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# 1 Radiocarbon dating of legacy music instrument collections: example of traditional 2 Indian *vina* from the Musée de la Musique, Paris

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14  
15 Keywords: 14C dating, modern music instrument, small sample

## 16 **Abstract**

17 Although <sup>14</sup>C dating is commonly used for archeological music instruments, little research has been  
18 conducted on modern instruments (16<sup>th</sup> to 19<sup>th</sup> century). New technology, based on the mini carbon  
19 dating system (MICADAS), enables some of the recurring challenges (e.g. sampling size) to be  
20 circumvented and paves the way for a new field of investigation. We here address the Indian  
21 instrumentarium about which very little is known. We investigate the making and the restoration phases  
22 of two *vina*, a *kinnari vina* (E.1444) and a *rudra vina* or *bin* (E.997.24.1). By comparing <sup>14</sup>C measurements  
23 made on several samplings of elements of the instruments with museological information, we were able  
24 to specify a unique calibrated interval of ages [1666AD – 1690AD] for the making of the *kinnari vina* and  
25 a restoration phase [1678AD - 1766AD] for the upper nut. The *bin* is likely attributed to the [1650AD -  
26 1683AD] interval.

## 29 **Introduction**

30 Several challenges have to be met concerning the radiocarbon dating of modern music instruments  
31 made between the 16<sup>th</sup> and 19<sup>th</sup> century. Dendrochronology cannot be carried out on modern music  
32 instruments as the tree-ring record is too short and <sup>14</sup>C dating may be a priori rejected for historical  
33 periods as a <sup>14</sup>C physical measurement may result in several equiprobable age ranges. Several samplings  
34 and independent expertise are then required to make a well-considered choice between these intervals.  
35 Owing to the new generation of <sup>14</sup>C dating instruments, a compact radiocarbon dating system such as  
36 MICADAS (Synal et al., 2007) allows some hundreds of micrograms of material to be sampled. For wood,  
37 the sample is thus as small as a pinhead. This new technology opens the door to multisampling without it  
38 being visible and without it affecting the instrument's playing quality. This might at least partly resolve  
39 issues of multi-interval calibration. Beyond the physical analysis, museum studies are another reliable  
40 means of investigation to attempt to find clues to the manufacturing period and history of the  
41 instrument. This approach involves the gathering of documents, the expertise of curators and restorers,  
42 and reports of scientific analyses used in cultural heritage institutions that are required for the study of  
43 instruments using radiocarbon dating. The interdisciplinary framework makes it possible to combine any  
44 *ante quem* or *post quem* information on the age of relics or music instruments. In this approach, we will  
45 draw on an on-going project on modern music instruments involving radiocarbon dating specialists and  
46 museum experts. There are three challenges to be overcome: i- the sample size, which will not extend  
47 beyond a few hundred micrograms, ii- the composite constitution of the instrument (varnishes, glues,

48 restored parts), which requires specific and complex chemical protocols to extract the carbon to be  
49 dated, and iii- the historical period which is not favorable to radiocarbon dating due to complex  
50 calibration curves. Our goal here is to date two amazingly well preserved *vina* about which little  
51 information is available and possibly contribute to scientific knowledge about their origin and the history  
52 of their making.

53  
54

## 55 **Material and method**

### 56 **Material**

57 Our study focuses on two *vina*, Indian stringed instruments which belong to the tube zither family, and  
58 kept at the Musée de la musique in Paris. The first one is a *kinnari vina* (E.1444, Figure 1a,b). The second  
59 one is a *bin* (also called today *rudra vina*) (E.997.24.1, Figure 1d) and was played for centuries in Indian  
60 and Muslim princely courts. *Vina* are composed of a wooden tube onto which are fixed gourds which act  
61 as resonators. The conservation state of both *vinas* is exceptional although the constitutive and painted  
62 parts are very fragile and although the initial tropical climate was unfavorable, according to museum  
63 studies. Visual inspection under an optical microscope, endoscopic analysis, X-Ray digital radiography  
64 and XRF investigations were performed during museum studies and showed no visible evidence to  
65 suspect that certain parts had been replaced. None of the *vina* showed visible surface contamination.  
66 The decorations are original and it is very likely that gourds were chosen with care according to their  
67 acoustic properties (Bruguière et al., 2008).

68

69 **The *kinnari vina* (E.1444, Figure 1a,b)** is made of three gourds (*lagenaria siceraria*) fixed under a reed  
70 tube, made of *Arundo donax*, a species found in East and South-East Asia. This makes this *kinnari vina*  
71 singular. A piece of wood from a *Dalbergia latifoliae*, named “Indian rosewood”, was carved in the form  
72 of a bird and inserted at the end of the tube. This part was used as a string holder and a bridge. The  
73 upper nut painted yellow with orpiment is made of *Artocarpus chama Buch*, a wood commonly called  
74 “terap” and found in South-East Asia according to museum studies. An ancient iconography (page 135 in  
75 Day, 1891) presents a *kinnari vina* showing the same singular features without any decoration. The  
76 *kinnari vina* (E.1444) entered the collections in 1892. It was sold to the museum by Gand and Bernardel,  
77 renowned Parisian violin makers and valuable music instrument dealers of the 19<sup>th</sup> century, who may  
78 have bought it at public sale. The floral pattern of the *kinnari vina* (E.1444) is a motif found on 17<sup>th</sup> and  
79 18<sup>th</sup> century artifacts produced in the region of Hyderabad (Andhra Pradesh) situated in South-East India.  
80 According to the curator who relies on organological features and the painted patterns, this musical  
81 instrument could have been made in the 18<sup>th</sup> century.

82

83 **The *bin* or *rudra vina* (E.997.24.1, Figure 1d)** consists of two resonators made of gourds, a tube made of  
84 teak wood (*Tectona grandis*), and 13 wooden frets. The pegs and the string holder are missing. A mixture  
85 of beeswax and plant resin was traditionally used to stick the frets onto the tube. The highly  
86 sophisticated decoration of this *vina* comprises five successive layers: an undercoat of clay with iron  
87 oxides, a support of metallic sheet in tin, an organic layer with resin and paint layers. The *bin* E.997.24.1  
88 was acquired by the museum in 1997. It is referenced as coming from Rajasthan, a region in North-West  
89 India and it has been tentatively dated from the first half of the 17<sup>th</sup> century.

90

91

### 92 **Method**

#### 93 **Sampling**

94 The  $^{14}\text{C}$  activity was measured on 7 sub-samples, representative of each of the constituent elements, of  
95 the *kinnari vina* (E.1444, Figure 1c, table 1) and on two sub-samples of the *bin* (E.997.24.1, Figure 1d,  
96 table 1). An eighth sample was taken on the *kinnari vina*: a black glue residue found inside the tube  
97 (Figure 1c, sample H). All the samples were of less than a few hundred micrograms of carbon. Samples  
98 taken from both *vina* belong to original components of the instruments. Each of them is devoid of any  
99 traces of varnish, painting, and wax and protected from other environmental contamination. They were  
100 taken in non-visible areas inside the gourds or the tube, inside cracks, etc. (Figure 1b).

101  
102 *Figure 1: Indian vina from the Museum Collections and sampling locations. a- kinnari vina, E.1444, b- zoom on sampling in a*  
103 *crack from kinnari vina, E.1444, c- schematic view of the kinnari vina, E.1444 and location of the eight samples, d- bin or rudra*  
104 *vina, E.997.24.1 and sample locations. Pictures by Claude Germain (a, d) and Stéphane Vaiedelich (b) © Musée de la musique-*  
105 *Philharmonie de Paris.*

106  
107 *table 1: List of samples from kinnari vina and rudra vina (see Figure 1 to visualize locations)*  
108

## 109 **Treatment**

110 As no visible surface contamination was highlighted through previous investigations and as samples were  
111 extracted from hidden, uncolored parts of the instruments, a simple chemical treatment was enough to  
112 prepare the samples for  $^{14}\text{C}$  dating.

113 The samples were treated with the classical AAA chemical pretreatment for wood and charcoal samples  
114 (Van Klinken and Hedges, 1998). All chemicals were of ultrapure quality, and water was ultrapure (MilliQ  
115 grade). Chemical glasses were pre-combusted at  $500^\circ\text{C}$  overnight prior to use and were preserved in Al  
116 foil (burnt at the same time). The procedure is as follows:

117 HCl 0.5M, ambient temperature, sample is rinsed until pH= 5

118 NaOH 0.1M, ambient temperature, sample is hot rinsed until pH= 5 ( $80^\circ\text{C}$ )

119 HCl 0.5M, ambient temperature, sample is rinsed until pH= 5

120 Clean samples were transformed into  $\text{CO}_2$  by flame-combustion with pure  $\text{O}_2$ . Evolved gases were passed  
121 through a trap kept at  $-80^\circ\text{C}$  (ethanol – dry ice mixture) and on Cu/Ag to get rid of water,  $\text{O}_2$  excess and  
122 sulfur and nitrogen oxides. The amount of pure carbon was evaluated by a pressure transducer. Pure  $\text{CO}_2$   
123 was then flame-sealed, under vacuum, in one or several Pyrex tubes until measurement. No more than  
124  $140\mu\text{g}$  of C were preserved per tube.

125  
126 To control the impact of chemical treatment and of the combustion, we also ran "blank" and  
127 international standards (SIRI G – Scott et al., 2017). As "blank", we used a  $\text{F}^{14}\text{C}=0$  charcoal, known as  
128 "Afrique du Sud", from inside the Border cave (South Africa) in a Paleolithic level (Middle Stone Age)  
129 dated to more than 70 kya.

## 131 **Physical measurements**

132  
133 The mass spectrometer *ECHO*MICADAS ( $^{14}\text{C}$  AMS) was used to measure the  $^{14}\text{C}$  activity of each sample  
134 (Synal et al., 2007; Tisnérat-Laborde et al., 2015). The gaseous samples (from 30 to  $140\mu\text{gC}$ ) were  
135 directly injected into the MICADAS gas source through the Gas Ion Source Interface (GIS) (Ruff et al.,  
136 2010) by tube cracking. Ages were obtained from  $^{14}\text{C}$  measurements using Bats software by comparing  
137  $^{14}\text{C}/^{12}\text{C}$  ratios with OXII standards (Wacker et al., 2010). Most of the samples provided several tubes of  
138 gas. All the tubes were separately measured but results were statistically combined. The mean age of the  
139 sample then derives from the mean of the individual measurements, which pass the Chi2 test, and is  
140 associated to the maximum between the Chi2 reduced error and the standard deviation between the  
141 median of the individual measurements. Results are expressed in  $\text{F}^{14}\text{C}$  as recommended by Reimer et al.  
142 (2004) and provided as  $^{14}\text{C}$  ages (yr BP) following Stuiver and Polach's (1977) convention. Probability

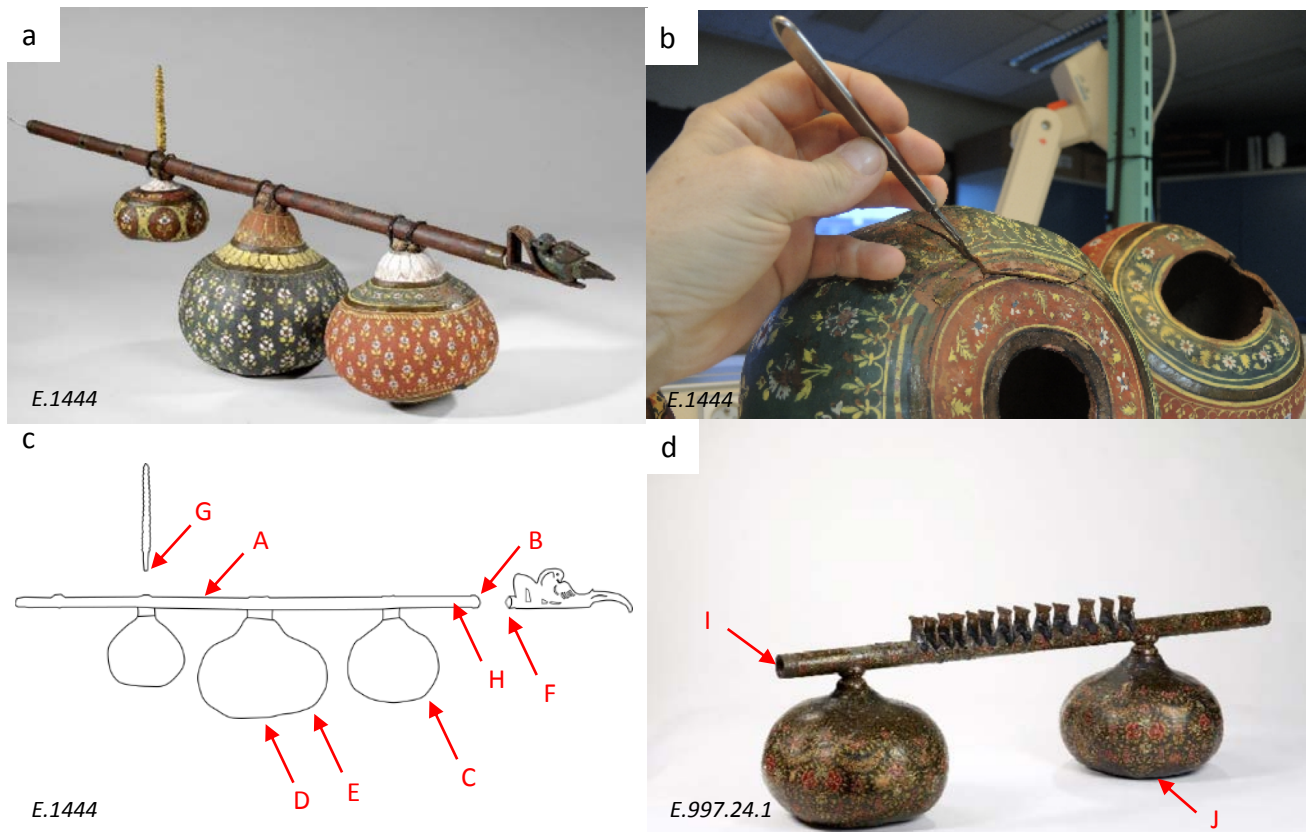


Figure 1 : Indian vina from the Museum Collections and sampling locations. a- kinnari vina, E.1444, b- zoom on sampling in a crack from kinnari vina, E.1444, c- schematic view of the kinnari vina, E.1444 and location of the eight samples, d- bin or rudra vina, E.997.24.1 and sample locations. Pictures by Claude Germain (a, d) and Stéphane Vaiedelich (b) © Musée de la musique-Philharmonie de Paris.

<i>vina</i>	sampling	GifA	Sampling description
<i>Kinnari-vina</i> E.1444	A	GifA18172	Inside the central part of the tube in the thickness of a crack.
	B	GifA18173	Inside the end of the tube on the bird bridge side.
	C	GifA18174	In the thickness of a broken part of the red gourd.
	D	GifA18175	On the inner surface of the green gourd.
	E	GifA18176	Inside a crack of the green gourd.
	F	GifA18177	Part of the bird bridge that fits into the end of the tube.
	G	GifA18179	Part of the upper nut that fits into the tube.
	H	GifA18178	Black glue-like residue from inside the tube
<i>Rudra-vina</i> E.997.24.1	I	GifA17279	Inside the tube
	J	GifA17278	Under a gourd

Table 1: List of samples from kinnari vina and rudra vina (see Figure 1 to visualize locations).

143 distributions of calibrated radiocarbon ages were generated using OxCal v4.3.2 (Bronk Ramsey, 2009)  
144 based on the IntCal13 calibration curve (Reimer et al., 2013). All data are provided in tables 1 and 2.  
145  
146

## 147 Results and discussion

148 *Vina* resonators are made of gourds that are fast growing and quickly dried plants. The same is true for  
149 the reed used as the tube for the *kinnari vina*. This means that the  $^{14}\text{C}$  dating will correspond to the year  
150 of manufacture to the nearest 1 to 3 years. The *rudra vina* tube, in contrast, is made of teak that is either  
151 a fast or a slow growing species depending on the environment. Examination of the tube revealed that it  
152 cannot have come from a branch but from a piece of turned wood. It comes from a beam that was  
153 drilled all along its length. We do not know *a priori* if it was extracted from the external part (the  
154 youngest part) or from the internal part (the oldest part) of the tree.  
155

### 156 *Kinnari vina* (E 1444)

157  $^{14}\text{C}$  data obtained for each sample are shown in Table 2 and Figure 2. The  $F^{14}\text{C}$  data recorded for six  
158 samples (GifA18172 to GifA18177) were unexpectedly very similar:  $0.983\pm 0.005$  (GifA18172),  
159  $0.977\pm 0.005$  (GifA18173),  $0.977\pm 0.005$  (GifA18174),  $0.977\pm 0.006$  (GifA18175),  $0.977\pm 0.005$  (GifA18176),  
160  $0.982\pm 0.007$  (GifA18176),  $0.977\pm 0.009$  (GifA18177). Hence they correspond respectively to similar  
161 radiocarbon dates:  $135\pm 40$  yr BP,  $190\pm 40$  yr BP,  $190\pm 50$  yr BP,  $190\pm 45$  yr BP,  $150\pm 55$  yr BP,  $190\pm 75$  yr BP.  
162 This result supports the conclusions of the museum studies that these pieces are original, and therefore  
163 correspond to the period when the instrument was made. The result for the upper nut (GifA18179) is an  
164 exception:  $0.986\pm 0.005$ , i.e., a radiocarbon date of  $115\pm 40$  yr BP. Unlike the first investigations carried  
165 out in the laboratory of the Musée de la Musique, this piece does not seem to be original.  
166

167 *table 2: Conventional, calibrated and modeled  $^{14}\text{C}$  ages obtained for the kinnari vina E.1444. Statistical results of Bayesian  
168 modeling are shown in the last four columns: for all vina pieces first and for the original pieces of the vina thereafter. Individual  
169 agreement ( $A_{\text{ind}}$ ) and combined agreement ( $A_{\text{comb}}$ ) are provided. Resulting modeling intervals are provided under the main part of  
170 the table.*  
171

172 Combining the results of this series (7 samples) using the "combine" option of Bayesian modeling (Bronk  
173 Ramsey, 2009) shows that the individual agreement index (A) for the upper nut sample (GifA18179) is  
174 60.4% whereas it is between 90 and 125% for the other six samples. It was therefore decided to perform  
175 the Bayesian modelling without the nut, i.e. using only the six sub-samples labeled GifA18172 to  
176 GifA18177 (Tables 1 and 2). The resulting equiprobable calendar ranges are (Figure 2, Table 2): [1666AD  
177 – 1690AD] (17.8%), [1730AD – 1784AD] (49.8%), [1796AD – 1810AD] (9.9%) (the last one, [1926AD - ... [  
178 is outlier data due to the Suess effect). The three main ranges of calibrated dates are defined as the end  
179 of the 17th century and the 18th century.  
180

181 As mentioned above, the upper nut may not be contemporaneous of the *vina* manufacture. It could be a  
182 replacement of the original nut that was probably lost or broken. This fragile part is subject to breakage  
183 and was likely changed during the period when the *vina* was played. The main probable ranges for the  
184 upper nut are: [1678AD - 1766AD] (32.5%), [1772AD - 1778AD] (1.0%), [1800AD - 1941AD] (61.9%).

185 The instrument was acquired in 1892 and no restoration has been carried out since it entered the  
186 museum. Any replacement was thus done before. The use of *terap* in nineteenth-century Europe in  
187 cabinet making and instrument making is not attested and remains highly unlikely. European instrument  
188 makers of this era probably did not have the organological knowledge of traditional Indian instruments  
189 to accurately reproduce this part either. It is very likely that the replacement was done while the  
190 instrument was still in India and was made by an Indian instrument maker. The only few slight traces of

identification				uncalibrated data						calibrated age [1]		statistical combination				
				individual measurement		Chi2-Test	mean value					model 1 (A->G) [2]		model 2 (A-> F) [3]		
Sample ID	Fig.1 ID	GifA #	ECHO #	F <sup>14</sup> C	±			F <sup>14</sup> C	±	age BP [yr]	±	calibrated age (±1 s) [range in yr ] (probability distribution)	calibrated age (±2 s) [range yr ] (probability distribution)	A <sub>ind</sub>	A <sub>comb</sub>	A <sub>ind</sub>
vina E1444 - P1 tube	A	GifA - 18172	ECHO - 2353	0.983	0.007	0.21/3.84 (5%)	0.983	0.005	135	40	[1680 - 1700] (8.9%) [1703 - 1707] (1.6%) [1720 - 1764] (18.0%) [1801 - 1819] (7.8%) [1824 - 1825] (0.2%) [1833 - 1881] (20.8%) [1915 - 1939] (10.7%)	[1669 - 1781] (41.7%) [1798 - 1894] (38.2%) [1905 - 1946] (15.6%)	99.1		89.8	
				0.984	0.007											
vina E1444 - P2 tube	B	GifA - 18173	ECHO - 2354	0.9738	0.0066	0.37/3.84 (5%)	0.977	0.005	190	40	[1663 - 1683] (13.6%) [1736 - 1806] (43.4%) [1931 - 1933] ( 0.7%) [1935 - ...] (10.5%)	[1645 - 1699] (22.7%) [1722 - 1817] (49.8%) [1834 - 1880] ( 6.6%) [1916 - ...] (16.4%)	106.4		116.4	
				0.9797	0.0070											
vina E1444 - P3 red resonator	C	GifA - 18174	ECHO - 2355	0.9768	0.0062	0.28/3.84 (5%)	0.977	0.006	190	50	[1653 - 1690] (16.7%) [1730 - 1810] (39.6%) [1926 - ...] (11.9%)	[1644 - 1712] (22.7%) [1719 - 1830] (45.2%) [1831 - 1891] (11.9%) [1909 - ...] (15.5%)	119.8		126.5	
				0.9795	0.0077											
vina E1444 - P4 green resonator	D	GifA - 18175	ECHO - 2356	0.9739	0.0076	0.28/3.84 (5%)	0.977	0.005	190	45	[1660 - 1685] (14.0%) [1733 - 1808] (41.8%) [1929 - ...] (12.4%)	[1645 - 1708] (22.8%) [1719 - 1821] (47.3%) [1822 - 1826] ( 0.4%) [1833 - 1886] ( 9.1%) [1914 - ...] (15.8%)	113.5	109.4	121.9	142.1
				0.9739	0.0076											
vina E1444 - P5 green resonator	E	GifA18176	ECHO-2357	0.9816	0.0066	0.01/3.84 (5%)	0.982	0.007	150	55	[1669 - 1698] (11.2%) [1724 - 1781] (22.8%) [1798 - 1816] ( 6.9%) [1835 - 1878] (15.8%) [1917 - 1946] (11.5%)	[1665 - 1788] (44.5%) [1790 - 1895] (34.6%) [1904 - ...] (16.3%)	115.3		111.9	
				0.9766	0.0088											
vina E1444 - P6 bird bridge	F	GifA18177	ECHO-2358	0.9766	0.0088	0.01/3.84 (5%)	0.977	0.009	190	75	[1647 - 1696] (16.8%) [1726 - 1814] (32.4%) [1837 - 1844] ( 2.0%) [1852 - 1869] ( 4.4%) [1872 - 1877] ( 1.1%) [1918 - ...] (11.5%)	[1523 - 1575] ( 5.0%) [1629 - ...] (90.4%)	127.1		131.2	
				0.9864	0.0064											
vina E1444 upper nut	G	GifA18179	ECHO-2360	0.9855	0.0073	0.01/3.84 (5%)	0.986	0.005	115	40	[1690 - 1730] (19.3%) [1810 - 1892] (40.4%) [1908 - 1926] ( 8.5%)	[1678 - 1766] (32.5%) [1772 - 1778] ( 1.0%) [1800 - 1941] (61.9%)	60.3			
				0.7973	0.0066											
vina E1444 - P7 inner tube deposit	H	GifA18178	ECHO-2359	0.7973	0.0066		0.797	0.007	1820	65						

resulting calibrated age (±2 s) [1668 - 1693] (16.2%) [1666 - 1690] (17.8%)  
[1728 - 1782] (49.7%) [1730 - 1784] (49.8%)  
[range yr ] [1798 - 1812] (10.7%) [1796 - 1810] (9.9%)  
(probability distribution) [1920 - 1949] (18.7%) [1926 - ...] (18.0%)

[1] using OxCal4.3.2 (Bronk Ramsey 2009) based on IntCal13 (Reimer et al. 2013)

[2] Chi2-Test: 3.30/12.59 (5%)

[3] Chi2-Test: T=1.54/11.07 (5%)

Table 2: Conventional, calibrated and modeled 14C ages obtained for the kinnari vina E.1444. Statistical results of Bayesian modeling are shown in the last four columns: for all vina pieces first and for the original pieces of the vina thereafter. Individual agreement (A<sub>ind</sub>) and combined agreement (A<sub>comb</sub>) are provided. Resulting modeling intervals are provided under the main part of the table.



191 (musical) use on the upper nut seem to reveal that it was not played as much as the other parts of the  
192 *vina*. It is thus assumed that the nut was replaced during the [1678AD - 1766AD] interval towards the  
193 end of the musical use of the *vina*. Consequently, the instrument was made (age of the original pieces)  
194 during the [1666AD – 1690AD] interval. It appears that the instrument is a little older than initially  
195 thought by the curator, who expected it to date from the 18<sup>th</sup> century.

196  
197 *Figure 2: Calibrated <sup>14</sup>C ages of the kinnari vina E.1444. The upper probability distribution diagram, underlined in blue*  
198 *corresponds to the Bayesian modeling of the combination of the vina's original parts. The probability distribution diagram of the*  
199 *restored piece (upper nut) is shown in the last line.*

200  
201 Residue sampled in the *vina* tube shows quite different results, with F<sup>14</sup>C equal to 0.797 ± 0.007,  
202 equivalent to an age of 1820 ± 65 BP (table 2). Chemical characterization (chromatography, XRF...) of a  
203 new sample of the same black residue is in progress. It is known that bitumen-derived glue was used to  
204 maintain the tube when aligning elements and perforating holes. A balance equation between expected  
205 age (F<sup>14</sup>C = 0.979, the modeled average of original pieces' F<sup>14</sup>C) and a null <sup>14</sup>C content for a potential  
206 bitumen-derived component would result in a mixture containing about 20% of dead carbon in the  
207 resulting black residue, which is quite likely.

208  
209 **Rudra vina (E 997.24.1)**  
210 <sup>14</sup>C data obtained for each sample are shown in Table 3. Samples from the *vina* tube (GifA-17279) and  
211 the *vina* resonator (GifA-17280) provided very similar F<sup>14</sup>C data: 0.976 ± 0.004 and 0.973 ± 0.005  
212 respectively, equivalent to 195 ± 30 yr BP and 225 ± 40 yr BP, respectively. Calibrated ranges of dates of  
213 both samples are thus also very close (Table 3 and Figure 3) yielding three major ranges of dates, during  
214 the 17<sup>th</sup> century, the 18<sup>th</sup> century and associated to the Suess effect modern period. This concomitance  
215 of ages reveals that the tube was extracted from the external part of the tree and this allows Bayesian  
216 modeling to combine dating and reduce uncertainties.

217  
218 *Table 3: Conventional, calibrated and modeled <sup>14</sup>C ages obtained for the bin E.997.24.1. Statistical results of Bayesian modeling*  
219 *are shown in the last two columns. Individual agreement (A<sub>ind</sub>) and combined agreement (A<sub>comb</sub>) are provided. Resulting*  
220 *modeling intervals are provided under the main part of the table.*

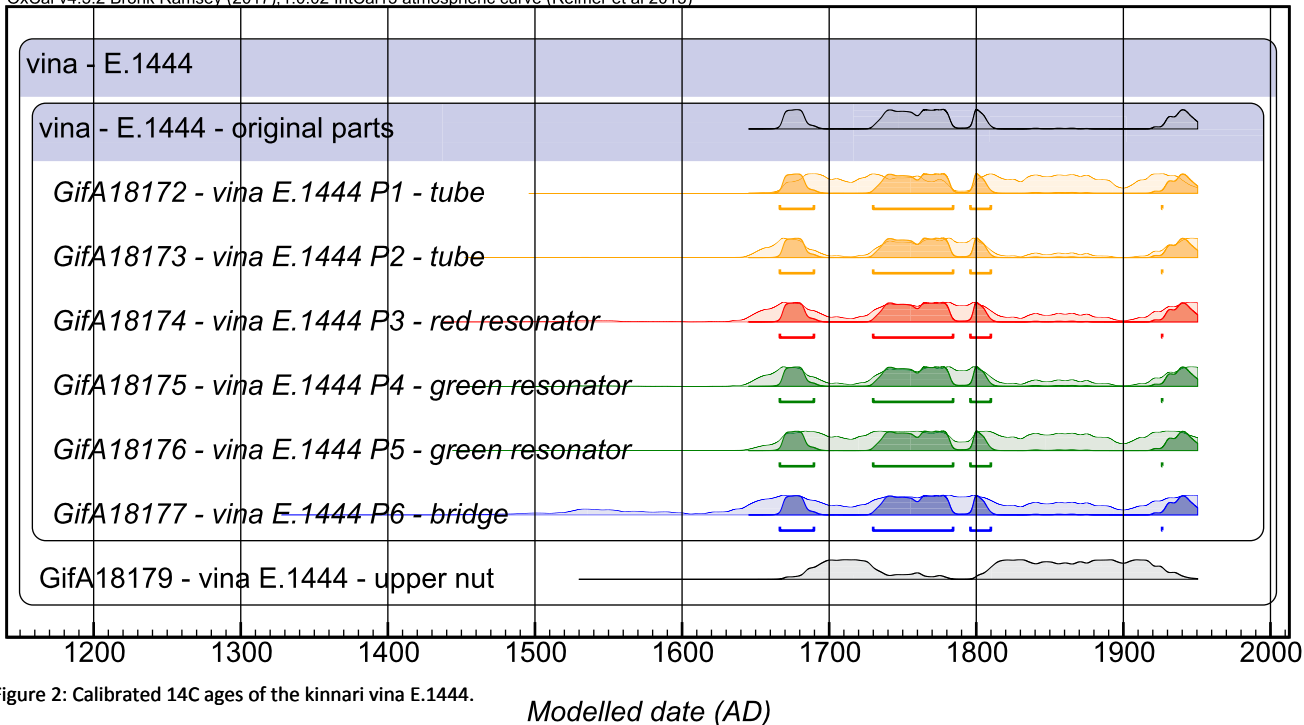
221  
222 Bayesian modeling with OxCal (Bronk Ramsey, 2009) reinforced the view that the two elements were  
223 associated at the same time and thus very likely correspond to the making of the instrument (Figure 3).  
224 Individual agreements, A, are 111.7% and 116.9%, respectively, resulting in a combined agreement  
225 factor of A<sub>comb</sub> = 120.7%. Modeling results in four equiprobable ranges of dates: [1650AD – 1683AD]  
226 (28.1%), [1737AD-1759AD] (8.8%) and [1761AD – 1805AD] (43.9%) and the last one ([1936AD - ...])  
227 corresponding to the modern period that we ruled out.

228  
229 *Figure 3: Calibrated <sup>14</sup>C ages for the two gaseous micro-samples from the bin or rudra vina E.997.24.1. The upper probability*  
230 *distribution diagram, underlined in blue corresponds to the Bayesian modeling obtained by combination of bin <sup>14</sup>C results.*

231  
232 According to the very accurate iconographical evidence and descriptions given in textual sources dating  
233 from the end of the 16<sup>th</sup> century and early 17<sup>th</sup> century, the curator speculated that the *vina* could have  
234 been made in the first half of the 17<sup>th</sup> century. The [1650AD - 1683AD] interval is presumably that when  
235 the instrument was made. It is slightly younger than expected.

236  
237

## 238 Conclusion

Figure 2: Calibrated  $^{14}\text{C}$  ages of the kinnari vina E.1444.

identification				uncalibrated data							calibrated age [1]		statistical combination [2]	
Sample ID	Fig. 1 ID	GifA #	ECHO #	individual measurement		Chi2-Test	mean value				calibrated age ( $\pm 1$ sigma) [range in yr AD] (probability distribution)	calibrated age ( $\pm 2$ sigma) [range yr AD] (probability distribution)	A <sub>ind</sub>	A <sub>comb</sub>
				F <sup>14</sup> C	$\pm$		F <sup>14</sup> C	$\pm$	age BP [yr]	$\pm$				
vina E997.24.1 tube	I	GifA - 17279	ECHO - 1938	0.979	0.007	0.574 / 5.990	0.976	0.004	195	30	[1663 - 1681] (16.2%)	[1649 - 1691] (23.9%)	111.7	120.7
				0.973	0.006						[1739 - 1746] (4.9%)	[1729 - 1811] (54.8%)		
				0.977	0.006						[1748 - 1751] (1.9%)	[1921 - 1923] (0.2%)		
vina E997.24.1 resonator	J	GifA - 17278	ECHO - 1939	0.972	0.007	0.007 / 3.840	0.973	0.005	225	40	[1763 - 1802] (33.5%)	[1925 - 1951] (16.6%)	116.9	120.7
				0.973	0.007						[1644 - 1681] (29.8%)	[1524 - 1559] (4.1%)		
											[1740 - 1742] (1.0%)	[1563 - 1571] (0.4%)		
										[1764 - 1801] (29.2%)	[1838 - 1842] (0.2%)			
										[1939 - 1950] (8.3%)	[1854 - 1858] (0.2%)			
											[1862 - 1867] (0.2%)			
											[1920 - 1950] (12.2%)			

resulting calibrated age [1650 - 1683] (27.9%)  
 $(\pm 2 s)$  [1736 - 1759] (9.4%)  
[range yr ] [1760 - 1805] (43.6%)  
(probability distribution) [1935 - 1951] (14.5%)

[1] using OxCal4.3.2 (Bronk Ramsey 2009) based on IntCal13 (Reimer et al. 2013)

[2] Chi2-Test: 0.30/3.84 (5%)

Table 3: Conventional, calibrated and modeled 14C ages obtained for the bin E.997.24.1. Statistical results of Bayesian modeling are shown in the last two columns. Individual agreement (A<sub>ind</sub>) and combined agreement (A<sub>comb</sub>) are provided. Resulting modeling intervals are provided under the main part of the table.

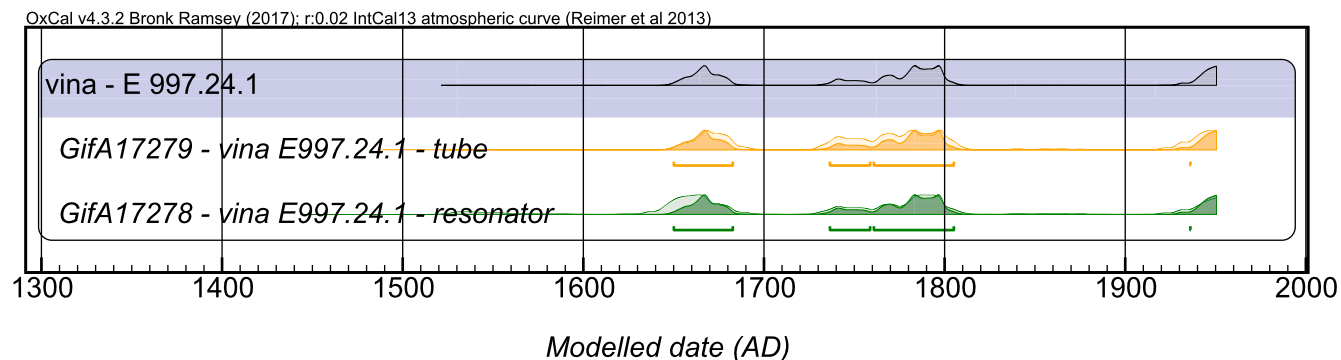


Figure 3: Calibrated 14C ages for the two gaseous micro-samples from the bin or rudra vina E.997.24.1. The upper probability distribution diagram, underlined in blue corresponds to the Bayesian modeling obtained by combination of bin 14C results.

239 Based on information from both geochronological analyses and museological resources, we were able to  
240 provide key elements on two *vina* from the Musée de la Musique The making of the *rudra vina* (E  
241 997.24.1) is now known and corresponds to [1650AD -1683AD]. The history of the *kinnari vina* (E 1444) is  
242 now known: it was made during the [1666AD – 1690AD] interval and its upper nut was changed before  
243 its arrival in France, likely during [1678AD - 1766AD]. Furthermore, we have highlighted the use of  
244 bitumen-derived glue used to assemble and make the instruments.  
245 To sum up on this first combined museological – geochronological study performed on legacy musical  
246 instruments, we have shown that like analysis performed on archeological musical instruments, <sup>14</sup>C  
247 dating can be a powerful tool to inform not only on the creation of a musical instrument but also on its  
248 use.  
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## 294 **Figures and tables**

295 *Figure 1 : Indian vina from the Museum Collections and sampling locations. a- kinnari vina, E.1444, b- zoom on sampling in a*  
296 *crack from kinnari vina, E.1444, c- schematic view of the kinnari vina, E.1444 and location of the eight samples, d- bin or rudra*  
297 *vina, E.997.24.1 and sample locations. Pictures by Claude Germain (a, d) and Stéphane Vaiedelich (b) © Musée de la musique-*  
298 *Philharmonie de Paris.*

299  
300 *Figure 2 : Calibrated  $^{14}\text{C}$  ages of the kinnari vina E.1444. The upper probability distribution diagram, underlined in blue*  
301 *corresponds to the Bayesian modeling of the combination of the vina's original parts. The probability distribution diagram of the*  
302 *restored piece (upper nut) is shown in the last line.*

303  
304 *Figure 3: Calibrated  $^{14}\text{C}$  ages for the two gaseous micro-samples from the bin or rudra vina E.997.24.1. The upper probability*  
305 *distribution diagram, underlined in blue corresponds to the Bayesian modeling obtained by combination of bin  $^{14}\text{C}$  results.*

306  
307 *Table 1: list of samples from kinnari vina and rudra vina (see Figure 1 to visualize locations)*

308  
309 *Table 2: Conventional, calibrated and modeled  $^{14}\text{C}$  ages obtained for the kinnari vina E.1444. Statistical results of Bayesian*  
310 *modeling are shown in the last four columns: for all vina pieces first and for the original pieces of the vina thereafter. Individual*  
311 *agreement ( $A_{\text{ind}}$ ) and combined agreement ( $A_{\text{comb}}$ ) are provided. Resulting modeling intervals are provided under the main part of*  
312 *the table.*

313  
314 *Table 3: Conventional, calibrated and modeled  $^{14}\text{C}$  ages obtained for the bin E.997.24.1. Statistical results of Bayesian modeling*  
315 *are shown in the last two columns. Individual agreement ( $A_{\text{ind}}$ ) and combined agreement ( $A_{\text{comb}}$ ) are provided. Resulting*  
316 *modeling intervals are provided under the main part of the table.*

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