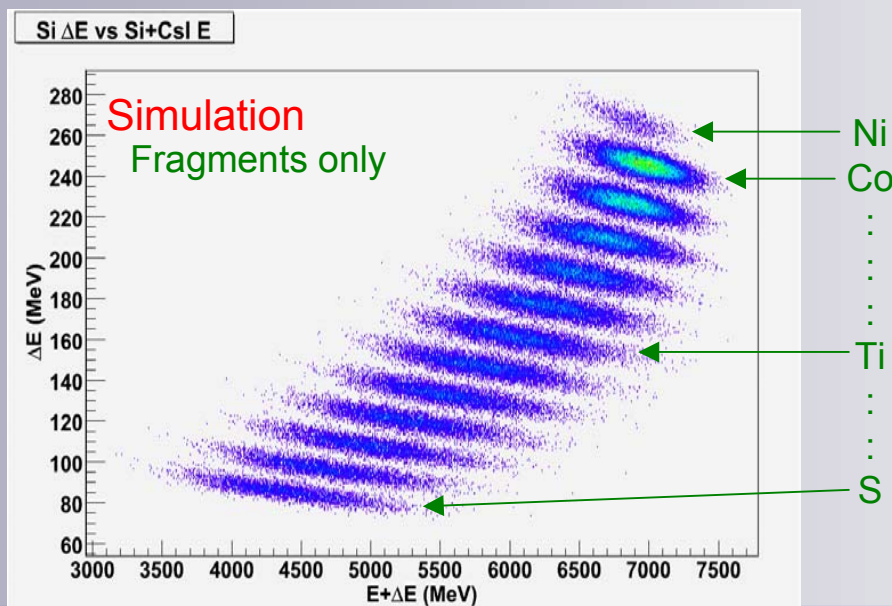
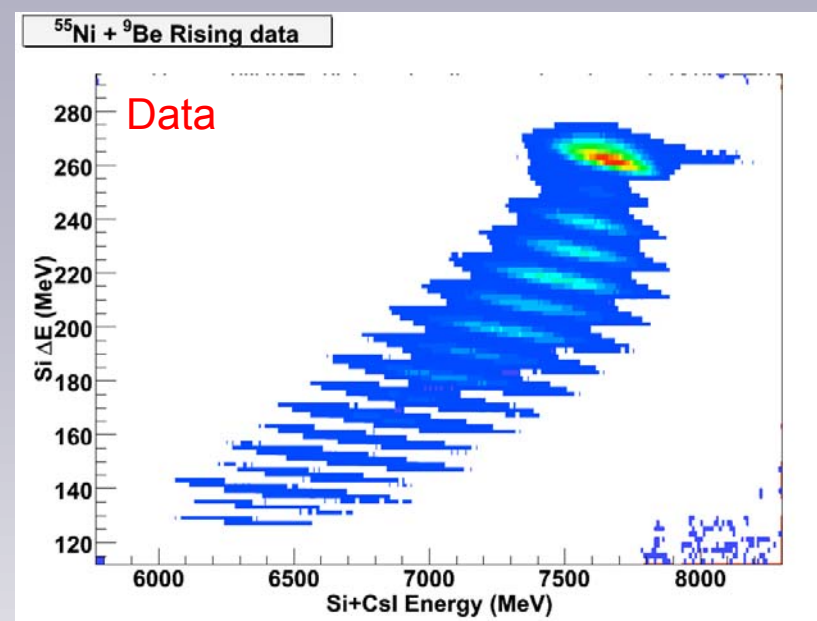
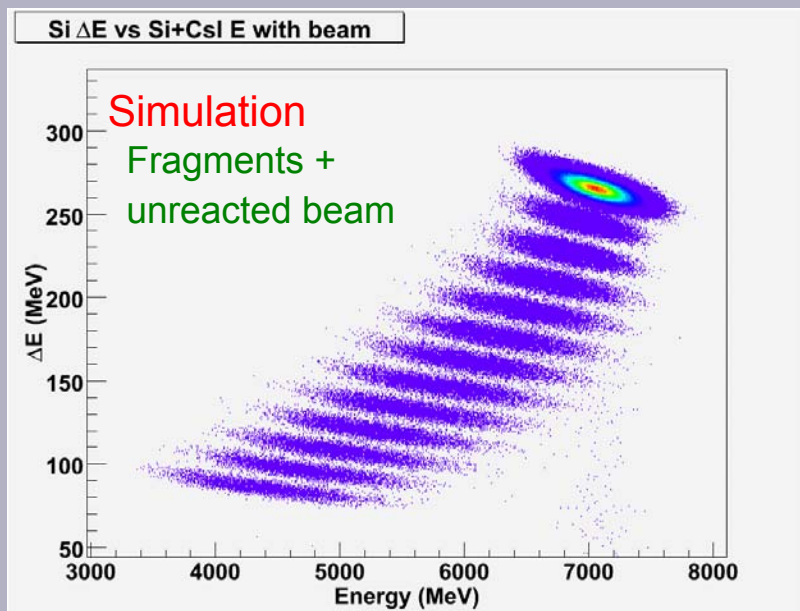
1. Fragment number
2. X-position (cm)
3. X angle (mrad)
4. Y-position (cm)
5. Y angle (mrad)
6. Energy (AMeV)
7. Time (ps)
8. Mass (amu)
9. Z
10. Charge state

# Generation of Simulation Event File

(M. Taylor, University of York)



# Fragment Identification From Energy Signals (M. Taylor, York University)



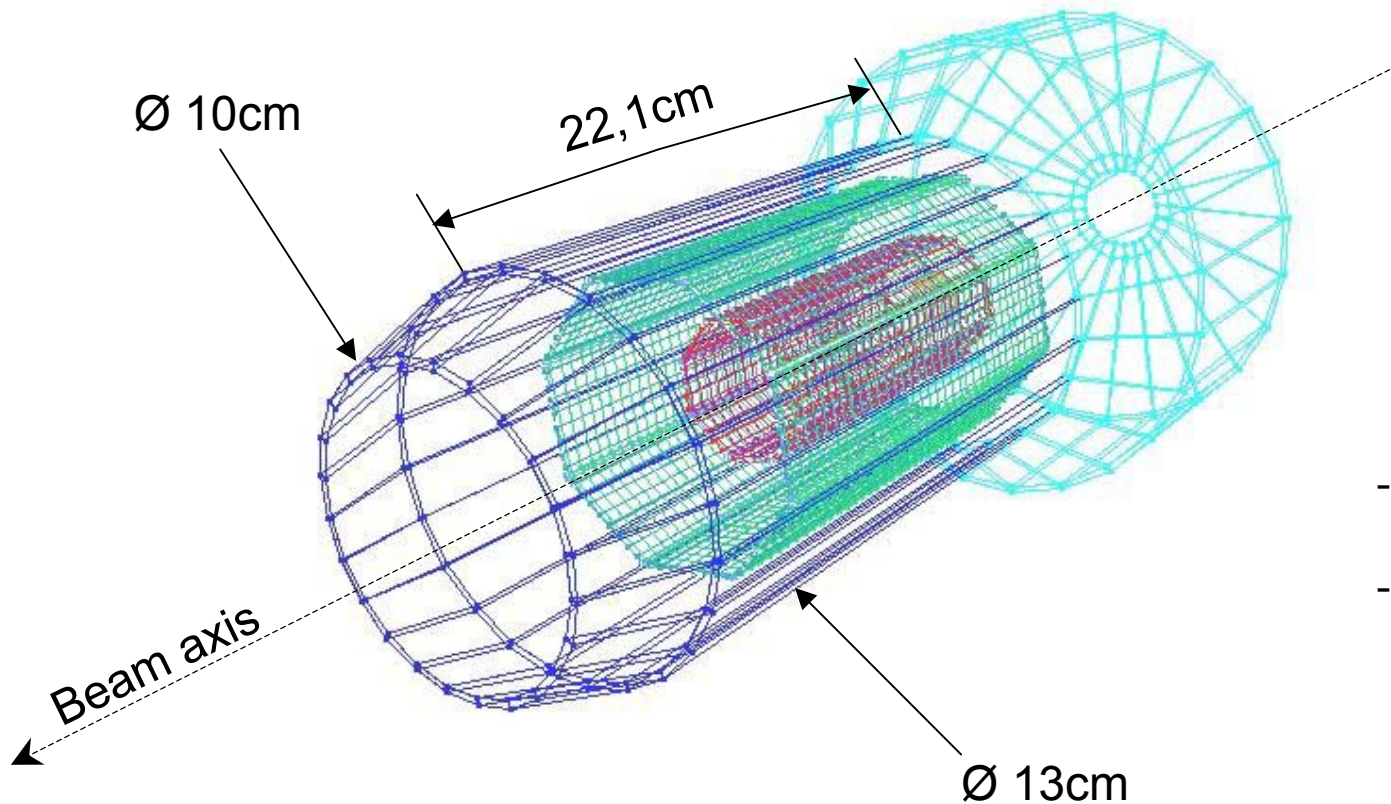
- 175 MeV/u  $^{55}\text{Ni}$  beam  
130000 primary events
- 700 mg/cm<sup>2</sup>  $^9\text{Be}$  target
- 91 fragments produced  
with cross-sections  $> 10^{-2}$  mb  
(Z range: Ni – S)
- Tgt-Si distance 2.02m

## Event generators for all key experiments

How can we make a unique and efficient event generator for any experiments ?

- an event generator on the fly ?
- an input file of events which would give  $T, \theta, \phi$  of all the products of a given reaction and which would reflect the cross section ? (M. Taylor)
- Include Beam characteristics ?
- Include background ?

# Vacuum chamber for the target recoil Si Detectors in the R3BSim code



- Material: Aluminium
- Thickness: 2.5 mm

By Jerome Bettarel

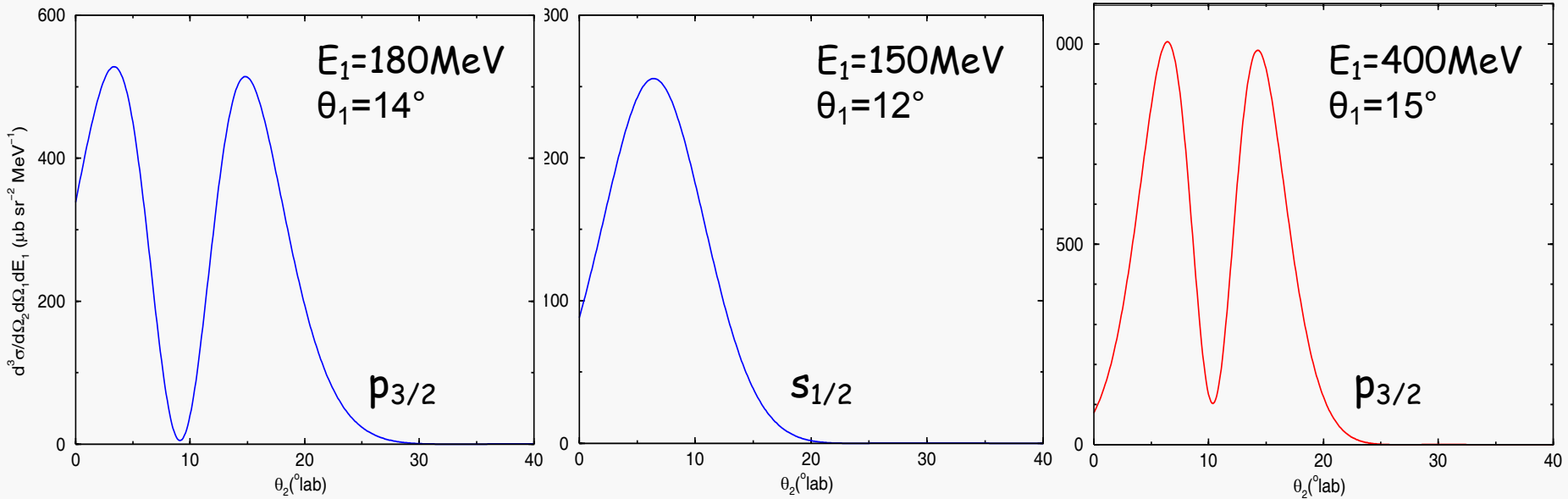


# PWBA Calculations in Inverse kinematics

C.E. Carter, University of Surrey

@ 150MeV/u

@ 300MeV/u



- cross sections are at forward angles
- $p_{3/2}$  state contributes more to  $\sigma_{\text{tot}}$  than  $s_{1/2}$  state
- angular correlation is narrower for higher  $E_0$