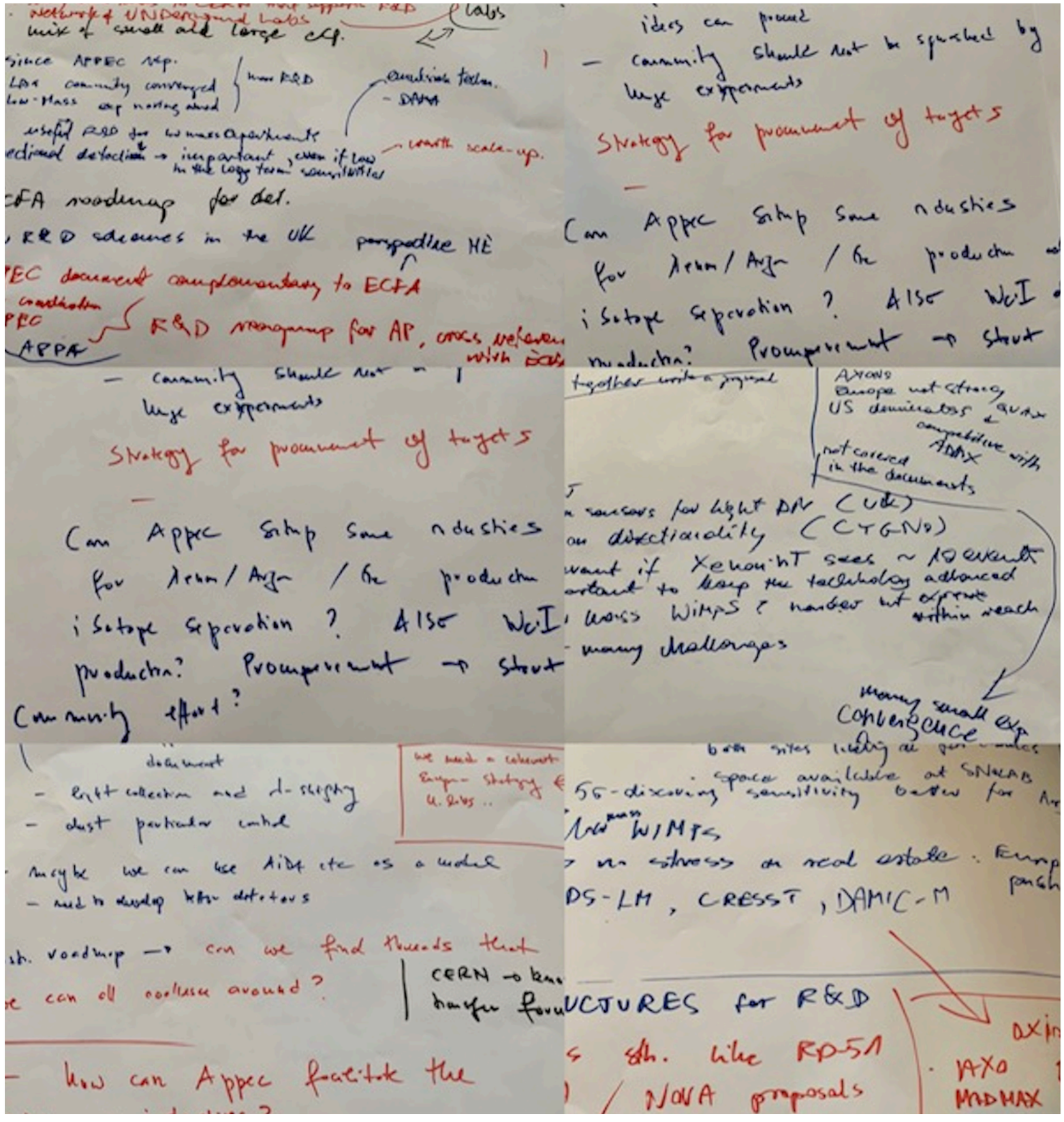
APPEC TOWN MEETING BERLIN 2022

Dark Matter

Laura Baudis, Marcin Kuźniak, Marc Schumann

Berlin, June 10, 2022

APPEC
TOWN MEETING
BERLIN 2022



Dark matter strategy statement 2017-2026

- Elucidating the nature of Dark Matter is a key priority at the leading tip of astroparticle physics - we still agree with this statement

- Among the plethora of subatomic particles proposed to explain the Dark Matter content of our Universe, one category stands out: the Weakly Interacting Massive Particle (WIMP). WIMPs arise naturally, for instance, in supersymmetric extensions of the Standard Model of particle physics - still true, and axions/ALPs added to the dark matter report

- Many experiments located in deep-underground laboratories are searching for WIMP interactions. For masses in excess of a few GeV, the best sensitivity to WIMPs is reached with detectors that use ultra-pure liquid noble-gas targets; such detectors include XENON1T (using 3.5 tons of xenon) and DEAP (using 3.6 tons of argon) - leading results from these experiments, next-generation taking data (XENONnT, 8.6 t Xe) or under construction (DarkSide-20k, 50 t of Ar). We are close to observe the neutrino background

- Also strong progress in low-mass DM experiments (CRESST, DAMIC-M) and enhancing the low-mass capabilities of established technologies (e.g., argon programme, Migdal effect)

Dark matter strategy statement 2017-2026

- A suite of smaller-scale experiments is exploring, in particular, low-mass WIMPs and other Dark Matter hypotheses such as those based on dark photons and axions - still valid, some consolidation in the field (Madmax, IAXO)

- APPEC encourages the continuation of a diverse and vibrant programme (including experiments as well as detector R&D) searching for WIMPs and non-WIMP Dark Matter - still valid, also recommended by the APPEC dark matter report

- With its global partners, APPEC aims to converge around 2019 on a strategy aimed at realising worldwide at least one 'ultimate' Dark Matter detector based on xenon (in the order of 50 tons) and one based on argon (in the order of 300 tons), as advocated respectively by DARWIN and ARGO - since then, consolidation in the field, with GADMC (DarkSide, DEAP, ArDM, MiniCLEAN) and with XENON/XMASS + DARWIN + LZ (MoU signed in July 2021, common WGs, summer meeting in June 2022 at KIT)

APPEC Dark Matter Report

- *APPEC commissioned a DM report, that came out in 2021 (discussed and endorsed by the community)*
  - The European community should aspire to retain its global leadership role in dark matter direct detection, underpinned by the pioneering LNGS programme, with the aim of realising worldwide at least one ‘ultimate’ xenon (of the order of 50 tons) and one argon (of the order of 300 tons) dark matter detector, as advocated by the DARWIN and ARGO collaborations, respectively
  - We also strongly endorse the recommendations of the 2021 APPEC Dark Matter Report that “the experimental underground programmes with the best sensitivity to detect signals induced by dark matter WIMPs scattering off the target should receive enhanced support to continue efforts to reach down to the so-called neutrino floor on the shortest possible time scale
  - Also several structural activities that APPEC should undertake to help the field are recommended: these include
    - establishing coordinated programmes for dark matter detector development in Europe, similar to the AIDA programme that has stimulated developments across accelerator-based detector R&D
    - encouraging continuing dedicated and diverse theoretical activity in this area
    - exploring the formation of a distributed *European Laboratory of Underground Science,* leveraging the synergies of the underground laboratories

Summary of round table discussions

- Organisation of common R&D (find thread that we can coalesce about, e.g., light detection and collection, integrated digital readout, advanced manufacturing methods, cleanliness control, purification)
  - APPEC could have its own R&D roadmap, complementary to ECFA
  - Could APPEC coordinate an R&D-focussed proposal to the European Commission?
- Can APPEC facilitate the relations with industries?

Summary of round table discussions

- APPEC should push for at least one, if not two, "ultimate" detectors to be located in Europe. A chance for Europe to host such world-leading experiments
- Directional detectors with potential scalability to competitive sensitivity (at least for light DM) are important
- Would it be sensible for the European underground labs to form a European Centre for Underground Physics to coordinate and distribute funding for major R&D programmes?
- Include in the report the non-WIMP science channels of WIMP detectors, now missing
- Mention importance of theory in the mid-term report

General comment on the APPEC document

- Have an executive summary for each sections
- What was achieved since 2017
- Where are we going
- Any updated recommendations

The end

Reminder: APPEC dark matter report main recommendations

APPEC Dark Matter Report

- *Recommendation 1*: The search for dark matter with the aim of detecting a direct signal of DM particle interactions with a detector should be given top priority in astroparticle physics, and in all particle physics, and beyond, as a positive measurement will provide the most unambiguous confirmation of the particle nature of dark matter in the Universe

- *Recommendation 2*: The diversified approach to probe the broadest experimentally accessible ranges of particle mass and interactions is needed to ensure the most conservative and least assumption-dependent exploration of hypothetical candidates for cosmological dark matter or subdominant relics.

- *Recommendation 3:* The experimental underground programmes with the best sensitivity to detect signals induced by dark matter WIMPs scattering off the target should receive enhanced support to continue efforts to reach down to the so-called neutrino floor on the shortest possible time scale

- *Recommendation 4:* European participation in DM search programmes and associated, often novel, R&D efforts, that currently do not offer the biggest improvement in sensitivity should continue and be encouraged with view of a long-term investment in the field and the promise of potential interdisciplinary benefits. We recommend that coordinated programmes are established for dark matter detector development

APPEC Dark Matter Report

- *Recommendation 5:* The long-term future of underground science in Europe would strongly benefit from creating a distributed but integrated structure of underground laboratories for the needs of the forthcoming generation of new experiments, and beyond. This strategic initiative would be most efficiently implemented by forming the *European Laboratory of Underground Science*

- *Recommendation 6:* European-led efforts should focus on axion and ALPs mass ranges that are complementary to the established cavity approach and this is where European teams have a unique opportunity to secure the pioneering role in achieving sensitivities in axion/ALP mass ranges not yet explored by experiments conducted elsewhere. In parallel, R&D efforts to improve experimental sensitivity and to extend the accessible mass ranges should be supported

- *Recommendation 7:* Continuing dedicated and diverse theoretical activity should be encouraged not only in its own right but also as it provides some highly stimulating, and mutually beneficial, interdisciplinary environment for DM and new physics searches.

APPEC Dark Matter Report

- *The recommendations align with the strategy set out in the 2017 APPEC dark matter roadmap*
- The European community should aspire to retain its global leadership role in dark matter direct detection, underpinned by the pioneering LNGS programme, with the aim of realising worldwide at least one ‘ultimate’ xenon (of the order of 50 tons) and one argon (of the order of 300 tons) dark matter detector, as advocated by the DARWIN and ARGO collaborations, respectively
- We also strongly endorse the recommendations of the 2021 APPEC Dark Matter Report that “the experimental underground programmes with the best sensitivity to detect signals induced by dark matter WIMPs scattering off the target should receive enhanced support to continue efforts to reach down to the so-called neutrino floor on the shortest possible time scale
- Also several structural activities that APPEC should undertake to help the field are recommended: these include *(i)* establishing coordinated programmes for dark matter detector development in Europe, similar to the AIDA programme that has stimulated developments across accelerator-based detector R&D; *(ii)* encouraging continuing dedicated and diverse theoretical activity in this area; and *(iii)* exploring the formation of a distributed *European Laboratory of Underground Science,* leveraging the synergies of the underground laboratories.