

Introduction

- Penetrating captive bolt is a common method of euthanasia for swine, specifically sows, boars, and grower-finishers, with a common frontal application. However, there are 3 possible identified sites: frontal, temporal, and behind the ear toward the opposite eye.
- Limited validation research has been published for captive bolt euthanasia of pigs and the majority has focused on the frontal application site.
- Theoretically, the curious nature of swine could make euthanasia by the frontal location more difficult than the behind the ear location.
- Peer-reviewed published data to validate either the temporal or behind the ear location for pigs did not appear to exist at the time of our study.
- This study was designed to serve as a first step in scientifically validating the behind the ear location for the euthanasia of market weight pigs.

Hypothesis

- The cadaver heads in the caudal to pinna treatment (behind the ear) would display soft tissue thickness, cranial thickness, total tissue thickness, cross-sectional brain area, and bolt – brain contact that was not different than the cadaver heads treated with the frontal application.

Objectives

- To compare the soft tissue thickness, cranial thickness, total tissue thickness, cross-sectional brain area, and bolt – brain contact from the common frontal application of captive bolt euthanasia with the alternative location behind the ear in cadaver swine heads.

Materials and Methods

CADAVER HEAD DESCRIPTION

- 23 heads, with skin and intact jowls, with an average temperature of 30.7°C from pigs commercially slaughtered at a federally inspected regional processing facility. Heads were separated from their respective carcasses between the atlas and axis.
- Estimated average BW of the pigs was approximately 136 kg and they were approximately 6 mo of age.

TREATMENT ASSIGNMENTS

- All treatments were applied with a Jarvis Model PAS – Type P 0.25R Caliber Captive Bolt Pistol equipped with the Medium stunning Rod Nosepiece Assembly; Jarvis Blue Powder Cartridges 0.25 R Caliber, 3GR were utilized.
- For the **FRONTAL** (n = 11) location, the captive bolt shot was placed 2.54 cm superior to a line drawn across the top of the eyes at midline.
- For the **CAUDAL TO PINNA** (n = 12) location, the captive bolt shot was placed directly caudal to the pinna of the right ear on the same plane as the eyes and targeting the middle of the opposite eye.

DEPENDENT VARIABLES

- For both **FRONTAL** and **CAUDAL TO PINNA** treatments, the following dependent variables were recorded: soft tissue thickness (mm), cranial thickness (mm), total tissue thickness (mm), cross-sectional brain area (cm²), and bolt – brain contact (count/%).

DATA COLLECTION

- For both **FRONTAL** and **CAUDAL TO PINNA**, soft tissue thickness, cranial thickness, and total tissue thickness were collected immediately following the splitting of each head.
- Visually noticeable differences were recognized in tissue thicknesses on each side of the bolt path, so two measurements were recorded and then averaged prior to statistical analysis.
- Cross-sectional brain area was determined from images collected during head processing. An online irregular area calculator application was utilized to calculate the cross-sectional surface area of exposed brain within the plane of the bolt path.
- Bolt – brain contact was determined from the images referenced above and was recorded on a yes/no basis (yes = brain was contacted by the bolt, no = brain was not contacted by the bolt).

Abstract

The objective of this study was to contrast the soft tissue thickness, cranial thickness, total tissue thickness, cross-sectional brain area, and bolt – brain contact from the common frontal application of captive bolt euthanasia with the alternative location behind the ear in cadaver swine heads. Twenty-three cadaver heads from pigs that were approximately 136 kg and 6 months of age were collected from a regional slaughter establishment following CO₂ stunning and assigned to either the **FRONTAL** (n = 11) or the **CAUDAL TO PINNA** (n = 12) application of the captive bolt. The soft tissue thickness was different ($P < 0.0001$) between the two applications (**FRONTAL**: 8.3 ± 3.4 mm; **CAUDAL TO PINNA**: 56.5 ± 3.4 mm). The cranial thickness was different ($P < 0.0001$) between the applications (**FRONTAL**: 23.4 ± 2.9 mm; **CAUDAL TO PINNA**: 26.5 ± 2.9 mm). There was also a difference ($P < 0.0001$) in the total tissue thickness between the two applications (**FRONTAL**: 31.7 ± 3.8 mm; **CAUDAL TO PINNA**: 73.4 ± 3.8 mm). Cross-sectional area was calculated from images collected immediately after the heads were cut along the plane of bolt travel by bandsaw and was different ($P = 0.0028$) between the two applications (**FRONTAL**: 25.2 ± 1.3 cm²; **CAUDAL TO PINNA**: 18.9 ± 1.3 cm²). Bolt – brain contact was also assessed from the images, and a difference ($P = 0.0360$) between the two applications (**FRONTAL**: 100 ± 10.5%; **CAUDAL TO PINNA**: 66.7 ± 10.5%) was identified. The results of this study suggest that the **FRONTAL** application may provide a bolt path with less tissue to travel through when compared with the **CAUDAL TO PINNA** application for pigs of the approximate age and weight of those in this study. Ultimately, the **FRONTAL** location may present less risk for the captive bolt euthanasia of swine at market weight at this time. Additional refinement of the **CAUDAL TO PINNA** procedure and modification to the captive bolt device to penetrate to a suitable depth to ensure brain damage is recommended.

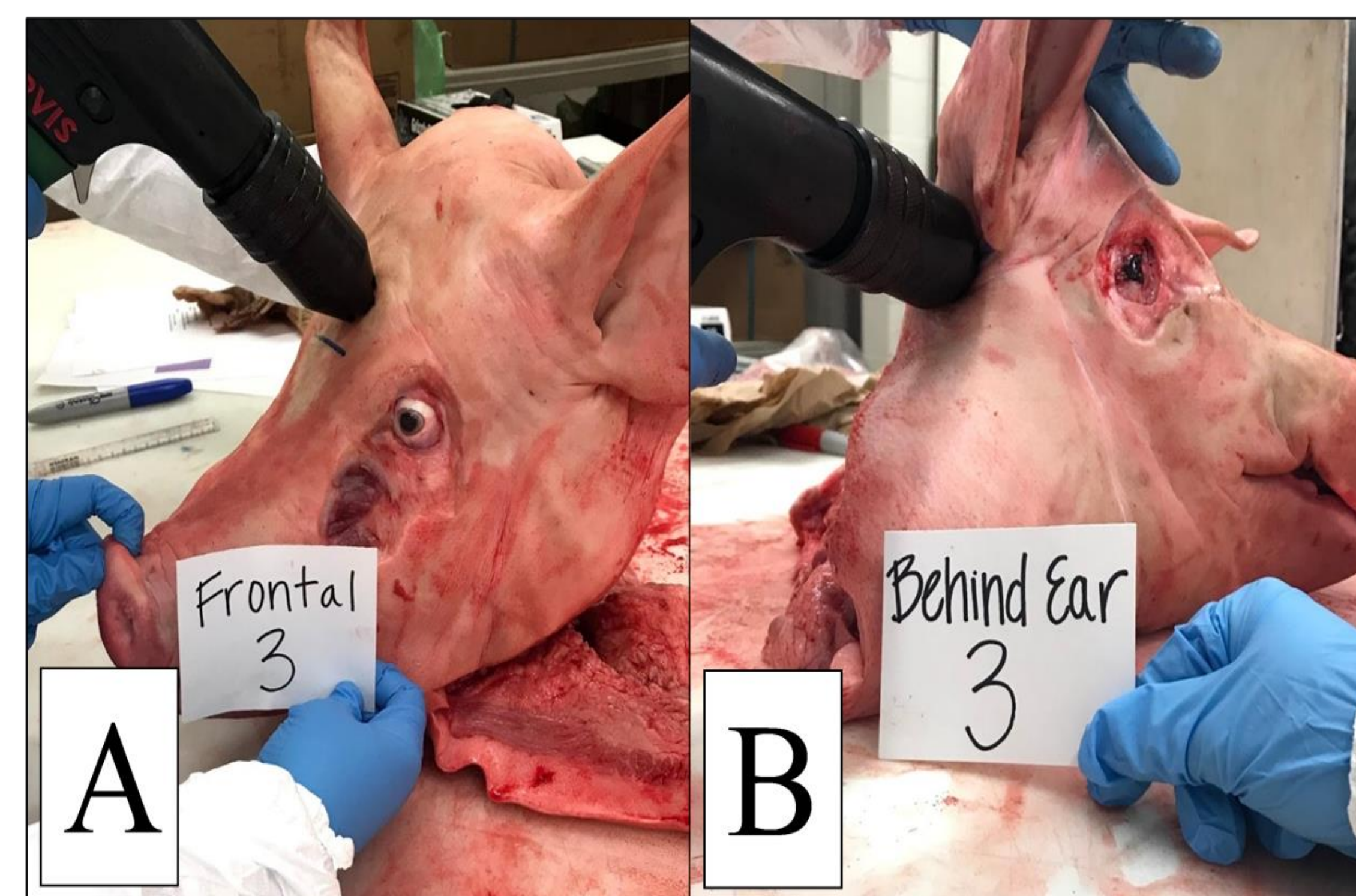


Figure 1. Placement of captive bolt device for placement treatments. A) **FRONTAL** – Medial bolt entry approximately 2.54 cm superior to a line across the top of both eyes and perpendicular with the external surface of the head; B) **CAUDAL TO PINNA** – Bolt entry directly caudal to the right pinna with aim toward the left eye on a plane that included both eyes.

Implications

- ✓ Overall, the data indicated that of the two location treatments the **FRONTAL** position appears to be a more reliable location for captive bolt euthanasia at this time. The reliability of the **FRONTAL** position over the **CAUDAL TO PINNA** position is indicated by greater incidence of bolt – brain contact noted in the cadaver heads treated with the **FRONTAL** location.
- ✓ It was identified that refinement of the **CAUDAL TO PINNA** position is necessary to ensure its reliability in practice: due to the observed incidence of bolt – brain contact, as well as the increased accuracy with aim and angle of the captive bolt device.
- ✓ At this time, the **FRONTAL** position may present less risk for the captive bolt euthanasia of market weight swine.

Statistical Analyses

- All continuous data for captive bolt application treatment effects were analyzed using the MIXED procedure of SAS (Statistical Analysis System Institute, Inc., Cary, NC).
- Categorical data for treatment effects were analyzed using the GLIMMIX procedure of SAS (Statistical Analysis System Institute, Inc.).
- Significant differences in treatment effects were realized at $\alpha \leq 0.05$.

Results

Table 1. Effects of location on tissue parameters and cross-sectional brain area of cadaver heads from market weight hogs assigned to two shot location treatments¹ and sectioned by band saw following the plane of bolt entry (N = 23).

Dependent Variable	Captive Bolt Placement Location			P - value
	FRONTAL (n = 11)	CAUDAL TO PINNA (n = 12)	Pooled SE	
Soft tissue thickness, mm	8.3	56.5	3.4	< 0.0001
Cranial thickness, mm	23.4	26.5	2.9	< 0.0001
Total tissue thickness, mm	31.7	73.4	3.8	< 0.0001
Cross sectional brain area, cm ²	25.2	18.9	1.3	0.0028
Bolt – brain contact ² , count / %	11 / 100	8 / 66.7	10.5	0.0360

¹ Treatments: **FRONTAL** – Medial bolt entry approximately 2.54 cm superior to a line across the top of both eyes and perpendicular with the external surface of the head; **CAUDAL TO PINNA** – Bolt entry directly caudal to the right pinna with aim toward the left eye on a plane that included both eyes.

² Bolt – brain contact: Images of heads sectioned by band saw within the plane of bolt entry were assessed for occurrence of bolt contact with brain tissue.

- All measurements collected were significantly ($P < 0.05$) different between the **FRONTAL** and **CAUDAL TO PINNA** treatments.
- Soft tissue thickness, cranial thickness, and total tissue thickness were all greater in the **CAUDAL TO PINNA** than the **FRONTAL** heads ($P < 0.05$).
- Heads treated with the **FRONTAL** location displayed greater cross-sectional brain area than those treated with the **CAUDAL TO PINNA** location ($P < 0.05$).
- Bolt-brain contact was greater ($P < 0.05$) in the **FRONTAL** location than the **CAUDAL TO PINNA** location.

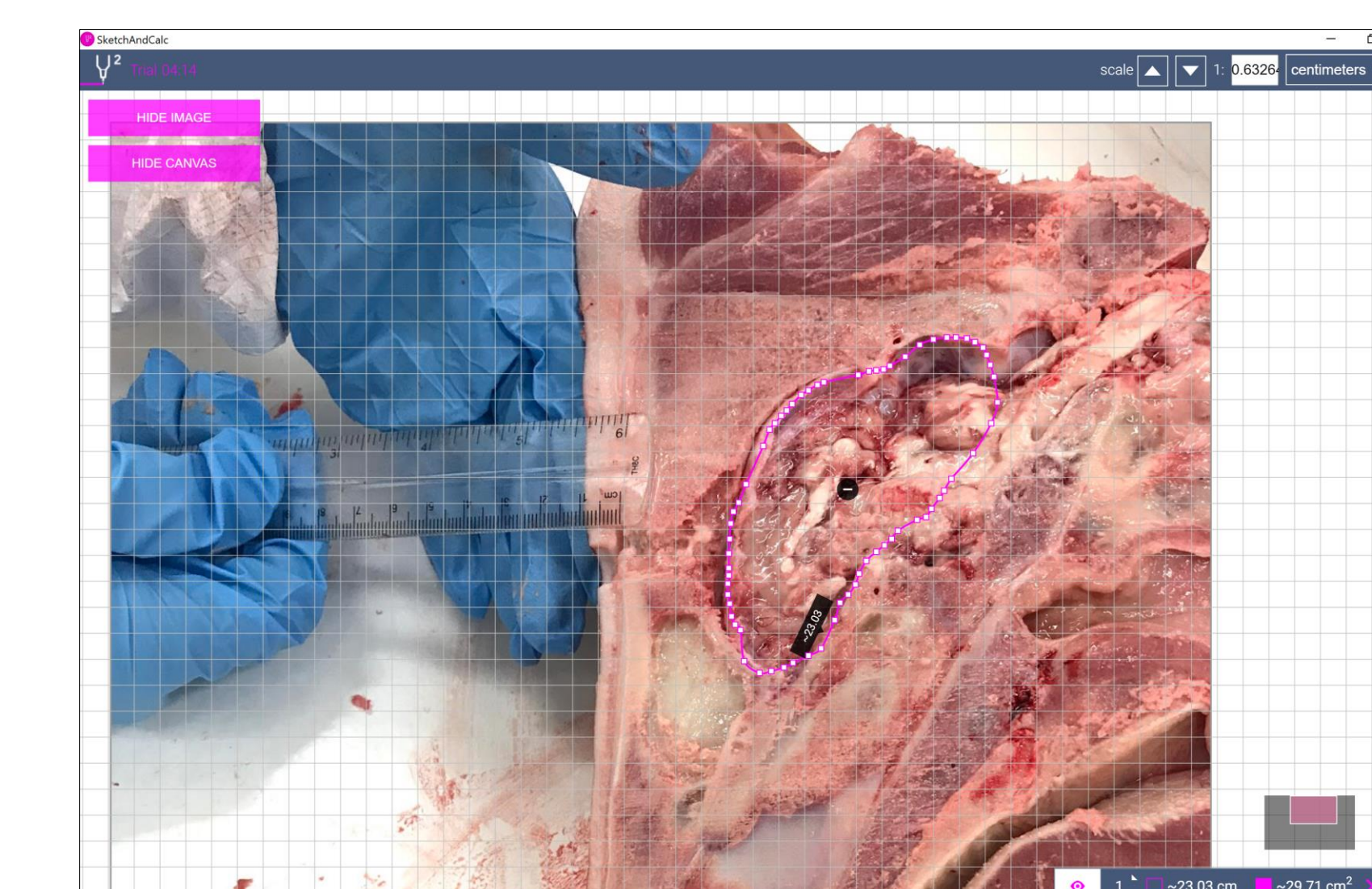


Figure 2. Calculation of cross-sectional brain area from an online irregular area calculator application. Cross-sectional brain area resulting from the **FRONTAL** is shown.