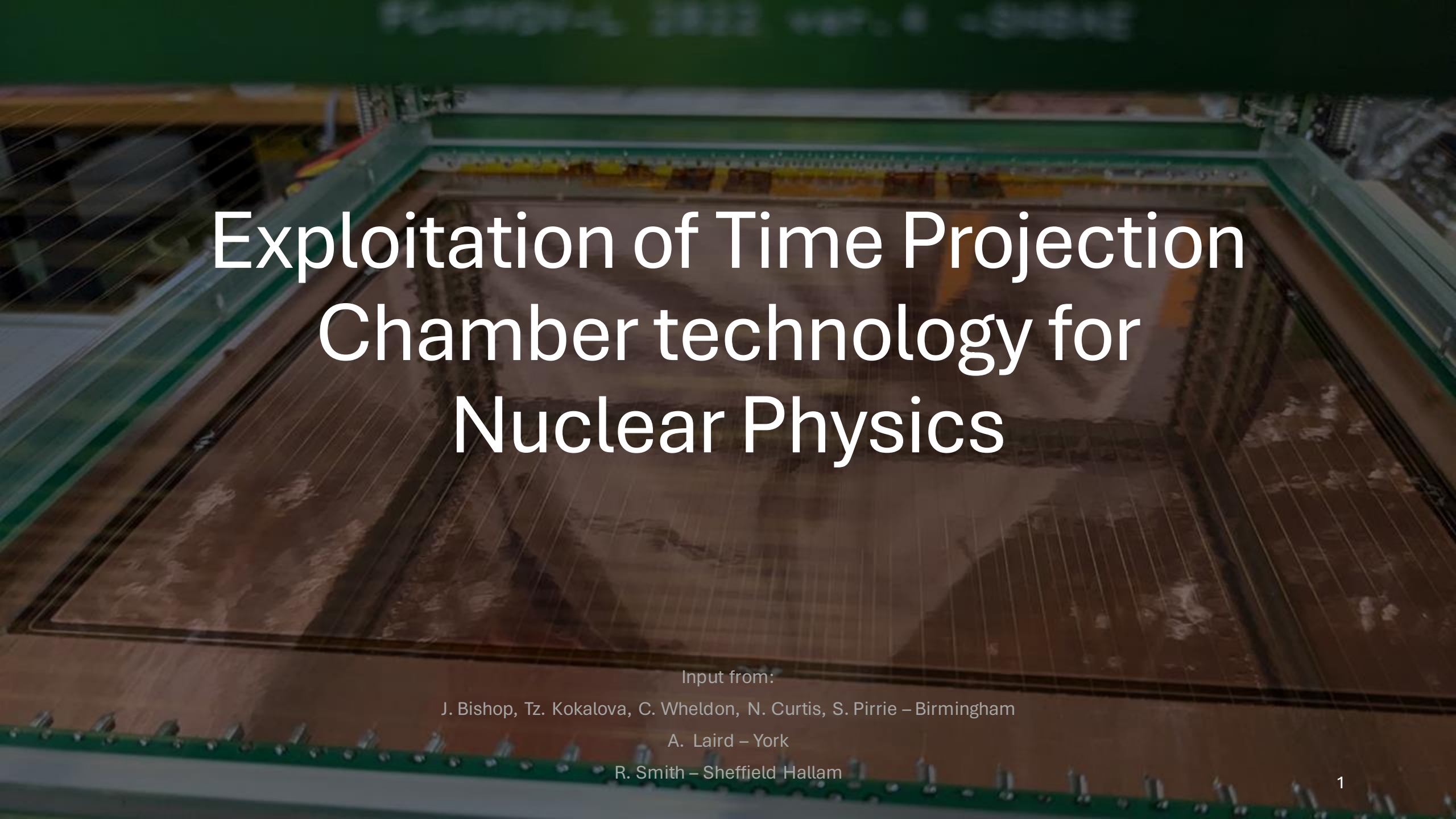

# Exploitation of Time Projection Chamber technology for Nuclear Physics

Input from:

J. Bishop, Tz. Kokalova, C. Wheldon, N. Curtis, S. Pirrie – Birmingham

A. Laird – York

R. Smith – Sheffield Hallam

# Overview:

1. Time Projection Chambers (TPCs) offer great opportunities across many different areas of nuclear physics
2. It is an area with great synergies with both PP and AP

# Aims:

1. Promote broader UK-collaboration of TPC technology and utilisation
2. Develop the capabilities among the UK community of TPCs
3. Be prepared for a reactive proposal to develop a new (portable) TPC

# Detector Developments: What needs to be solved

Problems of TPCs:

- Active-target approach – needs a good target gas
  - Lots of development now for pure $H_2$, $D_2$ , He TPC gas
  - Development of thin-membrane gas regions, used for $^3$He or even tritium
- High-rate issues – phase charge distorts your E-field + dE/dx
  - Beam region agnostic approach e.g. TACTIC, ANASEN
  - Field-restoring wires near the beam region – being looked at by a few people
- Highest-possible dynamic gain – very low dE/dx particles (MIPs) **+ beam**
  - Unique challenge to NP!
    - Some electronics approaches
    - Spark protection still required – resistive micromegas "may" help

# Current Electronics Issues

- GET (General Electronics for TPCs) is reaching EOL
  - Production of chips harder (low batch size/old technology)
  - Highly-useful unit, MuTANT, no longer produced
    - Efforts to solve both these problems are ongoing and making progress
  - Community decision (TPC2023) was essentially to wait it out until the next generation technologies are available over ~3-5 years
- Why use special electronics at all?
  - High channel count: bespoke ASICs ~25% of cost per channel c.f. CAEN digitisers
  - Operating in magnetic fields
  - Trigger modules e.g. MuTANT capabilities allow for very specific triggering schemes that may not be possible elsewhere

# New Electronics – what is coming up? AKA why bother waiting?

- Triggerless/streaming electronics (e.g. SAMPA – 5(?) years)
  - Allows access into traditionally rate-limited TPC area
- High dynamic range CSA (e.g. FEANICS – small-scale testing 2024)
  - Automatic fast-switching CSA gain (within the rise of the pulse)
  - Up to $2^{15}$ gain factor difference
  - Allows (e.g.) access into low E or dE/dx particle fragments from heavy ion collisions

- To get the best outcome:cost ratio of a new device, needs to be built with next-generation electronics – timescale dictated by the development/availability of this
  - If the UK NP community has specific needs – we need to steer development

# New Physics cases (or new edge for TPCs)

- Not all (most(?)) experiments are not suited to TPCs
- Not suggesting developing a TPC for the sake of it
- Some areas where niche is there but unexplored e.g.:
  - Neutron-induced reactions in an active target TPC (TexAT/TeBAT)
  - Hybrid TPC devices (ISOLDE, DAPPER)
  - GasDDSAM: TPC + HPGe. Lifetimes of octupole-deformed acitinides - D. O'Donnell

"If the only tool you have is a hammer, you tend to see every problem as a nail." Abraham Maslow

# UK TPC Collaborations

UK NP community has links with/are driving:

- Existing/upgraded TeBAT, TACTIC, MUSIC, Warsaw e-, and AT- TPCs.
- Proposed hybrid TPC at ISS
- UK-DRD1 community (Detector Research & Development) - ECFA:
  - Improve time and spatial resolution for gaseous detectors with long-term stability
  - Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with low material budget and different read-out schemes
  - Develop environmentally friendly gaseous detectors for very large areas with high-rate capability
  - Achieve high sensitivity in both low and high-pressure TPCs

# UK TPC Collaborations

UK NP community has links with/are driving:

- Existing/upgraded TeBAT, TACTIC, MUSIC, Warsaw e-, and AT- TPCs.
- Proposed hybrid TPC at ISS
- UK-DRD1 community (Detector Research & Development) - ECFA:

Let's get an informal network of interested people together to form a UK TPC collaboration (independent of the roadmap)

A) Lots of fantastic links from various groups – we need to utilise this shared knowledge pool
B) Lower the barrier for developing/entering TPC world
C) Possible aux. detector/electronics pooling?

**<u>When the opportunity arises to propose a new device, we should be ready!</u>**

# UK TPC

Driven by new detector developments, new electronics, new facilities and/or new physics:

- New UK-TPC involving all interested parties
- Development costs ~£1-3M depending on specifications
- Typical timescale of 3 years
- Community device – short campaign driven
- GANIL SPIRAL2/NFS, Jyväskylä IGISOL, GSI FAIR, LNL SPES, CERN ISOLDE, FRIB, TRIUMF ISAC, UOB MC40/HF-ADNeF, RIKEN RIBF, ABRA(?)