

SUPA TEOPS

STRATEGY MEETING

Kelvin Building, University of Glasgow

Nov 20th 2006

Rev 05

What is TEOPS?

- Technology for Experimental and Observational Physics in Scotland
- Initiative in SUPA Astrophysics and Space Research theme
- “Spans the areas of particle physics, astrophysics and astronomy with a common theme of leading edge technology”
- Collaboration between ATC and Glasgow University Institute for Gravitational Research and Experimental Particle Physics groups

Institute for Gravitational Research (IGR)

- *The work of the Institute is focused on*
 - *the development of detectors to search for gravitational waves from astrophysical sources*
 - *data analysis activities within the LIGO Scientific Collaboration.*
- *The main areas of experimental research are*
 - *development of precision novel interferometric techniques*
 - *development of systems of ultra low mechanical loss for the suspensions of mirror test masses along with research towards the space-based LISA mission*
 - Development of multiple pendulum systems using silica fibres to support the test masses
 - New bonding technology (hydroxide-catalysis bonding), which exhibits very low mechanical loss and is compatible with ultra-high vacuum
- *The technology developments within the IGR are of broader relevance to a number of areas of current PPARC interest and extensions of the bonding technology are being pursued with general application to precision optical systems on the ground and in space.*

- *Examples of current/recent projects include:*
 - CERN ATLAS - Production and testing of modules for the LHC/ATLAS
 - CERN LHCb - Design of LHCb/Velo upgrade detectors
 - CERN Medipix - High sensitivity X-ray imaging for medical and synchrotron applications
 - CERN RD50 - New technologies for super radiation hard detectors
 - Retinal imaging - Measuring the electrical activity of retinal tissues
 - Retinal implants - Pixel detectors as a cure for some forms of blindness
 - Medipix detector system and x-ray image of shell (collaborative work with CERN Medipix)
 - 3D - Novel detector geometry for high speed radiation hard detectors
 - Silicon carbide - Materials for high radiation environment
 - Gallium nitride - Materials for protein studies
 - Gallium arsenide - Materials for enhanced X-ray detection
 - Detector simulation - Simulation using tools such as Medici, ISE, MCNP, Geant4 and SRIM coupled with the ScotGrid computing hardware
 - Active pixel sensors - New pixel detector technologies

- Some current / recent projects include;
 - WFCAM - largest infrared camera ever built, a cryogenic instrument now undertaking unique surveys in the Northern Hemisphere skies
 - SCUBA2 - the successor to SCUBA, one of the most successful ground-based instruments ever built, utilising a new generation of sub-millimetre CCD-like detectors
 - MIRI - hosting the European PI and opt-mechanical design leads for this key instrument on the JWST, successor to the Hubble Space Telescope
 - VISTA - an infrared survey telescope destined for the Southern hemisphere and a component of the UKs membership of ESO - the European Southern Observatory
- The UK ATC is also involved in several UK and European network and technology development initiatives coordinated by our Technology Development Director, Colin Cunningham;
 - Smart Optics - the UK ATC is a managing partner in this DTI-funded Faraday Partnership
 - OPTICON - A European network in Optical and Infrared astronomy
 - Smart Focal Planes - A Framework 6 technology development programme aimed at maximising focal plane 'real estate' in the next generation of Extremely Large Telescopes such as OWL or Euro50

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Commonality

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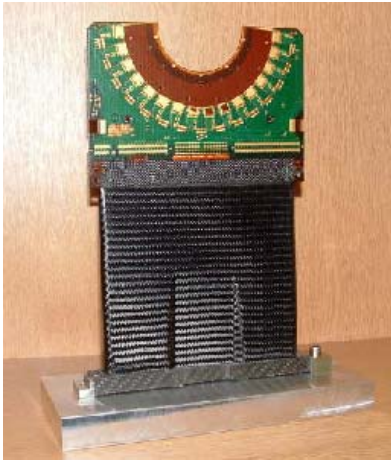
Commonality

- Significant areas of commonality: some examples:
 - Cryogenics
 - The ATC has decades of experience in constructing reliable and robust instruments operating at cryogenic temperatures (as low as 4 K and even below 100 mK)
 - Cryogenic operation is now of interest for future generations of both gravitational wave detectors and colliders for particle physics



Commonality

- New materials
 - e.g. silicon-carbide being looked for use in both astronomical instruments and in gravitational wave detectors



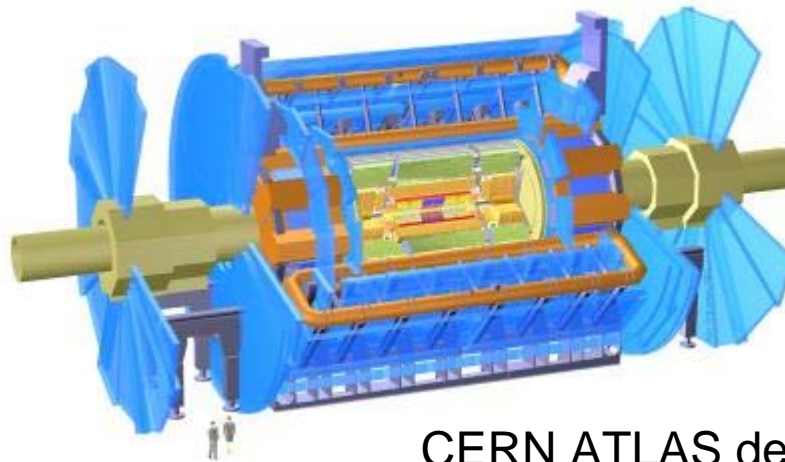
LHC module using carbon fibre mount
– Si-C considered as replacement



Si-C lightweighted telescope mirror
(courtesy M. Krodel)

Commonality

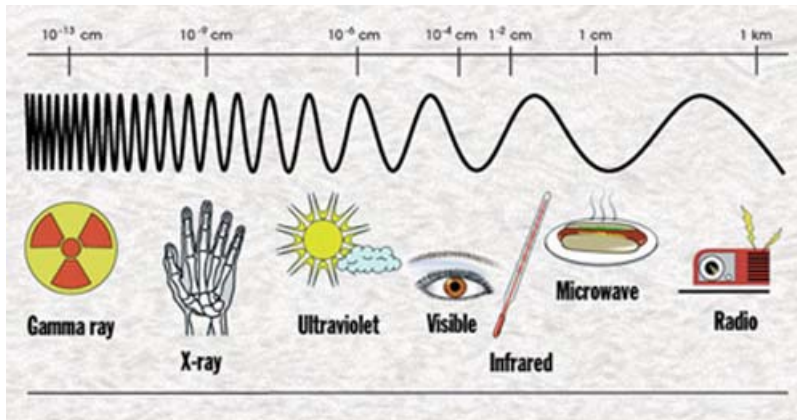
- Particle physics detector groups have experience in constructing detectors on an “industrial” scale
 - will be required in astronomy as telescopes increase in size (and number of telescopes in the case of arrays)



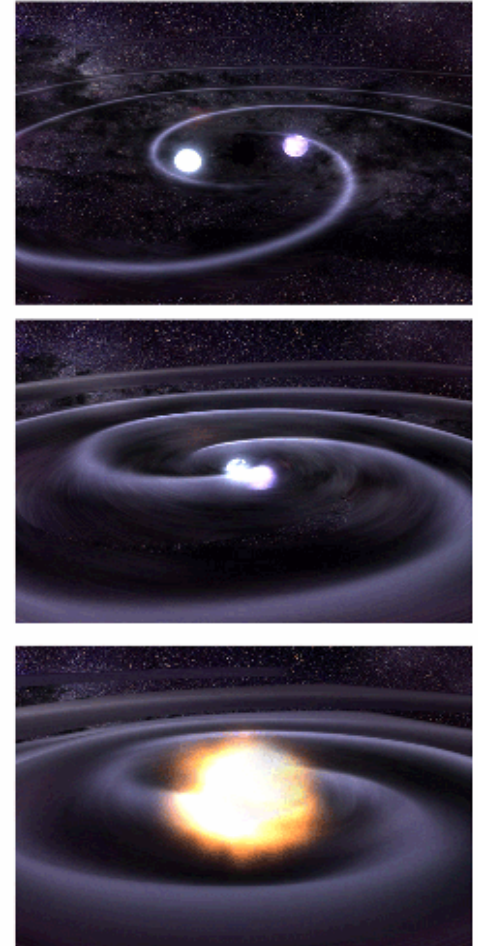
CERN ATLAS detector

Further Commonality

- Commonality not just in technology, but also in the resulting science
 - Gravitational wave detection is astronomy, albeit unconventional (“multi-messenger” astronomy; going outside e/m spectrum)



Orbiting white dwarf stars discovered by X-ray emission should be ‘bright’ source of gravitational waves



Further Commonality

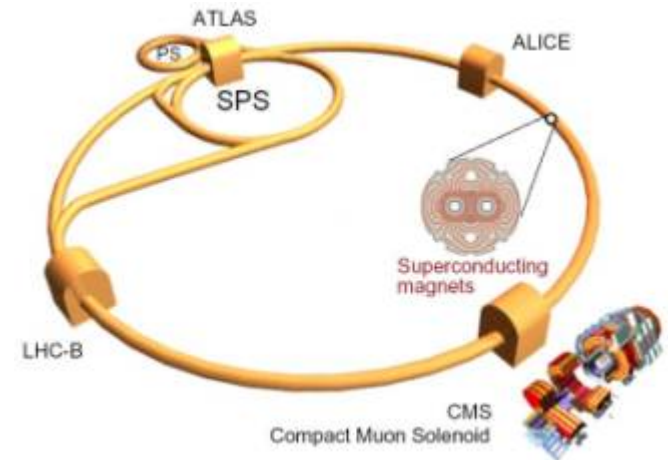
- Commonality not just in technology, but also in the resulting science
 - Particle physics and cosmology are converging (e.g. dark matter: can look for astronomical evidence, try to detect, or try to produce in accelerators)



X-ray image of Abell 2029 tracing dark matter distribution (NASA)



CRESST dark matter detector



LHC

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ACTIVITY UPDATE

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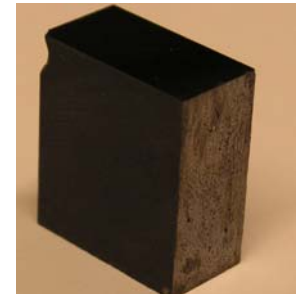
TEOPS Activity - EGO Proposal

- European Gravitational Wave Observatory (EGO)
 - Development of laser fabricated silica ribbons for monolithic suspensions for an upgrade to the French-Italian VIRGO Gravitational wave detector:
 - Proposal submitted (start date April 2007 for 2 years)
 - PI Calum Torrie Co-I's Sheila Rowan, Alastair Heptonstall & Adam Woodcraft
- Strategy: provide leverage on possible PPARC/STFC funding for future UK input to planned VIRGO upgrade



TEOPS Activity - European ELT

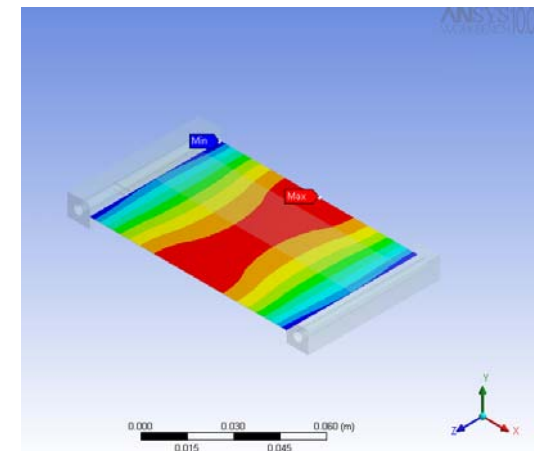
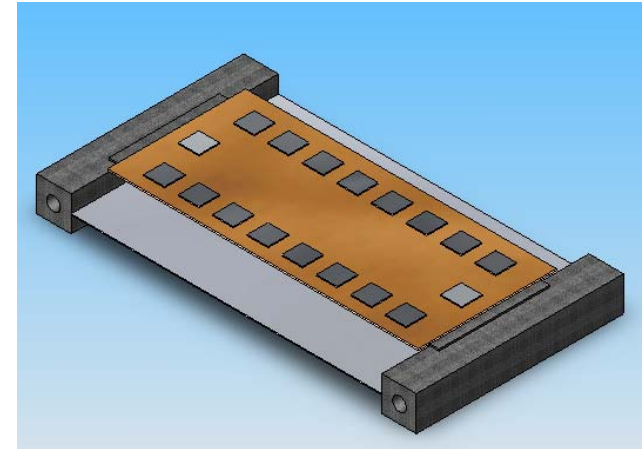
- TEOPS Proposal part of larger PPARC proposal - UCL - lead institution
 - Development of key passive and adaptive mirror technologies using silicon carbide mirrors, for the ELT
 - Submitted
 - ATC PI - Mel Strachan, Glasgow PI Calum Torrie, (Co-I Sheila Rowan)
 - Duration 2 years (March 2007)



- Strategy: enhance UK (SUPA) base in technologies relevant to the ELT thus enhancing chances in bidding for future ELT-related funding

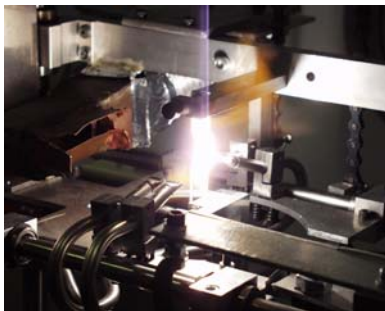
TEOPS Activity - ATLAS upgrade

- Development of supermodule structures
 - Submitted to PPRP (June 2007)
 - Project
 - FEA analysis
 - Prototype
 - using Si/CC to evaluate design
 - measure thermal & mechanical properties
 - Work
 - Design (SW) & FEA (ANSYS)
 - Experiment
 - Conceptual Design

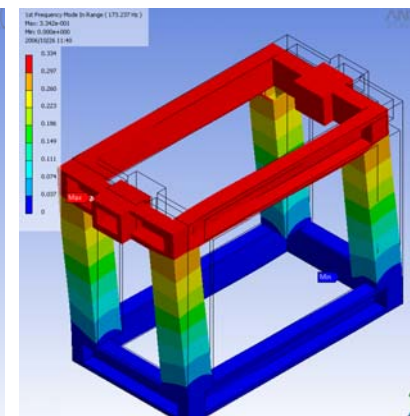
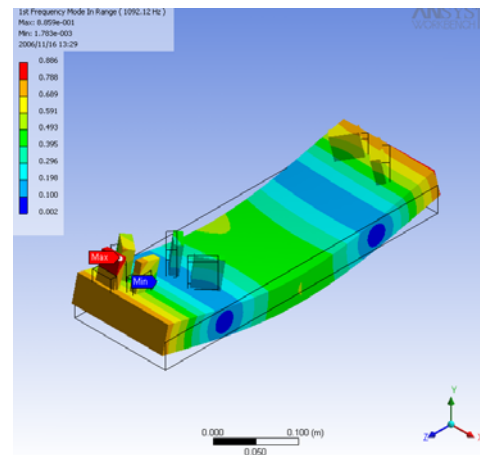
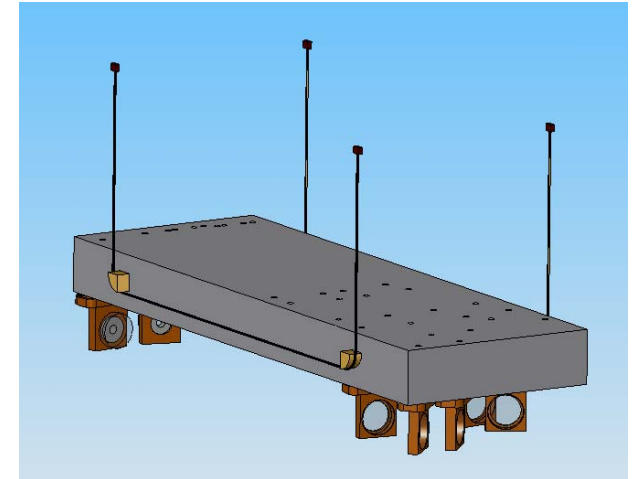


TEOPS Activity - Advanced LIGO

- Advanced LIGO
 - Optical and Mechanical Systems
 - Installations
 - mirror suspension prototype at MIT
 - New Suspensions
 - output mode cleaner (including silicate-bonded bench)
 - Structures
 - alternative materials



- Output Mode Cleaner Suspension
 - Enhanced & Advanced LIGO
 - Controls prototype
 - Suspension design
 - FEA
 - Metal bench
 - Noise Prototype
 - Silica Bench
 - Silicate Bonded mirrors
 - Proposal
 - Discussion stage (10%)
 - Groups
 - IGR & UKATC



Cryogenic Material Property Testbed

- Will be located in lab space at UK ATC
 - Labs fully equipped for cryogenic work
 - Make measurements from 300 mK to 300 K
- Sample size up to 40 cm high, 20 cm diameter
- Optical access (four windows)
- Mechanically cooled - no cryogenes required
- Measurements include:
 - Thermal conductivity
 - Heat capacity
 - Thermal expansion
 - Refractive index
 - (what do you want....?)
- Status
 - Order placed following tender process
 - Currently discussing detailed design with company
 - Delivery date March 9th 2007(!)



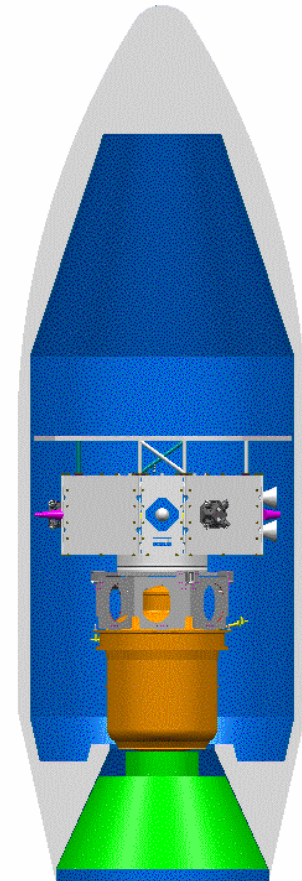
TEOPS Activity - GEO 600

- GEO 600 and Hannover AEI Prototype
 - Upgrades to existing detector
 - AEI prototype
 - Isolation and Suspension design
 - Contract
 - Discussion stage with Benno Willke & Ken Strain
 - 10-20% effort over 2 to 3 years
 - Cooperation contract through University

TEOPS Activity - Astronomy

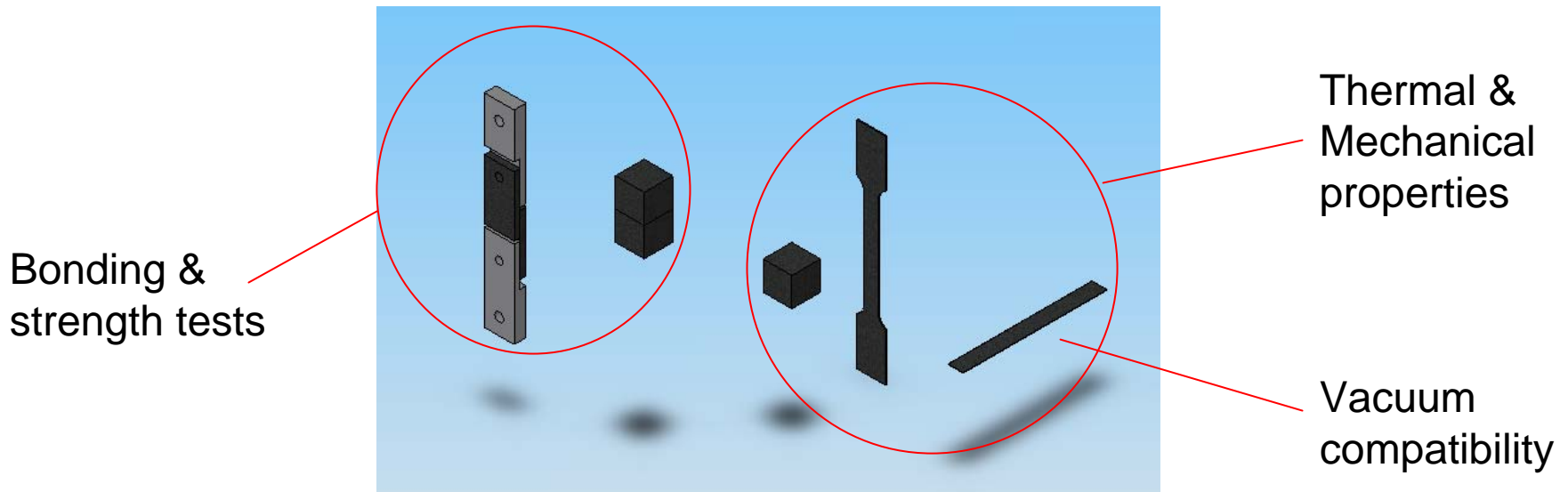
- Taking part in FIRI Cosmic Visions proposal
 - Far infrared astronomy interferometric space mission
 - Free flying formation (like LISA)
- Also ESI-SPICA
 - European instrument on FIR space mission
- Key technologies for both missions:
 - detectors and cryogenics (both TEOPS areas)
- Detectors
 - Spin-offs (Medical, security...)
 - ATC is part of ERP-IIS (links ATC, Edinburgh, H-W)
 - Road-mapping, national/European detector strategy

- Taking part in GrAnd Unification Gravity Explorer (GAUGE) Cosmic Visions proposal
 - Fundamental physics space mission
 - “key issues at the interface between gravity and quantum interactions”
 - Based around copy of LISA-pathfinder spacecraft bus with LISA technology platform inertial sensor



TEOPS Activity - C/SiC Trials

- C/SiC investigation
 - European ELT & ATLAS proposals
 - Interest from LIGO
 - Companies, types, properties etc ...
 - Support from Mel Strachan & Marielle Van Veggel (Eindhoven)



TEOPS Activity - Training

- ANSYS (FEA) Course
 - Run by Calum & Wilde FEA
 - Summer 2006 open to TEOPS

- Facilities
 - SRDG lab Glasgow
 - Talk later by Liam

 - Equipment Training
 - Liam Glasgow

- SUPA Graduate Lecture Course
 - Advanced Astronomical Technology
 - Adaptive optics, telescope design & New generation interferometers

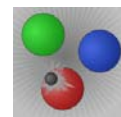


TEOPS Activity - Outreach

- (1S2R) 1st Steps to Research
 - draft PPARC Small Awards Scheme Proposal completed
- Other Outreach examples
 - Ambassador Scheme
 - Physics Dept & SETPOINT
 - Astronomical Society talks
 - High School Project Supervisors
 - School & College links
 - UK & US
 - Undergraduate scholarship
 - US company

TEOPS Activity - Departments / Industry

- Links / Departments
 - California Institute of Technology
 - Edinburgh Research Partnership
 - (ATC, Edinburgh and Heriott Watt)
 - Glasgow School of Art
 - Glasgow
 - Mech. Eng. Civil Eng Medical Dept
- Outside Companies
 - BAE Systems
 - Via European ELT collaboration
 - Scottish Football Association
 - Funding a student project
 - DMG / Gildemeister
 - Next slide
 - Mitsui Babcock
 - Caroline Cantley



TEOPS Activity- Industry

- Ultrasonic Milling Machine
 - DMG / Gildemeister
 - Glass sample trials
 - Don Whiteford, R&E
 - Hans Green, JILA (Jim Faller)



SUPA TEOPS Activity - Collaboration / KT

- Jack McConnell would like to see the University of Glasgow / Caltech collaboration on gravity wave detection expanded
- Possibility for broadening collaboration beyond gravity waves - support expressed by UK consulate in Los Angeles
- Possible areas for this expansion include
 - Optical & mechanical systems for Advanced LIGO
 - Bonding technology
 - Bayesian Inference Data Analysis
 - Similar techniques in financial, medical
 - CCAT (more later from UK ATC talk)
 - major opportunity to expand UKATC's role in Scottish Astronomy?
 - Part of Astro-theme bid for SUPA2



The first minister visiting LIGO labs, Caltech, Oct 2006