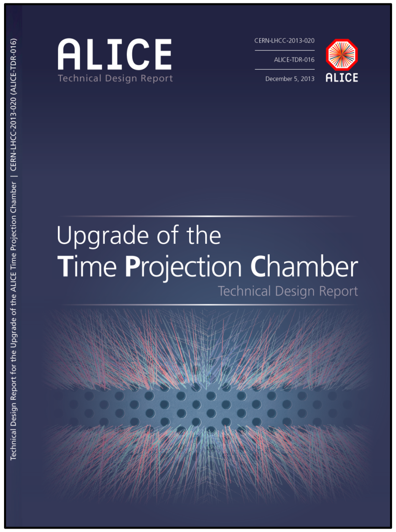
ALICE TPC upgrade
production planning

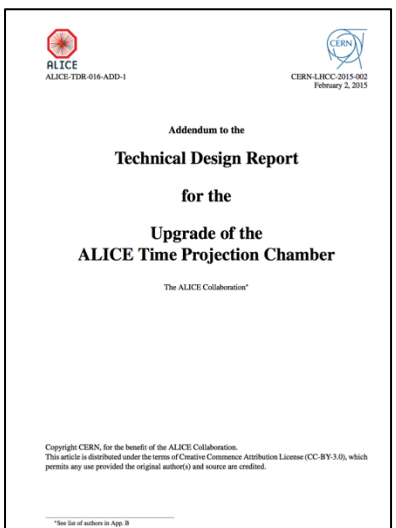
P.Gasik
(Technische Universität München)

15th RD51 Collaboration Meeting

TPC upgrade for RUN3



TDR


ALICE
ALICE-TDR-016-ADD-1

CERN-LHCC-2015-002
February 2, 2015

Addendum to the

Technical Design Report

for the

Upgrade of the
ALICE Time Projection Chamber

The ALICE Collaboration*

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*See list of authors in App. B

TDR Addendum

Accepted by LHCC !

Operate ALICE at high luminosity
($\mathcal{L}=6\times10^{27}$ $cm^{-2}s^{-1}$ for Pb-Pb)

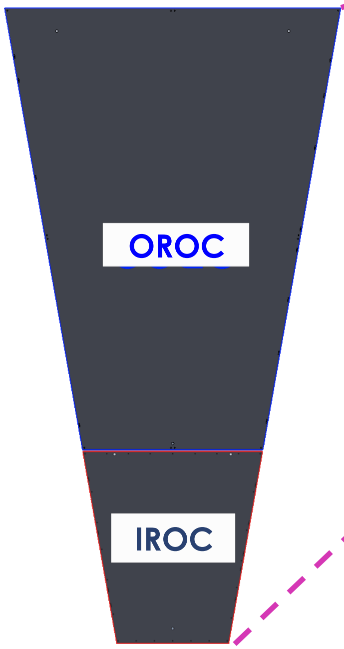
- Record all minimum bias events
  50 kHz Pb-Pb collisions (100× higher than present)
- Event pile-up in TPC: ~5 overlapping events
- **No gating** and **continuous readout** with GEMs

Requirements for GEM readout:

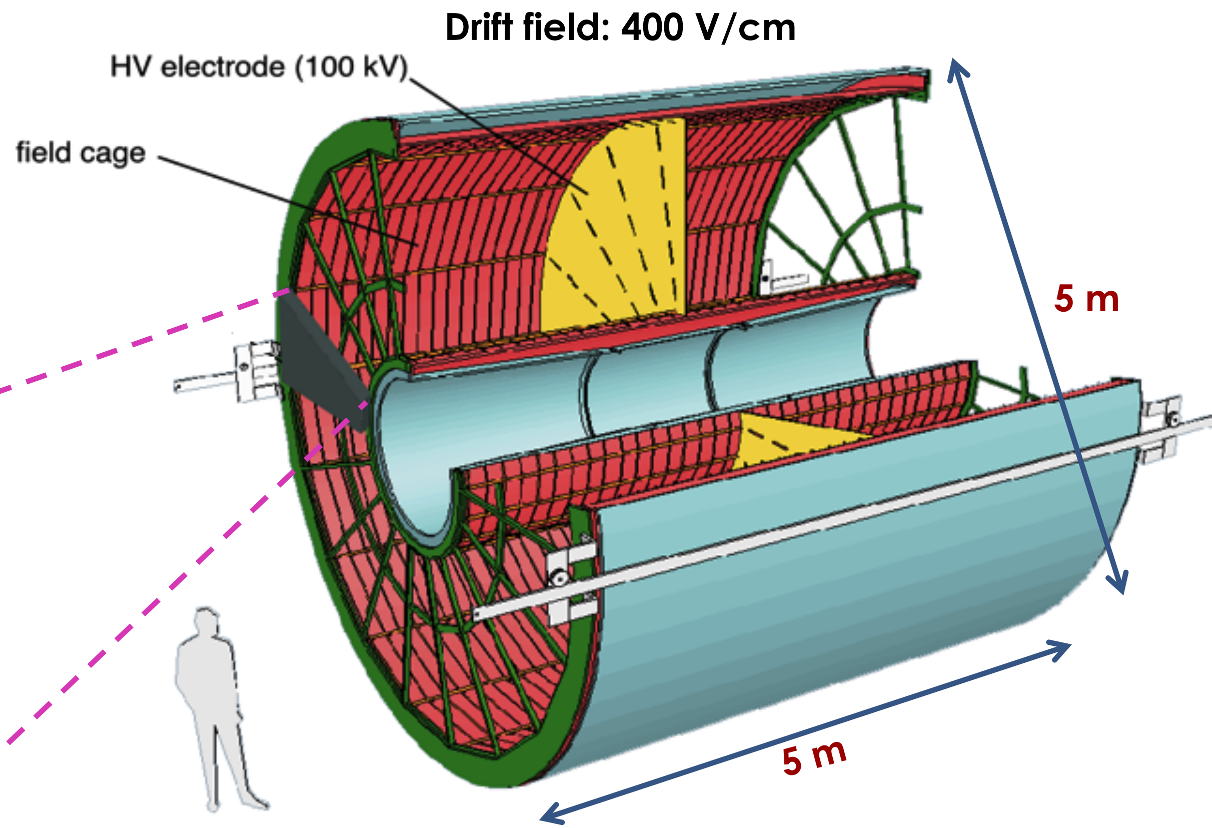
- Operate at the gain of 2000 in Ne-CO_2-N_2
- IBF < 1% at Gain = 2000 → ε = 20
- σ_E/E < 12% for ^{55}Fe
- Stable operation under LHC conditions
- + new electronics *(negative polarity, self-triggered)*
- + novel calibration and online reconstruction schemes
  (data compression by factor 20 and space charge distortions)

ALICE TPC

2 x 18
Outer **R**ead **O**ut **C**hambers

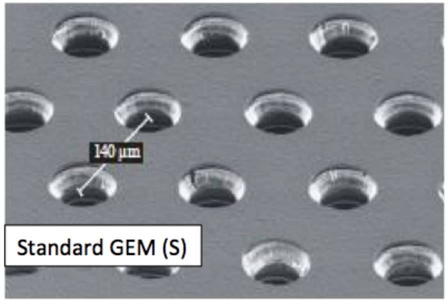


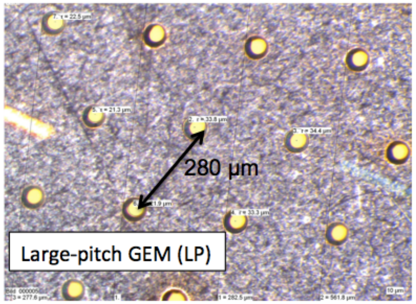
2 x 18
Inner **R**ead **O**ut **C**hambers

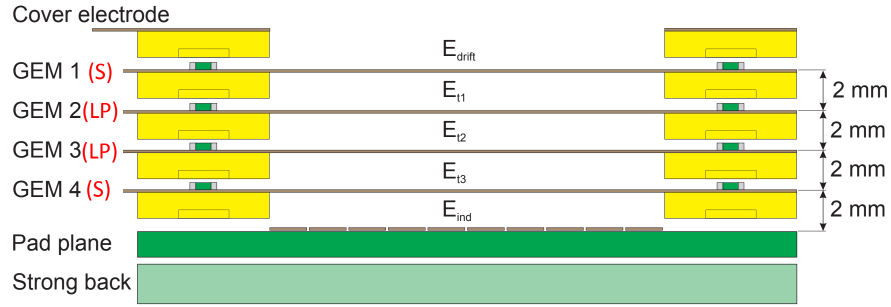


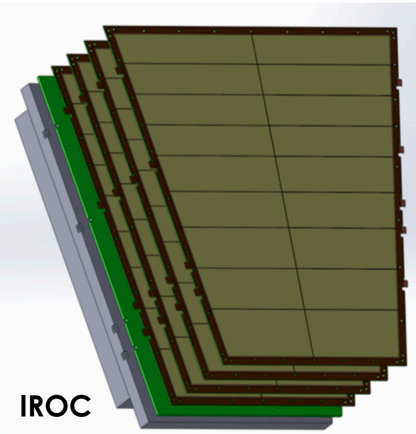
GAS:
~90 m^3
$Ne-CO_2-N_2$ (90-10-5) in RUN3
v_{drift} = 2.73 cm/μs (@ 400 V/cm)
Maximum drift time: ~92 μs

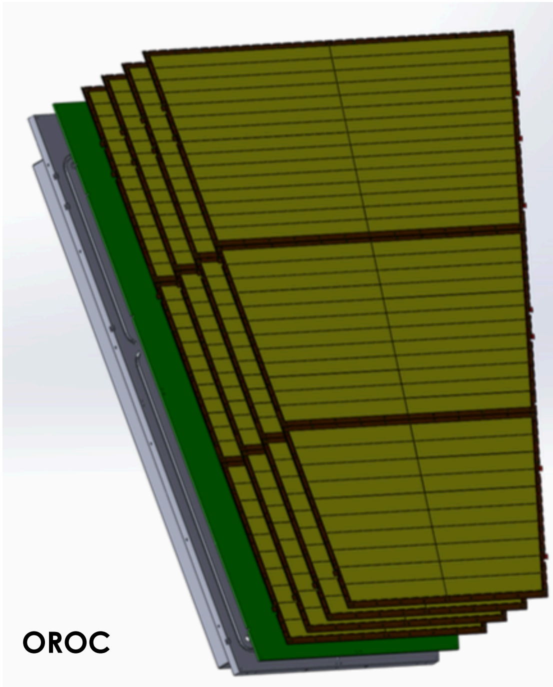
Baseline solution: 4GEM setup





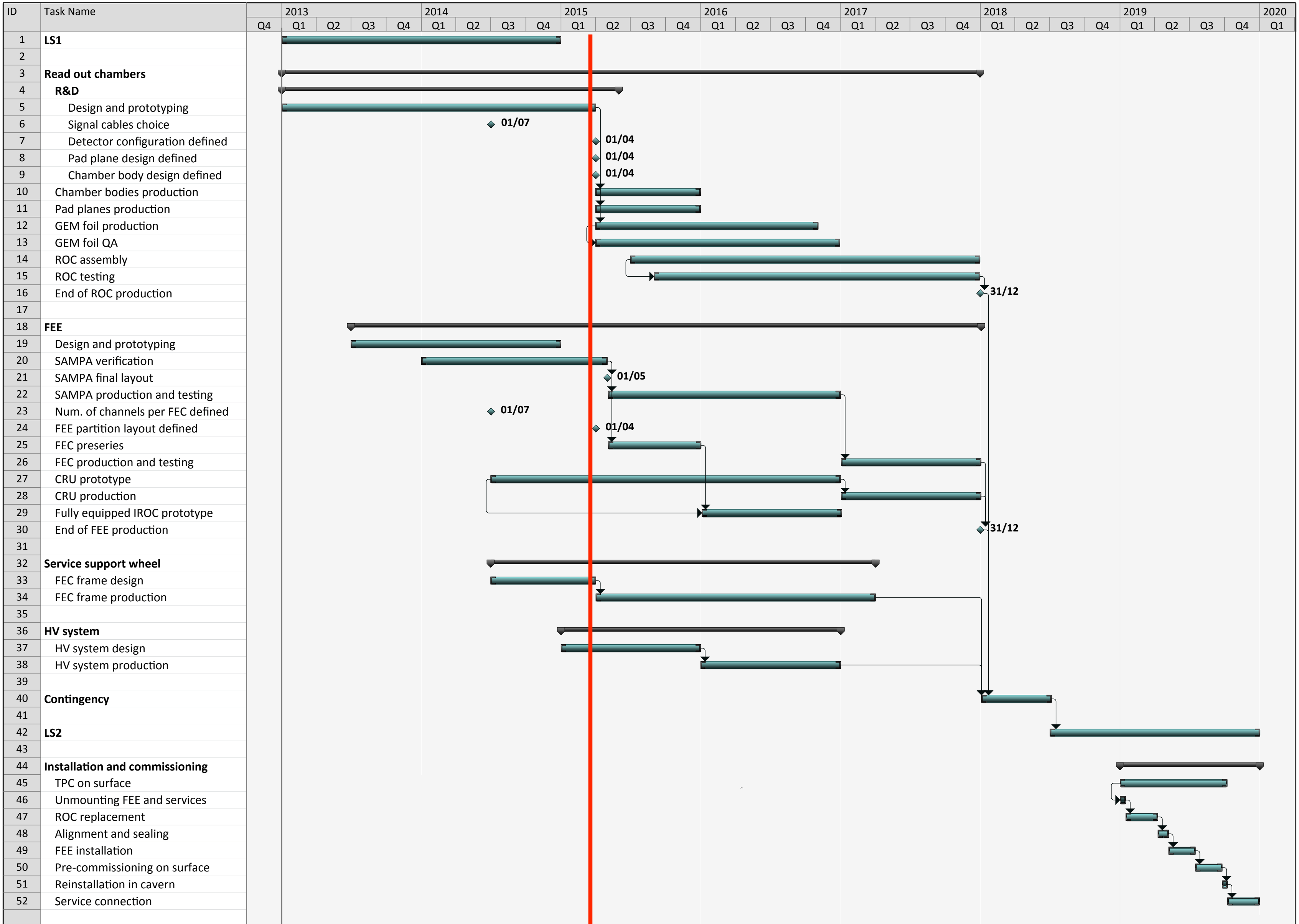






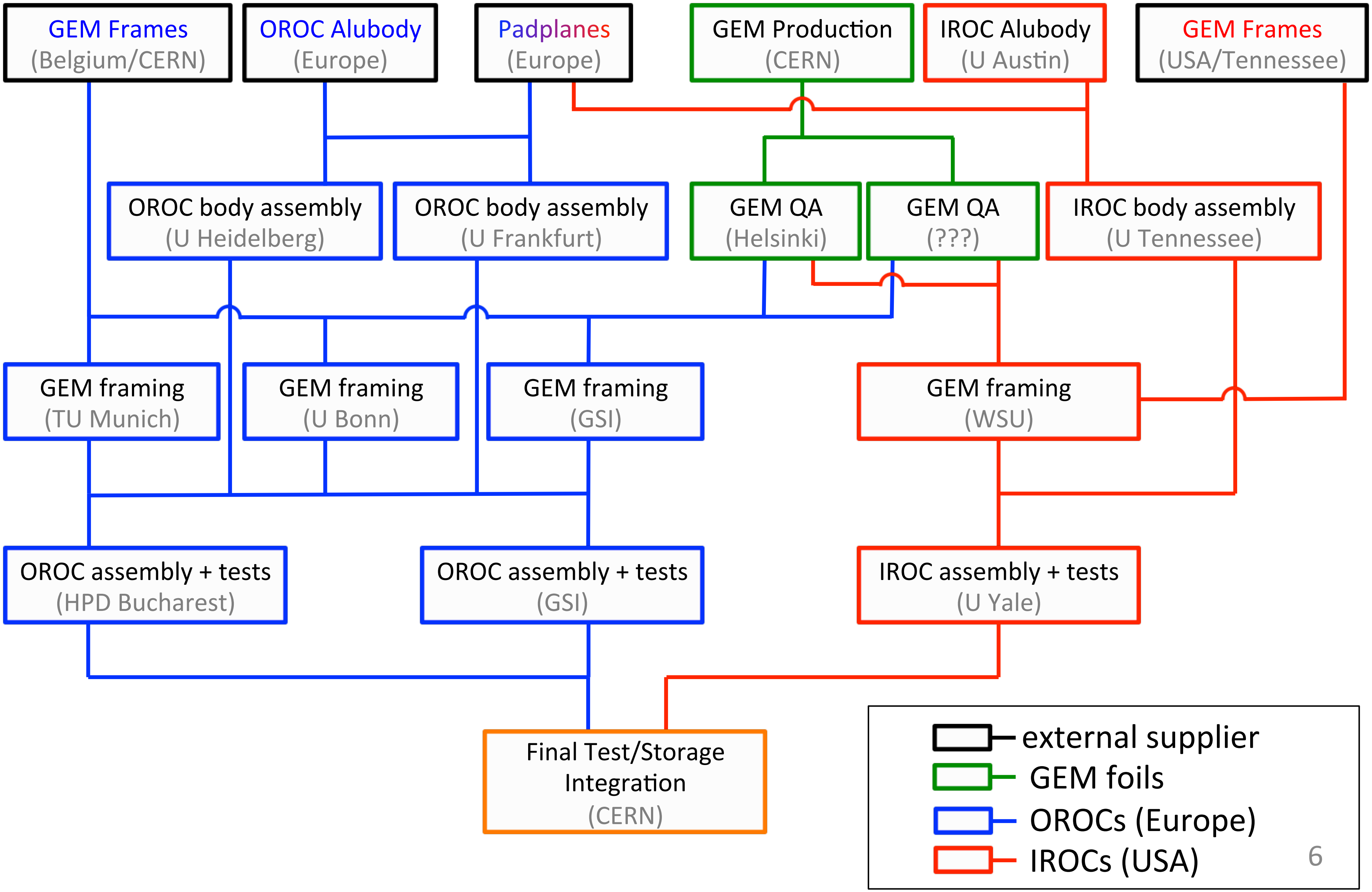
- **Gas mixture: Ne-CO_2-N_2 (90-10-5)**
  - **Gain: 2000**
- **Baseline solution performance:**
  - **IBF = 0.6 %**
  - **σ_E/E < 12 %** for 5.9 keV (^{55}Fe)
  - **d*E*/dx evaluation at PS**
    - 1-3 GeV/c e^- and π^-
    - $S_{e-\pi} \approx 4.5$
    - Relative energy res.: 9.1 % (e^-), 10.4 % (π^-)
  - **Discharge probability**
    - < 1.5×10^{-10} with alphas
    - $(6.4\pm3.7)\times10^{-12}$ with hadrons (SPS)

Timeline (TDR)



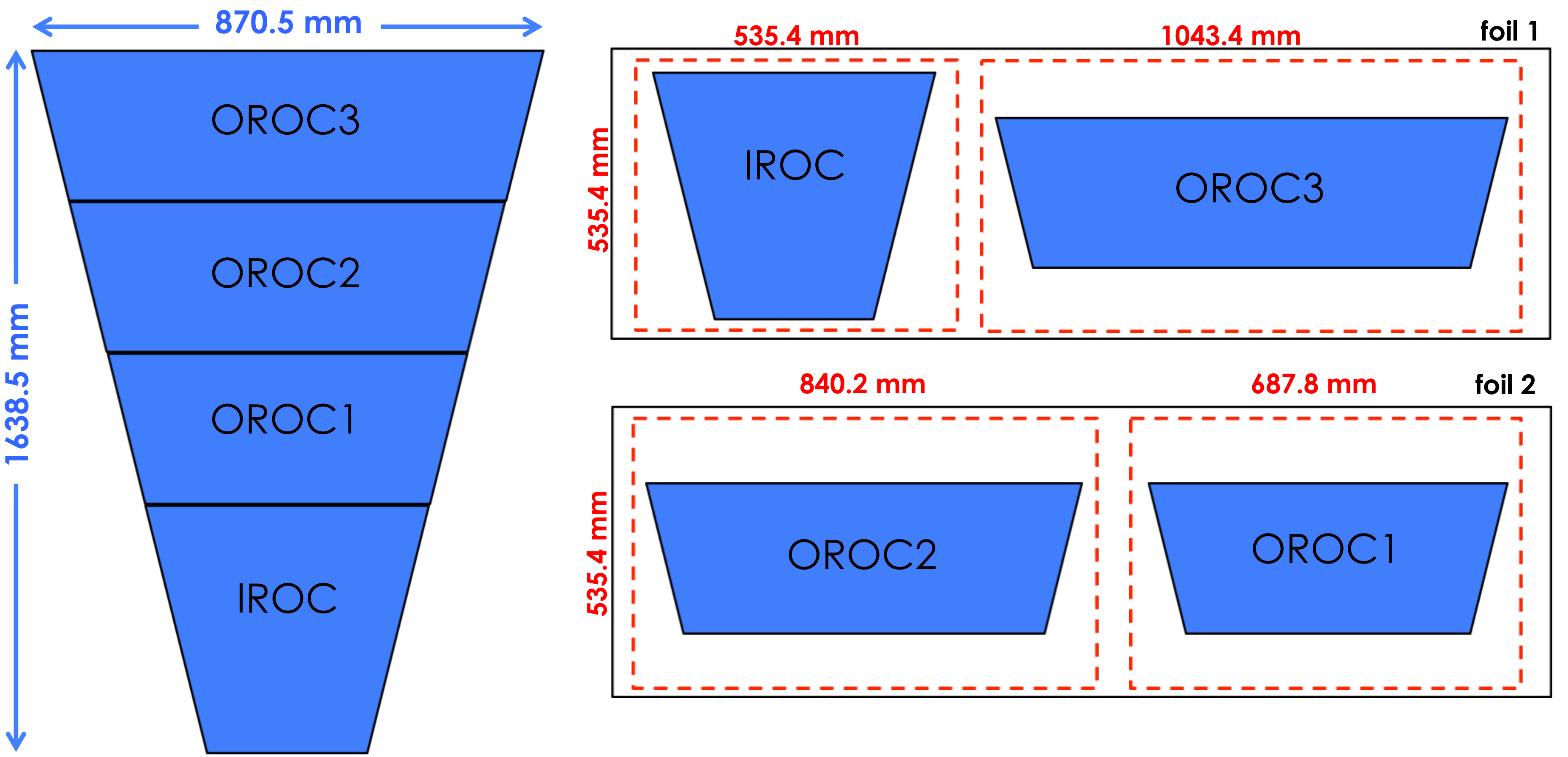
RD51, 18.03.2015

Read-Out Chamber material flow



GEM production

GEM production



- 144 GEMs of each type + 25…50% spares
- **720 GEMs** (125%) = **180 × "foil 1"** + **180 × "foil 2"**
- Different foil flavors: S, LP, 90° rotated, not-rotated

GEM production at CERN

Collaboration Agreement between PH-DT & ALICE for the production of GEM foils for the ALICE TPC Upgrade

- Production rate: 18 foils (foil1 + foil2) per month = **36 GEMs/month**

	2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GEM Production	WP Preparation	Training and preproduction	Production	Production	Production	Production	Production	Production	Production (125%)	Production (150%)	*Possible delay*	*Possible delay*

QUALITY ASSURANCE

Quality Assurance

- **Basic** – directly at CERN + at each assembly institute
  - Coarse optical check
  - HV cleaning
  - Leakage current

- **Advanced**
  - HV test (long-term)
  - HD scan
  - Gain uniformity

Quality Assurance

- **Basic** – directly at CERN + at each assembly institute
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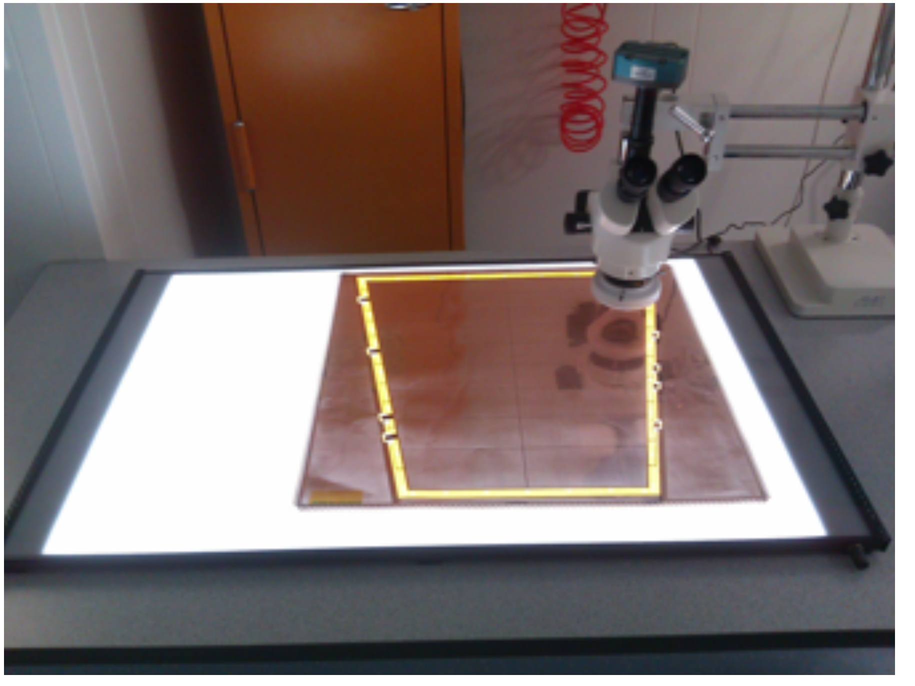

✓ *Search for fatal defects*

✓ *Spot larger defects*

Quality Assurance

- **Basic** – directly at CERN + at each assembly institute
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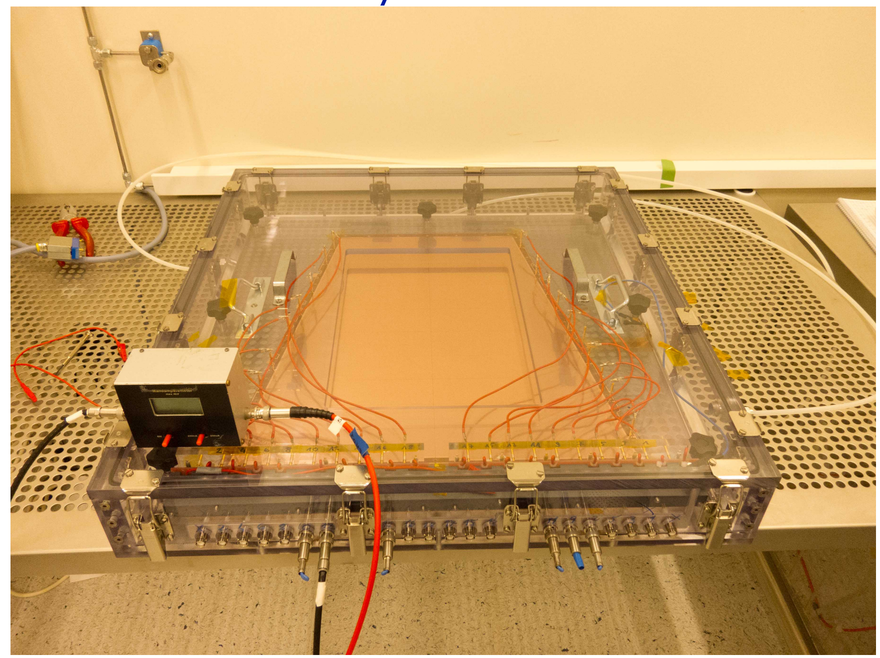

✓ *Apply HV (550 - 600 V)*

✓ *Burn dust with discharges*

- *measure sparking rate*
- *watch out sparks position*

Quality Assurance

- **Basic** – directly at CERN + at each assembly institute
  - Coarse optical check
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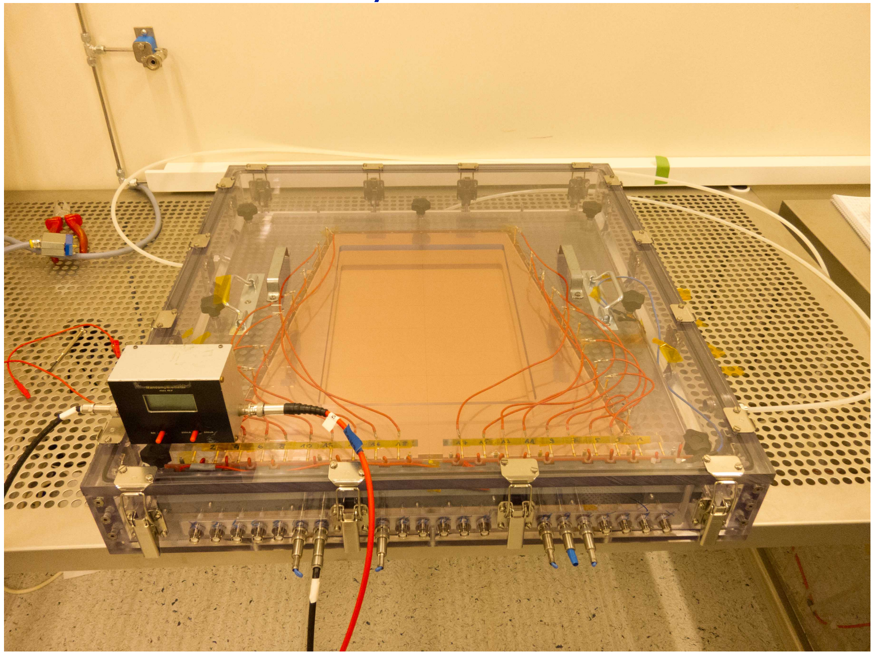


✓ *Apply HV (550 - 600 V)*

✓ *Burn dust with discharges*

- *measure sparking rate*
- *watch out sparks position*

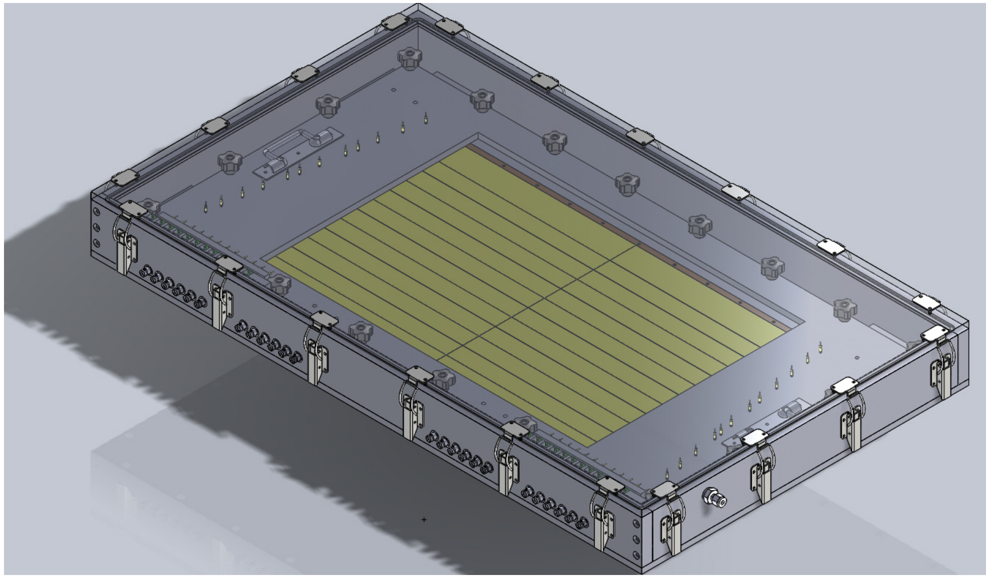
✓ *Measure I_{leak}*

- *I_{leak} < 0.5 nA/100 cm^2*

Quality Assurance

- **Basic**
  - Coarse optical check
  - HV cleaning
  - Leakage current

- **Advanced** – 2 sites
  - HV test (long-term)
  - HD scan
  - Gain uniformity



✓ *Sparking rate and I_{leak} measurements*

✓ *Dry environment*

✓ *Long-term (~hours)*

✓ *Automatisation*

- *R&D still ongoing (Helsinki, Bonn)*

Quality Assurance

- **Basic**
  - Coarse optical check
  - HV cleaning
  - Leakage current

- **Advanced** – 2 sites
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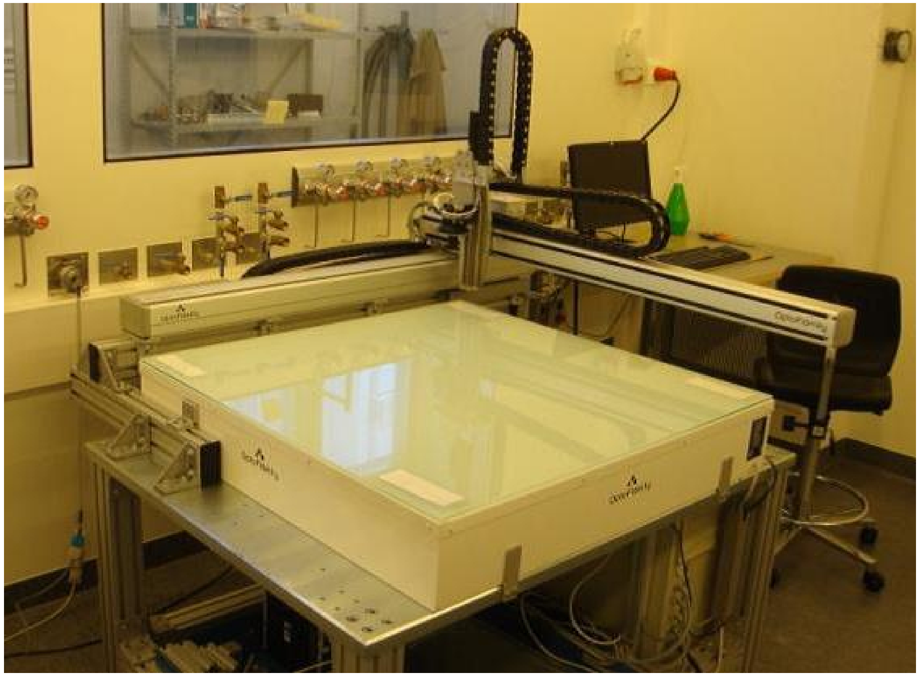
  - HD scan
  - Gain uniformity



✓ *High resolution scanning (2.5 μm)*

✓ *Defects detection*

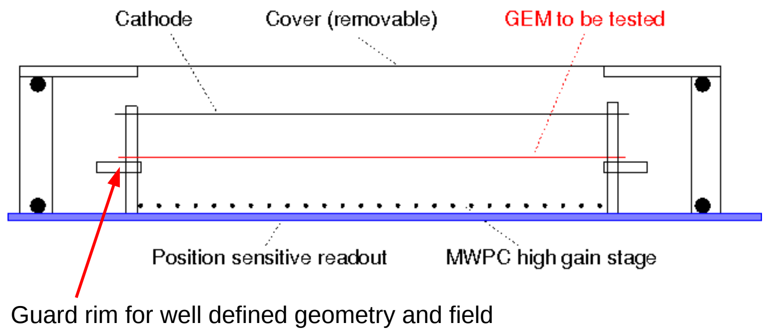
✓ *Hole diameter measurements*

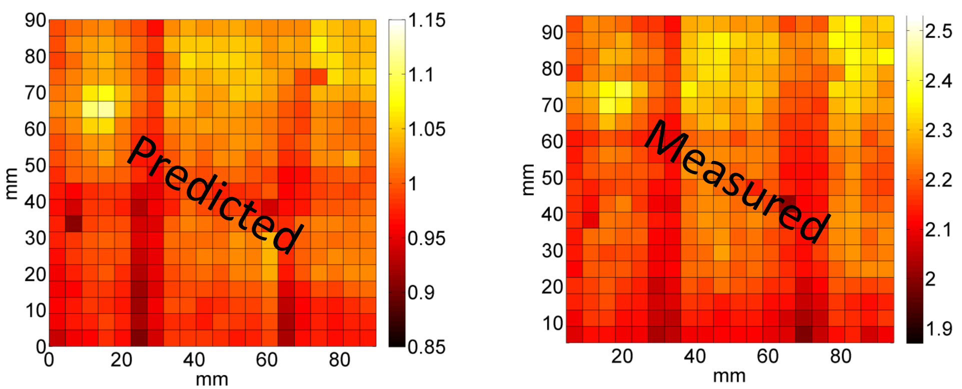
✓ *Gain uniformity predictions*

- *R&D still ongoing (Helsinki, Budapest)*

Quality Assurance

- **Basic**
  - Coarse optical check
  - HV cleaning
  - Leakage current
- **Advanced** – 2 sites
  - HV test (long-term)
  - HD scan
  - Gain uniformity



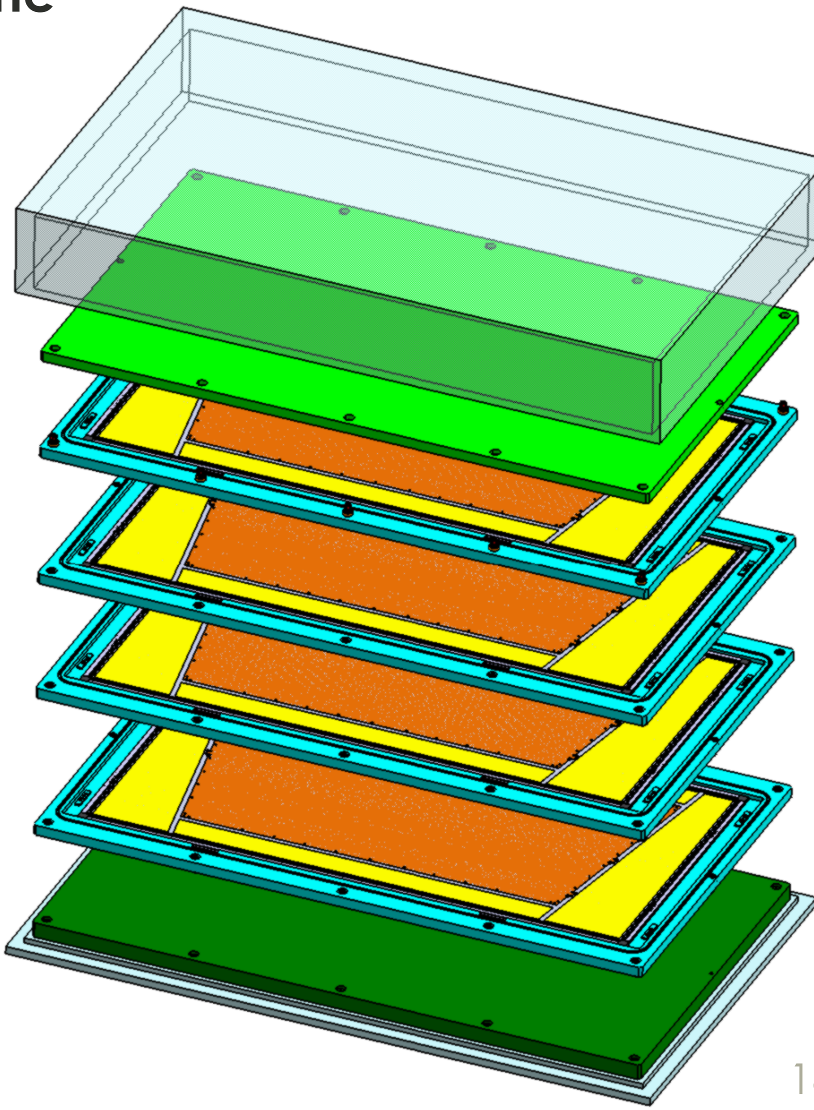


NIM A 770 (2015)113

- ✓ *Gain measurement of a single GEM*
- ✓ *Prediction from the HD scanning*
- ✓ *Possibility to skip this step, or to test single foils from a new batch*
- ✓ *R&D is ongoing (Helsinki, Budapest)*

Transportation

- **Transport Box + GEM support frame** *(Uni Heidelberg)*
  - Raw GEMs
  - Framed GEMs
  - GEM stacks
  - Possibility to flush with gas

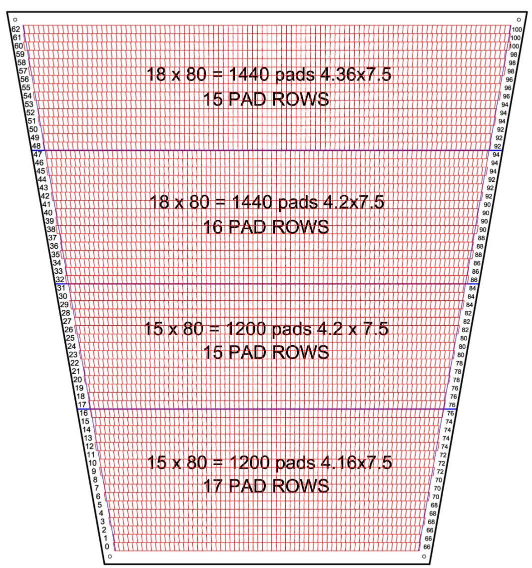


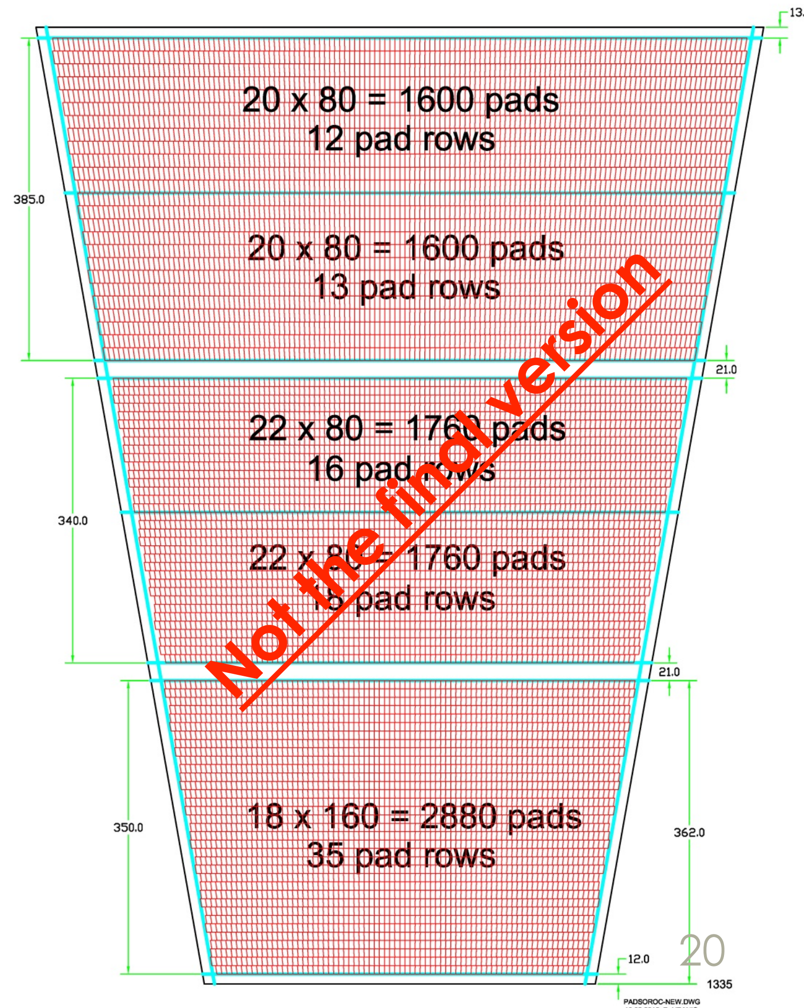
Readout Chambers

Alubodies and padplanes

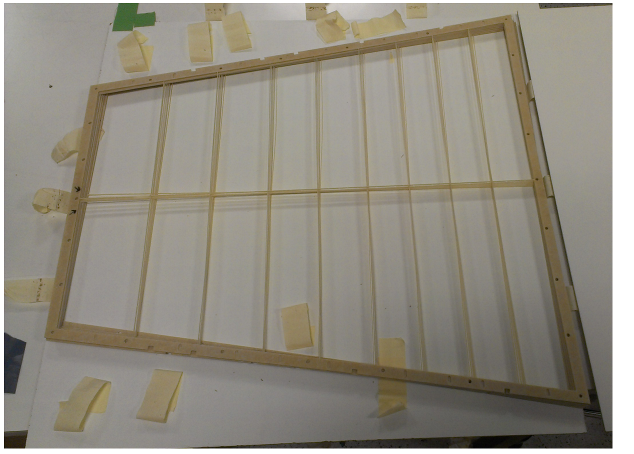
(Uni Heielberg, Uni Frankfurt)

- **40 OROCs and 40 IROCs will be produced**
  - OROC bodies→ Europe
  - IROC bodies → US
  - Padplanes → Europe
- **Alubody and Padplane design ongoing** *(Uni Heidelberg)*
- **FEE connectors chosen:** ERNI SMC 1.27 mm 40 pin
- **Assembly in HD+FRA**
  - **2-3 chambers/month**





GEM frames



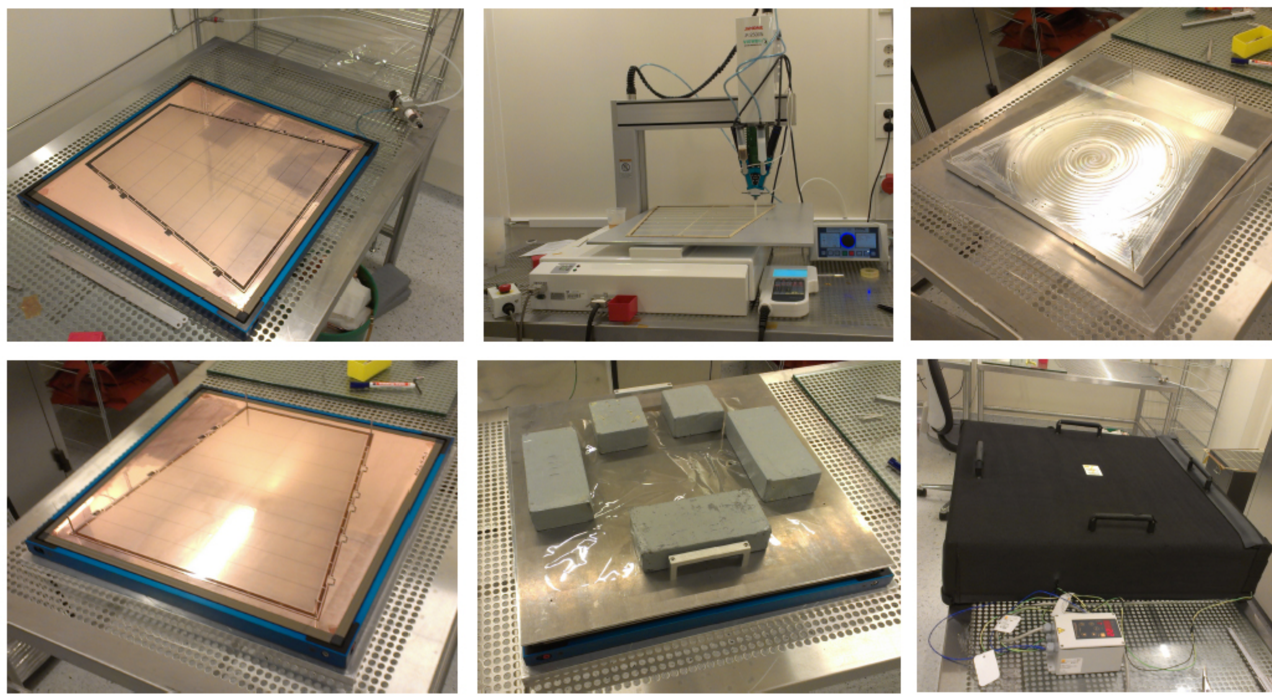
- **GEM supporting frames:**
  - Permaglas
  - Material: Resarm Belgium
  - Machining (currently): PCB Workshop CERN (IROC), Resarm (OROC)
  - Price defined by material losses and precise machining (400μm grid)

- **Checking the possibility of producing frames from single pieces**
  - Spacer grid: **needed at all? differnet material?**
  - Frames assembled at CERN or HD
  - Covering with PU, final polishing can be done at CERN(?)
  - Substantial cost reduction

GEM Framing

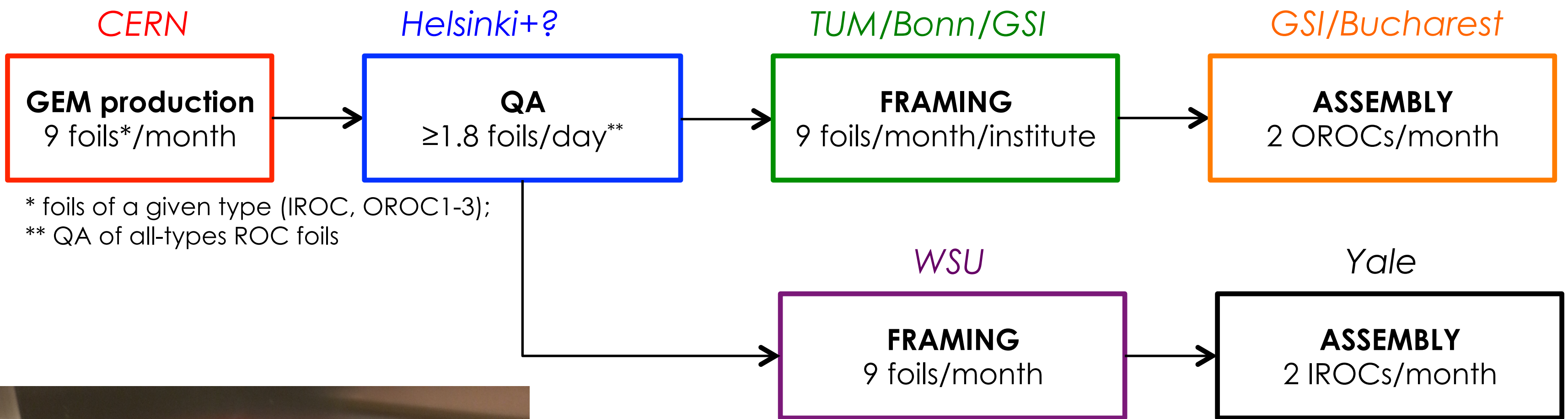
*(**OROC**: TUM, Uni Bonn, GSI; **IROC**: Wayne State University)*

- **Basic QA**
  - Check foils after transportation
  - Large defects + HV cleaning
- **Framing**
  - Stretching
  - Gluing
- **HV cleaning**
- **Soldering SMD resistors**

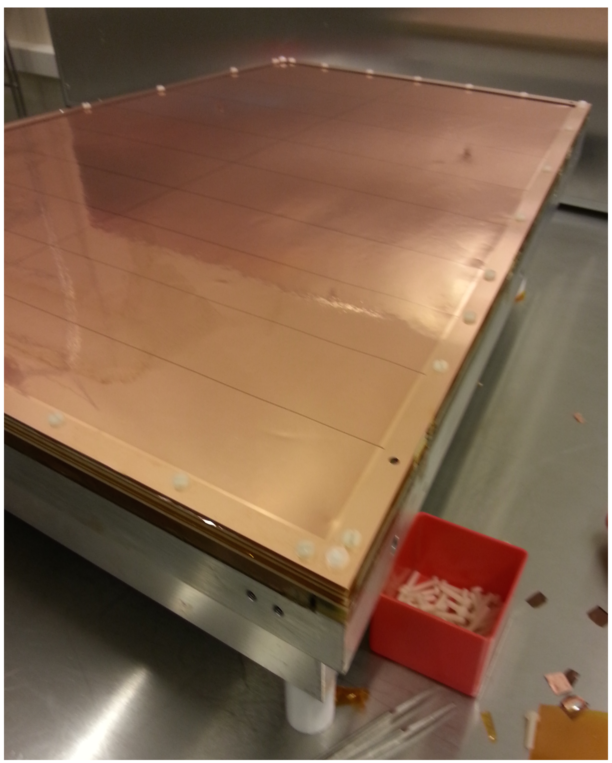


IROC GEM framing for the prototype

ROC assembly

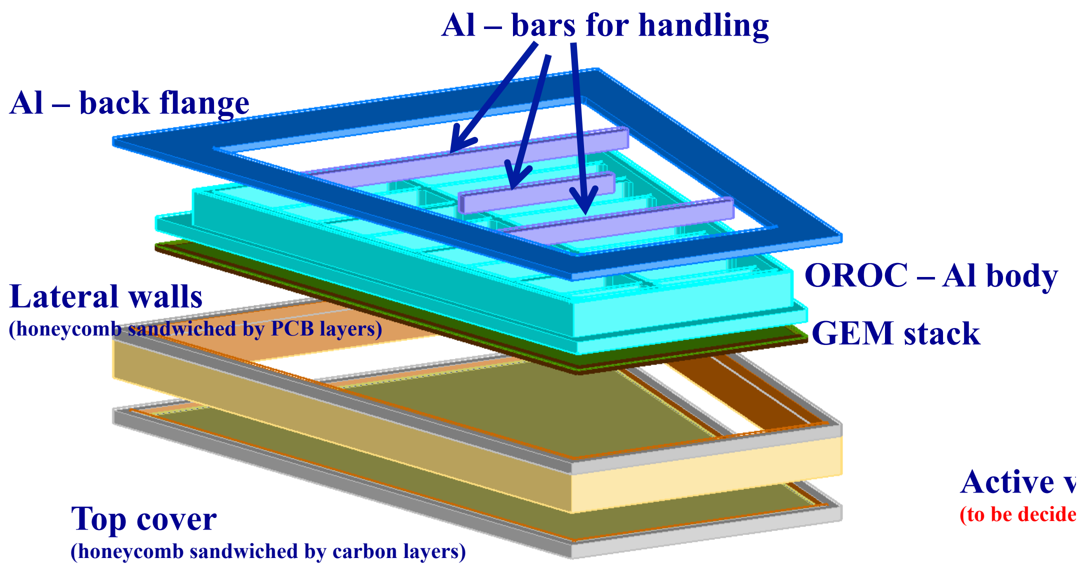


* foils of a given type (IROC, OROC1-3);
** QA of all-types ROC foils



- Stacks (4-GEM) are screwed to the alubody using rigid, plastic screws
- GEM1 flipped (unsegmented side facing drift electrode) to assure drift field uniformity

ROC commissioning



(HPD Bucharest)

- Gas tightness
- Gain curve with ^{55}Fe
- Long term (~days) HV test
  - ^{55}Fe resolution
  - gain uniformity
  - stability with internal alpha source

- Full irradiation at GIF (CERN)
  - to be evaluated with the preprodcution chambers

Data documentation and storage

- Database prepared by P. Glaessel
- Test version available
- Prepared for the OROC prototype assembly

ALICE TPC production database logged in: Piotr

Table 'parts'

Piotr has no privileges to edit this table

part	description	perType	types	serialprefix	auth	new
chamber body		1	iroc oroc	body		2014-11-30
padplane		1	iroc oroc	pad		2014-11-30
strongback		1	iroc oroc	strong		2014-11-30
GEM foil	individual foil	4	iroc o1 o2 o3 o4	gem	Peter	2015-02-16
GEM stack		1	iroc oroc	stack	Peter	2015-02-16
chamber	complete chamber	36	iroc oroc	ch	Peter	2015-02-16
pad plane section	OROC pad plane sections	1	inner mid outer	padsect	Peter	2015-02-16
ALICE_G_14_02_02_200mu_S	test case for DB	1	iroc	G_14_02_02_200mu_S	Peter	2015-02-22
Test GEM		1	none	gem0	Peter	2015-02-25
new						

parts | types | stock | show all actions

Timelines

	2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
GEM Production	Prep.	Train. Preprod.	Prod.	Prod.	Prod.	Prod.	Prod.	Prod.	Prod. (125%)	Prod. (150%)	BKP	BKP
Basic QA		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Advanced QA		✓	/ ✓	✓	✓	✓	✓	✓	✓	✓	✓ / ✓	✓
ROC bodies		✓	✓		✓	✓	✓	✓	✓	(✓)	(✓) / ✓	✓
Framing		✓	✓ / ✓	✓	✓	✓	✓	✓	✓	✓	✓ / ✓	✓

- **March/April –** building the first OROC prototype at TUM+CERN
  - People from all of the institutes involved in the GEM QA, IROC and OROC production will join the effort
  - TUM: QA, framing, discussion on the procedures, tooling and design
  - CERN: OROC assembly
  - Finalize the design
- **May – August** – preproduction of 2 OROCs
  - Test all the procedures, transportation, assembly
  - Last changes to the final design possible

High Voltage

Power Supply for the upgraded TPC

- **Several Power Supplies systems are considered**
  - Passive Resistor Chain
  - GEM Active Voltage Divider *(RD51-SRS development)*
  - Cascaded power supply by ISEG
    - Prototype ordered (available by mid 2015)
  - Cascaded power supply by CAEN
    - Prototype available in Apr/May 2015
- HV supply tests and simulations

Other HV equipment

- **Current meters**
  - High frequency current measurements at **GEM4B** for the space charge map
  - Sampling freq. ~500 Hz; Part of DAQ (not DCS)
  - Current resolution ~1 nA; Max current <100 uA
  - Number of channels: 144
  - **Status**
    - Prototypes by UNAM (Mexico City)
    - Implementation to the DAQ stream
- **HV cabling**
  - Searching for a new type of cables (4 kV rating) and connectors
  - Implementation: *patch boxes/cables/HV distribution/current meters*

Installation

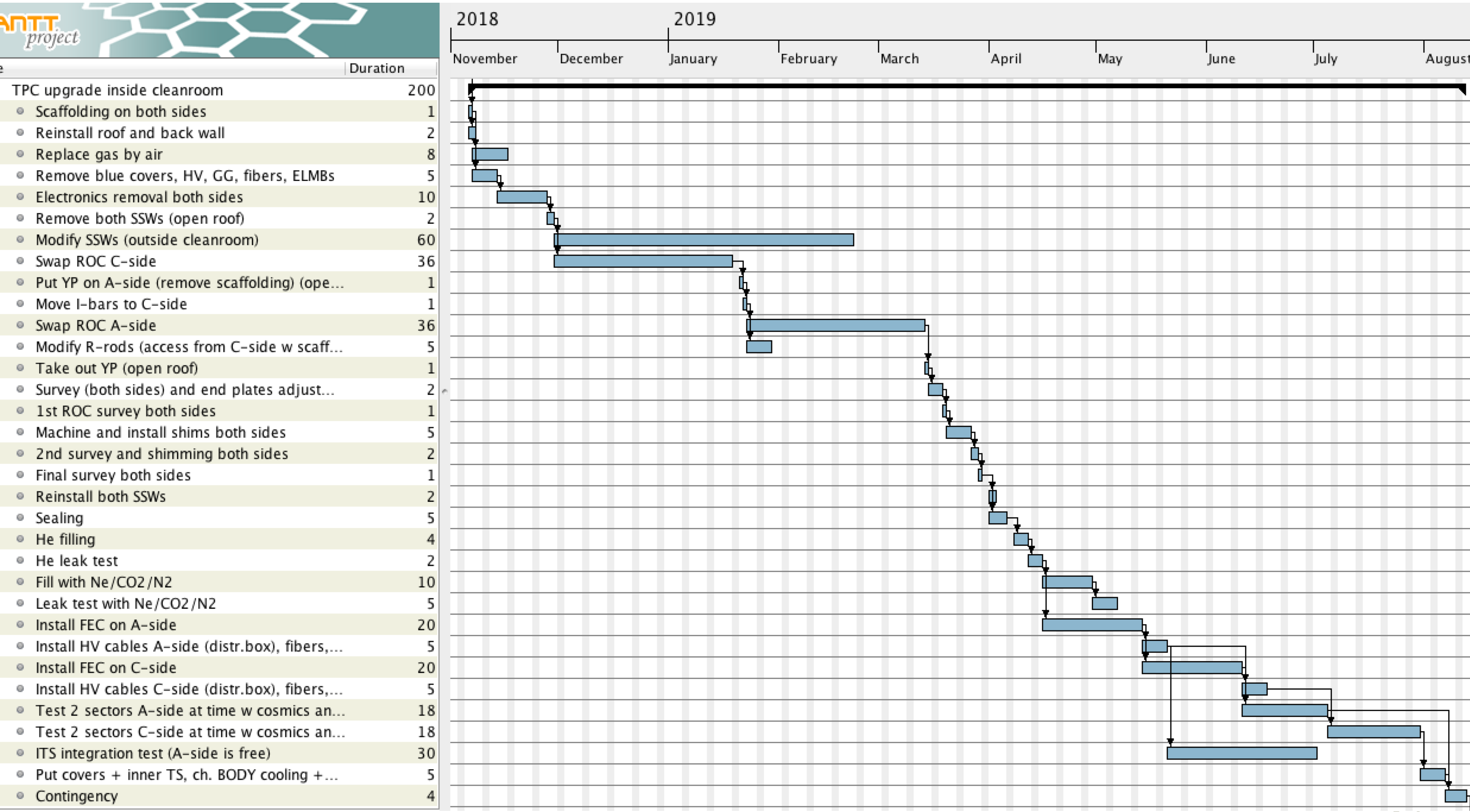
LS2
(07.2018-12.2019)

- TPC in the cleanroom: Nov. 2018
- ROC swapping: start December 2018

- **In case of delay, last chambers may be produced until mid of 2018**

Installation

TPC upgrade in a cleanroom, during 40 weeks of LS2



by A. Tauro

Summary

ALICE-TDR-016-ADD-2

CERN-LHCC-2015-???
February 22, 2015

Addendum to the

Technical Design Report

for the

Upgrade of the ALICE Time Projection Chamber

(Project Organisation, Cost Estimate and Schedule)

The ALICE Collaboration*

*See list of authors in App. ??

Backup

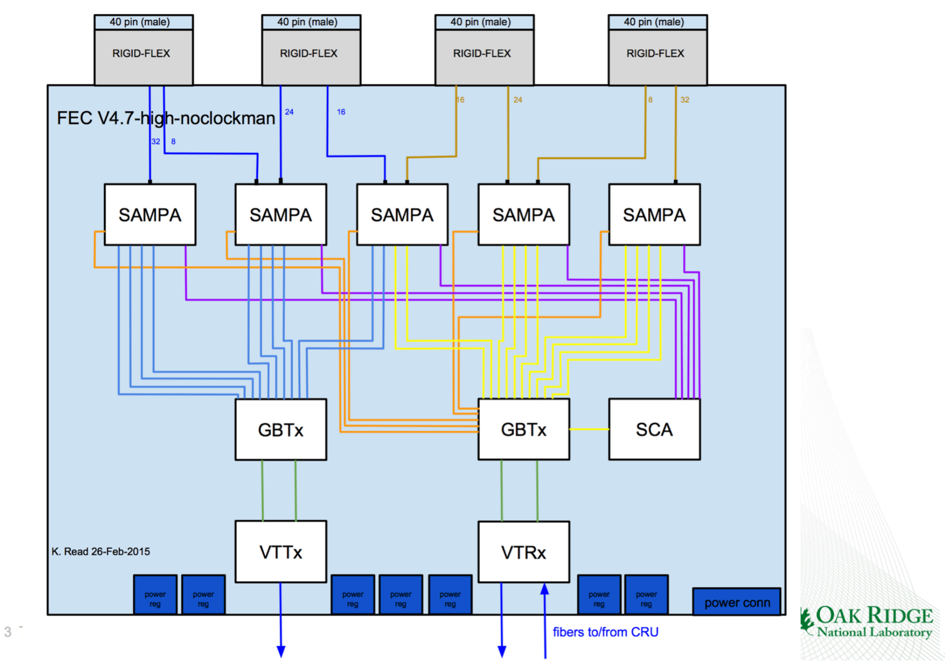
FEE

Involved institutes

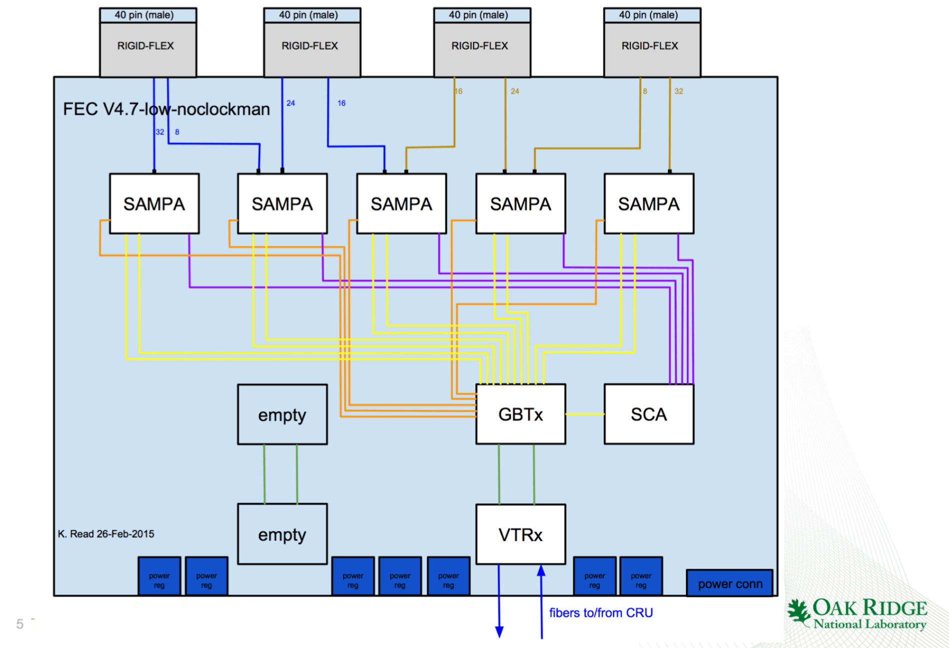
- **ORNL and UT-K, Houston**
  - FEC design, production and testing
  - SAMPA MPW2 test board
  - GBT evaluation board
- **Lund**
  - FEC testing
- **Sao Paulo**
  - SAMPA
- **Norway (Bergen, Oslo)**
  - SAMPA Radiation tests
  - SAMPA MPW1 tests
  - SAMPA MPW2 test board
  - GBT evaluation board

Front End Card

FEC Conceptual Drawing



FEC Conceptual Drawing



- Concept based on 2 FEC versions for high and low occupancy regions

LEGEND

For IROC1, IROC2, OROC1, and OROC2: 4 SAMPA Elinks, 8 TPC ch/Elink, install left GBTx, install left VTTx, install left fiber

blue = SAMPA data out to left GBT receiver at 320 Mbit/s
yellow = SAMPA data out to right GBT receiver at 320 Mbit/s
orange = SAMPA 320 MHz clock in from right GBT transmitter at 320 Mbit/s
NOT SHOWN: 20 similar orange differential SLVS lines: SAMPA trigger in (80 Mbps), heartbeat in (80 Mbps), sync in (160 Mbps), reset in (320 Mbps) from right GBT transmitter
purple = I^2C bus (five)
protection diodes on all input TPC channels
Power regulator, 1.2 V, 3 A: Micrel MIC69302WU

K. Read, ORNL

Readout System

Involved institutes

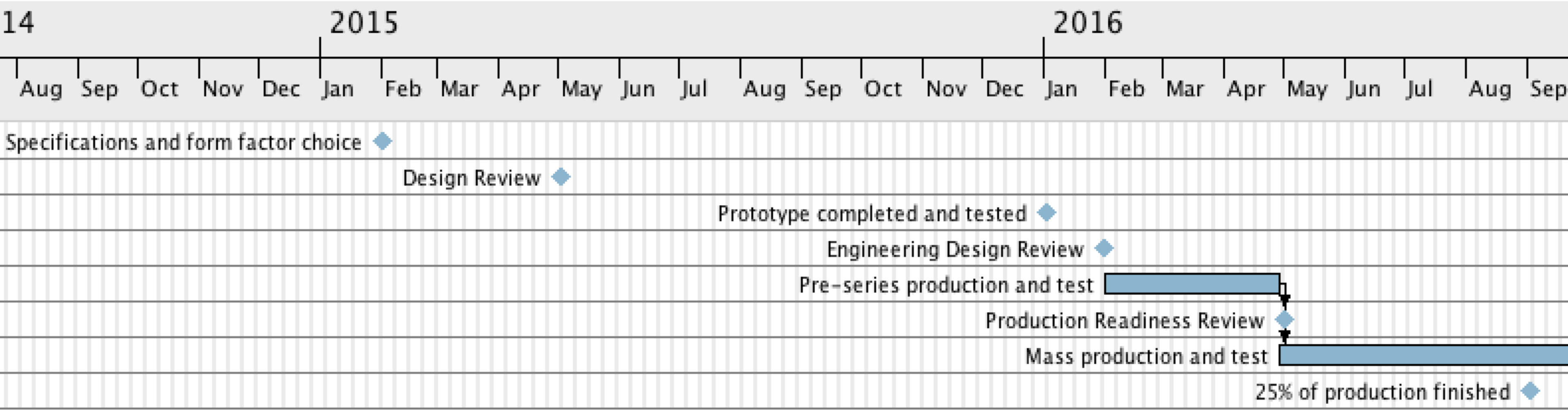
- **CRU team (Budapest and India)**
  (part of the "Electronics,Readout and Trigger Systems" project)
  - Hardware design
  - Common firmware design
- **NIAS (Japan)**
  - TPC specific concept
  - TPC firmware design
- **Norway**
  - Read-out simulations
  - TPC firmware development

Read-Out

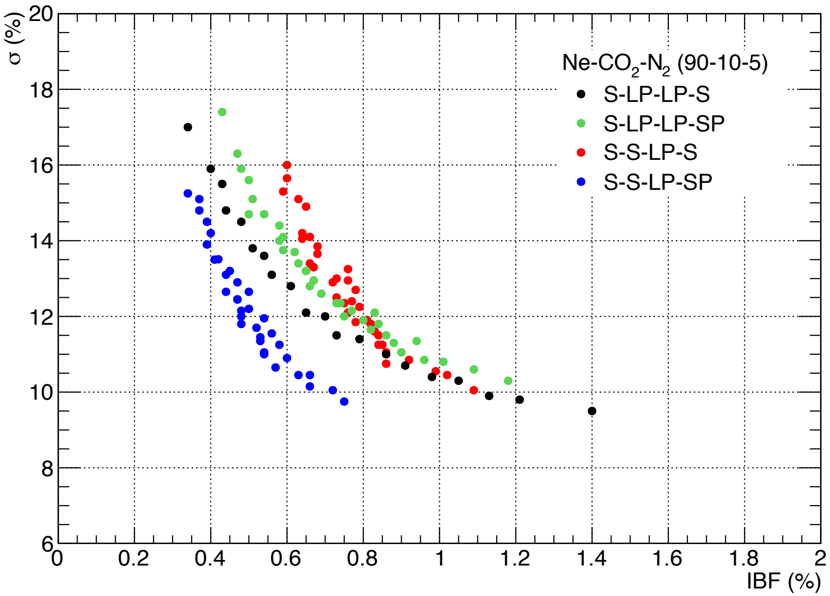
- **1/2015 Specifications and form factor choice**
- 4/2015 Design Review
- 12/2015 Prototype completed and tested

- 1/2016 Engineering Design Review
- 4/2016 Pre-series production finished and tested + PRR
- 8/2016 25% of production finished

- 4/2017 Production and test finished



Small Detectors – IBF



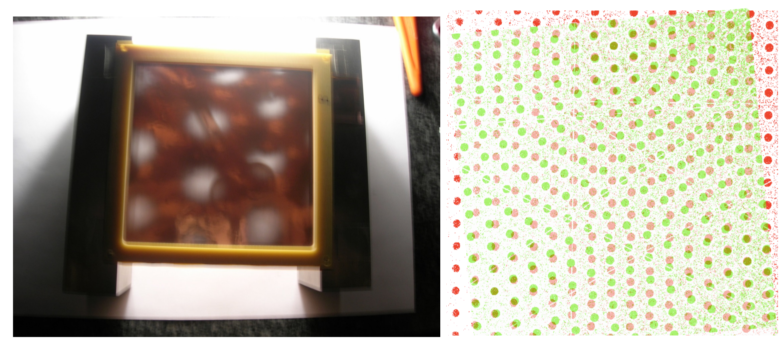


Figure 3.5: Left: Optical transparency of two standard GEM foils. Right: Illustration of the interference pattern that occurs when the foils are slightly rotated.

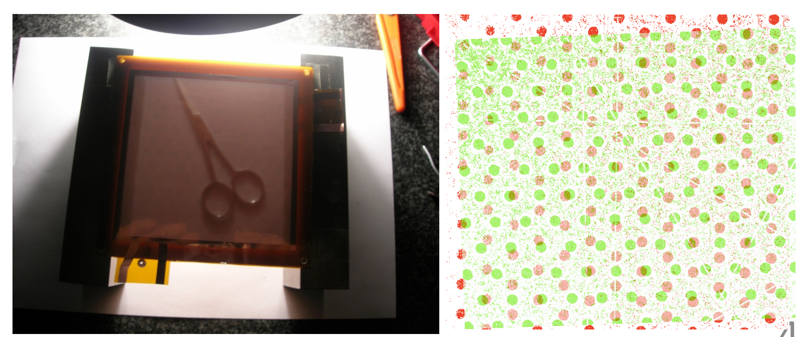
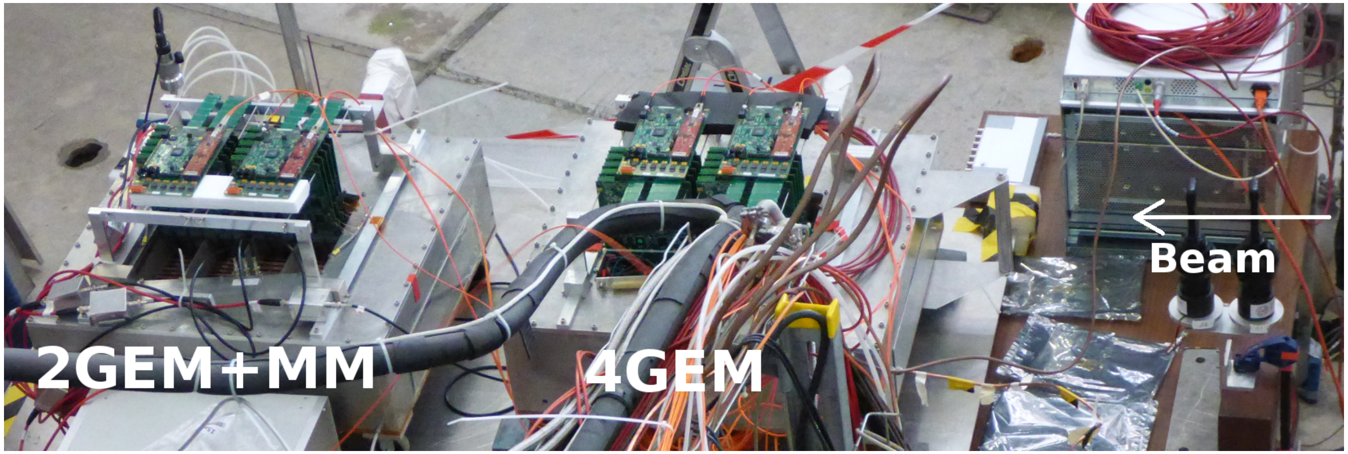


Figure 3.6: Left: Optical transparency of two standard GEM foils after rotation of one foil by 90°. Right: Illustration of the randomization of the relative hole positions.

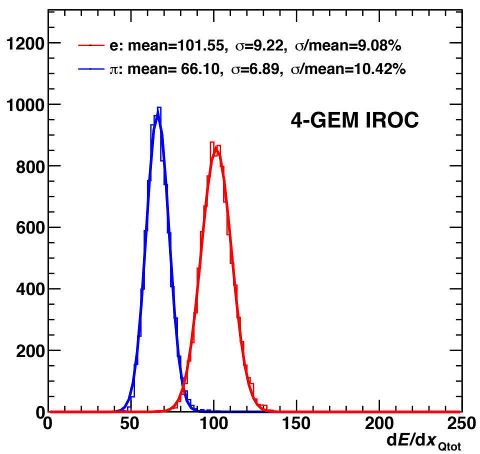
Small Detectors – discharges

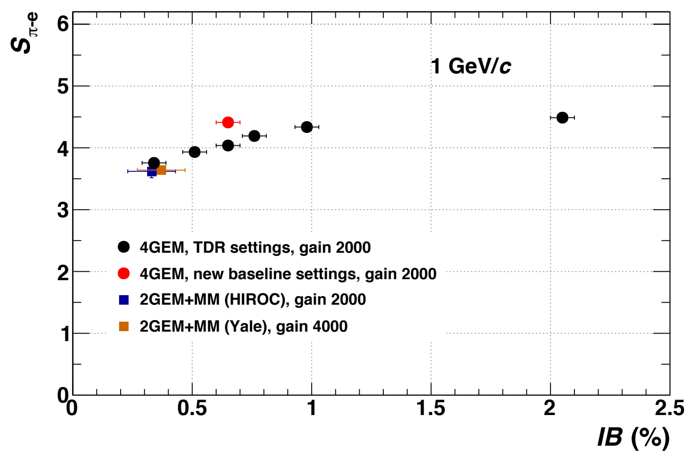
	S-S-S 'standard' HV G = 2000	**S-S-S-S** *IB* = 2.0% G = 2000	**S-LP-LP-S** *IB* = 0.34% G = 1600	*IB* = 0.34% G = 3000	*IB* = 0.34% G = 5000	*IB* = 0.63% G = 2000
^{220}Rn E_α = 6.4 MeV rate = 0.2 Hz	$\sim 10^{-10}$			$< 2\times10^{-6}$	$< 7.6\times10^{-7}$	
^{241}Am E_α = 5.5 MeV rate = 11 kHz						$< 1.5\times10^{-10}$
^{239}Pu+^{241}Am+^{244}Cm E_α = 5.2+5.5+5.8 MeV rate = 600 Hz		$< 2.7\times10^{-9}$	$< 2.3\times10^{-9}$	$(3.1\pm0.8)\times10^{-8}$		$< 3.1\times10^{-9}$
^{90}Sr $E_\beta < 2.3$ MeV rate = 60 kHz					$< 3\times10^{-12}$	

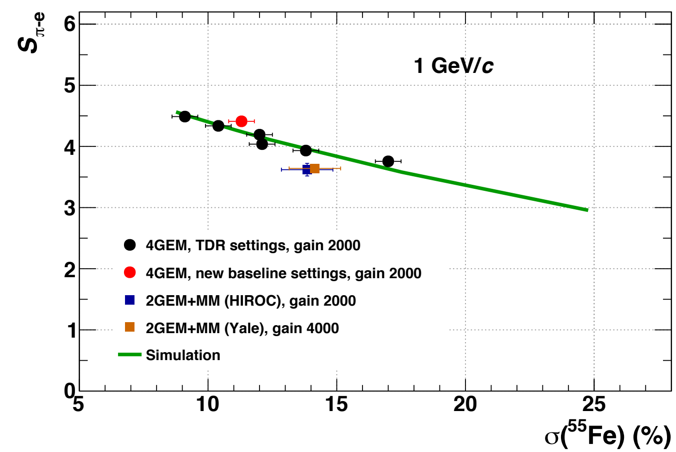
PS



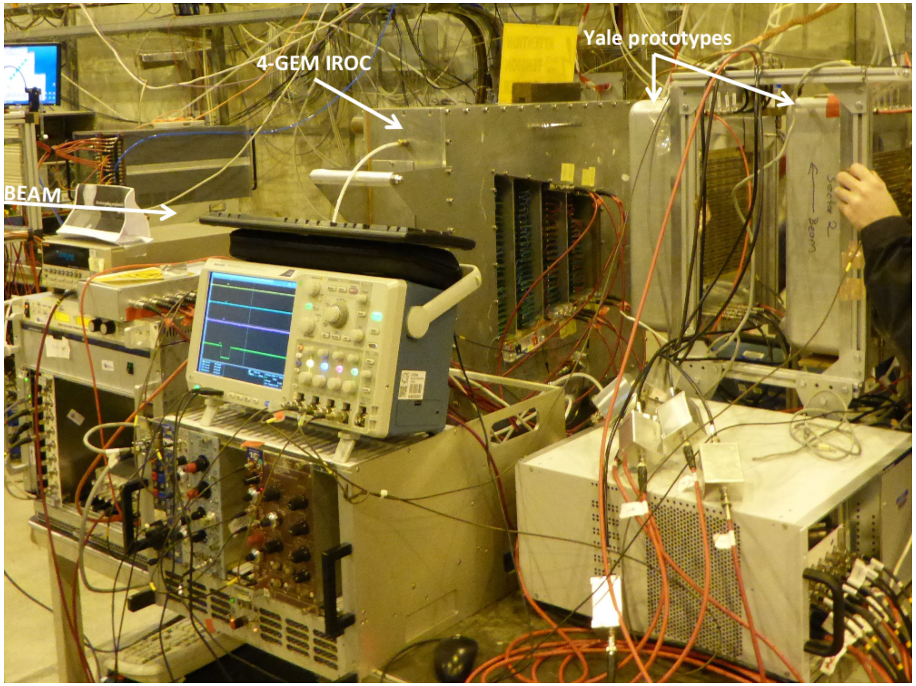
- XI 2014
- 1-3 GeV/c e^- and π^-

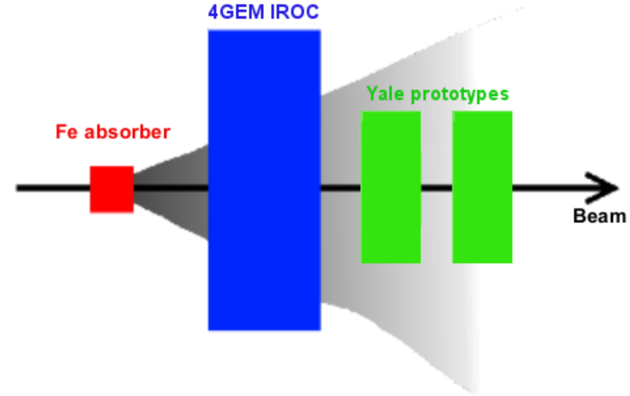






SPS – XII 2015 (RD51 beamtime)





$$(6.4 \pm 3.7) \times 10^{-12}$$