

# The peaked arch, and the earliest domnicall rib vaults in the Paris Basin

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Medievalists often prefer a mixture of French and English terms for the arches that encompass a vault: the shorter French 'doubleau' is used more often than the longer English 'transverse arch'. In addition, the following words are used in particular ways in this article:

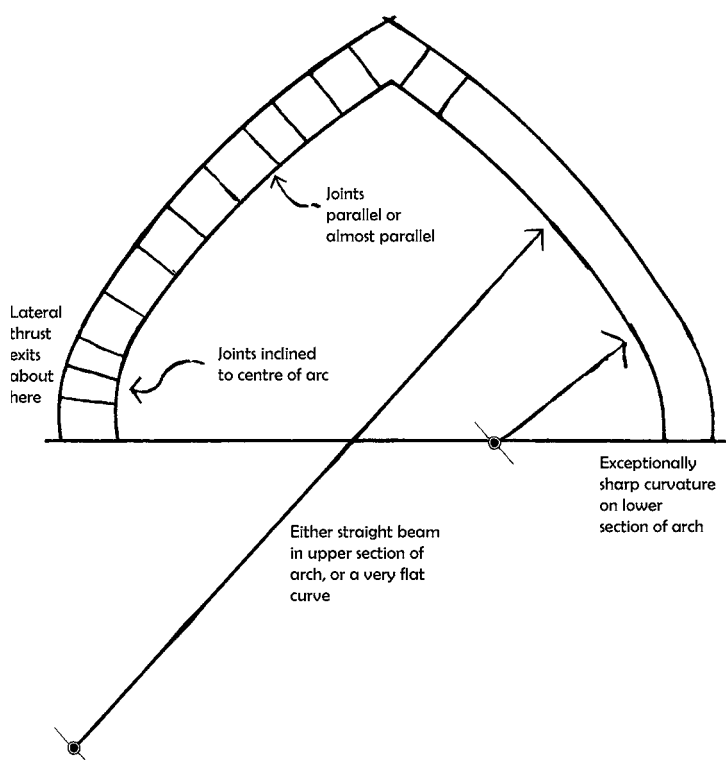
- level or domed refers to the three-dimensional form of the vaulting space;
- round, segmented, pointed or peaked to refer to the shape or outline of an arch in the vertical plane and therefore to the shape of the centring which supported it;
- torus, scotia or circular refers to the cross-section through the stones, being the profile marked on the template.

Pointed arches and rib vaults were first employed in European architecture shortly before 1100.<sup>1</sup> The pointed arch stemmed from Mesopotamia, probably via Sicily, and was rapidly accepted in France, though not so quickly elsewhere. The long-term impact on the evolution of Gothic architecture was profound.

The round arch, whether with stilts or not, will be struck from a single centre; the pointed arch from two so that the arcs intersect at the top. There has been much discussion on how these centres were located along the line of the springing, but I have found no discussion of the use, at this early time, of arches constructed from a number of curves from more than two centres [left, Airaines].

I understand this motif not being noticed. It is difficult to observe if one is not looking for it, and one often has to stand in a certain position to see it. I will call it the 'peaked' arch. Though historians of Islamic architecture refer to the same arch as 'keeled', where it is found in a multitude of buildings between Persia and Egypt from the ninth century, in the west the word 'keel' is used to describe profiles with curved faces meeting at a point, not unlike a pointed arch in section. The outline of the peaked arch being entirely different, referring to them as 'peaked' will prevent confusion.

In them the lower voussoirs are curved to a short radius as if for a much smaller span, and the upper to a much longer radius that looks as if it was almost straight. The upper curvature is often so slight it gives the impression of acting like a "beam" [right]. This multiple-centred pointed arch occurs in parts of the Paris Basin at virtually the same time as those with two centres, some time before 1120. It continued to be popular



for the next century and a half, occurring in more than one third of all churches, especially in the high vaults. Also, my far from complete observations suggest that the peaked arch is relative rare in other parts of Europe, suggesting that there may be reasons for its almost exclusive adoption in the Royal Domain.

In some churches the double curvature may have resulted from distortion with settlement or damage over the centuries, and this could tighten the curvature in the haunch. However, in the examples we shall be discussing are part of rib vaults in which the space above the springing has been filled with mortar to such a height that such distortion would be unlikely. For greater certainty we would need to know the history of each building's restorations backed up with photogrammetric or similar measured surveys.

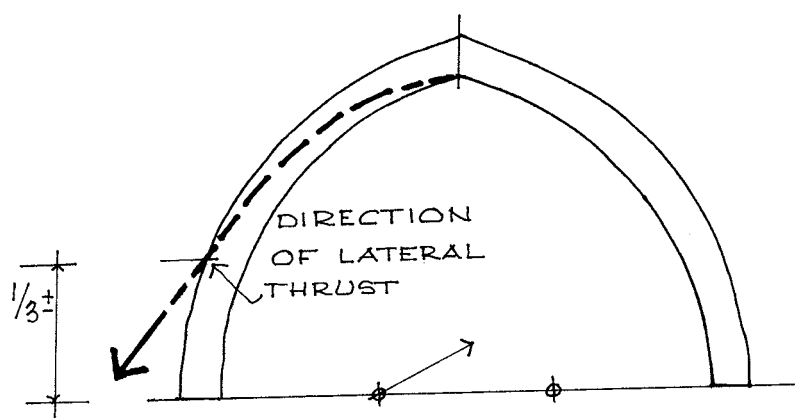
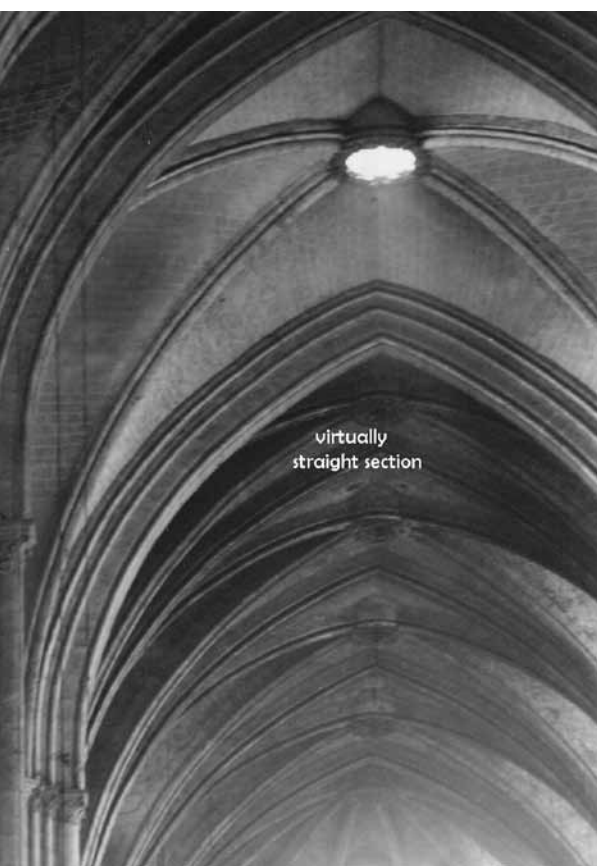
It seems not insignificant that they occur mainly in the Paris area, that they are contemporary with the first pointed arch, and nearly always occur under some of the earliest rib-vaults in the area, all of which are domical in form. These characteristics may identify one master mason who introduced the motif into domical rib vaults.

I have visited almost every European rib-vaulted church built before 1145 gathering information on the evolution of the rib, with details to be published shortly in this COGA site. It appears that with the exception of three before the Crusade, most of these building should be dated to the 1110s. Refer to the site for details.

### The advantages of a peaked arch

With the double-curved peaked arch I have the impression that the masons envisaged that the short-span arch in the lower section *supported* a beam producing minimal lateral thrust. If this were the case, then it shows an understanding of arch construction and lateral thrusts that seems more sophisticated than needed for the pointed arch. The concept of using only a slight curvature to maintain stability was later used to stabilise the cells between the ribs. There are four reasons for its use: engineering, formwork, constructional and contracting procedures.

**Engineering:** In a normal arch shifts along the voussoirs, and is tipped slightly downwards at the junction between each stone. This continues from the apex to about two-thirds of the way down the arch, where the thrust has developed a greater lateral vector than can be contained within the turn of the arch, and therefore exits beyond the thickness of the voussoirs [right]. We still don't understand its precise dynamics, but photoelastic analysis suggests that pointing the arch does appreciably reduce the outward thrust.<sup>2</sup> If an arch is not to collapse at this exit point it must be buttressed in some way, both externally and by filling the space between the arch and the adjacent wall to the exit point or higher with a stone and mortar mass that turns the lower part of the vault into a solid block.



The situation in a peaked arch is slightly different. In the upper part the loads are contained within the depth of the beam. It is only in the curved lower section that the line of thrust exits the curve of the arch. As this section is seldom more than one third the height of the arch, the lateral thrust leaves the voussoirs at an invariably lower point than where it would have been if the arch had a single curve. Peaking lowered the line of thrust as if it had been a smaller opening, thus increasing the stability of the building.

**Formwork:** Slightly curved formwork can be assembled on straight beams with different sized chocks under each stone, whereas curved centring has to be made up from many specially cut and shaped pieces of wood, which is an expensive and time-consuming operation. In peaked arches the lower portion can usually be erected without any centring, and formwork under the straight section was readily reusable.<sup>3</sup> The advantages of this system would have been considerable, especially as serviceable timber was becoming scarce in some regions around Paris.<sup>4</sup>

**Constructional:** To take one example, in the clerestory of the cathedral of Chartres [left, page 2], most doubleau and many ribs are peaked, including those around the crossing. There is little consistency across the great spans of the high vaults where few arches follow exactly the same outline. The amount of peaking was dependent on the curvature and stiling established in the bottom courses.

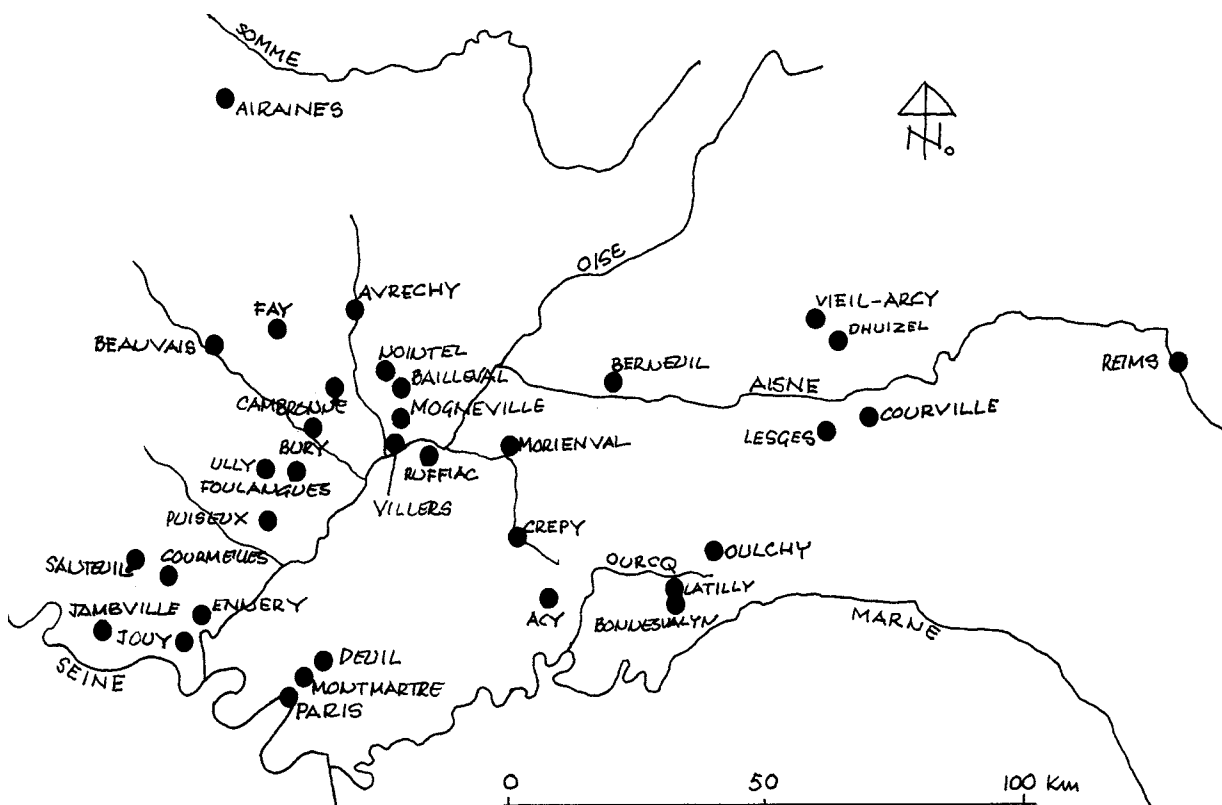
**Contractual:** At Chartres four masters, Rose, Scarlet, Bronze and Ruby, cut and placed the *tas-de-charge* in the nave and choir, each with their own ideas on what the height of the crown of the vault was to be.<sup>5</sup> Rose was preparing for a boss height of 36,700 mm from the floor, his successor Scarlet for a height of 120 Roman feet at 35,450 mm, and Bronze, who actually set the bosses in place, and was therefore in charge of the final centring and placement of the straightened upper stones of the ribs, at the somewhat lower 34,360 mm. With different teams cutting the lowest stones, the two-meter difference in the heights would have affected the curvature required in each master's template. Peaking was a practical solution to these varied conditions.

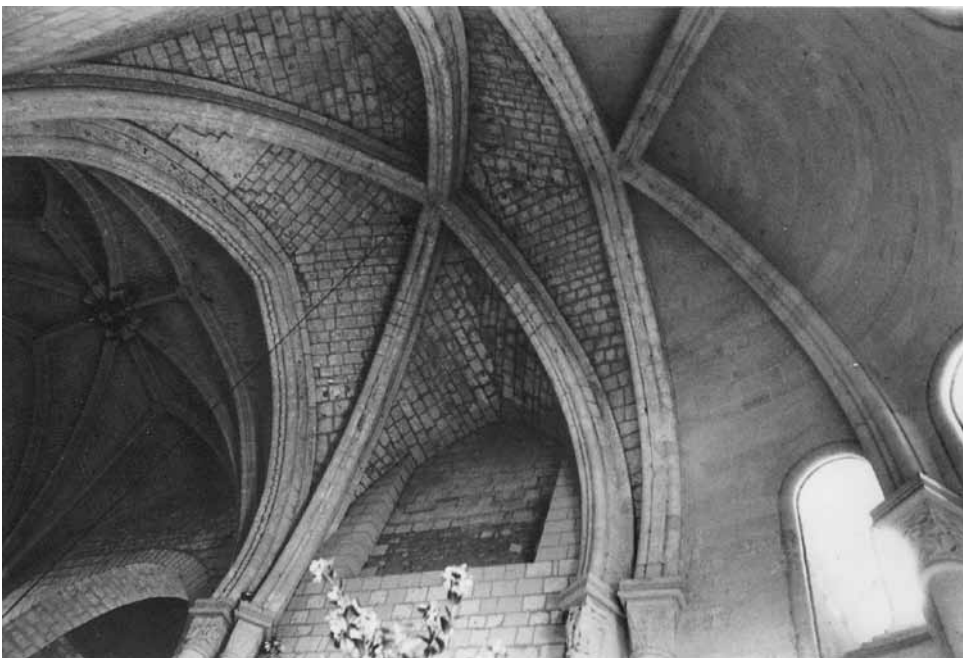
### Early peaked arches in the Paris Basin.

To my knowledge, the earliest peaked arches in Europe appear in the Paris Basin, all north of the Seine and Marne rivers [Map]. They are in ten buildings that were erected prior to 1130. It is of the utmost significance that all ten buildings have rib vaults, they are always domical in form, and the ribs are often pointed. All except Airaines have ribs carved to a similar profile, and six have capitals angled precisely in the direction of the ribs [Morienvall, left next page].

Outside the Paris Basin I am aware of only one peaked arch of this period, the crypt under the Ripon chapter House after 1110, and around 1130, the naves of Worms cathedral and San Ambrogio, Milan. Whereas the peaked arch is found in half the vaults in northern France before 1160, there are only two among 80 English ribbed vaults before 1150: the doubleau of Kirkstall and St. Peter in Oxford. It was a northern French phenomenon, and by the 1180s the peaked arch is found in some part of nearly every major church in the area. The table on the next page describes their more telling characteristics.

During the 1990s I visited nearly every European rib-vaulted church built before 1145 gathering information on the evolution of the rib. All the vaulting figures set out in the table come from this survey.





This data will be published shortly on the COGA site. Prior to 1130, 34 rib vaulted buildings in Western Europe have domical crowns, while 54 are level, though with some small undulation. In level crowns the bays form a connected sequence. By contrast, domical vaults emphasized each bay at the expense of the whole. It is therefore interesting to note that within the Paris Basin this proportion is reversed - 24 buildings are domical compared with only 11 that are level. These figures show that the conventional view that the north preferred level crowns and segmental ribs while the south preferred domical crowns and pointed ribs is not tenable.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1090±	Santeuil	east	D				p p p	OvO	<	s			1087
	Nointel	crossing	VD				p p p	O_O	#		?		1092
	Jouy-le-Moutier	east		?	^		^	?	<		?	O+I	1094
1100+	Morienvall	choir	D		^		^ p ^	OvO	<	s		O+I	1103
	Bury	south aisle			L		p r r	OvO	<<	s			1105
	Foulangues	apse	D				p r p	OvO	<<	s		O+I	1107
1110+	Mogneville	transept	D		^		p ^ p	OvO	<<	s			1110
	Latilly	crossing	VD				p p p	O_O	#		d		1111
	Cambronne	north arm	VD		^		p ^ p	OvO	<<	s			1112
	Cambronne	south arm			L		p ^ p	OvO	<<	s			1113
	Airaines	nave	D		^		^ r p	V	<<		d		1114
	Foulangues	crossing	D				p p p	OvO	<<		d		1115
	Lesges	apse	VD		^		^ p p	OvO	<		d	O+I	1116
	Mogneville	apse	D				p p p	OvO	<	s			1117
	Bonesvalyn	crossing	VD		^		p p ^	OuO	#		d	O+I	1118
	Avrechy	apse	VD				p p p	O_O	<	s			1119
1120+	Bailleval	east	VD		^		^ r p	OvO	?		d	O+I	
	Bourgogne	north, south		D			p r p	O_O	<		d		
	Jambville	crossing	VD		^		p ^ p	OvO	#	s			
	Beauvais, St Etienne	South transept			L		^ r r	OvO	<	s			
	Ully-Saint-George	north	D				p p p	OvO	<	s			

Bailleval unknown, as the capitals have been destroyed

Jouy-le-Moutier vault destroyed when height of interior was raised in the 1220s

Airaines rib profile is a pointed torus on a square base on capitals that are typically Prad's, suggesting that he carved the capitals, set up the doubleau and left while the mortar set, leaving another to insert the ribs

Jambville capitals set square, placed by an earlier master

Foulangues non-structural boss may be the work of a later crew who completed vaults begun by Prad.

Beauvais, St Etienne vaults follow the north that are not domical

## Identifying the Master of the peaked arch

In the Ile-de-France seventeen vaults form the core of this study. The table shows their characteristics in approximate chronological order. The three columns in the first frame (D-F) refer to the spatial form of the vault, taken towards the centre: Very Domical, Domical or Level. The 'very domical' are those that appear, from visual observation, to be more than one-and-half times as high as they are wide. Level may include those in which the ridge of the cell is level in one direction and very slightly sloping in the other.

The peaked arches are marked '^' in the fourth column G. They were employed in the doubleau, ribs and, on one occasion, in formerets. The next column H which are pointed and which peaked. The letters stand for the form of the doubleau, rib and formeret, in that order. The symbol '^' is peaked, 'r' round and 'p' pointed. There was considerable variety in the forms chosen, and I would guess often to adjust to prior conditions. In nearly every case the arrangement has raised the volume of the interior.

It may seem remarkable that most of the peaked arches occur in smaller buildings, suggesting that its inventor was either a local builder or he recognised it was less risky to experiment on a small scale than on a larger.<sup>6</sup> The largest span in the Beauvais transepts are among the latest in this group.

The profile used in the ribs was not unusual at this time [left]. It is marked 'OvO' bold in column I. It occurs in a number of English and Norman churches during these two decades, Thus its use in the Paris Basin at the same time is not exceptional, except in so far as it appears in conjunction with the peaked arch.

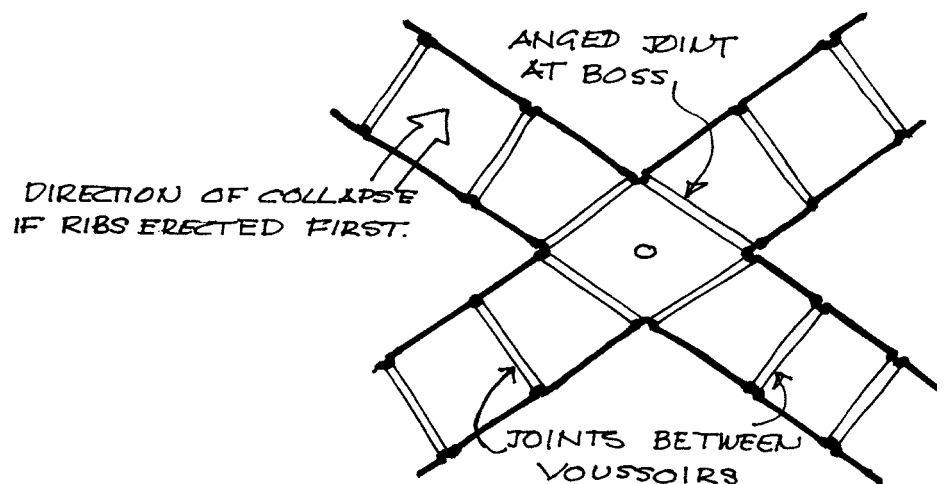
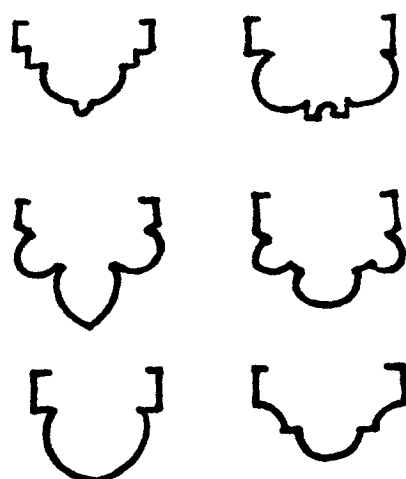


There is a wider version of this profile in which a short flat section separates the lower splays, marked 'O\_O' in the table, and another in which the pointed middle section has been rounded, marked 'OuO', shown centre and right. The spatial form of the vaults with the 'O\_O' profile is mostly rounded arches and level cells, while the latter is nearly always with pointed arches and somewhat domical cells, but never peaked arches. Together, over half the rib-vaulted churches in the Basin built prior to 1130 have these rib profiles. The profiles used in other churches of this period are quite different [see examples below left].

It had been normal practice before the introduction of intersecting ribs to set impostes and capitals square to the walls or piers. After 1110 capitals some were angled to face the direction of the rib, and were therefore placed either at 45° to the wall or (more subtly) directed tangentially at the boss.<sup>7</sup> These three arrangements are marked '#', '<' and '<<' in column J. Though angled capitals were an extremely rare device in England, it became the dominant form in the Paris Basin, occurring in 60 percent of vaults before 1140. Nearly all the vaults with peaked arches have angled capitals, of one type or another. Where the bays are nearly square, as in Lesges, Jouy, Santeuil and Morienval, you cannot tell whether they are tangential.

These tangential capitals may well be the first in Europe.

Lastly, only five of the vaults with peaked arches have ribs that are 'structural'. This became the standard construction technique of mature Gothic in which ribs were erected first, which then supported the cells that were laid onto the top of them. Prior to this, both groin and rib vaults were erected in the same way: the cells and ribs were built up together, layer by layer, and the boss was inserted after all the other stones had been laid up. The shape of these bosses show that the ribs could not have stayed up on their own [right].<sup>8</sup> This primitive



mode of construction was rarely used after 1130, only one quarter of the ribs in the Paris Basin during the 1130s being non-structural compared to all before 1120. Non-structural ribs are marked 'd' in column L, and structural ribs are marked 's' in column K. We can presume that on the whole the later buildings will be those with the more advanced technology.

The six crucial features listed in the table, with those features unique to this group of building in italics:

1. the pointed arch and (in most), *the peaked arch*;
2. domical and very domical vaults;
3. ribs pointed rather than round as other arches;
4. diagonally placed capitals, and some that are angled tangentially at the centre of the boss;
5. the use of the profiles [upper, previous page]
6. ribs in the earlier vaults were built with the cells, but ribs in the later vaults appear to be *among the earliest to be erected before the cells*.

The congruence of so many crucial and, in the main, unique features in these vaults suggests they were the work of one master mason, whom I will refer to as the Prad Master from the initials of Peak, Rib And Dome. The introduction of new structural and design arrangements in one building after the other shows him to have been a highly original person.

### Accepted dating.

Though there is little documentary information, the dates in COGA arise from comparative analysis of capital designs, and are based on the foundation of the few documents. group to the north of Paris - Cambronne, Foulanges and Mogneville - is usually considered contemporary to one another, though the dates suggested have varied from the 1120s to after 1170.<sup>9</sup> Jouy-le-Moutier is often dated to the mid-20s;<sup>10</sup> Acy, Airaines, Bailleval, Bonnesvalyn [below] and Lesges have not been well researched.<sup>11</sup> A recent article has accepted the traditional date for the completion of the crossing at Cambronne to 1130/35.<sup>12</sup>

The basis for the conventional dating of so many buildings to the 1130s lies in a host of publications



during the first two decades of last century by French and English scholars. Six key monuments are mentioned repeatedly: Saint-Etienne and Saint-Lucien in Beauvais, the apses of Morienvall and Bellefontaine, and the westworks at Chartres and Saint-Denis. However, no documents date the first, and as the second was destroyed we cannot be sure in what sequence it was built nor when the transept bases and ribs were laid down.<sup>13</sup> The documentary evidence that placed the apses of the second pair in the mid-20s has been reassessed and found sufficiently irrelevant that both have since been shifted forward into the 30s or later, though earlier could have been just as likely.<sup>14</sup> Only the last two can be dated in any way at all: the Chartres north tower following the fire of 1134 and the Saint-Denis narthex to the decades prior to 1140. There is also the little chapel of Saint-Aignan on the Ile-de-la-Cité, not mentioned in the older publications, that may be dated to 1115/18.<sup>15</sup>

The traditional dates have been supported by such curious reasons as the smallness of the spans or the narrowness of the windows,<sup>16</sup> or by the self-validating yet absurd assumption that square profiles were only employed during the reign of Louis VI (1108-1137), or that the more complex profiles were not used before Bellefontaine about 1125. It has not been recognized that these same arguments could just as easily be used to support an earlier dating, even back to the turn of the century.

On the whole, the evidence assembled in COGA suggests these dates would be a decade or more too late. The decadic dates are listed in the first column of the table, and the column N gives approximate DetailDates from the analysis of the capitals and the interactions of their individual carving styles across many buildings.

Though ten or a dozen years may not seem much in the context of centuries, it makes a considerable difference to the art-historical view of how ideas and techniques travelled, and to their sources – particularly in relation to their possible origins in other countries.

Studies by Vermand and Johnson have delineated issues of design and carving that help to establish a chronology for the period before 1110 in the Oise region to the north of Paris.<sup>17</sup> However, few buildings have been assigned to the decades of the 1100s and 1110s. The emptiness of these years suggests an unlikely twenty-year “black hole” in church construction, especially as so many works have been assigned to the following decade. There is also the hiatus from debt arising from the Crusade, and that few funds would have been given to building works while the debts were being settled.

There are three buildings noted as being before the First Crusade, to which we might add Morienvall as the fourth. The reasons for these dates depend on the style of the capitals.

It looks like the idea of the peaked arch did not have to come from the Middle East, but may have been devised in France well before the crusaders marched overseas. In the same way, the first rib vaults were built in Durham and Lessay before the Crusade, not afterwards.. This is an important consideration for the study of the period and deserves much more research and attention from scholars. This subject is so complex that one should consider the matter through the multiple images available in COGA.

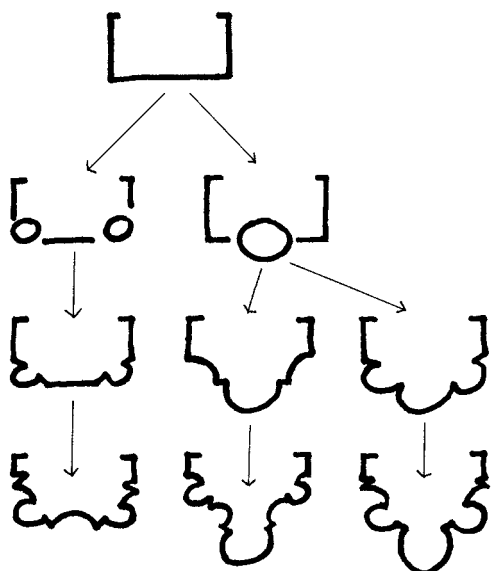
On the same issue, among nineteen rib-vaulted building in Europe built in the next decade, nine are Prad’s. Only Prad’s have peaked or pointed arches (besides the Milan narthex) and only Prad’s are domical, and only his group has angled capitals. Is it not possible that these items could identify one creative master?

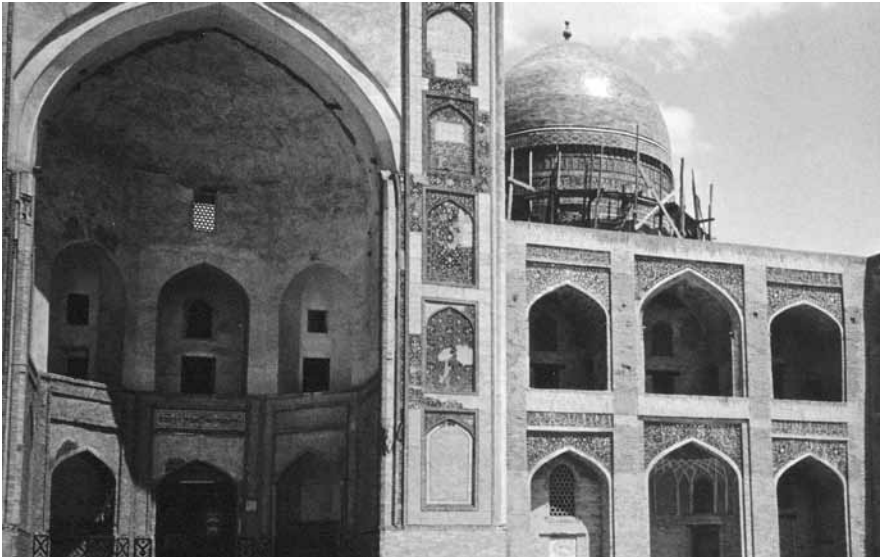
### Source of Prad’s style

If Anglo-Norman and Italian architecture are not the source of the Ile-de-France peaked arch, where should we look? Pointed arches were unheard of in either England or Normandy before the Durham nave 1130±. The earliest in Europe are generally dated before 1100, first in Italy and then in central France, whence the idea slowly percolated northwards. As far as I can follow the origin of the peaked arch, Prad introduced the idea on his own.

Prad’s rib profile most often occurs in southern England and the Cotentin peninsula. The idea would have been bizarre at the time for, in the words of Laurence Hoey, “bending a slice of column around an arch must have looked like a solecism to most masons at the time”.<sup>18</sup>

This slice was added either along the edge to soften the severity of the square corner, or down the middle to emphasize the centre line of the arch [right in left image]. The former appeared





quite early around window frames, and only towards the end of the century in arches, as in the Norwich and Gloucester choirs. The rolls down the middle were used only rarely before 1100, as in the crypts at Auxerre (c.1030) and Saintes (c.1085) and the aisles at Bernay (c.1060), and in some English chancel arches such at Wittering and Clayton, before being magnificently presented at Durham (after 1094).

Nearly all rib and arch profiles spring from one or other of these two modes. Among vaulted churches in the Basin during Prad's time, almost 60 percent evolve from the former and the rest from the latter. Prad occasionally used a central profile for doubleau and arcade arches. However, except at Morienvall, he mixed his types only in the earliest buildings, see 'O+I' in column I of the table. Elsewhere all profiles are consistently derived from a rectangular base.

Both the peaked and pointed arch had been known in Islamic architecture, in Egypt, Syria and Persia in particular, since the eighth century. It is still used today [above].<sup>19</sup> For example, the Masjid Jami in Isfahan (around 1100) has markedly peaked transverse arches under all vaults and domes, especially in the library. The outline of the latter ribs is almost identical to those in Airaines [page 1]. The vault cells are domical and formed by bricks laid in a curved manner not unlike Bailleval. Pope wrote that "in much of the Near East, materials, working conditions and necessity (scarcity of timber) had for centuries combined to encourage invention that should either be, or at least should look adequate for support of the myriad of domes and vaults that roofed every village and city in Mesopotamia and Persia."<sup>20</sup> For necessity the masons of that region preferred to build without centring whenever possible, a tradition that continued in countries with little timber until recently, instanced in Antonio Gaudi's work in Barcelona.<sup>21</sup> The same desire to minimize timber may also have inspired Prad's use of the peaked arch.

## Conclusion

As many have pointed out, eleventh- and twelfth-century architects were greatly interested in the amalgamation of the pure forms of cube, sphere and cylinder. Windows, for example, were assembled from rectangles surmounted by arcs of circles. The same purity was maintained in all building elements and profiles. Even when the pointed arch made a gradual appearance, the curves remained pure almost everywhere. The peaked arch was, therefore, an aberrant form within the normal medieval geometric setting.

The omission of any discussion on peaked arches in the prodigious literature on arch construction may be due to the same bias among nineteenth century architects. Willis makes this abundantly clear in his important and often-neglected article on rib vaults.<sup>22</sup> In his day, architects were more dedicated to regular geometric figures than were some of the masters of the middle ages. From impeccable measurements made of existing vaults while being rebuilt or restored, Pugin and others showed that curvature was seldom regular. Replaced work as often as not "improved" on what was seen as "errors" by regularizing the curves geometrically. This mind-set may have made it difficult for historians to see that curves were more often irregular than not, and that these were deliberate.<sup>23</sup>



## Endnotes

- 1 Jean Bony, *French Gothic Architecture of the 12th and 13th Centuries*, Berkeley, 1983, 17-18, 468. The earliest true pointed arch is that of the sixth-century Qasr-ibn-Wardan in Syria: K. A. C. Creswell, *A Short Account of Early Muslim Architecture*, Harmondsworth, 1958, 102-4. Illustrations in Arthur Pope, "Possible Iranian Contributions to the Beginning of Gothic Architecture", *Beitrag zur kunstgeschichte Asiens, in memoriam Ernst Diez, Istanbul*, ed. Oktay Aslanapa, Istanbul, 1963, 1-29 and M. Dieulaloy, *L'art Antique de la Perse*, Paris, 1884. See also John Harvey, "The Origins of Gothic Architecture: some further thoughts", *Antiquaries Journal*, 48, 1968, 87-99. M. Dieulaloy, *L'art Antique de la Perse*, Paris, 1884.
- 2 Robert Mark, *Experiments in Gothic structure*, Cambridge MA, 1982; Jacques Heyman, "The safety of masonry arches", *International Journal of Mechanical Science*, 1969, 363-385; Pol Abraham, "Les données plastiques et fonctionelles du problème de l'ogive", *Le problème de l'ogive*, Paris, 1939, 29-51.
- 3 John Fitchen, *The Construction of Gothic Cathedrals. A study of medieval vault erection*, Oxford, 1961..
- 4 M. Roblin, *Le Terroir de Paris aux époques Gallo-Romaines en France*, Paris, 1951; M. Devèze, *La vie de la forêt française au XIIIe siècle*, Paris, 1961.
- 5 James, *The Contractors of Chartres*, ch. XVIII., 458-59 and 478-485.
- 6 Dominique Vermand, "La voûte d'ogives et l'architecture de 'transition' dans l'Oise: les premières expériences (1100-1150)", *L'art roman dans l'Oise et ses environs, GMOB 1995*, Beauvais 1998, 137.
- 7 In reconstructed buildings where the vaults may have disappeared, diagonal placement of pier bases or imposts is often used as evidence that rib vaults were intended. In buildings that have been dated to the 1120s this conclusion is assumed without question, as at Jouy and Evreux, but has been inconsistently questioned in the crypt of Saint-Arnoul at Crépy-en-Valois with its diagonally placed pilaster capitals, which Vergnolle dates to 1090/1103. She considers they are too early for a rib vault, a mistake I have attempted to reassess in COGA: Vergnolle, "St.-Arnoul", 233-72.
- 8 This is explained in more detail in John James, "The rib vaults of Durham cathedral", *Gesta*, xxii 1983, 135-145.
- 9 Marcel Aubert, "Les plus anciennes croisées d'ogives, leur role dans la construction", *Bulletin monumental*, 93, 1934, 5-67 and 137-237; Marcel Aubert, "L'église de Mogneville", *Congrès archéologique*, 72, 1905, 475-88; M. Hermite, "L'église Saint-Denis de Foulanges", *Concours d'architects des Monuments Historiques*, 1956; Eugene Lefèvre-Pontalis., "L'église de Foulanges", *Bulletin monumental*, 107, 1949; J. Vergnet-Ruiz, "L'église de Foulanges", *Bulletin monumental*, 72, 1949, 101-23; Eugene Lefèvre-Pontalis., "L'église de Cambronne", *Congrès archéologique*, 72, 1905, 43-47; Phillippe Plaignieux, "Deux phases successives de la première architecture gothique dans l'Oise: l'église de Cambronnes-Clermont" *Bulletin de GEMOB*, 27, 1987, 59-69; J. Rocard, "Rapport descriptive et archéologique sur l'église Saint-Etienne de Cambronne", *Concours d'architect en chef de Monuments Historiques*, 1956, 32-38. Dominique Vermand, *Eglises de l'Oise*, Paris, c.1981.
- 10 Join-Cambert, "Jouy-le-Moutier", *Congrès archéologique*, 103, 1944, 161-74.
- 11 The fact that the apse of Bonnesvalyn is polygonal in plan without buttresses (the present ones were added later) does not militate against this argument, even though it had been thought that the first straight-sided apse was at Laon. There are similar apses scattered throughout the region: Bitry, Fontenay-Saint-Père and Luzarches about the same time, and afterwards Auvers-sur-Oise, Bougival, Courville and Saint-Pierre in Chartres. For a list of polygonal apses, James, *Template-makers*, 98-104. M. Dansac, "L'église de Lesges", *Congrès archéologique*, 78, 1911, 201-25.
- 12 Plaignieux, "Cambronne", 3.
- 13 Vermand, "La voûte d'ogives", 137.
- 14 Bellefontaine had been dated from an 1125 document giving permission to build: Eugene Lefèvre-Pontalis, *L'architecture religieuse dans l'ancien diocèse de Soissons au XI<sup>e</sup> et au XII<sup>e</sup> siècle*, Paris, I, 1894, 83 and 114. Aubert, "croisées d'ogives", 134 thought the form of the vault was like Saint-Denis and therefore (*sic!*) dated it long afterwards around 1150. Concerning Morierval, the relevance of the documents have been conventionally assessed (but without examination of the capitals) in Anne Prache and Danielle Johnson, "L'architecture et la sculpture de l'église de Morierval", *L'art roman dans l'Oise et ses environs, GMOB 1995*, Beauvais, 1998, 96.
- 15 Yvan Christ, "La chapelle Saint-Aignan", *Document Archéologia*, 3, 1973, 31.
- 16 Lefèvre-Pontalis, "Cambronne"; Vergnet-Ruiz, "Foulanges", 109.
- 17 Danielle Johnson, "Architectural sculpture of the Aisne and Oise valleys during the second half of the eleventh century", *Cahiers archéologiques*, 1998, 19-44; Danielle Johnson and Dominique Vermand, "La chapelle de Rouffiac a Pontpoint", *Mémoires de la Société d'Histoire et d'Archéologie de Senlis*, Senlis, 1991, 98-122; Dominique Vermand, *Rhuis: église Saint-Gervais-Saint-Protais*, Poitiers, 1992 and *Pontpoint, église Saint-Gervais*, Poitiers, 1991.
- 18 Email to author, February 1998.
- 19 See note 1. On the possibility of travel: *Memoirs of an Arab-Syrian Gentleman*, trans. K. Hitti, Beirut, 1964, 160 in Harvey, "Gothic architecture", 99.
- 20 Arthur Pope, "Possible Iranian contributions to the beginning of Gothic architecture", *Beitrag zur kunstgeschichte Asiens, in memoriam Ernst Diez, Istanbul*, ed. Oktay Aslanapa, 1963, 7.
- 21 G. Roseborough, *Antonio Gaudi*, London, 1960.
- 22 R. Willis, "On the Construction of Vaults", *Transactions of the Royal Institute of British Architects*, I/2, 1842, 1-69
- 23 Exemplified in discussions on vault projection in François Bucher, "Design in Gothic Architecture, a preliminary assessment", *JSAH*, 27, 1968, 49-71 and "The Dresden sketch-book of vault projection", *Acts of the 22nd. International Congress of Art History*, Budapest, 1972, 527-37.