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HIE-ISOLDE

ALIGNMENT AND MONITORING SYSTEM SOFTWARE AND TEST MOCK-UP

Jean-Christophe Gayde	BE/ABP-SU
Guillaume Kautzmann	BE/ABP-SU
Sebastian Waniorek	BE/ABP-SU

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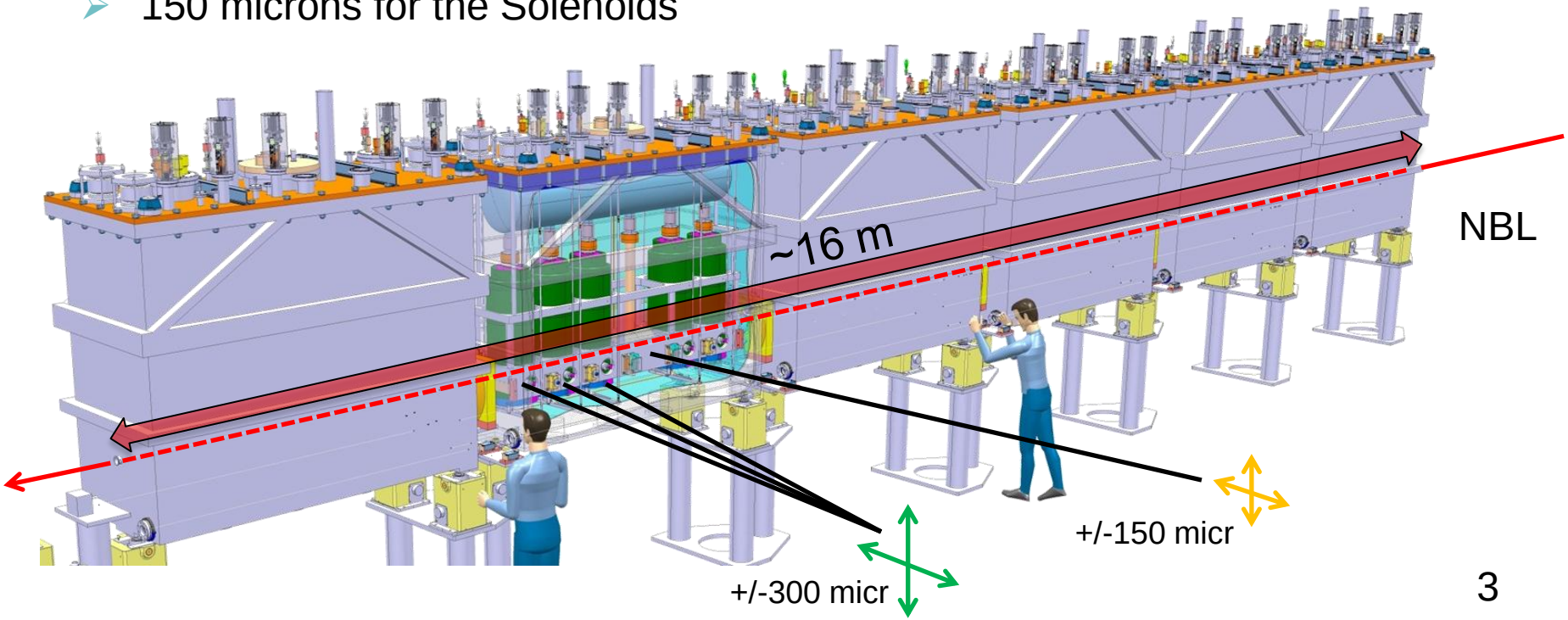
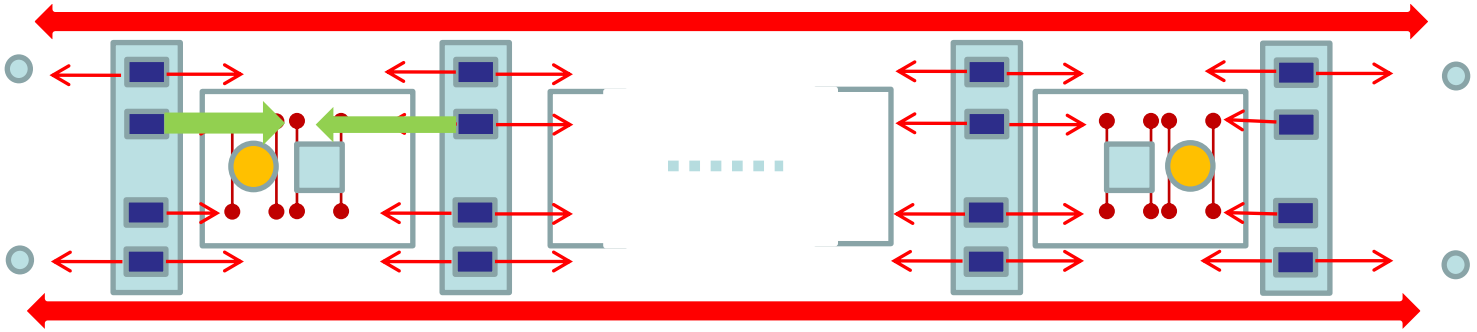
General
Alignment Specifications

- HIE-ISOLDE : Upgrade of the existing REX-ISOLDE
- Alignment and monitoring of the Cavities and Solenoids in the Cryomodules w.r.to a common nominal beam line (NBL) along the Linac
- Permanent system
- Precision demanded along radial and height axis at 1 sigma level :
  - 300 microns for the Cavities
  - 150 microns for the Solenoids



General
Alignment Concept

Proposed concept:



Overlapping zone of BCAM obs. on external lines

Double sided targets observations on internal lines

Hardware:

- BCAM based observations
- Metrological tables
- Targets
- Viewports

Conditions:

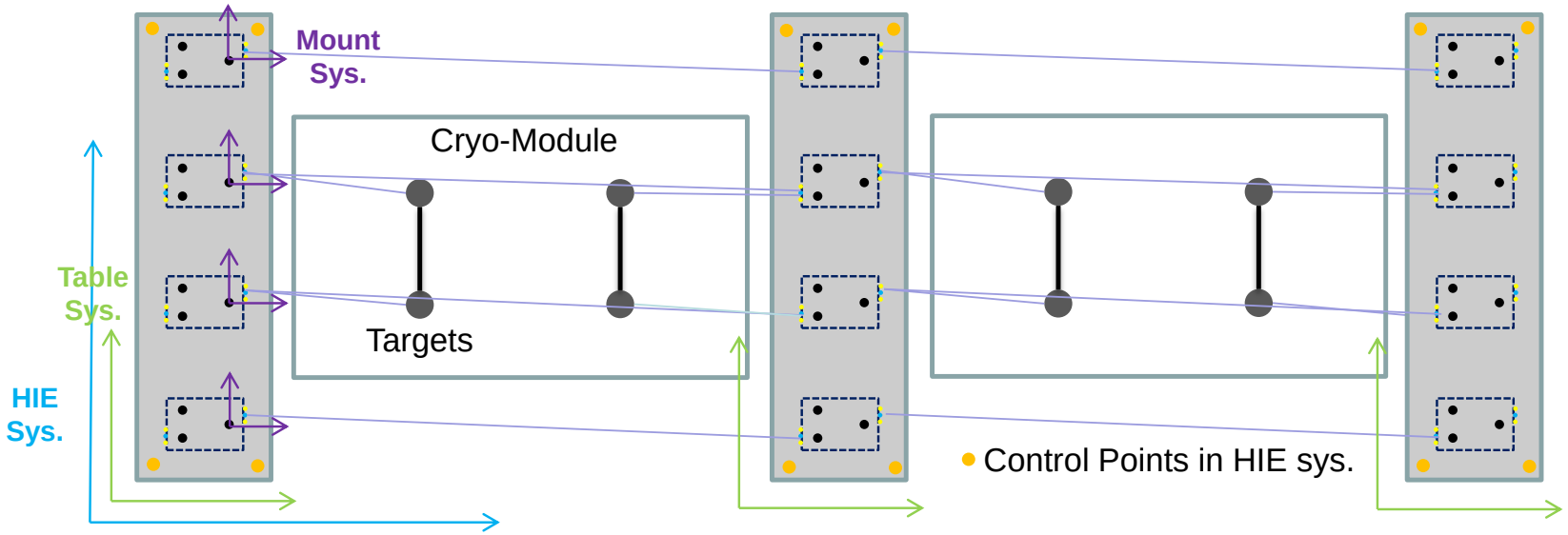
- Cryogenic conditions (4.5K)
- High Vacuum

Software is needed to reconstruct the target and table positions

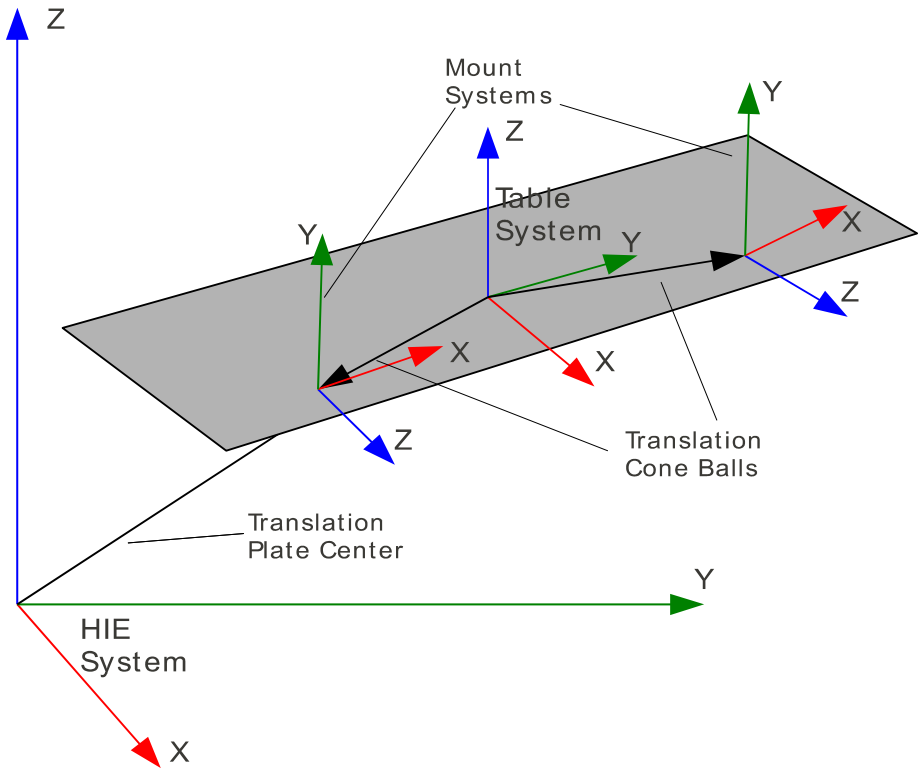
Mathematical concept
Coordinate Systems

Hierarchical scheme of coordinates systems :

Topmost:	HIE system	→ Link to the NBL
For each table:	Table system	→ Link between the BCAMs
For each BCAM:	Mount system	→ Calibration parameters
	CDD System	→ Observations



Mathematical concept
Adjusted Parameters



Translations and rotations for each table need to be estimated: 6 parameters per table in the setup

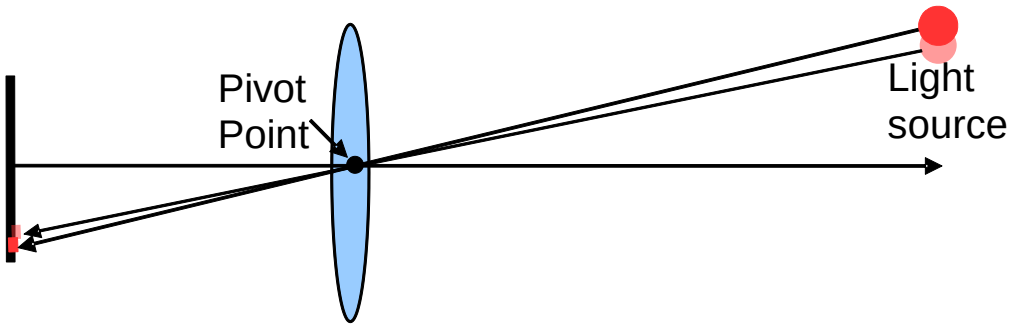
Relations between mount systems on the same table are fixed → Tables considered as a rigid body

Mathematical concept
BCAM Observations

Two observations per spot: the x and y coordinates of the image coordinate on the CCD, transformed in the mount system by calibration parameters

The spot approximated theoretical position is projected on the observing CCD and in the same mount system.

Transformation parameters of the observing and observed plate are included.

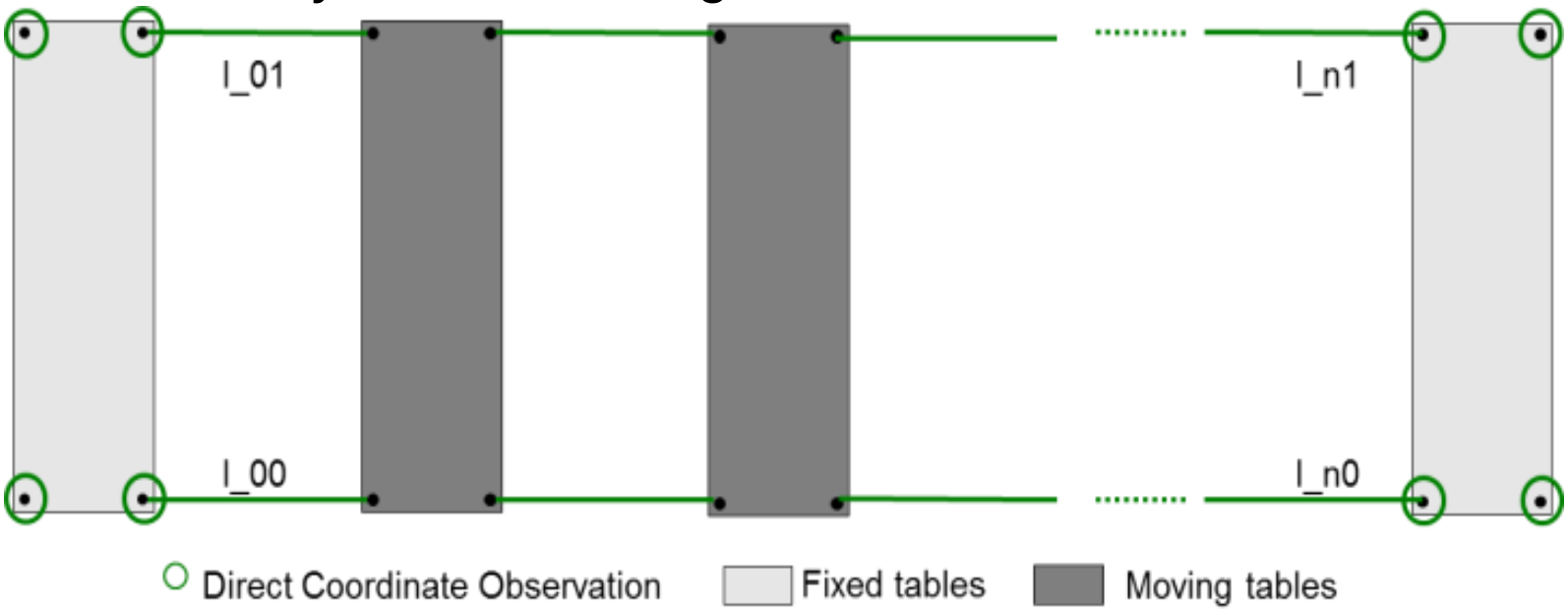


Mathematical concept
External Observations

BCAMs (angle monitors) cannot measure distances directly

For the first implementation, distance measurements between the plates are introduced manually

Coordinates of end plate corners as direct observations with their accuracy to set the weight

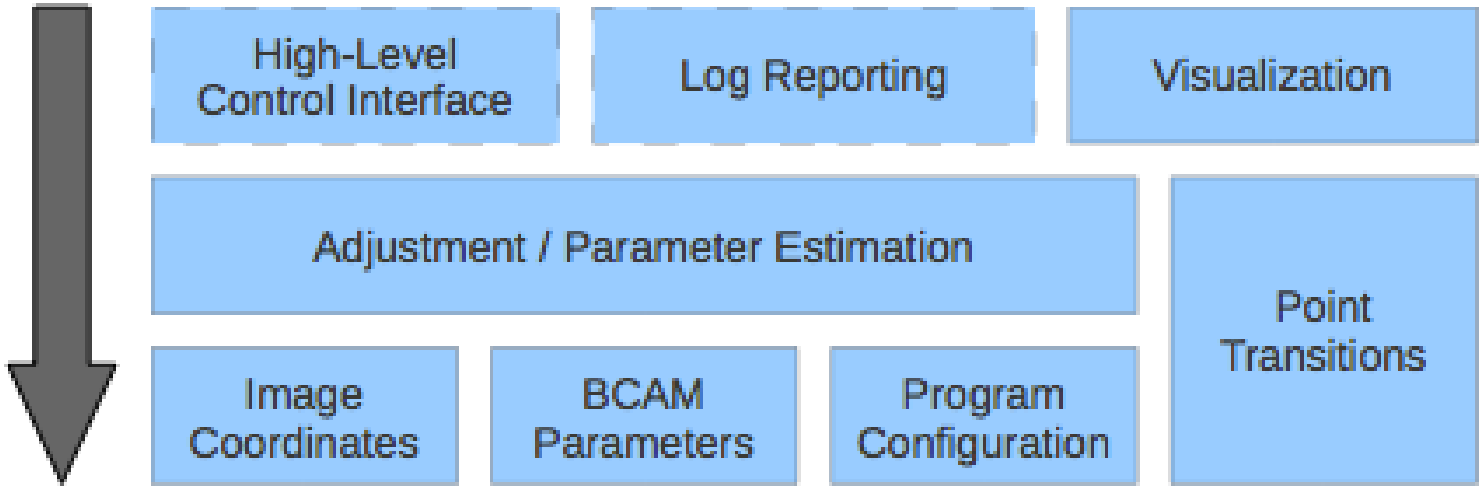


Software Principles

Designed as a portable, modular C library with some C++ implementation parts, uses only C99 and ANSI C++98

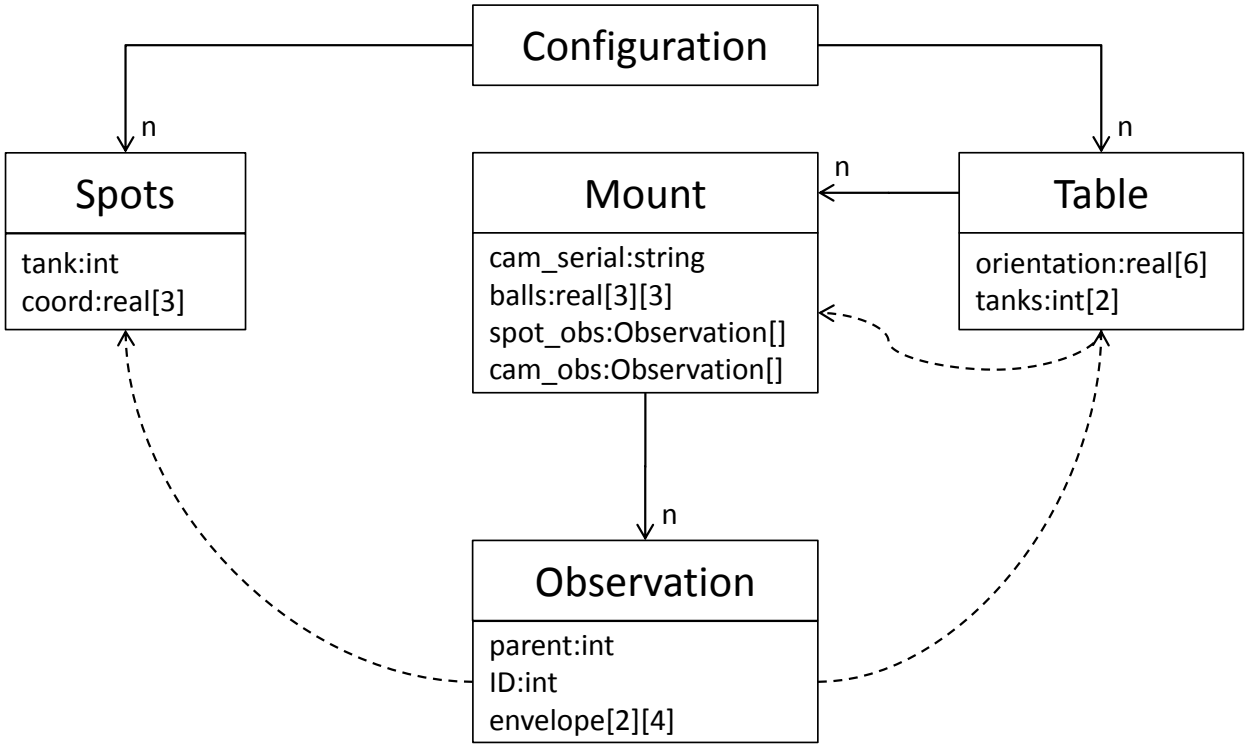
Can be included into any software that provides a user interface to the algorithms

Flexible description of the setup using configuration files



Software Configuration

The description of the setup and measurement data is defined in an INI-style, hierarchical configuration file



Software Configuration

The description of the setup and measurement data is defined in an INI-style, hierarchical configuration file

Global parameters

```
[global]
num_tanks=0
targets_per_tank=4
default_corners=4
ball_order=CPS
T_now=21.0
num_plates=3
mounts_per_plate=4
```

Plate parameters

```
[plate_0]
T_calib=21.0
bcam_0=20MABNDM000001
bcam_1=20MABNDM000002
bcam_2=20MABNDM000003
bcam_3=20MABNDM000004
mount_0=(( 40.331853   289.733413   17.112434) \
         (-32.699243   310.622060   17.260898) \
         (-32.617383   268.609930   17.132177) )
...
```

```
mount_3=(( 40.364771  -290.018916   17.064705) \
         (-32.667150  -269.194411   16.986794) \
         (-32.571635  -311.180136   17.128102) )
corner_0=(-79.944554    334.956959  12.650798)
...
corner_3=( 80.002741    -334.934947 12.650798)
corner_0_glob=(-79.944554   334.956959  12.650798)
...
corner_3_glob=( 80.002741   -334.934947 12.650798)
corner_0_stddev=(0.009874   0.010039   0.008885)
...
corner_3_stddev=(0.006916   0.010091   0.009259)
orientation=(0 0 0 0 0 0)
dist_next_0=(1:0 2440.159 100)
dist_next_1=(3:2 2439.943 100)
```

...

Mount parameters

```
[0:0]
basetype=blue_polar
fc_s=(1:0 2:0 3:0 6:0)
#allow_rotation=Z
```

Software
Observation and Calibration Input

Observations

Observations parameters

```
1:1:f-2:1:r=((-5428.100482 -36921.756262)(-5923.367747 -36923.639923))
1:1:r-0:1:f=((3848.356195 36847.430243)(3378.175308 36846.759877))
1:2:f-2:2:r=((-5363.953988 -36904.042160)(-5859.841422 -36898.226763))
1:2:r-0:2:f=((3943.024769 36813.277294)(3473.546186 36829.834536))
1:3:f-2:3:r=((-5112.576507 -36899.471260)(-5608.656915 -36895.959989))
1:3:r-0:3:f=((4229.487731 36794.866784)(3761.073152 36806.677201))
2:0:f-3:0:r=((-5030.791231 -36910.195882)(-5511.938968 -36908.250208))
2:0:r-1:0:f=((4300.932652 36827.660404)(3818.414704 36814.894554))
2:1:f-3:1:r=((-5037.445174 -36857.118969)(-5526.478225 -36858.900684))
2:1:r-1:1:f=((4324.328417 36750.029708)(3840.965613 36765.207447))
```

Observation of one spot transformed in the Mount System

Calibration parameters of the BCAM – Provided by OSI

# of lines in file				
timestamp	type	serial number	6/8*value	6/8*stddev

Example:

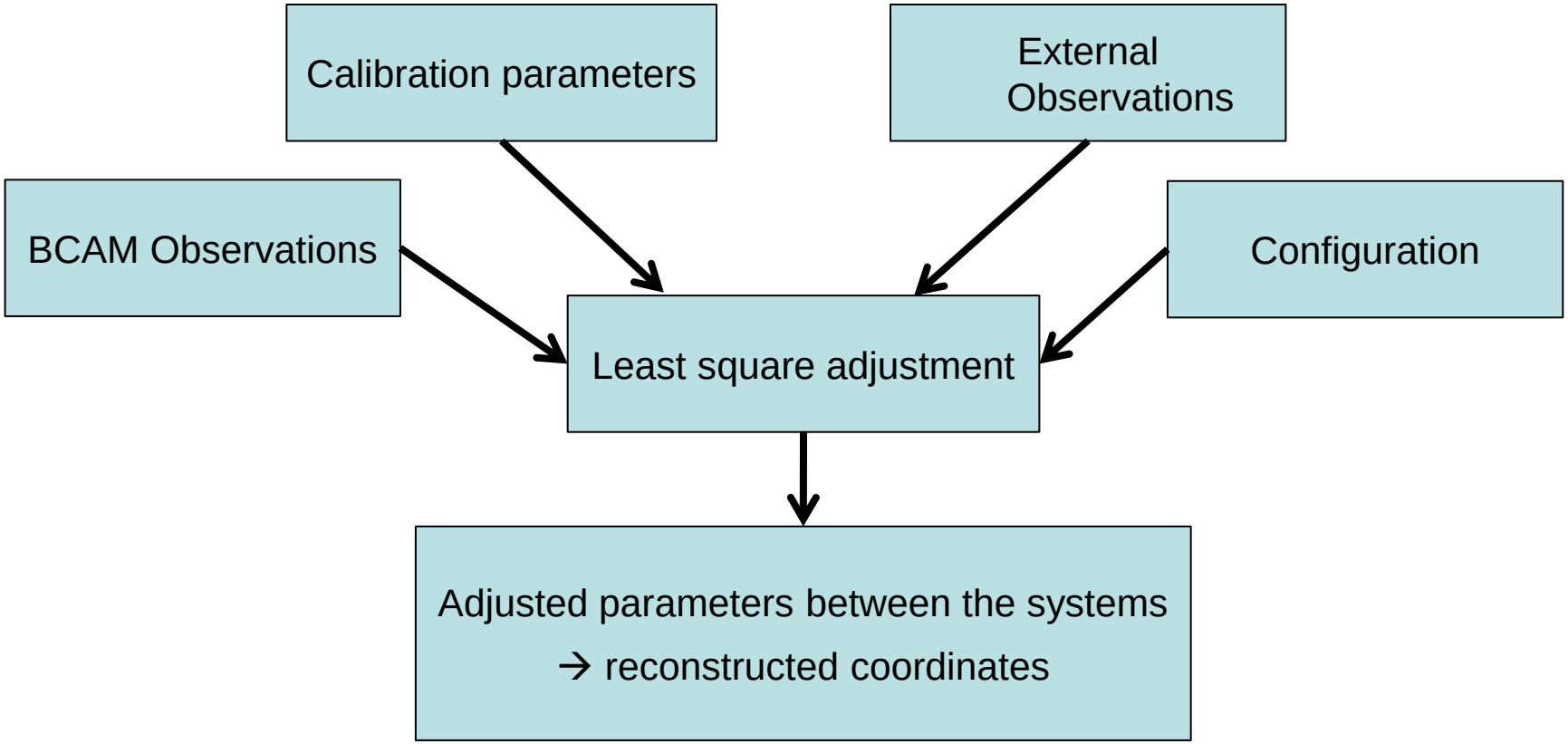
5124

20020819140700 black_polar_rs 20MABNDL000099 -4.74231264628081E+000 … 1.45386202984383E-002

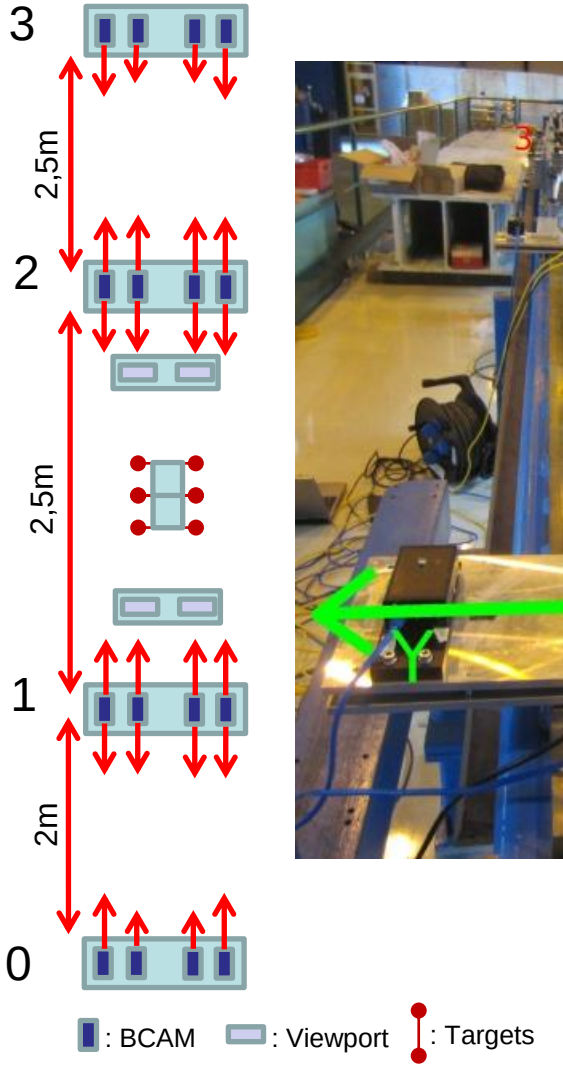
…

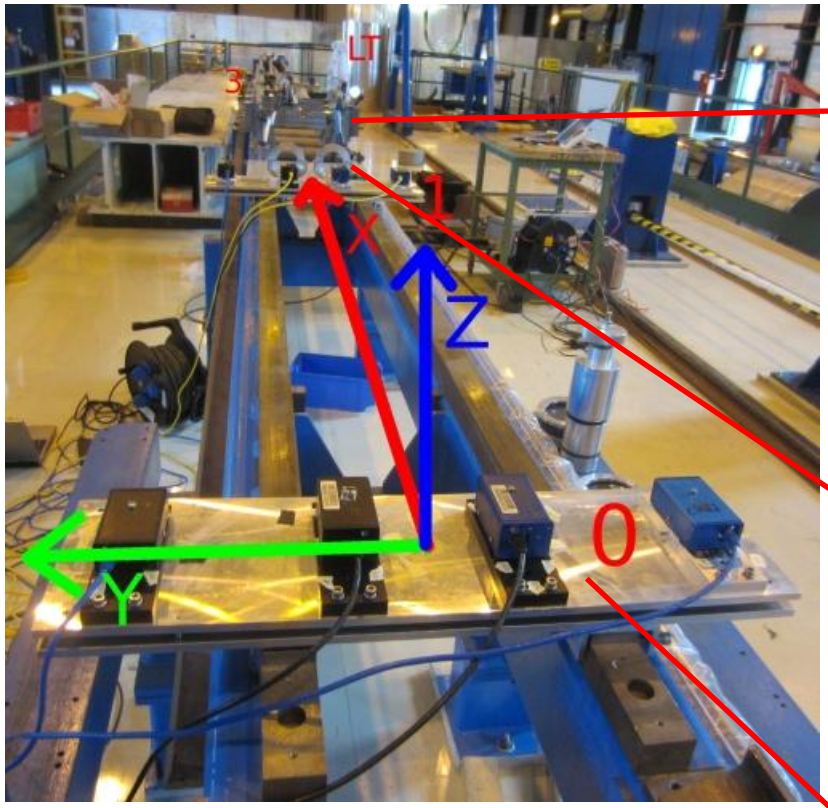
20090429102929 blue_azimuthal_c 20MABNDB000354 -1.26310133593828E+001 … 6.23945700435415E-003

Software
Adjustment



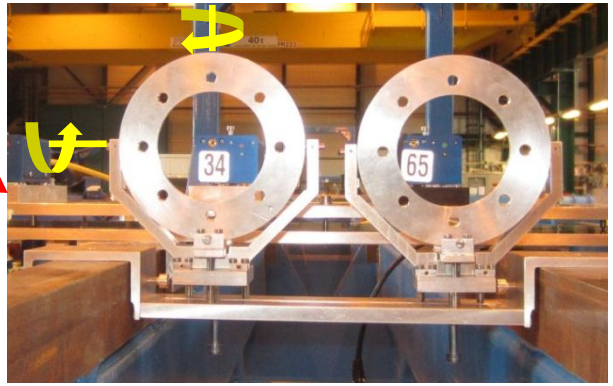
Model Validation
Mock-Up



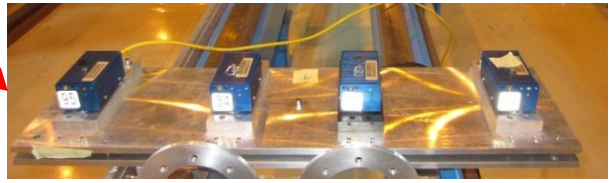


Complete set-up in SMI2
Almost 1:1

Cavity support mockup



Adjustable viewport table

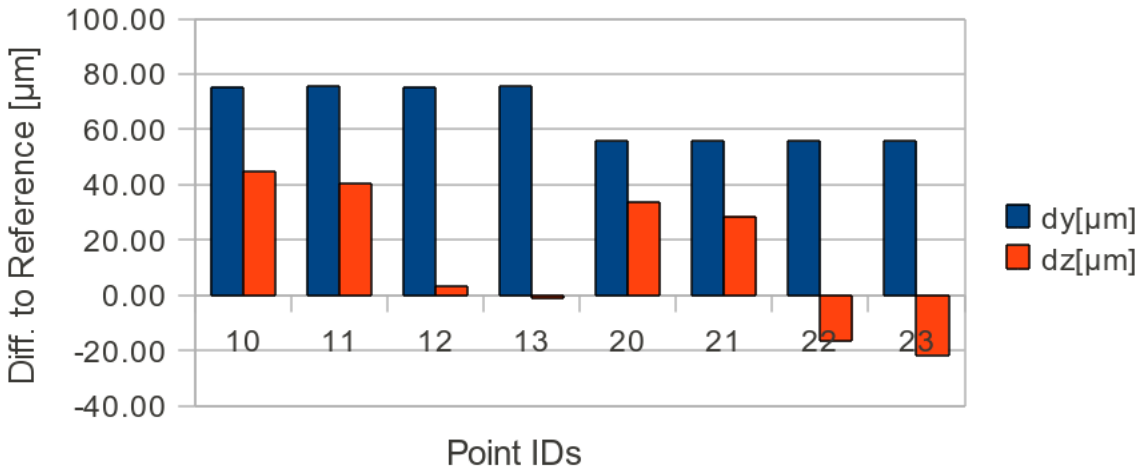


Adjustable BCAM table

Model Validation
Results

Very first validation test:

Point ID	dy[µm]	dz[µm]
10	75.42	44.65
11	75.52	40.29
12	75.36	3.25
13	75.47	-1.10
20	55.66	33.71
21	55.69	28.63
22	55.67	-16.48
23	55.68	-21.56



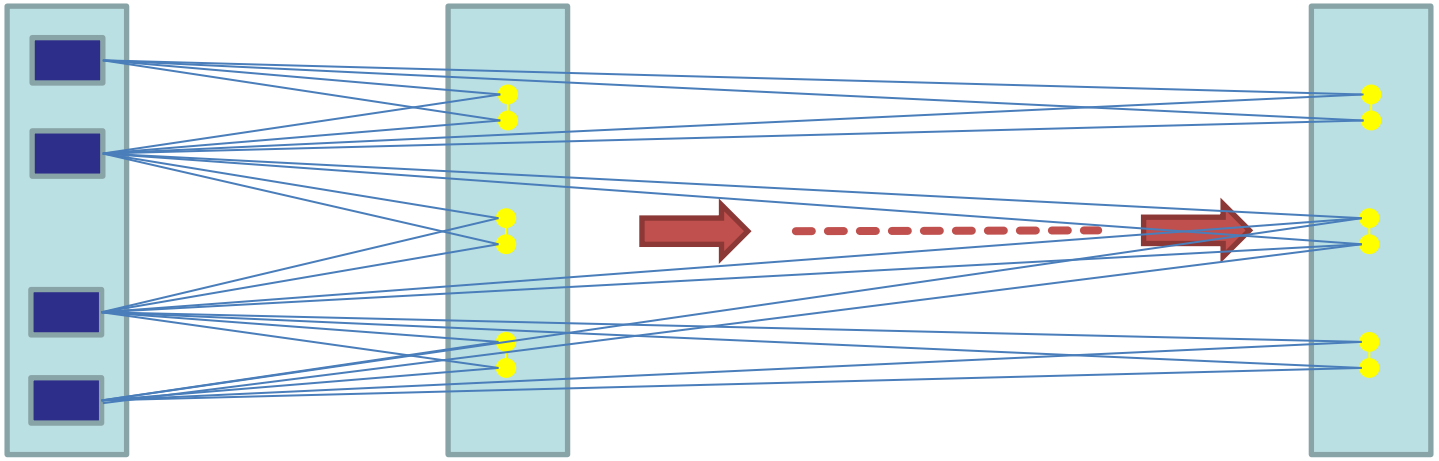
Stochastic results of reconstruction

	σty [µm]	σtz [µm]	σrx [µrad]	σry [µrad]	σrz [µrad]
0	2.9	3.2	9.2	29.5	7.5
1	70.1	55.9	177.8	26.0	111.2
2	78.5	66.5	198.8	23.9	111.2
3	5.4	6.4	19.0	36.0	7.7

BCAM rotations

Comparison of simulations and reference measurements suggests to investigate an in-situ determination of the mount rotations in an extra preprocessing step

Determine mount rotations by collinearity equation approach



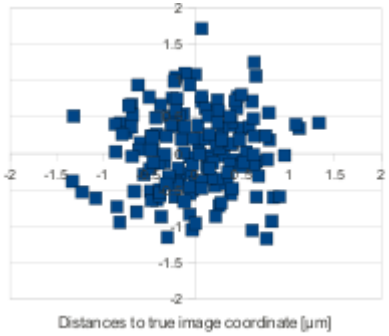
Simulation
Setup

Basically the same layout as in the reference measurements but with 7 plates like in the final extension of HIE-ISOLDE

To improve redundancy and add additional robustness, the outer BCAMS were elevated to see more than one BCAM

Overlap adds 128 observations, a rise from 228 to 356 for the same number of 42 unknowns

Image Coordinates were calculated from the positions and randomized by 1.5 micron



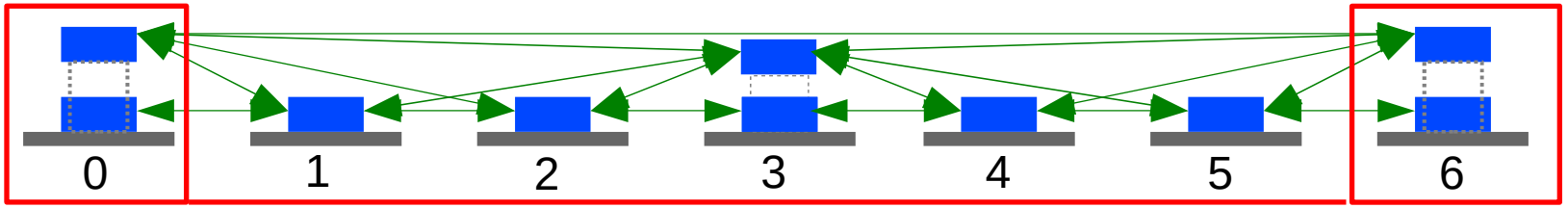
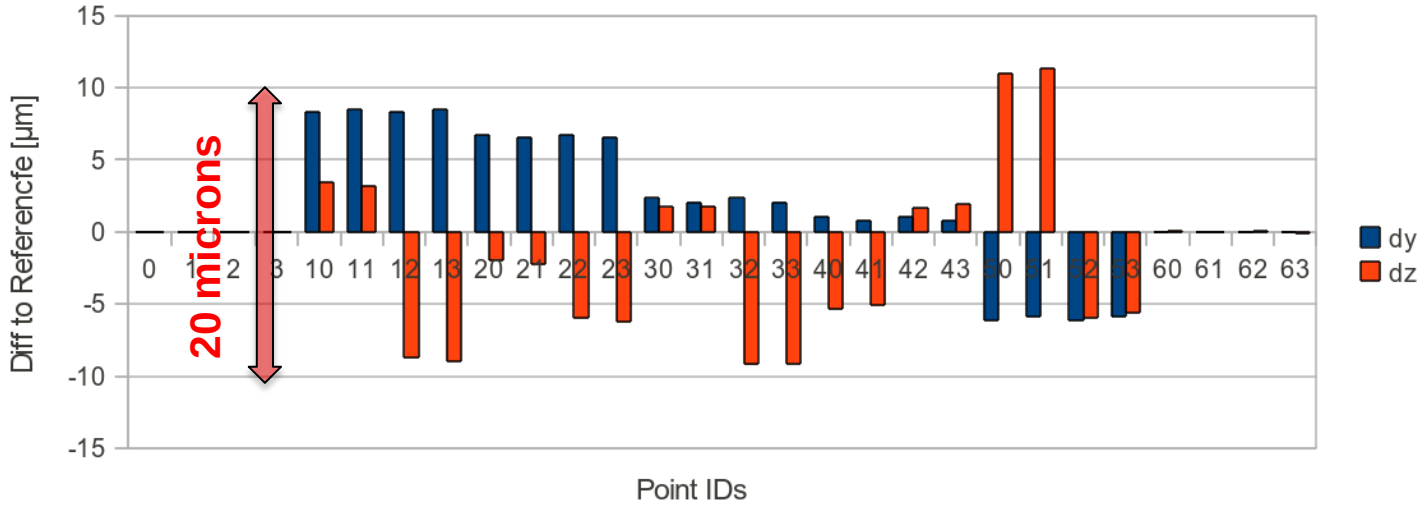


Table 0 and 6 fixed

Simulation
Results



Σ_0^2=0.0117	σty [µm]	σtz [µm]	σrx [µrad]	σry [µrad]	σrz [µrad]
0	0.49	0.53	1.54	3.51	1.2
1	9.19	10.72	34.5	4.16	3.78
2	12.72	15.38	38.2	3.59	3.39
3	13.67	16.87	38.02	2.82	2.69
4	12.73	15.6	38.27	3.56	3.39
5	9.21	11.01	34.54	4.18	3.78
6	0.9	1.07	3.18	3.93	1.23

Overlapping improves the results by a factor 2

Still some error budget for the reconstruction of the targets

Conclusion

Conclusions:

Validation of the theoretical model and software implementation

Promising simulations

Development well advanced

But still work to do:

Analysis of the second set of measurement on the test bench

New features on the software (Target reconstruction, Viewport and double-viewport correction, Image analysis, thermal expansion…)

Extended test bench

…

Acknowledgement:

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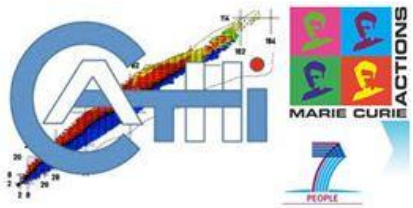

Thanks for your attention