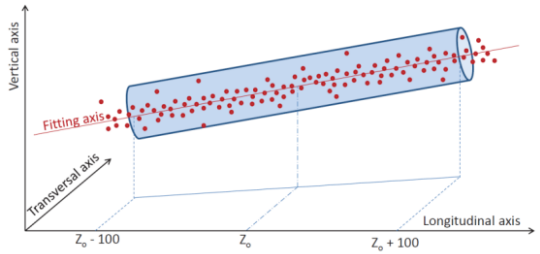
Alignment and Survey results from CLEX and LAB module

M. Sosin
on behalf of CLIC Pre-Alignment Team

CLIC pre-alignment requirements

To achieve ultra-low emittance and nanometer beam size

→ Components have to be pre-aligned



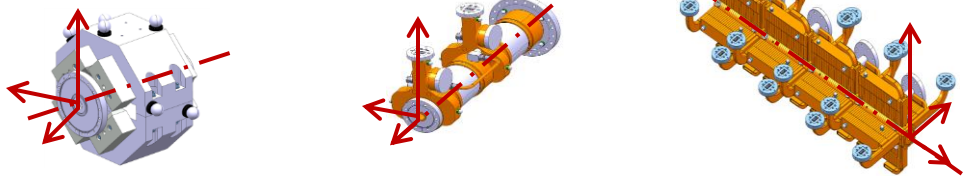
Component	Alignment requirements
Main Linac component	14 - 17 µm
Main Linac reference points	10 µm
Beam Delivery System	10 µm

→ How-to achieve the requirements ?

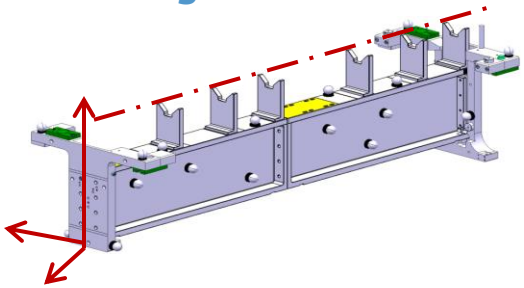
- Microprecision machining of parts that make up the module components
- Components and reference fiducials measurements - **fiducialisation**
- Precise assembly of components on support girders, determination and control of its position in support coordinate system – **initial alignment**
- Active Pre-alignment
  - Determination of the position using sensors
  - Adjustment using actuators

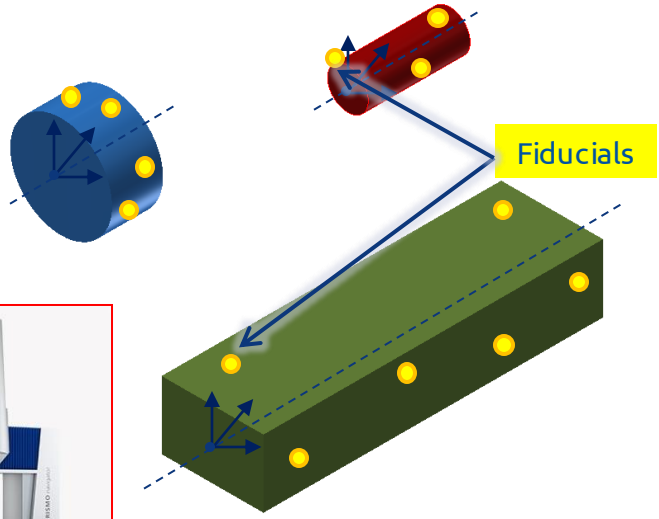
CLIC pre-alignment strategy on short range

1-Fiducialisation of components



2-Fiducialisation of the girder



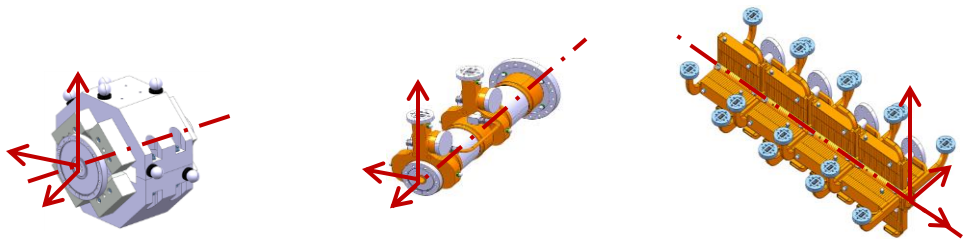


Fiducialisation of components

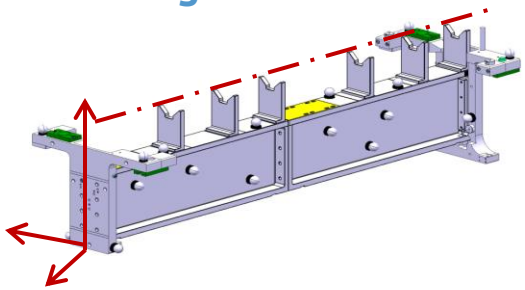
- the position of the alignment targets (fiducials) and reference surfaces is determined at the micron level w.r.t the reference axis of the component

CLIC pre-alignment strategy on short range

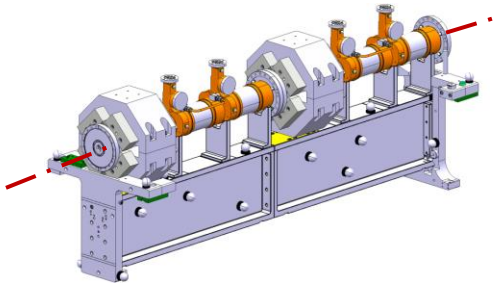
1-Fiducialisation of components



2-Fiducialisation of the girder

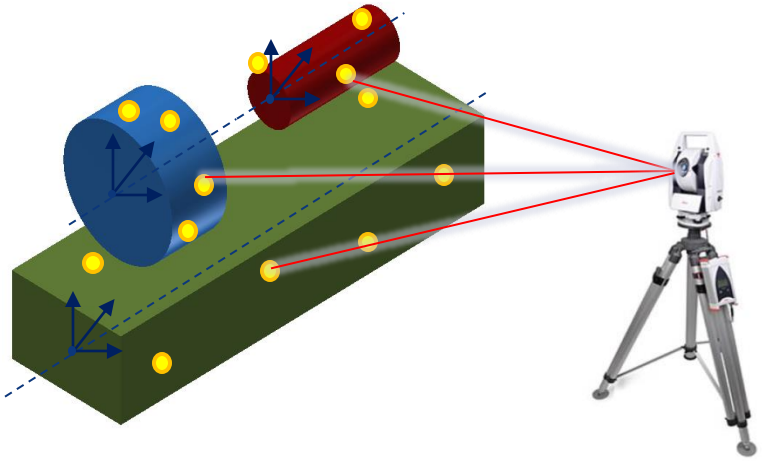


3-Alignment of components on the girder



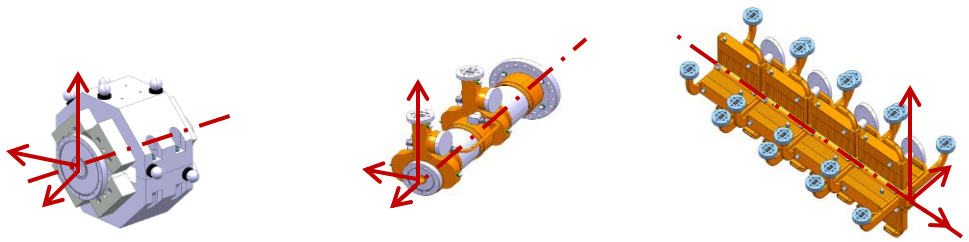
Alignment on the girder

- In case of an assembly of components - each component is pre-aligned on the support
- Thanks to **fiducialisation** – the position of each component is determined within a few microns in the support CS

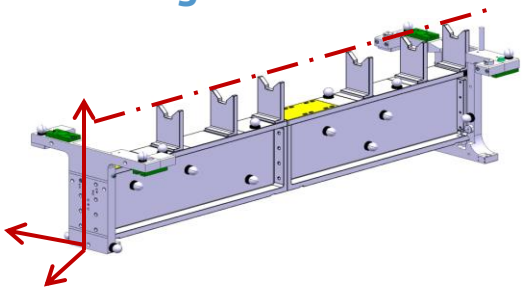


CLIC pre-alignment strategy on short range

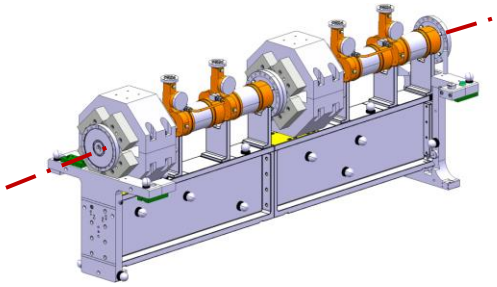
1-Fiducialisation of components



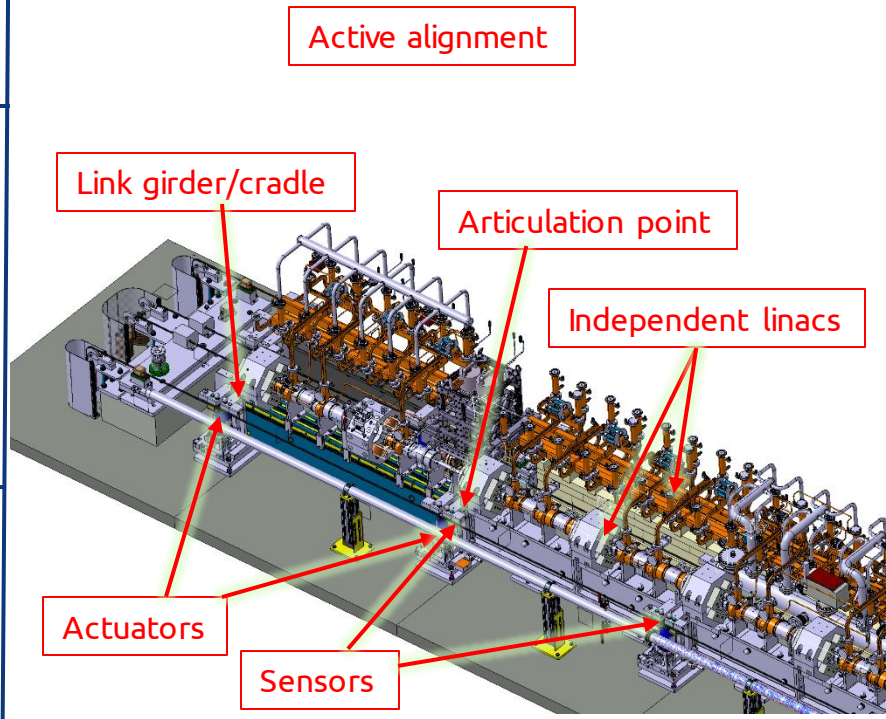
2-Fiducialisation of the girder



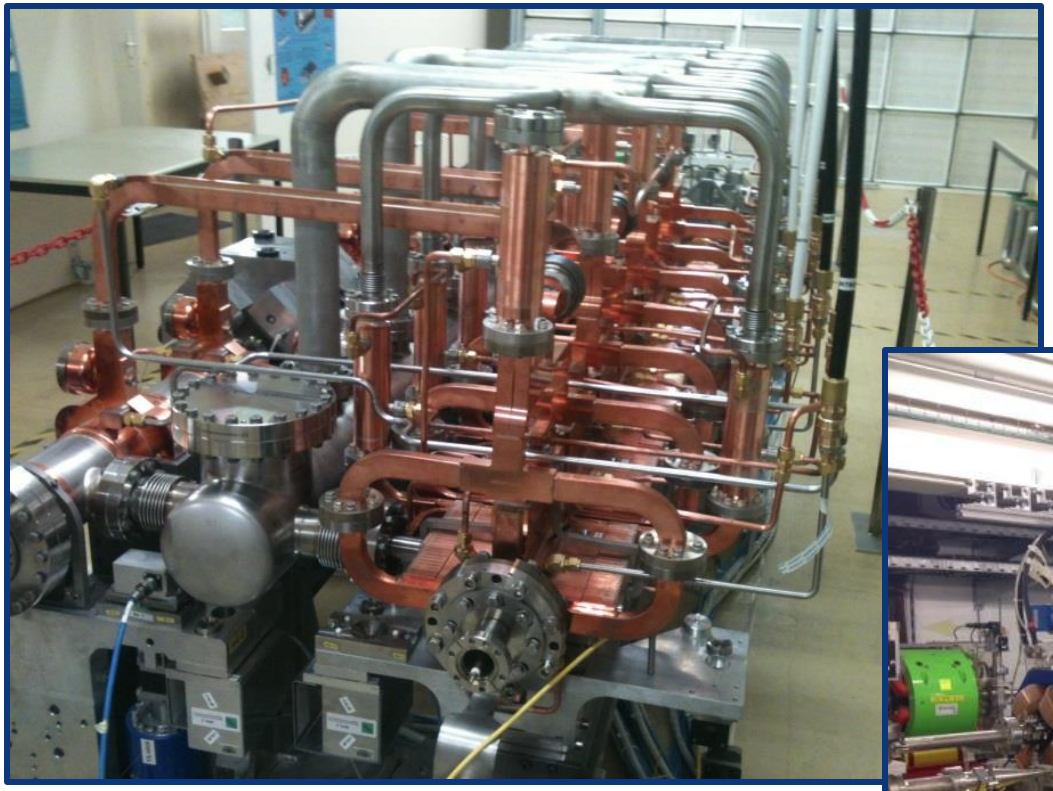
3-Alignment of components on the girder

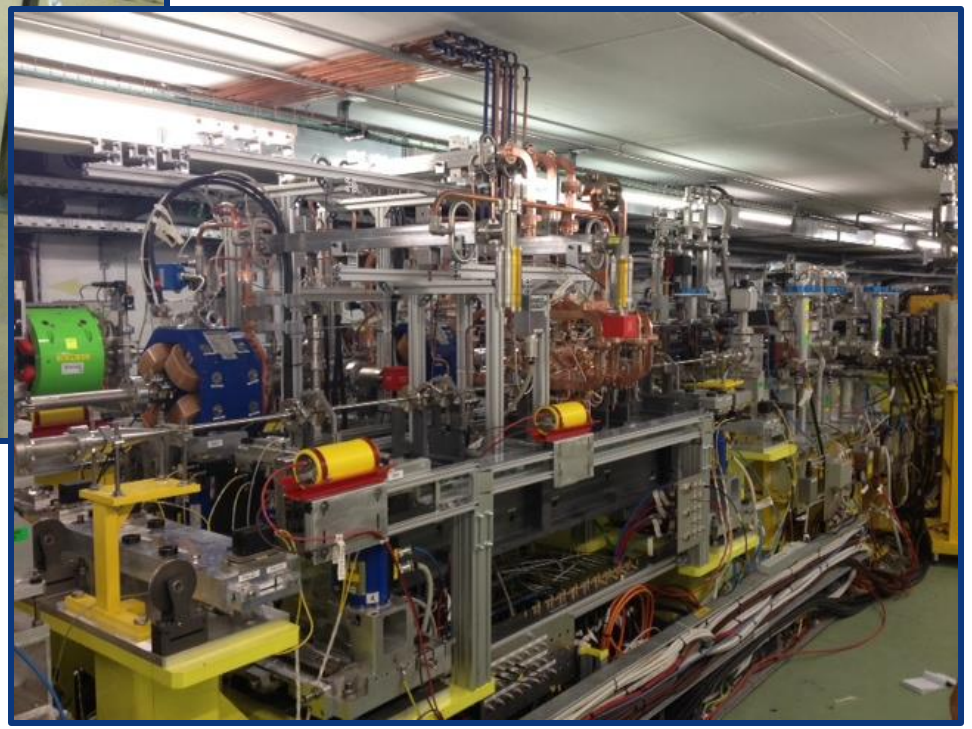


4-Pre-alignment in the tunnel



LAB / CLEX





Fiducialisation of components

DBQ (+/- 20 µm)

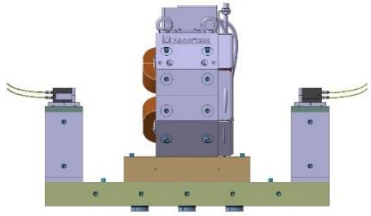
LAB (since 4 years)

Fiducialisation with respect to the mechanical axis

↓

CLEX (installation in October 2014)

Fiducialisation of magnetic axis



Accuracy **below 10 um**

↓

LAB (Future)

Fiducialisation of 2 new DBQ

Accelerating Structure (+/- 14 µm)

LAB (since 4 years)

AS structure of 2 m long,

Straightness **> 1 mm**

↓

CLEX (installation October 2014)

AS structure of 0.5 m long

Straightness **≤ 60 µm**

↓

LAB (Future)

Only 0.5 m AS structure Mock-Up

(copper cylinder)

RF team is looking for new approach of AS manufacturing
(problem with brazing impact on final dimensions)

PETS (+/- 100 µm)

LAB (since 4 years)

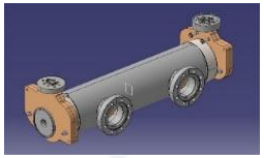
Coaxiality between PETS flanges and PETS internal geometry **< 100µm**

↓

CLEX (installation October 2014)

New PETS design

Always within tolerance



↓

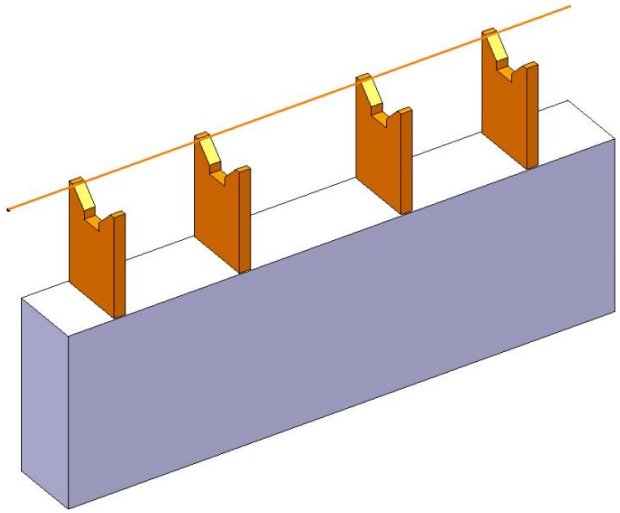
LAB (Future)

OK

Fiducialisation of the girders

Required straightness of „V shape supports" common axis:

10 µm (girder loaded)



LAB (since 4 years)

Boostec Girders < 15 µm ,

Micro-contrôle Girders < 15 µm,

↓

CLEX (installation October 2014)

BOOSTEC girders → 9.3 µm / 14 µm

↓

LAB (Future)

BOOSTEC (new batch) girders under validation
EPUCRET Girders: adjustable „V-shape supports"

Micro-Contrôle – upgraded, to be verified by CMM

Alignement of components on the girder

DBQ (+/- 20 µm)

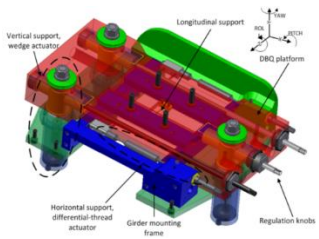
LAB (since 4 years)

Alignment of the plates with shims & hammer

Long-term stability w.r.t. V-mean axis: **> 150 µm**

CLEX (installation October 2014)

Solution for 5DOF adjustment platform for DBQ on the girder



Regulation resolution at um level; adjustment in 20',

Misalignment w.r.t. V-mean axis: **< 20 µm**

LAB (Future)

Remote and active adjustment of DBQ supporting platform

Accelerating Structure (+/- 14 µm)

LAB (since 4 years)

AS structure of 2 m long

Misalignment w.r.t. V-mean axis: **>1mm**

↓

CLEX (installation October 2014)

AS structure of 0.5 m long,

Misalignment w.r.t. V-mean axis: **≤161 µm**

↓

Misalignment of the girder to minimize the differences

Misalignment w.r.t. theoretical beam axis: **≤65 µm**

↓

LAB (Future)

Only 0.5 m AS structure Mock-Up

Depends on final AS structure geometry

Study on longitudinal position of AS

PETS (+/- 100 µm)

LAB (since 4 years)

Misalignment w.r.t. V : 120 µm,

↓

CLEX (installation October 2014)

New PETS design,

Misalignment w.r.t. V-mean axis: **80 µm**

↓

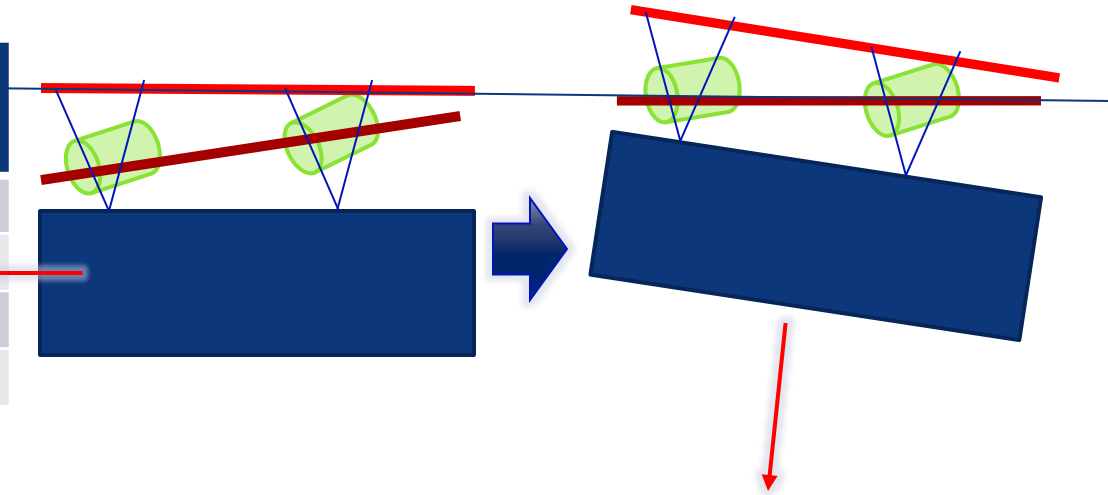
LAB (Future)

OK

Alignement of components on the girder

MEASUREMENT DATA

Component Main Beam		Radial (µm)	Vertical (µm)	Error budget (µm)
AS1	Enter	-51	-59	14
	Exit	-161	-16	14
AS2	Enter	-68	-85	14
	Exit	-139	-103	14



Component Drive Beam		Radial (µm)	Vertical (µm)	Error budget (µm)
PETS1	Enter	65	37	100
	Exit	-27	15	100
DBQ1	Enter	-9	-4	20
	Exit	-2	19	20
PETS2	Enter	28	78	100
	Exit	-51	58	100
DBQ2	Enter	8	11	20
	Exit	-3	-14	20

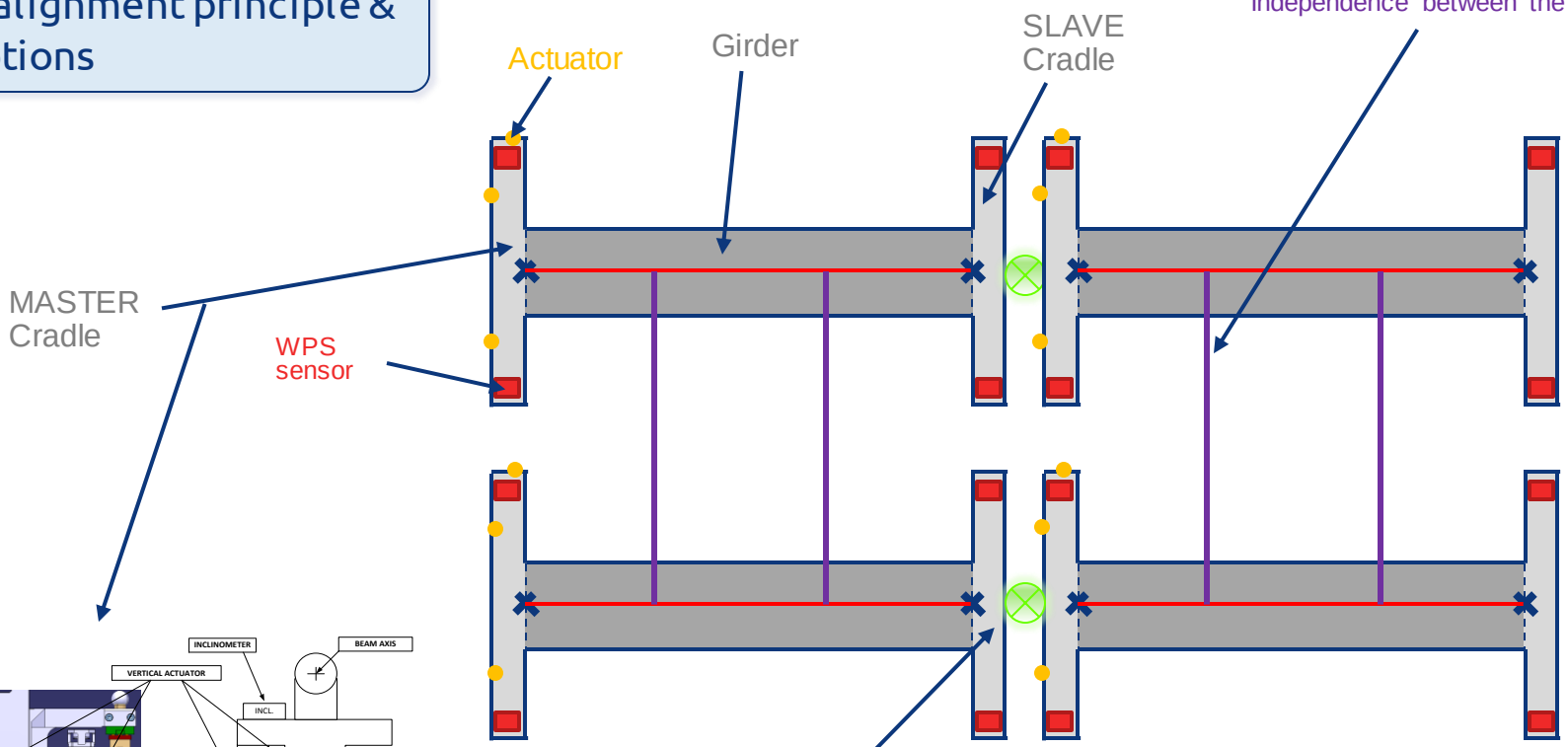
Component Main Beam		Radial (µm)	Vertical (µm)	Error budget (µm)
AS1	Enter	29	-24	14
	Exit	-65	39	14
AS2	Enter	46	-8	14
	Exit	-10	-7	14

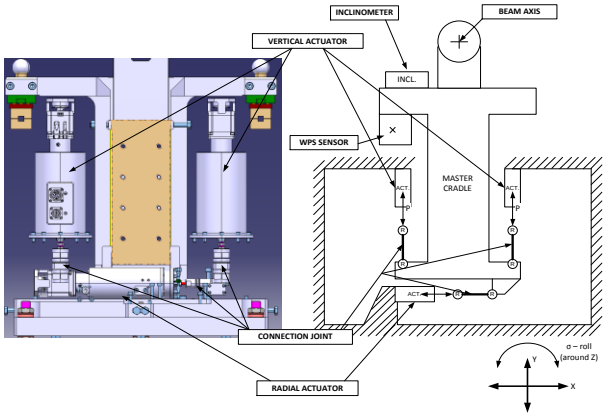
Pre-alignment in the tunnel

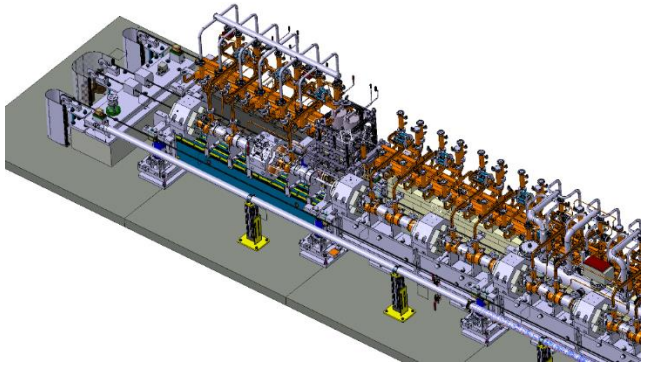
Active alignment principle & assumptions

ASSUMPTION:

Independence between the 2 linacs





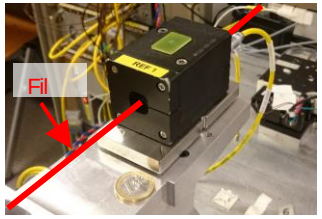


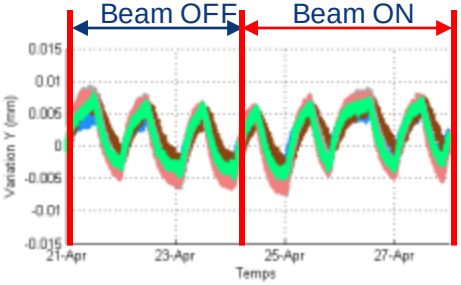
Pre-alignment in the tunnel

Sensors
- Study of different configurations
- Inter-comparison between sensors
- Study of the supporting solutions

cWPS (capacitve Wire Positioning System)

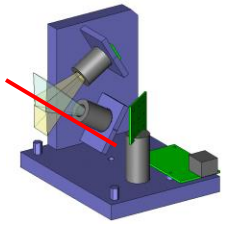
- Range : +/- 5 mm
- Repeatability: +/- 1 µm
- Linearity : ~ 2 µm/mm
- Accuracy : 5 µm
- Resolution : < 1 µm
- RAD-HARD

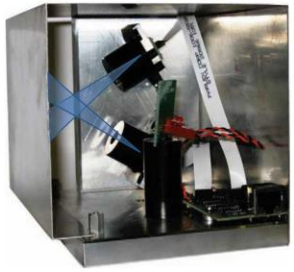




oWPS (optical Wire Positioning System)

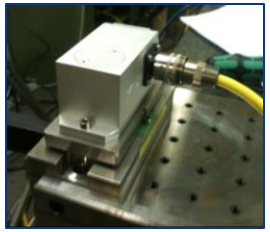
- Range : +/- 15 mm
- Repeatability: +/- 1 µm
- Linearity : ~ 3 µm/mm
- Accuracy : ~ 10 µm
- Resolution : < 1 µm



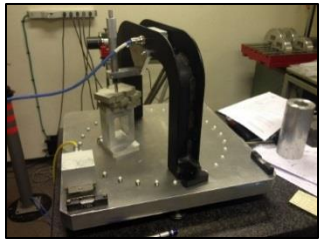


Tilt-meter

- Range : +/- 15 mrad
- Repeatability system: +/- 5 µrad
- Linearity : ~ 2 µrad / mrad
- Resolution : < 1 µrad

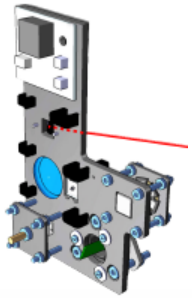


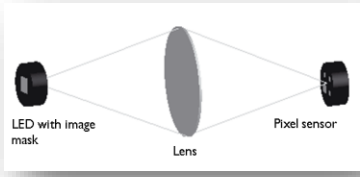
Absolute Tilt-meter



RasChain

- System 3 points
- Range : +/- 10 mm
- Repeatability: under tests
- Resolution : under tests

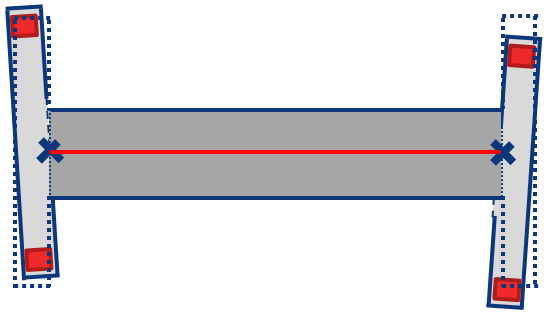


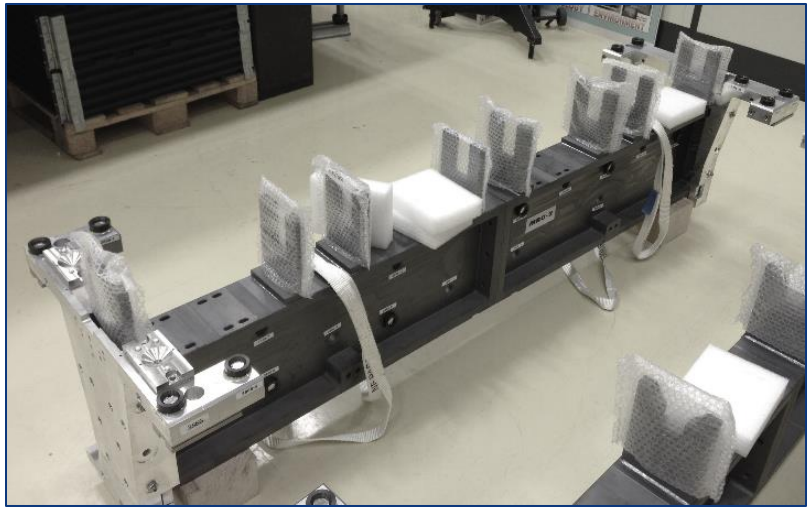


- *LAB (2011 – 2013) : 2 cWPS + 2oWPS + 1 Relative Tilt meter (without beam)*
- *LAB (2013 – 2014) : 2 cWPS + 2 Nik hef sensors + 1 Relative Tilt meter (without beam)*
- *CLEX (2014-2015) : 4 cWPS (With Beam)*
- *LAB (2015) : 2 cWPS + 2oWPS + 1 Absolute Tiltmeter (without beam) FUTURE*

Pre-alignment in the tunnel

Girder-Cradle connection

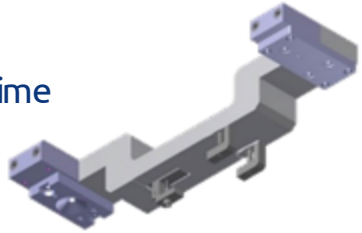


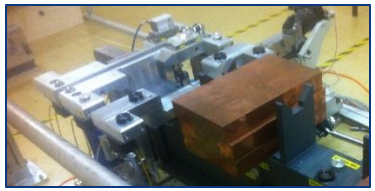


- LAB or CLEX : girder-cradle link performance does not meet the CLIC requirements
  → We loose the fiducialisation of the cradle

- Temporary solution : fiducialisation IN-SITU
  → Difficult to achieve 10 µm accuracy
  → Link girder-cradle is not stable in the time (we need to fiducialise several times per year)

- First solution : New interface – position stable in the time

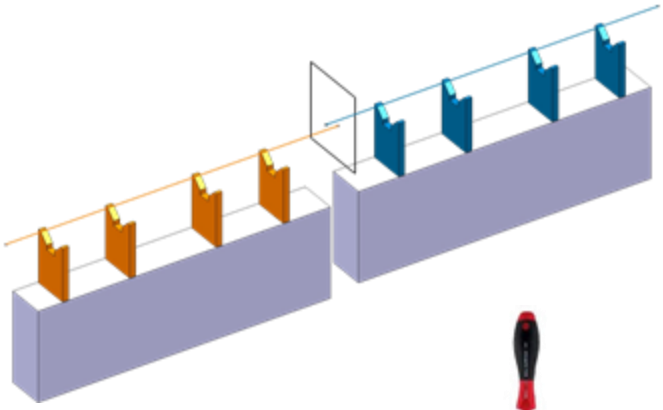




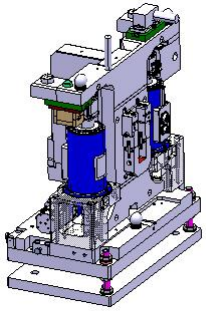
- Second solution : New design of cradle (Future)

Pre-alignment in the tunnel

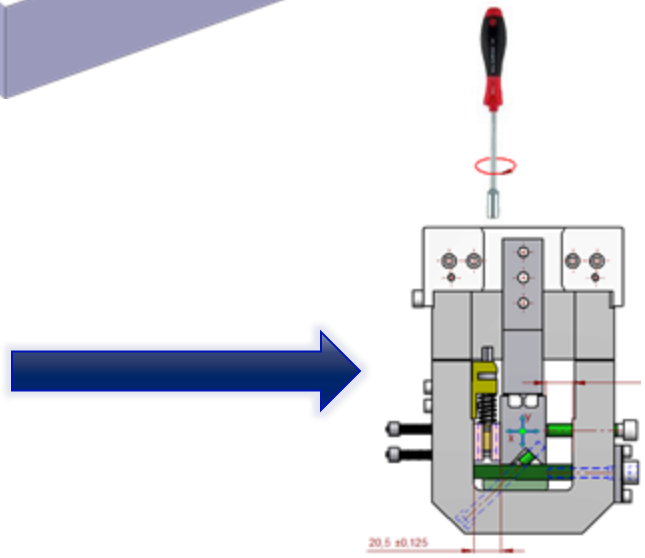
Articulation point
Link between MASTER & SLAVE cradle



- LAB : the Articulation point is fixed and linked to the cradle



- CLEX : the Articulation point is adjustable and linked to the cradle



- Future : The Articulation point have to be adjustable and stable in time.
  Validation of articulation point, what was not possible before due to cradle-girder geometry change

Pre-alignment in the tunnel

Independence between
MB and DB linacs

CDR

MB & DB should be independent

↓

LAB (since 4 years)

Requested roll: **571 µrad (DB)**

Measured roll: **465 urad (DB) + 16 µrad (MB)!**

Hypothesis: due to the vacuum tank

↓

CLEX (installation October 2014)

Installation of small vacuum pumps

Requested roll: **571 µrad (DB)**

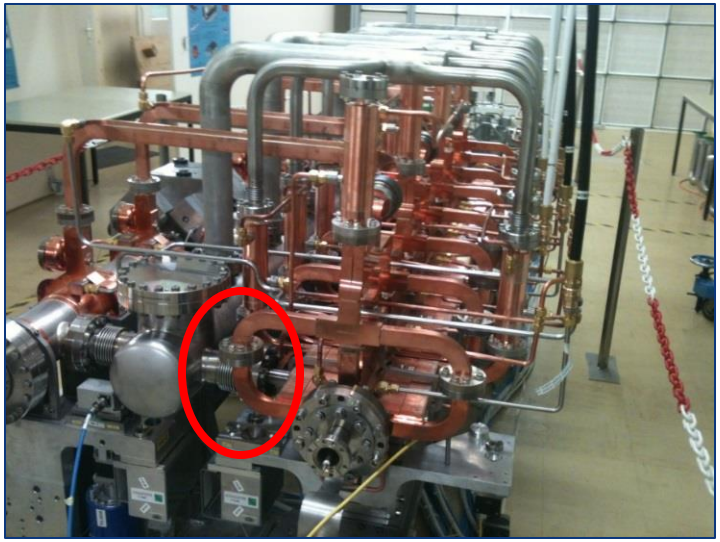
Measured roll: **449 urad (DB) + Roll 56 urad (MB)!**

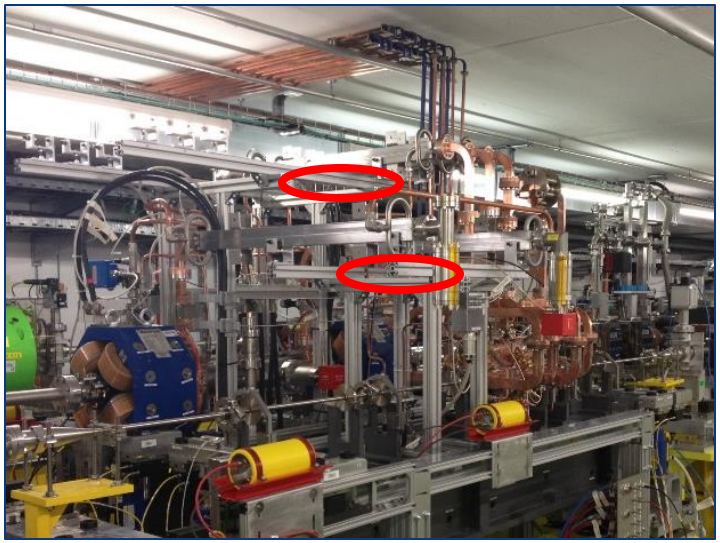
Hypothesis : Waveguide connections,
waveguide support fixed to the girders

↓

LAB (Future)

Upgrade fixation of the waveguides and their supports





Perspectives

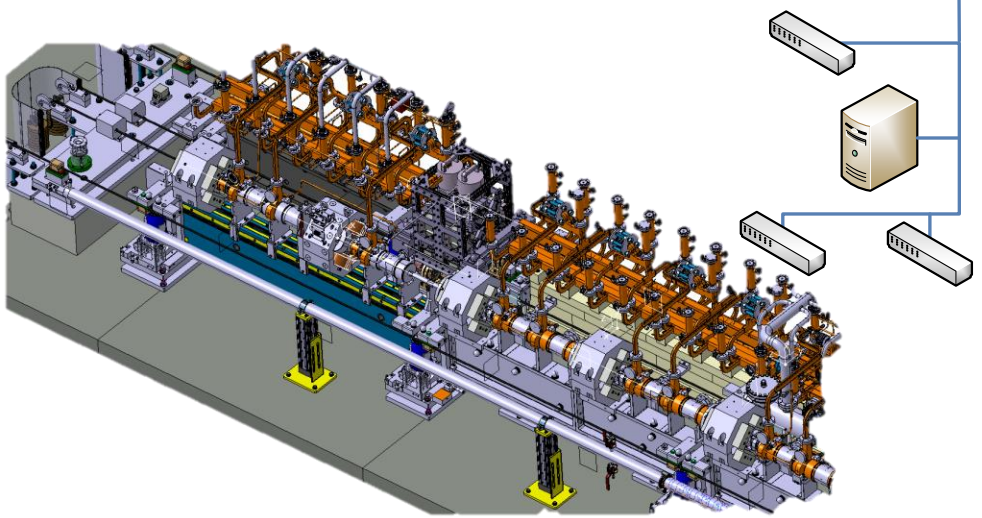
1. Study on thermal duty cycles of supporting structures to create model allowing prevision of thermal geometry changes for girders position compensation

2. Active alignment

If all problems solved

Active alignment system:

- Real time misalignment/alignment demonstration
- Alignment visible „on screen" – control system including all necessary functionalities



THANK YOU