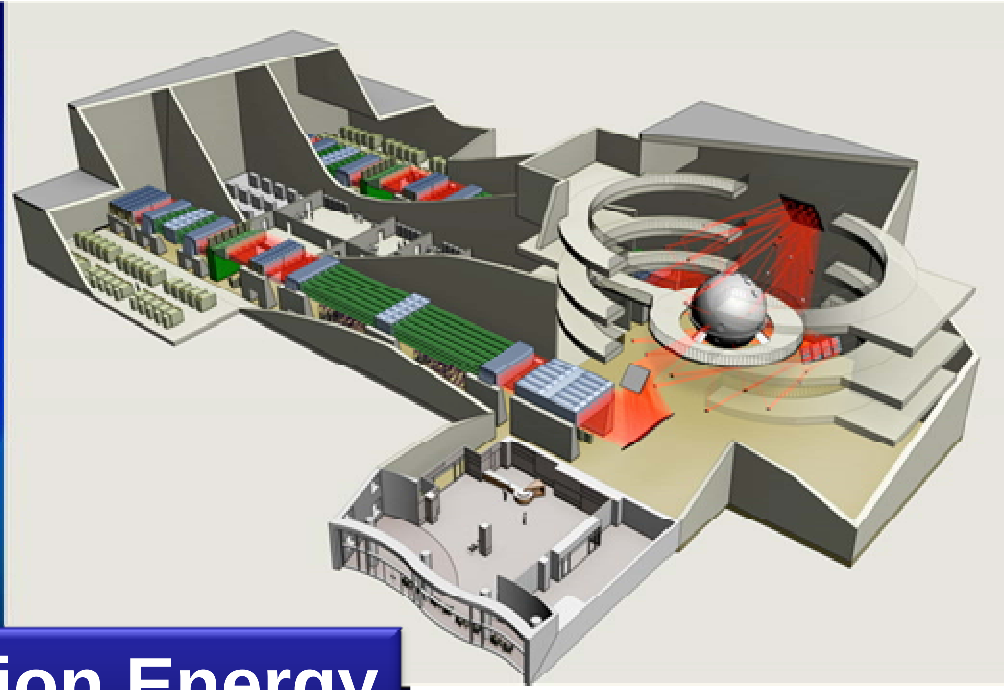
HiPER



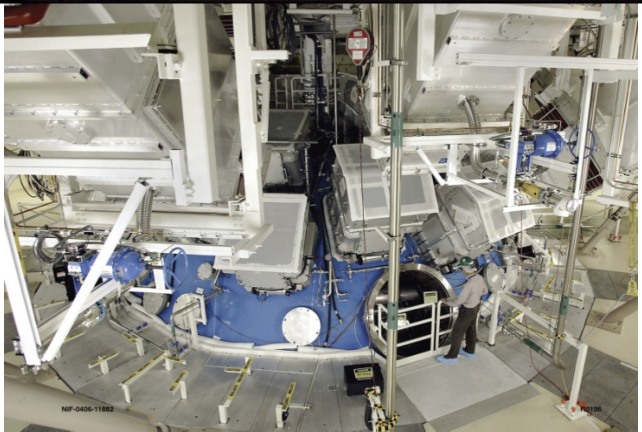
Laser Fusion Energy

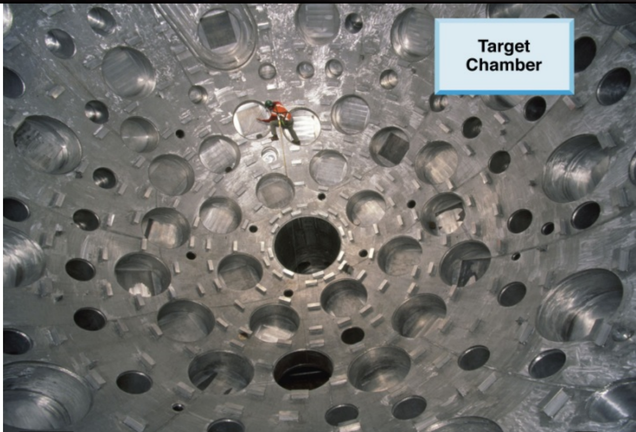
m.dunne@stfc.ac.uk

HiPER Overall perspective on laser fusion

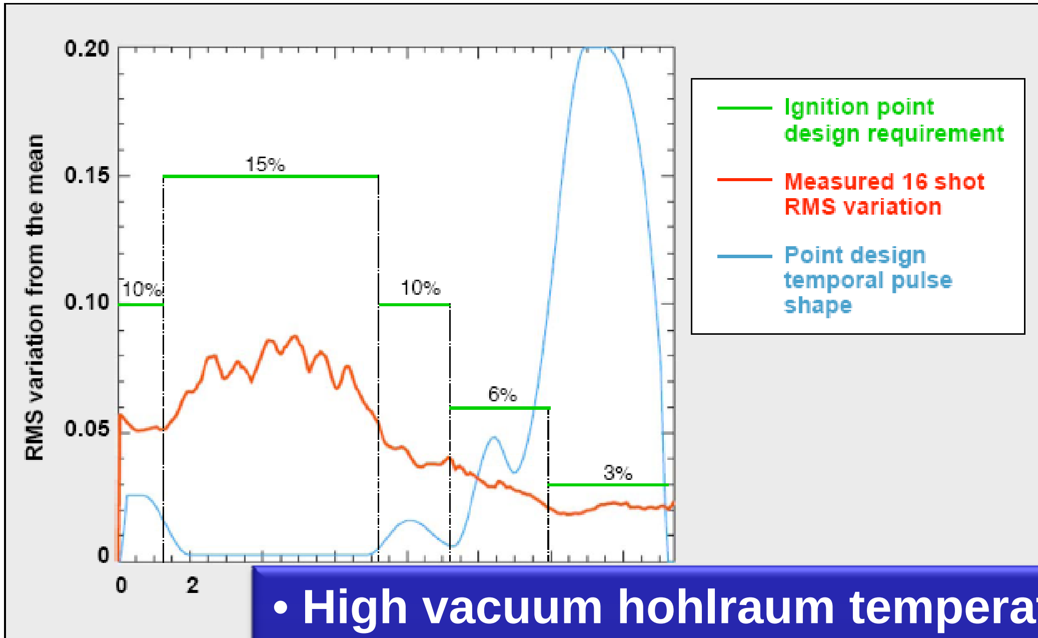
- It's been a long time since the early promises in the 1960s !
- The 50 year scientific journey for laser fusion culminates in ~2 years
- The driver technology will be finalised in the next ~7 years
  - benefits from major (multi-100 M€) funding from Europe
- Wealth of industrial & investment opportunities – IP, jobs, skills, export
  - builds from existing supply chain & opens new markets
  - overlap with MFE in the fusion technology area
- Funding shift from public to private sector as risk decreases
- Next phase commitment contingent on evidence of energy gain (NIF)
- UK leadership from systems prototypes to demo power plant ?

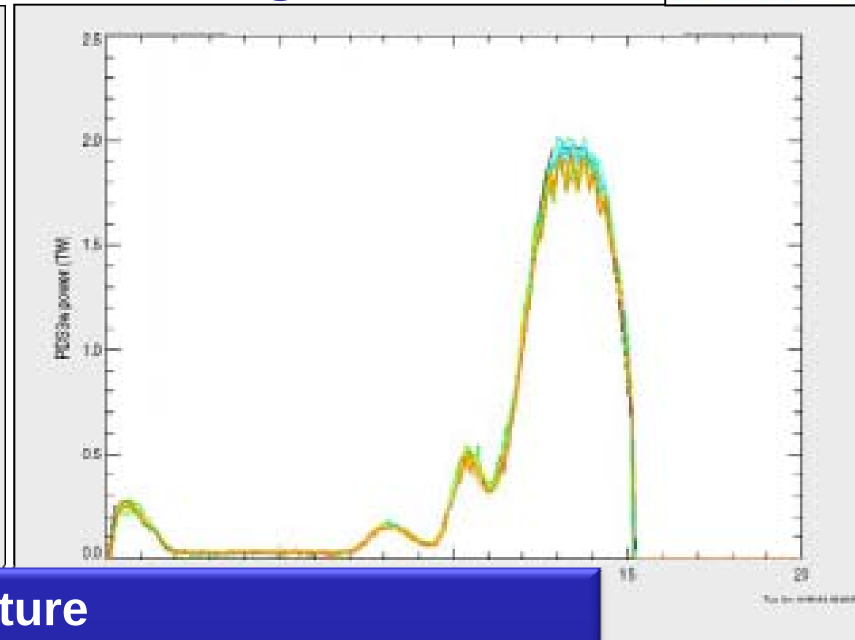
- $4 Billion US **National Ignition Facility**
- Completed in March 2009
- **Ignition** & **energy gain (Q~10-30)** in **1 to 3 years**
- Culmination of over 50 years' research



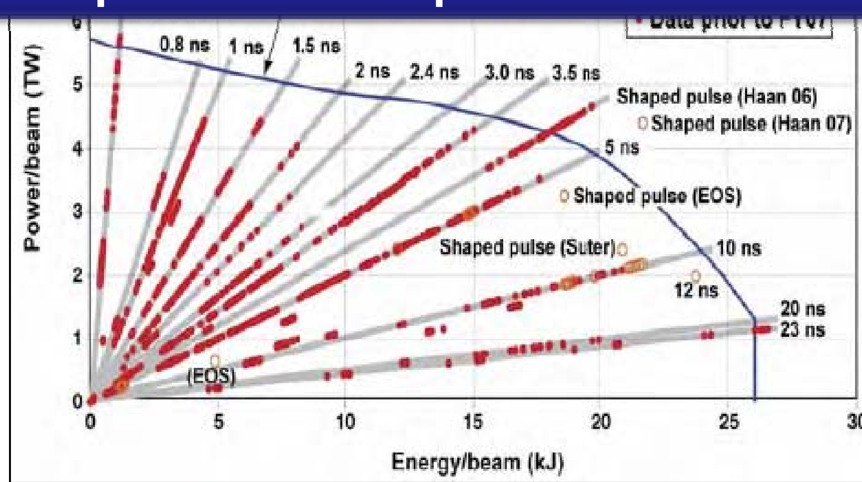


NIF performance meets (often greatly exceeds) baseline specification – as required for Ignition

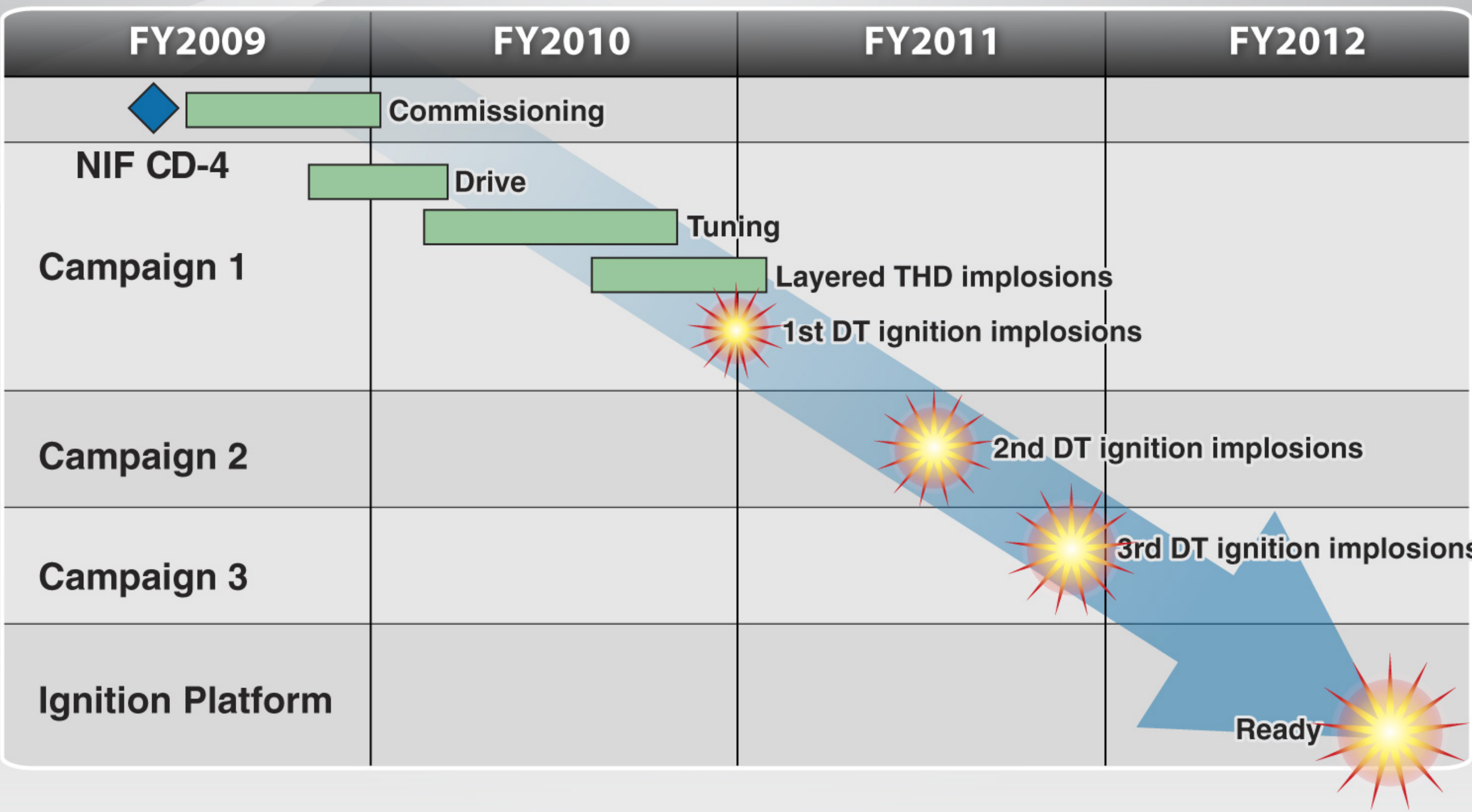




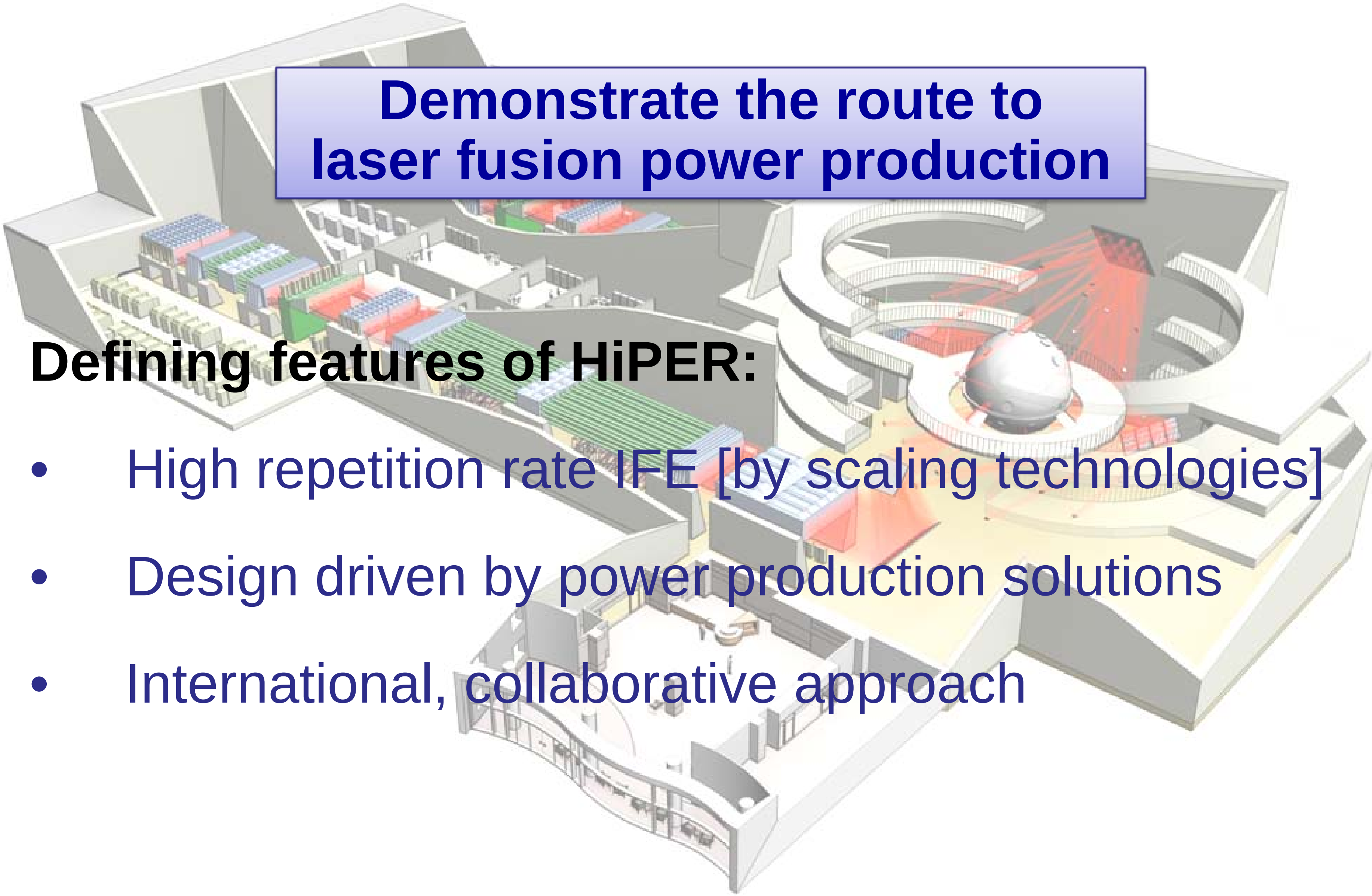
- High vacuum hohlraum temperature
- Symmetric implosion of cryogenic capsules
- Parametric instability control (e.g. energy transfer via δλ)
- Neutron output from D2 implosions



NIF will execute four major ignition campaigns in the next four years



Next step (after fusion ignition)



Demonstrate the route to laser fusion power production

Defining features of HiPER:

- High repetition rate IFE [by scaling technologies]
- Design driven by power production solutions
- International, collaborative approach

HiPER The current 26 European Partners

Funding Agency involvement by 9 partners

- STFC (UK)
- CEA, CNRS and CRA (France)
- MSMT (Czech Republic)
- GSRT (Greece)
- MEC and CAM (through UPM) (Spain)
- ENEA and CNR (Italy)

Institutional involvement by 17 other partners

- IST Lisbon (Portugal)
- CNSIM (Italy)
- TEI, TUC (Greece)
- IOP-PALS (Czech Republic)
- IPPLM (Poland)
- FVB, FSU Jena, GSI, TUD (Germany)
- Lebedev Physical Institute, Institute of Applied Physics-RAS (Russia)
- Imperial College London, Universities of York, Oxford, Strathclyde, Queens Belfast (UK)

HiPER Technology focus for the next phase

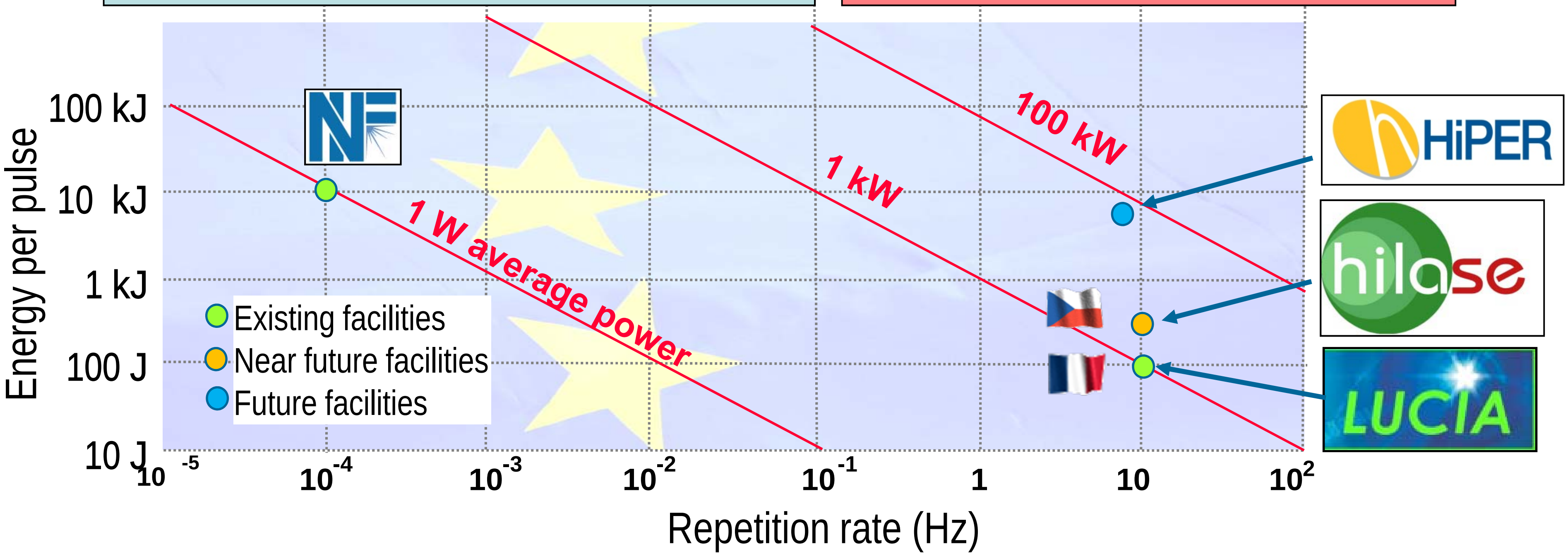
1. Driver
   - Diode laser pump source, Ceramic gain media?
   - High peak power / harmonic conversion options
2. Interaction chamber
   - Fuel pellet injection into plasma exhaust plume
   - Thermal stress and deformation of components
   - Vibrational stability and management
   - Control system hardness to EMP and shot loading
   - Vacuum management
   - Beam delivery - phased array, steering, thermal cycle
3. Lifetime studies
   - Material 1st wall – neutron, shock, X-ray and particle
   - Debris management- absorption, diversion, mitigation
   - Robotic maintenance- Inspection, remote replacement, minimisation
   - Optics- Transmissive aging, Multilayer degradation
4. Fuel pellets
   - Flow manufacturing process, characterisation, cost
   - Injection, steering and tracking
   - Thermal shroud

A combined academic & industrial approach is needed

HiPER Laser Technology Development

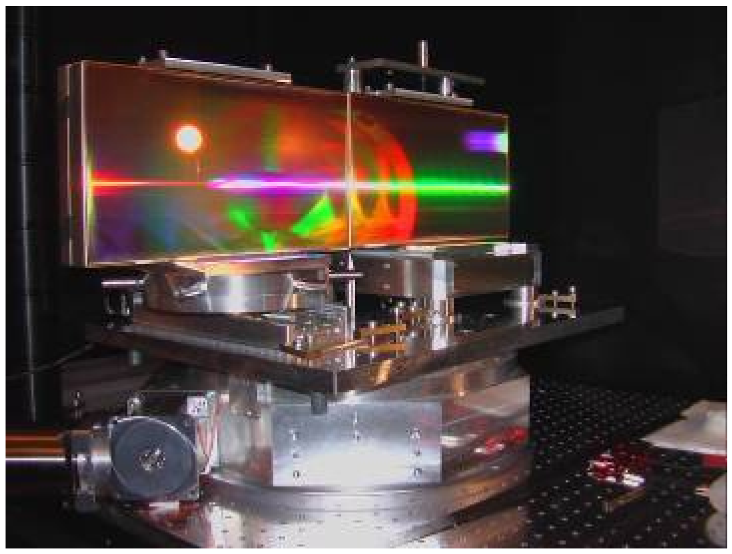
MERCURY
Pulsed
US Nat Lab
1 kW

JHPSSL
CW
Industry
100 kW



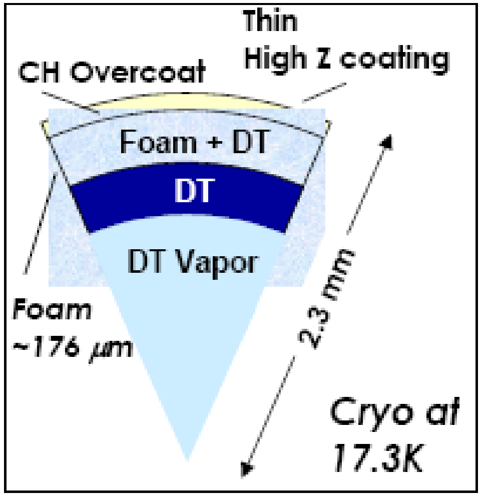
Coherent Beam Combination

- HiPER may need an array of beams that act coherently
- Aperture ~ 25 m^2
- Similar challenge for telescopes – e.g. E-ELT 45m^2
- Beam combination not component combination

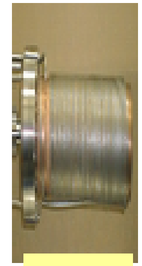


HiPER Fuel pellet technology

1. Fabricating the target



Dry DVB shells



Cell

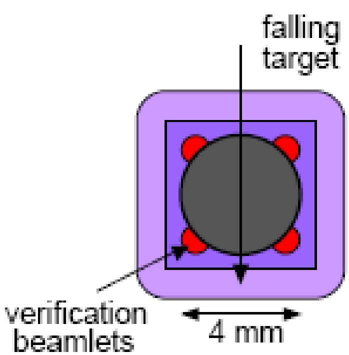
Layering cryostat

2. Injecting the target

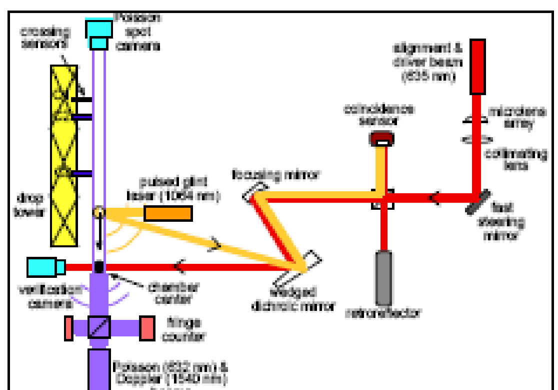
EM Inject.

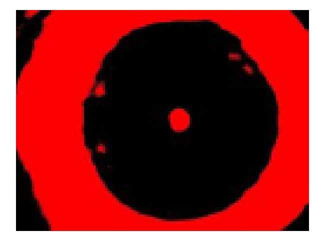
3. Tracking the target

4. Engaging the target



Engagement Verification (table-top demo)

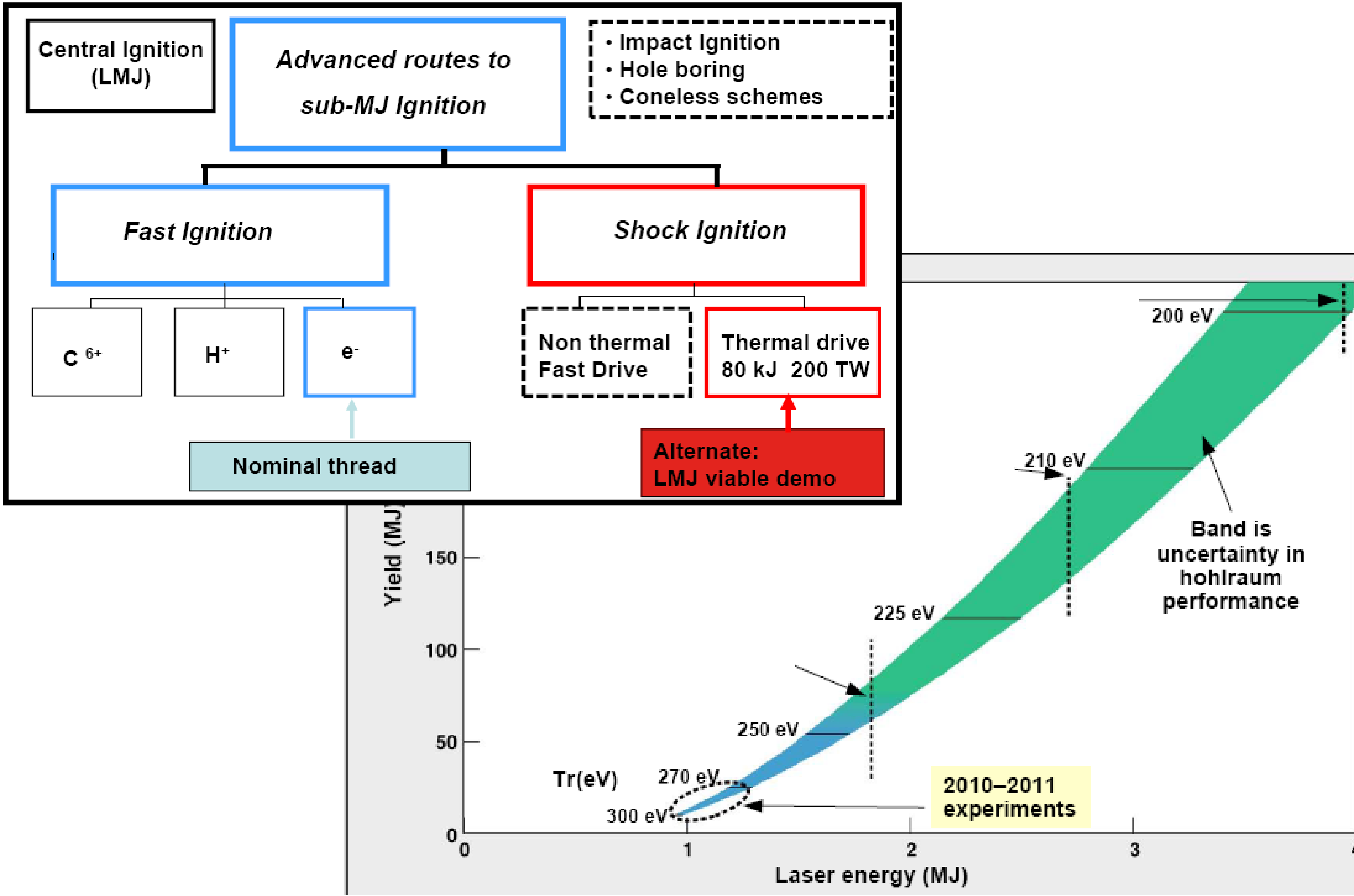




Thresholding pixels

Courtesy of General Atomics

Optimisation of high gain – multiple routes



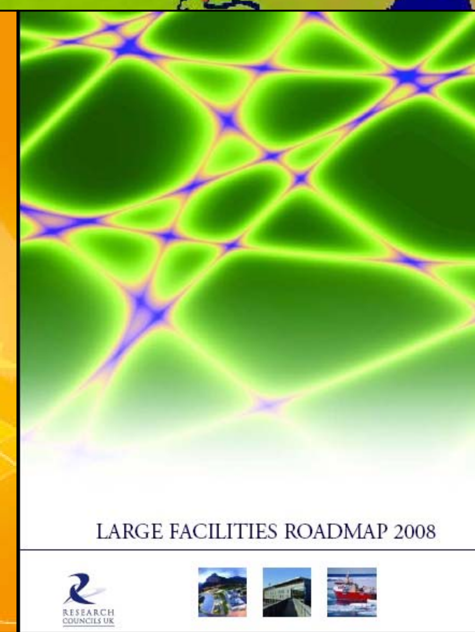
HiPER Pathway to Inertial Fusion Energy

2010	2015	2020	2025	2030

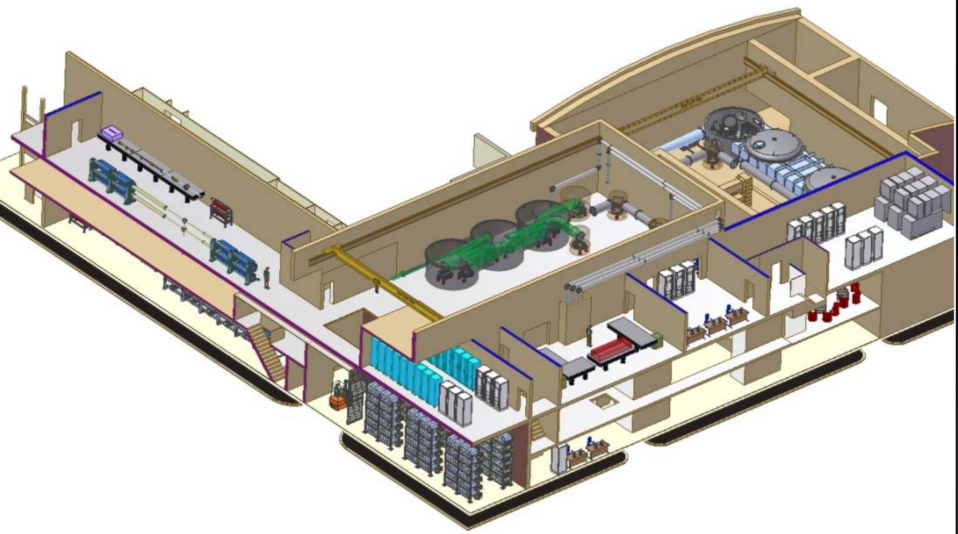
Prep Phase | **Technology Phase** | **Construction & Operations Phase** | **Delivery Phase**

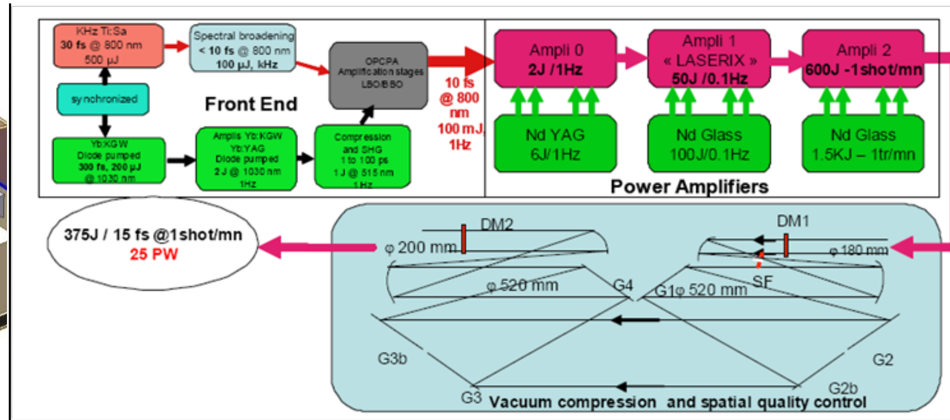
NIF Ignition

HiLASE & ELI (40 + 750 M€)

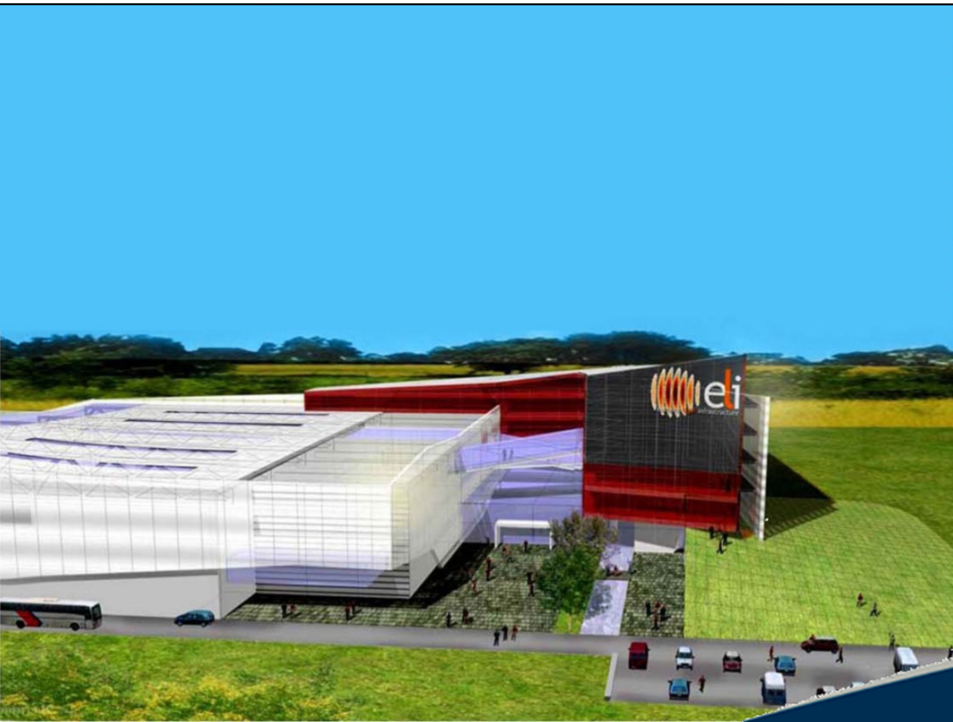


Ultrahigh power: to 10 PW then 200 PW+





ILE, Vulcan, MPQ, …



leading to ELI

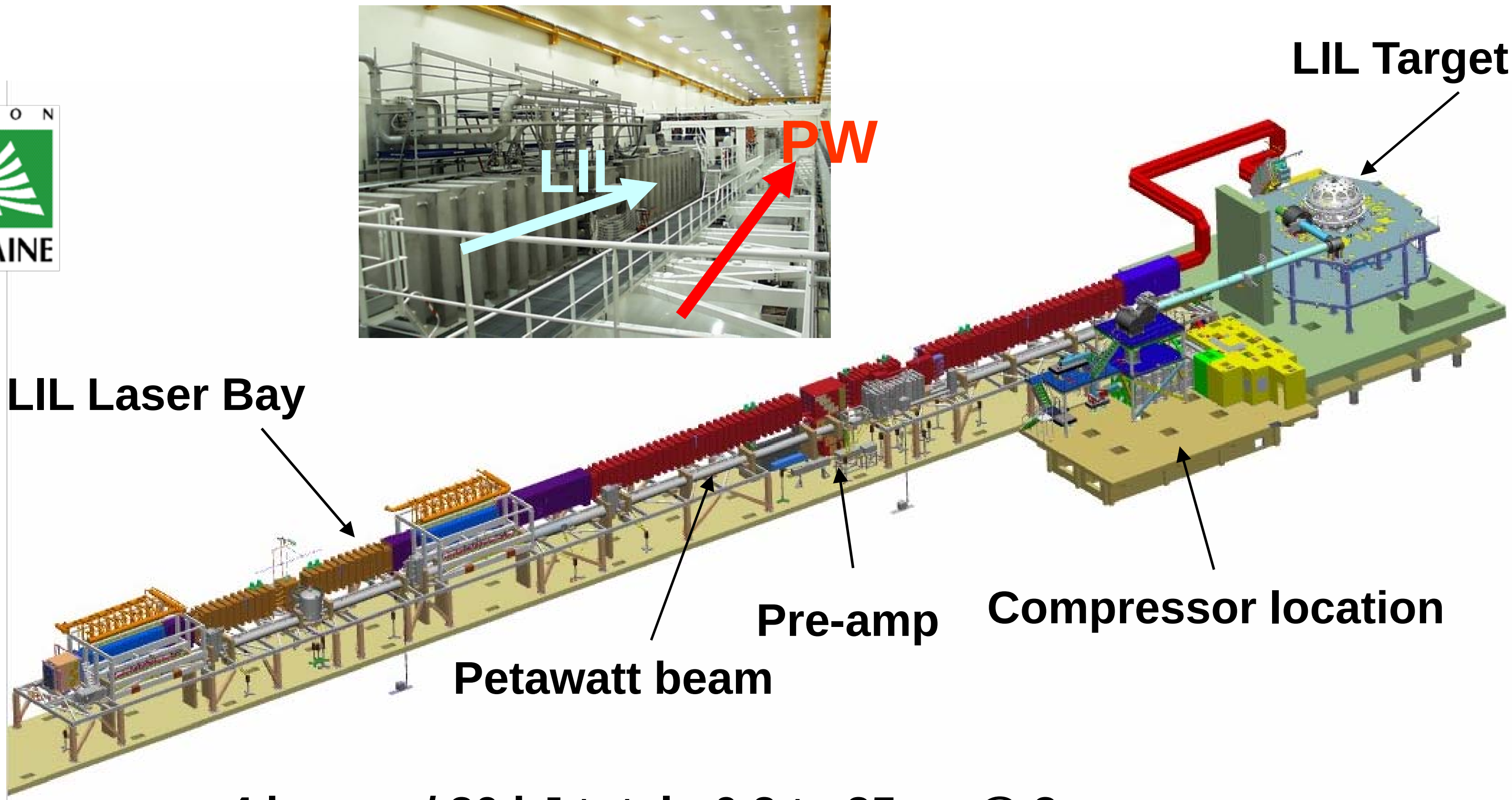
extreme light infrastructure

Prague, Hungary, Romania
ELI pillars (~750 M€ *allocated*)

Science & Technology Facilities Council

HiPER PETAL for fast ignition research and HEDP

objective: to combine high energy beams (LIL) with multi-petawatt beam for fast ignition studies, high energy density physics … as a 1st step to HiPER



4 beams / 30 kJ total - 0.2 to 25 ns @ $3\omega_0$
+ 1 beam / 3.5 kJ – 10 to 0.5 ps (7 PW) @ $1\omega_0$ - 2012

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HiPER So – what's next?

- **Fast Ignition / Advanced Ignition**
  - Define the research program needed to underwrite a robust point design (cf. NOVA technical contract)
  - Define criteria for down selection of options
- **Technology Development**
  - DPSSL prototypes (few-100J to few-kJ): HiLASE, DIPOLE, …
  - High repetition targetry production and fielding, consistent with pt design
- **Broader Facility Development & Use**
  - PETAL integration with LIL
  - High intensity facilities (ILE, Vulcan-10PW, ELI)
- **Community growth**
  - Exploitation of NIF, PETAL, LMJ, EP, FIREX & high intensity facilities
  - Realisation of ELI (probably on 3 sites)
  - Delivery of HiPER phase 3: *design, technology dev, community growth*

Conclusions

- Laser fusion demonstration is imminent (<3 years)
- UK leading the European project – alignment to final step
- Included on national & European roadmaps
- Builds from UK expertise in this field
- Strong industrial opportunities to capture critical IP
- Public-private partnership approach
- Entry of AWE into this open community is a hugely important step, enabling multiple new possibilities …

HiPER

www.hiper-laser.org