ICE and Gadgetron Reconstruction Based on the Pulseq Framework

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Outline

- Workflow for data acquisition and image reconstruction
- How to enable ICE/Gadgetron (based on *s21_GRE2D_GRAPPA:* https://github.com/pulseq/ISMRM-Virtual-Meeting--November-15-17-2023/tree/main/tutorials/day2_imageReconstruction)
  - ADC labeling & label debugging
  - sequence definitions
  - interface setting
- Example reconstructions
  - MPRAGE with GRAPPA = 2
  - Multi-slice EPI with navigator and ramp sampling

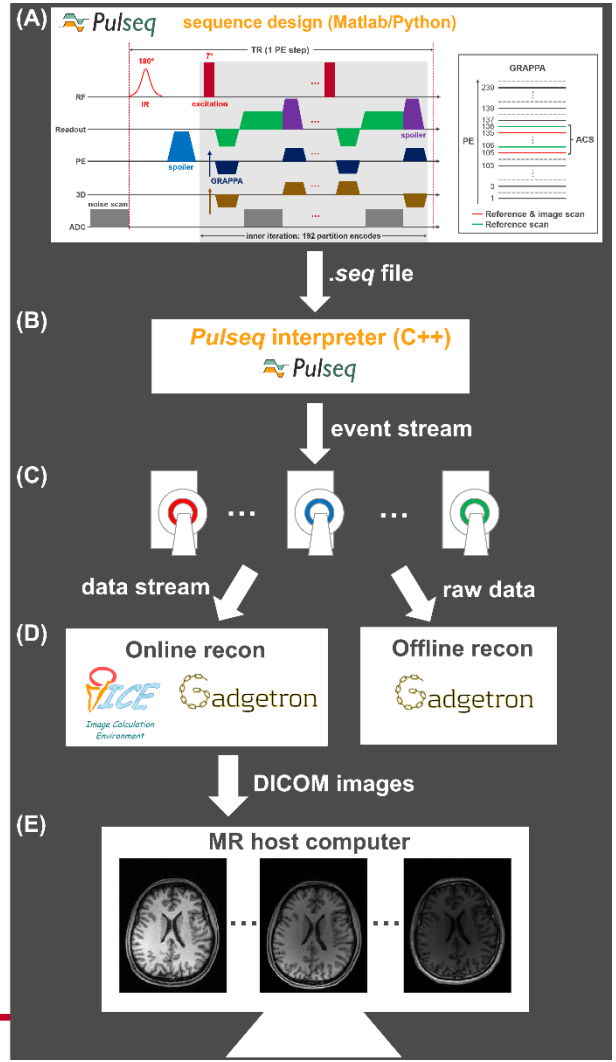
Workflow

- Sequence design in the Pulseq software:
  - ADC labeling
  - sequence definitions (`seq.setDefinition(…)`)
- Extended Pulseq interpreter *sequence*
  - Load ADC labels and sequence definitions
  - Link to ICE and Gadgetron[1,2]
- ICE is integrated to Siemens, while Gadgetron is vendor-independent by employing ISMRMRD[3] data format (Siemens, GE, Philip, Bruker, etc).

  Gadgetron: https://github.com/gadgetron/gadgetron

  ISMRMRD: https://github.com/ismrmrd/ge_to_ismrmrd

  IceGadgetron: https://github.com/NHLBI-MR/ISMRM2019_demo/tree/master/Siemens_Scanner_Setup



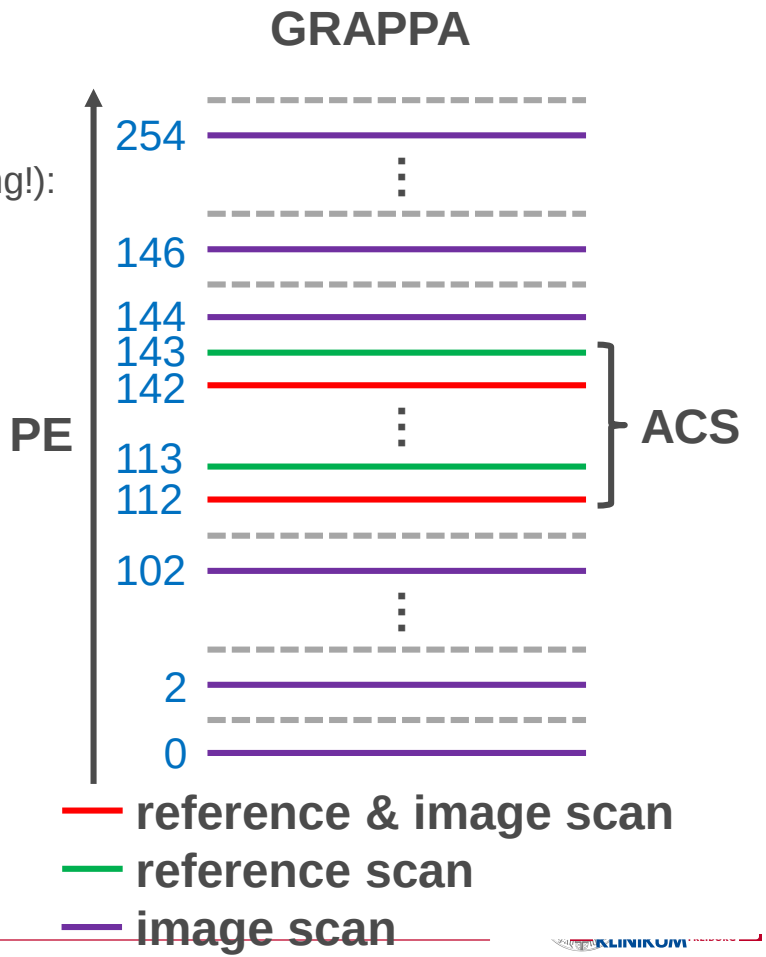
1. Hansen, et al., MRM, 2013. 2. Xue, et al., MRM, 2015. 3. Inati, et al. MRM, 2017.

ICE/Gadgetron Setup

ADC labeling

- Phase-encoded **index** labeling (caution: c-style numbering!):
  - Index setting
    - `mr.makeLabel( 'SET', 'LIN', 0 )`
  - Index increment
    - `mr.makeLabel('INC', 'LIN', 2 )`

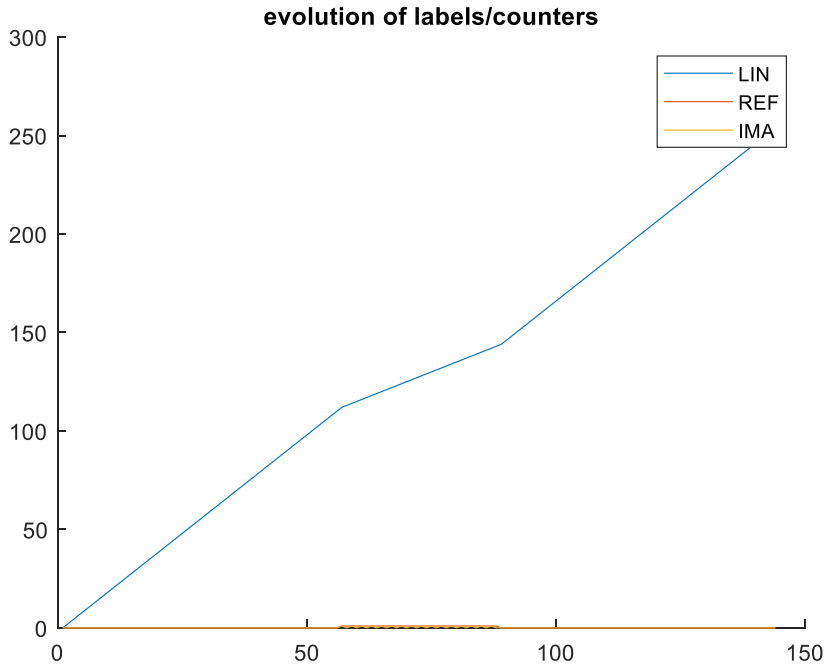
- ACS **flag** labeling:
  - Reference & image scan
    - `mr.makeLabel('SET', 'REF', true )`
    - `mr.makeLabel('SET', 'IMA', true )`
  - Reference scan
    - `mr.makeLabel('SET', 'REF', true )`
    - `mr.makeLabel('SET','IMA', false )`
  - Image scan
    - `mr.makeLabel('SET', 'REF', false )`
    - `mr.makeLabel('SET','IMA', false )`



ICE/Gadgetron Setup

ADC debugging

```
adc_lbl =
seq.evalLabels('evolution','adc');
figure ;
hold on ;
plot(adc_lbl.LIN) ;
plot(adc_lbl.REF) ;
plot(adc_lbl.IMA) ;
```

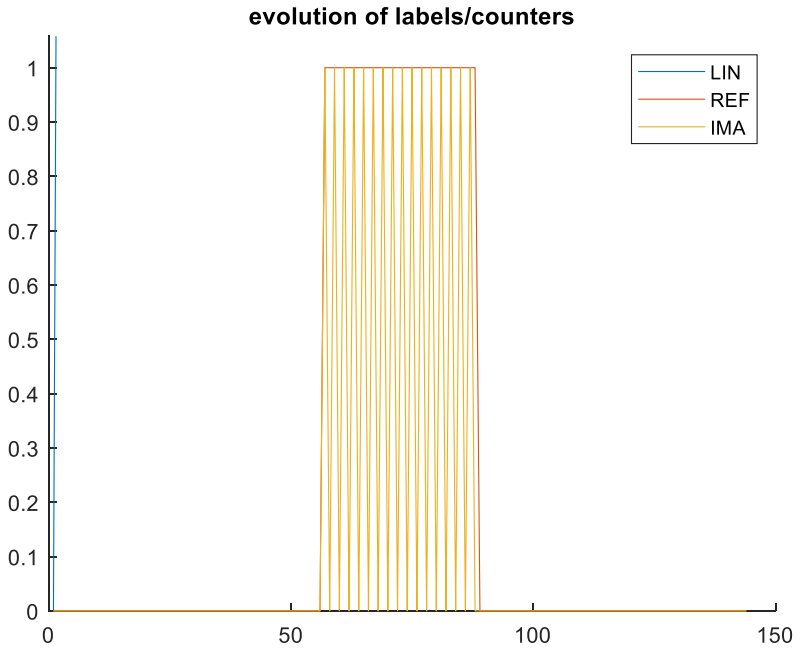


LIN: PE index

ICE/Gadgetron Setup

ADC debugging

```
adc_lbl =
seq.evalLabels('evolution','adc');
figure ;
hold on ;
plot(adc_lbl.LIN) ;
plot(adc_lbl.REF) ;
plot(adc_lbl.IMA) ;
```



REF: ACS reference scan flag
IMA: ACS reference&image scan flag

ICE/Gadgetron Setup

Sequence definitions

- **2D multi-slice mode**

```
seq.setDefinition('SlicePositions', 0) ;
seq.setDefinition('SliceThickness', sliceThickness) ;
seq.setDefinition('SliceGap', sliceGap) ;
```

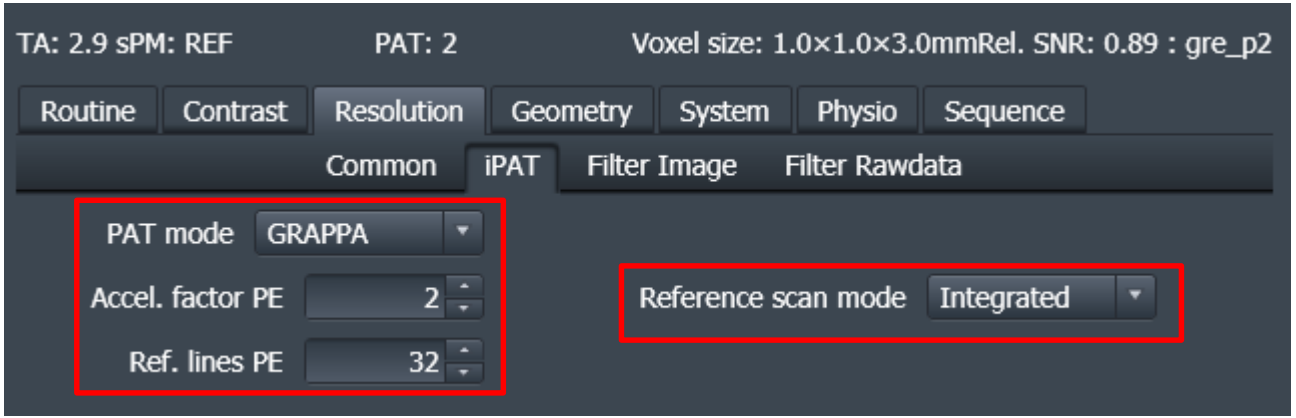
- **Additional information required by GRAPPA**

```
seq.setDefinition('kSpaceCenterLine', centerLineIdx-1) ;
seq.setDefinition('PhaseResolution', phaseResoluion) ;
```

ICE/Gadgetron Setup

Interface setting

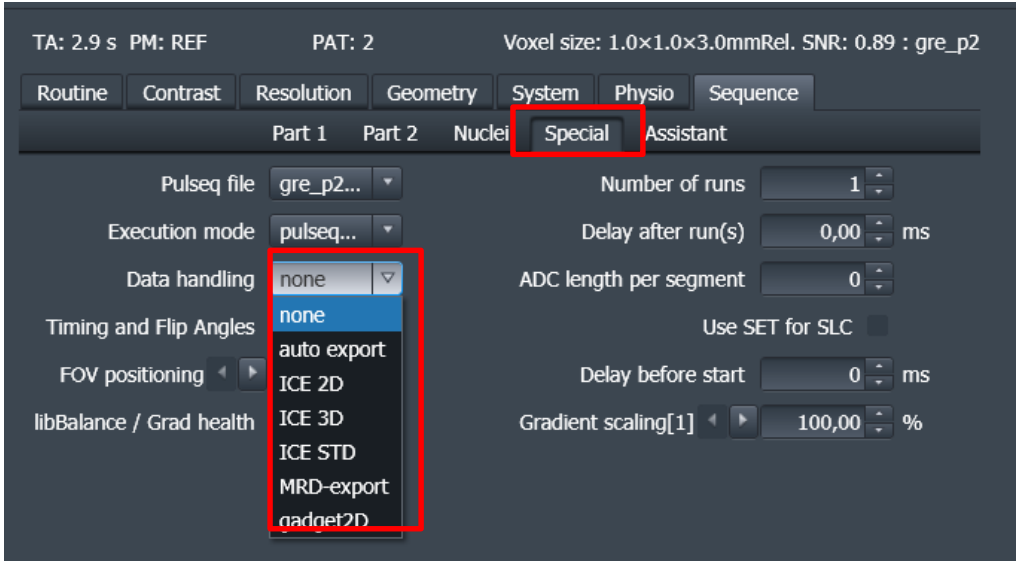
- Turn on iPAT setting: *PAT mode*
- Set *Accel. factor PE*, *Ref. lines PE*, and *Reference scan mode*
- **Caution**: GRAPPA mode must be turned on for ICE/Gadgetron recon. **Do not** forget to turn it off after data acquisition.



ICE/Gadgetron Setup

Interface setting

- Select “Data handling”
  - none: no data handling
  - auto export: NIH data catcher
  - ICE 2D: 2D recon (VB, VE, etc)
  - ICE 3D: 3D recon (VB, VE, etc)
  - ICE STD: 2D&3D recon (XA, etc)
  - MRD-export: ISMRMRD[1] data export
  - gadget2D: gadgetron online recon

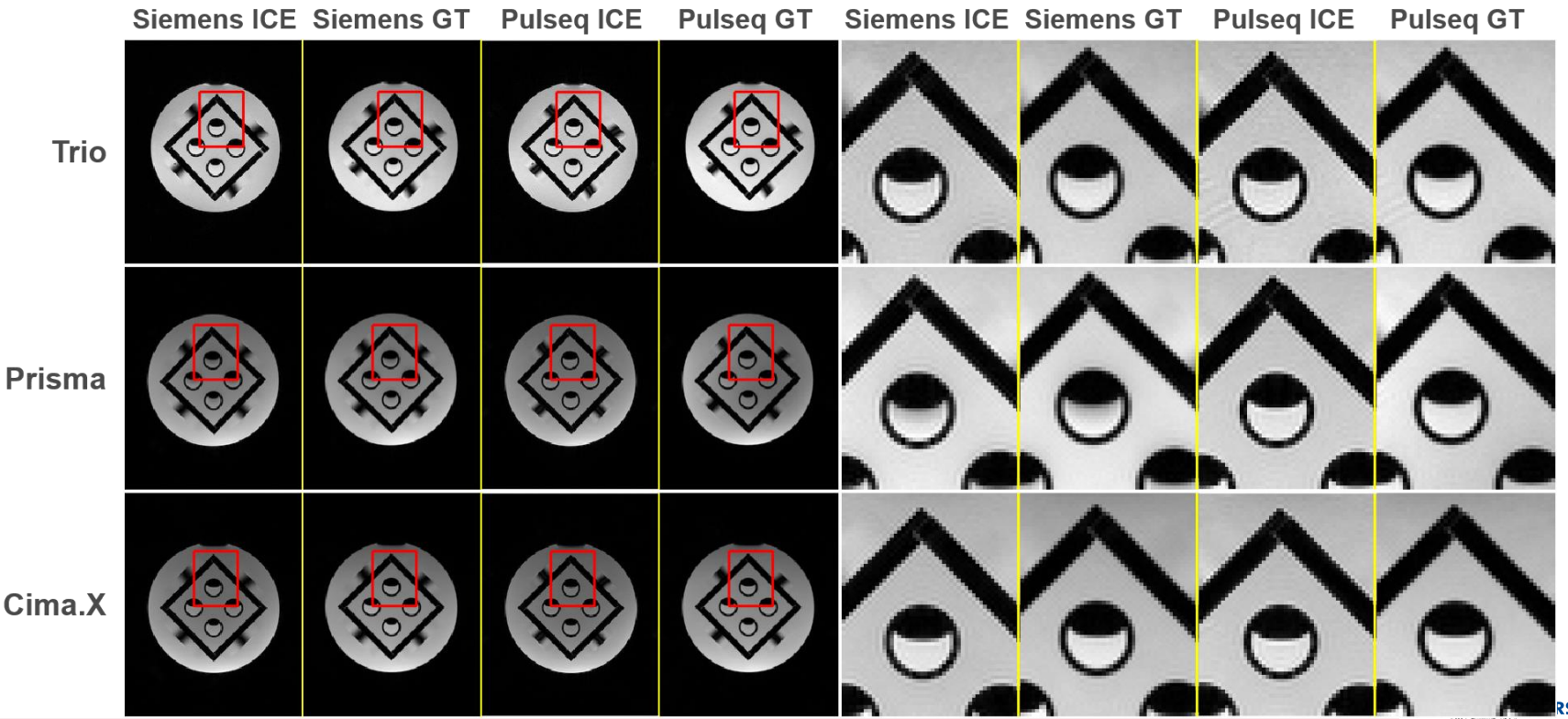


- Caution: IceGadgetron[2] needs to be installed in the Siemens scanner for online Gadgetron reconstruction.

1. Inati, et al. MRM, 2017.; 2. Xue, et al., MRM, 2015.

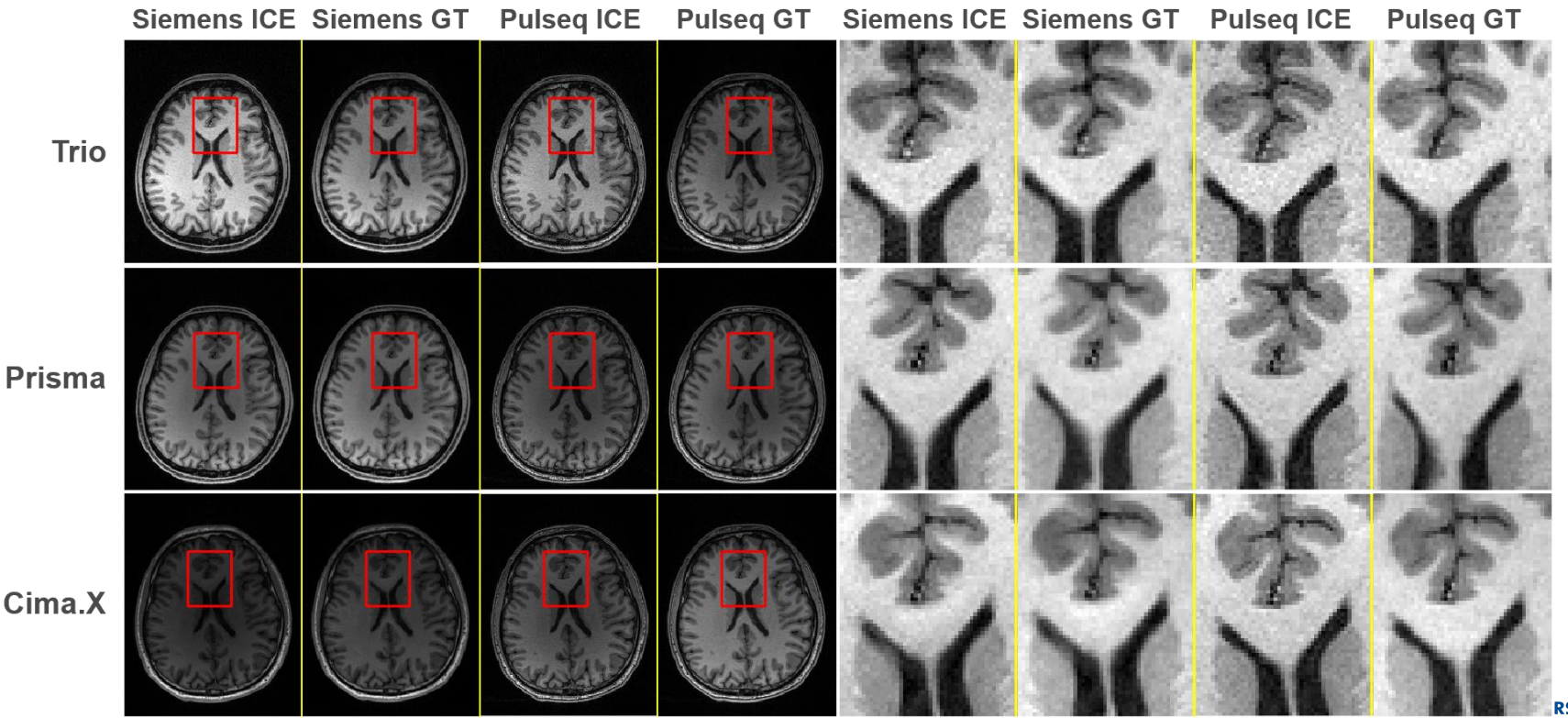
Example reconstructions

MPRAGE with GRAPPA = 2



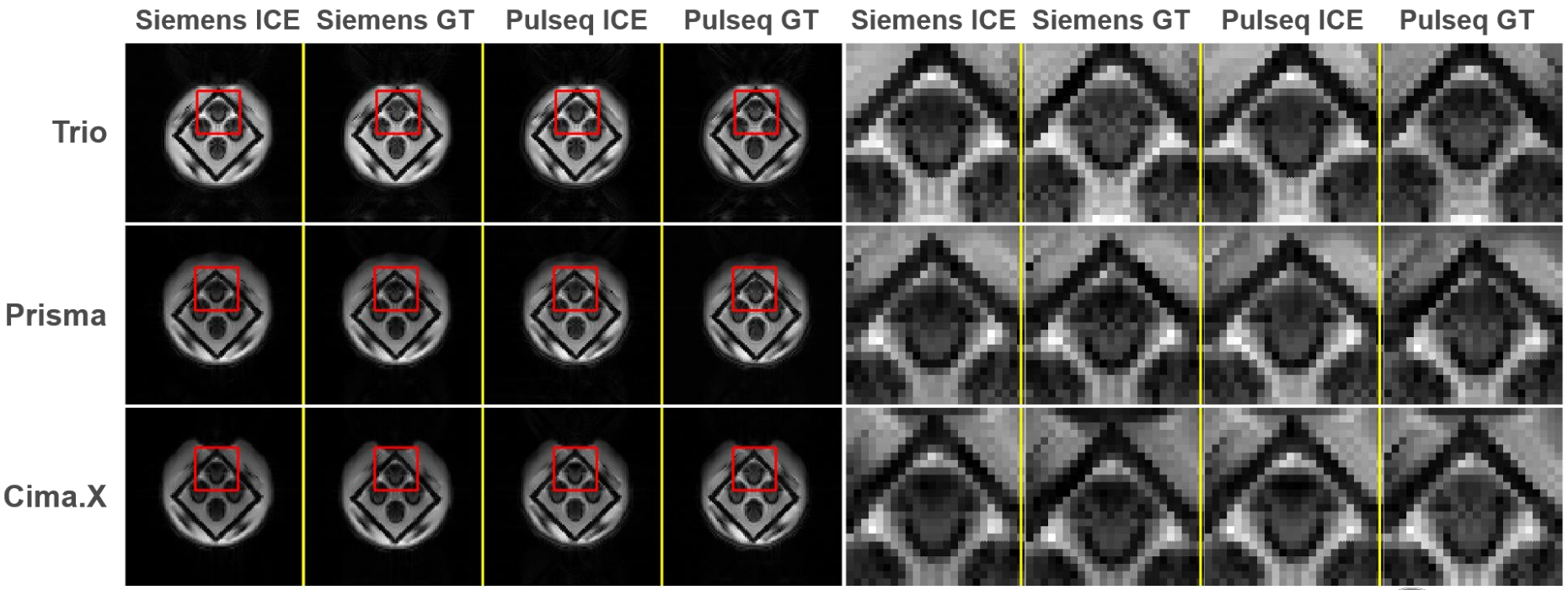
Example reconstructions

MPRAGE with GRAPPA = 2



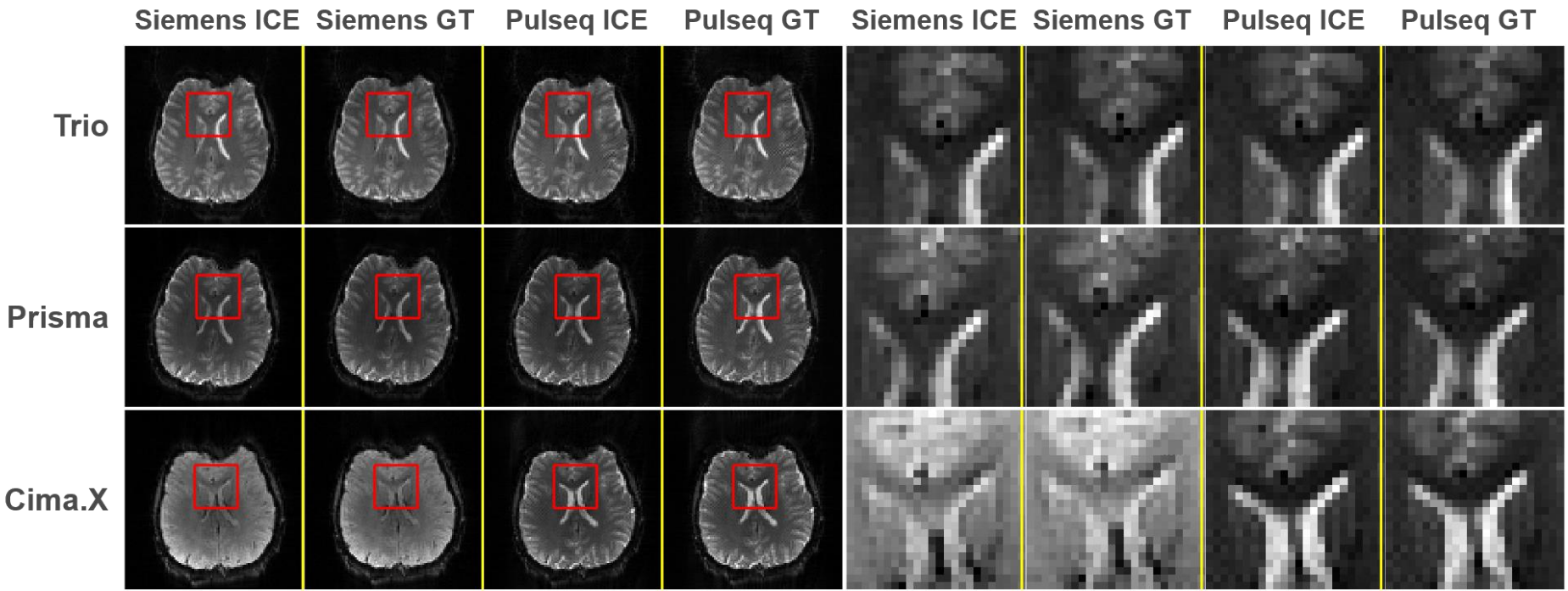
Example reconstructions

Multi-slice EPI with navigator and ramp sampling



Example reconstructions

Multi-slice EPI with navigator and ramp sampling



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pypulseq Python

TOPPE

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