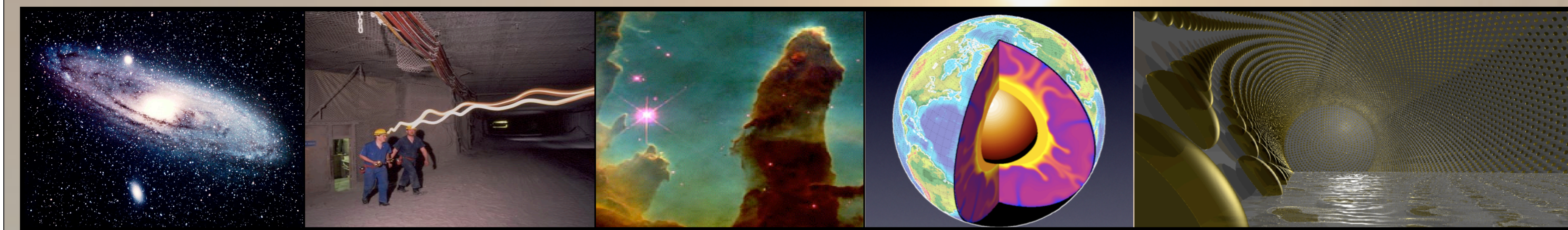
LAGUNA/LBNO



Design of a pan-European infrastructure for Large Apparatus for Grand Unification and Neutrino Astrophysics (LAGUNA)

Proton decay
Supernova neutrinos
Diffuse SN neutrinos
Solar neutrinos
Atmospheric neutrinos
Geo-neutrinos
Reactor neutrinos
Neutrino beams
Indirect dark matter
(direct DM and DBD)

Neil Spooner - University of Sheffield, Boulby

Thanks to Andre Rubbia for many of the slides here

The LAGUNA Consortium

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- about 100 members
- 28 institutions
- 10 countries
- multidisciplinary
- academic and industrial partners

Science of LAGUNA

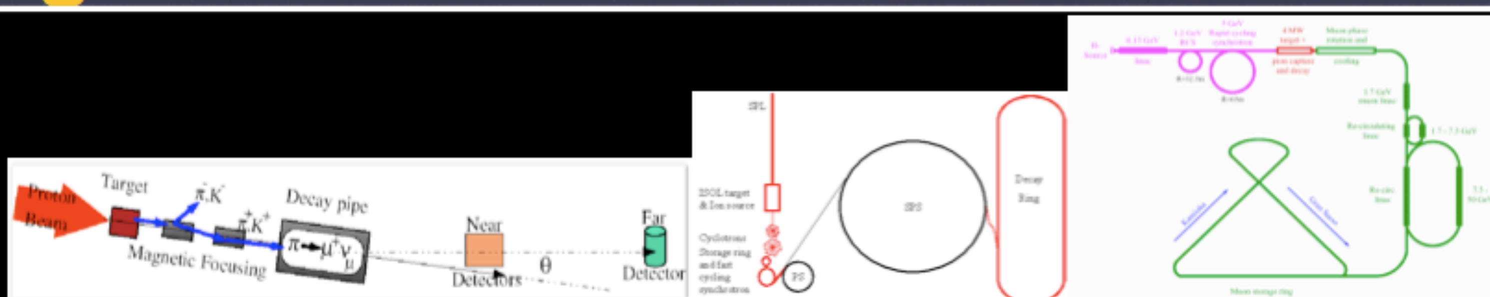
See Ref. D. Autiero et al., JCAP 0711 (2007) 011

Physics "white paper" in preparation (Editor: S. Pascoli)

Particle Physics and Particle Astrophysics

Supernova neutrinos | Solar neutrinos | Proton decay | Atmospheric neutrinos | Reactor neutrinos | Geo neutrinos

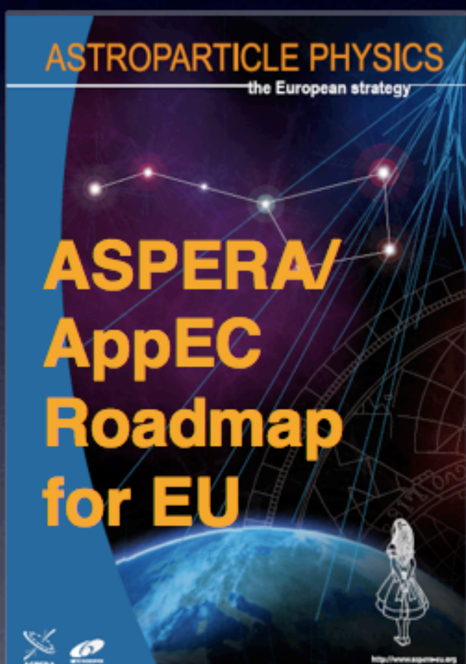
Long baseline neutrinos with accelerators



Superbeams | Betabeams | Neutrino factory

Why LAGUNA ?

- **Prof. Christian Spiering**, DESY
  Chair of the ASPERA PRC & roadmap editor



2008

"We recommend that a new large European infrastructure is put forward as a future international multi-purpose facility on the 100-1000 ktons scale for improved studies of proton decay..."

" The three detection techniques being studied for such large detectors in Europe,
- *Water Cherenkov,*
- *Liquid Scintillator*
  and
- *Liquid Argon,*

should be evaluated in the context of a common design study which should also address the underground infrastructure and the possibility of an eventual detection of future accelerator neutrino beams."

LAGUNA Design Study

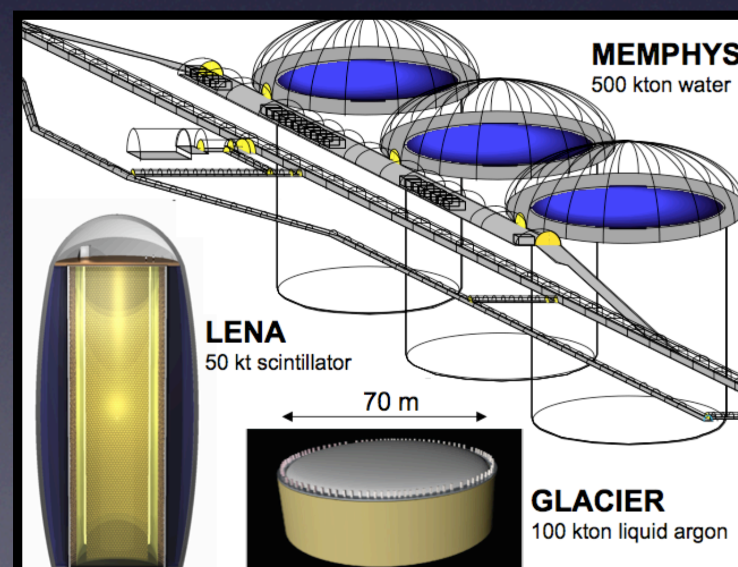
Large **A**pparatus for **G**rand **U**nification and **N**eutrino **A**strophysics

- **Objective: assess feasibility of a new far detector at a new site**
  7 preselected sites and 3 detector concepts
- **Participation (open): very interdisciplinary - most European physicists interested in massive detectors; geo-technical experts, geo-physicists; structural engineers; tank and mining engineers**
- **EU Funding and beneficiaries: €1.7M - 9 (+4) HE institutes; 8 research organizations; 4 companies**

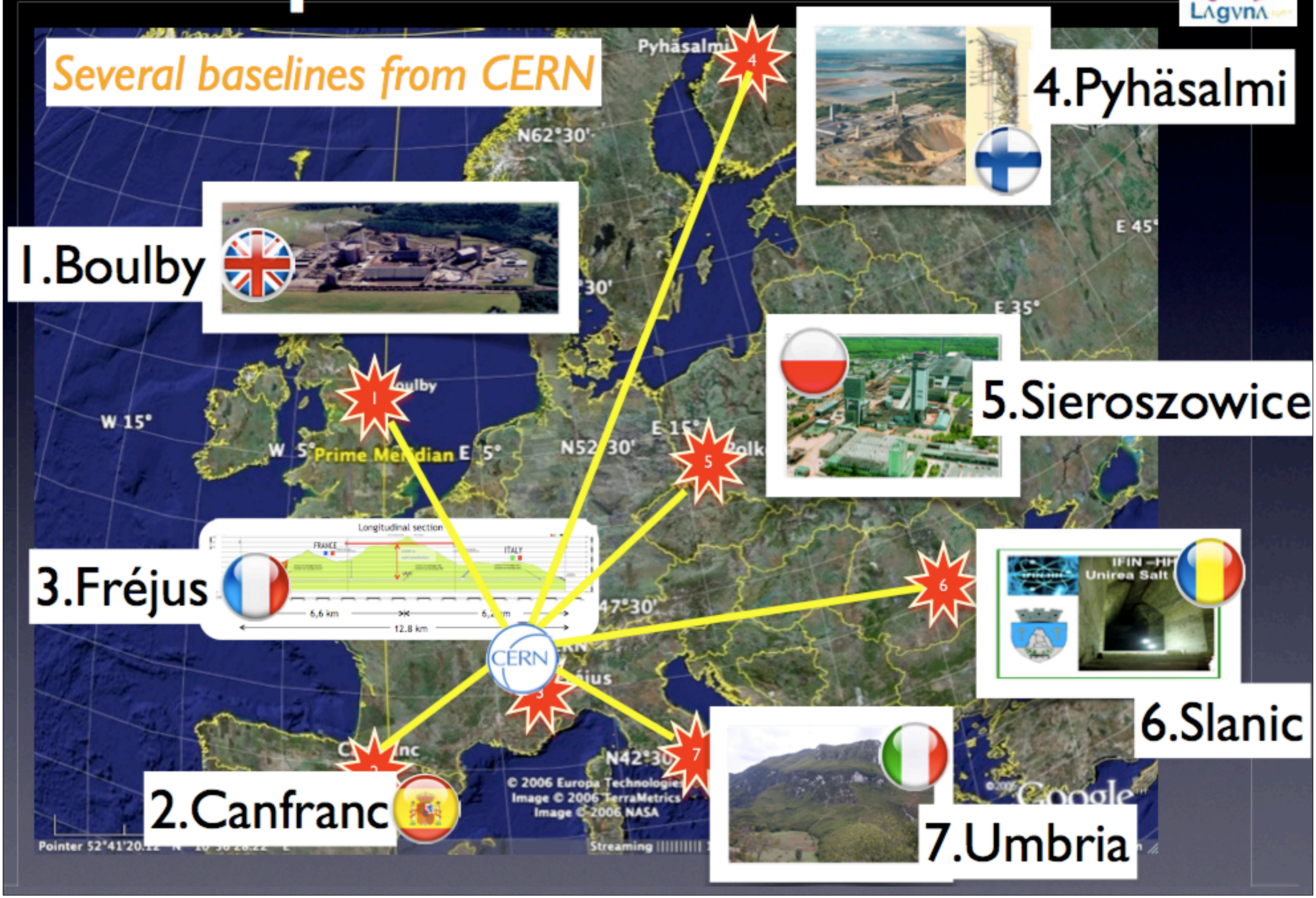
WP2: Underground Infrastructure and Engineering ↔

WP3: Safety, Environmental and Socio-Economic ↔

WP4: Science Impact and Outreach ↔



Seven pre-selected EU sites



LAGUNA at work (2008-2011)

Typical questions addressed

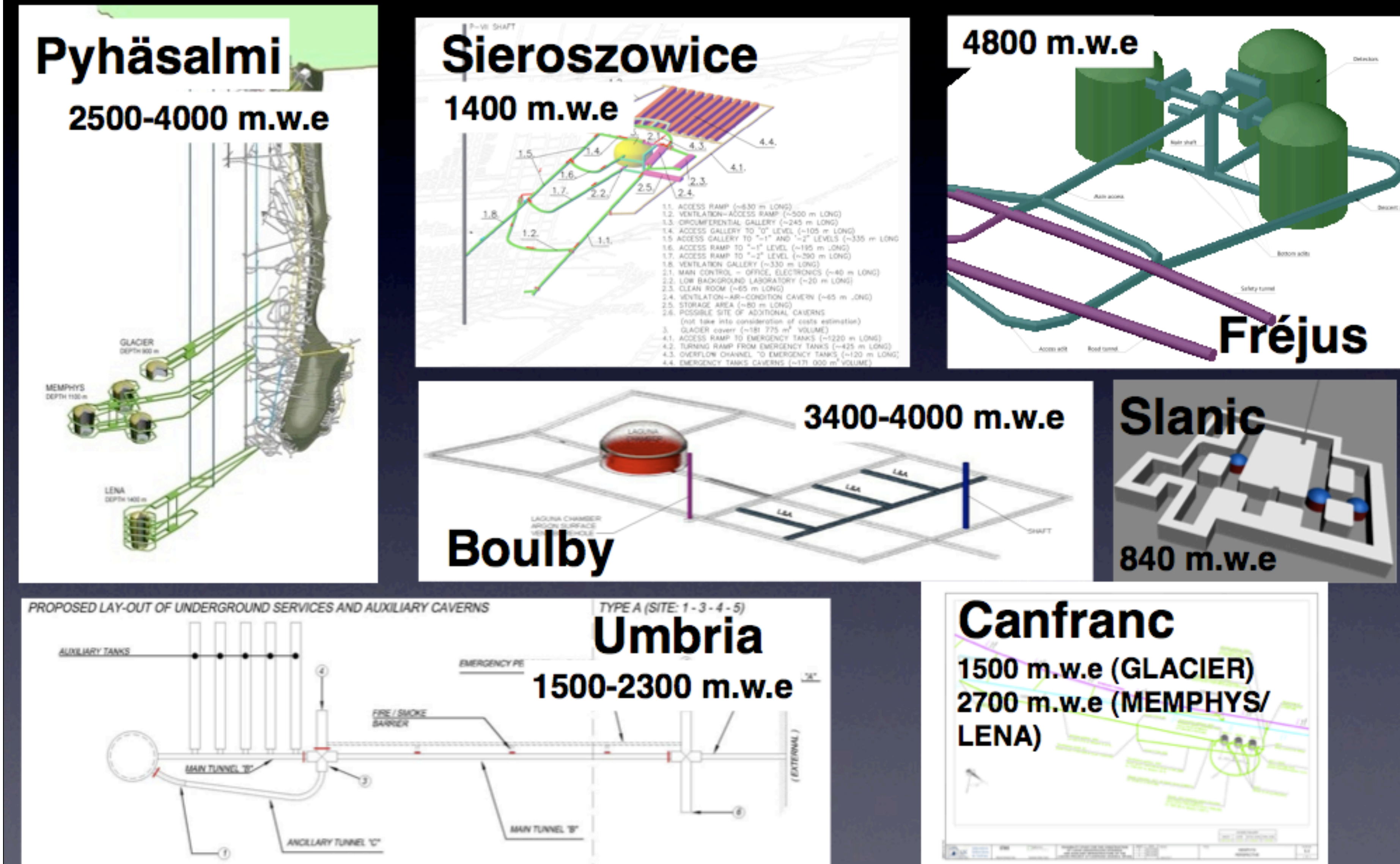
- assessment of strengths and weaknesses
- rock mechanics of caverns
- design of tanks in relation to sites
- overburden vs. detector options
- transport, access, delivery of liquids
- safety e.g. tunnel vs. mine
- environment e.g. rock removal
- relative costs

Site visits and meeting

- sites work together on common areas

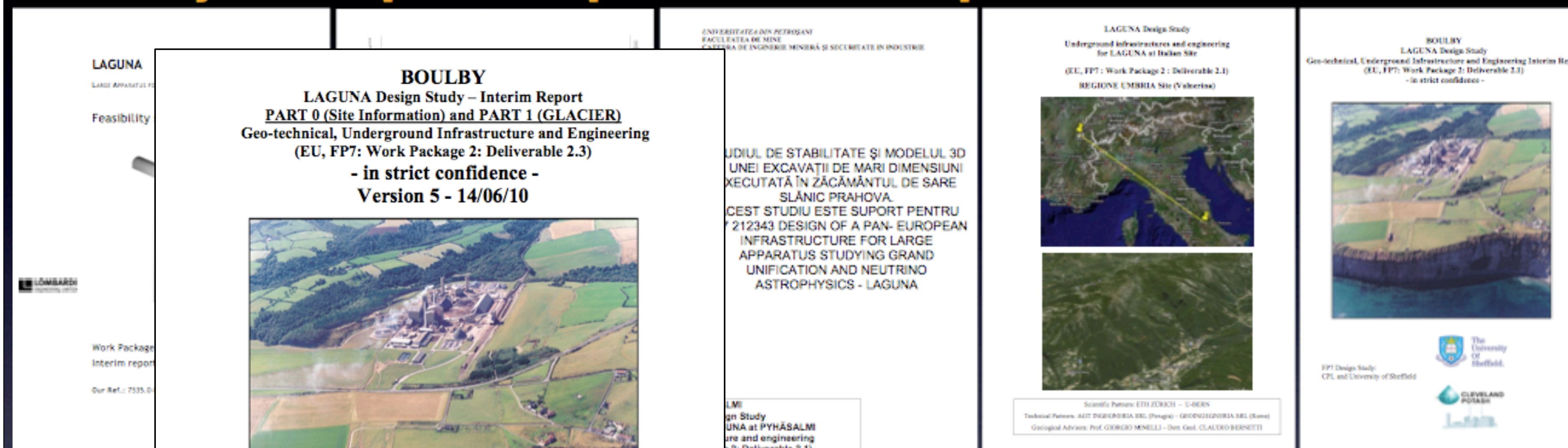
Underground Layouts

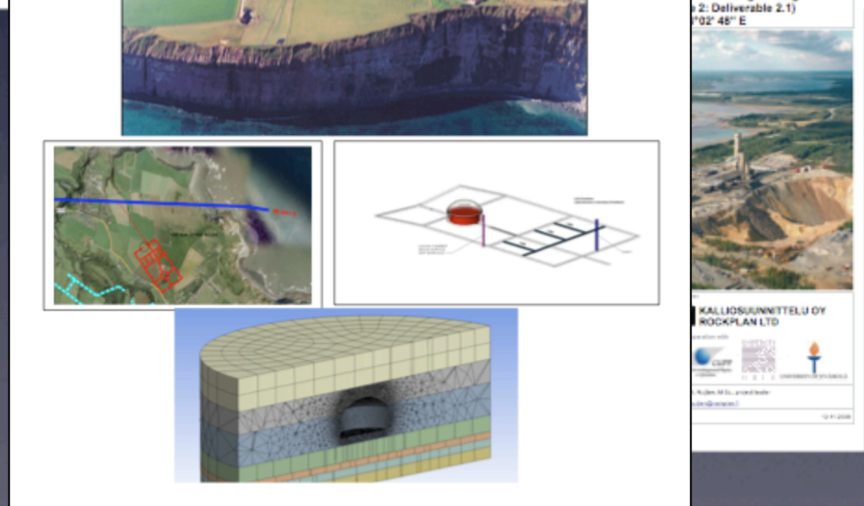
Details of layout including MDC, auxilliary caverns, access, escape routes, etc...



Seven technical reports

Interim site-dependent geotechnical reports: delivered!
Final joint report on potential European sites: soon



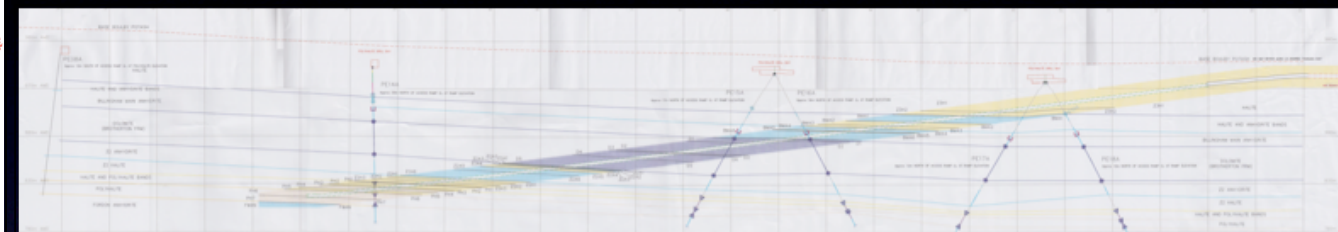


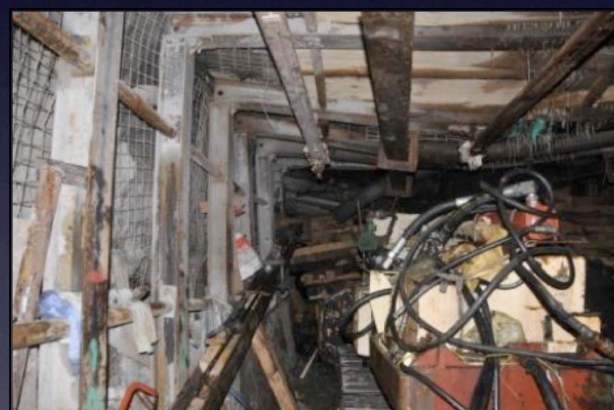
- more than 1200 pages
- large amount of information and details
- wealthy competition among sites
- publicly available

BOULBY
In-situ Rock Studies from Ramp

- Extensive surveys across the site: bore-holes but also IN-SITU studies

New ramp to 1300m now complete through dolomite





- New excavation to start in East region to 1500m
- New studies of dolomite below shafts

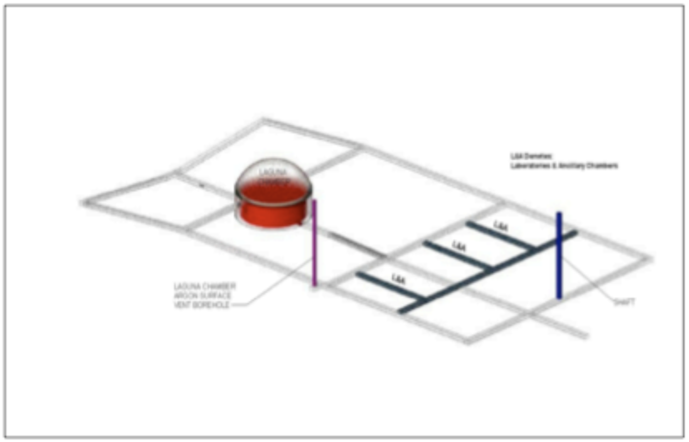
Boulby Glacier Cavern Design

Alan Auld Ltd. Design

AMCO Ltd. Construction and Cost

Part 1 GLACIER

This section details the feasibility study for constructing the massive GLACIER detector at Boulby comprising up to 100 ktons of liquid argon. As outlined in the introduction the approach has been to employ two independent companies, SES Ltd. and AMCO/AAE Ltd. experienced at working at Boulby to assess feasibility, design and cost the facility.



Figures G4.3.1 and G4.3.2 show schematics of the completed chamber design with tank installed.

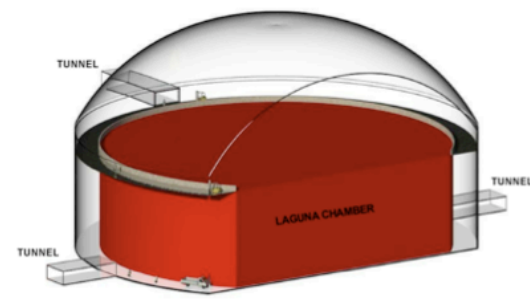


Fig. G4.3.1 Schematic of the main cavern showing access roadways and space around the tank volume

Fig. G4.3.2 Schematic downwards view of the main cavern showing access roadways and space around the tank volume

G4.3.2 Construction Sequence Outline

The construction for the main cavern is foreseen in four phases in line with the plans below. The envisaged timeline for these phases is given in Sec. 4.8. This is a conservative timeline that does not allow for the possibility of more parallel working. The phases are:

Phase 0: Preparation and Procurement
Phase I: Dome Excavation and Bolting
Phase II: Main Volume Excavation and Bolting
Phase III: Shotcrete and Finish

Boulby GLACIER Engineering

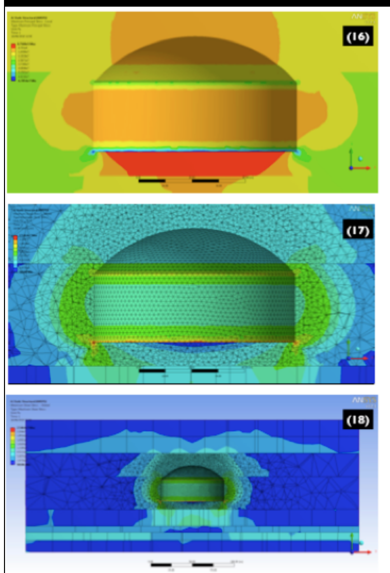
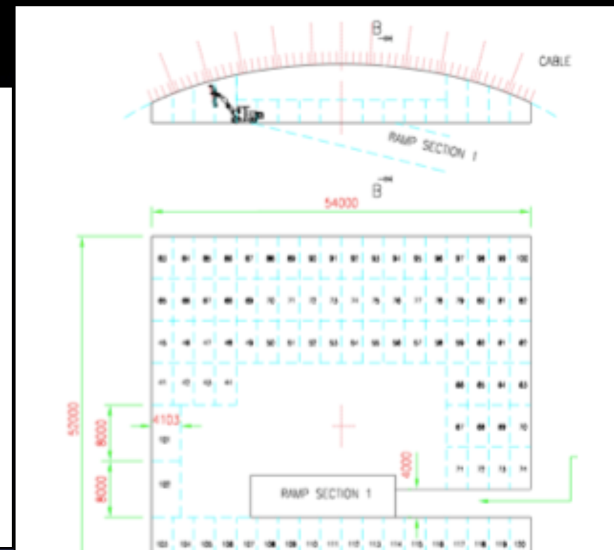


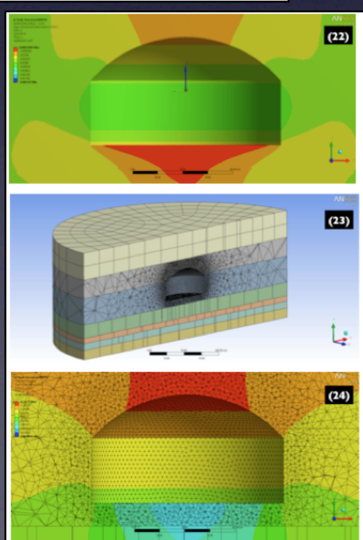
Fig. G4.3.3 shows the first critical stage of the dome construction. This involves drill and blast technology to build a 1 in 4 ramp towards the cavern roof, then a turn and drive of the the ramp to the centre of the roof.

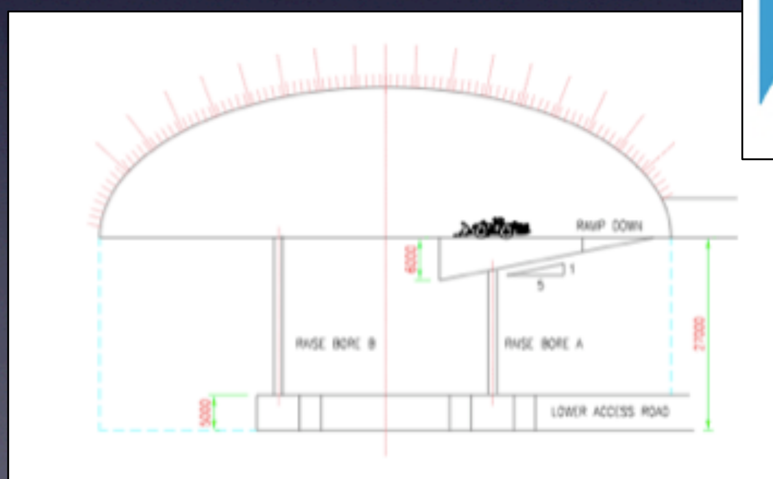
Fig. G4.3.3 First stage construction methodology for formation of the dome roof.



Alan Auld ENGINEERING

1 South Parade, Doncaster, South Yorkshire, DN1 2DY, England
Tel: 01302 329911 Fax: 01302 329922 Email: mail@alanauld.co.uk





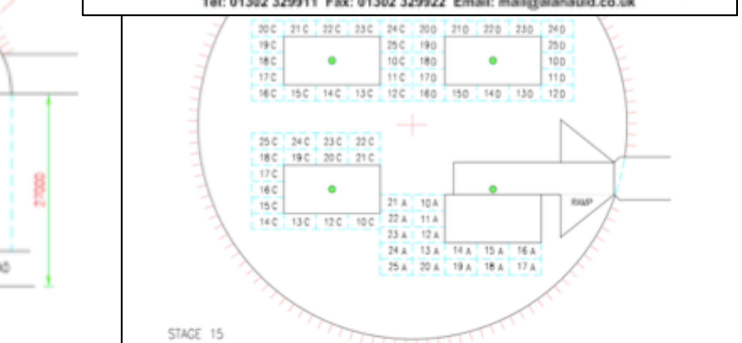
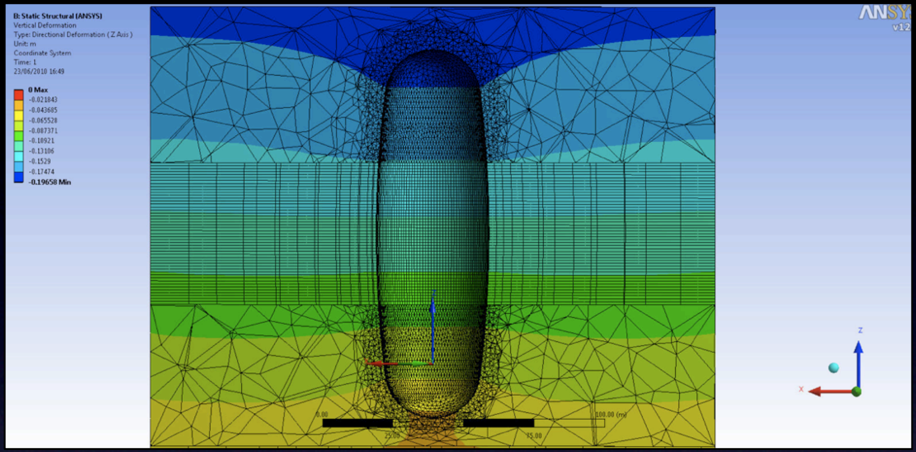
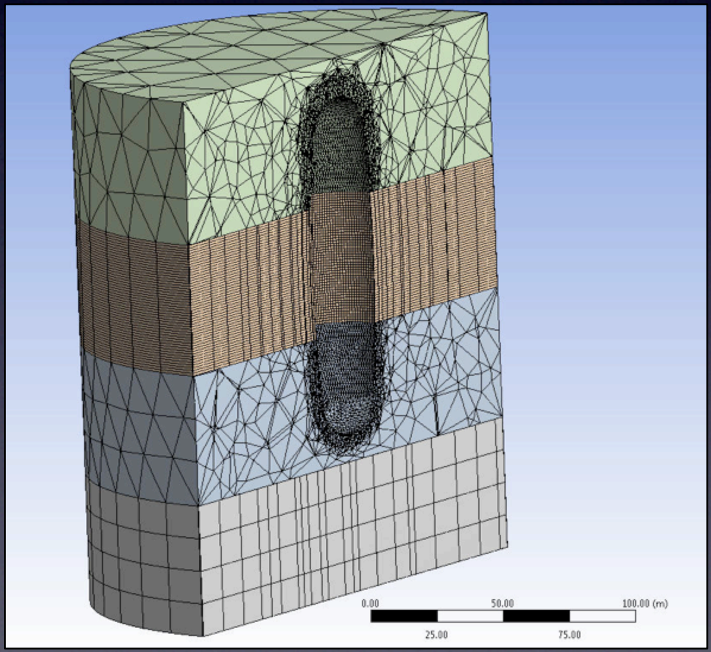


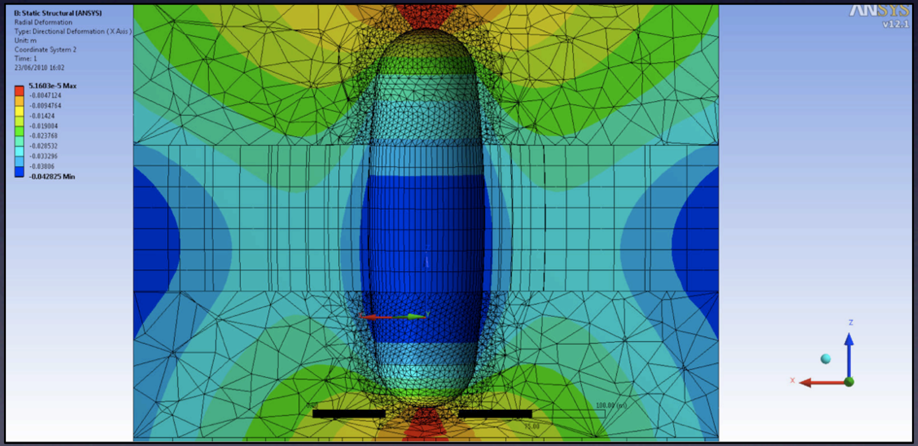
Fig. G4.3.7 Details of the blocking excavation at stage 15

Boulby LENA - ANSYS work

New studies at
1400-1500m in







etc....

AAE conclusions agree with others

Main LAGUNA findings

1. All investigated sites can <u>technically</u> and <u>environmentally</u> host the desired detectors, so there are several options.
2. The cost of the excavation is well understood. It is not the dominant cost of the project.
3. The liquid procurement with the needed quantities is feasible for all sites and for all liquids (Water, LAr, LScint), although it might take several calendar years to reach the full *in-situ* procurement.
4. In order to proceed towards a technology choice, a better understanding of the costs of the full detector design and construction including their instrumentation for the <u>three</u> detector options is essential.
5. Studies indicate that some European options offer potential physics and/or technical advantages that need to be specially and carefully confronted with other options worldwide.
6. The physics goals play a dominant role in selecting the site !

LBNO

Why LAGUNA-LBNO ?

- **The LAGUNA FP7 had a very positive effect:**

  1. it has united neutrino scientists across Europe
  2. the industrial support enabled, via the study of seven pre-selected locations (Finland, France, Italy, Poland, Romania, Spain and UK), a detailed geo-technical assessment of the giant underground cavern needed, concluding finally that no geo-technical show-stoppers to cavern construction exist.
  3. produced a very strong multidisciplinary collaboration

- **Building on this concept, LAGUNA-LBNO proposes a new study on two challenges vital to making a final detector and site choice:**

  (i) to determine the full cost of construction underground, commissioning and long-term operation of the infrastructure, and

  (ii) to determine the full impact of including long baseline neutrino physics with beams from CERN.

LAGUNA-LBNO

Switzerland
University Bern
University Geneva
ETH Zürich
Lombardi Engineering

Finland
University Jyväskylä
University Helsinki
University Oulu
Rockplan Oy Ltd

CERN

France
CEA
CNRS-IN2P3
Sofregaz

Germany
TU Munich
University Hamburg
Max-Planck-Gesellshaft
Aachen
University Tübingen

Poland
IFJ PAN
IPJ
University Silesia
Wroklaw UT
KGHM CUPRUM

Greece
Demokritos

Spain
LSC
UA Madrid
CSIC/IFIC
ACCIONA

United Kingdom
Imperial College London
Durham
Oxford
Liverpool
Sheffield
RAL
Warwick
Technodyne Ltd
Alan Auld Ltd
Rhyal Engineering

Romania
IFIN-HH
Bucharest

Denmark
Aahrus

Italy
AGT

Russia
INR
PNPI

Japan
KEK

LAGUNA-LBNO case studies

– Seven preselected sites
– Three detector options

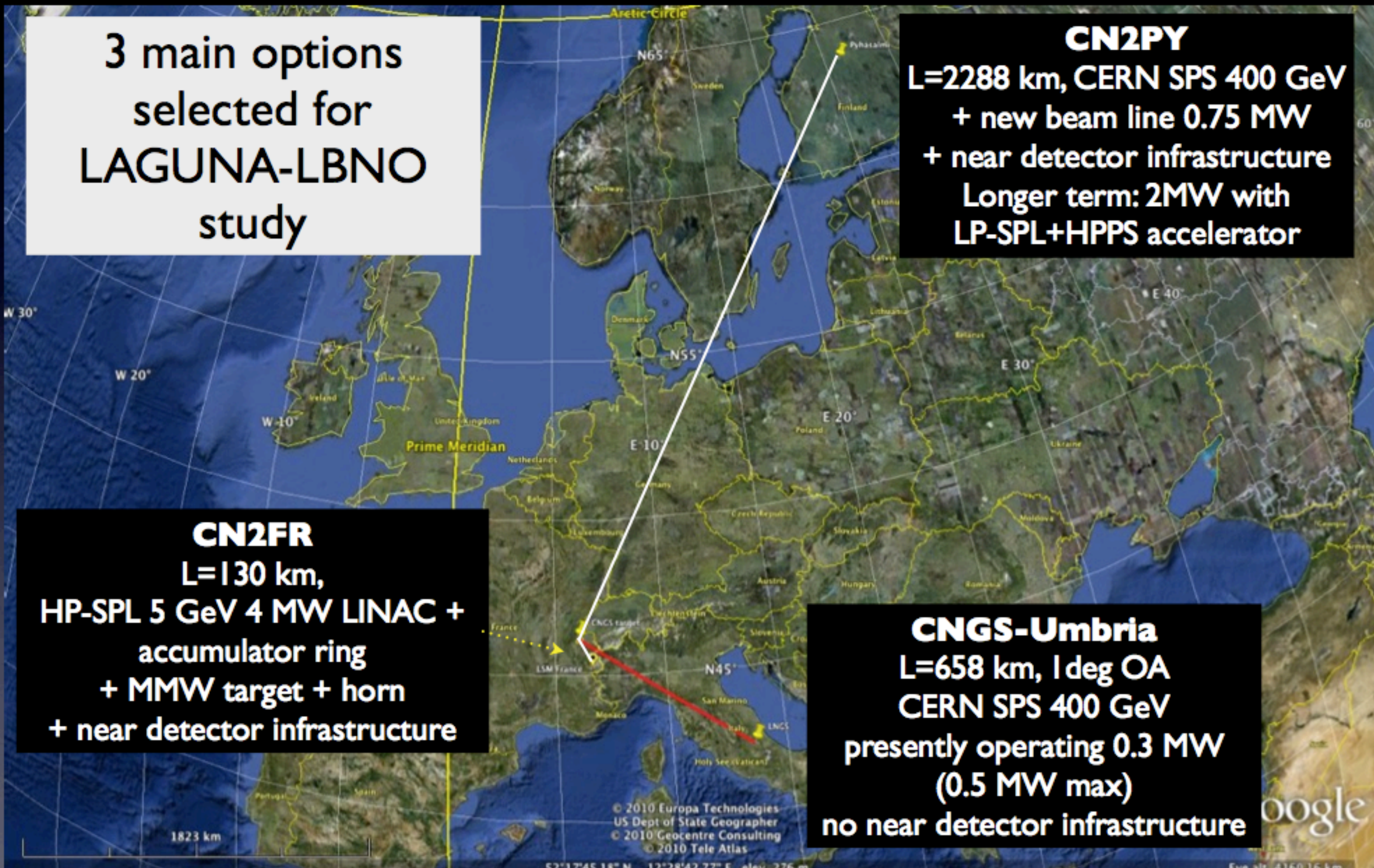
Astroparticle

- Fix driving physics program:
  1. long baseline neutrino oscillations
  2. proton decay
  3. astrophysical neutrino sources

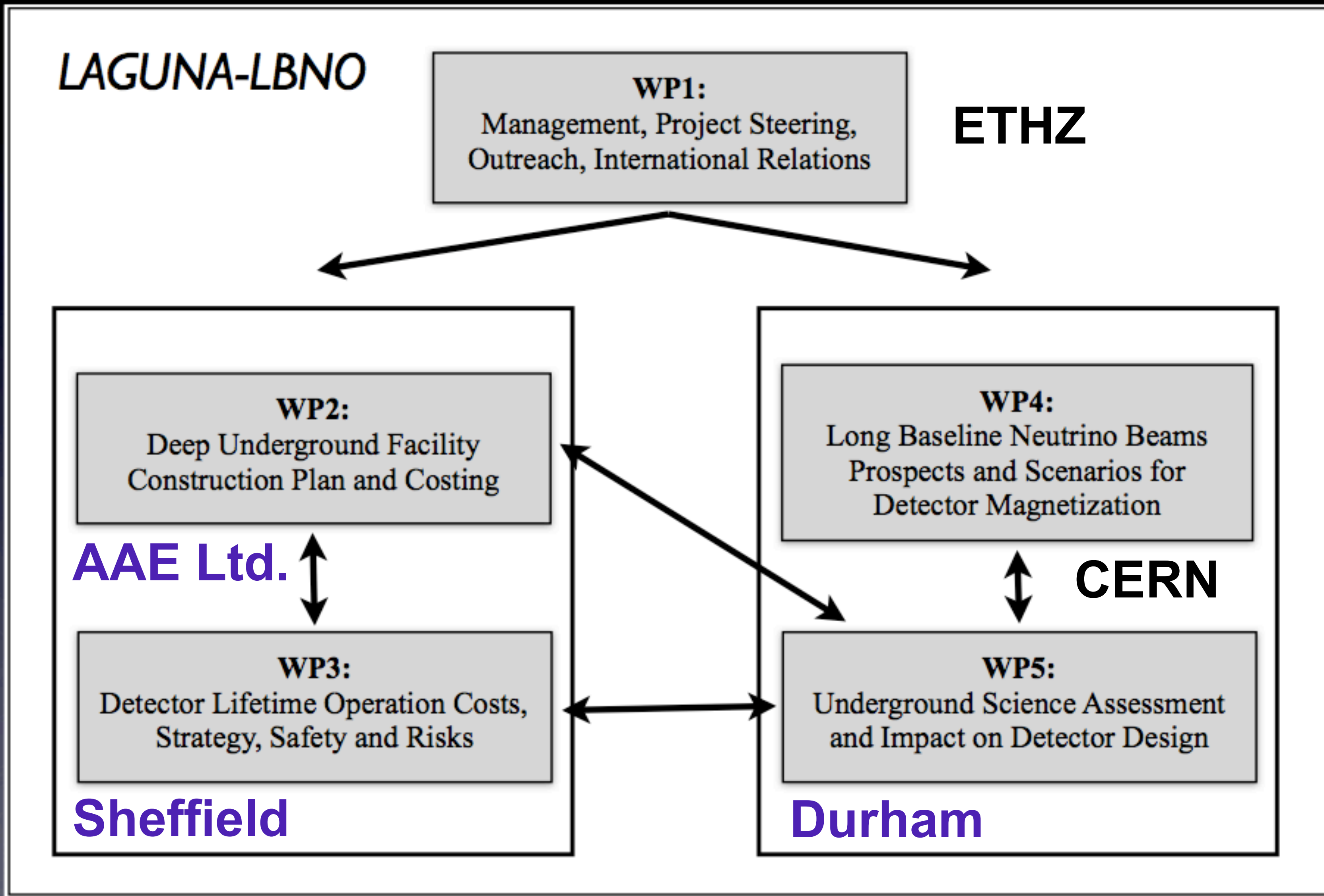
- Aim at concrete plans and costing:
  1. generic → concrete
  2. evolutive scenarios
  3. overall convergence

Three case studies

Three main options



Proposed work packages



WP1 – Management, Project Steering, Outreach, International relations

Lead by ETHZ + Executive Board

- **Task 1.1** Development of a management framework
- **Task 1.2** Yearly progress and final reports
- **Task 1.3** Steering of the LAGUNA project and definition of the next steps
- **Task 1.4** Prospects for interdisciplinary underground science at the LAGUNA site
- **Task 1.5** Development of a task governance for potential future phases of the project

WP2 – Deep Underground Facility Construction Plan and Costing

Lead by AAE + Technical Board

- **Task 2.1** Appraisal and assessment of the LAGUNA background
- **Task 2.2** General risk identification, preliminary analysis and risk registry
- **Task 2.3** Feasibility of construction of the underground tanks
- **Task 2.4** Update of the tank reference designs
- **Task 2.5** Update of the undergound layouts and logistics of cavern construction
- **Task 2.6** Auxilliary Tanks and Liquid Transfer Infrastructure

WP3 – Production and Installation of Instrumentation, Commissioning and Facility Lifetime Costs

Lead by USFD + Technical Board

- **Task 3.1** Transfer and Installation Underground of Scientific Instrumentation - Costs, Safety and Risks
- **Task 3.2** Transfer and Installation Underground of Purification Plant Infrastucture, Maintenance of Liquid Quality, Costs and Safety Impact
- **Task 3.3** Initial Liquid Fill and Liquid Operation Commissioning
- **Task 3.4** Full Lifetime Operational Costs and Implications of the LAGUNA-LBNO Research Infrastructure

WP4 – Long Base Line Neutrino Beams Prospects and Scenarios for Detector Magnetization

Lead by CERN + Scientific Board

- **Task 4.1** Study of impact of CERN SPS accelerator intensity upgrade to neutrino beams
- **Task 4.2** Feasibility of intensity upgrade of CNGS facility
- **Task 4.3** Conceptual design of the CN2PY neutrino beam
- **Task 4.4** Feasibility study of a 30-50 GeV high power PS
- **Task 4.5** Definition of the accelerators and beamlines layout at CERN
- **Task 4.6** Study of the Magnetic Configuration for the LAGUNA detector
- **Task 4.7** Definition of near detector requirements and development of conceptual design

WP5 – Underground Science Assessment and Impact on Detector Design

Lead by UDUR + Scientific Board
Cross-collaboration between experimentalists, phenomenologists, theorists

- **Task 5.1** Common and unified simulation of the detectors performance
- **Task 5.2** Detector performance for Long Baseline Neutrino Oscillations and High Energy neutrinos
- **Task 5.3** Phenomenological studies of neutrino properties in long baseline neutrino oscillation experiments
- **Task 5.4** High energy astrophysical neutrinos
- **Task 5.5** Low energy neutrinos
- **Task 5.6** Proton decay

Important Points (UK funding?)

- UK has strong position in LBNO - leads 3 of 5 WPs
  - Leads 3 of 5 WPs, two “co-PIs”
  - UK has strong industrial participation (AAE, Rhyal, Technodyne)
  - UK has 25% of funding request
- LBNO includes T2K groups (France, UK etc...)
- Good cooperation growing with LBNE (as well as Japan)
  - common meetings, looking at common R&D
  - potential CERN-Fermilab agreement?
- CERN directorate is supporting LBNO
  - Sergio Bertolucci (Research Director) has given endorsement
  - Fits new policy to do science outside CERN
- LAGUNA/LBNO encompasses Particle Astrophysics

UK SOI Discussion (Tony Medland, PPAN)

- Old FJNE proposal (alpha 3) still on table; suggests “pre-SOI” update with all interested parties signing.
- Participation of industry very important...
- Participation of T2K groups very important...

Funding Opportunities

- FP7
- Marie-Curie
- ERC
- IPS
- KTP
- PRD
- SOI-RG
- International exchange schemes