Comments on preparation towards technology decision

A Random List of Personal Concerns

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Are we ready?

or

Will we be ready?

First worry about Si-T vs TPC question (?)

Advantages of TPC

First we have to sell TPC for

1. continuous tracking for **redundancy**:
    1. track-to-cluster matching in jetty environment,
    2. ID of low Pt curling μ,
    3. largely displaced vertices (BSM),
2. **low material budget**:
    1. not to hamper calorimetry,
    2. higher momentum resolution for low Pt tracks,
3. particle ID with **dE/dx**:
    1. K/π for flavor tag, vertex charge,
    2. e/h separation.

Then worry about technology choice within TPC

Remaining Issues Common to all designs

Field distortion near boundaries

- Insulator surface facing drift volume should be removed; Avoid charge up effects!
- Electric field distortion near module boundaries should be shaped away.

High B-field performance

- Is Neff at B=3.5T the same as at B=1T?
- Is electron attachment by CF_4 in amplification region negligible?
- Tracking in non-uniform B-field: ExB and deviation from helix

Positive ions and Gate

- Develop ion gate: transparency, distortion, ion leak
- Is primary positive ion effect really negligible? (effects of heavy micro-curlers?)
- Establish distortion correction method

Z measurement

- Hodoscope effect?
- Angular effect? (primary ionization statistics)

Neutron BG

- Is gas mixture with a hydrocarbon molecule such as iso-C_4H_{10} OK?

P/T control of gas volume

- 2PCO_2 cooling of the whole gas volume?

Remaining Issues Specific to each Design

DESY GEM Module

- HV routing and connection w/o causing E-field distortion
- Integration of ion gate
- Mounting of electronics and cooling channels

Asian GEM Module

- Mitigation of micro-discharge
- Effect of module boundaries and secondary ion-leakage
- Integration of ion gate
- Mounting of electronics and cooling channels

Micromegas Module

- Charge collected not by pads but by the surrounding electrode:
    - Is pile up OK? (no undershoot?)
- Remove the guard ring surrounding the module.
- Integration of ion gate
- Mounting of electronics and cooling channels

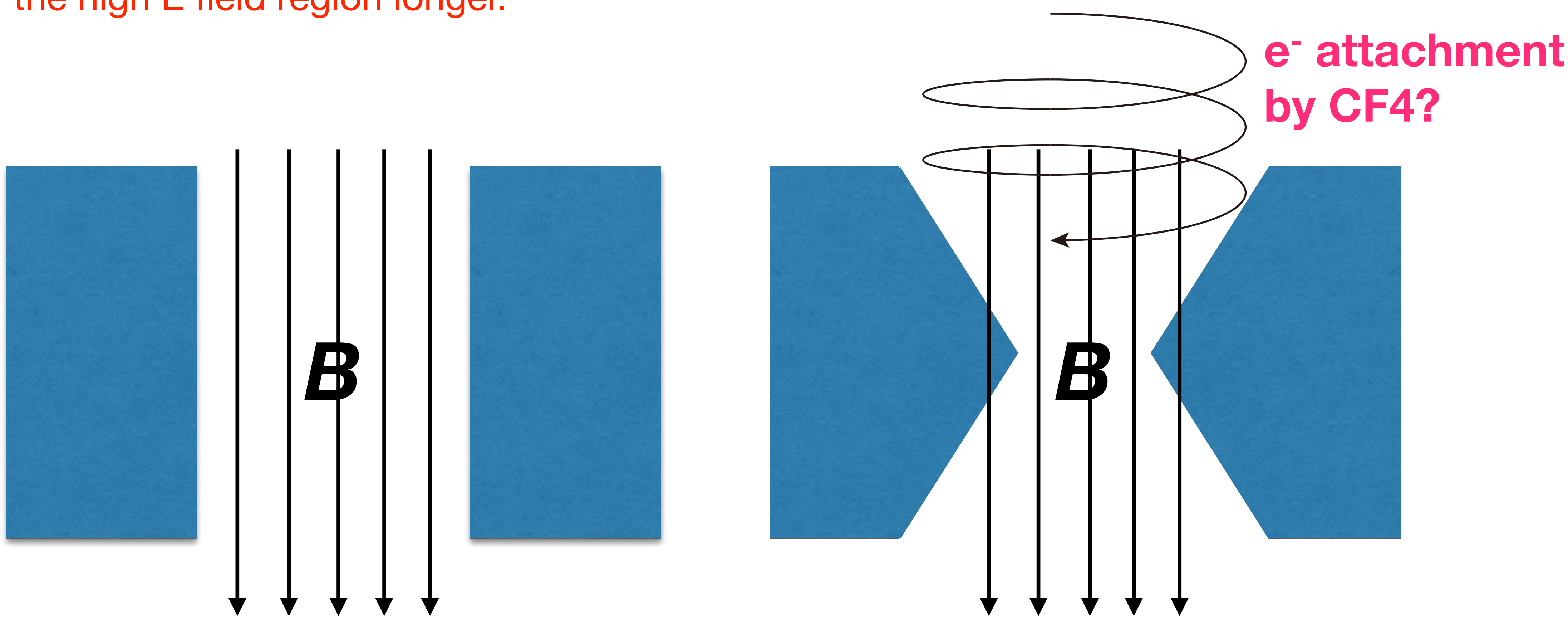
Random List of Personal Concerns

GEM Hole Shape

Conical vs Straight?

High B-field performance

- Is Neff at B=3.5T the same as at B=1T?
- Is a conical hole more difficult for an electron to go through than a straight hole at B=3.5T?
  - At high B, electrons tend to follow B
- Is electron attachment by CF4 in amplification region negligible?
  - At high B, high E, ExB makes electrons near the hole edge rotate around and force to stay in the high E field region longer.



Need to know how Neff depends on B!

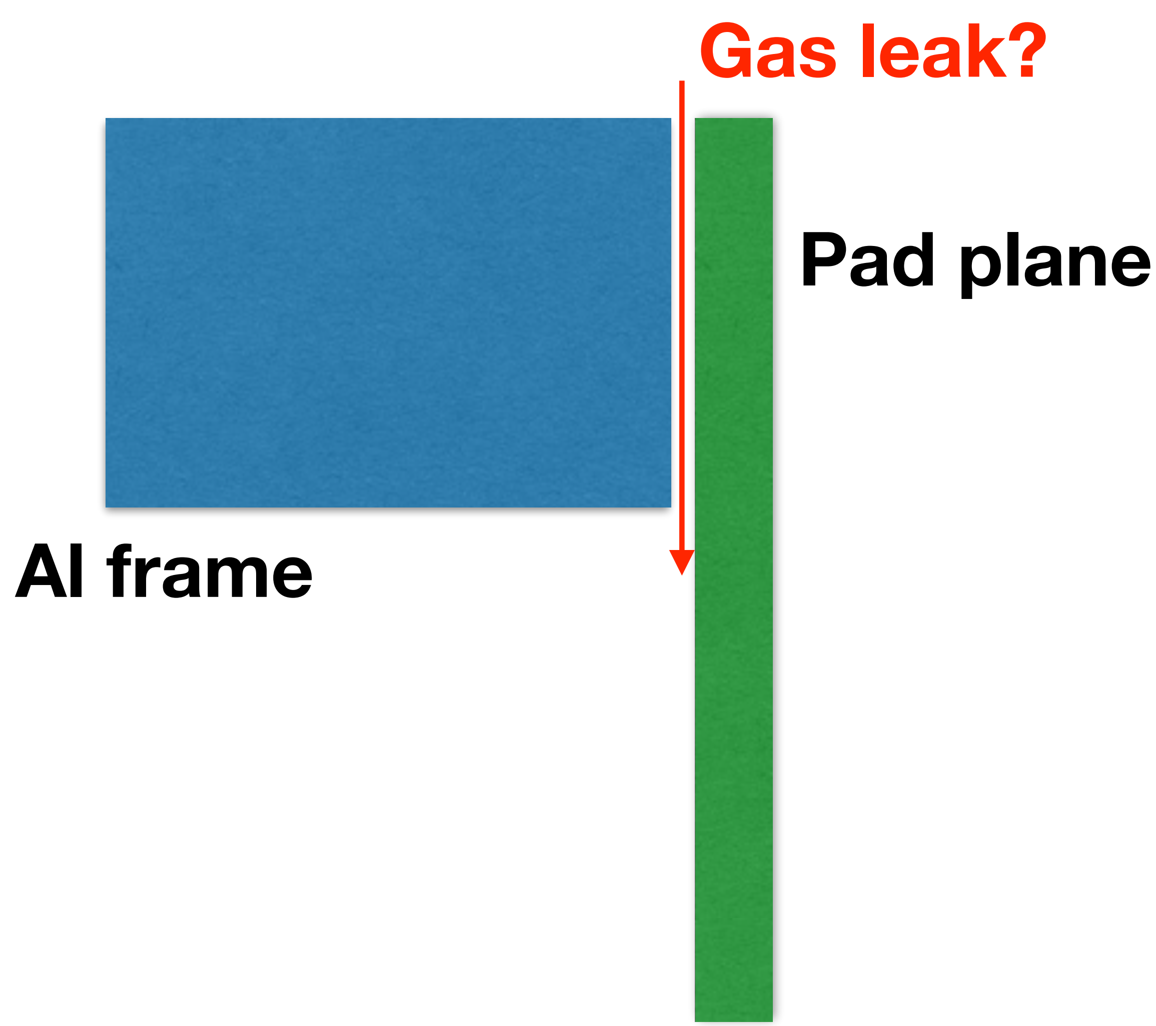
Need serious simulations!

Micro-discharge

Thin vs Thick

Thick GEM issue (potential source of inefficiency)

- Need to define clear discharge rate limit that we can tolerate
- Identify the cause of micro-discharge
  - High discharge rate has not been reproduced by a test box experiment….
  - Discharge rate seemed to be correlated with outside humidity???



Is gluing enough?

More robust mechanical design?

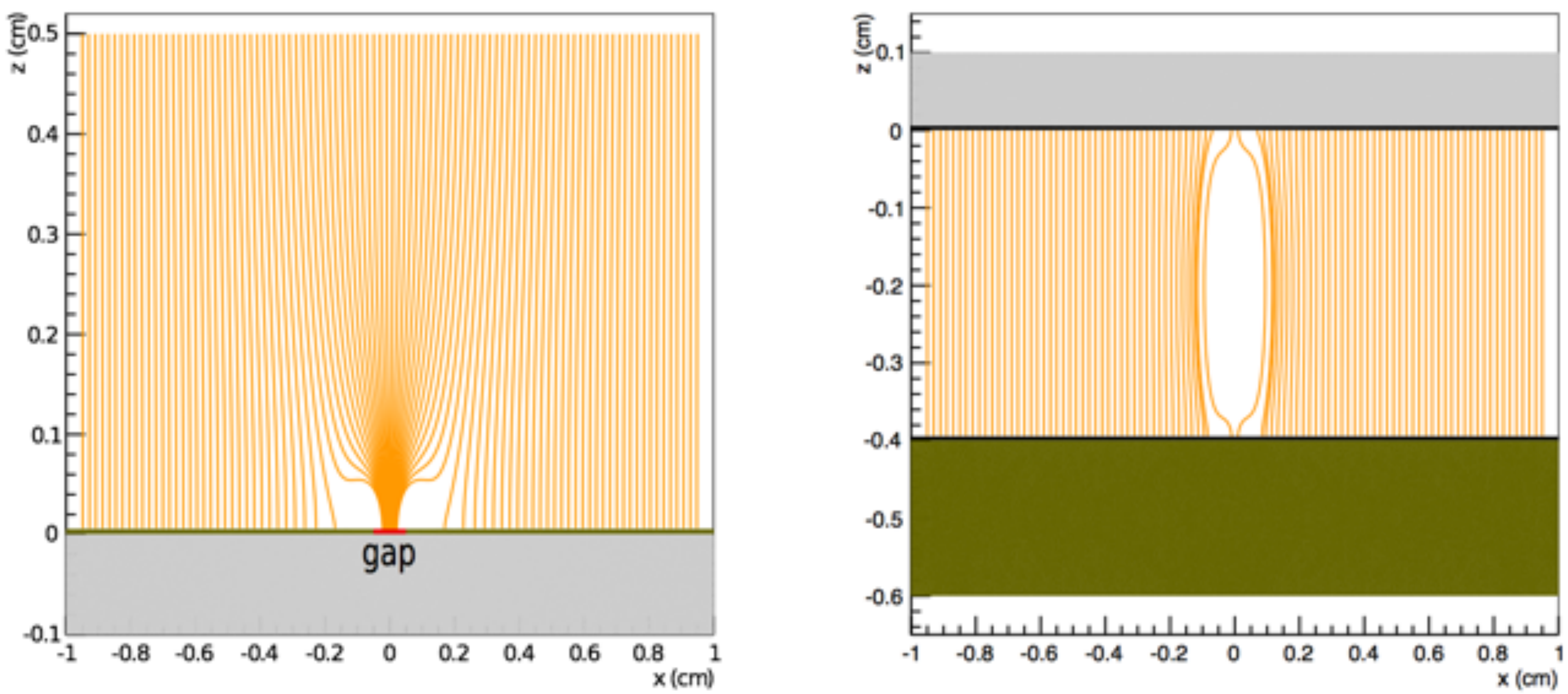
More test needed.

Charge Up Effects

Minimize insulator surface facing drift volume

Electrode Gaps / Side Walls

- What about gaps in the lower electrode of the Asian GEM foil?
- What about the insulator strips surrounding the GEM foil of the Asian GEM foil?
- What about side wall facing the drift or amplification regions?



(a) Old GEM (b) New GEM

The distortion so far observed is consistent with no significant charge up in the gaps.

Is this also true in high rate environment?

Resistive Anode

Pileup effect?

Resistive anode issues

- Charge collected not by pads but by the surrounding electrode:
    - Is pile up OK?
- Electronics issues:
    - Need to avoid undershoot (charge amplification mode → long enough integration time)
    - How many bits are needed?
- Analysis method:
    - How to handle time-dependent charge spreading for tracks recoded in a single time frame.

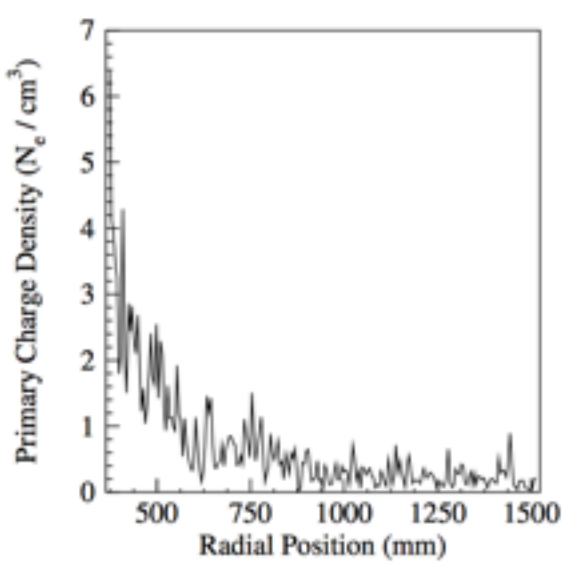
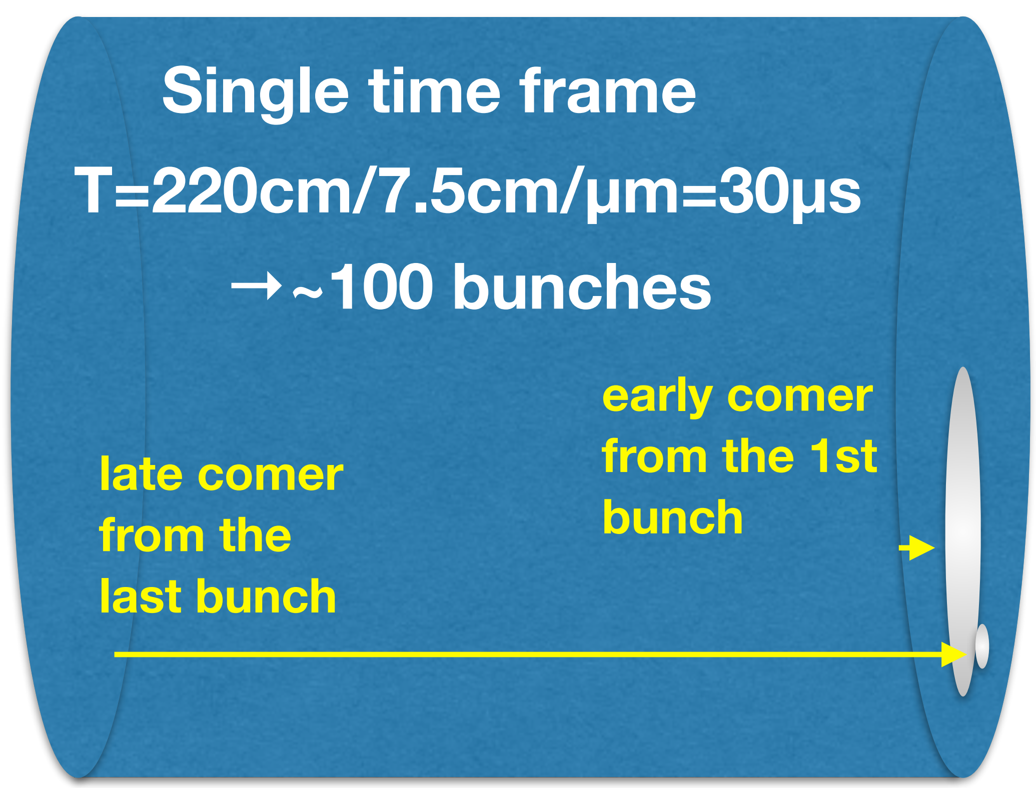
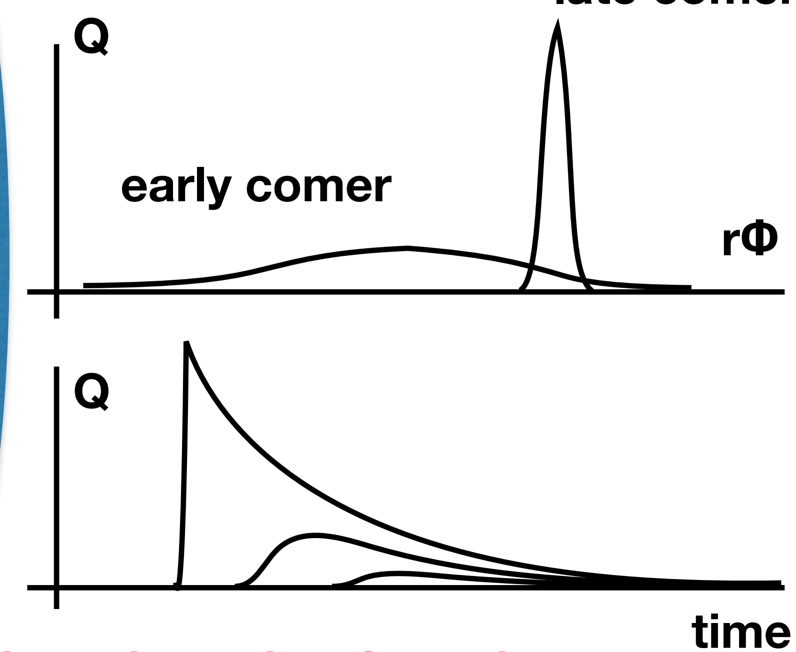


Figure 7.45: Primary charge density in the sensitive TPC volume in dependency of the radial position (overlay of 100 bunch crossings). Neither the gas amplification nor backdrifting ions are taken into account here.



Need proper simulation!

Hit from the 1st bunch near the anode plane would spread over
σ = 30μs / RC
→many pads



side pads peak at later time

If differentiated → undershoot

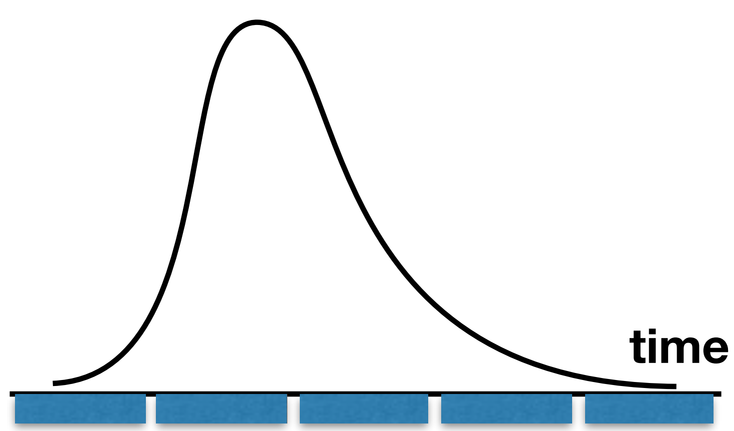
Z Measurements

Time estimator (analysis method)

Coordinate calculation method?

- Hodoscope effect / S-shape systematics?
- Angular effect? (primary ion statistics and gas gain fluctuation)

Z measurement is just like rΦ measurement with an asymmetric PRF



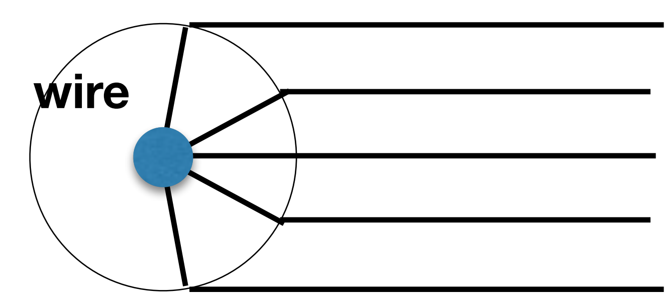
With infinitely fine time sampling with delta-function like time response, the COG must give the best answer:

$$\sigma_t^2 = \frac{1}{N_{eff}} \left(\frac{(\Delta t)^2}{12} + D_L^2 \cdot z \right)$$

For finite σ_{PRF}, the constant term becomes smaller by charge sharing in time direction

For normal incidence (tanλ=0), all seed electrons have essentially the same arrival time for short drift distance (= negligible longitudinal diffusion), subject to hodoscope effect or S-shape systematics if charge centroid in t-directions is not properly estimated.
→might underestimate Z resolution! → need to check carefully.

For wire chamber, at short distance, the electron arrival time is not common due to radial field around wire and primary ionization statistics →better use leading edge



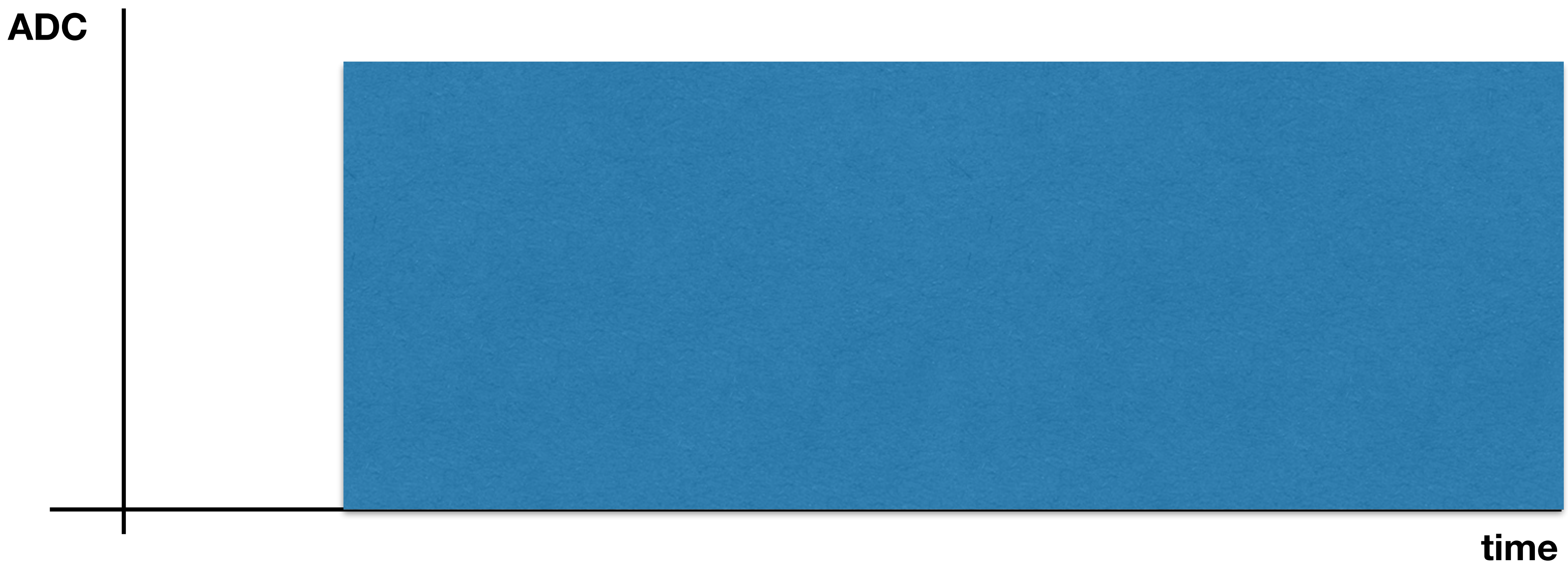
Is E field distortion making a wire chamber-like/large tanλ situation???

Angle effect would dominate for larger tanλ tracks →should not make pad length too long!

Neutron BG

Are we sure if we can use iso-C4H10?

- Saturated pulses in readout electronics that hamper subsequent signal detection?
- Source of micro-discharge?



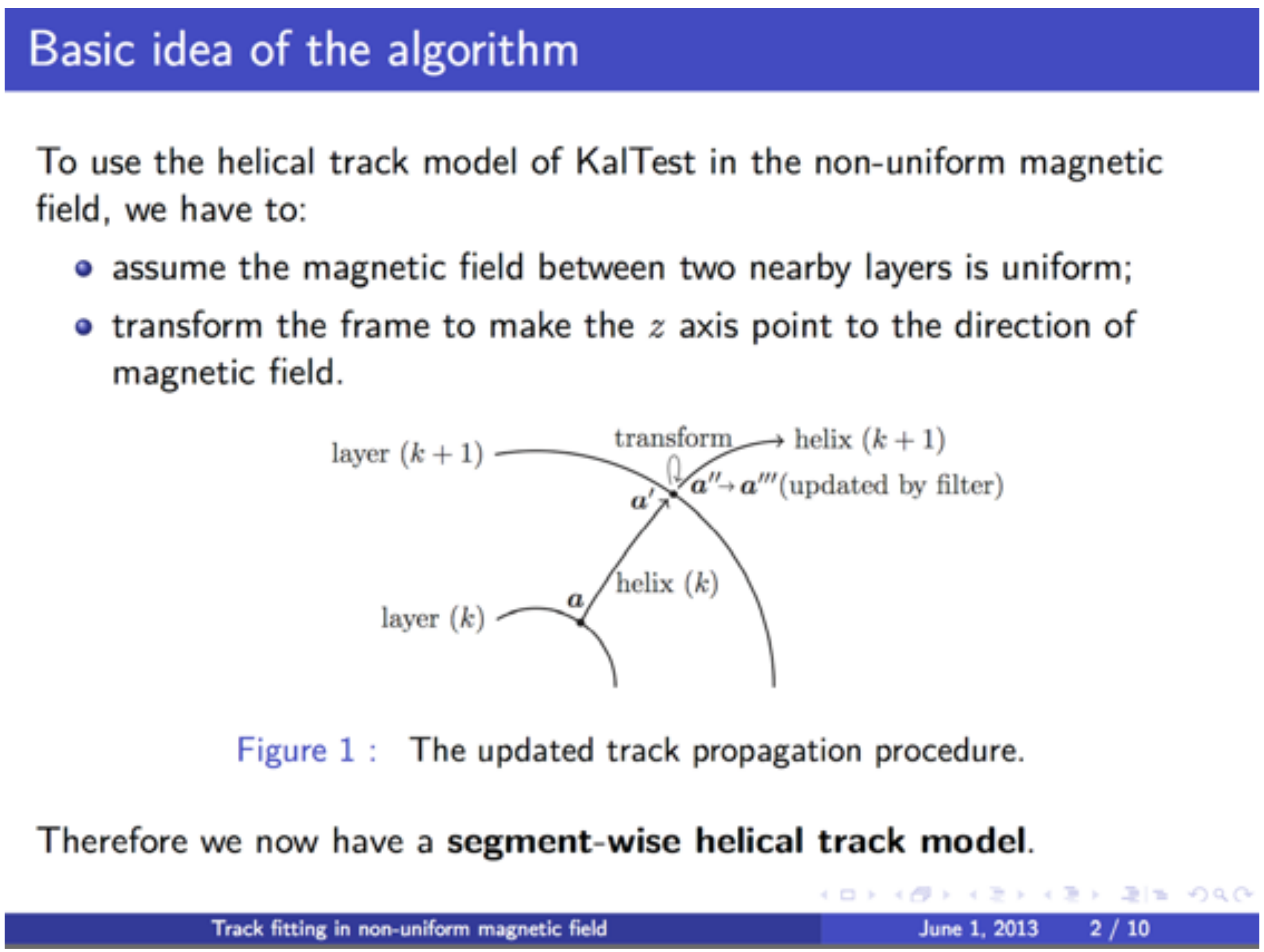
Need simulation with proper signal digitization!

Non-uniform B-field

Deviation from a helix

Use the B field map

- Use the B-field map and test the non-uniform B-field version of KalTest
- Try ExB correction based on E-field simulation and the B-field map


Basic idea of the algorithm

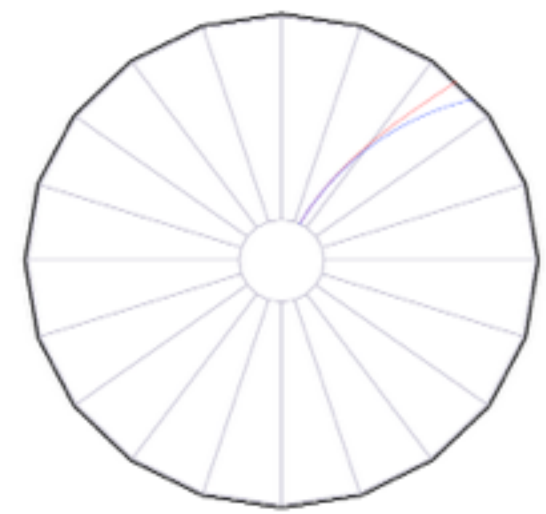
To use the helical track model of KalTest in the non-uniform magnetic field, we have to:

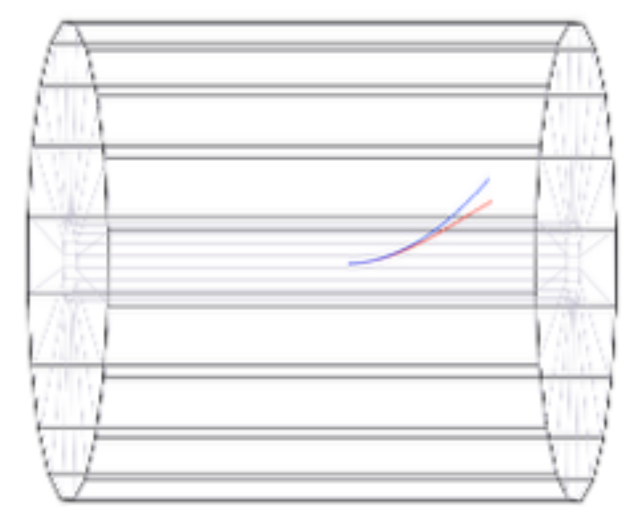
- assume the magnetic field between two nearby layers is uniform;
- transform the frame to make the z axis point to the direction of magnetic field.

Figure 1 : The updated track propagation procedure.

Therefore we now have a **segment-wise helical track model**.

Track fitting in non-uniform magnetic field June 1, 2013 2 / 10





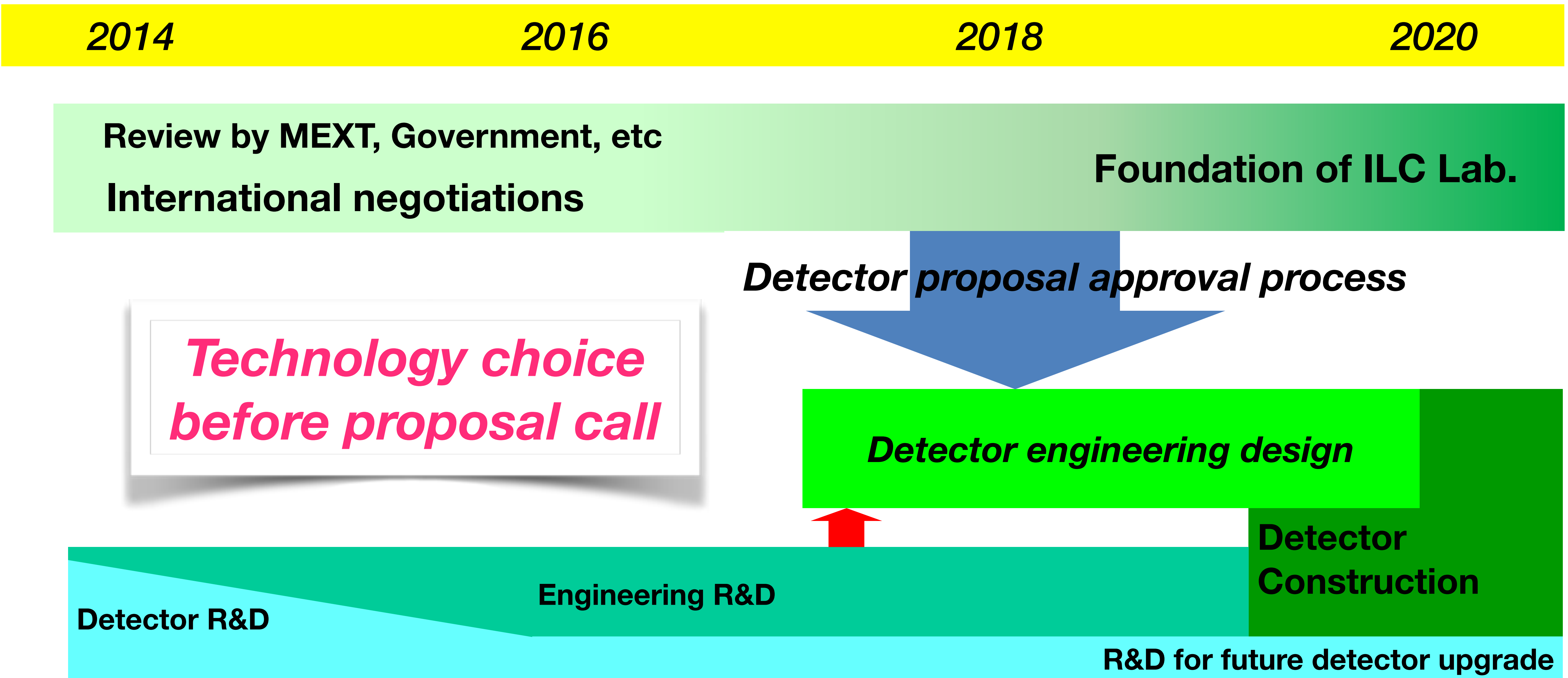
CPC.2013.11.003 (arXiv: 1305.7300)

Timeline

It’s probably too early to worry about it

Expected Timeline

Working assumption for detector R&D and design



Evaluation Axes (?)

Modules have to

1. be equipped with an ion gate,
2. be equipped with a proper cooling system to prevent heat from flowing into the gas volume,
3. ensure stable operation (no micro-discharge causing inefficiency),
4. provide a spatial resolution (rφ) of 100μm or better over the full drift length at B=3.5T,
5. be able to resolve two hits as close as 2mm to each other w/o resolution deterioration,
6. tolerate multi-tracks in jetty environment,
7. be mechanically well-engineered for robustness,
8. keep required low material budget,
9. be free from E-field distortion,
10. be robust against beam induced BG.

No Conclusions