An on-disk binary data container, query engine and computational kernel

Overview

- What PyTables is?
- Data structures in PyTables
- Compressing data
- Advanced capabilities in PyTables

What it is

- A binary data container for on-disk, structured data
- Can perform operations with data *on-disk*
- Based on the standard de-facto HDF5 format
- Free software (BSD license)

About HDF5
(Hierarchical Data File version 5)

- A **versatile data model** that can represent complex data objects as well as associated metadata
- A **portable** file format with **no limit** on the number or size of data objects in the collection
- Implements a high-level API with C, C++, Fortran 90, and Java interfaces
- Free software (BSD, MIT kind of license)

PyTables distinctive features

- Supports a good range of compressors: Zlib, bzip2, LZO and Blosc
- Powerful query capabilities for Table objects, including indexing
- Can perform out-of-core operations very efficiently

What it is not

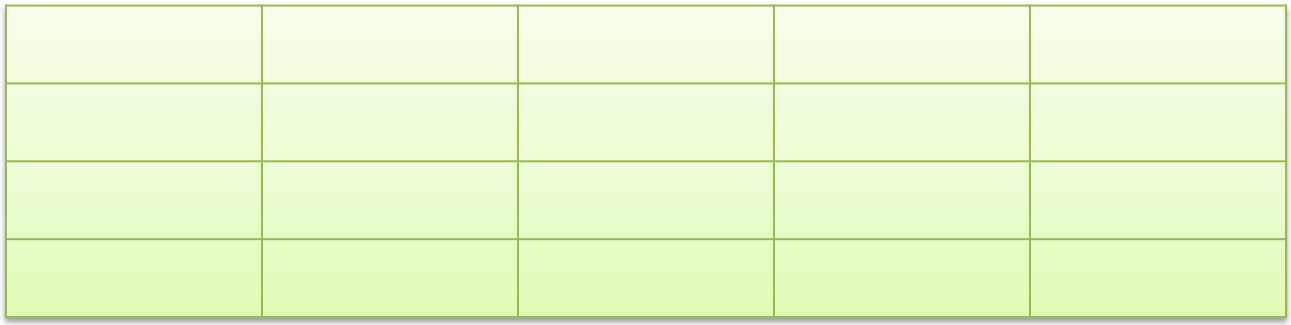
- Not a relational database replacement
- Not a distributed database
- Not extremely secure or safe (it's more about speed!)
- Not a mere HDF5 wrapper

DATA STRUCTURES

Data structures

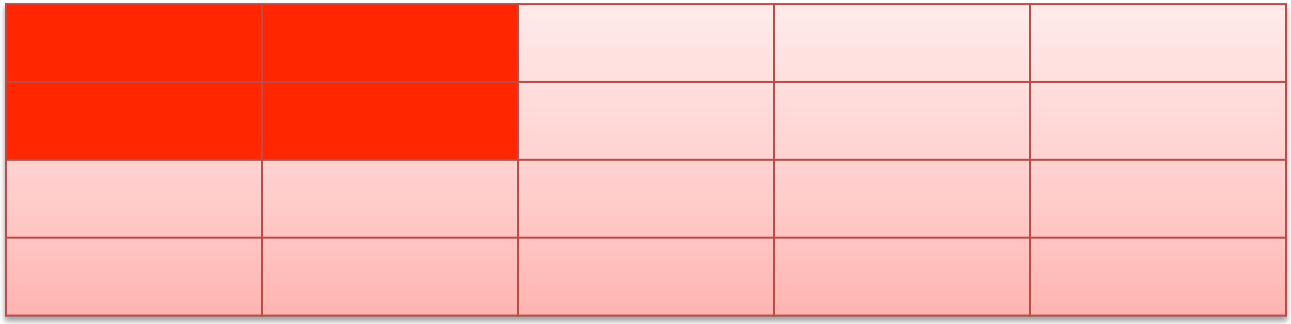
- High level of flexibility for structuring your data:
  - Datatypes: scalars (numerical & strings), records, enumerated, time…
  - Tables support multidimensional cells and nested records
  - Mutidimensional arrays
  - Variable length arrays

The Array object



- Easy to create:
  - file.createArray(mygroup, ‘array’, numpy_arr)
- Shape cannot change
- Cannot be compressed

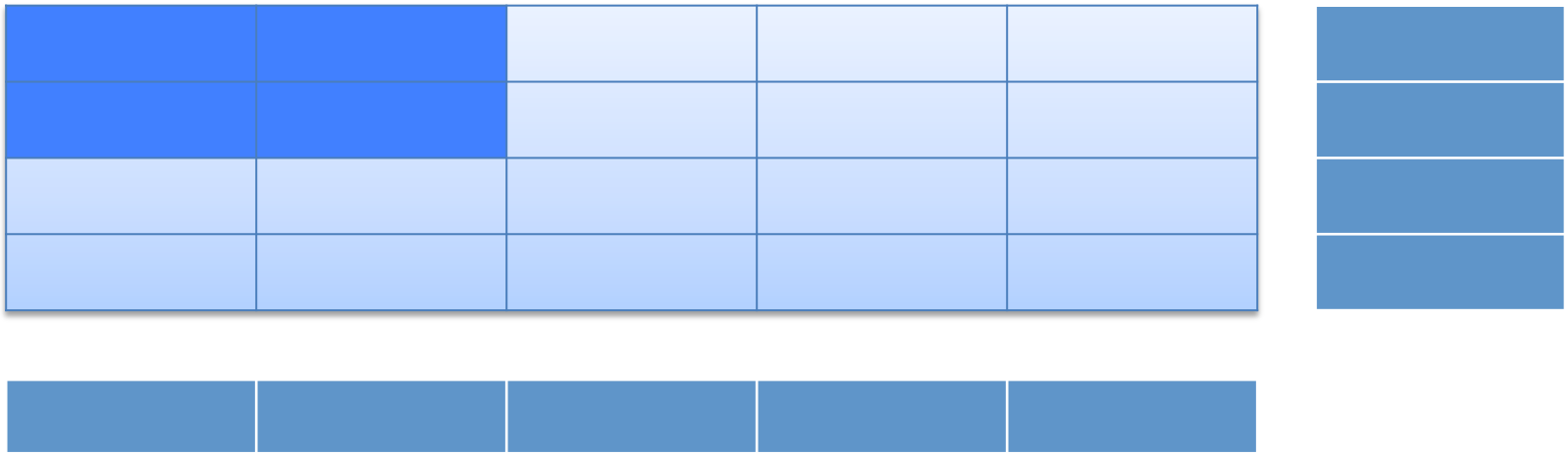
The CArray object



- Data is stored in chunks
- Each chunk can be compressed independently

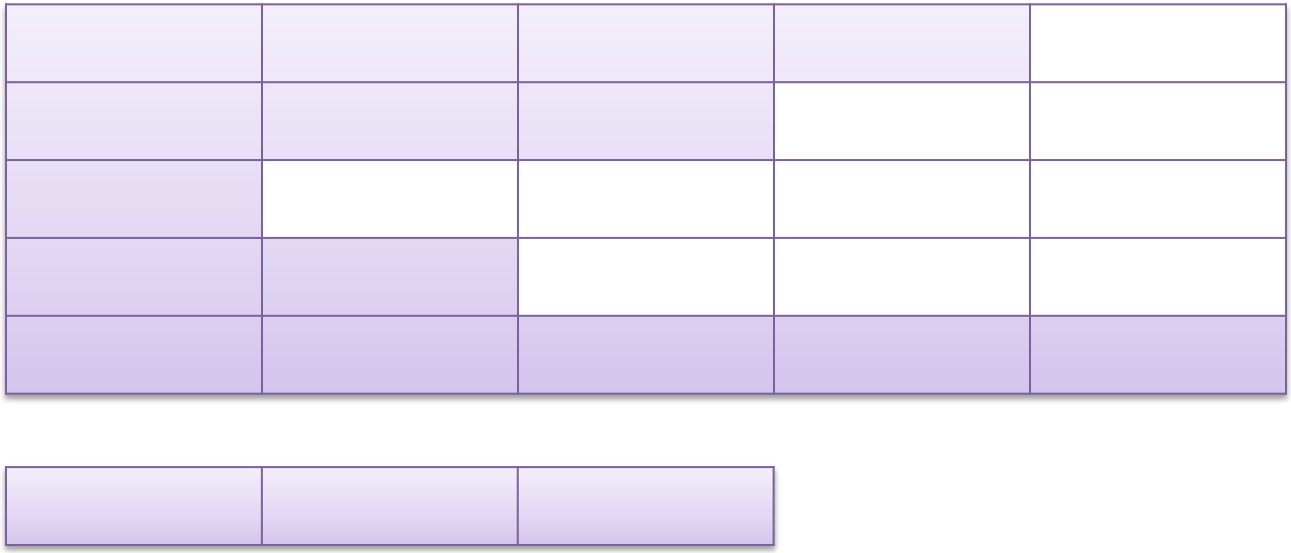
- Shape cannot change

The EArray object



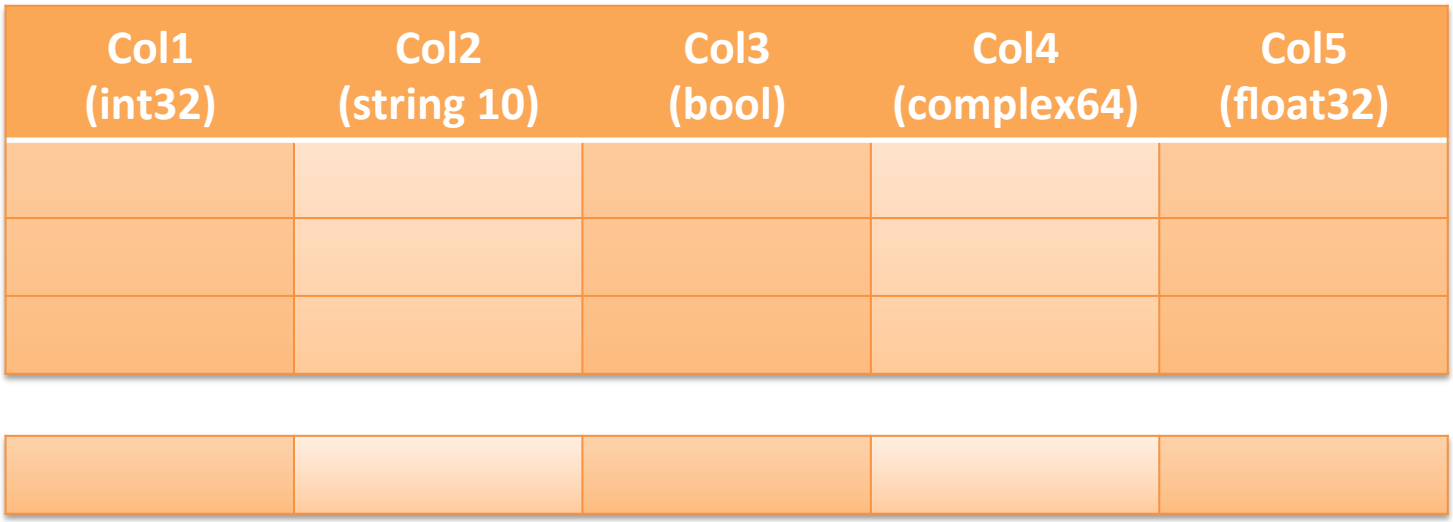
- Data is stored in chunks
- Can be compressed
- Shape can change (either enlarged or shrunk)
- Shape must be kept regular

The VLArray object



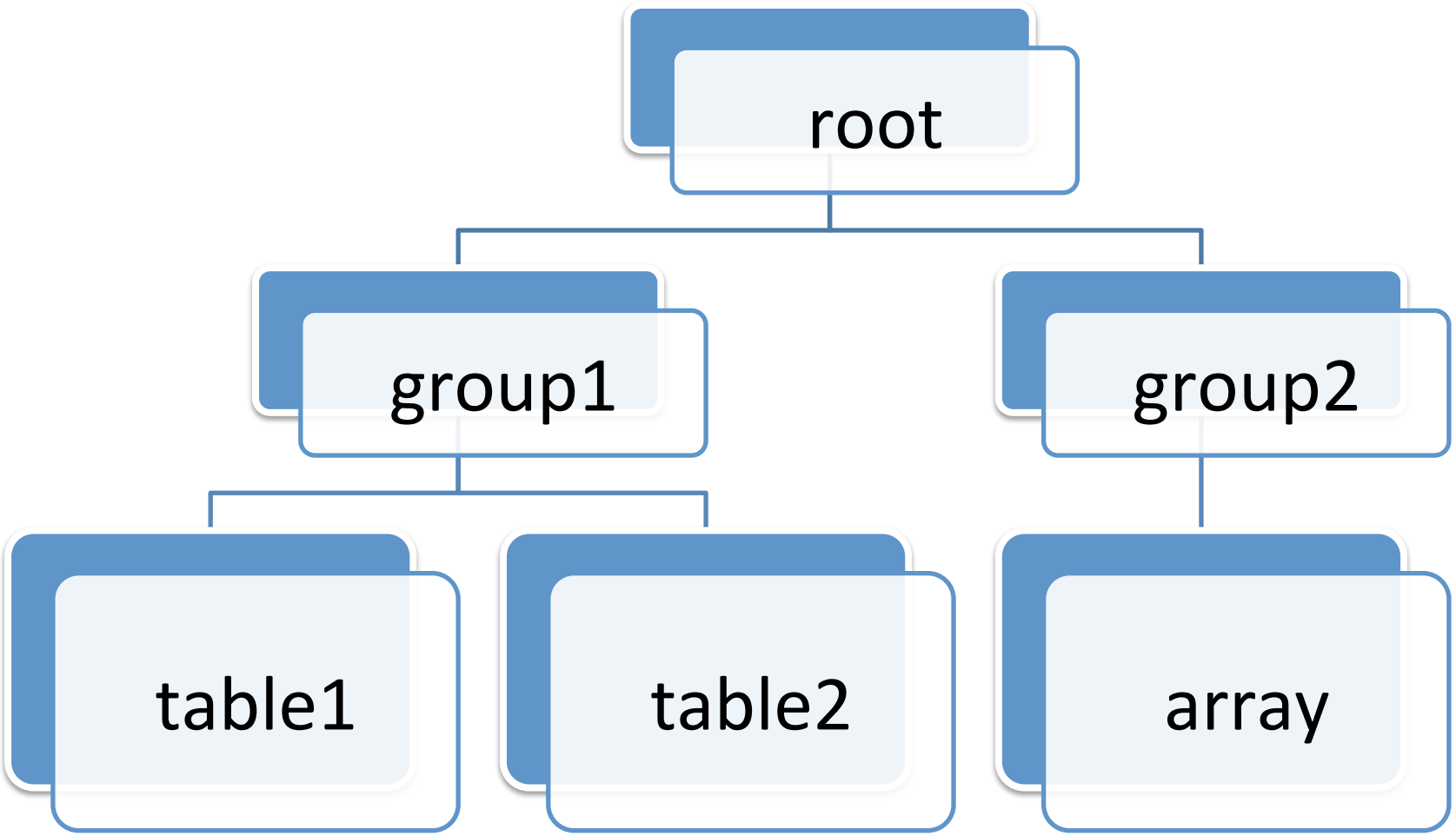
- Data is stored in variable length rows
- Can be enlarged or shrunk
- Data cannot be compressed

The Table object

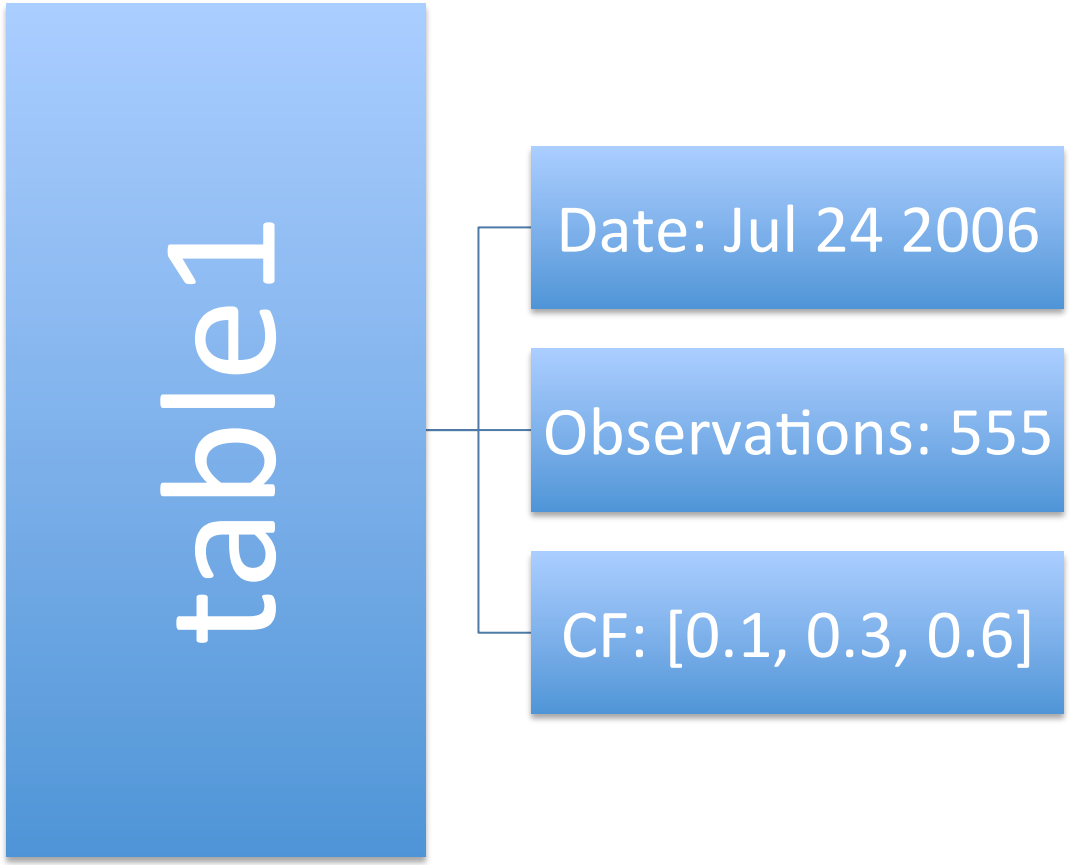


- Data is stored in chunks
- Can be compressed
- Can be enlarged or shrunk
- Fields cannot be of variable length

Dataset hierarchy



Attributes:
Metadata about data

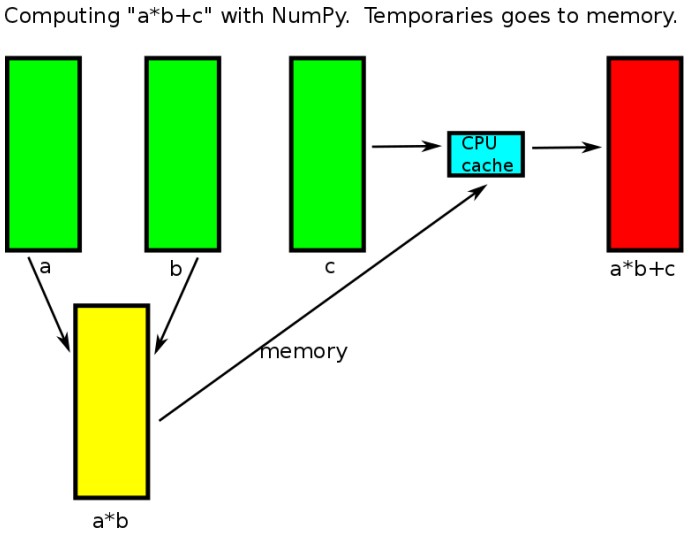


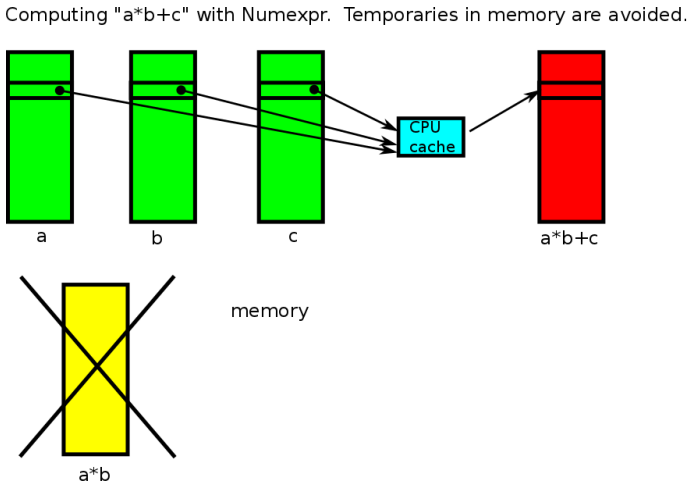
OUT-OF-CORE COMPUTATIONS

Operating with disk-based arrays

- tables.Expr is an optimized evaluator for expressions of disk-based arrays.
- It is a combination of the Numexpr advanced computing capabilities with the high I/O performance of PyTables.
- Similarly to Numexpr, disk-temporaries are avoided, and multi-threaded operation is preserved.

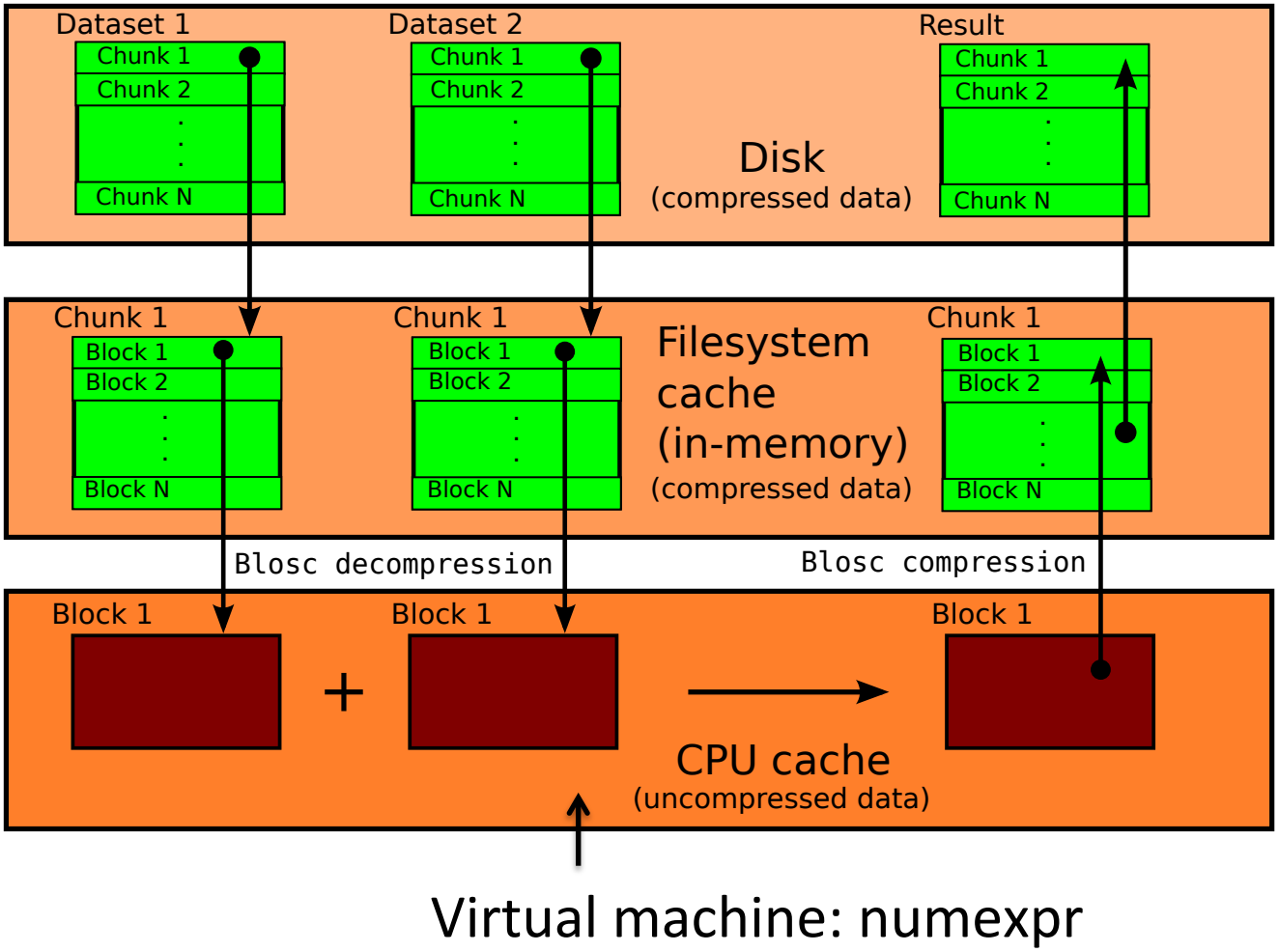
Avoiding temporaries with Numexpr





Tables.Expr follows the same approach,
but with disk instead of memory

Performing out-of-core computations with PyTables



ADVANCED QUERY CAPABILITIES

Different query modes

Regular query:

- `[ r['c1'] for r in table`
  `if r['c2'] > 2.1 and r['c3'] == True)) ]`

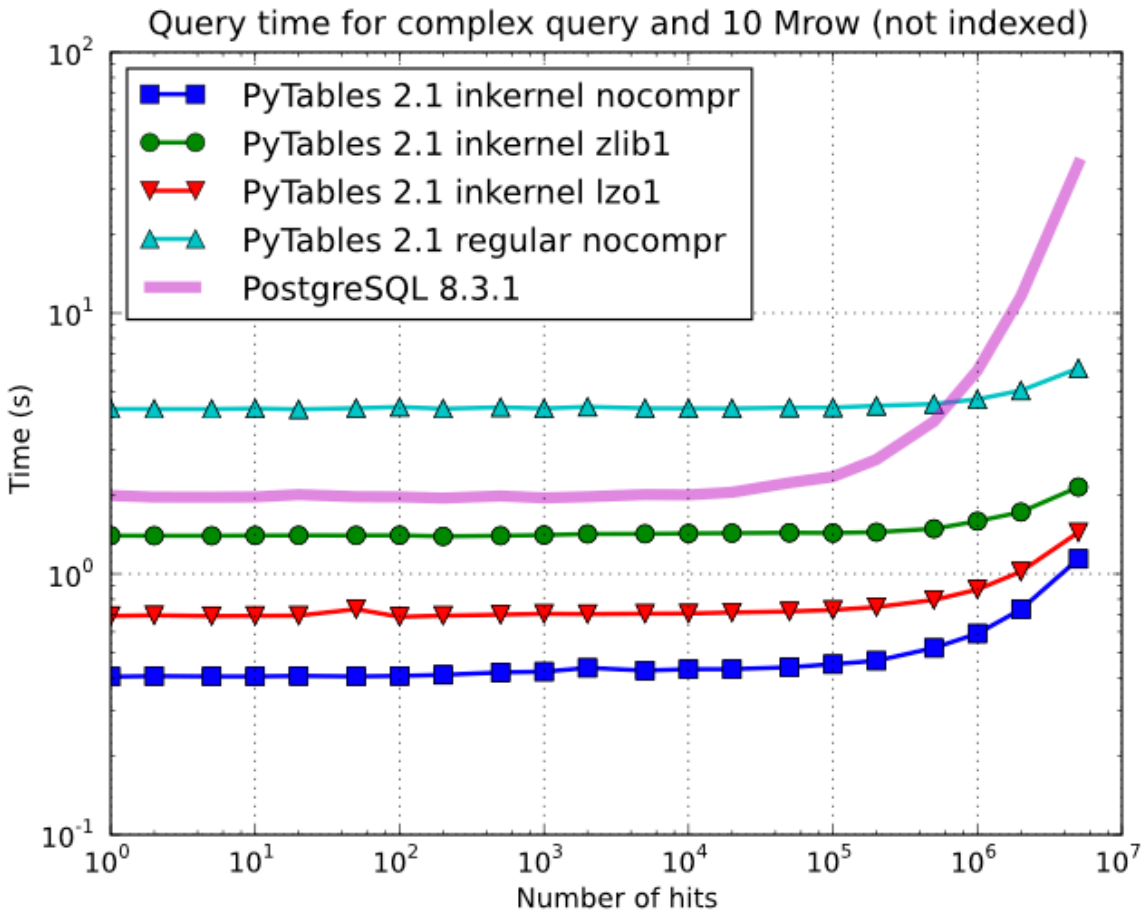
In-kernel query:

- `[ r['c1'] for r in table.where('(c2>2.1)&(c3==True)') ]`

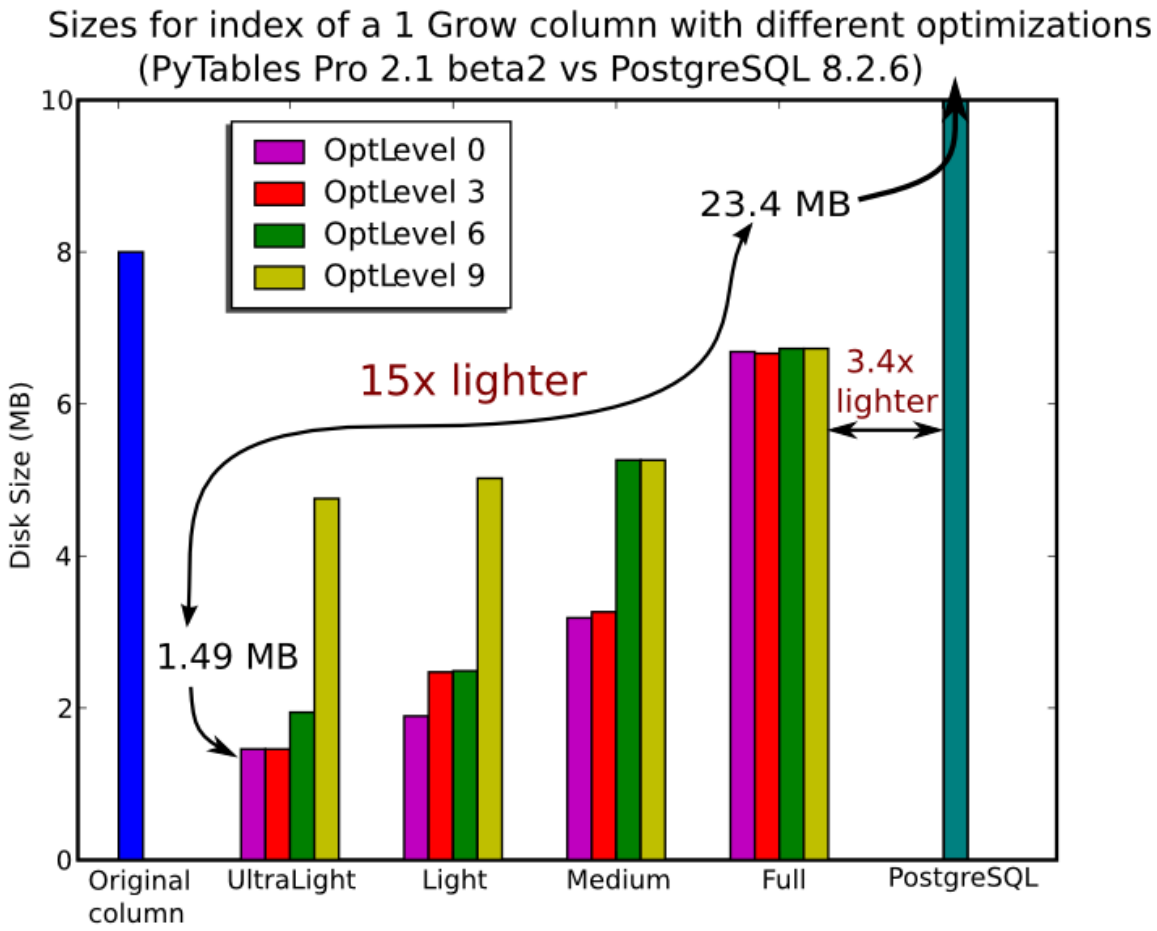
Indexed query:

- `table.cols.c2.createIndex()`
- `table.cols.c3.createIndex()`
- `[ r['c1'] for r in table.where('(c2>2.1)&(c3==True)') ]`

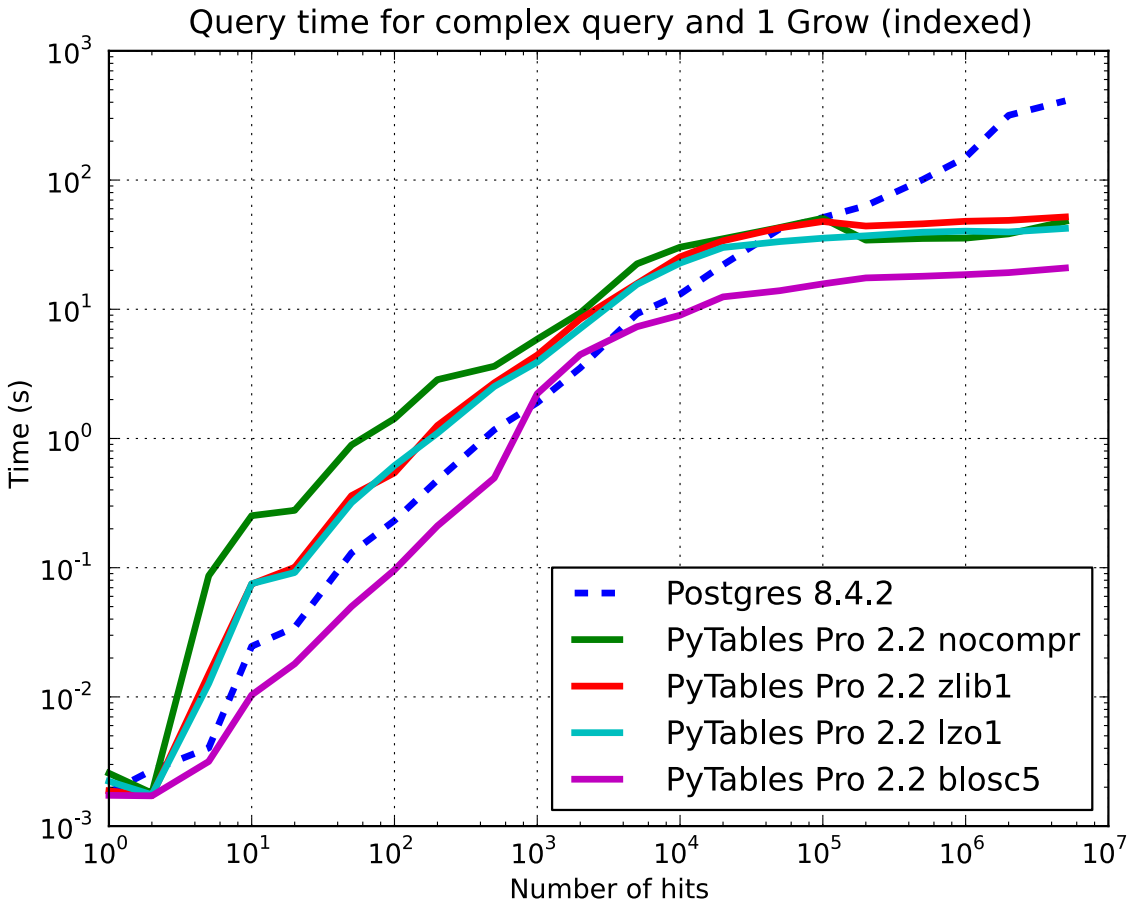
Regular and in-kernel queries



Customizable indexes



Indexed query performance



Concepts to take home

- PyTables is optimized to deal with data on disk
- Most of the operations use the iterator/ generator machinery in Python: the goal is not to bloat memory with data
- Queries, indexes and out-of-core operations are good examples of the above