

# fn make\_geometric

Michael Shoemate

This proof resides in “**contrib**” because it has not completed the vetting process.

Proves soundness of the implementation of `make_geometric` in `mod.rs` at commit `f5bb719` (outdated<sup>1</sup>).

The implementation of this function constructs a random variable denoting the noise distribution to add, and then dispatches to the `MakeNoise<DI, MI, MO>` trait which constructs the core mechanism and wraps it in pre-processing transformations and post-processors to match the desired parameterization.

## 1 Hoare Triple

### Precondition

#### Compiler-Verified

- generic DI implements trait `Domain`
- generic MI implements trait `Metric`
- generic MO implements trait `Measure`
- type `DiscreteLaplace` implements trait `MakeNoise<DI, MI, MO>`
- type `ConstantTimeGeometric` implements trait `MakeNoise<DI, MI, MO>` These traits constrain the choice of input domain, input metric and output measure to those that can form valid measurements when adding noise from these distributions.
- type `(DI, MI)` implements trait `MetricSpace`

#### User-Verified

None

### Pseudocode

```
1 def make_geometric(  
2     input_domain: DI,  
3     input_metric: MI,  
4     scale: f64,  
5     bounds: Option[tuple[DI_Atom, DI_Atom]],  
6 ) -> Measurement[DI, DI_Carrier, MI, MO]:  
7     input_space = input_domain, input_metric  
8     if bounds is None:  
9         return DiscreteLaplace(scale, k=None).make_noise(input_space)  
10    else:  
11        return ConstantTimeGeometric(scale, bounds).make_noise(input_space)
```

<sup>1</sup>See new changes with `git diff f5bb719..86c6f12 rust/src/measurements/noise/distribution/geometric/mod.rs`

## Postcondition

**Theorem 1.1.** For every setting of the input parameters (`input_domain`, `input_metric`, `scale`, `bounds`, `DI`, `MI`, `MO`) to `make_geometric` such that the given preconditions hold, `make_geometric` raises an exception (at compile time or run time) or returns a valid measurement. A valid measurement has the following properties:

1. (Data-independent runtime errors). For every pair of elements  $x, x'$  in `input_domain`, `function(x)` returns an error if and only if `function(x')` returns an error.
2. (Privacy guarantee). For every pair of elements  $x, x'$  in `input_domain` and for every pair  $(d_{in}, d_{out})$ , where  $d_{in}$  has the associated type for `input_metric` and  $d_{out}$  has the associated type for `output_measure`, if  $x, x'$  are  $d_{in}$ -close under `input_metric`, `privacy_map(d_in)` does not raise an exception, and `privacy_map(d_in) ≤ d_out`, then `function(x), function(x')` are  $d_{out}$ -close under `output_measure`.

*Proof.* If bounds are supplied, this constructor builds a specialized mechanism that adds noise to the input data from the `ConstantTimeGeometric` random variable. Otherwise noise is added from the `DiscreteLaplace` random variable, which uses a logarithmic-time discrete laplace sampling algorithm.

Since `MakeNoise.make_noise` has no preconditions, the postcondition follows, which matches the postcondition for this function.  $\square$