



# RD51 COLLABORATION MEETING

13–15 October, Paris

A LARGE AREA  
GEM DETECTOR

Serge Duarte  
Pinto

TOTEM

T upgrade

Challenges

Single mask  
technique

Manufacturing

Performance

GEM splicing

Coverlay

Test

Manufacturing

Framing & honeycomb

Cathode & assembly

High voltage

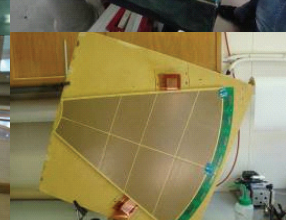
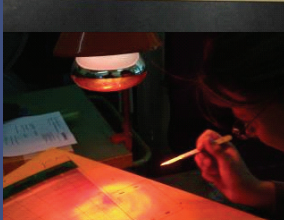
Prototype

The detector

Gain

Perspectives

Other ideas



## A LARGE AREA GEM DETECTOR

First tests of full scale prototype

Serge Duarte Pinto

CERN-GDD group

16 October 2008



# TOTEM T1 UPGRADE

Based on large GEM chambers

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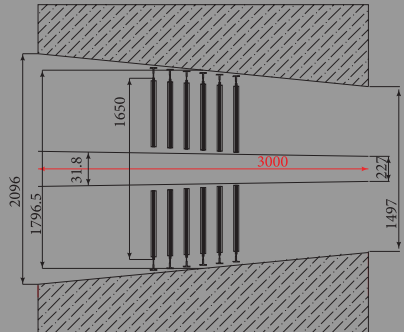
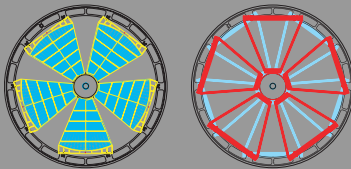
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## Ideas for upgrade of TOTEM T1

- Large triple GEM chambers ( $\sim 2000 \text{ cm}^2$ )
- Discs of  $2 \times 5$  chambers, back to back
- Overlap allows adjustable disc radius





# TOTEM T1 UPGRADE

*Technical challenges for such large active area*

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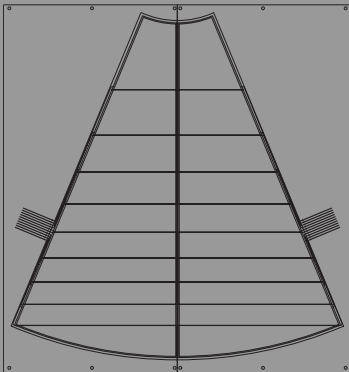
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## Technical hurdles for fabrication of large GEMs

- Double mask technique introduces alignment errors at such dimensions
- Base material is only 457 mm wide





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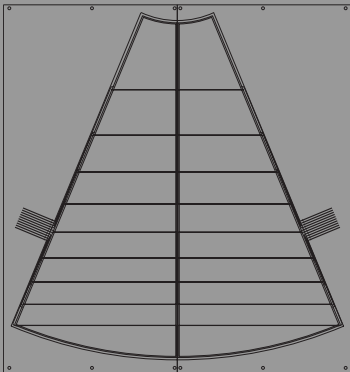
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## Technical hurdles for fabrication of large GEMs

- Double mask technique introduces alignment errors at such dimensions → *use single mask technique*
- Base material is only 457 mm wide





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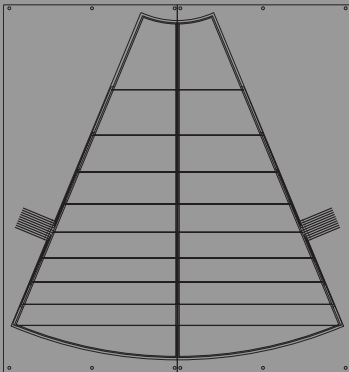
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## Technical hurdles for fabrication of large GEMS

- Double mask technique introduces alignment errors at such dimensions → *use single mask technique*
- Base material is only 457 mm wide → *splice foils together*





# GEM MANUFACTURING

*Double mask vs. single mask technique*

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## DOUBLE MASK



50 $\mu$ m kapton foil  
5 $\mu$ m copperclad

photoresist coating,  
masking, exposure

metal etching

kapton etching

metal etching

second masking

metal etching,  
and cleaning

## SINGLE MASK





# SINGLE MASK TECHNIQUE

*Similar performance at lower cost*

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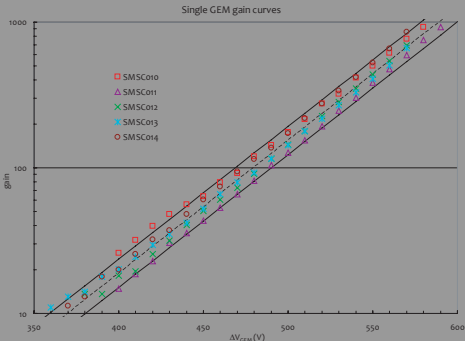
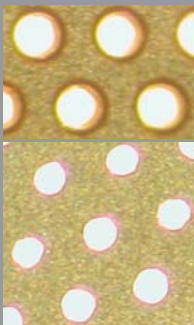
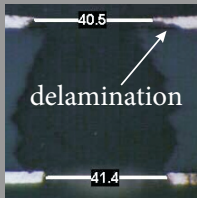
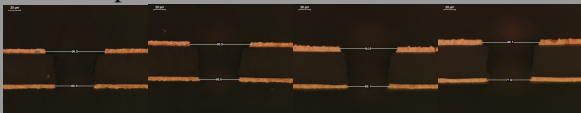
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First results were not encouraging →  
SMT now performs similar to standard GEM.





# SINGLE MASK TECHNIQUE

*Rate capability and charging-up of tripleGEM*

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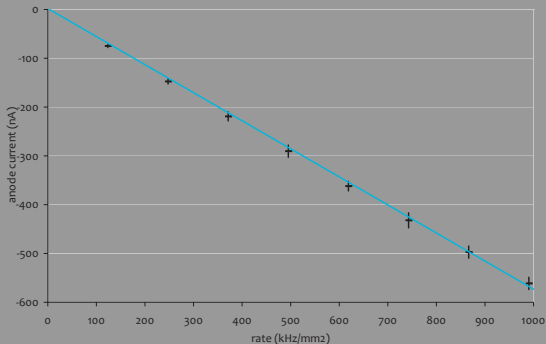
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Other ideas

## Rate capability with copper X-ray



- Multiply by 320 for rate of primaries
- Charging up is stronger but very fast (seconds)
- Needs to be studied, and can still be improved by optimizing hole profile on new foils





# SPLICING GEMs

*Glue foils with pyralux coverlay*

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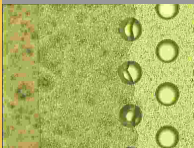
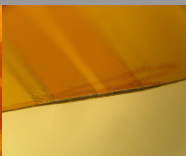
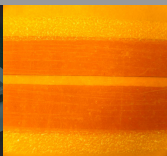
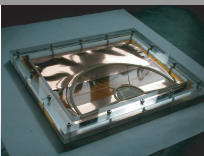
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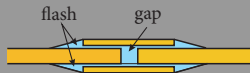
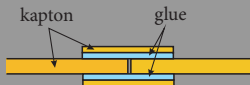
Perspectives

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Coverlay to glue GEMs

Seam is flat, regular,  
mechanically and dielectrically  
strong, and only 2 mm wide.





# SPLICING GEMs

*Test performance near the seam*

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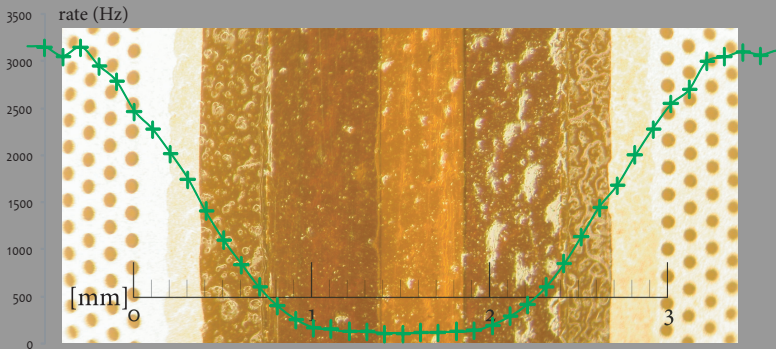
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Other ideas

- X-ray with  $\varnothing 0.5$  mm collimator
- Rate scan over the seam
- Behaves normally until at the seam
- Performance rest of GEM surface unaffected





# MANUFACTURING

*From the design to a prototype*

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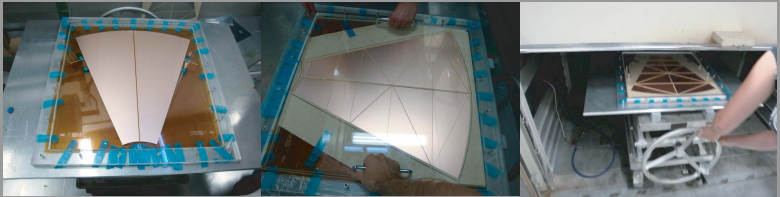
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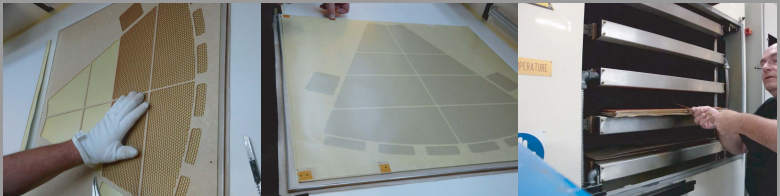
Perspectives

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## Stretching and framing the spliced single mask GEM foils



## Making the honeycomb base plane and top cover





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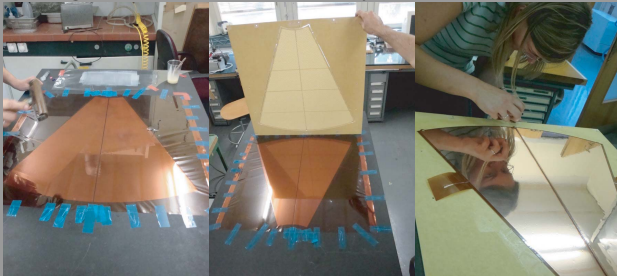
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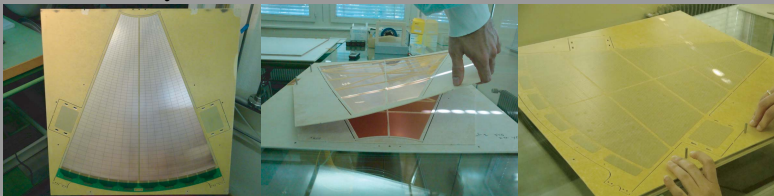
Perspectives

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## Gluing the cathode to the honeycomb frame

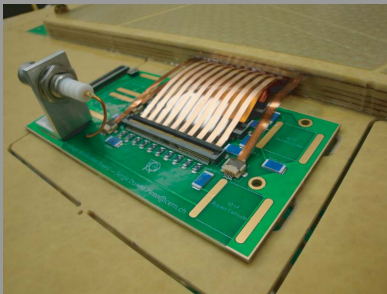


## Final assembly of all frames





## Compact high voltage divider board



- Based on only SMD components
- Using ZIF sockets to connect to GEM terminals
- Traces that lead to GEM sectors are embedded in frame
- Easy to make, and to replace or debug



# THE PROTOTYPE

*The final detector and its performance*

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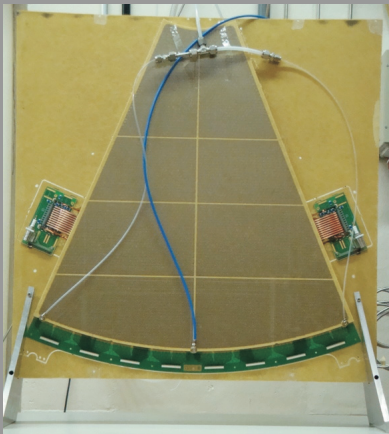
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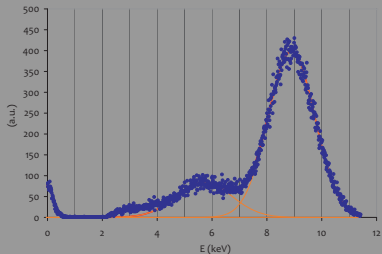
Gain

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- Gas tightness & high voltage stability Ok
- Too late for testbeam by lack of electronics
- $\frac{\sigma_E}{E} = 9.5\%$  measured with Cu X-ray (8.9 keV)





# THE PROTOTYPE

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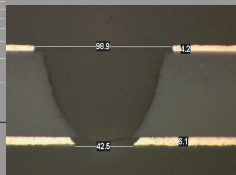
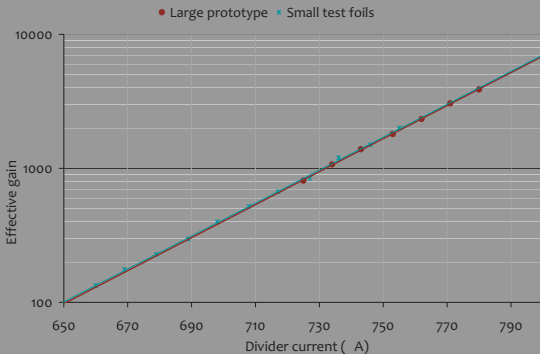
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## Gain consistent with $10 \times 10$ cm test foils



- Lower gain at equal voltage than standard (double mask) GEM, as expected from wide hole diameter
- Development of optimal hole profile still continues



## Conclusions

- Single mask technique proved viable and cheap alternative
- Splicing method allows to go beyond limits of base material
- These techniques open the way for large area GEMS

## Perspectives

- Connect to fast electronics (VFAT or GP5/7) to study efficiency
- Discharge studies
- Test gain homogeneity
- Charging-up studies of single-, double- and tripleGEM
- Pursue optimization of SMT (steeper holes, smaller rim)

already many foils waiting to be tested ...





# EMBEDDED RESISTORS

*Screen-printed PTF resistors to be glued in the frame*

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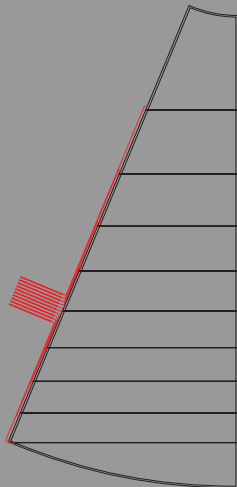
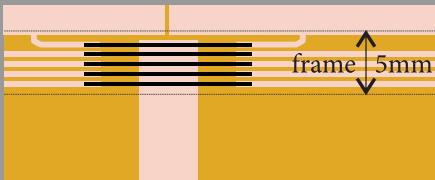
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- A half T1 GEM foil requires 10 sectors
- Makes 60 sectors per chamber, complicates HV circuitry
- Embedding resistors in frame would solve the issue
- Tolerance requirements for resistors extremely low, but still waiting for suitable high-resistivity paste



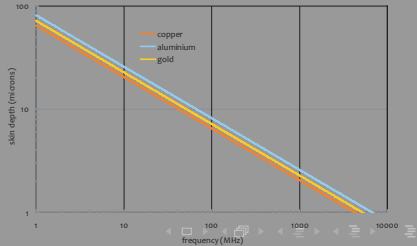
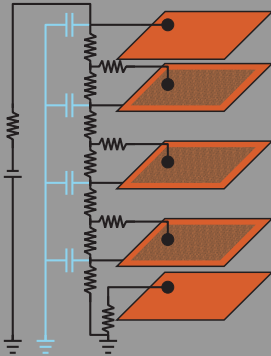


# SHIELDING OF GEM CHAMBER

Using decoupling capacitors

Use bottom electrodes as shield by applying decoupling capacitors

- Simulations indicate negligible effect on discharges
- HV distribution boards of prototype have features to implement these capacitors
- must be tested with fast electronics to verify suppression of noise



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