GEM chambers for SoLID

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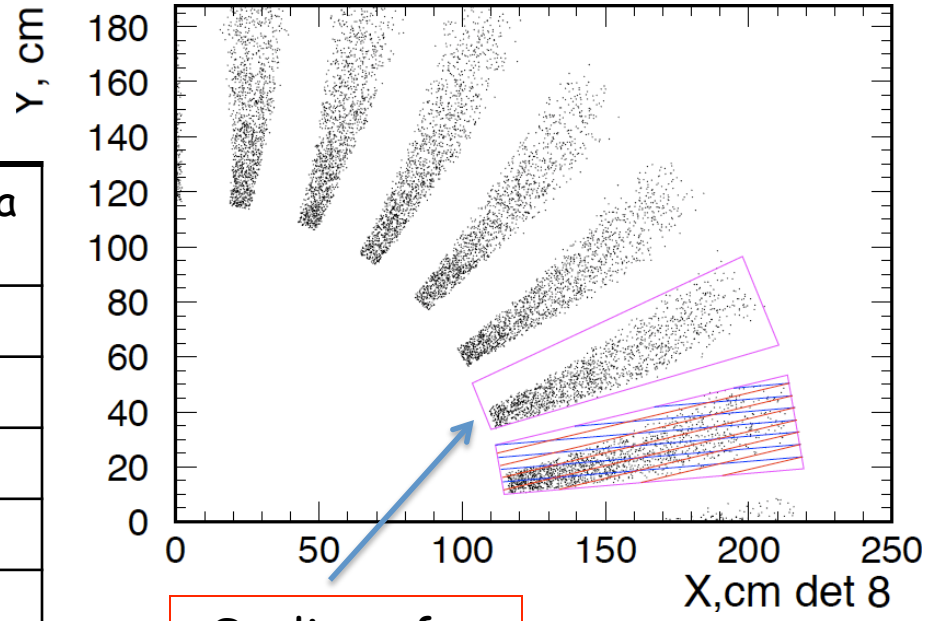
PVDIS GEM configuration

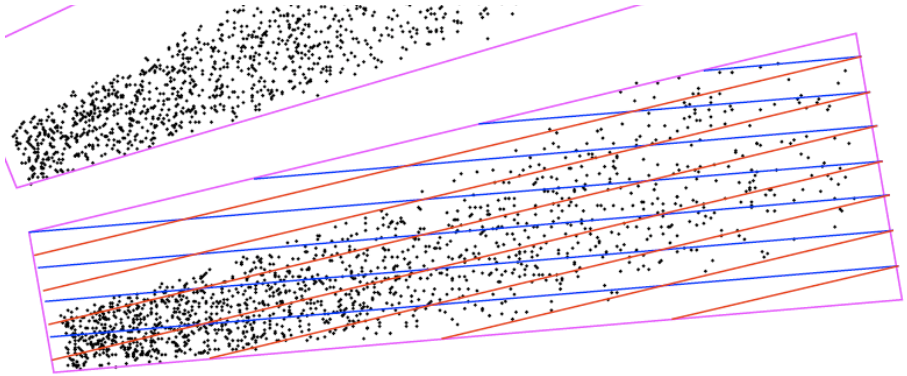
- Current proposal to instrument locations 4, 5, 6, 7, and 8 with GEM:
  - need to determine the number of GEM layers required and their locations, using the simulation
- 30 GEM modules at each location: each module with a 10-degree angular width.

Plane	Z (cm)	R_I (cm)	R_O (cm)	Active area (m^2)
4	120	40	90	1.7
5	150	55	115	2.7
6	190	65	140	4.0
7	290	105	200	7.6
8	310	115	215	8.6
total:				~ 25



PVDIS GEM configuration

- Suggested readout scheme:
  - a 2D readout optimized to get high accuracy in the ϕ coordinate, lower but sufficient resolution in the **r** coordinate.
  - each set of stripes parallel to one of the radial sides of the module: i.e. stripes at a 10-deg stereo angle to each other.
  - strip pitch is 0.6 mm for locations 7 and 8;
  - 0.4 mm for locations 4, 5 and 6.
  - Issues:
    - A full tracking simulation needs to determine that this readout scheme gives the required tracking resolution.
    - How well will the 10-deg stereo angle separated strip layers work ? – need to test with prototypes.



PVDIS GEM configuration

- For this readout scheme readout channel estimation

Plane	Z (cm)	R_I (cm)	R_O (cm)	# of channels
4	120	40	90	24 k
5	150	55	115	30 k
6	190	65	140	36 k
7	290	105	200	35 k
8	310	115	215	38 k
total:				164 k

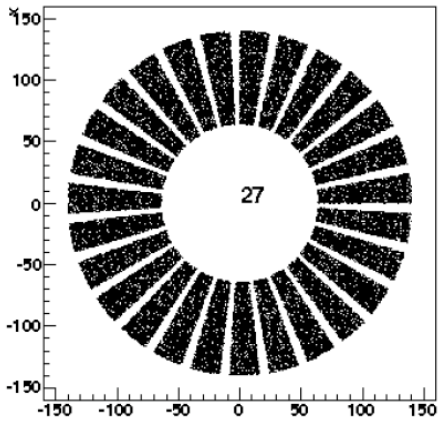
- with 20% spares, we will need about 200 k channels.
- Simulations and prototypes may indicate that we need more channels for high rate tracking; can be as much as 300 k total.
- Good news: cost of electronics going down – cost per channel for the RD51 SRS APV-25 based readout is estimated to be ~ $ 2.50 - $ 3.00

The total cost of readout electronics can be less than $ 1 M

SIDIS GEM configuration

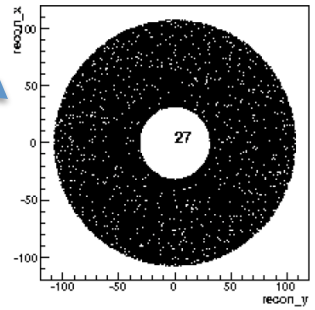
- Six locations instrumented with GEM:
- PVDIS GEM modules can be re-arranged to make all chamber layers for SIDIS. – move the PVDIS modules closer to the axis so that they are next to each other

Plane	Z (cm)	R_I (cm)	R_O (cm)	Active area	# of channels
1	197	46	76	1.1	24 k
2	250	28	93	2.5	30 k
3	290	31	107	3.3	33 k
4	352	39	135	5.2	28 k
5	435	49	95	2.1	20 k
6	592	67	127	3.7	26 k
total:				~18	~ 161 k



PVDIS

SIDIS



- More than enough electronic channels from PVDIS setup.
- The two configurations will work well with no need for new GEM or electronics fabrication.

large area GEM chamber challenges

- SoLID needs GEM modules as large at 100 cm x 40 cm.
- The biggest challenge used to be the non-availability of large area GEM foils.
- Not a problem anymore: CERN shop can make foils as large as 200 cm x 50 cm now.
- One problem may be the production capacity of the CERN shop: especially if a LHC related large GEM project gets underway.
- Need to develop large GEM production capabilities in China.

Bottom-line

- With the strong effort led by RD-51 towards large GEM chambers and readout electronics:
  - Costs are coming down
  - Many technical challenges are overcome
- But SoLID is a very large and very complicated GEM project from any standard; no one has ever done anything even close to this size.
- We are soon starting on SBS GEM construction, this is about half the size of the SoLID GEM project.
- So with large GEM chamber construction for SBS in Rome and at Uva and with the infrastructure and expertise we gain from the SBS project we would be ready for the SoLID GEM construction in a couple of years.

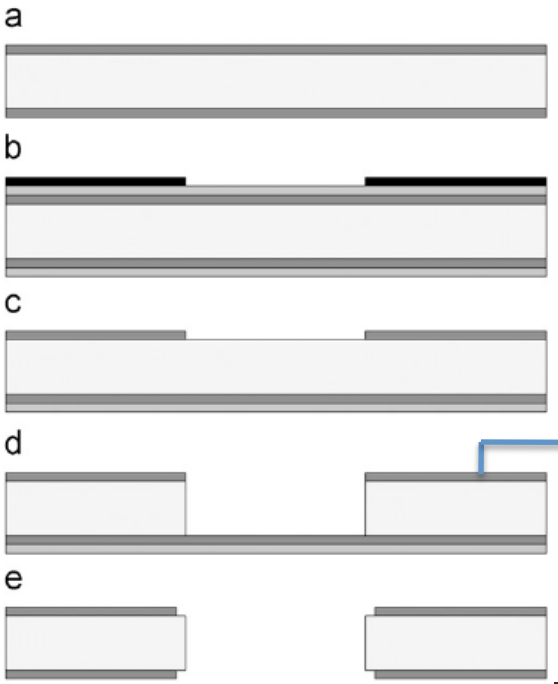
Production at CERN

- GEM size
  - With existing equipments 1.5m x 0.5m active area
  - Mid 2011: 2m x 0.5m active area
- Volumes
  - With existing equipment: 10 GEMs/month.technician
    - We can hire one more technician
  - Mid 2011: 24GEMs/month.technician (240GEM/year)
  - With some offers for large volume production we start to see the limit price of the GEMs : in the range of 600 CHF/sqr.meter

Major recent development at CERN PCB shop towards large GEM foils

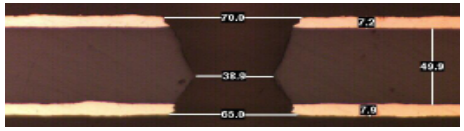
- Base material only ~ 45 cm wide roll.
- Used a double mask technique for etching: hard to the two masks accurately: Max area limited to ~ 45 cm x 45 cm previously.

Double Mask



Bias top surface to – w.r.t chemical bath

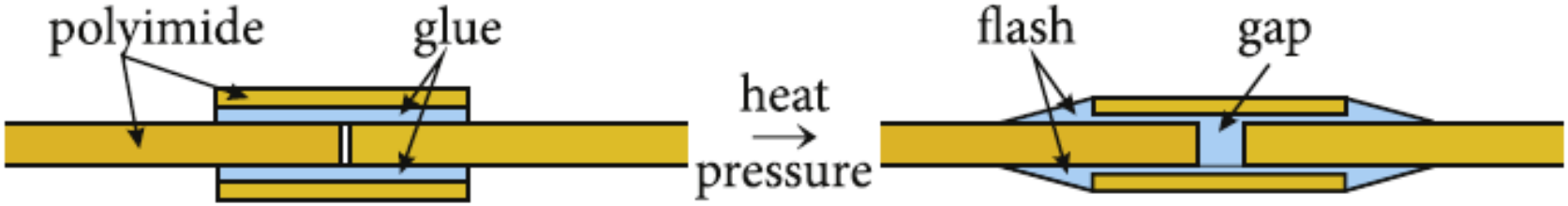
Single Mask

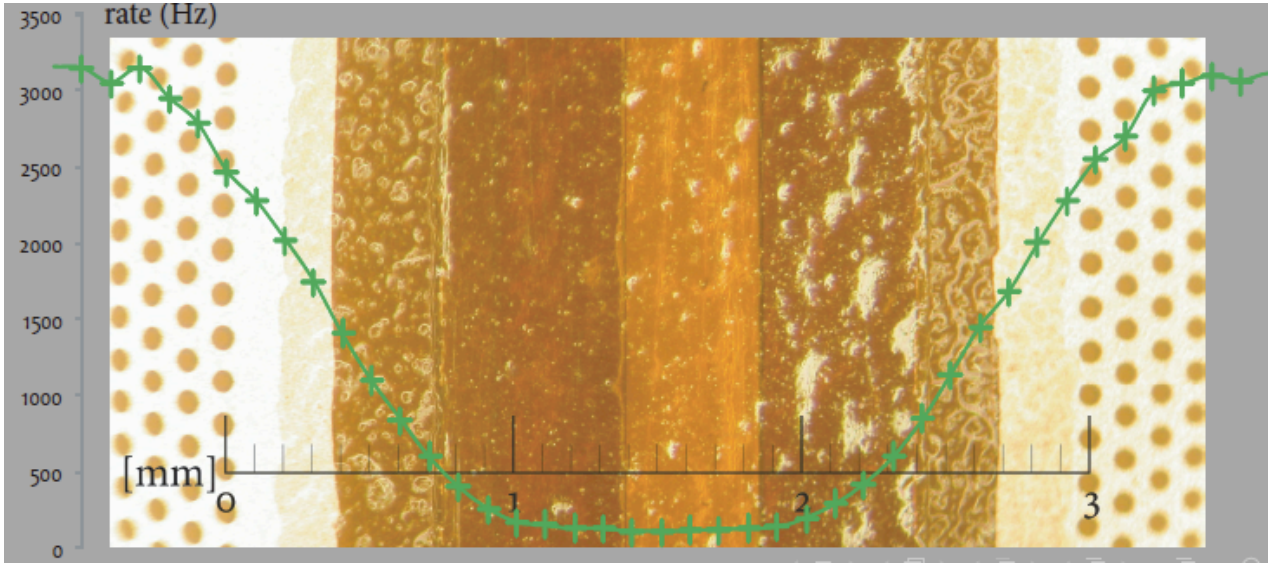


Single Mask technique allows to make GEM foils as large as 200 cm x 50 cm

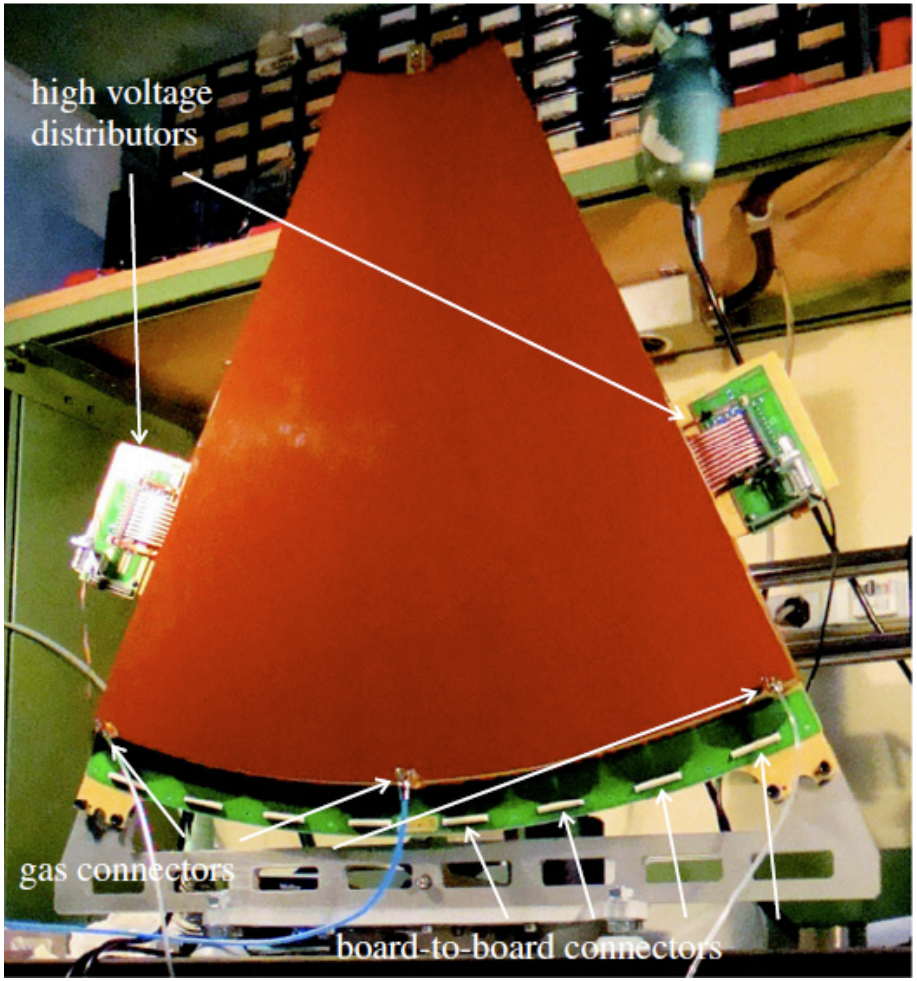
Major recent development towards large GEM foils

- Splicing GEM foils together: seam is only 2 mm wide
- Performance of the rest of the GEM foil unaffected





TOTEM T1 prototype chamber made with single mask GEM foils spliced together (33 cm x 66 cm)



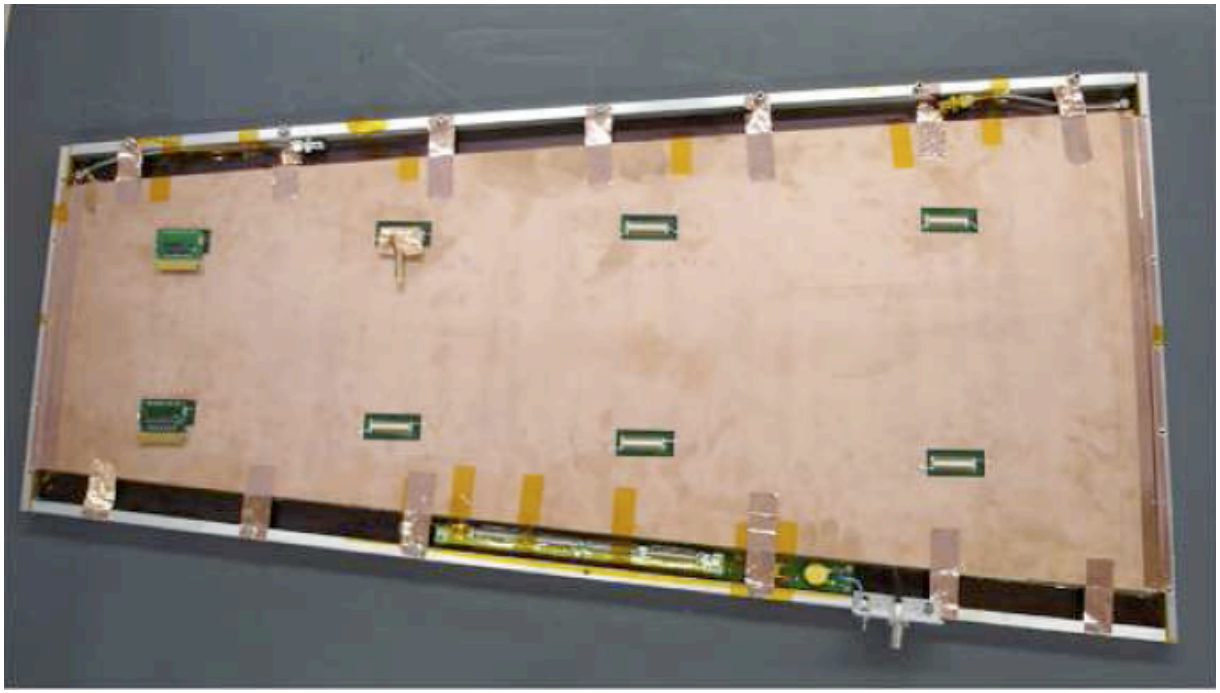
- Base material up to 51.4 cm wide now available
- CERN plans to buy equipment capable of producing 200 cm x 50 cm GEM foil.

This combined with Splicing: 200 cm x 100 cm GEM foil may be possible in the next two years

M. Villa, et al., Nucl. Instr. and Meth. A (2010), doi:10.1016/j.nima.2010.06.312

M. Alfonsi et al. / Nuclear Instruments and Methods in Physics Research A 617 (2010)

Recently, a very large prototype GEM module for CMS was constructed and tested at CERN

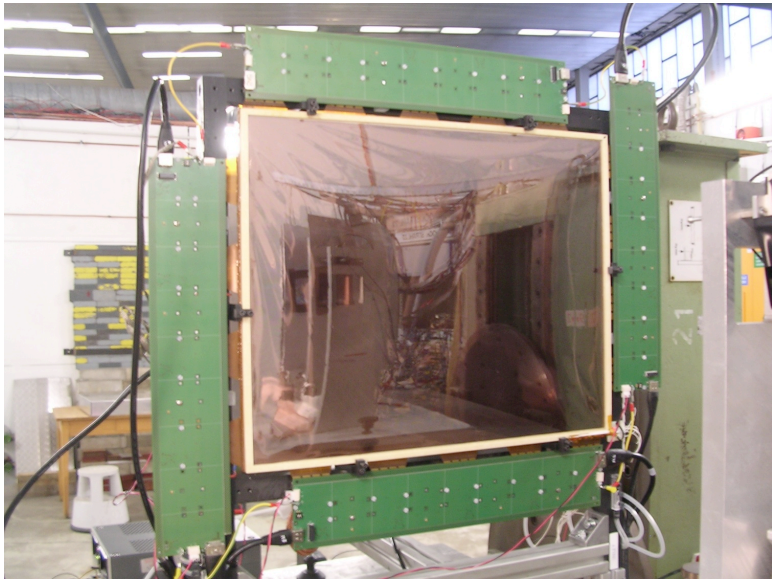


99 cm x (22 – 45.5) cm – very close the the dimensions of largest SoLID chambers

UVa GEM development status

- Beam test at Mainz in September with 10 cm x 10 cm prototype chambers and APV-25 electronics.
- Construct two 40 cm x 50 cm prototype chambers this Fall
  - GEM and readout foils already ordered
  - Expect chamber construction in October
  - Move to Jlab and beam testing with APV-25 electronics: November-May

The 40 cm x 50 cm prototypes
- Size: 40x50 cm^2 active area + 8 mm frame width
- 2D strip readout (a la COMPASS) - 0.4 mm pitch
- INFN is now going into 40x50 cm^2 GEM module production for SBS

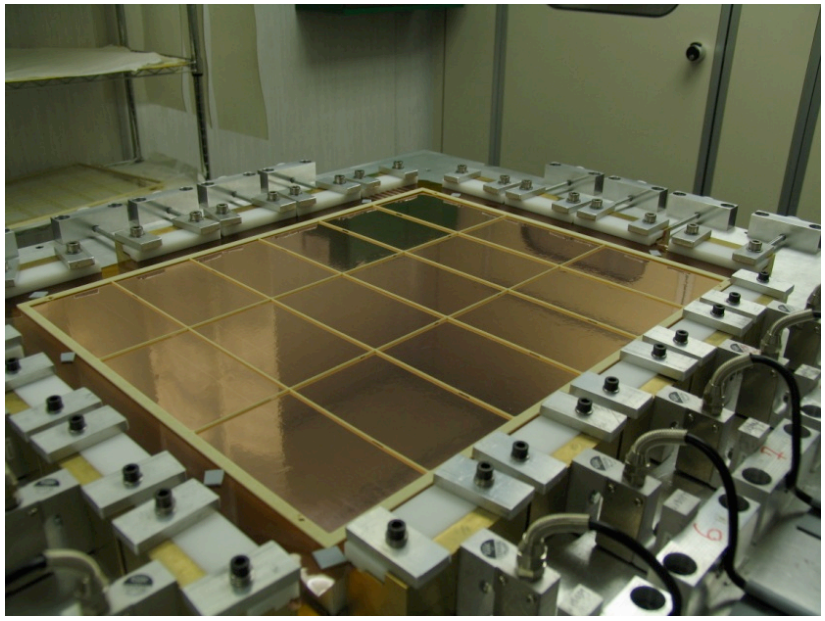


The INFN 40 cm x 50 cm prototype: the Uva chambers will be similar with small modifications

UVa GEM development status

At present preparing lab for large prototype production

- Refurbish the clean room with new filters etc.
- Dry Nitrogen high voltage boxes for GEM foil testing
- Dry Nitrogen storage cabinets for foil storage (to minimize oxidization effects)
- mechanical stretcher for GEM foils. Etc. etc.



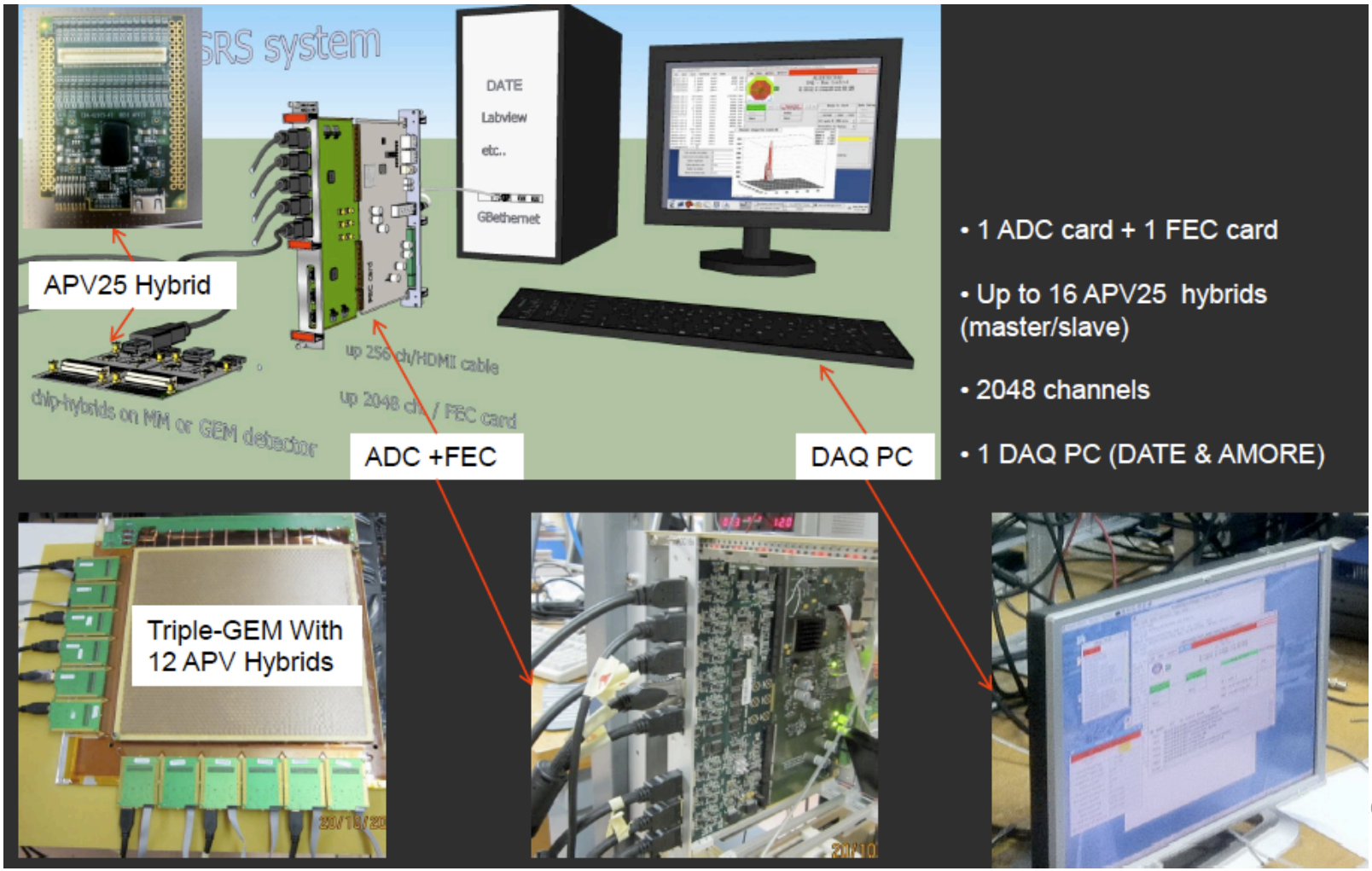
mechanical stretcher for GEM foils

Dry Nitrogen cabinets for foil storage

UVa GEM development status

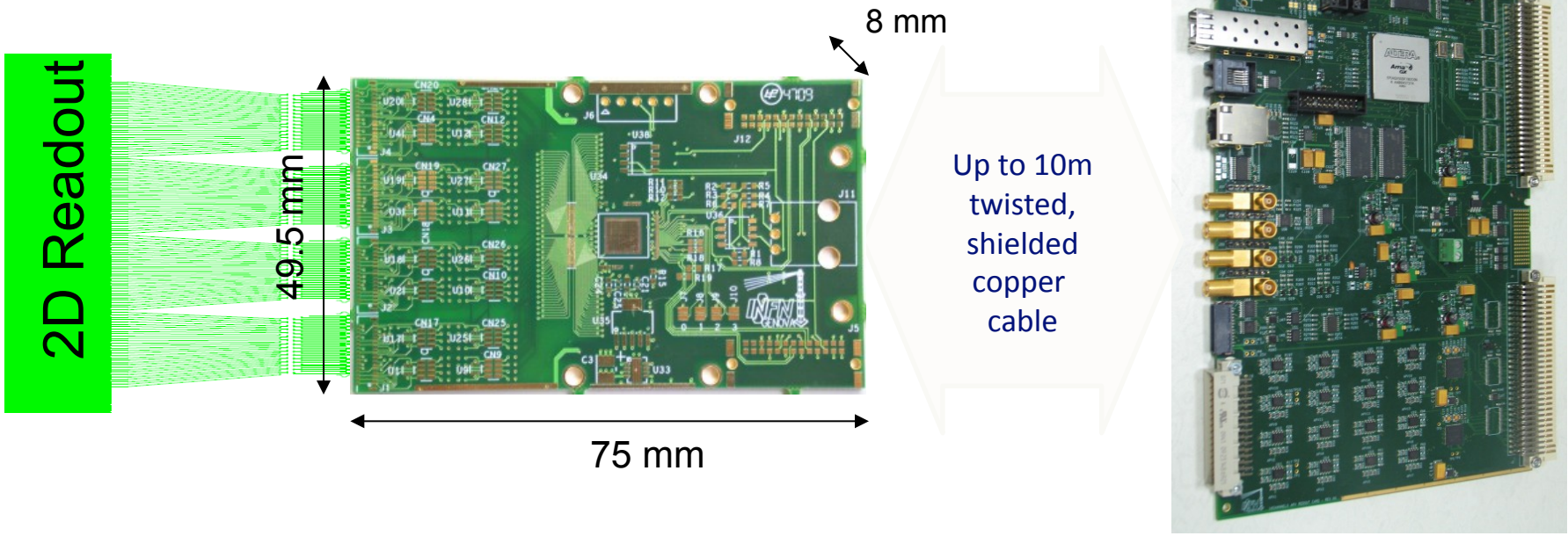
- Funding received under EIC detector R&D for a large prototype: ~ 100 cm x 40 cm section of a circle.
- Close to large chamber module sizes of SoLID
- Plan to fabricate this chamber in the spring.
- Can learn a great deal for SoLID GEMs from this
  - develop techniques for fabrication of large GEM modules.
  - study readout schemes: 10 degree stereo angle
  - Study issues of signal to noise ratio for long readout strips.

- Uva group now owns an APV25 system (2000 chan.) from the RD-51 Scalable Readout System (SRS) development.
- SRS system cost is lower; plus has the benefit of the large team effort backed by RD-51
- RD-51 plans to commercialize the fabrication; there will be the possibility to get very large systems in the future.



Electronics

- Uva is also getting another APV-25 based prototype readout system (2800 chan.) from the INFN group
- Some delays due to problems at the company fabricating the boards; hope to get soon



rough cost estimate

Item	Quantity	Unit cost	Total cost	Material only unit cost	Material only total cost
GEM foil	~100 m^2	\$2000/m^2	0.2 M	\$3000/m^2	0.2 M
readout boards	120	\$ 2500	0.3 M	\$ 2500	0.3 M
chamber support frame	120	\$ 1500	0.2 M	\$ 1500	0.2 M
Supplies and tooling			0.1 M		0.1 M
FEE and DAQ	200 k	\$ 3.0	0.6 M	\$ 3.0	0.6 M
cables, power, etc			0.5 M		0.5 M
Gas system			0.1 M		0.1 M
Labor: Technicians	12 FTE-years	\$ 80 k	1.0 M		-
Labor: Grad students	6 student-years	\$ 50 k	0.3 M		-
support structure and integration			???		???
TOTAL:			**~ 3.3 M**		**~ 2.0 M**
With 33% contingency			**~4.4 M**		**~2.7 M**

R&D and prototyping expenses: ~ \$ 150 k