The X-ArT's context

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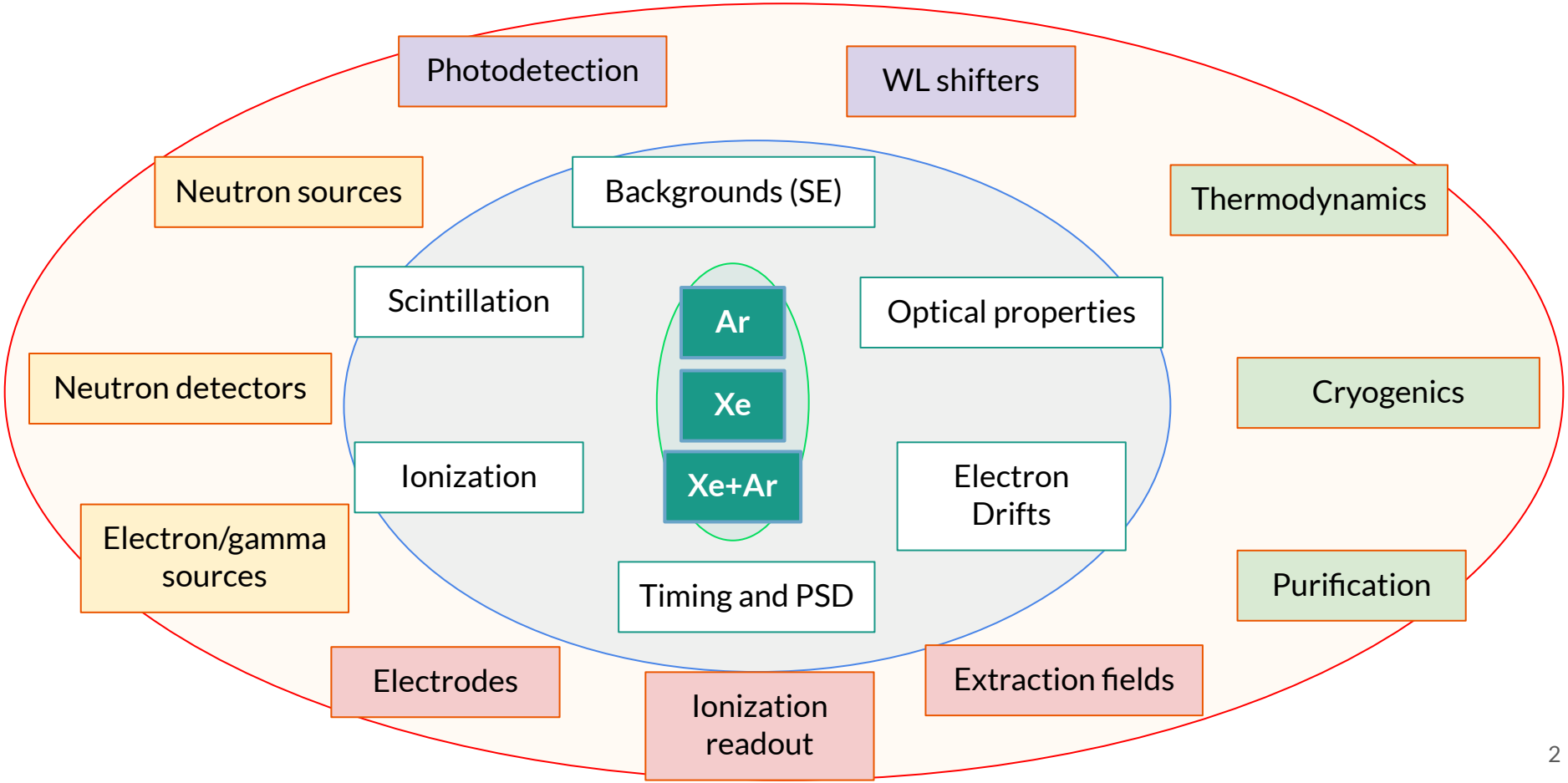
5/04/2023 - X-ArT kick-off meeting

R&Ds on microphysics and thermodynamics of noble liquids



ECFA roadmap under construction

Detector R&D 2 (DRD2): Liquid Detectors

Community Meeting on April 20th

Charge Readout
- Pixels
- Amplification electroluminescence and charge multiplication
- Charge + light readouts
- Charge to light readouts

Light readout
- Increased sensor QE
- Wavelength shifters and increasing light collection
- Improved sensors for liquid scintillators and water detectors

Target Properties
- Doping and isotope loading
- Purification
- Light emission and transport
- Microphysics and Characterization

Scaling-up Challenges
- Radiopurity and background mitigation
- Detector & Target procurement/production
- Large-area readout

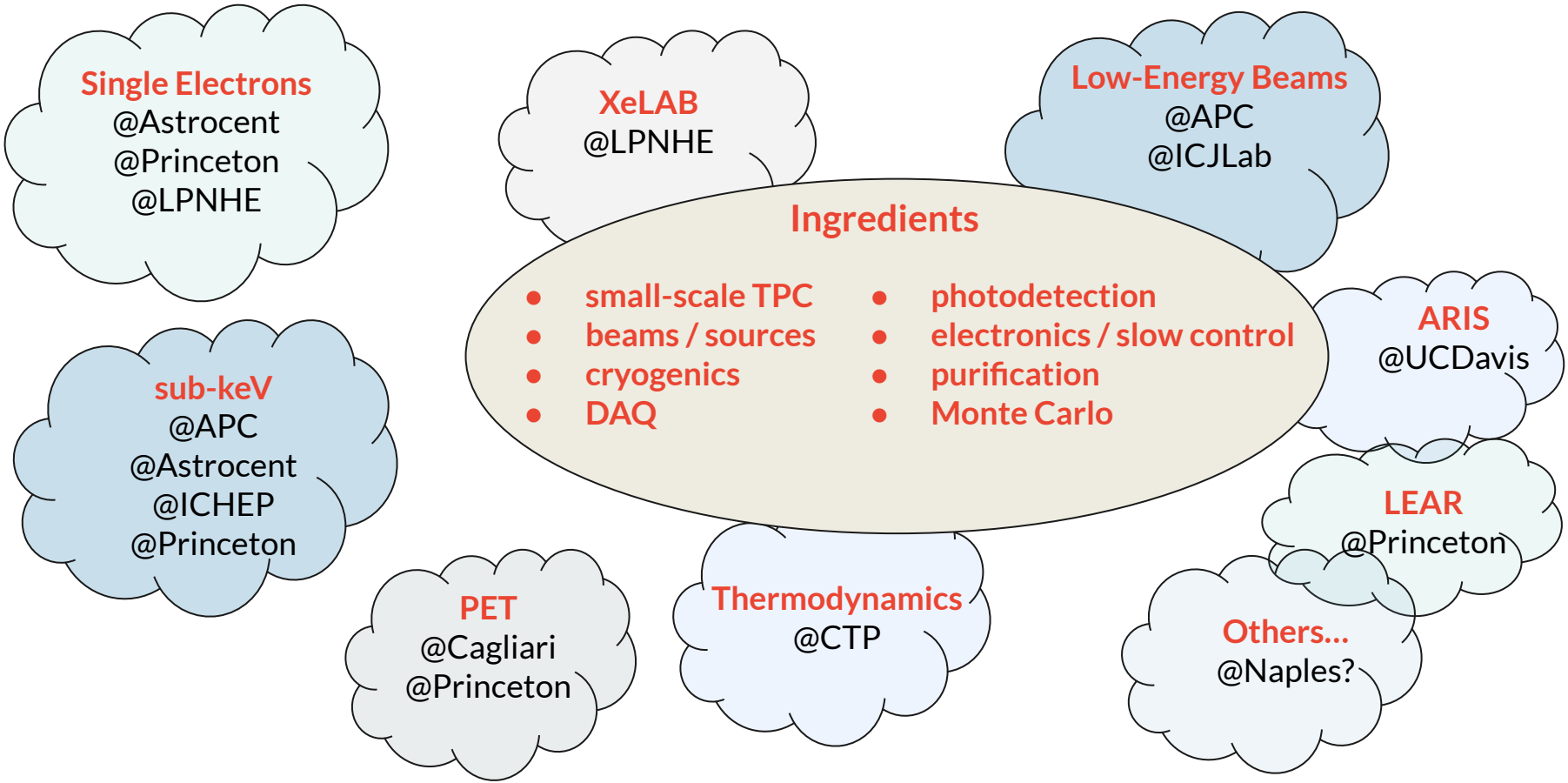
My personal roadmap

- **Characterization of LAr and LXe response in the sub-keV range (golden region for dark matter and SN neutrinos)**
  - Time response and electric field dependence
  - Nuclear and electron recoil quenching
  - Single electron emission from LAr and LXe impurities

- **Calibration sources and neutron detectors for exploring the sub-keV regime**
  - Novel low-energy electron and neutron calibration sources
  - Novel low-energy (monochromatic) neutron beams and detectors **(the novel capture-on-flight neutron detector)**

- **Scintillation, ionization, and thermodynamics of Xe-Ar mixtures (the X-ArT program)**
  - Phase diagram and maximal solubility of Xe in LAr
  - Scintillation and ionization vs Xe doping

Synergies?


Single Electrons
@Astrocent
@Princeton
@LPNHE
XeLAB
@LPNHE
Low-Energy Beams
@APC
@ICJLab
Ingredients
small-scale TPC
beams / sources
cryogenics
DAQ
photodetection
electronics / slow control
purification
Monte Carlo
ARIS
@UCDavis
sub-keV
@APC
@Astrocent
@ICHEP
@Princeton
LEAR
@Princeton
PET
@Cagliari
@Princeton
Thermodynamics
@CTP
Others...
@Naples?

Synergy?

The **primary goal** of this meeting is to define a roadmap and identify resources and needs to **complete the X-ArT program**

The **secondary goal** of this meeting is more **ambitious** but **optional**: create a **synergy** among the various projects to broaden the goals **beyond X-ArT**

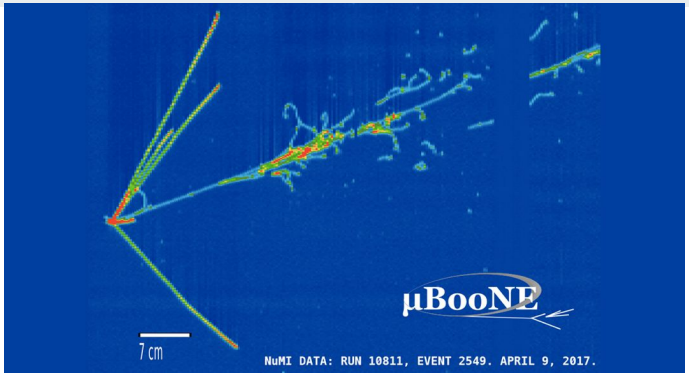
X-Art the Xenon-Argon Technology for AstroParticle Physics

Liquid argon is an excellent target for particle detection

- excellent scintillator and ionizer
- excellent particle identification
- radio-pure
- scalable to massive targets

➔ See DUNE 4 x 20 kton for neutrino CP violation (GeV scale)

➔ See DarkSide 50 ton for direct dark matter search (keV scale)



Liquid argon drawbacks

- hard to reach O(1 ns) resolution
- 128 nm photon detection requires wavelength shifter
- standard wavelength shifters cannot be mixed in the LAr bulk

Doping liquid argon with Xe

- efficient wavelength shifter
- higher light yield
- much faster scintillation
- more transparent

Xe-doped LAr potential

- faster signal (Xe-LAr PET)
- high solubility (0nuBB with ^{136}Xe in LAr)
- transparency (large volume scintillators like DUNE)

X-Art deliverables

Xe-doped LAr unknown

- what is the maximum solubility of Xe in LAr?
- what about ionization? and scintillation at the maximum Xe solubility?
- which is the Xe-Ar phase diagram?

WPA Xe-Ar thermodynamics

WPA-1 Bibliographic research
WPA-2 Experimental study of Xe-Ar phase diagram
WPA-3 Molecular simulation
WPA-4 Development of the Equation of State (EoS)

Mines ParisTech
ICB - U. Bourgogne

WPB Xe-Ar scintillation and ionization

WPB-1 TPC construction
WPB-2 Photoelectronics and DAQ
WPB-3 Cryogenics
WPB-4 Operation
WPB-5 Simulation and data analysis

France APC, LPNHE, Mines ParisTech
Italy GSSI, INFN Naples
US UC Davis, Princeton
China ICHEP