Packaging Medical Imaging Software with Nix

https://github.com/ryanorendorff/medical-imaging-nix

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Overview of the talk

- Introduction to Magnetic Particle Imaging (MPI).
- How to set up systems with tons of dependencies like MPI.
- What worked well, what did not work as well.

Disclaimer: The Nix work was done at Magnetic Insight, my employer.

Magnetic Particle Imaging: Detecting Iron Nanoparticles using Magnetic Fields

MPI detects iron in the blood

Magnetic Particle Imaging (MPI) is an emerging medical imaging technology that images iron particle distribution in a body.

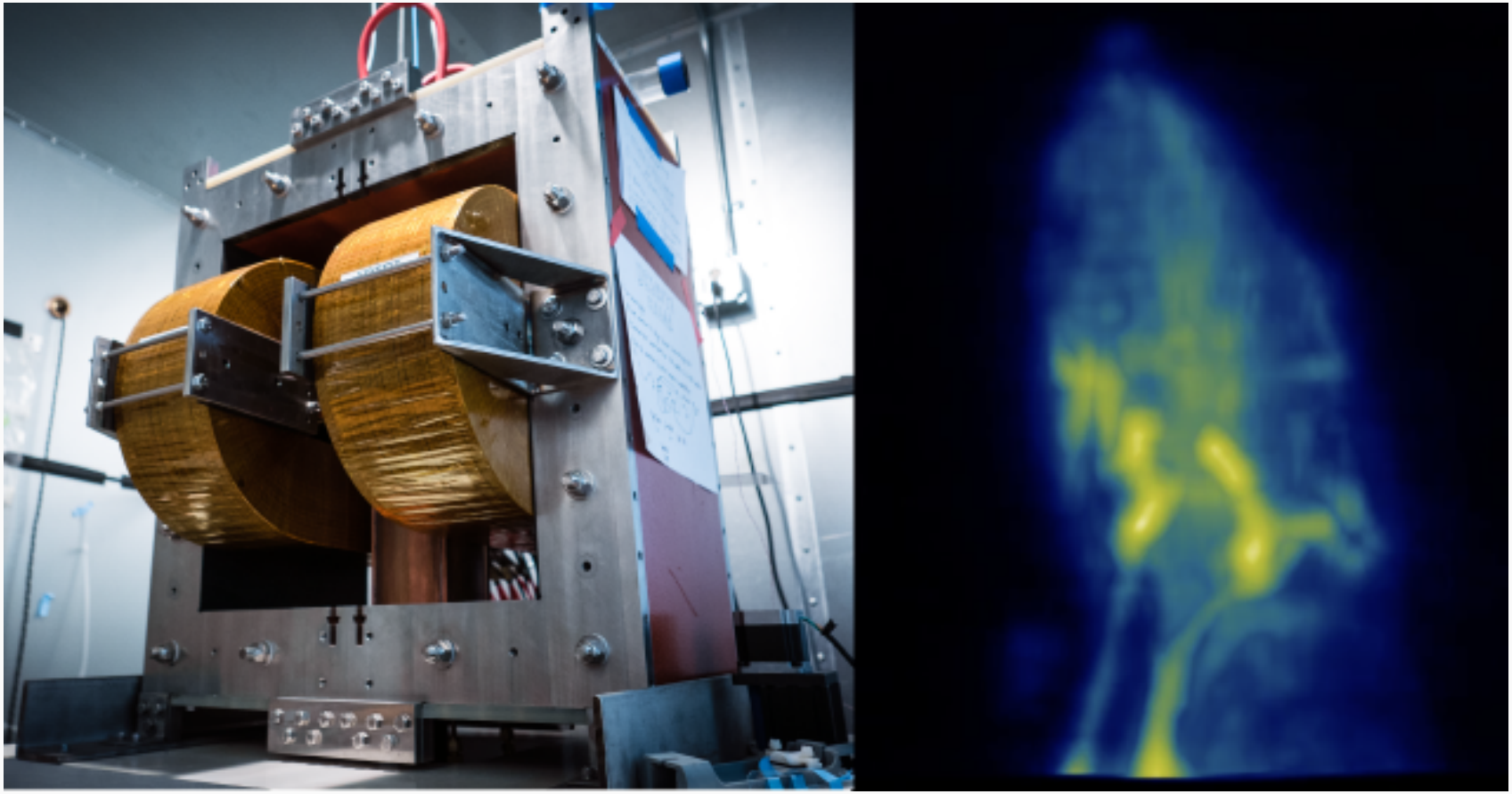
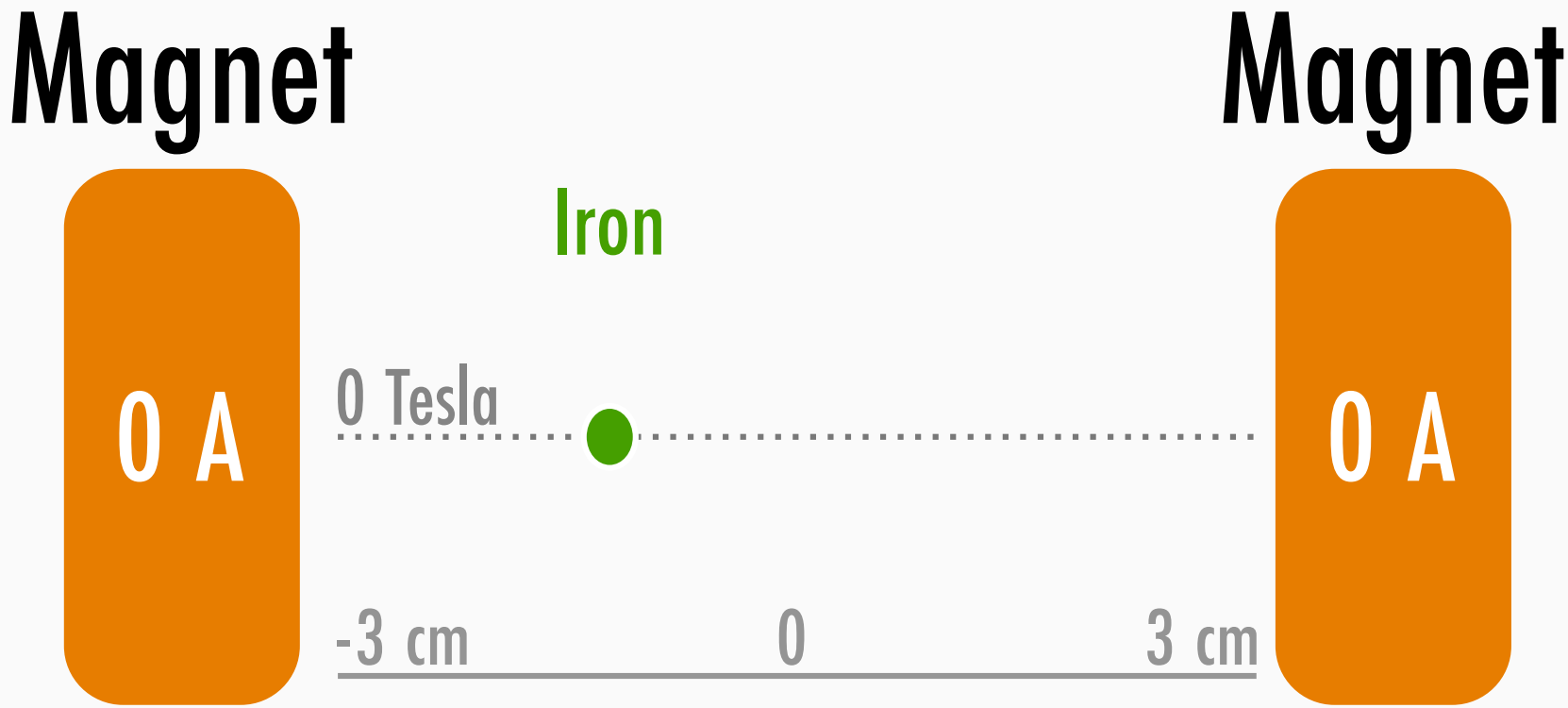


Figure 1: Left: MPI Hardware. Right: Can you guess? Courtesy Conolly Lab, UC Berkeley

MPI is all about moving around a gradient magnetic field

In MPI, we move around a magnetic field to detect where an iron sample is.



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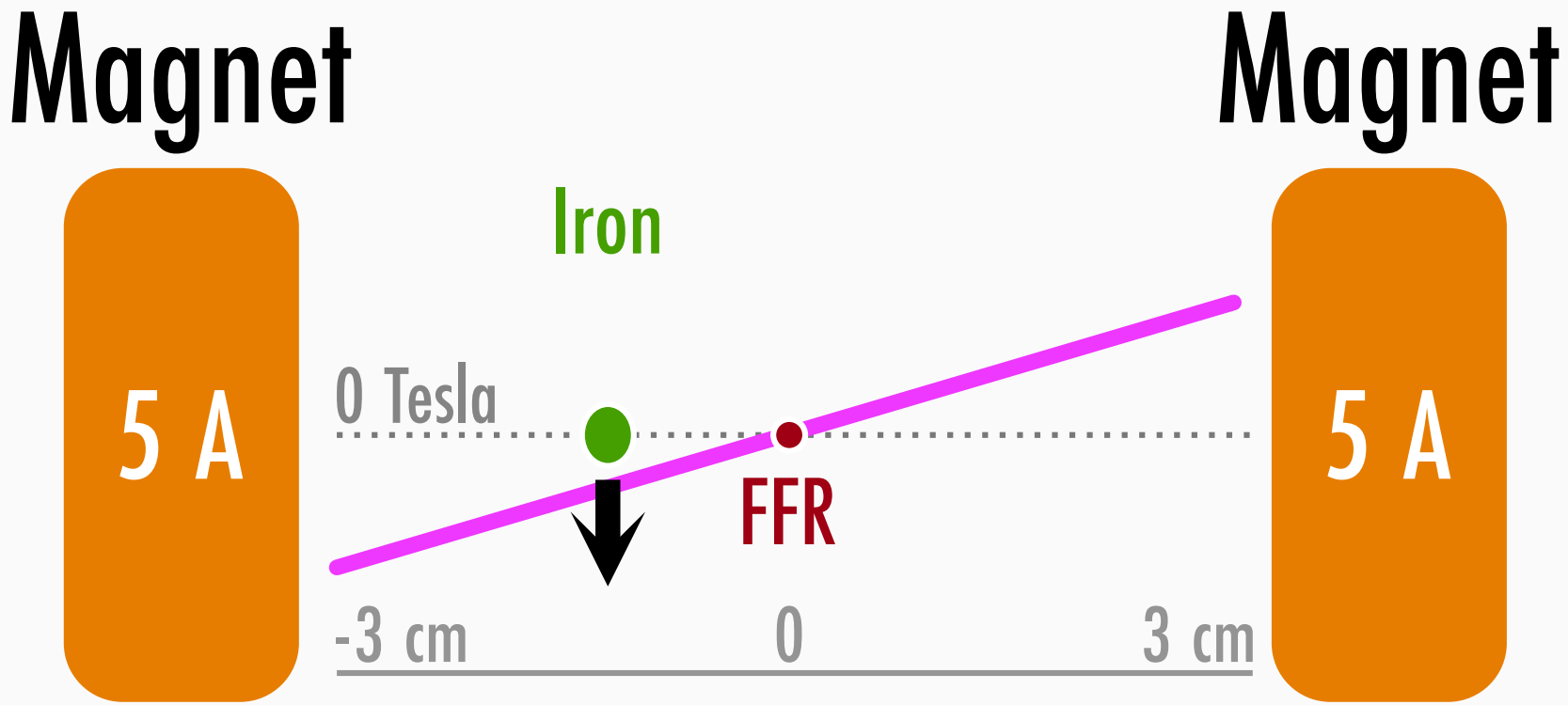

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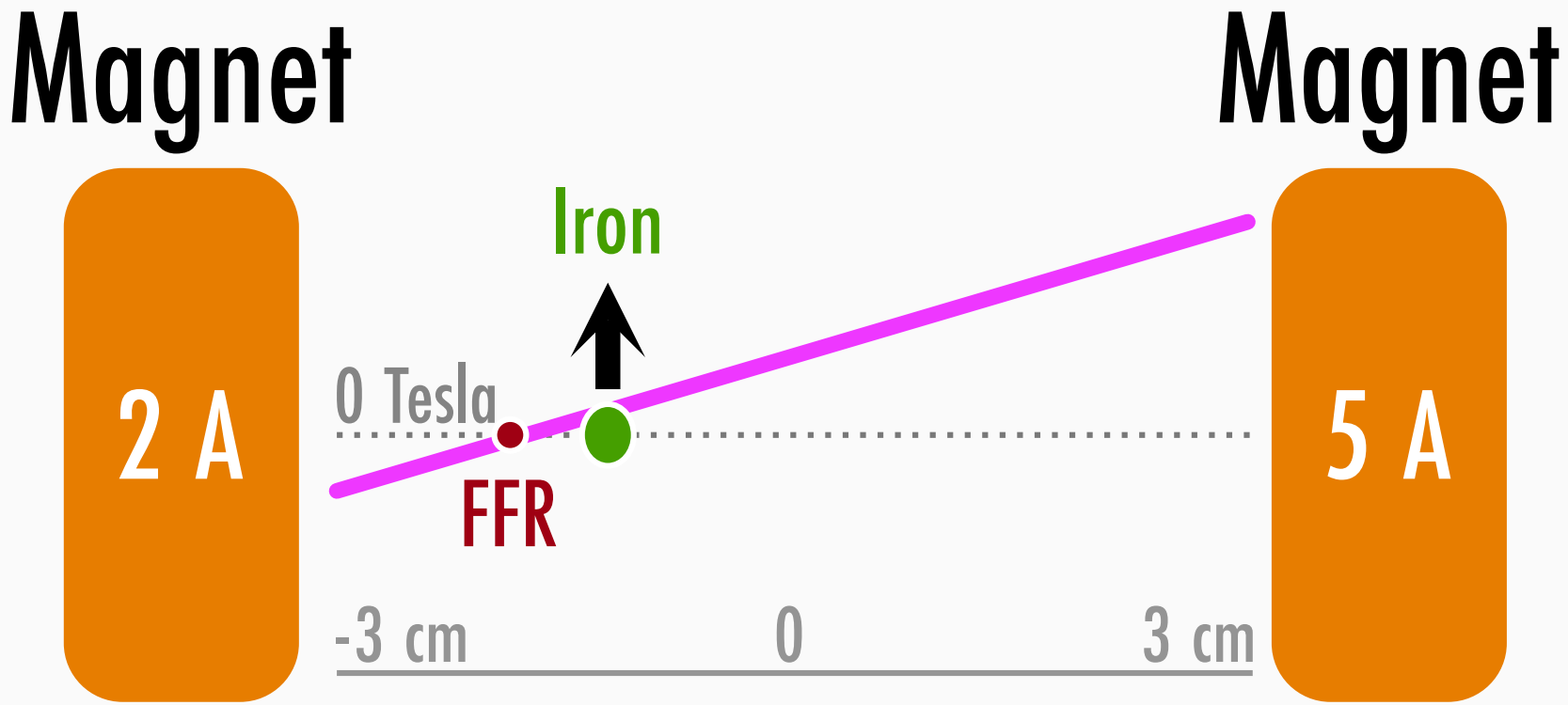

Components used in MPI systems

MPI systems require quite a few components to be handled by the software to acquire an image.

- Auxillary devices (DAQs, custom electronics, motors, safety systems).

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Pinning all this down can be hard!

System Diagram of what is required

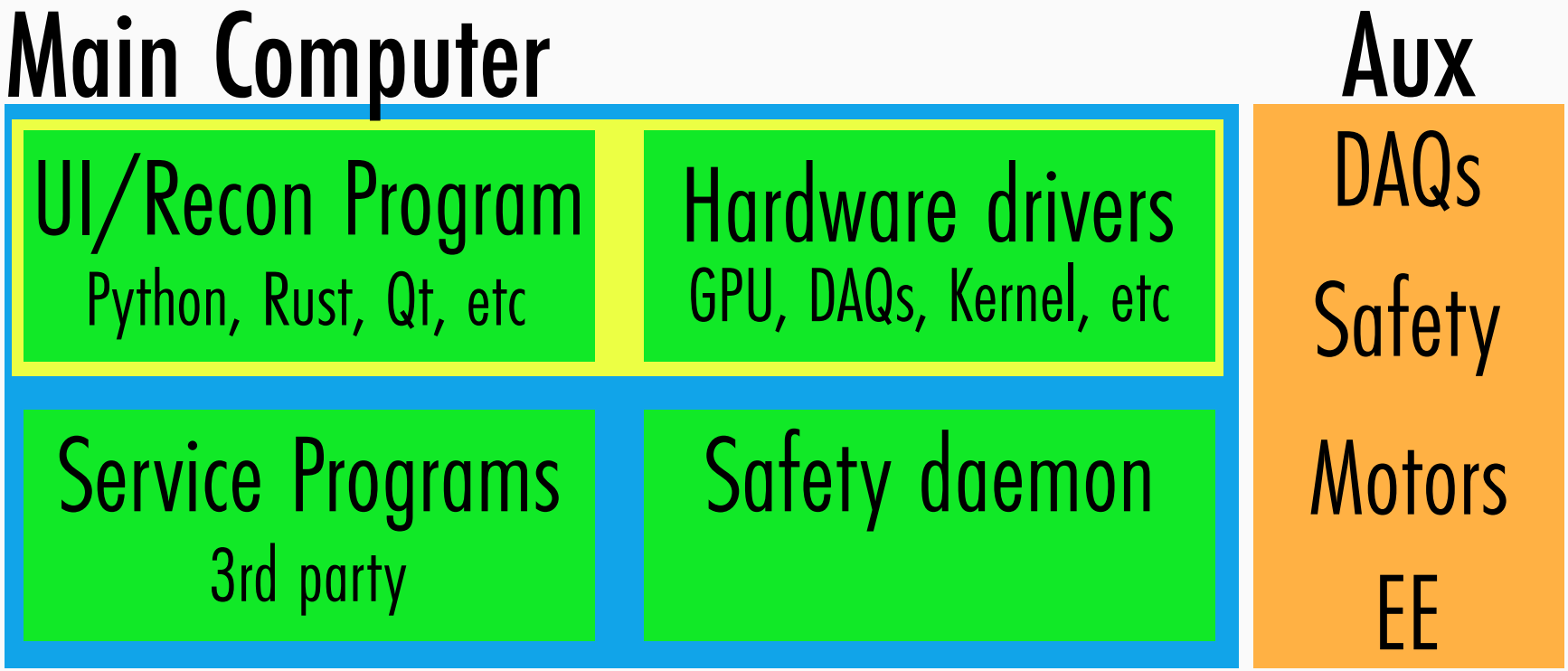

Figure 2: System layout. Items in blue box are located on NixOS machine; items in orange box are connected by networking

And all the connections!

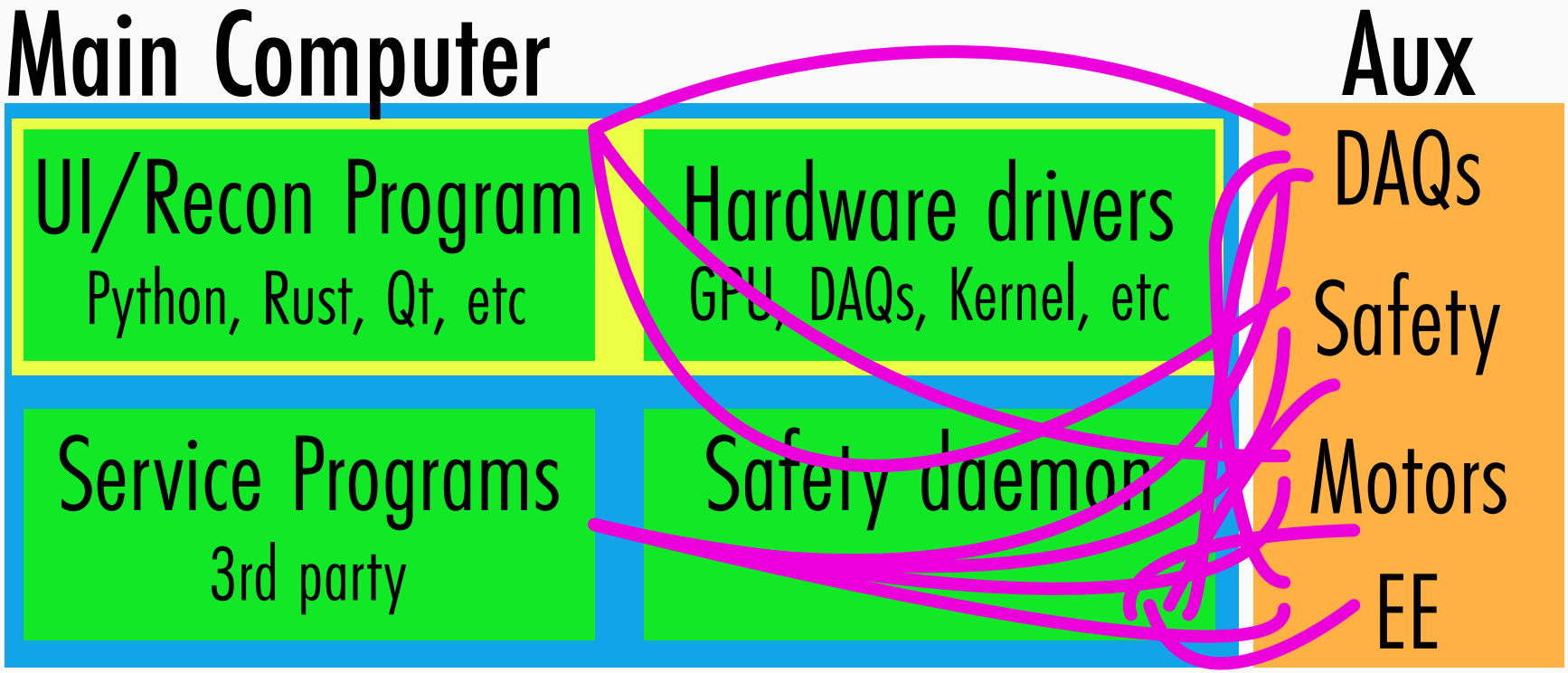

Figure 3: System layout. Items in blue box are located on NixOS machine; items in orange box are connected by networking. Pink is a dependency

Prior challenges faced

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- Creating the same setup twice is hard.
- Creating the same setup *over time* is very hard.
- Windows likes to update itself.
- Upgrading/servicing devices in the field detailed knowledge of the changes being applied.

Our Requirements for NixOS

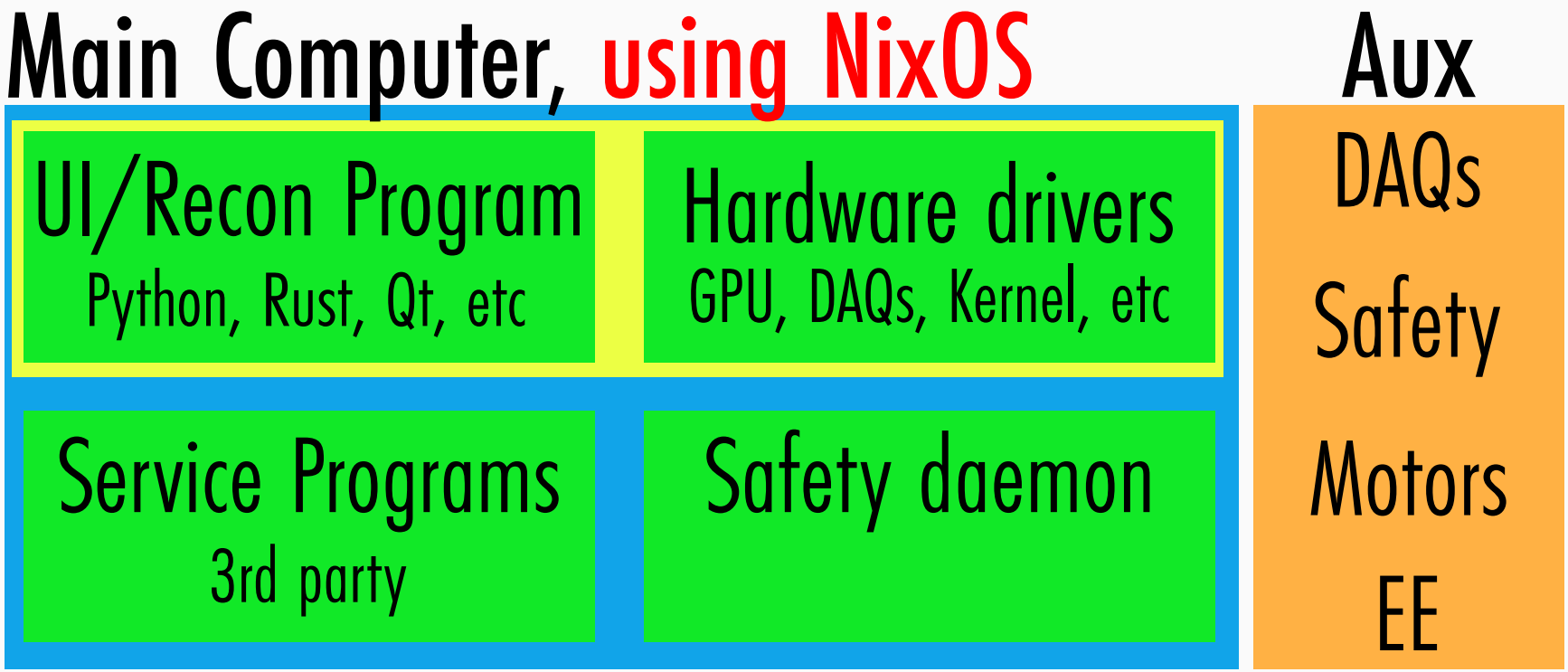
To solve our pain points, we defined the following requirements.

- An easy deployment strategy that any developer/field technician can run.
- No knowledge of the system version changes required.
- Well defined system state, both for our software and the OS.

NixOS to the rescue!

We used NixOS to pin down a bunch of our software stack

We decided to convert the main machine to NixOS. Let's go through each block in turn! What can we *learn* from each subsystem?



Packaging the main environment: Python Advantages

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```
stdenv.mkDerivation {
  ...
  buildInputs = pkgs.python37.withPackages (p: with p; [
    numpy
    scipy
    pyfftw
  ]);
  propagatedBuildInputs = [ pkgs.fftw ];
}
```

Packaging the main environment: Python Challenges

If nixpkgs does not have your desired python package, it can be included easily using an overlay. Here we

```
python37.override {
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Lesson: python support is good but you may spend quite a bit of time defining dependencies.

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Lesson: the basics for Rust work but you want to use some tooling (like `cargo2nix`, bazel) to reduce build times.

How to package proprietary drivers

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Don't. It can be quite difficult.

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To get around this, you can bootstrap a chroot environment using the building blocks of `buildFHSUserEnv`.

```
let
  pkgs = import <nixpkgs> {};
  chrootenv = pkgs.callPackage (pkgs.path +
    "/pkgs/build-support/build-fhs-userenv/chrootenv/")
    {};
in
  # can now use the ${chrootenv}/bin/chrootenv binary.
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Lesson: FHS assumptions are common in software; you may need to roll your own solutions/do a lot of patching.

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Lesson: you can apply patches before they are in the main code.

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  unpackPhase = "dpkg -x $src .";

  preFixup = let
    libPath = lib.makeLibraryPath [ stdenv.cc.cc.lib ];
  in ''for f in $out/lib/lib* ; do
        patchelf --set-rpath "${libPath}:$out/lib" $f
      done'';}
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Lesson: Handling packages from other package managers is not too bad; dependency management is manual.

How to package service/hardware programs: the hard times

Programs for hardware are often only for Windows. In these cases, NixOS has great virtualbox support. You can enable it with the following flag in your `configuration.nix` file (or equivalent).

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virtualisation.virtualbox.host.enable = true;
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Lesson: You won't always succeed in the attempts to package things in a timely manner. But there are escape hatches.

How to pin the whole system

Pin using the method Gabriel mentions.

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let
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in import "${nixpkgs-src}/nixos" {
  system = "x86_64-linux";
  configuration = import ./configuration.nix;
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Lesson: Pinning the whole system make deployment wasy and help identify missing dependencies.

Pro tip: Use `nix-diff` to determine the difference between two systems!

How to package services

Packaging up service is pretty simple. Just import a file like this into your `configuration.nix`

```
let

  cfg = config.services.vnc;

in {

  options.services.vnc.enable = mkEnableOption "vnc";
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Lesson: After defining a package, it is relatively painless to define a daemon.

Deployment strategy

Deployment is pretty simple after these changes.

1. Define a system configuration with everything needed.
2. Build that system using `nix-build`
3. Copy to a remote system using `nix-copy-closure`
4. Run `switch-to-configuration` to change the system over to the new state.

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Lesson: Anyone can do deployment with a few commands that can be scripted.

Lessons Learned

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- Software is not always forthcoming with all of its assumptions on the system state.
- Some code (especially proprietary) is too hard to wrap. You can use docker/virtualbox as escape hatches to work on your main goal.
- You will end up a great understanding of your dependencies; those dependencies will be documented in the process of becoming nix expressions.

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- We will need training to get people to make their own nix expressions.

Questions?