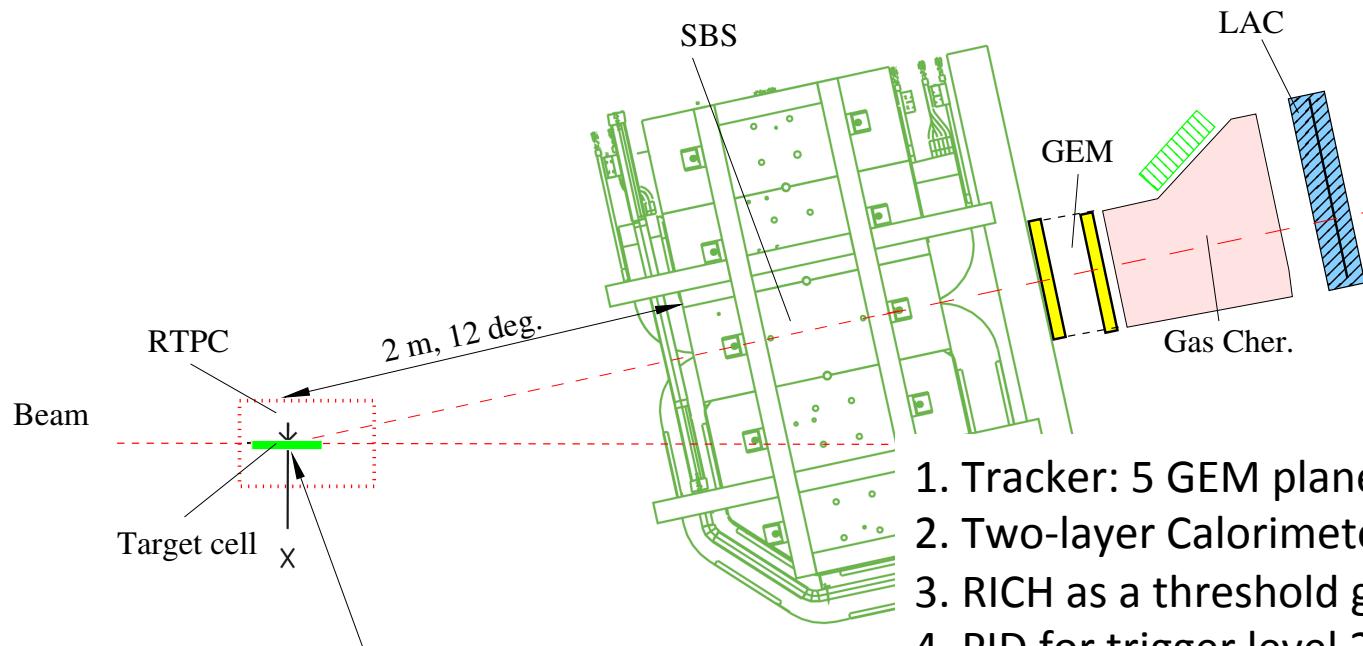


TDIS Experiment Layout

Scattered electron detection in
Super Bigbite Spectrometer

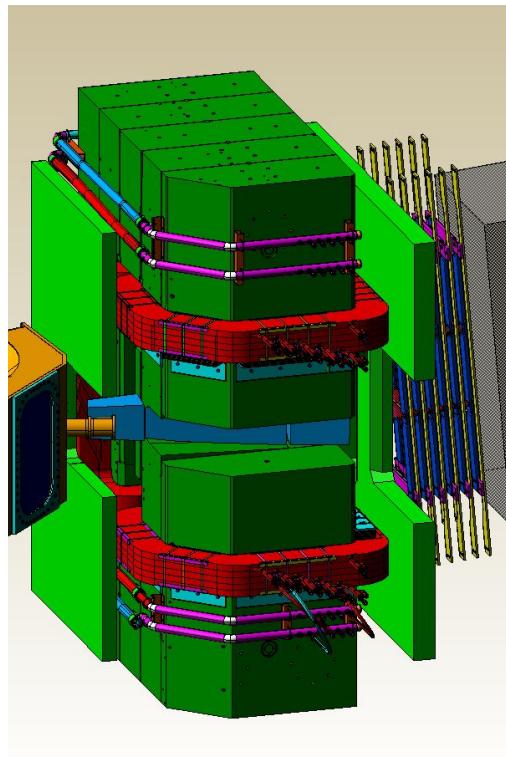


- ✓ High luminosity,
 $50 \mu\text{A}, \mathcal{L} = 3 \times 10^{36} \text{ cm}^2/\text{s}$
- ✓ Large acceptance
Super Bigbite ~ 50 msr, electron
RTPC calibration via $D(e,e'n)p$
- Need to...
add a BONUS-type RTPC,
a 40 cm bore solenoid (UVa)

1. Tracker: 5 GEM planes (from G_E^P expt.)
2. Two-layer Calorimeter (LAC from CLAS6)
3. RICH as a threshold gas Cherenkov
4. PID for trigger level 2: LAC + Cherenkov

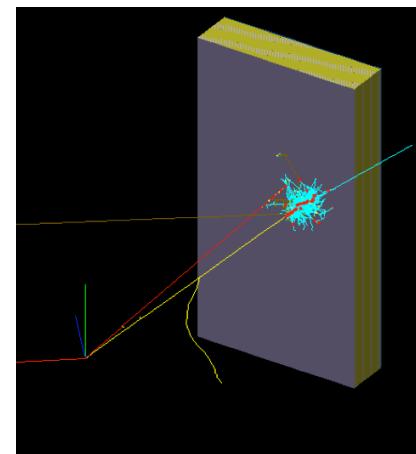
Hadron calorimeter (HCAL)
for the RTPC calibration by
the proton tagged in $D(e,e'n)p$
quasi-elastic neutron knockout

Super Bigbite Spectrometer, Electron Detection

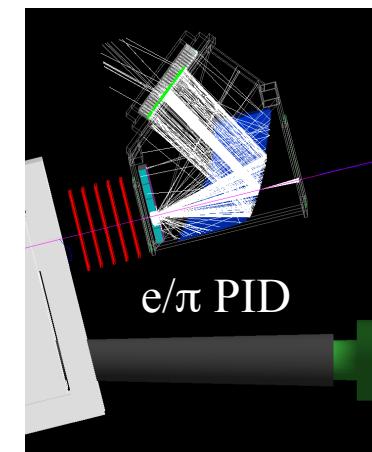


- Location from the target, - 2 meters
- Mid. scattering angle, - 12 degrees
- Solid angle at 2-m drift, - 50 msr
- Momentum resolution, - 0.5%
- Angular resolution, - 0.6 mrad
- Vertex resolution (y), - 1.5 mm
- Time resolution (LAC), < 0.5 ns
- PID (e/π) trigger level 1 (LAC), - 10-20 \ / = 500+
- PID (e/π) trigger level 2 (RICH), > 50 \ / = 500+

SBS trigger, level 1



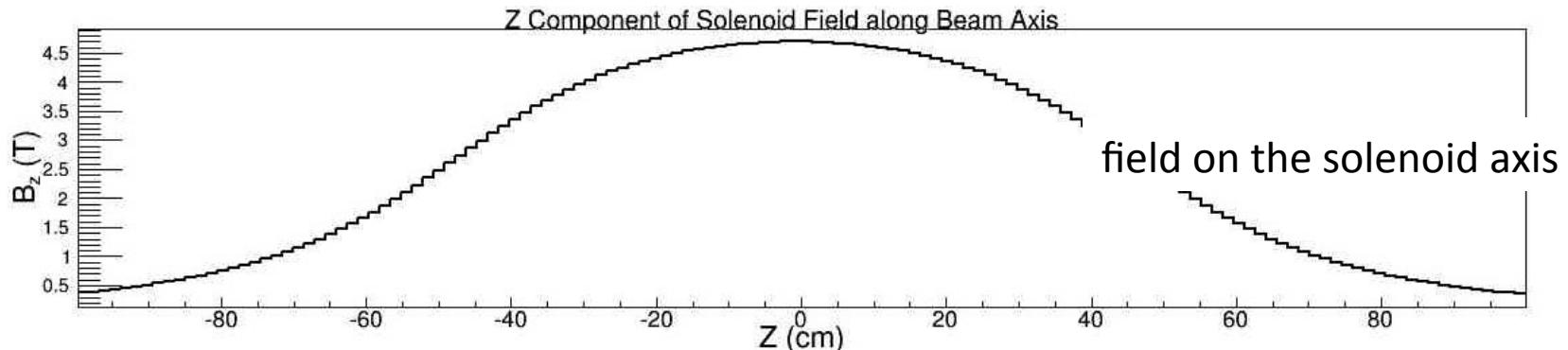
SBS RICH simulation



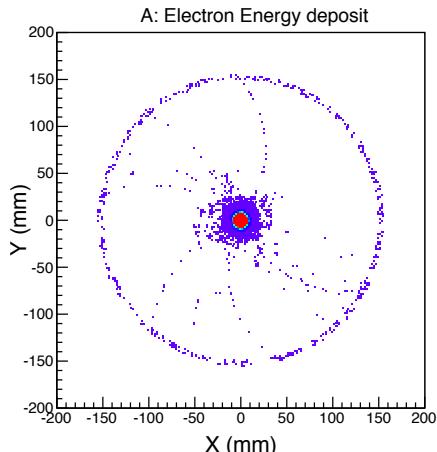
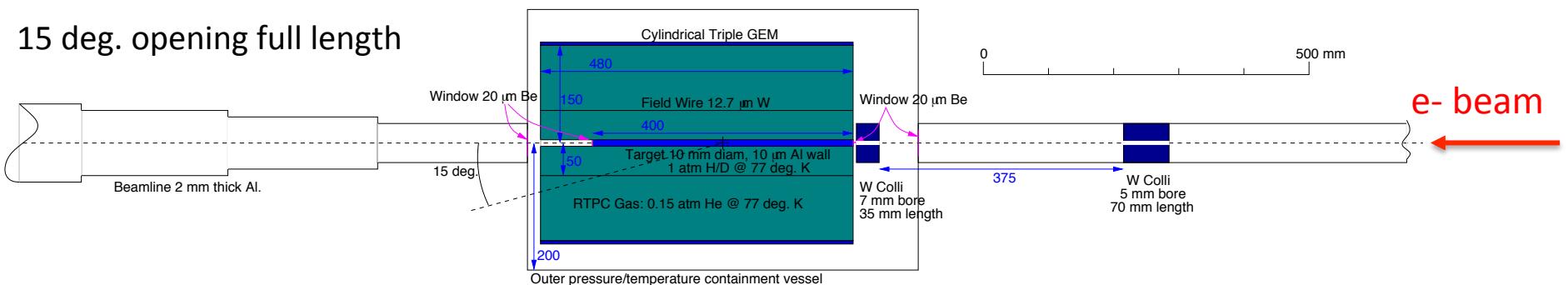
CLAS6 Large Angle Calorimeter

2.17 m x 4 m active area
33 layers (17 + 16)
Time resolution ~ 0.25 ns
Energy resolution $7.5\%/\sqrt{E}$
 π rejection factor $\sim 10-20$

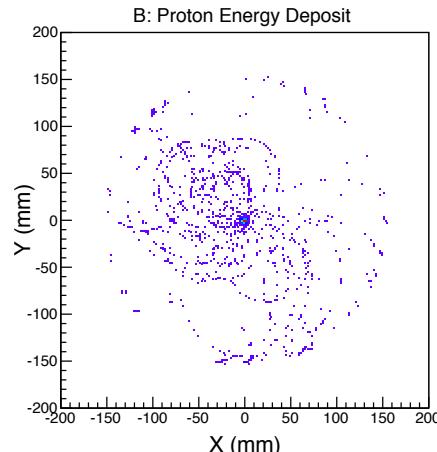
Radial TPC in the detail MC study



15 deg. opening full length



δ -electrons are confined

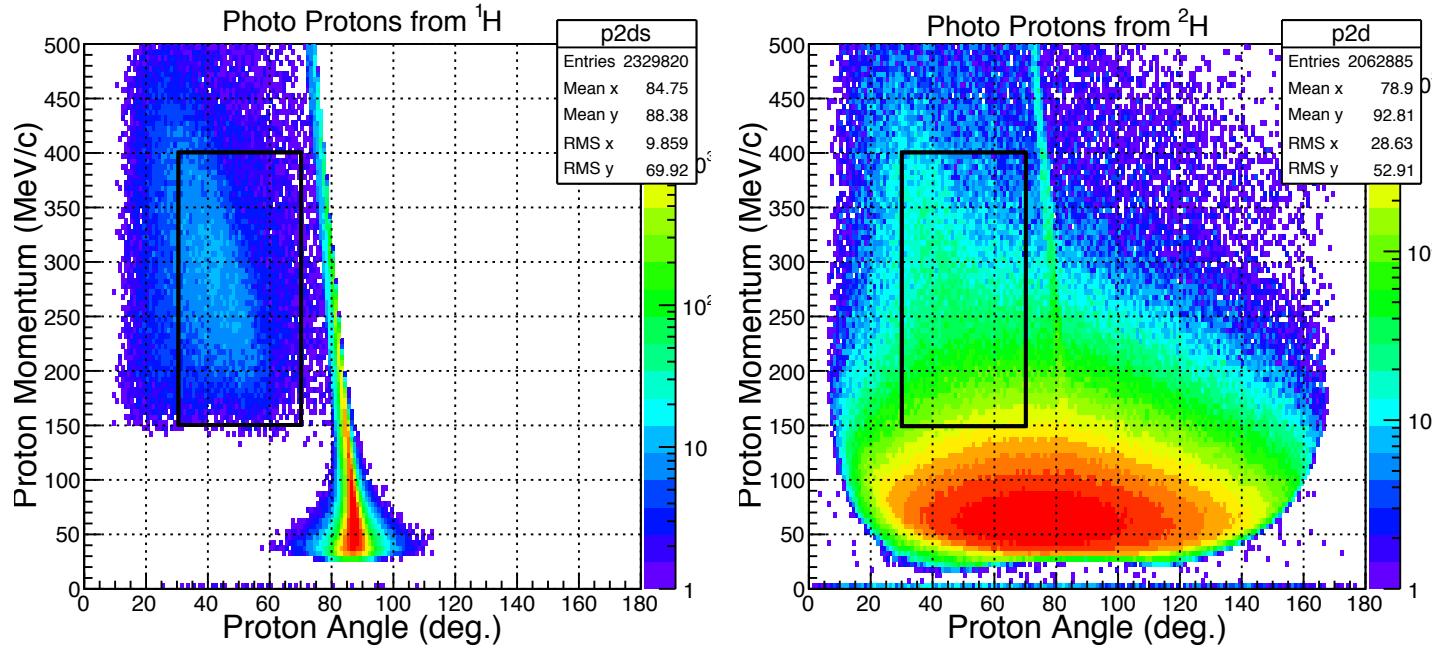


protons in RTPC

Monte Carlo simulates electromagnetic interactions
Includes deuteron photodisintegration
Elastic scattering by far largest direct calculation ~ 170 MHz
Effective ionization $\sim 30x$ of normal GEM

Hit rate ~ 4 MHz cm^2/s - OK for GEMs
Readout pixel area is 0.2 cm^2

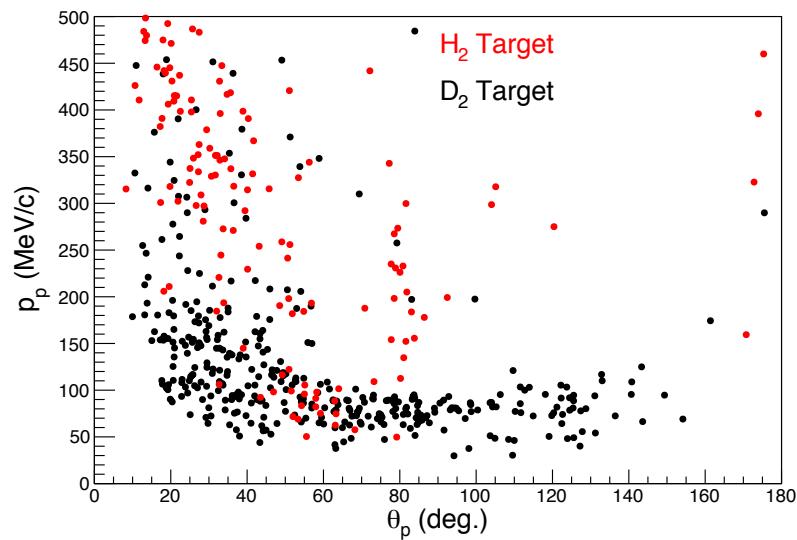
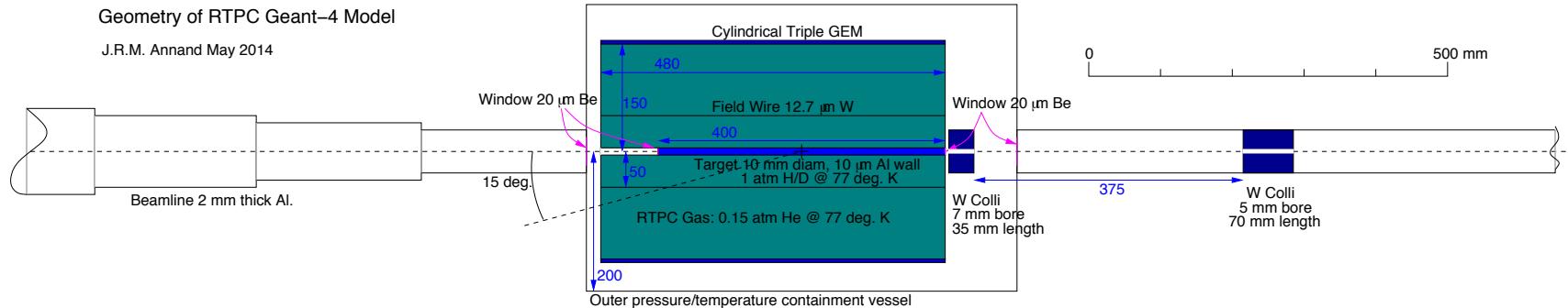
Radial TPC in the detail MC study



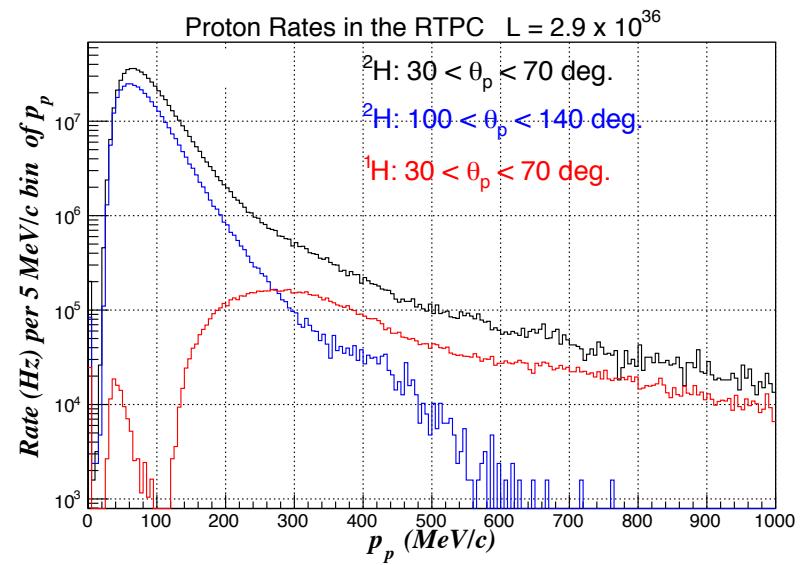
Target	θ_p (deg.)	$70 < p_p < 250$ (MHz)	$p_p > 250$ (MHz)	$150 < p_p < 400$ (MHz)
^1H	30 - 70	2.3	7.4	6.3
^2H	30 - 70	357	20.1	64
^2H	100 - 140	204	3.1	—
^{27}Al	30 - 70	0.37	0.0	0.05
^{27}Al	100 - 140	0.10	0.0	—

Table 2: Proton Rates in the sensitive region of the RTPC after cuts have been made on proton angle and proton momentum.

Radial TPC in the detail MC study

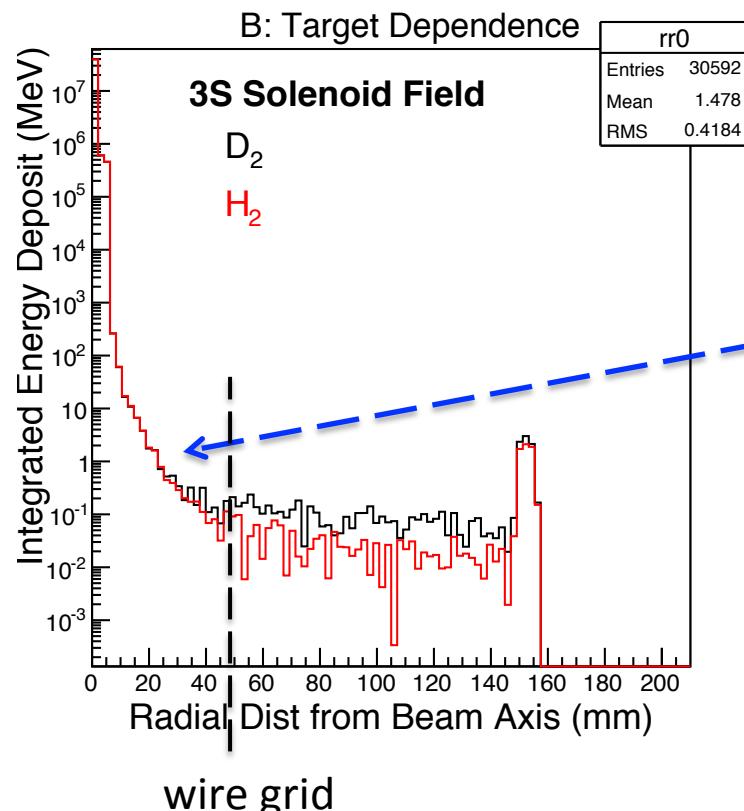
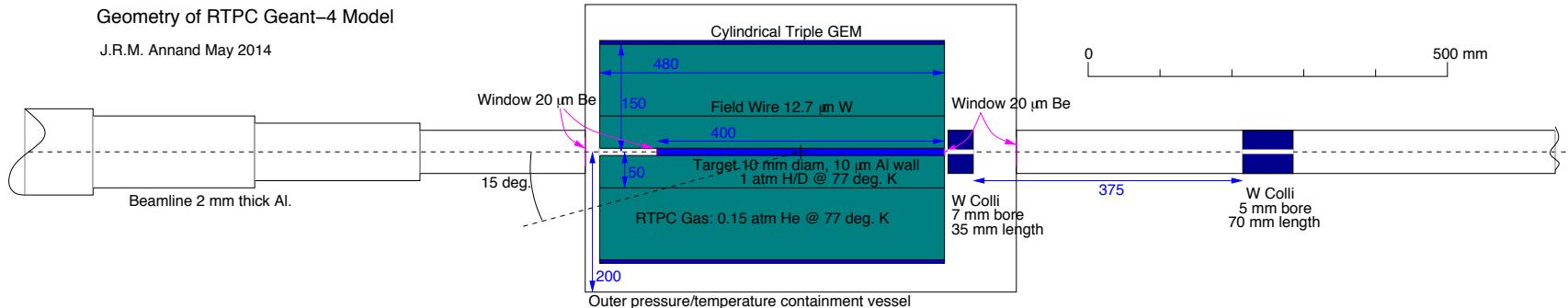


Momentum – Angular correlation



Proton momentum spectra

Radial TPC in the detail MC study



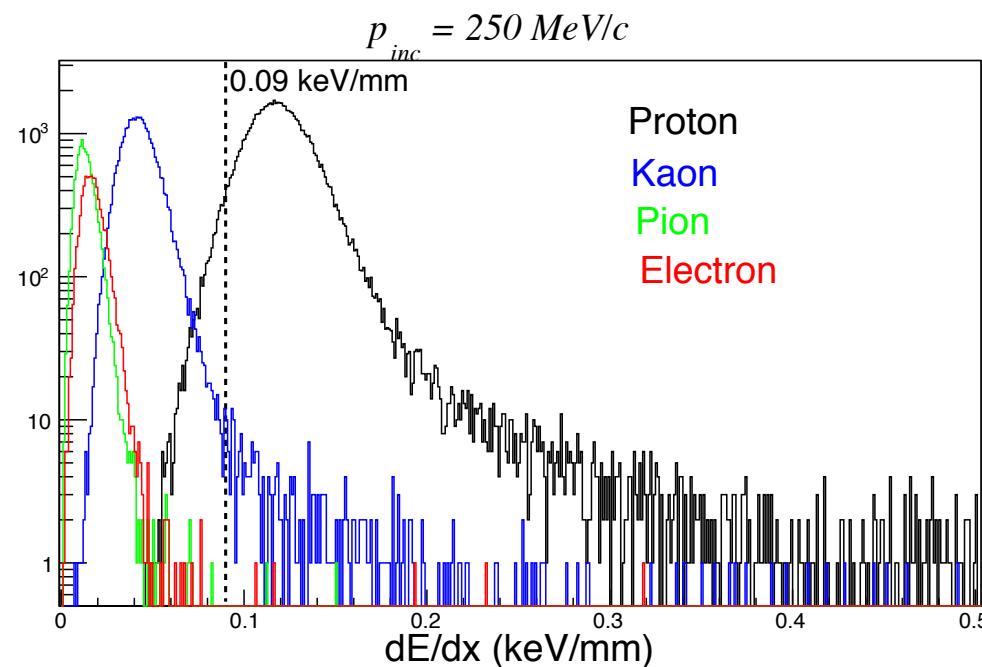
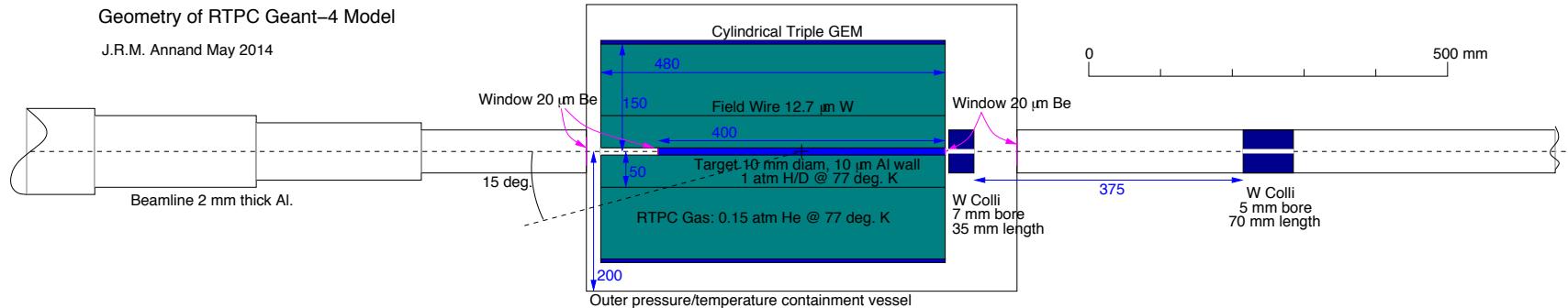
Radial distribution of the ionization

Highest ionization density ($R < 50$ mm)

is confined by the solenoid field

Ions are confined by a wire grid

The PID MC study



RTPC at 0.15 atm 77K

Above the 0.09 keV/mm cut the efficiencies are
96% proton;
1% kaon;
0.02% pion

Target	θ_p (deg.)	$70 < p_p < 250$ (MHz)	$p_p > 250$ (MHz)	$150 < p_p < 400$ (MHz)
^1H	30 - 70	2.3	7.4	6.3
^2H	30 - 70	357	20.1	64
^2H	100 - 140	204	3.1	—
^{27}Al	30 - 70	0.37	0.0	0.05
^{27}Al	100 - 140	0.10	0.0	—

Table 4: Proton Rates in the sensitive region of the RTPC after cuts have been made on proton angle and proton momentum.

1131 **Particle Identification** Analysis of step-by-step information along particle tracks pro-
 1132 duced by the simulation have been analyzed to determine dE/dx in the RTPC gas
 1133 for p , π^+ , K^+ , e . Particles have been produced at angles $\theta = 30 - 70^\circ$, at position
 1134 $z = 0.0 \pm 5$ mm, and at momenta p_{inc} of 100 ± 1 , 250 ± 1 and 400 ± 1 (MeV/c). Fig.29 dis-
 1135 plays the resulting distributions at 250 MeV/c, for tracks with a total length greater than
 1136 50 mm. The dotted line shows the position of the cut used to select proton events. Mean
 1137 and rms values for dE/dx distributions are given in Tab. 5, along with the particle accep-
 1138 tance after the conditions $dE/dx > 0.5, 0.09, 0.05$ keV/mm for $p_{inc} = 100, 250, 400$ MeV/c
 1139 respectively have been applied. These thresholds lead to a K^+ acceptance fraction of 1%.

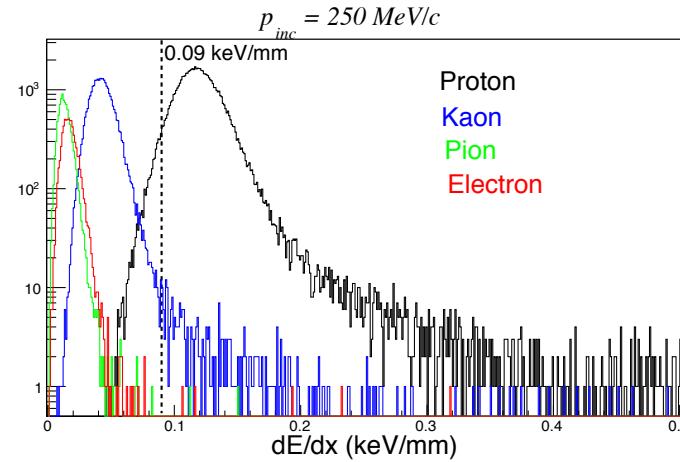
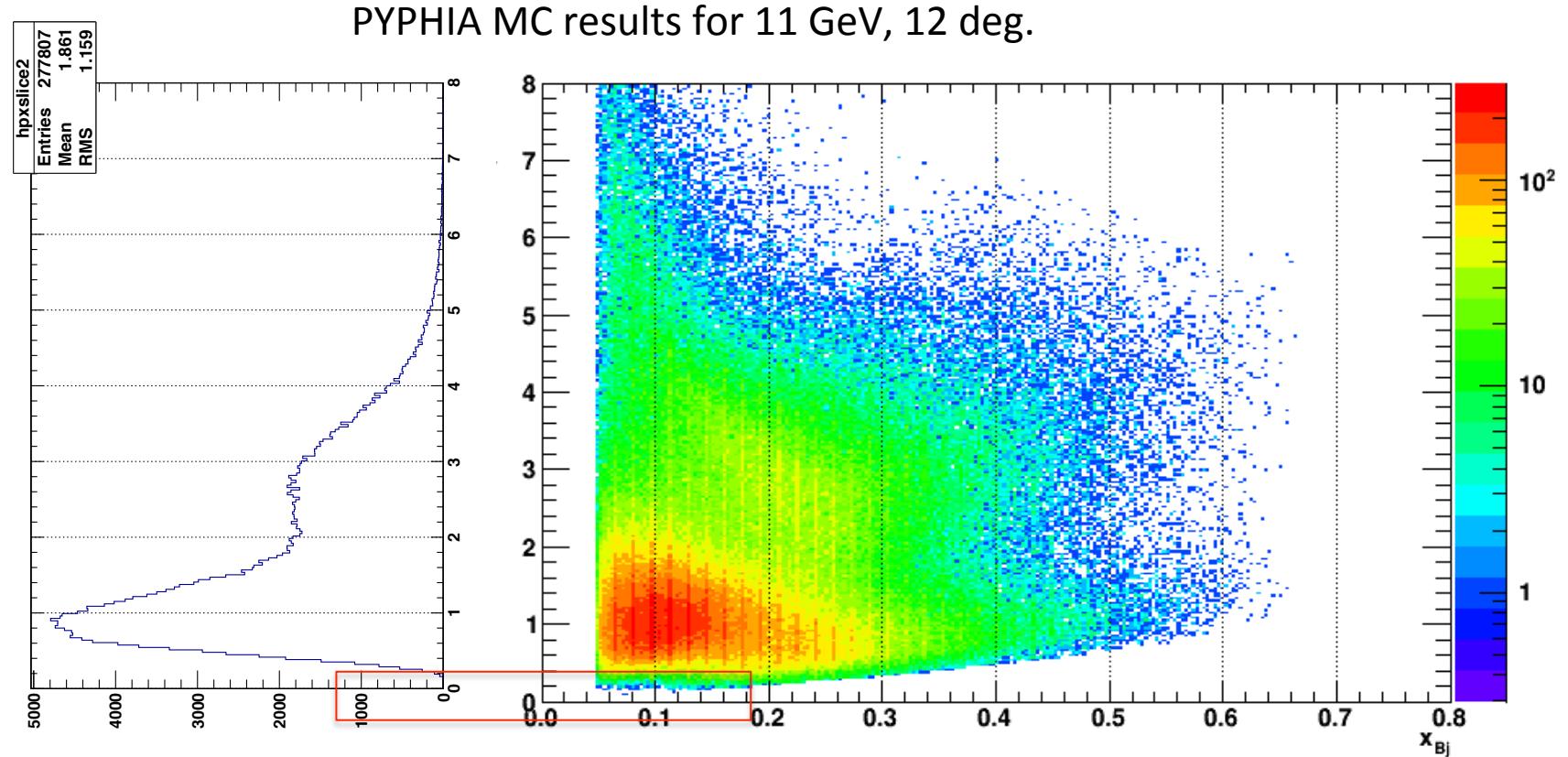


Figure 29: dE/dx for particles of momentum $250 \text{ MeV}/c$ detected in the outer He volume of the RTPC.

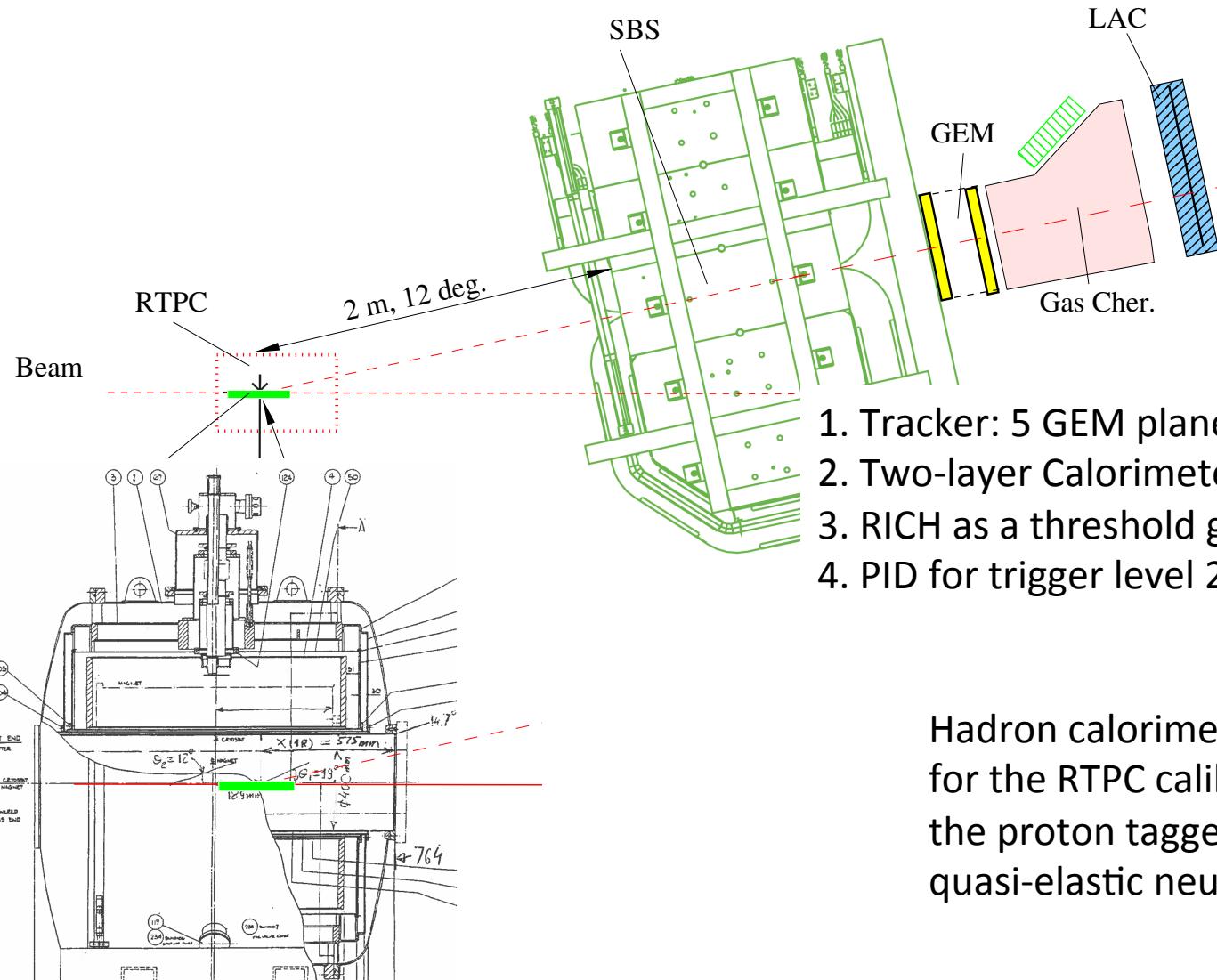
Detector rates of this Experiment: protons in RTPC



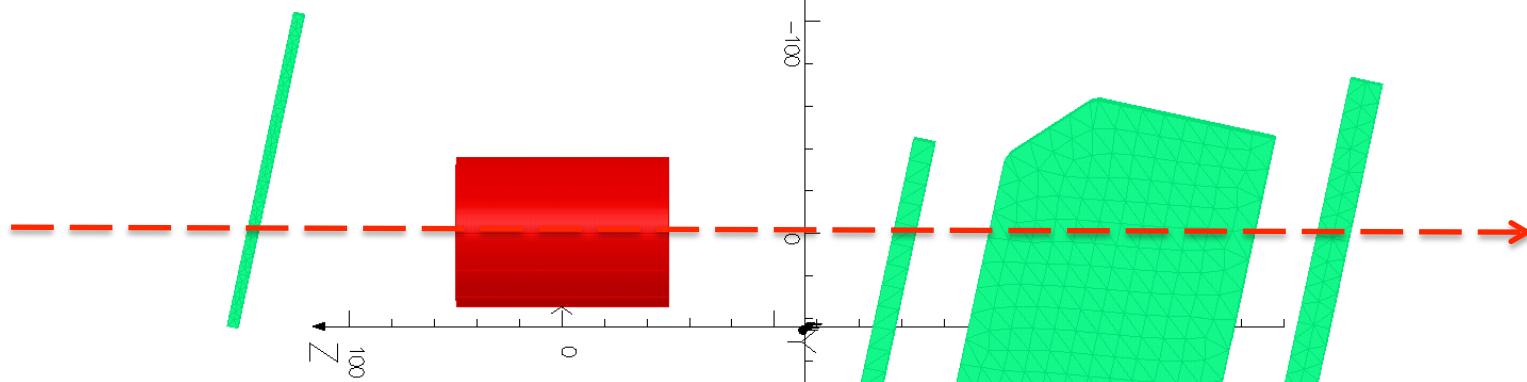
The probability of a DIS event having a true coincidence soft proton ($p < 0.4 \text{ GeV}/c$) in the acceptance is $< 2 \times 10^{-3}$.

The experiment new key element: the RTPC

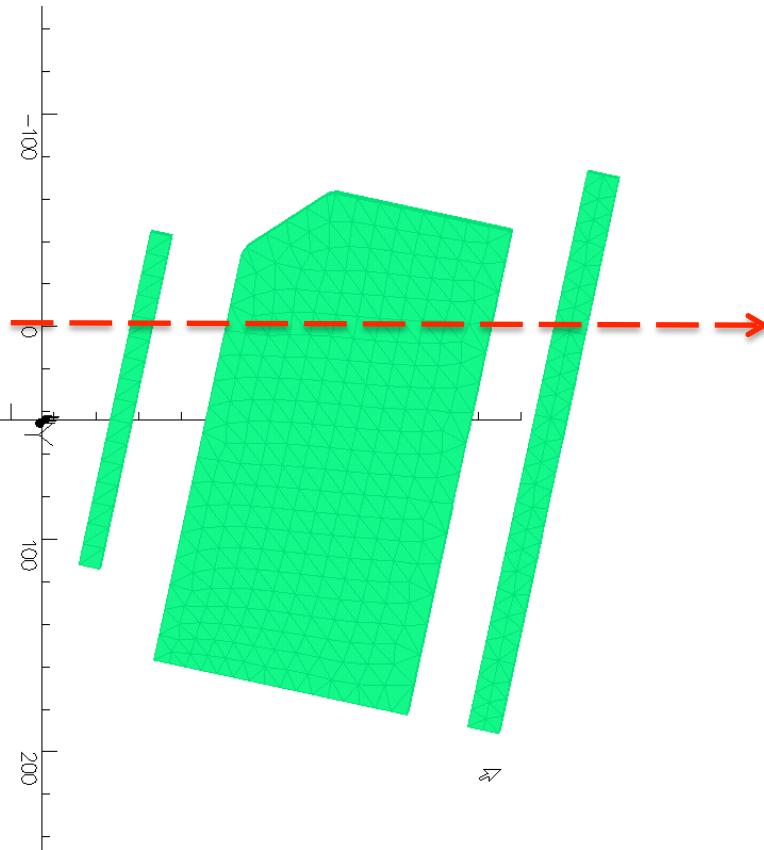
Scattered electron detection in
Super Bigbite Spectrometer (SBS)



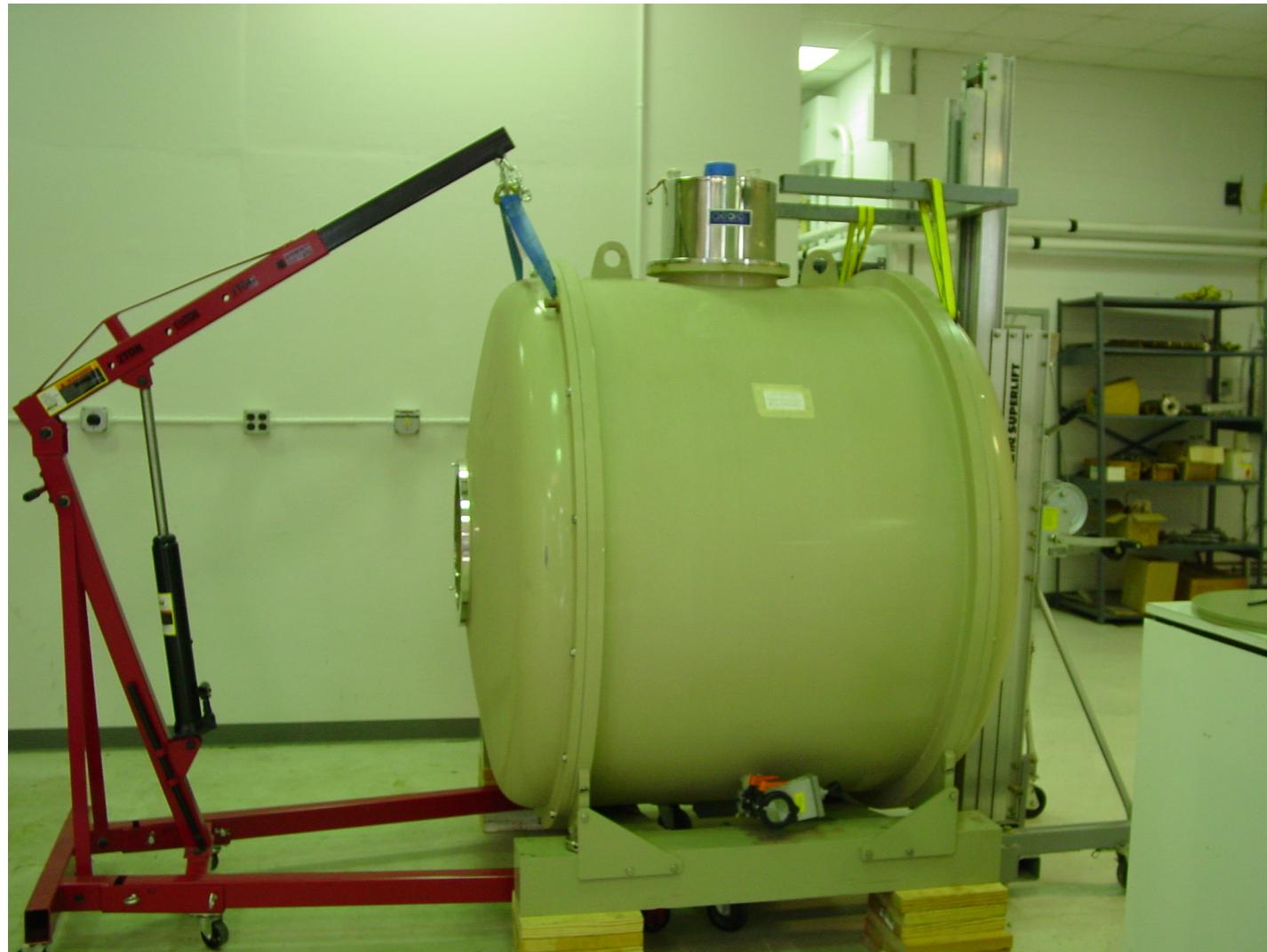
The magnetic forces on the solenoid



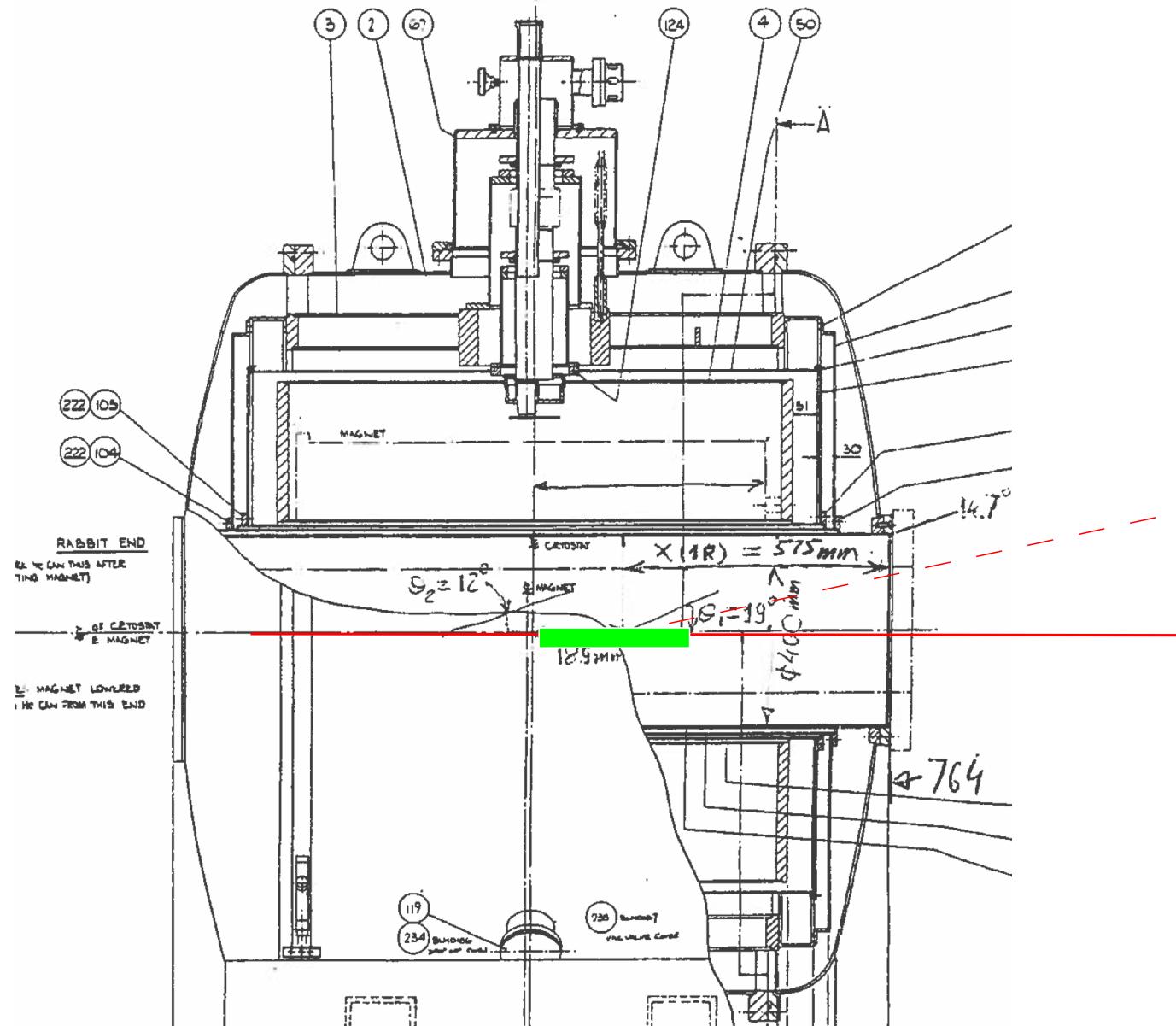
The main force is along the “z” direction:
without compensation $F_z = 400 \text{ kG}$
with the compensation plate $F_z = 20 \text{ kG}$



The RTPC magnet



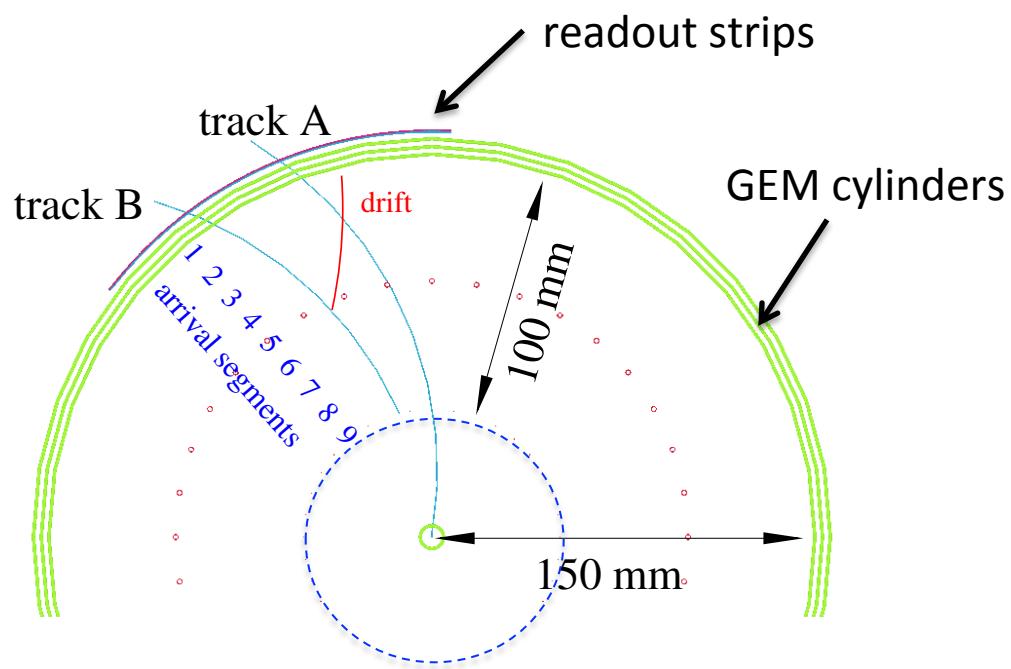
The experiment new key element: the RTPC



RTPC occupancy for TDIS

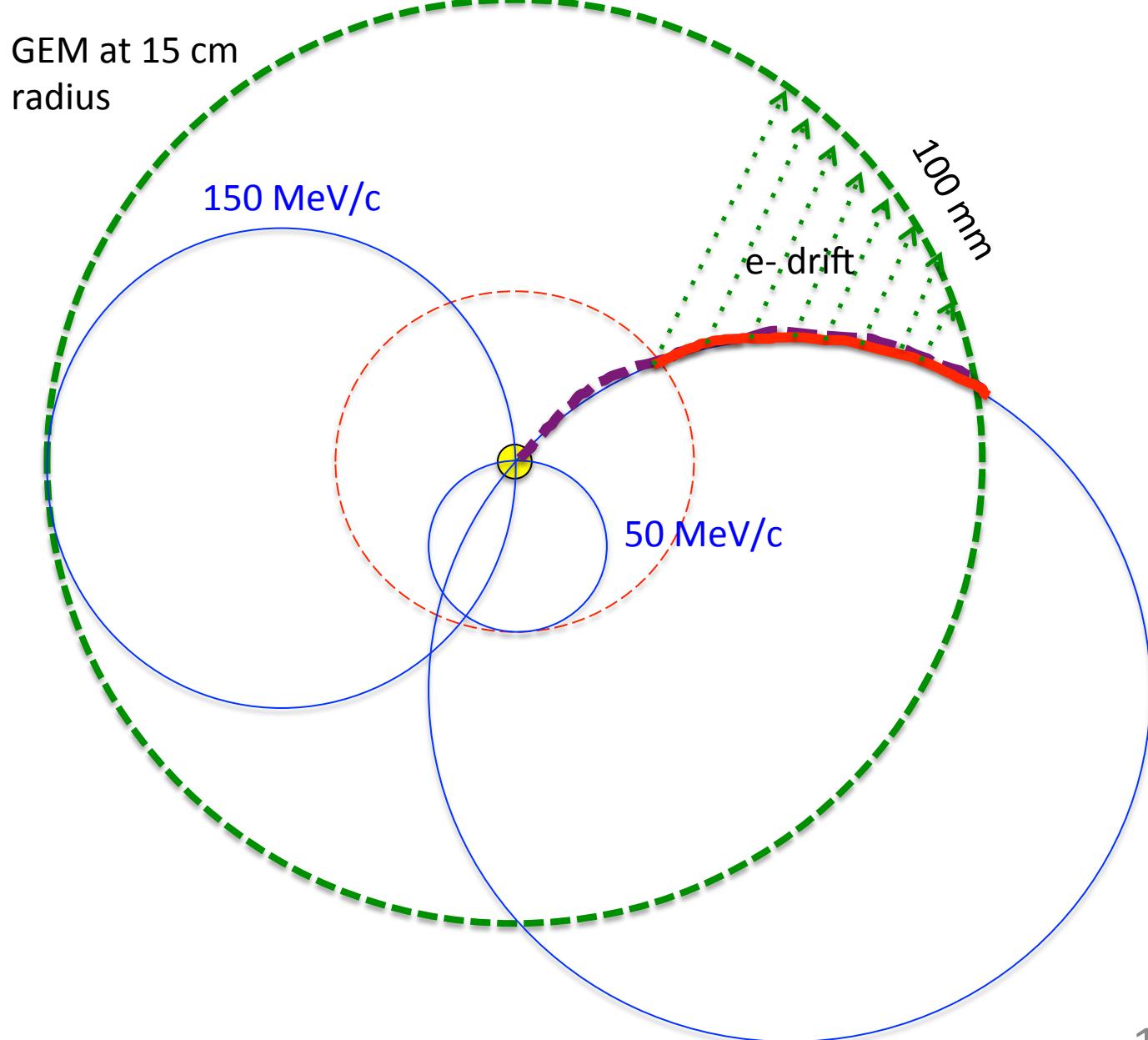
- 4 Tesla magnetic field
- 5 cm inner radius
- 15 cm outer radius
- 1mm x 20mm pixel dimensions
- 36,000 pixels of U-type; 36,000 pixels of V-type
- Trajectory momenta from 50-400 MeV/c
- 200 MHz rate of soft protons (70-250 MeV/c)
- Protons dominate in the sensitive volume

The Radial Time Projection Chamber

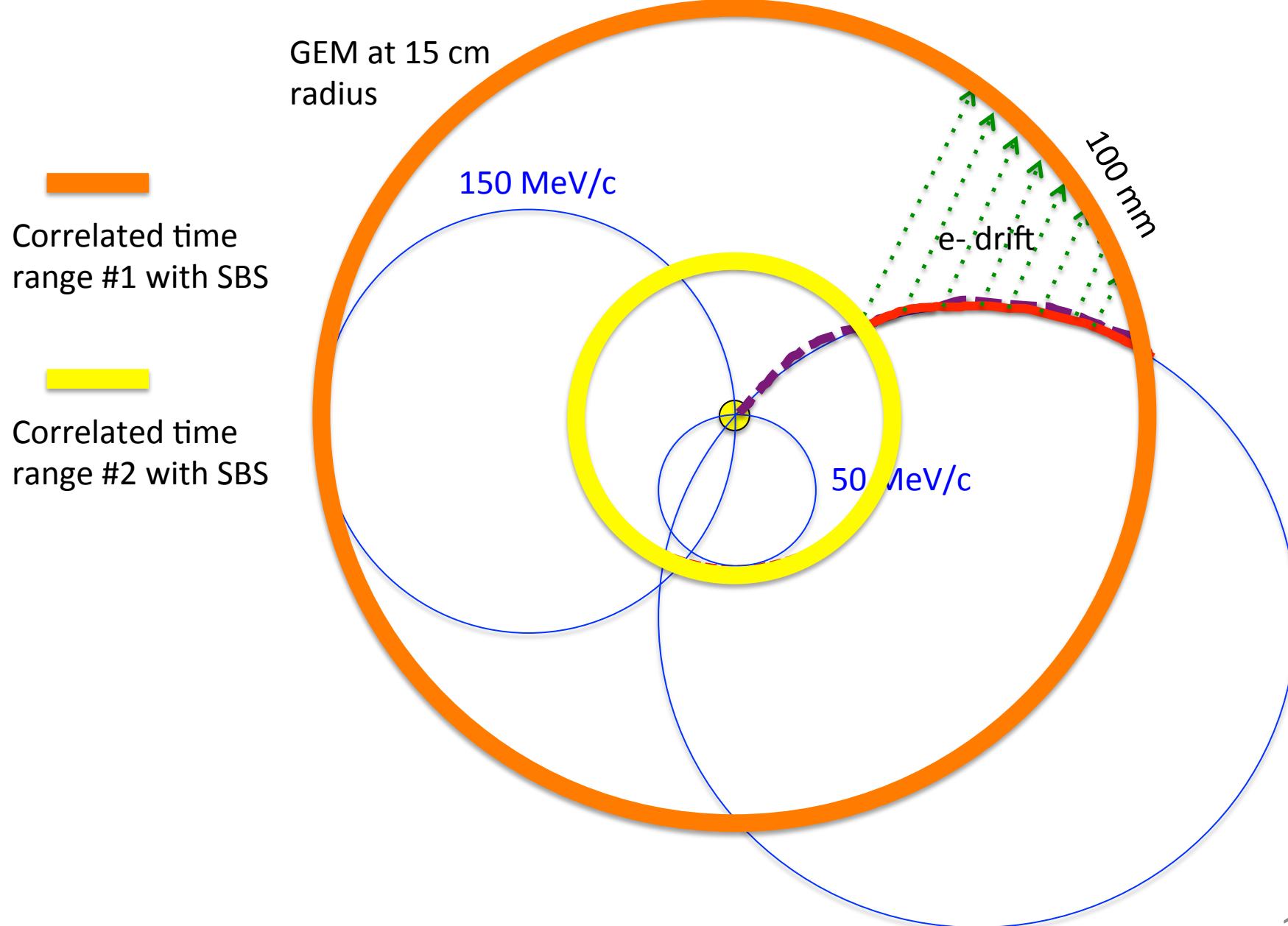


Track parameters:	total length	100-200 mm
	total time is	$\sim 3 \mu\text{s}$
	pixels per track	~ 100
	coordinate resolution	$\sim 1 \text{ mm}$
	time resolution	$\sim 15 \text{ ns}$

The tracks in RPTC

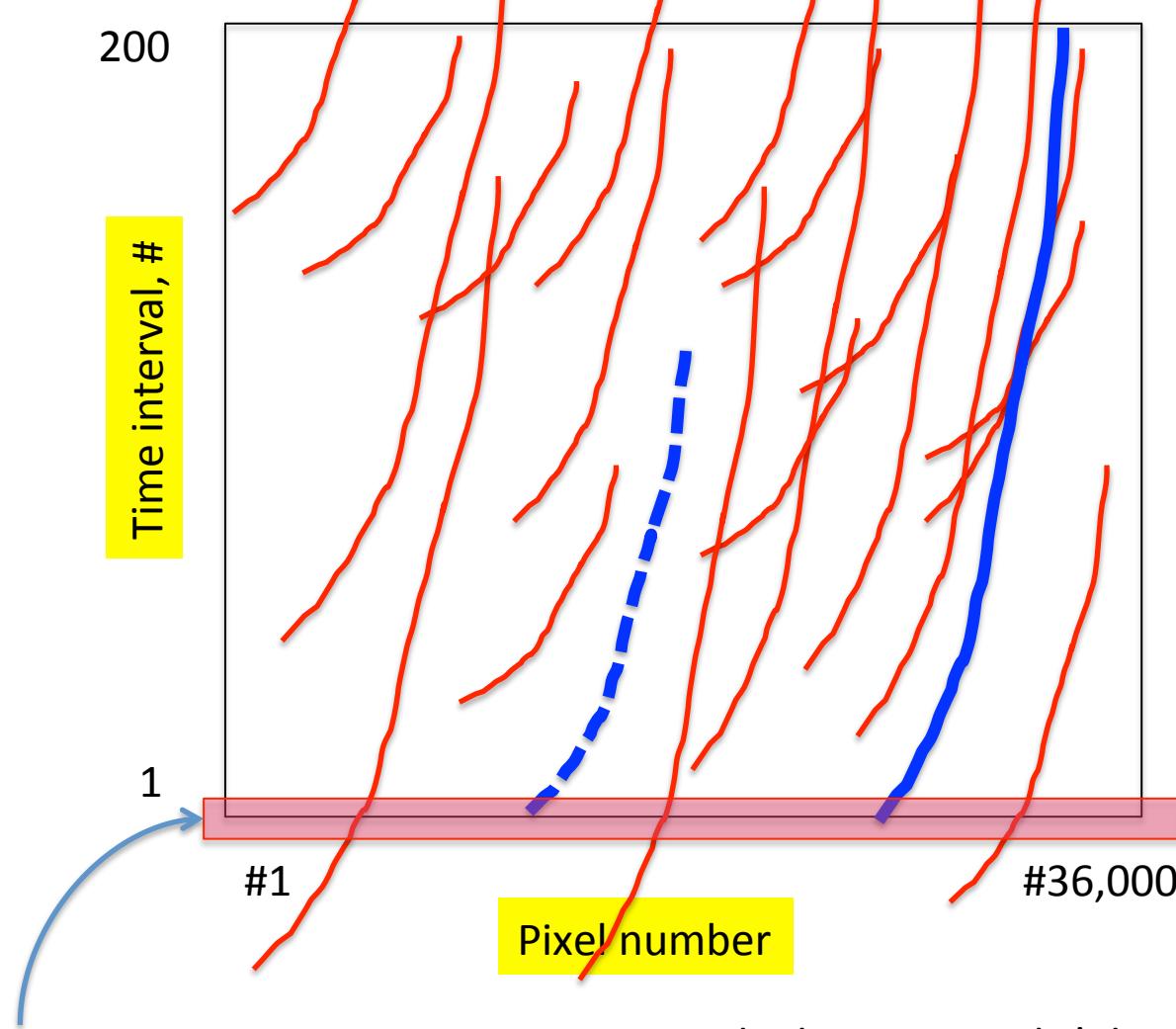


The tracks in RPTC – analysis logic



GEM time
resolution
is 15 ns

Total number of hits in 3 μ s is about 60k



Only 10 tracks start within a 50 ns interval from the electron hit in the SBS spectrometer.

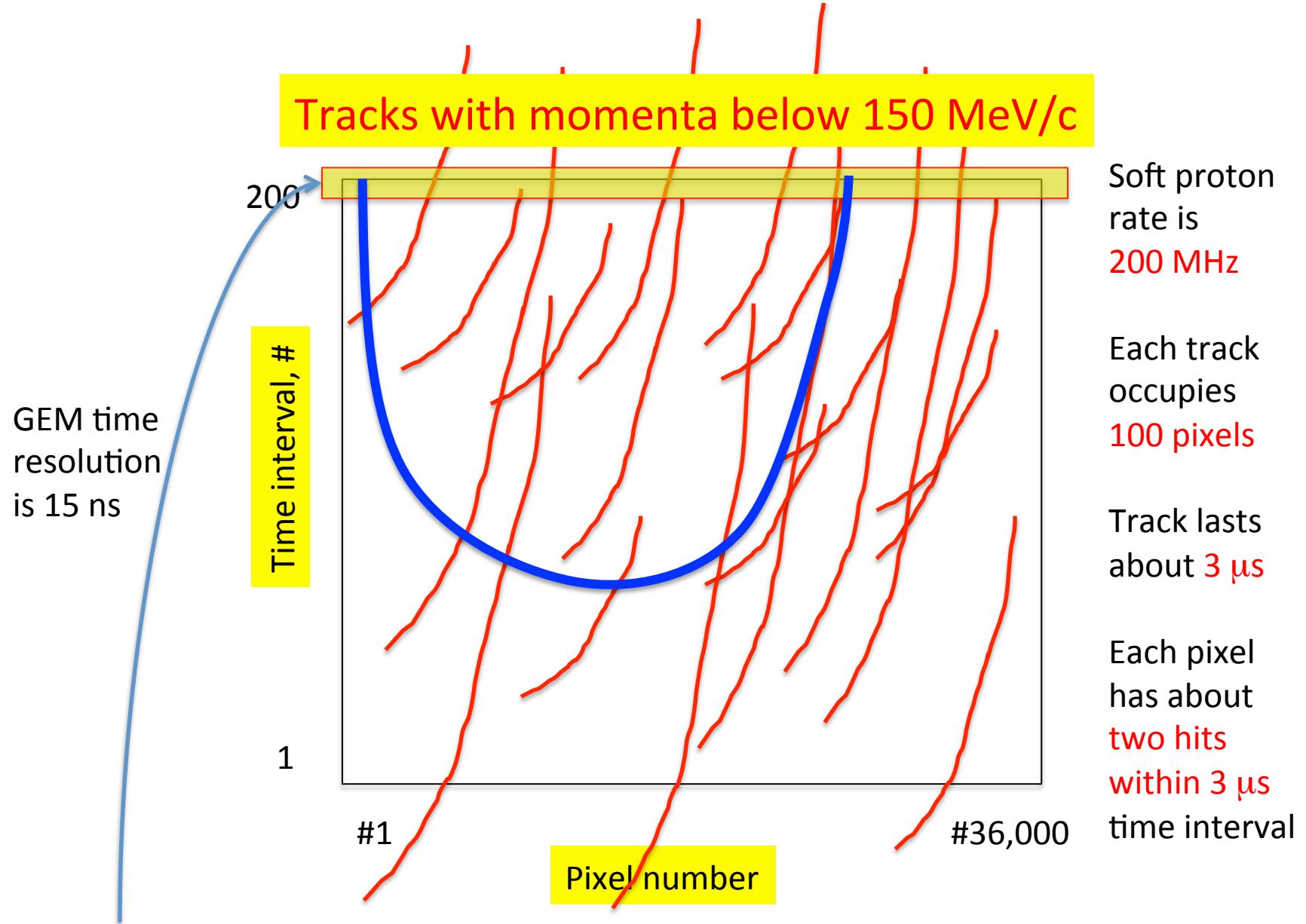
Only those 10 tracks' data should be recorded per event: 1000 hits.
Total = 1k x 3 (time) x 3 (space) = 9k

Soft proton
rate is
200 MHz

Each track
occupies
100 pixels

Track lasts
about 3 μ s

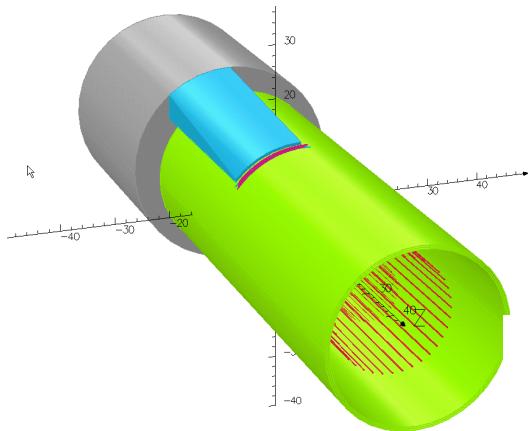
Each pixel
has about
two hits
within 3 μ s
time interval



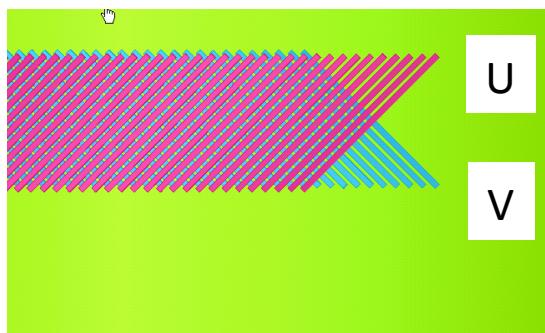
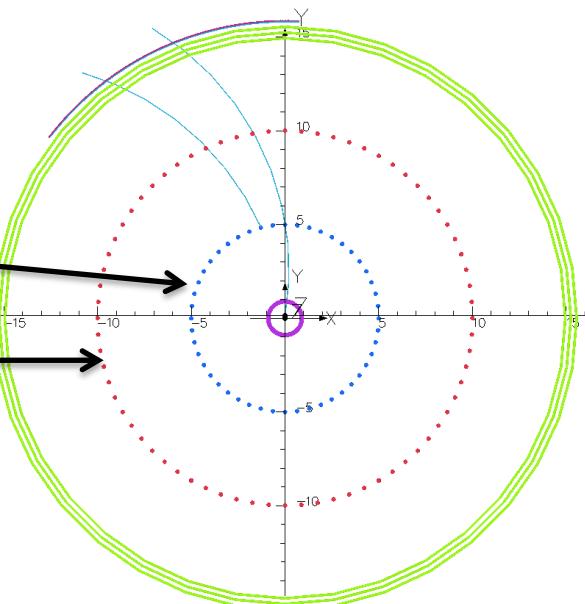
Only 10 tracks start within a 50 ns interval from the electron hit in the SBS spectrometer.

Only those 10 tracks' data should be recorded per event: 1000 hits.
Total = $1k \times 3$ (time) $\times 3$ (space) = 9k

The conceptual design of the RTPC

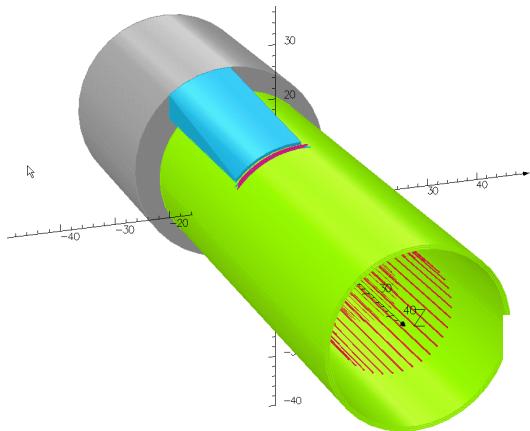


5 cm radius of inner
electrical wire grid
 10 cm radius of middle
electrical wire grid
 15 cm radius of GEM foil
 15.6 cm radius of U&V
readout strips

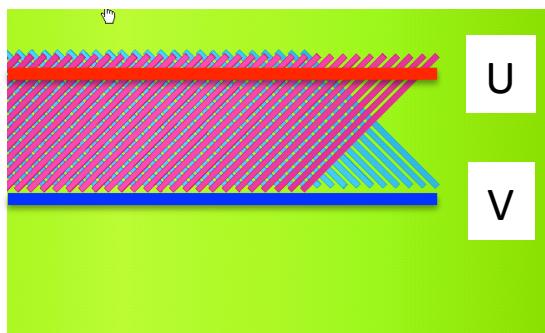
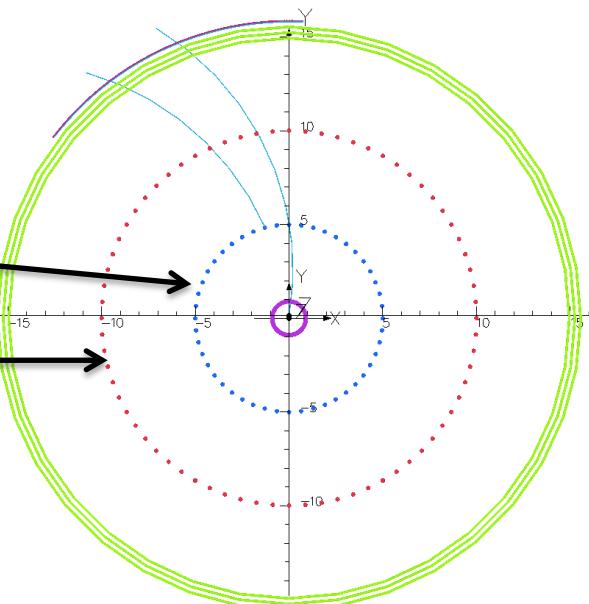


- Luminosity of $3 \times 10^{36} \text{ Hz/cm}^2$
Higher current of 60 μA
- Low mass target cell (p tagging)
40 cm long target cell (1 atm H_2 at 77 K)
- Large magnet, 4.7 Tesla field
10 cm long drift region
Improved momentum resolution
Momentum up to 400 MeV/c
- Resolution
1 mm x 21 mm in each U&V
Angular resolution of 0.2 degrees
dE/dx for proton PID (100 samples)
24,000 readout pads
- Sensitive volume parameters
He-CH₄ (10%) – 0.15 atm & 77K
Inner radius (track) of 5 cm
Outer radius (track) of 15 cm

The readout pads of the RTPC

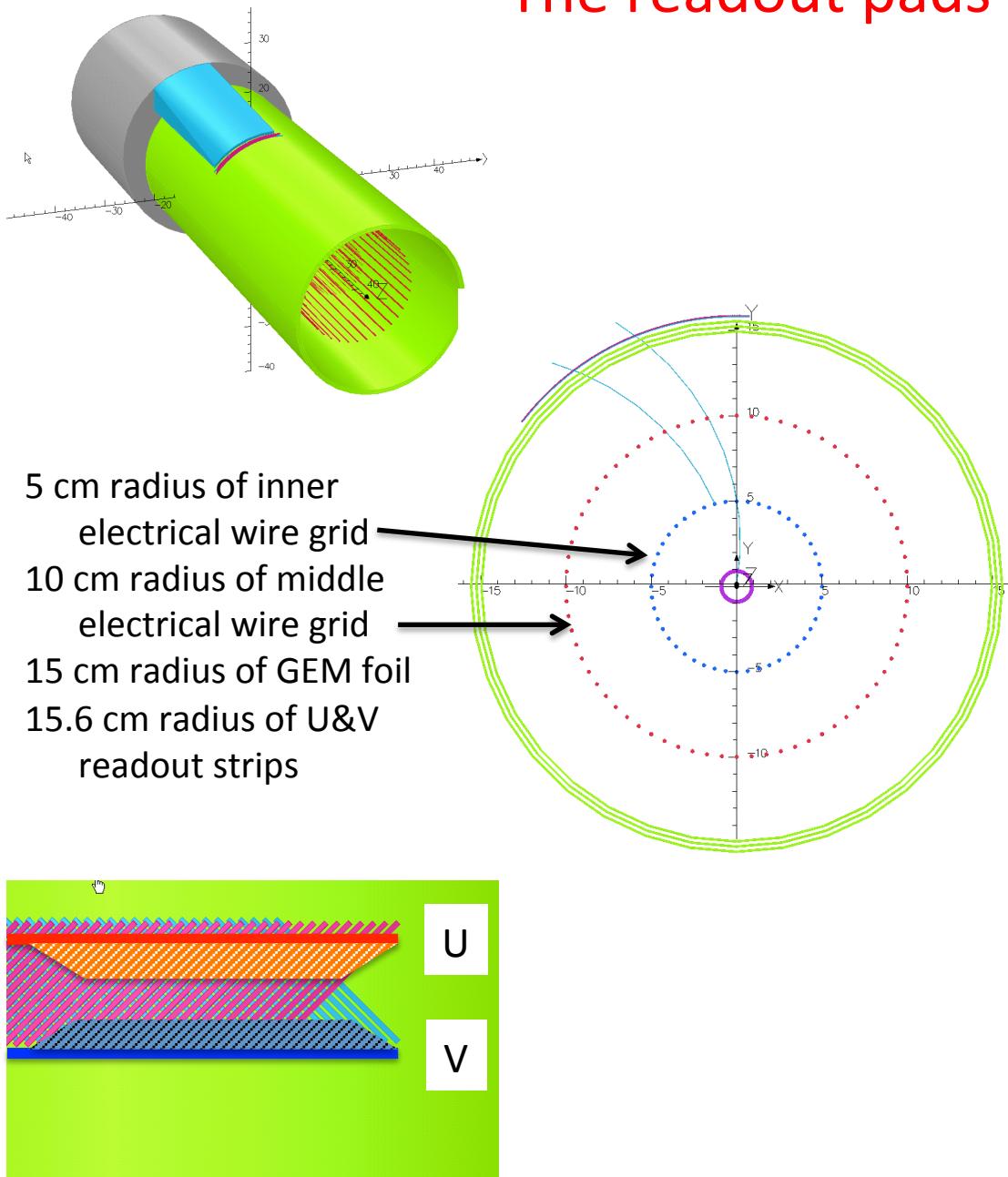


5 cm radius of inner
electrical wire grid
 10 cm radius of middle
electrical wire grid
 15 cm radius of GEM foil
 15.6 cm radius of U&V
readout strips



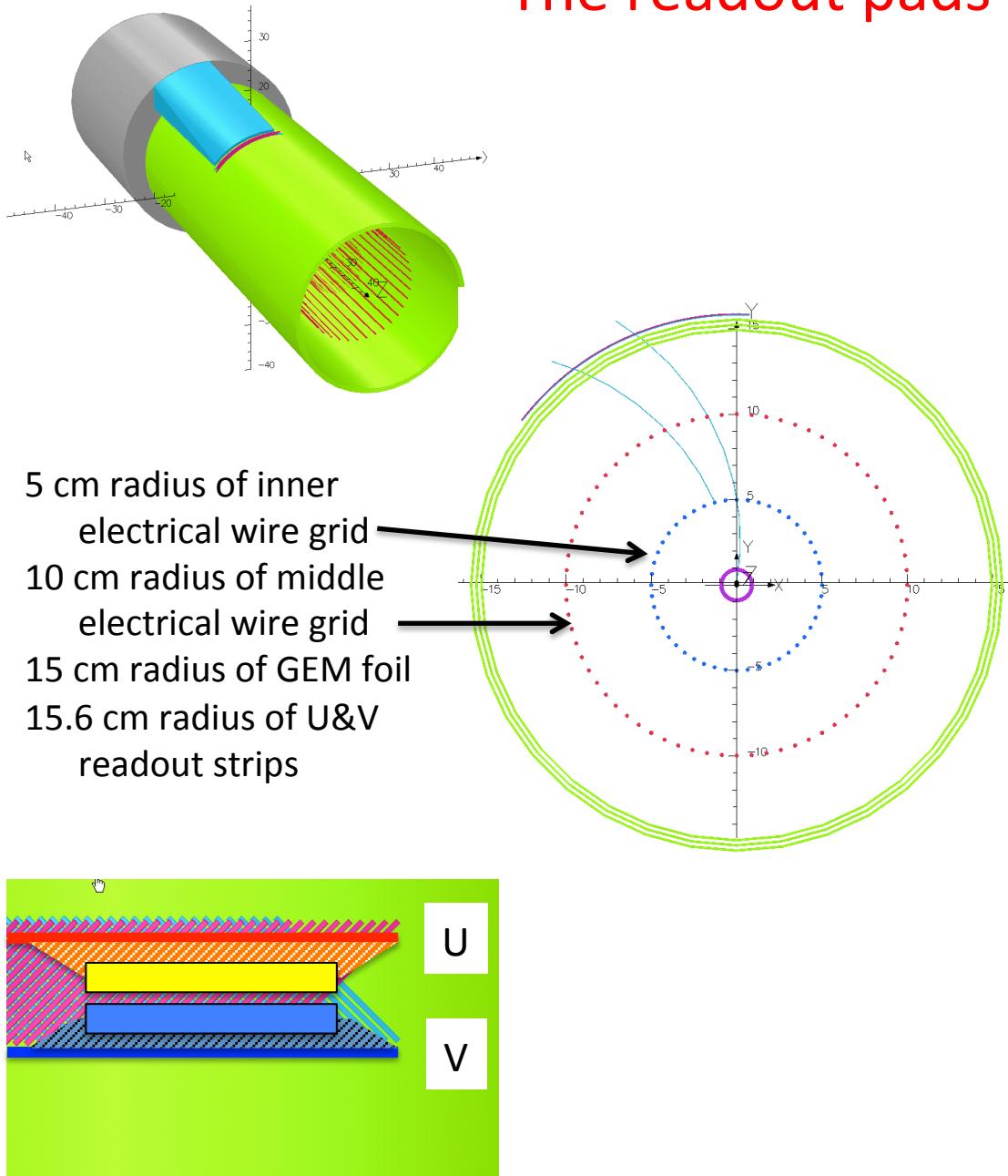
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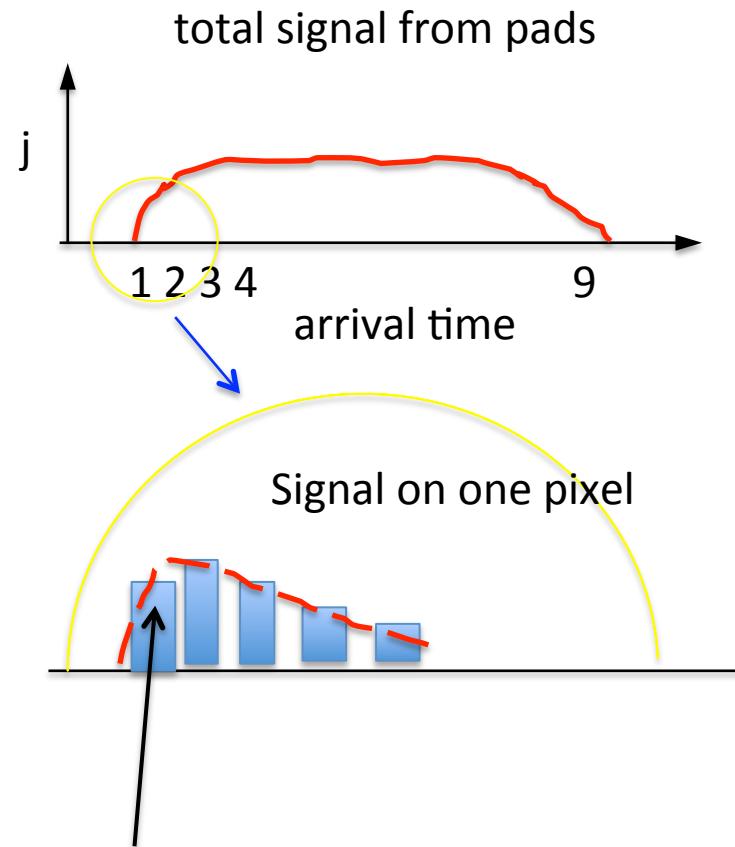
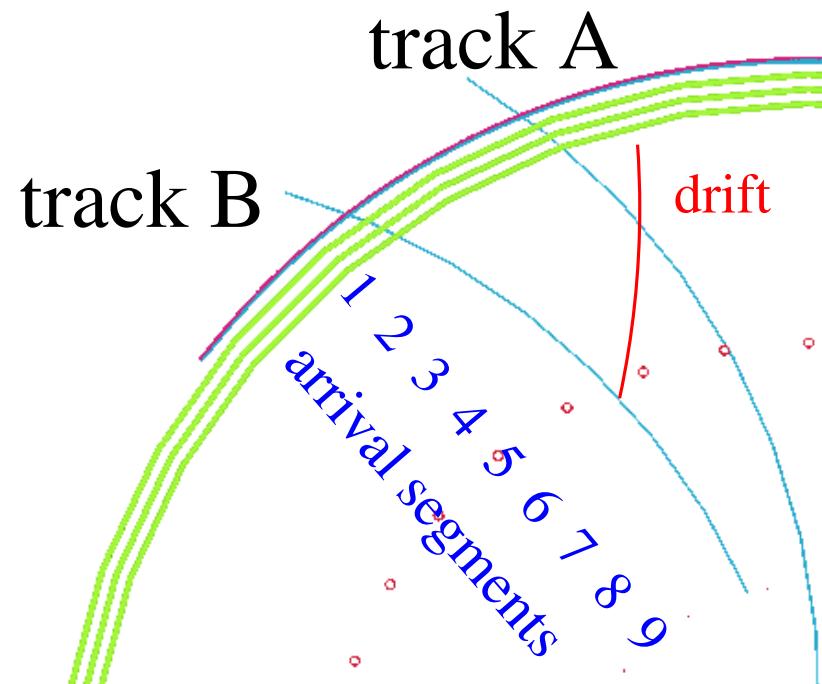
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The readout pads of the RTPC



- Luminosity of $3 \times 10^{36} \text{ Hz/cm}^2$
Higher current of 60 μA
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24,000 readout pads
- Sensitive volume parameters
He-CH₄ (10%) – 0.15 atm & 77K
Inner radius (track) of 5 cm
Outer radius (track) of 15 cm

The signal from the pad



The design of the down stream end of the RTPC

