for Vendor-Agnostic Pulse Programming

Keerthi Sravan Ravi

Doctoral student,
Department of Biomedical Engineering,
Columbia Magnetic Resonance Research Center,
Columbia University in the City of New York,
NY, USA

Pre- and post- Pulseq

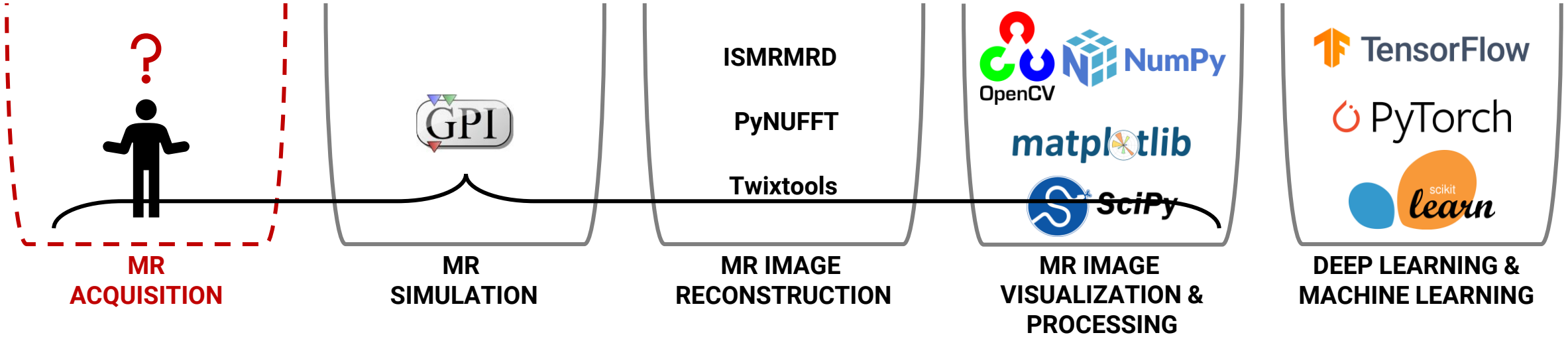
Pulse sequence development (PSD) had a high entry barrier

- Low-level or vendor-specific programming languages
- Multi-site multi-vendor studies were difficult

- Pulseq introduced in 2017[1]
- MATLAB-based open-source framework for PSD
- **.seq** file format: vendor-independent, low-level, human-readable file format

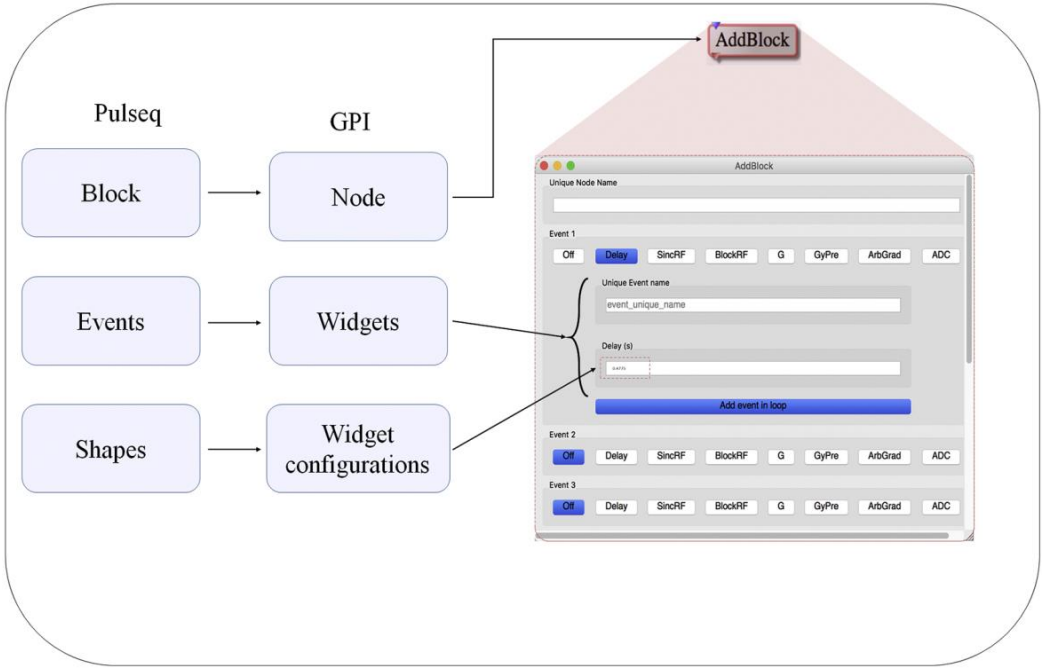
[1] Layton et al., MRM, 2017

Python for MRI



Visual PSD using GPI

- Pulseq-GPI[2] – translated Pulseq to Python
- Leveraged GPI's GUI elements[3] to develop Pulseq sequences

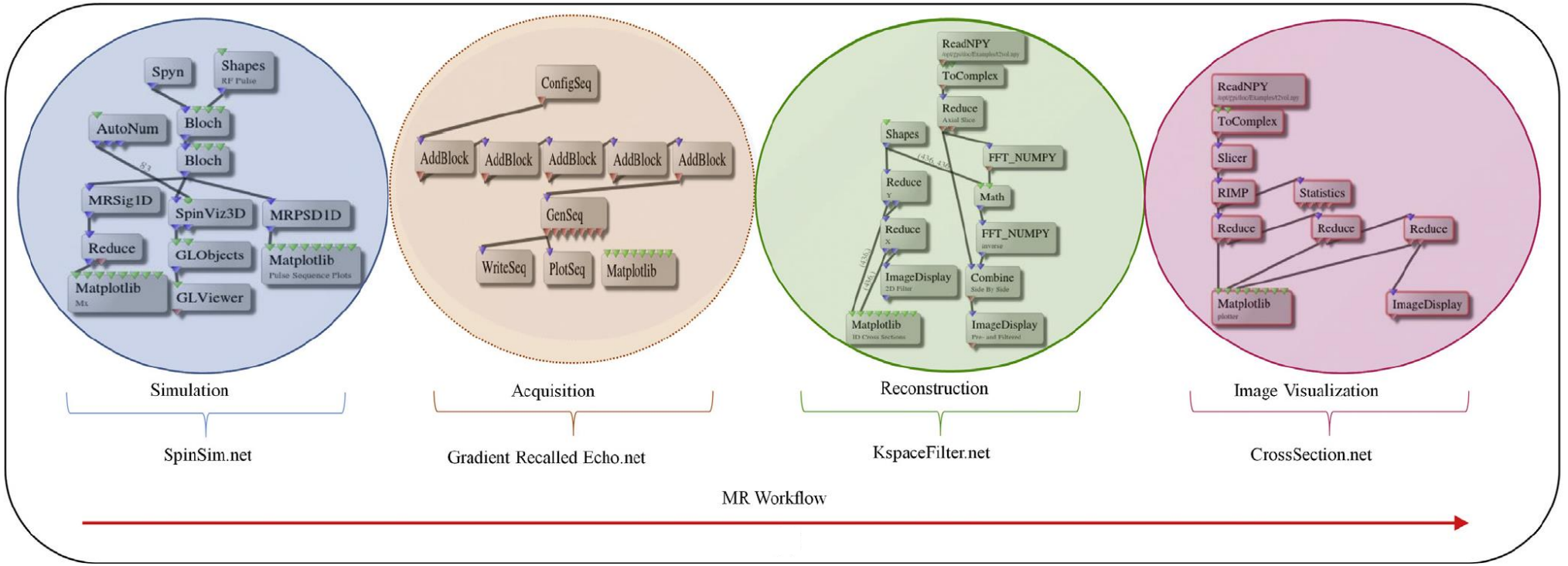


Reproduced from Ravi et al., MRI 2018

[2] Ravi et al., MRI, 2018 | [3] Zwart et al., MRM, 2015

Pulseq-GPI

- GPI's library of **`Nodes`**: entire MRI pipeline on a single platform



Reproduced from Ravi et al., MRI 2018

pypulseq: all you need is a browser

- Single-line installation: **`pip install pypulseq`**
- Google Colab – free tool to run Python in a browser
- Zero footprint usage of PyPulseq
- Jumpstart PSD-
    1. Upload a notebook
    2. Import a notebook (Google Drive/GitHub)

pypulseq: features

SAR calculation

```
from pypulseq.SAR import SAR_calc
# make seq object
SAR_calc.calc_SAR(seq)
```

Credits: @imsg

pypulseq: features

SAR calculation

Advanced RF pulses

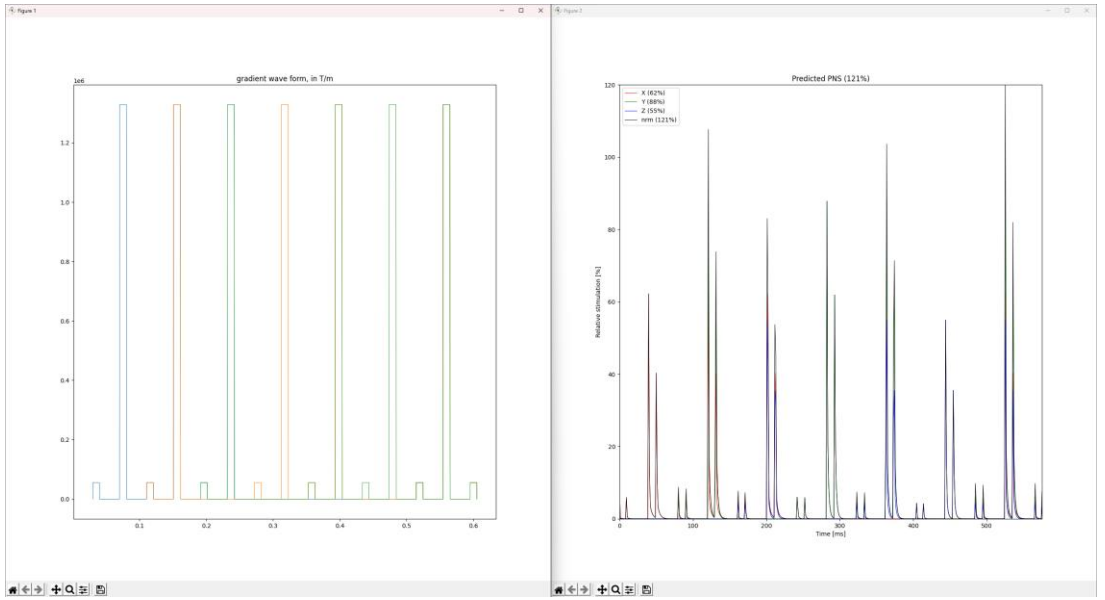
```
from pypulseq import make_sigpy_pulse

make_sigpy_pulse.make_slr(…) # Shinnar-Le Roux RF Pulses
make_sigpy_pulse.make_sms(…) # Simultaneous multi-slice
```

Credits: github.com/mikgroup/sigpy
(SigPy is a PyPulseq dependency)

pypulseq: features

- SAR calculation
- Advanced RF pulses
- PNS calculation

```
# make seq object
seq.calculate_pns(safe_example_hw(), do_plots=True)
```



Credits: @FrankZijlstra

pypulseq: applications

Virtual Scanner[4]

An end-to-end hybrid MRI simulator/console designed to be zero-footprint, modular, and supported by open-source standards.

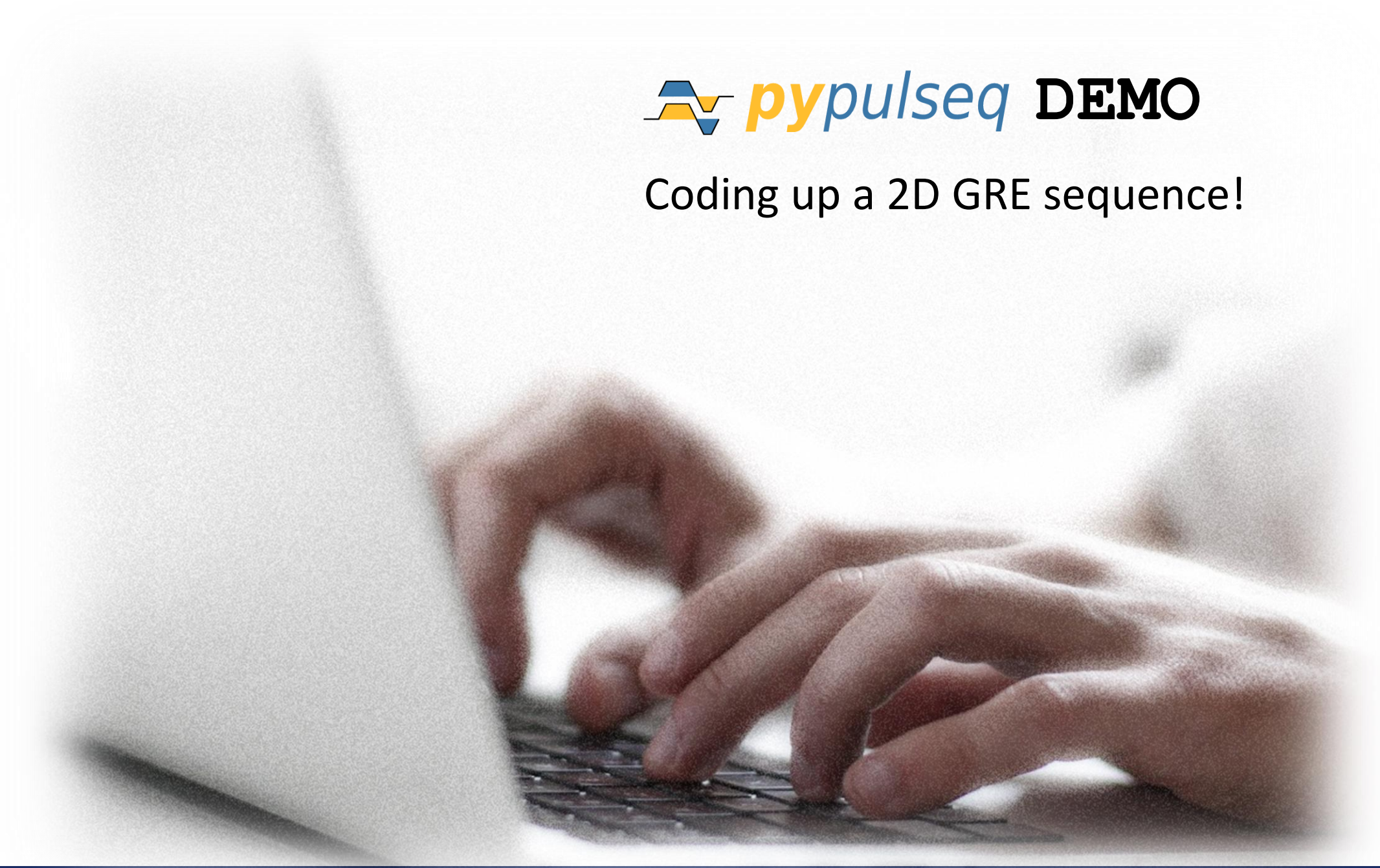
MRI4ALL 2023[5]

Hackathon to jointly develop a fully-fledged open-source and low-field MRI scanner.

[2] Tong et al., JOSS, 2019| [3] mri4all.org

pypulseq DEMO

Coding up a 2D GRE sequence!



pypulseq DEMO

Visit tinyurl.com/ISMRM-Virtual-2023

Acknowledgements

- Maxim Zaitsev
- Jon-Fredrik Nielsen

- Sairam Geethanath
- John Thomas Vaughan Jr.


THANK YOU
ks3621@columbia.edu
pypulseq.github.io