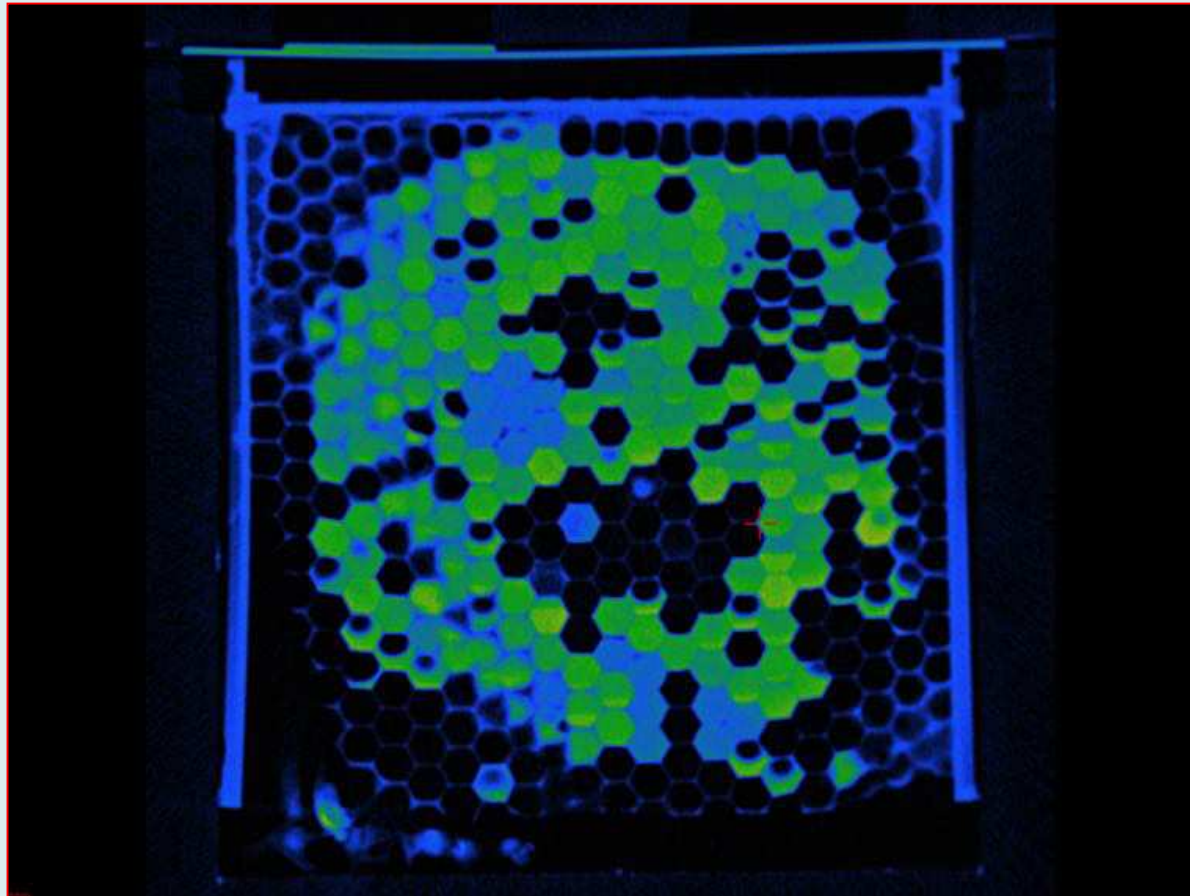


ASSESSING DECISION MAKING IN STORER HONEYBEES USING DIAGNOSTIC RADIOENTOMOLOGY: DO HONEYBEES EXHIBIT OPTIMAL STORAGE STRATEGIES?

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We tried to Mark and Track Varroa using Diagnostic Radioentomology (DR)

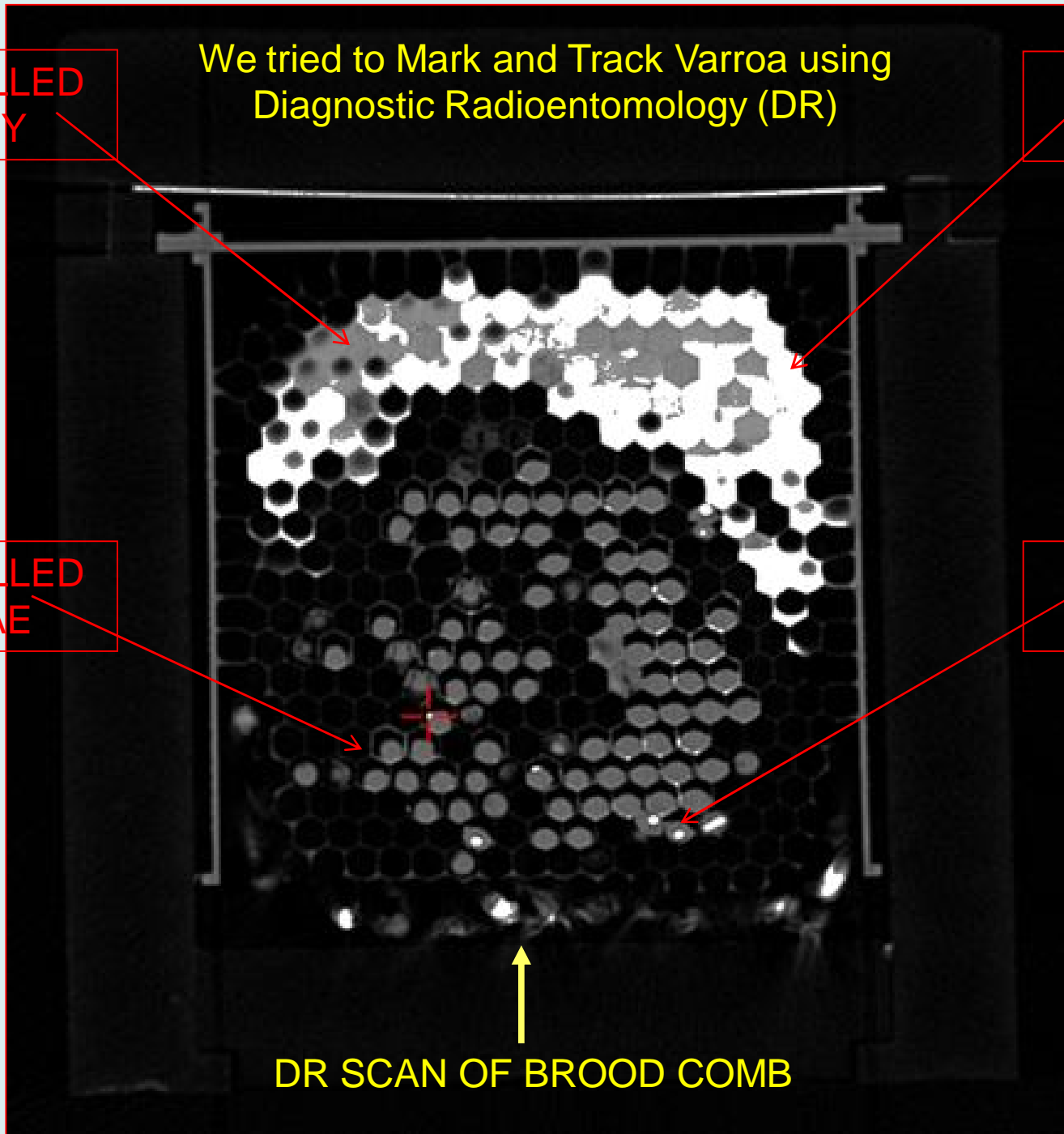
UNLABELLED HONEY

LABELLED HONEY

UNLABELLED LARVAE

LABELLED LARVAE

DR SCAN OF BROOD COMB



THE NEW EXPERIMENT

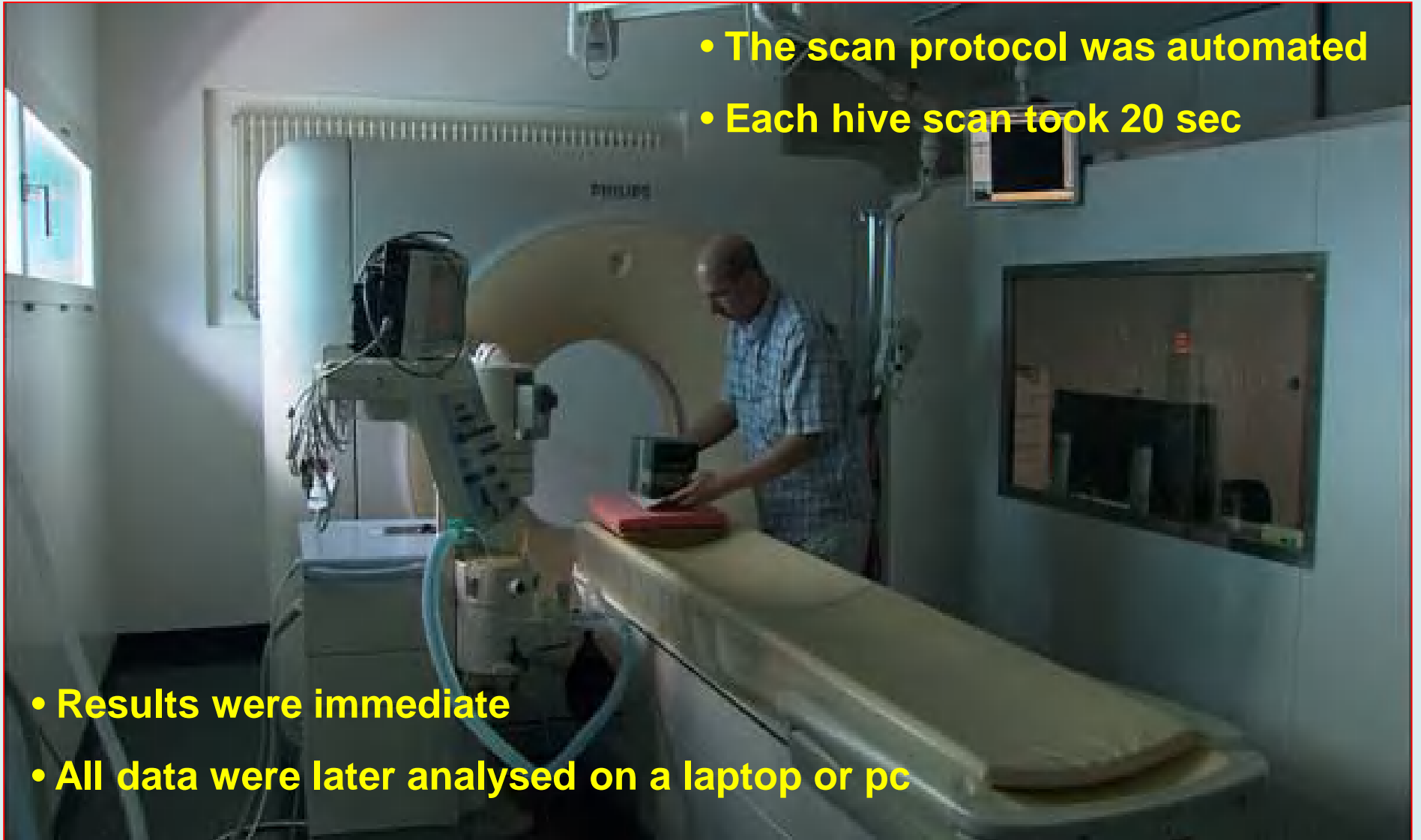
We explored, **using DR**, the honey storage behaviour of bees from nine *Apis mellifera* colonies that were fed solutions with three different sugar concentrations.

M&M's

- 9 closed Apidae hives
- Each hive contained one physogastric, actively laying queen and approximately 1000 workers aged between 1 and 28 days
- Each hive contained 1 control (unlabelled) and 1 treatment (labelled) feeder
- Control food - 50% sucrose solution
- **T1** – 30% sucrose, **T2** – 50% sucrose , **T3** – 70% sucrose (labelled food)
- Hives were scanned 48 hours after introduction of bees, combs and food

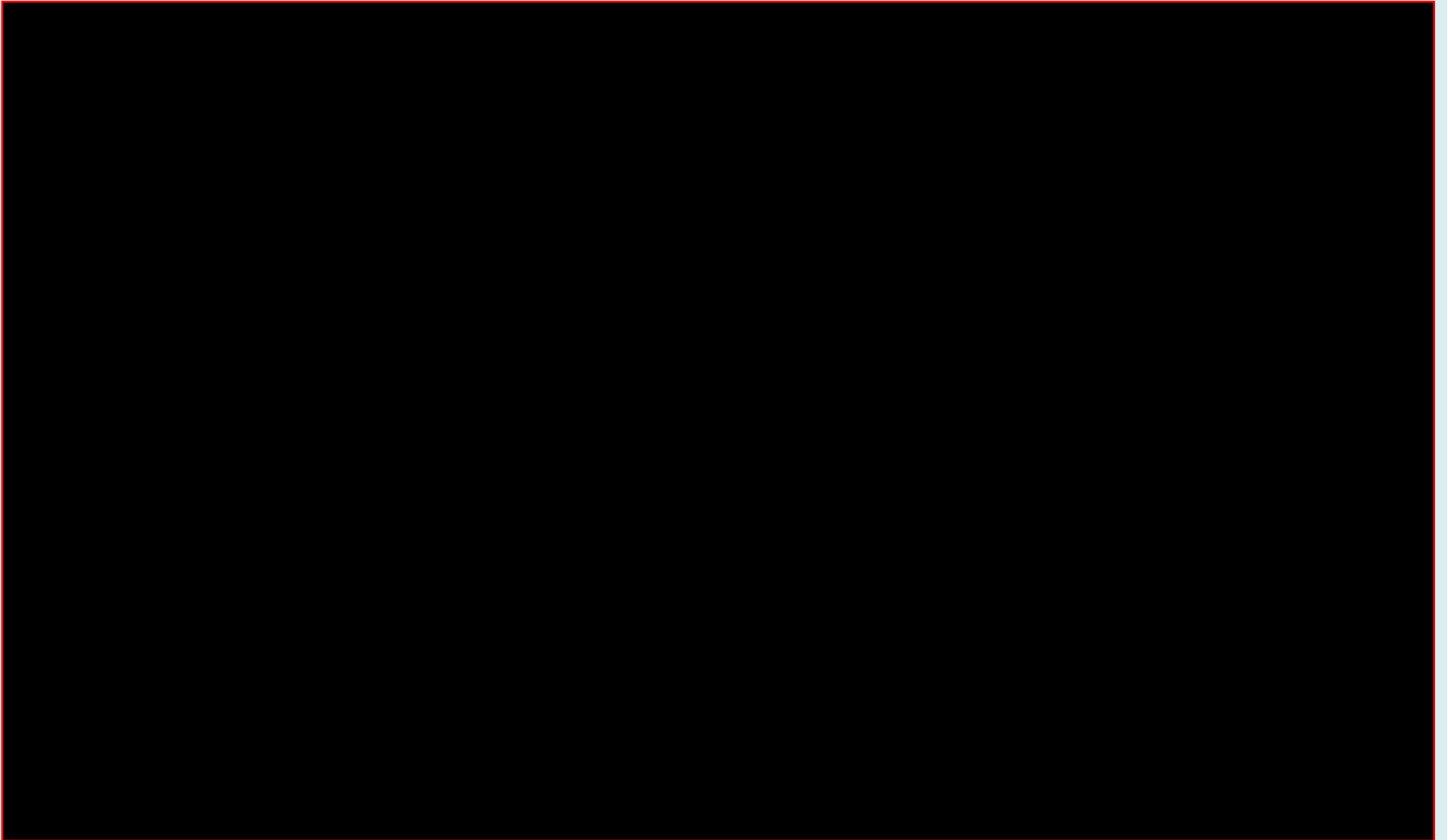
Positioning the Apidae hive for scanning

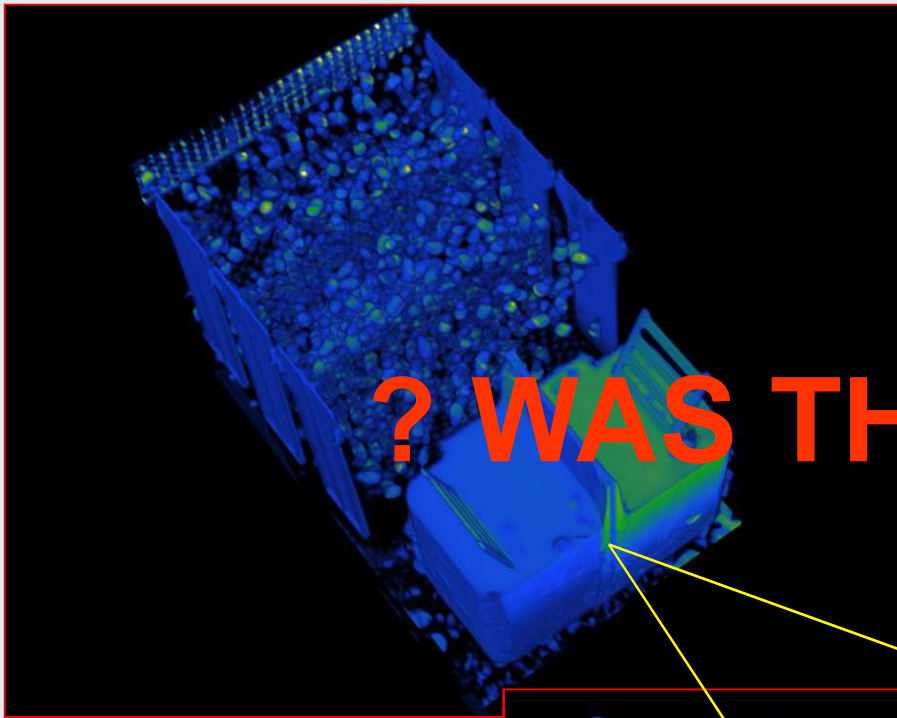
- The scan protocol was automated
- Each hive scan took 20 sec



- Results were immediate
- All data were later analysed on a laptop or pc

Apidae hive movie





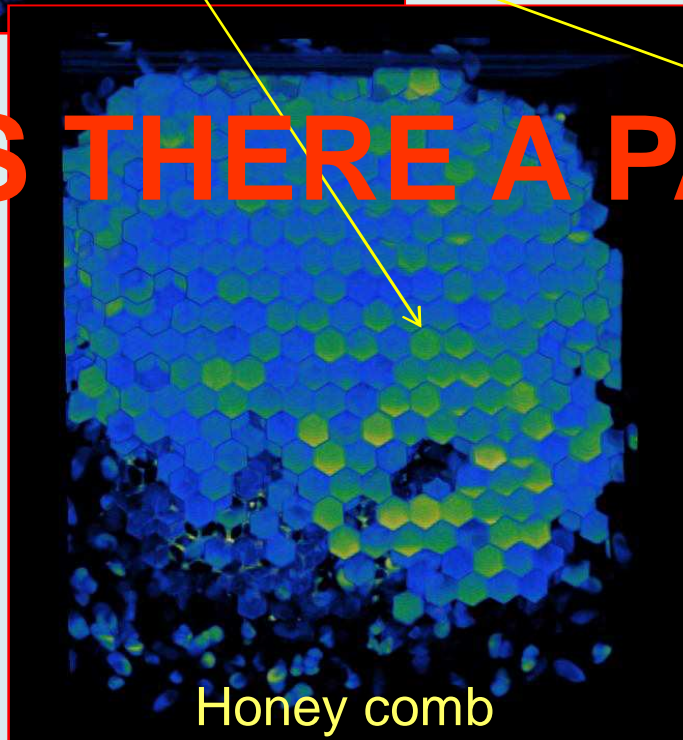
Closed Apidae hive with
labelled
and
unlabelled food

? WAS THIS RANDOM

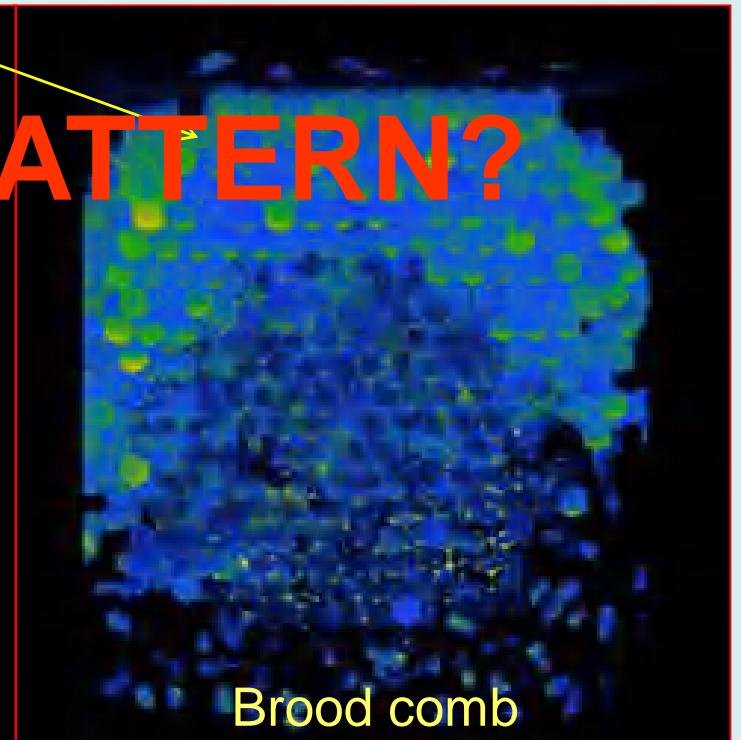
OR

WAS THERE A PATTERN?

Differing storage
patterns



Honey comb



Brood comb

HONEY COMB

IF IT IS RANDOM
This would happen

SUCROSE FEEDER

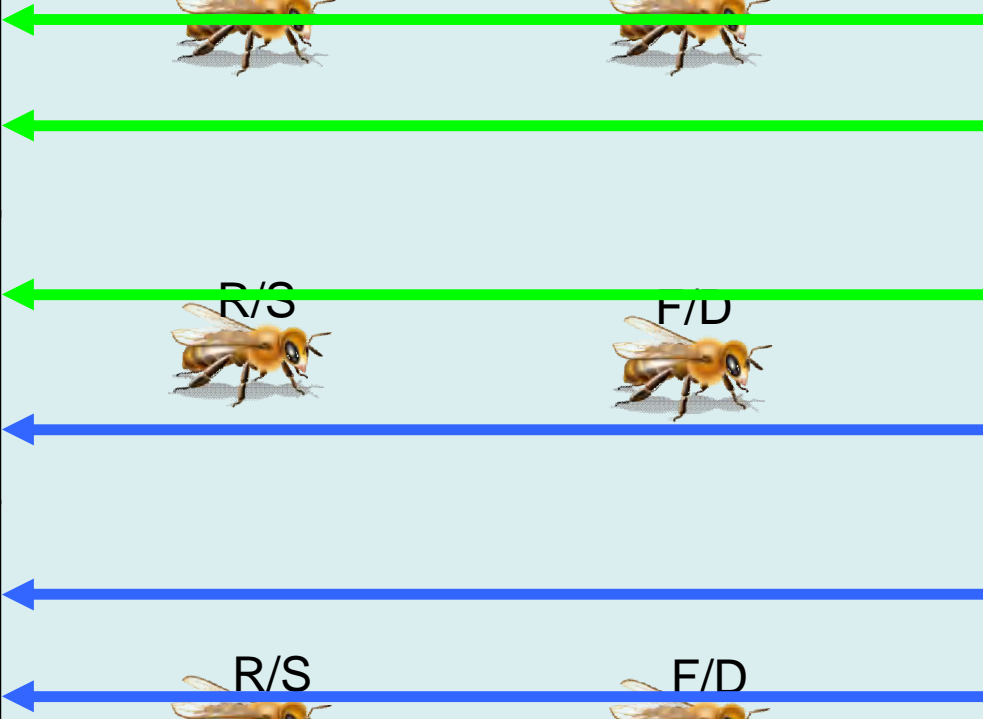
CELLS WITH
CONTRAST

CELLS
WITH
SUCROSE
AND
CONTRAST

CELLS WITH
SUCROSE

30%
OR
70%

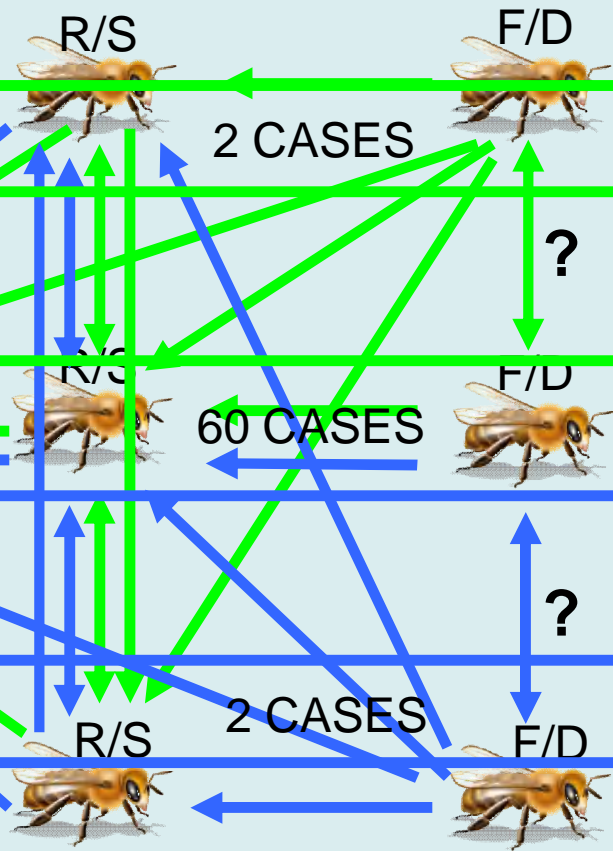
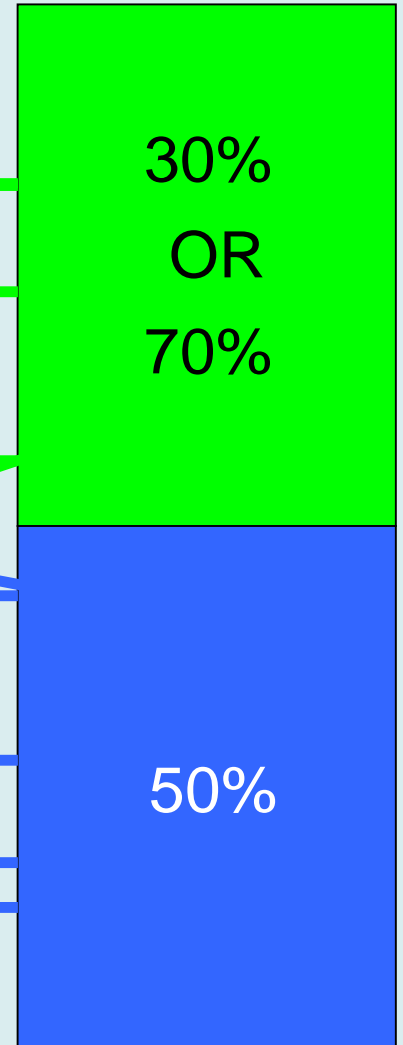
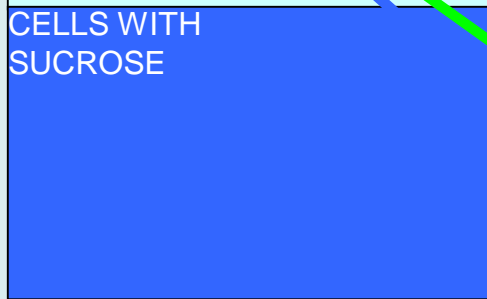
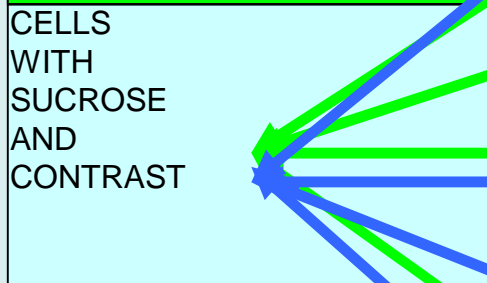
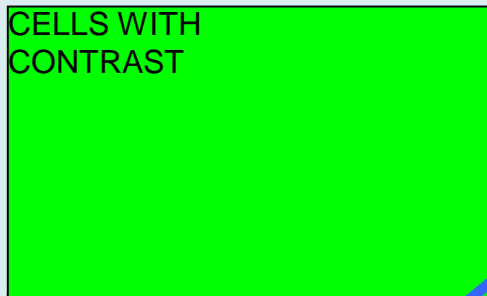
50%



HONEY COMB

“Theoretical” honey storage ratio

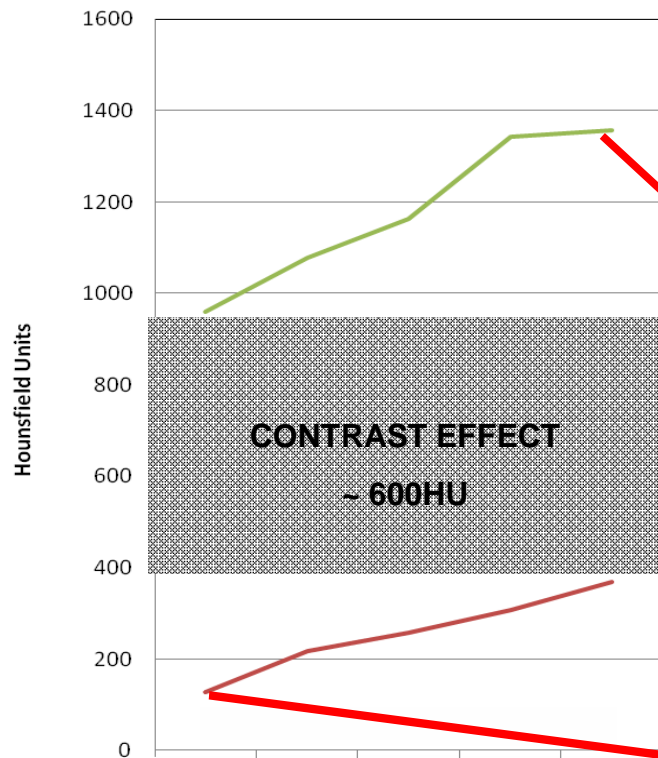
SUCROSE



“Theoretical RANDOM RATIO”

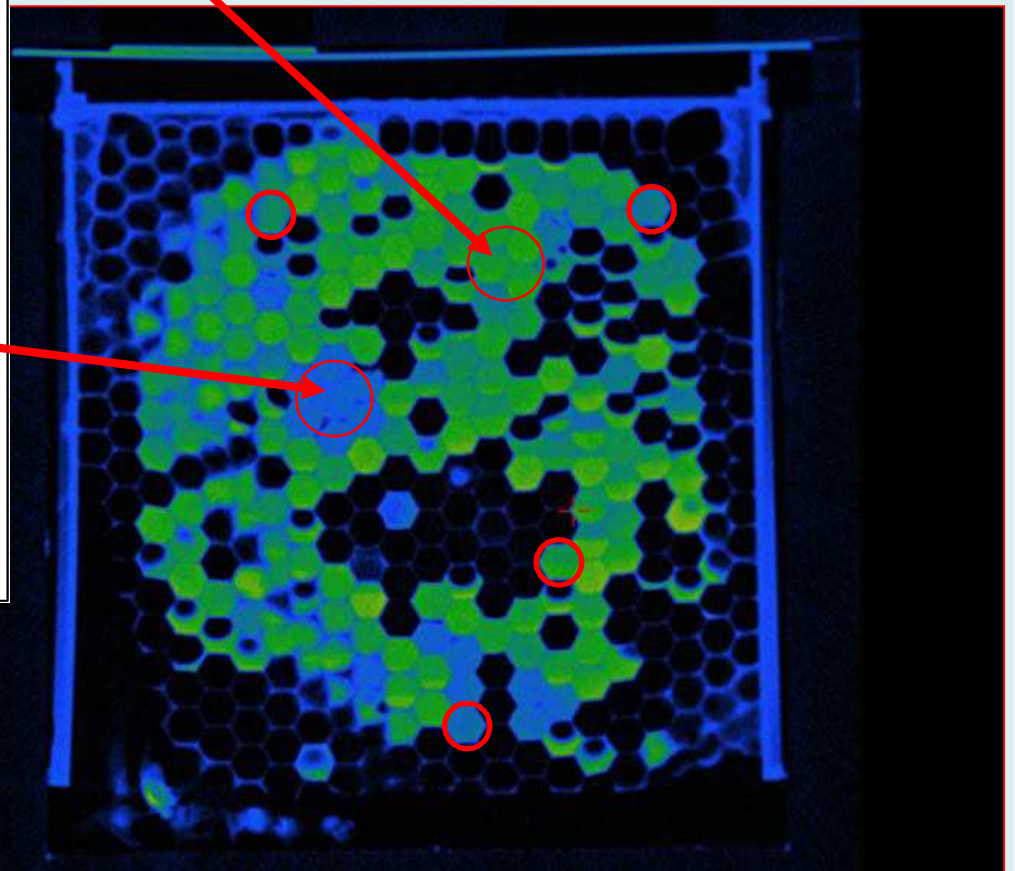
1 : 30 : 1

HONEY DISTRIBUTION (HU) STANDARD CURVE



| SUCROSE CONCENTRATION (%) | 30 | 50 | 60 | 70 | 80 |
|----------------------------|-------|-------|-------|--------|--------|
| — SUCROSE SOLUTION HU | 128.8 | 217.3 | 256.8 | 307.6 | 369 |
| — SUCROSE/VISIPAQUE 10% HU | 958.8 | 1078 | 1162 | 1343.8 | 1356.1 |

We then developed a standard curve using DR based on honey density
(SUGAR CONCENTRATION)



STATISTICS

Honey storage frequency ratios

- Using the standard curve each cell was allocated a HU (Based on sugar concentration)
- We compared the frequencies of cells (2790 data points) to the theoretical random honey storage frequency ratio (1:30:1) for the nine hives

STATISTICS

Distribution of storage cells on combs

- We tested the distribution of labelled and unlabelled honey for uniformity
- The uniformity tested was given by the null hypotheses that the HU of the honey (plus a random fluctuation) is the same in each cell
- The tests were on normal distribution of HU (Shapiro Wilk, Anderson-Darling and Kolmogorov-Smirnov-Lilliefors)

STATISTICS

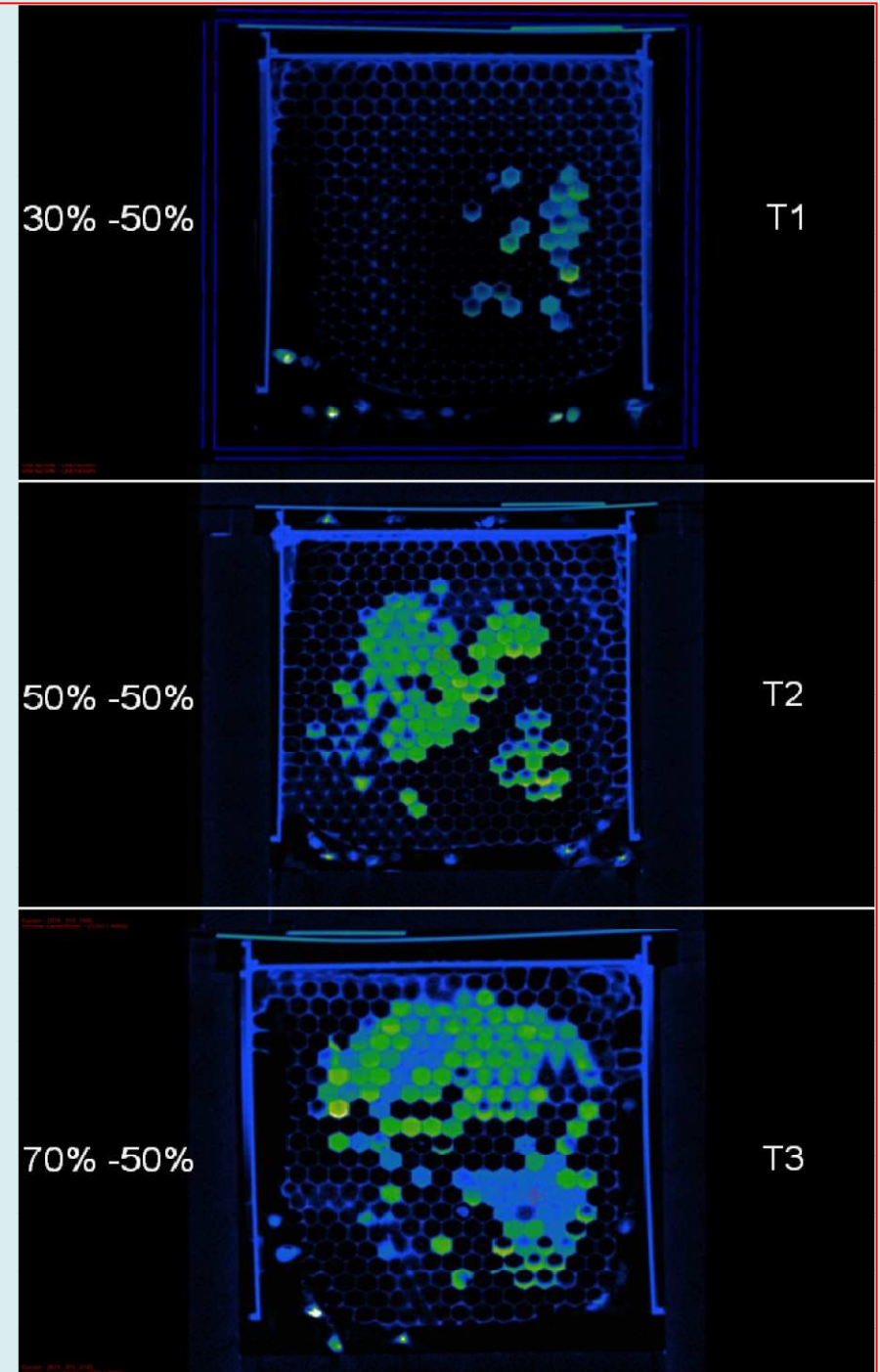
Sugar concentration vs distance from brood centre

- We tested correlations between sugar concentrations (HU) within cells and their Euclidean vector distances from the brood centre
- Brood centre was estimated by locating the centre of the three dimensional brood co-ordinates (on-screen)
- Spearman correlations and Kruskal-Wallis tests for T1, T2, T3 and pooled results were performed to compare the honey sugar concentrations in cells with Euclidean vector distances from brood centre.

Results

Theoretical Random Ratio: 1 : 30 : 1

- T1 honey storage frequency ratio: 1:2:1
($p < 0.001$) i.e. **NOT RANDOM**
- T2 honey storage frequency ratio: 3:1:3
($p < 0.001$) i.e. **NOT RANDOM**
- T3 honey storage frequency ratio: 1:2:4
($p < 0.001$) i.e. **NOT RANDOM**



Results

Distribution of storage cells on combs

- Bees did not show preferences for labeled or unlabelled food
- The null hypothesis was not rejected for T1. This could be related to smaller sample size leading to low power for the test for T1
- The null hypothesis was rejected for T2 and T3
- For T2 and T3 the labelled food was stored in groups or patches by the bees

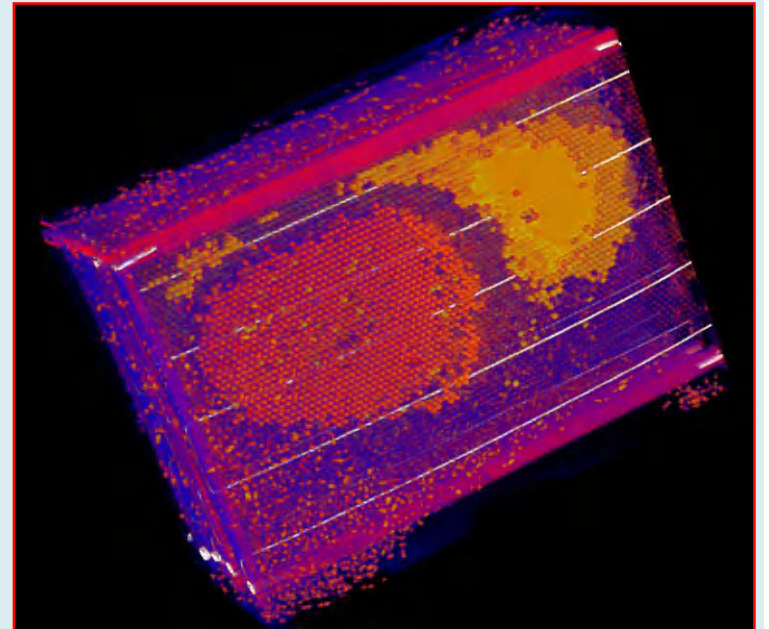
Results

Sugar concentration vs distance from brood centre

- The sugar concentrations in cells for T2 and T3 were statistically different and were grouped together
- Correlations between honey sugar concentrations within cells and their Euclidian distances from the brood centre for the three treatments were very weak
- The results indicate that there were no significant relationships between honey sugar concentrations and a cell's distance from the brood centre.

Discussion

- Our results suggest that at least for 50% and 70% nectar sugar concentrations bees store honey in a non-random way
 - This indicates that decision making in storer bees is influenced by nectar sugar concentrations
 - Bees store nectar with similar sugar concentrations in groups or patches
 - Patchy spatial cell distributions, might help to hasten the ripening process (Pers comm., Tom Seeley 2010)
 - Colonies that exhibit optimal storage behaviours such as these would have an evolutionary advantage and improved colony survival expectations over less efficient colonies
- **More DR experiments to follow**



Acknowledgements

- Karl Crailsheim (Knowledge and discussion)
- Tom Seeley (Insight into bee behaviour)





**THANK
YOU**