CEPC TPC Detector's Plan

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Outline

- Status of TPC and MPGD
- Activities & milestones
- Corporation with ILD-TPC

Status of TPC and MPGD

Experiment/ timescale	Application Domain /	MPGD technology	Total detector size / single module size)	Operation characteristics/ performance	Special requirements
ATLAS Muon System Upgrade Start: 2018-2019 Operation > 15years	High Energy Physics (Tracking/ Triggering)	Micromegas	Total area: 1200 m^2 Single unit detect: ($2.2x1.4 m^2$) ~ 2-3 m^2	**Max. rate**:15 kHz/cm^2 **Spatial res.**: <100μm **Time res.**: ~ 10 ns **Rad. Hard.**: 1 C/cm^2	Redundant tracking and triggering Robustness against ageing Challenging constraints in mechanical precision:
ATLAS Muon Tagger Upgrade: start > 2023	High Energy Physics (Tracking/triggering)	μ-PIC	Total area: ~2m^2	**Max.rate**:100kHz/cm^2 **Spatial res.**: <100μm	
CMS Muon System Upgrade: start > 2020	High Energy Physics (Tracking/ Triggering)	GEM	Total area: ~ 143 m^2 Single unit detect: 0.3-0.4m^2	**Max. rate**:10 kHz/cm^2 **Spatial res.**: ~100μm **Time res.**: ~ 5-7 ns **Rad. Hard.**: 10 LHC y	Redundant tracking and triggering Robustness against ageing
ALICE Time Projection Chamber: start > 2020	Heavy-Ion Physics (Tracking + dE/dx)	GEM with TPC	Total area: ~ 32 m^2 Single unit detect: up to 0.3m^2	**Max.rate**:100 kHz/cm^2 **Spatial res.**: ~300μm **Time res.**: ~ 100 ns **dE/dx**: 12 % (Fe55) **Rad. Hard.**: 50 mC/cm^2	50 kHz Pb-Pb int. Rate; continues TPC readout Low IBF and good energy resolution
TOTEM Tracking: Start 2009-now	High Energy/ Forward Physics ($5.3 \leq \lvert eta \rvert \leq 6.5$)	GEM (semicircular shape)	Total area: ~ 4 m^2 Single unit detect: up to 0.03m^2	**Max.rate**:20 kHz/cm^2 **Spatial res.**: ~120μm **Time res.**: ~ 12 ns **Rad. Hard.**: ~ mC/cm^2	Operation in pp, pA and AA collisions.
LHCb Muon System Start: 2010 - now	High Energy / B-flavor physics (muon triggering)	GEM	Total area: ~ 0.6 m^2 Single unit detect: 20-24 cm^2	**Max.rate**:500 kHz/cm^2 **Spatial res.**: ~ cm **Time res.**: ~ 3 ns **Rad. Hard.**: ~ C/cm^2	Redundant triggering Robustness against ageing
FCC Collider Start > 2035	High Energy Physics (Tracking/Triggering/ Calorimetry/ Muon detect./)	GEM/MM/ THGEM/ InGrid μ - PIX	Total area: 10.000 m^2 (for MPGDs around 1.000 m^2)	**Max.rate**:100 kHz/cm^2 **Spatial res.**: <100μm **Time res.**: ~ 1 ns	Maintenance free for decades

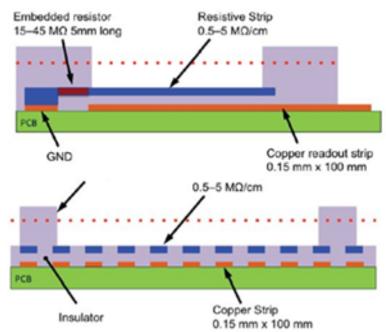
Status of TPC and MPGD

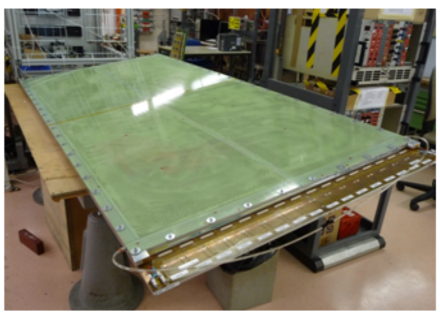
MM for the ATLAS Muon System Upgrade:

Standard Bulk MM suffers from limited efficiency at high rates due to discharges induced dead time
Solution: Resistive Micromegas tecgnology:

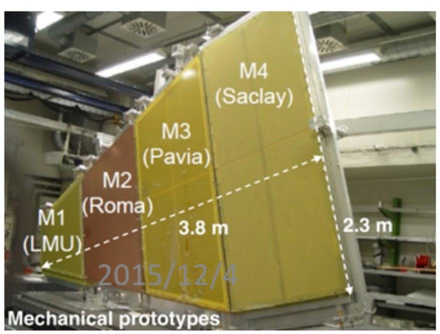
→ Add a layer of resistive strips above the readout strips

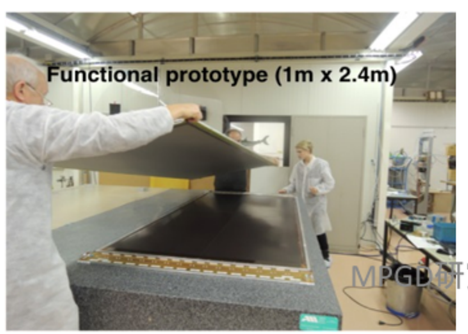
❖ Spark neutralization/ suppression (sparks still occur, but become inoffensive)





2.4 x 1m^2
MM resistive chamber constructed and characterized at CERN RD51 lab

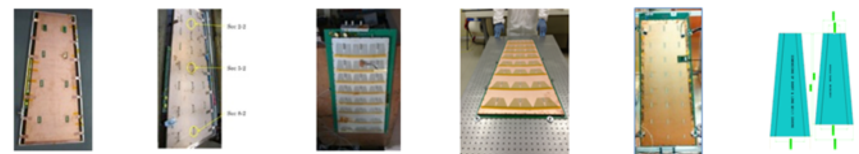




GEMs for the CMS Muon System Upgrade:

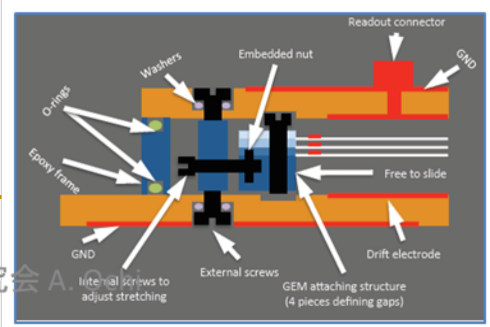
Single-mask GEM technology (instead of double-mask)
→ Reduces cost /allows production of large-area GEM

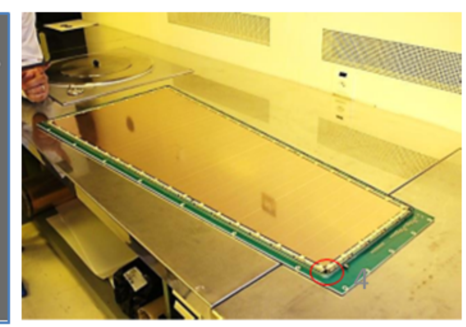
→ R&D: 6 generations of triple-GEM detectors



2010	2011	2012	2013	2014	2014/2015
Generation I	Generation II	Generation III	Generation IV	Generation V	Generation VI
The first 1m-class detector ever built but still with spacer ribs and only 8 sectors total. **Ref.: 2010 IEEE (also RD51-Note-2010-005)**	First large detector with 24 readout sectors (3x8) and 3/1/2/1 gaps but still with spacers and all glued. **Ref.: 2011 IEEE. Also RD51-Note-2011-013.**	The first sans-spacer detector, but with the outer frame still glued to the drift. **Ref.: 2012 IEEE N14-137.**	First detector with complete mechanical assembly; no more gluing parts together! **MPGD 2013; and IEEE2013.**	Nearly final CMS design: stretching apparatus that is now totally inside gas volume. **Ongoing test beam campaign for final performance measurements.**	Latest detector design; **to be installed in CMS.** Optimized final dimensions for max. acceptance and final eta segmentation. **Ongoing test beam campaign for DAQ**

Assembly optimization: self-stretching technique:
assembly time reduction from 3 days → 2 hours



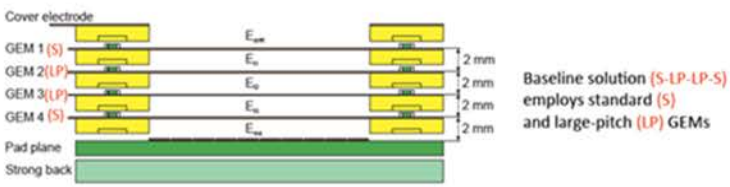


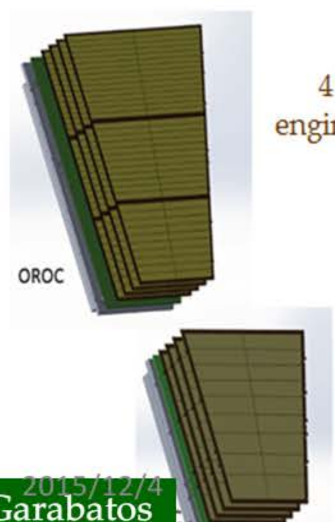
Status of TPC and MPGD

ALICE TPC Upgrade → replace MWPC with 4-GEM
(to limit space charge effects)

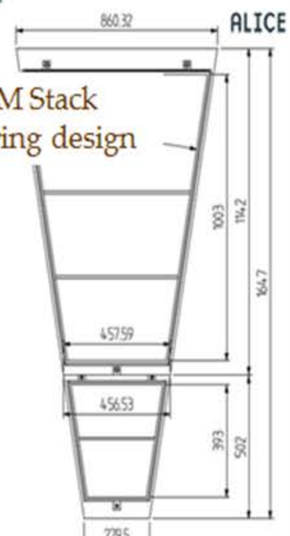
- Continuous TPC readout for 50 kHz Pb-Pb readout
- Maintain physics requirements:
  IBF < 1%, energy; σ(E)E < 12% achieved

4 GEM Stack Configuration
(to minimize IBF)



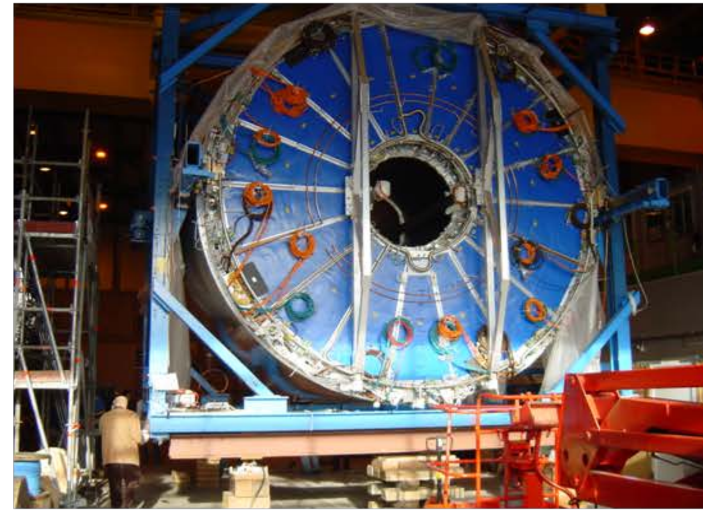


4 GEM Stack
engineering design

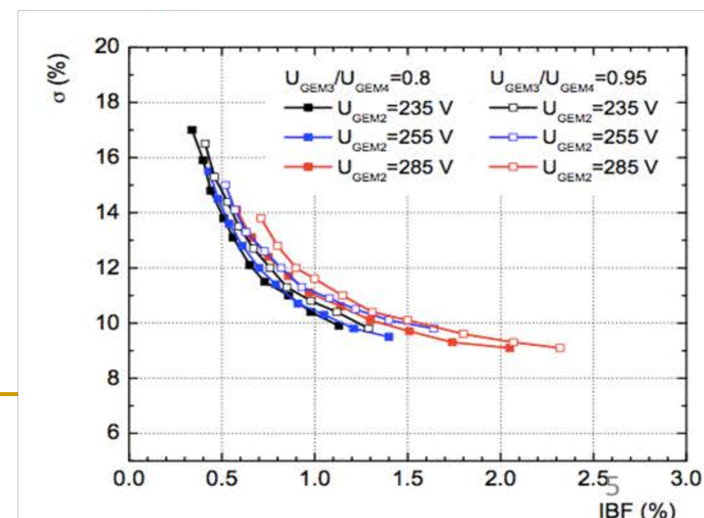


Preproduction:

Single-mask GEM allows for production of ~1 m foils



Ion Back Flow in a GEM system reduced from > 5 % (3 GEM) to < 1% (4 GEM)
→ discovered enhanced ion trapping at high rates



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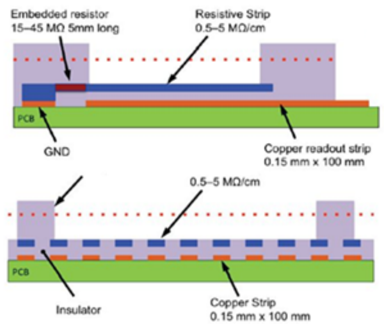

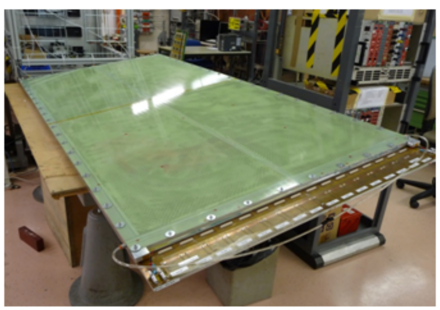

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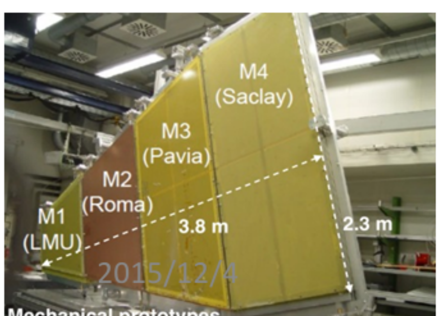

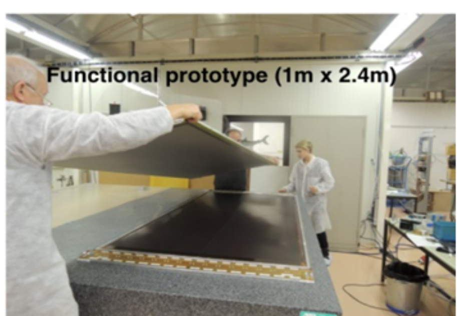

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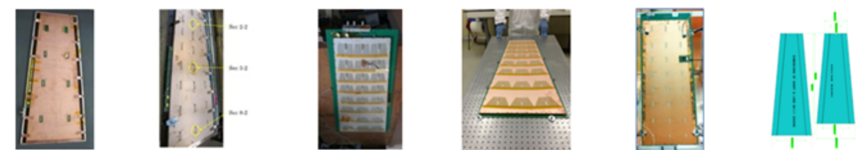

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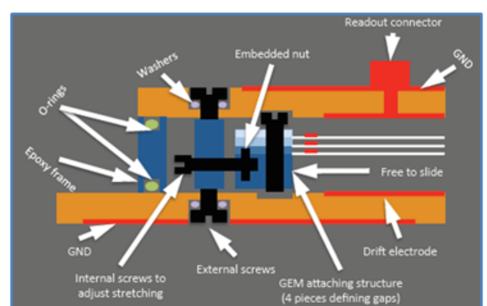
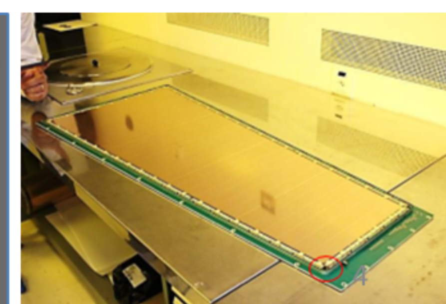
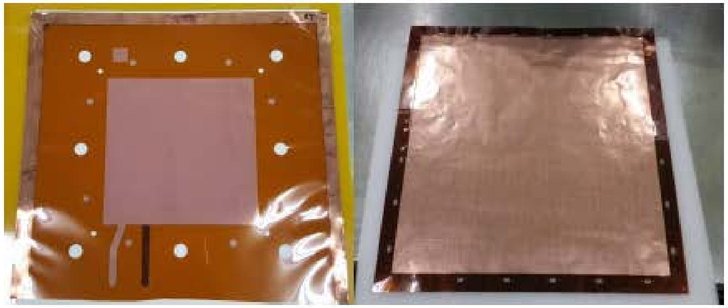




Status of TPC and MPGD

- ❑ Small size GEM (10x10 cm²)
  - – Mass production phase since 2015
    - Plan: ~2000 foils/year
- ❑ Mid-size GEM (30x30 cm²)
  - – Order-based production
- ❑ Large size GEM (50x100 cm²)
  - – Still R&D phase (almost done)
  - – For the CMS upgrade (GE11)
    - Plan: ~500 GEM foils by 2017
- ❑ Custom design GEM
  - – IBS LAMPS project : 10 x 20 cm²
  - – KU-KEK: GEM-TPC 10 x 20 cm²



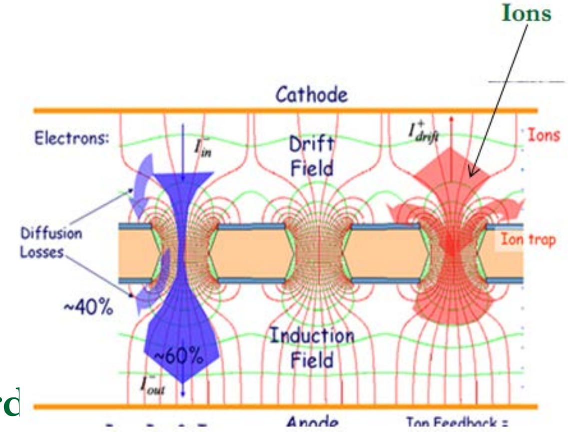
GEM foil production by MECARO @Korea

Activities & milestones

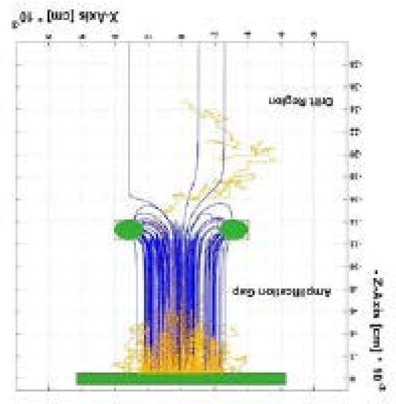
New ideas for the ions

Supported by 高能所创新基金

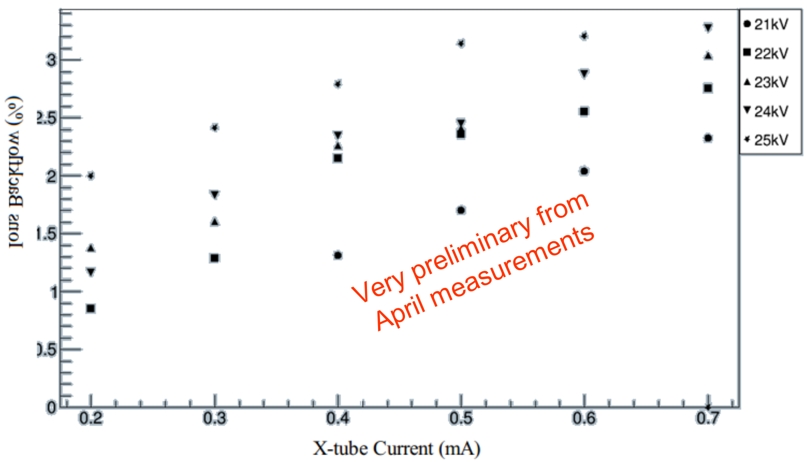
- GEM+Micromegas hybrid module
  - GEM as the preamplifier device
  - GEM as the device to reduce the ion back flow continuously
  - Stable operation in long time
  - Reach to the higher gain than standard Micromegas with the pre-amplification GEM detector
  - Increase the operating voltage of GEM detector to enlarge the whole gain



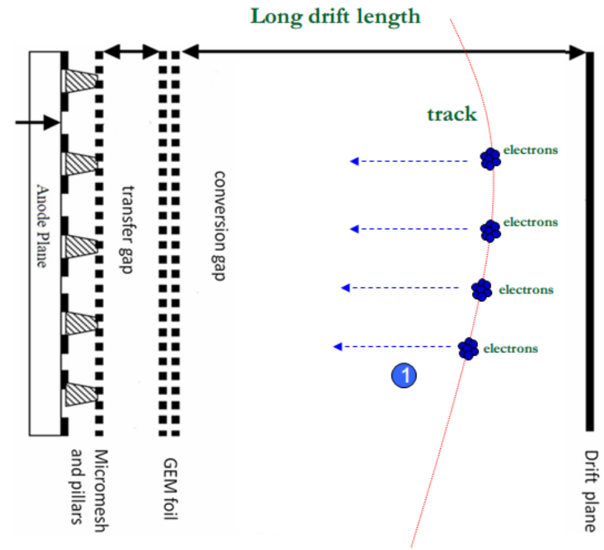
IBF of GEM



IBF of GEM and Mciromegas



IBF of the hybrid module

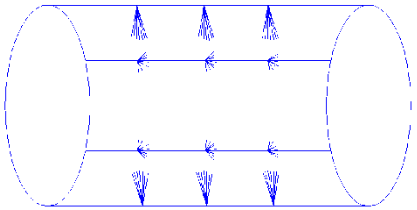


Particles track in the hybrid module

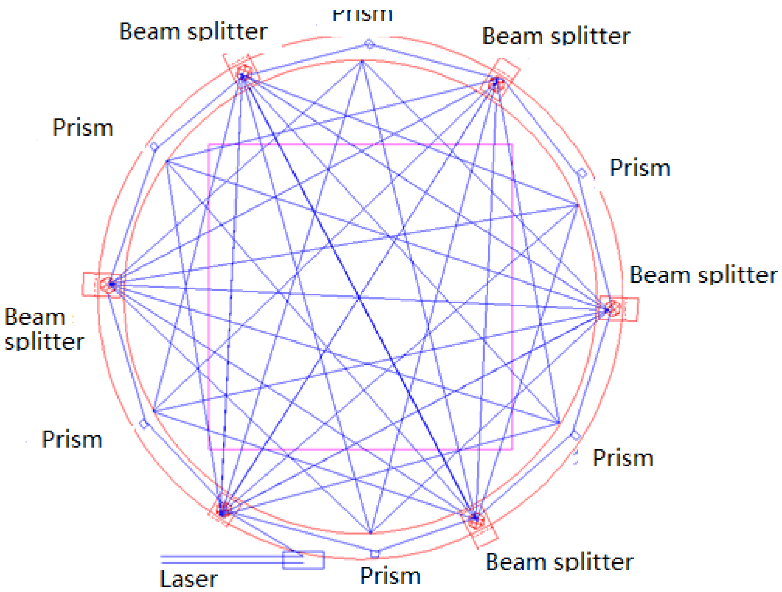
Laser calibration system for TPC

Supported by the State Key Program of National Natural Science of China

- Principle of laser for TPC detector
  - The ionization in the gas volume along the laser path occurs via two photon absorption by organic impurities
- To reduce the distortion effect
  - E×B effect study
  - Drift Velocity measurement
- Laser features for TPC
  - λ = 266 nm or E = hν = 4.66 eV
  - Energy: ~100 uJ/pulse
  - Duration of pulse: 5 ns
- Advantages
  - Transportable and flexible test beam setup
  - Good resolution in space and time
    - No production of σ-rays
    - No multiple scattering
  - No curvature in magnetic fields
  - Ionisation density controllable and small fluctuation
  - Simple beam reflection similar to light



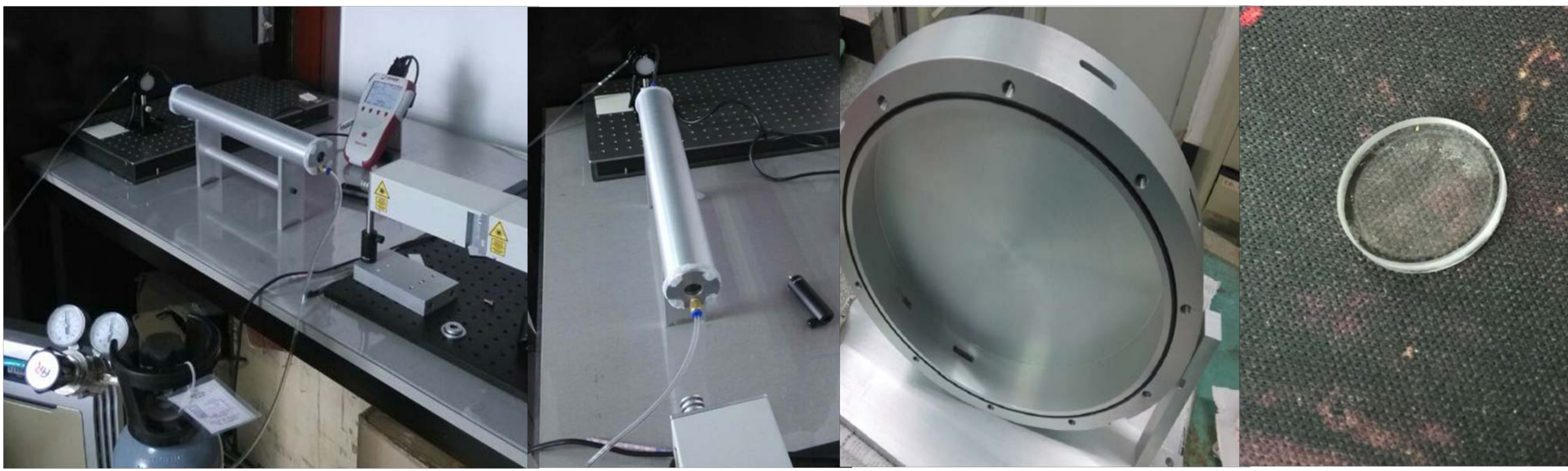
Laser in Drift length



Laser profile map in TPC

First step: study on the laser and design prototype

- Laser transmissive window material@266nm
  - Nano SG120-20 Laser machine
  - Windows materials: Mylar foil, Kapton, PE plastic, Artificial sapphire(Al_2O_3), Fused silica
  - Fused silica (JS2) : light transmittance 80%~90%
  - Working gas with fused silica windows: Ar+CO_2, light transmittance 80%~90%
- Design and test
  - Design and setup the prototype with the fused silica windows
  - Measurement the GEM modules using 266nm laser



266nm Laser test photos

Common efforts on IBF R&D

Collaboration for the future electron-positron colliders:

CEA Scalay (France)

IHEP, Tsinghua Univ., CIAE, Shandong Univ.,

Lanzhou Univ., UCAS (China)

Aleksan Roy (Saclay)
GAO Yuanning (TH)
QI Huirong (IHEP)

Targets:

- **Simulation and optimize the Hybrid modules of TPC with the active area of $100mm^2 \sim 200mm^2$**
- **R&D of IBF used UV light**
  - **Goal: ~0.1% IBF, Resistive Micromegas modules, Hybrid modules**
- **Assembled Bulk Micromegas detector**
- **Toward CEPC CDR**
- **…**

Common efforts on Laser calibration R&D

Collaboration for the future electron-positron colliders:

Tsinghua Unviversity,Beijing

IHEP, Beijing

LI Yulan (THU)
DENG Zhi (THU)
QI Huirong (IHEP)

Targets:

- **Simulation and optimize the calibration methods and the TPC detector for CEPC**
- **Laser optical design**
    - **Wave length: 266nm, Optical power: ~15mJ, independent optical tracks**
- **TPC Prototype design with Laser calibration**
    - **Readout active area: ~200mm^2, Drift length: ~500mm**
    - **Position resolution: ~100um, Calibration for Drift velocity. Stability tests**
- **ASIC electronic readout**
    - **Goal: ~32Chs/CHIP, Channels: ~1K**

Corporation with ILD-TPC

Thanks！