Cf xcpegf 'Ugpuqt u'hqt 'Gpgt i { 'Kphf cuvt wevvet g'O qpksqt kpi

Rtgugpvgt **<'T wkuj w'HOY t ki j v.'Rj (F** Tgugctej 'Uekgpvkuv' Vgej pkecn'Rqtvhqrkq'Ngcf

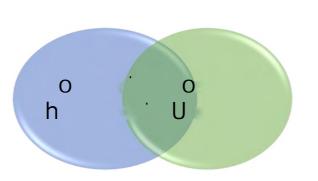


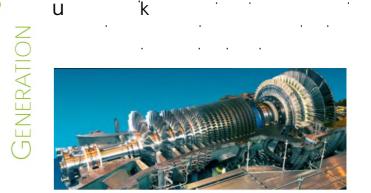
GYbgcf A UhYf]U'g'Zcf 7 f]h]WU bZfUghfi WhifY UbX'9 IhYa Y'9 bj]fcba Ybhg

NET NATIONAL ENERGY TECHNOLOGY LABORATORY

5 XjUbWYX GYbgcfg Zcf 9bYf[m 9ZZ]W YbWm ZGUZYhm ZF Yg]]Yb WY ZUbX SigHUjbUV]]hm

Alcb]hcf`gmghYag UbX WcbX]hjcbg |adfcjY dYfZcfaUbWY / YZJWJYbWm 9b\UbWY fY`]UV]`]hm / gUZYhm |Yadž UWcighjWg , WYYa]WU , [UgžWcffcg]cb 7 cadcg]hY bUbc!aUhYf]Ug , h`]b`Zj`ag'/ ZJVYf`cdhjWgžgYbgcf`XYj]WYg XYjY`cdaYbh





9в9F; мі89@ J9FM / GHCF5; 9

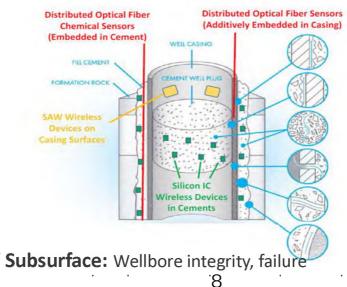


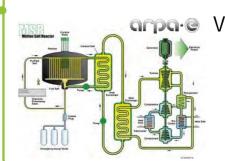
h U u

V8 ′= ′#∖

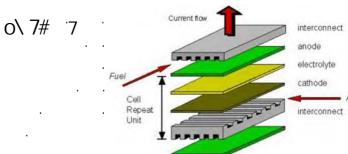


8 u





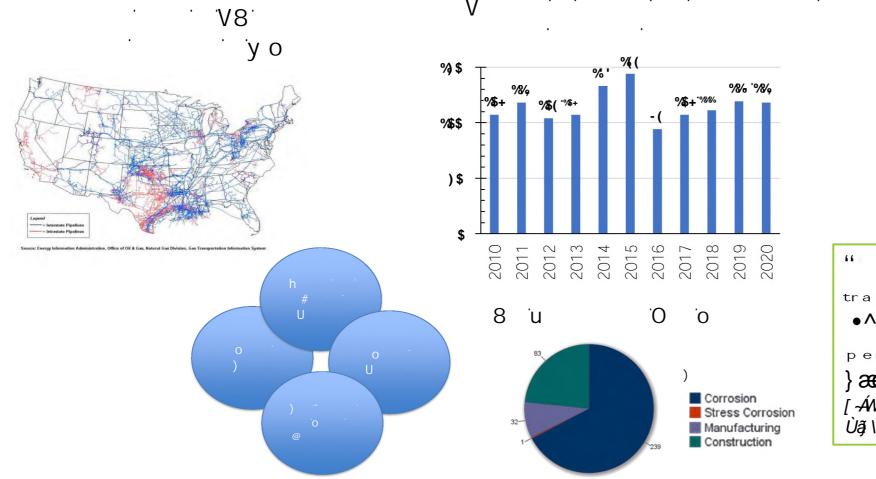
#





FY]ability/Gustainability o ZBUHifU; Ug Infrastructure





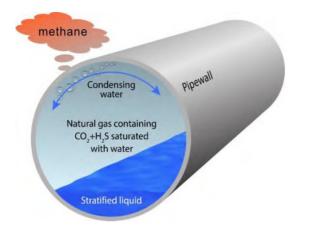
| Properties of Methane | | | | | |
|--|----------|--|--|--|--|
| Chemical Formula | CH4 | | | | |
| Lifetime in Atmosphere | 12 years | | | | |
| Global Warming Potential (100– year) | 28-36 | | | | |

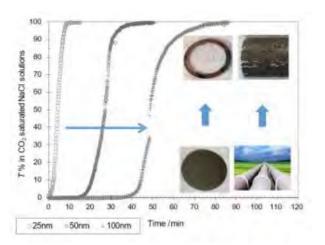


Tgcn/vłog'Oqpkvqt kpi'cpf'NgcmFgvgevkqp1Okski cvkqp'hqt'yjg'PcvvstchIcu'Kphtcuvtwevvstg'ctg'' Kpetgcukpin{'Korqtvcpv'hqt'Tgnkcdkds{.'Tgukdgpe{.'cpf'EJ₆'gokukqp'tgfwevkqp0



A Yh UbY @YU_ A cb]hcf]b [UbX 7 cffcg]cb D YhYWjcb





O gyj cpg'NgcmO qpkqt kpi 'cpf 'Kp/r krg'I cu'Ugpukpi

- " Gpi kpggtgf 'O gvcn/qti cpke "Htco gy qtm'*O QHt+"Nc{gtu
- " Gpikpggtgf "Rqn{ogt 'Eqckpi' Nc{gtu
- " P cpqr ct vkeng "cpf "P cpqeqo r qukvgu "Dcugf "Wr qp "Rqn{ o gtu" I'O QHu

 $\label{eq:constraint} Vctigv'ogvteu<'>3' 'EJ_6'lp'clt'*gzvgtpcn+'' ovndeqorqpgpv'J_4Q.'EQ_4.'EJ_6.'J_4.'J_4U'*lpvgtpcn+''$

Gctn{ 'Eqttqukqp'Qpugv'F gvgevkqp'cpf 'Nqecnk cvkqp

- " Eqttqukqp'Rtqz { "Ugpukpi 'O cvgtkcnu'*g0 0'Hg/Dcugf 'O gvcmke'Hkro u+
- "F gvgevkqp"cpf 'Ej go kecn'Ej ctcevgtk cvkqp"qh'Eqpf gpugf 'Y cvgt Rj cugu'*g0 0r J .'f kuuqnxgf 'EQ₄.''gve0+

Vcti gv'O gvt leu<'Gct n{ 'Eqtt qukqp'Qpugv'F gvgevkqp.

>'208'o o 'Vj lenpguu'T gf wevlqp



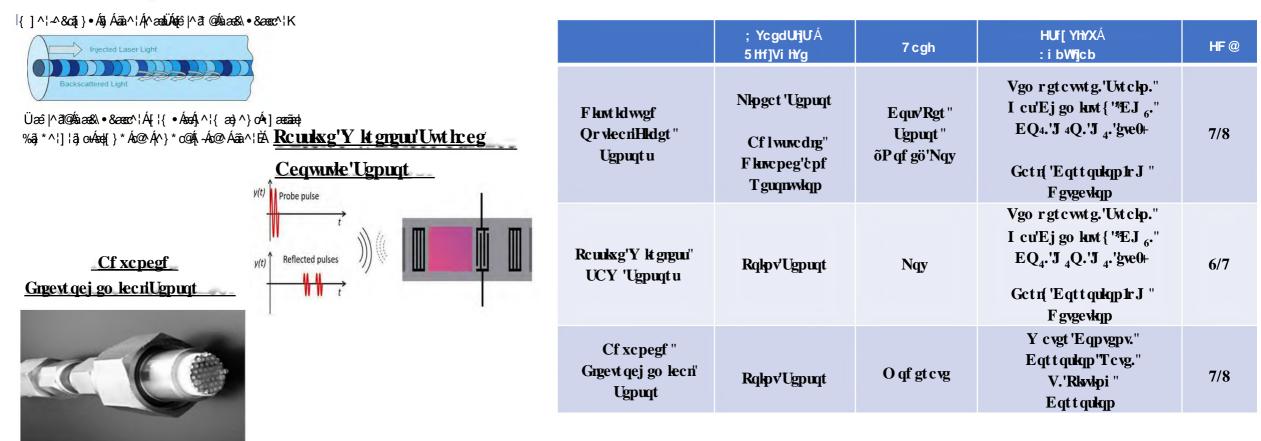
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TECHNOLOGY

5 ppfcWh: Advanced Gebgcr T YW bc`c[]Yg



<u>F kwt kdwwgf 'Qr vlecn'Hkdgt 'Ugpuqt</u>



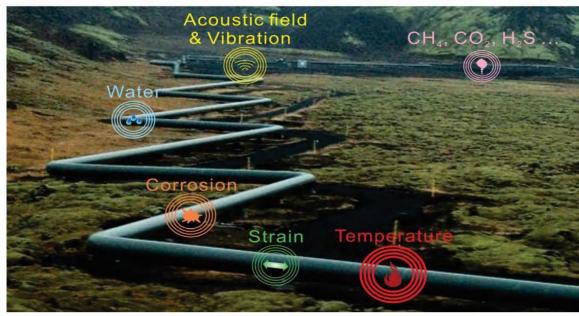
Vjtgg'U{ pgtikuvle'Ugpuqt'Rncvlqtou'y kvj'Eqorngogpvct{'Equv.'Rgtlqtocpeg.'cpf'Igqurcvlcn' Ejctcevgtkuvleu'ctg'dglpi'Fgxgnqrgf'y kvj'cp'Gorjculu'qp'Eqttqulqp'('Icu'Oqpkvqtlpi0



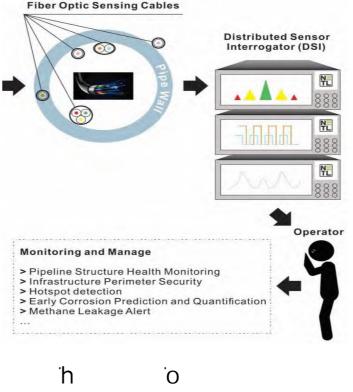
D]ghf]Vi hYX'CdhJWU':]VYf'Gensor BYhwork for D]dY]bYg



Pipeline Integrated with Distributed Optical Fiber >100 km



9a d\Ug]gK]h\]bB9H@FYgYUfVX7 =bbcjUh]cb7YbhYf. Cdh]a]nY=bhYffc[Uh]cbGmghYafFUb[YžFYgc`ih]cbž7cghL 9Uf`m7cffcg]cbCb!GYh8YhYVh]cb AYh\UbY@YU_8YhYVh]cb7 =b!D]dY;Ug7cadcg]h]cbAcb]hcf]b[

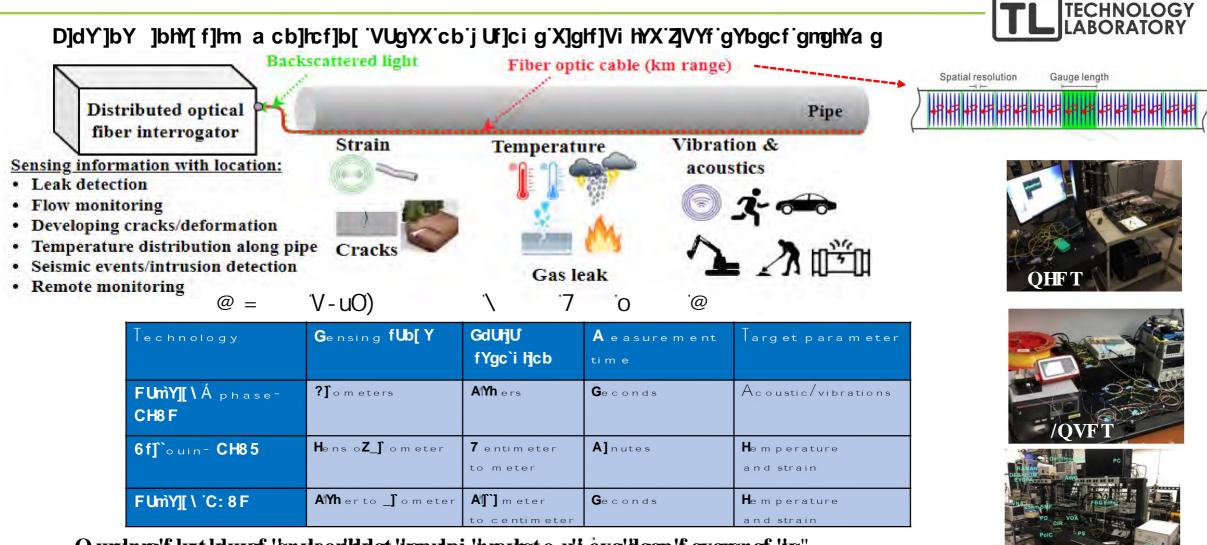


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Ownk/Retco gygt.'F kwtkdwygf 'Qr vleen/Hkdgt 'Ugpuqt 'Rnevhqto 'vq'Gpedng'Tgrledng'epf 'Tgukhgpv'Rkrghpgu0 <u>Veti gy'Ogytleuk'</u>@22'mo 'Køygttqi evkqp.'>7'o 'Ur evken'Tguquwkqp



8]ghf]VihYX C'dh]WU :]VYf | bhYffc[Uhcf 8 YjY`cda Ybh



O wndr ng'f kut kdwegf 'dr dec rikkdgt 'ugpulpi 'r ne drat o u'j cxg'dggp'f gxgnur gf 'dq" gpcdng'int wevnt crij gcnj 'o qplaqt kpi 'dh'r kr grlpg'cpf 'dvj gt 'lpht cunt wevnt g0

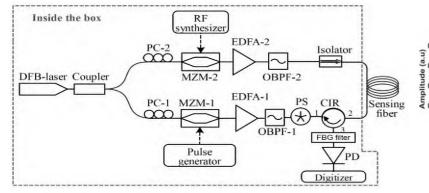


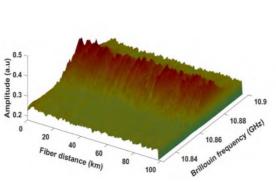
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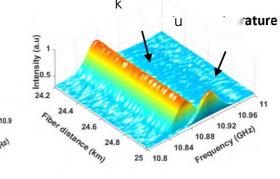
d ShfUjb AlYUgi fYa Ybhg



Dt kmywlp'Qr vlecnVlog/f qoclp'Cpcn(uku'*DQVFC+

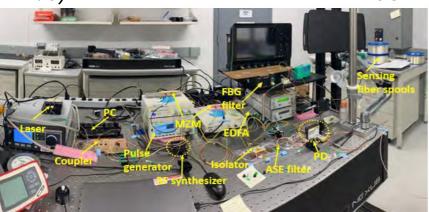


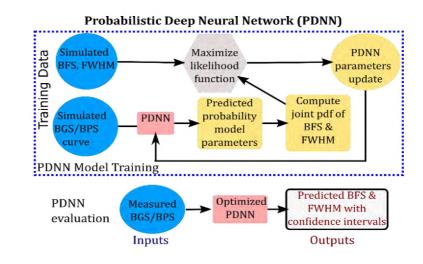












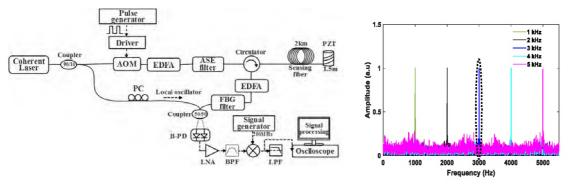
- P RFPP'rtqeguugu'tjg'DIU'(" DRUfcvc'kp'tgcn/vkog'*3'iuge+." eqorctgf'tq'gzkuvkpi'DQVFC" ecrcdkdw{'*3'okp+
- Kpetgcugf "eqphkf gpeg" kp"f cvc<" r tqr ci cvgu" pqkug" kp"f cvc" cu" r tgf kevkqp" vpegtvckpv{
- Dgwgt''y cp'Ewtxkpi "Hkwkpi "cpf" Uwr gtxkugf 'O cej kpg'Ngctpkpi

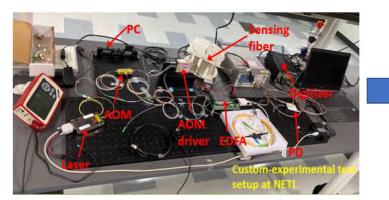
F knt klwygf 'int chp'ht 'V'o gcunt go gpwi'kphyt o 'r kr grhpg'he knut gu'e pf 'i cu'igemu'hp't gent vlo g'wr 'vy'372'm 0



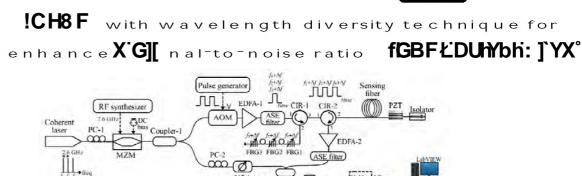
Rj cug/QVFT'F kwt klwygf 'Ceqwwle'Ugpulpi '*FCU+

Rj cug/ugpulskxg'qr vlecntko g'f qo clp't gh
ngevqo gvt { '* /QVFT+





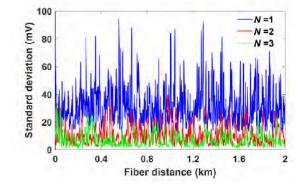




Hcf kpi 'pqkug'y cu'uki pkhecpvn{ 'o kpko k gf 0

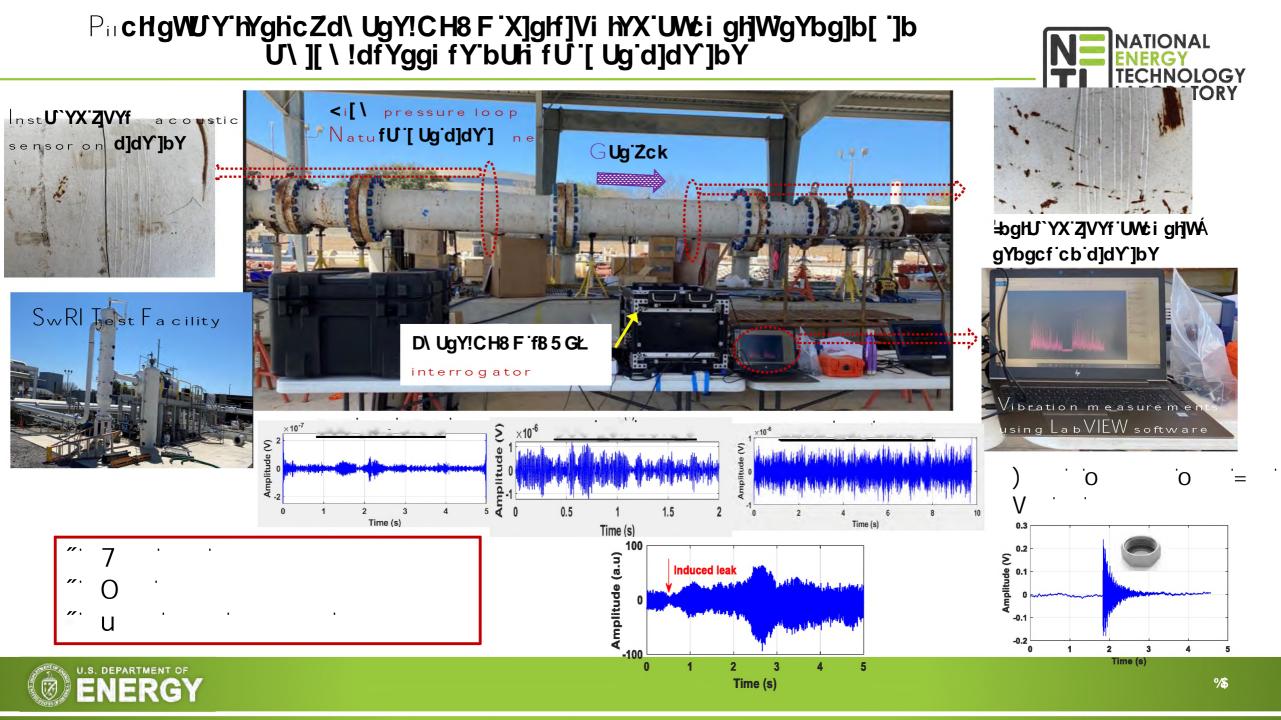
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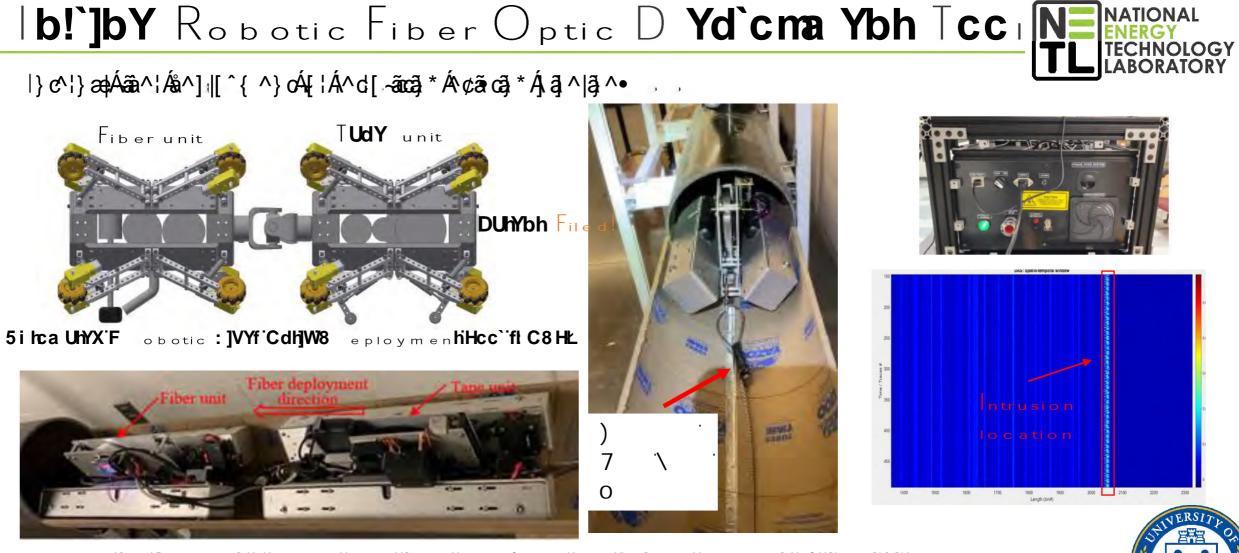
HNOLOGY Oratory



- "'' PqxgnCrrtqcej 'tq'kortqxg'UPT'kp'rjcug/QVFT'hqt'fkintkdwygf 'δ gcuntgo gpvu'qh'ceqwunke'ý cxgu' cpf 'tkdtcvkqp0
- "'' Rqt vcdrg'Rt qvqv{ r g'qh'P GVN'E wuvqo 'r j cug/QVF T IF CU







- WRkw'j cu'f gxgnpr gf 'c'T qdqvle'Hkdgt 'Qr vle'F gr nq{ o gpv'Vqqn'*HQF V+'iwr r qt vgf 'd{ 'CT RC/G0
- Vjtqwij'eqmedqtevlqp.'f kuvtkdwvgf'eqqwuvle'ugpulpi'wulpi'PGVN'lpvgttqievqt'y cu'fgoqpuvtevgf" lp'e'uvggnirkrg0

@'#



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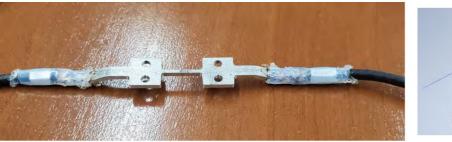
Ga Ufh'HUdY cf C'dh'JWU $\ F$]VYf Ge bgcfs

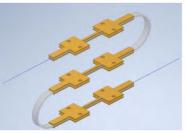


Uo ctv'Vcr gu'hqt'Rkr grkpg'F gr
 mq{o gpv $\$



Hkdgt 'Rcemci kpi 'Vgej pqnqi {<'wr '\q'622'9E





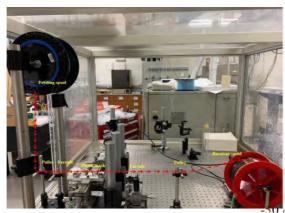
Uo ctv'vcr gu'ĥqt''r kr gnkpg'f gr nq {o gpvu<'y tgg'ugpuqtu'ĥqt'xkdtcvkqp.''vgo r gtcwetg.''cpf '' ceqwuvke''o gcuwetgo gpvu= Gcu{ ''vq''cr r n{ ''qpvq''r kr gnkpgu= I tgcv'r qvgpvkcn'ĥqt''cv'ngcuv'32z ''equv'tgf wevkqp''kp'Tc{ngki j/gpj cpegf ''ugpukpi ''hkdgtu0

@`#



Tcrkf 't ggn/vq/t ggniugpuqt 'hcdt kecvkqp'qh my /equv'Tc{ngki j /gpj cpegf 'ugpuqt u

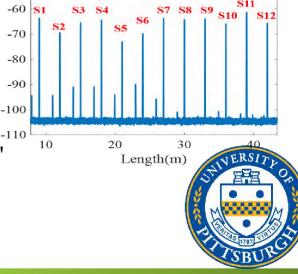
Amplitude(dB/mm)



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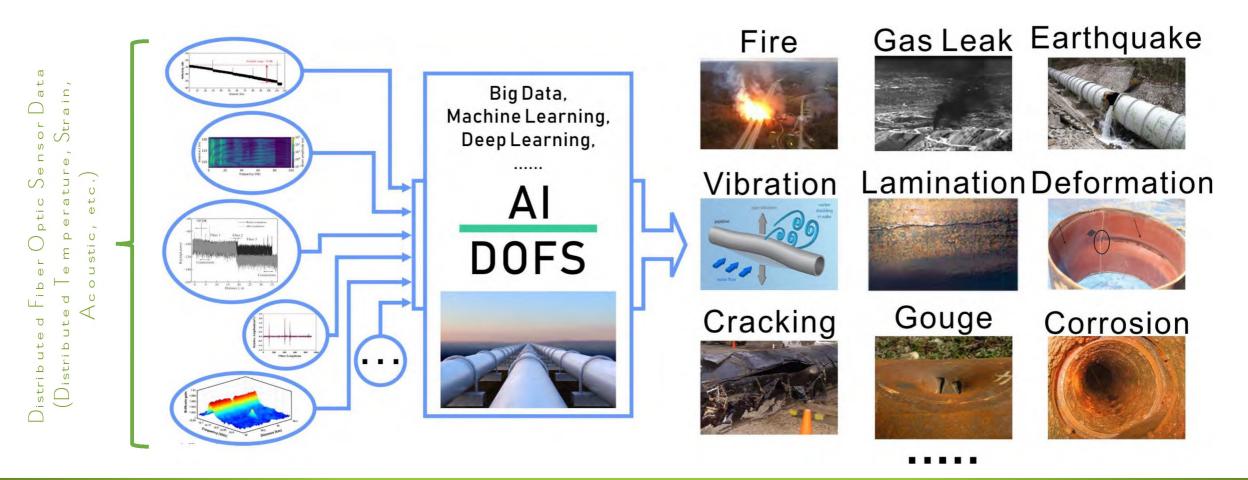
DUhYbh



CKGpj cpegf 'F kwt klwgf 'QHU'P gw qt m

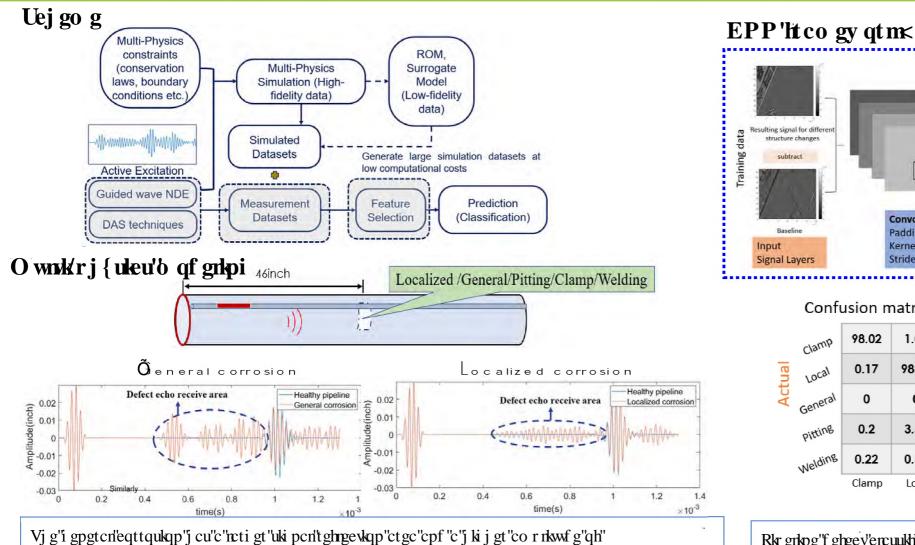


Hedgt 'Qrvke'Dcugf 'F kuvt kdwegf 'QHU'Vgej pqnqi { 'Kpvgi t cvgf 'y kvj 'Cf xcpegf 'Cpcn{ vleu'Kpenvf kpi 'Rcvegt p'cpf " Hegcvet g'T geqi pkskqp'Ecp'Eqpxgt v'Nct i g'F cvc'Ugvu'vq'Cevkqpcdrg'Kphqt o cvkqp0





D\ysics 6 ase XA odeling Ž5=: cfD ipeline m cb]cf]b[



f ghgev'gej q'uki pcn'hqt''y g'uco g'y cm'y kenpguu't gf wevkqp''y cp''necnt gf 'eqttqukqp0



tesulting signal for differen data structure changes subtract rainin Convolution Baseline Padding = 1; Max pooling Output Kernel = 2*2 **Fully Connected** Kernel = 3*3 Input Corrosion Signal Layers Stride = 1; Stride = 2: Layer + Dropout type

Confusion matrix:

| | Clamp | 98.02 | 1.05 | 0.45 | 0.23 | 0.25 | |
|--------|---------|---|-------|------|------|-------|--|
| lal | Local | 0.17 | 98.67 | 0.76 | 0.21 | 0.19 | |
| Actual | General | 0 | 0 | 98.6 | 0.8 | 0.6 | |
| | Pitting | 0.2 | 3.52 | 0.61 | 95.1 | 0.53 | |
| | Welding | 0.22 | 0.36 | 0.08 | 0.3 | 99.04 | |
| | •. I | Clamp Local General Pitting We Predicted | | | | | |

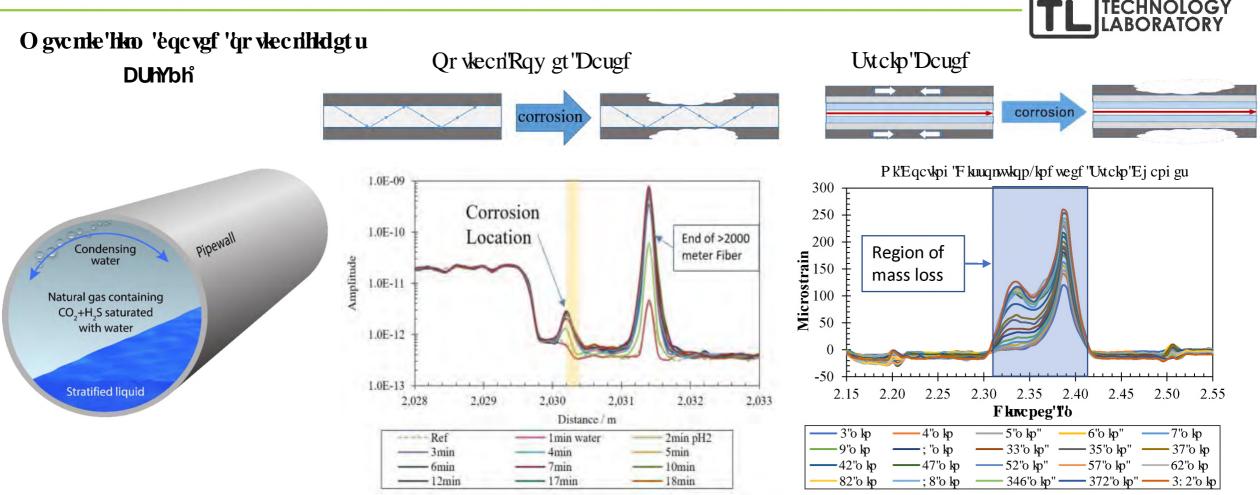


Rkr grkpg'f ghgev'encuukhecvkqp'dcugf ''qp'EPP 'htco gy qtm0

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'n



Eqt t qukqp'ecp'dg'f gvgevgf 'cpf 'hqecvgf 'cnqpi 'vj g'qr vlecnhkdgt.'y j kej 'gpcdngu'f kwt kdwvkxg" eqt t qukqp'o qpkvqt kpi 'hqt 'hqpi /f kwcpeg'kpht cuvt wevvit g0



NATIONAL ENERGY

8]gtributed Water Co bXYbgUjcbk umidity Alonitoring

TECHNOLOGY ABORATOR KUher provides electrolytes for corrosion onset Utckp/dcugf."hvm{"fkrtkdwgf"ugpuqt"wukpi" **UDX** is an indicator of potential corrosion. r qn{o gt'lcengygf 'eqo o gtekcm{ 'cxckrcdrg'hkdgtu Pate bh: **YX** Glass core - 8 um diameter Glass cladding - 125 um diameter Inner Primary - 190 um diameter Soft, Cushioning Layer 150 130 Regions of Outer Primary - 250 um diameter 110 Local Water Hard, Abrasion-Resistant Laver 90 Condensation Amplitude 70 160 50 140 30 100% RH 140 Humidity 120 100% RH **DI** water 10 75% RH 120 -10 100 -30 100 1min 1min Microstrain 80 50% RH -50 80 60 2,023.5 2,024.0 2,024.5 Micr Water 60 Distance / m 40 25% RH dry 40 ----- 2min ---- Ref _____1min N2 20 5min -12min 20 -20 200 0 50 100 150 250 300 120 180 240 300 360 Time / min dry N2 Time / min

> NqecnJ wolf kx{ 'cpf 'Y cvgt 'Eqpf gpucvkqp'O qpkvqt kpi 'F wg'vq'Uy gmkpi 'qh' Rqn{ ogt 'Lcengvu'qp'Qr vlecnHkdgt u 'cu'cp'Kpf lecvqt 'hqt 'Eqt t qukqp0

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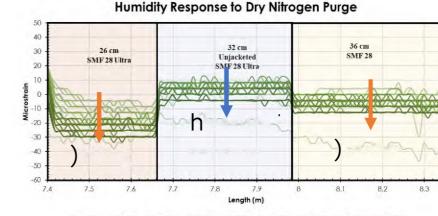
9Uf`m:]YX'HYghcZ8]ghf]VihYX'C:G'GYbgcf'=bg]XY'U<][\ DfYggifY'BUhifU';Ug'D]dY`]bY'ff/\$\$\$'dg]Ł



| | Humidity Sensor | | | Corrosion Sensor | | | |
|-----------------|-----------------|-------|----------------|-------------------------|-----------------|------------------|--|
| 415 cm | € 26 cm | 32 cm | € 36 cm | 1 cm | 30 cm | ▶ 4 10 cm | |
| | Polymer Jacket | | Polymer Jacket | | Coreless Fiber | Polymer Jacket | |
| Fiber Ribbon | SMF-28 Ultra | | SMF-28 | Multi- mode Fiber | Fe Costed Fiber | Multimode Fiber | |





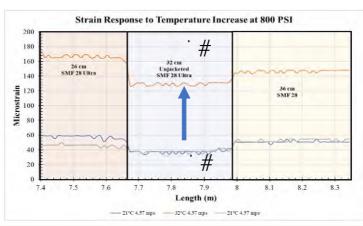


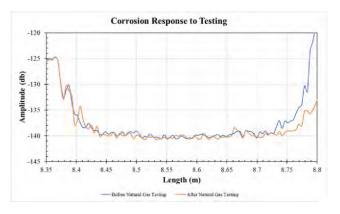
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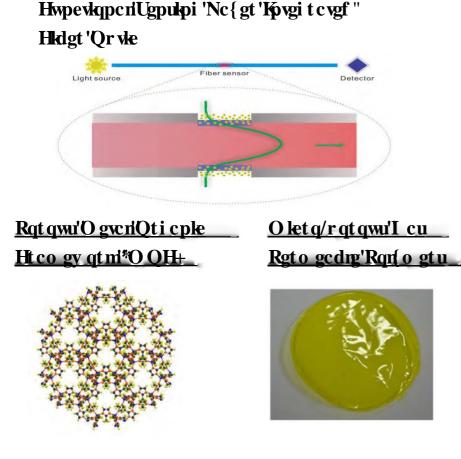


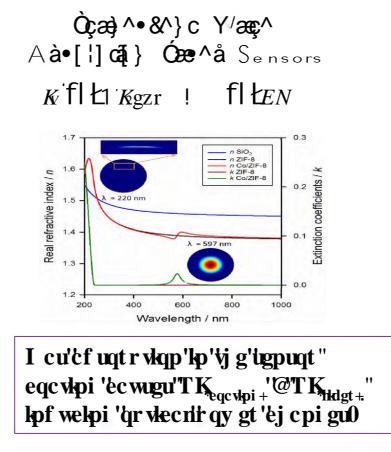


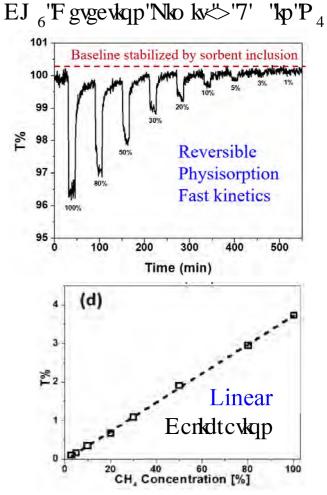
••

I min 2 min 3 min 5 min 6 min 7 min 8 min 9 min 10 min
 Il min 13 min 15 min 17 min 9 min 21 min 21 min 23 min 27 min
 28 min 29 min 31 min 31 min 37 min 37 min 39 min 41 min 43 min 45 min
 47 min 49 min 51 min 51 min 55 min 57 min 57 min 57 min 61 min 63 min









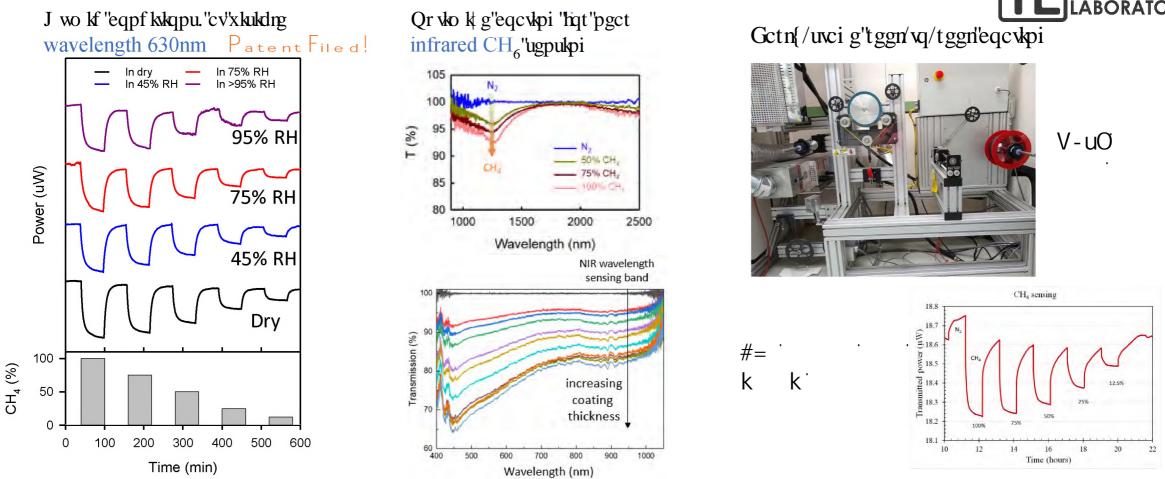
- Nki j v'Køvgpuks{ 'Dcugf 'O gyj cpg'Ugpukpi 'Vgej pqnqi { 0
- Kovgi t c vkqp'qh'Hkdgt 'Qr vke'Ugpuqt u'y kyj 'Gpi koggt gf 'Rqt qwu'Ugpukpi 'Nc { gt u'd{ 'F guki p0



C dhjWU : jVYf A Yh UbY Ge bgcf jb < i a jX 7 cbX hjcbg UbX G

c ale-up





- " Vwpg'y g'y cxgrepi y 'vq'P KT 'tcpi g'vq'dg'tgcf kn{ "eqo r cvkdrg'y ky "eqo o qpn{ 'wugf 'f kuvtkdwvgf 'QHU'kpvgttqi cvqtu.0
- " F go qputcvgf "gctn{/uvci g'tggn/vq/tggnleqcvkpi "qhio gyj cpg"ugpukpi "o cvgtkcnu"qpvq"qr vkecn"hkdgtu0



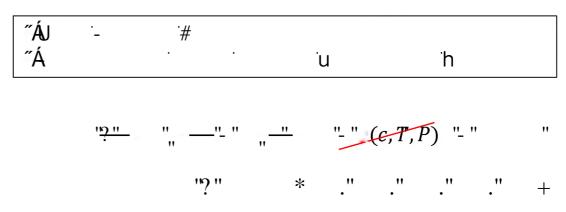
Surface Acoustic Wave **fG5KŁG**e**bgcf**s

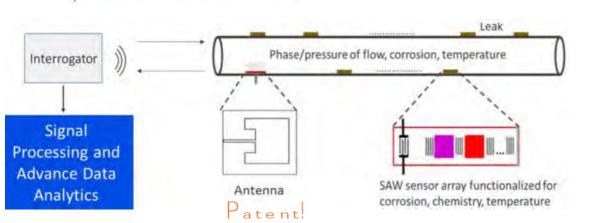
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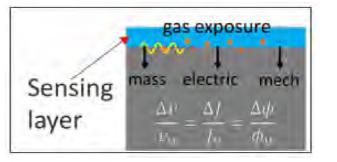
• PUgg]jY,K]fYYgg,AlUhifYX 8Yj]WYg

- GYbg]h]jY,7 \YUd Dc]bh GYbgcfg
- Dcgg]VYZcfÄi`h]!DUFU a YhYf CdYfUh]cb (Temperature, Pressure, Strain, Ô@{ & e Species, Corrosion etc.)











<u>Vcti gv'O gvt leu</u><Uo cm^{*}¢7z7'ėo ⁴+'Nqy 'Equv'*>'&3022'**1**f gxleg'- 'ċpvgppc'lpuvcmgf +'' Wdls wlsqwu'Y lt grguu'Ugpuqt u'ėcp'dg'F gr m{ gf 'Gz vgt pcn'ċpf 'Kpvgt pcn'ኣq'ኣj g'Rkr grlpg

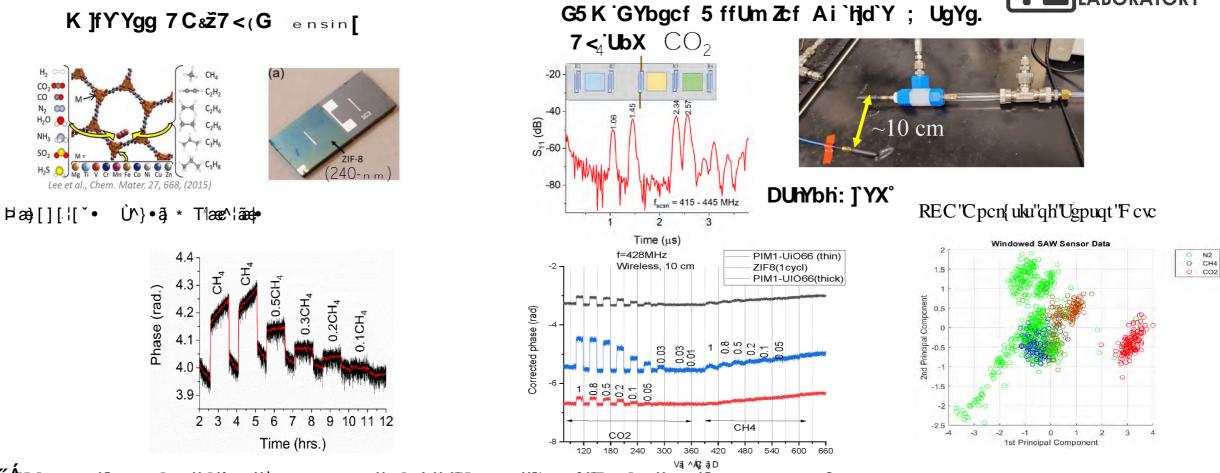


y(t) Probe pulse

Reflected pulses

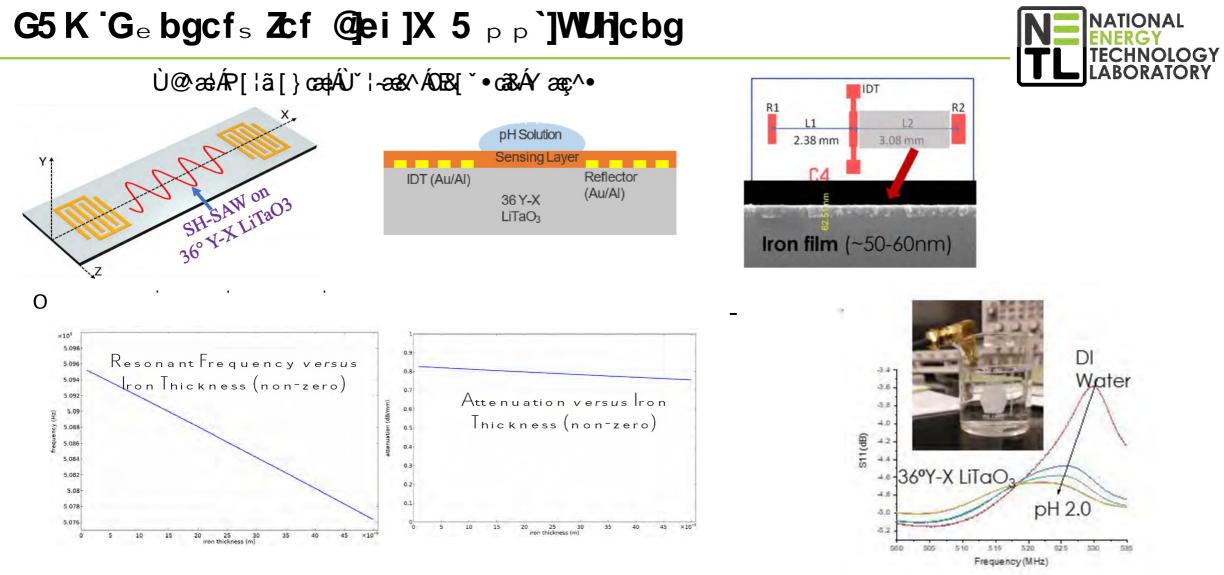
K]fY Ygg G5 K 'G $_{\rm e}$ bgcf $_{\rm s}$ Zcf ; Ug GYbg]b [





"ÁY kt grguu'f gvgevkqp'qh'i cu'éqo r qpgpvu'wukpi 'c'Ugpuqt 'Cttc{ 'F gxkeg'y cu'f go qpuvt cvgf
"ÁCf xcpegf 'f cvc'cpcn{ vkeu'o gvj qf 'y cu'cr r nkgf 'hqt 'encudkhecvkqp'qh'o wnk/gngo gpv'ugpuqt 'cttc{ 'f cvc
hqt 'uko wncpgqwu'o qpksqt kpi 'qh'o wnkr ng'i cugu0



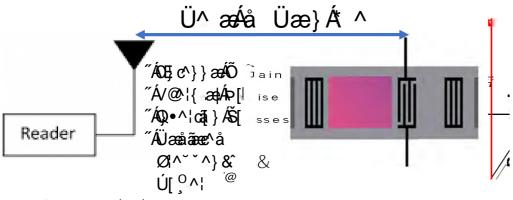


UCY 'Ugpuqtu'y gtg'f gxgnqrgf 'hqt'iks wkf 'rjcug'crrnkecwlqp'cpf 'Fgoqpuwtcwgf 'vjg'ecrcdkdw{ 'hqt" oqpkwqtkpi 'ktqp'hkno'eqttqukqp'kp'hqy 'rJ'*cekfke+'uqnwwlqpu'xkc'dqvj'ukowncwlqp'cpf 'gzrgtkogpwu0



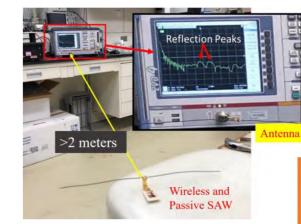
9 nabling Telemetry for G5K 8 evices U'bX'D pelines





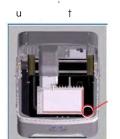
- helemetry of wirelesscopf "r[‡] assive SAW senstors ku" uko krct" vq" tcf ct" qr gtcvkqpf0' #
- Nqy mquuUCY fgx kegucpf⁰jkijg tvjgtcfkcvgf rqygt"vq"kortqxg"vjg"tcpig0

<u>K]reless 7 ci d</u>]b[. ÚCEY/ÁÖevice + EM Radiator



Lcb['FUb[Y] Telemetry UbX Interrogation

5 behnna 8 esign an X abrication.

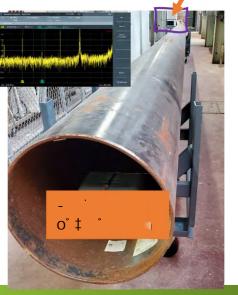




Eqor#c e v" O $gc#p f gt Fkrq_ng$

Y kt gnguu'Kpvgt t qi c vkqp'qh UCY 'Ugpuqt u'Kpulf g'O gvcn' Rkr g'hqt '34'o gvgt u'*62'hv+'y cu F go qpuvt c vgf 'kp'tj g'ir d0

Xct kqwu'Crrtqcej gu'j cxg'dggp'F guki pgf cpf 'F goqpuvt cvgf 'vq'Cej kgxg'Y kt grguu' Køvgt tqi cvkqp'qh'UCY 'Ugpuqt u'kp'Rkr grkpgu0





tV^{*}

:]YXXYacbghfUhjcb cZ9`YWFfcaU[bYhjW f9A1LKUjY DfcdU[Uhjcb bg]XYUghYYDidY





° ‡

-20

-40

-80

-100

0.0 0.5 1.0 1.5 2.0 2.5

S11(DB) -e0

20-in pipe, End1-Meander Dipole, End2-

Time (s)

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34MHz_SAW +Meander Dipol





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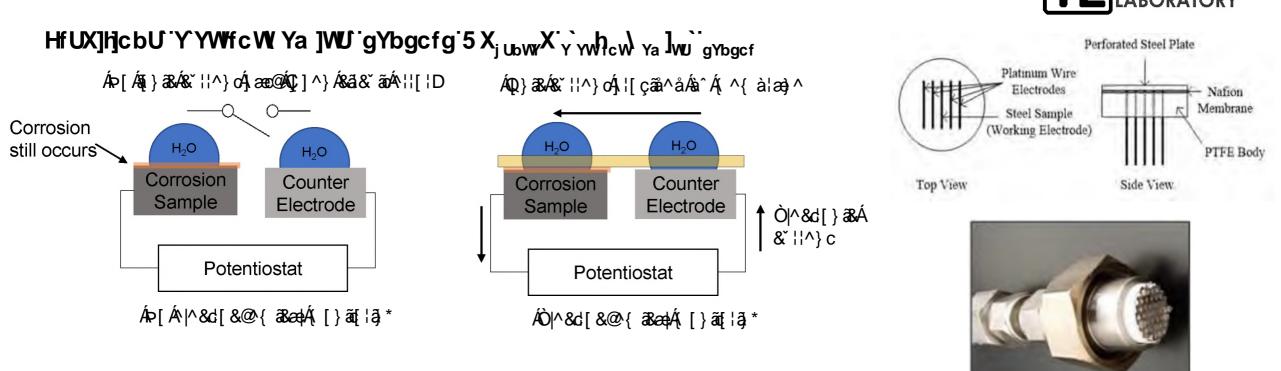


Uweegudwif go qpuvt <u>c vkqp'qh'y kt giguu'TH'r t qr ci c vkqp'kpukf g'¢9</u>2'o 'hqpi 'uvggn'r kr gu

4.0



5 d j UbWYX 9 YWF c W Ya JWU I Ge bg cr f 5 9 GL



Kovgi t cvkqp'qh'Kqp/eqpf wevkpi 'O go dt cpg'O cngu'CGU'E cr cdng'qh'Tgcn' Vko g'Kp/Ukw'O qpksqt kpi 'qh'Y cvgt 'Eqpvgpv.'Uvggn'Eqt t qukqp'T cvg.'cpf " Rkvvkpi 'I'Nqecnk gf 'Eqt t qukqp'R ct co gvgt u'Kpukf g'P cvwt cni cu'R kr gn kpgu)

PennState

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TECHNOLOGY



In Collaboration with Prof. Lvov and Prof. Hall, Penn State

59GZcf KUHYf 7 cbhYbh / 7 cffcg]cb FUHY A cb]hcf]b [

&^{bx};Yb ... T1^{_à¦æ}^Ëaæ^å : OEÒÙ].¦[d[cî]^ ~æà¦ã&æe^åÁçãæÁ]`cc^¦ãj*Áæ}åÁæååãããç^ {.æ}`~æ&c`¦ãj*ÉÅ,ãc@ _^{_à^åå^åÅv@o`¦{ [&[č]|^•È



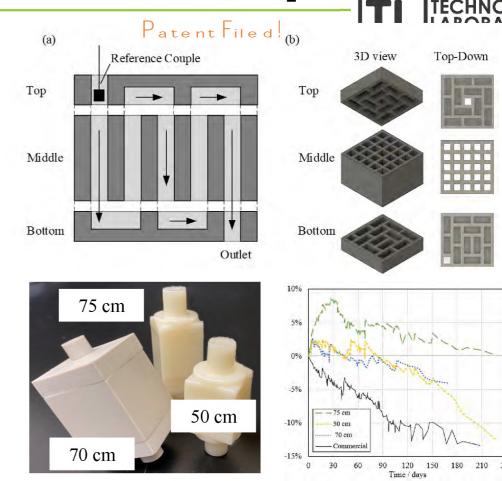




- - G¹å *^}^¦æaāį} OEÒÙåč¦āj* c^•cāj*ÁşiÁ, æe^¦Ëe æe覿e∿åÁ }æe覿eÁáæÁôÒÒÒÙQč|(aË-].@æ•^Áų[[, Áæs&ajãcási, GeGeE.

Ò|^&d[&@{ ã&æ‡Ác∿∙cāj*Á ^č ĩāj{.^}o/śārÁ§jÁ,^æc@\¦Ë],¦[[-Á&[}cæaj,^¦È

59G YUgmihc]bghUi VmZUN[]hmicd Yf Uhcfg 7 UdUV`Y cZf Ya chY XUHU'Vt``YW]cb Gi WWYggZI``m m cb]hcf YX`]bWf YUg YX \ia]X]hm UbX'Wcffcg]cb f UhY`]b k YhibUhi f U`[Ug



BYk 'gc`]X!glUhY'fYZYfYbWY'Y'YWfcXYgÁ PennState fGGF9Łci hdYfZcfa YX'Wca a YfWJU'dfcVYgÁ]b'a i `h]!a cbh` 'hYgh]b[

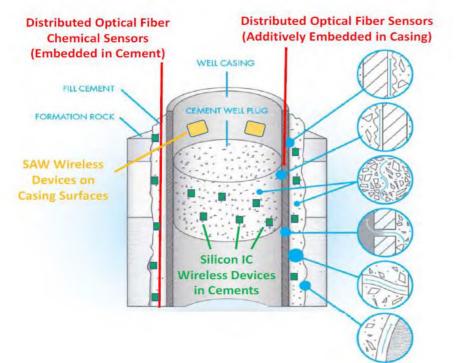


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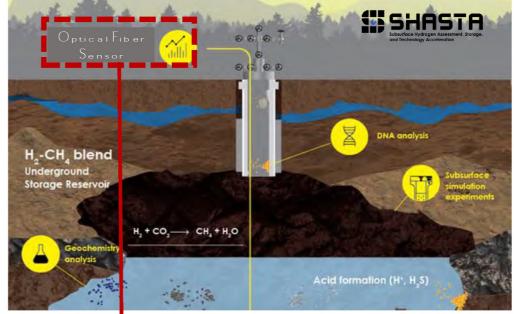
Ge **bgc**r T**YW bc`c[]Yg Zcf'Gi Vgi fZWY** CO₂ or H_&-NG Storage



KY`VcfY bhY[f]m A cb]hcf]b g fGi VH9FŁ



C'uwkg''qhi'vgej pqnqi kgu'hwpevkqpcnk gf 'hqt''ej go kecn'ugpukpi qhij ki j 'r tkqtkx{ 'r ctco gvgtu'***r J .'eqt t qukqp'**qpugv.''gve0+0 <2[!]B; 'G i Vgi fZUWY G hcfU[Y K Y`g fG<5 GH5Ł



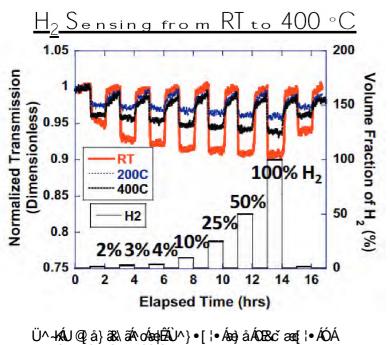
Álwduwthceg''**J**₄.'**EJ**₆.'**cpf** '**r J** 'o qpkqtkpi Á cu''Ngcm'cpf ''Y gmdqtg''Kpvgi tkv{ 'O qpkqtkpi

Ô@æ|^}*āj* @æt•@kk[}åãāā]}• ;}Á*`à•`¦~æ&^Á^``ã^Á/jãæà|^ÁæjåÅå`¦æà|^Á<>•[¦Ác^&@;[|[*ā?•È
 OE]]|ã&æà|^Á{[æàæ]}Å{[>^åÁ[^||• , *^[o@~;{æ:,^/||•, æ)åÅæš`jã^;E

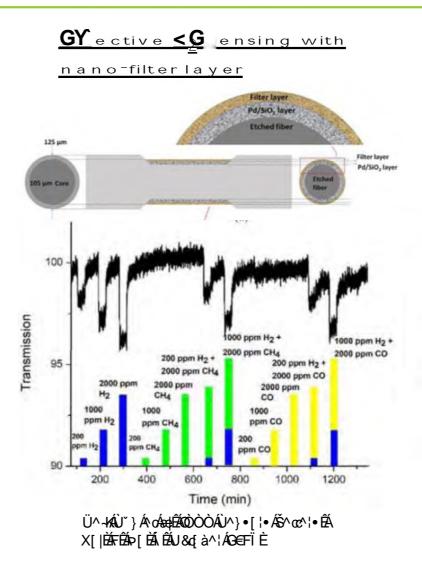


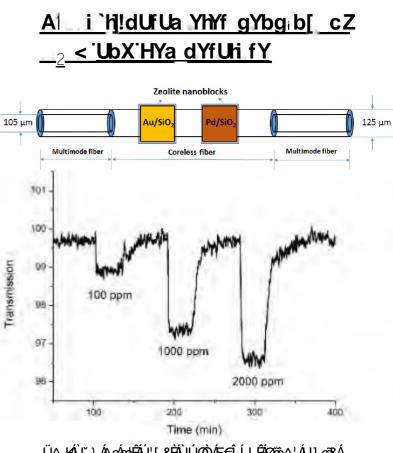
C'dhjWU::]VYf <mXfc[Yb GYbgcr

DX BUbcdUfhjWY!=bWcfdcfUhY X G]C²H]b Fila WcUhYX C dhjWU :iVYf GYbgcf



U^-kAU@(à}a&\aA\O&aqt£U^}•[¦•Aag)àAO&SC`aag ¦ GFIÁÇG€FÍDFÍJ.FÎÌÈ





NATIONAL ENERGY

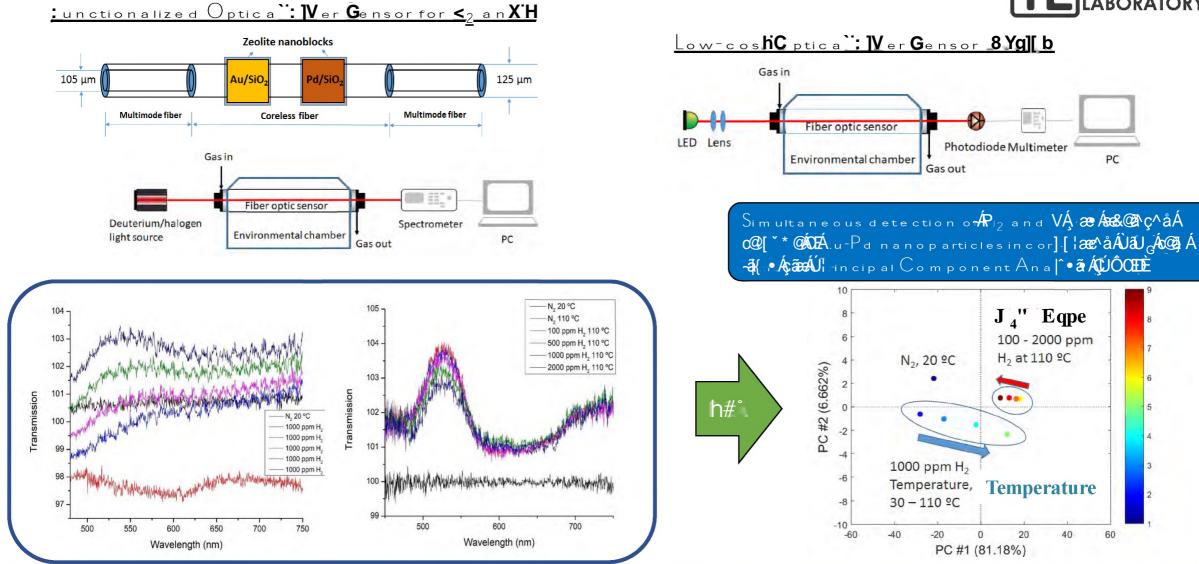
TECHNOLOGY LABORATORY

Ü^-kAÛ"}Á∾ó septébú¦[& běbù ú côc Á∓€ĨÍIÉa 26aa ^¦Áu]ca8kÁ Ù^}•[¦•Áse)å ÁOEJ]|a8aasaã[}•Á′XÉA∓€ĨÍI€ÍÁGFITæ?Á G€E ÌDL



G]ai`HJbYcig'8Yh ection o**Z<_&'UbX'H**emperature



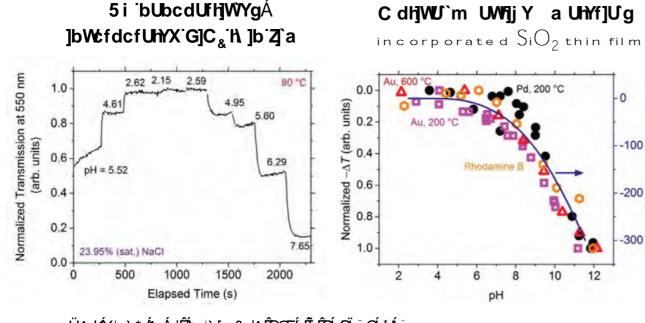


$$\begin{split} & \dot{U}^{A}\dot{A}\dot{U}^{*} \} \stackrel{A}{\to} \dot{A} \stackrel{$$



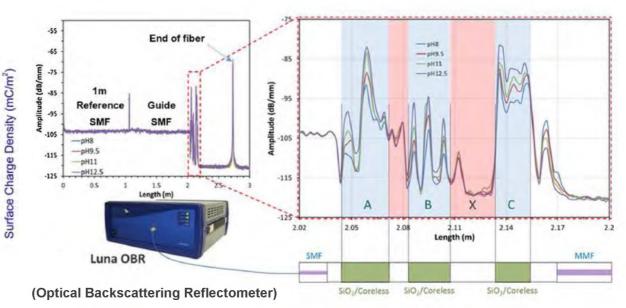
8]ghf]Vi hYX d< GYbg]b[





Ü^-kÁY/æ)*Á\vÁæjÉAPæ)[•&æ‡^ÊG€FÍ+ĒÊÊGÍGÏČGÍHͰ

r J ''ugpukkxkx{ ''y cu''f go qpuvtcvgf ''y ký ''qr vkecm{ ''cevkxg'' o cvgtkcnu/kpeqtr qtcvgf ''UkQ₄''ý kp''hkm ''vukpi ''ý g''qr vkecn'' hkdgt ''ugpuqtu0 8]ghf]VihYX'd<'Gensing

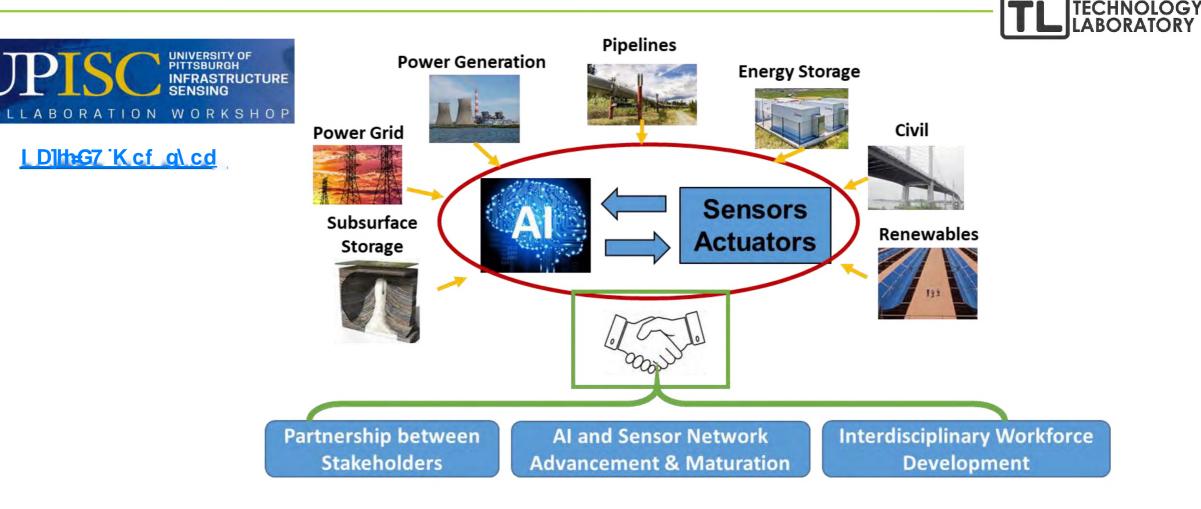


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Ur cvkcm{ 'f kuvtkdwgf 'r J 'ugpukpi 'y kj 'nqecvkqp'' kphqto cvkqp'y cu'f go qpuvtcvgf 'wukpi 'y g''qr vkecn' dcemiecwgt 'tghrgevqo gygt "*QDT+'cv'tqqo 'vgo r gtcwrtg0' Qpn{ 'y g'hwpevkqpcnk gf ''UkQ₄''eqcvgf ''ugi o gpvu'j cxg'' y g''r J ''ugpukxkxk{0



ID]HB9H@=bZastructure Gensing 7c WcfUjcbfI D=G7Ł



 $\label{eq:constraint} Wpkxgtukv{.'Ncd.'Kpfwuvt{.'cpf'I qxgtpo gpv'Rctvpgtuj kru'ctg'P geguuct{'vq'O czko k g'Ko r cev}{}$

B9 H@ bli Yf glhm cZD]htgVi f[\ G][b ACI cb | bZ Ughfi Wi fY SYbgcf D Yj Ycda Ybh | bYh''XcY'[ci

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Gia m Ufm



- O wnkr ng "eqor ngo gpvct { "ugpuqt "vgej pqnqi kgu"ctg"f gxgnqr gf "vq"ngxgtci g"vj g"cf xcpvci gu"qh" 'qr vkecn gngevtqej go kecn "cpf "o ketqy cxg" I 'y ktgnguu 'ugpuqt "r ncvhqto u. "vq" dwknf "cp" kp/ukww. "o wnk/r ctco gvgt." f kuvtkdwgf. "cpf "equv/ghhgevkxg" ugpuqt "pgwqtm" hqt" gpgti { "kphtcuvt wewtg0
- " C'y lf g'tcpi g'qh'ugpulpi 'o cvgtlcnu'ctg'f gxgnqr gf 'vq'cej lgxg'j ki j 'ugpulkkx kv{.'ugngevlxkv{.'cpf 'hcuv' tgur qpug.'lpenwf lpi 'OQH'r qn{ogtu.'ogvcmle'hknou.'cpf 'pcpqeqor qulkgu0

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I cu
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Ej go kecn
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" Ctvkhkekcn'kpvgmki gpeg/gpj cpegf "ugpuqt"pgvy qtm'y kj "vdks wkvqvun{ "go dgf f gf "ugpuqtu'y km'wnko cvgn{" cej kgxg'f guktgf "xkukdkrkv{ "cetquu'y g"gpgti { "kphtcuvtvevvtg0

"' Cfxcpegf 'ugpuqtu'cpf 'o cvgtkcnu'hqt'etkkecn'kphicuvtvevvtg'cpf 'gzvtgo g'j ki j/V'gpxktqpo gpvu0





Tgugctej ''Vgco <'Twkuj w''Y tki j v' *RKŁ ''P ci guy ctc'' Ncnco .''O kej cgn' Dwtke.'' Rcwn' Qj qf pkenk' *WRkw+.'' Lci cppcyj '' Fgxmqvc.'' Tkej ctf '' Rkpi tgg.'' '' o gt'' Fq cp.'' Fgtgm'' J cm'' *RgppUcvg+.'' Lghftg{ ''Ewr .'' Mtkuvc'' Dwnctf .'' P cy cp'' F kgo ngt.'' F cglkp'' Mko .'' Cngzcpf gt '' Uj wo unk '' O cwj gy '' Dtkuvgt.'' Mk/Lqqpi '' Mko .'' Mgxkp''Ej gp'' *WRkw+.'' J ctk'Dj cvc.'' Ucpf ggr 'Dwnnc0

Fkencko gt

Vj ku'r tqlgev'y cu'hwpf gf "d{ "y g''Wpkgf "Ucvgu'F gr ctvo gpv'qh'Gpgti {."P cvkqpcn'Gpgti { "Vgej pqmi { "Ncdqtcvqt {."kp''r ctv."y tqwi j "c" ukg''uwr r qtv'eqpvtcev0P gkj gt "y g''Wpkgf "Ucvgu'I qxgtpo gpv'pqt"cp{"ci gpe{"y gtgqh"pqt"cp{"qh'y gkt"go r m{ggu."pqt"y g''uwr r qtv' eqpvtcevqt."pqt"cp{"qh'y gkt"go r m{ggu."o cngu"cp{"y cttcpv{."gzr tguu"qt"ko r nkgf."qt"cuuwo gu"cp{"ngi cn'hcdktk{"qt"tgur qpukdkkk{"hqt" y g"ceewtce{."eqo r ngvgpguu."qt"wughwpguu"qh"cp{"kphqto cvkqp."cr r ctcwu."r tqf wev."qt"r tqeguu"f kuemugf."qt"tgr tgugpw"y cv''ku"wug" y qwf "pqv'kphtkpi g"r tkxcwn{"qy pgf "tk j w0'Tghgtgpeg"j gtgkp" vq"cp{"ur gekhke"eqo o gtekcn'r tqf wev."r tqeguu."qt"ugtxkeg"d{ "vtcf g" pco g." vtcf go ctm" o cpwhcewtgt."qt"qy gty kug"f qgu" pqv' pgeguucth{"eqpukwwg" qt" ko r n{"ku" gpf qtugo gpv." tgeqo o gpf cvkqp."qt" hcxqtkpi "d{"y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj g"xkgy u"cpf "qr kpkqpu"qh'cwj qtu"gzr tguugf "j gtgkp" f q"pqv" pgeguucth{"ucvg"qt"tghrgev'y qu"qh'y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj g"xkgy u"cpf "qr kpkqpu"qh'cwj qtu"gzr tguugf "j gtgkp" f q"pqv" pgeguucth{"ucvg"qt"tghrgev'y qu"qh'y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj g"xkgy u"cpf "qr kpkqpu"qh'cwj qtu"gzr tguugf "j gtgkp" f q"pqv" pgeguucth{"ucvg"qt"tghrgev'y qu"qh'y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj g"xkgy u"cpf"qr kpkqpu"qh'cwj qt"gzr tguugf "j gtgkp"f q"pqv" pgeguucth{"ucvg"qt"tghrgev'y qu"qh'y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj g"xkgy u"cpf"qr kpkqpu"qh'cwj qtu"gzr tguugf "j gtgkp"f q"pqv" pgeguucth{"ucvg"qt"tghrgev'y qu"qh'y g"Wpkgf "Ucvgu'I qxgtpo gpv'qt"cp{"ci gpe{"y gtgqhD'Vj gtgqhD



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