

Phased Array ultrasonic inspection in the Aerospace community

“Is there really any value to multiple angle manual ultrasonic inspection ?”

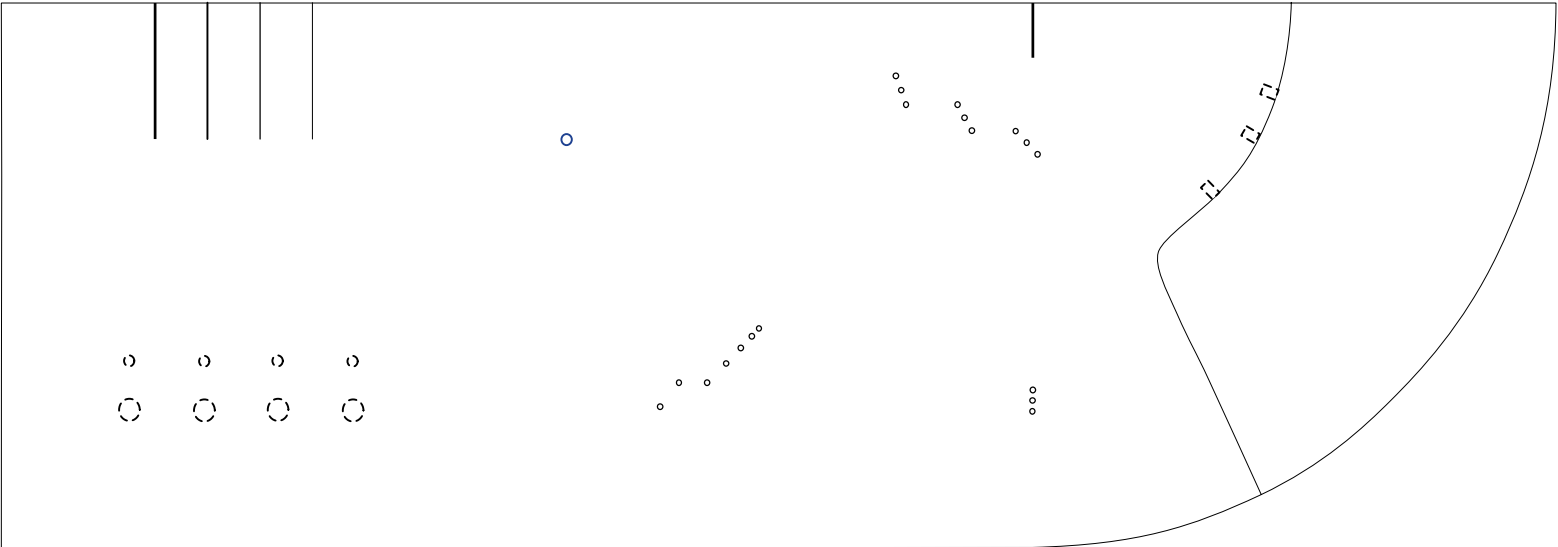


imagination at work

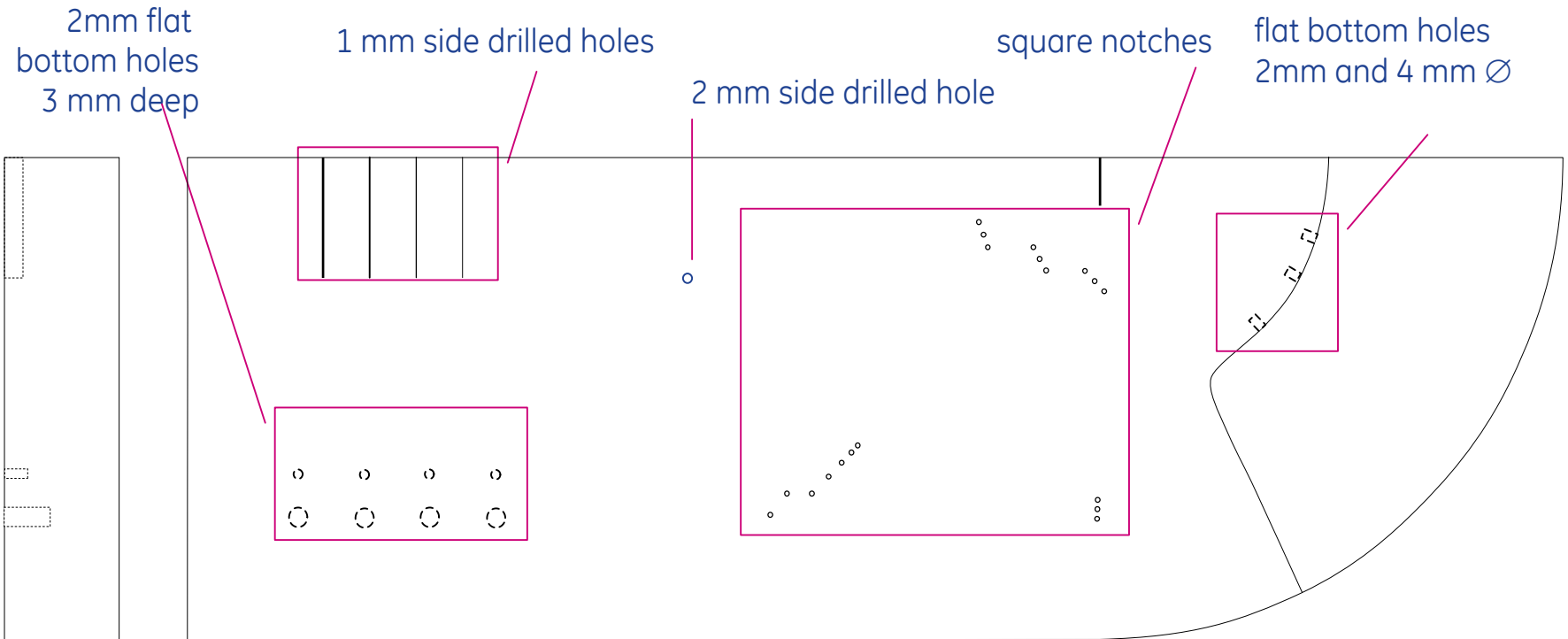
Exercise

- Create a test block depicting defects in Aluminum
 - Patterned after IIW Type II or V1
- Choose conventional and phased array probe
- Select areas of interest

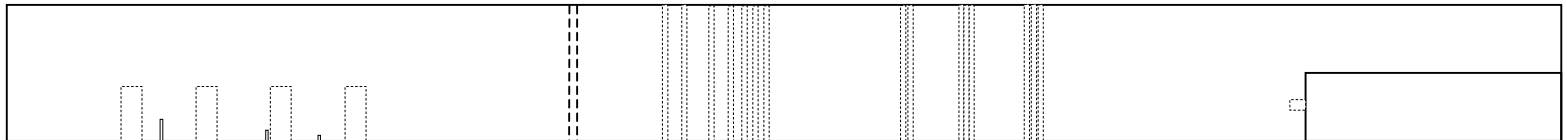
Phased Array test Block



Description



Material: Aluminium



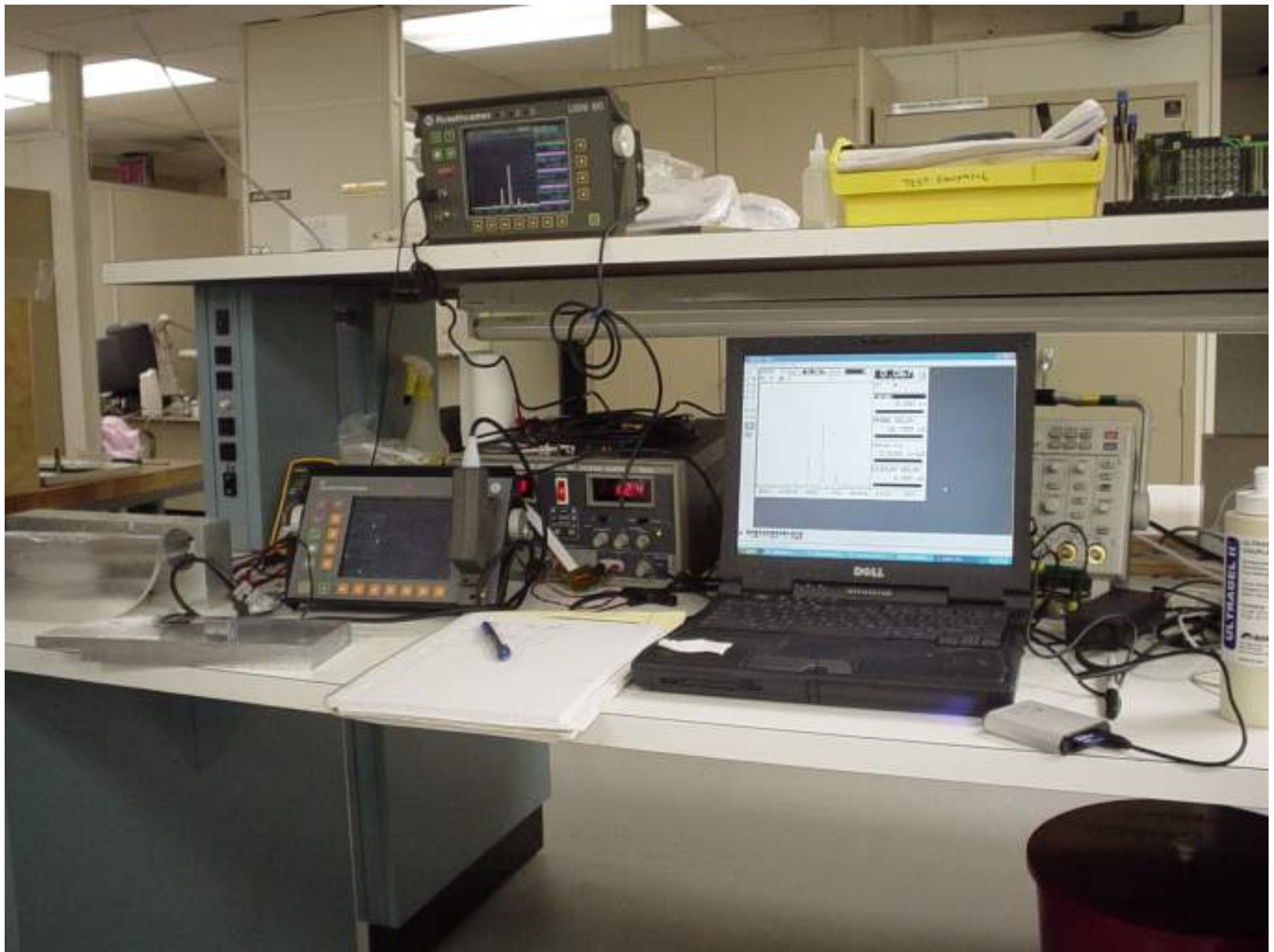
Equipment used -

- MWB 70 – 4 – fixed wedge angle beam probe conventional shear wave probe
- MWBPA-5- detachable wedge 32 element 0.5mm, pitch 10 mm elevation – 16 element aperture phased array probe
- USN60 conventional flaw detector
- Phasor XS Portable PA
- UltraDoc vers. 4.42 Software
- GE Modeling Excel Sheet



The block





GE Modeling Tool – Excel Spreadsheet Angle Correction mode

PROBE			
Probe DAT	Probe GEO	Wedge DAT	Wedge GEO
Type	Frequency	Angle (°)	Velocity (m/s)
MS-D4-03	4	36	2320
Name	Nbr of Elements	Opt. Beam (°)	Offset X (mm)
BLN25-30	32	51.8	14
Set Nr	Pitch (mm)	Set Nr	Offset Y
	0.5		
	Elevation (mm)	Element 1 position	Offset Z (mm)
	10	Low End	
PART			
Plan	Curved	Plan Weld	
Velocity LV (m/s)	Velocity L	Type	Weld Wiz
5920		None	
Velocity SV (m/s)	Velocity T	OverCap (mm)	TOFD Wiz
3100		15	
Thickness (mm)	Thickness	LowerCap (mm)	
25		0	
SCAN			
Elem Scan	Scan Pat	Aperture	Probe Offset
Type	Angle Start	Size (Nb of Ele.)	Index X (mm)
Sectorial	38	16	12.1
Focal type	Angle Stop	Size (mm)	Index y
None	75	8	
Focal (mm)	1st Element		Slew (°)
1000	1		90
Wave Type		Angle Step	
SV	32	1	
DISPLAY			
Ray tracing	Disp. 1st Ray	Disp. Last Ray	Leg
	2	2	
Beam width	-6	-6	dff
Wedge Ray-Trac	Off	Off	
View Mode	Angle corrected		
Mirror (TOFD)	Off		
Blind zone (TOFD)	Off		

Select the field & step, then click on "+".

Comments

BEAM STATISTICS	Passive	First	Last
Steering angle		-8.8	88.3
Max steering (in wedge)		38.5	38.5
Min Beam angle		8.7	8.7
Max Beam angle		38.8	38.8
Fresnel distance (depth)	25.4	10.2	2.7 mm
FresnelZ (depth)	12.7	2.2	8.2 mm
Focusing Coef		63.2	183.8
Focusing Effect		No	No
Angles mode convert		90.0	90.0
TOFD 1st Ray			
Wedges separation (front to	26.3 mm		
Lateral wave arrival time	16.982 µs		
Backwall arrival time	23.275 µs		
Delta T	6.293 µs		

rev 3F-Test 060227

GE Modeling Tool – Excel Spreadsheet Volume Correction Mode

PROBE			
Probe DAT	Probe GED	Wedge DAT	Wedge GED
Type	Frequency	Angle (°)	Velocity (m/s)
	15.124.500	4	36
Name	Nbr of Elements	Opt. Beam (°)	Offset X (mm)
	32	5Lb	14
Set Nr	Pitch (mm)	Set Nr	Offset Y
	0.5		
	Elevation (mm)	Element 1 positio	Offset Z (mm)
	10	Low End	11
PART			
Plan	Cored	Plan Weld	
Velocity LV (m/s)	Velocity L	Type	
5920		None	Weld Wiz
Velocity SV (m/s)	Velocity T	OverCap (mm)	
2100		15	TOFD Wiz
Thickness (mm)	Thickness	LowerCap (mm)	
25		0	
SCAN			
Elec Scan	Scan Pat	Aperture	Probe Offset
Type	Angle Start	Size (Nbr of Ele.)	Index X (mm)
Sectorial	38	16	13.1
Focal type	Angle Step	Size (mm)	Index y
None	75	8	
Focal (mm)	1st Element		Skew (°)
1000	1		90
Wave Type		Angle Step	
SV		37	1
DISPLAY			
Disp. 1st Rag		Disp. Last Rag	
Rag tracing	2	2	Leg
Beam width	-6	-6	dB
Wedge Rap-Trac.	Off	Off	
View Mode	Volume Corrected		
Mirror (TOFD)	Off		
Blind zone (TOFD)	Off		

Select the field to step, then click on "+".

Delay (ns)

Index X (mm)

Value (X) axis

Index X (mm)

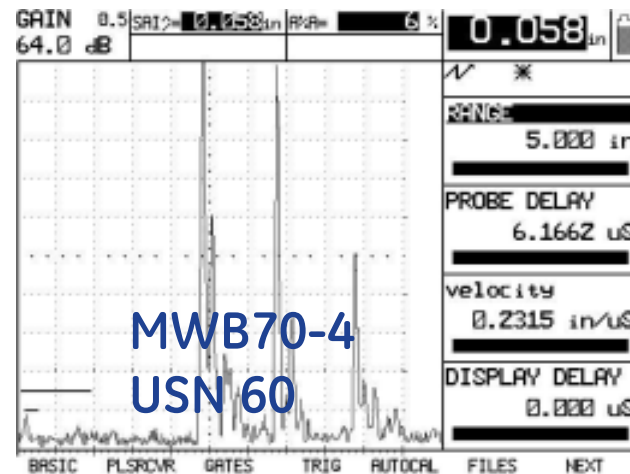
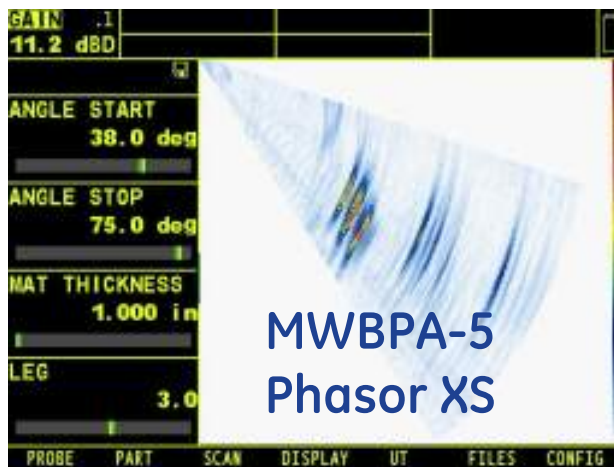
Comments

BEAM STATISTICS	Passive	First	Last
Steering angle		-8.4	10.3
Max steering (in wedge)		35.5	35.5
Min Beam angle		8.7	8.7
Max Beam angle		90.0	90.0
Fresnel distance (depth)	25.4	10.2	2.7 mm
Fresnel2 (depth)	12.7	2.2	0.2 mm
Focusing Coef		53.2	193.8
Focusing Effect		No	No
Angles mode convert		90.0	90.0
TOFD 1st Rag			
Vedges separation (front to	26.3 mm		
Lateral wave arrival time	16.982 μs		
Backwall arrival time	23.276 μs		
Delta T	6.293 μs		

Method

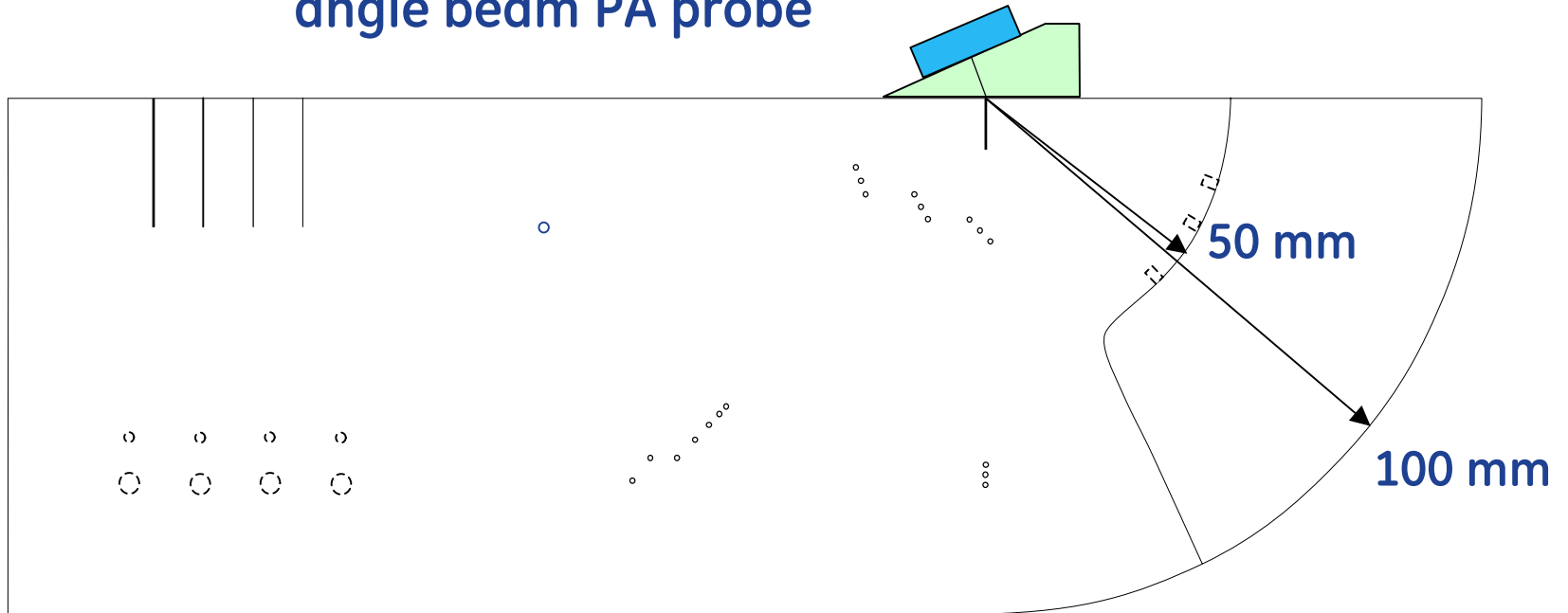
- Model the Beam from Phased array probe
- Place fixed angle conventional probe and phased array probe in same position on the block.
- Record display, compare results.

Subjective comparison and image observation

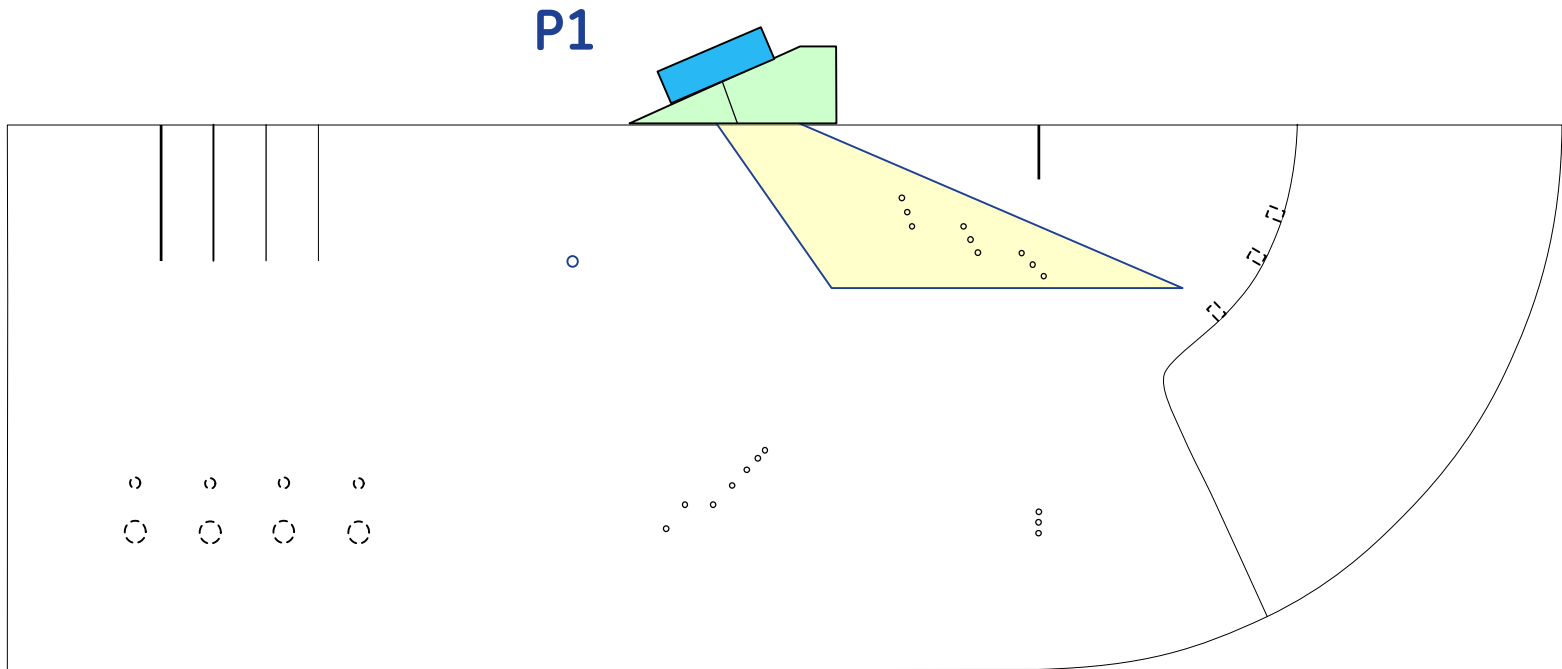


Calibration (angle)

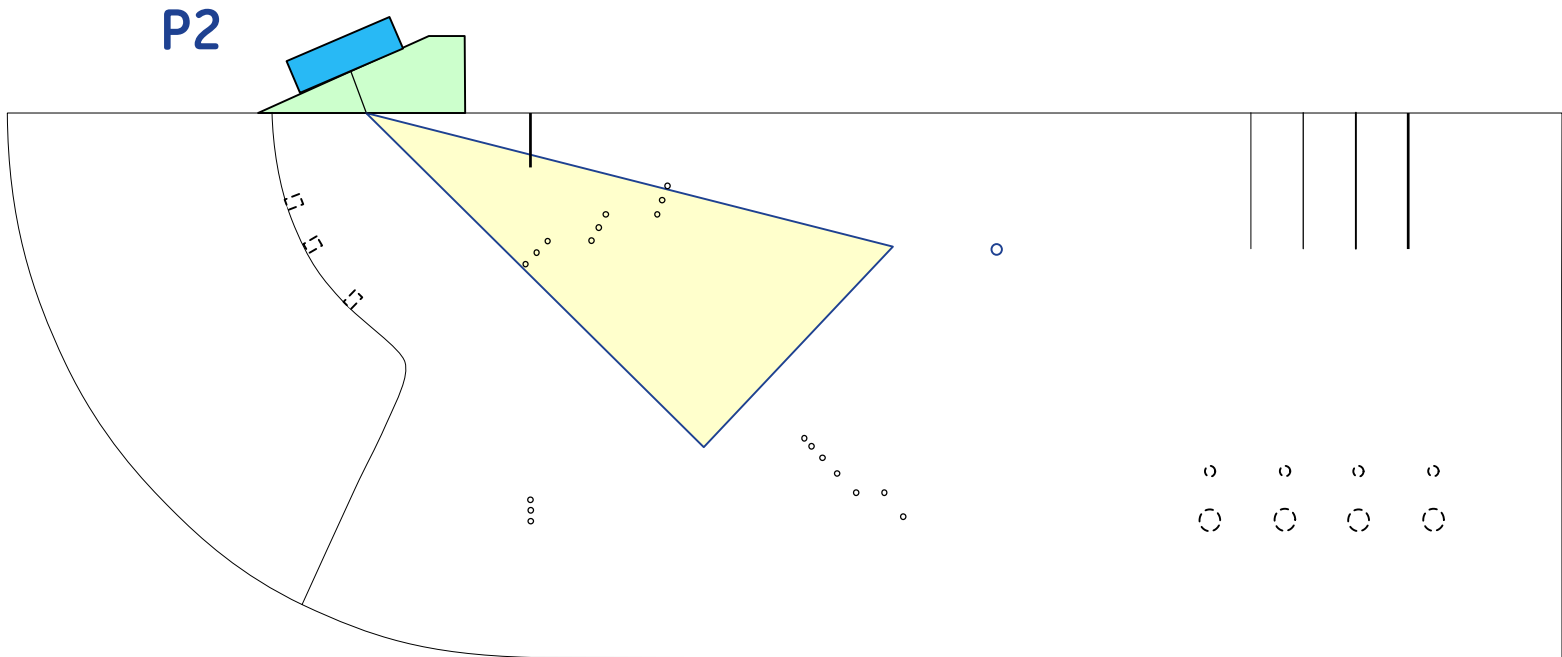
angle beam PA probe



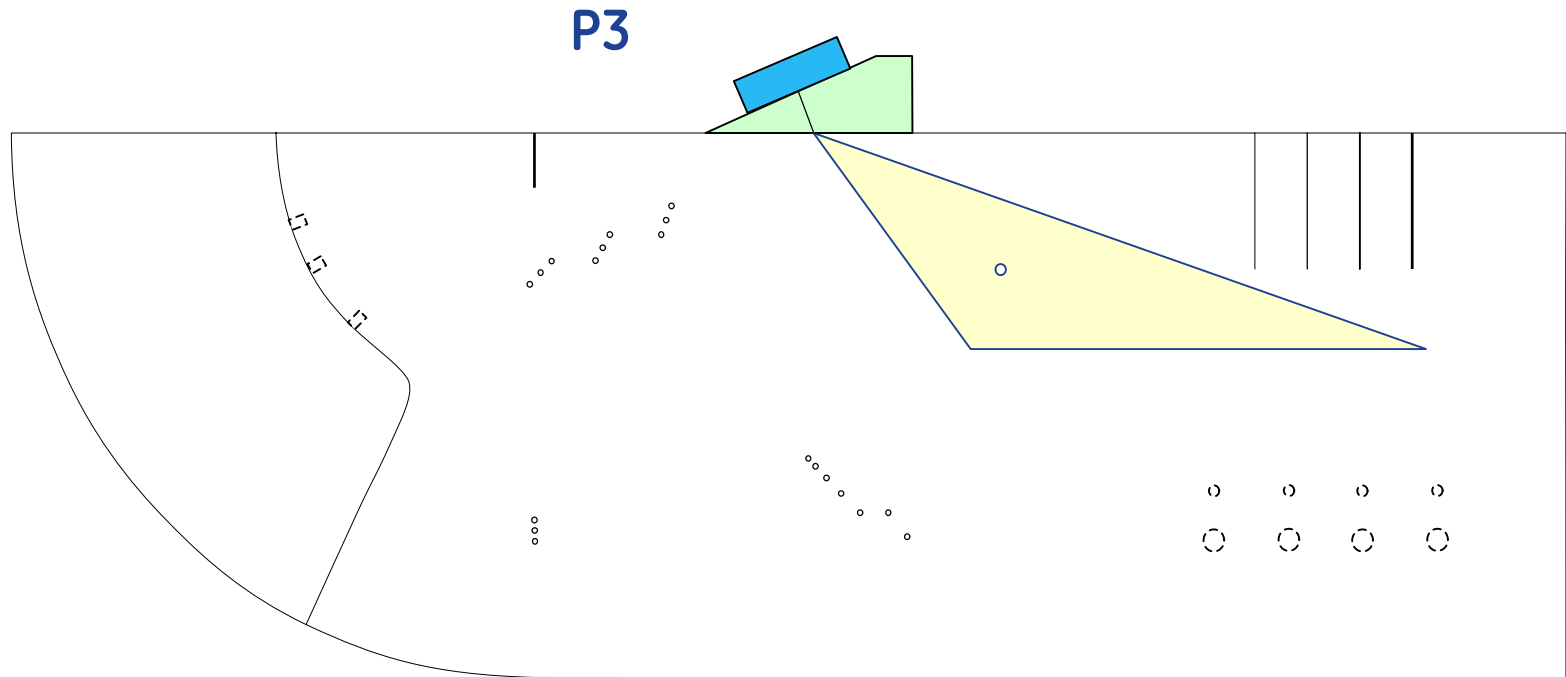
Angle scanning – 38°-75°



Angle scanning – 38°-75°

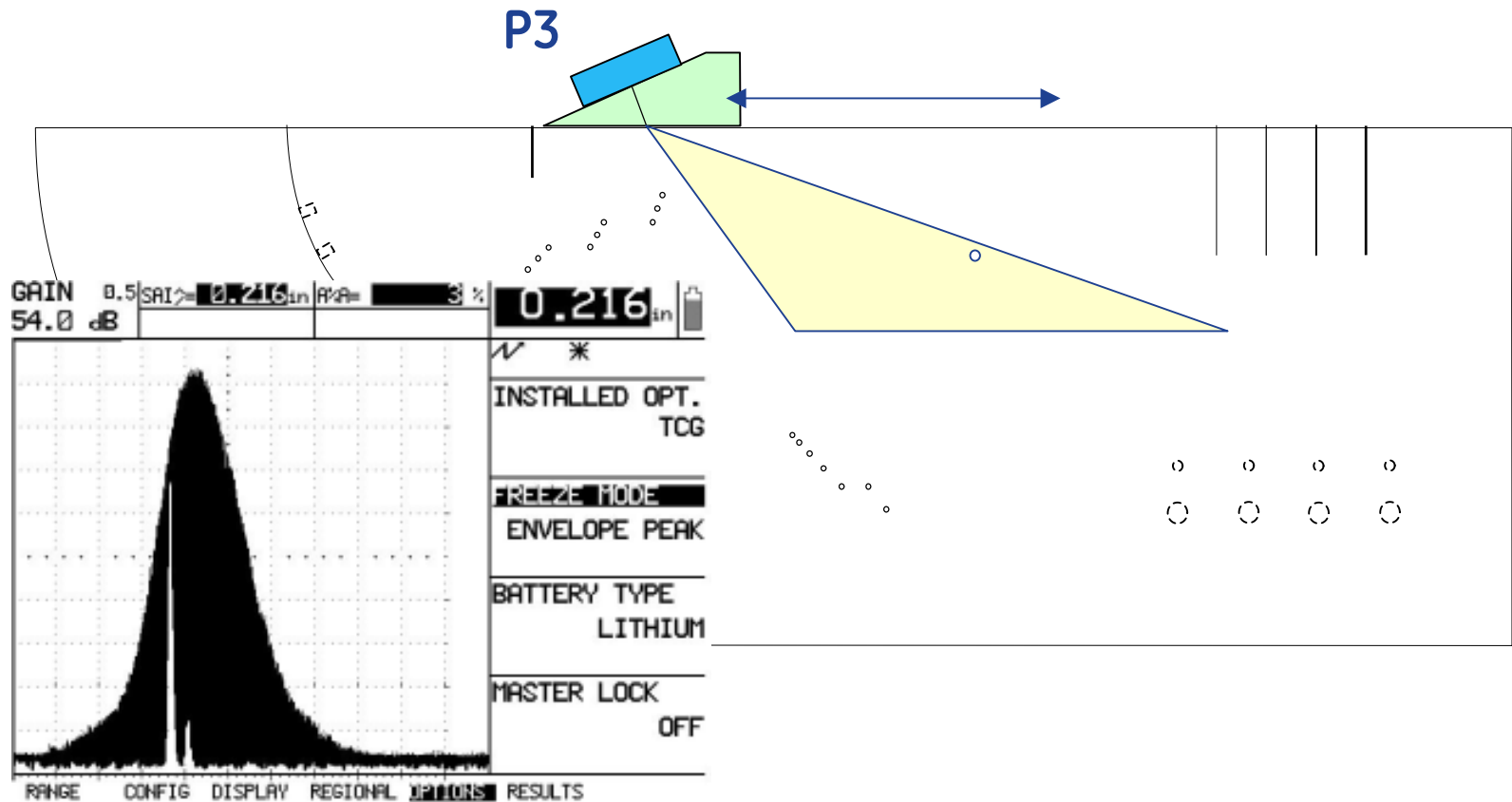


Probe at 2 mm SDH Angle scanning – 38°-75°



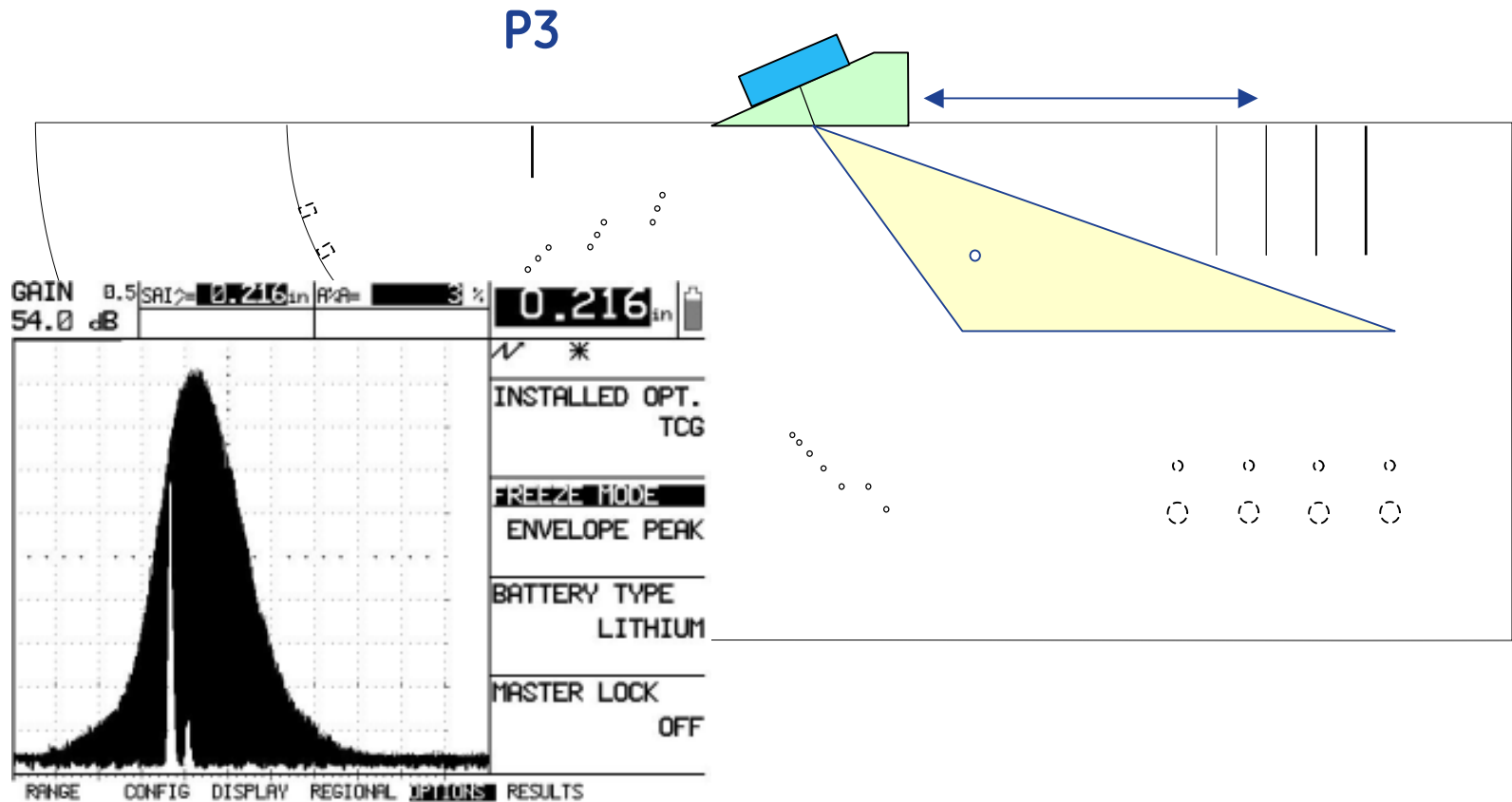
Probe at 2 mm SDH

Conventional probe was scanned forward and back



Probe at 2 mm SDH

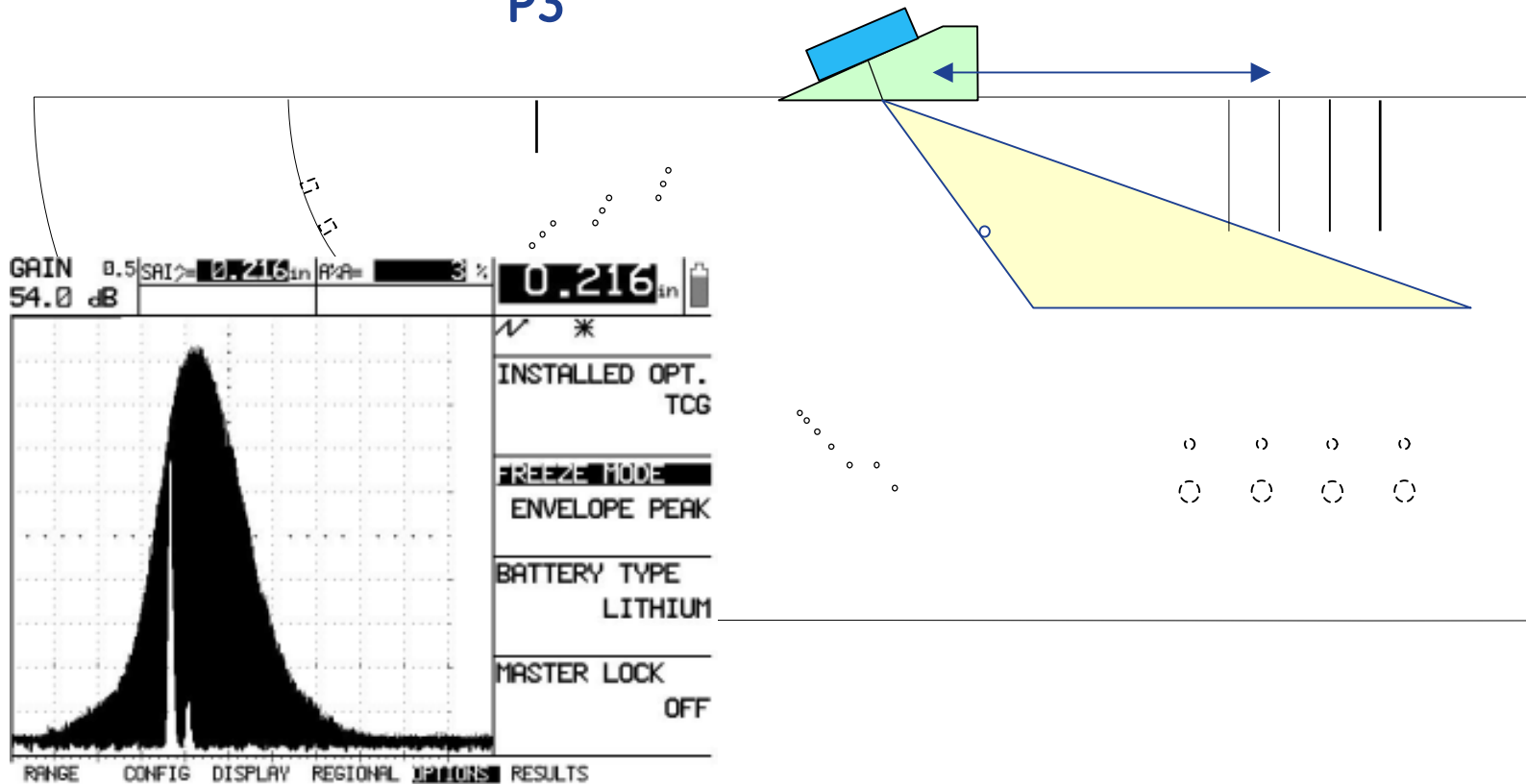
Conventional probe was scanned forward and back



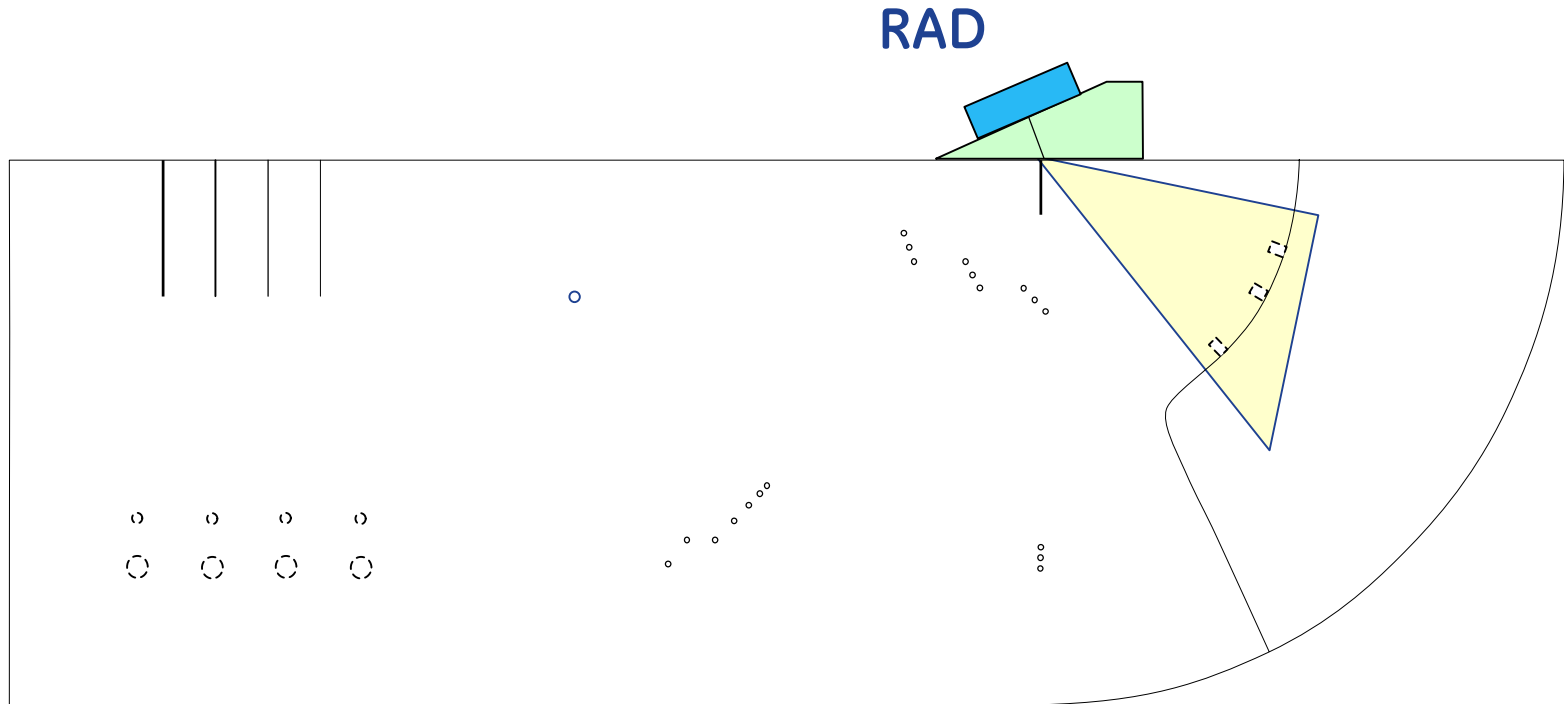
Probe at 2 mm SDH

Conventional probe was scanned forward and back

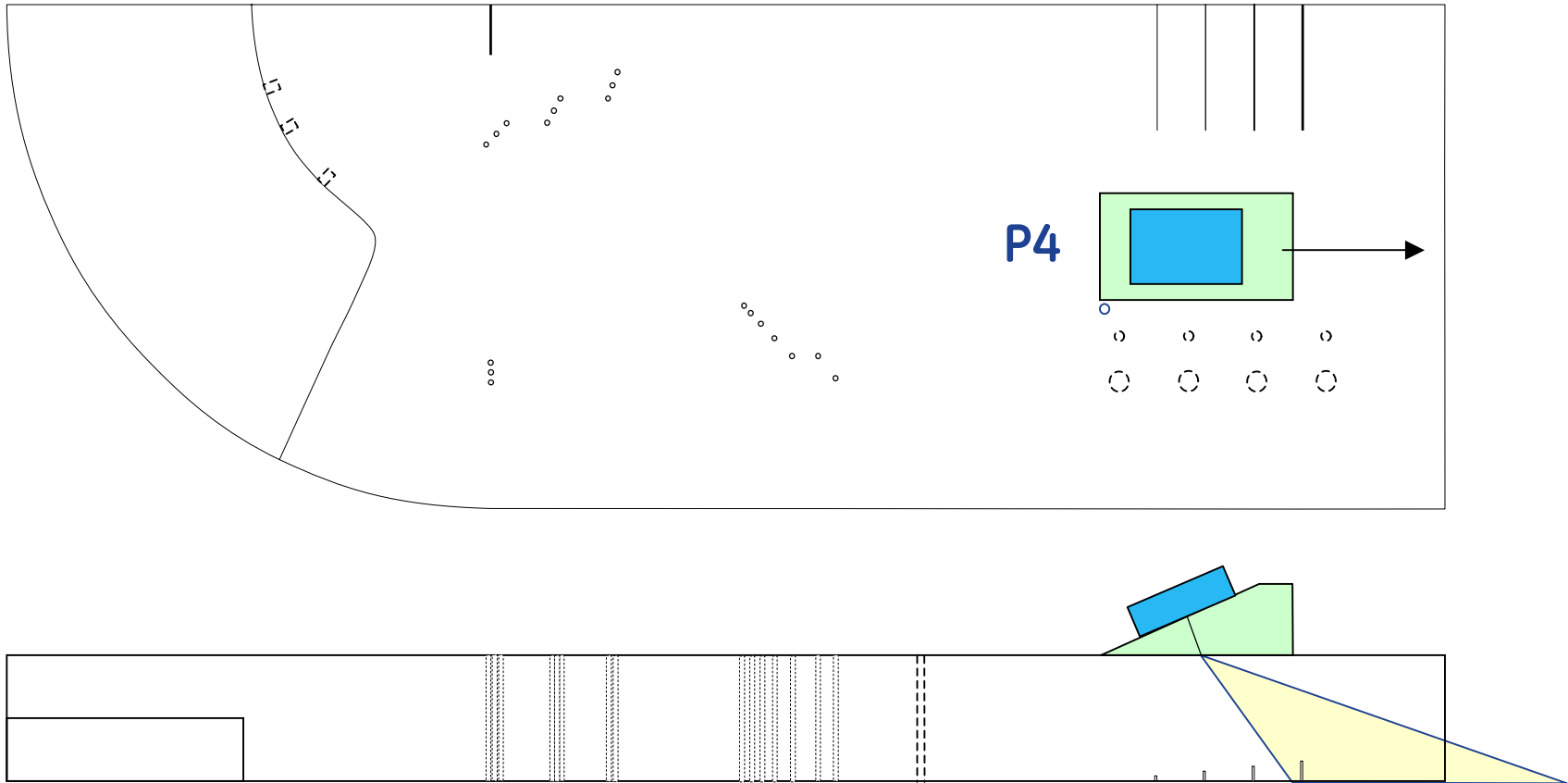
P3



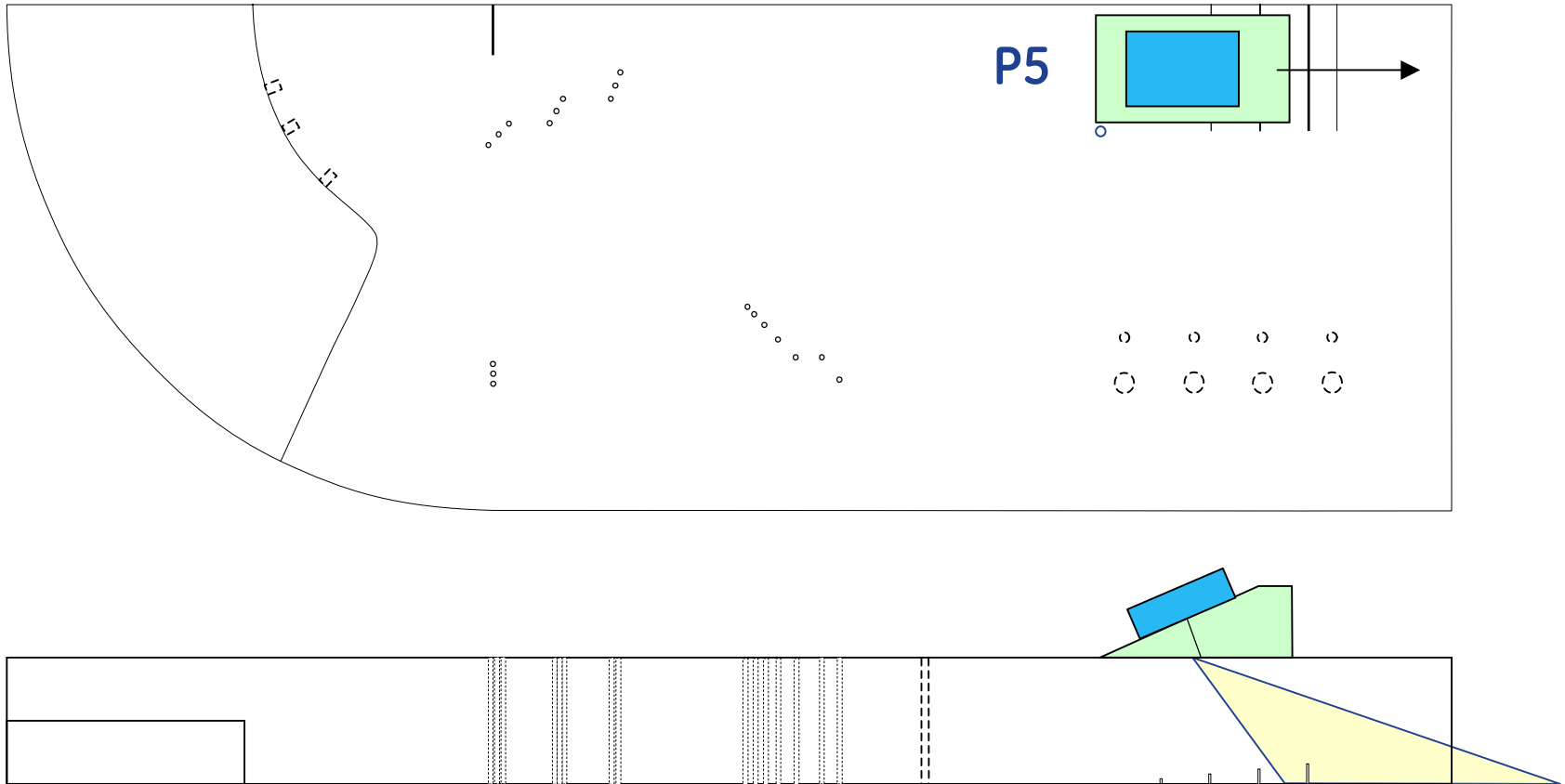
Angle scanning – 38°-75° – resolution before BW



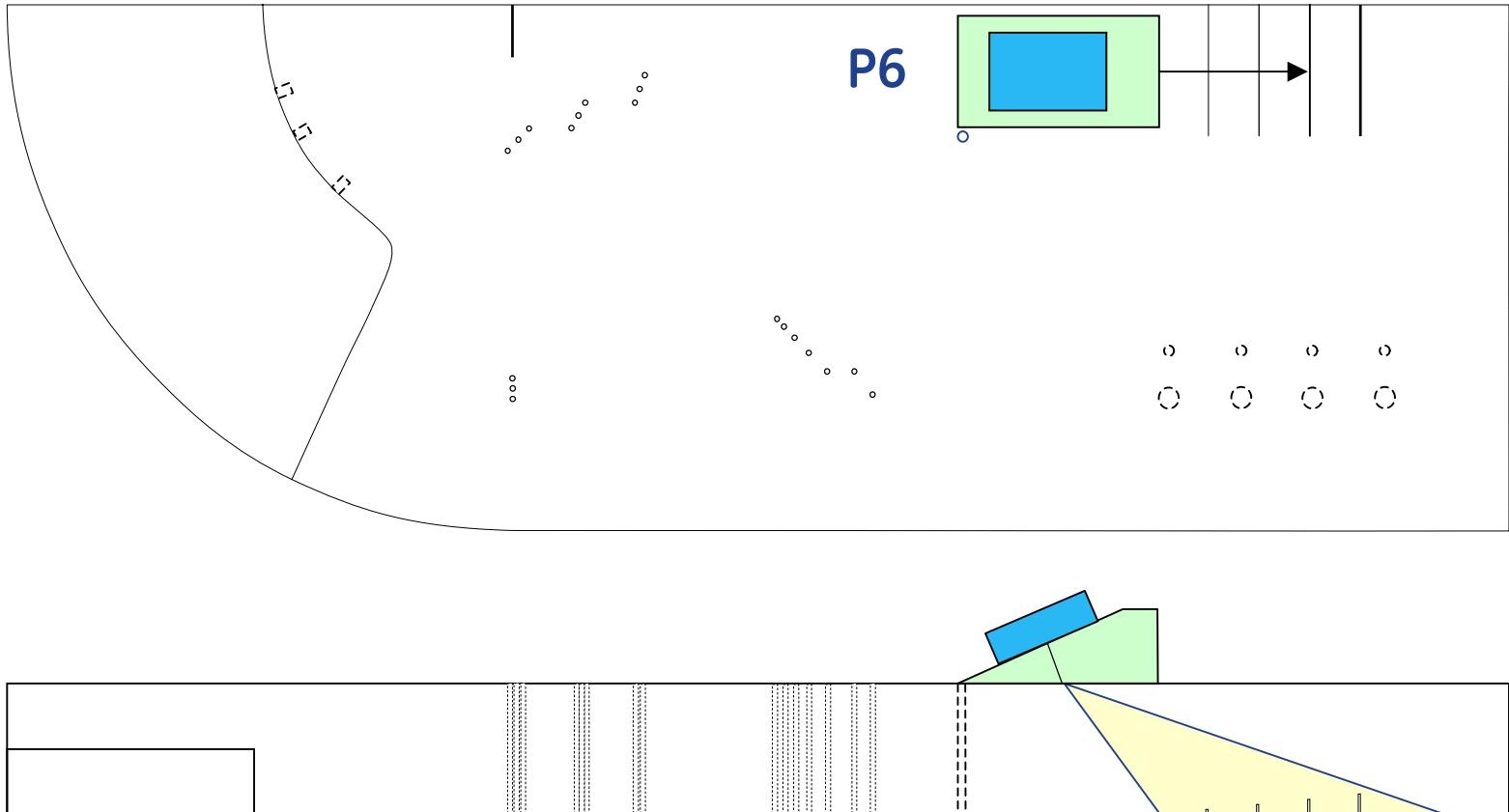
Angle scanning – Corner shot



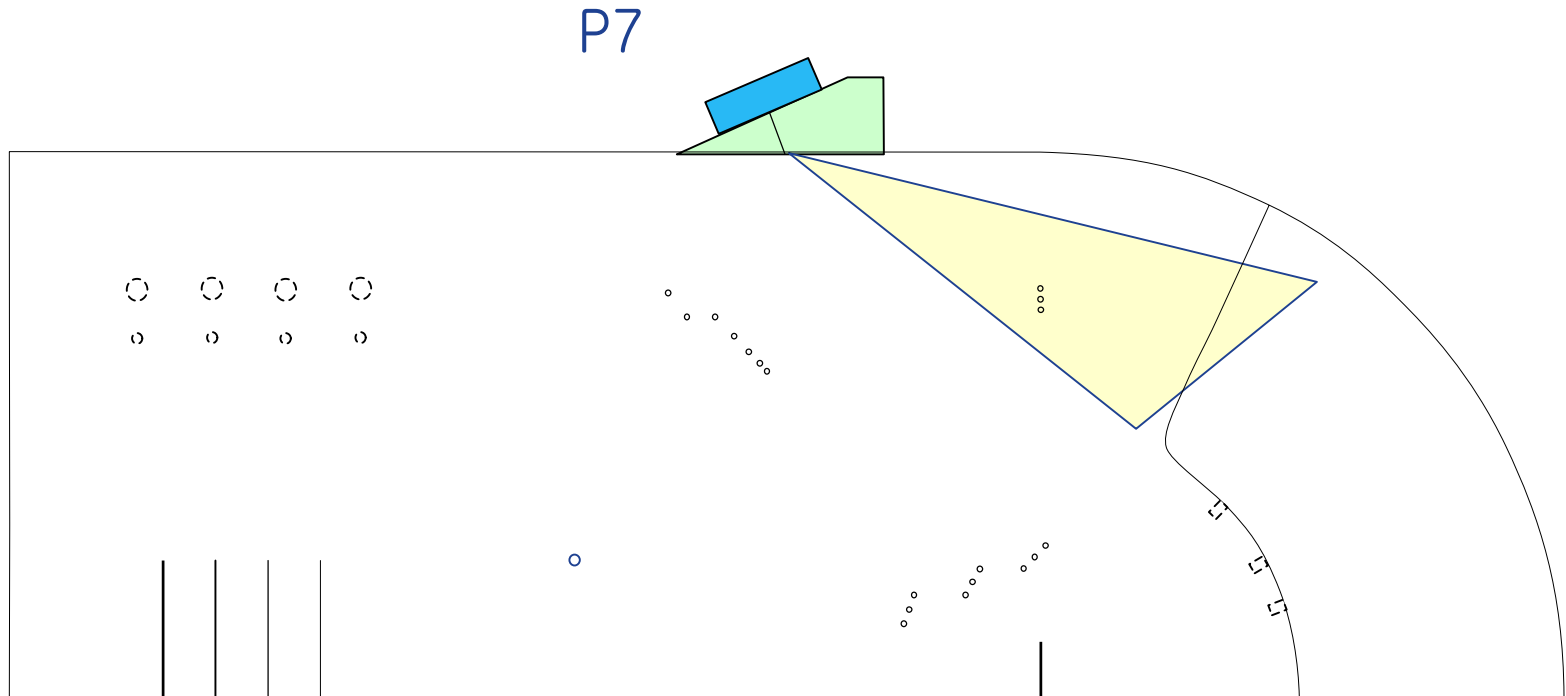
Angle scanning – crack evaluation



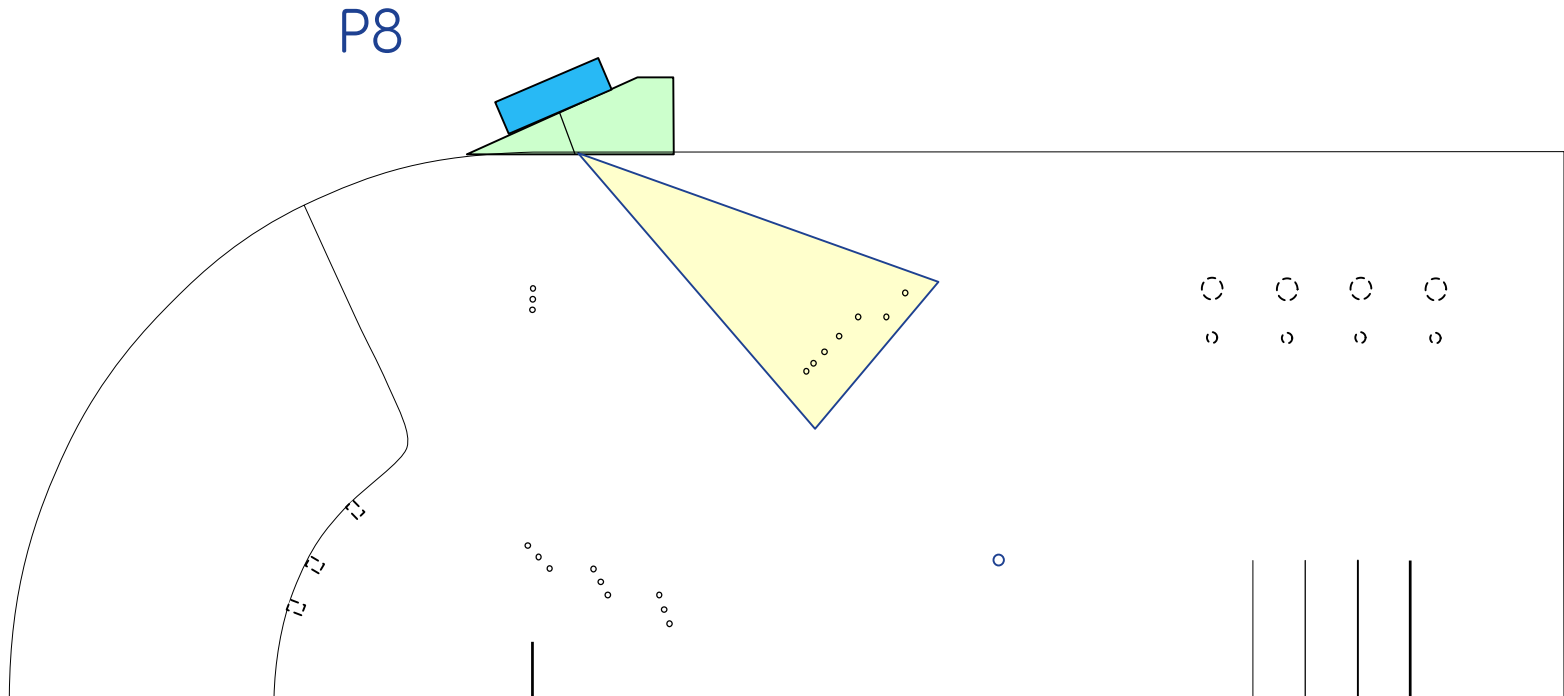
Angle scanning – crack evaluation



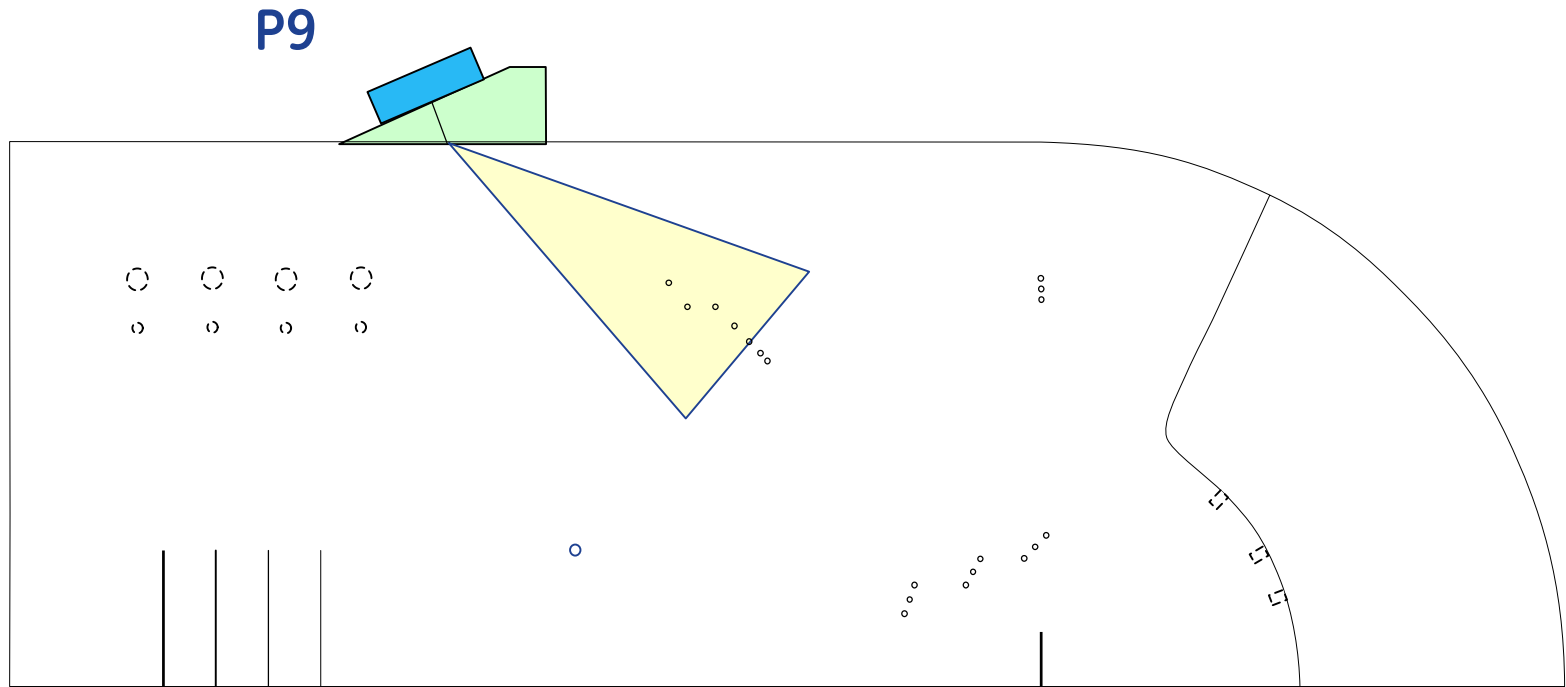
Angle scanning – resolution



Angle scanning – resolution



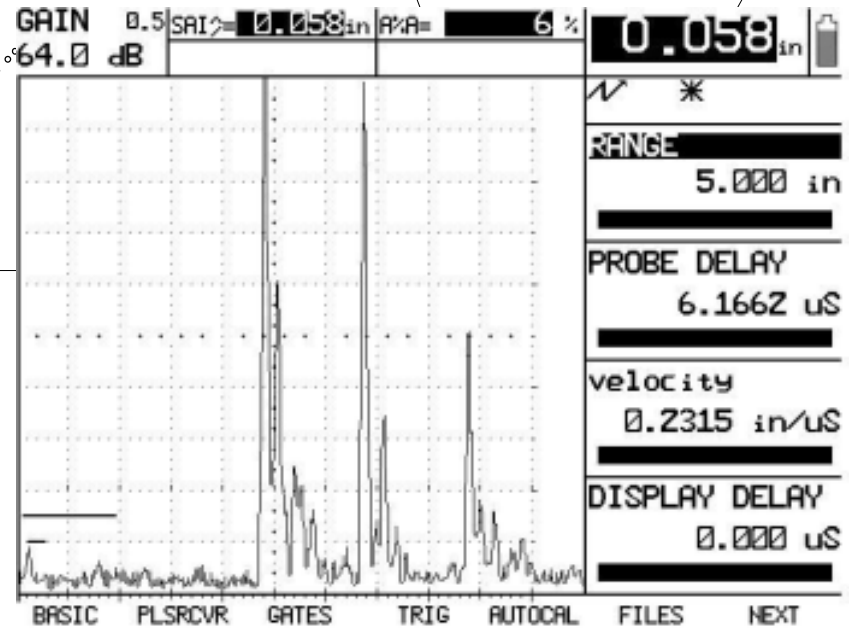
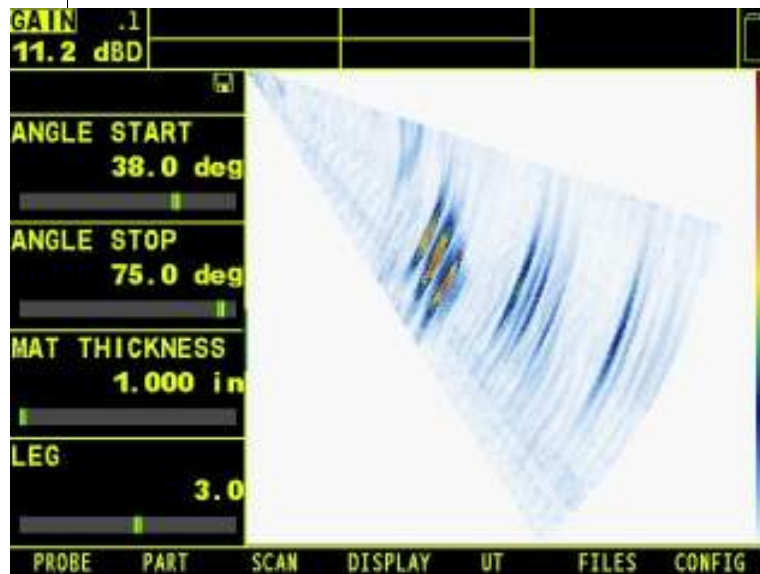
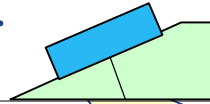
Angle scanning – resolution



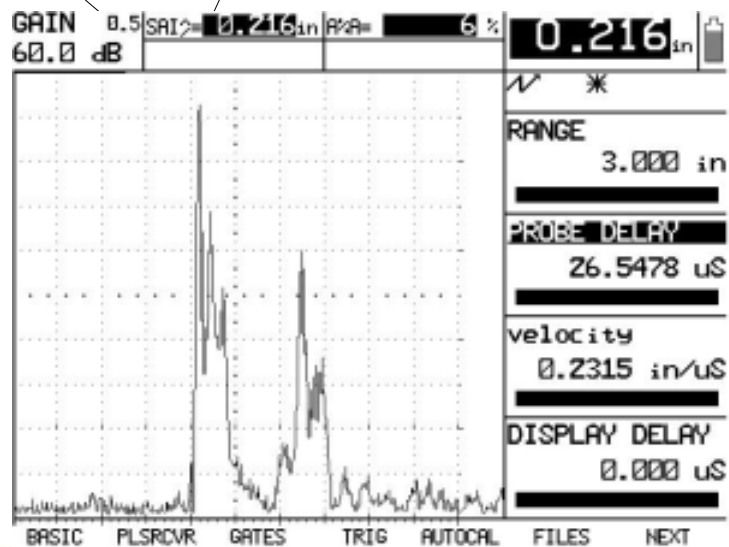
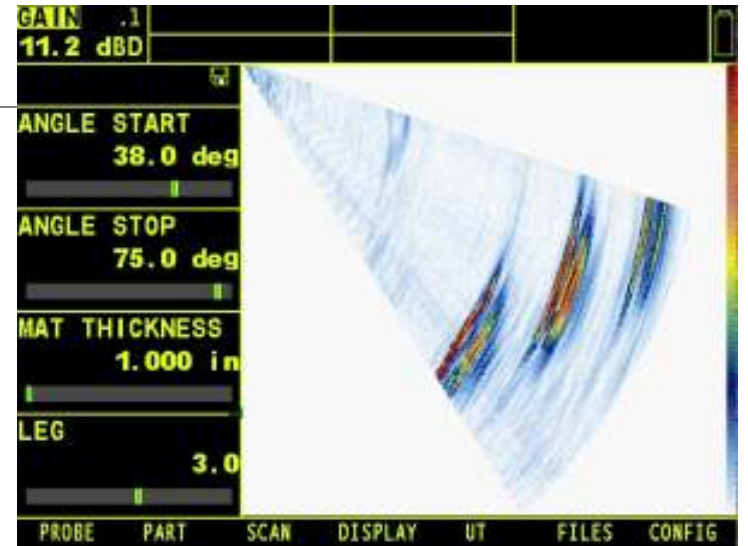
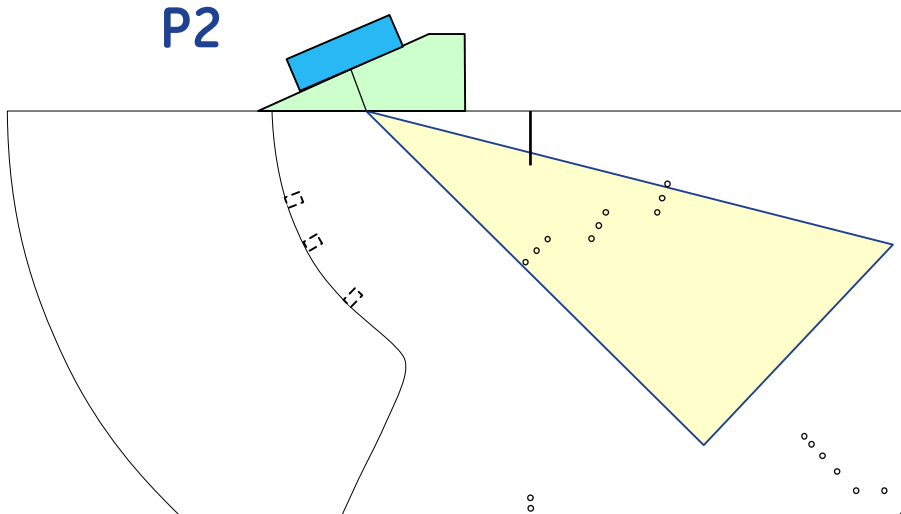
P1 – No probe movement

Conventional probe peaked on near holes

P1



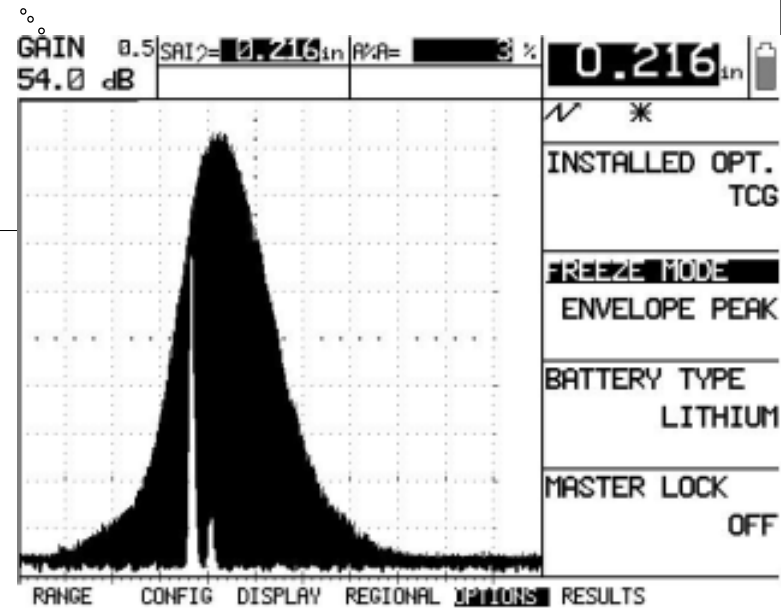
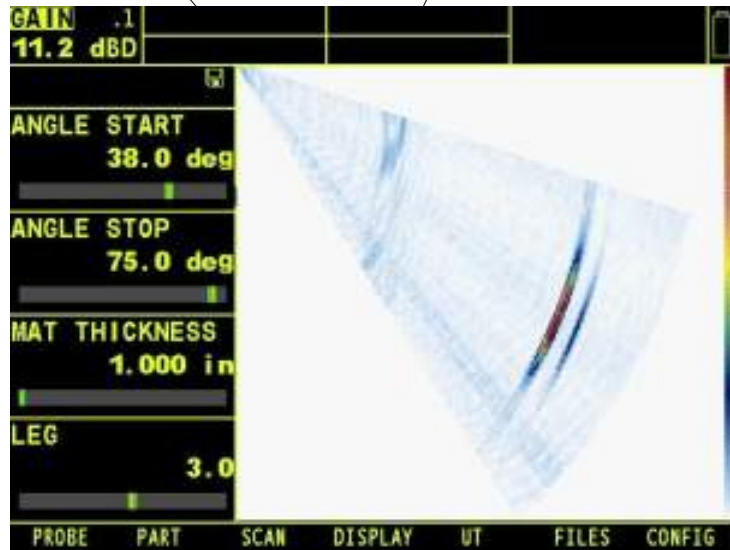
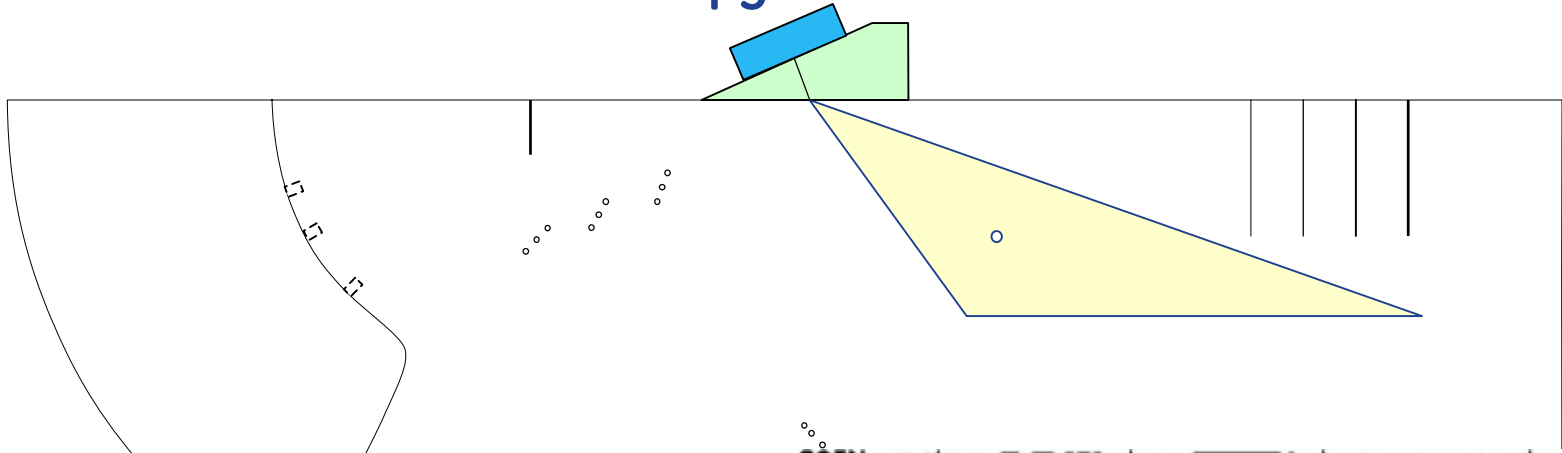
Angle scanning 1 – 38°-75° No probe movement



Probe normalization at 2 mm SDH - conventional probe scanned

Peak envelope recorded to show beamspread

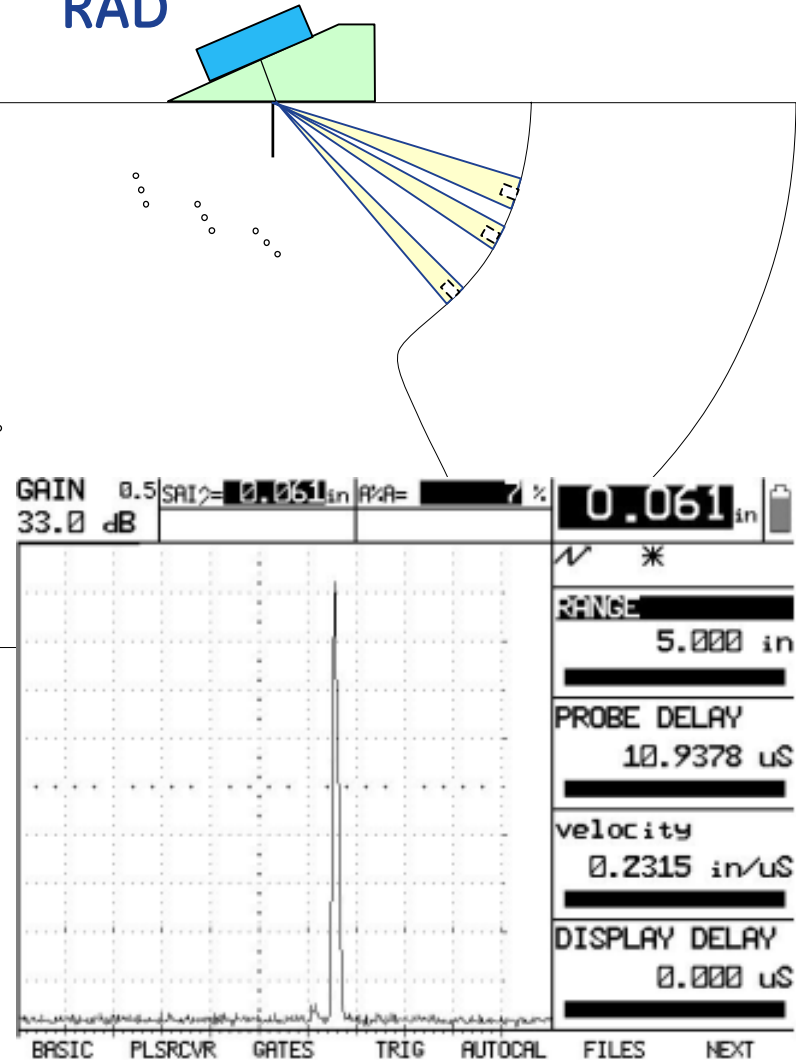
P3



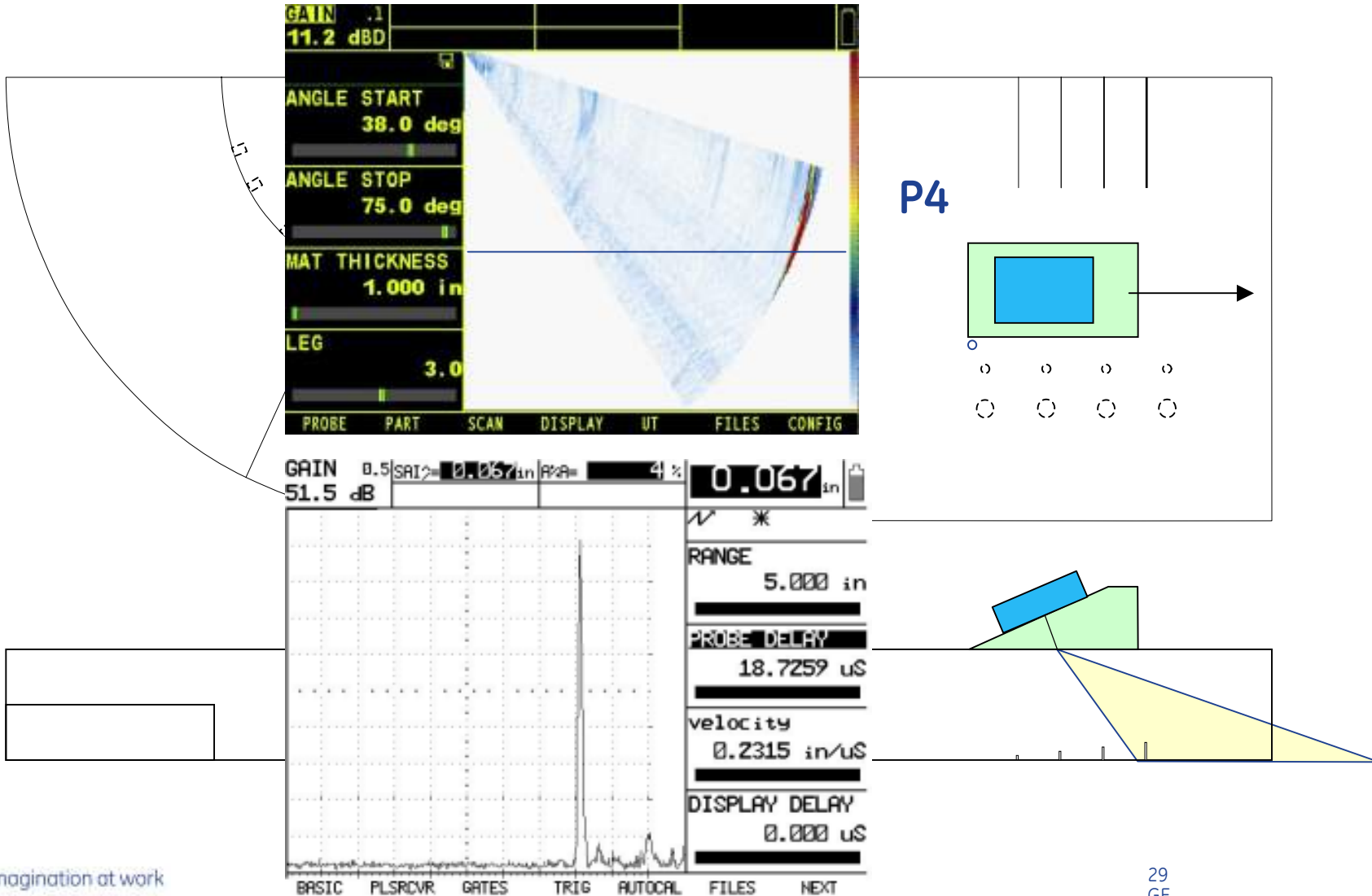
Angle scanning 5 – resolution before BackWall



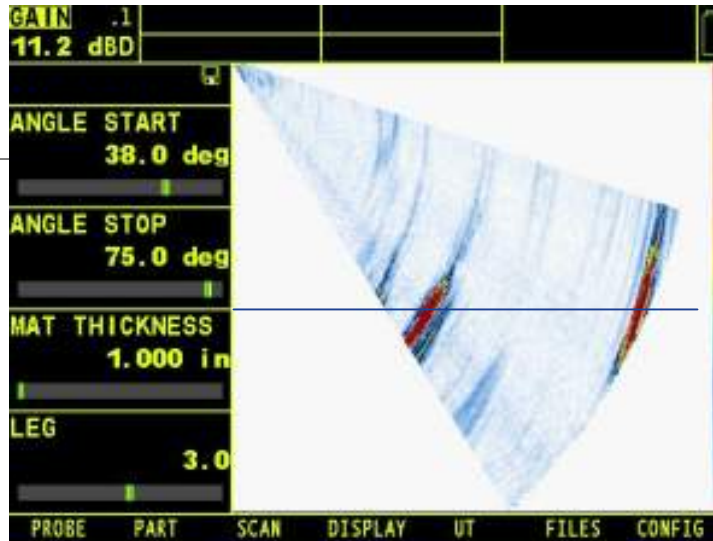
RAD



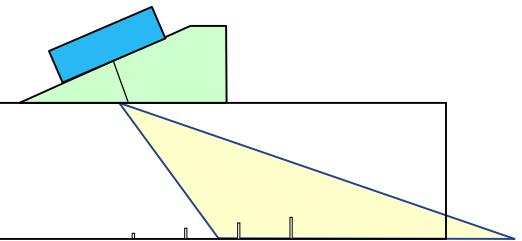
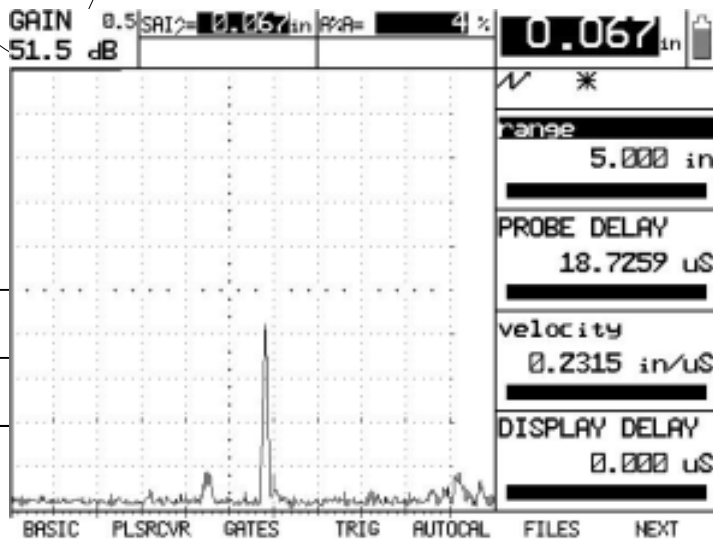
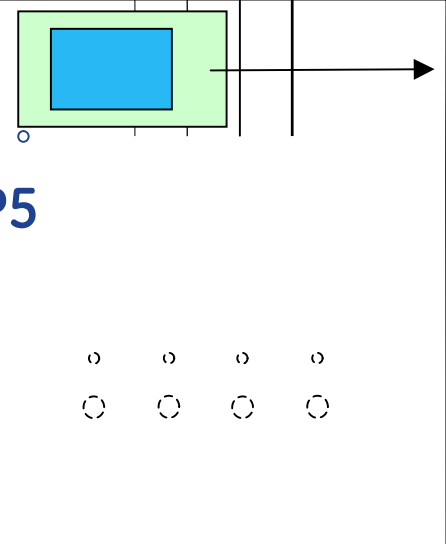
Angle scanning 5 – simulated crack evaluation



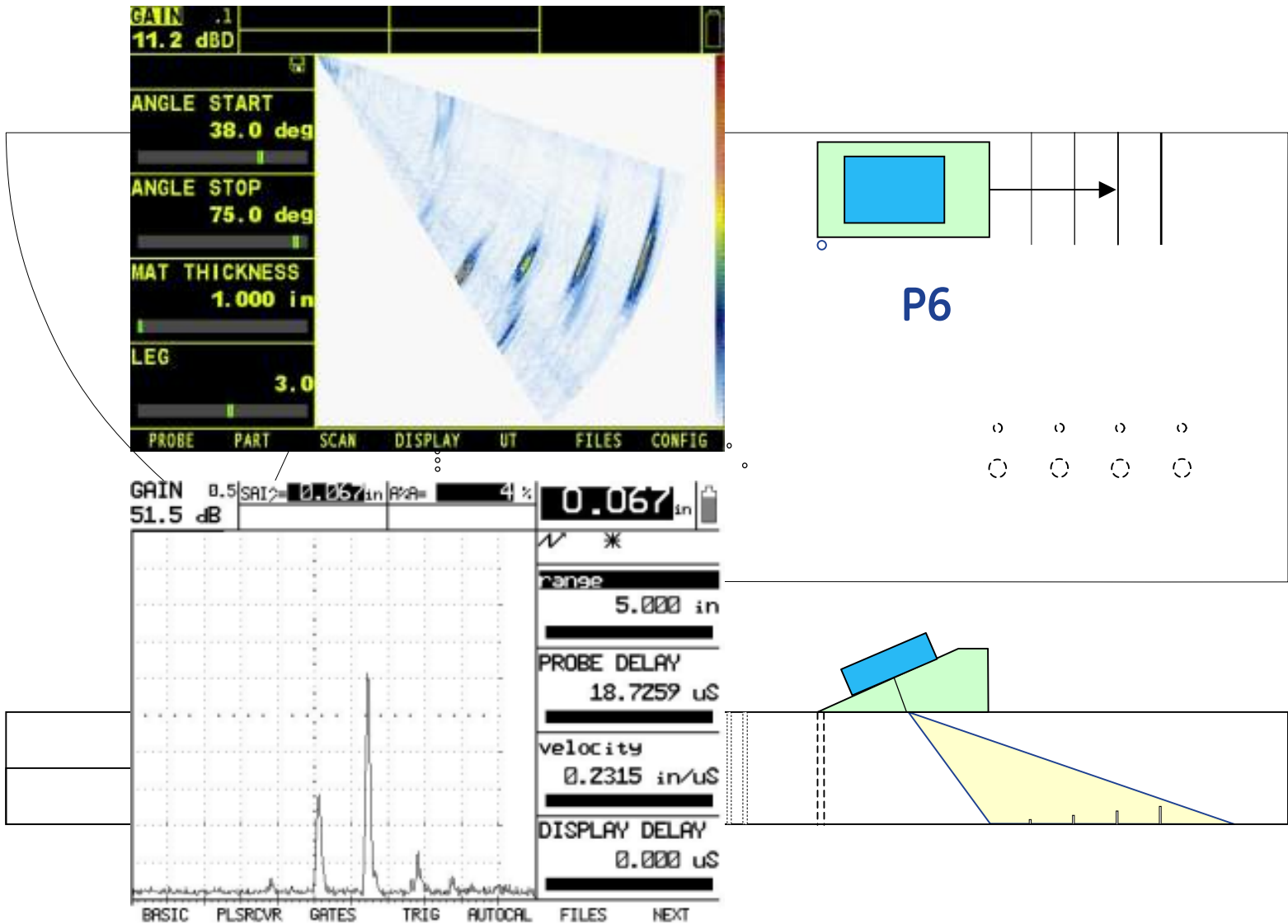
Angle scanning 5 – crack evaluation



P5

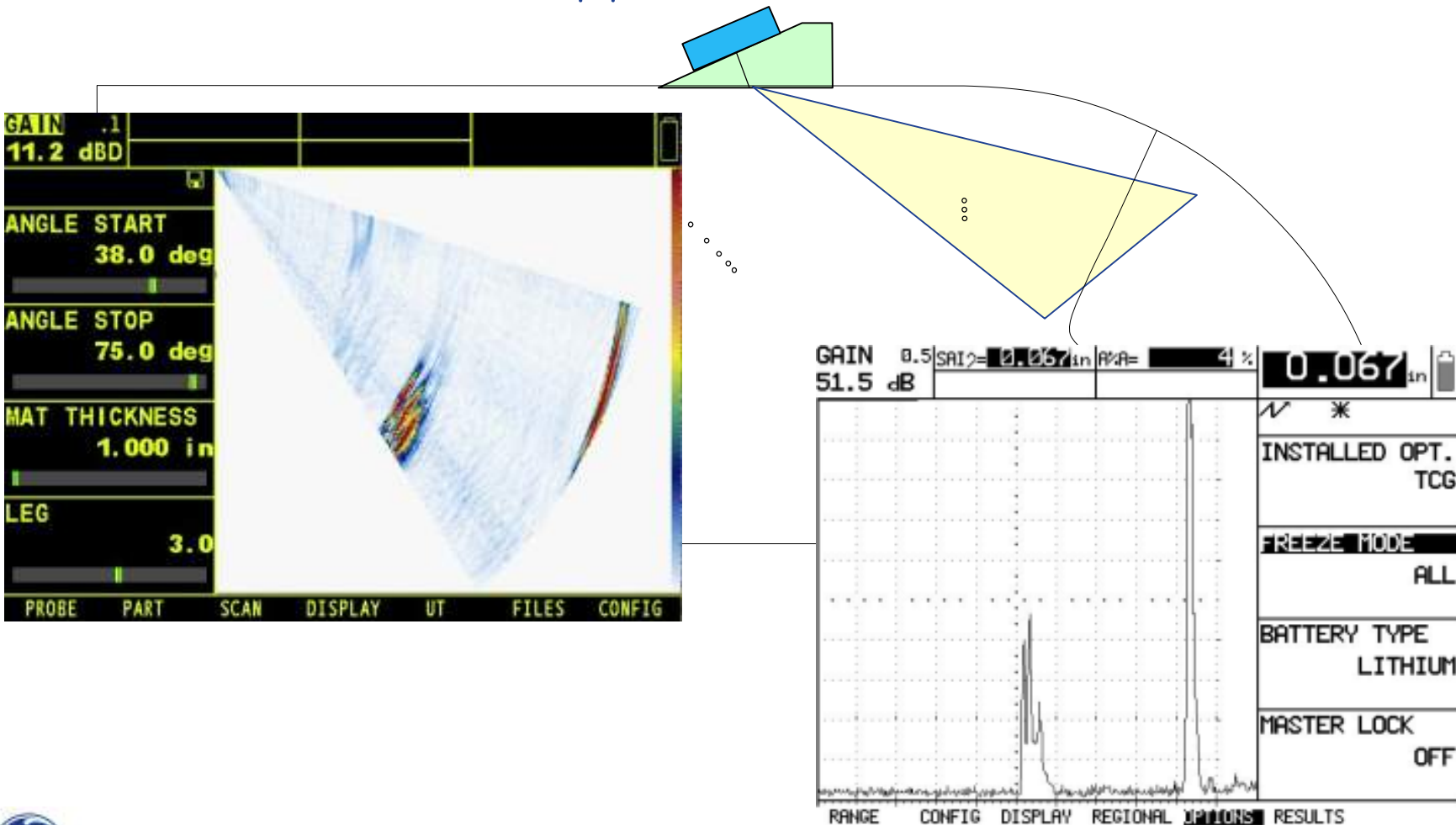


Angle scanning – simulated crack evaluation



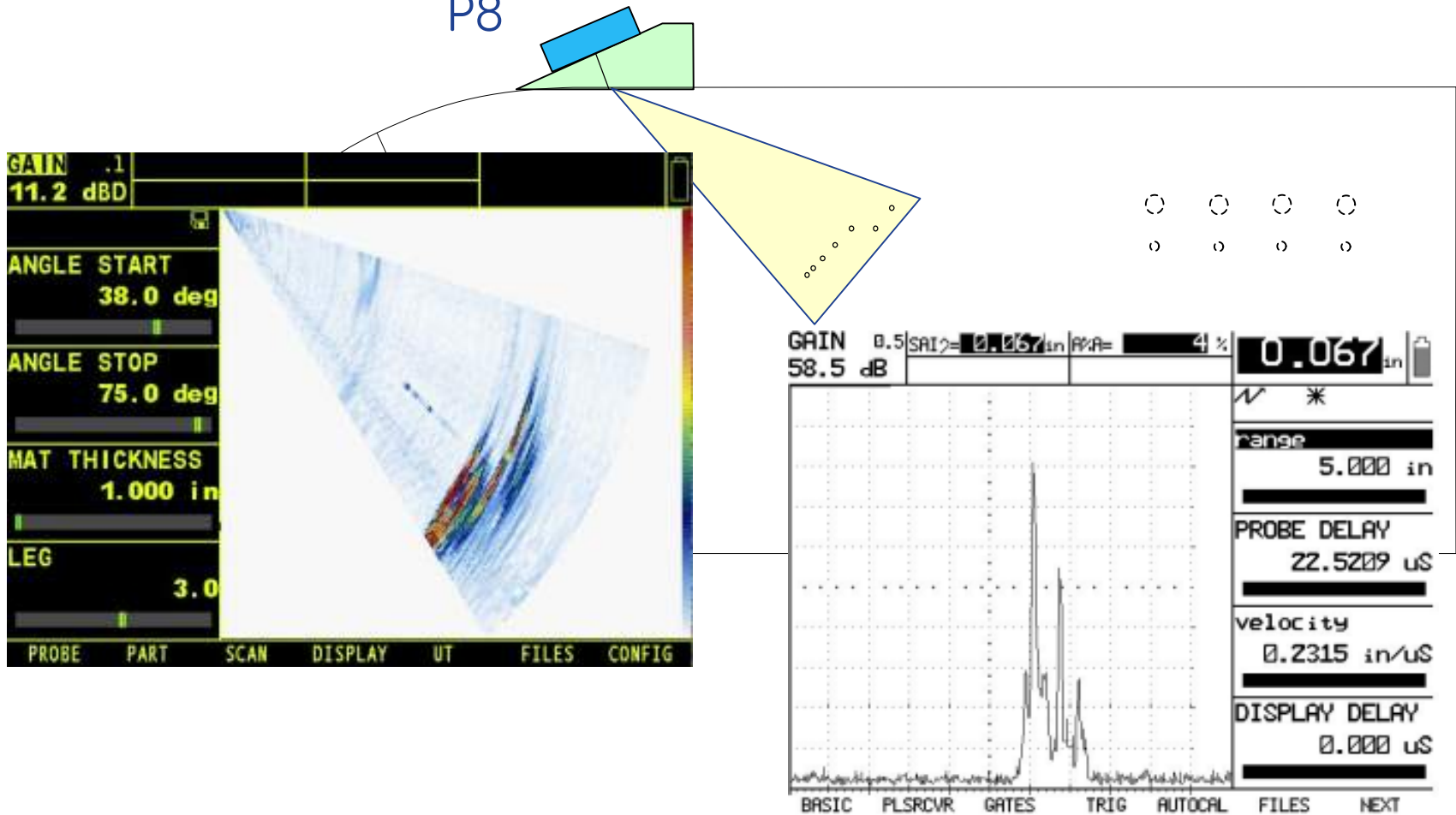
Angle scanning – 38°-75°

P7



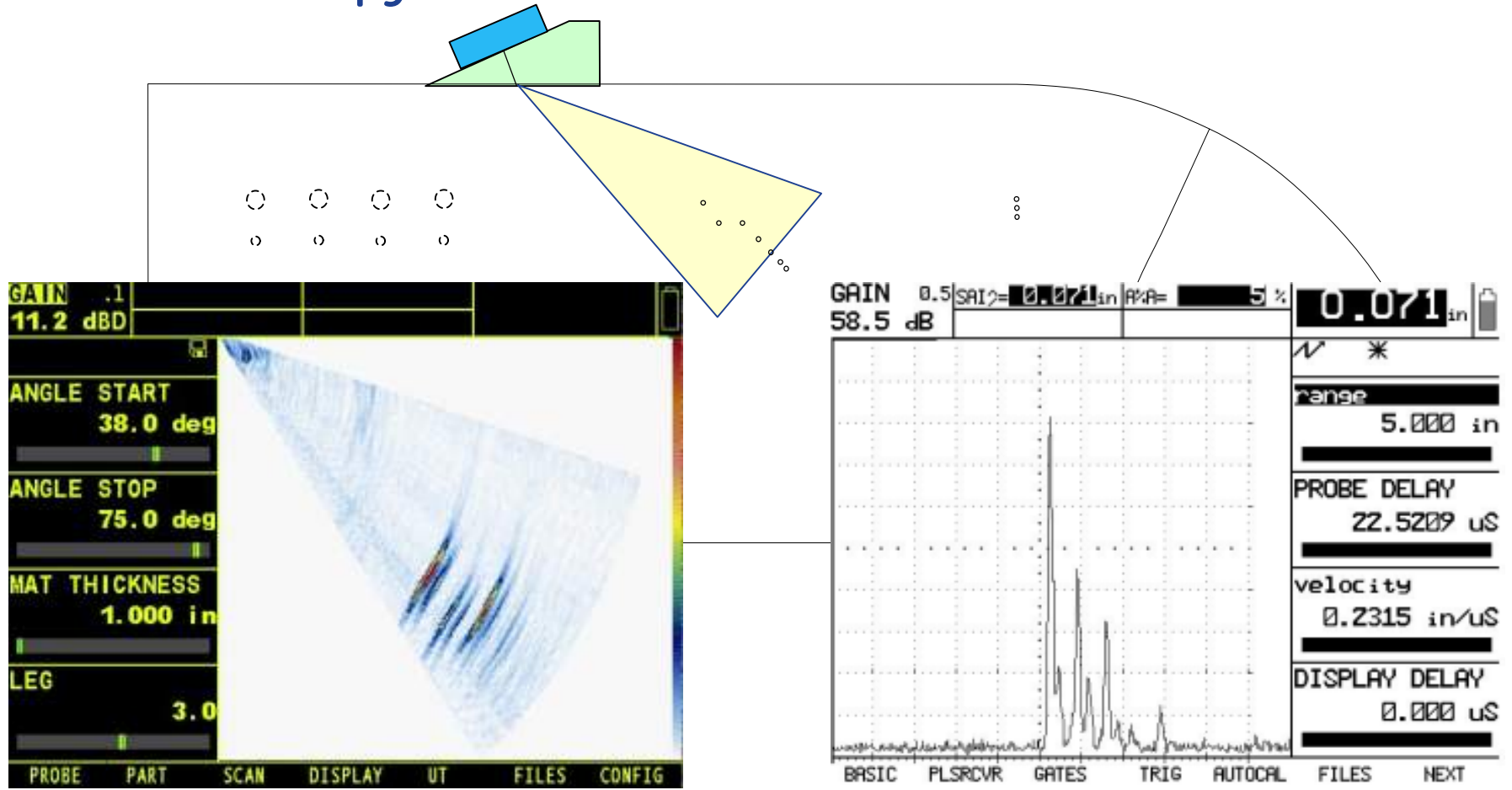
Angle scanning – 38°-75°

P8

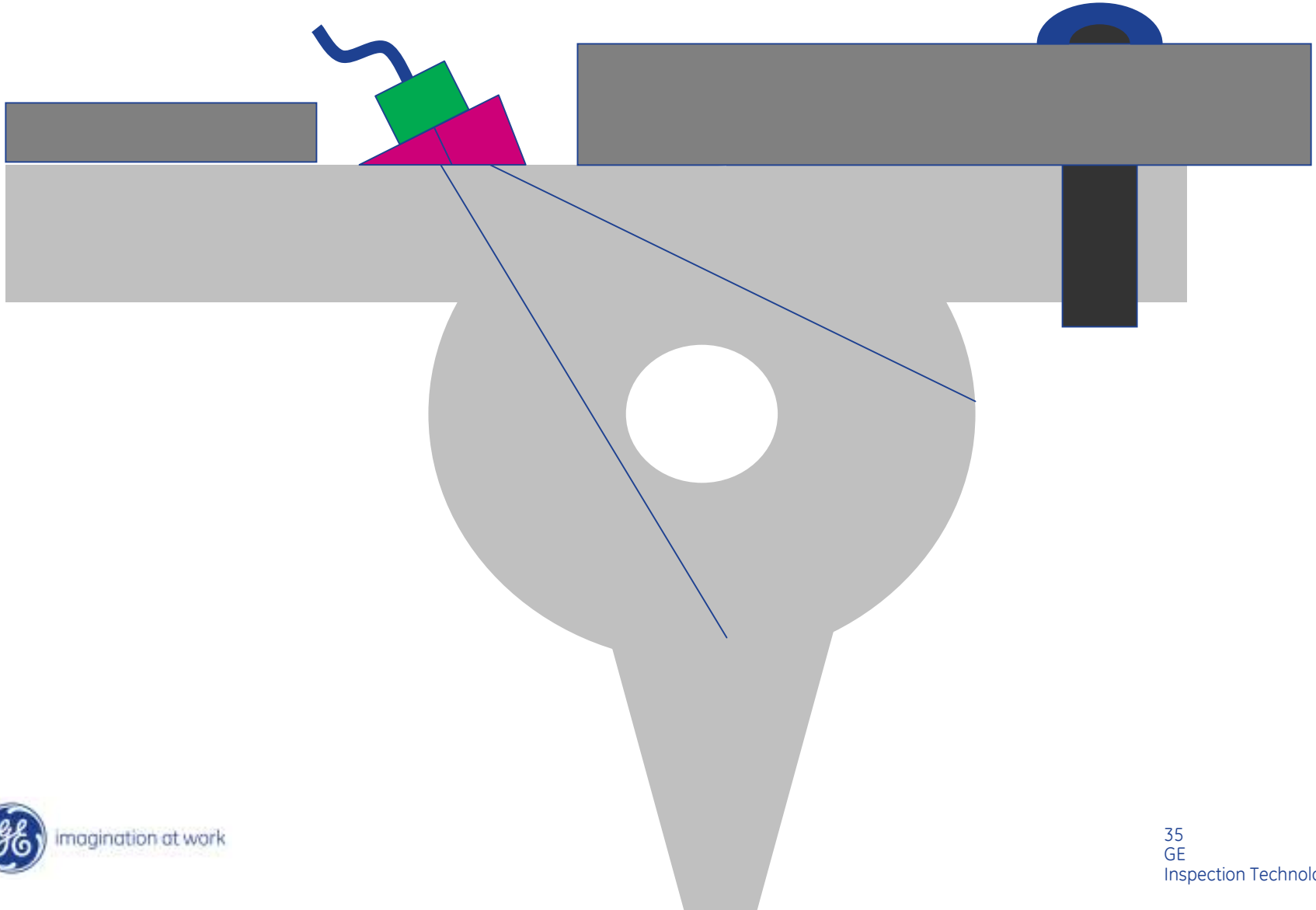


Angle scanning – 38°-75°

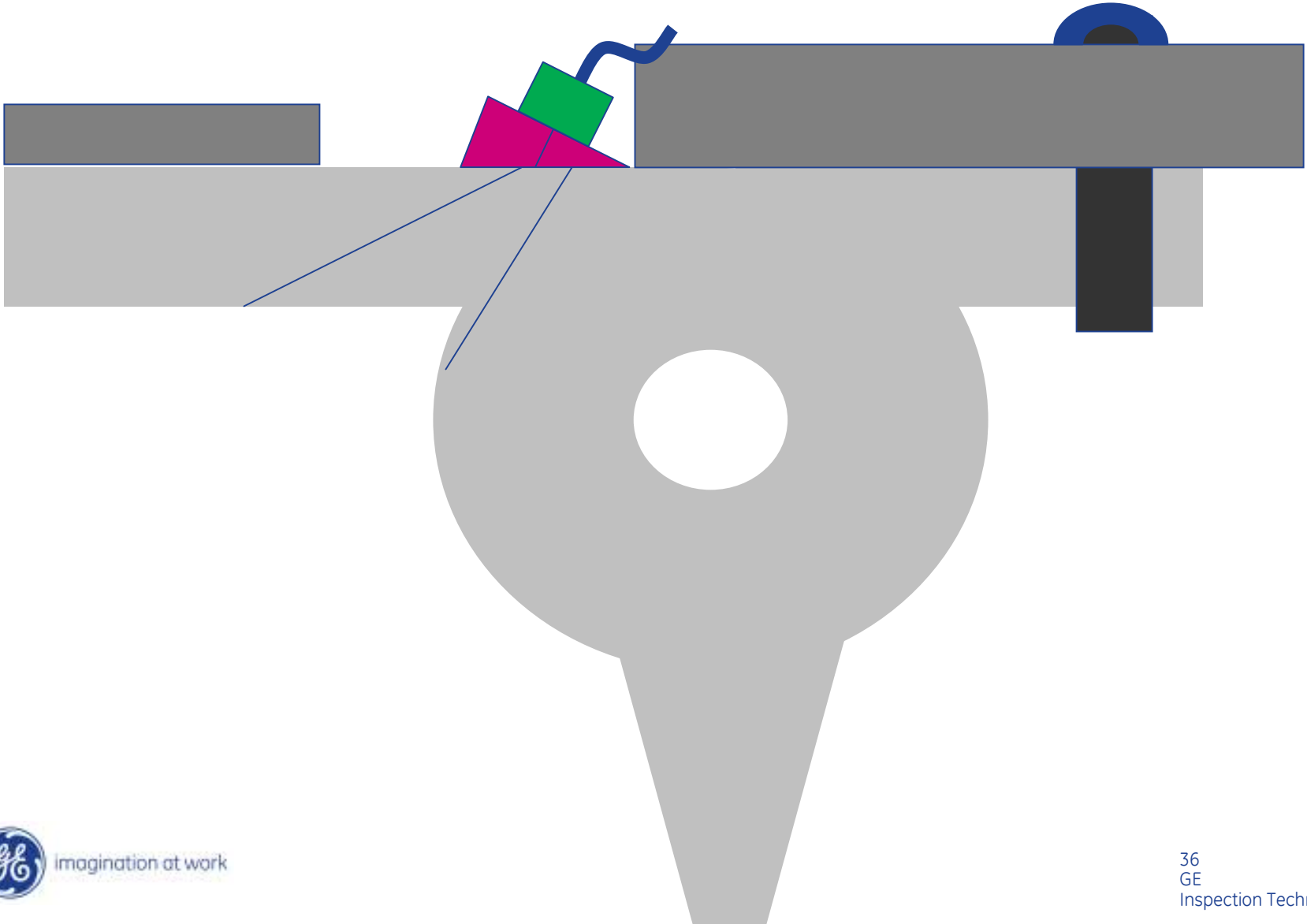
P9



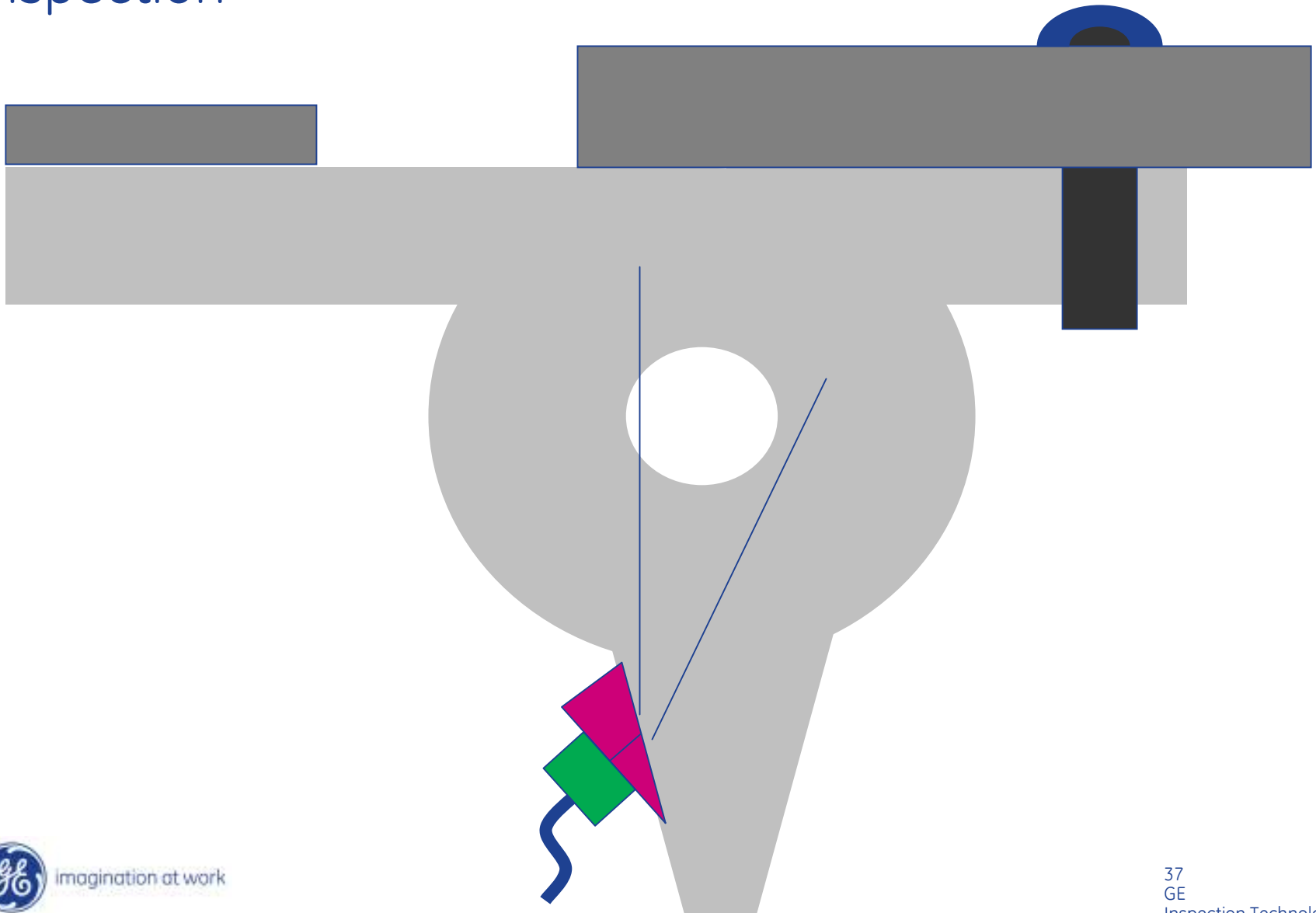
Limited access testing improved



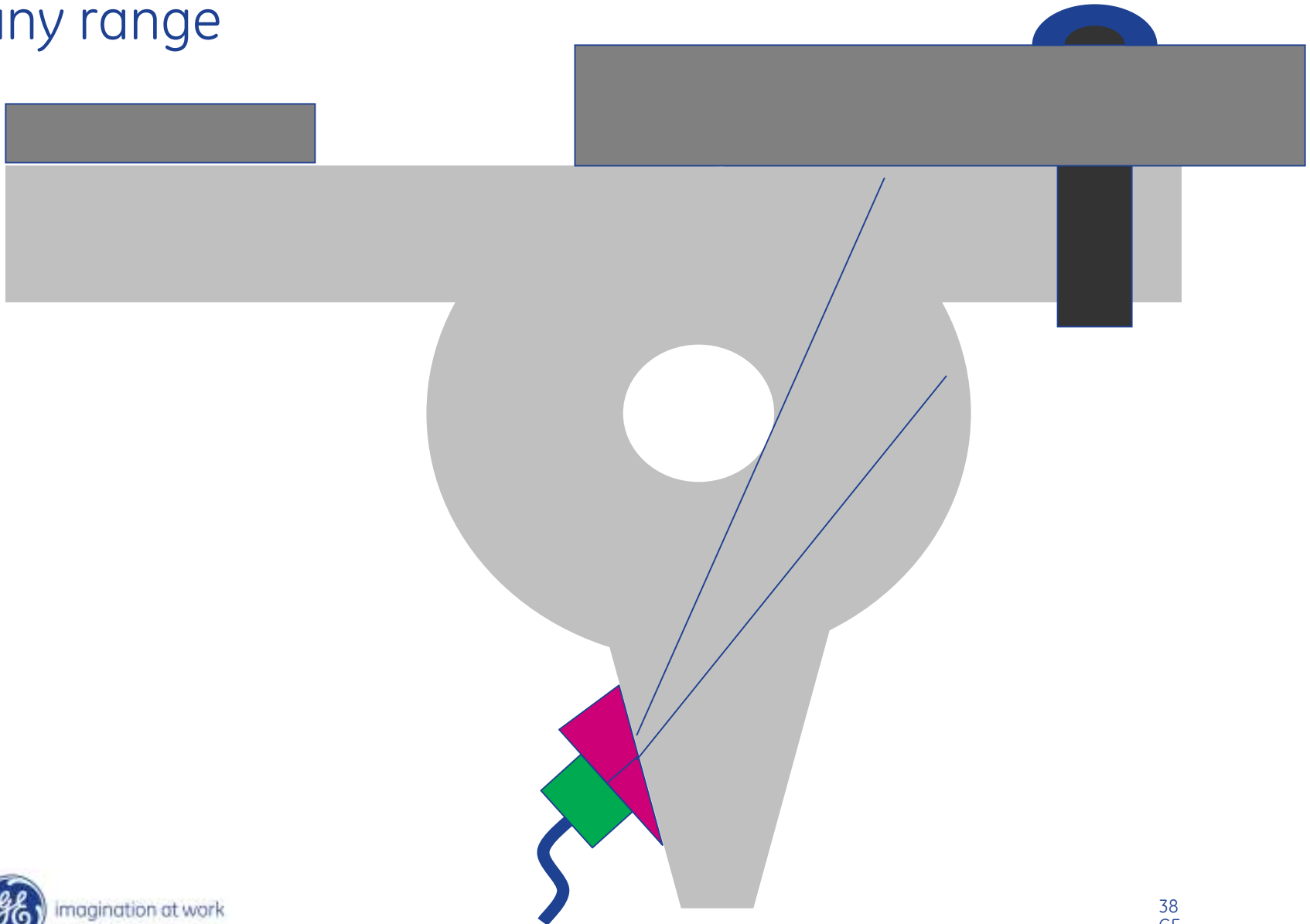
Geometric echoes can be differentiated from defect over a broader range



Defect orientation less critical with multiple angle inspection



Focus control allows ideal beam spot to be selected for any range



Conclusions

- True depth imaging provides spatial relationship of multiple defects when beam spread is controlled
- Multiple angle inspection improves the chance for right angle acoustic impingement on a defect.
- Multiple angle inspection improved POD when there is limited access to an inspection surface.
- Multiple angle inspection from one probe saves time and equipment expense compared to achieving the same results conventionally.
- Visualization of the ultrasound helps distinguish echoes from acceptable geometry and unacceptable reflections