# Improvements to the next phase of PICASSO and anticipated Dark Matter exclusion limits

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For the PICASSO Collaboration

Overview of PICASSO

- Tiny superheated C4F10 droplets embedded in a gel.
- Recoiling nuclei (from WIMP, α, or n interactions) have sufficient energy to induce the phase transitions which are recorded using piezoelectric transducers.

200 μm

Time (us)
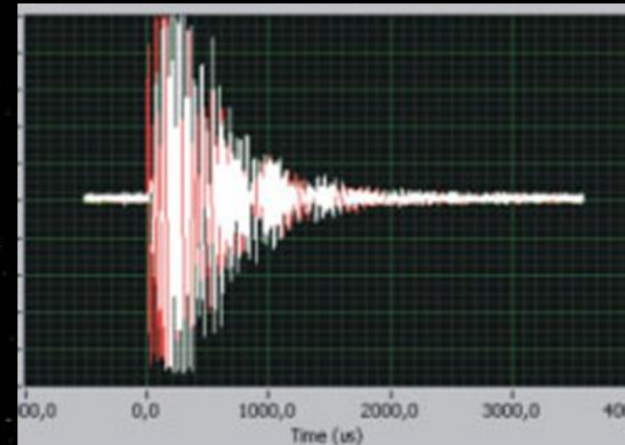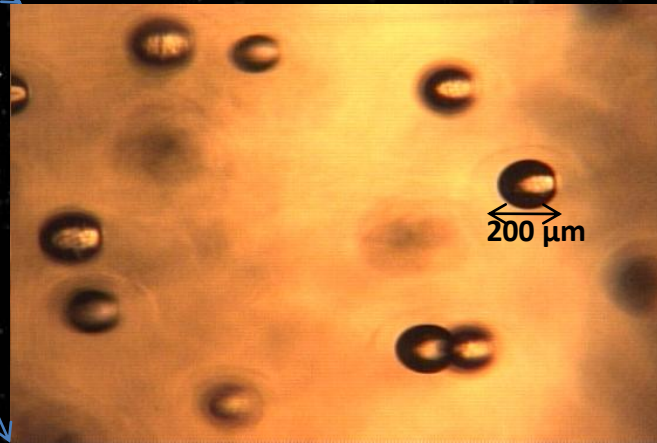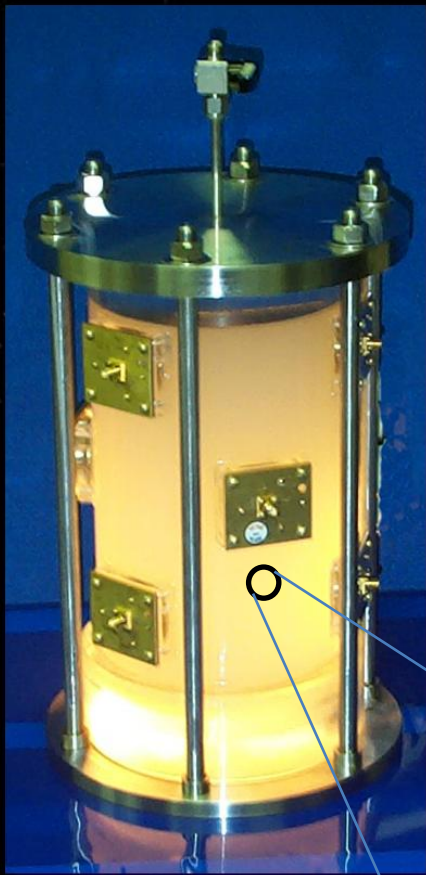
A bubble forms if the particle creates a heat spike
- with enough energy Emin
- deposited within Rmin

Mainly sensitive to heavily ionizing particles.
Alphas are main background
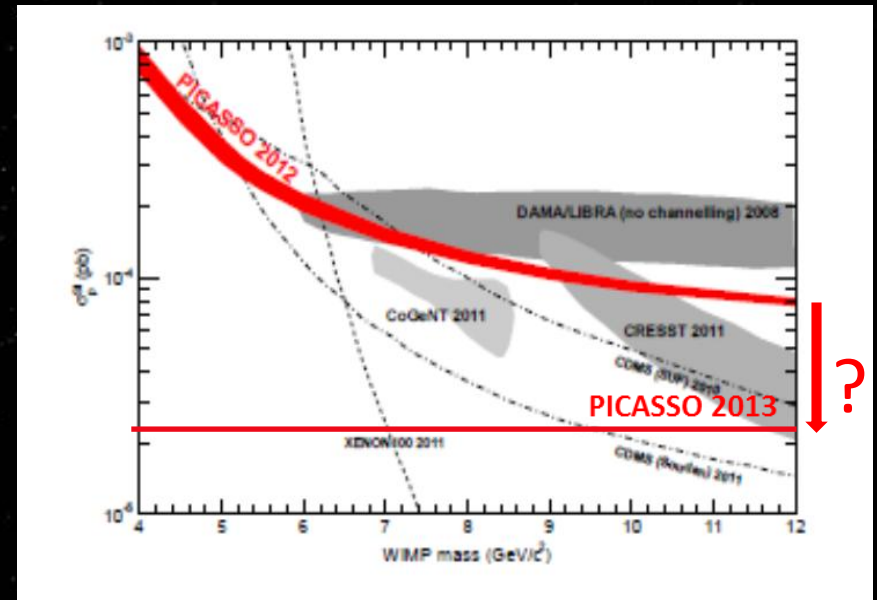
Status of Physics Analysis (PICASSO 2012)

Talk by Marie-Cecile Piro

- 10<<golden detectors>> with 114 kgd exposure
  - ➤ Results better than 2009 by a factor of 5 (SD sector)!
- 19F & low energy threshold → improved sensitivity for M_W <15GeV/C^2
  - ➤ PICASSO is for the first time competitive in the Spin Independent sector !
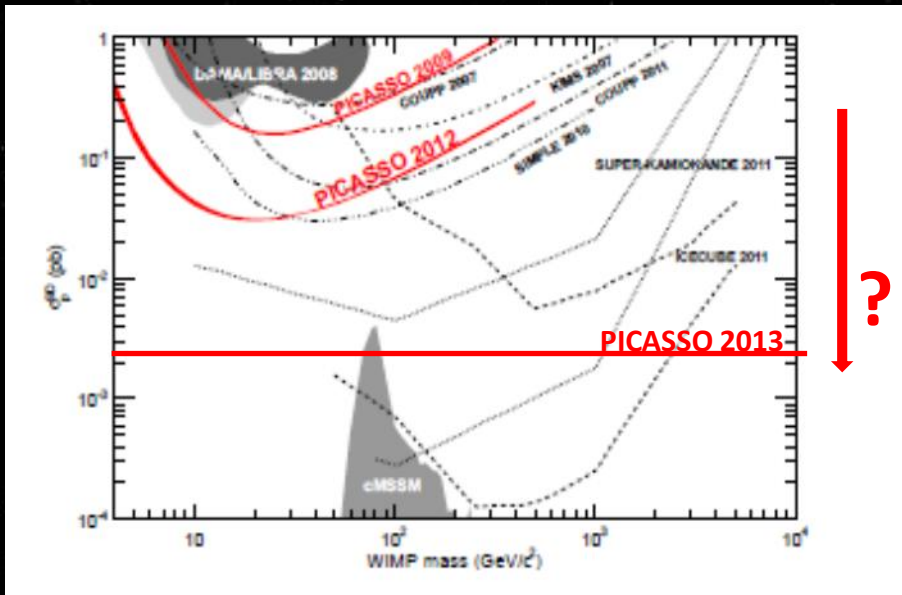
SD sector, arXiv:1202.1240


SI sector, arXiv:1202.1240

Strategies towards greater sensitivity

- Run longer → Not useful!

- Reduced backgrounds → very useful!
  - Improved neutron shielding set up
  - Cleaner detectors for low α contamination
  - Better α –recoils discrimination
    - Improved DAQ
    - Improved electronics
    - Improved 3D event localization

OUTLINE

- Improvement on background reduction
- Improvement on background discrimination
  - Status of the α-WIMP/neutron before the move
  - Current status of the α-WIMP discrimination
- Outlook and projected Sensitivity
- Summary

The move ...
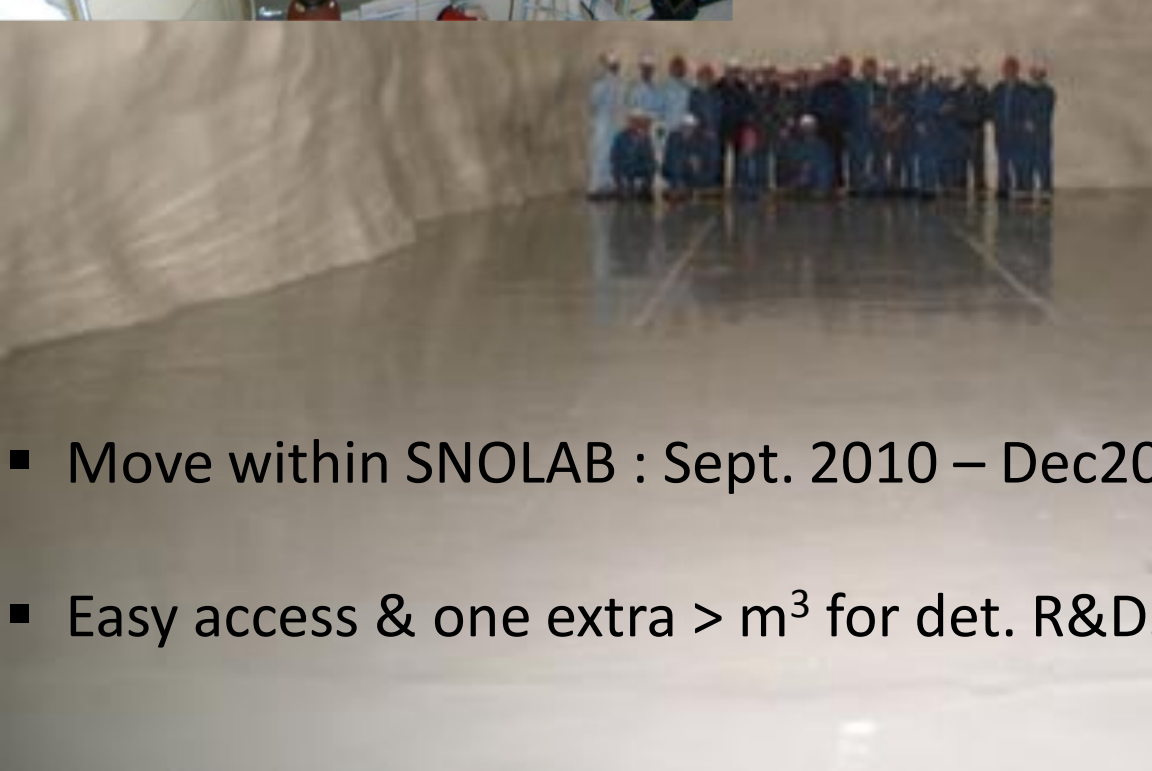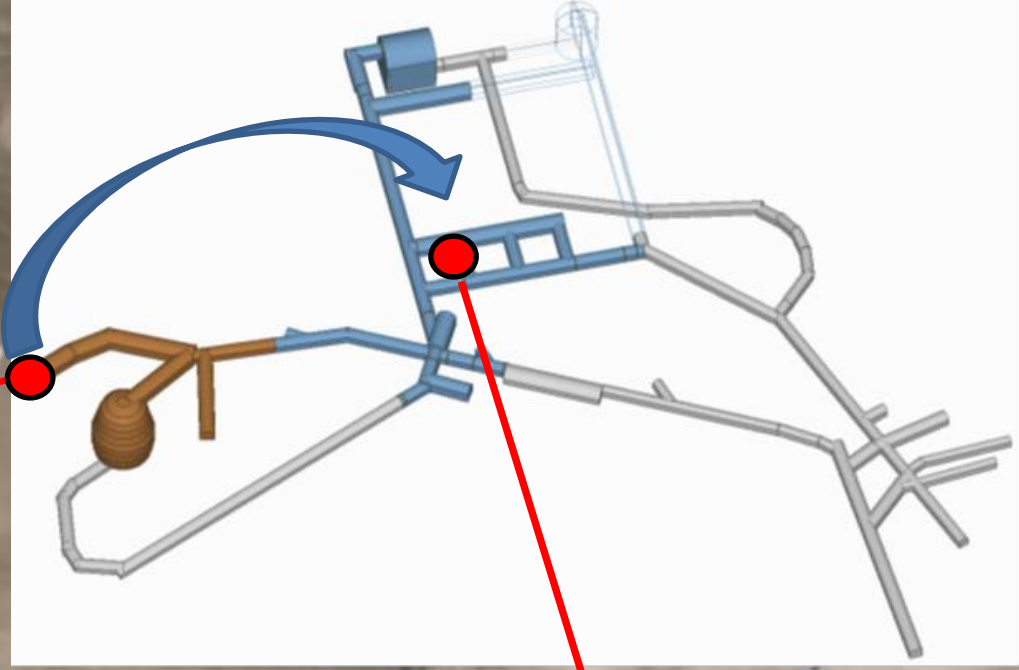
- Move within SNOLAB : Sept. 2010 – Dec2010.

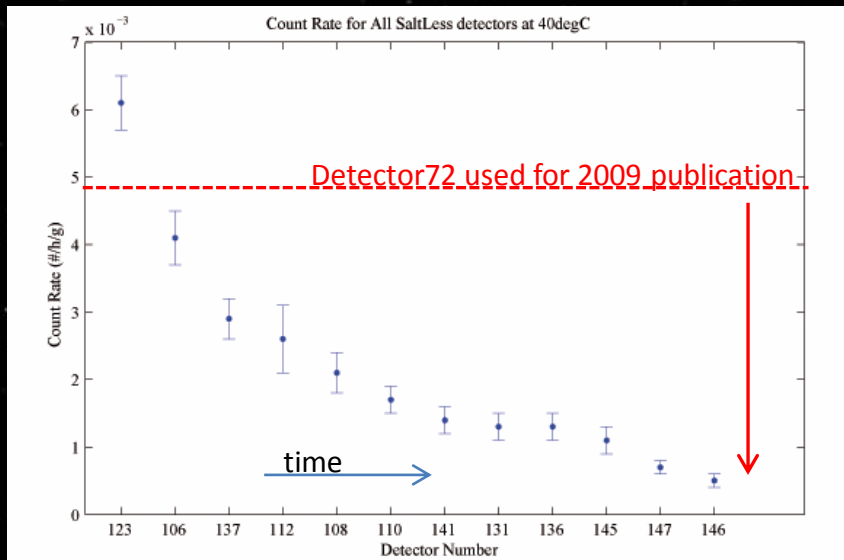- Easy access & one extra > m^3 for det. R&D.

Improvement on background reduction

Neutron background

- Improved UPW shielding (30 cm →50cm).
- Improved shielding design (thicker & hermetic)
 - ➤ Ambient N-flux reduced by >400!

Alpha background

- Build more detectors with very clean gel matrix.

→ Rate reduced by a factor of 10!

➤ From 15/32 → ~32/32 detectors "clean"

Count Rate for All SaltLess detectors at 40degC

Detector72 used for 2009 publication

Count Rate (#/h/g)

time

Detector Number

Discrimination of nuclear recoil from Alpha Particles

α- events have "louder" noise than recoil induced events
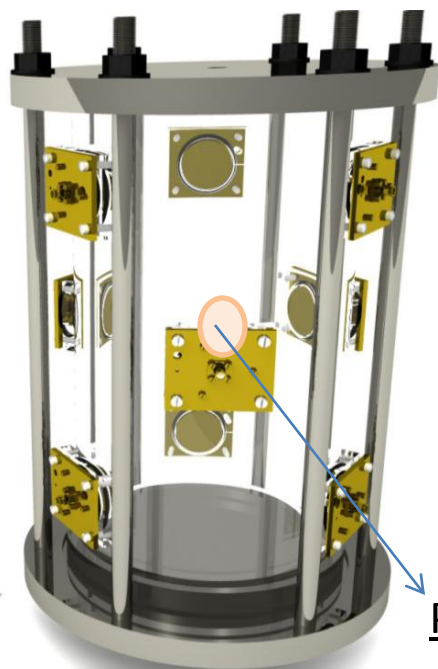
- $I = \dfrac{\rho \ddot{V}}{4\pi C}$

  I : Intensity of acoustic signal
  ρ: density of liquid
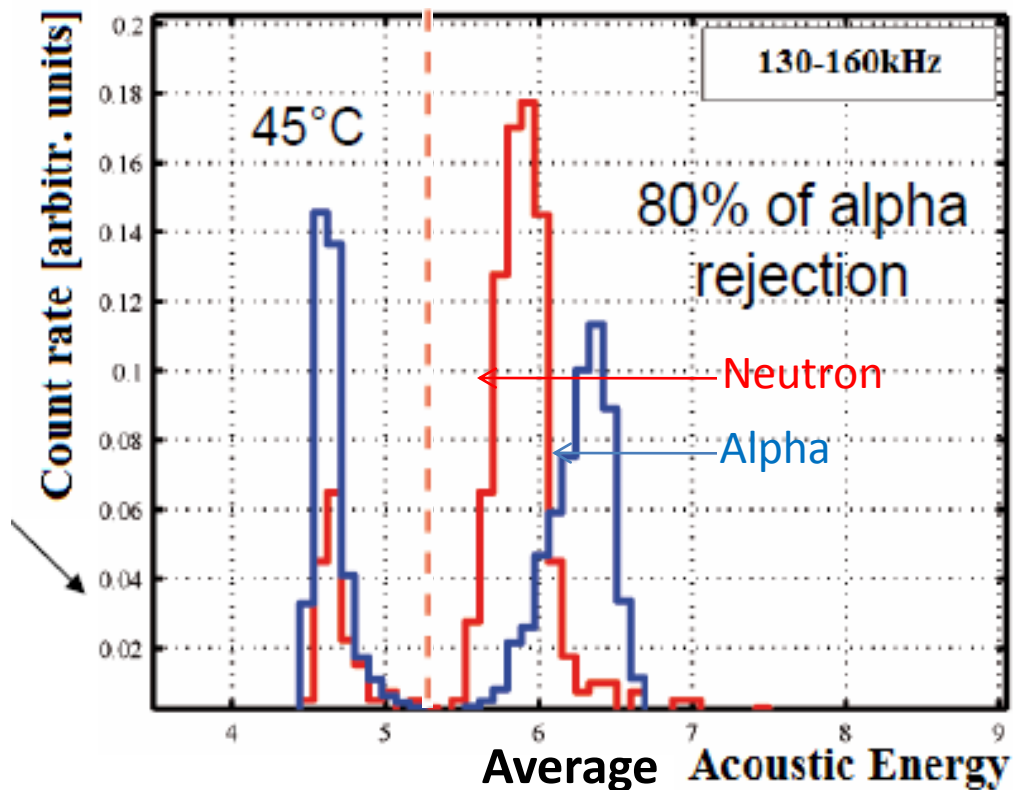 c : speed of sound
  V : volume of expanding region

particle

C4F10

Protobubble

recoil

recoil

alpha
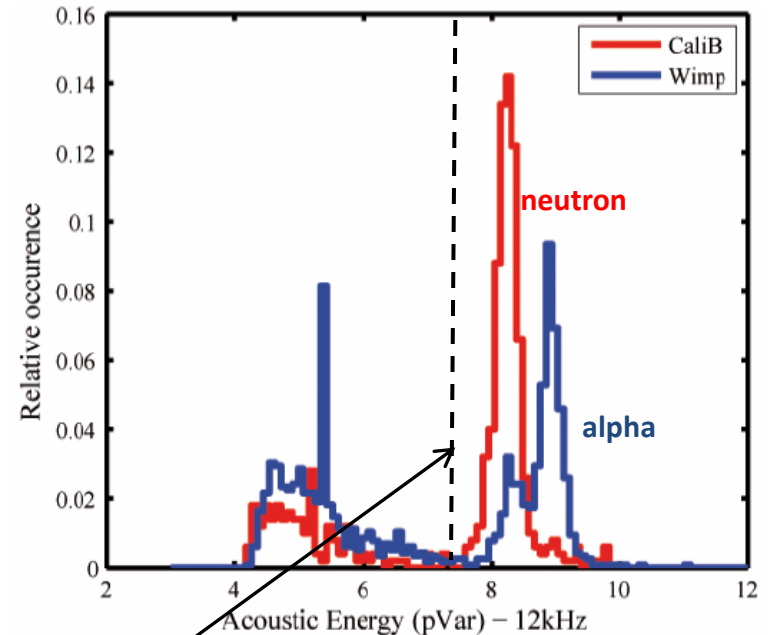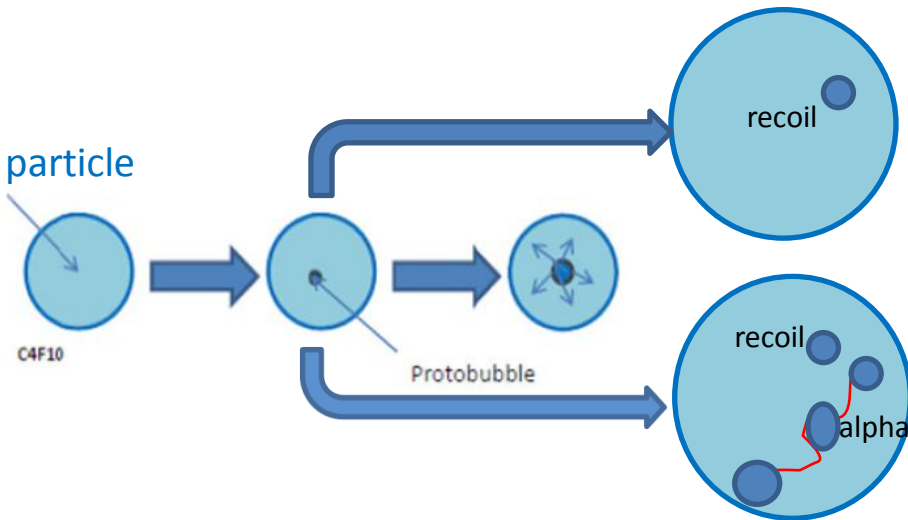
Very good separation between physics events and acoustic/electronic noises background events.

NJP 13(2011)103017 arXiv: 1011.4553

Status of the α-n discrimination before the move

The best we could do...

Need of a better resolution
- Narrowed peaks for better separation
➔ Improve on 3D event localization
using a corrected weighted average for all piezos

Position of an event respect to the nine piezoelectric sensors

Limitations on the discrimination technique and solutions

❖ High gain preamp

o Saturated signal at high temperature

→ Loss of frequency information
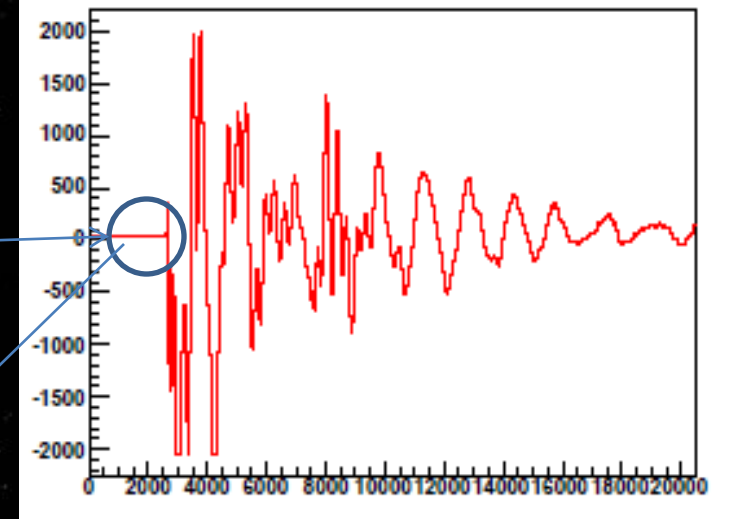
→ Optimized gain of preamps.
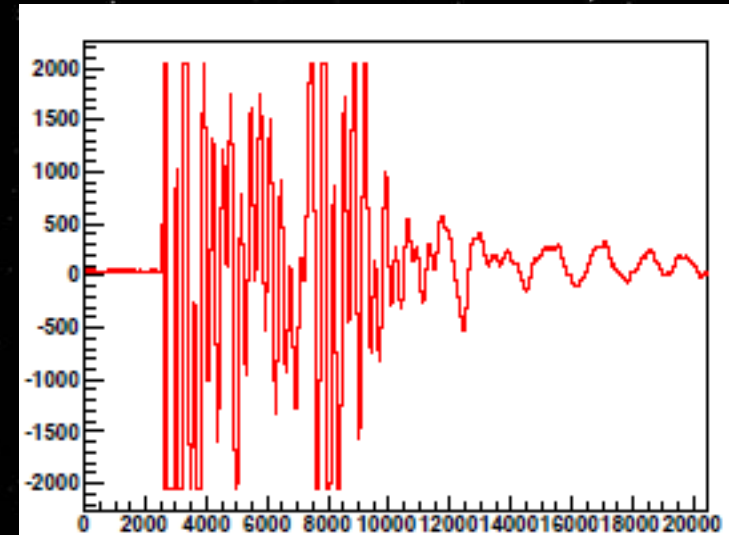
❖ "slow" DAQ

o Fairly rough pulse shape.

→ Loss of information in the important part of the signal

→ Event localization not optimum due to uncertainty on t0

→ Faster DAQ

First few moment in time crucial for particle discrimination

Current status of the α-recoil discrimination

The α-WIMP discrimination has improved :

❖ With improved electronics (gain) → use all information in signals
❖ With improved event localization →position dependent amplitude adjustment
❖ With Temp. dependent frequency filter: 20 kHz@25^0 →140 kHz @45^0
❖ With Increased sampling frequency 400kHz →800 kHz
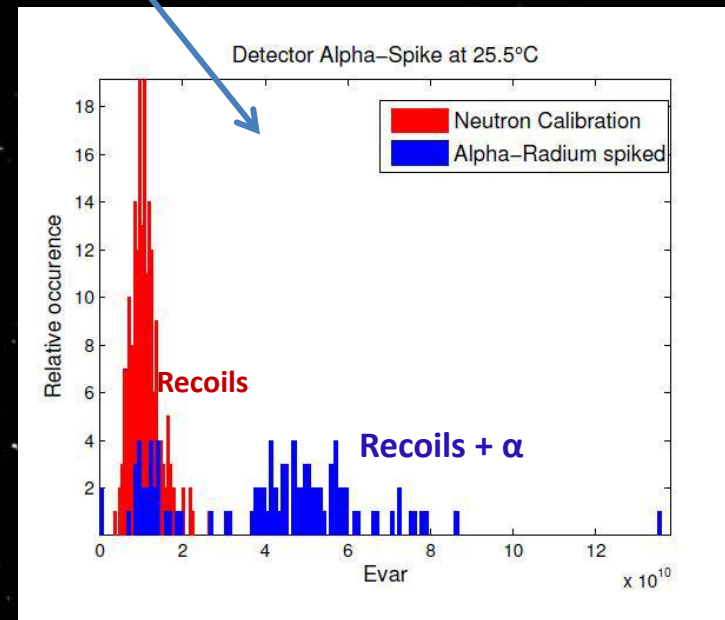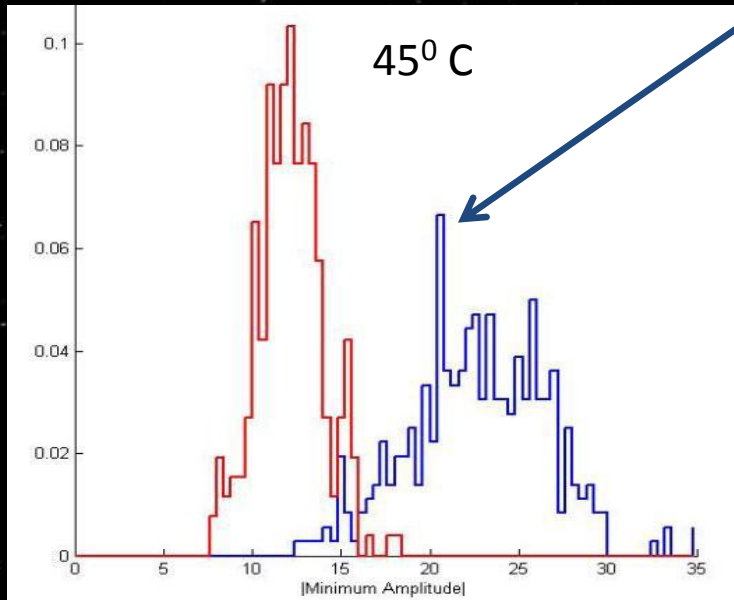
99.34 % α rejection @80%WIMP acceptance

50% of detectors are operating with new DAQ and electronics

Outlook & Projected sensitivity
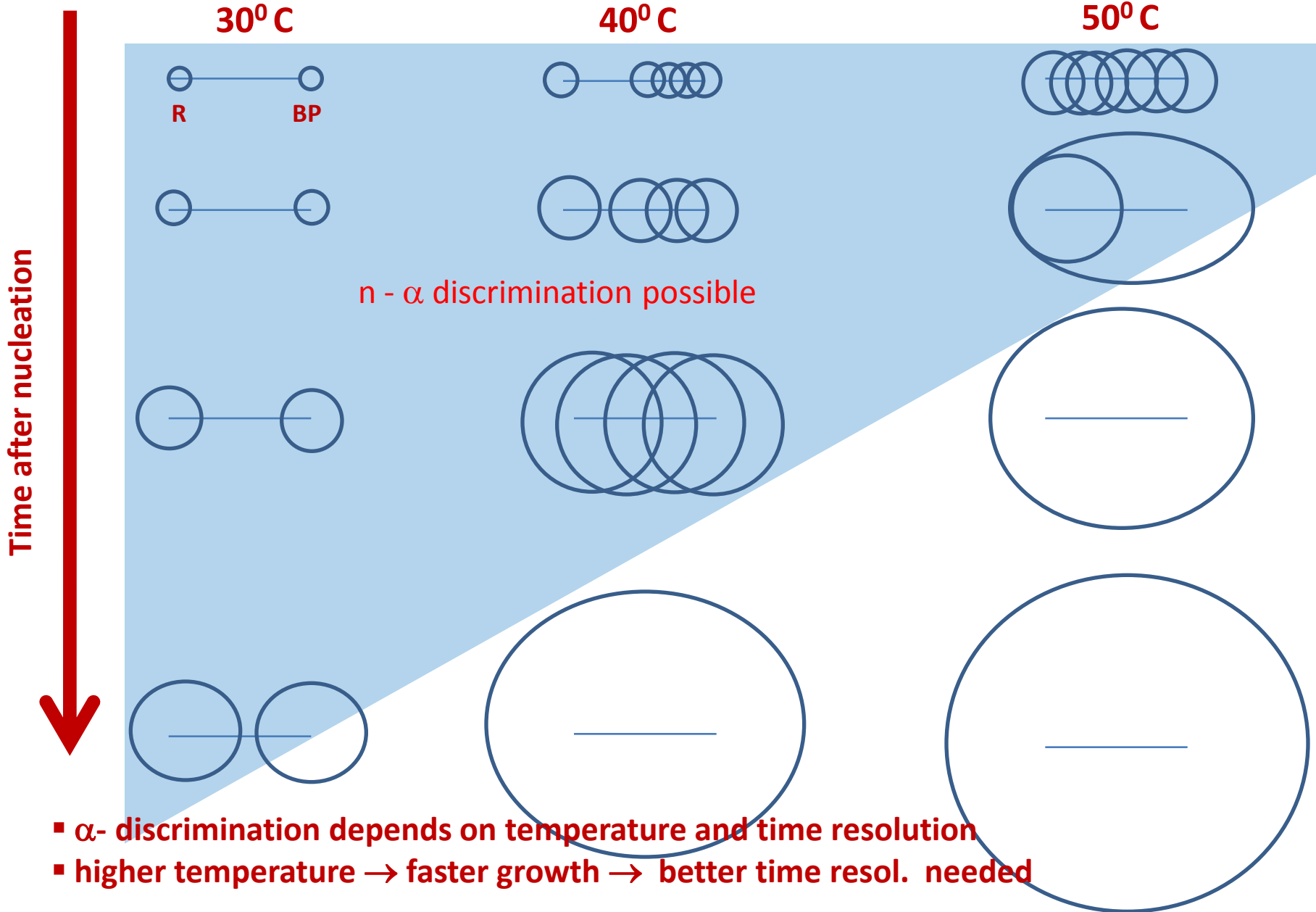

Viktor Zacek, TAUP 2011
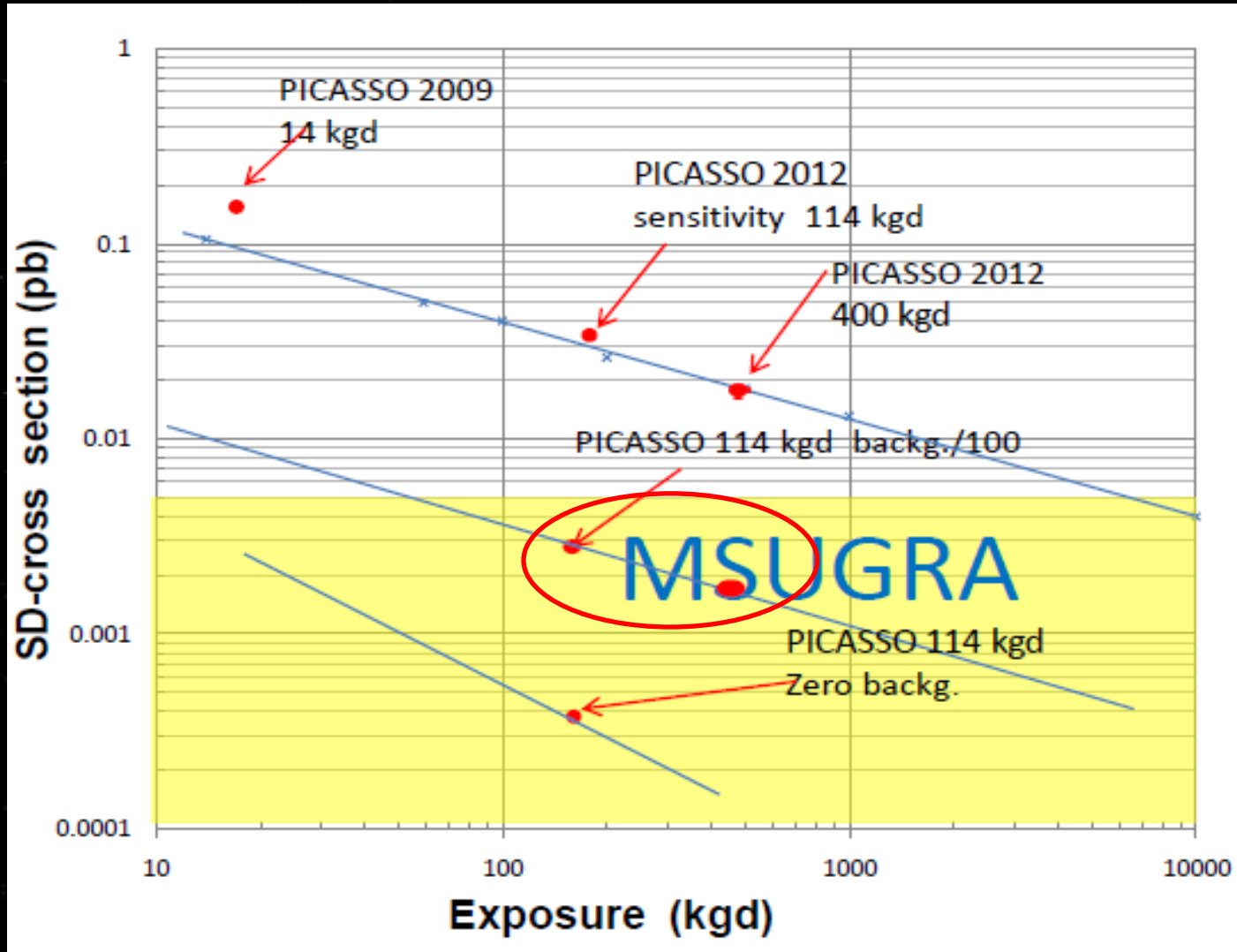
Summary

- N-shielding in PICASSO new phase reduces amb. N by >400!
- Almost all the detectors are operating with very low alpha contamination
- The background discrimination is understood and upgrades in electronics and DAQ lead to an average of ~99% α rejection @ 80% WIMP acceptance.
  - 50% of detectors are running with new and improved DAQ and electronics and rest will be operational within one month.

- PICASSO new phase is underway to run background/100 and results expected in the near future will be world leading in spin dependent interactions and very competitive in spin independent interactions.

Back up slide

- Insight into α-neutron/WIMP discrimination

# Fully contained α-tracks

30⁰ C   40⁰ C   50⁰ C

R   BP

Time after nucleation

n - α discrimination possible

- α- discrimination depends on temperature and time resolution
- higher temperature → faster growth → better time resol. needed

Partially contained tracks: Bragg peak outside

30⁰ C   40⁰ C   50⁰ C

R   BP

Time after nucleation

n - α discrimination possible
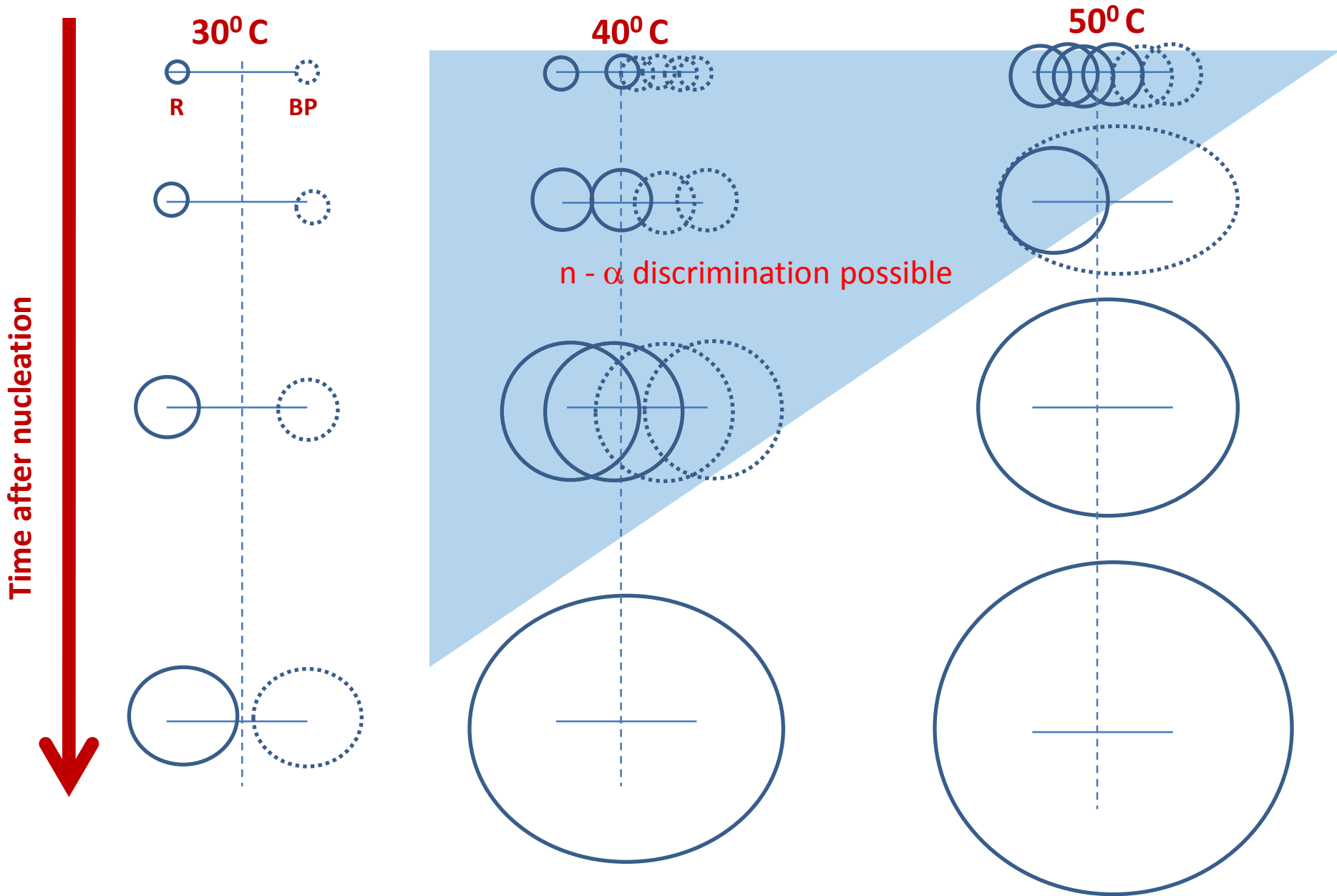
There is an optimal frequency for discrimination for each temperature

Partially contained tracks: Bragg peak inside

Time after nucleation

30^0 C

BP   R

40^0 C

50^0 C

n - α discrimination possible
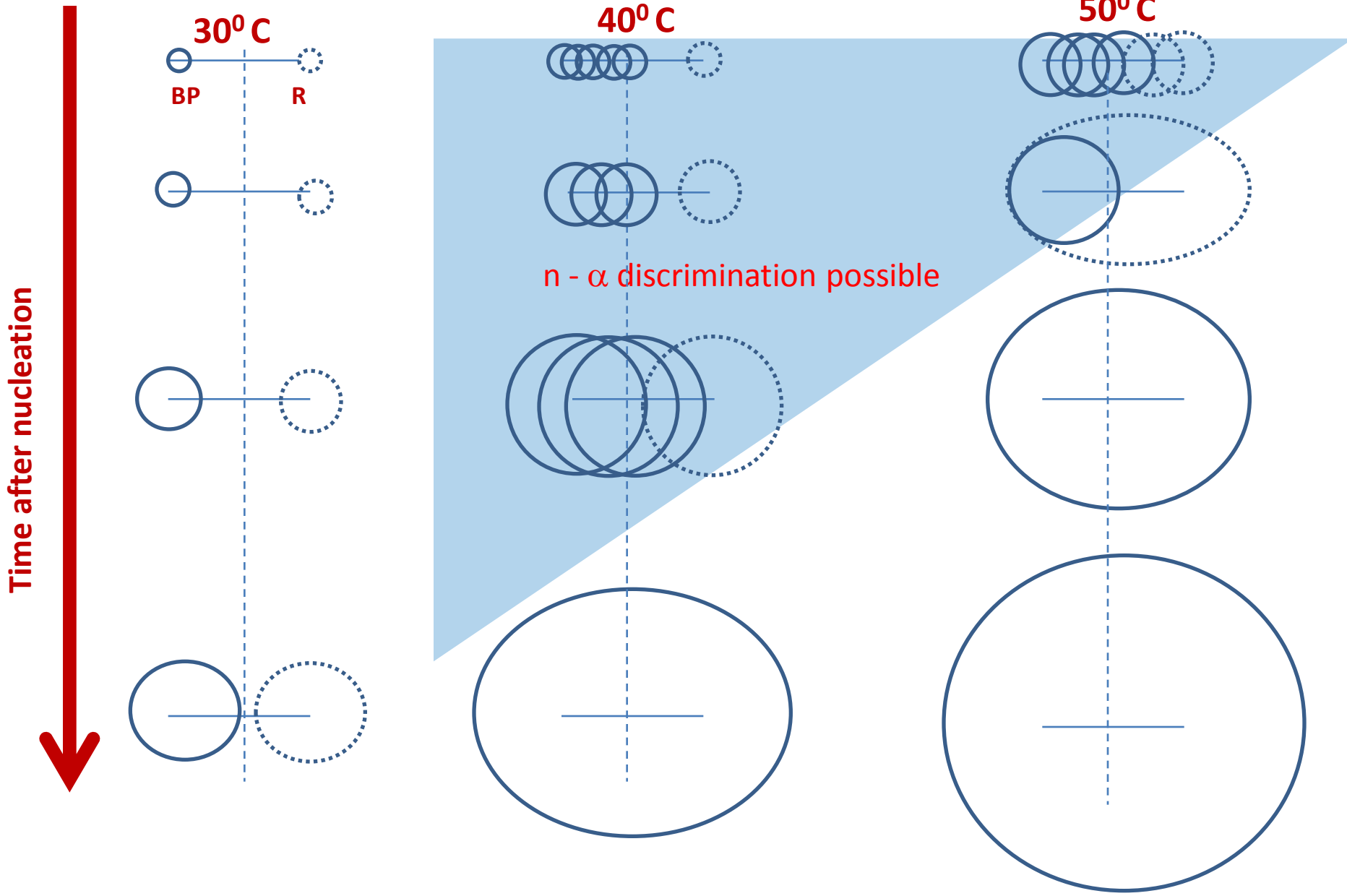
Similar temperature dependance of discrimination for « insiders » and « outsiders »