

Pulseq on Siemens

or

how to use *Pulseq* MR pulse sequence environment
on Siemens scanners

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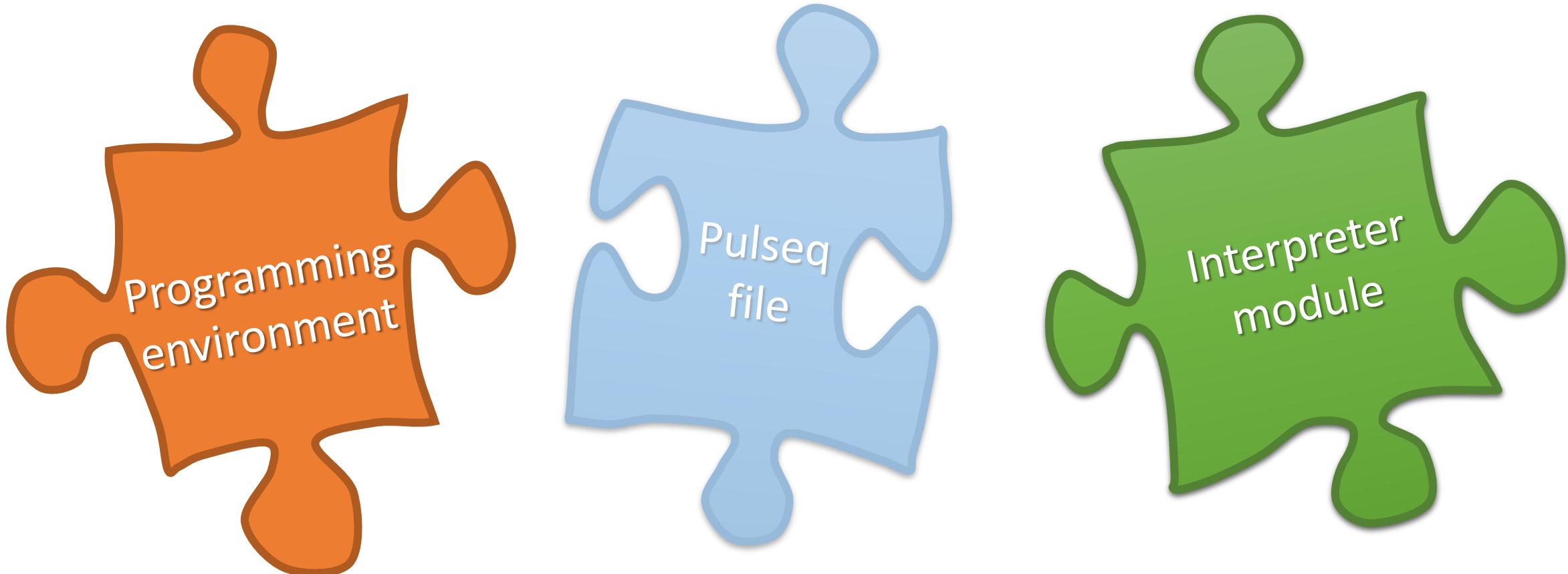




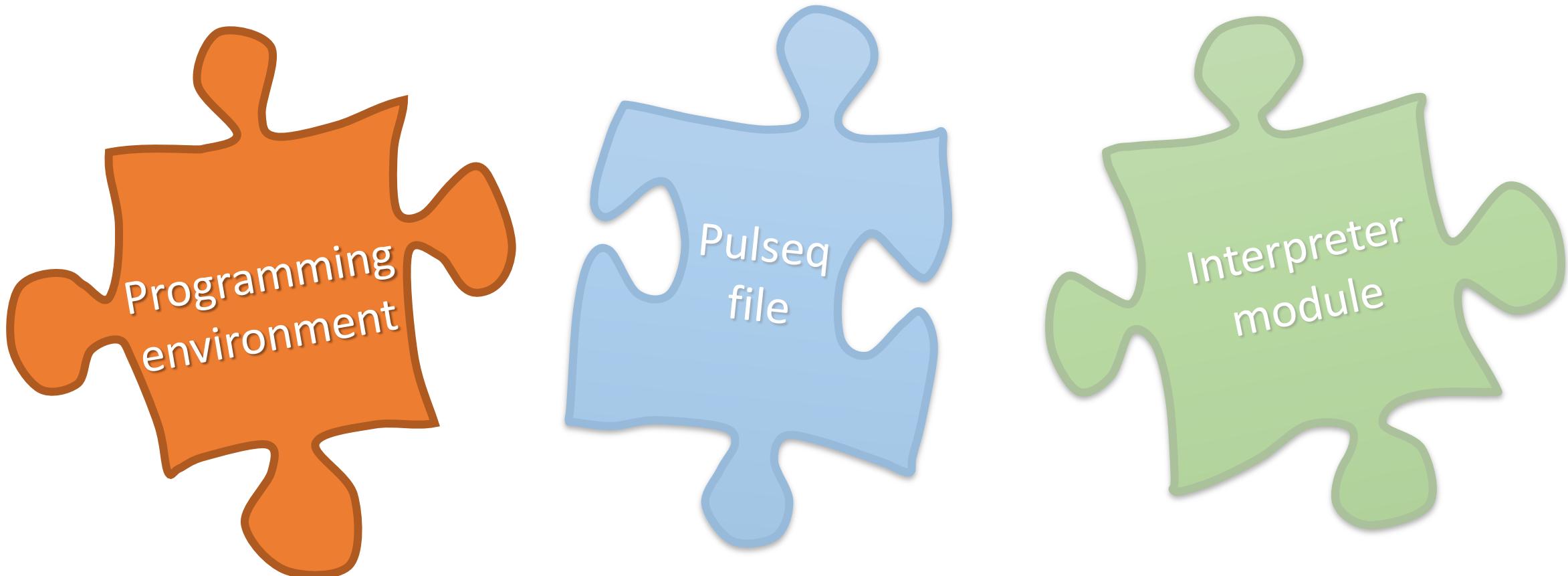
Outline

- Features of the **Pulseq** environment that are Siemens specific:
(as for now)
 - Integrated image reconstruction / Gadgetron / MRD conversion
 - 2D slice-selective mode
 - Accurate peripheral nerve stimulation prediction using the SAFE model
 - Acoustic resonances analysis with
 - Gradient warp (distortion) correction
- Using **Pulseq** on Siemens scanners:
 - **Pulseq** Interpreter Sequence
 - IDEA simulation
 - Scanner set up and special use cases

Pulseq : pieces of the puzzle

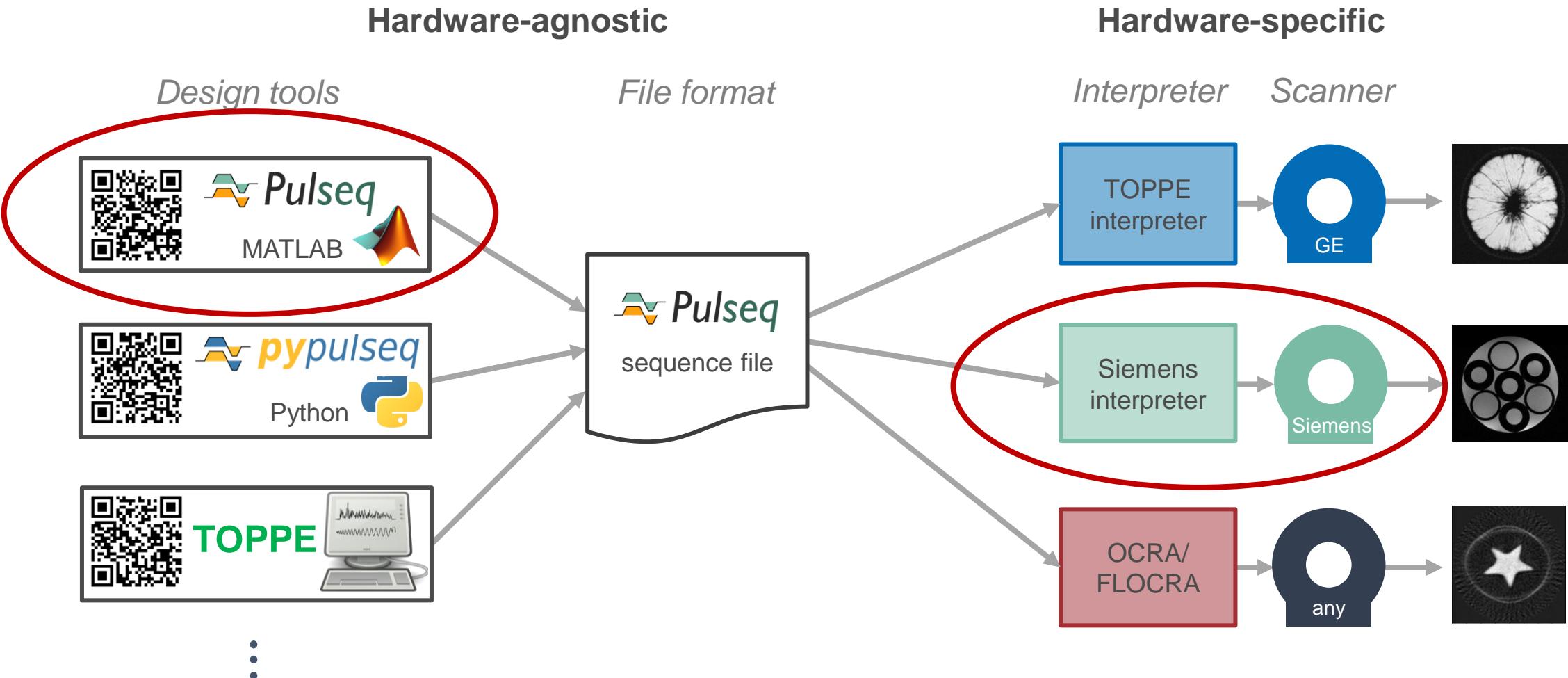


Pulseq : pieces of the puzzle





Pulseq framework overview





Pulseq PNS prediction

- Peripheral neural stimulation (PNS) prediction on Siemens is based on the so-called SAFE model

F.X. Herbank and M. Gebhardt. SAFE-Model - A New Method for Predicting Peripheral Nerve Stimulations in MRI. ISMRM 2000, #2007.

<https://cds.ismrm.org/ismrm-2000/PDF7/2007.PDF>

- Open-source implementation by Filip Szczepankiewicz and Thomas Witzel:

https://github.com/filip-szczepankiewicz/safe_pns_prediction



- Direct interface in Pulseq since v1.4.0



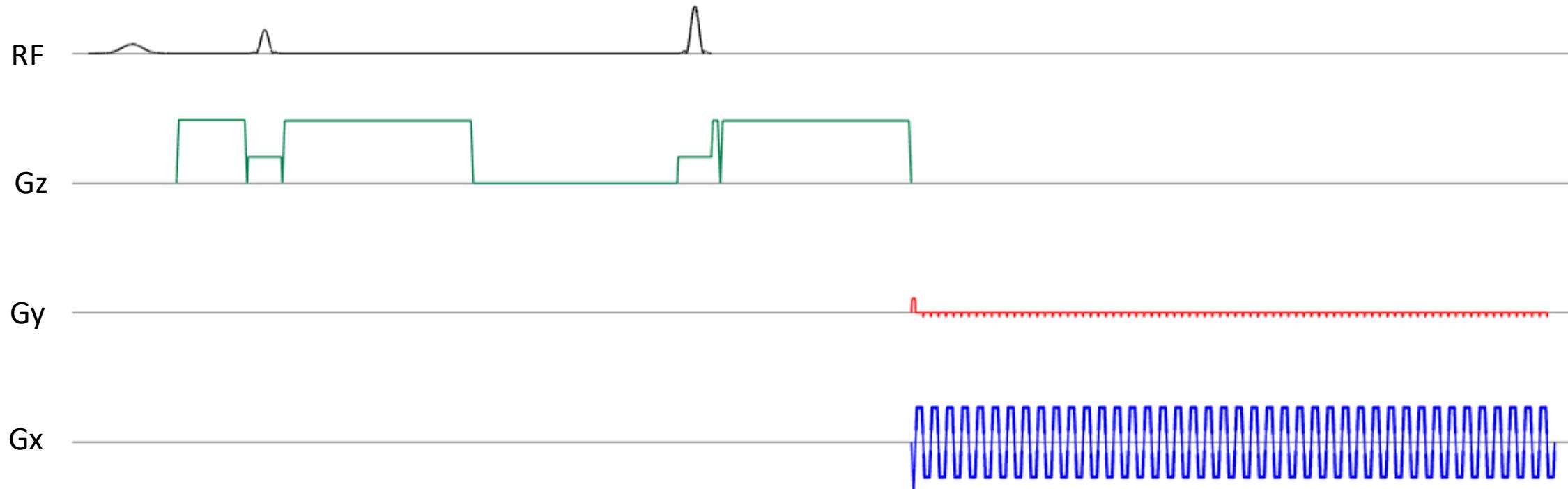
PNS prediction ingredients

- Open-SAFE by Filip Szczepankiewicz
- Extract your gradient system description file from IDEA
 - Type “sys” in the IDEA shell selecting your system
(you may need to select something else first to see the verbose output)
 - Note the strings after “GPA Type” and “GC Type”
 - Go to C:\MIDEA\N4_VE####\n4\pkg\MrServers\MrMeasSrv\Config\InitMeas and pick the file named MP_GPA_<your_GPA>_<your_coil>.asc and copy it somewhere where your Matlab can read it
- You can now predict PNS in the same way IDEA and scanner do it



Example: DW-EPI

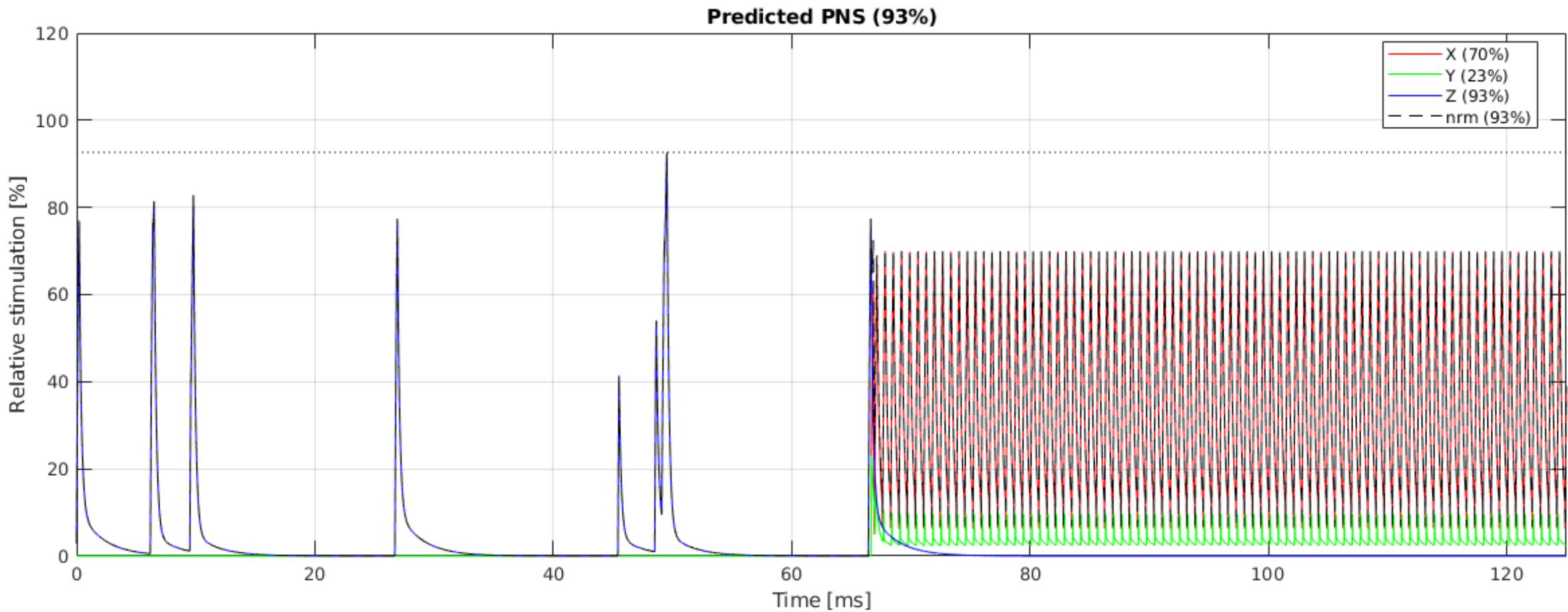
- bFactor=1000, TE=78ms, Gmax=38mT/m SR=180T/m/s





PNS Stimulation: DW-EPI

```
seq.calcPNS('idea/asc/MP_GPA_K2309_2250V_951A_AS82.asc');
```



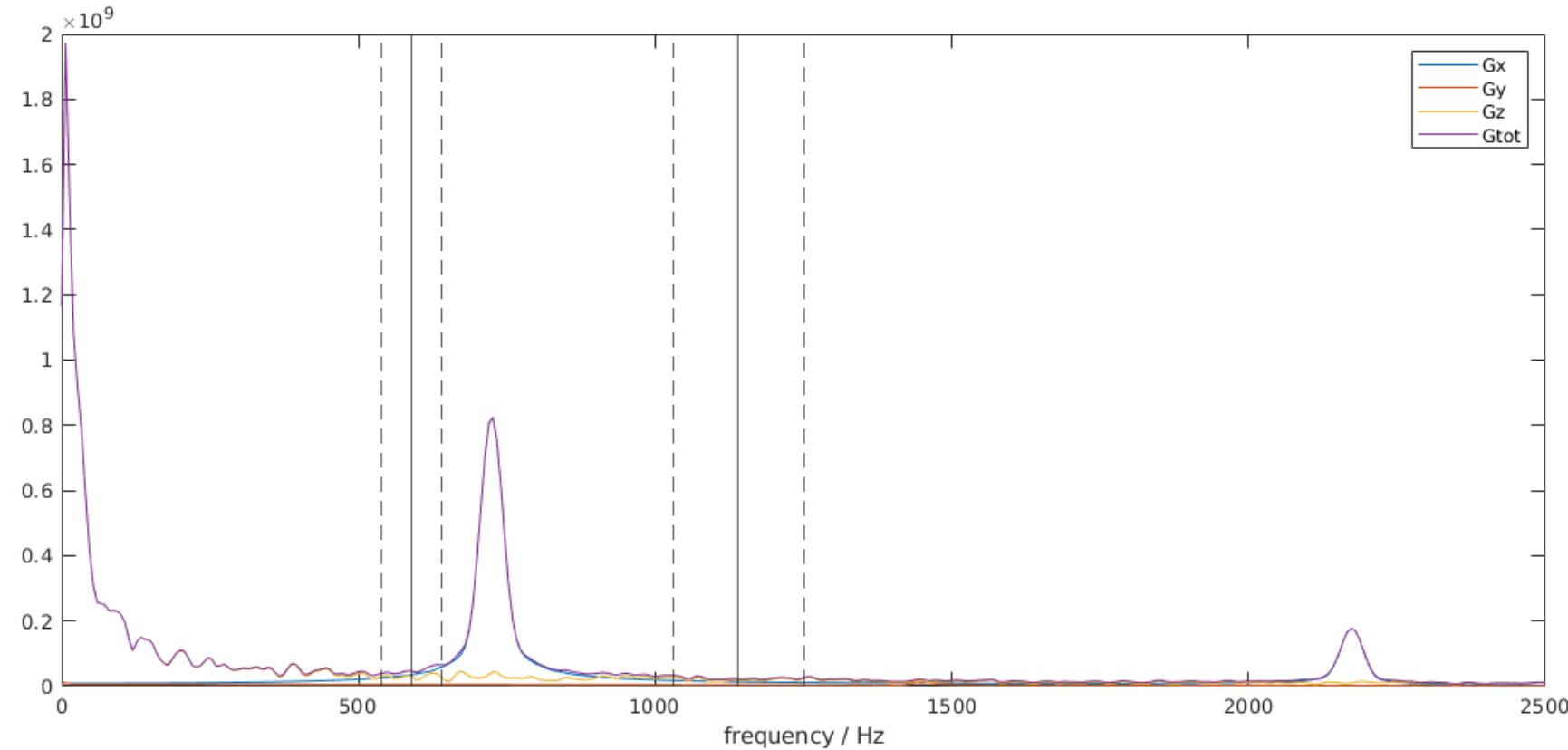


Acoustic resonances analysis

- Extract your gradient system description file from IDEA as before
- Create your sequence in memory (populate the “seq” object with events)
- Run “gradSpectrum.m” script in “matlab/demoUnsorted”
 - Set ascName='....' to your gradient system .asc file to see resonances marked



Acoustic analysis: DW-EPI



```
seq.sound(); % another option for the acoustic assessment ;-)
```

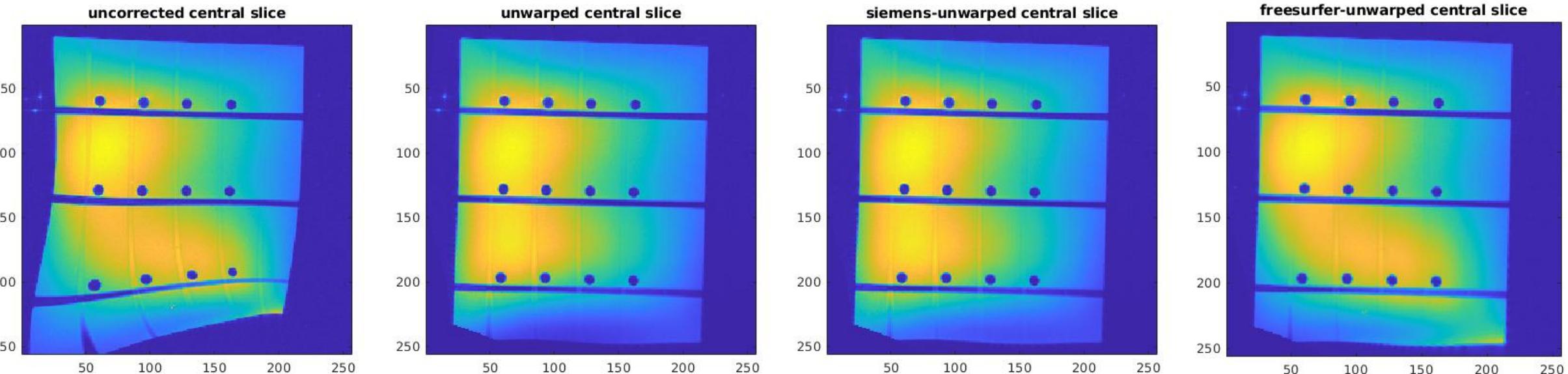


Very new: grad-warp correction

- *Not yet available in github (see below)*
- Extract your gradient distortion parameters from IDEA
 - Go to C:\MIDEA\N4_VE###\n4\pkg\MrServers\MrVista\MrEvaAlgos\MrDistorCor2D\GradientCoils and extract file called coeff_<your_coil>.grad
- Or use your Skope Dynamic Field Camera in N positions
 - Submitted to the ISMRM 2024, to be published soon
- Works for 2D/3D sequences with arbitrary slice/slab positioning



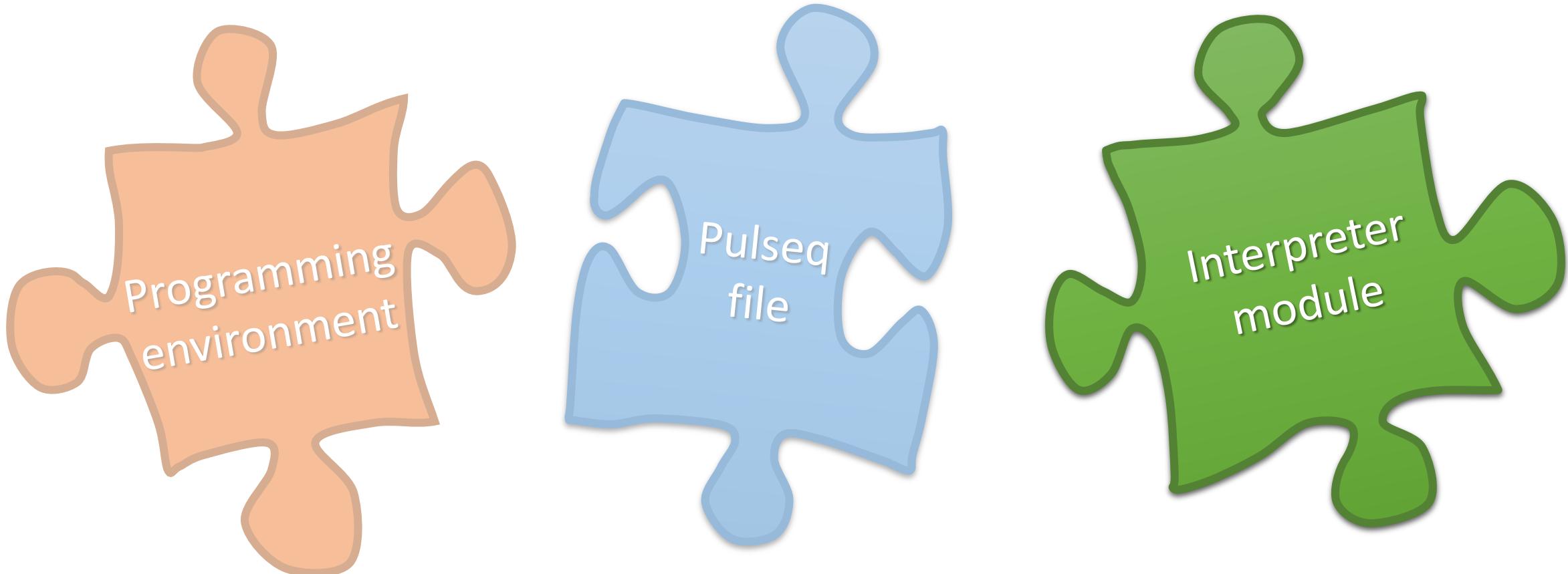
3D grad-warp correction example



Very close match to Siemens

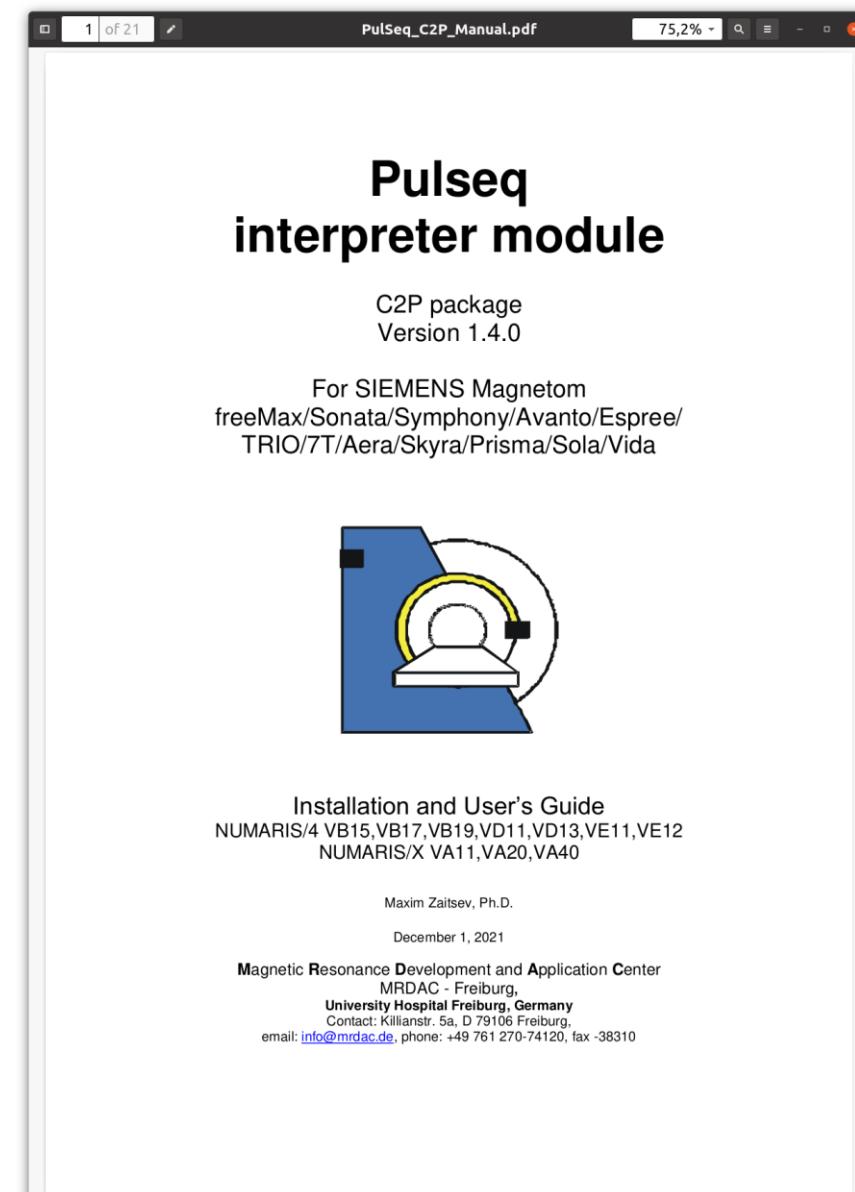
100% the same geometry as in FreeSurfer but with an amplitude correction
...will be made available within few weeks/months

Pulseq : pieces of the puzzle



Pulseq Siemens interpreter

- Just a “normal” sequence
 - Loads its “content” from a Pulseq file
 - Almost all aspects of the sequence are pre-defined in the Pulseq file
 - FOV positioning and rescaling possible
- Based on miniFlash
 - No product code
 - No hacks, no backdoors
- Distributed as a C2P package in **source form**
- Standard SAR calculation
- Since 1.3.1: libBalance applicable to all sequences
- PNS and acoustic resonance analysis possible in Matlab
- **Safety equal or higher than a typical IDEA sequence**





Pulseq on Siemens platforms

- About 100 C2P sites
- Works on:
 - All Numaris4 platforms (tested on vb15...ve12u) and numerous hardware platforms (Symphony, Trio, 7T, 3T Connectom, Skyra, Prisma,...)
 - Many NumarisX versions (xa11, xa20, xa30, xa40, xa5x, xa6x ...)





Pulseq interpreter C2P

- Universal platform-independent source code
 - Known to compile for everything between Numaris4 vb15 and NumarisX xa61
 - **You have to compile** it one time for each of your different scanners
- Comes with 20 Pages of documentation
 - Please read it before starting to use the package
- The same module can be used for IDEA simulation and scanning on the MRI device



to acquire Pulseq C2P e-mail us at
pulseq.mr@uniklinik-freiburg.de

**Pulseq
interpreter module**

C2P package
Version 1.4.0

For SIEMENS Magnetom
freeMax/Sonata/Symphony/Avanto/Espree/
TRIO/7T/Aera/Skyra/Prisma/Sola/Vida



Installation and User's Guide
NUMARIS/4 VB15,VB17,VB19,VD11,VD13,VE11,VE12
NUMARIS/X VA11,VA20,VA40

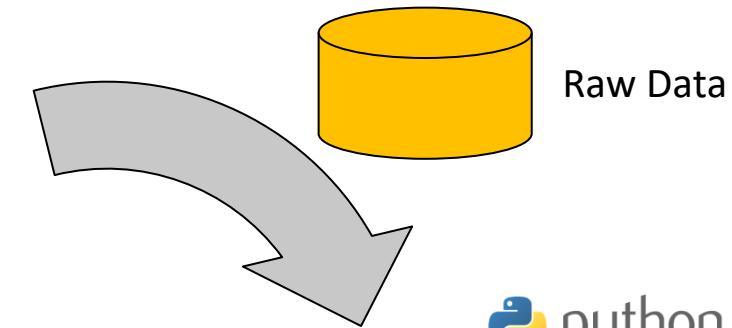
Maxim Zaitsev, Ph.D.
December 1, 2021

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Pulseq on Siemens scanners

- *Optional initial step: connect your PC to the scanner*
- Save the .seq file on the scanner as external.seq
- Run the interpreter_sequence on the scanner
- *Optional step: stream raw data to your PC with NIH_DataCatcher*
- or export raw data manually

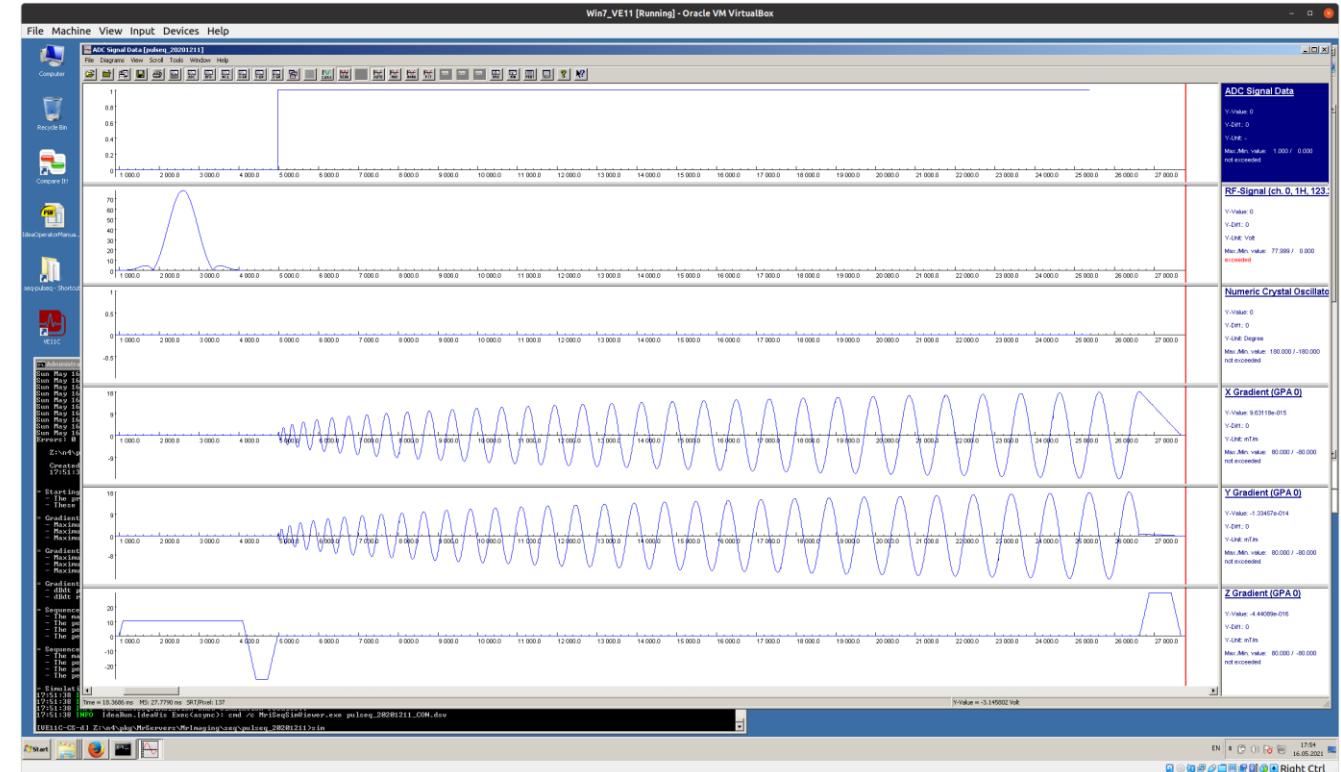
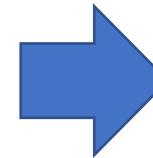
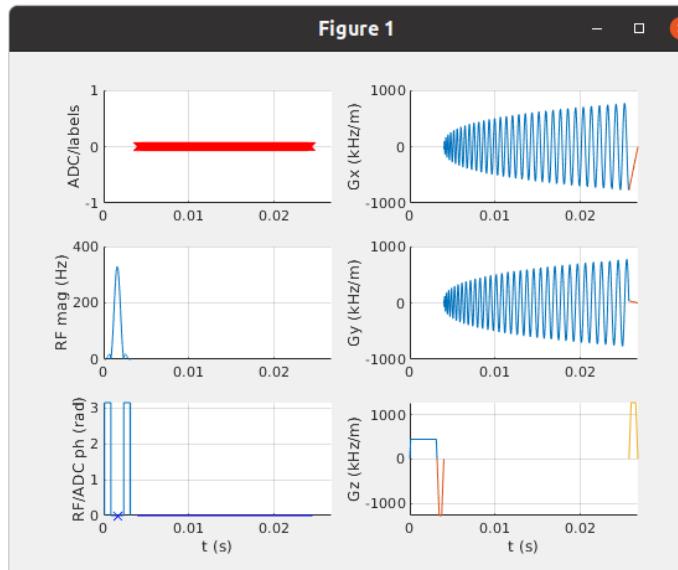




IDEA simulation with *Pulseq*

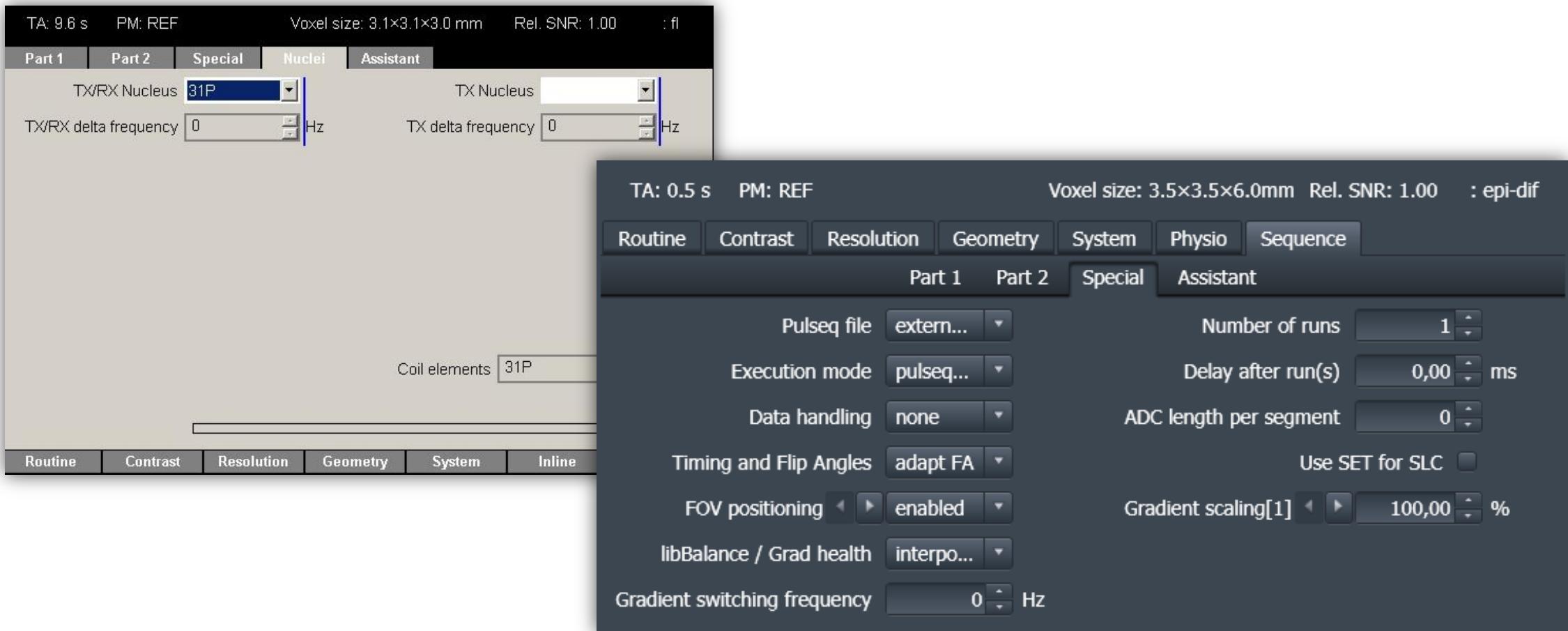
Pulseq interpreter sequence can also be used with the Siemens' IDEA

1. Save your .seq file as %CustomerSeq%/Pulseq/external.seq
2. In the IDEA command run
sim



Pulseq interpreter parameters

- Yes, you can still change few things on the console





Pulseq for Siemens: image recon

- Image reconstruction is up to the researcher
- Integration with ICE is possible for some sequences
 - 2D GRE
 - 2D EPI with ramp sampling
 - 3D MPRAGE with GRAPPA
- Online & offline reconstruction with Gadgetron for some sequences
- Offline reconstruction in Matlab
 - Examples for 2D / 3D Cartesian reconstruction
 - Simple gridding reconstruction
 - Example of automated BART reconstruction
- All-in-one FIRE solution : Marten Veldmann et all, MRM 2022, doi:10.1002/mrm.29384

Qingping Chen's Talk



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