The old CORSIKA program, a historical review

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CORSIKA

The name CORSIKA stands for:

COsmic Ray SImulation for KASCADE

KASCADE = KArlsruhe Shower Core and Array DEtector

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Aims of EAS Simulations

Determine measurable EAS parameters:

- **mean values**
- **fluctuations**
- **correlations**

With this knowledge one tries to deduce from the measurements relevant properties of primary particle:

- **particle type (γ, proton, ... iron, ν, ...)**
- **energy (spectral slope, knee, ankle, GZK-cutoff)**
- **direction (anisotropy, point source)**

Interaction Models

High energy hadronic interaction models:

DPMJET, EPOS, (NeXus, QGSJET01), QGSJET-II, SIBYLL, (VENUS)

Why so many hadronic interaction models ?

Different interaction models produce different mean values. Scattering of mean values gives estimation on systematic uncertainty introduced by different extrapolations of accelerator data to high energy and forward direction.

CORSIKA: Technical Features

program language (portability):
Fortran 77 / 90 + some few C-routines

source code size: ≈ 81 700 lines (without external programs)
≈ 340 routines (≈ 30 outdated)

optional code: ≈ 60 preprocessor options selectable
during installation with ./coconut

steering input: free format with key words + parameters
≈ 125 key words

availability: download from anonymous ftp: ikp-ftp.ikp.kit.edu
with an internet browser (needs password)

documentation: physics: FZKA 6019 (1998)
User's Guide: http://www.ikp.kit.edu/corsika/70.php
variables used in COMMONS:
patch VARINDEX (corsika.h) contains list

Header of First CORSIKA Version

```
C=====================================================================
C
C       OOO        OOO      OOOO         OOOO     OO   O        O         O
C      O   O     O     O     O     O     O    O   OO   O     O          O O
C     O          O     O    O      O    O         OO    O  O           O   O
C     O          O     O    O     O      OOOO     OO    OO            O     O
C     O          O     O    OOOO              O   OO    O  O          OOOOOOO
C      O   O     O     O     O    O     O     O   OO    O     O       O     O
C       OOO        OOO      O      O     OOOO     OO    O        O     O     O
C
C    COSMIC RAY SIMULATION AT KARLSRUHE
C
C
C  A PROGRAM TO SIMULATE EXTENSIVE AIR SHOWERS IN ATMOSPHERE
C
C  BASED ON A PROGRAM OF P.K.F. GRIEDER, UNIVERSITY BERN
C  DUAL PARTON MODEL ACCORDING TO J.N. CAPDEVIELLE, UNIVERSITY BORDEAUX
C  EGS4 AND NKG FORMULAS FOR SIMULATION OF ELECTROMAGNETIC PARTICLES
C
C  INSTITUT FUER KERNPHYSIK
C  KERNFORSCHUNGSZENTRUM AND UNIVERSITY OF KARLSRUHE
C
C  VERSION :  1.0
C  DATE    :  26.  OCTOBER 1989
C
C=====================================================================
```

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Origin of CORSIKA

October 26, 1989 CORSIKA Vers. 1.0 merged from:

SH2C-60-K-OSL-E-SPEC (Grieder, 1980):
main structure, isobar model

ESKAR (HDPM) (Capdevielle, 1987):
high-energy hadronic interactions

EGS4 (Nelson et al., 1985):
electron gamma shower

NKG (Capdevielle, 1989):
analytical treatment of EM-subshowers

Source code size: $\approx$ 13 000 lines (1/6 of present version 7.6400)

CORSIKA: Development

1994 CORSIKA Vers. 4.06

GHEISHA (Fesefeldt, 1985):
low-energy hadronic interactions

VENUS (Werner, 1993):
high-energy hadronic interactions

CERENKOV option (HEGRA Collaboration, 1993):
treatment of Cherenkov radiation

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CORSIKA: Development

1997 CORSIKA Vers. 5.20

SIBYLL (Fletcher, Gaisser et al., 1996):
high-energy hadronic interactions

DPMJET (Ranft, 1996):
high-energy hadronic interactions

QGSJET (Kalmykov et al., 1996):
high-energy hadronic interactions

THIN option:
simulate highest energies in reasonable time

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CORSIKA: Development

2000 CORSIKA Vers. 6.00

IACT option (Bernlöhr, 2000):
Cherenkov routines incl. telescopes

NEXUS (Drescher et al., 2000):
high-energy hadronic interactions

CURVED option (Schröder, 2000):
option for very inclined showers

URQMD (Bleicher et al., 2000):
low-energy hadronic interactions

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CORSIKA: Development

2004 CORSIKA Vers. 6.20

PRESHOWER option (Homola et al., 2002):
UHE primary gammas

FLUKA (Fassò, Ferrari et al., 2002):
low-energy hadronic interactions

NUPRIM option (Ambrosio, Pisanti et al., 2003):
primary neutrinos (HERWIG)

muons (after Bottai & Perrone, 2001):
improved muon interactions

SLANT option:
slant depth (instead of vertical depth)

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CORSIKA: Development

2007 CORSIKA Vers. 6.60

EPOS (Werner et al., 2005):

high-energy hadronic interactions

QGSJET-II (Ostapchenko, 2006):

improved model for high energies

COAST option:

output as ROOT file

2009 CORSIKA Vers. 6.900

CHARM option:

PYTHIA treats charmed hadrons

./coconut:

automated installation of CORSIKA

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CORSIKA: Development

2012 CORSIKA Vers. 7.350

CONEX option (Bergmann et al., 2007):

hybrid simulation by cascade equations

QGSJET-II-04 (Ostapchenko, 2011):

improved model for highest energies

EPOS-LHC (Pierog et al., 2013):

improved model for highest energies

PARALLEL option:

parallel treatment on multi-CPU cluster

2013 CORSIKA Vers. 7.400

CoREAS (Huege et al., 2013):

coupling with radio emission program

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Success of CORSIKA

Documentation: Report FZKA 6019 on physics of CORSIKA
(more than 890 citations),
User's Guide explains how to run CORSIKA

Availability: FTP-download with internet browser,
more than 1270 registered users (outside KIT)

Source: open source for users to see what is programmed

Support: help in case of problems,
reference persons for advice and questions

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Alternative Programs

AIRES	**transscript of MOCCA to Fortran (Sciutto)**
CONEX	**hybrid with cascade equations (Kalmykov et al.)**
COSMOS	**hybrid with subshower library (Kasahara et al.)**
FLUKA	**multi-purpose detector MC (Ferrari et al.)**
GEANT 4	**multi-purpose detector MC (CERN)**
HEMAS	**used for MACRO (Battistoni, Forti et al.)**
MOCCA	**split algorithm, thinning, Pascal language (Hillas)**
SENECA	**hybrid with cascade equations (Drescher et al.)**

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CORSIKA Users Worldwide

am	=	Armenia	ge	=	Georgia	pl	=	Poland
ar	=	Argentina	gr	=	Greece	pt	=	Portugal
at	=	Austria	gt	=	Guatemala	ro	=	Romania
au	=	Australia	hk	=	Hong Kong	rs	=	Rep. Serbia
be	=	Belgium	hr	=	Croatia	ru	=	Russia
bd	=	Bangladesh	hu	=	Hungary	sa	=	Saudi Arabia
bg	=	Bulgaria	ie	=	Ireland	se	=	Sweden
bo	=	Bolivia	il	=	Israel	si	=	Slovenia
br	=	Brazil	in	=	India	sk	=	Slovakia
ca	=	Canada	iq	=	Iraq	tj	=	Tajikistan
ch	=	Switzerland	ir	=	Iran	tr	=	Turkey
cn	=	China	it	=	Italy	tw	=	Taiwan
co	=	Colombia	jp	=	Japan	ua	=	Ukraine
cz	=	Czech Republic	ke	=	Kenya	uk	=	United Kingdom
de	=	Germany	kr	=	South Korea	edu/gov	=	USA
dk	=	Denmark	kz	=	Kazakhstan	ve	=	Venezuela
dz	=	Algeria	mx	=	Mexico	vn	=	Vietnam
es	=	Spain	nl	=	Netherlands	za	=	Rep. South Africa
fi	=	Finland	no	=	Norway			
fr	=	France	pe	=	Peru			

In 58 countries $\approx$ 1270 registered CORSIKA users (outside KIT).