Reflections on Moving and Aligning Large Masses at CLIC

(for example an experiment)

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Together with ILC and CLIC MDI Groups

CLIC Workshop 16 February 2011

Content of the talk

- Push-pull system and more generally movement in and out of Interaction Point,
- Platform considerations,
- Rollers vs. Airpads,
- Problems associated with movements of the area.
- Conclusions

Push-Pull Considerations

Push-pull consideration

• The fact that it is too expensive at a Linear Collider to provide two Interaction Regions, imposes either:

•To have only only one experiment with the necessary spares for a fast repair,

or:

•To use the push-pull system to operate alternatively two experiments.

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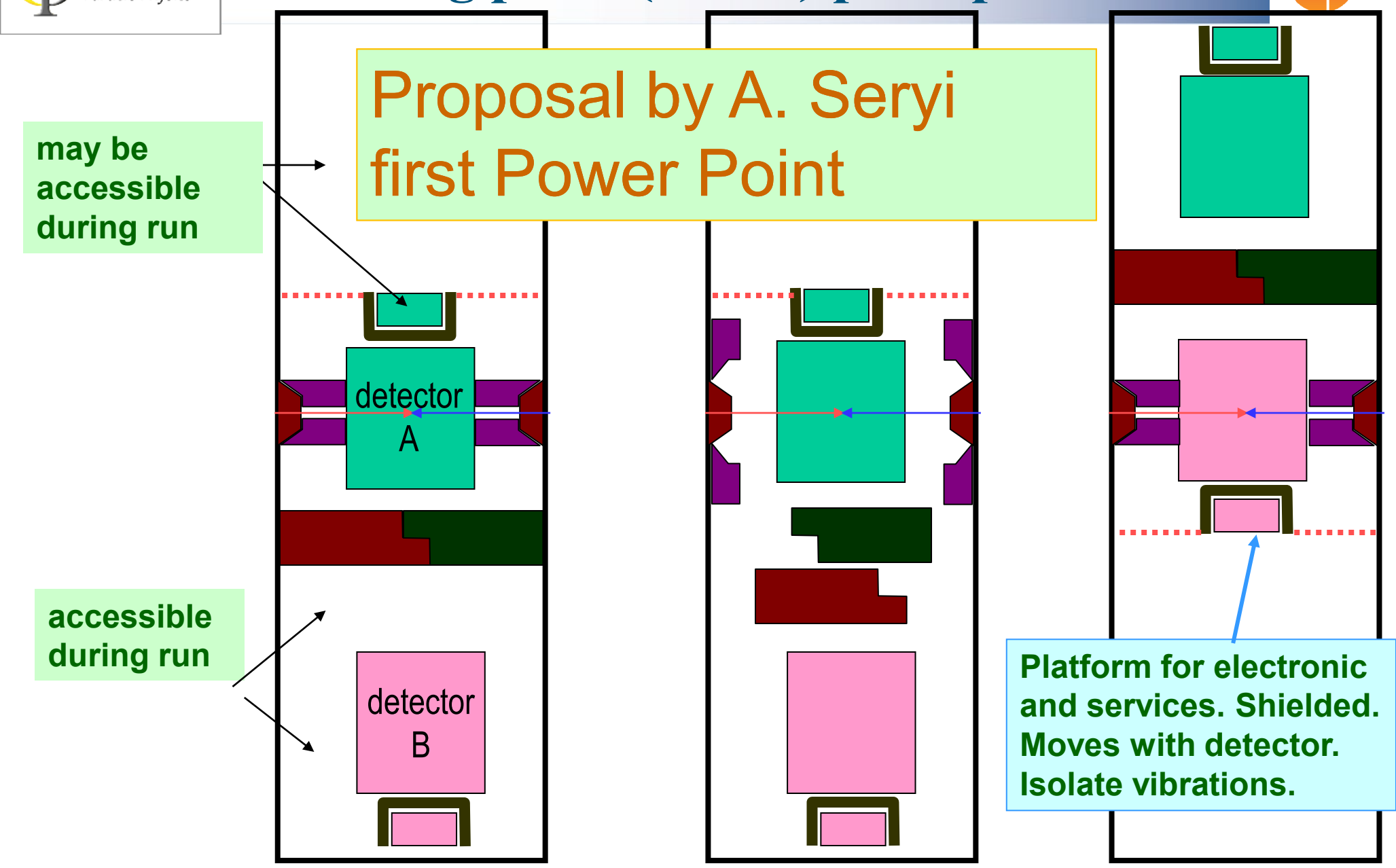
Starting point (~2006) push-pull for ILC



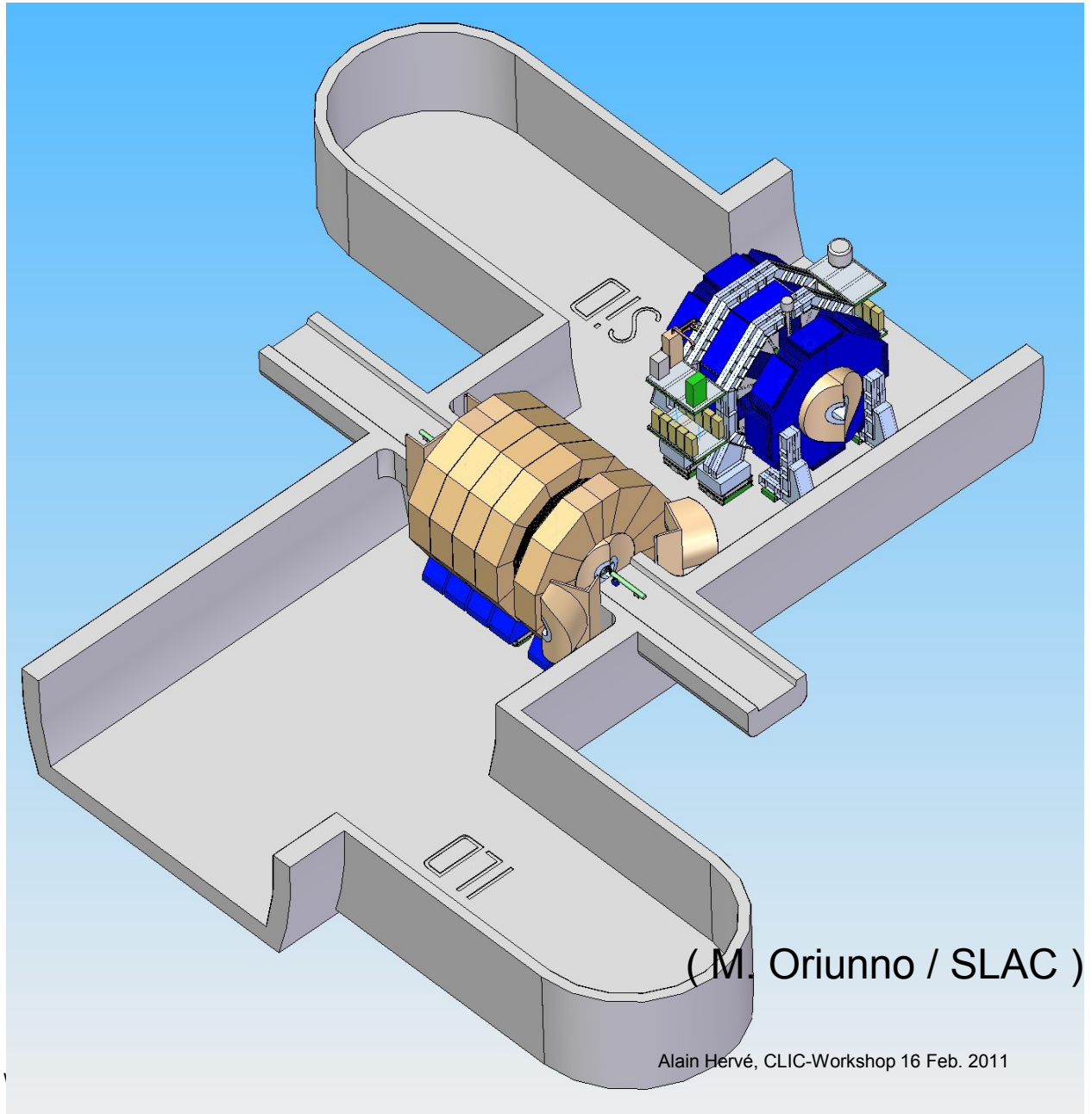
Push-pull Project

- The push-pull project, to exchange quickly two experiments on IP, is a very ambitious one.
- In size of loads to be moved > 12'000 tons, number of movements, 6 per year ➽ 180 over 15 years.
- It is demanding considering: environment, final precision, and time constraints, (full exchange in less than three or four days) including precise realignment in the mm range.

If there is only one experiment ?

- In any case, one must always be able to extract sideway an experiment for maintenance at least every year.
- Thus the Push-Pull project is just a more demanding normal maintenance displacement scenario!
- Having possibly only one experiment does not change much what has to be prepared and studied at this stage.

Original Push-pull system at ILC



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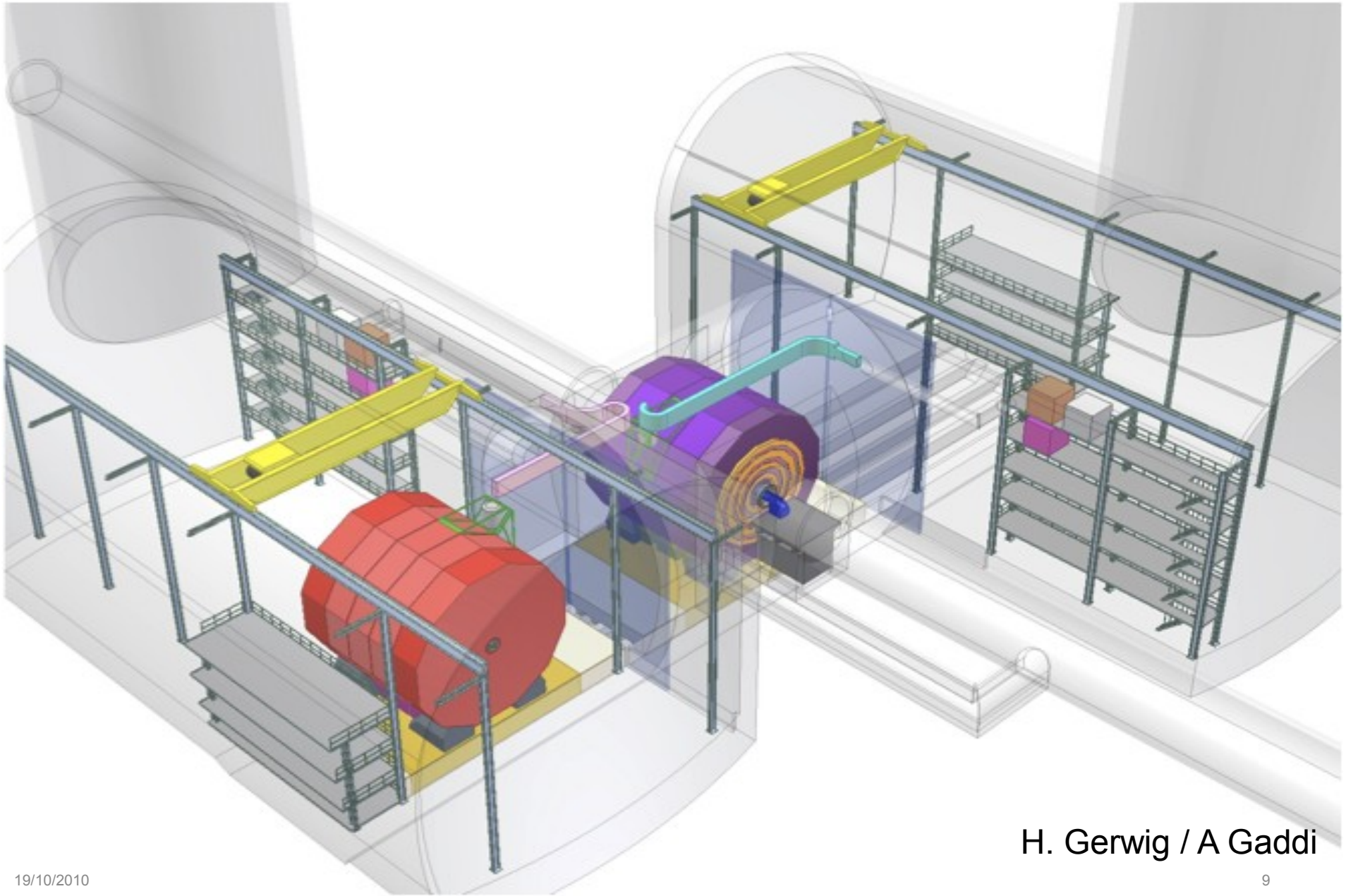
Push-Pull for CLIC detectors



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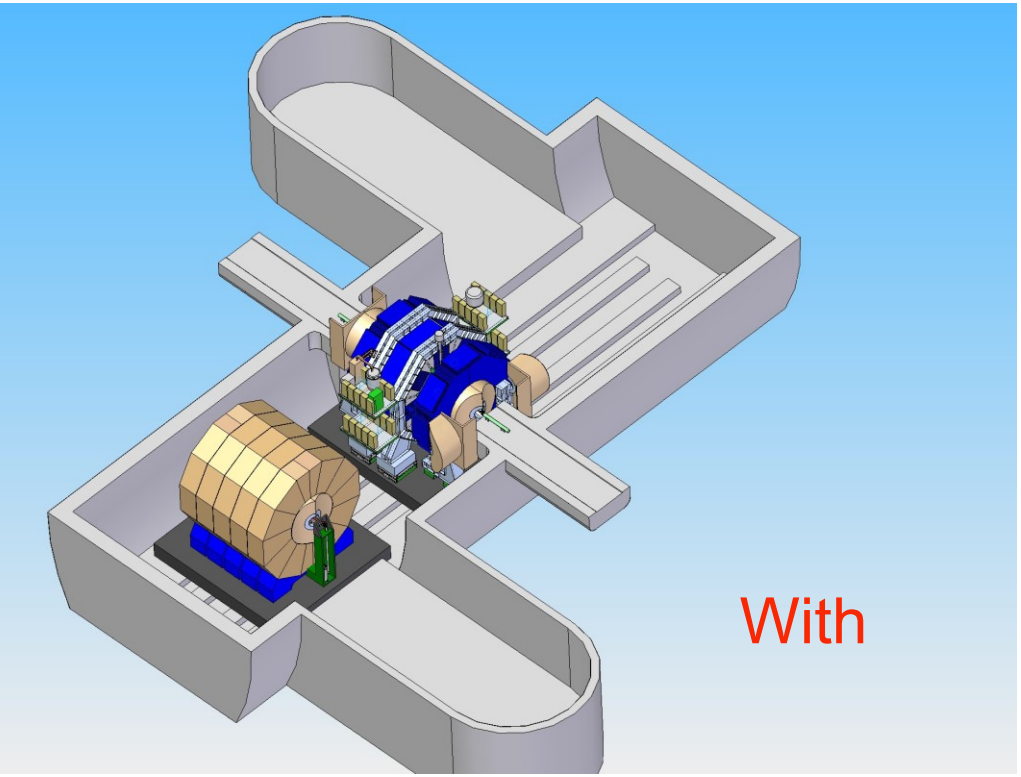
PLATFORM CONSIDERATIONS

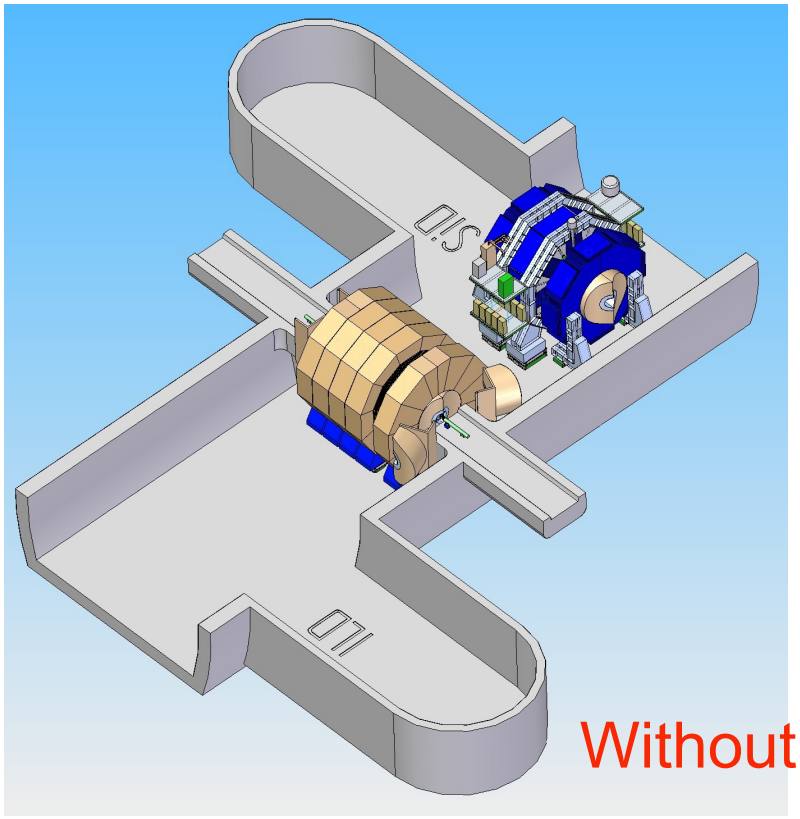
Platform considerations

- A large detector is a complex, precise and expensive object.
- Although it is massive its overall rigidity is (very) small and any internal deformation can be dangerous.
- It must be moved and realigned quickly & precisely.
- From integration and operation point of view it is much more simpler to decouple the transport system from the experiment proper.
- A good solution satisfying these requests it to use a platform.

SiD and ILD with or without a platform ?

Presently the two solutions for SiD and ILD are not compatible, and discussion are going on and a work plan has been adopted to converge fairly quickly.





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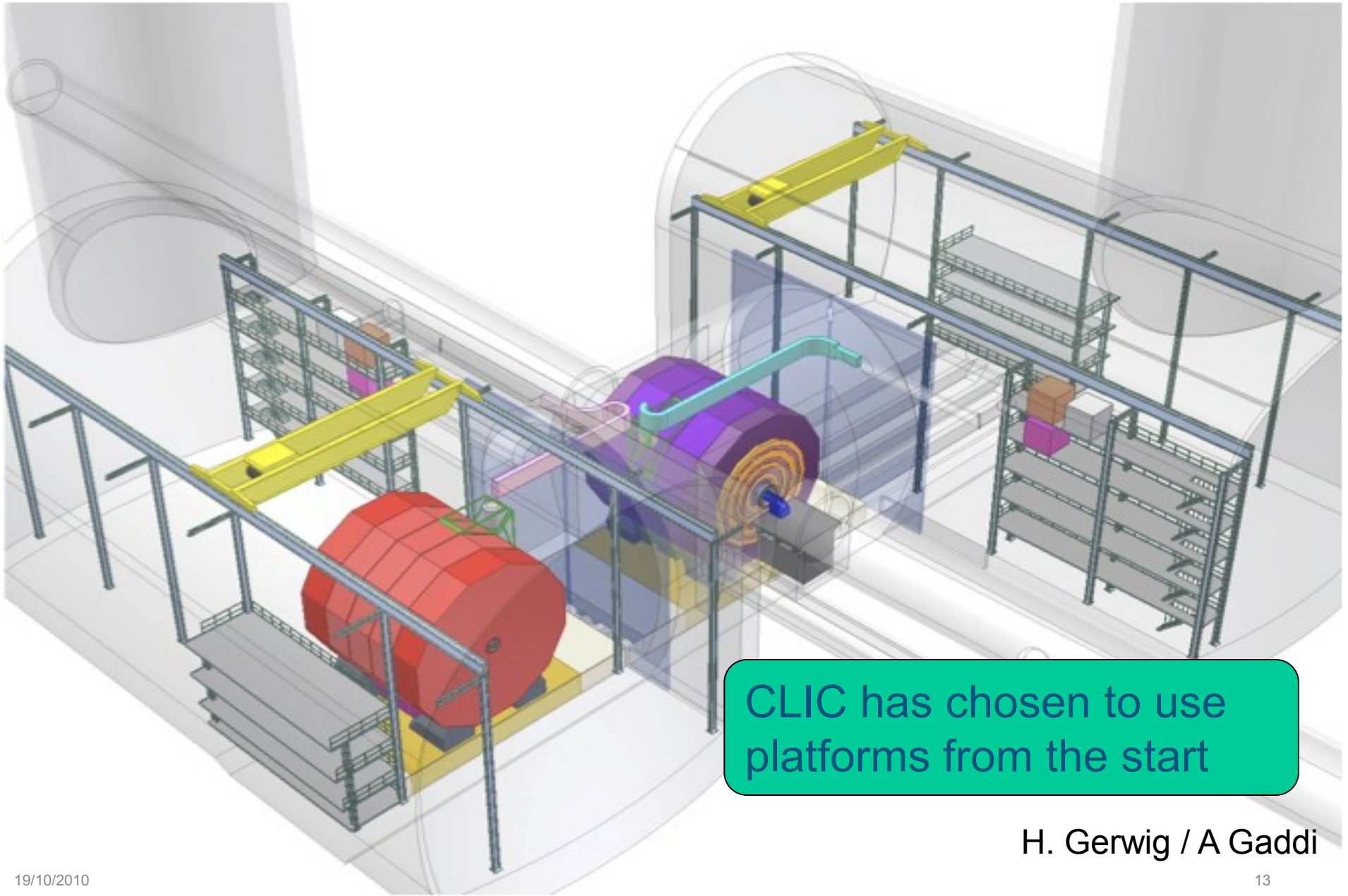
Push-Pull for CLIC detectors



CLIC has chosen to use platforms from the start

H. Gerwig / A Gaddi

Platform considerations

- The CMS plug is a good example of what can be a platform for both ILC and CLIC.
- It has the necessary size and rigidity (maybe the thickness can be reduced).
- However it must be constructed underground and this should be studied.
- Also a platform must not be detrimental to the experiment from the vibration point of view (especially for SiD and M. Oriunno is looking at this point!)

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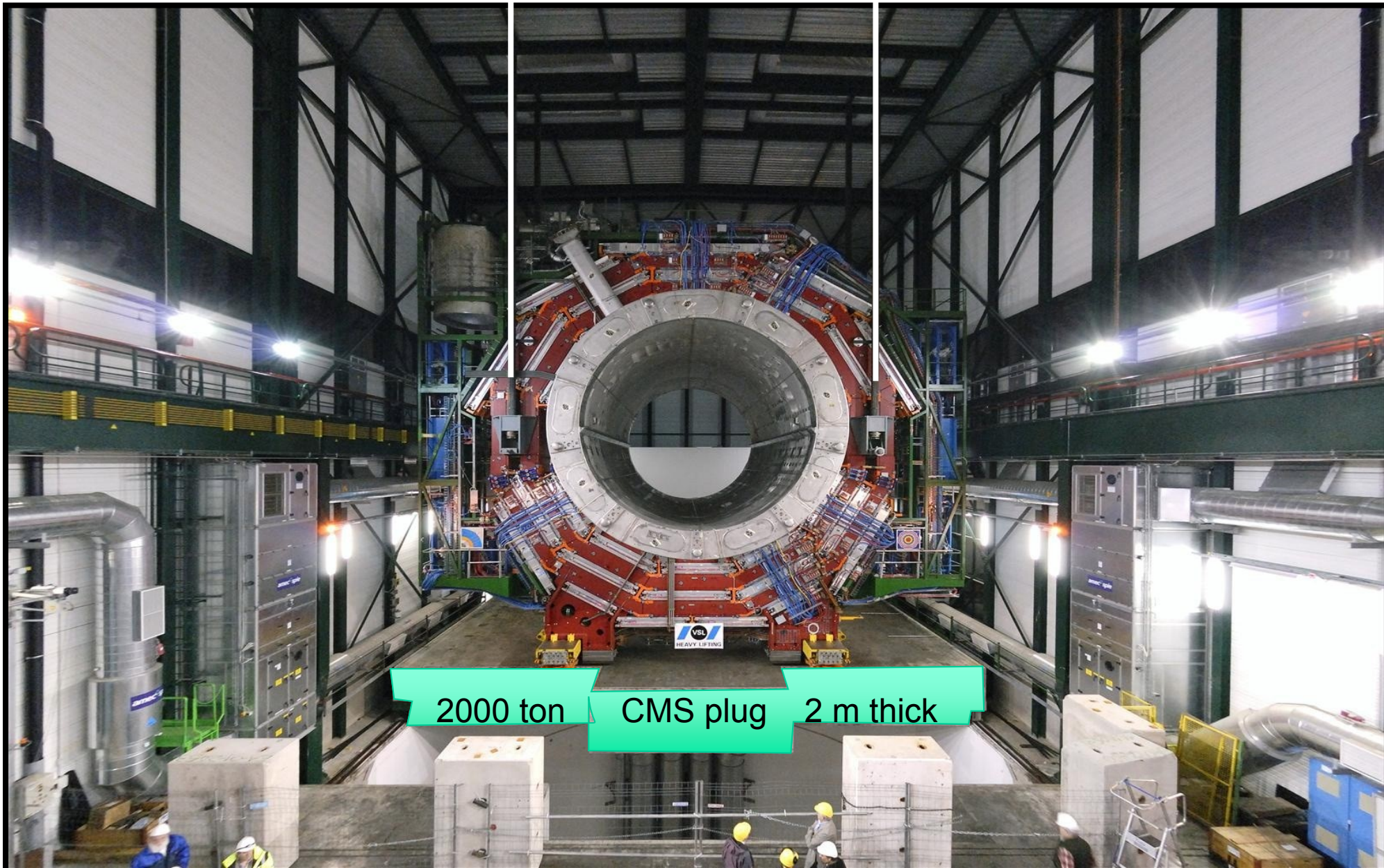
The 2000-ton CMS Plug has been used for the Heavy Lifting operation



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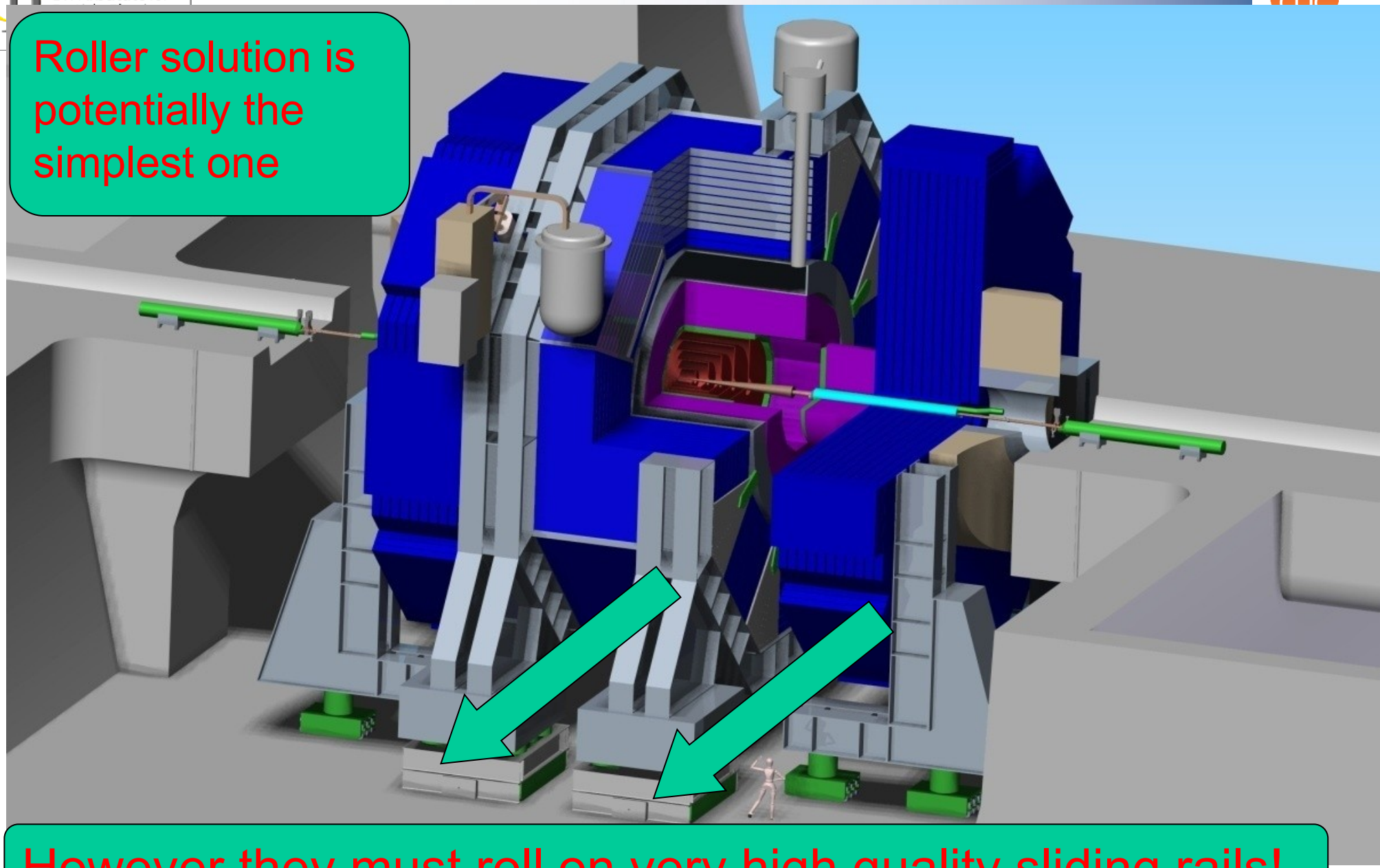
The CMS Plug finished looks neat!

Steel reinforcement of CMS Plug

- Clearly models need benchmarking to evaluate damping coefficient and Young's modulus

ROLLER VS. AIRPADS

SiD equipped with Rollers



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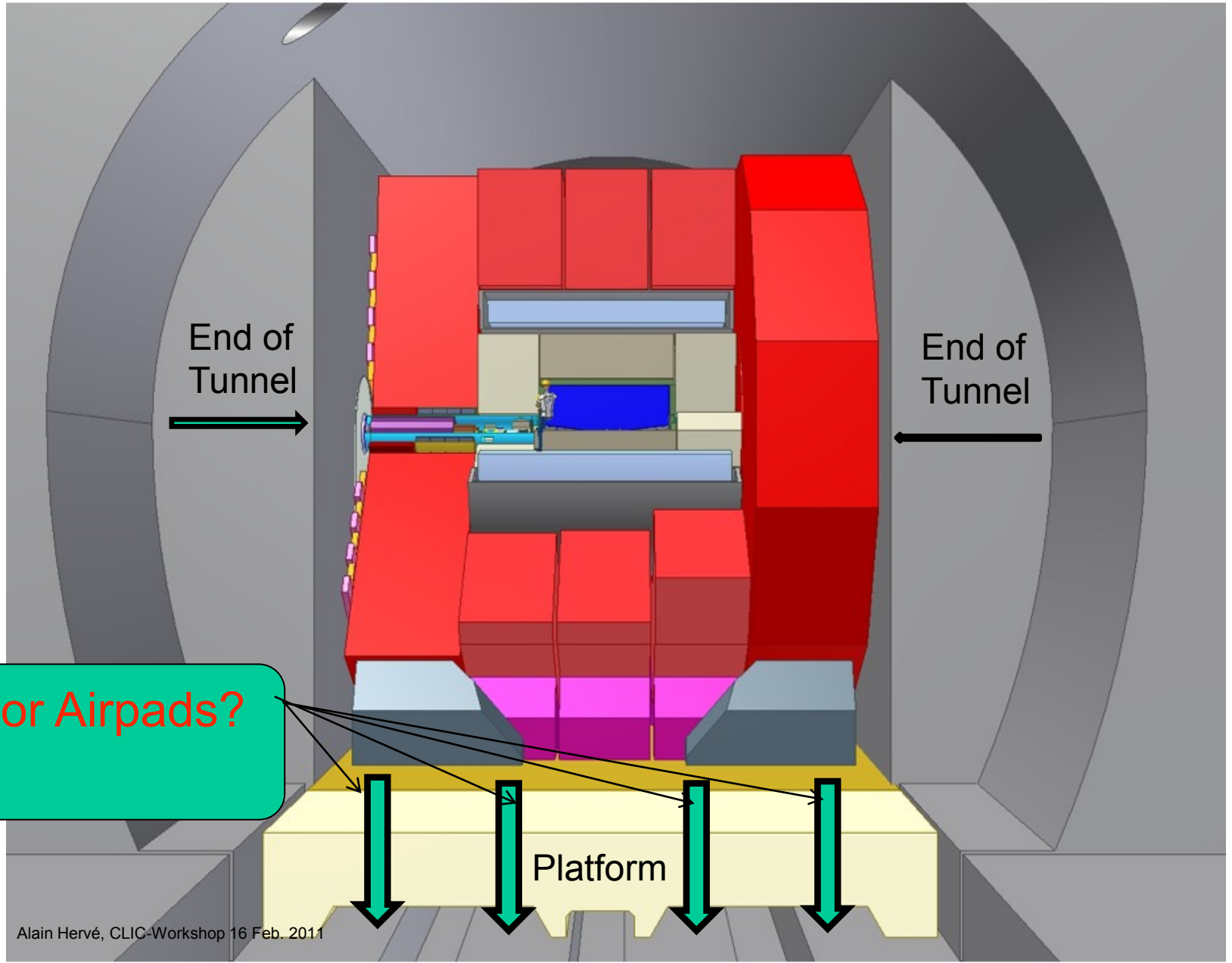
Supporting platform - Rollers or Airpads?



Requirements for Rollers

- They require high-grade steel rail 700 MPa yield, hardened in surface HBC 55 to 58.
- This kind of rails cannot be welded or grinded.
- The flatness under load must be around 0.2 mm on the full surface of the roller.
- Thus the sliding rails foundations must thus be arranged on top of pillars going to the molasse to get a sufficient stiffness.

This quality must be guaranteed for the full life time although such an arrangement is very difficult to be repaired in situ !

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Requirements for Airpads

- Sliding surface in normal steel are sufficient.
- This kind of rails can easily be welded or grinded.
- The flatness under load can be in the order of 5 mm.
- Thus the sliding rails foundations supported by the civil engineering invert is sufficient as demonstrated in CMS.

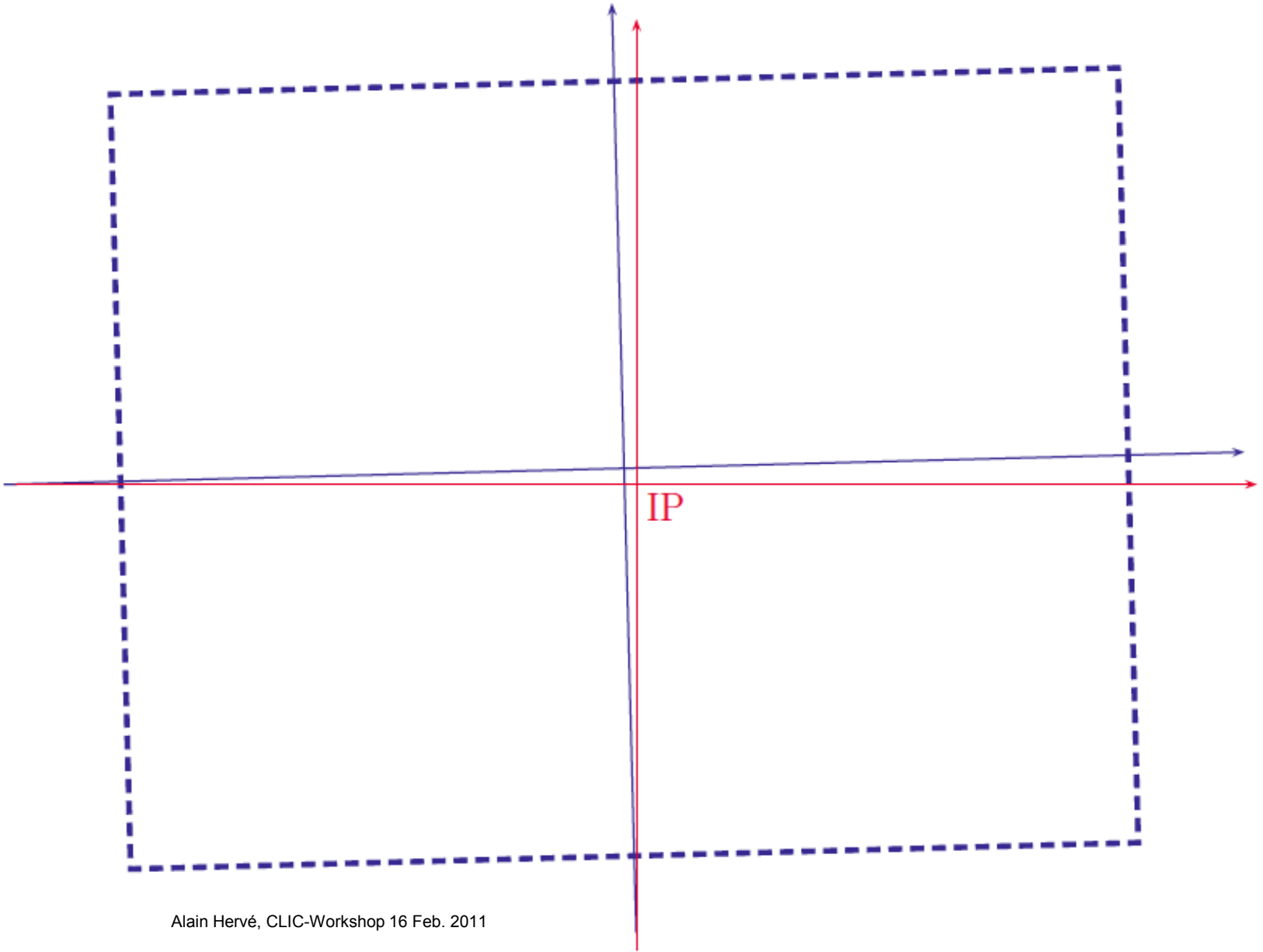
This arrangement is easy to be repaired in situ by grouting, welding and grinding!

Comparison Roller / Airpads

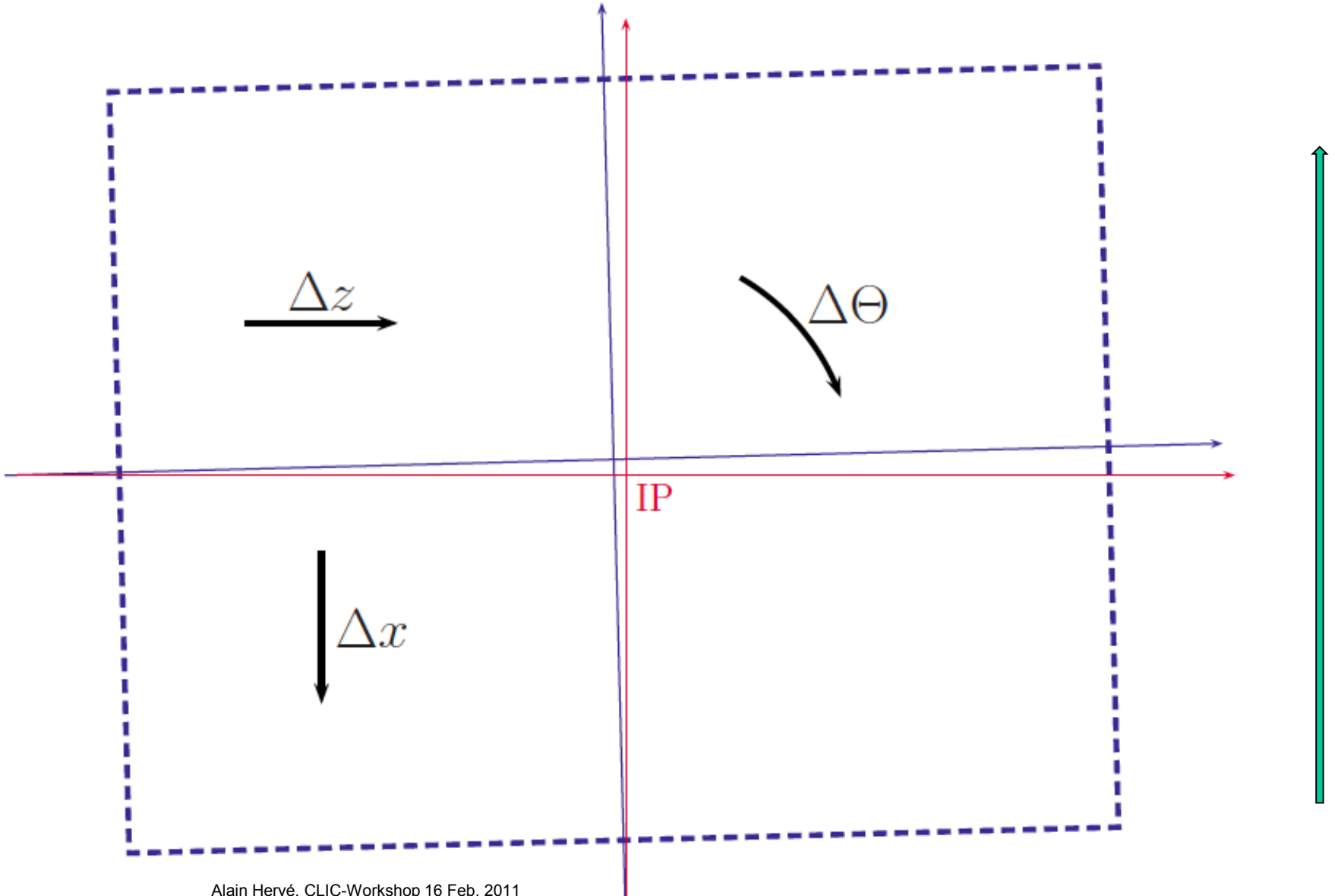
Rollers have a well define direction of movement, in opposition to Airpads that can go in any direction.

This makes a great difference for a fast and precise realignment on IP!

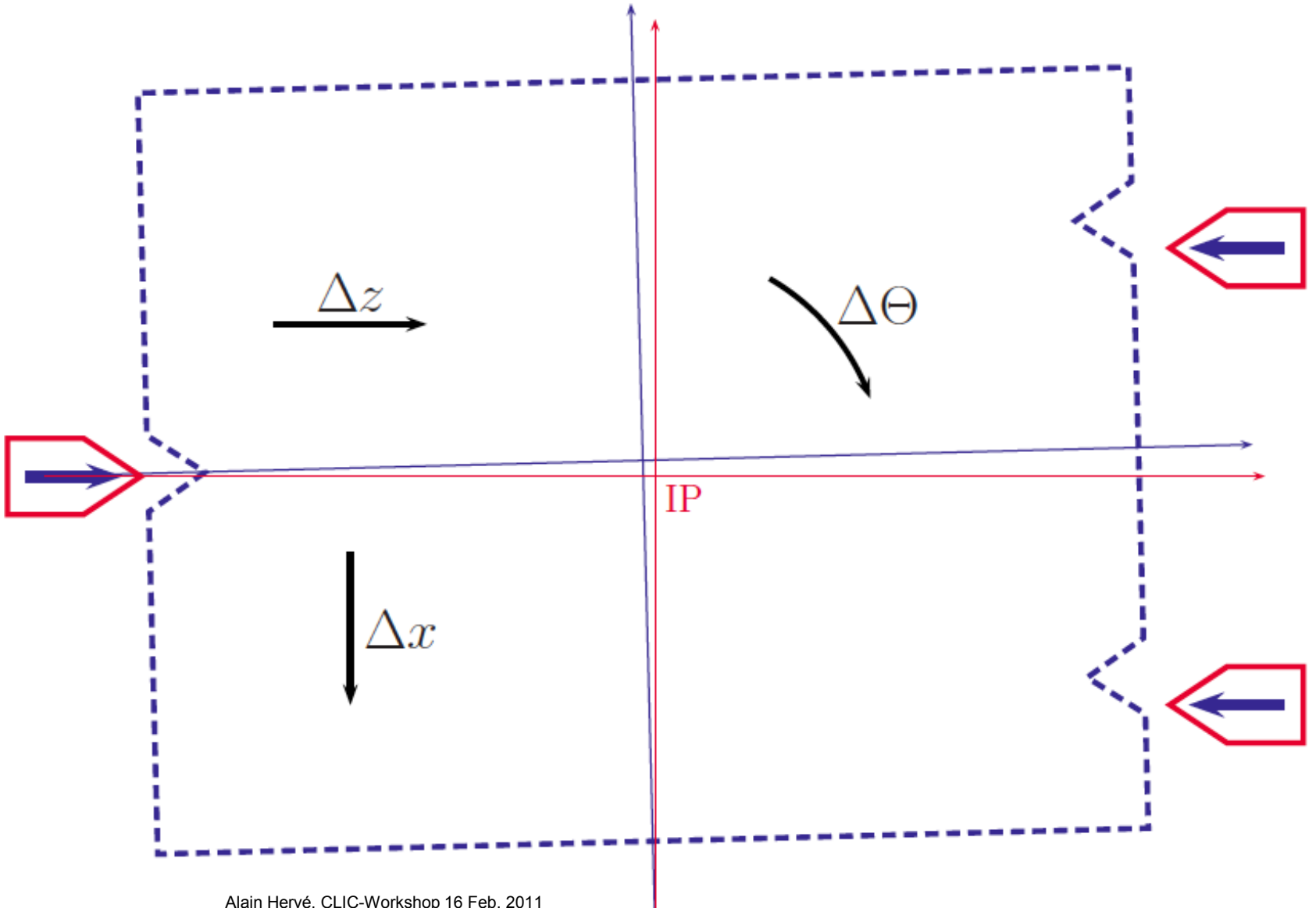
Platform with Load will arrive off-center and off-axis



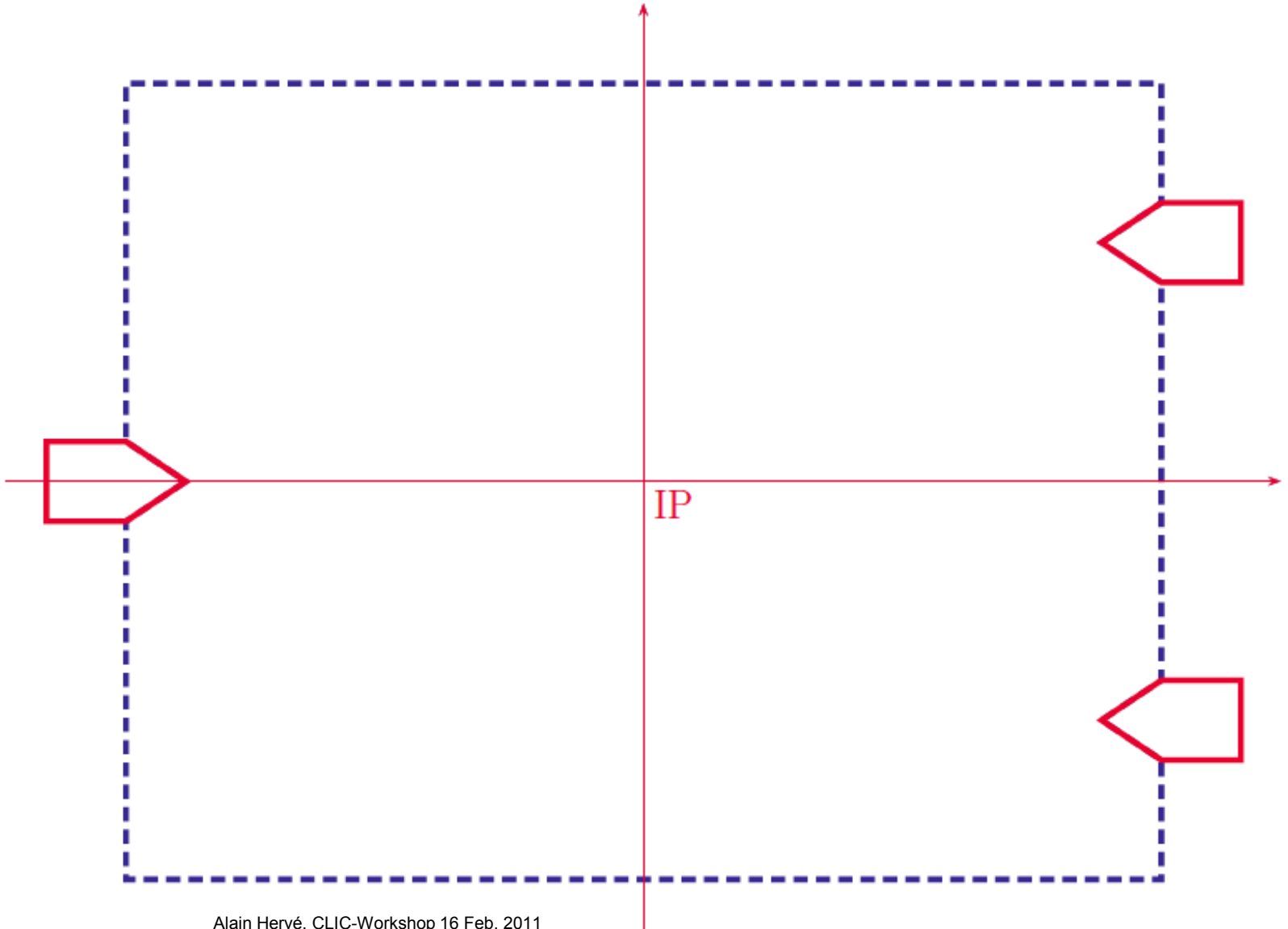
2D movement and a rotation are needed this is very difficult with rollers



With Airpads a simple positive indexing mechanism is possible giving ≈mm precision



The final precision could be +-1 mm and +-0.1 mrad.



Platform / Airpads consideration

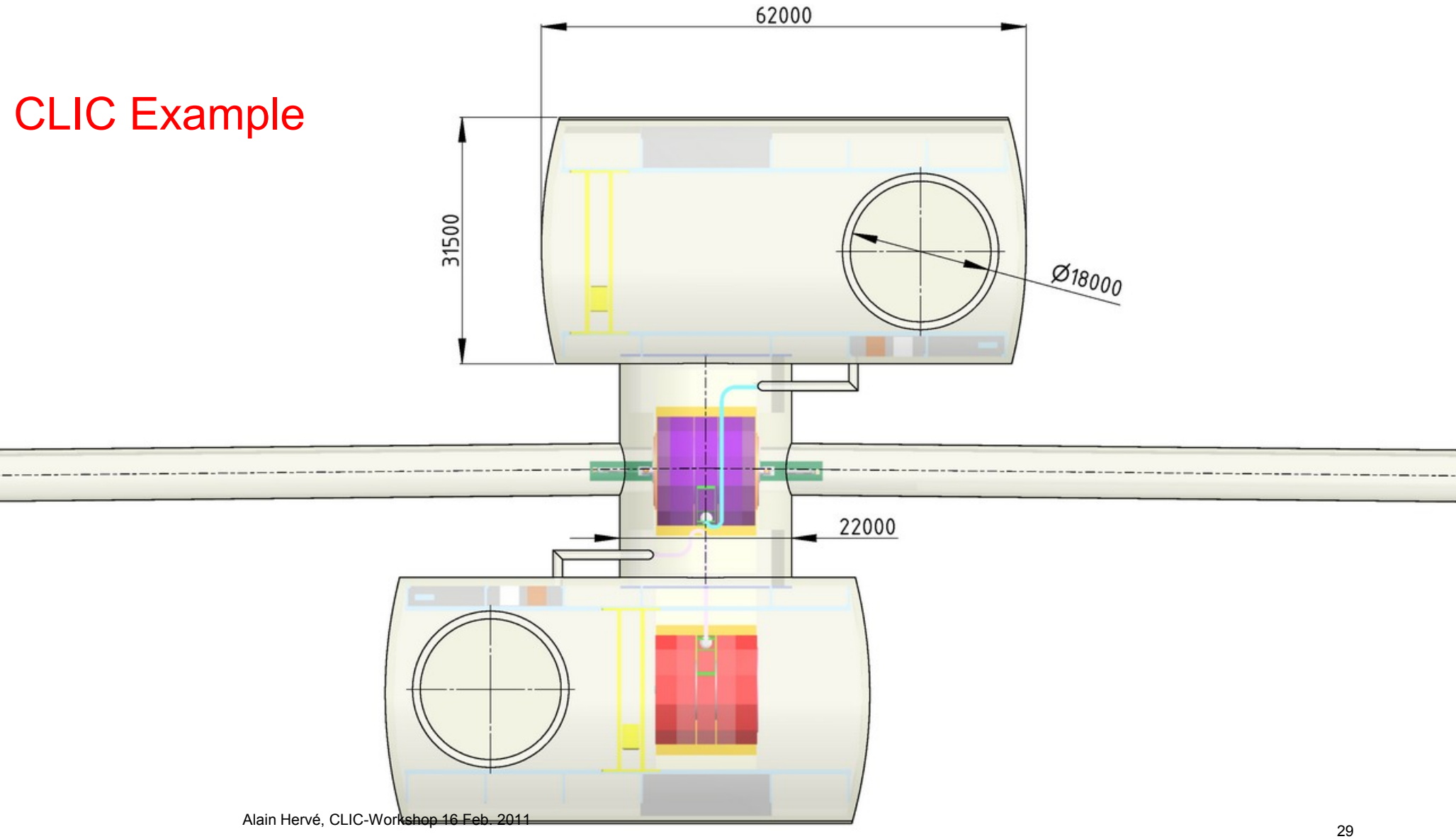
The platform solution shows all its advantages when used in conjunction with Airpads (as opposed to Rollers), because Airpads:

- have no preferred direction of movement.
- allow a fast and safe positioning of the experiment on beam.
- allow an easy repair of the rail / support system, removing the high risk of staying blocked.

This last argument is a major one. Nobody can take the risk of being stuck underground when moving such a load, preventing the accelerator to run!

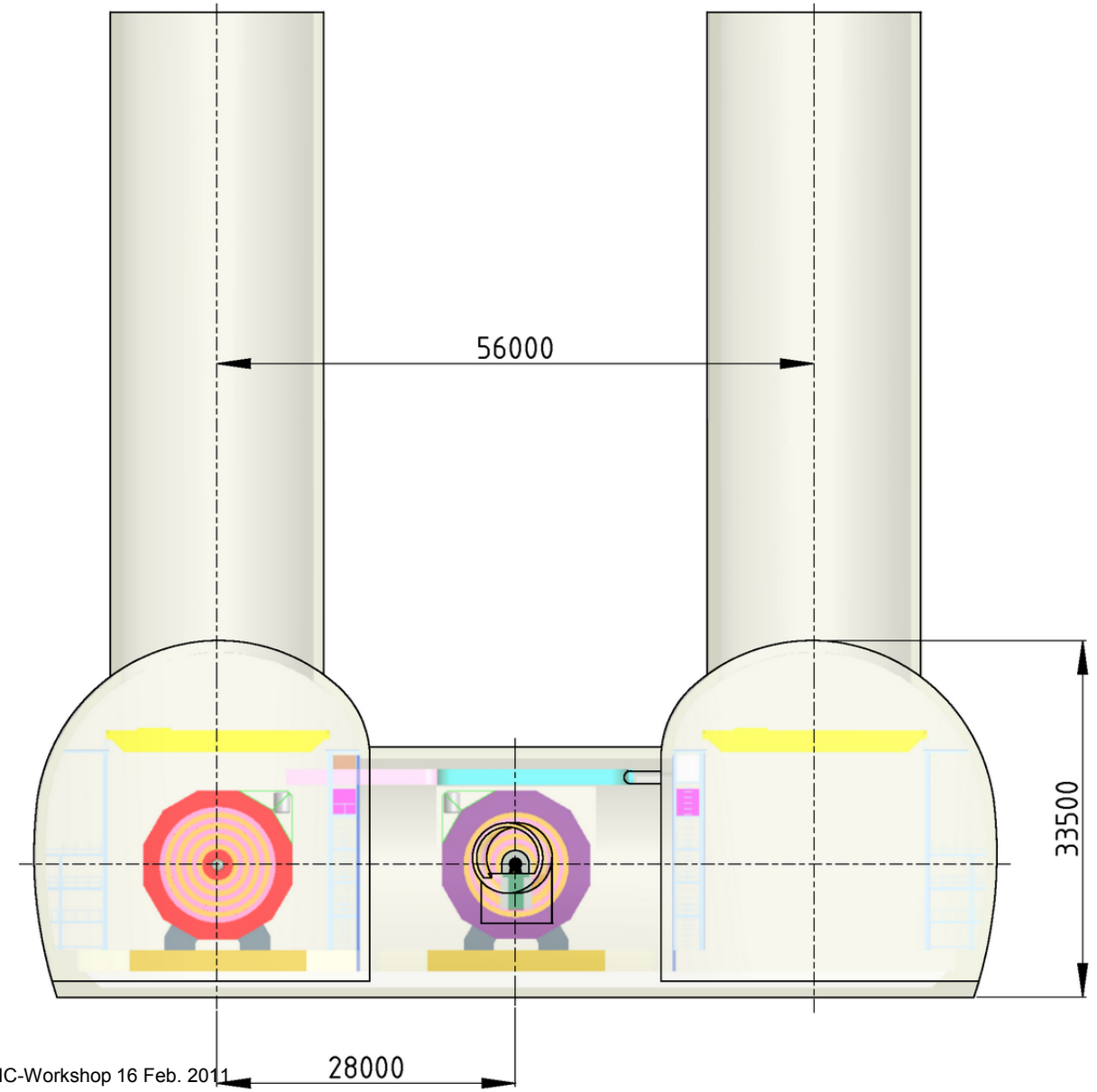
The choice of Platform / Airpads governs the experimental area geometry

CLIC Example



First concept of experimental area

CLIC Example



PROBLEMS ASSOCIATED WITH MOVEMENTS OF THE AREA

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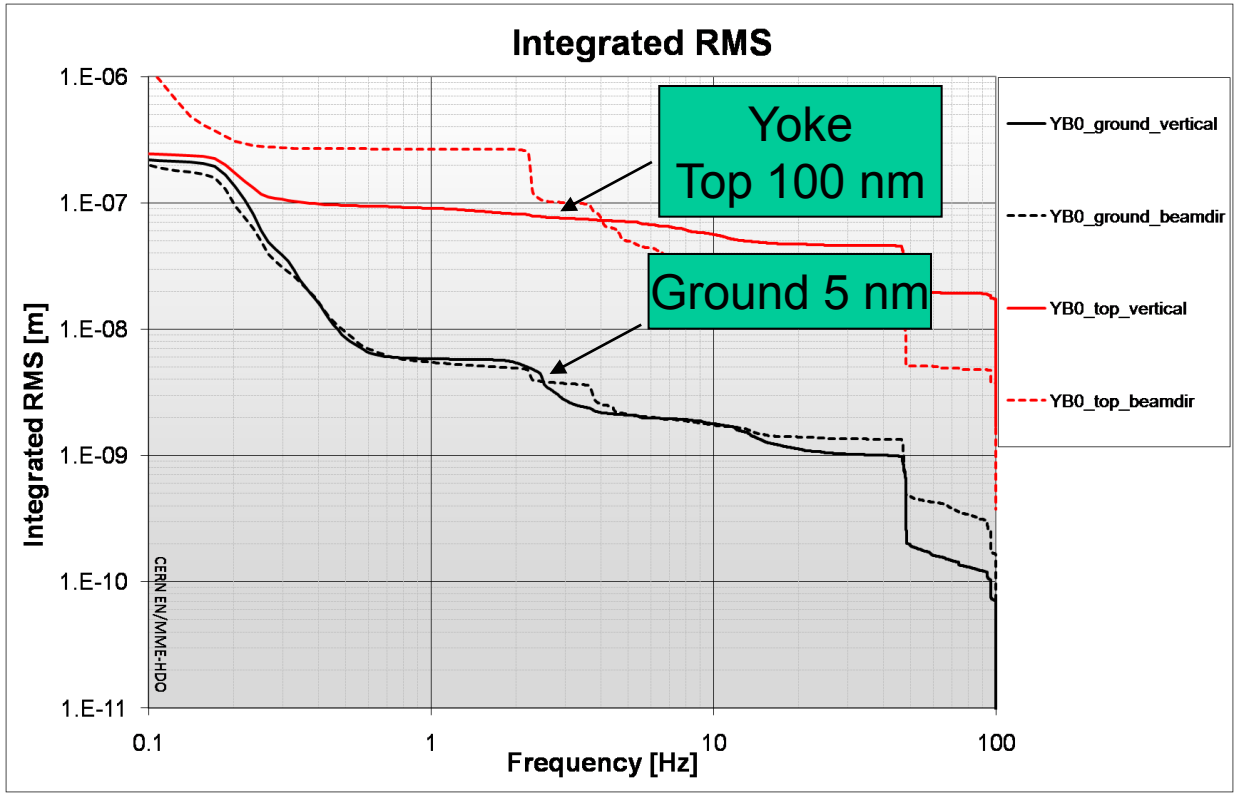
Vibration and movements connected to civil engineering

- LHC experimental areas for ATLAS and CMS are a good example of how such systems behave in the CERN geology.
- However, the level of the requirements for CLIC necessitates to re-examine the situation of general movements, ground vibration and micro-seisms.

Vibration measurements have already been performed in CMS

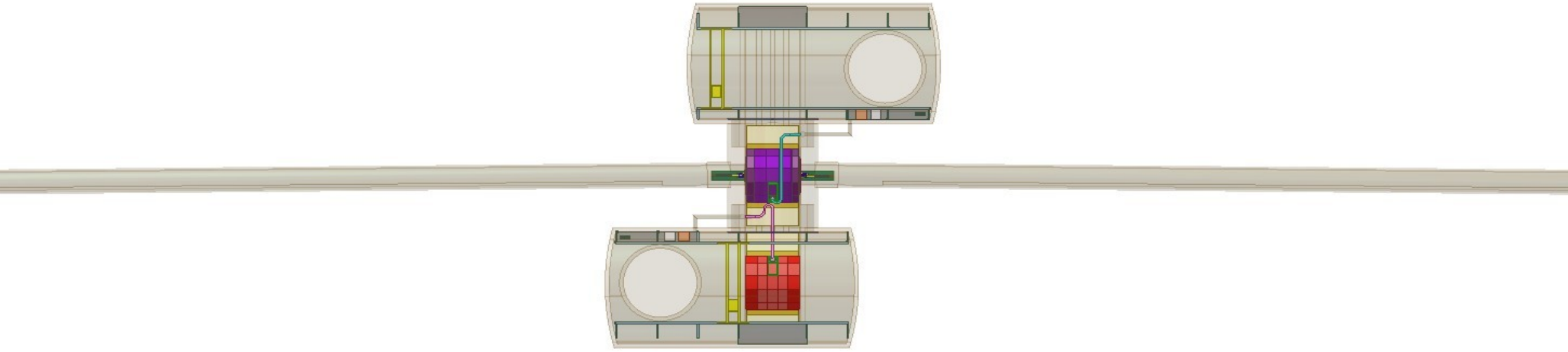
The most stable element is the tunnel floor and not the yoke of the experiment.



⇐ Measurements in "quiet" CMS area end of 2009.

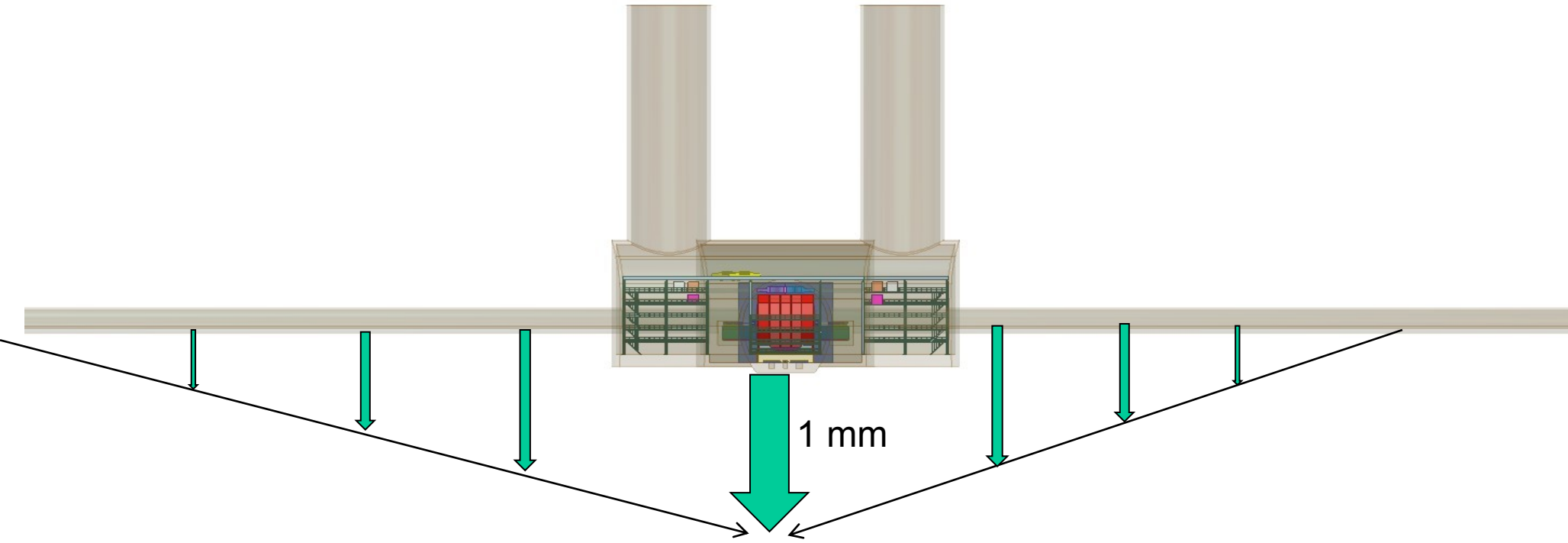
Vertical movement

- Exchanging 12’000+ ton experiments will induce a movement of the whole experimental zone and adjacent machine tunnels maybe on +-100 m.



Vertical movement

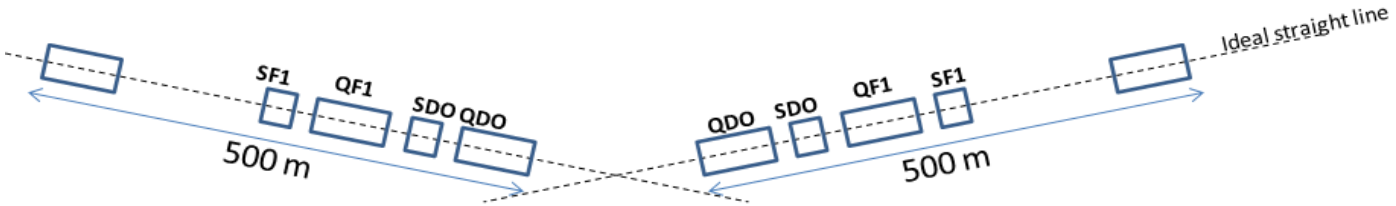
As an example let's assume a vertical movements in the millimeter range that can take one month to recover.



Vertical adjustment

- 1 mm in 1 month
- This means 20 nm / min.
- Or 5 µm in 3 hours.

Pre-alignment system, example of CLIC
(H. Maynaud et al. /CERN)



For the last 500 meters on each side of IP

- Position of the BDS elements and QD0 aligned at ± 10 μm rms w.r.t ideal straight line.

To stay inside the range of the precise alignment system (10 μm) in the region of the QD0 a readjustment by the slow alignment system must be made every ≠ 5 μm, that is ≠ every 3 hours.

Conclusions

Conclusions-I

- The Push-Pull system is a very demanding project and there is no real example to refer to.
- CLIC has adopted a platform to move each experiment.
- ILC concepts are in discussion to adopt a common solution and a working plan has been drafted.
- It is important to make sure that the platform solution does not worsen the vibration performance of the supporting system.

Conclusions-II

- To use a platform to move quickly, precisely and safely a compound mass like an experiment looks a good solution.
- The CMS plug is a good example of what a platform could be, but now it would have to be built underground and this has to be looked at.
- The CMS plug can be used to benchmark simulation models for deformation and vibration.
- Further vibration measurements on the CMS plug will be needed.

Conclusions-III

- The Push-pull operation, or the movement of one experiment on IP after a shut-down, will act on the area as a whole and will extend on both sides up to 100 m.
- The area may move back of say 1 mm in 1 month, needing a readjustment of the active pre-alignment system every 3 hours.
- More studies are needed from the civil engineering point of view to ascertain these slow movements and the vibration situation.

Thank You !