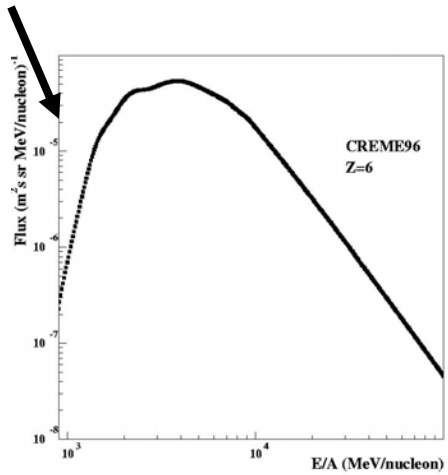
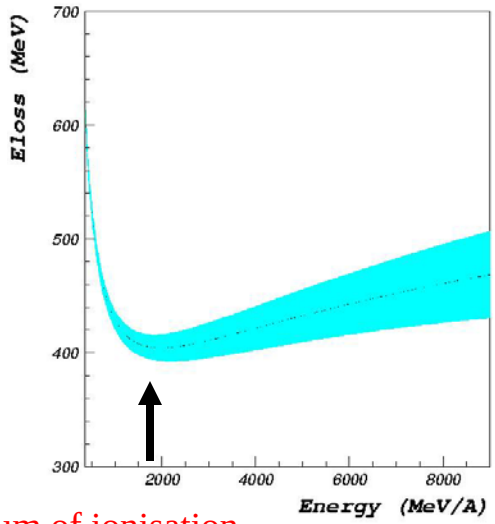
In-orbit calibration

Geomagnetic cutoff

CR energy spectrum



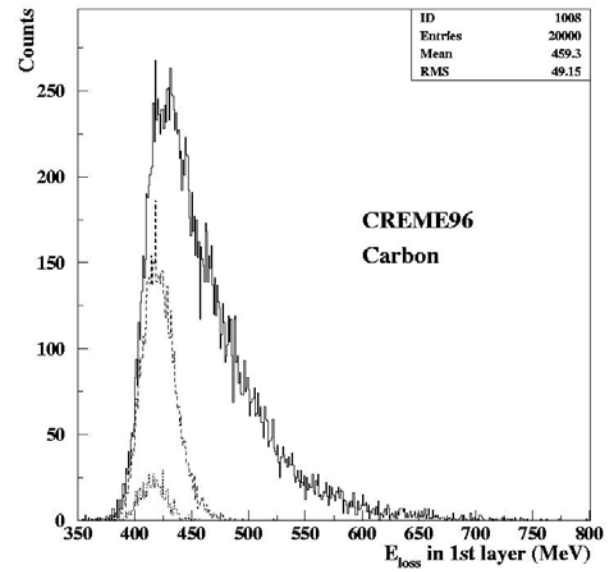
E_{loss} (E)



minimum of ionisation

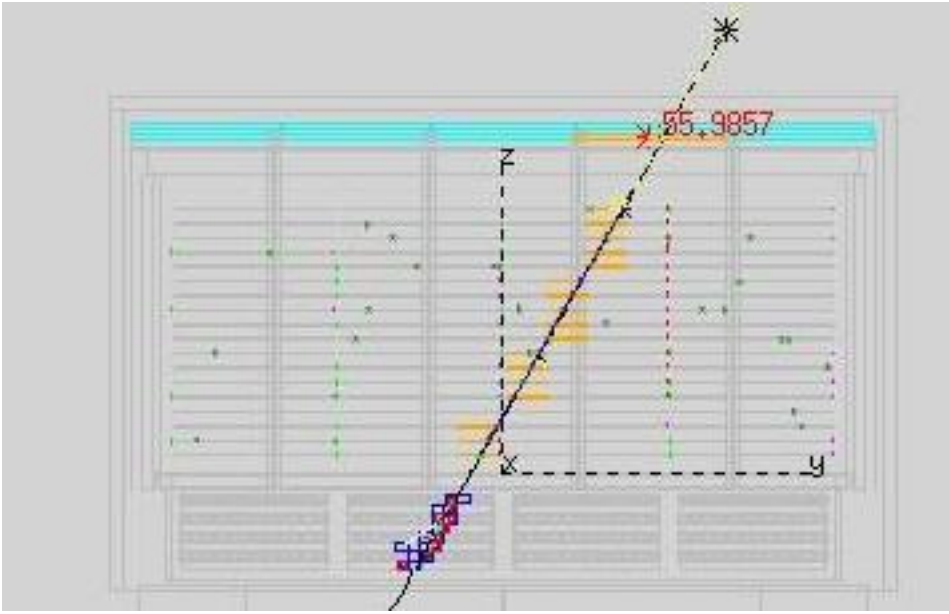
Use of the ionisation energy loss of cosmic-ray heavy ions

C, N, O, Mg, Si, Fe



"minimum-ionisation" peak

Elements of heavy-ion calibration



Source: cosmic rays

ACD: Trigger CNO

Tracker:
- trajectory selection
- identification of reactions
- Z identification (TOT)

Calorimeter:
- ion identification
- rejection of nuclear reactions
- selection & correction for trajectories (angle, hit position)
- feeding histograms, comparison to simulation results and extraction of calibration values

Heavy-ion simulation: where do we stand?

We currently use standalone GEANT4 v6.0 simulations for the GSI analysis.
Needed process: ionisation only.

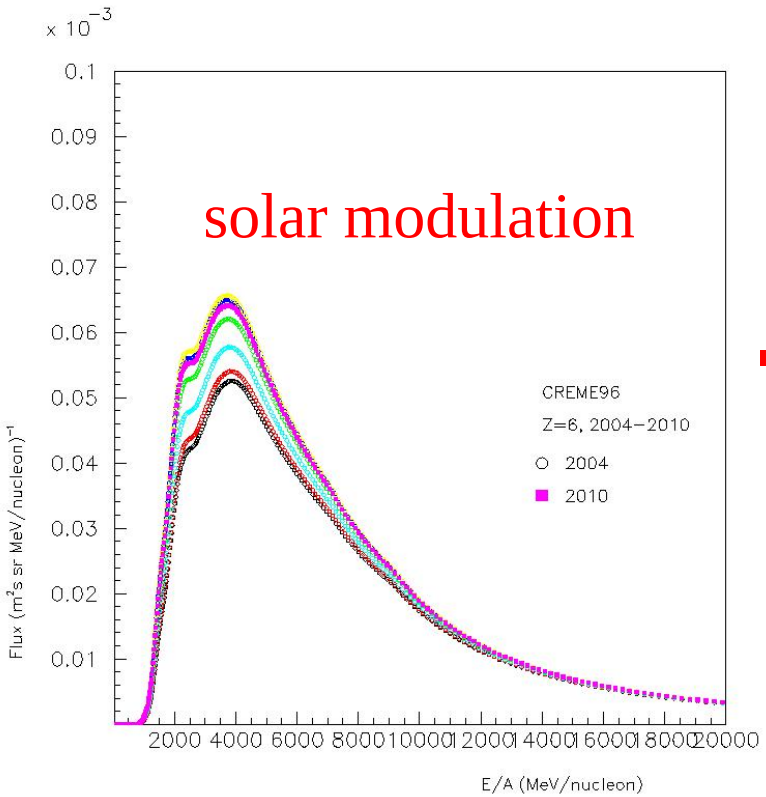
Data allow models of nuclear interaction to be validated (or rejected).
Ex: JQMD

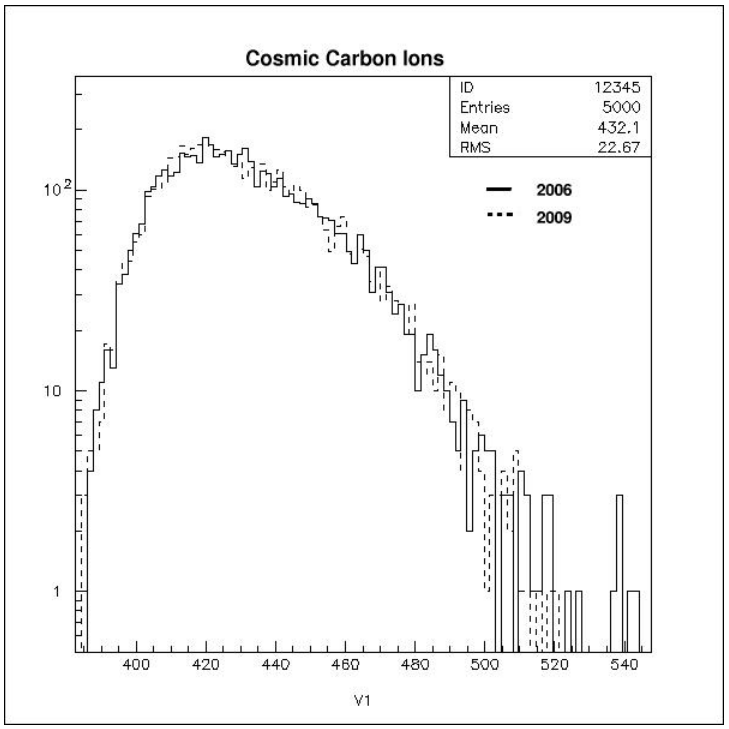
Ultimately, the heavy-ion package must be incorporated into Gleam, included in GlastRelease.

Gleam is currently based on GEANT4 v5.1:
There is a bug in the ionisation energy loss for ions in v5.x:
the ionisation energy loss is OK for primary ions
wrong for secondaries
Observed both in standalone and Gleam simulations.
The problem is fixed in v6.0.

Ion flux & spectrum

CREME 96





no change in resulting spectrum

Definition of valid trajectories

"No edges or glancing hits"

selection of trajectories with tracker /CAL:

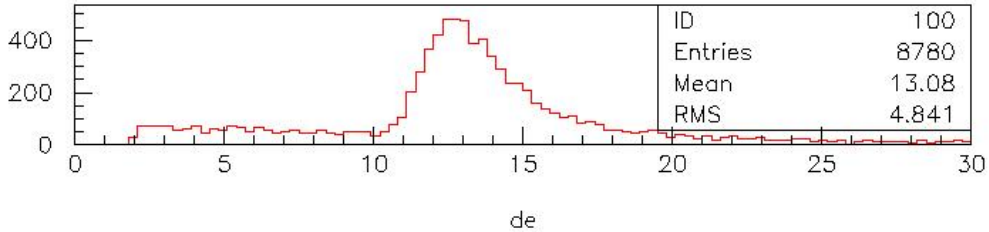
- calculate the entrance-exit points for each layer
- compare these points against the crystals' face coordinates to figure if a crystal boundary was crossed
- deduce the length in each crystal:in principle, some trajectories can be recovered by multiplying Eloss*$l_{nocrossing}$/length with $l_{nocrossing}$ =thickness/cos(theta)
- calculate E=Eloss*cos(theta)
- calculate the closest distance to a face must be greater than 1 mm (delta electrons)
- fill flag-array (0,1,.....) of valid layers

A prototype of this package exists in root format.

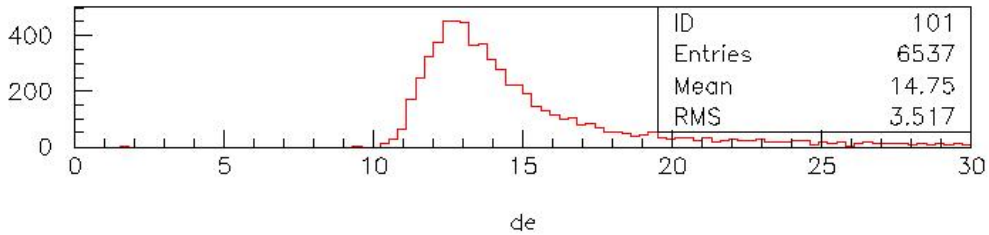
Example: muons

20cmx20cm, θ between 0 and 30°

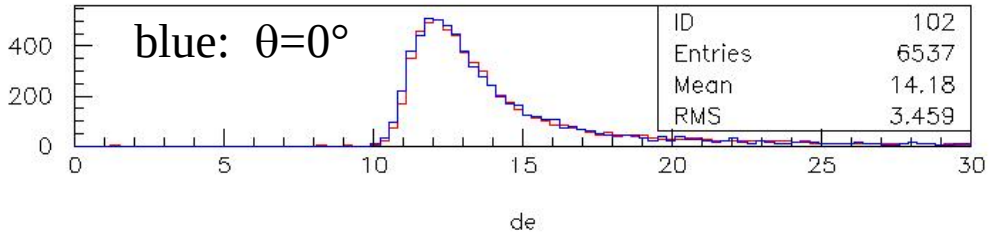
« Raw »



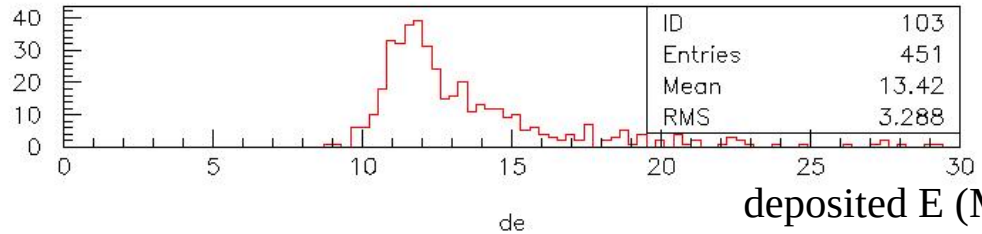
Valid hits



Corrected (cos θ)



« Recovered »



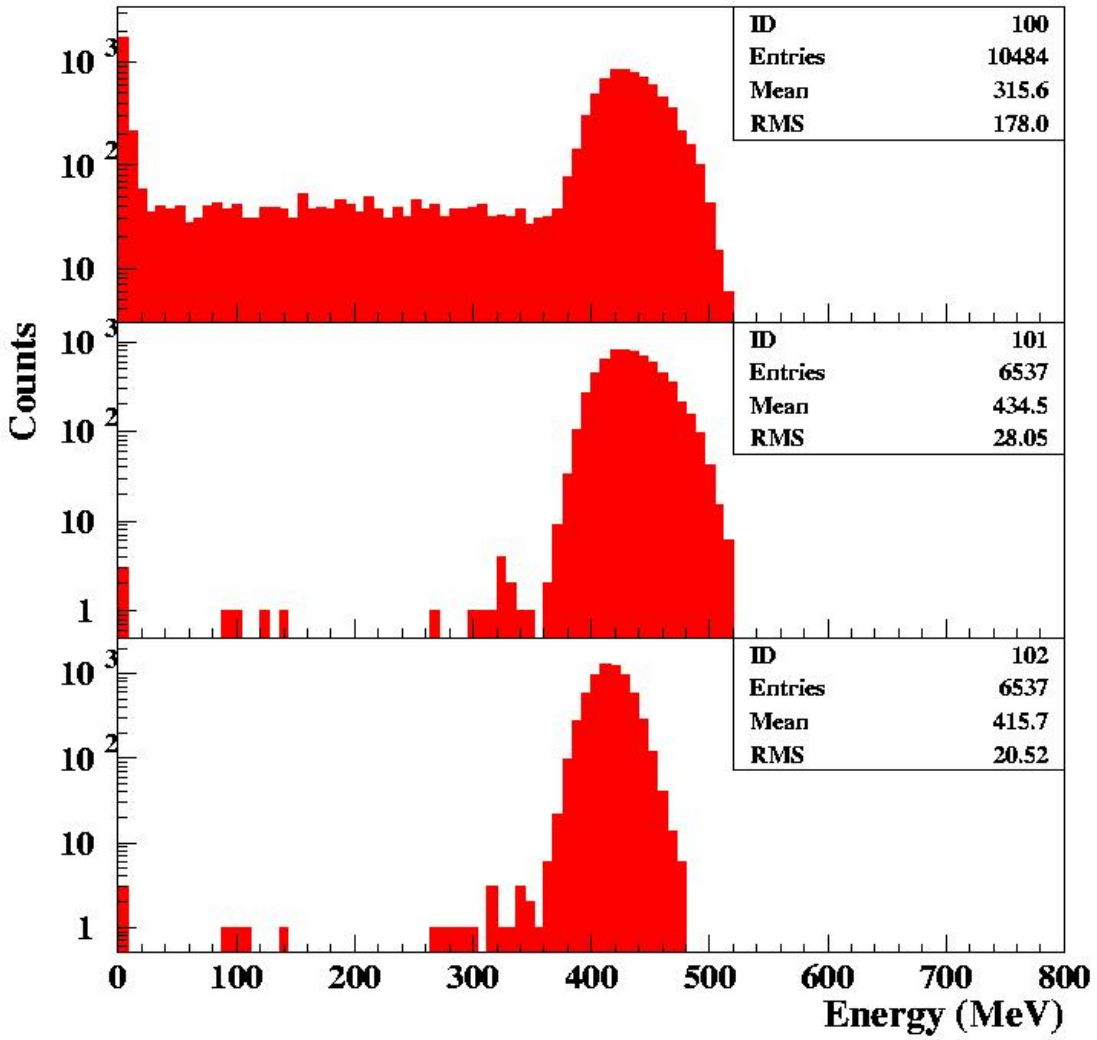
deposited E (MeV)

Example: Carbone

« Raw »

Valid hits

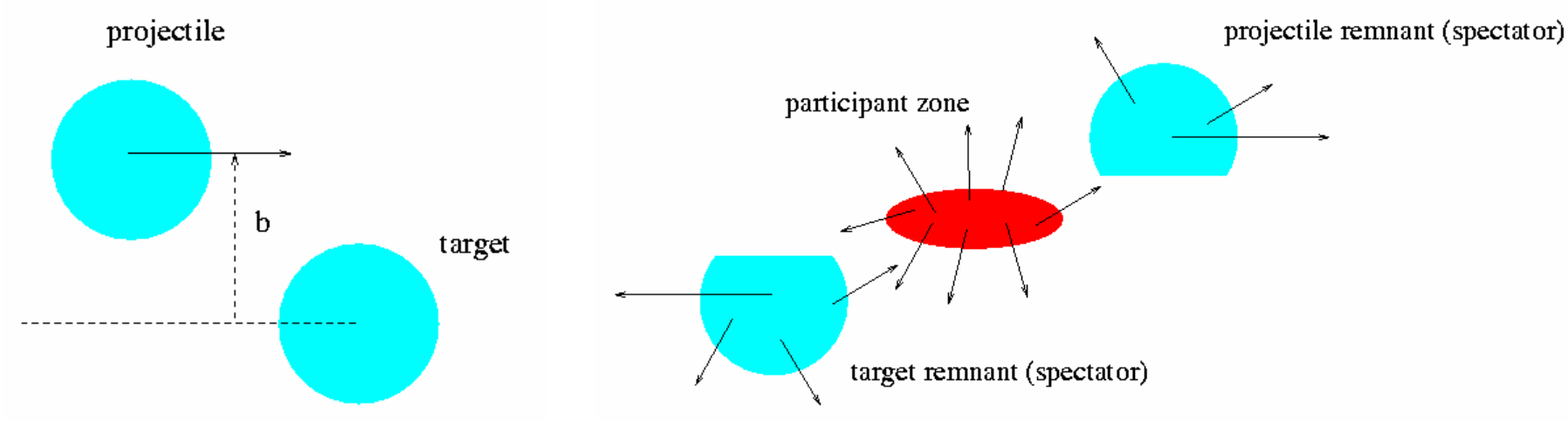
Corrected (cos θ)



20cmx20cm
0° <θ < 30°

V)

Nuclear reactions: simulation



« Central » reactions (high multiplicity of particles, high deposited energy) will be easy to eliminate.
Most annoying in our case are the « gentle » reactions where the ion fragment remains close to the incident ion.

Simulating nuclear reactions properly is much more difficult than simulating EM showers, and requires many fine-tuned parameters (nuclear equation of state, in-medium cross sections, level density parameter, fission widths…)

Blank & Sümmerer

JQMD

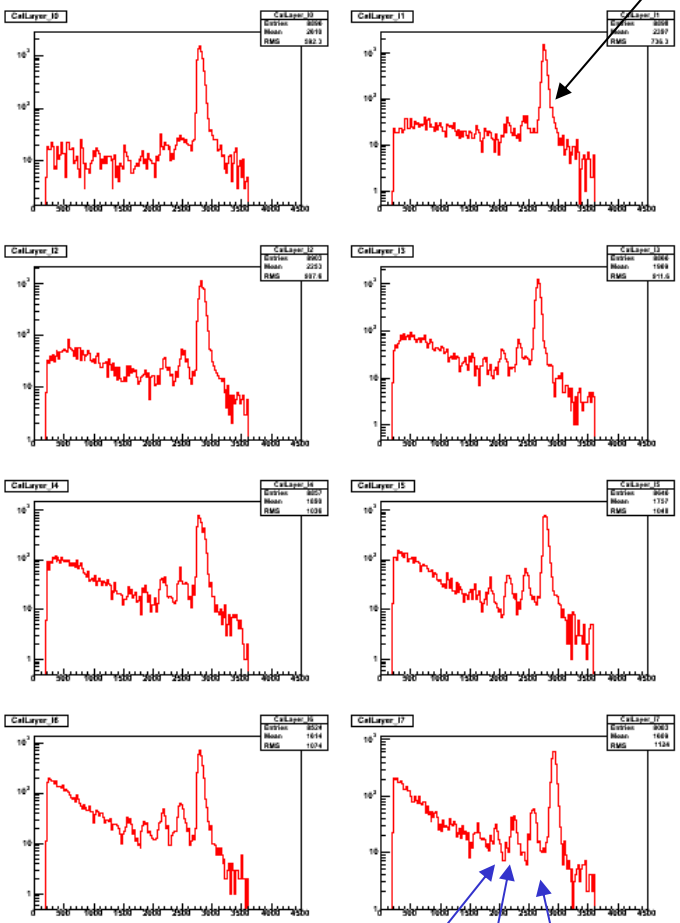
- Stands for Jaeri Quantum Molecular Dynamics
- Kindly provided to us by Tatsumi Koi (SLAC), who wrote an interface to GEANT4
- Limited to 3 GeV/nucleon
- Uses Tripathi total cross sections
- Runs with GEANT4 v6.0
- Deficiencies observed: too much excitation energy in fragments close to incident ion (Z-1,Z-2,Z-3) which decay into lighter fragments. Not easy to fix

Comparison between data and JQMD predictions (Z=14)

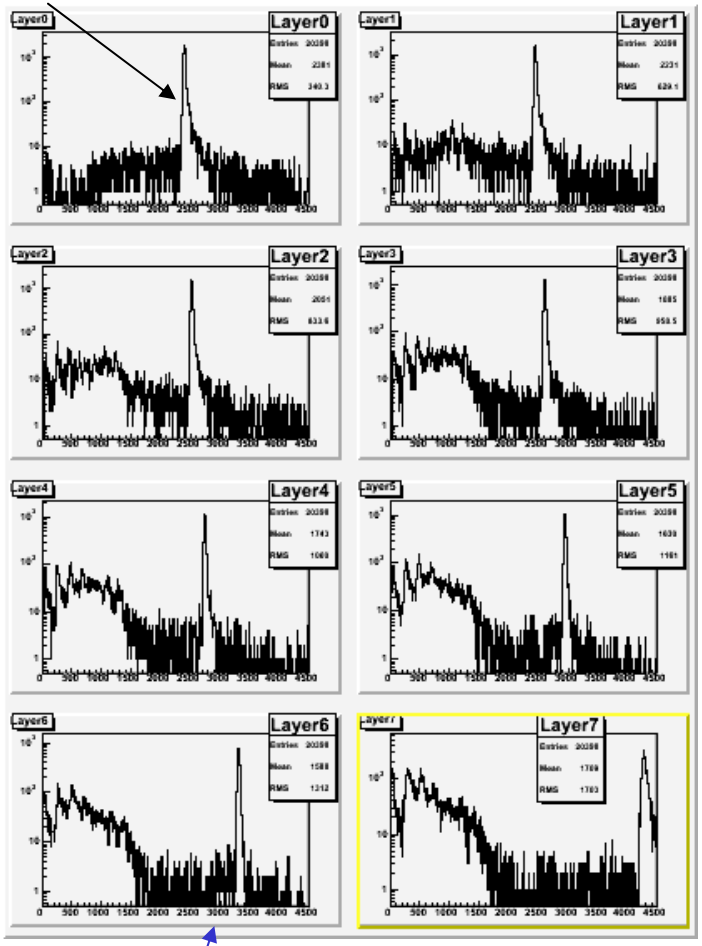
GSI data (1.7 GeV/nucleon)

Ionisation peaks

JQMD (1 GeV/nucleon)



Counts



Energy (MeV)

Energy (MeV)

Charge-changing events: Z=11 Z=12 Z=13

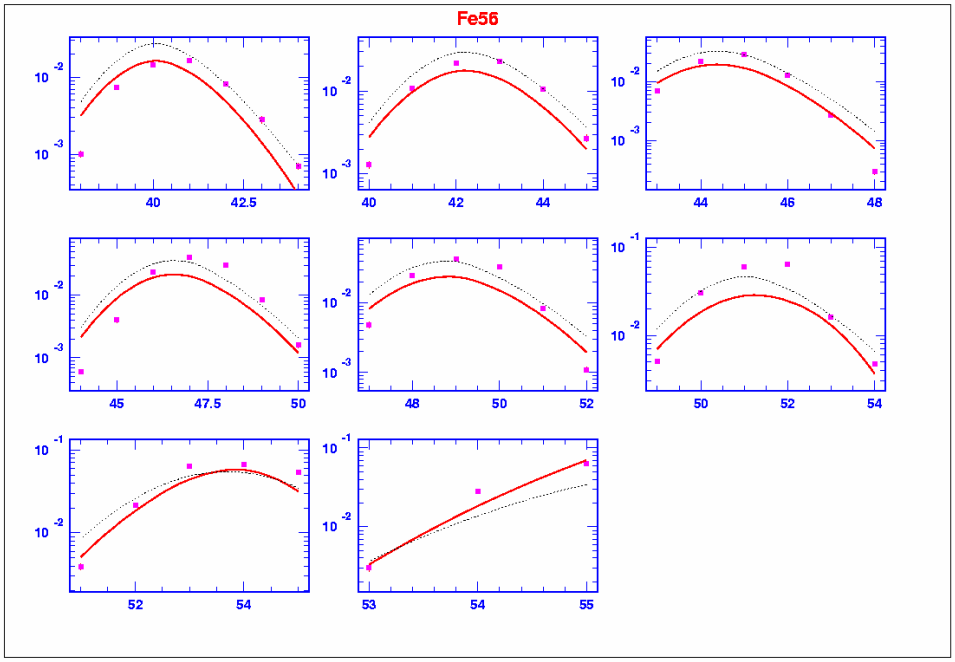
Charge-changing events?

Alternative: EPAX-based phenomelogical model

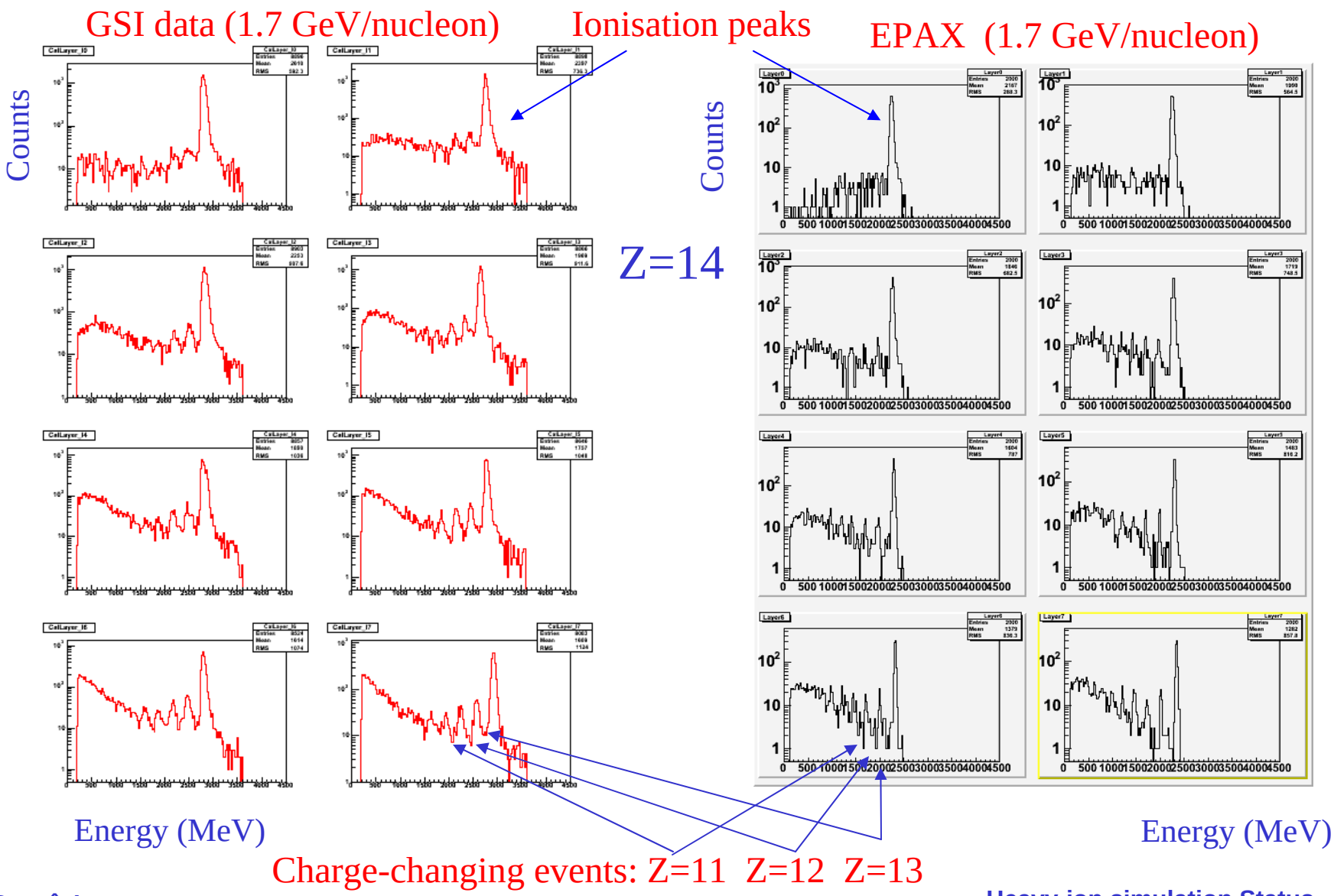
The cross sections are *known* for charge-changing reactions.
Empirical formulae exist: EPAX (Blank & Sümmerer) valid in the « limiting-fragmentation » regime (s independent of Ebomb)

EPAX only considers the projectile, neither the target nor the missing lighter fragments or particles (charged or neutrons).
The number of these particles and their energies can be estimated from the litterature:
N~0.75*(Zproj-Zfinal)

These parameters can be tuned from the GSI data.



EPAX-based phenomelogical model: comparison with data



Future plans

- iterate at least once more with JQMD;

- tune Epax-based model;

- incorporate this model into G4 v6-based Gleam (Tracy Usher has one running);

- code quenching factors;

- incorporate simple versions of different algorithms…

All this can be accomplished by DC2 (?)

Calibration with Heavy Ions

From Eric's presentation at the SAS Software eMeeting Nov.2001

Algoritms

-Physic inputs:

-dE/dx for heavy ions. Code expressions from the literature.

-dL/dE for heavy ions. Measure it than code it. Analytic expr. exist.

- Elements of calibration events

1. Extract multiMIP events.
2. Identify likely GCRs, reject obvious junk
3. Fit tracks.
4. Accept events with clean track through log, no edges or glancing hits.
5. Identify charges.
6. Identify charge-changing interactions.
7. Identify mass-changing interactions.
8. Fit dE/dx
9. Accumulate energy losses and light asymmetries.

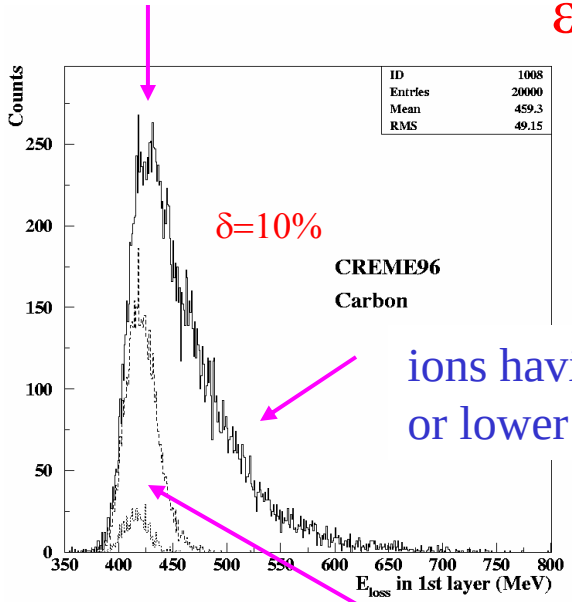
Rejection of high-E tail

- can be done if tail is mainly due to "logarithmic rise" instead of Landau fluctuations
- more effective on Fe than on C

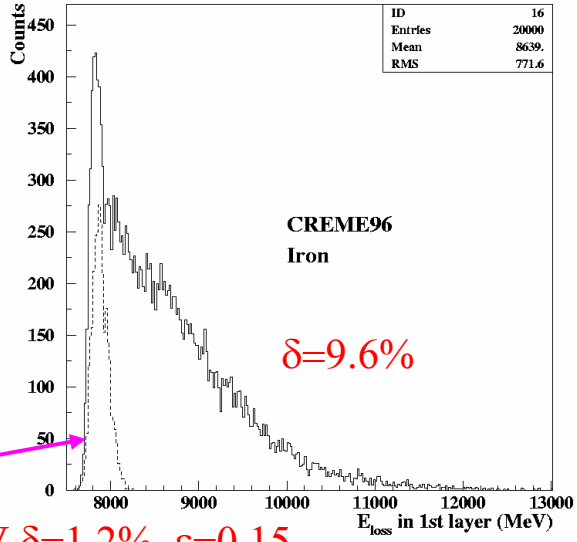
minimum ionizing ions

$\delta \equiv RMS/\langle E_{loss} \rangle$

$\varepsilon \equiv N_{cuts}/N_{tot}$



ions having higher or lower E



Eloss <450 MeV
δ=3.6% ε=0.27

Eloss <8 GeV δ=1.2% ε=0.15

distributions resulting from a cut on Eloss in the 7 other layers

Rejection of high-E tail

C: δ=10% cut at Eloss <450 MeV: δ=3.6% ε=0.27

$\Delta E/E$ <1% 100 evts 13 evts 50 evts total

factor of 100/50= 2 improvement

Fe: δ=9.6% cut at Eloss <8 GeV : δ=1.2% ε=0.15

$\Delta E/E$ <1% 92 evts 1.5 evts 10 evts total

factor of 92/10= 9 improvement

The resulting distributions are more gaussian-like: easily fitted.