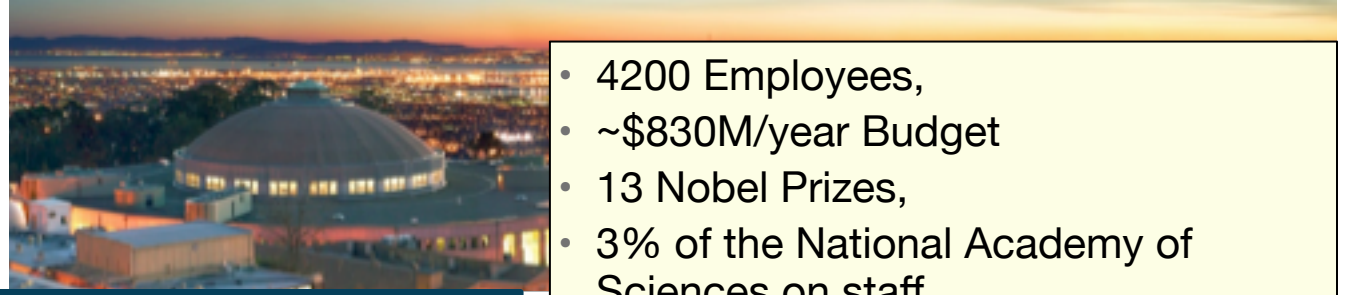
Lawrence Introduces Big Team Science

LBNL ENGINEERING

~1936

Berkeley Lab



- 4200 Employees,
- ~$830M/year Budget
- 13 Nobel Prizes,
- 3% of the National Academy of Sciences on staff
- Deep connections to UC
- Open teaming environment
- Workforce Development

Managed by the University of California for the United States Department of Energy

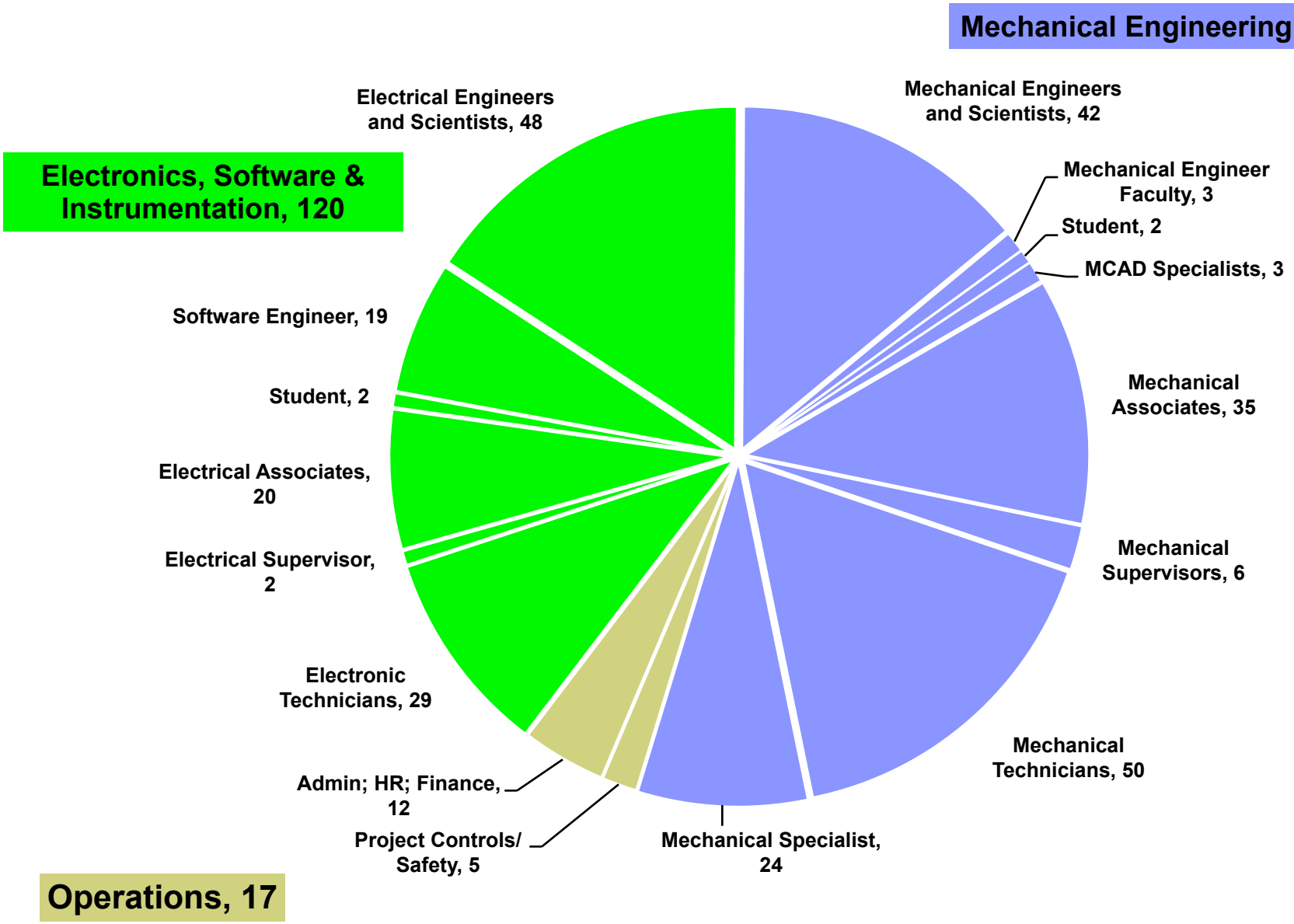
BERKELEY LAB Lawrence Berkeley National Laboratory

- Develop multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions
- Execute long-term scientific and technological missions, often with complex safety, project management, or other operational challenges;
- Develop and sustain critical scientific and technical capabilities
- Develop, build and safely operate world-class scientific facilities

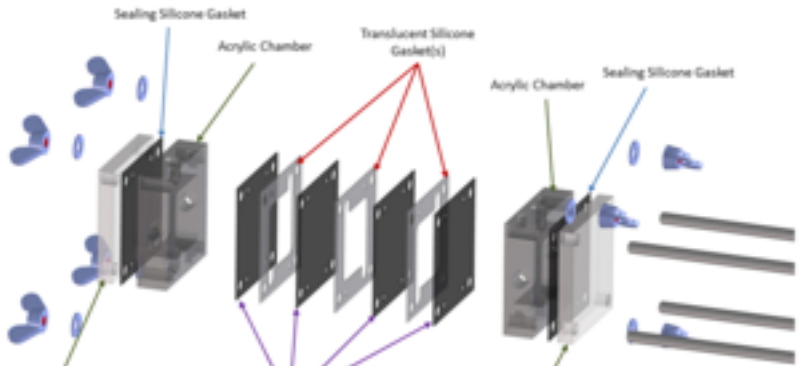
Selected Core Laboratory Strengths

- Biological Systems Science
- Chemical and Molecular Science
- Chemical and Molecular Engineering
- Subsurface and Environmental Science
- Energy Efficiency Technologies Energy Applications System Analysis
- Photon Science
- Computational Science

Engineering Division Composition



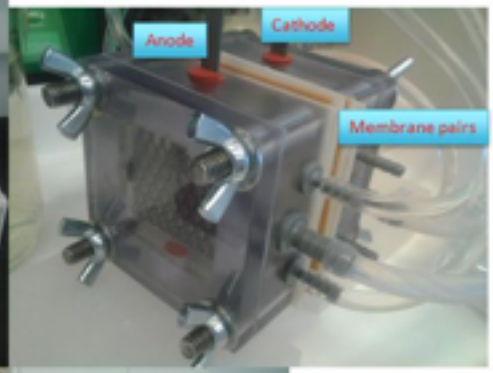
Small Project Engineering (SPE)



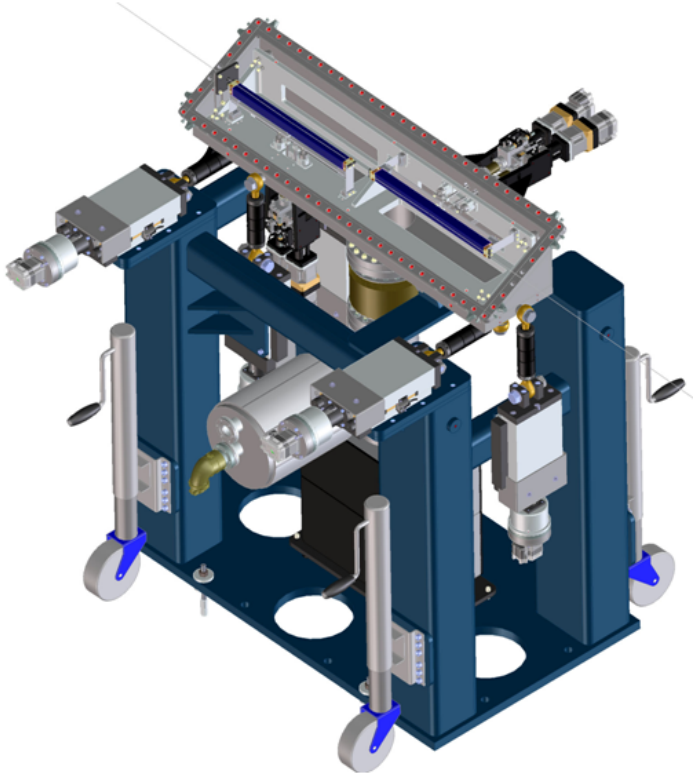
The actual ED system

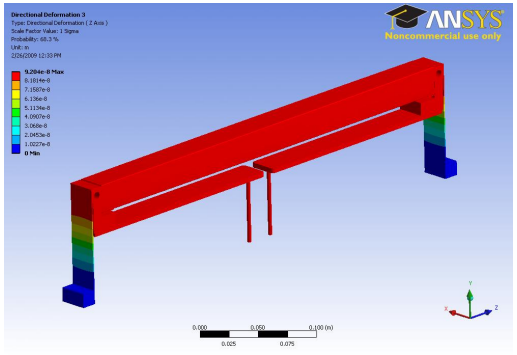
A portable cryo-plunger

for on-site intact cryogenic microscopy sample preparation in natural environments

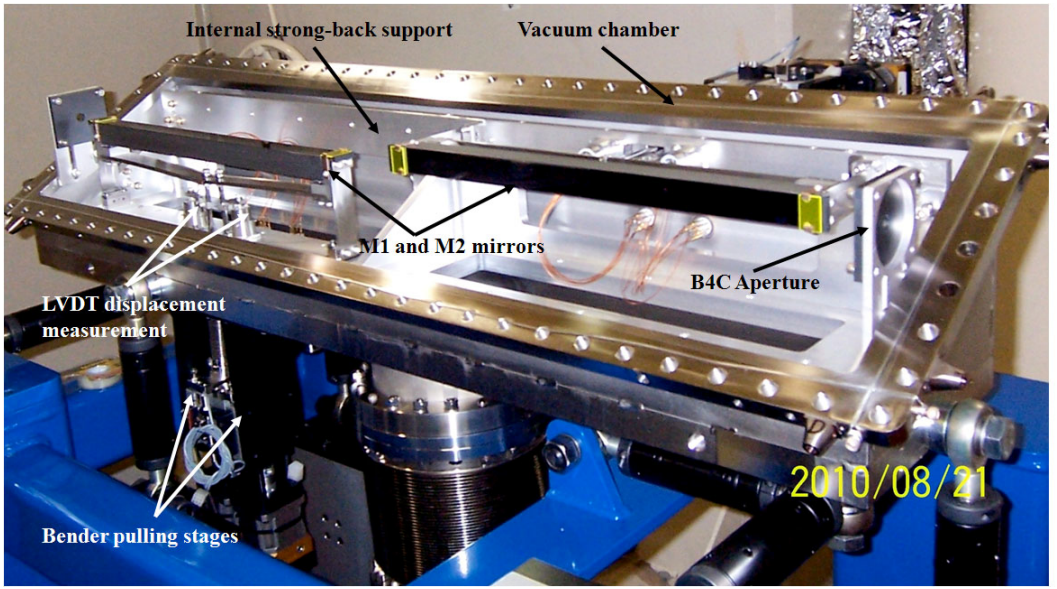


Small Project Engineering (SPE)

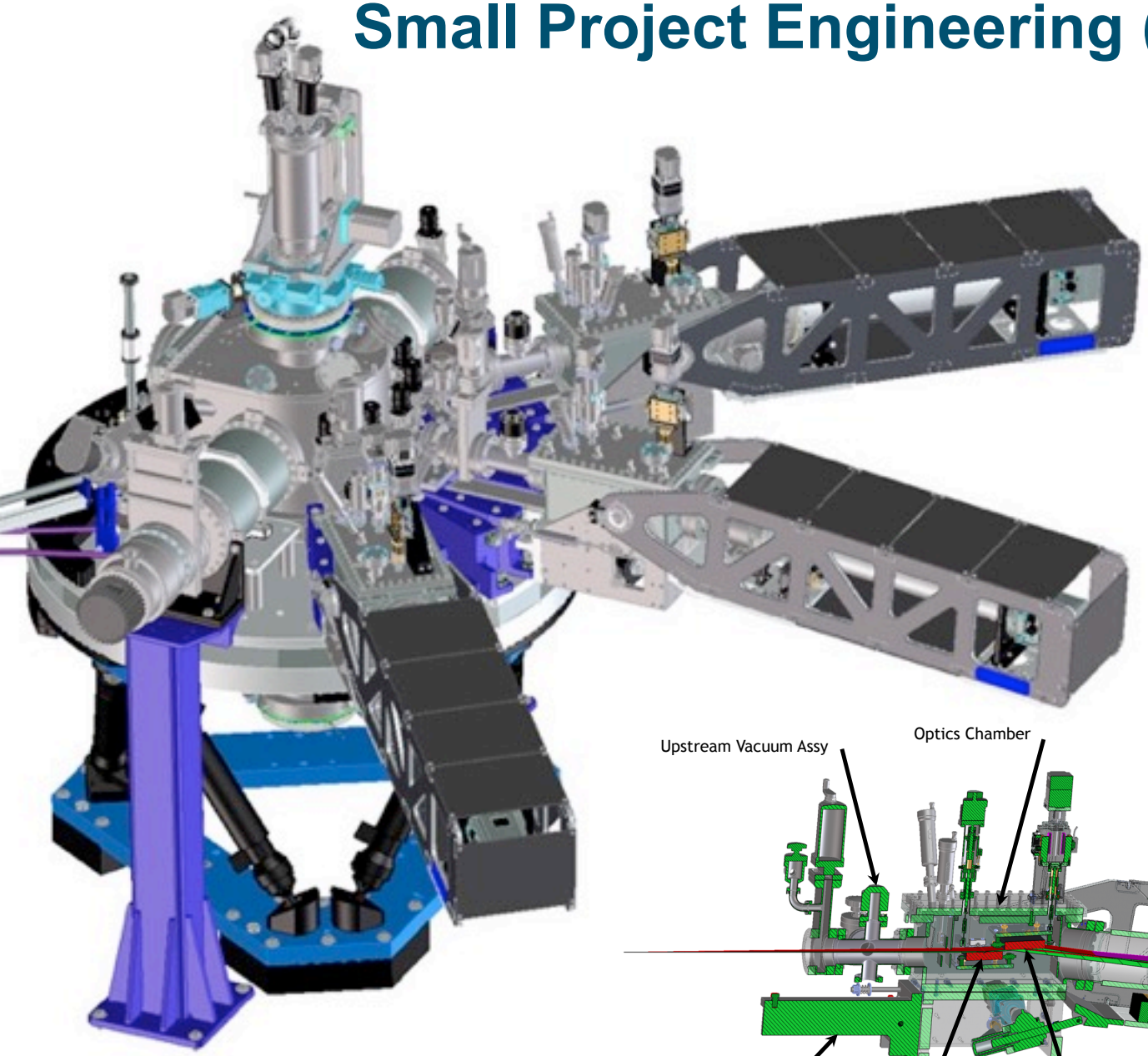


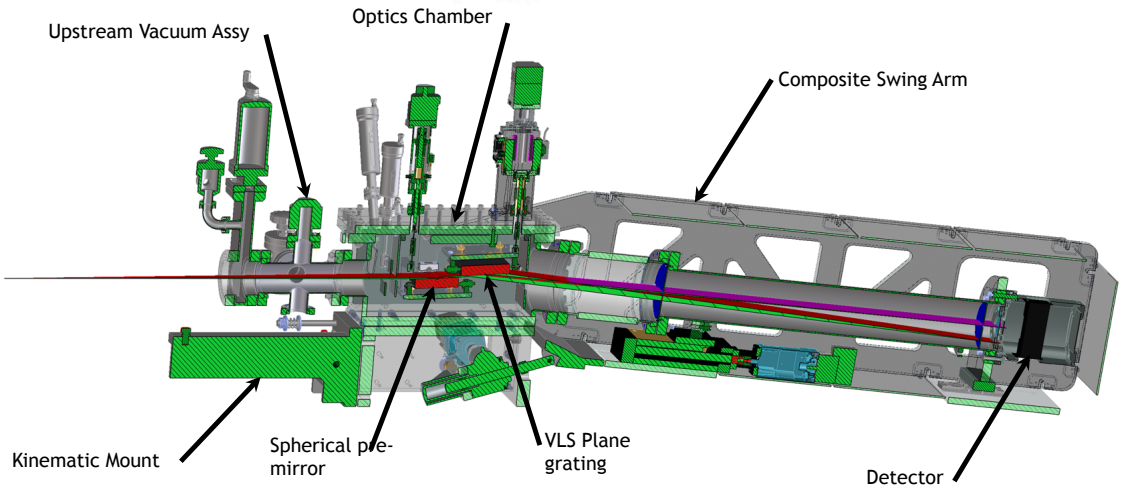


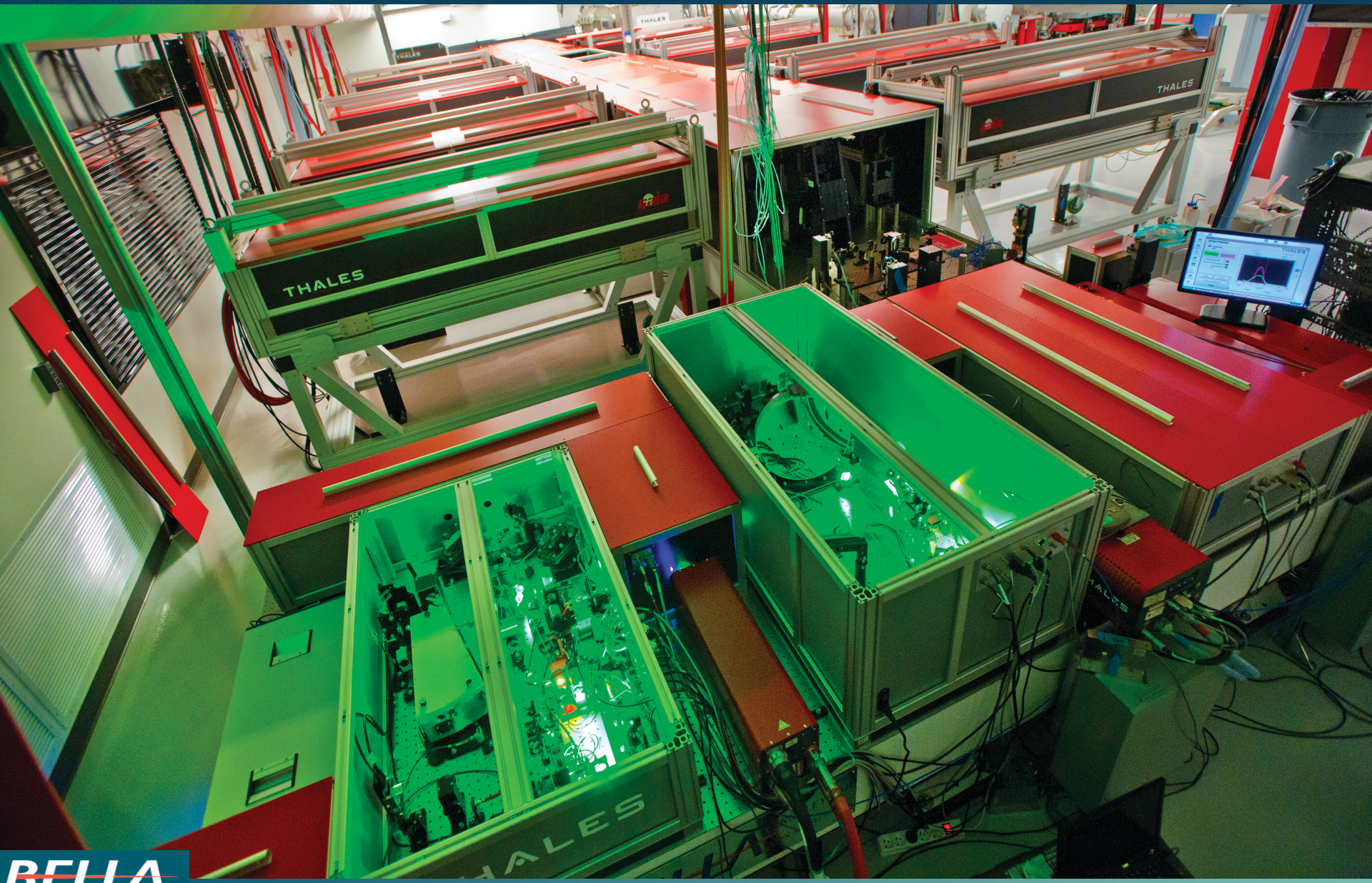
X-Ray Optics
Kirkpatrick-Baez Mirror pair
LCLS AMO Beamline



Small Project Engineering (SPE)

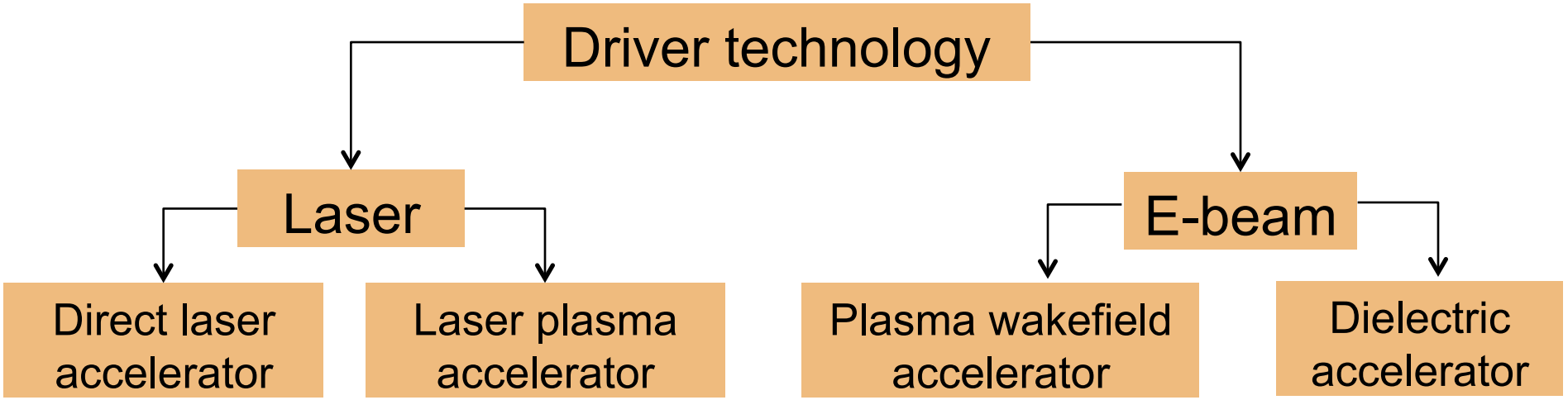





THALES
THALES
THALES

Next Step in Advanced Accelerator Development

- Collider size set by maximum particle energy and maximum achievable gradient limited by breakdown
- Motivates R&D for ultra-high gradient technology



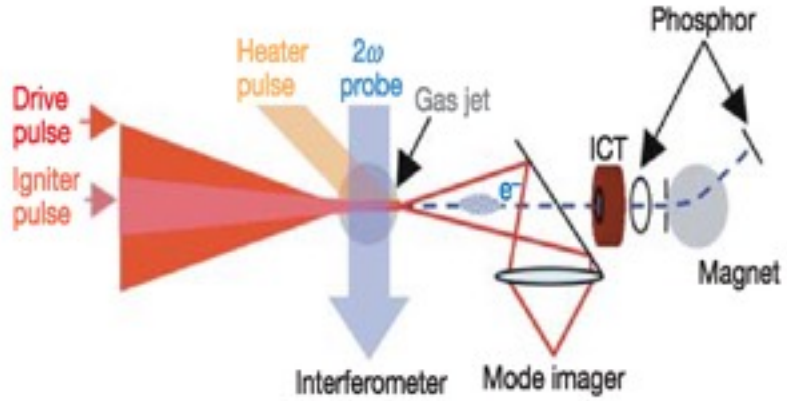
BELLA BERKELEY LAB LASER ACCELERATOR

FACET

- Accelerator technology for radiation sources

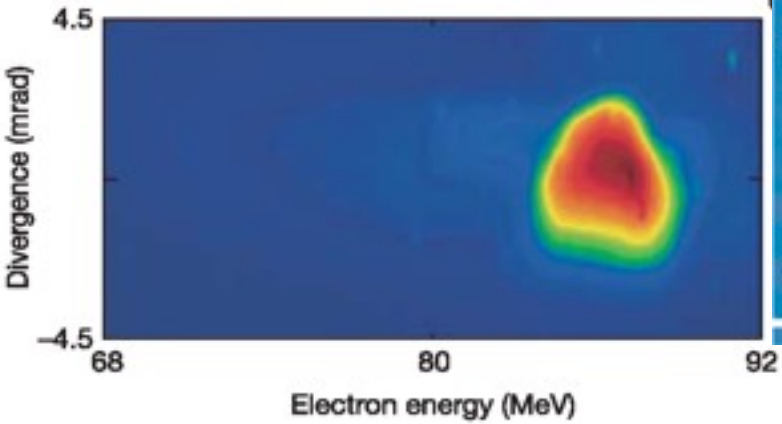
Channel Guided Laser Plasma Accelerators

2004 Result

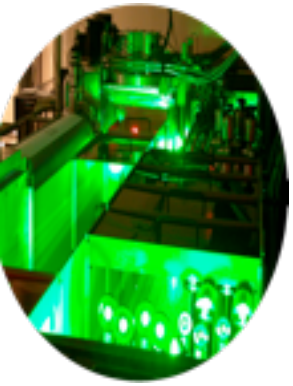


C. G. R. Geddes et al, Nature,431, p538 (2004)

10 TW laser => 100 MeV e-beam



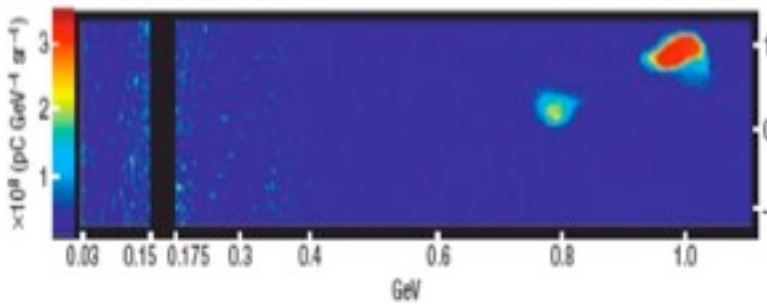
2006 Result

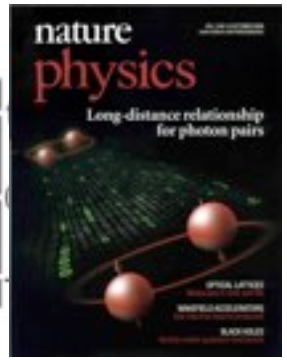


1 GeV

e⁻

40 TW laser => 1 GeV e-beam





W.P. Leemans et. al, *Nature Physics* 2, p696 (2006)

BELLA Project

BELLA Project Goal:

40 J pulses of 40 fs duration at a repetition rate of 1 Hz and supporting infrastructure

Funds:

ARRA ($19.218 M) and HEP Program ($8M) = $27.218 M

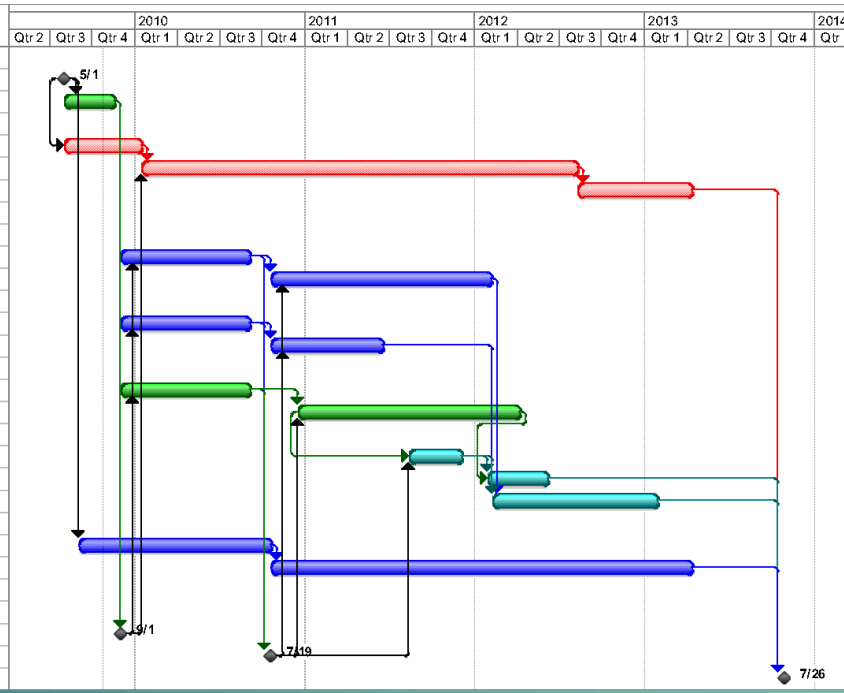
Schedule:

Three and a half year project: ~30 Months to build laser

CD-4 date: December 2014

Managed to an early finish - January 2013

ID	WBS	Task Name	Start	Finish
1	1	**BELLA Project**	**5/1/09**	**7/26/13**
2		Project Start	5/1/09	5/1/09
3		Environmental Assessment (NEPA/CEQA)	5/1/09	8/18/09
4	1.1	**Laser System**	**5/1/09**	**1/8/13**
5	1.1.1	Bid & Award Subcontract	5/1/09	10/14/09
6	1.1.2	Laser System Production	10/15/09	5/7/12
7	1.1.3	Laser Installation & Acceptance Testing	5/8/12	1/8/13
8	1.2	**Ancillary Systems**	**9/1/09**	**11/4/11**
9	1.2.1	**Opto-Mechanical Systems**	**9/1/09**	**11/4/11**
10	1.2.1.1	Design	9/1/09	6/3/10
11	1.2.1.2	Production	7/20/10	11/4/11
12	1.2.2	**Electronics & Controls Systems**	**9/1/09**	**3/15/11**
13	1.2.2.1	Design	9/1/09	6/3/10
14	1.2.2.2	Production	7/20/10	3/15/11
15	1.3	**Conventional Facilities**	**9/1/09**	**1/5/12**
16	1.3.1	Design	9/1/09	6/3/10
17	1.3.2	Construction	9/15/10	1/5/12
18	1.4	**Site & System Integration**	**5/11/11**	**10/25/12**
19	1.4.1	Planning	5/11/11	9/1/11
20	1.4.2	Outfitting	10/28/11	3/5/12
21	1.4.3	Installation & Integration	11/7/11	10/25/12
22	1.5	**Project Management/ES&H**	**6/1/09**	**1/8/13**
23	1.5.1	Phase A	6/1/09	7/19/10
24	1.5.2	Phase B	7/20/10	1/8/13
25				
26		**Critical Decision Milestones**	**9/1/09**	**7/26/13**
27		CD1/2A/3A Approval	9/1/09	9/1/09
28		CD 2B/3B Approval	7/19/10	7/19/10
29		CD 4A/4B Approval	7/26/13	7/26/13



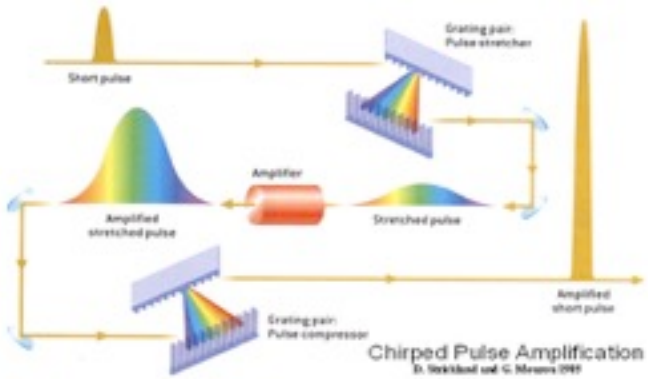
BELLA utility room

Seed oscillator → multiple booster amplifier stages

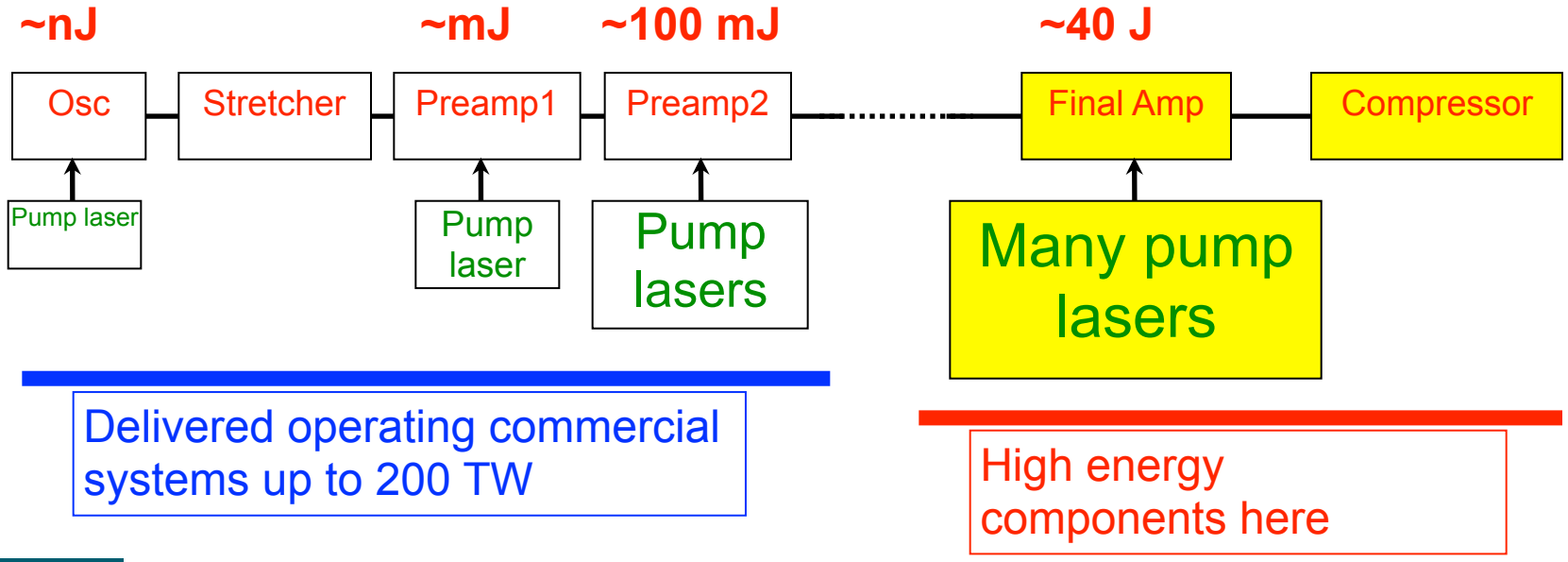
To avoid optical damage during amplification:

expansion → amplification → compression

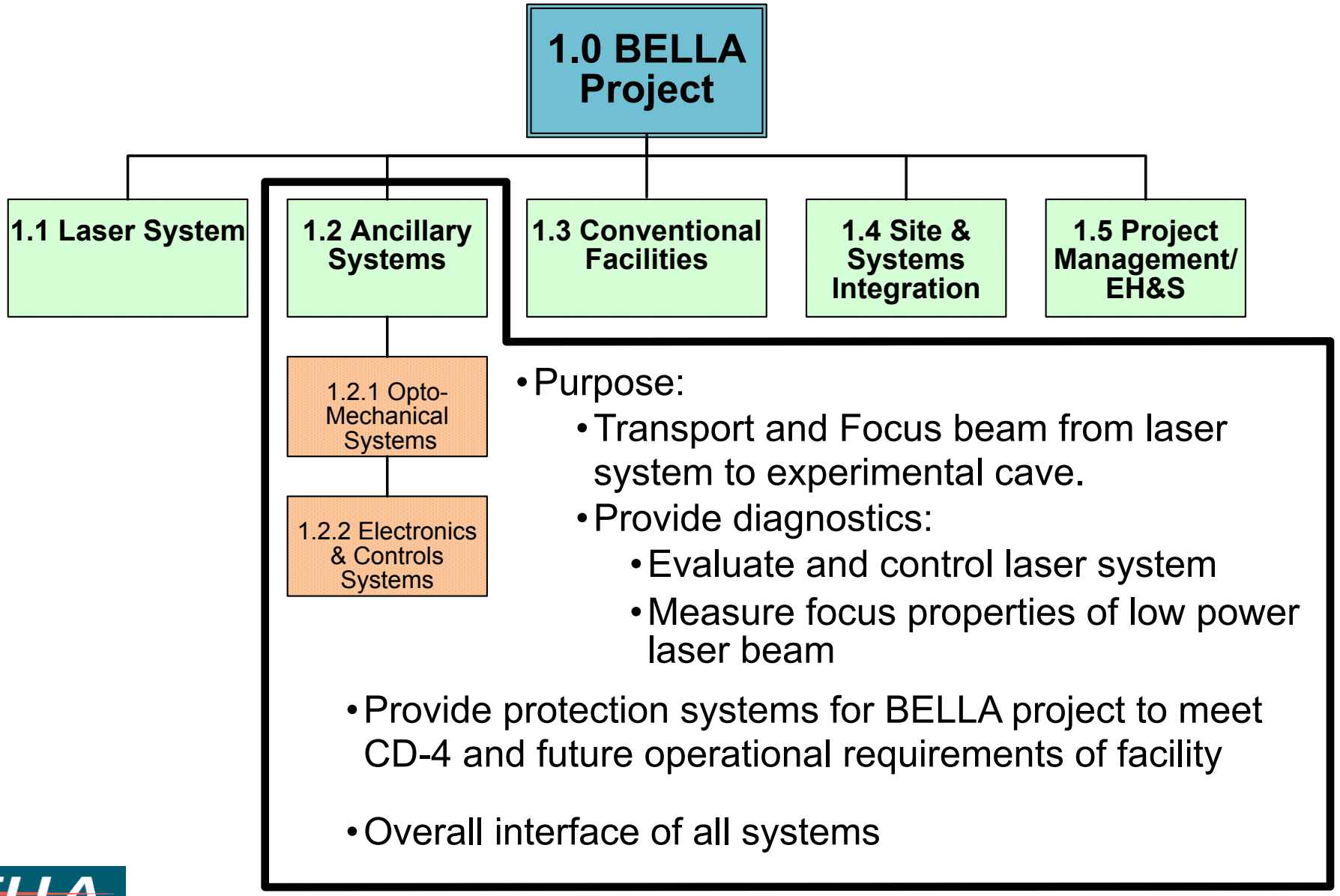
both in space and time



- Ti:sapphire active material - **800 nm**
- Pumped with SHG of Nd:YAG lasers - **532 nm**



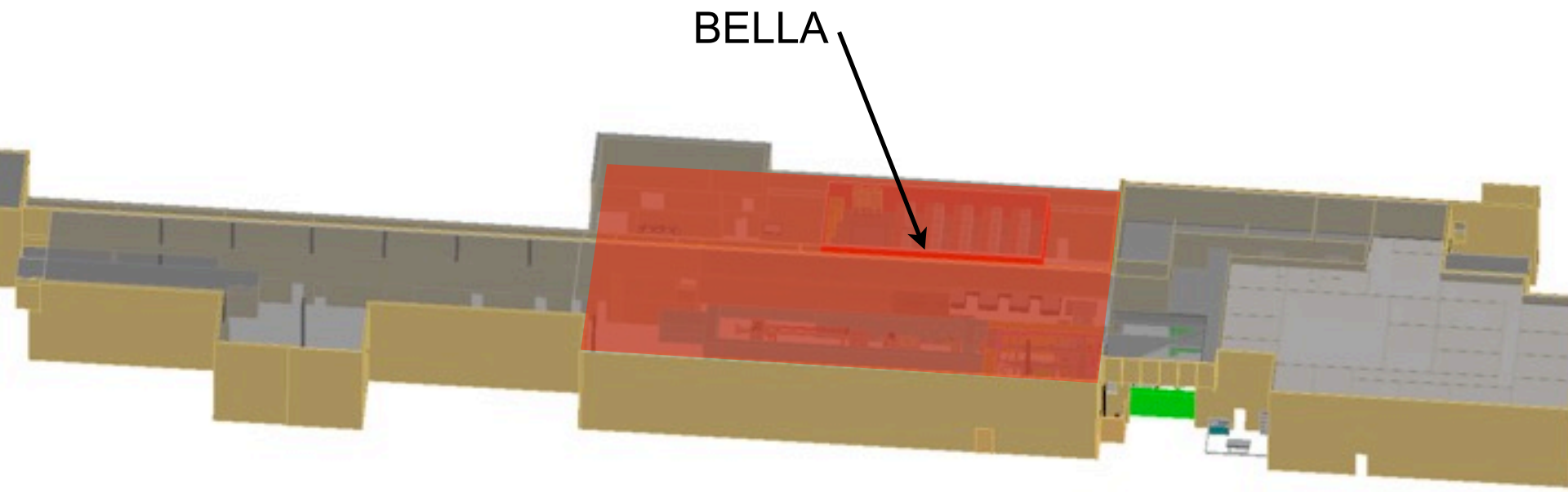
Ancillary Systems



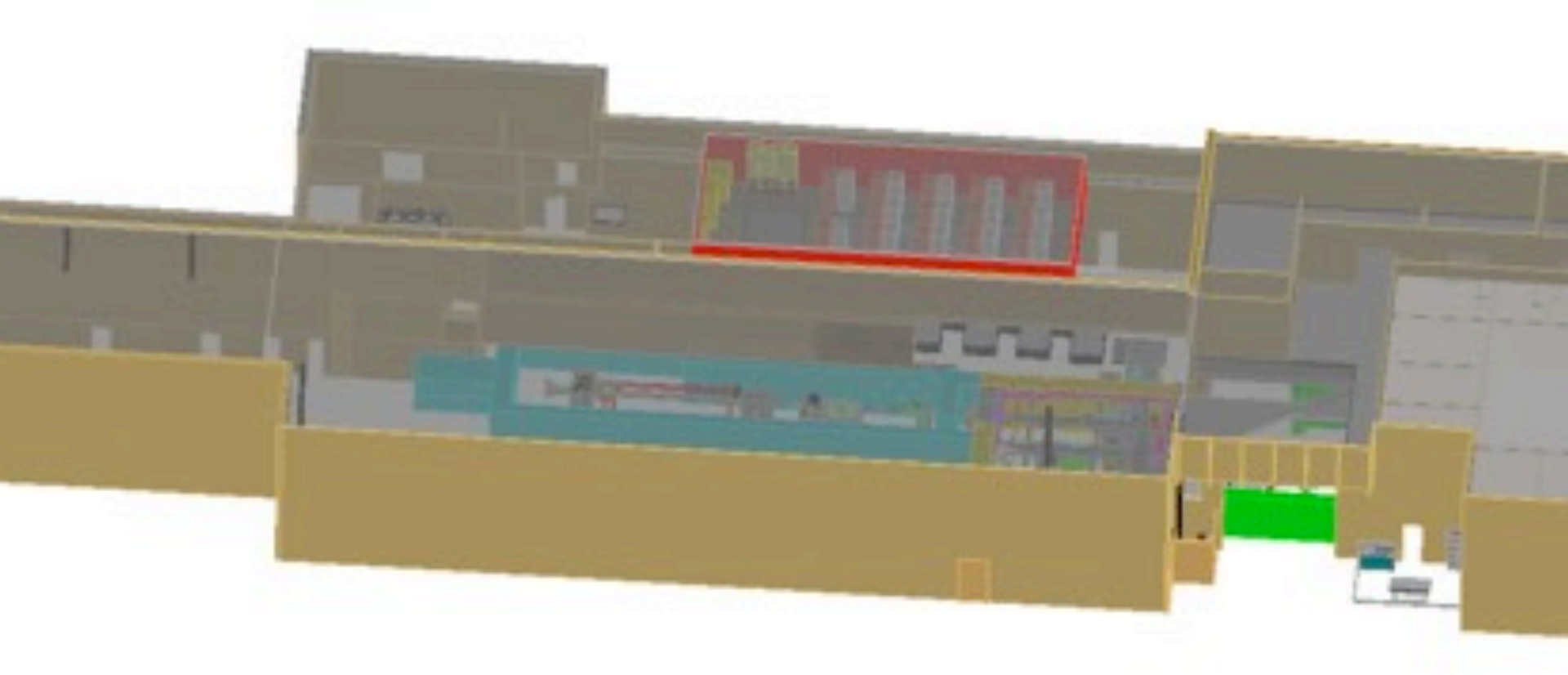
Building 71 location

Building 71 location

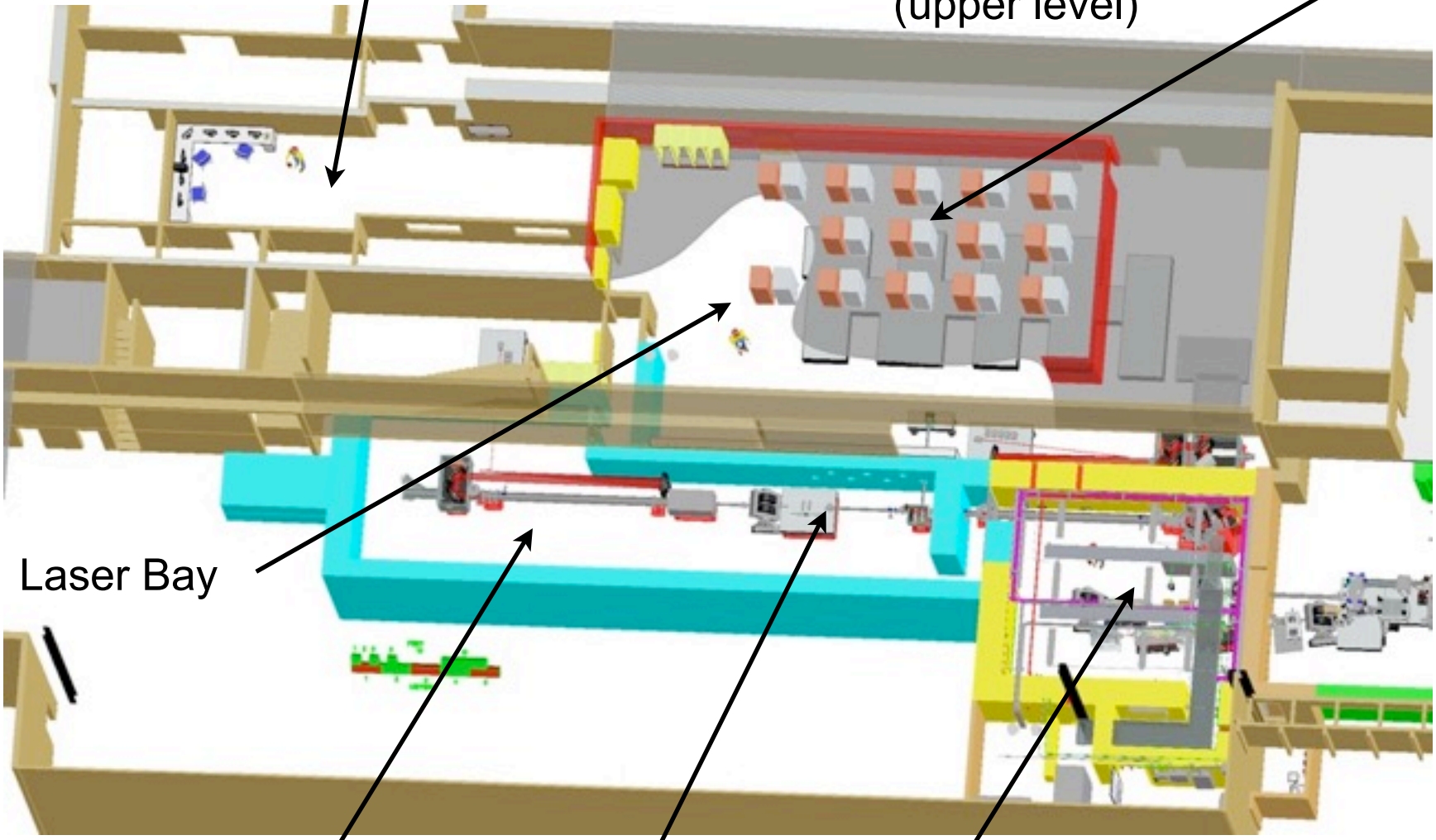
Building 71 location CAD Layout



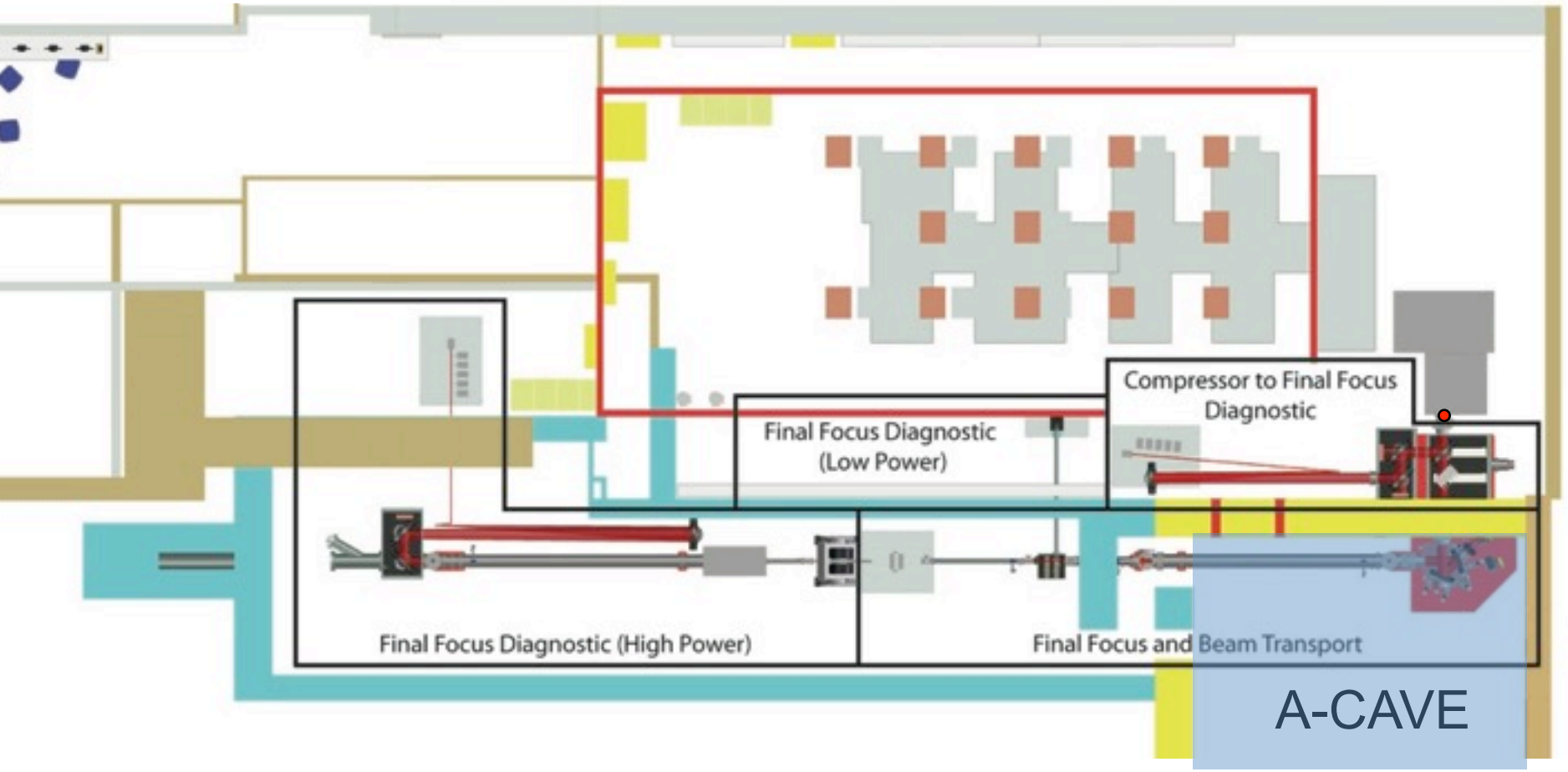
Building 71 location CAD Layout



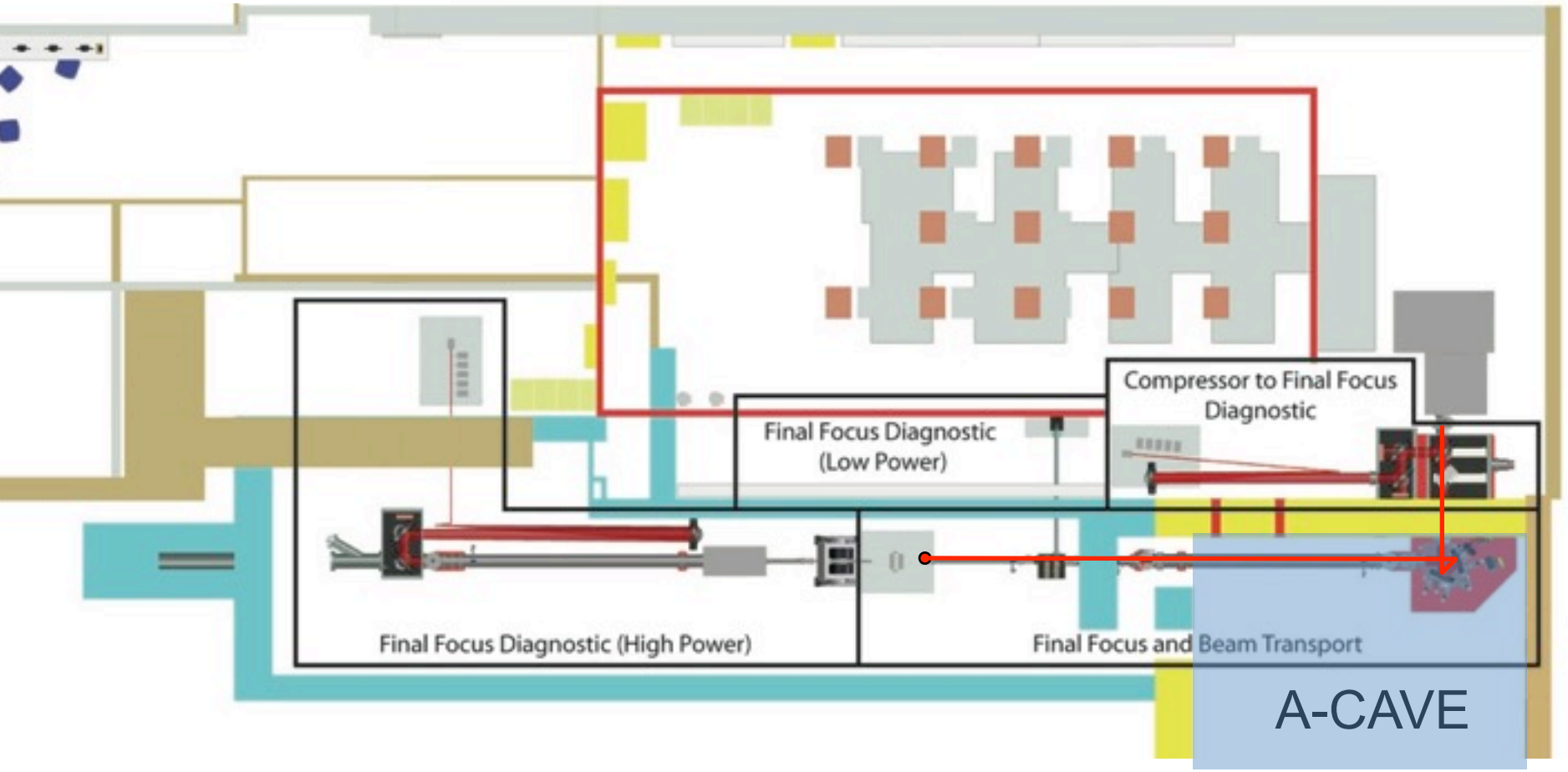
BELLA A-Cave Detail



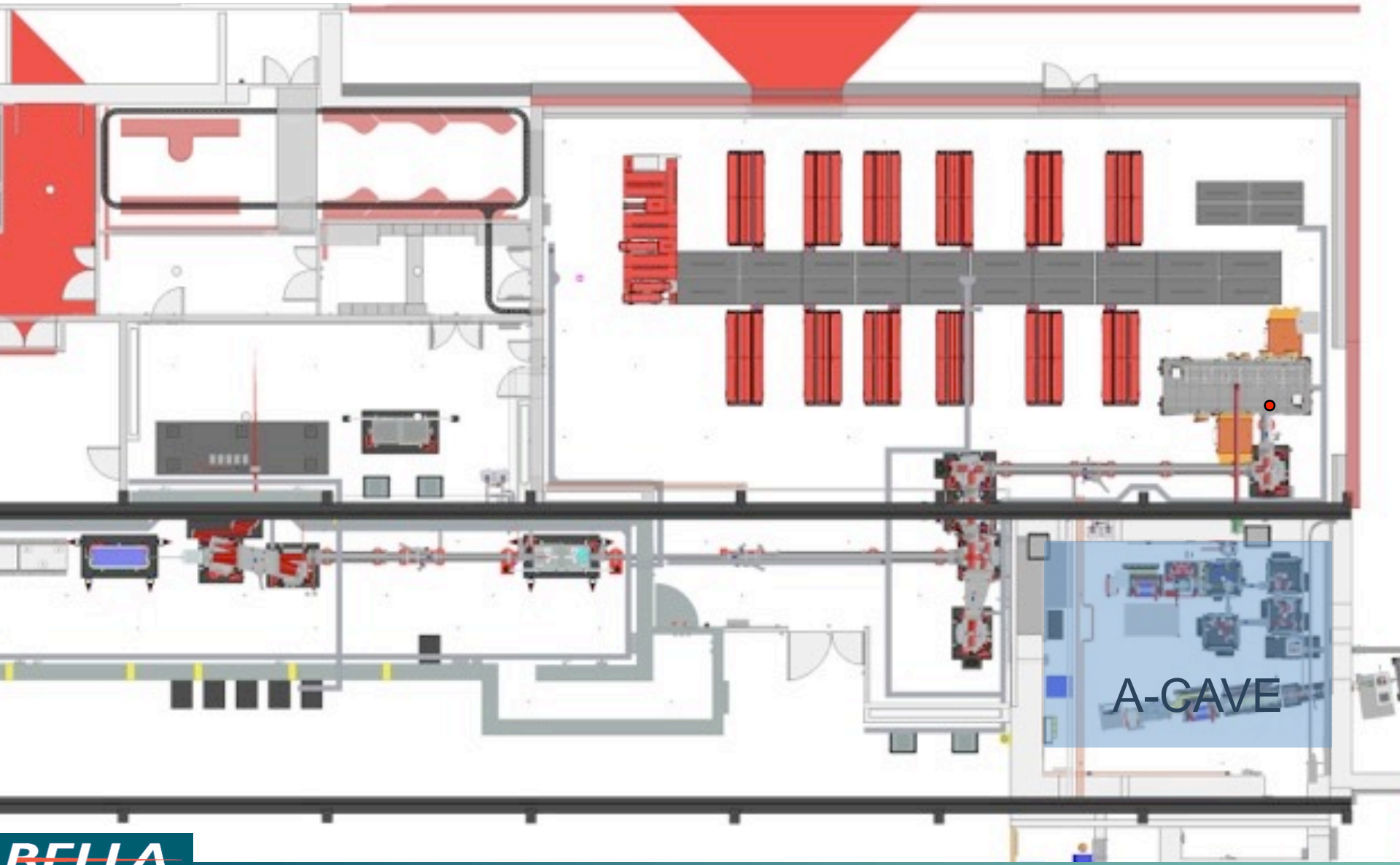
CD-1 layout for BELLA coupled operations with A-Cave



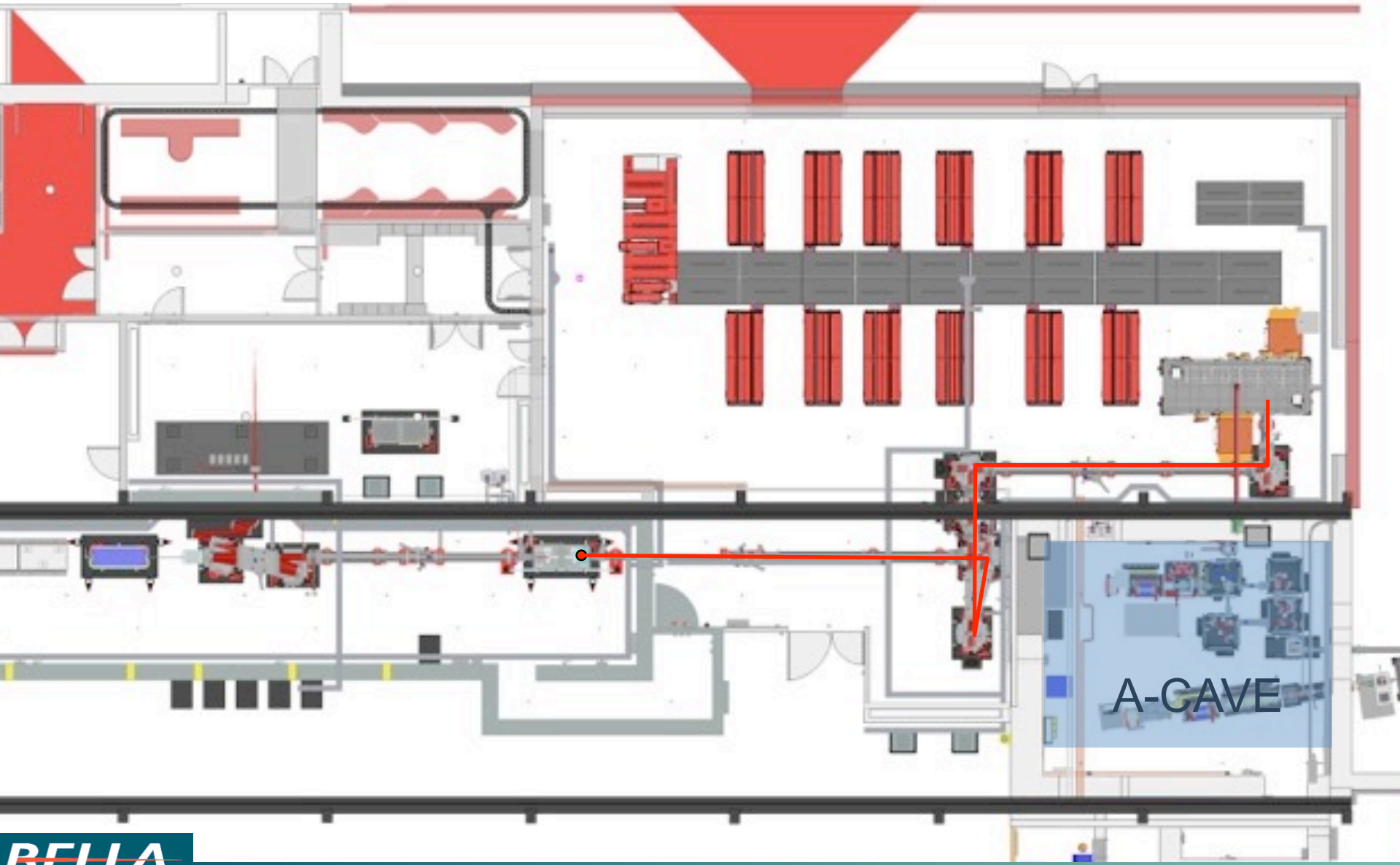
CD-1 layout for BELLA coupled operations with A-Cave



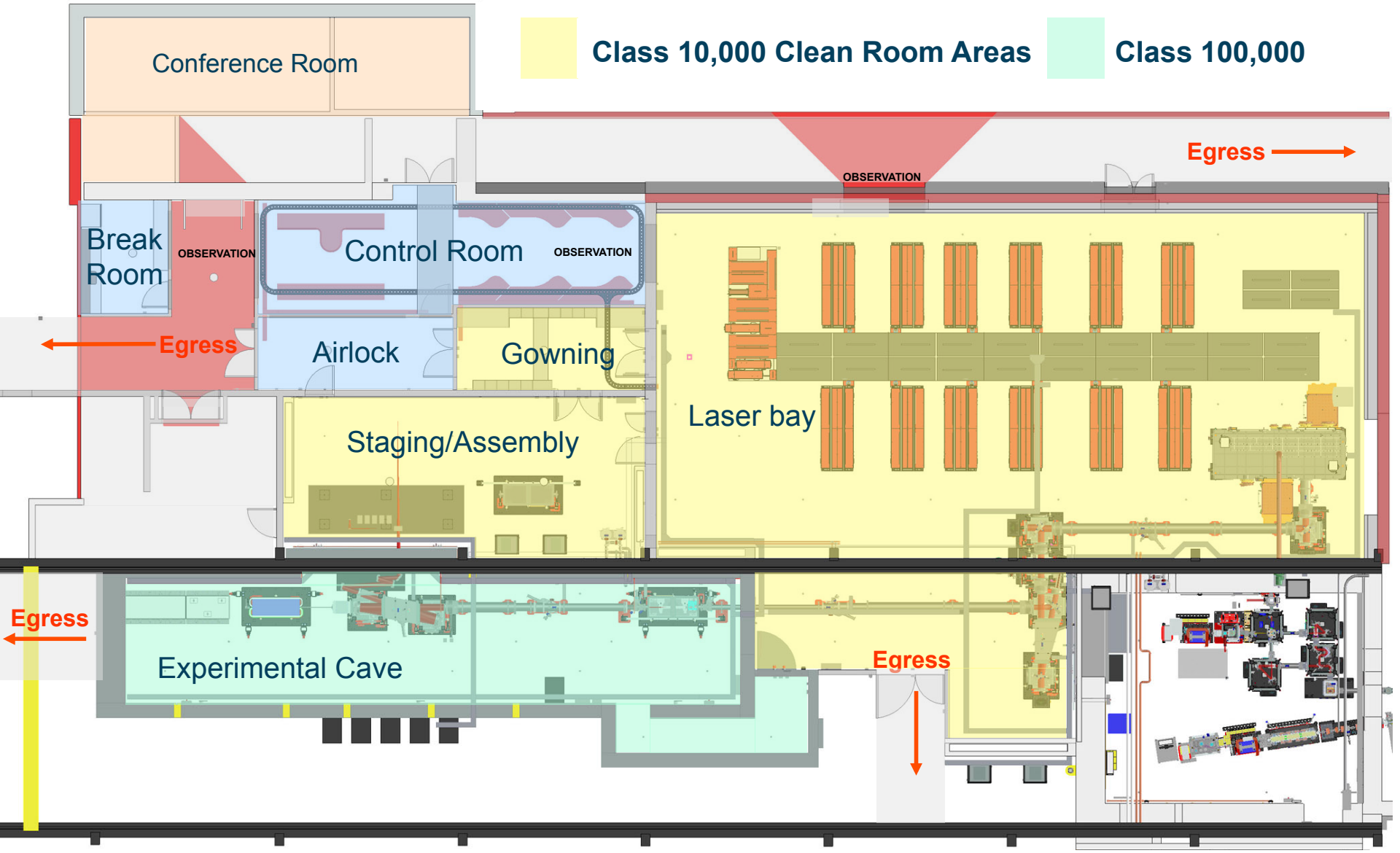
BELLA final layout
allows Independent operations BELLA and A-Cave



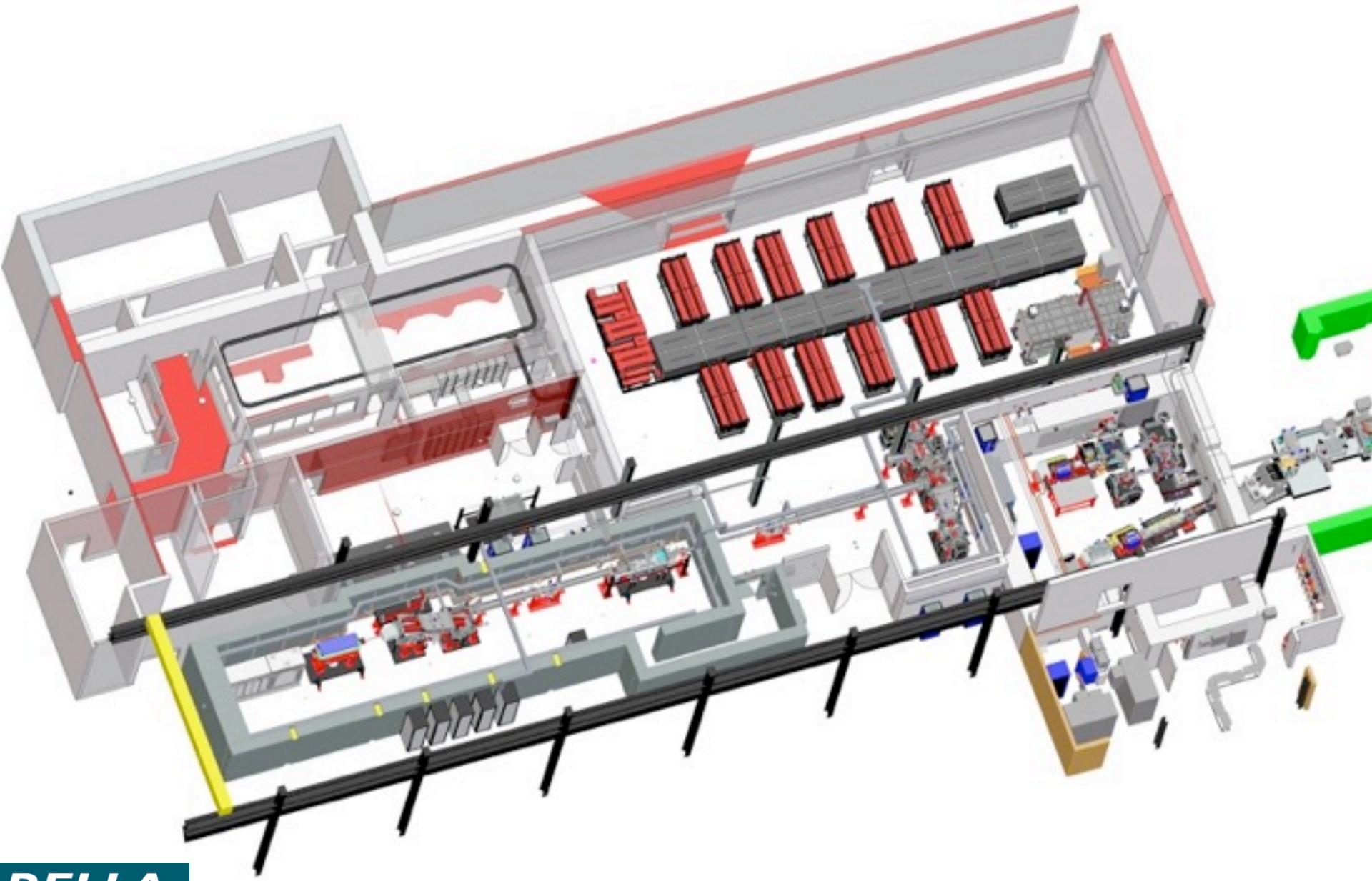
BELLA final layout
allows Independent operations BELLA and A-Cave



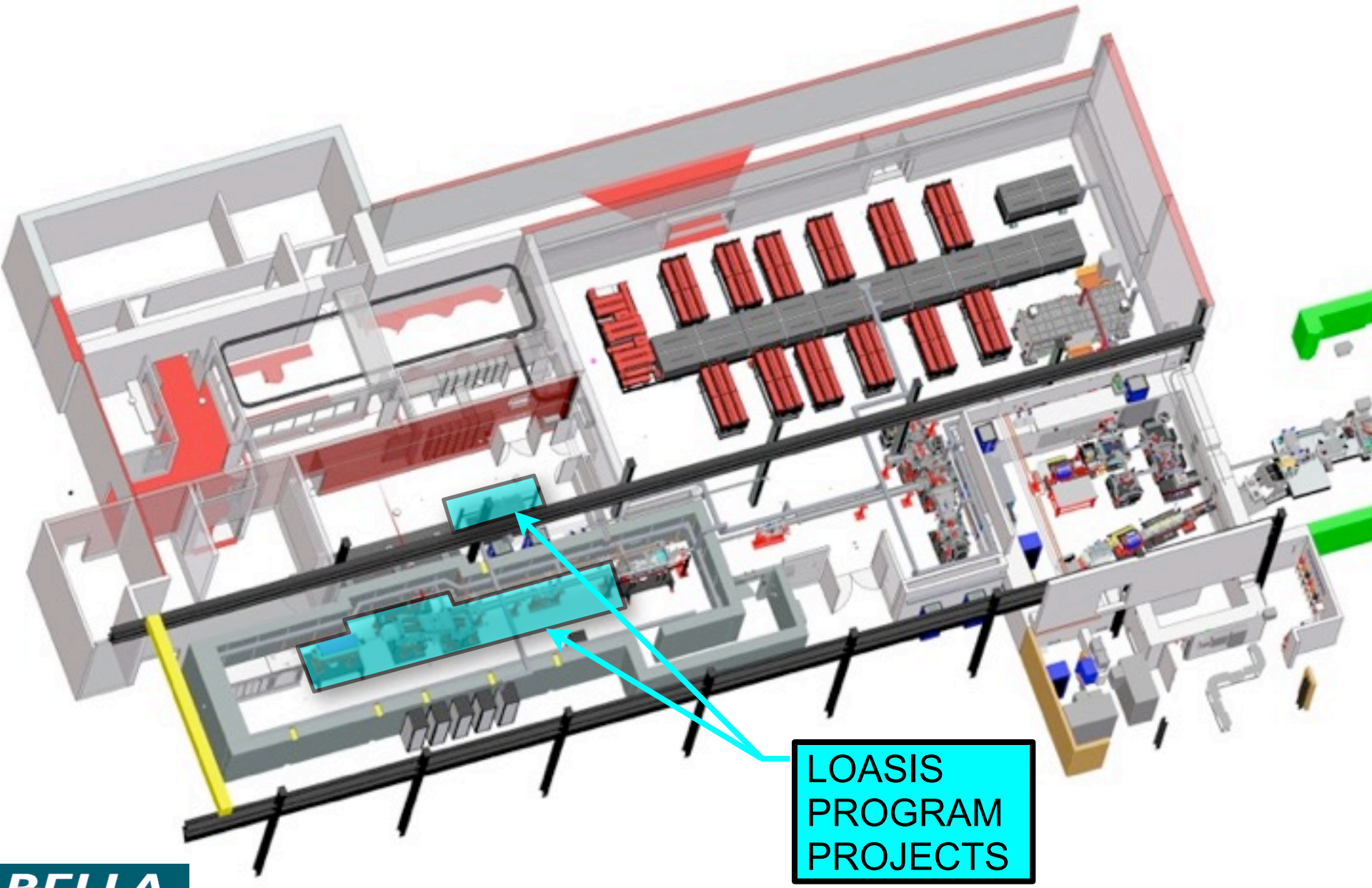
BELLA Room Layout



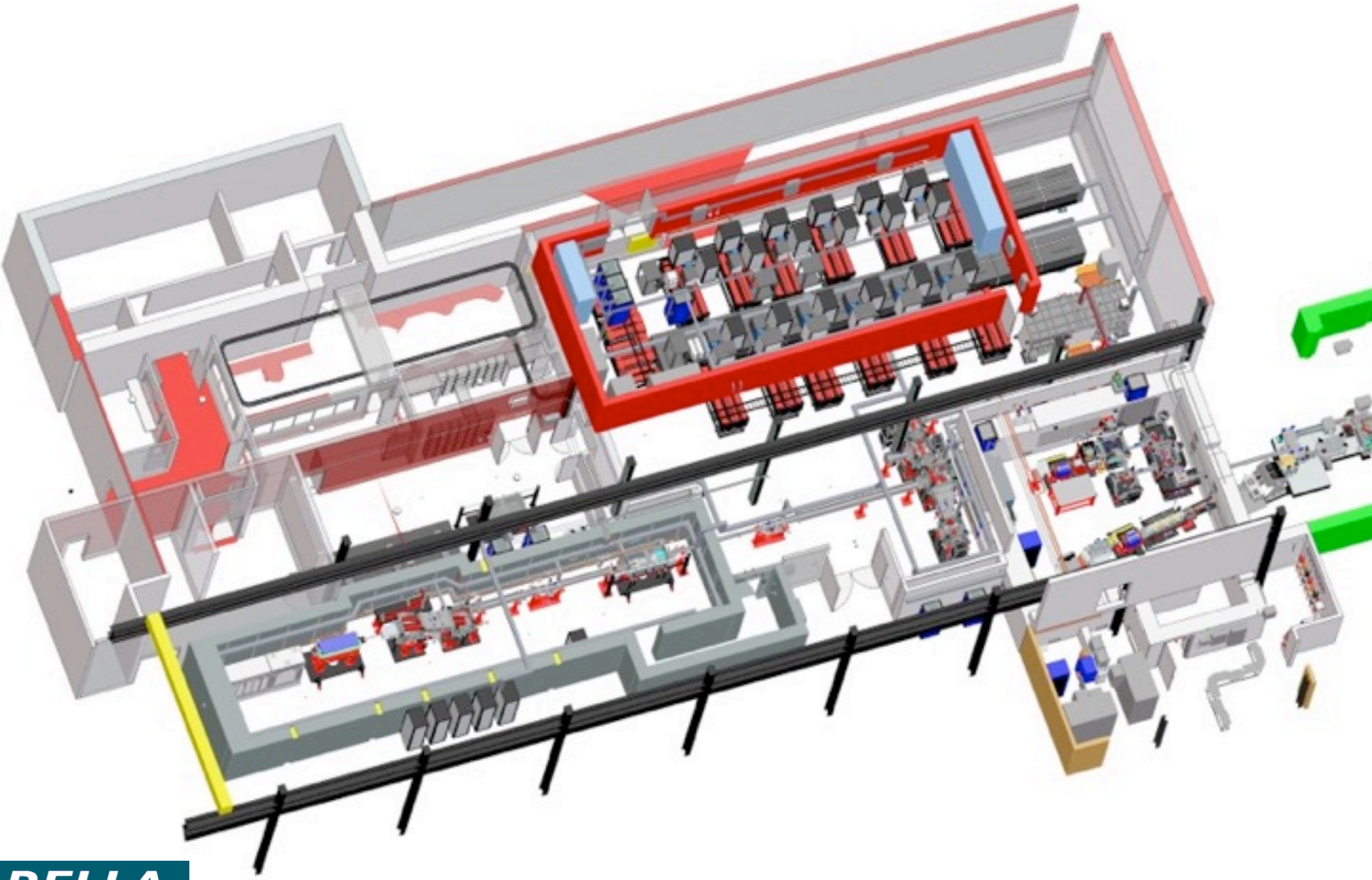
Post BELLA equipment for BELLA operations



Post BELLA equipment for BELLA operations



BELLA utility room

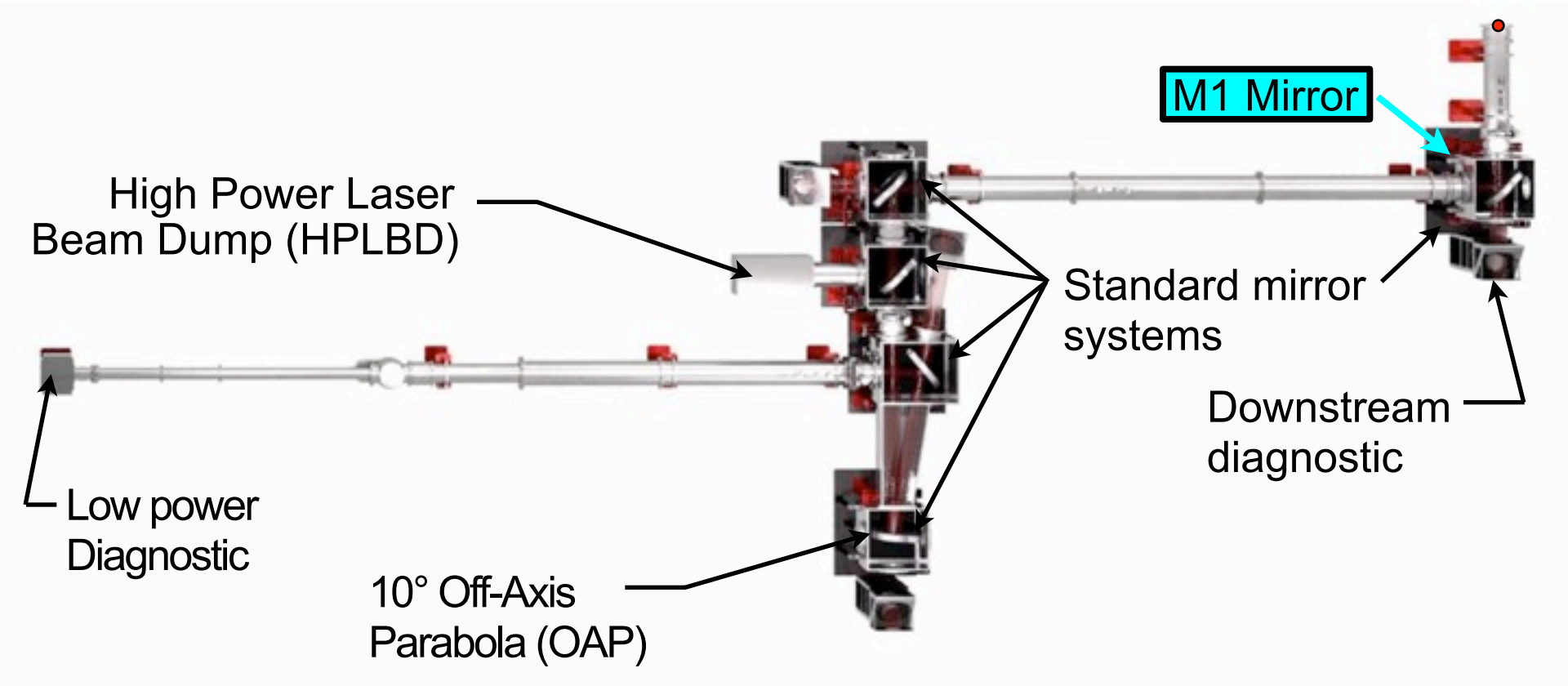


Utility Room Built on Roof

Utility Room inside (THALES power supplies delivered)

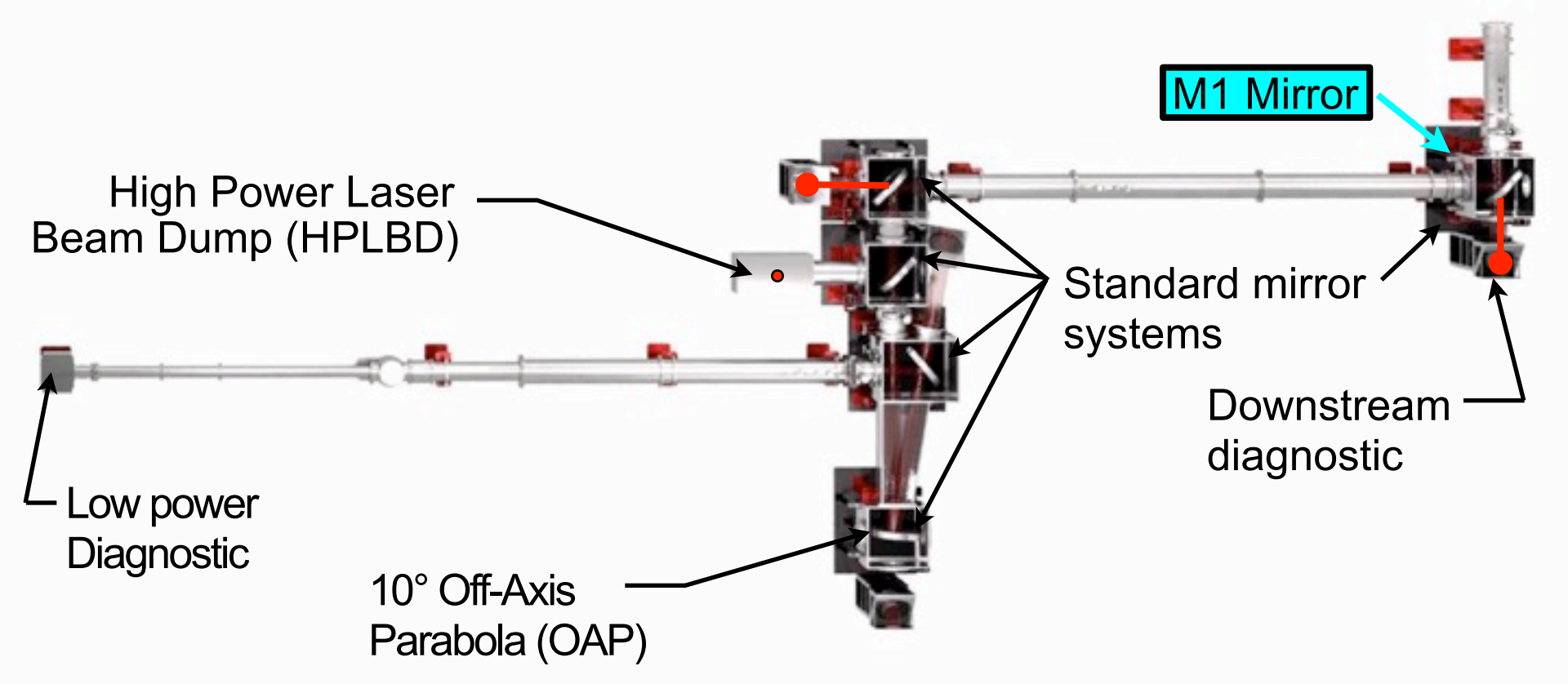
Final Focus and Beam Transport

- Based on standard design to meet KPP
  - Five nearly identical mirror systems
  - Focused spot size of ⌀50 -⌀100 μm
  - Stability and pointing <2.5 urad (0.8, 1.0 urad)



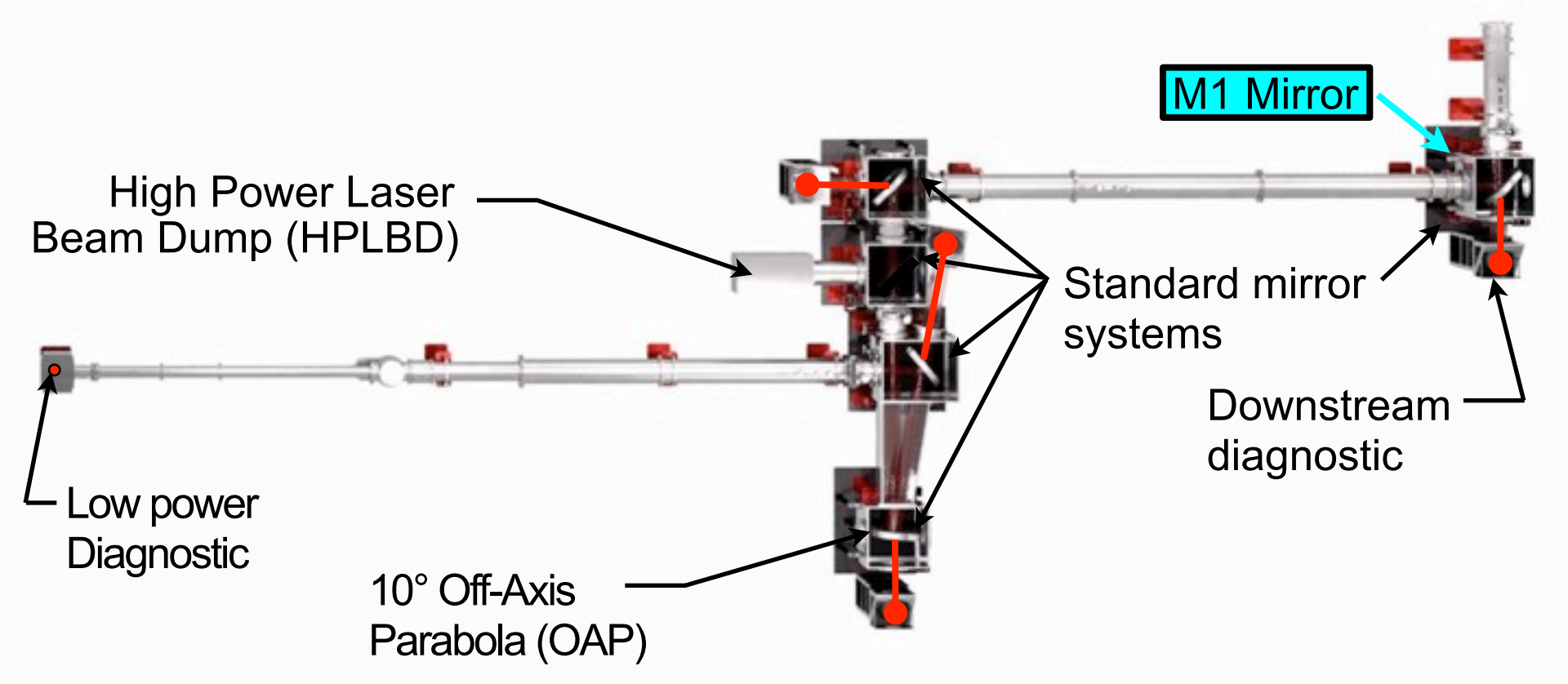
Final Focus and Beam Transport

- Based on standard design to meet KPP
  - Five nearly identical mirror systems
  - Focused spot size of ∅50 -∅100 μm
  - Stability and pointing <2.5 urad (0.8, 1.0 urad)

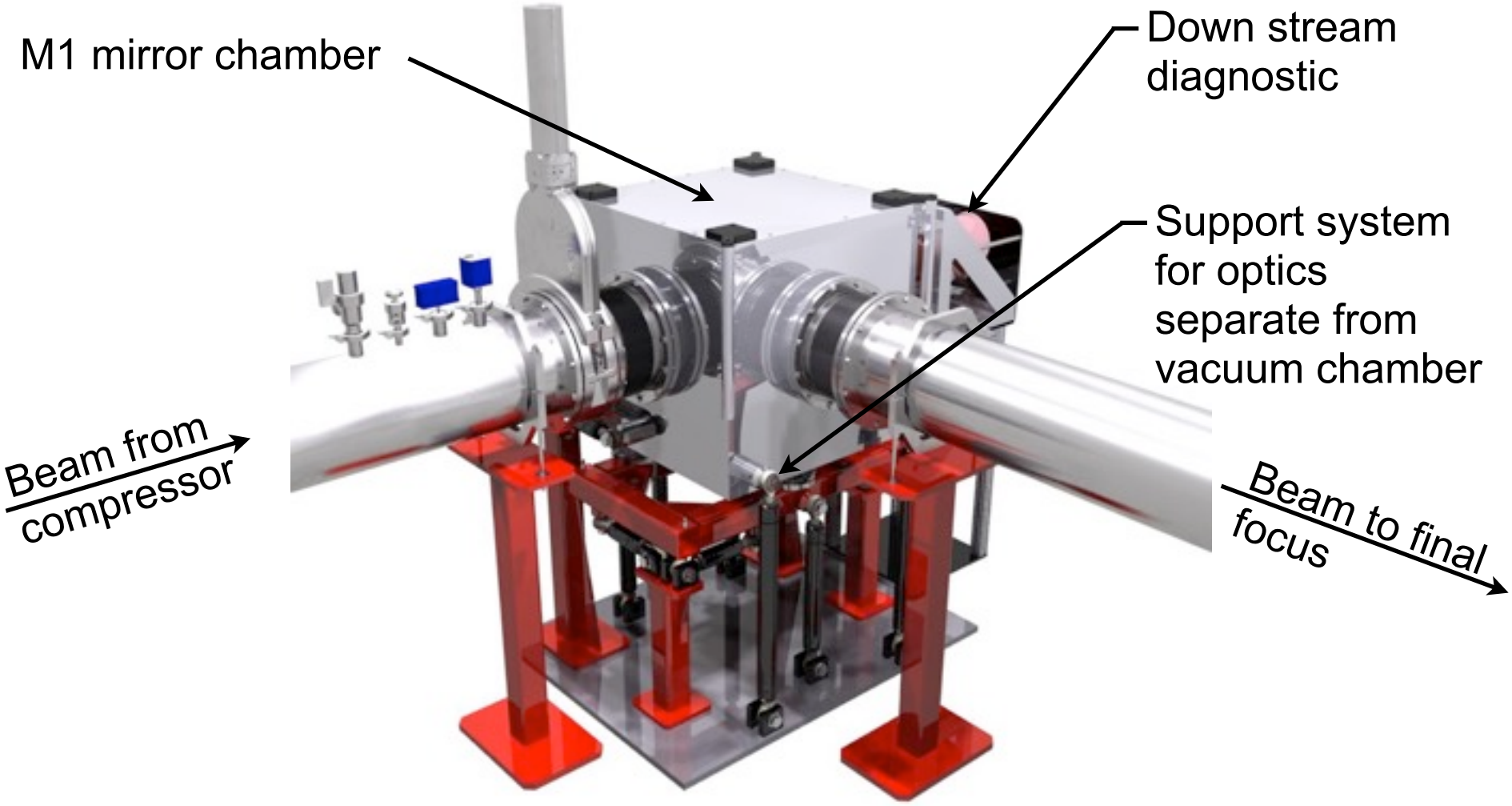


Final Focus and Beam Transport

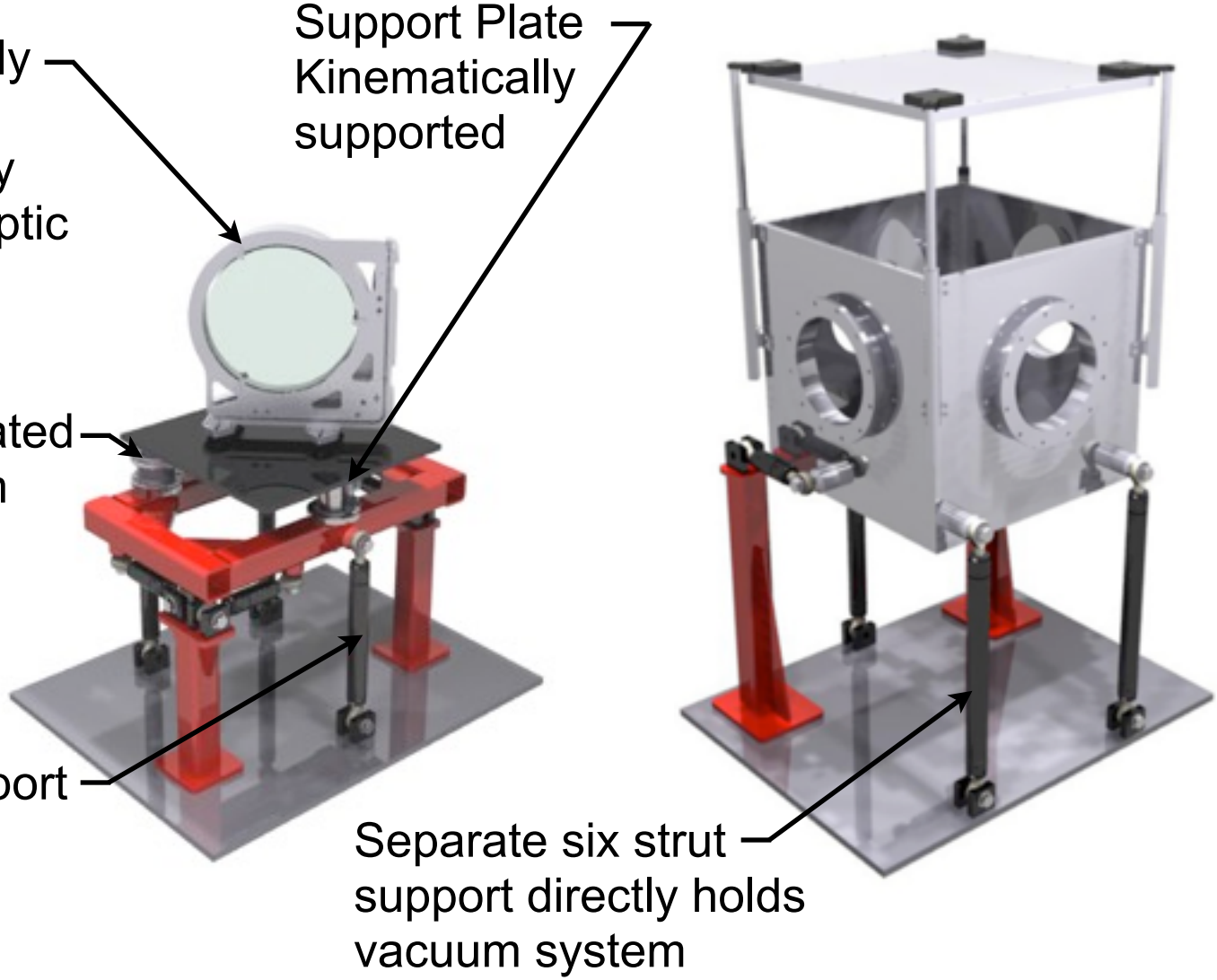
- Based on standard design to meet KPP
  - Five nearly identical mirror systems
  - Focused spot size of ⌀50 -⌀100 μm
  - Stability and pointing <2.5 urad (0.8, 1.0 urad)



Standard optics chamber and support based on six strut system

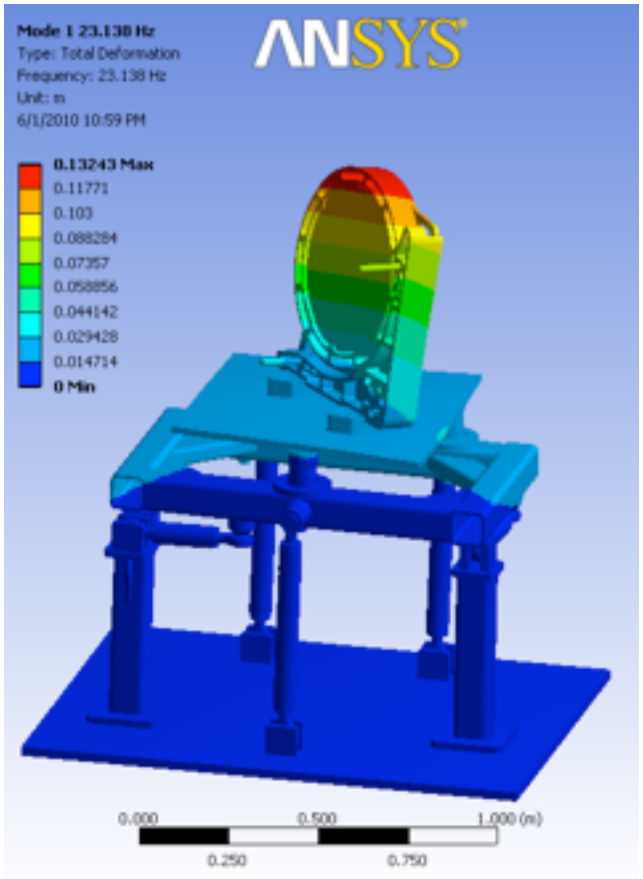


Optics system supports isolated from vacuum chamber supports

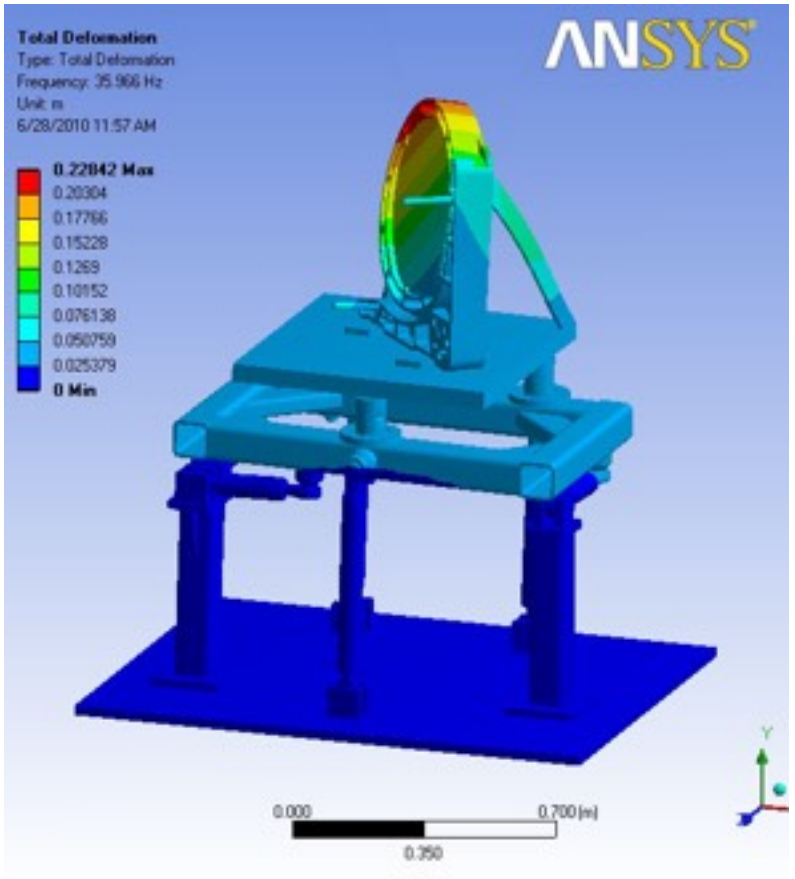


Supports optimized to isolate and minimize vibration of optic system

- Optics system supports isolated from vacuum chamber supports

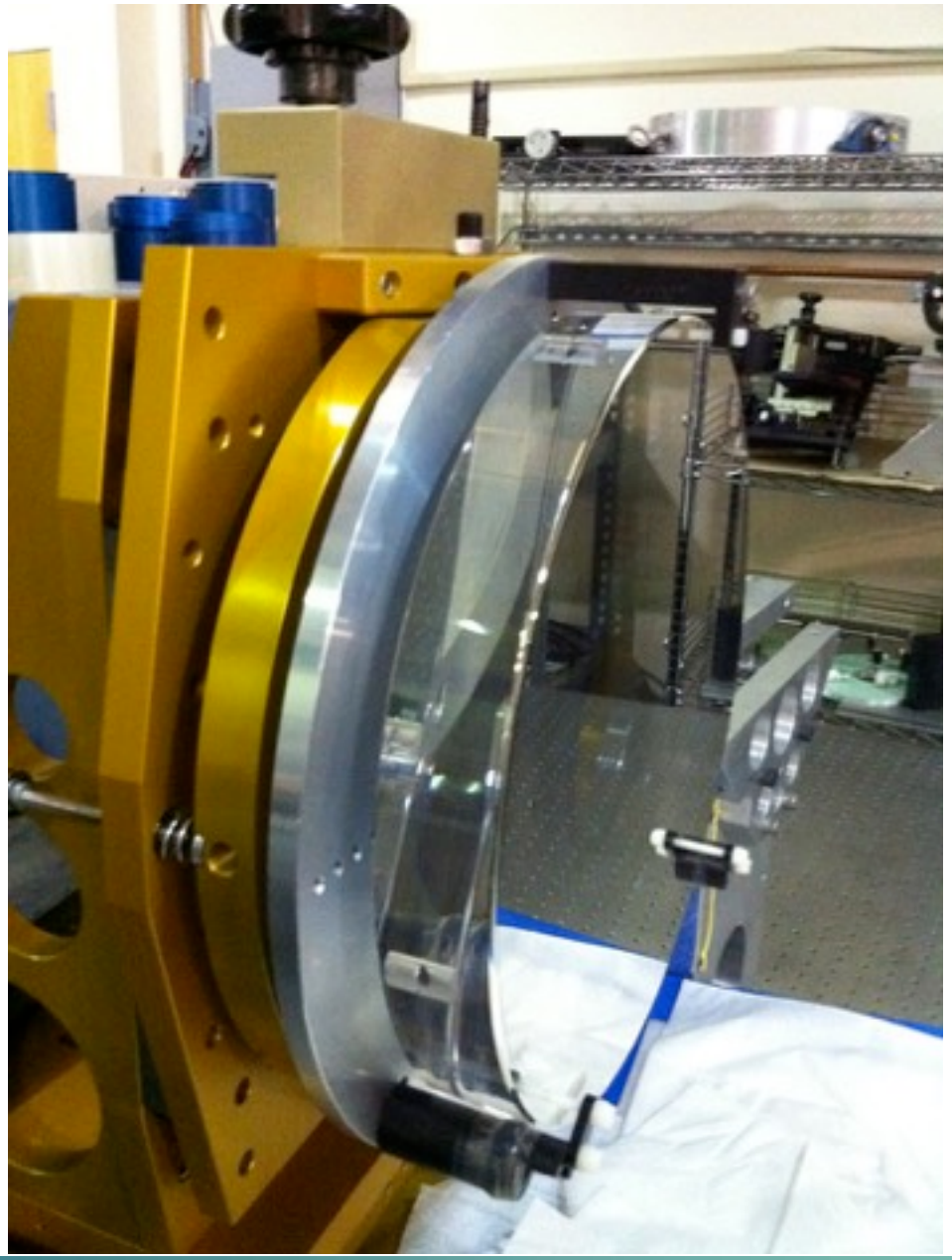


Optic support
first mode 23 Hz

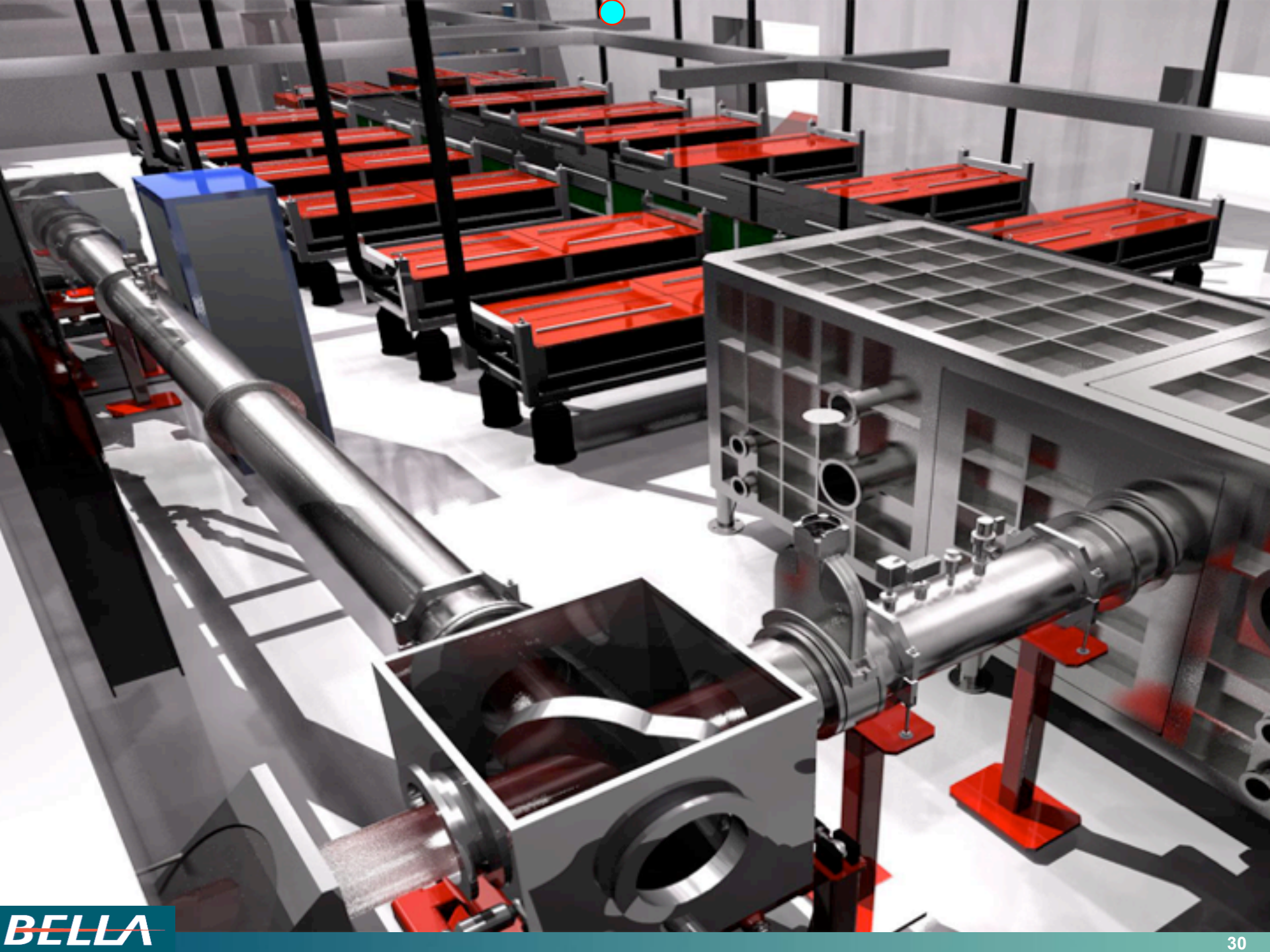


Optimized optic support
first mode (36 Hz)

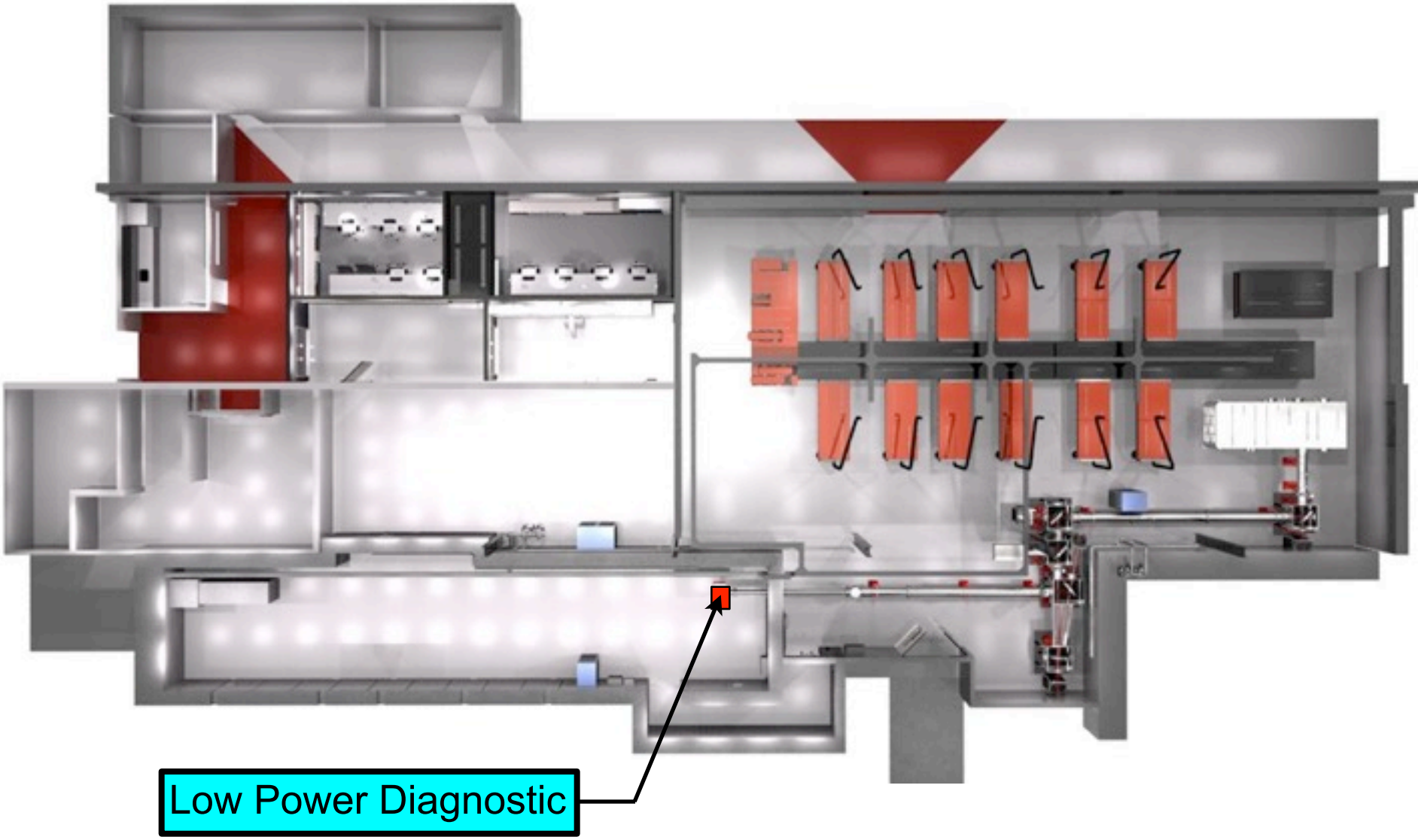
Mirror systems assembled and testing in process



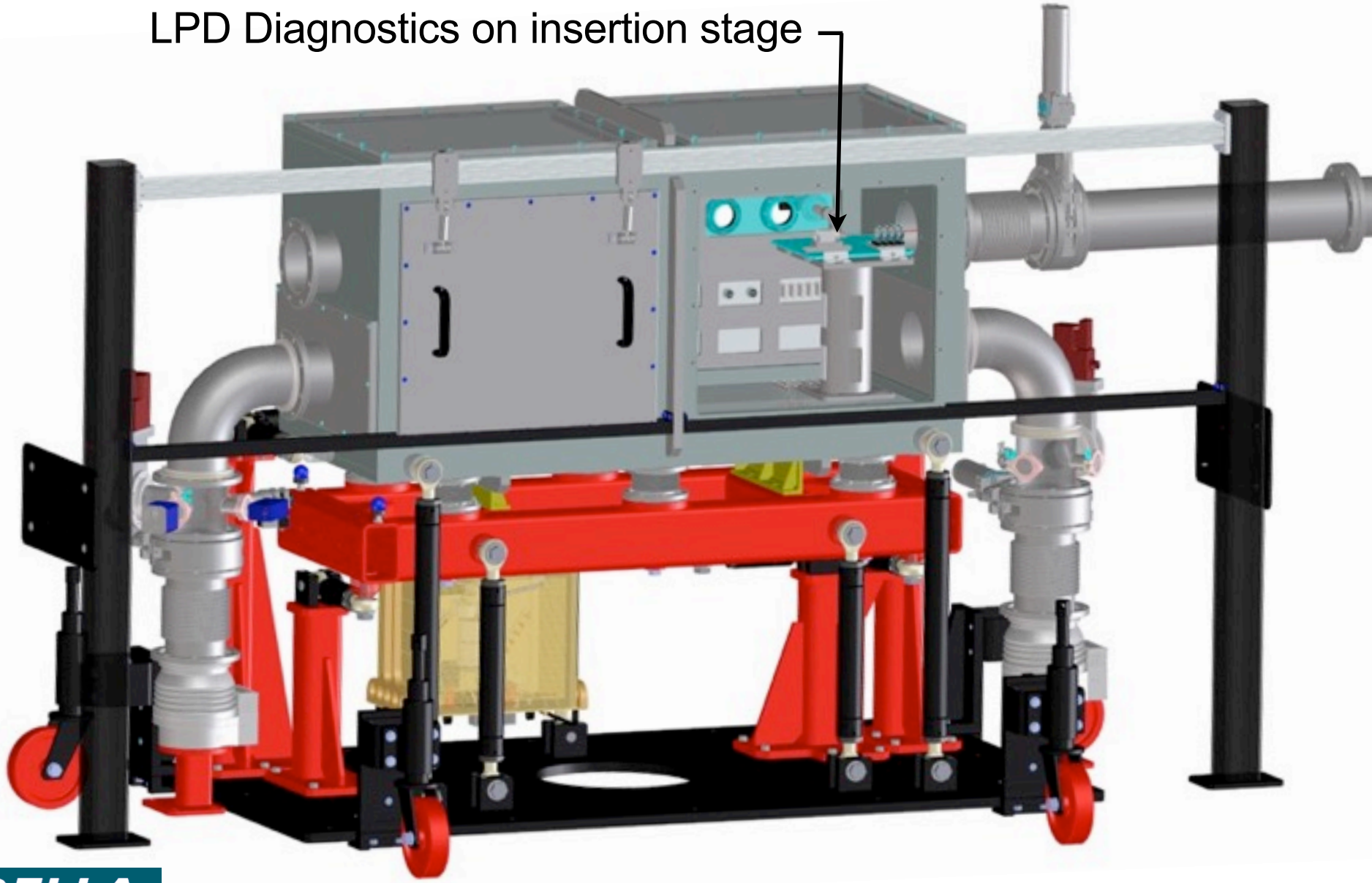

THALES
THALES



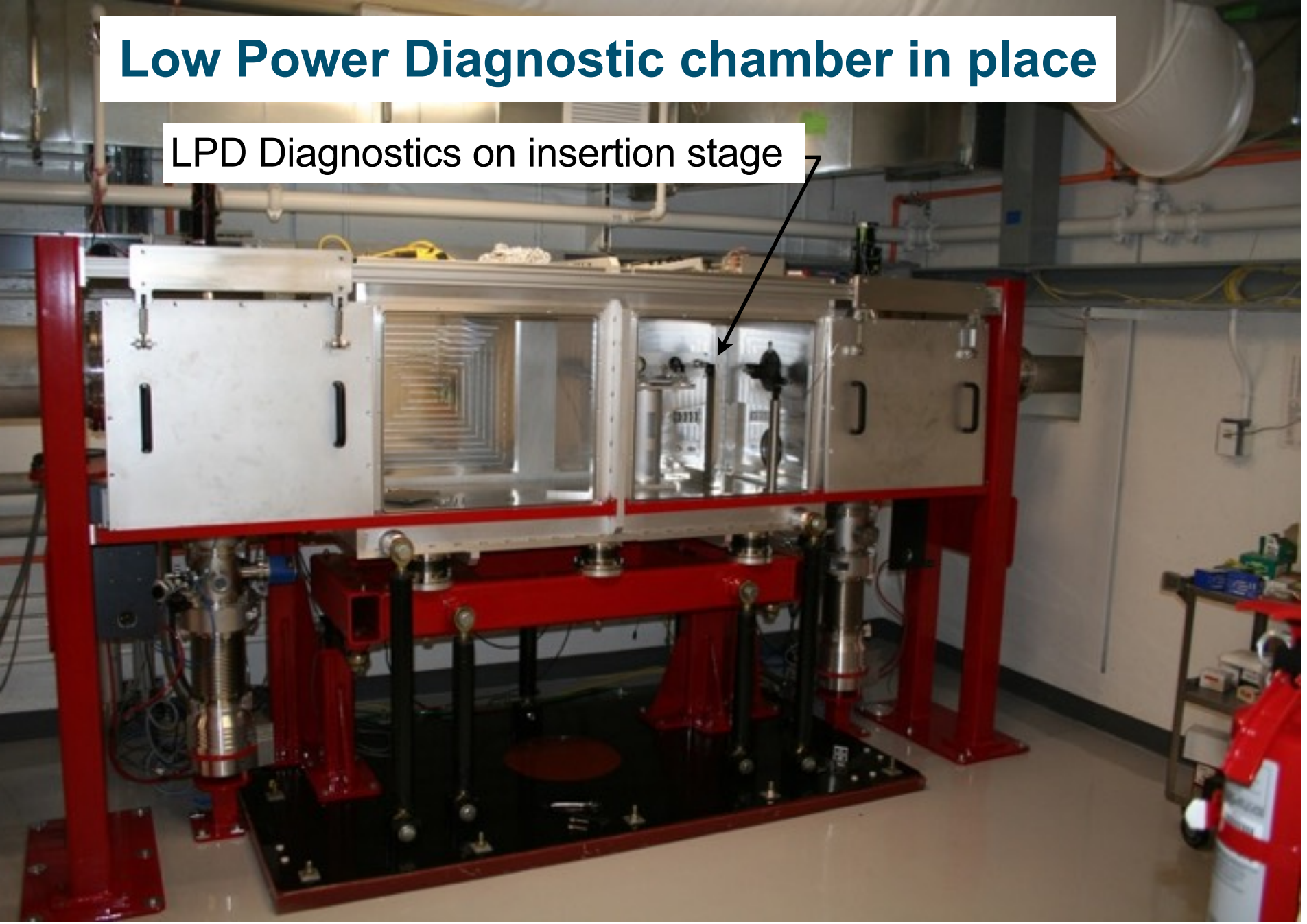
Low power diagnostic system designed for KPP validation



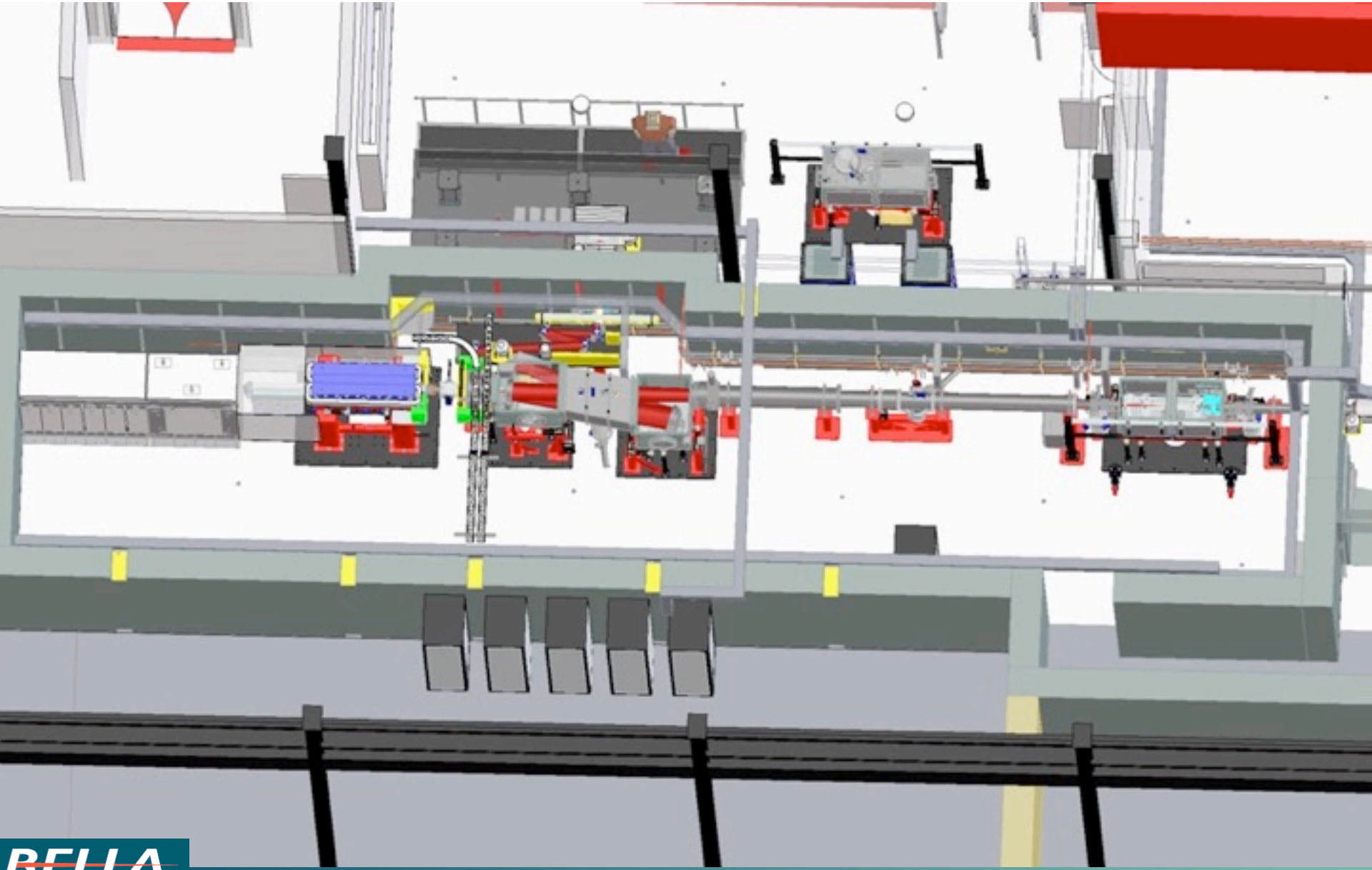
Low Power Diagnostic chamber in place

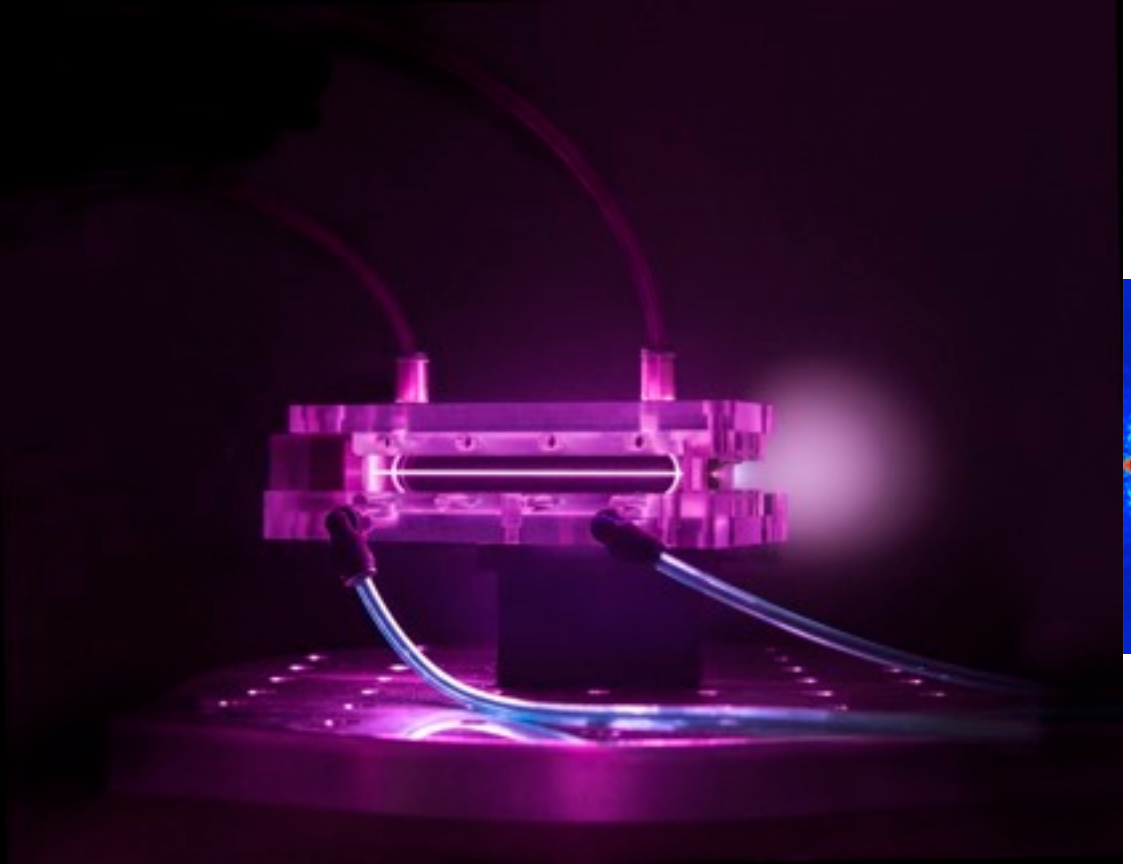


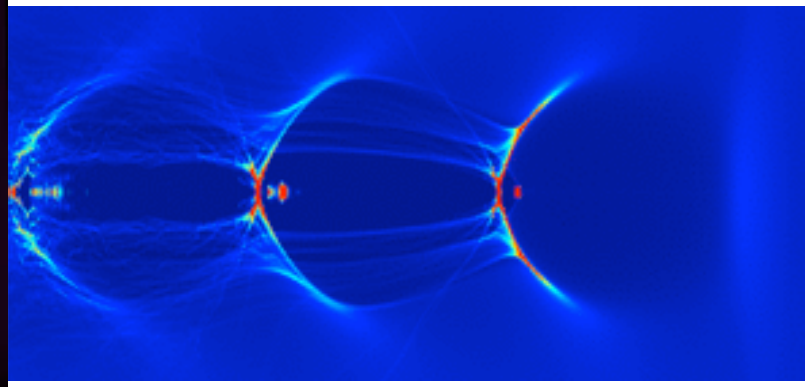
Low Power Diagnostic chamber in place



Post BELLA equipment for BELLA operations







Multi-GeV electron beams with energy up to 4.2 GeV, 6% rms energy spread, 6 pC charge, and 0.3 mrad rms divergence have been produced from a 9-cm-long capillary discharge waveguide with a plasma density of ≈7×10e17 cm−3, powered by laser pulses with peak power up to 0.3 PW.

Lessons Learned (hopefully)

3-D CAD *Modeling of the whole* BELLA *Facility.*
3rd Party review of complete design.

Long lead optics are always a significant risk

Logistical planning

The laser was transported in approximately 90 crates weighing a total of 40 metric tons. It took 3 large flatbed trucks to carry this entire load from the San Francisco International airport to LBNL. All these boxes were stored in a high-bay area in building 71 (see photograph), the same building that houses the BELLA facility.

Clean room details and experience

It may be part of the design specs on paper, but if the construction contractor does not have significant experience with cleanroom construction, the bid will likely ignore significant additional time and cost.

Transition to Operations

The BELLA management team was in place to keep the BELLA project on track and several members of the team had to devote time to the design and development of systems needed for the post-project phase. Part of the technical staff had to be shared between BELLA project and post-BELLA.

Adequate management effort has to be allocated to tasks associated with the transition to operations and future scientific operations, and the planning and scheduling have to be synchronized between the project and post-project activities.

Thank You