The CRESST Dark Matter Search

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for

the CRESST group

MPP Annual Project Review 2014
15 – 16 December 2014, MPI für Physik

Outline

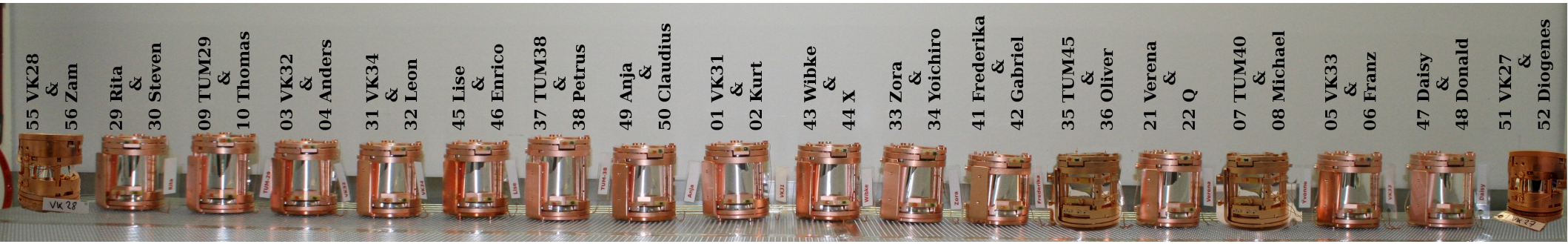
- Status of CRESST II – Phase 2 (*)
- Goals of CRESST II – Phase 2
- First results
- Schedule and Perspectives

(*) The collaboration agreed on a common naming scheme for the measuring campaigns (the runs):
CRESST-II commissioning run ≡ Run 30
CRESST-II phase 1 ≡ Run 32
CRESST-II phase 2 ≡ Run 33

Status

Status of CRESST II – Phase 2:

18 detector modules mounted in spring 2013



- 12 conventional modules
- 6 fully active modules with 3 different designs

Data taking since July 30

- July 30th 2013 – January 7th 2014: non-blind data set
- January 7th 2014 onwards: blind data set

Smooth running conditions

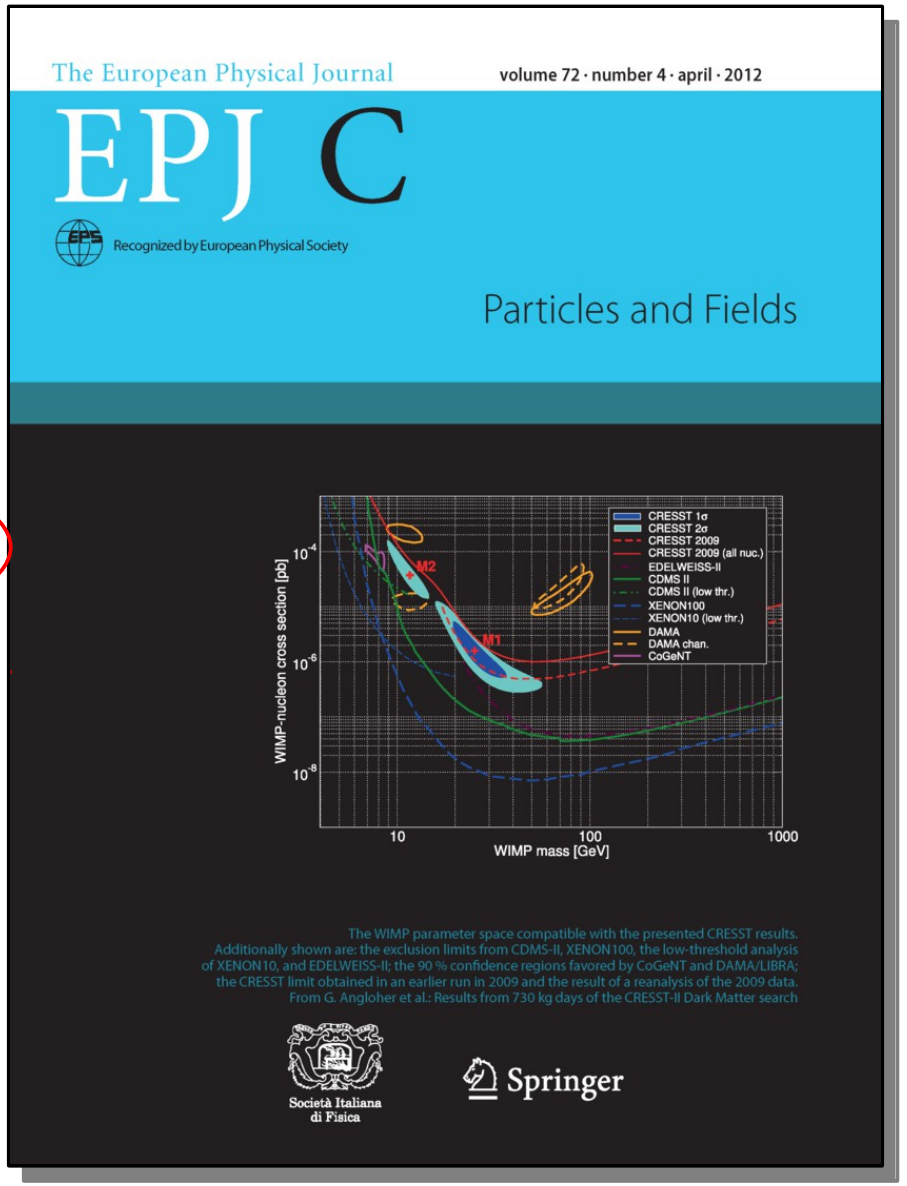
- >90% duty cycle

CRESST II – Phase 1

- Extended physics run from June 2009 to April 2011
- 8 $CaWO_4$ modules used for Dark Matter analysis
- Net exposure after cuts: 730 kg days
- 67 events observed in WIMP search region

	M1	M2
e/γ-events	8.00 ± 0.05	8.00 ± 0.05
α-events	$11.5\,^{+2.6}_{-2.3}$	$11.2\,^{+2.5}_{-2.3}$
neutron events	$7.5\,^{+6.3}_{-5.5}$	$9.7\,^{+6.1}_{-5.1}$
Pb recoils	$15.0^{+5.2}_{-5.1}$	$18.7\,^{+4.9}_{-4.7}$
signal events	$29.4\,^{+8.6}_{-7.7}$	$24.2\,^{+8.1}_{-7.2}$
m_χ [GeV]	25.3	11.6
σ_{WN} [pb]	$1.6 \cdot 10^{-6}$	$3.7 \cdot 10^{-5}$

- High contribution of backgrounds



Goals of Phase 2

Lower backgrounds to clarify the low mass WIMP scenario

Measures for background reduction

Alpha events:

New CuSn6 clamps

- ultra pure Sn + low background Cu and careful monitoring of all production steps
- sputter coating with high purity Al

Neutron events:

Additional 5cm PE layer inside the Pb/Cu shield

- reduce background from neutrons originating in the Pb/Cu shield

Pb recoils:

Radon prevention during production of clamps and assembling of detectors

New designs with active veto for ^{206}Pb recoils

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Radon prevention during production of clamps and assembling of detectors ☒

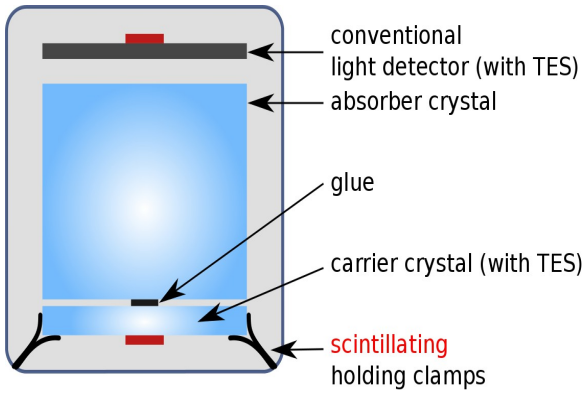
New designs with active veto for ^{206}Pb recoils ☑

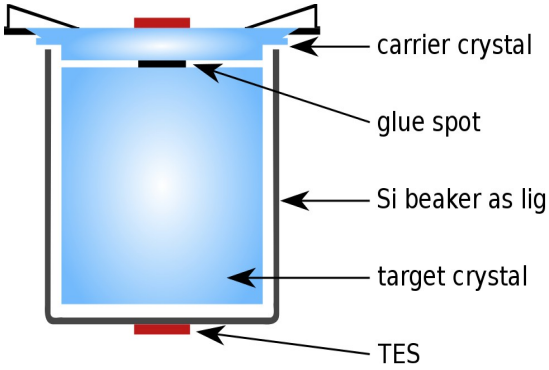
Active modules

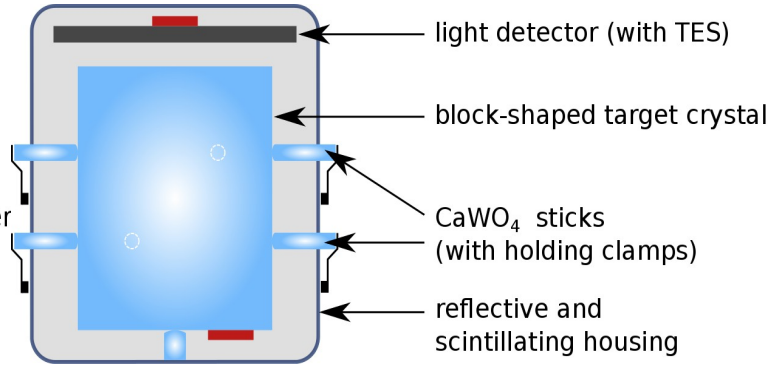
Active modules (6 modules):

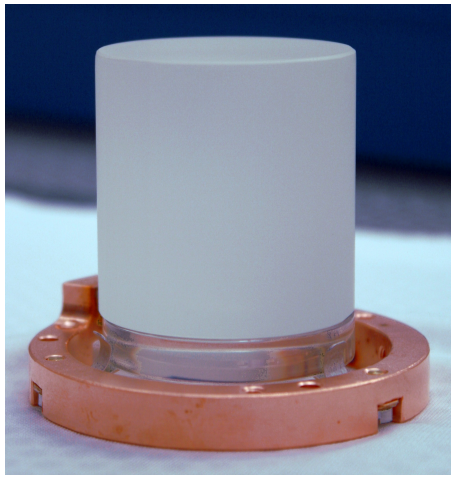
- Crystal Clamped on Carrier
- Silicon Beaker Light Detector
- Crystal Held by Sticks

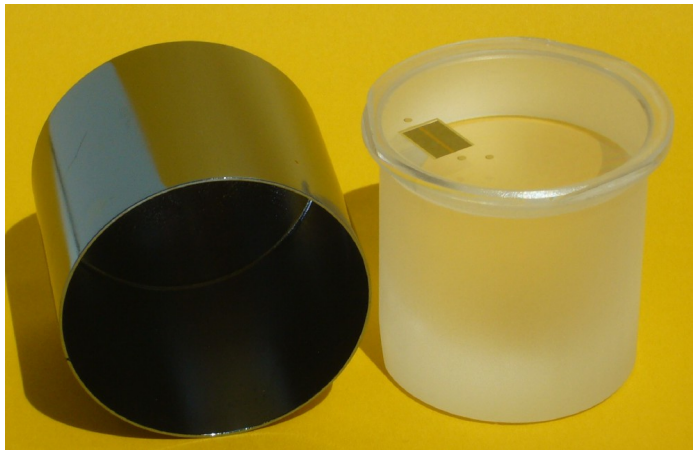
Tag alpha decays originating from all inner surfaces of the detector module

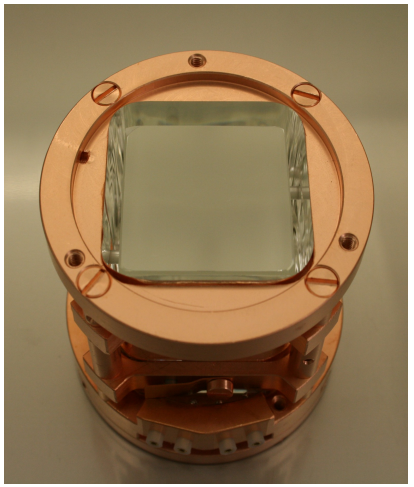




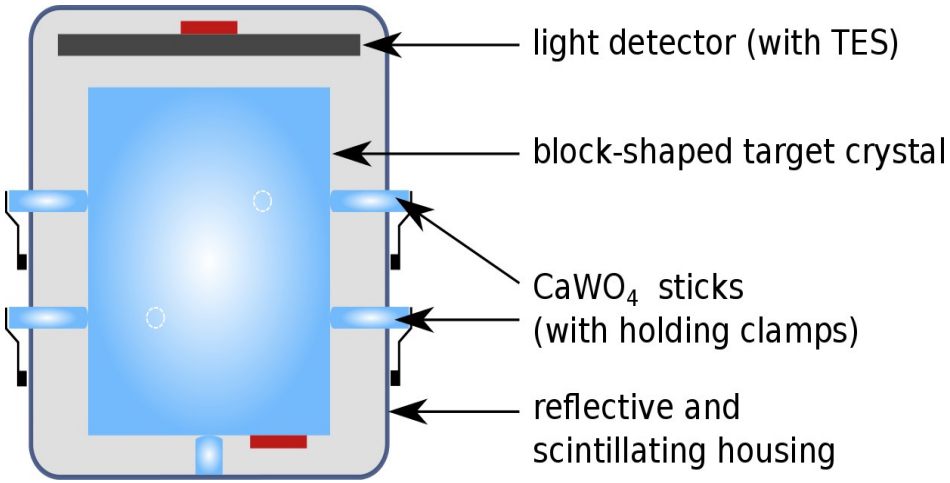


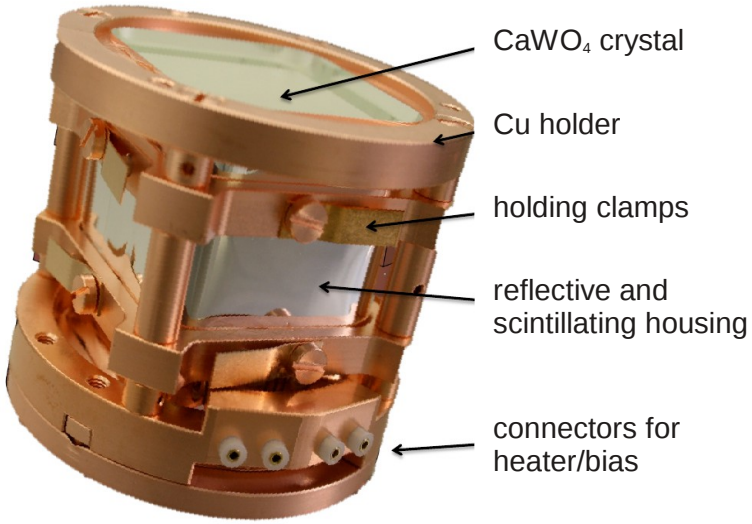






First results: detector module





Non-blind dataset of ≈ 29 kg days:

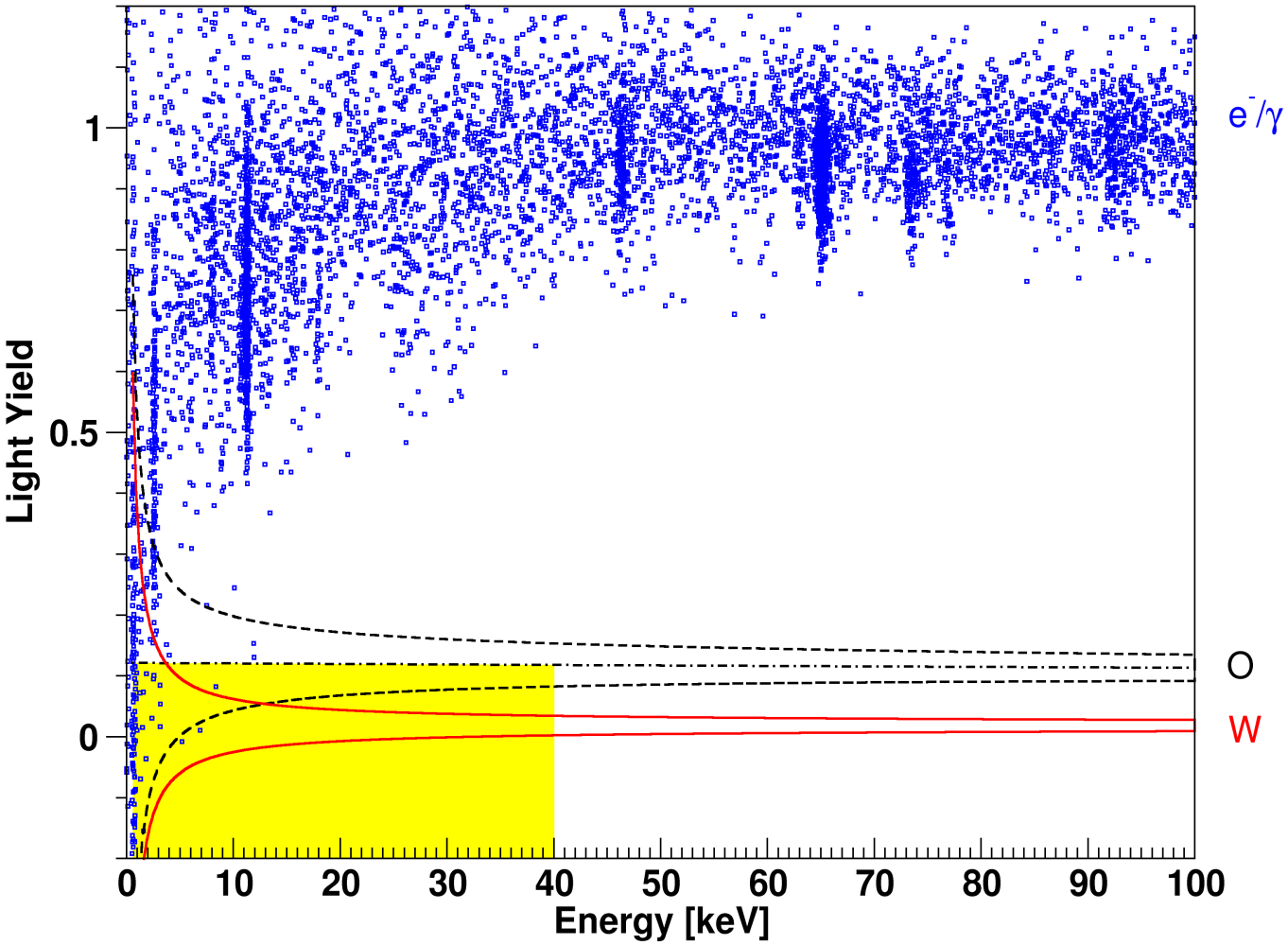
- no surface background
- best radiopurity (≈ 3.5 /[kg keV day])
- low trigger threshold (≈ 600 eV)
- excellent resolution (σ ≈100 eV at 2.6 keV)

→ Low threshold analysis

arXiv:1410.1753 [physics.ins-det]

arXiv:1410.4188 [physics.ins-det]

First results: data set



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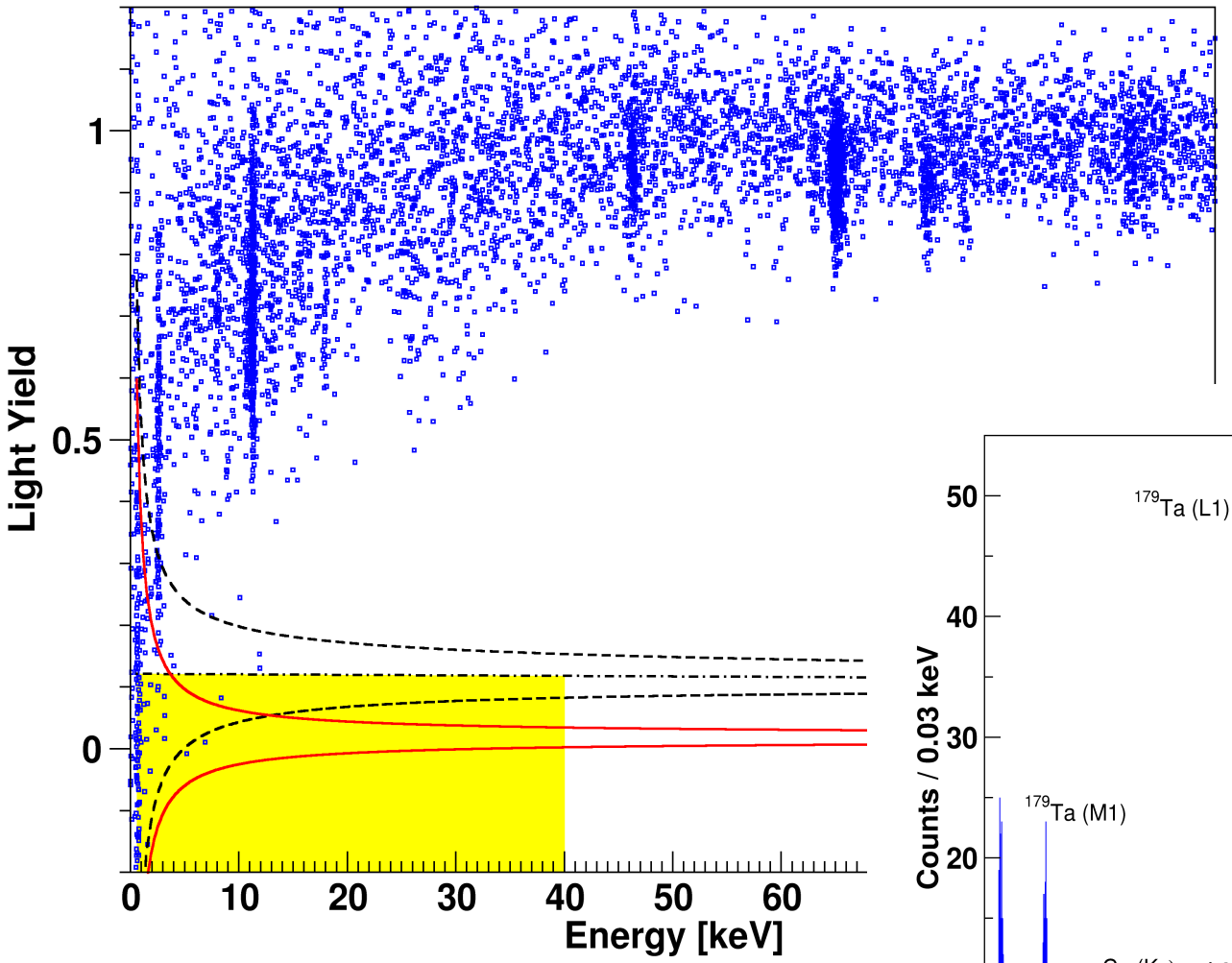
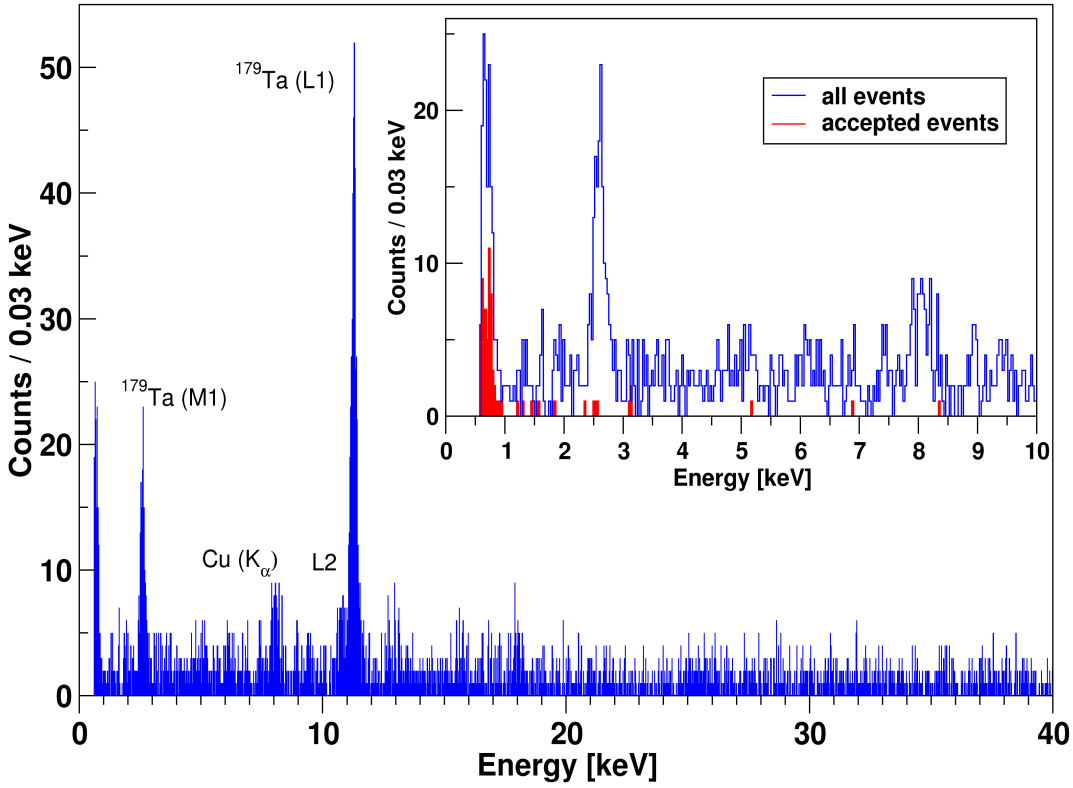
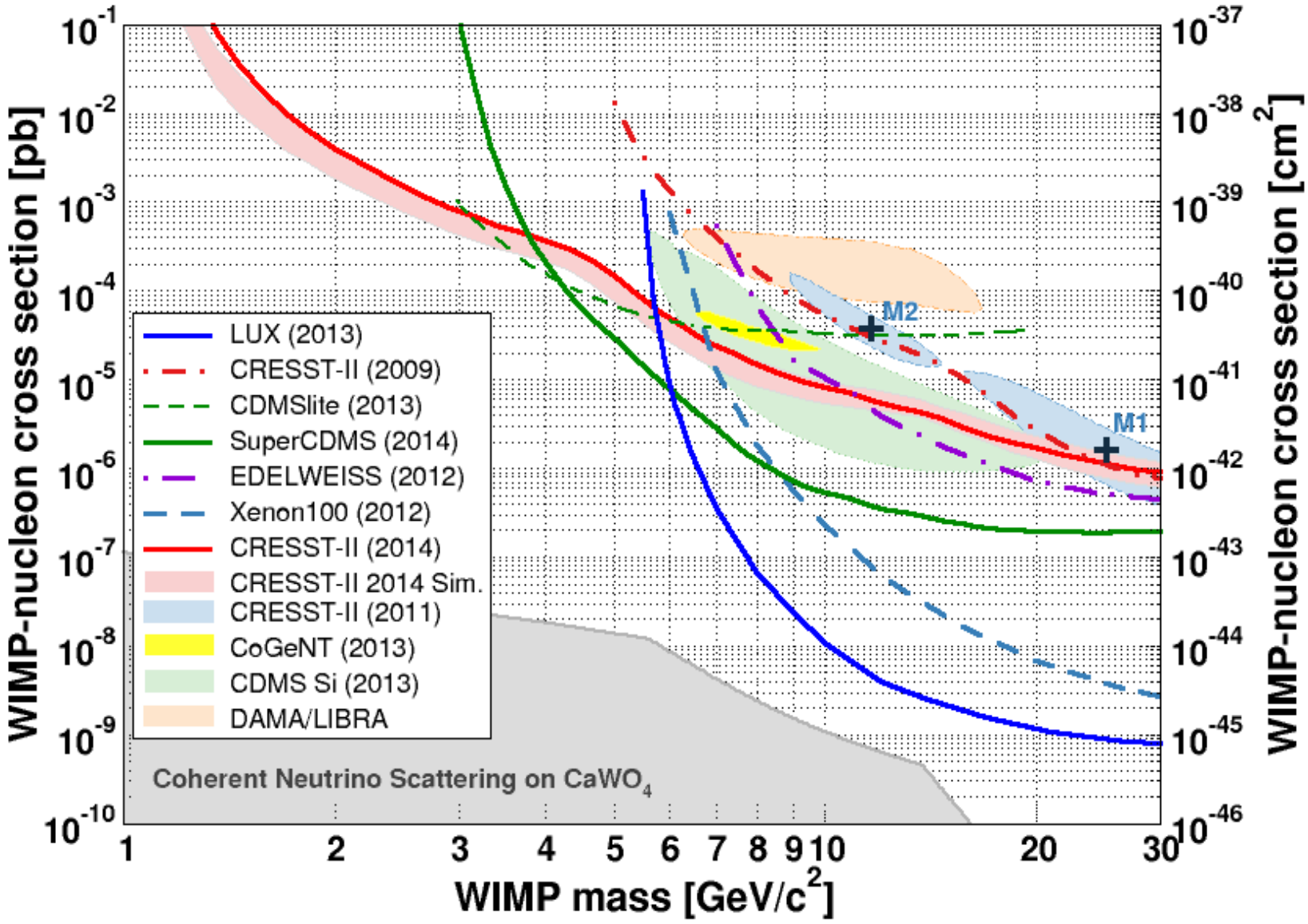


All events are accepted as WIMP candidates



First results: limits

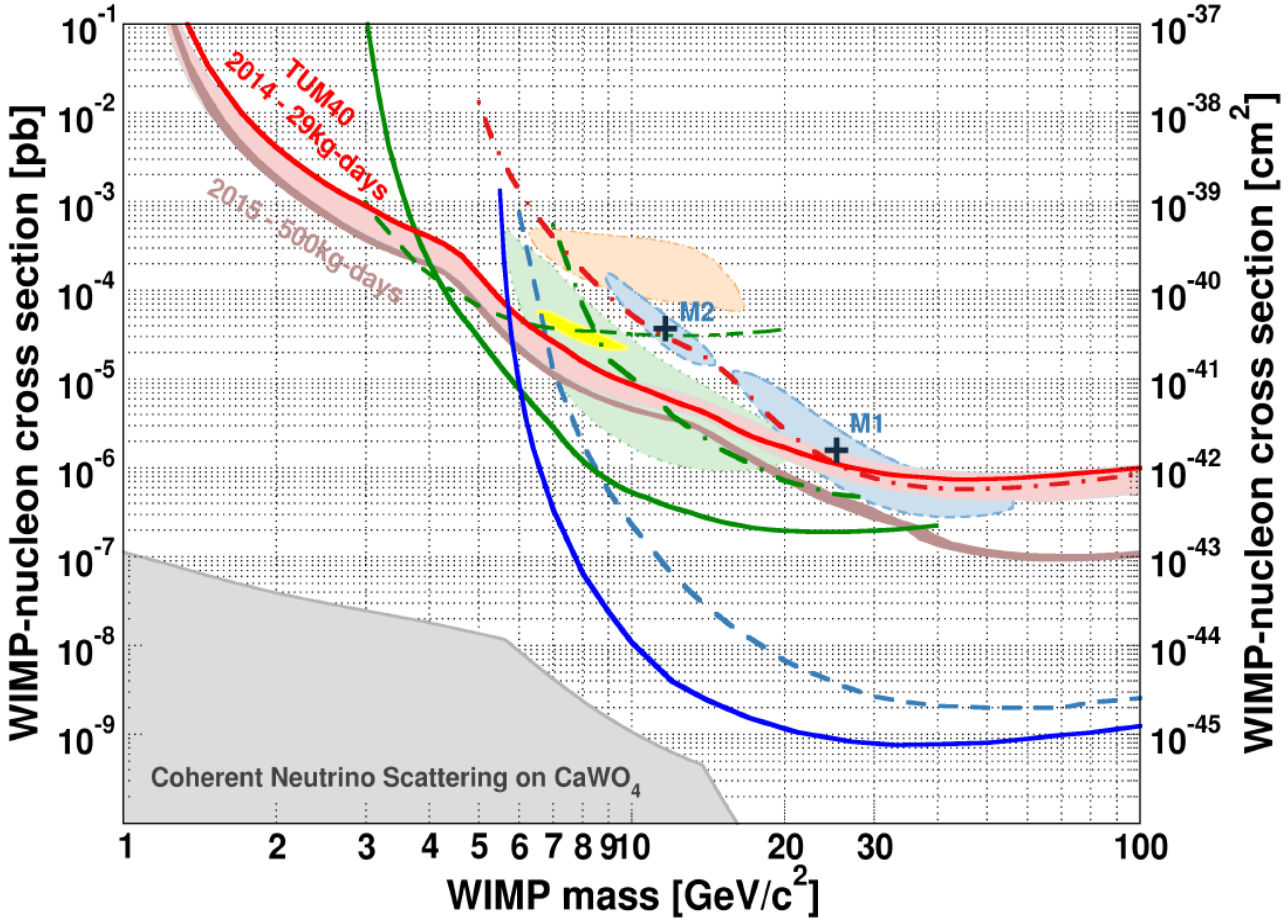


arXiv:1407.3146 [astro-ph.CO]

Schedule and perspective

Data taking

- Current run (Phase 2) planned to go on until enough statistics is achieved to exclude M1
  exposure goal: 500 kg days with the new actively discriminating modules (summer 2015)



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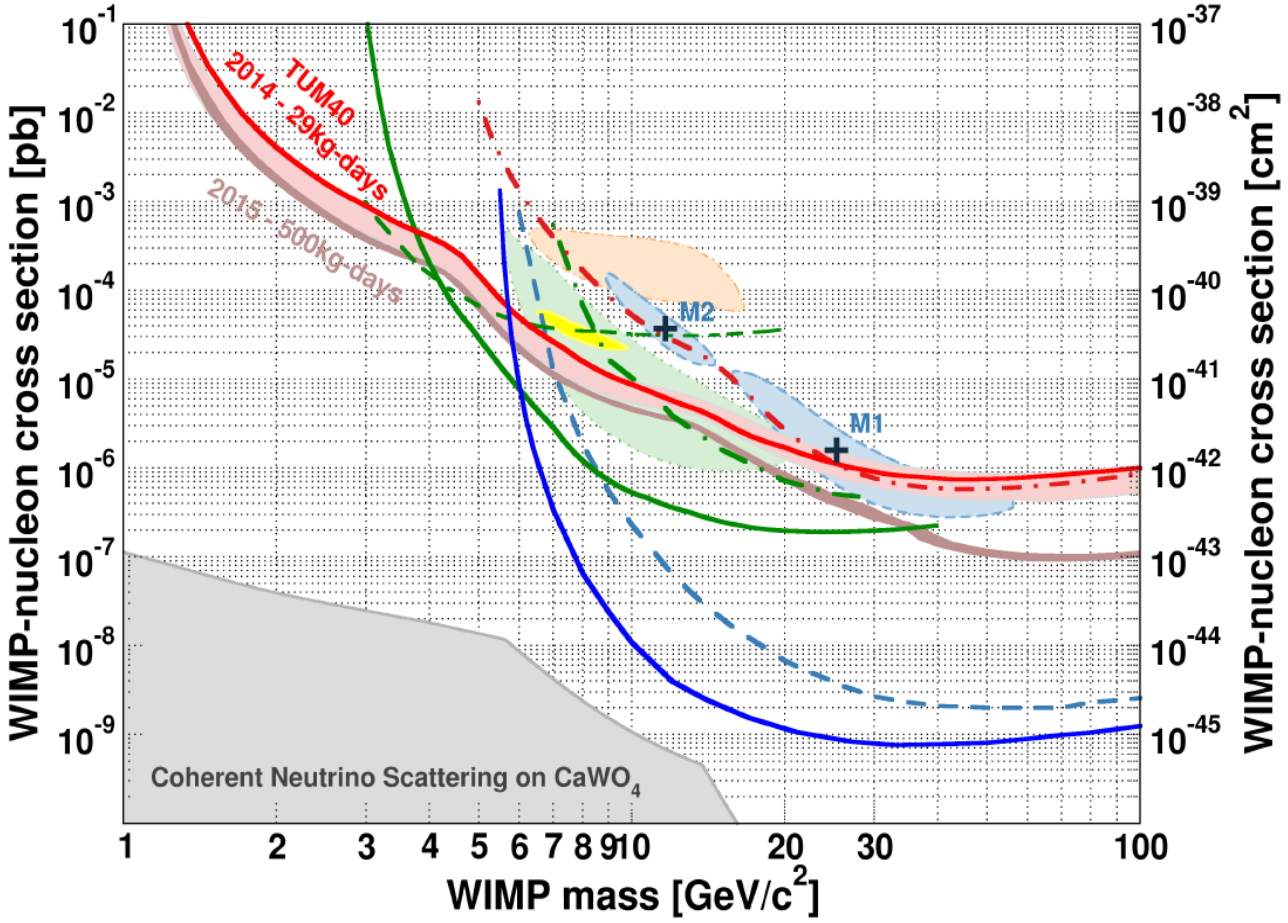
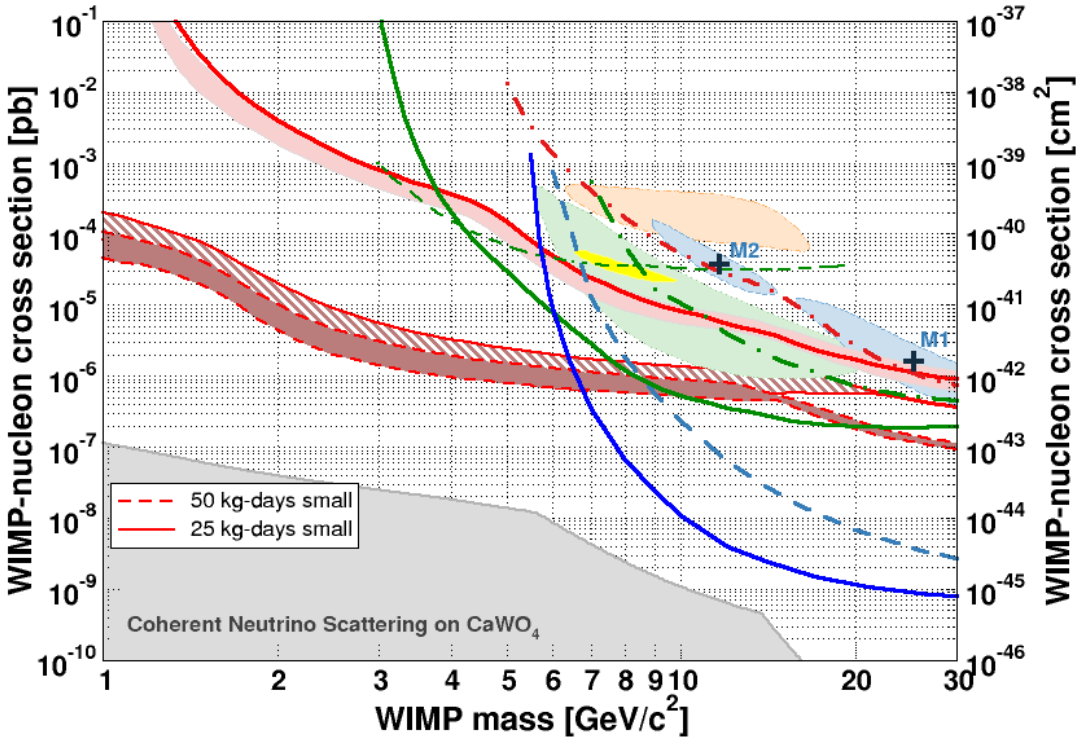


- Thresholds of a number of detectors recently lowered (down to 400 eV) to further improve the sensitivity for low WIMP masses with the current run.

Future potential

Detector layout

- Crystal quality as TUM40
- Block shaped crystal of (20×20×10)mm^3 (~ 20g)
- Two light detectors (20×20)mm^2
- Detected light increased by a factor of 3
- 100 eV threshold
- Light detector noise reduced by a factor of 2

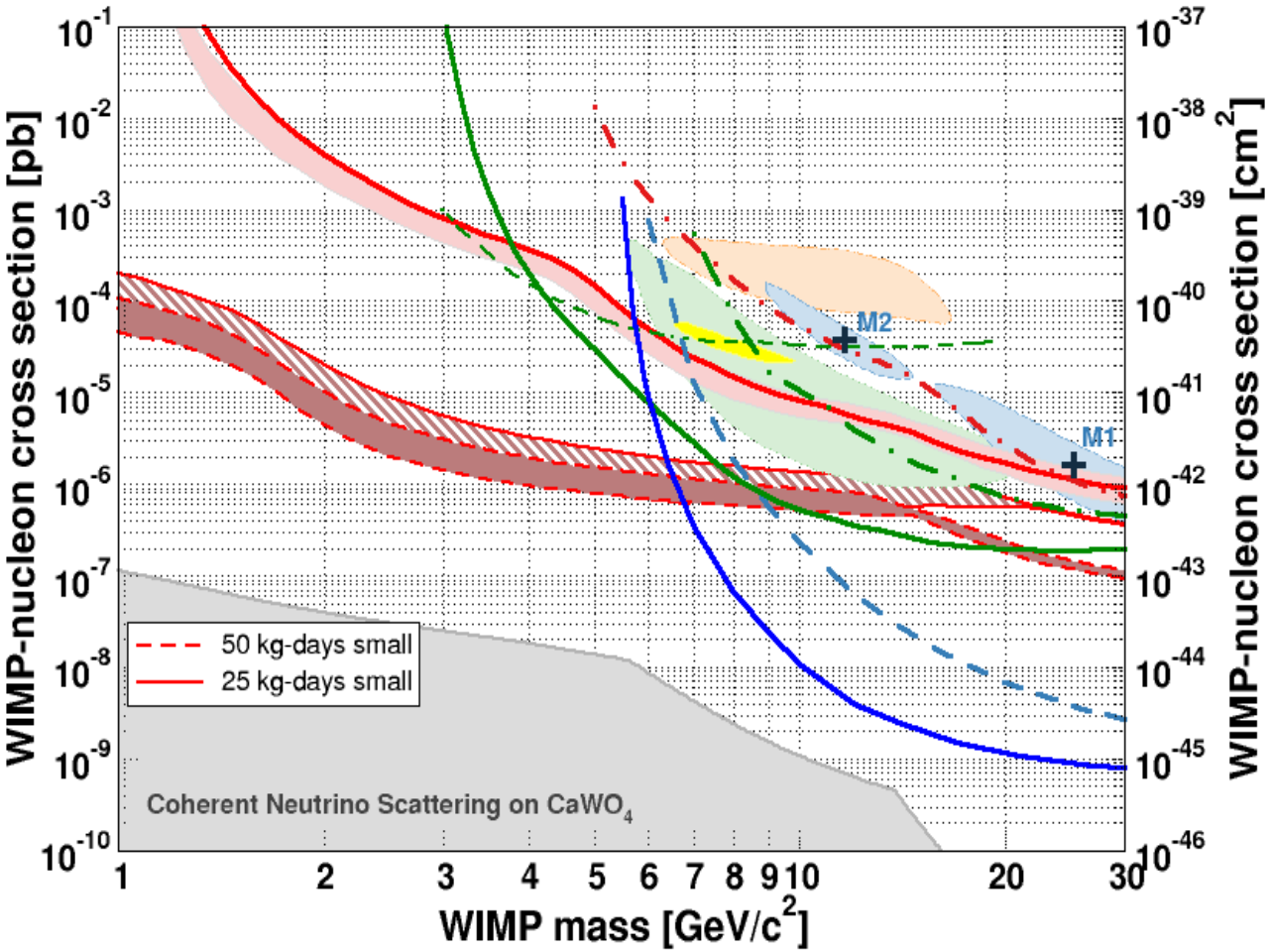


Milestones:

- direct evaporation of TES;
- amount of detected light;
- performance of the new holding system.

Future potential

50 kg-days small ≈ 1 year of running with ~10 small modules of 20g each



Leading results with moderate exposure

Possible improvement using better crystals

New infrastructure

New infrastructure

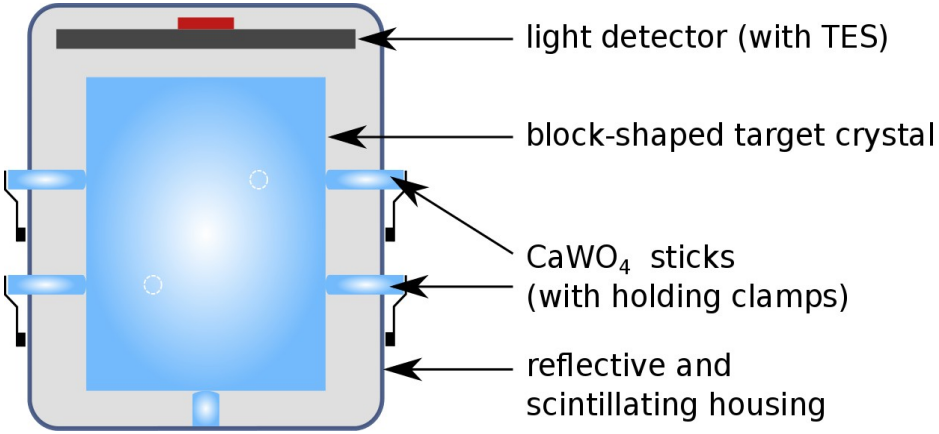
Conclusions

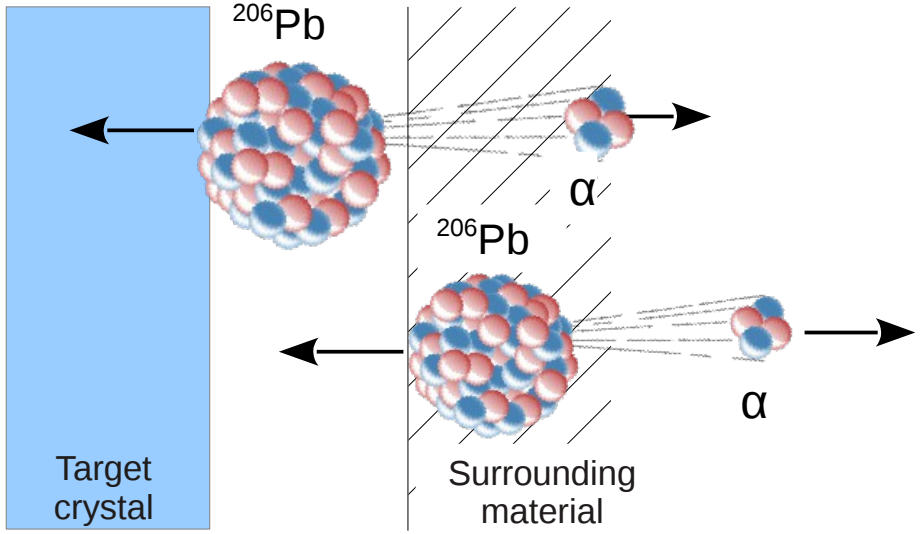
- Experiment smoothly running since summer 2013
- Results for a low threshold analysis of a single detector module provide the currently world-best sensitivity for WIMP masses below 3GeV/c^2
- More statistics required to improve the limit at higher WIMP masses
- Blind analysis of a subset of the data expected early 2015
- CRESST detectors extremely well suited for detecting low mass WIMPs
- Next generation of detectors to achieve a substantial sensitivity gain for low WIMP masses
- Experiment with moderate target mass to fix a new state of the art in the low mass WIMP exploration

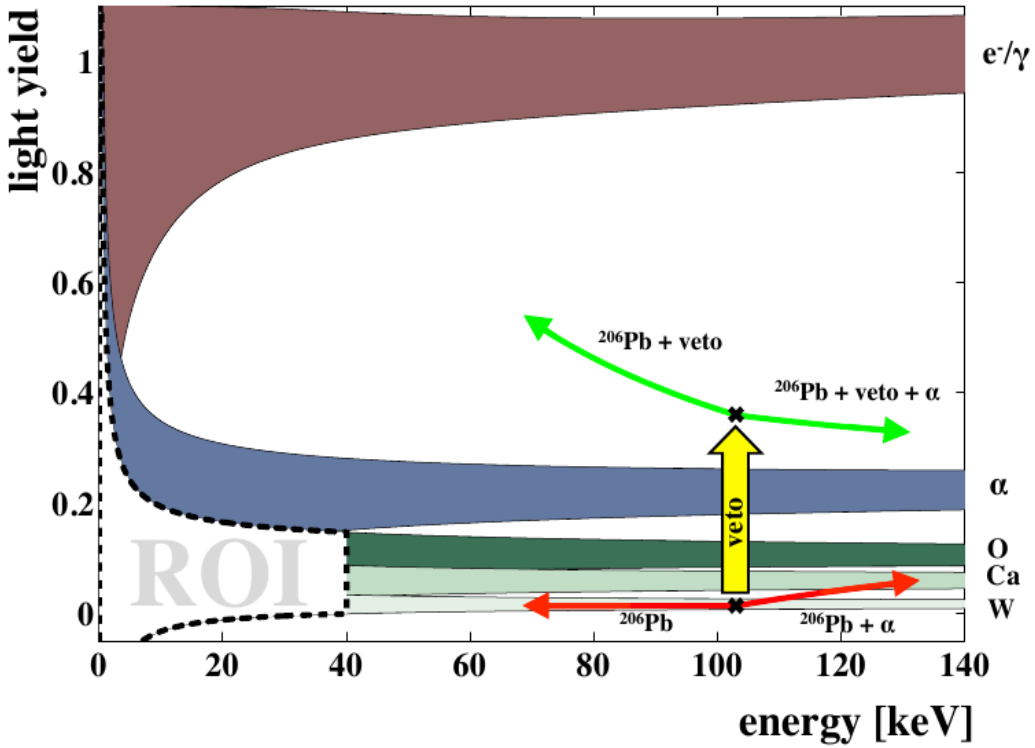
Additional material

Crystal Held by Sticks

Fully scintillating housing to veto surface alpha decays







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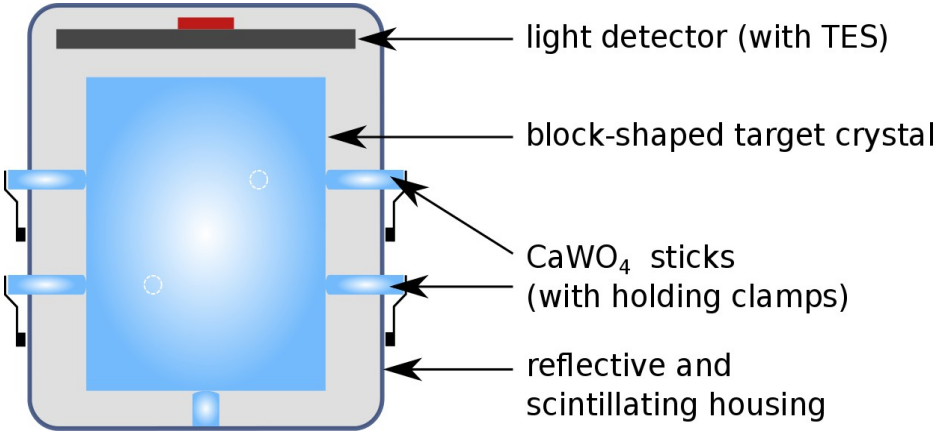
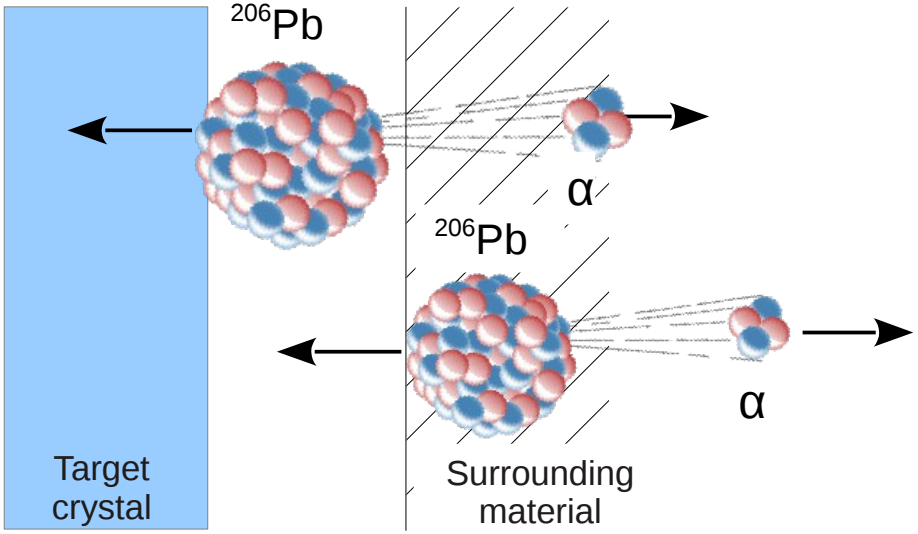
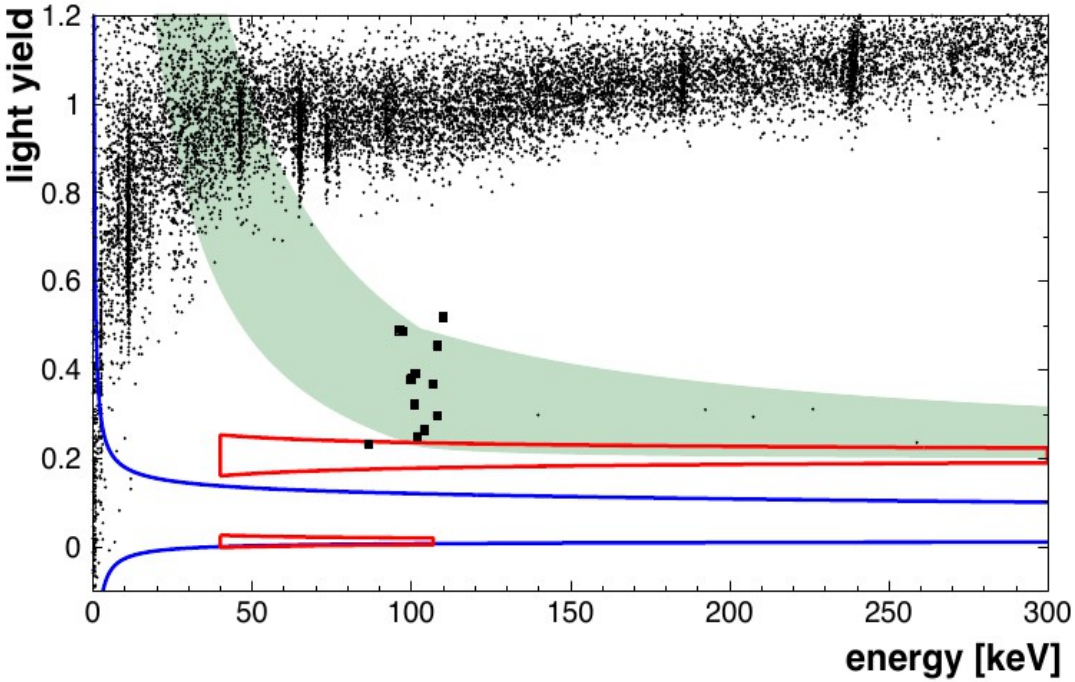






A detector module with highly efficient surface-alpha event rejection operated in CRESST-II Phase 2

arXiv:1410.1753 [physics.ins-det]

Self grown crystal - TUM40

$^{181}W + e^- \rightarrow {}^{181}Ta + \nu_e + \gamma$ (121d)

L-shell
11.7 keV + 6.2keV

K-shell
67.4 keV +6.2keV

$^{179}Ta + e^- \rightarrow {}^{179}Hf + \nu_e$ (1.8y)

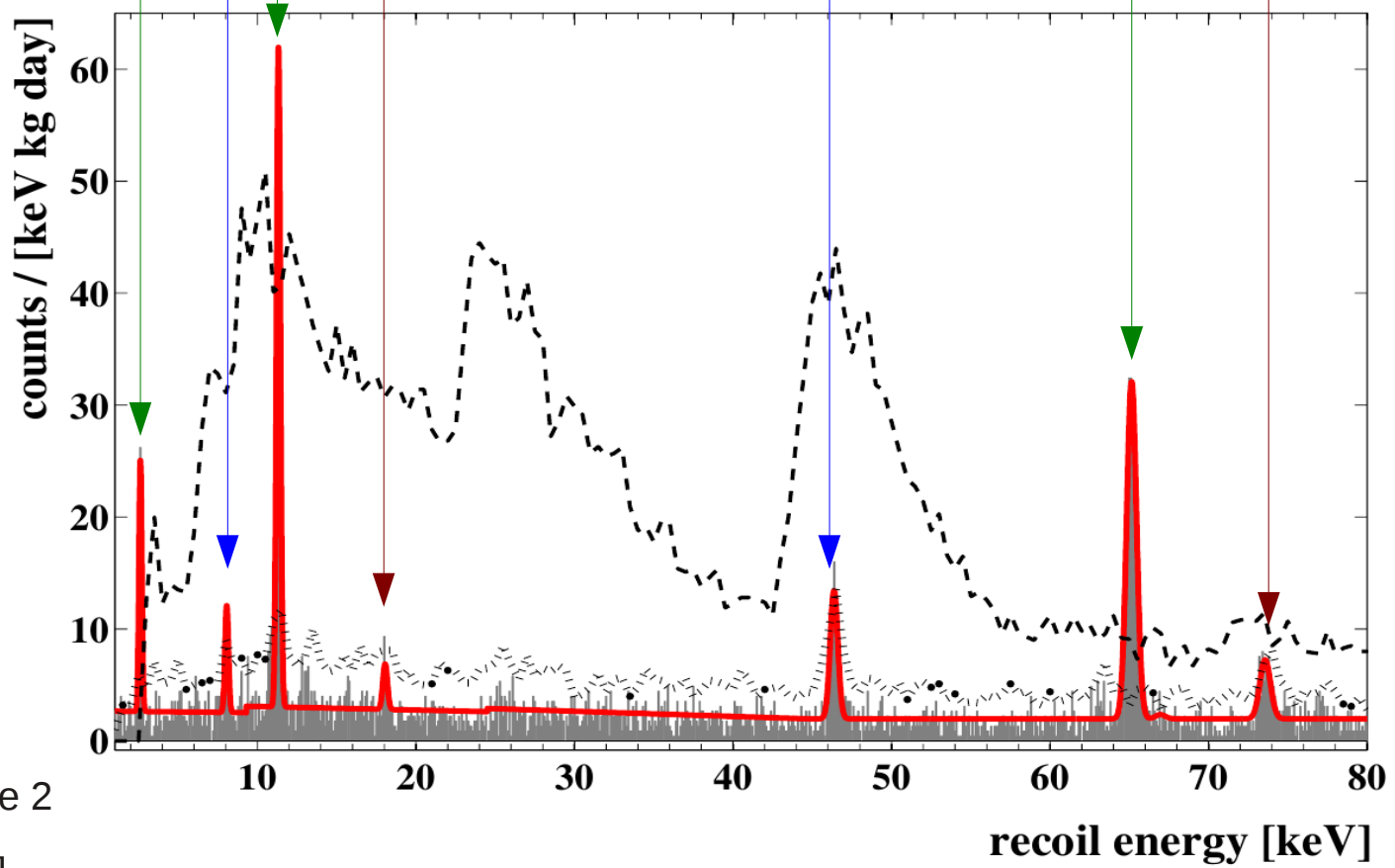
M-shell
2.6 keV

L-shell
11.3 keV

K-shell
65.4 keV

Cu X-ray
8.0 keV

^{210}Pb
46.5 keV

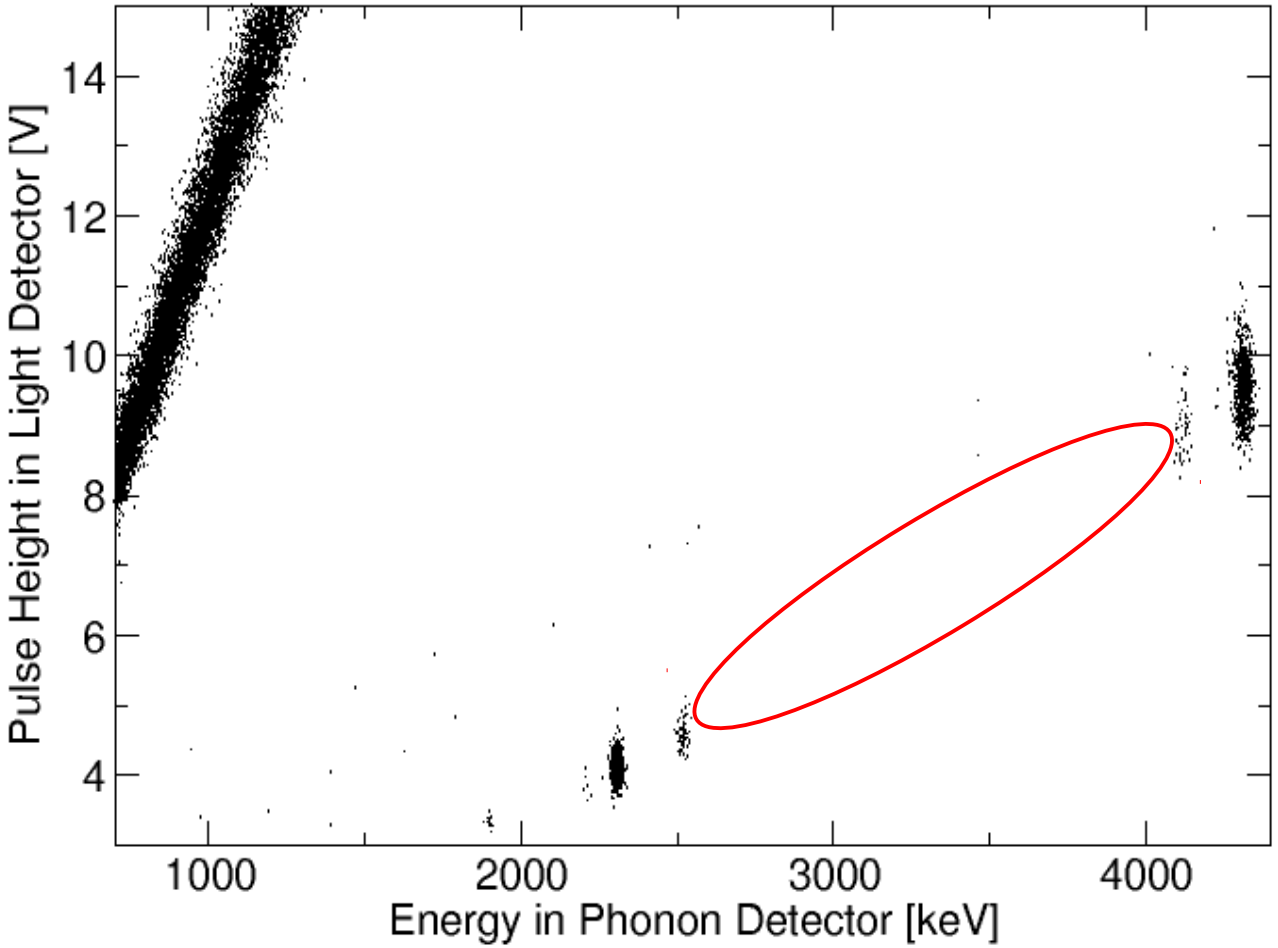


Electron/gamma and alpha backgrounds in CRESST-II Phase 2

arXiv:1410.4188 [physics.ins-det]

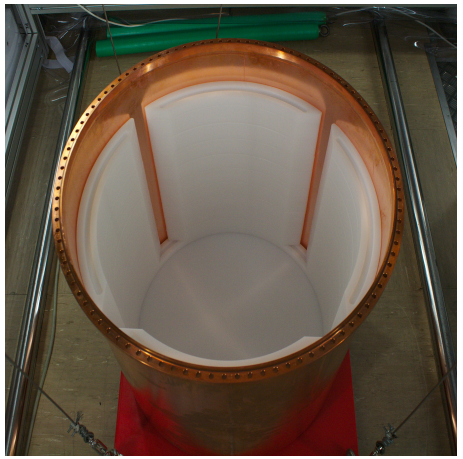
Non-blind data set – degraded alphas

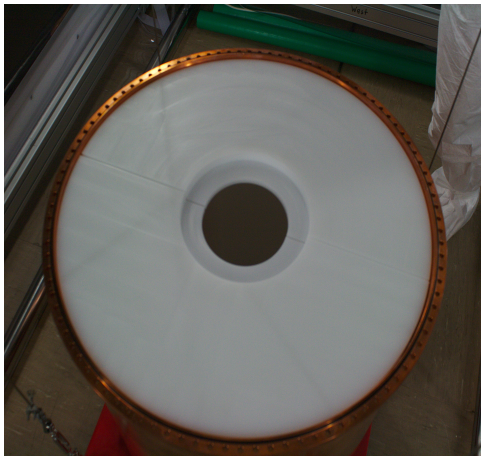
Conventional module Frederika/Gabriel



Clear region between α lines

Non-blind data set – neutron background





Additional 5cm PE layer inside the Pb/Cu shield

- reduce background from neutrons originating in the Pb/Cu shield

Run32 (730 kg days)

Coincident with muon-veto:
13 single scatterings*
27 multiple scatterings

*2 accidental coincidences expected

Run33 (377 kg days)

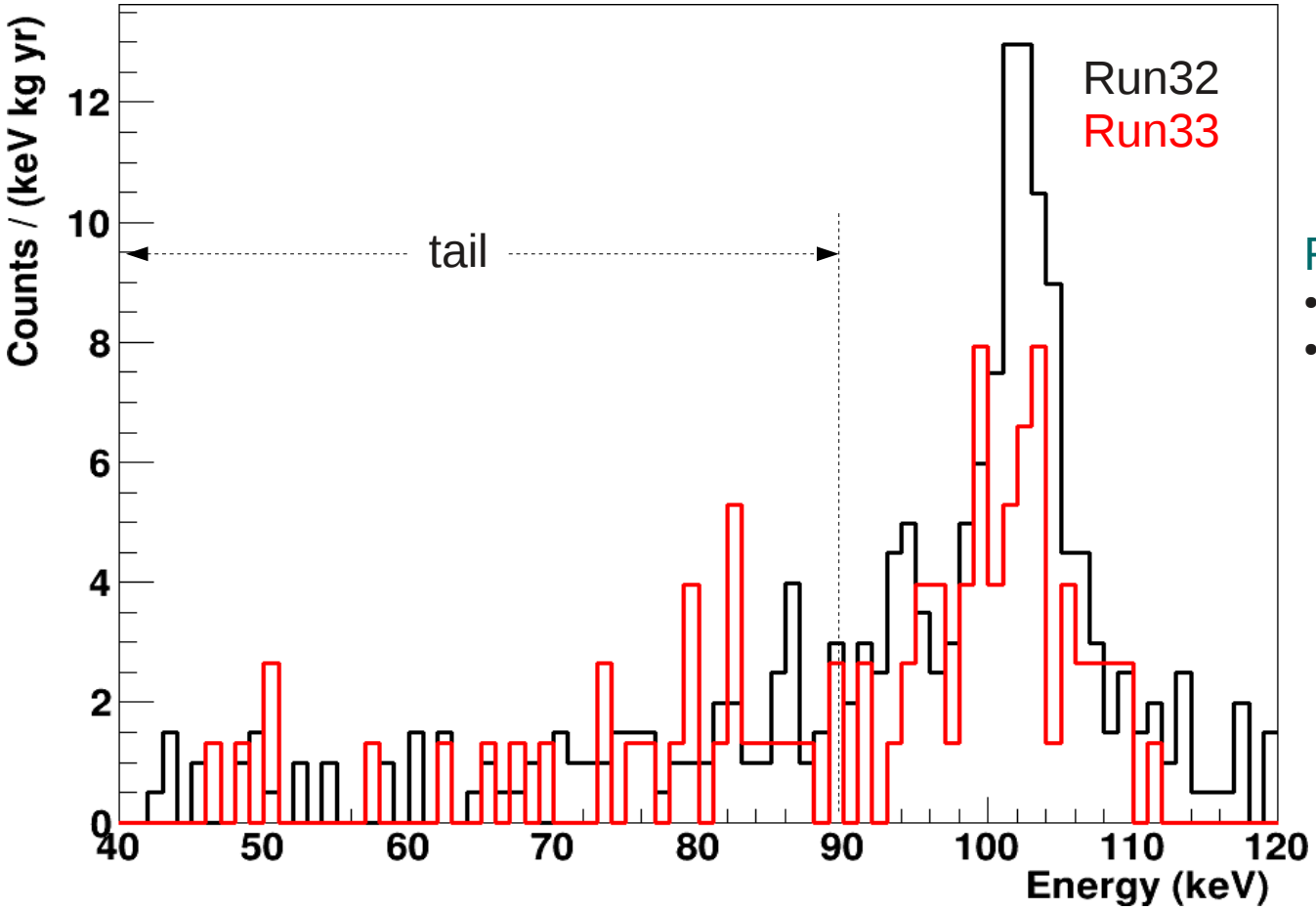
Coincident with muon-veto:
8 single scatterings*
0 multiple scatterings

*9 accidental coincidences expected

Non-blind data set – ^{206}Pb recoils

Conventional modules:

- different coating (sputtered Al instead of electrolytically deposited Ag)
- no exposure to Rn during production and assembling



Reduction in tail only ~30%

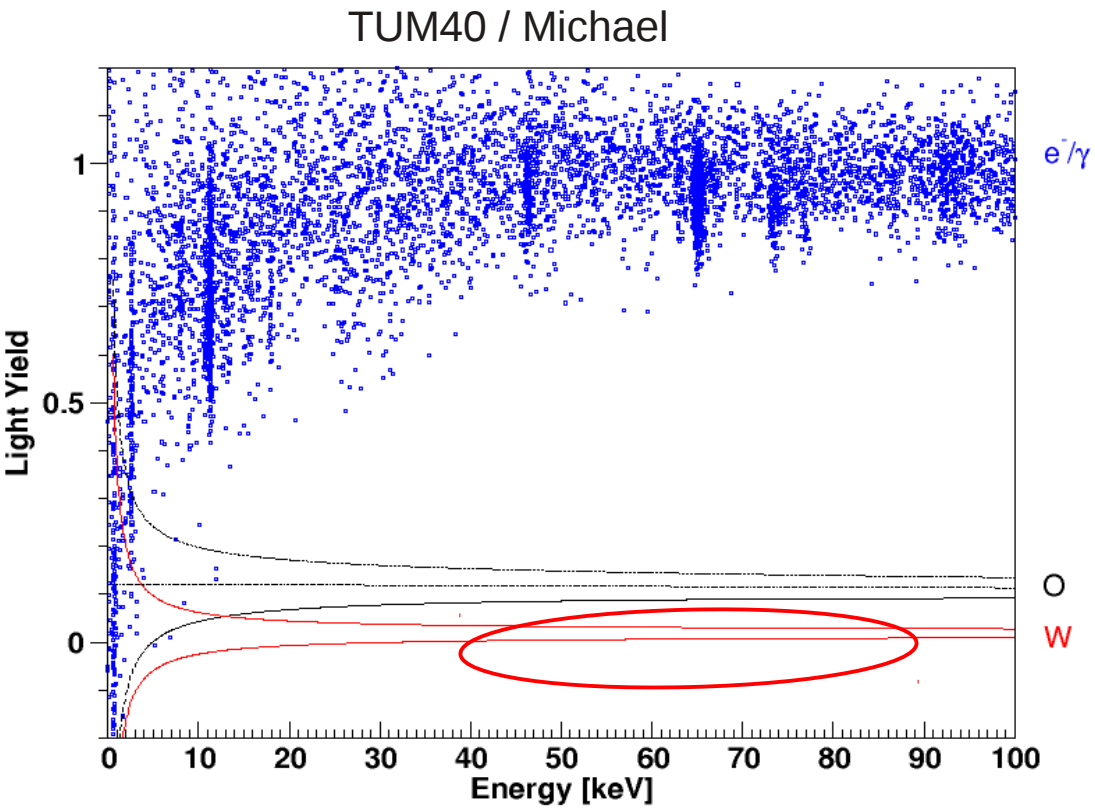
- contamination of clamp surface?
- alpha emitters with lower recoil energy on crystals?

Non-blind data set – ^{206}Pb recoils

Active modules (6 modules):

- Crystal Clamped on Carrier
- Silicon Beaker Light Detector
- Crystal Held by Sticks

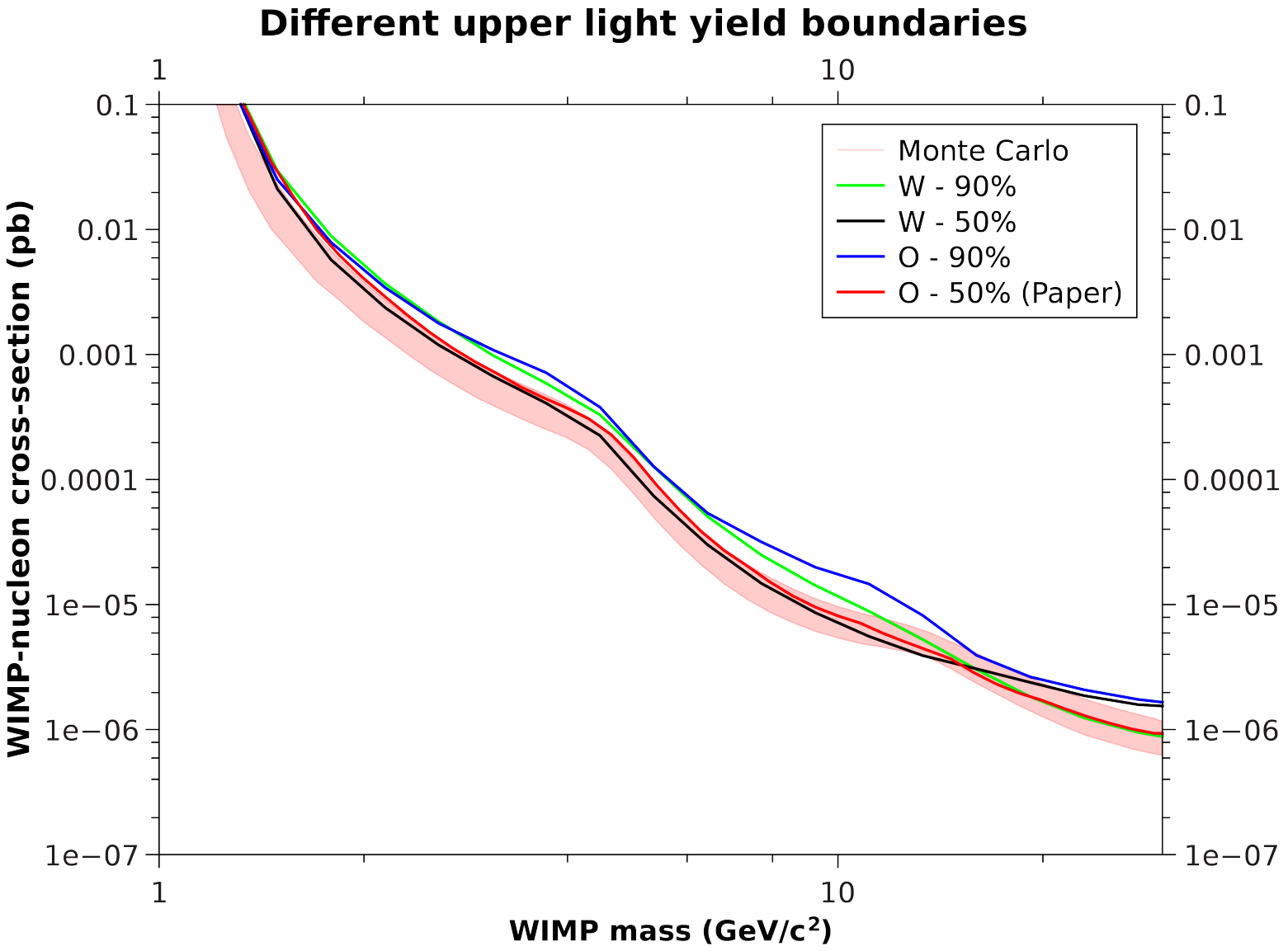
} Tag alpha decays originating from all inner surfaces fo the detector module



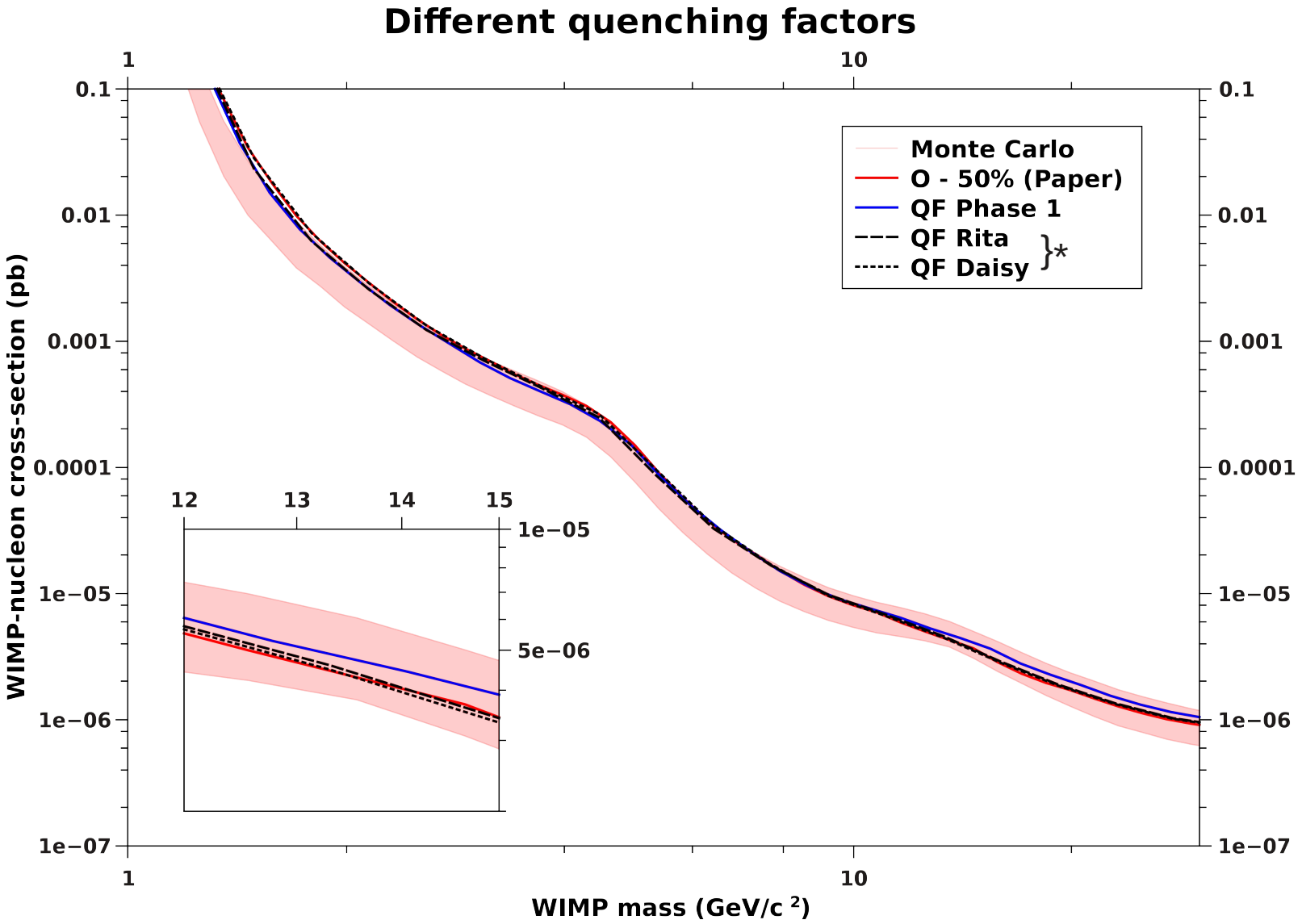
- non-blind data set collected with active modules: ~100 kg days
- reference regions defined as in Run32

^{206}Pb recoils observed:	0
^{206}Pb expected with rate of Run32:	12

Different LY boundaries

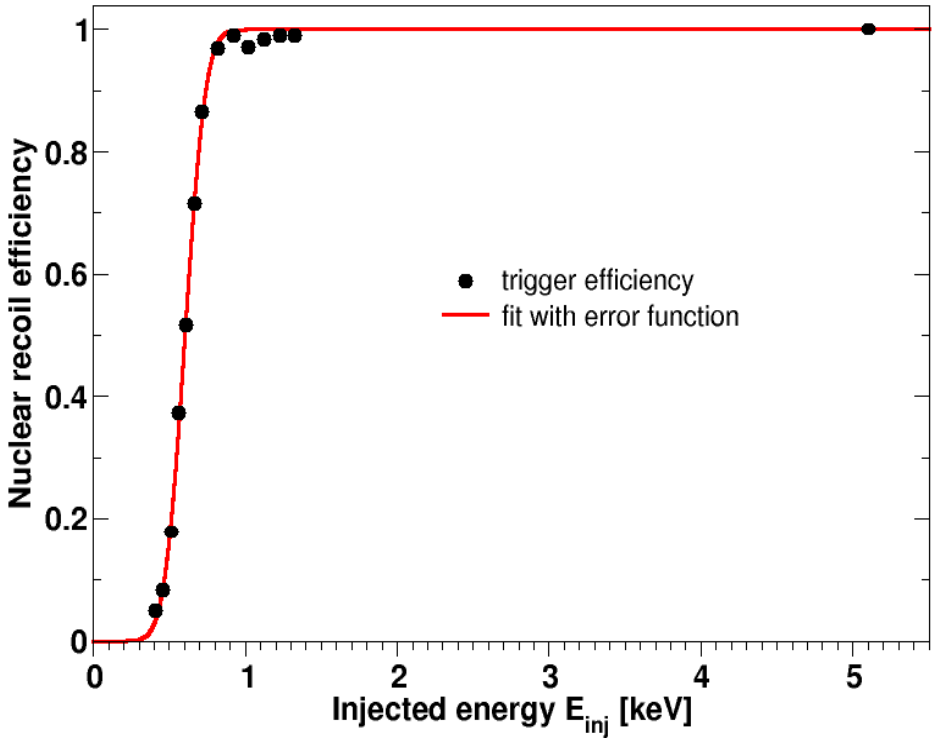


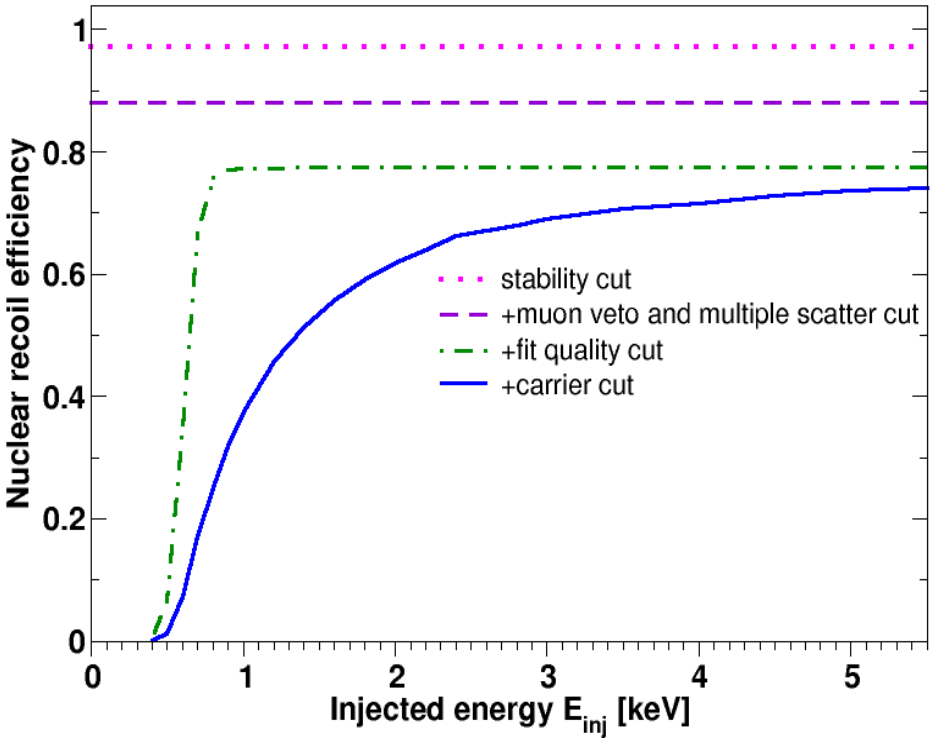
Different QF



* Eur. Phys. J. C 74 (2014) 74:2957

Trigger & cut efficiencies





Future potential