

Live coding

bringing scientific computing to life

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THE AUSTRALIAN NATIONAL UNIVERSITY



Live (interactive) programming

tight feedback loop between programmer **action** and system **reaction**, between **intuition** and **validation**

not so common in HPC (for a variety of socio-technical reasons) although people are starting to talk about real-time/online—streaming, in-situ analysis etc.

(lisp)



Extempore

<https://github.com/digego/extempore>

Andrew
Sorensen

OSCON
OPEN SOURCE CONVENTION



native code
efficiency

+

dynamic
interactivity

JIT-compiled on the
node with LLVM

no-restart hot-swapping
of functions, variables

From multimedia arts to HPC

music = real-time DSP

- need **efficiency**: native code, no interpreter
- need **determinism**: no garbage collector
- need **interoperability**: native interface to C/Fortran lib

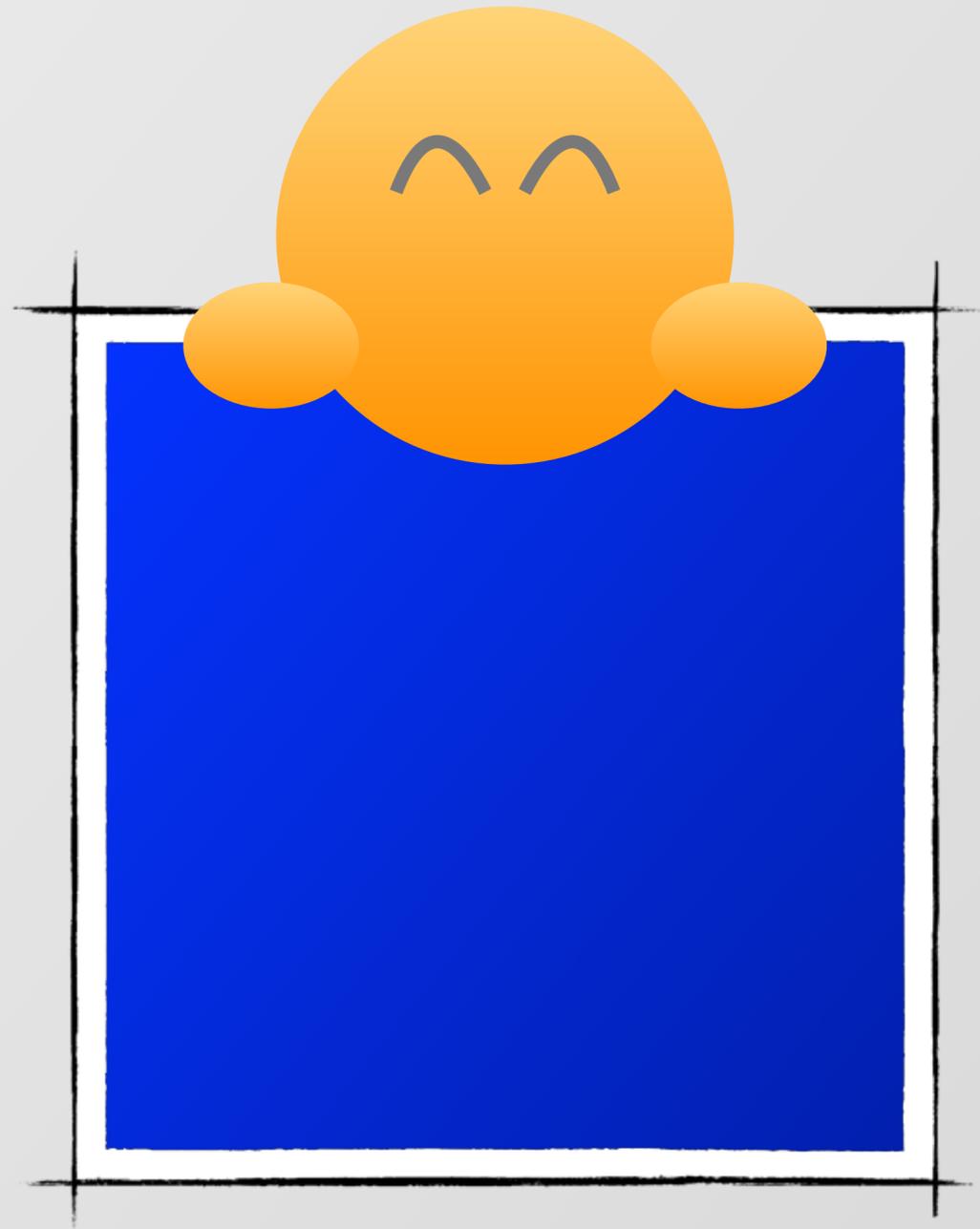
some overlap with scientific & numerical computing

(lisp)



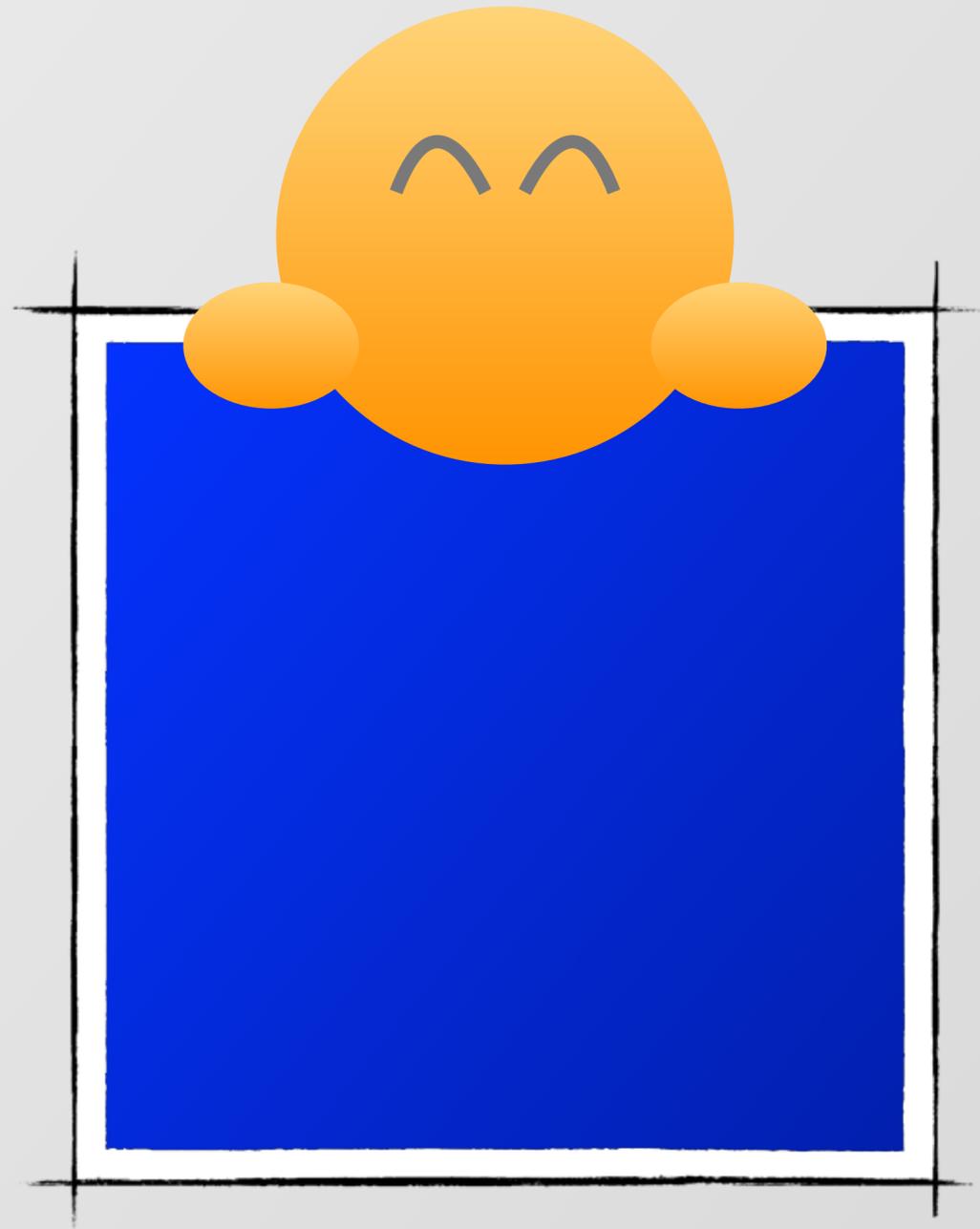
but what does *liveness*
mean in HPC?

**traditional HPC
workflow**



source code

compile



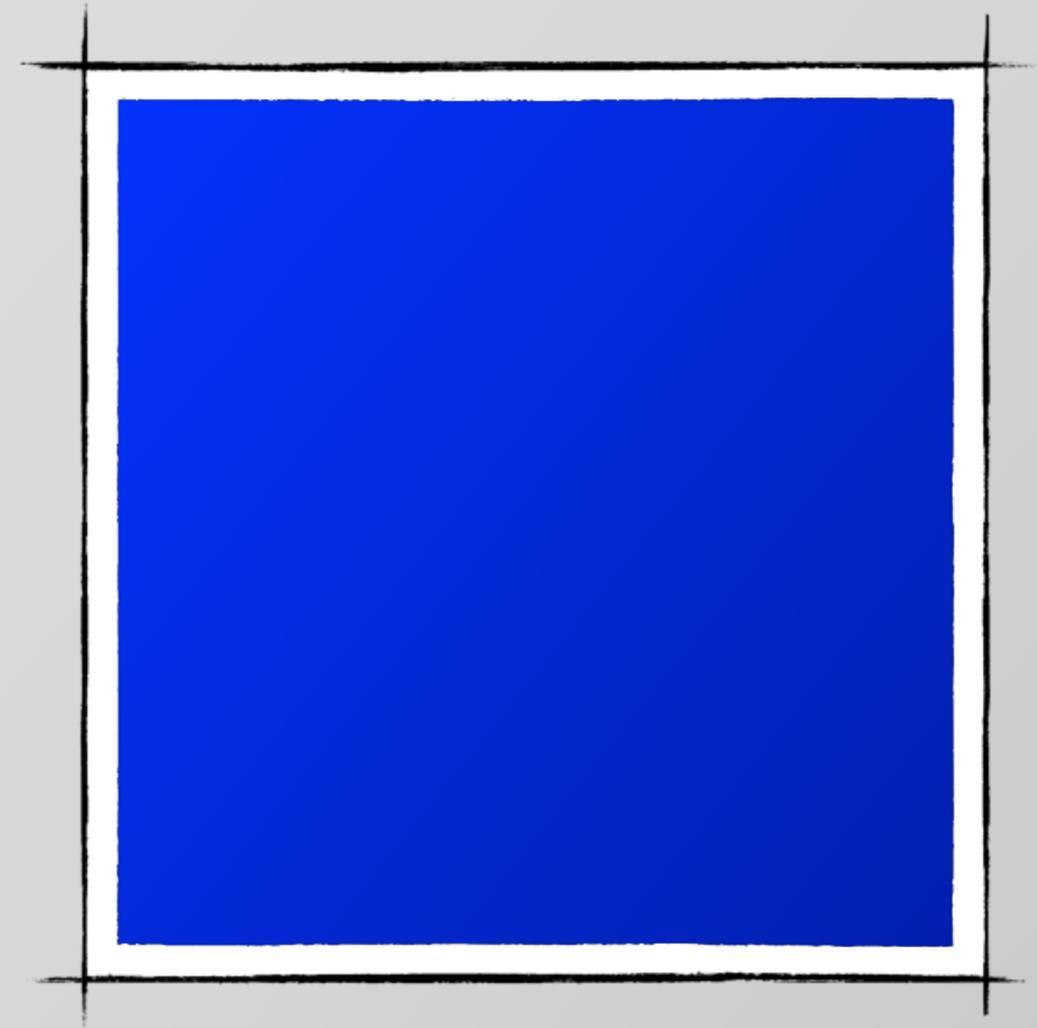
source code

run

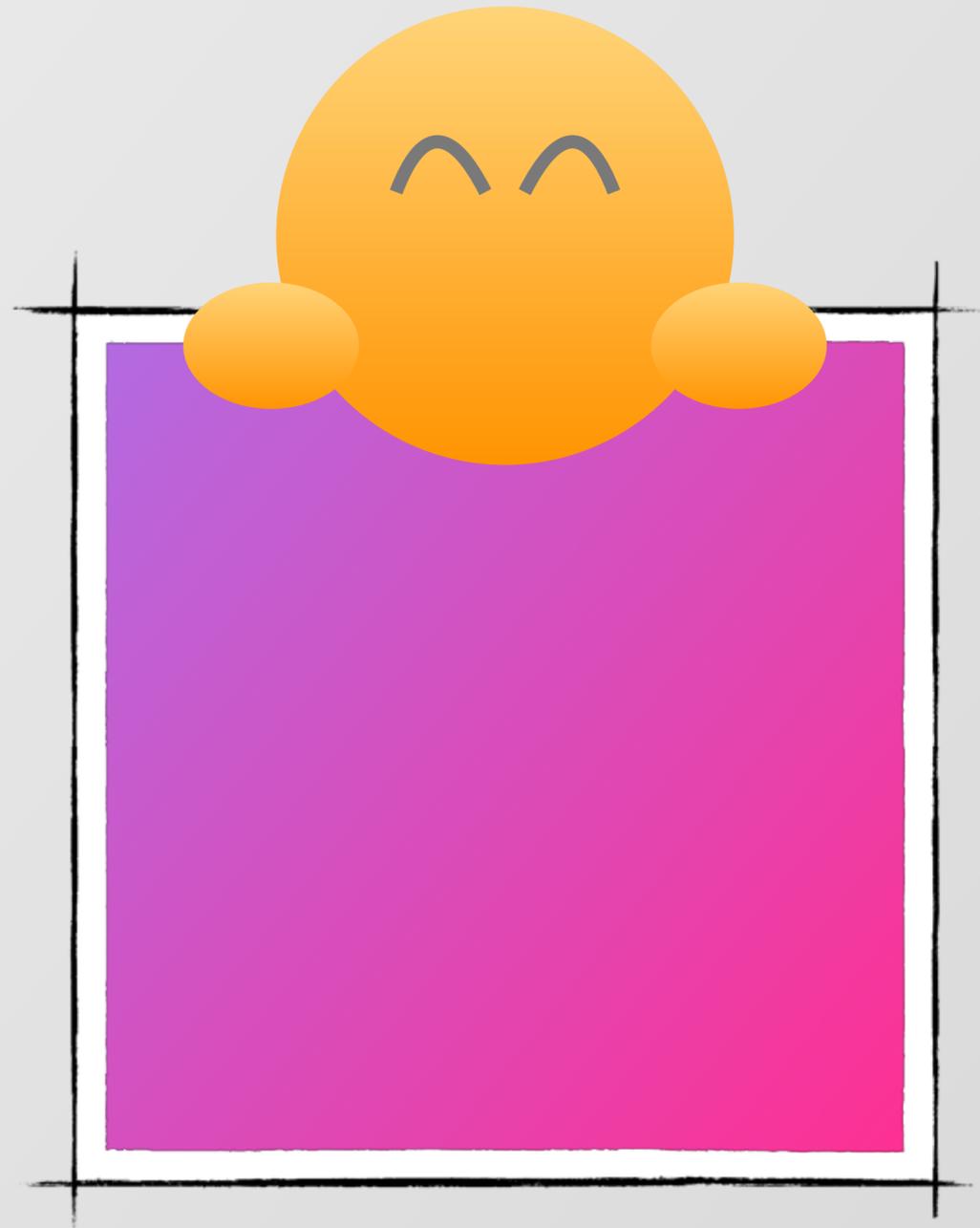
running program



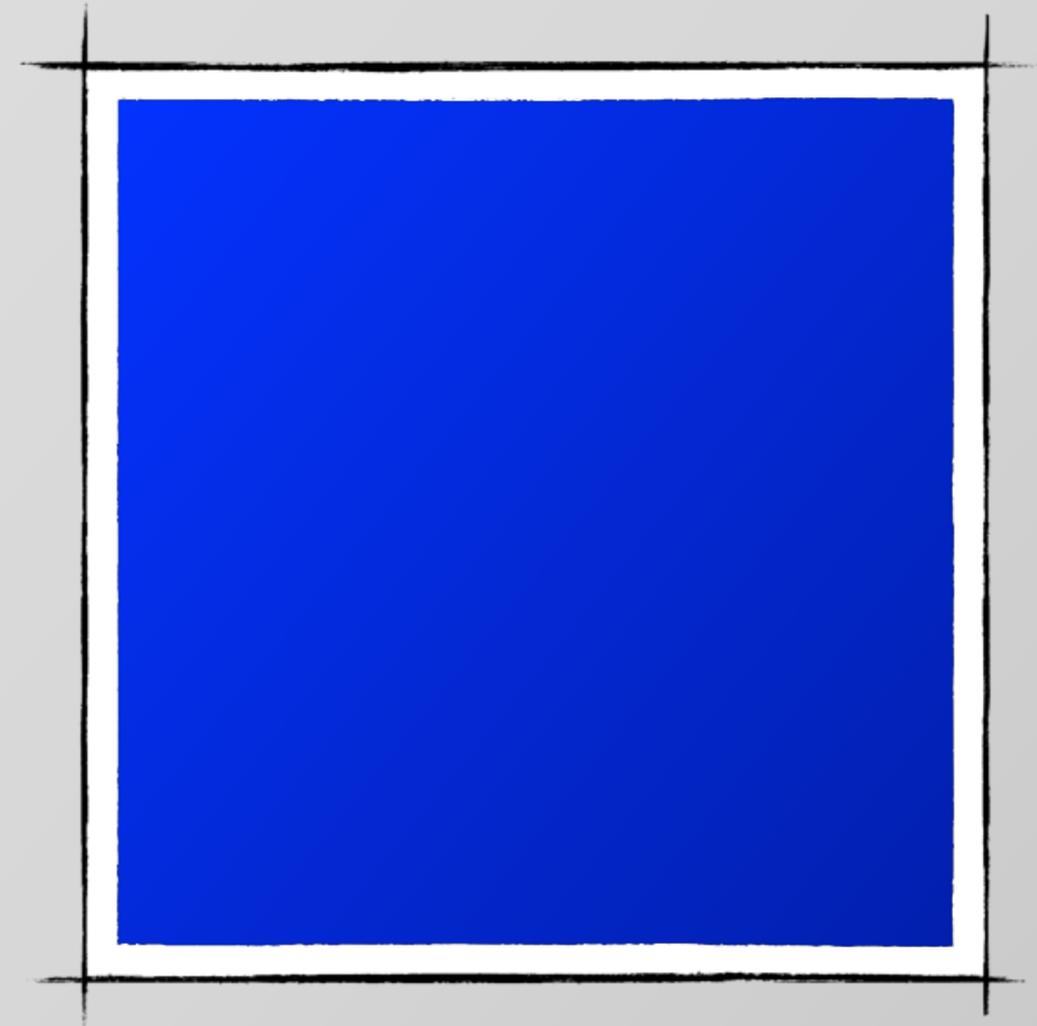
source code



running program



source code

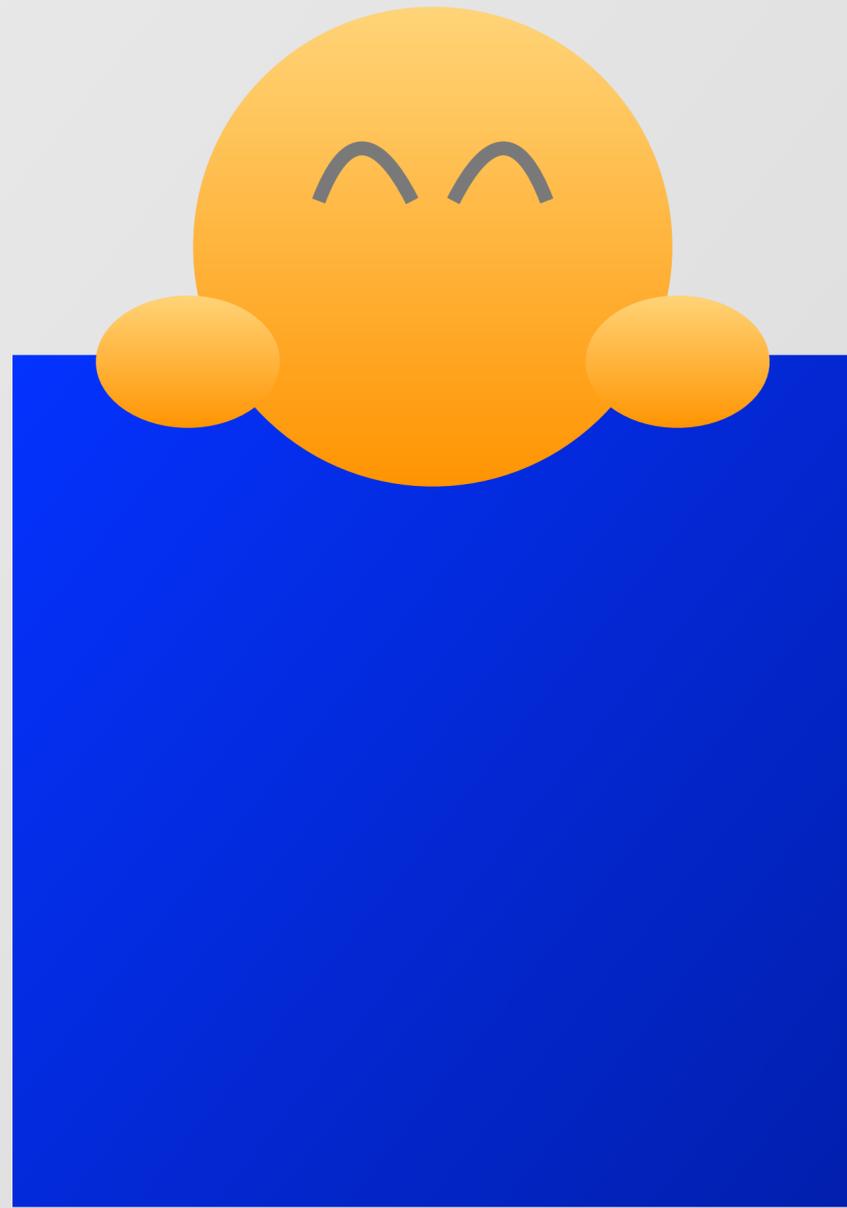


running program

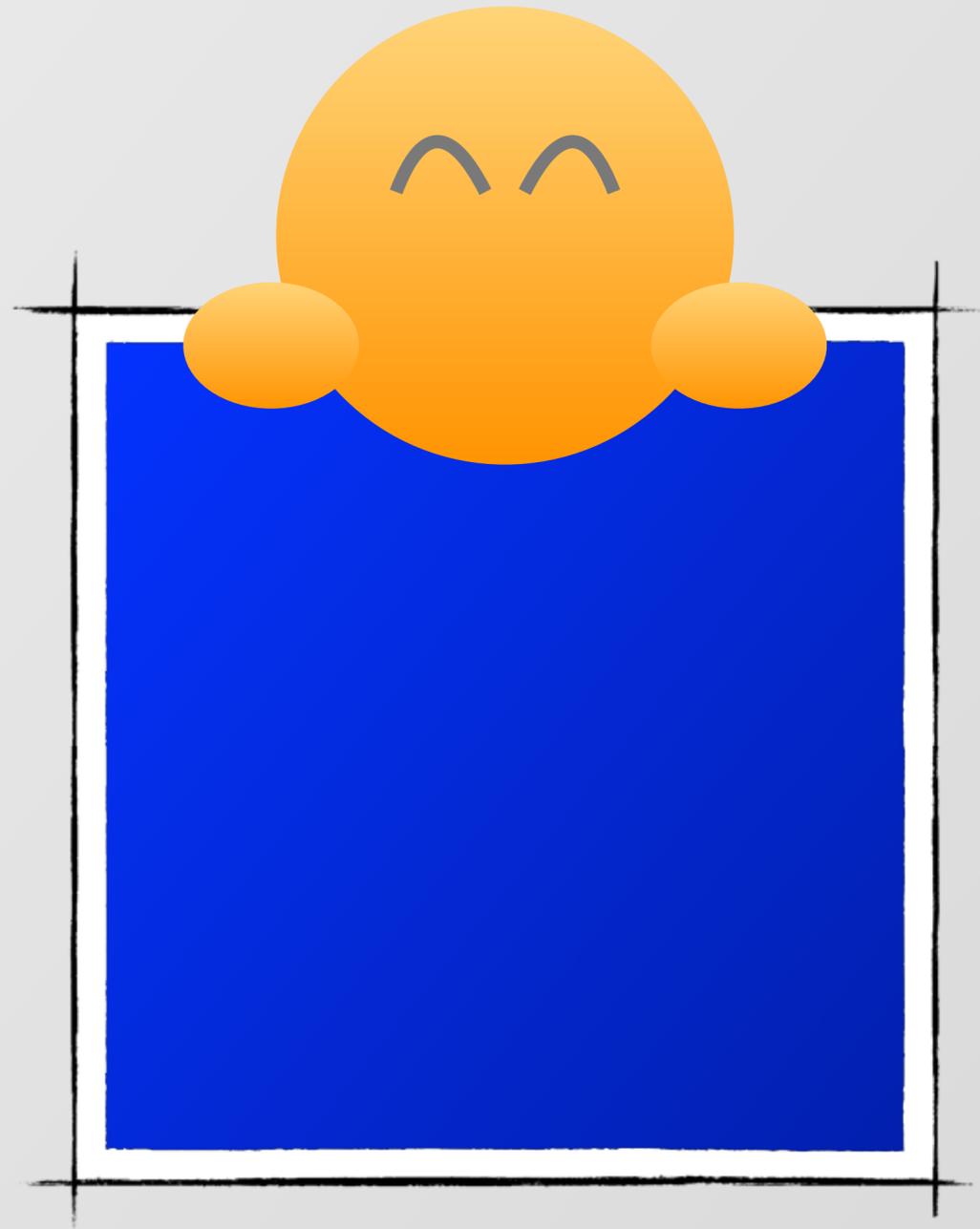
this can be **tedious**,
especially in the early stages

and we discard
useful **program state**

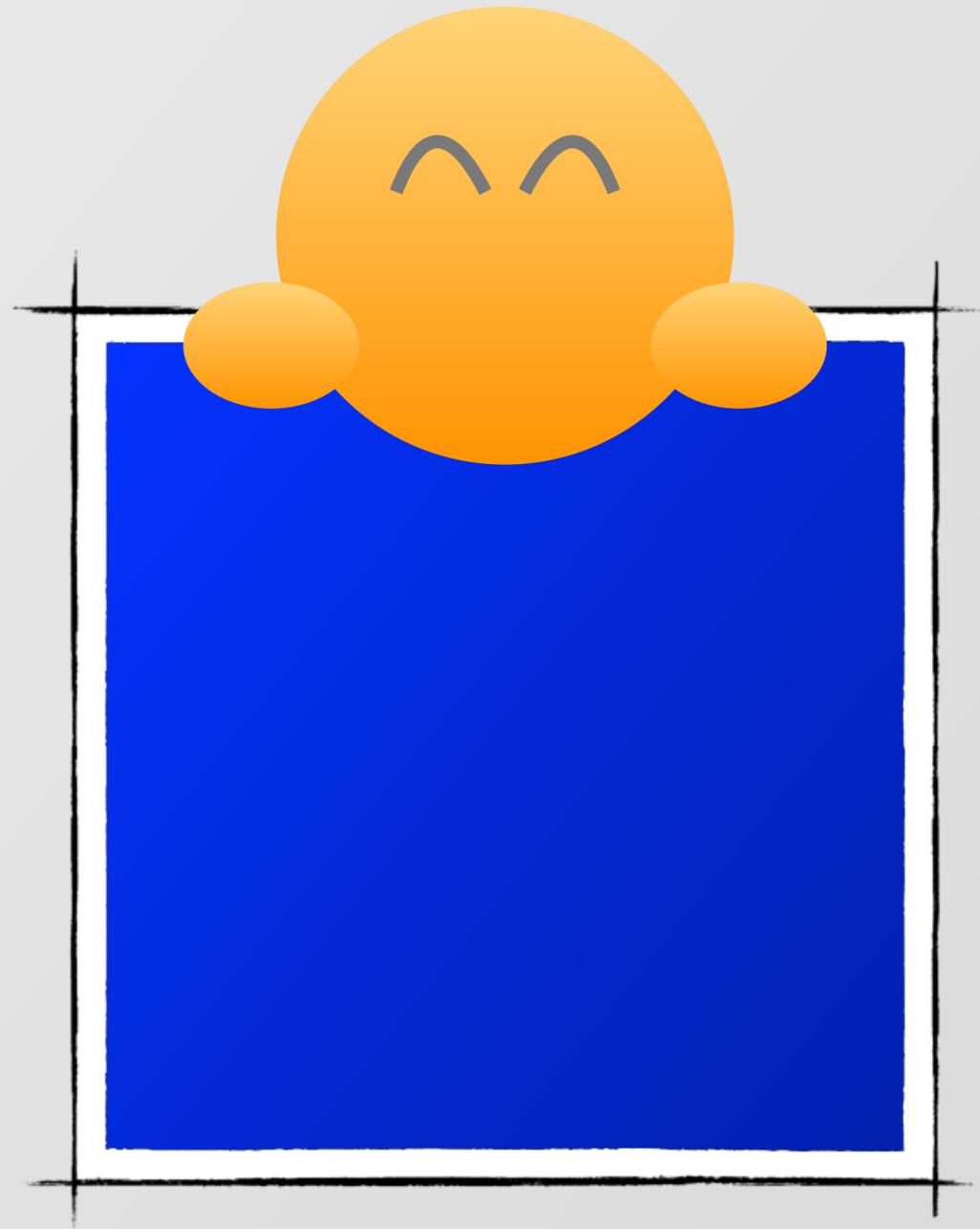
live programming
workflow



source code

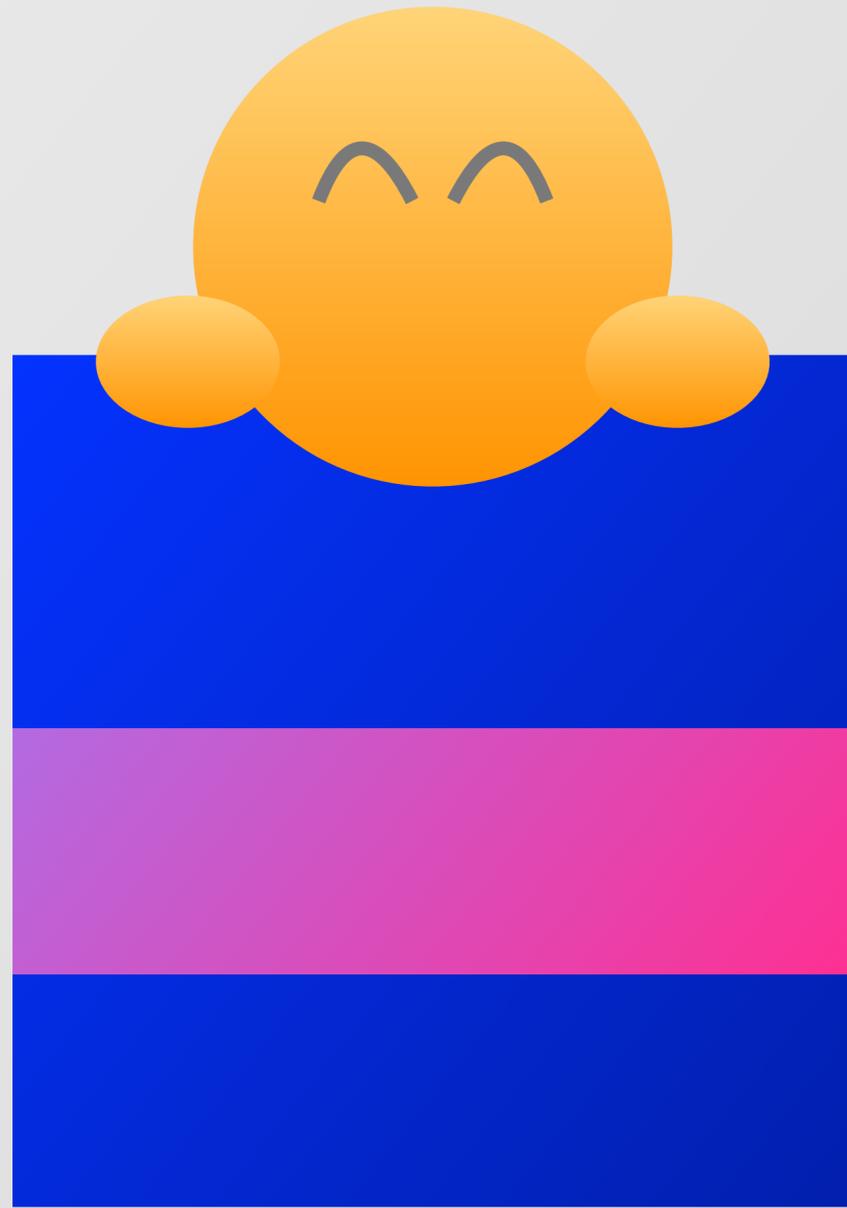


source code

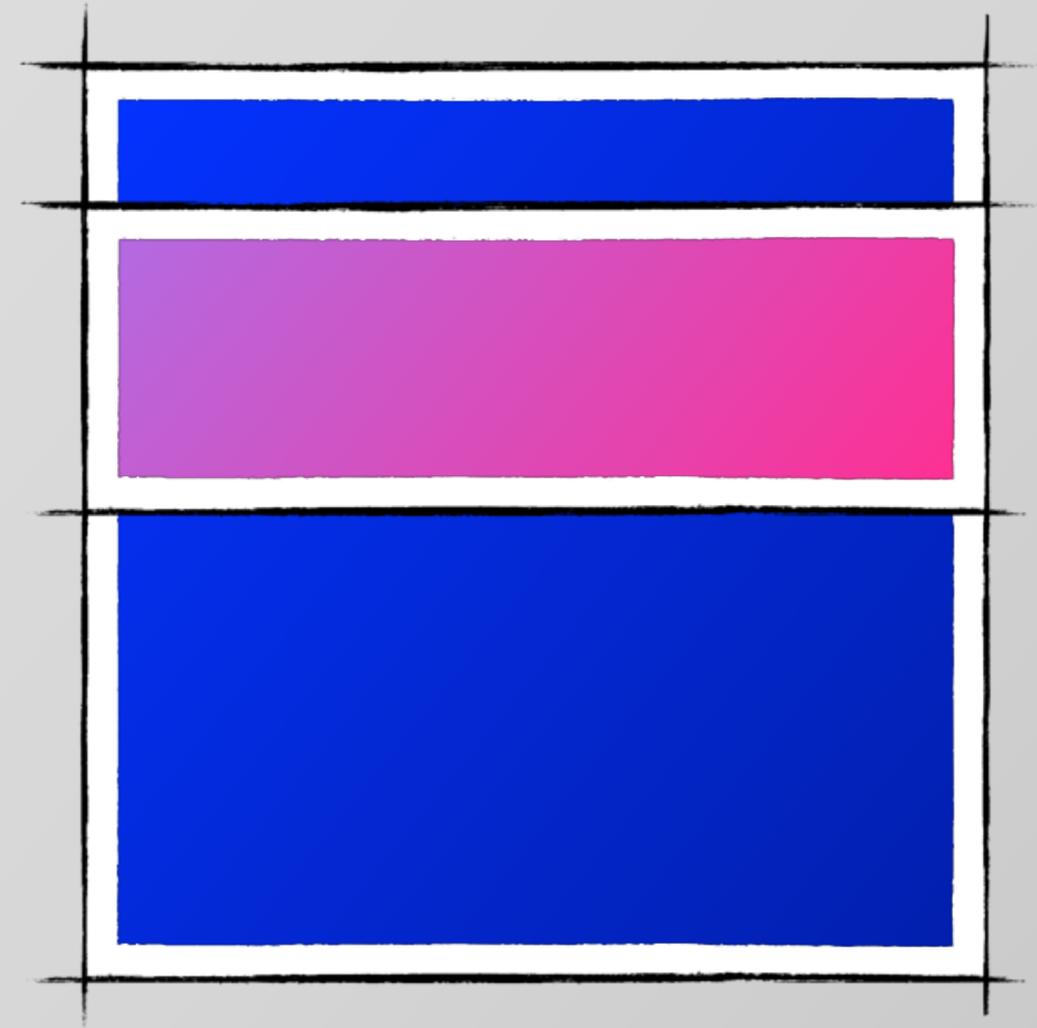


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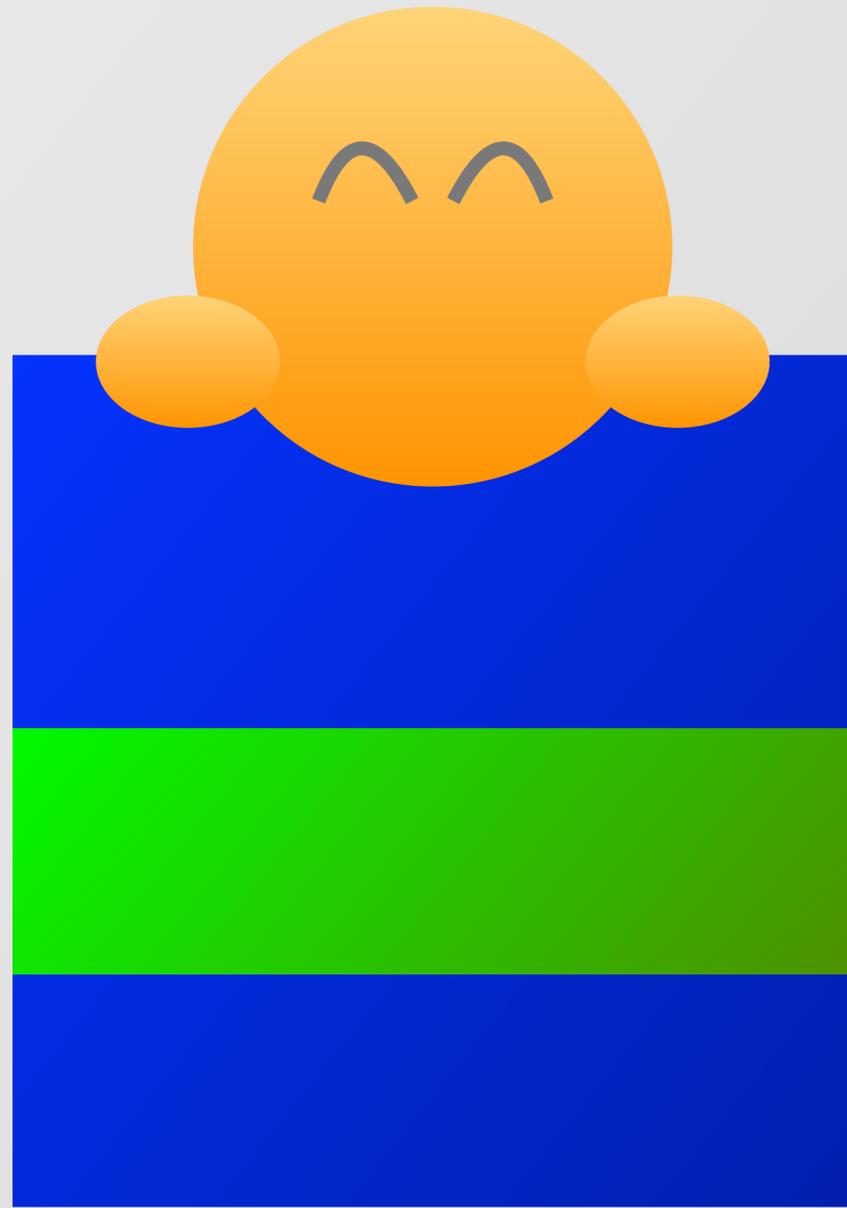
running program



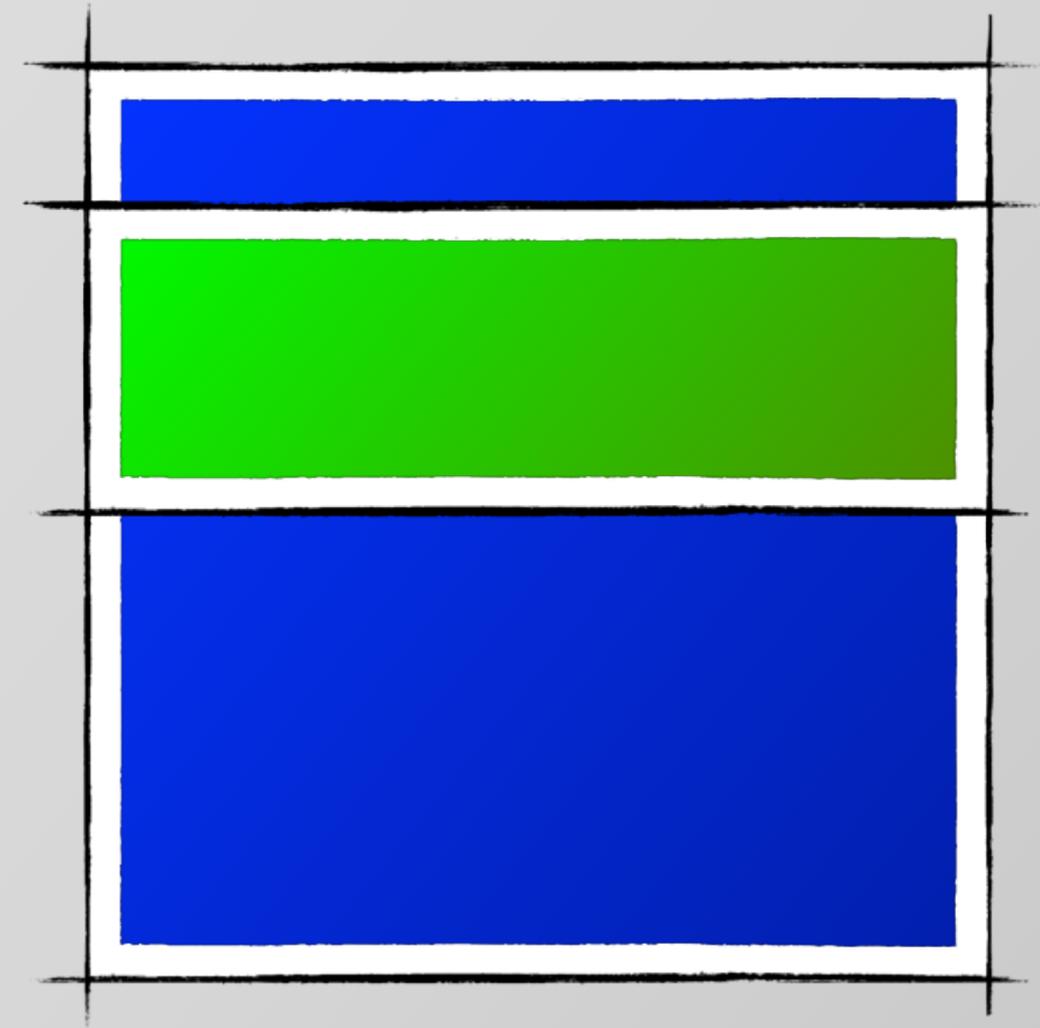
source code



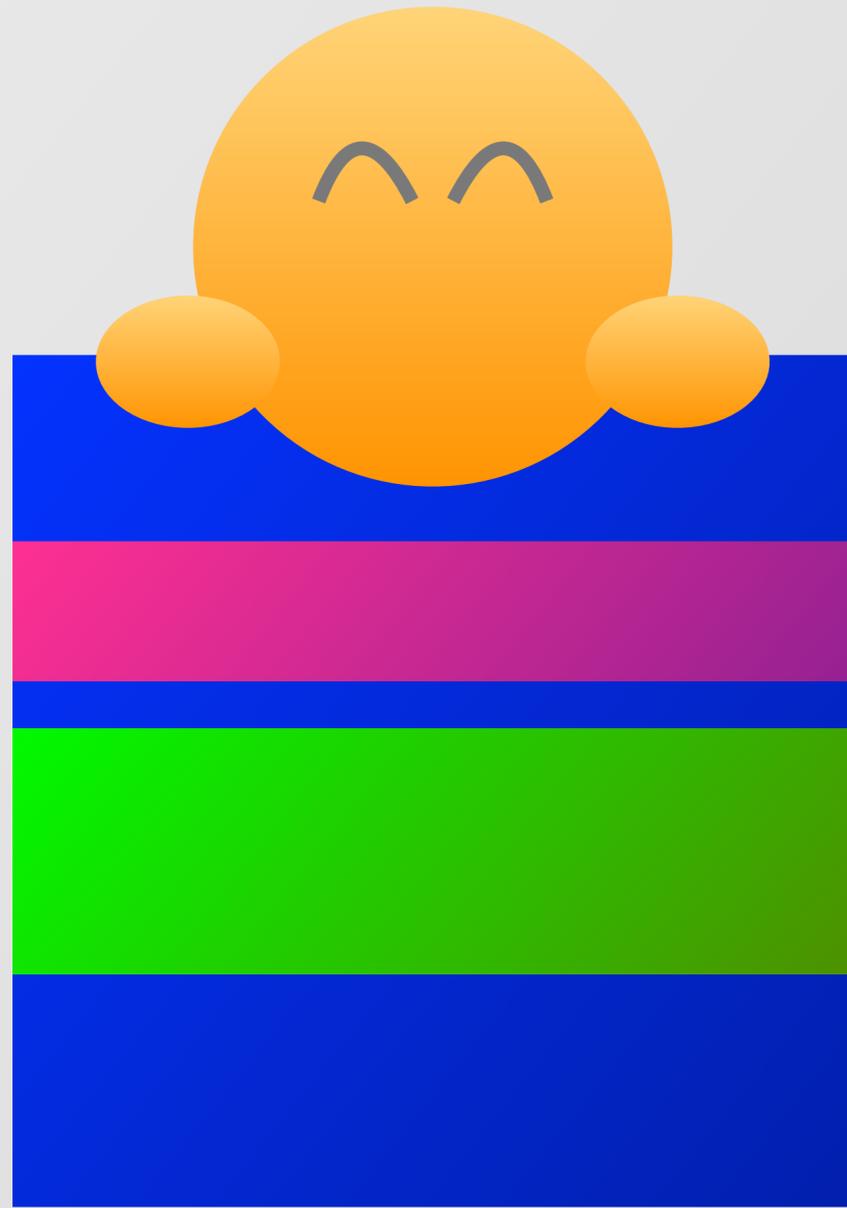
running program



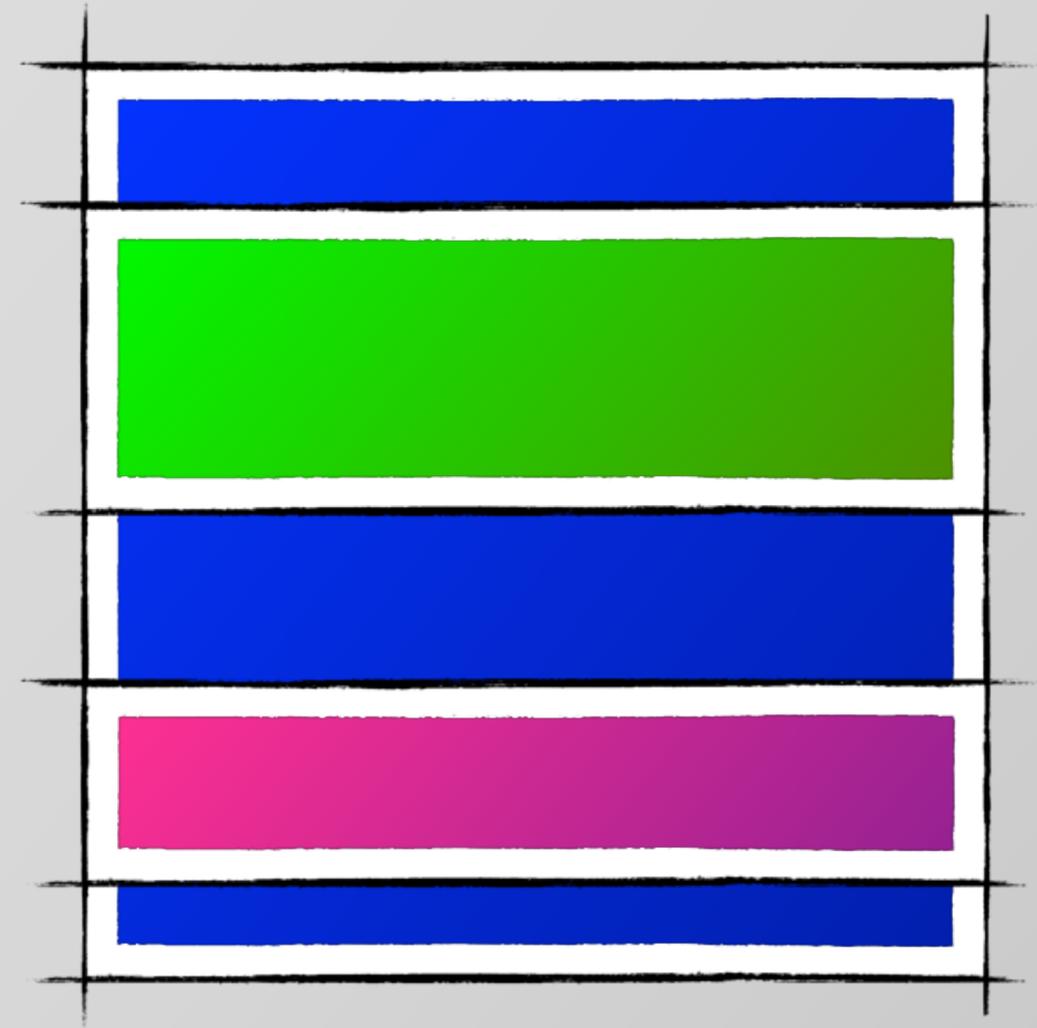
source code



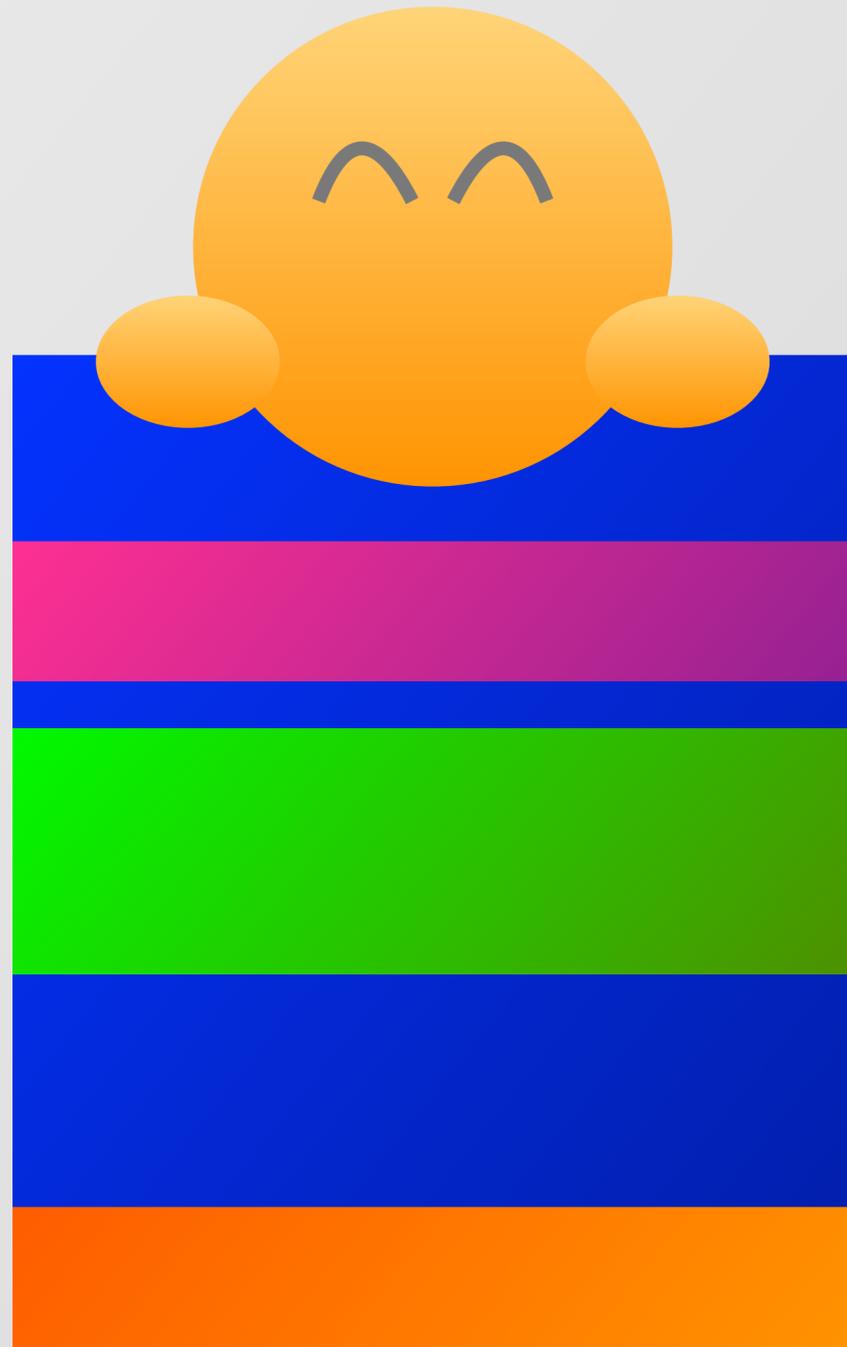
running program



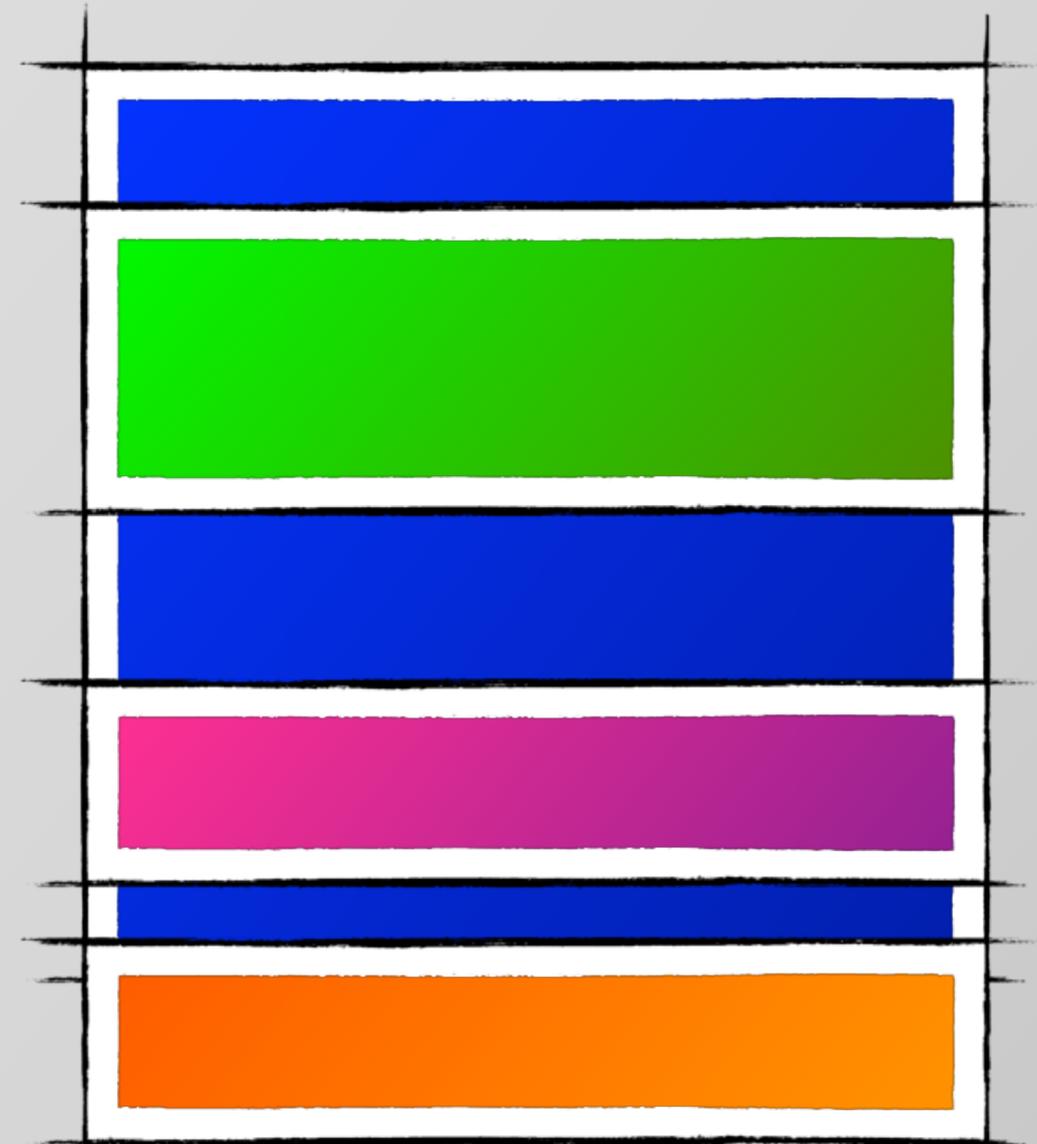
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running program



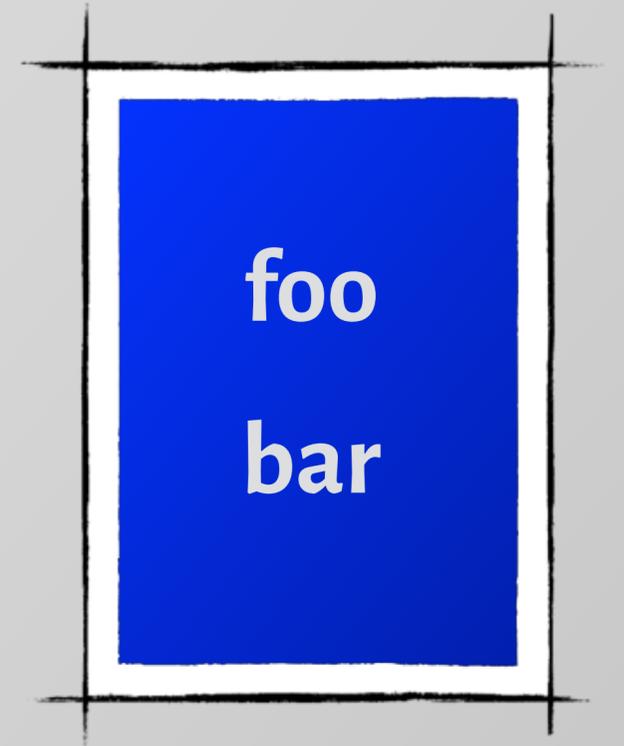
source code



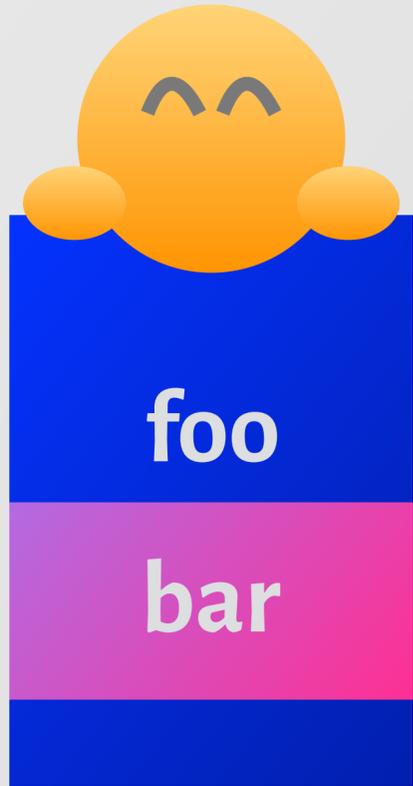
running program



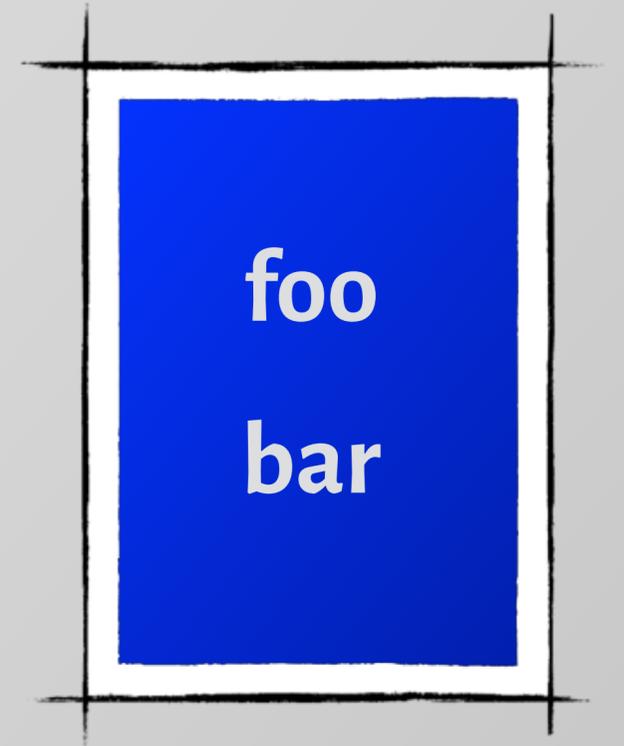
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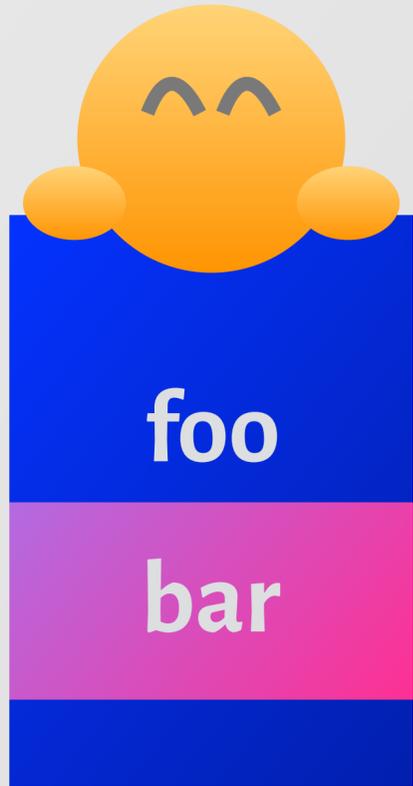
running program



source code



running program



source code

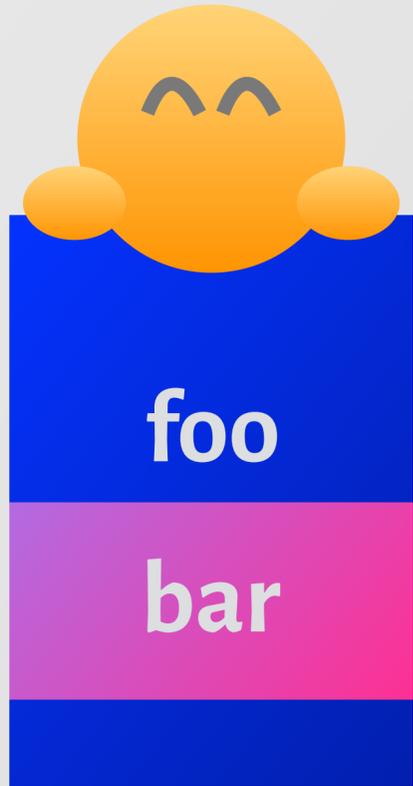


```
define i32 @bar
entry:
store i32* %x
ret %x
```

LLVM IR



running program

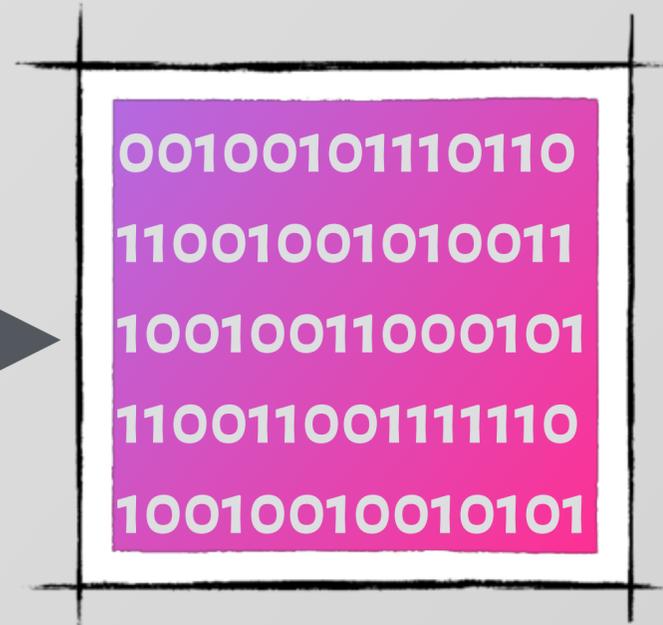


source code

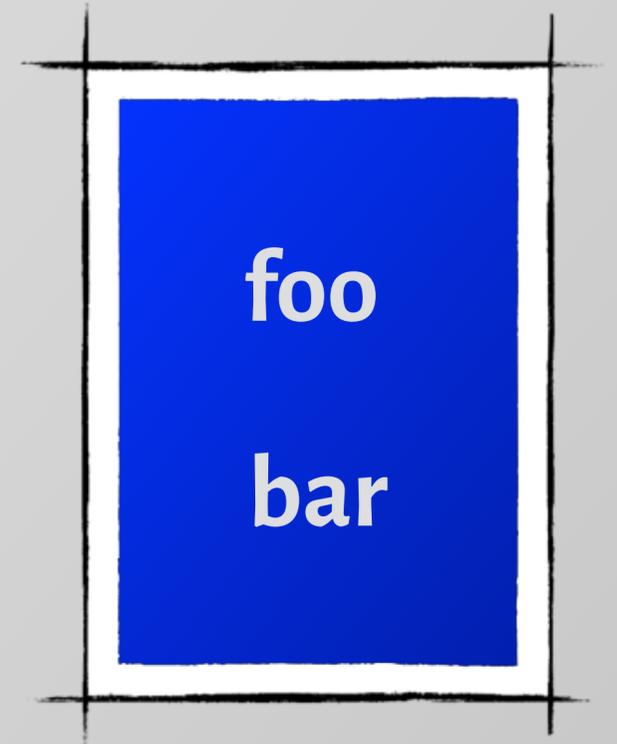


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ret %x
```

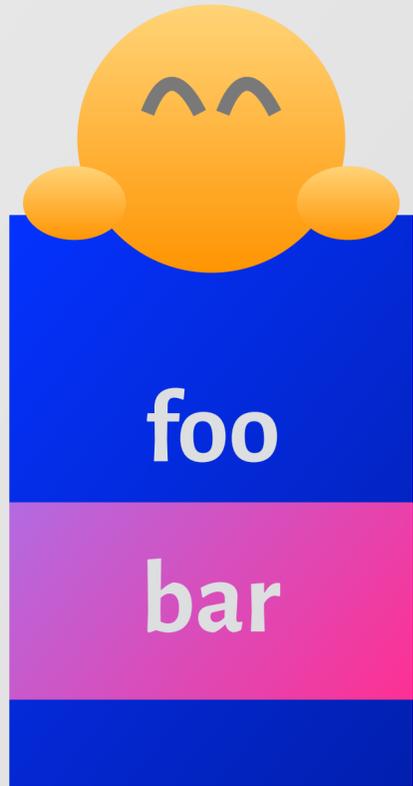
LLVM IR



native
code



running program

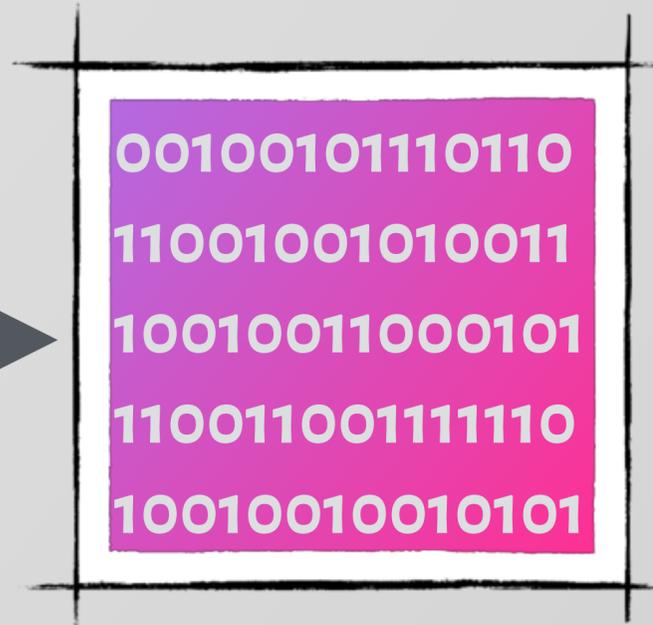


source code

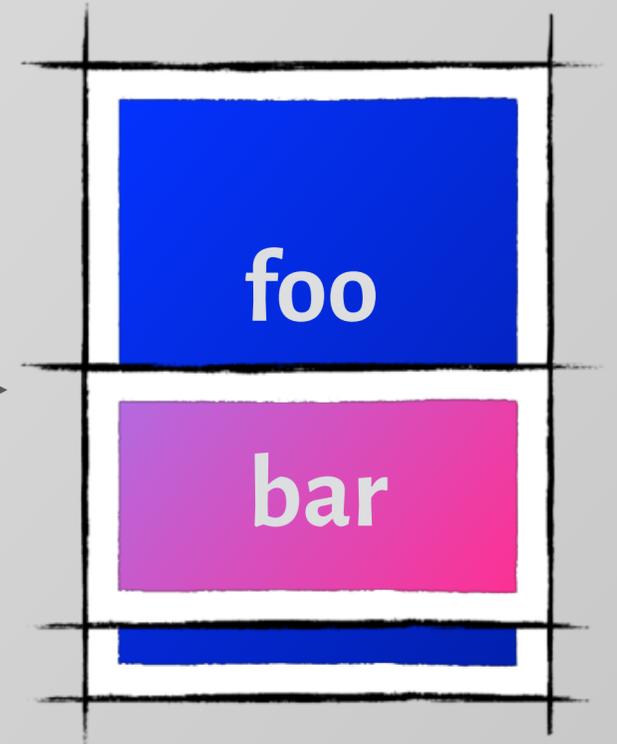


```
define i32 @bar
entry:
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ret %x
```

LLVM IR



native
code



running program

But our HPC codes work pretty well...

Extempore is ABI compatible with C/Fortran, so you can

- call compiled C/Fortran routines from a shared library
- read and write directly to memory (pointers)
- use e.g. MPI for message passing, OpenMP for threading

*...all with **live** hot-swapping*

Live PIC: a case study

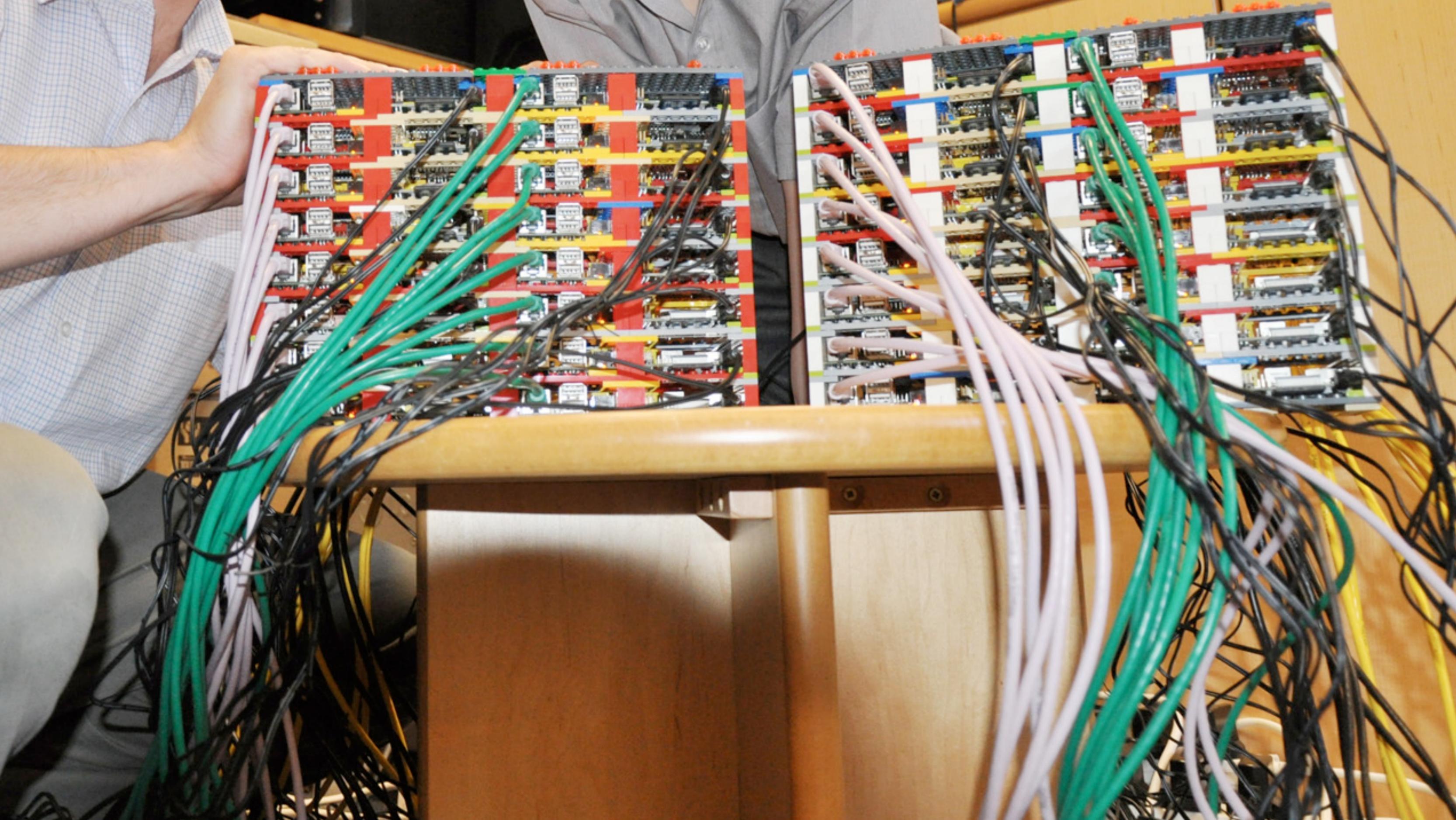
2½D electromagnetic PIC skeleton code

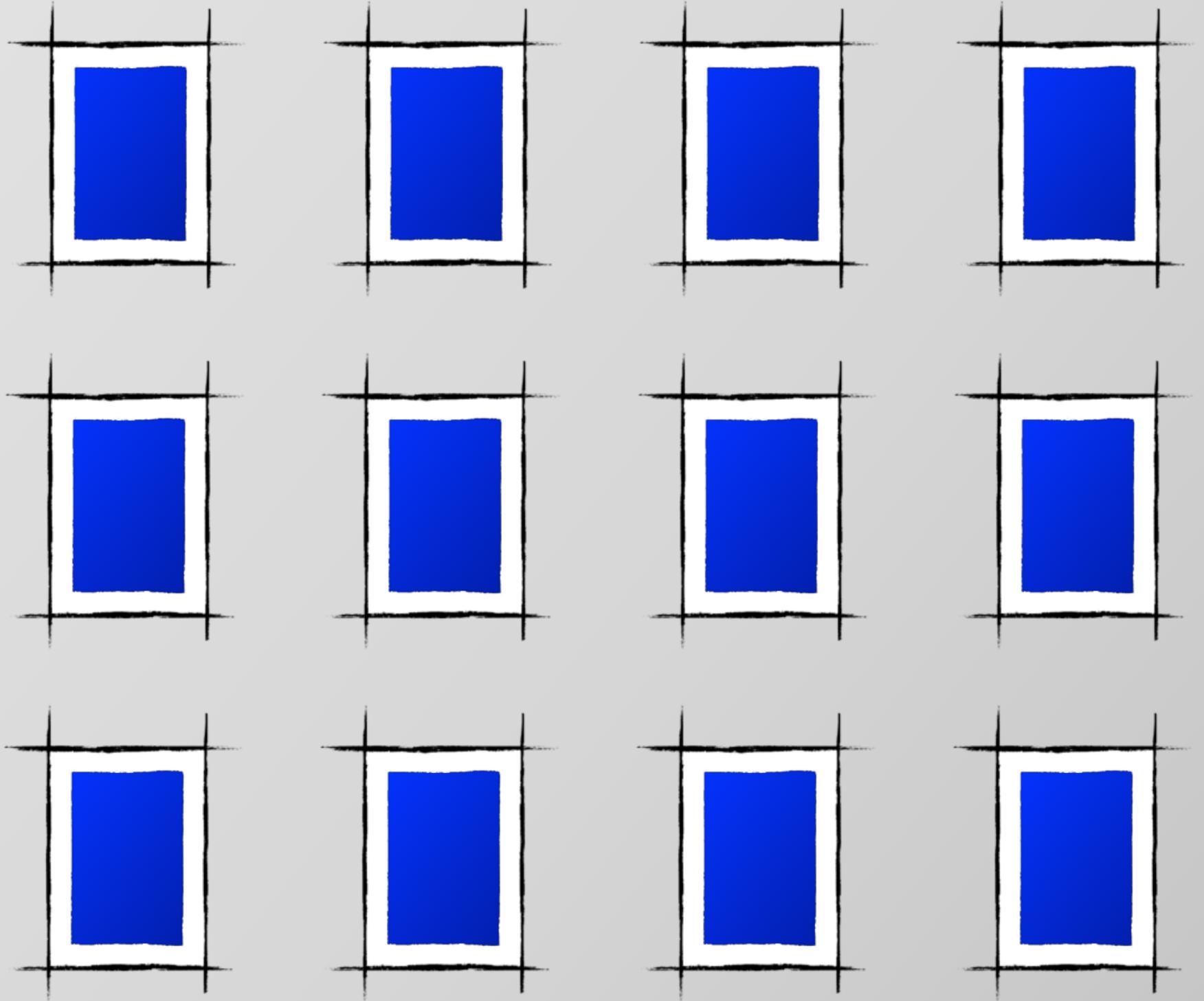
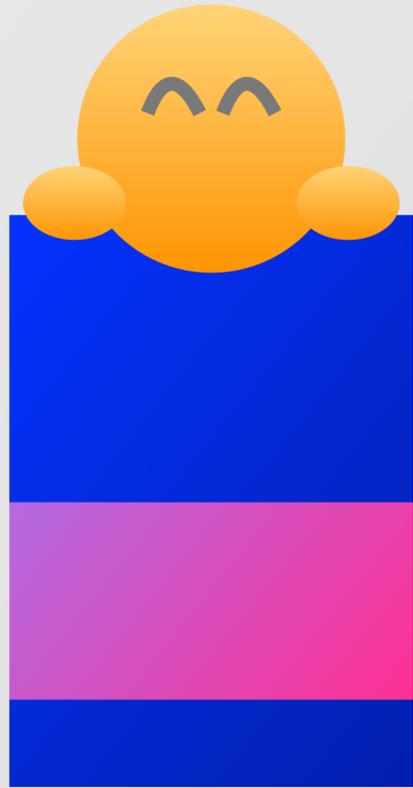
running **live**, distributed memory (MPI)

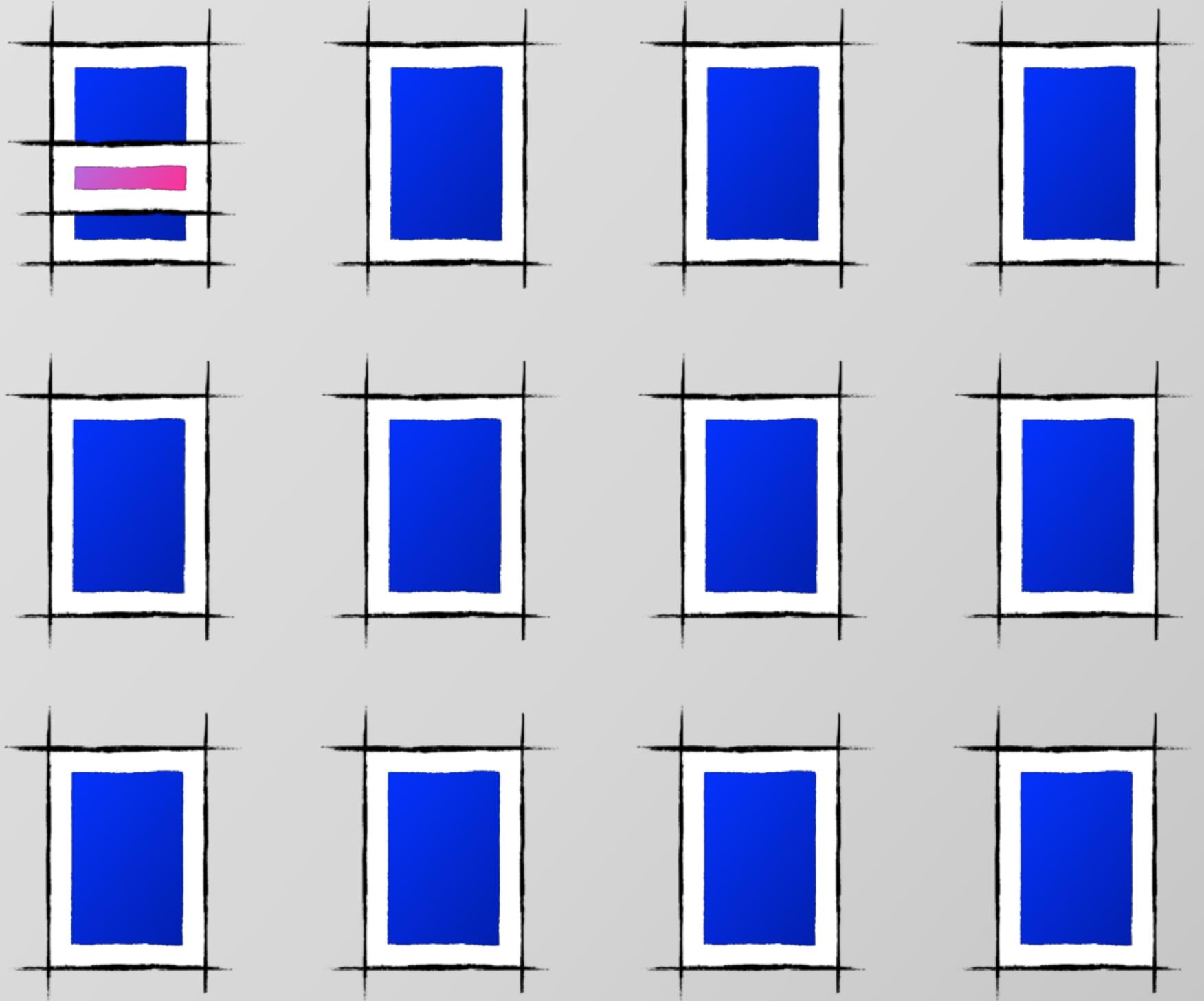
on my laptop (for practical reasons) but could be on a cluster

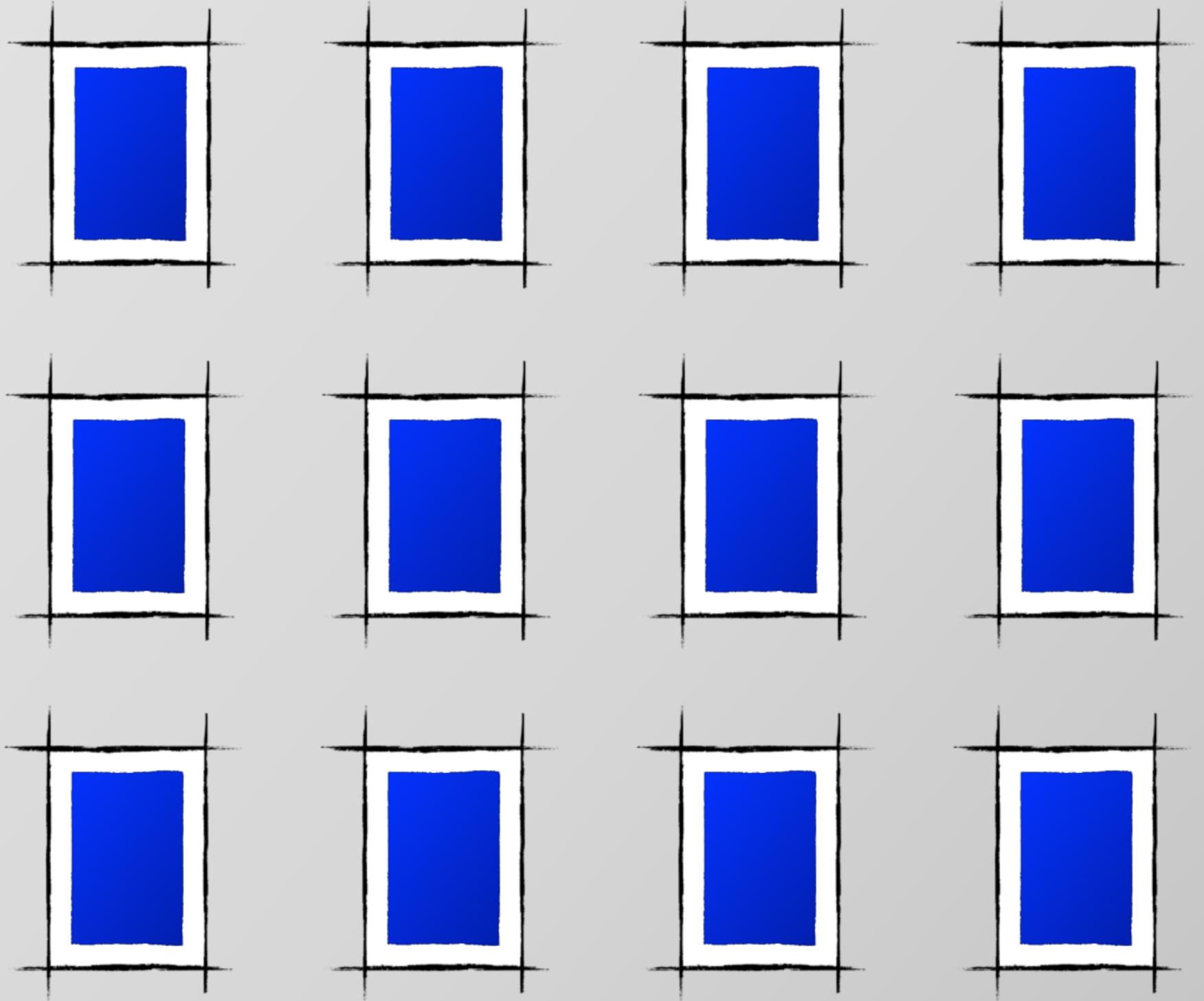
visualisation code also live, running on head node

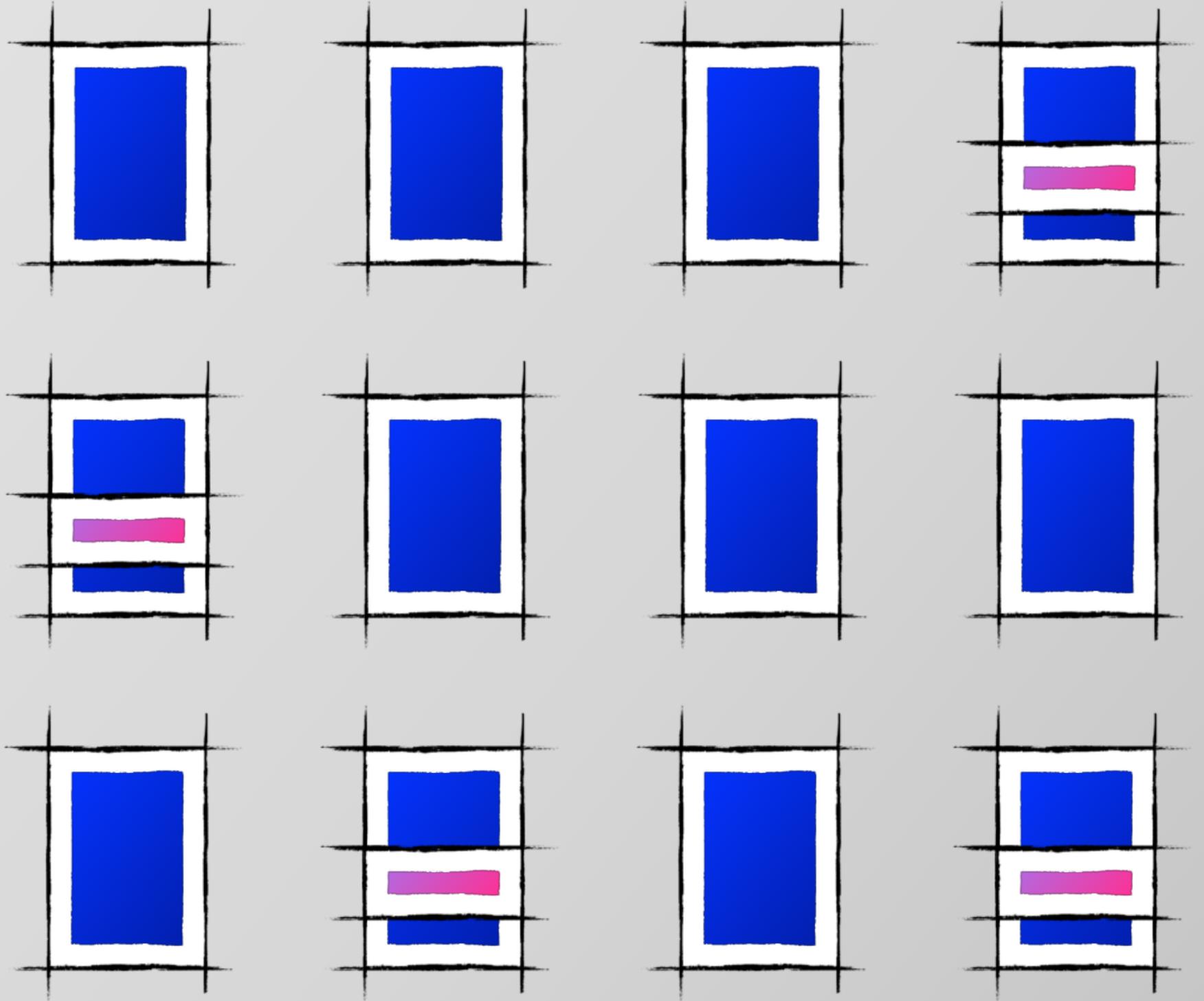
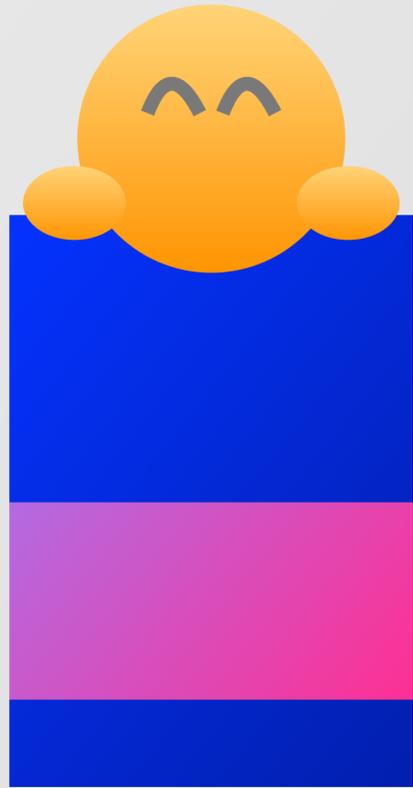


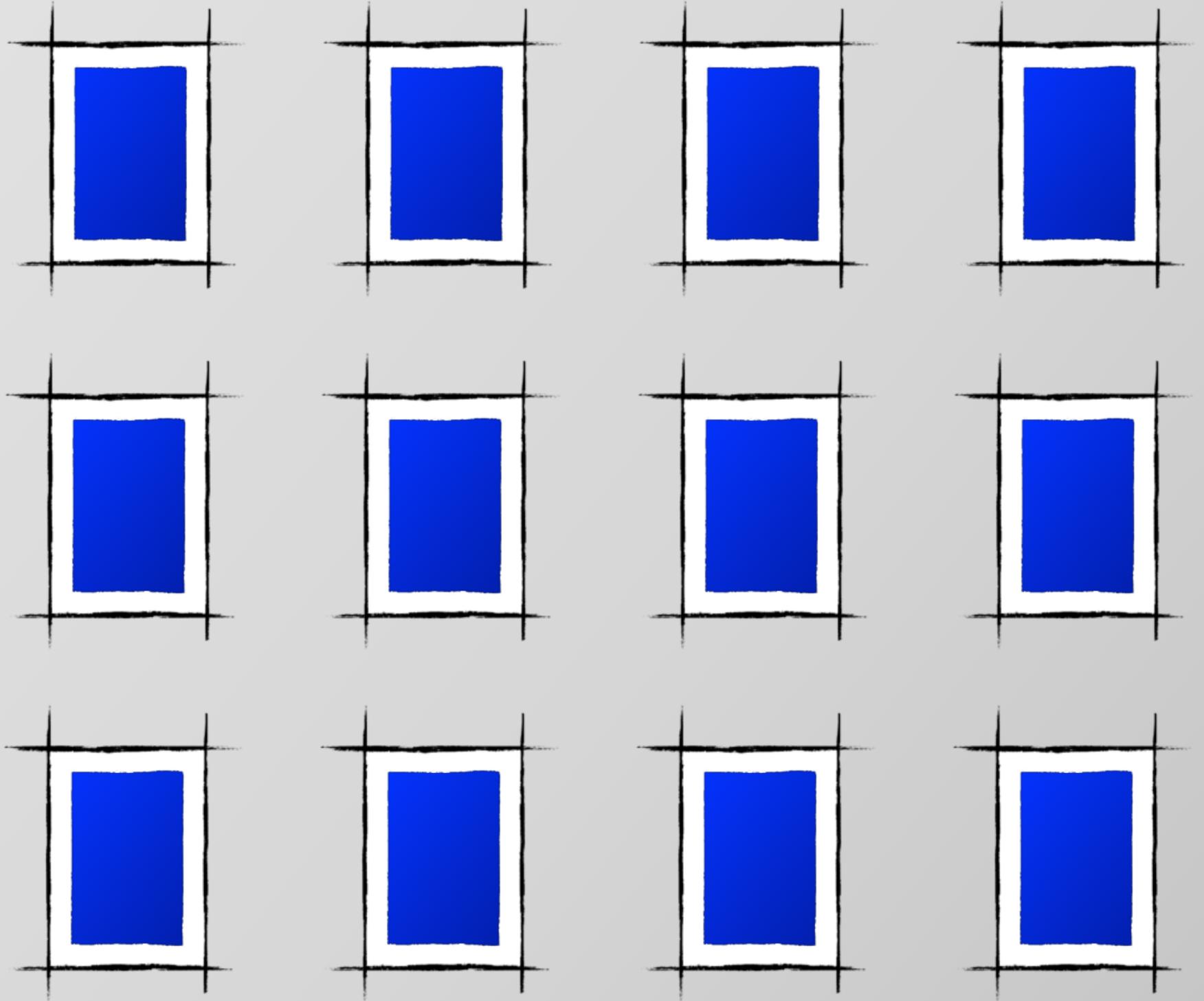
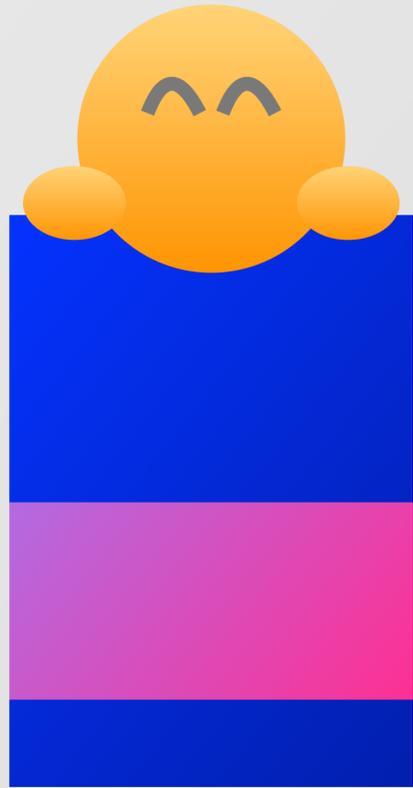


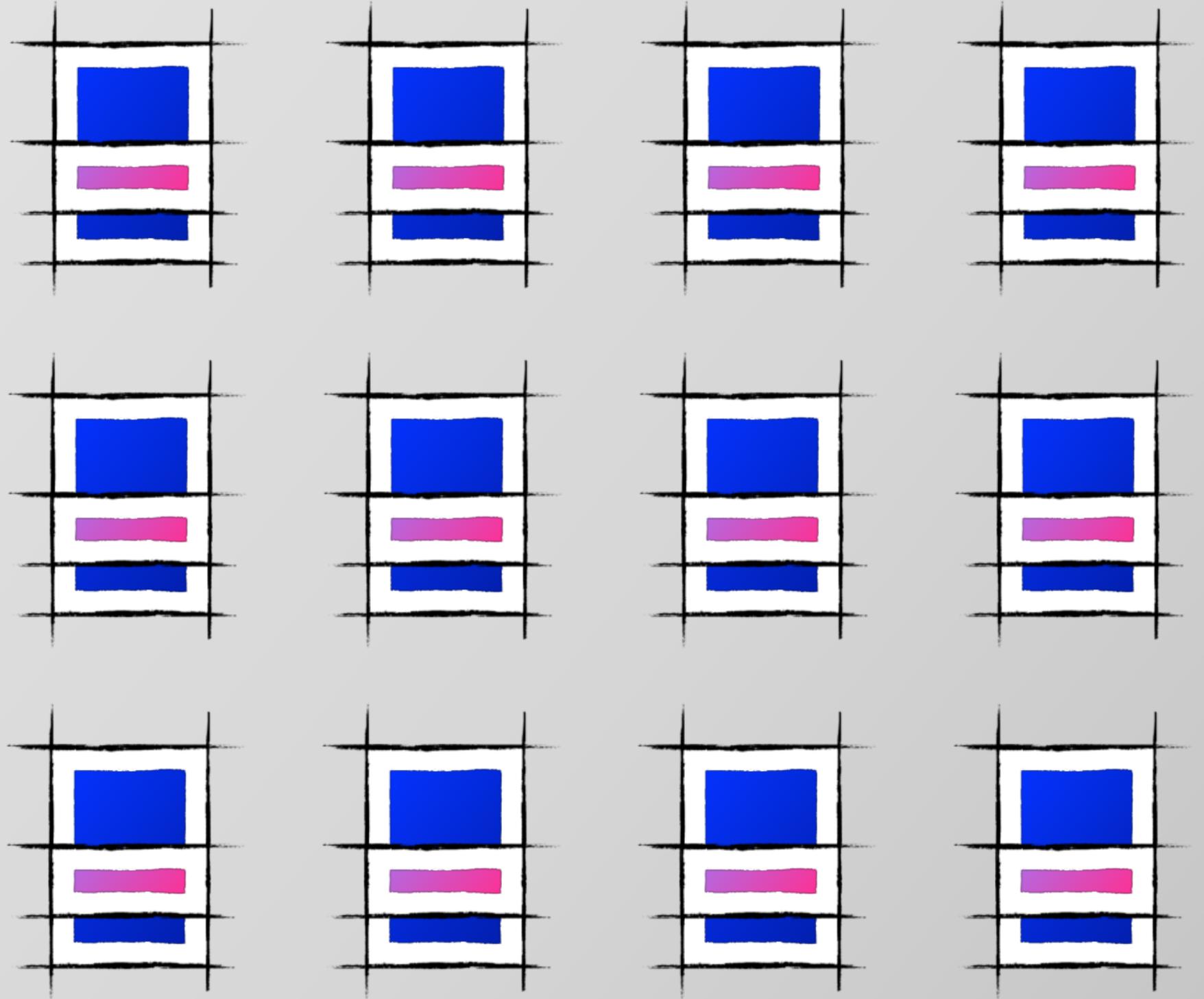


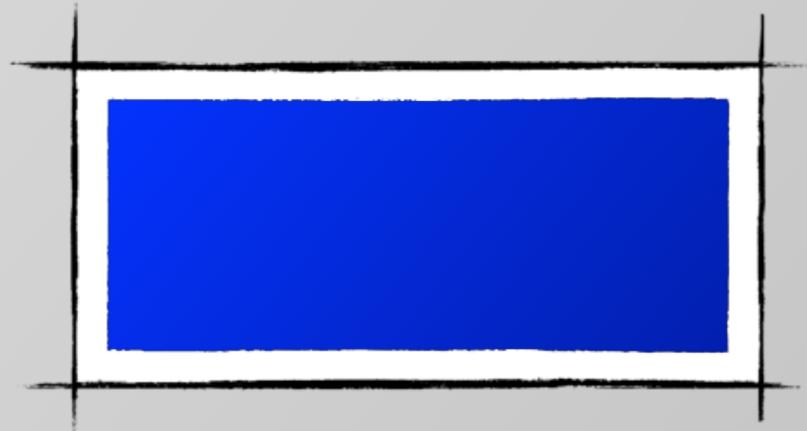
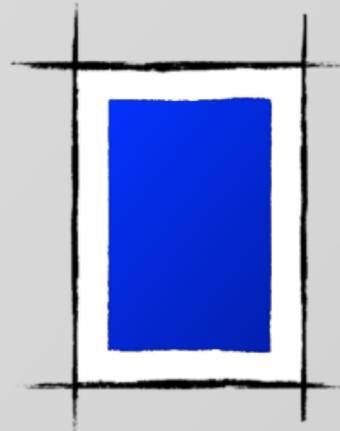
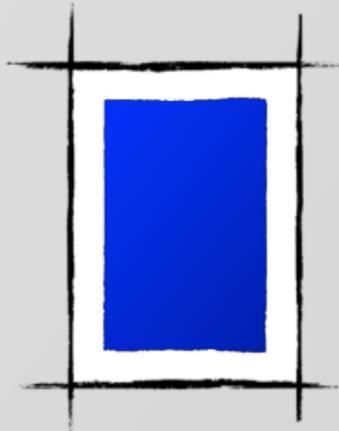
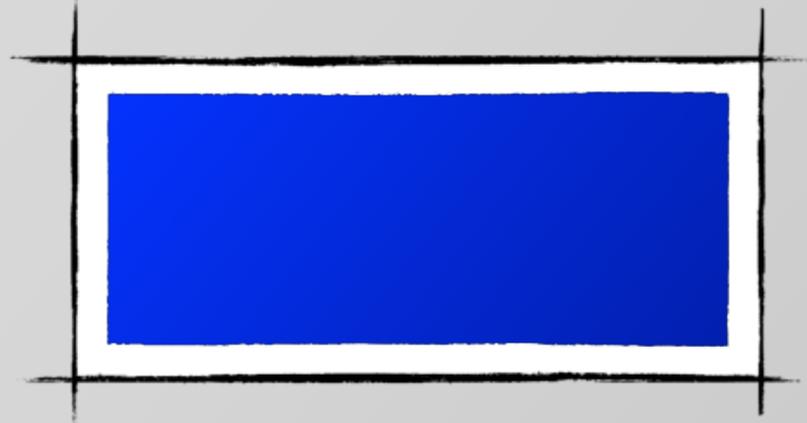
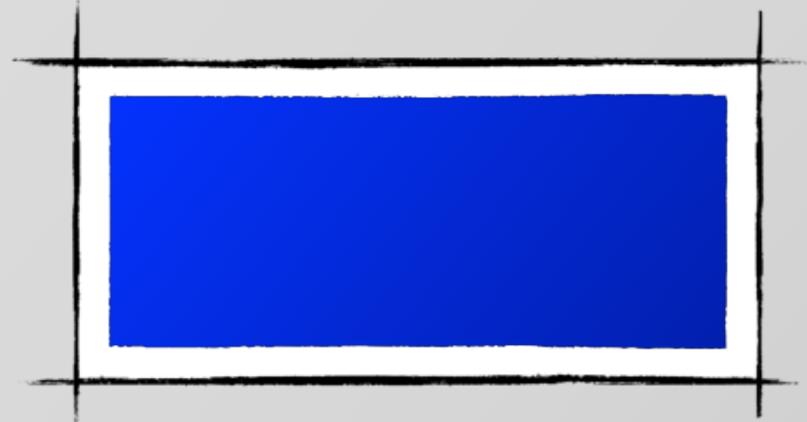
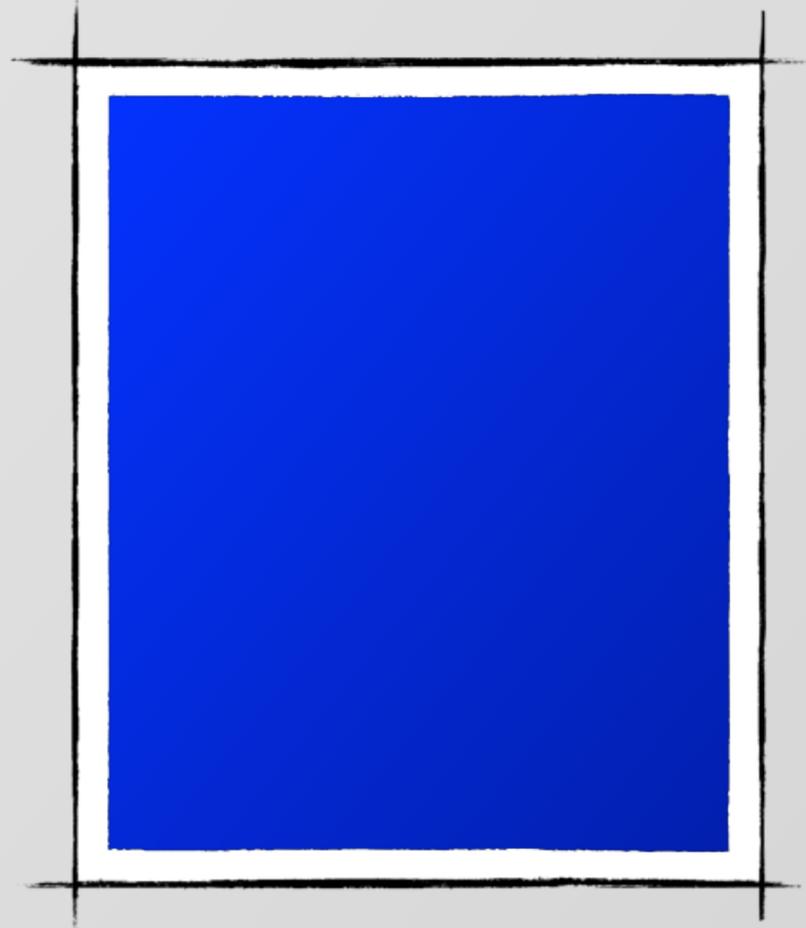


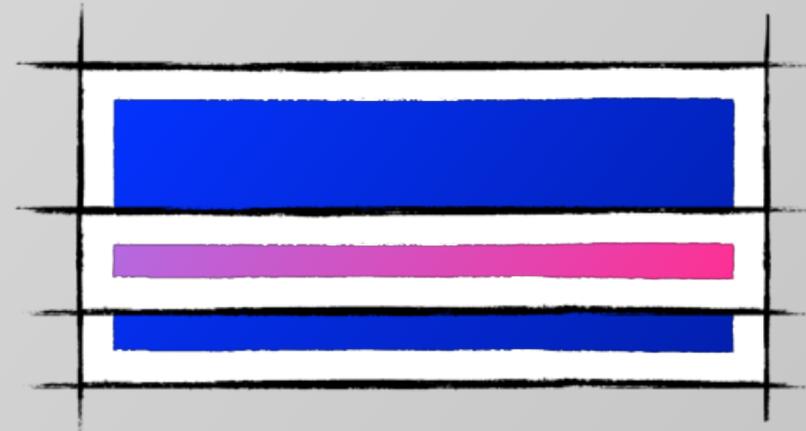
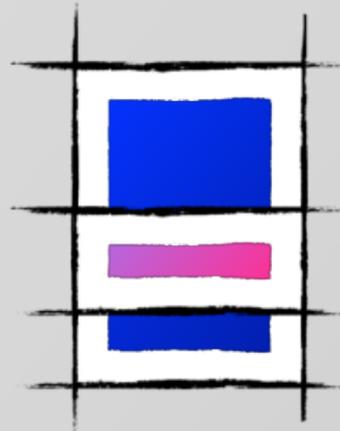
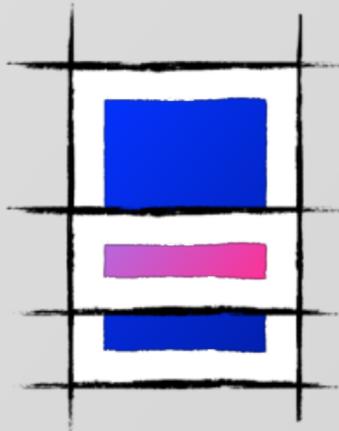
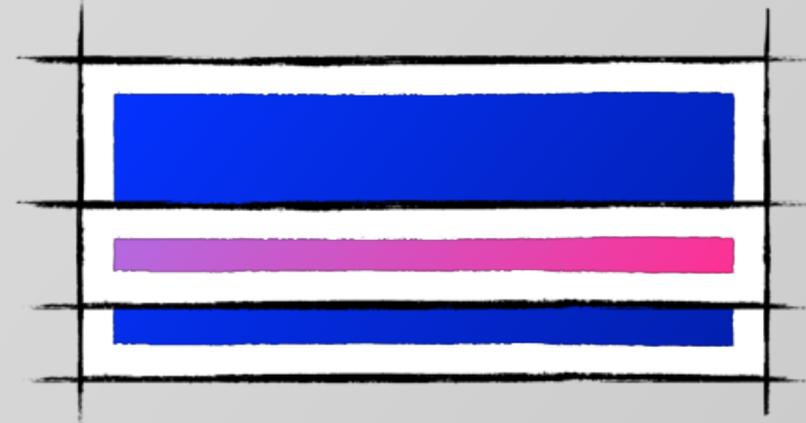
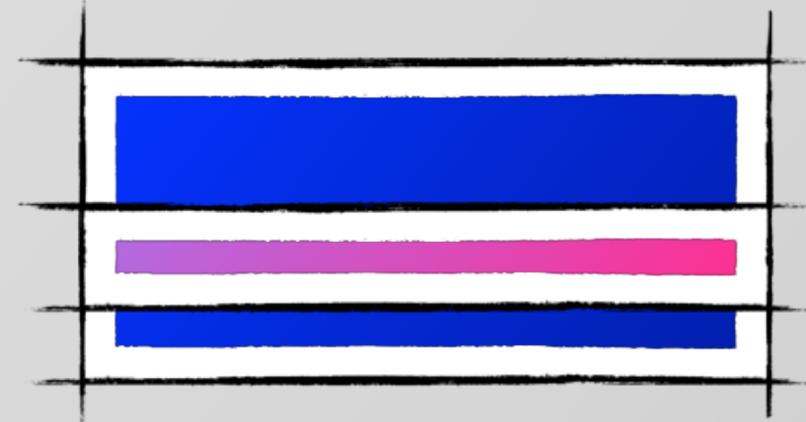
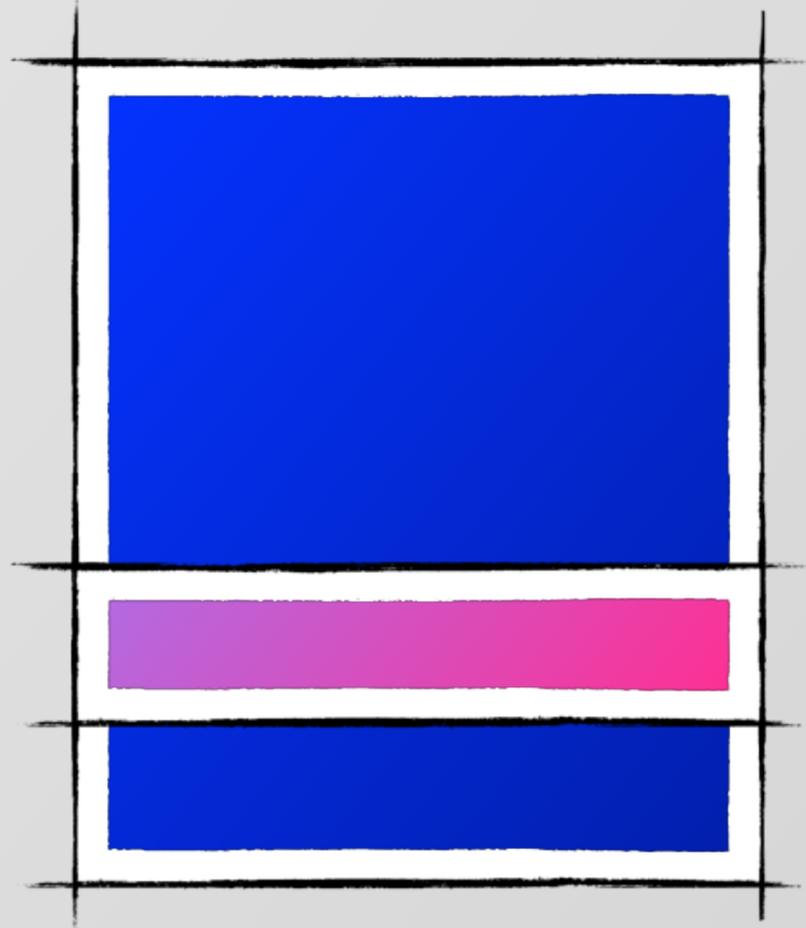












When might this be useful?

code **exploration**

in-situ & in-transit analysis

complex performance tuning, with live feedback

qualitative domain *understanding*

Open research challenges

safety (the Peter Parker principle)

reproducibility (and provenance)

balance of human & machine guidance



What we're doing at ANU

building Extempore & other live programming tools

applying live programming techniques in scientific simulation & high-performance computing

creating art + science research

teaching in live programming

modern HPC codes are
complex systems, with many
connections & dependencies

live feedback helps us **explore**
and **understand** these
relationships in our codes

For more information

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<https://github.com/digego/extempore>

<http://benswift.me/extempore-docs>

#extempore on freenode

<http://cs.anu.edu.au>