# TPC considerations

tpc.nb

## Initialize

## Criteria for Pad Granularity

### ■ General considerations

The detection plane should be roughly 10x10 cm2. With 1cm pads we get readout 100 channels, with 5mm pads 400 readout channels. Around 100 would be a convenient number for existing FADC etc.

### ■ Muon energy deposition

The muon energy deposition relative to the stopping pad is shown in the figure. A 10x10 $mm^2$ pad has the advantage of "seeing" all muons entering the chamber, a 5x5 $mm^2$ pad has higher resolution, but the muons are only seen ~35 mm upstream of the stop pad.

```
T[r_] := ( r / KHmu )^(1/1.8)

KHmu = 9.3786218; (* φ=5% *)

delT[d_, an_, alen_] := T[d + alen an] - If[an > 0, T[d + alen (an - 1)], 0.]

del = 0.15;

pp = ParametricPlot[{Table[{delT[d, i, 5], i}, {i, 0, 14}],
    Table[{delT[d, i, 10], i + del}, {i, 0, 14}], {0.15, d 14 / alen}},
    {d, 0.0, alen}, FrameLabel → {"E(MeV)", "anode"}];

l = {{Graphics[{Red, Thick, Line[{{0.05, .7}, {0.4, .7}}]}],
    "pad: 5x5 mm^2 "},
    {Graphics[{Green, Thick, Line[{{0.05, .7}, {0.4, .7}}]}],
    "pad: 10x10 mm^2 "},
    {Graphics[{Blue, Thick, Line[{{0.05, .7}, {0.4, .7}}]}], "E threshold"}
    };

p2 = ShowLegend[Show[pp],
    {l, LegendPosition → {-.0, 0.4}, LegendSize → {.7, .2},
     LegendShadow → {0, 0}, LegendBackground → LightYellow}]

Export["mu.eps", p2];
```
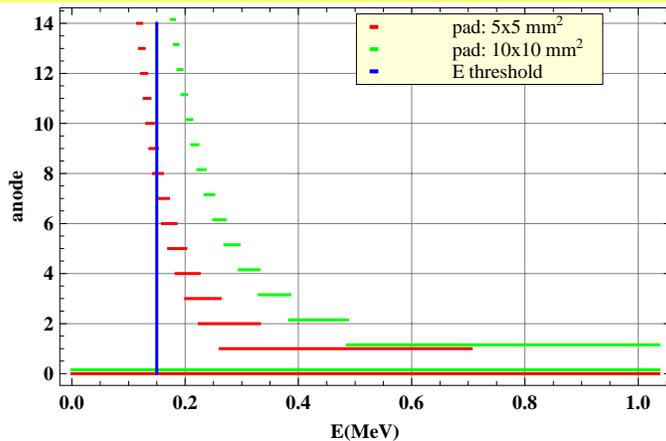


For reference we include the table of fusion products and their range.

|                | E (MeV) | $E_{obs}$ (MeV) | R (mm) |
|----------------|---------|------------------|--------|
| $^3$He         | 0.82    | 0.6              | 0.18   |
| $^3$Heμ        | 0.80    | 0.75             | 0.6    |
| t              | 1.01    |                  | 1      |
| p              | 3.02    |                  | 16     |

■ **Energy resolution**

We simply assume that a fusion recoils escape a pixel, if they are within R/4 to the next wall. The relative escape fraction then is

$\frac{L^2-(L-R/4)^2}{L^2} \sim \frac{R}{2L}$ , which gives for 5 mm and 10 mm pixels

```
R = 0.18; { R/10 , R/20 }
{0.018, 0.009}
```

which in both cases seems small compared to the intrinsic 1-sigma energy resolution of

```
30./800
0.0375
```

Of course, in principle, one can always add neighbouring pixels to contain the whole signal. The noise, however, will probably add with the square root of the number of pixels used.
MC is needed for a quantitative assessment.


■ **Impurity detection**

Probably the most convincing requirement for good granularity comes from the possibility of detection of proton emission after capture. We are working on a model for this, but 5x5 certainly would be an advantage in this measurement.


■ **Impact parameter cut**

For the run 8 analysis an impact parameter cut 120mm was used. Probably we cannot cut tigher than a 50mm inpact parameter cut. Two dimensions ( z from dE/dx and y from drift) can be reconstructed at the mm level. So both choices, 5x5 or 10x10 $mm^2$ pixels are acceptable.


■ **Systematics due to fusion products**

At the nominal $\phi$=0.05, the probability for emission of charged fusion products is several precent. Does the interference of these tracks with the muon track distort the $\mu$-e time distribution?

The probability distribution restricted to the range tf<tm can be written as

$$f (tf, tm) = ff (tf) fm (tm)$$
(1)

Eqn.1 indicates that the marginal probabilities are independent. (Does the restriction affect this statement?). If that is the case, we would not affect any systematic distortions.
Eqn.1 can be derived in the following way

$$P (tf, tm) = P (tf | tm > tf) fm (tm - tf)$$
(2)

where P (tf | tm' > tf) can be expressed as ff(tf) P(tm'>tf), and ff(tf) is the solution of the kinetic equations setting the muon decay rate $\lambda$ to 0. So the terms together, we get P(tf,tm) = $e^{-\lambda tf}$ ff(tf) $\lambda e^{-\lambda (tm-tf)}$ = ff(tf) $\lambda e^{-\lambda tm}$.

Of course, these arguments are always prone to mistakes, so one could check that statement with simple MC models.

Let us consider that case where there exists a systematic correction s(t) due to a time dependent correction effect. The most obvious example is md diffusion. In that case Eqn.1 is not the full story, but is should be modified to include s(t). The s(t) is predicted from a diffusion model assuming $\mu$-e vertex resolution, diffusion etc. In that case changing the muon stop resolution by overlap with fusion might modify the predicted s(t) and a modified s'(t). In that sense the fusion products can change the observed distribution. Thus the model prediction of s'(t) has to correctly account for the new situation.

## Conclusions

Let us define the 10x10 $mm^2$ pad as the baseline configuration and a mixed configuration inner 4x4 $cm^2$ has 5x5 $mm^2$ (64 pixel) and outer 3 cm have 10x10 $mm^2$ pixel (84 pixel) as an option to study.