Linear Collider Workshop 2012, Arlington, USA

Earthquake protection for Linear Collider detectors

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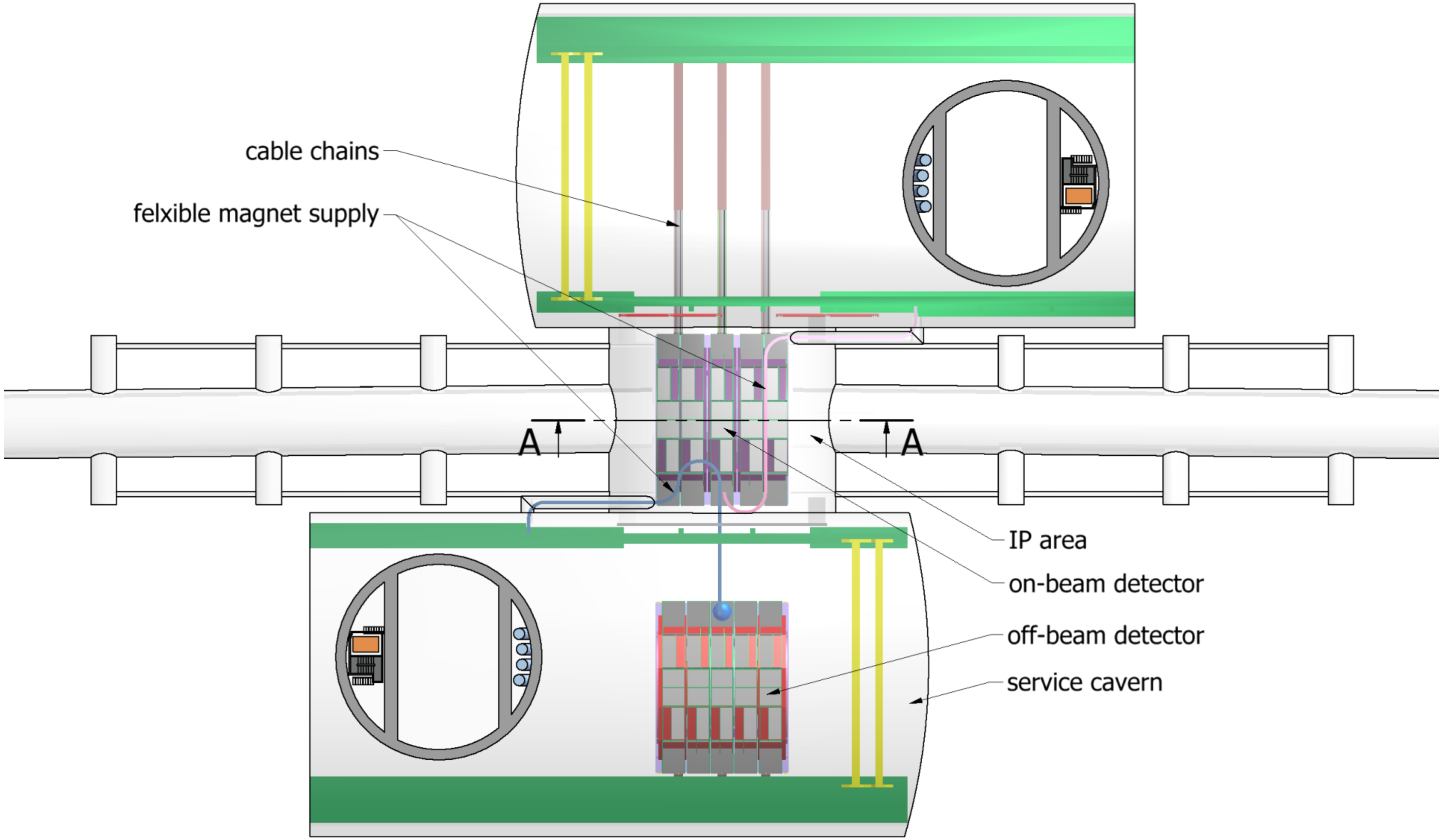
October 25th, 2012

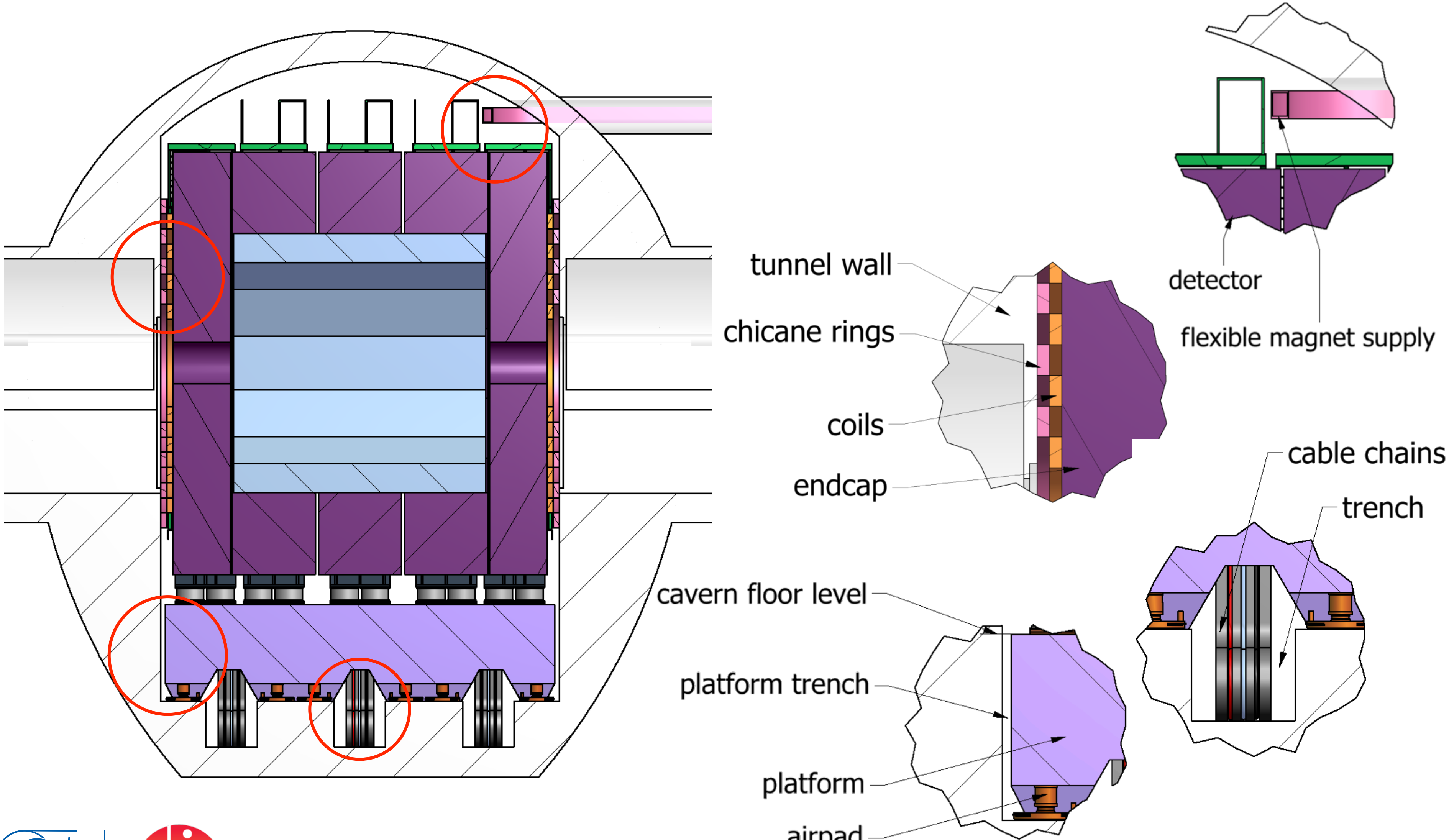
Outline

- CLIC experimental area layout;
- Seismic action at CERN;
- Seismic isolation strategies;
- First FEA simulations results (CERN & J-PARC spectra);
- Above platform seismic isolation.

CLIC experimental area layout



CLIC experimental area layout




DON'T TEXT
WHILE DRIVING
IT'S THE LAW

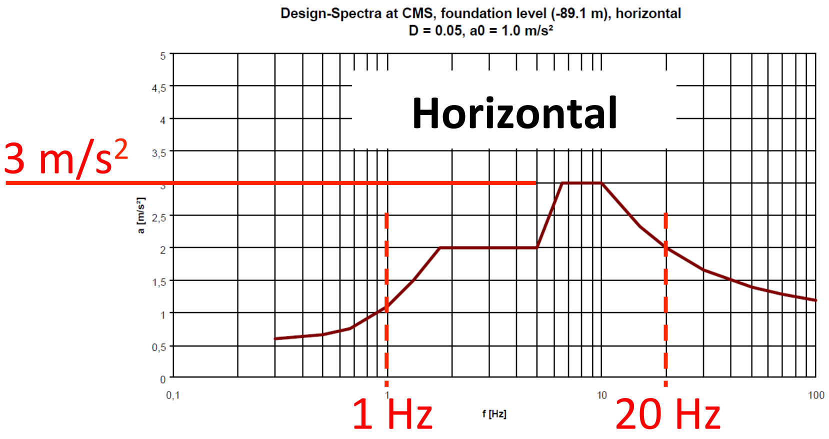

DESIGN YOUR DETECTORS TO BE
EARTHQUAKE RESISTANT
IT'S THE LAW

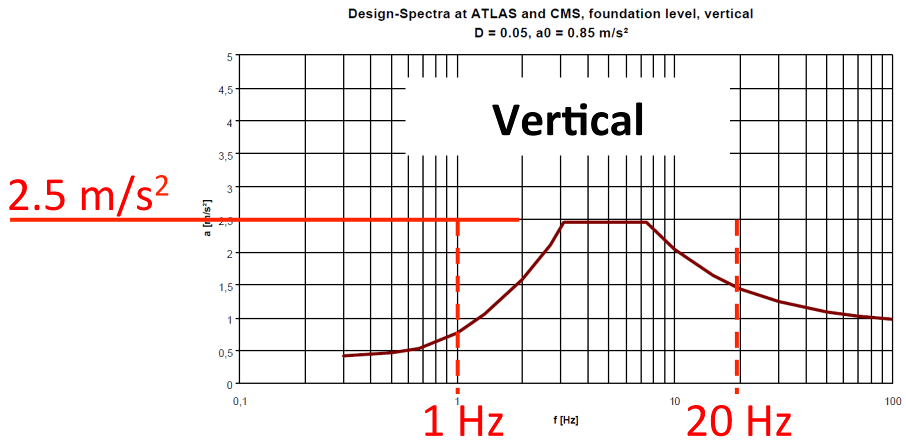
Seismic action at CERN

- CERN is within a “moderate seismicity” zone;
- Nominal earthquake:

Period	Epicentral distance	Magnitude (Richter)	Duration
60-75 years	15 km	5.5-6.1	15 s

- French/Swiss/European regulations enforced;





G. Benincasa and R. Schmidt, “Seismic design spectra for ATLAS and CMS”, March 2000

Seismic isolation strategies

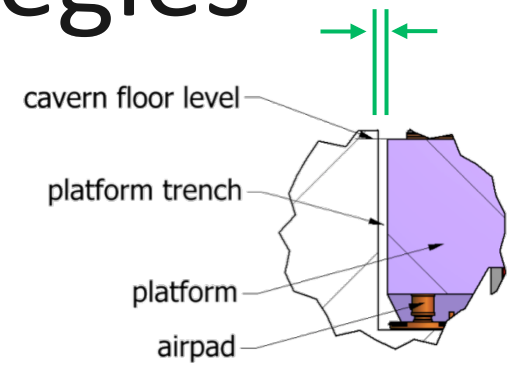
Four seismic isolation strategies:

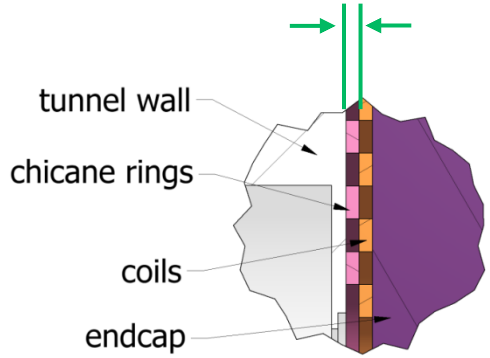
- Rigid detector support;
- Isolation under platform;
  - Using airpads;
  - Using friction pendulum isolators;
- Isolation above platform;

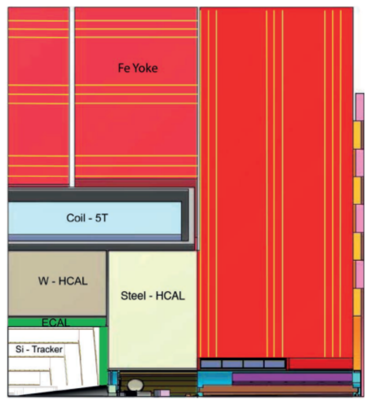
Seismic isolation strategies

- Rigid detector support;
- Isolation under platform;
  - Using airpads;
  - Using friction pendulum isolators;
- Isolation above platform;

Pros	• Most straightforward to implement; • No impacts with trenches or cavern walls;
Cons	• Design detector to withstand loads;
Feasibility	✓



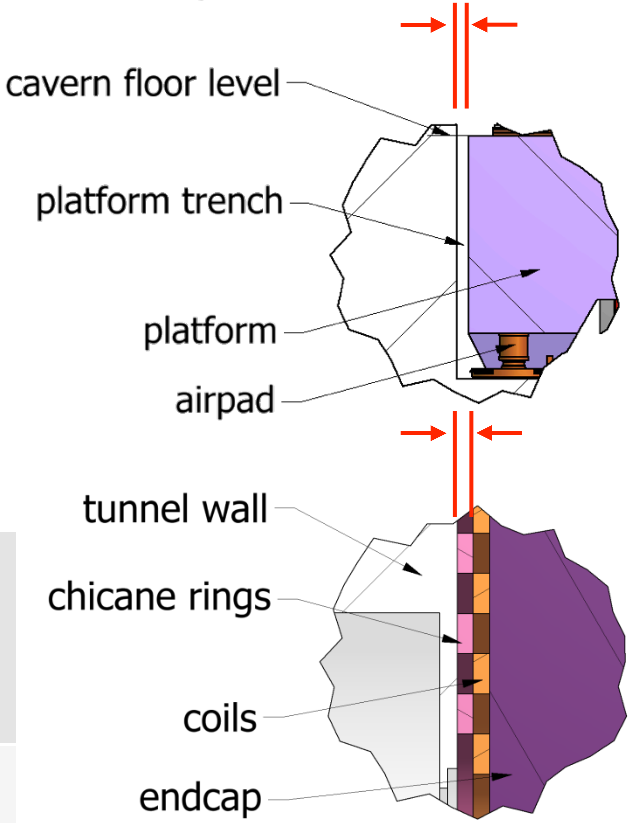




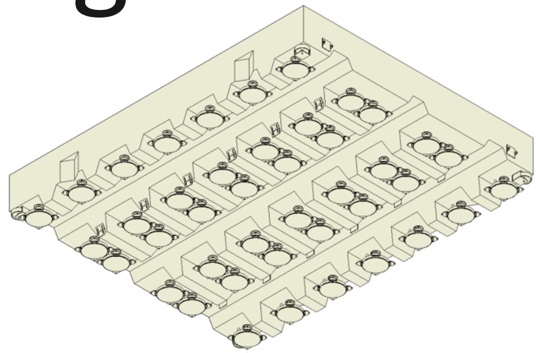
Seismic isolation strategies

- Rigid detector support;
- Isolation under platform;
  - Using airpads;
  - Using friction pendulum isolators;
- Isolation above platform;

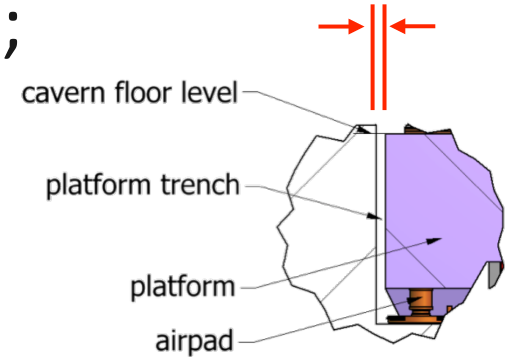
Pros	• Isolation of both platform and detector; • No additional elements;
Cons	• No earthquake detection network; • Limited time to inflate airpads; • Possible impacts with trenches and cavern walls;
Feasibility	✘



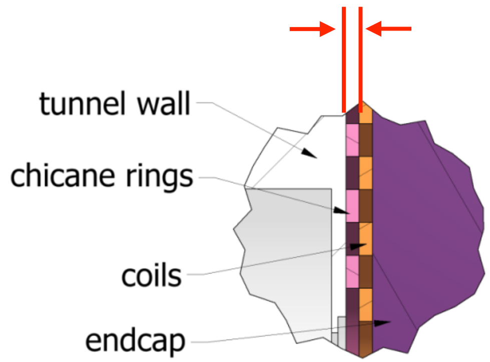
Seismic isolation strategies



- Rigid detector support;
- Isolation under platform;
  - Using airpads;
  - Using friction pendulum isolators;
- Isolation above platform;



Pros	• Isolation of both platform and detector;
Cons	• Not enough space beneath the platform; • Possible impacts with trenches and cavern walls;
Feasibility	✘



Seismic isolation strategies

- Rigid detector support;
- Isolation under platform;
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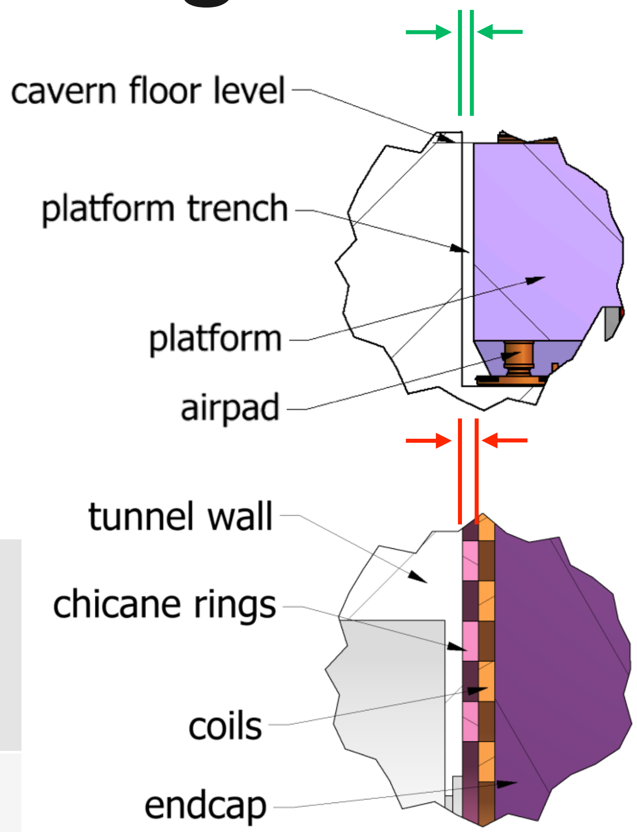
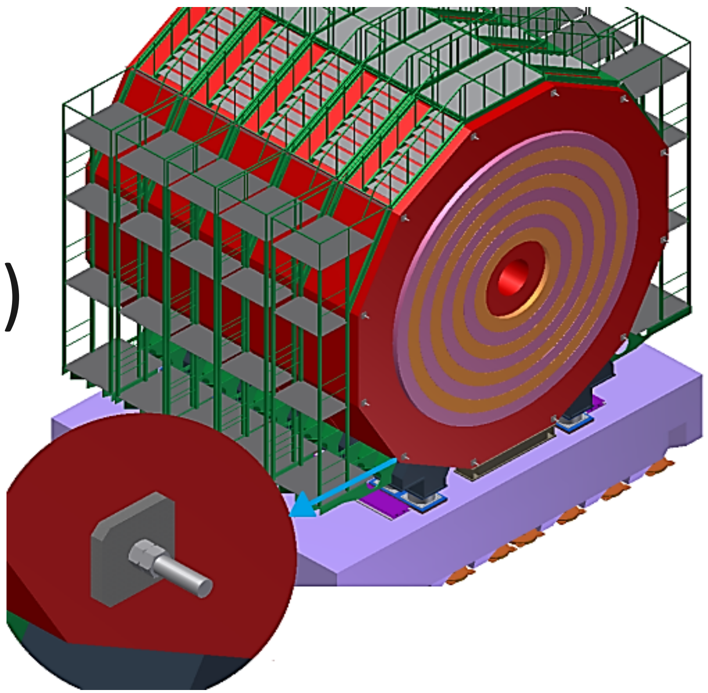
- Isolation above platform;



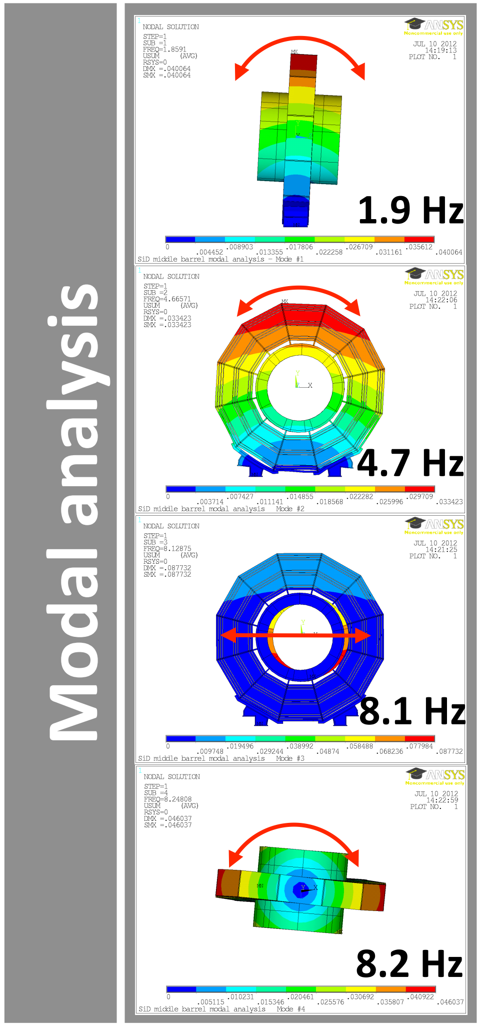
Pros	• Isolation during assembly and maintenance;
Cons	• Possible impacts with cavern walls;
Feasibility	✓

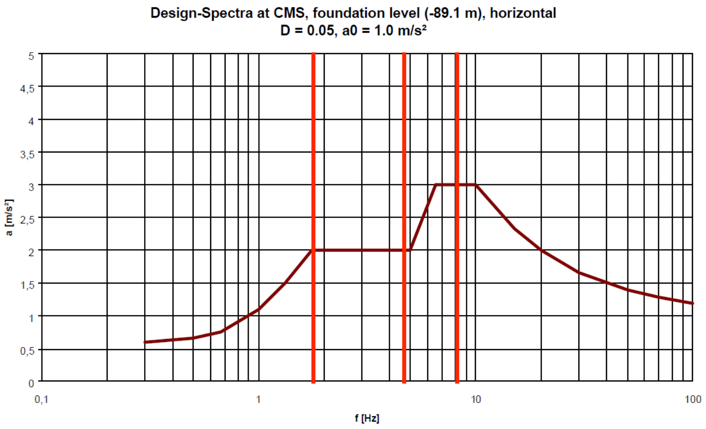
Rigid detector support

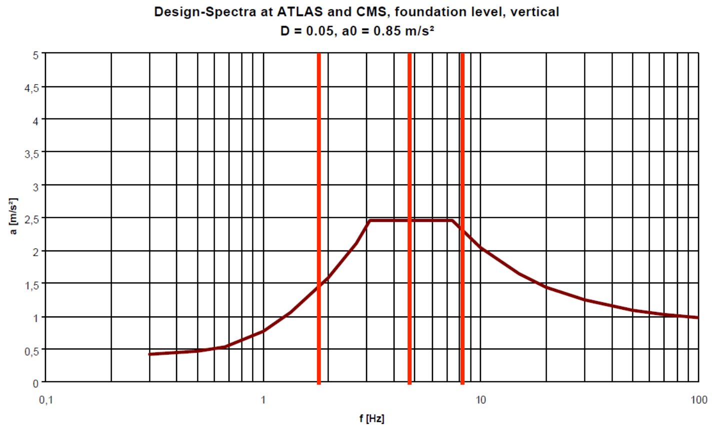
- Detector must withstand moderate seismic events;
- Tie-rods and magnetic forces maintain detector closed when in data-taking position;
- Integrity of all detector components must be maintained in garage (opened) and data-taking (closed) position;

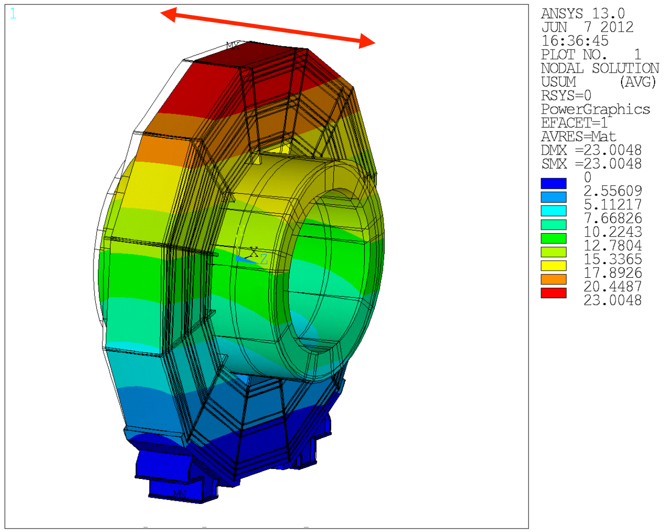


CLIC_SiD yoke – Garage

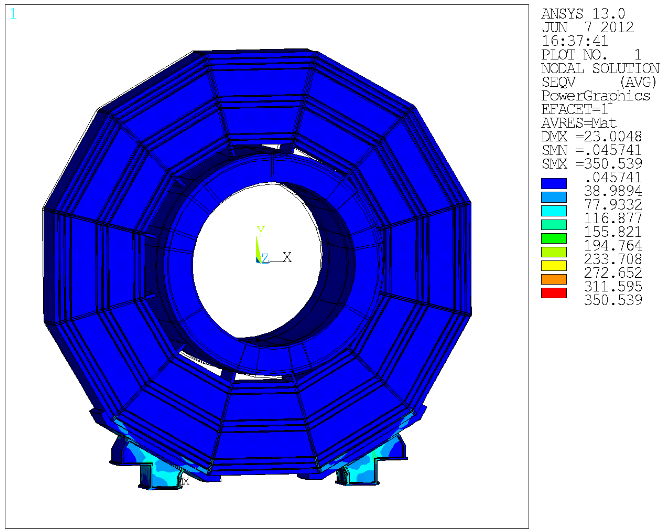








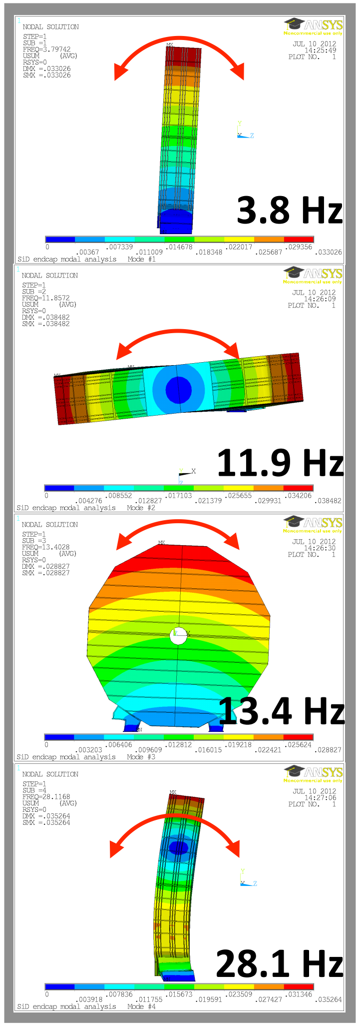
Maximum deformation: **23 mm**

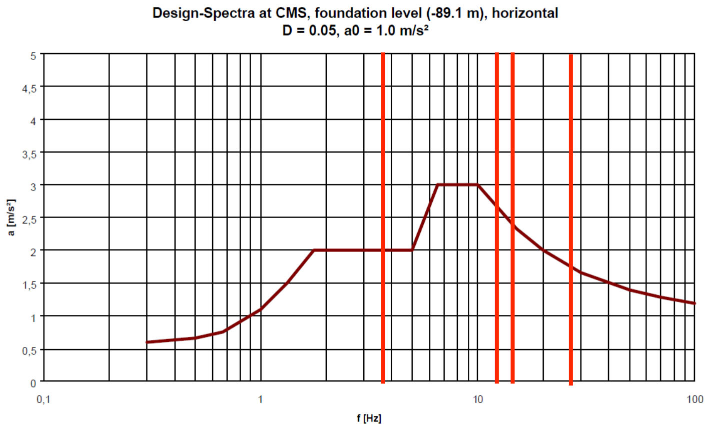


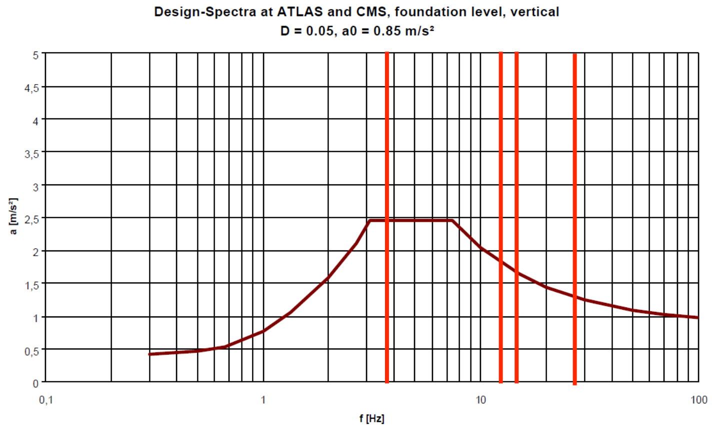
Maximum v. Mises stress: **350 MPa**

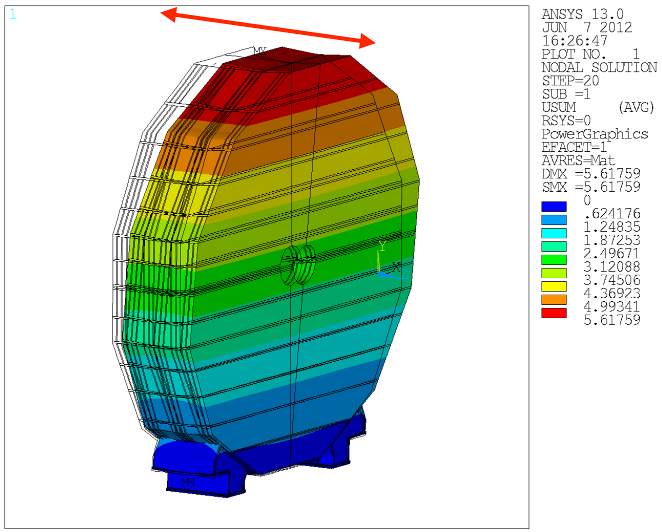
CLIC_SiD yoke – Garage

Modal analysis

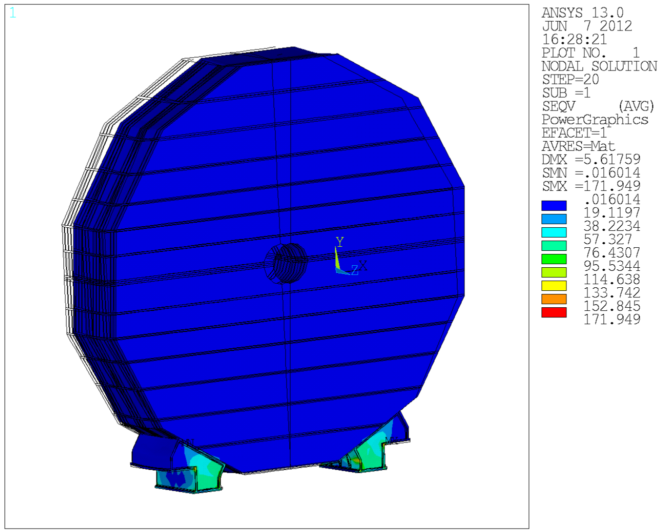








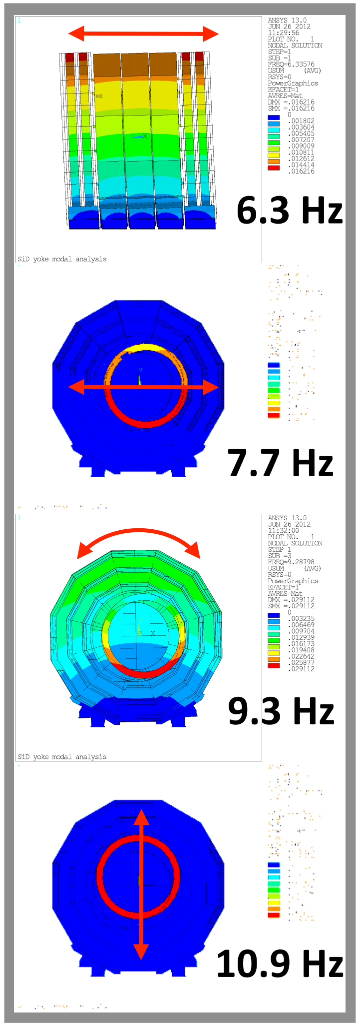
Maximum deformation: **5.6 mm**

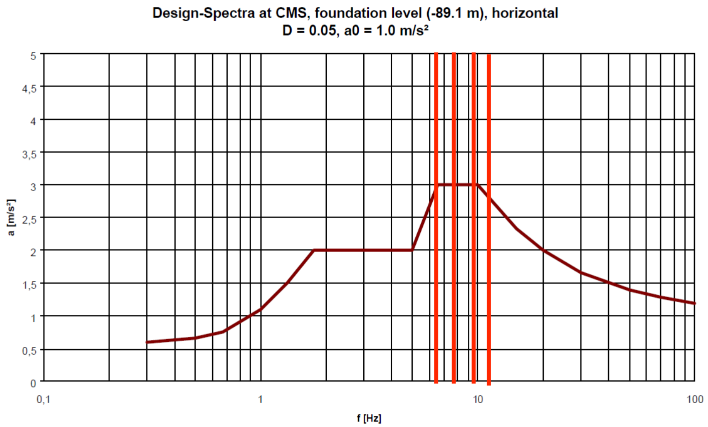


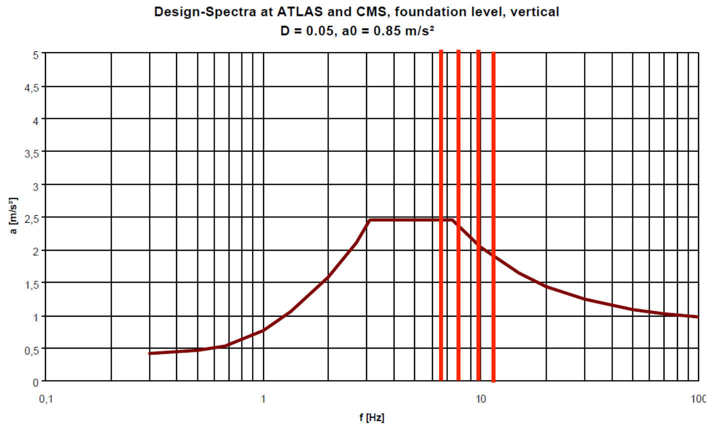
Maximum v. Mises stress: **172 MPa**

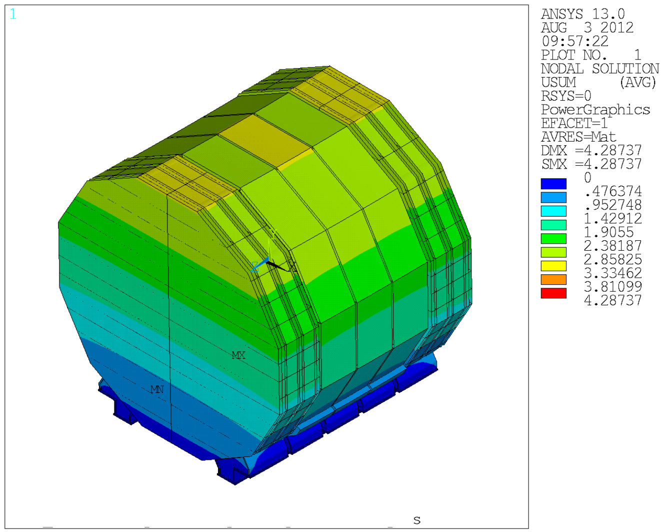
CLIC_SiD yoke – Data-taking

Modal analysis

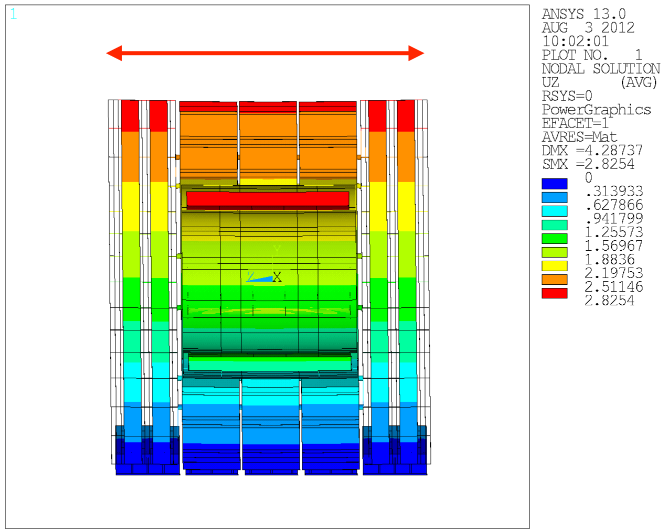






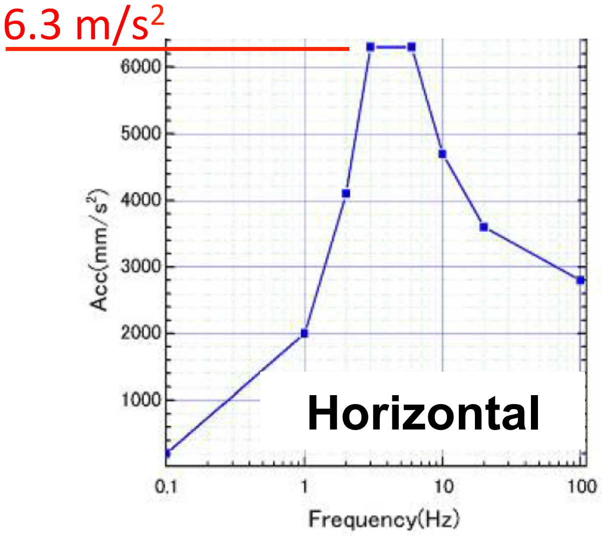


Maximum deformation: **4.3 mm**

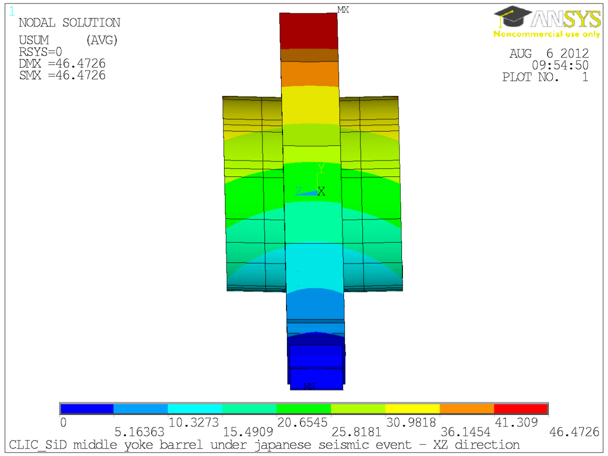


Deformation along beam axis: **2.8 mm**

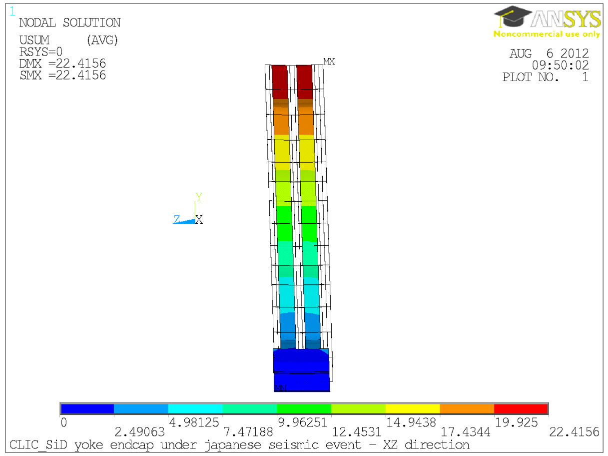
CLIC_SiD yoke – J-PARC spectrum



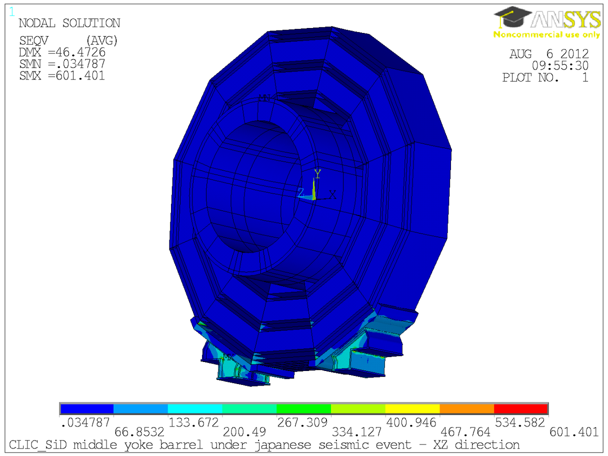
J-PARC - ND280 magnet system spectrum
Courtesy: T. Tauchi (KEK)



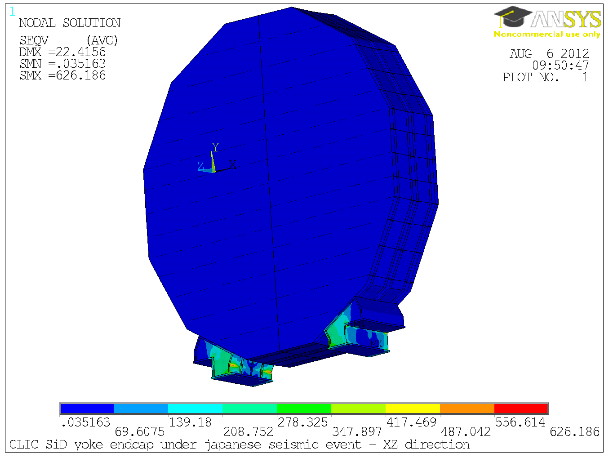
Maximum deformation: **46.4 mm**



Maximum deformation: **22.4 mm**



Maximum v. Mises stress: **601 MPa**



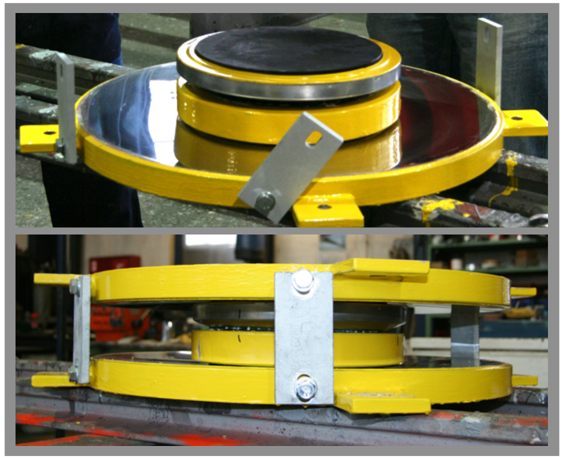
Maximum v. Mises stress: **626 MPa**

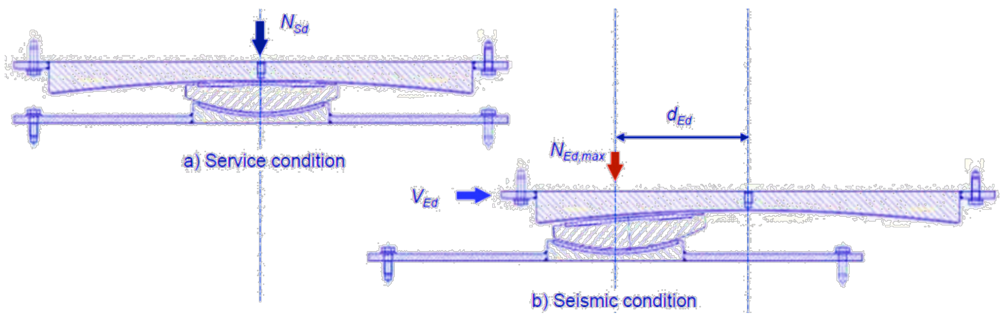
Rigid strategy **not feasible** in high seismicity locations

Above platform isolation

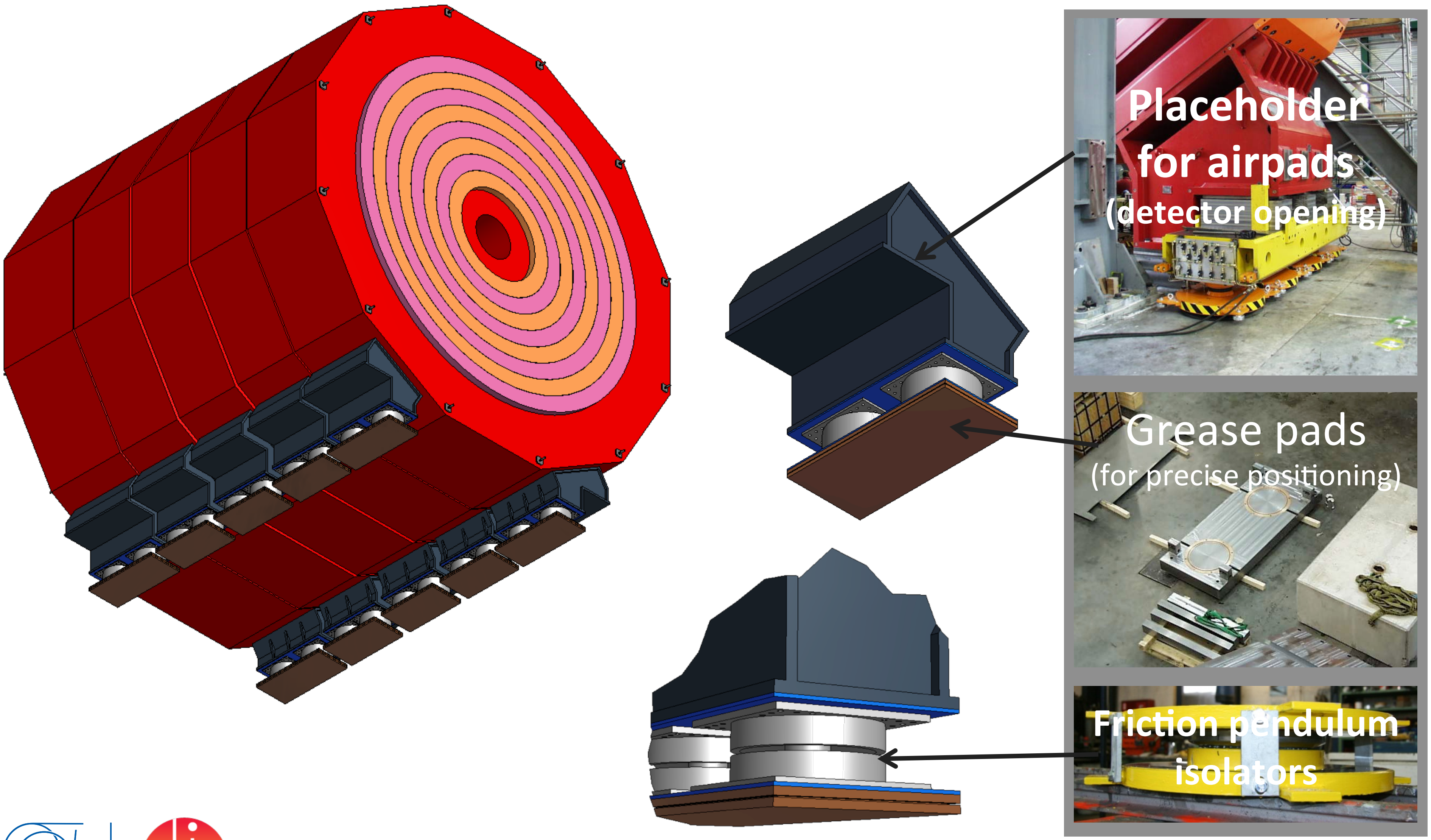
- Friction pendulum isolators beneath the detector feet;
- Reliable technology;
- No high compliance elements (e.g. rubber) improves the positioning of the detector;

Pendulum isolators



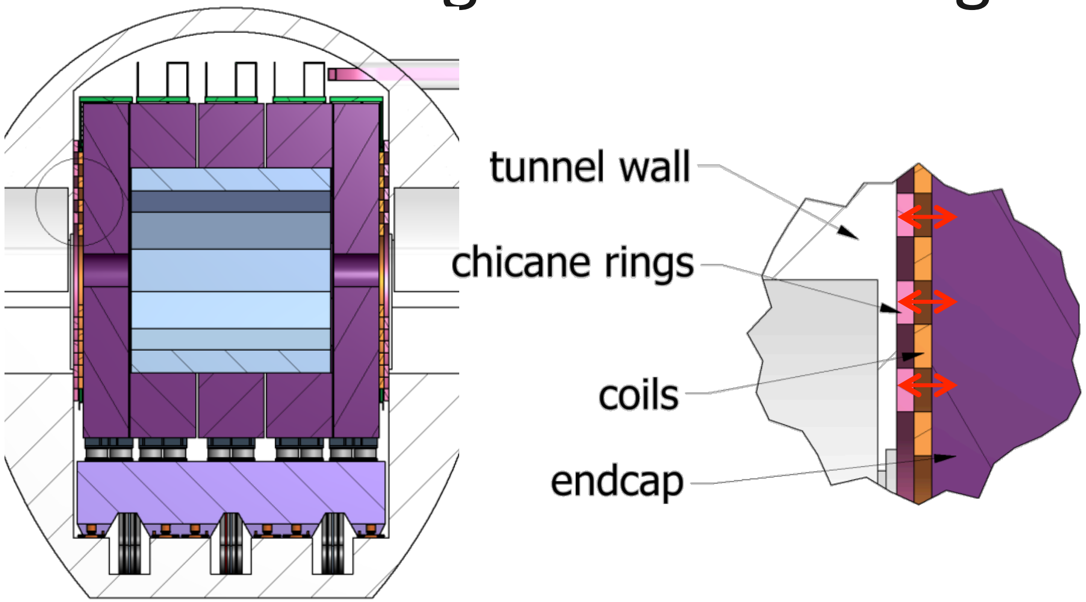


Above platform isolation



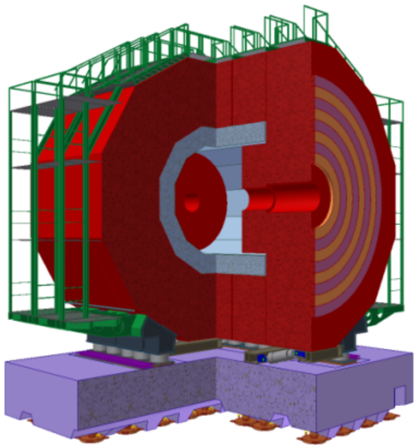
IP area constraints

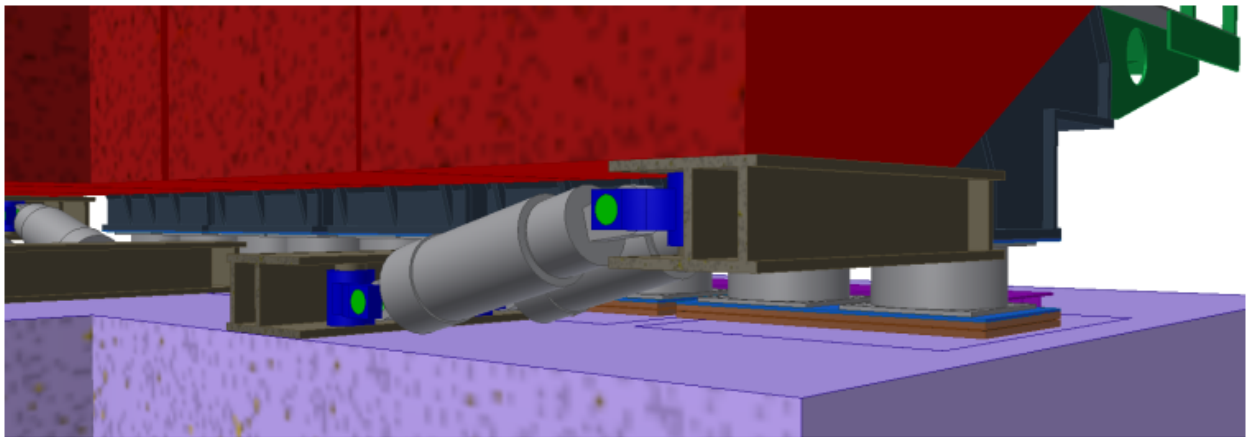
- Movement of detector restricted by cavern walls;
- Viscous dampers can be used to limit oscillation amplitudes along the beam direction;
- Chicane rings will allow longitudinal movement;



Energy dissipation

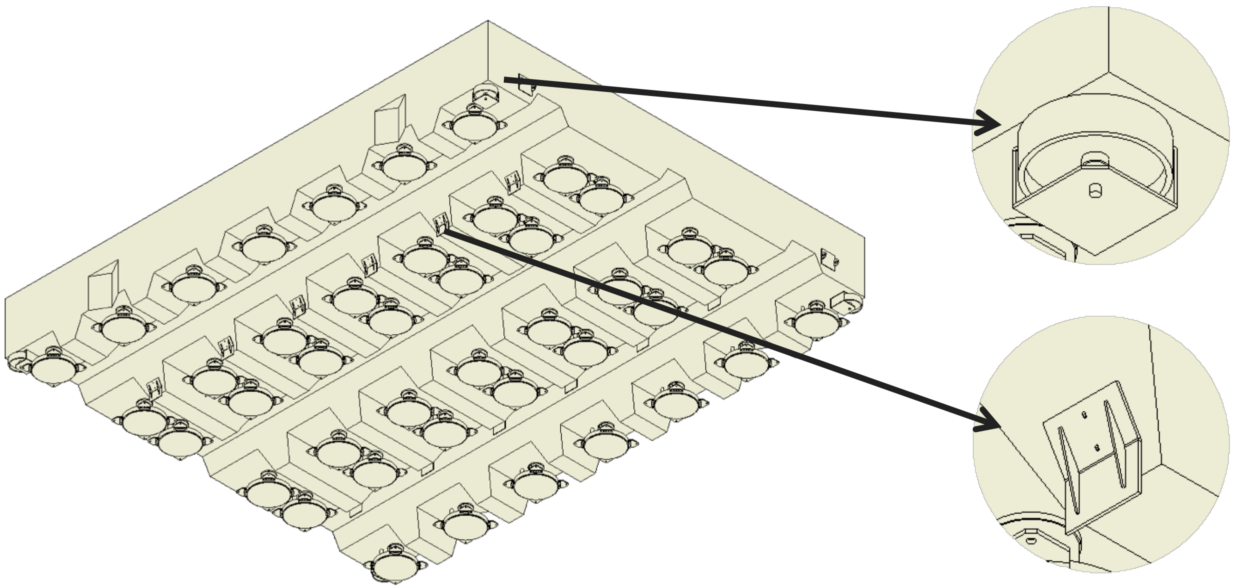
- 8 dampers connect the closed detector to the platform;
- Mechanical "fuse" provides rigidity under normal operating conditions;
- Removal upon opening of detector;





Earthquake during Push-Pull

- Isolation provided by inflated airpads;
- Guidance elements prevent colisions of the platform with the trenches;



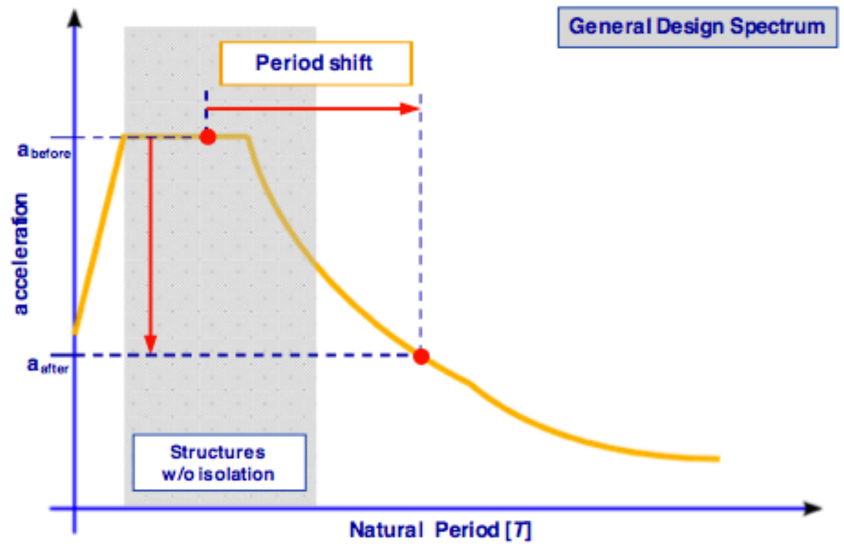
Summary

- Design of detectors must follow enforced regulations;
- In low to moderate seismicity areas, a rigid detector support might be an option;
- Validation through extensive FEA analyses is needed (special emphasis to calorimeters and inner detectors);
- Otherwise, above platform seismic isolation will be required;
- Cavern design, push-pull operation and available space will dictate the final design.

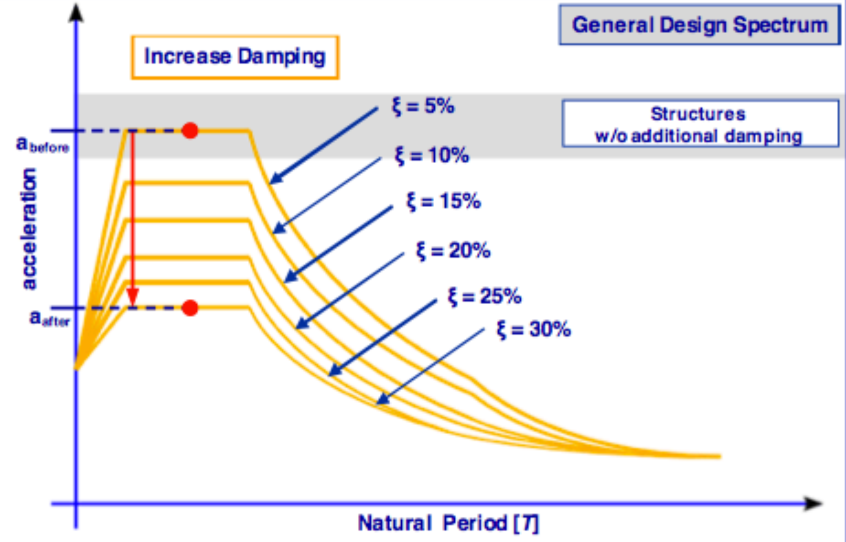
Thank You.

Spare Slides

Seismic isolation and damping principle



Reduction of acceleration by seismic isolation



Reduction of acceleration by additional damping