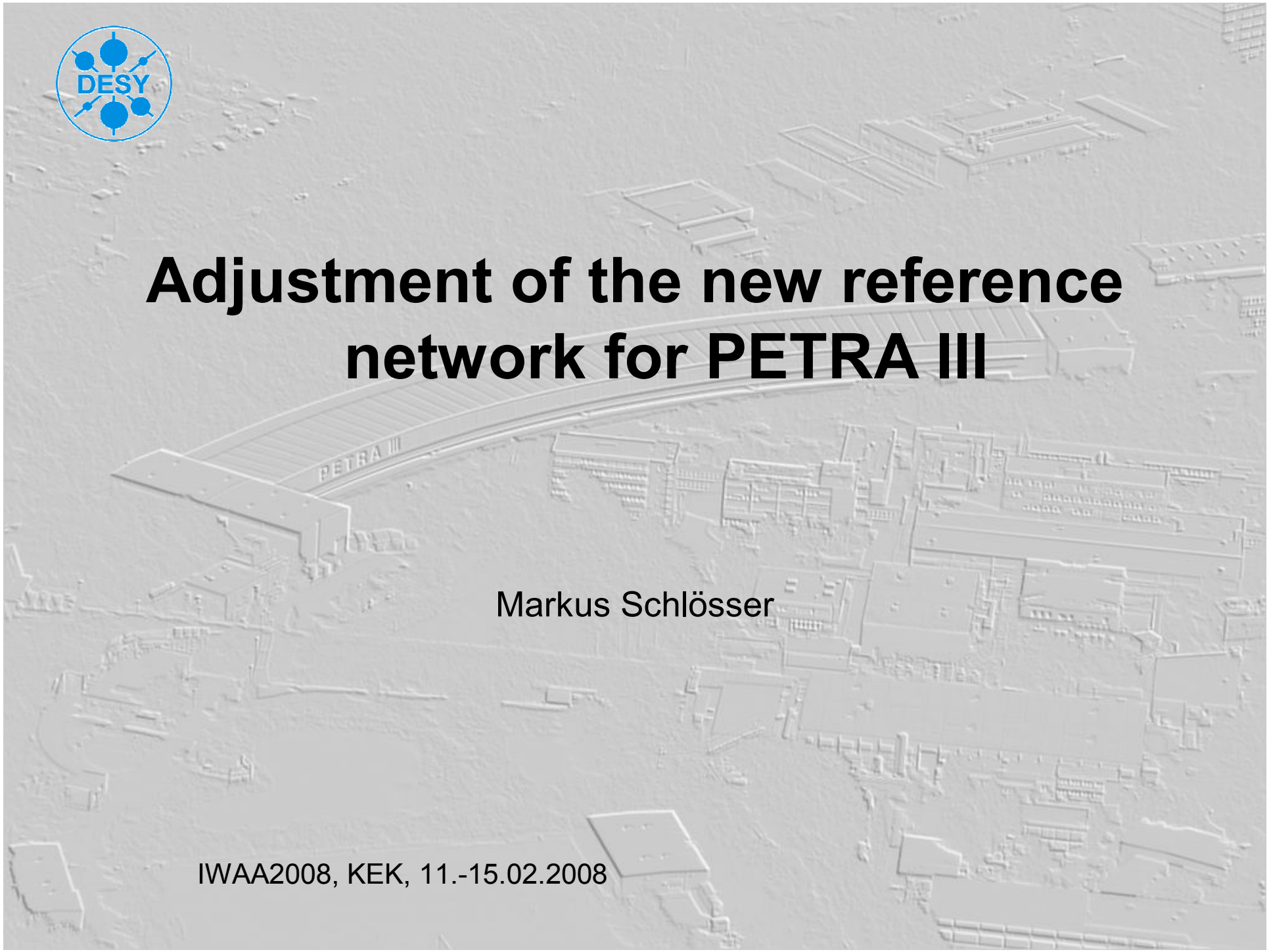


Adjustment of the new reference network for PETRA III

Markus Schlösser

IWAA2008, KEK, 11.-15.02.2008

PETRA II -> PETRA III

- end of HERA operation June, 30th 2007
- PETRA is no longer needed as pre-accelerator
- as with July, 1st 2007 PETRAII is rebuilt as a 3rd generation lightsource called PETRAIII
- 1/8 of the tunnel is replaced by the new experimental hall, approximately 300m in lenght
- all the machine components are removed from the tunnel and „refurbished", nearly all magnets got new coils

old alignment conecpt

- when built in 1975 distance measurement was still crucial
- consequently the machine was aligned with stands and targets directly on the machine
- magnets were not fiduzialized individually
- this concept worked well and was never changed during the operation of PETRA II

old alignment concept

PII -> PIII

adjustment model

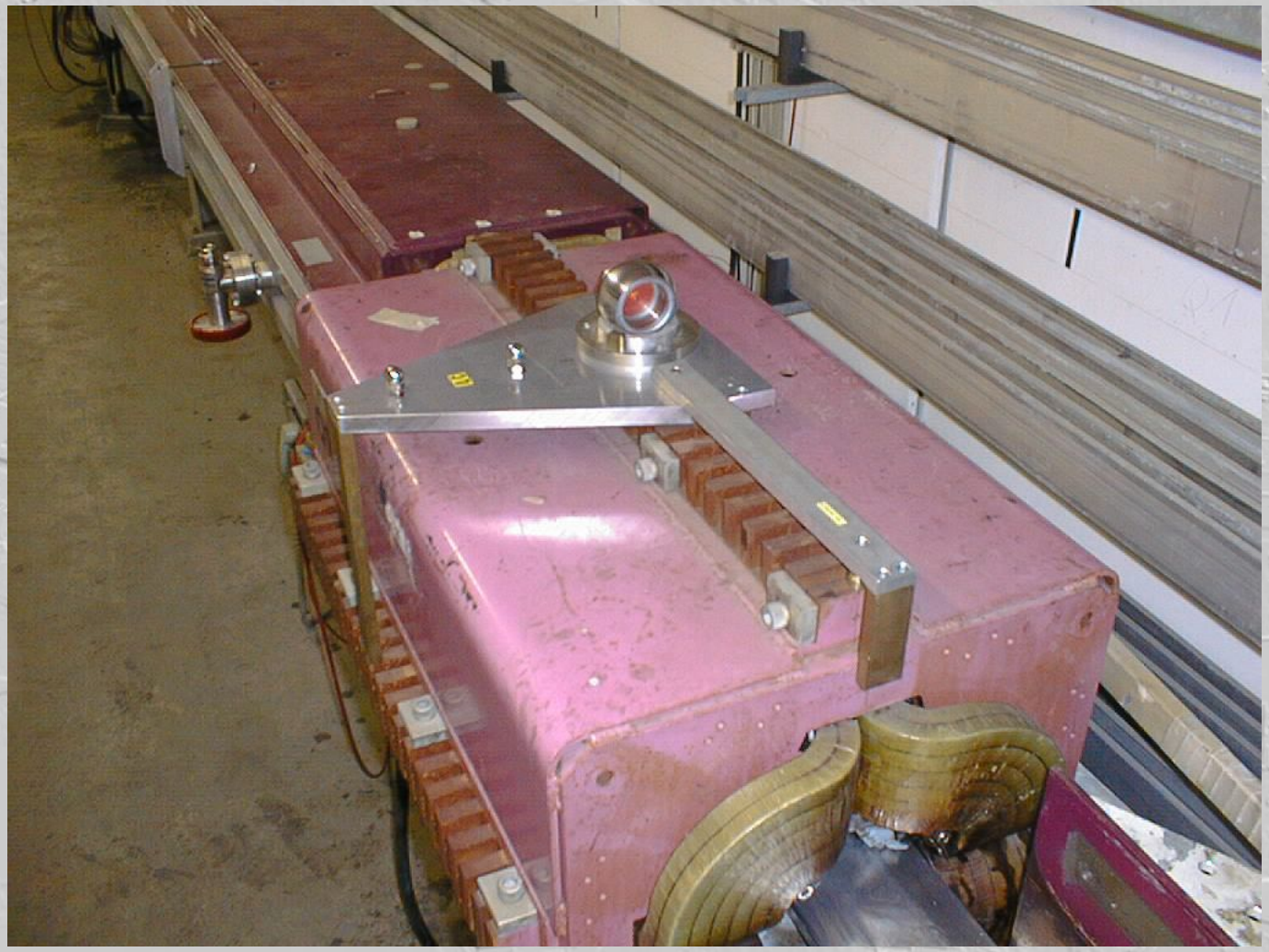
reference network

simulation

result

misalignment

conclusion



new alignment concept

- alignment tolerances are closer with PETRA III while shutdown times are reduced
- measurement techniques have improved, distance measurements are now as accurate as angular measurements
- computers and software have improved, large data sets can be handled easily
- adjustment of large networks is possible on PCs

new alignment concept

this leads to a new concept where

1. all components are fiducialized individually
2. the coordinate information is stored in reference points separate from the machine
3. instruments can be placed everywhere in the tunnel, concpet of „free stationing“

common requirements

- geodetic measurement values are continuous random variables
- $\lim_{n\to\infty} \mu_x = E(x)$

  μx : mean value
  E(x) : expectancy
- $E(x) = \tilde{X} + \Delta$

  $\tilde{X}$: true value
  Δ : bias
- all geodetic measurement values are unbiased expectancys

common requirements

- central limit theorem (Moivre-Laplace limit theorem) -> if an expectancy is formed by lots of small and independent random values it follows in good approximation a gaussian distribution

- all geodetic measurements are normal distributed and have no autocorrelation

Gauss-Markov model

Gauss-Markov Common

functional model

$$\tilde{L} = \varphi(\tilde{X}) \qquad \psi(\tilde{L}, \tilde{X}) = 0$$

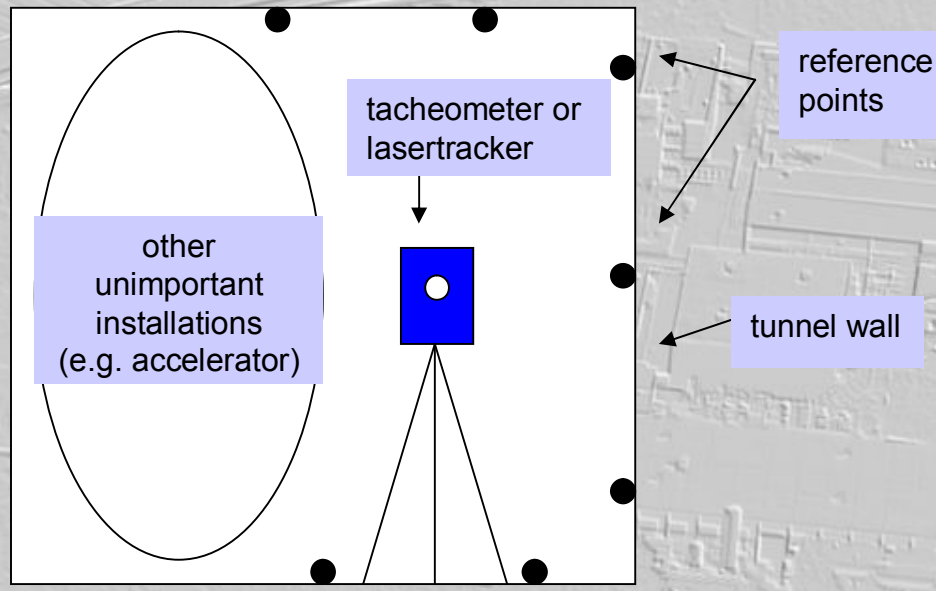
stochastic model

$$\Sigma_{LL} = \sigma_0^2 Q_{LL}$$

Gauss-Markov model is „BLUE"
(Best Linear Unbiased Estimator)

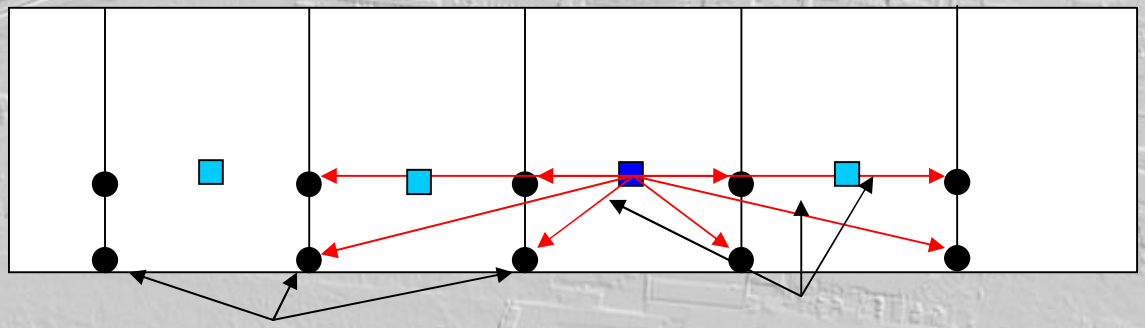
network layout

- a „ring" of 7 reference points every 10m (2 in the floor, 3 at the inner wall, 2 at the ceiling)



network layout

two rings in front and two rings in the rear are measured from each instrument stand



reference „rings“, equidistance 10m

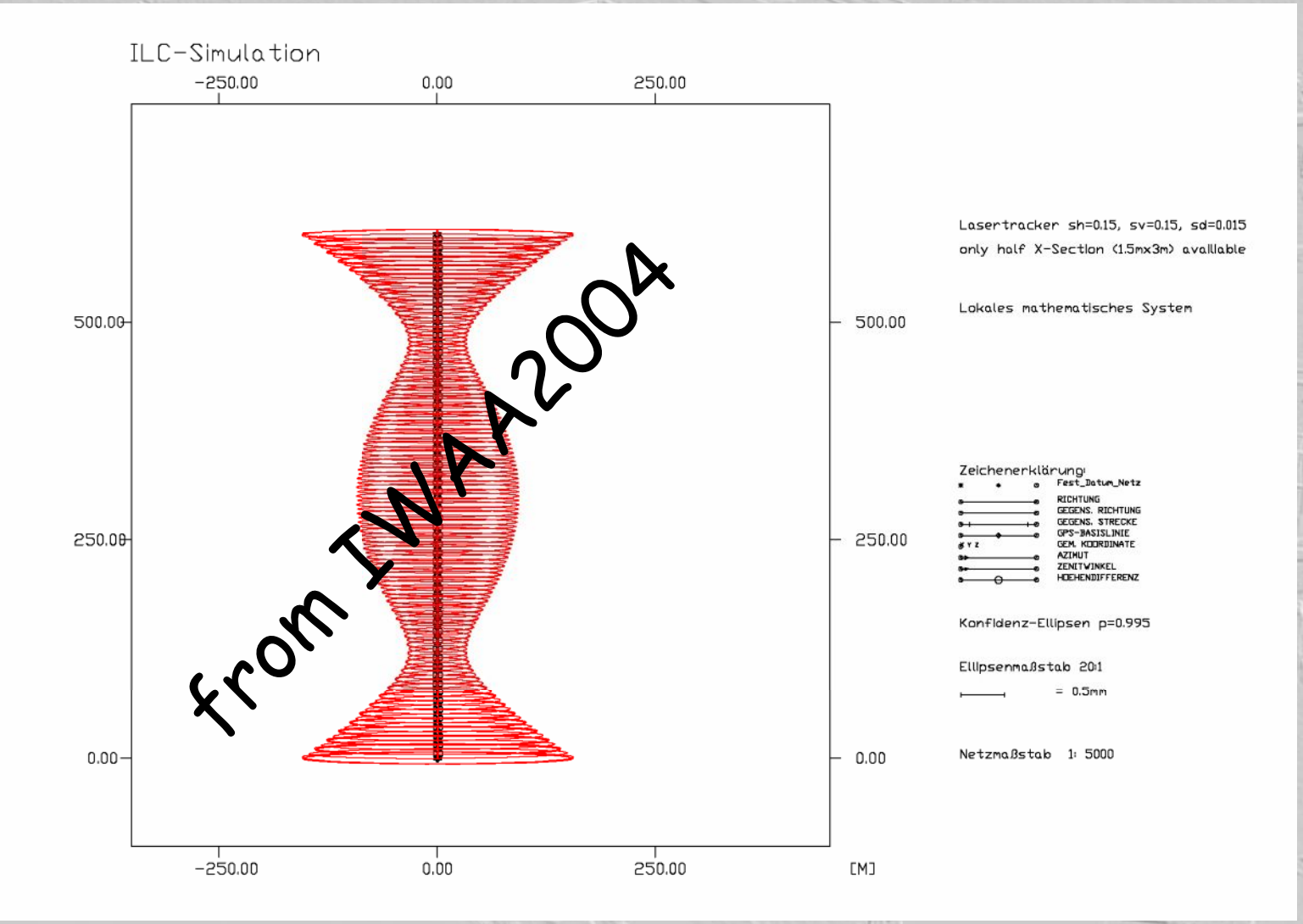
observations

measurement of network

- measurement of the whole network (reference points and components) with lasertracker
- measurement of selected reference points with optical level

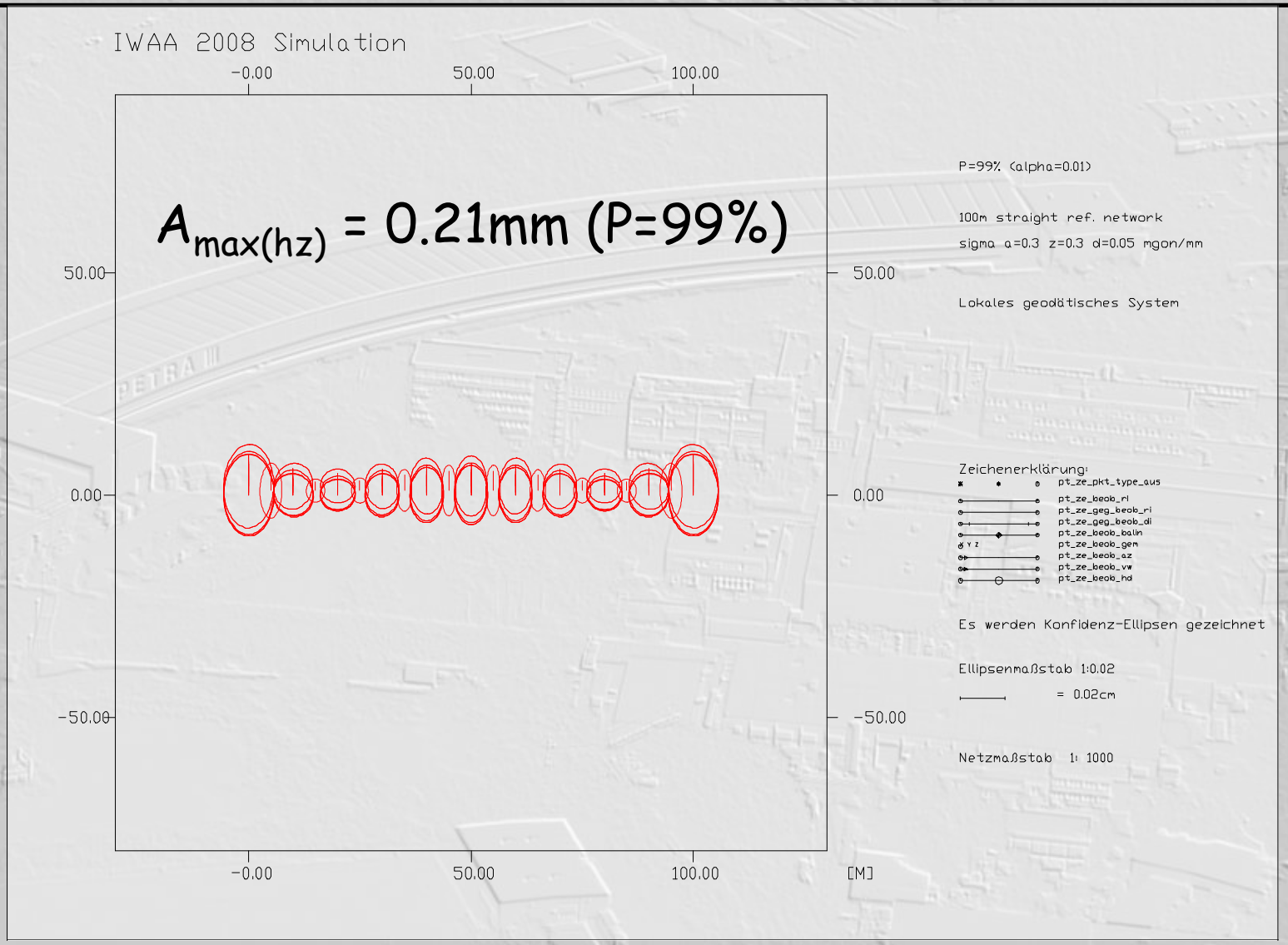
network simulation

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



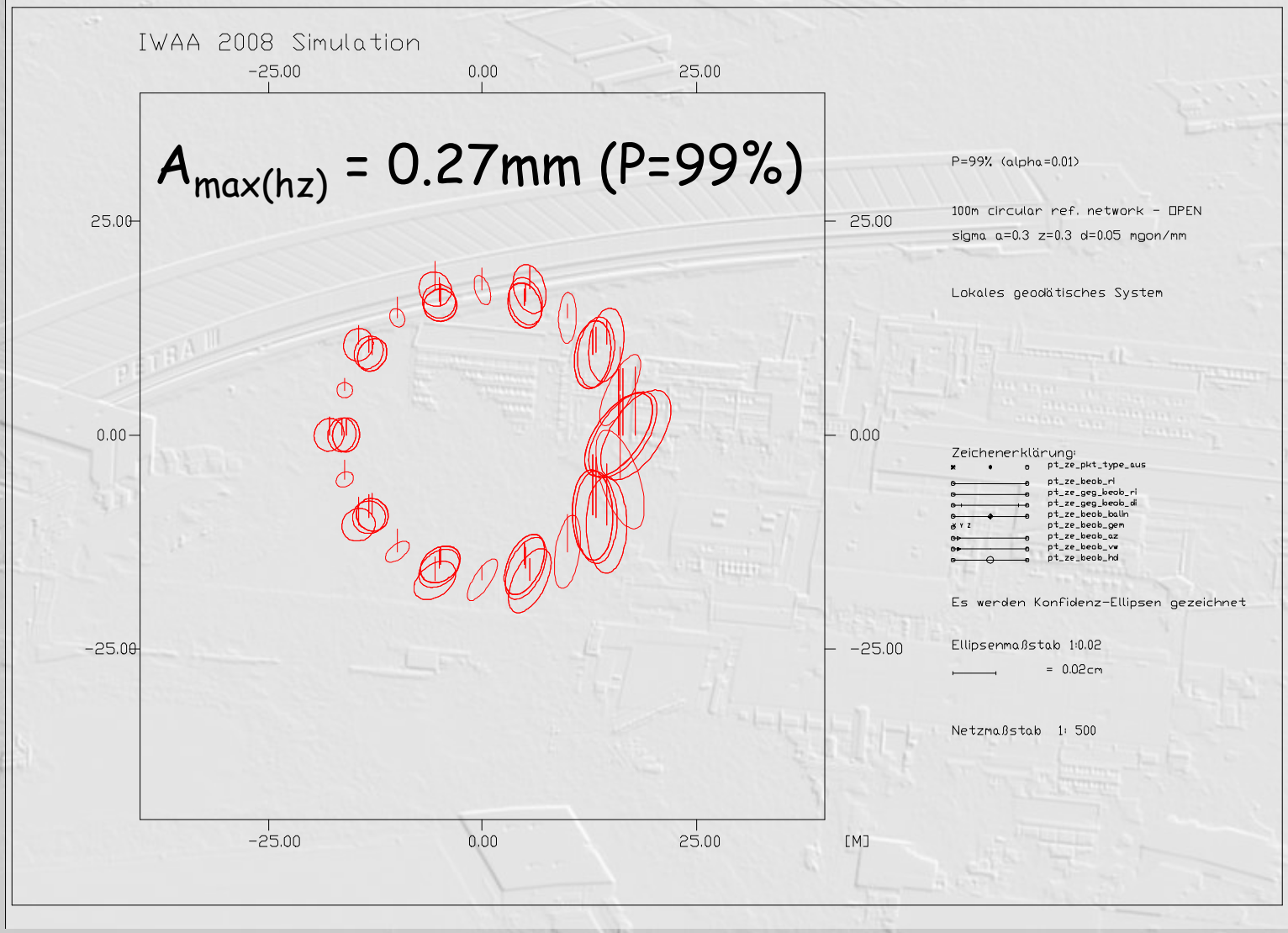
100m straight network

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



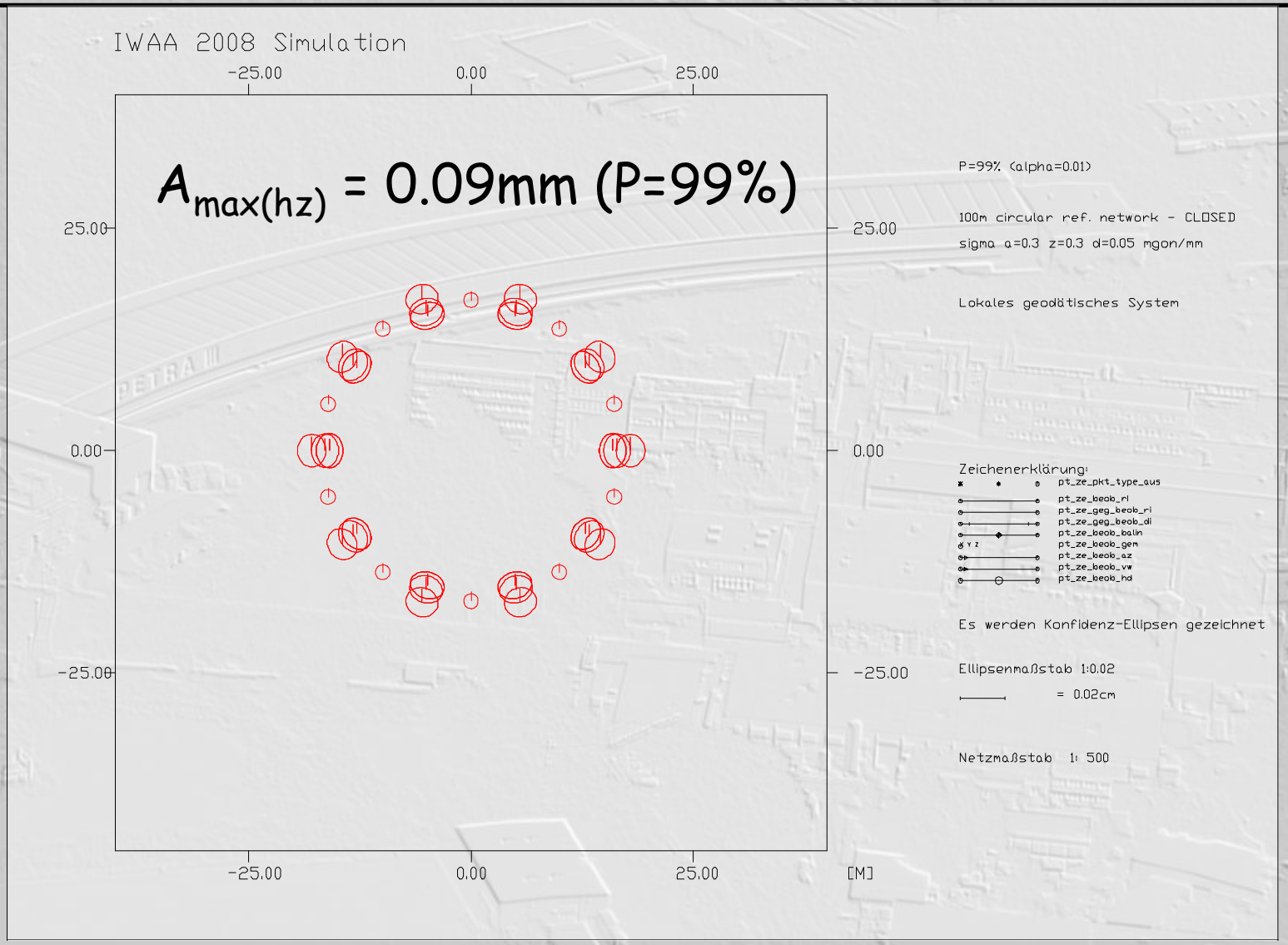
100m circular network - OPEN

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



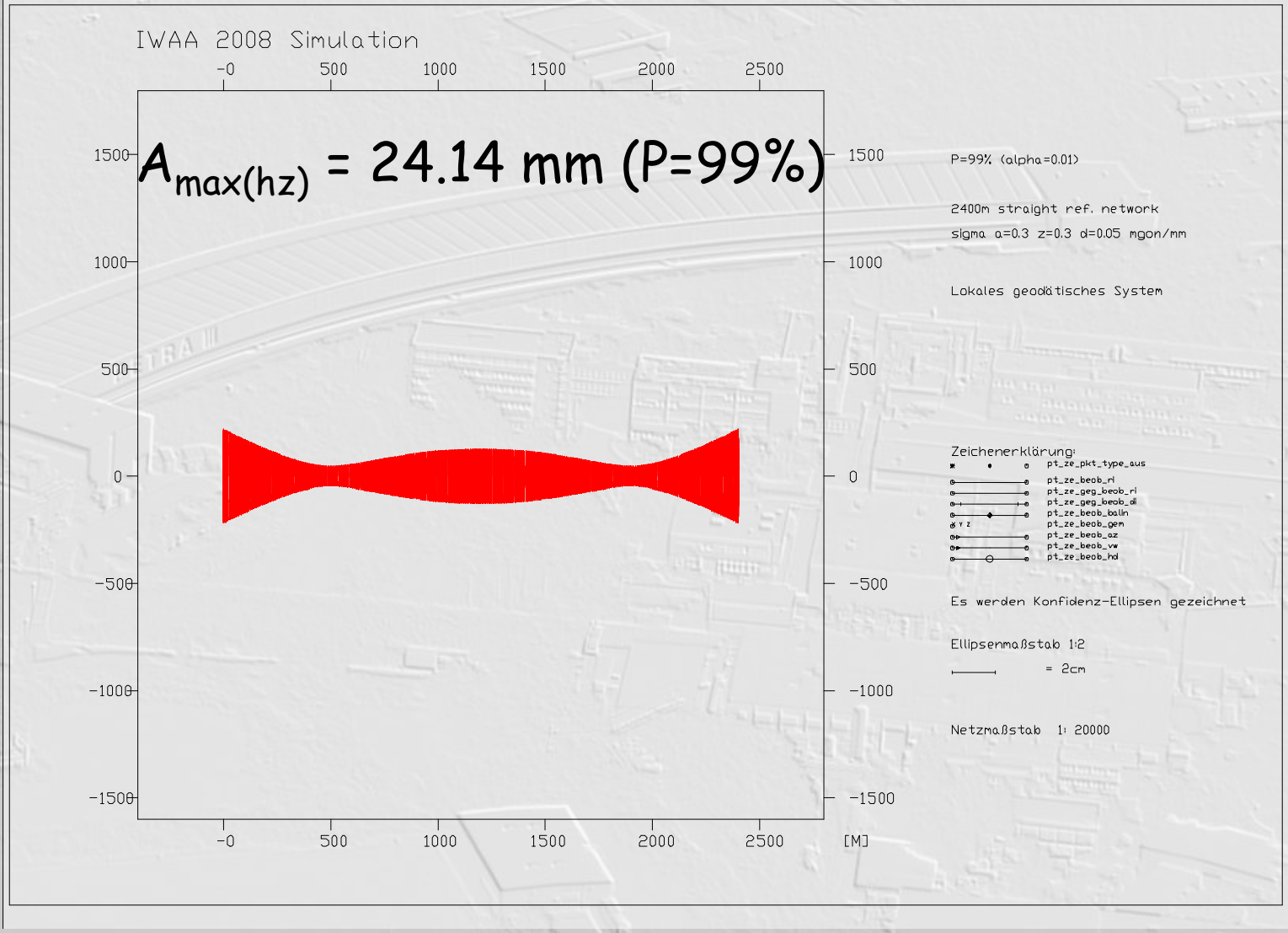
100m circular network - CLOSED

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



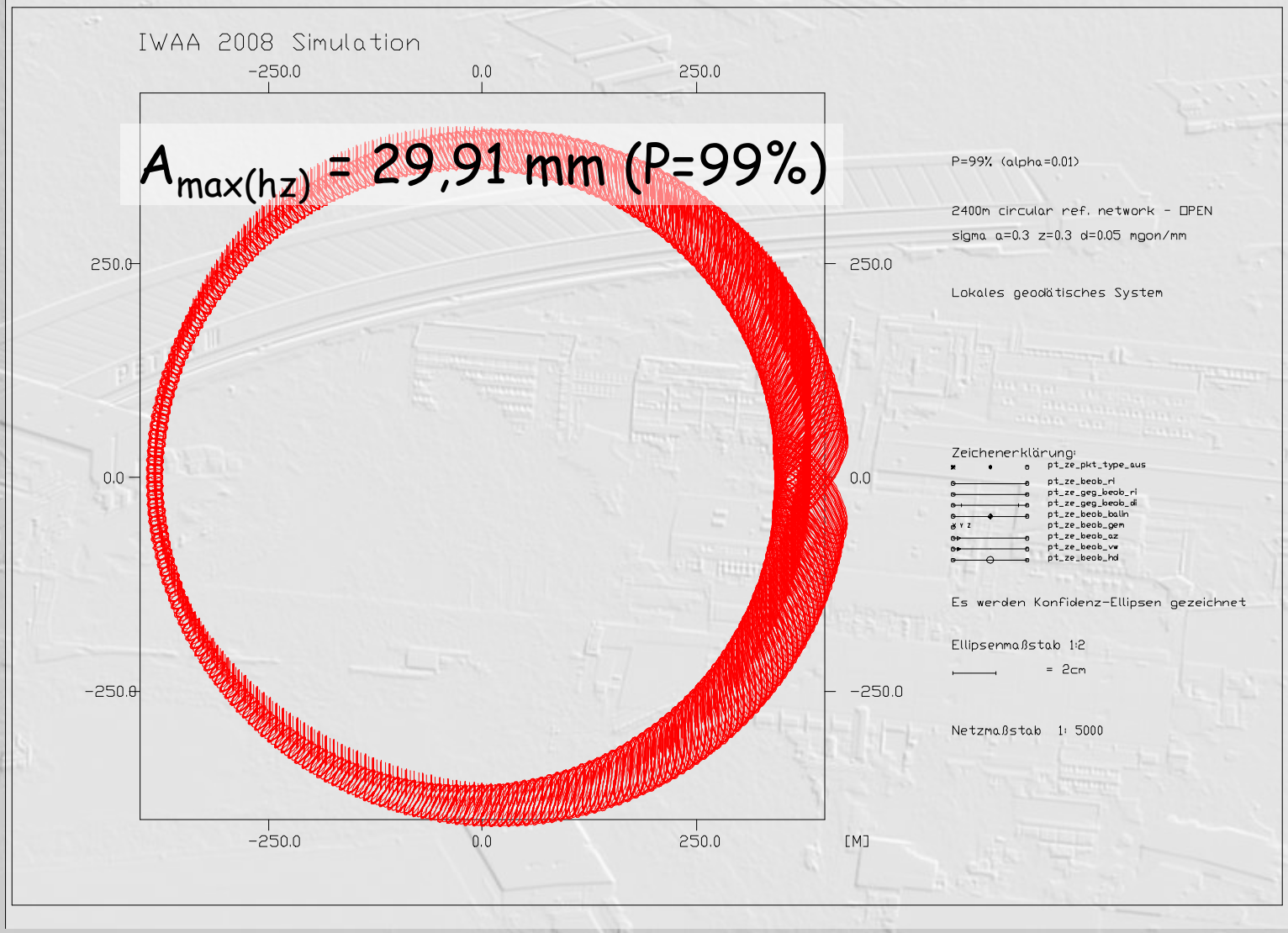
2400m straight network

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



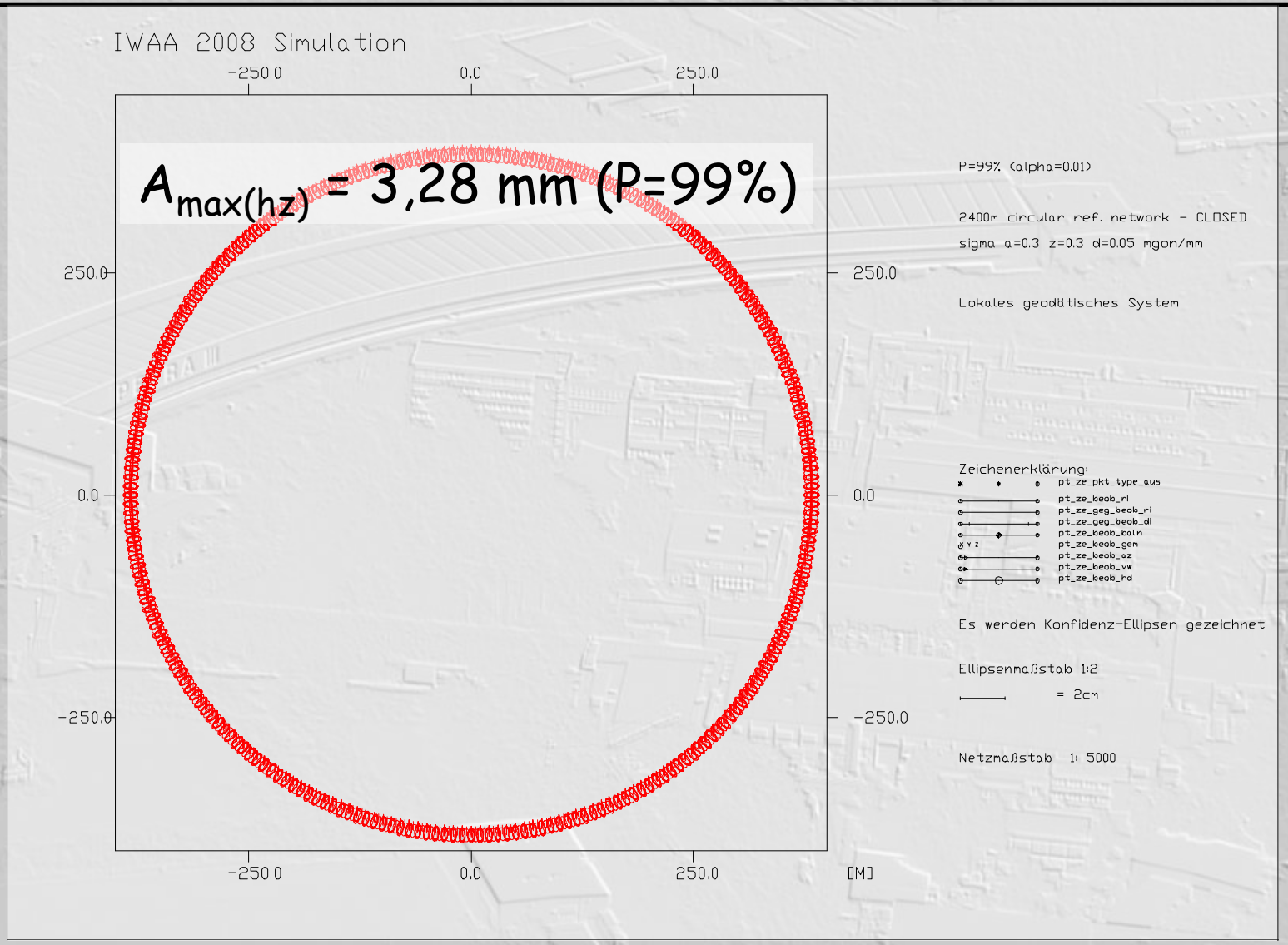
2400m circular network - OPEN

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



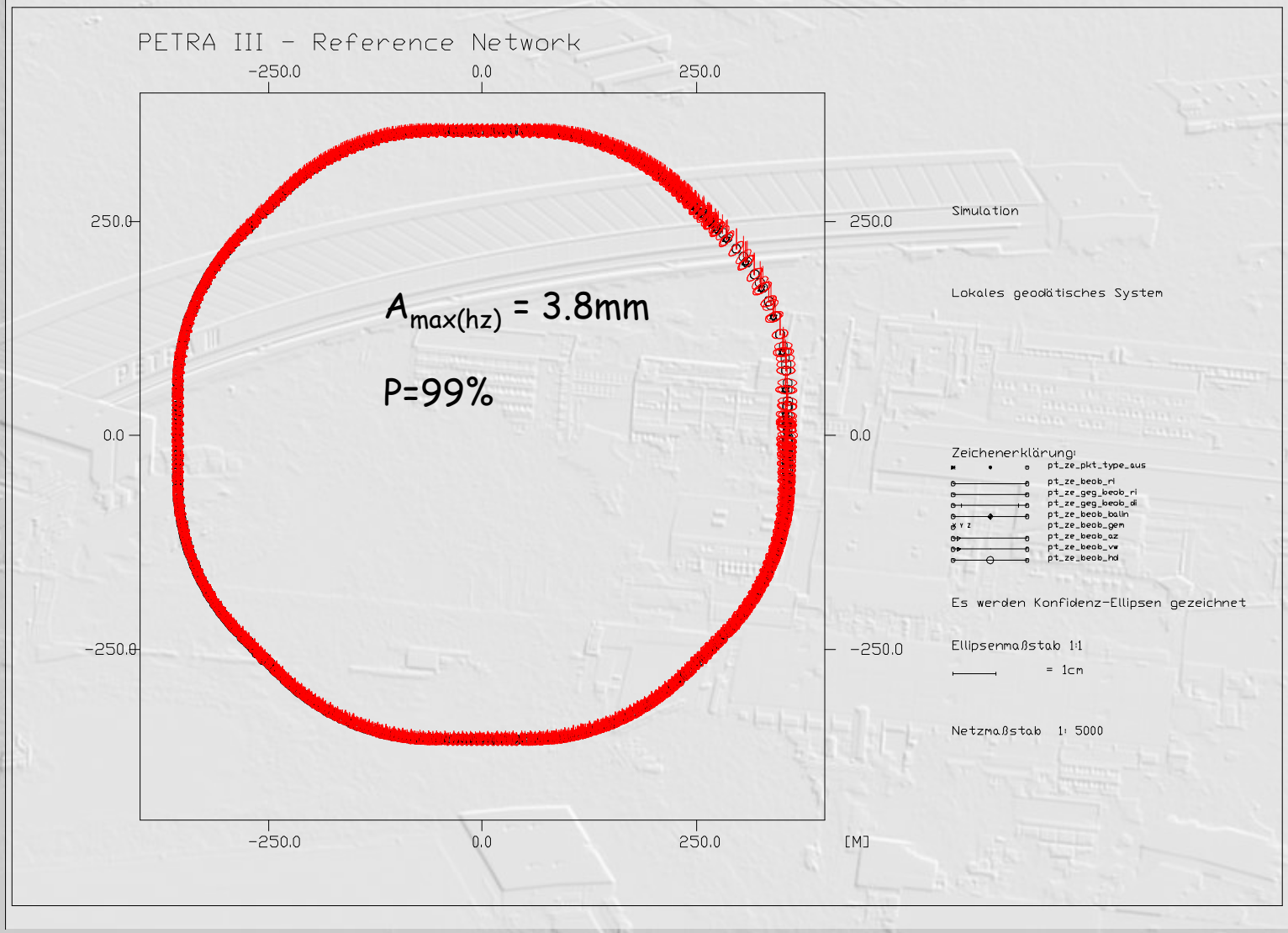
2400m circular network - CLOSED

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion



real PETRAIII network, ~2400m

- PII -> PIII
- adjustment model
- reference network
- simulation
- result
- misalignment
- conclusion

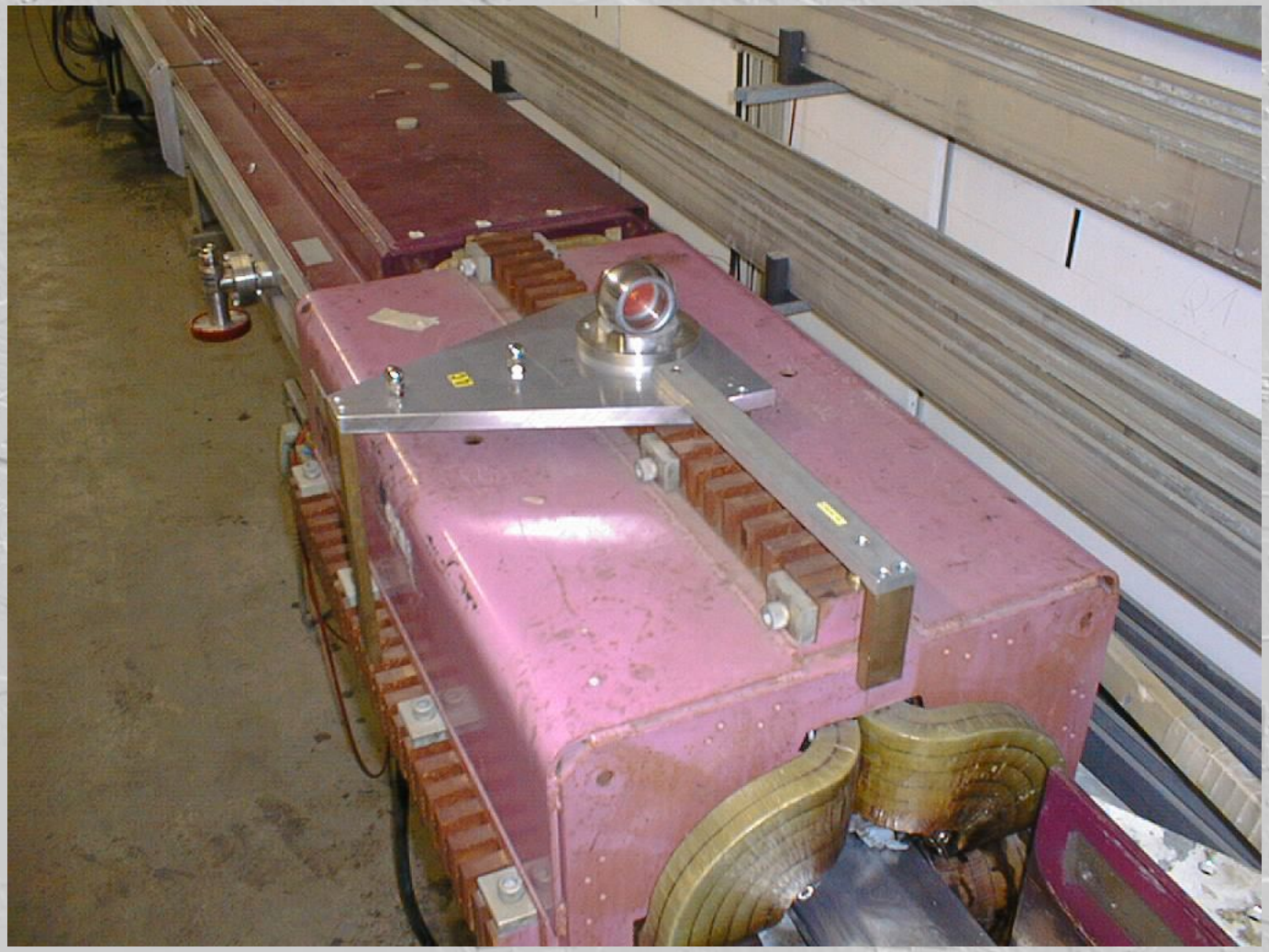


network parameters

number of observations :	35286
number of azimuts :	11762
number of vertical angles :	11762
number of distances :	11762
number of points :	1954
instrument stands :	475
reference points :	1479

PANDA CPU-Time : 183 sec (3 GHz, dual CPU)

reference point on magnet (old system)



concept of network adjustment

1. free network solution with laser tracker and levelling information, without magnet points
2. include magnet points while keeping the coordinates of reference points fixed
3. best fit of the adjusted network to nominal coordinates of the old machine
4. transformation to new origin and new axis direction

Error of old magnet positions

PII -> PIII

adjustment model

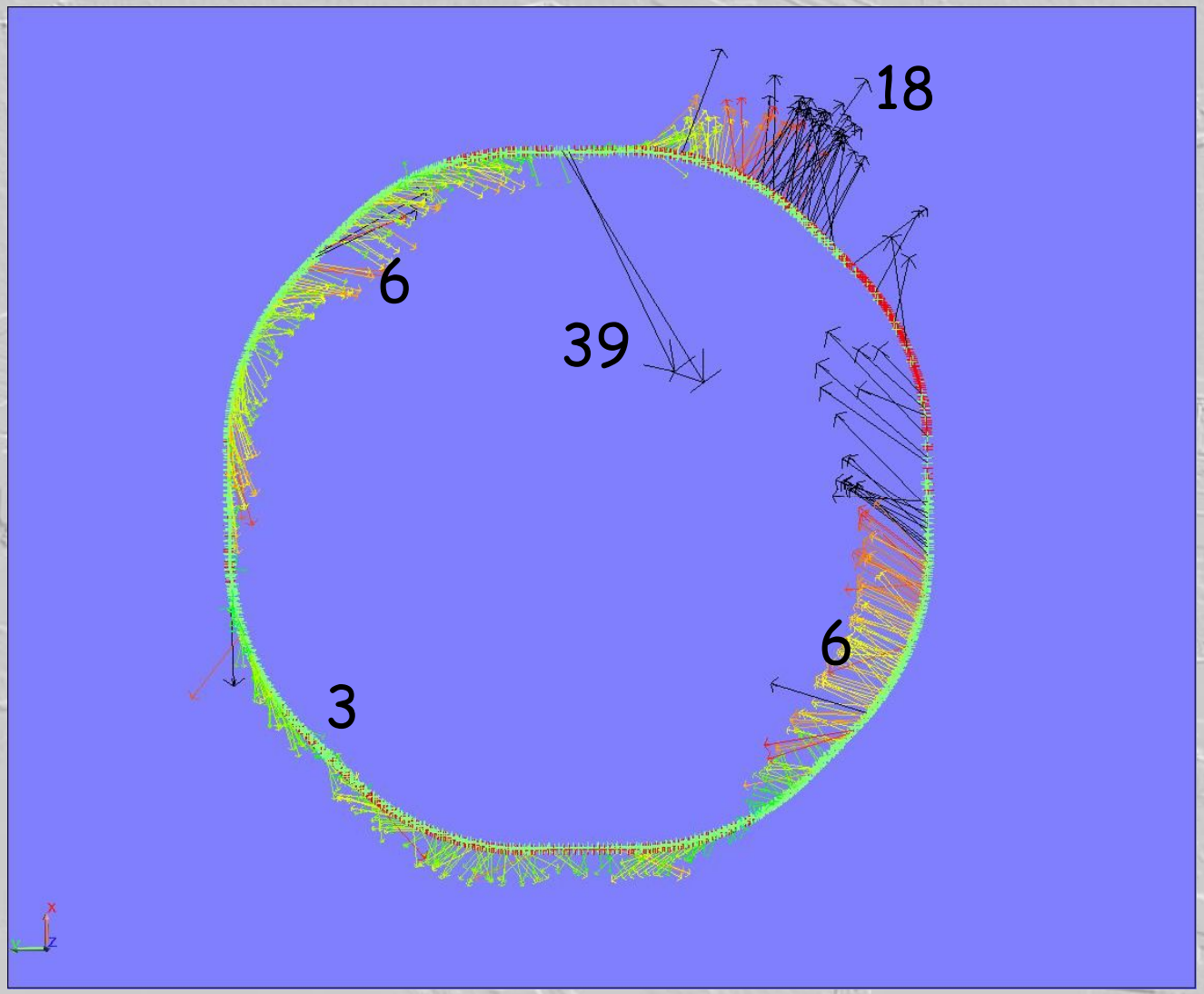
reference network

simulation

result

misalignment

conclusion



conclusion

- measurement concept of PETRA II was migrated to a new concept
- the new concept involves a reference point field and free stationing
- network accuracy is within the expectations derived from the simulation
- network solution was calculated in different stages, because old magnet points are not as stable as the new reference points
- new measurements revealed a misalignment of the old machine by several mm – this will be re-checked in the near future