Follow this link to view the full presentation, with animated (scans)

https://docs.google.com/presentation/d/10Z646nL0SNAtWqknQ7BCpWcpevJxT_GHyK5vZl9EGXo

Another Philips Pulseq Interpreter

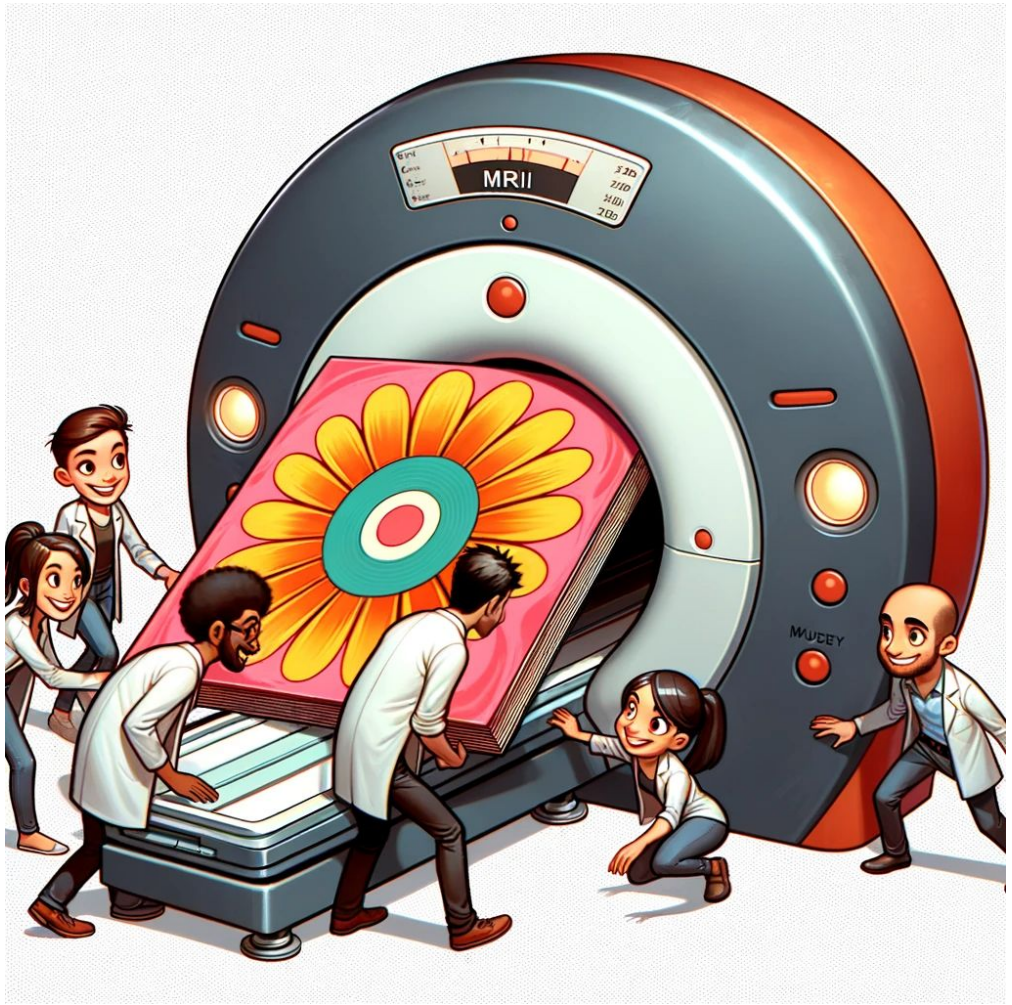
from basics to pTx

UMC Utrecht

ISMRM Virtual Meeting - 17 November 2023
Thomas Roos

Pulseq is like music

While Philips *invented* CDs…



Philips MRI scanners are *no* CD players

Why is Pulseq challenging?

Philips platform is *too* optimised **- or is it?**

Build

Fixed objects

Console

Waveform loading

Runtime

Limited runtime changes
&
Clever re-use

Aim

Compatible

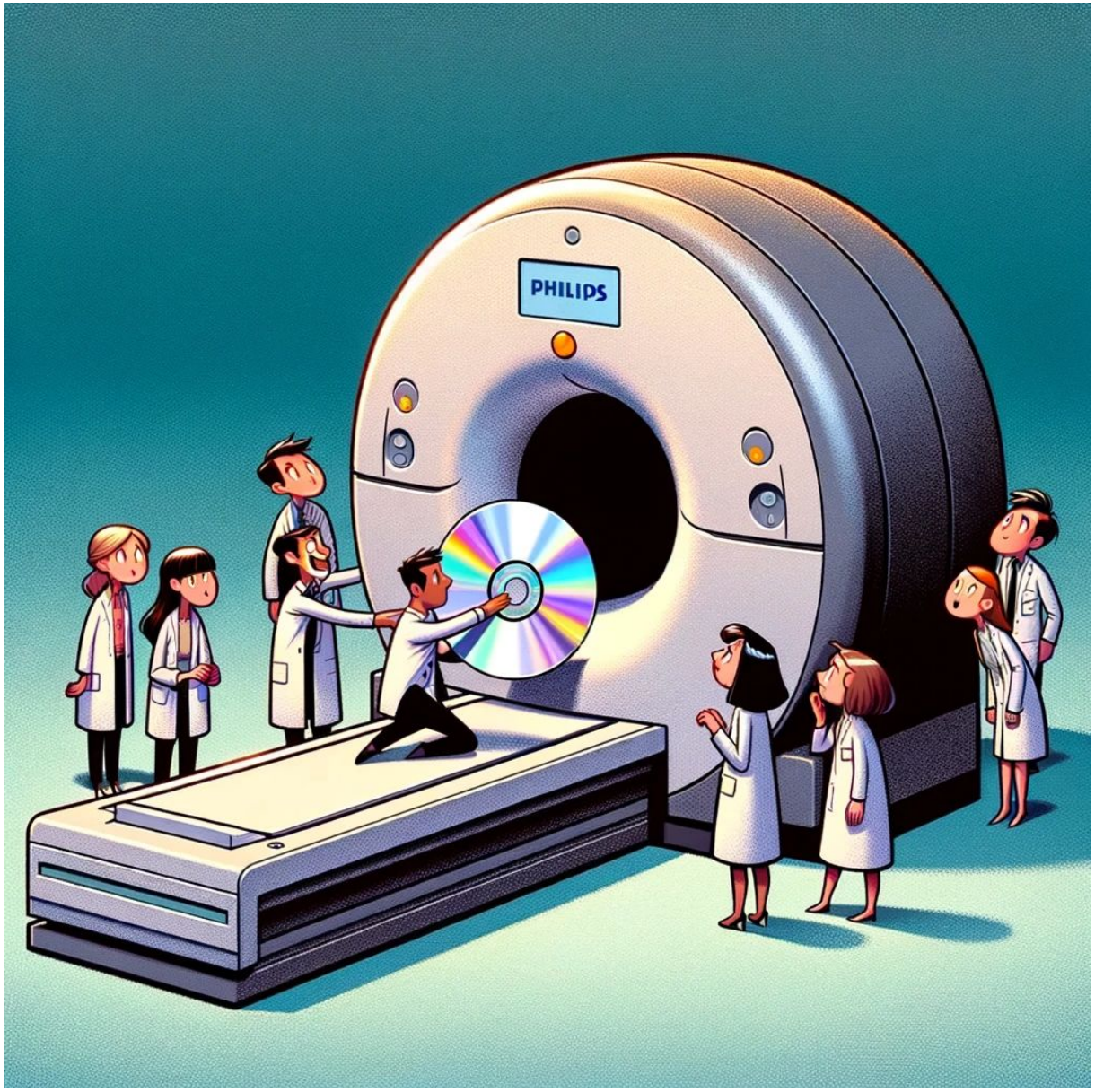
- ➔ Current sequences & timing

Generic & easy

- ➔ No conversions
- ➔ Runs .seq directly
- ➔ No required labels, etc

Accurate

- ➔ No timing changes



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Architecture

.seq

Select & load

Console

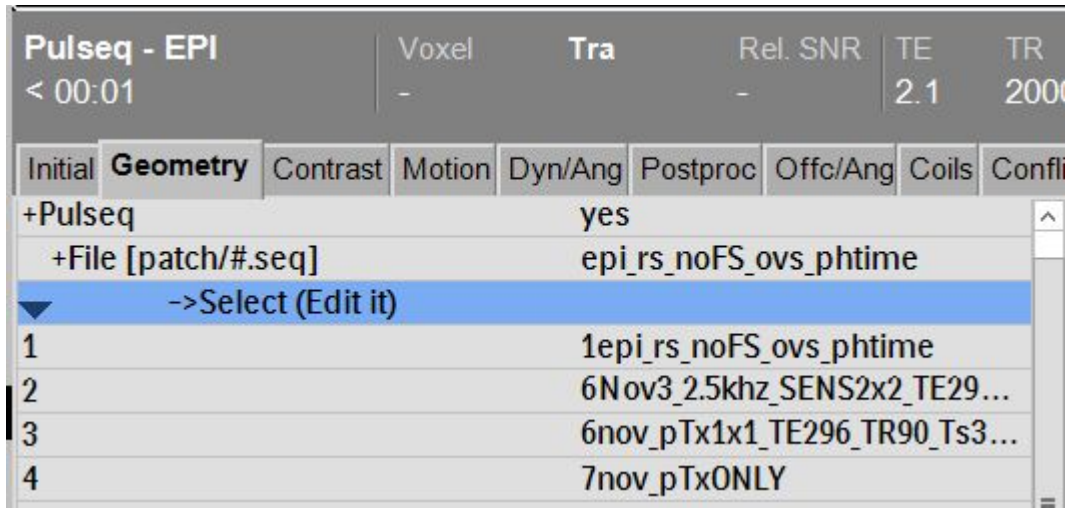
.seq file

Dummy sequence

Runtime

Modifies dummy sequence

to convert **Pulseq blocks** to **Philips *'blocks'***



Images

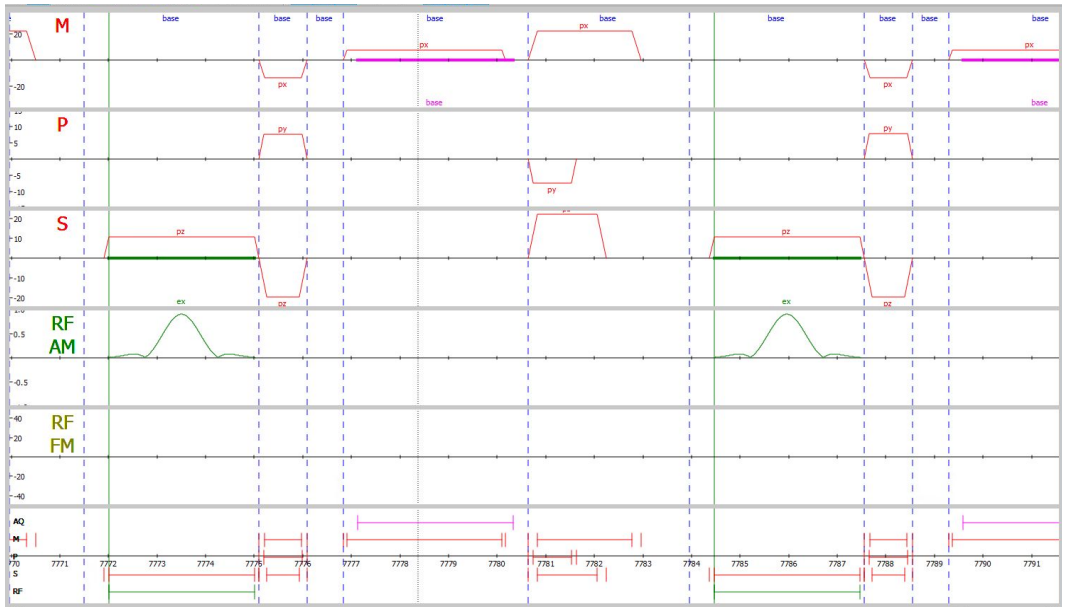
Philips encoding

Recon

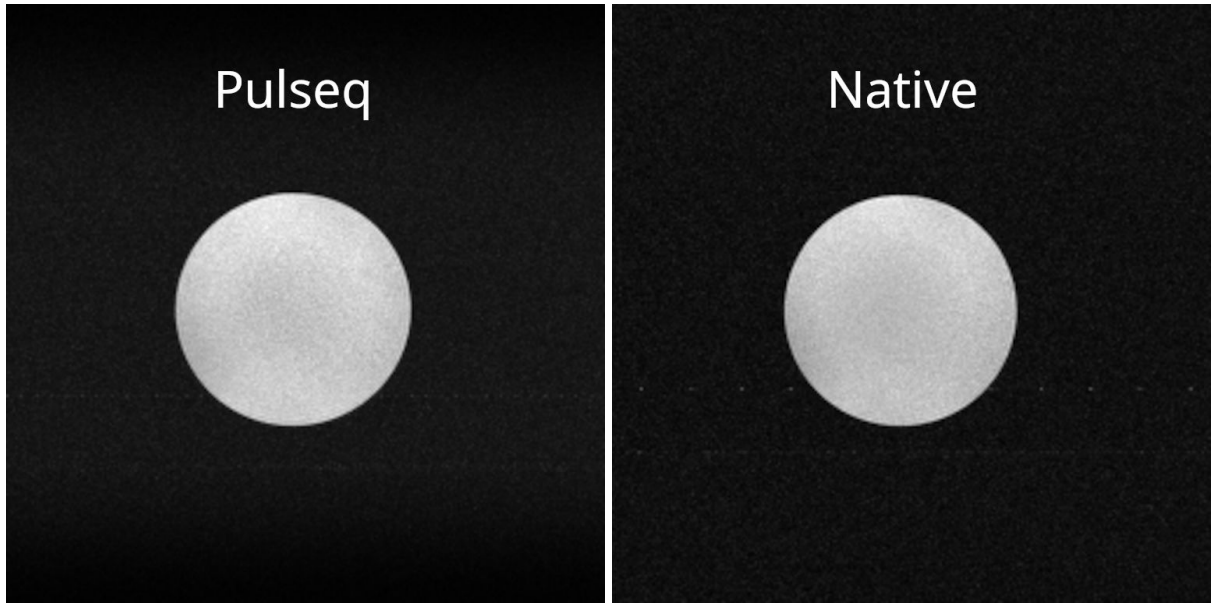
Raw

Pulseq encoding

Playing: *a gradient echo*



Pulseq GRE
in Philips simulator



Pulseq & Native GRE
using Philips Achieva 7T
version R5.4

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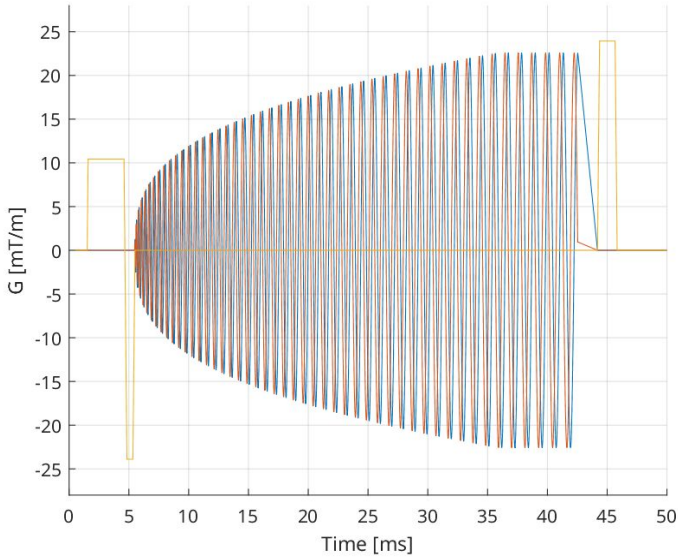
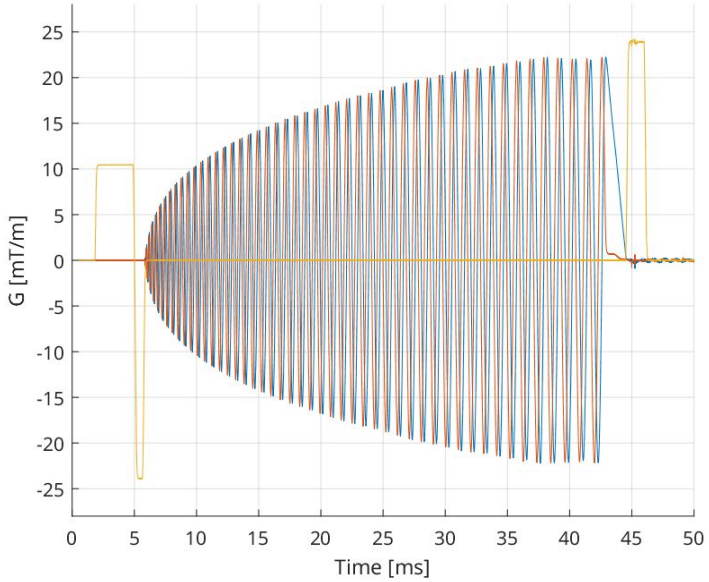
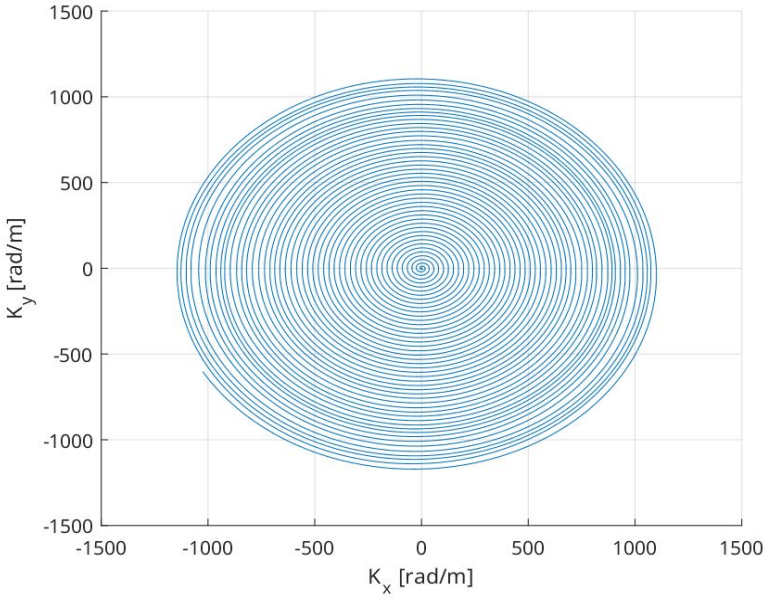
Playing: *a spiral readout*



Requested
in .seq

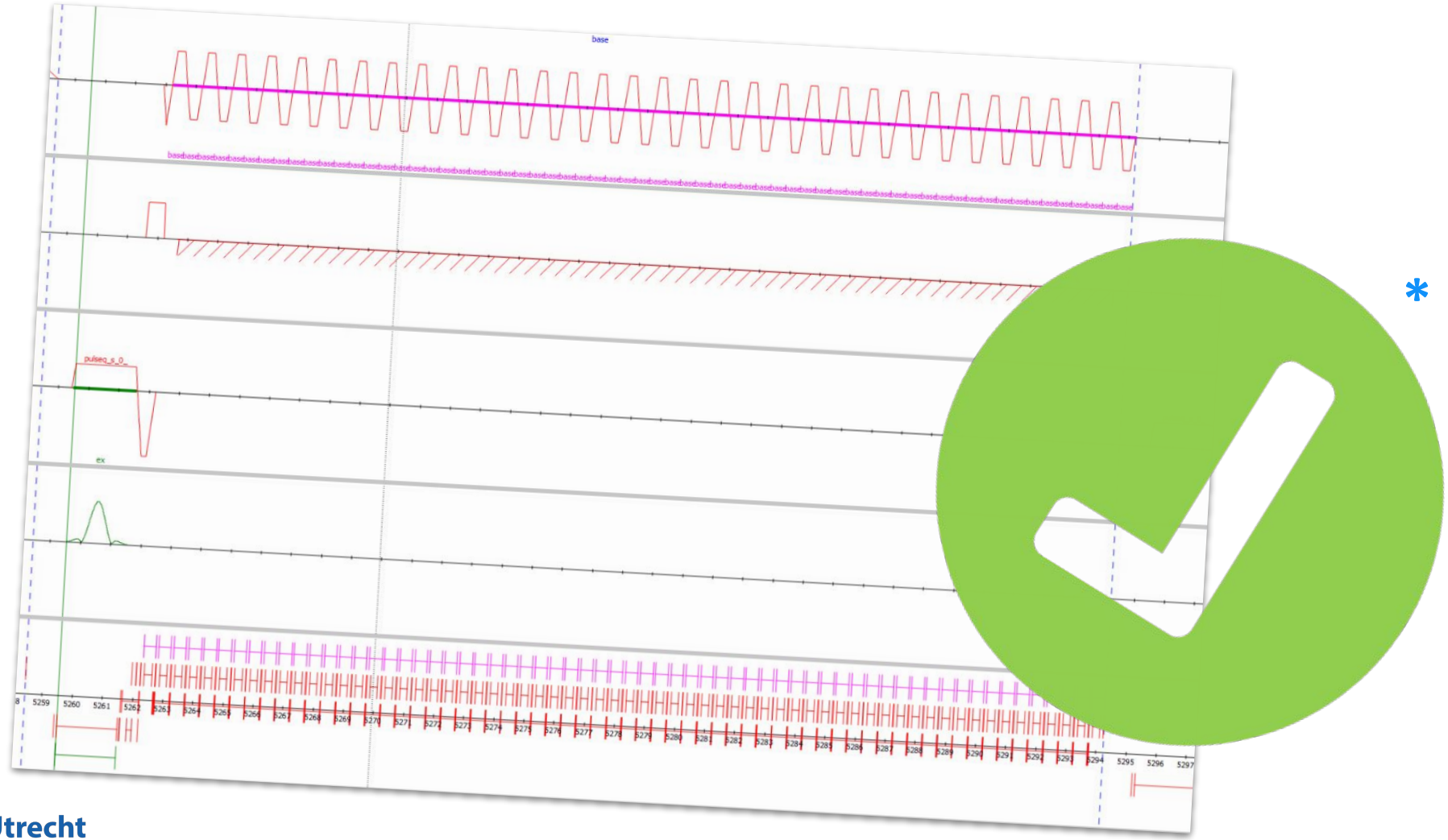


Measured
using Skope



k-space
trajectory

Playing: *an EPI ?!*



*

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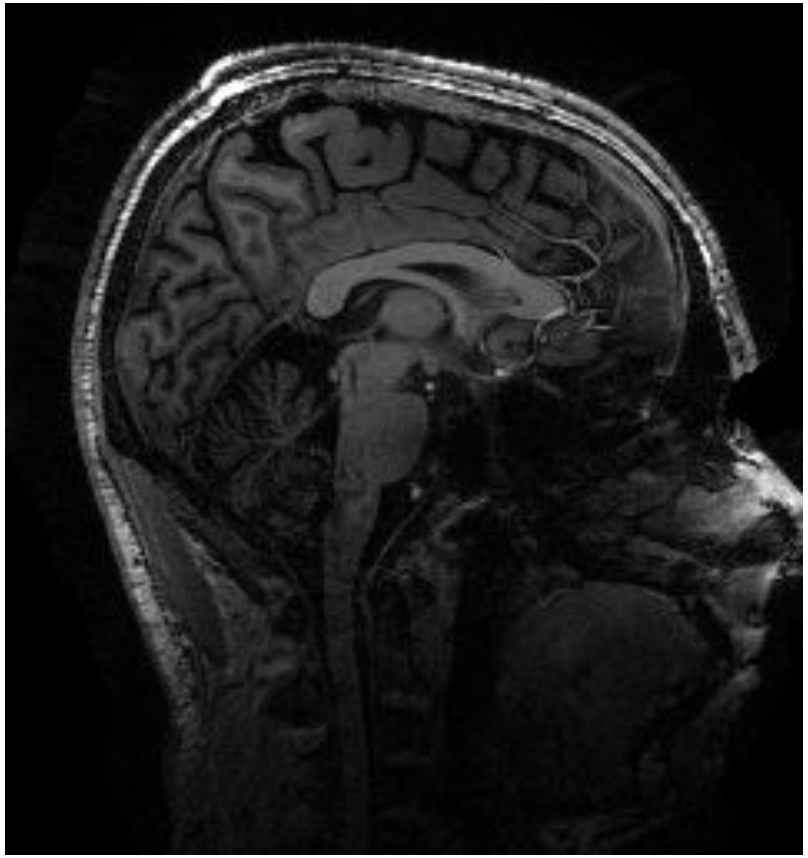
*not tried on scanner *yet*

Playing: *a MP-RAGE*

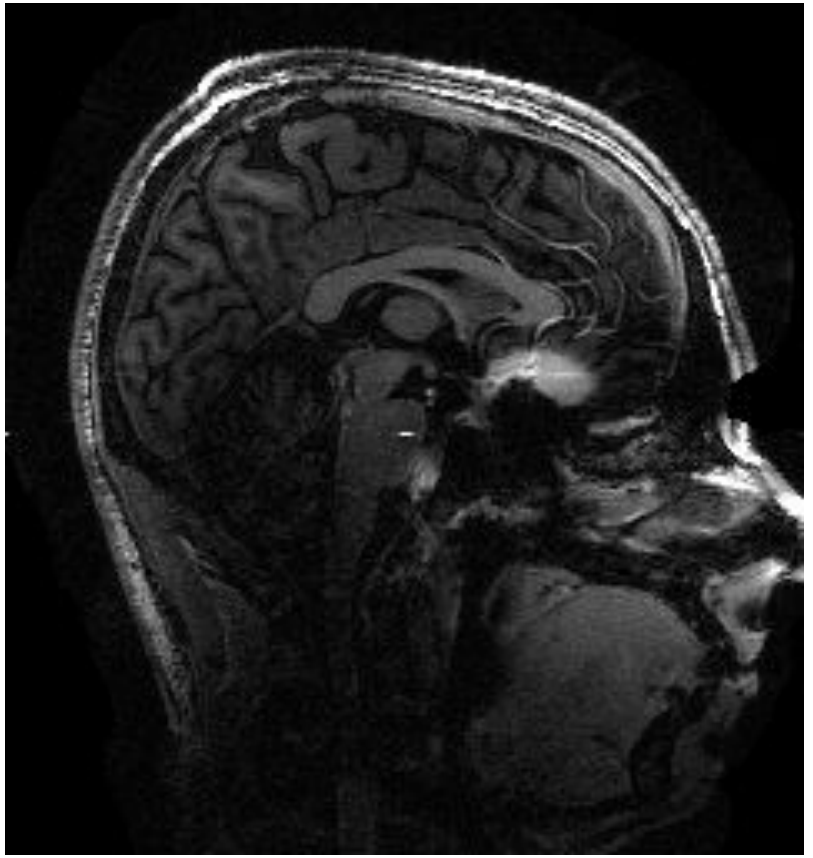
Philips Achieva 7T

1mm^3 resolution

2x2 SENSE 3min



Philips sequence



Pulseq sequence

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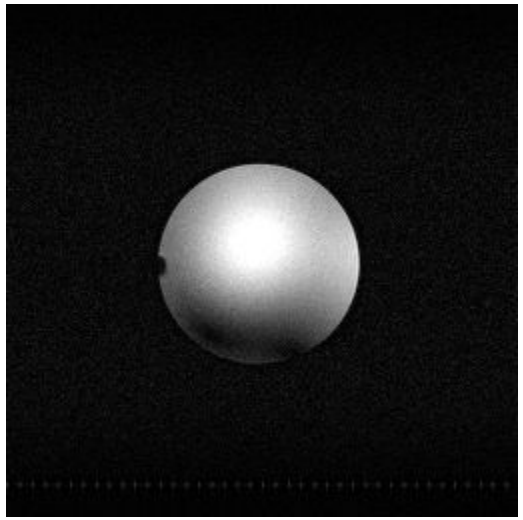
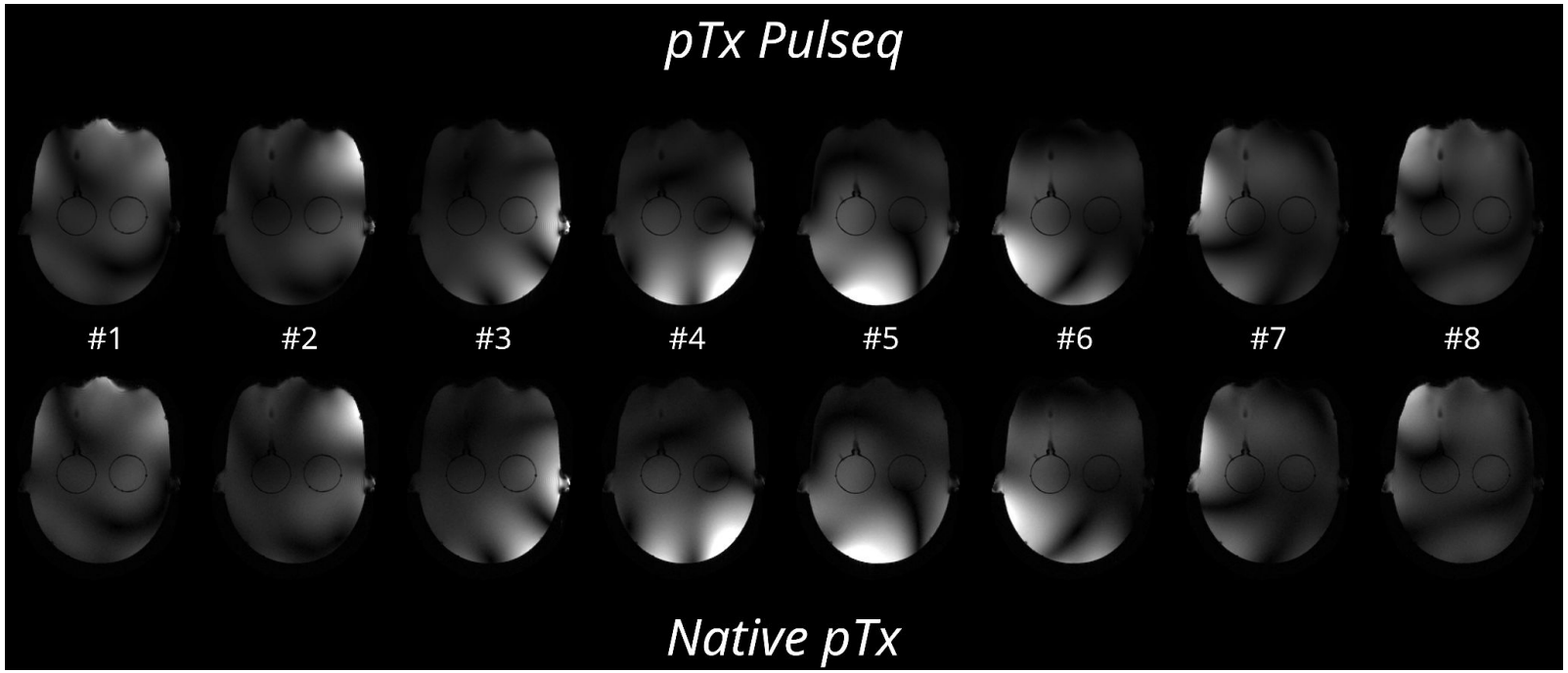
pTx Pulseq



Let’s make Universal Pulses, **Truly Universal**!

pTx Pulseq



2D GRE

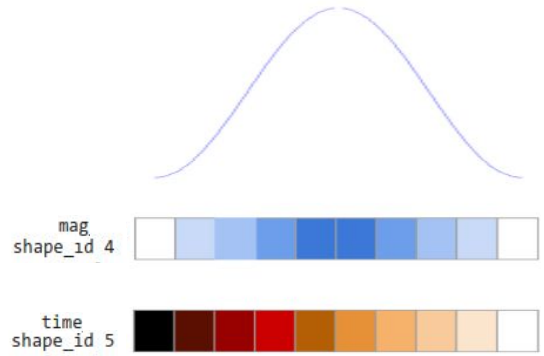
Single transmit channels

pTx-Pulseq

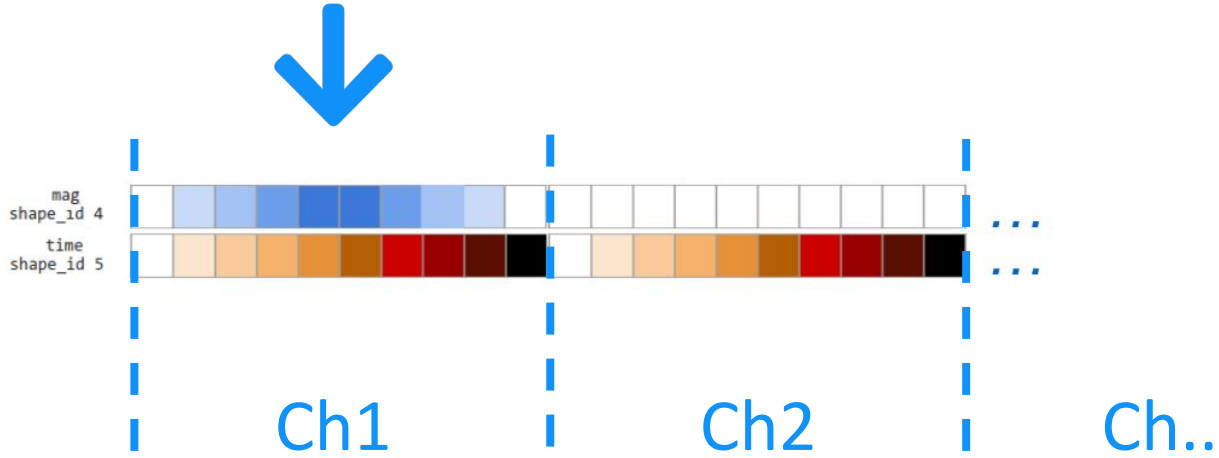
Full pTx
- Magnitude & phase

Backwards compatible
- No changes to MATLAB toolbox
- Current interpreter reads ch1

Repeating time-points for the different channels




```
# Format of RF events:
# id amplitude mag_id phase_id time_shape_id
# ..        Hz   ....     ....          ....
[RF]
1      61.2234 4 5 6 1100 0 0
```




```
tx_pattern = [ 1 0 0 0 0 0 0 0 ]; % Only Tx #1

rf_singleTx = rf; % Start with regular RF pulse

rf_singleTx.signal = reshape(rf.signal' .* tx_pattern, 1, []);
rf_singleTx.t      = repmat(rf.t, 1, num_tx);
```

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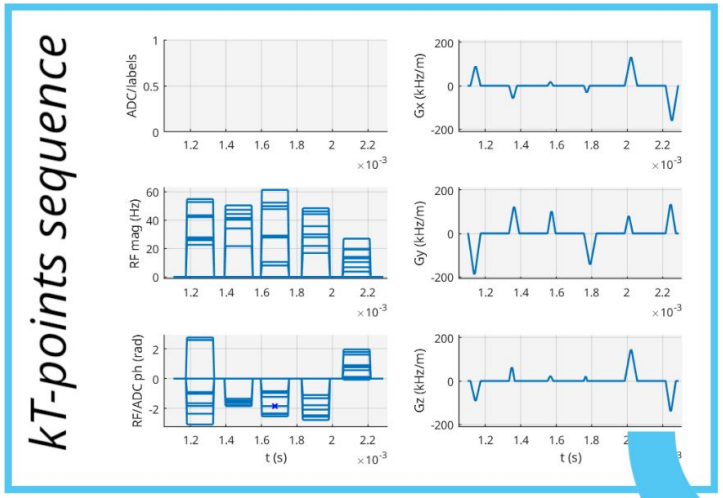
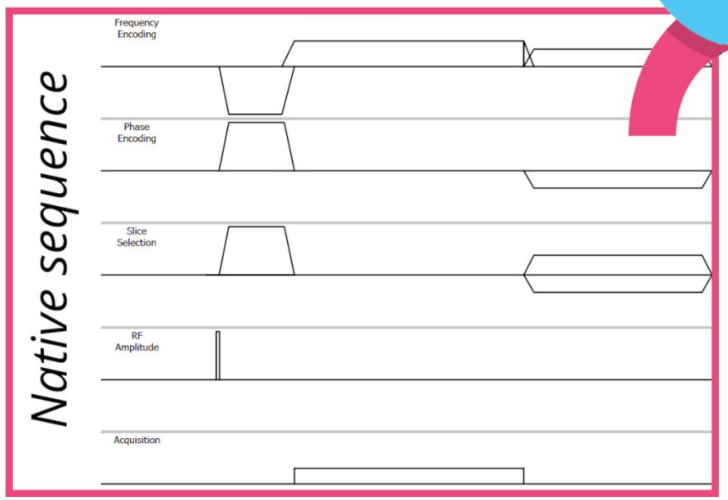
Hybrid sequence

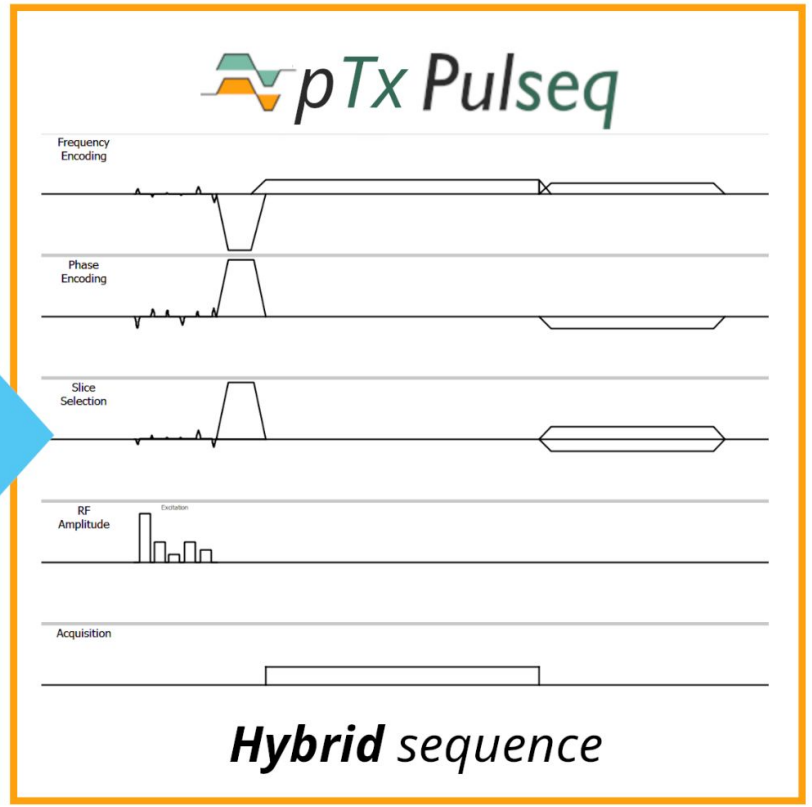
Best of both worlds

Pulseq
Features
Flexibility

Native
Optimizations
Recon
Accessibility





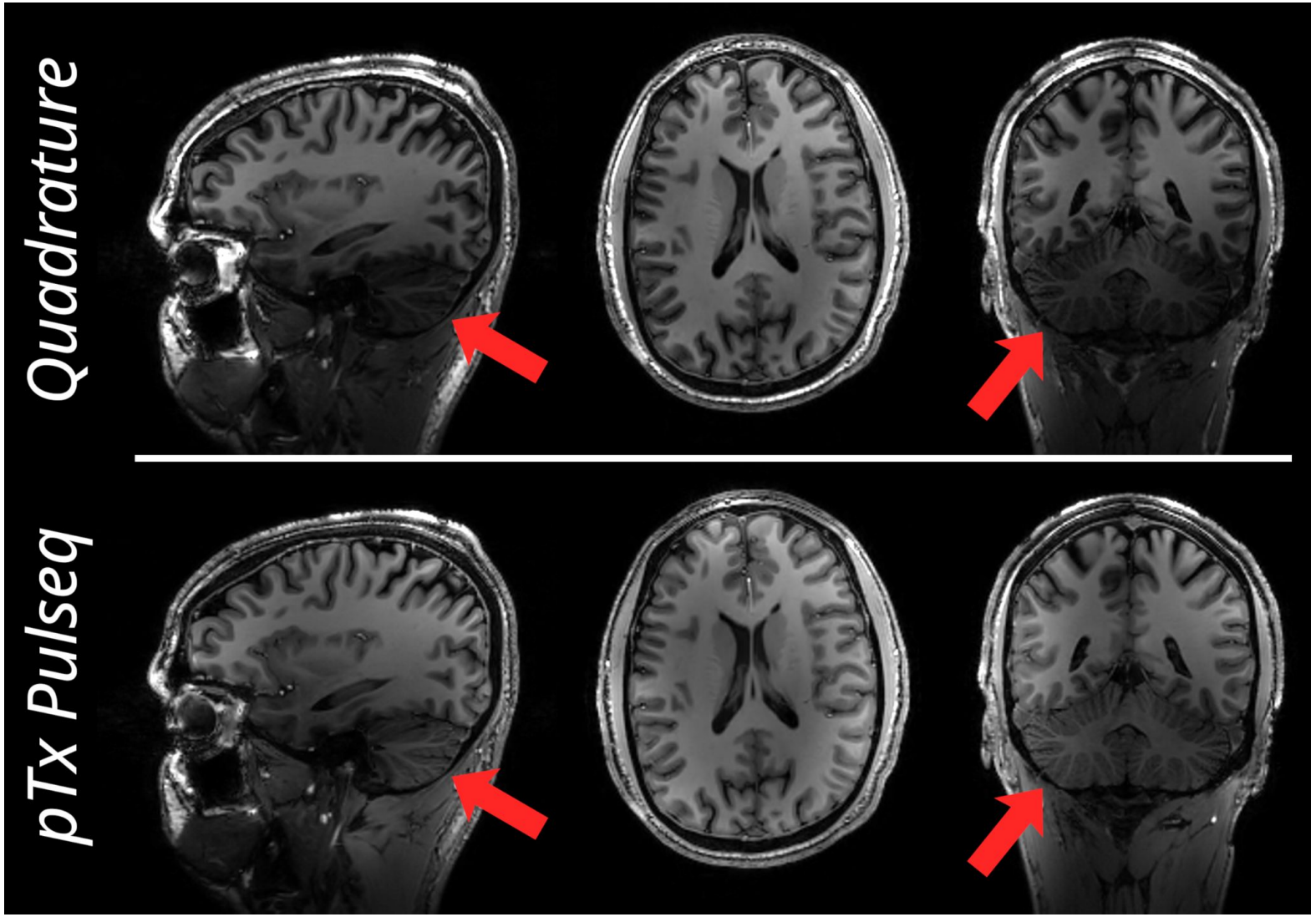


Playing: *Hybrid pTx-Pulseq*

1mm^3
resolution

R=4
using CS

On-scanner reconstruction



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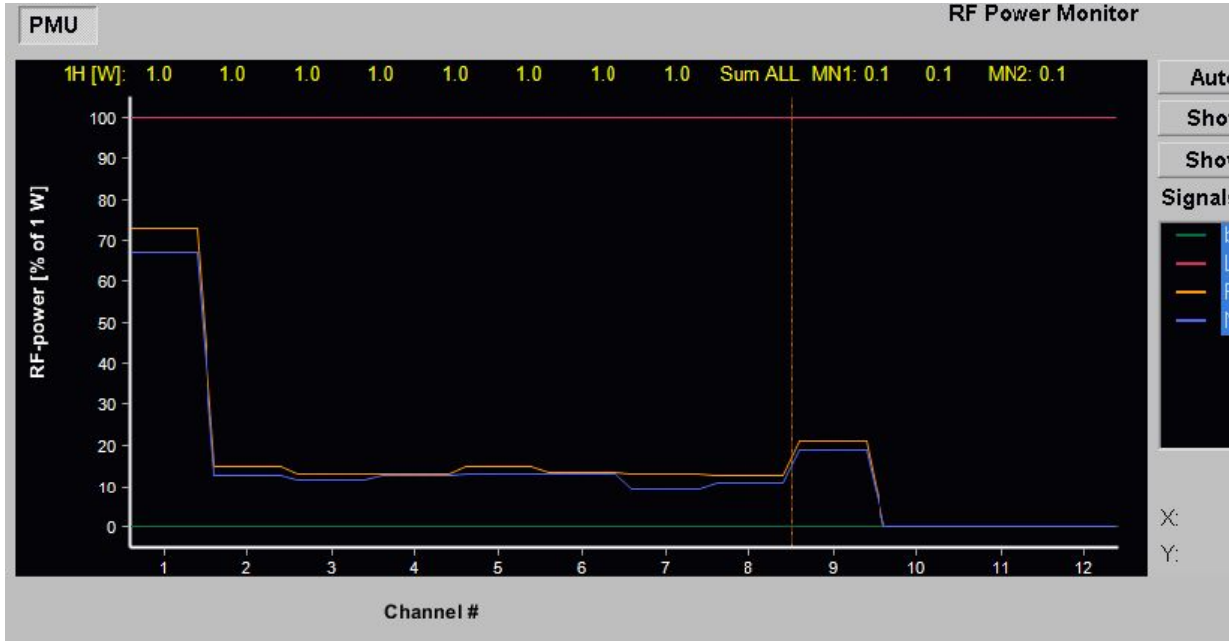
Safety checks

During scan:
- SAR (average power)
- System specs (slew, strength)
- System safety (grad temp)

Using Pulseq:
- PNS (MATLAB model)
- Gradient resonances

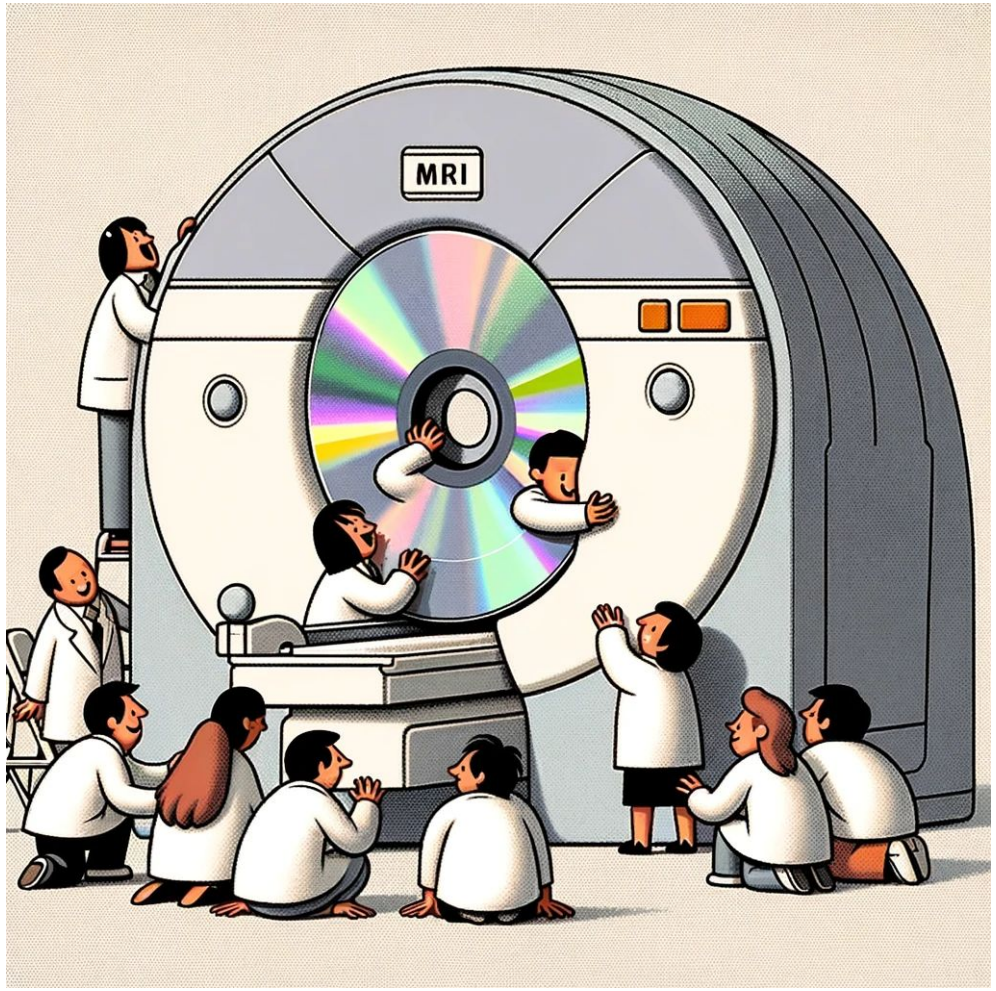
To be implemented:
- SAR prediction
- Gradient temp prediction



Current state

Highlights

- Timing flexibility
- Full pTx
- Hybrid sequences



Next steps

- Improve simulations
- Add labels to data
- On-scanner recon of Pulseq encoding
- Off-center FOV

Will be made available through **openmr.nl**

Acknowledgement

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Hans Hoogduin
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Jeroen Siero
Jannie Wijnen

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Spinoza Centre for Neuroimaging