simulation software and simulation production in IceCube

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University of Wisconsin - Madison

MANTS 2009
Berlin

September 26th, 2009
simulation (coordinator Alex Olivas)
simulation chain

- generator
- propagator
- ice properties + pmt
- hit generator + noise
- detector response
  - PMT simulator
  - DOM simulator
- detector response
  - Trigger simulator
- filter/processing
simulation chain
simulation chain

- physics input
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```
physics input

generator

photontables

hit generator + noise

PMT simulator
DOM simulator

ice properties + pmt
detector response

trigger simulator

filter/processing
```
simulation chain

- Generator
- Propagator
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generators: CORSIKA

- currently using CORSIKA v6.720 (→ v6.900)
  - QGSJET-II : ~30% lower µ rate than exp
  - SIBYLL v2.1 : within 10% of exp µ rate
  - EPOS v1.60 : ~30% higher µ rate than exp

poly-gonato model of CR flux & composition (Hörandel)

CORSIKA up to Fe (27)

EGCR not modeled
generators: CORSIKA

- bulk \(\mu\) energy \(\sim 1-5\) TeV (\(\Rightarrow\) CR energy \(\sim 10-50\) TeV)

  - poly-gonato model and easier to use

  - weighted events: \(\propto E^{-\gamma+1}\)
    - better livetime efficiency @ 10 TeV but poor efficiency @ TeV
    - energy-targeted generation of (H, He, CNO, Mg, Fe) with \(E^{-1(2)}\)
    - coincidence of uncorrelated events contribute \(\sim 20\%\) in IC40
      - very important for physics analyses
2-component by Glasstetter et al, 1999

poly-gonato model fails > 10-100 PeV & @ horizon

using individual CR masses for re-weighting
coincident atmospheric shower events in IceCube
generators: neutrino-generator, Juliet

- produces a $E^{-\gamma} \nu_\mu, \nu_e, \nu_\tau$ with
  - PRELIM Earth’s density model
    - homogeneous density
  - CTEQ5 parton distribution functions
  - CTEQ6 ~ 1% difference

- cross section re-evaluation based on HERA data (Anchordoqui, Cooper-Sarkar, Sarkar)
  - prop & interaction of neutrinos into a weight: flexible spectral weight
  - Honda 2007, Bartol, extra-terrestrial fluxes, ...
propagator: MMC, Juliet

- also a neutrino generator it propagates $\mu$, $e$, $\tau$ & monopoles

Figure 35: Bremsstrahlung cross section parameterizations for muons
Figure 37: Photon-nucleon cross sections, as described in the text: Kokoulin [45], W. Rhode [46], BB 1981 [47], ZEUS 94 [48], ALLM 91 and 97 [49], Butkevich [50]. Curves 5-7 are calculated according to \( \sigma_{\gamma N} = \lim_{Q^2 \rightarrow 0} \frac{4\pi^2 \alpha F^N_{\gamma}}{Q^2} \).

Figure 38: Photonuclear energy losses (divided by energy), according to formulae from Section 9.3. Higher lines for the parameterizations 1-4 include the hard component [51], higher lines for 5-7 calculate shadowing effects as in Section 9.3.3, lower as in Section 9.3.2.
hit (i.e. p.e.) generator

- \( \mu \) energy lost + cascades \( \rightarrow \) photons \( \rightarrow \) p.e.

- photon propagation: ice properties + PMT response + DOM glass/gel

- pre-generated lookup table: amplitude ad time distribution
PMT simulator, romeo

- sigle photo electron template

- PMT saturation model
DOM mother board simulation

- core of detector simulation
  - digitization & timing @ MB

![Diagram of DOM mother board simulation](image)

![Graphs showing 29.55/10 Hz decay in channel 0](image)
simulation production
quick overview @ high level : where it stands

- geometry calibration detector status
- simulation release
- offline filter/processing
- dataset settings priorities
- simulation production
- low level checks verification
- high level verification
- physics working groups
- software support and development
quick overview @ high level: how it runs
from demand to production plan

- detector (geometry), calibration configuration defined
- simulation (filtering/processing) software are frozen and tested

- working group coordinators determine needs for physics analyses

- needs are quantified in terms of **amount** of background & signal to produce
  - physics parameters and det. configuration are determined (tested)
  - physics datasets (i.e. sim data for analyses) are defined
  - benchmark datasets (i.e. sim data for systematics) are determined
    - set up simulation dataset configurations (**templates**)
from plan to production: the sites

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<th>contact person</th>
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<th>cpu type</th>
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from plan to production: the sites

• assess data size and **CPU** time & distribute jobs throughout production sites
the production brain: IceProd (Juan Carlos Díaz Vélez)

- cataloging steering params & software versions for simulation datasets
- distributed job management and monitoring system
- written in python
- daemons manage cluster job submission
- Jobs communicate to daemons via SOAP
IceProd: the daemons
IceProd: job management
IceProd: distributed computing system

- adapt to different sites and **batch** and **grid** systems

  - PBS, sge, condor, ...

  - GLOW, Grid Engine, Nordugrid (Swegrid), Open Science Grid, LONI

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IceProd: web interface
production monitoring and statistics collection
production history and configurations search engine
## IceProd: Community

### Ticket System:

- Document discussions on requests
- Link to a given dataset

### Daily Email Usage Report

```plaintext
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<th>Ticket</th>
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<th>Subject</th>
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- **ox**: 7048.0
- **usr_t**: 79776955.6935
- **real_t**: 119054545.388
- **suspended**: 430.0
- **error**: 0.0
- **events**: 1210641.0

**Simprod mailing list**

[Simprod@icecube.wisc.edu](mailto:Simprod@icecube.wisc.edu)

[http://www.icecube.wisc.edu/mailman/listinfo/simprod](http://www.icecube.wisc.edu/mailman/listinfo/simprod)
IceProd : GUI

![IceProd GUI Image]

- **URL:** https://condor.icecube.wisc.edu:9080
- **Events:** 0
- **Iterations:** 1
- **IceProdPre Modules Services IceProdPost Projects**

### IceProdPre
- **name:**
  - generate_corsika i3.IceTray

### Parameter Table
- **Type** | **Name** | **Value** | **Unit**
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string | IPEmoduleClass | generators.CorsikaIC | 
string | gcdfile | $steering(gcdfile_09)$ | 
string | outputfile | $steering(current_file)$ | 
string | summaryfile | $steering(summaryfile)$ |
IceProd: production verification
simulation verification
extra
flow of experimental and simulation data

**data**  |  **on-line**  |  **off-line**  |  **physics analyses**
---|---|---|---
experimental | filter @ South Pole | level 1 filtering (recreate on-line filter) | level 3 processing | physics

DAQ  |  P&F computing  |  spade  |  core computing  |  working groups

simulation generation  |  level 1 filtering (recreate on-line filter)  |  level 2 processing  |  level 3 processing  |  physics

distributed computing  |  working groups
how to handle photon tables

- split jobs in pieces, each of which uses a subsample of photon tables (~700 MB)
- run jobs in sequence in the same node

► brake simulation chain in separate trays
how to handle photon tables

Use Condor DAGMan to divide a simulation job into multiple Condor jobs

Each Condor job is called a “task” that runs part of a simulation job

Status updates are tracked for each task in the DB and displayed on the web