An attempt to efficiently determine whether two data sets are “equivalent”

Instrument Analysis Workshop
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GLAST LAT

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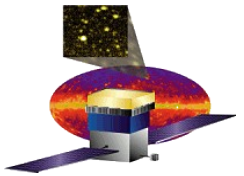
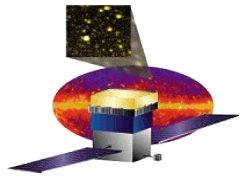


- Motivation
- Cross Validation and classification trees; an estimator whether two data sets are equal
- Application to artificial data
- Application to MC GLAST data
- Outlook

Task: Get the photons, discard the background



Method 1 (successful): Classification Trees (B. Atwood[1])

- Train Classification Tree with MC: all_gamma and background
- Run real data through CT

Method 2 (also successful): Manually (E. Bissaldi[2])

- Results from Method 1
- Use MC to compare with real data
- Make cuts, using physical insight

Method 3 (not even close): Manually, enhanced (Berenji, Bloom, Schmitt)

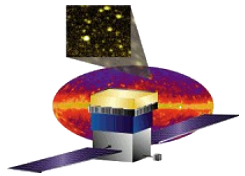
- Like Method 2: make MC all_gamma and real data equal, making physically intuitive cuts
- Then: use Mechanism(?) to see if they differ and where

[1] B. Atwood, *The 3rd Pass Back Rejection Analysis using V7R3P4 (repo)*, SCIPP/UCSC, 2006

[2] E. Bissaldi, *Raiders of the lost Photon*, IA Workshop 5, 2005

(?): Need suitable Mechanism to find differences between two datasets => this talk.

Motivation



Is MC data "equivalent" to GLAST ground data?

Ideal algorithm:

1. Two sets of bins: n bins per variable
2. "Fill" bins with MC and GLAST ground data
3. Define measurement to compare bin filling topology

But: 269 variables (think MeritTuple) → n^269 bins

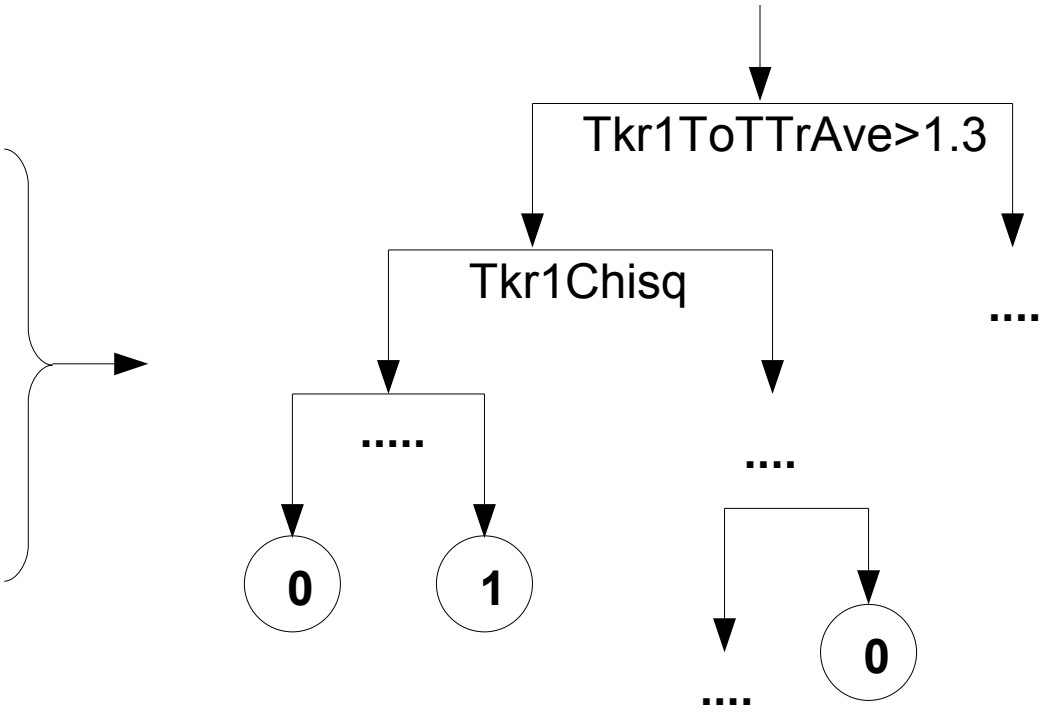
→ **Classification trees**

With traditional methods, comparing two large datasets is a daunting task.

Classification and regression trees

Example: B. Atwood's background rejection[3]

- sample s out of training data
- training data: MC of all_gamma and background
- $y(s) = \begin{pmatrix} 1 & (s \in \texttt{allgamma}) \\ 0 & (s \in \texttt{background}) \end{pmatrix}$

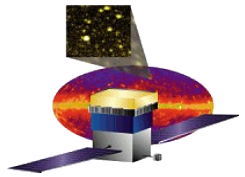


⇨ Feeding a sample of real data through the tree yields prediction (0 or 1)

[3] B. Atwood, *The 3rd Pass Back Rejection Analysis using V7R3P4 (repo)*, SCIPP/UCSC, 2006

A classification tree makes predictions on one variable ("y") from a new dataset. It is built from a training dataset for which y is known.

Classification trees with MC/Ground data



Is MC data "equivalent" to GLAST ground data?

→ **Classification trees**

Algorithm:

1. Two data sets `MCdata`, `Grounddata`
2. response variable y; sample s out of {`MCdata`, `Grounddata`}

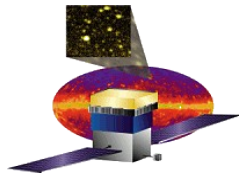
$$\texttt{y(s)} = \begin{pmatrix} \texttt{TRUE} & (\texttt{s} \in \texttt{MCdata}) \\ \texttt{FALSE} & (\texttt{s} \in \texttt{Grounddata}) \end{pmatrix}$$

3. generate CT from $\texttt{y} \sim \{\texttt{MCdata}, \texttt{Grounddata}\}$
4. Can CT distinguish between `MCdata` and `Grounddata`?

Point 4 is not yet clear: explanation follows

A C.T. is constructed and used to find differences between two datasets

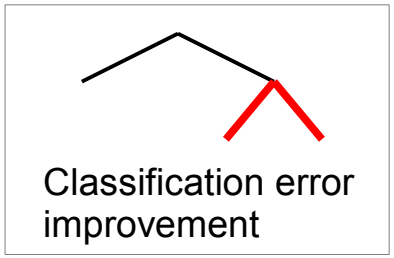
Quality of classification trees[3]



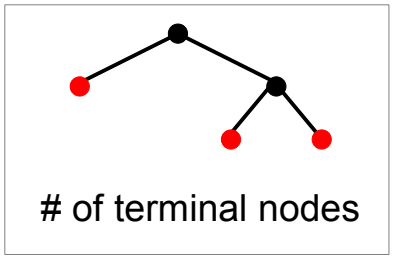
Breiman et al.[4]:

- complexity parameter `cp` (complexity punished growing/pruning):

Abort tree growth when:



$- \quad cp \; * \;$



$< \quad 0$

- 10-fold cross-validation of each `T(cp)`
- best tree: generated by the `cp` with least cross validation error `CVE`
- standard error $SE = \sqrt{s^2/N}$, with $s^2 = \langle CVE^2 \rangle - \langle CVE \rangle^2$

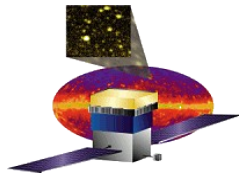
$\Rightarrow$ $CVE + SE < 0.5 \Rightarrow$ The two datasets are different.

~~$\Leftarrow$~~ $CVE \pm SE \approx 0.5 \Rightarrow$ The two datasets are (not necessarily) equivalent.

[4] L. Breiman et al., *Classification and Regression trees*, Thomson Science, 1984, New York

The classification error (from cross validation) is a measure for equivalence.

Test the algorithm: Create two hypothetical data sets



Common properties of `simMCdata`, `simGLASTdata`

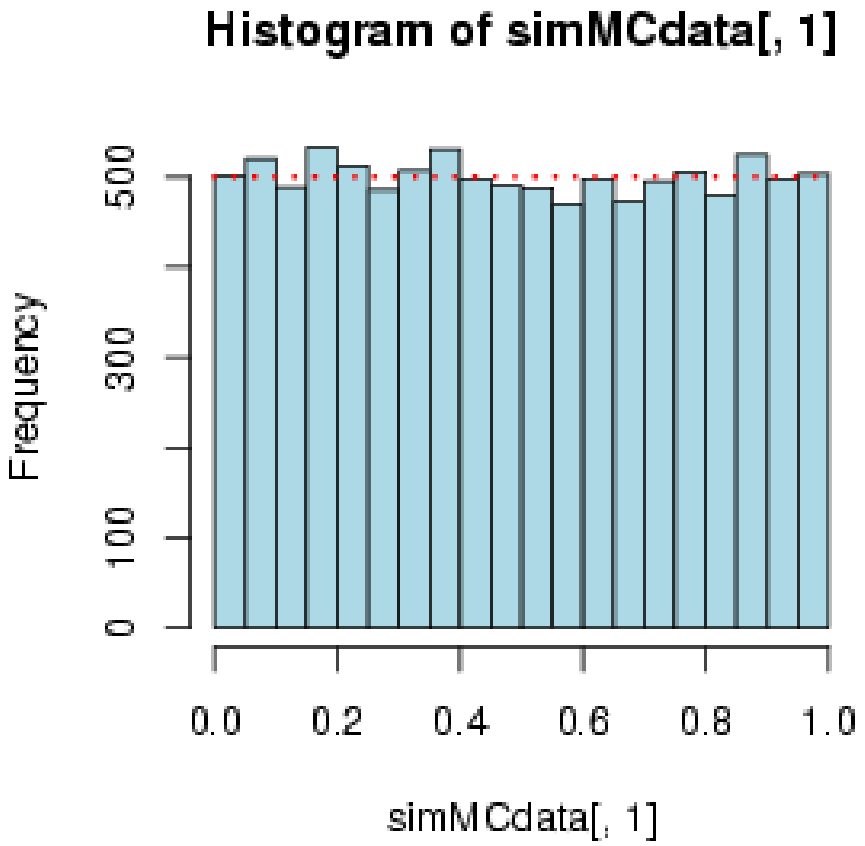
- 300 variables
- generated from uniform random distribution between [0, 1]

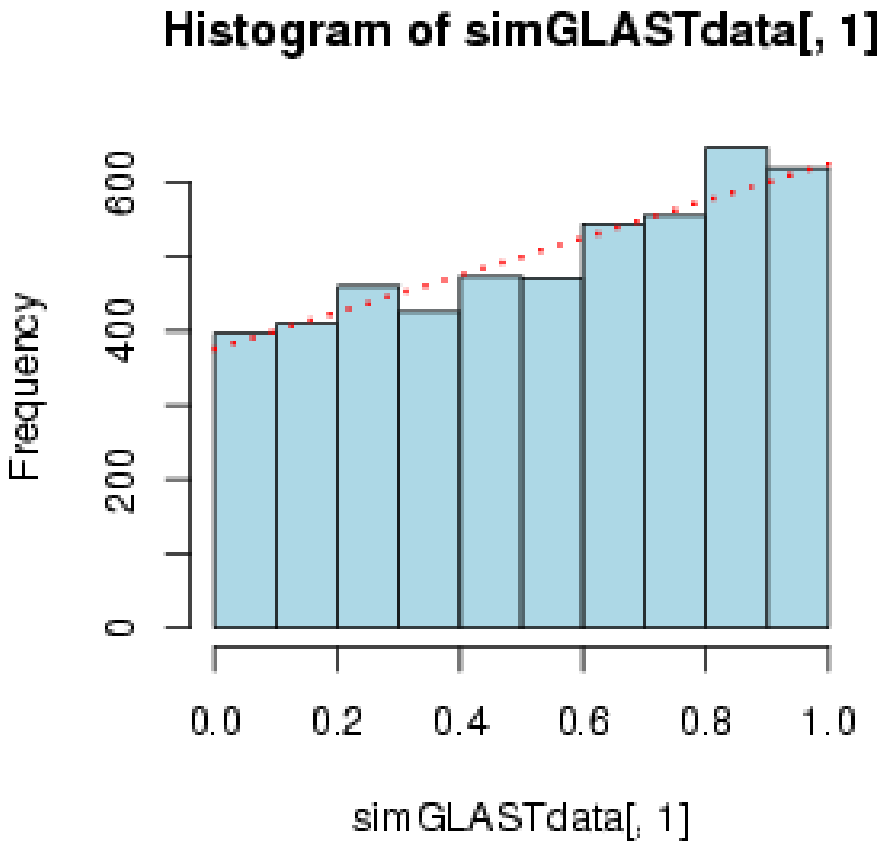
Differences of `simMCdata` and `simGLASTdata`

- `simMCdata`: 10k events
- `simGLASTdata`: 5k events
- distribution difference in first variable

simGLASTdata and simMCdata are purely hypothetical datasets to test the C.T. They have ABSOLUTELY NO physical meaning.

Two fake data sets

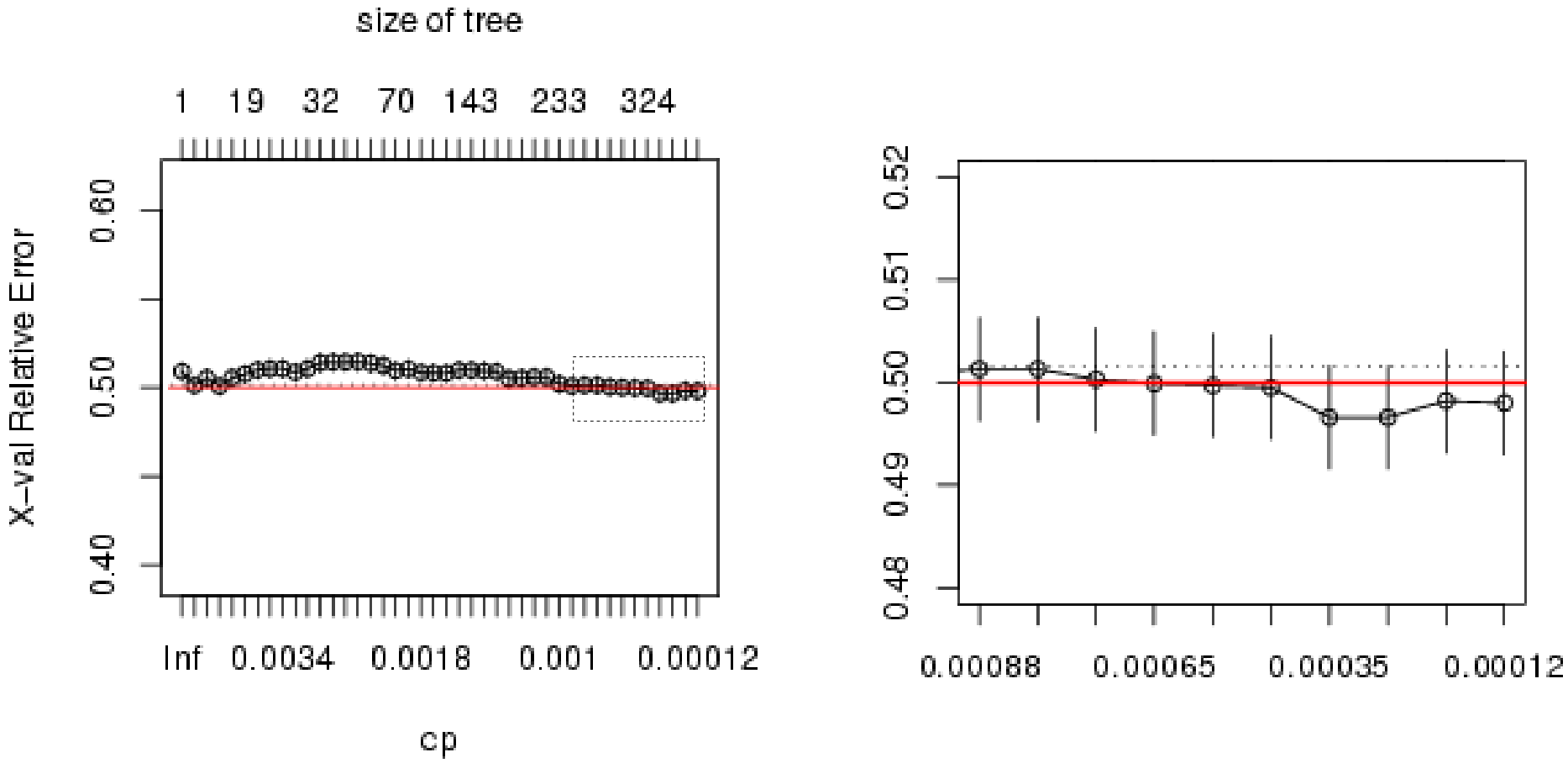




- distribution in simGLASTdata slanted by atan(0.5)

Distribution difference of the two fake datasets

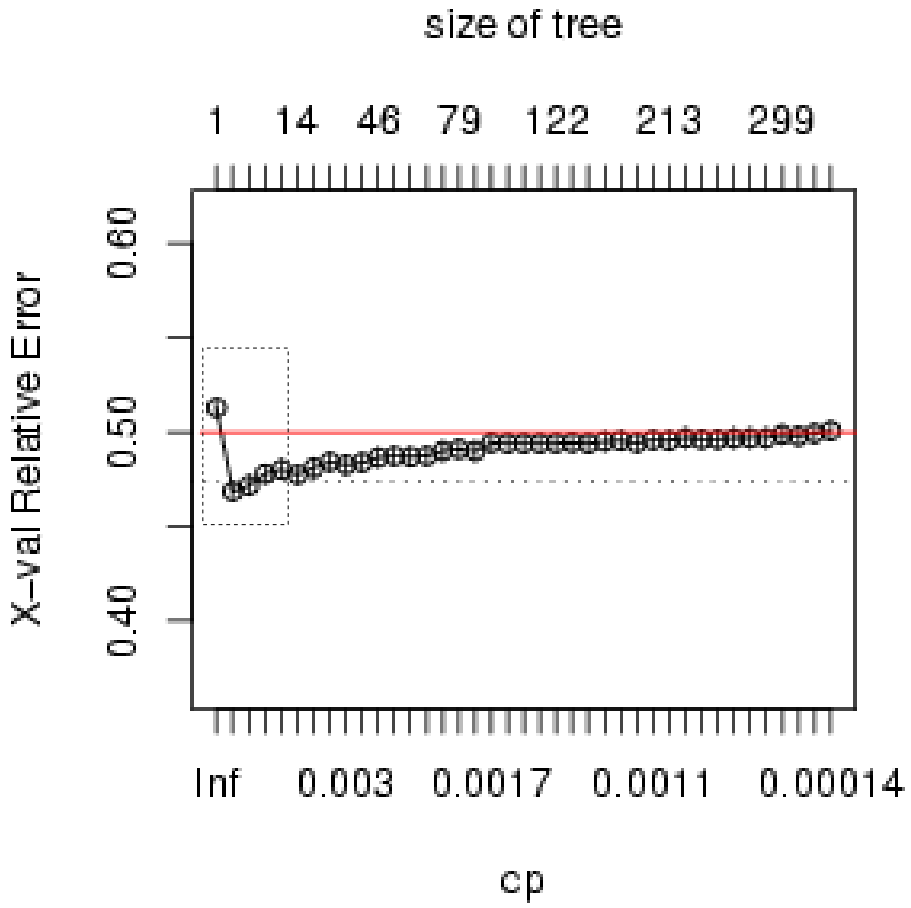
Check I: compare two equivalent data sets

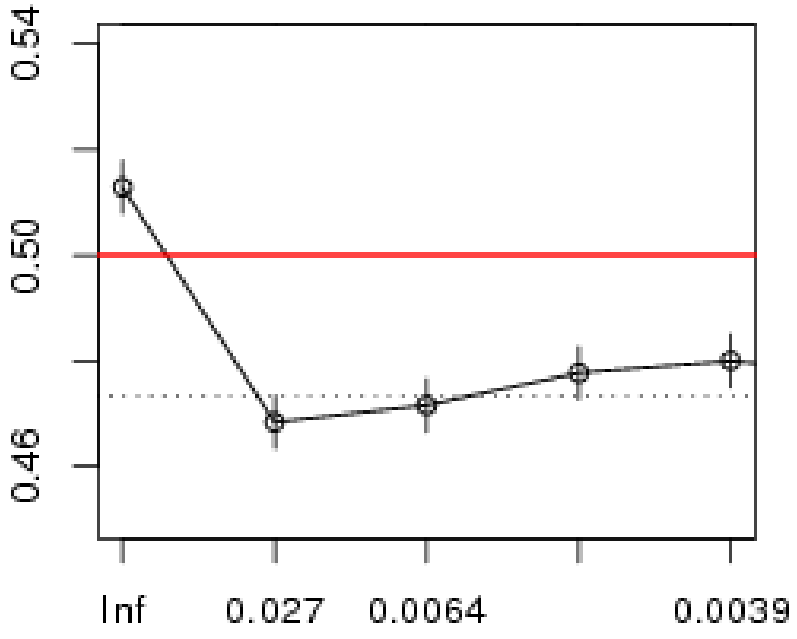


- simMCdata is randomly split in half and compared to itself

As expected, C.T.s are not able to find a difference between two equal data sets

Check II: does the C.T. find our prepared difference?

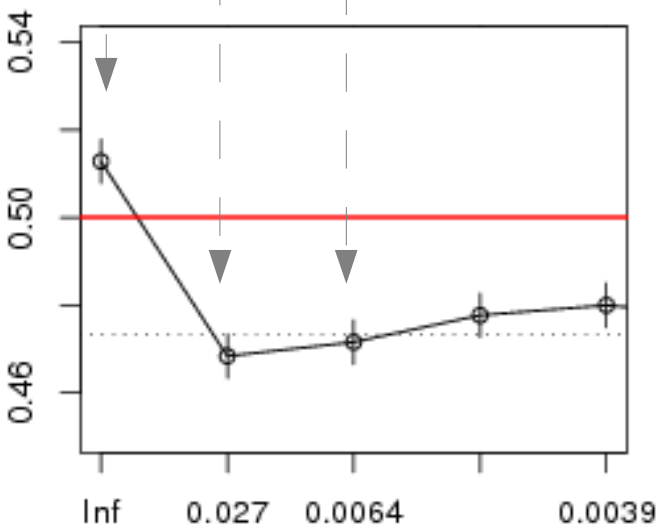


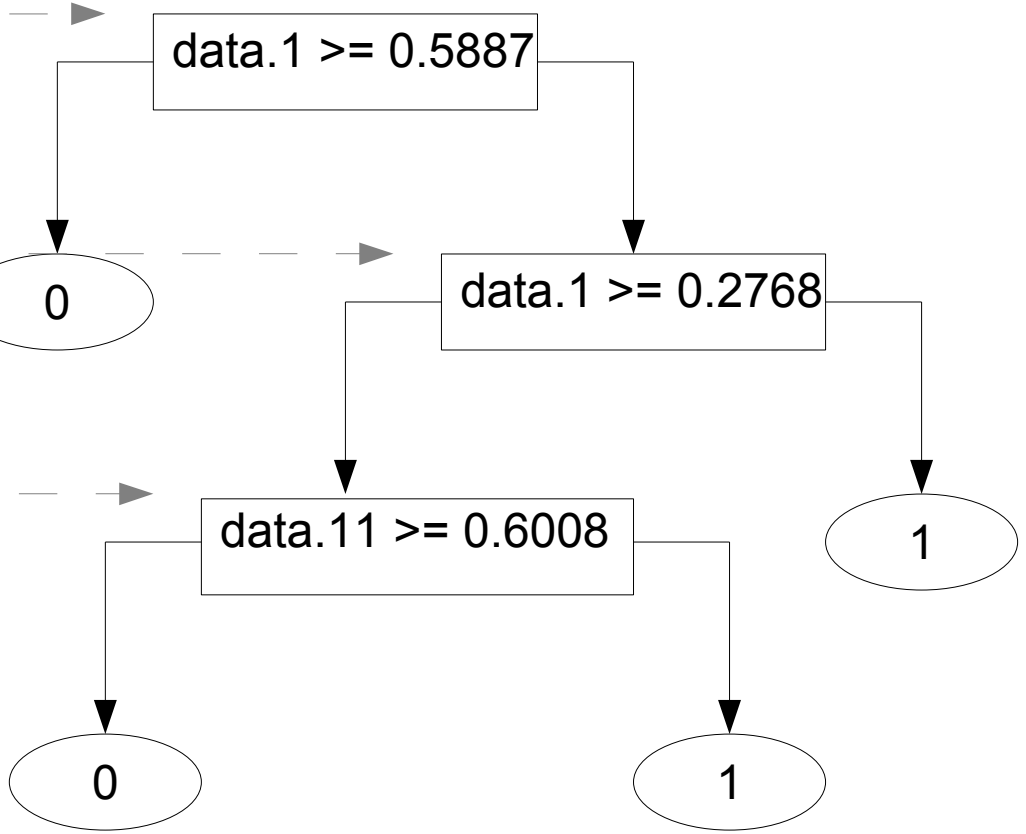


- simMCdata is compared to simGLASTdata

The C.T. found a difference between the two fake datasets with different histograms.

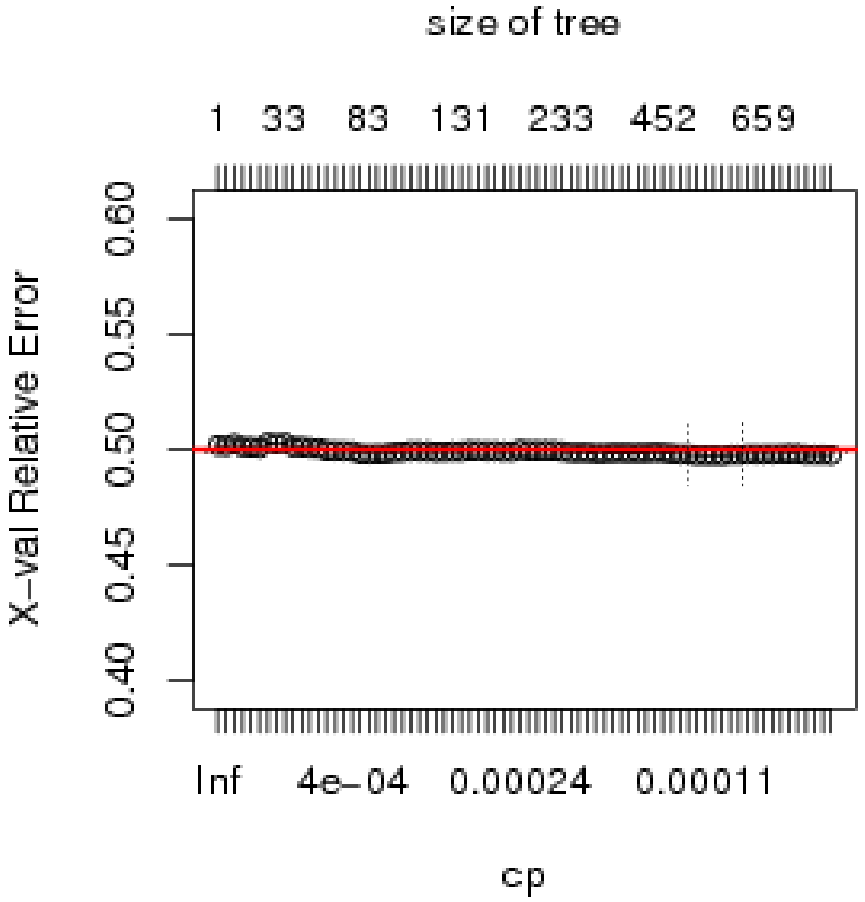
Check III: They are different, but where?

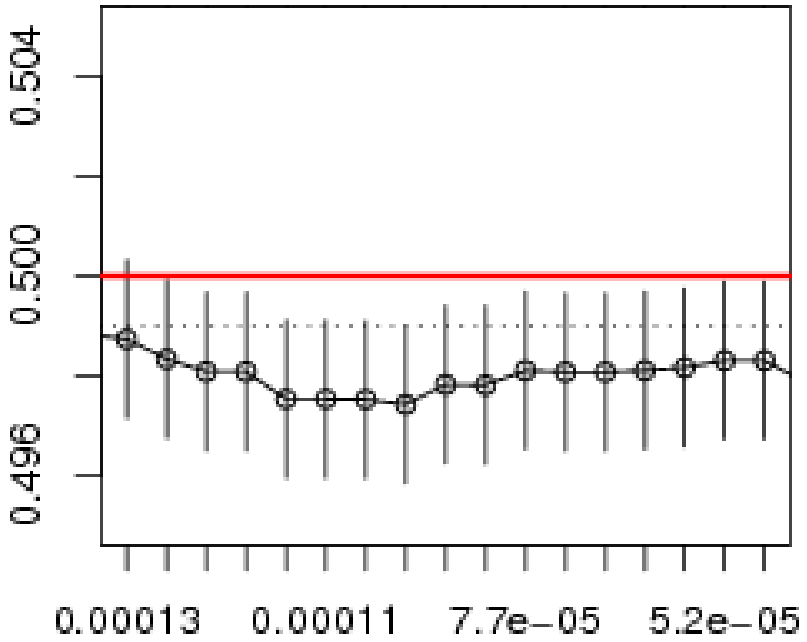




C.T.s also give (limited) information about where the differences originate.

Reality: compare (actual) MC data to itself

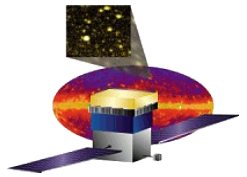




- the first 100k events from `all_gamma_10Mev20GeV_4M_merit`
- split in half, compared to itself

As expected, C.T.s are not able to find a difference between two equal data sets

Why I like R:



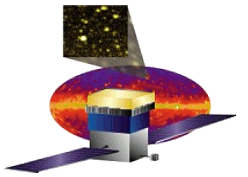
The entire code for everything I have said so far is exactly this:

```
# this grows me the classification tree:
fit <- rpart(y ~ data, method="class", minbucket=25, cp=1e-5)

# due to some (of course undocumented) funkiness in the module
# rpart, the cross-val error gets scaled with the resub. error
# of the (left split) of the root node. Reverse this:
fit$cptable[,3:5] <- diffReal$frame$yval2[1,4] * fit$cptable[,3:5]

# plot out x-val classification error in dependence of cp:
plotcp(fit)
```

BUT: only “documentation” of rpart is the source code itself :-(

The classification error (from cross validation) is a measure for equivalence.

Problems & Outlook



Problems:

- R memory consumption high: 1.3GB for 100,000 samples
- `rpart` may not grow trees optimally
- No pre-prepared ground data available yet

Outlook:

- choose another CT implementation (maybe in c/c++)
- try `gbm` or `rforest` package for more accuracy? (if needed)
- compare actual MCS and Ground data

Thank you:

- Elliott Bloom
- Eduardo do Couto e Silva
- Bijan Berenji