Test beam results of MCP in “ionisation mode” for detection of single charged particles and EM showers

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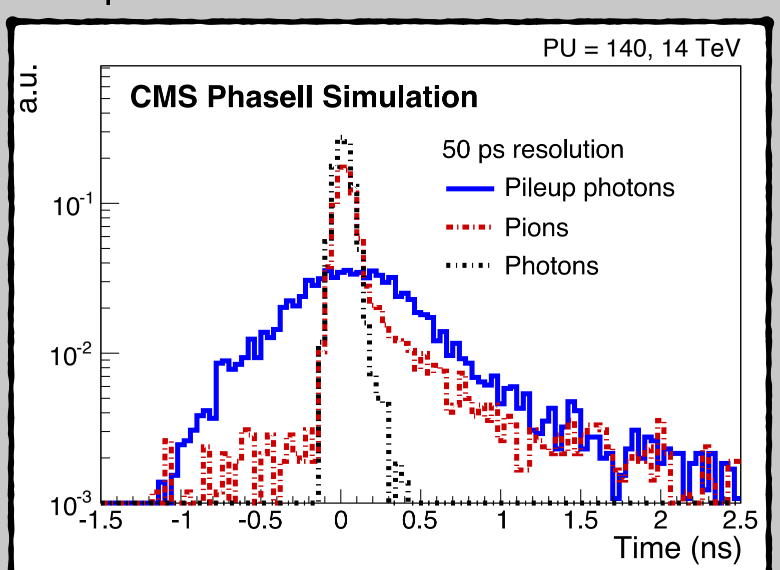
Pile-up @ future hadron colliders

High instantaneous luminosity $>10^{34}\ cm^{-2}s^{-1}$ in pp colliders is achieved at a cost of large number of collisions for BX.
e.g.: **HL-LHC (2024): 140 PU. Time spread ~200ps**

Idea: use time-of-flight information in calorimeters to aid the full event reconstruction

- ➡ **pile-up mitigation**: remove energy deposits in calorimeters not associated to the hard interaction (e.g. pile-up jets identification, improve MET resolution…)
- ➡ **triangulate high energy photons** from Higgs decay to production vertex



<50ps TOF resolution is needed to get rejection in forward EM calorimeter of pile-up photons

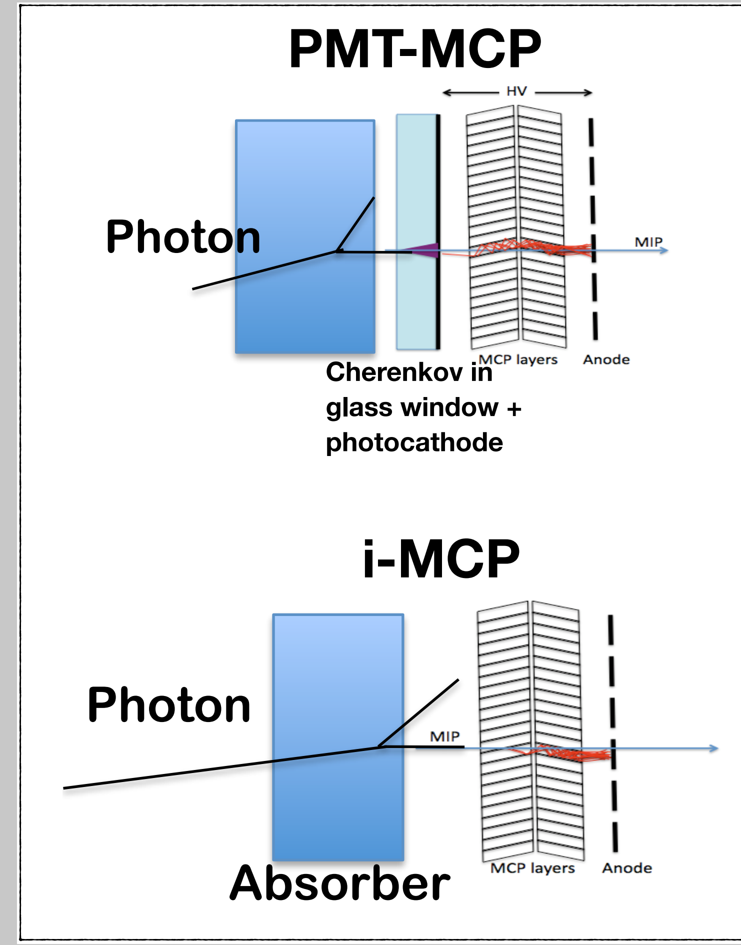
MCP as MIP/EM shower TOF detector

PMT-MCP mode

- ➡ High efficiency & excellent time resolution (<20ps)
- ➡ Issues for colliders: lifetime & radiation hardness (photocatode)

i-MCP mode

- ➡ Secondary emission in the MCP, no photocathode
- ➡ more radiation hard, improved lifetime, robust/easier assembly

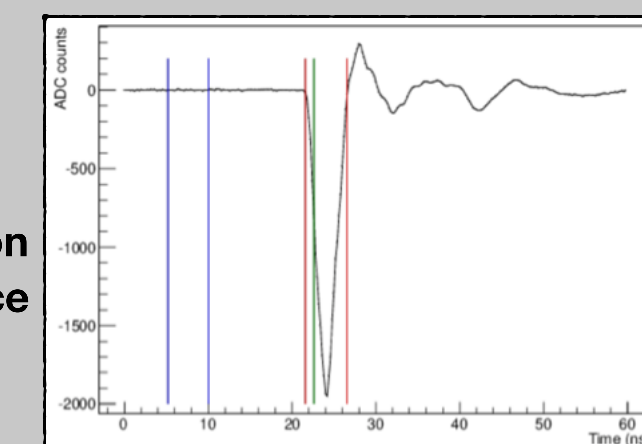


i-MCP test beam setup

1 PMT-MCP: trigger and time reference (15ps resolution)

Different configurations tested in **i-MCP mode:**

- ➡ **2 MCP layers (d/L=1:40) chevron**
- ➡ **2 MCP layers (d/L=1:40), surface chemically treated to enhance SEE, chevron**
- ➡ **3 MCP layers (d/L=1:40) Z-stack**



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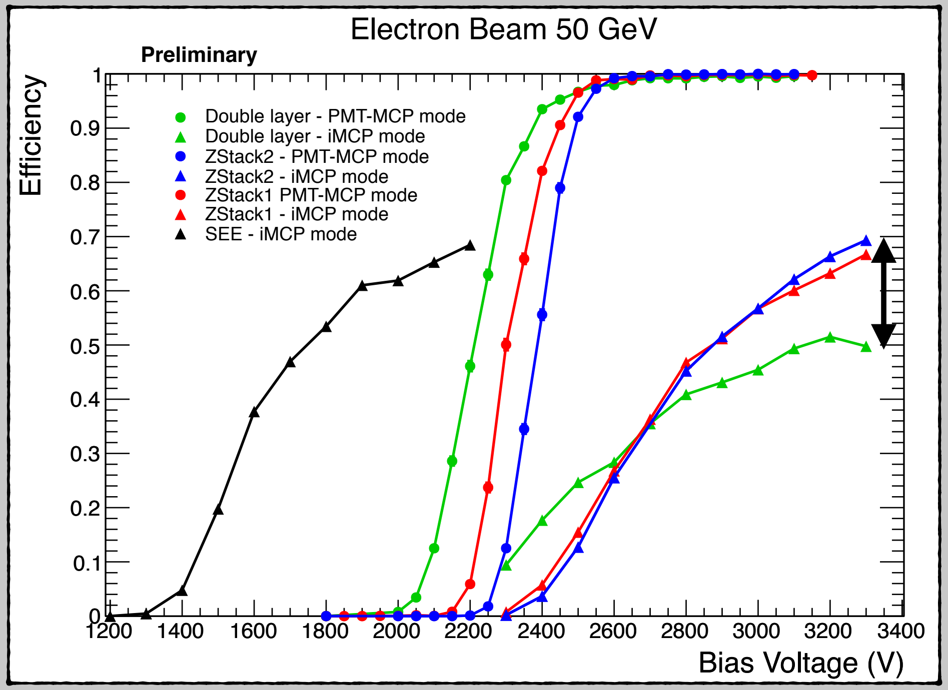
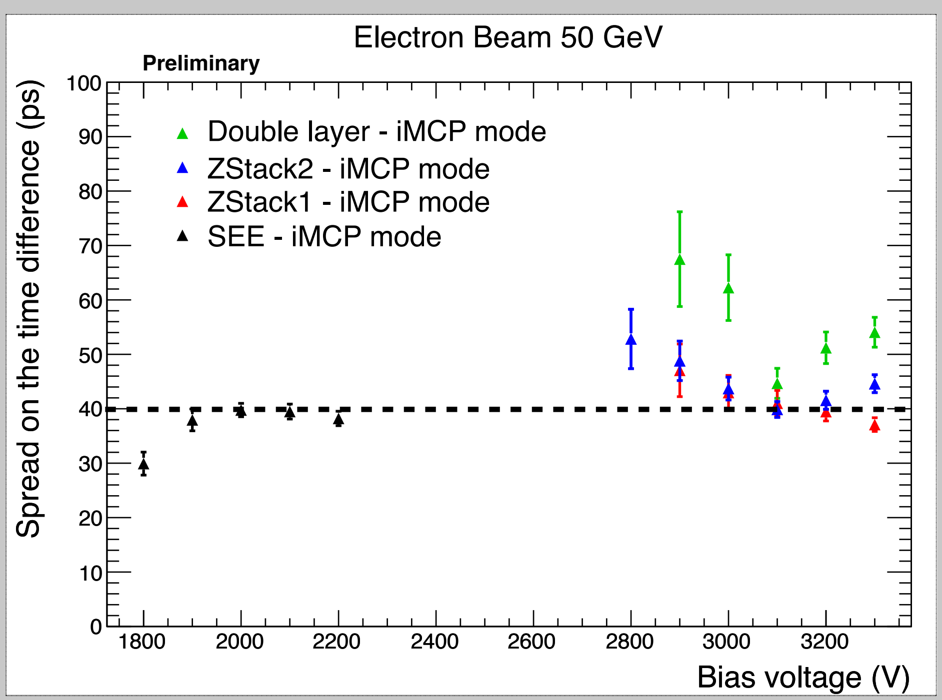
Single charged particle results



PMT-MCP mode:
100% efficiency

Z-stack & enhanced SEE i-MCP mode:
~ 70% efficiency

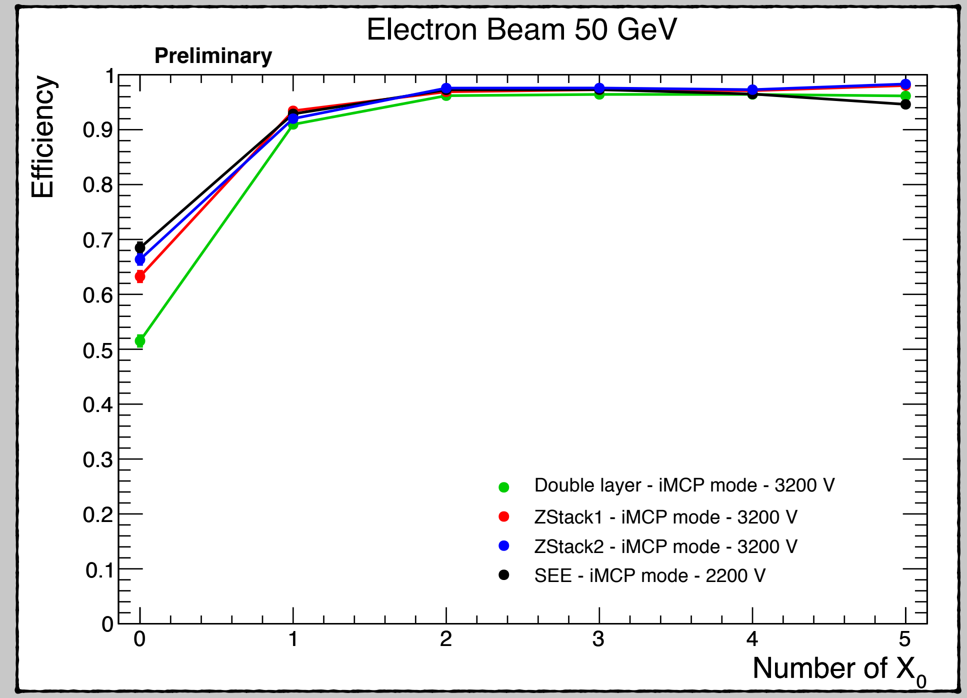
20% improvement over standard chevron configuration



$\sigma(t_{TRIG}-t_{MCP})$ ~ 40 ps for Z-stack & enhanced SEE:

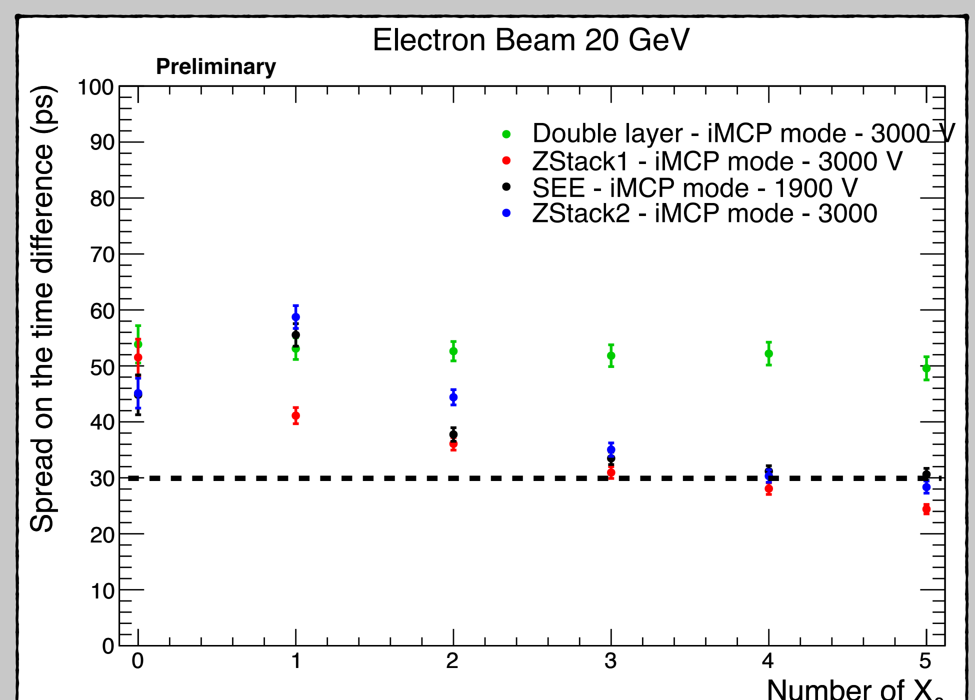
35ps resolution on single charged particle for a single detector

EM shower results



0-5X_0 in front of i-MCP with configurable lead absorber

100% efficiency for EM showers after 2-3 X_0



$\sigma(t_{TRIG}-t_{MCP})$ ~ 30 ps for showers:

25ps resolution for a single EM shower