JASS and PSA
current status and developments

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Overview

- JASS
  - Narval
  - Open issues
  - Effects of grid size
    - Where are the biggest errors ?
    - How are the trajectories affected ?
- PSA
  - Performance with different metrics
  - Systematic effects of mobility parameters / response functions
  - Neural Net implementation
- Summary & Outlook

JASS – AGATA Pulse Shape Simulation

- Simple binary file format defined
  - Read function implemented into NARVAL emulator
  - Decides automatically on file format (JASS/ADL/Venturelli)
- Paper prepared for EPJA
- Open issues
  - Signals in front row not well reproduced

JASS: Effects of grid size

- Tests conducted with true coaxial detector
  - Same dimension as AGATA crystals (r_{min} = 5 cm; r_{max}=40 cm)
  - Space charge 0.5* 10^10 1/cm^3
  - Analytic solution available:

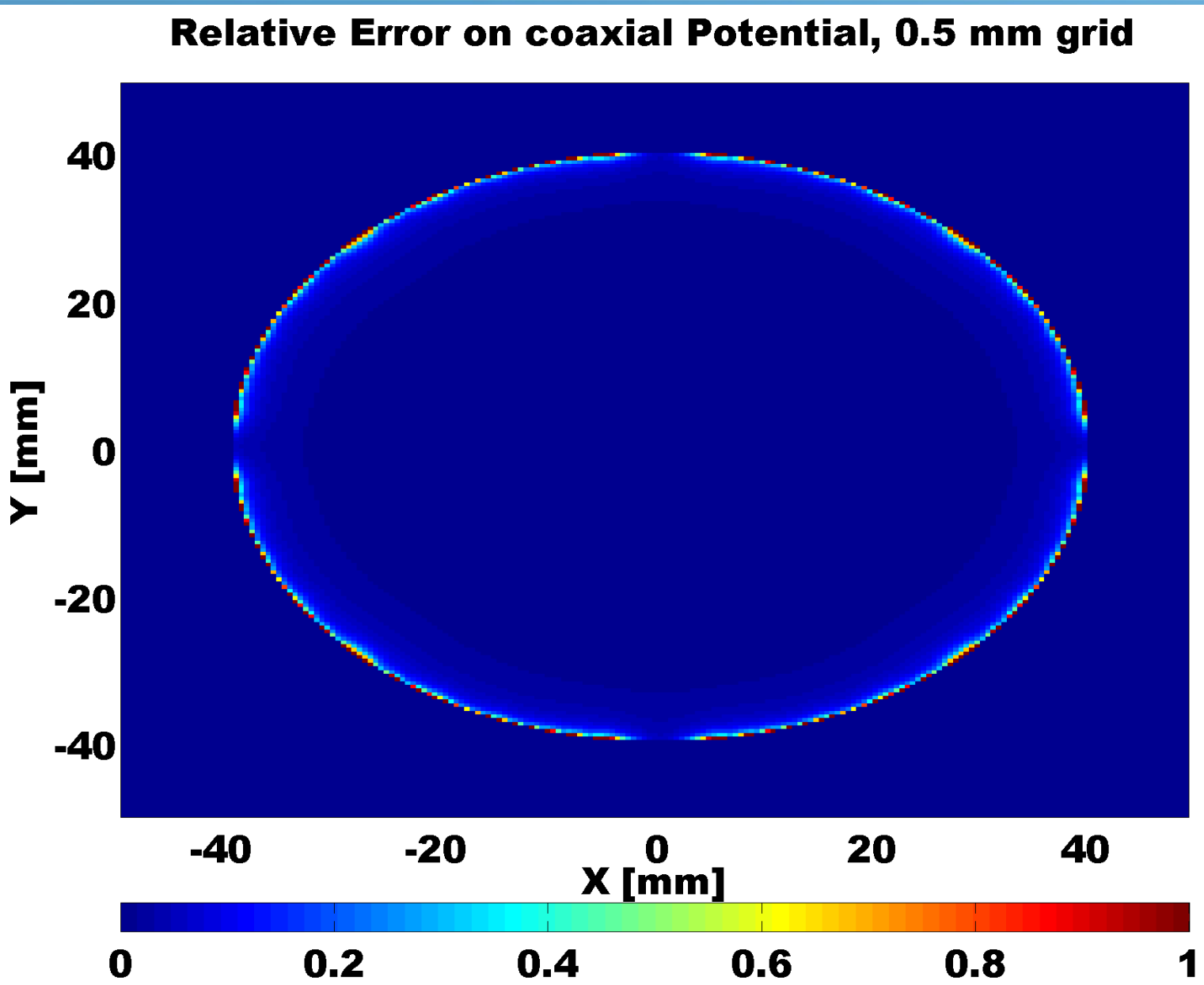
$$\Phi(\vec{r}) = a \cdot \ln(\vec{r}) + \frac{s\,\vec{r}^{\,2}}{4} + b$$

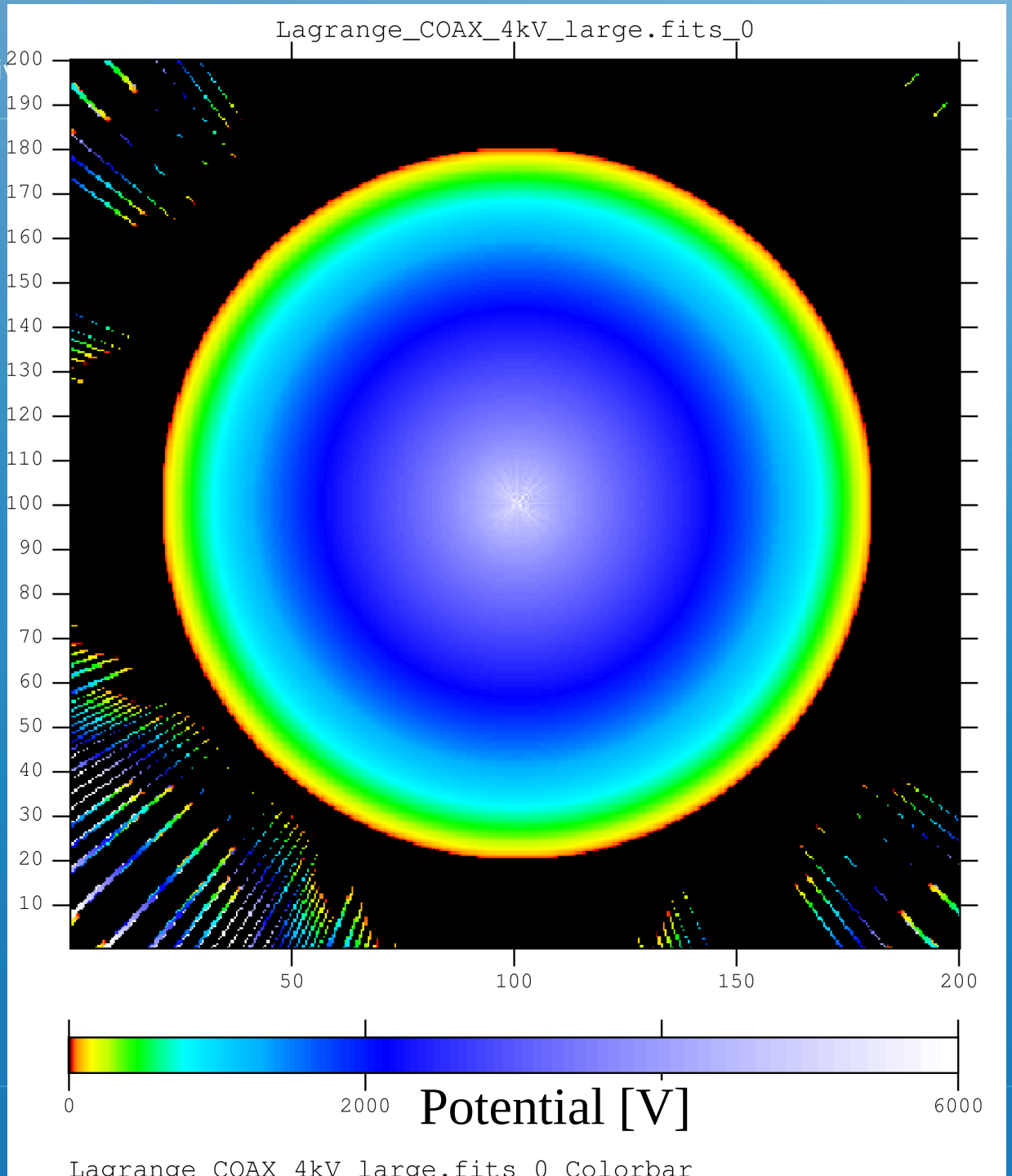
    - Constants including space charge: s
    - a and b are given by boundary conditions
  - Grid sizes of 0.5 mm, 0.25 mm and 0.1mm tested

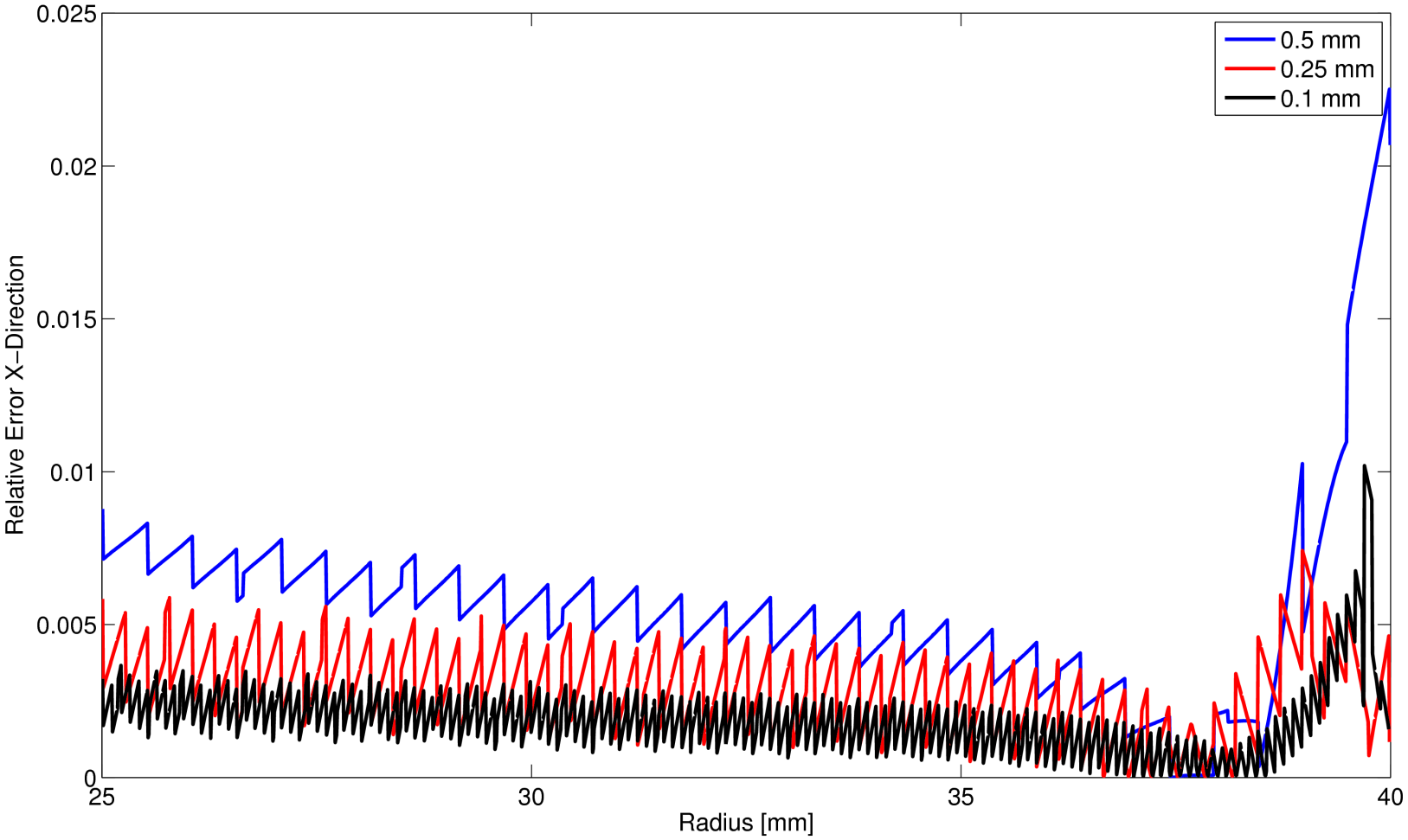
Errors on calculated potential (1st Order approach)

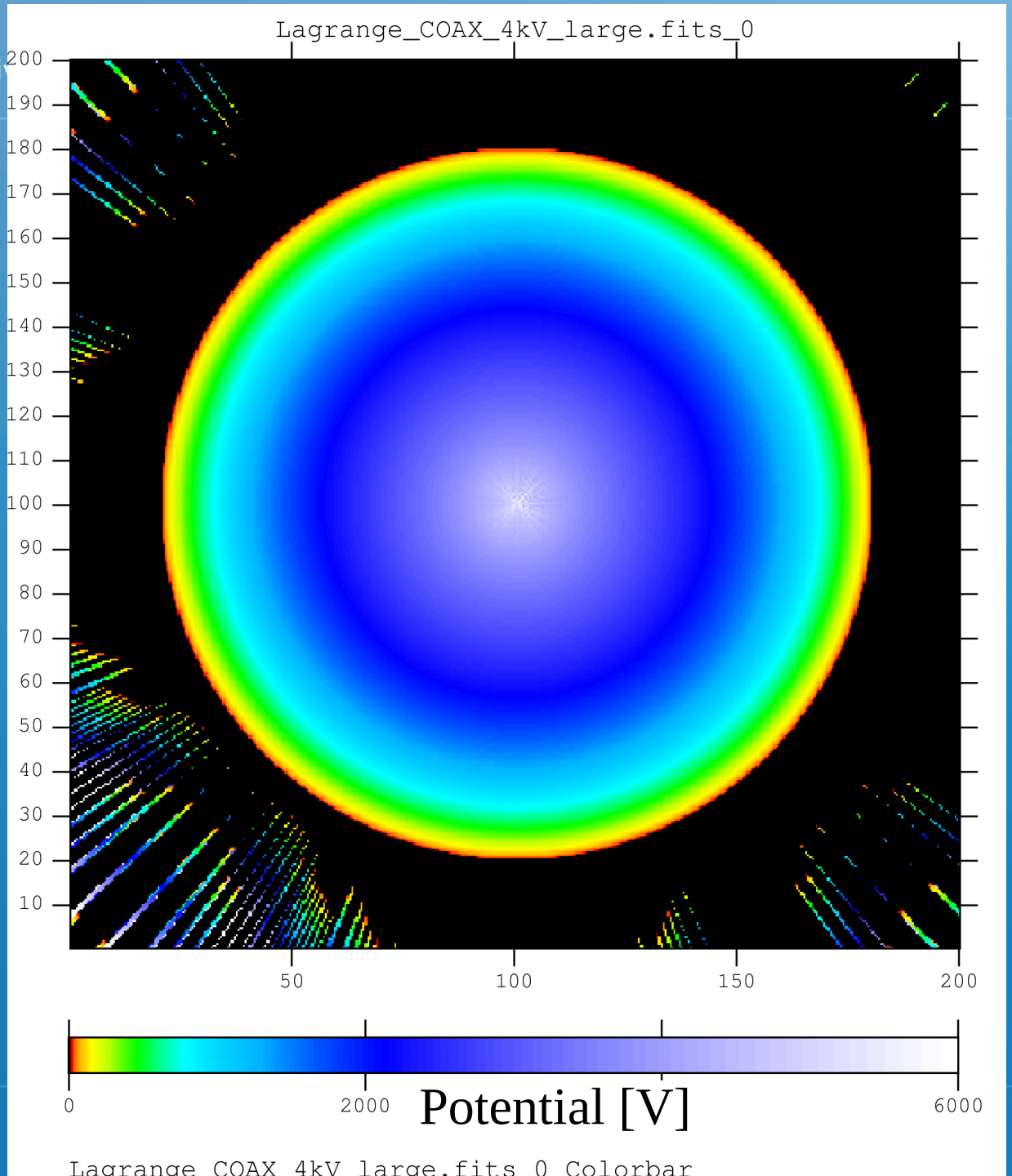
- First order central difference
- $$\Phi(r) = \frac{\Phi(r-h) + \Phi(r+h) + h^2 s}{2}$$
- Grid size: h
- Intrinsically parallel

Rel. Error	0.5 mm	0.25 mm	0.1 mm
< 0.5 %	42 %	58 %	76 %
< 1%	58 %	72 %	86 %
< 5 %	87 %	93 %	97 %
< 10 %	93 %	96 %	98 %
Time [s]	42	685	24504


Relative Error on coaxial Potential, 0.5 mm grid
40
20
0
-20
-40
Y [mm]
-40
-20
0
20
40
X [mm]
0
0.2
0.4
0.6
0.8
1

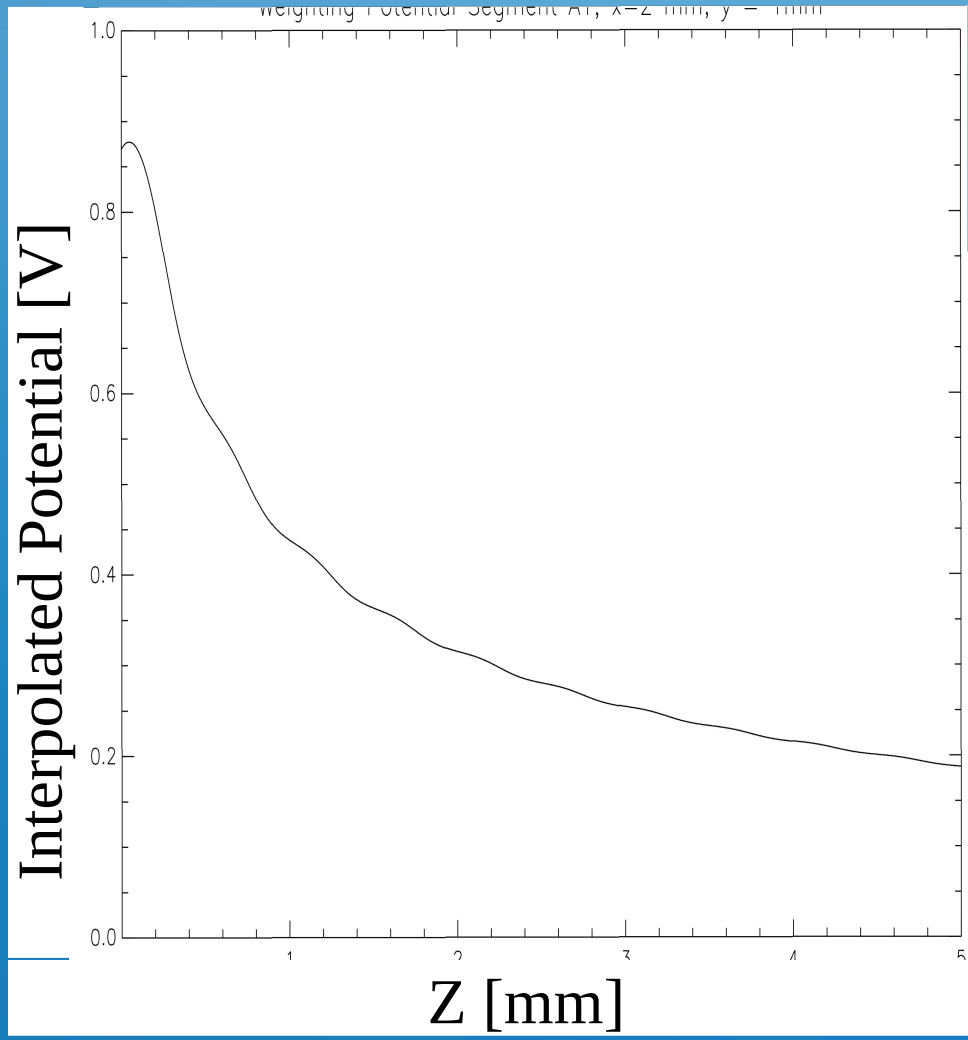

Lagrange_COAX_4kV_large.fits_0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
50
100
150
200
0
2000
6000
Potential [V]
Lagrange_COAX_4kV_large.fits_0_Colorbar

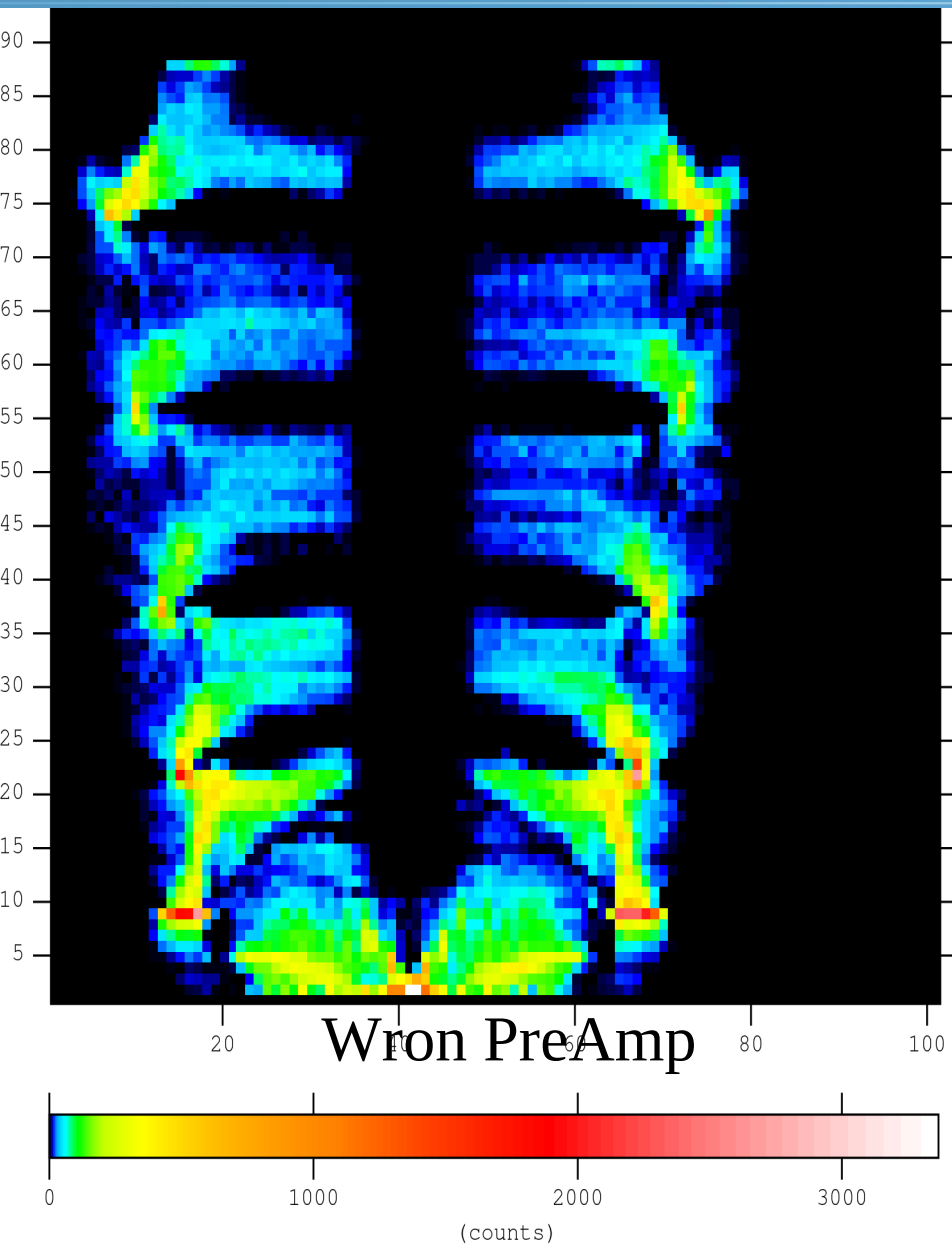

0.5 mm
0.25 mm
0.1 mm
Relative Error X–Direction
Radius [mm]
0.025
0.02
0.015
0.01
0.005
0
25
30
35
40


Lagrange_COAX_4kV_large.fits_0
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
50
100
150
200
0
2000
6000
Potential [V]
Lagrange_COAX_4kV_large.fits_0_Colorbar

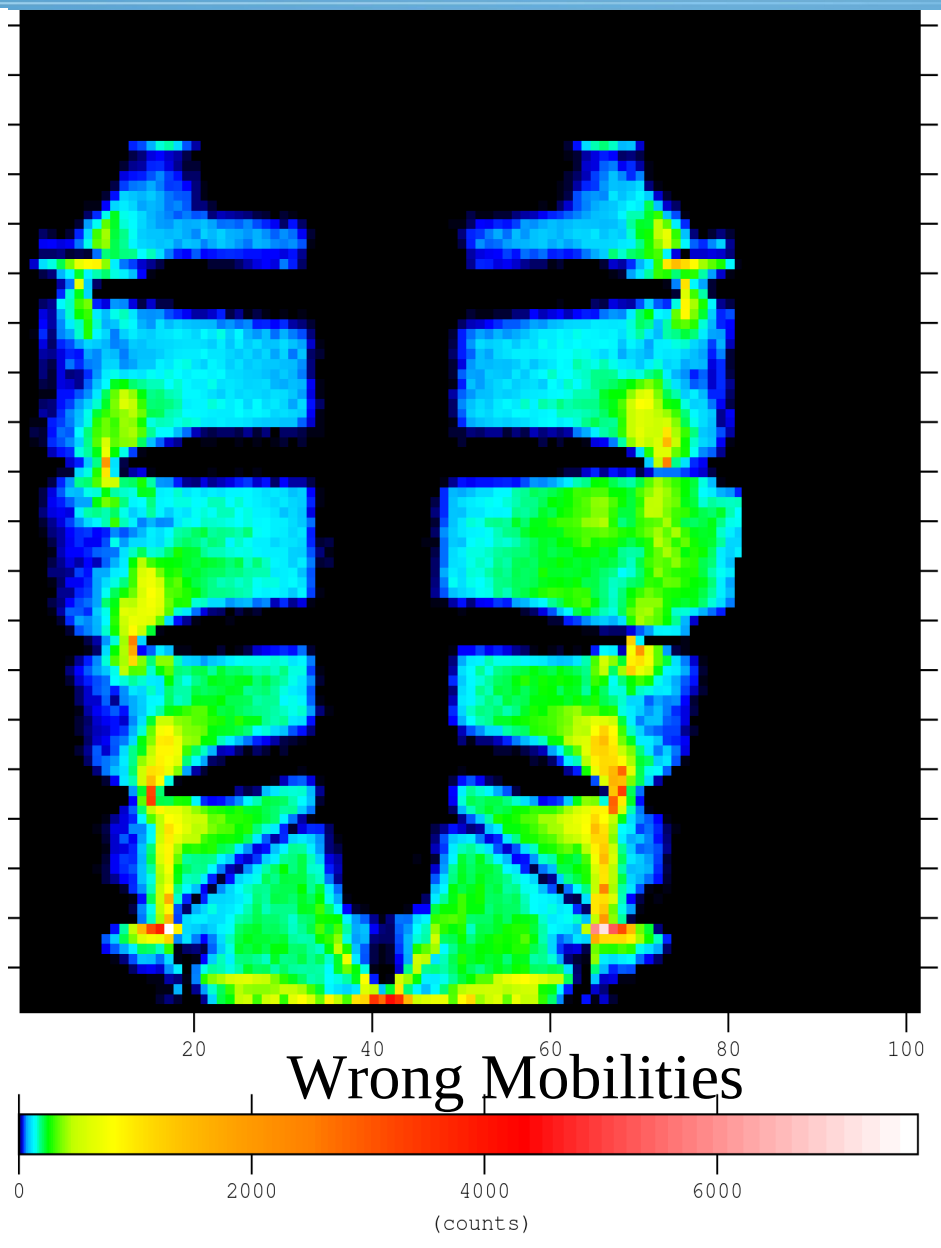
Problems with front electrodes

- Interpolation has problems at tips of electrodes
- Net Charge Signals
  - WP underestimated
  - Charge loss
    - Rescaling of signal
- Transient Signals
  - WP overestimated
  - Hole contribution overestimated
    - Longer drift time for e^-
      - Amplitude underestimated
    - Longer drift time for h
      - Amplitude overestimated
- Extrapolation of potential in 3D





Wron PreAmp



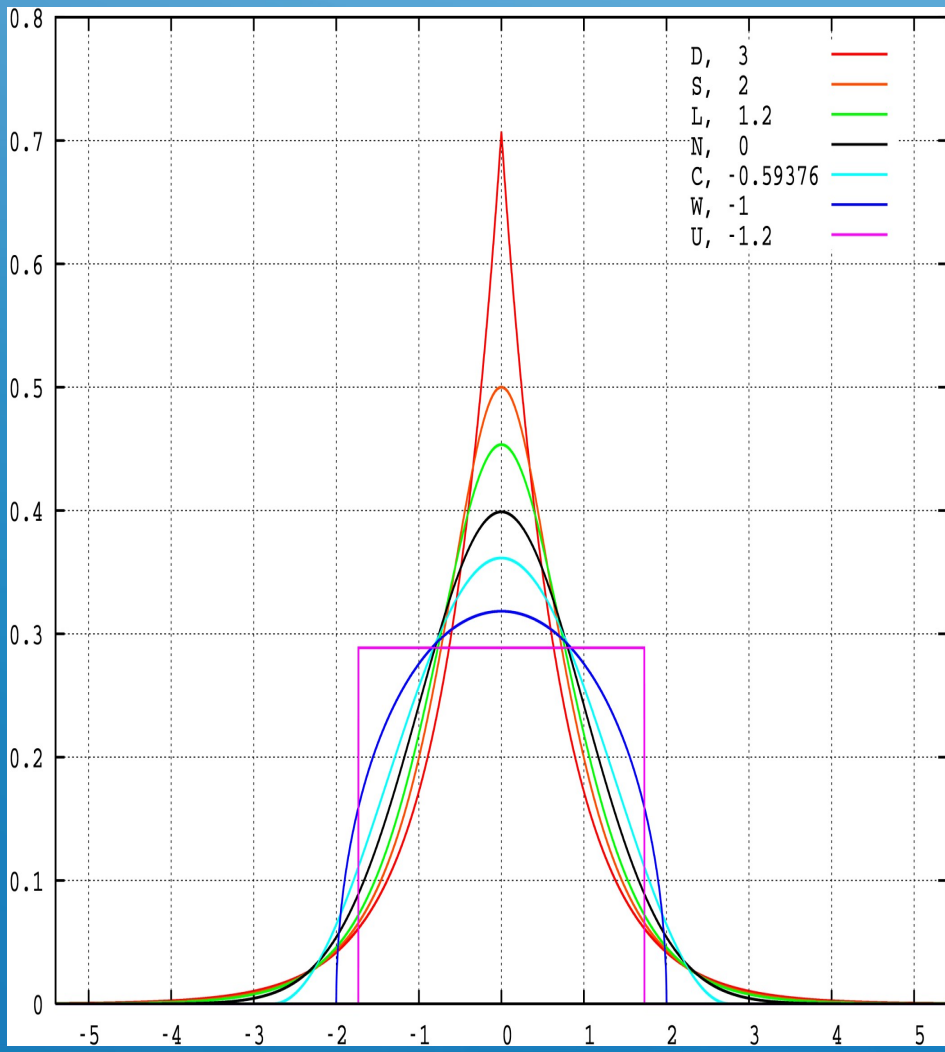
Wrong Mobilities

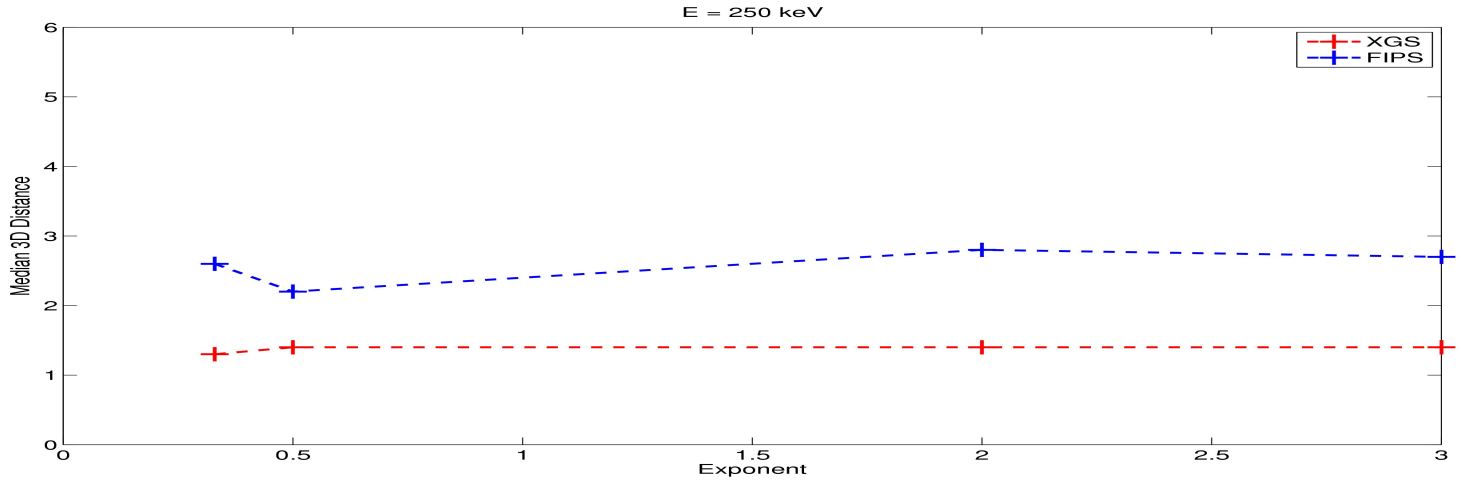
Pulse Shape Analysis

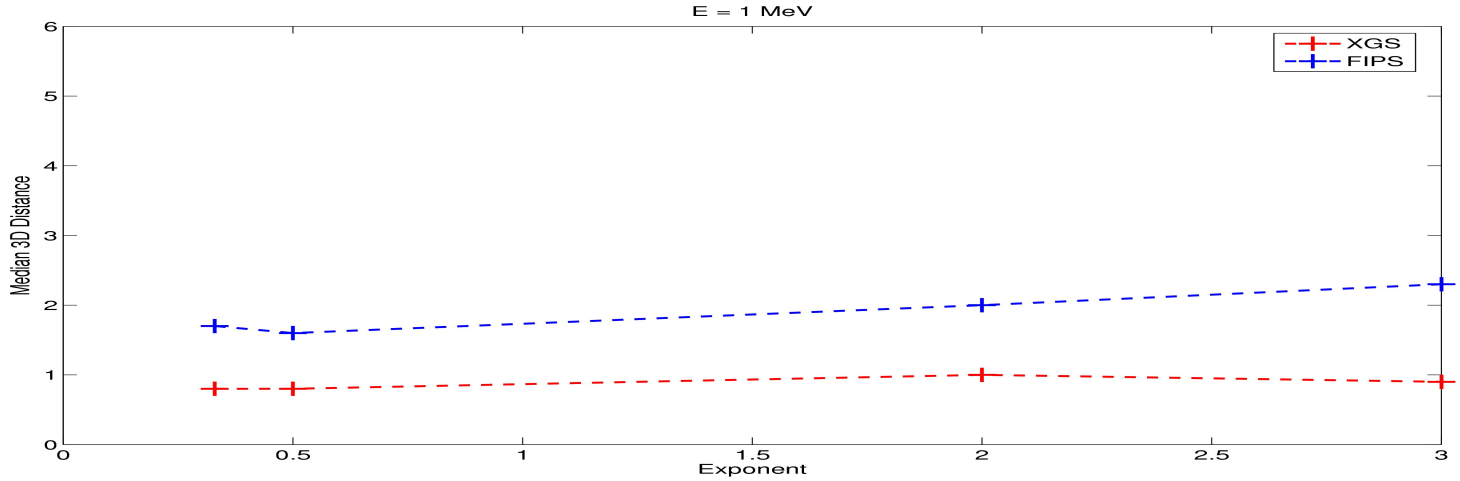
- EPJA Paper in preparation
- Which is the best metric for PSA

$$M = \sum |S(t) - D(t)|^k$$

  - K=0.33/0.5/2/3
- What numbers to use in comparison?
  - Independent of distribution shape
  - Summarize performance in all 3 dimensions
  - Median 3D distance

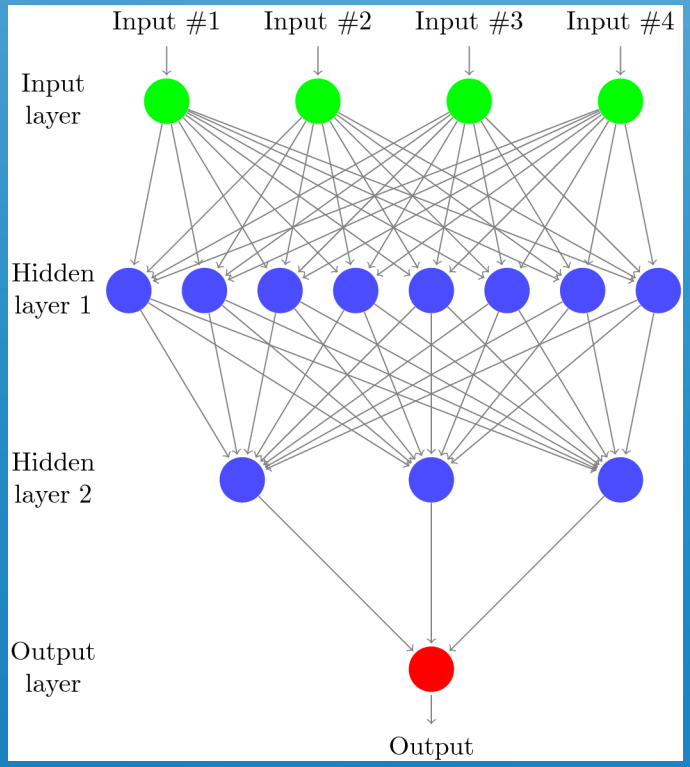



E = 250 keV
XGS
FIPS
Median 3D Distance
Exponent
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4
5
6


E = 1 MeV
XGS
FIPS
Median 3D Distance
Exponent
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4
5
6

Implementation of Neural Net into NARVAL

- Neural Network for t_0 determination
  - First step of PSA
- Uses sum of net charge signals
  - ~straight line
- Preliminary implementation
  - Only one hidden layer
  - Changed XML config file to binary
- Will be tested with ^{60}Co data
  - Debugging



Summary & Outlook

- JASS
  - Problems identified
  - Grid sizes smaller than 0.25 mm not useful
  - 3D extrapolation of potential / weighting potentials
- PSA
  - FIPS performs best with SQRT-Metric
  - GS not affected
  - Neural Net implementation

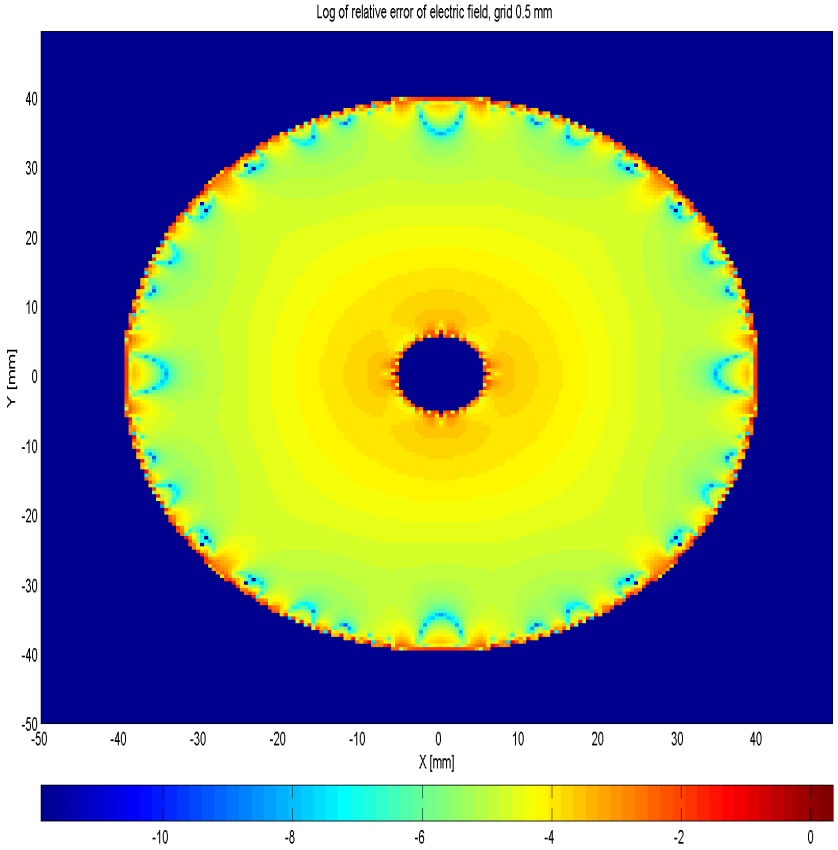
Error on electric field

- Only absolute value shown
- Calculated on grid points
  - Using central difference formula

$$E(r) = \frac{\Phi(r+h) - \Phi(r-h)}{2h}$$

  - Values used for interpolation

- Error < 0.5%
  - 50 % (0.5 mm)
  - 64 % (0.25 mm)
  - 80 % (0.1 mm)
- Errors largest at boundaries



How to improve ?

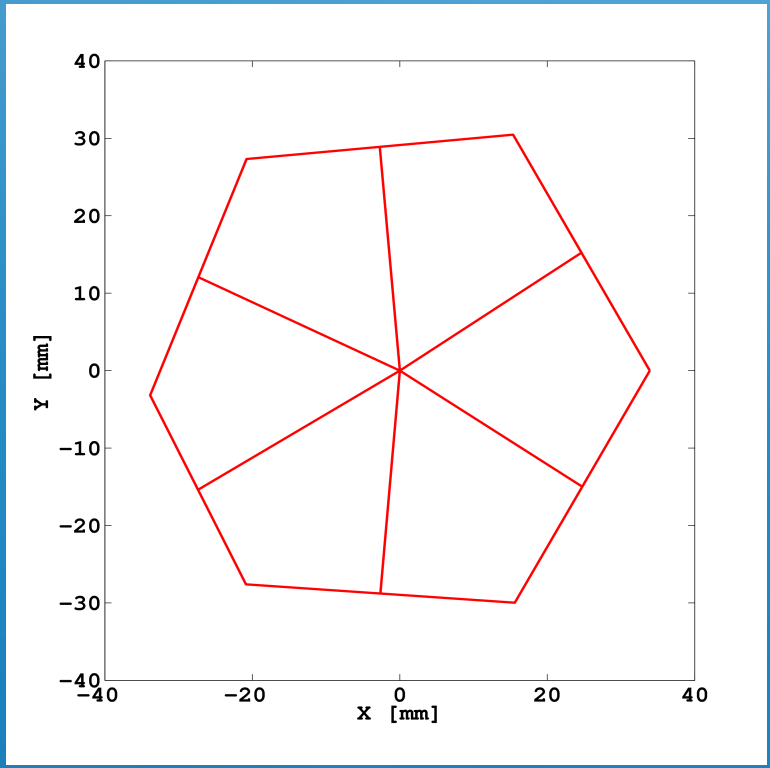
- Even smaller grid sizes are not useful
- Higher order approximations for derivatives

$$\Phi(r) = \frac{12h^2 s(r) - \Phi(r+2\mathrm{h}) + 16\Phi(r+h) + 16\Phi(r-h) - \Phi(r-2\mathrm{h})}{30}$$

  - No longer intrinsically parallel
  - Boundaries need special treatment
  - Potentials/Fields are slightly improved
- Lagrange Extrapolation of potential for points outside the detector

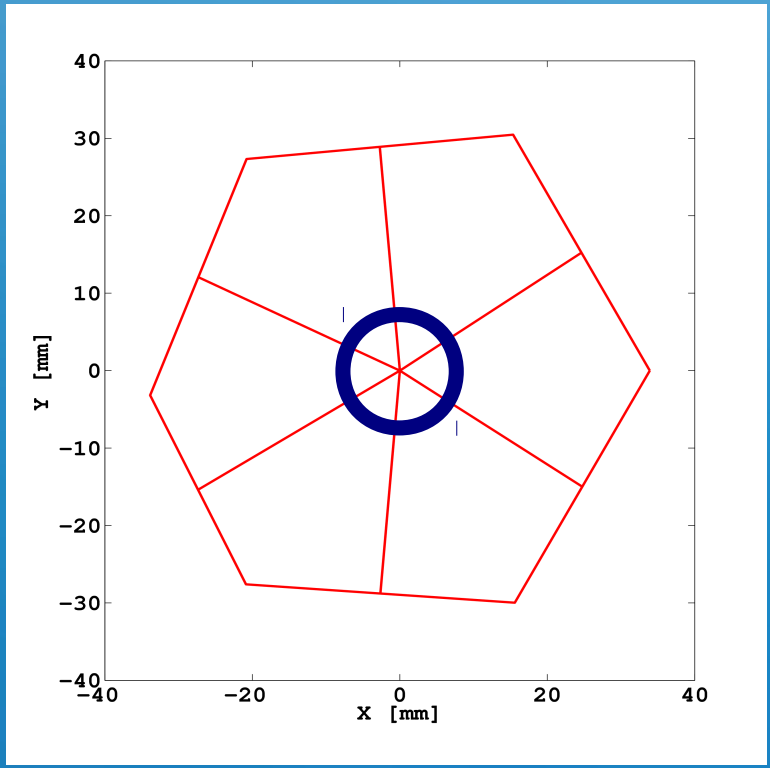
Problems with front electrodes

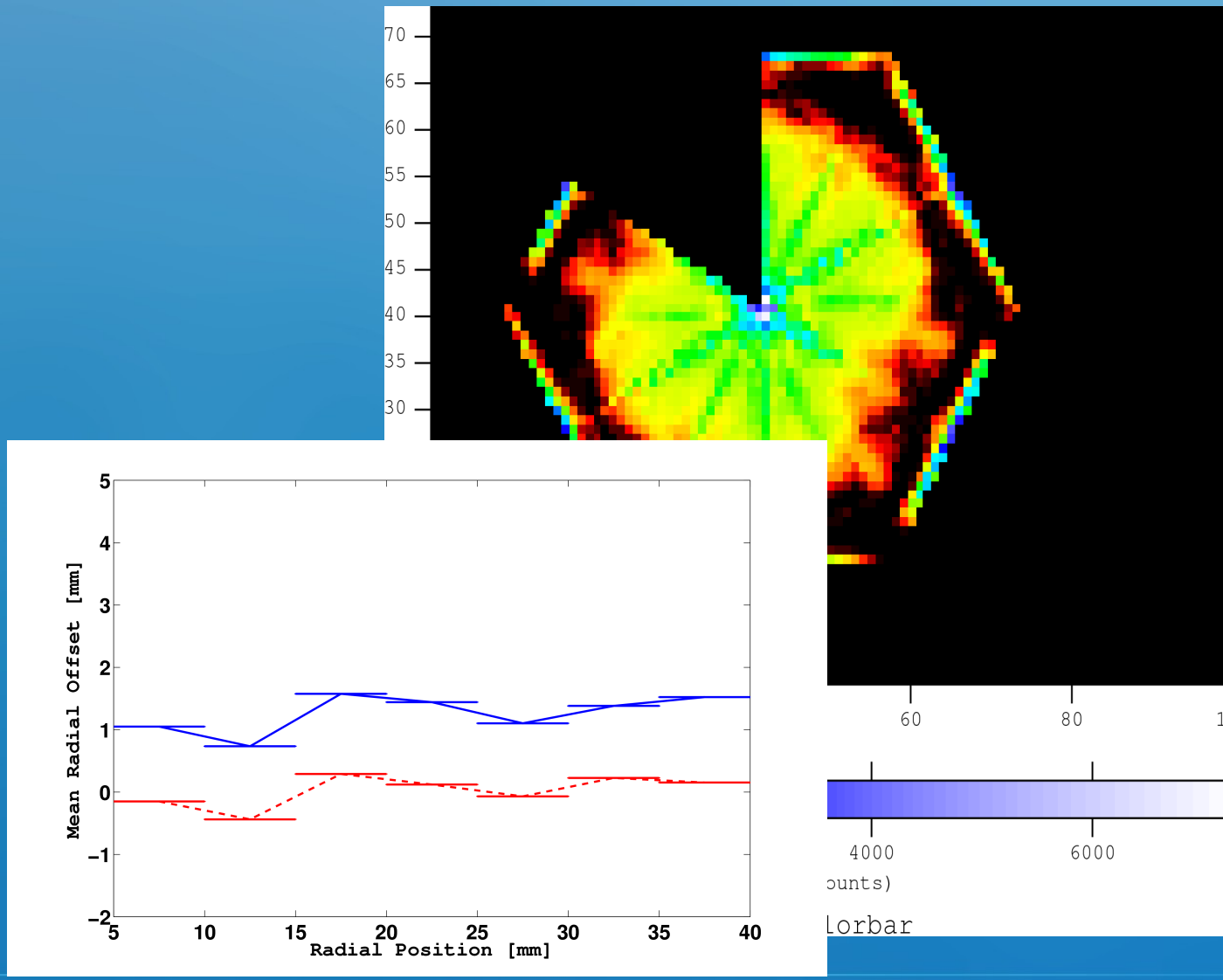
- Interpolation has problems at tips of electrodes
-



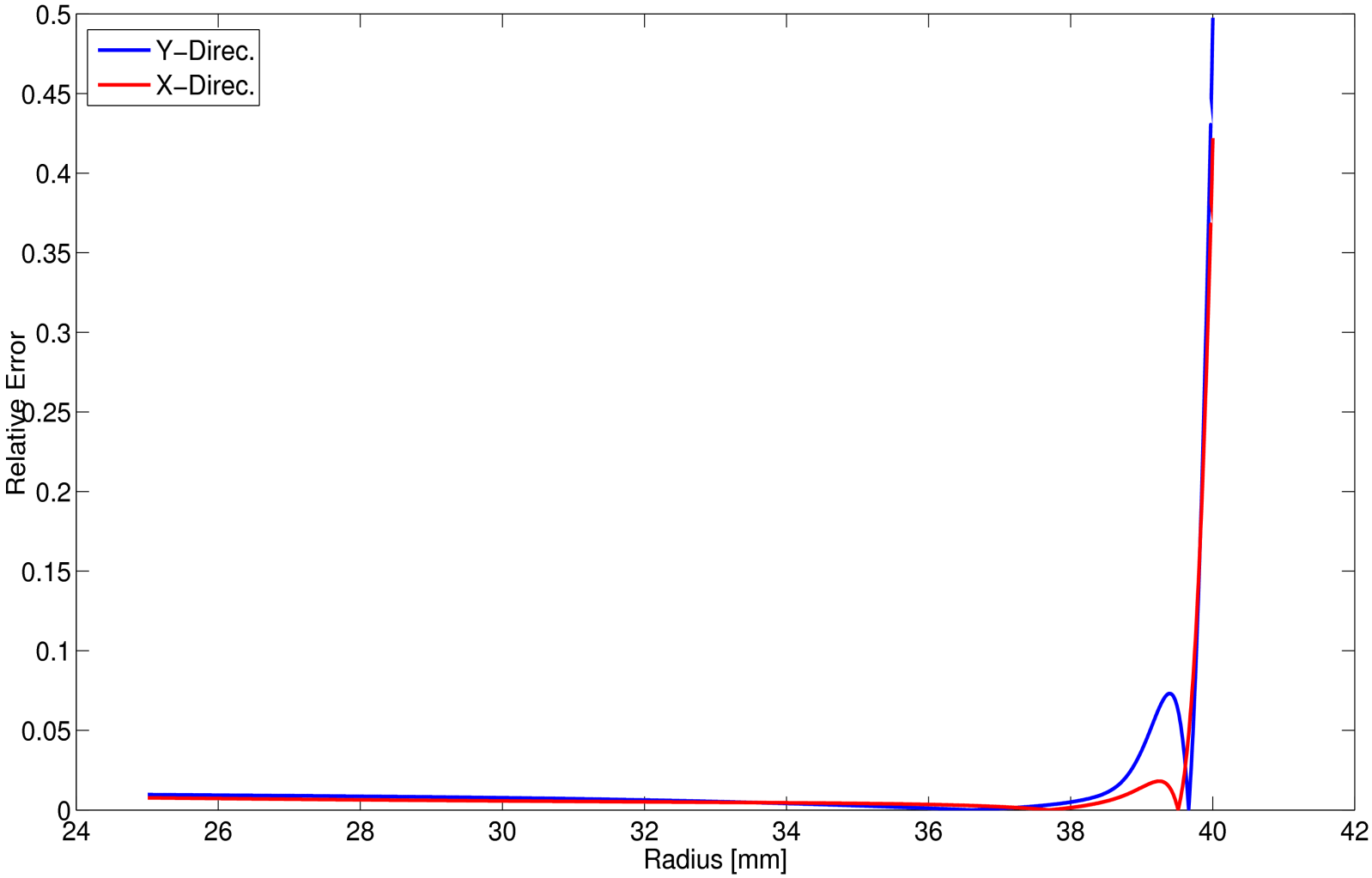
Problems with front electrodes

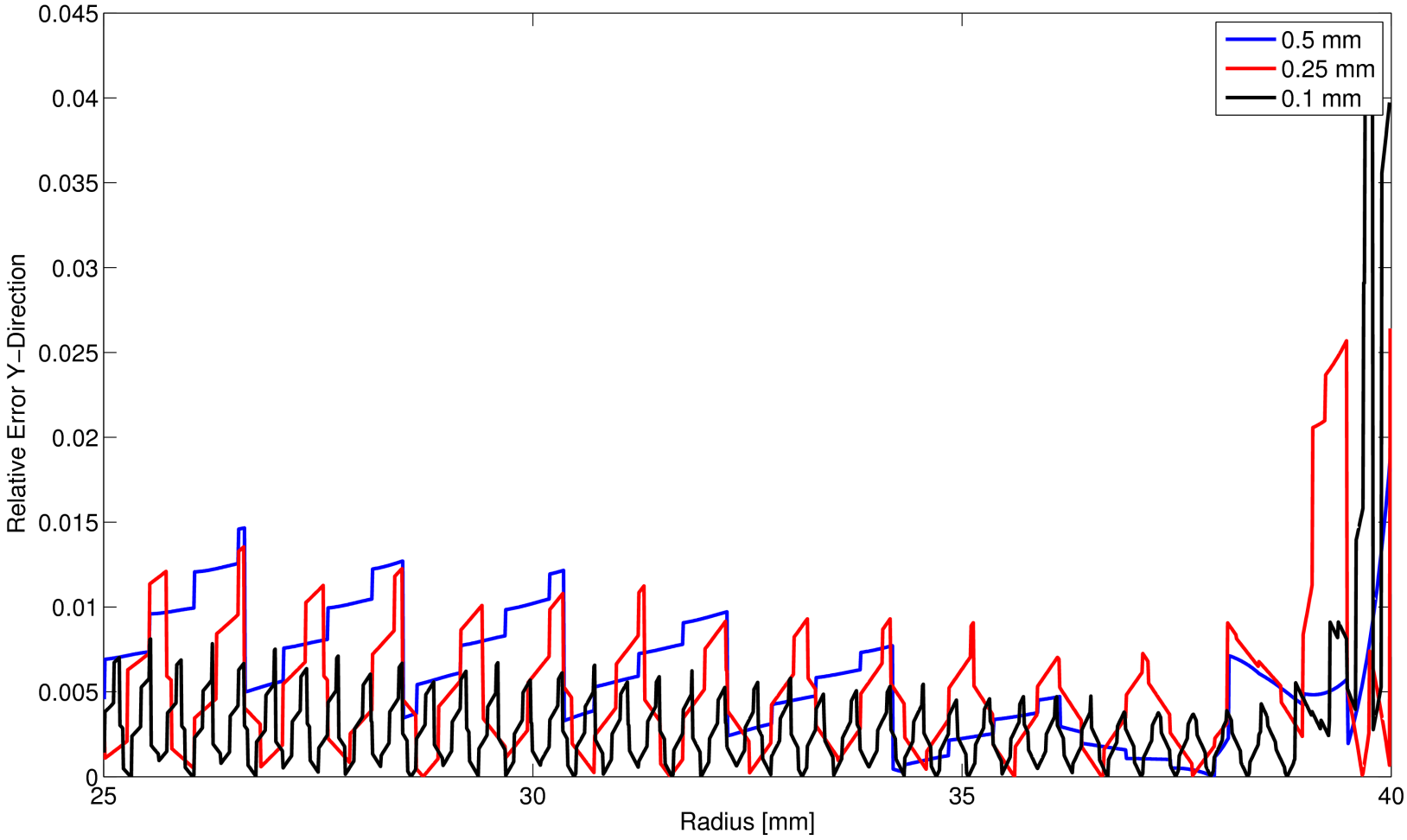
- Interpolation has problems at tips of electrodes

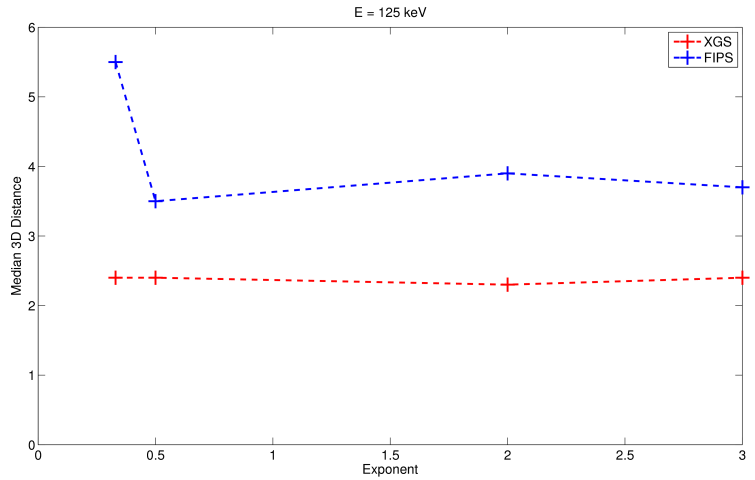


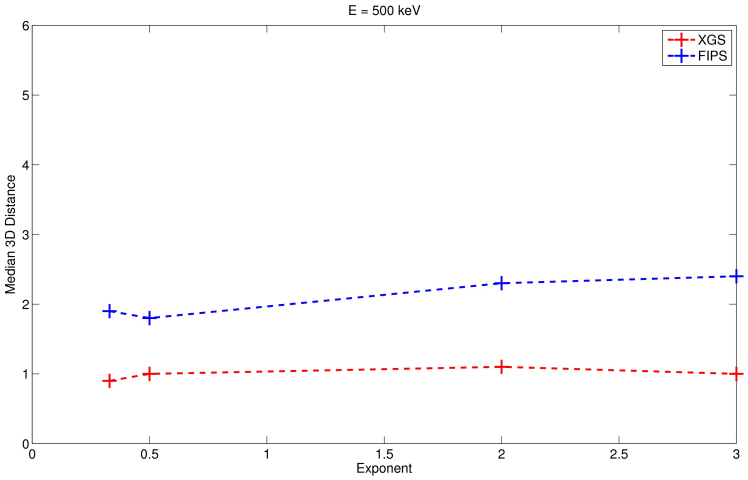

70
65
60
55
50
45
40
35
30
60
80
4000
6000
ounts)
lorbar
Mean Radial Offset [mm]
5
4
3
2
1
0
−1
−2
5
10
15
20
25
30
35
40
Radial Position [mm]

Relative error on field vector




0.5 mm
0.25 mm
0.1 mm
Relative Error Y−Direction
Radius [mm]
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
25
30
35
40


E = 125 keV
XGS
FIPS
Median 3D Distance
Exponent
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3


E = 500 keV
XGS
FIPS
Median 3D Distance
Exponent
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3

Implementation of FIPS/Neural Net into NARVAL

- FIPS
  - Reuse existing code where possible
    - It works
    - But I don't like the design
  -