FAIR

FINAL CONCEPT OF THE PHOTOGRAMMETRIC ALIGNMENT SYSTEM RALF FOR HIGH-RADIATION AREAS OF FAIR

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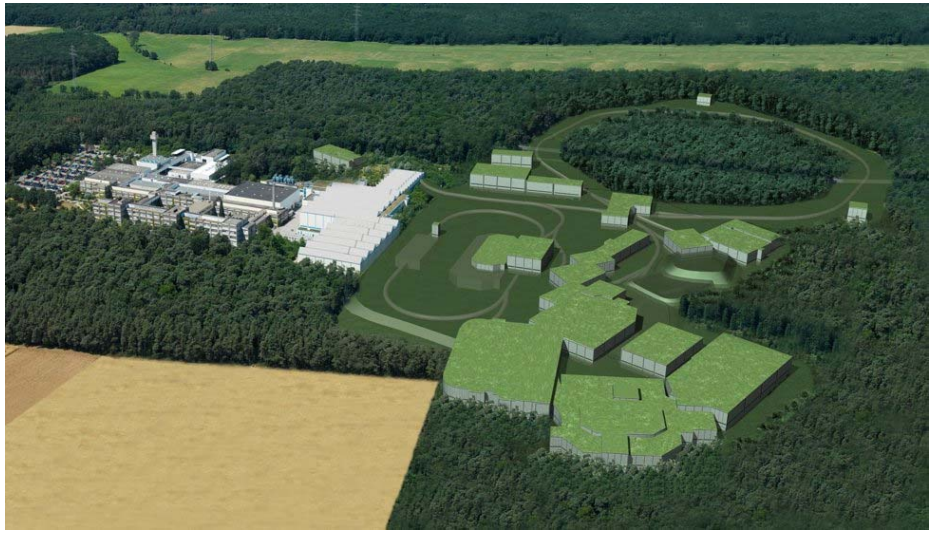
Outline

- FAIR
- RALF - Alignment concept
- **Test installation**
- Conclusion

FAIR – Facility for Antiproton and Ion Research



- new accelerator facility
- start of construction: winter 2008/09
- completion: 2015/16
- Double ring synchrotron SIS 100/300: circumference 1100 m
- Diverse new storage rings: CR, HESR, RESR, NESR
- Super-Fragment-Separator
- Cost: 1.1 billion €

New constraints for accelerator alignment

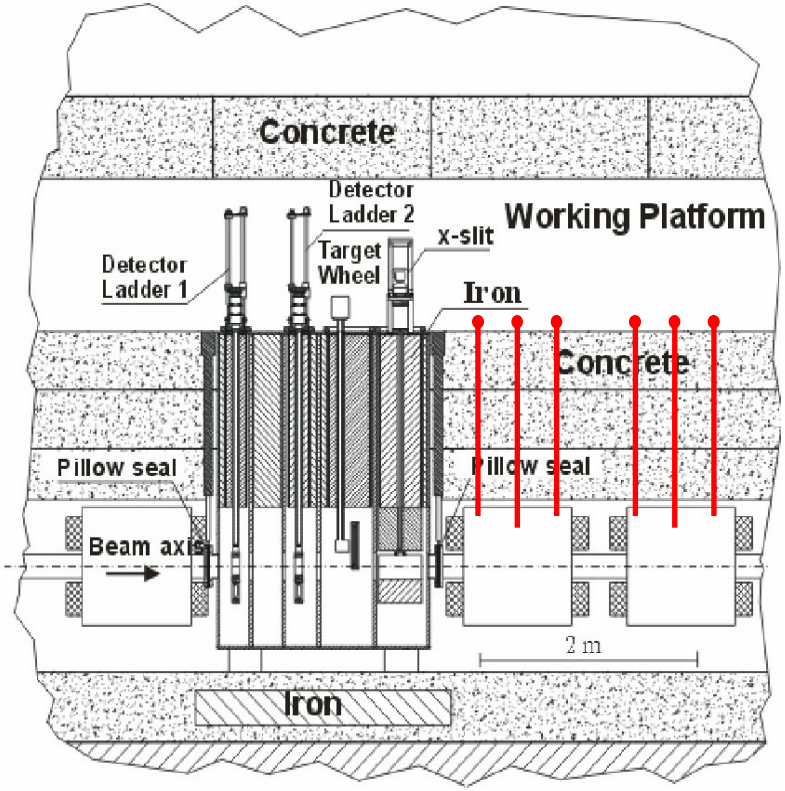
- No access to accelerator tunnel after commissioning of FAIR due to **high radiation environment** in some areas of Super-FRS
- Accuracy requirements: 0.1 mm
- stretched, non-linear geometry
- Lack of space (iron and concrete shieldings)
- automatic and remote-controlled adjustment of machine geometry (high radiation! huge masses!)

Concept (introduced at IWAA 2006)

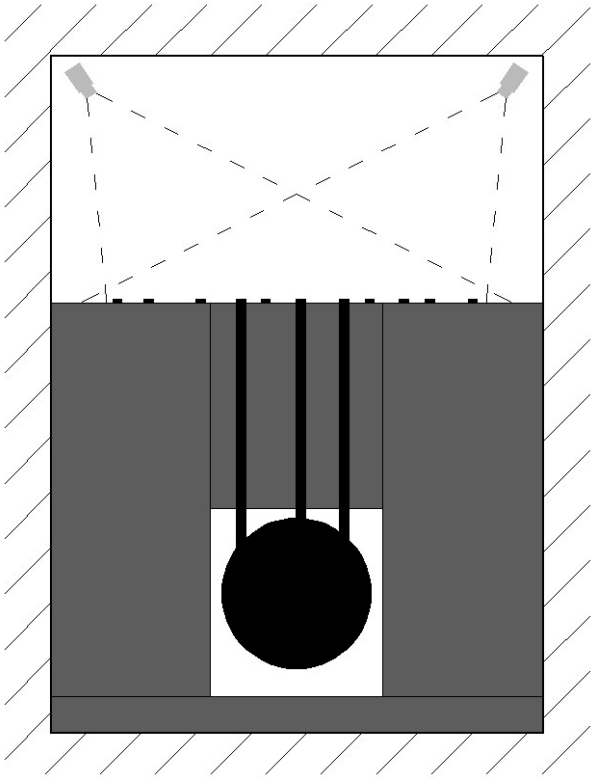
„R A L F“ – Remote ALignment on the Fly

- Photogrammetric solution
- Remote-controlled vehicle equipped with digital cameras
- Photogrammetric targets on magnets
- Automatic target detection, image measurement and bundle adjustment
- Remote-controlled motorized jacks for geometric adjustment of magnets

Configuration of RALF

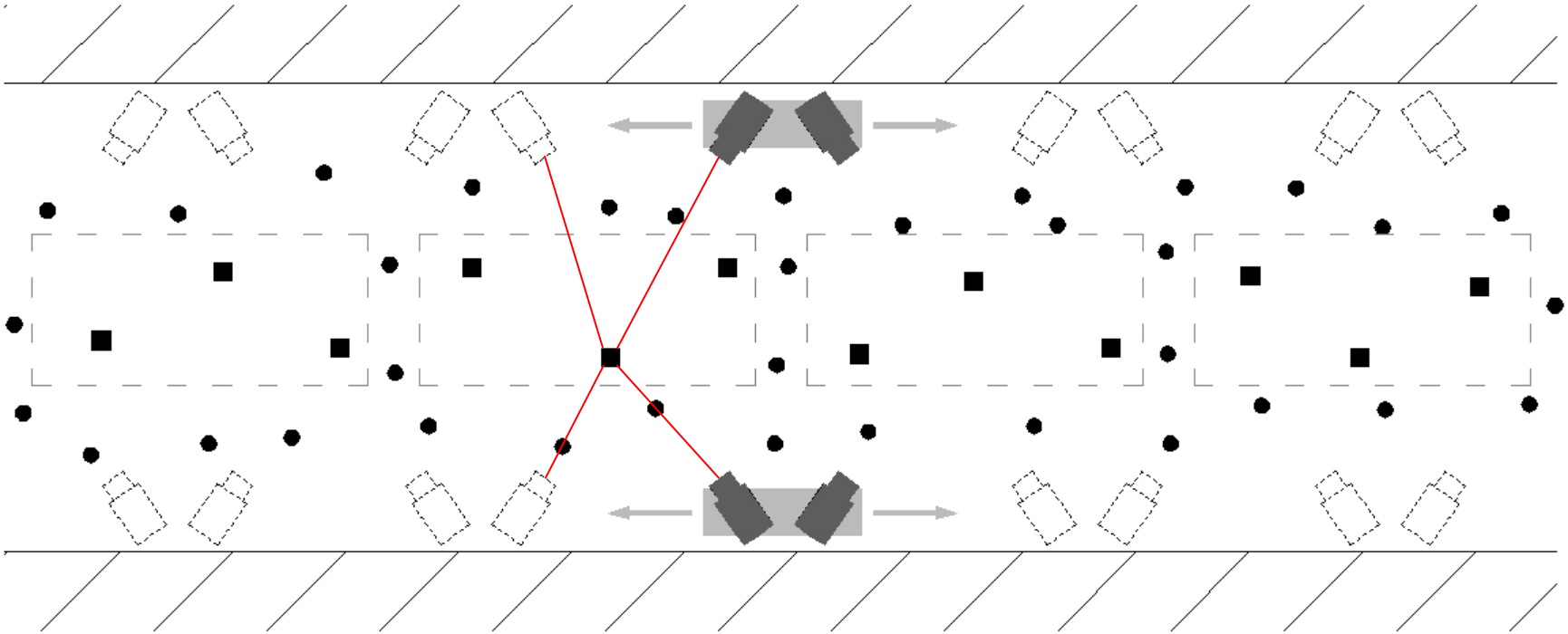


Configuration of RALF

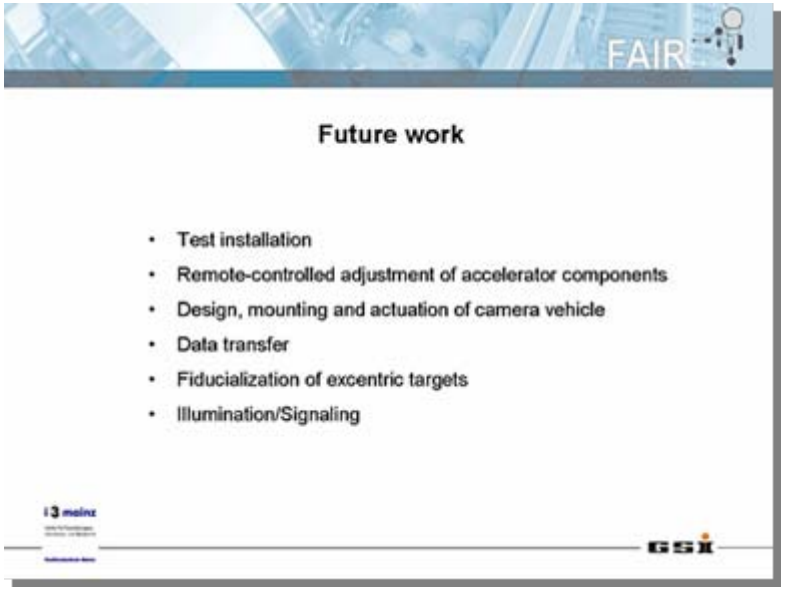


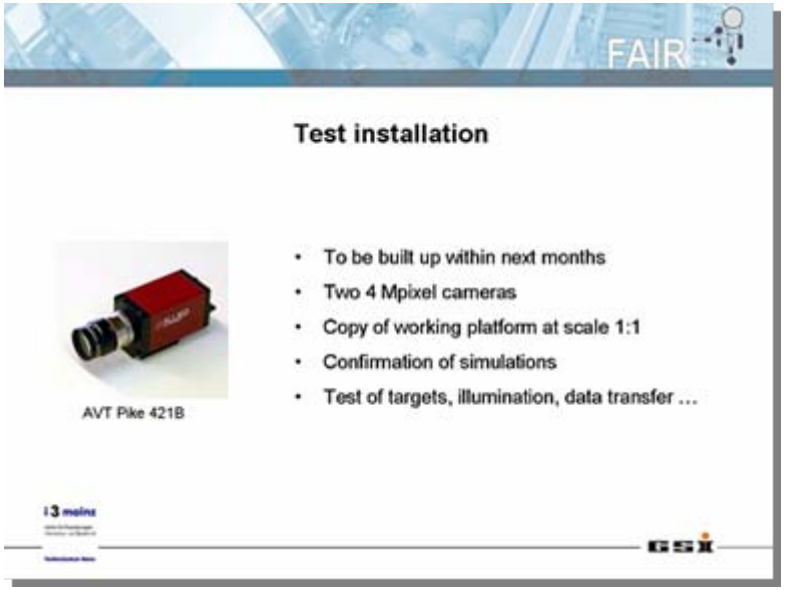
- Dimensions of working platform: approx. 4 m x 1.3 m x 30 m
- Two camera vehicles
- At least three excentric fiducial points per magnet
- Large number of additional tie-points for stable network geometry

Configuration of RALF



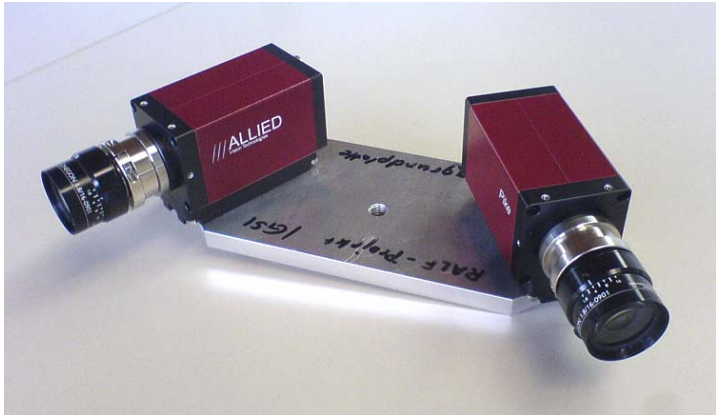
Final slides of IWAA06 presentation





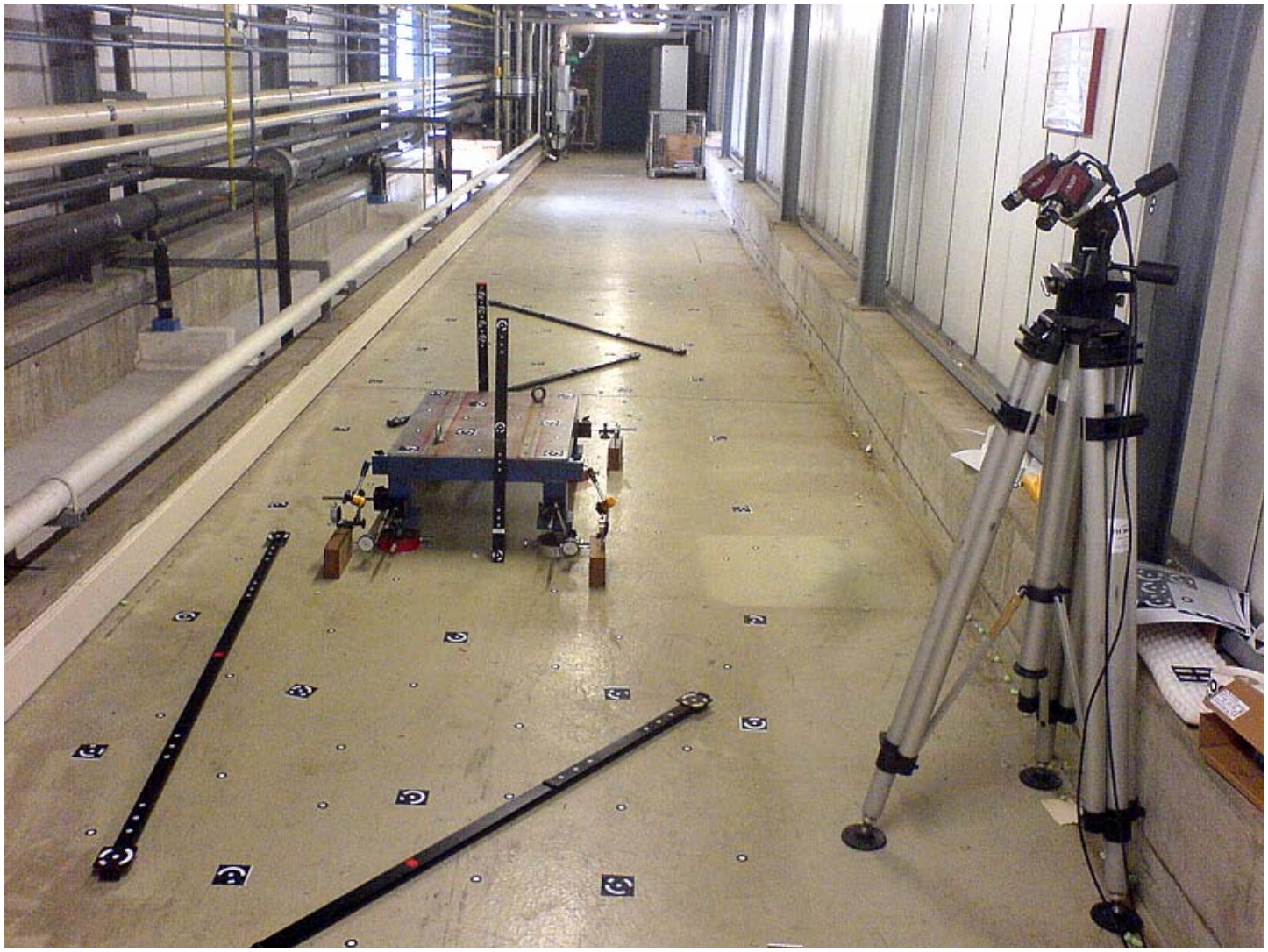
Goal

- Verify simulations
- Test of image analysis on different types of targets
- Practical tests of cameras
- Investigation of the influence of a fixed relative orientation
- Run through a complete alignment scenario



Procedure

- Signaling of the corridor floor with coded and uncoded targets
- Test of different target types (size, white/reflective)
- Calibration of cameras
- Image bundle from both sides of the corridor
- Controlled Movement of “magnet dummy”. Reference measurement using analogue dial indicators
- Second image bundle
- Image analysis using ImetricS, bundle adjustment using Ax.Ori



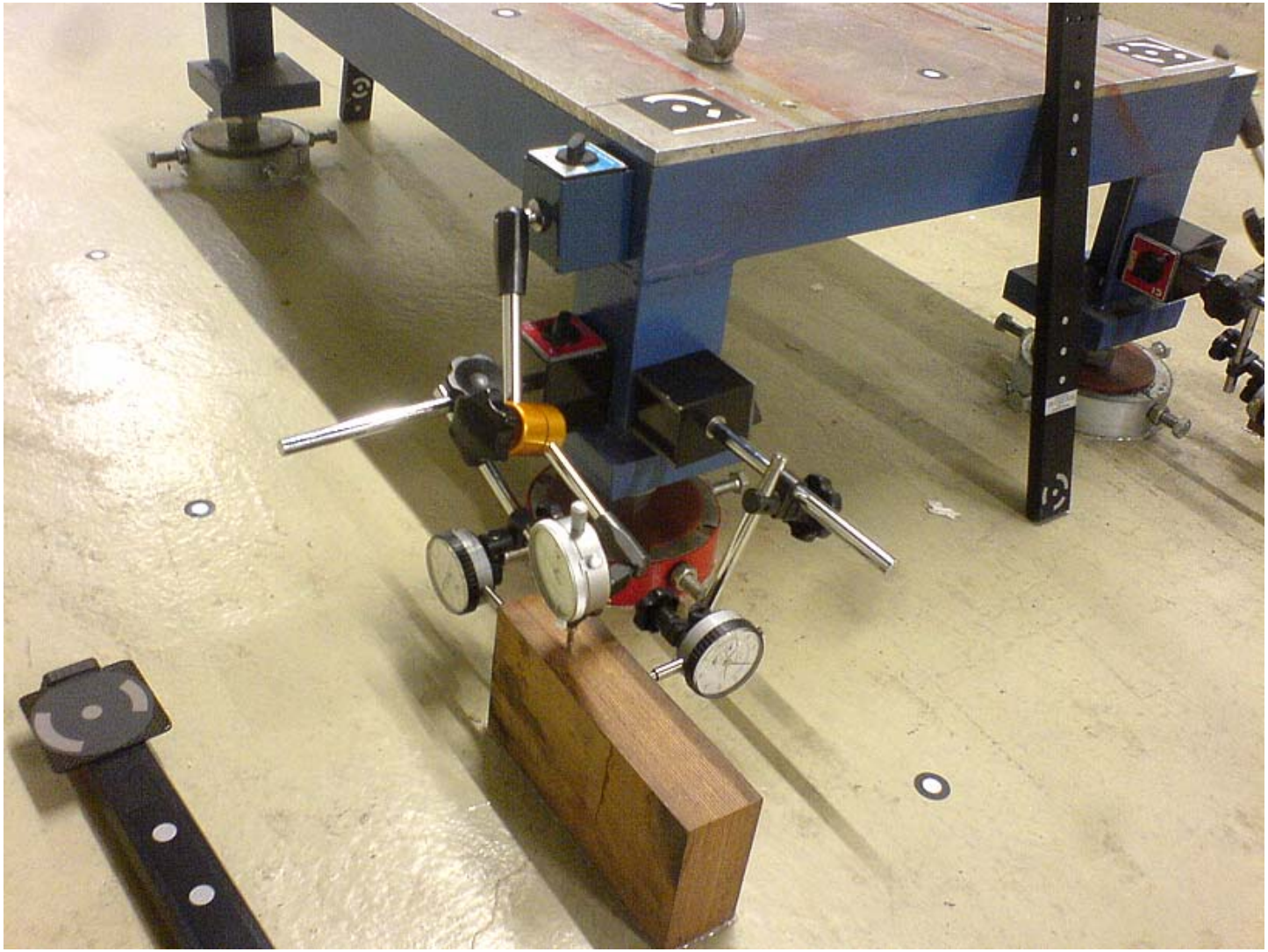
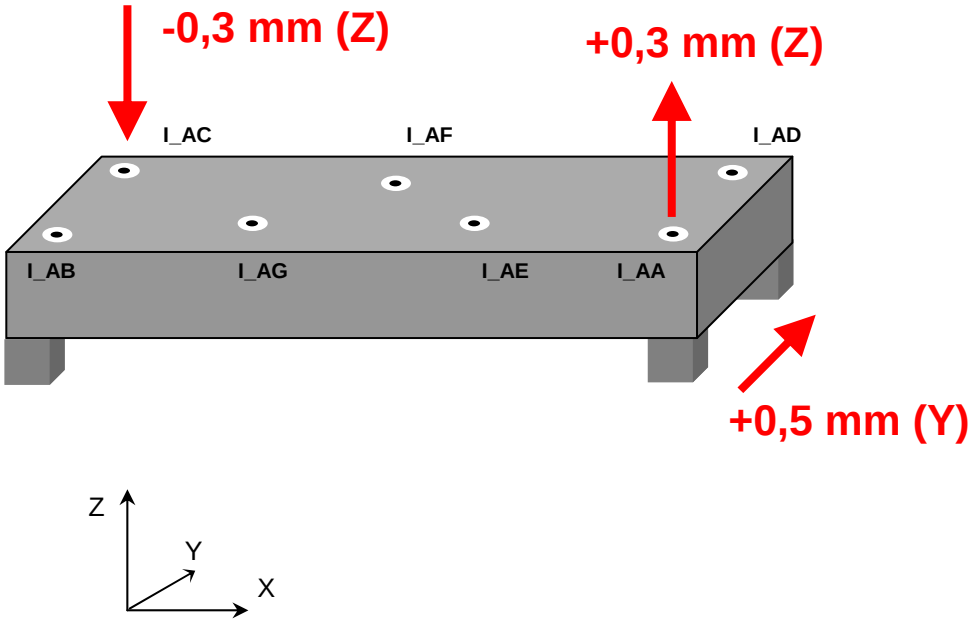
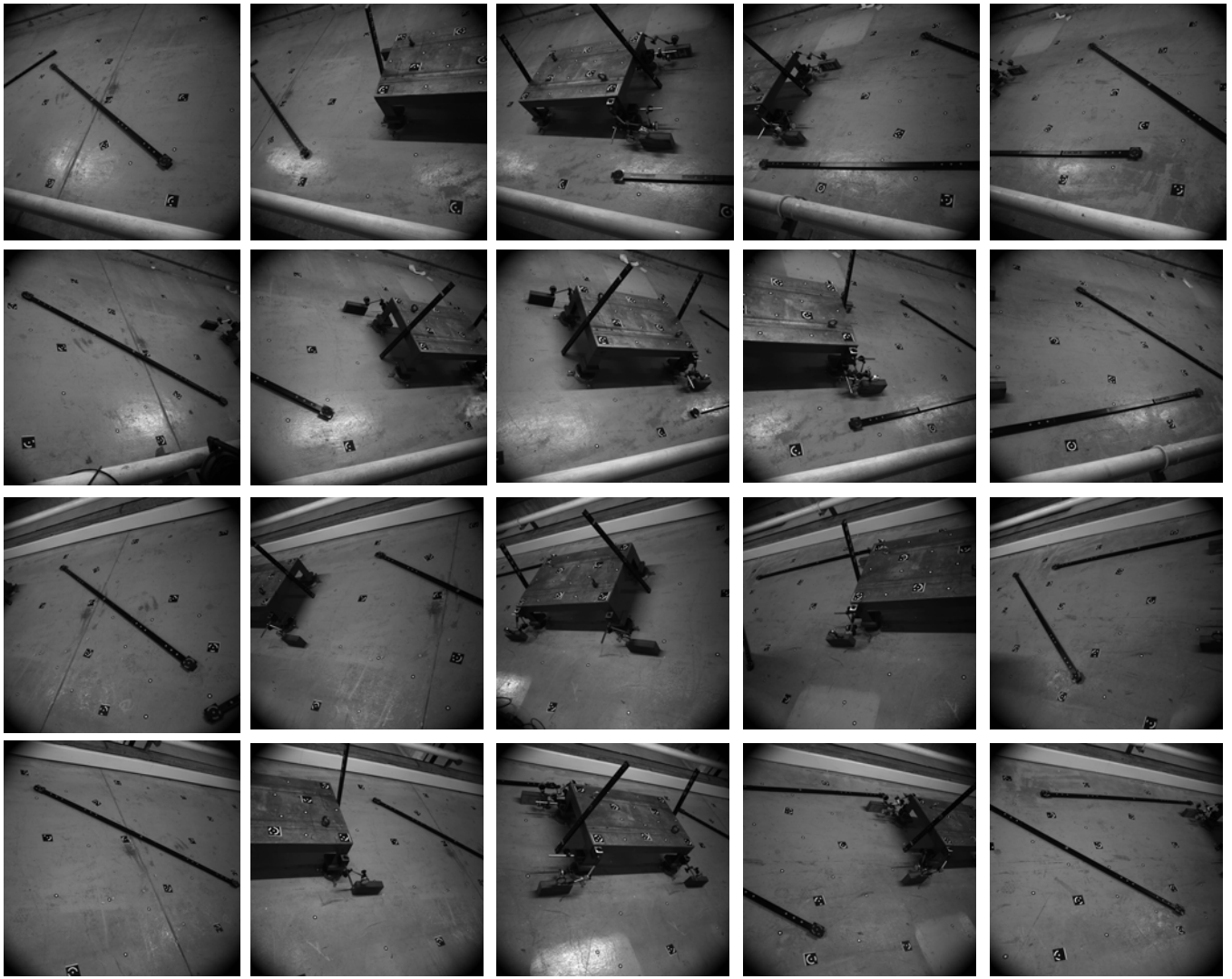
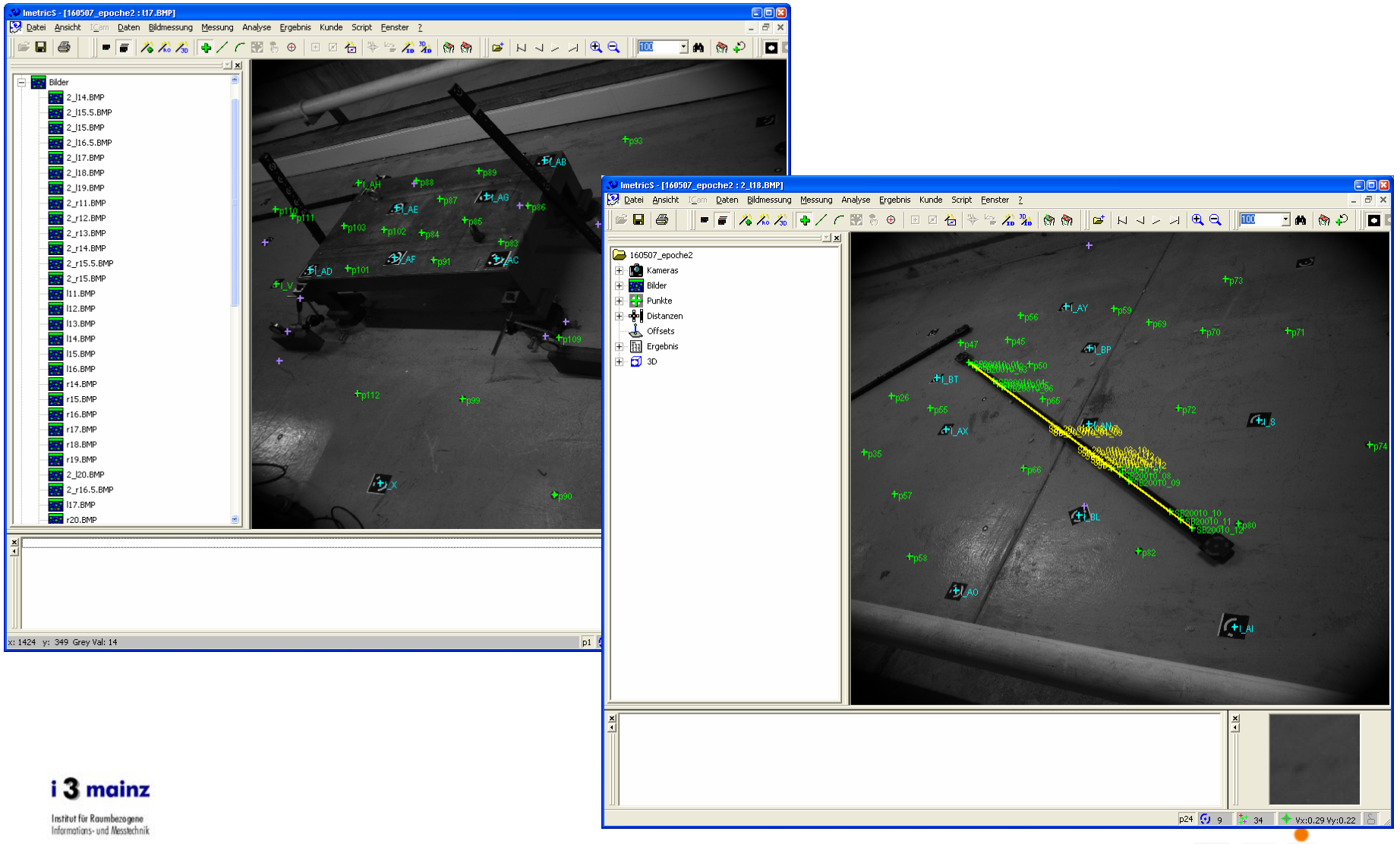


	Table movement (reference measurements with dial indicators)		
	X	Y	Z
I_AA	0,08	0,54	0,31
I_AB	0,08	0,22	0,00
I_AC	-0,12	0,22	-0,27
I_AD	-0,12	0,54	0,05
I_AE	0,01	0,44	0,13
I_AF	-0,10	0,38	-0,09
I_AG	0,01	0,29	-0,03






Imetric5 - [160507_epoche2 : I17.BMP]
Datei Ansicht iCam Daten Bildmessung Messung Analyse Ergebnis Kunde Script Fenster ?
Bilder
2_I14.BMP
2_I15.5.BMP
2_I15.BMP
2_I16.5.BMP
2_I17.BMP
2_I18.BMP
2_I19.BMP
2_r11.BMP
2_r12.BMP
2_r13.BMP
2_r14.BMP
2_r15.5.BMP
2_r15.BMP
I11.BMP
I12.BMP
I13.BMP
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I15.BMP
I16.BMP
r14.BMP
r15.BMP
r16.BMP
r17.BMP
r18.BMP
r19.BMP
2_I20.BMP
2_r16.5.BMP
I17.BMP
r20.BMP
x: 1424 y: 349 Grey Val: 14
Imetric5 - [160507_epoche2 : 2_I18.BMP]
160507_epoche2
Kameras
Bilder
Punkte
Distanzen
Offsets
Ergebnis
3D
Vx:0.29 Vy:0.22

	Reference Movement (Dial indicators)			Movement determined with RALF		
	X	Y	Z	X	Y	Z
I_AA	0,08	0,54	-0,31	0,06	0,59	-0,37
I_AB	0,08	0,22	0,00	0,02	0,19	0,06
I_AC	-0,12	0,22	0,27	-0,18	0,24	0,32
I_AD	-0,12	0,54	-0,05	-0,19	0,64	0,16
I_AE	0,01	0,44	-0,13	-0,08	0,48	0,02
I_AF	-0,10	0,38	0,09	-0,17	0,39	0,04
I_AG	0,01	0,29	0,03	-0,01	0,32	0,18
RMS						

- Bundle adjustments of the two measurement runs
- Transformation of run 2 to run 1 using 49 tie points (w/o points on table)
- Comparison of coordinate differences of the points on the table

	Reference Movement (Dial indicators)			Movement determined with RALF			Difference		
	X	Y	Z	X	Y	Z	diff X	diff Y	diff Z
I_AA	0,08	0,54	-0,31	0,06	0,59	-0,37	0,02	-0,06	0,06
I_AB	0,08	0,22	0,00	0,02	0,19	0,06	0,06	0,03	-0,06
I_AC	-0,12	0,22	0,27	-0,18	0,24	0,32	0,06	-0,02	-0,04
I_AD	-0,12	0,54	-0,05	-0,19	0,64	0,16	0,07	-0,10	-0,21
I_AE	0,01	0,44	-0,13	-0,08	0,48	0,02	0,10	-0,03	-0,14
I_AF	-0,10	0,38	0,09	-0,17	0,39	0,04	0,06	-0,01	0,04
I_AG	0,01	0,29	0,03	-0,01	0,32	0,18	0,03	-0,04	-0,15
RMS							**0,06**	**0,05**	**0,12**

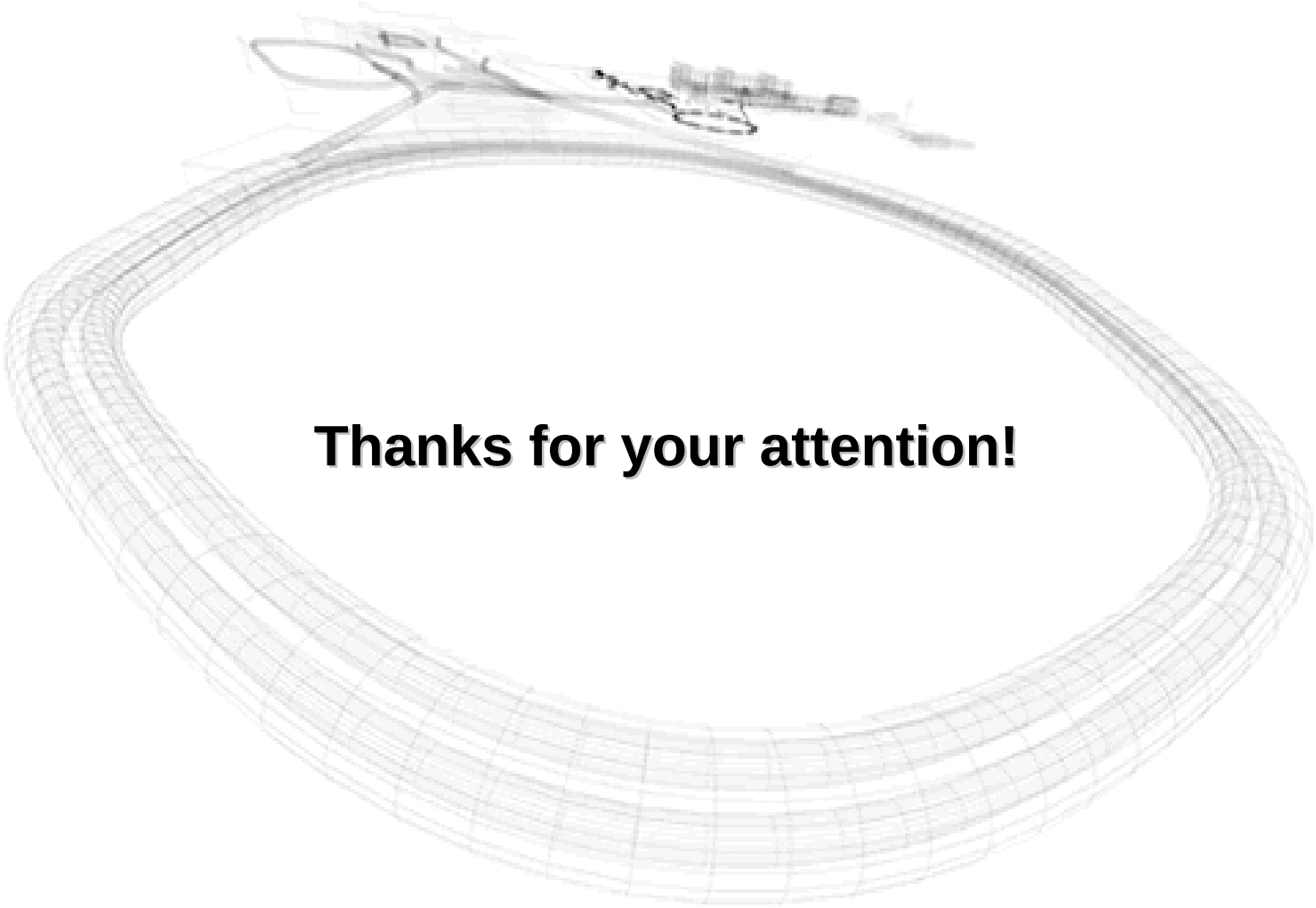
- Note: Reference measurement using the dial indicators is only of limited accuracy and reliability

	X	Y	Z
RMS	**0,03**	**0,02**	**0,06**
Max.	0,07	0,09	0,15

- Transformation of all points from run 2 to run 1 (except points on magnet dummy)
- Good repeat accuracy confirms accuracy potentialof RALF
- Room for additional error sources in practice: e.g. hidden points, bad point distribution etc.
- When using only images from one corridor side, accuracy becomes worse by factor 2 to 4

Conclusion

- Test installation confirms simulations!
- Goals of RALF can be achieved
- Measurement accuracy below 0.1 mm
- Some practical aspects of RALF are still under discussion (see paper), e.g.
  - Transfer of accelerator geometry to service platform
  - Movement of the magnets
  - Motion system
  - Connection to adjacent sections of Super-FRS
- Concept is a promising alternative to traditional alignment methods and may be applicable at many accelerator sections, not only at GSI



Thanks for your attention!