Simulations (LET beam dynamics) Group report

20080502 Kiyoshi Kubo

LET beam dynamics related Work Packages and roll of Simulations Group

- Almost all Work Packages proposed by Simulations Group were overlapped with WPs of other groups.
- Work items related to (almost) one single area are under Area Groups (RTML, ML or BDS).
- Basically, inter area beam dynamics work items are under Simulations Group.
- All LET beam dynamics simulation workers should be in Simulations Group and closely communicate each other.
- Important simulation results should be cross checked by more than one group.

Organization

- K. Kubo and D. Schulte are co-leader
- Several “contact persons” have been assigned
  - Main Linac:
    - Static tuning: Paul Lebrun (FNAL)
    - Dynamic tuning: Freddy Potier (DESY)
    - Initial Alignment: Kiyoshi Kubo (KEK)
    - Energy error: Daniel Schulte (CERN)
  - RTML:
    - Static tuning: Steve Molloy (SLAC) → Cancelled
    - Dynamic tuning: Jeff Smith (SLAC) → Cancelled
    - Stray field: Dmitri Sergatskov (FNAL) + ?
    - Halo generation: (Cornell) → Cancelled (?)
    - Alternative short BC: Eun-San Kim (KNU)
    - Collimator : Grahame Blair (RHUL)
  - BDS:
    - Glen White (SLAC) (?)
- ILC-CLIC collaboration
  - K.Kubo and N.Walker (ILC), D.Schulte and A.Latina (CLIC)
- We have phone meeting about once a month. (Intended to be every other weeks.)

RTML

- RTML: Simulation results are not far from our goal.
  - May need more emittance budget (from ML)
  - Check whether assumptions of misalignment, BPM performance, mechanical vibration, ground motion etc. are reasonable.
    - But assumptions have not been documented clearly.
    - Stray field in the long return line (~nT) may cause problem
  - Need to check possibility of shorter Bunch Compressor
  - Affected by US (SLAC) budget cut.

Review of RTML tuning, J.Smith

- Not there yet... Budget just 4 nm

Region	BBA method	Dispersive or Chromatic mean Emittance Growth	Coupling mean emittance Growth
Return Line	Kick Minimization and feed-forward to remove beam jitter	0.15 nm	2 nm (without correction)
Turnaround and spin rotator	Kick Minimization and Skew Coupling Correction	1.52 nm (mostly chromatic)	0.4 nm (after correction)
Bunch Compressor	KM or DFS and Dispersion bumps	greater than 4.9 nm (KM + bumps) 2.68 nm (DFS and bumps)	0.6 nm (without correction)
Total		~5 nm almost all from BC	3 nm (without complete correction)

ML

- ML: Simulation results look fine.
  - Check whether assumptions of misalignment, BPM performance, mechanical vibration, ground motion etc. are reasonable.
    - Need approval or rejection from hardware groups.
  - Some remaining issues we picked up:
    - RF error model (input from LLRF etc.)
    - Realistic alignment model (long range)
    - Coupler kick (effect of asymmetries of couplers of cavities)

BDS

- BDS: Simulation results look fine.
  - Check whether assumptions of misalignment, BPM performance, mechanical vibration, ground motion etc. are reasonable.
  - Need to confirm results by independent person and code.
  - Need to include jitters come from upstream

BDS tuning simulation

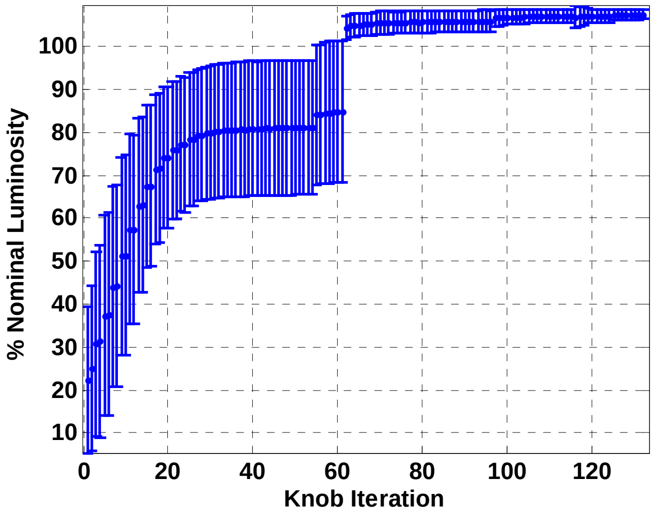


Figure 5: Mean and RMS luminosity vs, multi-knob iteration # (100 seeds).

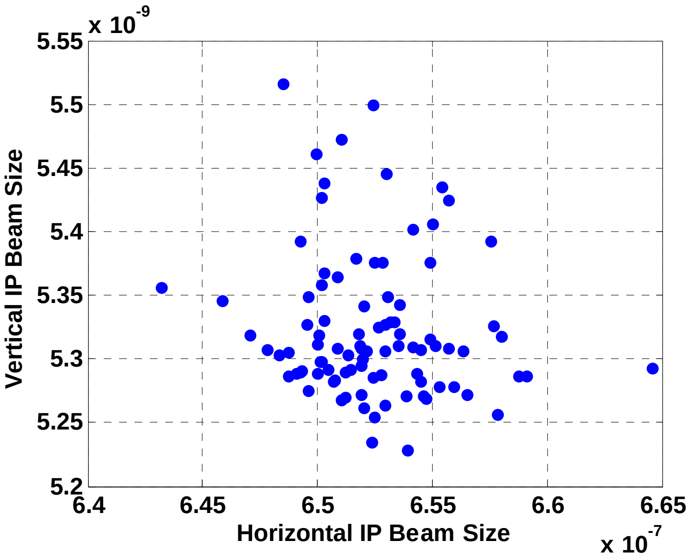


Figure 7: IP beam spot sizes (vertical vs. horizontal) for 100 simulated seeds. Nominal values are 655nm (x) and 5.7nm (y).

By Glen White

Start to End Simulations (inter-area simulations)

- We agreed that Start to End study is important, especially considering time dependent errors.
- Very little results (?)

Generally, work is going slow, since last December.

- Assignment of contact persons in RTML Beam Dynamics was cancelled.
- BDS Beam Dynamics contact persons assignment is not clear.
  - May be just communication problem.
  - ATF2 is independent.
- With a few exceptions, LET beam dynamics works rely on volunteers. (?)

Recent Progress (in 2008)

- Solving remaining puzzles in ML simulations (Apparent discrepancies between different codes/algorithms)
- Making realistic alignment model
  - → see next slides
- Understanding coupler kicks in SC Cavities
- Probably, there are more. But have not been reported to “Simulations Group”

Assumed ("standard") errors

“Standard” Error in RTML and ML

Error	Cold Sections	Warm Sections	With Respect To...
Quad Offset	300 μm	150 μm	Cryomodule/Survey
Quad strength	0.25%	0.25%	Design
Quad roll	300 μrad	300 μrad	Gravity
RF Cavity Offset	300 μm		Cryomodule
RF Cavity Pitch	200 μrad		Cryomodule
BPM Offset (initial)	300 μm	200 μm	Cryomodule/Survey
Cryomoduloe Offset	200 μm		Survey Line
Cryomodule Pitch	20 μrad		Survey Line
Bend offset		300 μm	Survey Line
Bend Roll		300 μrad	
Bend Strength		0.5%	Design

Monitor “Standard” error in RTML and ML

Error	Cold Sections	Warm sections	With Respect To...
BPM Offset after Quad Shunting	20 μm?	7 μm?	Quadrupole
BPM Resolution	1 μm	1 μm	True Orbit
BPM Scale error	2%	2% ?	
Beam size monitor resolution	1 μm ?		Real beam size (σ)

Error set in BDS simulation (2006)

Quad, Sext, Oct x/y transverse alignment	200 um
Quad, Sext, Oct x/y roll alignment	300 urad
Initial BPM-magnet field center alignment	30 um
dB/B for Quad, Sext, Octs	1e-4
Mover resolution (x & y)	50 nm
BPM resolutions (Quads)	1 um
BPM resolutions (Sexts, Octs)	100 nm
Power supply resolution	14 - bit
FCMS (Final CryoModule System): Assembly alignment	200 um / 300urad
FCMS: Relative internal magnet alignment	10um / 100 urad
FCMS: BPM-magnet initial alignment (i.e. BPM-FCMS Sext field centers)	30 um
FCMS: Oct – Sext co-wound field center relative offsets and rotations	10um / 100urad
Corrector magnet field stability (x & y)	0.1 %
Luminosity (pairs measurement or x/y IP sigma measurements)	Perfect

By Glen White

Modeling of Survey Line
+ Local Alignmemnt

By Armin Reichold and Kiyoshi Kubo

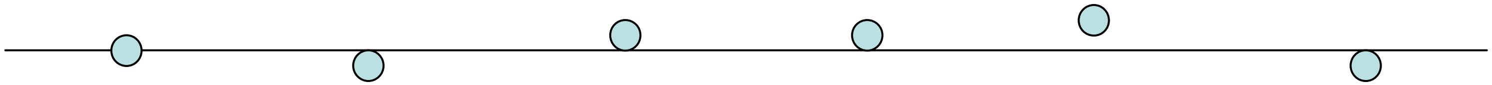
With contribution from

Ryuhei Sugahara, D. Schulte, Catherine LeCocq, Grzegorz Grzelak, Freddy Potier,

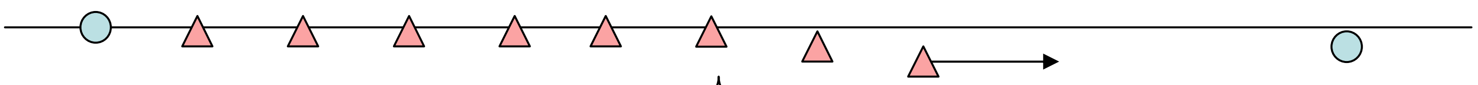
and more ? ? ?

Alignment procedure

Every 2.5 km, primary references,
? using GPS? Random error.

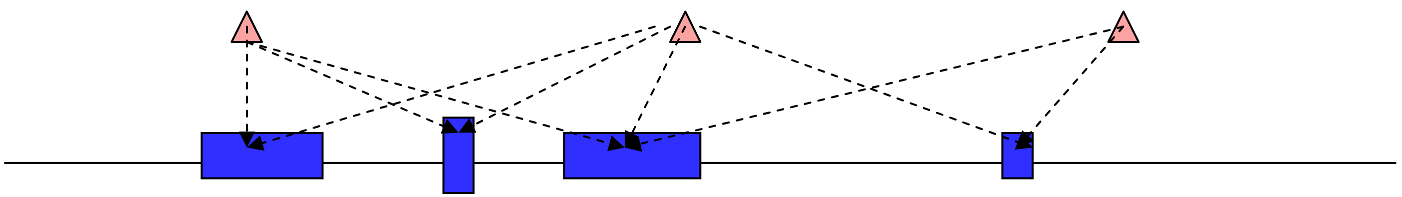


Survey from one primary reference to the next.
Every about 5~50 m, mark reference point



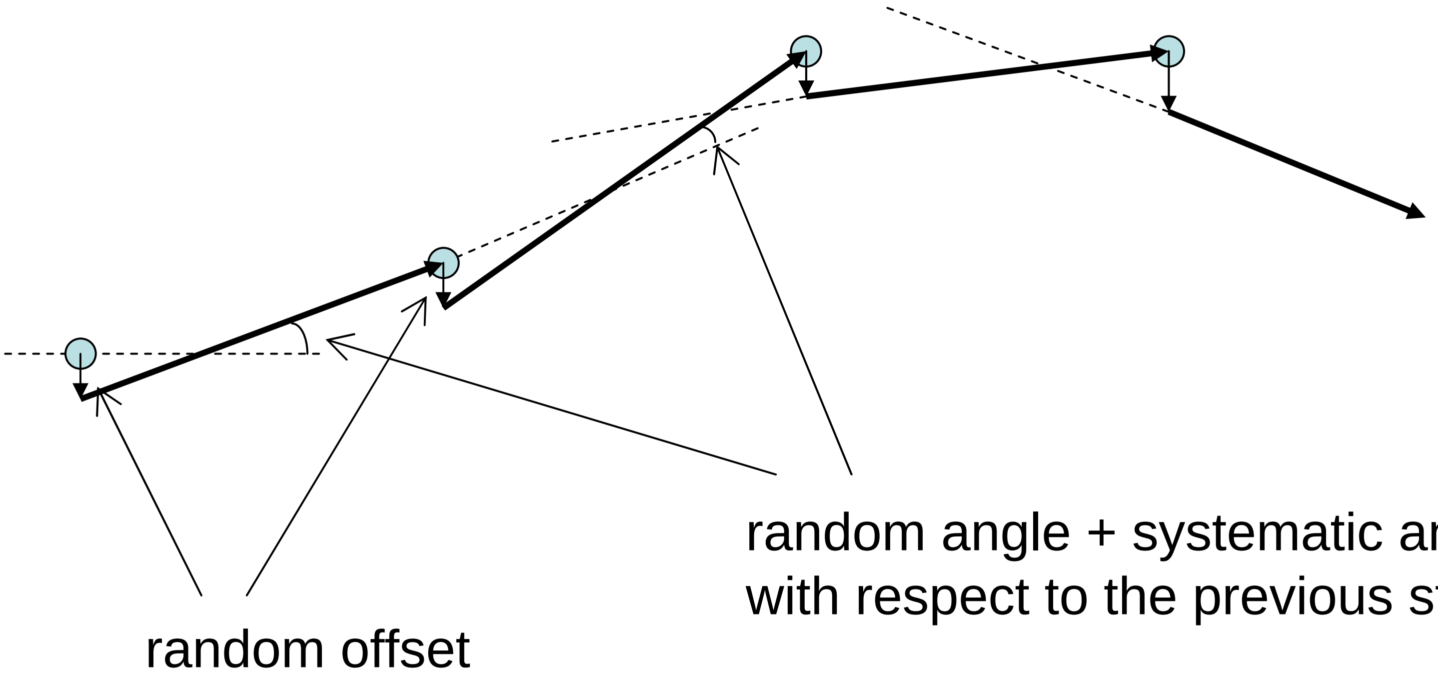
Applied to tracking simulation

Girders, cryomodules, etc. are aligned w.r.t. the reference.



Not yet applied to simulation

Step by step survey:
Random Walk + systematic angle error



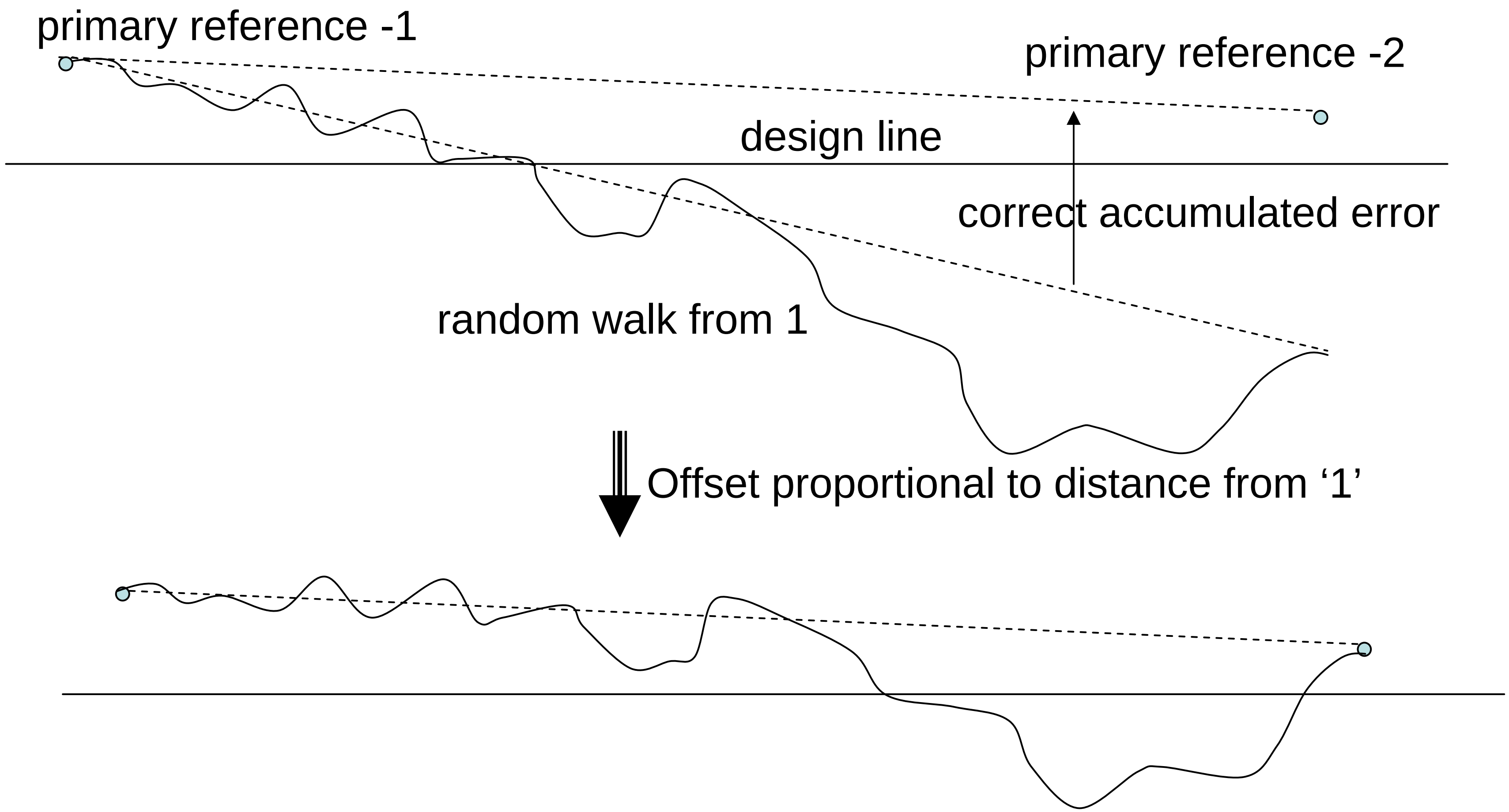
Parameters: l_{step} : length of one step

a_y : random offset/step

a_θ : random angle error/step

θ_O : systematic angle error

Correction of accumulated error in Random Walk using primary reference



This simple correction makes kinks at primary references and may not be good choice. (see beam simulation results later.)

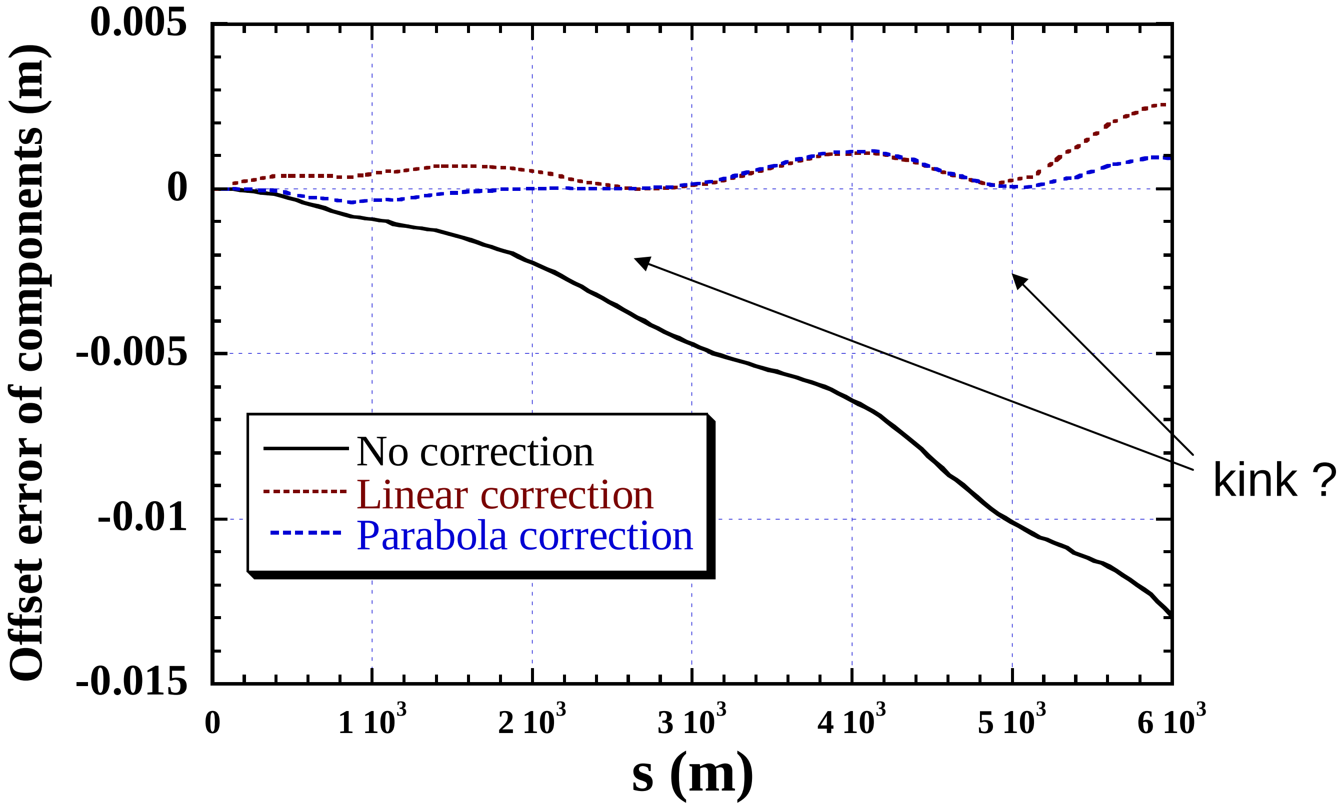
There must be better methods? Still under study.

Correction of accumulated survey line error using primary references

- Linear correction
  - Correction proportional to distance from the start point.
  - Causes kinks at primary reference. (Problem?)
- Parabola correction: We have chosen this temporarily!
  - Correction proportional to square of distance from the start point.
  - No kinks.
- Other methods (?)

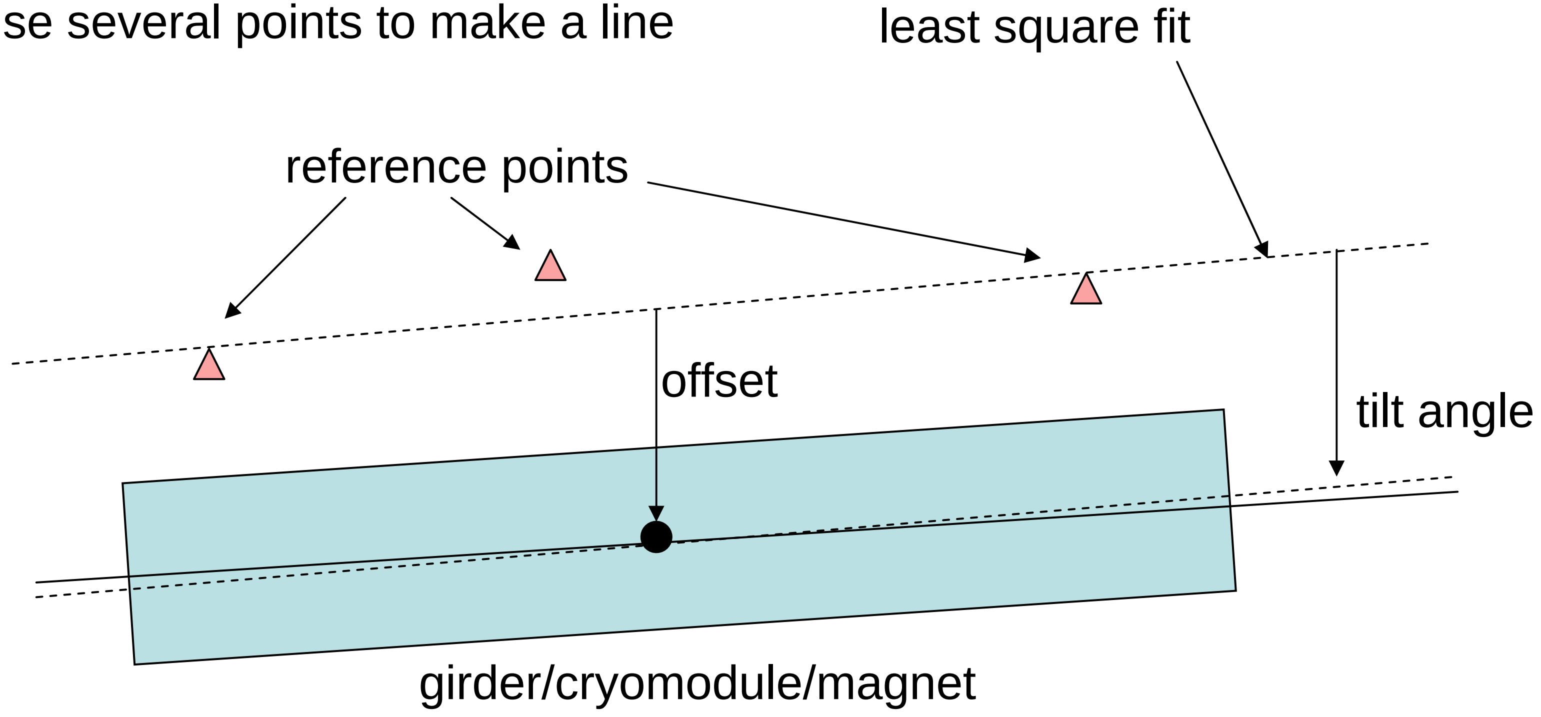
Example: Comparison of correction of accumulated error

Spacing of primary references: 2500 m, Error of primary reference: 0
Step length of survey (random walk): 50 m
Offset error /step, $a_y = 0$, Angle error/step, $a_\theta = 1\ \mu rad$



Survey line to component alignment, Alignment model w.r.t. reference points (example)

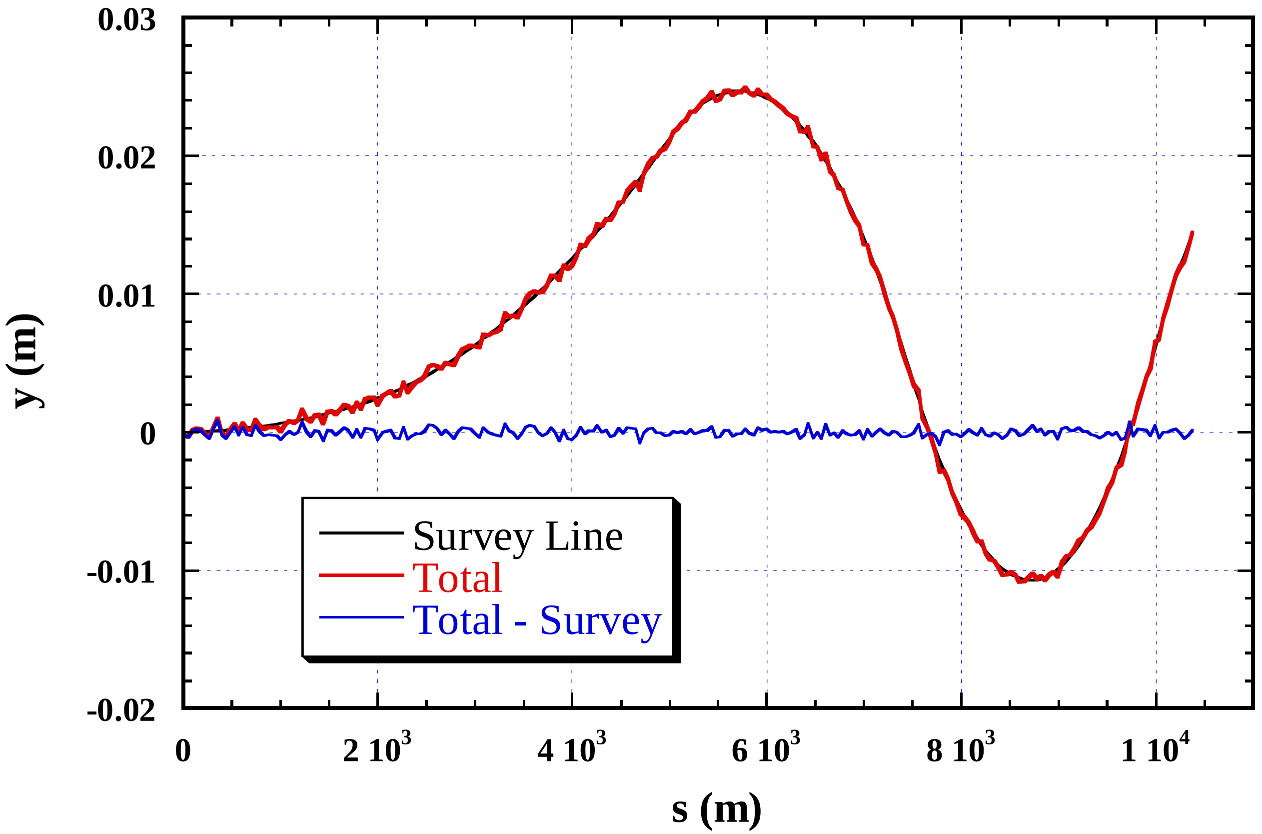
use several points to make a line



Example of misalignment in ML

Step Length: 25 m, Random angle: 60 nrad/step,
Random offset: 5 μm/step, Systematic angle: 250 nrad/step,
Primary reference: 10 mm
+ “Standard” local misalignment

(Suggested by LiCAS Group)



ML simulation with misalignment

Mean of emittance and standard deviation from 40 random seeds.
(initial emittance is 2E-8 m)

	$<\Delta\gamma\varepsilon>$ (m)	STD
Survey	0.053E-8	0.052E-8
Local misalignment	0.670E-8	0.581E-8
Survey + local	0.673E-8	0.591E-8

Assumed survey line error has only little effect.