KANE: a simulation tool for TAPS user manual

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1 Introduction

In this document we describe Kane, a software package designed to study the TAPS response to various kind of particles, for various kind of geometries.
Kane rely on GEANT3 for the simulation of the detectors (geometry definition and tracking of particles). Input events and generation of outputs compatible with experiment outputs are home made.
Rather than a description of how Kane is programmed, this document is meant to give some keys to use it properly.

2 What can Kane do for you ?

2.1 Implementation of TAPS geometry

In this section we recall basics about the detector.
TAPS (Two Arms Photon Spectrometer) is divided into blocks. Each block consists of an array of 8x8 modules (Ganil 19 pack and super-cluster geometries - which are not based on 64-modules blocks- are not yet implemented in Kane). Each module is the assembly of a Charged Particle Veto (CPV), light guides (and their phototubes) and one BaF_2crystal.
The CPV has a hexagonal shape, is 4 mm thick and is made out of a plastic scintillator NE102.
The light guides have a rectangular shape, are 4 mm thick and are made out of lucite (NE102 in Kane). Note that, depending on its position in the block, a module can be masked by 0,1,2 or 3 light guide(s) (see figure1).
The BaF_2 module is divided in two parts: the front part (first seen by particle coming from the target) has a hexagonal shape and is 225 mm thick, whereas the back part is a cylinder (25 mm thick) with the same section as the phototube (see figure 2).

Figure 1: Detailled view of one TAPS block

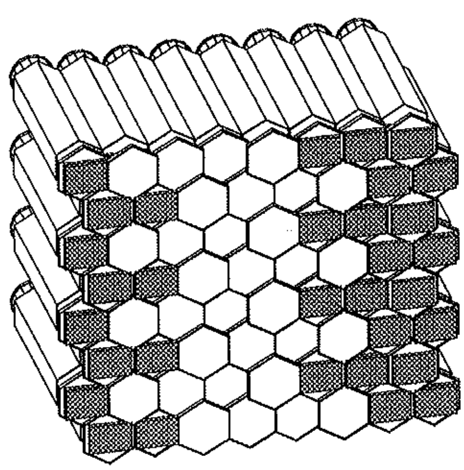


Table 1: Description of the different TAPS configurations

Configuration name	GANIL	GSI	KVI96P	KVI96S
# of blocks	5	6	6	6
Distance from target (cm)	65.2,64.5, 62.1,61.3,60.0	80	66	60
θ block (degree)	-64.58,-108.55, 147.89,101.82, 50.89	70,-70	71,112.5, 154,-71, -112.5,-154	55,100,145, -55,-100,-145
ϕ block (degree)	0	39.6,0,-39.6	0	0
Other detectors	none	Start Detector KAOS Forwar Wall	none	Dwarf Ball, KVI Forward Wall
Misc.		beam tube	reaction chamber	reaction chamber

Notes:

1. We have included details such as the wrapping materials (teflon+black tape, PVC in Kane, 1 mm thick) of the modules.

2. Nevertheless, light guides are not exactly as in the real detector, in order to simplify their positionning.

2.2 Event generation

With the event generation we do not want to mean that Kane is able to generate particles from a collision of two nuclei, but rather that Kane is able to generate the proper particles in the proper way to allow to study what we want. Tricky sentence, isn't it ?
We are essentially interested in photons, neutral pions and eta mesons. Nevertheless, we have recently improve the capability of Kane to study the response to charged particles. For that purpose, we have simply extended Kane to generate all kind of particles that GEANT can handle.

2.2.1 Generation of singles.

By singles we mean that Kane generates one particle per event. Kane can generate single particles in three different ways:

1. For photons, neutral pions and eta mesons, for which a systematics exists, energy and angular distributions reproduce the experimental ones.

2. For all the particles (including photons, neutral pions and eta mesons) Kane can generate white spectra with user defined boundaries.

3. For all the particles, energy and angular distributions can be extracted from user-given histograms.

White spectra

White energy (either in laboratory or in center of mass) and angular spectra. The user has to define the energy boundaries (E_{min}, E_{max}) and angular boundaries (θ_{min}, θ_{max}, ϕ_{min} and ϕ_{max}). See figure 3 for the reference system used. The 4-vector momentum is then deduced by:

$$\vec{p} = \begin{pmatrix} \sqrt{E^2 - m^2}\cos\phi\sin\theta \\ \sqrt{E^2 - m^2}\sin\phi \\ \sqrt{E^2 - m^2}\cos\phi\sin\theta \end{pmatrix}$$

A Lorentz transformation is then applied if momentum has been calculated in the center of mass. Note that E is randomly distributed between E_{min} and E_{max}, $\sin\phi$ is randomly distributed between $\sin\phi_{min}$ and $\sin\phi_{max}$, and θ is randomly distributed between θ_{min} and θ_{max}.

Related data cards : TPAR, PROD(= 1), PORI(= 0), GENE(= 1,4), KEMM, PHMM, THMM

White transverse momentum and rapidity spectra The user has to define the transverse momemtum boundaries (p_{tmin},p_{tmax}) and the rapidity boundaries (y_{min}, y_{max}). The momentum is then deduced by:

$$\begin{aligned} p_{\|} &= \sqrt{p_t^2 + m^2}\sinh(y) \\ p &= \sqrt{p_t^2 + p_{\|}^2} \\ \vec{p} &= \begin{pmatrix} p_t\cos\phi \\ p_t\sin\phi \\ p_{\|} \end{pmatrix} \end{aligned}$$

Note that p_t is randomly distributed between p_{tmin} and p_{tmax}, y is randomly distributed between y_{min} and y_{max}, and ϕ is randomly distributed between ϕ_{min} and ϕ_{max} *(it is strongly recommended to choose $\phi_{min} = 0$ and $\phi_{max} = 360$)*

Related data cards : TPAR, PROD(= 1), PORI(= 0), GENE(= 2), PTMM, YMM, PHMM

White transverse mass and rapidity spectra The user has to define the transverse mass boundaries and the rapidity boundaries. Momentum is then deduced by formulas similar to the previous ones.

Related data cards: TPAR, PROD(= 1), PORI(= 0), GENE(= 3), MTMM, YMM, PHMM

Related data card: PROD(= 5)

2.3 CPU time usage considerations

As GEANT simulations are quite long calculations, an effort has been put on speeding up Kane. To do so, we do not track particles that have no chance to reach a TAPS block.
In the Kane initialisation phase, we fill a 2D histogram (θ, ϕ) of the spatial occupation of the TAPS blocks. Then, when a particle is generated, two cases are to be considered (which give different results depending on the value of the data card COIN):

1. The particle is stable. We check its direction (θ, ϕ). If it is in the filled part of the 2D histogram (or if COIN=-1), this particle is tracked.
2. The particle can decay. When the particle decays, we check if the (θ, ϕ) of the decay products are in the 2D histogram. Depending on the value of the data card COIN (see 3.2), these decay products are tracked or not.

This accelerating technique is really worthwhile when one considers many particles or particles for which the TAPS efficiency is very low.

3 What do you have to do for Kane ?

Kane needs (at least) two external input files to run properly : a filenames data file and a simulation data file. The first one gives the names of all the files used by Kane (on input and on output), and the second one gives information about the simulation to be performed.

3.1 Filenames data file

This file must have the following structure:

One line of 10 numbers, indicating the Kane reserved logical units.
By now, only 9, 77 and 88 are forbidden logical units.

Two times twenty lines of file description, with the following format:

```
NO CHIO LUN CHNAME CHEXT CHSTATUS
```

where :

```
2 'OUT' 040 'SIM_FILE'     'LOG'    ' ' ! Log file
        .
        .
5 'OUT' 041 'OUTPUT'      'HBOOK' 'N' ! Detectors Ntuple
```

3.2 Simulation data file

This file is the most important one, for it indicates what Kane has to do. Its format is the one of a standard GEANT data card file, e.g.:

```
CARD [value1 value2  value3 ...]
```

3.2.1 What cards must be changed ?

In this section we will show how to write a simulation data file. The easiest way to do this is to copy the file KANE_DEF_SIM.DAT to YOUR_SIMULATION_FILE.DAT. Then just change the cards to suit your objectives. The simulation data file cards can be classified as follows:

geometry the 3 cards RPOS,TPOS,PPOS define the positions of the TAPS blocks;

reaction the 3 cards ENER, AFZF, ACZC define the reaction studied (these informations are used only in the case of events computed from the systematics); the card IMPA defines the impact parameter range (used only for FREESCO events);

event generator the cards PROD and GENE define the kind of generator ; KEMM defines the range in energy, PTMM the range in transverse momentum, MTMM the range in transverse mass, THMM the range in theta angle, PHMM the range in phi angle, YMM the range in rapidity; the card TPAR defines the type of particle to generate; the card PORI defines the particle's origin (Kane, external histogram or external Ntuple);

systematics the 3 cards GAMA, PION, ETA define a few parameters for the generation of photons, neutral pions or eta from the systematics;

```
( (CPV flag) AND (CFD flag) AND (LEDi flag) ) = TRUE
```

Please note that LED1 and LED2 can not be used both at the same time.

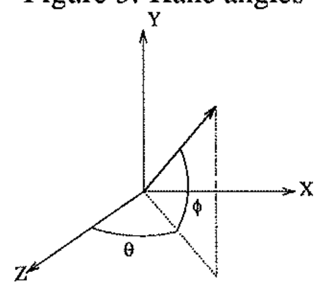
3.2.2 List of the cards understood by Kane

In the following, the parameters of the different cards are labelled Nx for integer ones, and Xx for real ones. No character parameter is allowed !

geometry

Card	*Parameter*	*Meaning*
RPOS	XR_i	TAPS blocks distance from target (in cm)
TPOS	$X\theta_i$	TAPS blocks θ (in degree) (see figure 3)
PPOS	$X\phi_i$	TAPS blocks ϕ (in degree) (see figure 3)

Figure 3: Kane angles



$$-180 \leq \theta \leq 180 \text{ and } -90 \leq \phi \leq 90$$

reaction

ENER	XE	Beam energy in MeV/A
AFZF	NA | NZ	Beam A and Z
ACZC	NA | NZ	Target A and Z
IMPA	Xb	Impact parameter for FREESCO (in fm) b<0: random impact parameter $\in [0, b_{max}]$ b>0: fixed impact parameter

event generator

GAMA	XS | XP | XA	Probability, Slope (in MeV), and Anisotropy for photon (by now, XP is not used)(GENE=0,TPAR=1)
PION	XS | XP	Probability, Slope (in MeV) for neutral pions (same note for XP as GAMA) (GENE=0,TPAR=7)
ETA	XS | XP	Proba., Slope (in MeV) for etas (see GAMA for XP) (GENE=0,TPAR=17)

thresholds and related

Card	*Parameter(s)*	*Meaning*
PHTG	NT	TOF gate (in ns)(default value is 2000)
CFD	XT | XU | XC	T is CFD threshold, U=0 or 1 indicates
		if CFD is used, C=0,1 indicates the condition
LED1	"	"
LED2	"	"
CPV	"	"
DEGR	XP	Energy degradation factor (in %)

Please note that data card DEGR is not yet used.

triggers

STHR	Start detection threshold (MeV)(real)
BTHR	Dwarf Ball detection threshold (MeV) (real)
FTHR	Forward Wall (either GSI or KVI one) detection threshold (MeV)(real)
TTRI	TAPS trigger (see below)
STRI	START trigger (see below)
FTRI	Forward Wall trigger (same use as STRI)
BTRI	Dwarf Ball trigger (same use as STRI)
BMUL	Dwarf Ball multiplicty (for BTRI=1 only)
FMUL	Forward Wall multiplicity (for FTRI=1 only)
SMUL	Start multiplicity (for STRI=1 only)
TMUL	TAPS multiplicity (for TTRI=1 only)
COIN	Coincidence card (see previous section)(-1,0 or 1)

IMPORTANT WARNING

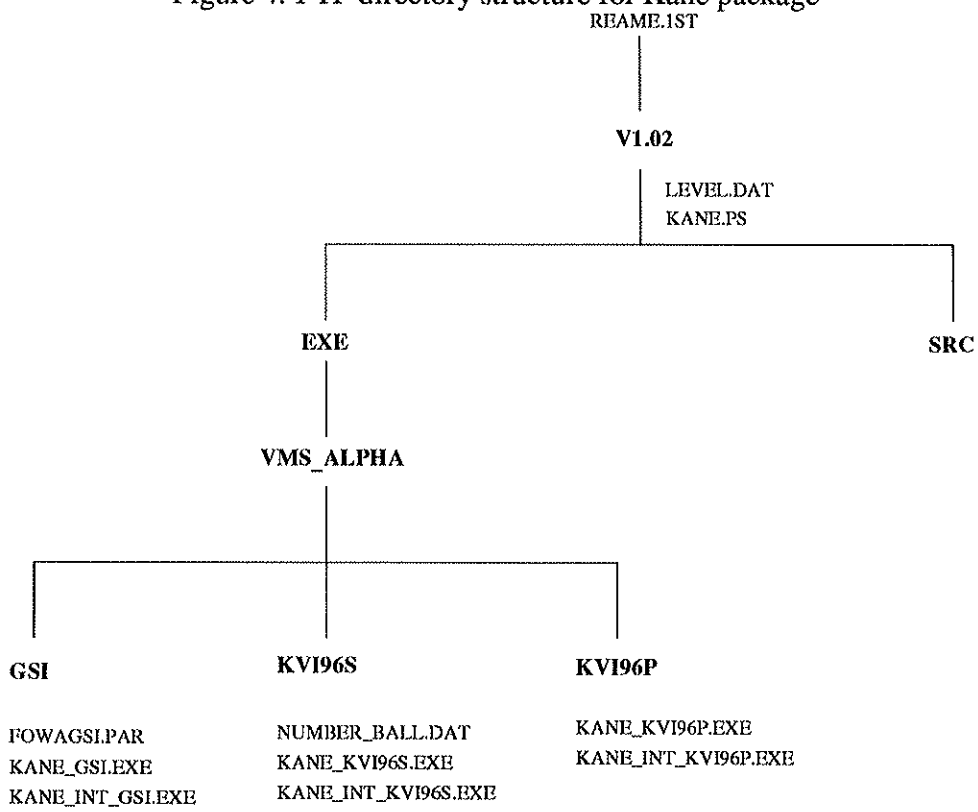
By now, almost no verification is made about the values of the data cards. That is to say that the philosophy of Kane is: ***User knows what he does.***

4 How to run Kane

4.1 How to install it

Required machine configuration : AXP station under VMS (no Unix support so far).
Just ftp at the TAPS account at GSI (e.g. axp627.gsi.de), or via anonymous ftp at GANAC4.IN2P3.FR, and get the files you need from the X subdirectory, where X is the name of the configuration you want to use (GSI,KVI96S,KVI96P) (see figure 4)

Figure 4: FTP directory structure for Kane package



The file README.1ST, as you might guess, must be read first, for it contains the latest news about Kane. The file LEVEL.DAT is used by FREESCO. FOWAGSI.PAR and NUMBER_BALL.DAT are geometry related files for the GSI Forward Wall and the Dwarf Ball, respectively. The file KANE_X.EXE is the executable for the version X, and KANE_INT_X.EXE is the interactive

Block	Variables	Config.
KINE	KINE_CWN_MUL[0,500]:I*4 KINE_CWN_IPART(KINE_CWN_MUL):I*4 KINE_CWN_ENE(KINE_CWN_MUL):R*4 KINE_CWN_PX(KINE_CWN_MUL):R*4 KINE_CWN_PY(KINE_CWN_MUL):R*4 KINE_CWN_PZ(KINE_CWN_MUL):R*4	
TAPS	TAPS_MUL[0,number_of_taps_modules]:I*4 TAPS_DET(TAPS_MUL):I*4 TAPS_EW(TAPS_MUL):R*4 TAPS_EN(TAPS_MUL):R*4 TAPS_TOF(TAPS_MUL):R*4 TAPS_EVETO(TAPS_MUL):R*4 TAPS_PVT(TAPS_MUL):I*4	KVI96S,KVI96P
START	START_MUL[0,32]:I*4 START_DET(START_MUL):I*4 START_ENE(START_MUL):R*4 START_TOF(START_MUL):R*4	GSI
FOWA	FOWA_MUL[0,92]:I*4 FOWA_DET(FOWA_MUL):I*4 FOWA_E(FOWA_MUL):R*4 FOWA_DE(FOWA_MUL):R*4 FOWA_TOF(FOWA_MUL):R*4	KVI96S,GSI KVI96S,GSI KVI96S,GSI KVI96S KVI96S,GSI
BALL	BALL_MUL[0,72]:I*4 BALL_DET(BALL_MUL):I*4 BALL_E(BALL_MUL):R*4 BALL_DE(BALL_MUL):R*4	KVI96S

- `xxx_MUL` is the multiplicity of the event;
- `xxx_DET()` is the number of the hit detectors;
- `xxx_TOF()` is the time of flight for the hit detectors;
- `xxx_DE()` is the energy loss in thin detectors;
- `xxx_E()` is the energy loss in detectors;
- `TAPS_EW()` is the integration of the energy deposited in BaF_2 over a wide time gate (controlled in Kane by the data card `PHTG`);
- `TAPS_EN()` is the integration of energy over a narrow time gate (in Kane EW=EN);
- `TAPS_PVT()` is 5 for neutral hit, 2 otherwise.

1. GAM: cut for gammas (default=0.001) (100 KeV should be better)
2. ELE: cut for electrons (default=0.001) (should be set equal to the GAM cut)
3. NEU: cut for neutral hadrons (default=0.01) (10 MeV is somehow too high if you want to simulate low energy neutral pions...)
4. HAD: cut for charged hadrons (default=0.01) (should be nice if you are not interested in charge hadrons, otherwise lower this value to 1 MeV or less)
5. MUO: cut for muons (default=0.01)
6. BCUTE: cut for electron bremsstrahlung (default=GAM)
7. BCUTM: cut for muon and hadron bremsstrahlung (default=GAM)
8. DCUTE: cut for δ-rays by electrons (default=10^4)
9. DCUTM: cut for δ-rays by muons (default=10^4)
10. PPCUTM: total energy cut for direct pair production by muons (default=0.01)
11. TOFMAX: time of flight cut in seconds (default=10^{10})
12. GCUTS: 5 user words (defaults=0) not used.

Q: When Kane reads the simulation data file, it says: "DATA CARD ERROR: ADDRESS x OUT OF RANGE"
A: Well, actually, these seems to be a FFREAD-package bug. Try to delete and write again the correponding line in your data file, or remove the comment (!) at the end of the line.

Q: When Kane reads the simulation data file, it says: "DATA CARD ERROR: COMMAND NOT FOUND IN DICTIONNARY"
A: This is not really and error: you just used a data card that is not defined for the configuration you use. You can safely ignore this message.