8th EURADOS Webinar (28/10/2021)

Intercomparisons of personal dosimeters: Lessons learnt

Individual Results

Ana M. Romero – CIEMAT, Radiation Dosimetry

European Radiation Dosimetry Group

EURADOS

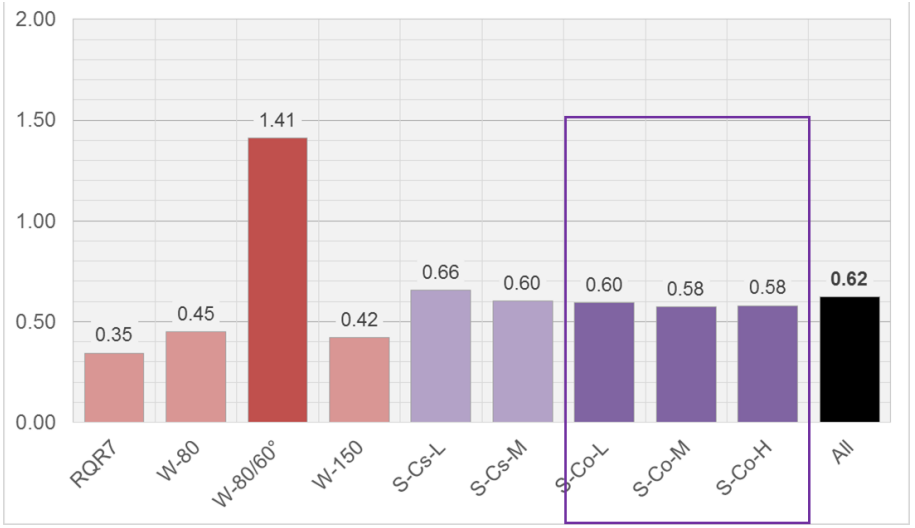
OUTLINE

- Irradiation plan: lessons learnt by participants
- Whole body dosemeters
- Extremity dosemeters
- Eye-lens dosemeters

Irradiation plan was designed to allow IMSs to check:

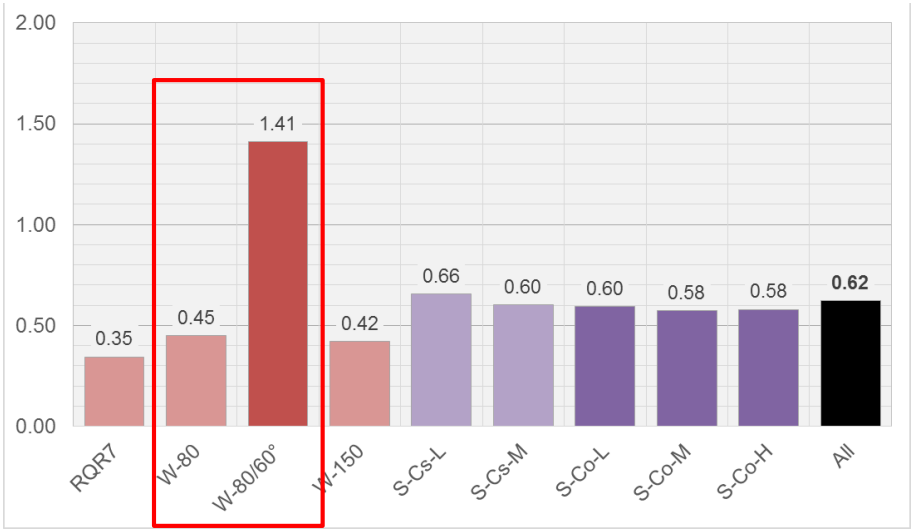
LINEARITY

- Low, Medium and High doses for the same radiation quality



ANGULAR RESPONSE

- Normal and angular incidence irradiations to a similar dose value for the same radiation quality

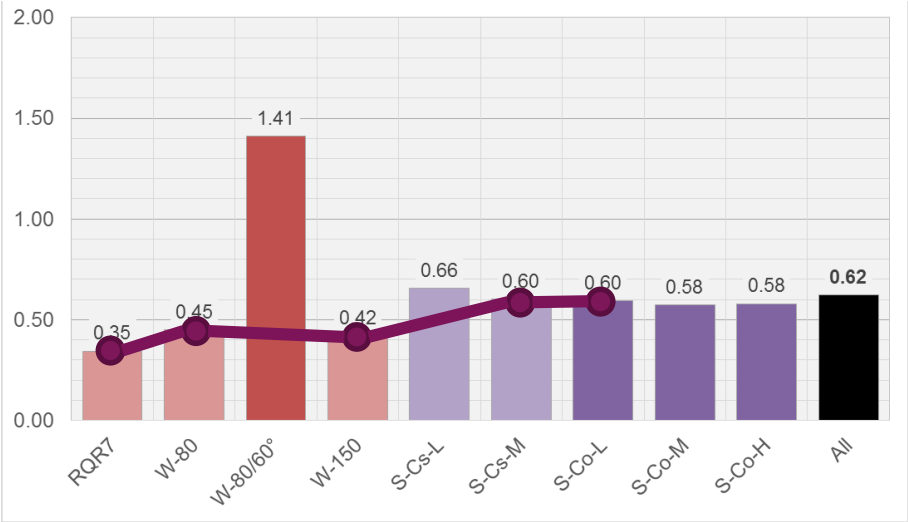


EURADOS

Irradiation plan was designed to allow IMSs to check:

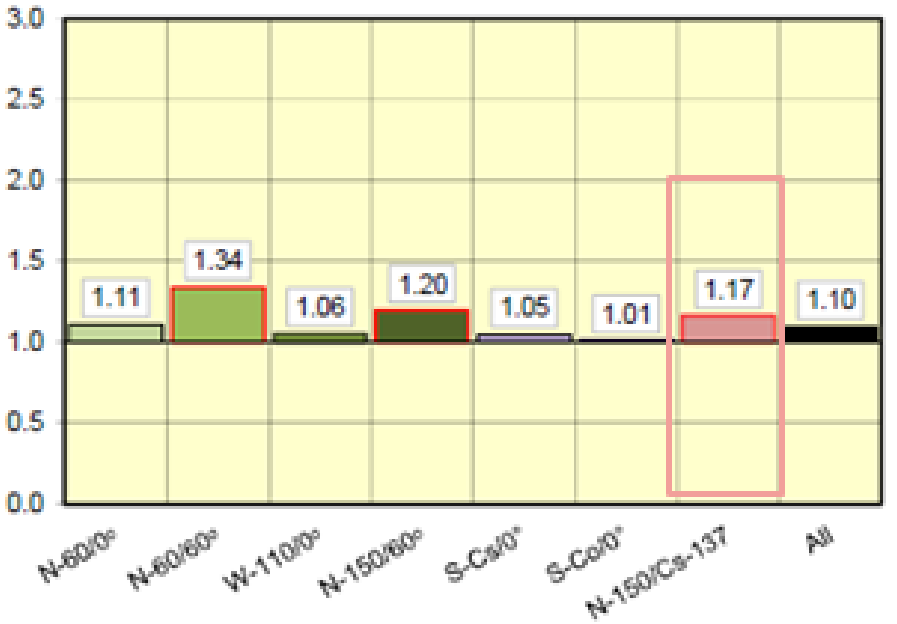
ENERGY RESPONSE

- Radiation qualities in a wide range of energies



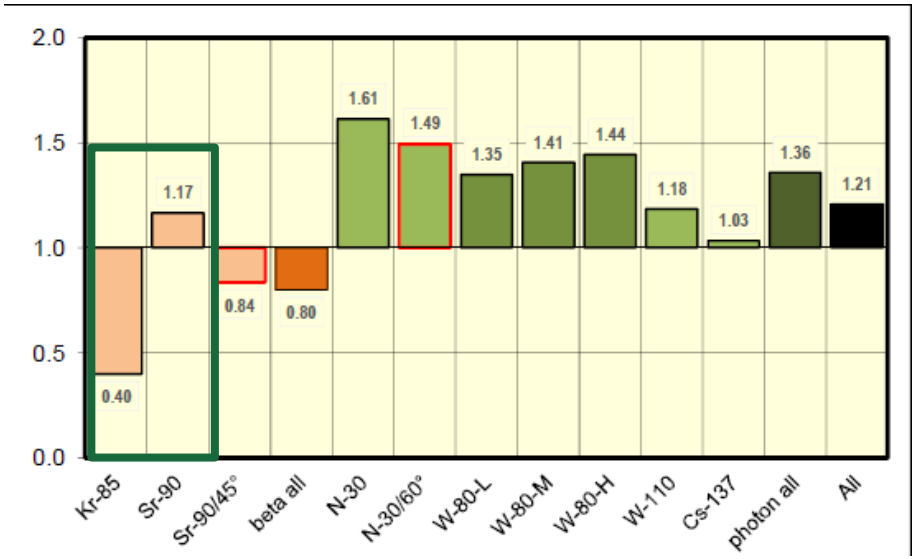
RESPONSE TO MIXED FIELDS

- Same dosemeter irradiated to mixed radiation qualities

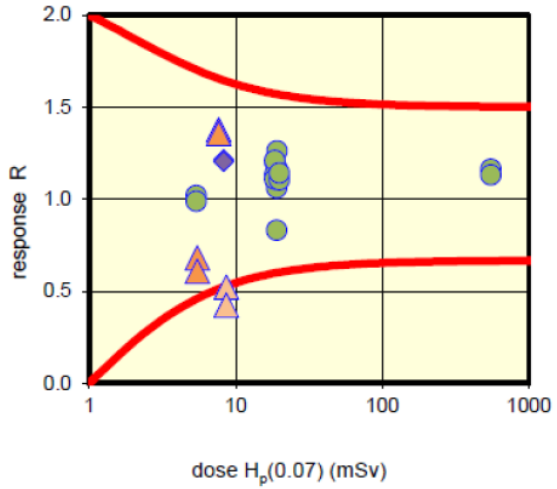


Irradiation plan was designed to allow IMSs to check:

RESPONSE TO BETA RADIATION
- Always for extremity dosemeters. Sometimes for whole body dosemeters.



… and to test compliance with ISO-14146: “trumpet curves”

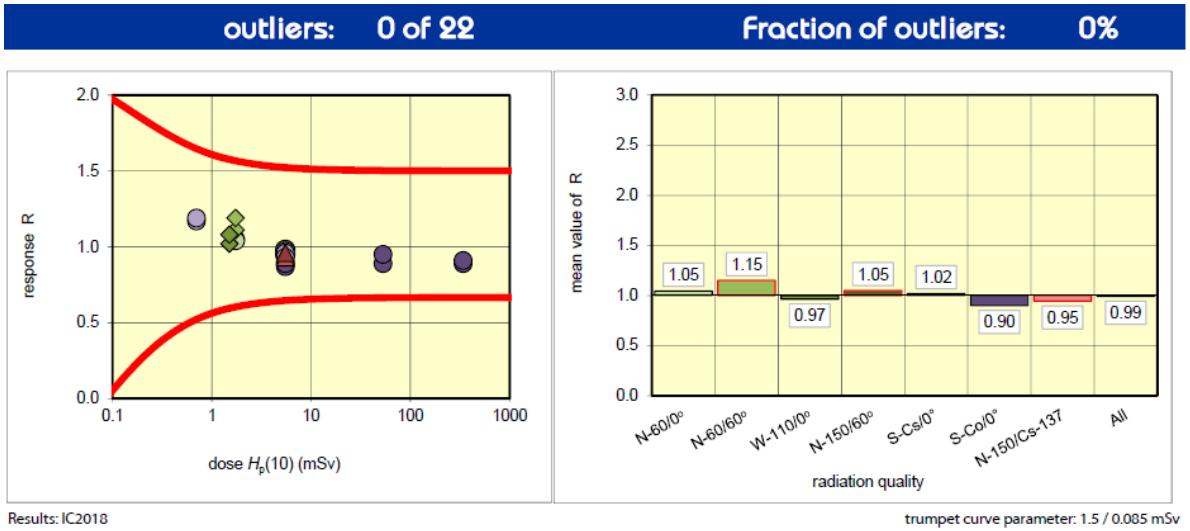


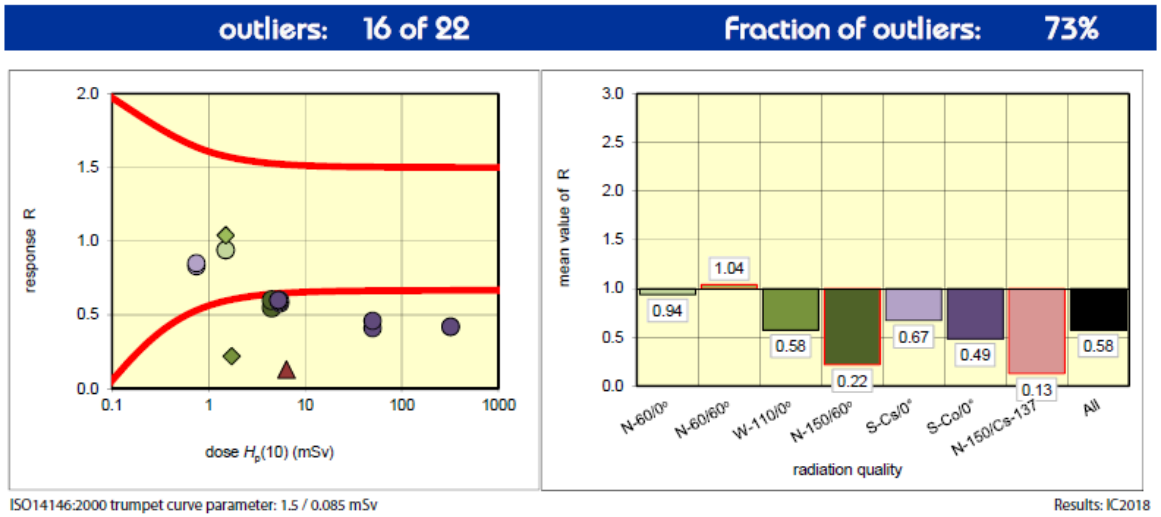
WHOLE BODY DOSEMETERS

- Film
- TLD
- OSL
- Other (RPL, DIS, APD)

Wide range of $H_p(10)$ performance:

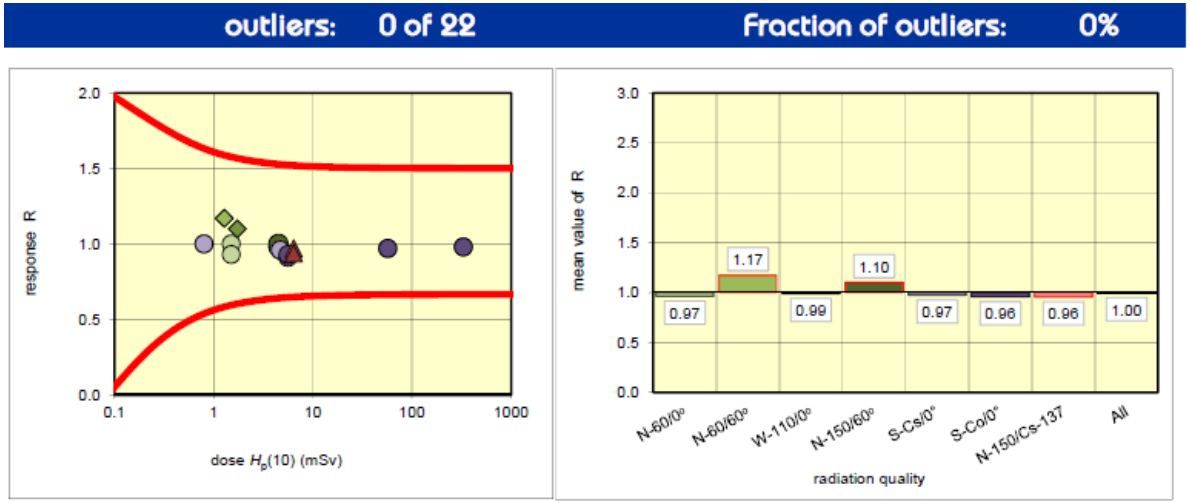
FILM dosemeters

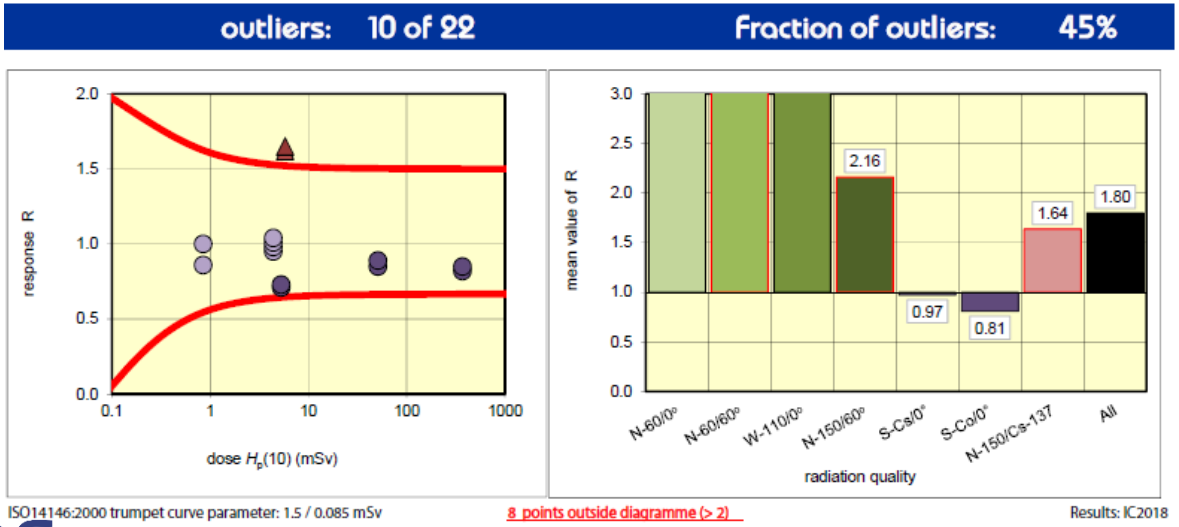




Wide range of $H_p(10)$ performance:

TLD dosemeters

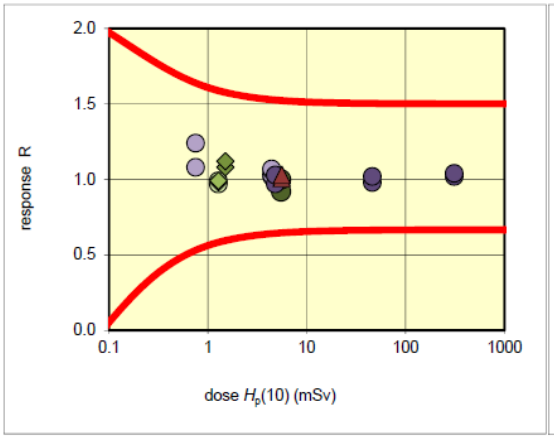


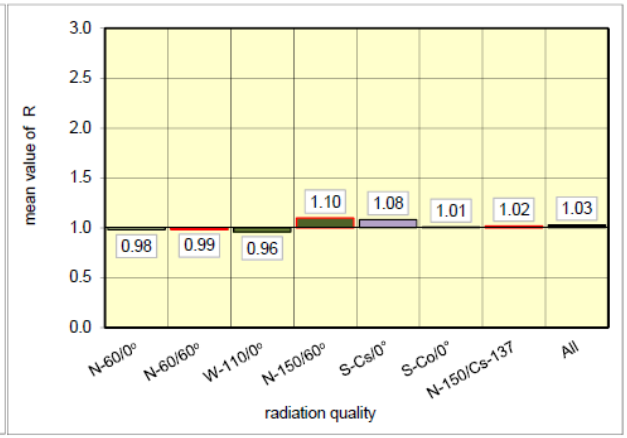


Better $H_p(10)$ performance:

OSL

outliers: 0 of 22 Fraction of outliers: 0%



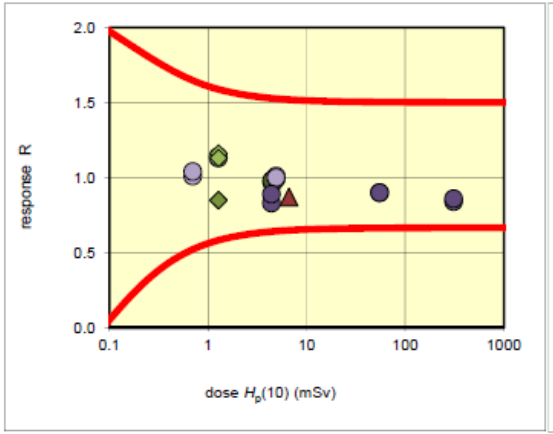


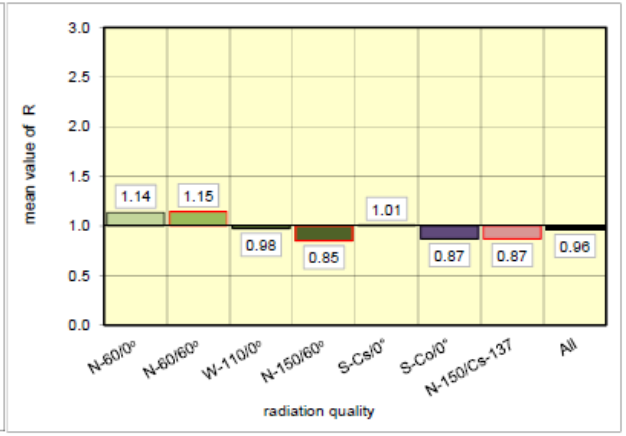
Results: IC2018

trumpet curve parameter: 1.5 / 0.085 mSv

Other types

outliers: 0 of 22 Fraction of outliers: 0%





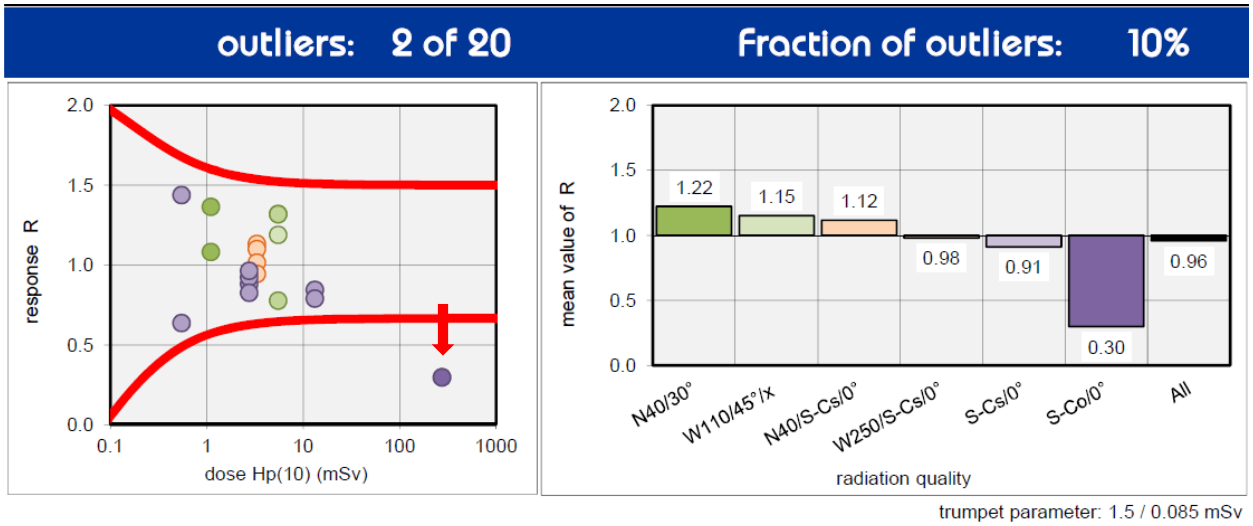
ISO14146:2000 trumpet curve parameter: 1.5 / 0.085 mSv

Results: IC2018

EURADOS

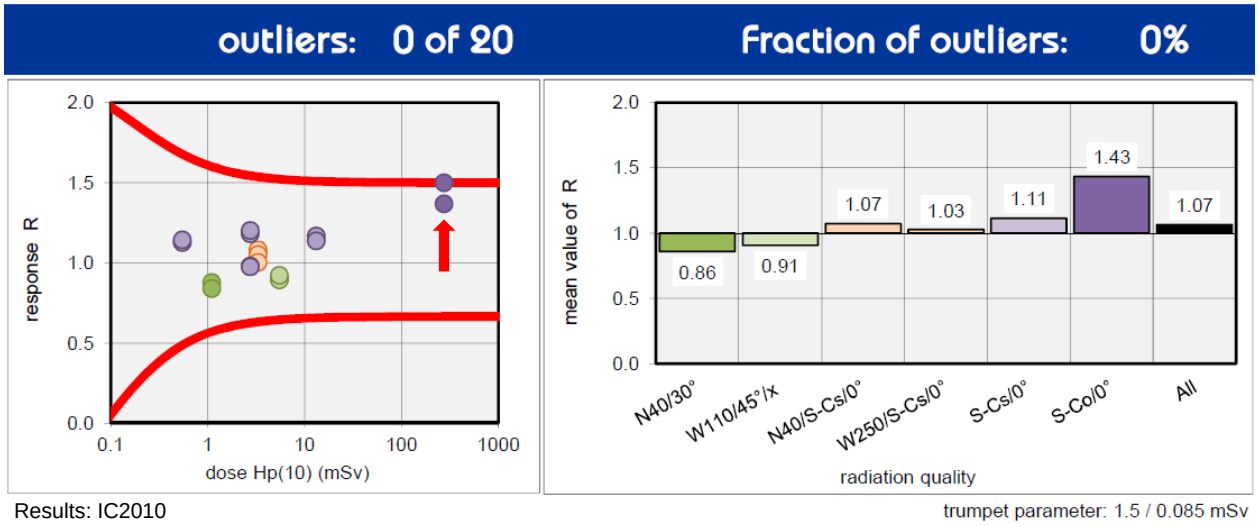
Linearity / High doses:

$H_p(10)$



FILM

Sub-linear response



TLD

Supra-linear response

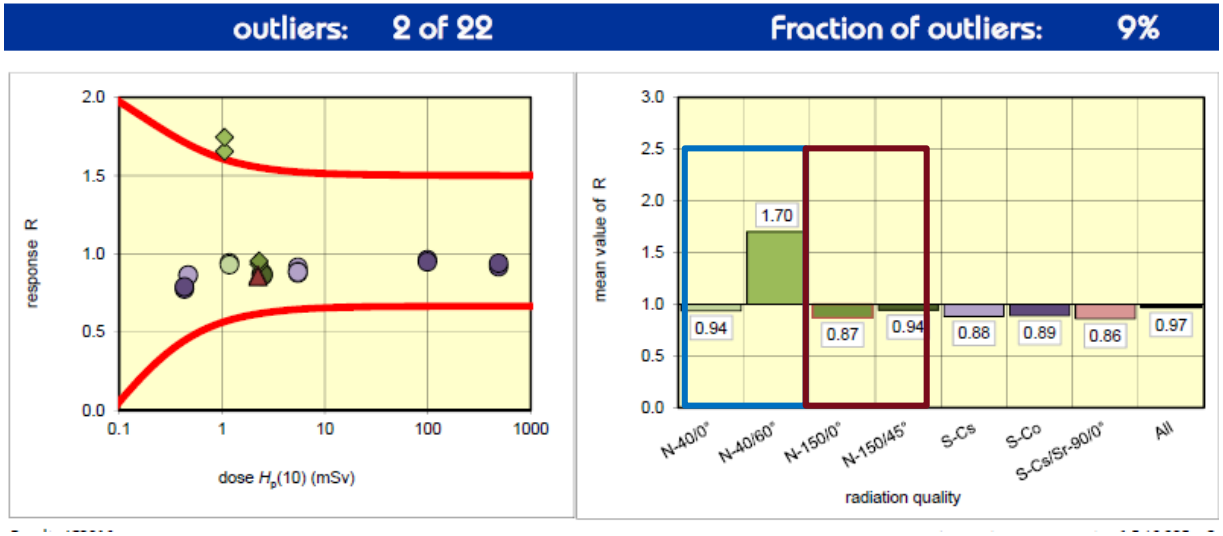
- Reader?
- Saturation?
- Detector material?

Results: IC2010

EURADOS

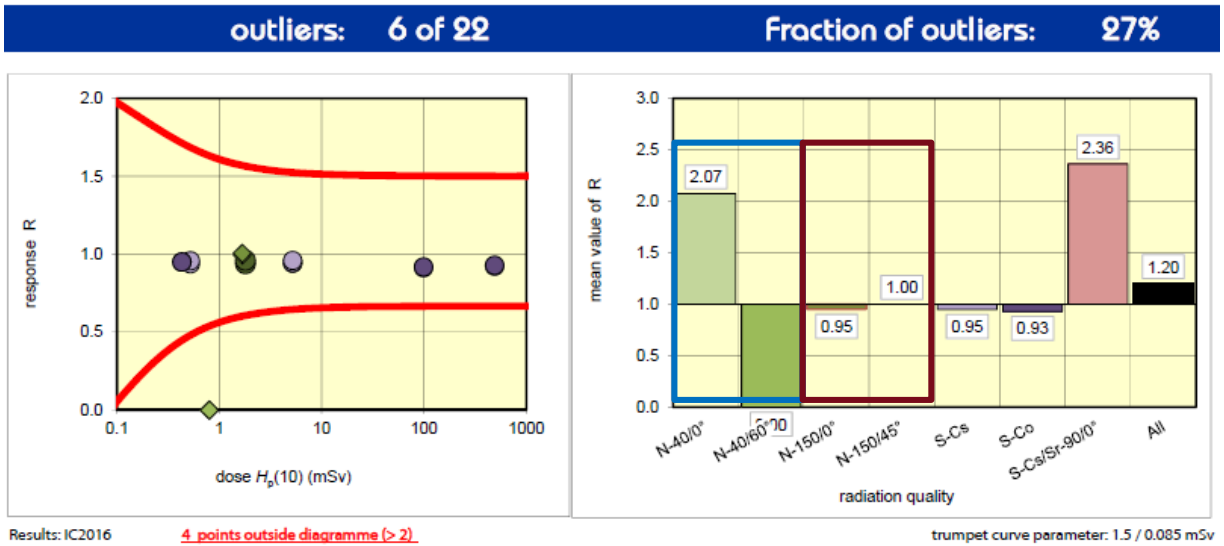
Angular response:

$H_p(10)$



TLD

Remarkable angular dependance for N-40:60º that is not shown for N-150:45º - very common behaviour in IC2016 -



TLD

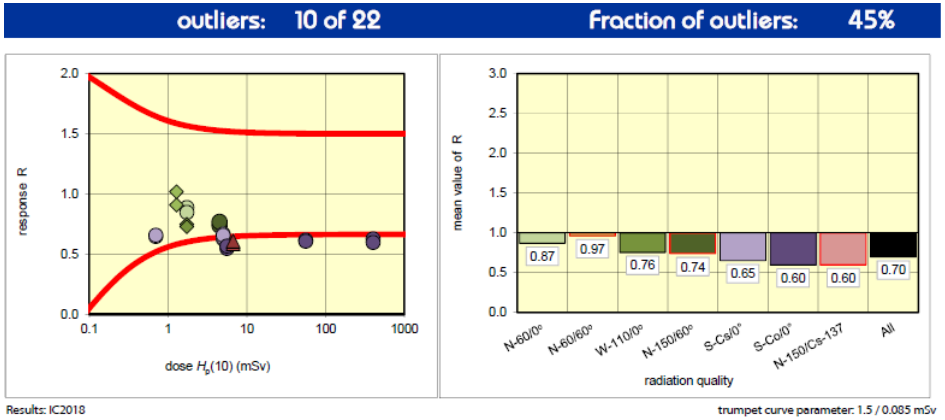
Anomalous response for N-40 angular response – range of application? -

EURADOS

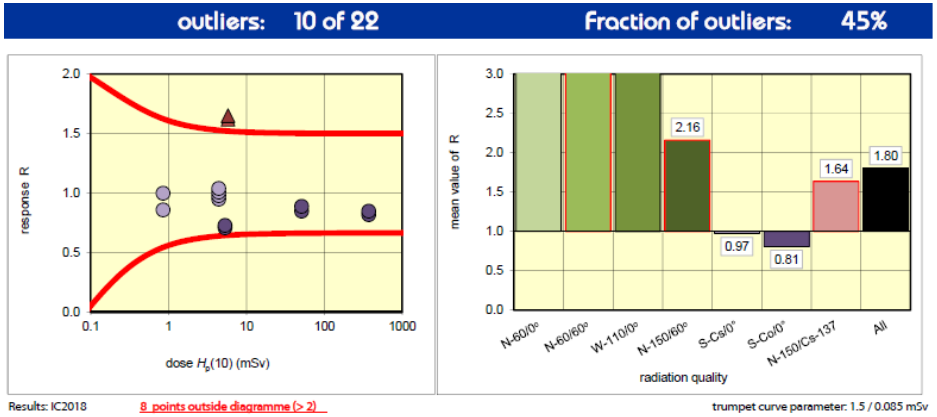
Energy response:

$H_p(10)$

TLD - good for x-ray but poor for Cs, Co and mixed



TLD - only good for Cs y Co



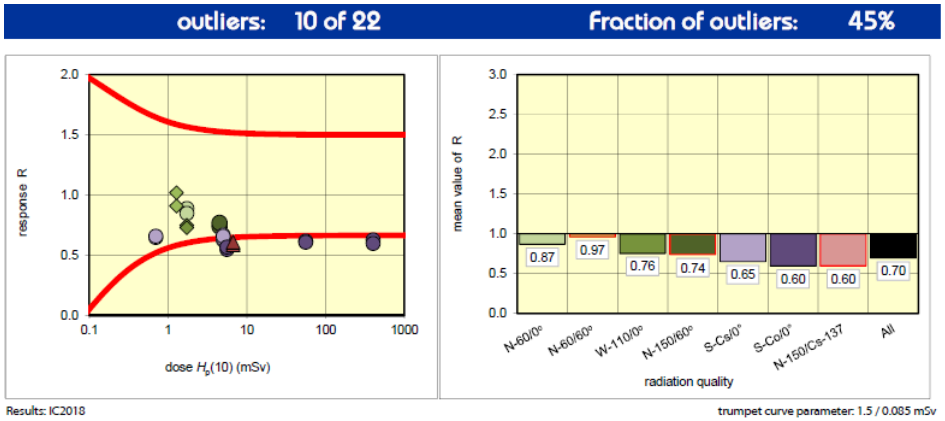
- Detector material?
- Algorithm/badge design?
- Range of application?

EURADOS

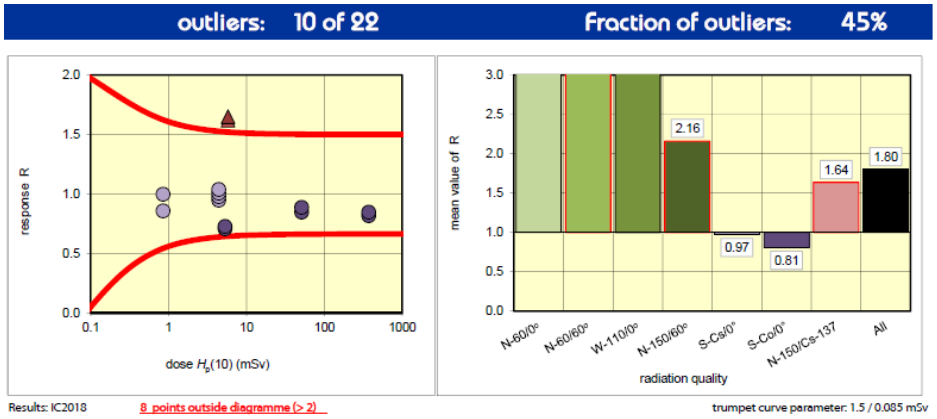
Photon Energy response:

$H_p(10)$

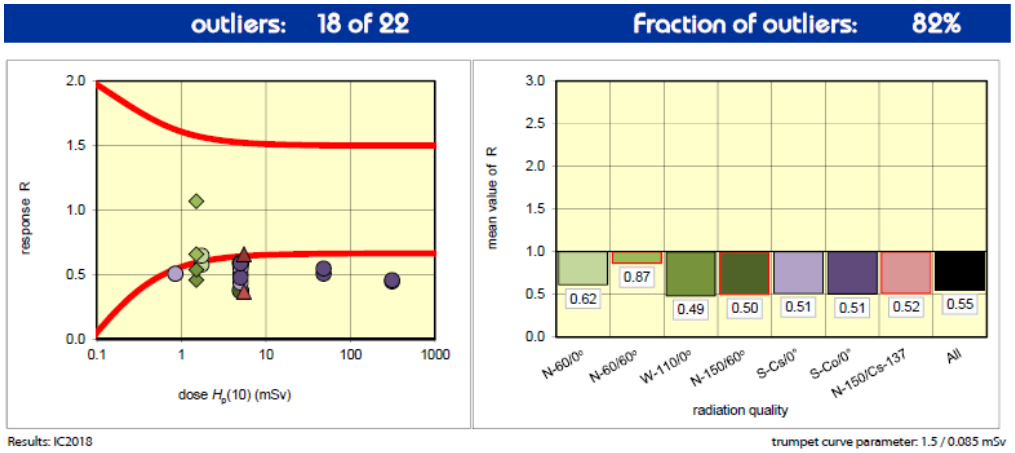
TLD - good for x-ray but poor for Cs, Co and mixed



TLD - only good for Cs y Co



TLD - many outliers but good energy response.



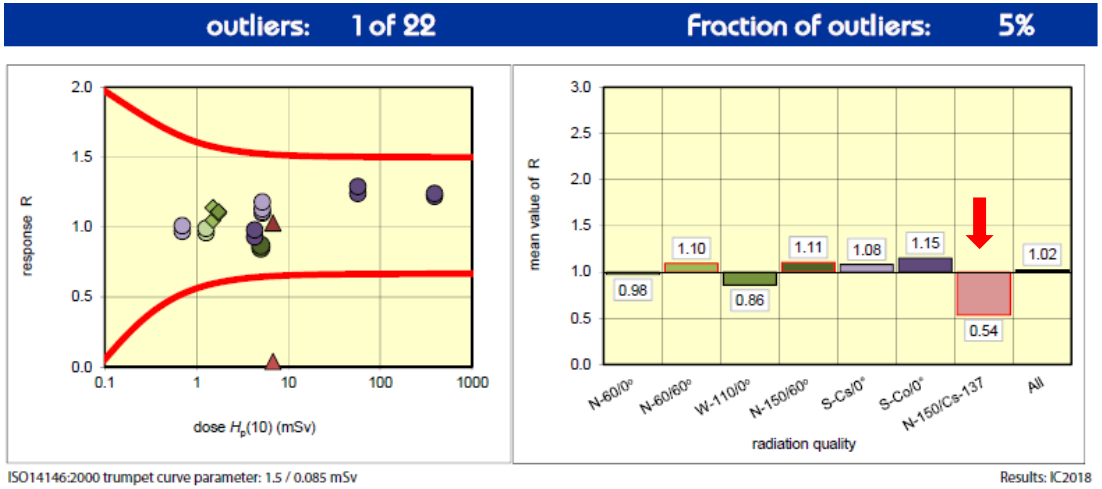
- Detector material?
- Algorithm/badge design?
- Range of application?

- Calibration problems

EURADOS

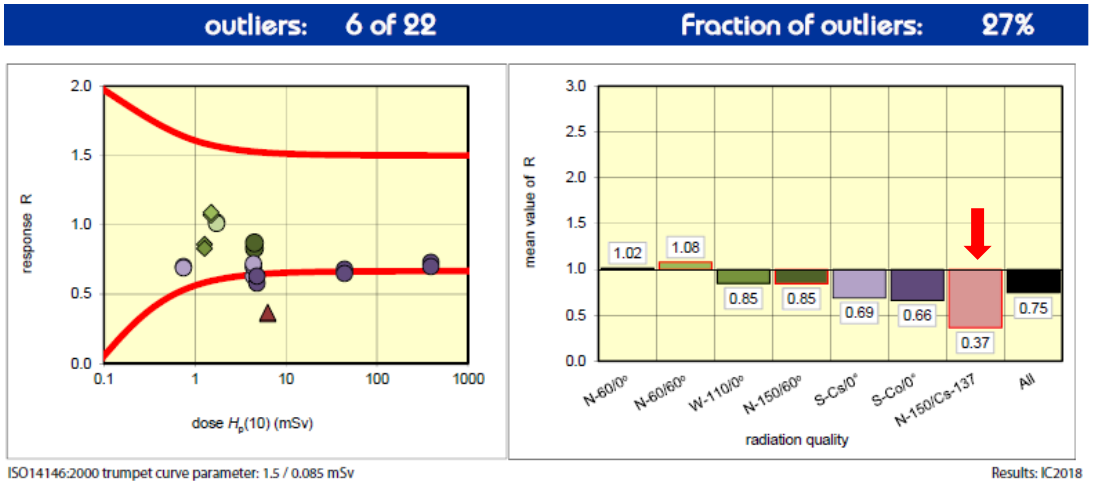
Mixed N150+S-Cs radiation:

$H_p(10)$



TLD

Good N150 and S-Cs responses but remarkable under-response for mixed radiation (only 1 outlier)



TLD

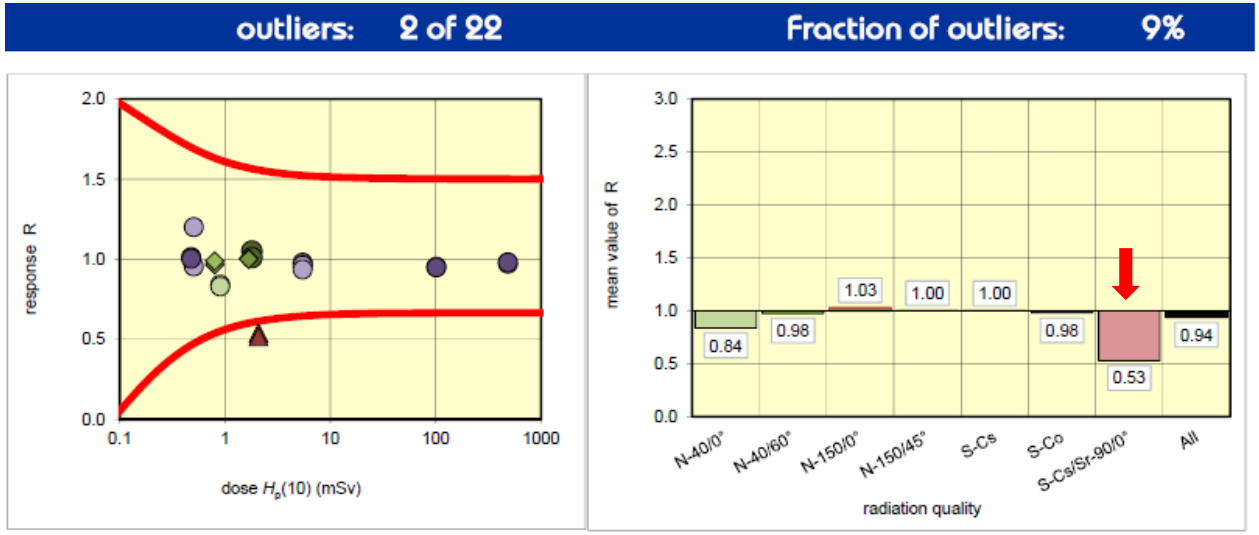
Under-response to N150 and S-Cs but much more pronounced for mixed radiation

- Algorithm?

EURADOS

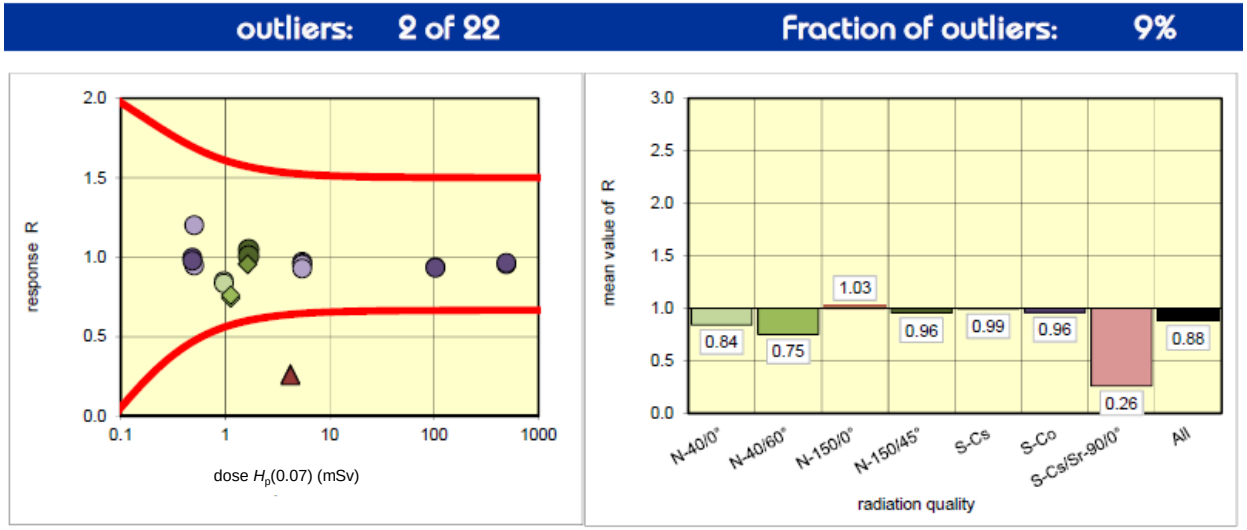
Mixed beta+gamma field response:

FILM



$H_p(10)$

Remarkable under response for mixed beta+gamma field



$H_p(0.07)$

Same behaviour

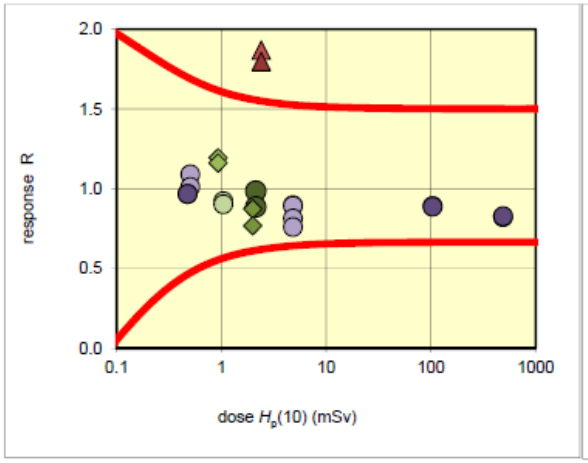
- Algorithm?
- Filtration?

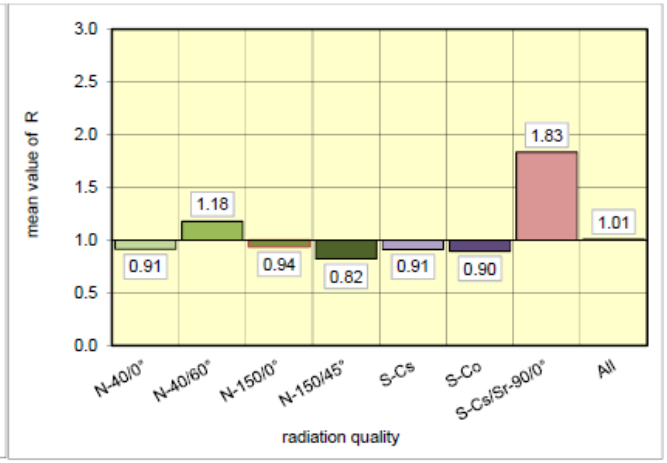
EURADOS

Mixed beta+gamma field response:

outliers: 2 of 22 **Fraction of outliers: 9%**

TLD

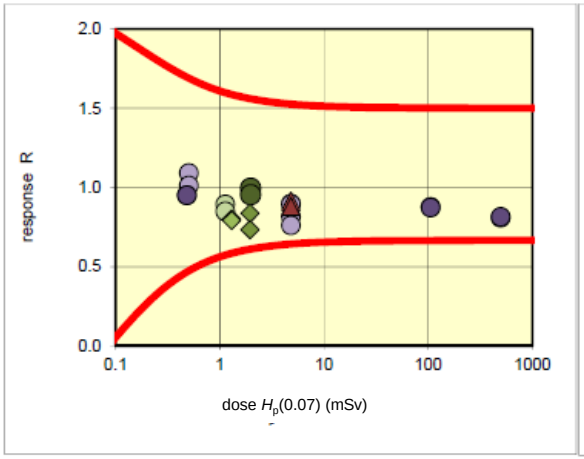


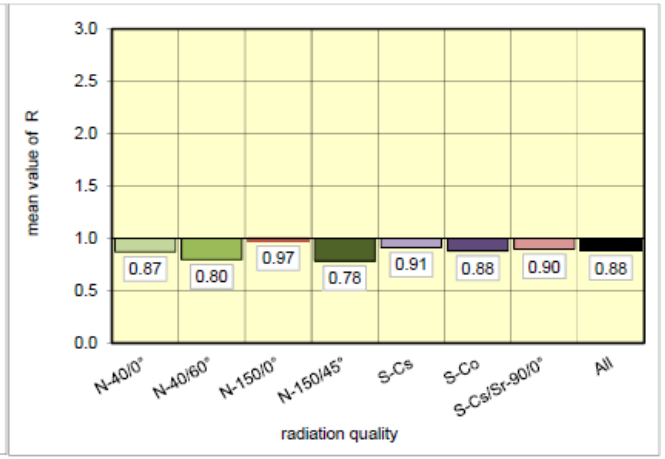


$H_p(10)$

Remarkable over response for mixed beta+gamma field

outliers: 0 of 22 **Fraction of outliers: 0%**





$H_p(0.07)$

Not reproducible behaviour

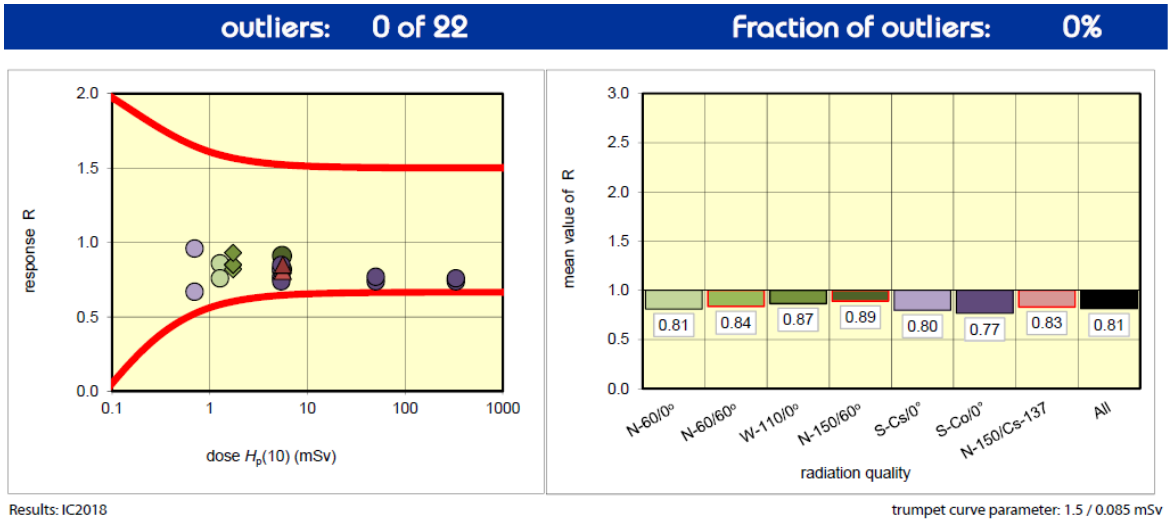
- Algorithm?
- Badge design

EURADOS

Calibration procedure can improve results:

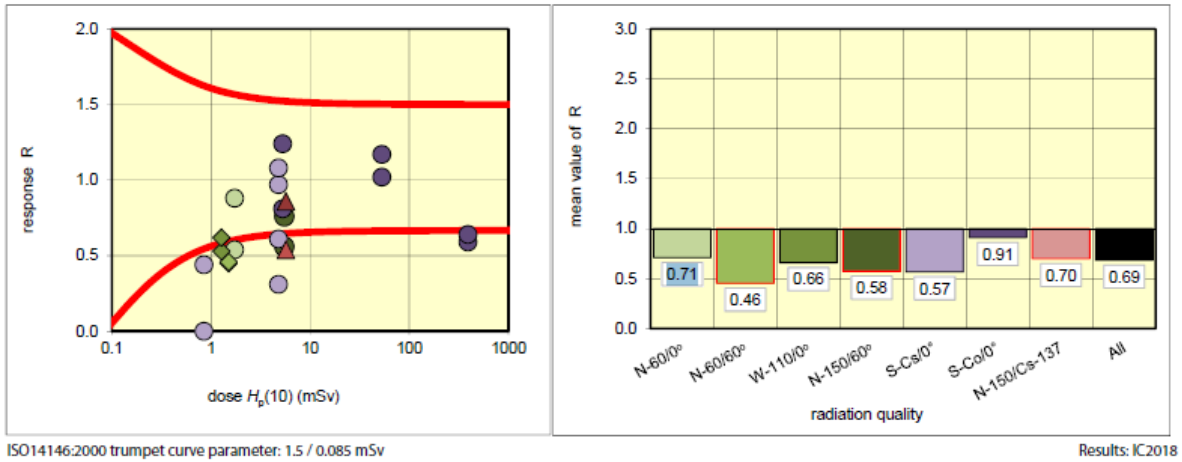
$H_p(10)$

TLD



Good results that can be improved by calibration factor

TLD



Outliers would be reduced by improving calibration procedure

EURADOS

Conclusions (Whole body dosemeters):

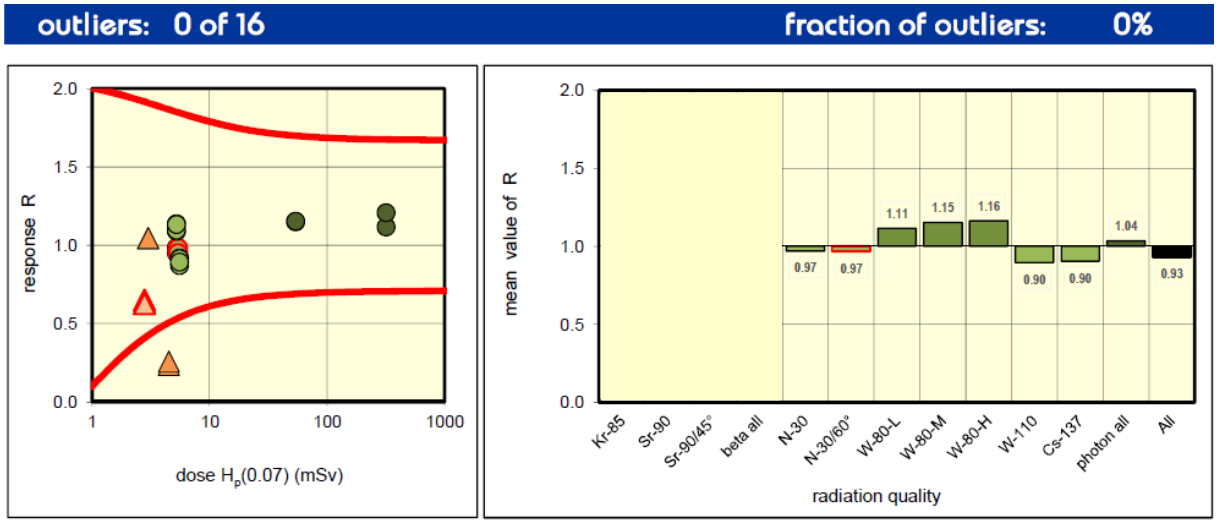
$H_p(10)$, $H_p(0.07)$

- Wide variation of performance for all type of dosemeters, regardless the type of detector. Good procedures can produce good results with all type of dosimetry systems.
- OSL and Other systems present very few outliers.
- High dose response should be checked for many systems.
- Improvement is possible by checking **calibration** procedures, dose algorithms and badge design.
- $H_p(0.07)$ response follows trend of $H_p(10)$, but usually with a lower performance.

EXTREMITY DOSEMETERS

- Ring, wrist and finger tip
- Ph, β and Ph+β dosemeters

Wide range of $H_p(0.07)$ performance:

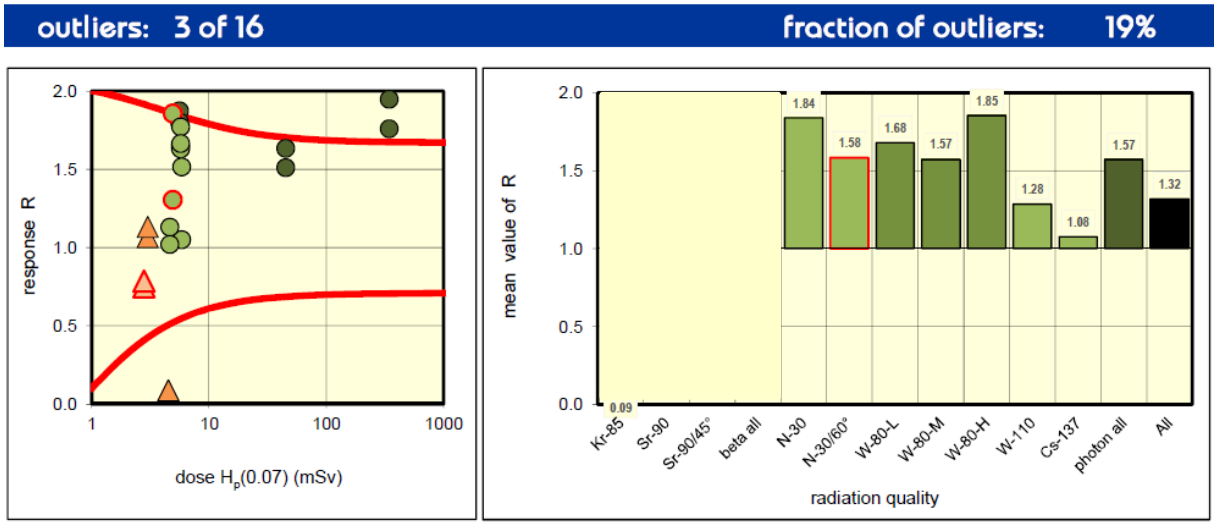


Results: $IC2019_{ext\ eye}$

ISO 14146:2018 trumpet curve, lower dose limit (H_0): 1.0 mSv

Ph only

Good Ph performance



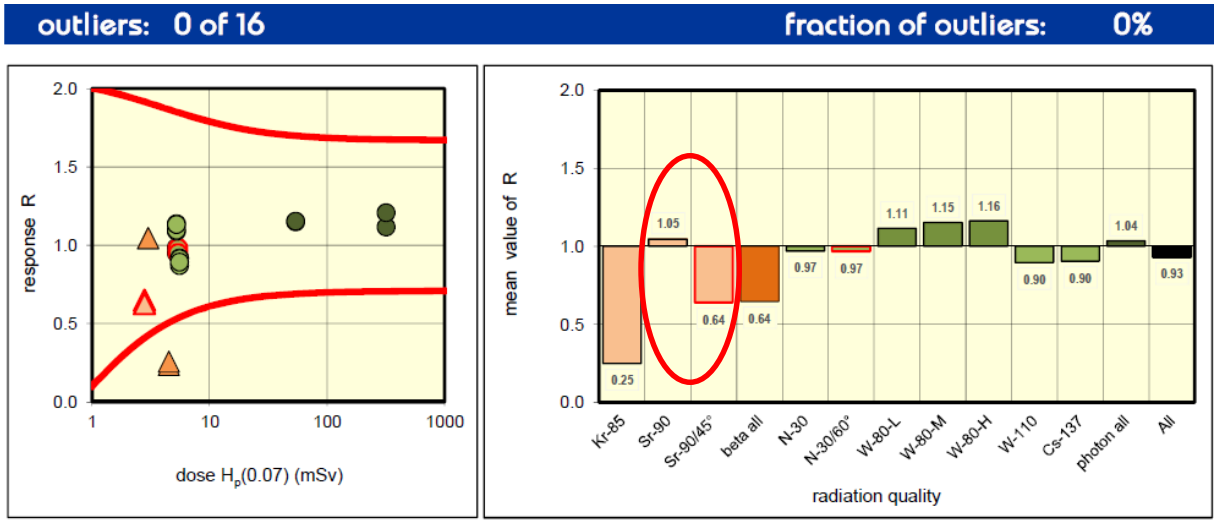
Results: $IC2019_{ext\ eye}$

ISO 14146:2018 trumpet curve, lower dose limit (H_0): 1.0 mSv

Poor Ph performance

EURADOS

Wide range of $H_p(0.07)$ performance:



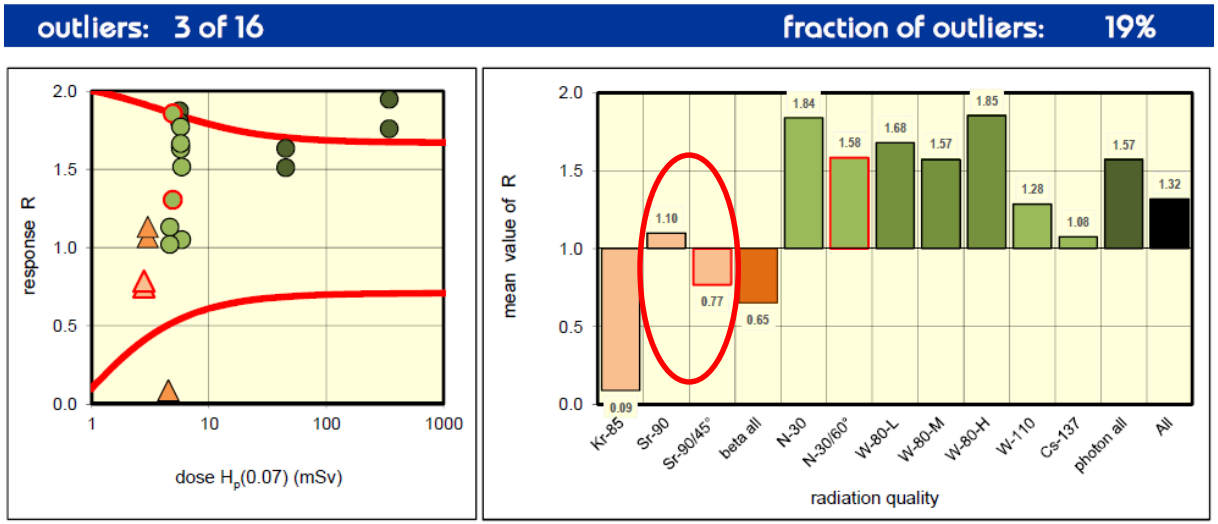
Results: $IC2019_{ext\ eye}$

ISO 14146:2018 trumpet curve, lower dose limit (H_0): 1.0 mSv

Ph only

Good Ph performance

Acceptable Sr-90 performance



Results: $IC2019_{ext\ eye}$

ISO 14146:2018 trumpet curve, lower dose limit (H_0): 1.0 mSv

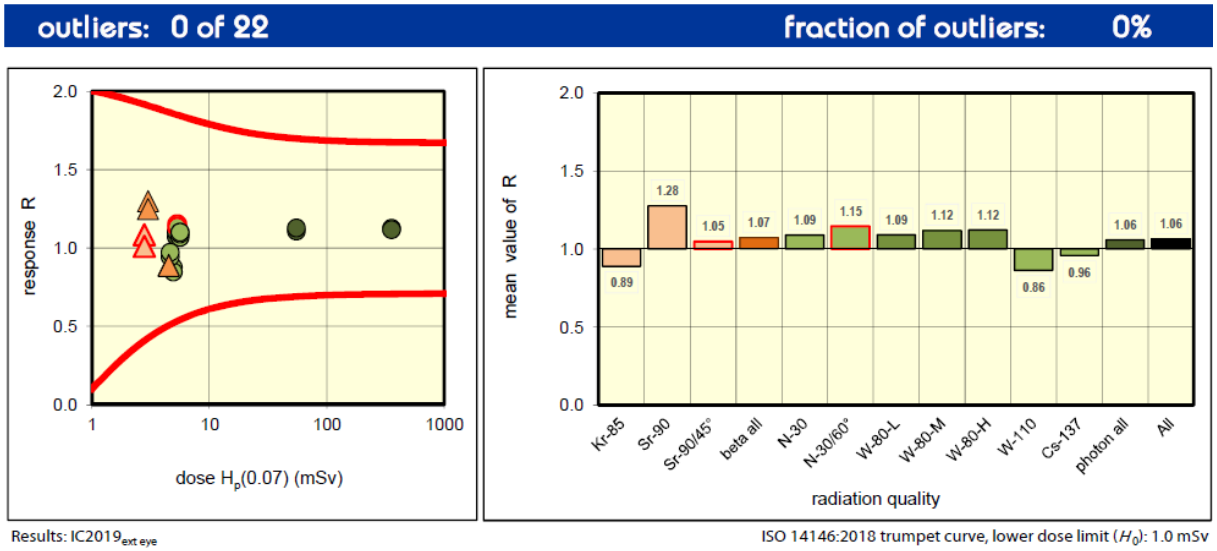
Ph only

Poor Ph performance

Acceptable Sr-90 performance

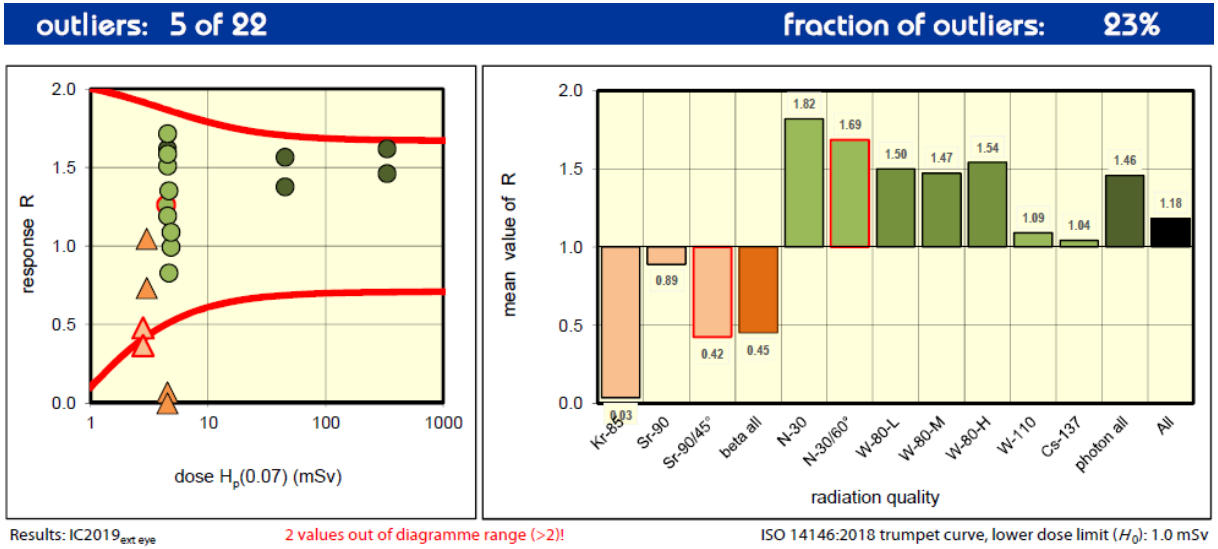
EURADOS

Wide range of $H_p(0.07)$ performance:



Ph + β

Good Ph + β performance



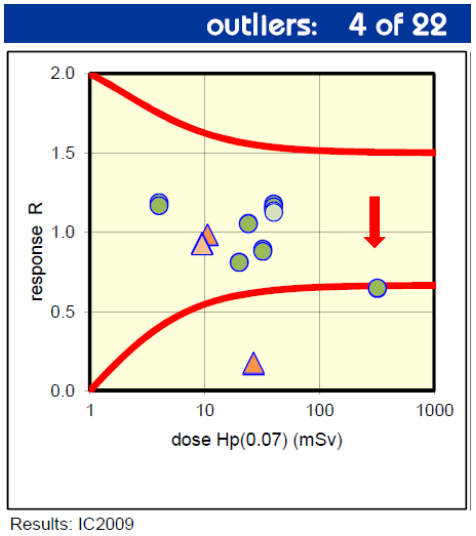
Ph + β

Poor Ph + β performance

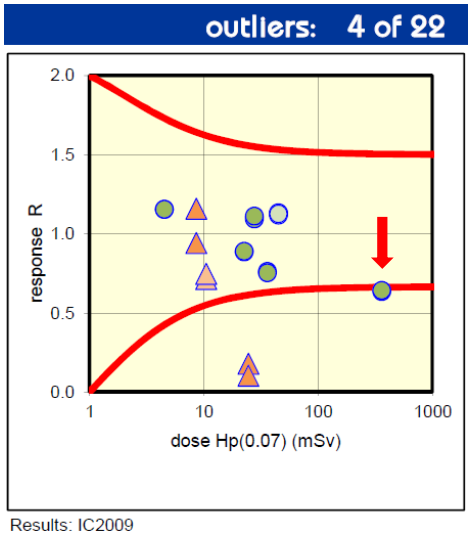
EURADOS

Linearity / High doses:

$H_p(0.07)$

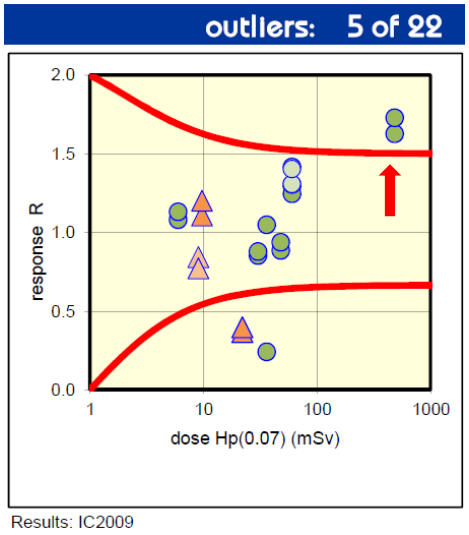


RING

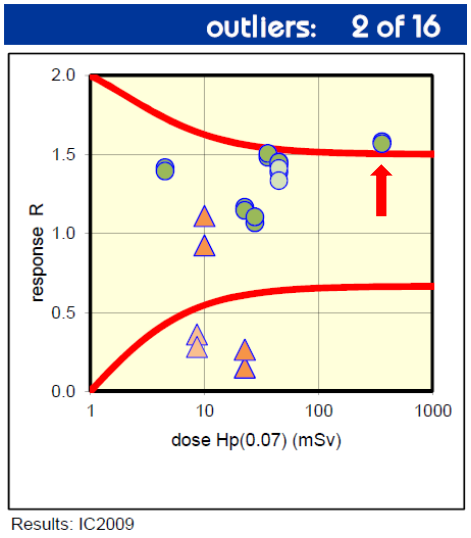


WRIST

Sub-linear response



RING



WRIST

Supra-linear response

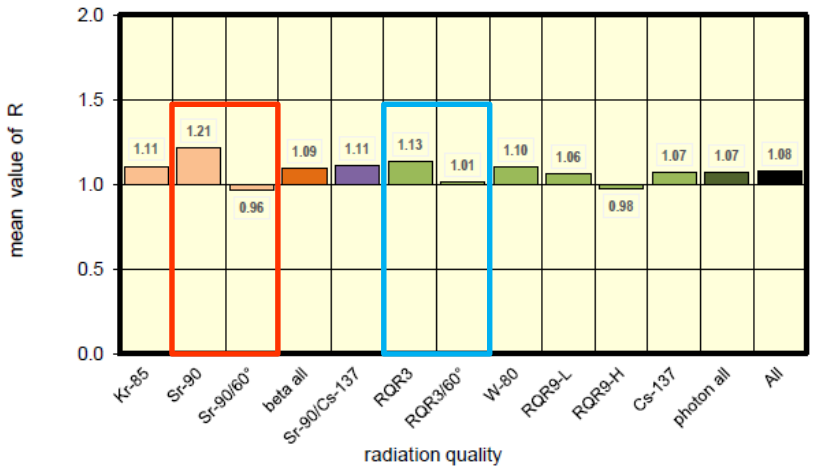
- Reader?
- Saturation?
- Detector material?

EURADOS

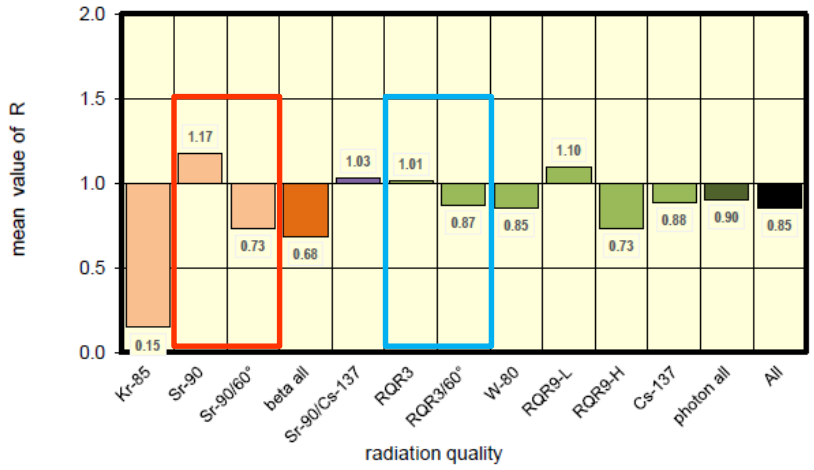
Angular response:

$H_p(0.07)$

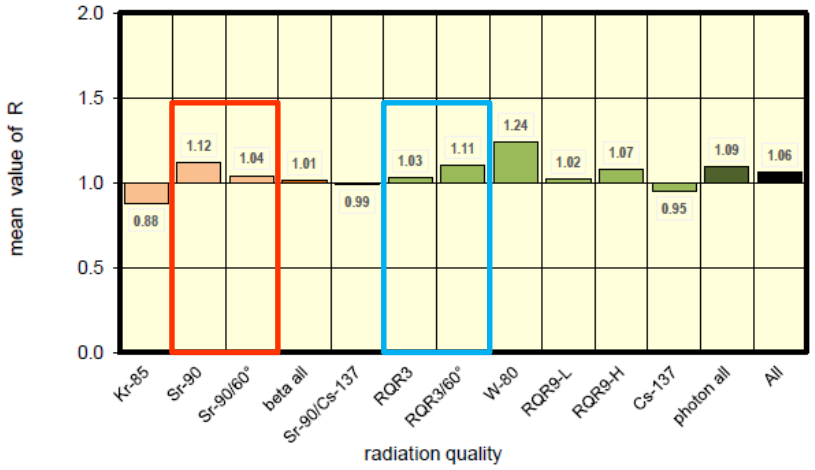
Ring



Wrist



Finger tip



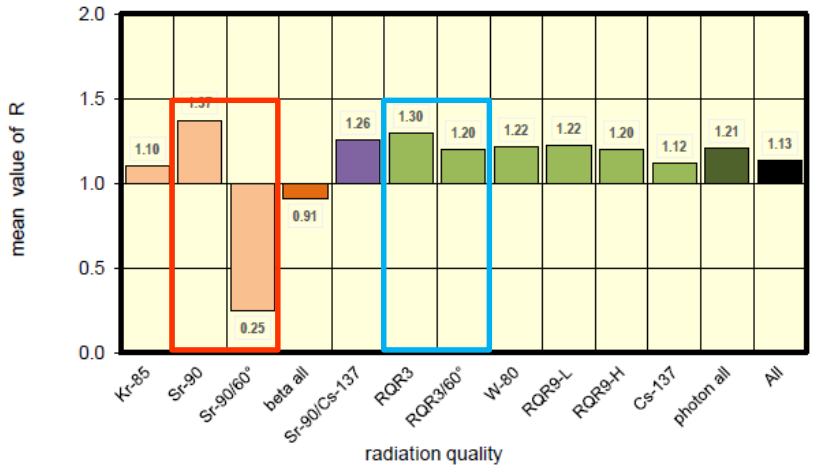
Examples of good performance for ring, wrist and finger tip dosemeters. Better angular response for photon than for beta but…

EURADOS

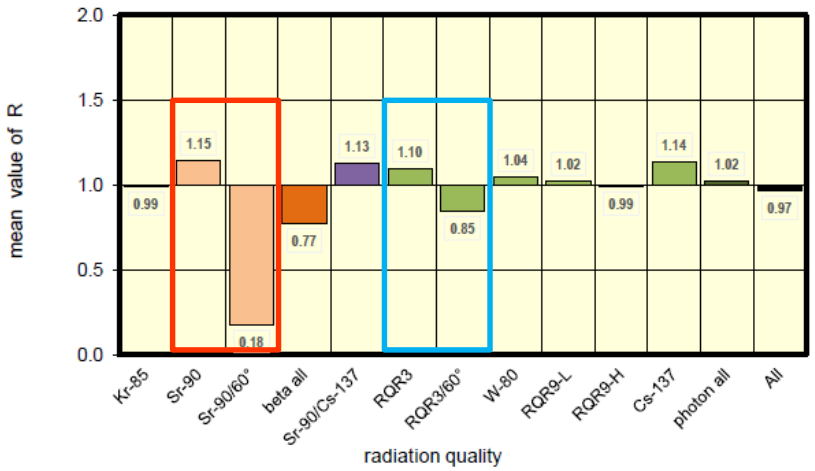
Angular response:

$H_p(0.07)$

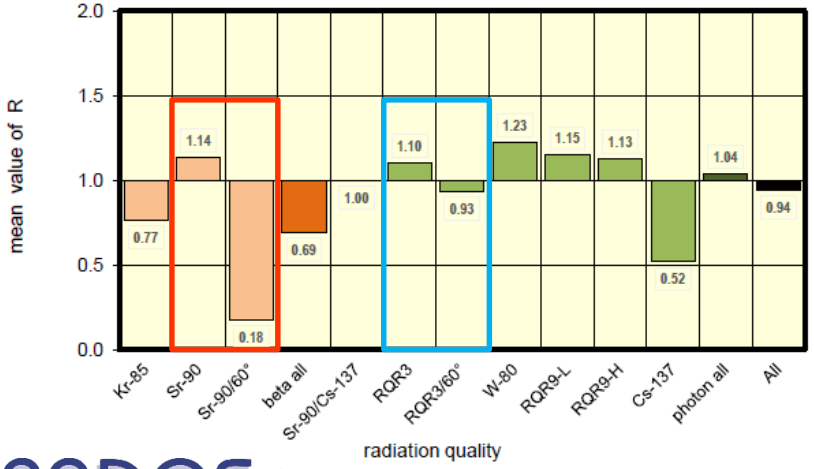
Ring



Wrist



Finger tip



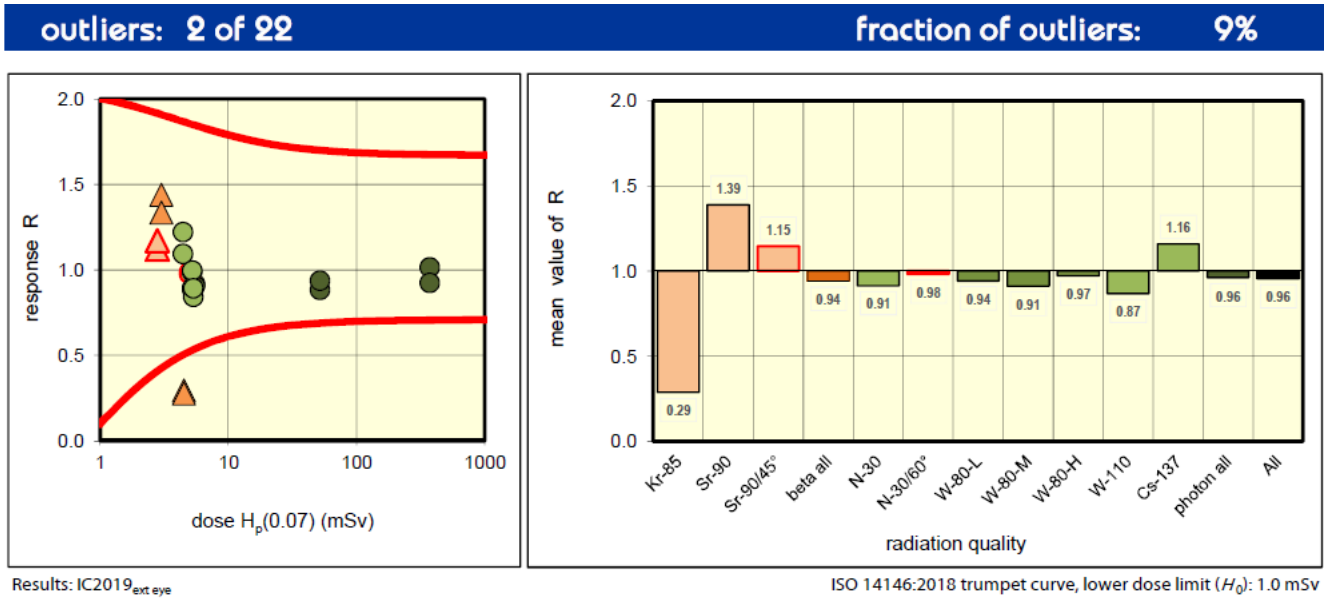
…also examples where the beta angular response is remarkably worse than photon angular response

- Higher influence of filtration for beta radiation

EURADOS

Beta energy response:

$H_p(0.07)$



Ph + β

General trend in all extremity ICs:

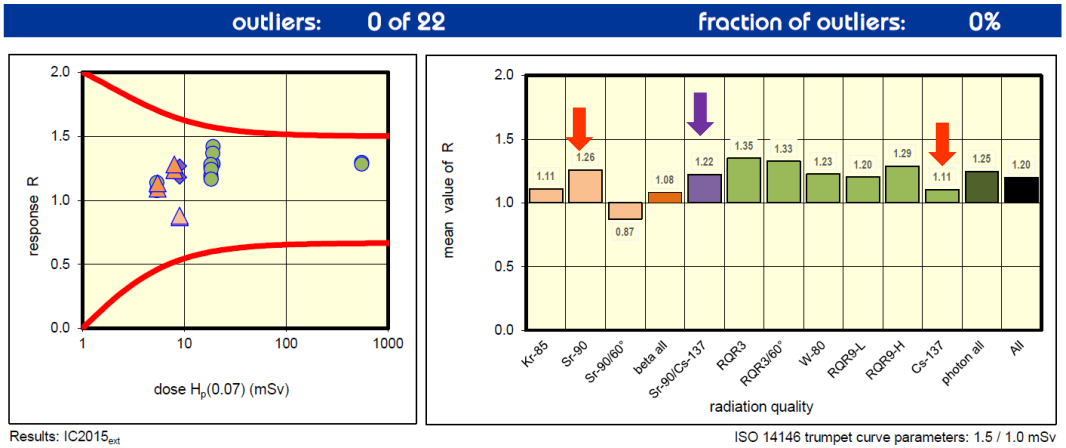
Ph + β dosemeters show good response to Sr-90 but greatly underestimate low energy beta radiation (Kr-85).

Badge design and detector thickness are critical

EURADOS

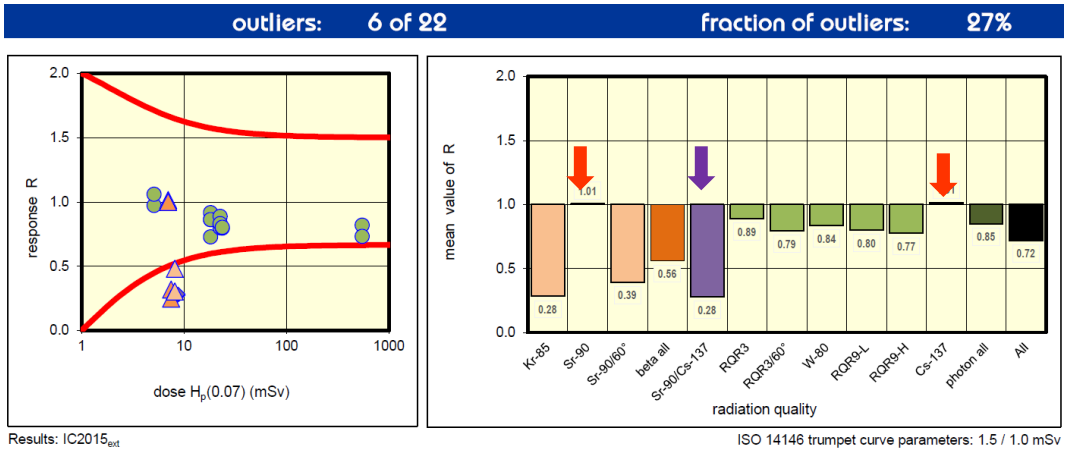
Mixed Sr-90+S-Cs radiation:

$H_p(0.07)$



Ph+β

Coherent behaviour among S-90, S-Cs, and mixed Sr-90+S-Cs



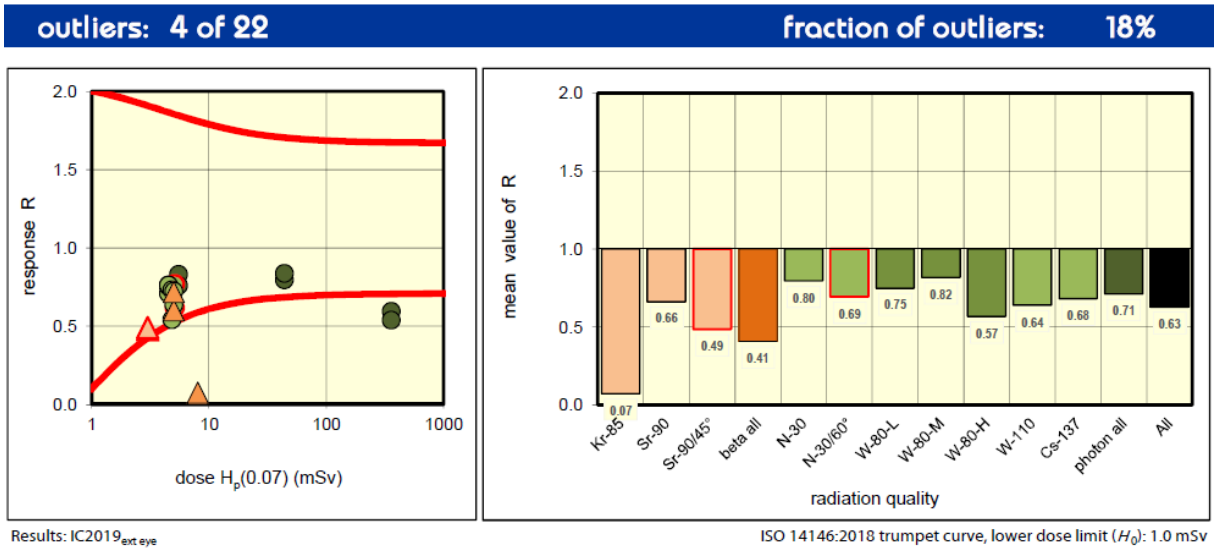
Ph+β

Anomalous response to mixed gamma+beta field, but…
… only for 1 system

EURADOS

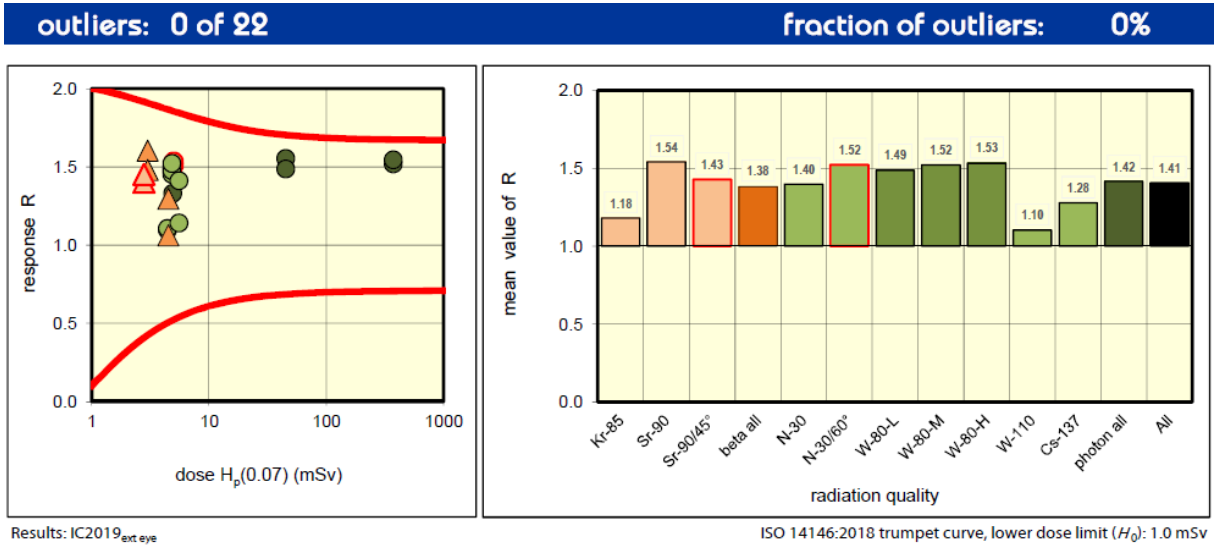
Calibration problems:

$H_p(0.07)$



Ph + β

Under-response



Ph + β

Over-response

EURADOS

Conclusions (Extremity dosemeters):

$H_p(0.07)$

- Wide variation of performance for all type of extremity dosemeters. Good procedures can produce good results with all type of dosimetry systems.

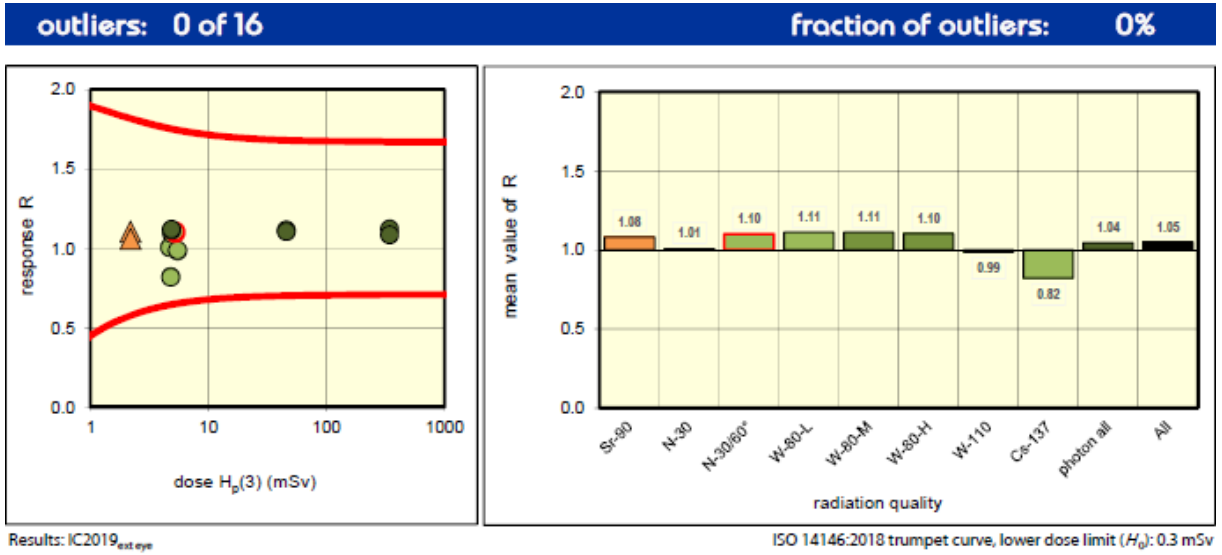
- Improvement is possible by checking **calibration** procedures and badge design. Filtration is really important.

- Ph+β dosemeters show better performance for photon than for beta radiation.

EYE LENS DOSEMETERS

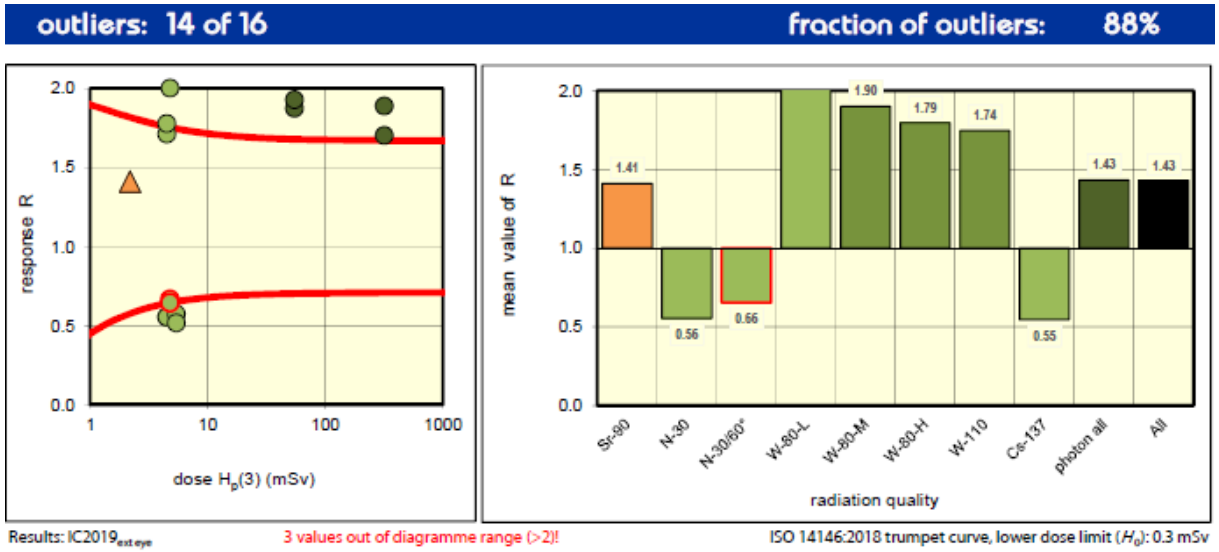
- Ph and Ph+β dosemeters

Wide range of $H_p(3)$ performance:



Ph only

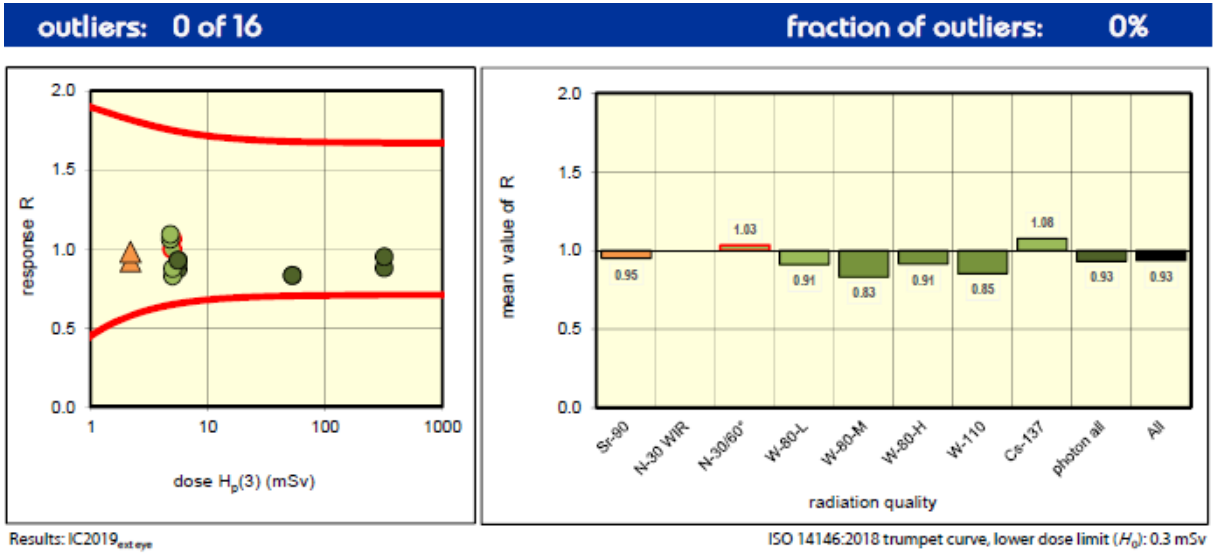
Good Ph performance
(and β response)



Poor Ph performance
(and good β response!)

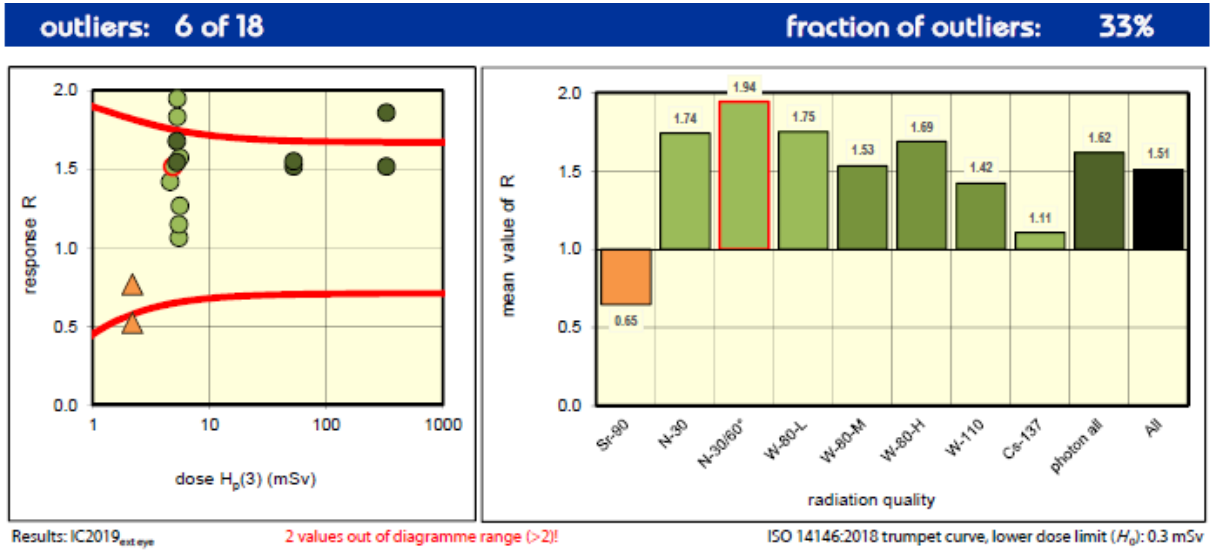
EURADOS

Wide range of $H_p(3)$ performance:



Ph + β

Good performance

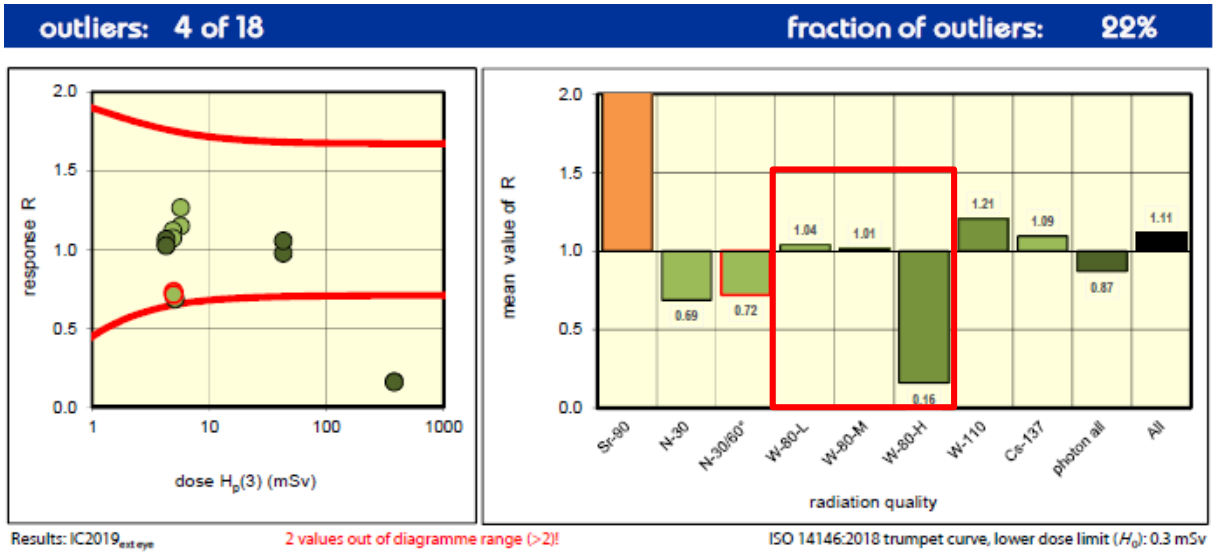


Poor performance

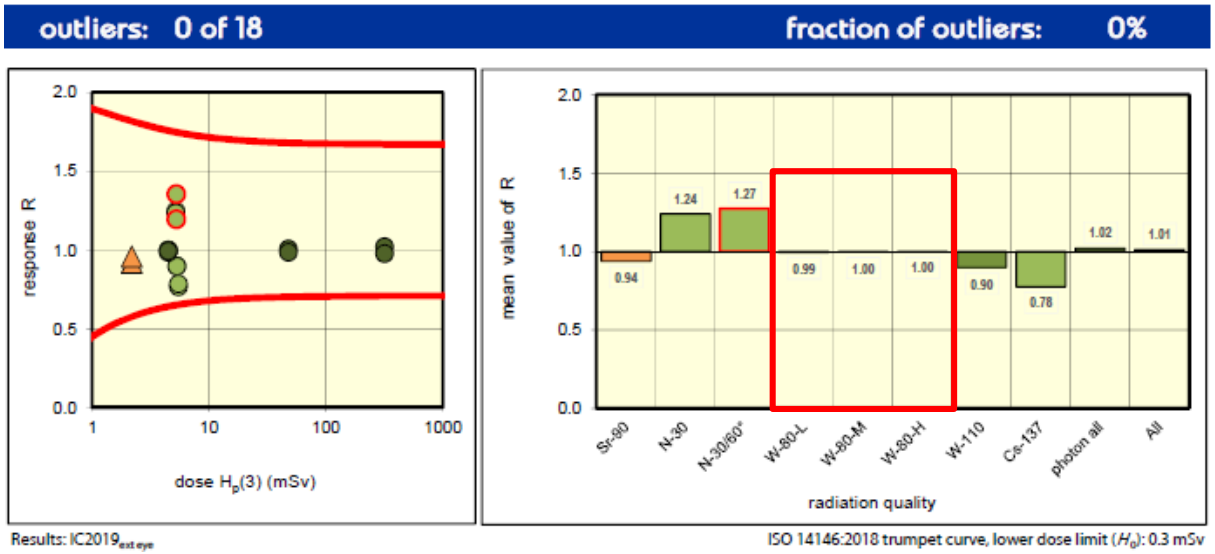
EURADOS

Linearity / High doses:

$H_p(3)$



Underresponse



Excellent linearity

EURADOS

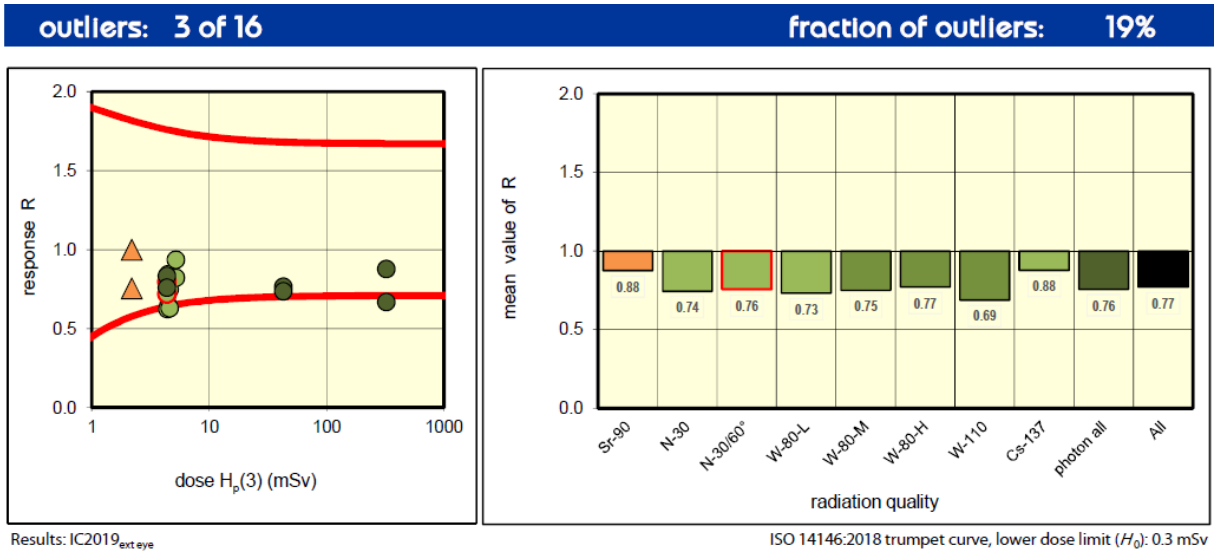
Angular response:

$H_p(3)$

No problems found, very good angular response in all eye lens dosemeters

Calibration problems:

Good linearity, angular and energy responses, even good for beta!



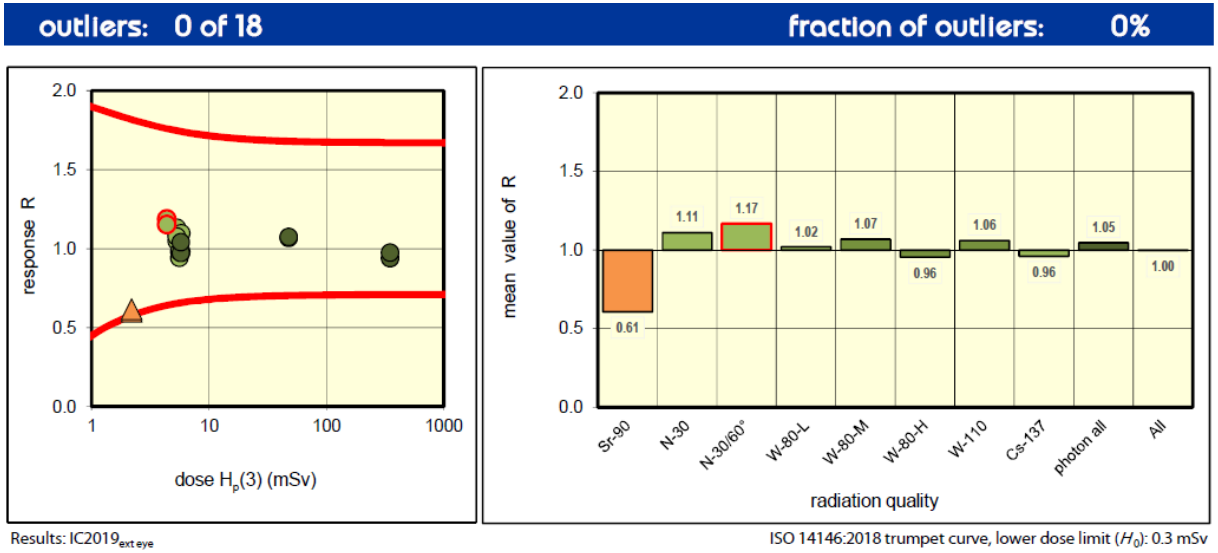
Results: $IC2019_{ext\ eye}$

ISO 14146:2018 trumpet curve, lower dose limit (H_0): 0.3 mSv

Ph only

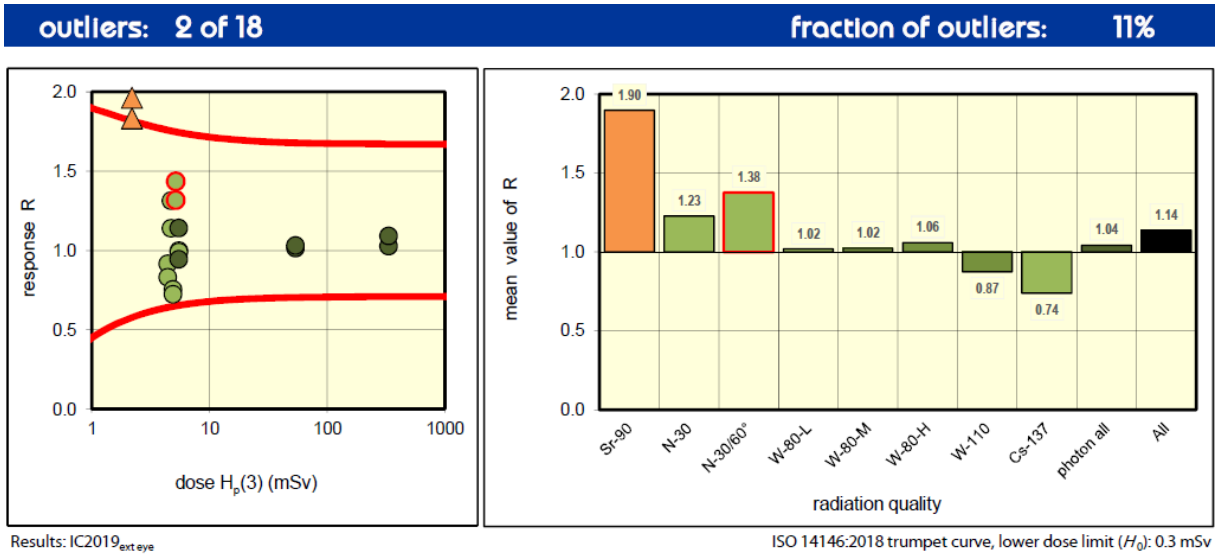
Beta energy response:

$H_p(3)$



Ph + β

Similar to extremity dosemeters trend



Ph + β

Opposite to extremity dosemeters trend

EURADOS

Conclusions (Eye lens dosemeters):

$H_p(3)$

- Wide variation of performance for all type of eye lens dosemeters. Good procedures can produce good results with all type of dosimetry systems.

- All dosemeters show a good angular response.

- Improvement is possible by checking **calibration** procedures and badge design.

- Ph+β dosmeters show better performance for photon than for beta radiation.

Conclusions:

$H_p(3)$

- Wide variation of performance for all type of eye lens dosemeters. Good procedures can produce good results with all type of dosimetry systems.
- All dosemeters show a good angular response.
- Improvement is possible by checking **calibration** procedures and badge design.
- Ph+β dosmeters show better performance for photon than for beta radiation.

THANK YOU FOR YOUR ATTENTION!

☺