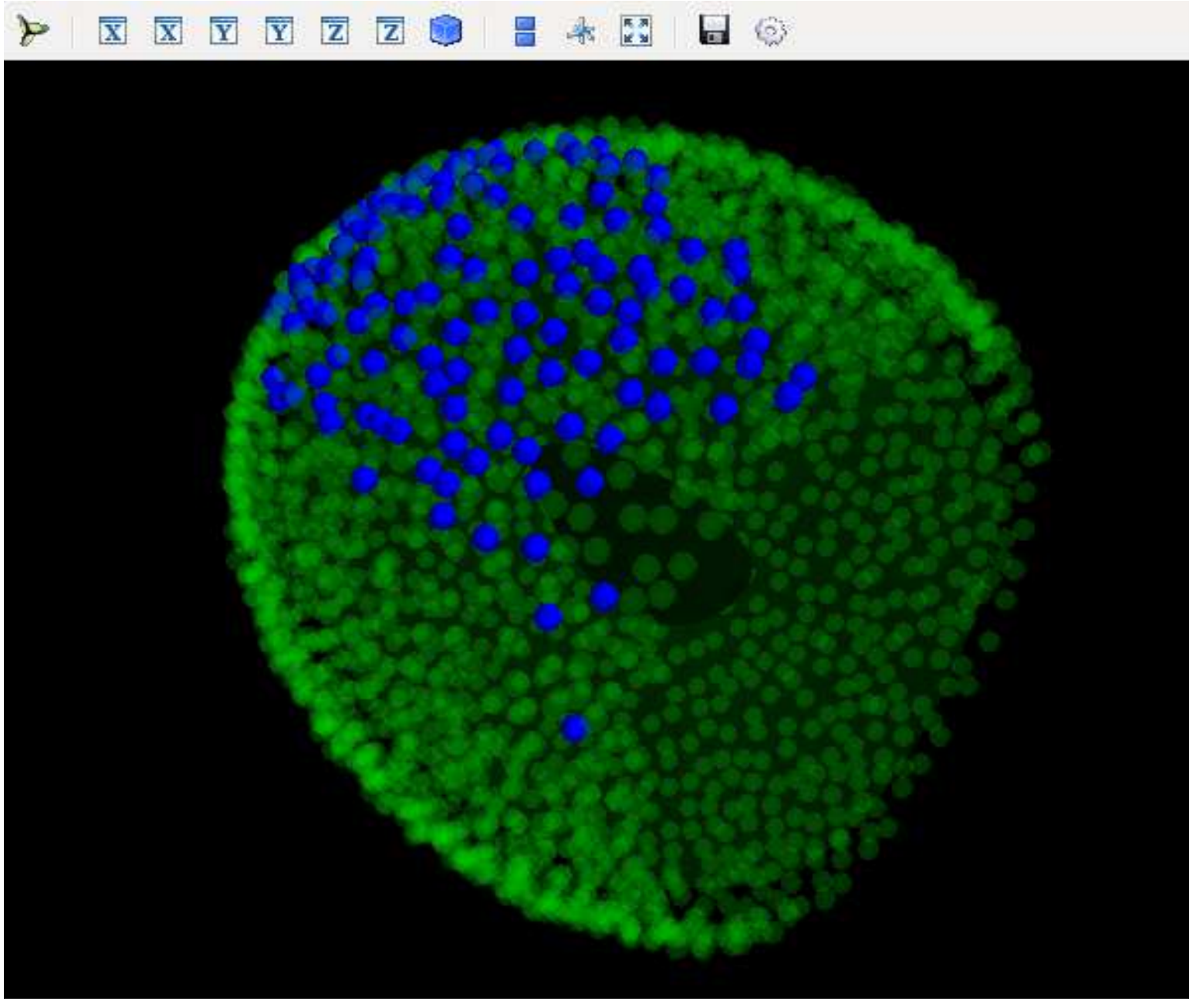
Parallel NEURON idioms:

- Information exchange during setup
- Random numbers
- Debugging

Michael Hines

CodeJam 2014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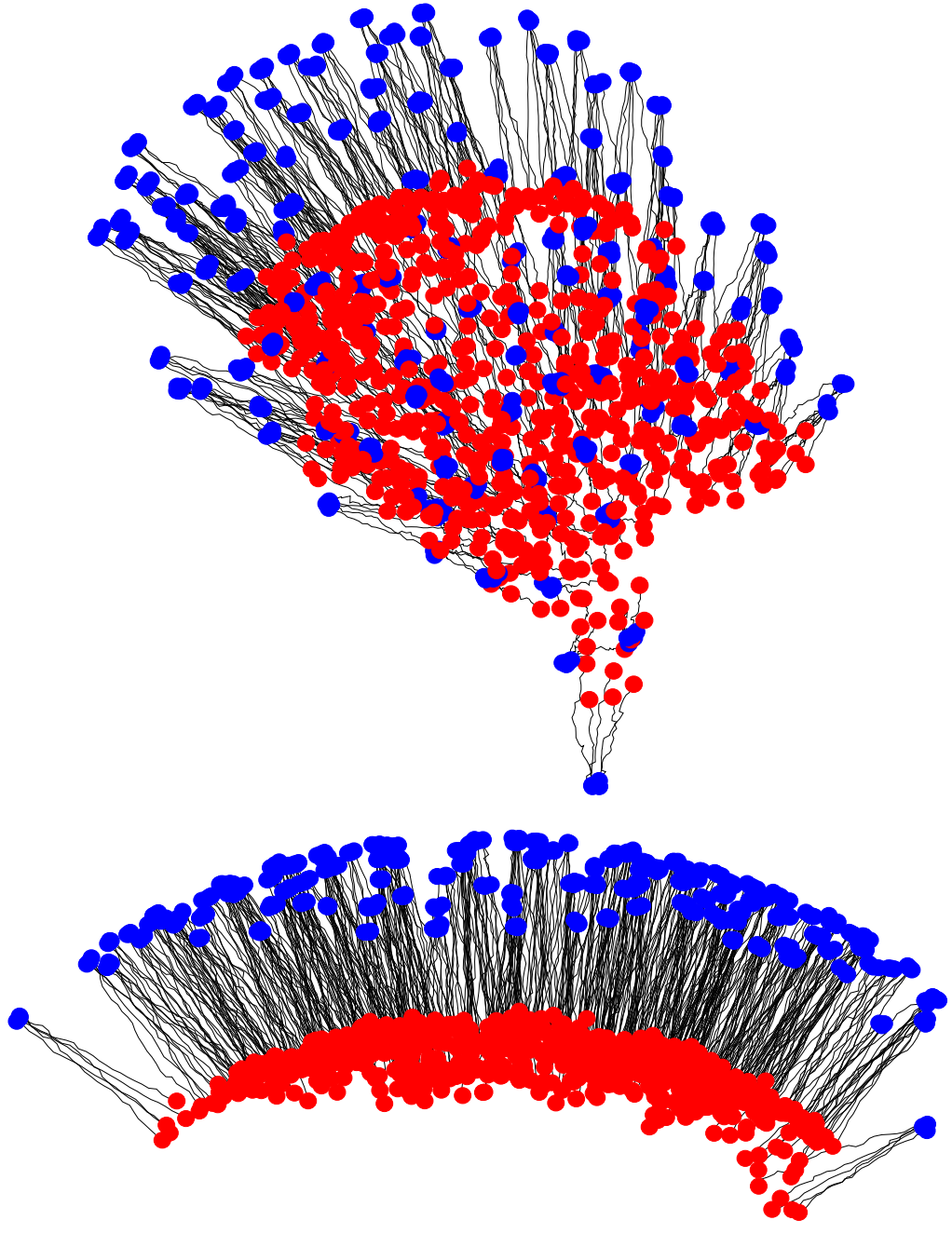

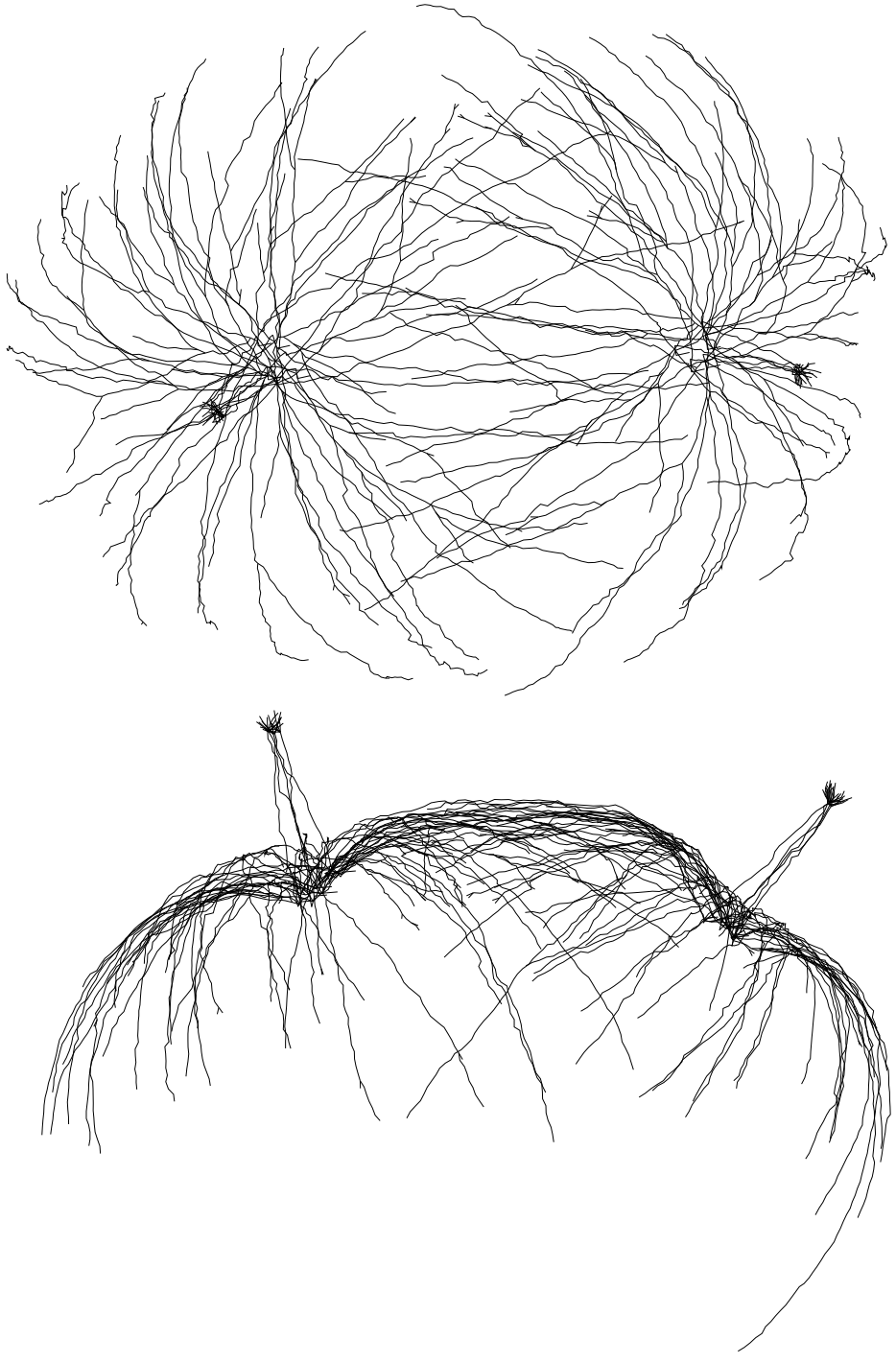

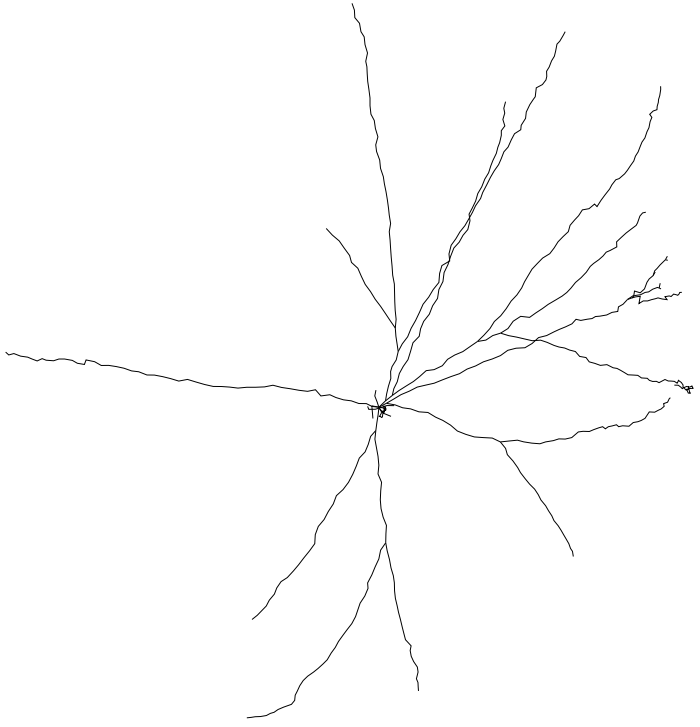

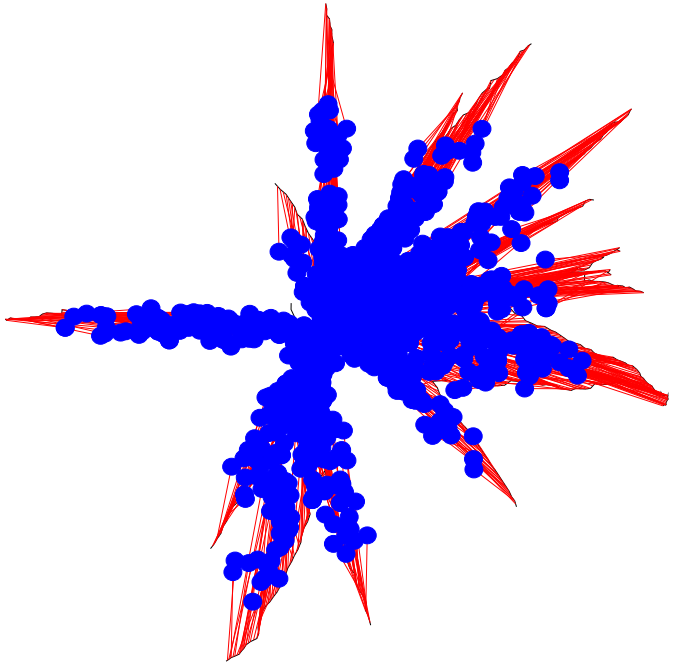

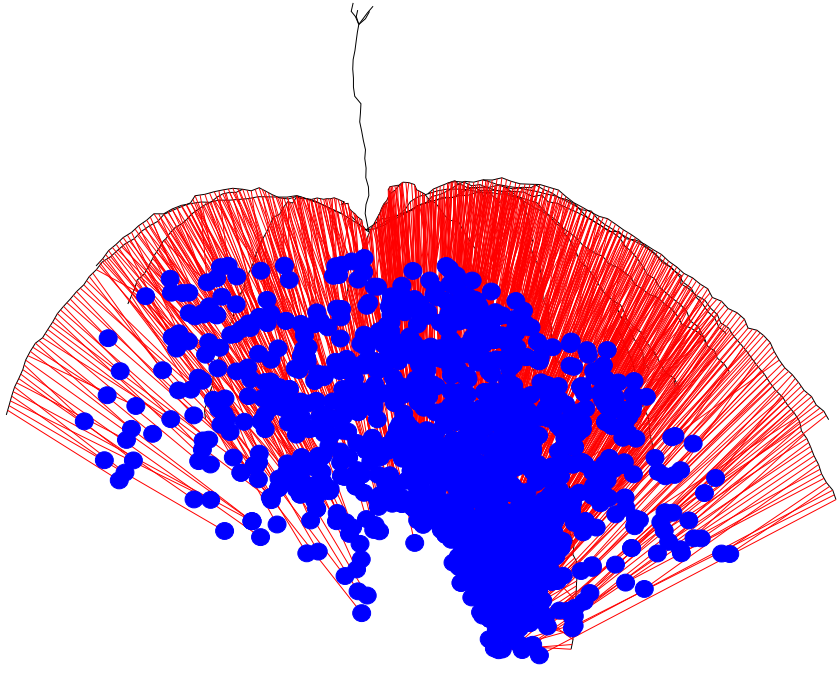

Information exchange during setup

Results must be independent of

Number of processors

Distribution of cells

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And the process that owns the object does not know who is interested in it.

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A process is often interested in all the objects with a particular property.

But it generally does not know where the objects are.

And the process that owns the object does not know who is interested in it.

There is not enough memory in any one process to hold a map of which ranks hold which objects.

Example: MPI_ISend/Recv spike exchange

Cells do not know which ranks are interested in its spikes.

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Example: Source/Target connectivity

Reciprocal synapse connection description.

(mitral_gid, mdend_index, xm, granule_gid, gdend_index, xg, ...)

Construct a mitral => all the tuples with that mitral_gid.

Granules don’t know enough for construction of the tuples.

Construct a granule => gather all the tuples with that granule_gid.

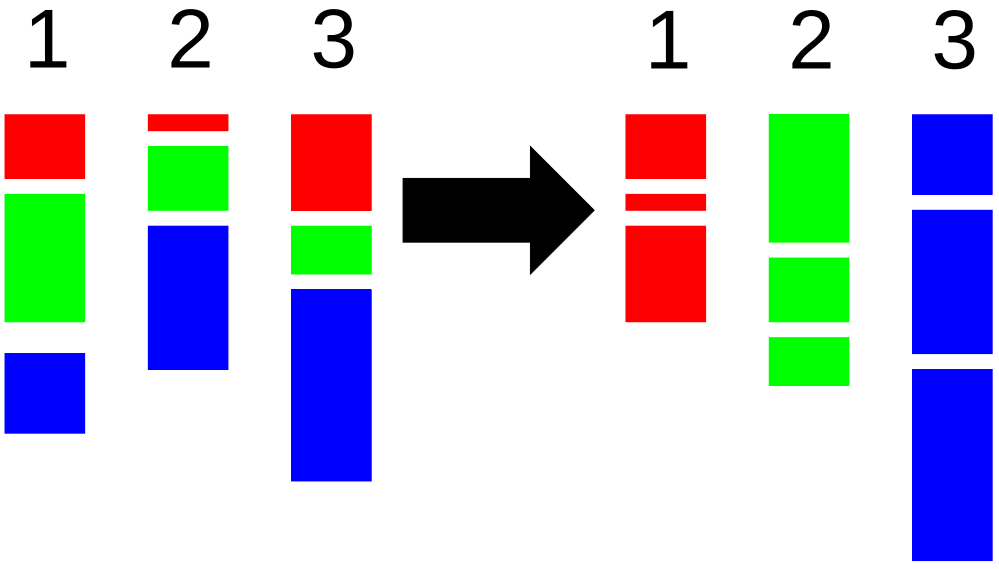
Basic exchange:

dest = ParallelContext.py_alltoall(src)

src and dest are a list of nhost pickleable objects.

src[j] on the ith rank will be copied to dest[i] on the jth rank.

Likely identical to mpi4py.MPI comm.alltoall(src, dest).



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Essentially a wrapper for:

```
MPI_Alltoallv(s, scnt, sdispl, MPI_CHAR,
                        r, rcnt, rdispl, MPI_CHAR, comm);
```

along with a preliminary
MPI_all2all(scnt, 1, MPI_INT, rcnt, 1, MPI_INT, comm);
in order to calculate rcnt and rdispl.

But:

No one knows who holds what.

No room for anyone to have a global map.

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Solution: A rendezvous rank function:

rank = rendezvous(property)

usually

rank = gid % nhost

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Solution: A rendezvous rank function:

rank = rendezvous(property)

usually

rank = gid % nhost

1) Everyone sends the keys they own to the rendezvous rank.
2) Everyone sends the keys they want to the rendezvous rank.
3) The rendezvous rank sends back to the owners, which ranks want which keys.
4) The owners send the objects to the ranks that want them.

Usually simplification is possible:

If the objects are small.

1) Everyone sends the keys and objects they own to the rendezvous rank.
2) Everyone sends the keys they want to the rendezvous rank.
3) The rendezvous rank sends the objects to the ranks that want them.

Usually simplification is possible:

If rendezvous(property) is known to be the source rank for all the keys (a−priori or by verifying with an all_reduce).

1) Everyone sends the keys they want to the owner ranks.

2) The owners send the objects to the ranks that want them.

Usually simplification is possible:

If rendezvous(property) is known to be the destination rank for all the keys (a−priori or by verifying with an all_reduce).

1) The owners send the objects to the ranks that want them.

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Thanks! to Eilif Muller for suggesting:

Parallel Random Numbers: As Easy as 1, 2, 3
Salmon et al. SC11 (2011)
D. E. Shaw Research, New York, NY 10036, USA

We introduce several counter−based PRNGs: some based on cryptographic standards (AES, Threefish) and some completely new (Philox). All our PRNGs pass rigorous statistical tests (including TestU01's BigCrush) and produce at least 2^64 unique parallel streams of random numbers, each with period 2^128 or more.

http://www.deshawresearch.com/resources_random123.html

Use cryptographic transformation of several integers.

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Random123:

- Eight integers define x(n1, ..., n8)
  - But we use 4 (two for the stream number).
  - Philox variant

Use cryptographic transformation of several integers.

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Random123:

- Eight integers define x(n1, ..., n8)
  - But we use 4 (two for the stream number).
  - Philox variant
- Good performance

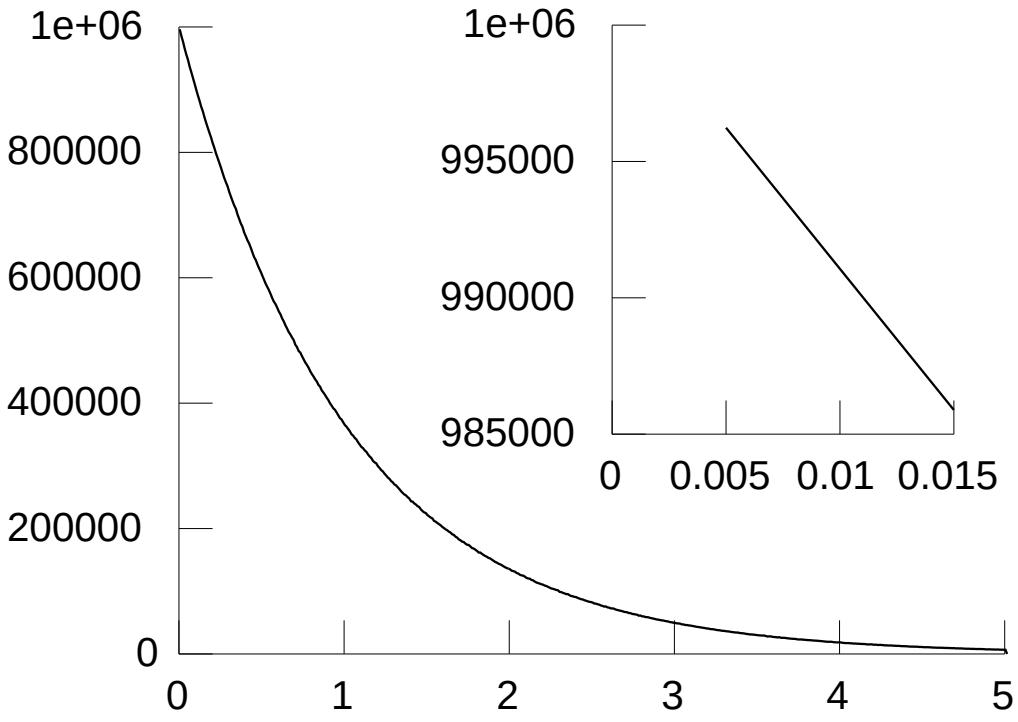
10 million picks

ACG	0.329s	
MLCG	0.681s	
MCellRan4	0.150s	
numpy.random.rand(n)	0.233s	(Mersenne Twister)
Random123	0.201s	

```
from neuron import h
r = h.Random()
r.Random123(1,2)
r.negexp(1)
```

```
from neuron import h
r = h.Random()
r.Random123(1,2)
r.negexp(1)

n=100000000
dx = .01
y = h.Vector(n).setrand(r)
y = y.histogram(0,5,dx).rotate(−1,0)
x = y.c().indgen(dx/2,dx)
g = h.Graph()
y.line(g, x)
```



nrnran123.h (abridged)

all generator instances share the global index
extern void nrnran123_set_globalindex(uint32_t gix);

extern nrnran123_State*
    nrnran123_newstream(uint32_t id1, uint32_t id2);

extern uint32_t nrnran123_ipick(nrnran123_State*);
  uniform 0 to 2^32−1

extern double nrnran123_dblpick(nrnran123_State*);
  uniform open interval (0,1)
  minimum value is 2.3283064e−10
  max value is 1−min

extern double nrnran123_negexp(nrnran123_State*);

mean 1.0

min value is 2.3283064e−10

max is 22.18071

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−log(1/2^32) 22.18071

−log(2/2^32) 21.487563

−log(10/2^32) 19.878125

−log(11/2^32) 19.782815

exp(−5)*2^32 28939262

−log(28939262/2^32) 5.0000000001

−log(28939263/2^32) 4.99999996

extern double nrnran123_negexp(nrnran123_State*);
  mean 1.0
  min value is 2.3283064e−10
  max is 22.18071

stateless (though the global index is still used)
extern nrnran123_array4x32
    nrnran123_iran(uint32_t seq, uint32_t id1, uint32_t id2);

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1) GID and time of first spike difference.

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1) GID and time of first spike difference.
2) All spikes delivered to synapses of that Cell?

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1) GID and time of first spike difference.
2) All spikes delivered to synapses of that Cell?
3) When and what is the first state difference?

```
h.load_file('prcellstate.hoc')
if pc.gid_exists(gid):
    h.prcellgid(gid)
```