1 history only
5373 collisions
15 particle types
ICODE 102 (PARTICLE DECAY)

PARENT: 13 ($\pi^+$) 0.139569953 GeV decays at rest
DAUGHTERS: EACH 0.00411977619 GeV
as presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by me@marychin.org
as presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by me@marychin.org
Fluka incident beam properties:

- Beam particle: HEAVION Id: -2 (Fluka) 9999 (PDG) Charge: 6 Baryon n.: 12
  - Mass: 11.17 (GeV/c^2) Mean life: 1.0000E+18 (s) Weight: 1.000
- Average beam momentum: 11.415723 (GeV/c)
- Average beam kinetic energy: 4.800000 (GeV)
- Momentum deviation at FWHM (rectangular): 0.0000000 (GeV/c)
- Beam hit position: 0.00000000 0.00000000 0.00000000 cm
- Beam direction cosines: 0.00000000 0.00000000 1.00000000
- Beam spot FWHM X-width (Rectangular): 0.0000 cm
- Beam spot FWHM Y-width (Rectangular): 0.0000 cm
- Beam FWHM angular divergence (Isotropic): ****** (mrad)

(Spatial distribution, polarization, and angular direction and distribution are given in the beam frame of reference)

Beam reference frame (world coordinates):
- Beam X axis: 1.00000000 0.00000000 0.00000000
- Beam Y axis: 0.00000000 1.00000000 0.00000000
- Beam Z axis: 0.00000000 0.00000000 1.00000000

The nominal beam position belongs to region: 3(RSEA), lattice cell: 00

Heavy ion beam requested, properties:

- Mass number of the projectile: 12
- Charge number of the projectile: 6
- Isomer number of the projectile: 0
- Laboratory momentum of the projectile: 0.9513 (GeV/c/amu)
- Laboratory kin. energy of the projectile: 0.4000 (GeV/amu)
- Laboratory tot. energy of the projectile: 1.331 (GeV/amu)

**COLLISION TAPE**

Source particle(s), n. of: 1
- Part.id.: -30 Tot.en.: 15.9748669 Weight: 1.
  - Position: 0.0 0.0 0.0

400 MeV/A 12C source starts here

As presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by m@marychin.org
SO MANY NEUTRONS
where do they come from?

<table>
<thead>
<tr>
<th>count</th>
<th>icode</th>
<th>parent</th>
<th>siblings</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>101</td>
<td>$^{12}\text{C} + ^{40}\text{Ca}$</td>
<td>$^{24}_{12}\text{Mg} + ^{4}_2\text{He} + ^{2}_1\text{H} + ^{1}_1\text{p} + 13\text{n} + 2\pi^+ + 2\gamma$</td>
</tr>
<tr>
<td>5</td>
<td>101</td>
<td>$\text{p}$</td>
<td>$\text{n+p}$ $\text{n+3p+3}\gamma$ $\text{n+3p}$ $\text{2n+2p+}\gamma$</td>
</tr>
<tr>
<td>3</td>
<td>101</td>
<td>$\pi^-$</td>
<td>$\text{p+3n+4}\gamma$</td>
</tr>
</tbody>
</table>
| 103   | 101   | $\text{n}$ | 2 to 12 siblings
many $x_1\text{n}+x_2\text{p}+x_3\gamma$
$2\text{p}+4\text{n}+2\gamma+^{2}\text{H}$
$3\text{n}+3\text{p}+2\gamma+\pi^-+^{2}\text{H}+^{3}\text{He}+2\alpha$ |
| 3998  | 100, 101 or 300 | $\text{n}$ | solo |
instead of the usual \( N_p, K_{part}, T_{ki} \)

```fortran
IF (ICODE.EQ.101 .AND. JTRACK.EQ.-2 .AND. npheav.GT.0) THEN
  DO I=1,npheav
    WRITE(IODRAW) NCASE,SNGL(ETRACK),SNGL(PTRACK),
                  npheav, kheavy(I),
                  ibheav(kheavy(I)), icheav(kheavy(I)),
                  SNGL(tkheav(I)), SNGL(pheavy(I))
  END DO
END IF
```

### Table: Heavy Ion Interaction

<table>
<thead>
<tr>
<th>count</th>
<th>icode</th>
<th>parent</th>
<th>siblings</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>101</td>
<td>(^{12}\text{C} + ^{40}\text{Ca})</td>
<td>(^{24}\text{Mg} + ^{4}\text{He} + ^{2}\text{H} + ^{9}\text{p} + 13n + 2\pi^+ + 2\gamma)</td>
</tr>
<tr>
<td>5</td>
<td>101</td>
<td>p</td>
<td>n+p, n+3p+3(\gamma), n+3p, 2n+2p+(\gamma)</td>
</tr>
<tr>
<td>3</td>
<td>101</td>
<td>(\pi^-)</td>
<td>p+3n+4(\gamma)</td>
</tr>
<tr>
<td>103</td>
<td>101</td>
<td>n</td>
<td>2 to 12 siblings, many (x_1n + x_2p + x_3\gamma), 2p+4n+2(\gamma)+^2\text{H})</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3n+3p+2(\gamma)+(\pi^-)+^2\text{H}+^3\text{He}+2\alpha</td>
</tr>
<tr>
<td>3998</td>
<td>100, 101 or 300</td>
<td>n</td>
<td>solo</td>
</tr>
</tbody>
</table>

HEAVY ION INTERACTION
\[(n,3n+3p+2\gamma+\pi^-+^2H+^3He+2\alpha)\]

\[ETRACK (GeV) \quad ICODE\]

\begin{tabular}{|c|c|c|}
\hline
\(\pi^-,\pi^-\) & 1.63923711e-01 & 100 [elastic interaction] \\
\(\pi^-,p+3n+4\gamma\) & 1.39570951e-01 & 101 [inelastic interaction] \\
\hline
\end{tabular}

Tki=3.17791216e-02 GeV
6 steps in
7.34588257e-09 s
8 steps in 1.9292605e-10 s

\[
\begin{align*}
12^6 C + 40^20 Ca &\rightarrow 24^{12}Mg + 4^2He + 2^1H + 9^1p + 13^0n + 2\pi^+ + 2\gamma \\
\end{align*}
\]
$^{12}\text{C} + ^{40}\text{Ca} \rightarrow ^{24}\text{Mg} + ^{4}\text{He} + ^{2}\text{H} + ^{9}\text{Li} + ^{1}\text{p} + 13_0^1n + 2\pi^+ + 2\gamma$
PROTONS

<table>
<thead>
<tr>
<th>Tki (GeV)</th>
<th>next step</th>
<th>icode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.85969377e-01</td>
<td>(p,2n+2p+γ)</td>
<td>101</td>
</tr>
<tr>
<td>7.94009790e-02</td>
<td>(p,n+3p)</td>
<td>101</td>
</tr>
<tr>
<td>6.70373663e-02</td>
<td>10 steps to cutoff</td>
<td></td>
</tr>
<tr>
<td>3.0097659e-03</td>
<td>1 step to cutoff</td>
<td></td>
</tr>
<tr>
<td>2.87470937e-01</td>
<td>(p,n+3p+3γ)</td>
<td>101</td>
</tr>
<tr>
<td>1.83140948e-01</td>
<td>(p,np)</td>
<td>101</td>
</tr>
<tr>
<td>9.14871842e-02</td>
<td>11 steps to cutoff</td>
<td></td>
</tr>
<tr>
<td>1.23939060e-01</td>
<td>13 steps to cutoff</td>
<td></td>
</tr>
<tr>
<td>5.24589885e-03</td>
<td>1 step to cutoff</td>
<td></td>
</tr>
</tbody>
</table>

CUTOFF (GeV)
1.00000000e-02

@cutoffs: ETRACK = 9.38272297e-01 GeV

\[ ^{12}\text{C} + ^{40}\text{Ca} \rightarrow ^{24}\text{Mg} + ^{4}\text{He} + ^{2}\text{H} + ^{9}_{1}\text{p} + 13_{0}n + 2\pi^{+} + 2\gamma \]
<table>
<thead>
<tr>
<th>Tk'i (GeV)</th>
<th>fate</th>
<th>icode</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.08318811e-01</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>2.59359460e-03</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>1.59814935e-02</td>
<td>4 steps to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>3.70376068e-03</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>1.80191698e-03</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>2.15159506e-02</td>
<td>4 steps to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>1.03988886e-01</td>
<td>6 steps to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>3.61582404e-03</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>1.02260048e-02</td>
<td>2 steps to cutoff</td>
<td>101</td>
</tr>
</tbody>
</table>

2nd generation of protons

<table>
<thead>
<tr>
<th>Tk'i (GeV)</th>
<th>fate</th>
<th>icode</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.85969377e-01</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
<tr>
<td>7.94009790e-02</td>
<td>(p,2n-2p+γ)</td>
<td>101</td>
</tr>
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<td>6.70373663e-02</td>
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<td>10 steps to cutoff</td>
<td>101</td>
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<tr>
<td>2.87470937e-01</td>
<td>(p,n+3p+3γ)</td>
<td>101</td>
</tr>
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<td>1.83140948e-01</td>
<td>(p,np)</td>
<td>101</td>
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<tr>
<td>9.14871842e-02</td>
<td>11 steps to cutoff</td>
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<td>101</td>
</tr>
<tr>
<td>5.24589885e-03</td>
<td>1 step to cutoff</td>
<td>101</td>
</tr>
</tbody>
</table>

CUTOFF (GeV)

1.00000000e-02

@cutoffs: ETRACK = 9.38272297e-01 GeV

as presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by me@marychin.org
4.0526269e-03 GeV γ travels 2.3 cm

4.9829512e-4 γ travels 14 cm

Compton after 14 cm

Compton pair production

Compton positron annihilation at rest

\[ ^{12}_6 \text{C} + ^{40}_2 \text{Ca} \rightarrow ^{24}_2 \text{Mg} + ^4_2 \text{He} + ^2_1 \text{H} + 9^1_p + 13^1_n + 2\pi^+ + 2\gamma \]
11 steps to ICODE 102

[particle decay]

Etrack=1.39569953e-01 GeV
decay at rest: ETRACK=m_0
age=6.70014799e-08 s

\[ \pi^+ + 4.62922305e-02 \text{ GeV} \]

\[ \mu^+ + 4.11977619e-03 \text{ GeV} \]

\[ \nu_\mu 2.97917854e-02 \text{ GeV} \]

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\[ \pi^+ \quad 4.62922305 \times 10^{-2} \text{ GeV} \]

Number of decay products produced per beam particle:

<table>
<thead>
<tr>
<th>Prompt radiation</th>
<th>Radioactive decays</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2000E+01 (100%)</td>
<td>0.0000E+00 (100%)</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) POSITRON</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) NEUTRIE</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) PHOTON</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) MUON+</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) NEUTRIM</td>
</tr>
<tr>
<td>2.0000E+00 (16.7%)</td>
<td>0.0000E+00 ( 0.0%) ANEUTRIM</td>
</tr>
</tbody>
</table>

as presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by me@marychin.org
π+
4.62922305e-02 GeV

Number of particles decayed per beam particle:

<table>
<thead>
<tr>
<th>Prompt radiation</th>
<th>Radioactive decays</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0000E+00 (100.%)</td>
<td>0.0000E+00 (100.%)</td>
</tr>
<tr>
<td>2.0000E+00 (40.0%)</td>
<td>0.0000E+00 (0.0%)</td>
</tr>
<tr>
<td>2.0000E+00 (40.0%)</td>
<td>0.0000E+00 (0.0%)</td>
</tr>
<tr>
<td>1.0000E+00 (20.0%)</td>
<td>0.0000E+00 (0.0%)</td>
</tr>
</tbody>
</table>

$^{12}C + ^{40}Ca \rightarrow ^{24}Mg + ^{4}He + ^{2}H + ^{1}p + ^{1}n + 2^{0}n + 2\pi^+ + 2\gamma$ 

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11 steps to icode 102

[particle decay]

ETRACK=1.39569953e-01 GeV

age =4.77300999e-9 s

\[π^+ + 7.92727247e-02 GeV \rightarrow \text{EM shower} + e^- + e^- + \nu_\mu + \bar{\nu}_\mu + 4.11977619e-03 GeV + 2.97917854e-02 GeV\]

positron bremsstrahlung followed by pair production

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11 steps to icode 102
[particle decay]

ETRACK = 1.39569953e-01 GeV
age = 4.77300999e-9 s

EXACTLY IDENTICAL TO THE OTHER π+
because this is a decay at-rest.

ETRACK = m_0

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recoil, elastic
recoil, inelastic
local energy deposition
below threshold
target recoil

as presented at the 1st FLUKA Advanced Course & Workshop 2010 (Ericeira) by me@marychin.org
Dear Contributor,

we are happy to announce you that on the basis of the abstract you submitted we allocated a 30min slot for your presentation (including 8min of discussion) in the program of the workshop taking place along with the 1st FLUKA advanced course.

We would like to point out that special emphasis should be given to:
- the technical implementation of the simulation carried out;
- the evaluation of main sources of uncertainties;
- comparison with experimental outcome when available;
- possible open points for further discussion;

The presentation should be intended in a didactive style more than as a conference talk.

Looking forward seeing you in Portugal

The FLUKA course team
THIS HISTORY
(in no way representative)
IN THE CONTEXT OF
THE OTHER HISTORIES
12C steps before absorption / collision

the history in here