• What is a Research Proposal?
• What we are looking for
• Examples
What is a Research Proposal?

Research Proposal
• Opportunity to express yourself
• Explain what research excites you
• Communicate the project well / succinctly
• Illustrate the potential impact of the project

Show us how you think
Show us how you communicate

Why is the research necessary?
Is there a demand?
Has the problem already been solved?

Who are the beneficiaries of the research?
industry sector
a specific company or organisation
is there a societal benefit?
will this work assist the UK economy?

You will not be bound to this project - need to find matching supervisor
You can contact potential supervisors now (see links in introduction slides)
We can assist in finding suitable supervisor
Projects will be adapted / refined with supervisor if you are successful
What is a Research Proposal?

Structure Of A Research Proposal

- A catchy title helps grab attention
- Give some background to the problem
- What is the challenge? Why is this needed?
- What techniques/facilities will be used? Where will the data come from?
- Can you outline a work-plan for the research?
- Include a short bibliography (excluded from word count) not necessarily academic journal papers
What We are Looking For

Strictly 700 words maximum (excl. bibliography)
Describe 1 or 2 projects (max.)
Not much space to describe your proposal(s)

Below I list some things to consider
we do not expect all of these to be met in your proposal
consider what is most relevant to your topic

Proposal should show
• Clearly structured thought
• Ability to plan out a project - timeline and resources
• Informed background knowledge
• Match to your skills / competencies

Have you thought about the problem from more than one perspective?
Do you have the resources needed, how will you acquire them?
Are there ethical considerations, e.g. using personal data?
Are you framing the right research question?
Can you articulate why it is interesting?

In-depth academic knowledge of the stat-of-the-art is not necessary
…but if you have it then tell us about it!
## Research Opportunities

Examples of Doctoral Research Projects on offer - please email supervisors for more information

<table>
<thead>
<tr>
<th>Supervisor</th>
<th>School</th>
<th>Project Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Chris Jones</td>
<td>Biological &amp; Chemical Sciences</td>
<td>Developing of Novel Cannabinoids with Machine Learning</td>
</tr>
<tr>
<td>Prof. Christian Beck</td>
<td>Mathematics</td>
<td>Data-driven analysis and modelling of power-grid frequency</td>
</tr>
<tr>
<td>Dr Akram Alomainy</td>
<td>Electronic Engineering</td>
<td>Development of Novel Data-Centric Techniques in emergent wireless technologies</td>
</tr>
<tr>
<td>Dr Richard Clegg</td>
<td>Electronic Engineering</td>
<td>Data-centric engineering for prediction and analysis of software</td>
</tr>
<tr>
<td>Prof. Adrian Bevan</td>
<td>Physics</td>
<td>Application of the Bayes Factor in Maximum Likelihood Fits in Data-Centric Disciplines</td>
</tr>
<tr>
<td>Prof. David Dunstan</td>
<td>Physics</td>
<td>Designing novel ultra-thin low mass curved silicon imaging sensors for X-ray diffraction and nuclear security</td>
</tr>
<tr>
<td>Dr Lin Wang</td>
<td>Computer Science</td>
<td>Deep Audio Inpainting for Digital Restoration and Music Enhancement</td>
</tr>
<tr>
<td>Prof. Josh Reiss</td>
<td>Computer Science</td>
<td>Parametric Controls from Data Analytics</td>
</tr>
<tr>
<td>Dr Seth Zenz</td>
<td>Physics</td>
<td>Designing novel ultra-thin low mass curved silicon imaging sensors for X-ray diffraction and nuclear security</td>
</tr>
<tr>
<td>Dr Yannick Wurm</td>
<td>Biological &amp; Chemical Sciences</td>
<td>A toolkit for pragmatic interrogation exploration &amp; hypothesis testing of disconnected genomic data</td>
</tr>
<tr>
<td>Dr Anthony Phillips</td>
<td>Physics</td>
<td>Using machine-learning techniques to identify new perovskite materials with electrical properties that exceeding those of inorganic perovskites</td>
</tr>
<tr>
<td>Dr Jens-Dominik Mueller</td>
<td>Engineering</td>
<td>Adaptive multi-fidelity robust design optimisation driven by machine learning</td>
</tr>
</tbody>
</table>

### Links to Available Doctoral Research Projects in our Schools
- [School of Electronic Engineering and Computer Science](https://www.qmul.ac.uk/dce/research/)
- [School of Engineering and Materials Science](https://www.qmul.ac.uk/dce/research/)
- [School of Chemical and Biological Sciences](https://www.qmul.ac.uk/dce/research/)
- [School of Physics and Astronomy](https://www.qmul.ac.uk/dce/research/)
- [School of Mathematical Sciences](https://www.qmul.ac.uk/dce/research/)
Research into new black holes
exciting topic - Nobel Prize for physics 2020!
vague title - what will you investigate?
not data-centric engineering
do you have skills in general relativity?
will industry partners be willing to participate? probably not…
not applied research

Building a large-scale distributed database for financial assets
no research element - application of existing technology
where is the challenge? This is a solved problem

Using machine learning to increase vehicle fuel efficiency
good topic
potential interest from many industry organisations
clearly a data-engineering problem
you will need a background in vehicle design engineering
Using machine-learning to identify new perovskite materials with novel electrical properties
new application of machine learning
potential benefit to industries using perovskites (e.g. renewable solar energy)
merges chemical / materials engineering with data science approach

Designing novel ultra-thin curved silicon sensors for nuclear security
interesting data-centric engineering topic
requires software modelling skills
methodology is not clear from title
target industry is clear

Building a model of urban air pollution
hot topic currently
potential interest from many industry and governments (incl. internationally)
clearly a data-engineering problem: use input data to generate software model
Good exercises to prepare the proposal
Outline with bullet-point headings
Re-order bullet points for logical flow
Assign rough word counts to each paragraph in order of importance
Draft each paragraph

....
Forget about the draft for 1-2 days
Return to it with fresh eyes and re-order sections if needed
Cut the word-count by 20% or 30% but without losing any content

....
Repeat if you have time

This process helps you focus on what is important
Your final draft will be much ‘tighter’
in the calibration of the electron and HFS energy. This is determined by varying $\theta_e$ and $\gamma_h$ by the angular measurement uncertainty.

### 5.3 Neutral Current Measurement Requirement

Inelastic $ep$ interactions are required to have a well reconstructed interaction vertex to suppress beam induced background events. High $Q^2$ neutral current events are selected by requiring each event to have a compact and isolated cluster in the electromagnetic part of the LAr calorimeter. The scattered lepton is identified as the cluster of highest transverse momentum. In the central detector region, $\theta \geq 30^\circ$, the cluster must be associated to a CTD track. Forward going leptons with $\theta < 30^\circ$ traverse the region between the FTD and CTD where an increased amount of dead material causes electrons to shower. Since in this kinematic region the scattered lepton has high energy and the contribution from photoproduction background is very small, no tracker information is required to be associated with the lepton for $\theta < 30^\circ$.

Energy-momentum conservation requires the variable $E - P_t$ summed over all final state particles (including the electron) to be approximately equal to twice the initial electron beam energy. Restricting $E - P_t$ to be greater than 35 GeV considerably reduces the photoproduction background and the radiative processes in which the scattered lepton or bremsstrahlung photons escape undetected in the beam direction.

The photoproduction background increases rapidly with decreasing electron energy, therefore the analysis is separated into two distinct regions: the *nominal* analysis ($y_e < 0.63$ for $Q^2 < 890 \text{ GeV}^2$ and $y_e < 0.93$ for $Q^2 > 890 \text{ GeV}^2$) for which the minimum electron energy is $11 \text{ GeV}$ and the *high $y$* analysis ($0.63 < y_e < 0.9$ and $56 < Q^2 < 890 \text{ GeV}^2$) for which the minimum electron energy is $5 \text{ GeV}$. The techniques employed to control background in each analysis are described below.

#### 5.3.1 Nominal Analysis

For the *nominal* analysis the small $e^p$ contribution is statistically subtracted using the background simulation. The subtraction of the background simulation is checked using a sample of data $e^p$ in which a true scattered lepton is observed in the electron tagger which, however, is not required to be associated to a CTD track.

The comparison of the $e^p$ data and the simulation is shown in figure 4(a) for the scattered lepton energy spectrum and polar angle, and the distribution of $E - P_t$, which are all used in the kinematic reconstruction of $x$ and $Q^2$ using the $e\Sigma$-method. The corresponding distributions for $e^p$ data and simulation are shown in figure 4(b). In the figure the $R$ and $L$ data are combined and the simulation is normalised to the luminosity of the data, as is also done for all later performance figures. All distributions are described well by the simulation aside from a small difference in normalisation which is discussed in section 7.2 where the data are compared to the NLO QCD fit.

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For the NC analysis in the region $y < 0.19$ the noise component has an increasing influence in the transverse momentum balance $P_{T,h}/P_{T,\bar{h}}$ through its effect on $P_{T,\bar{h}}$. The event kinematics reconstructed with the $e\Sigma$-method in which the HFS is formed from hadronic jets only, limits the noise contribution and substantially improves the $P_{T,h}/P_{T,\bar{h}}$ description. The jets are found with the longitudinally invariant $k_t$ algorithm [59, 60] as implemented in FastJet [68, 69] with radius parameter $R = 1.0$ and are required to have transverse momenta $P_{T,h} > 2 \text{ GeV}$. In figure 5(a) the quality of the simulation and its description of the $e^p$ data for $y_e < 0.19$ can be seen for the distributions of the $P_{T,h}/P_{T,\bar{h}}$, $\gamma_h$, and $E - P_t$ where all HFS quantities are obtained using the vector sum of jet four-momenta. Distributions for the $e^p$ sample are also shown in figure 5(b). Overall both sets of distributions are well described in shape by the simulation.

At low $y$, the forward going hadron final state particles can undergo interactions with material of the beam pipe. In some cases the products of these secondary interactions are incorrectly assigned as originating from the primary vertex, potentially leading to a determination of the primary interaction vertex position. Such cases are corrected by considering a vertex position calculated using a stand-alone reconstruction of the track associated with the electron cluster [65, 67].

For the nominal analysis the $e^p$ contribution is low, and this allows the electron candidate track verification to be supplemented with an alternative method which increases the NC events with no CTD track associated to the electron cluster, the tracks are achieved by searching for hits in the CIP located on the line from the positron to the electron cluster.

An improved treatment of the vertex determination and verification of the electron cluster and the tracker information improves the reliability of the vertex position determination and increases the efficiency of the procedure to 99.5%.

#### 5.3.2 High $y$ Analysis

In the *high $y$* region the neutral current analysis is extended to lower energies of the scattered electron, $E_{te} > 3 \text{ GeV}$. At low energies photoproduction background contributions arise due to $\pi^0 \rightarrow \gamma \gamma$ decays and charged hadrons being mis-identified as electron candidates. Part of this background is suppressed by requiring a well measured track linked to the calorimeter cluster. The track is furthermore required to have the same charge as the beam lepton. The remaining background in the correctly charged sample is estimated from the number of data events in which the detected lepton has opposite charge to the beam lepton. A charge asymmetry can arise due to the different detector response to particles compared to anti-particles, in particular for $p$ and $\bar{p}$ [70, 75]. By taking into account the charge asymmetry between negative and positive background, the background estimate is statistically subtracted from the correctly charged sample.

The charge asymmetry between fake lepton candidates in the $e^p$ and $e^p$ data sets is determined by measuring the ratio of wrongly charged fake scattered lepton candidates in $e^p$ and $e^p$ scattering, taking into account the difference in luminosity. The asymmetry is found to be $1.03 \pm 0.05$. This is cross checked using a sample of photoproduction events in which the scattered electron is detected in the electron tagger. Further details are given in [57, 71].

The $e\Sigma$-method using scattered lepton variables alone has the highest precision in this region of phase space and is used to reconstruct the event kinematics.
the editing process was brutal - but helped produce a great final draft!