

# LCTPC for ILD content to be reported in the Snowmass White paper about MPGDs for TPCs at future lepton colliders

Alain Bellerive



## Part of IF5 on Instrumentation Frontier Topical group on Micro-Pattern Gaseous Detectors (MPGDs)

Conveners: Bernd Surrow, Maxim Titov, Sven Vahsen

<https://snowmass21.org/instrumentation/mpgd>

Slides:

Sven Vahsen reported December 2021 and Alain Bellerive for MPGDs for TPCs at future lepton colliders

# Snowmass Frontiers

Today: Report on Micropattern Gas Detector (MPGD) relevant for ILD at the ILC. Part of the Instrumentation Frontier

Remark: The critical working group for ILC is the Accelerator Frontier

My goal: convinced our US colleagues of the relevance of MPGD's, and in particular if ILD at ILC goes ahead in Japan



- ✓ White Paper submission to arXiv: no later than March 15, 2022.
- ✓ Preliminary reports by the Topical Groups due: no later than May 31, 2022.
- ✓ Preliminary reports by the Frontiers due: no later than June 30, 2022.
- ✓ Snowmass Community Summer Study (CSS): July, 2022 at UW-Seattle.
- ✓ All final reports by TGs and Frontiers due: no later than September 30, 2022.
- ✓ Snowmass Book and the on-line archive documents due: October 31, 2022.

- Snowmass Frontiers

Energy Frontier

Neutrino Physics Frontier

Rare Processes and Precision

Cosmic Frontier

Theory Frontier

Accelerator Frontier

Instrumentation Frontier

Computational Frontier

Underground Facilities

Community Engagement

Snowmass Liaisons

# Snowmass Frontiers

Today: Report on Micropattern Gas Detector (MPGD) relevant for ILD at the ILC. Part of the Instrumentation Frontier.

Remark: The critical working group for ILC is the Accelerator Frontier

My goal: convinced our US colleagues of the relevance of MPGD's, and in particular if ILD at ILC goes ahead in Japan



- ✓ White Paper submission to arXiv: no later than March 15, 2022.
- ✓ Preliminary reports by the Topical Groups due: no later than May 31, 2022.
- ✓ Preliminary reports by the Frontiers due: no later than June 30, 2022.
- ✓ Snowmass Community Summer Study (CSS): July, 2022 at UW-Seattle.
- ✓ All final reports by TGs and Frontiers due: no later than September 30, 2022.
- ✓ Snowmass Book and the on-line archive documents due: October 31, 2022.

- Snowmass Frontiers

Energy Frontier

Neutrino Physics Frontier

Rare Processes and Precision

Cosmic Frontier

Theory Frontier

Accelerator Frontier

Instrumentation Frontier

Computational Frontier

Underground Facilities

Community Engagement

Snowmass Liaisons

# Instrumentation Frontier (IF)

## Description

The Instrumentation Frontier group is geared to discussing detector technologies and R&D needed for future experiments in collider physics, neutrino physics, intensity physics and at the cosmic frontier. It is divided into more or less diagonal sub-groups with some overlap among a few of them. Synergies between the different sub-groups, as well as with other Frontier groups and research areas outside of HEP will be paid close attention to.

## Topical groups

- IF1: Quantum Sensors
- IF2: Photon Detectors
- IF3: Solid State Detectors and Tracking
- IF4: Trigger and DAQ
- IF5: Micro Pattern Gas Detectors (MPGDs)
- IF6: Calorimetry
- IF7: Electronics/ASICs
- IF8: Noble Elements
- IF9: Cross Cutting and Systems Integration
- IF10: Radio Detection



# MPGD IF5 White Papers

	Topic	Executive Summary Length	White Paper Leads
1	MPGDs: Recent advances and current R&D	3	Klaus Dehmelt, Andy White
2	MPGDs for nuclear physics experiments	1.5	Kondo Gnanvo, Matt Posik
3	Recoil imaging for DM, neutrino, and BSM physics*	1.5+1.5+1.5 (IF+NF+CF)	Dinesh Loomba, Ciaran O'Hare
4	MPGDs for TPCs at future lepton colliders	1.5	Alain Bellerive
5	MPGDs for muon detection at future colliders	1.5	Anna Colaleo, Kevin Black
	Grand summary table + text	1	IF5 conveners

\*Multi-frontier paper with Cosmic and Neutrino Frontiers

- Based on 40 Letter of Intends were submitted to IF5 (<https://snowmass21.org/instrumentation/mpgd>)
- Special topical group on MPGD created (5 topics based on MPGD's specific LOI's)
- All white paper leads (WPLs) are in place
- Aiming for first WP drafts January 15th
- Aiming for 1.5-page executive summary for most WPs → combine into 10-page summary of IF5
- WP draft outlines and milestones in place (see following pages)

# Snowmass effort on MPGD White Paper #4

## *“MPGDs for TPCs at future lepton colliders”*

*Editor / Author: Alain Bellerive, Carleton University*

The paper should cover the following Letters Of Intent (LOIs), with contact persons listed in parentheses:

1. Belle II TPC: Peter Lewis ([lewis@physik.uni-bonn.de](mailto:lewis@physik.uni-bonn.de))
2. Time projection chamber R&D for CEPC detector ([qihr@ihep.ac.cn](mailto:qihr@ihep.ac.cn))
3. A time projection chamber using advanced technology for the International Large Detector at the International Linear Collider ([kaminski@physik.uni-bonn.de](mailto:kaminski@physik.uni-bonn.de) and [alainb@physics.carleton.ca](mailto:alainb@physics.carleton.ca))
4. A high-gain, low ion-backflow double micro-mesh gaseous structure ([zhzhy@ustc.edu.cn](mailto:zhzhy@ustc.edu.cn))

People contacted.

Here are links to the LOIs:

1. [https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF2\\_IF7\\_IF3\\_IF4\\_IF5\\_IF6-056.pdf](https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF2_IF7_IF3_IF4_IF5_IF6-056.pdf)
2. [https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF3\\_IF5-EF1\\_EF4-183.pdf](https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF3_IF5-EF1_EF4-183.pdf)
3. [https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5\\_IF3-015.pdf](https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5_IF3-015.pdf)
4. [https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5\\_IF0-184.pdf](https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5_IF0-184.pdf)

# Timeline

## *“MPGDs for TPCs at future lepton colliders”*

- November 15 – December 15, 2021:  
Putting together the material and working on skeleton of the White Paper (A.Bellerive)
- December 21, 2021:  
First version of the executive summary of 1.5 pages (A.Bellerive)
- January 15, 2022:  
Provide the first draft (including the 1.5 pages Executive Summary) to the TG conveners
- **January 15 – January 30, 2022:**  
**Iterate with authors, circulate to collaborators & contacts and TG conveners**
- February 1, 2022: second drafts of WP and executive summary
- February 15, 2022: final draft submitted
- March 1, 2022:  
Conclude the activity of the MPGD topical working for inputs to Snowmass long range planning

# Structure of the White Paper for “MPGDs for TPCs at future lepton colliders”

1.5 page executive summary: advantages of MPGD, technologies, synergy (USA), TPC's at lepton colliders

LCTPC at ILD

Belle2 TPC

TPC for a CEPC detector and other applications

R&D and other applications



# Structure of the White Paper for “MPGDs for TPCs at future lepton colliders”

1.5 page executive summary: advantages of MPGD, technologies, synergy (USA), TPC's at lepton colliders

LCTPC at ILD

Belle2 TPC

TPC for a CEPC detector and other applications

R&D and other applications

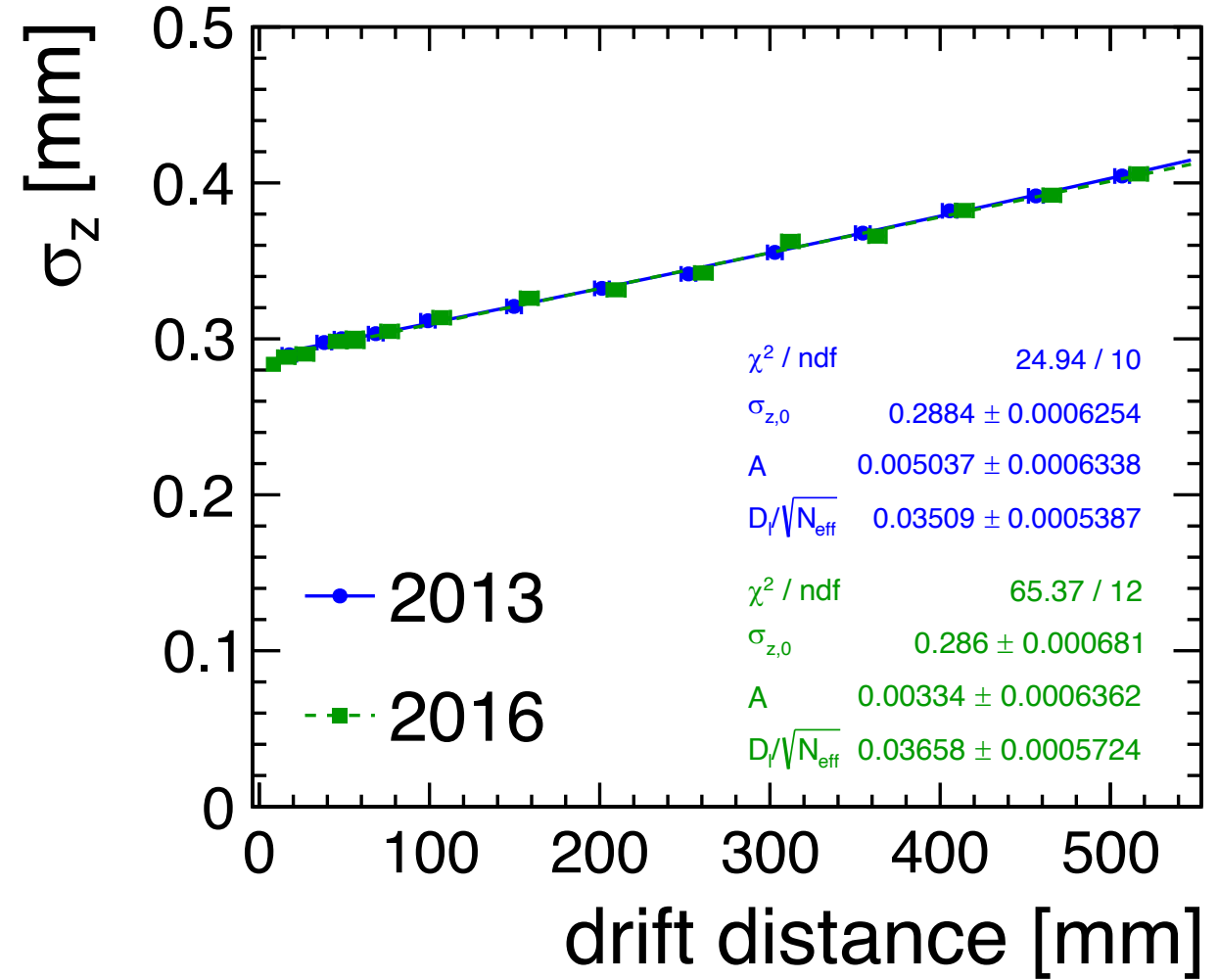
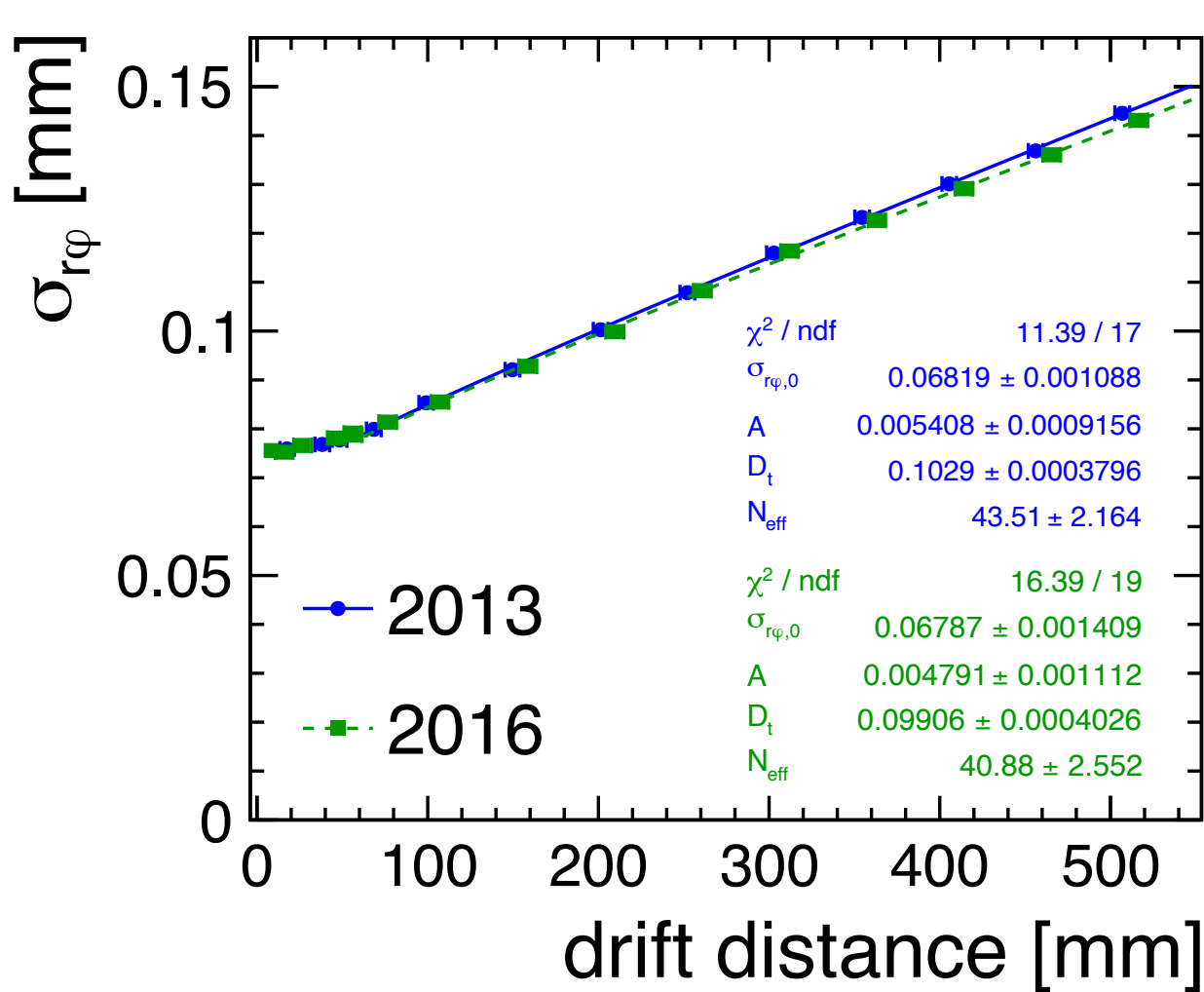
# Structure and content of the LCTPC section

1. Introduction (institute members and scope of the LCTPC collaboration)
2. Design parameters
3. MPGD (from ILC Detector R&D - <https://doi.org/10.5281/zenodo.3749461>)
  - a) GEM
  - b) Micromegas
  - c) GridPix
4. Ongoing study and future plan

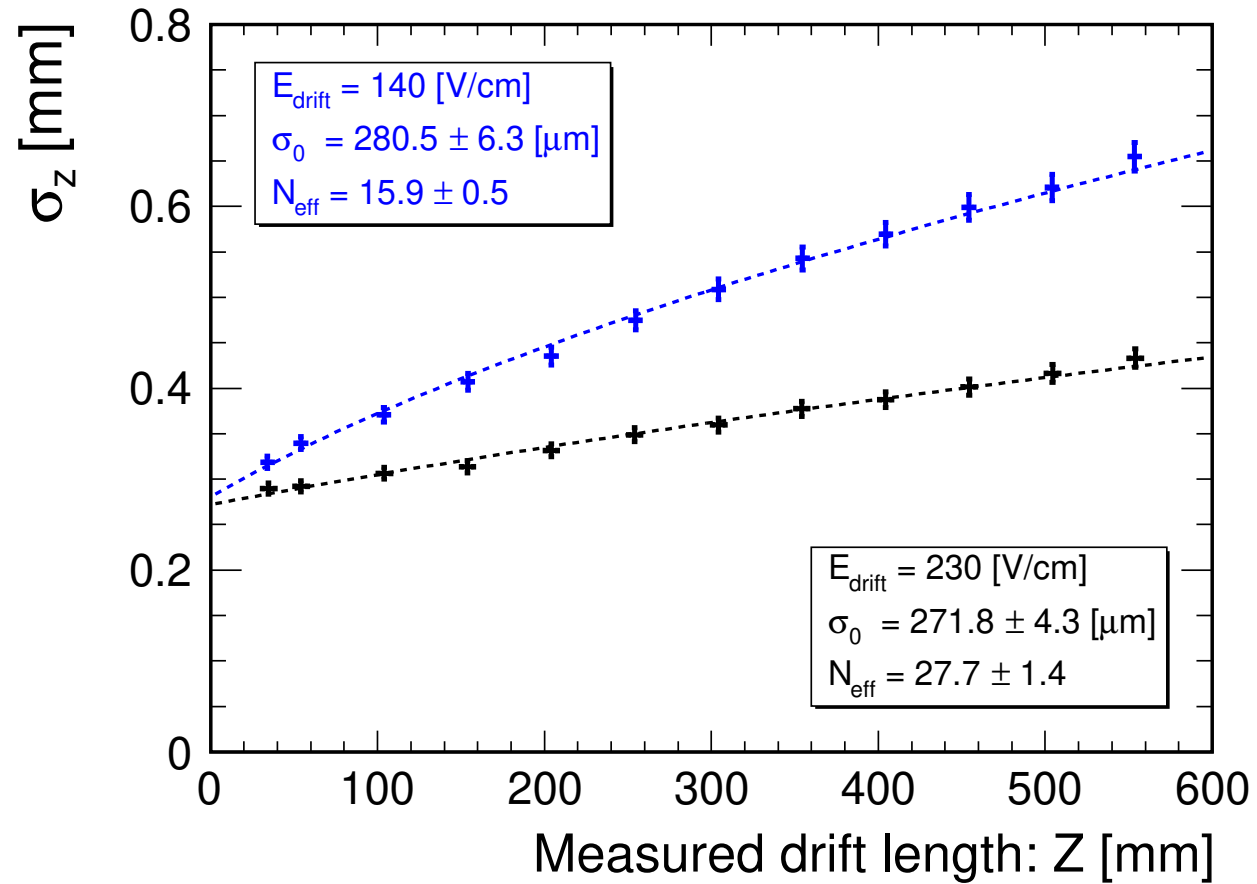
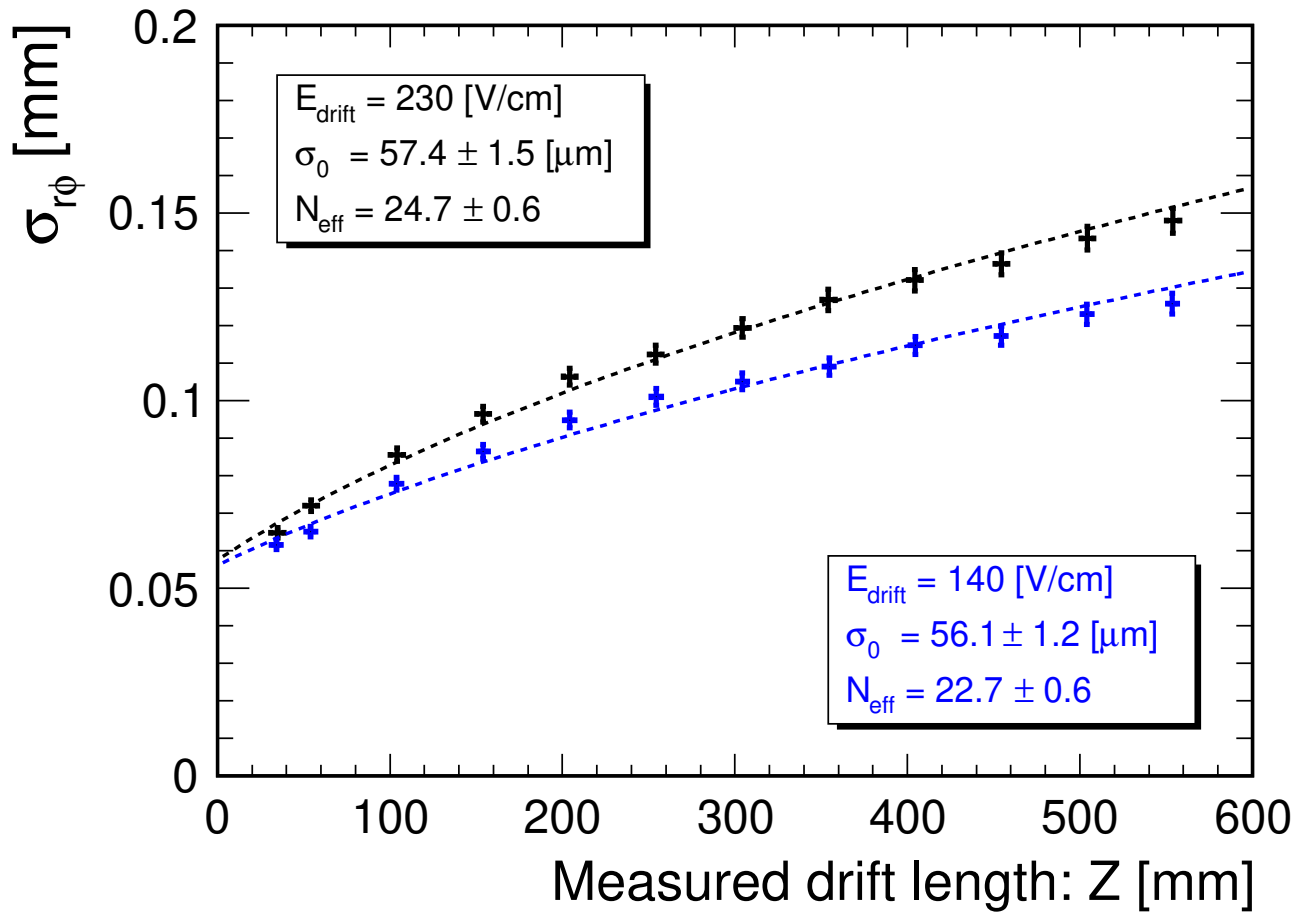
# Design parameters

Parameter			
Geometrical parameters	$r_{\text{in}}$	$r_{\text{out}}$	$z$
	329 mm	1808 mm	$\pm 2350$ mm
Solid angle coverage	up to $\cos \theta \simeq 0.98$ (10 pad rows)		
TPC material budget	$\simeq 0.05 X_0$ including outer fieldcage in $r$ $< 0.25 X_0$ for readout endcaps in $z$		
Number of pads/timebuckets	$\simeq 1\text{-}2 \times 10^6/1000$ per endcap		
Pad pitch/ no.padrows	$\simeq 1 \times 6 \text{ mm}^2$ for 220 padrows		
$\sigma_{\text{point}}$ in $r\phi$	$\simeq 60 \mu\text{m}$ for zero drift, $< 100 \mu\text{m}$ overall		
$\sigma_{\text{point}}$ in $rz$	$\simeq 0.4 - 1.4$ mm (for zero – full drift)		
2-hit resolution in $r\phi$	$\simeq 2$ mm		
2-hit resolution in $rz$	$\simeq 6$ mm		
dE/dx resolution	$\simeq 5 \%$		
Momentum resolution at B=3.5 T	$\delta(1/p_t) \simeq 10^{-4}/\text{GeV}/c$ (TPC only)		

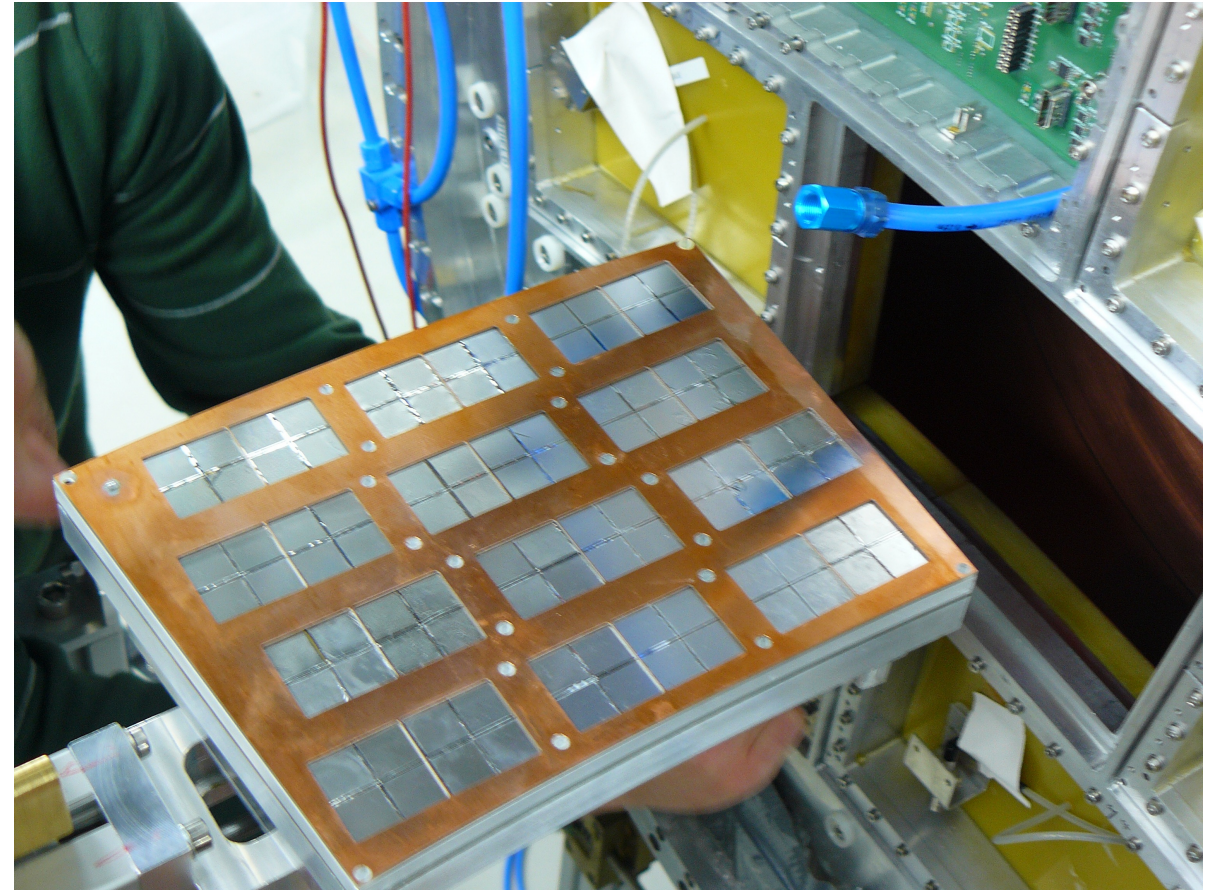
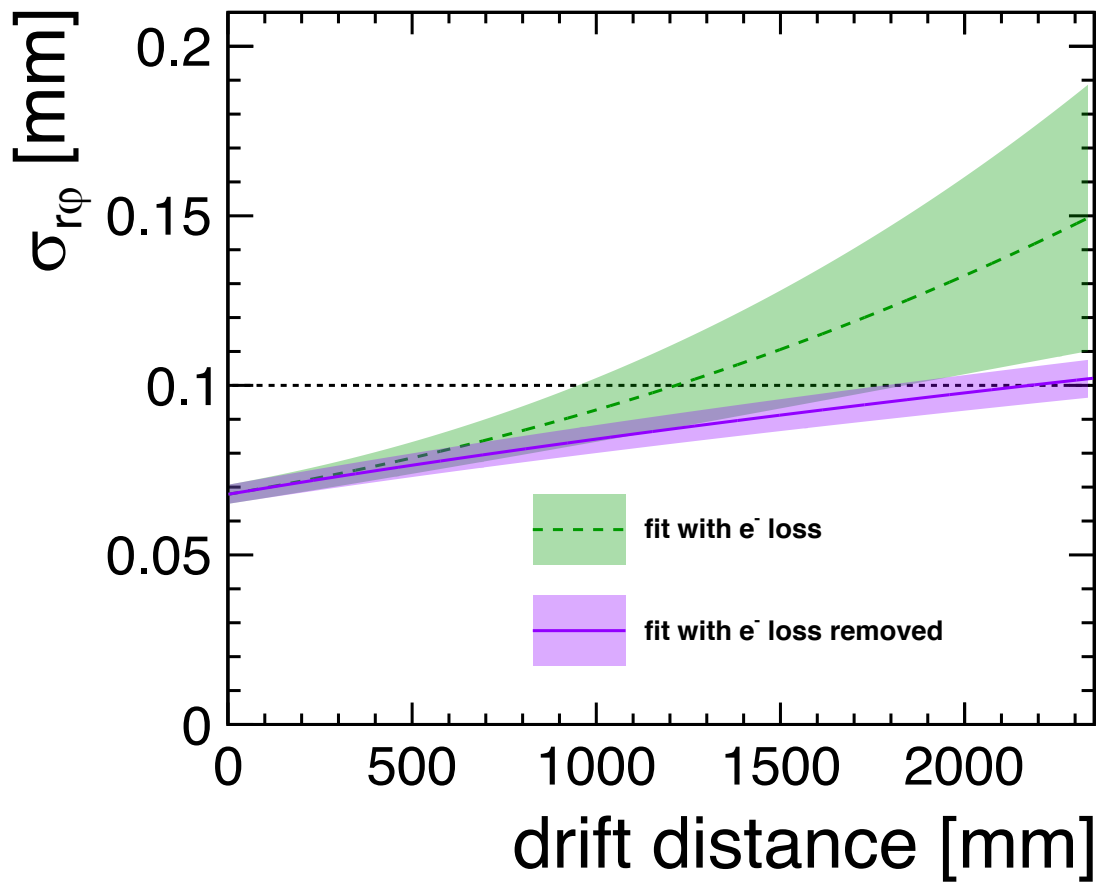
# Figure 1 (GEM prototype)



# Figure 2 (MM prototype)



# Figure 3 (Extrapolation at 3.5T and GridPix)





# Summary & Discussion & Input & Suggestion

Snowmass is a US driven exercises: The P5, Particle Physics Project Prioritization Panel, will take the scientific input from Snowmass and develop a strategic plan for U.S. particle physics that can be executed over a 10 year timescale, in the context of a 20-year global vision for the field.

Draft almost completed (see latex). Need to tell a *story* with vision and synergy!

LCTPC: conceptually ready, meet design specifications and engineeringly possible

**Today: (i) info and (ii) input from LCTPC for up-to-date figures**

**Plan to circulate the LCTPC section (and the executive summary) to the LCTPC collaboration January 17-21, 2022 [need replies by February 1]**

**Submit WP by March 1 (submit to archive March 15)**

Then, final P5 report in 2023