

Pisa group simulation updates

BULLKID digest meeting 11/12/25

Tommaso Lari

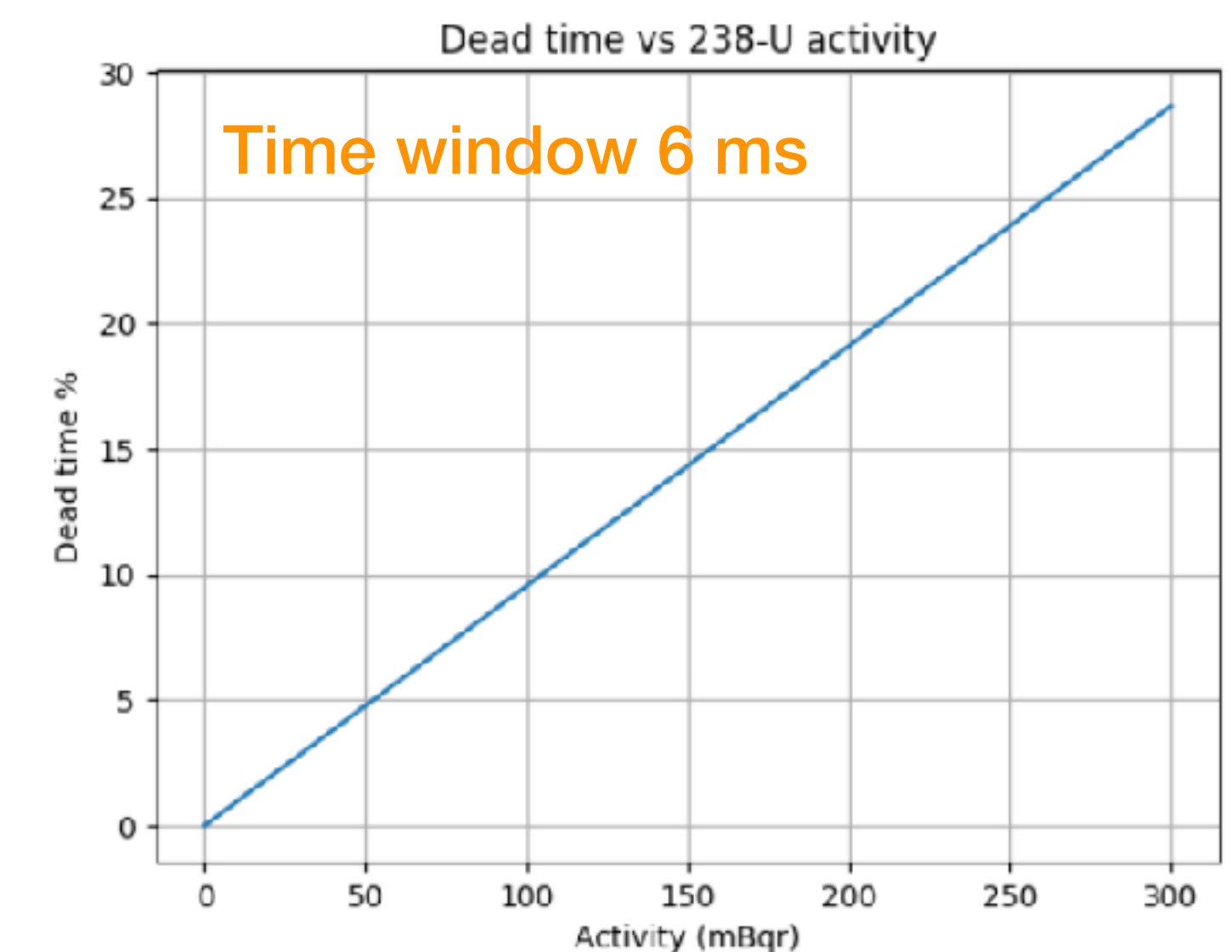
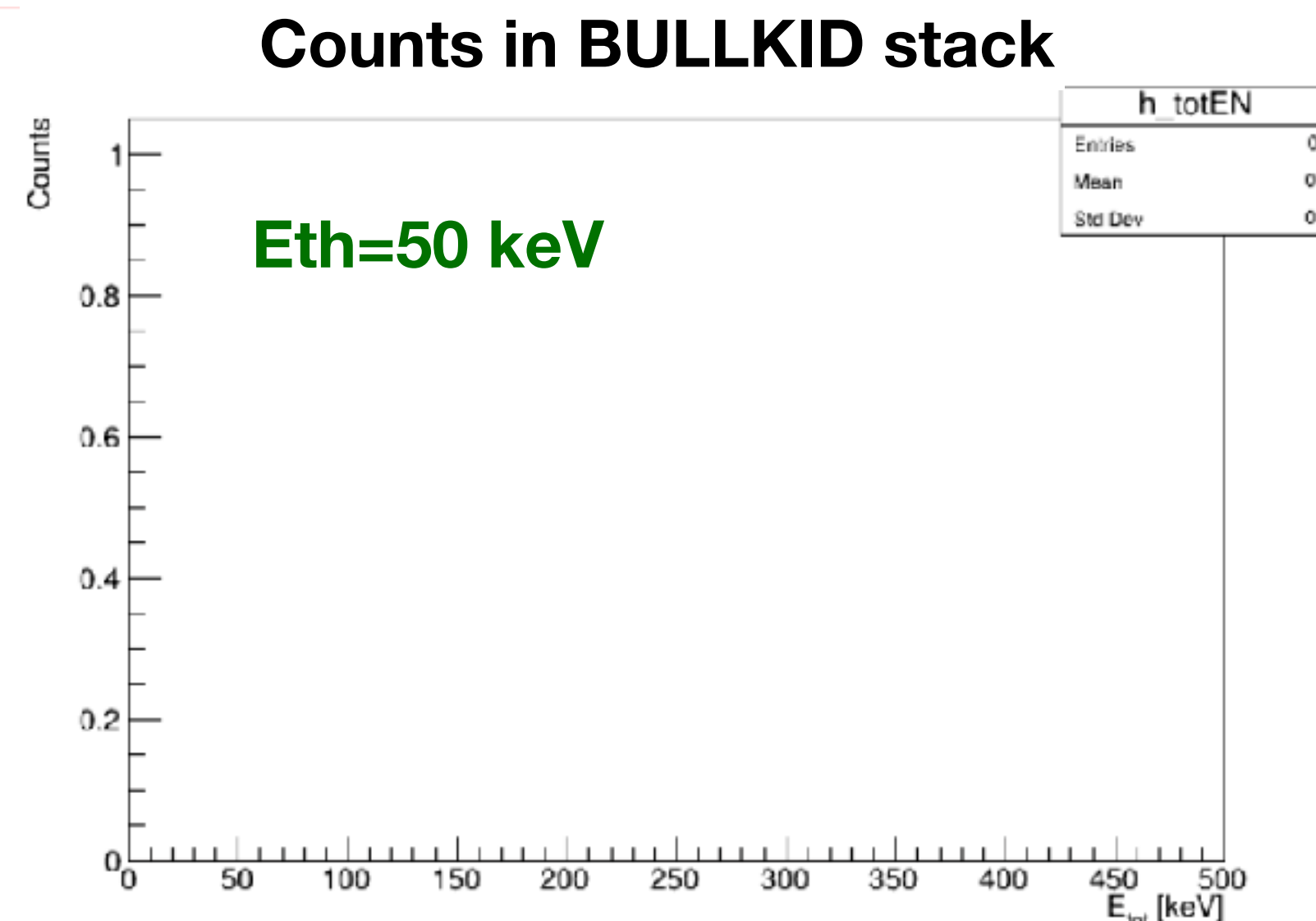
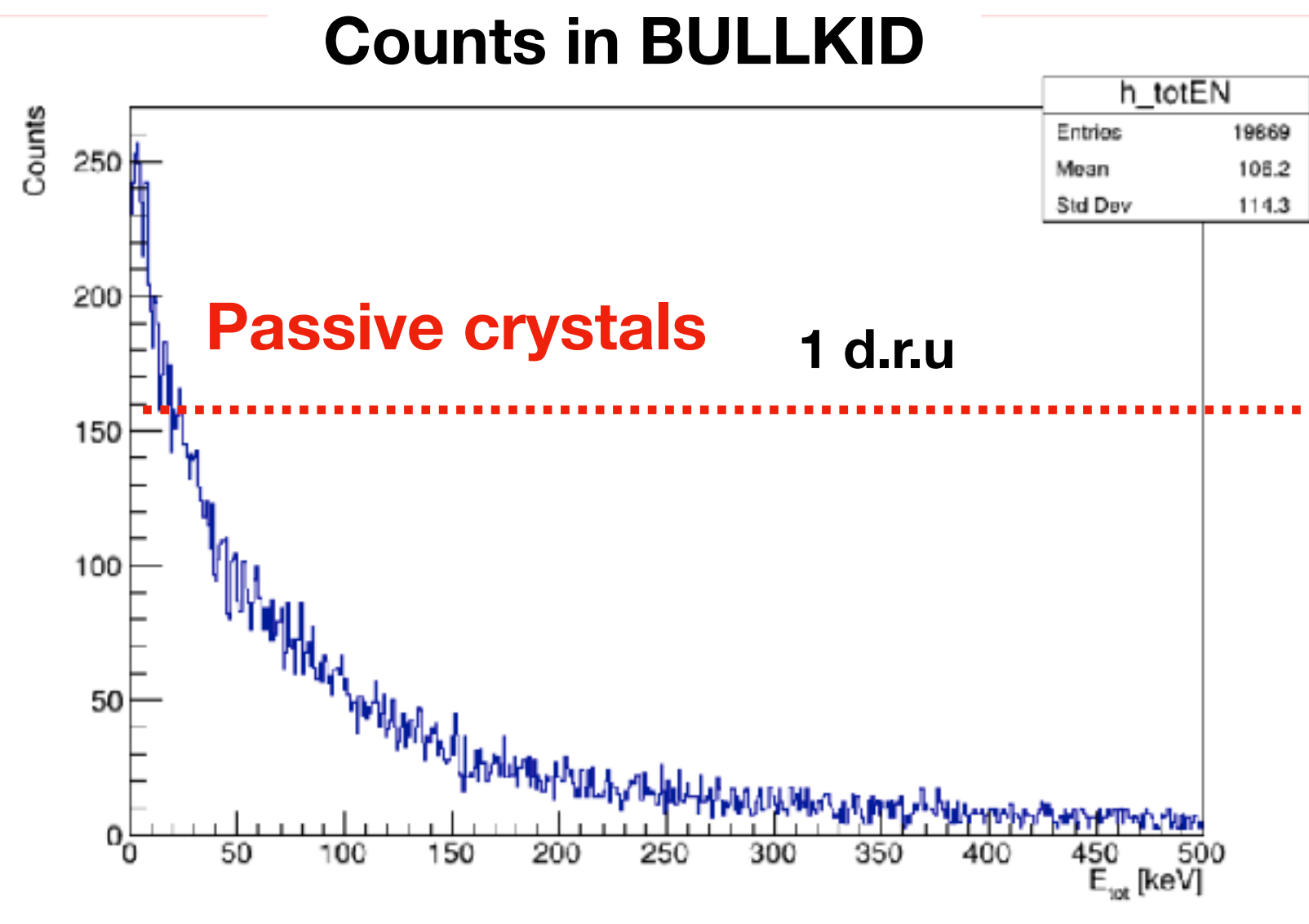


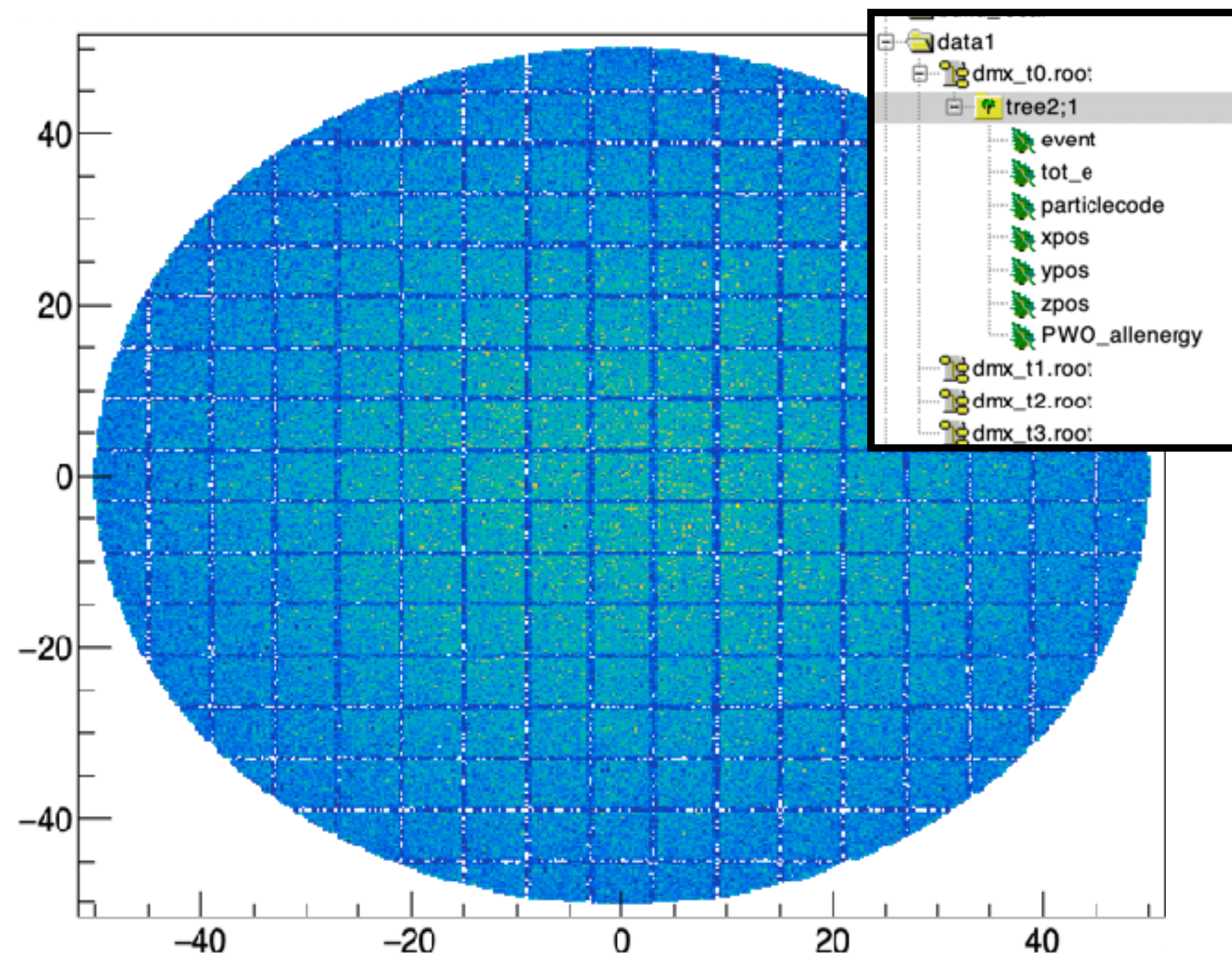
Background due to veto crystals activity

1

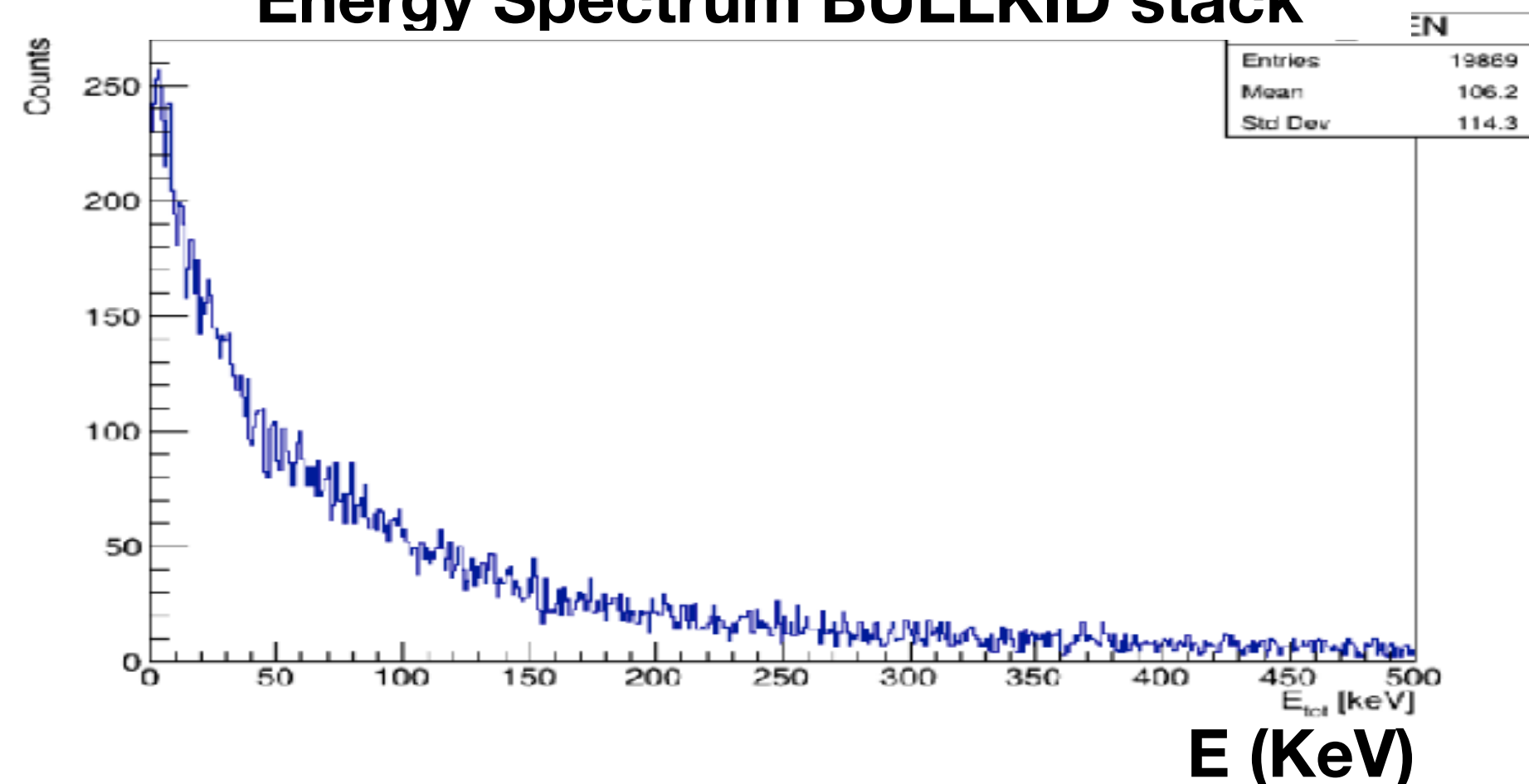
- Improved modelling of **background induced by crystals**
- **Decays:** ^{238}U , ^{232}Th , ^{214}Bi
- **Before:**
 - included only gamma emission-> too pessimistic
- **Now:**
 - **Included α and β emission (α quenching 1/5)**
- **Preliminary result:**
 - **The veto can detect it's self radiation**
- **Implication:**
 1. **Constraint on crystal activity relaxed**
 2. **Activity limited by experiment dead time**

Configuration # 4 (inner veto):
Shields (side): 30 mm BGO Veto +30 mm Cu
Mass= 219 kg
Veto Mass= 74 kg





Energy Spectrum BULLKID stack



Sim output (directly from geant4)-> All hit (energy deposit) at position (x,y,z) mm

1. From the hit position (x, y, z), determine which part of the detector stack was hit:
Wafer Number Nz, Die Number (Nx, Ny) Optional:
common disk , half-moons
2. Evaluate x-talk
3. Sum all hits contributing to the amplitude of the same KID
4. Use Veto information (if the veto is present)
5. Detector Logic And Event Selection:
 - Which dice are “master” or used for anticoincidence
 - Perform selection cuts
6. Generate final Output

Idea: to have a common software to process simulation output

Final Output-> BULLKID Energy spectrum

BULLKIDSimAnalysis

Private

Watch0

main

1 Branch

0 Tags

Go to file

Add file

Code

TomL90

Update requirements section in README

da22070 · yesterday

9 Commits

AnalysisConfig	First Commit of BullkidSimAnalysis project	yesterday
Data/ExampleData/DataIn	Re-add smaller ROOT files and update .gitignore	yesterday
DetectorConfig	First Commit of BullkidSimAnalysis project	yesterday
apps	First Commit of BullkidSimAnalysis project	yesterday
include	First Commit of BullkidSimAnalysis project	yesterday
src	First Commit of BullkidSimAnalysis project	yesterday
test	First Commit of BullkidSimAnalysis project	yesterday
.gitattributes	Stop tracking .root files with Git LSF	yesterday
.gitignore	Re-add smaller ROOT files and update .gitignore	yesterday
CMakeLists.txt	First Commit of BullkidSimAnalysis project	yesterday
README.md	Update requirements section in README	yesterday

README

BULLKIDSimAnalysis

Framework to process BULLKID Geant4 simulations into detector-level energy spectra with detector geometry, crosstalk modeling, and event selection.

Installation

Requirements

- CMake ≥ 3.12
- C++17
- ROOT

Build Instructions

Clone the repository

```
git clone https://github.com/TomL90/BULLKIDSimAnalysis.git
cd BULLKIDSimAnalysis
```

Create a build directory, configure with cmake and compile

```
mkdir build
cd build
cmake ..
make
```

Packages

No packages published
[Publish your first package](#)

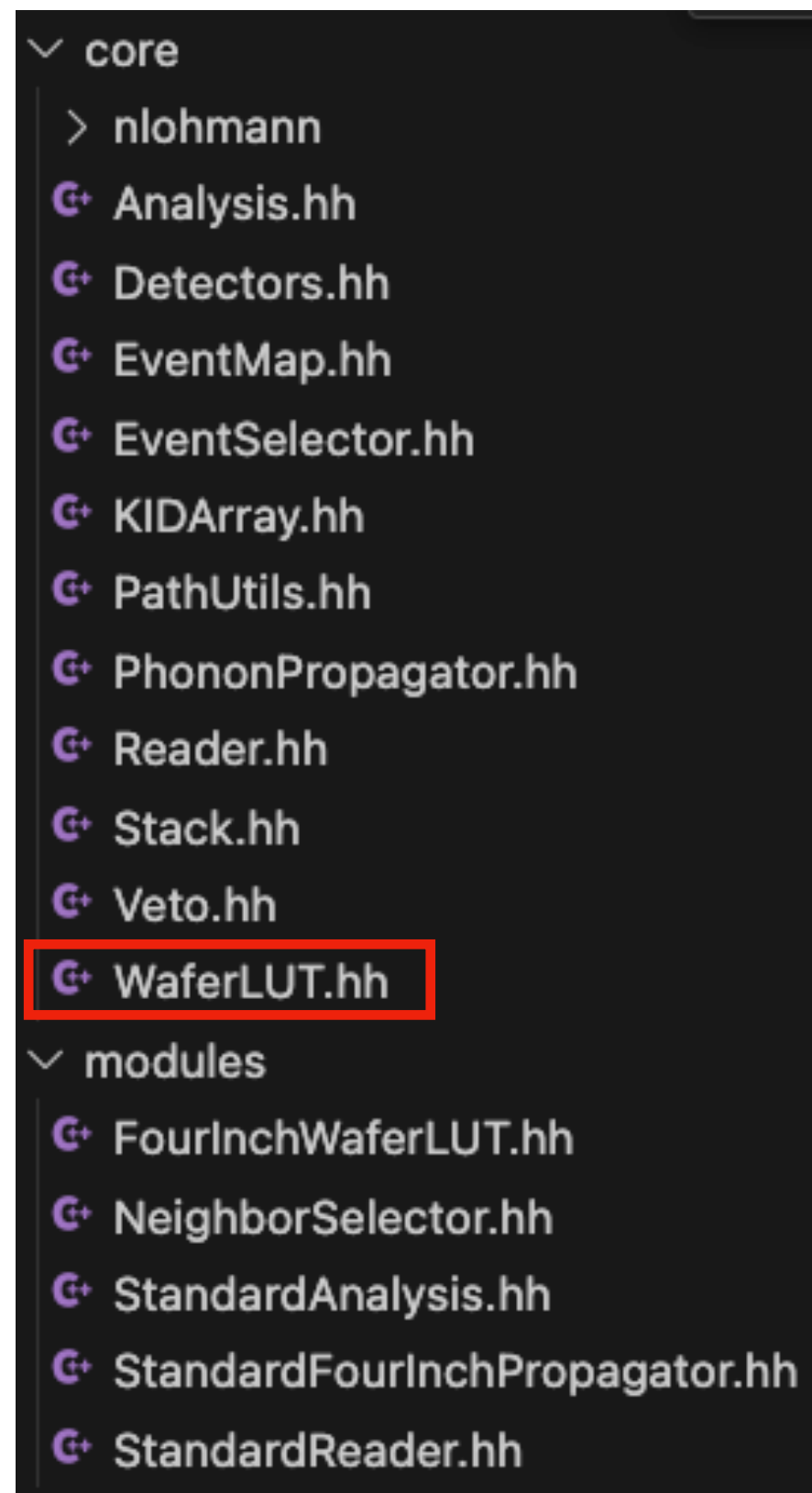
Languages

C++ 99.8%

CMake 0.2%

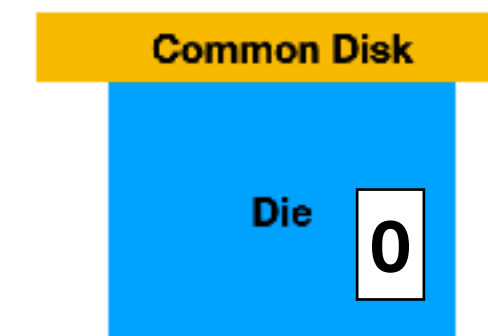
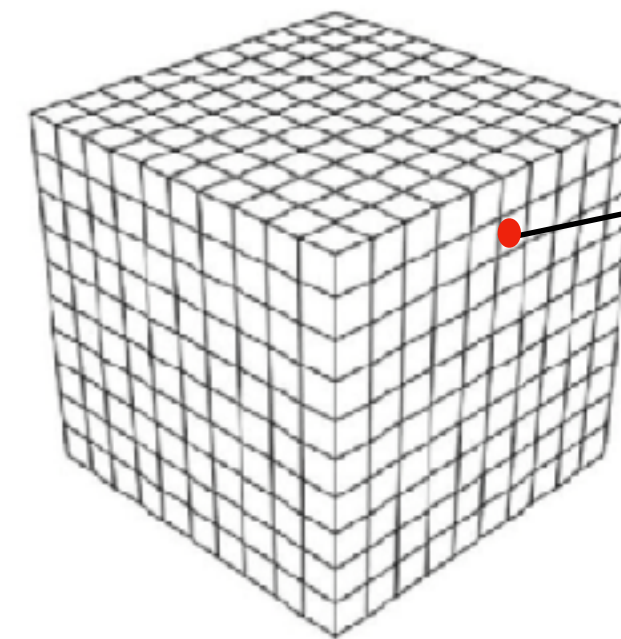
To get access to the repository, contact me at:
tommaso.lari@pi.infn.it

Tools:

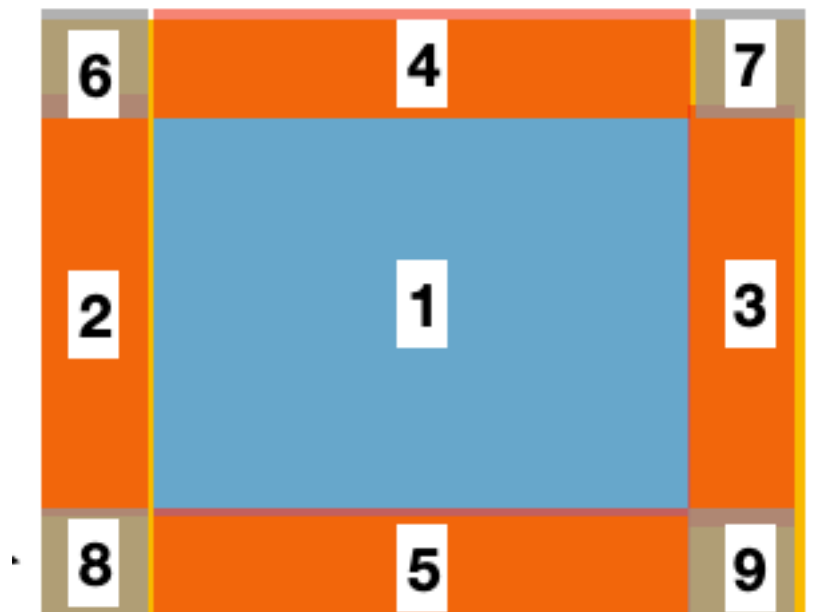


Geometry Look Up table:

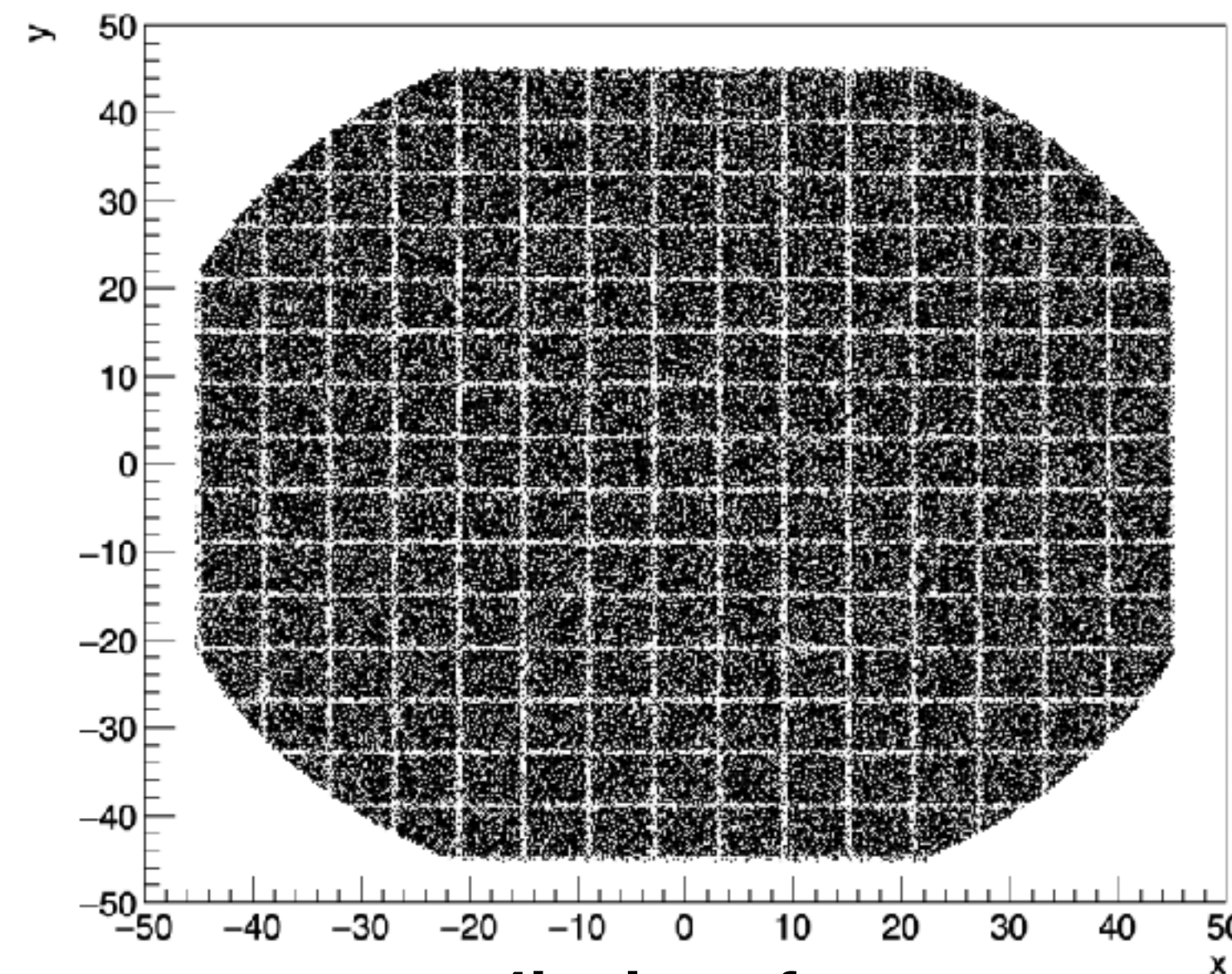
- Maps Position (x,y,z)-> Array Region (Wafer N,Nx,Ny, region:die, common disk..)
- Wafer Geometry split in a mesh grid
- Pre computed before starting analysis
- Access to geometry info at O(1)



Common Disk regions

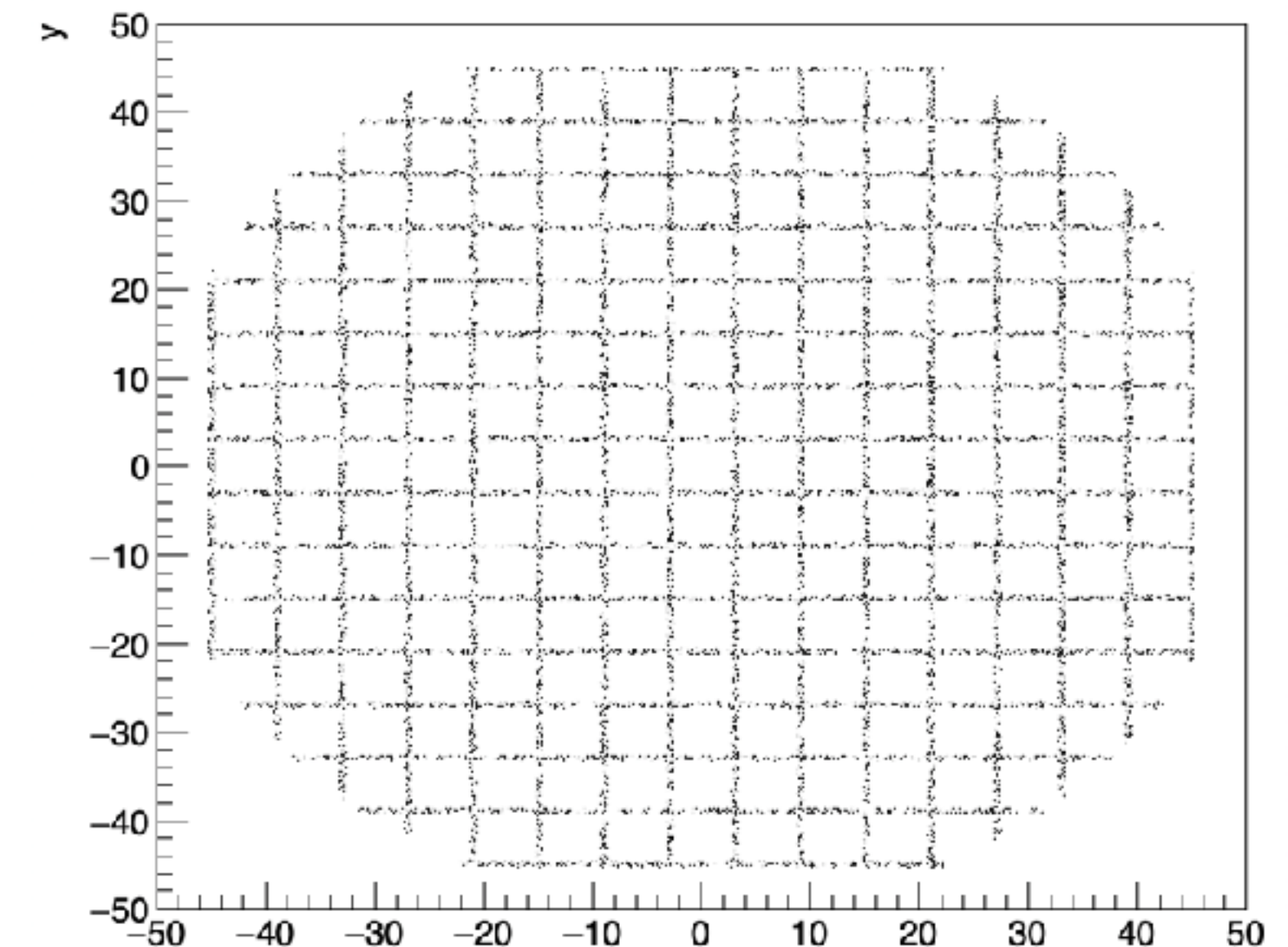


y:x



4inch wafer

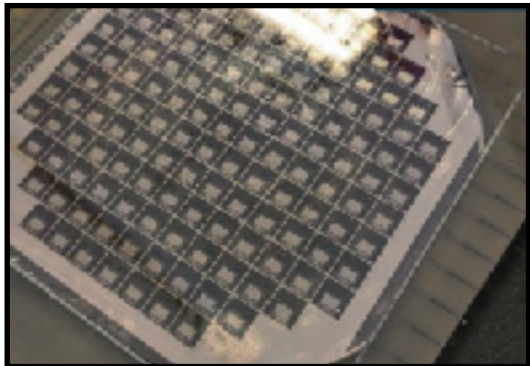
y:x {region>1}



4inch wafer common disk connections only

KID array map:

- Maps KID position (waferZ,Nx,Ny)->KID Status (Master, Anticoincidence, Inactive)
- Map defined via json file



Tools:

core

nlohmann

Analysis.hh

Detectors.hh

EventMap.hh

EventSelector.hh

KIDArray.hh

PathUtils.hh

PhononPropagator.hh

Reader.hh

Stack.hh

Veto.hh

WaferLUT.hh

modules

FourInchWaferLUT.hh

NeighborSelector.hh

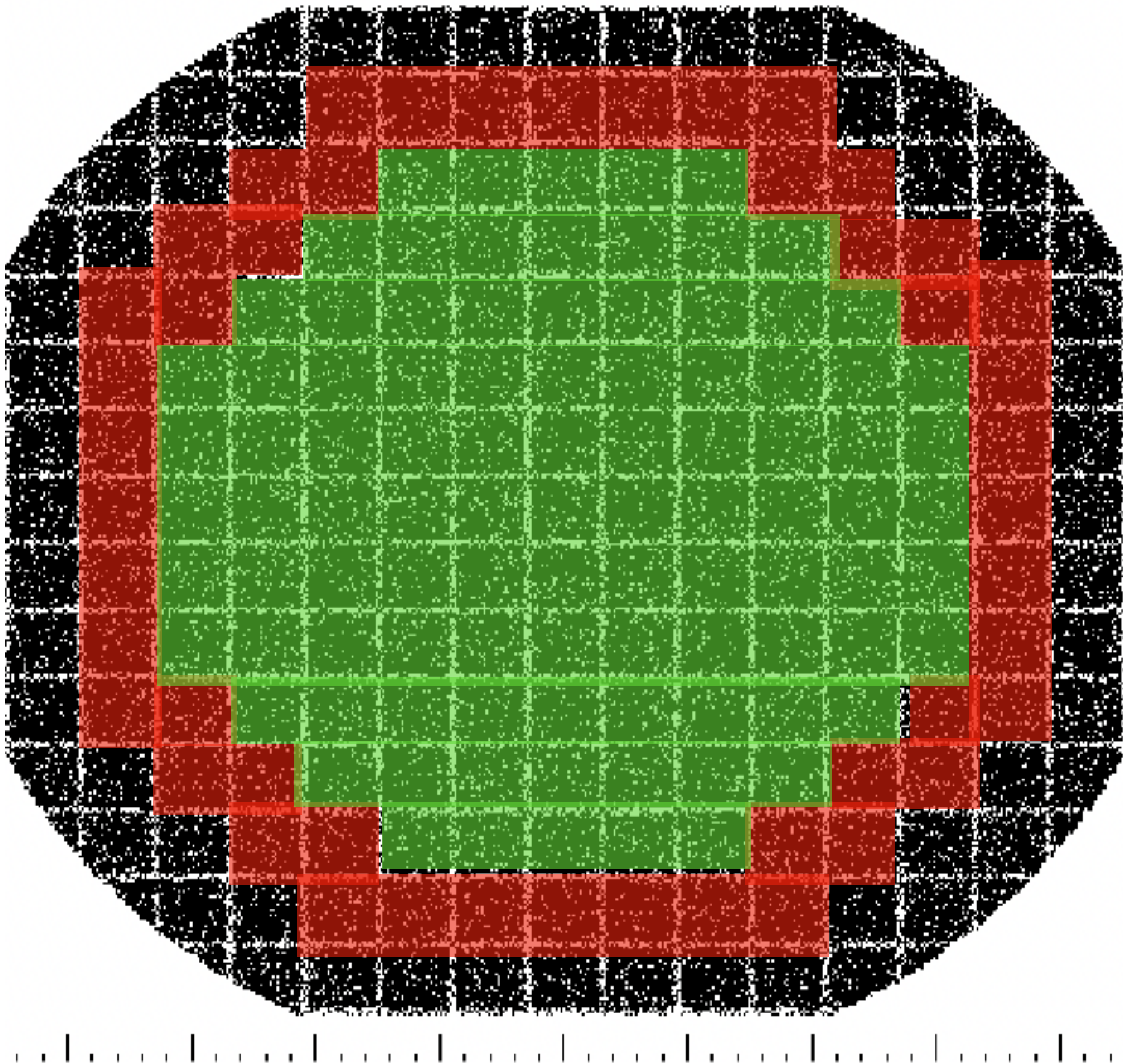
StandardAnalysis.hh

StandardFourInchPropagator.hh

StandardReader.hh

```
{
  "wafer1": [
    ["x","x","x","x","x","x","x","x","x","x","x","x","x","x"],
    ["x","x","x","x","a","a","a","a","a","a","x","x","x","x"],
    ["x","x","x","a","a","m","m","m","m","m","a","a","x","x"],
    ["x","x","a","a","m","m","m","m","m","m","m","a","a","x"],
    ["x","a","a","m","m","m","m","m","m","m","m","a","a","x"],
    ["x","a","m","m","m","m","m","m","m","m","m","m","a","x"],
    ["x","a","m","m","m","m","m","m","m","m","m","m","a","x"],
    ["x","a","m","m","m","m","m","m","m","m","m","m","a","x"],
    ["x","a","m","m","m","m","m","m","m","m","m","m","a","x"],
    ["x","a","m","m","m","m","m","m","m","m","m","m","a","x"],
    ["x","a","a","m","m","m","m","m","m","m","m","a","a","x"],
    ["x","x","a","a","m","m","m","m","m","m","m","a","a","x"],
    ["x","x","x","a","a","m","m","m","m","m","m","a","a","x"],
    ["x","x","x","x","a","a","a","a","a","a","a","x","x","x"],
    ["x","x","x","x","x","x","x","x","x","x","x","x","x","x"]
  ],
}
```

m="Master"
a="Anticoincidence"
x="Inactive" (Not instrumented or broken)



4inch wafer

Xtalk Modeling:

- Maps position (x,y,x)->Energy weights [(KID NX, KID NY, fraction), (...), (...) , ...]
- Pre computed Look Up Table before starting analysis
- Access weights at O(1)
- Implemented simple propagation model based on measured Xtalk (+,x).
- A more sophisticated Xtalk model (based on data / phonon propagation sim) can be plugged directly in this framework

Tools:

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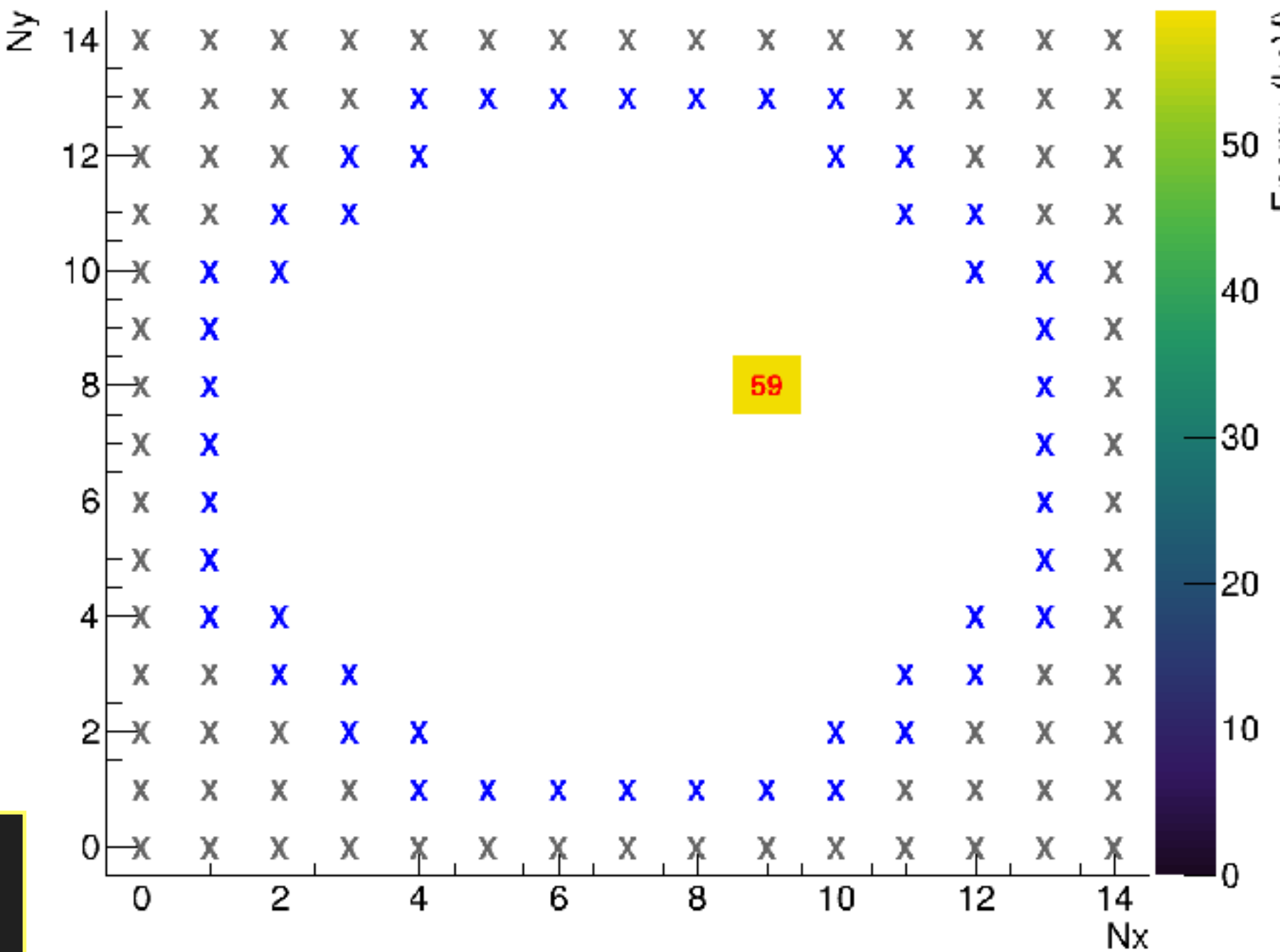
StandardAnalysis.hh

StandardFourInchPropagator.hh

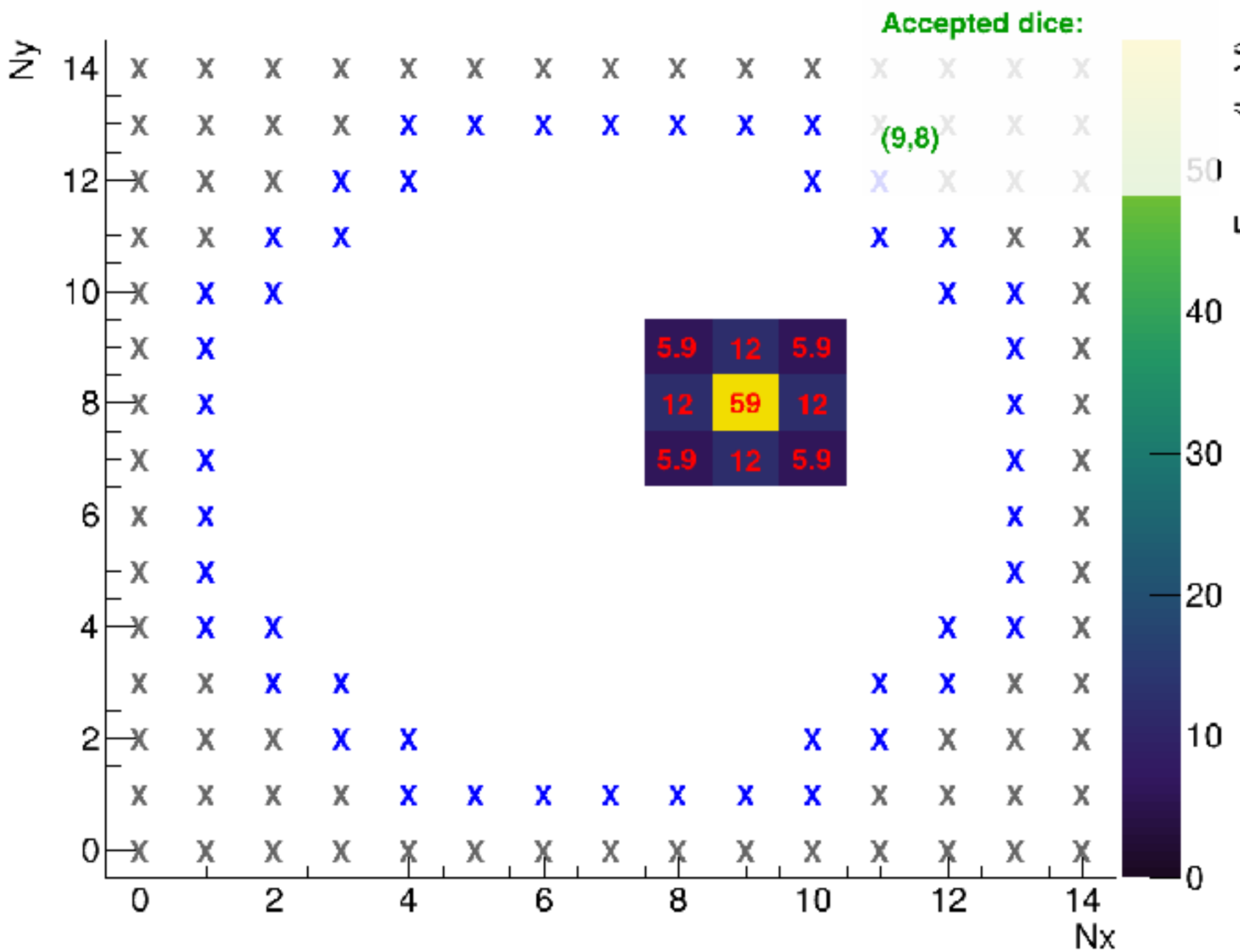
StandardReader.hh

```
"CrossTalkPlus": 0.2,
"CrossTalkCross": 0.1,
"CrossTalkMatrix": [
  [0.1,0.2,0.1],
  [0.2,1.0,0.2],
  [0.1,0.2,0.1]
],
```

Event 2 - Before propagation



Event 2 - After propagation



Tools:

core

> nlohmann

Analysis.hh

Detectors.hh

EventMap.hh

EventSelector.hh

KIDArray.hh

PathUtils.hh

PhononPropagator.hh

Reader.hh

Stack.hh

Veto.hh

WaferLUT.hh

modules

FourInchWaferLUT.hh

NeighborSelector.hh

StandardAnalysis.hh

StandardFour

StandardRead

],

"SigmaPercent":5.0,

"Kernel": [

[0.1, 0.2, 0.1],

[0.2, 1.0, 0.2],

[0.1, 0.2, 0.1]

]

Event Selector:

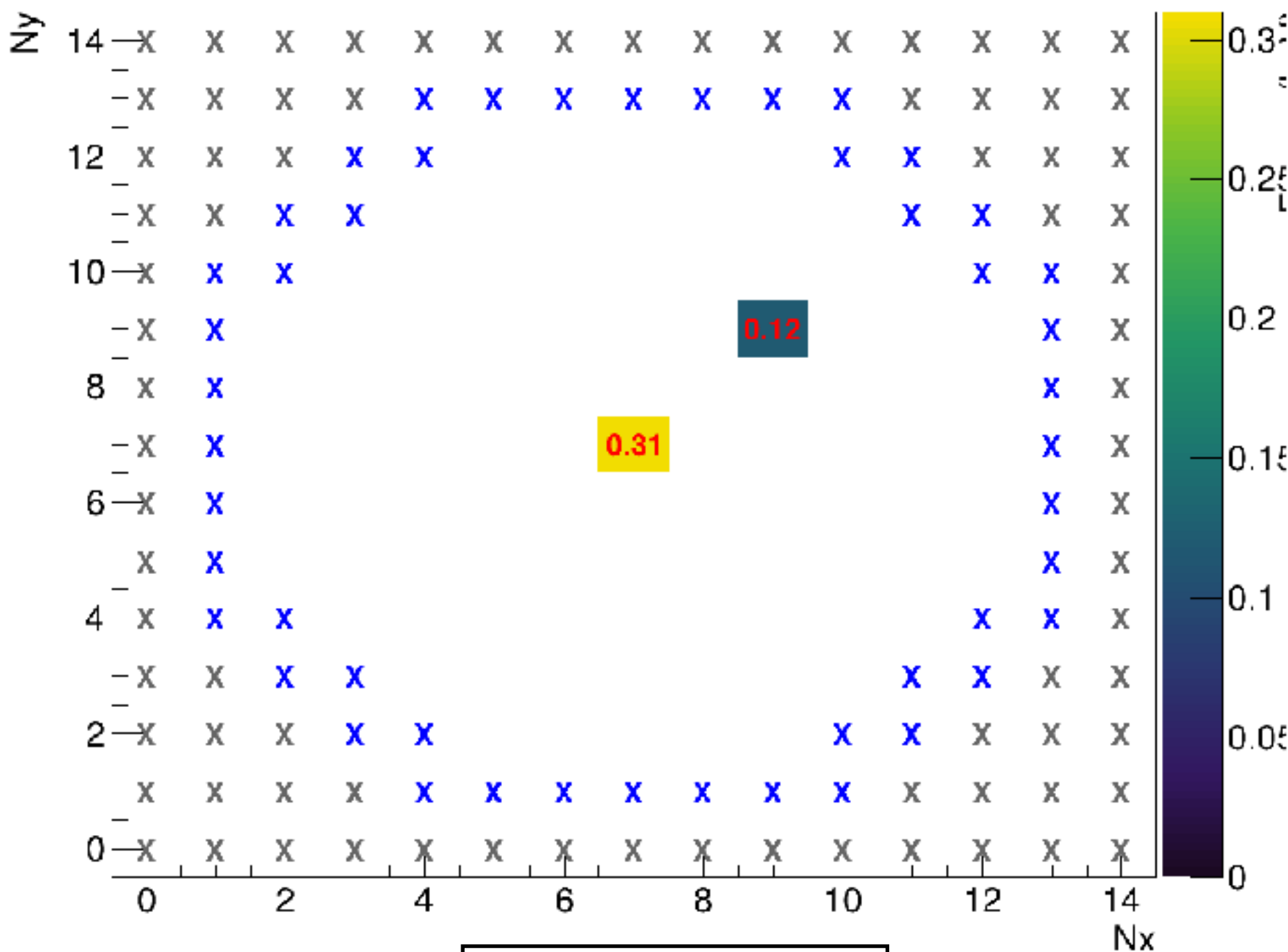
- Event is accepted only if:
 - Amplitudes of neighbouring KIDs respect a defined kernel
- Check if neighbouring KIDs are Active

Neighborhood around (5,4) on wafer 1:

Energy (keV)		KID status			
0.0	0.0	0.0	M	M	M
9.4	10.4	0.0	M	M	M
19.9	9.4	0.0	M	M	M

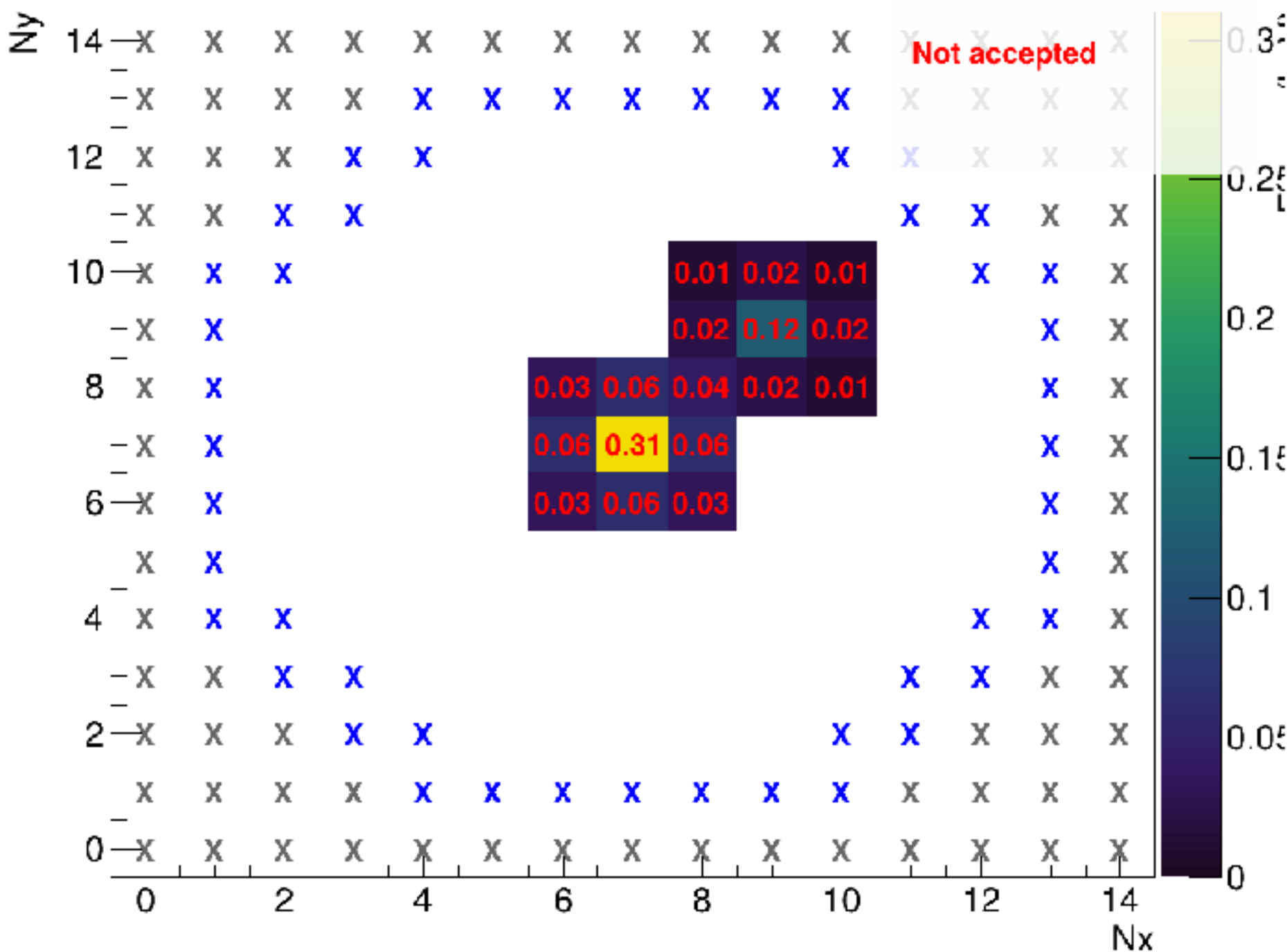
XTALK match: NO

Event 3 - Before propagation



X Anticoincidence
X No die or inactive

Event 3 - After propagation



Thank You

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Tommaso Lari

