



Development of a Heavy-Ion-Capable Integrated Monte Carlo Transport Code Based on FLUKA, DPMJET and ROOT

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The Project

FLEUR-S [Fluka Executing Under Root – Space]

This project was initiated by, and has been primarily funded by **NASA** in order to develop an integrated Monte-Carlo based transport code to be used in the simulation of the Space Radiation environment.

FLUKA was chosen for the basic transport framework, and **DPMJET** (2.5 & 3) has been integrated into the code to provide an internal event generator for nucleus-nucleus interactions above 3-5 GeV/A.



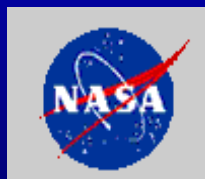
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FLEUR – S Project Goals

- . . . To provide:
 - a single **user-friendly GUI-based** environment...
 - employing Monte Carlo techniques...
 - for the simulation of space radiation transport...
 - through realistic 3-D material geometries,
 - including the integrated analysis tools...
 - by using modifications of existing particle physics software codes (i.e. FLUKA & ROOT)



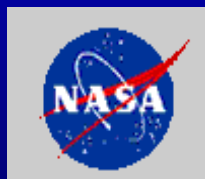


Radiation Transport - FLUKA

- Why use FLUKA?
 - Arguably the best existing integrated physics package. (Based on recent CERN LHC evaluations of existing Monte Carlo codes...)
 - Fully integrated physics in one common code
 - incorporates EGS4-like electromagnetic interactions
 - excellent MORSE-like neutron transport capabilities
 - an Intra-Nuclear Cascade hadronic event generator with pre-equilibrium stage extensions...



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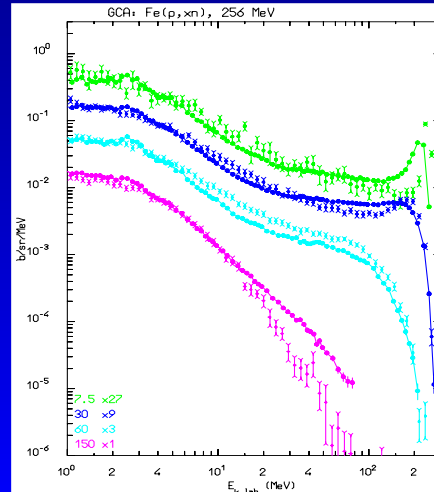




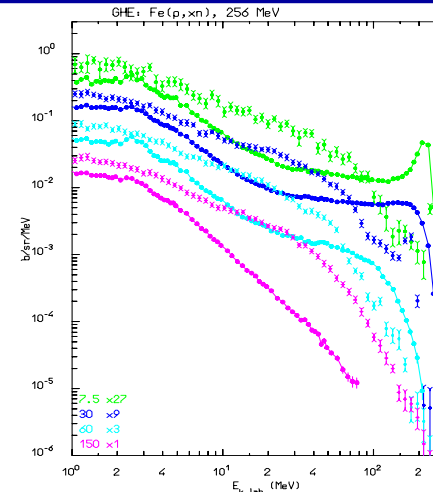
FLUKA Comparisons



G-Calor

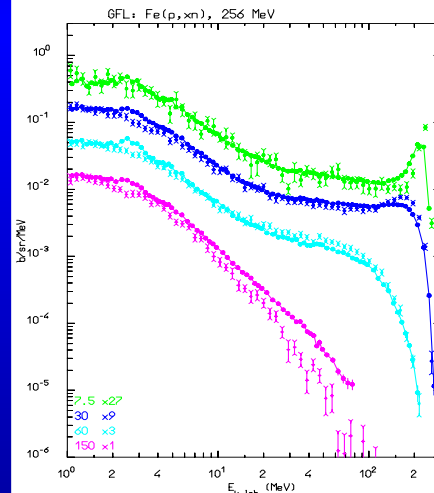


Geisha

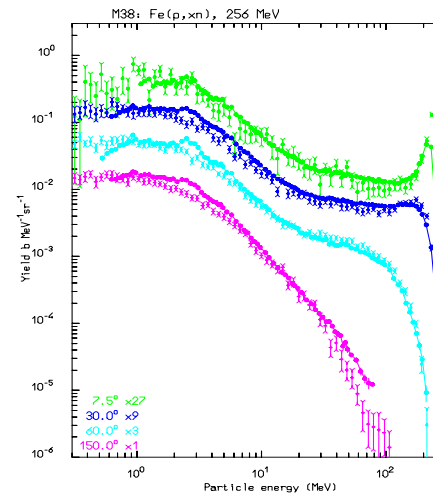


Fe(p,xn)
@ 256 MeV
 $d^2\sigma/d\Omega dE$

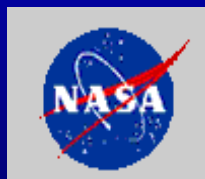
G-FLUKA
FLUKA's
10 year old
Hadronic
generator used in
GEANT 3.21



← FLUKA



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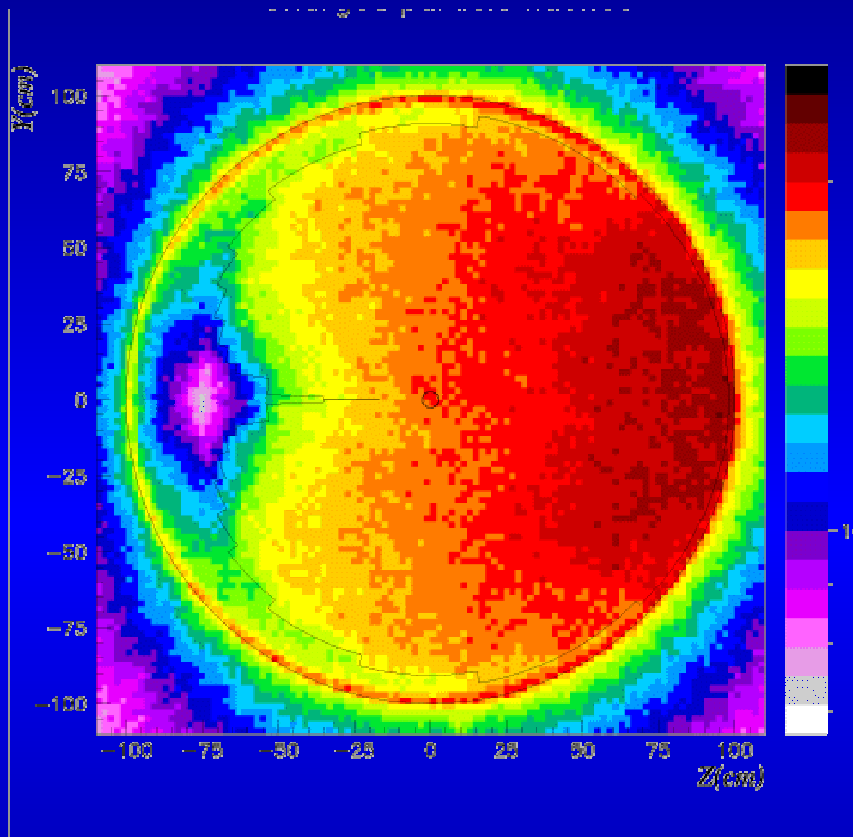


Independent Comparison
by Atlas (CERN/LHC) expt.

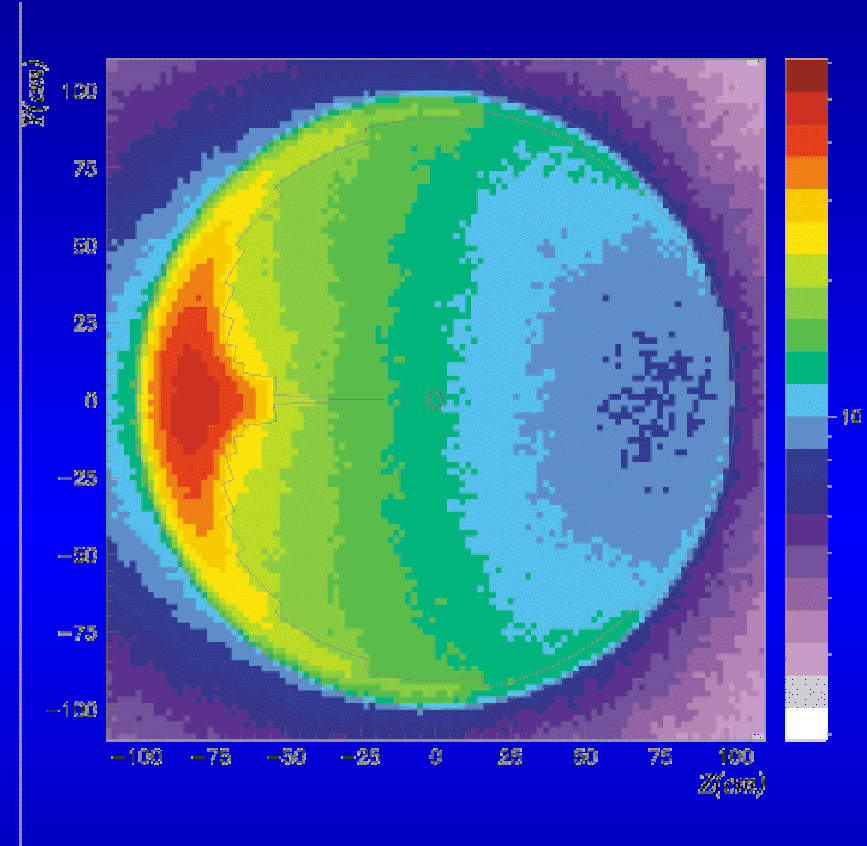




FLUKA MIR TPEC Simulations



Charged Particle Fluences



Neutron Fluences

(Note the albedo fluences outside of the phantom...)



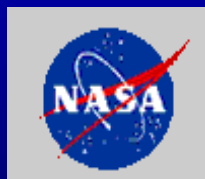
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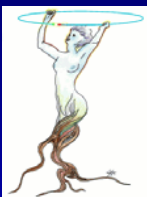




What is ROOT ?

- ROOT is a Complete **GUI-based Object-Oriented** Data Analysis Infrastructure (Similar to IDL, but more versatile and *FREE*). [<http://root.cern.ch>]
 - Developed & Maintained at CERN by Rene Brun, Fons Rademakers, Phillipe Canale, Masaharu Goto & Others
- Uses C++ as a Scripting Language
- **Powerful Object Oriented Data Structure** ←
- Widely Used in Particle Physics (CERN, BNL, FNAL, JLAB, and in a growing number of non-physics users).





Some ROOT GUI “Widgets”

Select Element/Reaction

Material

Element:

Charge (Z): 1 Atomic Mass: 1.00794 (7)
Density: 8.988E-5 Oxidation: +1,-1
Melting Pt (C): -259.34 Boiling Pt (C): -252.87
Isotope (A): 1 Isotope Info: 1/2+ 7.269 99.985%

Reaction

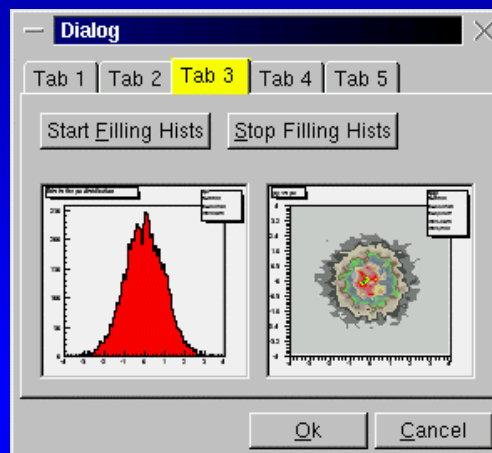
Projectile:
Temperature: 293 Reaction:
Database:
Reaction Info: -

Options

Line Width: Line Color:
Marker Style: Marker Color:
Marker Size: ErrorBar Color:

Information

Symbol name: 1-H - 1
Laboratory: LANL
Evaluation Date: EVAL-OCT89
Author(s): HALE, DODDER, SICILIANO, WILSO
Reference: NO REF TO DATE
Distribution Date: DIST-SEP91
Last Revision Date: REV1-JUL91
Master Entry Date: 910806



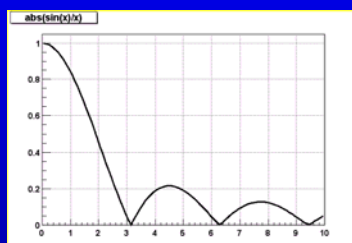
Dialog

Tab 1 | Tab 2 | **Tab 3** | Tab 4 | Tab 5

Options

Module 1
Module 2
Module 3
Module 4

Tab Handling



RQuant Data Analysis Studio

File Edit View Project Tools

Project Manager

- Market search
- Portfolio rebalancing
- Neural strategies
- Trading systems

Canvas Editor

```

Title: next(AssetList);
while (Asset = (TAsset*) next()) {
  Tst_P LastEntry = Asset->GetEntries()-1;

  Float_t SMA11 = Asset->SMA(Order1, TAsset->Price.LastEntry);
  Float_t SMA12 = Asset->SMA(Order2, TAsset->Price.LastEntry);
  Float_t Delta1 = SMA12-SMA11;

  Float_t SMA21 = Asset->SMA(Order1, TAsset->Price.LastEntry-1);
  Float_t SMA22 = Asset->SMA(Order2, TAsset->Price.LastEntry-1);
  Float_t Delta2 = SMA22-SMA21;

  Bool_t Hold = TRUE;

  TString Output;
  char Entry[128];

  if (Delta1 < Delta2) {
    Output = " ";
    if (TMath::Abs(Delta1-Delta2) > 2) {
      sprintf(Entry, "%s-%10s - BUY\n", Asset->GetName());
      Output += Entry;
      Hold = FALSE;
    }
  }
}
if (Delta1 < Delta2) {
  Output += " ";
}
}

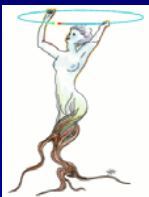
Message Output Command line
12-24-58: Welcome to R-Quant Data Analysis Studio
12-24-58: R-Quant project, A new project, loaded and initialized
12-25-07: New macro: MarketSearch.C, added to Order Market search

```

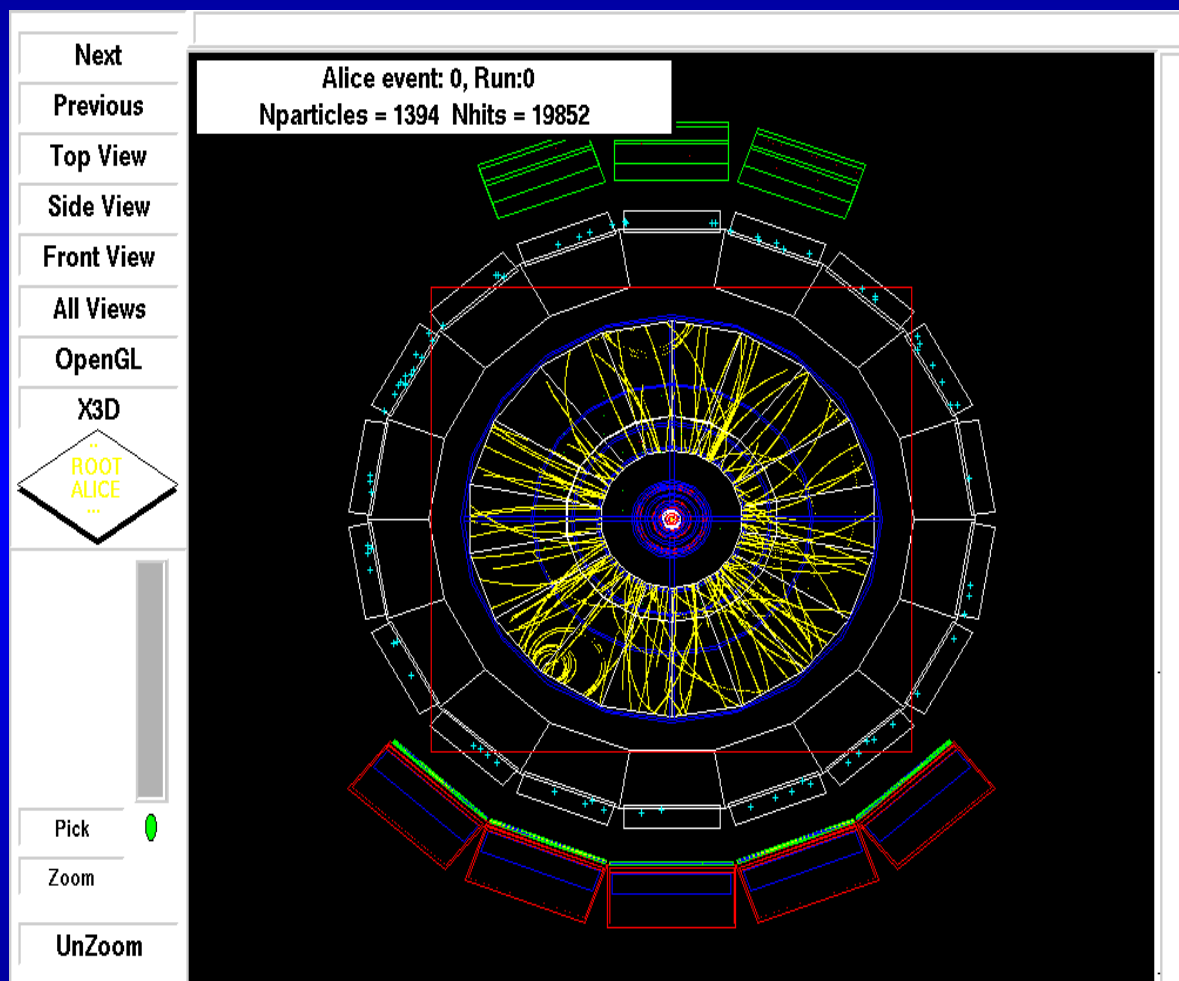


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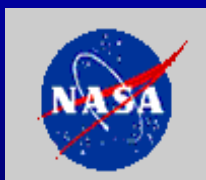




ROOT-Based Event Display



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AliROOT



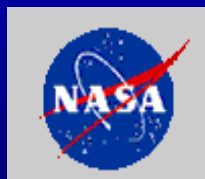


FLEUR-S – Major Task 1

- Add Heavy Ion (Nucleus- Nucleus) Interactions to FLUKA
 - > 3 GeV/A – Use DPMJET Event Generator – *Done (Available)*
 - < 3 GeV/A – Long Term Project (NRA 01-OBPR-05)
 - *Short Term Solution – Use Existing QMD (Quantum Molecular Dynamics) Event Generator – Work in Progress—This Year*
 - *Intermediate Solution – Use PEANUT (Pre-Equilibrium Intra-Nuclear Cascade) Generator – Next Year*



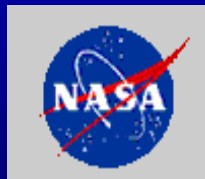
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DPMJET Versions Incorporated

- DPMJET is an implementation of the **two-component Dual Parton Model** for the description of interactions involving nuclei. It is based on the **Gribov-Glauber approach** and treats both **soft and hard scattering processes** in an unified way. Soft processes are parametrized according to Regge-phenomenology whereas lowest order perturbative QCD is used to simulate the hard component. **Multiple parton interactions** in each individual hadron/nucleon/photon-nucleon interaction which are described by the **PHOJET** event generator. The fragmentation of parton configurations is treated by the Lund model **PYTHIA**.
- Particle production in the fragmentation region(s) of the participating nucleus (nuclei) is described by a **formation zone suppressed intranuclear cascade** followed by Monte Carlo realizations of models for **evaporation processes** of light nucleons and nuclei, **high-energy fission**, **spectator fragmentation** (so far limited to light spectator nuclei) and **deexcitation** of residual nuclei by photon emission.
- DIS off nuclei is simulated by LEPTO followed by the full intranuclear cascade and fragmentation treatment as mentioned above.
- DPMJET II.5.3 (Johannes Ranft) [**Available Now** embedded in FLEUR version of FLUKA]
 - <http://www.physik.uni-siegen.de/kolloquium/dpmjet>
- DPMJET III (Stefan Roesler) [**Coming Soon** embedded in FLEUR version of FLUKA]
 - <http://sroesler.home.cern.ch/sroesler/dpmjet3.html>



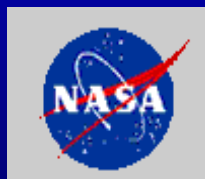


FLEUR-S – Major Task 2

- Provide ROOT GUI Interface
 - Input File Creator
 - *Short Term Simple Translator – This Year (~Now)*
 - *Long Term Interactive “Smart” Interface– Next Year*
 - Output Analysis Tools
 - *Output Format translator into ROOT data structures – This Year*
 - *Convert Existing FLUKA Analysis Tools – Ongoing...*
 - *Develop New Dedicated Analysis Tools – Ongoing...*
 - Virtual Monte Carlo Interface – *Ongoing—Next Year*



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Proposed Major Task 3

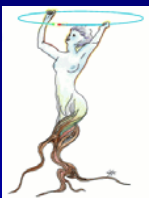
(Currently Unfunded by NASA, but expected soon...)

- Provide Easier Geometry Input for Existing FLUKA Geometry...
 - GEANT 3.21 to FLUKA Translator – *Done*
 - Add Functionality to Existing FLUKA Geometry (Volume Naming and Logical Parentheses) – *Done*
- Provide New Geometric Modeling Format
 - In Progress by CERN (ROOT) Colleagues...
 - Part of the NRA 01-OPBR-05 Proposed Tasks...



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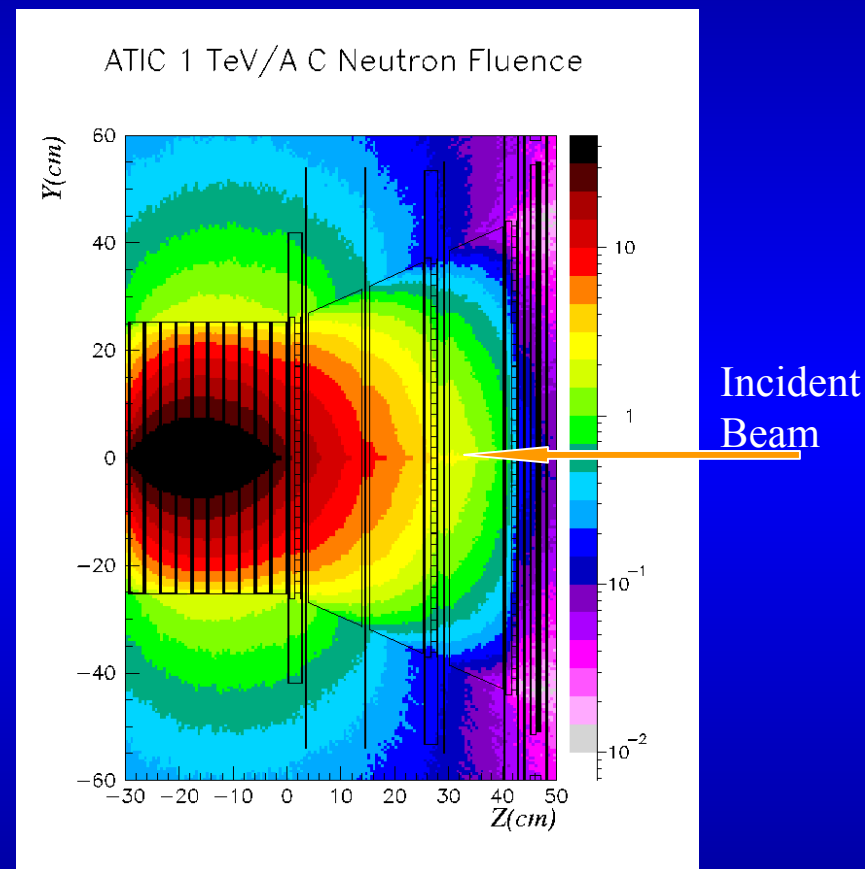
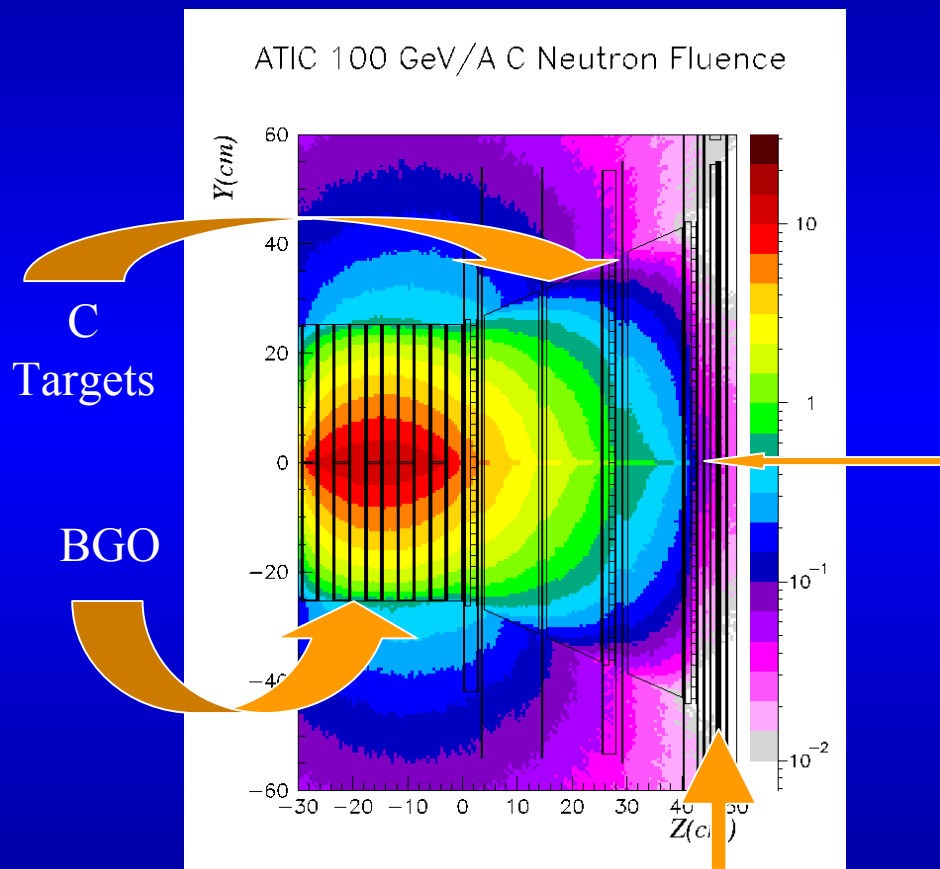




A Simulation of the ATIC Cosmic Ray Balloon Experiment with a Version of FLUKA that has the DPMJET 2.5 Event Generator Built In...

100 GeV/A Incident Carbon

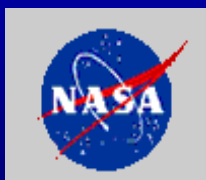
1 TeV/A Incident Carbon



Si Detectors



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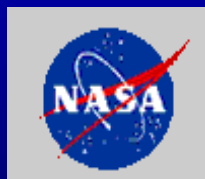
Predicted n fluences from a central C beam incident on the ATIC cosmic ray balloon expt. apparatus

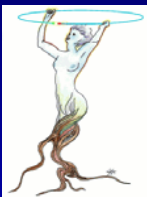




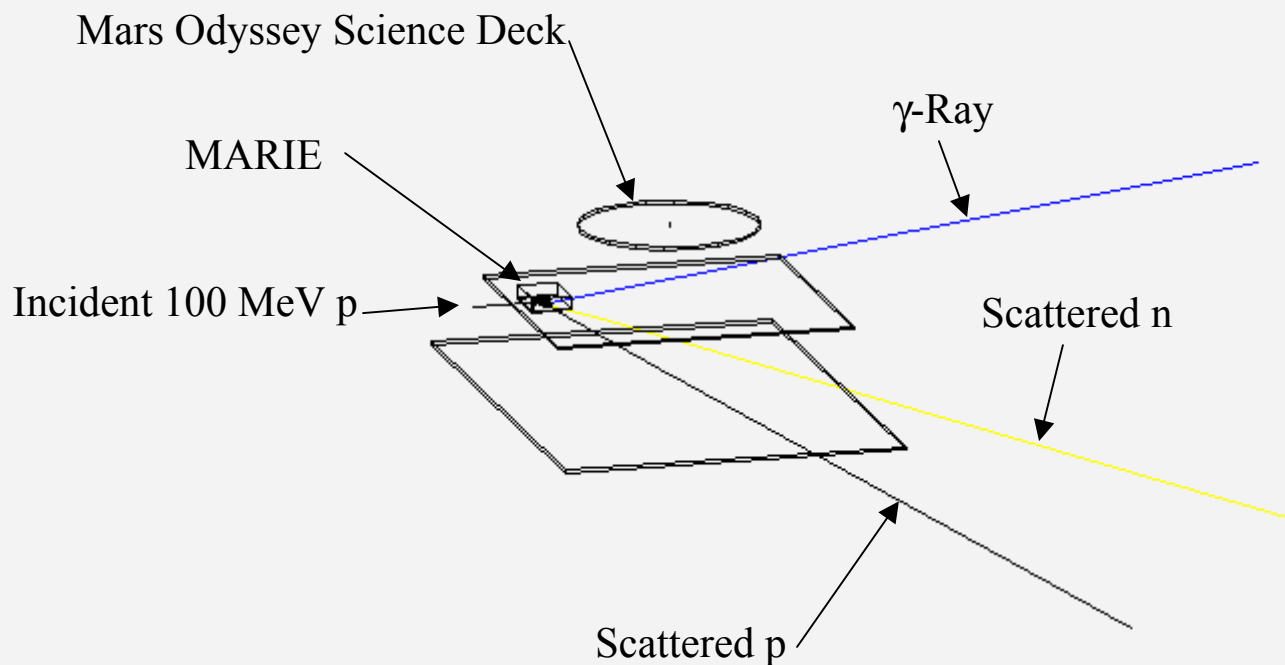
Web Sites...

- FLEUR-S <<http://www.cern.ch/~fleur>>
 - Project status and publications—Downloads soon!
- FLUKA <<http://www.fluka.org>>
 - Download manuals and software (Linux, Unix, VMS)
- ROOT <<http://root.cern.ch>>
 - Download tutorials and software (Linux, Unix, Windows, Mac)





MARIE Simulation with FLEUR-S



New ROOT Visualization Tools Using MC Geometry

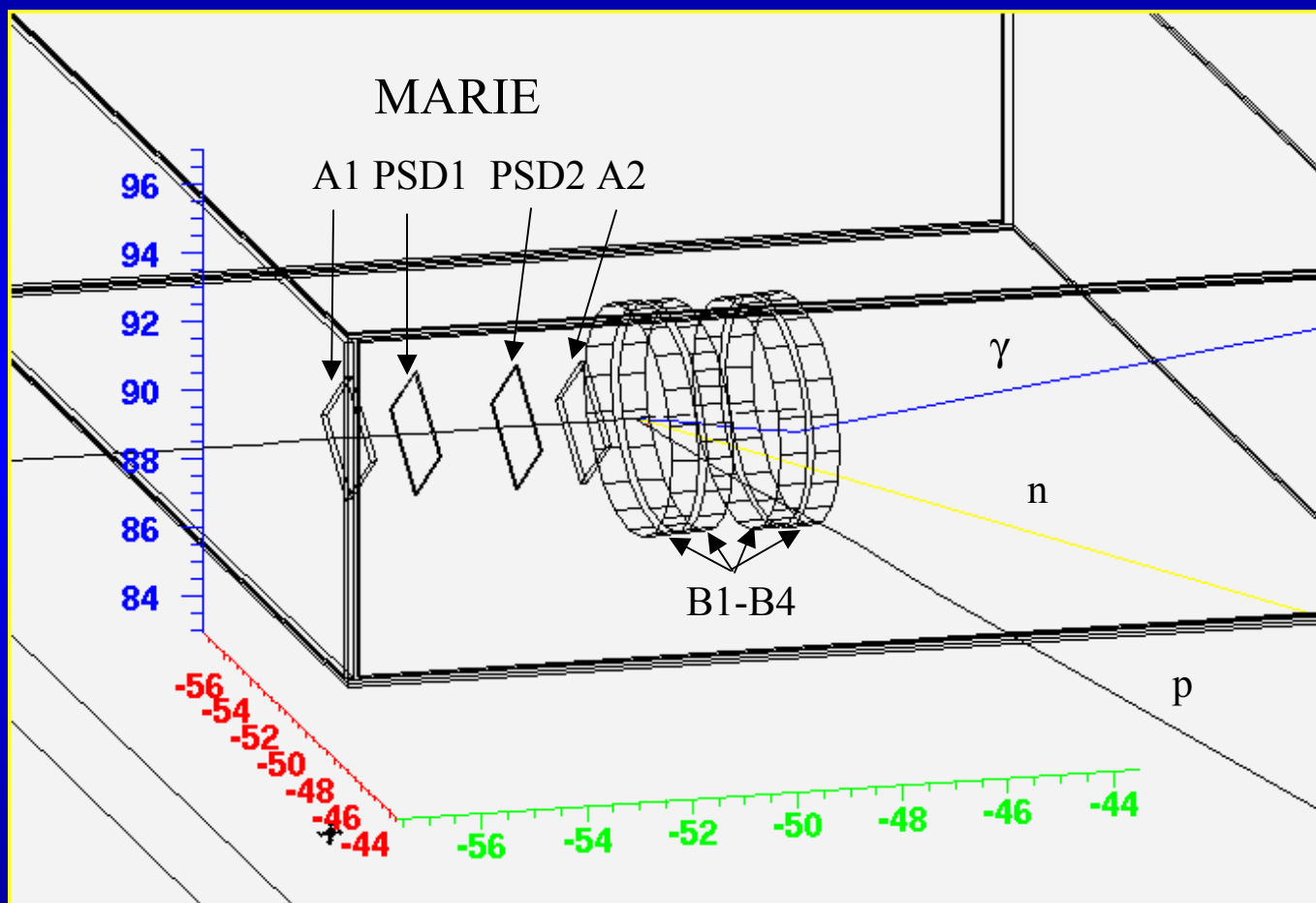


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Zoomed and Rotated View of Event from Previous Slide

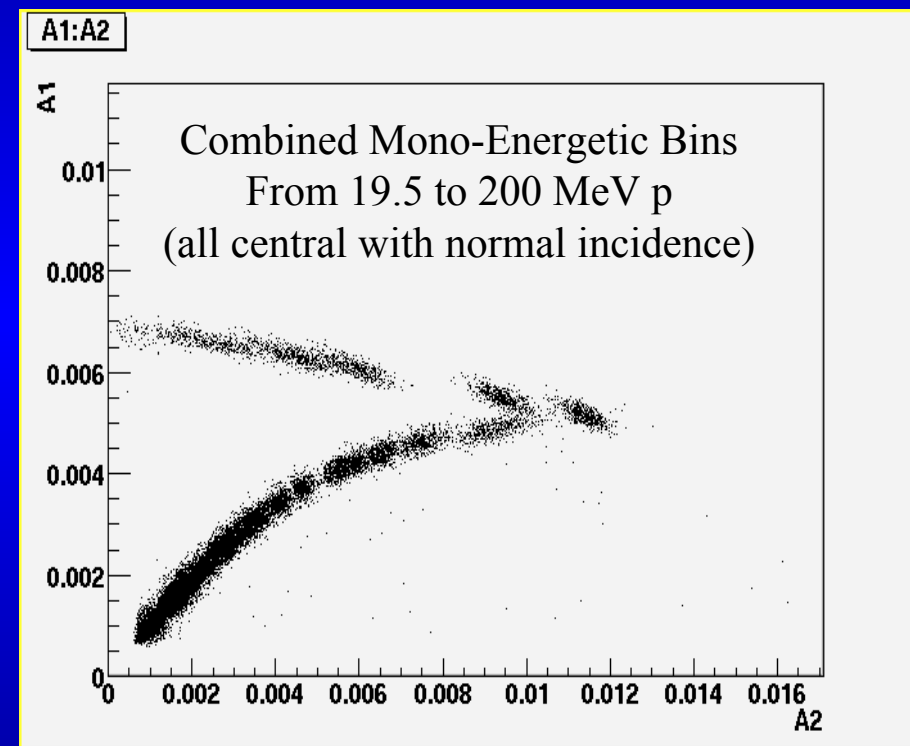
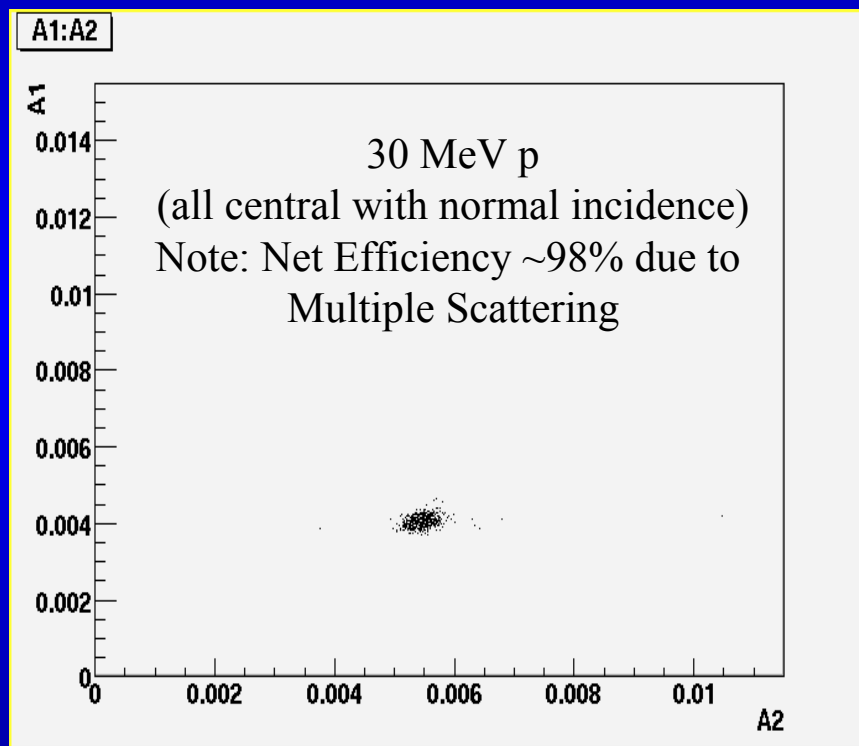


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MARIE A1 vs. A2 from FLEUR-S Simulation



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More to Come Soon...



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