Status of the TRIUMF Annular Chamber for the Tracking and Identification of Charged Particles (TACTIC)

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NPA 2005, Debrecen

Motivation: The $^{8}Li(\alpha,n)^{11}B$ reaction

New r-process calculations of nucleosynthesis in neutrino driven winds in supernovae [Terasawa et al., ApJ **562**(2001)470] include **light elements**.

Two **new reaction chains** can change the heavy element synthesis by one order of magnitude. These are:

$$\alpha(\alpha n,\gamma)^{9}Be(n,\gamma)^{10}Be(\alpha,\gamma)^{14}C$$

OR

$$\alpha(t,\gamma)^{7}Li(n,\gamma)^{8}Li(\alpha,n)^{11}B$$

$T_9 = 0.62 \rightarrow$ Gamow peak: $E_{c.m.} = 240$ to 580 keV

or $E_{lab} = 90$ to 220 keV/u

Lowest energy ISAC/TRIUMF: 120 keV/u

Last $^{8}Li(\alpha,n)^{11}B$ measurement using a Multiple Sampling and Tracking Proportional Chamber (MSTPC)

T. Hasimoto, Nuc. Phys. A **764** (2004)330

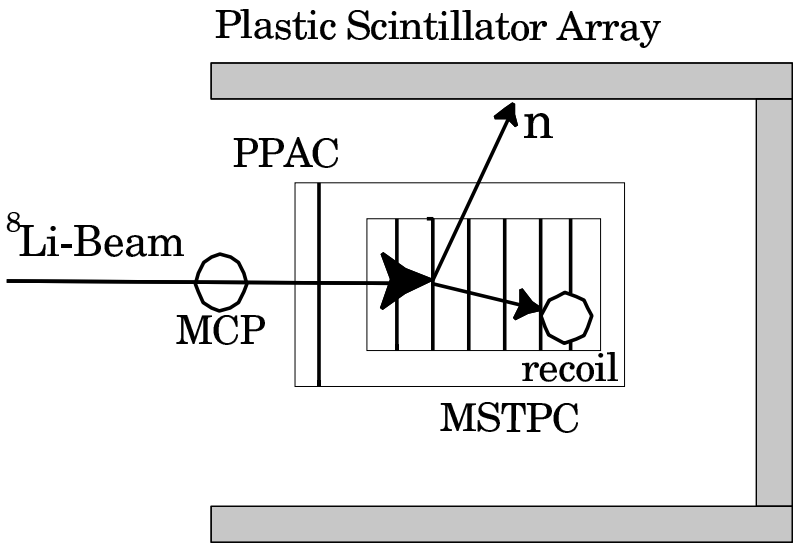
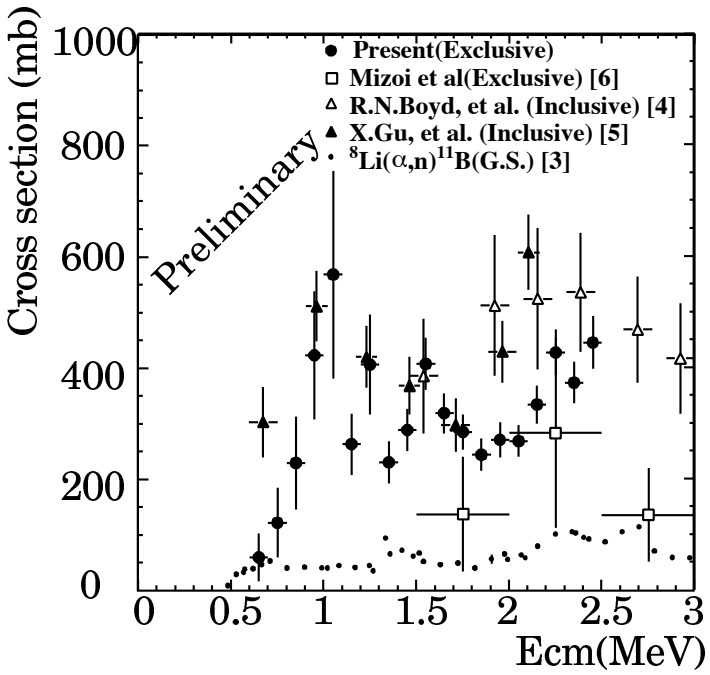
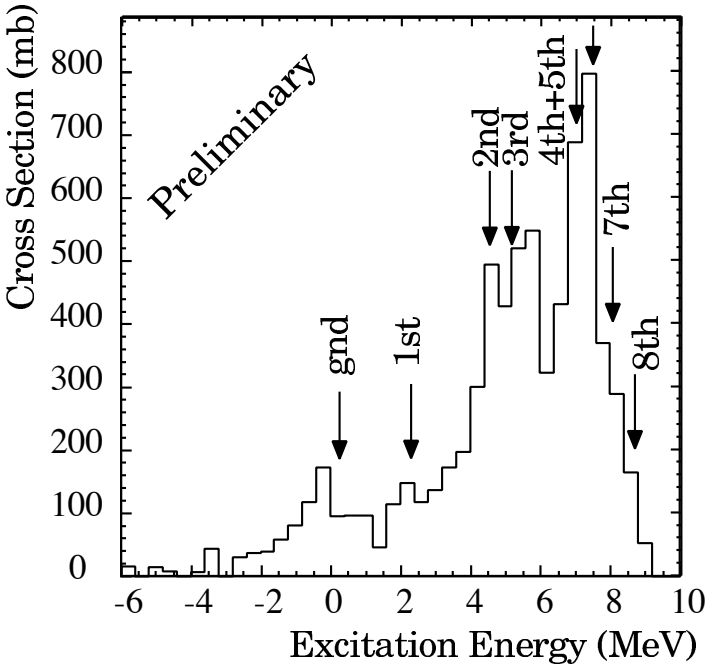


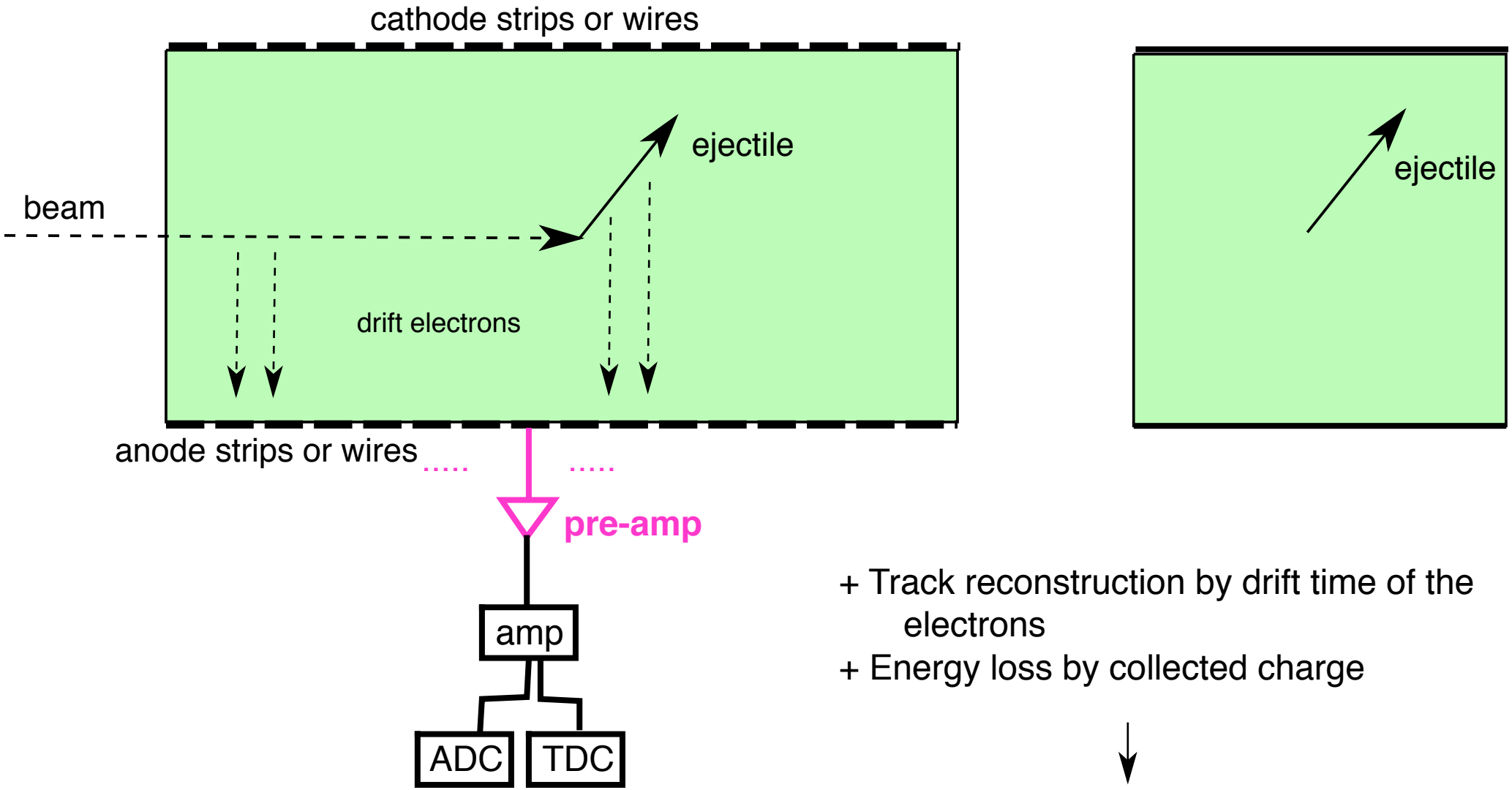
Figure 1. Schematic illustration of the detector system.





+ Helium as <u>target gas</u> and <u>counter gas</u>
+ Threedimensional tracking plus energy loss
- ^{8}Li beam directly into the chamber
- Beam stopped in chamber
- Low beam intensity
- Broad energy spectrum of the beam

Schematic and simplified view of a tracking chamber for nuclear reactions

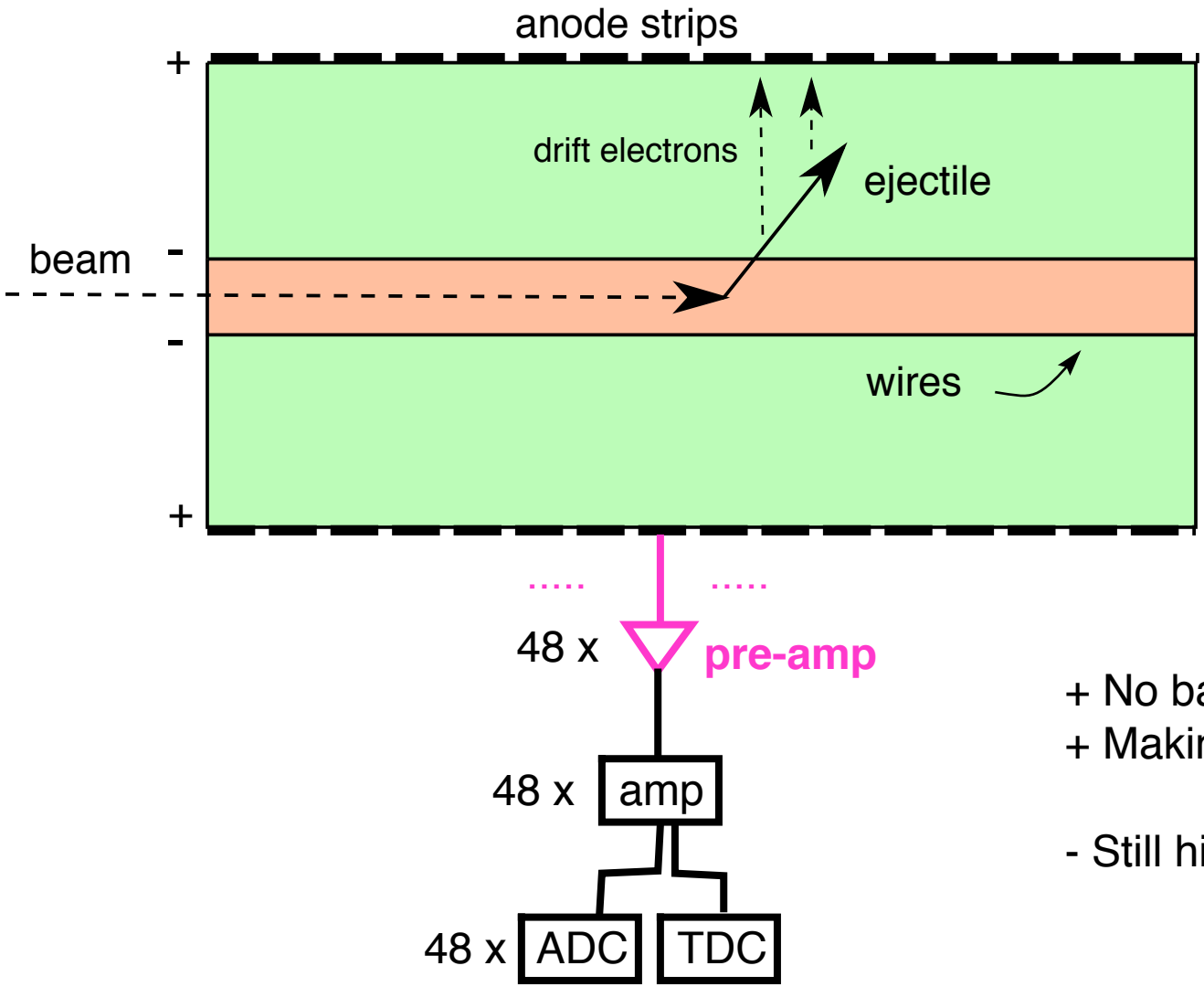


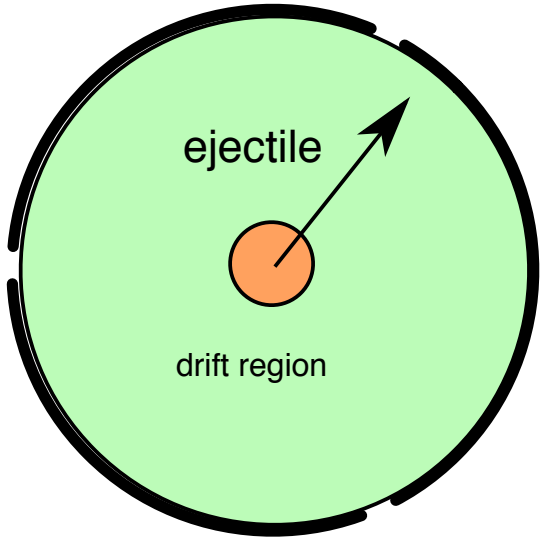
+ Track reconstruction by drift time of the electrons
+ Energy loss by collected charge

↓

Particle identification

Cylindrical chamber

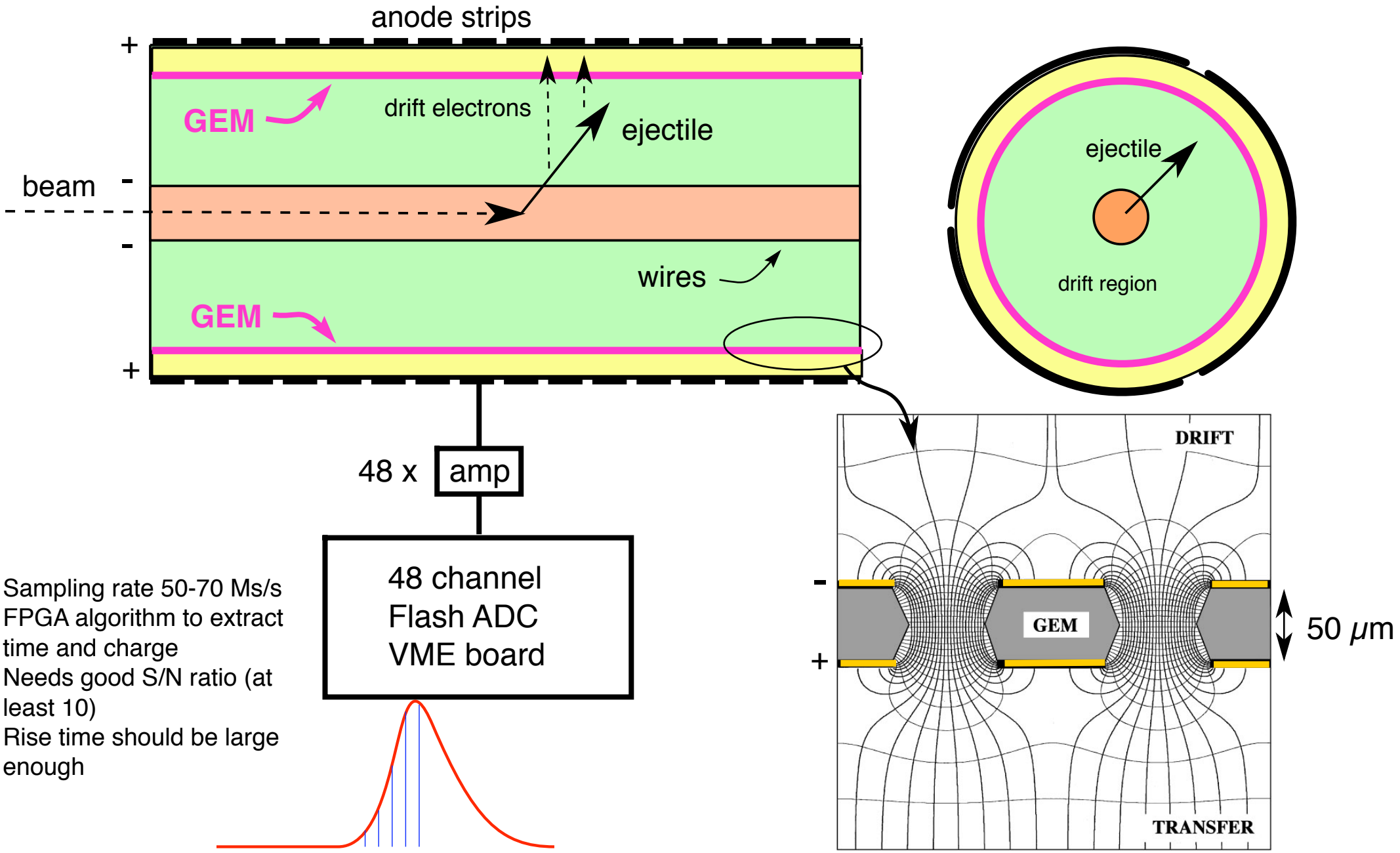




+ No background from beam
+ Making use of rotational symmetry

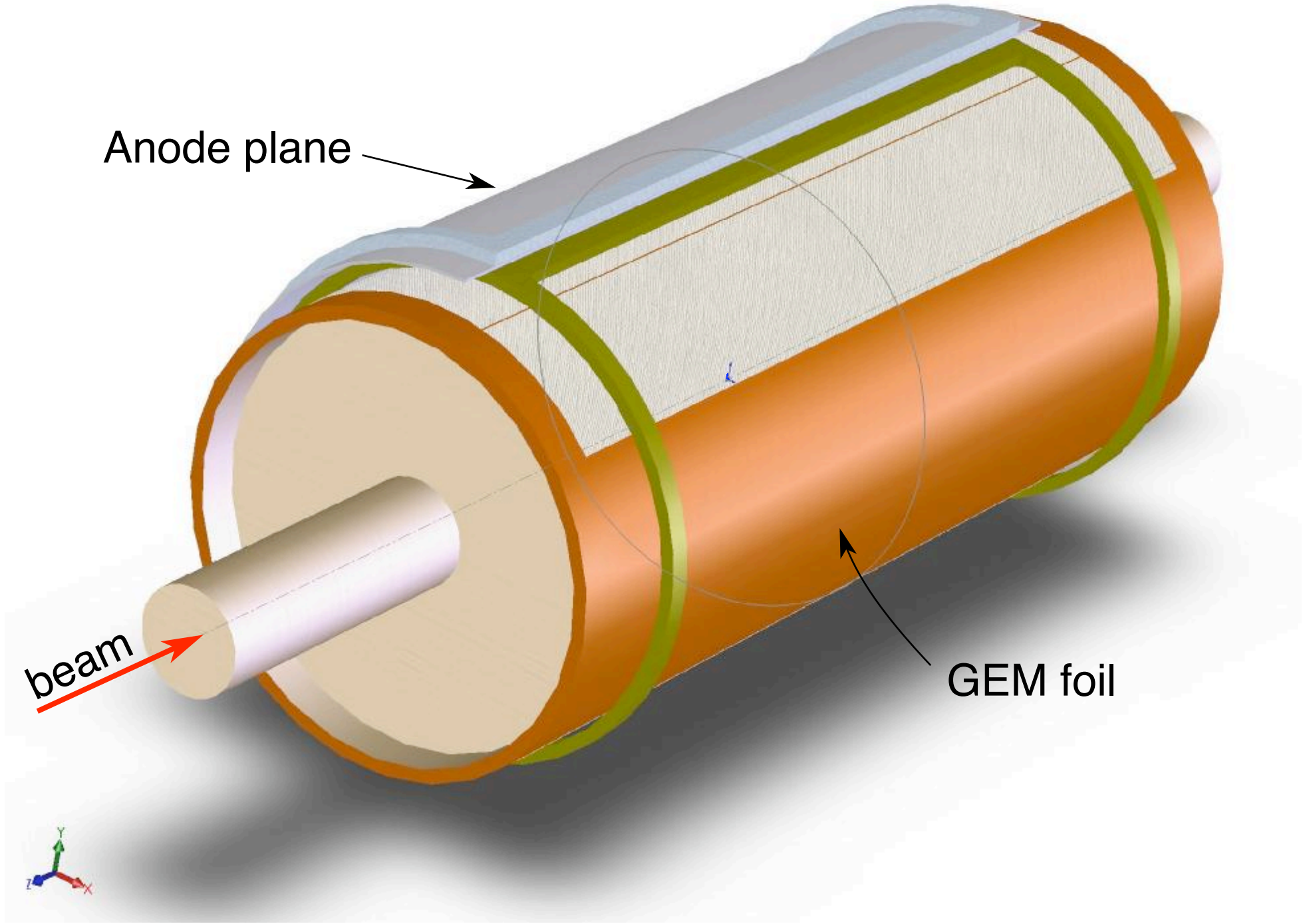
- Still high noise from weak signals

New Set-up using a Gas Electon Multiplier and Flash ADCs

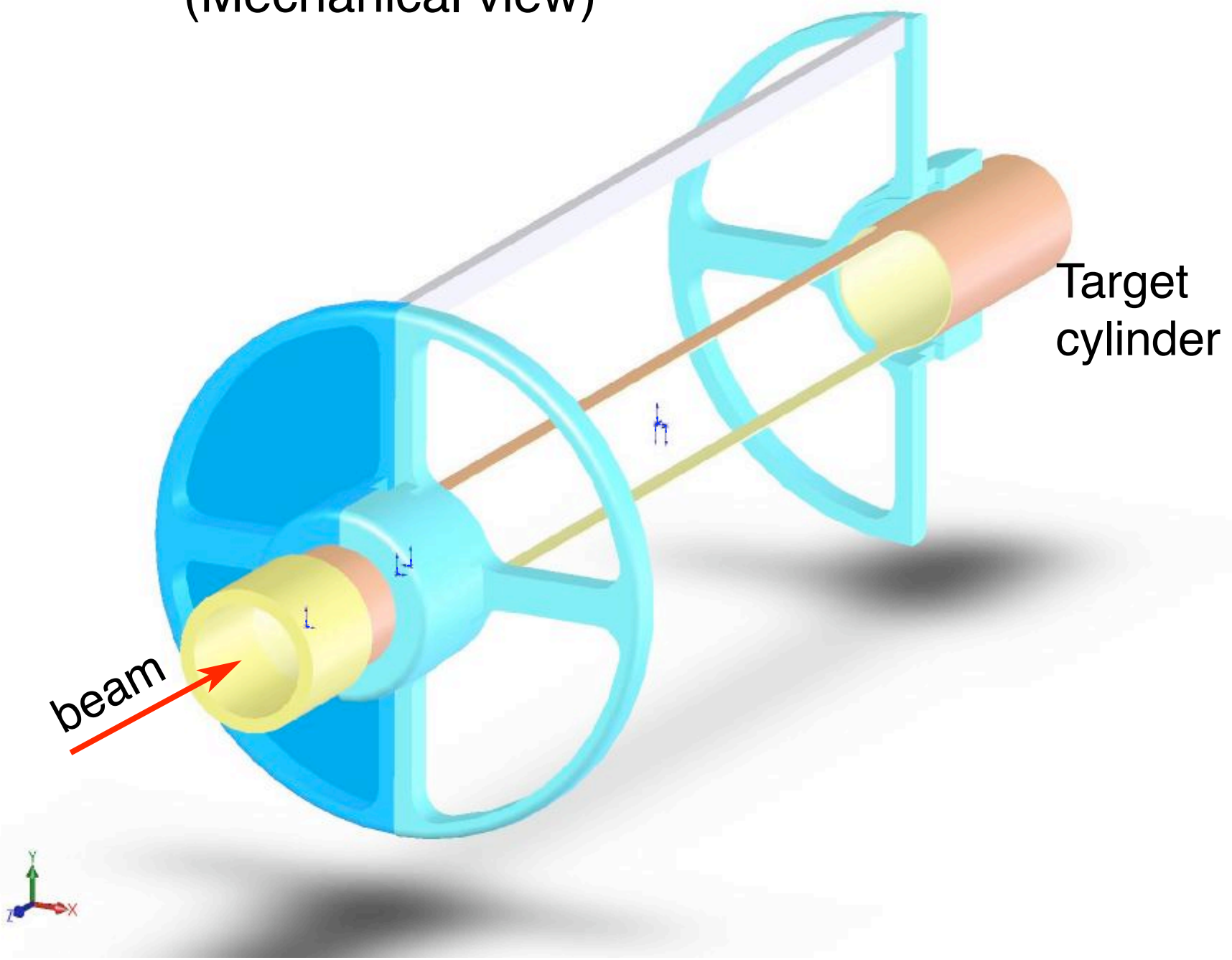


Sampling rate 50-70 Ms/s
FPGA algorithm to extract time and charge
Needs good S/N ratio (at least 10)
Rise time should be large enough

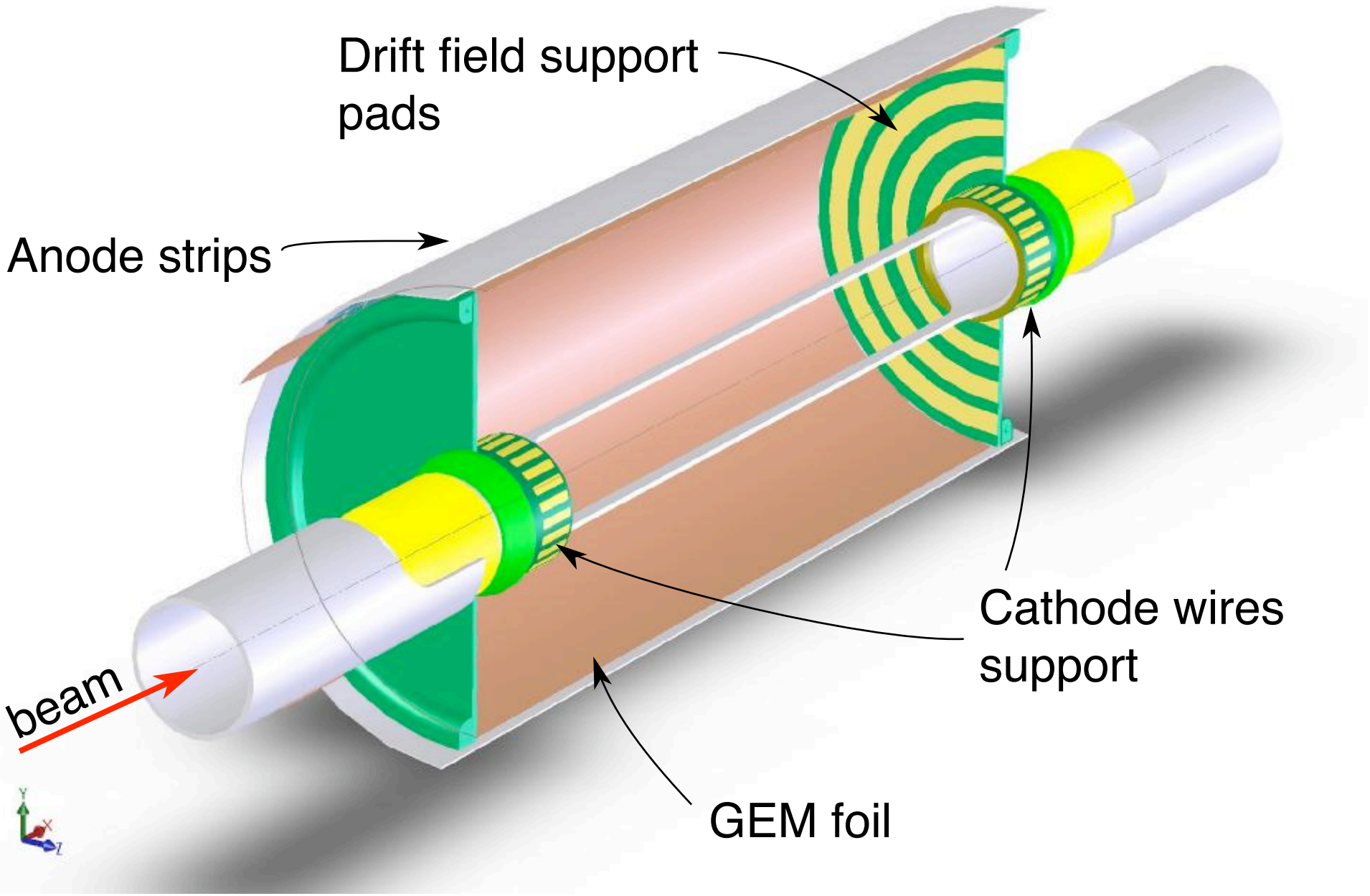
The TACTIC Drum

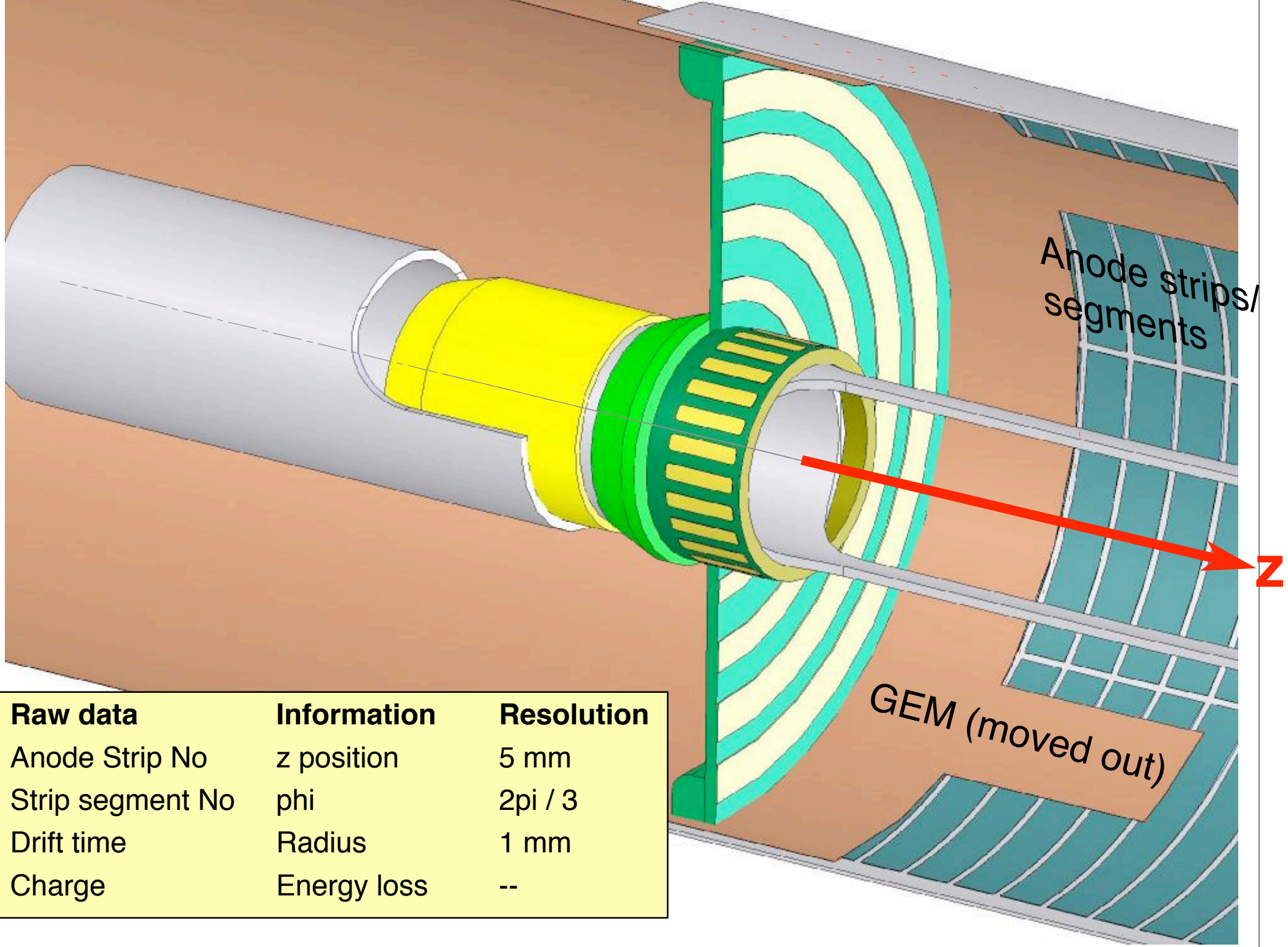


The TACTIC Drum
(Mechanical view)



The TACTIC Drum
(Inside view)





Raw data	Information	Resolution
Anode Strip No	z position	5 mm
Strip segment No	phi	2pi / 3
Drift time	Radius	1 mm
Charge	Energy loss	--

Problems

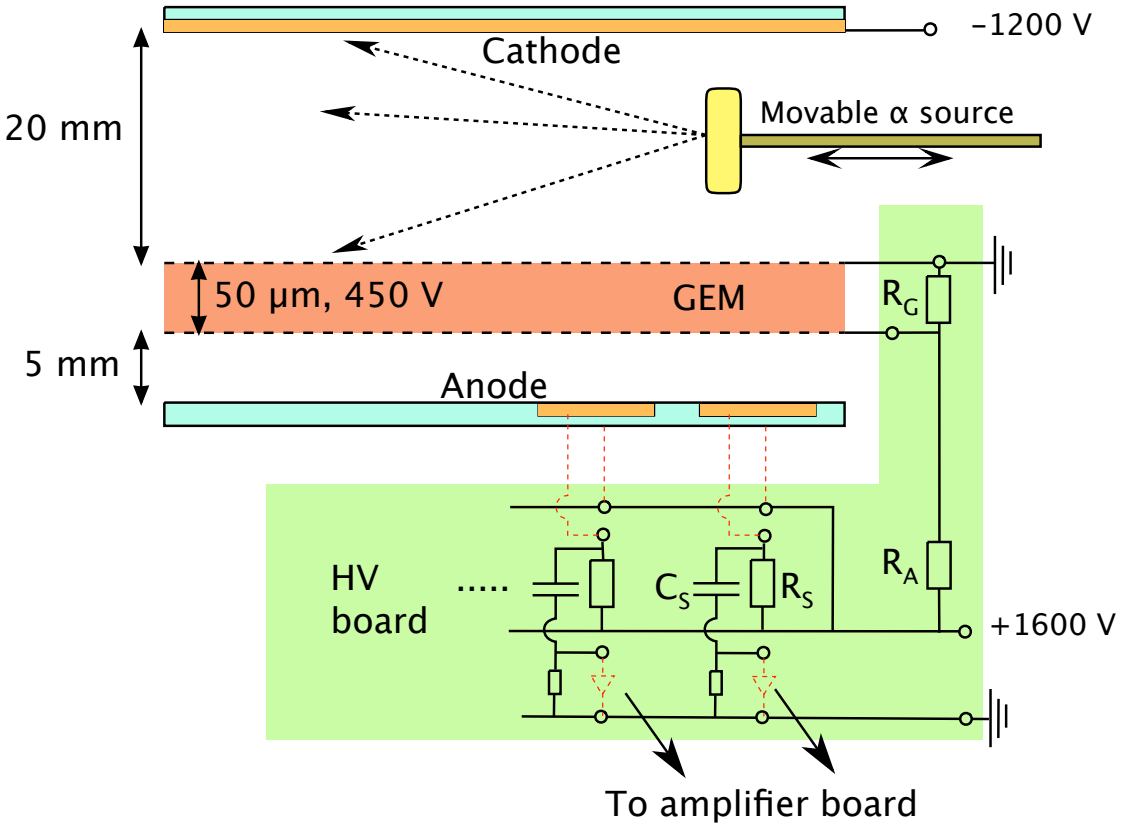
1. How is the GEM working with Helium?

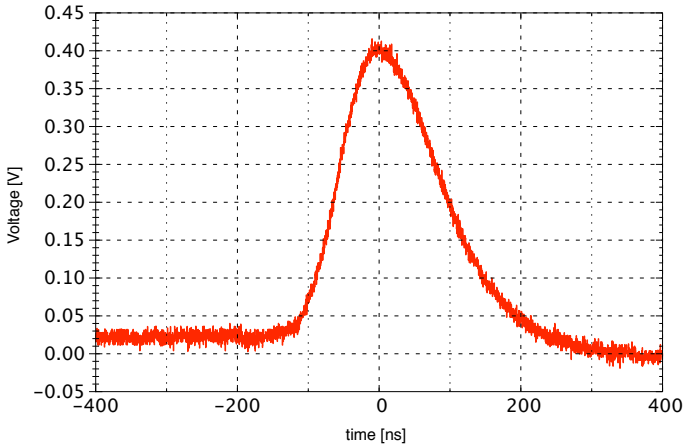
2. What is the optimal geometry?
   Length, diameter vs. pressure, kinematics

3. Pulse shapes, signal/noise ratio vs. pressure

4. How to suppress beam electrons?

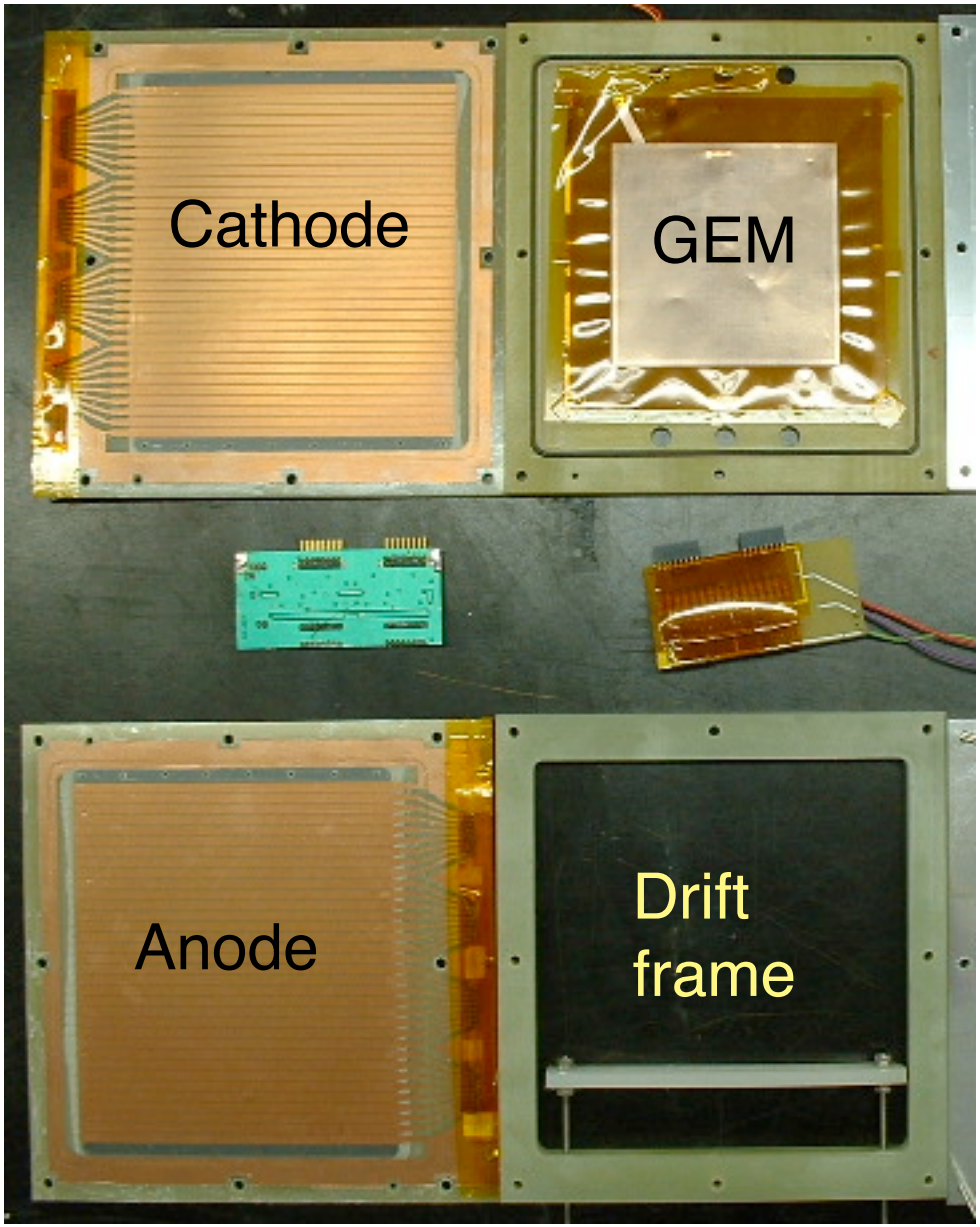
Testchamber



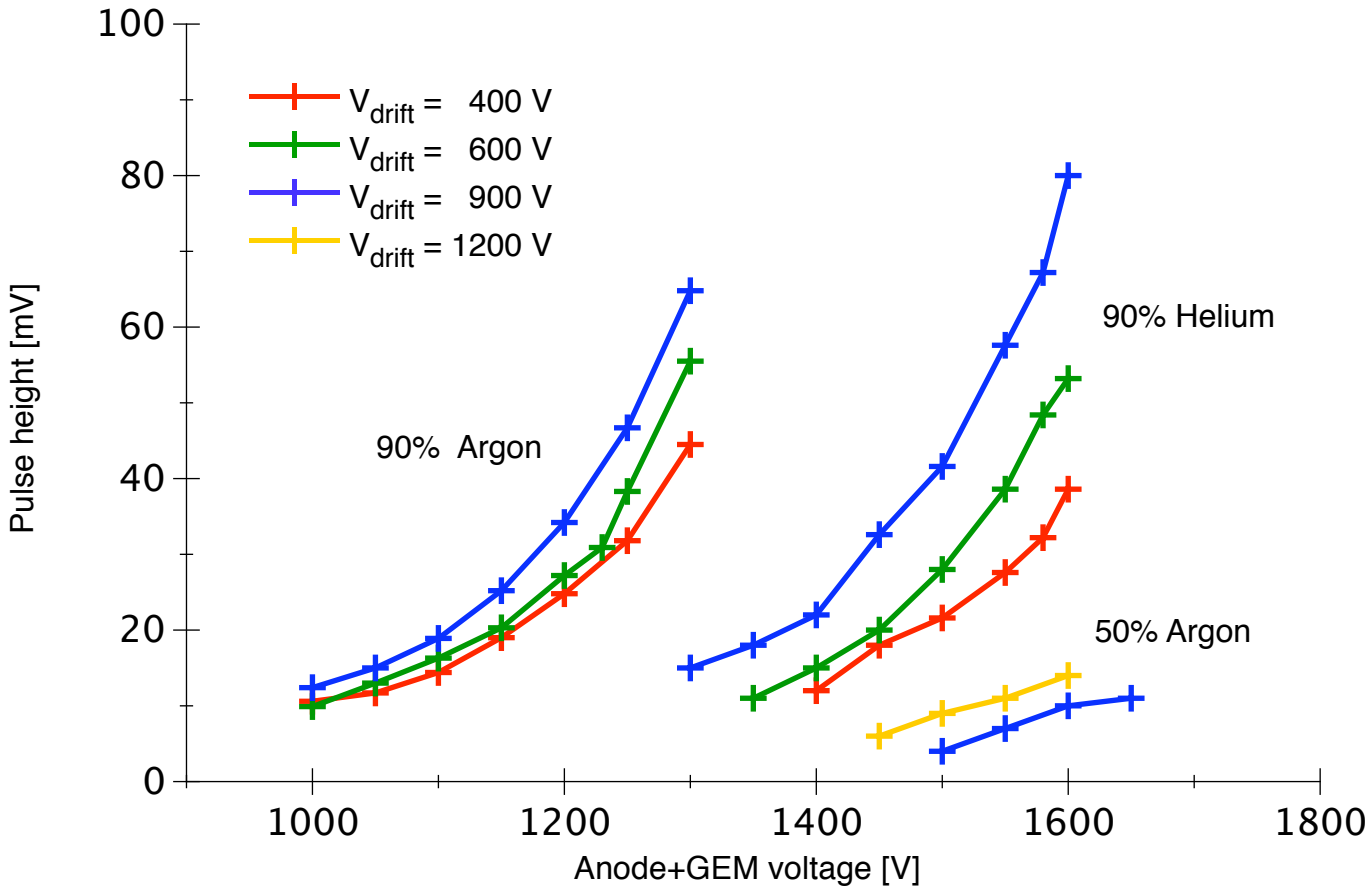


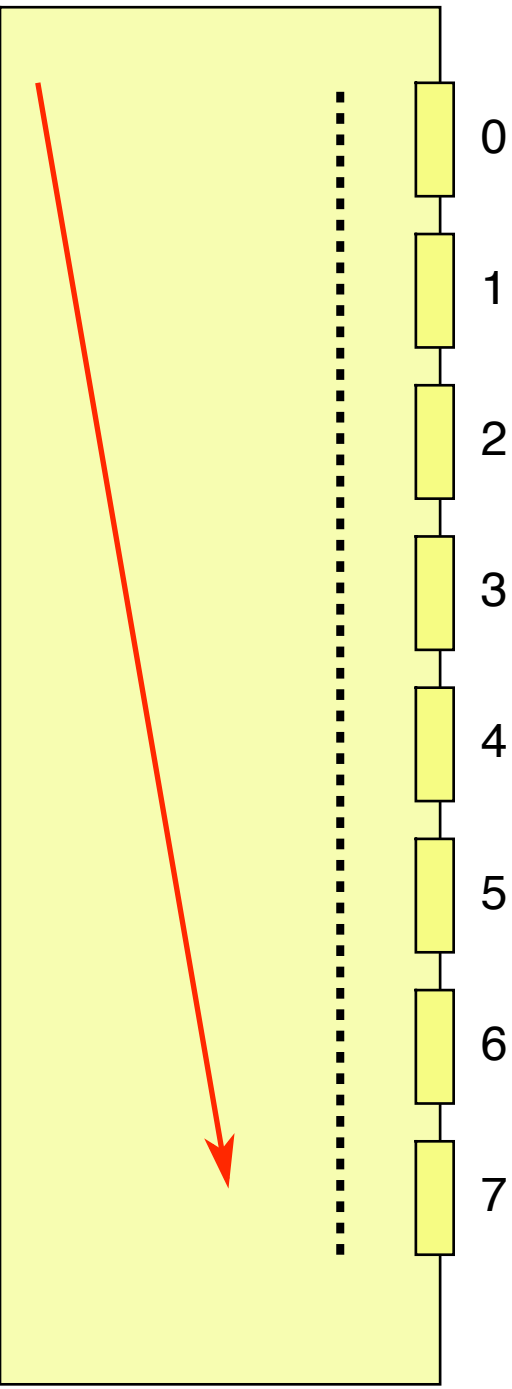
Pulse with 90% Helium, 10% CO_2 gas mixture at STP.

Pulse height: 400 mV
Rise time: 100 ns
Noise: 10 mV

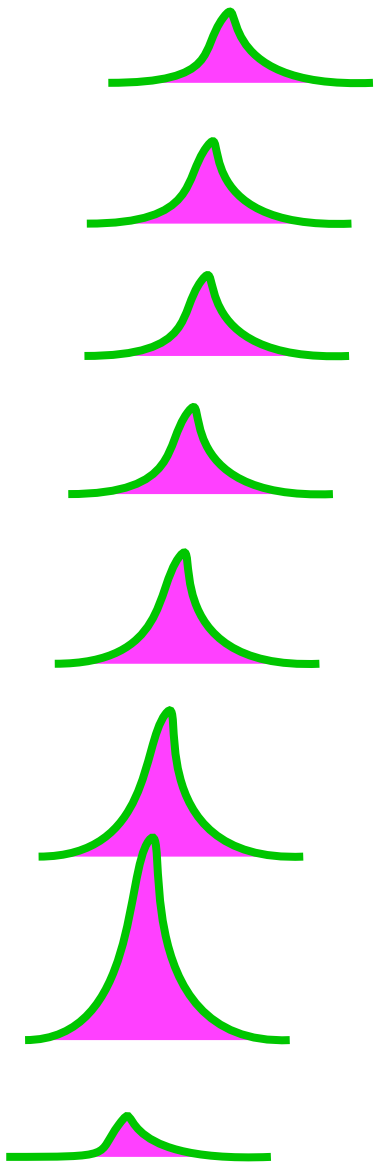


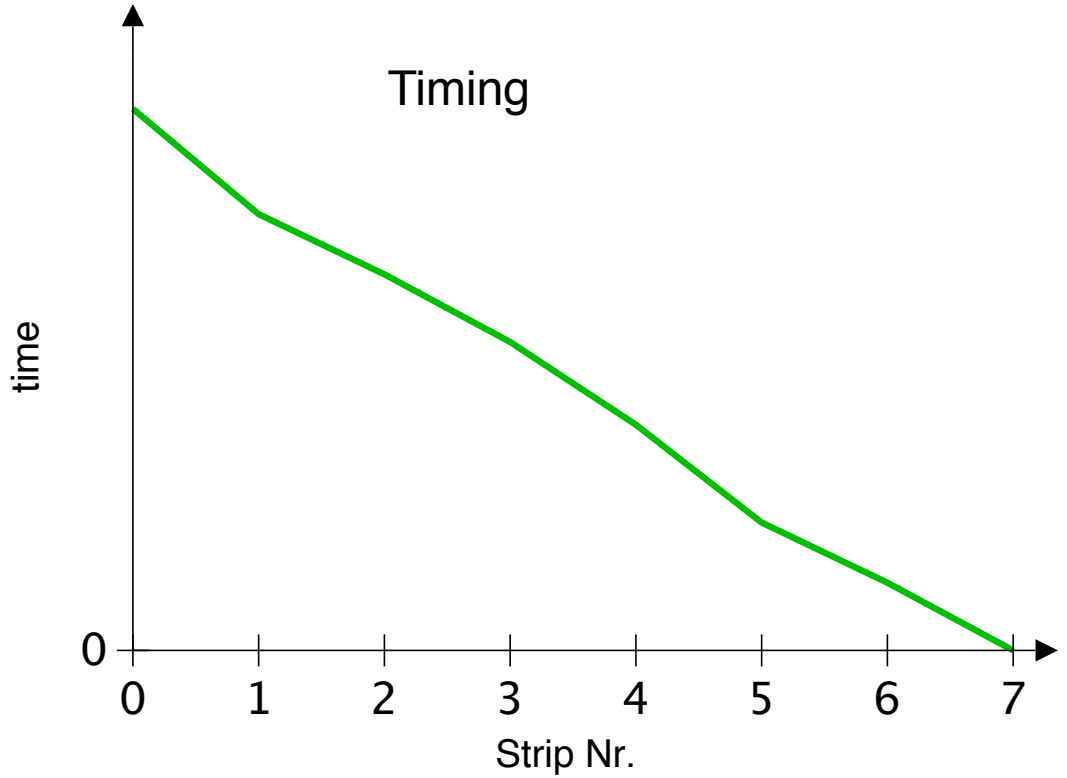
How is the GEM working with Helium?

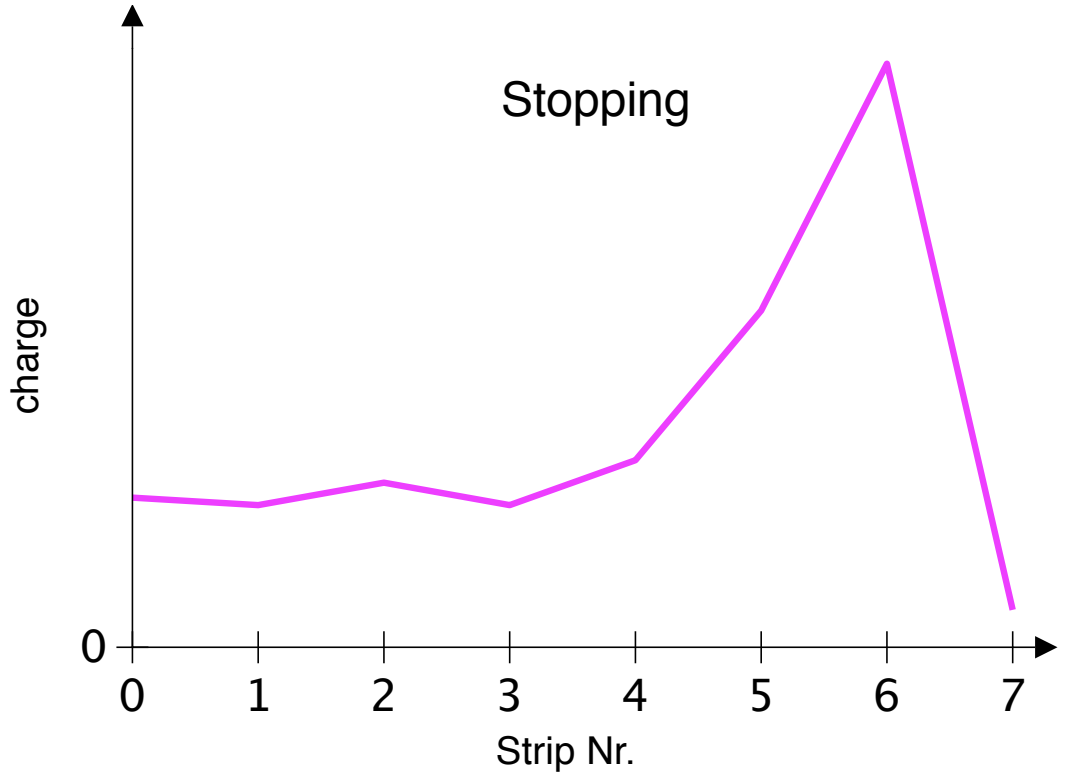



0
1
2
3
4
5
6
7

Signal

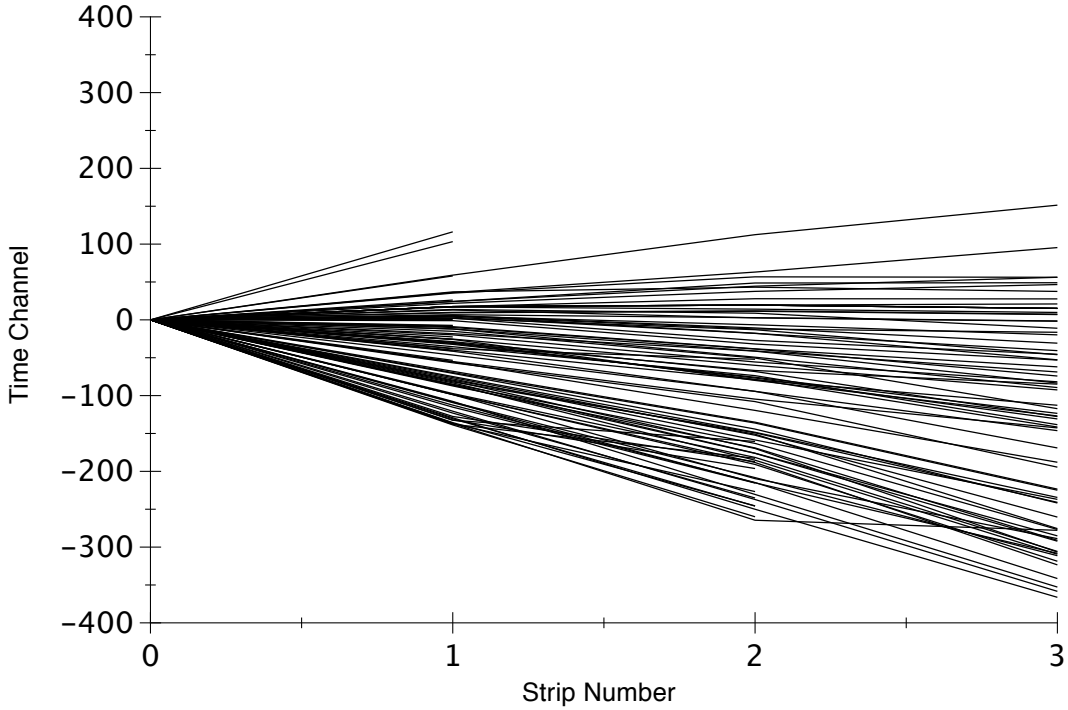


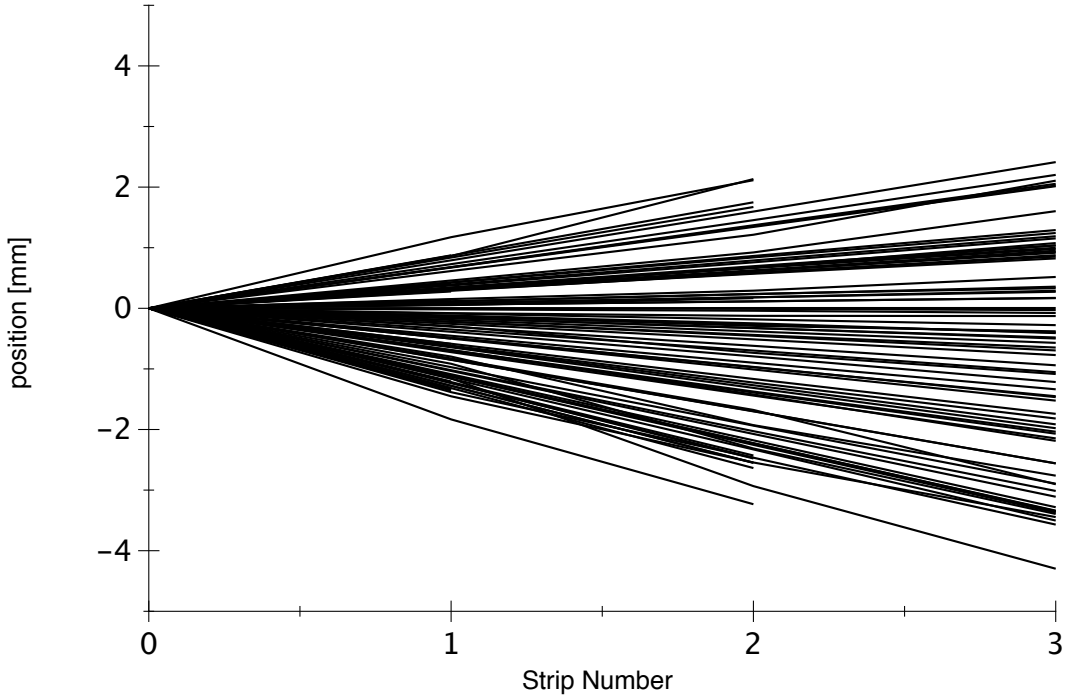

Timing
time
0
0
1
2
3
4
5
6
7
Strip Nr.


Stopping
charge
0
0
1
2
3
4
5
6
7
Strip Nr.

Alpha tracks: Measured and simulated

Mock chamber
measured
100 events



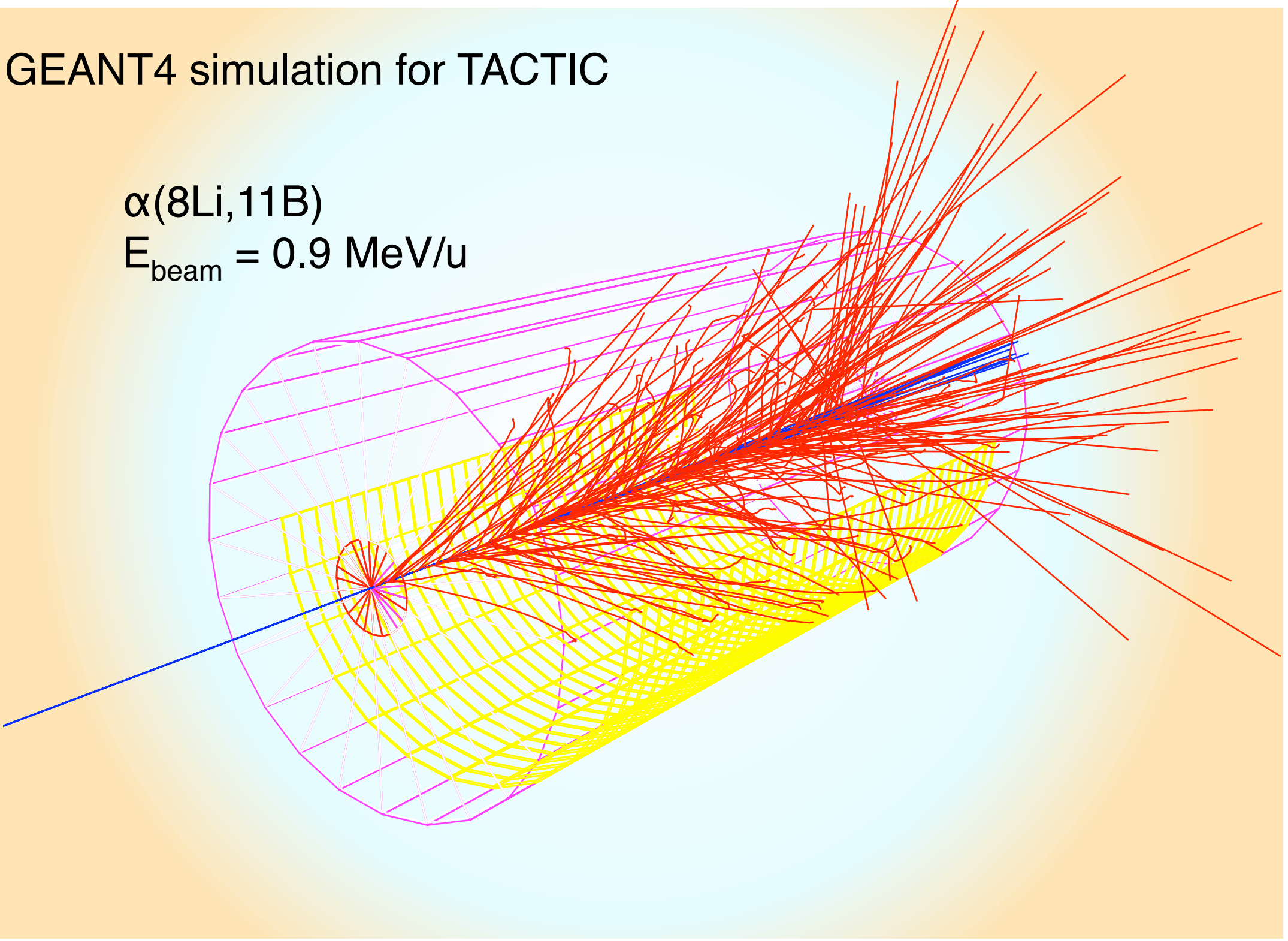


Mock chamber,
GEANT4 simulation
100 events

GEANT4 simulation for TACTIC

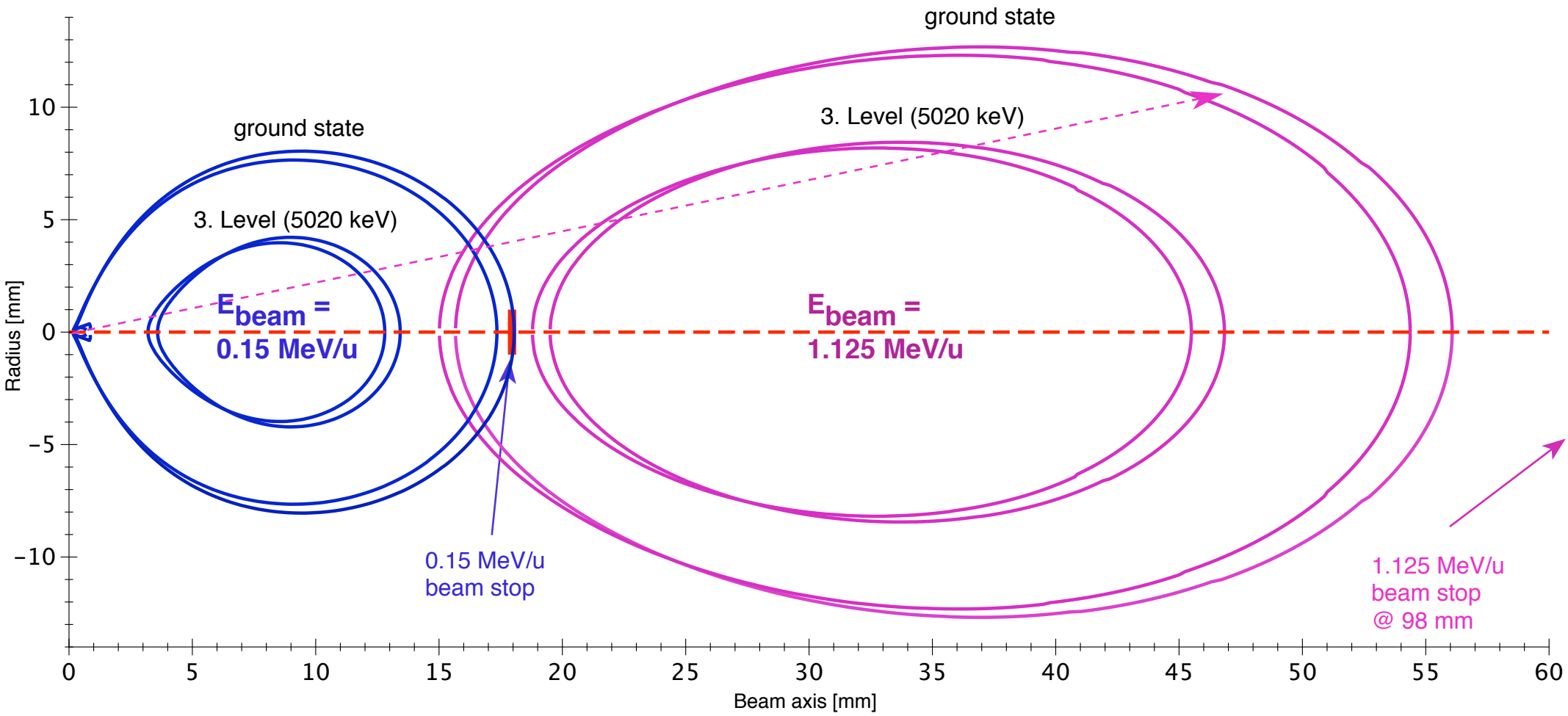
α(8Li,11B)

E_{beam} = 0.9 MeV/u



Range of ^{11}B from $\alpha(^{8}Li,^{11}B)n$ in 90% He 10% CO_2 gas mixture at STP

What is the optimal geometry?



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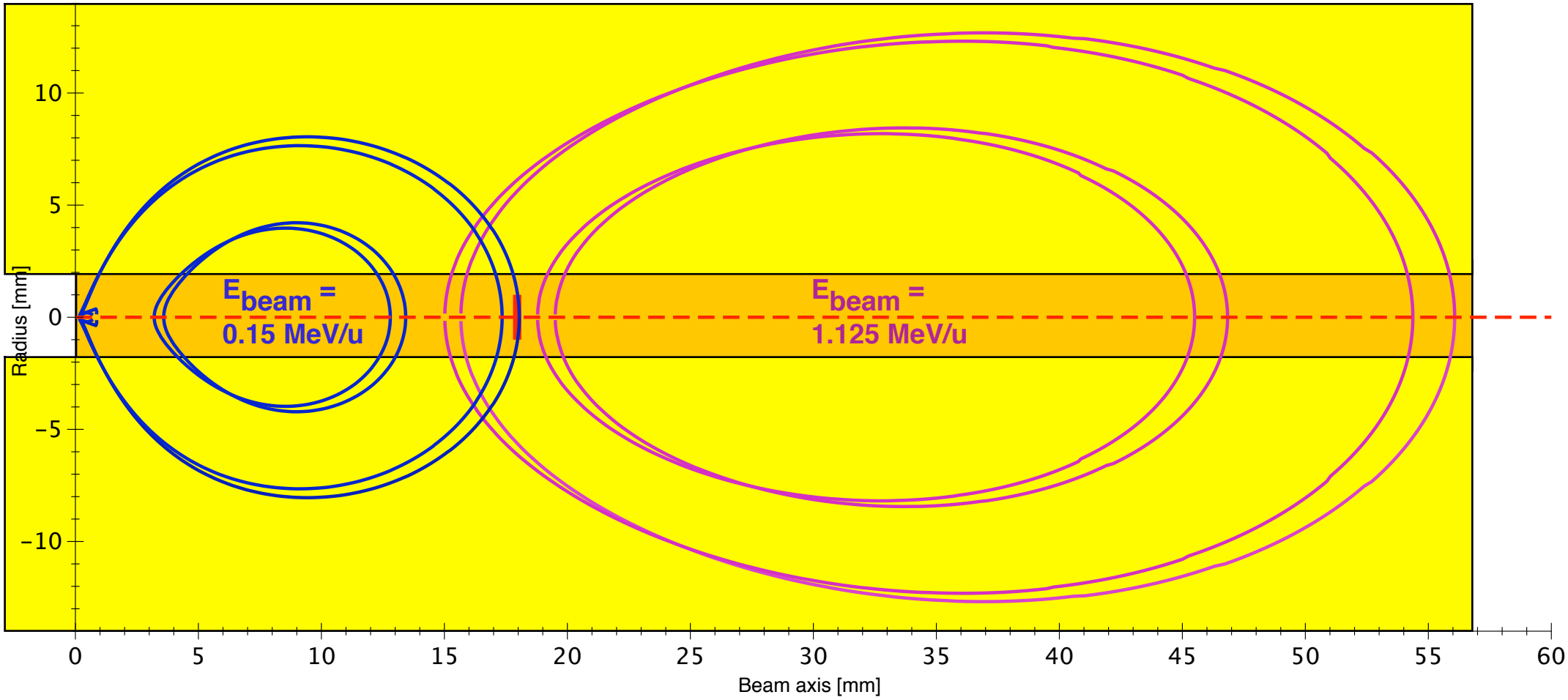
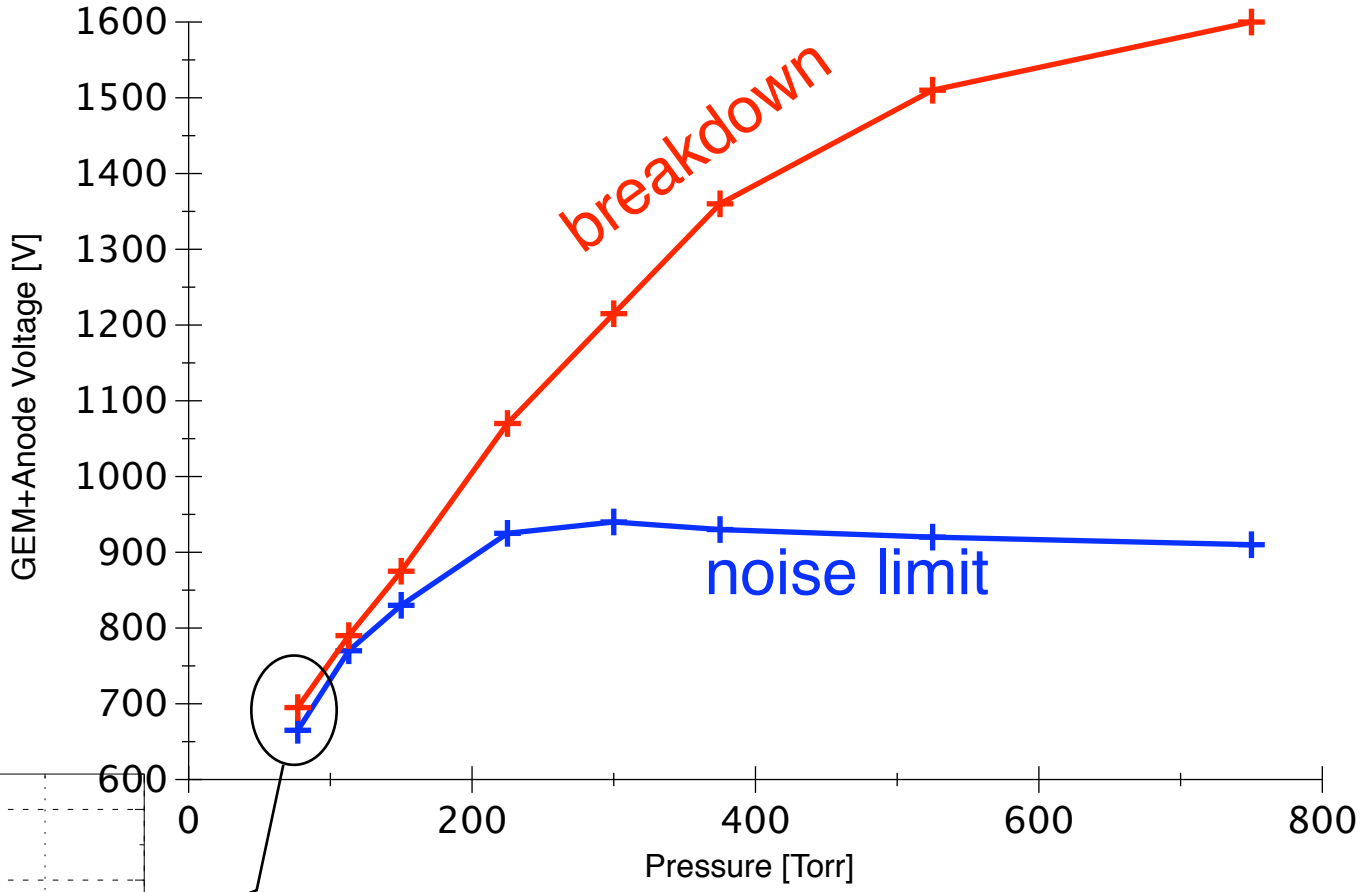
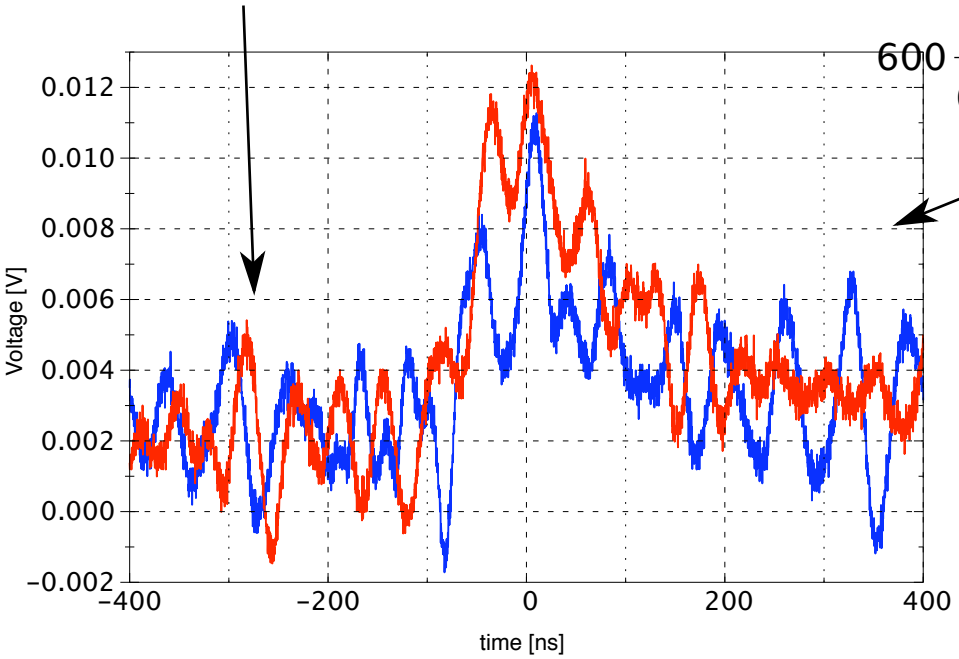


Pulse shapes, signal/noise ratio vs. pressure



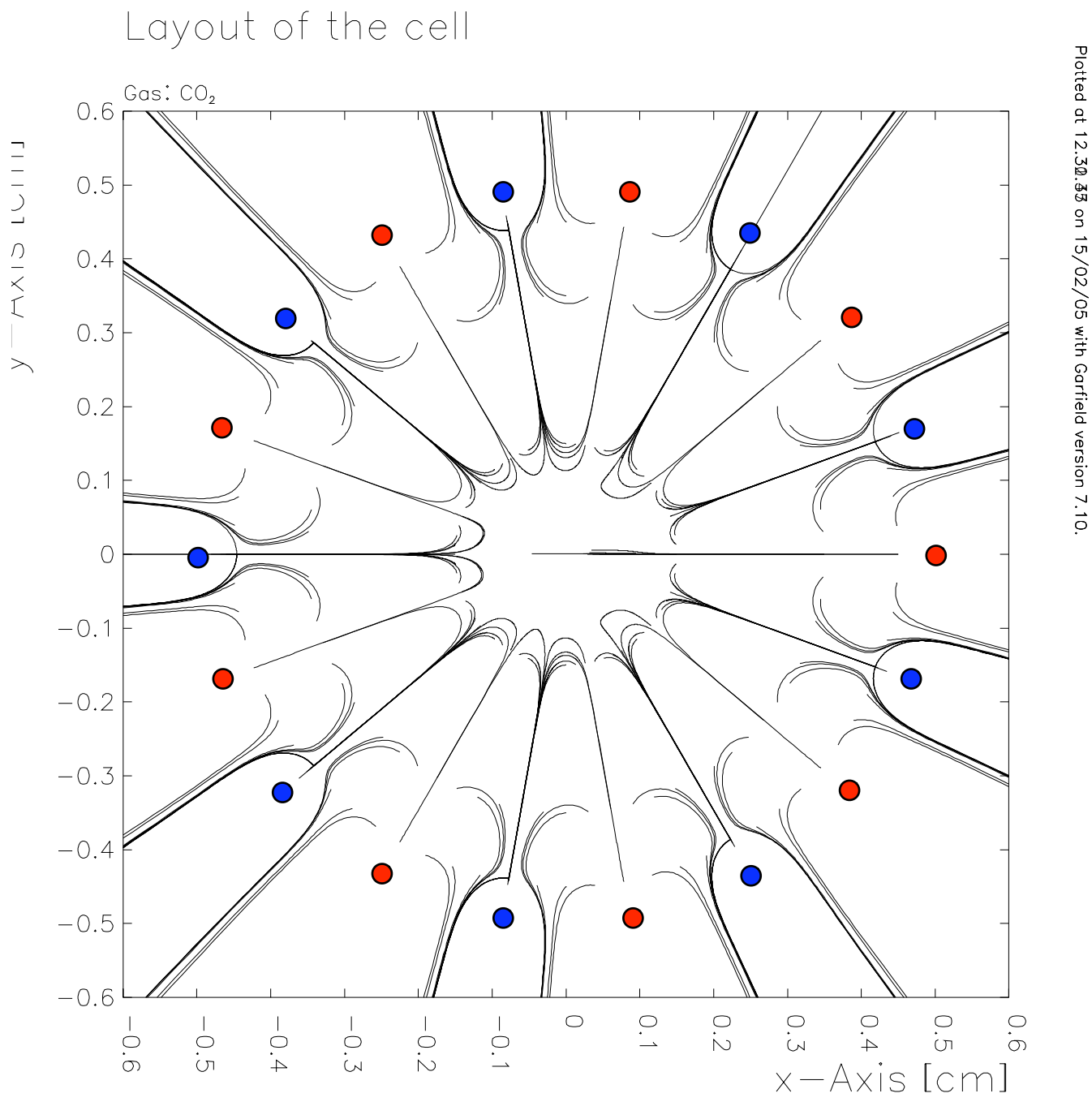
Laboratory noise from unshielded electronics



5.5 MeV a particles with 18 μm Mylar foil

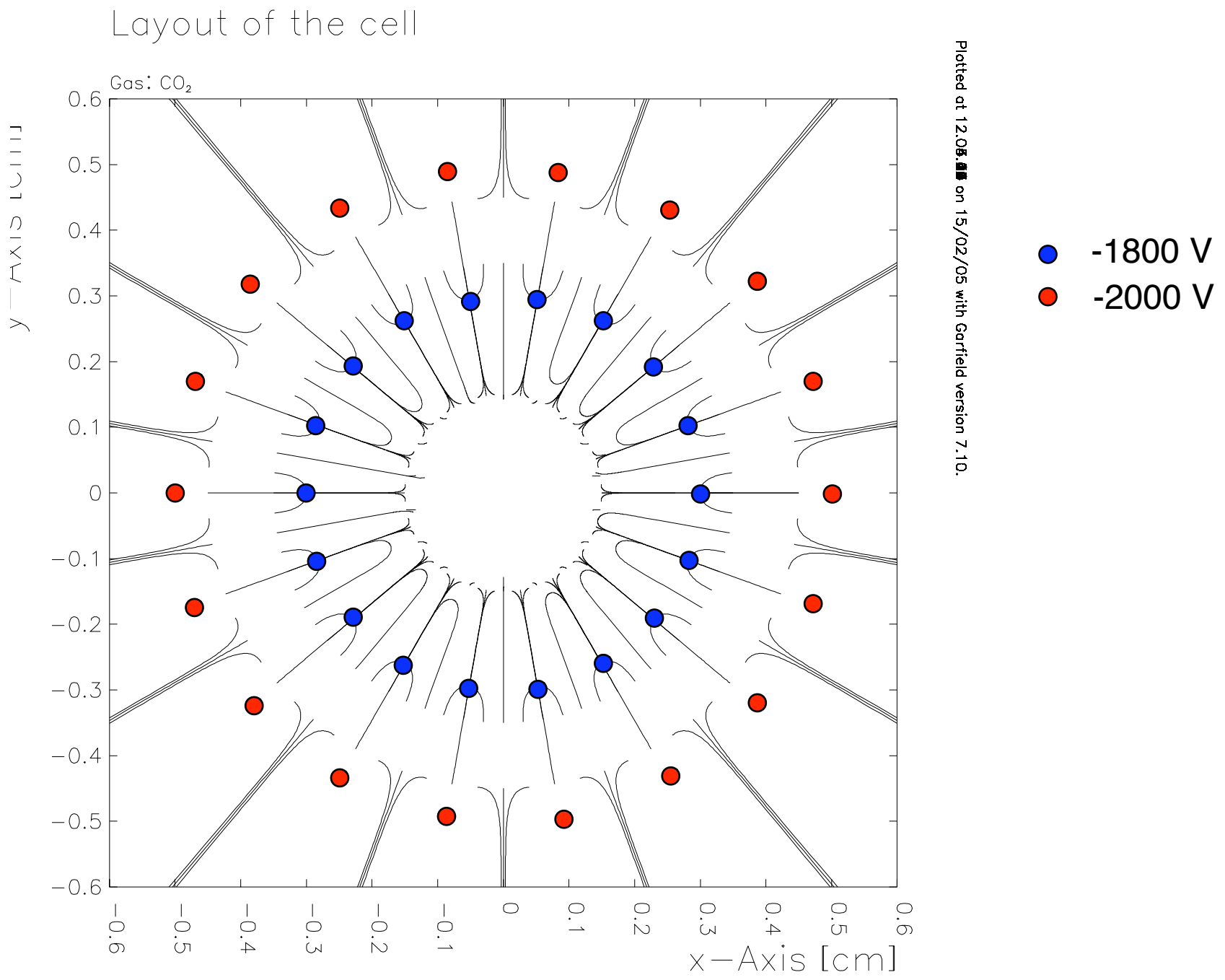
For the real case, the ^{11}B stopping is much higher

How to suppress beam electrons?

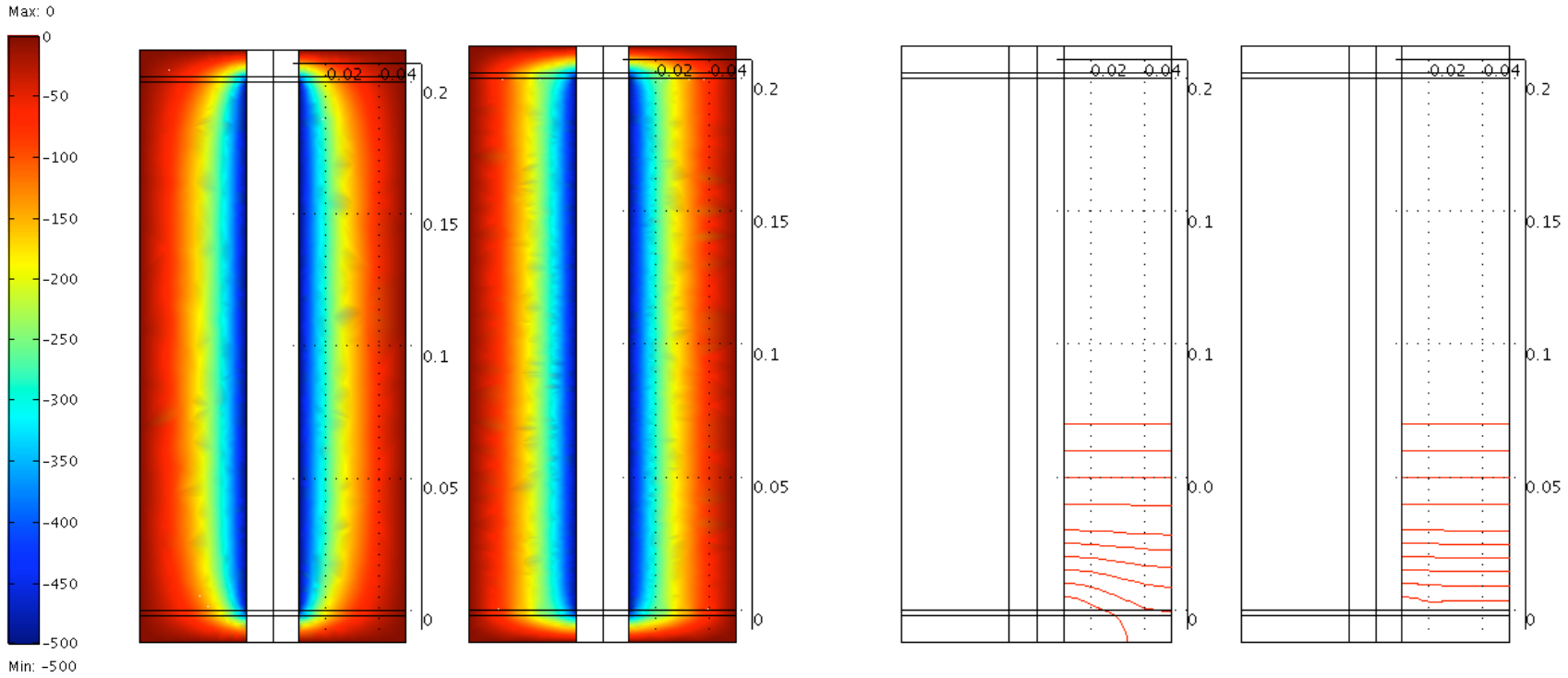


-1800 V
-2000 V

How to suppress beam electrons?



Potential - Fieldlines

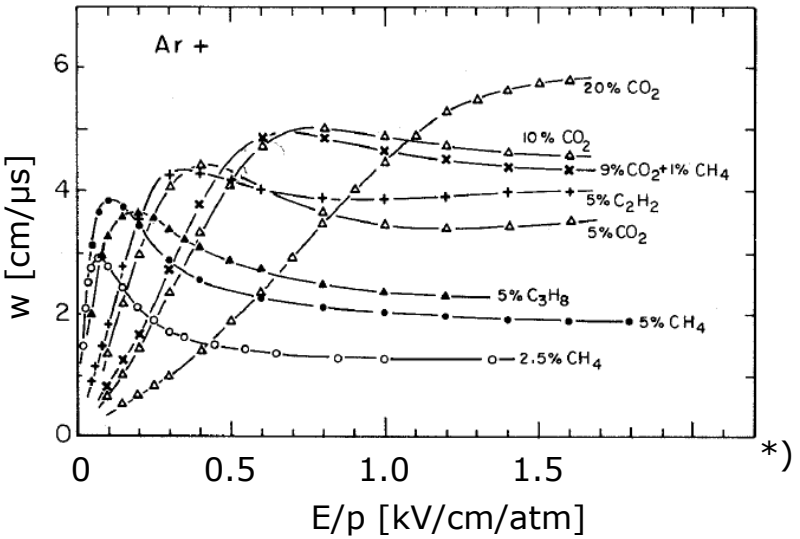


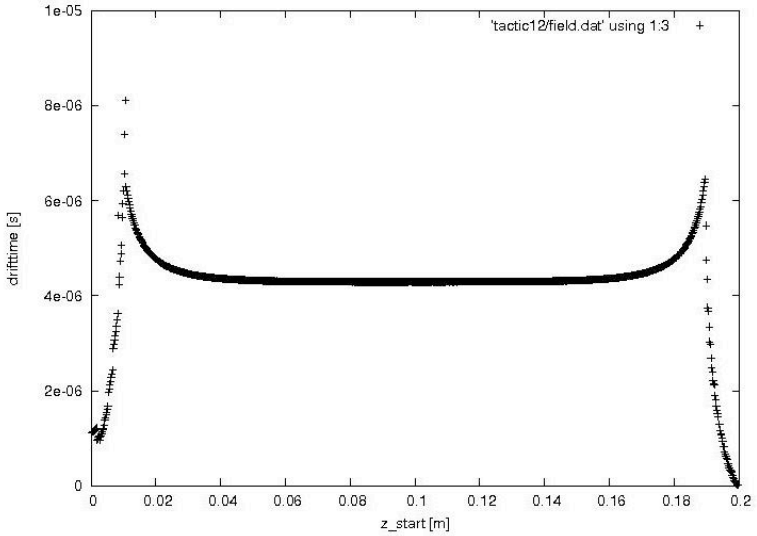
no pads 3 pads no pads 3 pads

e^- drift time

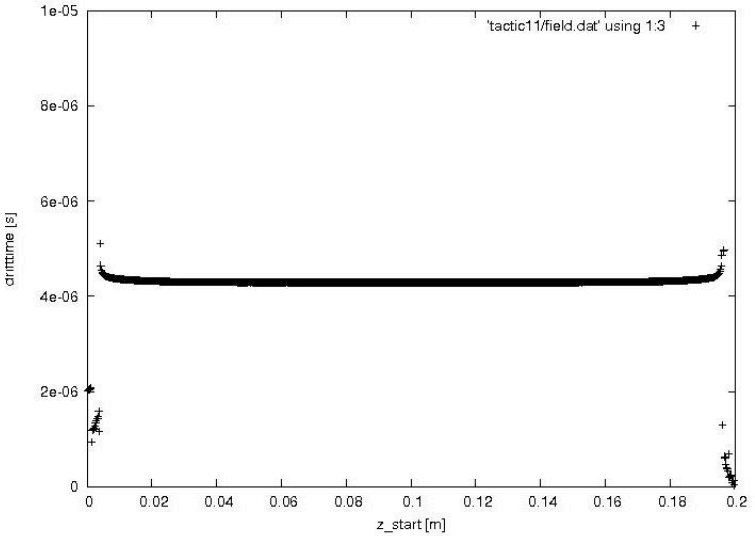
- assume $w_{drift}(E) = 0.9 \, {}^{\mathrm{m}}_{\mathrm{s}} / {}^{\mathrm{V}}_{\mathrm{m}} \cdot E$

  (approx. for 90% Ar + 10% CO_2)





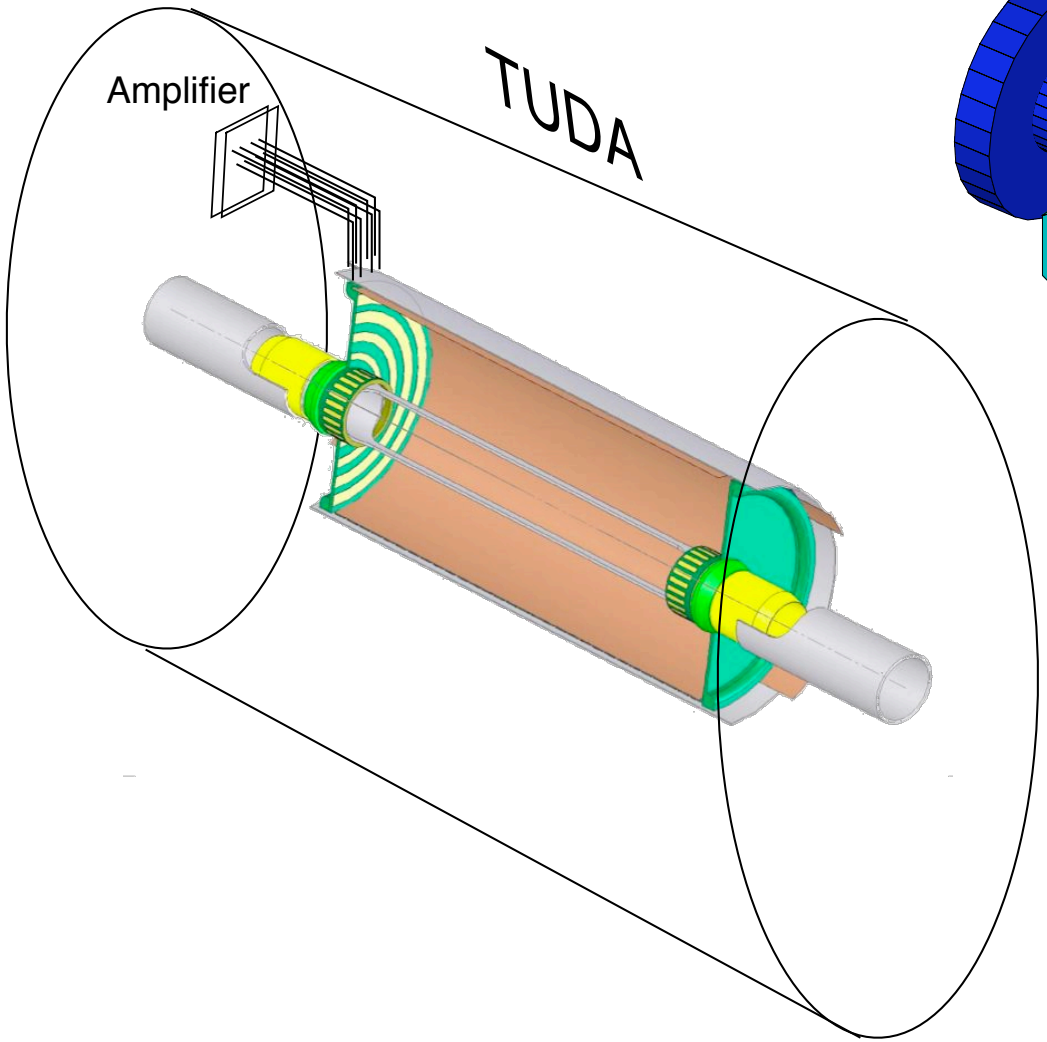
no pads

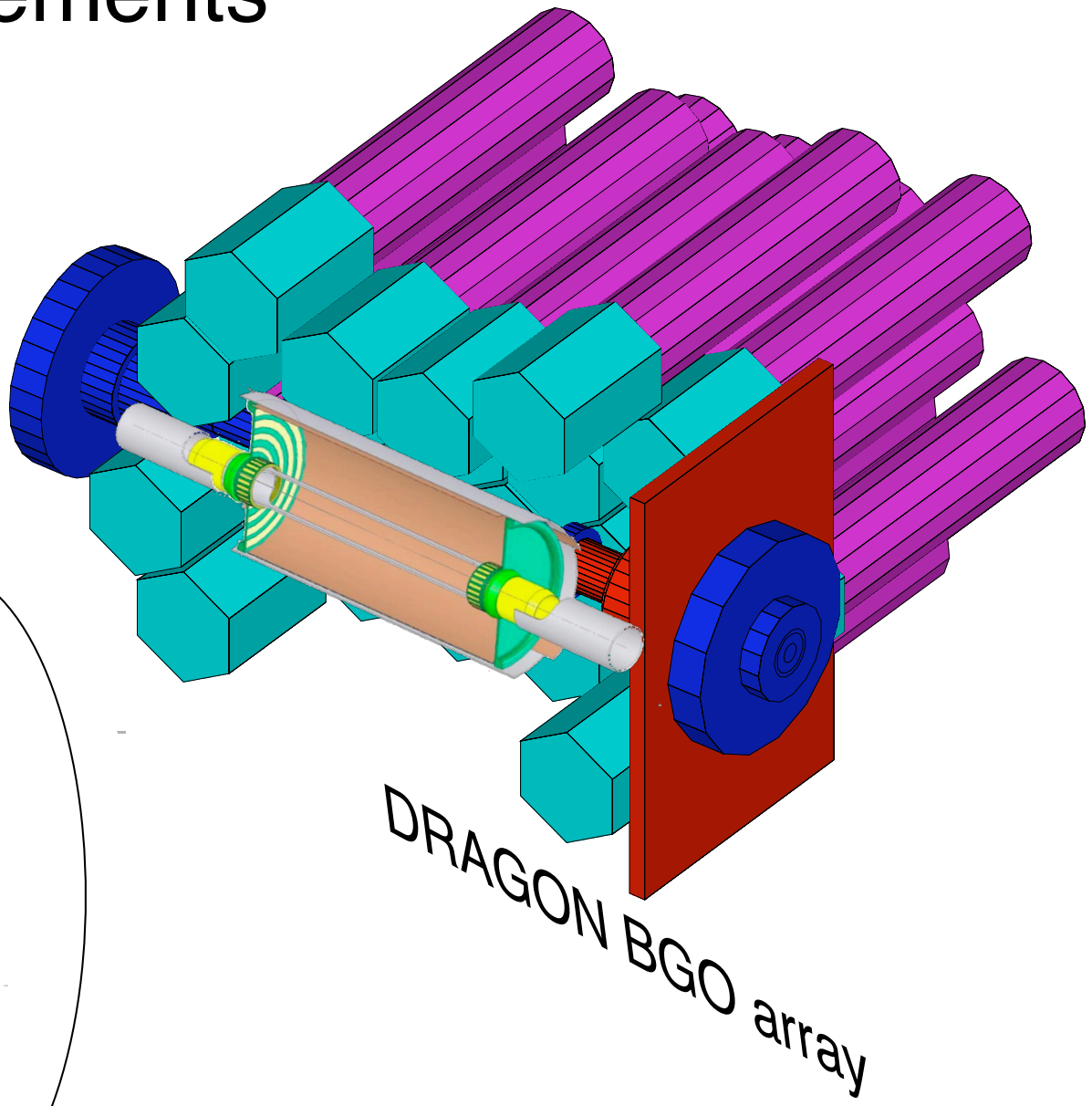


3 pads

*) from A. Peisert, F. Sauli: Drift and Diffusion of Electrons in Gases, Fig. 63, CERN, 1984

Possible placements





Schedule

- Spring 2005: Design first prototype
- Summer 2005: Fabrication and assembling
- Late summer 2005: Initial testing

Other reactions

- ^{7}Be+p elastic scattering
- ^{12}C + ^{12}C scattering

Summary

- TACTIC allows the measurement of low-energetic ejectiles over a wide angle range
- Excellent results for the GEM with Helium
- Good results for lower pressures
- Beam electron suppression possible

Thanks

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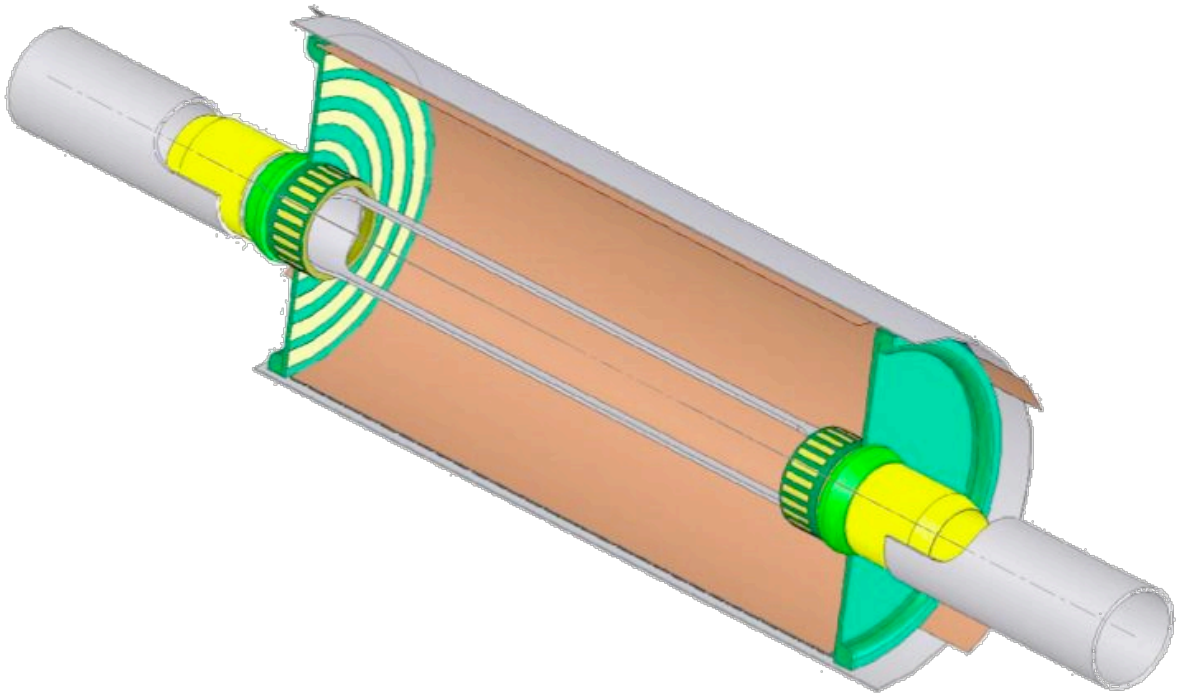

We are not alone...

The BoNuS detector

Prototype Construction

- Curved Prototype Test Fit