Short overview on Fluka calculations

Collimator meeting,
April 17, 2003 CERN

- Total energy loss, including "nuclear" dE/dx
- Why single scattering is necessary and why it takes man and CPU time to implement and run
- What is still required (see Ralph's transparencies): how much time/manpower?

Total energy losses

Problem: calculations based on dE_{ion}/dx underestimates the actual energy loss (GRS rule of thumb: "multiply by two"), even for very thin layers where no buildup takes place.

$$\Delta E_{tot} = \left[dE_{ion\ restr}/dx + \frac{\sigma \rho N_{av}}{P_A} \sum_i E_{rec\ i} \right] dx$$

MonteCarlo finding for 7 TeV p on a 1 cm thick graphite slab:

- Ionization only: $E_{dep} = 3.00 \pm 0.01$ MeV
- Ionization+nuclear: $E_{dep} = 4.40 \pm 0.05$ MeV
- Ion. only at 1 μm from the edge !NO mcs!: $E_{dep} = 2.75 \pm 0.01$ MeV
- Ion.+nucl at 1 μm from the edge !NO mcs!: $E_{dep} = 3.47 \pm 0.03$ MeV

Important numbers

Please note some numbers:

- CSDA range of a few (5) MeV proton in carbon: 4.1×10^{-2} gr/cm^2
- CSDA range of a few (10) MeV alpha particle in carbon: 1.3×10^{-2} gr/cm^2
- CSDA range of few (1) MeV/n Carbon recoils in carbon: 2.1×10^{-3} gr/cm^2
- CSDA range of a 1000 keV electron in carbon: 5.0×10^{-1} gr/cm^2
- CSDA range of a 100 keV electron in carbon: 1.6×10^{-2} gr/cm^2
- CSDA range of a 10 keV electron in carbon: 2.8×10^{-4} gr/cm^2
- CSDA range of a 1 keV (FLUKA limit!) electron in carbon: 1.0×10^{-5} gr/cm^2

but...

- Proton impact parameter for the slow case: $\approx$ 0–3.5 $\times10^{-5}$ gr/cm^2
- Radius of the "bulk" ion column of a charged particle: $\approx$ 1 $\times10^{-5}$ gr/cm^2
- Relevant thickness for secondary electron emission: $\approx$ 5 $\times10^{-7}$ gr/cm^2

Why "single" scattering?

In few words: because multiple scattering is simply WRONG in our "slow" case conditions!

More in detail:

- MCS could be wrong every time the lateral distance to a boundary becomes comparable with lateral displacement in a "condensed history" step or with the mfp for a "single" scattering ($\lambda_{Coul} = 4.5 \times 10^{-5}$ gr/cm^2, $\chi_a = 7 \times 10^{-10}$ rad at 7 TeV on Carbon)
- MCS is wrong *regardless of the step length* every time charged particle fluences across an interface and at grazing angles are of importance (there is a spurious ∞)
- MCS can produce artefacts (even strong ones) every time the incidence is grazing compared with the MCS typical scattering angle
- MCS is completely unsuitable if one wishes to check in some way the possible effect of the surface roughness, ie generating a randomly varied surface at the subμm level
- All the above conditions become much worse for ions

Future work (taken from Ralph list)

Rough manpower estimate (FTE working days no account for CPU time, Blue: already done, Green: feasible within june, Purple: hardly within june, Red: no chance within june, Black: excluded)

Generic cases for material selection:

- (Work up now: 30)
- Slow case: 15 already + 10–15 (no surface roughness)
- Energy deposition in downstream tank and pipe walls: 5–20 depending on accident/slow and geometry complexity
- Ion case (accident+slow): 8 already + 4–8
- Cu doped C: 1
- Carbon-carbon (simple Graphite might be used? Yes if same density): 0–1
- E-cloud, pretty much undefined, even the feasibility: from a *very crude* estimate of > 1 keV electrons to a more complex (still possibly badly wrong) calculation 5--20

Future work (taken from Ralph list): cont.

Checks for background in experiments for three-stage system:

- Showering in tertiary collimators: for collimators only 8
- Tracking of showers through the IP's (IP1, IP5, IP8, IP2) and detectors: geometry till quadrupoles included 20-40, detectors no way
- Evaluation of expected background, false trigger rate: detector duty, at maximum one could provide fluence maps of particles entering the exp. halls

Total AF+VV time available till end of june: 2x45. Other duties:

- nTOF+FIC: 20+2
- ICARUS+CNGS (physics): 5
- CNGS (engineering): 4 or 4
- LCB: 5
- (RF electronics radiation: 10–15 or 10–15)
- Congress (invited talk): 15 (preparation+participation)
- Lectures: 5
- (Installation EET PC cluster: 5–10, 2–5)
- Vacations: none! Contingency: none (unrealistic)!

Total (no parentheses): 56 $\rightarrow$ 34 available