Molière Radius Analysis: Pipeline & Preliminary Results

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Analysis Pipeline

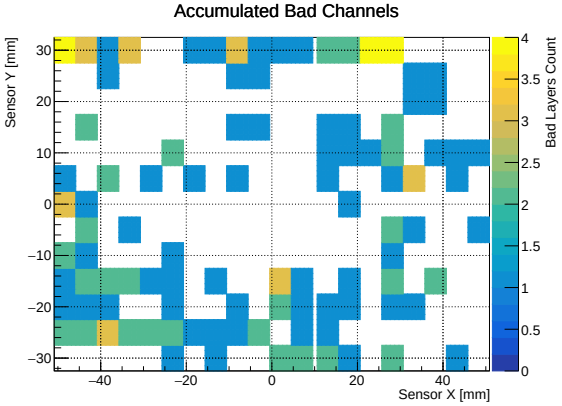
- **1. Laod Reconstructed Data**
- **2. Planes Alignment**
- **3. Topology Filtering:**
  Select clean single-particle events (require 1 hit in first plane).
- **4. Center of Gravity (CoG)**
- **5. Amplitude threshold**
- **6. Sub pad division**
- **7. Filter on events where CoG are within bad channel or gap region**
- **8. Geometric Correction:**
  Crucial Step! Scale energy in radial rings to recover signal lost in sensor gap, dead channels and area out of sensor.
- **9. Profiling & Fitting:**
  Stack thousands of corrected events to build a high-resolution radial profile and extract R_M.

Missing acceptance - dead channels and gap

The Reality: Our detector has a lot of dead area

1. **Inter-sensor Gap:** ~ 1.72mm spaces between wafers.
2. **Dead Channels:** Masked noisy or not working pads.

The Effect: When a shower crosses a gap or dead area, artificially decrees measured energy. This creates "dips" in the radial profile and lowers the total energy.



Map of Dead Channels & Gaps

Geometric Correction: How it works

Assumption: Electromagnetic showers are **Radially Symmetric**.

The Algorithm - per Radial Ring (width = dr):

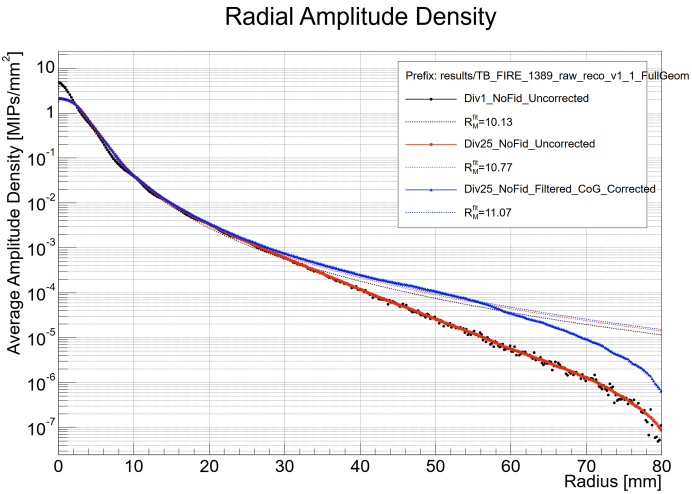
1. Calculate the **Theoretical** number of sub pads within the ring (N_{total}).
2. Calculate the number of **Active** sub pads (excluding number of dead sub pads within the ring) (N_{good}).
3. Scale the measured energy:

$$E_{corrected} = E_{measured} \times \frac{N_{total}}{N_{good}}$$

Example

If a ring falls 25% into a dead area:

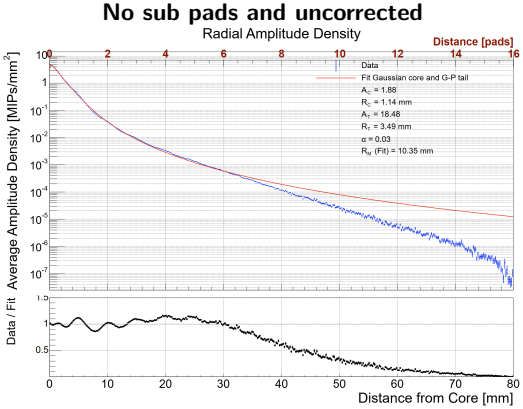
- We only see 75% of the energy.
- We multiply by $1/0.75 = 1.33$.

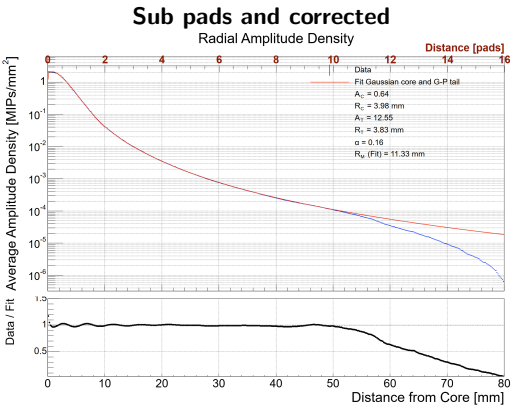


Comparison of each step of correction

1. Basic filters
2. Basic filters with 25x25 sub pad division
3. Full filters with 25x25 sub pad division and geometric correction

Results: Radial Profiles



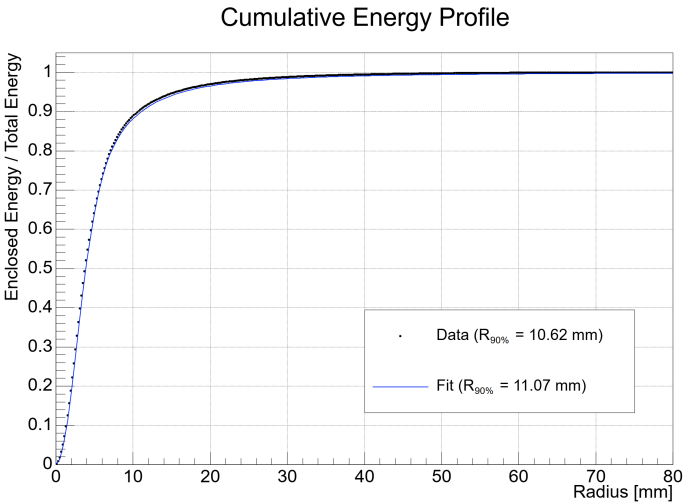


The correction successfully smooths out geometric artifacts, allowing for a precise fit.

Gaussian Core + Grindhammer-Peters Tail

$$\rho(r) = \underbrace{A_C \exp\left(-\frac{r^2}{R_C^2}\right)}_{\text{Core}} + \underbrace{A_T \frac{2r^\alpha R_T^2}{(r^2 + R_T^2)^2}}_{\text{Tail}}$$

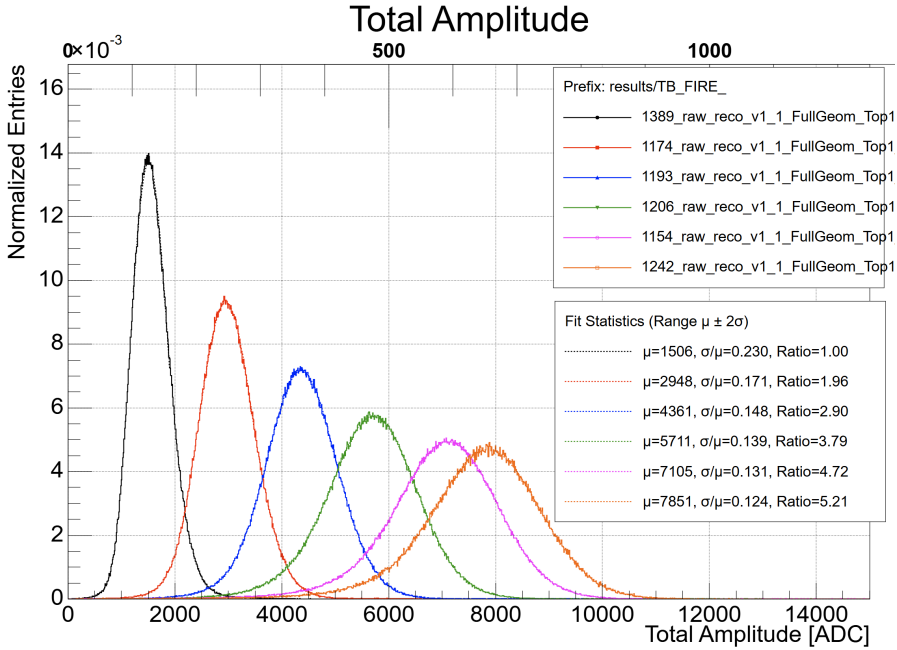
Result: Molière Radius Extraction

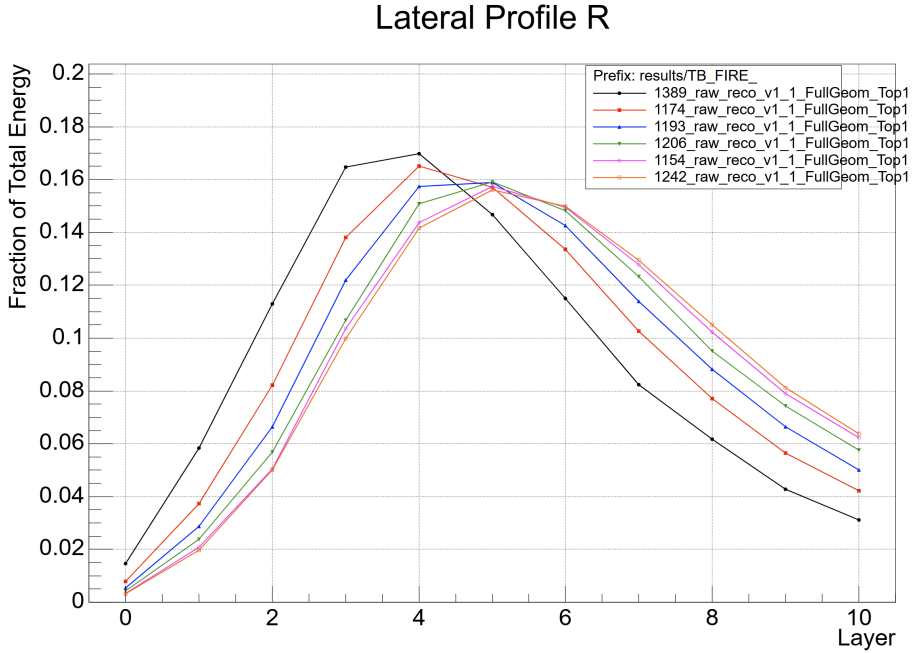


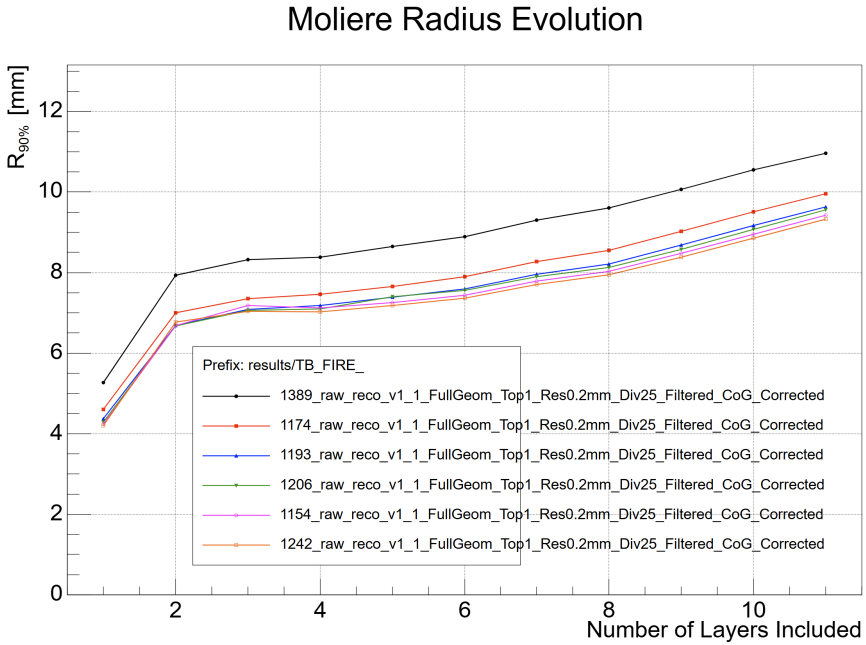
Methodology:

1. Integrate the corrected radial energy profile.
2. Normalize to Total Energy.
3. Find the radius containing **90%**.

Result: Comparison for different beam energy




Lateral Profile R
Prefix: results/TB_FIRE_
1389_raw_reco_v1_1_FullGeom_Top1
1174_raw_reco_v1_1_FullGeom_Top1
1193_raw_reco_v1_1_FullGeom_Top1
1206_raw_reco_v1_1_FullGeom_Top1
1154_raw_reco_v1_1_FullGeom_Top1
1242_raw_reco_v1_1_FullGeom_Top1
Fraction of Total Energy
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2
4
6
8
10
Layer


Moliere Radius Evolution
R90% [mm]
0
2
4
6
8
10
12
2
4
6
8
10
Number of Layers Included
Prefix: results/TB_FIRE_
1389_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected
1174_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected
1193_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected
1206_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected
1154_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected
1242_raw_reco_v1_1_FullGeom_Top1_Res0.2mm_Div25_Filtered_CoG_Corrected

Summary

- **Correction:** Geometric weighting (N_{tot}/N_{good}) successfully recovers energy lost to sensor dead area.
- **Fit:** The corrected data is well-described by the Core+Tail model.
- **Outcome:** We extract a reliable, geometry-independent measurement of the Molière Radius.
- **The above are very preliminary results. The detailed results with assumptions and all intermediate analyses steps will be presented next week.**