Science & Technology Facilities Council

AIDA WP8.4 Materials and components irradiation and database progress

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WP8.4 Members

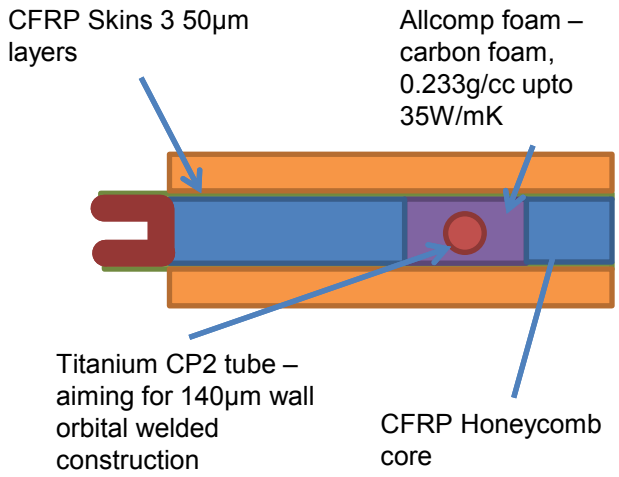
- Partners and interests:
  - INFN-Milan; electronic components and circuits
  - INFN Perugia; silicon pixel detectors (APS)
  - STFC-RAL; polymers and composite structures
  - Associate ETHZ; scintillator crystals

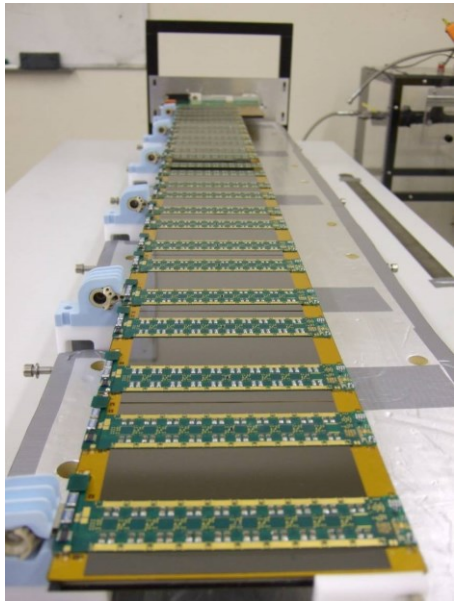
Materials irradiation

- Thermoset polymers are widely used in detector structures in HEP, eg ATLAS detectors
  - Main structure as composite matrix eg CFRP
  - Other adhesives for assembly
- High stiffness, Low Z materials
- Properties of the organic matrix change as a result of doses present in current LHC detectors
  - Typically crosslink density increases, modulus (stiffness) increases
  - State of cure increases
  - Pendant groups knocked off >gas evolution

Application Example: ATLAS stave

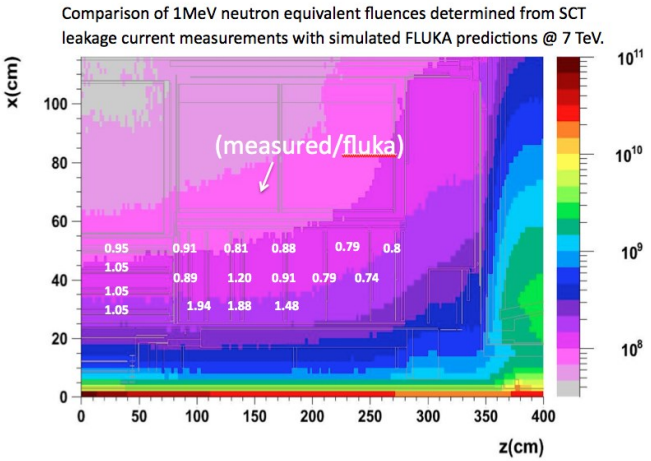
- Stave components rely on adhesive bonding
- Flexible materials are desirable but these are considered to be more prone to radiation damage than stiffer, more highly crosslinked polymers
- Anecdotal evidence suggests this isn't always true
- How do material properties change with radiation dose?
- If stiffness increases (as expected) then stress states within stave also change

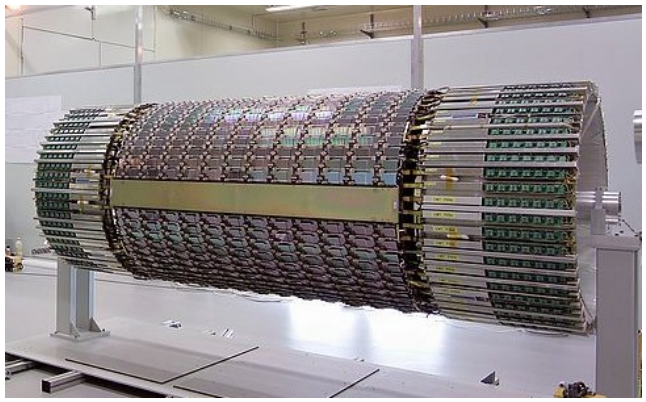




AIDA TA

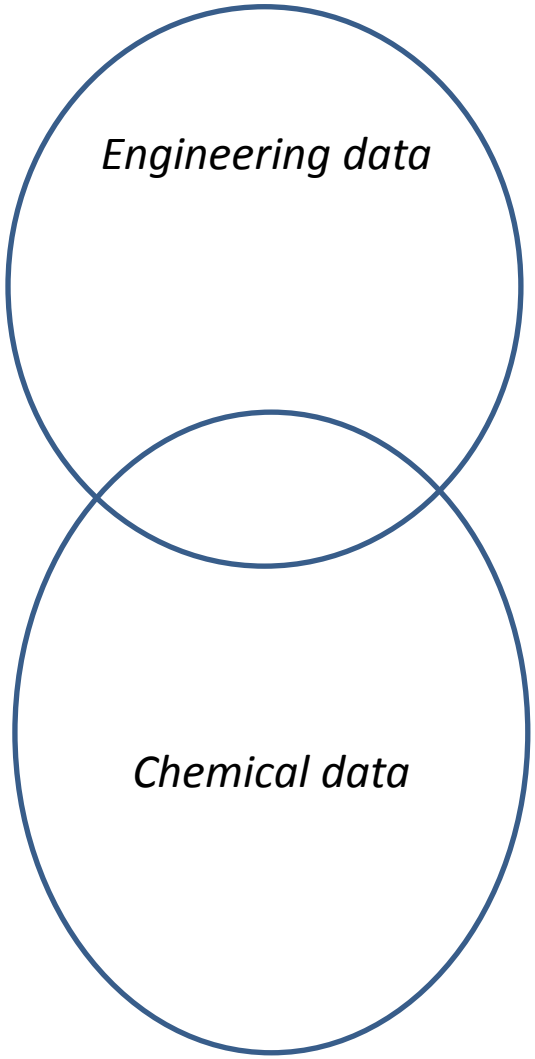
- Opportunities within AIDA to use irradiation facilities
- Need to understand how doses available via AIDA-TA compare to doses required
- Need to consider activation issues and how to mitigate (eg by testing unfilled adhesives only, to remove metals)





Existing ATLAS tracker

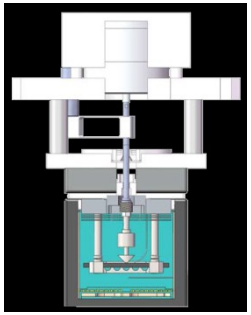
Test methods for characterising radiation damage in polymers

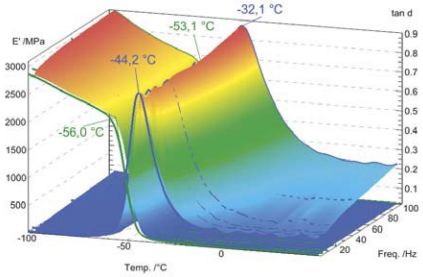


- Macro-Mechanical
  - Tensile
  - Bond strength eg lap shear
- Micro-mechanical
  - DMA, modulus, transitions, molecular mobility
- FTIR analysis
  - Chemical bond changes
- Thermal
  - DSC, state of cure
  - TGA, thermal stability

Flexible adhesives test plan

- Data exists on rigid, rad-hard epoxies which tend to be highly crosslinked, high modulus and brittle.
- Focus on characterising the rad-hardness of more flexible epoxies and silicones
- A chemical structure-property relationship approach
- Test a range of chemistries to understand what changes occur after irradiation
- FTIR-ATR to detect chemical bond changes (non-destructive), then
- DMA to measure modulus, detect thermal transitions (also non-destructive)
- Can extend to TGA and DSC for example





DMA results of an elastomer showing tan-delta and modulus as a function of temperature and frequency (Netzsch)

Database Status

- “User Case Analysis” phase now finalised
- Mockups created
- We have a detailed specification to make the database implementation phase as efficient as possible, given resource constraints

Servers

- The new server has arrived but is not yet installed. This is Aonyx, which will be the backup for the Lutra server inside the firewall.
- Very robust system:
  - All data entry will be done on Lutra (backed up by Aonyx), and then exported nightly across the firewall to Tarka (backed up by Mijbil) on which the query system will run. Aonyx will be in a different building to Lutra (probably in the ATLAS centre at RAL).
  - The urls can be swapped between the pairs of machines to allow for power outages, patching and other similar occurrences; this process will be invisible to users.

Database specification

- Spreadsheet table of fields with example data
- Mockups were iterated with the steering group Oct-Nov 2012 Different query pages for “passive materials” and “detector materials”
- How to handle dose and fluences measured in different ways
- Discussed conversion between radiation dose and fluence?
  - Decided to report fluences only, as dose conversion is material-dependent
- Database expert availability delayed to end of May

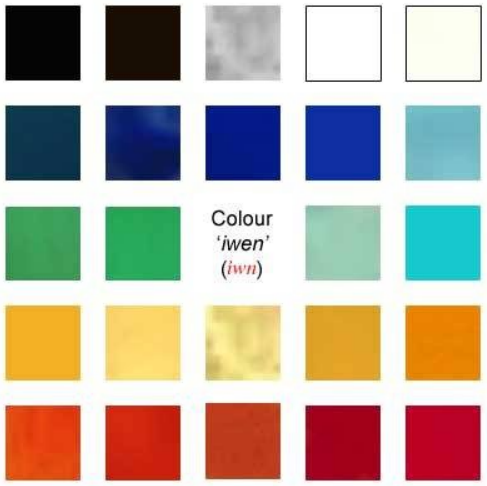
Spreadsheet to identify fields

- Drop-down boxes are preferred in the DB implementation
- The database will contain references to the detailed data via DOI and also include functionality for holding PDF files (where copyright allows).
- Comprehensive description of the radiation environment.
- To give a flavour of the results, a “headline” results figure will be included, to save users always looking for data in attachments.

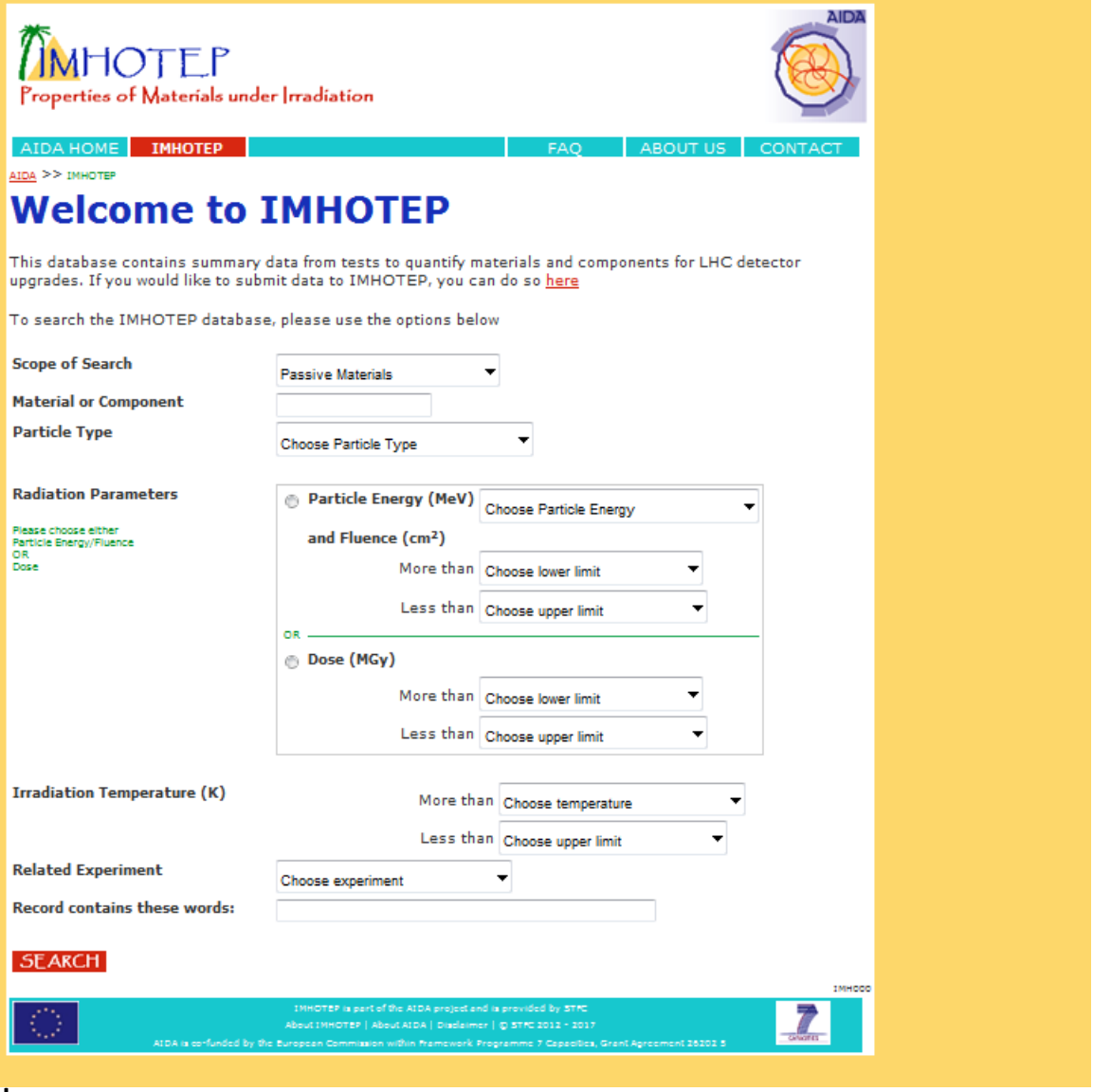
Field name	sample material/identifier	Grade	sample geometry or test type	sample dimensions	sample properties reference or datasheet	particle type	particle energy MeV	particle flux [/cm2/h]	particle fluence [cm2]	Dose [Mgy]	non-ionizing dose [Mgy]	irradiation temperature [K]	additional irradiation conditions	observable	value	measurement conditions	related experiment	reference DOI	main citations	comments	time after irradiation [hours]
data type	drop-down	drop-down	drop-down		freetext	drop-down	number	number	number	number	number	positive number	freetext	drop-down		freetext	drop-down	DOI	DOI	freetext	number
drop-down choices	epoxy	RAL71	tensile	n/a	n/a	N	n/a	n/a	n/a	n/a	n/a	n/a	n/a	stress at break	n/a	n/a	ATLAS	n/a	n/a	n/a	
	epoxy/glass	RAL237	compression			P								elongation at break			CMS				
	epoxy/carbon	Araldite2015	flexural			Gamma								breakdown voltage			LHCb				
	CE/carbon	Stycast2850FT	high voltage			electron											ALICE				
	CE/glass	epoxy-anhydride															LHCmachine				
	lead tungstate	epoxy-amine																			
		epoxy-aromaticamine																			
		epoxy-toughened																			

Database name

- Many acronyms were generated and this one chosen:
- IMhoTEP Irradiated MaTErials Properties – this one does carry on the Egyptian theme of AIDA as in the opera
- Database W3C accessibility compliant
- Colour scheme:



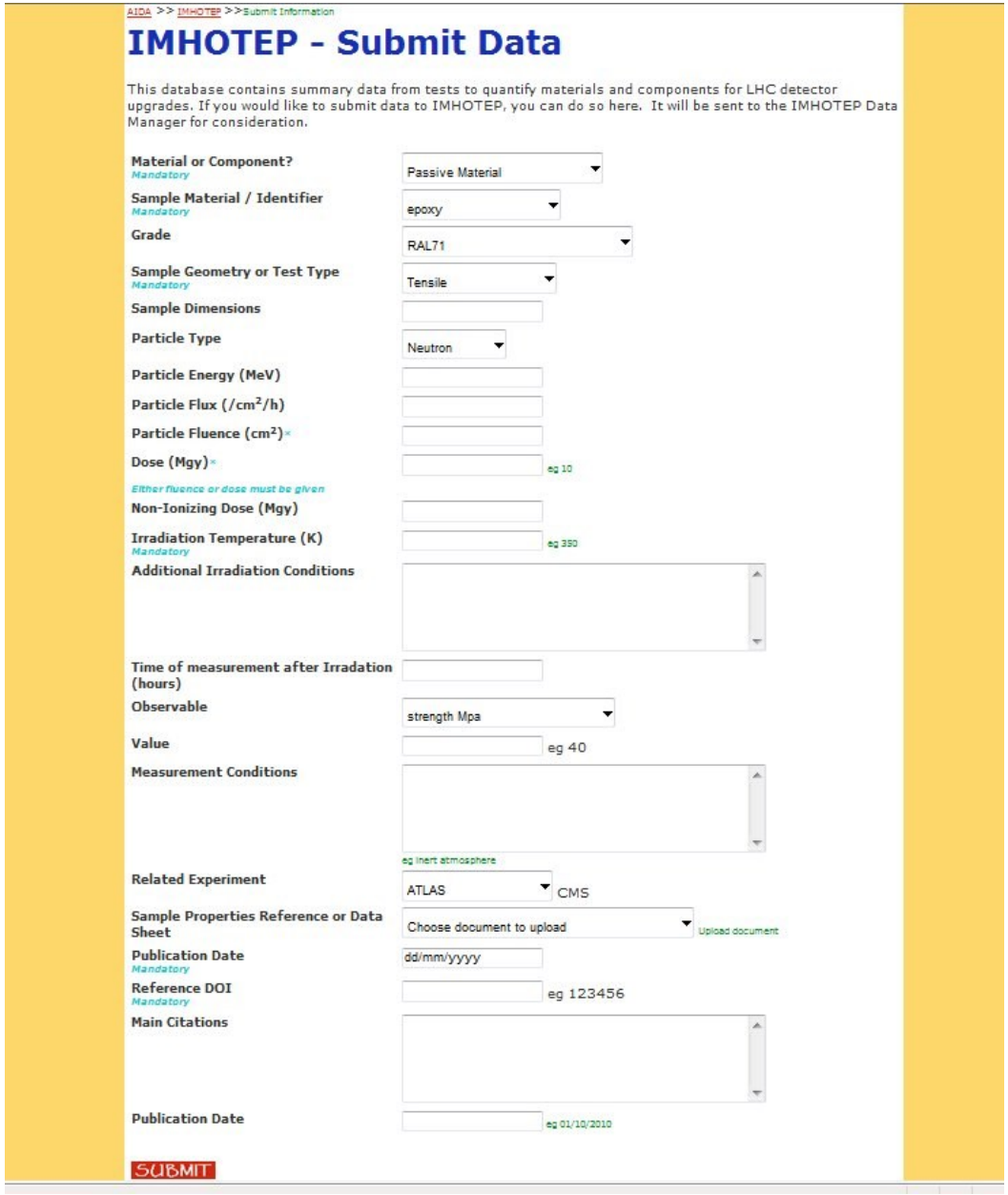
Front end and query page



- Version 6

URL with mock-ups:
http://imhotep.rl.ac.uk/Mock-Ups/IMH000.html

Data entry



AIDA >> IMHOTEP >> Submit Information

IMHOTEP - Submit Data

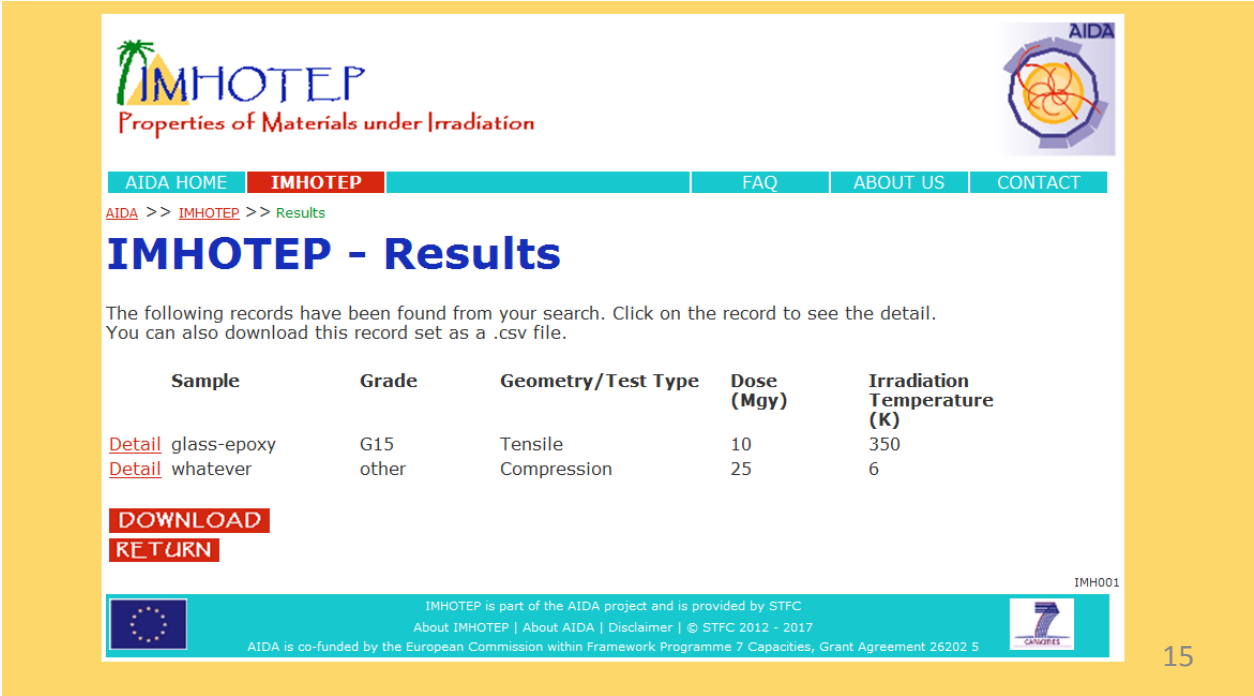
This database contains summary data from tests to quantify materials and components for LHC detector upgrades. If you would like to submit data to IMHOTEP, you can do so here. It will be sent to the IMHOTEP Data Manager for consideration.

Material or Component? *Mandatory*	Passive Material
Sample Material / Identifier *Mandatory*	epoxy
Grade	RAL71
Sample Geometry or Test Type *Mandatory*	Tensile
Sample Dimensions	
Particle Type	Neutron
Particle Energy (MeV)	
Particle Flux (/cm²/h)	
Particle Fluence (cm²) *	
Dose (Mgy) *	eg 10
Either fluence or dose must be given	
Non-Ionizing Dose (Mgy)	
Irradiation Temperature (K) *Mandatory*	eg 350
Additional Irradiation Conditions	
Time of measurement after Irradation (hours)	
Observable	strength Mpa
Value	eg 40
Measurement Conditions	eg inert atmosphere
Related Experiment	ATLAS CMS
Sample Properties Reference or Data Sheet	Choose document to upload Upload document
Publication Date *Mandatory*	dd/mm/yyyy
Reference DOI *Mandatory*	eg 123456
Main Citations	
Publication Date	eg 01/10/2010

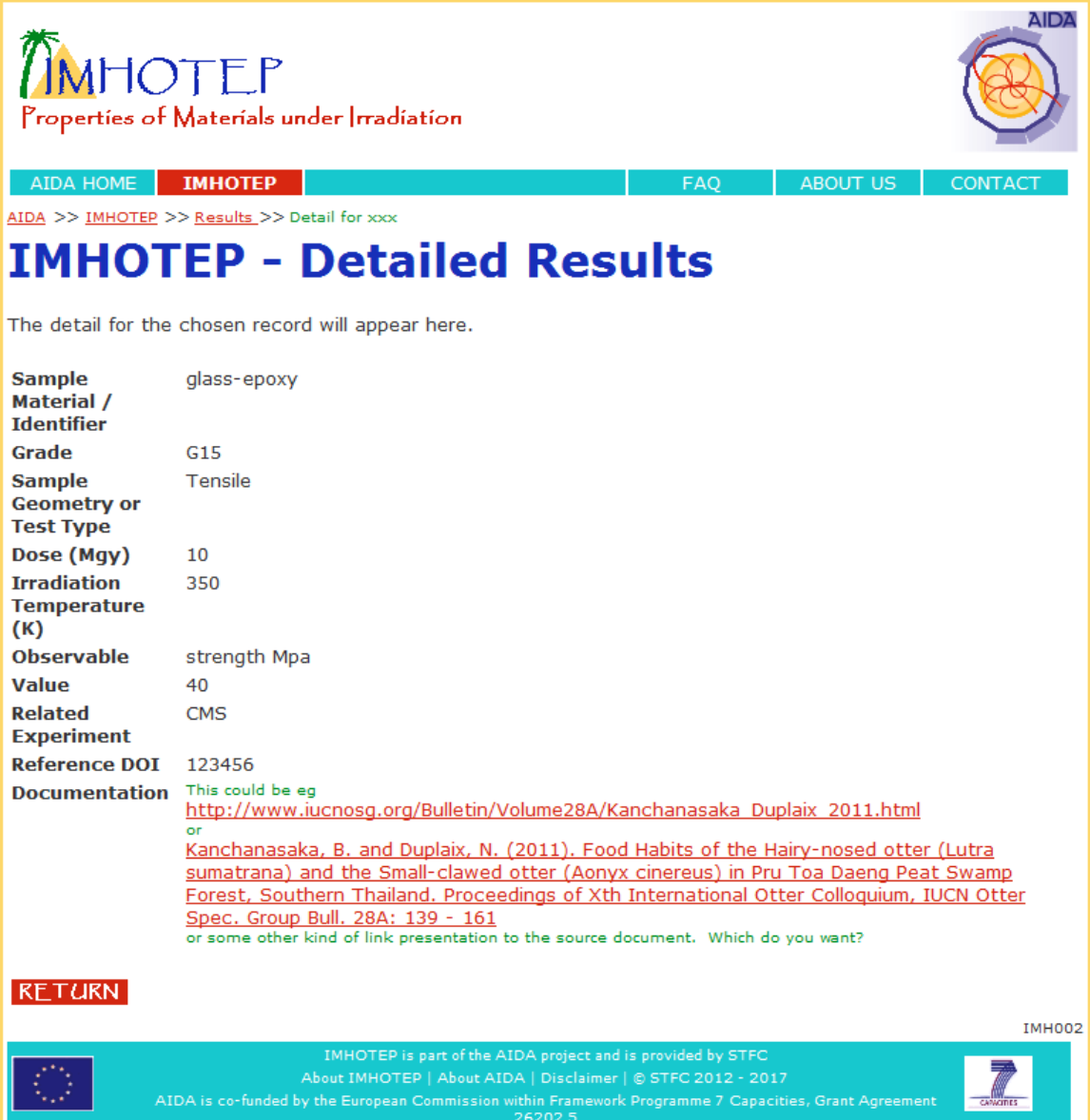
SUBMIT

Output

- Because of the large number of fields, results are summarised, with a link to a detailed page
- Exportable in CSV format
- Mockup:



Detailed output page



IMHOTEP
Properties of Materials under Irradiation

AIDA

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AIDA >> IMHOTEP >> Results >> Detail for xxx

IMHOTEP - Detailed Results

The detail for the chosen record will appear here.

Sample Material / Identifier	glass-epoxy
Grade	G15
Sample Geometry or Test Type	Tensile
Dose (Mgy)	10
Irradiation Temperature (K)	350
Observable	strength Mpa
Value	40
Related Experiment	CMS
Reference DOI	123456
Documentation	This could be eg http://www.iucnosg.org/Bulletin/Volume28A/Kanchanasaka_Duplaix_2011.html or Kanchanasaka, B. and Duplaix, N. (2011). Food Habits of the Hairy-nosed otter (Lutra sumatrana) and the Small-clawed otter (Aonyx cinereus) in Pru Toa Daeng Peat Swamp Forest, Southern Thailand. Proceedings of Xth International Otter Colloquium, IUCN Otter Spec. Group Bull. 28A: 139 - 161 or some other kind of link presentation to the source document. Which do you want?

RETURN

IMH002

IMHOTEP is part of the AIDA project and is provided by STFC
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AIDA is co-funded by the European Commission within Framework Programme 7 Capacities, Grant Agreement 262202.5

Deliverables

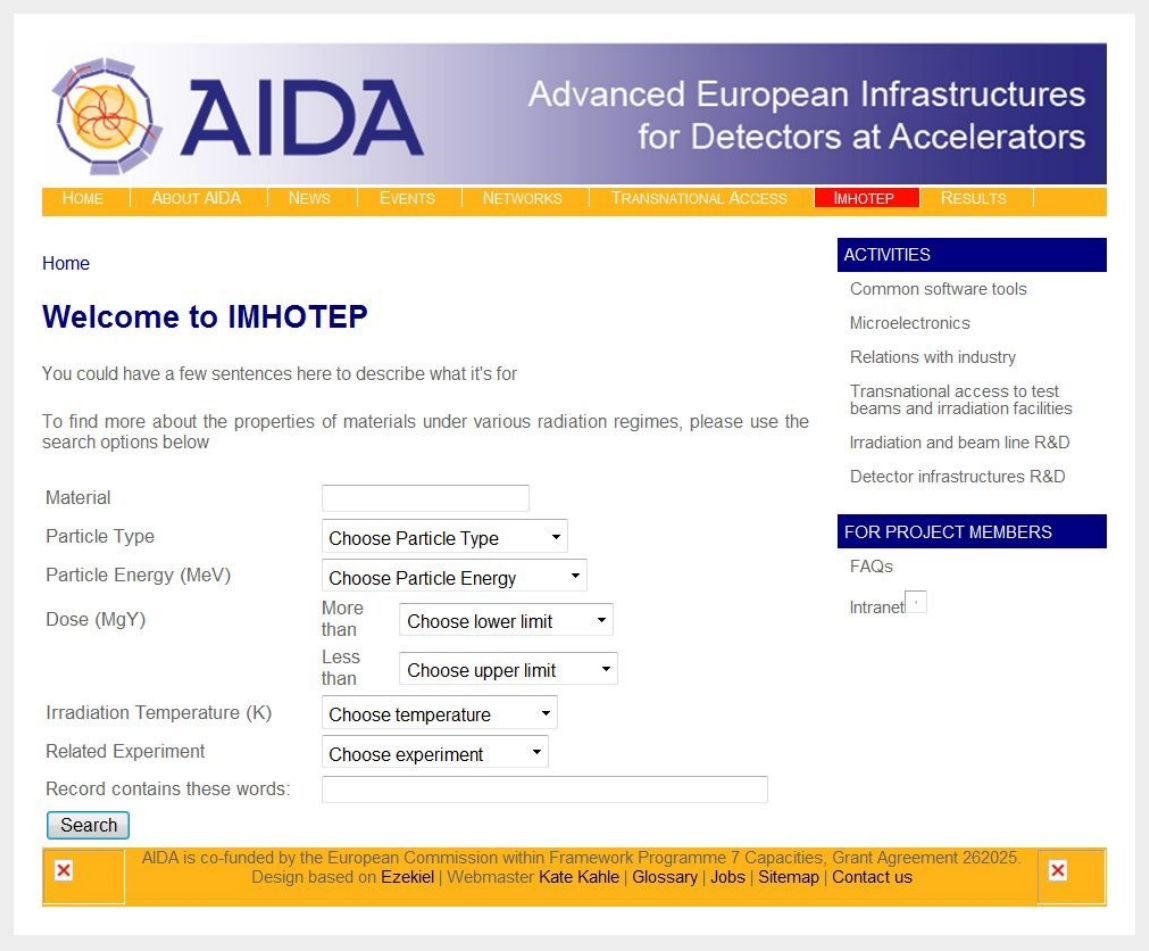
- D4.1 Experience at LHC: delivered
  - Definition of test programme: drafted and ongoing
- MS30 First results: in progress, see today's presentations
- *Thank you to our partners INFN and ETHZ for their work*

Thank you for your attention

Old slides

Front-end mockups 1

The query page style and content has been iterated: “spot the difference!”



Front-end mockups 2

Front-end mockups 3

Front-end mockups 4

Front-end mockups 5

- **System Design**
  - The system will hold local copies of source PDFs wherever copyright allows. All other sources will be represented by URLs. The Data Manager (Simon) will have to check that these links are still valid, probably as an annual housekeeping task.
    It will be possible to have more than one document per record.
  - We will not be converting between dose and fluence – the Data Manager will enter whatever is supplied in the source document
- Certain fields will be mandatory in the records – every record entered must contain at least these fields. Which fields are vital has to be **decided by the Steering Group**. Later during design we will decide on the validation needed during input to ensure consistency.