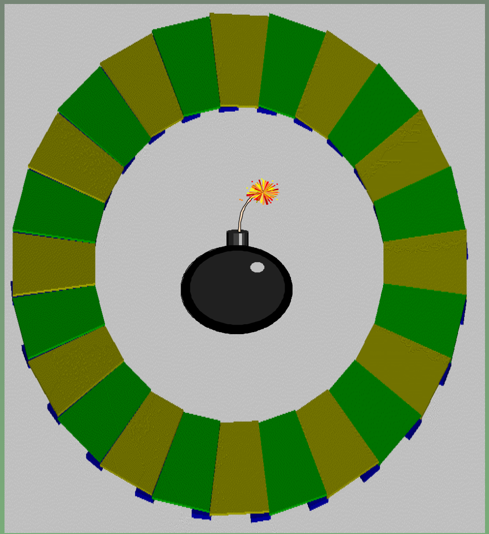
AGENDA

ALICE Si–FMD



- **SI–FMD design overview. JJG**
- **FE and RO electronics: B.S.Nielsen**
- **Electronics, A. Angelis**
- **V0 and role in trigger R.Guernane**
- **Open Discussion : choice of FE+RO electronics. JJG + All**
- **PMD design Lalit Mangotra**
- **Response and background simulations A. Maievskaia**
- **Mult. response A.Kurepin**

- **T0 design and electronics V.Grigoriev**
- **Organisation of future work (PPR, Design study, prototyping,...) JJG+All**

Design considerations

ALICE Si–FMD

PREMISES

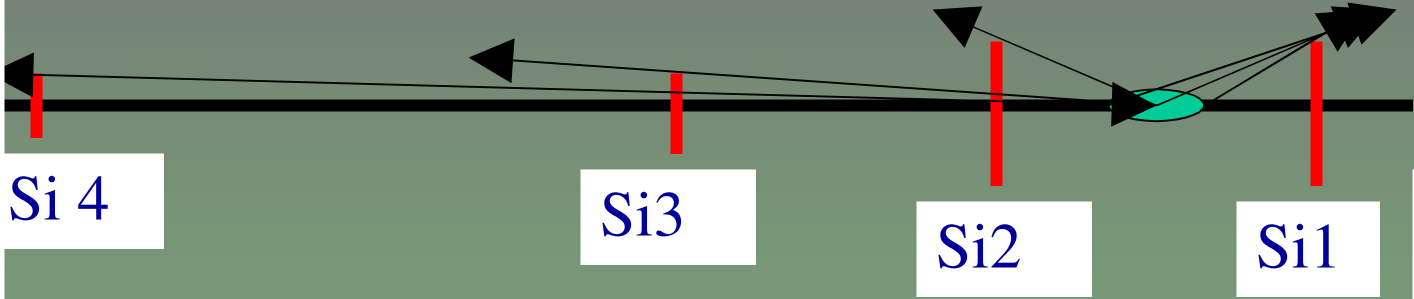
- Segmented Si ring counter for charged part. multiplicity
- Large eta coverage $1.5<|\eta|<6.0$.
- Highest possible symmetry
- Segmentation compatible with expected physics
- Global detector
- Accept occupancy > 1 for central Pb+Pb
- N_{ch} from Analog Energy signal or Hit Distribution
- Manageable development cost
- Electronics ”Community” available as ressource

QUESTIONS

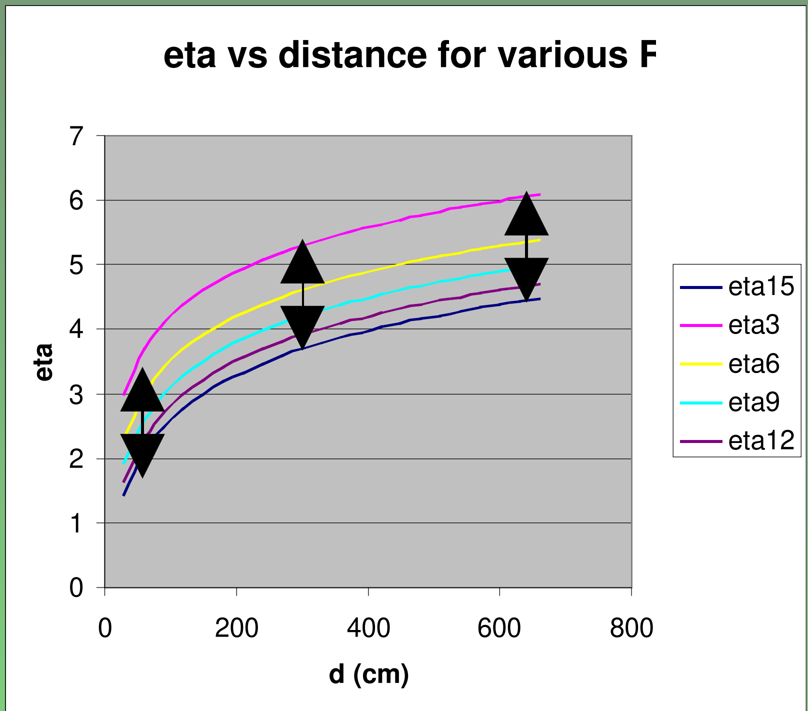
- Mechanical Integration in ALICE?
- Background?
- Segmentation?
- Matching to FE electronics?
- Readout and matching to DAQ?
- Role in ALICE trigger?
- Choice of electronics?
- Cost?
- Timetable?
- Responsibilities?

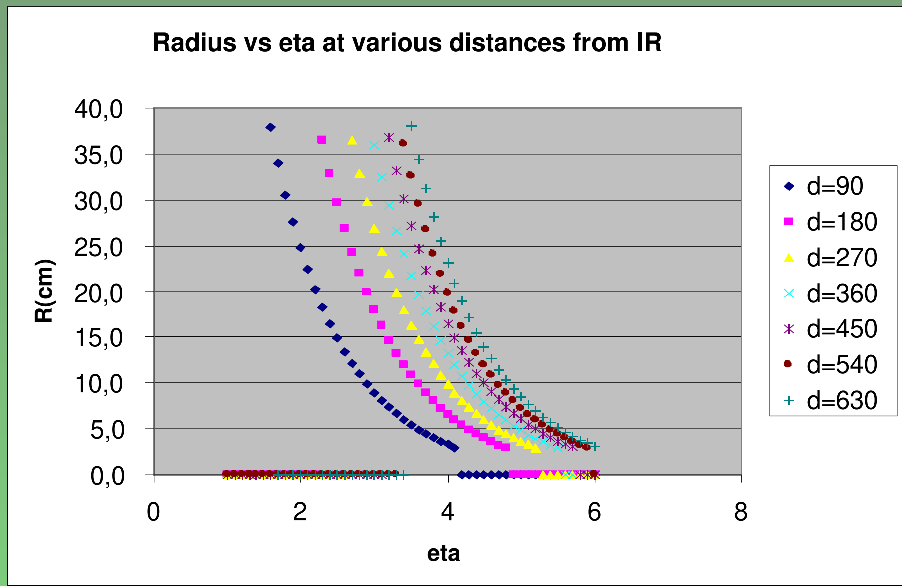
Overall Geometry

ALICE Si–FMD

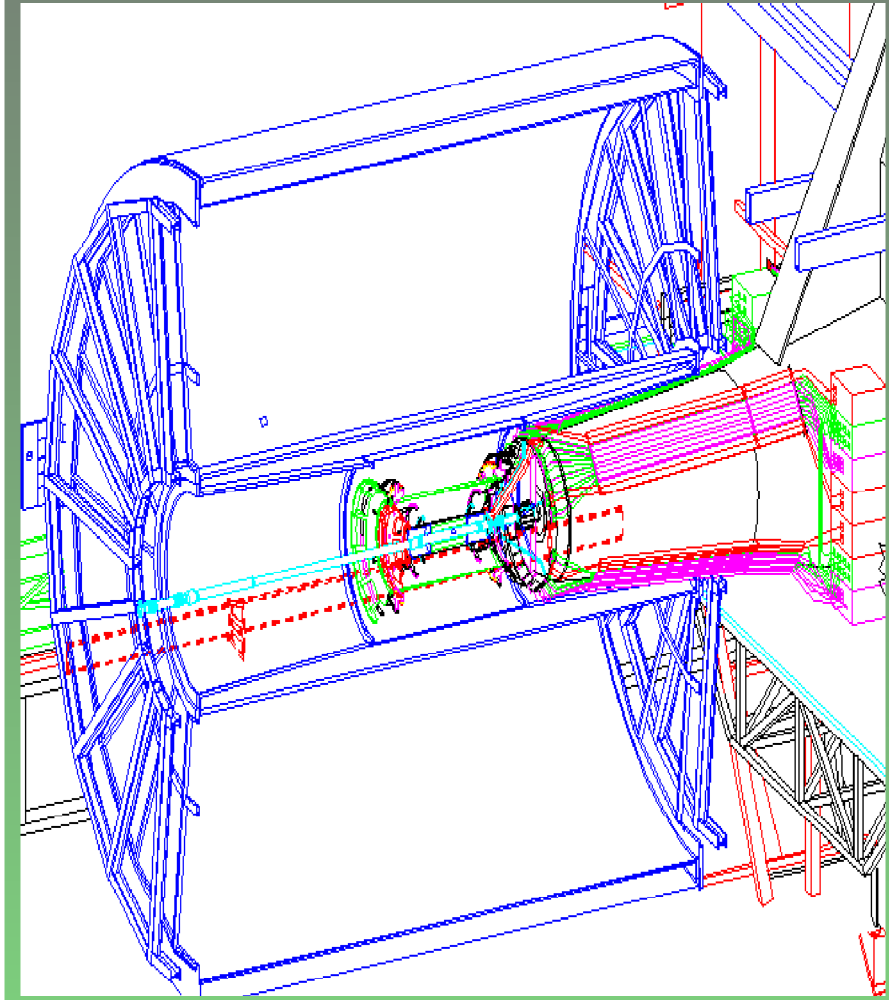


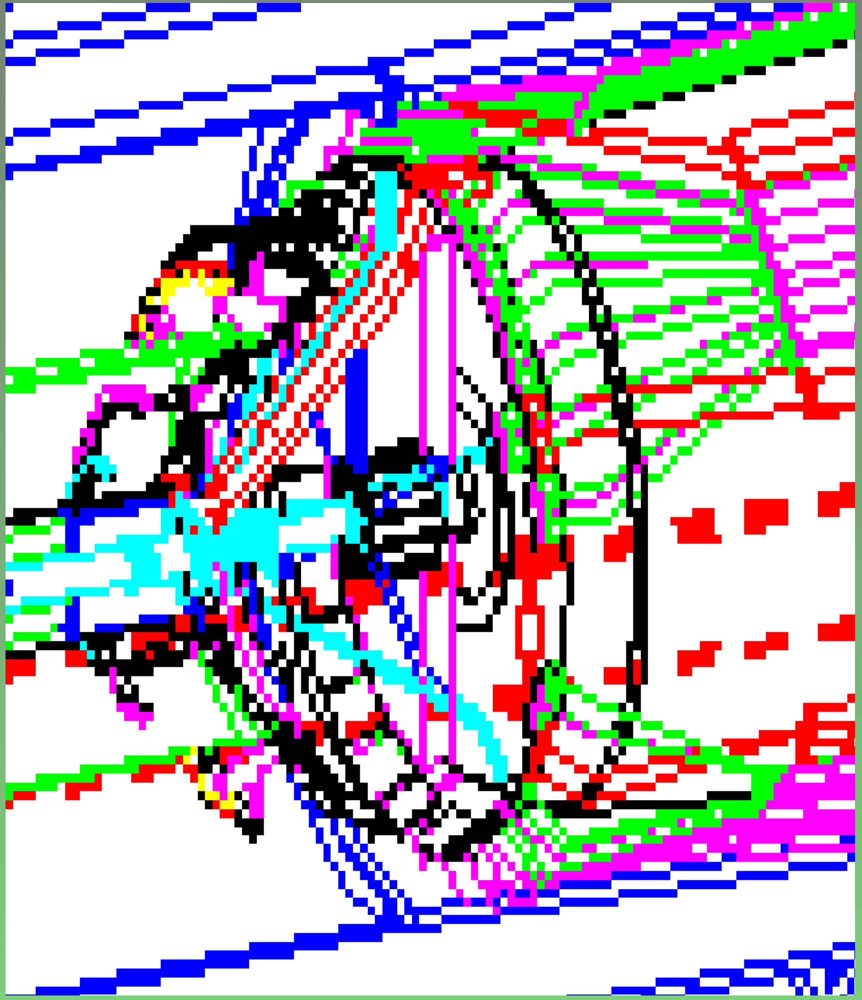
- $-6 < \eta < -1.6$
- $3 < \eta < 1.6$



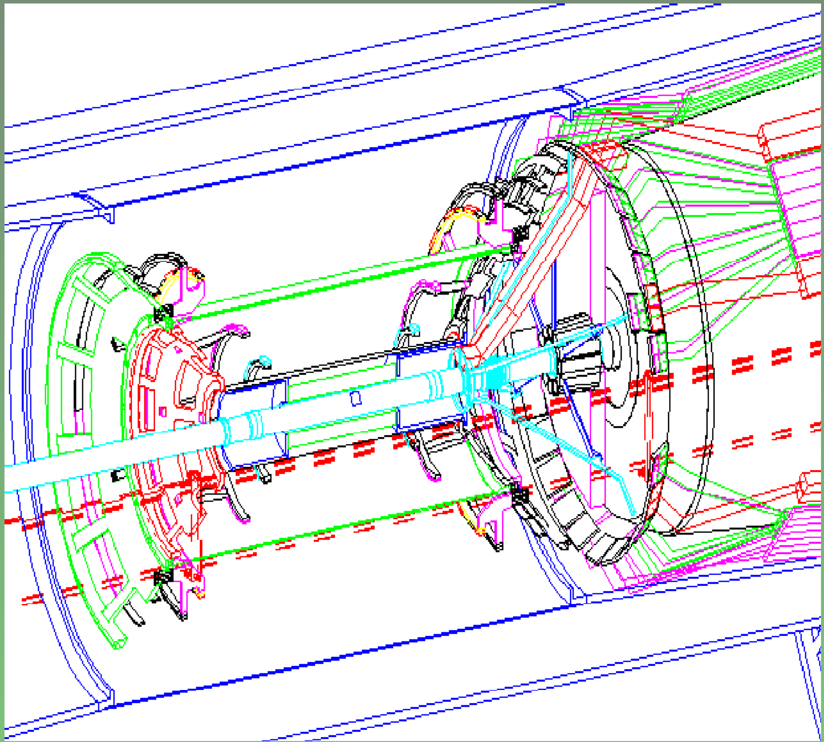


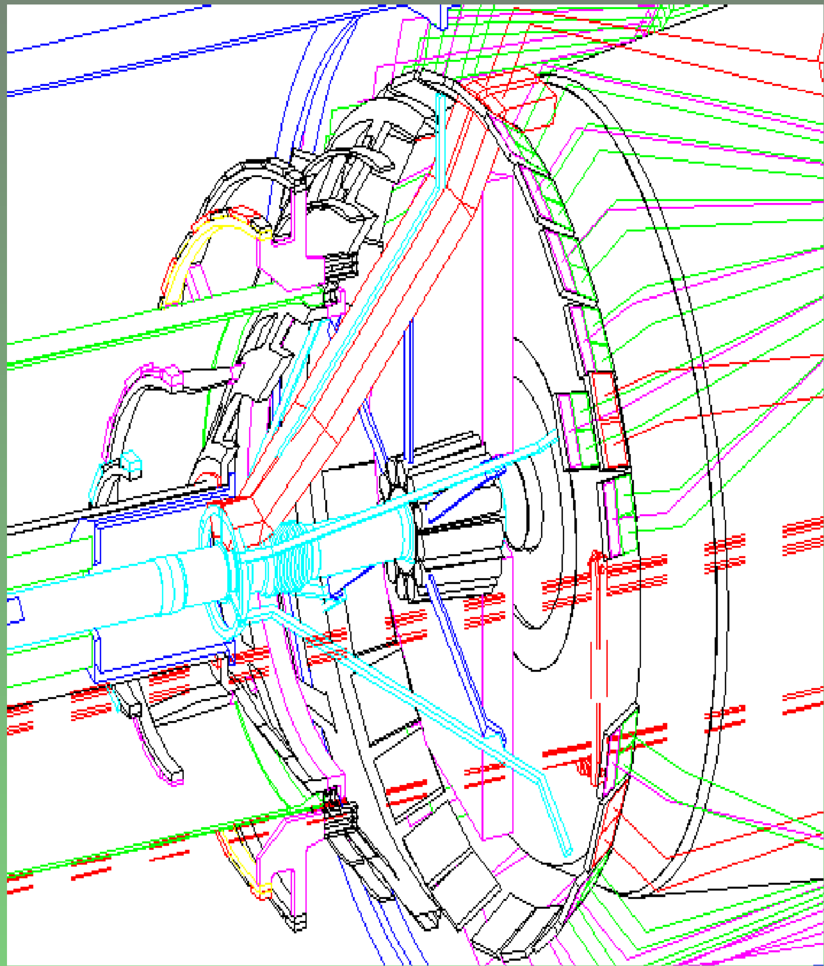
Integration in ALICE (1)





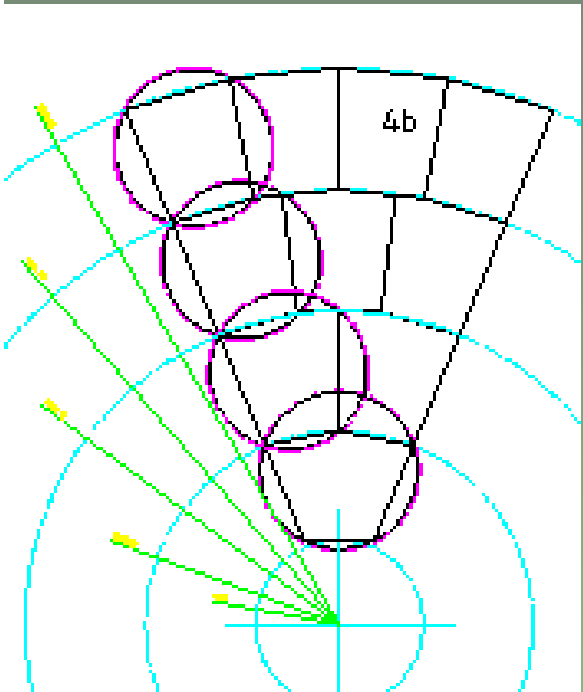
Integration in ALICE (2)



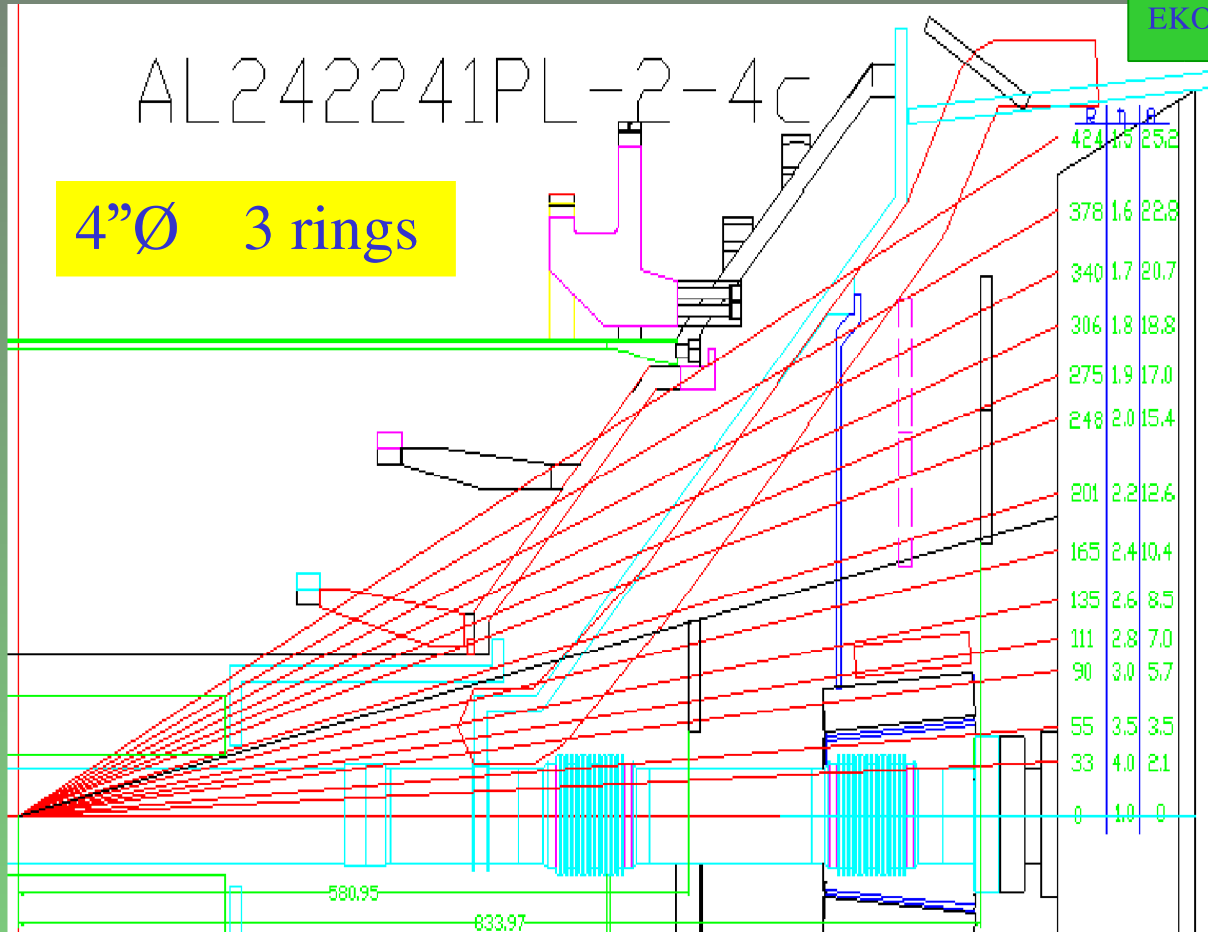


Si1 with 4” wafers

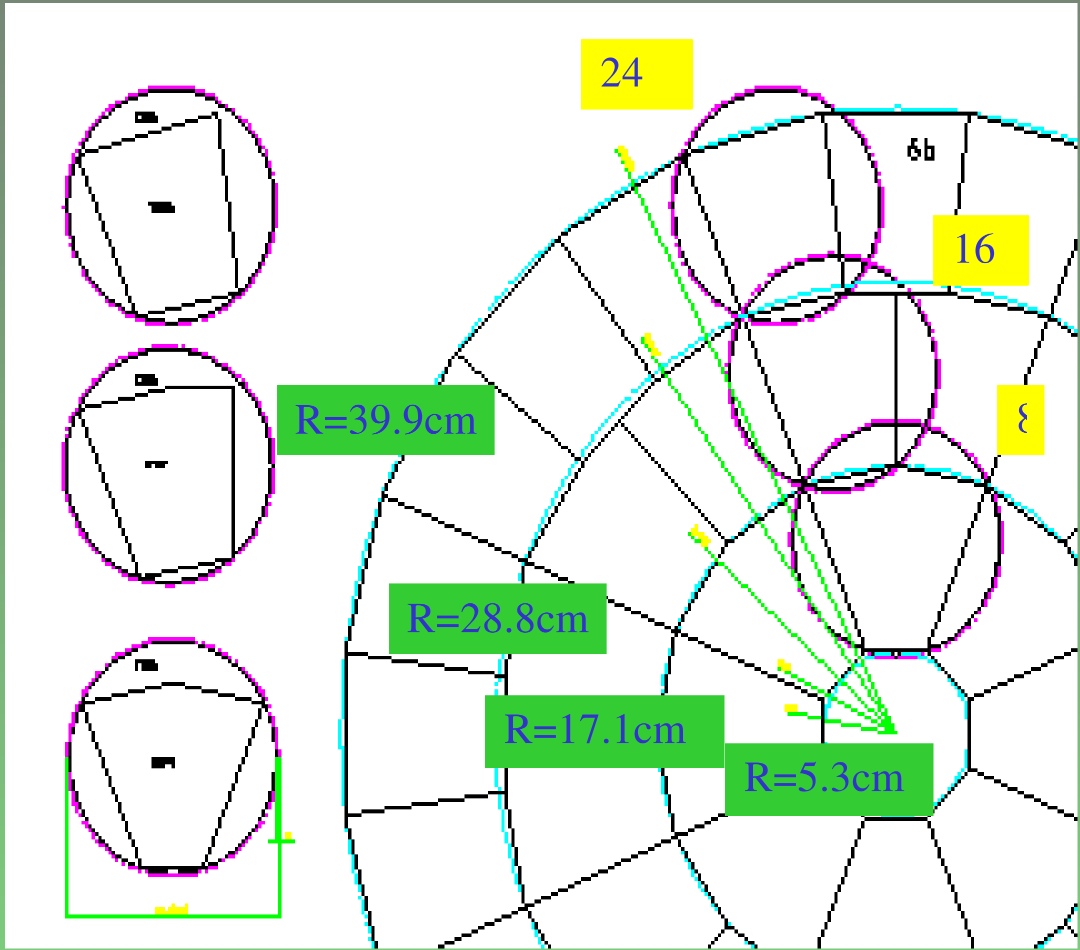
EKO

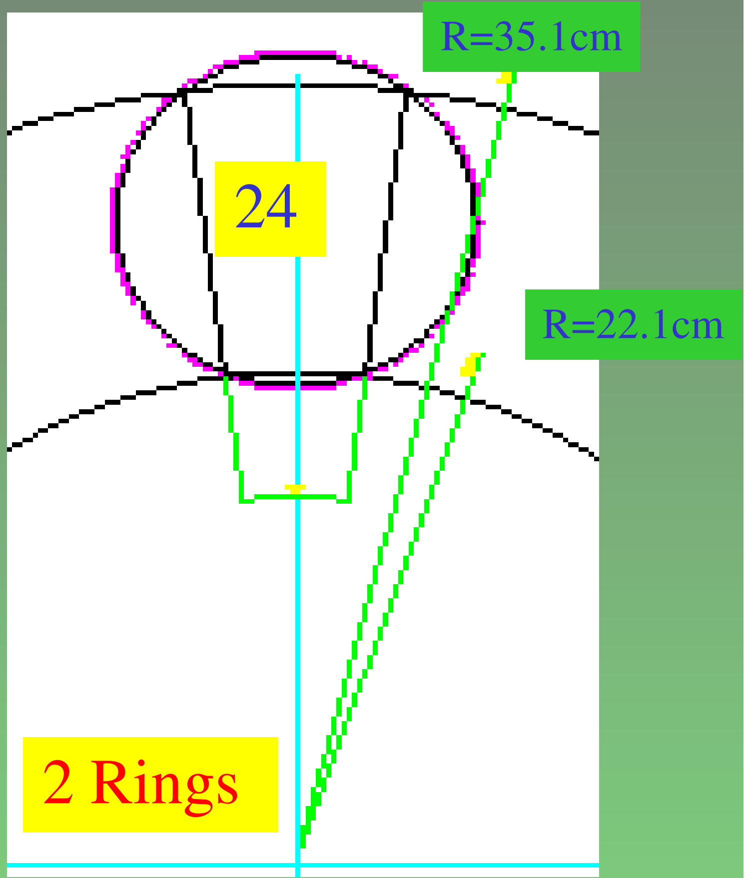


4”Ø 3 rings



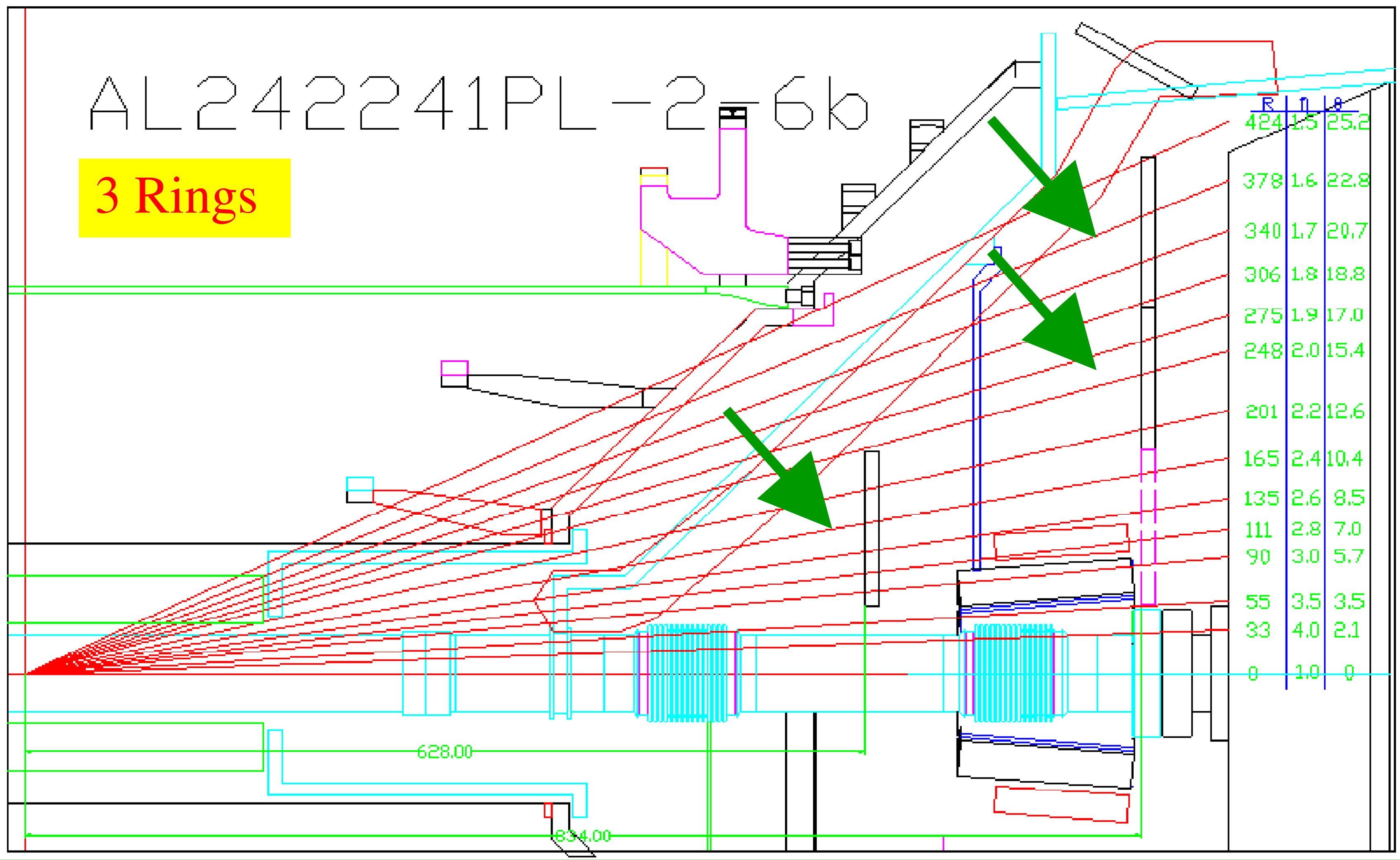
Si1 with 6" Wafers



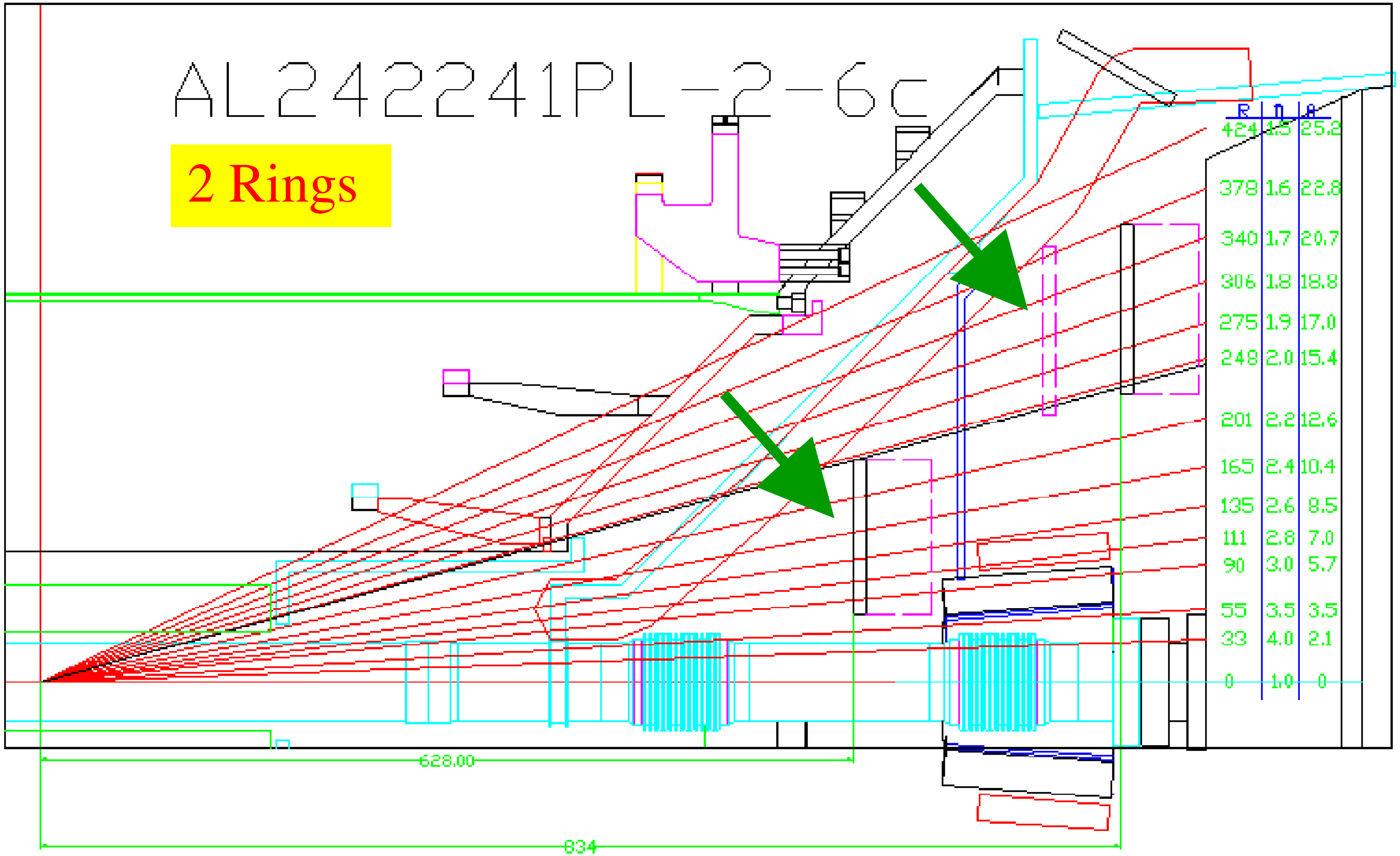


Si1 with 6" Wafers

ALICE Si–FMD



Si1 with 6” Wafers

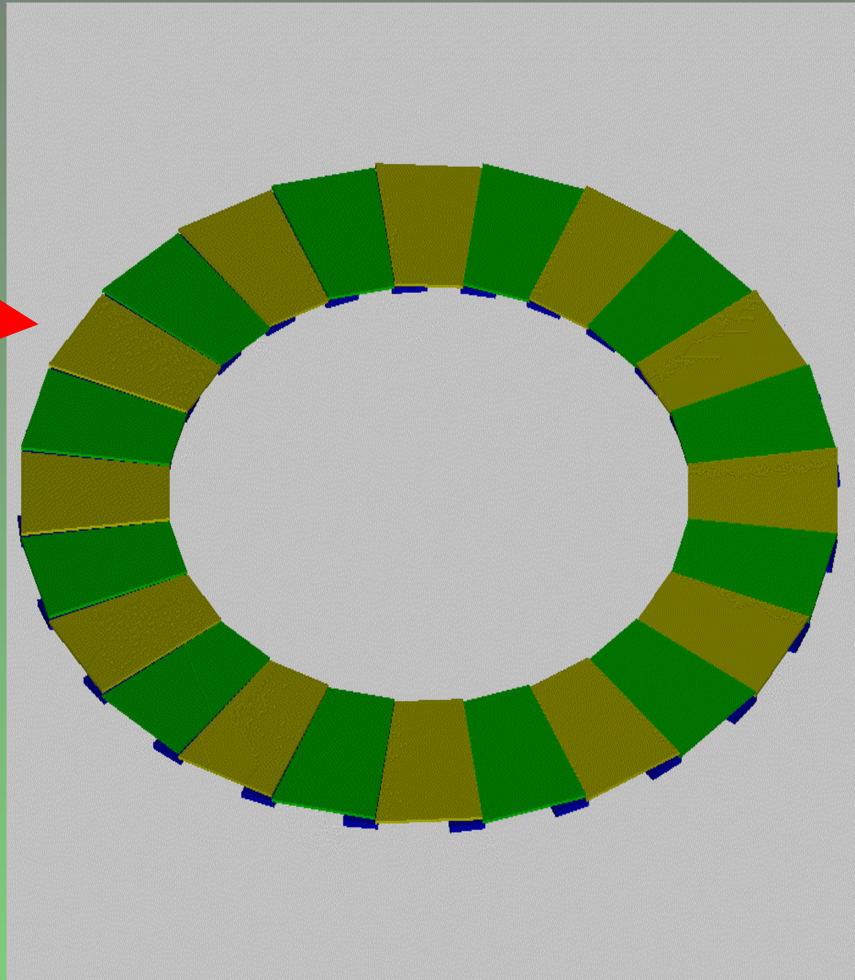


Ring geometry(2)

ALICE Si–FMD

Wafer Ø	Solution	#Rings	#Wafers	Eta coverage
6"	6b	3	8	3.2 –2.0
			16	2.3 –1.8
			24	1.8 –1.5
			48	
	6c	2	8	3.2 –2.0
			24	2.0 –1.6
			32	
4"	4b	4	8	3.2 –2.3
			16	
			24	
			32	
			80	
	4c	3	8	3.2 –2.3
			24	2.3 –1.9
			36	1.9 –1.65
			68	

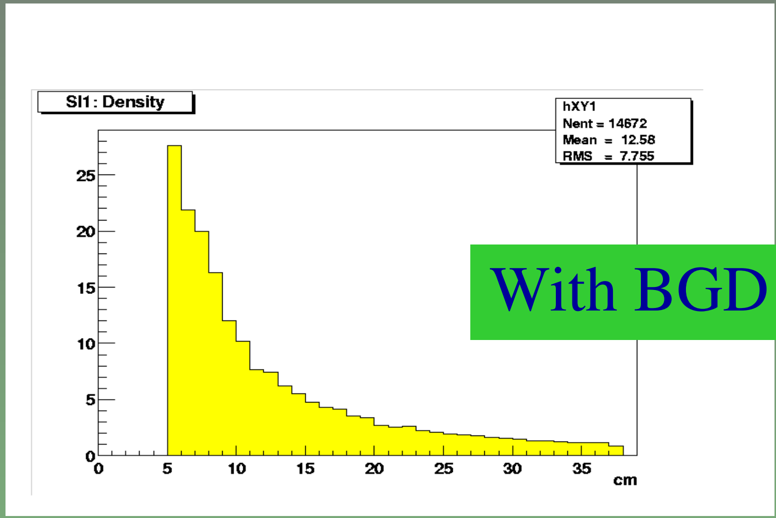
!!30 cm vertex shift: $\eta \rightarrow 1.2$

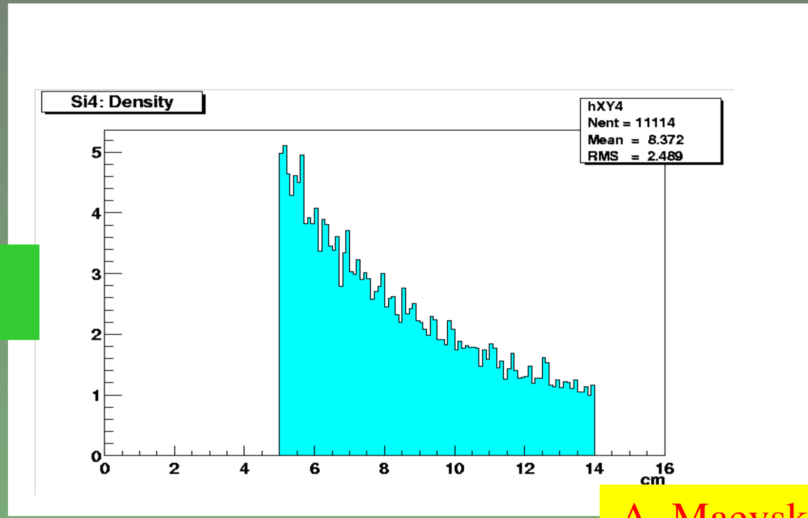


Background from secondaries (1)

ALICE Si–FMD

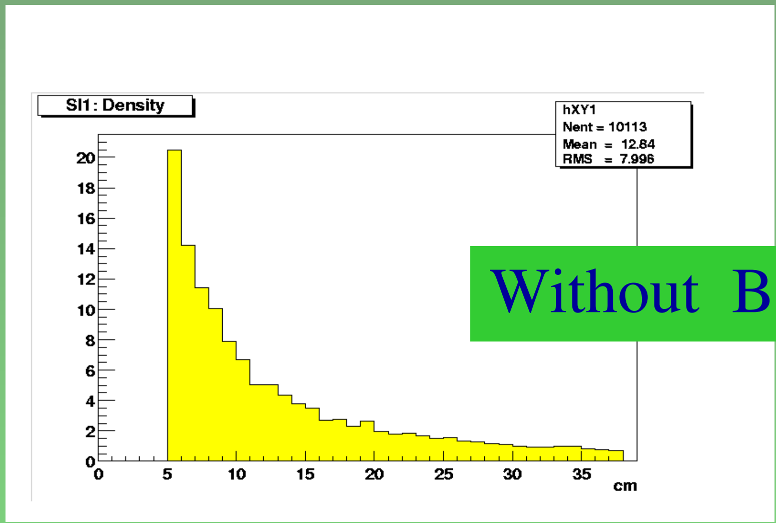
With BGD

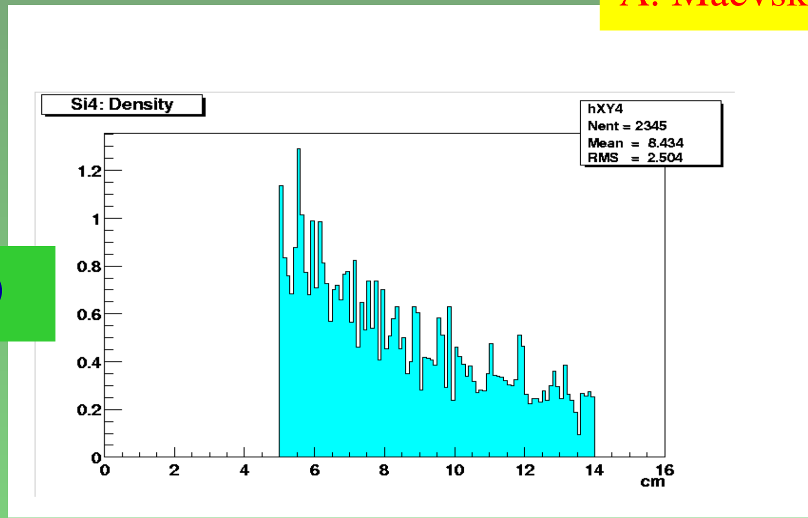




A. Maevskaia

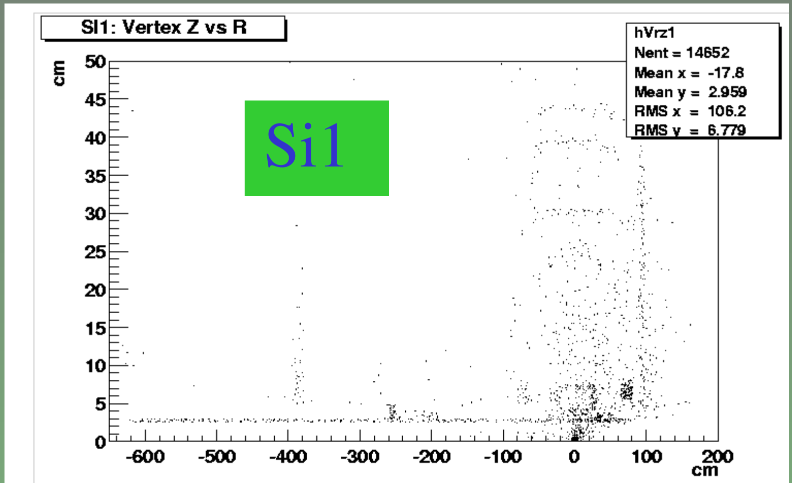
Without BGD

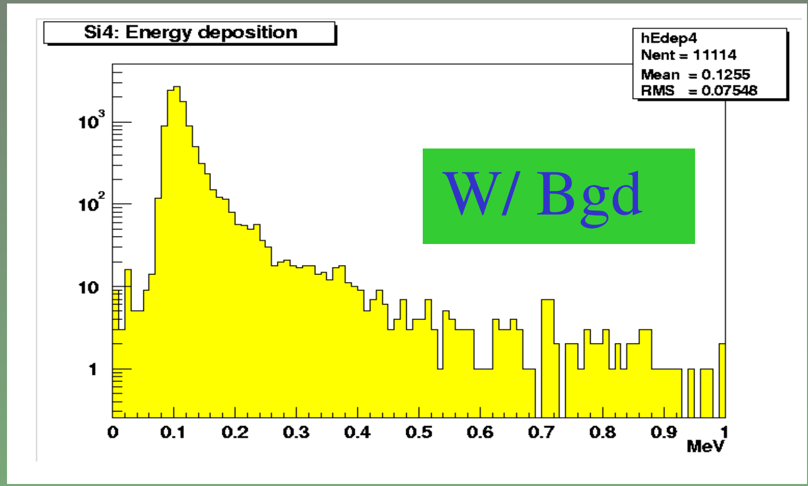


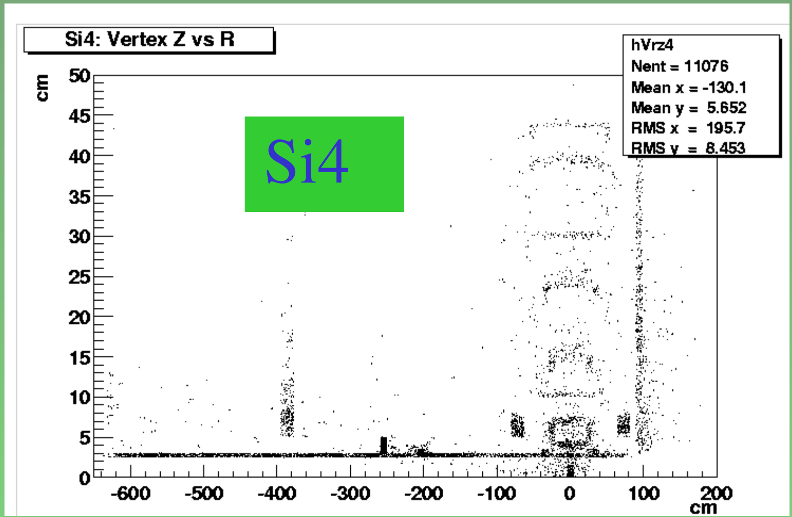


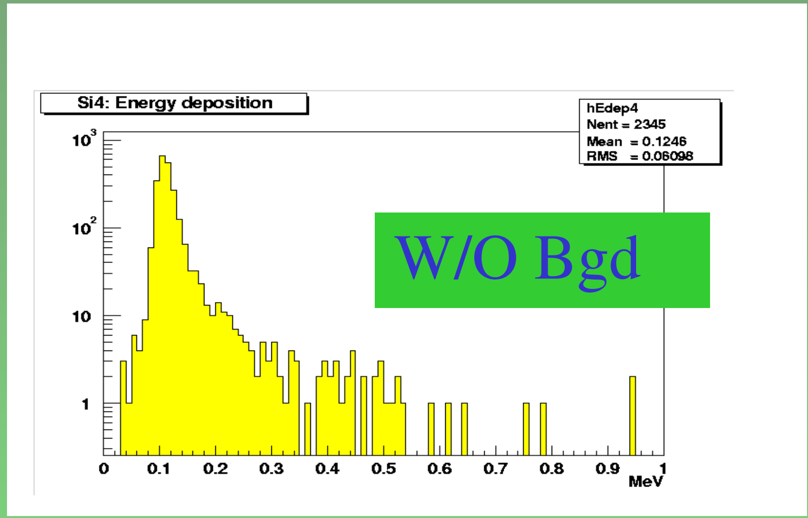
Background from secondaries (2)

ALICE Si–FMD









Bagground from secondaries (3)

ALICE Si–FMD

Si–Ring	Radius	W/O Bgd	W Bgd.	Bgd%	Pipe	Pipe%	ITS	ITS%	T0	T0%	Abs.	Abs%
		N/cm2										
Si1	5	20,7	27,6	33	24,8	19,8	20,8	0,5	22,1	6,8	22,3	7,7
d=95cm	10	6,6	10,2	55	7,5	13,6	7,2	9,1	7,6	15,2	7,4	12,1
	15	3,5	4,8	37	3,9	11,4	3,9	11,4	3,8	8,6	4,2	20,0
	20	1,9	2,7	42	2,2	15,8	2,3	21,1	2,0	5,3	2,3	21,1
	25	1,6	2,0	23	1,7	6,2	1,9	18,8	1,6	0,0	1,7	6,2
	30	1,1	1,4	31	1,1	0,0	1,2	9,1	1,1	0,0	1,1	0,0
	35	0,8	1,2	46	0,8	0,0	0,9	12,5	0,8	0,0	0,8	0,0
Si3	5	1,8	4,3	137	5,7	216,7	1,8	0,0	1,8	0,0	1,8	0,0
d=270cm	10	0,6	1,3	115	1,1	83,3	0,6	0,0	0,6	0,0	0,6	0,0
	15	0,2	0,5	153	0,3	65,0	0,2	0,0	0,2	0,0	0,2	0,0
Si4	5	0,9	5,0	456	4,0	344,4	0,9	0,0	0,9	0,0	0,9	0,0
d=630cm	10	0,4	1,9	375	1,5	275,0	0,4	0,0	0,4	0,0	0,4	0,0
	15	0,2	1,2	480	1,1	450,0	0,2	0,0	0,2	0,0	0,2	0,0

- **ITS and TO bgd. dominate at 1.5 $<\eta<3$**
- **Muon arm abs. important for Si1 bgd. (right side of IP)**
- **Beam Pipe bgd. dominates at $3<\eta<6$**

Background: Conclusions

- Significant background from secondaries at all η
- ITS and T0 important close to IP
- Secondaries from Beam Pipe is >> 100% at small angles
- Monte Carlo corrections very important => large systematic errors and reduced sensitivity to fluctuations.

- Must re−consider Beam Pipe design
- Better estimates for ITS background needed (cables etc..)
- Background from FMD to other detectors?

- !! Need updated simulations for current 2 ring geometry
- !! Check Event Generator

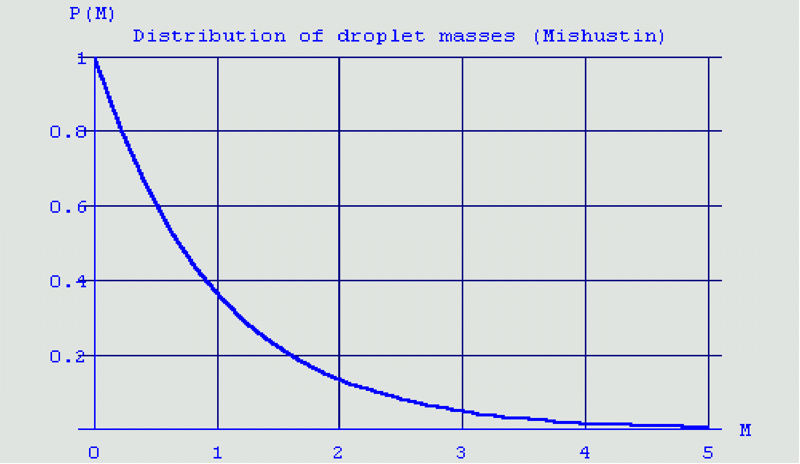
Segmentation

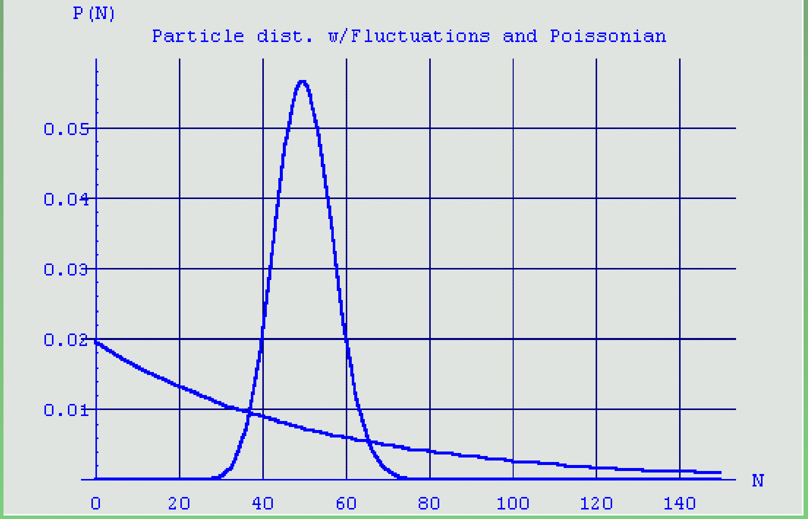
ALICE Si–FMD

REQUIREMENTS

- Physics:
  - $\Delta\eta<0.1$,
  - $\Delta\varphi<2\pi/10$

  (from current physics:
  droplets etc..)
- Multiplicity resolution better than 10%
- Compatibility with FE electronics:
  - pad area/capacitance/noise
  - dynamic range/gain
- Manageable cost





Si–Strip
Area and Occupancy (1)

ALICE Si–FMD

Si 1 Inner Ring at d=90cm		Number of strips			Phi	Density
		32	64	128	16	
R inner (cm)	5,3					27,50
R middle (cm)	11,23					8,00
R outer (cm)	17,15					4,50
Av. Pitch (cm)		0,37	0,19	0,09		
A inner (cm^2)		0,80	0,39	0,19		
A middle (cm^2)		1,66	0,82	0,41		
A outer (cm^2)		2,52	1,25	0,63		
<N inner>		21,94	10,78	5,35		
<N middle>		13,27	6,58	3,28		
<N outer>		11,34	5,64	2,81		

Si 1 Outer Ring at d=90 cm					Phi	
		32	64	128	24	density
R inner (cm)	22,1					2,60
Rmiddle (cm)	28,55					1,60
R outer (cm)	35,00					1,20
Av. Pitch (cm)		0,40	0,20	0,10		
A inner (cm2)		2,35	1,17	0,58		
A middle (cm2)		3,03	1,51	0,75		
A outer (cm2)		3,72	1,85	0,92		
<N inner>		6,12	3,05	1,52		
<N middle>		4,86	2,42	1,21		
<N outer>		4,46	2,22	1,11		

- Si1 Inner Ring 2.0–3.2
  N(ch) ≈ 4000
- Si1 Outer Ring 1.6–2.0
  N(ch) ≈ 2000

SI–Strip
Area and Occupancy (2)

ALICE Si–FMD

Si 3 Ring at d=270 cm					Phi	
		32	64	128	16	density
R inner (cm)	5,3					4,10
Rmiddle (cm)	11,23					1,00
R outer (cm)	17,15					0,30
Av. Pitch (cm)		0,37	0,19	0,09		
A inner (cm2)		0,80	0,39	0,19		
A middle (cm2)		1,66	0,82	0,41		
A outer (cm2)		2,52	1,25	0,63		
<N inner>		3,27	1,61	0,80		
<N middle>		1,66	0,82	0,41		
<N outer>		0,76	0,38	0,19		

- Si3 $3.5 < \eta < 4.6$

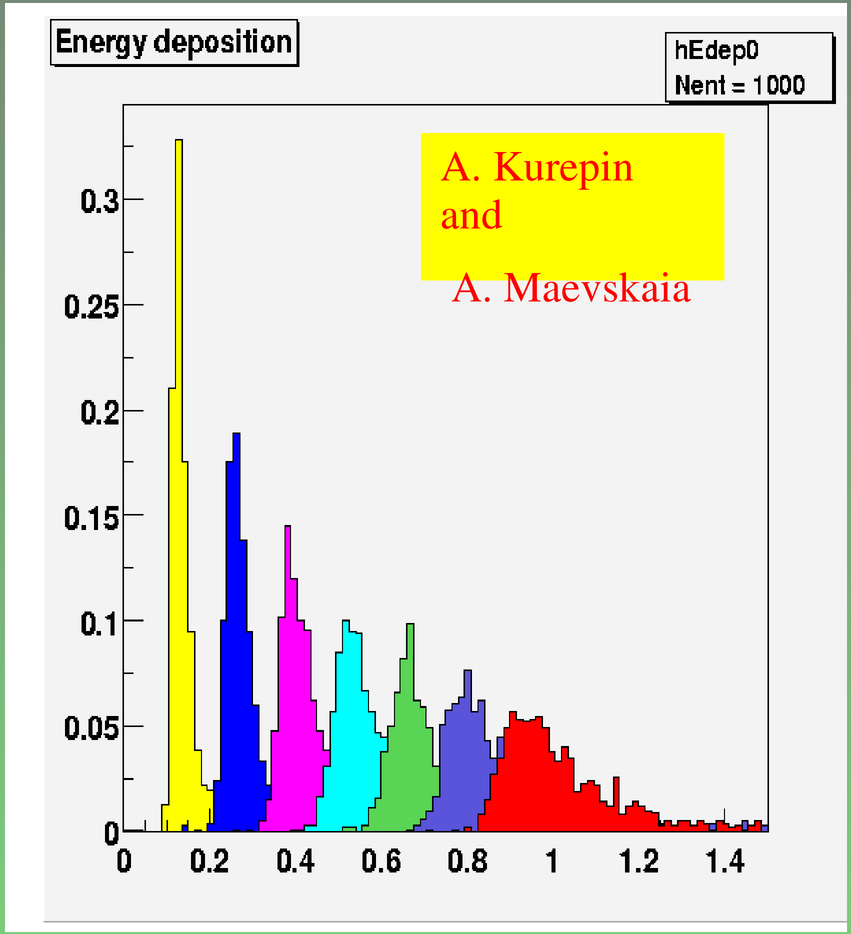
  N(ch) ≈ 2000
- Si4 $4.3 < \eta < 5.5$

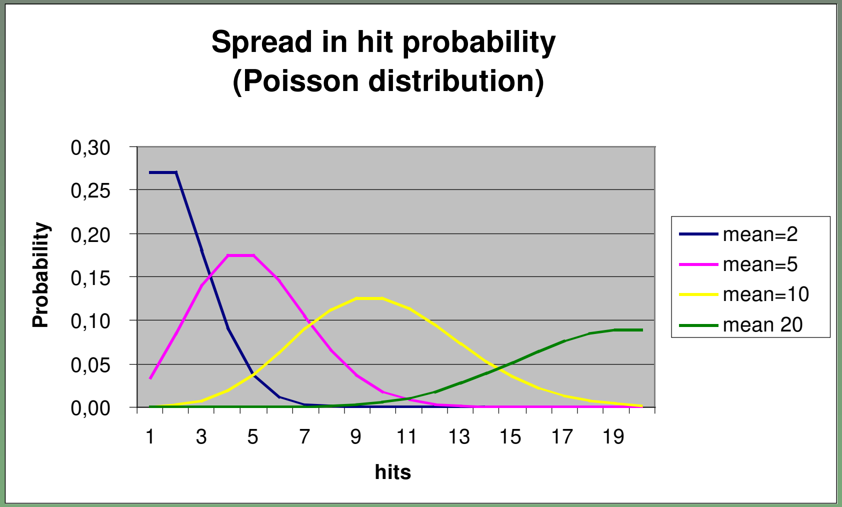
  N(ch) ≈ 1500

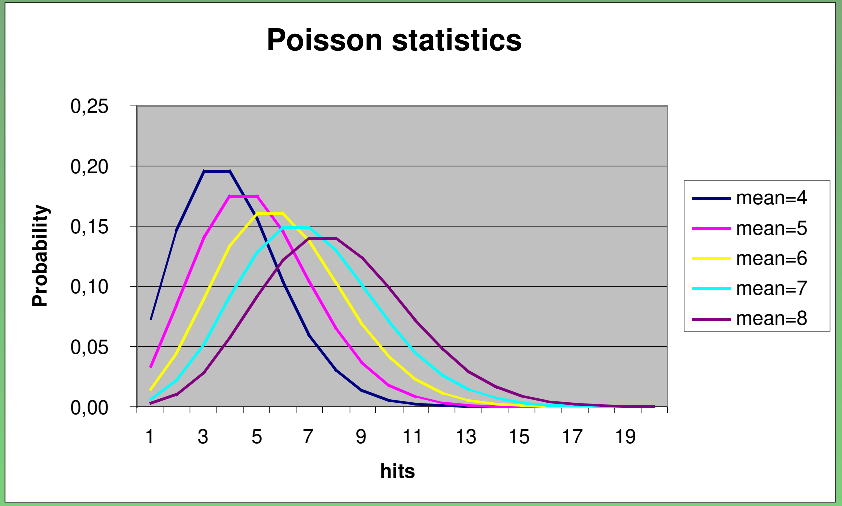
Si 3 Ring at d=630 cm					Phi	
		32	64	128	16	density
R inner (cm)	5,3					4,60
Rmiddle (cm)	11,23					1,60
R outer (cm)	17,15					0,80
Av. Pitch (cm)		0,37	0,19	0,09		
A inner (cm2)		0,80	0,39	0,19		
A middle (cm2)		1,66	0,82	0,41		
A outer (cm2)		2,52	1,25	0,63		
<N inner>		3,67	1,80	0,89		
<N middle>		2,65	1,32	0,66		
<N outer>		2,02	1,00	0,50		

Multiplicity resolution (1)

ALICE Si–FMD

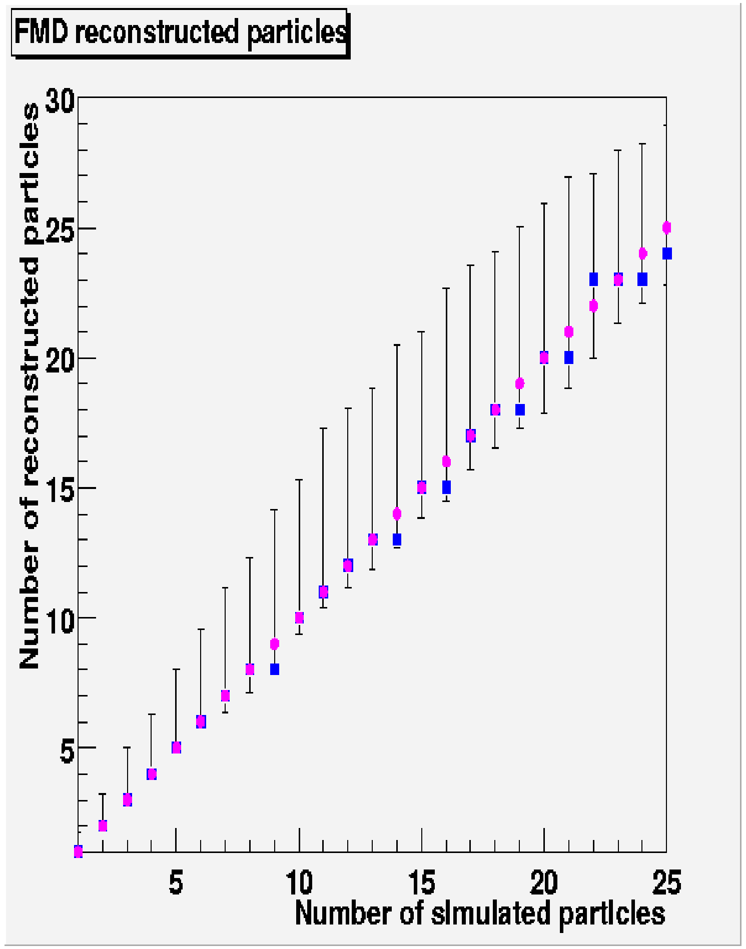






Multiplicity resolution (2)

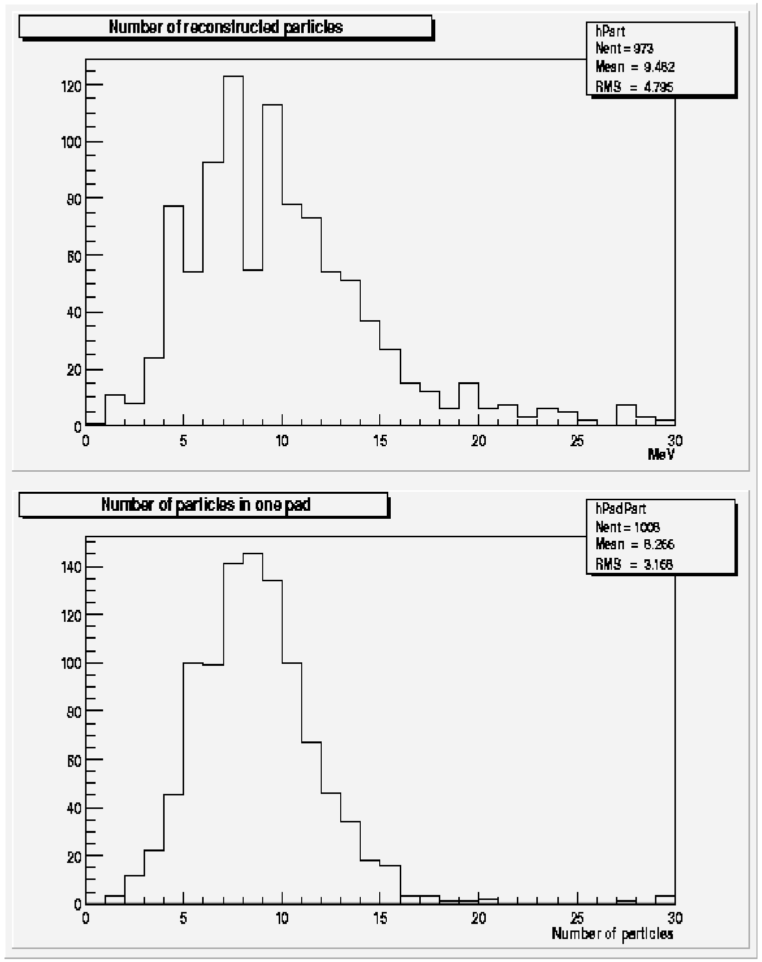
ALICE Si–FMD



- **Energy measurement**
  - **N = Σ dE / <E>**
  - **<E> depends on particle mix**
  - **N depends on background of secondaries**
  - **calibration is difficult**
  - **response is complicated**

- **Cell Occupancy**
  - **Poisson statistics**
  - **$P(0)/P(n\geq1)=1/(\exp(\mu)-1)$**
  - **sensitivity for small μ**

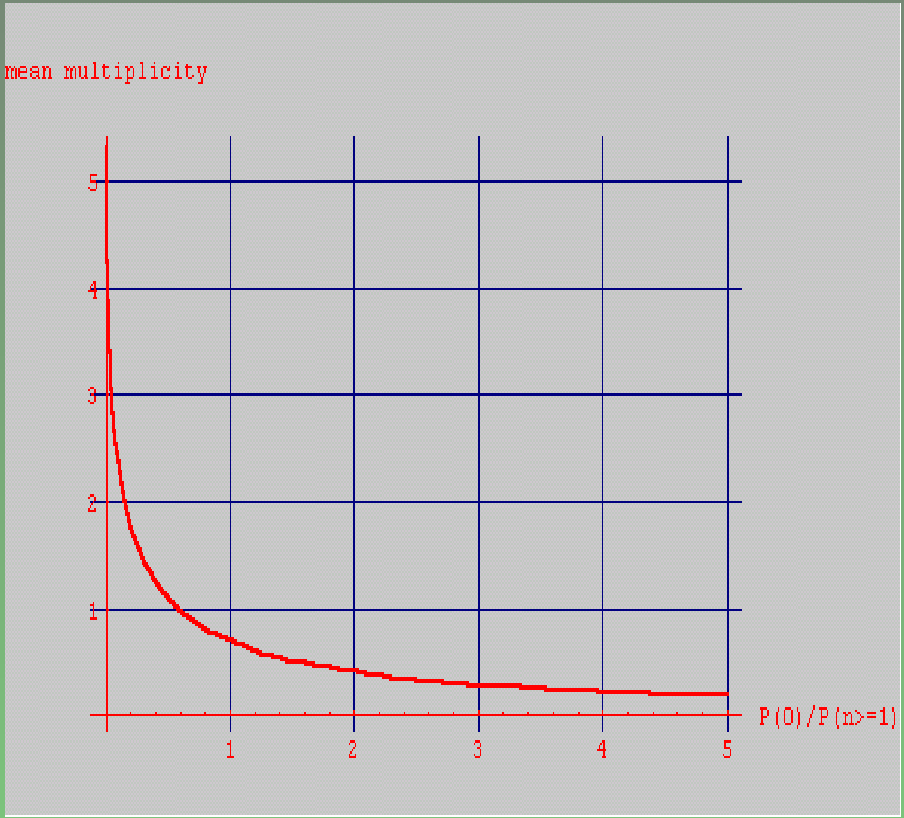
Multiplicity resolution (3)



- See A. Maievskaia and A. Kurepin

Occupancy factor

ALICE Si–FMD



- $P(n) = \mu^n / n! \exp(\mu)$
- $P(0)/P(n \geq 1) = 1/(\exp(\mu) - 1)$
- **Sensitive for $0.25 < \mu < 4$**

Si–FMD
Role in Trigger

WHO does it?

- LVL0 Timing: T0
- Vertex (≈ 1–2 cm) T0
- Vertex (≈ 0.1–0.2 cm) TPC
- Rough on–line Centrality cut on dE V0
- p+p trigger V0
- Timing+vertex(p+p) T0,V0

- Precise centrality Si
- Fluctuations Si
- Azimuthal distribution Si
- Off–Line PID (dE) Si
- Level 0 T0,V0
- Off–line, Higher level Si

Physics and rates

- Central Pb+Pb :
  Nch(Si) 15.000–20.000
- p+p
  Nch(Si) 50–100

- Pb+Pb 8kHz. 1kHz central
- Average event spacing >100µs

- p+p up to 1 coll/bunch crossing
- Average event spacing 25 ns

PACE2 electronics (CMS)

ALICE Si–FMD

CMS preshower FE

- Area= 1.2 cm^2
- 300 μm
- Dynamic range 1–50–400 MIPs
- 640 e– + 33 e–/pF
- C= 40pF + 12pF(inter–strip)
- $\approx$ 35000 e–/MIP
- S/N (1 MIP) $\approx$ 15
- DC coupled to electronics (<20 μA/ch).
- Radiation hard.
  - 10 MRad ionizing
  - 2. 10^{14} neutrons/cm^2
- 25 ns shaping

ALICE SI–FMD

- Strip Areas: 0.2–0.9 cm2
- 300–400 μm
- Occupancy central Pb+Pb N/strip= 0.2–5.4 $\Rightarrow$ 1–40 MIPS
- Fluctuations from statistics and background
- Radiation hard environment
- For p+p running?

LHC FE chips

ALICE Si–FMD

Survey of some LHC front-end chips

B.S.Nielsen

Front-end chip	PACE2	APV6/APVD	SCTA	ABCD	ALICE128	Beetle
Experiment	CMS	CMS	ATLAS	ATLAS	ALICE	LHCb
Detector	Preshower	Tracker	Tracker	Tracker	ITS	Vtx Det
Peaking time	25 ns	50 ns	25 ns	25 ns	1.4 μs	25 ns
Channels	32	128	32 or 128	128	128	128
Memory/pipe	160 ev.	160 ev.	112 ev.	132 ev.	1 ev.	128 ev.
Gain	4 mV/mip 40 mV/mip	75 mV/mip	100 mV/mip	50 mV/mip	50 mV/mip	
Dynamic range	0-400 mips 0-50 mips	few mips?	few mips?	$<$ 1 mip (discri)	13 mips	10 mips
Input capacitance	$<$ 50 pF	$<$ 20 pF	$<$ 20 pF	$<$ 20 pF	$<$ 20 pF	$<$ 20 pF
Noise	1100+36C	510+36C	720+33C	559+35C		300+34C
Noise @ 40 pF	2540 e^-	1950 e^-	2040 e^-	1959 e^-	280 e^- @ 10pF	1660 e^-
Technology	DMILL	1.2μ CMOS or DMILL	DMILL	DMILL		sub-μ
Read-out	20 MHz mux 3 events	20 MHz mux 1 event?	40 MHz mux 1 event?	digital 1 event?	10 MHz mux 1 event	40 MHz 1 event
Trigger on chip	no	no	no	no	no	no
Trigger on hybrid	yes	no	no	no	no	maybe

Electronics overview

ALICE Si–FMD

	Wafers	Phi sectors	Strips/wafer	Channels	FE Chips	Chips/card	FE Cards
Si 1 inner ring	8	16	128	2048	64	8	8
Si 1 outer ring	24	24	128	3072	96	8	12
Si 2 inner ring	8	16	128	2048	64	8	8
Si 2 outer ring	24	24	128	3072	96	8	12
Si 3	8	16	128	2048	64	8	8
Si 4	8	16	128	2048	64	8	8
Total inner	48	48		6144	192		24
Total outer	32	64		8192	256		32
Total system	80	112		14336	448		56

- Assume 128 strips/wafer
- Assume 32 channels/chip
- Assume 8 chips/RO card

Cost Estimate

ALICE Si–FMD

Item	Units	Unit price	Total	Summed
Si–wafers				
Proto 1	25		50000	
Proto 2	25		50000	
Production 1	25		25000	
Production 2	25		25000	
Misc.			20000	
Si total				**170000**
Electronics				
Chips	448	100	44800	
FE cards	56	300	16800	
Hybrids	112	100	11200	
Misc.			20000	
FE total				**92800**
Construction				
Assembly/bond			50000	
Mechanical			50000	
Test			70000	
Assembly total				**170000**
Transportation			20000	
Installation			20000	
Receiver				**100000**
DAQ				**50000**
Grand total				**582800**

- **VERY uncertain and preliminary estimate**
- **6”Ø: still experimental**
- **Test production batch: 16–25 wafers**
- **CMS: formal contact needed.**
- **Can probably buy/copy CMS chips, boards, RO system.**
- **Need decision soon**

Responsibilities/planning

ALICE Si–FMD

TASKS	WHO?
Update geometry and integration drawings	NBI
Update simulations of background, resolution and performance	INR +NBI
Choice of elctronics agreement with CMS	NBI+ALICE
Tender and order prototype 6” wafers	NBI
Construct and test FE+RO system	NBI +?
Test DAQ and integrate with DAQ	?
Update prelim–TDS–started	FMD group– before summer
PPR– needsa to start	FMD group– next few months

Responsibilities/planning (2)

ALICE Si–FMD

TASK	Who/WHEN
❑ T0 Tech. Design study	❑ Moscow , before summer
❑ T0– technology decision and funding	❑ ALICE , before summer
❑ T0 prototypingls –l	❑ Moscow, early 2002
❑ V0 Tech. Preliminary Design Study (TDS)	❑ Lyon, Mexico