

# G-Chron 2024 – Round #3

## — An International Proficiency Test for U-Pb Geochronology Laboratories — Report from the 2024 Round of G-Chron based on the Jurassic Peng-16 zircon (Distribution: January 2024)

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*Proficiency testing (PT) is one of the few means for an analytical laboratory to assess its data quality under routine operating conditions. Here we report the results of Round #3 of the G-Chron PT programme, which is sponsored by the International Association of Geoanalysts (IAG). G-Chron is the first PT scheme devoted to the U-Pb dating of minerals, primarily zircon, in geological materials. In this third round of G-Chron a total of 67 geochronology laboratories received the test material “Peng-16”, which previously had been characterized independently by two isotope dilution TIMS laboratories. A total of 52 of the participating laboratories reported data by the 15 May 2024 deadline. Here we report the submitted measurement results along with their related performance assessments. Our analysis provides a means for participating laboratories to assess their individual performance against the experimental fitness-for-purpose criteria proposed by the scheme’s organisers. This PT scheme also provides for laboratories that are active in the area of U-Pb zircon dating a compilation of the data quality produced by their peer community.*

### Introduction

In the Earth Sciences the understanding of timing and rates of geological events and processes is of paramount importance. Such information is commonly derived using radioactive decay systems. Due to the resistance of zircon to chemical alteration and its propensity to incorporate significant amounts of uranium and thorium into its crystal structure, while largely excluding the incorporation of lead at the time of crystallization, zircon is perhaps the most widely analysed mineral phase for defining the timing of igneous or metamorphic events. However, until the advent of the G-Chron programme there was scant information about the overall quality and comparability of this ever-expanding dataset. It is anticipated that this PT programme will provide information about the quality of the measurement processes employed by the participating laboratories. Ages based on the  $^{238}\text{U}$ – $^{206}\text{Pb}$  radioactive decay system are commonly reported with associated precisions ranging from less than  $\pm 0.1\%$  (isotope dilution, 1SE) to  $\pm 1\%$  (*in situ* methods, 1SE). The intent of the G-Chron PT scheme is to provide participating laboratories with an opportunity both to test for unrecognized bias in their age results and to provide information on the reliability of the assigned uncertainty estimations. In circumstances where results submitted are shown to be unsatisfactory, it is recommended that those specific laboratories should investigate their measurement procedures to identify unsuspected sources of measurement bias in their results or overlooked components in their uncertainty budget, allowing them to take corrective actions where warranted.

## The Organisation of G-Chron and its Scheduling in 2024

Having already established PT schemes in bulk geochemical analysis and microanalysis, namely the GeoPT and G-Probe programmes respectively, in March 2015 the governing Council of the IAG voted to launch a PT scheme devoted principally to U-Pb zircon geochronology. The intention of this initiative was to identify PT test materials consisting of concordant, homogeneous zircon. These test materials would be assigned ages based on U-(Th)-Pb isotope dilution results from multiple TIMS laboratories with established capabilities. Suitable material was to be identified, either from scientific publications or from other information sources, and the initial homogeneity testing of candidate zircon populations would be evaluated by Secondary Ion Mass Spectrometry (SIMS). It was intended that the G-Chron PT programme would distribute a single test sample per year. Left-over characterised materials would subsequently be made available to the geoanalytical community. It was agreed that other phases besides zircon could be included as supplementary materials on a case-by-case basis during future rounds.

The first round of G-Chron took place in 2019 and the results were reported in April 2020. Round #2 followed a similar approach, though with some modifications so as to expand the utility of the programme. Round #2 sample distribution took place in late August 2021, with a data reporting deadline of 19 January 2022 and the distribution of the report in August 2022.

For the current round, Round #3, the Peng-16 zircon test material was distributed to participants at the end of January 2024, with each participant receiving a 0.5 ml screw-top plastic vial that contained a ~ 90 mg split of nearly pure zircon with a grain size  $\leq 200 \mu\text{m}$ ; it was supplied in a Ziploc® plastic bag labelled “Peng-16 Zircon”. A one-page set of instructions accompanying the test material provided information about the material and the method for on-line submissions of each laboratory’s results. The deadline for data submission was 15 May 2024.

In April 2024 the [www.gchron.info](http://www.gchron.info) website was opened for Round #3 on-line data submission, enabling participants to submit their results. Laboratories were required to provide  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  ages and their associated precision expressed at the 1SE level. As an addition to the scheme’s first round, participants were also invited to report radiogenic isotope ratios and associated uncertainties for both the  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  age results. No isotope dilution thermal ionization mass spectrometry (ID-TIMS) data were available for the Th-Pb decay system for this test material, meaning that no TIMS-defined target age is available for this chronometer. Nonetheless  $^{208}\text{Pb}/^{232}\text{Th}$  ages and radiogenic isotope ratios and their associated uncertainties could be reported, allowing the participating labs to compare their Th-Pb results to those reported by other laboratories. All age values were to be reported in units of Ma (millions of years) with a minimum of at least one digit to the right of decimal point to be included. Furthermore, analysts were asked to provide metadata on key aspects of their procedures. All laboratories that registered to take part in this round of G-Chron are eligible to download this report from the G-Chron website when it becomes available in autumn 2024.

### Origin and Description of the Test Material

In October 2016 *circa* 400 kg of starting syenite material was sampled from near the town of Qinghu (清湖镇), Yulin City, Guangxi Province, China. The sampling site was the active Pengli Quarry at latitude/longitude N 22°01'34"; E 110°21'07". The Peng-16 name for the distributed material was derived from the name of the quarry and the year of sampling. Zircons from the same quarry had been previously characterized by Li et al. (2013), who recommended a  $^{206}\text{Pb}/^{238}\text{U}$  crystallization age of 159.5 Ma based on five ID-TIMS results using chemical abrasion sample preparation that were performed by a single

laboratory as reported earlier by Li et al. (2009). The sampled material was very fresh, being collected at the foot of a wall that was actively quarried at the southwest end of the pit. The collected material was subsequently transported to Potsdam, Germany for processing.

### **Preparation of the Test Material**

The material was crushed using a jaw crusher followed by further grain-size reduction using a roller mill and sieving, resulting in a <200 µm grain-size sieve fraction. Zircons were concentrated using a Wilfley table, followed by Frantz magnetic separation operated with 2.2 Amperes and a 7° side tilt, followed by heavy liquid separation using methylene iodide. A final clean-up involved leaching for 24 hours in 6 mol/L, room temperature HCl. Under a binocular microscope the resulting material was found to be dust-free where >99% of the grains were zircon with only trace amounts of pyrite and molybdenite; these zircons are mostly euhedral with a slightly pink to light brown hue. Many crystals have length to width ratios of between 3x and 5x.

At the end of this entire procedure 47.6 grams of zircon were recovered. A riffle splitter was used to prepare the individual units of material for use in both the ID-TIMS characterization and the G-Chron Round #3 Proficiency Test. A single unit consists of *circa* 90 mg of zircon which was placed in a screw top plastic vial. This amount of material is sufficient for producing 512 splits, though only 128 units were initially prepared, with three quarters of the full amount held in reserve for future use.

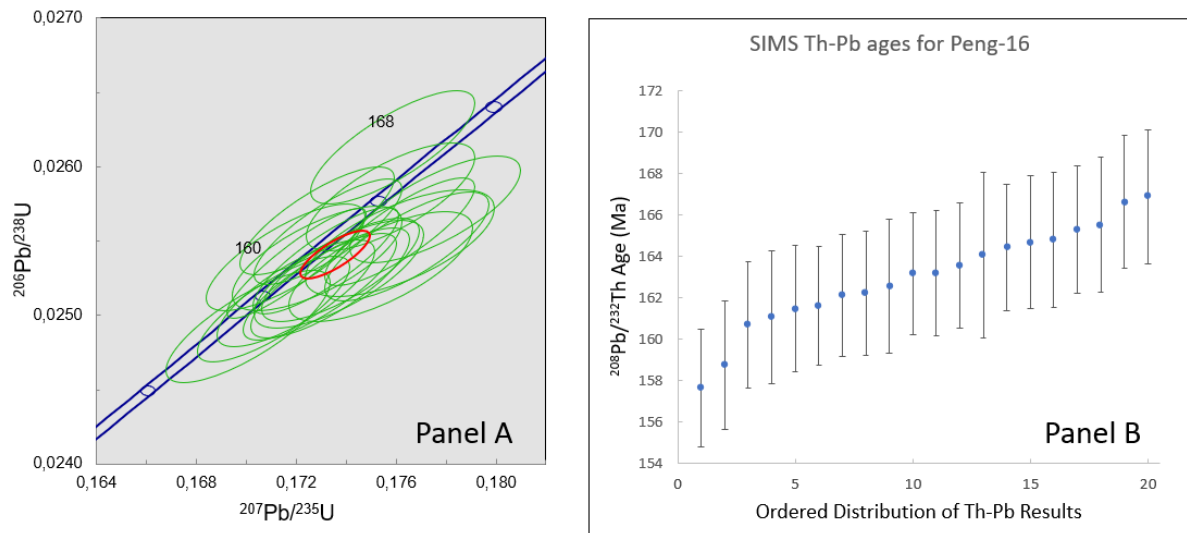
### **SIMS Homogeneity Testing**

Homogeneity testing of Peng-16 material started with mounting numerous zircon grains from a single split of material. A 25.4 mm diameter, well-polished epoxy disk was prepared along with the 91500 and Temora2 zircon calibration materials. As a first step, the mount was imaged in secondary electron, back scattered electron and panchromatic cathodoluminescence using the Potsdam Zeiss Ultra-plus scanning electron microscope. Most Peng-16 zircons were found to have strong euhedral zoning in both BSE and CL modes, and in some instances truncated internal zones with euhedral overgrowths were seen. Distinct rims indicative of a metamorphic or hydrothermal overprint were not found. Both mineral inclusions and fractures are visible in many grains, as would be expected of a real-world sample. No evidence was found for domains with significant radiation damage.

U-Th-Pb isotope ratio measurements on this mount were conducted using the Potsdam Cameca 1280-HR SIMS instrument. A total of 21 isotope ratio measurements were conducted. In order to have an unbiased picture of the Peng-16 zircon population this was done by selecting random locations on a total of 17 grains without the use of the advanced imaging information beyond a reflected light map of the entire 1-inch diameter mount. Subsequent observations on each crater using a reflected light microscope identified a single location that included a crack that was visible only after sputtering of the gold and which also gave an unusually high  $^{204}\text{Pb}/^{206}\text{Pb}$  ratio. The remaining 20 results formed a tight cluster on a Concordia plot that is consistent with a homogeneous population exhibiting little to no Pb-loss (Figure A panel A). These SIMS determinations were calibrated using the 91500 zircon reference material, which has an assigned  $^{206}\text{Pb}/^{238}\text{U}$  age of 1062.4 Ma (Wiedenbeck et al. 1995). We also assessed this dataset for the homogeneity of its Th-Pb system. The radiogenic  $^{208}\text{Pb}/^{232}\text{Th}$  ratios for those same 20 measurement results also indicated that no detectable Pb-loss has affected this geochronometer (Figure A panel B). Our SIMS data for this cluster gave the following unweighted mean ages for  $n = 20$  results as based on the decay constants recommended by Steiger and Jäger (1977) and corrected for using the observed  $^{204}\text{Pb}$  contents:

$^{206}\text{Pb}/^{238}\text{U}$  age: 161.8 Ma  
 $^{207}\text{Pb}/^{206}\text{Pb}$  age: 176.1 Ma  
 $^{208}\text{Pb}/^{232}\text{Th}$  age: 163.0 Ma

As this material was deemed well-suited for use in a U-Pb PT programme, two highly regarded ID-TIMS laboratories were recruited to provide data that would be used to assign the  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  target ages for this proficiency test.



**Figure A:** Results from SIMS homogeneity testing for the Peng-16 zircon material. These are for the 20 random locations that were free of cracks and inclusions. (Panel A) U-Pb Concordia plot for the data obtained from the Potsdam SIMS instrument. The green ellipses represent the 68% confidence interval of the individual results and the red ellipse is the 1SE confidence interval of the mean of that population. The Concordia curve is based on the decay constants and the  $^{238}\text{U}/^{235}\text{U}$  ratio recommended by Steiger and Jäger (1977) and the width of the curve indicates the decay constant uncertainties. Age labels are in Ma. (Panel B) Ordered distribution plot for the  $^{208}\text{Pb}/^{232}\text{Th}$  ages from the same 20 SIMS measurement results with uncertainty bars representing the 1SE values for each individual result.

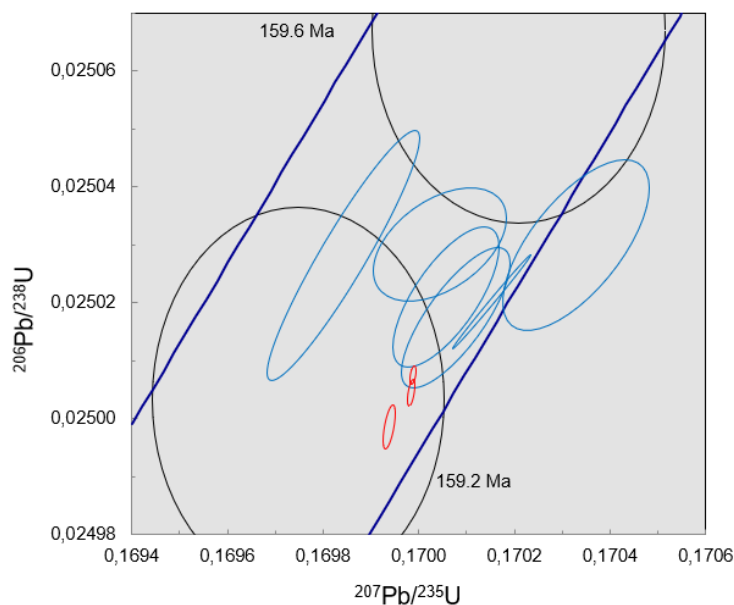
### Derivation of the Assigned (Target) Age Values

The two ID-TIMS laboratories that volunteered to provide data for this project were at ETH-Zurich and the University of Geneva. They provided a total of nine ID-TIMS results employing chemical abrasion (CA) pre-treatment; these data are shown on a conventional Concordia plot in Figure B. Although the data distribution is larger than the reported uncertainty estimates, these nine results still point to a material that is well-suited for use in this G-Chron proficiency testing scheme. A single ID-TIMS determinations based on a more-gentle acid washing pre-treatment was also provided by Zurich, which was 1.2 % discordant relative to the robust mean of the  $^{206}\text{Pb}/^{238}\text{U}$  ratio for the CA suite of results. For the purposes of this proficiency test, robust means from the nine chemically abraded determinations from the  $n = 2$  laboratories were used to define the target value for the  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  chronometers, leading to the following target ages and their associated standard uncertainty:

$^{206}\text{Pb}/^{238}\text{Pb}$  age: 159.267 +/- 0.069 Ma  
 $^{207}\text{Pb}/^{206}\text{Pb}$  age: 161.778 +/- 0.166 Ma

All of these data will be presented in a subsequent manuscript providing a detailed characterization of the Peng-16 zircon U-Pb system, after which it is intended that splits of the remaining Peng-16 material will be made available to the global geochemical community.

The organizers of this PT programme are not aware of any ID-TIMS facilities currently producing  $^{208}\text{Pb}/^{232}\text{Th}$  data. Therefore, it was not possible to obtain TIMS results for the Peng-16 material, and we are therefore unable to provide a target age for this system.



**Figure B:** U-Pb Concordia plot for nine ID-TIMS determinations on chemically abraded material reported by two independent TIMS laboratories. The colours are: red = ETH-Zurich, light blue = University of Geneva. Uncertainty estimates are at the 68 % confidence interval. The dark blue lines represent the upper and lower bounds for the Concordia based on the 95 % confidence level derived from the decay constant uncertainties and the two numbers indicate in Ma the age on the Concordia curve as represented by the adjacent black ovals.

### Submission of Results

Three months after receiving the test sample, participants were required to submit results via the G-Chron data submission website. Along with the determined  $^{206}\text{Pb}/^{238}\text{Pb}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  ages, participating laboratories were also encouraged to report the observed radiogenic  $^{206}\text{Pb}/^{238}\text{Pb}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  isotope ratios and the associated measurement uncertainties; these additional pieces of information had already been added to the reporting procedure for the earlier G-Chron Round #2. Although no target value had been established for the Th-Pb chronometer, the participating laboratories were nonetheless given the opportunity to report both their  $^{208}\text{Pb}/^{232}\text{Th}$  age and their  $^{208}\text{Pb}/^{232}\text{Th}$  radiogenic isotope ratio along with the associated measurement precision estimates. All uncertainty estimates were to be reported as 1SE values. The participating laboratories were also asked to report key parameters of their measurement procedures. Data were evaluated according to five distinct measurement principles: TIMS, SIMS, laser ablation sector field mass spectrometry (LA-ICP-MS: SFI), laser ablation quadrupole mass spectrometry (LA-ICP-MS: Quad) and “other”. For each of these five measurement principles the standard deviation for proficiency ( $s_{pt}$ ; hereafter referred to as “target precision”) was defined as the median value of the uncertainty estimates reported for that specific instrument class. These parameters are reported in Table A.

**Table A:** List of assigned ages, isotope ratios, their standard uncertainties (i.e., 68% confidence level) and corresponding target precision ( $s_{pt}$ ) values for the six measurands of Peng-16 zircon that are reported.

<b>206Pb/238U Age</b>				
Assigned Age (Ma)	Uncertainty (Ma)	Analytical Principle	Target Precision (spt, Ma)	Number of Values Reported
159.267	0.069	ID-TIMS	0.069	2
159.267	0.069	SIMS	0.615	6
159.267	0.069	LA-ICP-MS: SFI	0.920	12
159.267	0.069	LA-ICP-MS: Quad	0.460	31
159.267	0.069	OTHER	1.60	1
<b>207Pb/206Pb Age</b>				
Assigned Age (Ma)	Uncertainty (Ma)	Analytical Principle	Target Precision (spt, Ma)	Number of Values Reported
161.778	0.166	ID-TIMS	0.359	2
161.778	0.166	SIMS	6.50	6
161.778	0.166	LA-ICP-MS: SFI	6.97	12
161.778	0.166	LA-ICP-MS: Quad	5.60	31
161.778	0.166	OTHER	8.90	1
<b>208Pb/232Th Age</b>				
Assigned Age (Ma)		Analytical Principle	Median Precision (1SE, Ma)	Number of Values Reported
Not assigned		SIMS	1.02	5
Not assigned		LA-ICP-MS: SFI	1.78	9
Not assigned		LA-ICP-MS: Quad	0.82	29
Not assigned		Other	1.80	1
<b>206Pb/238U Ratio</b>				
Assigned Ratio	Uncertainty	Analytical Principle	Target Precision (spt)	Number of Values Reported
0.025014	0.000011	ID-TIMS	0.000011	2
0.025014	0.000011	SIMS	0.000056§	6
0.025014	0.000011	LA-ICP-MS: SFI	0.000167	12
0.025014	0.000011	LA-ICP-MS: Quad	0.000088	31
0.025014	0.000011	OTHER	0.000252	1
<b>207Pb/206Pb Ratio</b>				
Assigned Ratio	Uncertainty	Analytical Principle	Target Precision (spt)	Number of Values Reported
0.0493213	0.0000035	ID-TIMS	0.0000075	2
0.0493213	0.0000035	SIMS	0.000127§	6
0.0493213	0.0000035	LA-ICP-MS: SFI	0.000180	12
0.0493213	0.0000035	LA-ICP-MS: Quad	0.000190	31
0.0493213	0.0000035	OTHER	0.000545	1
<b>208Pb/232Th Ratio</b>				
Assigned Ratio		Analytical Principle	Median Precision (1SE)	Number of Values Reported
Not assigned		ID-TIMS	—*	1
Not assigned		SIMS	0.000044§	6
Not assigned		LA-ICP-MS: SFI	0.000083§	10
Not assigned		LA-ICP-MS: Quad	0.000059§	29
Not assigned		OTHER	0.000089	1

**Notes:**

Table A is an enhanced version of Table 1 which appears later in this report. Values of target precision are quoted here to 3 significant figures but to no more decimal places than quoted for the assigned value.

Assigned ages are best estimates from the ID-TIMS dataset. Target Precisions are taken as the median value of reported uncertainties (1SE) for each analytical technique/measurement principle. Due to the lack of an assigned value for the  $^{208}\text{Pb}/^{232}\text{Th}$  chronometer, no target precision can be defined but median uncertainty values (1SE) are listed.

\* Apparent input anomaly, value is disregarded

§ Excludes identified anomalous precision values when determining the median precision values

Codes:

ID-TIMS = Isotope Dilution Thermal Ionization Mass Spectrometry

SIMS = Secondary Ion Mass Spectrometry (ion probe)

LA-ICP-MS: SFI = laser ablation inductively coupled plasma mass spectrometry – sector field mass spectrometer

LA-ICP-MS: Quad = laser ablation inductively coupled plasma mass spectrometry – quadrupole mass spectrometer

## Review of Results

The age results contributed by all 52 reporting laboratories are presented in Table 2, ordered according to analytical technique/measurement principle and identified by a randomised laboratory code to ensure complete anonymity of participating laboratories. This table lists not only the ages and their reported precision estimates but also their corresponding z-scores, derived as explained below, indicative of the given laboratory's performance relative to the TIMS-defined assigned value. Table 2 also presents some of the details of the procedures employed. A variety of reference materials were used, with zircon 91500 the most common, being used by half of the reporting laboratories.

As was the case for G-Chron Round #2, for Round #3 the laboratories were asked to submit their determined radiogenic  $^{206}\text{Pb}/^{238}\text{U}$ ,  $^{207}\text{Pb}/^{206}\text{Pb}$  and  $^{208}\text{Pb}/^{232}\text{Th}$  isotope ratios in addition to their calculated ages. This is seen as a means of side-stepping any impact that would result from differing laboratories reporting ages based on differing decay constant values. These values are listed in Table 3.

We, the organizers of G-Chron, are not aware of any ID-TIMS laboratories that currently investigate the Th-Pb zircon system. For the current round of G-Chron we were not able to recruit such a laboratory, and as such we have neither target values for the  $^{208}\text{Pb}/^{232}\text{Th}$  age nor for the radiogenic  $^{208}\text{Pb}/^{232}\text{Th}$  ratio. Nonetheless, this report provides distribution plots (Figures 3 & 6) for the Th-Pb results from the participating laboratories. This allows programme participants to compare their results for the  $^{208}\text{Pb}/^{232}\text{Th}$  chronometer with those submitted by other laboratories from their peer group. The lack of defined target values means that no z-scores can be provided for the Th-Pb system.

Observations relating to the distribution of age results may be made not only from Table 2, but more easily from Figures 1, 2 and 3. Data for each isotopic system are ordered according to increasing age, shown with the reported 1SE precision values as error bars, which are colour coded according to the analytical principle that was used. Additionally, each of these figures shows how submitted results, identified by laboratory code, compare with the assigned ID-TIMS-derived assigned age. For the  $^{206}\text{Pb}/^{238}\text{U}$  age, a number of laboratories submitted results in close agreement with the assigned 159.267 Ma age, though a slight bias towards older ages can be seen within the dataset taken as a whole. However, many results diverge significantly. Significantly too, Figure 1 shows no well-defined inflection point in the distribution plot, as would be expected by a Gaussian distribution of results. For the  $^{207}\text{Pb}/^{206}\text{Pb}$  age, the dataset is nearly centred on the 161.778 Ma assigned age, though at both ends of the spectrum there are results that diverge by more than 10 Ma from the assigned value. In general, quoted uncertainties are smallest for SIMS, and range from relatively small to quite large for both the LA-ICP-MS: SFI and the LA-ICP-MS: Quad datasets. Finally, we note that Figure 3 reveals the lack of a clear consensus age value from the contributed data for the Th-Pb geochronometer.

The wide variations in the uncertainty estimates by almost all methods makes for difficulties in assigning appropriate values as target precisions for the assessment of results. Figures 1 and 2 reveal some laboratories reporting ages close to the assigned target values yet with associated large uncertainty assignments. In contrast, some reported ages differ significantly from the target ages, while also being associated with small uncertainty estimates. There were a number of cases where the input values seem to be anomalous, and in some of those it appears that the uncertainty estimates may have been reported in relative percent terms whereas the input required absolute values to be submitted. Such anomalous uncertainty values were disregarded when determining the median uncertainty estimates for a given instrumental class as listed in Table A. There were also cases where unusual results, such as "0" or "1" were reported; these were also disregarded when calculating the median precision values. These inputs seemed to signify that no data were available, in which case no value should have been input.

## Performance Assessment – Z-scoring

In proficiency testing, z-scoring provides a convenient way for laboratories to assess their performance in relation to a pre-defined fitness-for-purpose criterion. A z-score is a scaled measure of the deviation of the reported measurement result from an assigned value. In this round of the G-Chron Proficiency Test z-scores for each contributed measurement result are calculated as follows:

$$z_i = (x_i - x_{pt}) / s_{pt}$$

where  $x_i$  is a reported laboratory result,  $x_{pt}$  is the assigned value (based on ID-TIMS data) and  $s_{pt}$  is the target precision. The target precision to be applied in age determinations has no historical precedent, unlike some other classes of geochemical analysis. Consequently, for the purposes of the G-Chron programme we have elected to define the target precision as the median of the reported 1SE values for a particular measurement procedure: ID-TIMS, SIMS, LA-ICP-MS: SFI, LA-ICP-MS: Quad and “other”. We should emphasize that as PT programmes applied to isotopic age determination is not a well-developed field, there are no generally accepted performance criteria. Hence, as with the previous two rounds of G-Chron, our approach to defining target precisions must be viewed as experimental at this time. The target precision values applicable for this round of G-Chron are listed in Tables A and B. For the analytical technique/measurement principle “other” there was only a single submission, making the  $s_{pt}$  value effectively meaningless. For the two ID-TIMS data sets that were submitted the extremely small target precisions associated with this method also suggest this approach for z-scoring may not reflect the true performance of the reporting laboratories.

**Table B:** Listing of target precision ( $s_{pt}$ ) values and the limits of 'satisfactory' ranges whereby  $-2 \leq z \leq 2$ , for each isotopic system and each analytical procedure. Due to the lack of an assigned value for the Th-Pb chronometer it was not possible to provide z-scores for the thorium radioactive decay system.

Parameter	Measurement Principle	Target Precision ( $z = 1$ )	Satisfactory Range ( $z = \pm 2$ )
		$s_{pt}$	$\pm 2 s_{pt}$
$^{206}\text{Pb}/^{238}\text{U}$ age	ID-TIMS	0.069 Ma*	0.137 Ma*§
$^{206}\text{Pb}/^{238}\text{U}$ age	SIMS	0.615 Ma	1.23 Ma
$^{206}\text{Pb}/^{238}\text{U}$ age	LA-ICP-MS: SFI	0.920 Ma	1.84 Ma
$^{206}\text{Pb}/^{238}\text{U}$ age	LA-ICP-MS: Quad	0.460 Ma	0.920 Ma
$^{206}\text{Pb}/^{238}\text{U}$ age	Other	1.60 Ma*	3.20 Ma*
$^{207}\text{Pb}/^{206}\text{Pb}$ age	ID-TIMS	0.359 Ma*	0.718 Ma*§
$^{207}\text{Pb}/^{206}\text{Pb}$ age	SIMS	6.50 Ma	13.0 Ma
$^{207}\text{Pb}/^{206}\text{Pb}$ age	LA-ICP-MS: SFI	6.97 Ma	13.9 Ma
$^{207}\text{Pb}/^{206}\text{Pb}$ age	LA-ICP-MS: Quad	5.60 Ma	11.2 Ma
$^{207}\text{Pb}/^{206}\text{Pb}$ age	Other	8.90 Ma*	17.8 Ma*§
$^{206}\text{Pb}/^{238}\text{U}$ isotope ratio	ID-TIMS	0.000011*	0.000022*§
$^{206}\text{Pb}/^{238}\text{U}$ isotope ratio	SIMS	0.000056	0.000112
$^{206}\text{Pb}/^{238}\text{U}$ isotope ratio	LA-ICP-MS: SFI	0.000167	0.000334
$^{206}\text{Pb}/^{238}\text{U}$ isotope ratio	LA-ICP-MS: Quad	0.000088	0.000176
$^{206}\text{Pb}/^{238}\text{U}$ isotope ratio	Other	0.000252*	0.000504*

Cont'd...

**Table B: (Continued)**

$^{207}\text{Pb}/^{206}\text{Pb}$ isotope ratio	ID-TIMS	0.0000075*	0.0000150*§
$^{207}\text{Pb}/^{206}\text{Pb}$ isotope ratio	SIMS	0.000127	0.000254
$^{207}\text{Pb}/^{206}\text{Pb}$ isotope ratio	LA-ICP-MS: SFI	0.000180	0.000360
$^{207}\text{Pb}/^{206}\text{Pb}$ isotope ratio	LA-ICP-MS: Quad	0.000190	0.000380
$^{207}\text{Pb}/^{206}\text{Pb}$ isotope ratio	Other	0.000545*	0.00109*

\* Values to be regarded with extreme caution due to the very limited size of the data set.

§ z-values need to be regarded with caution due to the extremely small uncertainties provided by this method

The individual z-scores for the  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{207}\text{Pb}/^{206}\text{Pb}$  ages reported for the Peng-16 zircon are listed in Table 2. Likewise, corresponding values for the reported isotope ratios are listed in Table 3. As is routine in proficiency testing, participating laboratories are invited to assess their performance using the following criteria: z-score results in the range  $-2 < z < 2$  are considered to be 'satisfactory', in the sense that no action by the participant is required. 'Satisfactory' ranges are shown graphically in the form of 'error bars' at the right-hand sides of Figures 1, 2, 4 and 5. In addition, Figure 7 allows participating laboratories to readily assess whether their reported age can be considered 'satisfactory' according to the  $-2 < z < 2$  criterion. If the z-score for any result falls outside this range, and especially if it is outside the range  $-3 < z < 3$ , laboratories are encouraged to examine their procedures and, if necessary, take appropriate action to ensure that their determinations are not subject to one or more sources of unsuspected measurement bias.

There is a consequence of this approach for defining a target precision for each particular isotopic age system and for each particular measurement procedure based on the median of the reported measurement uncertainties: the performance of a given laboratory is assessed in relation to the performance of its methodological peer group. Hence, a given age result obtained by one method that is outside the 'satisfactory' range according to the assigned z-score, implying the presence of significant bias, might well, in the case of a different measurement procedure, have resulted in a 'satisfactory' z-score. We ask participating laboratories to take note of this possibility.

We are aware that our empirically derived target precisions, and therefore the derived z-scores, provide a somewhat generalized portrait of laboratory performance. We therefore additionally recommend that participants check the difference between their laboratory's reported age and the assigned age. If this difference is greater than twice the reported measurement uncertainty estimated at the 1SE confidence level then a review of the methodology for assigning uncertainties may well be prudent.

### **Overall Performance**

A summary of the overall performance of individual laboratories for G-Chron Round #3 is provided by a multiple z-score chart shown in Figure 7. In this chart the z-score performance for each result is distinguished by symbols that make it easy to identify whether the measurement results were satisfactory or if they gave z-scores that exceeded the action limits (as shown by either the small or large triangle symbols). This chart is designed to help individual laboratories judge their overall performance within the context of this proficiency test. Note, however, that participants should always review their z-scores in accordance with their own fitness-for-purpose requirements.

## Future G-Chron Participation

This report, along with those of the two preceding rounds of the G-Chron proficiency test, provide a unique survey of data trends in the field of U-Pb age determination. It is intended that further such rounds of G-Chron will be conducted in order to further support the global geochronological community. Assuming suitable material can be obtained, in conjunction with the ongoing support from expert ID-TIMS laboratories, it is intended that further such proficiency tests will be conducted at roughly one-to-two-year intervals. As zircon is the most widely employed phase for U-(Th)-Pb geochronology research, zircon will remain the focus of future rounds. However, if suitably concordant material from other geochronologically important mineral phases can be obtained then such materials may also be employed in the G-Chron testing programme. News concerning upcoming rounds will be made available via both the [www.geoanalyst.org](http://www.geoanalyst.org) and [www.gchron.info](http://www.gchron.info) websites.

## Future Actions Planned for the Peng-16 Zircon Material

Due to the good yield of zircon from the collected rock starting material resulting in 46.6 grams of zircon concentrate, it was possible to generate 512 units of Peng-16 zircon. This circa 430 remaining splits of this material will be made available to the geoanalytical community via [www.IAGeo.com](http://www.IAGeo.com), the website of IAGeo Limited, which is the trading arm of the International Association of Geoanalysts. They will be available for distribution once the characterization report for this material has been published in the scientific literature.

It is intended that a discussion of the results from the first three rounds of the G-Chron proficiency test will be submitted for publication at a future date. Links to reports and scientific literature resulting from the G-Chron programme will also be provided by the [www.geoanalyst.org](http://www.geoanalyst.org) website at a future date.

## Acknowledgements

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### **Previous Reports**

#1 Webb P., Wiedenbeck M. and Glodny J. (2020) G-Chron 2019 – Round 1 — An International Proficiency Test for U-Pb Geochronology Laboratories — Report on the 2019 Round of G-Chron based on Palaeozoic Zircon Rak-17 (Distribution: September 2019). International Association of Geoanalysts: Keyworth. Unpublished report.

#2 Wiedenbeck M., Webb P.C., Glodny J. and Meisel T.C. (2022) G-Chron 2021 – Round 2 — An International Proficiency Test for U-Pb Geochronology Laboratories — Report on the 2021 Round of G-Chron based on Archean Zircon Kara-18 (Distribution: September 2021). International Association of Geoanalysts: Keyworth. Unpublished report.

**Table 1 - G-Chron #3 Peng-16 zircon - Assigned ages and corresponding uncertainties (1SE), with target precisions for each isotopic system and each analytical procedure.**

<b>206Pb/238U Age (Ma)</b>	<b>Uncertainty (Ma)</b>	<b>Analytical Technique</b>	<b>Target Precision (Ma)</b>	<b>Number of Values Reported</b>
159.267	0.06873	ID	0.0687	2
159.267	0.06873	SIMS	0.615	6
159.267	0.06873	LA-ICP-MS: SFI	0.920	12
159.267	0.06873	LA-ICP-MS: Quad	0.460	31
159.267	0.06873	OTHER	1.60	1
<b>207Pb/206Pb Age (Ma)</b>	<b>Uncertainty (Ma)</b>	<b>Analytical Technique</b>	<b>Target Precision (Ma)</b>	<b>Number of Values Reported</b>
161.778	0.1657	ID	0.359	2
161.778	0.1657	SIMS	6.50	6
161.778	0.1657	LA-ICP-MS: SFI	6.97	12
161.778	0.1657	LA-ICP-MS: Quad	5.60	31
161.778	0.1657	OTHER	8.90	1
<b>206Pb/238U Ratio</b>	<b>Uncertainty</b>	<b>Analytical Technique</b>	<b>Target Precision</b>	<b>Number of Values Reported</b>
0.025014	0.00001093	ID	0.0000109	2
0.025014	0.00001093	SIMS	0.0000560	6
0.025014	0.00001093	LA-ICP-MS: SFI	0.000167	12
0.025014	0.00001093	LA-ICP-MS: Quad	0.0000880	31
0.025014	0.00001093	OTHER	0.000252	1
<b>207Pb/206Pb Ratio</b>	<b>Uncertainty</b>	<b>Analytical Technique</b>	<b>Target Precision</b>	<b>Number of Values Reported</b>
0.0493213	0.000003495	ID	0.00000750	2
0.0493213	0.000003495	SIMS	0.000127	6
0.0493213	0.000003495	LA-ICP-MS: SFI	0.000180	12
0.0493213	0.000003495	LA-ICP-MS: Quad	0.000190	31
0.0493213	0.000003495	OTHER	0.000545	1

Note: Assigned ages are best estimates. Target Precisions are derived as the median value of reported uncertainties for each analytical technique category.

Codes: SIMS = Secondary Ion Mass Spectrometry (ion probe)  
 LA-ICP-MS: SFI = Laser Ablation Inductively Coupled Plasma Mass Spectrometry - Sector Field mass spectrometer  
 LA-ICP-MS: Quad = Laser Ablation Inductively Coupled Plasma Mass Spectrometry - Quadrupole mass spectrometer  
 ID = Isotope Dilution Thermal Ionization Mass Spectrometry

**Table 2 - G-Chron #3 Contributed data and z-scores for Peng-16 zircon, ordered according to analytical method and identified by randomised laboratory code. 15/05/2024**

Lab Code	Method	206Pb /238U Age (Ma)	206Pb /238U Uncer -tainty (1SE, Ma)	206Pb /238U z-score	207Pb /206Pb Age (Ma)	207Pb /206Pb Uncer -tainty (1SE, Ma)	207Pb /206Pb z-score	208Pb /232Th Age (Ma)	208Pb /232Th Uncer -tainty (1SE, Ma)	208Pb /232Th z-score	Total Number of Measurements	Number of Rejections	Common Pb Correction	ID Spike	RM Name	RM 206Pb /238U Age (Ma)	RM 206Pb /238U Age 1SE (Ma)
C14	ID	159.54	0.02	3.97	161.79	0.39	0.03				11	5	204Pb modern	InHouse-mix			
C75	ID	159.34	0.028	1.06	160.99	0.328	-2.19				6	0	other	InHouse ET-Calib			
C4	SIMS	160.88	0.42	2.62	162.68	6.29	0.14	160.54	0.88		18	0	other		Temora2	416.8	0.57
C28	SIMS	163.2	0.9	6.40	149.0	13.0	-1.97	163.3	2.0		24	2	other		FC-1	1099	20.6
C38	SIMS	158.58	0.97	-1.12	155.8	6.7	-0.92	150.4	5.0		29	0	other		FC-1	1099	13.2
C54	SIMS	160.59	0.28	2.15	160.0	6.0	-0.27				26	0	204Pb ancient		Temora2	416.78	
C58	SIMS	159.51	0.81	0.40	147.25	9.66	-2.24	154.1	1.02		29	0	204Pb ancient		M257	561.3 Ma	0.25%
C71	SIMS	161.6	0.2	3.79	159.1	5.8	-0.41	163.1	0.7		30	0	204Pb modern		M257	561.3	0.4
C19	LA-ICP-MS: SFI	158.37	2.84	-0.97	157.76	15.78	-0.58	150.68	9.03		630	109	none		91500	1065	10
C20	LA-ICP-MS: SFI	164.7	0.8	5.91	166.0	6.0	0.61	161.6	2.0		79	0	none		91500	1062.4	1.5
C31	LA-ICP-MS: SFI	158.2	1.6	-1.16	164.8	6.2	0.43				20	0	none		GJ-1	605.95 (ID TIME)	0.5
C35	LA-ICP-MS: SFI	153.13	2.46	-6.67	157.0	13.0	-0.69	159.4	1.6		30	4	none		Temora2	417	0.00013
C37	LA-ICP-MS: SFI	170.6	3.4	12.32	167.1	2.2	0.76	0.1	0.1		5	0	none		Plesovice	337.1	0.95
C39	LA-ICP-MS: SFI	161.0	0.8	1.88	154.0	10.5	-1.12	165.8	1.6		60	20	none		91500	1065	1.2
C45	LA-ICP-MS: SFI	163.27	0.47	4.35	152.0	11.0	-1.40	163.4	2.4		15	0	none		Temora2	416	
C48	LA-ICP-MS: SFI	159.2	1.18	-0.07	161.5	10.8	-0.04	155.3	3.93		48	13	none		GJ-1	600.62	8.39593E-06
C56	LA-ICP-MS: SFI	160.39	1.04	1.22	153.2	7.73	-1.23	159.76	1.96		100	2	none		91500	1062.44	2.5
C60	LA-ICP-MS: SFI	156.8	0.5	-2.68	170.7	5.6	1.28	164.8	1.1		42	4	none		91500	1062.4	1.2
C68	LA-ICP-MS: SFI	162.6	0.1	3.62	161.4	1.8	-0.05				87	2	none		91500	1065	0.6188
C70	LA-ICP-MS: SFI	157.2	0.3	-2.25	160.4	3.9	-0.20	148.0	0.9		40	4	none		91500	1065.4	0.3
C3	LA-ICP-MS: Quad	157.6	0.6	-3.62	202.0	21.0	7.18	157.3	1.6		20	0	none		Temora2	416.75	2.3
C5	LA-ICP-MS: Quad	159.1	0.55	-0.36	161.1	8.7	-0.12	157.2	0.64		30	5	none		91500	1063	2.5
C6	LA-ICP-MS: Quad	159.9	0.2	1.38	161.8	5.6	0.00	156.6	0.9		40	5	none		GJ-1	600.23	0.78
C7	LA-ICP-MS: Quad	158.64	0.285	-1.36	159.9	2.3	-0.34	160.4	0.65		132	0	none		91500	1065 Ma in the	0.28
C8	LA-ICP-MS: Quad	166.04	0.82	14.72	184.0	11.0	3.97	164.4	2.1		23	0	204Pb ancient				
C9	LA-ICP-MS: Quad	161.85	1.36	5.62	101.3	16.0	-10.80	162.72	1.54		6	0	none		91500	1065	
C10	LA-ICP-MS: Quad	161.39	1.36	4.62	169.78	36.28	1.43	159.24	2.46		36	0	none		91500	1065	2.98
C16	LA-ICP-MS: Quad	159.7	2.8	0.94	140.9	29.2	-3.73	159.2	4.1		32	2	none		91500	1062.4	6.6
C17	LA-ICP-MS: Quad	159.24	0.46	-0.06	161.0	8.9	-0.14	159.8	1.2		80	10	none		91500	1062	2.1
C22	LA-ICP-MS: Quad	161.6	1.2	5.07	173.0	17.0	2.00	163.6	1.0		30	3	none		91500	1065	7.6
C24	LA-ICP-MS: Quad	160.0	0.8	1.59	98.0	13.6	-11.39	158.1	1.0		50	4	none		91500	1065	7.5
C25	LA-ICP-MS: Quad	160.6	0.4	2.90	132.7	3.5	-5.19	158.5	0.4		100	1	none		Temora2	417	0
C30	LA-ICP-MS: Quad	160.86	0.46	3.46	153.8	4.45	-1.42	163.4	1.2		40	0	none		91500	1065	2.38
C32	LA-ICP-MS: Quad	159.4	1.2	0.29	159.0	1.4	-0.50				24	0	none		91500	1065	3.3

Table 2 - G-Chron #3 Contributed data and z-scores for Peng-16 zircon, ordered according to analytical method and identified by randomised laboratory code. 15/05/2024

Lab Code	Method	206Pb /238U Age (Ma)	206Pb /238U Uncer -tainty (1SE, Ma)	206Pb /238U Age z-score	207Pb /206Pb Age (Ma)	207Pb /206Pb Uncer -tainty (1SE, Ma)	207Pb /206Pb Age z-score	208Pb /232Th Age (Ma)	208Pb /232Th Uncer -tainty (1SE, Ma)	208Pb /232Th Age z-score	Total Number of Measurements	Number of Rejections	Common Pb Correction	ID Spike	RM Name	RM 206Pb /238U Age (Ma)	RM 206Pb /238U Age 1SE (Ma)
C34	LA-ICP-MS: Quad	134.08	0.22	-54.75	135.73	2.76	-4.65	136.46	0.52		30	4	none		91500	1065	0.161
C36	LA-ICP-MS: Quad	158.59	0.94	-1.47	170.83	5.32	1.62	159.62	1.3		45	3	none		91500	1063.51	2
C40	LA-ICP-MS: Quad	158.7	0.2	-1.23	159.9	2.6	-0.34	159.0	0.4		35	3	none				
C42	LA-ICP-MS: Quad	159.1	0.8	-0.36	159.5	2.9	-0.41	158.8	0.5		35	0	none		91500	1064	
C43	LA-ICP-MS: Quad	161.2	0.9	4.20	170.1	8.6	1.49				124	7	none		91500	1063	0.5
C47	LA-ICP-MS: Quad	159.4	0.3	0.29	164.4	5.4	0.47				40	3	none		91500	1062.4	1.8
C49	LA-ICP-MS: Quad	159.7	0.2	0.94	158.9	2.3	-0.51	161.6	3.1		50	2	none		GJ-1	600	4.2
C50	LA-ICP-MS: Quad	161.43	0.2	4.70	158.1	2.6	-0.66	159.41	0.46		43	0	none		Plesovice	337	0.41
C52	LA-ICP-MS: Quad	158.98	0.47	-0.62	149.0	6.0	-2.28	166.8	0.7		50	11	none		GJ-1	601.8	1.4
C55	LA-ICP-MS: Quad	161.2	0.3	4.20	161.5	0.6	-0.05	161.2	0.3		45	0	none		91500	1063.7	1.3
C57	LA-ICP-MS: Quad	162.2	0.39	6.38	146.5	4.5	-2.73	162.9	0.55		69	5	none		Other	526.26 Ma	4.1 Ma (2 standar
C59	LA-ICP-MS: Quad	152.53	0.56	-14.65	172.4	28.37	1.90	162.01	1.25		60	1	none		GJ-1	601.9	0.80
C62	LA-ICP-MS: Quad	158.14	0.16	-2.45	133.0	8.5	-5.14	154.6	0.75		30	27	none		91500	1062.4	3.5
C65	LA-ICP-MS: Quad	159.85	1.5	1.27	172.3	5.2	1.88	1.1	1.001		50	3	none		GJ-1	601.8	0.4
C69	LA-ICP-MS: Quad	165.6	0.4	13.77	159.6	4.6	-0.39	171.2	0.6		36	2	none		91500	1062.9	1.6
C74	LA-ICP-MS: Quad	161.5	0.3	4.85	170.9	14.3	1.63	161.0	0.7		20	0	none		91500		
C76	LA-ICP-MS: Quad	158.15	0.3	-2.43	179.0	9.0	3.08	153.0	0.6		92	7	none		Plesovice	336.9	0.59
C23	OTHER	147.5	1.6	-7.35	246.2	8.9	9.49	150.5	1.8		32	0	none				

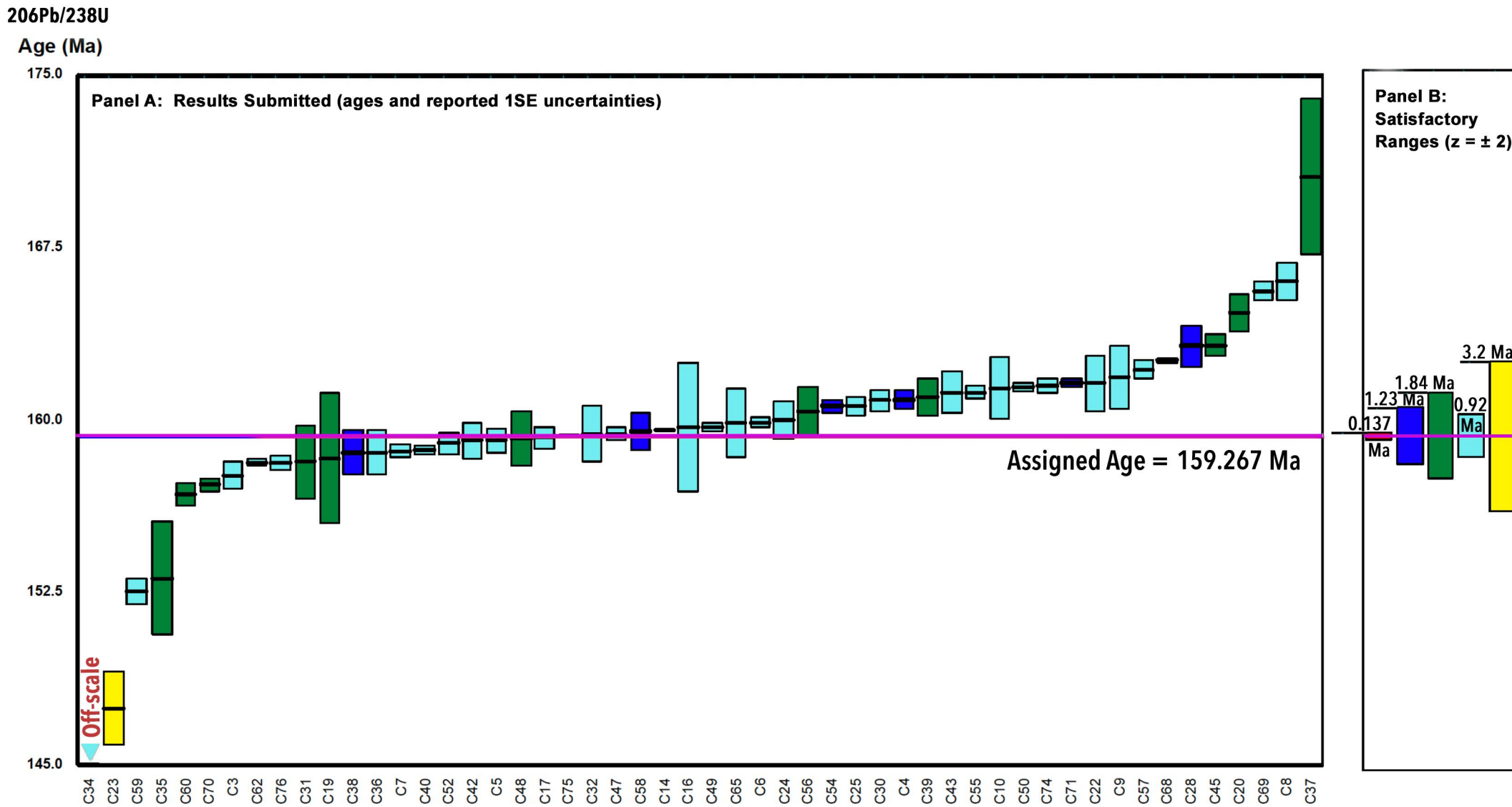
**Table 3 - G-Chron #3 Contributed isotope ratios for Peng-16 zircon, ordered according to analytical method and identified by randomised laboratory code. 15/05/2024**

Lab Code	Method	206Pb /238U Ratio	206Pb /238U Uncer (1SE)	206Pb /238U Ratio z-score	207Pb /206Pb Ratio	207Pb /206Pb Uncer (1SE)	207Pb /206Pb Ratio z-score	208Pb /232Th Ratio	208Pb /232Th Uncer (1SE)	208Pb /232Th Ratio z-score	Total Number of Measurements	Number of Rejections	Common Pb Correction	ID Spike	RM Name	RM 206Pb /238U Ratio	RM 206Pb /238U Age 1SE (Ma)
C14	ID	0.025058	0.000004	4.04	0.049315	0.000008	-0.84	0.1	0.100000		11	5	204Pb modern	InHouse-mix			
C75	ID	0.025026	0.000004	1.10	0.049298	0.000007	-3.11				6	0	other	InHouse ET-Calib			
C4	SIMS	0.025271	0.000067	4.59	0.049297	0.000133	-0.19	0.007974	0.000044		18	0	other		Temora2	416.8	0.57
C28	SIMS	0.025665	0.172140	11.36	0.04867	1.131600	-5.13	0.00811	1.229690		24	2	other		FC-1	1099	20.6
C38	SIMS	0.0249	0.197500	-2.04	0.04881	1.138000	-4.03	0.00747	3.336850		29	0	other		FC-1	1099	13.2
C54	SIMS	0.025225	0.000045	3.77	0.04923	0.000120	-0.72	0.1	0.100000		26	0	204Pb ancient		Temora2	416.78	
C58	SIMS	0.02507	0.000125	1.00	0.048852	0.000198	-3.70	0.00764	0.000050		29	0	204Pb ancient		M257	561.3 Ma	0.25%
C71	SIMS	0.025382	0.000027	6.57	0.049243	0.000122	-0.62	0.008101	0.000036		30	0	204Pb modern		M257	561.3	0.4
C19	LA-ICP-MS: SFI	0.0248	0.000500	-1.29	0.0493	0.001800	-0.12	0.00748	0.000450		630	109	none		91500	1065	10
C20	LA-ICP-MS: SFI	0.02587	0.000030	5.14	0.04938	0.000130	0.33	0.00803	0.000085		79	0	none		91500	1062.4	1.5
C31	LA-ICP-MS: SFI	0.02485	0.000250	-0.98	0.04936	0.000130	0.22				20	0	none		GJ-1	605.95 (ID TIM)	0.5
C35	LA-ICP-MS: SFI	0.02404	0.000400	-5.85	0.049125	0.000300	-1.09	0.007917	0.000081		30	4	none		Temora2	417	0.00013
C37	LA-ICP-MS: SFI	0.02681	0.000540	10.79	0.0494	0.000050	0.44	0.1	0.100000		5	0	none		Plesovice	337.1	0.95
C39	LA-ICP-MS: SFI	0.0253	0.000120	1.72	0.0491	0.000240	-1.23	0.00824	0.000080		60	20	none		91500	1065	1.2
C45	LA-ICP-MS: SFI	0.02565	0.000170	3.82	0.04908	0.000230	-1.34	0.00811	0.000110		15	0	none		Temora2	416	
C48	LA-ICP-MS: SFI	0.024999	0.000187	-0.09	0.049426	0.000238	0.58	0.007714	0.000196		48	13	none		GJ-1	600.62	8.39593E-06
C56	LA-ICP-MS: SFI	0.025192	0.000163	1.07	0.049049	0.000317	-1.51	0.007914	0.000097		100	2	none		91500	1062.44	2.5
C60	LA-ICP-MS: SFI	0.02462	0.000080	-2.37	0.04961	0.000120	1.60	0.00819	0.000050		42	4	none		91500	1062.4	1.2
C68	LA-ICP-MS: SFI	0.025549	0.000031	3.21	0.049307	0.000074	-0.08	0.007848	0.000102		87	2	none		91500	1065	0.6188
C70	LA-ICP-MS: SFI	0.02469	0.000020	-1.95	0.04923	0.000050	-0.51	0.00736	0.000020		40	4	none		91500	1065.4	0.3
C3	LA-ICP-MS: Quad	0.02476	0.000090	-2.89	0.05159	0.000640	11.94	0.00781	0.000080		20	0	none		Temora2	416.75	2.3
C5	LA-ICP-MS: Quad	0.024988	0.000088	-0.30	0.04913	0.000110	-1.01	0.007806	0.000032		30	5	none		91500	1063	2.5
C6	LA-ICP-MS: Quad	0.025116	0.000034	1.16	0.049322	0.000117	0.00	0.00034	0.000036		40	5	none		GJ-1	600.23	0.78
C7	LA-ICP-MS: Quad	0.024915	0.000045	-1.13	0.04963	0.000055	1.62	0.007968	0.000034		132	0	none		91500	1065 Ma in the	0.28
C8	LA-ICP-MS: Quad	0.0261	0.000120	12.34	0.04978	0.000410	2.41	0.00815	0.000100		23	0	204Pb ancient				
C9	LA-ICP-MS: Quad	0.025426	0.000237	4.68	0.048344	0.000316	-5.14	0.008083	0.000076		6	0	none		91500	1065	
C10	LA-ICP-MS: Quad	0.02535	0.000273	3.82	0.049779	0.000897	2.41	0.007911	0.000133		36	0	none		91500	1065	2.98
C16	LA-ICP-MS: Quad	0.02509	0.000440	0.86	0.04884	0.000640	-2.53	0.00791	0.000200		32	2	none		91500	1062.4	6.6
C17	LA-ICP-MS: Quad	0.025002	0.000073	-0.14	0.04923	0.000300	-0.48	0.007926	0.000059		80	10	none		91500	1062	2.1
C22	LA-ICP-MS: Quad	0.02571	0.000060	7.91	0.04951	0.000190	0.99	0.00803	0.000020		30	3	none		91500	1065	7.6
C24	LA-ICP-MS: Quad	0.02513	0.000110	1.32	0.04931	0.000250	-0.06	0.00785	0.000470		50	4	none		91500	1065	7.5
C25	LA-ICP-MS: Quad	0.02523	0.000040	2.45	0.04883	0.000070	-2.59	0.00787	0.000020		100	1	none		Temora2	417	0
C30	LA-ICP-MS: Quad	0.02527	0.000070	2.91	0.0492	0.000095	-0.64	0.00812	0.000060		40	0	none		91500	1065	2.38
C32	LA-ICP-MS: Quad	0.02503	0.000370	0.18	0.04921	0.000290	-0.59				24	0	none		91500	1065	3.3

Table 3 - G-Chron #3 Contributed isotope ratios for Peng-16 zircon, ordered according to analytical method and identified by randomised laboratory code. 15/05/2024

Lab Code	Method	206Pb /238U Ratio	206Pb /238U Uncertainty (1SE)	206Pb /238U Ratio z-score	207Pb /206Pb Ratio	207Pb /206Pb Uncertainty (1SE)	207Pb /206Pb Ratio z-score	208Pb /232Th Ratio	208Pb /232Th Uncertainty (1SE)	208Pb /232Th Ratio z-score	Total Number of Measurements	Number of Rejections	Common Pb Correction	ID Spike	RM Name	RM 206Pb /238U Ratio	RM 206Pb /238U Age 1SE (Ma)
C34	LA-ICP-MS: Quad	0.02101	0.000270	-45.50	0.04877	0.000450	-2.90	0.00681	0.000120		30	4	none		91500	1065	0.161
C36	LA-ICP-MS: Quad	0.02491	0.000110	-1.18	0.04951	0.000170	0.99	0.00793	0.000070		45	3	none		91500	1063.51	2
C40	LA-ICP-MS: Quad	0.024924	0.000030	-1.02	0.049218	0.000050	-0.54	0.007899	0.000020		35	3	none				
C42	LA-ICP-MS: Quad	0.024987	0.000040	-0.31	0.049207	0.000060	-0.60	0.007895	0.000020		35	0	none		91500	1064	
C43	LA-ICP-MS: Quad	0.02533	0.000340	3.59	0.049533	0.001682	1.11	0.007939	0.000425		124	7	none		91500	1063	0.5
C47	LA-ICP-MS: Quad	0.02505	0.000050	0.41	0.0496	0.000100	1.47				40	3	none		91500	1062.4	1.8
C49	LA-ICP-MS: Quad	0.1666	0.001500	1608.93	0.0487	0.003000	-3.27	40.1123	0.379400		50	2	none		GJ-1	600	4.2
C50	LA-ICP-MS: Quad	0.025361	0.000031	3.94	0.049272	0.000055	-0.26	0.007918	0.000023		43	0	none		Plesovice	337	0.41
C52	LA-ICP-MS: Quad	0.02497	0.000080	-0.50	0.04901	0.000140	-1.64	0.00829	0.000030		50	11	none		GJ-1	601.8	1.4
C55	LA-ICP-MS: Quad	0.02529	0.000390	3.14	0.04928	0.001300	-0.22	0.00842	0.000270		45	0	none		91500	1063.7	1.3
C57	LA-ICP-MS: Quad	0.02548	0.000070	5.30	0.04902	0.000100	-1.59	0.008093	0.000028		69	5	none		Other	526.26 Ma	4.1 Ma (2 standar
C59	LA-ICP-MS: Quad	0.023944	0.000089	-12.16	0.050352	0.000612	5.42	0.008048	0.000063		60	1	none		GJ-1	601.9	0.80
C62	LA-ICP-MS: Quad	0.02484	0.000250	-1.98	0.04924	0.000160	-0.43	0.00768	0.000037		30	27	none		91500	1062.4	3.5
C65	LA-ICP-MS: Quad	0.025107	0.000096	1.06	0.04953	0.000170	1.10	1.1	1.001000		50	3	none		GJ-1	601.8	0.4
C69	LA-ICP-MS: Quad	0.026002	0.000057	11.23	0.049255	0.000093	-0.35	0.008507	0.000028		36	2	none		91500	1062.9	1.6
C74	LA-ICP-MS: Quad	0.02538	0.000060	4.16	0.04947	0.000310	0.78	0.00799	0.000030		20	0	none		91500		
C76	LA-ICP-MS: Quad	0.024836	0.000048	-2.02	0.04954	0.000190	1.15	0.0076	0.000032		92	7	none		Plesovice	336.9	0.59
C23	OTHER	0.023149	0.000252	-7.40	0.051134	0.000545	3.33	0.007474	0.000089		32	0	none				

Figure 1: - Ordered distribution of contributed  $^{206}\text{Pb}/^{238}\text{U}$  ages with reported 1SE uncertainties shown as  $\pm$  bars for G-Chron Round #3 in relation to the assigned age, and corresponding satisfactory ranges ( $z = \pm 2$ ) for Peng-16 zircon



**Panel A: Data plotted according to method, as shown by colour, with reported uncertainties (1SE) shown as error bars.**

**Panel B: Satisfactory ranges ( $z = \pm 2$ ) for each analytical method.**

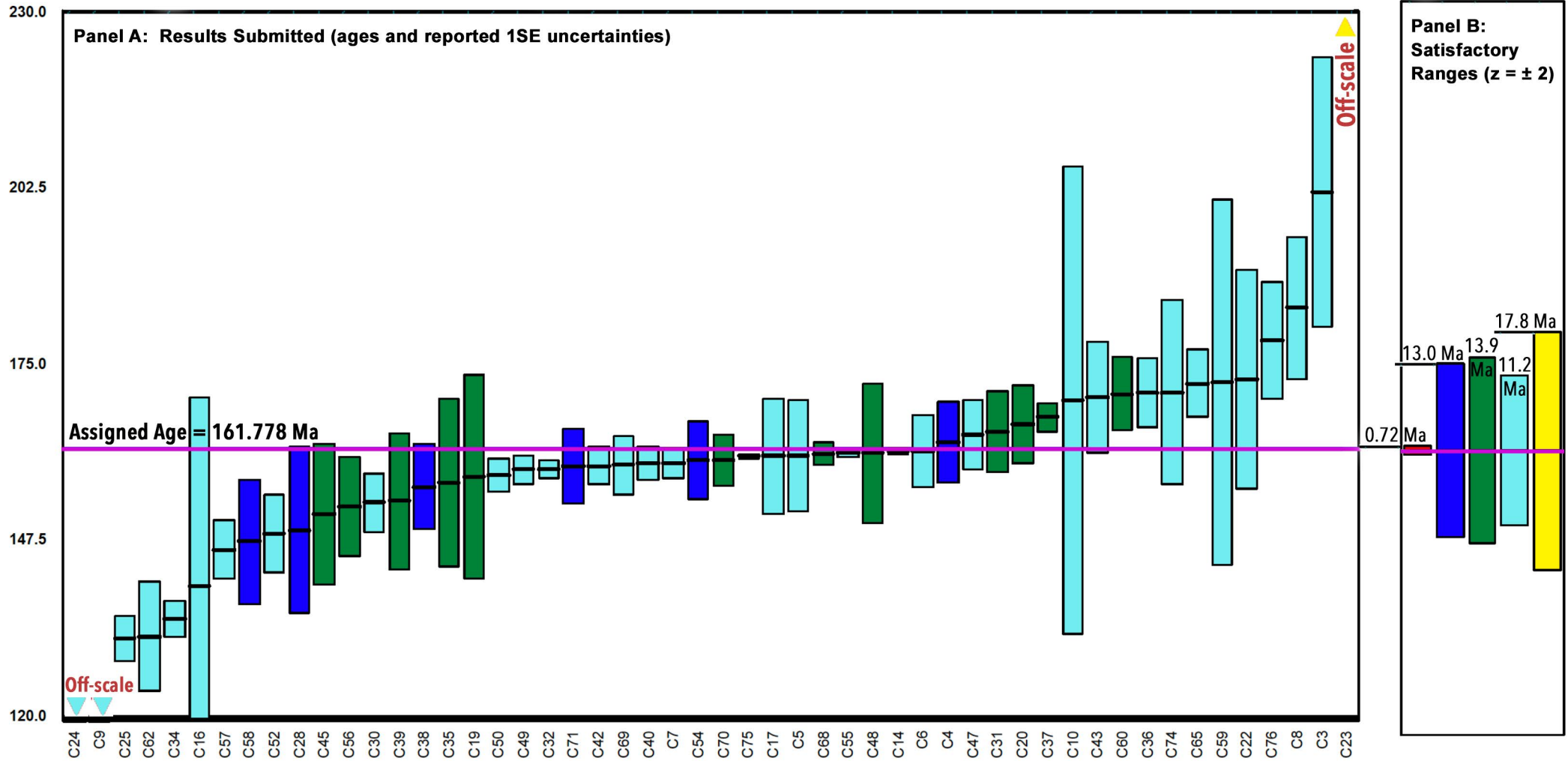
**In KEY to the right: Target Precision ( $z = 1$ ) values (Ma) specified, with colour code defined for each analytical method.**

**KEY:**

Isotope Dilution	0.069
SIMS	0.615
LA-ICP-MS: SFI	0.92
LA-ICP-MS: QuadToF	0.46
Other	1.6

Figure 2: - Ordered distribution of contributed  $^{207}\text{Pb}/^{206}\text{Pb}$  ages with reported 1SE uncertainties shown as  $\pm$  bars for G-Chron Round #3 in relation to the assigned age, and corresponding satisfactory ranges ( $z = \pm 2$ ) for Peng-16 zircon

**$^{207}\text{Pb}/^{206}\text{Pb}$   
Age (Ma)**

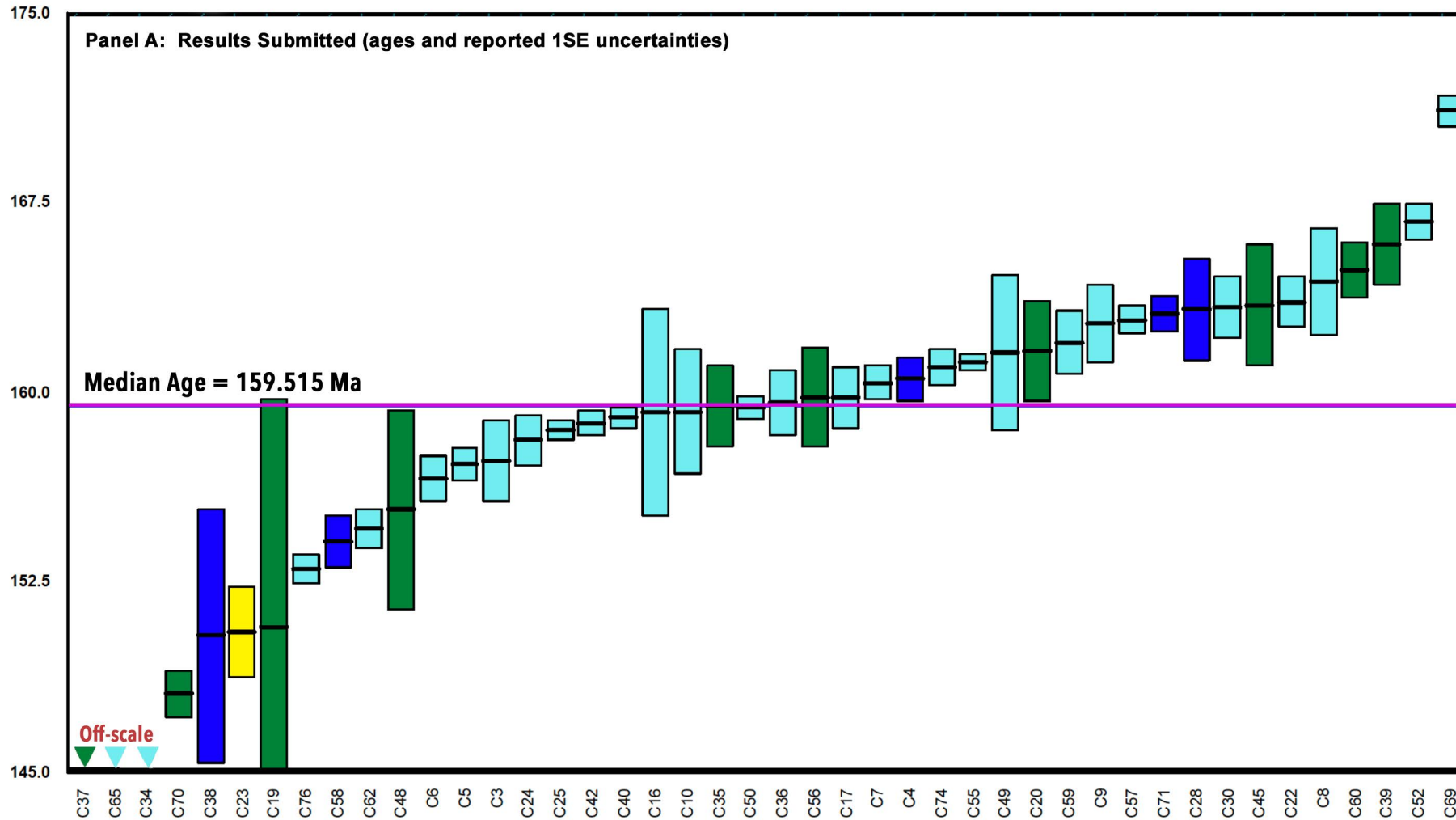


**Panel A: Data plotted according to method, as shown by colour, with reported uncertainties (1SE) shown as error bars.**  
**Panel B: Satisfactory ranges ( $z = \pm 2$ ) for each analytical method.**  
**In KEY to the right: Target Precision ( $z = 1$ ) values (Ma) specified, with colour code defined for each analytical method.**

Figure 3: - Ordered distribution of contributed  $^{208}\text{Pb}/^{232}\text{Th}$  ages with reported 1SE uncertainties shown as  $\pm$  bars for G-Chron Round #3 Peng-16 zircon

$^{208}\text{Pb}/^{232}\text{Th}$

Age (Ma)



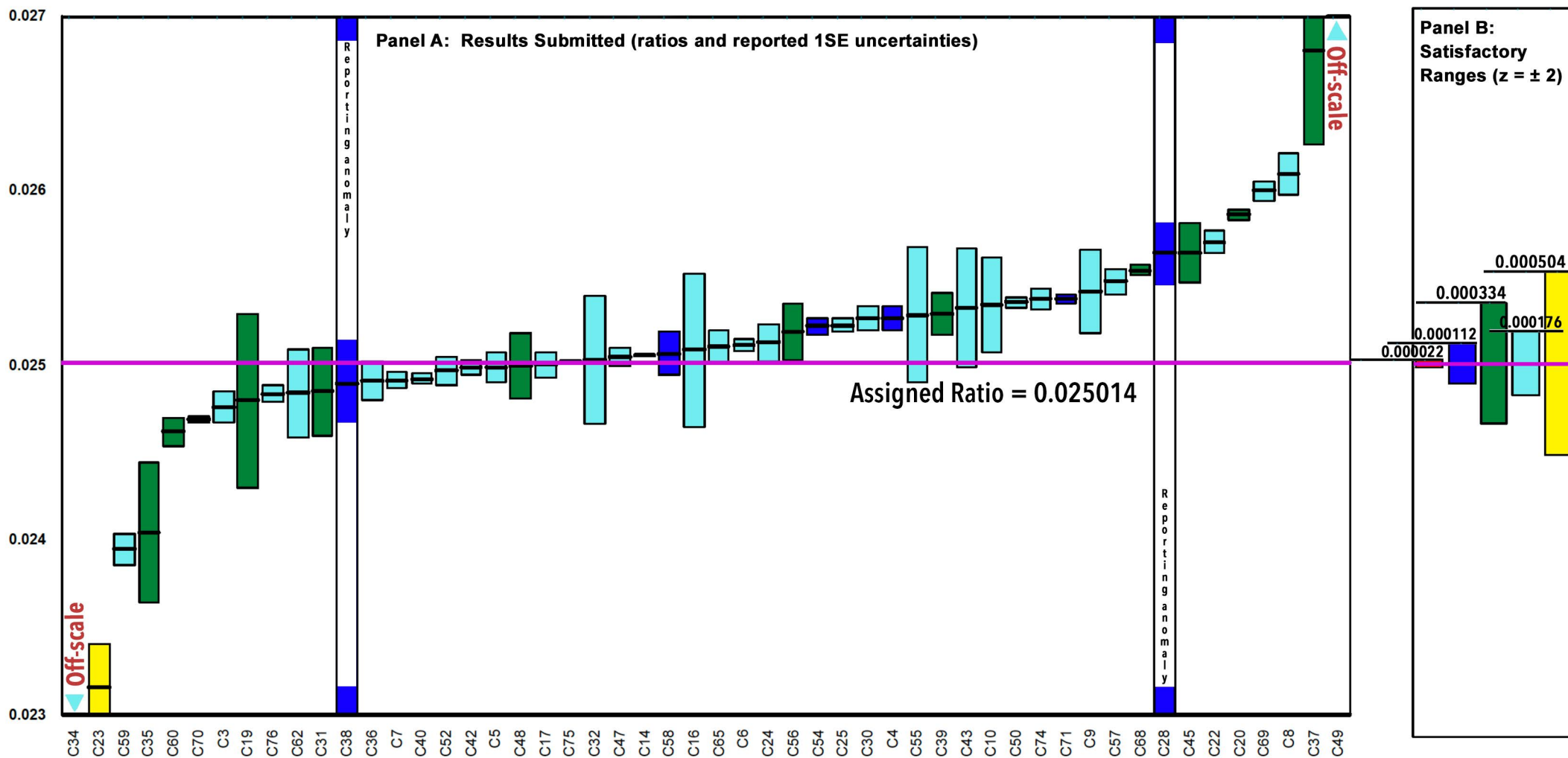
Panel A: Data plotted according to method, as shown by colour, with reported uncertainties (1SE) shown as error bars.  
 In KEY to the right: Colour code defined for each analytical method.

**KEY**

SIMS	<span style="color: blue;">█</span>
LA-ICP-MS: SFI	<span style="color: green;">█</span>
LA-ICP-MS: QuadToF	<span style="color: cyan;">█</span>
Other	<span style="color: yellow;">█</span>

Figure 4: - Ordered distribution of contributed  $^{206}\text{Pb}/^{238}\text{U}$  ratios with reported 1SE uncertainties shown as  $\pm$  bars for G-Chron Round #3 in relation to the assigned ratio, and corresponding satisfactory ranges ( $z = \pm 2$ ) for Peng-16 zircon

### $^{206}\text{Pb}/^{238}\text{U}$ Ratio



Panel A: Data plotted according to method, as shown by colour, with reported uncertainties (1SE) shown as error bars.

Panel B: Satisfactory ranges ( $z = \pm 2$ ) for each analytical method.

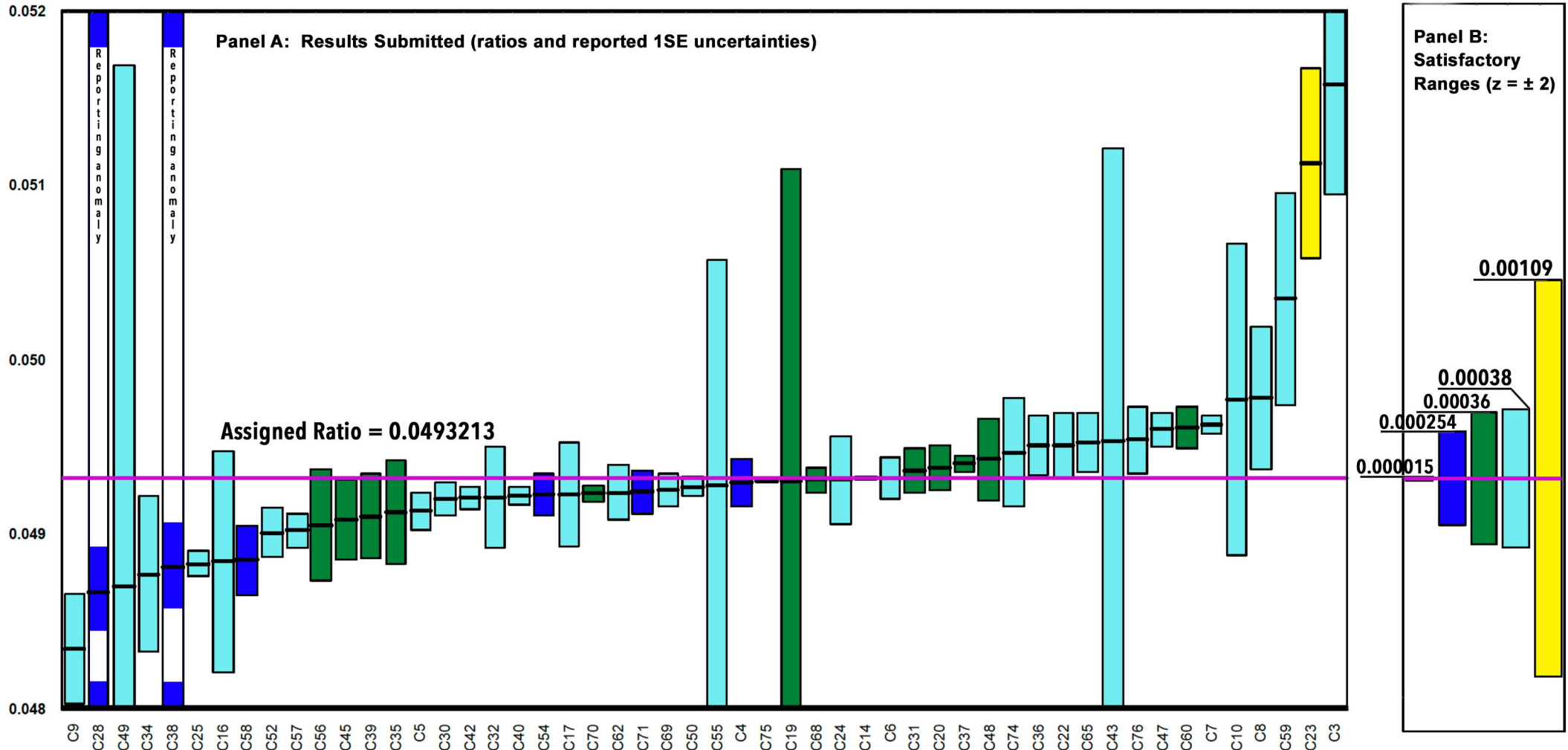
In KEY to the right: Target Precision ( $z = 1$ ) values specified, with colour code defined for each analytical method.

**KEY**

Isotope Dilution	0.000011
SIMS	0.000056
LA-ICP-MS: SFI	0.000167
LA-ICP-MS: QuadToF	0.000088
Other	0.000252

Figure 5: - Ordered distribution of contributed  $^{207}\text{Pb}/^{206}\text{Pb}$  ratios with reported 1SE uncertainties shown as  $\pm$  bars for G-Chron Round #3 in relation to the assigned ratio, and corresponding satisfactory ranges ( $z = \pm 2$ ) for Peng-16 zircon

**$^{207}\text{Pb}/^{206}\text{Pb}$  Ratio**



**Panel A: Data plotted according to method, as shown by colour, with reported uncertainties (1SE) shown as error bars.**

**Panel B: Satisfactory ranges ( $z = \pm 2$ ) for each analytical method.**

**In KEY to the right: Target Precision ( $z = 1$ ) values specified, with colour code defined for each analytical method.**



**Figure 7: G-Chron Round #3 - Peng-16 zircon. Multiple z-score charts for laboratories participating in G-Chron Round #3. Symbols indicate how a reported measurement complies in relation to the criteria keyed below (see key).**

